CSST strong lensing preparation

Ran Li
(on behalf of CSST strong lensing science group)

2020.10.29 ISSI/ISSI-BJ CSST-EUCLID Strong Lensing

CSST strong lensing science collaboration

- Formed in 2016, Recognized in 2017
- Members: Ran Li (NAOC), Nan Li (NAOC) , Shan Huanyuan (SHAO), Chen Yun (NAOC) , Shu Yiping (Cambridge), Dezi Liu (YNU), Xiaoyue Cao (NAOC), Ye Cao (NAOC), Yushan Xie(NAOC), Chunxiang Wang (NAOC), He Qiuhan (Durham) ,Guoliang Li (PMO), Xin Wang (UCLA), Xiaolei Meng (Tsinghua), Xingzhong Er(YNU) , Bin Hu (BNU), Xuheng Ding (UCLA), Shuo Cao (BNU), LiaoKai (WHU), Bingxiao Xue (PKU), Dandan Xu (THU), Shude Mao (THU), Du Wei (NAOC), Zhiyu Zhang (NJU)……

CSST science projects to be funded by 921 office

- Building the lens model (Nan Li)
- Science application of gravitational lensing (Ran Li)
- Gravitational lensing and high redshift galaxies (Dandan Xu)
- Lensed supernove (Guoliang Li)

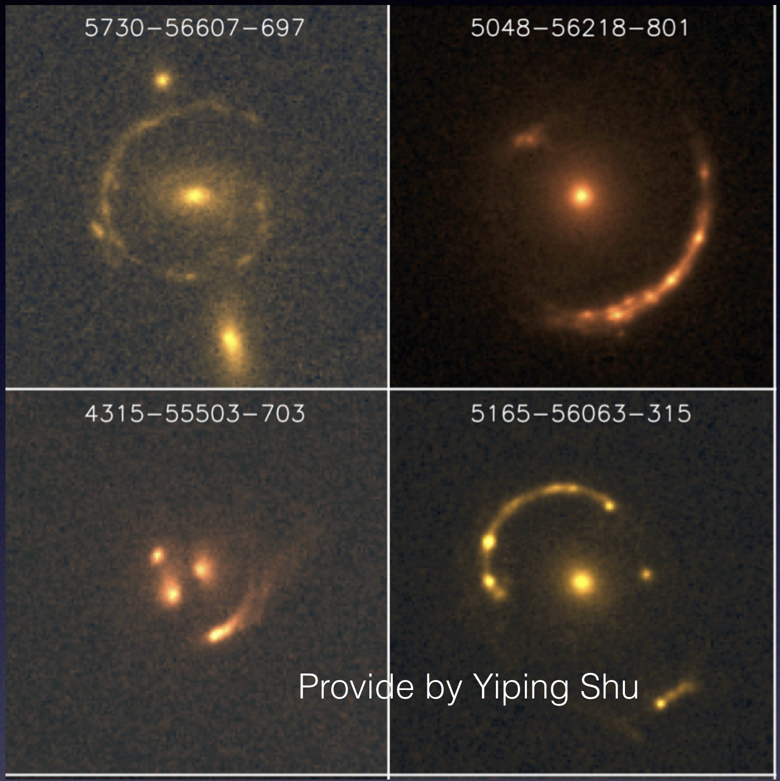
Bi-week discussion

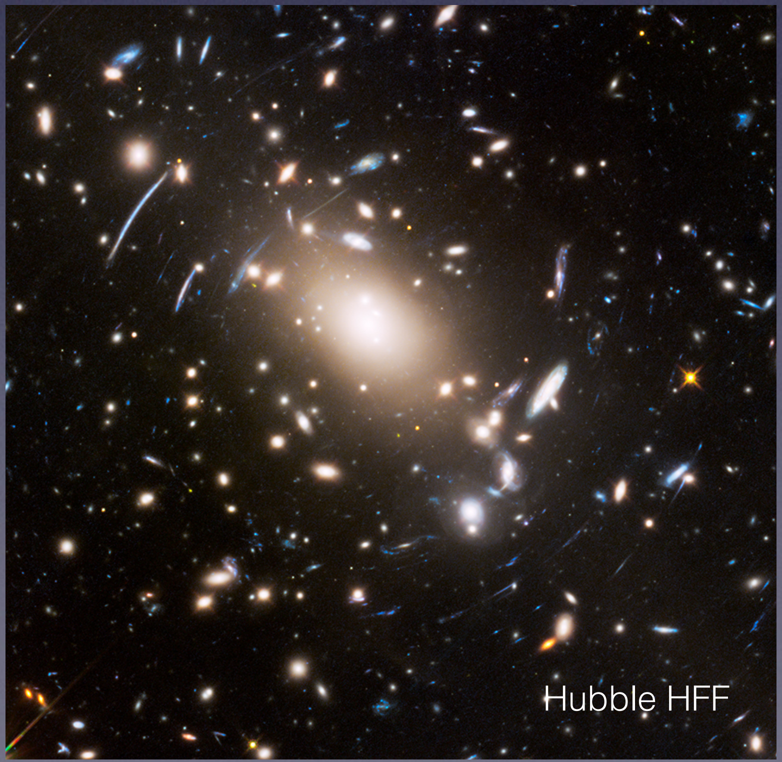
Organization

- Working package list https://kdocs.cn/l/sVUSxyue1
  - CO-1-5：LEV1-LEV3 pipeline searching/modelling/simulation
  - CO-4-1 : Science application packages except high-z, Lensed SNe
  - GA-4-5: high-z science, focusing on high-z source galaxies
  - TD-1-9: Lensed SNe

