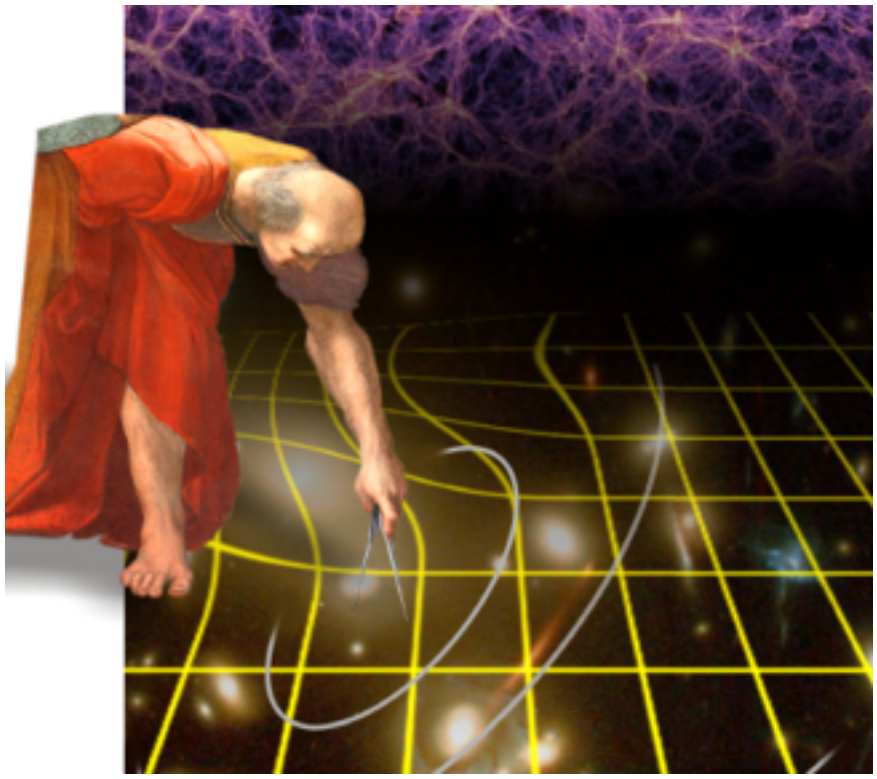
Cosmological Simulations
Science Working Group for Euclid



Pablo Fosalba
Romain Teyssier

70 members in the mailing list
Regular telecons
ITN project ECOSIM submitted

Euclid France

Science Requirements on Simulations

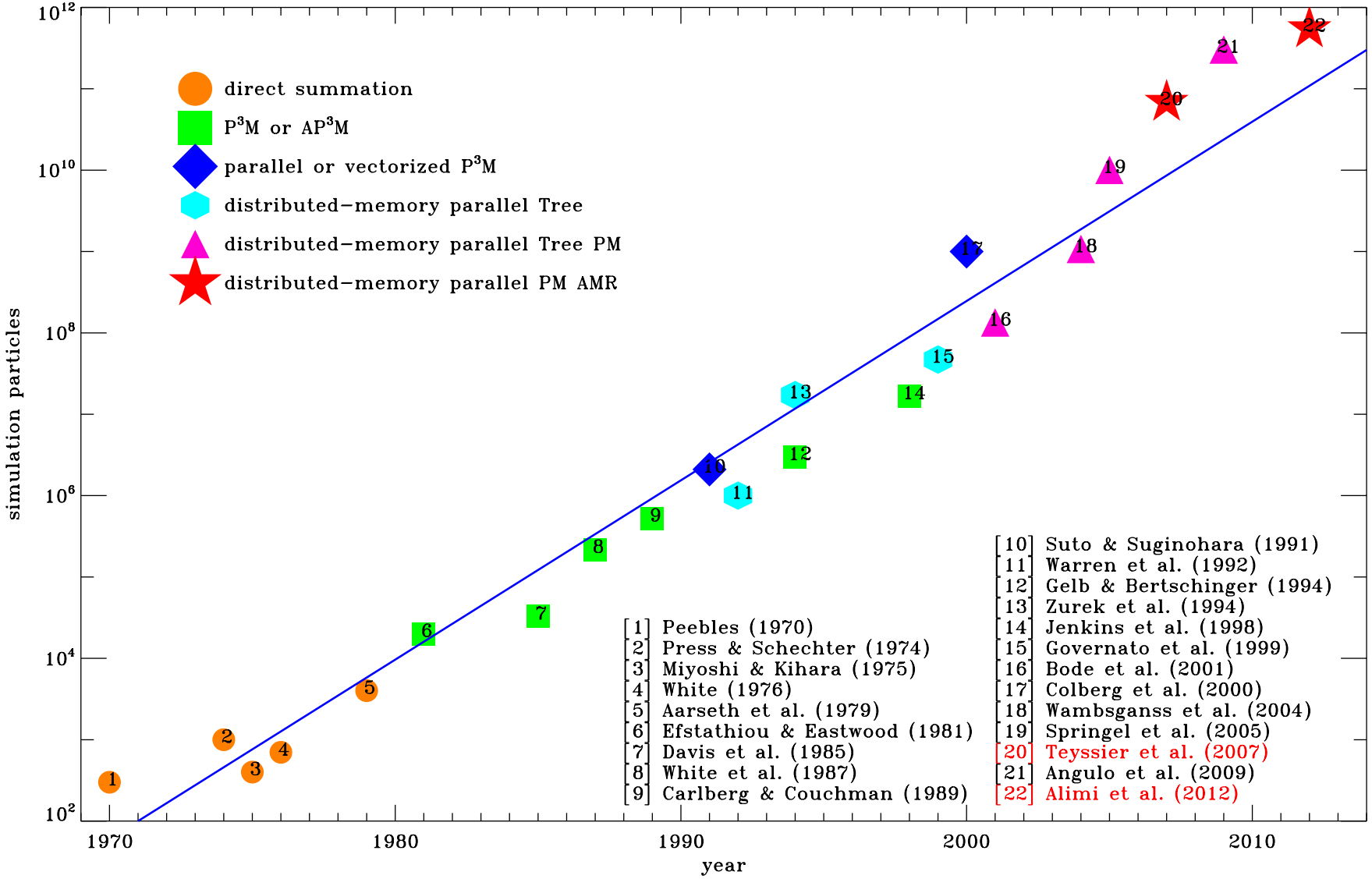
- Internal doc produced (ECSRD) in June 2011 with requirements from WL, GC, Clusters and Theory WG inputs
- Translation of SciRD into requirements on simulations to achieve Euclid science goals.
- CSWG replied in July with 2 docs, addressing basic requirements:
  - P(k) accuracy from N-body simulations < 1%
  - Impact of baryonic physics on the PS < 10% understood < 1%
- Theory WG defined 8 classes of non-standard (and viable) cosmological models to be implemented in N-body algorithms

