An update on Euclid and comments on CSS-OS/Euclid collaboration

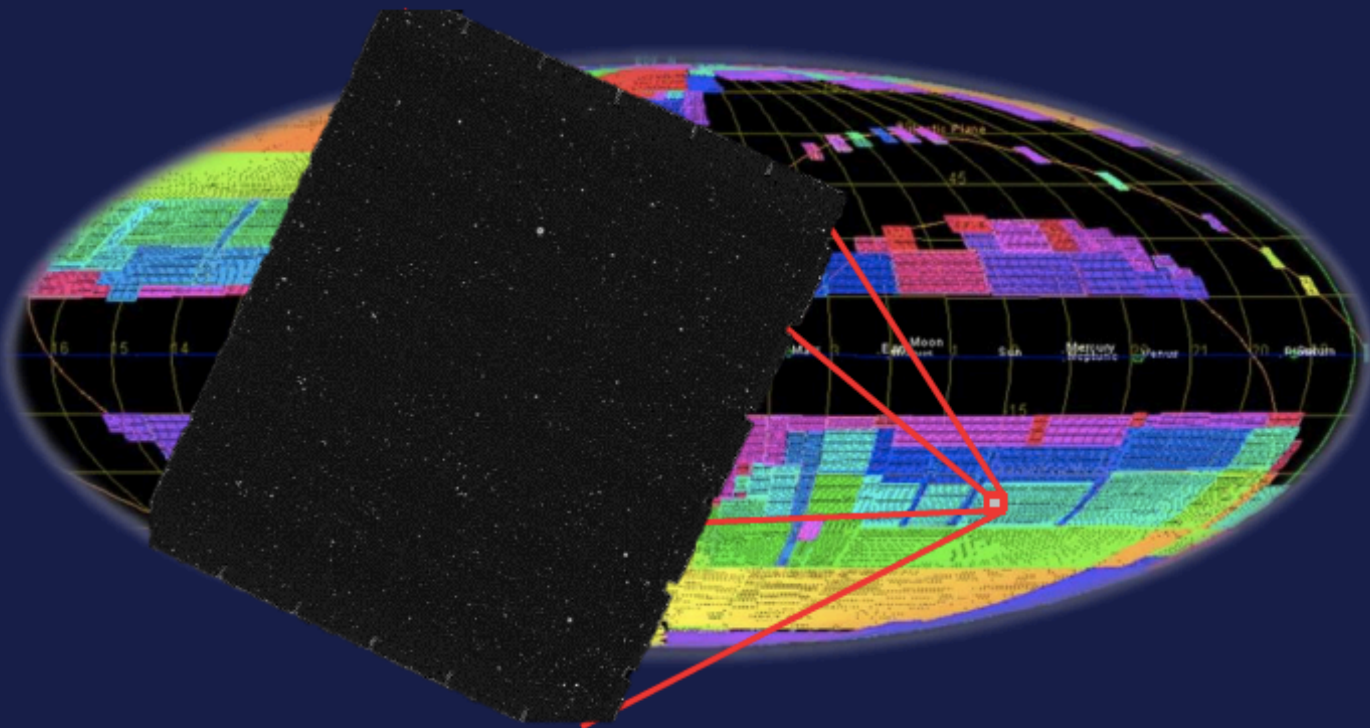
Charling Tao

ISSI-BJ meeting

Beijing, Nov 4-8, 2019

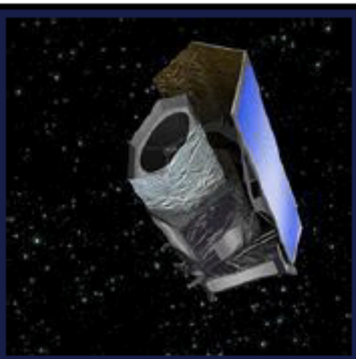
www.euclid-ec.org

Euclid Survey



Euclid

- **Survey 15000 deg²**
- **Visible & Infrared**
- **Diameter 1.2 m**
- **Field 0.5 deg²**



15 000 deg² covered in 5 years

Survey build of 30 000 fields observation 0,5 deg² repeated on the sky (+10 000 fields of calibrations)

160 000 frames in Visible / Y / J / H bands and Spectroscopy [1200-1850] nm

The Euclid Project

Euclid consortium

18 countries
285 institutes
2020 members or former members
about 300 Alumni

esa

EST
Euclid Science Team
10 members

Euclid Consortium Board (ECB)
22 members

ECL
Yannick Mellier
(IAP)

ECL Support

- Support Office
- Coordination support
- Mission System
- Mission survey WG
- Calibration WG
- Science Performance Verification
- Tracking Team
- Communication
- Complementary data group
- Coordination Group
- Editorial Board

SWG (Science Working Groups)

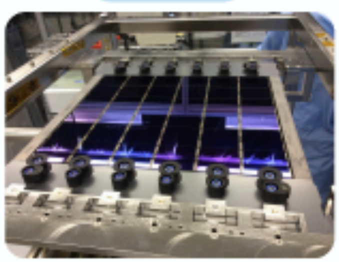
Cosmology

- Weak Lensing
- Galaxy Clustering
- Clusters
- CMB Cross Correlation
- Strong Lensing
- Cosmology theory
- Cosmological simulations

Legacy

- Primeval Universe
- Galaxy & AGN evolution
- Local Universe
- Planets
- Super Novae & transients
- Solar System Objects
- Milky Way & resolved stellar population

VIS



NISP

SGS

OBS

Recent and future milestones

Euclid consortium

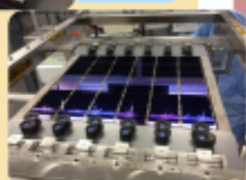
Instruments and Satellite		SGS	Survey and External data	Flagship Sim.	Science and Management

June 2018 — EC Meeting Bonn

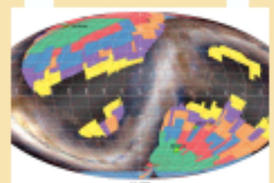
Mission CDR and Science Performance Verification 2, ESA
Oct 2-Nov 21 2018

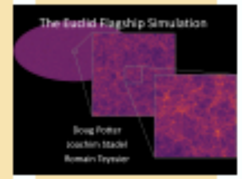
NISP

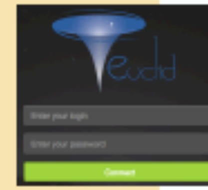
VIS



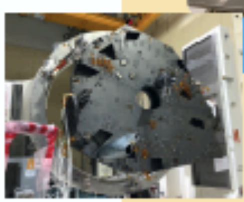
Science Challenges 4-5-6







Tracking, publication, projects definitions



June 2019 — EC Meeting Helsinki

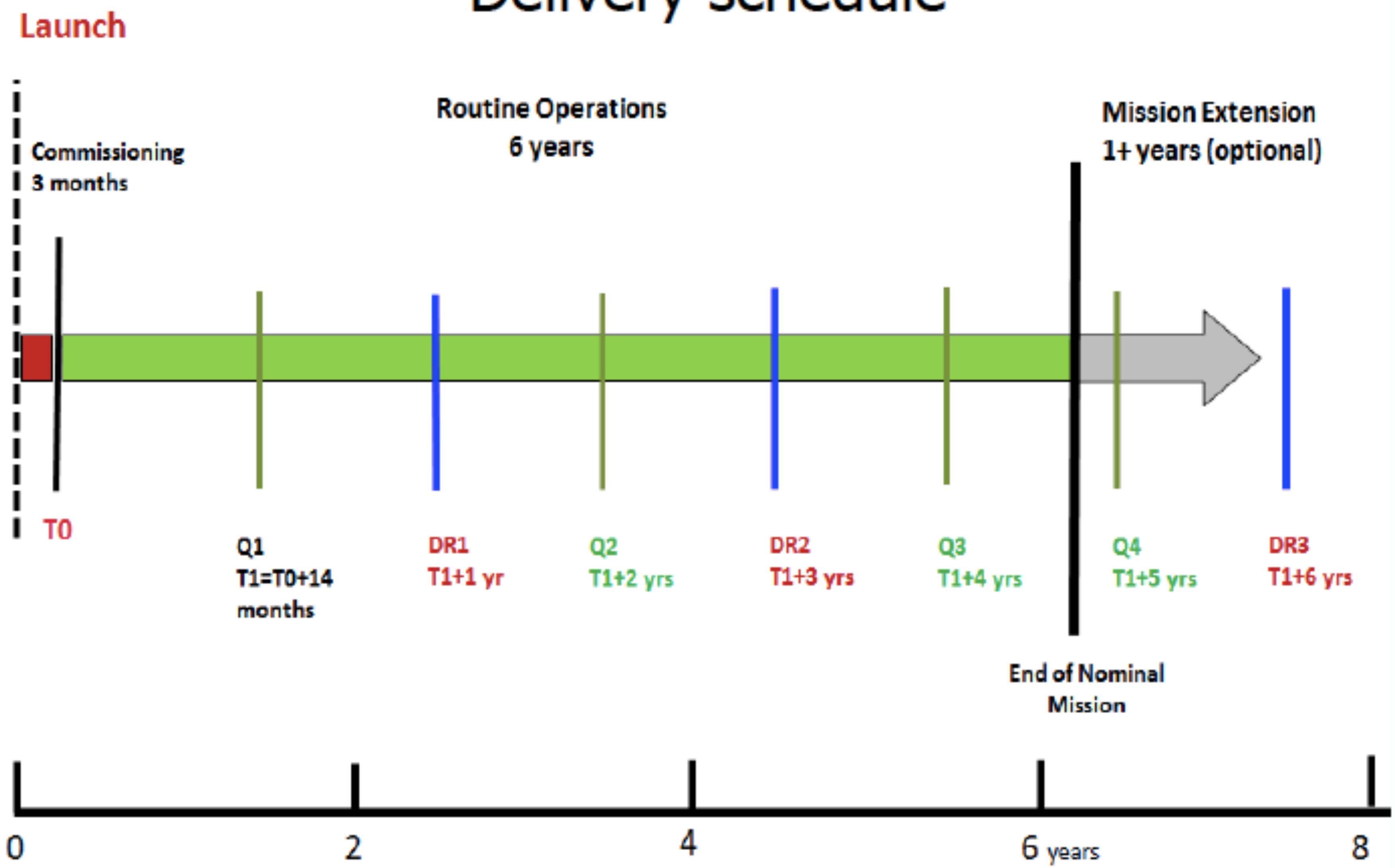
Oct. 2019 — SGS TK2

Inst. delivery	Dec 2019			Wide Galaxy mock	Def. of pre-launch Key-Projects
PLM completion and test	2020			Deep Galaxy mock	Def. of KP and SP for Q1 and DR1

