

# The GenomeGraphs user's guide

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## 1 Introduction

Genomic data analyses can benefit from integrated visualization of the genomic information. The GenomeGraphs package uses the biomaRt package to do live queries to Ensembl and translates e.g. gene/transcript structures to viewports of the grid graphics package, resulting in genomic information plotted together with your data. Possible genomics datasets that can be plotted are: Array CGH data, gene expression data and sequencing data.

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```
> library(GenomeGraphs)
```

## 2 Creating a Ensembl annotation graphic

To create an Ensembl annotation graphic, you need to decide what you want to plot. Genes and transcripts can be plotted individually using the **Gene** and **Transcript** objects respectively. Or one can plot a gene region the forward strand or reverse strand only or both. In this section we will cover these different graphics.

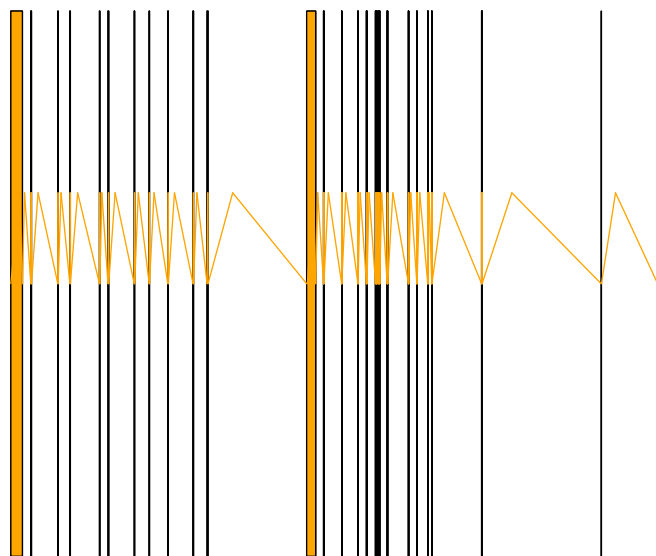
### 2.1 Plotting a Gene

If one wants to plot annotation information from Ensembl then you need to connect to the Ensembl BioMart database using the useMart function of the biomaRt package.

