TOPCAT Visualisation — Recent developments

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Outline

- Visualisation overview

- Recent enhancements
  - Multi-zone Time plot
  - New plot layer types
    - ▷ **Fill** plotter
    - ▷ **HEALPix** plotter
    - ▷ **Grid** plotter
    - ▷ **Quantile** plotter
    - ▷ **Gaussian** plotter
  - GUI changes
    - ▷ Free colour chooser
    - ▷ Form GUI toolbar → menu
  - Plot data export
  - Documentation improvements

- Outlook

Visualisation Overview

Visualisation capabilities in TOPCAT/STILTS

- Many visualisation options
  - ▷ 2d, 3d, Sky, Time
  - ▷ Markers, contours, vectors, error bars, text labels, density maps, histograms, ...
  - ▷ You can overplot many different *layer* types on the same axes

- Special focus on:
  - ▷ Interactive use (data exploration)
    - ○ interactive configurability
    - ○ interactive performance
  - ▷ Scalability
    - ○ does not run out of memory for large/huge datasets
    - ○ plots make visual sense for large/huge datasets

- Everything you can do in TOPCAT (point'n'click), you can do in STILTS (command line)
  - ▷ STILTS generally more scalable (unlimited row counts)
  - ▷ ... but there is a bit of a learning curve

Recent Release Summary

- ## TOPCAT v4.3-3 (06/2016)
  - Multi-zone Time plot (& other Time plot improvements)
  - **Fill** plotter

- ## TOPCAT v4.3-4 (09/2016)
  - **HEALPix** plotter
  - Import/Save HEALPix maps from **SkyDensity** plotter

- ## TOPCAT v4.4 (03/2017)
  - Free colour chooser
  - **Grid** plotter
  - **Quantile** plotter
  - **Gaussian** plotter
  - Form GUI changed
  - Improved documentation - more screenshots in manual/help

- ## Other
  - various bugfixes, performance improvements, minor enhancements and non-viz things

Time Plot

Time Plot window

- Like *Plane Plot*, but horizontal axis is labelled in Time (ISO-8601, Decimal Year, MJD, Unix seconds)
- Marked *Experimental* in current versions:
  - ▷ some things don't work perfectly
- Allows *multi-zone* (vertically stacked) plots
  - ▷ Useful for comparing different plots (different Y axes) over common interval
  - ▷ Works mostly OK
  - ▷ Some issues — e.g. configure axes per-zone or locally?
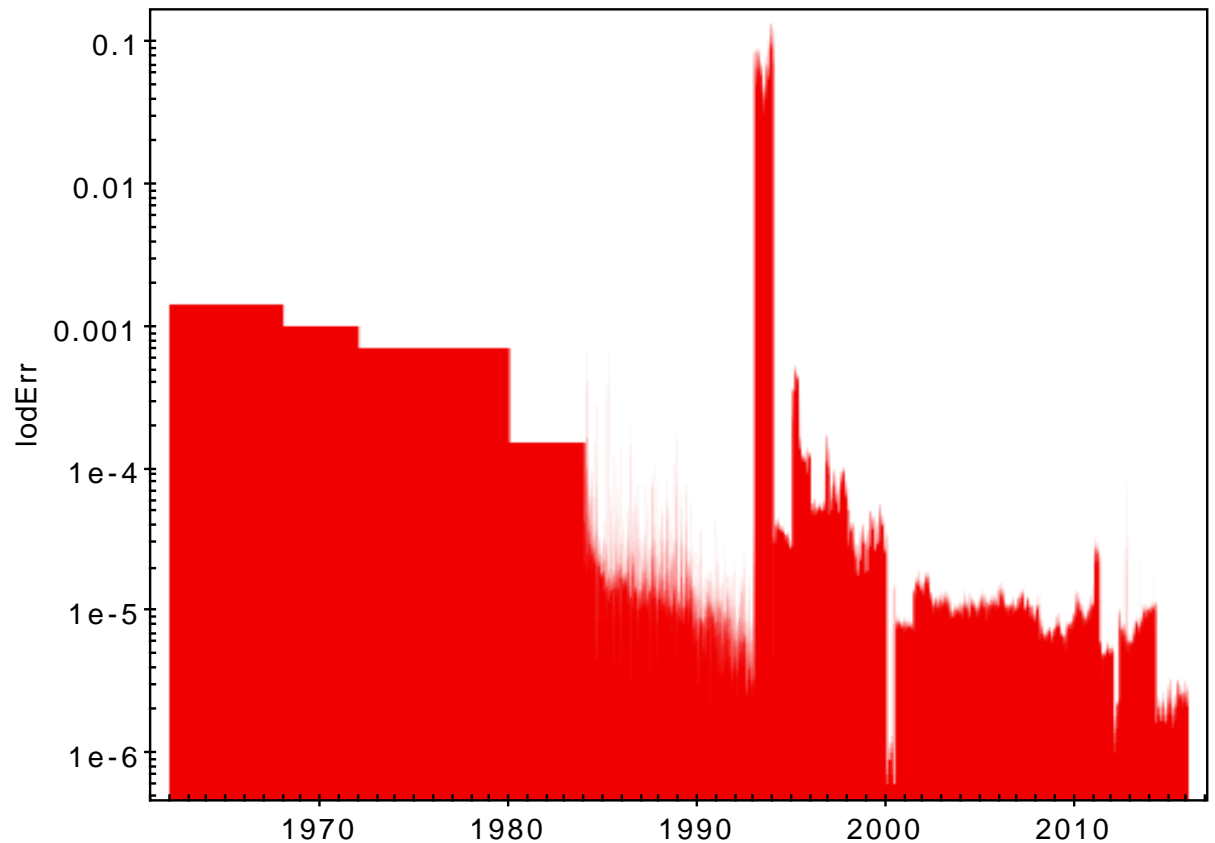 - ▷ Multi-zone framework usable for other plot types — but GUI is hard
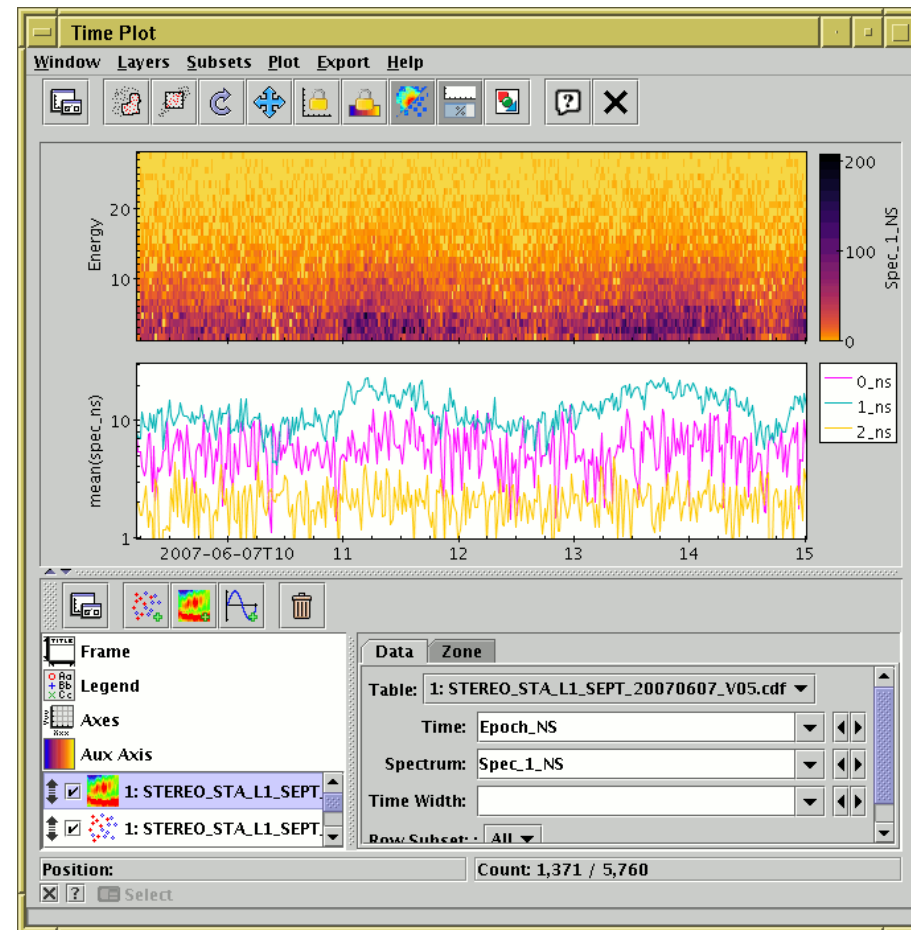
Fill plot

![Fill plot icon] **Fill** plot layer type

- Represents X,Y data like a histogram
- Horizontal or vertical bars available
- Data does not need to be on a regular grid
- Antialiasing for bars with sub-pixel spacing

Healpix plot

Healpix plot layer type

- Plots pregenerated Healpix maps
- Can degrade to coarser HEALPix level
- Can resample onto different sky projection
- Maps must be represented as tables (not FITS 1d images)
- Identifying HEALPix id column & level still problematic
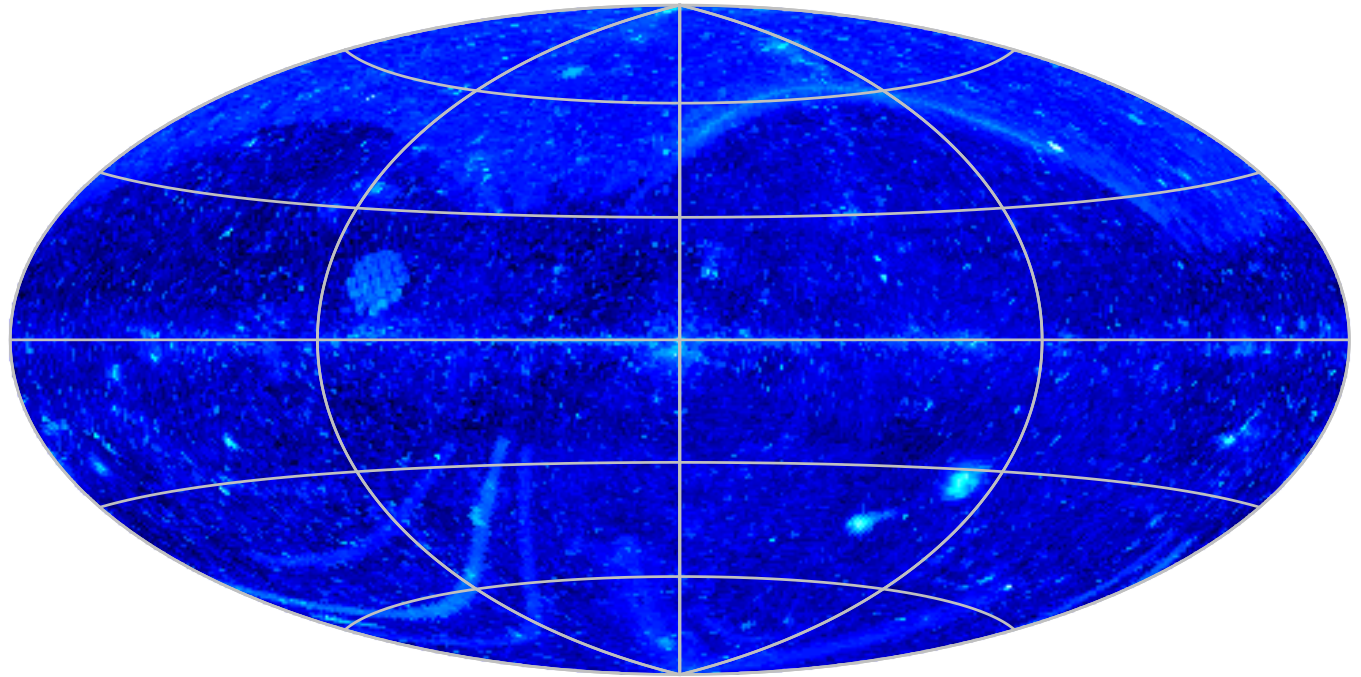
Grid plot

