# Package 'Rsamtools'

January 4, 2025

**Type** Package

**Title** Binary alignment (BAM), FASTA, variant call (BCF), and tabix
file import

**Description** This package provides an interface to the 'samtools',
'bcftools', and 'tabix' utilities for manipulating SAM (Sequence
Alignment / Map), FASTA, binary variant call (BCF) and compressed
indexed tab-delimited (tabix) files.

**biocViews** DataImport, Sequencing, Coverage, Alignment, QualityControl

**URL** https://bioconductor.org/packages/Rsamtools

**Video** https://www.youtube.com/watch?v=Rfon-DQYbWA&list=UUqaMSQd_h-2EDGsU6WDiX0Q

**BugReports** https://github.com/Bioconductor/Rsamtools/issues

**Version** 2.23.1

**License** Artistic-2.0 | file LICENSE

**Encoding** UTF-8

**Depends** methods, GenomeInfoDb (>= 1.1.3), GenomicRanges (>= 1.31.8),
Biostrings (>= 2.47.6), R (>= 3.5.0)

**Imports** utils, BiocGenerics (>= 0.25.1), S4Vectors (>= 0.17.25),
IRanges (>= 2.13.12), XVector (>= 0.19.7), bitops,
BiocParallel, stats

**Suggests** GenomicAlignments, ShortRead (>= 1.19.10), GenomicFeatures,
TxDb.Dmelanogaster.UCSC.dm3.ensGene,
TxDb.Hsapiens.UCSC.hg18.knownGene, RNAseqData.HNRNPC.bam.chr14,
BSgenome.Hsapiens.UCSC.hg19, RUnit, BiocStyle, knitr

**LinkingTo** Rhtslib (>= 3.3.1), S4Vectors, IRanges, XVector, Biostrings

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**Author** Martin Morgan [aut],
        Hervé Pagès [aut],
        Valerie Obenchain [aut],
        Nathaniel Hayden [aut],
        Busayo Samuel [ctb] (Converted Rsamtools vignette from Sweave to
         RMarkdown / HTML.),
        Bioconductor Package Maintainer [cre]

**Maintainer** Bioconductor Package Maintainer <maintainer@bioconductor.org>

# Contents

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Rsamtools-package *'samtools' aligned sequence utilities interface*

---

## Description

This package provides facilities for parsing samtools BAM (binary) files representing aligned sequences.

## Details

See packageDescription('Rsamtools') for package details. A useful starting point is the scanBam manual page.

## Note

This package documents the following classes for purely internal reasons, see help pages in other packages: bzfile, fifo, gzfile, pipe, unz, url.

## Author(s)

Author: Martin Morgan

Maintainer: Biocore Team c/o BioC user list <bioconductor@stat.math.ethz.ch>

## References

The current source code for samtools and bcftools is from https://github.com/samtools/samtools. Additional material is at http://samtools.sourceforge.net/.

## Examples

```
packageDescription('Rsamtools')
```

---

applyPileups *Apply a user-provided function to calculate pile-up statistics across multiple BAM files.*

---

## Description

WARNING: Starting with Bioconductor 3.14, applyPileups is deprecated in favor of pileup.

applyPileups scans one or more BAM files, returning position-specific sequence and quality summaries.

## Usage

```
applyPileups(files, FUN, ..., param)
```

## Arguments

files          A [PileupFiles](#) instances.

FUN            A function of 1 argument, x, to be evaluated for each yield (see yieldSize,
               yieldBy, yieldAll). The argument x is a list, with elements describing the
               current pile-up. The elements of the list are determined by the argument what,
               and include:

   **seqnames:** (Always returned) A named integer() representing the seqnames
      corresponding to each position reported in the pile-up. This is a run-length
      encoding, where the names of the elements represent the seqnames, and the
      values the number of successive positions corresponding to that seqname.

   **pos:** Always returned) A integer() representing the genomic coordinate of
      each pile-up position.

   **seq:** An array of dimensions nucleotide x file x position.
      The 'nucleotide' dimension is length 5, corresponding to 'A', 'C', 'G', 'T',
      and 'N' respectively.
      Entries in the array represent the number of times the nucleotide occurred
      in reads in the file overlapping the position.

   **qual:** Like seq, but summarizing quality; the first dimension is the Phred-
      encoded quality score, ranging from '!' (0) to '~' (93).

...            Additional arguments, passed to methods.

param          An instance of the object returned by ApplyPileupsParam.

## Details

Regardless of param values, the algorithm follows samtools by excluding reads flagged as un-
mapped, secondary, duplicate, or failing quality control.

## Value

applyPileups returns a list equal in length to the number of times FUN has been called, with each
element containing the result of FUN.

ApplyPileupsParam returns an object describing the parameters.

## Author(s)

Martin Morgan

## References

[http://samtools.sourceforge.net/](http://samtools.sourceforge.net/)

## See Also

[ApplyPileupsParam](#).

## Examples

```
## The examples below are currently broken and have been disabled for now
## Not run:
fl <- system.file("extdata", "ex1.bam", package="Rsamtools",
                  mustWork=TRUE)

fls <- PileupFiles(c(fl, fl))

calcInfo <-
    function(x)
{
    ## information at each pile-up position
    info <- apply(x[["seq"]], 2, function(y) {
        y <- y[c("A", "C", "G", "T"),,drop=FALSE]
        y <- y + 1L                    # continuity
        cvg <- colSums(y)
        p <- y / cvg[col(y)]
        h <- -colSums(p * log(p))
        ifelse(cvg == 4L, NA, h)
    })
    list(seqnames=x[["seqnames"]], pos=x[["pos"]], info=info)
}
which <- GRanges(c("seq1", "seq2"), IRanges(c(1000, 1000), 2000))
param <- ApplyPileupsParam(which=which, what="seq")
res <- applyPileups(fls, calcInfo, param=param)
str(res)
head(res[[1]][["pos"]])  # positions matching param
head(res[[1]][["info"]])  # inforamtion in each file

## 'param' as part of 'files'
fls1 <- PileupFiles(c(fl, fl), param=param)
res1 <- applyPileups(fls1, calcInfo)
identical(res, res1)

## yield by position, across ranges
param <- ApplyPileupsParam(which=which, yieldSize=500L,
                           yieldBy="position", what="seq")
res <- applyPileups(fls, calcInfo, param=param)
sapply(res, "[[", "seqnames")

## End(Not run)
```

---

ApplyPileupsParam          *Parameters for creating pileups from BAM files*

---

## Description

Use `ApplyPileupsParam()` to create a parameter object influencing what fields and which records are used to calculate pile-ups, and to influence the values returned.

## Usage

```
# Constructor
ApplyPileupsParam(flag = scanBamFlag(),
    minBaseQuality = 13L, minMapQuality = 0L,
    minDepth = 0L, maxDepth = 250L,
    yieldSize = 1L, yieldBy = c("range", "position"), yieldAll = FALSE,
    which = GRanges(), what = c("seq", "qual"))

# Accessors
plpFlag(object)
plpFlag(object) <- value
plpMaxDepth(object)
plpMaxDepth(object) <- value
plpMinBaseQuality(object)
plpMinBaseQuality(object) <- value
plpMinDepth(object)
plpMinDepth(object) <- value
plpMinMapQuality(object)
plpMinMapQuality(object) <- value
plpWhat(object)
plpWhat(object) <- value
plpWhich(object)
plpWhich(object) <- value
plpYieldAll(object)
plpYieldAll(object) <- value
plpYieldBy(object)
plpYieldBy(object) <- value
plpYieldSize(object)
plpYieldSize(object) <- value

## S4 method for signature 'ApplyPileupsParam'
show(object)
```

## Arguments

| | |
|---|---|
| flag | An instance of the object returned by [scanBamFlag](), restricting various aspects of reads to be included or excluded. |
| minBaseQuality | The minimum read base quality below which the base is ignored when summarizing pileup information. |
| minMapQuality | The minimum mapping quality below which the entire read is ignored. |
| minDepth | The minimum depth of the pile-up below which the position is ignored. |
| maxDepth | The maximum depth of reads considered at any position; this can be used to limit memory consumption. |
| yieldSize | The number of records to include in each call to FUN. |
| yieldBy | How records are to be counted. By range (in which case yieldSize must equal 1) means that FUN is invoked once for each range in which. By position means |

that `FUN` is invoked whenever pile-ups have been accumulated for `yieldSize` positions, regardless of ranges in `which`.

| | |
|---|---|
| yieldAll | Whether to report all positions (`yieldAll=TRUE`), or just those passing the filtering criteria of `flag`, `minBaseQuality`, etc. When `yieldAll=TRUE`, positions not passing filter criteria have '0' entries in `seq` or `qual`. |
| which | A `GRanges` or `IntegerRangesList` instance restricting pileup calculations to the corresponding genomic locations. |
| what | A `character()` instance indicating what values are to be returned. One or more of `c("seq", "qual")`. |
| object | An instace of class `ApplyPileupsParam`. |
| value | An instance to be assigned to the corresponding slot of the `ApplyPileupsParam` instance. |

## Objects from the Class

Objects are created by calls of the form `ApplyPileupsParam()`.

## Slots

Slot interpretation is as described in the 'Arguments' section.

flag Object of class `integer` encoding flags to be kept when they have their '0' (keep0) or '1' (keep1) bit set.

minBaseQuality An `integer(1)`.

minMapQuality An `integer(1)`.

minDepth An `integer(1)`.

maxDepth An `integer(1)`.

yieldSize An `integer(1)`.

yieldBy An `character(1)`.

yieldAll A `logical(1)`.

which A `GRanges` or `IntegerRangesList` object.

what A `character()`.

## Functions and methods

See 'Usage' for details on invocation.

Constructor:

**ApplyPileupsParam:** Returns a `ApplyPileupsParam` object.

Accessors: get or set corresponding slot values; for setters, `value` is coerced to the type of the corresponding slot.

**plpFlag, plpFlag<-** Returns or sets the named `integer` vector of flags; see [scanBamFlag](scanBamFlag).

**plpMinBaseQuality, plpMinBaseQuality<-** Returns or sets an `integer(1)` vector of miminum base qualities.

**plpMinMapQuality, plpMinMapQuality<-** Returns or sets an `integer(1)` vector of miminum map qualities.

**plpMinDepth, plpMinDepth<-** Returns or sets an `integer(1)` vector of miminum pileup depth.

**plpMaxDepth, plpMaxDepth<-** Returns or sets an `integer(1)` vector of the maximum depth to which pileups are calculated.

**plpYieldSize, plpYieldSize<-** Returns or sets an `integer(1)` vector of yield size.

**plpYieldBy, plpYieldBy<-** Returns or sets an `character(1)` vector determining how pileups will be returned.

**plpYieldAll, plpYieldAll<-** Returns or sets an `logical(1)` vector indicating whether all positions, or just those satisfying pileup positions, are to be returned.

**plpWhich, plpWhich<-** Returns or sets the object influencing which locations pileups are calculated over.

**plpWhat, plpWhat<-** Returns or sets the `character` vector describing what summaries are returned by pileup.

Methods:

**show** Compactly display the object.

### Author(s)

Martin Morgan

### See Also

[applyPileups](#).

### Examples

```
example(applyPileups)
```

---

BamFile                         *Maintain and use BAM files*

---

### Description

Use `BamFile()` to create a reference to a BAM file (and optionally its index). The reference remains open across calls to methods, avoiding costly index re-loading.

`BamFileList()` provides a convenient way of managing a list of `BamFile` instances.

## Usage

```
## Constructors

BamFile(file, index=file, ..., yieldSize=NA_integer_, obeyQname=FALSE,
        asMates=FALSE, qnamePrefixEnd=NA, qnameSuffixStart=NA)
BamFileList(..., yieldSize=NA_integer_, obeyQname=FALSE, asMates=FALSE,
            qnamePrefixEnd=NA, qnameSuffixStart=NA)

## Opening / closing

## S3 method for class 'BamFile'
open(con, ...)
## S3 method for class 'BamFile'
close(con, ...)

## accessors; also path(), index(), yieldSize()

## S4 method for signature 'BamFile'
isOpen(con, rw="")
## S4 method for signature 'BamFile'
isIncomplete(con)
## S4 method for signature 'BamFile'
obeyQname(object, ...)
obeyQname(object, ...) <- value
## S4 method for signature 'BamFile'
asMates(object, ...)
asMates(object, ...) <- value
## S4 method for signature 'BamFile'
qnamePrefixEnd(object, ...)
qnamePrefixEnd(object, ...) <- value
## S4 method for signature 'BamFile'
qnameSuffixStart(object, ...)
qnameSuffixStart(object, ...) <- value

## actions

## S4 method for signature 'BamFile'
scanBamHeader(files, ..., what=c("targets", "text"))
## S4 method for signature 'BamFile'
seqinfo(x)
## S4 method for signature 'BamFileList'
seqinfo(x)
## S4 method for signature 'BamFile'
filterBam(file, destination, index=file, ...,
    filter=FilterRules(), indexDestination=TRUE,
    param=ScanBamParam(what=scanBamWhat()))
## S4 method for signature 'BamFile'
indexBam(files, ...)
```

```
## S4 method for signature 'BamFile'
sortBam(file, destination, ..., byQname=FALSE, maxMemory=512, byTag=NULL, nThreads=1L)
## S4 method for signature 'BamFileList'
mergeBam(files, destination, ...)

## reading

## S4 method for signature 'BamFile'
scanBam(file, index=file, ..., param=ScanBamParam(what=scanBamWhat()))

## counting

## S4 method for signature 'BamFile'
idxstatsBam(file, index=file, ...)
## S4 method for signature 'BamFile'
countBam(file, index=file, ..., param=ScanBamParam())
## S4 method for signature 'BamFileList'
countBam(file, index=file, ..., param=ScanBamParam())
## S4 method for signature 'BamFile'
quickBamFlagSummary(file, ..., param=ScanBamParam(), main.groups.only=FALSE)
```

