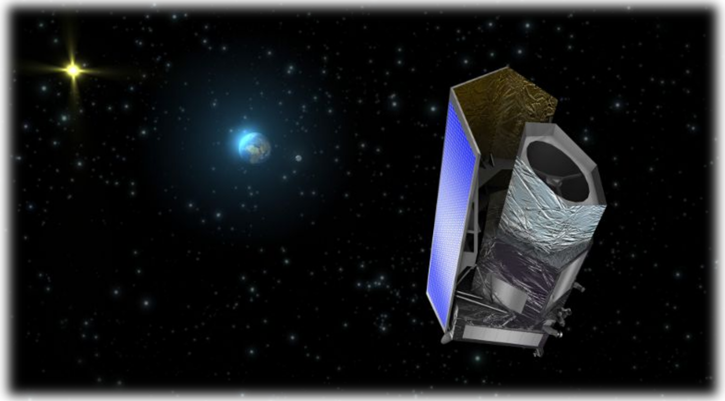
Euclid

2020-06-30 IN2P3 Scientific Council



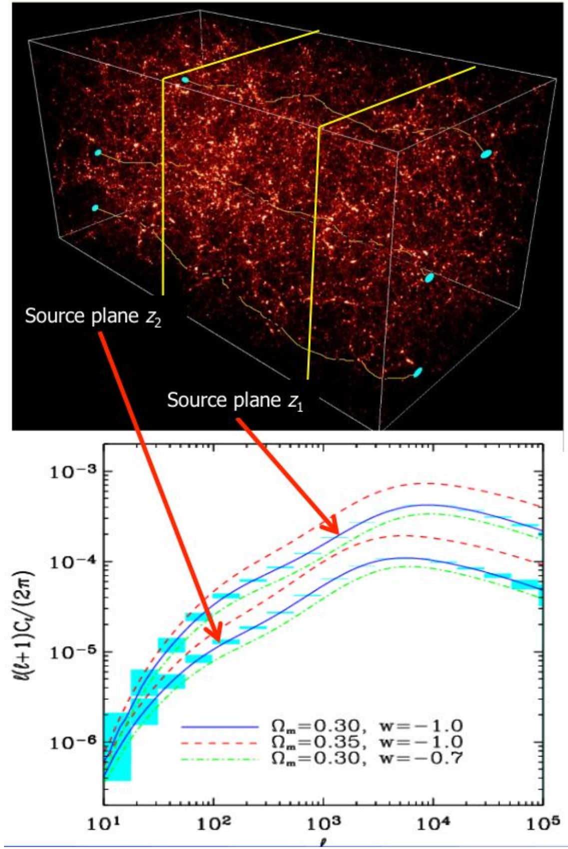
An artist's impression of (an early design of) Euclid observing from its orbit at the second Sun-Earth Lagrange point, ~$1.5 \cdot 10^6$ km beyond the Earth from the Sun

Science

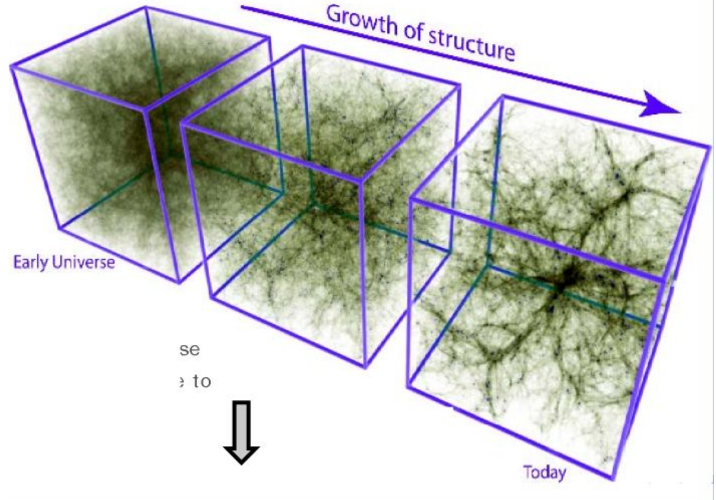
Euclid will use weak lensing and more traditional spectroscopic methods to map the sky in 3-D and thereby measure the statistics of Large-Scale Structure in the Universe.

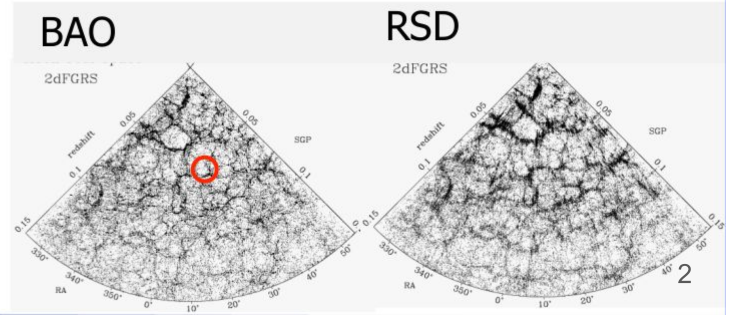
This will allow us to investigate Dark Matter, Dark Energy, cosmology and gravity.

Weak Lensing (WL), Clusters of Galaxy (Strong and Weak lensing CG) probes: Cosmic shear over 0.2<z<2 : 1.5 billion galaxies shapes, shear and phot-z (u,g, r,i,z,Y,J,H) with 0.05 (1+z) accuracy over 15,000 deg^2 (Wide) and 40 deg^2 (Deep)



Galaxy Clustering (GC); Baryon Acoustic Oscillations (BAO), Redshift-Space Distortion (RSD) probes: 3-D positions of galaxies over 0.9<z<1.8: about 30 million spectroscopic redshifts with 0.001 (1+z) accuracy over 15,000 deg^2 (Wide) and 40 deg^2 (Deep)