Cosmological simulations: task list

1. Development of large simulations & access to HPC facilities [V.Springel]
2. Lightcone data format & ray-tracing tools [S.Colombi,S.Hilbert]
3. Halo/sub-halo, mass function, merger-trees [A.Knebe]
4. Database of simulation products
5. Covariance estimation of observables [A.Kiessling]
6. Tools for non-standard models [M.Baldi,K.Koyama]
7. Beyond 1% accuracy in dark-matter statistics [R.Smith,P.Fosalba]
8. Impact of baryons [R.Teyssier,K.Dolag,J.Schaye]
9. Generation of galaxy catalogs [C.Baugh,F.Castander]
10. Simulation output comparison/validation [F.Pearce]

Cosmological N body simulations

Euclid resolution: particle mass = 0.1 billion solar masses



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Simulations beyond LCDM

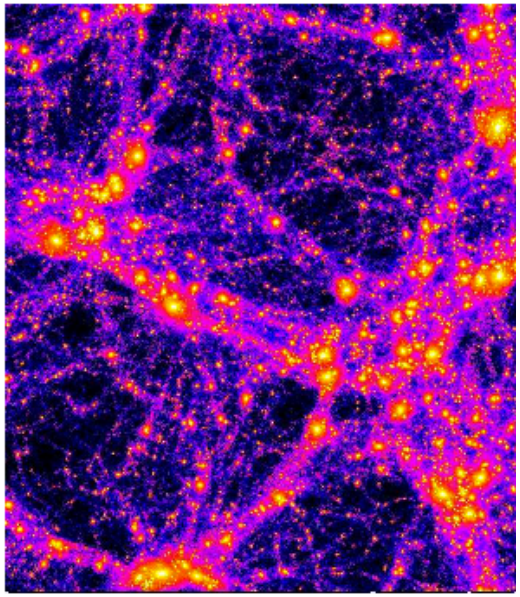
1. Quintessence and Early Dark Energy
including dynamic **scalar field models** and **phenomenological parametrizations**
Simulations for this class have already been carried out by e.g. **Grossi & Springel 2009, Jennings et al. 2009**
✔ **N-body codes already available**

