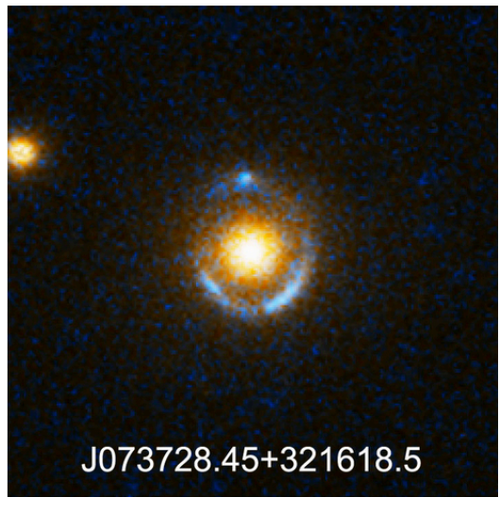
The Euclid Strong Lensing Pipeline

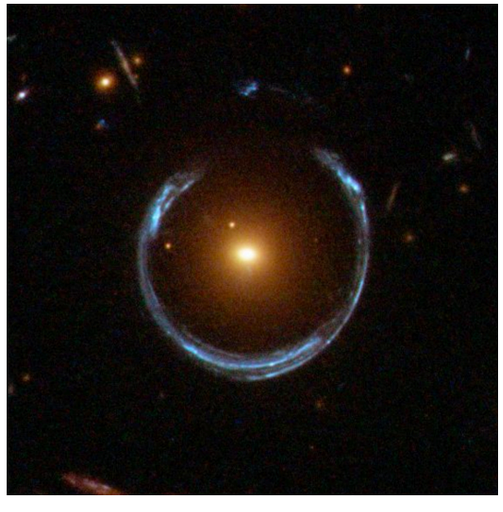
Benjamin Clément - Hubert Degaudenzi - Frédéric Courbin
Karina Rojas - Elodie Savary
EPFL / Unige

