Rubin Observatory

LSST Solar System Processing Pipeline

Siegfried Eggl, Mario Jurić, Joachim Moeyens, Lynne Jones, AP team

Solar System Processing Pipeline

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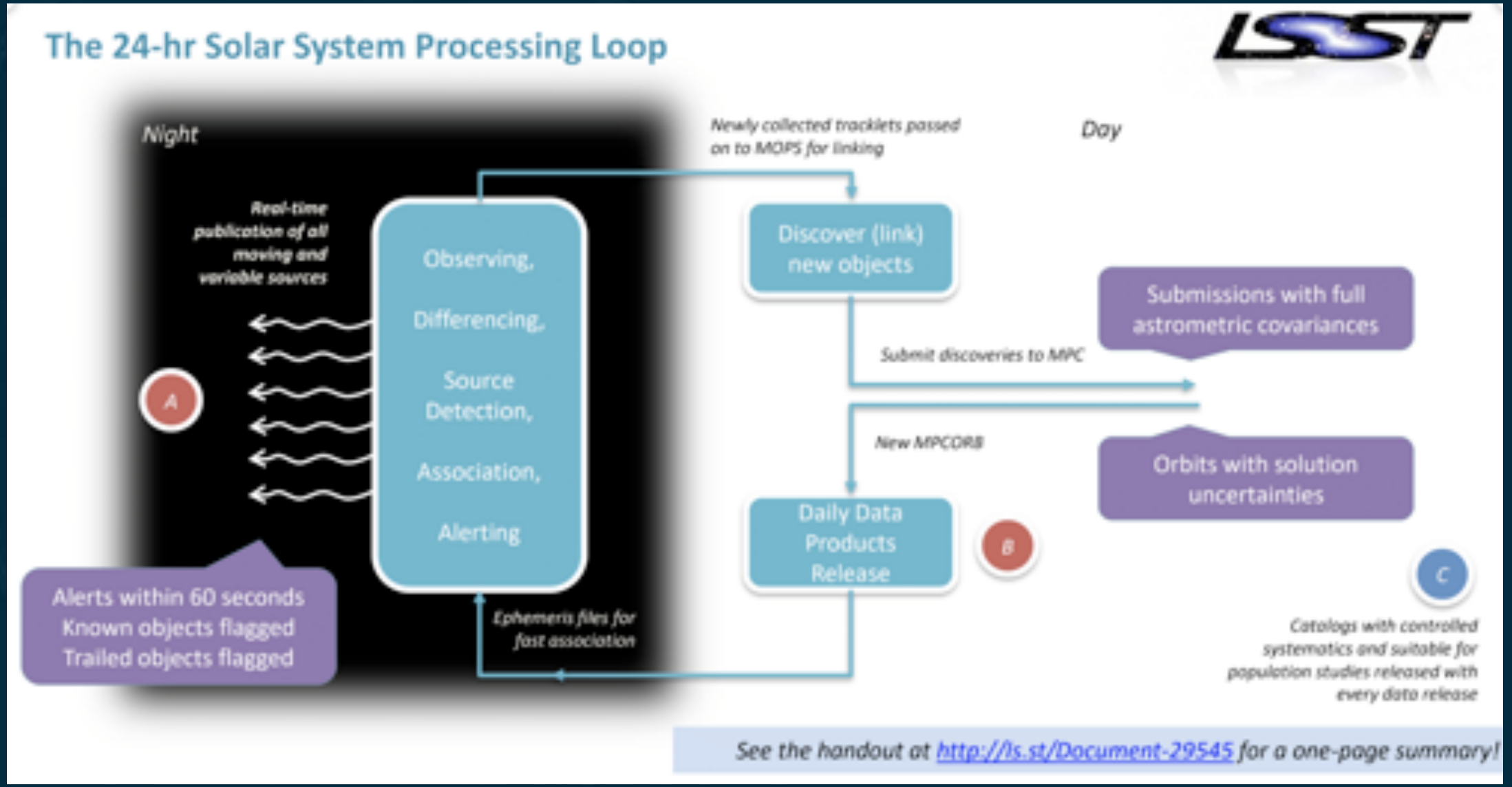
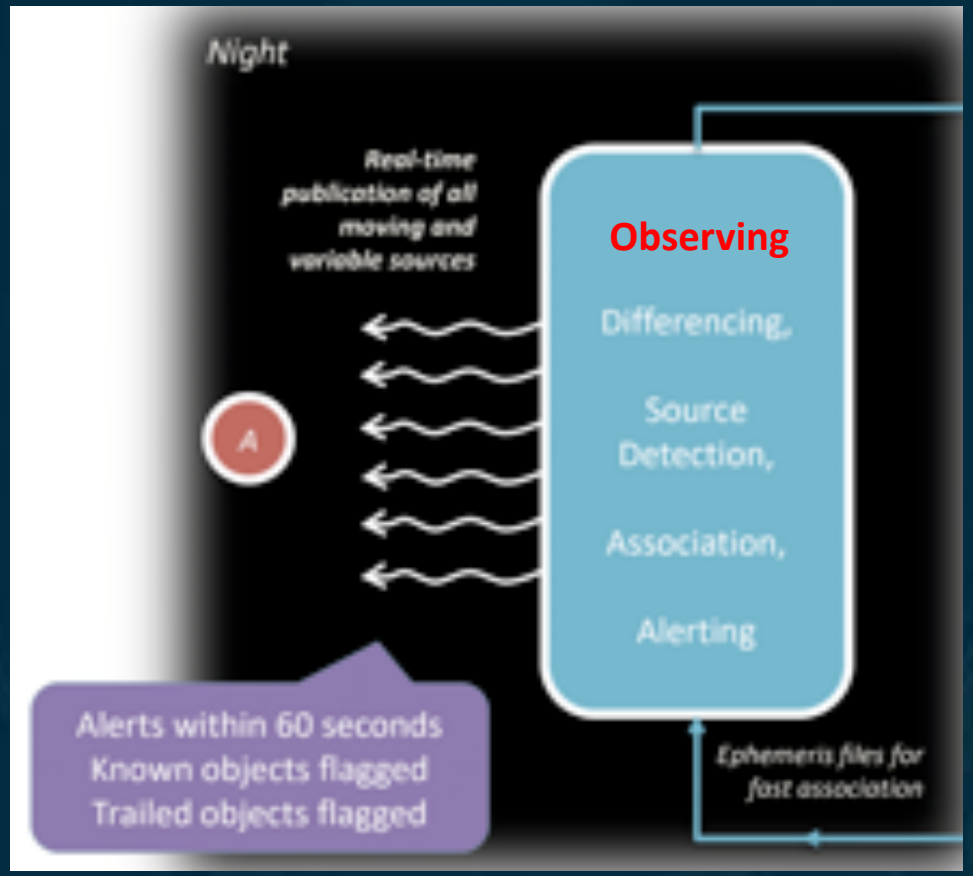
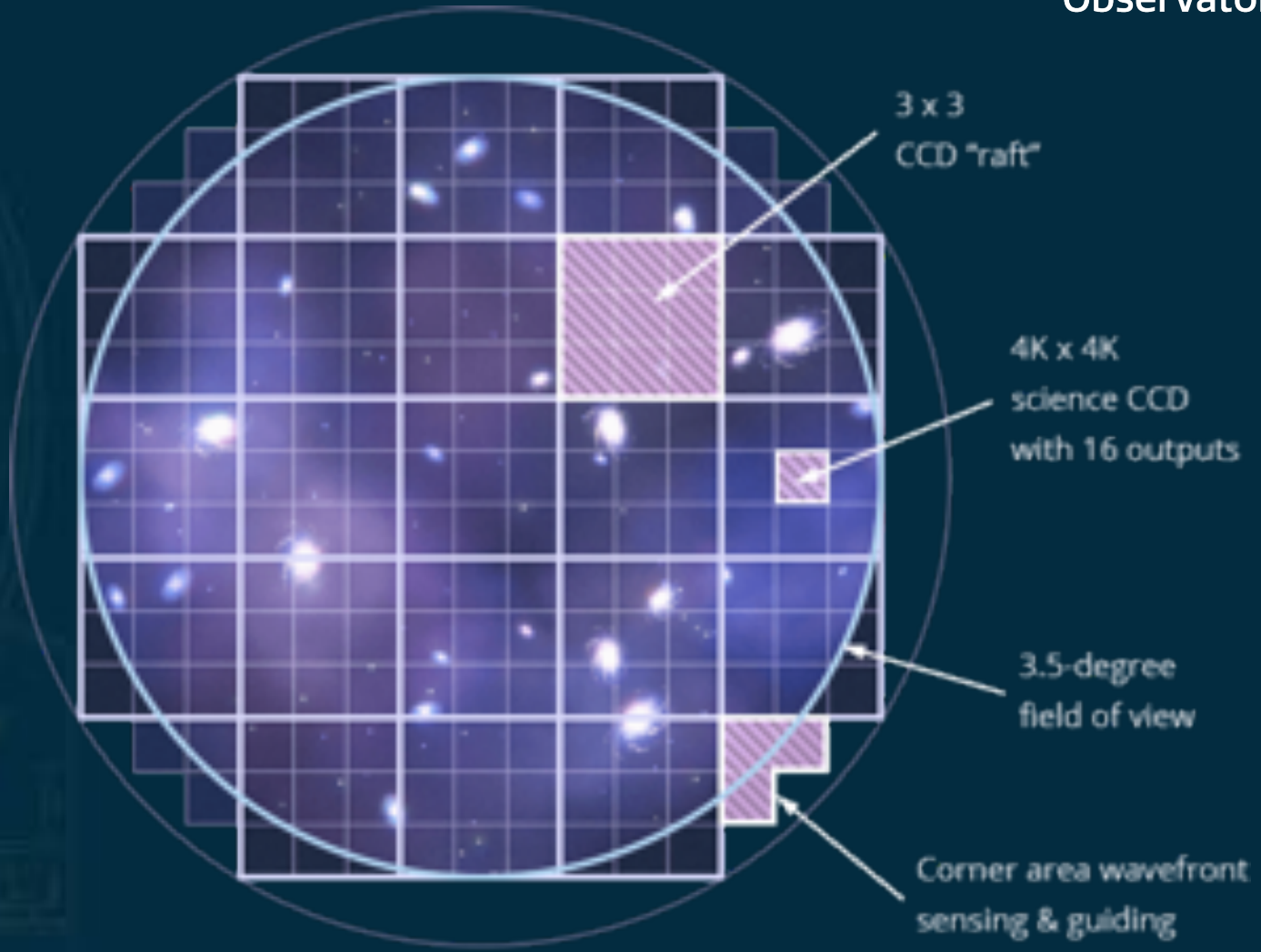


Solar System Processing

Rubin Observatory





Alert Production Team

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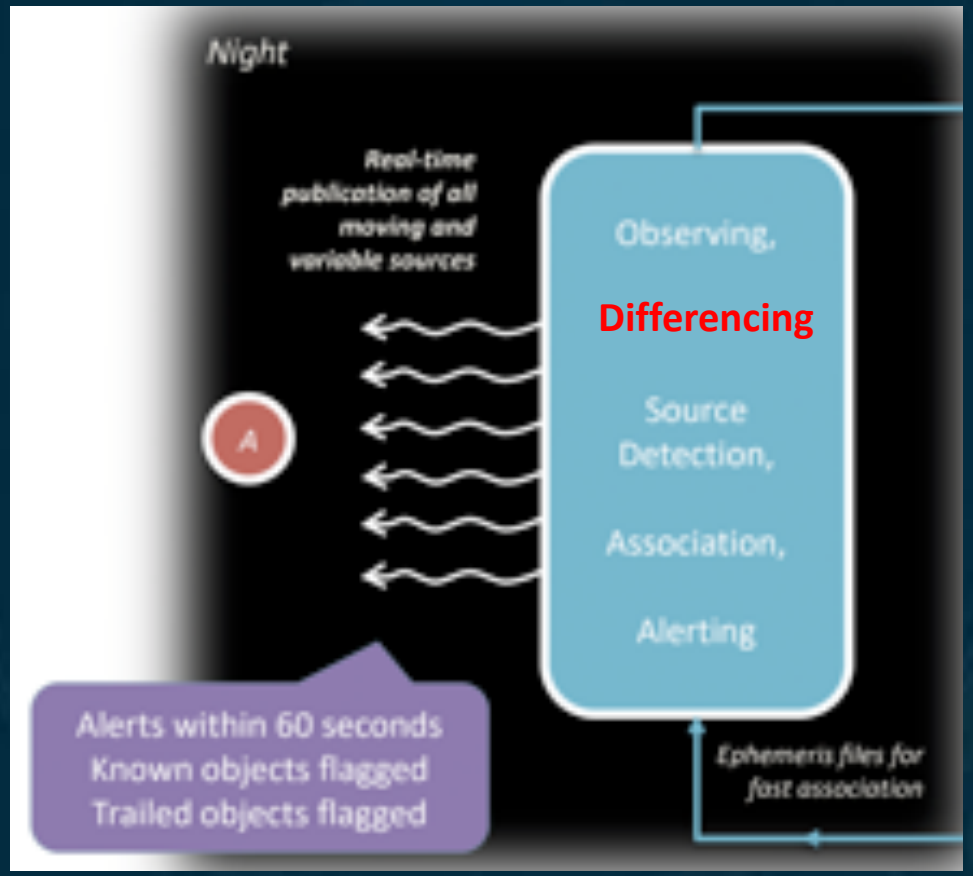