### Arguments

| | |
|---|---|
| ... | Additional arguments. |
| | For `BamFileList`, this can either be a single character vector of paths to BAM files, or several instances of `BamFile` objects. When a character vector of paths, a second named argument 'index' can be a `character()` vector of length equal to the first argument specifying the paths to the index files, or `character()` to indicate that no index file is available. See `BamFile`. |
| con | An instance of `BamFile`. |
| x, object, file, files | |
| | A character vector of BAM file paths (for `BamFile`) or a `BamFile` instance (for other methods). |
| index | character(1); the BAM index file path (for `BamFile`); ignored for all other methods on this page. |
| yieldSize | Number of records to yield each time the file is read from with `scanBam`. See 'Fields' section for details. |
| asMates | Logical indicating if records should be paired as mates. See 'Fields' section for details. |
| qnamePrefixEnd | Single character (or NA) marking the end of the qname prefix. When specified, all characters prior to and including the qnamePrefixEnd are removed from the qname. If the prefix is not found in the qname the qname is not trimmed. Currently only implemented for mate-pairing (i.e., when asMates=TRUE in a BamFile. |
| qnameSuffixStart | |
| | Single character (or NA) marking the start of the qname suffix. When specified, all characters following and including the qnameSuffixStart are removed from |

the qname. If the suffix is not found in the qname the qname is not trimmmed. Currently only implemented for mate-pairing (i.e., when asMates=TRUE in a BamFile.

obeyQname  Logical indicating if the BAM file is sorted by qname. In Bioconductor > 2.12 paired-end files do not need to be sorted by qname. Instead use asMates=TRUE for reading paired-end data. See 'Fields' section for details.

value  Logical value for setting asMates and obeyQname in a BamFile instance.

what  For scanBamHeader, a character vector specifying that either or both of c("targets", "text") are to be extracted from the header; see [scanBam](#) for additional detail.

filter  A [FilterRules](#) instance. Functions in the FilterRules instance should expect a single DataFrame argument representing all information specified by param. Each function must return a logical vector, usually of length equal to the number of rows of the DataFrame. Return values are used to include (when TRUE) corresponding records in the filtered BAM file.

destination  character(1) file path to write filtered reads to.

indexDestination
  logical(1) indicating whether the destination file should also be indexed.

byQname, maxMemory, byTag, nThreads
  See [sortBam](#).

param  An optional [ScanBamParam](#) instance to further influence scanning, counting, or filtering.

rw  Mode of file; ignored.

main.groups.only
  See [quickBamFlagSummary](#).

## Objects from the Class

Objects are created by calls of the form BamFile().

## Fields

The BamFile class inherits fields from the [RsamtoolsFile](#) class and has fields:

**yieldSize:**  Number of records to yield each time the file is read from using scanBam or, when length(bamWhich()) != 0, a threshold which yields records in complete ranges whose sum first exceeds yieldSize. Setting yieldSize on a BamFileList does not alter existing yield sizes set on the individual BamFile instances.

**asMates:**  A logical indicating if the records should be returned as mated pairs. When TRUE scanBam attempts to mate (pair) the records and returns two additional fields groupid and mate_status. groupid is an integer vector of unique group ids; mate_status is a factor with level mated for records successfully paired by the algorithm, ambiguous for records that are possibly mates but cannot be assigned unambiguously, or unmated for reads that did not have valid mates.

Mate criteria:

- Bit 0x40 and 0x80: Segments are a pair of first/last OR neither segment is marked first/last

- Bit 0x100: Both segments are secondary OR both not secondary
- Bit 0x10 and 0x20: Segments are on opposite strands
- mpos match: segment1 mpos matches segment2 pos AND segment2 mpos matches segment1 pos
- tid match

Flags, tags and ranges may be specified in the ScanBamParam for fine tuning of results.

**obeyQname:**  A logical(0) indicating if the file was sorted by qname. In Bioconductor > 2.12 paired-end files do not need to be sorted by qname. Instead set asMates=TRUE in the BamFile when using the readGAlignmentsList function from the **GenomicAlignments** package.

## Functions and methods

BamFileList inherits additional methods from [RsamtoolsFileList](RsamtoolsFileList) and [SimpleList](SimpleList).

Opening / closing:

**open.BamFile**  Opens the (local or remote) path and index (if bamIndex is not character(0)), files. Returns a BamFile instance.

**close.BamFile**  Closes the BamFile con; returning (invisibly) the updated BamFile. The instance may be re-opened with open.BamFile.

**isOpen**  Tests whether the BamFile con has been opened for reading.

**isIncomplete**  Tests whether the BamFile con is niether closed nor at the end of the file.

Accessors:

**path**  Returns a character(1) vector of BAM path names.

**index**  Returns a character(0) or character(1) vector of BAM index path names.

**yieldSize, yieldSize<-**  Return or set an integer(1) vector indicating yield size.

**obeyQname, obeyQname<-**  Return or set a logical(0) indicating if the file was sorted by qname.

**asMates, asMates<-**  Return or set a logical(0) indicating if the records should be returned as mated pairs.

Methods:

**scanBamHeader**  Visit the path in path(file), returning the information contained in the file header; see [scanBamHeader](scanBamHeader).

**seqinfo, seqnames, seqlength**  Visit the path in path(file), returning a [Seqinfo](Seqinfo), character, or named integer vector containing information on the anmes and / or lengths of each sequence. Seqnames are ordered as they appear in the file.

**scanBam**  Visit the path in path(file), returning the result of [scanBam](scanBam) applied to the specified path.

**countBam**  Visit the path(s) in path(file), returning the result of [countBam](countBam) applied to the specified path.

**idxstatsBam**  Visit the index in index(file), quickly returning a data.frame with columns seqnames, seqlength, mapped (number of mapped reads on seqnames) and unmapped (number of unmapped reads).

**filterBam** Visit the path in `path(file)`, returning the result of [filterBam](#) applied to the specified path. A single file can be filtered to one or several destinations, as described in [filterBam](#).

**indexBam** Visit the path in `path(file)`, returning the result of [indexBam](#) applied to the specified path.

**sortBam** Visit the path in `path(file)`, returning the result of [sortBam](#) applied to the specified path.

**mergeBam** Merge several BAM files into a single BAM file. See [mergeBam](#) for details; additional arguments supported by `mergeBam,character-method` are also available for BamFileList.

**show** Compactly display the object.

### Author(s)

Martin Morgan and Marc Carlson

### See Also

- The [readGAlignments](#), [readGAlignmentPairs](#), and [readGAlignmentsList](#) functions defined in the **GenomicAlignments** package.

- [summarizeOverlaps](#) and [findSpliceOverlaps-methods](#) in the **GenomicAlignments** package for methods that work on a [BamFile](#) and [BamFileList](#) objects.

### Examples

```
##
## BamFile options.
##

fl <- system.file("extdata", "ex1.bam", package="Rsamtools")
bf <- BamFile(fl)
bf

## When 'asMates=TRUE' scanBam() reads the data in as
## pairs. See 'asMates' above for details of the pairing
## algorithm.
asMates(bf) <- TRUE

## When 'yieldSize' is set, scanBam() will iterate
## through the file in chunks.
yieldSize(bf) <- 500

## Some applications append a filename (e.g., NCBI Sequence Read
## Archive (SRA) toolkit) or allele identifier to the sequence qname.
## This may result in a unique qname for each record which presents a
## problem when mating paired-end reads (identical qnames is one
## criteria for paired-end mating). 'qnamePrefixEnd' and
## 'qnameSuffixStart' can be used to trim an unwanted prefix or suffix.
qnamePrefixEnd(bf) <- "/"
qnameSuffixStart(bf) <- "."

##
```

```
## Reading Bam files.
##

fl <- system.file("extdata", "ex1.bam", package="Rsamtools",
                  mustWork=TRUE)
(bf <- BamFile(fl))
head(seqlengths(bf))                    # sequences and lengths in BAM file

if (require(RNAseqData.HNRNPC.bam.chr14)) {
    bfl <- BamFileList(RNAseqData.HNRNPC.bam.chr14_BAMFILES)
    bfl
    bfl[1:2]                            # subset
    bfl[[1]]                            # select first element -- BamFile
    ## merged across BAM files
    seqinfo(bfl)
    head(seqlengths(bfl))
}


length(scanBam(fl)[[1]][[1]])  # all records

bf <- open(BamFile(fl))         # implicit index
bf
identical(scanBam(bf), scanBam(fl))
close(bf)

## Use 'yieldSize' to iterate through a file in chunks.
bf <- open(BamFile(fl, yieldSize=1000))
while (nrec <- length(scanBam(bf)[[1]][[1]]))
    cat("records:", nrec, "\n")
close(bf)

## Repeatedly visit multiple ranges in the BamFile.
rng <- GRanges(c("seq1", "seq2"), IRanges(1, c(1575, 1584)))
bf <- open(BamFile(fl))
sapply(seq_len(length(rng)), function(i, bamFile, rng) {
    param <- ScanBamParam(which=rng[i], what="seq")
    bam <- scanBam(bamFile, param=param)[[1]]
    alphabetFrequency(bam[["seq"]], baseOnly=TRUE, collapse=TRUE)
}, bf, rng)
close(bf)
```

---

BamInput                         *Import, count, index, filter, sort, and merge 'BAM' (binary alignment)*
                                 *files.*

---

### Description

Import binary 'BAM' files into a list structure, with facilities for selecting what fields and which
records are imported, and other operations to manipulate BAM files.

## Usage

```
scanBam(file, index=file, ..., param=ScanBamParam(what=scanBamWhat()))

countBam(file, index=file, ..., param=ScanBamParam())

idxstatsBam(file, index=file, ...)

scanBamHeader(files, ...)
## S4 method for signature 'character'
scanBamHeader(files, ...)

asBam(file, destination=sub("\\.sam(\\.gz)?", "", file), ...)
## S4 method for signature 'character'
asBam(file, destination=sub("\\.sam(\\.gz)?", "", file),
    ..., overwrite=FALSE, indexDestination=TRUE)

asSam(file, destination=sub("\\.bam", "", file), ...)
## S4 method for signature 'character'
asSam(file, destination=sub("\\.bam", "", file),
    ..., overwrite=FALSE)

filterBam(file, destination, index=file, ...)
## S4 method for signature 'character'
filterBam(file, destination, index=file, ...,
    filter=FilterRules(), indexDestination=TRUE,
    param=ScanBamParam(what=scanBamWhat()))

sortBam(file, destination, ...)
## S4 method for signature 'character'
sortBam(file, destination, ..., byQname=FALSE,
    maxMemory=512, byTag=NULL, nThreads=1L)

indexBam(files, ...)
## S4 method for signature 'character'
indexBam(files, ...)

mergeBam(files, destination, ...)
## S4 method for signature 'character'
mergeBam(files, destination, ..., region = GRanges(),
    overwrite = FALSE, header = character(), byQname = FALSE,
    addRG = FALSE, compressLevel1 = FALSE, indexDestination = FALSE)
```

## Arguments

| | |
|---|---|
| file | The character(1) file name of the 'BAM' ('SAM' for asBam) file to be processed. |
| files | The character() file names of the 'BAM' file to be processed. For mergeBam, must satisfy length(files) >= 2. |

| index | The character(1) name of the index file of the 'BAM' file being processed; this is given *without* the '.bai' extension. |
|---|---|
| destination | The character(1) file name of the location where the sorted, filtered, or merged output file will be created. For asBam asSam, and sortBam this is without the ".bam" file suffix. |
| region | A GRanges() instance with <= 1 elements, specifying the region of the BAM files to merged. |
| ... | Additional arguments, passed to methods. |
| overwrite | A logical(1) indicating whether the destination can be over-written if it already exists. |
| filter | A [FilterRules](#) instance allowing users to filter BAM files based on arbitrary criteria, as described below. |
| indexDestination | |
| | A logical(1) indicating whether the created destination file should also be indexed. |
| byQname | A logical(1) indicating whether the sorted destination file should be sorted by Query-name (TRUE) or by mapping position (FALSE). |
| header | A character(1) file path for the header information to be used in the merged BAM file. |
| addRG | A logical(1) indicating whether the file name should be used as RG (read group) tag in the merged BAM file. |
| compressLevel1 | A logical(1) indicating whether the merged BAM file should be compressed to zip level 1. |
| maxMemory | A numerical(1) indicating the maximal amount of memory (in MB) that the function is allowed to use. |
| byTag | A character(1) indicating whether the BAM file should be sorted by the supplied tag value. |
| nThreads | An integer(1) indicating the number of threads the function should use. |
| param | An instance of [ScanBamParam](#). This influences what fields and which records are imported. |

### Details

The scanBam function parses binary BAM files; text SAM files can be parsed using R's [scan](#) function, especially with arguments what to control the fields that are parsed.

countBam returns a count of records consistent with param. If param is empty then entire file would be counted.

idxstatsBam visit the index in index(file), and quickly returns the number of mapped and unmapped reads on each seqname.

scanBamHeader visits the header information in a BAM file, returning for each file a list containing elements targets and text, as described below. The SAM / BAM specification does not require that the content of the header be consistent with the content of the file, e.g., more targets may be present that are represented by reads in the file. An optional character vector argument containing

one or two elements of what=c("targets", "text") can be used to specify which elements of the header are returned.

asBam converts 'SAM' files to 'BAM' files, equivalent to samtools view -Sb file > destination. The 'BAM' file is sorted and an index created on the destination (with extension '.bai') when indexDestination=TRUE.

asSam converts 'BAM' files to 'SAM' files, equivalent to samtools view file > destination.

filterBam parses records in file. Records satisfying the bamWhich bamFlag and bamSimpleCigar criteria of param are accumulated to a default of yieldSize = 1000000 records (change this by specifying yieldSize when creating a BamFile instance; see BamFile-class). These records are then parsed to a DataFrame and made available for further filtering by user-supplied FilterRules. Functions in the FilterRules instance should expect a single DataFrame argument representing all information specified by param. Each function must return a logical vector equal to the number of rows of the DataFrame. Return values are used to include (when TRUE) corresponding records in the filtered BAM file. The BAM file is created at destination. An index file is created on the destination when indexDestination=TRUE. It is more space- and time-efficient to filter using bamWhich, bamFlag, and bamSimpleCigar, if appropriate, than to supply FilterRules. filter may be a list of FilterRules instances, in which case destination must be a character vector of equal length. The original file is then separately filtered into destination[[i]], using filter[[i]] as the filter criterion.

sortBam sorts the BAM file given as its first argument, analogous to the "samtools sort" function.

indexBam creates an index for each BAM file specified, analogous to the 'samtools index' function.

mergeBam merges 2 or more sorted BAM files. As with samtools, the RG (read group) dictionary in the header of the BAM files is not reconstructed.