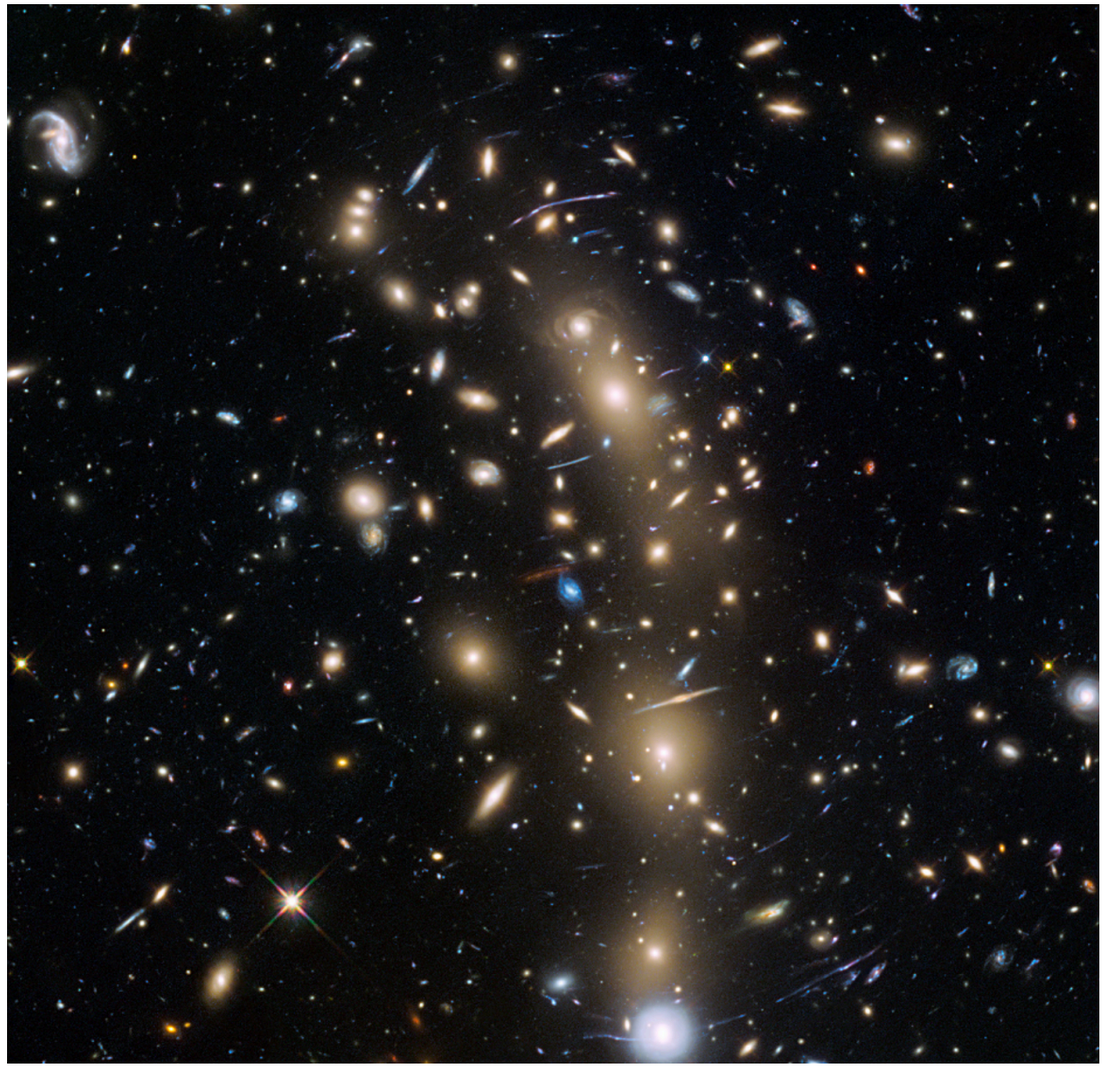
Euclid Swiss Days - February 2020

Galaxy and group/cluster scales

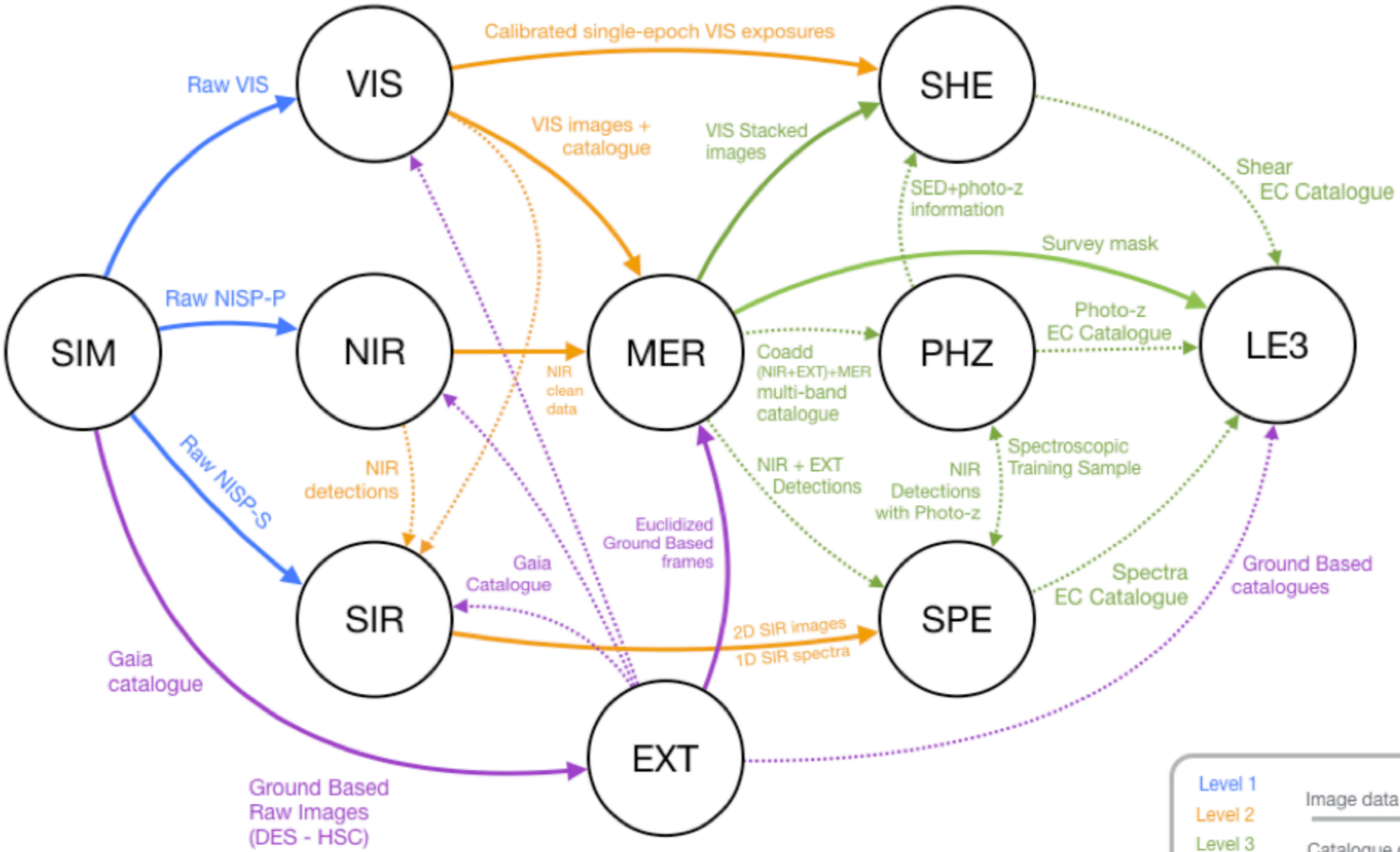
- GGL : Galaxy-Galaxy Lens Re ~ 1” - 3”
- GrGL : Group-Galaxy Lens Re ~ 3” - 10”
- CL : Cluster Lens Re ~ 20” - 50”