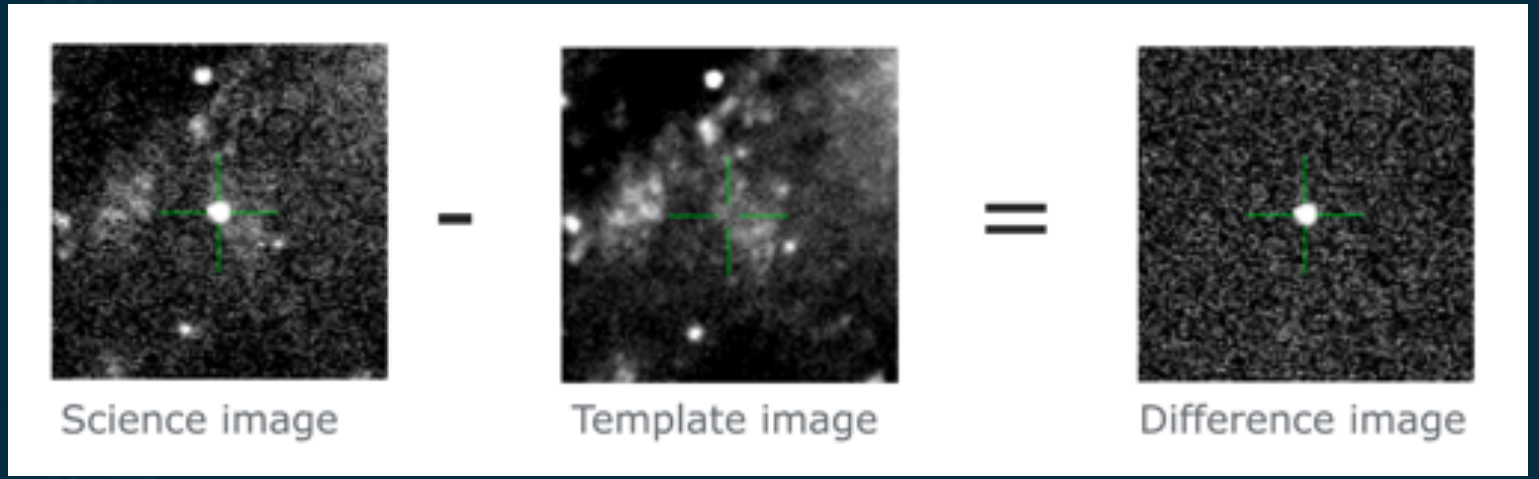

Bellm et al. (2020)

Alard & Lupton + ZOGY algorithms.
Incremental template construction during year 1.

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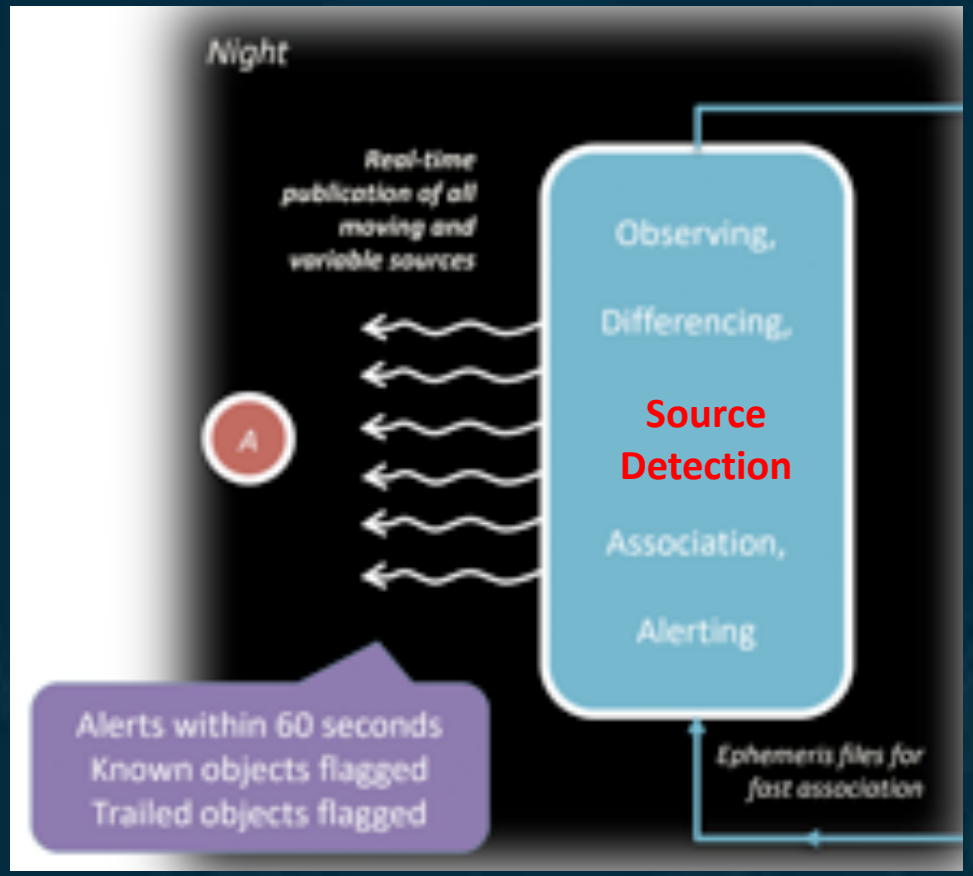

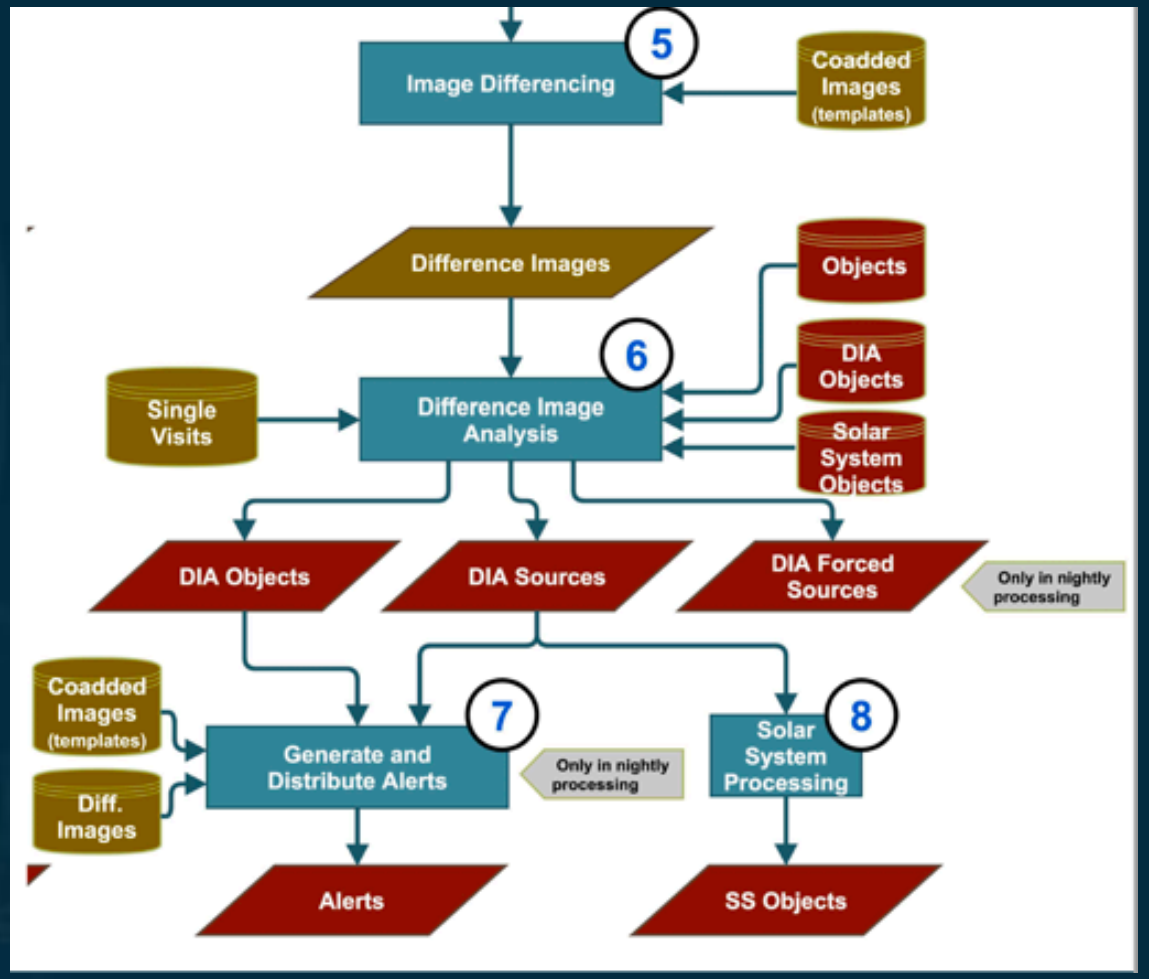

Bellm et al. (2020)