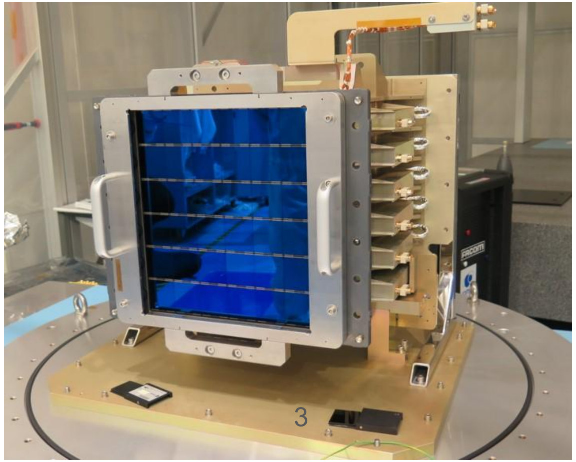




The Two Instruments

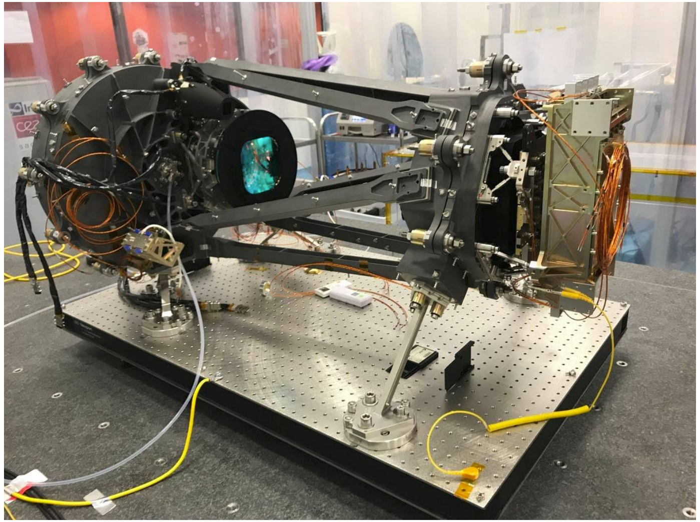
The VIS focal plane is composed of a matrix of 6×6 4096×4132 (~600 Mpix) 12 micron pixel CCDs covering a field of view of 0.57 deg^2 with 0.1 arc-second pixels. It will reach a signal-to-noise ratio of at least 10 for 1.5 billion galaxies down to magnitude 24.5 in 4000 seconds.

The NISP is composed of an array of 4×4 2040×2040 (~70 Mpix) 18-micron pixel detectors covering a field of view of 0.53 deg^2 shared with VIS, with 0.3 arc-second pixels. The NISP spectrograph will provide redshift of about 30 million emission line galaxies over the redshift range 0.7 to 2.0 in about 4000 s



Euclid/VIS
Optical
(550-900 nm)

Euclid/NISP
Near IR (0.9-1.8 μm)
Spectro-Photometer



Calendar

Launch: 2022 (ish)

Intermediate, Readiness & Commissioning Reviews to come

6¼ years of survey

3 “quick” releases & 3 “regular” deliveries

Further data analysis will certainly take us past 2030.

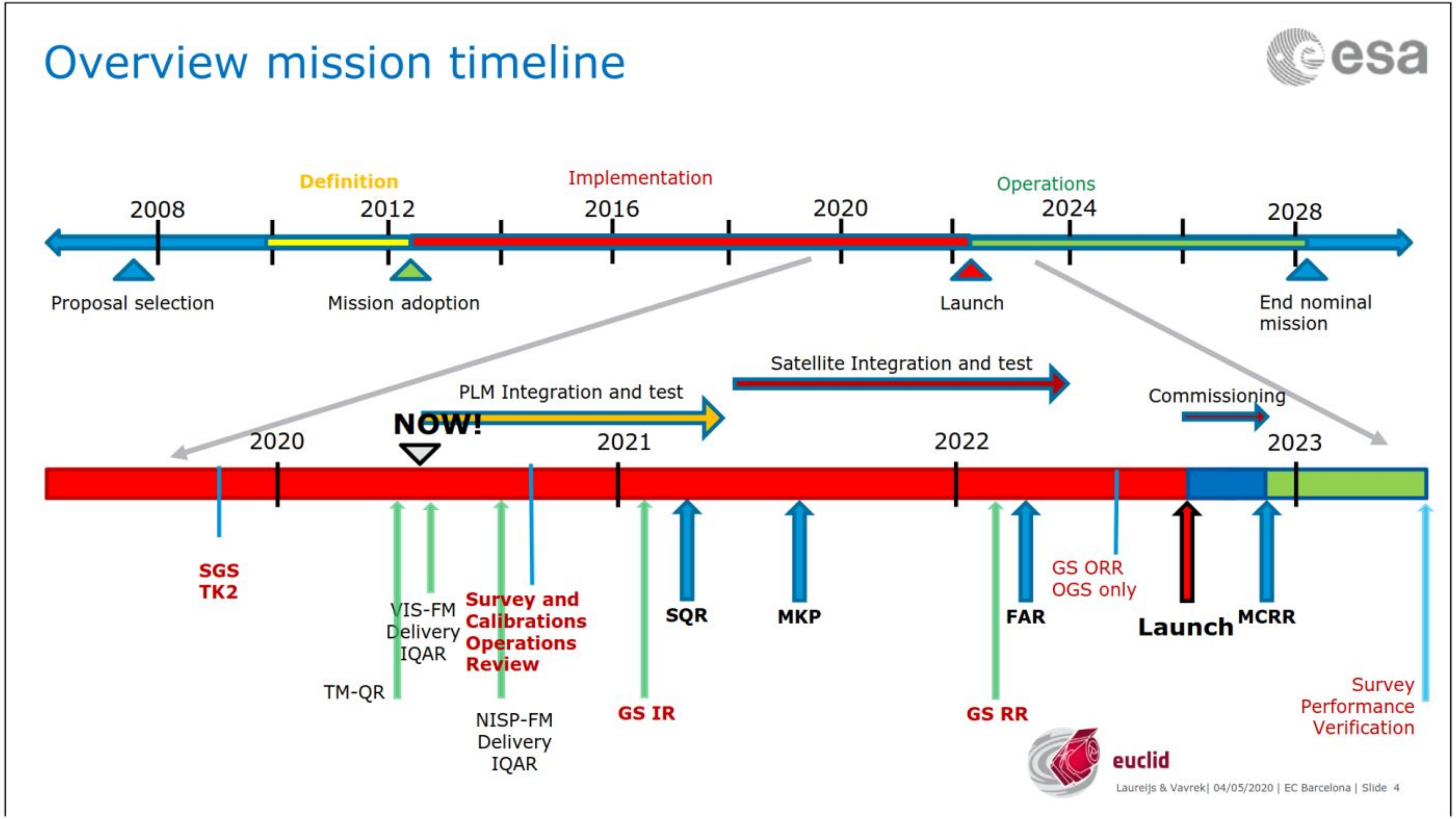


Figure 2: Overview of current mission time-line from the Project Scientist at the May, 2020 Euclid ConsortiumMeeting.

