Galaxy cluster detection with LSST : photometric calibration, bright object masks and AMICO

CSI 2025

Nathan Amouroux

General context

- 10 year photometric survey

Credit: RubinObs/NSF/DOE/NOIRLab/SLAC/AU

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  - Data Preview 1 July 2025
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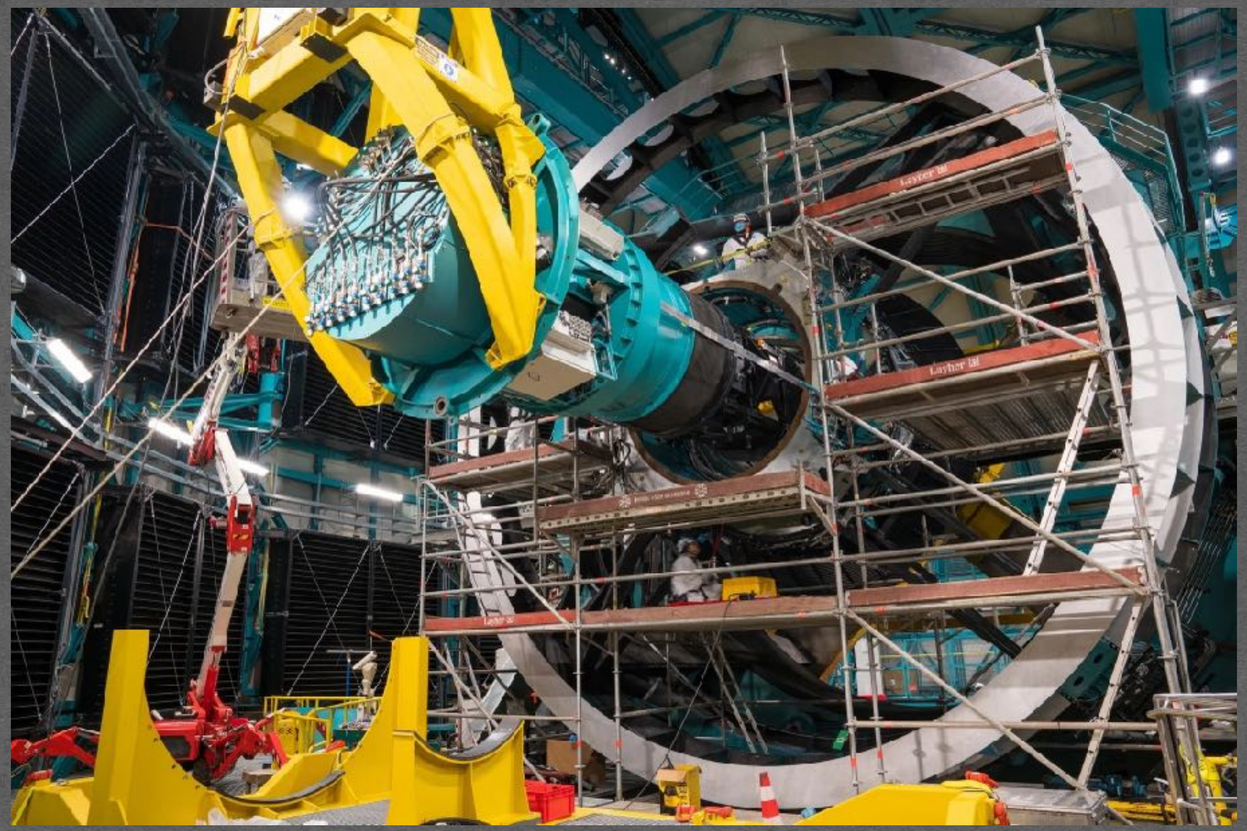

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Credit: NSF–DOE Vera C. Rubin Observatory

Cosmology with LSST

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  - Weak Lensing
  - BAO
  - Supernovae
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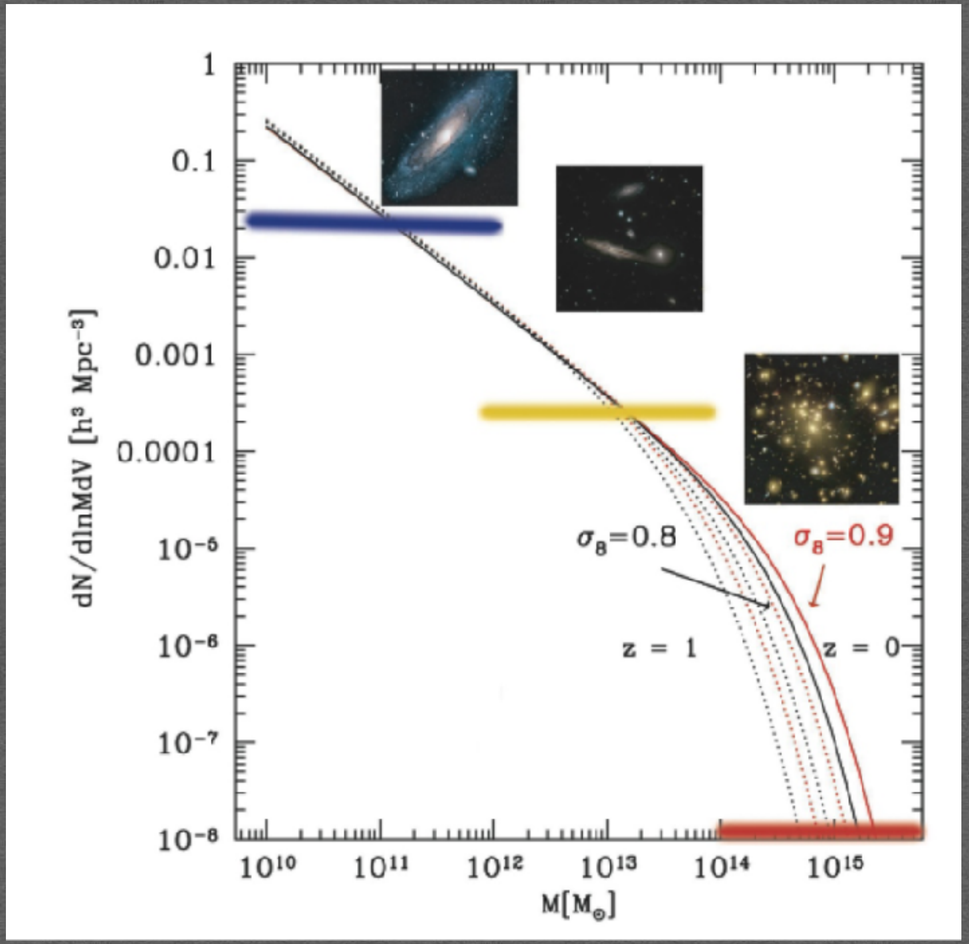

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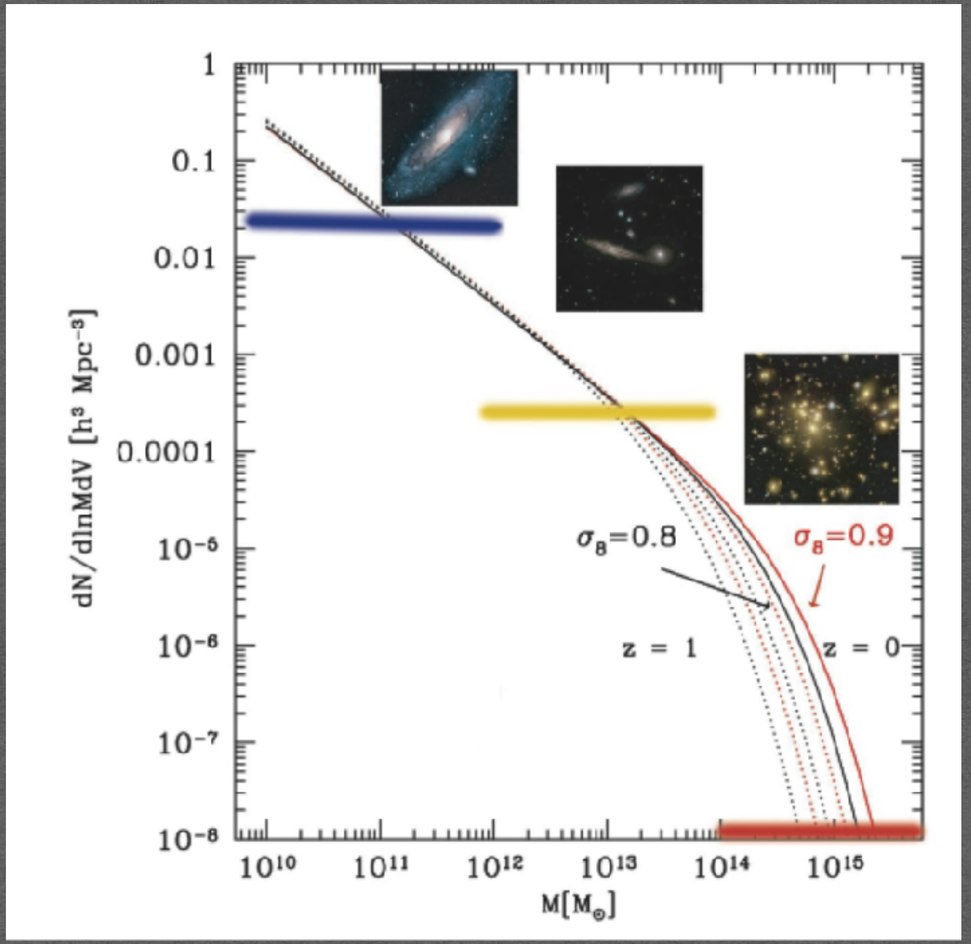
- Largest virialized structure of the universe
- Abundance = Counting clusters in bins of mass and redshift
- Ingredients to constrain cosmological parameters:



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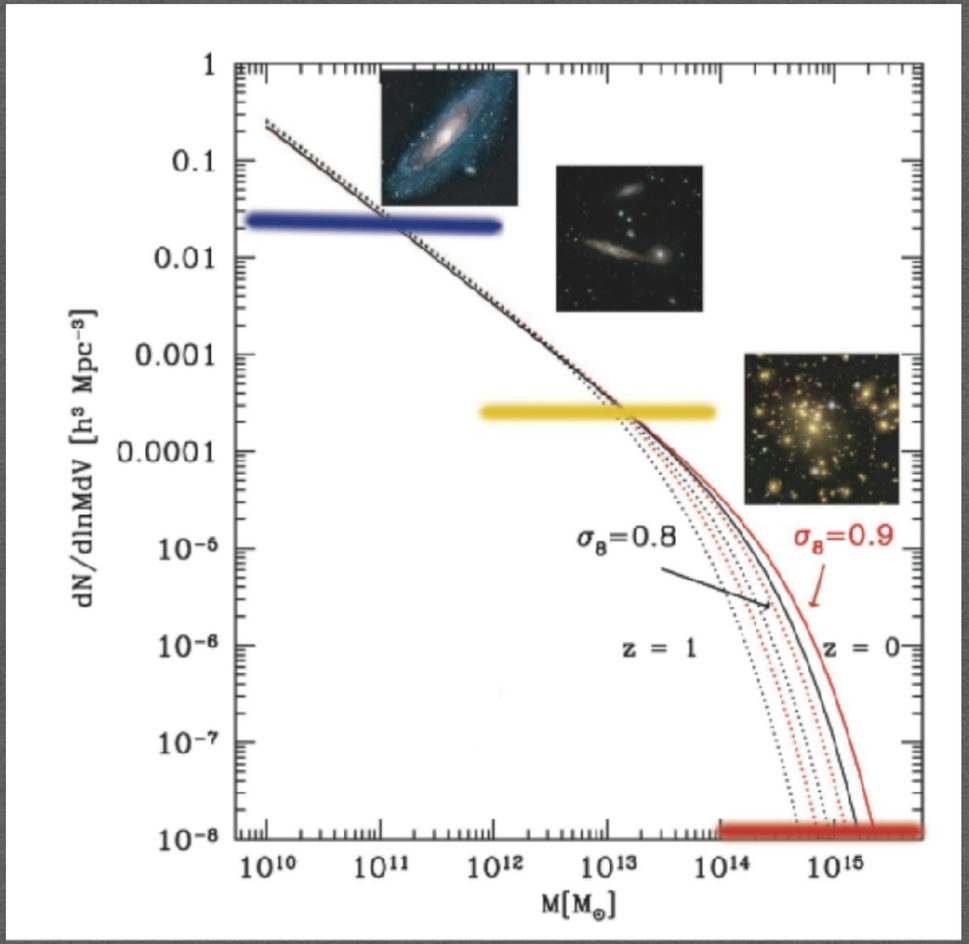

