

# Package ‘simPIC’

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**Type** Package

**Title** simPIC: flexible simulation of paired-insertion counts for single-cell ATAC-sequencing data

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**Imports** BiocGenerics, checkmate (>= 2.0.0), fitdistrplus, matrixStats, Matrix, stats, SummarizedExperiment, actuar, rlang, S4Vectors, methods, scales, scuttle

**Description** simPIC is a package for simulating single-cell ATAC-seq count data. It provides a user-friendly, well documented interface for data simulation. Functions are provided for parameter estimation, realistic scATAC-seq data simulation, and comparing real and simulated datasets.

**biocViews** SingleCell, ATACSeq, Software, Sequencing, ImmunoOncology, DataImport

**License** GPL-3

**Encoding** UTF-8

**Suggests** ggplot2 (>= 3.4.0), knitr, rmarkdown, BiocStyle, testthat (>= 3.0.0)

**VignetteBuilder** knitr

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**Config/testthat/edition** 3

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simPIC-package	<i>simPIC: A uniform quantification based method for simulating Paired-Insertion count matrices for single-cell ATAC sequencing data</i>
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## Description

simPIC is a package for simulating single-cell ATAC-seq count data. It provides a user-friendly, well documented interface for data simulation. Functions are provided for parameter estimation, realistic scATAC-seq data simulation, and comparing real and simulated datasets.

- count class ([newsimPICcount](#))
- estimate ([simPICestimate](#))

- simulate ([simPICsimulate](#))
- plots ([simPICcompare](#))

### Author(s)

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- Heejung Shim

### See Also

Useful links:

- <https://github.com/sagrikachugh/simPIC>
- Report bugs at <https://github.com/sagrikachugh/simPIC/issues>

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addFeatureStats	<i>Add feature statistics</i>
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---

### Description

Add additional feature statistics to a SingleCellExperiment object

### Usage

```
addFeatureStats(  
  sce,  
  value = "counts",  
  log = FALSE,  
  offset = 1,  
  no.zeros = FALSE  
)
```

### Arguments

sce	SingleCellExperiment to add feature statistics to.
value	the count value to calculate statistics.
log	logical. Whether to take log2 before calculating statistics.
offset	offset to add to avoid taking log of zero.
no.zeros	logical. Whether to remove all zeros from each feature before calculating statistics.

**Details**

Currently adds the following statistics: mean and variance. Statistics are added to the `rowData` slot and are named `Stat[Log]Value[No0]` where `Log` and `No0` are added if those arguments are true.

**Value**

SingleCellExperiment with additional feature statistics

---

<code>convert_to_SCE</code>	<i>Convert Sparse Matrix to SingleCellExperiment object</i>
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---

**Description**

This function converts a `dgc/sparse` matrix into a `SingleCellExperiment(SCE)` object.

**Usage**

```
convert_to_SCE(sparse_data)
```

**Arguments**

`sparse_data` A sparse matrix containing count data, where rows are peaks and columns represent cells.

**Value**

A `SingleCellExperiment(SCE)` object with the sparse matrix stored in the "counts" assay.

---

<code>getCounts</code>	<i>Get counts from Single Cell Experiment object</i>
------------------------	--

---

**Description**

Get counts matrix from a `SingleCellExperiment` object. If `counts` is missing a warning is issued and the first assay is returned.

**Usage**

```
getCounts(sce)
```

**Arguments**

`sce` `SingleCellExperiment` object

**Value**

counts matrix

---

global	<i>simPIC: Simulate single-cell ATAC-seq data</i>
--------	---

---

**Description**

simPIC: Simulate single-cell ATAC-seq data

**Value**

globalvariables

---

newsimPICcount	<i>newsimPICcount</i>
----------------	-----------------------

---

**Description**

Create a newsimPICcount object to store parameters.

**Usage**

```
newsimPICcount(...)
```

**Arguments**

... Variables to set newsimPICcount object parameters.

**Details**

This function creates the object variable which is passed in all functions.