Launch date : June 2022

Science with Euclid

Delivery schedule



LSST : Euclid sky coverage under discussion

- LSST responded positively to the LSST-Euclid White paper:
  - Simulation to explore how additional zones (north and south) can be made by optimising telescope operation
  - No decision before the end of the simulations in progress

1. The original footprint, as defined in the current baseline OpSim runs. Again, it extends in declination from $\delta = -62^\circ$ to $\delta = +2^\circ$, and has a cut at low Galactic latitudes that is designed to remove the highest stellar density regions.

2. The original footprint, but with no Galactic latitude cut.

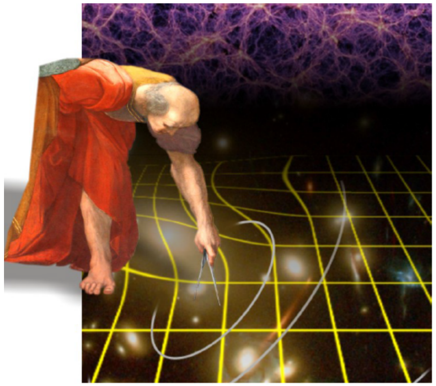
3. A declination cut $-72^\circ < \delta < +12^\circ$, with the original cut at low Galactic latitudes.

4. A declination cut $-72^\circ < \delta < +12^\circ$, with a cut in Galactic extinction at $E(B-V) < 0.15$, or a reasonably smooth approximation to this. This could be crudely approximated as a cut in Galactic latitude, e.g., $|b| < 15^\circ$, as has been suggested in several white papers, but it is worth making a cut on more principled arguments.

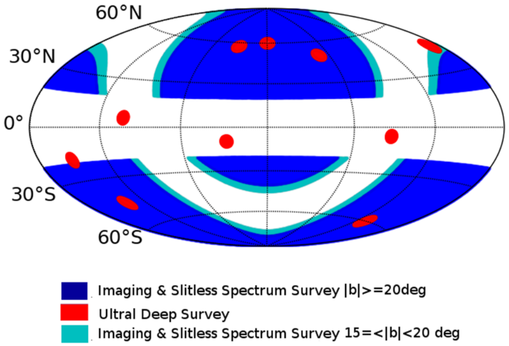
December 2018, Bern ISSI-BJ international team meeting

Summary of the presentations Cosmology with ESA Euclid* and CSS-OS**

Charling Tao
CPPM/IN2P3/CNRS
and
THCA, Tsinghua University



- Euclid/CSSOS Project office
- Euclid Transient SWG co-lead
- Void BAO
- Probe combinations



- Cf Presentations of Euclid and CSSOS by Tim SCHRABBACK* and ZHAN Hu**

Euclid/CSSOS: Cosmology Objectives

- Understanding the origins of the Universe accelerating expansion
- Derive properties and nature of Dark Energy(DE), test gravity (MG)
- Distinguish DE,MG, DM (Dark Matter) effects

- *Decisively* by:
  - Using at least 2 independent but complementary probes
  - Tracking their observational features on the
    - Geometry of the Universe with 2 main probes:

      Weak Lensing (WL), Galactic Clustering (GC)
    - Cosmic history of structure formation: WL, redshift space distortion, Clusters of galaxies

  - **Precise Control of systematics**

Weak Lensing Science

- **Cf Summaries** for CSS-OS and Euclid by ZHAN Hu and Tim SCHRABBACK
- **Magnification** Brice MENARD
- **Constraints on f(R) with peak statistics** FAN Zuhui
- **Stellar-to-halo mass ratio with DECam** SHAN HuanYuan

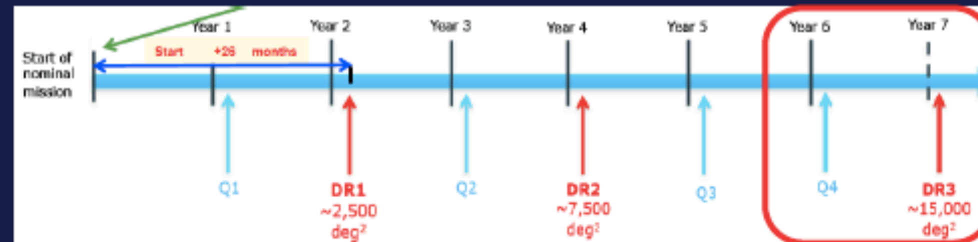
Systematics and controls of systematics

- **Photo z : dispersions and catastrophic errors***
  - Jean-Paul KNEIB, LI Ran
  - Angus WRIGHT first combined CSSOS-Euclid results for the « White book »
  - Complementary data from ground for Euclid (/CSSOS) Martin KILBINGER
  - message from Henry McCRACKEN
- **PSF** with galaxy images LI Guo Liang
- **CCD effects** on shear measurements Reiko NAKAJIMA
- Experience with **VOICE shear measurements** FU Liping
- **Shear Measurements in Fourier Space** ZHANG Jun

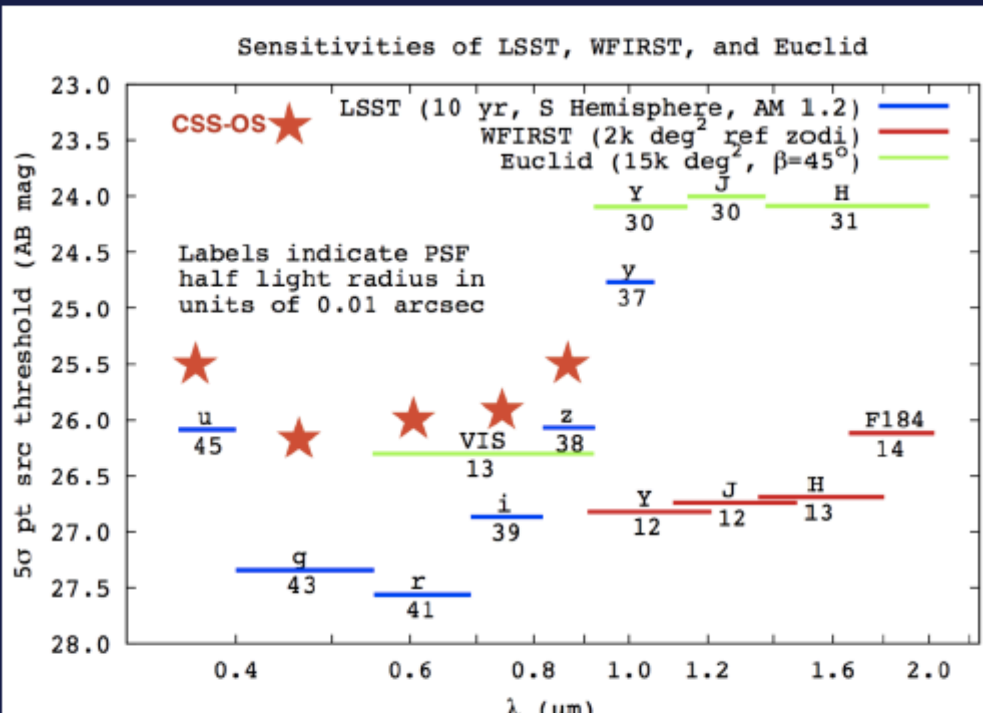
WL data analyses pipeline Samuel FARRENS
Full sky WL simulation WEI Chengliang/KANG Xi

Euclid and CSS-OS will share strong synergy in the 2025 / 2030 timescale:

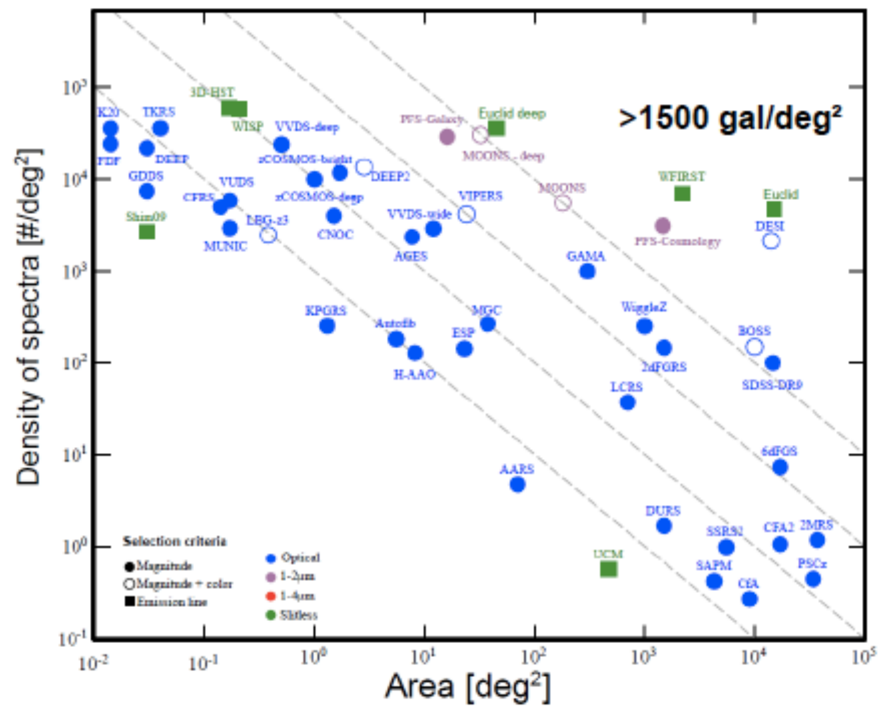
- Space Quality data over the best sky for cosmology
- Coverage of multi-wavelength data from UV to Near InfraRed
- Imaging and Spectroscopy data



Imaging



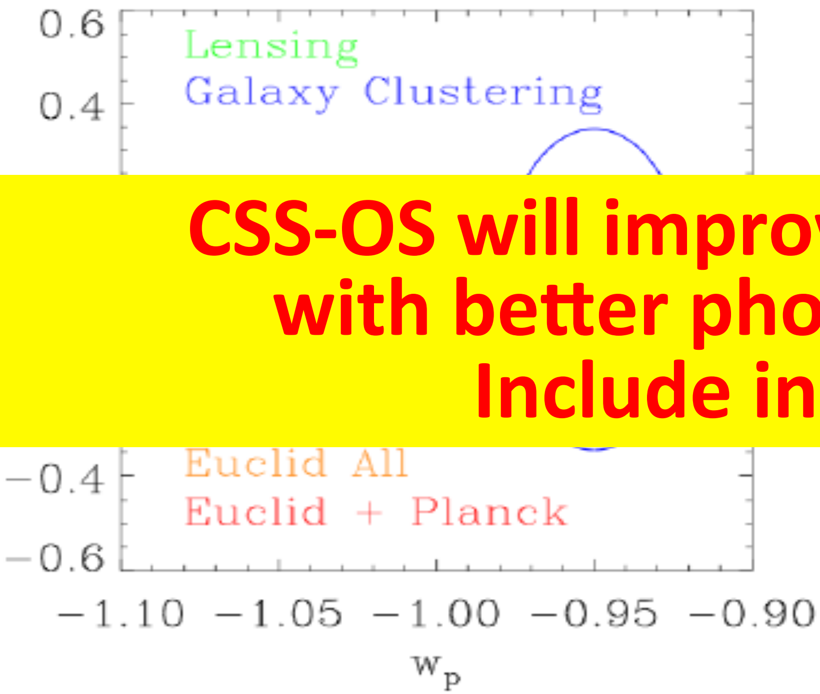
Spectroscopy



EUCLID

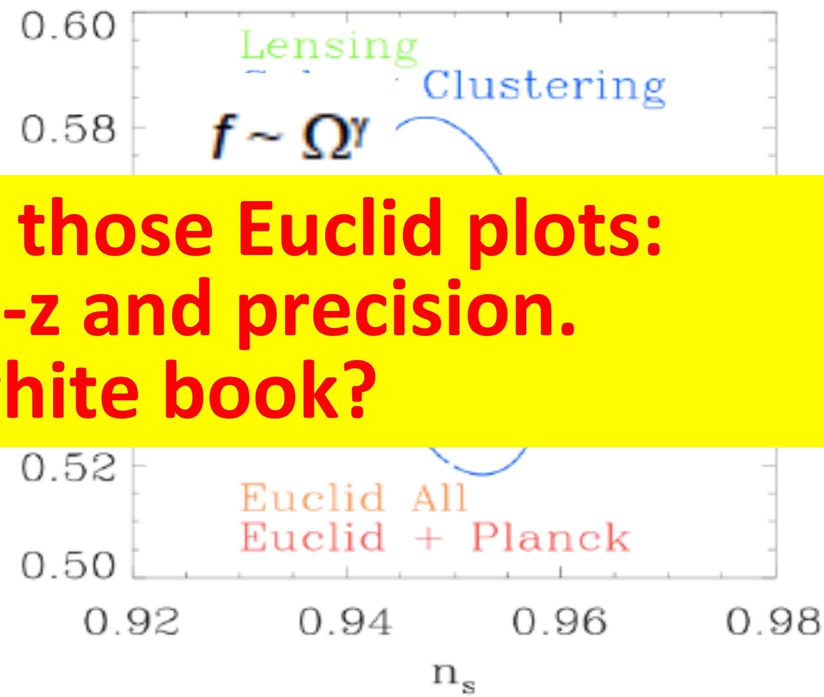
- DE equation of state:

$P/\rho = w$ and $w(a) = w_p + w_a(a_p - a)$



DE constraints from Euclid: 68% confidence contours in the (w_p, w_a).

- Growth rate of structure formation controlled by gravity:



Constraints on the γ and n_s. Errors marginalised over all other parameters.

CSS-OS will improve those Euclid plots: with better photo-z and precision. Include in white book?

Ref: Euclid RB arXiv:1110.3193

Beyond ISSI Proposal about WL,

What other topics could be included in Euclid-CSS/OS collaboration

- People time and efforts are needed
Optimization of survey strategies for best science output combining all existing surveys…

- Cosmology, my area
- Many other topics/collaborations could be considered.

Cosmology Highlights 2019

The Concordance ΛCDM model of the
Dark Universe
stands quite strong!

- DE or Cosmological constant ?

- Is there DM? What DM?

Galaxy formation in the light of massive galaxies at high redshift?

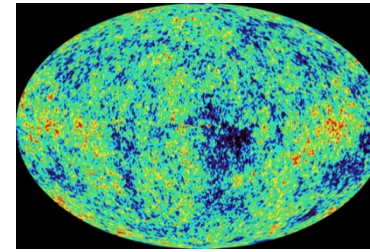
Main Cosmological Probes

CMB

Snapshot at ~400,000 yr, viewed from z=0

Angular diameter distance to z~1000

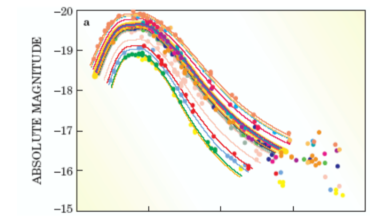
Growth rate of structure (from ISW)