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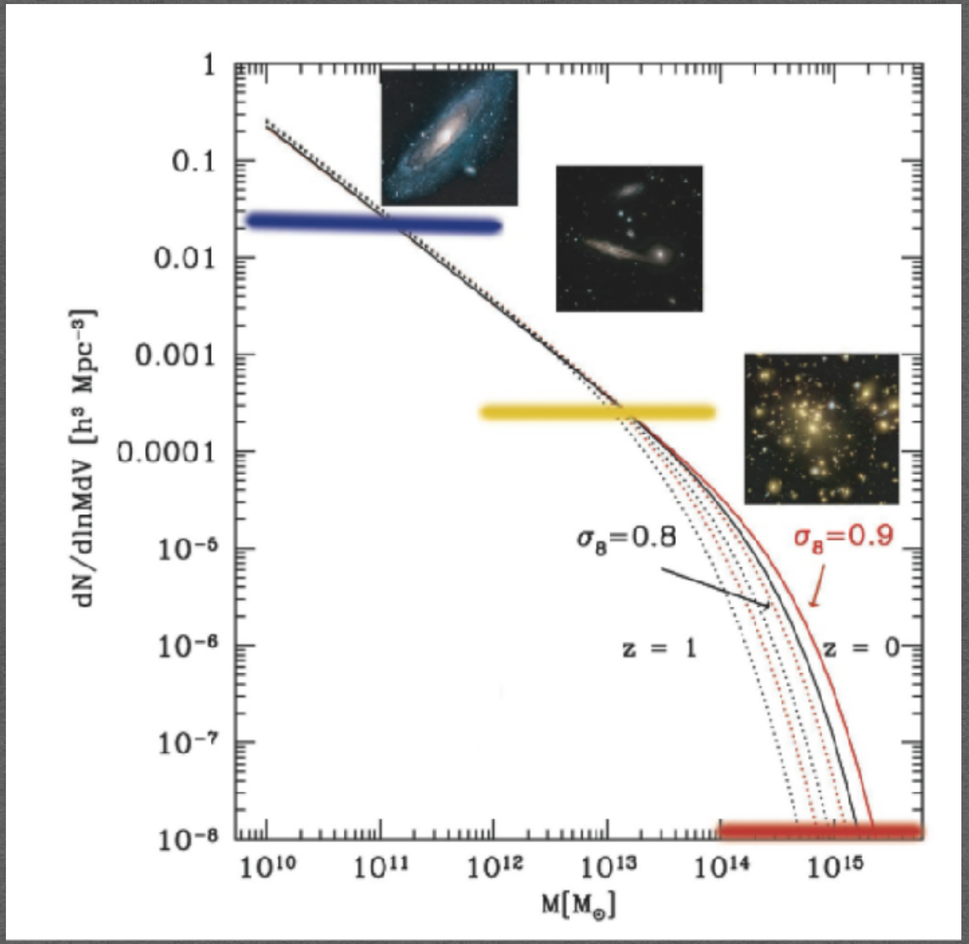

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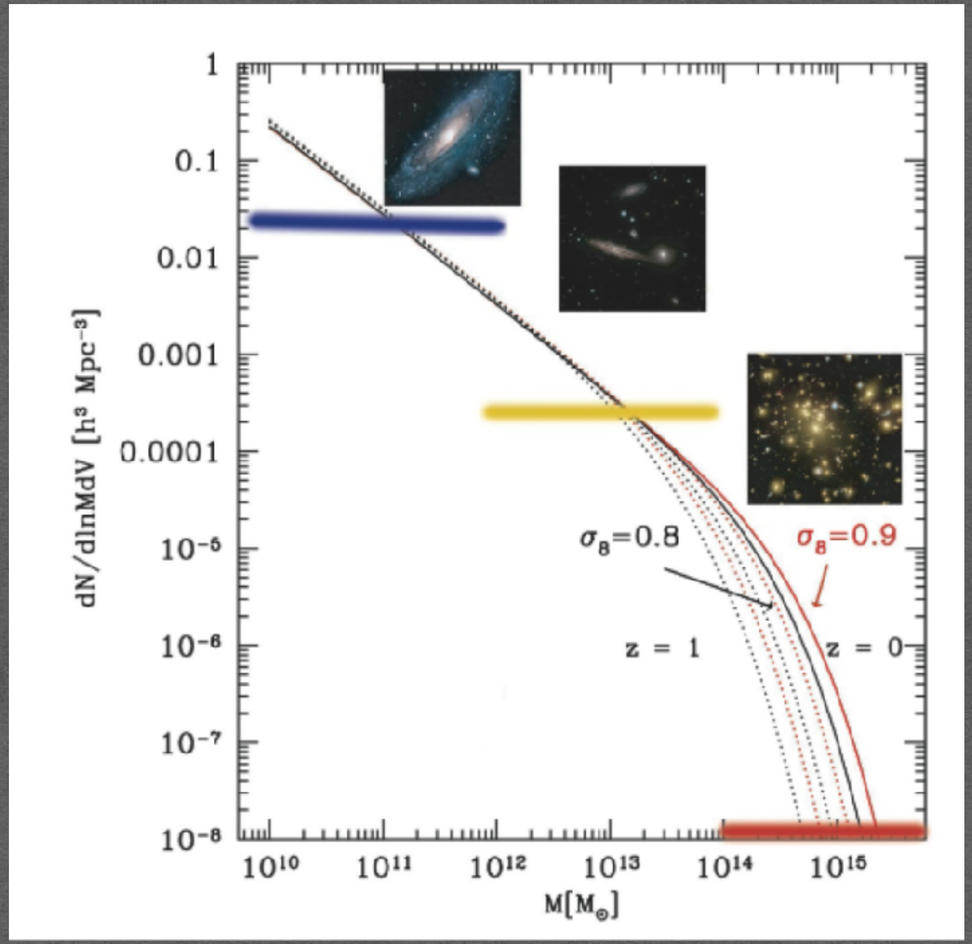
  3) Cluster detection algorithms



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I. Collimated Beam Projector

CBP General principle

Goal = Calibrate an instrument photometric response (per-mil) mostly for SNIa cosmology

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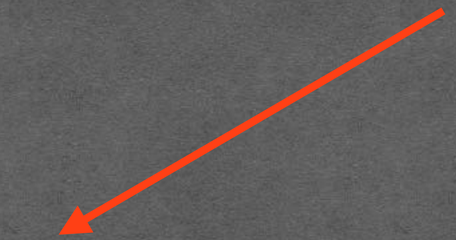

Monochromatic source

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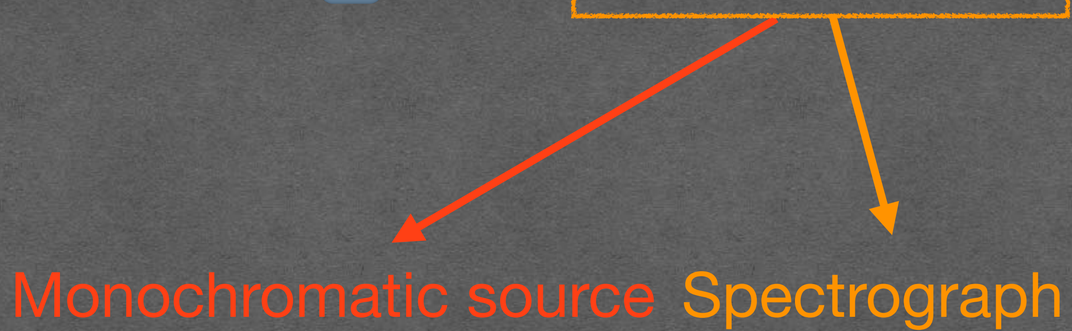

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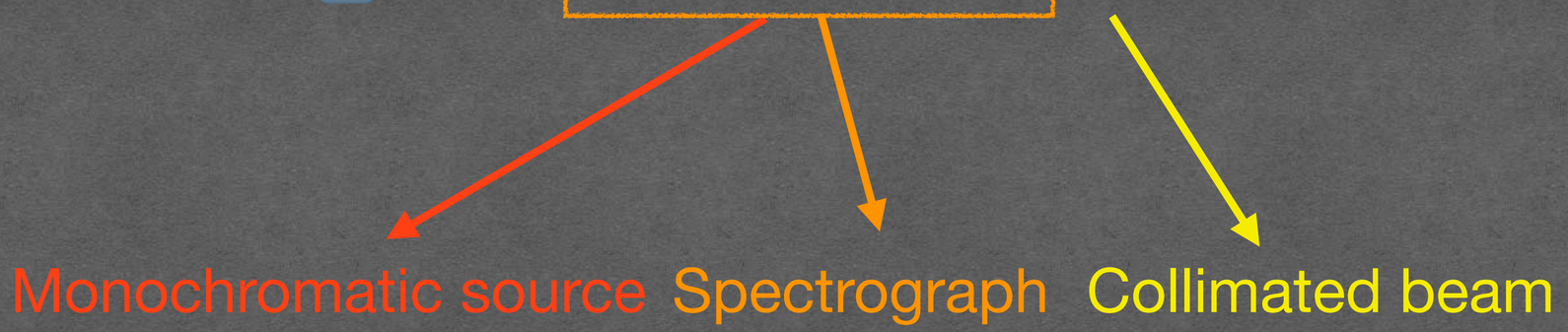

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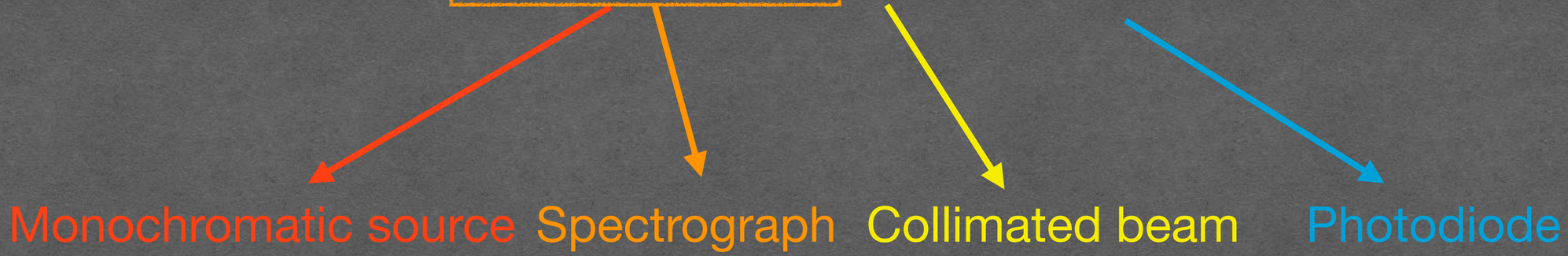

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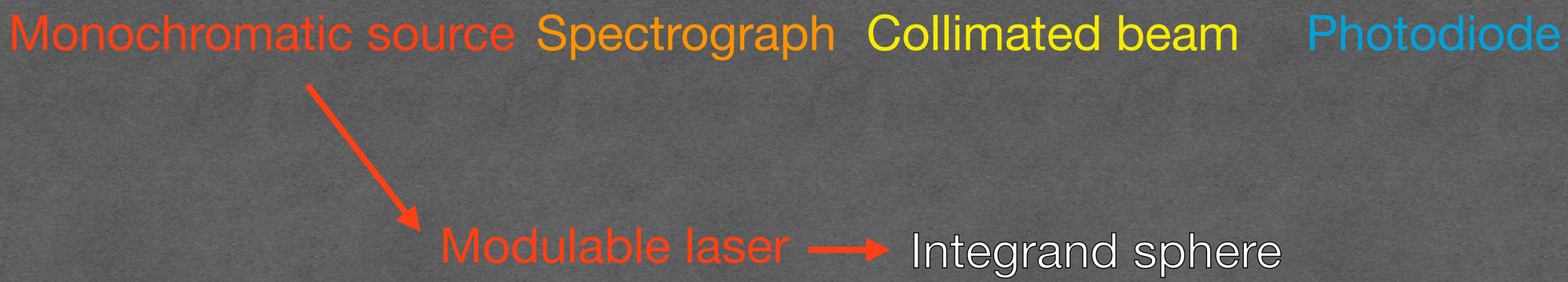

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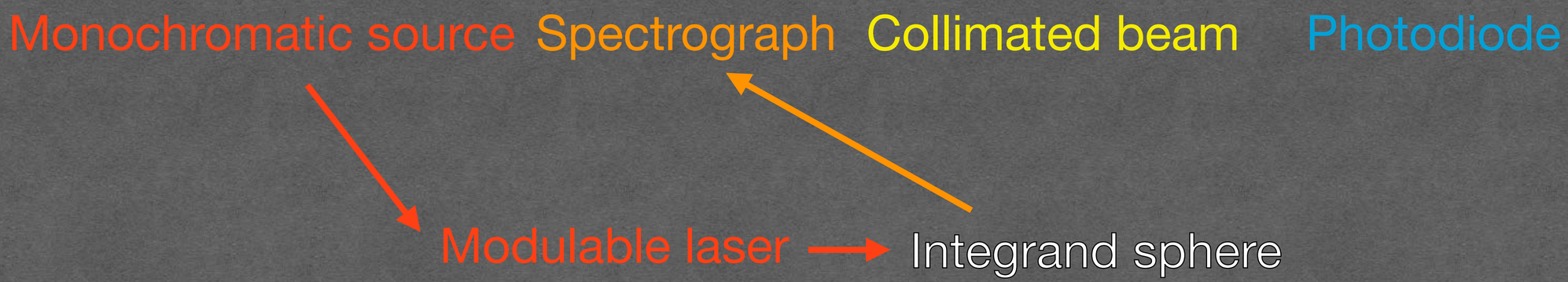

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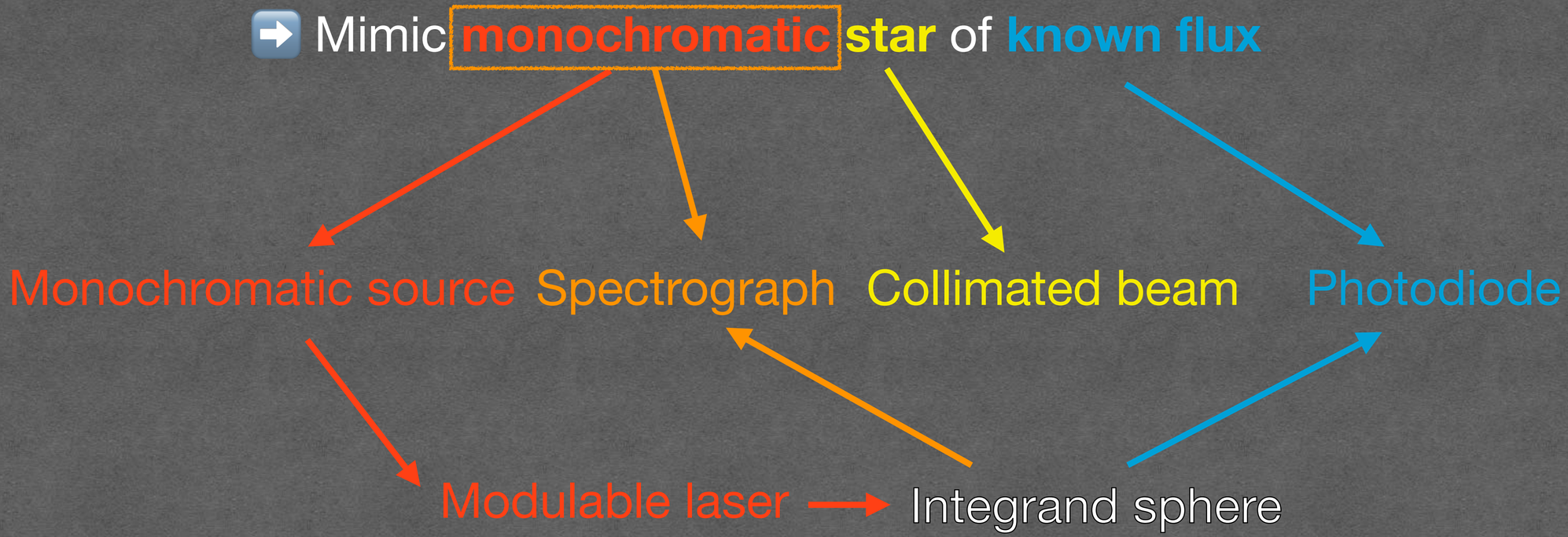

