

data tracks

SESSION 2

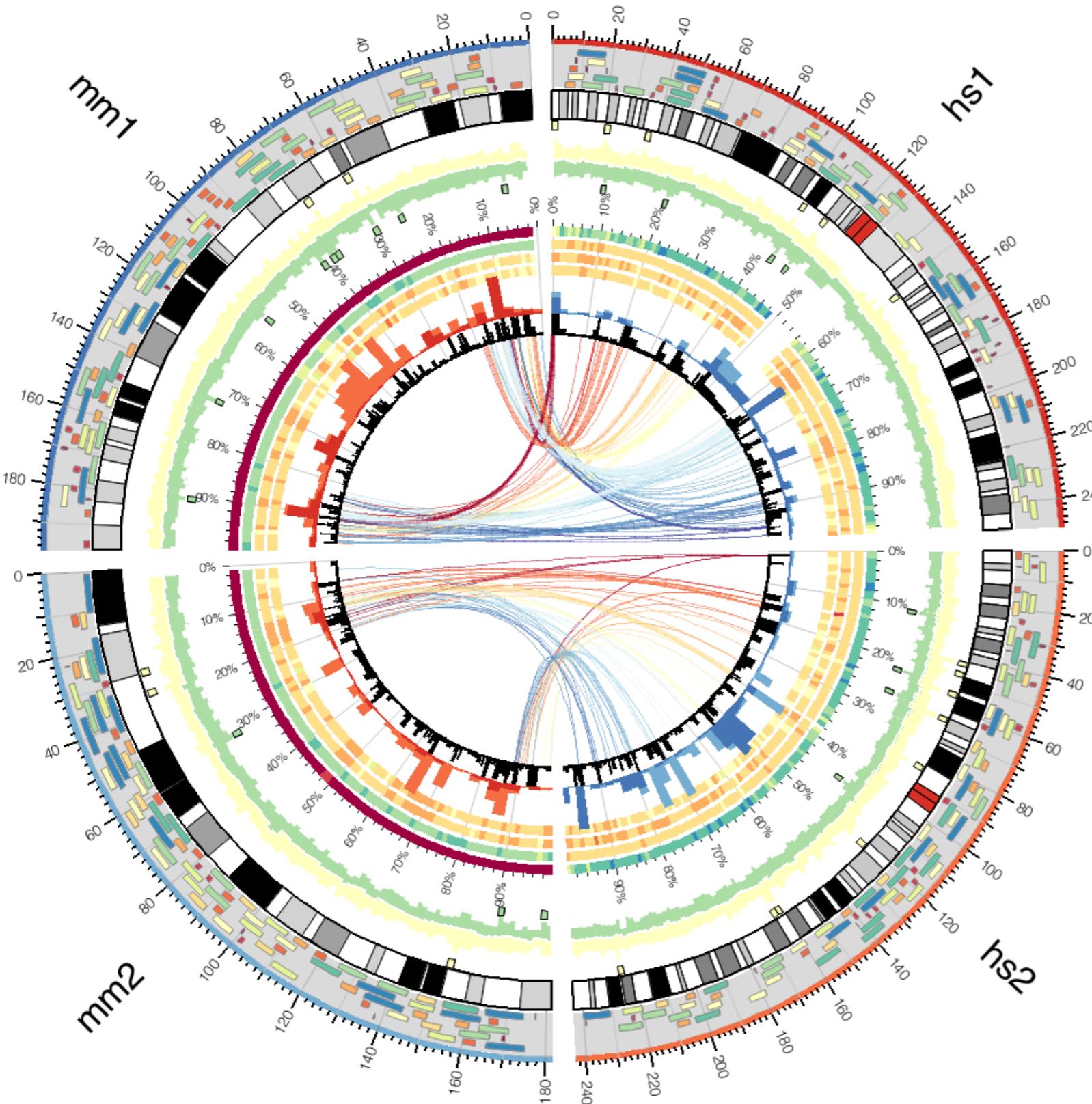
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**EMBO PRACTICAL COURSE:
BIOINFORMATICS GENOME ANALYSES**

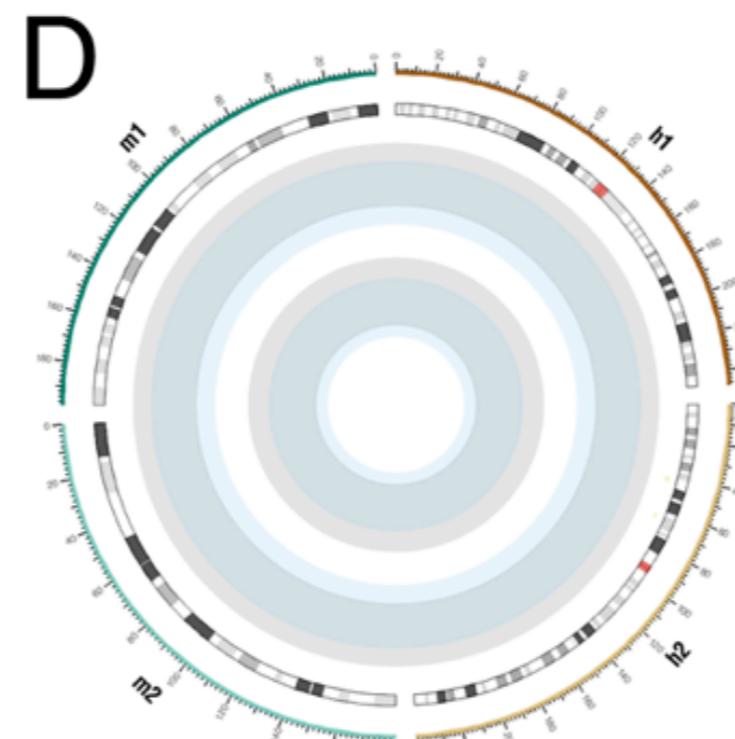
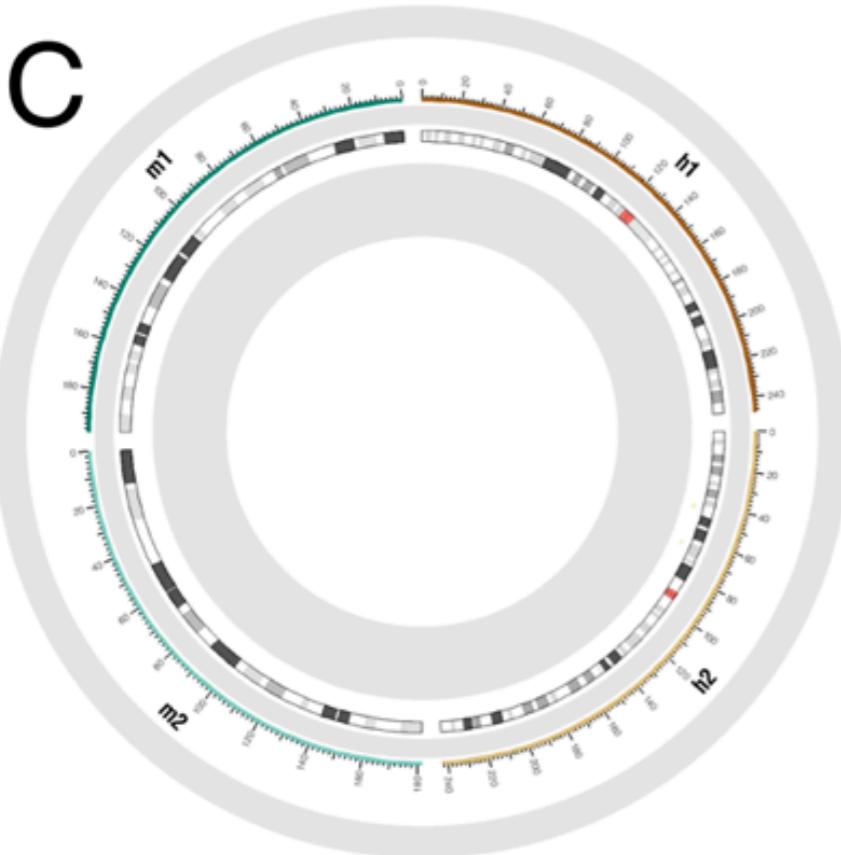
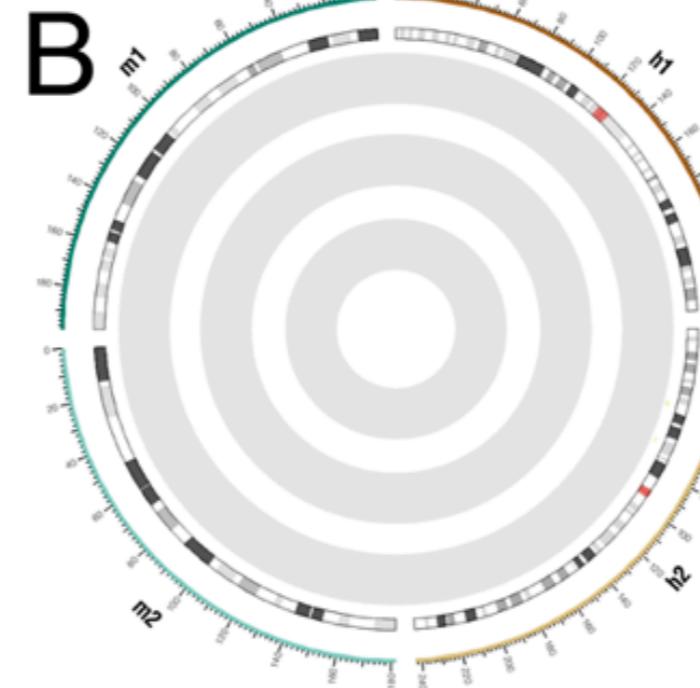
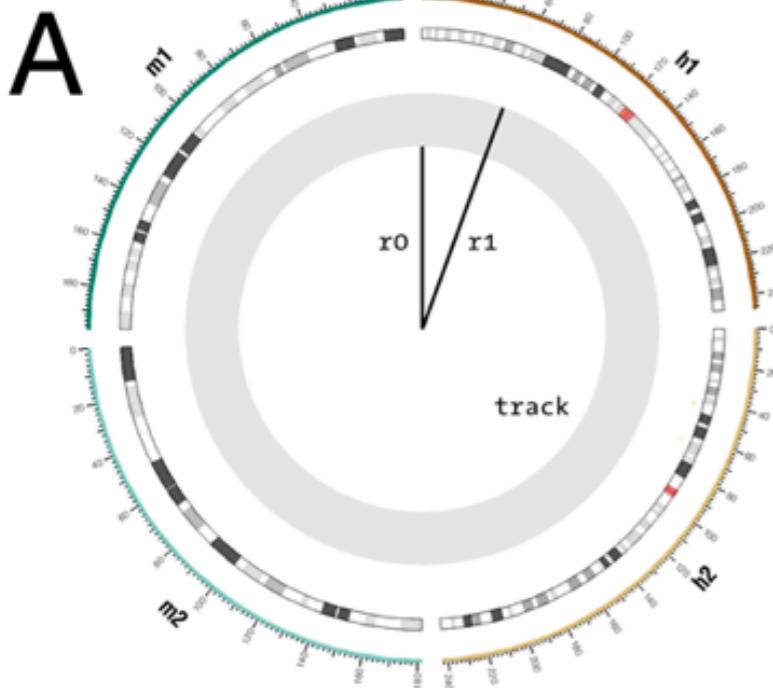
Izmir Biomedicine and Genome Center, Izmir, Turkey
May 2–14, 2016

SESSION FINAL IMAGE



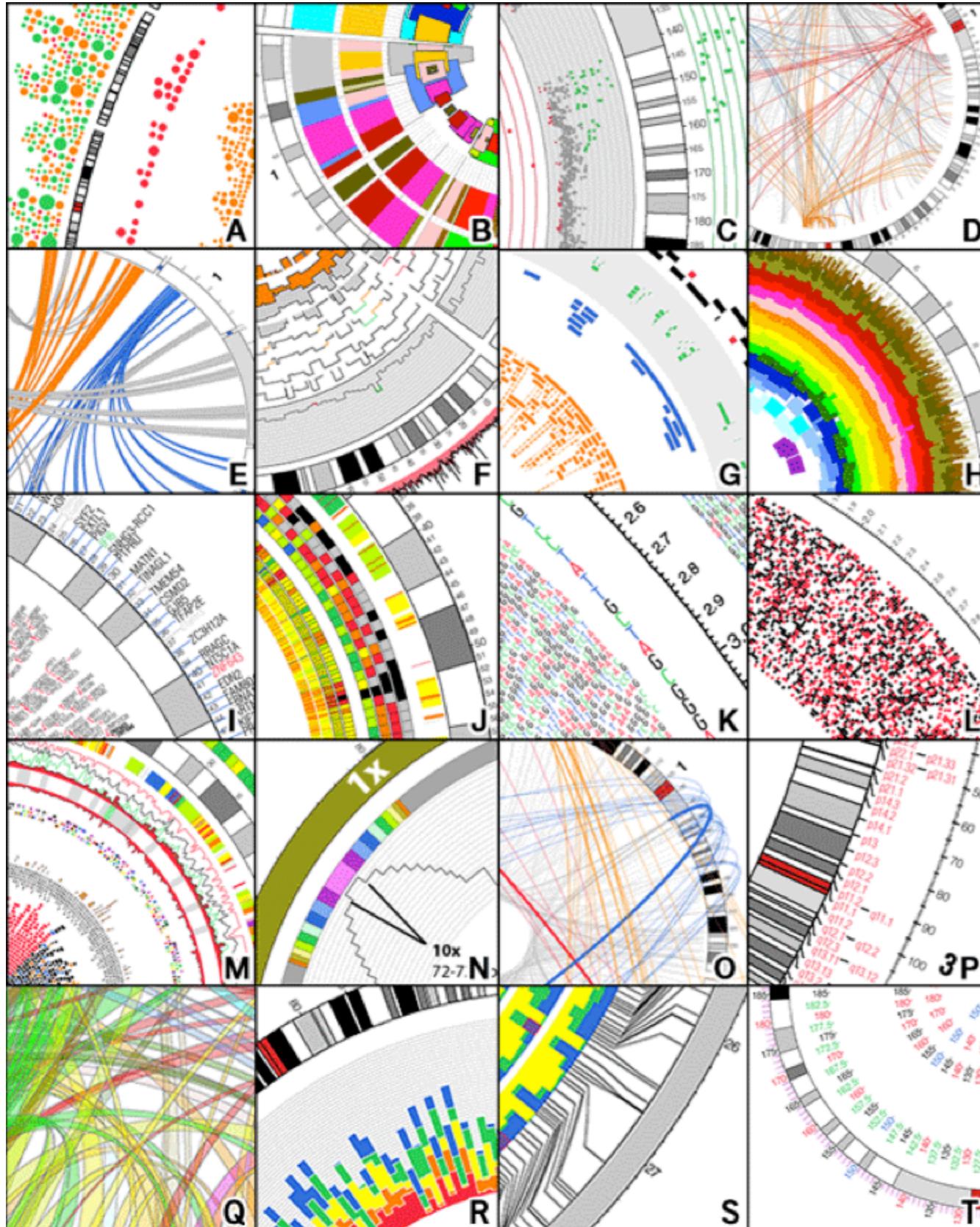
histograms
heatmaps
histograms
tiles
links
dynamic rules
highlights

DATA TRACK LAYOUT



(A) Each data track confined to an annulus bounded by radii r_0 and r_1 . (B) Any number of tracks can be placed on the figure, and (C) at any radial position, including inside/outside ideogram circle and inside/outside ticks. (D) Tracks can be made to overlap and the order in which they are drawn is controlled by the z parameter.

DATA TRACK TYPES

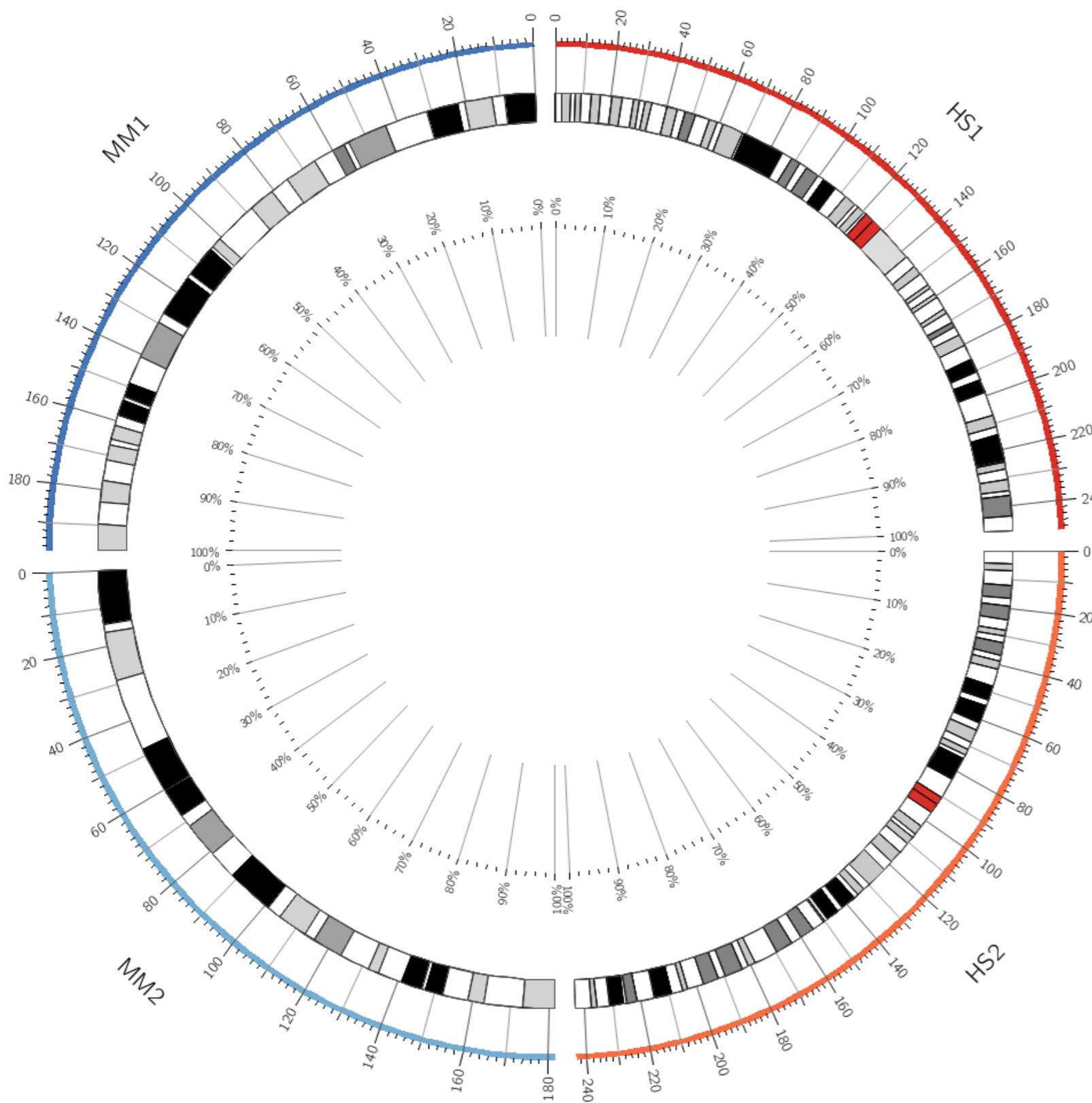


(A) glyph (B) highlight with depth control (C) scatter (D) paired-location (E) ribbon (F) histogram (G) tile (H) highlight with auto depth (I) text with auto arrange (J) heat map (K) high-density text (L) high-density glyph (M) multi-type composite (N) variable scale control (O) fine geometry control (P) flexible text and element placement (Q) transparent ribbons (R) stacked histogram (S) connectors (T) tick rings

ideogram layout

LESSON 1

IDEOGRAM LAYOUT



```
# <<include>> directives keep the  
# configuration file short and modular
```

```
<<include ../etc/karyotype.and.layout.conf>>  
  
<<include ../etc/ideogram.conf>>  
  
<<include ../etc/ticks.conf>>  
  
<<include ../../etc/image.conf>>  
  
<<include etc/colors_fonts_patterns.conf>>  
  
<<include etc/housekeeping.conf>>
```