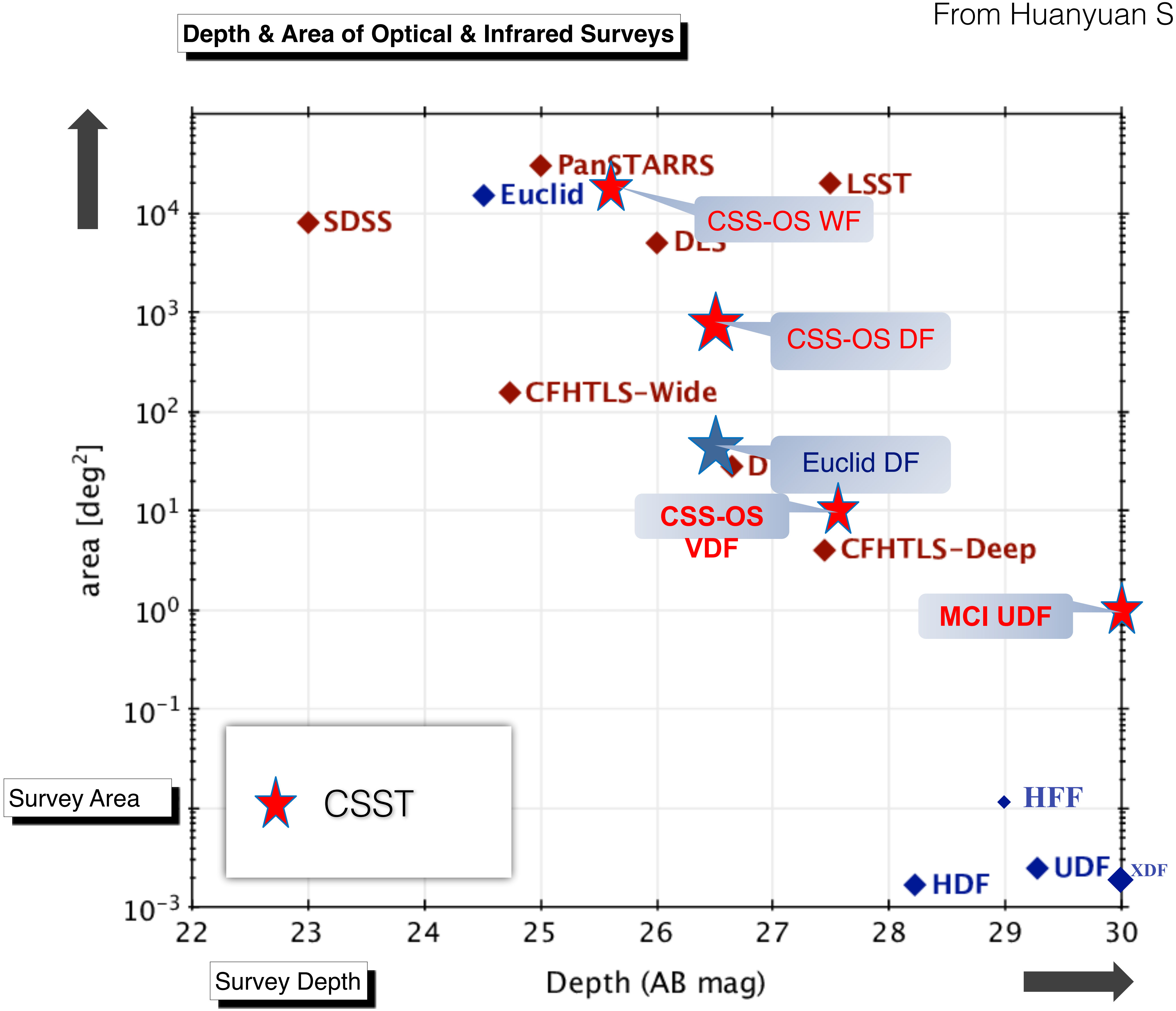
Expectation for CSS-OS

- More than 10^5 galaxy scale strong lens systems
- Hundreds of massive clusters with many multiple images
- Accurate photo-z for both lens and source.





From Huanyuan Shan



CSST from the point of view of strong lensing

High resolution imaging (R80=0.15”)：Great for lens modeling

Multi-band coverage: accurate photo-z, many science goals can be accomplished without follow-up spectroscopic observations.

Slitless spectra: searching for emission line lenses; lens redshift; lensed supernova; high-redshift lensed galaxies in cluster region.

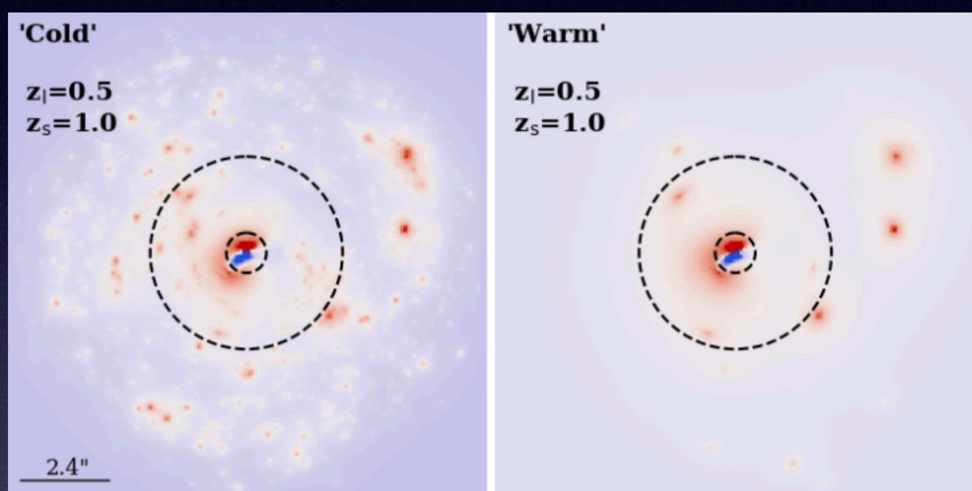
Depth: wide survey is shallower than Hubble SLAC sample / HOLICOW (300s vs ~3000s), deep survey 400 deg^2 ~2400s exposure, Ultra-deep comparable to HFF

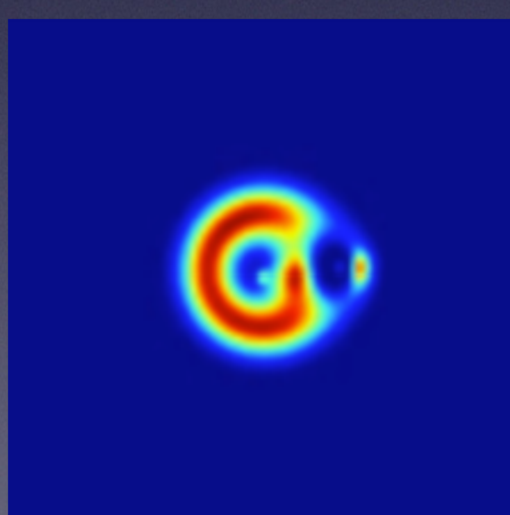
Large sky coverage: statistical analysis; many rare cases.

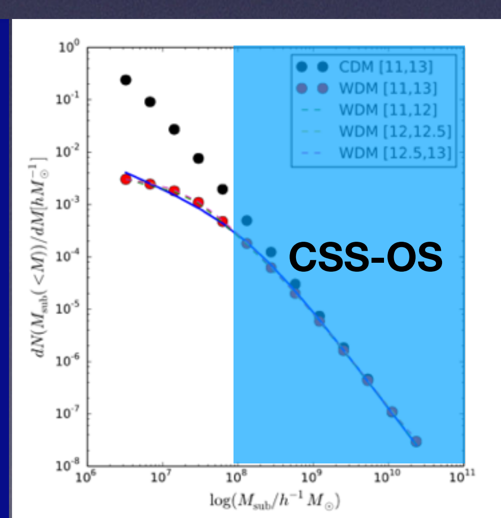
Time domain: providing an all-sky high-res strong lensing map for time-domain surveys.