Supernovae

Standard candle

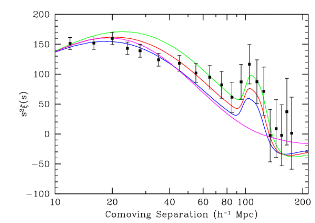
Luminosity distance



Baryon Wiggles

Standard ruler

Angular diameter distance

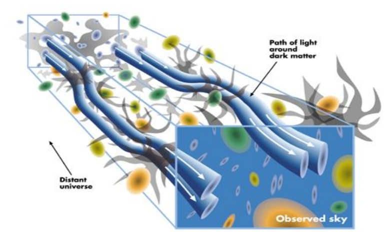


Cosmic Shear

Evolution of dark matter perturbations

Angular diameter distance

Growth rate of structure

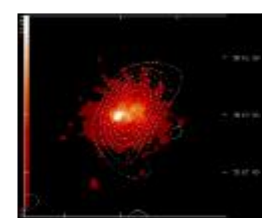


Cluster counts

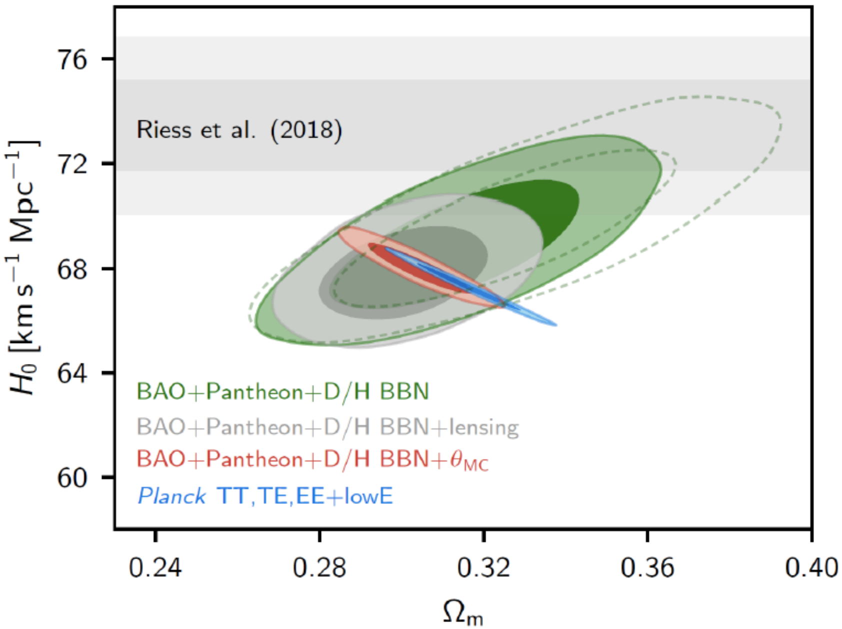
Evolution of dark matter perturbations

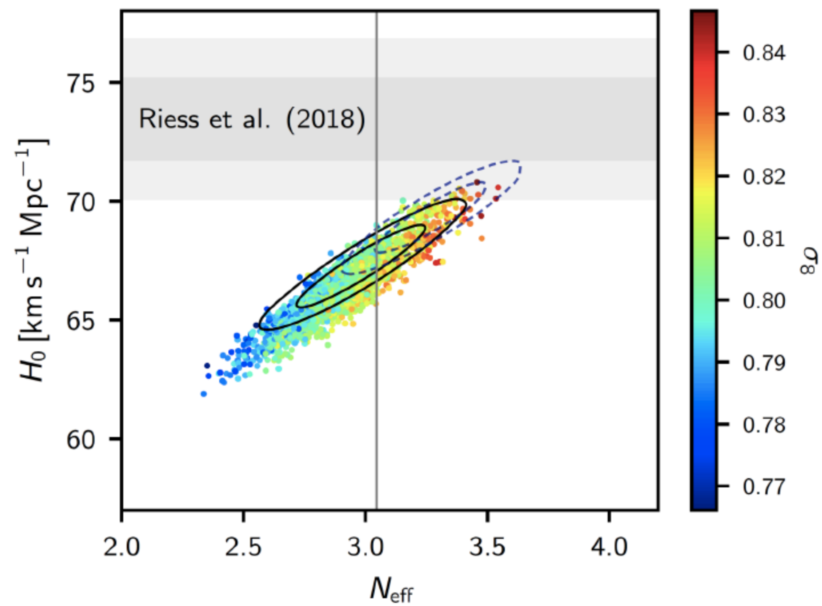
Angular diameter distance

Growth rate of structure



3.6 σ (now 5.3 σ!) tension between (Planck + ΛCDM) and SH0ES





Planck + ΛCDM : 67.36 +/- 0.54 km/s/Mpc
Riess et al. 2018: 73.52 +/- 1.62 km/s/Mpc
Riess et al. 2019: 74.03 +/- 1.42 km/s/Mpc

SH0ES 2019: Riess, Casertano, Yuan, Macri, Scolnic. arxiv 1903.07603

The trouble with H_0 … or r_s ?

Bernal, Verde, Riess. arXiv:1607.05617 JCAP 10 (2016) 019

- Measurements are combination $r_s h$,

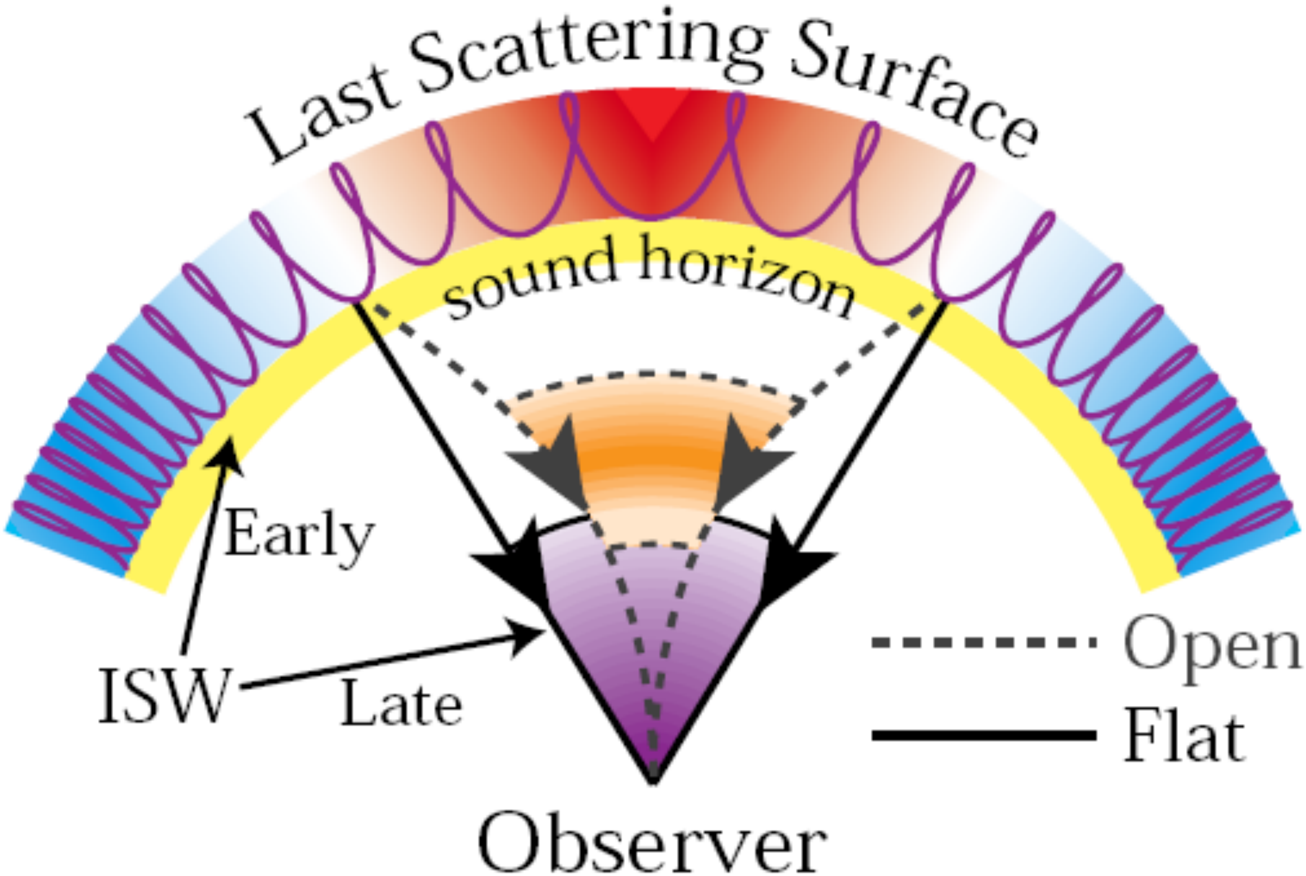
$H_0 = h \times 100$ km/s/Mpc and r_s is the sound horizon at radiation drag
(the standard ruler), constrained by CMB observations.

- r_s and H_0 absolute scales for distance measurements (anchors) at opposite ends of the observable Universe

- calibrate the cosmic distance ladder and obtain a model-independent determination of the standard ruler for acoustic scale, r_s.

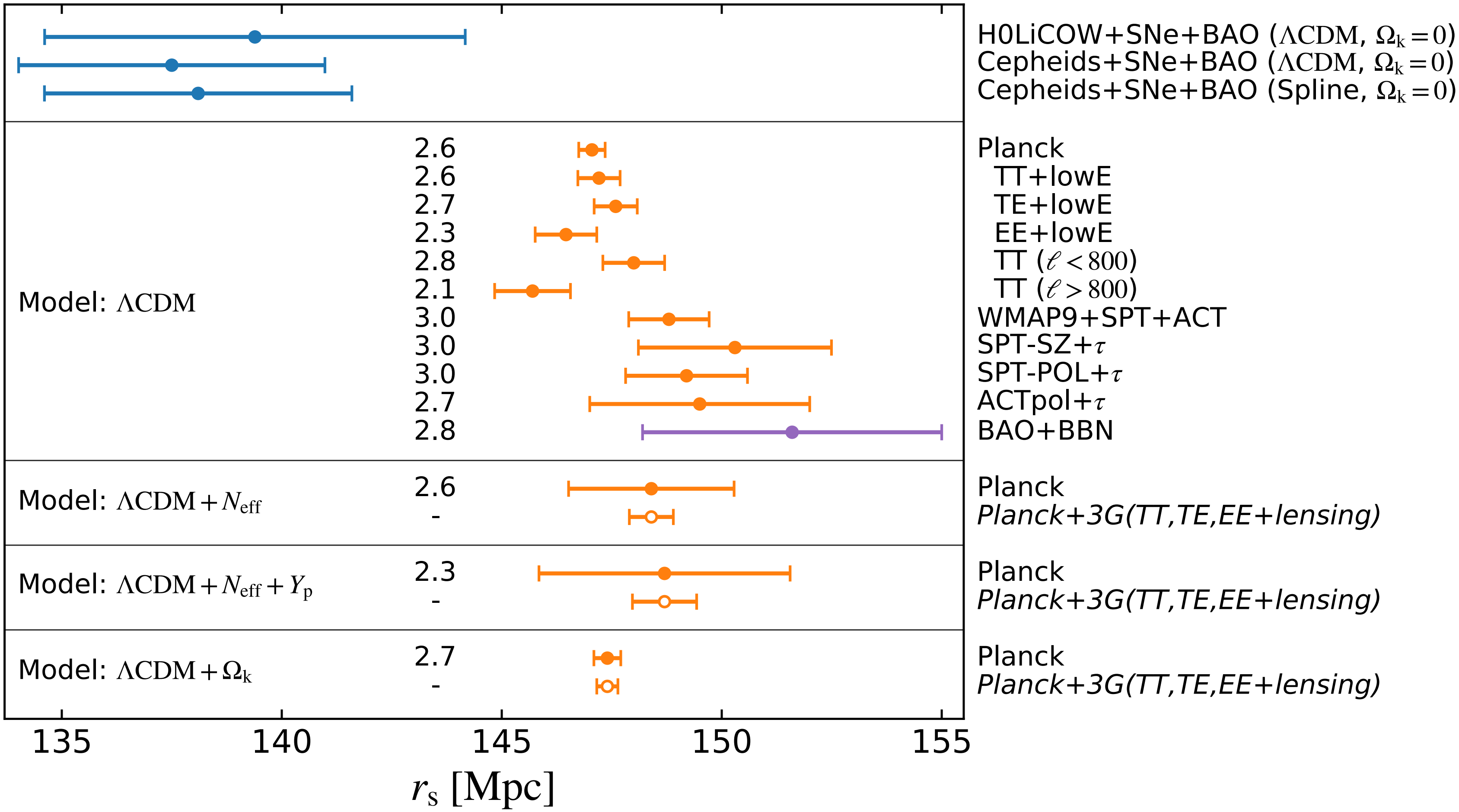
- **The tension in H_0 could reflect a mismatch between the determination of r_s and its standard CMB-inferred value.**