```
> mart <- useMart("ensembl", dataset = "hsapiens_gene_ensembl")
```

Next we can retrieve the gene structure of the gene of interest.

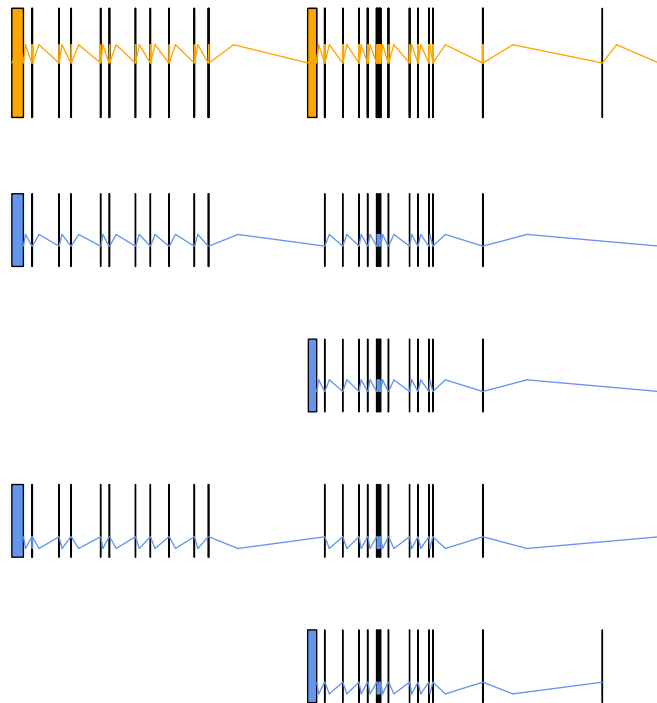
```
> gene <- makeGene(id = "ENSG00000095203",  
+   type = "ensembl_gene_id", biomaRt = mart)  
> gdPlot(gene)
```



## 2.2 Adding alternative transcripts

To add alternative transcripts you first have to create a **Transcript** object. Note that the order of the objects in the list determines the order in the plot.

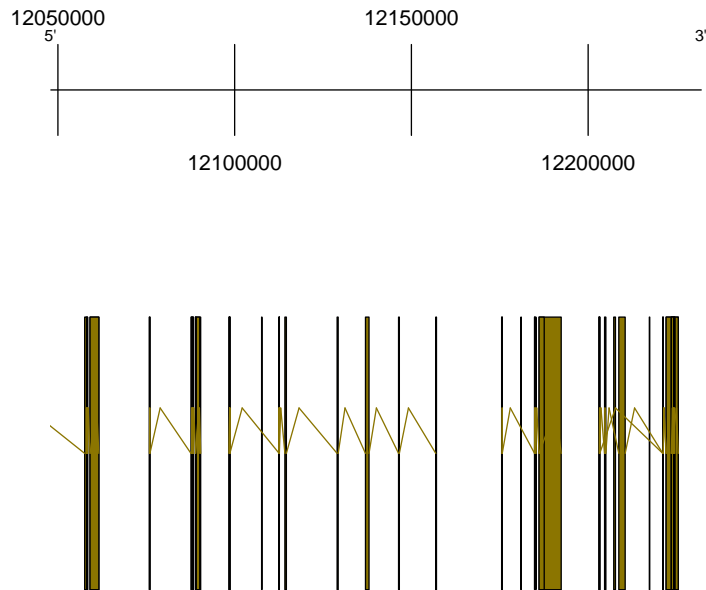
```
> transcript <- makeTranscript(id = "ENSG00000095203",  
+   type = "ensembl_gene_id", biomart = mart)  
> gdPlot(list(gene, transcript))
```



## 2.3 Plotting a gene region

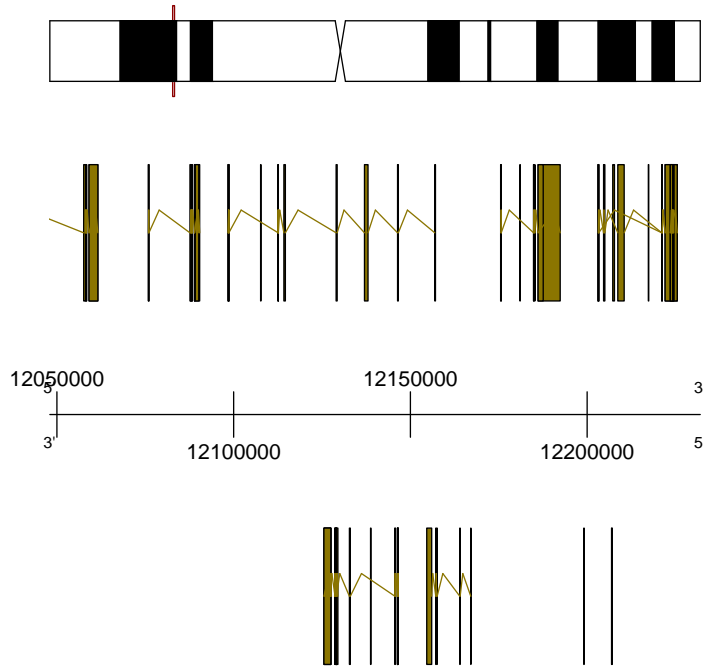
If you're interested in not just plotting one gene but a whole gene region then you should create a **GeneRegion** object. Note that a **GeneRegion** object is strand specific. In the example below we will retrieve the genes on the forward (+) strand only and add a genomic axis as well to give us the base positions.

```
> plusStrand <- makeGeneRegion(chromosome = 19,
+   start = 12050000, end = 12230000,
+   strand = "+", biomaRt = mart)
> genomeAxis <- makeGenomeAxis(add53 = TRUE)
> gdPlot(list(genomeAxis, plusStrand))
```



Let's now add the genes on the negative strand as well and an ideogram of chromosome 17, highlighting the region we are looking at.