Science cases: properties of dark matter

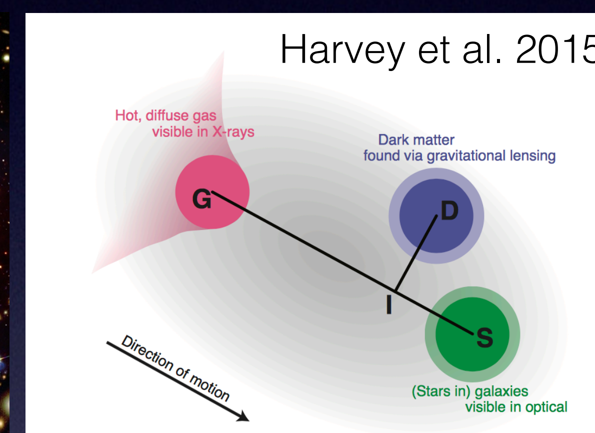
COLD vs WARM

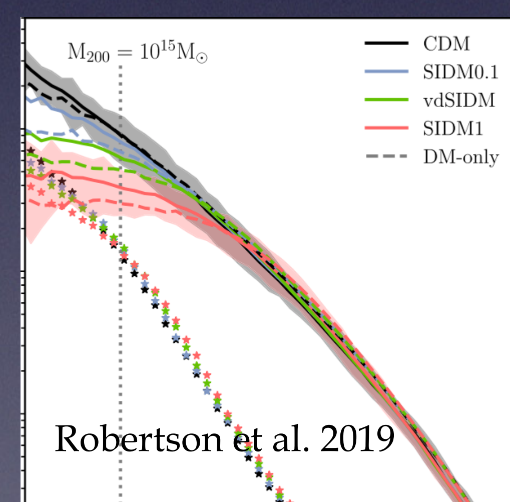


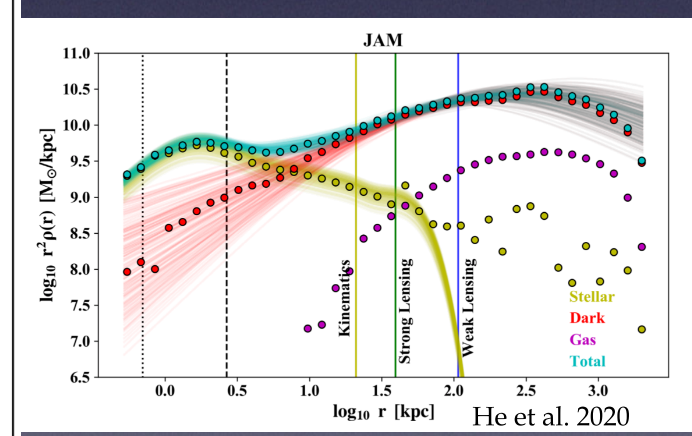




Self-Interaction ?