LAYOUT PARAMETERS VIA <<INCLUDE>>

```
# 2/1/etc/circos.conf

<<include ../../etc/karyotype.and.layout.conf>>

# 2/etc/karyotype.and.layout.conf

karyotype = ../../data/karyotype/karyotype.human.txt,../../data/karyotype/karyotype.mouse.txt

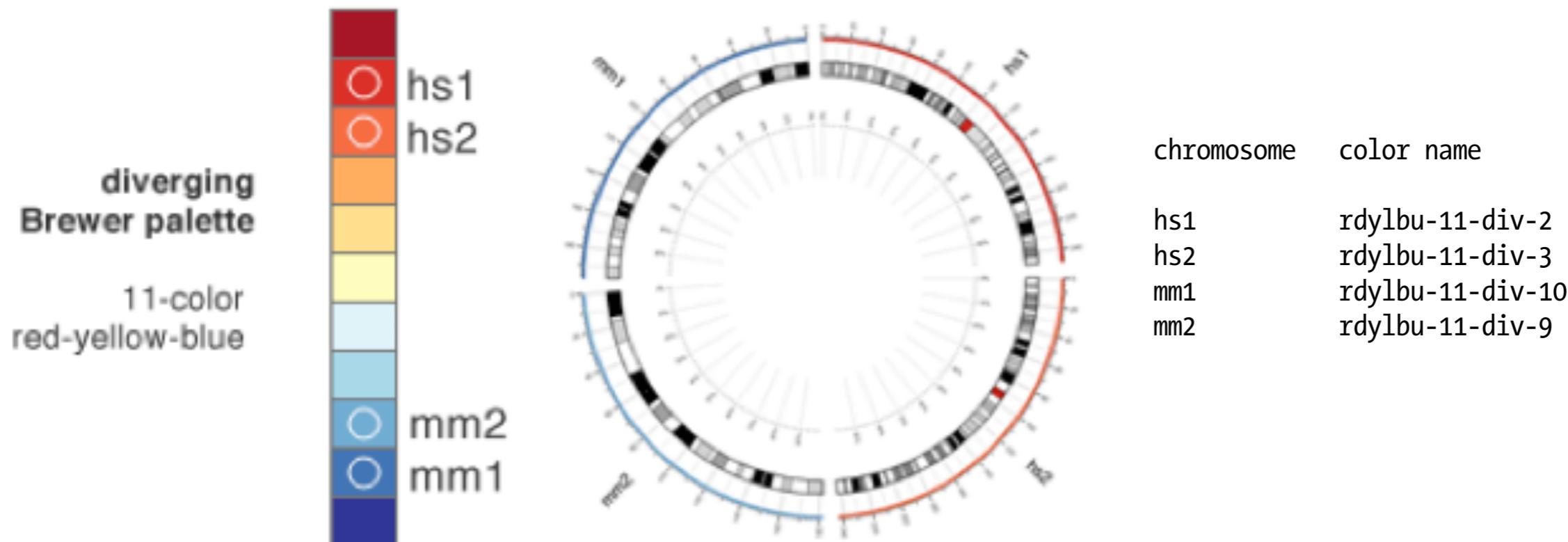
chromosomes_units          = 1000000
chromosomes_display_default = no

chromosomes      = hs1;hs2;mm1;mm2
chromosomes_order = hs1,hs2,mm2,mm1
chromosomes_color = hs1=rdylbu-11-div-2,hs2=rdylbu-11-div-3,mm1=rdylbu-11-div-10,mm2=rdylbu-11-div-9

chromosomes_reverse = /mm/
chromosomes_scale    = ./=0.25r

<highlights>
<highlight>
file = ../../data/highlight.txt
r0   = 1r+40p
r1   = 1r+45p
</highlight>
</highlights>
```

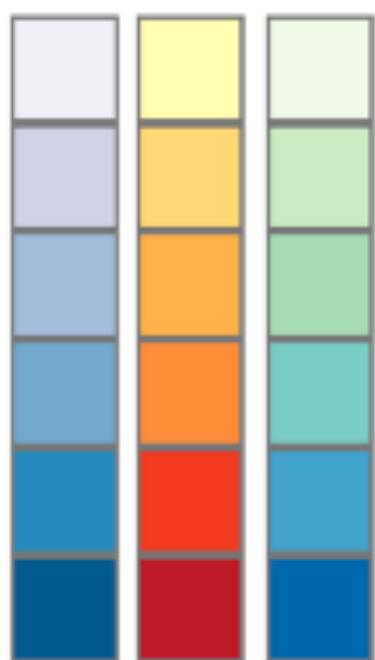
BREWER COLOR PALETTE FOR IDEOGRAMS



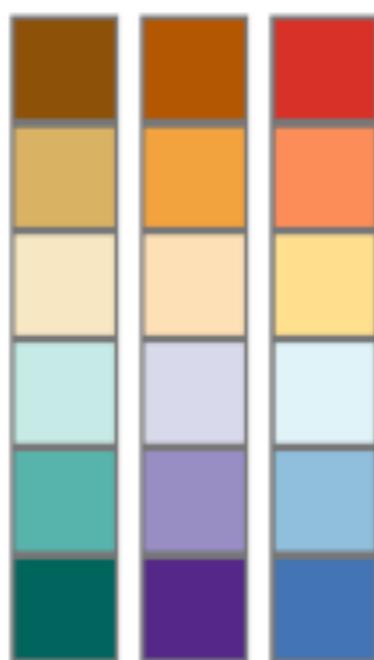
OTHER BREWER PALETTES

Examples of 5-color Brewer Palettes

sequential



diverging



qualitative

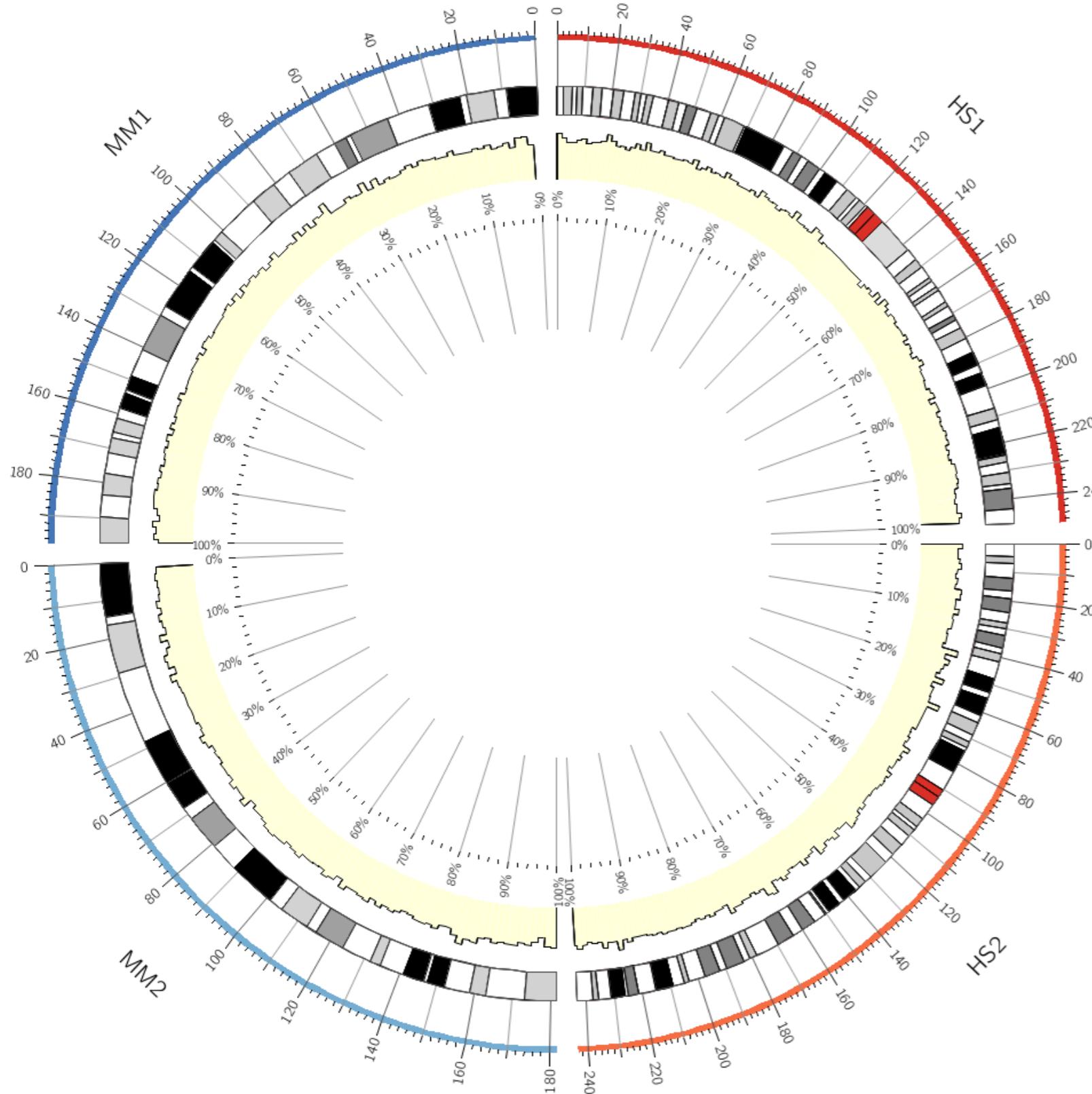


<http://www.colorbrewer.org>

histograms

LESSON 2

HISTOGRAMS

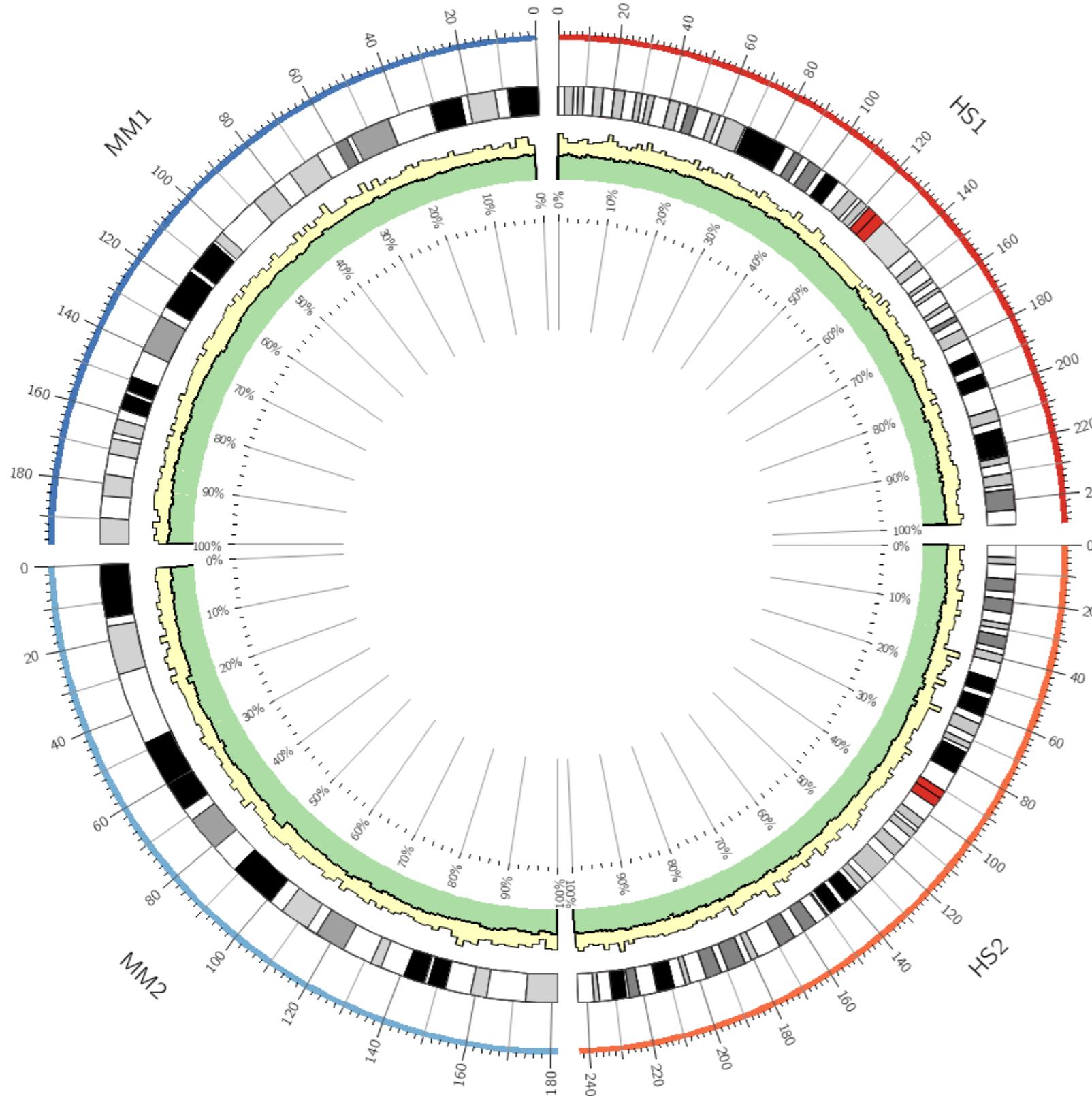


```
# 2/2/etc/circos.conf
```

```
<plots>
```

```
type      = histogram  
thickness = 1p  
color     = black  
#color    = white  
min      = 0  
max      = 1  
r0       = 0.85r  
r1       = 0.975r  
  
<plot>  
file      = ../data/both.cons.2e6.max.txt  
fill_color = spectral-5-div-3 # yellow  
</plot>  
  
<plot>  
show     = no  
file      = ../data/both.cons.2e6.avg.txt  
fill_color = spectral-5-div-4 # green  
thickness = 2p  
</plot>  
  
<plot>  
show     = no  
file      = ../data/both.cons.2e6.min.txt  
fill_color = spectral-5-div-5 # blue  
#fill_color = white  
</plot>  
  
</plots>
```

HISTOGRAMS



```
# 2/2/etc/circos.conf
```

```
<plots>
```

```
type      = histogram  
thickness = 1p  
color     = black  
#color    = white  
min      = 0  
max      = 1  
r0       = 0.85r  
r1       = 0.975r
```

```
<plot>
```

```
file      = ../data/both.cons.2e6.max.txt  
fill_color = spectral-5-div-3 # yellow  
</plot>
```

```
<plot>
```

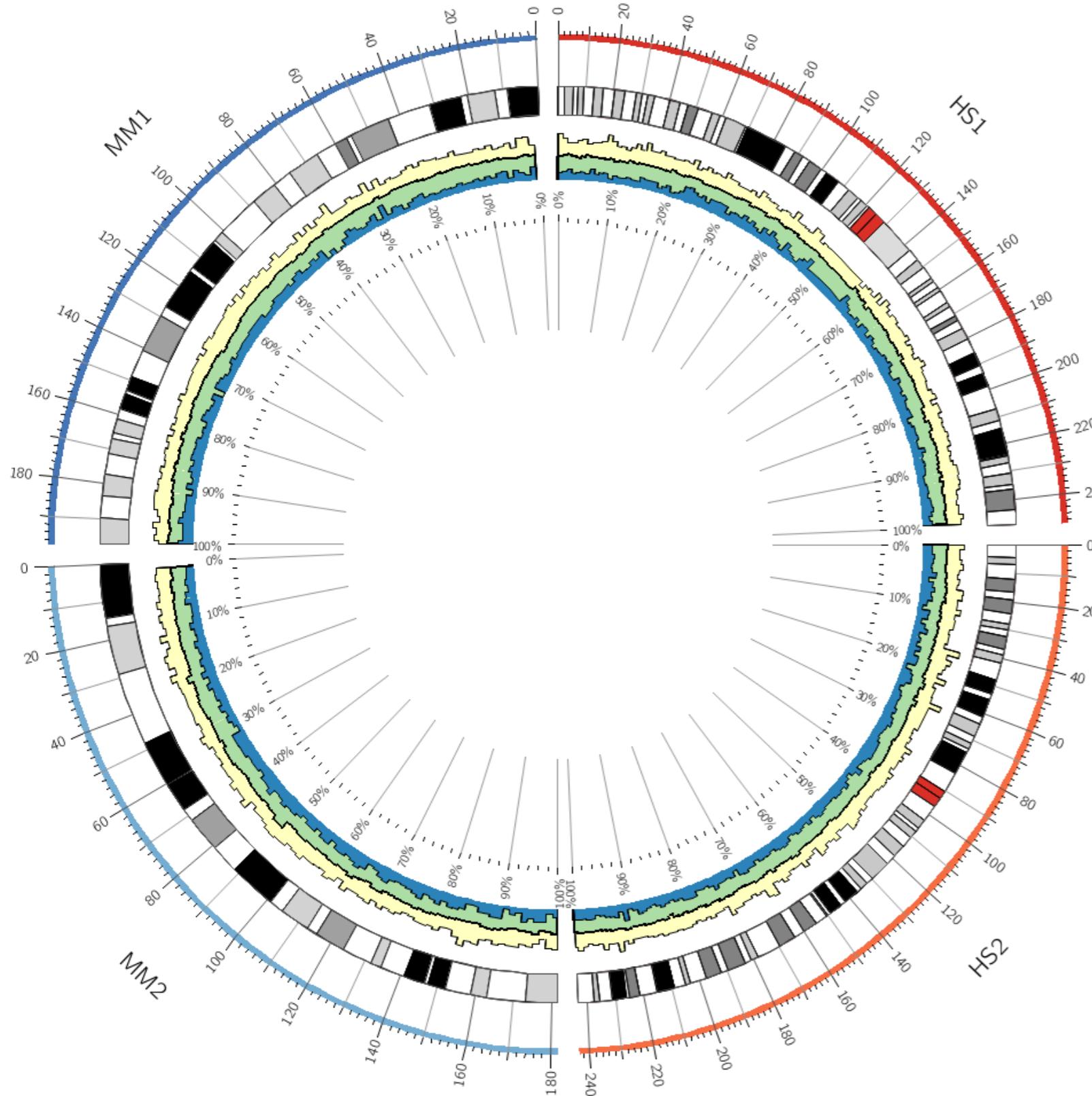
```
show     = yes  
file      = ../data/both.cons.2e6.avg.txt  
fill_color = spectral-5-div-4 # green  
thickness = 2p  
</plot>
```

```
<plot>
```

```
show     = no  
file      = ../data/both.cons.2e6.min.txt  
fill_color = spectral-5-div-5 # blue  
#fill_color = white  
</plot>
```

```
</plots>
```

HISTOGRAMS



```
# 2/2/etc/circos.conf
```

```
<plots>
```

```
type      = histogram  
thickness = 1p  
color     = black  
#color    = white  
min      = 0  
max      = 1  
r0       = 0.85r  
r1       = 0.975r
```

```
<plot>
```

```
file      = ../data/both.cons.2e6.max.txt  
fill_color = spectral-5-div-3 # yellow  
</plot>
```

```
<plot>
```