Test: DECam HITS dataset

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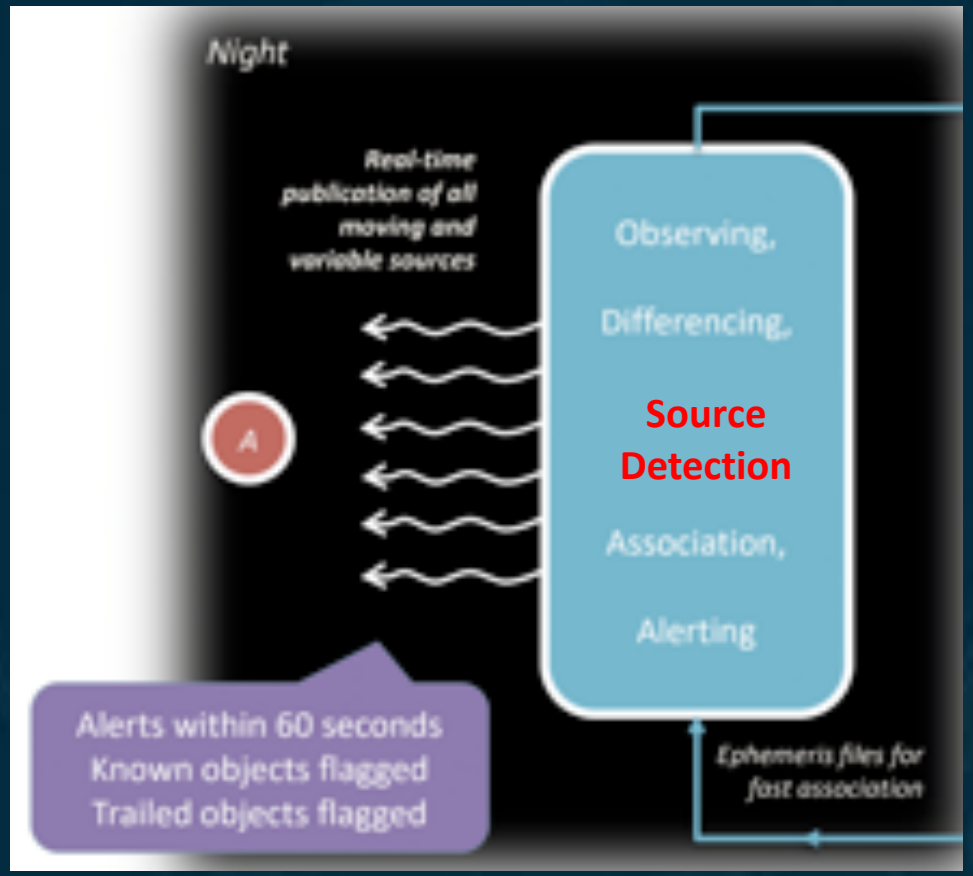
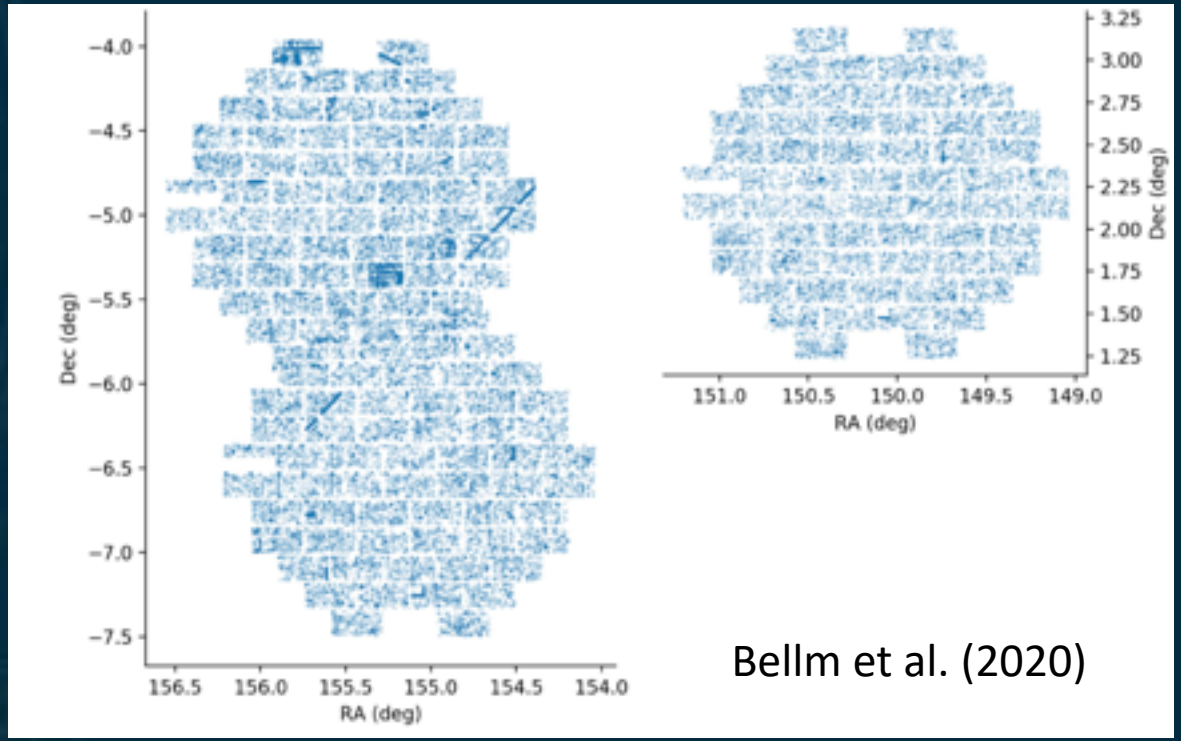


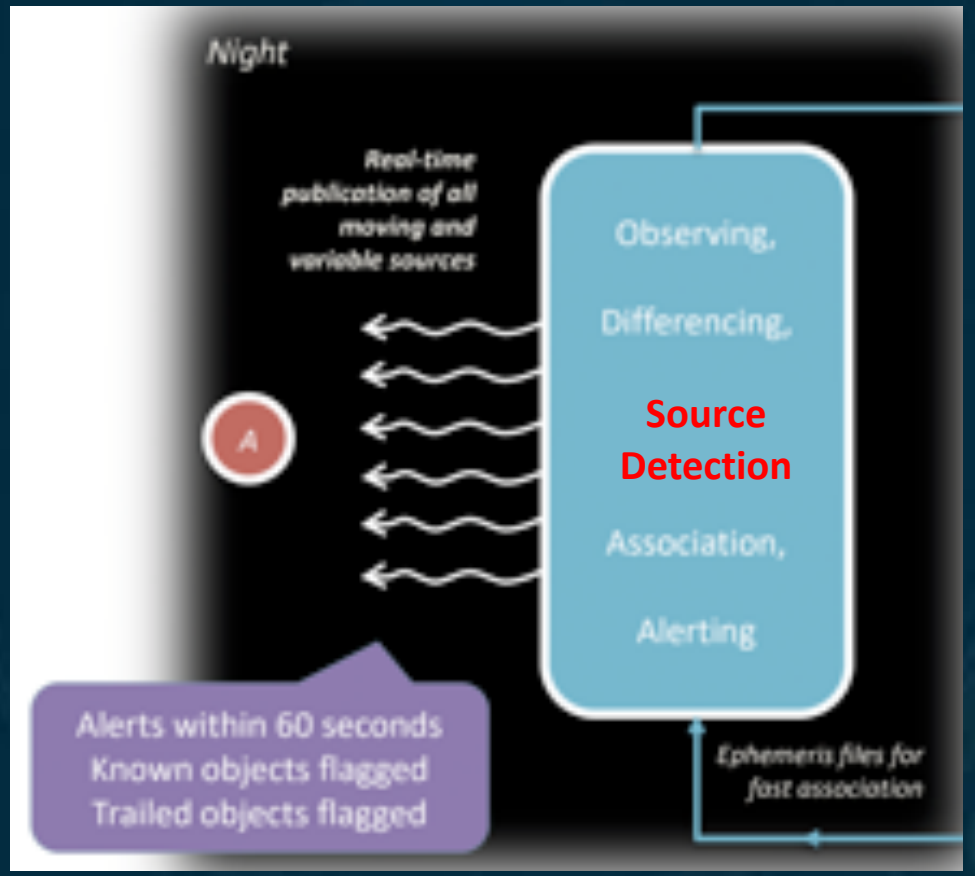
3 multi-season DECam field, g-band 4-5 visits/night for 1 week in 2015

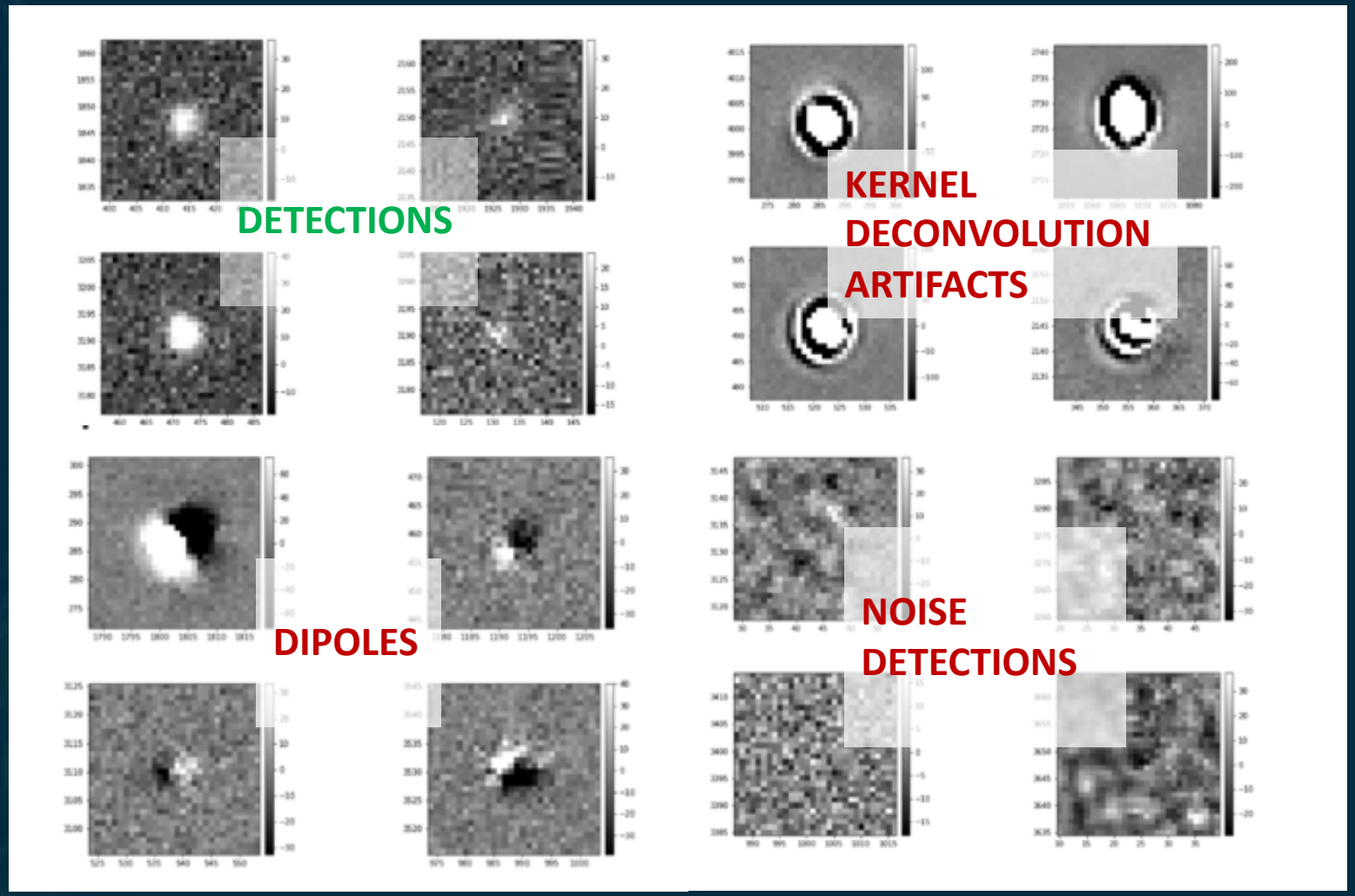


Bellm et al. (2020)

Test: DECam HITS dataset

Rubin Observatory





Bellm et al. (2020)

