STILTS Server-Side Visualisation

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Outline

- Visualisation in TOPCAT/STILTS
- New server-side capabilities
- Usage possibilities

TOPCAT Visualisation

- Highly configurable
  - Plane, sky, 3D, ...
  - Scatter plot, histogram, vector, ellipse, contour, polygon, label, KDE, spectrogram, ...
  - Colours, colour maps, shapes, shading options, line style, ...
  - Plot coordinates & selections can be calculated on the fly using rich expression language
- Highly interactive
  - Pan/zoom/rotate with mouse
  - GUI controls to adjust all config options
  - Immediate visual feedback
- Scalable
  - Fast plotting
  - Low memory usage
  - Since v3.2 (Nov 2019), plotting is multithreaded
  - Copes with large data sets: $\sim 10^7$ rows on modest hardware

~~TOPCAT~~ STILTS Visualisation

- Highly configurable
  - Plane, sky, 3D, ...
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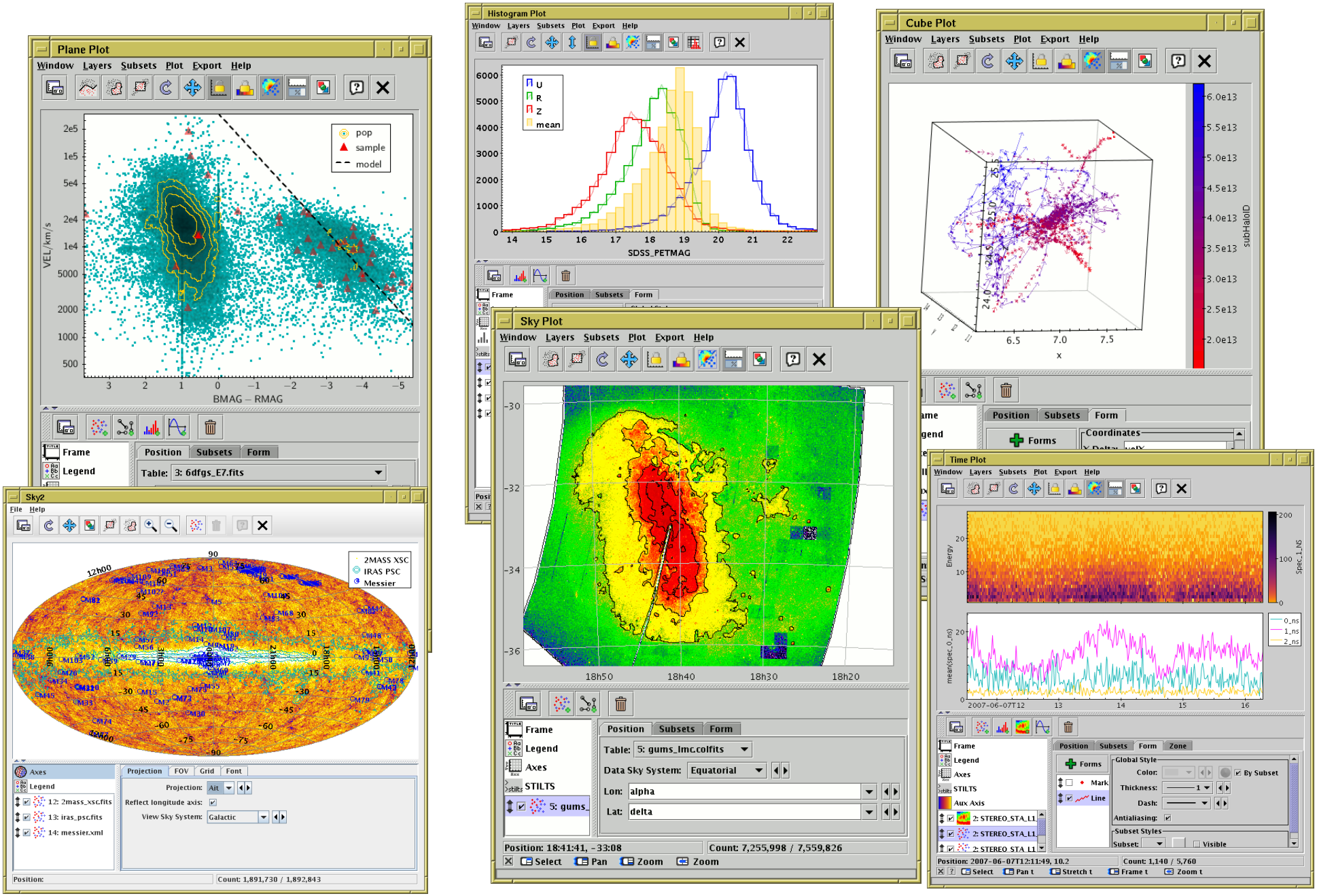
  - Immediate visual feedback
- Scalable
  - Fast plotting
  - ~~Low~~ Fixed low memory usage
  - Since v3.2 (Nov 2019), plotting is multithreaded
  - Copes with large data sets: $\sim$~~10^7~~ 10^8 rows on modest hardware (or more, but slow)

