

Euclid cosmological simulations WG: the Flagship mock

P.Fosalba (ICE, CSIC)
on behalf of the CosmoSim-SWG

Objectives:

- 👤 Develop simulations for the SWGs and SGS (via OU-SIM)
- 👤 Provide validation tools for “Euclid” simulations

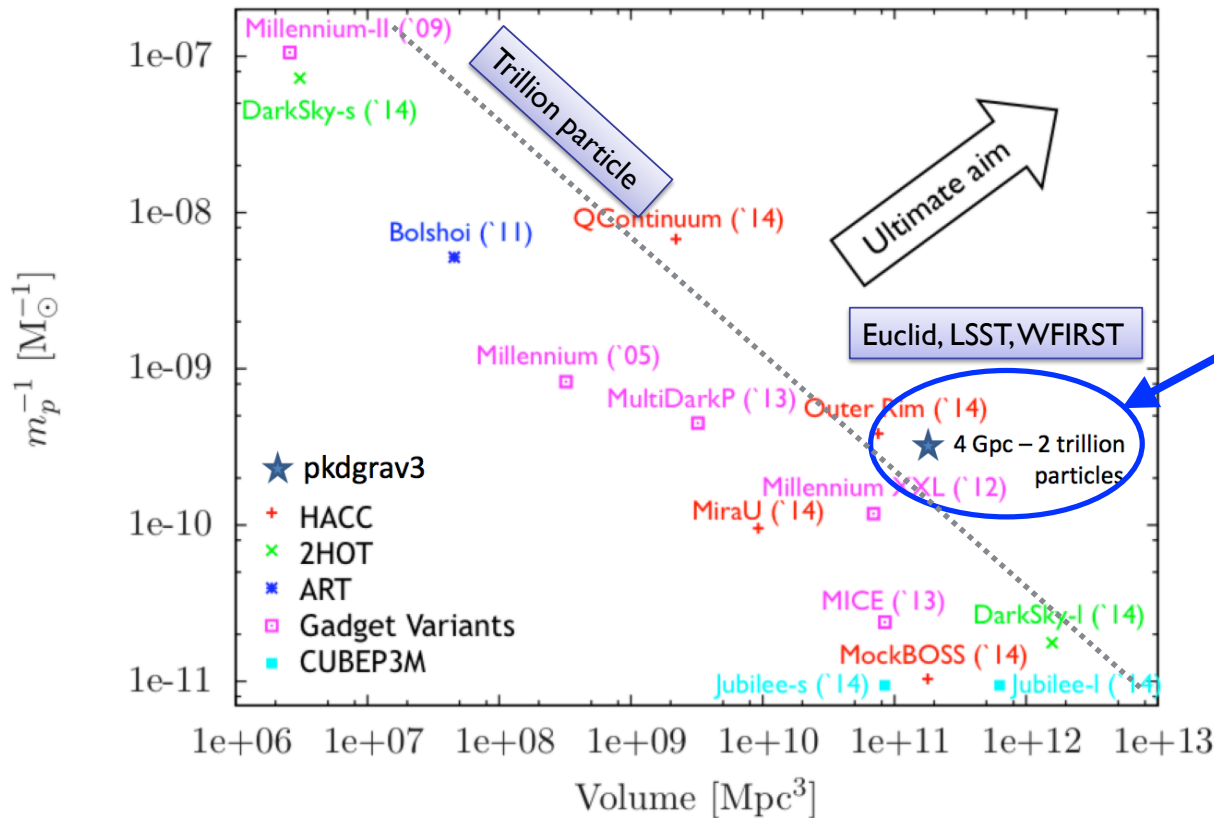
WG has about 100 registered members

Wiki page (basic docs, telecon minutes, meeting presentations, etc) :
<https://euclid.roe.ac.uk/projects/simswg/wiki>

Slack channel for discussions/news
<https://euclidcosmosim.slack.com/>

☑ **SPV exercise:** assess the overall performance of the Euclid mission with the best current knowledge of the system [SPV2 during 2017]

➔ **[March 2016]:** The Cosmological Simulation SWG was tasked to produce a massive comprehensive simulation as key input for this exercise



Euclid requirements:

- 2 trillion particles
- 4 Gpc box

The Flagship simulation

Pkdgrav3 code
(Stadel, Potter, Teyssier)

Tree-based code
Fast Multipole Method
Optimized for GPU



Runtime = 80 hours on 4000 Nodes

Input

- 2 trillion DM particles
- 3840 Mpc/h box
- $m_p = 2.4 \times 10^9 \text{ Msun/h}$
- Planck 2015 cosmology

Raw

Compressed
(1%)

Outputs

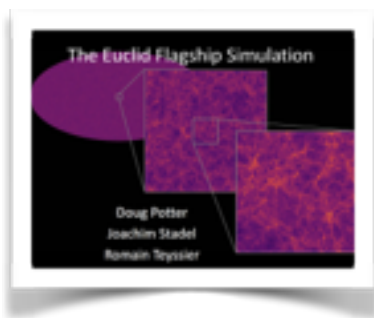
- 3D particle Lightcone (220TB), $z < 2.3$
- 11 comoving snapshots (150TB), $z < 1$
- **LC Halo catalog (Rockstar):** 5×10^9 halos/sub-halos (5.5TB)
- **2D Dark-Matter counts maps:** ~ 300 (1TB)

0.4 Petabytes

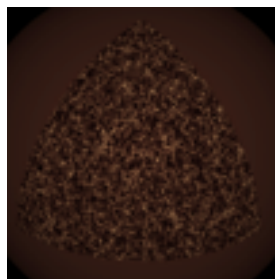
The Flagship galaxy mock: end-2-end pipeline

Massive coordinated efforts:

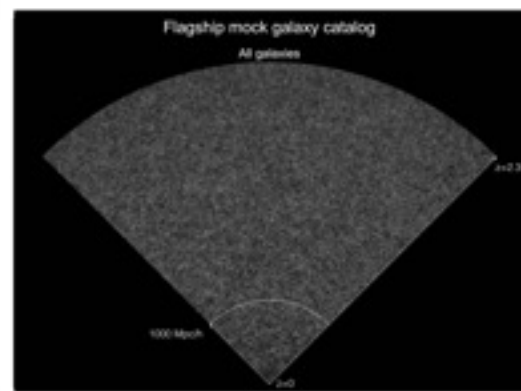
- record-setting N-body
- modular HOD galaxy pipe
- big-data platform (CosmoHub)
- mock validation (ongoing)**