The Full Picture



Data

- OU-MER Tiles FOV is 32’ x 32’ or 1024 arcmin^2 or 0.2844 deg^2
- How many tiles in total ?

  15000 deg^2 ~ 50000 tiles

- 12 bands : **VIS, NIR (YJH)**, EXT DECAM (griz), EXT OMEGACAM (ugri)
- How many objects to inspect ?

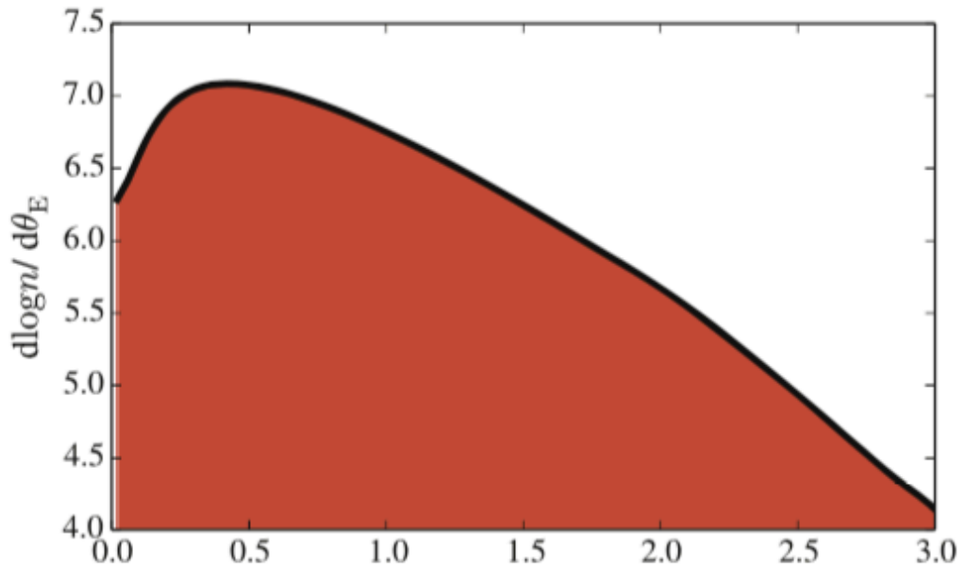
  naive magnitude cut in VIS < 22 : ~1000 objects per tile