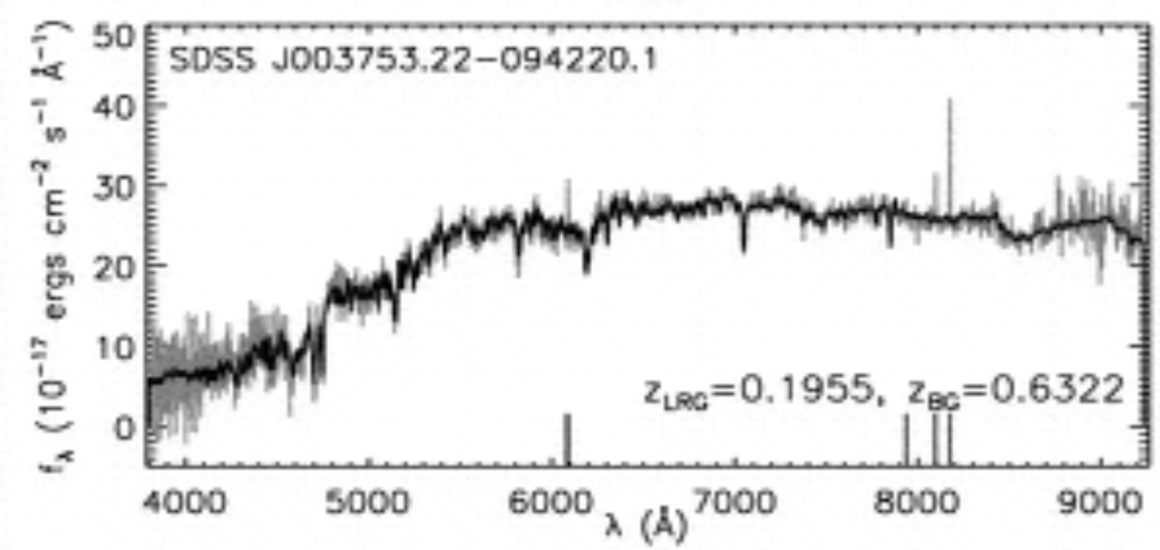


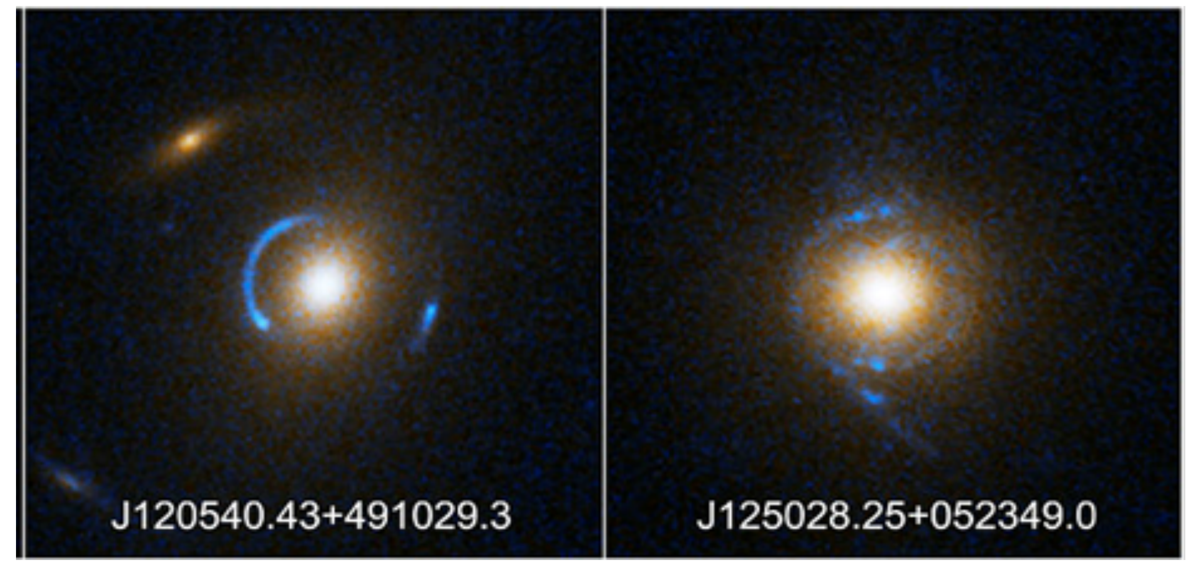




Figs: Li et al. 2016, He et al. 2020 submitted

Science cases: Testing gravity





Velocity dispersion → Dynamical mass

Gravitational mass

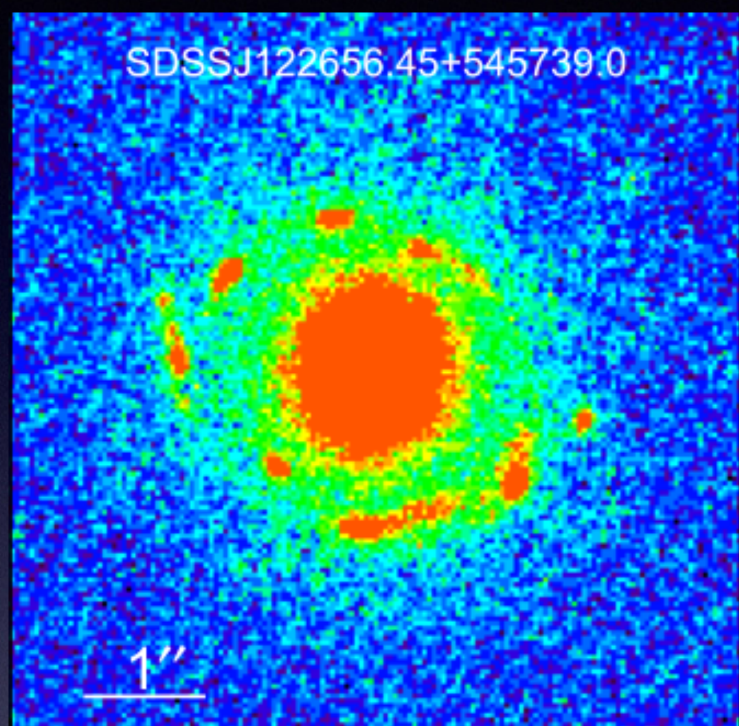
$$ds^2 = -(1+2\Psi)dt^2 + (1-2\Phi)\delta_{ij}dx^i dx^j$$

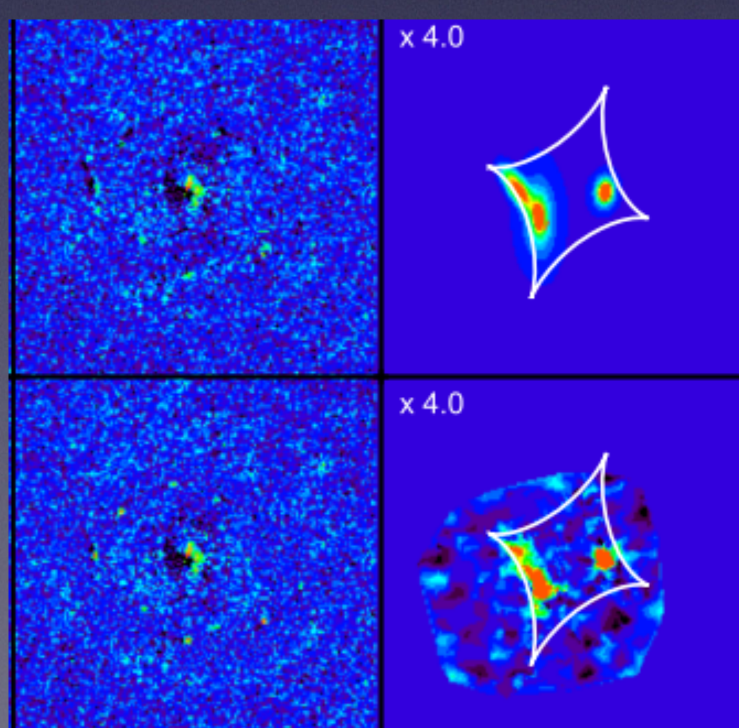
Ψ : Newtonian dynamical potential

Φ : space curvature potential

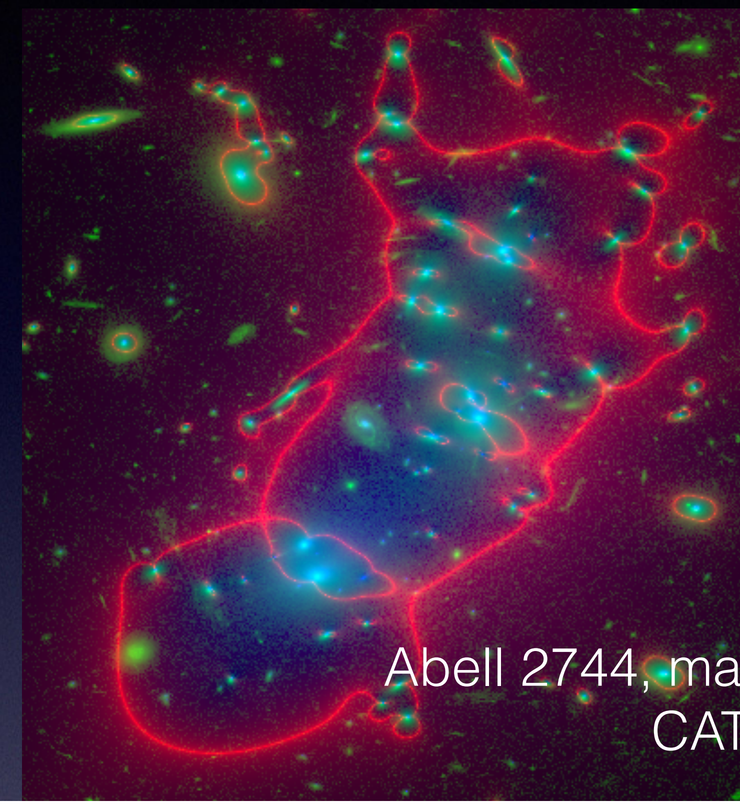
In GR, $\Phi = \Psi$

Science cases: Galaxy lensing as a telescope (DF, UDF)