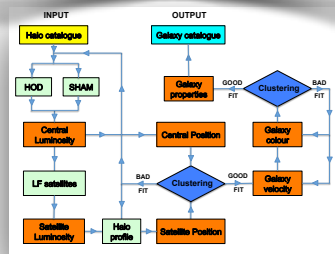
All-sky Halo catalog



Full octant galaxy mock [5000 sq.deg, $z < 2.3$]

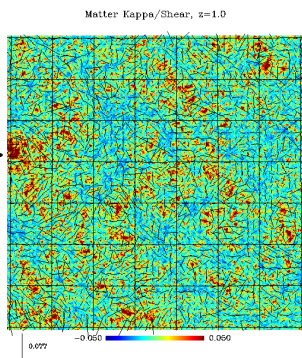
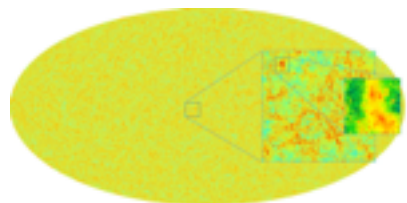


HOD Galaxy pipeline



All-sky DM counts maps

All-sky Lensing maps



1TB mock

2 billion galaxies
30 (Gpc/h)³

Timeline: Aug/Sept-16

Nov-16

(Mar-16...May-17)

May-17



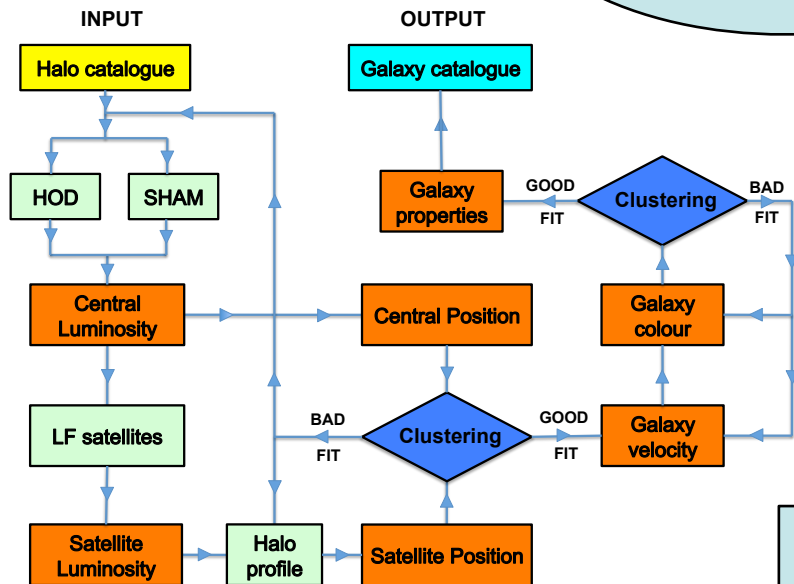
The HOD pipeline: from Halos to Galaxies

- Largely based on MICE pipeline
- Fully re-written and improved (python/modular)
- Runs on massively parallel DB (Hadoop)

HOD+HAM calibrated against observations:
 LF, clustering vs color and luminosity, color-mag relation

Galaxy properties

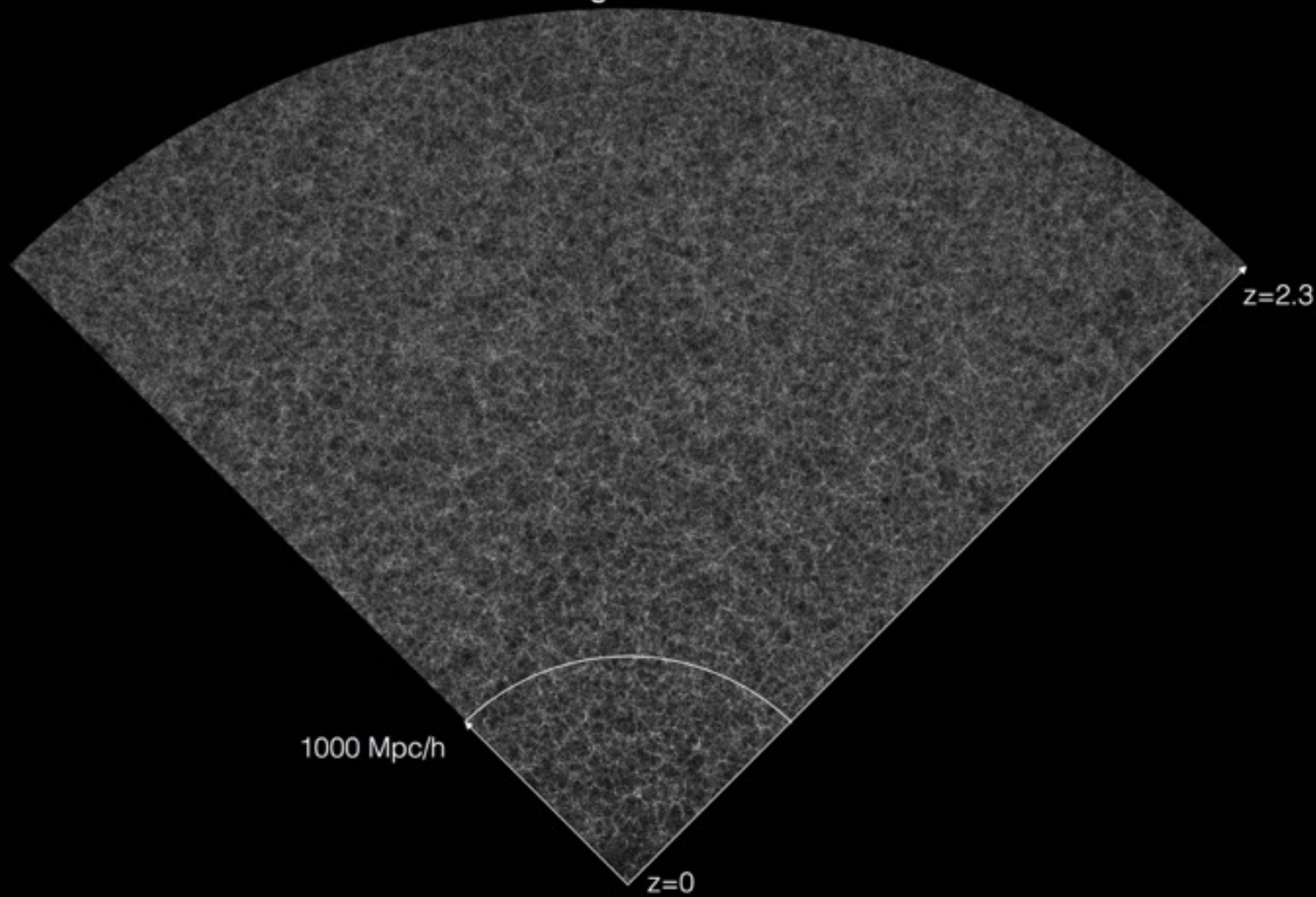
- ✓ spectroscopic and photometric
- ✓ lensing
- ✓ shapes