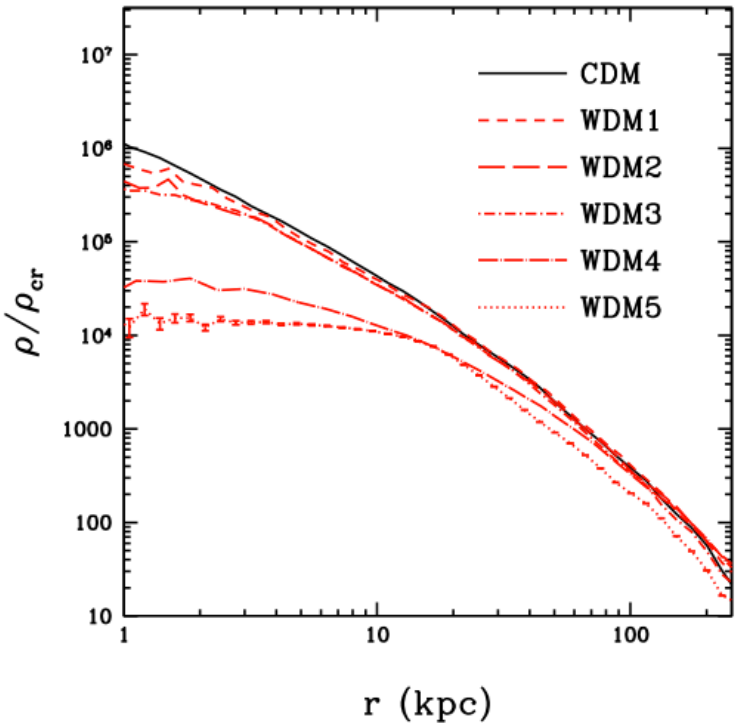
2. Inhomogeneous large-void models
including LTB cosmologies parametrized by the structural properties of the **density void**, in particular of its radius r_0.
Simulations for this class have already been carried out by **Alonso et al 2010**
✔ **N-body codes already available**

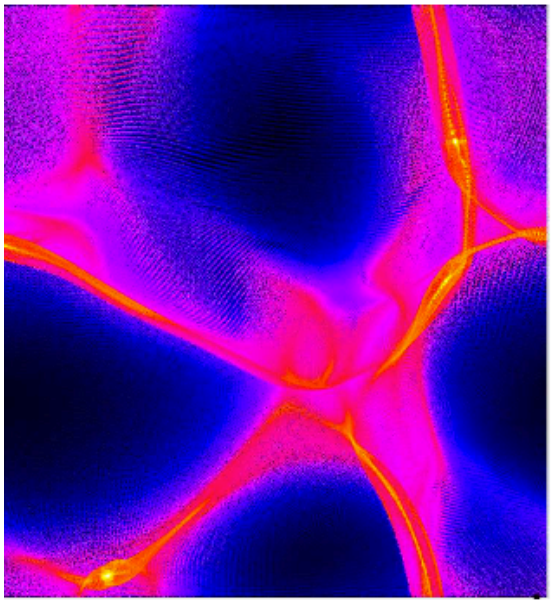
3. Warm Dark Matter
including models with a thermal relic of particles with **mass in the range m_{WDM}=[0.5,2.0] keV**.
Simulations for this class have already been carried out by e.g. **Zavala et al. 2009, Lovell et al 2011, Viel et al. 2011**
✔ **N-body codes and Initial Conditions codes already available**

4. Non-Gaussian initial conditions
including **Local, Equilateral, and Orthogonal** types of non-Gaussianity in the primordial density field.
Simulations for this class have already been carried out by e.g. **Grossi et al 2007, Pillepich et al 2008, LoVerde & Smith 2011, Sefusatti et al 2010, Wagner et al 2010**.
✔ **N-body codes already available**
✘ **Initial Conditions codes yet to be developed (for general non-Gaussianity)**

