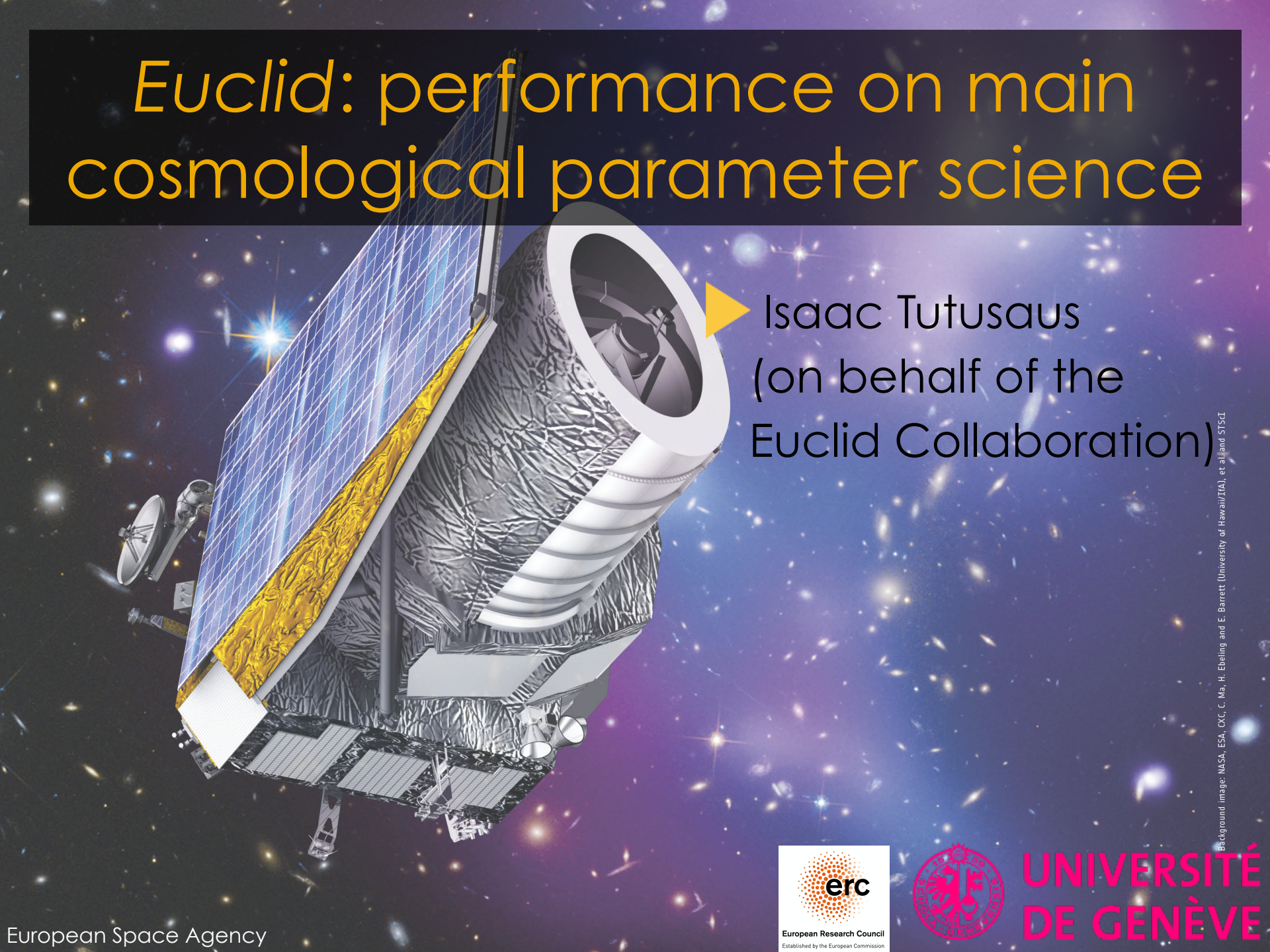
Euclid: performance on main cosmological parameter science