IN2P3 in the Organization

- ~1500 members
- >900 researchers
- >200 astrophysics, cosmology, theoretical physics, high energy, particle physics and space science laboratories
- 16 countries

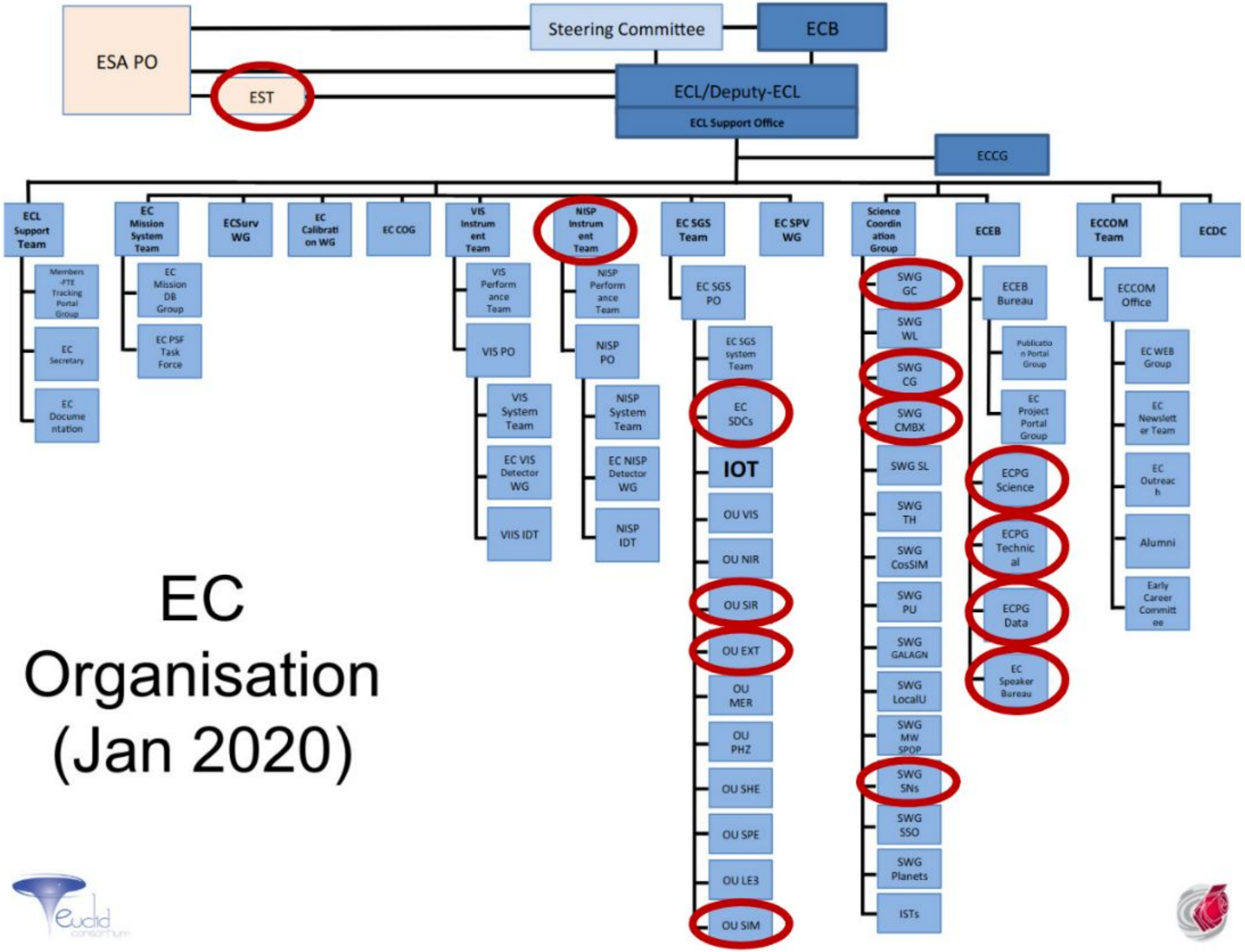


Figure 3: Euclid Consortium organization chart as of January, 2020. We have highlighted those parts to which the IN2P3 contributes regularly.

Hardware Delivery and Characterization

- CPPM, IP2I, & LPSC contributed to the NISP detector characterization
- CPPM & IP2I contributed to the NISP instrument-level validation and performance tests.
  - The instrument's optics are excellent, which promises high-quality science images.
- CPPM will engage in PLM-level tests to verify NISP's optical stability once the PLM optics (the dichroic and the primary & secondary mirrors) are inserted into NISP's optical path.