**Value**

new object from class simPICcount.

**Examples**

```
object <- newsimPICcount()
```

---

plot_theme	<i>Custom theme for ggplot2</i>
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---

**Description**

This function defines a custom theme for ggplot2 to ensure consistent visual appearance across multiple plots.

**Usage**

```
plot_theme()
```

**Value**

A ggplot2 theme object with predefined settings.

---

rbindMatched	<i>Bind rows (matched)</i>
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---

**Description**

Bind the rows of two data frames, keeping only the columns that are common to both.

**Usage**

```
rbindMatched(df1, df2)
```

**Arguments**

df1	first data.frame to bind.
df2	second data.frame to bind.

**Value**

data.frame containing rows from df1 and df2 but only common columns.

---

selectFit	<i>Select fit</i>
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---

**Description**

Trying two fitting methods and selecting the best one.

**Usage**

```
selectFit(data, distr, verbose = TRUE)
```

**Arguments**

data	The data to fit.
distr	Name of the distribution to fit.
verbose	logical. To print messages or not.

**Details**

The distribution is fitted to the data using each of the [fitdist](#) fitting methods. The fit with the smallest Cramer-von Mises statistic is selected.

**Value**

The selected fit object

---

setsimPICparameters	<i>Set simPIC parameters</i>
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---

**Description**

Set input parameters of the simPICcount object.

**Usage**

```
setsimPICparameters(object, update = NULL, ...)
```

**Arguments**

object	input simPICcount object.
update	new parameters.
...	set new parameters for simPICcount object.

**Value**

simPICcount object with updated parameters.

**Examples**

```
object <- newsimPICcount()
object <- setsimPICparameters(object, nCells = 200, nPeaks = 500)
```

---

simPICcompare

*Compare SingleCellExperiment objects*


---

**Description**

Combine data from several SingleCellExperiment objects and produce some basic plots comparing them.

**Usage**

```
simPICcompare(
  sces,
  point.size = 0.2,
  point.alpha = 0.1,
  fits = TRUE,
  colours = NULL
)
```

**Arguments**

sces	named list of SingleCellExperiment objects to combine and compare.
point.size	size of points in scatter plots.
point.alpha	opacity of points in scatter plots.
fits	whether to include fits in scatter plots.
colours	vector of colours to use for each dataset.

**Details**

The returned list has three items:

RowData Combined row data from the provided SingleCellExperiments.

ColData Combined column data from the provided SingleCellExperiments.

Plots Comparison plots

Means Boxplot of mean distribution.

Variances Boxplot of variance distribution.

MeanVar Scatter plot with fitted lines showing the mean-variance relationship.

LibrarySizes Boxplot of the library size distribution.

ZerosPeak Boxplot of the percentage of each peak that is zero.

ZerosCell Boxplot of the percentage of each cell that is zero.



MeanZeros Scatter plot with fitted lines showing the mean-zeros relationship.

The plots returned by this function are created using [ggplot](#) and are only a sample of the kind of plots you might like to consider. The data used to create these plots is also returned and should be in the correct format to allow you to create further plots using [ggplot](#).

### Value

List containing the combined datasets and plots.

### Examples

```
sim1 <- simPICsimulate(  
  nPeaks = 1000, nCells = 500,  
  pm.distr = "weibull", seed = 7856  
)  
sim2 <- simPICsimulate(  
  nPeaks = 1000, nCells = 500,  
  pm.distr = "gamma", seed = 4234  
)  
comparison <- simPICcompare(list(weibull = sim1, gamma = sim2))  
names(comparison)  
names(comparison$Plots)
```

---

simPICcount

*The simPICcount class*

---

### Description

S4 class that holds parameters for simPIC simulation.

### Value

a simPIC class object. The parameters not shown in brackets can be estimated from real data using [simPICestimate](#). For details of the simPIC simulation see [simPICsimulate](#). The default parameters are based on PBMC10k dataset and can be reproduced using test data and script provided in inst/script

### Parameters

simPIC simulation parameters:

nPeaks The number of peaks to simulate.

nCells The number of cells to simulate.