Details of the ScanBamParam class are provide on its help page; several salient points are reiterated here. ScanBamParam can contain a field what, specifying the components of the BAM records to be returned. Valid values of what are available with scanBamWhat. ScanBamParam can contain an argument which that specifies a subset of reads to return. This requires that the BAM file be indexed, and that the file be named following samtools convention as <bam_filename>.bai. ScanBamParam can contain an argument tag to specify which tags will be extracted.

## Value

The scanBam,character-method returns a list of lists. The outer list groups results from each IntegerRanges list of bamWhich(param); the outer list is of length one when bamWhich(param) has length 0. Each inner list contains elements named after scanBamWhat(); elements omitted from bamWhat(param) are removed. The content of non-null elements are as follows, taken from the description in the samtools API documentation:

- qname: This is the QNAME field in SAM Spec v1.4. The query name, i.e., identifier, associated with the read.

- flag: This is the FLAG field in SAM Spec v1.4. A numeric value summarizing details of the read. See ScanBamParam and the flag argument, and scanBamFlag().

- rname: This is the RNAME field in SAM Spec v1.4. The name of the reference to which the read is aligned.

- strand: The strand to which the read is aligned.

- pos: This is the POS field in SAM Spec v1.4. The genomic coordinate at the start of the alignment. Coordinates are 'left-most', i.e., at the 3' end of a read on the '-' strand, and 1-based. The position *excludes* clipped nucleotides, even though soft-clipped nucleotides are included in seq.

- qwidth: The width of the query, as calculated from the cigar encoding; normally equal to the width of the query returned in seq.

- mapq: This is the MAPQ field in SAM Spec v1.4. The MAPping Quality.

- cigar: This is the CIGAR field in SAM Spec v1.4. The CIGAR string.

- mrnm: This is the RNEXT field in SAM Spec v1.4. The reference to which the mate (of a paired end or mate pair read) aligns.

- mpos: This is the PNEXT field in SAM Spec v1.4. The position to which the mate aligns.

- isize: This is the TLEN field in SAM Spec v1.4. Inferred insert size for paired end alignments.

- seq: This is the SEQ field in SAM Spec v1.4. The query sequence, in the 5' to 3' orientation. If aligned to the minus strand, it is the reverse complement of the original sequence.

- qual: This is the QUAL field in SAM Spec v1.4. Phred-encoded, phred-scaled base quality score, oriented as seq.

- groupid: This is an integer vector of unique group ids returned when asMates=TRUE in a BamFile object. groupid values are used to create the partitioning for a GAlignmentsList object.

- mate_status: Returned (always) when asMates=TRUE in a BamFile object. This is a factor indicating status (mated, ambiguous, unmated) of each record.

idxstatsBam returns a data.frame with columns seqnames, seqlength, mapped (number of mapped reads on seqnames) and unmapped (number of unmapped reads).

scanBamHeader returns a list, with one element for each file named in files. The list contains two element. The targets element contains target (reference) sequence lengths. The text element is itself a list with each element a list corresponding to tags (e.g., '@SQ') found in the header, and the associated tag values.

asBam, asSam return the file name of the destination file.

sortBam returns the file name of the sorted file.

indexBam returns the file name of the index file created.

filterBam returns the file name of the destination file created.

### Author(s)

Martin Morgan <mtmorgan@fhcrc.org>. Thomas Unterhiner <thomas.unterthiner@students.jku.at> (sortBam).

### References

<http://samtools.sourceforge.net/>

### See Also

[ScanBamParam](), [scanBamWhat](), [scanBamFlag]()

## Examples

```
fl <- system.file("extdata", "ex1.bam", package="Rsamtools",
                  mustWork=TRUE)

##
## scanBam
##

res0 <- scanBam(fl)[[1]] # always list-of-lists
names(res0)
length(res0[["qname"]])
lapply(res0, head, 3)
table(width(res0[["seq"]])) # query widths
table(res0[["qwidth"]], useNA="always") # query widths derived from cigar
table(res0[["cigar"]], useNA="always")
table(res0[["strand"]], useNA="always")
table(res0[["flag"]], useNA="always")

which <- IRangesList(seq1=IRanges(1000, 2000),
                     seq2=IRanges(c(100, 1000), c(1000, 2000)))
p1 <- ScanBamParam(which=which, what=scanBamWhat())
res1 <- scanBam(fl, param=p1)
names(res1)
names(res1[[2]])

p2 <- ScanBamParam(what=c("rname", "strand", "pos", "qwidth"))
res2 <- scanBam(fl, param=p2)

p3 <- ScanBamParam(
    what="flag",            # information to query from BAM file
    flag=scanBamFlag(isMinusStrand=FALSE))
length(scanBam(fl, param=p3)[[1]]$flag)

##
## idxstatsBam
##

idxstatsBam(fl)

##
## filterBam
##

param <- ScanBamParam(
    flag=scanBamFlag(isUnmappedQuery=FALSE),
    what="seq")
dest <- filterBam(fl, tempfile(), param=param)
countBam(dest)  ## 3271 records

## filter to a single file
filter <- FilterRules(list(MinWidth = function(x) width(x$seq) > 35))
dest <- filterBam(fl, tempfile(), param=param, filter=filter)
```

```
countBam(dest)  ## 398 records
res3 <- scanBam(dest, param=ScanBamParam(what="seq"))[[1]]
table(width(res3$seq))

## filter 1 file to 2 destinations
filters <- list(
    FilterRules(list(long=function(x) width(x$seq) > 35)),
    FilterRules(list(short=function(x) width(x$seq) <= 35))
)
destinations <- replicate(2, tempfile())
dest <- filterBam(fl, destinations, param=param, filter=filters)
lapply(dest, countBam)

##
## sortBam
##

sorted <- sortBam(fl, tempfile())

##
## scanBamParam re-orders 'which'; recover original order
##

gwhich <- as(which, "GRanges")[c(2, 1, 3)]    # example data
cnt <- countBam(fl, param=ScanBamParam(which=gwhich))
reorderIdx <- unlist(split(seq_along(gwhich), seqnames(gwhich)))
cnt
cnt[reorderIdx,]
```

---

BamViews                        *Views into a set of BAM files*

---

### Description

Use BamViews() to reference a set of disk-based BAM files to be processed (e.g., queried using
[scanBam](#)) as a single 'experiment'.

### Usage

```
## Constructor
BamViews(bamPaths=character(0),
     bamIndicies=bamPaths,
     bamSamples=DataFrame(row.names=make.unique(basename(bamPaths))),
     bamRanges, bamExperiment = list(), ...)
## S4 method for signature 'missing'
BamViews(bamPaths=character(0),
     bamIndicies=bamPaths,
     bamSamples=DataFrame(row.names=make.unique(basename(bamPaths))),
```

```
      bamRanges, bamExperiment = list(), ..., auto.range=FALSE)
## Accessors
bamPaths(x)
bamSamples(x)
bamSamples(x) <- value
bamRanges(x)
bamRanges(x) <- value
bamExperiment(x)

## S4 method for signature 'BamViews'
names(x)
## S4 replacement method for signature 'BamViews'
names(x) <- value
## S4 method for signature 'BamViews'
dimnames(x)
## S4 replacement method for signature 'BamViews,ANY'
dimnames(x) <- value

bamDirname(x, ...) <- value

## Subset
## S4 method for signature 'BamViews,ANY,ANY'
x[i, j, ..., drop=TRUE]
## S4 method for signature 'BamViews,ANY,missing'
x[i, j, ..., drop=TRUE]
## S4 method for signature 'BamViews,missing,ANY'
x[i, j, ..., drop=TRUE]

## Input
## S4 method for signature 'BamViews'
scanBam(file, index = file, ..., param = ScanBamParam(what=scanBamWhat()))
## S4 method for signature 'BamViews'
countBam(file, index = file, ..., param = ScanBamParam())

## Show
## S4 method for signature 'BamViews'
show(object)
```

## Arguments

bamPaths    A character() vector of BAM path names.

bamIndicies    A character() vector of BAM index file path names, *without* the '.bai' extension.

bamSamples    A [DataFrame](#) instance with as many rows as length(bamPaths), containing sample information associated with each path.

bamRanges    Missing or a [GRanges](#) instance with ranges defined on the reference chromosomes of the BAM files. Ranges are *not* validated against the BAM files.

bamExperiment    A list() containing additional information about the experiment.

| auto.range | If `TRUE` and all `bamPaths` exist, populate the ranges with the union of ranges returned in the `target` element of scanBamHeader. |
|---|---|
| ... | Additional arguments. |
| x | An instance of `BamViews`. |
| object | An instance of `BamViews`. |
| value | An object of appropriate type to replace content. |
| i | During subsetting, a logical or numeric index into `bamRanges`. |
| j | During subsetting, a logical or numeric index into `bamSamples` and `bamPaths`. |
| drop | A logical(1), *ignored* by all `BamViews` subsetting methods. |
| file | An instance of `BamViews`. |
| index | A character vector of indices, corresponding to the `bamPaths(file)`. |
| param | An optional [ScanBamParam](#) instance to further influence scanning or counting. |

## Objects from the Class

Objects are created by calls of the form `BamViews()`.

## Slots

**bamPaths**  A character() vector of BAM path names.

**bamIndicies**  A character() vector of BAM index path names.

**bamSamples**  A [DataFrame](#) instance with as many rows as length(bamPaths), containing sample information associated with each path.

**bamRanges**  A [GRanges](#) instance with ranges defined on the spaces of the BAM files. Ranges are *not* validated against the BAM files.

**bamExperiment**  A list() containing additional information about the experiment.

## Functions and methods

See 'Usage' for details on invocation.

Constructor:

**BamViews:**  Returns a `BamViews` object.

Accessors:

**bamPaths**  Returns a character() vector of BAM path names.

**bamIndicies**  Returns a character() vector of BAM index path names.

**bamSamples**  Returns a [DataFrame](#) instance with as many rows as length(bamPaths), containing sample information associated with each path.

**bamSamples<-**  Assign a [DataFrame](#) instance with as many rows as length(bamPaths), containing sample information associated with each path.

**bamRanges**  Returns a [GRanges](#) instance with ranges defined on the spaces of the BAM files. Ranges are *not* validated against the BAM files.

**bamRanges<-** Assign a [GRanges](GRanges) instance with ranges defined on the spaces of the BAM files. Ranges are *not* validated against the BAM files.

**bamExperiment** Returns a list() containing additional information about the experiment.

**names** Return the column names of the `BamViews` instance; same as `names(bamSamples(x))`.

**names<-** Assign the column names of the `BamViews` instance.

**dimnames** Return the row and column names of the `BamViews` instance.

**dimnames<-** Assign the row and column names of the `BamViews` instance.

Methods:

**"["** Subset the object by `bamRanges` or `bamSamples`.

**scanBam** Visit each path in `bamPaths(file)`, returning the result of `scanBam` applied to the specified path. `bamRanges(file)` takes precedence over `bamWhich(param)`.

**countBam** Visit each path in `bamPaths(file)`, returning the result of `countBam` applied to the specified path. `bamRanges(file)` takes precedence over `bamWhich(param)`.

**show** Compactly display the object.

### Author(s)

Martin Morgan

### Examples

```
fls <- system.file("extdata", "ex1.bam", package="Rsamtools",
                    mustWork=TRUE)
rngs <- GRanges(seqnames = Rle(c("chr1", "chr2"), c(9, 9)),
                ranges = c(IRanges(seq(10000, 90000, 10000), width=500),
                           IRanges(seq(100000, 900000, 100000), width=5000)),
                Count = seq_len(18L))
v <- BamViews(fls, bamRanges=rngs)
v
v[1:5,]
bamRanges(v[c(1:5, 11:15),])
bamDirname(v) <- getwd()
v
```

---

| BcfFile | *Manipulate BCF files.* |
|---|---|

---

### Description

Use BcfFile() to create a reference to a BCF (and optionally its index). The reference remains open across calls to methods, avoiding costly index re-loading.

BcfFileList() provides a convenient way of managing a list of BcfFile instances.

## Usage

```
## Constructors

BcfFile(file, index = file,
        mode=ifelse(grepl("\\.bcf$", file), "rb", "r"))
BcfFileList(...)

## Opening / closing

## S3 method for class 'BcfFile'
open(con, ...)
## S3 method for class 'BcfFile'
close(con, ...)

## accessors; also path(), index()

## S4 method for signature 'BcfFile'
isOpen(con, rw="")
bcfMode(object)

## actions

## S4 method for signature 'BcfFile'
scanBcfHeader(file, ...)
## S4 method for signature 'BcfFile'
scanBcf(file, ..., param=ScanBcfParam())
## S4 method for signature 'BcfFile'
indexBcf(file, ...)
```

## Arguments

| | |
|---|---|
| con, object | An instance of BcfFile. |
| file | A character(1) vector of the BCF file path or, (for indexBcf) an instance of BcfFile point to a BCF file. |
| index | A character(1) vector of the BCF index. |
| mode | A character(1) vector; mode="rb" indicates a binary (BCF) file, mode="r" a text (VCF) file. |
| param | An optional [ScanBcfParam](#) instance to further influence scanning. |
| ... | Additional arguments. For BcfFileList, this can either be a single character vector of paths to BCF files, or several instances of BcfFile objects. |
| rw | Mode of file; ignored. |

## Objects from the Class

Objects are created by calls of the form BcfFile().