Scale of sound Horizon



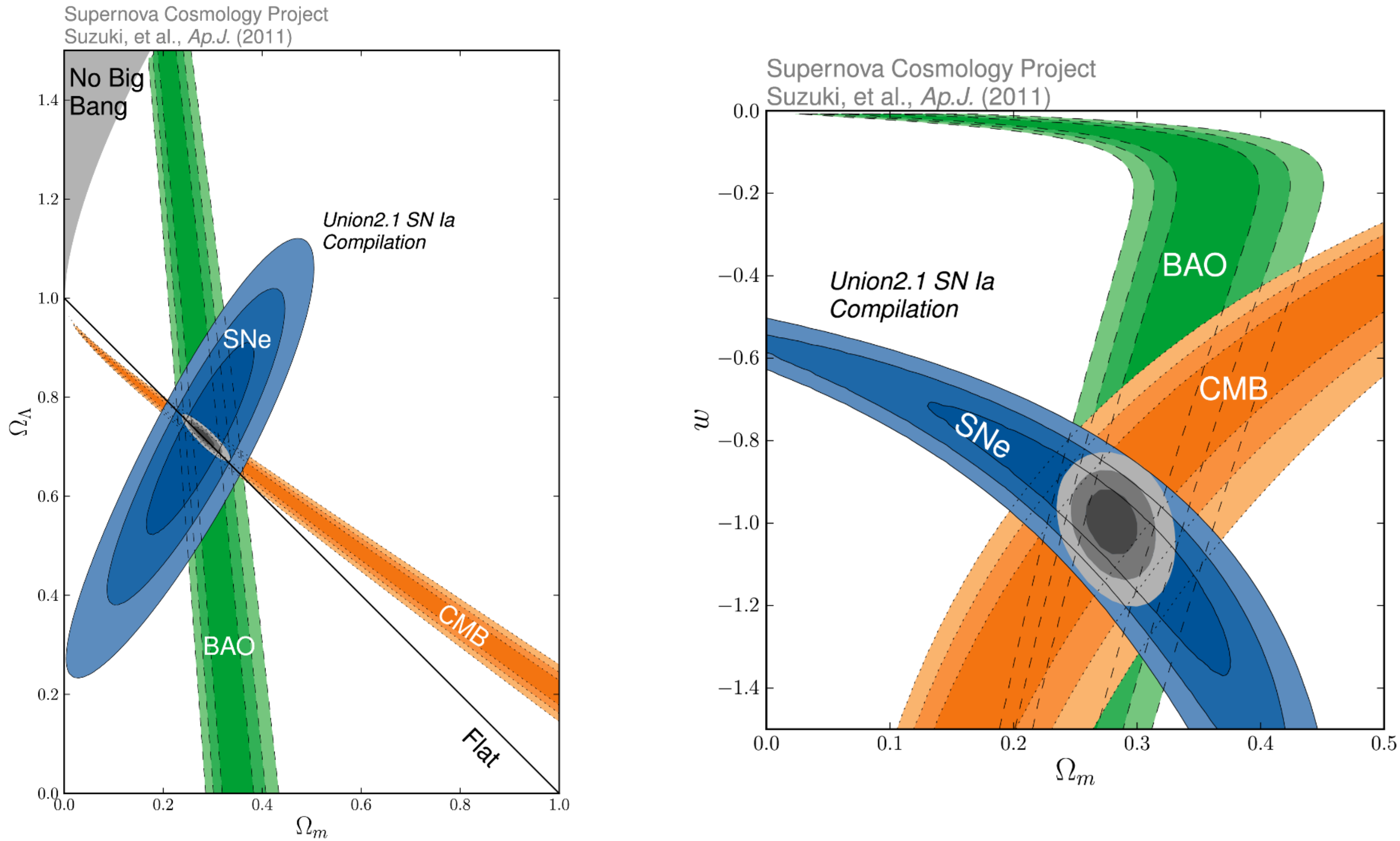
"Sounds Discordant: CLASSICAL DISTANCE LADDER & CDM-BASED DETERMINATIONS OF THE COSMOLOGICAL SOUND HORIZON »

Aylor et al. 1811.00537



➔ Modifications to cosmology at early times, before recombination, not at late times!

Combination of probes to constrain cosmological parameters



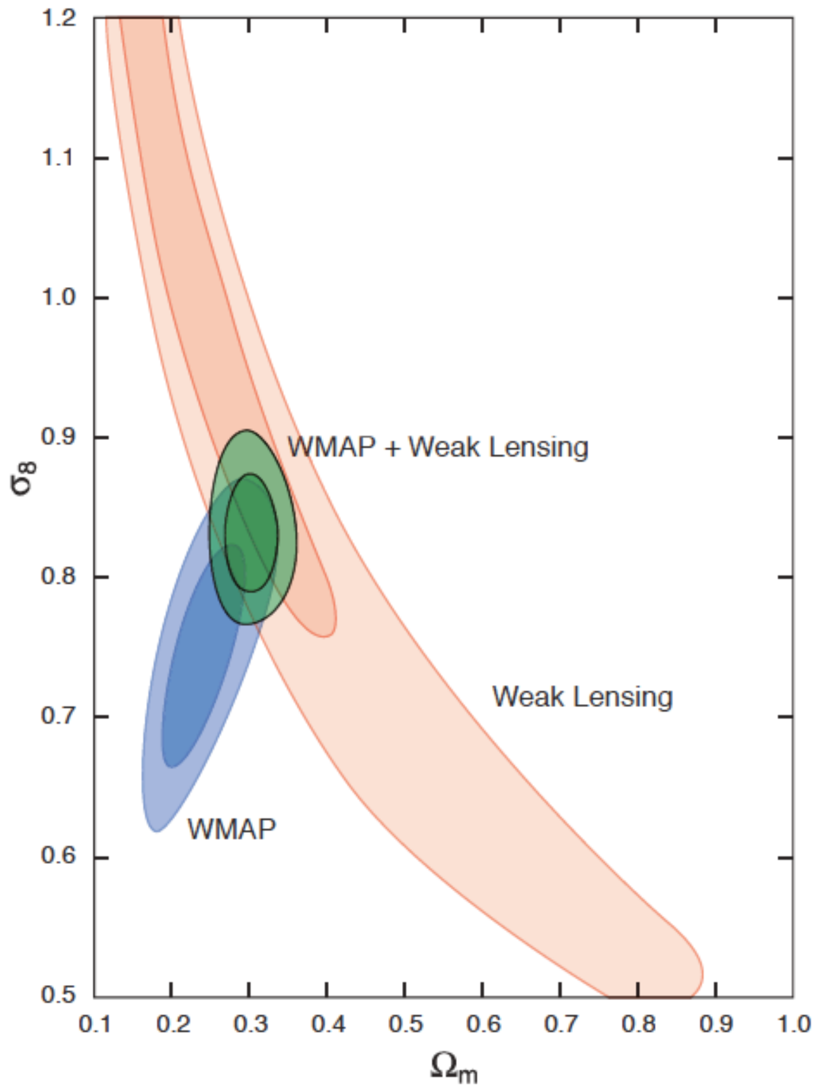
Concordance Λ−CDM model is strong!

Beware of data combinations!

Central values should be the same.

This is not always the case in the literature!

What not to do !



Spergel et al. 2007

WMAP!

2019: ΛCDM **Strong**

Scolnic et al.