Simulations beyond LCDM







Maccio et al. 2012, Schneider et al. 2012

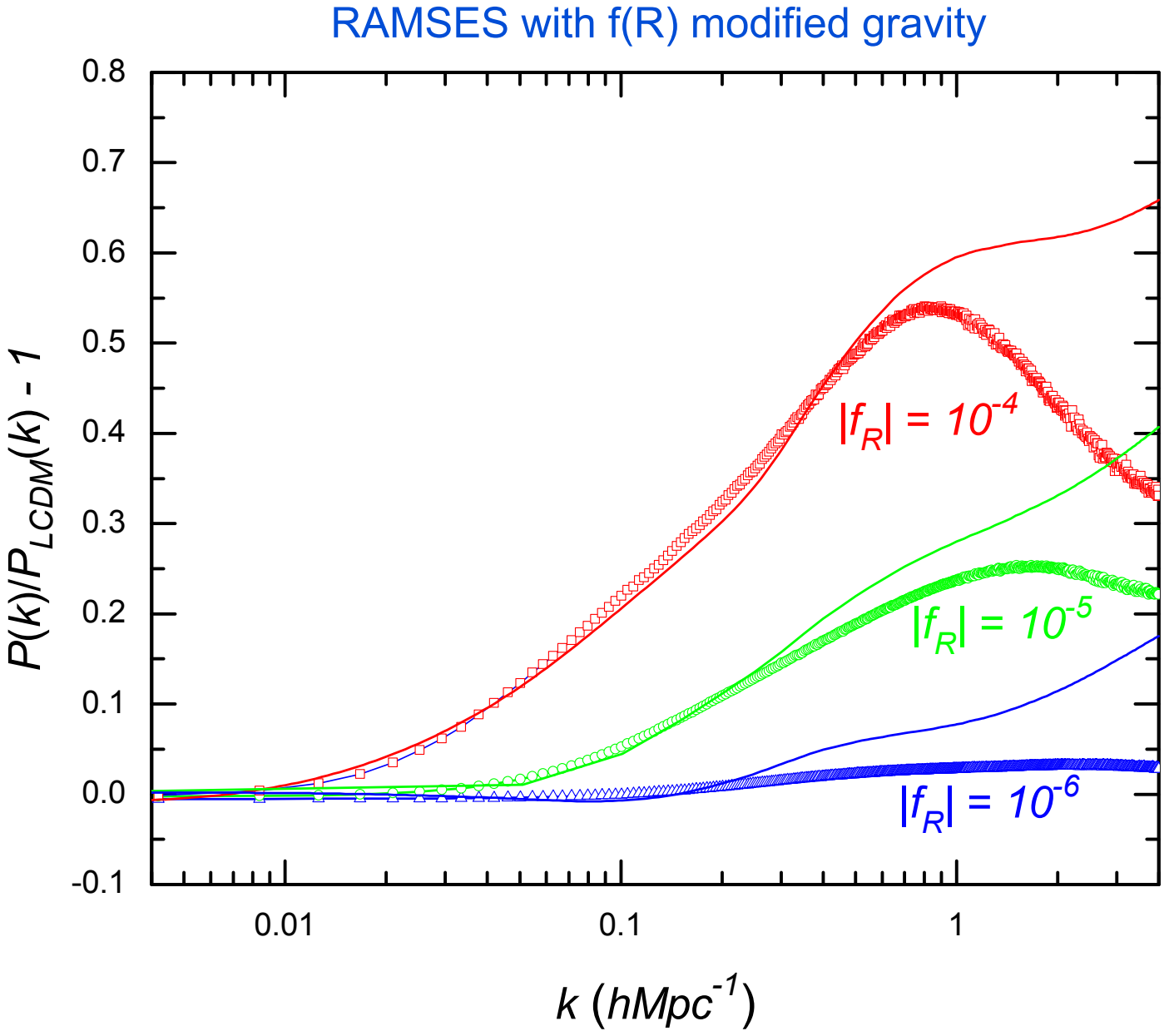
Simulations beyond LCDM

5. Massive Neutrinos
including models with a cosmological fraction of massive neutrinos.
Simulations for this class have already been carried out by e.g. Viel et al 2010, Brandbyge et al 2010.
✔ **N-body codes and Initial Conditions codes already available**

6. Self-Interacting Dark Matter
including microscopic models of **Dark Matter scattering** and **short-range scalar forces** (Loeb & Weiner 2011).
Simulations for this class have already been carried out by e.g. Dave et al 2001.
✘ **N-body codes yet to be developed and optimized**