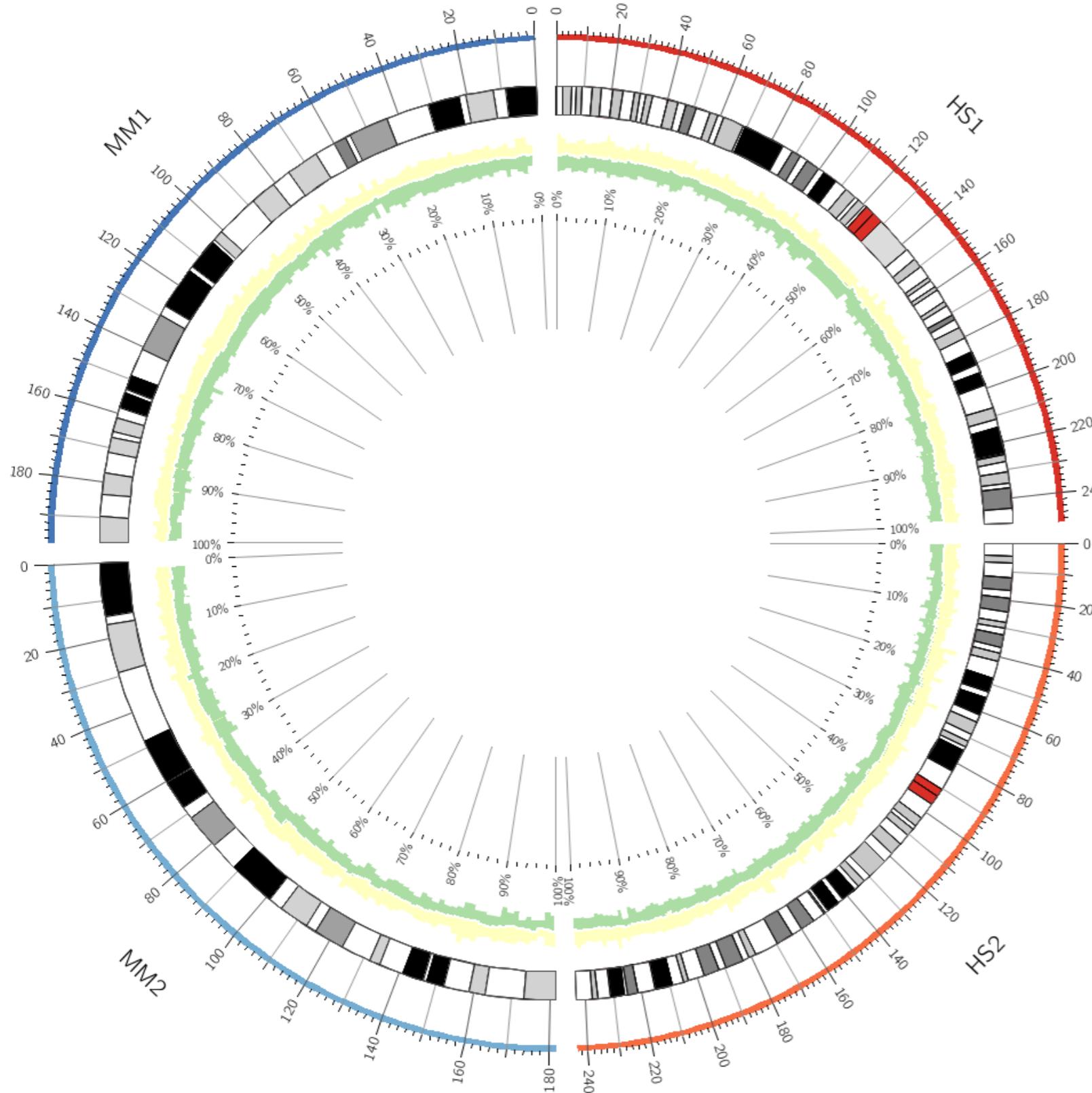
```
show     = yes  
file      = ../data/both.cons.2e6.avg.txt  
fill_color = spectral-5-div-4 # green  
thickness = 2p  
</plot>
```

```
<plot>
```

```
show     = yes  
file      = ../data/both.cons.2e6.min.txt  
fill_color = spectral-5-div-5 # blue  
#fill_color = white  
</plot>
```

```
</plots>
```

HISTOGRAMS



```
# 2/2/etc/circos.conf
```

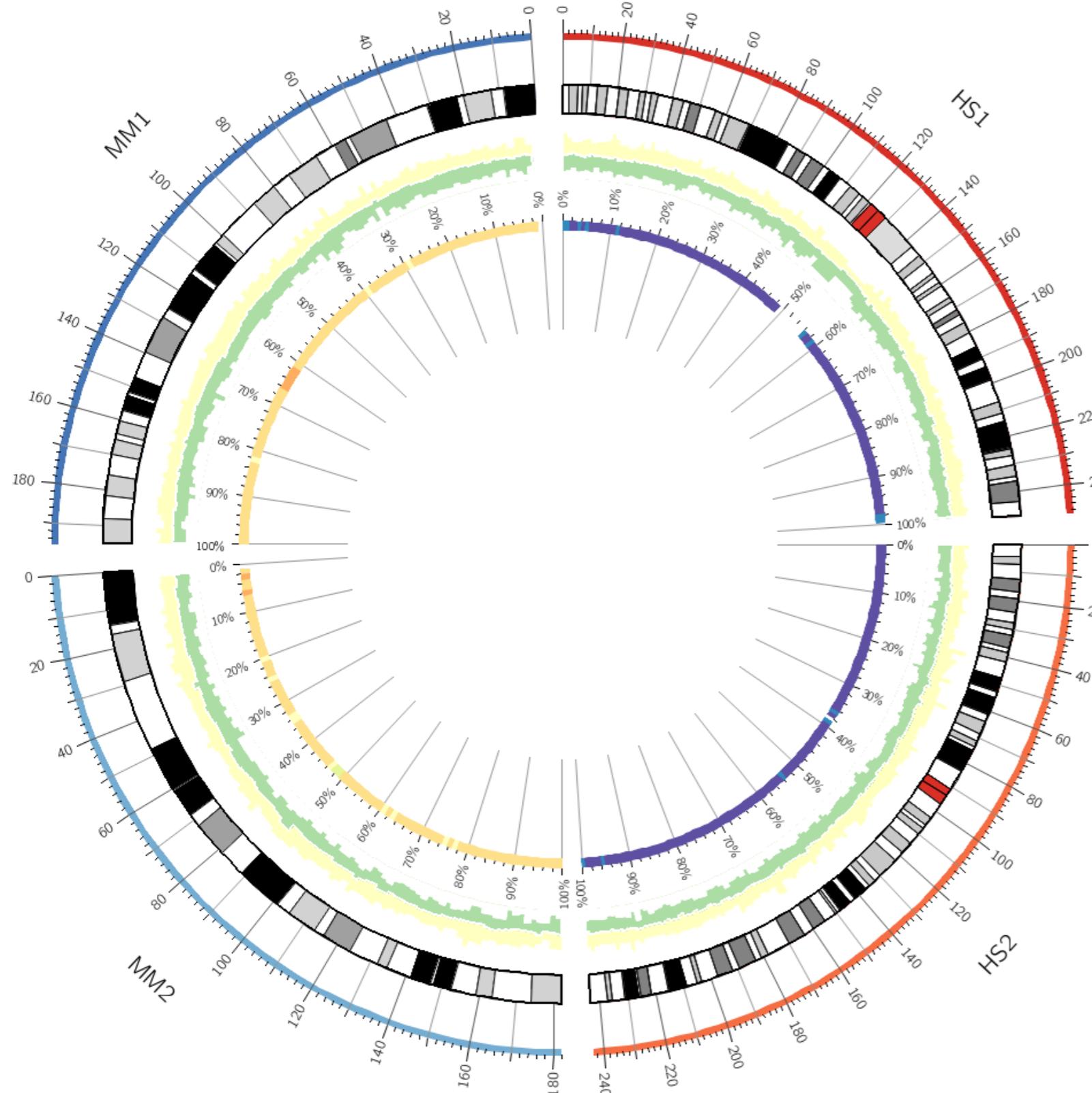
```
<plots>
```

```
type      = histogram  
thickness = 1p  
#color   = black  
color    = white  
min      = 0  
max      = 1  
r0       = 0.85r  
r1       = 0.975r  
  
<plot>  
file     = ../data/both.cons.2e6.max.txt  
fill_color = spectral-5-div-3 # yellow  
</plot>  
  
<plot>  
show    = yes  
file    = ../data/both.cons.2e6.avg.txt  
fill_color = spectral-5-div-4 # green  
thickness = 2p  
</plot>  
  
<plot>  
show    = yes  
file    = ../data/both.cons.2e6.min.txt  
#fill_color = spectral-5-div-5 # blue  
fill_color = white  
</plot>  
  
</plots>
```

heatmaps

LESSON 3

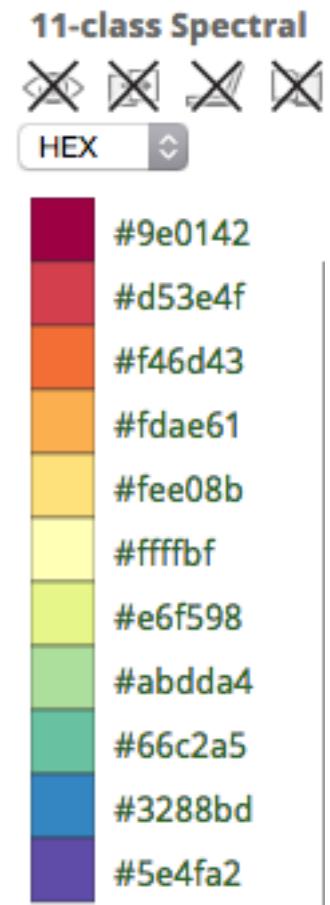
HEATMAPS



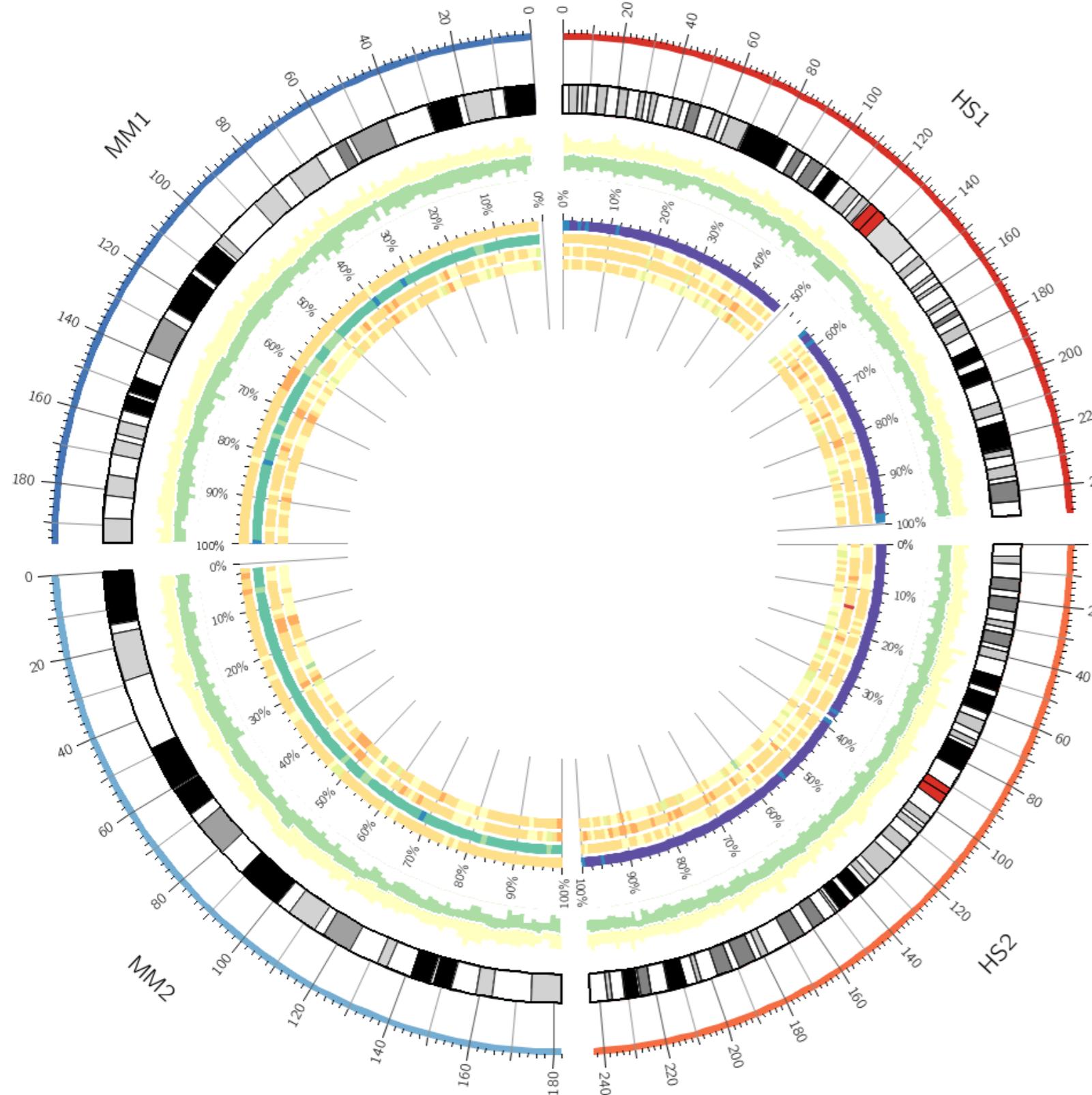
```
# 2/3/etc/circos.conf
```

```
# heatmaps map a range of values onto
# a list of colors
```

```
<plot>
type = heatmap
file = ../data/both.cons.2e6.rhe.avg.txt
min = 0.1
max = 0.9
r0 = 0.73r
r1 = 0.75r
color = spectral-11-div
#color = spectral-11-div-rev
#scale_log_base = 0.500
</plot>
```



HEATMAPS



```
# 2/3/etc/circos.conf
```

```
<plot>
```

```
type = heatmap  
file = ../../data/both.cons.2e6.rn.avg.txt  
min = 0.1  
max = 0.9  
r0 = 0.70r  
r1 = 0.72r  
color = spectral-11-div  
</plot>
```

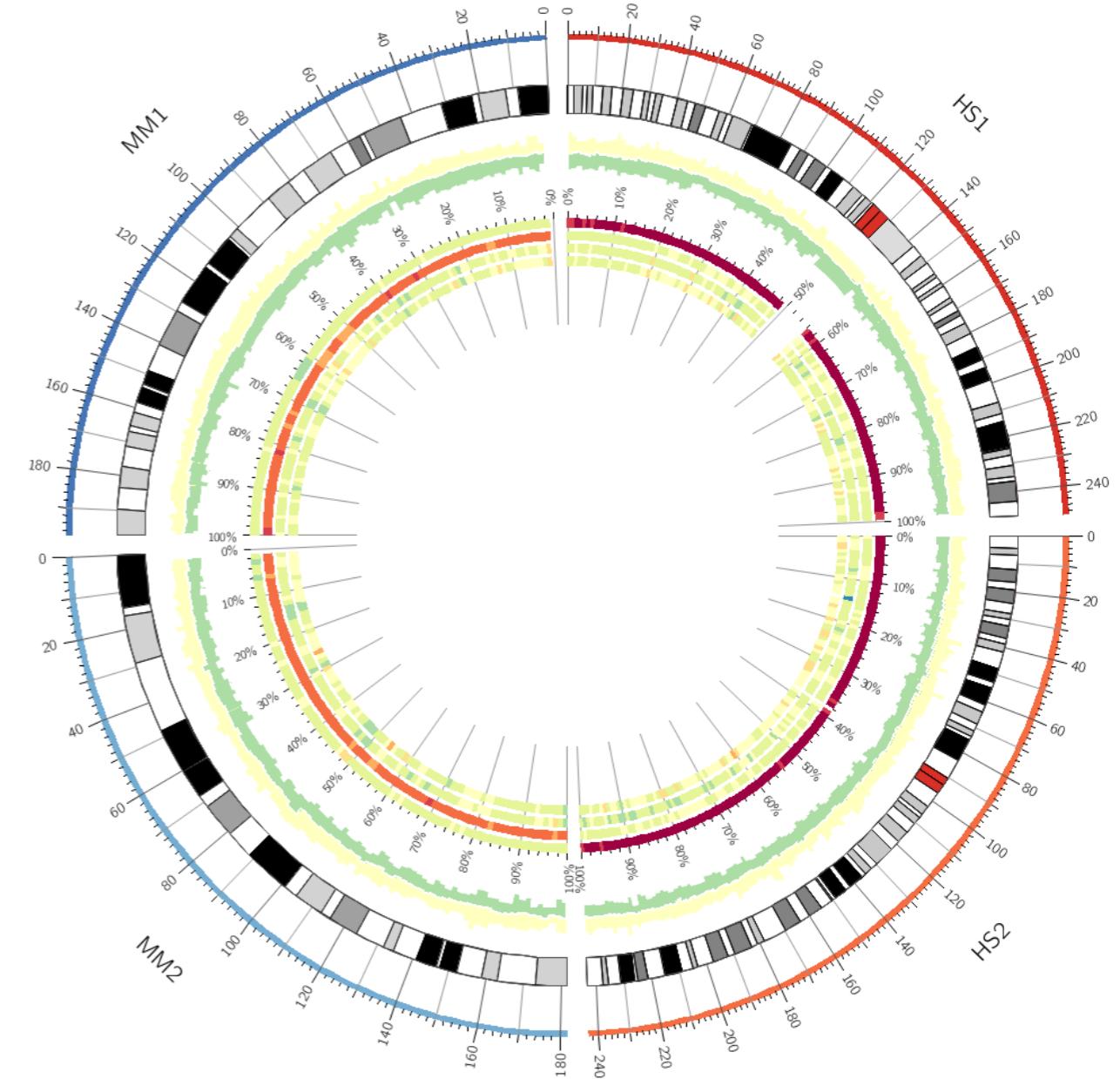
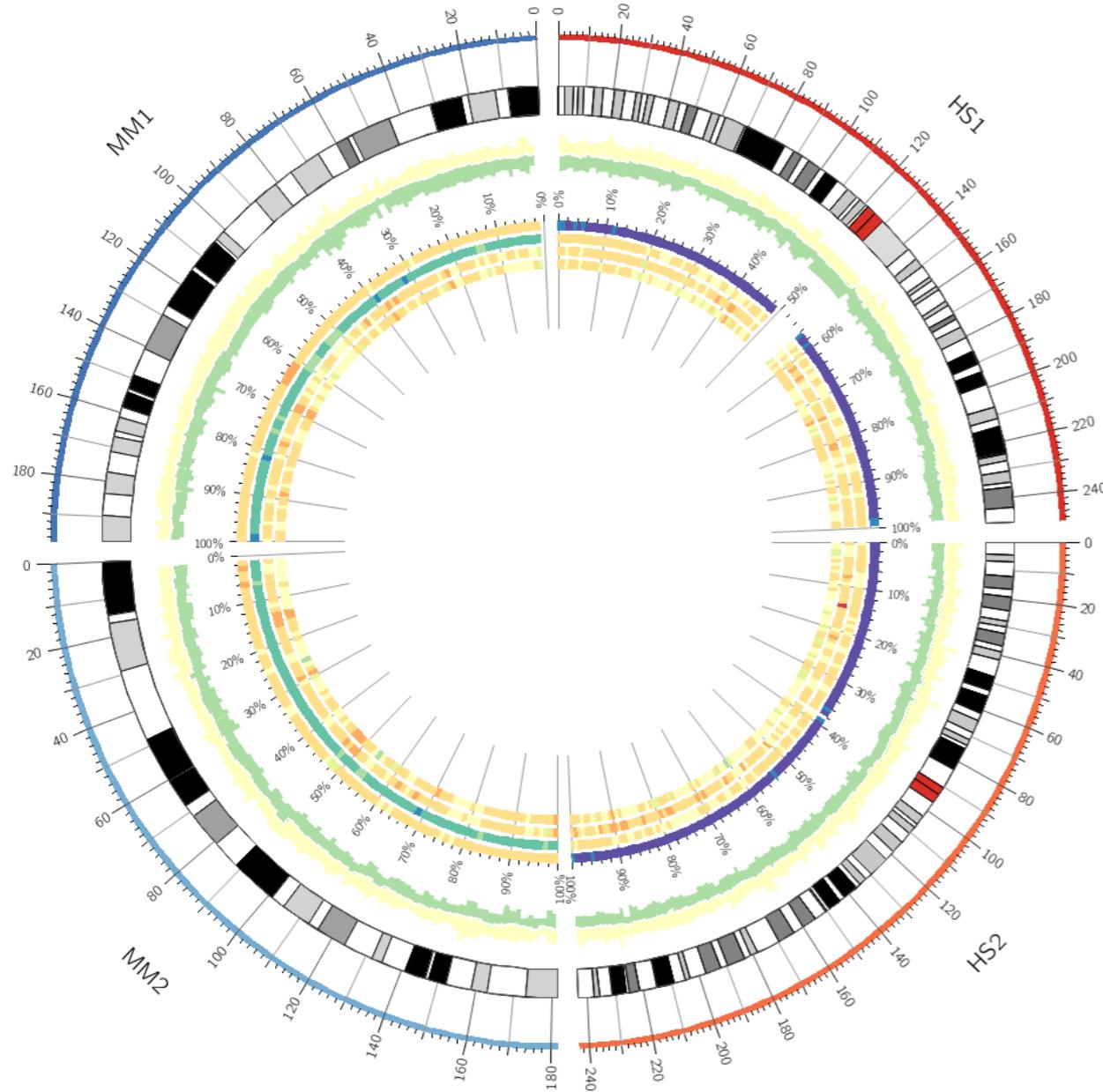
```
<plot>
```

```
type = heatmap  
file = ../../data/both.cons.2e6.danrer.avg.txt  
min = 0.1  
max = 0.9  
r0 = 0.67r  
r1 = 0.69r  
color = spectral-11-div  
</plot>
```

```
<plot>
```

```
type = heatmap  
file = ../../data/both.cons.2e6.fr.avg.txt  
min = 0.1  
max = 0.9  
r0 = 0.64r  
r1 = 0.66r  
color = spectral-11-div  
</plot>
```