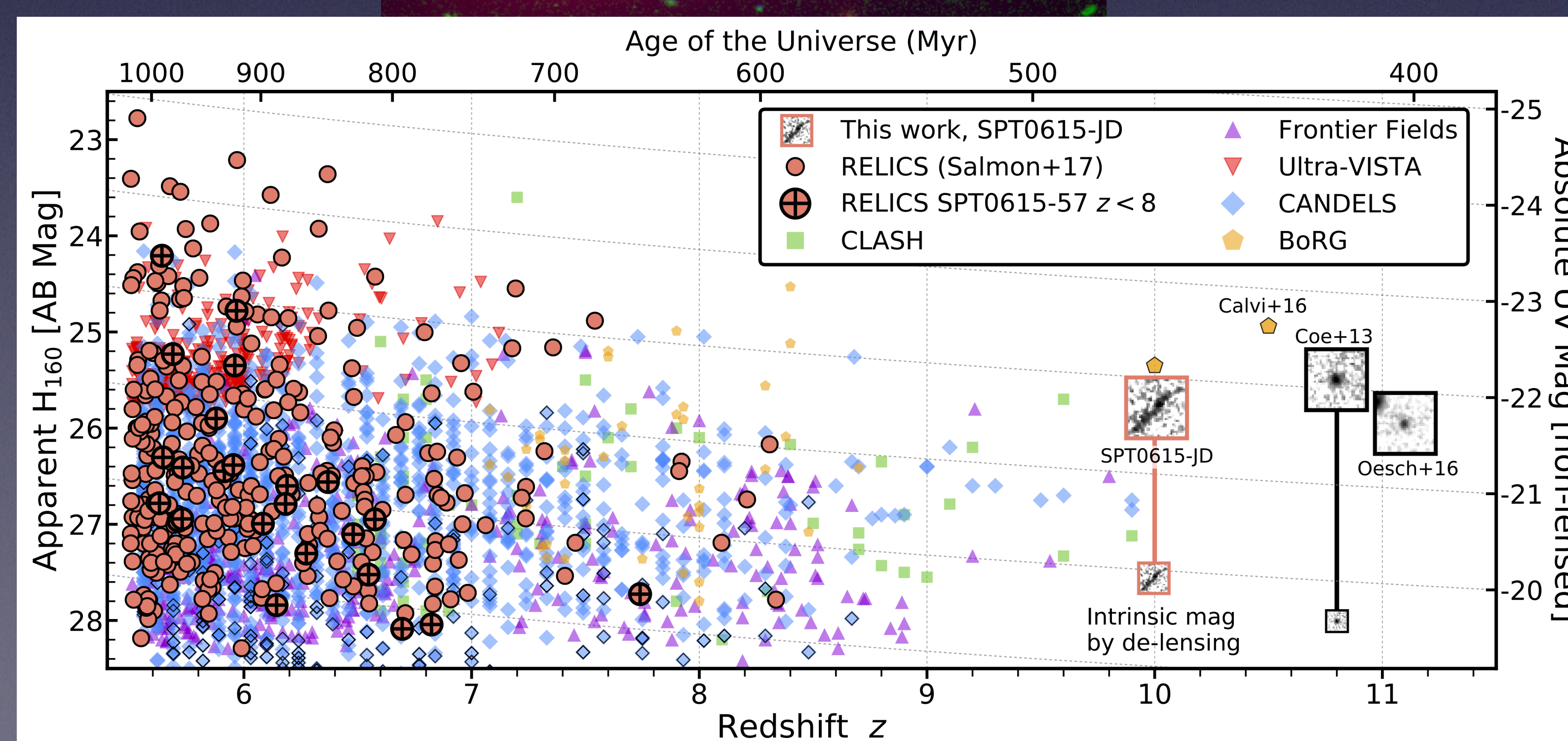




Lensd LAEs, Shu et al. 2016



Abell 2744, magnification map by CATS team



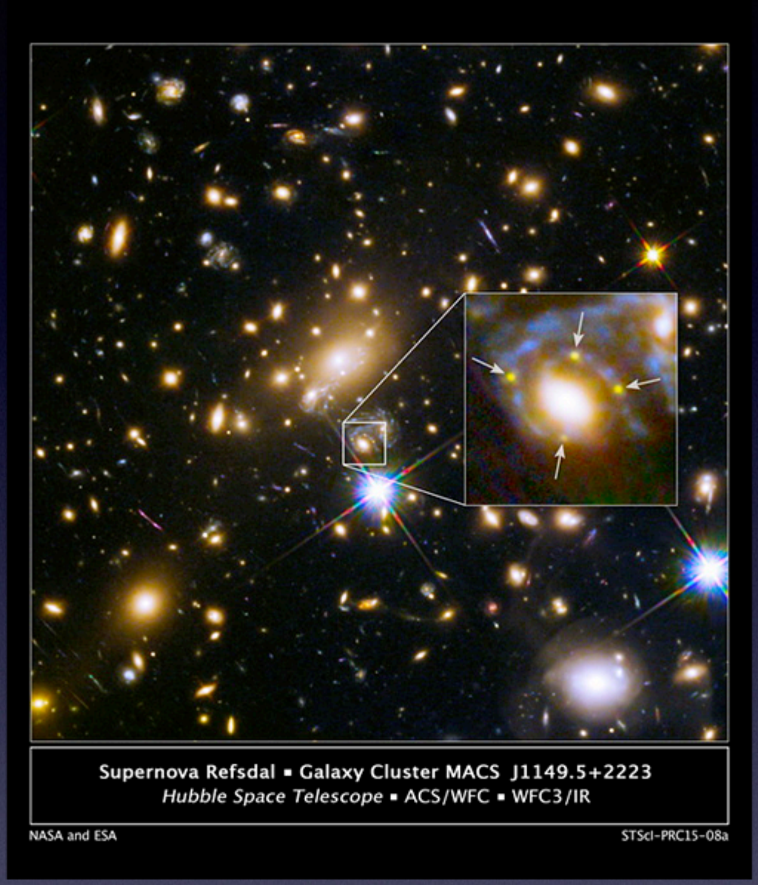
Salman et al. 2018

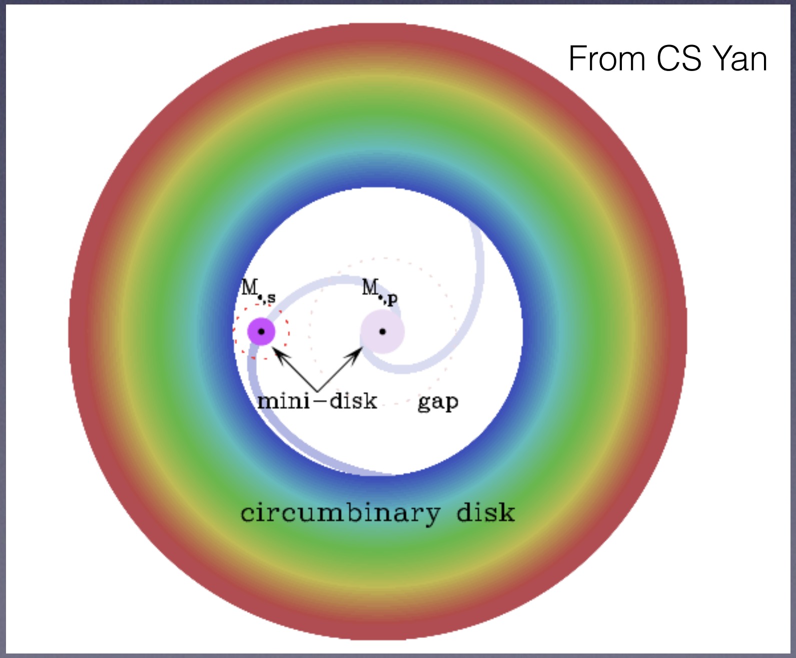
Galaxy science (SL+SSP+Kinematics)