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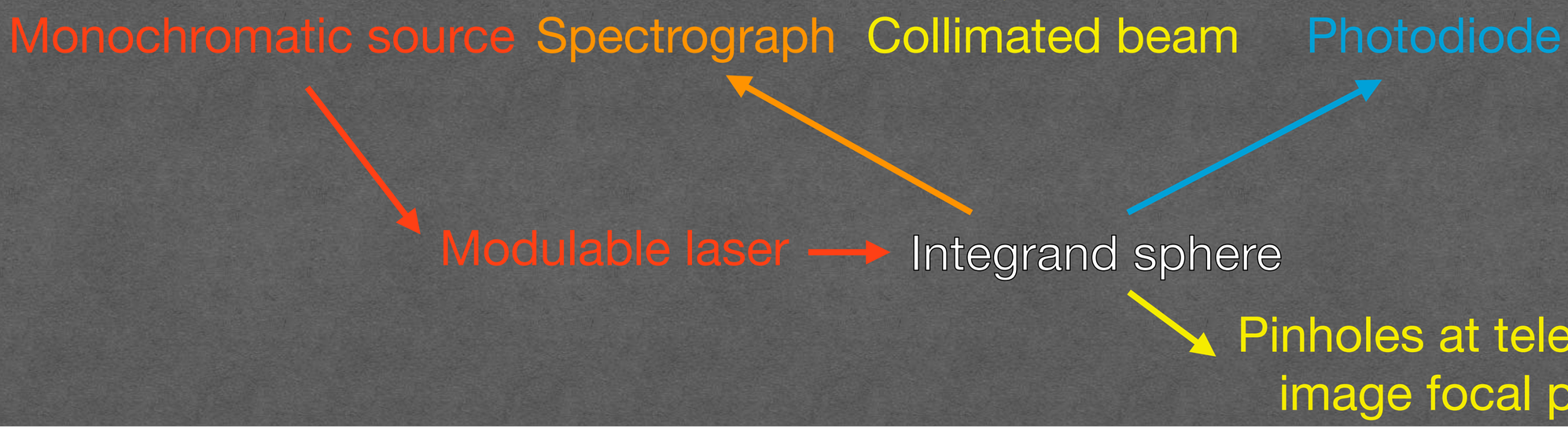

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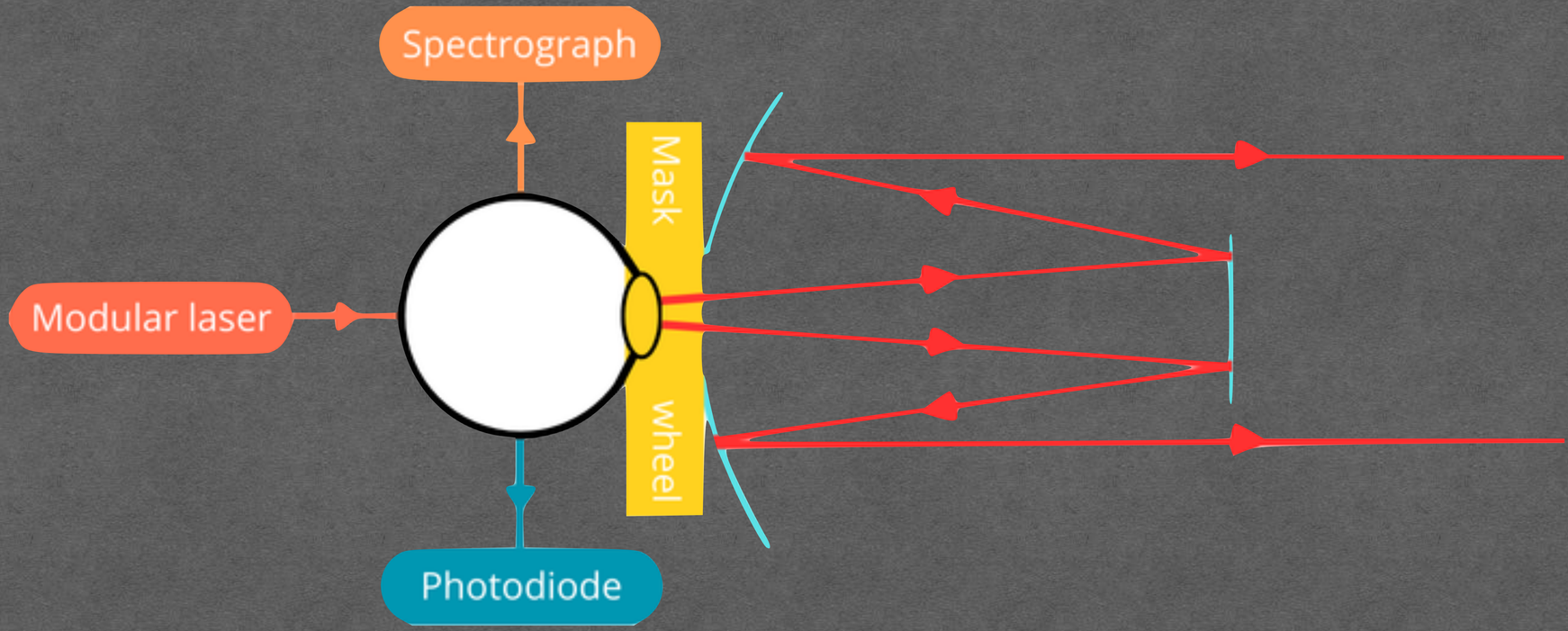

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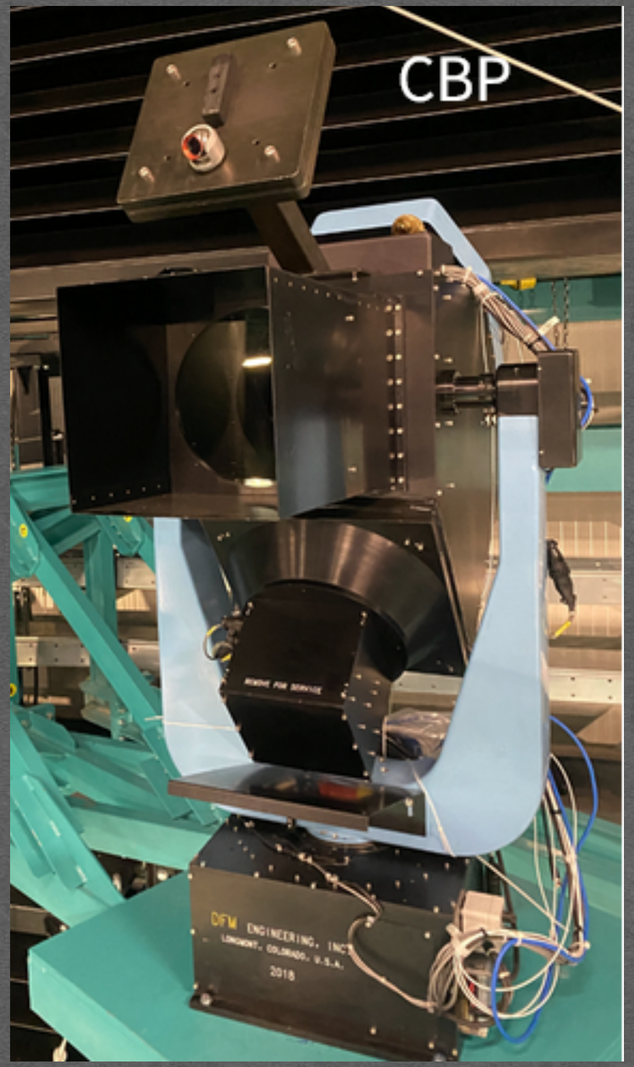
The Rubin-CBP



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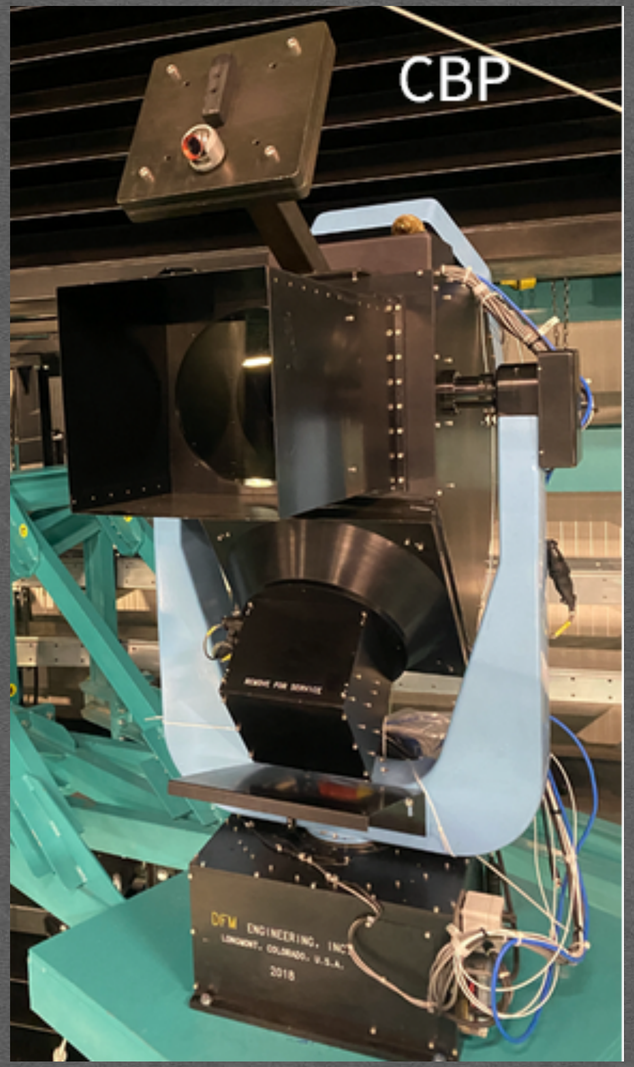
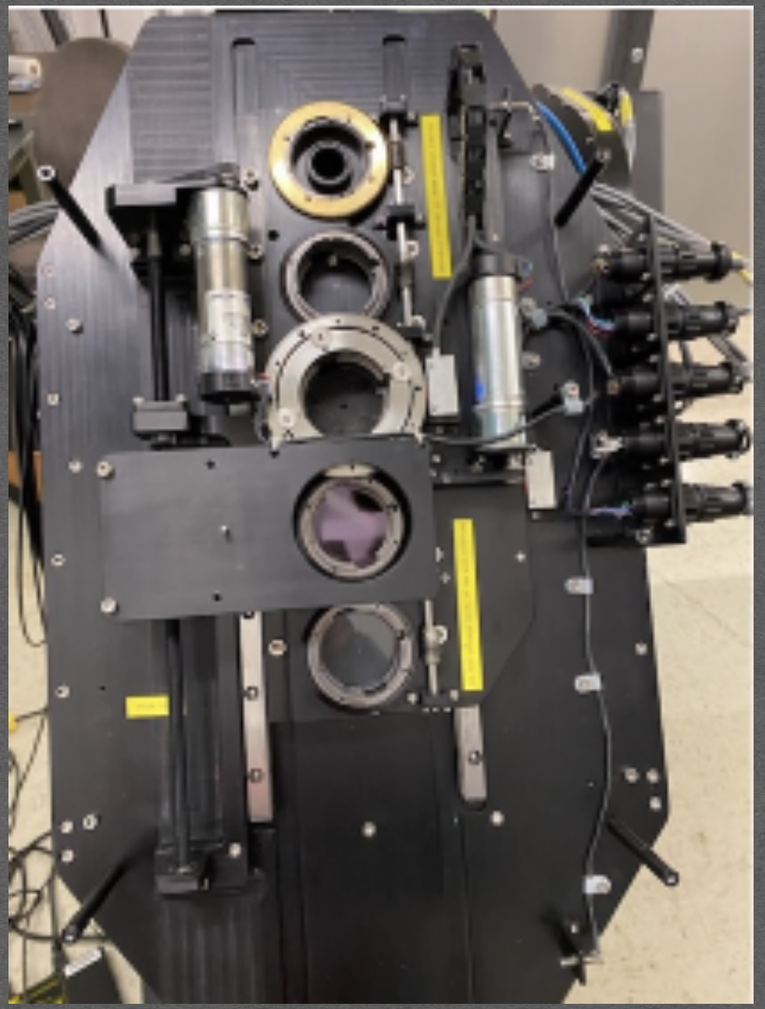


Mask holder (ComCam)