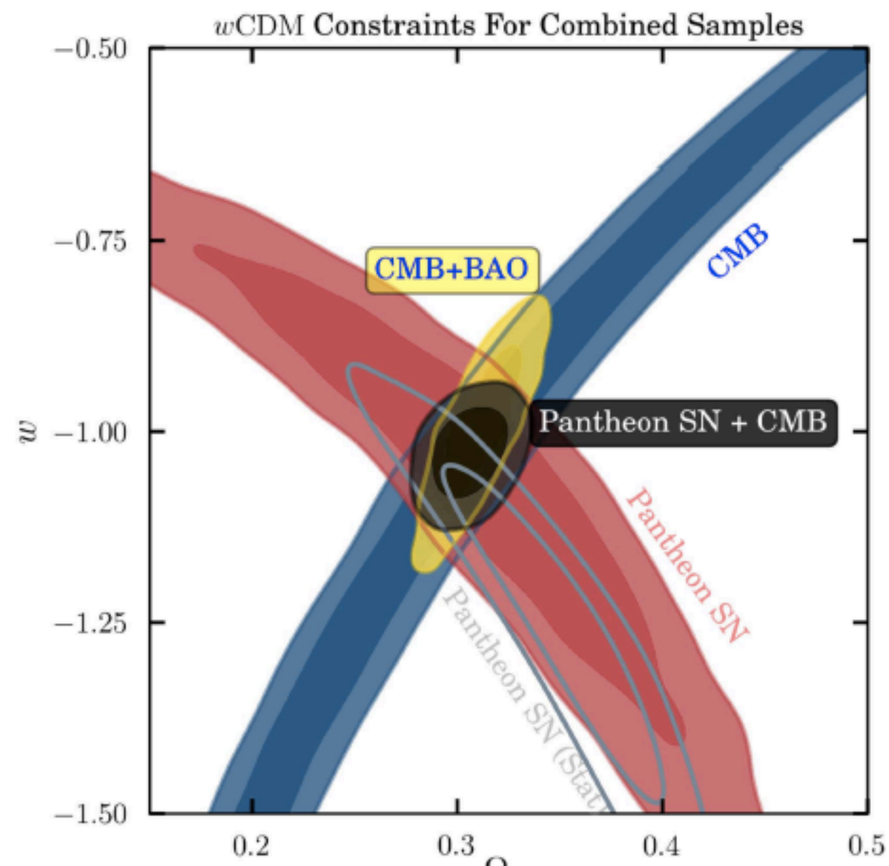
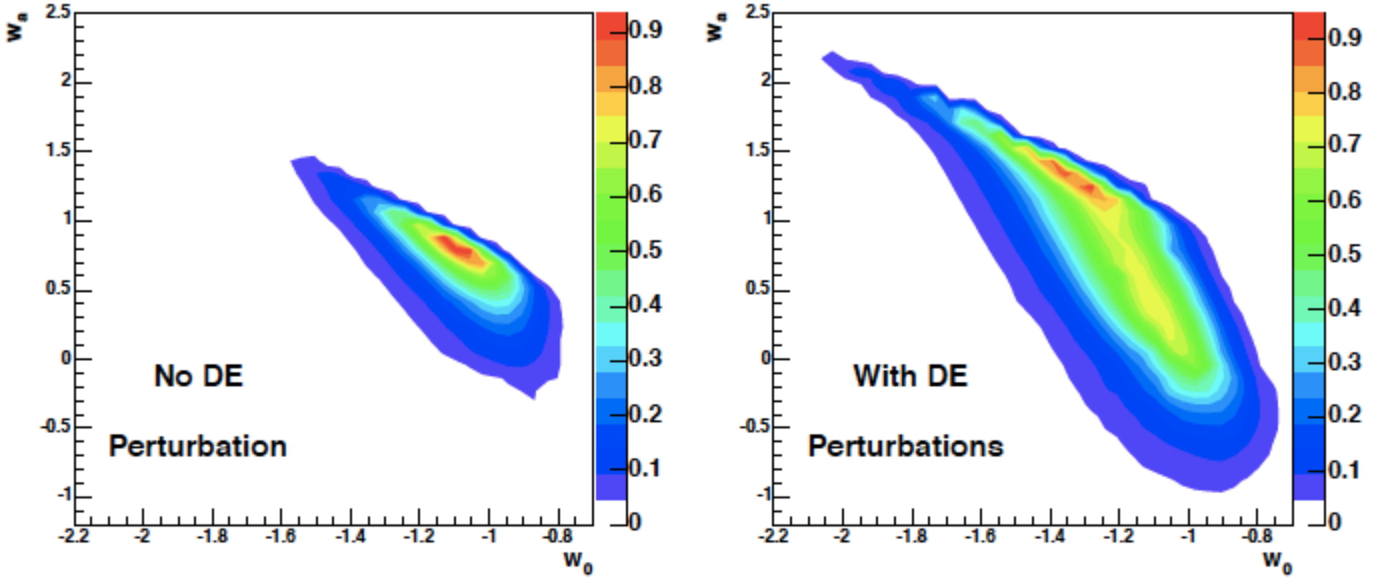


Figure 20. Confidence contours at 68% and 95% for the Ω_m and w cosmological parameters for the wCDM model. Constraints from CMB (blue),

- BUT, …
- Some tensions: H_0 tension, early massive galaxies
- We are testing only ΛCDM: error covariance matrices are computed in ΛCDM only ! So cannot exclude other models…

An example of the effect of one different extreme (?) DE model



Yèche et al. 2006. with our frequentist tool

A solution: CAVIAR vs PANDA models

Andrew Ng deeplearning.ai

PANDA: one child at a time

CAVIAR: fish many children

Move from one model (ΛCDM) to many models testing

A concept from Deep Learning requiring
new hardware, new infrastructure, new software!

Ongoing discucssions with Guo Quan + Shan HuanYuan + …

Important for all cosmology projects (LSST, SKA, Euclid, CSS-OS, …)

Available Hardware for CAVIAR system

- Dell Isilon

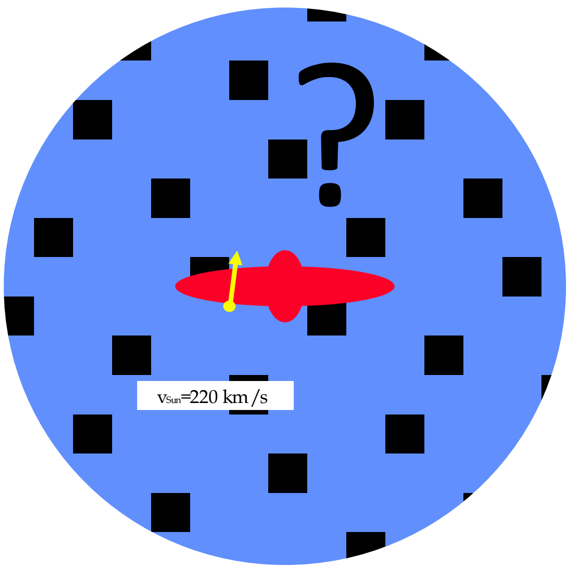
https://blog.dellemc.com/en-us/ai-deep-learning-unstructured-data-isilon/

- Huawei in 2020?

DM distribution in our Galaxy

Usual assumptions:

ρ_{DM}= 0.3 GeV/cm^3, β=10^{-3}, Maxwellian distribution of velocities, v_{rms}=270 km/s



« Simplified Model »of Matter in our Galaxy: SMMG

Used for most comparisons...

But is it the reality? Clumps? Corotation?

Galactic scale N-body simulations with Baryons

Ling+ 2009 Dark Matter Direct Detection Signals inferred from a Cosmological N-body Simulation with Baryons

➔2 DM populations : halo+disk DM
➔ only measurements can tell

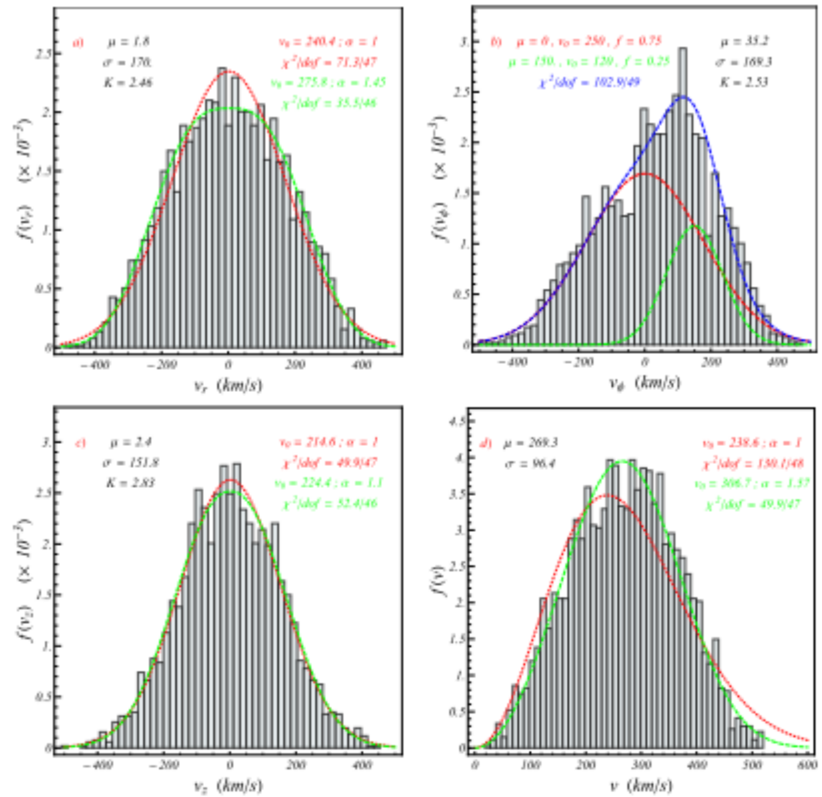


Figure 5: *Velocity distributions of dark matter particles ($N_{ring} = 2,662$) in a ring $7 < R < 9$ kpc, $|z| < 1$ kpc around the galactic plane.*
a) Radial velocity v_r, with Gaussian (red) and generalized Gaussian (green) fits (cfr. Eq. (2.1)).
b) Tangential velocity v_ϕ, with a double Gaussian fit. f indicates the fraction of each component.
c) Velocity across the galactic plane v_z, with Gaussian (red) and generalized Gaussian (green) fits (cfr. Eq. (2.1)).
d) Velocity module, with Maxwellian (red) and a generalized Maxwellian (green) fit (cfr. Eq. (2.2)). μ, σ (both in km/s) and K stand for the mean, the standard deviation and the Kurtosis parameter of the distribution. The goodness of fit is indicated by the value of the χ^2 vs. the number of degrees of freedom (dof).

Analysis of Gaia results

second release april 2018: high-precision positions, velocities, and distances for **1.3 billion stars**

1) GD-1 stream from Gaia ➔a new level of precision in simulating a stream-dark-matter encounter (A. Bonaca et al., 2019).

Need a clump of 10^7Mo!

2) Lisanti et al 2019: 2 non disk populations of stars :

i) Old, isotropic velocity distributions

ii) Young, large radial velocities from merger 7 billion years ago!