```
> minStrand <- makeGeneRegion(chromosome = 19,
+   start = 12050000, end = 12230000,
+   strand = "-", biomaRt = mart)
> ideogram <- makeIdeogram(chromosome = 19)
> genomeAxis <- makeGenomeAxis(add53 = TRUE,
+   add35 = TRUE)
> gdPlot(list(ideogram, plusStrand, genomeAxis,
+   minStrand))
```



### 3 Adding Array data to the plot

#### 3.1 Array CGH and gene expression array data

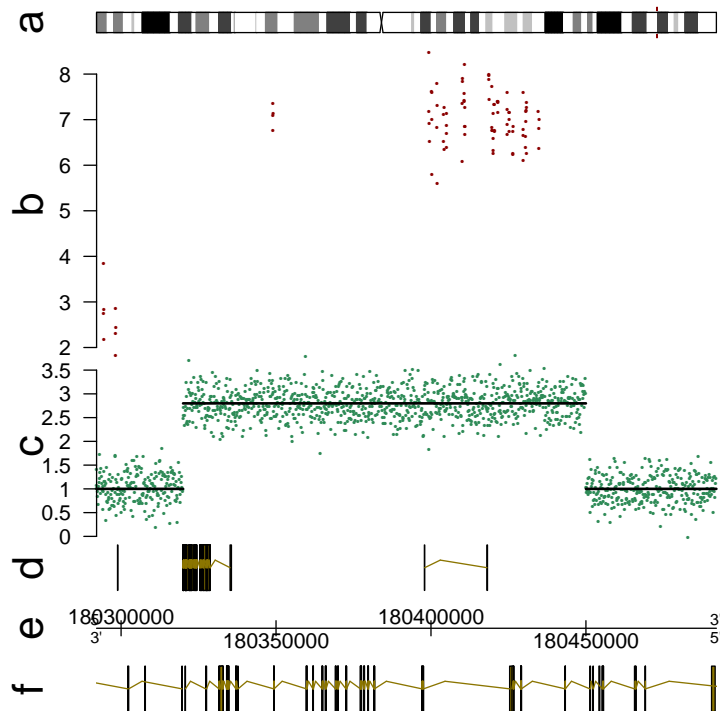
The `Generic Array` object enables plotting of expression and CGH array data together with segments if available. The array intensity data should be given as a matrix, with in the rows the different probes and in the columns the different samples. For each probe the start location should be given using the `probeStart` argument. This should be a one column matrix. Lets load some dummy data.

```
> data("exampleData", package = "GenomeGraphs")
> minbase <- 180292097
> maxbase <- 180492096
> genesplus <- makeGeneRegion(start = minbase,
+   end = maxbase, strand = "+", chromosome = "3",
+   biomart = mart)
> genesmin <- makeGeneRegion(start = minbase,
```

```

+     end = maxbase, strand = "-", chromosome = "3",
+     biomart = mart)
> seg <- makeSegmentation(segStart[[1]],
+     segEnd[[1]], segments[[1]], dp = DisplayPars(color = "black",
+     lwd = 2, lty = "solid"))
> cop <- makeGenericArray(intensity = cn,
+     probeStart = probestart, trackOverlay = seg,
+     dp = DisplayPars(size = 3, color = "seagreen",
+     type = "dot"))
> ideog <- makeIdeogram(chromosome = 3)
> expres <- makeGenericArray(intensity = intensity,
+     probeStart = exonProbePos, dp = DisplayPars(color = "darkred",
+     type = "point"))
> genomeAxis <- makeGenomeAxis(add53 = TRUE,
+     add35 = TRUE)
> gdPlot(list(a = ideog, b = expres, c = cop,
+     d = genesplus, e = genomeAxis, f = genesmin),
+     minBase = minbase, maxBase = maxbase,
+     labelCex = 2)

```



### 3.2 Exon array data

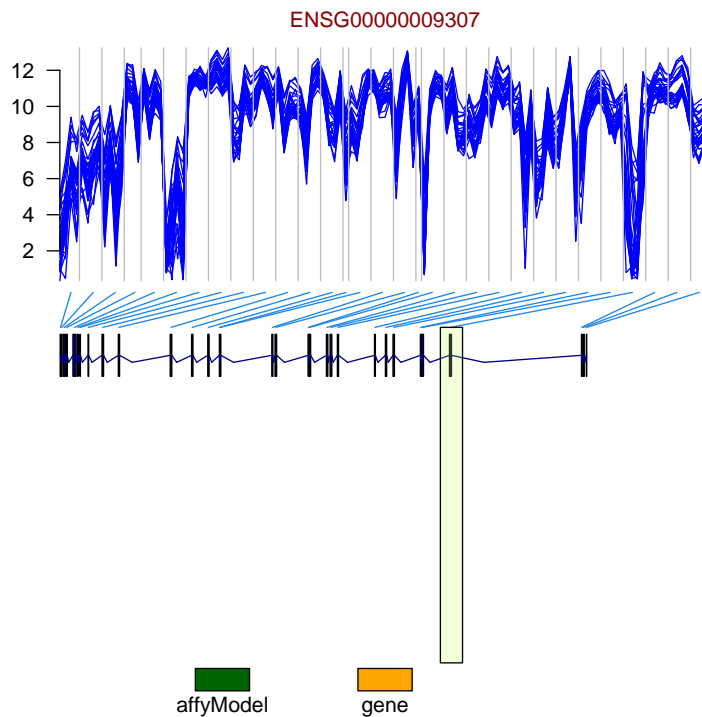
The example below plots probe level exon array data and is useful in relating alternative splicing with known transcript structures.