The Rubin-CBP

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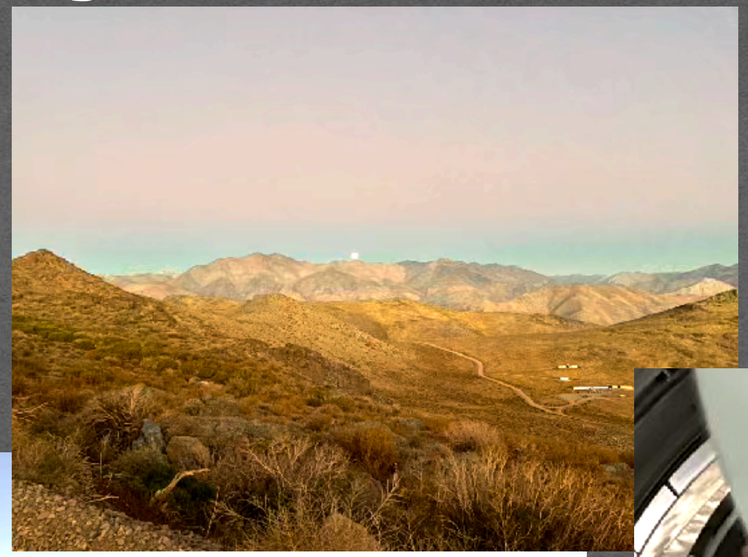
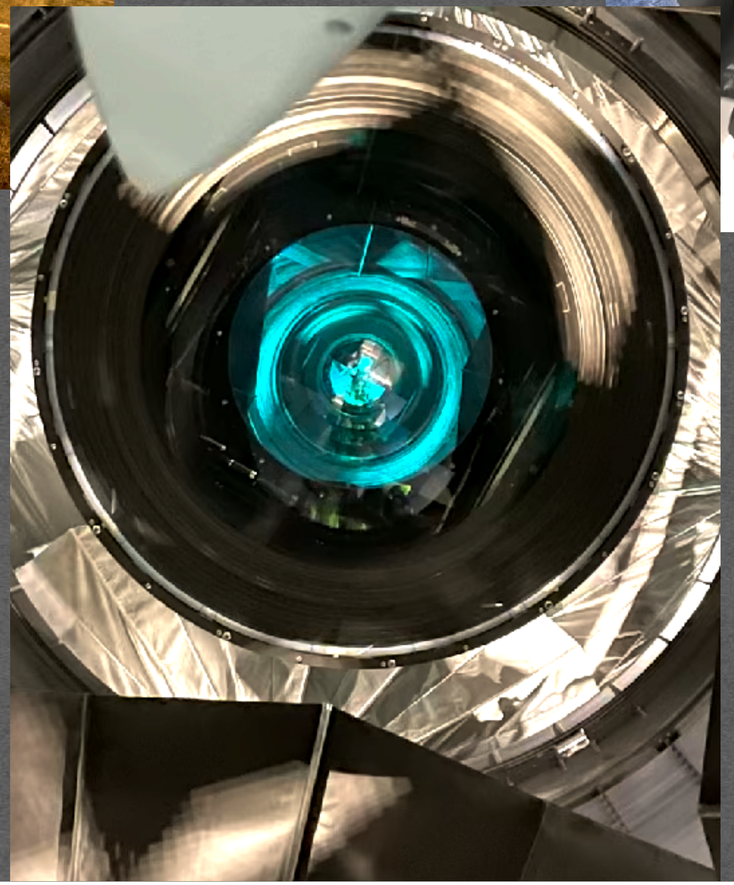
My work at the observatory





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CBP on ComCam

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- 4 nights campaign

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- 4 nights campaign
- Copoint CBP - Simonyi Telescope
  - night to night repeatability
  - small movements tests
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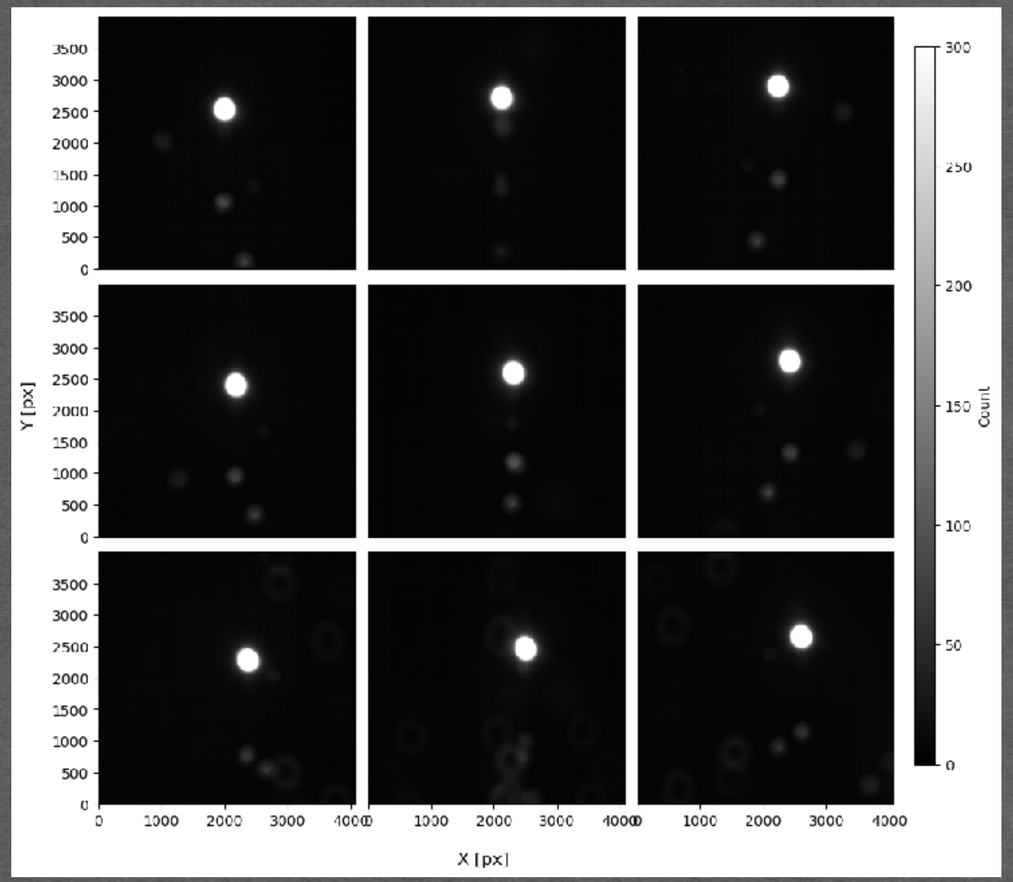
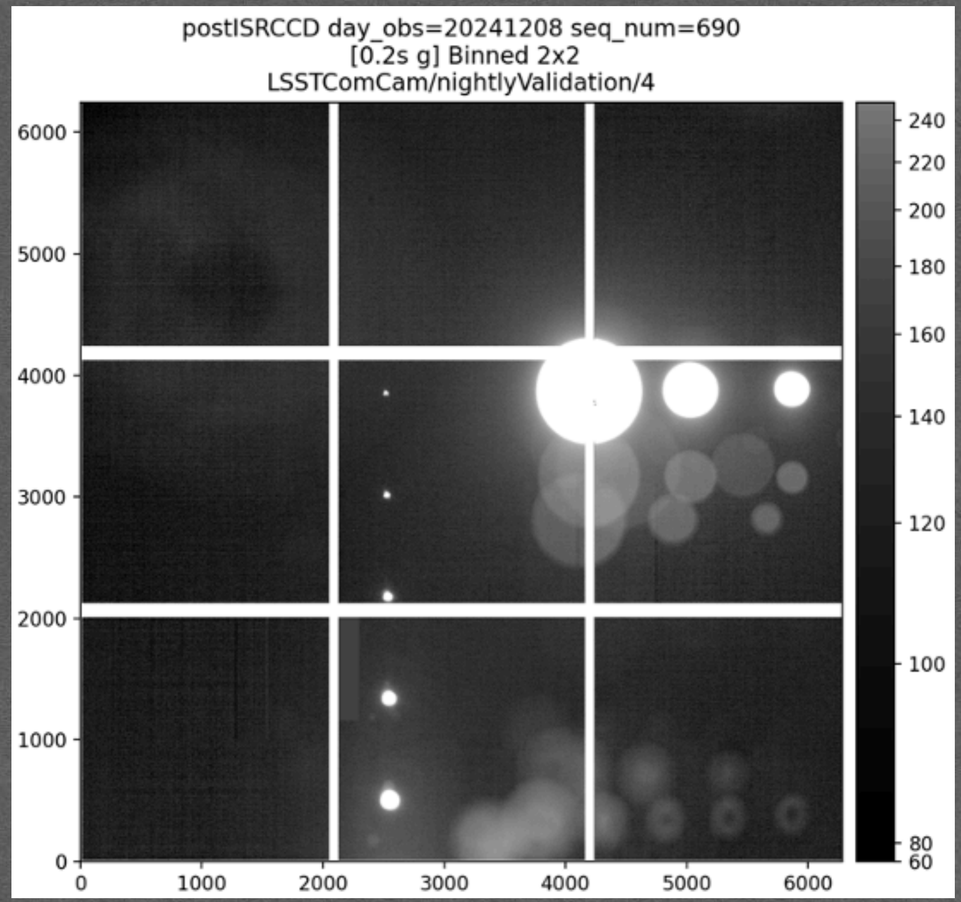


1 spot/CCD



2 lines spot

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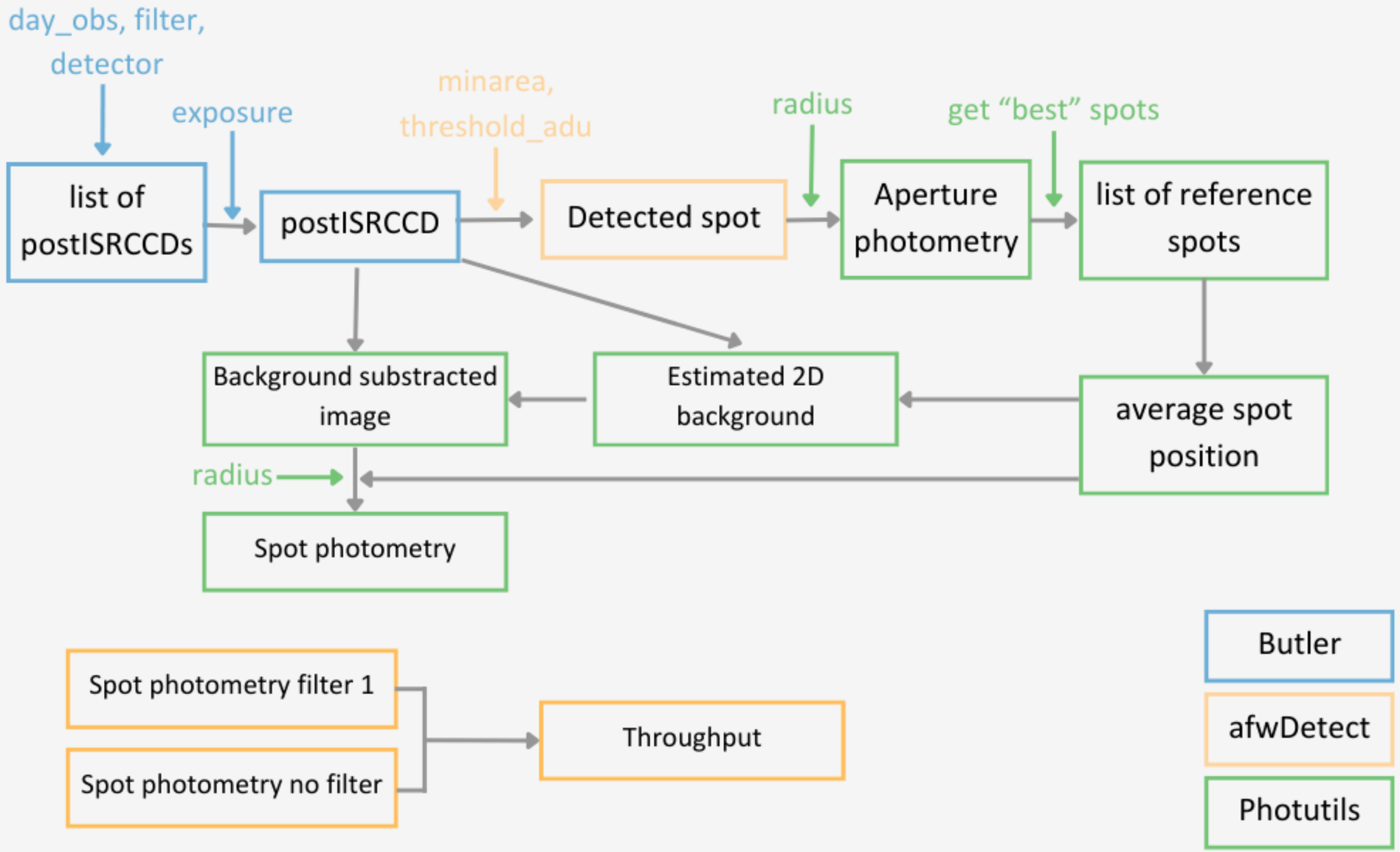
Workflow filter throughput measurement