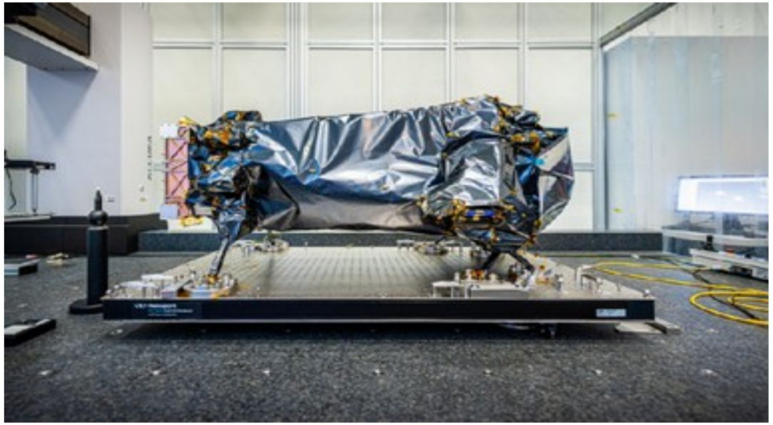
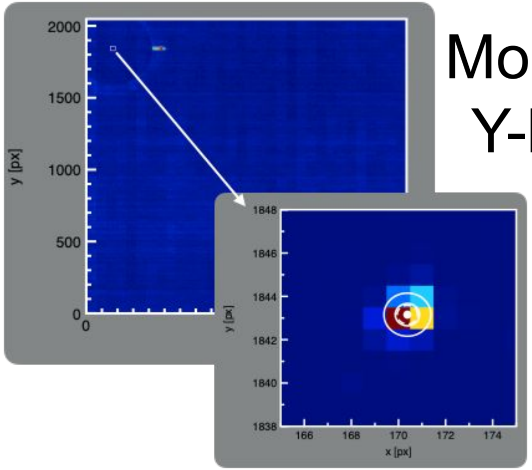


Figure 4: The NISP instrument was recently delivered to the European Space Agency.



Monochromatic Y-band source of 1000 nm PSF

Computing

The CC-IN2P3 will be the the production environment for the Euclid/France Science Data Center, and as such will develop the processing for French-led ‘OU’s and will provide approximately ¼ of all data processing for the Euclid pipeline products.

CODEEN: The IN2P3 (APC) has the responsibility for the “SDC-DEV”, the development platform, for the entire Euclid community.

France leads the VIS, SPE and LE3 “Organizational Units”, is co-Lead of SIR and was co-lead of SIM until the end of 2018, which means that the SDC-France at CC is:

- The main center for data reduction and for pipeline preparation for VIS, SPE & LE3.
- The second center for SIM (with SDC-ES) and recently for SIR. SIM is a particular case, because we started the deployment, integration & production of simulations well before other processing functions.

Software

- CPPM & CC-IN2P3 are responsible for coordination of the deployment, integration and production of Euclid simulations at the French part of the Euclid Science Data Center (SDC-Fr)
- CPPM/CC-IN2P3 & APC are responsible for the deployment, integration & production of Euclid simulations (SC3, SC456, SC7 et SC8) in general
- The IN2P3 develops two of the major Euclid simulators:
  - Rubin/LSST - APC
  - NISP Spectroscopy - CPPM

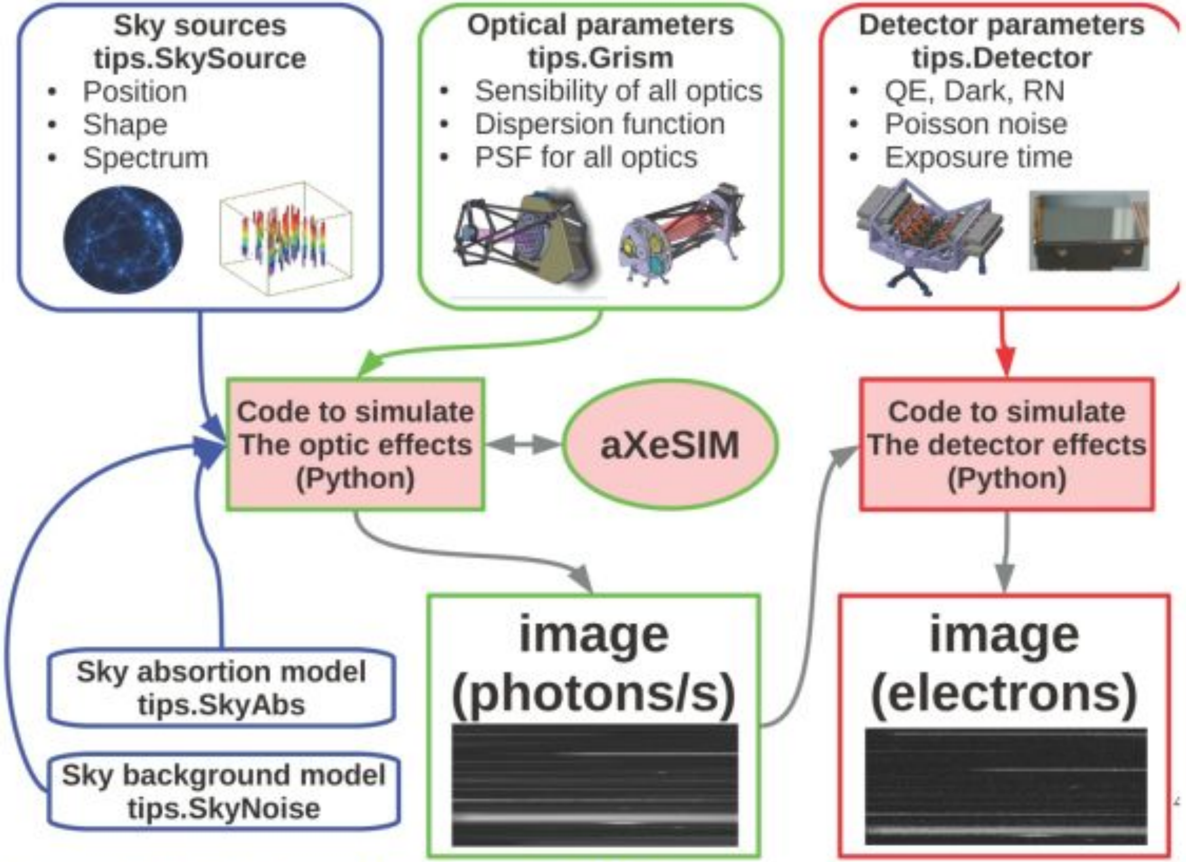


Figure 6: Schematic view of TIPS.