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European Space Agency

European Research Council
Established by the European Commission

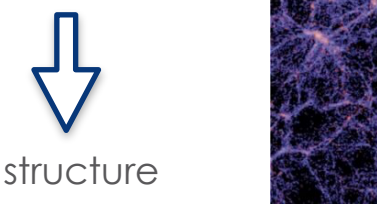
UNIVERSITÉ DE GENÈVE

Contents

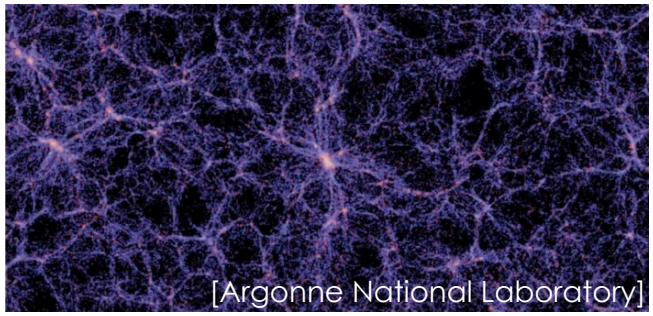
Introduction

- **Expansion** and large-scale **structure** — **dark matter** and **dark energy**:

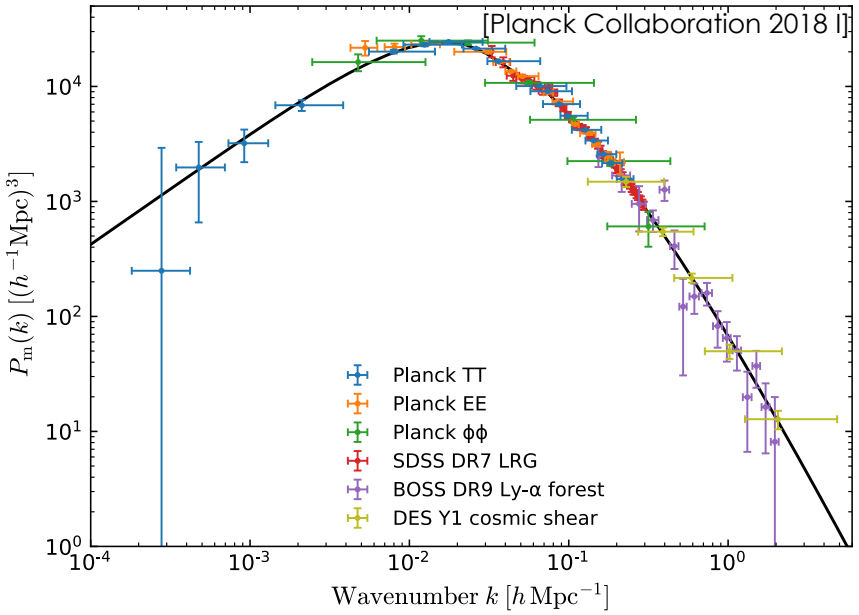
+ dark matter
- dark energy



+ structure

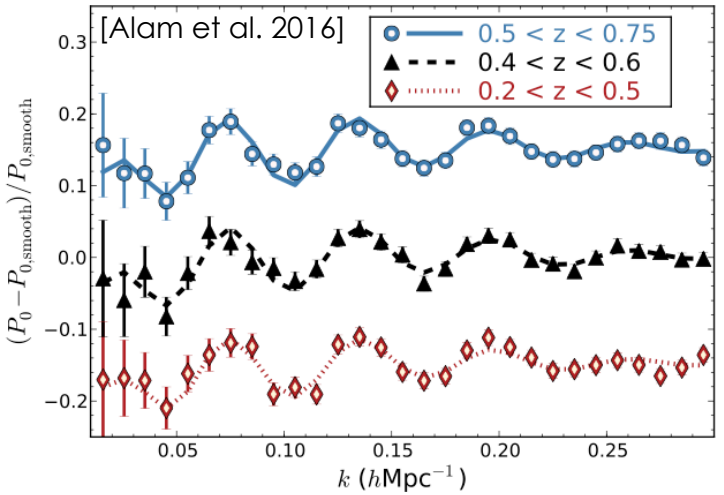