Each should have its own DM population!!!

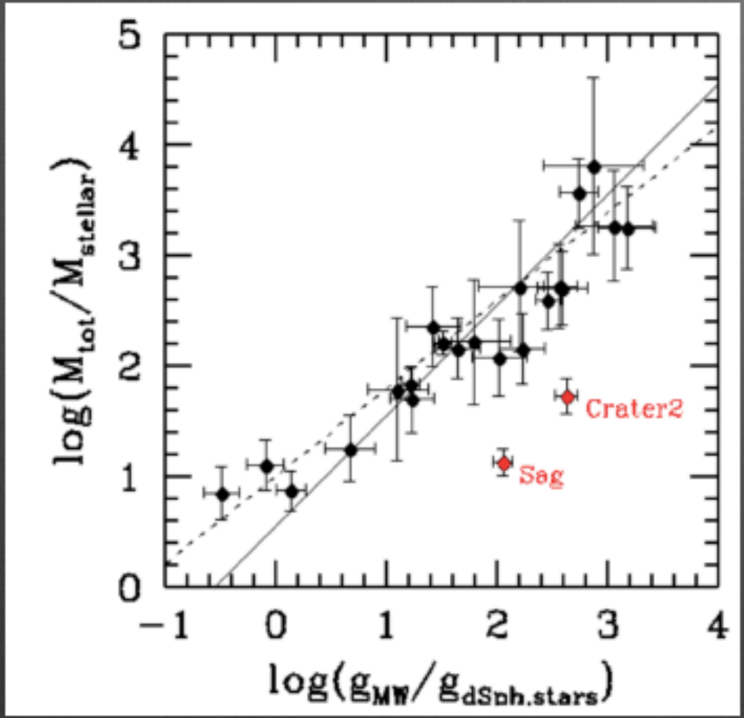
No need for DM in Dwarf galaxies ?

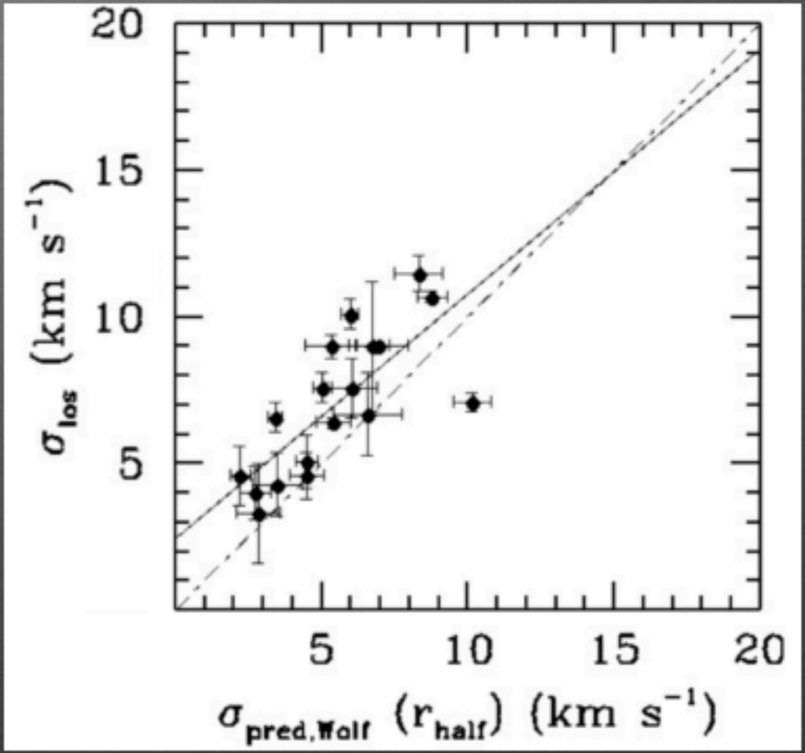
Yang Yanbin, Yunnan Sino French meeting Nov 2018

Galactic forces rule dynamics Milky Way dwarf galaxies

Yang Yanbin in Yunnan Sino french meeting Nov 2018

Hammer et al. 2018, ApJ

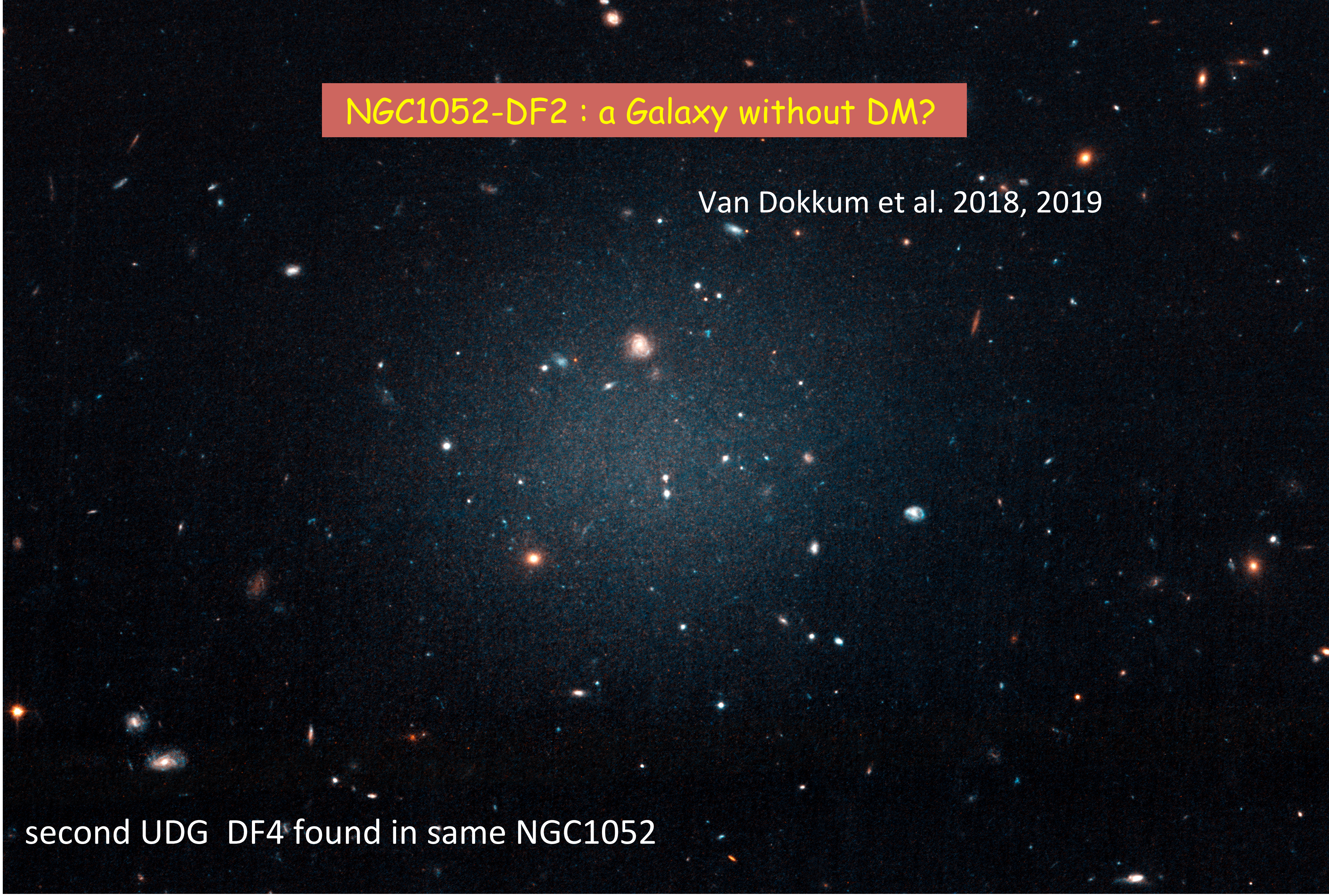




$$\sigma^2_{los,MW} = \sqrt{2}\, g_{MW}\, r_{half}$$

MW tidal shock predicts

This correlation falsifies the hypothesis of neglecting the MW impact!



➔ **Evidence for DM? (against modified gravity)**

Cosmology Highlights 2019

-DE or Cosmological constant ?

- **Planck 2018** : stable
- **SDSS BAO** (Alam et al. 2017), **RSD**
- **SN Pantheon (**Scolnic et al. 2018)
- **DES, KIDS, HSC** (Hikage et al. 2018)

- **H_0 tension** becomes **r_s tension**

Galaxy formation in the light of massive galaxies at high redshift?

- Is there DM? What DM?

- No need for DM in spheroidal dwarves: Hammer et al 2018
- Galaxy without DM van Dokkum et al 2018

➔ Argument for DM?

- SL can distinguish between WDM and CDM
- Caveat: Non-linear regions are regions of strong baryonic effects!

Galaxies…

Galaxies = Clusters of stars, but how are stars forming?
Today: Hierachical merging model with ΛCDM, bottom-up is leading model

- **The impossible Early Galaxy Problem**
- **A dominant population of optically invisible massive galaxies in the early Universe**

Oldest most distant observed galaxy: **GN-Z11** observed by CANDELS (HST) at z = 11.09 in Ursa Major, at proper distance: 32E^9 ly (9.8 E^9 parsec)

The Impossibly Early Galaxy Problem

arXiv:1506.01377 Charles L. Steinhardt, Peter Capak, Dan Masters, Josh S. Speagle

The current hierarchical merging paradigm and ΛCDM predict that the

$z \sim 4-8$ universe

the most massive galaxies are transitioning from their initial halo assembly to the later baryonic evolution seen in star-forming galaxies and quasars.