```
> data("unrData", package = "GenomeGraphs")
> title <- makeTitle(text = "ENSG00000009307",
+   color = "darkred")
> exon <- makeExonArray(intensity = unrData,
+   probeStart = unrPositions[, 3], probeEnd = unrPositions[,
+   4], probeId = as.character(unrPositions[,
+   1]), nProbes = unrNProbes, dp = DisplayPars(color = "blue",
+   mapColor = "dodgerblue2"), displayProbesets = FALSE)
> affyModel.model <- makeGeneModel(start = unrPositions[,
+   3], end = unrPositions[, 4])
> affyModel <- makeAnnotationTrack(start = unrPositions[,
+   3], end = unrPositions[, 4], feature = "gene_model",
+   group = "ENSG00000009307", dp = DisplayPars(gene_model = "darkblue"))
```

```

> gene <- makeGene(id = "ENSG00000009307",
+   biomart = mart)
> transcript <- makeTranscript(id = "ENSG00000009307",
+   biomart = mart)
> legend <- makeLegend(c("affyModel", "gene"),
+   fill = c("darkgreen", "orange"))
> rOverlay <- makeRectangleOverlay(start = 115085100,
+   end = 115086500, region = c(3, 5),
+   dp = DisplayPars(alpha = 0.2, fill = "olivedrab1"))
> gdPlot(list(title, exon, affyModel, gene,
+   transcript, legend), minBase = 115061061,
+   maxBase = 115102147, overlay = rOverlay)

```



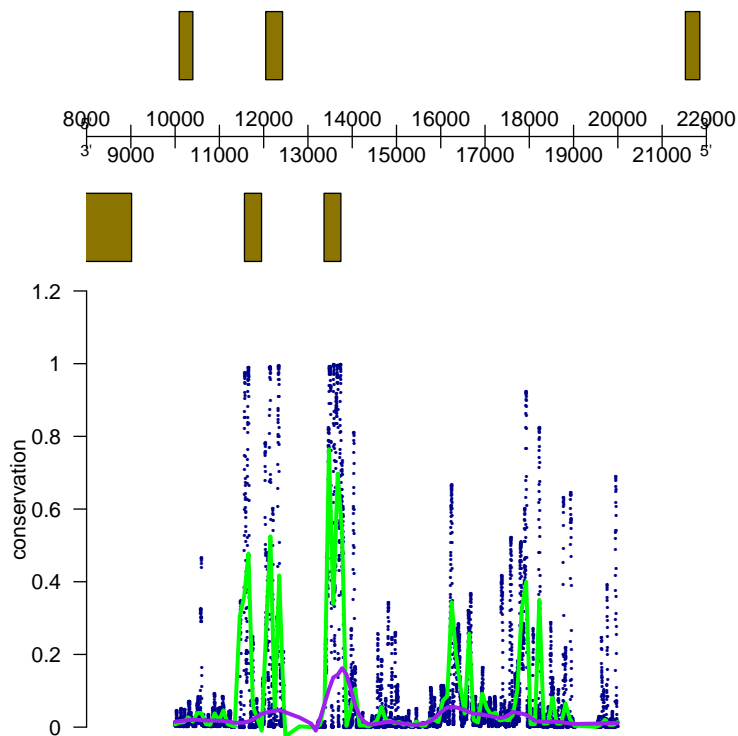
### 3.3 Plotting Conservation Data

The UCSC genome browser offers downloadable conservation data for a variety of species. Here we show how you can plot that conservation data along with annotation.