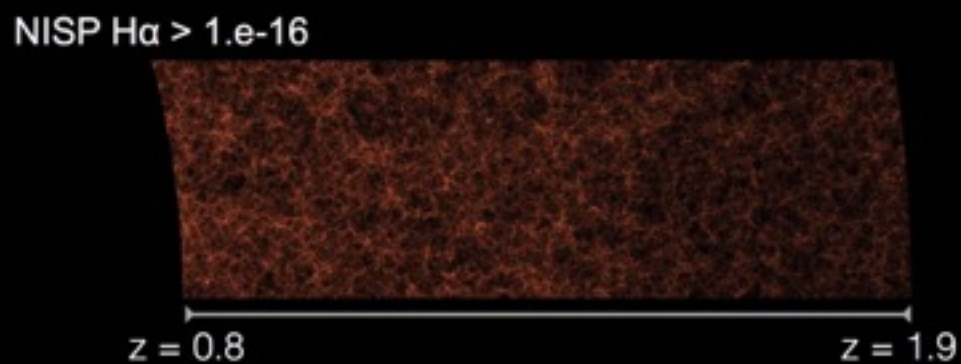
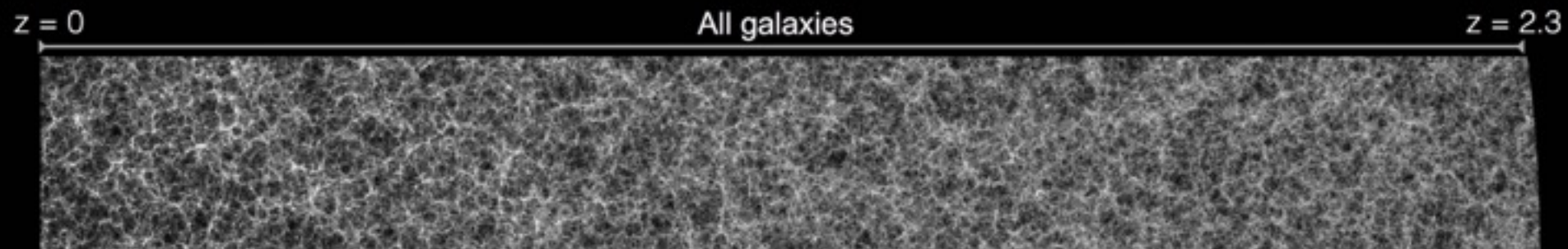
See Francisco's talk for details!

Flagship mock galaxy catalog

All galaxies



Flagship mock galaxy catalog





Flagship mock basic specs

Latest release: 1.5.2 @ cosmohub.pic.es

Area: 5000 sq.deg

Depth: $z_{\max}=2.3$

Counts for $H<24$: 1.0 B galaxies (Euclid Wide)

Counts for $H<26$: 2.6 B galaxies



~5 hours
in CosmoHub
Hadoop platform

Galaxy properties:

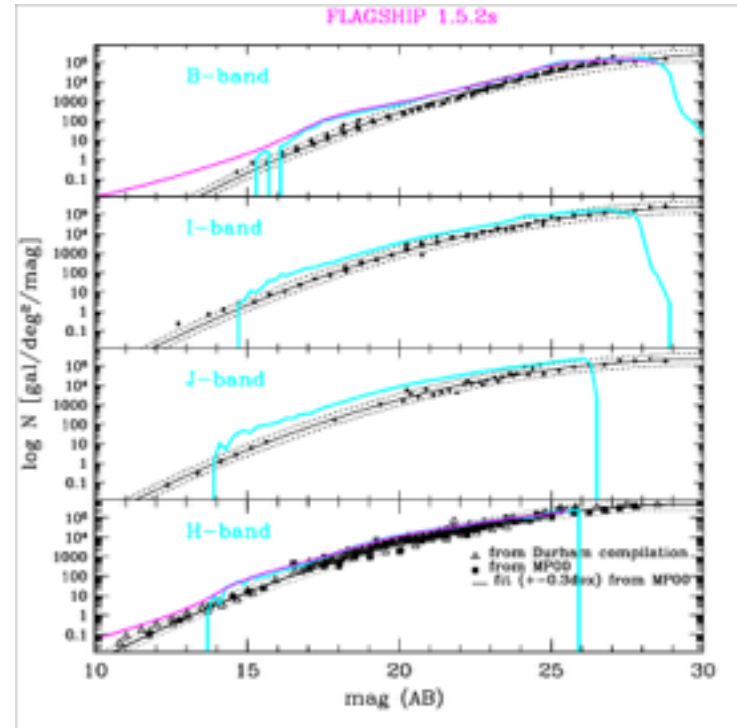
- ✓ position, velocities, redshift
- ✓ colors, SEDs, extinction, shapes
- ✓ host halo mass/position/velocities
- ✓ galaxy type (cen/sat), SFR, stellar mass, metallicity
- ✓ Mr, magnitudes in many bands (EUCLID, DES, CFHT, LSST, Subaru,...)
- ✓ Emission lines: Halpha, Hbeta, O2,...
- ✓ lensing (convergence, shear, deflected positions)

great deal of validation already done...
needs feedback from you to improve it further!