Human Resources

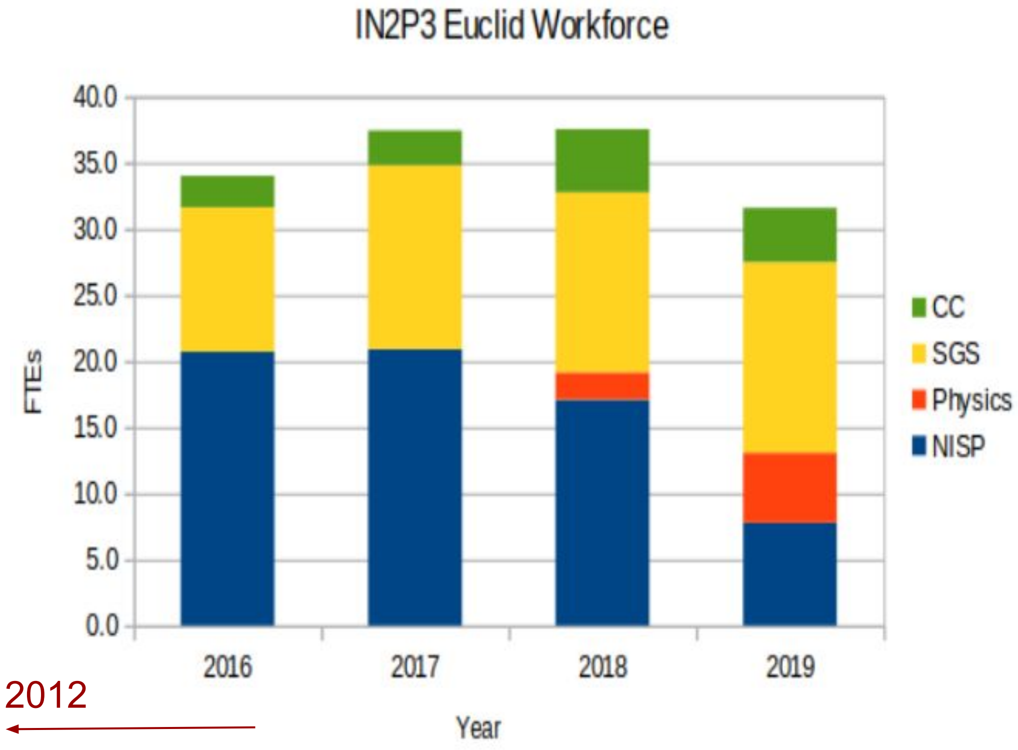
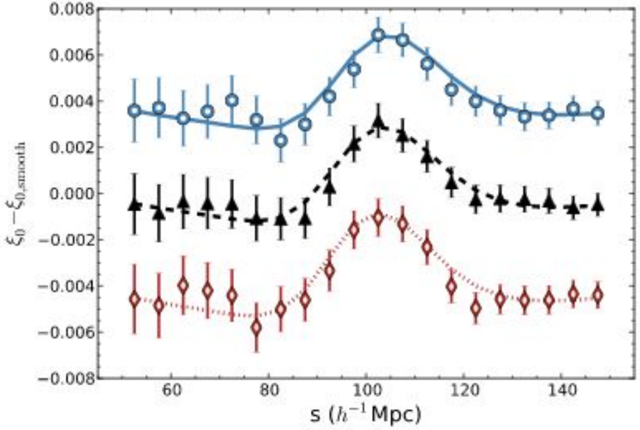


Figure 9: Chart of data from the previous Table.

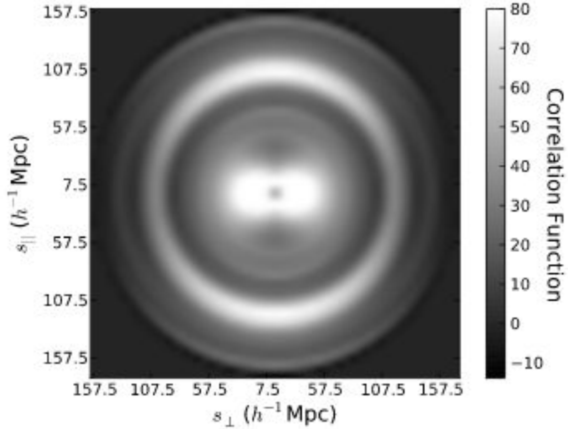
Lab	Total FTE Euclid <2020	Total FTE SWG <2020
APC	34.8	3.2
CC-IN2P3	11.6	
CPPM	78.3	3.8
IP2I	33.7	0.2
LPSC	4.0	

Table 2: A snapshot of IN2P3 human resources dedicated to Euclid to this point.

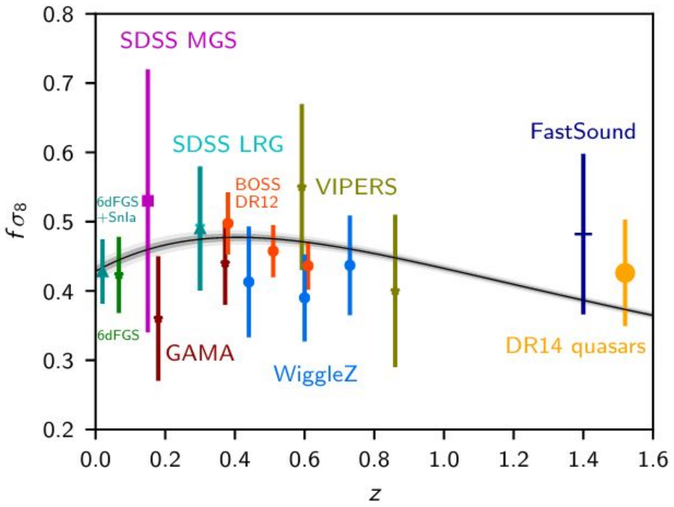
Cosmology with Galaxy Clustering



Baryon Acoustic Oscillation (BAO) imprint a characteristic scale detectable in the clustering of galaxies. This scale gives a measure of H(z) and D_A(z).