However, **no evidence of this transition** has been found in many high redshift galaxy surveys including CFHTLS, CANDELS and SPLASH, the first studies to probe the high-mass end at these redshifts.

Indeed, if halo mass to stellar mass ratios estimated at lower-redshift continue to $z \sim 6-8$, CANDELS and SPLASH report **several orders of magnitude more $M \sim 10^{12-13} M_\odot$ halos** than are possible to have formed by those redshifts.

Although known uncertainties can greatly reduce the disparity between recent observations and CDM merger simulations, even taking the most conservative view of the observations,

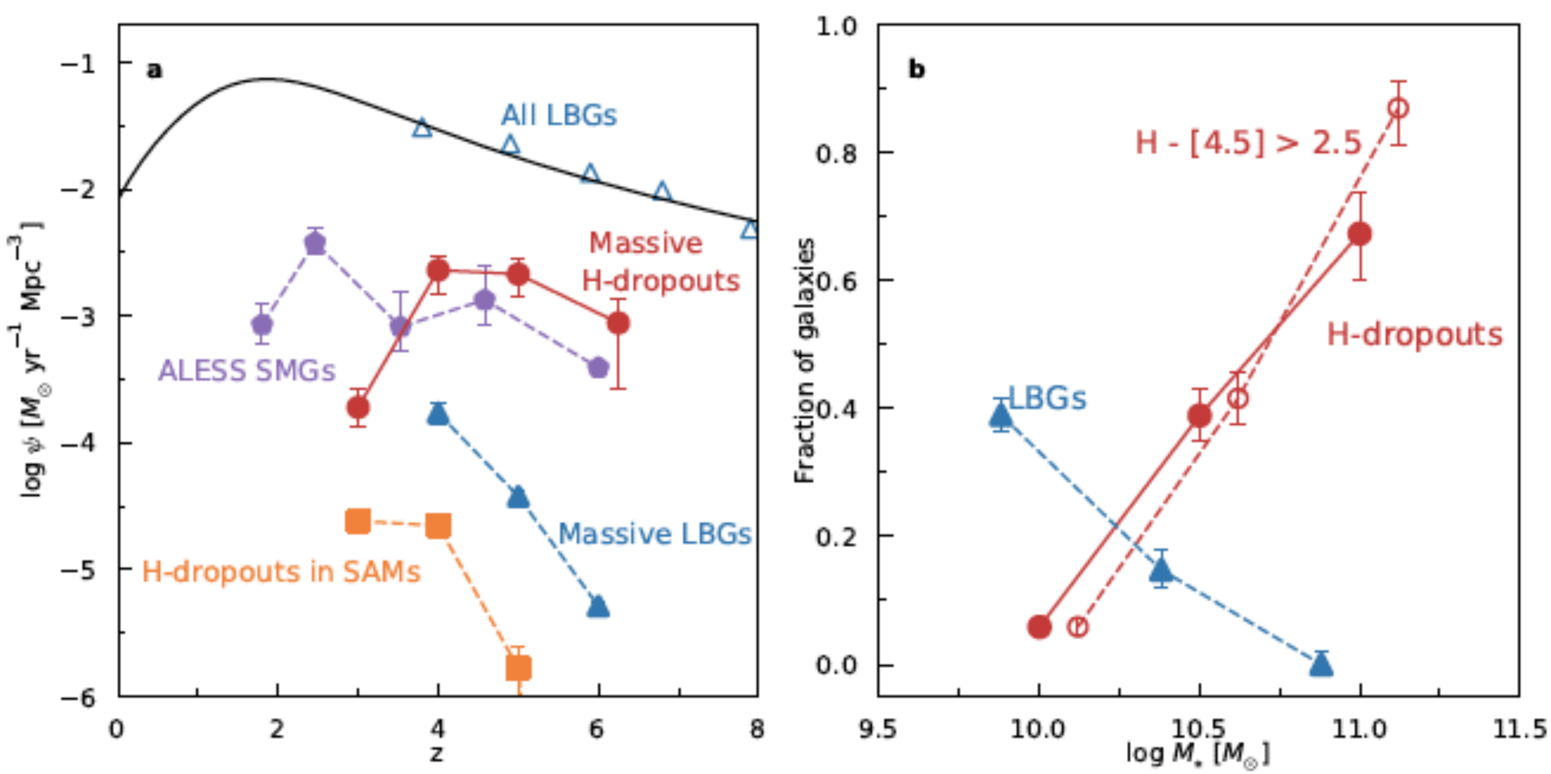
there remains considerable tension with current theory.

A dominant population of optically invisible massive galaxies in the early Universe

August 2019, Wang, Schreiber, Elbaz et al… arxiv: 1908.02372

https://www.nature.com/articles/s41586-019-1452-4

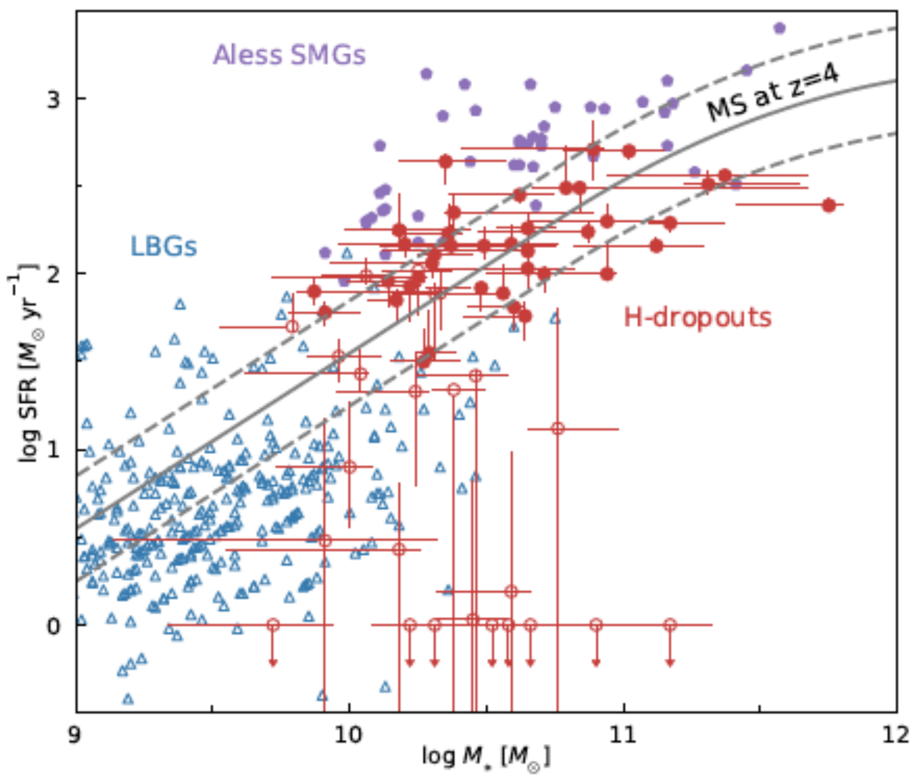
ALMA submm (870mm) detections of 39 massive star forming galaxies at z>3

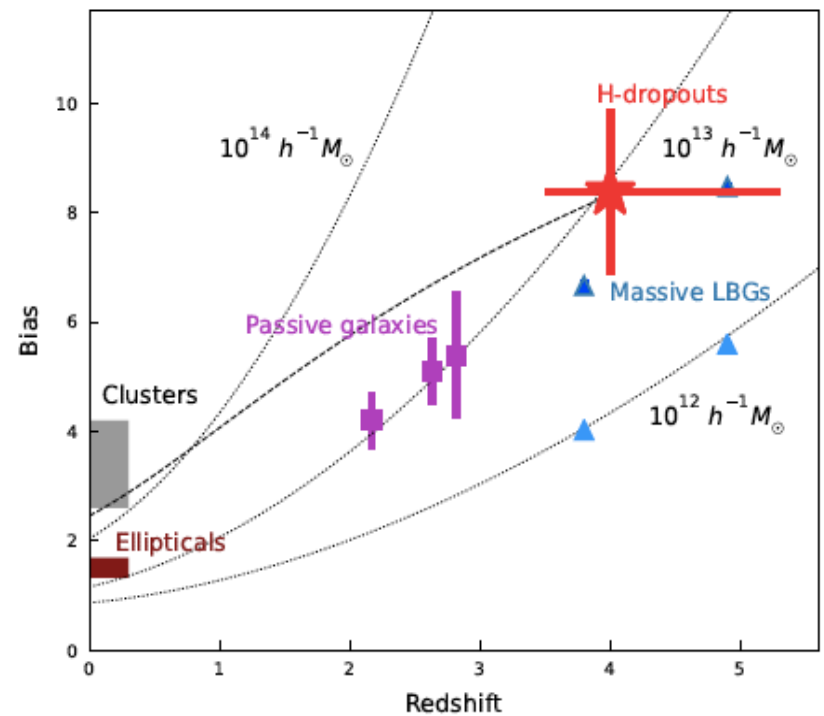


LBG= Lyman Break Galaxies + extreme Starbusts cannot explain all that is observed

H-dropouts properties ?

arxiv: 1908.02372





To follow more in the future !

- Spectroscopic follow-up of the population of H-dropouts
- Mid-infrared spectroscopy James Webb Space Telescope
- Other measurements? **SKA? Euclid? CSS-OS?**

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Looking forward to the next decade with CSS-OS/Euclid/WFIRST/LSST…!!!!

谢谢！

Thank you for your attention!

Merci!