Investigations for LSST with ML: Photometric redshift estimation, strong lens detection, and mass modeling

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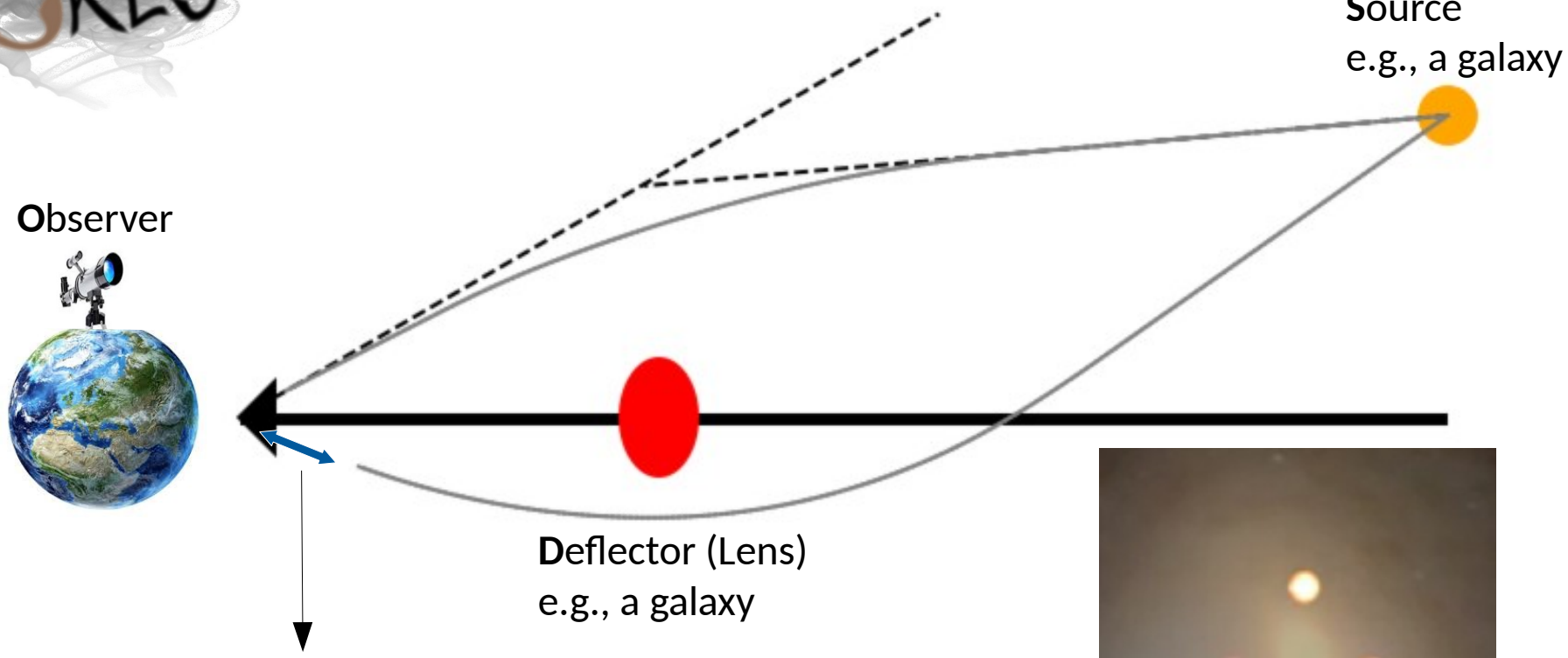
Strong gravitational lensing



- Time delay → Hubble constant H_0
- lensed supernova → early spectra → progenitor system

Wide field imaging surveys

- Ongoing:
  - Hyper Suprime Cam (HSC)
  - PanSTARRS

- Upcoming: Rubin Observatory

  Legacy Survey of Space and Time (LSST)