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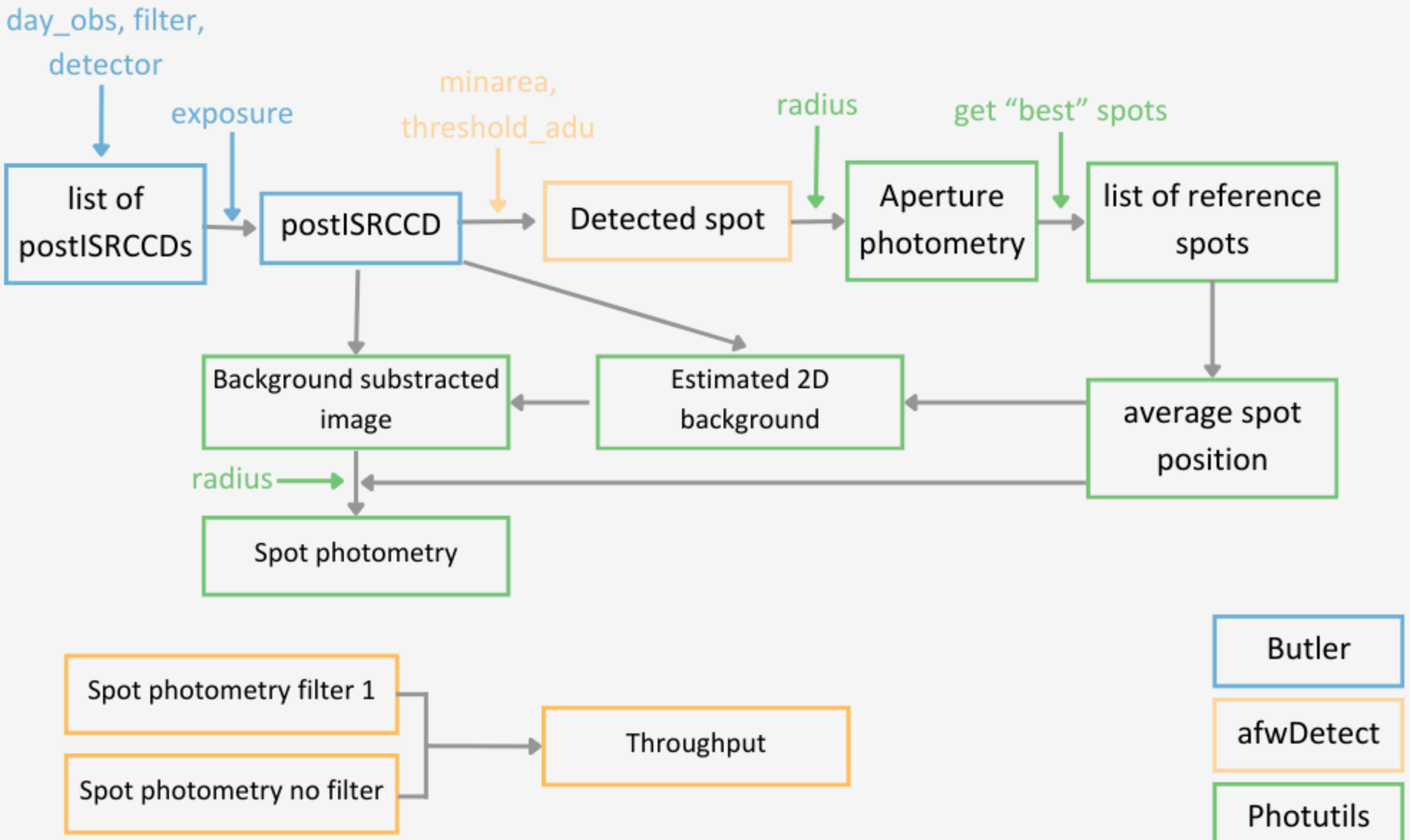
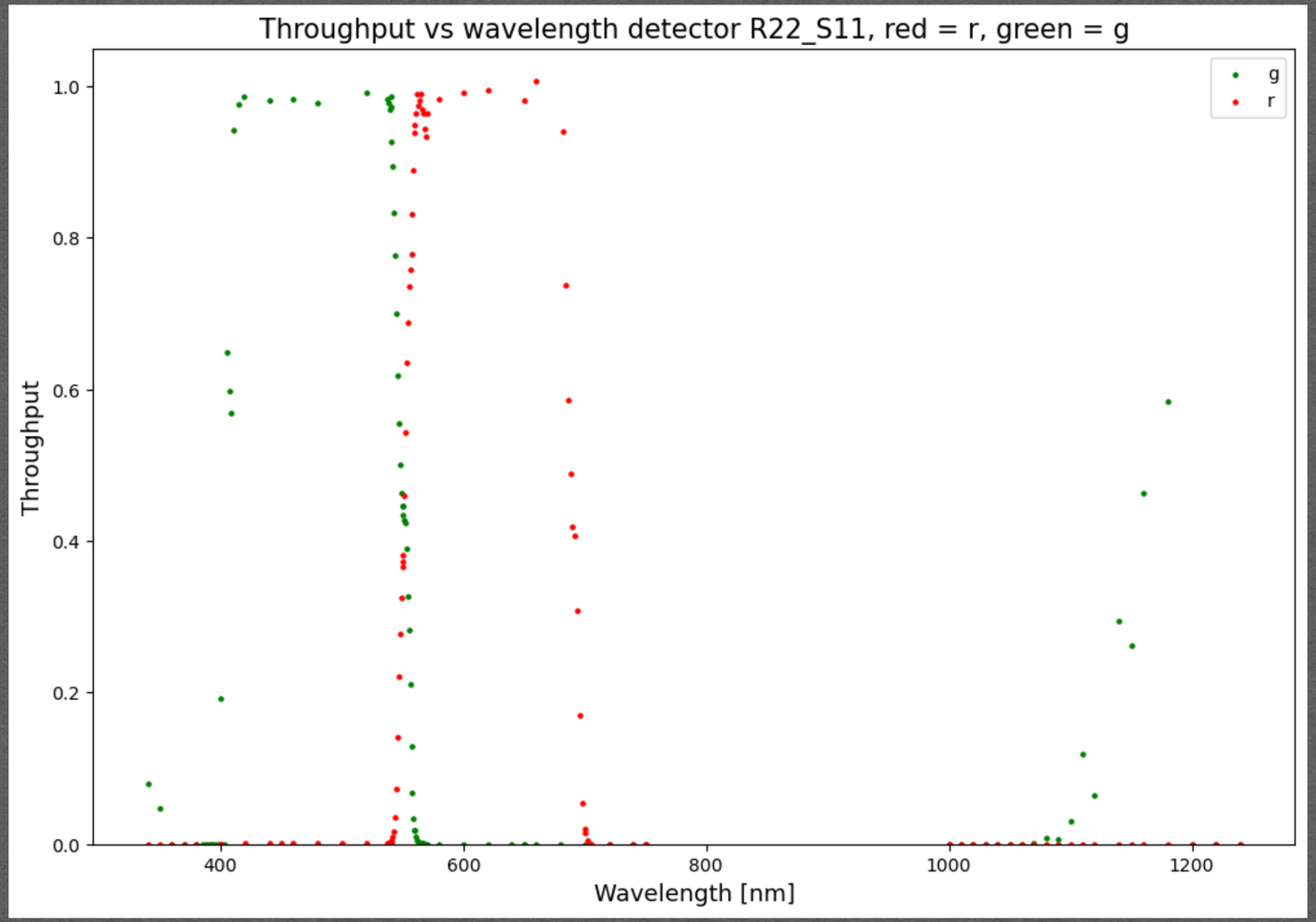


→ Integrated in the Data Management tools

ComCam g & r filters throughput measurement



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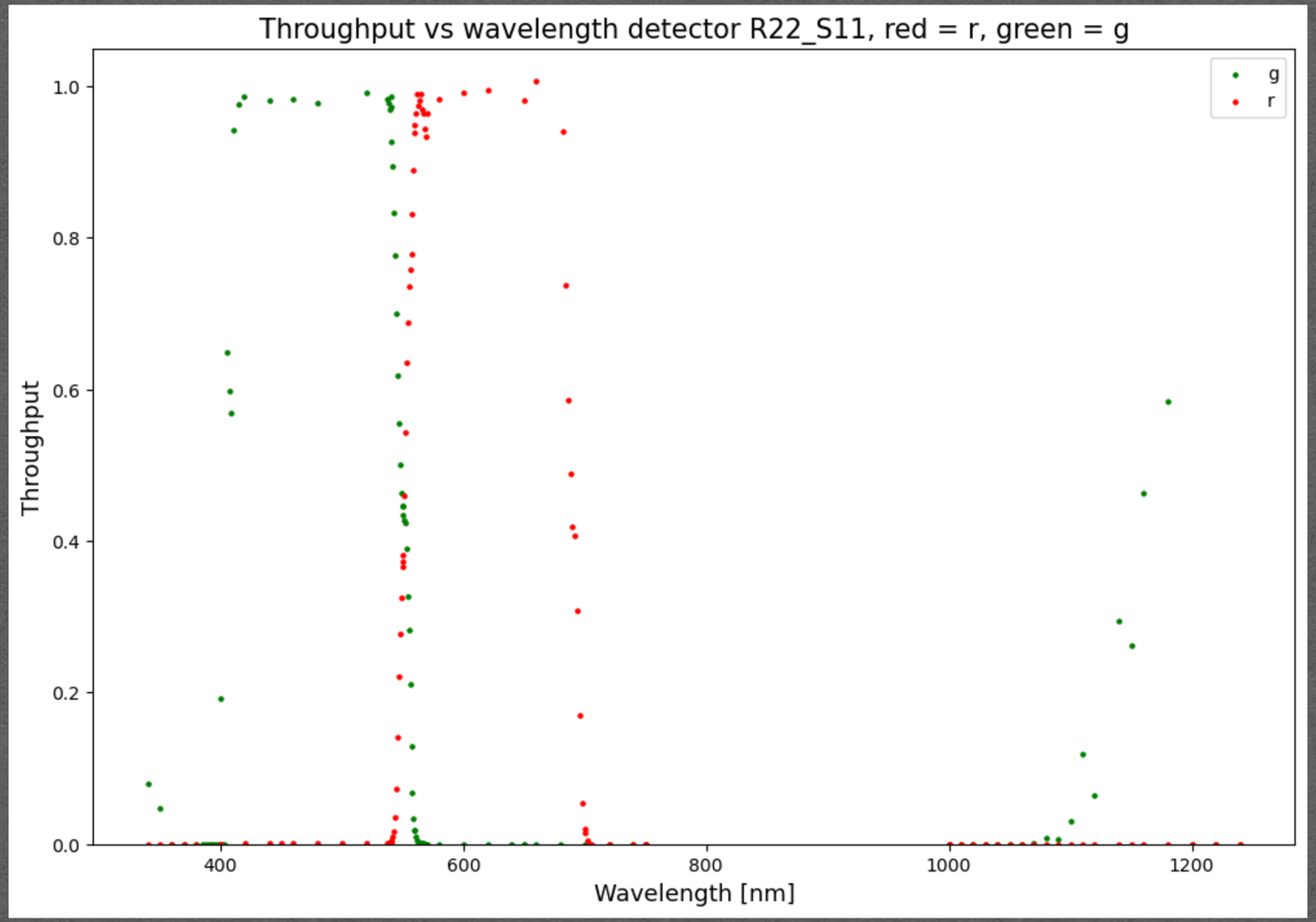
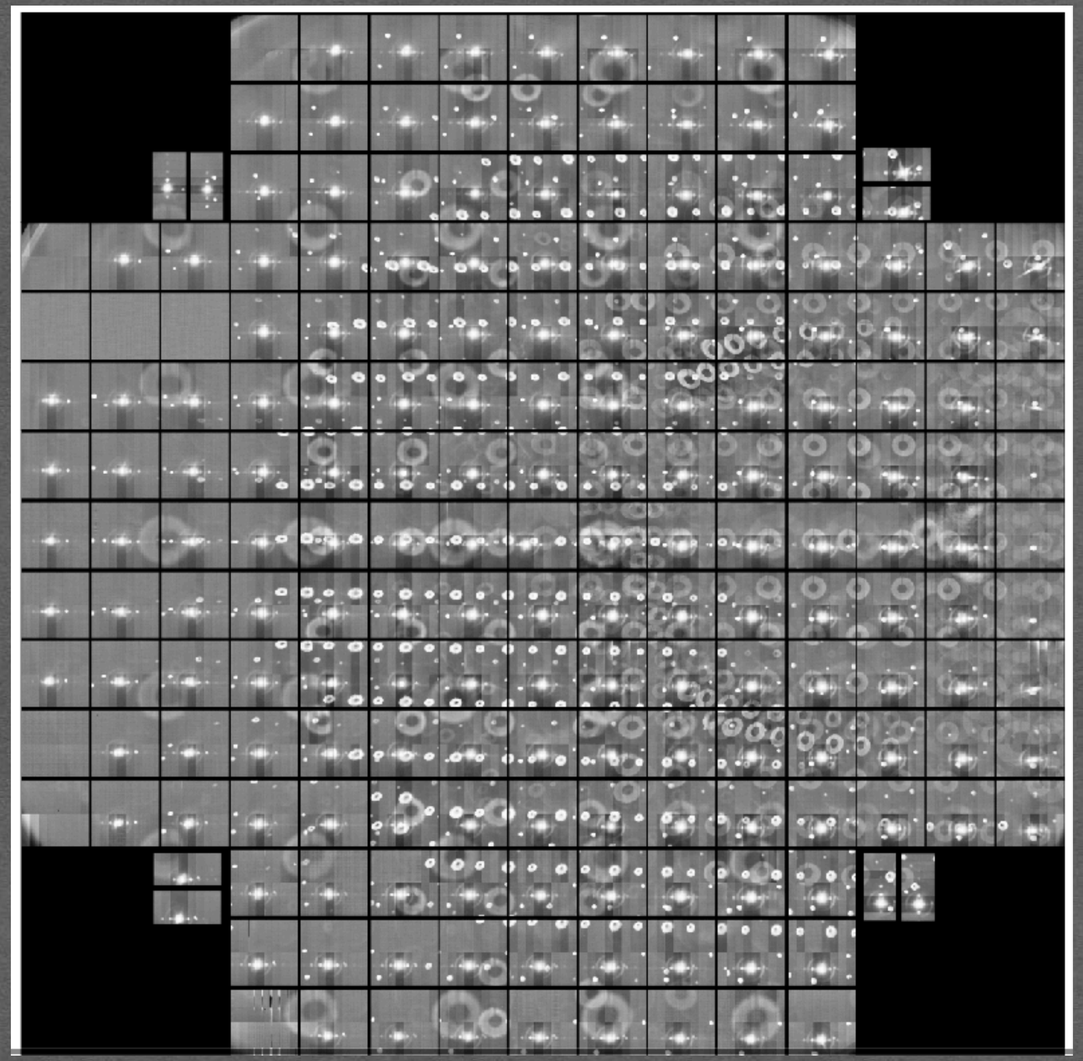
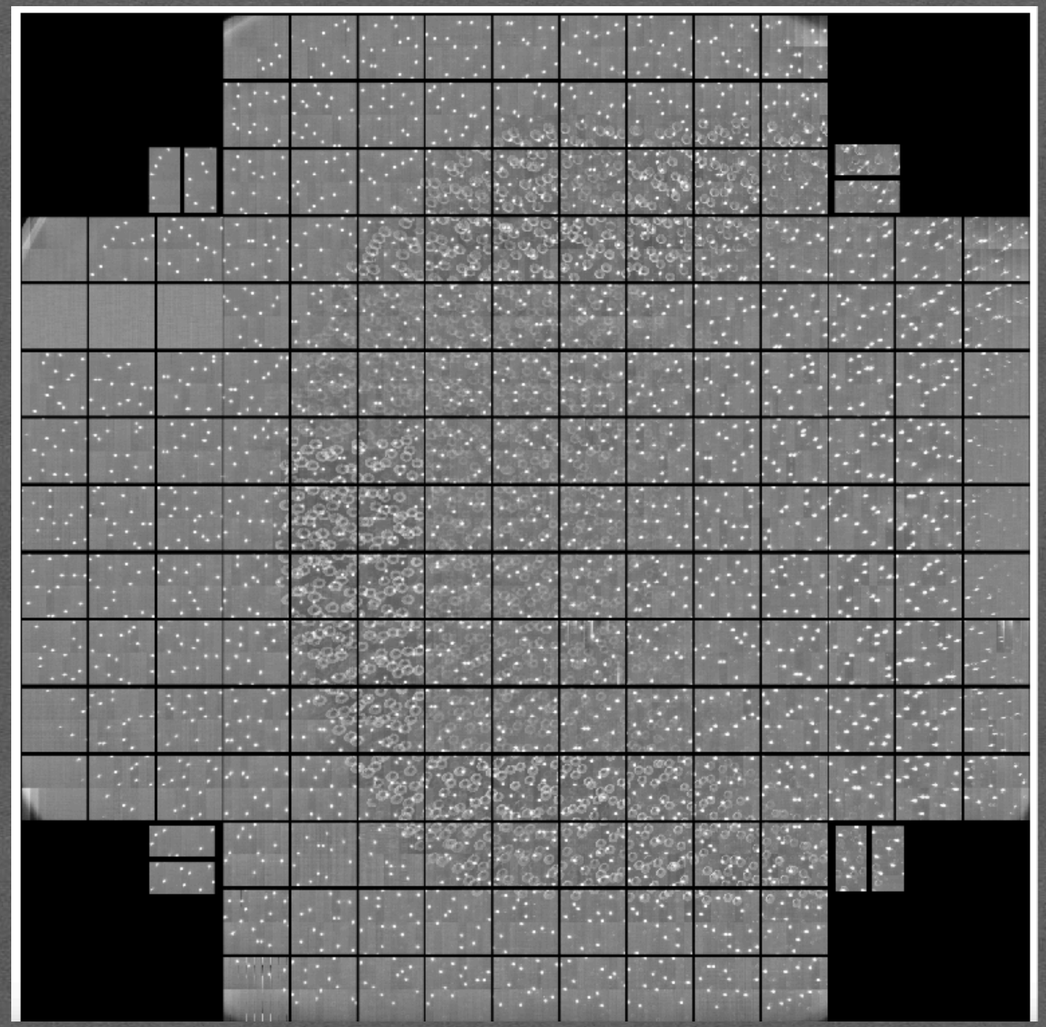