## Fields

The BcfFile class inherits fields from the [RsamtoolsFile](RsamtoolsFile) class.

## Functions and methods

BcfFileList inherits methods from [RsamtoolsFileList](RsamtoolsFileList) and [SimpleList](SimpleList).

Opening / closing:

**open.BcfFile** Opens the (local or remote) path and index (if bamIndex is not character(0)), files. Returns a BcfFile instance.

**close.BcfFile** Closes the BcfFile con; returning (invisibly) the updated BcfFile. The instance may be re-opened with open.BcfFile.

Accessors:

**path** Returns a character(1) vector of the BCF path name.

**index** Returns a character(1) vector of BCF index name.

**bcfMode** Returns a character(1) vector BCF mode.

Methods:

**scanBcf** Visit the path in path(file), returning the result of [scanBcf](scanBcf) applied to the specified path.

**show** Compactly display the object.

## Author(s)

Martin Morgan

## Examples

```
fl <- system.file("extdata", "ex1.bcf.gz", package="Rsamtools",
                  mustWork=TRUE)
bf <- BcfFile(fl)        # implicit index
bf
identical(scanBcf(bf), scanBcf(fl))

rng <- GRanges(c("seq1", "seq2"), IRanges(1, c(1575, 1584)))
param <- ScanBcfParam(which=rng)
bcf <- scanBcf(bf, param=param)  ## all ranges

## ranges one at a time 'bf'
open(bf)
sapply(seq_len(length(rng)), function(i, bcfFile, rng) {
    param <- ScanBcfParam(which=rng)
    bcf <- scanBcf(bcfFile, param=param)[[1]]
    ## do extensive work with bcf
    isOpen(bf)  ## file remains open
}, bf, rng)
```

---

**BcfInput**                          *Operations on 'BCF' files.*

---

### Description

Import, coerce, or index variant call files in text or binary format.

### Usage

```
scanBcfHeader(file, ...)
## S4 method for signature 'character'
scanBcfHeader(file, ...)

scanBcf(file, ...)
## S4 method for signature 'character'
scanBcf(file, index = file, ..., param=ScanBcfParam())

asBcf(file, dictionary, destination, ...,
      overwrite=FALSE, indexDestination=TRUE)
## S4 method for signature 'character'
asBcf(file, dictionary, destination, ...,
      overwrite=FALSE, indexDestination=TRUE)

indexBcf(file, ...)
## S4 method for signature 'character'
indexBcf(file, ...)
```

### Arguments

| | |
|---|---|
| file | For scanBcf and scanBcfHeader, the character() file name of the 'BCF' file to be processed, or an instance of class [BcfFile](#). |
| index | The character() file name(s) of the 'BCF' index to be processed. |
| dictionary | a character vector of the unique "CHROM" names in the VCF file. |
| destination | The character(1) file name of the location where the BCF output file will be created. For asBcf this is without the ".bcf" file suffix. |
| param | A instance of [ScanBcfParam](#) influencing which records are parsed and the 'INFO' and 'GENO' information returned. |
| ... | Additional arguments, e.g., for scanBcfHeader,character-method, mode of [BcfFile](#). |
| overwrite | A logical(1) indicating whether the destination can be over-written if it already exists. |
| indexDestination | |
| | A logical(1) indicating whether the created destination file should also be indexed. |

## Details

bcf* functions are restricted to the GENO fields supported by 'bcftools' (see documentation at the url below). The argument `param` allows portions of the file to be input, but requires that the file be BCF or bgzip'd and indexed as a `TabixFile`. For similar functions operating on VCF files see ?scanVcf in the `VariantAnnotation` package.

## Value

`scanBcfHeader` returns a list, with one element for each file named in `file`. Each element of the list is itself a list containing three elements. The `Reference` element is a character() vector with names of reference sequences. The `Sample` element is a character() vector of names of samples. The `Header` element is a DataFrameList with one DataFrame per unique key value in the header (preceded by "##").

NOTE: In Rsamtools >=1.33.6, the `Header` DataFrameList no longer contains a DataFrame named "META". The META DataFrame contained all "simple" key-value headers lines from a bcf / vcf file. These "simple" header lines are now parsed into individual DataFrames named for the unique key.

`scanBcf` returns a list, with one element per file. Each list has 9 elements, corresponding to the columns of the VCF specification: CHROM, POS, ID, REF, ALTQUAL, FILTER, INFO, FORMAT, GENO.

The GENO element is itself a list, with elements corresponding to fields supported by 'bcftools' (see documentation at the url below).

`asBcf` creates a binary BCF file from a text VCF file.

`indexBcf` creates an index into the BCF file.

## Author(s)

Martin Morgan <mtmorgan@fhcrc.org>.

## References

<http://vcftools.sourceforge.net/specs.html> outlines the VCF specification.

<http://samtools.sourceforge.net/mpileup.shtml> contains information on the portion of the specification implemented by bcftools.

<http://samtools.sourceforge.net/> provides information on samtools.

## See Also

`BcfFile`, `TabixFile`

## Examples

```
fl <- system.file("extdata", "ex1.bcf.gz", package="Rsamtools",
                  mustWork=TRUE)
scanBcfHeader(fl)
bcf <- scanBcf(fl)
## value: list-of-lists
str(bcf[1:8])
```

```
names(bcf[["GENO"]])
str(head(bcf[["GENO"]][["PL"]]))
example(BcfFile)
```

| Compression | *File compression for tabix (bgzip) and fasta (razip) files. IMPORTANT NOTE: Starting with Rsamtools 1.99.0 (Bioconductor 3.9),* razip() *is defunct. Please use* bgzip() *instead.* |

### Description

bgzip compresses tabix (e.g. SAM or VCF) or FASTA files to a format that allows indexing for later fast random-access.

### Usage

```
bgzip(file, dest=sprintf("%s.bgz", sub("\\.gz$", "", file)),
      overwrite = FALSE)

## Defunct!
razip(file, dest=sprintf("%s.rz", sub("\\.gz$", "", file)),
      overwrite = FALSE)
```

### Arguments

| file | A character(1) path to an existing uncompressed or gz-compressed file. This file will be compressed. |
| dest | A character(1) path to a file. This will be the compressed file. If dest exists, then it is only over-written when overwrite=TRUE. |
| overwrite | A logical(1) indicating whether dest should be over-written, if it already exists. |

### Value

The full path to dest.

### Author(s)

Martin Morgan <mtmorgan@fhcrc.org>

### References

<http://samtools.sourceforge.net/>

### See Also

TabixFile, FaFile.

## Examples

```
from <- system.file("extdata", "ex1.sam", package="Rsamtools",
                    mustWork=TRUE)
to <- tempfile()
zipped <- bgzip(from, to)
```

---

deprecated *Deprecated functions*

---

## Description

Functions listed on this page are no longer supported.

## Details

For yieldTabix, use the yieldSize argument of TabixFiles.

For BamSampler, use REDUCEsampler with reduceByYield in the GenomicFiles package.

## Author(s)

Martin Morgan <mtmorgan@fhcrc.org>.

---

Deprecated and Defunct
                          *Rsamtools Deprecated and Defunct*

---

## Description

The function, class, or data object you have asked for has been deprecated or made defunct.

---

FaFile                          *Manipulate indexed fasta files.*

---

### Description

Use `FaFile()` to create a reference to an indexed fasta file. The reference remains open across calls to methods, avoiding costly index re-loading.

`FaFileList()` provides a convenient way of managing a list of `FaFile` instances.

### Usage

```
## Constructors

FaFile(file, index=sprintf("%s.fai", file),
              gzindex=sprintf("%s.gzi", file))
FaFileList(...)

## Opening / closing

## S3 method for class 'FaFile'
open(con, ...)
## S3 method for class 'FaFile'
close(con, ...)

## accessors; also path(), index()

## S4 method for signature 'FaFile'
gzindex(object, asNA=TRUE)
## S4 method for signature 'FaFileList'
gzindex(object, asNA=TRUE)
## S4 method for signature 'FaFile'
isOpen(con, rw="")

## actions

## S4 method for signature 'FaFile'
indexFa(file, ...)

## S4 method for signature 'FaFile'
scanFaIndex(file, ...)
## S4 method for signature 'FaFileList'
scanFaIndex(file, ..., as=c("GRangesList", "GRanges"))

## S4 method for signature 'FaFile'
seqinfo(x)
```

```
## S4 method for signature 'FaFile'
countFa(file, ...)

## S4 method for signature 'FaFile,GRanges'
scanFa(file, param, ...,
    as=c("DNAStringSet", "RNAStringSet", "AAStringSet"))
## S4 method for signature 'FaFile,IntegerRangesList'
scanFa(file, param, ...,
    as=c("DNAStringSet", "RNAStringSet", "AAStringSet"))
## S4 method for signature 'FaFile,missing'
scanFa(file, param, ...,
    as=c("DNAStringSet", "RNAStringSet", "AAStringSet"))

## S4 method for signature 'FaFile'
getSeq(x, param, ...)
## S4 method for signature 'FaFileList'
getSeq(x, param, ...)
```

## Arguments

con, object, x  An instance of FaFile or (for gzindex and getSeq) FaFileList.

file, index, gzindex

A character(1) vector of the fasta or fasta index or bgzip index file path (for FaFile), or an instance of class FaFile or FaFileList (for scanFaIndex, getSeq).

asNA  logical indicating if missing output should be NA or character()

param  An optional [GRanges](#) or [IntegerRangesList](#) instance to select reads (and subsequences) for input. See Methods, below.

...  Additional arguments.

- For FaFileList, this can either be a single character vector of paths to BAM files, or several instances of FaFile objects.
- For scanFa,FaFile,missing-method this can include arguemnts to readDNAStringSet / readRNAStringSet / readAAStringSet when param is 'missing'.

rw  Mode of file; ignored.

as  A character(1) vector indicating the type of object to return.

- For scanFaIndex, default GRangesList, with index information from each file is returned as an element of the list.
- For scanFa, default DNAStringSet.

GRangesList, index information is collapsed across files into the unique index elements.

## Objects from the Class

Objects are created by calls of the form FaFile().

**Fields**

The FaFile class inherits fields from the [RsamtoolsFile](#) class.

**Functions and methods**

FaFileList inherits methods from [RsamtoolsFileList](#) and [SimpleList](#).

Opening / closing:

**open.FaFile** Opens the (local or remote) path and index files. Returns a FaFile instance.

**close.FaFile** Closes the FaFile con; returning (invisibly) the updated FaFile. The instance may be re-opened with open.FaFile.

Accessors:

**path** Returns a character(1) vector of the fasta path name.

**index** Returns a character(1) vector of fasta index name (minus the '.fai' extension).

Methods:

**indexFa** Visit the path in path(file) and create an index file (with the extension '.fai').

**scanFaIndex** Read the sequence names and and widths of recorded in an indexed fasta file, returning the information as a [GRanges](#) object.

**seqinfo** Consult the index file for defined sequences (seqlevels()) and lengths (seqlengths()).

**countFa** Return the number of records in the fasta file.

**scanFa** Return the sequences indicated by param as a [DNAStringSet](#) instance. seqnames(param) selects the sequences to return; start(param) and end{param} define the (1-based) region of the sequence to return. Values of end(param) greater than the width of the sequence cause an error; use seqlengths(FaFile(file)) to discover sequence widths. When param is missing, all records are selected. When length(param)==0 no records are selected.

**getSeq** Returns the sequences indicated by param from the indexed fasta file(s) of file.

For the FaFile method, the return type is a DNAStringSet. The getSeq,FaFile and scanFa,FaFile,GRanges methods differ in that getSeq will reverse complement sequences selected from the minus strand.

For the FaFileList method, the param argument must be a GRangesList of the same length as file, creating a one-to-one mapping between the ith element of file and the ith element of param; the return type is a SimpleList of DNAStringSet instances, with elements of the list in the same order as the input elements.

**show** Compactly display the object.

**Author(s)**

Martin Morgan

## Examples

```
fl <- system.file("extdata", "ce2dict1.fa", package="Rsamtools",
                   mustWork=TRUE)
fa <- open(FaFile(fl))                    # open
countFa(fa)
(idx <- scanFaIndex(fa))
(dna <- scanFa(fa, param=idx[1:2]))
ranges(idx) <- narrow(ranges(idx), -10)  # last 10 nucleotides
(dna <- scanFa(fa, param=idx[1:2]))
```

---

FaInput                         *Operations on indexed 'fasta' files.*

---

## Description

Scan indexed fasta (or compressed fasta) files and their indicies.