First light planned for 2024

Image southern sky every few days

→ expect ~**100,000 new galaxy-scale lenses** within billion of galaxies

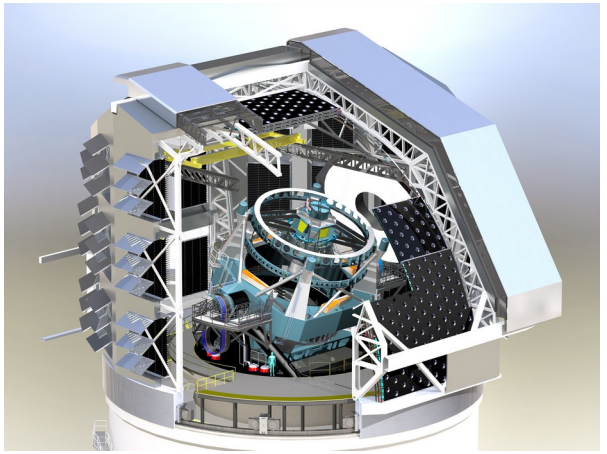
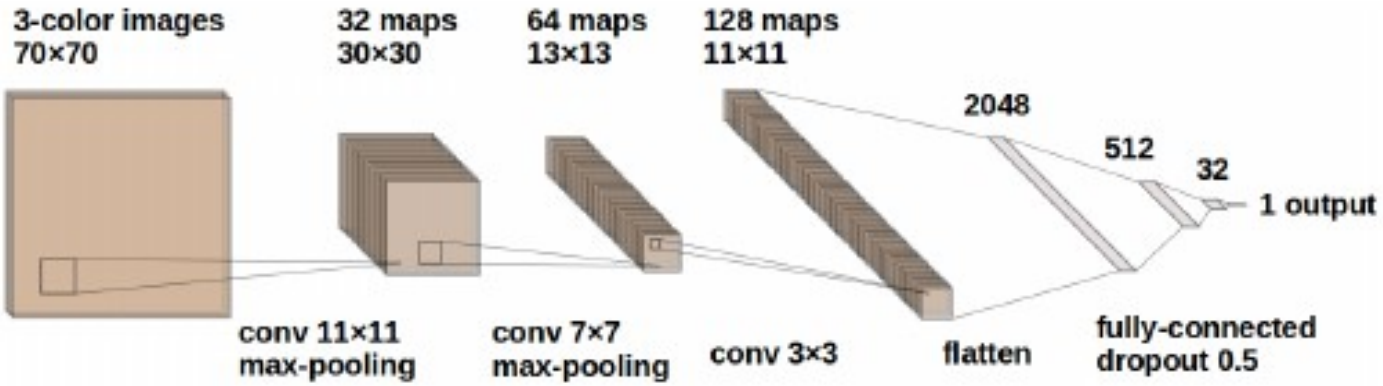
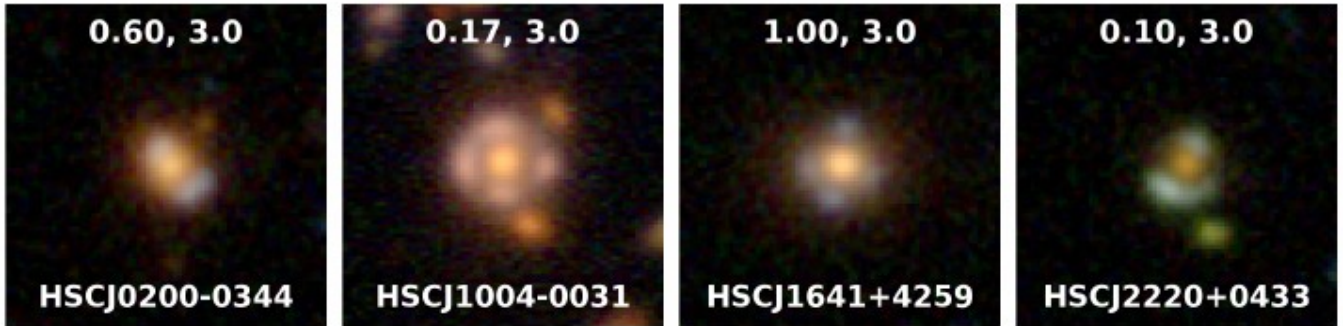


Image Credit: Rubin Obs./NSF/AURA.