- Overall evolution of galaxy mass and structure
- Dark matter fraction within galaxies and clusters
- Shape of dark matter haloes
- Evolution of Early type galaxies
- IMF variation of late type lenses
- ……

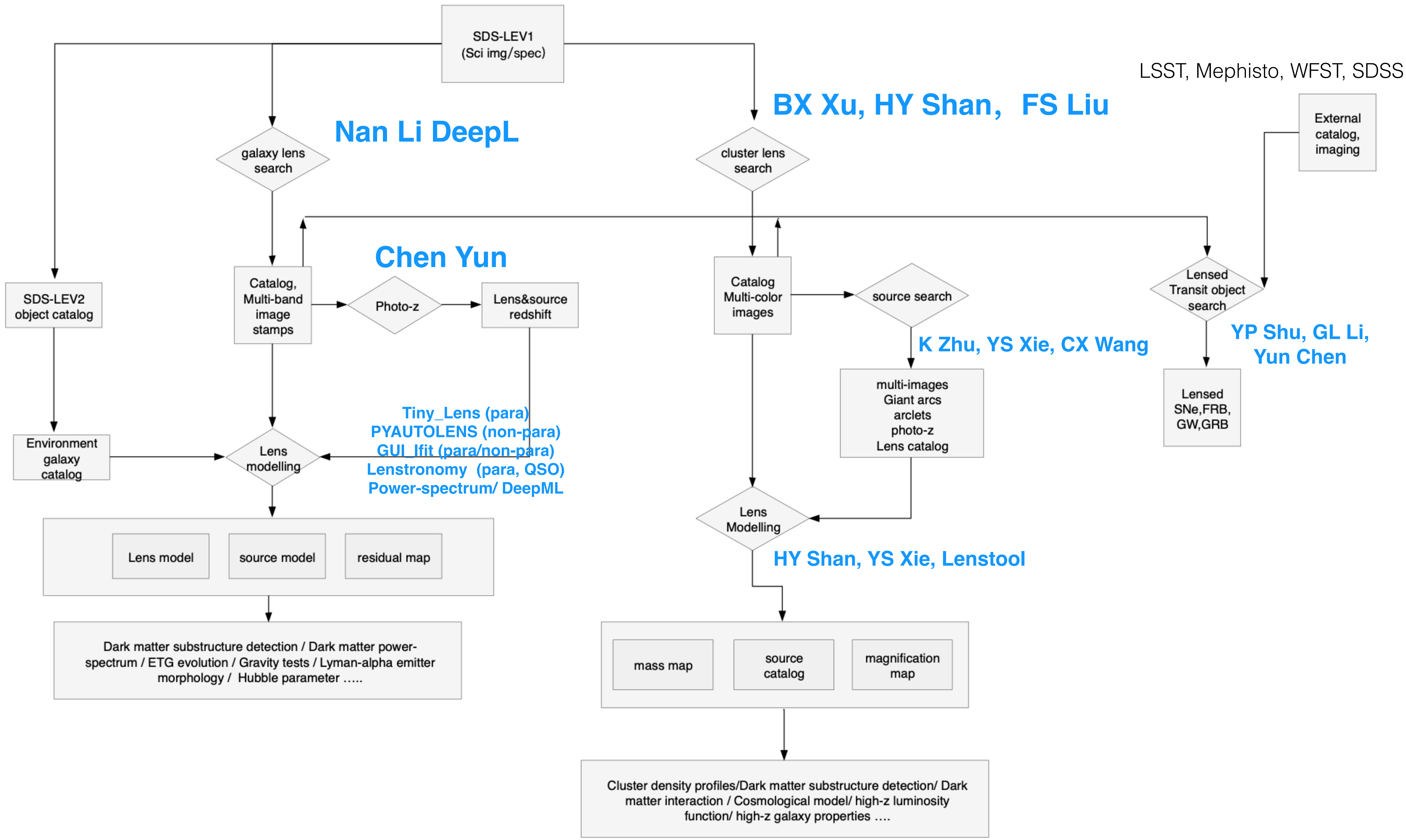
Time-Domain

- Proposed deep fields have potential time-domain capability.
- MCI-UDF: 4-5 clusters with 1500 x 300s exposures
- Main Survey: a 10 deg^2 field of 60x300s exposure is proposed.