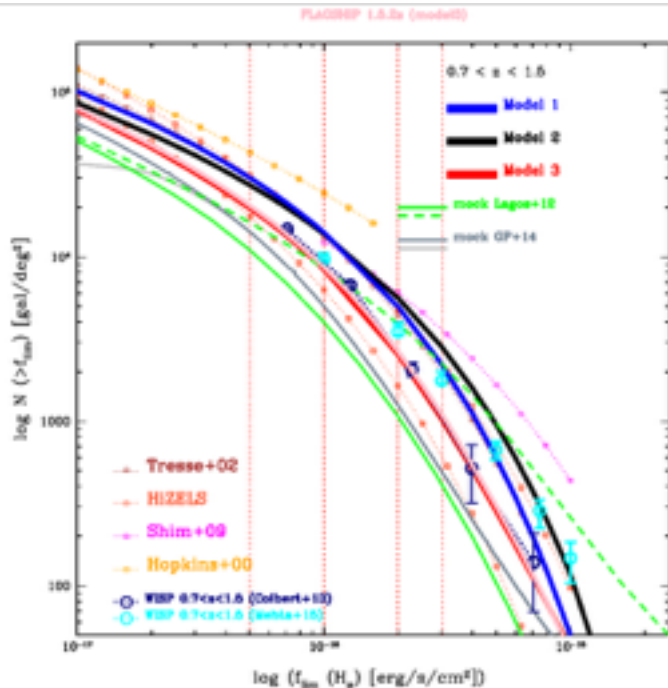
credit: L.Pozzetti

VIS/NIR counts OK,
small excess at bright mags.

Optical to H-band counts



Halpa counts

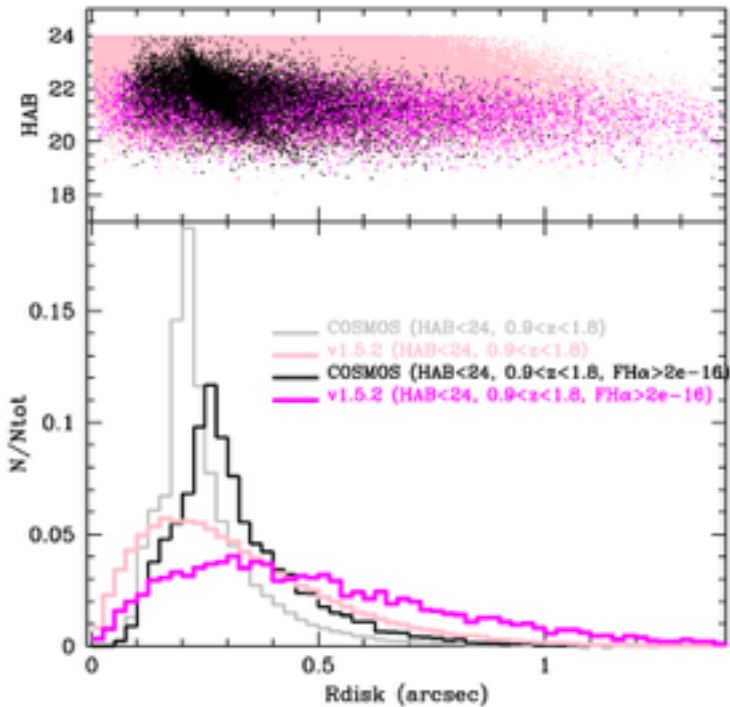


✓ Halpa number densities agree with data
and empirical models (Pozzetti+16) @ $0.7 < z < 1.5$