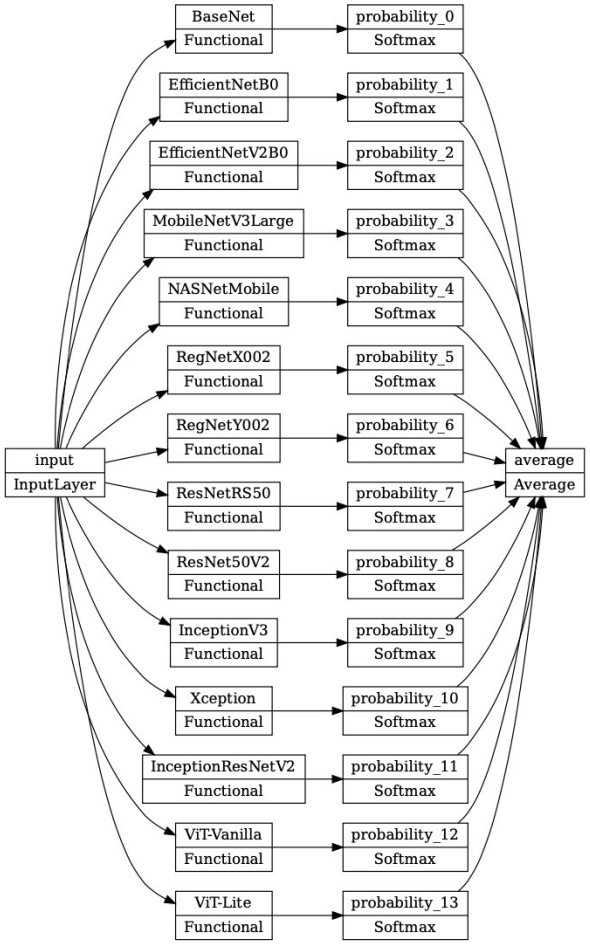
Various lens search projects



→ ResNet: FPR <0.01% on real COSMOS galaxies and ~60-70% completeness on SuGOHI lenses
(Cañameras et al. 2020, 2021)



gri-color images of newly identified lenses
→ thousands more!



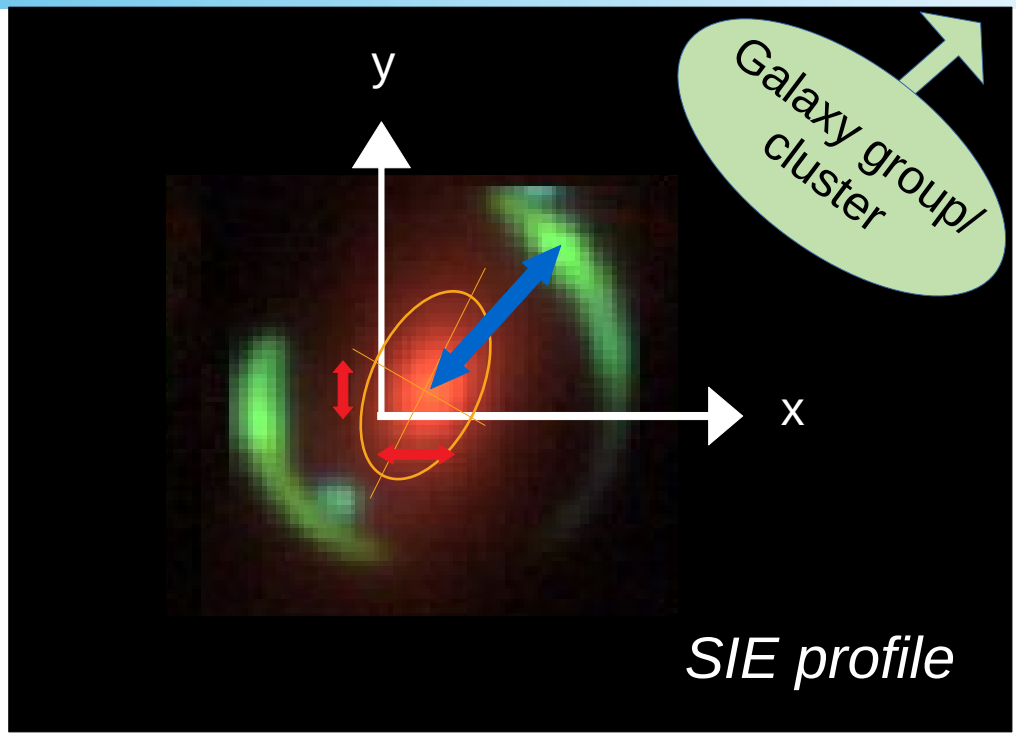
Ensemble classifier:
Searching for lensed quasars
(Taufkin et al. 2023)