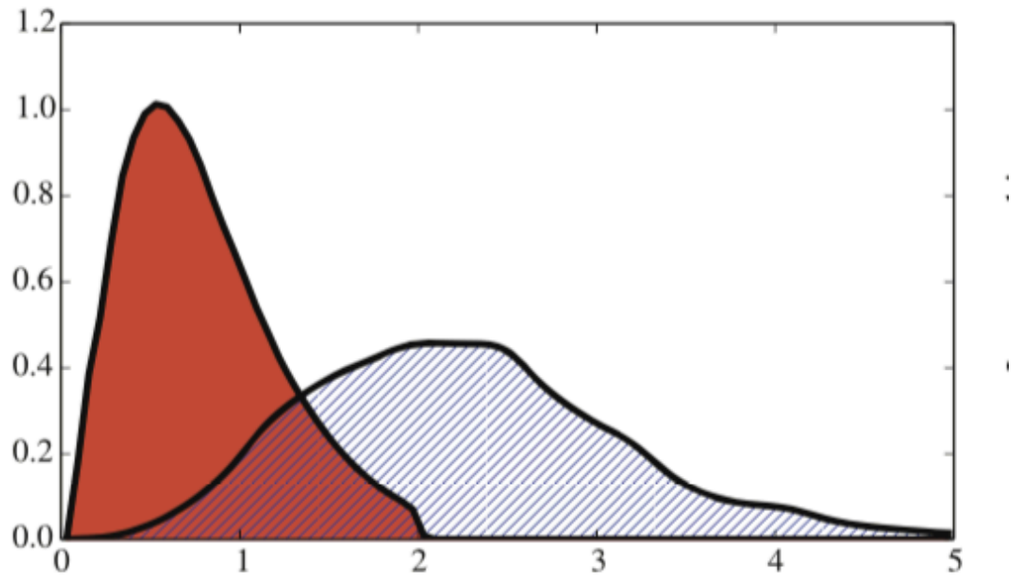
- How many lenses per tile to expect ?

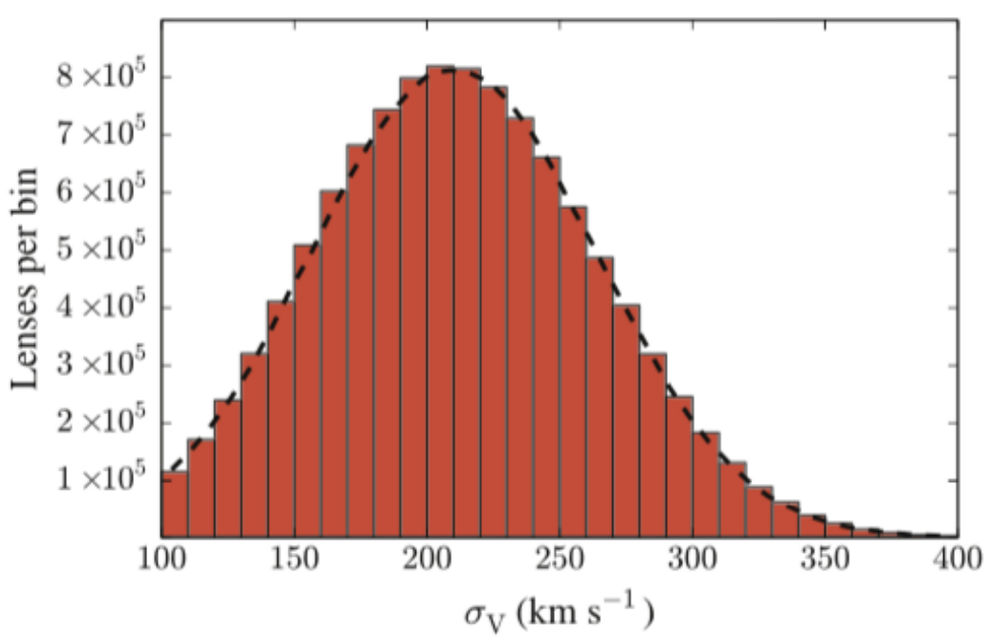
  ~170 000 lenses in the full survey (Collett 2015)
  ~ 1-10 / deg^2
  ~ 3 lenses / tile
  ~ 60 lenses / day

Expected properties of the lens sample

from Collett (2015)







GGL branch

MER Tile

MER images
- bkg sub VIS + NIR
- PSF ?