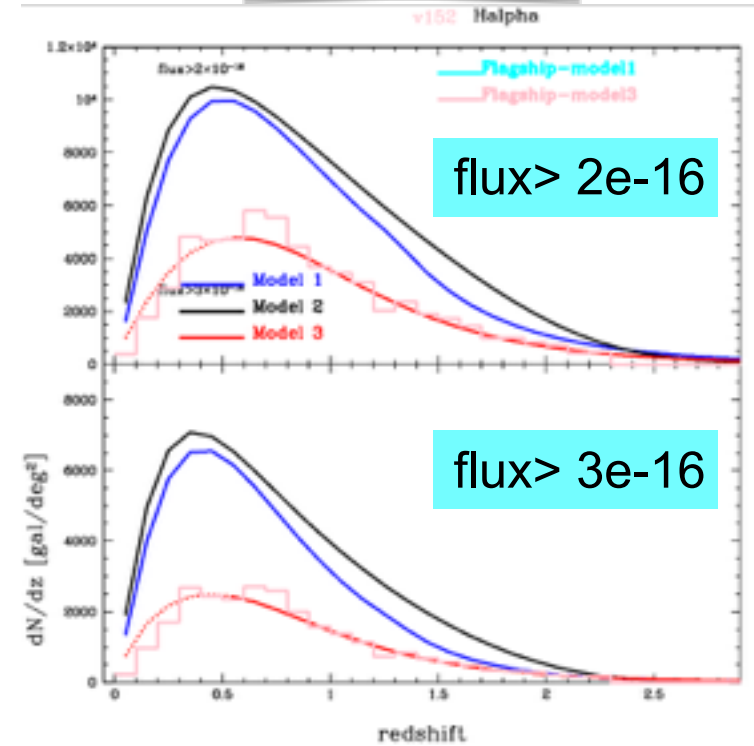
credit: L.Pozzetti

✓ z-distribution agrees with data

disk sizes



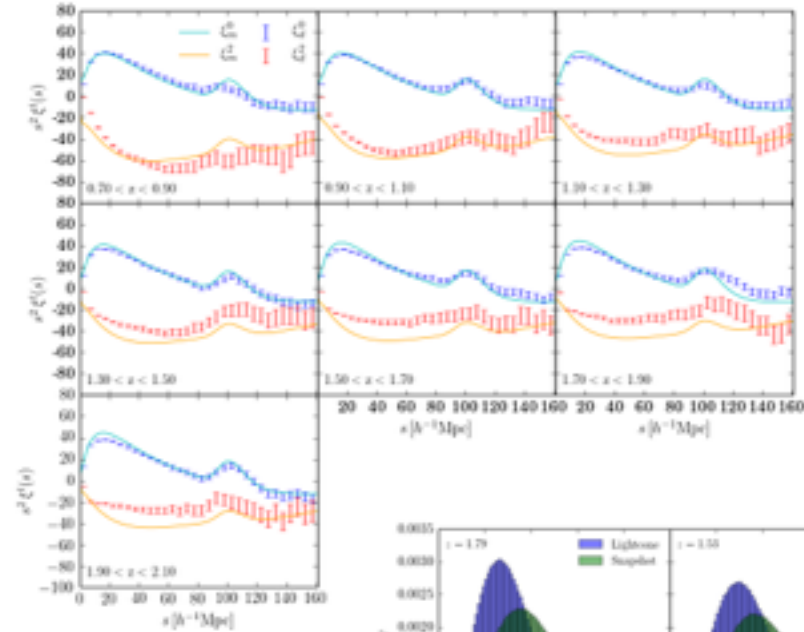
HalpHa dn/dz



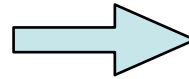
✓ *predicted* distribution roughly agrees with data
 ▶ broader than data for H<24 and flux>2.e-16

credit: A.Pezzotta, M.Crocce

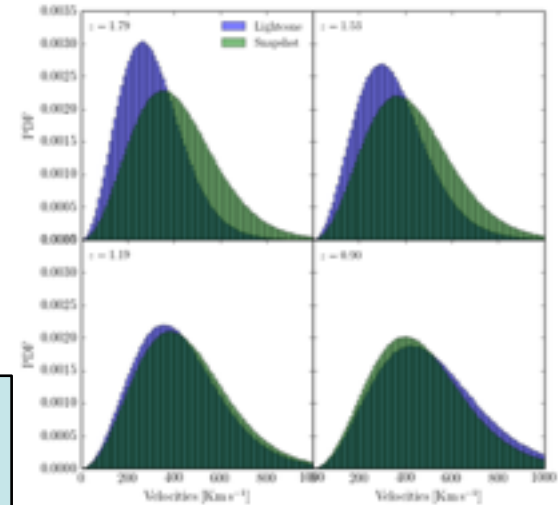
- Halpha clustering in real-space agrees with theory
- Redshift-space quadrupole moment is off at high-z...



Issue is related to host halos having “wrong” velocity PDFs

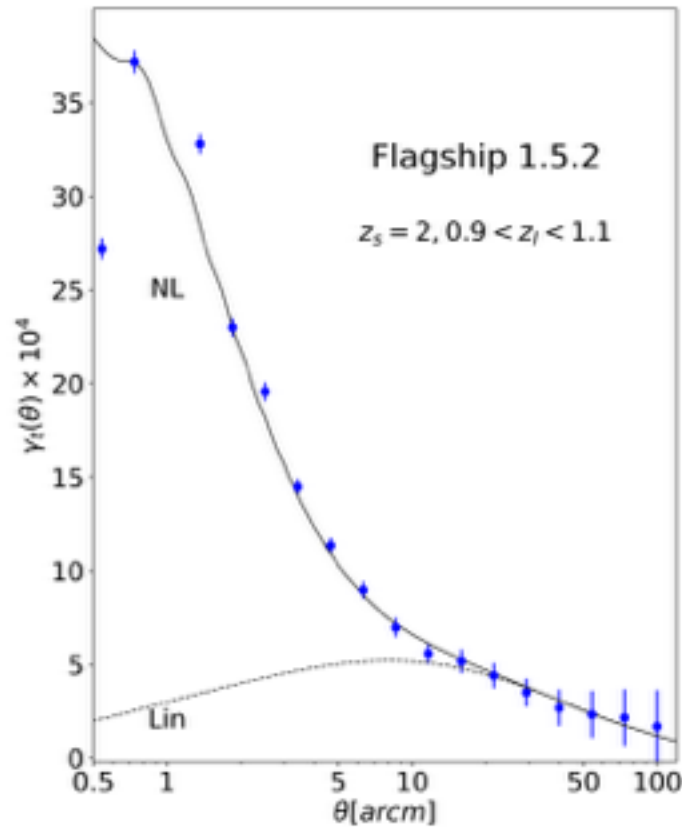


blue: Flagship-Rockstar halos
green: FoF halos

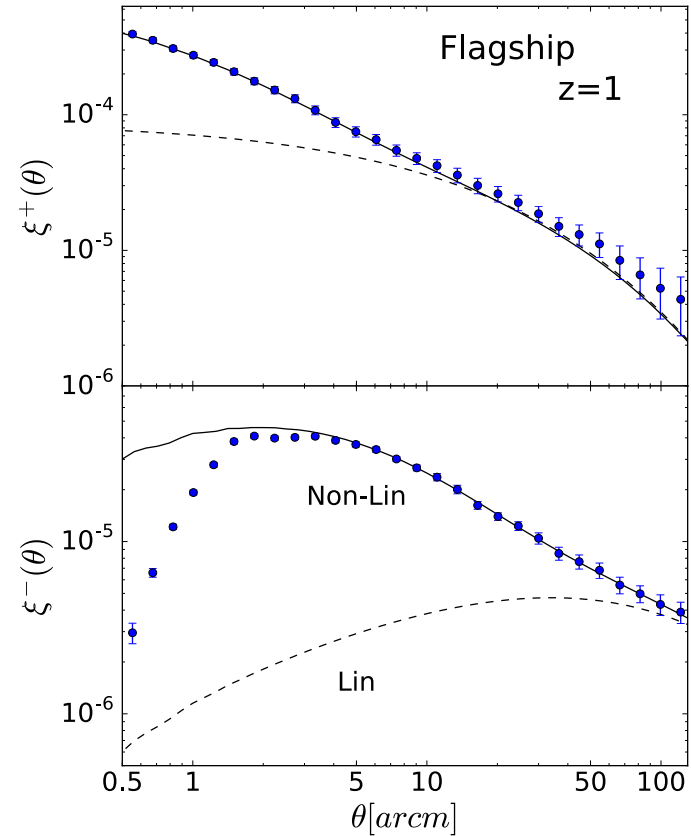


issue has been fixed and new halo catalog will be produced for Flagship 2.0

Galaxy-Galaxy lensing



Shear 2PCF



- ✓ Good agreement with NL theory down to ~ 1 arcmin (Takahashi+12)
- ✓ Broadly satisfies science requirements