See also: Bag et al. in prep., Cañameras et al. 2020, 2021, 2023,
Holloway et al. in prep., Melo et al. in prep., Shu et al 2022, Taufkin et al 2023, in prep,
And many more!

Convolutional neural network

- Lens mass distribution

  described by:
  - Lens center (*x*,*y*)
  - Ellipticity (e_x, e_y)
  - Einstein radius θ_E
- External shear:
  - γ_1 and γ_2



Inspired by Hezaveh, Perreault
Levasseur and Marshall (2017)

Schuldt et al. 2022, 2023a, 2023b

Convolutional neural network

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  - Lens center (x,y)
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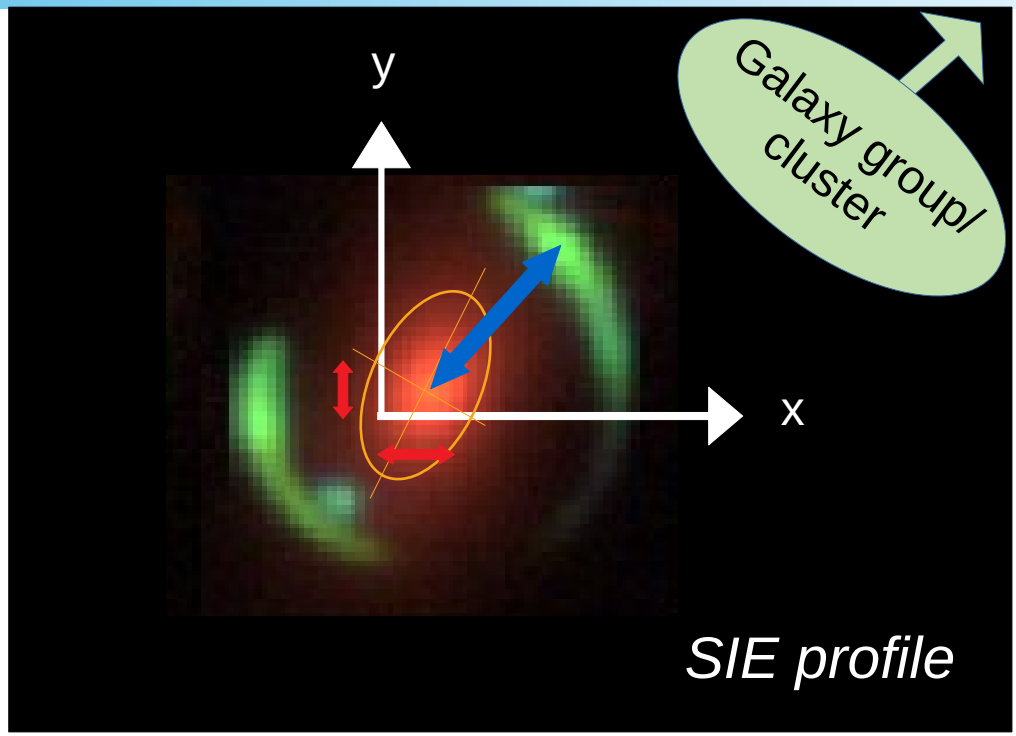
- External shear:
  - γ_1 and γ_2
- Speed-up with machine learning