Grid plot layer type

- Optionally weighted 2-d density map
- Choice of per-bin weight aggregators (sum, mean, median, min, max, stdev, ...)
- Specify X/Y bin size in data coords
- Specify bin phase if required
- Can be used in various ways:
  - ▷ Simple 2-d histogram
  - ▷ Weighted density map
  - ▷ Plot pre-gridded data
    (e.g. 2-d histogram generated
    by aggregate ADQL query)
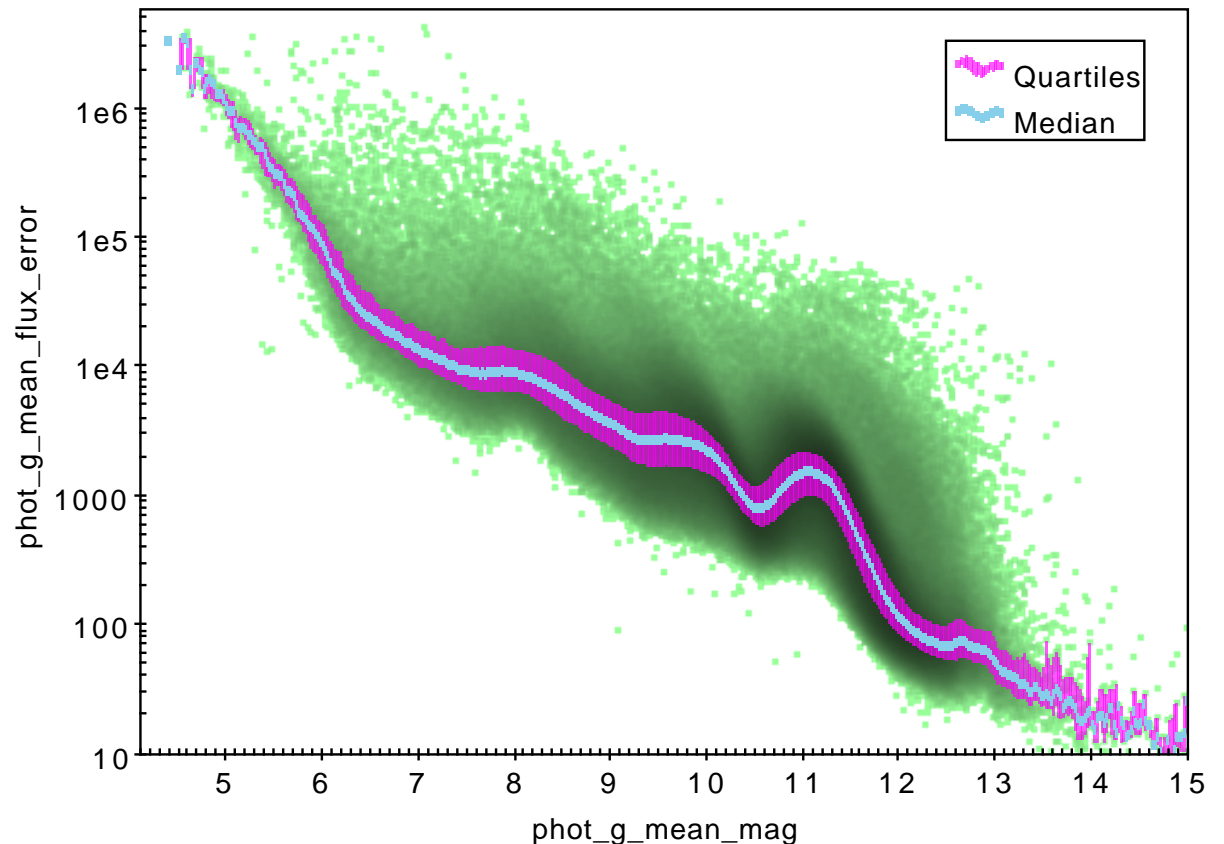- Replaces less-capable **Density** plot
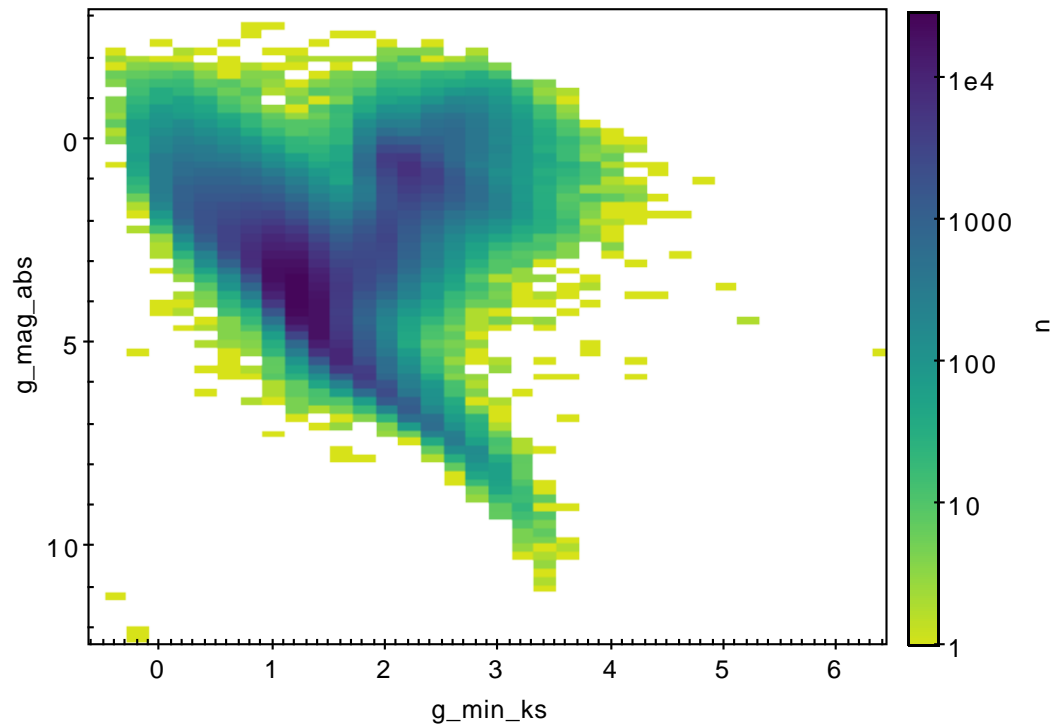
Quantile plot

Quantile plot layer type

- Plots median or other quantile point/range for each pixel column
- Optional smoothing of data (configurable width, choice of kernels)
- Useful to trace central values of a noisy function $f(x)$ (or $f(y)$)
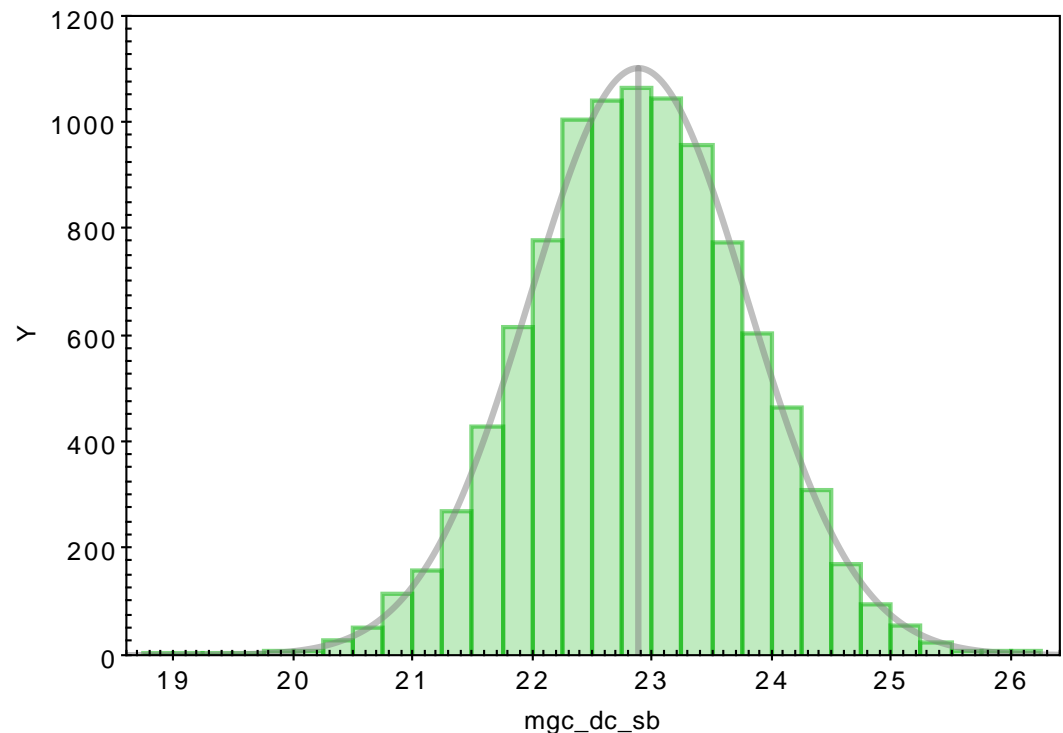- Quantiles only — should it offer mean as well?

Gaussian plot

Gaussian plot layer type

- Calculates mean and Standard Deviation of 1-d data, and plots as Gaussian curve
- Visually corresponds to a Gaussian fit of a plotted histogram
- Mean value is optionally represented by a line
- Data values can be weighted (as for Histogram)
- Useful for quantitative characterisation of normally distributed data
- Mean/S.D. values are reported in topcat plot window