- Main summary statistic: matter/galaxy power spectrum

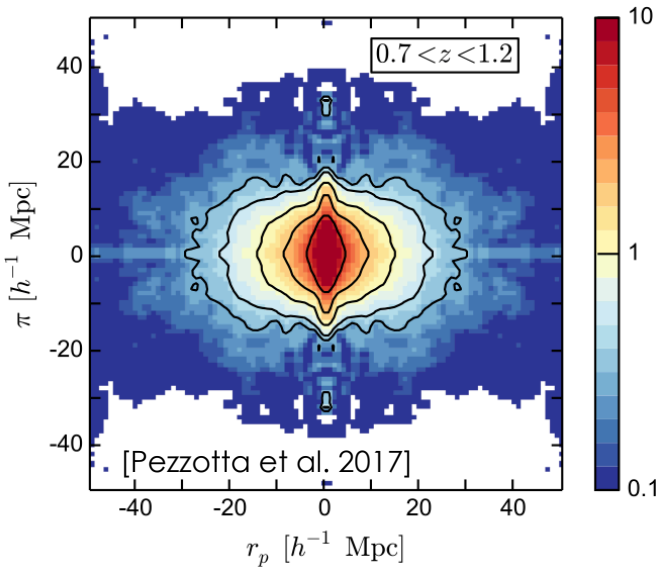


Introduction — galaxy clustering

- **Baryon acoustic oscillations** (BAO):
  - provide a **cosmic ruler**
  - sensitive to the **expansion** history and the angular-diameter **distance**

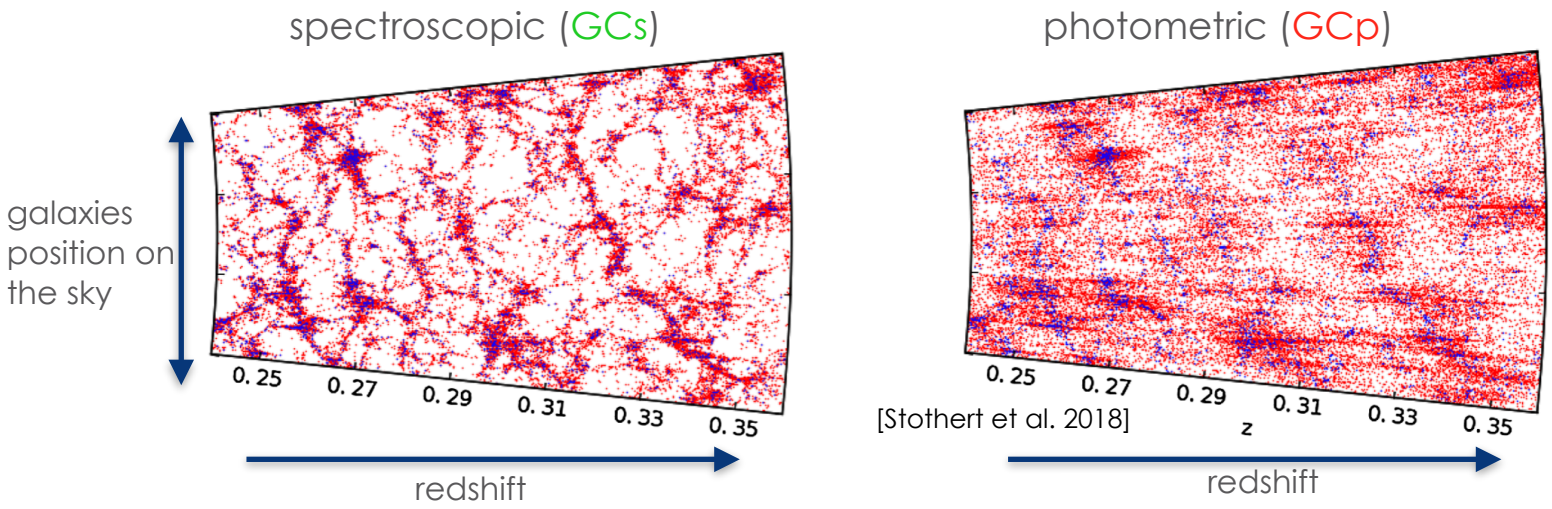


- **Redshift-space distortions** (RSDs):
  - sensitive to the **growth rate** of structures
  - tests of **modified gravity**