## Usage

```
indexFa(file, ...)
## S4 method for signature 'character'
indexFa(file, ...)

scanFaIndex(file, ...)
## S4 method for signature 'character'
scanFaIndex(file, ...)

countFa(file, ...)
## S4 method for signature 'character'
countFa(file, ...)

scanFa(file, param, ...,
    as=c("DNAStringSet", "RNAStringSet", "AAStringSet"))
## S4 method for signature 'character,GRanges'
scanFa(file, param, ...,
    as=c("DNAStringSet", "RNAStringSet", "AAStringSet"))
## S4 method for signature 'character,IntegerRangesList'
scanFa(file, param, ...,
    as=c("DNAStringSet", "RNAStringSet", "AAStringSet"))
## S4 method for signature 'character,missing'
scanFa(file, param, ...,
    as=c("DNAStringSet", "RNAStringSet", "AAStringSet"))
```

## Arguments

| | |
|---|---|
| `file` | A character(1) vector containing the fasta file path. |
| `param` | An optional [GRanges](#) or [IntegerRangesList](#) instance to select reads (and sub-sequences) for input. |
| `as` | A character(1) vector indicating the type of object to return; default `DNAStringSet`. |
| `...` | Additional arguments, passed to readDNAStringSet / readRNAStringSet / readAAStringSet when param is 'missing'. |

## Value

`indexFa` visits the path in `file` and create an index file at the same location but with extension '.fai').

`scanFaIndex` reads the sequence names and and widths of recorded in an indexed fasta file, returning the information as a [GRanges](#) object.

`countFa` returns the number of records in the fasta file.

`scanFa` return the sequences indicated by param as a [DNAStringSet](#), [RNAStringSet](#), [AAStringSet](#) instance. seqnames(param) selects the sequences to return; start(param) and end{param} define the (1-based) region of the sequence to return. Values of end(param) greater than the width of the sequence are set to the width of the sequence. When param is missing, all records are selected. When param is GRanges(), no records are selected.

## Author(s)

Martin Morgan <mtmorgan@fhcrc.org>.

## References

<http://samtools.sourceforge.net/> provides information on samtools.

## Examples

```
fa <- system.file("extdata", "ce2dict1.fa", package="Rsamtools",
                  mustWork=TRUE)
countFa(fa)
(idx <- scanFaIndex(fa))
(dna <- scanFa(fa, idx[1:2]))
ranges(idx) <- narrow(ranges(idx), -10)  # last 10 nucleotides
(dna <- scanFa(fa, idx[1:2]))
```

---

headerTabix *Retrieve sequence names defined in a tabix file.*

---

### Description

This function queries a tabix file, returning the names of the 'sequences' used as a key when creating the file.

### Usage

```
headerTabix(file, ...)
## S4 method for signature 'character'
headerTabix(file, ...)
```

### Arguments

| | |
|---|---|
| file | A character(1) file path or [`TabixFile`](#) instance pointing to a 'tabix' file. |
| ... | Additional arguments, currently ignored. |

### Value

A list(4) of the sequence names, column indicies used to sort the file, the number of lines skipped while indexing, and the comment character used while indexing.

### Author(s)

Martin Morgan <mtmorgan@fhcrc.org>.

### Examples

```
fl <- system.file("extdata", "example.gtf.gz", package="Rsamtools",
                   mustWork=TRUE)
headerTabix(fl)
```

---

indexTabix *Compress and index tabix-compatible files.*

---

### Description

Index (with indexTabix) files that have been sorted into ascending sequence, start and end position ordering.

## Usage

```
indexTabix(file,
            format=c("gff", "bed", "sam", "vcf", "vcf4", "psltbl"),
            seq=integer(), start=integer(), end=integer(),
            skip=0L, comment="#", zeroBased=FALSE, ...)
```

## Arguments

| | |
|---|---|
| file | A characater(1) path to a sorted, bgzip-compressed file. |
| format | The format of the data in the compressed file. A characater(1) matching one of the types named in the function signature. |
| seq | If format is missing, then seq indicates the column in which the 'sequence' identifier (e.g., chrq) is to be found. |
| start | If format is missing, start indicates the column containing the start coordinate of the feature to be indexed. |
| end | If format is missing, end indicates the column containing the ending coordinate of the feature to be indexed. |
| skip | The number of lines to be skipped at the beginning of the file. |
| comment | A single character which, when present as the first character in a line, indicates that the line is to be omitted. from indexing. |
| zeroBased | A logical(1) indicating whether coordinats in the file are zero-based. |
| ... | Additional arguments. |

## Value

The return value of indexTabix is an updated instance of file reflecting the newly-created index file.

## Author(s)

Martin Morgan <mtmorgan@fhcrc.org>.

## References

<http://samtools.sourceforge.net/tabix.shtml>

## Examples

```
from <- system.file("extdata", "ex1.sam", package="Rsamtools",
                        mustWork=TRUE)
to <- tempfile()
zipped <- bgzip(from, to)
idx <- indexTabix(zipped, "sam")

tab <- TabixFile(zipped, idx)
```

---

| pileup | *Use filters and output formats to calculate pile-up statistics for a BAM file.* |
|---|---|

---

## Description

pileup uses PileupParam and ScanBamParam objects to calculate pileup statistics for a BAM file. The result is a data.frame with columns summarizing counts of reads overlapping each genomic position, optionally differentiated on nucleotide, strand, and position within read.

## Usage

```
pileup(file, index=file, ..., scanBamParam=ScanBamParam(),
       pileupParam=PileupParam())

## PileupParam constructor
PileupParam(max_depth=250, min_base_quality=13, min_mapq=0,
    min_nucleotide_depth=1, min_minor_allele_depth=0,
    distinguish_strands=TRUE, distinguish_nucleotides=TRUE,
    ignore_query_Ns=TRUE, include_deletions=TRUE, include_insertions=FALSE,
    left_bins=NULL, query_bins=NULL, cycle_bins=NULL)

phred2ASCIIOffset(phred=integer(),
    scheme= c("Illumina 1.8+", "Sanger", "Solexa", "Illumina 1.3+",
              "Illumina 1.5+"))
```

## Arguments

| | |
|---|---|
| file | character(1) or [BamFile](); BAM file path. |
| index | When file is character(1), an optional character(1) of BAM index file path; see [scanBam](). |
| ... | Additional arguments, perhaps used by methods. |
| scanBamParam | An instance of [ScanBamParam](). |
| pileupParam | An instance of [PileupParam](). |
| max_depth | integer(1); maximum number of overlapping alignments considered for each position in the pileup. |
| min_base_quality | |
| | integer(1); minimum 'QUAL' value for each nucleotide in an alignment. Use phred2ASCIIOffset to help translate numeric or character values to these offsets. |
| min_mapq | integer(1); minimum 'MAPQ' value for an alignment to be included in pileup. |
| min_nucleotide_depth | |
| | integer(1); minimum count of each nucleotide (*independent* of other nucleotides) at a given position required for said nucleotide to appear in the result. |

min_minor_allele_depth

> integer(1); minimum count of *all* nucleotides other than the major allele at a given position required for a particular nucleotide to appear in the result.

distinguish_strands

> logical(1); TRUE if result should differentiate between strands.

distinguish_nucleotides

> logical(1); TRUE if result should differentiate between nucleotides.

ignore_query_Ns

> logical(1); TRUE if non-determinate nucleotides in alignments should be excluded from the pileup.

include_deletions

> logical(1); TRUE to include deletions in pileup.

include_insertions

> logical(1); TRUE to include insertions in pileup.

left_bins            numeric; all same sign; unique positions within a read to delimit bins. Position within read is based on counting from the *5' end regardless of strand*. Minimum of two values are required so at least one range can be formed. NULL (default) indicates no binning. Use negative values to count from the opposite end. Sorted order not required. Floating-point values are coerced to integer.

> If you want to delimit bins based on sequencing cycles to, e.g., discard later cycles, query_bins probably gives the desired behavior.

query_bins           numeric; all same sign; unique positions within a read to delimit bins. Position within a read is based on counting from the *5' end* when the read aligns to *plus strand*, counting from the *3' end* when read aligns to minus strand. Minimum of two values are required so at least one range can be formed. NULL (default) indicates no binning. Use negative values to count from the opposite end. Sorted order not required. Floating-point values are coerced to integer.

phred                Either a numeric() (coerced to integer()) PHRED score (e.g., in the range (0, 41) for the 'Illumina 1.8+' scheme) or character() of printable ASCII characters. When phred is character(), it can be of length 1 with 1 or more characters, or of any length where all elements have exactly 1 character.

scheme               Encoding scheme, used to translate numeric() PHRED scores to their ASCII code. Ignored when phred is already character().

cycle_bins           DEPRECATED. See left_bins for identical behavior.

### Details

*NB*: Use of pileup assumes familiarity with ScanBamParam, and use of left_bins and query_bins assumes familiarity with cut.

pileup visits each position in the BAM file, subject to constraints implied by which and flag of scanBamParam. For a given position, all reads overlapping the position that are consistent with constraints dictated by flag of scanBamParam and pileupParam are used for counting. pileup also automatically excludes reads with flags that indicate any of:

- unmapped alignment (isUnmappedQuery)
- secondary alignment (isSecondaryAlignment)

- not passing quality controls ([isNotPassingQualityControls](isNotPassingQualityControls))
- PCR or optical duplicate ([isDuplicate](isDuplicate))

If no `which` argument is supplied to the `ScanBamParam`, behavior reflects that of `scanBam`: the entire file is visited and counted.

Use a [yieldSize](yieldSize) value when creating a `BamFile` instance to manage memory consumption when using pileup with large BAM files. There are some differences in how `pileup` behavior is affected when the `yieldSize` value is set on the BAM file. See more details below.

Many of the parameters of the `pileupParam` interact. A simple illustration is `ignore_query_Ns` and `distinguish_nucleotides`, as mentioned in the `ignore_query_Ns` section.

Parameters for `pileupParam` belong to two categories: parameters that affect only the filtering criteria (so-called 'behavior-only' policies), and parameters that affect filtering behavior and the schema of the results ('behavior+structure' policies).

`distinguish_nucleotides` and `distinguish_strands` when set to TRUE each add a column (`nucleotide` and `strand`, respectively) to the resulting `data.frame`. If both are TRUE, each combination of `nucleotide` and `strand` at a given position is counted separately. Setting only one to TRUE behaves as expected; for example, if only `nucleotide` is set to TRUE, each nucleotide at a given position is counted separately, but the distinction of on which strand the nucleotide appears is ignored.

`ignore_query_Ns` determines how ambiguous nucleotides are treated. By default, ambiguous nucleotides (typically 'N' in BAM files) in alignments are ignored. If `ignore_query_Ns` is FALSE, ambiguous nucleotides are included in counts; further, if `ignore_query_Ns` is FALSE and `distinguish_nucleotides` is TRUE the 'N' nucleotide value appears in the nucleotide column when a base at a given position is ambiguous.

By default, deletions with respect to the reference genome to which the reads were aligned are included in the counts in a pileup. If `include_deletions` is TRUE and `distinguish_nucleotides` is TRUE, the nucleotide column uses a '-' character to indicate a deletion at a position.

The '=' nucleotide code in the `SEQ` field (to mean 'identical to reference genome') is supported by pileup, such that a match with the reference genome is counted separately in the results if `distinguish_nucleotides` is TRUE.

CIGAR support: `pileup` handles the extended CIGAR format by only heeding operations that contribute to counts ('M', 'D', 'I'). If you are confused about how the different CIGAR operations interact, see the SAM versions of the BAM files used for `pileup` unit testing for a fairly comprehensive human-readable treatment.

- Deletions and clipping:
  The extended CIGAR allows a number of operations conceptually similar to a 'deletion' with respect to the reference genome, but offer more specialized meanings than a simple deletion. CIGAR 'N' operations (not to be confused with 'N' used for non-determinate bases in the `SEQ` field) indicate a large skipped region, 'S' a soft clip, and 'H' a hard clip. 'N', 'S', and 'H' CIGAR operations are never counted: only counts of true deletions ('D' in the CIGAR) can be included by setting `include_deletions` to TRUE.
  Soft clip operations contribute to the relative position of nucleotides within a read, whereas hard clip and refskip operations do not. For example, consider a sequence in a bam file that starts at 11, with a CIGAR 2S1M and SEQ field `ttA`. The cycle position of the `A` nucleotide will be 3, but the reported position will be 11. If using `left_bins` or `query_bins` it might make sense to first preprocess your files to remove soft clipping.

- Insertions and padding:

  pileup can include counts of insertion operations by setting include_insertions to TRUE. Details about insertions are effectively truncated such that each insertion is reduced to a single '+' nucleotide. Information about e.g. the nucleotide code and base quality within the insertion is not included.

  Because '+' is used as a nucleotide code to represent insertions in pileup, counts of the '+' nucleotide participate in voting for min_nucleotide_depth and min_minor_allele_depth functionality.

  The position of an insertion is the position that precedes it on the reference sequence. *Note:* this means if include_insertions is TRUE a single read will contribute two nucleotide codes (+, plus that of the non-insertion base) at a given position if the non-insertion base passes filter criteria.

  'P' CIGAR (padding) operations never affect counts.

The "bin" arguments query_bins and left_bins allow users to differentiate pileup counts based on arbitrary non-overlapping regions within a read. pileup relies on cut to derive bins, but limits input to numeric values of the same sign (coerced to integers), including +/-Inf. If a "bin" argument is set pileup automatically excludes bases outside the implicit outer range. Here are some important points regarding bin arguments:

- query_bins vs. left_bins:

  BAM files store sequence data from the 5' end to the 3' end (regardless of to which strand the read aligns). That means for reads aligned to the minus strand, cycle position within a read is effectively reversed. Take care to use the appropriate bin argument for your use case.

  The most common use of a bin argument is to bin later cycles separately from earlier cycles; this is because accuracy typically degrades in later cycles. For this application, query_bins yields the correct behavior because bin positions are relative to cycle order (i.e., sensitive to strand).

  left_bins (in contrast with query_bins) determines bin positions from the 5' end, regardless of strand.

- Positive or negative bin values can be used to delmit bins based on the effective "start" or "end" of a read. For left_bin the effective start is always the 5' end (left-to-right as appear in the BAM file).

  For query_bin the effective start is the first cycle of the read as it came off the sequencer; that means the 5' end for reads aligned to the plus strand and 3' for reads aligned to the minus strand.