Technote : sitcomtn-152.lsst.io & DP1 paper in prep.

CBP on LSSTCam



1 spot/CCD - No filter scan



16 spots/CCD - Motion test

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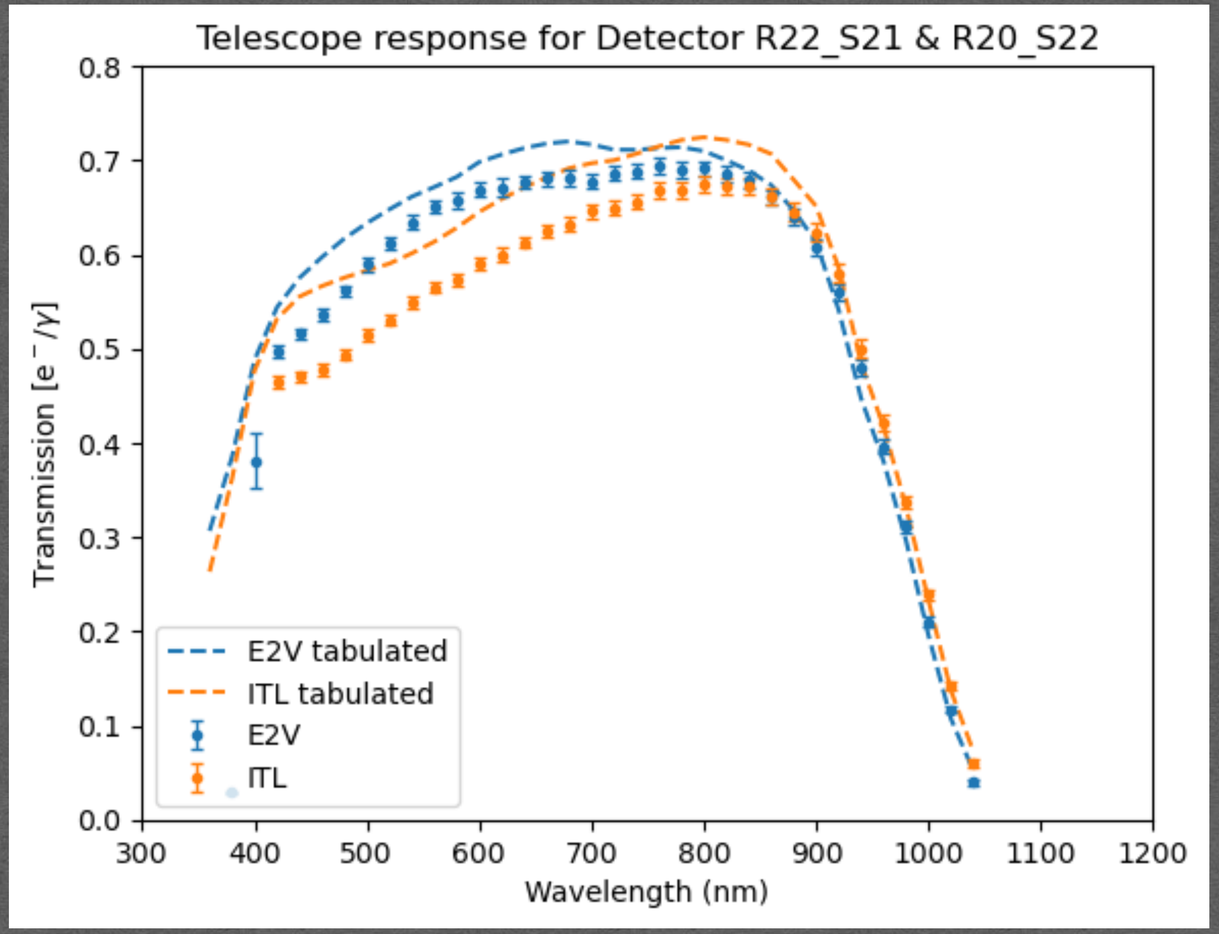
CBP QE scan

- Several ingredients
- Different detectors → different QE
- Work ongoing with filters
    - Transmission may vary with incidence angle → more complexity
- Tabulated data are not enough for long term and science requirements

→ Represent important calibration data for DP2 !



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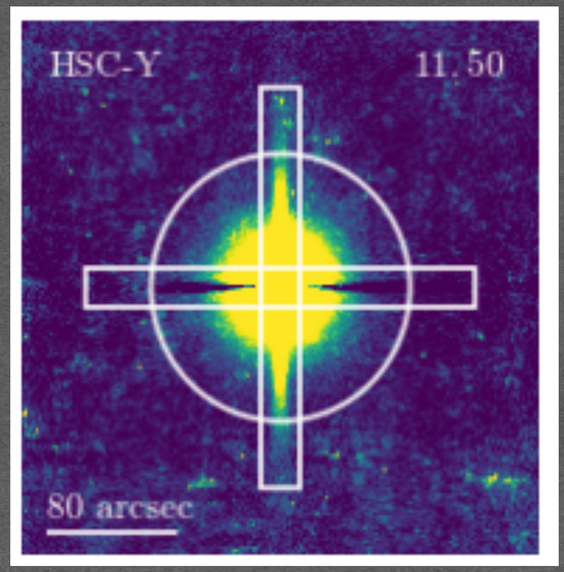
II. Bright object masks

Bright object masks

Bright stars reduce image quality by introducing optical/electronical effects

→ May induce biases in science results



Example of a saturated star and its mask in HSC-SSP Coupon et al. 2017

→ Concerns different working groups with different needs for masks

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Masking methodology

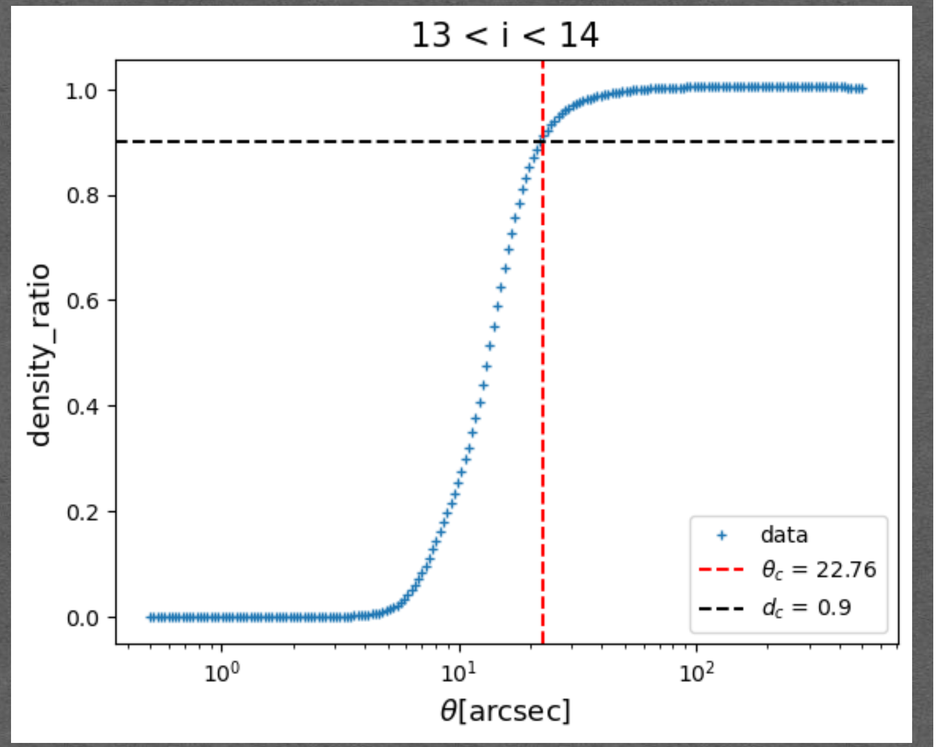
- Based on HSC-SSP method :

Not discussed here

1) Build a « bright object » sample and a galaxy sample

2) Determine disk radii to mask around bright star as a function of the magnitude using density profiles

3) For each object : mask the region contained within the corresponding disk



Radii from ~50" down to 7"

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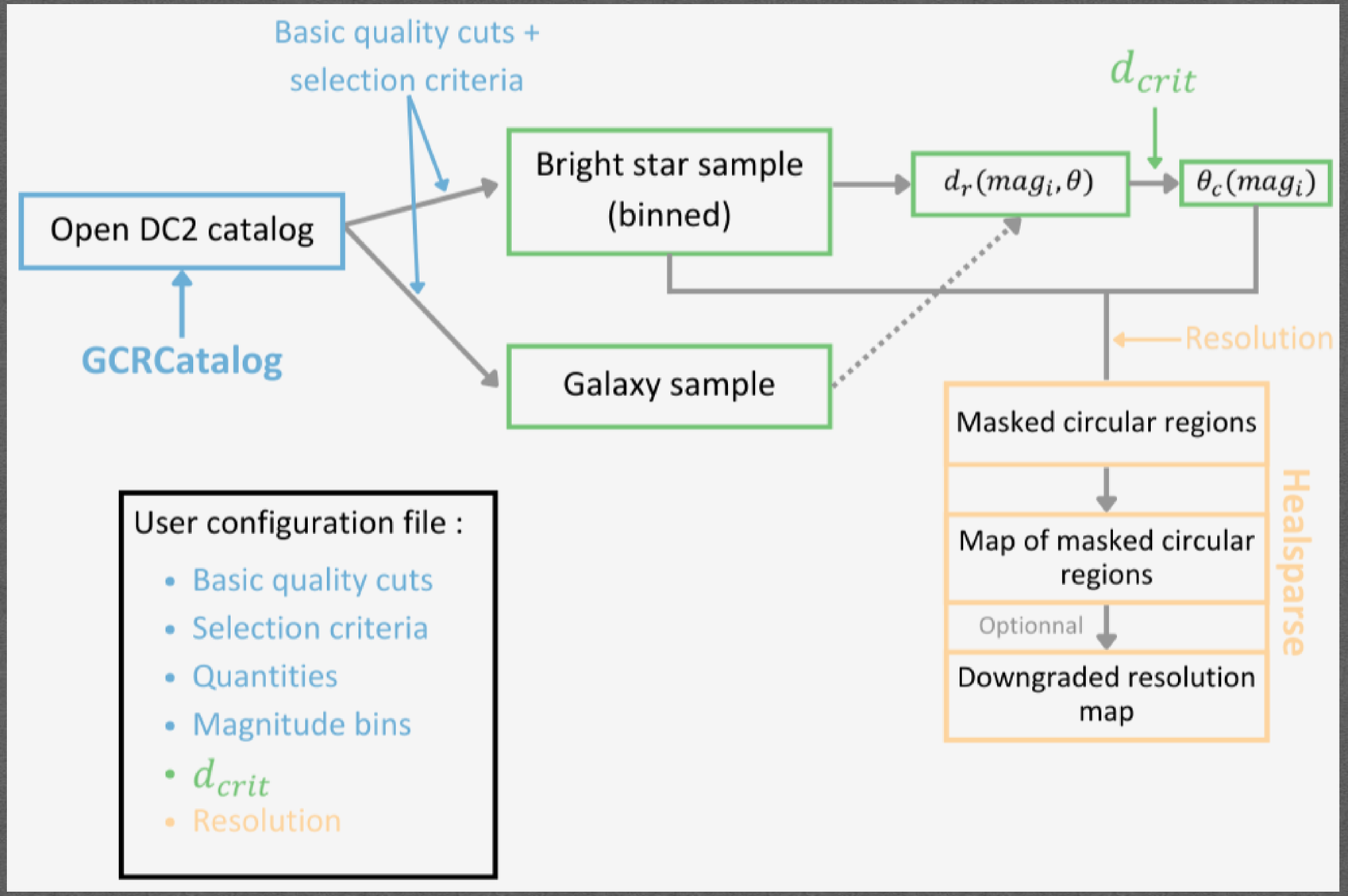
Masking methodology