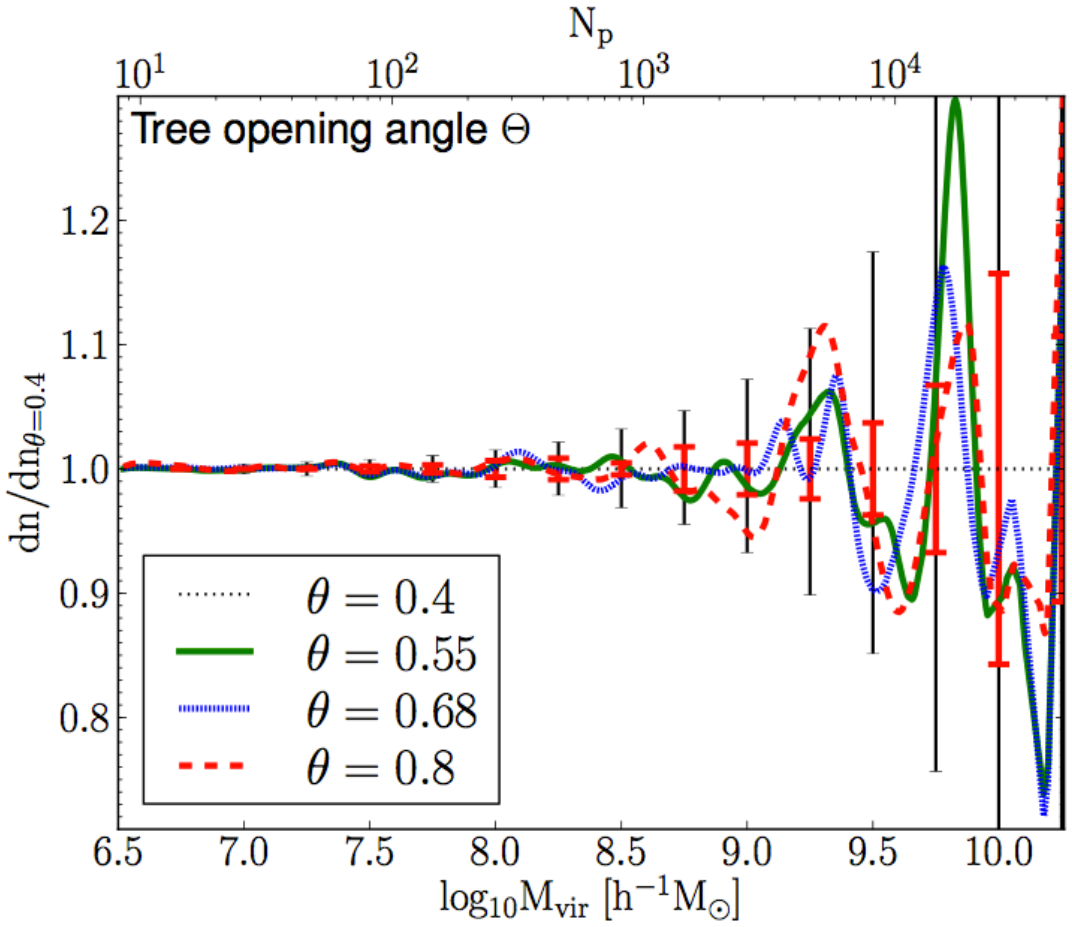
7. Linear spatial Dark Energy fluctuations
including **Coupled Dark Energy**, **Extended Quintessence**, and **Clustering Dark Energy** models.
Simulations for this class have already been carried out by e.g. Baldi et al. 2010, De Boni et al. 2011.
✔ **N-body and Initial Conditions codes already available for Coupled Dark Energy and Extended Quintessence**
✘ **N-body codes yet to be developed for Clustering Dark Energy**

8. Non-linear spatial Dark Energy fluctuations
including **Modified Gravity theories** and **massive coupled scalar field Dark Energy** scenarios.
Simulations for this class have already been carried out by e.g. Oyaizu et al. 2008, Zhao et al. 2011.
✘ **N-body codes yet to be developed and optimized**



Baojiu Li *et al.* 2011

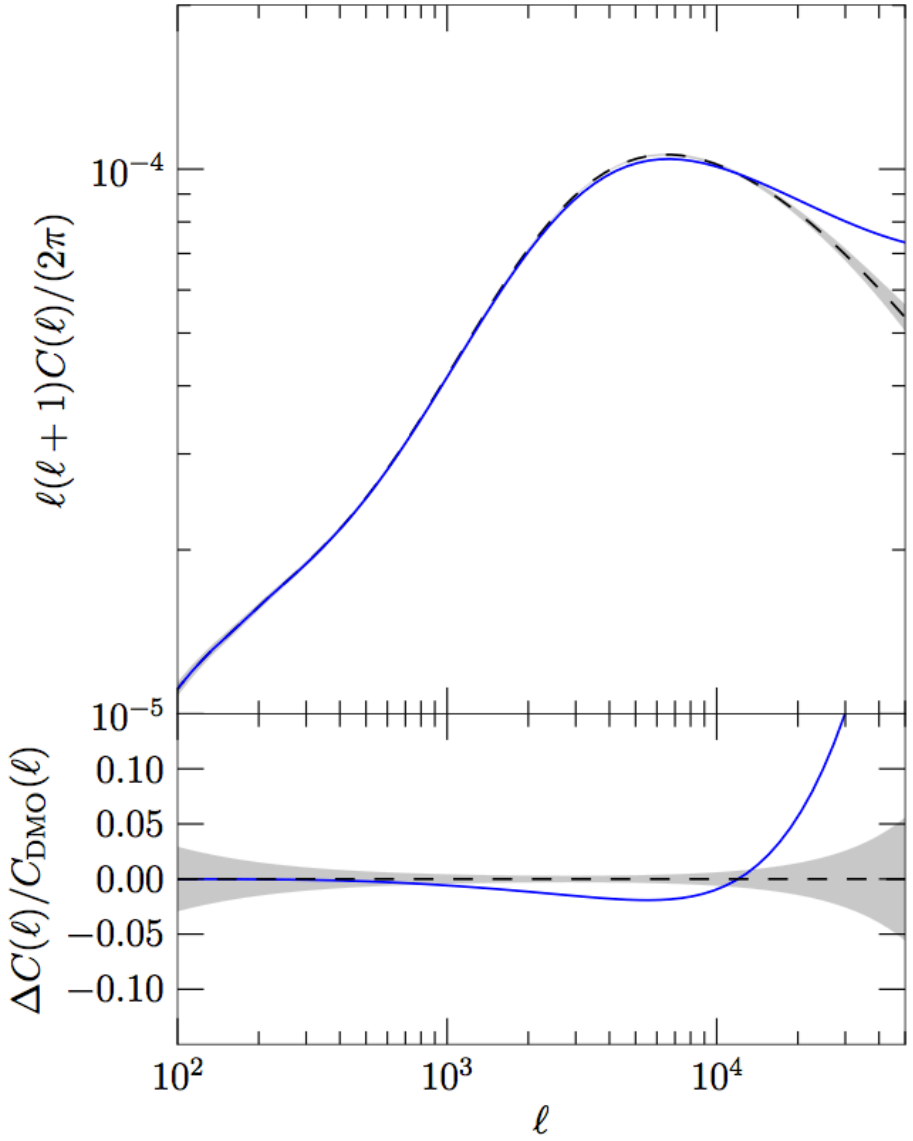
Beyond 1% accuracy for numerical models ?