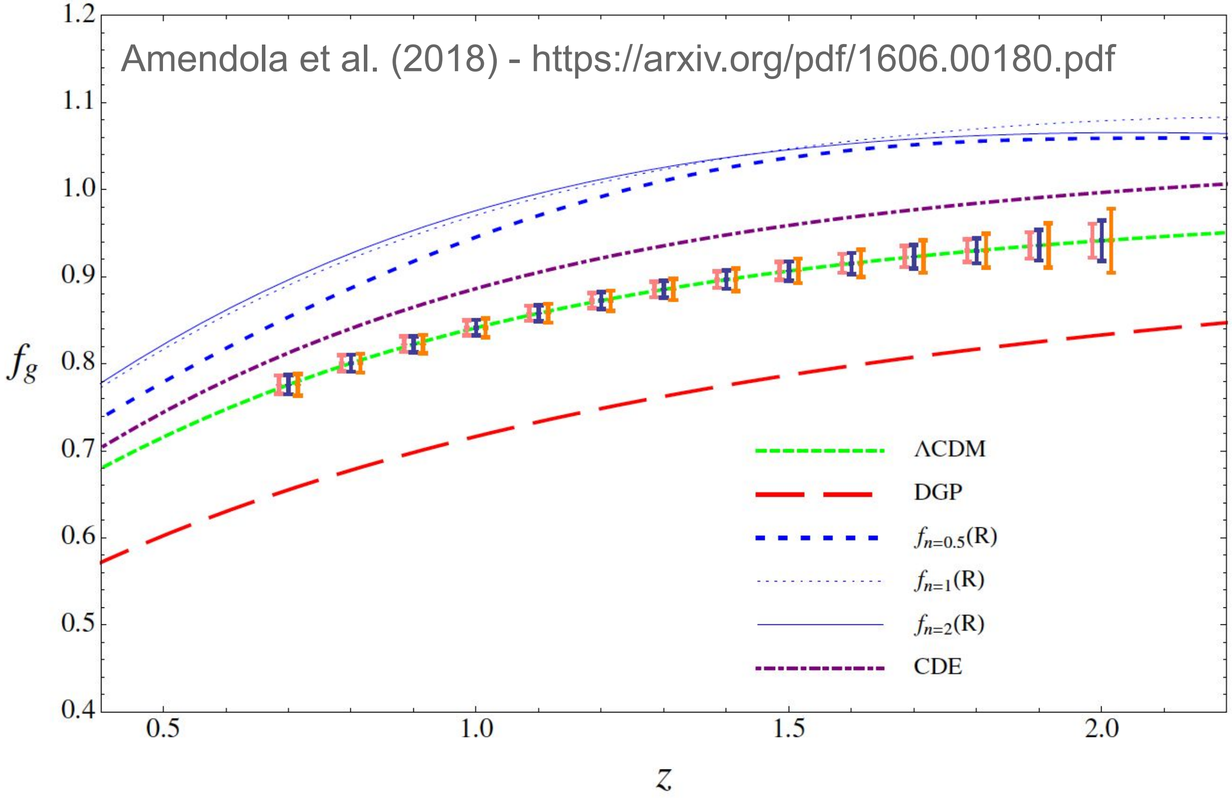
Distortions induced by peculiar velocities give rise to Redshift Space Distortions (RSD). Using anisotropic clustering of the density field, these distortions can be used to constrain the growth rate of structure.



Growth Rate Constraints -- Planck Collaboration (2018)

BOSS DR12 data -- Alam, et al. (2017)

Expected Euclid Constraints on the Growth Factor



Expected constraints with 50 million galaxies from Euclid

Different models for Dark Energy will couple to matter differently and change the Growth Factor, f_g.

Euclid should be able to measure this and distinguish between different forms of Dark Energy.

Galaxy Cluster Science

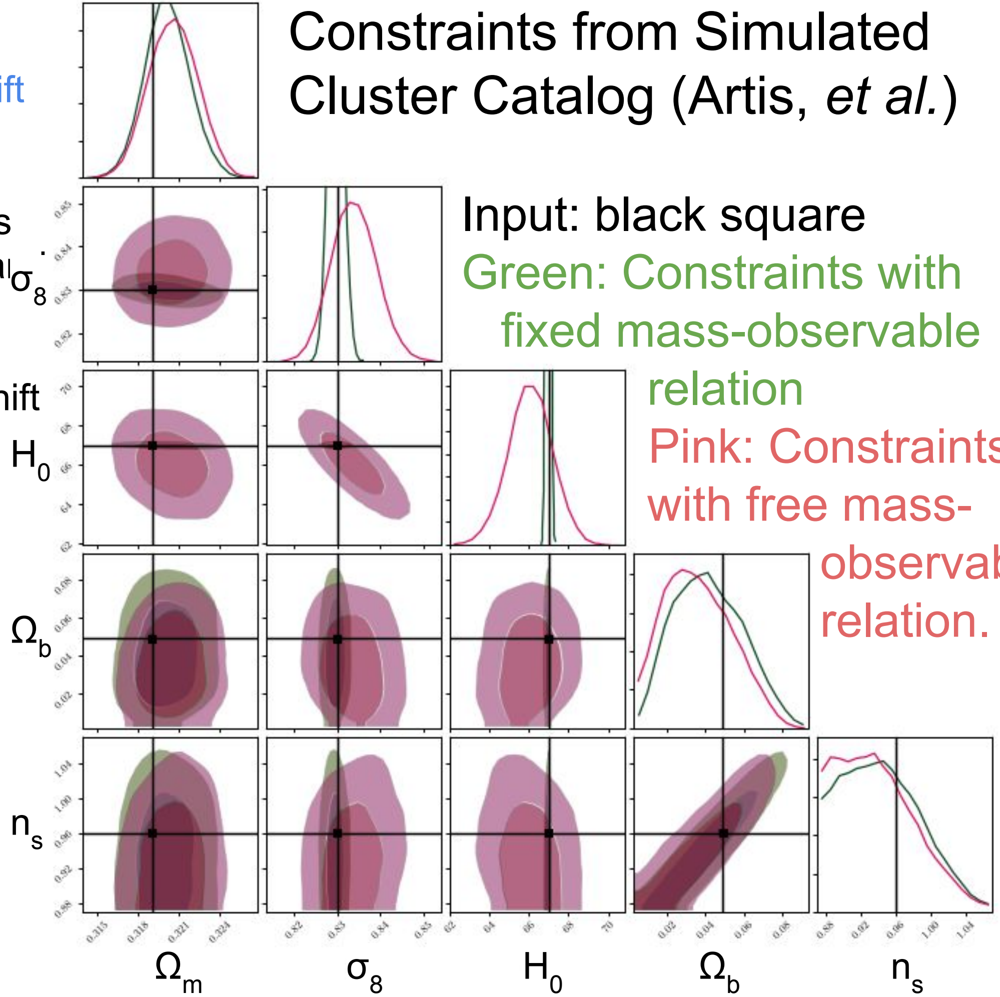
Cluster abundance and its evolution with redshift is a highly sensitive probe of dark energy