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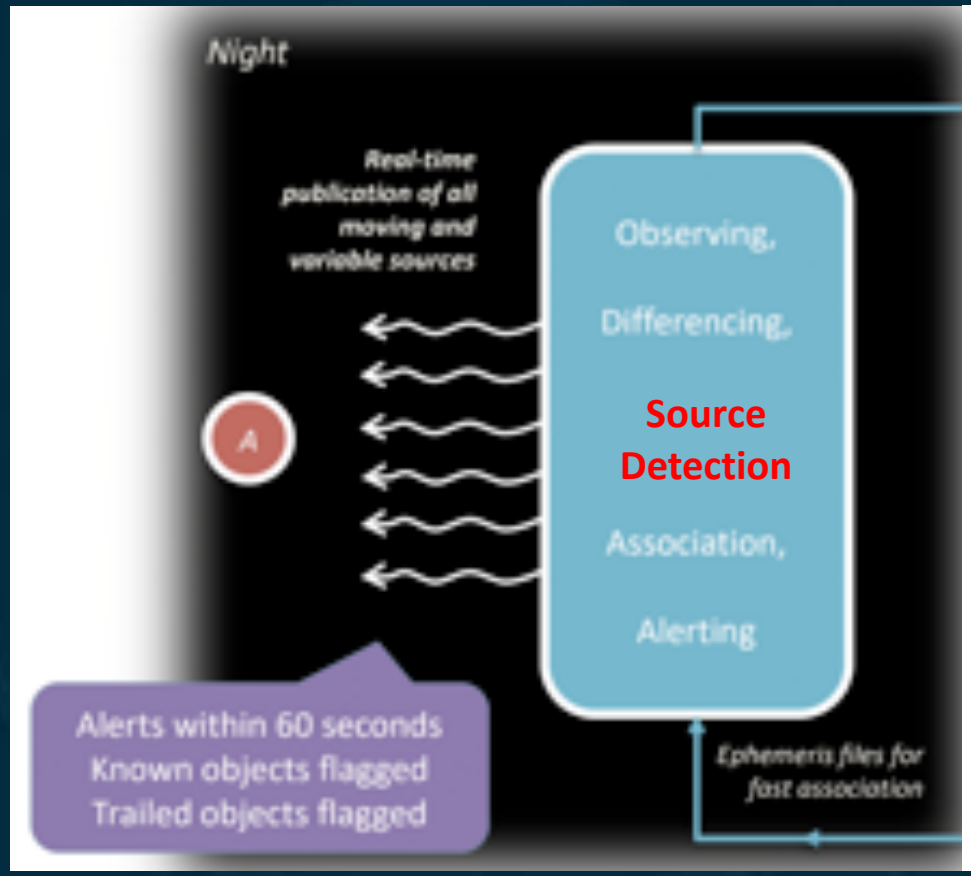
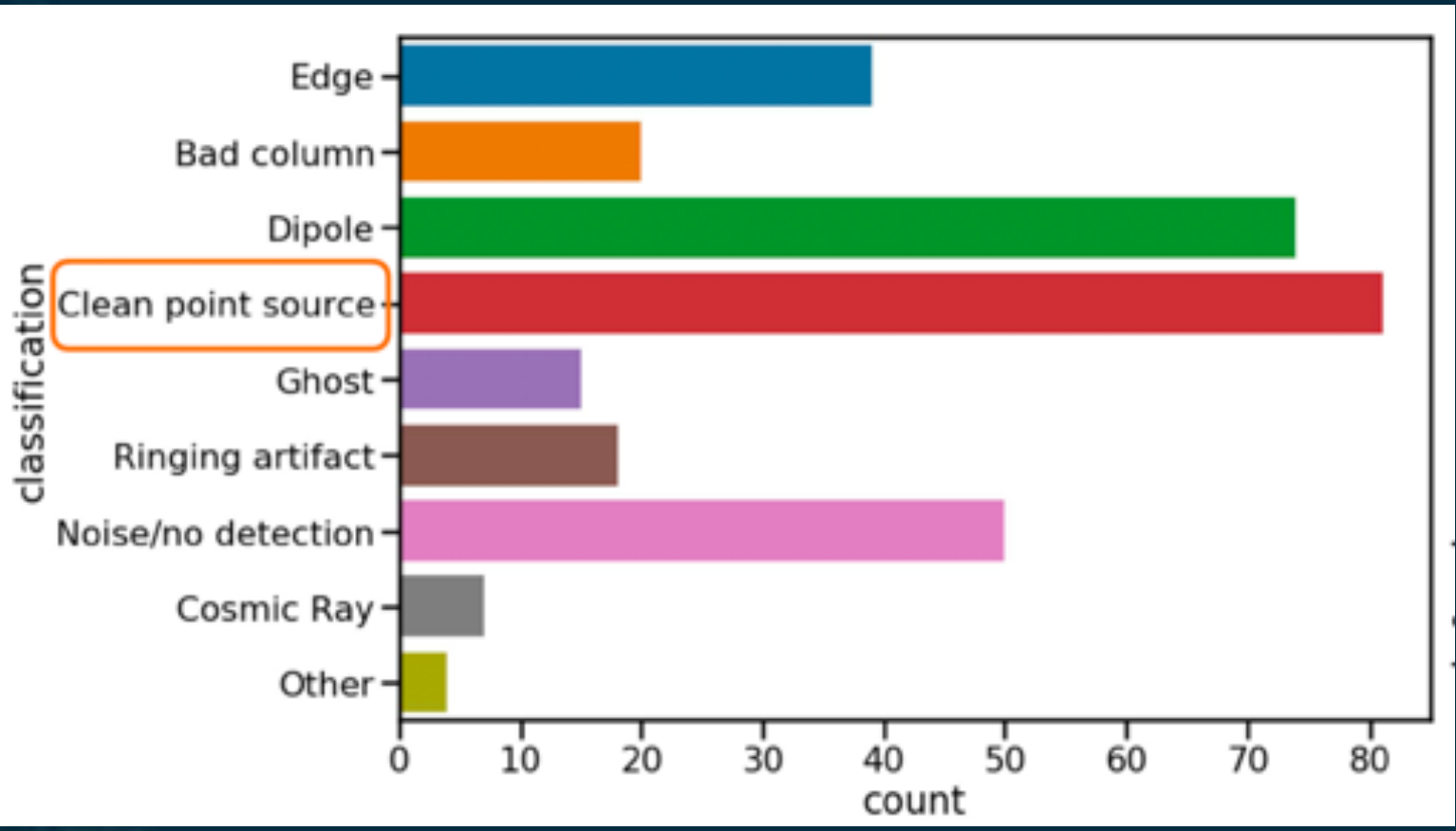
For all DIA sources current FD/clean ratio of ~ 3:1. Final performance likely better.





Bellm et al. (2020)

Solar System Processing Pipeline

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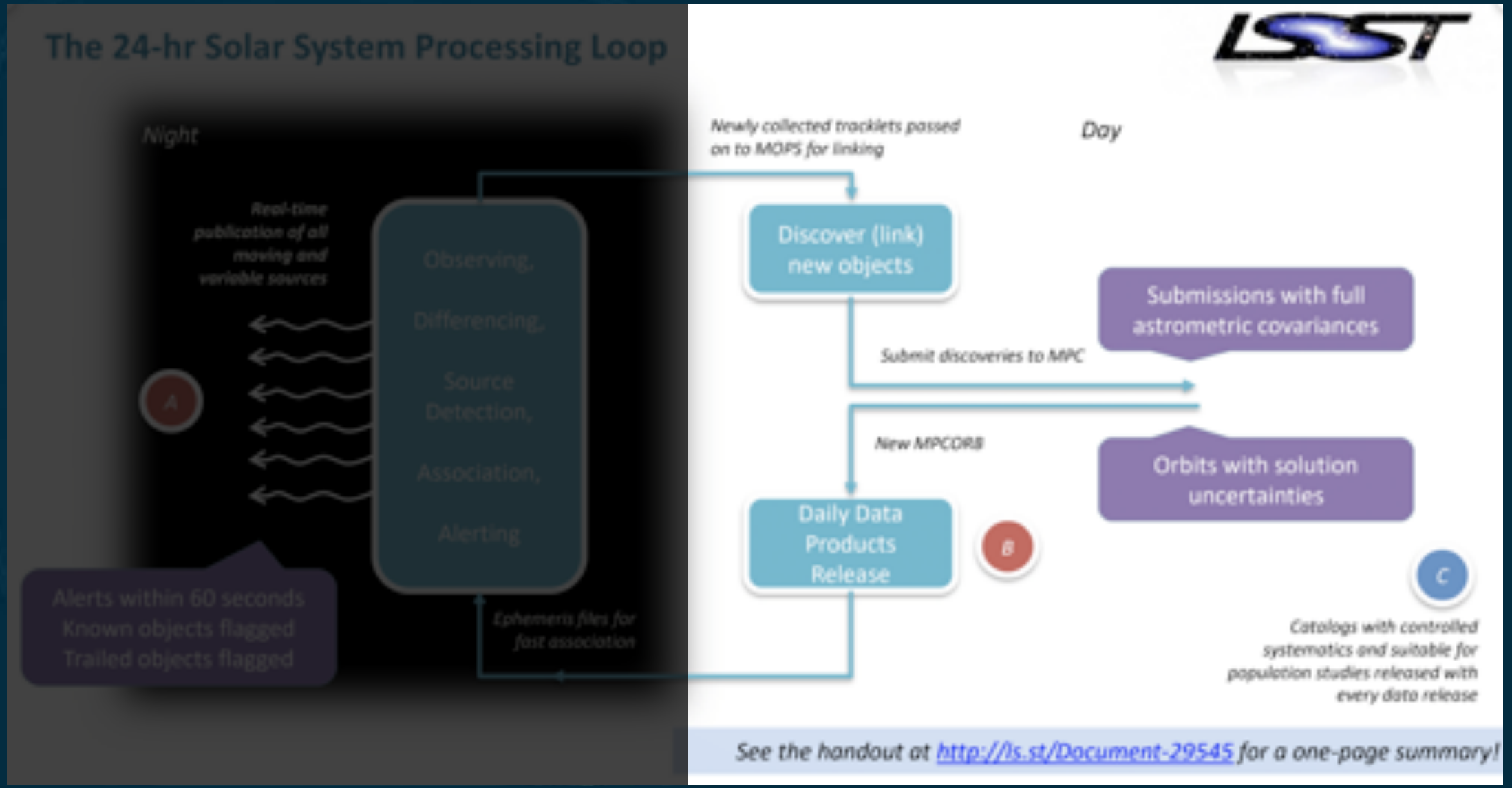

Solar System Processing: Linking

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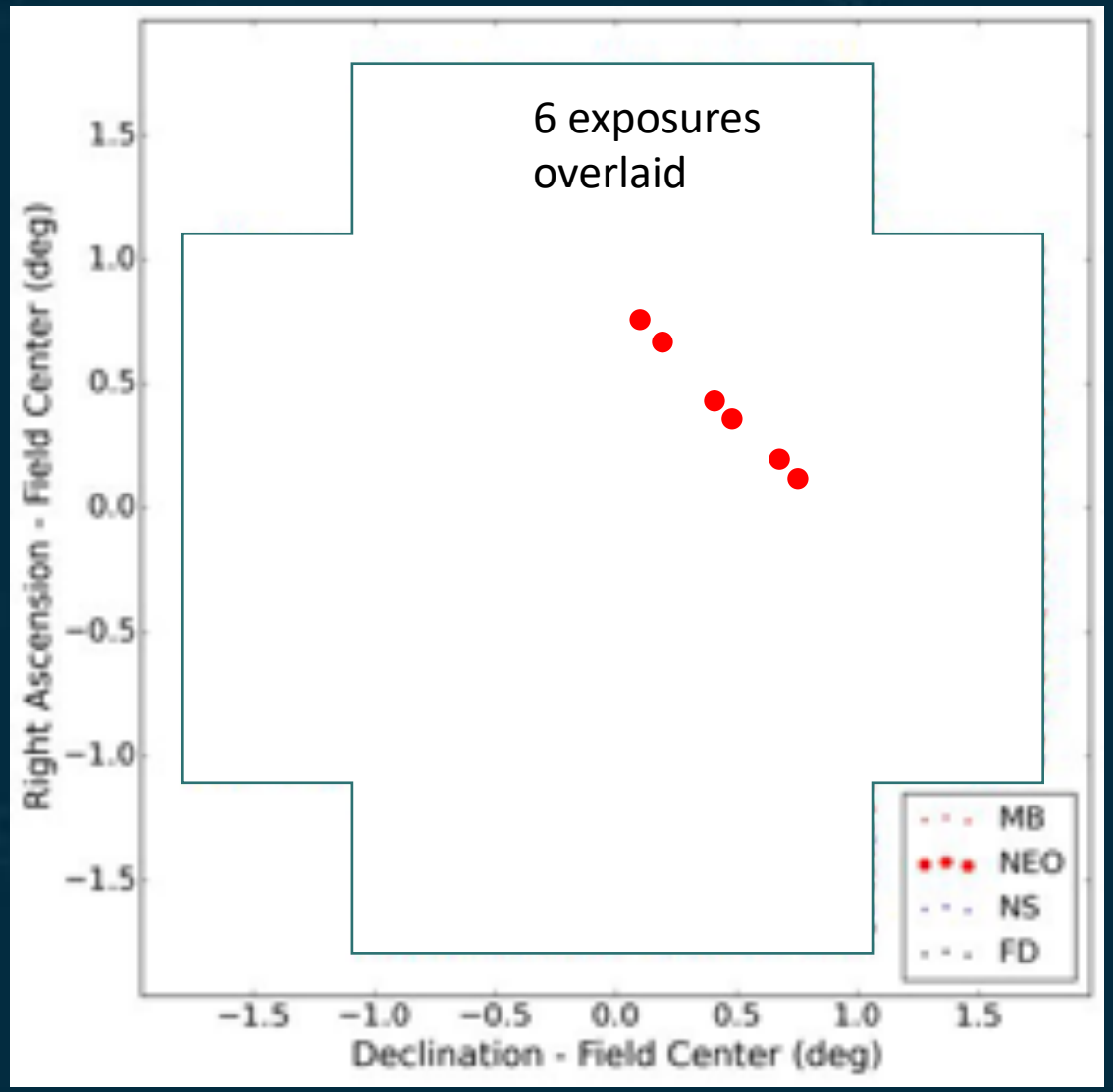