  - *From effective start of reads*: use positive values, 0, and (+)Inf. Because cut produces ranges in the form (first,last], '0' should be used to create a bin that includes the first position. To account for variable-length reads in BAM files, use (+)Inf as the upper bound on a bin that extends to the end of all reads.
  - *From effective end of reads*: use negative values and -Inf. -1 denotes the last position in a read. Because cut produces ranges in the form (first,last], specify the lower bound of a bin by using one less than the desired value, e.g., a bin that captures only the second nucleotide from the last position: query_bins=c(-3, -2). To account for variable-length reads in BAM files, use -Inf as the lower bound on a bin that extends to the beginning of all reads.

pileup obeys [yieldSize](#) on BamFile objects with some differences from how scanBam responds to yieldSize. Here are some points to keep in mind when using pileup in conjunction with yieldSize:

- BamFiles with a yieldSize value set, once opened and used with pileup, *should not be used* with other functions that accept a BamFile instance as input. Create a new BamFile instance instead of trying to reuse.

- pileup only returns genomic positions for which all input has been processed. pileup will hold in reserve positions for which only partial data has been processed. Positions held in reserve will be returned upon subsequent calls to pileup when all the input for a given position has been processed.

- The correspondence between yieldSize and the number of rows in the data.frame returned from pileup is not 1-to-1. yieldSize only limits the number of *alignments processed* from the BAM file each time the file is read. Only a handful of alignments can lead to many distinct records in the result.

- Like scanBam, pileup uses an empty return object (a zero-row data.frame) to indicate end-of-input.

- Sometimes reading yieldSize records from the BAM file does not result in any completed positions. In order to avoid returning a zero-row data.frame pileup will repeatedly process yieldSize additional records until at least one position can be returned to the user.

**Value**

For pileup a data.frame with 1 row per unique combination of differentiating column values that satisfied filter criteria, with frequency (count) of unique combination. Columns seqnames, pos, and count always appear; optional strand, nulceotide, and left_bin / query_bin columns appear as dictated by arguments to PileupParam.

Column details:

- seqnames: factor. SAM 'RNAME' field of alignment.
- pos: integer(1). Genomic position of base. Derived by offset from SAM 'POS' field of alignment.
- strand: factor. 'strand' to which read aligns.
- nucleotide: factor. 'nucleotide' of base, extracted from SAM 'SEQ' field of alignment.
- left_bin / query_bin: factor. Bin in which base appears.
- count: integer(1). Frequency of combination of differentiating fields, as indicated by values of other columns.

See [scanBam](#) for more detailed explanation of SAM fields.

If a which argument is specified for the scanBamParam, a which_label column (factor in the form 'rname:start-end') is automatically included. The which_label column is used to maintain grouping of results, such that two queries of the same genomic region can be differentiated.

Order of rows in data.frame is first by order of seqnames column based on the BAM index file, then non-decreasing order on columns pos, then nucleotide, then strand, then left_bin / query_bin.

PileupParam returns an instance of PileupParam class.

phred2ASCIIOffset returns a named integer vector of the same length or number of characters in phred. The names are the ASCII encoding, and the values are the offsets to be used with min_base_quality.

### Author(s)

Nathaniel Hayden [nhayden@fredhutch.org](nhayden@fredhutch.org)

### See Also

- [Rsamtools](Rsamtools)
- [BamFile](BamFile)
- [ScanBamParam](ScanBamParam)
- [scanBam](scanBam)
- [cut](cut)

For the relationship between PHRED scores and ASCII encoding, see [https://en.wikipedia.org/wiki/FASTQ_format#Encoding](https://en.wikipedia.org/wiki/FASTQ_format#Encoding).

### Examples

```
## The examples below apply equally to pileup queries for specific
## genomic ranges (specified by the 'which' parameter of 'ScanBamParam')
## and queries across entire files; the entire-file examples are
## included first to make them easy to find. The more detailed examples
## of pileup use queries with a 'which' argument.

library("RNAseqData.HNRNPC.bam.chr14")

fl <- RNAseqData.HNRNPC.bam.chr14_BAMFILES[1]
## Minimum base quality to be tallied
p_param <- PileupParam(min_base_quality = 10L)


## no 'which' argument to ScanBamParam: process entire file at once
res <- pileup(fl, pileupParam = p_param)
head(res)
table(res$strand, res$nucleotide)



## no 'which' argument to ScanBamParam with 'yieldSize' set on BamFile
bf <- open(BamFile(fl, yieldSize=5e4))
repeat {
    res <- pileup(bf, pileupParam = p_param)
    message(nrow(res), " rows in result data.frame")
    if(nrow(res) == 0L)
        break
}
close(bf)
```

```
## pileup for the first half of chr14 with default Pileup parameters
## 'which' argument: process only specified genomic range(s)
sbp <- ScanBamParam(which=GRanges("chr14", IRanges(1, 53674770)))
res <- pileup(fl, scanBamParam=sbp, pileupParam = p_param)
head(res)
table(res$strand, res$nucleotide)

## specify pileup parameters: include ambiguious nucleotides
## (the 'N' level in the nucleotide column of the data.frame)
p_param <- PileupParam(ignore_query_Ns=FALSE, min_base_quality = 10L)
res <- pileup(fl, scanBamParam=sbp, pileupParam=p_param)
head(res)
table(res$strand, res$nucleotide)

## Don't distinguish strand, require a minimum frequency of 7 for a
## nucleotide at a genomic position to be included in results.

p_param <- PileupParam(distinguish_strands=TRUE,
                       min_base_quality = 10L,
                       min_nucleotide_depth=7)
res <- pileup(fl, scanBamParam=sbp, pileupParam=p_param)
head(res)
table(res$nucleotide, res$strand)

## Any combination of the filtering criteria is possible: let's say we
## want a "coverage pileup" that only counts reads with mapping
## quality >= 13, and bases with quality >= 10 that appear at least 4
## times at each genomic position
p_param <- PileupParam(distinguish_nucleotides=FALSE,
                       distinguish_strands=FALSE,
                       min_mapq=13,
                       min_base_quality=10,
                       min_nucleotide_depth=4)
res <- pileup(fl, scanBamParam=sbp, pileupParam=p_param)
head(res)
res <- res[, c("pos", "count")] ## drop seqnames and which_label cols
plot(count ~ pos, res, pch=".")

## ASCII offsets to help specify min_base_quality, e.g., quality of at
## least 10 on the Illumina 1.3+ scale
phred2ASCIIOffset(10, "Illumina 1.3+")

## Well-supported polymorphic positions (minor allele present in at
## least 5 alignments) with high map quality
p_param <- PileupParam(min_minor_allele_depth=5,
                       min_mapq=40,
                       min_base_quality = 10,
                       distinguish_strand=FALSE)
res <- pileup(fl, scanBamParam=sbp, pileupParam=p_param)
dim(res) ## reduced to our biologically interesting positions
head(xtabs(count ~ pos + nucleotide, res))
```

```
## query_bins


## basic use of positive bins: single pivot; count bases that appear in
## first 10 cycles of a read separately from the rest
p_param <- PileupParam(query_bins=c(0, 10, Inf), min_base_quality = 10)
res <- pileup(fl, scanBamParam=sbp, pileupParam=p_param)

## basic use of positive bins: simple range; only include bases in
## cycle positions 6-10 within read
p_param <- PileupParam(query_bins=c(5, 10), min_base_quality = 10)
res <- pileup(fl, scanBamParam=sbp, pileupParam=p_param)

## basic use of negative bins: single pivot; count bases that appear in
## last 3 cycle positions of a read separately from the rest.
p_param <- PileupParam(query_bins=c(-Inf, -4, -1), min_base_quality = 10)
res <- pileup(fl, scanBamParam=sbp, pileupParam=p_param)

## basic use of negative bins: drop nucleotides in last two cycle
## positions of each read
p_param <- PileupParam(query_bins=c(-Inf, -3), min_base_quality = 10)
res <- pileup(fl, scanBamParam=sbp, pileupParam=p_param)


## typical use: beginning, middle, and end segments; because of the
## nature of sequencing technology, it is common for bases in the
## beginning and end segments of each read to be less reliable. pileup
## makes it easy to count each segment separately.

## Assume determined ahead of time that for the data 1-7 makes sense for
## beginning, 8-12 middle, >=13 end (actual cycle positions should be
## tailored to data in actual BAM files).
p_param <- PileupParam(query_bins=c(0, 7, 12, Inf), ## note non-symmetric
                       min_base_quality = 10)
res <- pileup(fl, scanBamParam=sbp, pileupParam=p_param)
xt <- xtabs(count ~ nucleotide + query_bin, res)
print(xt)
t(t(xt) / colSums(xt)) ## cheap normalization for illustrative purposes

## 'implicit outer range': in contrast to c(0, 7, 12, Inf), suppose we
##  still want to have beginning, middle, and end segements, but know
##  that the first three cycles and any bases beyond the 16th cycle are
##  irrelevant. Hence, the implicit outer range is (3,16]; all bases
##  outside of that are dropped.
p_param <- PileupParam(query_bins=c(3, 7, 12, 16), min_base_quality = 10)
res <- pileup(fl, scanBamParam=sbp, pileupParam=p_param)
xt <- xtabs(count ~ nucleotide + query_bin, res)
print(xt)
t(t(xt) / colSums(xt))
```

```
## single-width bins: count each cycle within a read separately.
p_param <- PileupParam(query_bins=seq(1,20), min_base_quality = 10)
res <- pileup(fl, scanBamParam=sbp, pileupParam=p_param)
xt <- xtabs(count ~ nucleotide + query_bin, res)
print(xt[ , c(1:3, 18:19)]) ## fit on one screen
print(t(t(xt) / colSums(xt))[ , c(1:3, 18:19)])
```

---

PileupFiles                 *Represent BAM files for pileup summaries.*

---

## Description

Use `PileupFiles()` to create a reference to BAM files (and their indicies), to be used for calculating pile-up summaries.

## Usage

```
## Constructors
PileupFiles(files, ..., param=ApplyPileupsParam())
## S4 method for signature 'character'
PileupFiles(files, ..., param=ApplyPileupsParam())
## S4 method for signature 'list'
PileupFiles(files, ..., param=ApplyPileupsParam())

## opening / closing
## open(con, ...)
## close(con, ...)

## accessors; also path()
## S4 method for signature 'PileupFiles'
isOpen(con, rw="")
plpFiles(object)
plpParam(object)

## actions
## S4 method for signature 'PileupFiles,missing'
applyPileups(files, FUN, ..., param)
## S4 method for signature 'PileupFiles,ApplyPileupsParam'
applyPileups(files, FUN, ..., param)

## display
## S4 method for signature 'PileupFiles'
show(object)
```

## Arguments

| | |
|---|---|
| files | For `PileupFiles`, a `character()` or `list` of `BamFile` instances representing files to be included in the pileup. Using a `list` of `BamFile` allows indicies to be specified when these are in non-standard format. All elements of `...` must be the same type. |
| | For applyPileups,PileupFiles-method, a `PileupFiles` instance. |
| ... | Additional arguments, currently ignored. |
| con, object | An instance of `PileupFiles`. |
| FUN | A function of one argument; see [applyPileups](#). |
| param | An instance of [ApplyPileupsParam](#), to select which records to include in the pileup, and which summary information to return. |
| rw | character() indicating mode of file; not used for `TabixFile`. |

## Objects from the Class

Objects are created by calls of the form `PileupFiles()`.

## Fields

The `PileupFiles` class is implemented as an S4 reference class. It has the following fields:

**files**  A list of [BamFile](#) instances.

**param**  An instance of [ApplyPileupsParam](#).

## Functions and methods

Opening / closing:

**open.PileupFiles**  Opens the (local or remote) `path` and `index` of each file in the `PileupFiles` instance. Returns a `PileupFiles` instance.

**close.PileupFiles**  Closes each file in the `PileupFiles` instance; returning (invisibly) the updated `PileupFiles`. The instance may be re-opened with open.PileupFiles.

Accessors:

**plpFiles**  Returns the `list` of the files in the `PileupFiles` instance.

**plpParam**  Returns the [ApplyPileupsParam](#) content of the `PileupFiles` instance.

Methods:

**applyPileups**  Calculate the pileup across all files in `files` according to criteria in `param` (or plpParam(files) if param is missing), invoking FUN on each range or collection of positions. See [applyPileups](#).

**show**  Compactly display the object.

## Author(s)

Martin Morgan

## Examples

```
example(applyPileups)
```

---

quickBamFlagSummary    *Group the records of a BAM file based on their flag bits and count the*
                       *number of records in each group*

---

### Description

quickBamFlagSummary groups the records of a BAM file based on their flag bits and counts the number of records in each group.

### Usage

```
quickBamFlagSummary(file, ..., param=ScanBamParam(), main.groups.only=FALSE)

## S4 method for signature 'character'
quickBamFlagSummary(file, index=file, ..., param=ScanBamParam(),
    main.groups.only=FALSE)

## S4 method for signature 'list'
quickBamFlagSummary(file, ..., param=ScanBamParam(), main.groups.only=FALSE)
```

### Arguments

file, index     For the character method, the path to the BAM file to read, and to the index file
                of the BAM file to read, respectively.

                For the list() method, file is a named list with elements "qname" and "flag"
                with content as from scanBam.

...             Additional arguments, perhaps used by methods.

param           An instance of ScanBamParam. This determines which records are considered in
                the counting.

main.groups.only
                If TRUE, then the counting is performed for the main groups only.

### Value

Nothing is returned. A summary of the counts is printed to the console unless redirected by sink.

### Author(s)

Hervé Pagès

### References

<http://samtools.sourceforge.net/>

## See Also

[scanBam](), [ScanBamParam]().

[BamFile]() for a method for that class.