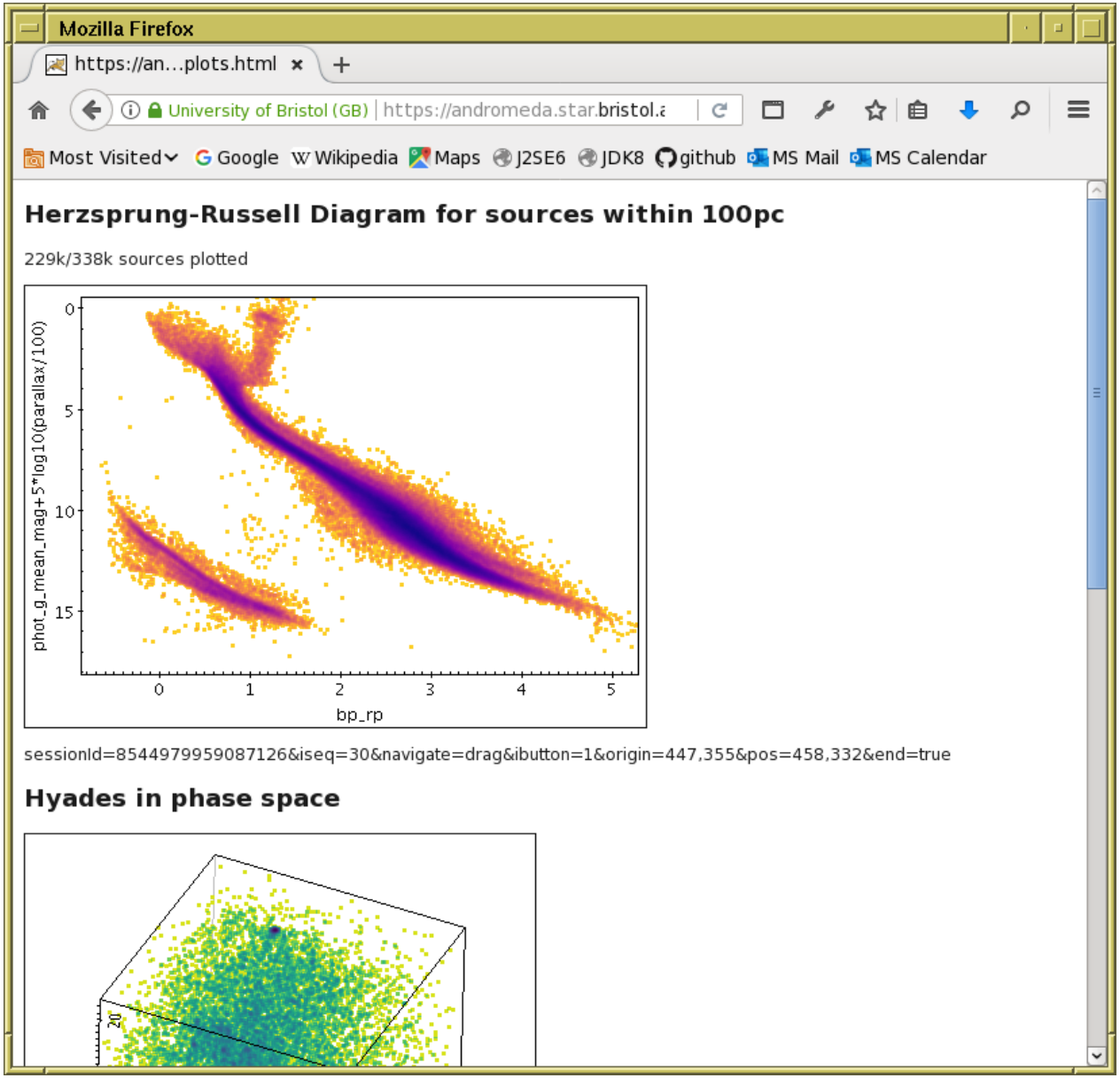

Plane Plot
Window Layers Subsets Plot Export Help
pop
sample
model
VEL/km/s
BMAG – RMAG
Frame
Legend
Position Subsets Form
Table: 3: 6dfgs_E7.fits
Histogram Plot
U
R
Z
mean
SDSS_PETMAG
Cube Plot
subHaloID
Sky Plot
Table: 5: gums_lmc.colfits
Data Sky System: Equatorial
Lon: alpha
Lat: delta
Position: 18:41:41, -33:08
Count: 7,255,998 / 7,559,826
Sky2
2MASS XSC
IRAS PSC
Messier
Projection: Ait
Reflect longitude axis:
View Sky System: Galactic
Position:
Count: 1,891,730 / 1,892,843
Time Plot
Energy
mean(spec_0_ns)
Position: 2007-06-07T12:11:49, 10.2
Count: 1,140 / 5,760