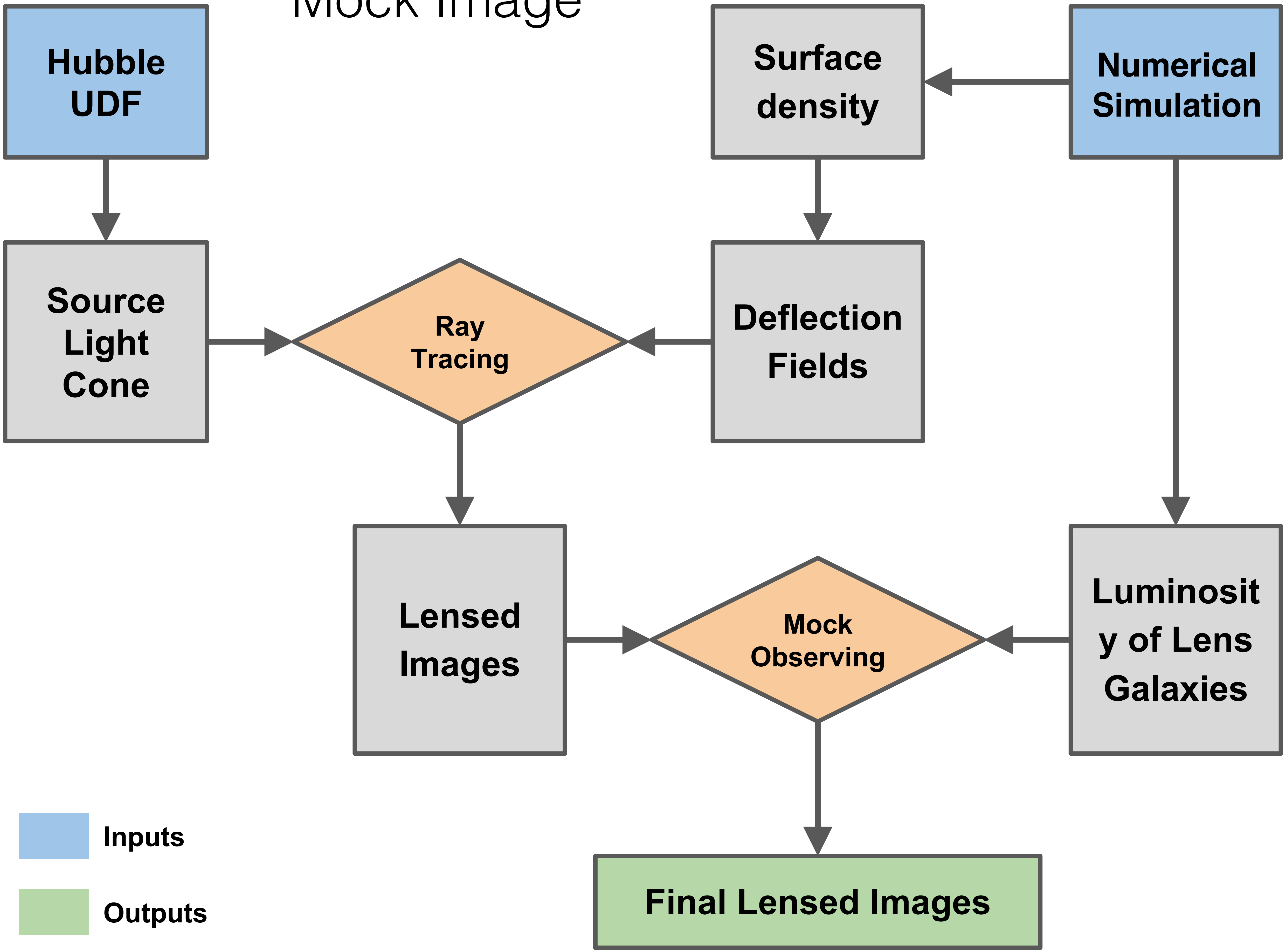




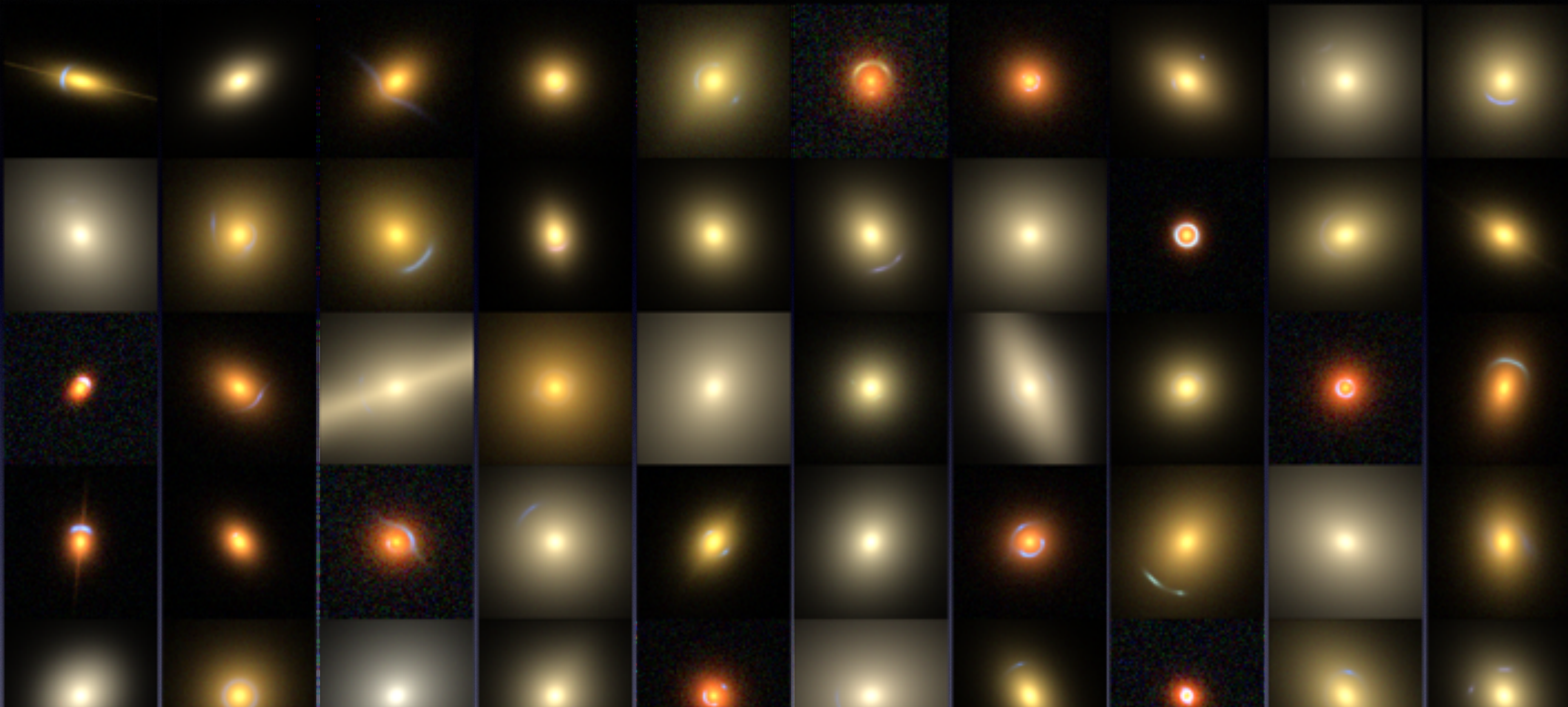
Science Validation RLi/ HY Shan/ YP Shu/ XYCAO