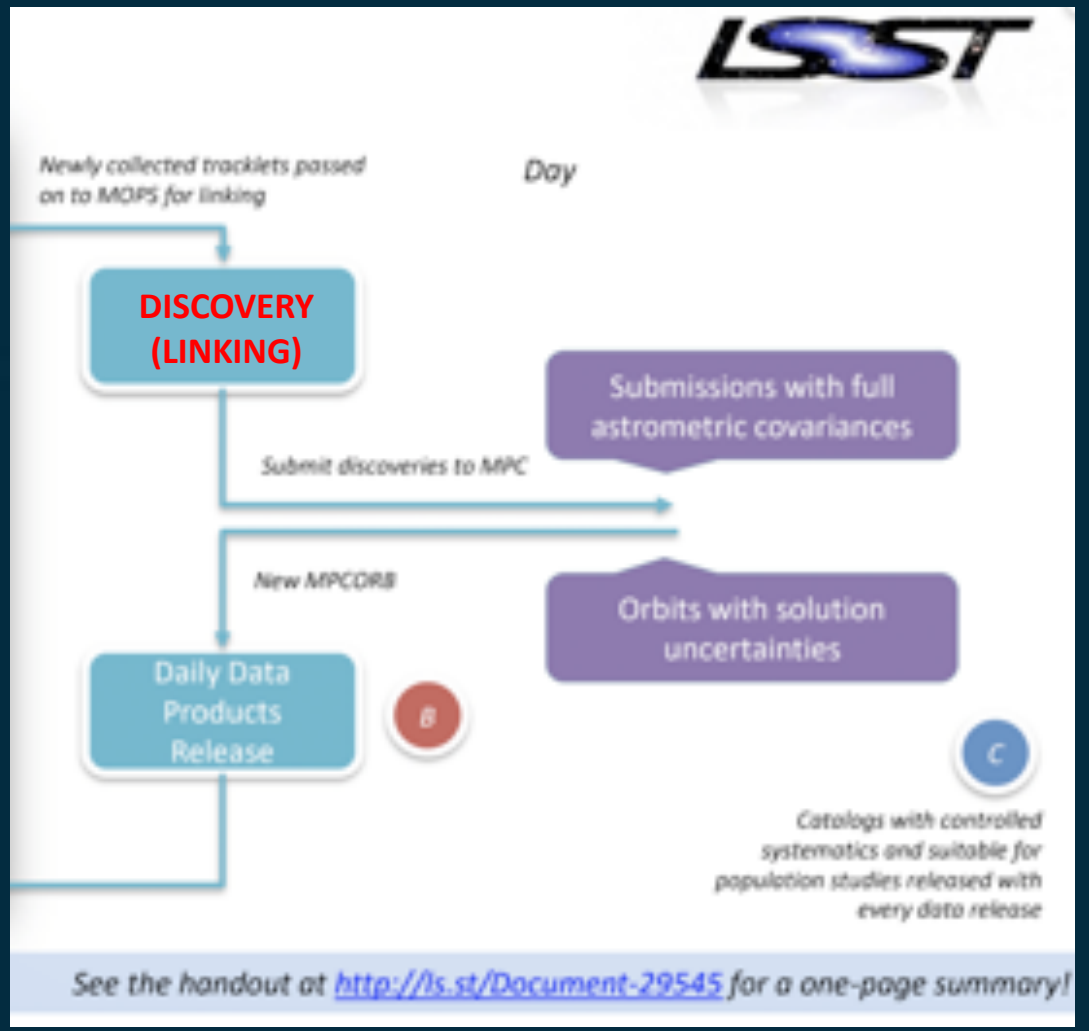

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Solar System Processing

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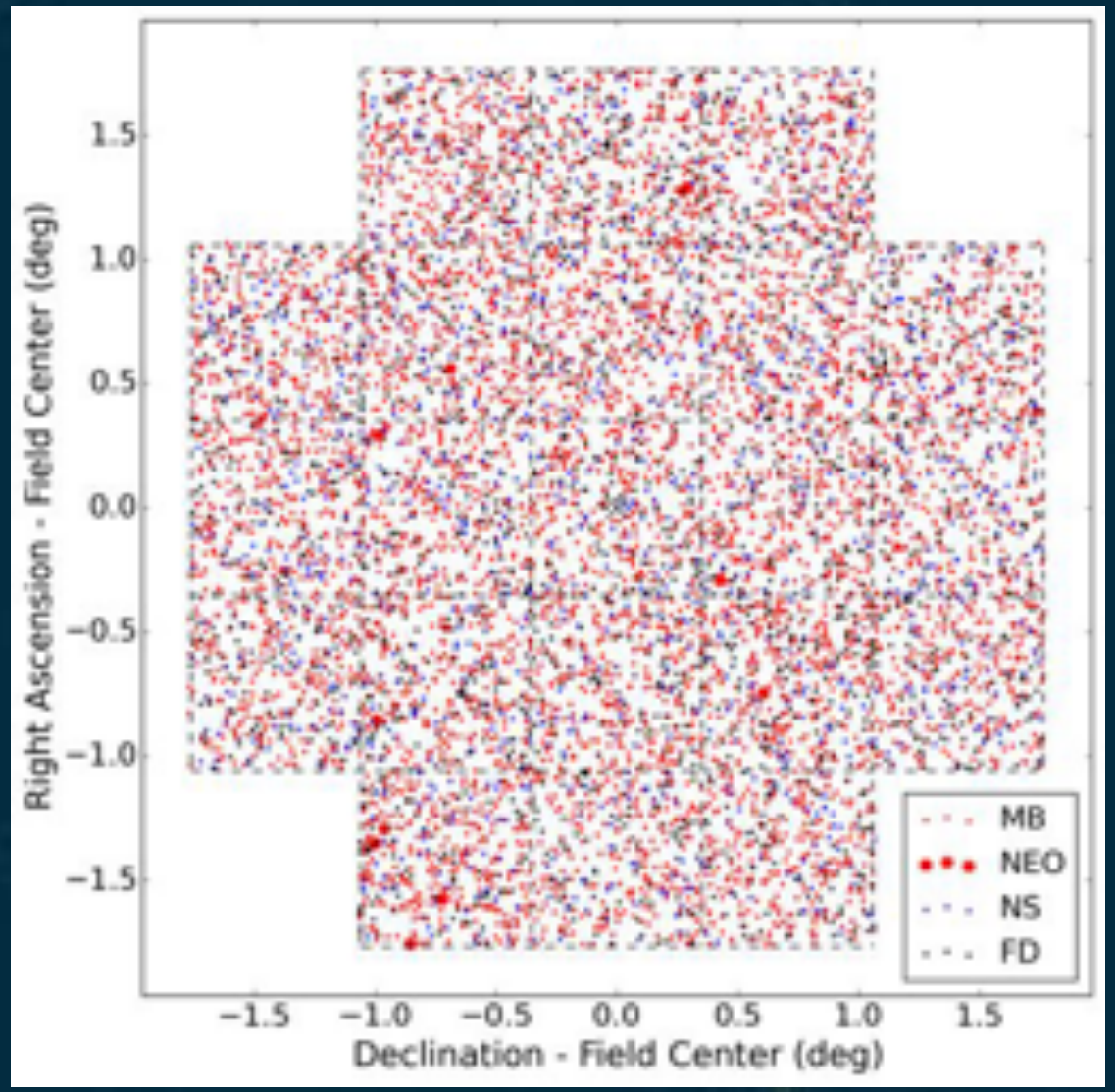
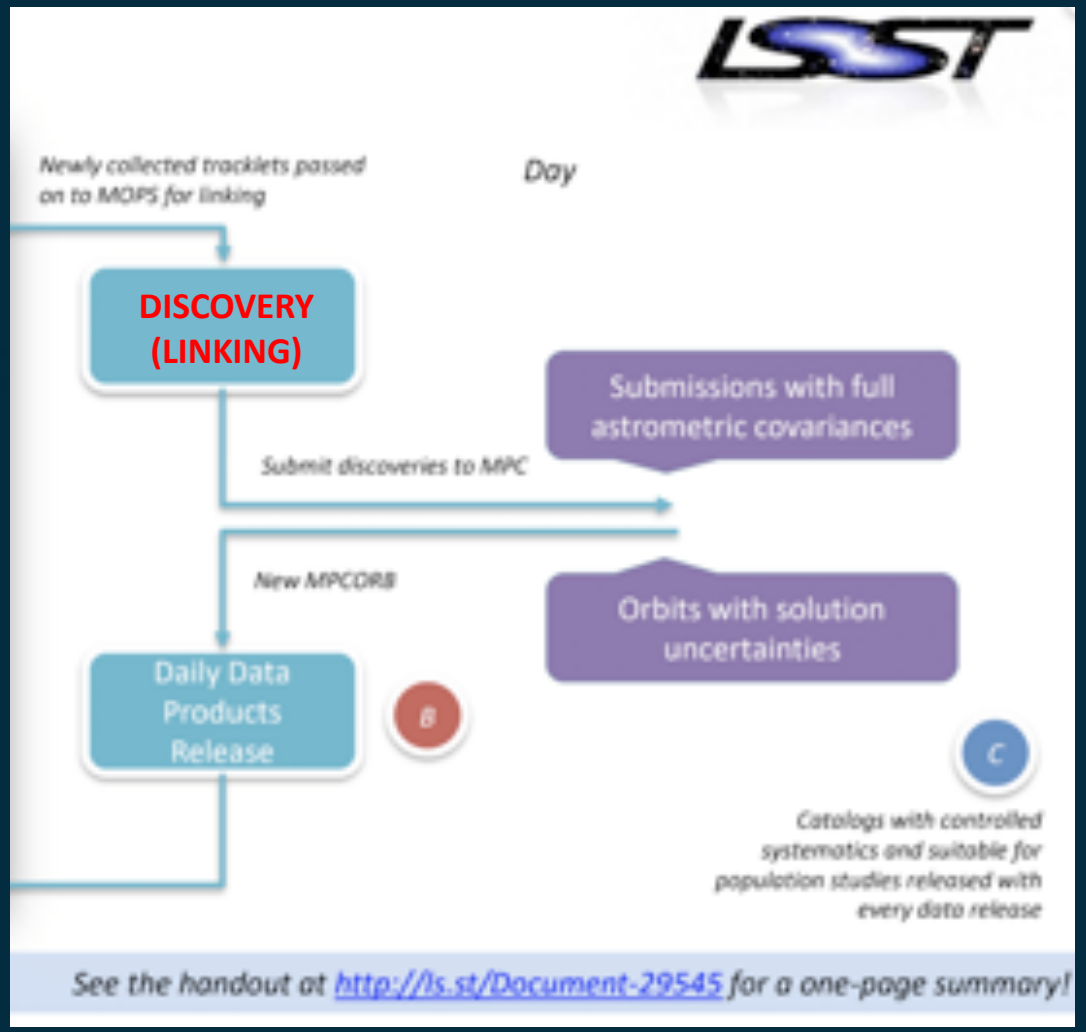


Chesley & Veres (2017)



HelioLinC / Pytrax

Holman et al. (2018)