Server-Side STILTS

STILTS can run on server side

- Runs near (large) table data
- Returns output table/image files to client over HTTP
- `stilts server` command or as servlet
- Available for static plots since several years
  - not much used to date?

New: Interactive Server-Side Plots



http://andromeda.star.bristol.ac.uk:8081/plotserv

Implementation Details

Design:

- Image files generated on server side from server-side tables
- Minimal HTML+js on client side: updates `IMG/@src` URL on user mouse events
- All TOPCAT/STILTS plotting options available
- All TOPCAT navigation actions: 2D and 3D pan, zoom, stretch, frame, re-center; resize
- Full-resolution image regenerated from data each frame
- Smart caching used to speed up replots (as in TOPCAT/STILTS)
- Interactive performance is fair to middling (good enough for data exploration)

Server requirements

- Data files in FITS (or other STIL-friendly format — even JDBC)
  — no data preparation or indexing required
- Disk cache, small or large (caches prepared column data and initial image on first plot)
- CPU (multiple cores good) & disk I/O (SSDs good)
- Server/servlet setup (.war file in Tomcat or standalone server)

Client requirements

- Any browser
- Minimal resource usage: low CPU, low memory, fairly low bandwidth
- Good network latency helps though

Example HTML

```
<html><body>
<script src="plot2Lib.js">
<script>
   onload = function() {
      var serverUrl = "plot";
      var plotNode = plot2.createPlotNode(serverUrl, plot2.wordsToPlotTxt([
          "plot2plane",
          "in=hrd-100pc.fits",
          "yflip=true",
          "icmd=select astrometric_excess_noise<1",
          "icmd=select phot_bp_rp_excess_factor<" +
                "polyLine(bp_rp,-0.56,1.307,0.03,1.192,1.51,1.295,4.31,1.808)",
          "layer1=mark",
          "x1=bp_rp",
          "y1=phot_g_mean_mag+5*log10(parallax/100)",
          "shading1=density",
          "densemap1=plasma",
      ]));
      document.getElementById("hrd-plot").appendChild(plotNode);
      ...
   }
</script>

<h2>Herzsprung-Russell Diagram for sources within 100pc</h2>
<p>229k/338k sources plotted</p>
<div id="hrd-plot"></div>
   ...
</body></html>
```

http://andromeda.star.bristol.ac.uk:8081/plotserv

Usage Possibilities

- General suitability:
  - Interactive browser plots of potentially large ($>10^5$ row?) server-side tables
    — for relatively small tables there are other/better solutions (Plotly? D3? ...?)
- Single instance on server
  - Custom interactive visualisations of fixed large tables
  - Visualisation of TAP async results before download
  - Preconfigured example plots for complex data sets
- Instance per science platform session
  - Session provides endpoint to make interactive plots of tables saved in user space
  - Users can visualise their saved tables without downloading data
  - Jupyter integration?
    - ▷ Python command sets up plot of user-saved tables, interactive result displayed in notebook
- Other possibilities?

Future Development

- General
  - Security, performance, documentation, server configurability, more examples ...
- Add plot decorations
  - Navigation UI help
  - Additional controls (e.g. graphic file export)
- Improve navigation GUI
  - Visual feedback on mouse gestures like in TOPCAT
- Additional plot controls
  - GUI to change non-navigation config options (colours, colourmaps, marker shape, ...)
- Additional table interaction options
  - Subset selection

    $\longrightarrow$ *TOPCAT-lite???*

(Some enhancements may need `XMLHttpRequest`-based redesign)

Current Status

- Working in prototype
  - Not in public STILTS release
  - Still under development
  - Available for experimental use
  - Missing features, underdocumented, not well tested, security holes
- Solution looking for an problem
  - Future development awaiting more concrete requirements
  - Does anybody (data/service provider) want to deploy something like this?
  - Are there specific requirements?

http://cdsxmatch.u-strasbg.fr/plotserv/
http://andromeda.star.bristol.ac.uk:8081/plotserv
http://andromeda.star.bristol.ac.uk/misc/plotserv/