[seed] Seed to use for generating random numbers.

[default] The logical variable whether to use default parameters (TRUE) or learn from data (FALSE)

**Library size parameters** `lib.size.meanlog` meanlog (location) parameter for the library size log-normal distribution.

`lib.size.sdlog` sdlog (scale) parameter for the library size log-normal distribution.

**Peak mean parameters** `mean.scale` scale parameter for the mean weibull distribution.

`mean.shape` shape parameter for the mean weibull distribution.

**Cell sparsity parameters** `sparsity` probability of openness to be multiplied to the input of poisson distribution to generate final simulated matrix.

---

simPICestimate

*Estimate simPIC simulation parameters*

---

## Description

Estimate simulation parameters for library size, peak means, and sparsity for simPIC simulation from a real peak by cell input matrix

## Usage

```
simPICestimate(
  counts,
  object = newsimPICcount(),
  pm.distr = c("gamma", "weibull", "pareto", "lgamma"),
  verbose = TRUE
)

## S3 method for class 'SingleCellExperiment'
simPICestimate(
  counts,
  object = newsimPICcount(),
  pm.distr = "weibull",
  verbose = TRUE
)

## S3 method for class 'dgCMatrx'
simPICestimate(
  counts,
  object = newsimPICcount(),
  pm.distr = "weibull",
  verbose = TRUE
)
```

## Arguments

`counts` either a sparse peak by cell count matrix, or a `SingleCellExperiment` object containing count data to estimate parameters.

`object` `simPICcount` object to store estimated parameters and counts.

pm.distr	statistical distribution for estimating peak mean parameters. Available distributions: gamma, weibull, lngamma, pareto. Default is weibull.
verbose	logical variable. Prints the simulation progress if TRUE.

**Value**

simPICcount object containing all estimated parameters.

**Examples**

```
counts <- readRDS(system.file("extdata", "test.rds", package = "simPIC"))
est <- newsimPICcount()
est <- simPICestimate(counts, pm.distr = "weibull")
```

---

simPICestimateLibSize *Estimate simPIC library size parameters.*

---

**Description**

Estimate the library size parameters for simPIC simulation.

**Usage**

```
simPICestimateLibSize(counts, object, verbose)
```

**Arguments**

counts	count matrix.
object	simPICcount object to store estimated values.
verbose	logical. To print messages or not.

**Details**

Parameters for the lognormal distribution are estimated by fitting the library sizes using [fitdist](#). All the fitting methods are tried and the fit with the best Cramer-von Mises statistic is selected.

**Value**

simPICcount object with estimated library size parameters.

simPICestimatePeakMean

*Estimate simPIC peak means*

---

### Description

Estimate peak mean parameters for simPIC simulation

### Usage

```
simPICestimatePeakMean(norm.counts, object, pm.distr, verbose)
```

### Arguments

norm.counts	library size normalised counts matrix.
object	simPICcount object to store estimated values.
pm.distr	distribution parameter for peak means.
verbose	logical. To print progress messages or not.

### Details

Parameters for gamma distribution are estimated by fitting the mean normalised counts using [fitdist](#). All the fitting methods are tried and the fit with the best Cramer-von Mises statistic is selected.

### Value

simPICcount object containing all estimated parameters

---

simPICestimateSparsity

*Estimate simPIC peak sparsity.*

---

### Description

Extract the accessibility proportion (sparsity) of each cell among all peaks from the input count matrix.

### Usage

```
simPICestimateSparsity(norm.counts, object, verbose)
```

### Arguments

norm.counts	A sparse count matrix to estimate parameters from.
object	simPICcount object to store estimated parameters.
verbose	logical. To print messages or not.

**Details**

Vector of non-zero cell proportions of peaks is calculated by dividing the number of non-zero entries over the number of all cells for each peak.

**Value**

simPICcount object with updated non-zero cell proportion parameter.