Mock Image

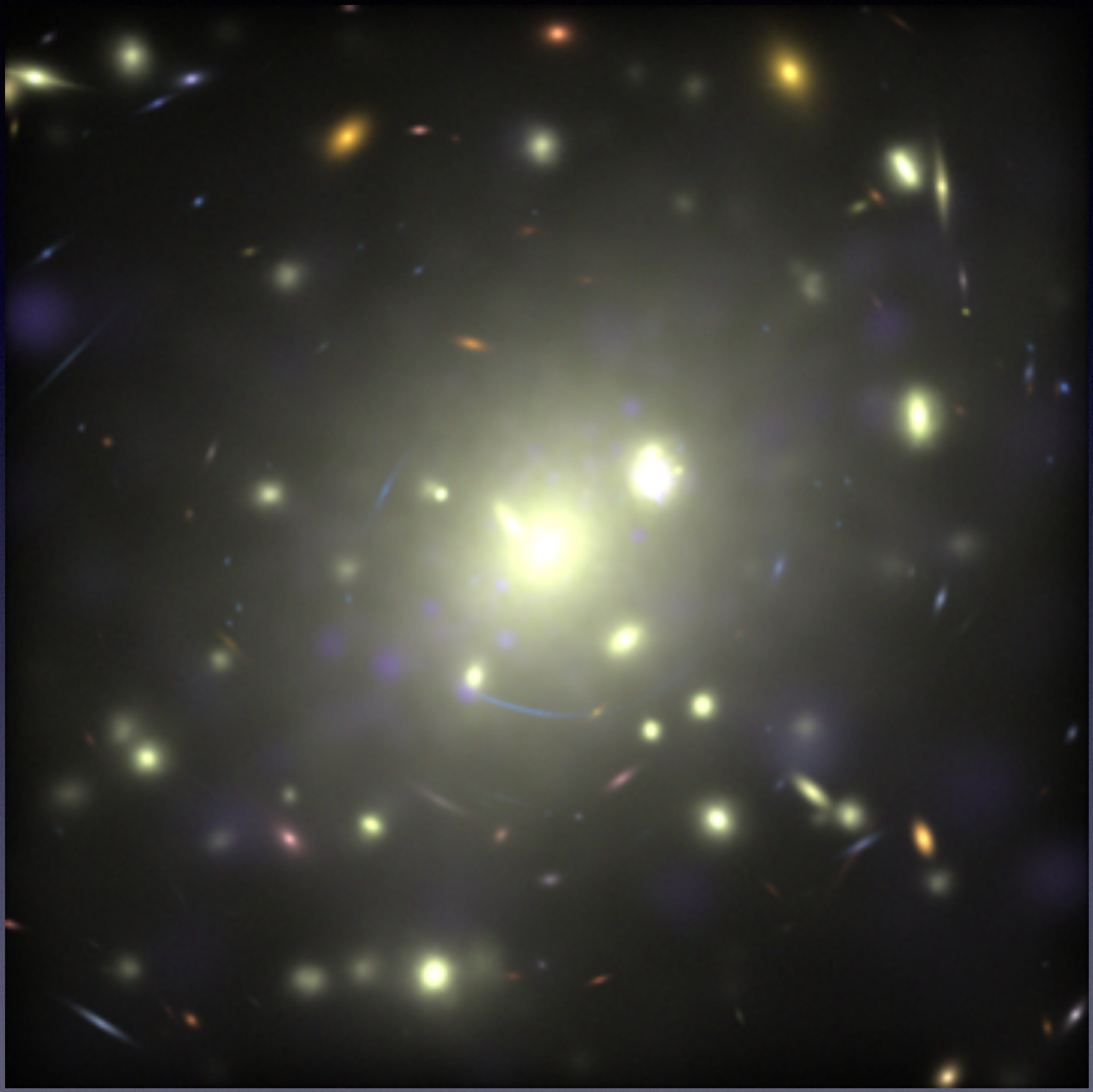


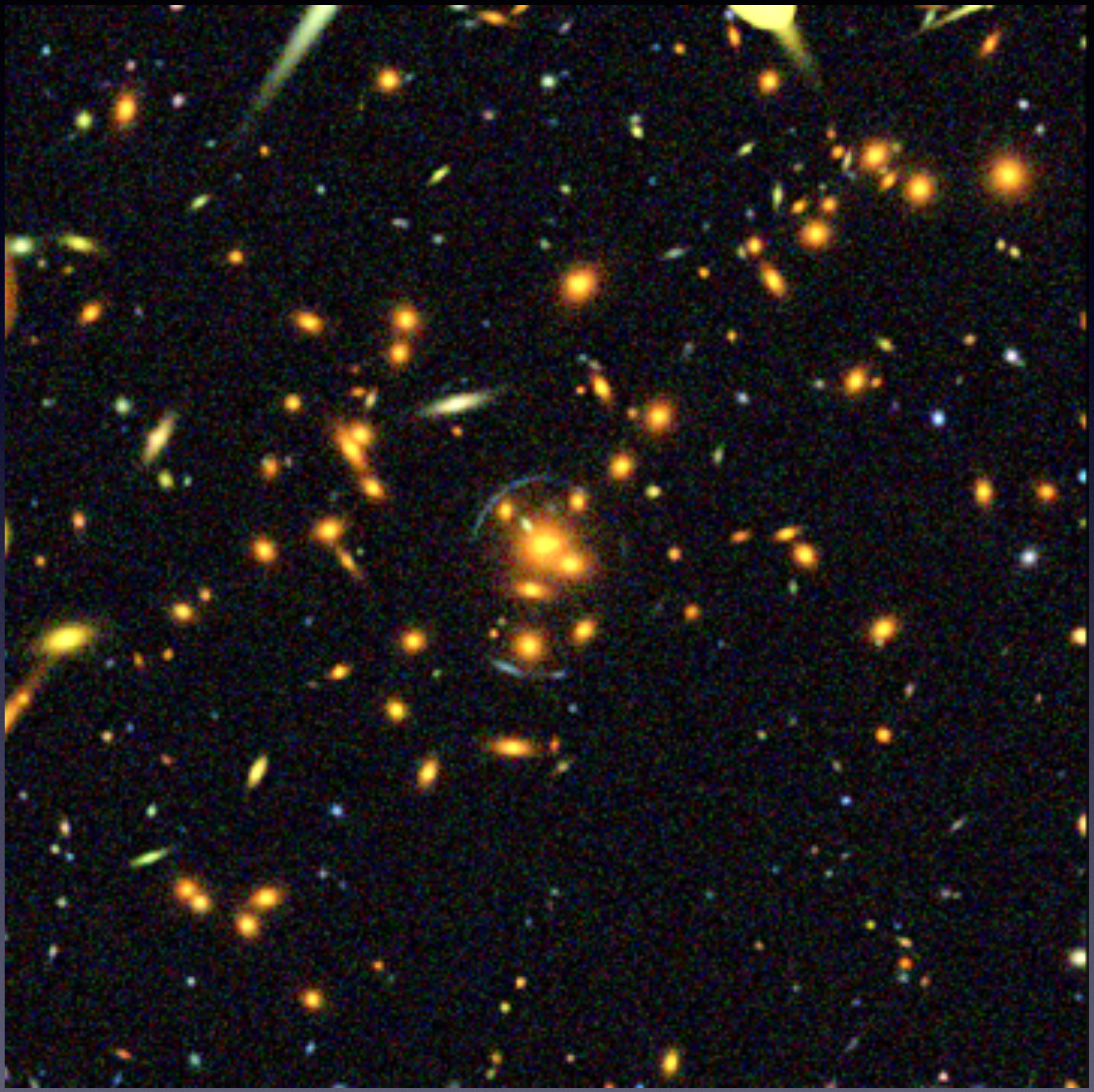
Hubble UDF
Surface density
Numerical Simulation
Source Light Cone
Ray Tracing
Deflection Fields
Lensed Images
Mock Observing
Luminosity of Lens Galaxies
Final Lensed Images
Inputs
Outputs



500k simulated galaxy-galaxy strong lenses based on CosmoDC2. Each image includes the flux in gri-bands, and the morphological model of the galaxies (both lens and source) is bulge + disk in the form of Sersic profile.

Nan Li, Ran Li, Dezi Liu





Nan Li, Ran Li, Dezi Liu

Thank You!