Introduction — galaxy clustering

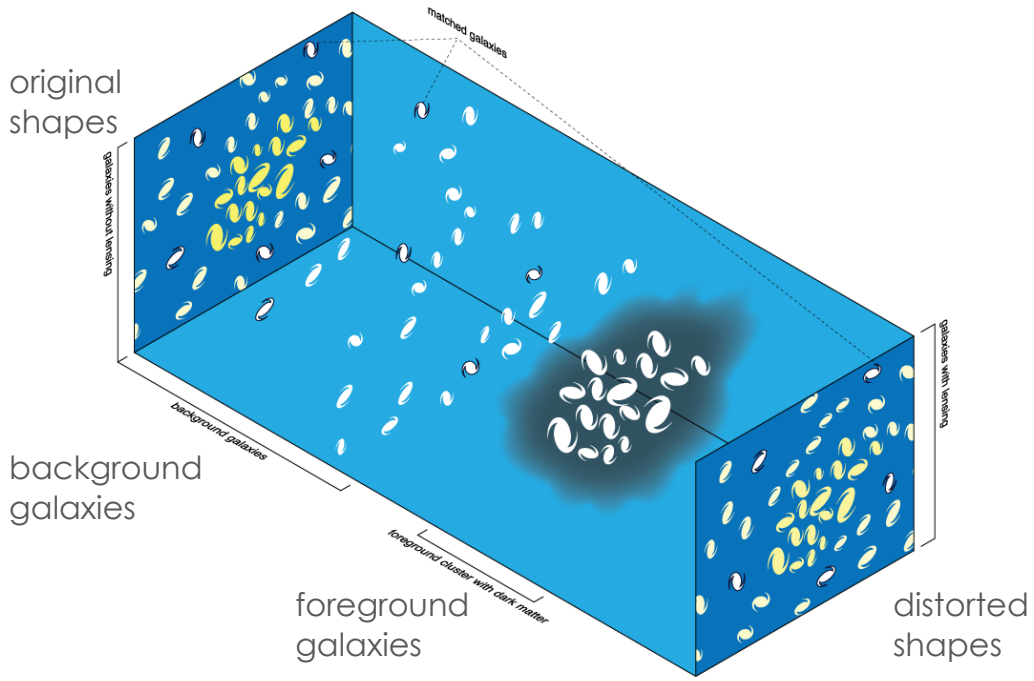
- Spectroscopic vs **photometric** galaxy clustering:
  - loss of radial information
  - higher number density & different systematic uncertainties
  - **source** of cosmological information



Introduction — weak lensing

Weak lensing (WL):

- information about **mass distribution** imprinted on galaxy images
- sensitive to **matter density**, initial conditions, and **growth of structures**

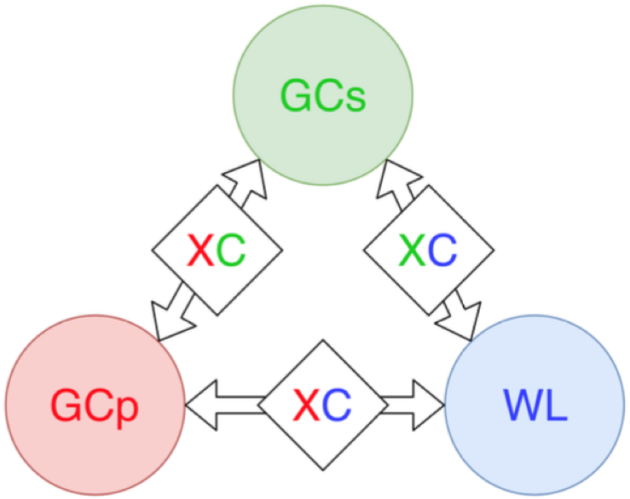


[Figure courtesy of M. Sachs]