Heliocentric state of asteroid

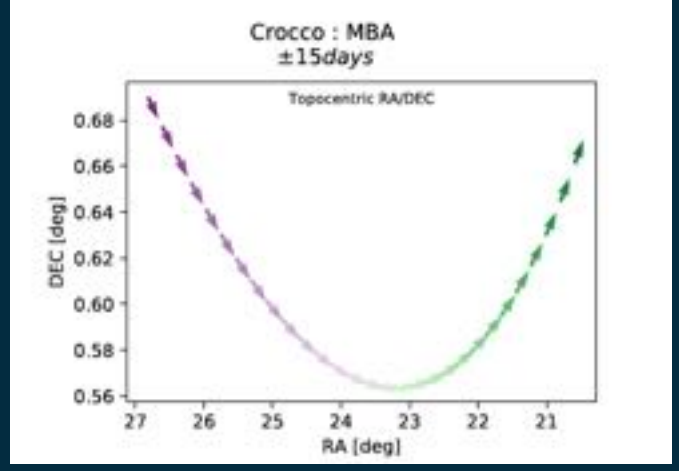
$$x(t) = x_0 + \dot{x}_0 t + g(t)$$

Gravitational perturbation

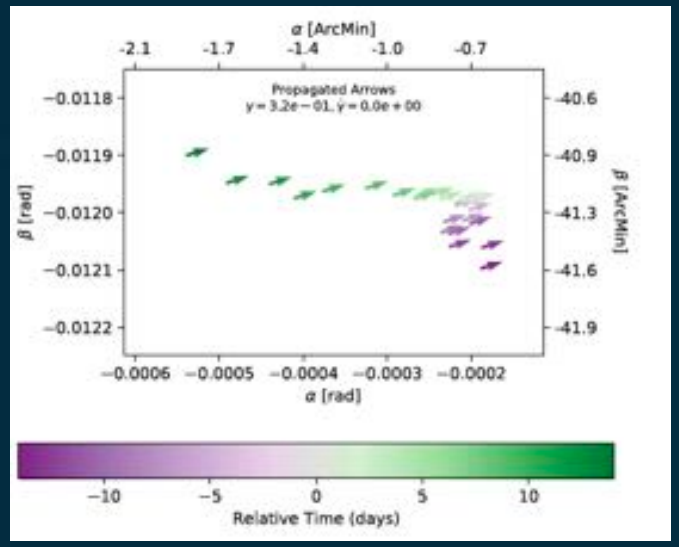
$$g(t=0) = 0,\ \dot{g}(t=0) = 0,\ \ddot{g}(t) \approx -GM_\odot \frac{x(t)}{|x(t)|^3},$$

Convenient coordinate system:

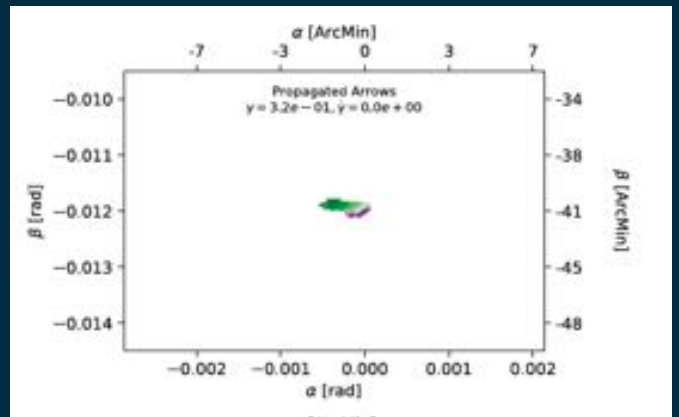
$$\alpha \equiv x_0/z_0,\ \beta \equiv y_0/z_0,\ \gamma \equiv 1/z_0$$
$$\dot{\alpha} \equiv \dot{x}_0/z_0,\ \dot{\beta} \equiv \dot{y}_0/z_0,\ \dot{\gamma} \equiv \dot{z}_0/z_0.$$



Sky plane motion



"Guessing" unknown parameters related to r and dr/dt



"Right guess"

Solar System Processing

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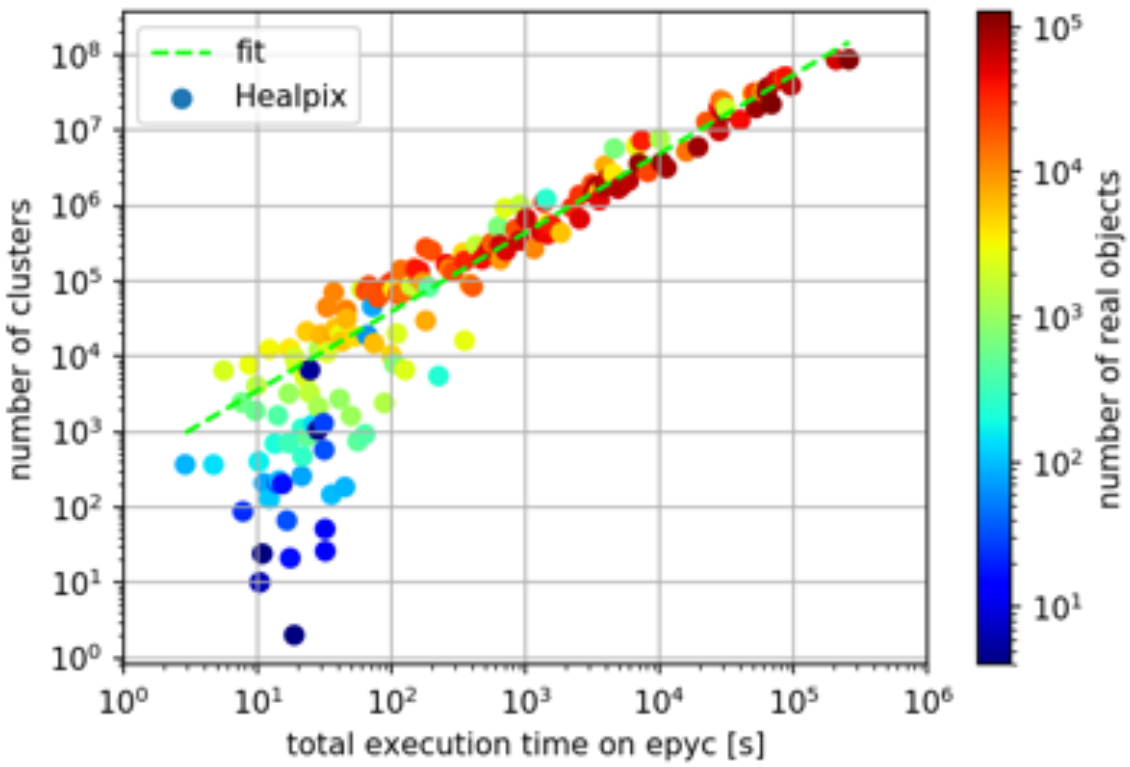
Pyrtrax all sky performance on simulated LSST data (Veres et al. 2017).



Single set of parameters
("guessed 1/distance + radial velocity)
Single clustering radius

Performance on epyc:
~2.5ms/cluster,
~5 clusters /real object
Average processing time per Heal Pix
Mean: 10,000s, Median 161s

Completeness (median):
MBAs: 95% (P+V), 38% (P)
NEOs: 60% (P+V), 40% (P)

Chesley & Veres (2017)

HelioLinC 3D

Eggl et al. (in prep)

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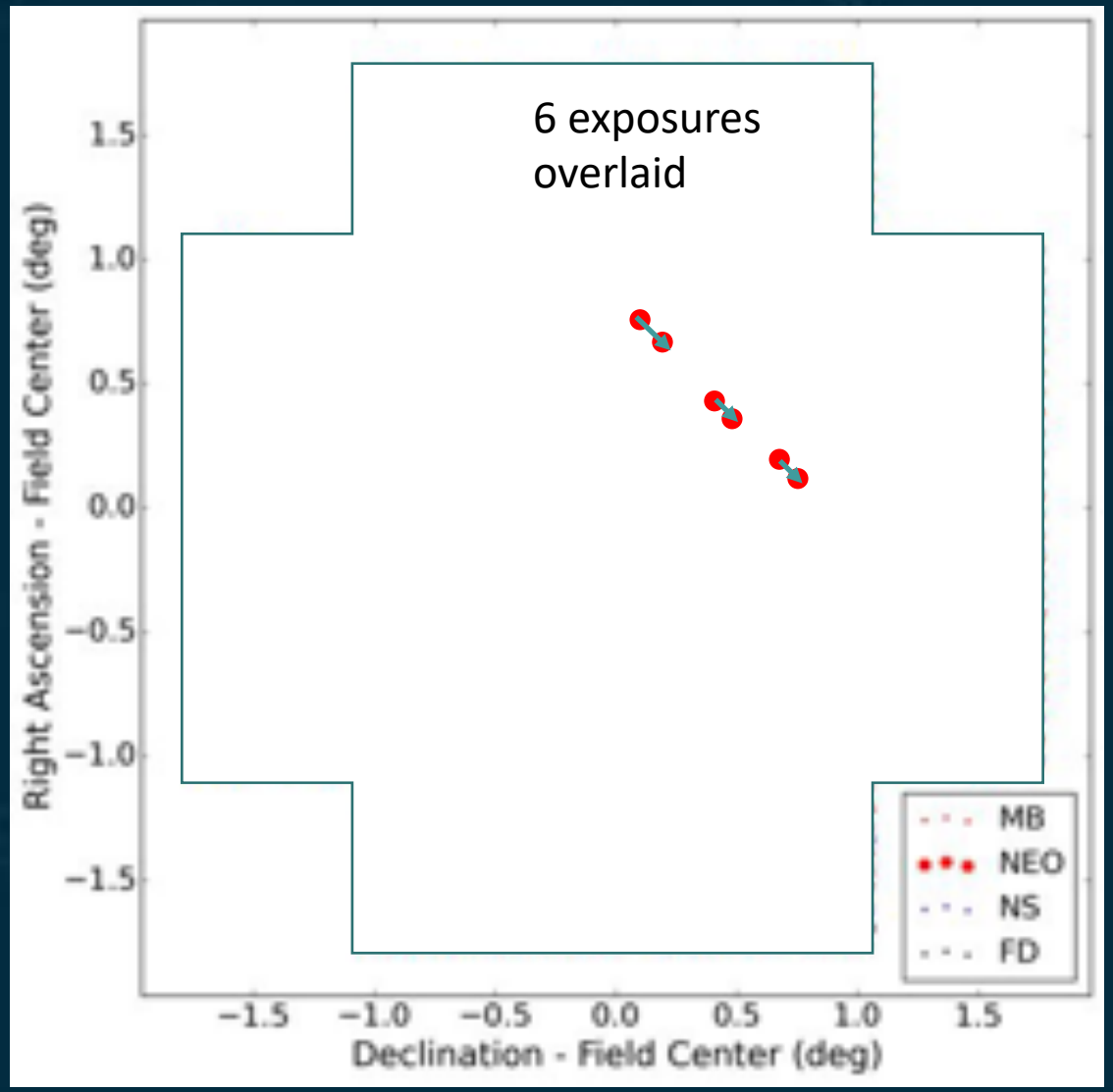

- LSST cadence -> on sky velocity
- Observer state known
- Guess r and dr/dt -> full heliocentric state vectors
- 2/N-body propagation
- Clustering in phase space

HelioLinC 3D

Eggl et al. (in prep)