★ Nbody simulation (U.Zurich/ICS)



Mischa Knabenhans



Doug Potter



Joachim Stadel



Romain Teyssier

★ Galaxy mock and big-data platform (ICE, PIC)



Linda Blot



Jorge Carretero



Francisco Castander



Santi Serrano



Pau Tallada

★ Validation “Tiger Team” (SWG, SGS)



Lucia Pozzetti

Validation team: A. Alarcon, H. Aussel, S. Avila, C. Baugh, J. Bel, M.Bolzonella, C. Carbone, M. Crocce, E.Gaztanaga, S.Hilbert, H.Hoekstra, A.Kannawadi, A.Knebe, M.Moresco, P.Norberg, F.Pearce, A.Pezzotta, R.Smith,...



What's next? Flagship 2.0

official Euclid galaxy mock for SPV3 (2019)

New coordinated efforts:

- new N-body (deep survey)
- galaxy pipe improvements: galaxy positioning, SED interpolation, automated calib.,...
- **“Euclidized” validation pipe**
- validation team!

Surveys/Samples:

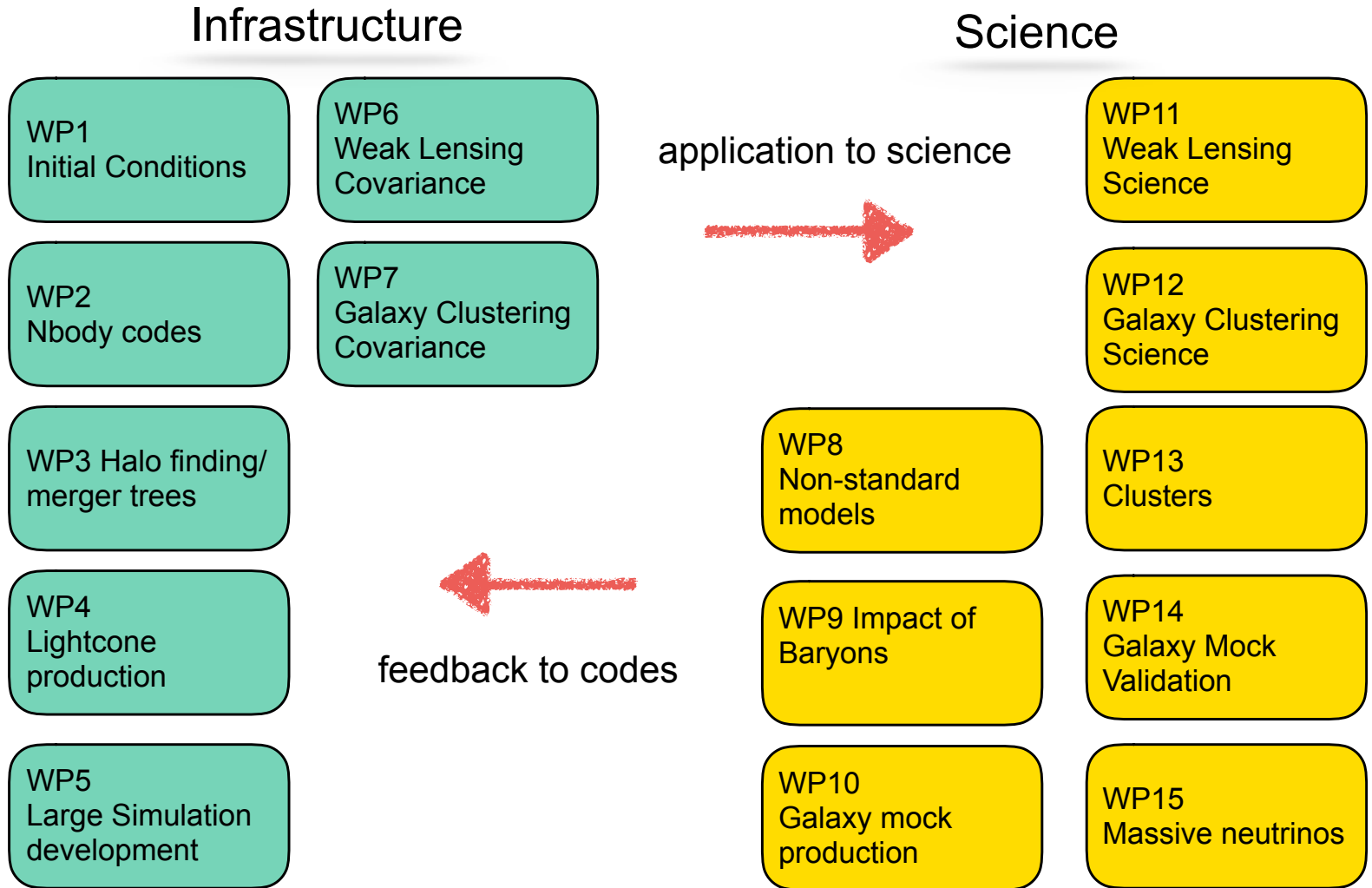
- **Wide survey:** do we need an all-sky, or can do with 1/2 sky (e.g, for Euclid footprint)
- **Deep survey** ($H=27$ + noise to reach $H=29$ for WL): what z_{max} we need ?
=> new Flagship body x2 in mass resolution wrt original run
- **AGN/QSO catalog:** just started thinking about this (F.Shankar and Durham group).