Introduction

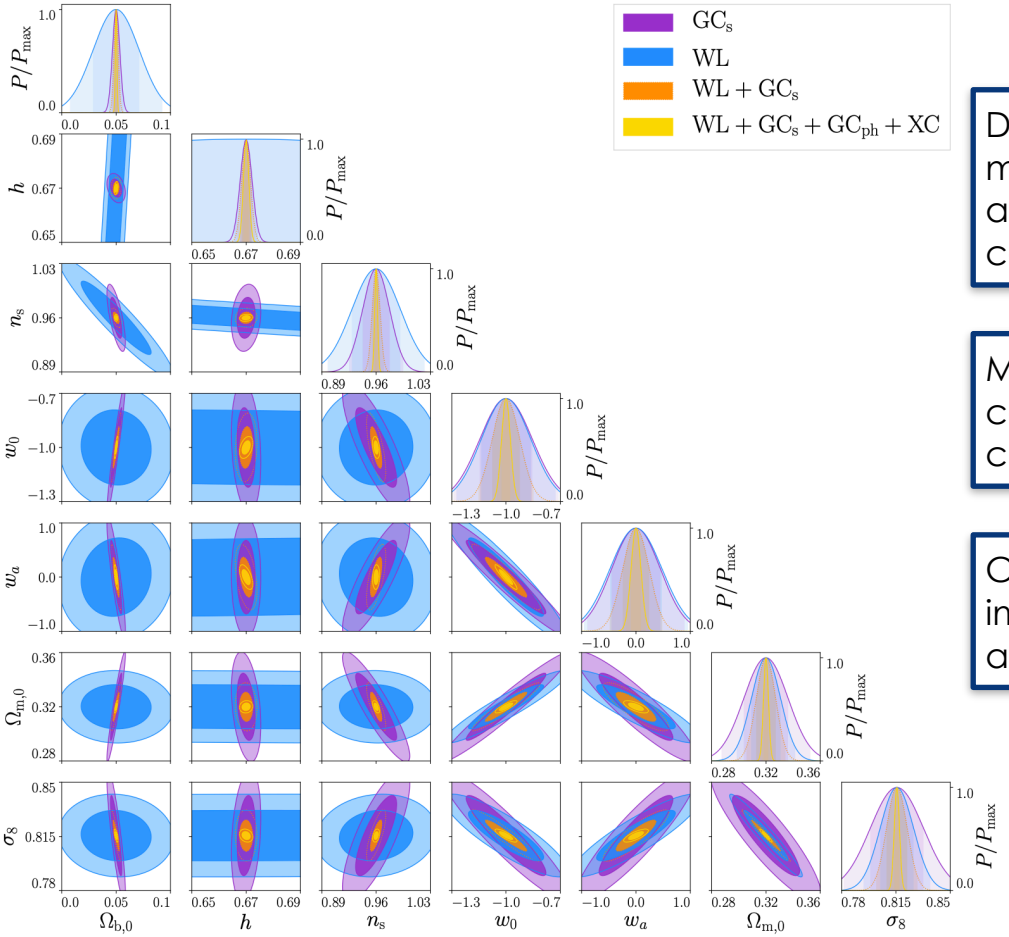
- *Euclid* is the ideal survey for a combined analysis:

  GCs, GCp, WL, and 3 **cross-correlations** (XC)



Cosmological constraints from the main probes

- Task-force to produce homogenised and validated forecasts:
  - Great complementarity between probes: breaking of degeneracies



[Euclid Collaboration VII. A&A 642, A191 (2020); I. Tutusaus *et al*. A&A 643, A70 (2020)]