Near circular orbits

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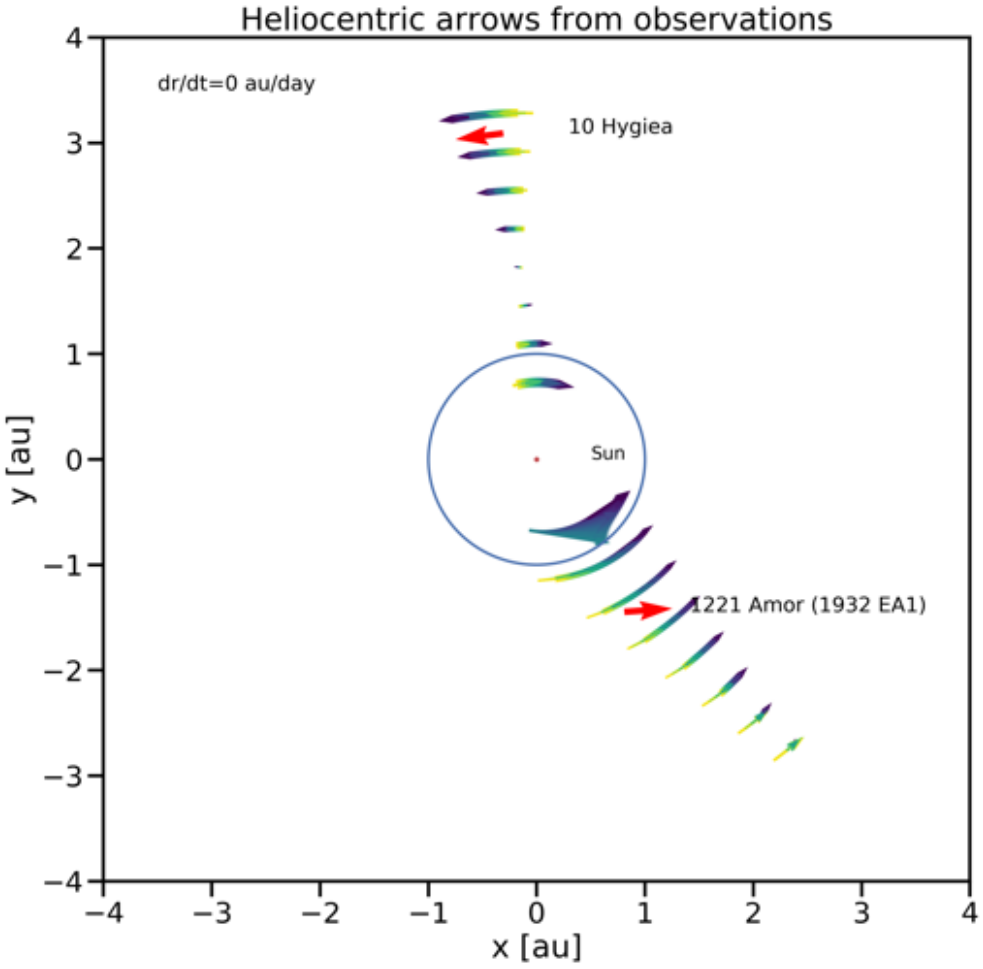
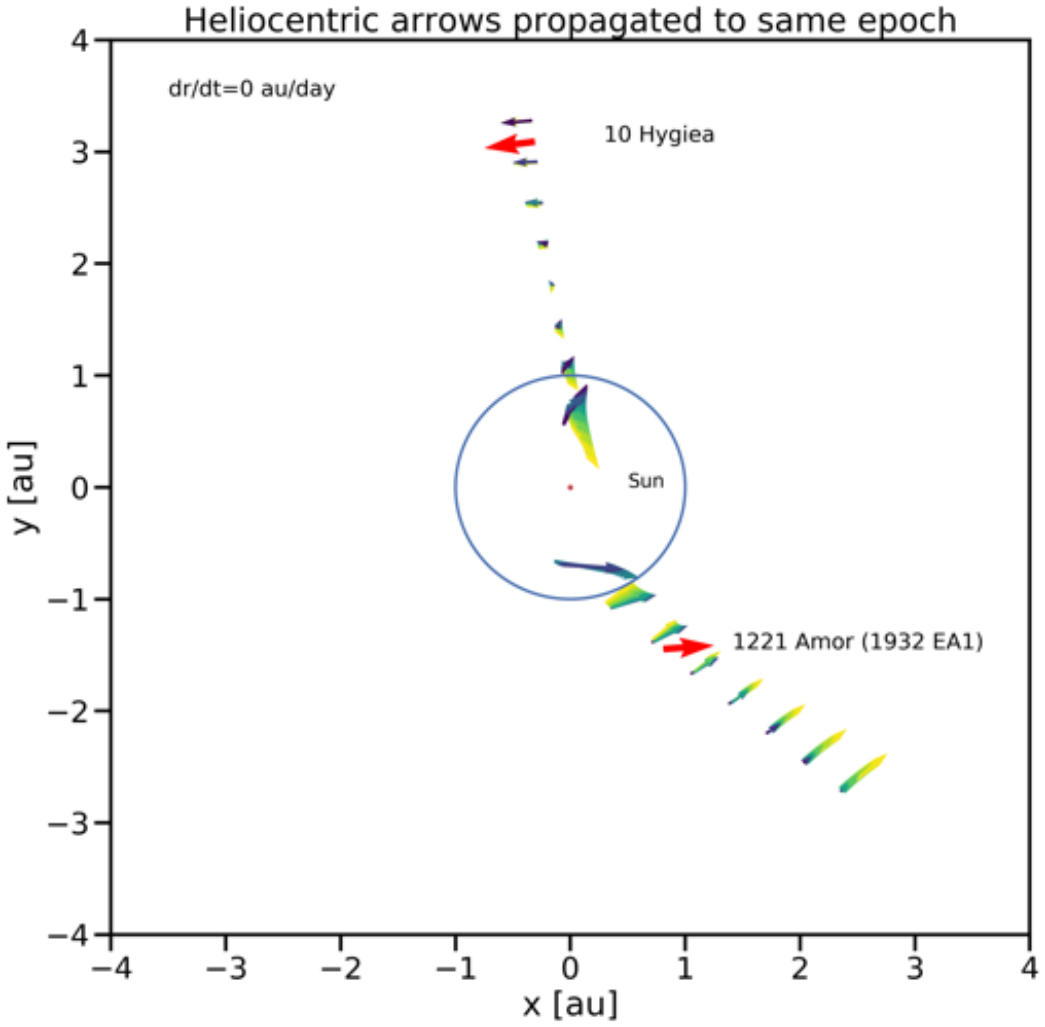


Propagate arrows to same epoch



HelioLinC 3D

Eggl et al. (in prep)

Orbits with eccentricity

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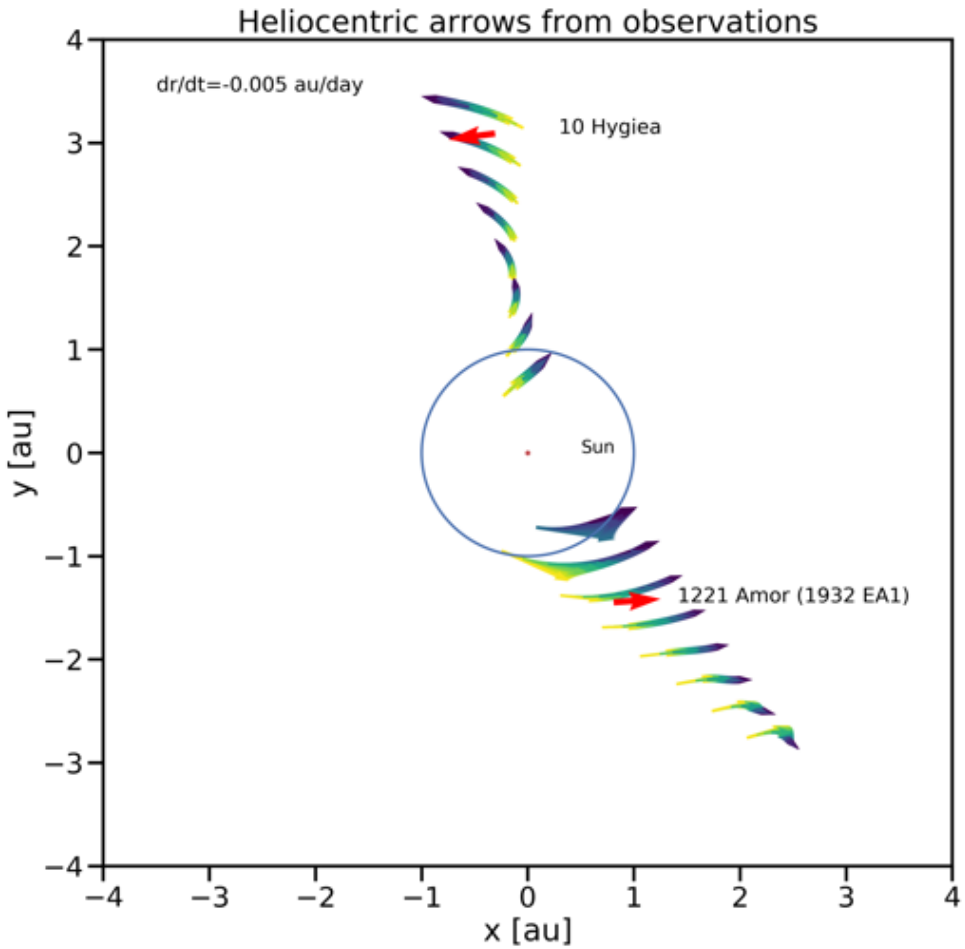
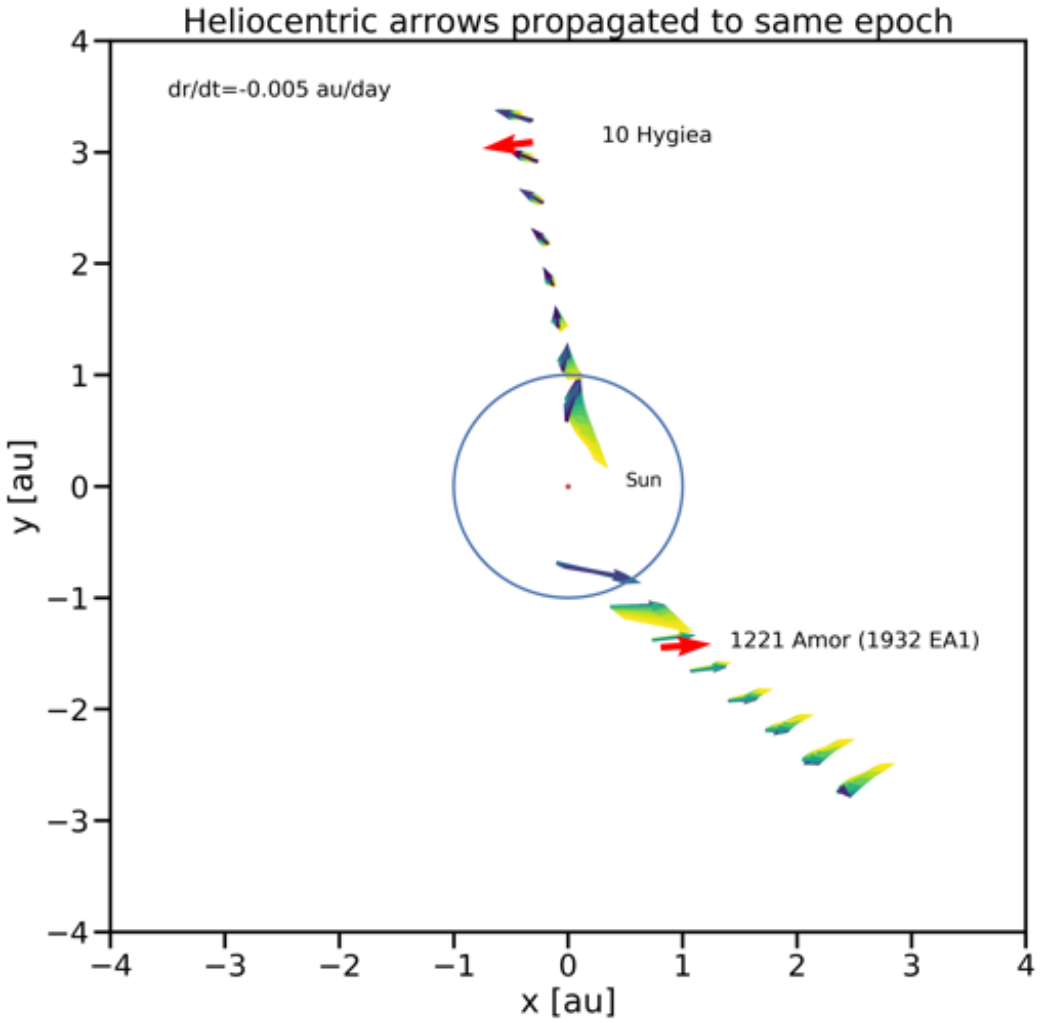


Propagate arrows to same epoch



HelioLinC 3D

Eggl et al. (in prep)

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Pros:

- Clustering in 3D/6D space -> high purity
- Includes IOD since mean cluster state = Initial Orbit
- Transparent clustering parameters (au, au/day)
- No tessellation / no mapping onto flat subspace
- Works for all types of orbits (as long as their r, dr/dt are scanned)

Cons:

- 2body propagation (slightly) slower than 2D linear arrow propagation
- Larger range of r, dr/dt required

Linking Summary

Rubin Observatory

HelioLinC 3D: Work in progress!