## Examples

```
bamfile <- system.file("extdata", "ex1.bam", package="Rsamtools",
                        mustWork=TRUE)
quickBamFlagSummary(bamfile)
```

---

readPileup                    *Import samtools 'pileup' files.*

---

## Description

Import files created by evaluation of samtools' pileup -cv command.

## Usage

```
readPileup(file, ...)
## S4 method for signature 'connection'
readPileup(file, ..., variant=c("SNP", "indel", "all"))
```

## Arguments

| | |
|---|---|
| file | The file name, or [connection](), of the pileup output file to be parsed. |
| ... | Additional arguments, passed to methods. For instance, specify variant for the readPileup,character-method. |
| variant | Type of variant to parse; select one. |

## Value

readPileup returns a [GRanges]() object.

The value returned by variant="SNP" or variant="all" contains:

**space:** The chromosome names (fastq ids) of the reference sequence

**position:** The nucleotide position (base 1) of the variant.

**referenceBase:** The nucleotide in the reference sequence.

**consensusBase;** The consensus nucleotide, as determined by samtools pileup.

**consensusQuality:** The phred-scaled consensus quality.

**snpQuality:** The phred-scaled SNP quality (probability of the consensus being identical to the reference).

**maxMappingQuality:** The root mean square mapping quality of reads overlapping the site.

**coverage:** The number of reads covering the site.

The value returned by variant="indel" contains space, position, reference, consensus, consensusQuality, snpQuality, maxMappingQuality, and coverage fields, and:

**alleleOne, alleleTwo** The first (typically, in the reference sequence) and second allelic variants.

**alleleOneSupport, alleleTwoSupport** The number of reads supporting each allele.

**additionalIndels** The number of additional indels present.

## Author(s)

Sean Davis

## References

[http://samtools.sourceforge.net/](http://samtools.sourceforge.net/)

## Examples

```
fl <- system.file("extdata", "pileup.txt", package="Rsamtools",
                  mustWork=TRUE)
(res <- readPileup(fl))
xtabs(~referenceBase + consensusBase, mcols(res))[DNA_BASES,]

## Not run: ## uses a pipe, and arguments passed to read.table
## three successive piles of 100 records each
cmd <- "samtools pileup -cvf human_b36_female.fa.gz na19240_3M.bam"
p <- pipe(cmd, "r")
snp <- readPileup(p, nrow=100)  # variant="SNP"
indel <- readPileup(p, nrow=100, variant="indel")
all <- readPileup(p, nrow=100, variant="all")

## End(Not run)
```

---

RsamtoolsFile                    *A base class for managing file references in Rsamtools*

---

## Description

RsamtoolsFile is a base class for managing file references in **Rsamtools**; it is not intended for direct use by users – see, e.g., `BamFile`.

## Usage

```
## accessors
## S4 method for signature 'RsamtoolsFile'
path(object, ...)
## S4 method for signature 'RsamtoolsFile'
index(object, ..., asNA = TRUE)
```

```
## S4 method for signature 'RsamtoolsFile'
isOpen(con, rw="")
## S4 method for signature 'RsamtoolsFile'
yieldSize(object, ...)
yieldSize(object, ...) <- value
## S4 method for signature 'RsamtoolsFile'
show(object)
```

### Arguments

| | |
|---|---|
| `con, object` | An instance of a class derived from `RsamtoolsFile`. |
| `asNA` | logical indicating if missing output should be NA or character() |
| `rw` | Mode of file; ignored. |
| `...` | Additional arguments, unused. |
| `value` | Replacement value. |

### Objects from the Class

Users do not directly create instances of this class; see, e.g., `BamFile`-class.

### Fields

The `RsamtoolsFile` class is implemented as an S4 reference class. It has the following fields:

**.extptr** An `externalptr` initialized to an internal structure with opened bam file and bam index pointers.

**path** A character(1) vector of the file name.

**index** A character(1) vector of the index file name.

**yieldSize** An integer(1) vector of the number of records to yield.

### Functions and methods

Accessors:

**path** Returns a character(1) vector of path names.

**index** Returns a character(1) vector of index path names.

**yieldSize, yieldSize<-** Return or set an integer(1) vector indicating yield size.

Methods:

**isOpen** Report whether the file is currently open.

**show** Compactly display the object.

### Author(s)

Martin Morgan

---

RsamtoolsFileList        *A base class for managing lists of Rsamtools file references*

---

#### Description

RsamtoolsFileList is a base class for managing lists of file references in **Rsamtools**; it is not intended for direct use – see, e.g., BamFileList.

#### Usage

```
## S4 method for signature 'RsamtoolsFileList'
path(object, ...)
## S4 method for signature 'RsamtoolsFileList'
index(object, ..., asNA = TRUE)
## S4 method for signature 'RsamtoolsFileList'
isOpen(con, rw="")
## S3 method for class 'RsamtoolsFileList'
open(con, ...)
## S3 method for class 'RsamtoolsFileList'
close(con, ...)
## S4 method for signature 'RsamtoolsFileList'
names(x)
## S4 method for signature 'RsamtoolsFileList'
yieldSize(object, ...)
```

#### Arguments

| | |
|---|---|
| con, object, x | An instance of a class derived from RsamtoolsFileList. |
| asNA | logical indicating if missing output should be NA or character() |
| rw | Mode of file; ignored. |
| ... | Additional arguments. |

#### Objects from the Class

Users do not directly create instances of this class; see, e.g., BamFileList-class.

#### Functions and methods

This class inherits functions and methods for subseting, updating, and display from the SimpleList class.

Methods:

**isOpen:** Report whether each file in the list is currently open.

**open:** Attempt to open each file in the list.

**close:** Attempt to close each file in the list.

**names:** Names of each element of the list or, if names are NULL, the basename of the path of each element.

### Author(s)

Martin Morgan

---

ScanBamParam                    *Parameters for scanning BAM files*

---

### Description

Use ScanBamParam() to create a parameter object influencing what fields and which records are imported from a (binary) BAM file. Use of which requires that a BAM index file (<filename>.bai) exists.

### Usage

```
# Constructor
ScanBamParam(flag = scanBamFlag(), simpleCigar = FALSE,
    reverseComplement = FALSE, tag = character(0), tagFilter = list(),
    what = character(0), which, mapqFilter=NA_integer_)

# Constructor helpers
scanBamFlag(isPaired = NA, isProperPair = NA, isUnmappedQuery = NA,
    hasUnmappedMate = NA, isMinusStrand = NA, isMateMinusStrand = NA,
    isFirstMateRead = NA, isSecondMateRead = NA, isNotPrimaryRead = NA,
    isSecondaryAlignment = NA, isNotPassingQualityControls = NA,
    isDuplicate = NA, isSupplementaryAlignment = NA)

scanBamWhat()

# Accessors
bamFlag(object, asInteger=FALSE)
bamFlag(object) <- value
bamReverseComplement(object)
bamReverseComplement(object) <- value
bamSimpleCigar(object)
bamSimpleCigar(object) <- value
bamTag(object)
bamTag(object) <- value
bamTagFilter(object)
bamTagFilter(object) <- value
bamWhat(object)
bamWhat(object) <- value
bamWhich(object)
bamWhich(object) <- value
```

```
bamMapqFilter(object)
bamMapqFilter(object) <- value

## S4 method for signature 'ScanBamParam'
show(object)

# Flag utils
bamFlagAsBitMatrix(flag, bitnames=FLAG_BITNAMES)
bamFlagAND(flag1, flag2)
bamFlagTest(flag, value)
```

## Arguments

flag
:   For ScanBamParam, an integer(2) vector used to filter reads based on their 'flag' entry. This is most easily created with the scanBamFlag() helper function.

    For bamFlagAsBitMatrix, bamFlagTest an integer vector where each element represents a 'flag' entry.

simpleCigar
:   A logical(1) vector which, when TRUE, returns only those reads for which the cigar (run-length encoded representation of the alignment) is missing or contains only matches / mismatches ('M').

reverseComplement
:   A logical(1) vectors. BAM files store reads mapping to the minus strand as though they are on the plus strand. Rsamtools obeys this convention by default (reverseComplement=FALSE), but when this value is set to TRUE returns the sequence and quality scores of reads mapped to the minus strand in the reverse complement (sequence) and reverse (quality) of the read as stored in the BAM file. This might be useful if wishing to recover read and quality scores as represented in fastq files, but is NOT appropriate for variant calling or other alignment-based operations.

tag
:   A character vector naming tags to be extracted. A tag is an optional field, with arbitrary information, stored with each record. Tags are identified by two-letter codes, so all elements of tag must have exactly 2 characters.

tagFilter
:   A named list of atomic vectors. The name of each list element is the tag name (two-letter code), and the corresponding atomic vector is the set of acceptable values for the tag. Only reads with specified tags are included. NULLs, NAs, and empty strings are not allowed in the atomic vectors.

what
:   A character vector naming the fields to return scanBamWhat() returns a vector of available fields. Fields are described on the [scanBam](#) help page.

mapqFilter
:   A non-negative integer(1) specifying the minimum mapping quality to include. BAM records with mapping qualities less than mapqFilter are discarded.

which
:   A [GRanges](#), [IntegerRangesList](#), or any object that can be coerced to a IntegerRangesList, or missing object, from which a IRangesList instance will be constructed. Names of the IRangesList correspond to reference sequences, and ranges to the regions on that reference sequence for which matches are desired. Because data types are coerced to IRangesList, which does *not* include strand information (use the flag argument instead). Only records with a read overlapping the specified ranges are returned. All ranges must have ends less than or equal

to 536870912. When one record overlaps two ranges in which, the record is returned *twice*.

isPaired             A logical(1) indicating whether unpaired (FALSE), paired (TRUE), or any (NA) read should be returned.

isProperPair         A logical(1) indicating whether improperly paired (FALSE), properly paired (TRUE), or any (NA) read should be returned. A properly paired read is defined by the alignment algorithm and might, e.g., represent reads aligning to identical reference sequences and with a specified distance.

isUnmappedQuery
                     A logical(1) indicating whether unmapped (TRUE), mapped (FALSE), or any (NA) read should be returned.

hasUnmappedMate
                     A logical(1) indicating whether reads with mapped (FALSE), unmapped (TRUE), or any (NA) mate should be returned.

isMinusStrand        A logical(1) indicating whether reads aligned to the plus (FALSE), minus (TRUE), or any (NA) strand should be returned.

isMateMinusStrand
                     A logical(1) indicating whether mate reads aligned to the plus (FALSE), minus (TRUE), or any (NA) strand should be returned.

isFirstMateRead
                     A logical(1) indicating whether the first mate read should be returned (TRUE) or not (FALSE), or whether mate read number should be ignored (NA).

isSecondMateRead
                     A logical(1) indicating whether the second mate read should be returned (TRUE) or not (FALSE), or whether mate read number should be ignored (NA).

isNotPrimaryRead
                     Deprecated; use isSecondaryAlignment.

isSecondaryAlignment
                     A logical(1) indicating whether alignments that are secondary (TRUE), are not (FALSE) or whose secondary status does not matter (NA) should be returned. A non-primary alignment ("secondary alignment" in the SAM specification) might result when a read aligns to multiple locations. One alignment is designated as primary and has this flag set to FALSE; the remainder, for which this flag is TRUE, are designated by the aligner as secondary.

isNotPassingQualityControls
                     A logical(1) indicating whether reads passing quality controls (FALSE), reads not passing quality controls (TRUE), or any (NA) read should be returned.

isDuplicate          A logical(1) indicating that un-duplicated (FALSE), duplicated (TRUE), or any (NA) reads should be returned. 'Duplicated' reads may represent PCR or optical duplicates.

isSupplementaryAlignment
                     A logical(1) indicating that non-supplementary (FALSE), supplementary (TRUE), or any (NA) reads should be returned. The SAM specification indicates that 'supplementary' reads are part of a chimeric alignment.

object               An instance of class ScanBamParam.

| | |
|---|---|
| value | An instance of the corresponding slot, to be assigned to `object` or, for `bamFlagTest`, a `character(1)` name of the flag to test, e.g., "isUnmappedQuery", from the arguments to `scanBamFlag`. |
| asInteger | logical(1) indicating whether 'flag' should be returned as an encoded integer vector (TRUE) or human-readable form (FALSE). |
| bitnames | Names of the flag bits to extract. Will be the colnames of the returned matrix. |
| flag1, flag2 | Integer vectors containing 'flag' entries. |

## Objects from the Class

Objects are created by calls of the form `ScanBamParam()`.

## Slots

flag Object of class `integer` encoding flags to be kept when they have their '0' (keep0) or '1' (keep1) bit set.

simpleCigar Object of class `logical` indicating, when TRUE, that only 'simple' cigars (empty or 'M') are returned.

reverseComplement Object of class `logical` indicating, when TRUE, that reads on the minus strand are to be reverse complemented (sequence) and reversed (quality).

tag Object of class `character` indicating what tags are to be returned.

tagFilter Object of class `list` (named) indicating tags to filter by, and the set of acceptable values for each tag.

what Object of class `character` indicating what fields are to be returned.

which Object of class `IntegerRangesList` indicating which reference sequence and coordinate reads must overlap.

mapqFilter Object of class `integer` indicating the minimum mapping quality required for input, or NA to indicate no filtering.

## Functions and methods

See 'Usage' for details on invocation.

Constructor:

**ScanBamParam:** Returns a `ScanBamParam` object. The `which` argument to the constructor can be one of several different types, as documented above.

Accessors:

**bamTag, bamTag<-** Returns or sets a `character` vector of tags to be extracted.

**bamTagFilter, bamTagFilter<-** Returns or sets a named `list` of tags to filter by, and the set of their acceptable values.

**bamWhat, bamWhat<-** Returns or sets a `character` vector of fields to be extracted.

**bamWhich, bamWhich<-** Returns or sets a `IntegerRangesList` of bounds on reads to be extracted. A length 0 `IntegerRangesList` represents all reads.