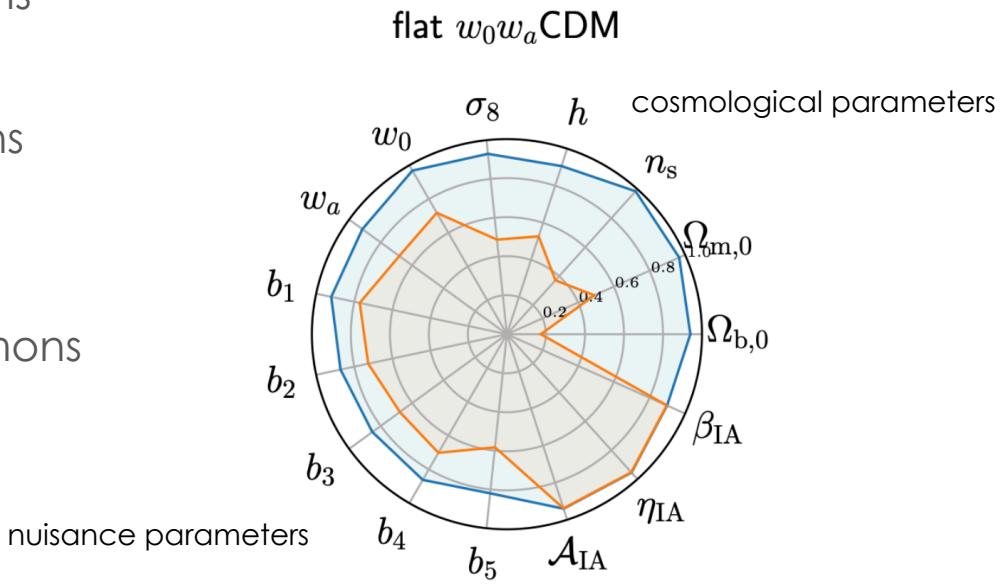
Dark energy figure-of-merit of 1257 (500) for a flat (non-flat) cosmology

Modified gravity constrained at 5% and curvature at 1%

Cross-correlations improve constraints by a factor 4

Beyond the main probes

- Cosmic microwave background — lever arm of different epochs [Ilic, Aghanim, Baccigalupi]
  - Euclid main probes + Simons Observatory CMB lensing (blue)
  - Euclid main probes + all Simons Observatory CMB probes (orange)

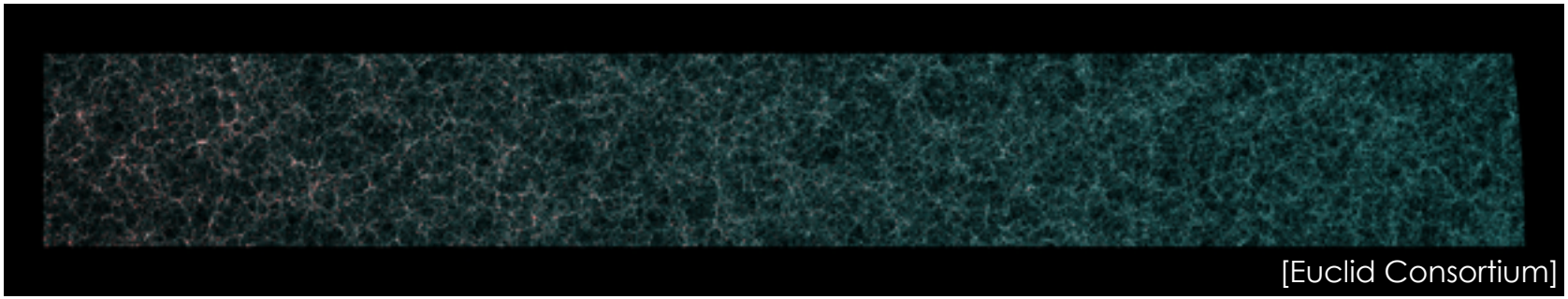


[Euclid Collaboration XV. A&A 657, A91 (2022)]

