The Pan-STARRS Archive at STScI

Armin Rest
Rick White
Brian McLean
Bernie Shiao
Anton Koekemoer
Knox Long
Jeff Valenti
Lou Strolger
and the STScI/JHU PS1 team

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The PS1 public archive

• STScI will provide the public archive for PS1 data
• Planned services:
  – Catalog access
    • Simple form interface
    • Web services (including VO-compatible interfaces)
    • SQL query interface
  – Image access
    • Whole images
    • Image cutouts either as FITS files or JPEG previews
    • Interactive display
  – We will use products from the PS1 project with existing tools developed by MAST and PS1
MAST and Pan-STARRS

• Pan-STARRS is not a MAST-funded project!
  – STScI research funding for archive development; NSF funding requested for long-term operations

• PS1 images & database are large compared with current MAST data holdings
  – GALEX photon database is ~150 TB
    • Larger than PS1 but simpler data
  – Total MAST holdings currently ~ 300 TB
    • PS1: ~ 2000 TB
    • Large future missions: JWST (4 PB), WFIRST-AFTA (9 PB)

• MAST is very heavily used
  – > 5000 users, 1 million searches/month, 18 TB/month downloaded

• Requires a new scale of infrastructure, but MAST experience is relevant
PS1 data @ STScI: Images

- Coadded stacked images and single-epoch warps
  - All PS1 surveys will be included:
    - 3PI (30,000 sq deg north of declination -30°)
    - Medium Deep Surveys (10 fields, 7 sq deg each)
    - Celestial North Pole, Ecliptic Plane, M31
  - Images dominate total data volume (mainly 3PI, MDS)
    - Total data volume without difference images ~ 1.8 PB
  - Includes auxiliary images (wt, expwt, exp, mask, num)
PS1 data @ STScI: Catalogs

• Catalog databases
  – Including stack detections, single-epoch detections, forced photometry & objects (linking multiple epoch detections)
  – High-quality photometry and astrometry
  – Total database volume ~100 TB

    • Most database volume is in single-epoch detections
    • 3PI database (PV1: ~90% of 3PI sky area, still incomplete in plane):
      – 29.4 x 10^9 detections
      – 5.9 x 10^9 objects
      – 1.4 x 10^9 objects with nDetections > 1
      – For comparison, SDSS DR9: 469 M objects (14,000 sq deg)
## PS1 3π survey versus SDSS

<table>
<thead>
<tr>
<th></th>
<th>SDSS</th>
<th>Pan-STARRS 3π</th>
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</thead>
<tbody>
<tr>
<td><strong>Sky area</strong></td>
<td>10,000 sq deg</td>
<td>30,000 sq deg</td>
</tr>
<tr>
<td><strong>Sky region</strong></td>
<td>High Galactic latitude</td>
<td>δ &gt; -30°, includes Galactic plane</td>
</tr>
<tr>
<td><strong>Filters and Magnitude limits</strong></td>
<td>u 22.5</td>
<td>g 23.4</td>
</tr>
<tr>
<td></td>
<td>g 23.2</td>
<td>r 23.2</td>
</tr>
<tr>
<td></td>
<td>r 22.6</td>
<td>i 22.7</td>
</tr>
<tr>
<td></td>
<td>i 21.9</td>
<td>z 22.0</td>
</tr>
<tr>
<td></td>
<td>z 20.8</td>
<td>y 21.1</td>
</tr>
<tr>
<td><strong>Median Seeing FWHM</strong></td>
<td>1.3”</td>
<td>1.1”</td>
</tr>
<tr>
<td><strong>Cadence</strong></td>
<td>1 epoch</td>
<td>12 epochs per filter</td>
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PS1 Relative Photometric Calibration:

- Uebercal (Finkbeiner, Schlafly):
  - Relative photometric calibration observations of PS1
- Differences between SDSS and PS1
- SDSS issues: stripes, north-south offsets
- PS1 issues: squares

RA in Degrees

Dec in Degrees

PS1 Issue: white spots due to 2 bad chips that will be masked
SDSS Issue: sets of 6 dark spots are clouds or contrails in SDSS
PS1 Relative Photometric Calibration: Ubercal

- Ubercal (Finkbeiner, Schlafly): use repeat observations of PS1
- Differences between SDSS and PS1
- SDSS issues: stripes, north-south offsets
- Systematics down to 2-3 mmag!
3PI Object counts, nDetections>2
1.10×10^9 objects
3PI g/r/y mean colors
4.57x10^8 objects
3PI g/r/y mean colors
4.57x10^8 objects