```

> yeastMart <- useMart("ensembl", dataset = "scerevisiae_gene_ensembl")
> minB <- 10000
> maxB <- 20000
> chrRoman <- as.character(as.roman(1))
> grP <- makeGeneRegion(start = minB, end = maxB,
+   strand = "+", chromosome = chrRoman,
+   biomaRt = yeastMart)
> grM <- makeGeneRegion(start = minB, end = maxB,
+   strand = "-", chromosome = chrRoman,
+   biomaRt = yeastMart)
> gaxis <- makeGenomeAxis(add53 = TRUE,
+   add35 = TRUE)
> conserv <- yeastCons1[yeastCons1[, 1] >
+   minB & yeastCons1[, 1] < maxB, ]
> s1 <- makeSmoothing(x = lowess(conserv[,
+   1], conserv[, 2], f = 0.01)$x, y = lowess(conserv[,
+   1], conserv[, 2], f = 0.01)$y, dp = DisplayPars(lwd = 3,
+   color = "green"))
> s2 <- makeSmoothing(x = lowess(conserv[,
+   1], conserv[, 2], f = 0.1)$x, y = lowess(conserv[,
+   1], conserv[, 2], f = 0.1)$y, dp = DisplayPars(lwd = 3,
+   color = "purple"))
> constTrack <- makeBaseTrack(base = conserv[,
+   1], value = conserv[, 2], dp = DisplayPars(lwd = 0.2,
+   ylim = c(0, 1.25), color = "darkblue"),
+   trackOverlay = list(s1, s2))
> gdPlot(list(grP, gaxis, grM, conservation = constTrack))

```

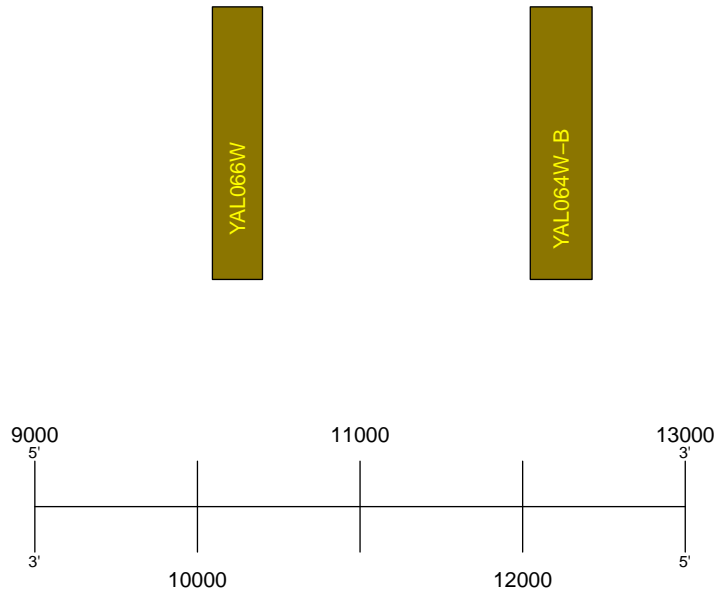


## 4 Odds and Ends

In addition to plotting the genes we can enable the plotting of names of genes.

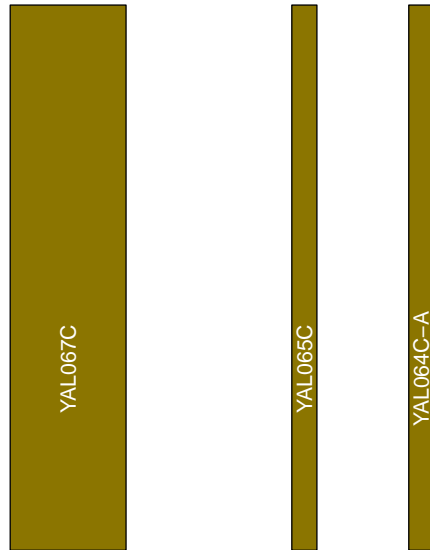
```
> plotGeneRegion <- function(chr = 1, minB = 9000,
+   maxB = 13000, rot = 0, col = "green") {
+   chrRoman <- as.character(as.roman(1:17)[chr])
+   grP <- makeGeneRegion(start = minB,
+     end = maxB, strand = "+", chromosome = chrRoman,
+     biomaRt = yeastMart, dp = DisplayPars(plotId = TRUE,
+       idRotation = rot, idColor = col))
+   gaxis <- makeGenomeAxis(add53 = TRUE,
+     add35 = TRUE, littleTicks = FALSE)
+   gdPlot(list(grP, gaxis), minBase = minB,
+     maxBase = maxB)
+ }
```