**bamFlag, bamFlag<-** Returns or sets an `integer(2)` representation of reads flagged to be kept or excluded.

**bamSimpleCigar, bamSimpleCigar<-** Returns or sets a `logical(1)` vector indicating whether reads without indels or clipping be kept.

**bamReverseComplement, bamReverseComplement<-** Returns or sets a `logical(1)` vector indicating whether reads on the minus strand will be returned with sequence reverse complemented and quality reversed.

Methods:

**show** Compactly display the object.

## Author(s)

Martin Morgan

## See Also

[scanBam](#)

## Examples

```
## defaults
p0 <- ScanBamParam()

## subset of reads based on genomic coordinates
which <- IRangesList(seq1=IRanges(1000, 2000),
                     seq2=IRanges(c(100, 1000), c(1000, 2000)))
p1 <- ScanBamParam(what=scanBamWhat(), which=which)

## subset of reads based on 'flag' value
p2 <- ScanBamParam(what=scanBamWhat(),
                   flag=scanBamFlag(isMinusStrand=FALSE))

## subset of fields
p3 <- ScanBamParam(what=c("rname", "strand", "pos", "qwidth"))

## use
fl <- system.file("extdata", "ex1.bam", package="Rsamtools",
                  mustWork=TRUE)
res <- scanBam(fl, param=p2)[[1]]
lapply(res, head)

## tags; NM: edit distance; H1: 1-difference hits
p4 <- ScanBamParam(tag=c("NM", "H1"), what="flag")
bam4 <- scanBam(fl, param=p4)
str(bam4[[1]][["tag"]])

## tagFilter
p5 <- ScanBamParam(tag=c("NM", "H1"), tagFilter=list(NM=c(2, 3, 4)))
bam5 <- scanBam(fl, param=p5)
table(bam5[[1]][["tag"]][["NM"]])
```

```
## flag utils
flag <- scanBamFlag(isUnmappedQuery=FALSE, isMinusStrand=TRUE)

p6 <- ScanBamParam(what="flag")
bam6 <- scanBam(fl, param=p6)
flag6 <- bam6[[1]][["flag"]]
head(bamFlagAsBitMatrix(flag6[1:9]))
colSums(bamFlagAsBitMatrix(flag6))
flag
bamFlagAsBitMatrix(flag)
```

---

ScanBcfParam-class          *Parameters for scanning BCF files*

---

**Description**

Use ScanBcfParam() to create a parameter object influencing the 'INFO' and 'GENO' fields parsed, and which sample records are imported from a BCF file. Use of which requires that a BCF index file (<filename>.bci) exists.

**Usage**

```
ScanBcfParam(fixed=character(), info=character(), geno=character(),
             samples=character(), trimEmpty=TRUE, which, ...)

## S4 method for signature 'missing'
ScanBcfParam(fixed=character(), info=character(), geno=character(),
             samples=character(), trimEmpty=TRUE, which, ...)
## S4 method for signature 'IntegerRangesList'
ScanBcfParam(fixed=character(), info=character(), geno=character(),
             samples=character(), trimEmpty=TRUE, which, ...)
## S4 method for signature 'GRanges'
ScanBcfParam(fixed=character(), info=character(), geno=character(),
             samples=character(), trimEmpty=TRUE, which, ...)
## S4 method for signature 'GRangesList'
ScanBcfParam(fixed=character(), info=character(), geno=character(),
             samples=character(), trimEmpty=TRUE, which, ...)

## Accessors
bcfFixed(object)
bcfInfo(object)
bcfGeno(object)
bcfSamples(object)
bcfTrimEmpty(object)
bcfWhich(object)
```

## Arguments

| | |
|---|---|
| `fixed` | A logical(1) for use with `ScanVcfParam` only. |
| `info` | A character() vector of 'INFO' fields (see [scanVcfHeader](#)) to be returned. |
| `geno` | A character() vector of 'GENO' fields (see [scanVcfHeader](#)) to be returned. `character(0)` returns all fields, `NA_character_` returns none. |
| `samples` | A character() vector of sample names (see [scanVcfHeader](#)) to be returned. `character(0)` returns all fields, `NA_character_` returns none. |
| `trimEmpty` | A logical(1) indicating whether 'GENO' fields with no values should be returned. |
| `which` | An object, for which a method is defined (see usage, above), describing the sequences and ranges to be queried. Variants whose `POS` lies in the interval(s) `[start, end)` are returned. |
| `object` | An instance of class `ScanBcfParam`. |
| `...` | Arguments used internally. |

## Objects from the Class

Objects can be created by calls of the form `ScanBcfParam()`.

## Slots

`which`: Object of class `"IntegerRangesList"` indicating which reference sequence and coordinate variants must overlap.

`info`: Object of class `"character"` indicating portions of 'INFO' to be returned.

`geno`: Object of class `"character"` indicating portions of 'GENO' to be returned.

`samples`: Object of class `"character"` indicating the samples to be returned.

`trimEmpty`: Object of class `"logical"` indicating whether empty 'GENO' fields are to be returned.

`fixed`: Object of class `"character"`. For use with `ScanVcfParam` only.

## Functions and methods

See 'Usage' for details on invocation.

Constructor:

**ScanBcfParam:** Returns a `ScanBcfParam` object. The `which` argument to the constructor can be one of several types, as documented above.

Accessors:

**bcfInfo, bcfGeno, bcfTrimEmpty, bcfWhich:** Return the corresponding field from `object`.

Methods:

**show** Compactly display the object.

## Author(s)

Martin Morgan [mtmorgan@fhcrc.org](mtmorgan@fhcrc.org)

## See Also

[scanVcf ScanVcfParam](scanVcf)

## Examples

```
## see ?ScanVcfParam examples
```

---

seqnamesTabix            *Retrieve sequence names defined in a tabix file.*

---

## Description

This function queries a tabix file, returning the names of the 'sequences' used as a key when creating the file.

## Usage

```
seqnamesTabix(file, ...)
## S4 method for signature 'character'
seqnamesTabix(file, ...)
```

## Arguments

file            A `character(1)` file path or [`TabixFile`](TabixFile) instance pointing to a 'tabix' file.

...             Additional arguments, currently ignored.

## Value

A `character()` vector of sequence names present in the file.

## Author(s)

Martin Morgan <mtmorgan@fhcrc.org>.

## Examples

```
fl <- system.file("extdata", "example.gtf.gz", package="Rsamtools",
                  mustWork=TRUE)
seqnamesTabix(fl)
```

---

TabixFile                            *Manipulate tabix indexed tab-delimited files.*

---

### Description

Use `TabixFile()` to create a reference to a Tabix file (and its index). Once opened, the reference remains open across calls to methods, avoiding costly index re-loading.

`TabixFileList()` provides a convenient way of managing a list of `TabixFile` instances.

### Usage

```
## Constructors

TabixFile(file, index = paste(file, "tbi", sep="."), ...,
    yieldSize=NA_integer_)
TabixFileList(...)

## Opening / closing

## S3 method for class 'TabixFile'
open(con, ...)
## S3 method for class 'TabixFile'
close(con, ...)

## accessors; also path(), index(), yieldSize()

## S4 method for signature 'TabixFile'
isOpen(con, rw="")

## actions

## S4 method for signature 'TabixFile'
seqnamesTabix(file, ...)
## S4 method for signature 'TabixFile'
headerTabix(file, ...)
## S4 method for signature 'TabixFile,GRanges'
scanTabix(file, ..., param)
## S4 method for signature 'TabixFile,IntegerRangesList'
scanTabix(file, ..., param)
## S4 method for signature 'TabixFile,missing'
scanTabix(file, ..., param)
## S4 method for signature 'character,ANY'
scanTabix(file, ..., param)
## S4 method for signature 'character,missing'
scanTabix(file, ..., param)
```

```
countTabix(file, ...)
```

## Arguments

| | |
|---|---|
| con | An instance of `TabixFile`. |
| file | For TabixFile(), A character(1) vector to the tabix file path; can be remote (http://, ftp://). For countTabix, a character(1) or TabixFile instance. For others, a TabixFile instance. |
| index | A character(1) vector of the tabix file index. |
| yieldSize | Number of records to yield each time the file is read from using scanTabix. Only valid when param is unspecified. yieldSize does not alter existing yield sizes, include NA, when creating a TabixFileList from TabixFile instances. |
| param | An instance of GRanges or IntegerRangesList, used to select which records to scan. |
| ... | Additional arguments. For TabixFileList, this can include file, index, and yieldSize arguments. The file can be a single character vector of paths to tabix files (and optionally a similarly lengthed vector of index), or several instances of TabixFile objects. The arguments can also include yieldSize, applied to all elements of the list. |
| rw | character() indicating mode of file; not used for TabixFile. |

## Objects from the Class

Objects are created by calls of the form TabixFile().

## Fields

The TabixFile class inherits fields from the [RsamtoolsFile](#) class.

## Functions and methods

TabixFileList inherits methods from [RsamtoolsFileList](#) and [SimpleList](#).

Opening / closing:

**open.TabixFile** Opens the (local or remote) path and index. Returns a TabixFile instance. yieldSize determines the number of records parsed during each call to scanTabix; NA indicates that all records are to be parsed.

**close.TabixFile** Closes the TabixFile con; returning (invisibly) the updated TabixFile. The instance may be re-opened with open.TabixFile.

Accessors:

**path** Returns a character(1) vector of the tabix path name.

**index** Returns a character(1) vector of tabix index name.

**yieldSize, yieldSize<-** Return or set an integer(1) vector indicating yield size.

Methods:

**seqnamesTabix** Visit the path in `path(file)`, returning the sequence names present in the file.

**headerTabix** Visit the path in `path(file)`, returning the sequence names, column indicies used to sort the file, the number of lines skipped while indexing, the comment character used while indexing, and the header (preceeded by comment character, at start of file) lines.

**countTabix** Return the number of records in each range of `param`, or the count of all records in the file (when `param` is missing).

**scanTabix** For `signature(file="TabixFile")`, Visit the path in `path(file)`, returning the result of `scanTabix` applied to the specified path. For `signature(file="character")`, call the corresponding method after coercing `file` to TabixFile.

**indexTabix** This method operates on file paths, rather than `TabixFile` objects, to index tab-separated files. See `indexTabix`.

**show** Compactly display the object.


### Author(s)

Martin Morgan


### Examples

```
fl <- system.file("extdata", "example.gtf.gz", package="Rsamtools",
                  mustWork=TRUE)
tbx <- TabixFile(fl)

param <- GRanges(c("chr1", "chr2"), IRanges(c(1, 1), width=100000))
countTabix(tbx)
countTabix(tbx, param=param)
res <- scanTabix(tbx, param=param)
sapply(res, length)
res[["chr1:1-100000"]][1:2]

## parse to list of data.frame's
dff <- Map(function(elt) {
    read.csv(textConnection(elt), sep="\t", header=FALSE)
}, res)
dff[["chr1:1-100000"]][1:5,1:8]

## parse 100 records at a time
length(scanTabix(tbx)[[1]]) # total number of records
tbx <- open(TabixFile(fl, yieldSize=100))
while(length(res <- scanTabix(tbx)[[1]]))
   cat("records read:", length(res), "\n")
close(tbx)
```

---

TabixInput                    *Operations on 'tabix' (indexed, tab-delimited) files.*

---

### Description

Scan compressed, sorted, tabix-indexed, tab-delimited files.

### Usage

```
scanTabix(file, ..., param)
## S4 method for signature 'character,IntegerRangesList'
scanTabix(file, ..., param)
## S4 method for signature 'character,GRanges'
scanTabix(file, ..., param)
```

### Arguments

| | |
|---|---|
| file | The character() file name(s) of the tabix file be processed, or more flexibly an instance of class [TabixFile](). |
| param | A instance of GRanges or IntegerRangesList providing the sequence names and regions to be parsed. |
| ... | Additional arguments, currently ignored. |

### Value

scanTabix returns a list, with one element per region. Each element of the list is a character vector representing records in the region. If param is empty then all records will be returned.

### Error

scanTabix signals errors using signalCondition. The following errors are signaled:

scanTabix_param yieldSize(file) must be NA when more than one range is specified.

scanTabix_io A read error occured while inputing the tabix file. This might be because the file is corrupt, or of incorrect format (e.g., when path points to a plain text file but index is present, implying that path should be a bgziped file. The error message may include an error code representing the logical OR of these cryptic signals: 1, BGZF_ERR_ZLIB; 2, BGZF_ERR_HEADER; 4, BGZF_ERR_IO; 8, BGZF_ERR_MISUSE.

### Author(s)

Martin Morgan <mtmorgan@fhcrc.org>.

### References

<http://samtools.sourceforge.net/tabix.shtml>

### Examples

```
example(TabixFile)
```

---

testPairedEndBam  *Quickly test if a BAM file has paired end reads*

---

### Description

Iterate through a BAM file until a paired-end read is encountered or the end of file is reached; report the occurrence of paired-end reads to the user.

### Usage

```
testPairedEndBam(file, index=file, ...)
```

### Arguments

| | |
|---|---|
| file | character(1) BAM file name, or a [BamFile](#) instance. Open BamFiles are closed; their yield size is respected when iterating through the file. |
| index | (optional) character(1) name of the index file of the 'BAM' file being processed; this is given *without* the '.bai' extension. |
| ... | Additional arguments, currently unused. |

### Value

A logical vector of length 1 containing TRUE is returned if BAM file contained paired end reads, FALSE otherwise.

### Author(s)

Martin Morgan [mailto:mtmorgan@fhcrc.org](mailto:mtmorgan@fhcrc.org), Sonali Arora [mailto:sarora@fhcrc.org](mailto:sarora@fhcrc.org)

### Examples

```
fl <- system.file("extdata", "ex1.bam", package="Rsamtools")
testPairedEndBam(fl)
```

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