Selection
- all
- color cuts, flux, size, …

MER Final Catalog
- id, ra, dec, mag, …

Clusters ? Groups ?

Cutouts

Pre-lauch
Simulated data

Training set

CNN
GGL ?

yes

GGL candidate catalog
- id, ra, dec, tile, **score/p** …

Cutouts

no

Modeling

PHZ ?

?

Visual Inspection

GGL candidate Final Catalog
- id, ra, dec, tile, **score/p**, **Re,** …

Cutouts

DB
SHE

reuse ?

Calibration

Input

Task

Tmp product

Output

GGL branch

MER Tile

MER images
- bkg sub VIS + NIR
- PSF ?

Selection
- all
- color cuts, flux, size, …

MER Final Catalog
- id, ra, dec, mag, …

Clusters ? Groups ?

Cutouts

Pre-lauch Simulated data

Training set

CNN GGL ?

yes

GGL candidate catalog
- id, ra, dec, tile, **score/p** …

Cutouts

no

PHZ ?

?

reuse ?

Inputs

GGL branch

MER Tile

MER images
- bkg sub VIS + NIR
- PSF ?

Selection
- all
- color cuts, flux, size, …

MER Final Catalog
- id, ra, dec, mag, …

Clusters ? Groups ?

Cutouts

Pre-lauch Simulated data

Training set

CNN GGL ?

yes

GGL candidate catalog
- id, ra, dec, tile, **score/p** …

Cutouts

no

PHZ ?

?

reuse ?

1. Catalog filtering

a sample of objects is selected
based on various criteria (e.g. magnitude, color cuts, size, etc.)

GGL branch

MER Tile

MER images
- bkg sub VIS + NIR
- PSF ?

Selection
- all
- color cuts, flux, size, …

MER Final Catalog
- id, ra, dec, mag, …

Clusters ? Groups ?

Cutouts

Pre-lauch
Simulated data

Training set

CNN
GGL ?

yes

GGL candidate catalog
- id, ra, dec, tile, **score/p** …

Cutouts

no

PHZ ?

?

reuse ?

2. Cutout production

10”x10” for galaxy scale lenses
2’ x 2’ for cluster cores

GGL branch

MER Tile

MER images
- bkg sub VIS + NIR
- PSF ?

Selection
- all
- color cuts, flux, size, …

MER Final Catalog
- id, ra, dec, mag, …

Clusters ? Groups ?

Cutouts

Pre-lauch
Simulated data

Training set

CNN
GGL ?

yes

GGL candidate catalog
- id, ra, dec, tile, **score/p** …

Cutouts

no

PHZ ?

?

reuse ?

3. Classification

score or probability of being a lens
using a convolutional neural network

GGL branch

MER Tile

MER images
- bkg sub VIS + NIR
- PSF ?

Selection
- all
- color cuts, flux, size, …

MER Final Catalog
- id, ra, dec, mag, …

Clusters ? Groups ?

Cutouts

Pre-lauch
Simulated data

Training set

CNN
GGL ?

yes

GGL candidate catalog
- id, ra, dec, tile, **score/p** …

Cutouts

no

PHZ ?

?

Calibra

Inpu

Tasl

Tmp pro

Outpu

reuse ?

3. Classification

score or probability of being a lens
using a convolutional neural network

GGL branch

MER Tile

MER images
- bkg sub VIS + NIR
- PSF ?

Selection
- all
- color cuts, flux, size, …

MER Final Catalog
- id, ra, dec, mag, …

Clusters ? Groups ?

Cutouts

Pre-lauch
Simulated data

Training set

CNN
GGL ?

yes

no

GGL candidate catalog
- id, ra, dec, tile, **score/p** …

Cutouts

PHZ ?

?

reuse ?

3. Classification

score or probability of being a lens
using a convolutional neural network

GGL branch

MER Tile

4. Modelling

basic physical properties :
Einstein radius R_e, mass enclosed in R_e,
number of images, type of lens, …

Pre-la
Simulated data

training set

GGL ?

- id, ra, dec, tile, **score/p** …

Cutouts

no

Modeling

PHZ ?

?

Visual Inspection

GGL candidate Final Catalog
- id, ra, dec, tile, **score/p**, **Re,** …

Cutouts

DB
SHE

reuse ?

Calibration

Input

Task

Tmp product

Output

GGL branch

MER Tile

5. Visual inspection

lens candidates with probability above a certain threshold are reviewed by human eye and given a grade
(e.g. citizen science)

Pre-la
Simulated data

GGL ?

- id, ra, dec, tile, **score/p** …

Cutouts

no

Modeling

PHZ ?

?

Visual Inspection

GGL candidate Final Catalog
- id, ra, dec, tile, **score/p**, **Re,** …

Cutouts

DB
SHE

reuse ?

Calibration

Input

Task

Tmp product

Output

GGL branch

MER Tile

Main data product

Pre-la
Simulated data

GGL ?

- id, ra, dec, tile, **score/p** …

Cutouts

no

Modeling

PHZ ?

?

Visual Inspection

GGL candidate Final Catalog
- id, ra, dec, tile, **score/p**, **Re,** …

Cutouts

DB
SHE

reuse ?

Calibration

Input

Task

Tmp product

Output

GGL branch

MER Tile

MER images
- bkg sub VIS + NIR
- PSF ?

Selection
- all
- color cuts, flux, size, …

MER Final Catalog
- id, ra, dec, mag, …

Clusters ? Groups ?

Cutouts

Pre-lauch
Simulated data

Training set

CNN
GGL ?

yes

GGL candidate catalog
- id, ra, dec, tile, **score/p** …

Cutouts

no

Modeling

PHZ ?

?

Visual Inspection

GGL candidate Final Catalog
- id, ra, dec, tile, **score/p**, **Re,** …

Cutouts

DB
SHE

reuse ?

Calibration

Input

Task

Tmp product

Output

Training set branch

MER Tile

MER images
- bkg sub VIS + NIR
- PSF ?

Selection
- all
- color cuts, flux, size, …

MER Final Catalog
- id, ra, dec, mag, …

Clusters ? Groups ?

Cutouts

Classifier

source

lens

others

PHZ ?

Lensing

simulated GGL

non GGL

Training set

?