  Weeks → fractions of a second



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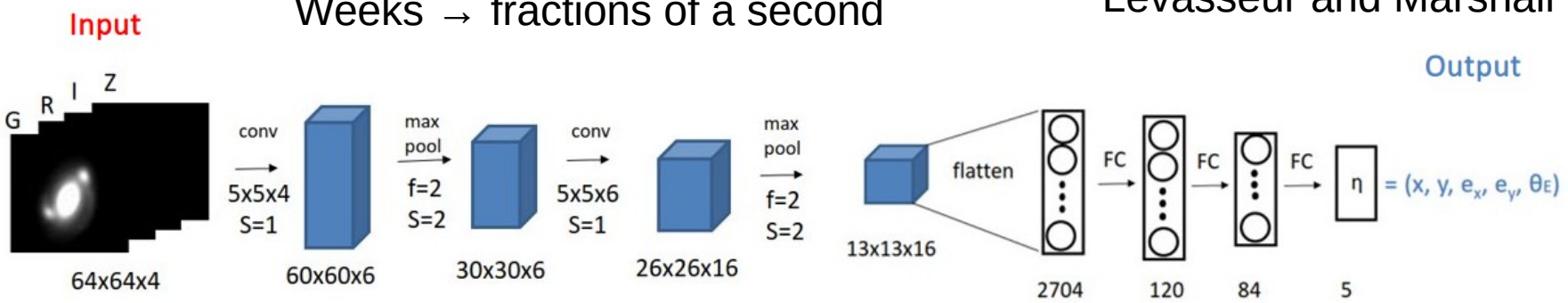
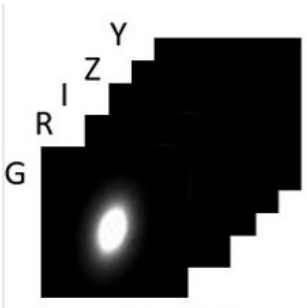


Schuldt et al. 2022a, 2023a, 2023b

Redshift estimation

→ key quantity in astrophysics, also needed for lensing

photometric redshift:



→

Catalog:
- size
- compactness
- color
- magnitude
- etc.

→

Redshift pipeline
- Spectral energy distribution (SED) template fitting
- Machine learning

→

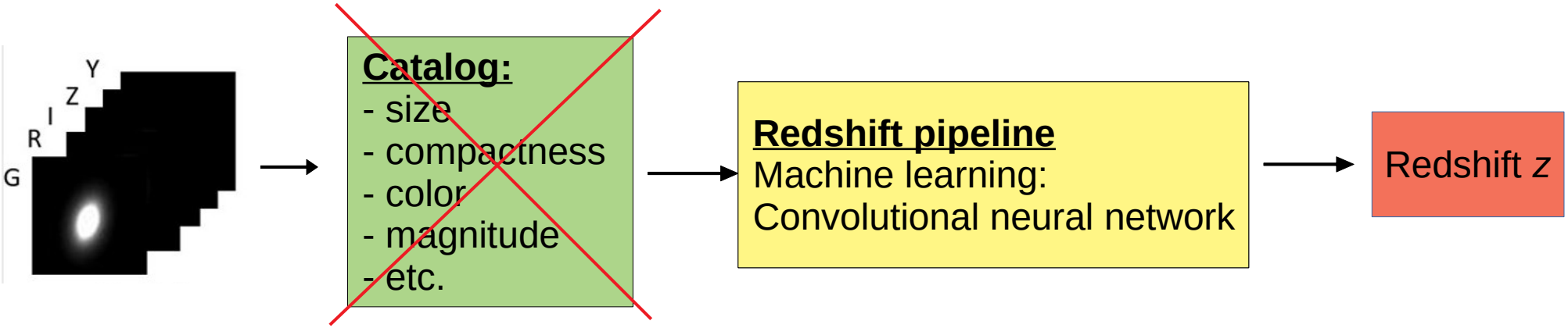
Redshift *z*

Schuldt et al. 2022b

Redshift estimation

→ key quantity in astrophysics, also needed for lensing

photometric redshift: NetZ → predict > 34 million redshifts



trained on HSC images with spectroscopic or ~30 band photometric redshifts

→ reference redshifts

→ direct comparison to DEmP:
performance comparable with other techniques!

Schuldt et al. 2022b

Questions?

- In person at Paris node
- Slack: Stefan Schuldt
- Email: stefan.schuldt@unimi.it

Thank you!