Colour Chooser
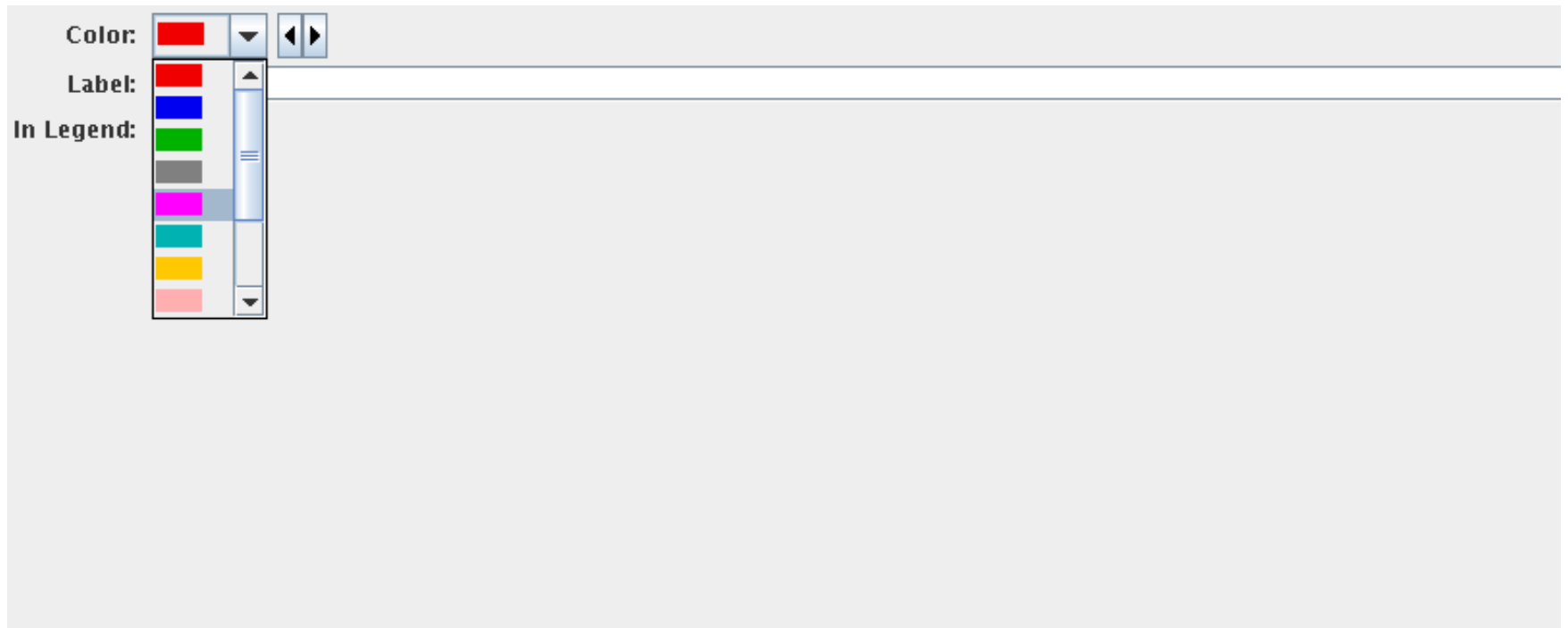
Lots more options for choosing plot colours:
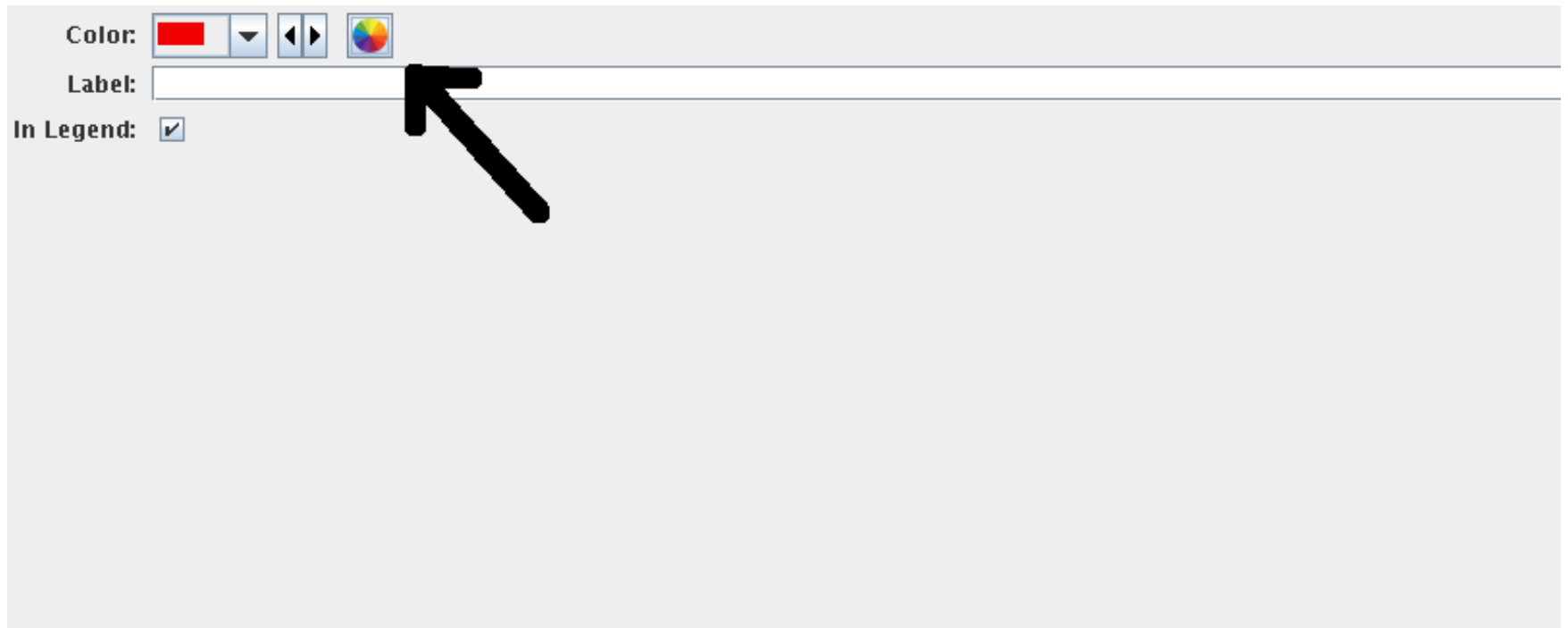

Old

Colour Chooser

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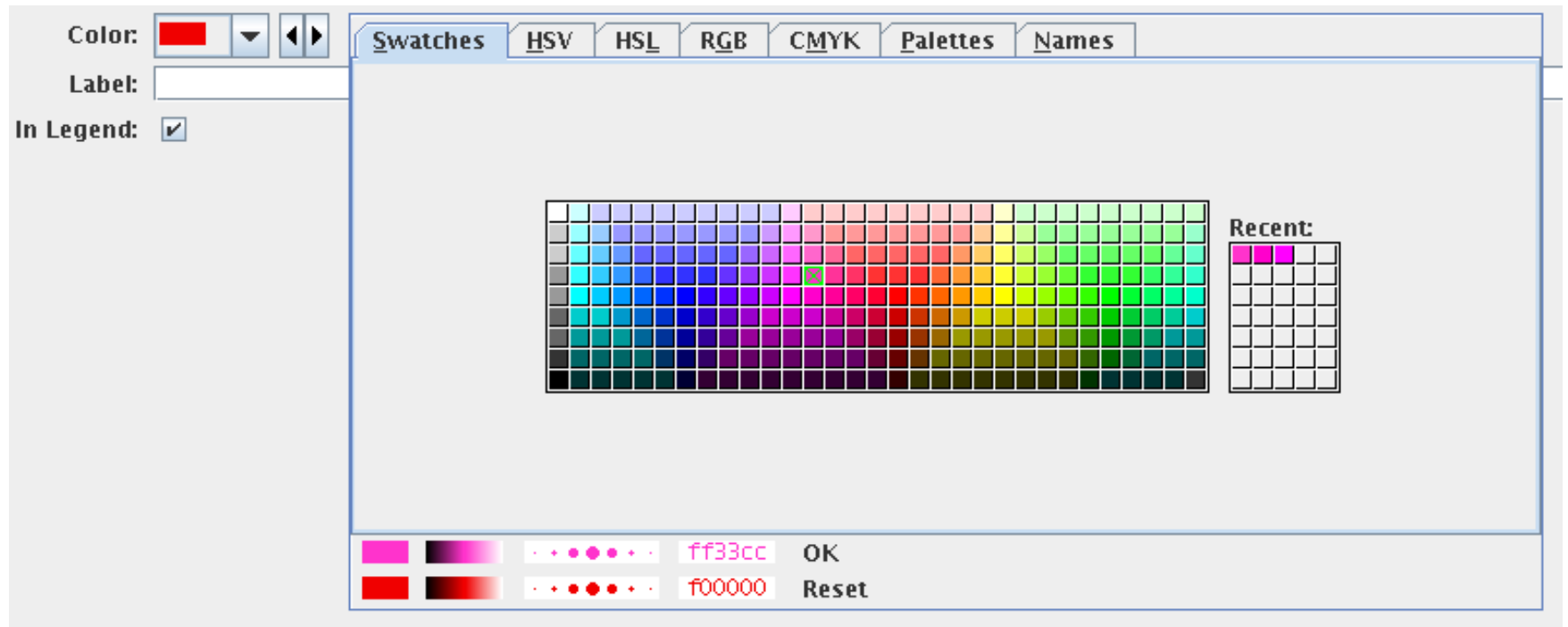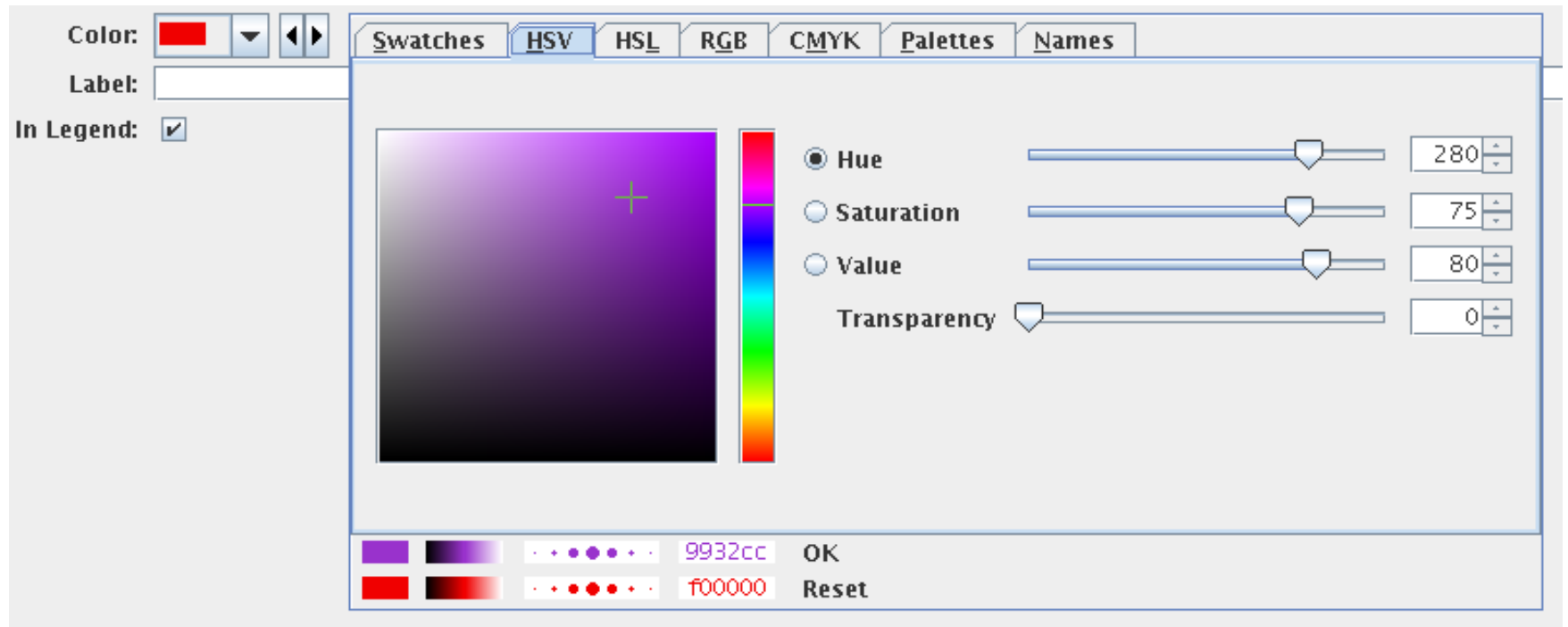

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New (Java 7+ only)