REVERSE COLOR LISTS

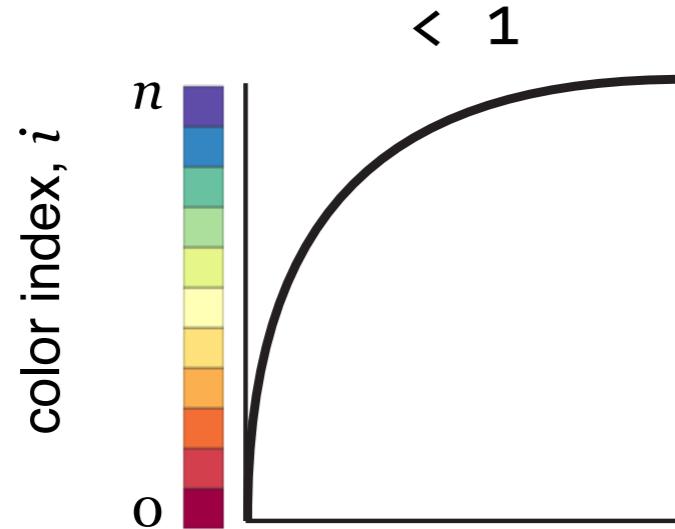


```
<plot>
...
color = spectral-11-div
...
</plot>
```

```
# each color list has a corresponding reverse version
# suffixed with -rev
```

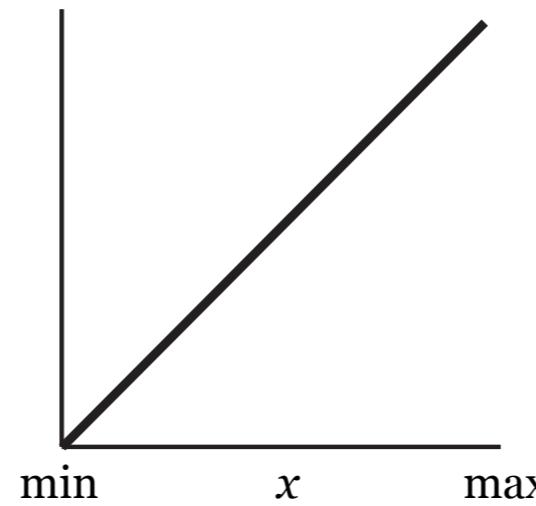
```
<plot>
...
color = spectral-11-div-rev
...
</plot>
```

LOG COLOR MAPPING

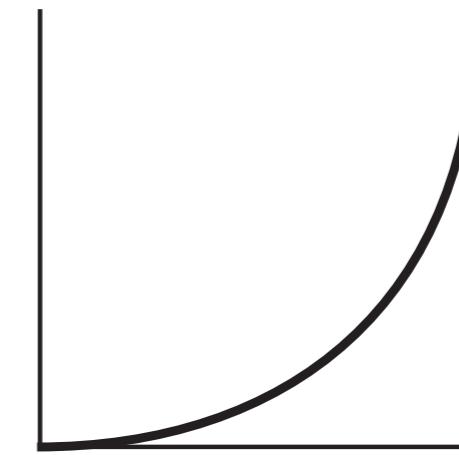


scale_log_base

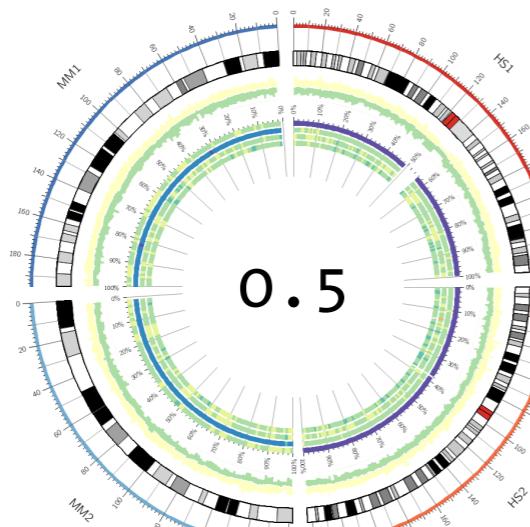
1



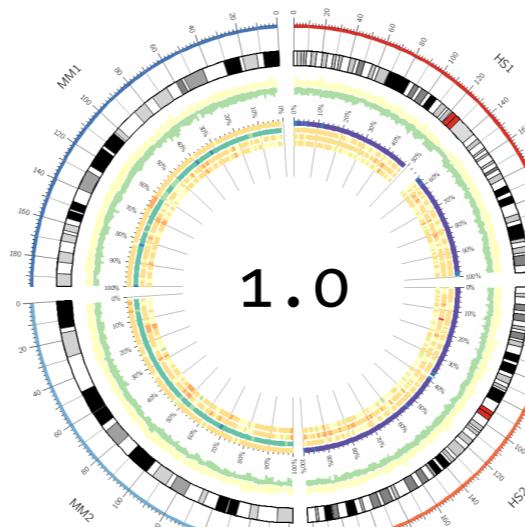
>1



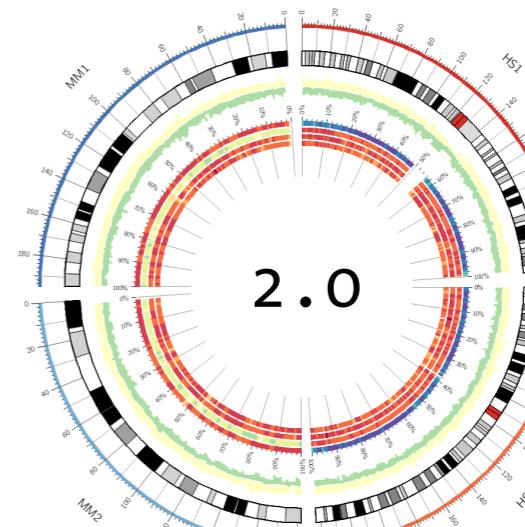
$$i = n \cdot \frac{x - \text{min}}{\text{max} - \text{min}}^{\frac{1}{\text{scale_log_base}}}$$



greater dynamic range
of color for smaller values

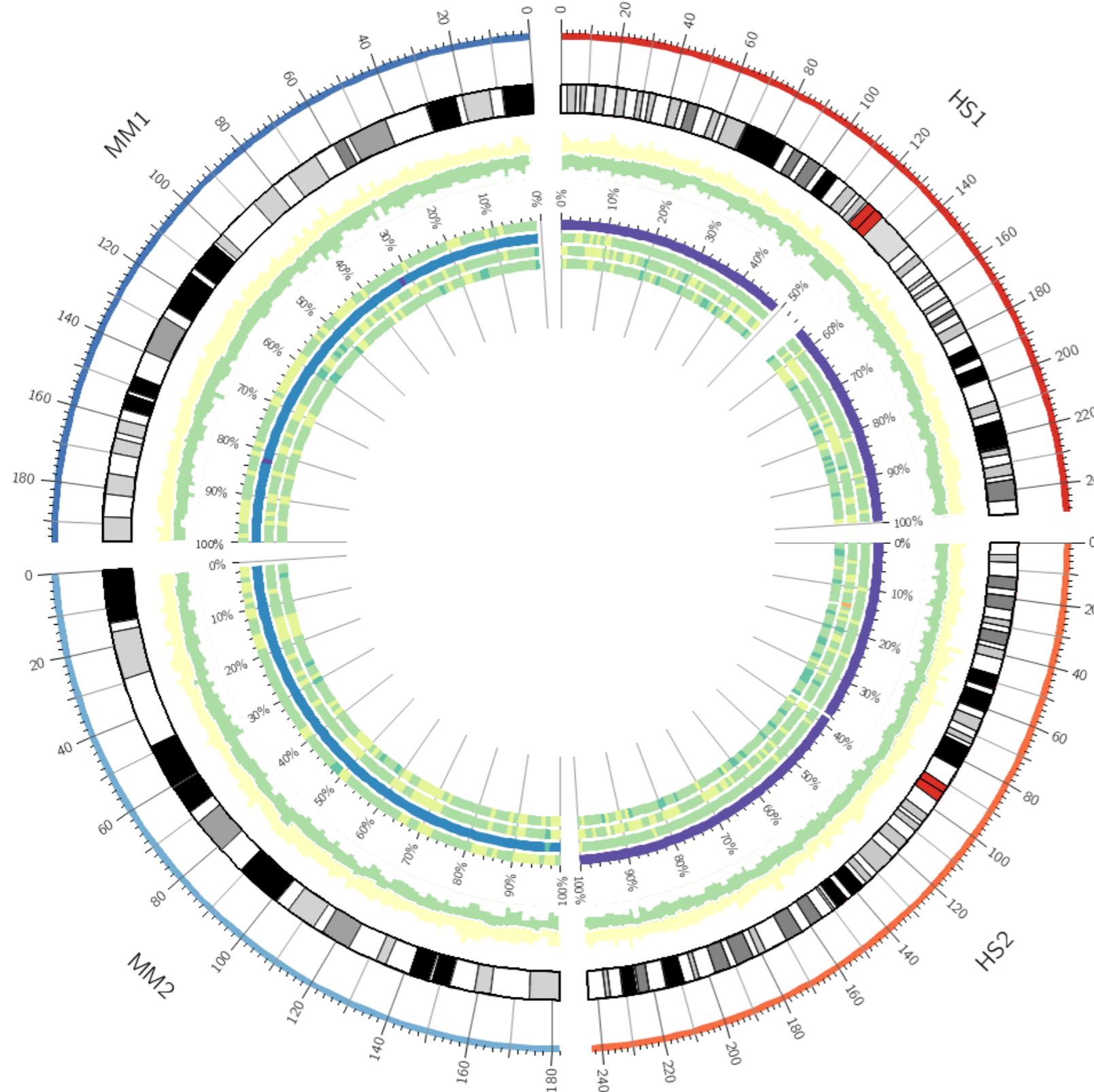


colors uniformly distributed
across range of values



greater dynamic range
of color for larger values

LOG COLOR MAPPING



```
# 2/3/etc/circos.conf
```

```
<plot>
```

```
...
```

```
scale_log_base = 0.5
```

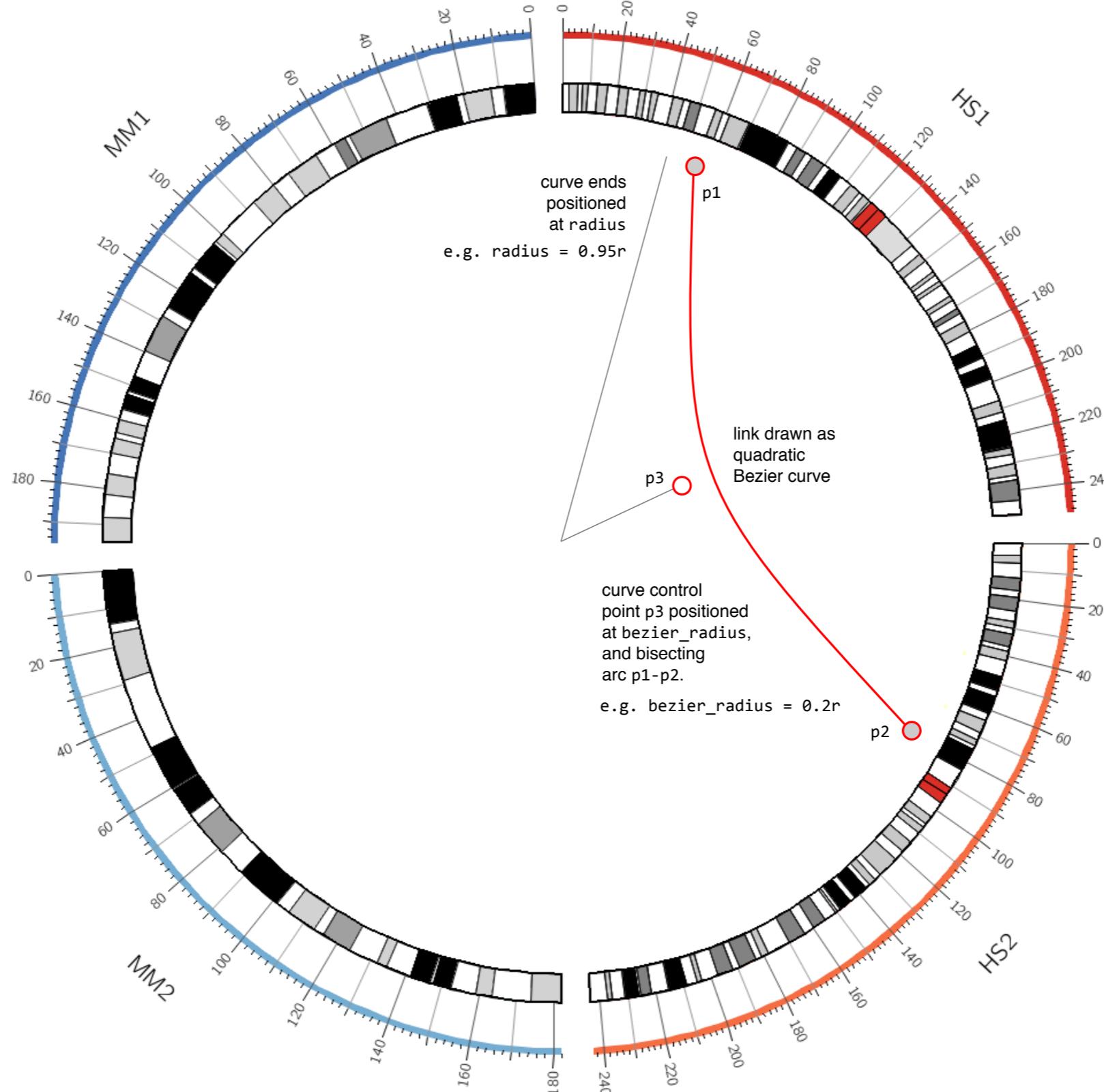
```
...
```

```
</plot>
```

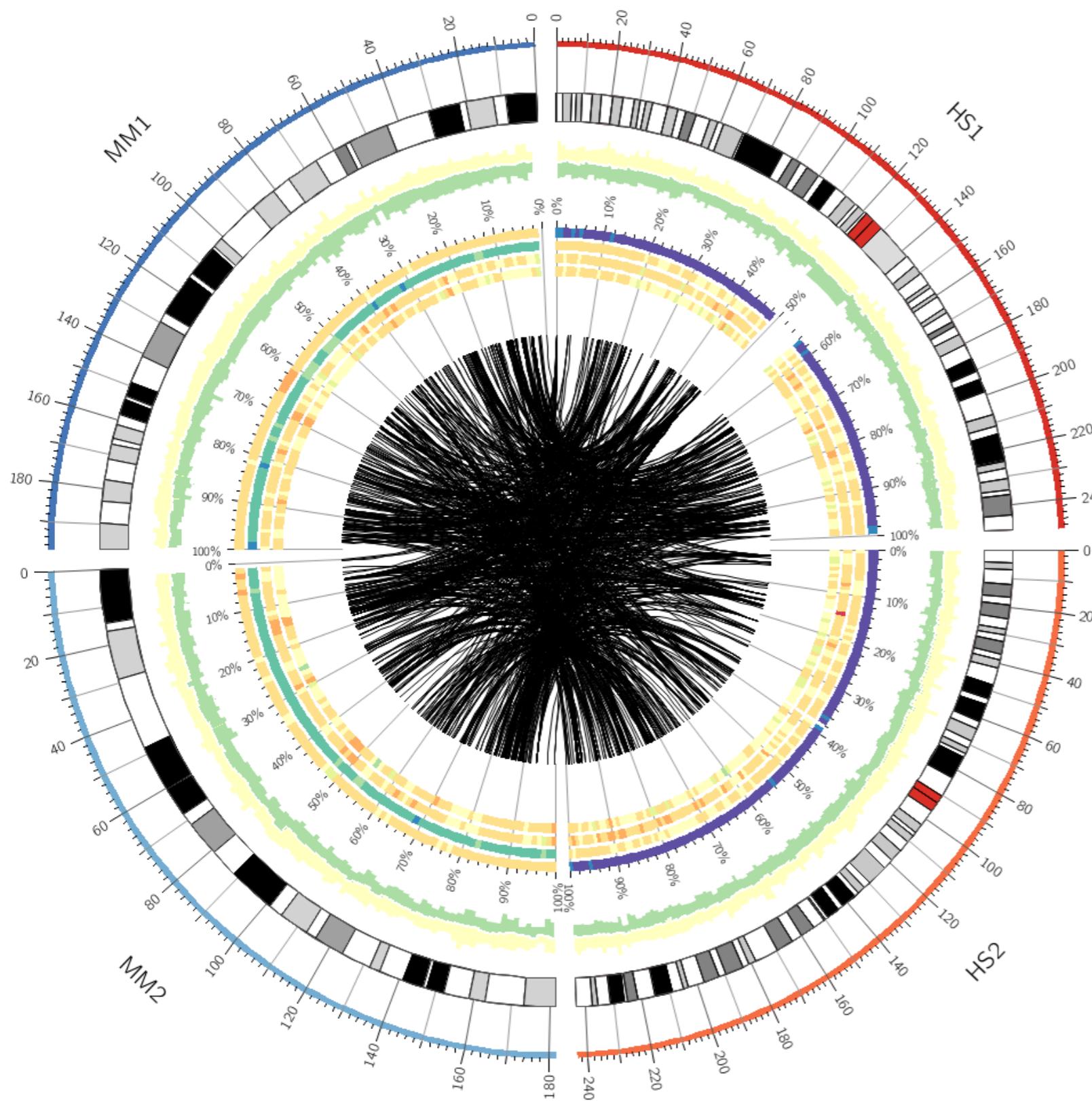
links

LESSON 4

LINK GEOMETRY



LINKS



```
# 2/4/etc/circos.conf
```

```
<links>
```

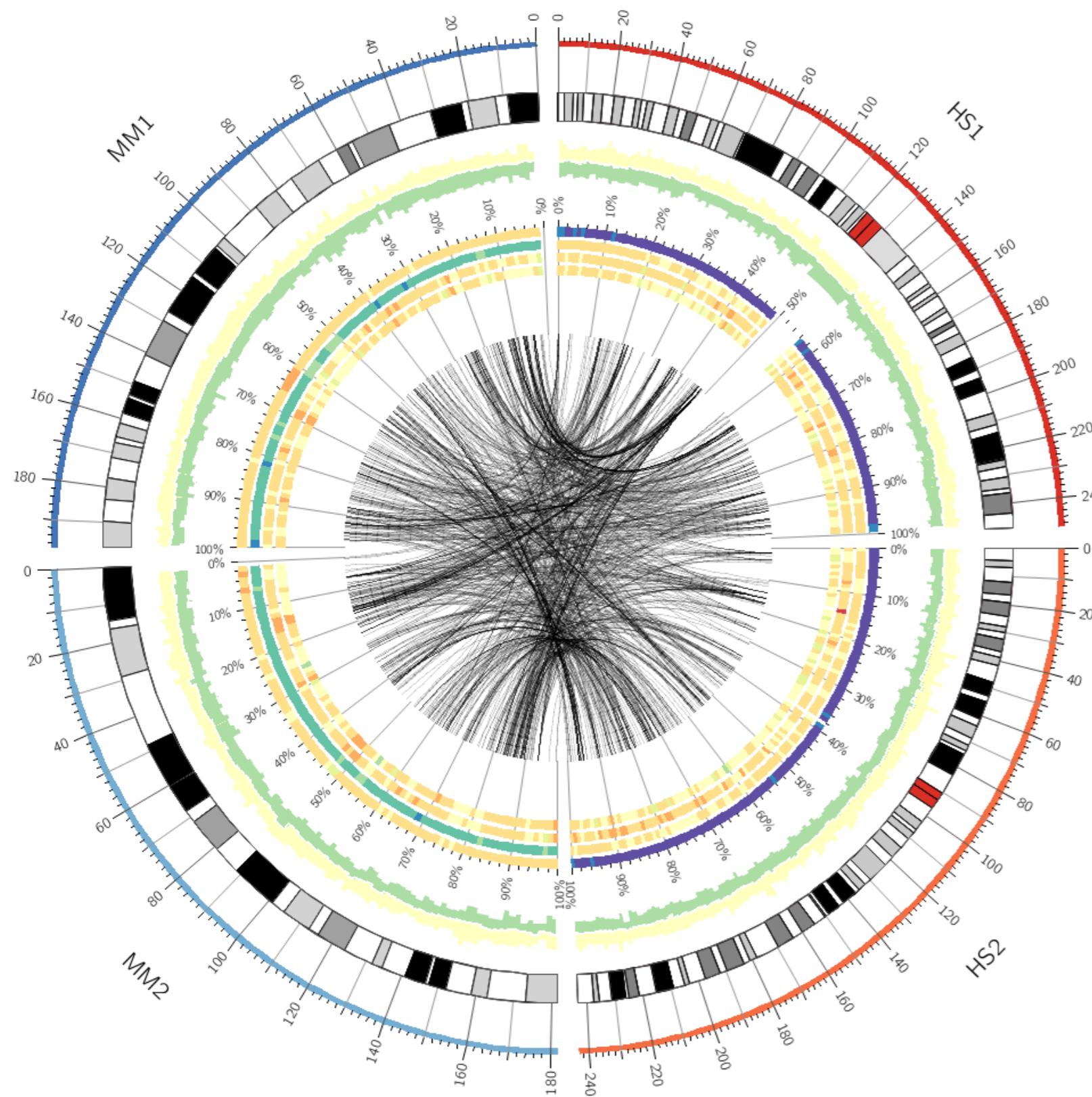
```
<link>
```

```
file          = ../../data/links.txt  
bezier_radius = 0r  
radius        = 0.5r  
thickness     = 1p  
color         = black  
#color        = black_a5
```

```
</link>
```

```
</links>
```