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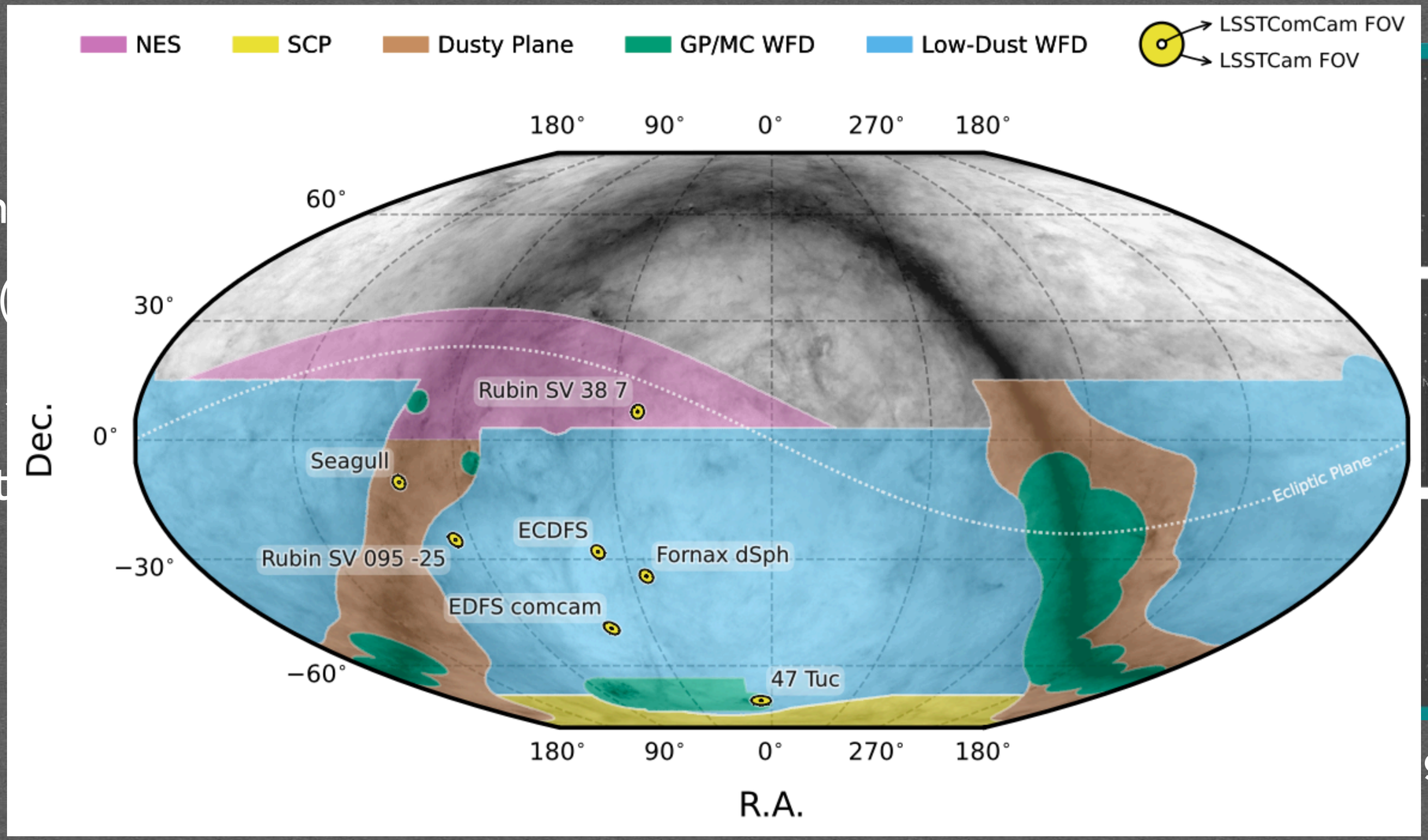
DP1 catalog

- 3 months of ComCam data
- 7 fields (wide, deep, stellar, …)
- 6 filters similar to LSSTCam (u,g,r,i,z,y)
- Final catalog made by running LSST Science pipeline on the images

Example of a DP1 image

DP1 catalog

- 3 month
- 7 fields (
- 6 filters
- Final cat
  pipeline



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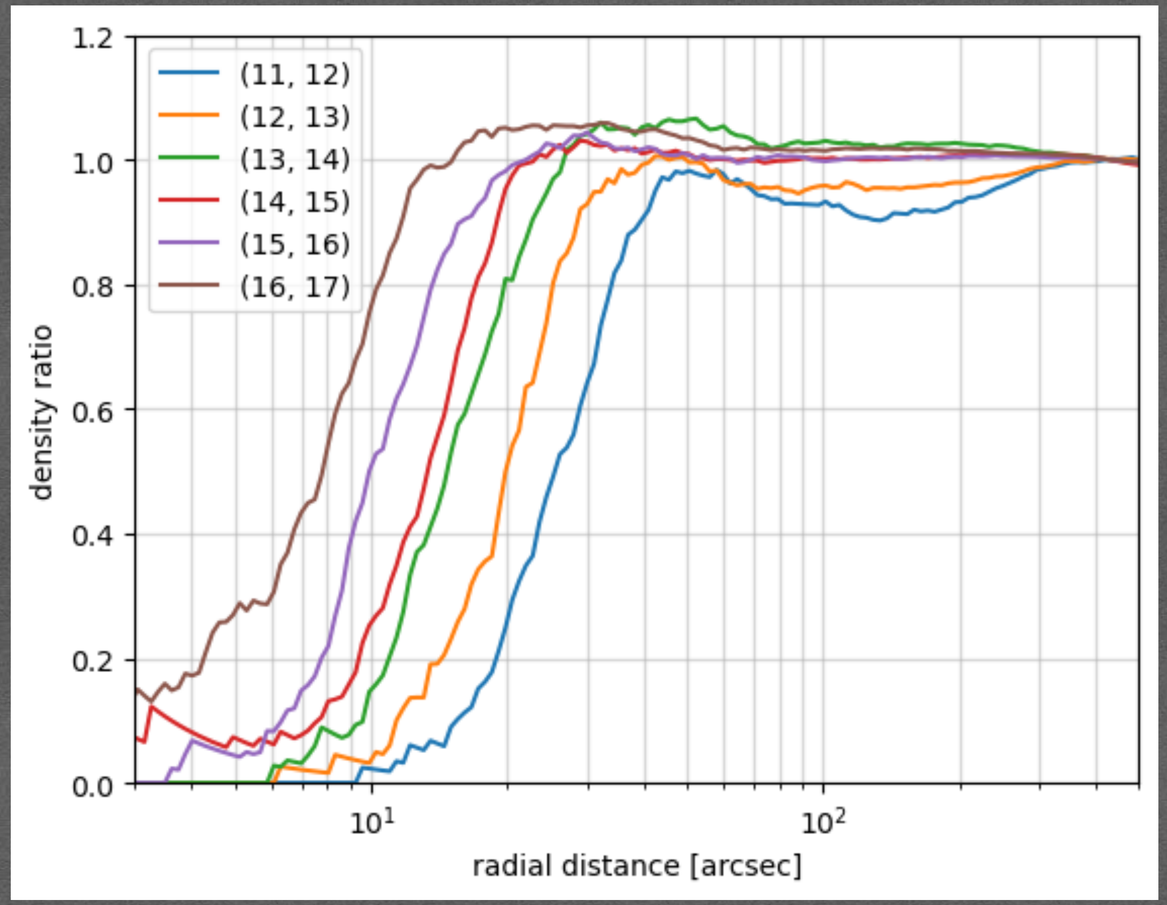
DP1 bright object mask

- Required modification for data access
  - The monster as reference catalog
  - galaxies from DP1 with quality cut (ongoing study)
- Same critical radii for every field
- This version is being used in A360 studies
- A technote is being written

Density ratio in the ECDFS field



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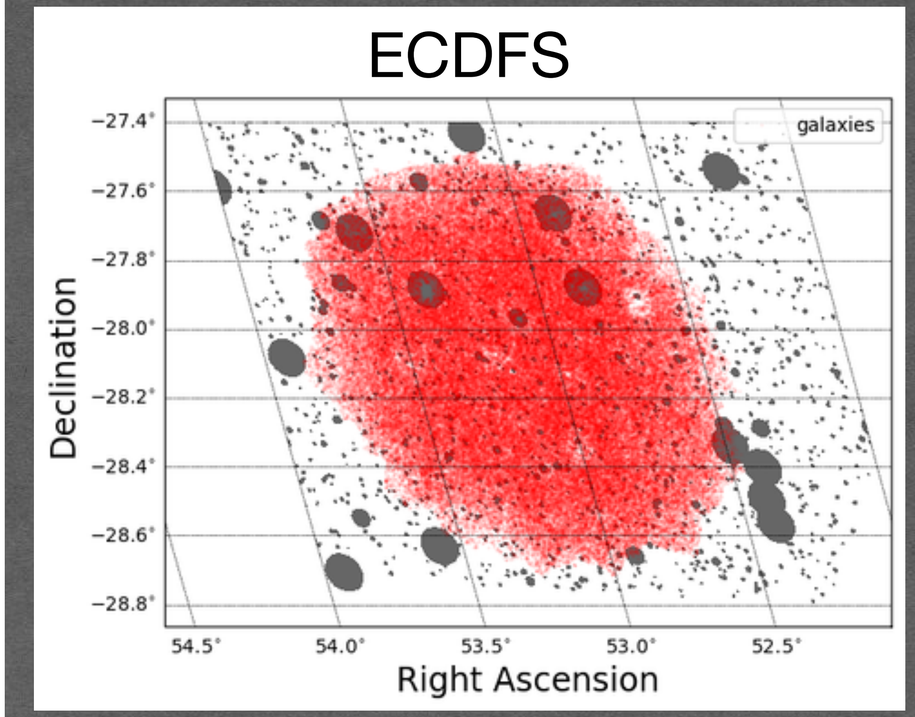
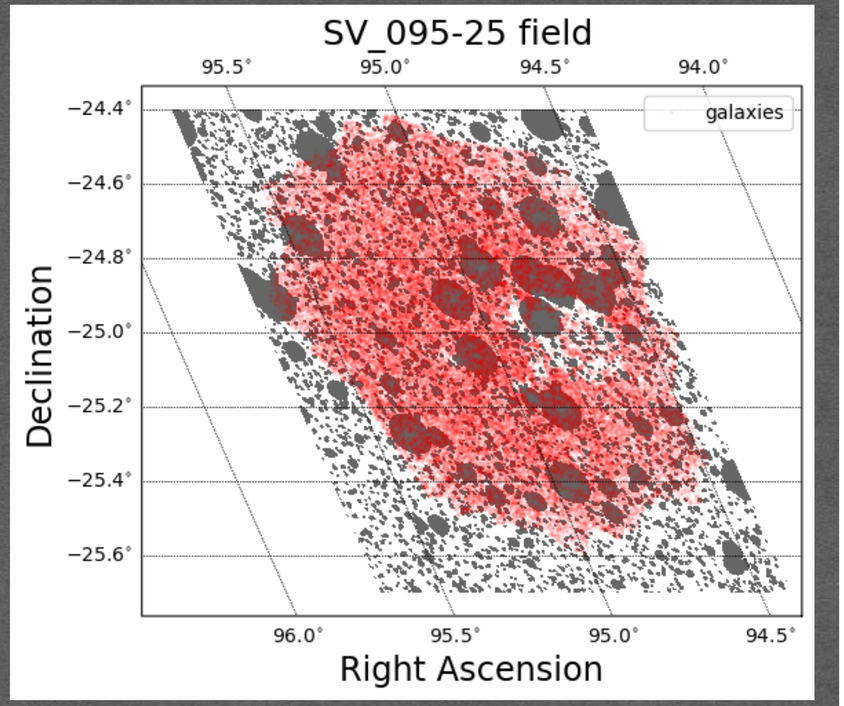
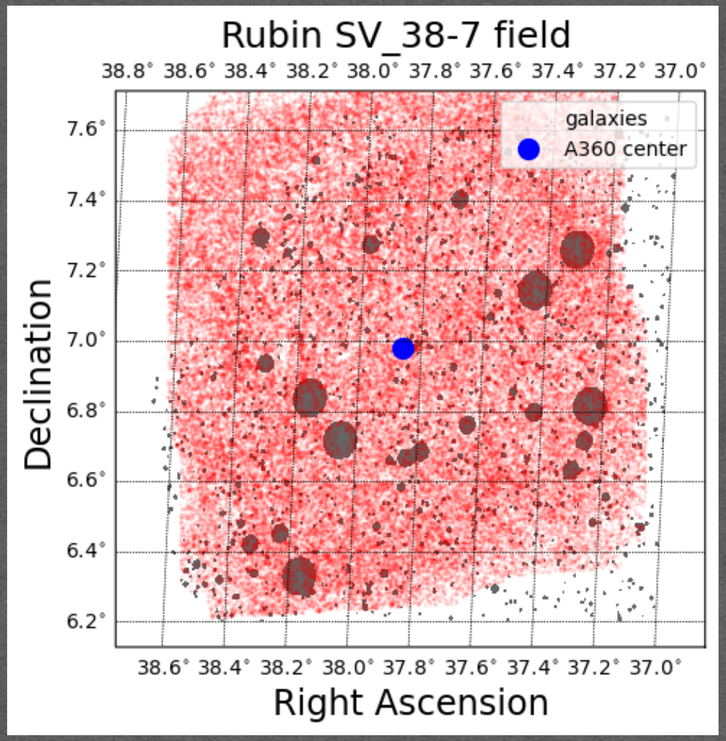
DP1 bright object mask maps