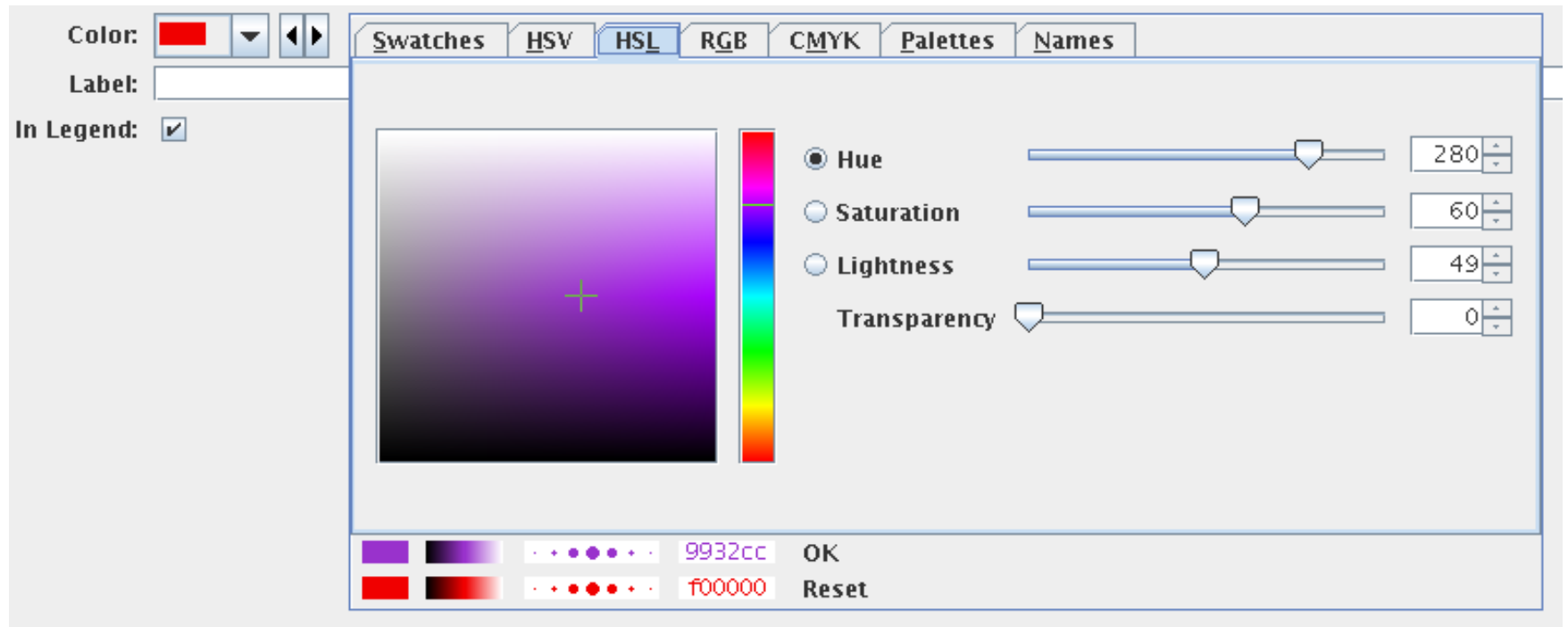# Colour Chooser

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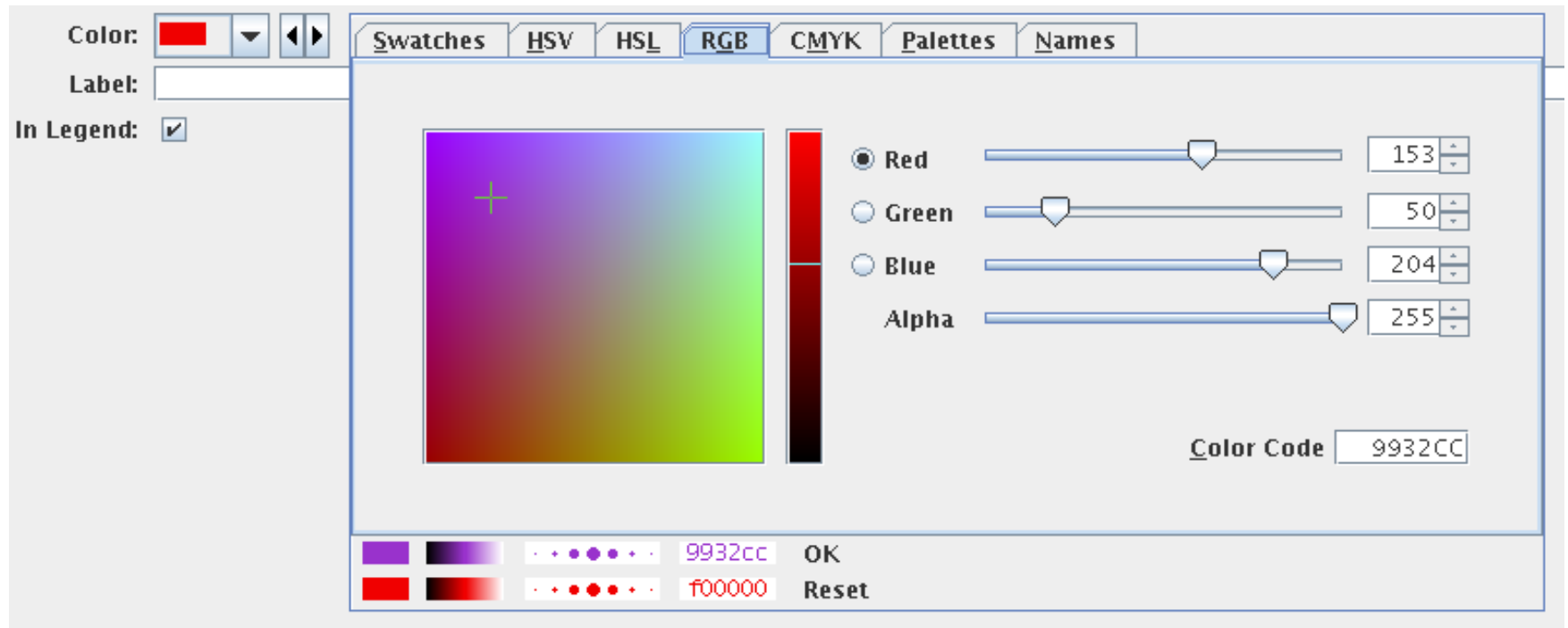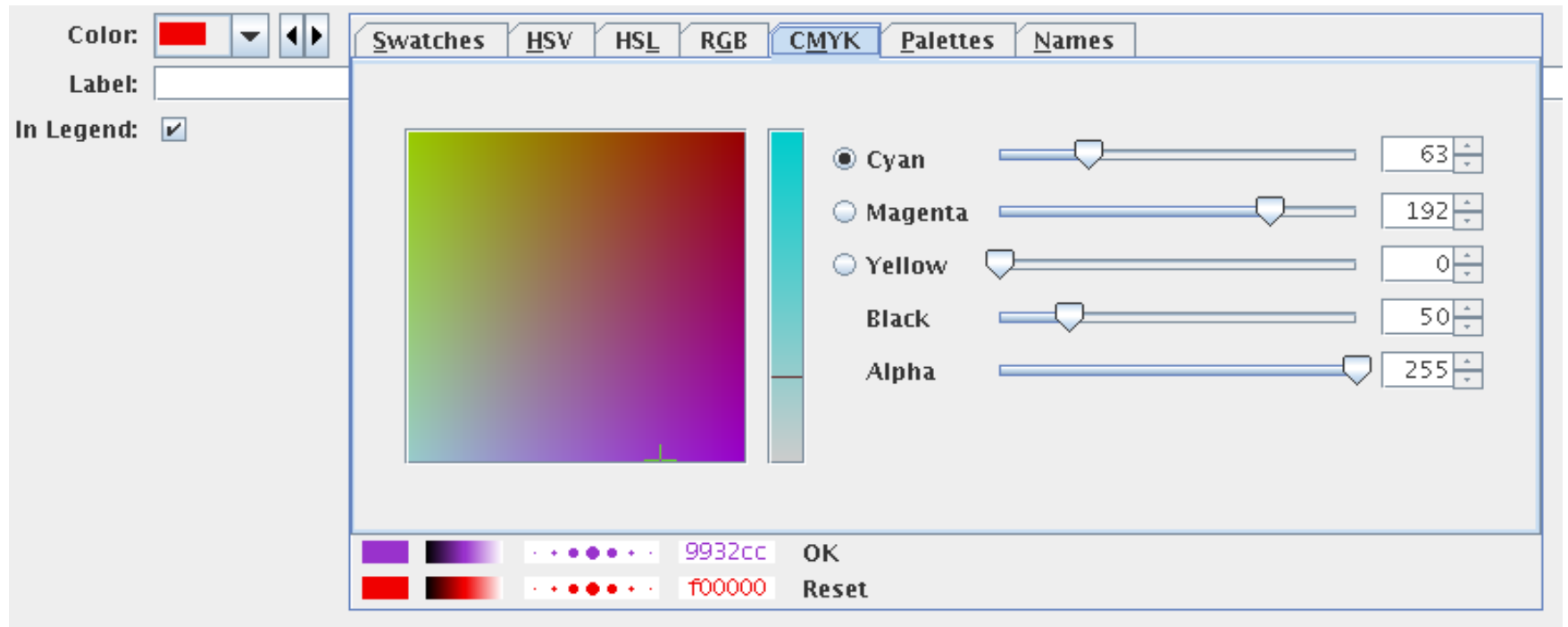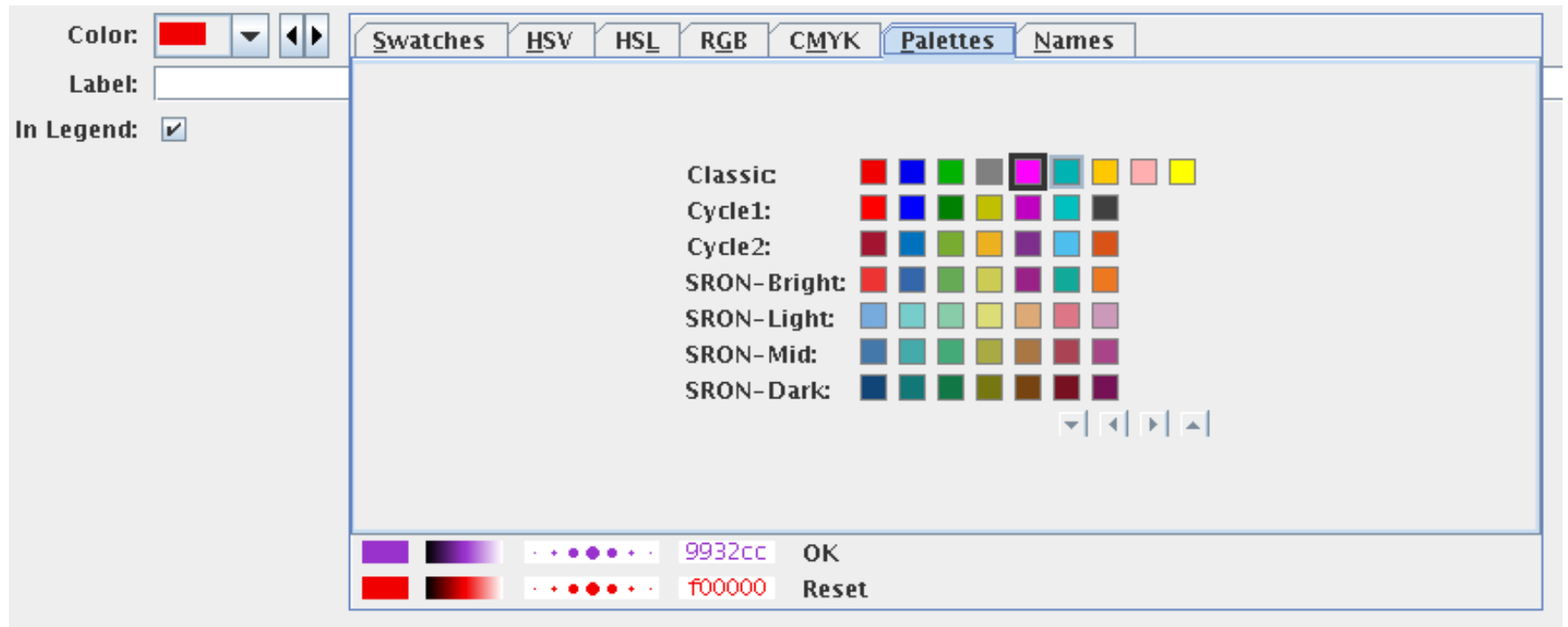*Lots* more options for choosing plot colours:
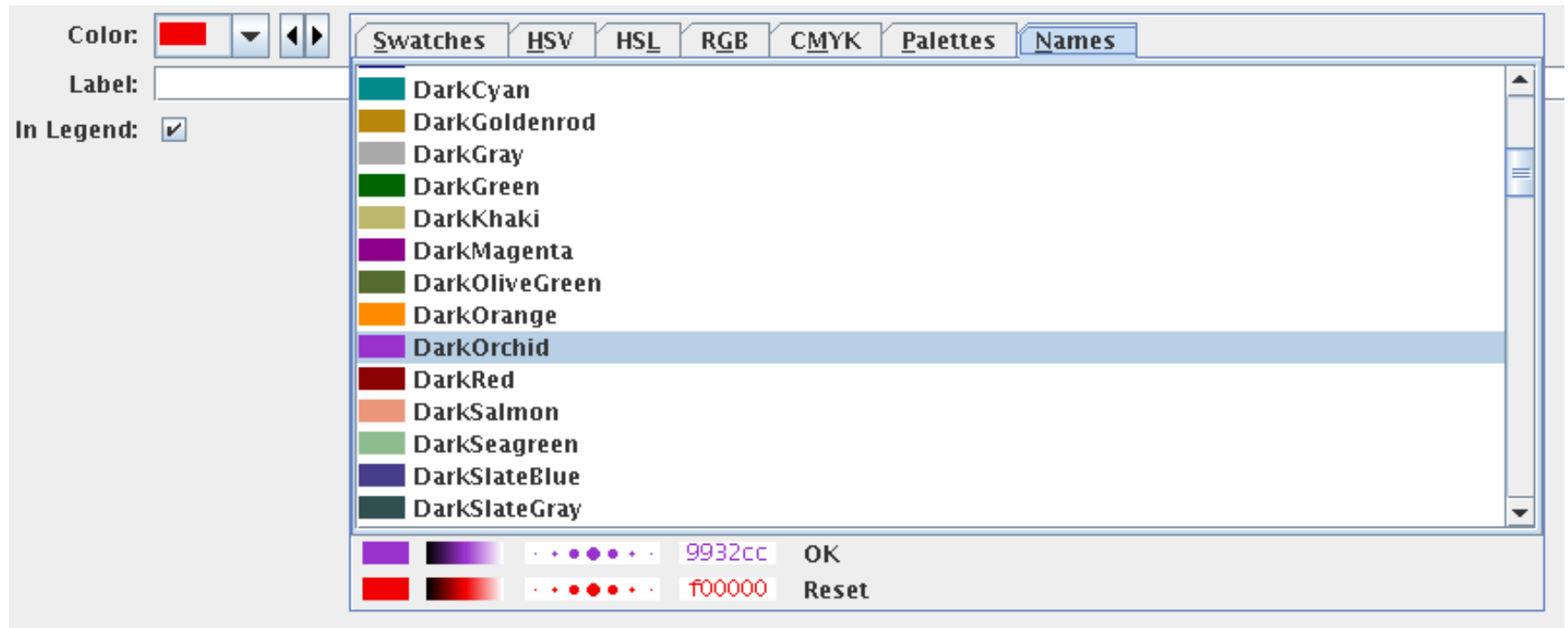