LINKS



```
# 2/4/etc/circos.conf
```

```
<links>
```

```
<link>
```

file	= ./data/links.txt
bezier_radius	= 0r
radius	= 0.5r
thickness	= 1p
#color	= black
color	= black_a5

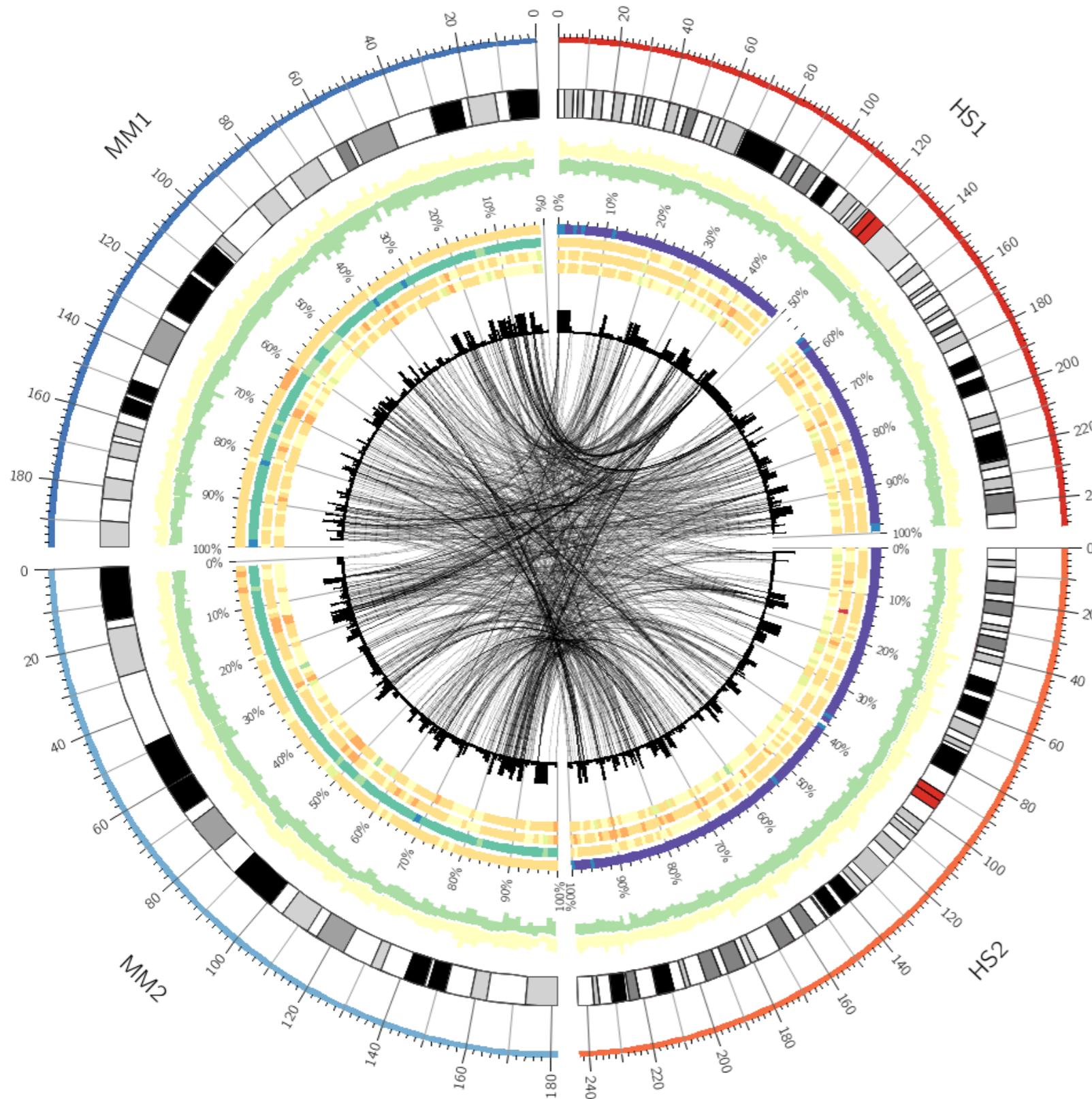
```
</link>
```

```
</links>
```

density histograms & axis grids

LESSON 5

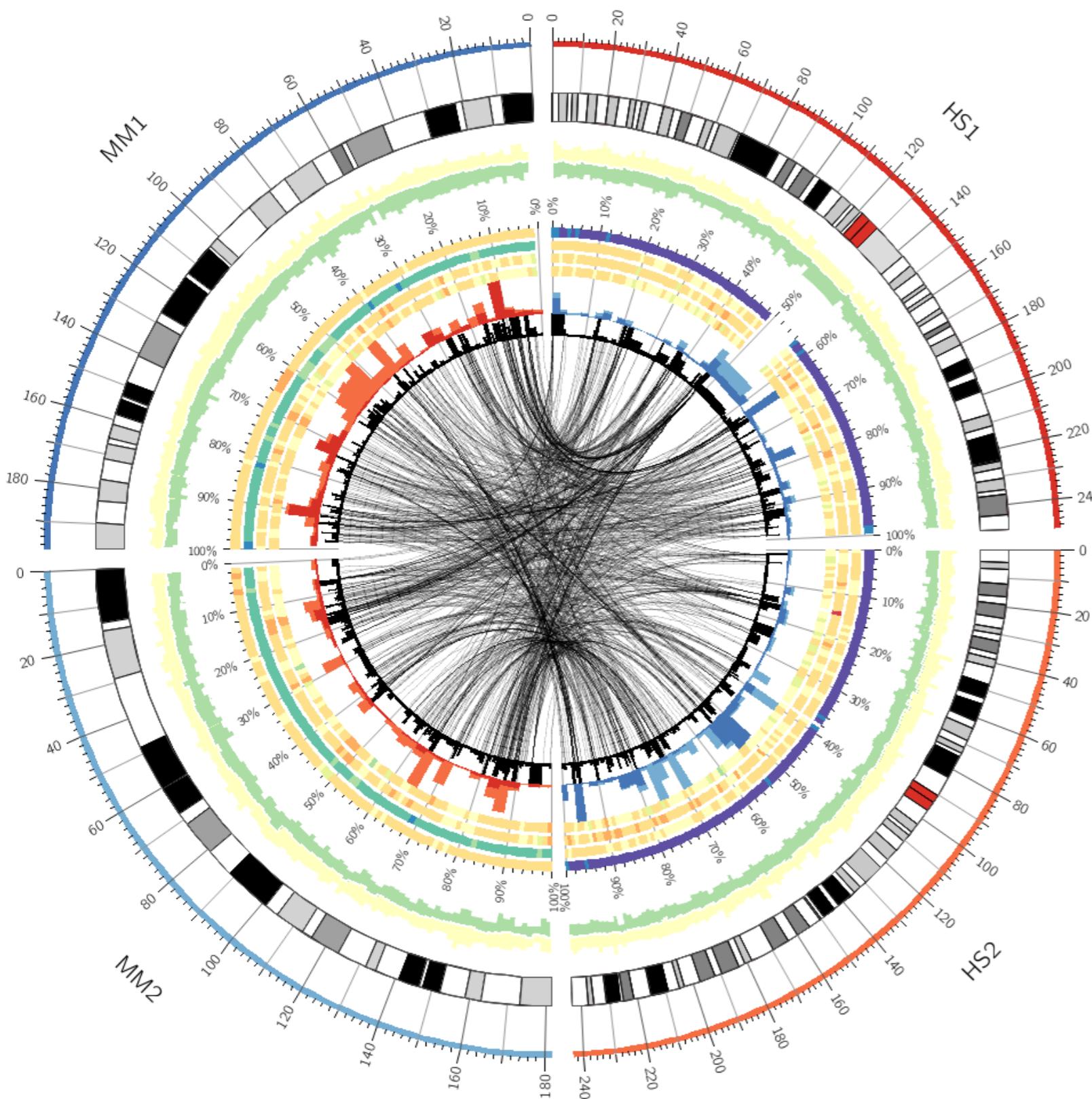
DENSITY HISTOGRAMS



2/5/etc/circos.conf

```
<plot>
type = histogram
file = ../data/links.density.txt
min = 0
max = 10
r0 = 0.5r
r1 = 0.55r
thickness = 0
fill_color = black
</plot>
```

DENSITY HISTOGRAMS

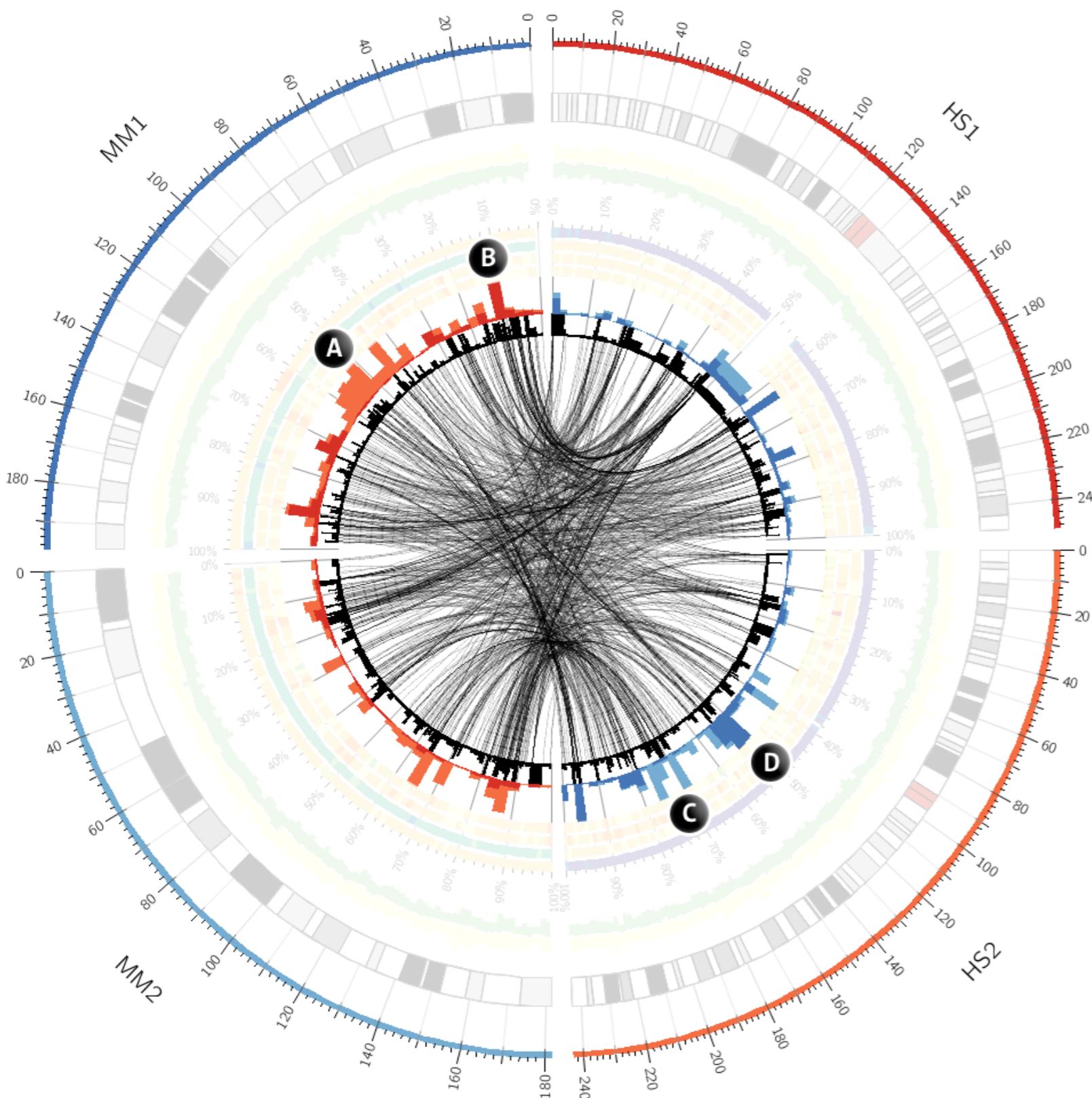


```
# 2/5/etc/circos.conf
```

```
<plot>
type = histogram
file = ../data/links.density.txt
min = 0
max = 10
r0 = 0.5r
r1 = 0.55r
thickness = 0
fill_color = black
</plot>
```

```
<plot>
show = yes
type = histogram
file = ../data/links.density.stacked.txt
min = 0
max = 300000
r0 = 0.55r
r1 = 0.65r
thickness = 0
fill_color = rdylbu-11-div-10,
rdylbu-11-div-2,
rdylbu-11-div-3,
rdylbu-11-div-9
</plot>
```

DENSITY HISTOGRAMS



Histogram bars are colored by color of ideogram corresponding to the link's other end. (A) most links from hs2 (B) most links from hs1 (C) most links from mm2 (D) most links from mm1

```
# 2/5/etc/circos.conf
```

```
<plot>
type = histogram
file = ../data/links.density.txt
min = 0
max = 10
r0 = 0.5r
r1 = 0.55r
thickness = 0
fill_color = black
</plot>

<plot>
show = yes
type = histogram
file = ../data/links.density.stacked.txt
min = 0
max = 300000
r0 = 0.55r
r1 = 0.65r
thickness = 0
fill_color = rdylbu-11-div-10,
rdylbu-11-div-2,
rdylbu-11-div-3,
rdylbu-11-div-9
</plot>
```

STACKED HISTOGRAM DATA FORMAT

```
# 2/data/links.density.txt
```

```
# - normal histogram
```

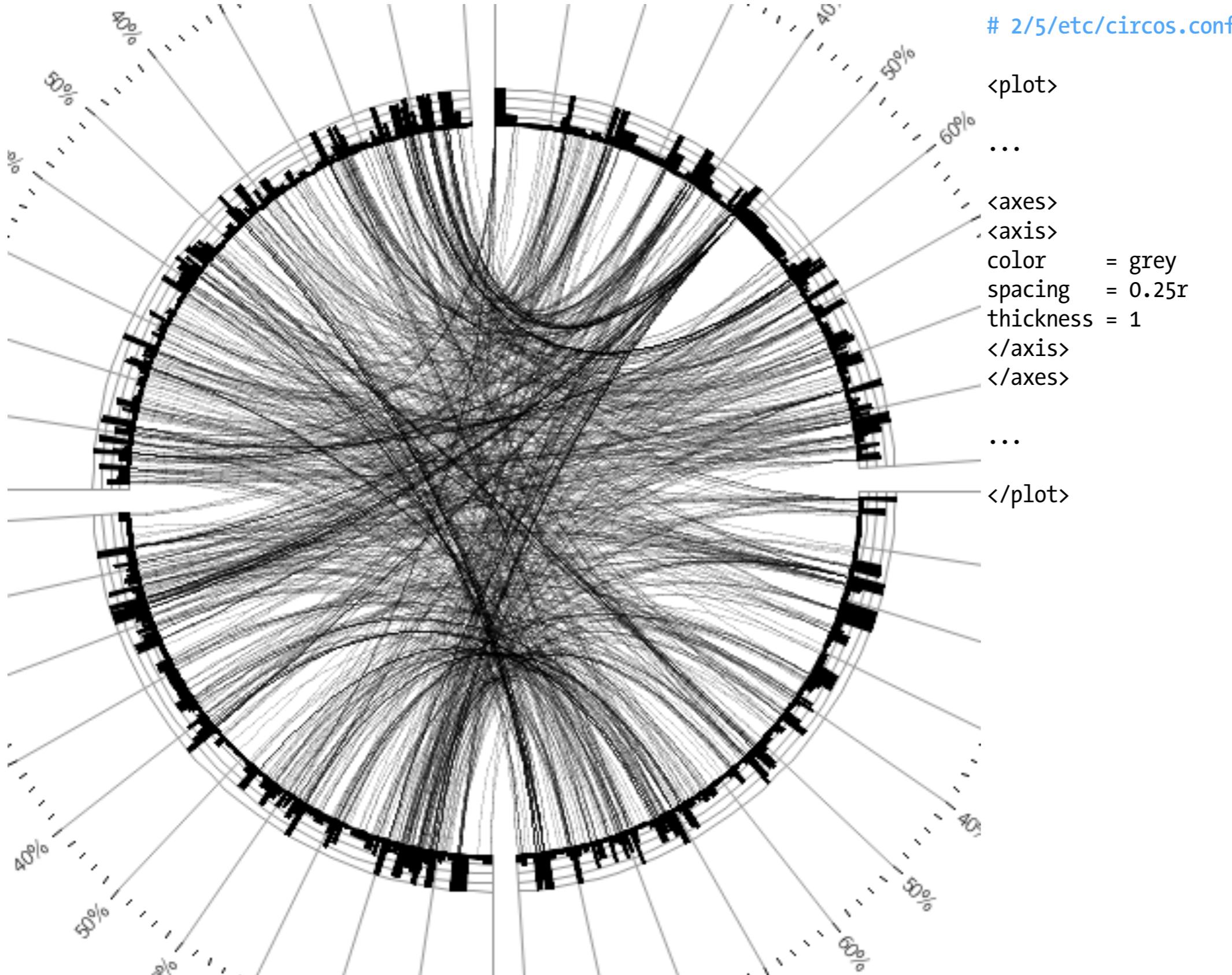
```
hs2 3000000 3999999 15.0000
hs2 4000000 4999999 1.0000
hs2 6000000 6999999 1.0000
hs2 9000000 9999999 7.0000
hs2 10000000 10999999 1.0000
hs2 11000000 11999999 1.0000
hs2 25000000 25999999 1.0000
```

```
# 2/data/links.density.stacked.txt
```