Improvements up to a factor of 10

Towards data analysis

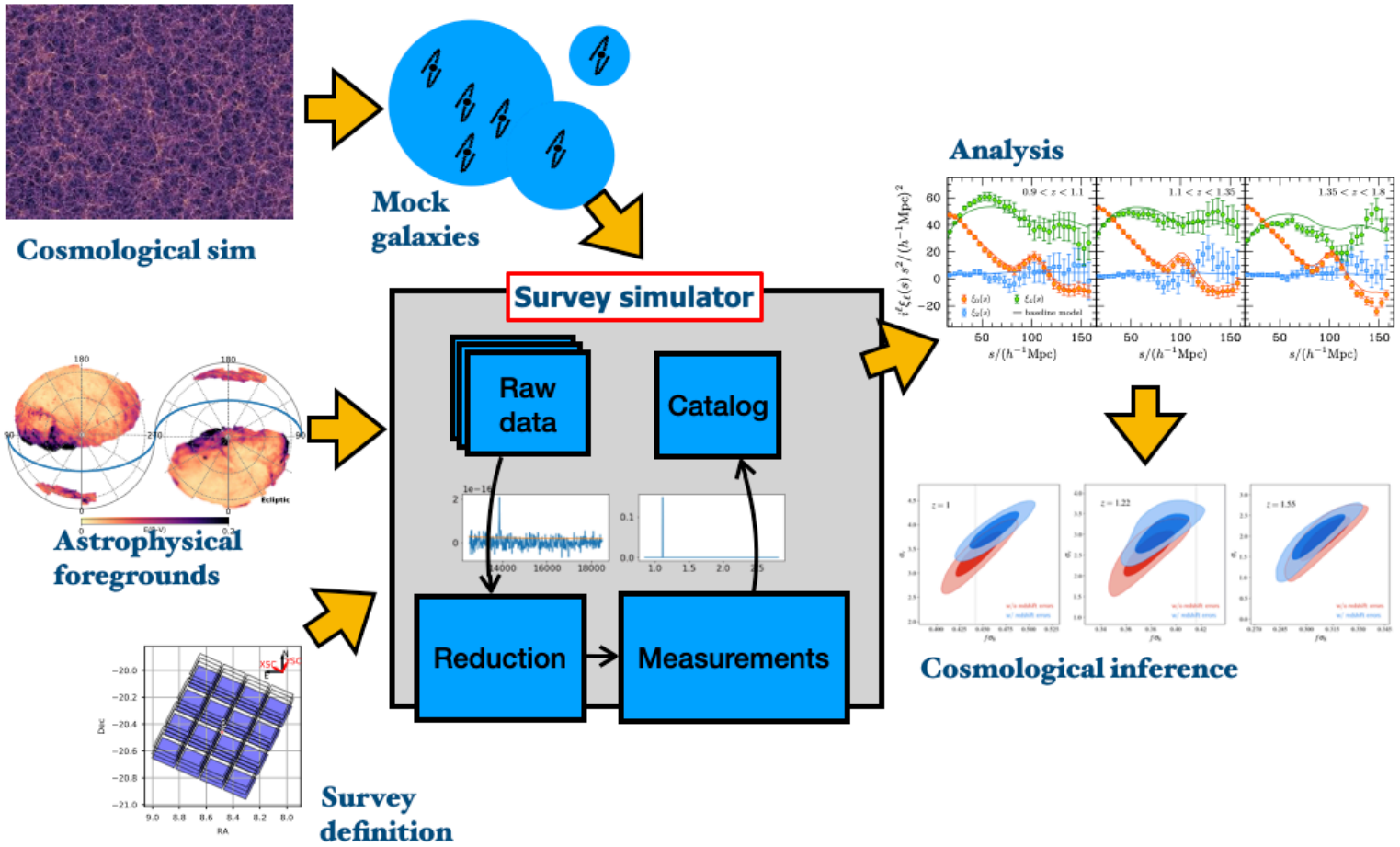
- Development of cosmological simulations to develop the analysis pipelines:
  - Flagship galaxy catalog [Carretero, Castander, Fosalba, Neissner, Pozzetti, Stadel, Tallada++]:



- WIDE: 10^9 M_{sun} resolution (4.1 trillion particles, 3600 Mpc/h box)
- DEEP: 10^8 M_{sun} resolution (0.9 trillion particles, 1000 Mpc/h box)