DB
SHE

Input

Task

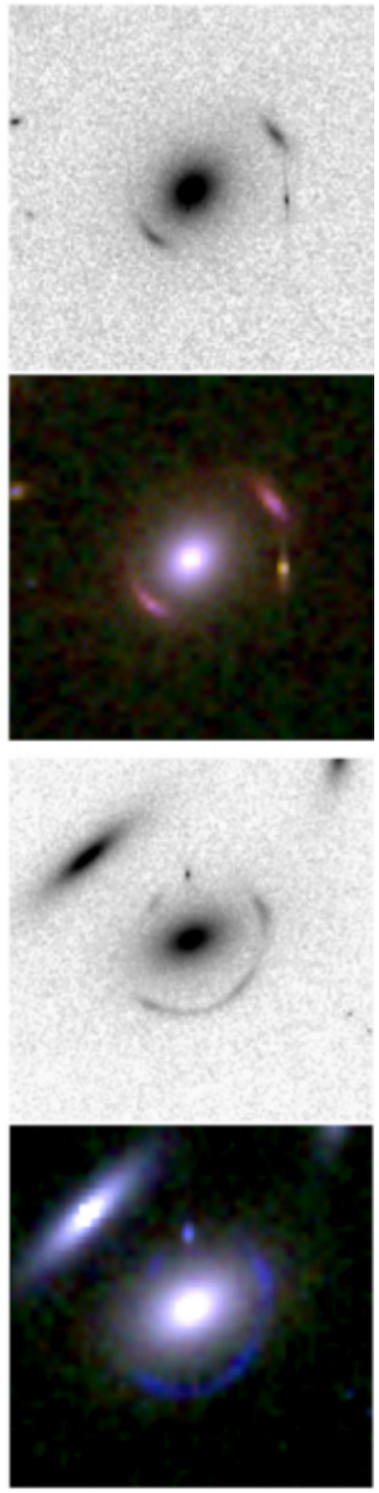
Tmp product

Output

Simulating the lens sample

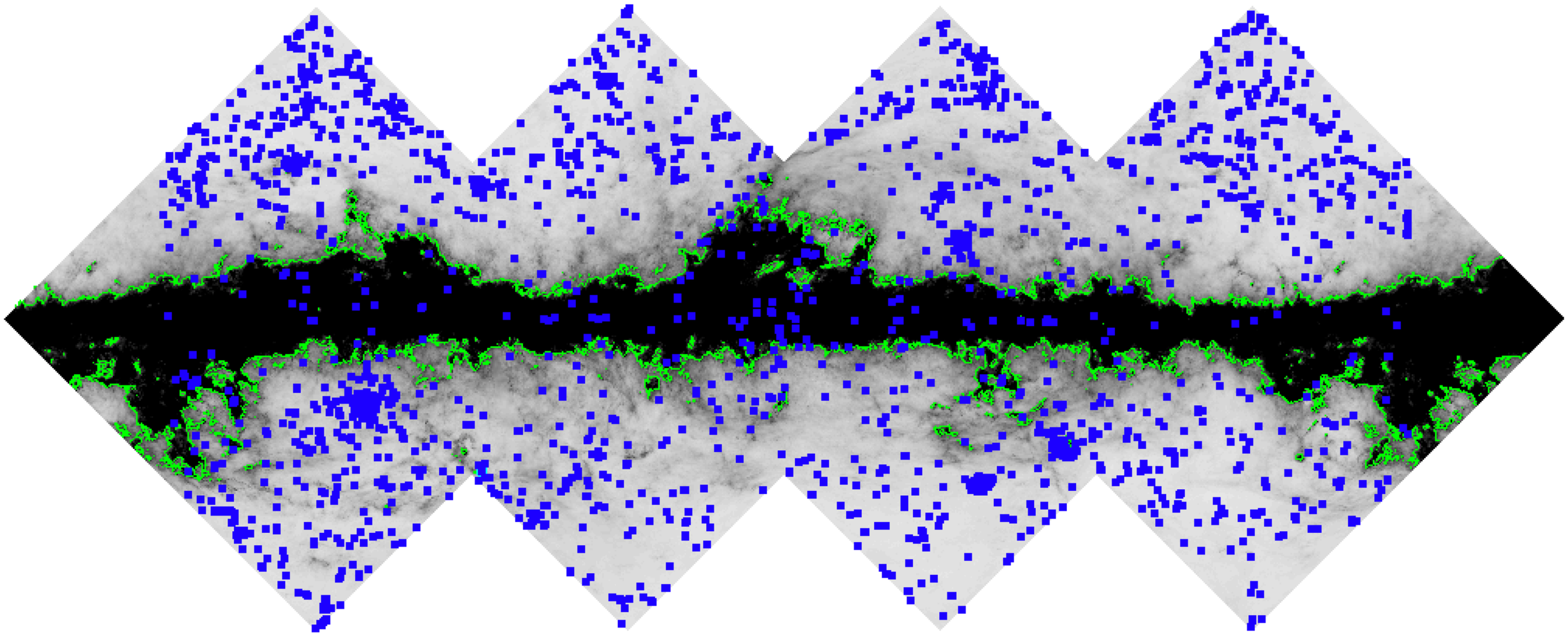
- GLAMER software
- Field and lens galaxy drawn from flagship mock
- Source from HST UDF
- Realistic PSF and noise properties

- Challenge 1.0 (Metcalf+2018)
  Challenge 2.0 (on-going, see E. Savary's talk)
- Add strong lenses in SC8 images
- Test the pipeline



Testing the simulation with HST data

- Hubble Source Catalog (V3) and Hubble Legacy Archive
- ~158000 objects selected (F814W < 22 AB)
- 5886 ACS images in F814W (~15-18 deg^2)
- Extend the search to other ACS filters, WFPC2, WFC3-UVIS/IR



Summary and future actions

- Lens finding pipeline based on CNN
- Improve simulation of the training set and be prepared to make use of real Euclid data after launch
- Test the procedure on “large scale” high-resolution dataset (e.g. HST)
- Citizen science
- Spectroscopic follow-up (e.g. DESI, 4MOST, WEAVE)
- Be ready for Quick Release 1 and the first ~500 lenses