For Vereš & Chesley (2017) LSST 3 month dataset

- Performs on average better than classical MOPS, especially for NEOs.
- Is currently on par with Pytrax (HelioLinC) wrt completeness of objects in pure clusters.
- Overall completeness to be improved (~75%)

Closed Loop with the MPC

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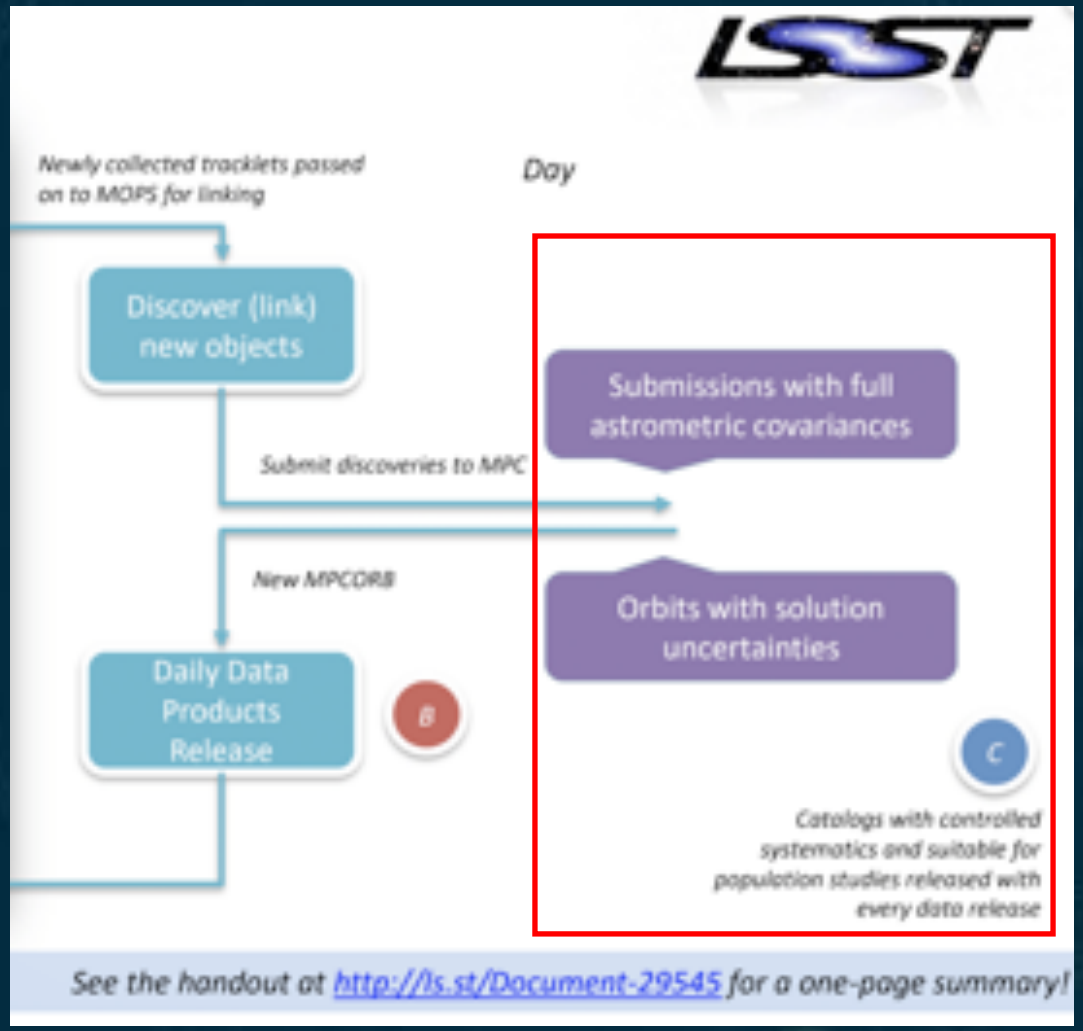

Memorandum of Understanding

Advantages:

- Timely submission for follow-up guaranteed
- Observations of other facilities included in new, high quality orbits
- Avoids designation issues

Vera C. Rubin Observatory/LSST still retains all essential capabilities IOD, OD (openorb), high precision orbit propagation (B612 ADAM, SSOPY)

LSST S3 Data Products Catalog

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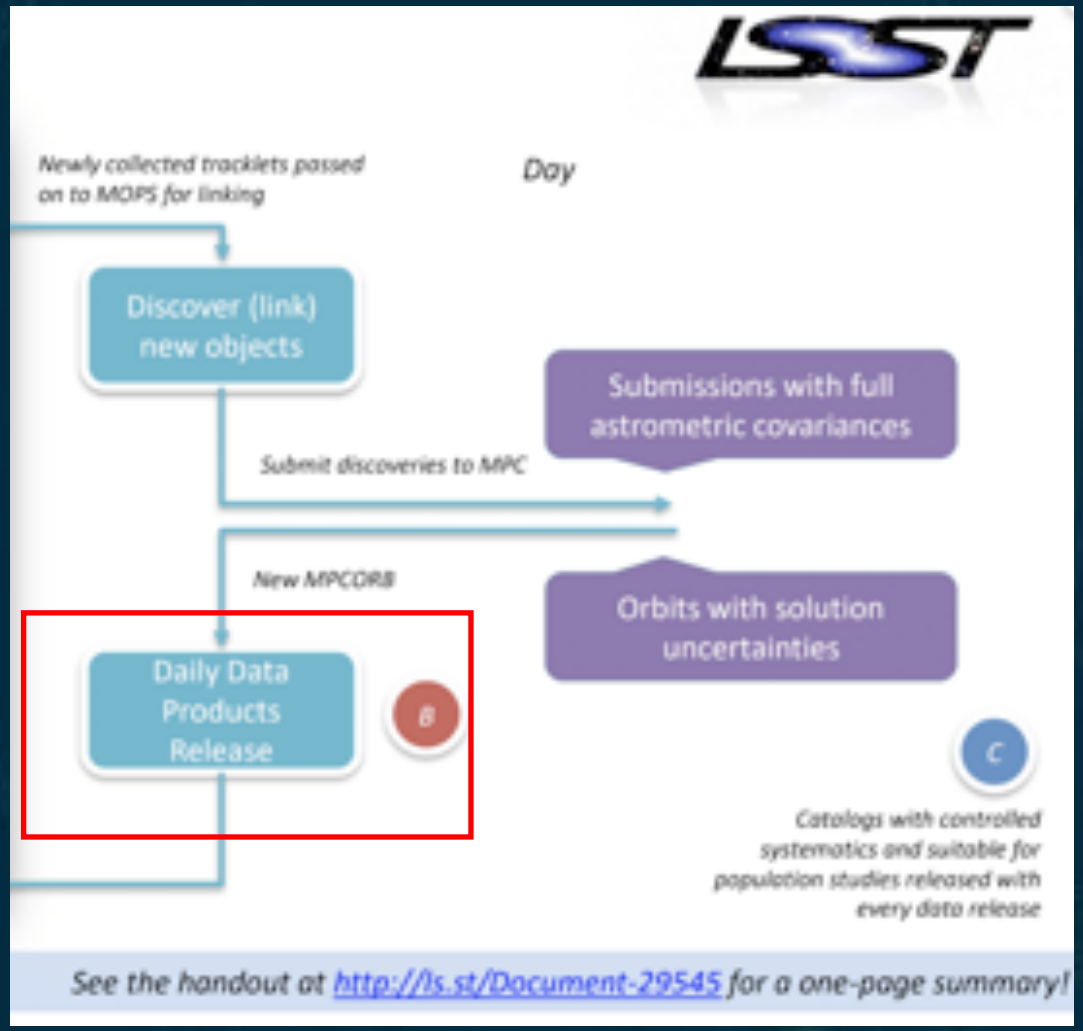

See upcoming presentation!

Questions?

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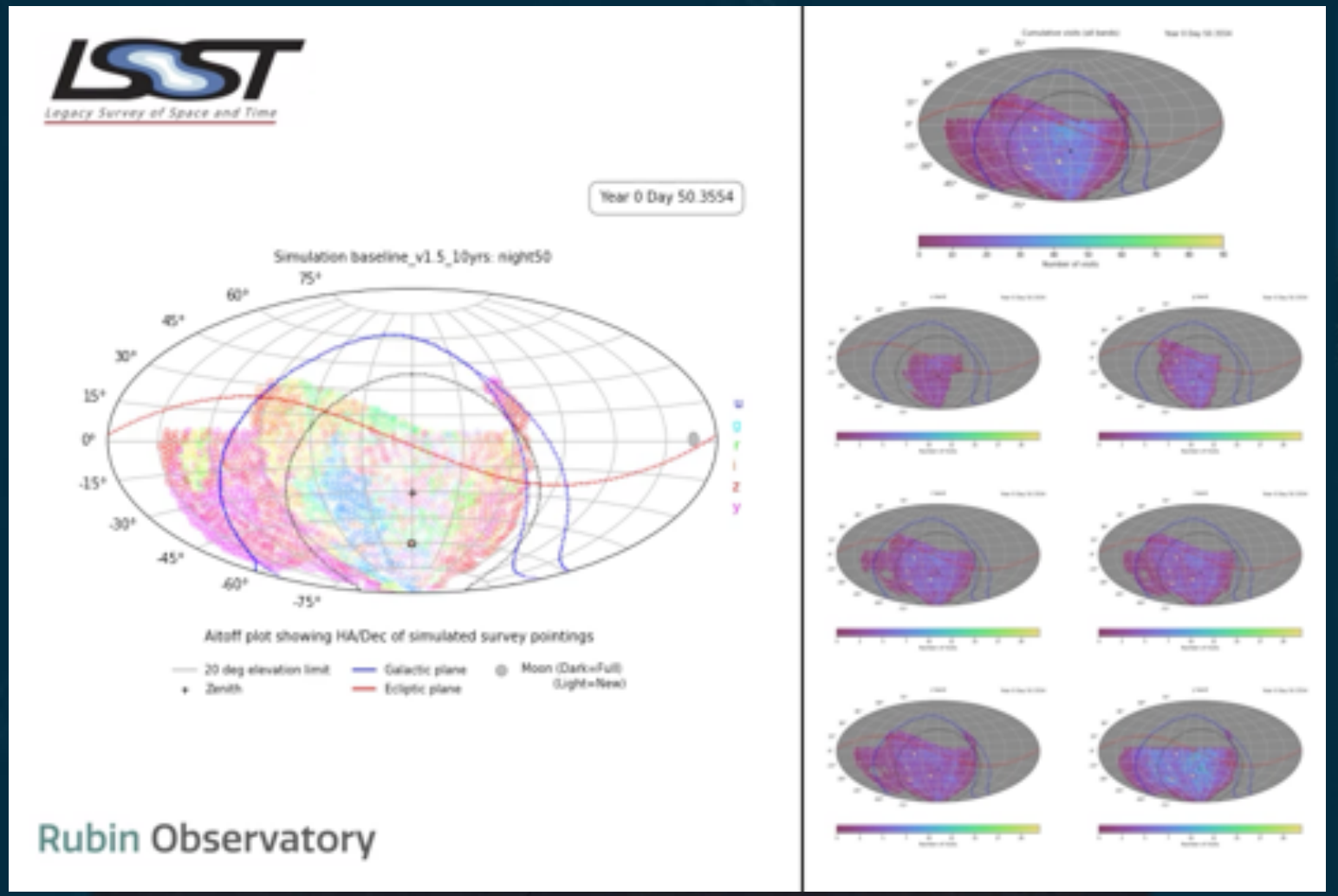

Credit: L. Jones