```
> plotGeneRegion(col = "yellow", rot = 90)
```



Finally, if you are interested in seeing how things look you can just plot the object without the list, or without the *minBase*, *maxBase* arguments.

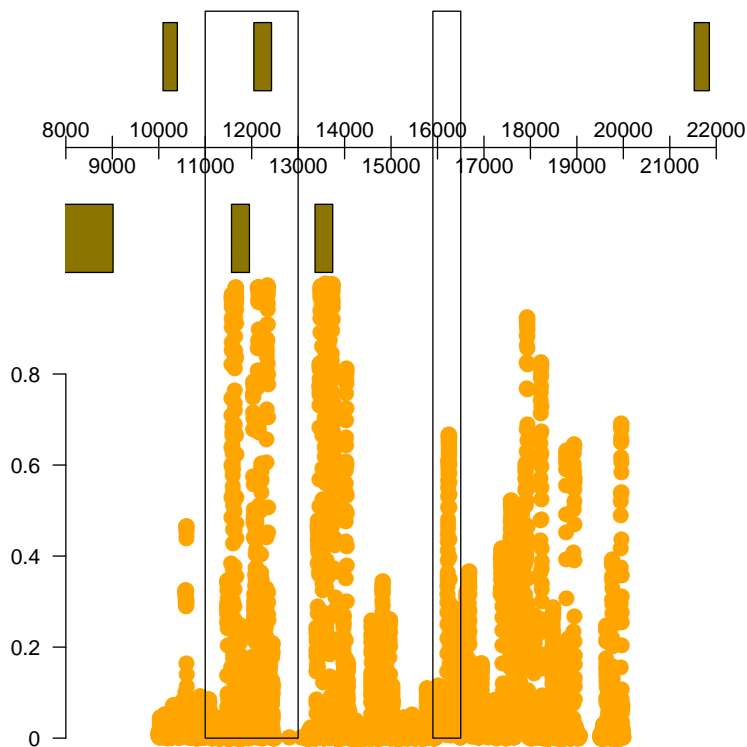
```
> gdPlot(makeGeneRegion(start = 9000, end = 15000,
+   biomart = yeastMart, strand = "-",
+   chromosome = "I", dp = DisplayPars(plotId = TRUE)))
```



## 4.1 Overlays

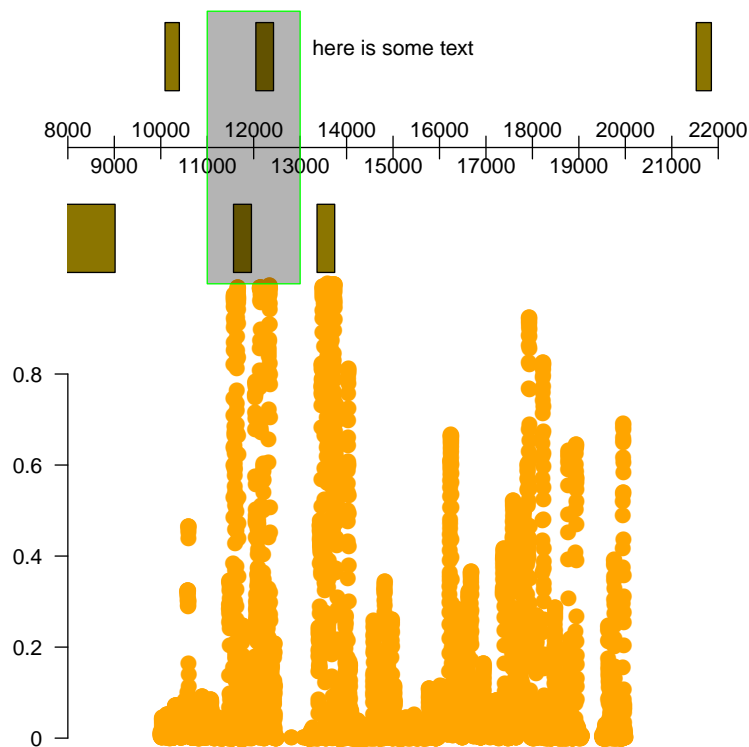
Overlays can be used to annotate different regions of the plot. Currently, we can draw boxes and write text on the plot.