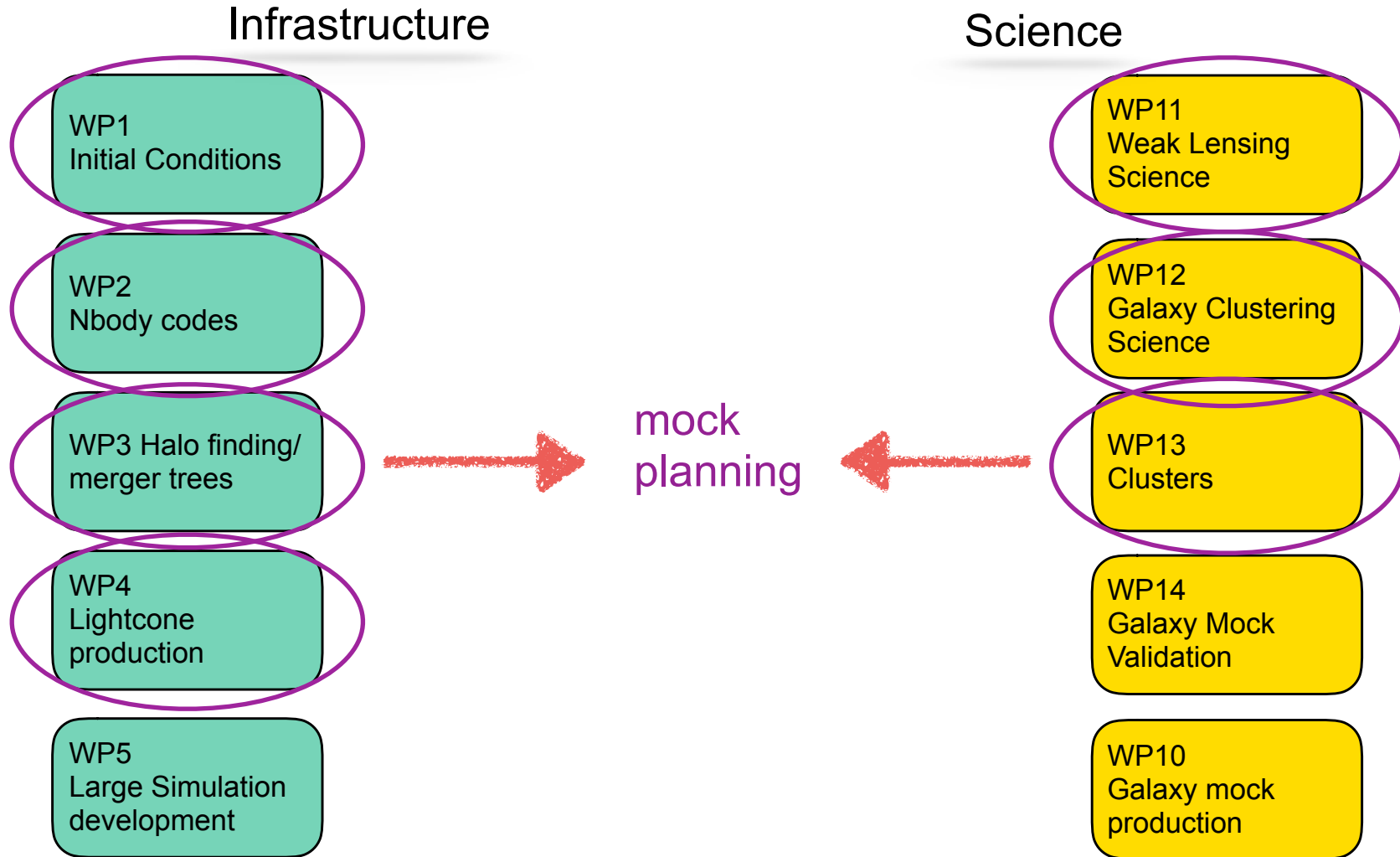
New/Improved Properties:

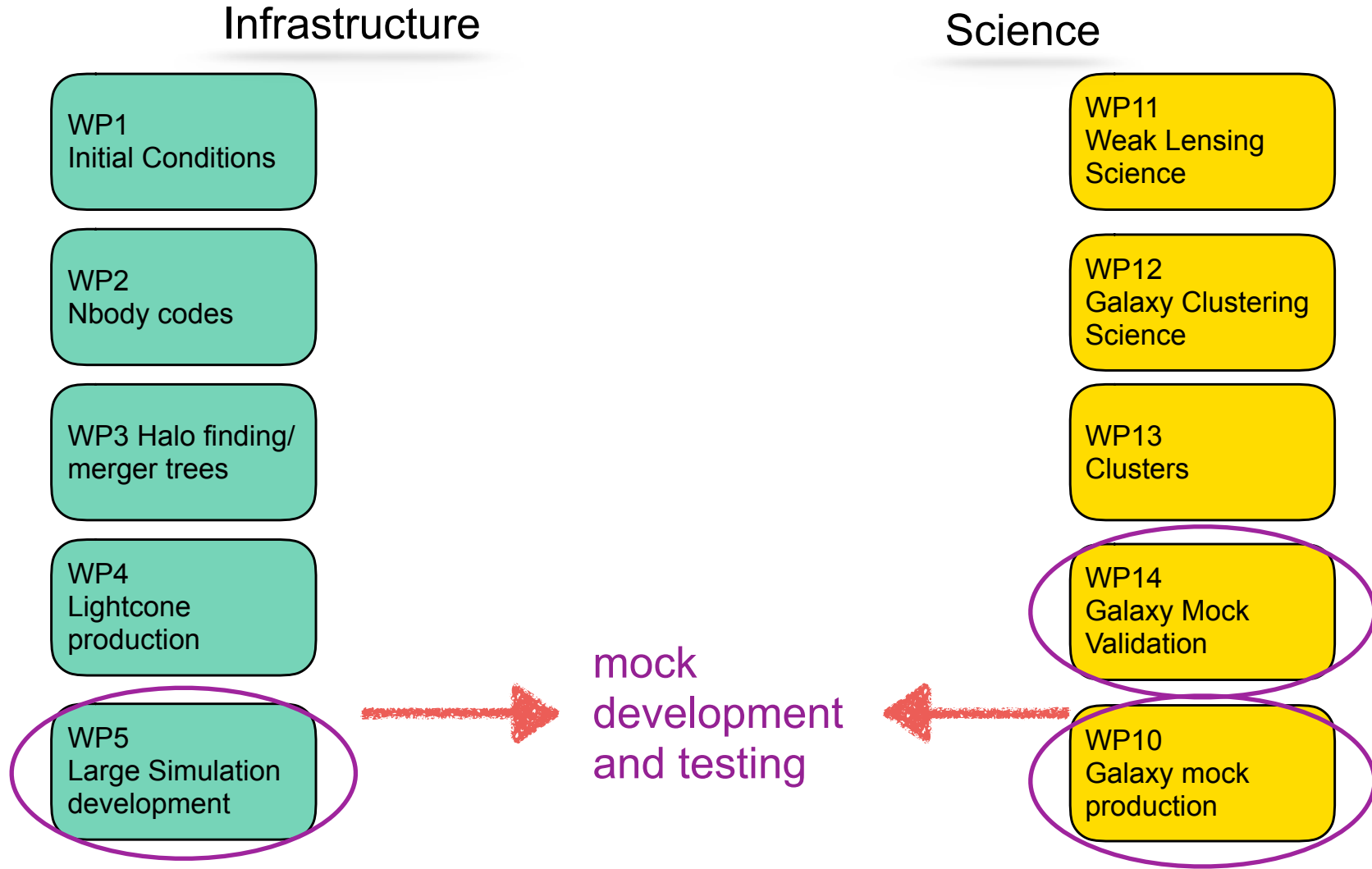
- alternative finder to produce halo catalog (FoF instead of Rockstar) ?
- subhalo catalog to assign galaxies (instead of NFW profile)
- better scaling relations between gal properties (stellar mass, metallicity, emission lines)