Galactic plane
North Equatorial Cap
Dec = -30°
Survey Limit
Status of archive preparations

• 2 PB of disks purchased for image storage
  – Located at Hawaii for use in data processing
  – Will be shipped back to STScI (with data) in January 2015

• Database servers purchased & are now set up
  – Faster, more memory & cores than the current PS1 database machines in Hawaii
  – Current database was transferred via network and is available to PS1 science consortium
  – Final database will be copied in 2015
### High-level schedule

<table>
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<tr>
<th>STScI Specific PS1 Milestone</th>
<th>Timeframe</th>
<th>Pan STARRS Project-Wide Milestone</th>
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<tbody>
<tr>
<td>1 PB of STScI disks delivered to Hawaii</td>
<td>2012 May</td>
<td></td>
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<tr>
<td>1 PB of disks delivered to Hawaii</td>
<td>2013 June</td>
<td></td>
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<tr>
<td>DB &amp; image subsets at STScI for experiments</td>
<td>2013 November</td>
<td></td>
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<tr>
<td></td>
<td>2014 April</td>
<td>Pan STARRS observations complete</td>
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<tr>
<td>Database servers purchased</td>
<td>2014 May</td>
<td>PV1 database complete; PV3 processing begins</td>
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<tr>
<td>Pan-STARRS workshop (@STScI)</td>
<td>2014 June</td>
<td>Pan-STARRS consortium meeting (@STScI)</td>
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<tr>
<td>PV2 database copied to STScI</td>
<td>2014 December</td>
<td>PV2 database complete</td>
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<tr>
<td>Prototype DB and image interfaces available for consortium testing at STScI</td>
<td>2015 January</td>
<td>PV3 images complete</td>
</tr>
<tr>
<td>2 PB data-loaded disks shipped from Hawaii; PV3 database copied to STScI</td>
<td>2015 January</td>
<td>PV3 database complete</td>
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<tr>
<td>All disks arrive at STScI, hardware and software integration begins</td>
<td>2015 February</td>
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<tr>
<td></td>
<td>2015 April</td>
<td>Public archive opens (1 year after end of obs)</td>
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- PV1, PV2, PV2 are versions of the image & catalog processing
- PSPS is the PS1 object catalog database
- Post-ship schedule is optimistic; might release DB only to start, images later
Sample PS1 image using HLA tools

Simple cutout search page for SAS2 + MDS field demo
MAST Portal Catalog/Image Interface

• Hubble Source Catalog portal interface will be adapted for PS1
  – Similar structure: multi-epoch, multi-filter observations integrated with image database
  – Cutout services, interactive display, etc., are also being used for PS1

• MAST will incorporate & benefit from PS1 data
  – PS1 images are a better background for AstroView
  – Current PS1 catalog is already being used as a deep astrometric reference catalog for HSC

Note: Current PS1 catalog was used as astrometric reference for Hubble Source Catalog v0.3
Summary

• STScI archive will provide an integrated interface for access to PS1 catalogs & images
  – Reuse existing MAST and current PS1 databases and interfaces wherever possible
• MAST will utilize PS1 images and catalogs to improve our other data products
• Pan-STARRS is a step into big data for MAST
  – Valuable experience for future multi-petabyte datasets including JWST, WFIRST
EXTRA SLIDES
Confluence is being used to describe sample PS1 database queries in detail.

Catalog Cross-Matching (Rick White)

Part of my science project requires doing a cross-match between the FIRST catalog and the PS1 data. I started with Jim Heasley’s example on the PSFS sample query page, but I have made significant improvements.

2. Run the cross match

On the Query Page, select the database (e.g., PanSTARRS_SAS21) and run this query:

```
DECLARE @size FLOAT = 5.0/3600.0;

SELECT f.search_id AS source_id, f.ra AS source_ra, f.dec AS source_dec, o.*
INTO mydb.[first_sas21]
FROM mydb.firstsas3 f
CROSS APPLY dbo.FltmGetObjFromRectEq(f.ra-@size/cos(radians(f.dec)), f.dec-@size, 10.0, @size/cos(radians(f.dec)), f.dec+@size, 10.0, @size/cos(radians(f.dec)), f.dec) t
JOIN Object o ON o.objID=t.objID
```
Data products not @ STScI

• Difference images
  – Data volume large, probably fast enough to generate them on-the-fly

• Convolved images
  – Images convolved to match PSFs
  – Have not reached quality of unconvolved images (yet)
  – Could also be generated on demand

• Raw data
  – STScI will not run image processing pipeline