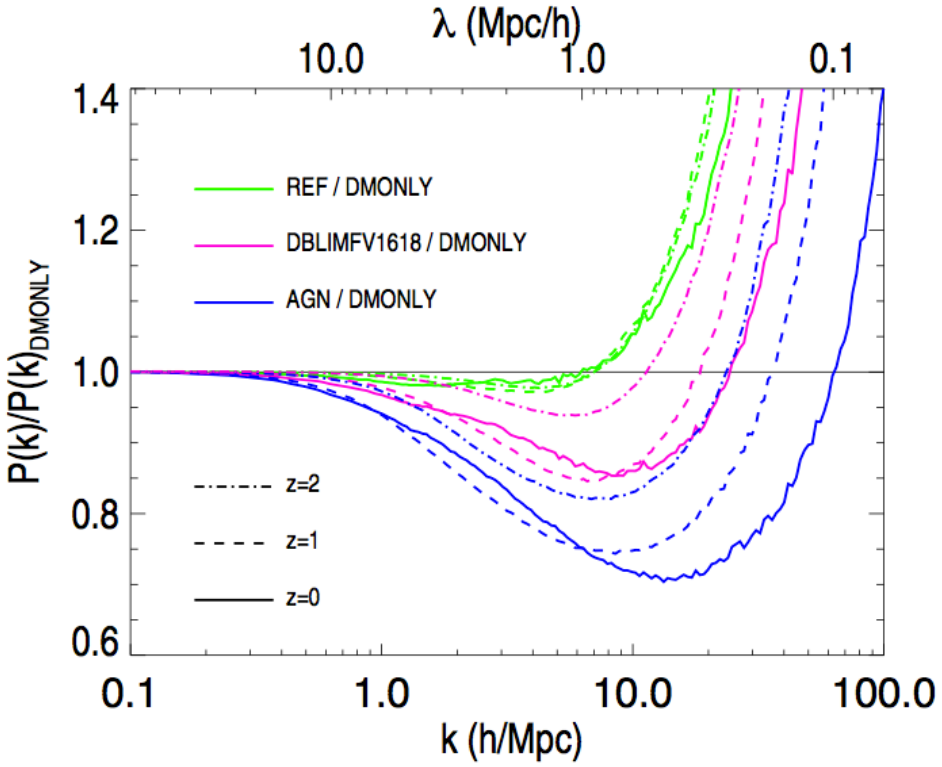
Reed et al. 2012

The impact of baryons on the matter power spectrum

Guillet *et al.* 2010

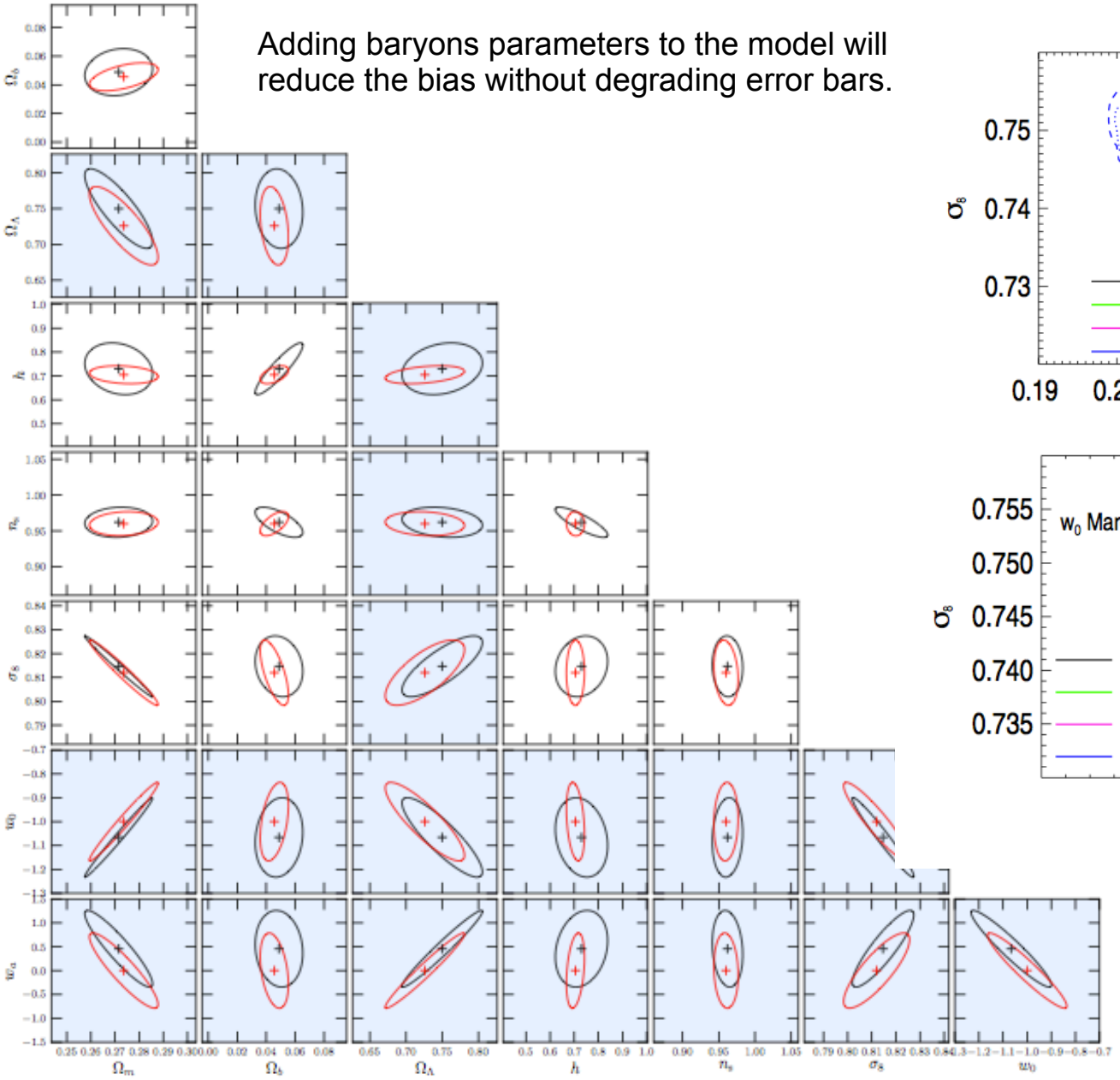