As the most massive collapsed objects, clusters are exquisitely sensitive to the expansion rate a modified gravity.

Euclid will detect ~100,000 clusters out to redshift z~2, the most extensive cluster catalog ever constructed.

The IN2P3 (APC & LPSC) is involved in every key aspect of cluster cosmology:

- Cluster selection function
- Cluster mass measurements with weak lensing and CMB lensing
- Likelihood function
- Cluster spatial correlation function
- Mass function calibration
- Follow-up at other wavelengths (e.g., SZ effect)



Constraints from Simulated Cluster Catalog (Artis, *et al.*)

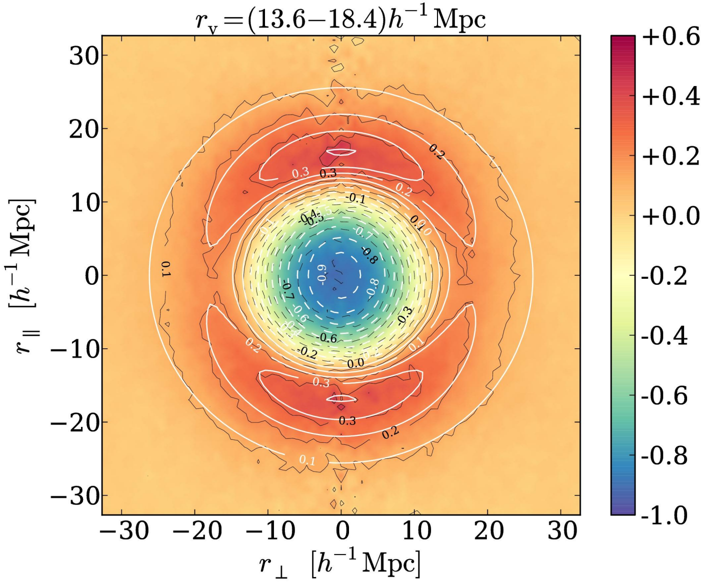
Input: black square

Green: Constraints with fixed mass-observable relation

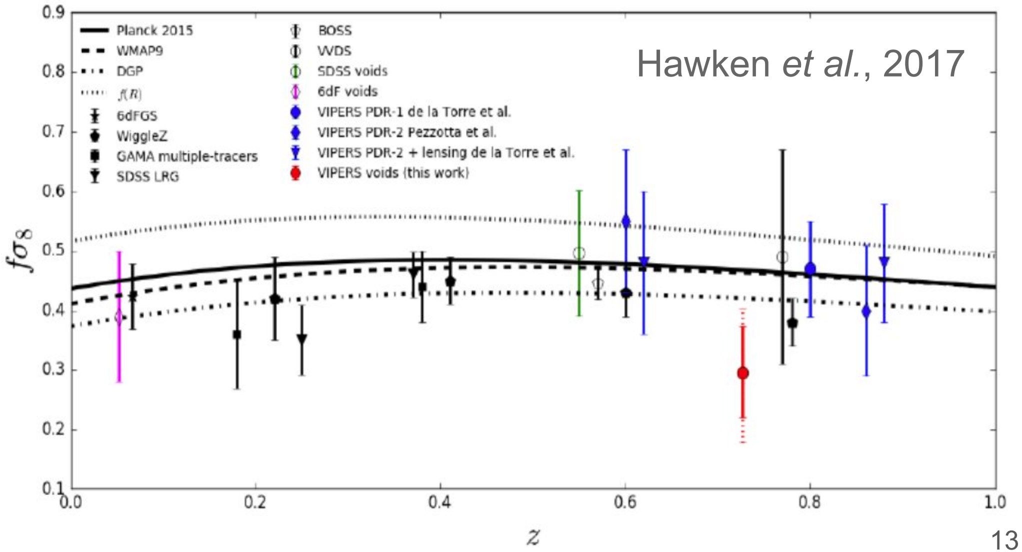
Pink: Constraints with free mass-observable relation.

Probing the Growth Rate of Structure using RSD Around Voids

Cosmic Voids are large, underdense regions that account for about 80% of the volume of the Universe. As they are nearly devoid of matter, voids are anticipated to be promising objects to test gravity.