---

simPICget	<i>Get a single simPICcount parameter</i>
-----------	---

---

**Description**

Get the value of a single variable from input simPICcount object.

**Usage**

```
simPICget(object, name)
```

**Arguments**

object	input simPICcount object.
name	name of the parameter.

**Value**

Value of the input parameter.

**Examples**

```
object <- newsimPICcount()
nPeaks <- simPICget(object, "nPeaks")
```

---

simPICgetparameters	<i>Get parameters</i>
---------------------	-----------------------

---

**Description**

Get multiple parameter values from a simPIC object.

**Usage**

```
simPICgetparameters(object, names)
```

**Arguments**

object           input object to get values from.  
 names           vector of names of the parameters to get.

**Value**

List with the values of the selected parameters.

**Examples**

```
object <- newsimPICcount()
simPICgetparameters(object, c("nPeaks", "nCells", "peak.mean.shape"))
```

---

simPICsimulate           *simPIC simulation*

---

**Description**

Simulate peak by cell count matrix from a sparse single-cell ATAC-seq peak by cell input using simPIC methods.

**Usage**

```
simPICsimulate(
  object = newsimPICcount(),
  verbose = TRUE,
  pm.distr = "weibull",
  ...
)
```

**Arguments**

object           simPICcount object with simulation parameters. See [simPICcount](#) for details.  
 verbose         logical variable. Prints the simulation progress if TRUE.  
 pm.distr        distribution parameter for peak means. Available distributions: gamma, weibull, lngamma, pareto. Default is weibull.  
 ...             Any additional parameter settings to override what is provided in simPICcount object.

**Details**

simPIC provides the option to manually adjust each of the simPICcount object parameters by calling [setsimPICparameters](#).

The simulation involves following steps:

1. Set up simulation parameters

2. Set up SingleCellExperiment object
3. Simulate library sizes
4. Simulate sparsity
5. Simulate peak means
6. Create final synthetic counts

The final output is a `SingleCellExperiment` object that contains the simulated count matrix. The parameters are stored in the `colData` (for cell specific information), `rowData` (for peak specific information) or `assays` (for peak by cell matrix) slots. This additional information includes:

### Value

`SingleCellExperiment` object containing the simulated counts.

### Examples

```
# default simulation
sim <- simPICsimulate(pm.distr = "weibull")
```

---

`simPICsimulateLibSize` *Simulate simPIC library sizes*

---

### Description

Generate library sizes for cells in simPIC simulation based on the estimated values of  $\mu$ s and  $\sigma$ s.

### Usage

```
simPICsimulateLibSize(object, sim, verbose)
```

### Arguments

<code>object</code>	<code>simPICcount</code> object with simulation parameters.
<code>sim</code>	<code>SingleCellExperiment</code> object containing simulation parameters.
<code>verbose</code>	logical. To print progress messages.

### Value

`SingleCellExperiment` object with simulated library sizes.

---

simPICsimulatePeakMean

*Simulate simPIC peak means.*

---

### Description

Generate peak means for cells in simPIC simulation based on the estimated values of shape and rate parameters.

### Usage

```
simPICsimulatePeakMean(object, sim, pm.distr, verbose)
```

### Arguments

object	simPICcount object with simulation parameters.
sim	SingleCellExperiment object containing simulation parameters.
pm.distr	distribution parameter for peak means. Available distributions: gamma, weibull, lngamma, pareto. Default is weibull.
verbose	logical. Whether to print progress messages.

### Value

SingleCellExperiment object with simulated peak means.

---

simPICsimulateTrueCounts

*Simulate true counts.*

---

### Description

Counts are simulated from a poisson distribution where each peak has a mean, expected library size and proportion of accessible chromatin.

### Usage

```
simPICsimulateTrueCounts(object, sim)
```

### Arguments

object	simPICcount object with simulation parameters.
sim	SingleCellExperiment object containing simulation parameters.

### Value

SingleCellExperiment object with simulated true counts.



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