```
> ga <- makeGenomeAxis()
> grF <- makeGeneRegion(start = 10000, end = 20000,
+   chromosome = "I", strand = "+", biomart = yeastMart)
> grR <- makeGeneRegion(start = 10000, end = 20000,
+   chromosome = "I", strand = "-", biomart = yeastMart)
> bt <- makeBaseTrack(base = yeastCons1[,
+   1], value = yeastCons1[, 2])
> hr1 <- makeRectangleOverlay(start = 11000,
+   end = 13000)
> hr2 <- makeRectangleOverlay(start = 15900,
+   end = 16500)
> gdPlot(list(grF, ga, grR, bt), overlays = list(hr1,
+   hr2))
```



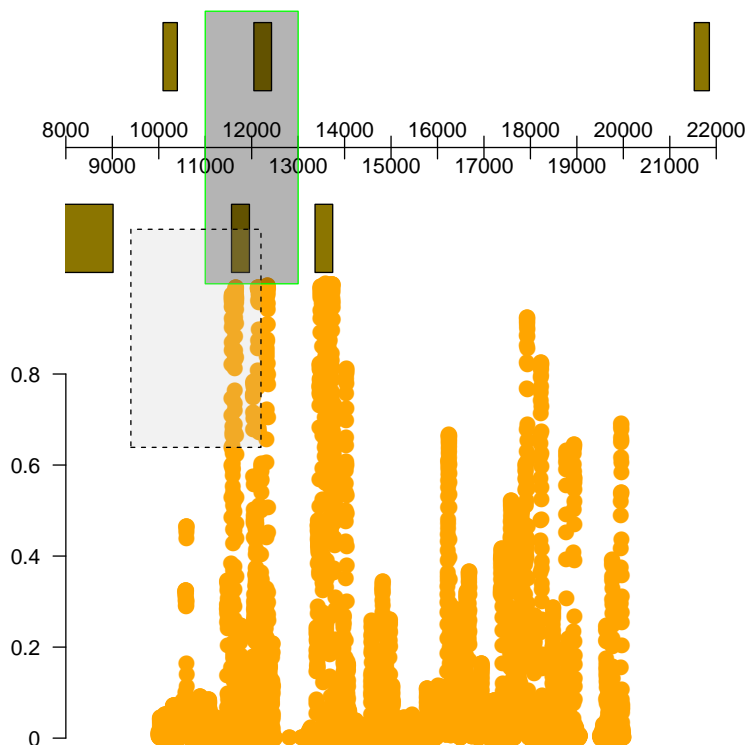
A little nifty feature is to allow alpha blending to make things slightly transparent. If the device you wish to plot on however, does not support transparency then you will get a warning.

```
> ro <- makeRectangleOverlay(start = 11000,
+   end = 13000, region = c(1, 3), dp = DisplayPars(color = "green",
+   alpha = 0.3))
> to <- makeTextOverlay("here is some text",
+   xpos = 15000, ypos = 0.95)
> gdPlot(list(grF, ga, grR, bt), overlay = c(ro,
+   to))
```



Also, one can use "absolute" coordinates to specify a region just in case one wants to be a bit more precise.