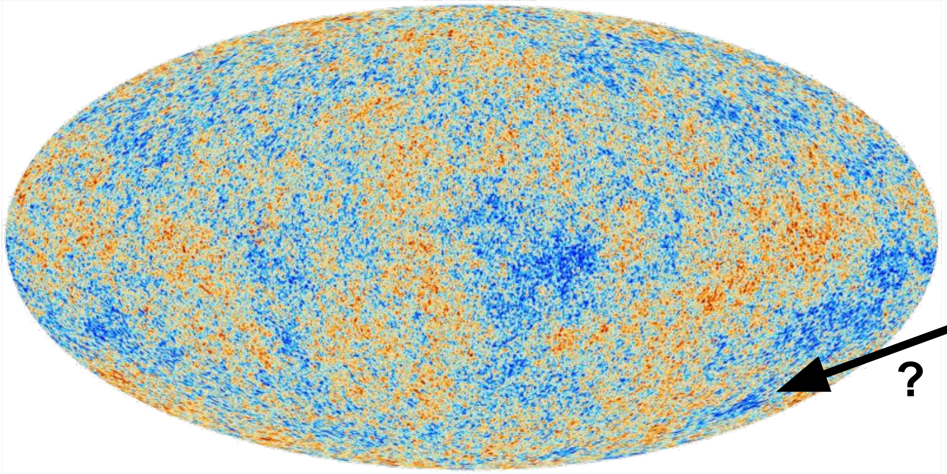
Hamaus *et al.*, 2015



Hawken *et al.*, 2017

Velocity Fields & CMB Features

Peculiar velocity fields (obtained through RSD) are direct probes of $f \cdot \sigma_8$ (a measure of the growth of structure) and the expansion rate. They can be used to define large scale structures dynamically: basins of attraction and their converses. These basins of attraction are dynamic definitions of large scale structure that can be studied for profile evolution in Euclid, growth factor, and more. IN2P3 Euclid members have coded a methodology that allows us to partition coherent volumes in the Universe. Once some LSS is dynamically defined in the Euclid survey, we will look for cross-correlation with CMB features



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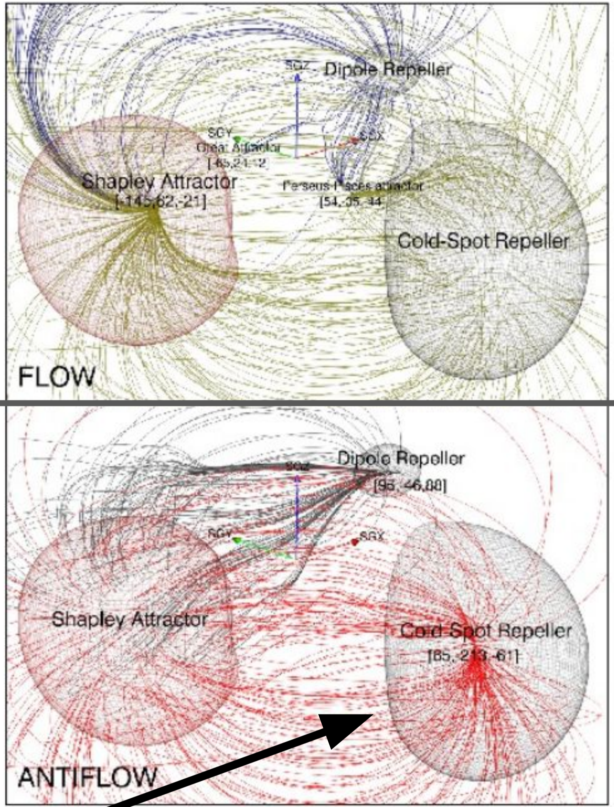
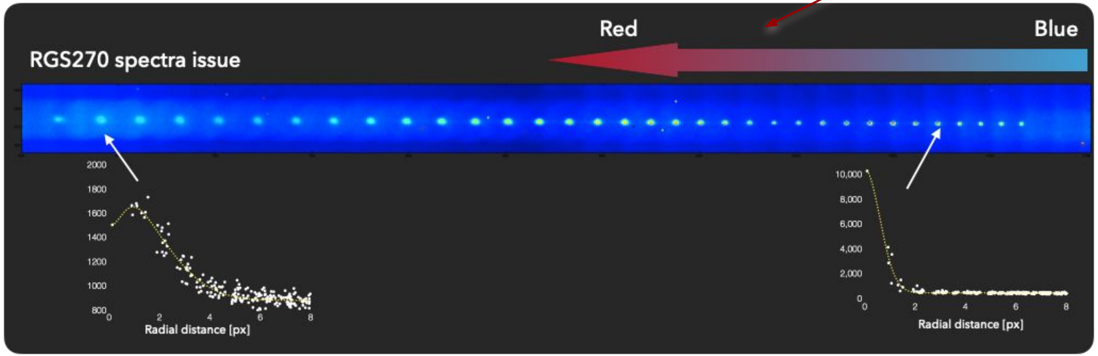


Fig. 1.— Dominant attractors and repellers in the nearby universe. In the top panel flow streamlines are seeded in the Dipole and Cold Spot repellers, flows respectively blue and green, and converge predominantly onto the Shapley and Perseus-Pisces attractors. In the bottom panel anti-flow streamlines are seeded in the Shapley attractor, with flows in red and black that travel to the Cold Spot and Dipole repellers respectively. Our home is located by the red, green, blue arrows of length 10,000 km s^{-1} directed along the supergalactic SGX, SGY, SGZ axes. The locations of the attractors and repellers lie at the local extrema of the potential. The surfaces that represent the attractors and voids are at symmetric values of the potential field of ±580. The positions are in supergalactic coordinates and are expressed in units of 100 km s^{-1}.

Courtois et al. 2017

Strengths, Weaknesses, Opportunities & Threats

- Strengths
  - In-depth understanding of NISP and its data (redshift) & Euclid software in general
  - Abundant experience with previous and concurrent cosmological experiments
- Weaknesses
  - Lack of commissioning and Performance Verification visibility
  - Relative Pipeline vs Science Working Group representation
  - Lack of connection with Roman (WFIRST)
  - Lack of connection with SPHEREx
- Opportunities
  - Synergy with Rubin (LSST)
  - Synergy with DESI
  - Synergy with Simons Observatory
  - Synergy with NIKA2
- Threats
  - Dichroic
  - Launch uncertainties
  - Grism RGS270 non-conformity
  - Loss of Expertise



Thank You

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Olivier Le Fèvre

> ***Cartographier l'Univers, c'est une manière d'approcher nos origines. Les progrès fascinants de notre connaissance dans le domaine de l'évolution des galaxies et de la structure de l'Univers au cours de ces dix dernières années vont sans aucun doute se poursuivre dans les années qui viennent avec les moyens considérables qui sont mis en jeu. . . . Mon souhait le plus cher est que les jeunes générations attrapent aussi le virus de la science qui m'a contaminé quand j'avais 15ans, et se penchent à leur tour sur les questions les plus profondes qui sont devant nous.***
>
> — Olivier Le Fèvre

OLF nous a quittés le 25 juin 2020