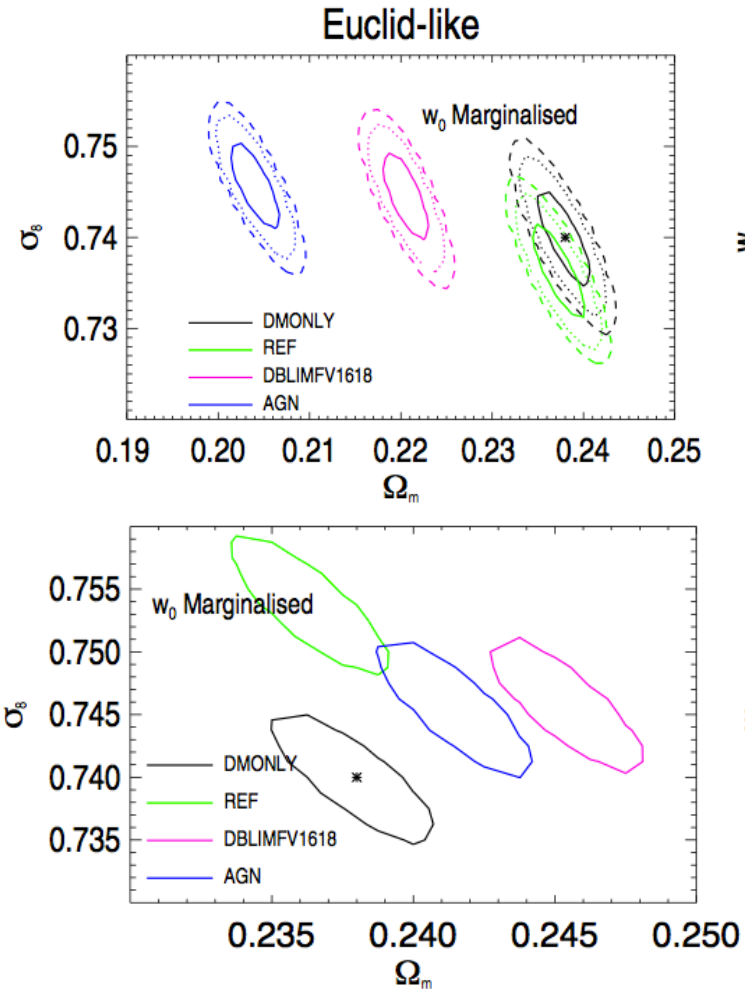
Semboloni *et al.* 2011



The impact of baryons on the matter power spectrum

Adding baryons parameters to the model will reduce the bias without degrading error bars.