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Form GUI

GUI for *Plot Form* addition

- Several actions for adding new plot layers using the same data
    - ▷ Mark, Contour, Line, Error, Size, ...

- Previously toolbar
    - ▷ plot type list growing → too wide

- Now menu button
    - ▷ Room for more options
    - ▷ Form names visible as well as icons

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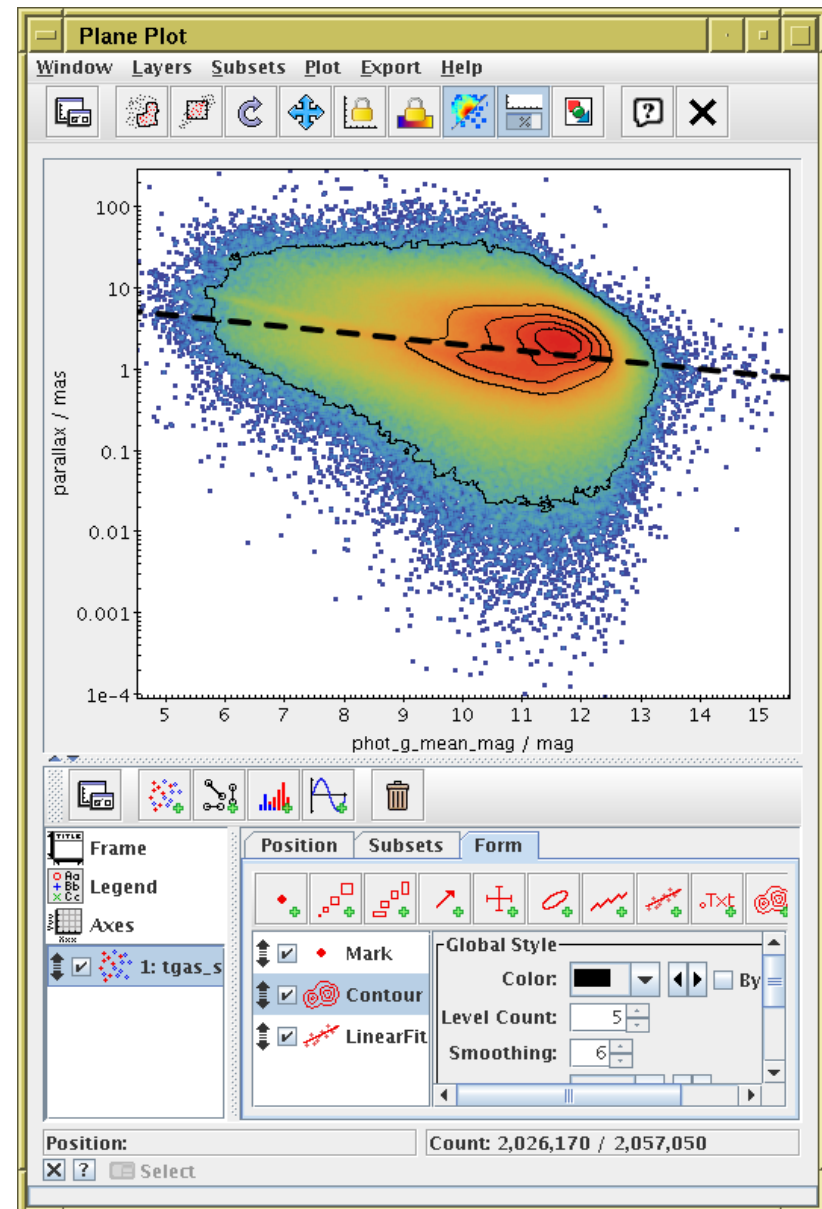 - ▷ Form names visible as well as icons

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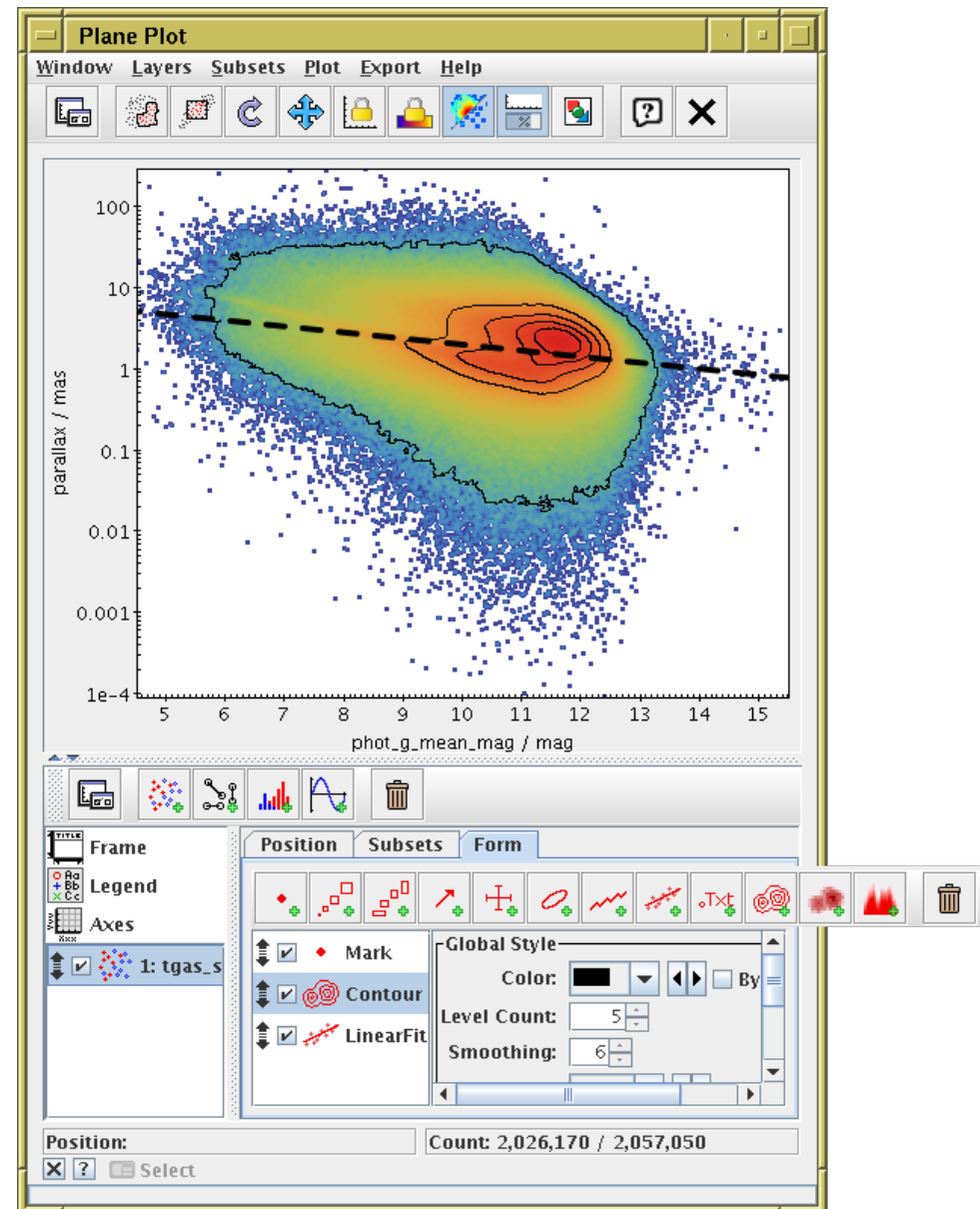 - ▷ Room for more options
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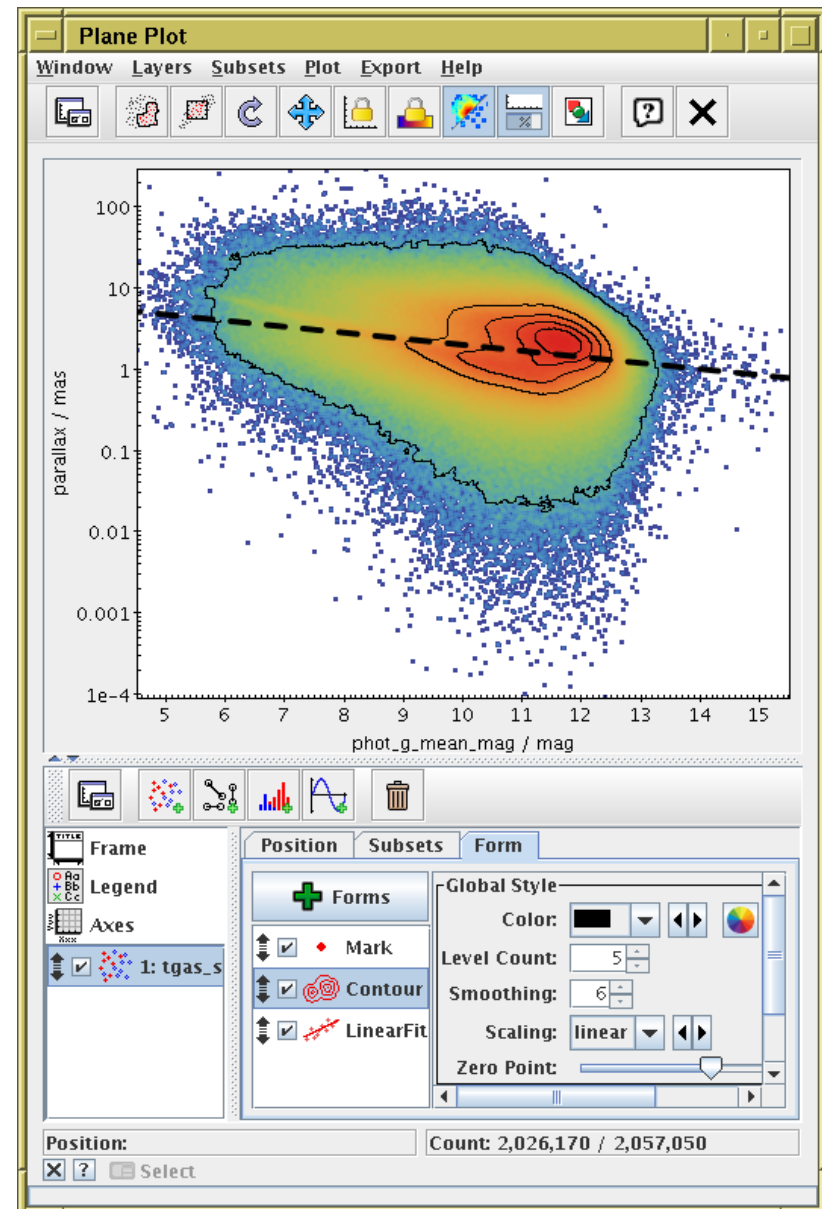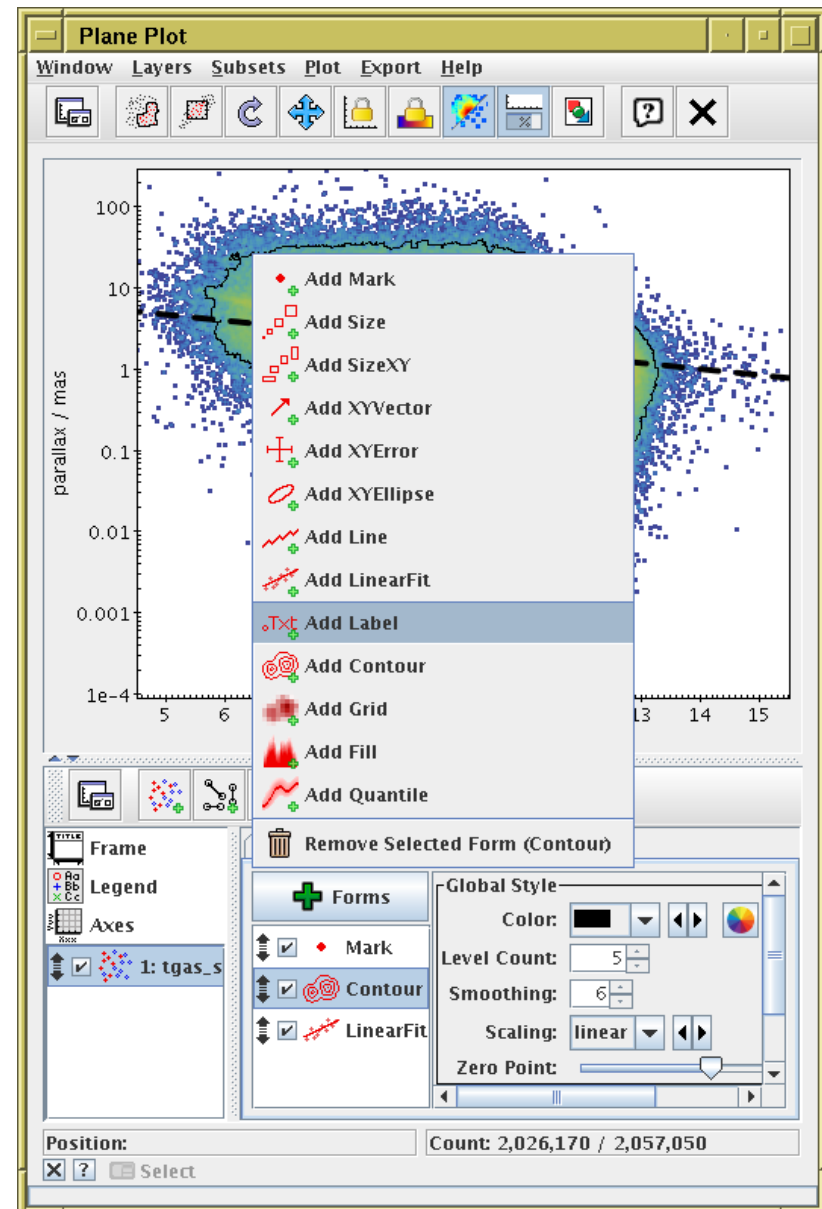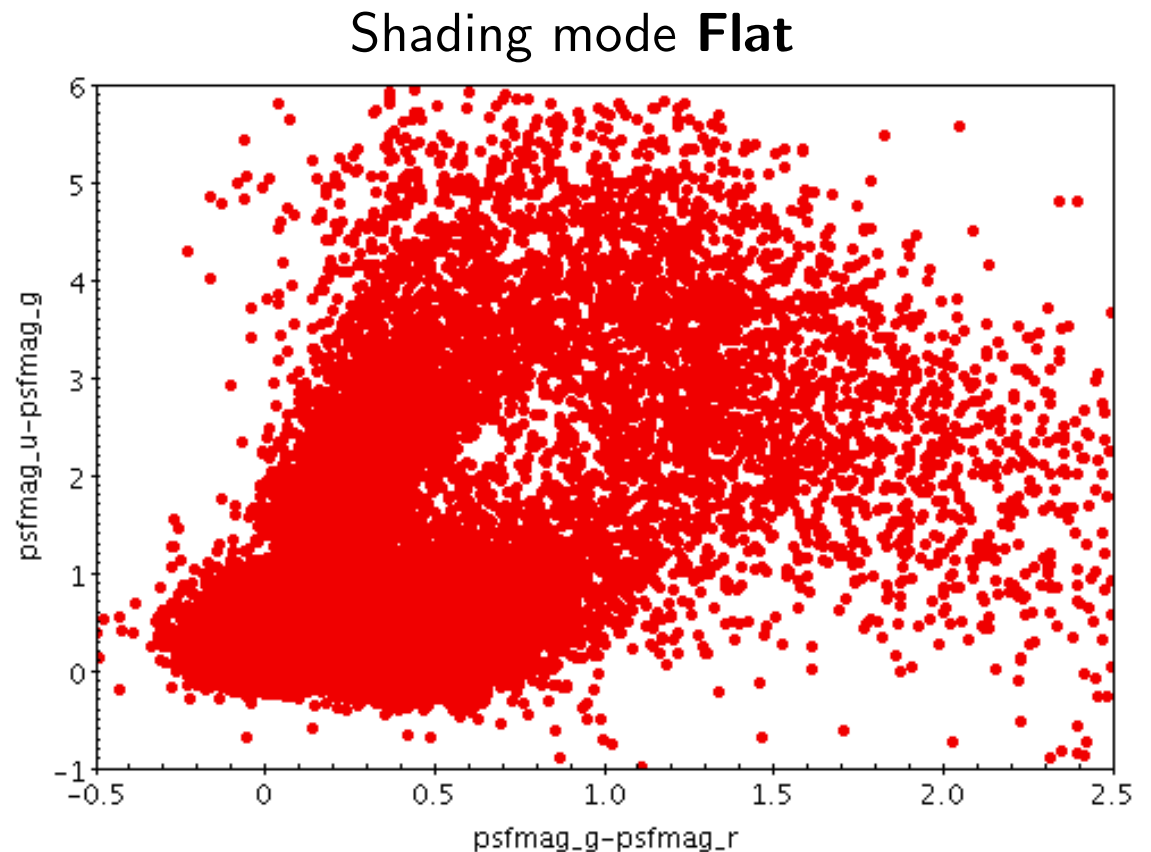 - ▷ Form names visible as well as icons

New

Improved Documentation

More screenshots in user documents:

- All plot *layer types* and *shading modes* have screenshots
- In STILTS user document, exact command is shown
- Helps to understand capabilities ...

  ... especially since there are lots of options
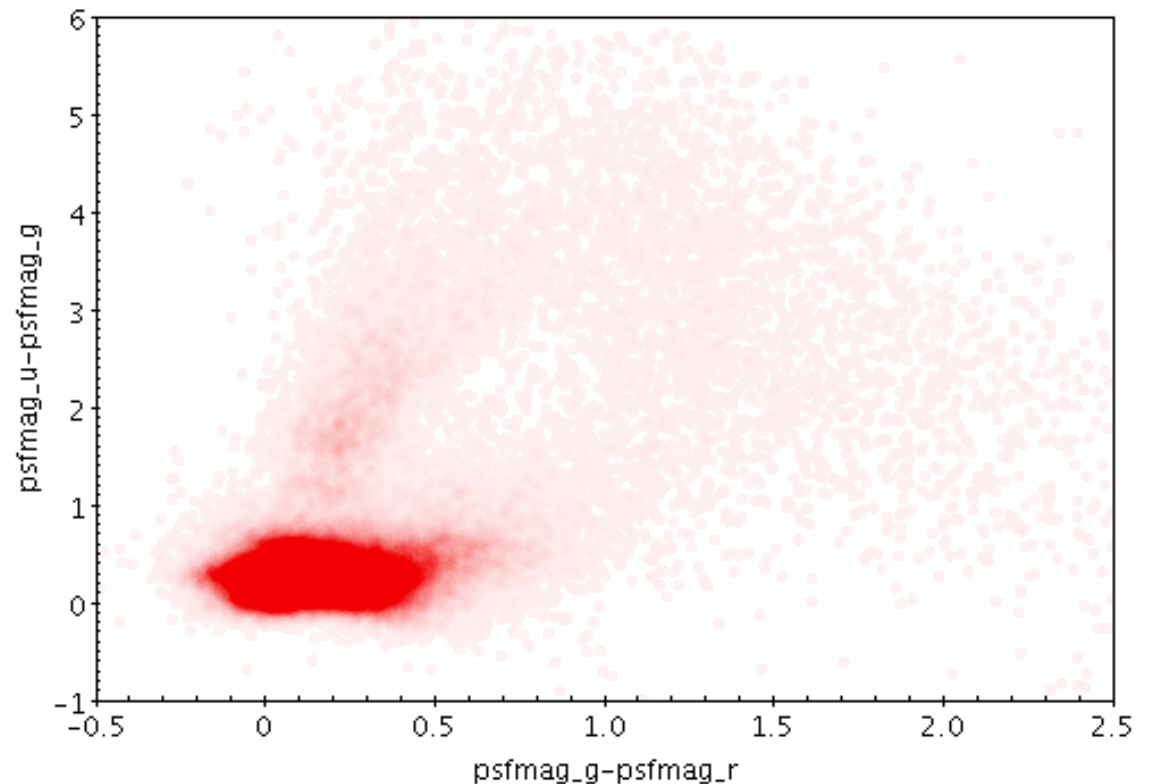
Shading mode **Flat**

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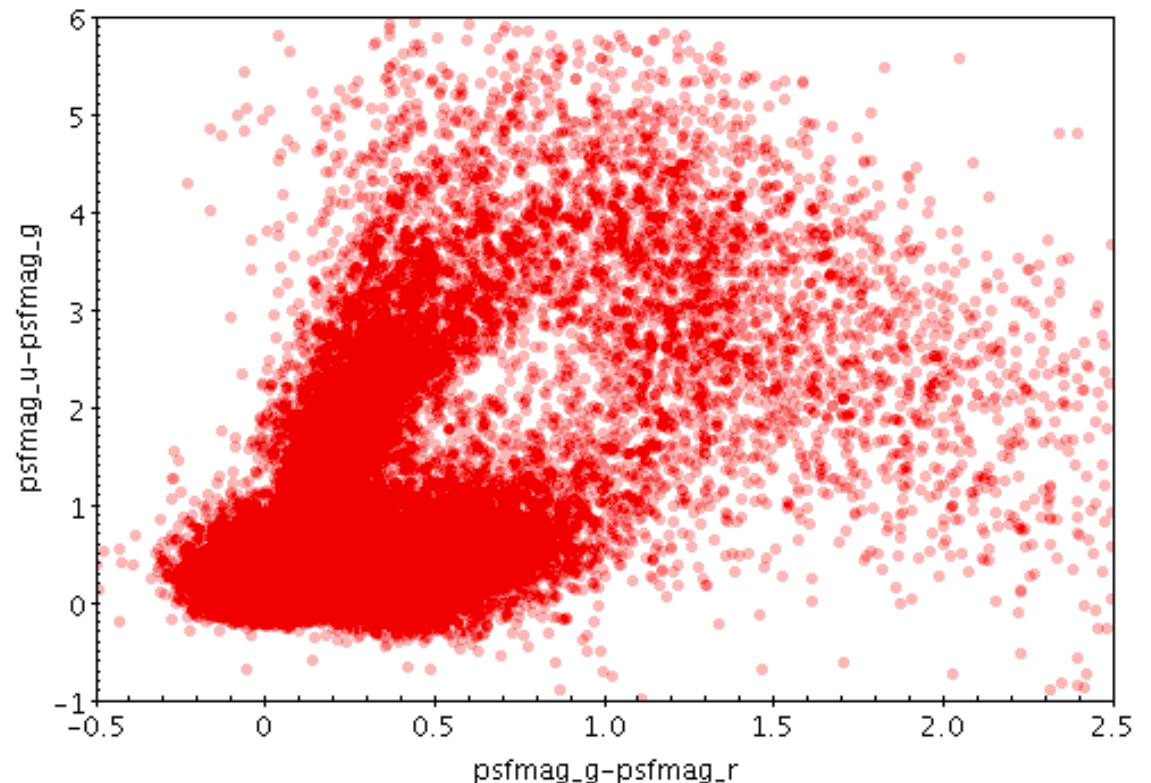
Shading mode **Translucent**

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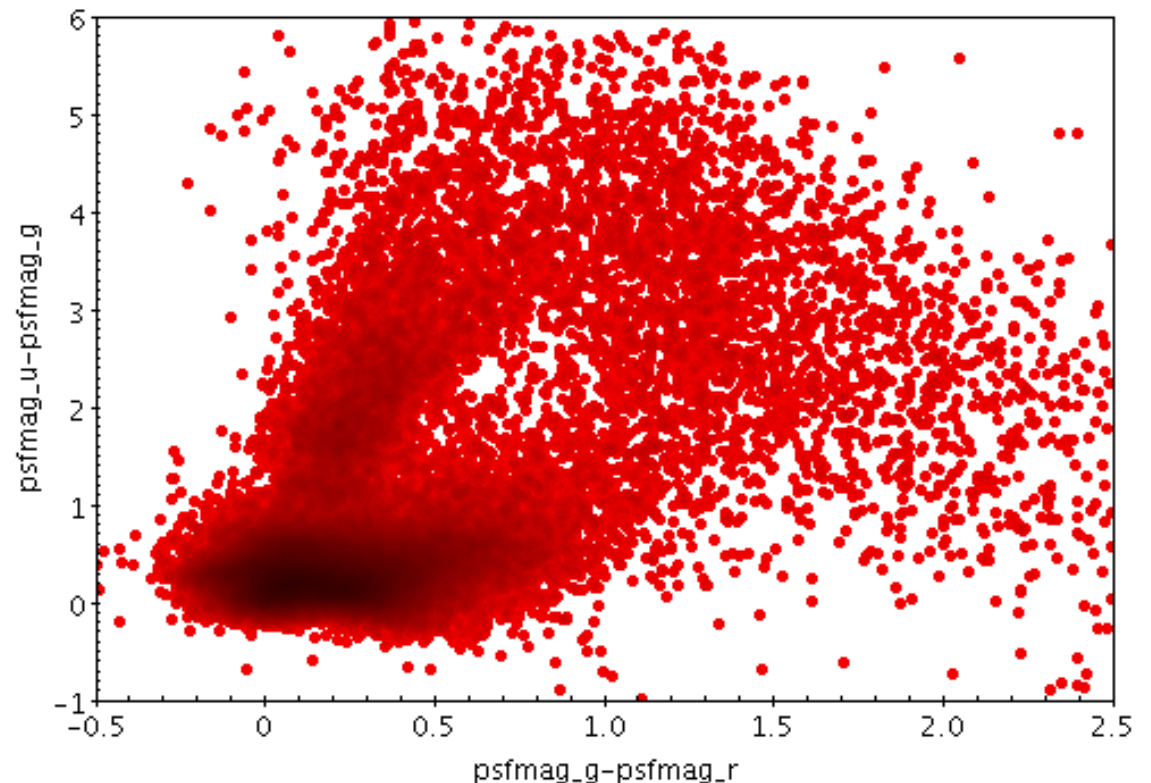
Shading mode **Transparent**

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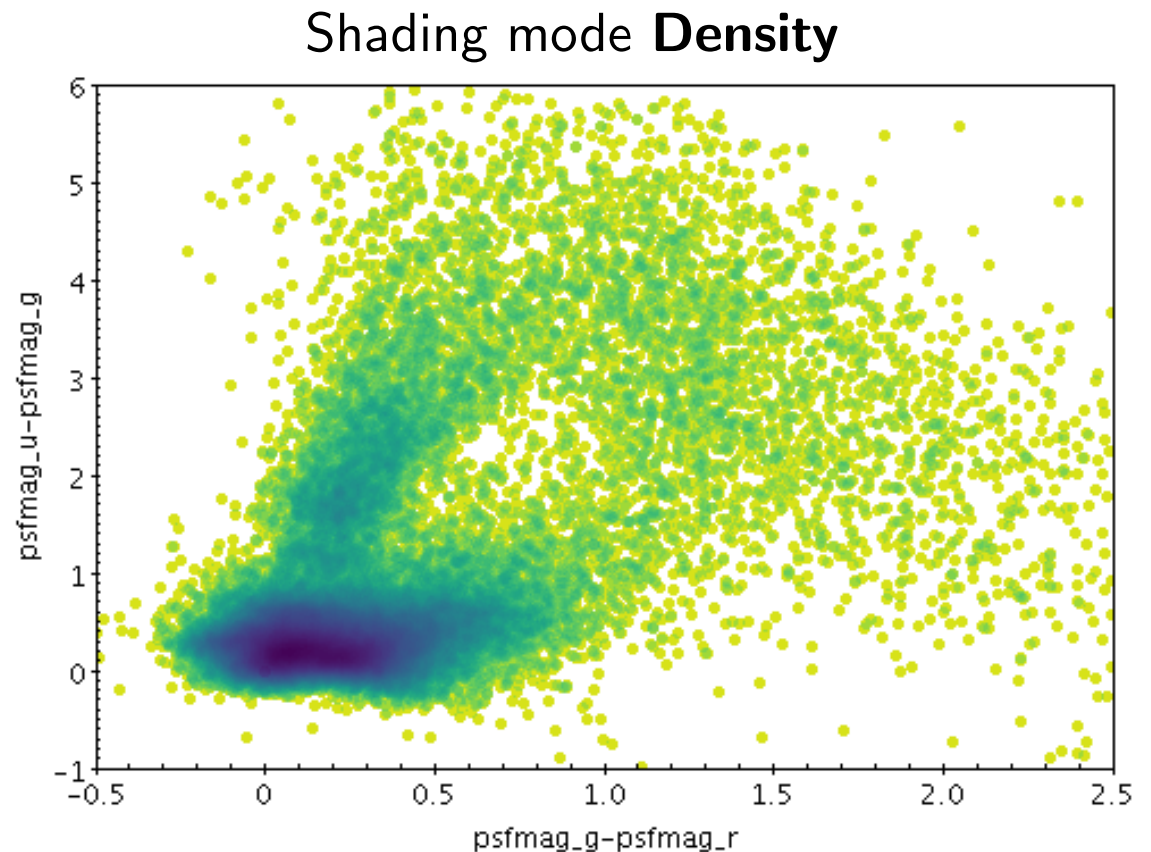 ... especially since there are lots of options

Shading mode **Auto**

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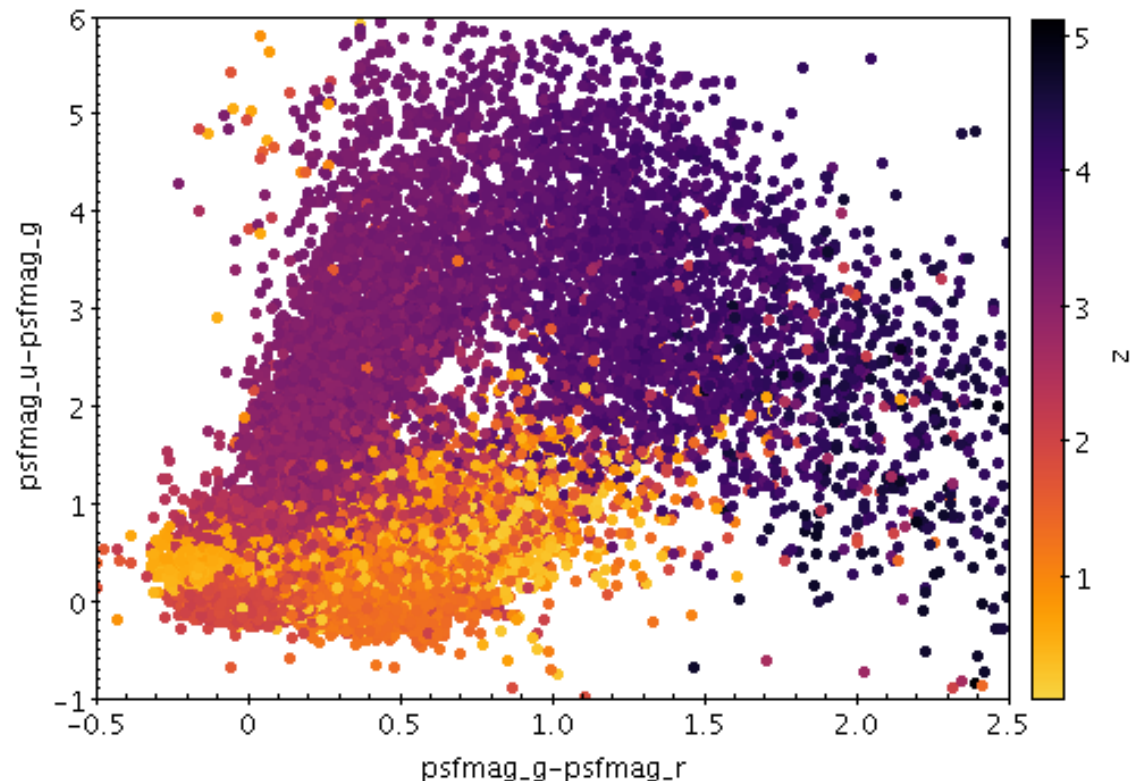## Shading mode **Density**

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Shading mode **Aux**

Improved Documentation

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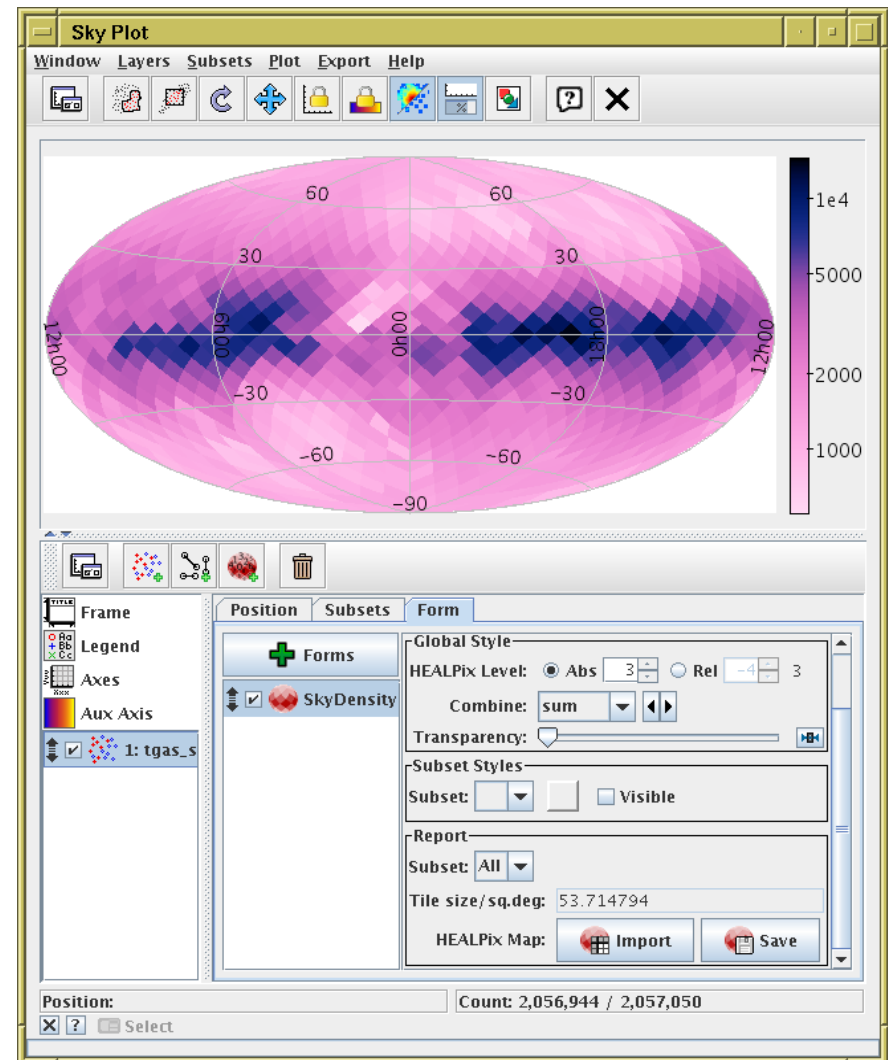 ... especially since there are lots of options

Shading mode **Weighted**
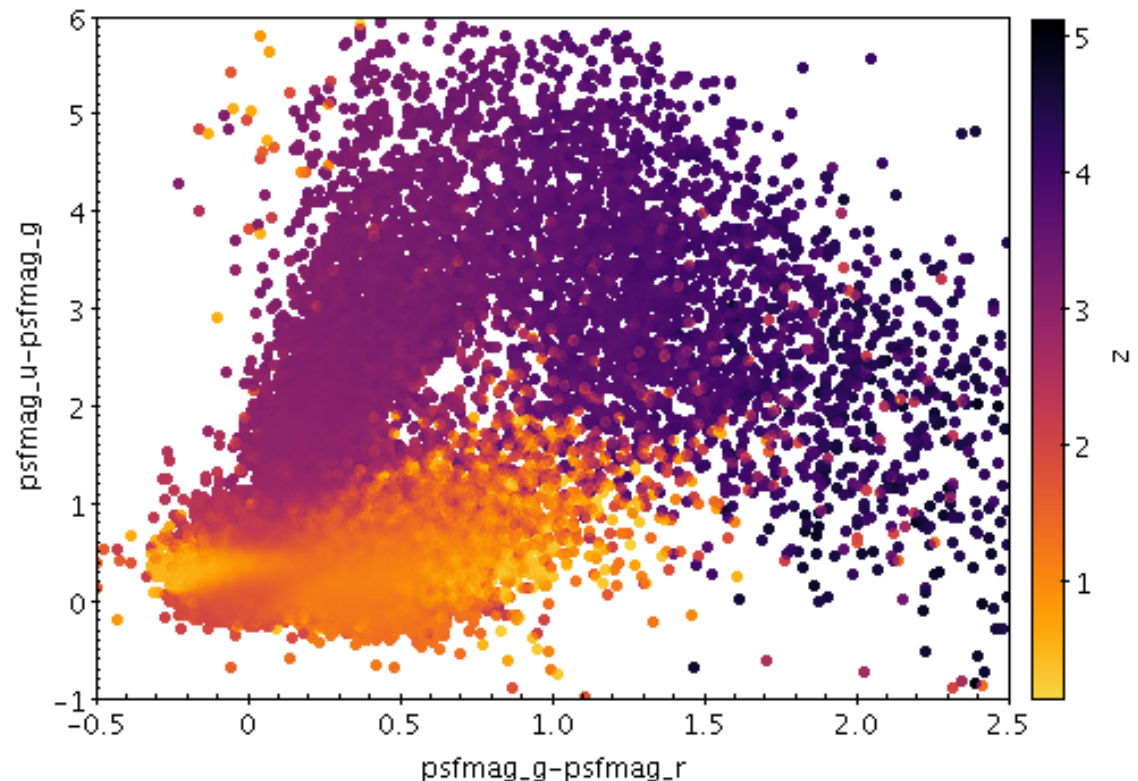
Plot data export

Some plots can now export table data

- Some plot types calculate tabular data while running:
  - ▷ Histogram plot
  - ▷ SkyDensity layer

- It can be useful to analyse this, not just view it in a plot

Plot data export

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  - ▷ Histogram plot
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- Actions in the **Export** menu & **Report** panel let you use such tables
  - ▷ **Save** to disk as a table
  - ▷ **Import** into TOPCAT's table list

- In some cases you can feed them back to other plot types
  - ▷ SkyDensity → Healpix
  - ▷ Histogram → Fill

- More exporting layer types in future?
  - ▷ **Grid** layer
  - ▷ **Histogram** layer (in Plane/Time plots)
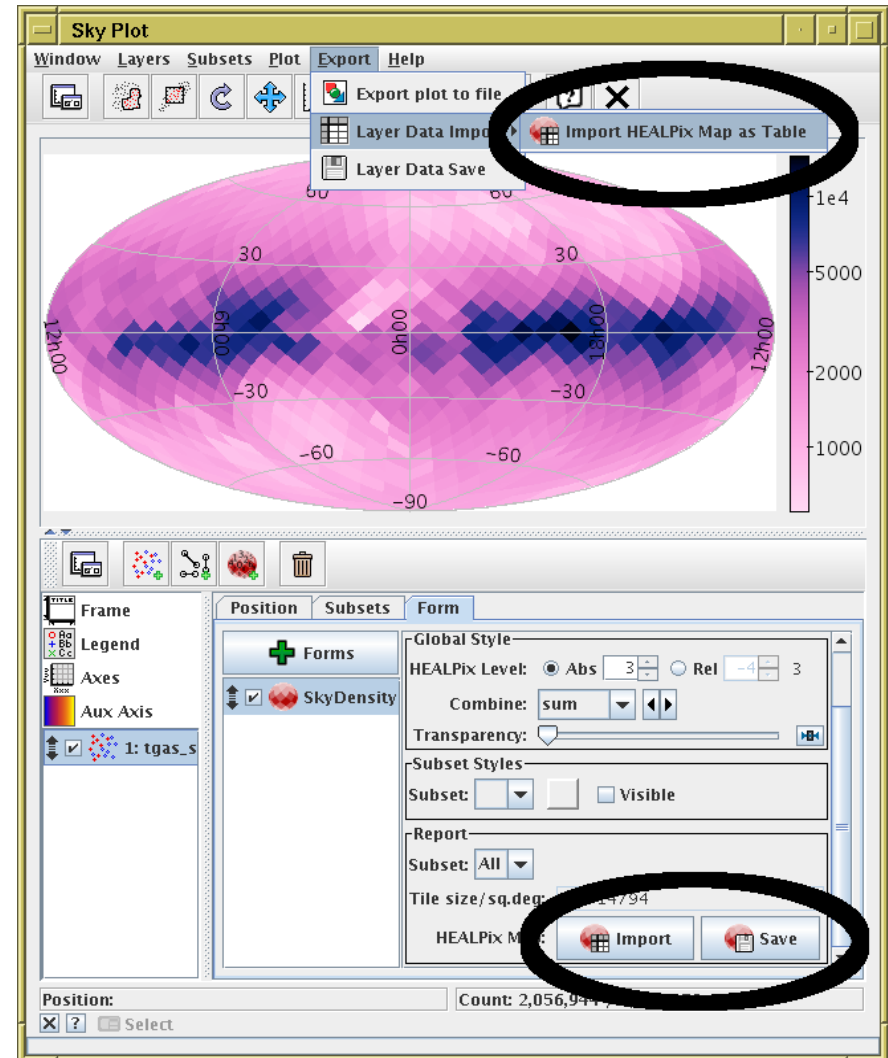
Concerns

- Usability

  - Are there just too many options now? Will there be if I add more things?
  - Some plot types (e.g. Fill, Quantile, Grid) are hard to explain/understand
  - Documentation helps, but people have to read it...

- Metadata markup issues

  - Time columns
    - ▷ hard (impossible?) to mark columns as, e.g., MJD in VOTable

  - HEALPix columns
    - ▷ impossible to mark column as HEALPix with given [*order*, *scheme*, *skysys*]

Future Plans

- ## Major functionality planned

  - TOPCAT/STILTS integration
  - Visualisation multithreading

- ## Other possible enhancements

  - More plotters
    - ▷ Correlation-based error ellipses (`gaia_source`-style)
    - ▷ RGB density plot?
    - ▷ Grand smoothed 2d KDE/density map?

  - More work on Time plot?
    - ▷ is there interest from VO Time Domain work? ESFRI projects?
    - ▷ not clear what's required/whether TOPCAT is the right tool

  - Extend multi-zone to non-Time plot types?
  - Sky coverage visualisation/manipulation? (MOC, STC)
  - Scatter plot matrix?
  - *... lots more ideas ...*
  - *... but try not to make it even harder to use/understand*