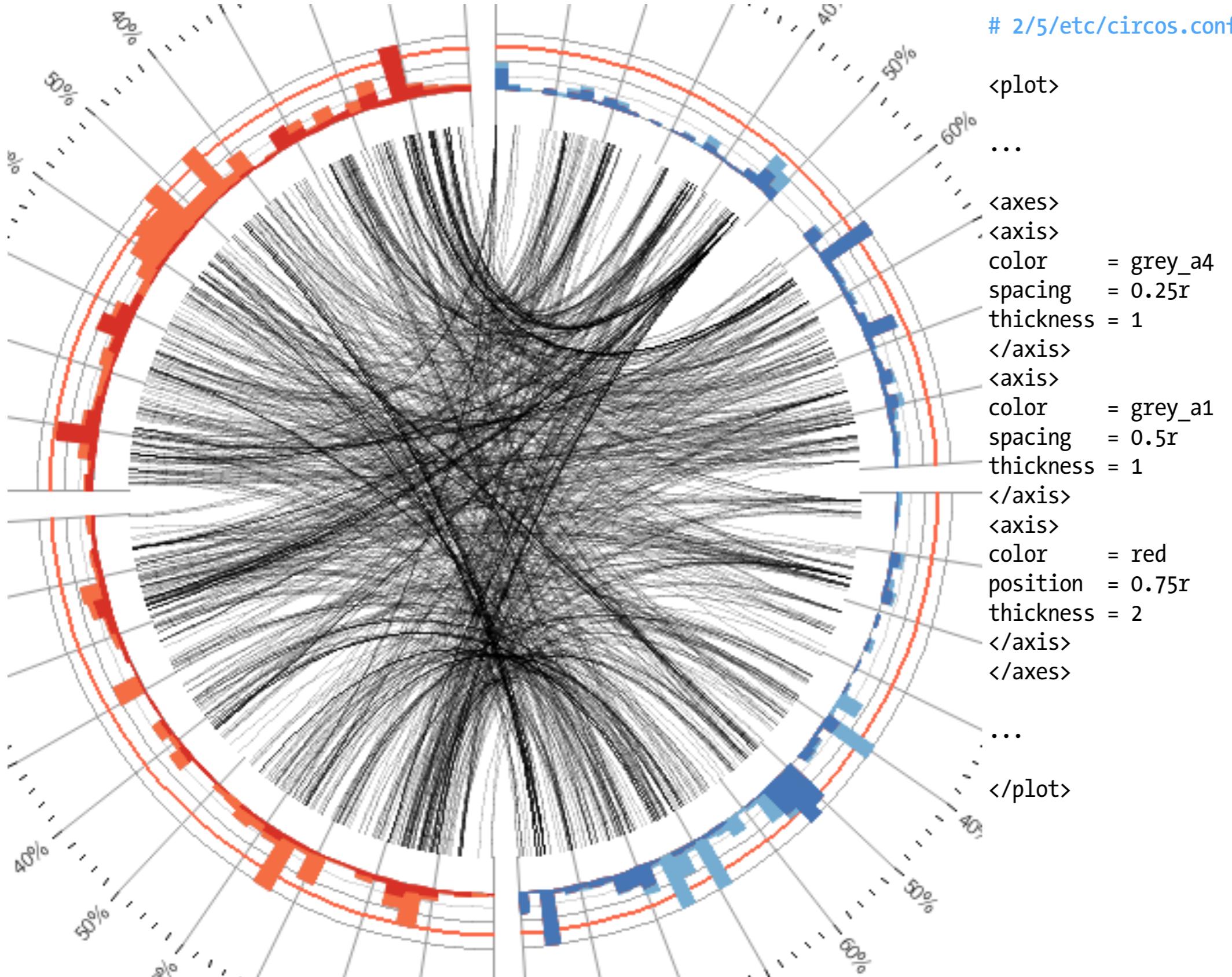
```
# - stacked histogram
```

```
hs2 0 4999999 7755.0000,0.0000,0.0000,15461.0000
hs2 5000000 9999999 7877.0000,0.0000,0.0000,9648.0000
hs2 10000000 14999999 4877.0000,0.0000,0.0000,1319.0000
hs2 25000000 29999999 40722.0000,0.0000,0.0000,20747.0000
hs2 30000000 34999999 7664.0000,0.0000,0.0000,2691.0000
hs2 35000000 39999999 11408.0000,0.0000,0.0000,23640.0000
hs2 40000000 44999999 42742.0000,0.0000,0.0000,16721.0000
hs2 50000000 54999999 7745.0000,0.0000,0.0000,7684.0000
hs2 60000000 64999999 7016.0000,0.0000,0.0000,23395.0000
hs2 70000000 74999999 2685.0000,0.0000,0.0000,5510.0000
hs2 80000000 84999999 950.0000,0.0000,0.0000,12583.0000
hs2 85000000 89999999 0.0000,0.0000,0.0000,123674.0000
hs2 90000000 94999999 0.0000,0.0000,0.0000,8511.0000
```

DENSITY HISTOGRAMS



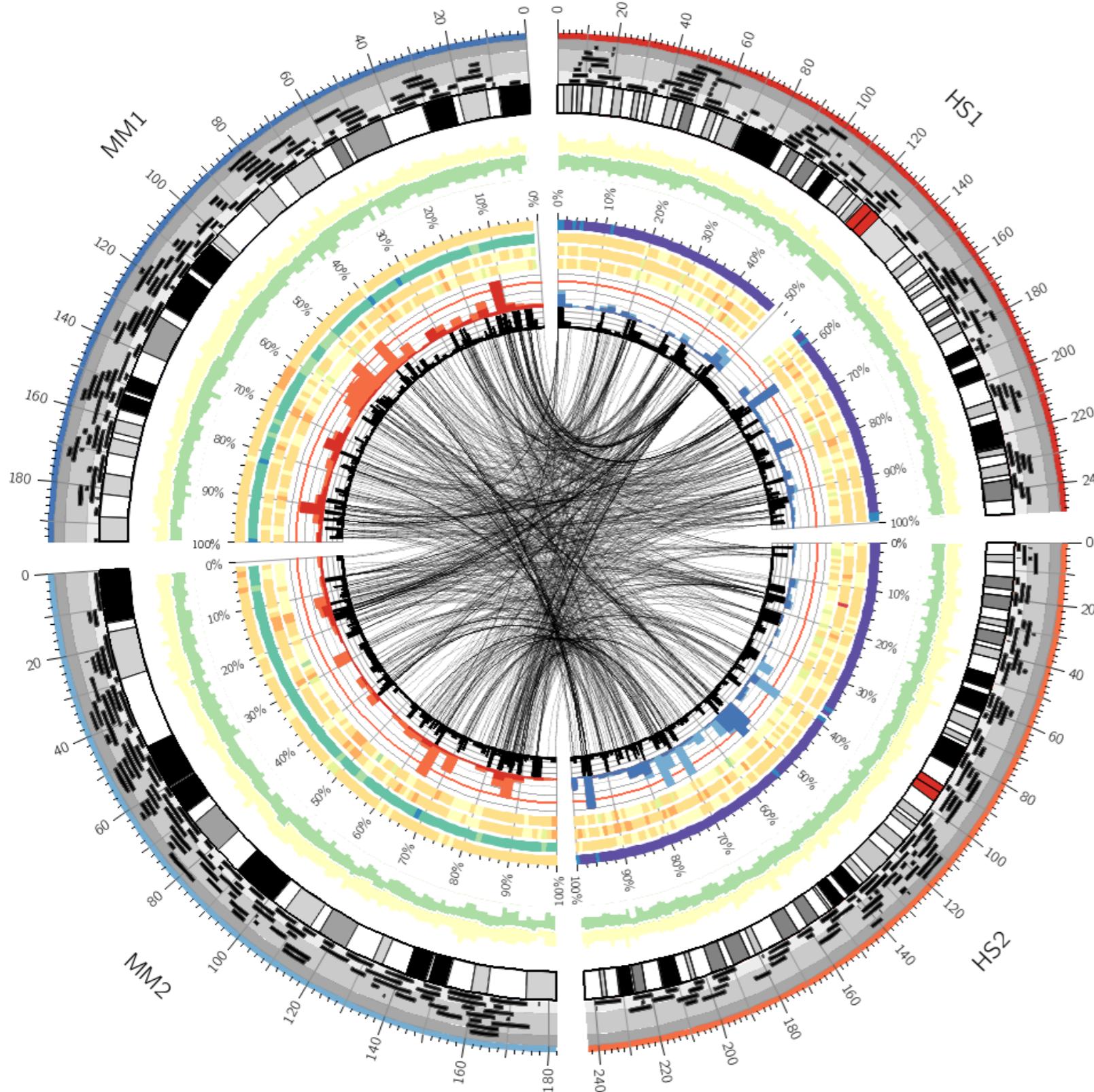
DENSITY HISTOGRAMS



tiles, backgrounds & dynamic rules

LESSON 6

TILES



```
# 2/6/etc/circos.conf
```

```
<plot>
```

```
type      = tile  
file     = ../data/tiles.txt  
r0       = 1r+2p  
r1       = 1r+40p
```

```
layers          = 7  
layers_overflow = hide  
layers_overflow_color = red
```

```
margin        = 1u
```

```
thickness    = 3
```

```
padding      = 2
```

```
orientation = out
```

```
color        = black
```

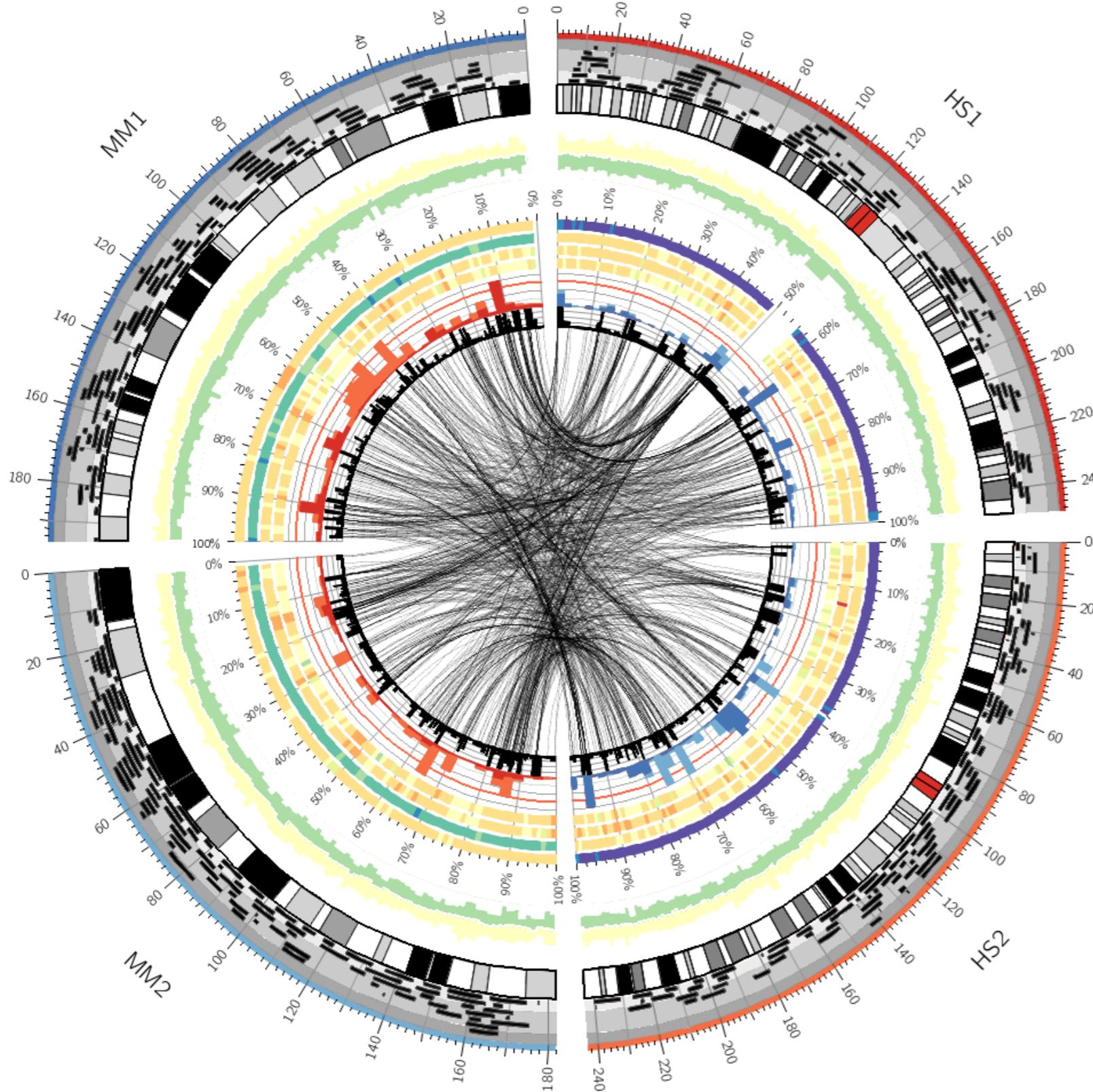
```
stroke_thickness = 1
```

```
stroke_color   = vdgrey
```

```
...
```

```
</plot>
```

TILES



```
# 2/6/etc/circos.conf
```

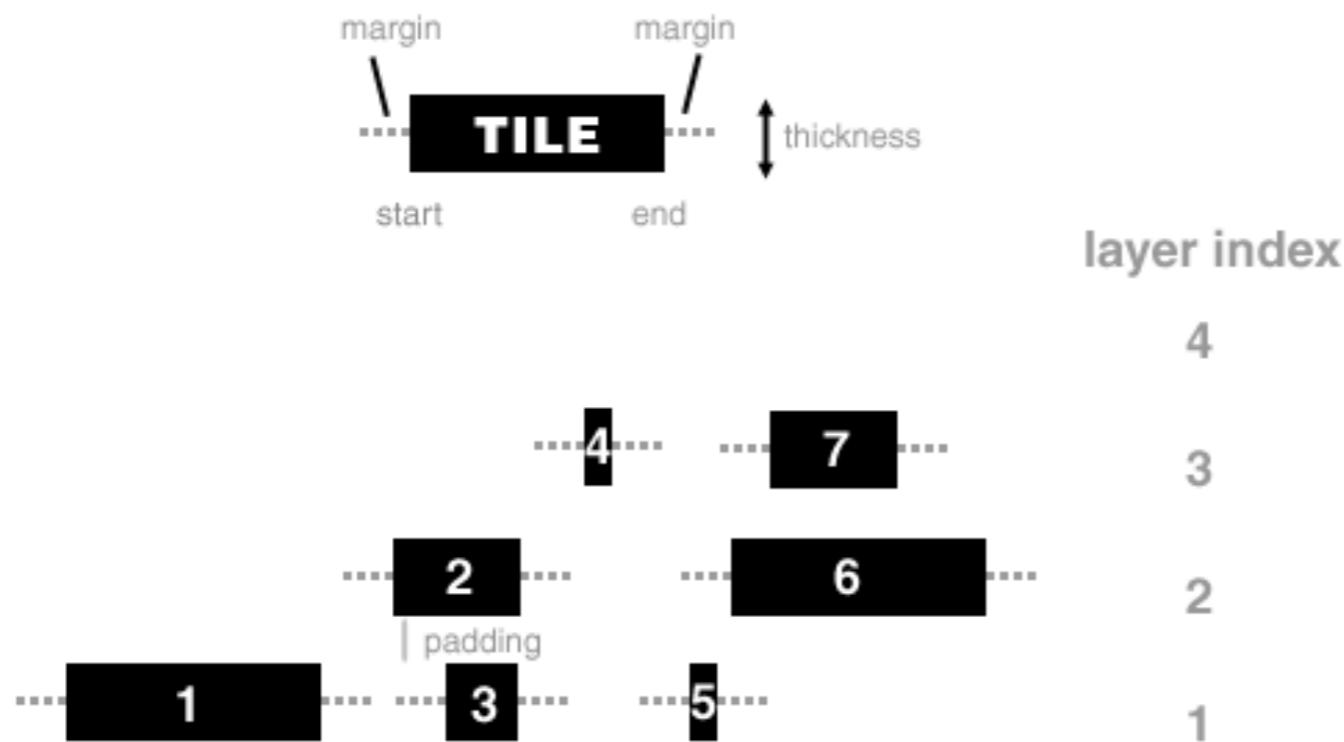
```
<plot>
```

```
...
```

```
<backgrounds>
<background>
y0      = 0.75r
color   = grey_a1
</background>
<background>
y0      = 0.25r
y1      = 0.75r
color   = grey_a3
</background>
<background>
y1      = 0.25r
color   = grey_a5
</background>
</backgrounds>
```

```
</plot>
```

TILE GEOMETRY

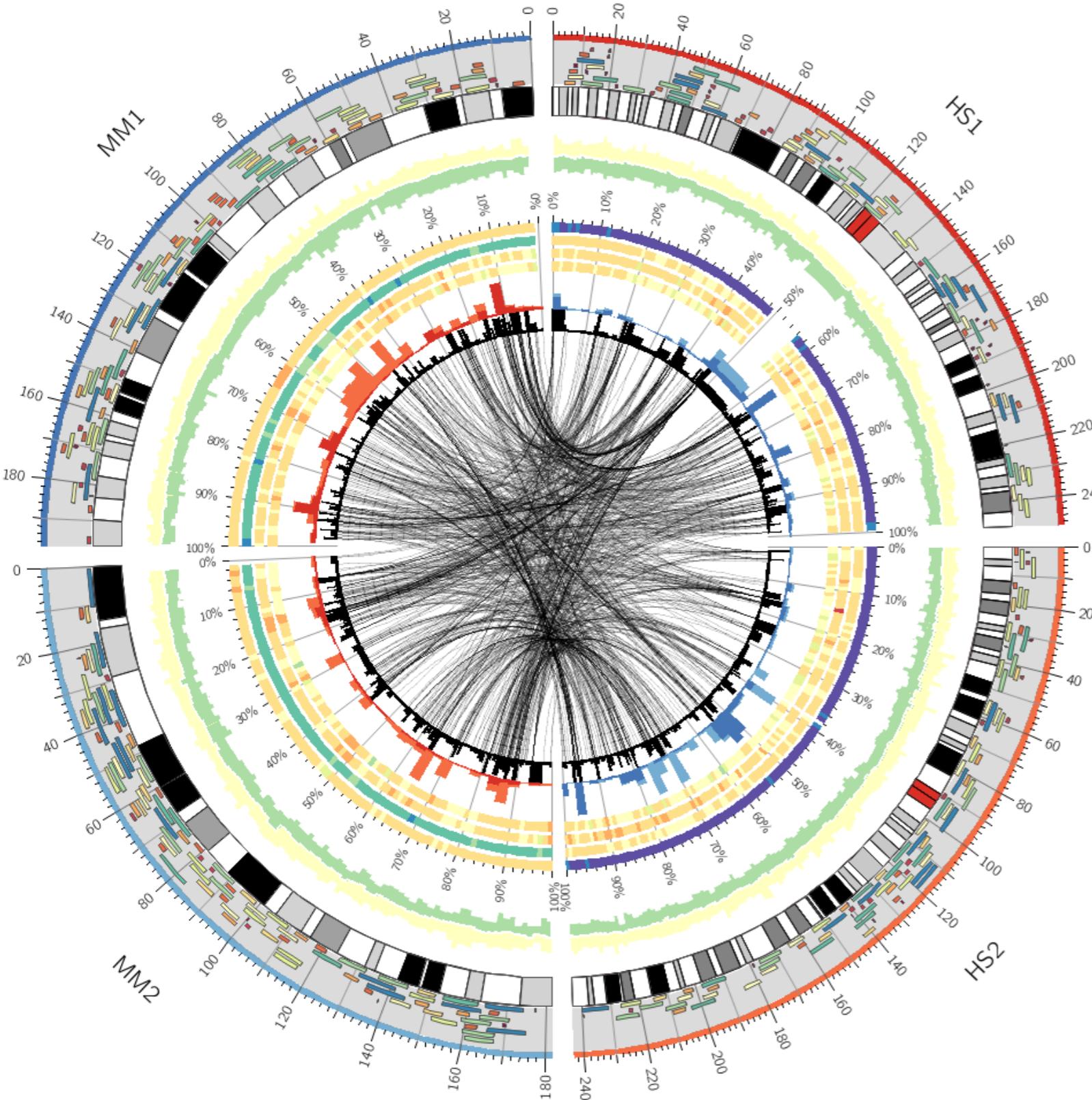


Tiles are placed in layer with smallest index that can accommodate tile's extent without overlap with other tiles in the layer. Tile's extent is defined as the region **[start-margin,end+margin]**. Spacing between layers is defined by **padding**. Relationship between layer index and layer distance from center of circle is defined by tile plot **orientation** (*in*, *out*, or *center*).