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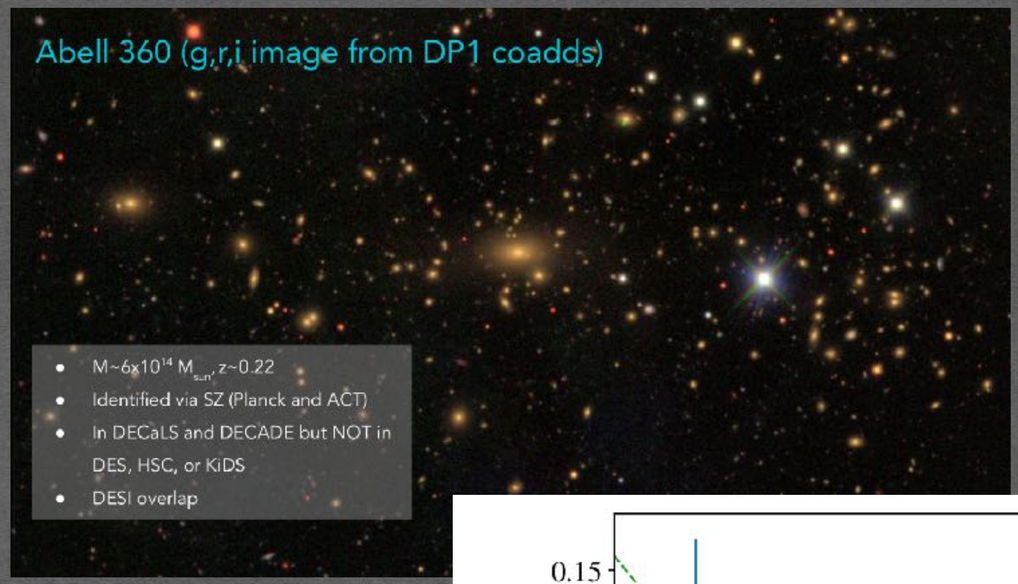
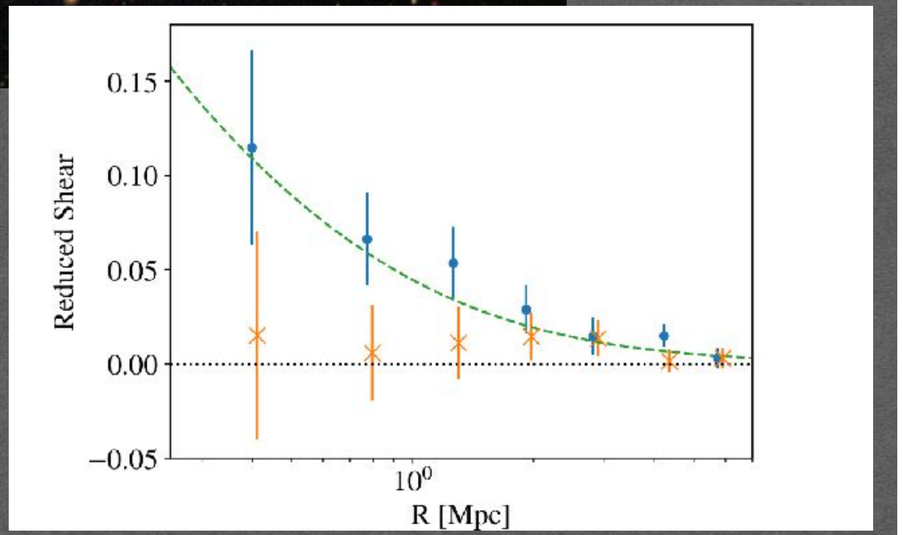
The A360 project

- Massive galaxy cluster
- Observed with LSSTCam and other Surveys (DECaLS and DECADE) & SZ (Planck & ACT)
- Masks critical for science with A360
- Commissioning of tools for science !
- Paper in preparation





Credit : C. Combet

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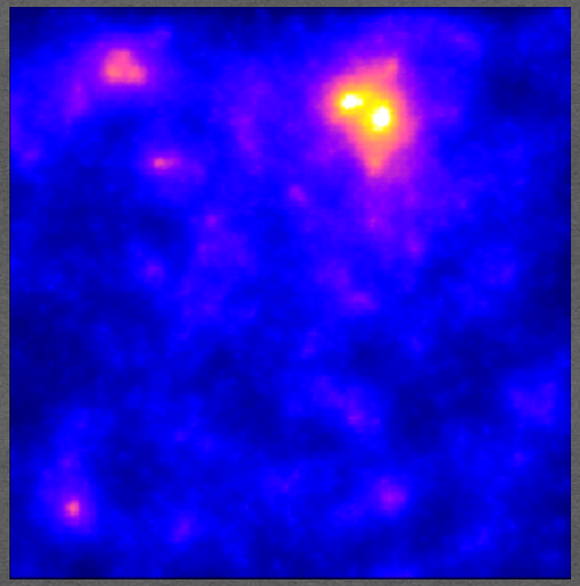
III. Galaxy cluster detection algorithms

AMICO algorithm

- AMICO = Adaptative Matched Identifier of Clustered Objects
- New algorithm to add to DESC galaxy cluster algorithms
- Optimal Filtering → Non biased signal amplitude estimator with minimal error
- 3D SNR map → cluster detection
- Galaxy member association to clusters



Example of SNR map on 1x1 deg^2 portion of the sky

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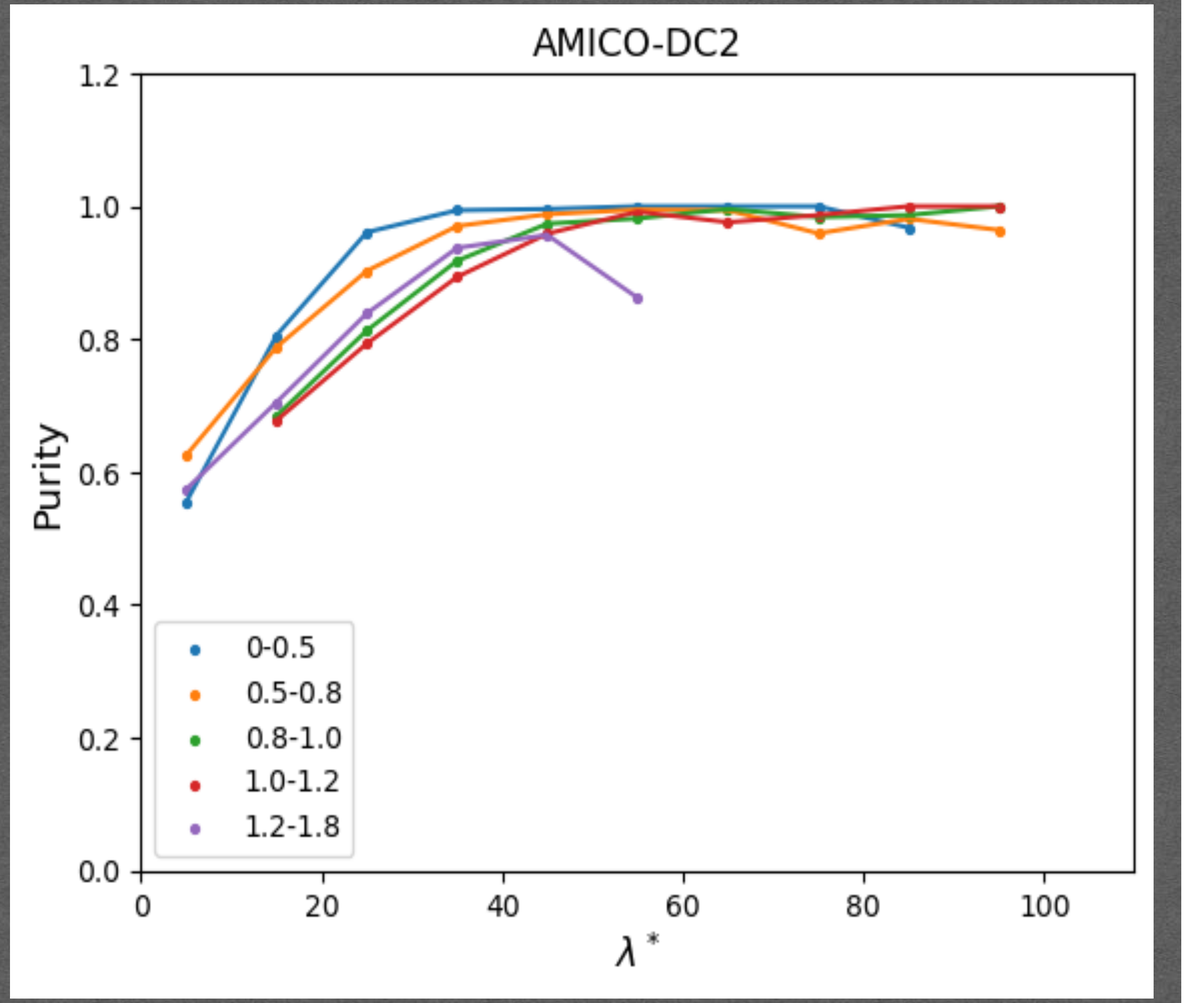
AMICO validation

Validation / Optimization work :

- ➢Richness validation
- ➢Galaxy selection criteria
- ➢Selection functions
- ➢Tests on cosmological constraints
- ➢Mask validation



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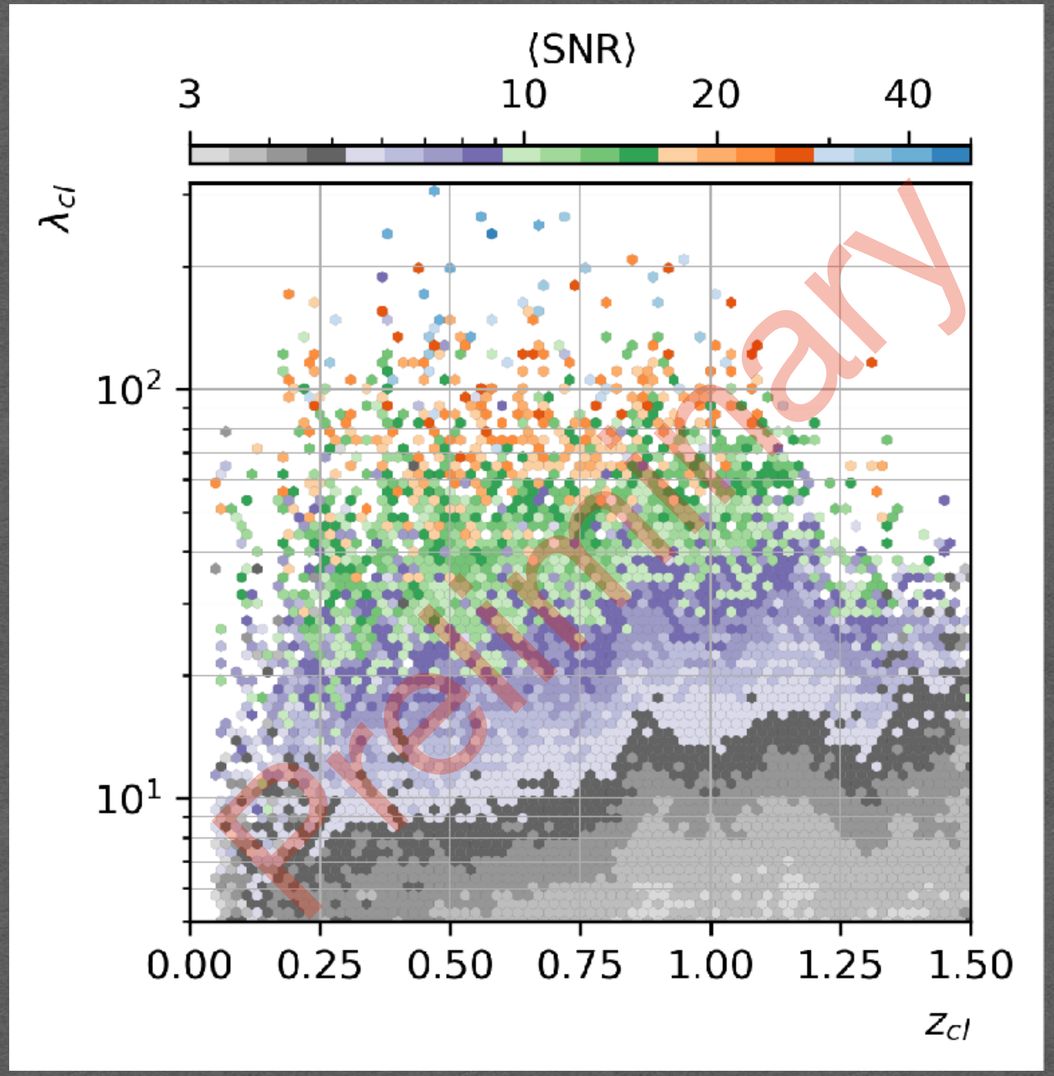
WAZP algorithm

- WAvelet Z Photometric
- Run within LAPP group
- Decomposition in redshift slice
- Validated in DC2
- Paper in preparation
- Need photo-z → in discussion for DP1 processing



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Conclusion

✦ CBP:

- Developped and used official Rubin tool to analyze CBP data
- Successful ComCam campaign !
- First results with LSSTCam data

✦ Bright object masks:

- Developped official DESC tool to generate modulable masks
- Generated masks on simulation - validated with cluster finder studies
- Generated masks on DP1 - utilized within A360 studies

✦ Galaxy cluster detection algorithms:

- AMICO under validation on simulation
- WAZP validated on simulation

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Prospects

✦CBP :

- Filter data to analyze
- Continue analysis for QE scans

✦ Bright objects masks :

- Technical note to be done
- Study DP1 masks with different source selection

✦ AMICO :

- To be discussed
- More help may be needed with WAZP

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