```
> roR <- makeRectangleOverlay(start = 0.1,
+   end = 0.3, coords = "absolute", dp = DisplayPars(fill = "grey",
+   alpha = 0.2, lty = "dashed"),
+   region = c(0.4, 0.7))
> gdPlot(list(grF, ga, grR, bt), overlays = list(ro,
+   roR))
```



## 4.2 GenomeGraphs Classes

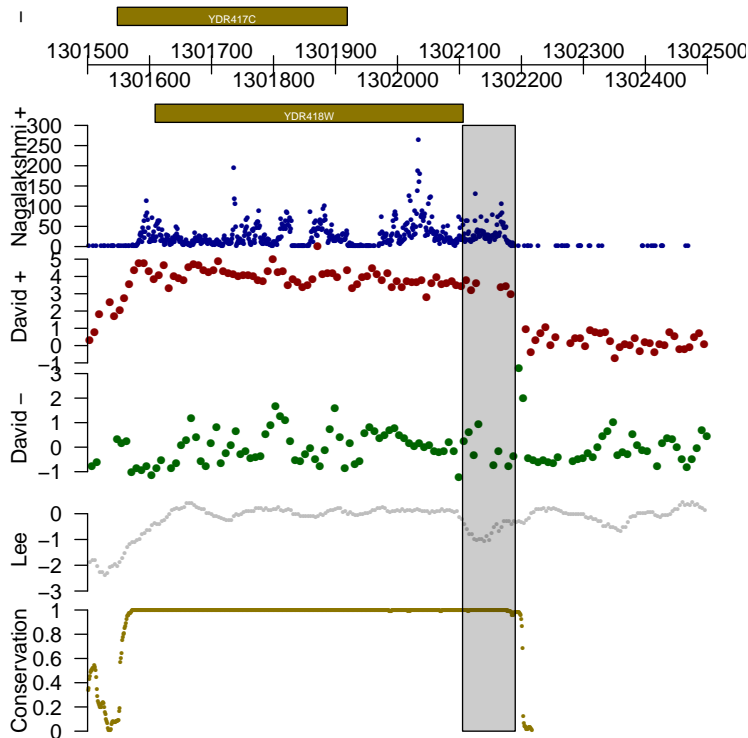
```
> data("seqDataEx", package = "GenomeGraphs")
> str = seqDataEx$david[, "strand"] == 1
> biomart = useMart("ensembl", "scerevisiae_gene_ensembl")
> pList = list(`-` = makeGeneRegion(chromosome = "IV",
+   start = 1300000, end = 1310000, strand = "-"),
+   biomart = biomart, dp = DisplayPars(plotId = TRUE,
+     idRotation = 0, cex = 0.5)), makeGenomeAxis(dp = DisplayPars(size = 3)),
+   `+` = makeGeneRegion(chromosome = "IV",
+     start = 1300000, end = 1310000,
+     strand = "+", biomart = biomart,
+     dp = DisplayPars(plotId = TRUE,
+       idRotation = 0, cex = 0.5)),
+   Nagalakshmi = makeBaseTrack(base = seqDataEx$snyder[,
+     "location"], value = seqDataEx$snyder[,
+     "counts"], dp = DisplayPars(lwd = 0.3,
+     color = "darkblue", ylim = c(0,
```

class	description
<code>gdObject</code>	the root class of the system, never directly instantiated
<code>Gene</code>	class representing a gene
<code>GeneRegion</code>	class defining a region of a chromosome, generally a set of genetic elements (genes)
<code>Transcript</code>	class defining a transcript
<code>TranscriptRegion</code>	class defining a region of a chromosome, generally a set of genetic elements (transcripts)
<code>Ideogram</code>	an ideogram
<code>Title</code>	class to draw a title
<code>Legend</code>	class to draw a legend
<code>GenomeAxis</code>	class to draw a axis
<code>Segmentation</code>	class to draw horizontal lines in various sets of data
<code>GenericArray</code>	class to draw data from microarrays.
<code>ExonArray</code>	class to draw data from exon microarrays.
<code>GeneModel</code>	class to draw custom gene models (intron-exon structures)
<code>BaseTrack</code>	class to draw whatever kind of data at a given base
<code>MappedRead</code>	class to plot sequencing reads that are mapped to the genome
<code>DisplayPars</code>	class managing various plotting parameters
<code>AnnotationTrack</code>	class used to represent custom annotation
<code>Overlay</code>	root class for overlays, never directly instantiated
<code>RectangleOverlay</code>	class to represent rectangular regions of interest
<code>TextOverlay</code>	class to draw text on plots

```

+         300))), `David +` = makeGenericArray(probeStart = seqDataEx$david[str,
+         "location"], intensity = seqDataEx$david[str,
+         "expr", drop = FALSE], dp = DisplayPars(pointSize = 0.5)),
+ `David -` = makeGenericArray(probeStart = seqDataEx$david[!str,
+         "location"], intensity = seqDataEx$david[!str,
+         "expr", drop = FALSE], dp = DisplayPars(color = "darkgreen",
+         pointSize = 0.5)), Lee = makeBaseTrack(base = seqDataEx$nislow[,
+         "location"], value = seqDataEx$nislow[,
+         "evalr"], dp = DisplayPars(color = "grey",
+         lwd = 0.25)), Conservation = makeBaseTrack(base = seqDataEx$conservation[,
+         "location"], value = seqDataEx$conservation[,
+         "score"], dp = DisplayPars(color = "gold4",
+         lwd = 0.25)))
> gdPlot(pList, minBase = 1301500, maxBase = 1302500,
+         overlay = makeRectangleOverlay(start = 1302105,
+         end = 1302190, region = c(4, 8),
+         dp = DisplayPars(alpha = 0.2)))

```



We can also employ different plotting types for the BaseTrack object.

```

> setPar(pList$Lee@dp, "type", "h")
> setPar(pList$Lee@dp, "color", "limegreen")
> setPar(pList$Lee@dp, "lwd", 2)
> gdPlot(pList, minBase = 1301500, maxBase = 1302500,
+       overlay = makeRectangleOverlay(start = 1302105,
+       end = 1302190, region = c(4, 8),
+       dp = DisplayPars(alpha = 0.2)))

```