orientation		
	in	out
layer index	1	6
	2	5
	3	4
	4	3
	5	2
	6	1
	center	

↓
image center

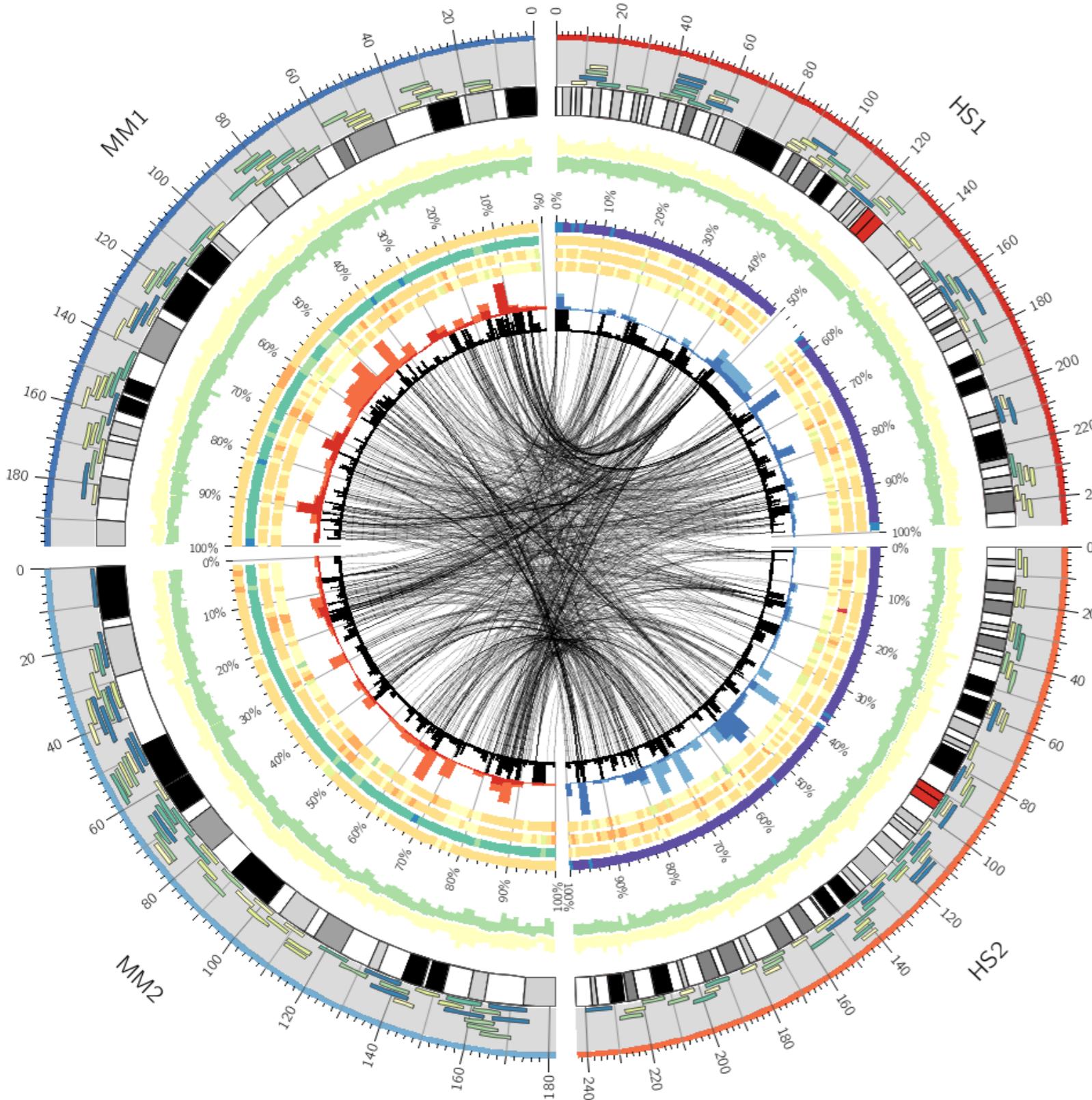
DYNAMIC FORMATTING RULES



```
# 2/6/etc/circos.conf

<plot>
  ...
<rules>
  <rule>
    condition = 1
    color =
    eval(
      sprintf("spectral-11-div-%d",
        remap_int(var(size),0,10e6,1,11)
      )
    )
  </rule>
</rules>
</plot>
```

DYNAMIC FORMATTING RULES



```
# 2/6/etc/circos.conf
```

```
<rules>
```

```
<rule>
```

```
use = yes
```

```
condition = var(size) < 5e6
```

```
show = no
```

```
</rule>
```

```
<rule>
```

```
condition = 1
```

```
color =
```

```
eval(
```

```
 sprintf("spectral-11-div-%d",  
 remap_int(var(size),0,10e6,1,11)
```

```
)
```

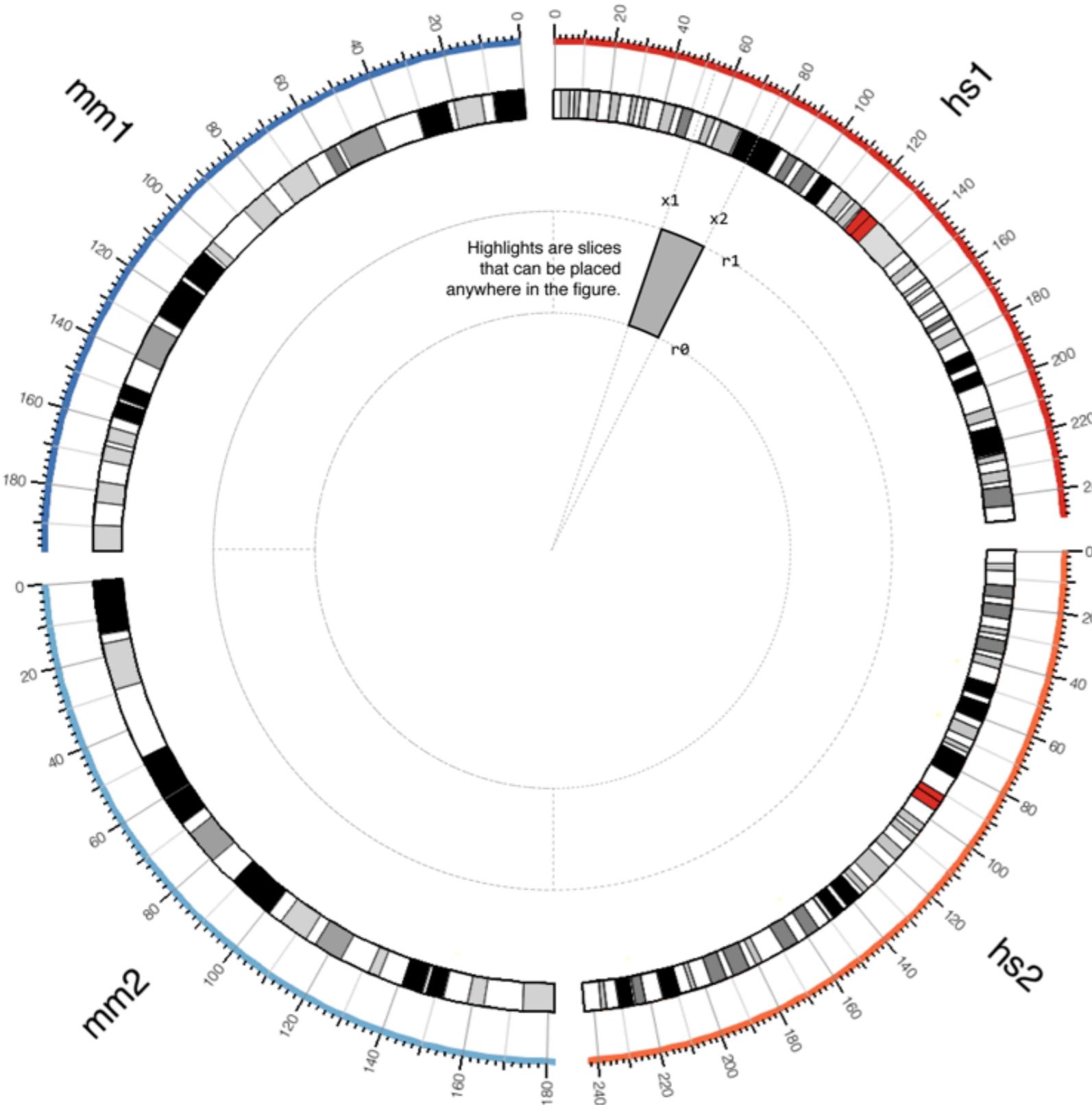
```
</rule>
```

```
</rules>
```

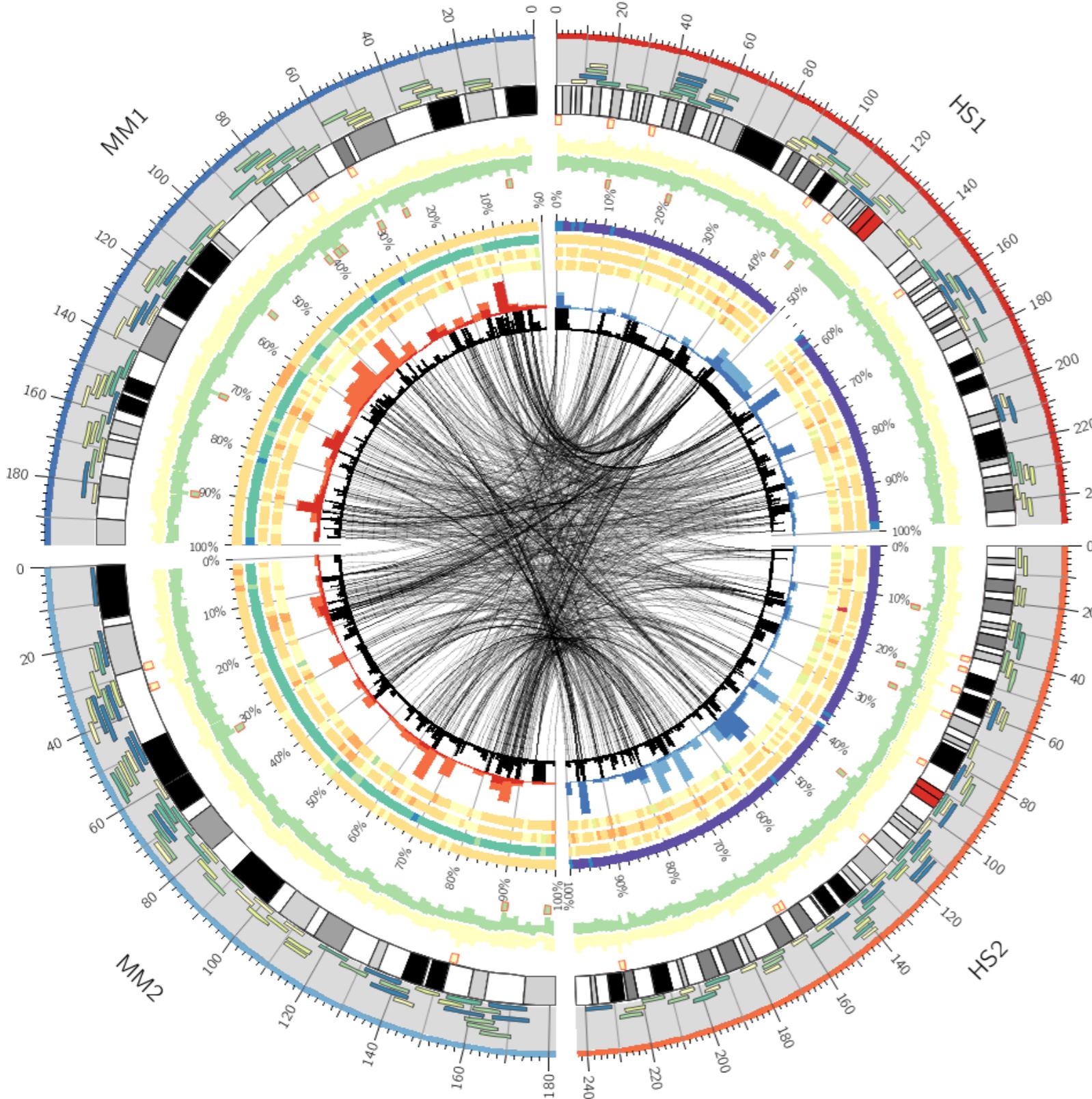
highlights

LESSON 7

HIGHLIGHT GEOMETRY



HIGHLIGHTS



```
# 2/7/etc/circos.conf
```

```
<plot>
```

```
type = highlight
```

```
file = ../../data/highlight.max.top20.txt
```

```
r0 = 0.975r
```

```
r1 = 0.995r
```

```
#r0 = 0.9r
```

```
#r1 = 0.975r
```

```
#r0 = dims(ideogram, radius_inner)
```

```
#r1 = dims(ideogram, radius_outer)
```

```
fill_color = spectral-5-div-3
```

```
stroke_thickness = 1p
```

```
stroke_color = red
```

```
z = 15
```

```
</plot>
```

```
<plot>
```

```
type = highlight
```

```
file = ../../data/highlight.min.top20.txt
```

```
r0 = 0.835r
```

```
r1 = 0.855r
```

```
#r0 = 0.835r
```

```
#r1 = 0.9r
```

```
#r0 = dims(ideogram, radius_inner)
```

```
#r1 = dims(ideogram, radius_outer)
```

```
fill_color = spectral-5-div-4
```

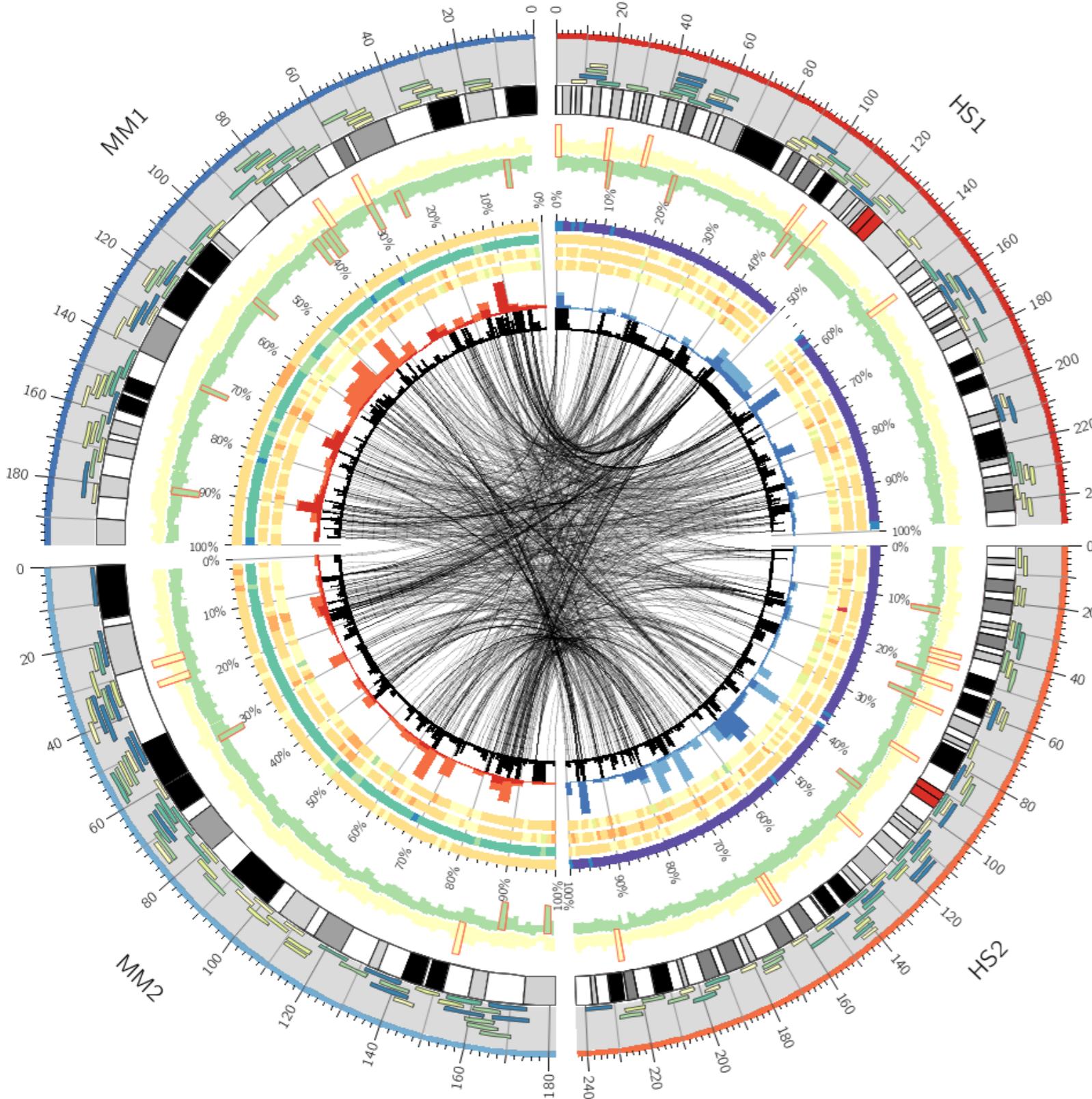
```
stroke_thickness = 1p
```

```
stroke_color = red
```

```
z = 15
```

```
</plot>
```

HIGHLIGHTS



```
# 2/7/etc/circos.conf
```

```
<plot>
```

```
type = highlight
```

```
file = ../../data/highlight.max.top20.txt
```

```
#r0 = 0.975r
```

```
#r1 = 0.995r
```

```
r0 = 0.9r
```

```
r1 = 0.975r
```

```
#r0 = dims(ideogram, radius_inner)
```

```
#r1 = dims(ideogram, radius_outer)
```

```
#fill_color = spectral-5-div-3
```

```
stroke_thickness = 1p
```

```
stroke_color = red
```

```
z = 0
```

```
</plot>
```

```
<plot>
```

```
type = highlight
```

```
file = ../../data/highlight.min.top20.txt
```

```
#r0 = 0.835r
```

```
#r1 = 0.855r
```

```
r0 = 0.835r
```

```
r1 = 0.9r
```

```
#r0 = dims(ideogram, radius_inner)
```

```
#r1 = dims(ideogram, radius_outer)
```

```
#fill_color = spectral-5-div-4
```