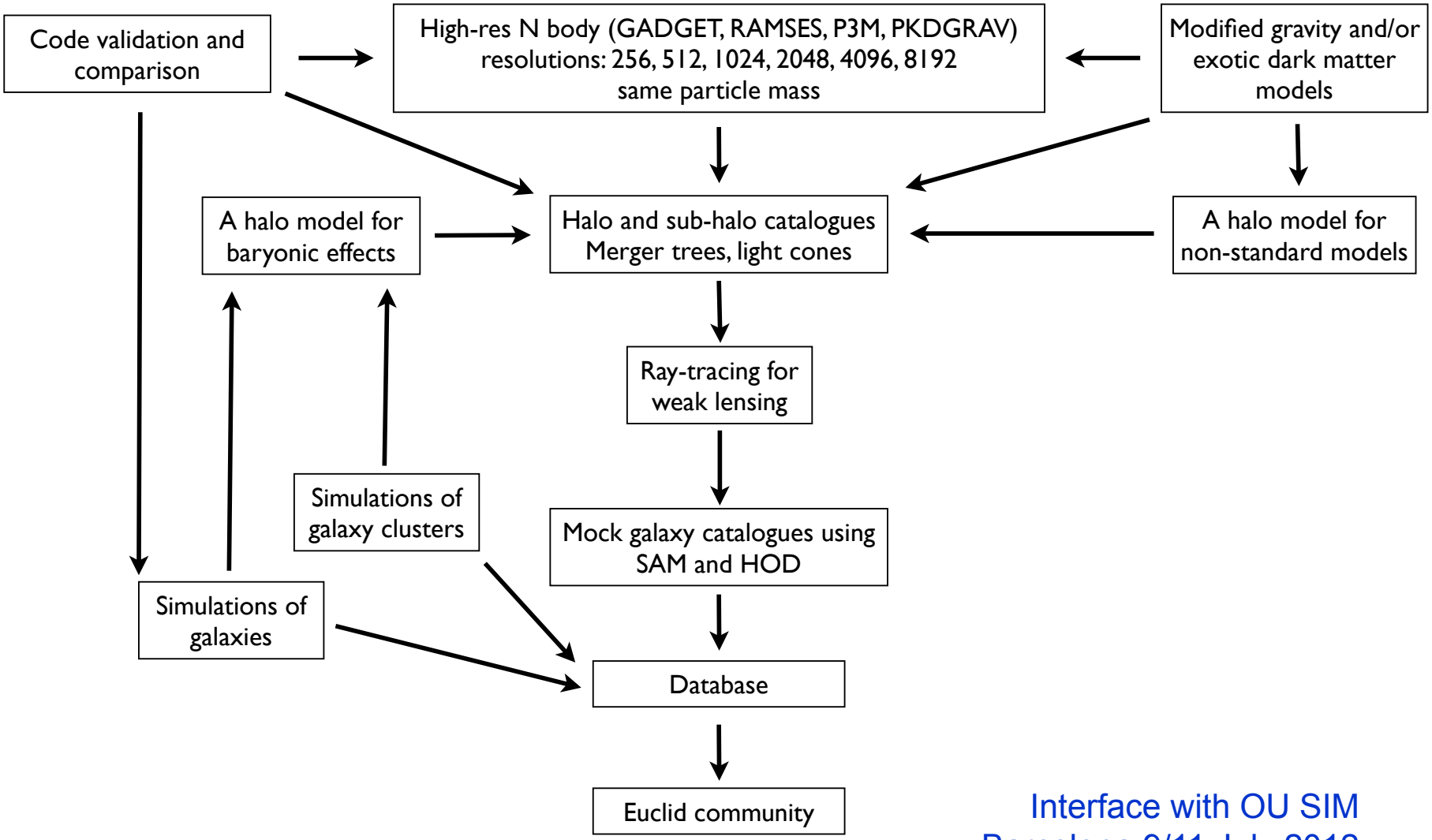




Semboloni *et al.* 2011

Guillet *et al.* 2010

Cosmological simulations workflow



Interface with OU SIM
Barcelona 9/11 July 2012

Cosmological Simulations Science Working Group

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