...

Backup

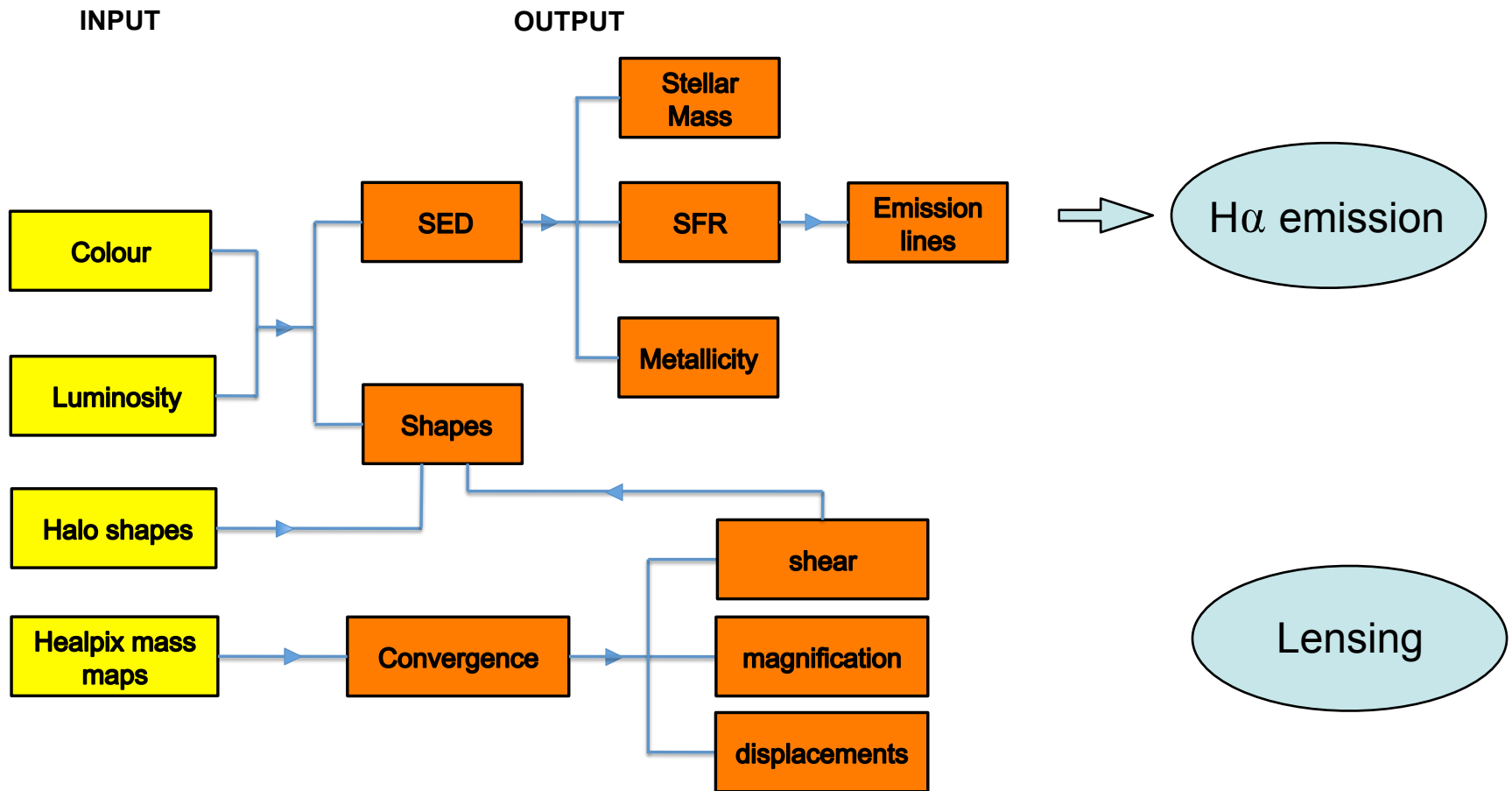






The HOD pipeline: $H\alpha$ and Lensing

See Francisco's talk for details!



Apache Hadoop & Hive

- Apache Hadoop:
 - one of the most popular solutions to work with Big Data
 - open-source software framework for distributed storage and distributed processing on computer clusters built from commodity hardware
 - scalable from dozens up to even thousands of nodes
 - failure tolerance
- Hive is built on top of Hadoop and provides a very fast data query over massive data volume



Flagship mock galaxy catalog