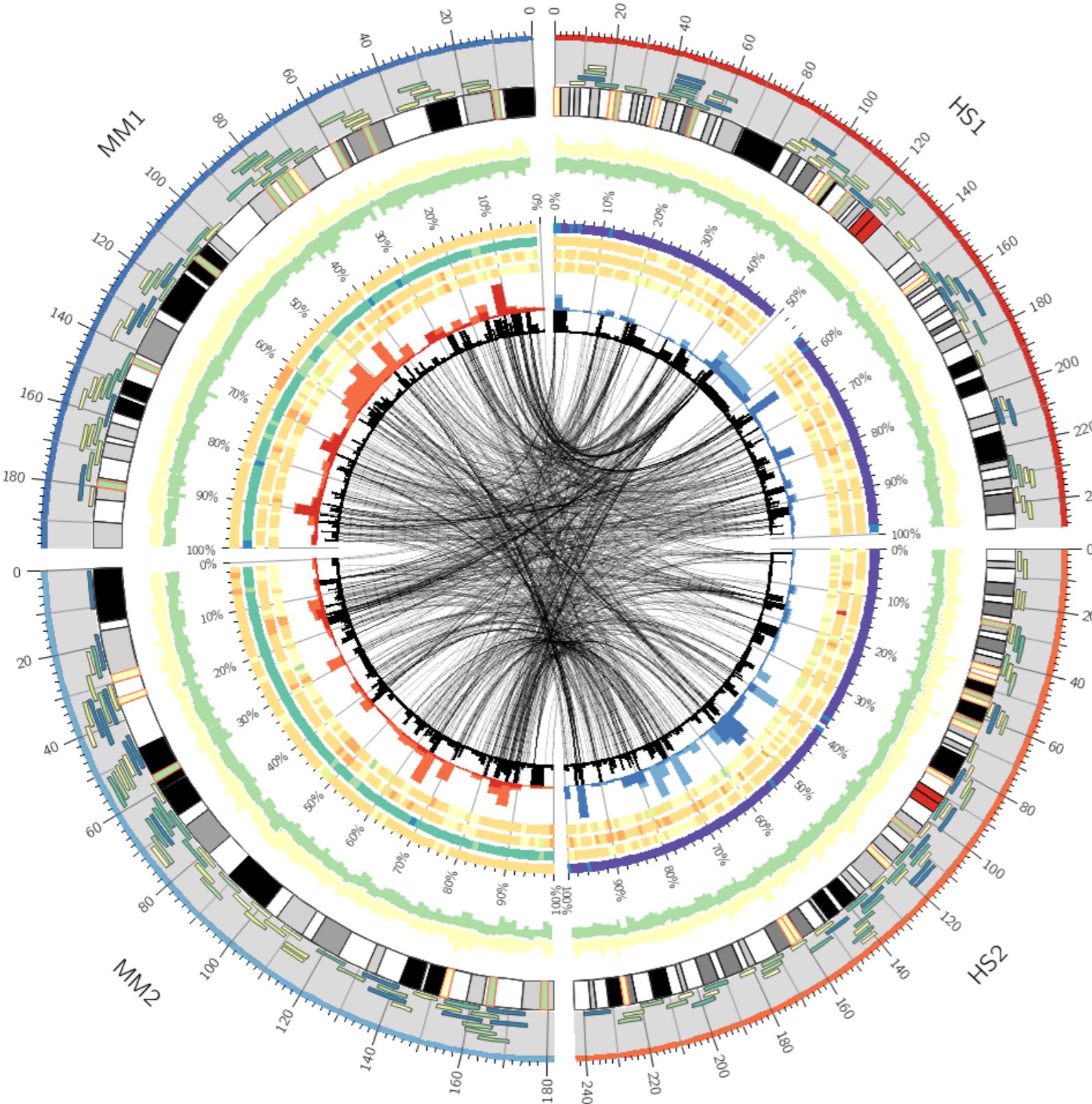
```
stroke_thickness = 1p
```

```
stroke_color = red
```

```
z = 15
```

```
</plot>
```

HIGHLIGHTS



```
# 2/7/etc/circos.conf
```

```
<plot>
```

```
type = highlight
```

```
file = ../../data/highlight.max.top20.txt
```

```
#r0 = 0.975r
```

```
#r1 = 0.995r
```

```
#r0 = 0.9r
```

```
#r1 = 0.975r
```

```
r0 = dims(ideogram,radius_inner)
```

```
r1 = dims(ideogram,radius_outer)
```

```
fill_color = spectral-5-div-3
```

```
stroke_thickness = 1p
```

```
stroke_color = red
```

```
z = 15
```

```
</plot>
```

```
<plot>
```

```
type = highlight
```

```
file = ../../data/highlight.min.top20.txt
```

```
#r0 = 0.835r
```

```
#r1 = 0.855r
```

```
#r0 = 0.835r
```

```
#r1 = 0.9r
```

```
r0 = dims(ideogram,radius_inner)
```

```
r1 = dims(ideogram,radius_outer)
```

```
fill_color = spectral-5-div-4
```

```
stroke_thickness = 1p
```

```
stroke_color = red
```

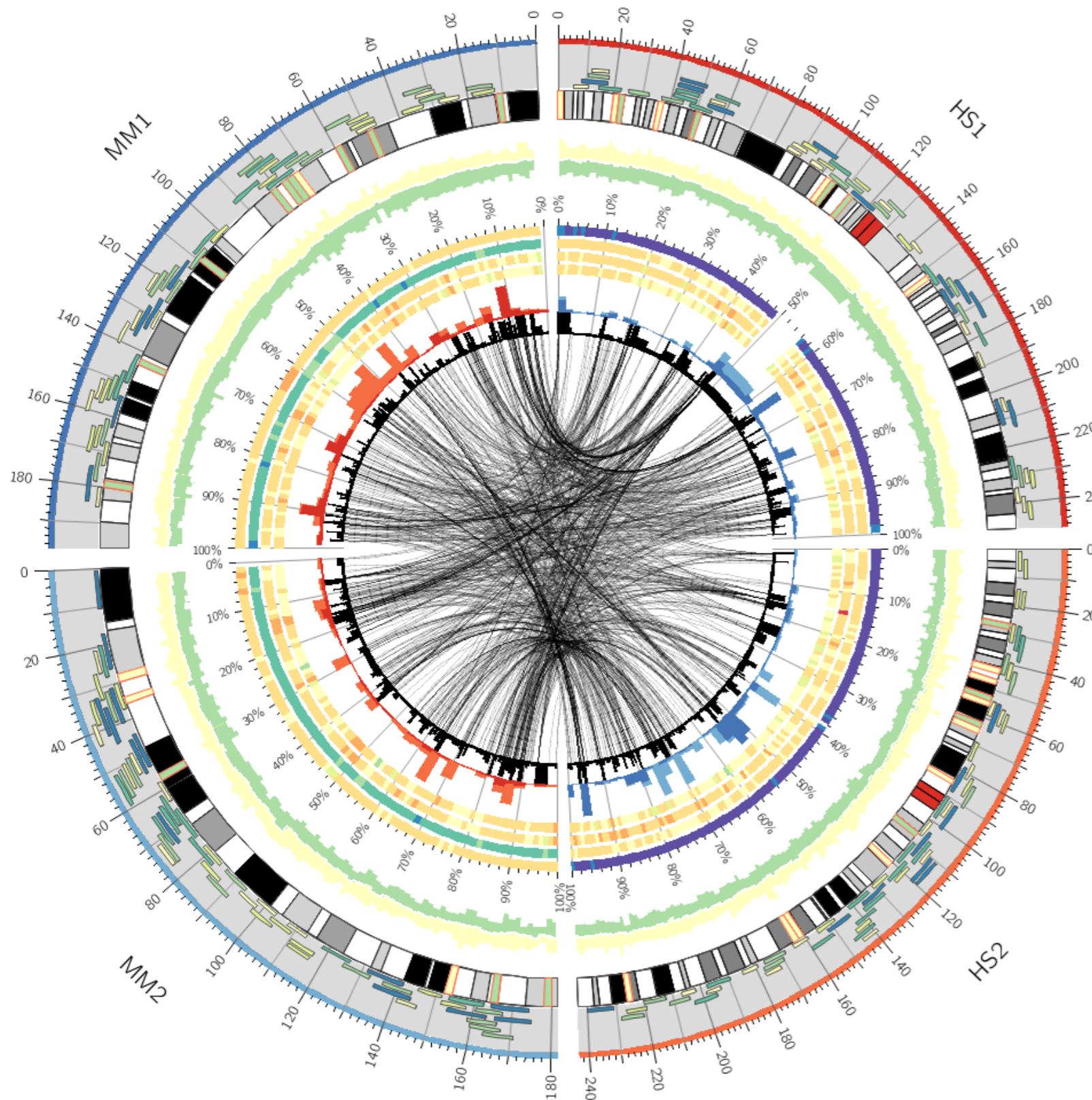
```
z = 15
```

```
</plot>
```

formatting links with dynamic rules

LESSON 8

RULES FOR LINKS



2/8/etc/circos.conf

<link chain>

file = ../../data/links.txt

bezier_radius = 0r

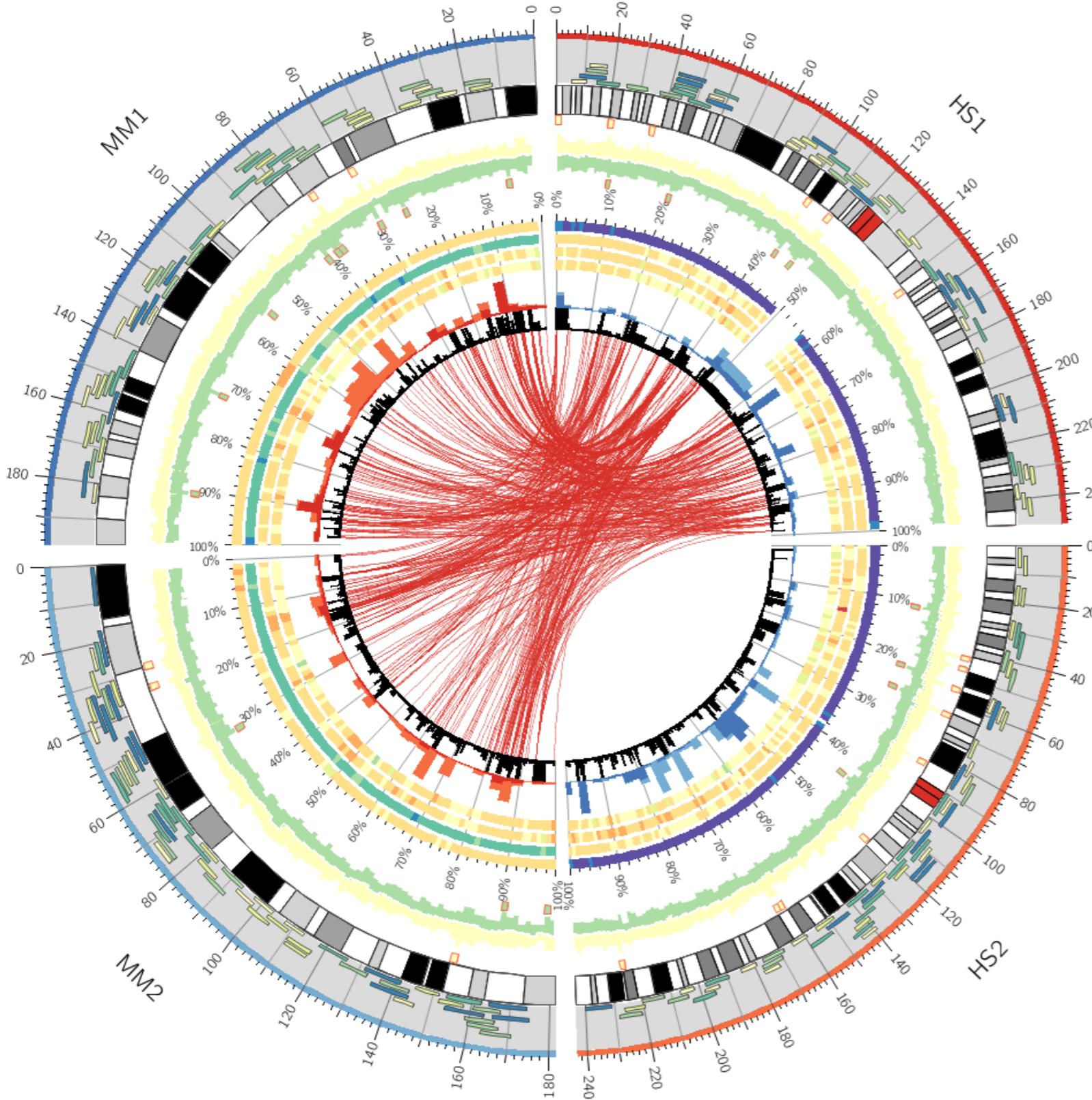
radius = 0.5r

thickness = 1p

color = black_a5

</link>

RULES FOR LINKS



```
# 2/8/etc/circos.conf
```

```
<rules>
```

```
use = yes
```

```
<rule>
```

```
use = yes
```

```
condition = on(hs1)
```

```
color = rdylbu-11-div-2_a3
```

```
</rule>
```

```
<rule>
```

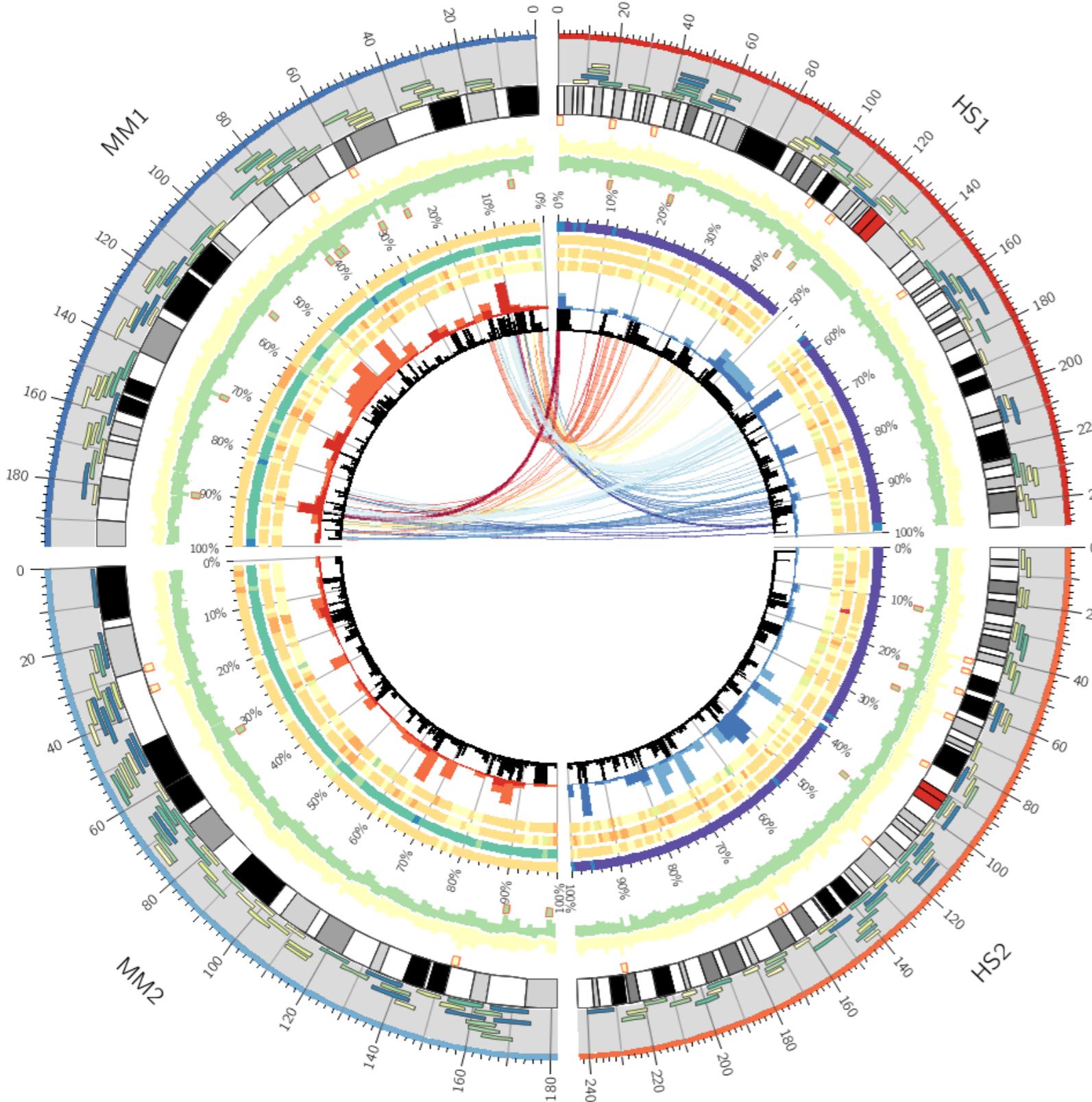
```
condition = 1
```

```
show = no
```

```
</rule>
```

```
</rules>
```

RULES FOR LINKS



```
# 2/8/etc/circos.conf

<rule>

# multiple conditions evaluated with AND

condition = between(hs1,mm1)
condition =
var(start2) < 40Mb || var(start2) > 160Mb

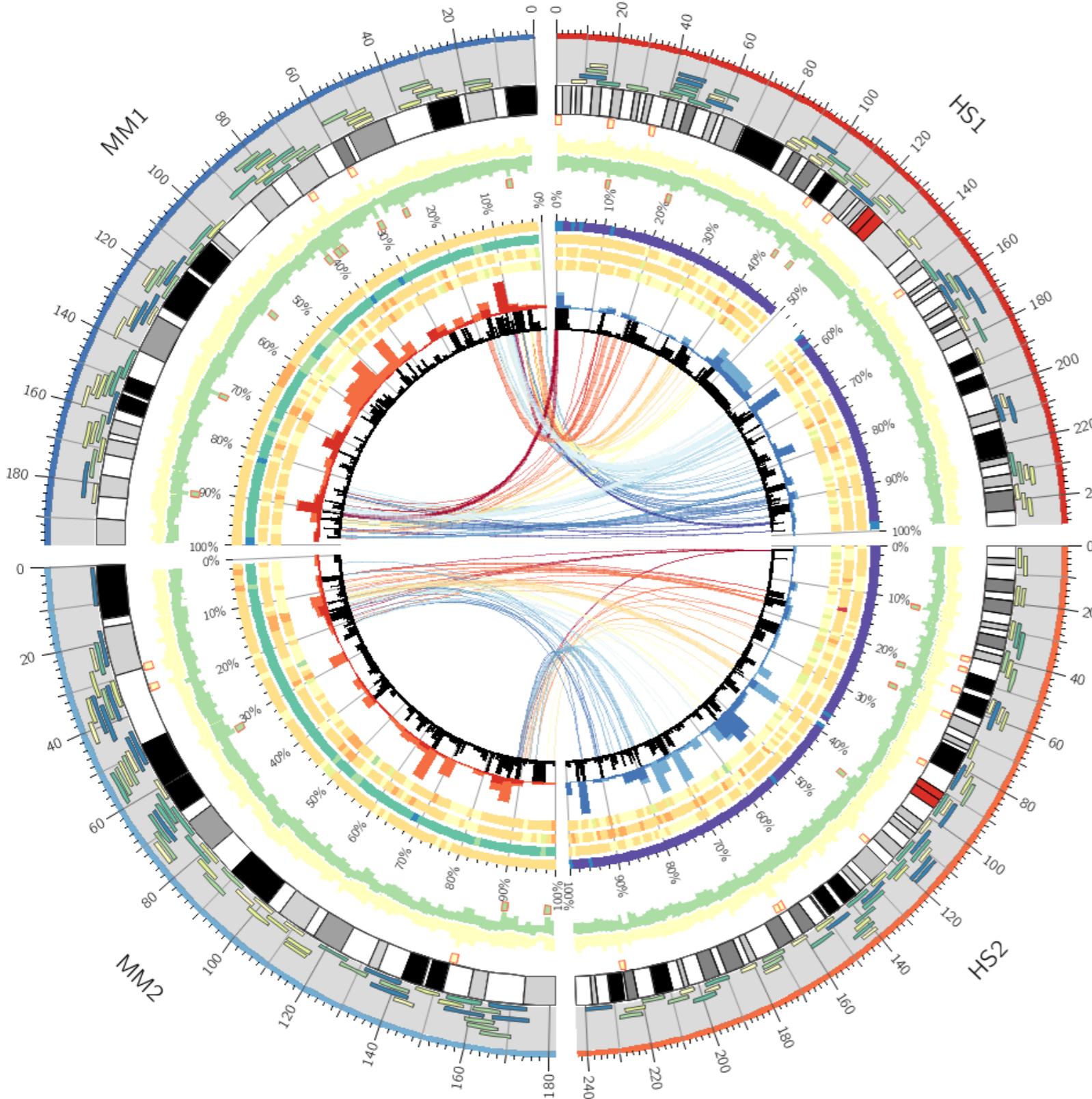
thickness = eval(
    remap_round(var(size1),0,50000,1,5)
)

z = eval(
    remap_round(var(size1),0,50000,1,5)
)

color = eval(
    sprintf("rdylbu-11-div-%d_a3",
    remap_round(var(start1),0,250e6,1,11)
)
)

</rule>
```

RULES FOR LINKS



```
# 2/8/etc/circos.conf
```

```
<rule>
```

```
# multiple conditions evaluated with AND
```

```
condition =
```

```
between(hs1,mm1) || between(hs2,mm2)
```

```
condition =
```

```
var(start2) < 40Mb || var(start2) > 160Mb
```

```
thickness = eval(
```

```
remap_round(var(size1),0,50000,1,5)
```

```
)
```

```
z = eval(
```

```
remap_round(var(size1),0,50000,1,5)
```

```
)
```

```
color = eval(
```

```
sprintf("rdylbu-11-div-%d_a3",
```

```
remap_round(var(start1),0,250e6,1,11)
```

```
)
```

```
)
```

```
</rule>
```