Towards data analysis

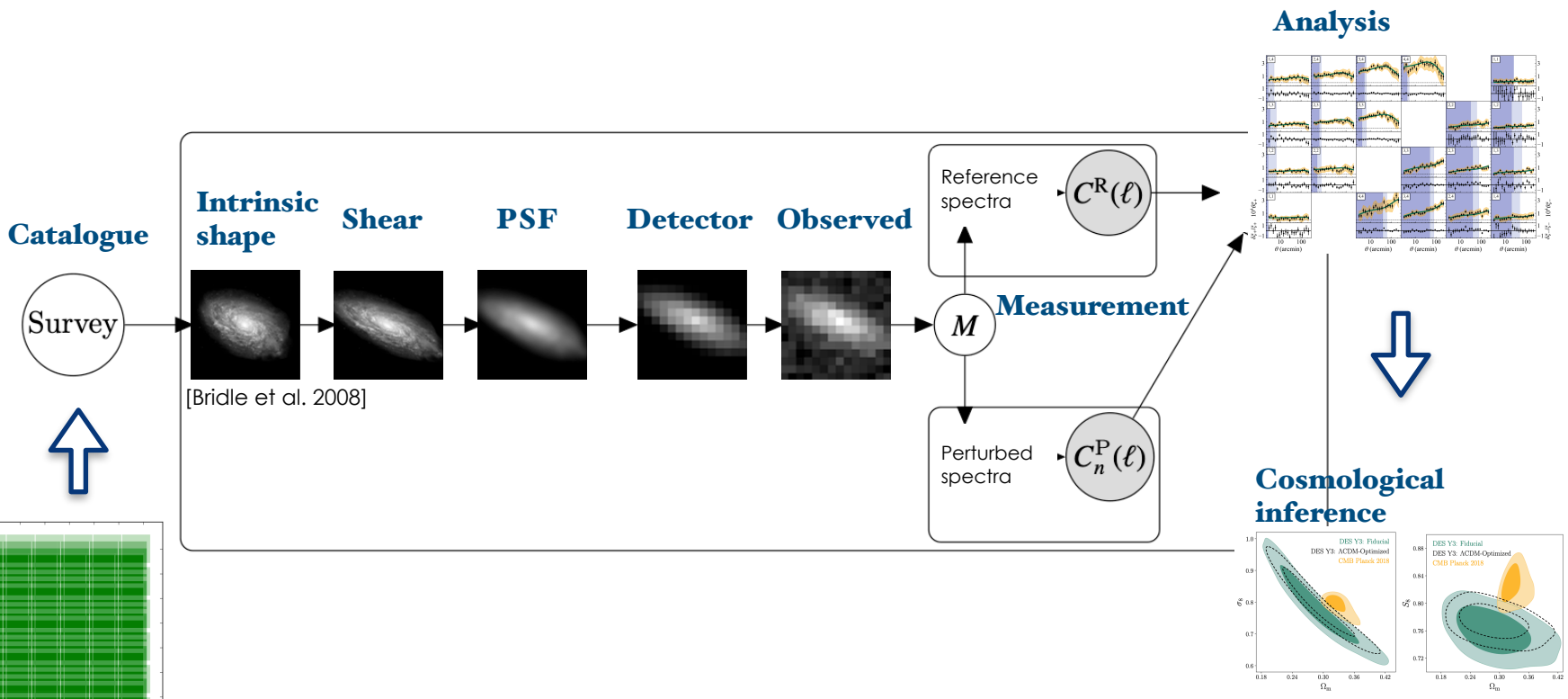
- Complex measurements: End-to-end simulations — spectroscopic galaxy clustering



[Slide courtesy of B. Granett and GC end-to-end group]

Towards data analysis

- Complex measurements: End-to-end simulations — weak lensing & photometric galaxy clustering



[Euclid Collaboration VI. A&A 635, A139 (2020)]

Towards data analysis

- **Simulations**:
  - more volume and resolution, emulators
  - end-to-end pipelines
- **Modelling** of the observables:
  - nonlinear modelling of the matter and galaxy power spectra, including RSDs
  - magnification and other relativistic contributions
- Towards the **coming data**:
  - addition of systematic uncertainties and mitigation techniques

Conclusions

- *Euclid* will provide unprecedented constraints on **dark matter**, **gravity** at cosmological scales and will constrain **dark energy better than all current observations together**: