

A classical statue of Euclid, an ancient Greek mathematician, is shown from the waist up, leaning forward and holding a compass. He is dressed in a traditional red and yellow robe. The background features a dark, star-filled space with a grid of galaxies, symbolizing the universe he studied.

# Euclid

Y. Mellier

On behalf of the Consortium Euclid

# Euclid objectives

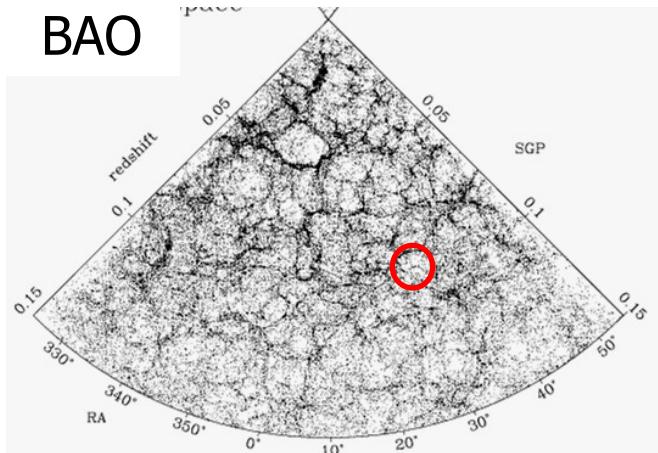
- Understand the origin of the Universe's accelerating expansion
  - Probe the properties and nature of dark energy, dark matter, gravity → Distinguish their effects by:
    - Using at least 2 independent complementary probes (5 probes)
    - Tracking their observational signatures on the
      - geometry of the universe: Weak Lensing (WL) and Galaxy Clustering (GC)
      - cosmic history of structure formation: WL, Redshift-Space Distortion (RSD), clusters of galaxies (CL)
    - Controlling systematic residuals to an unprecedented level of accuracy.
  - Maximise the Legacy value of the Euclid mission/data sets

# Euclid primary probes

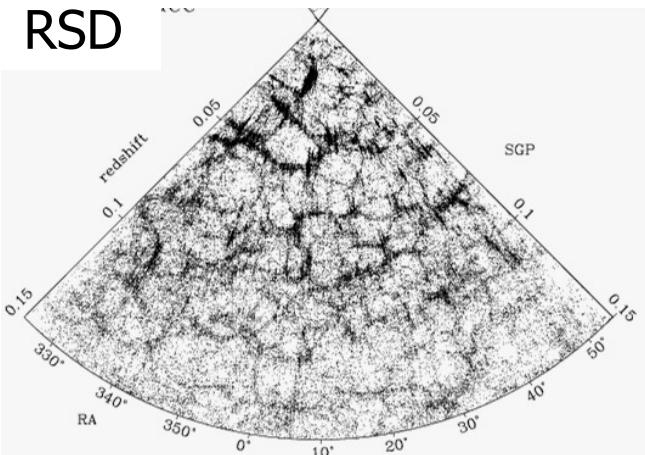
## BAO, RSD and WL over 15,000 deg<sup>2</sup>

50 million galaxies with redshifts

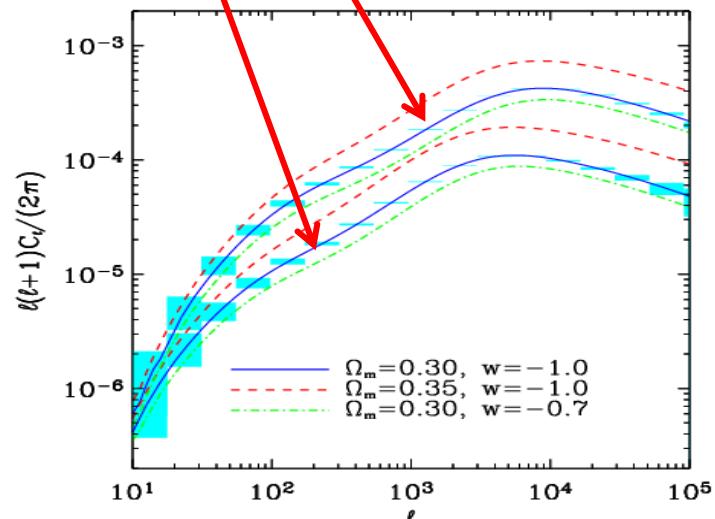
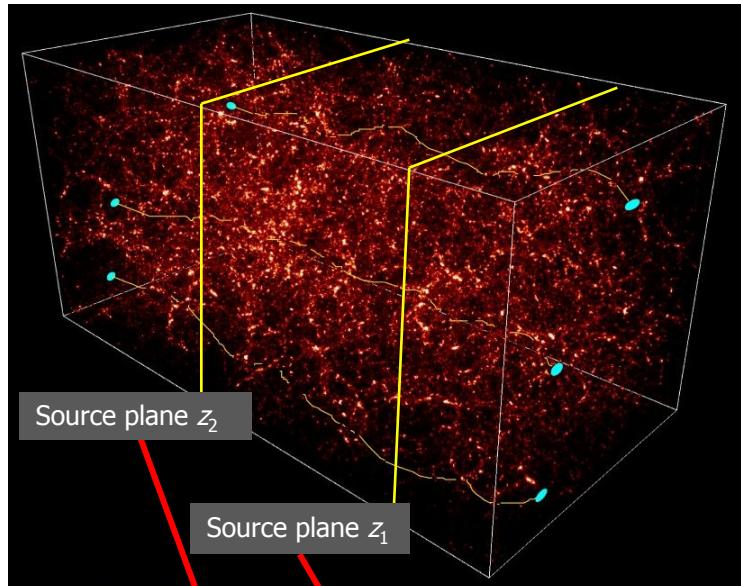
BAO



RSD



1.5 billion sources with shapes, 10 slices



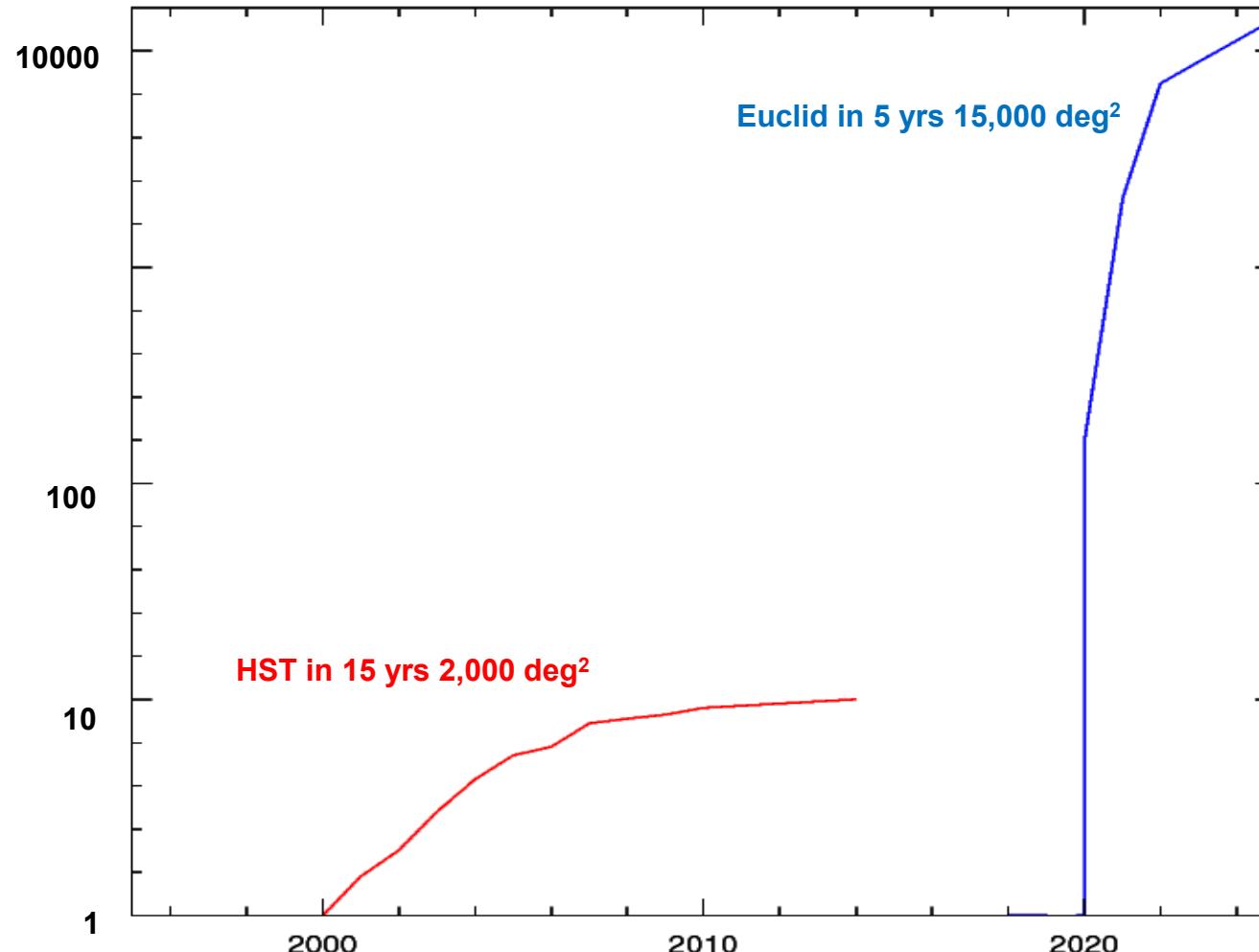
# Forecasts for the primary cosmology programme

|                           | Modified Gravity | Dark Matter         | Initial Conditions | Dark Energy   |               |  |
|---------------------------|------------------|---------------------|--------------------|---------------|---------------|--|
| Parameter                 | $\gamma$         | $m_\nu / \text{eV}$ | $f_{NL}$           | $w_p$         | $w_a$         | $FoM$<br>$= 1/(\Delta w_\theta \times \Delta w_a)$ |
| Euclid primary<br>(WL+GC) | 0.010            | 0.027               | 5.5                | 0.015         | 0.150         | 430  |
| Euclid All                | 0.009            | 0.020               | 2.0                | 0.013         | 0.048         | 1540   |
| Euclid+Planck             | 0.007            | 0.019               | 2.0                | 0.007         | 0.035         | 4020 → 6000  |
| Current (2009)            | 0.200            | 0.580               | 100                | 0.100         | 1.500         | ~10  |
| <b>Improvement Factor</b> | <b>30</b>        | <b>30</b>           | <b>50</b>          | <b>&gt;10</b> | <b>&gt;40</b> | <b>&gt;400</b>                                     |

Ref: Euclid RB arXiv:1110.3193

Assume systematic errors are under control

# Euclid Legacy: a revolution in wide field space surveys



# Euclid Legacy

- Very large samples
  - → diversity of populations
  - → distribution functions
- Very large volumes, very large numbers
  - → rare sources, probing the extremes
- Exquisite imaging of galaxies
  - → morphological studies, mergers, strong galaxy-scale lenses
- Weak Lensing
  - → Galaxy evolution as function of halo properties
  - → Galaxy alignment
- NIR Spectroscopy
  - → Metals, star formation@  $z>1$
  - → Cool stars
  - → Very high- $z$  QSOs

# Euclid mission baseline: Launch in 2020

**Photo-z:** Ground based Photometry and Spectroscopy

|  |   | SURVEYS  | In ~6 years                         |                           |  |  |  |  |  |  |  |  |
|--|---|--|-------------------------------------|---------------------------|--|--|--|--|--|--|--|--|
|  | Area (deg2)                                 | Description  |                                     |                           |  |  |  |  |  |  |  |  |
| Wide Survey  | <b>15,000 deg<sup>2</sup></b>               | Step and stare with 4 dither pointings per step.                                       |                                     |                           |  |  |  |  |  |  |  |  |
| Deep Survey  | <b>40 deg<sup>2</sup></b>                   | In at least 2 patches of > 10 deg <sup>2</sup><br>2 magnitudes deeper than wide survey |                                     |                           |  |  |  |  |  |  |  |  |
| <b>PAYOUT</b>                                      |   |  |                                     |                           |  |  |  |  |  |  |  |  |
| Telescope  | 1.2 m Korsch, 3 mirror anastigmat, f=24.5 m |  |                                     |                           |  |  |  |  |  |  |  |  |
| Instrument   | VIS   | NISP   |                                     |                           |  |  |  |  |  |  |  |  |
| Field-of-View                                      | 0.787×0.709 deg <sup>2</sup>                | 0.763×0.722 deg <sup>2</sup>   |                                     |                           |  |  |  |  |  |  |  |  |
| Capability   | Visual Imaging                              | NIR Imaging Photometry   |                                     |                           | NIR Spectroscopy   |  |  |  |  |  |  |  |
| Wavelength range                                   | 550– 900 nm                                 | Y (920-1146nm),  | J (1146-1372 nm)                    | H (1372-2000nm)           | 1100-2000 nm   |  |  |  |  |  |  |  |
| Sensitivity  | 24.5 mag<br>10σ extended source             | 24 mag<br>5σ point source  | 24 mag<br>5σ point source           | 24 mag<br>5σ point source | $3 \cdot 10^{-16}$ erg cm-2 s-1<br>3.5σ unresolved line flux |  |  |  |  |  |  |  |
| Shapes + Photo-z of $n = 1.5 \times 10^9$ galaxies |   |  | $z$ of $n = 5 \times 10^7$ galaxies |                           |  |  |  |  |  |  |  |  |

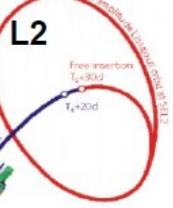
**Possibility other surveys:** SN and/or μ-lens surveys, Milky Way (TBC)?

Ref: Euclid RB Laureijs et al arXiv:1110.3193

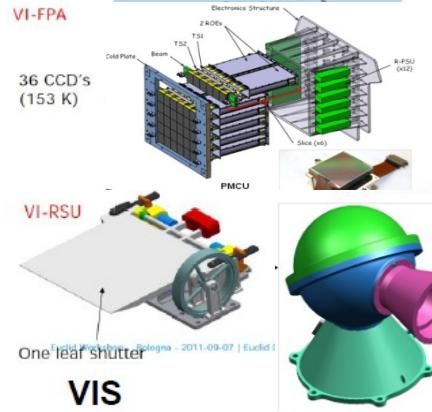
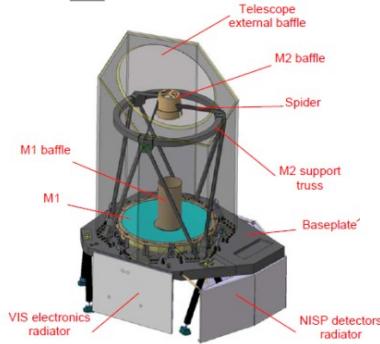
# Euclid in one slide

Soyuz@Kourou

Q1 2020



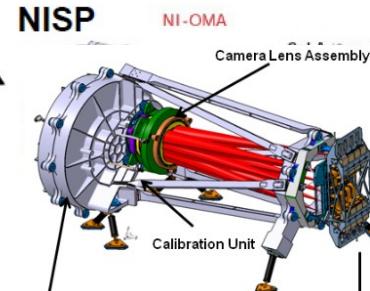
PLM+SVM: 2010-2019



VIS imaging:  
2010-2020

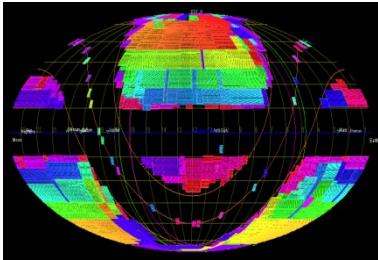
(VIS team)

NIR spectro-imaging



2010-2020 (NISP team)

Surveys: 2010-2028 (Survey WG)



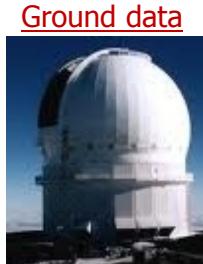
6 yrs - 15,000 deg<sup>2</sup>

Commissioning – SV

Euclid opération:

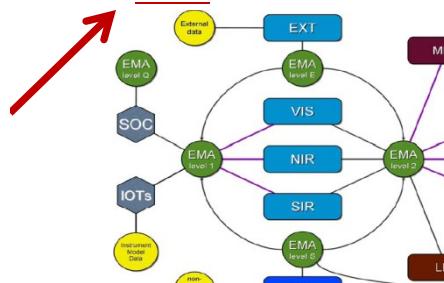
5.5 yrs: Euclid Wide+Deep

+: SNIa, mu-lens, MW?



Ground data

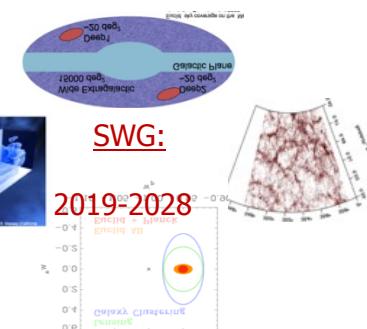
SGS: 2010-2028



20-30 PB data processing (EC-SGS team)

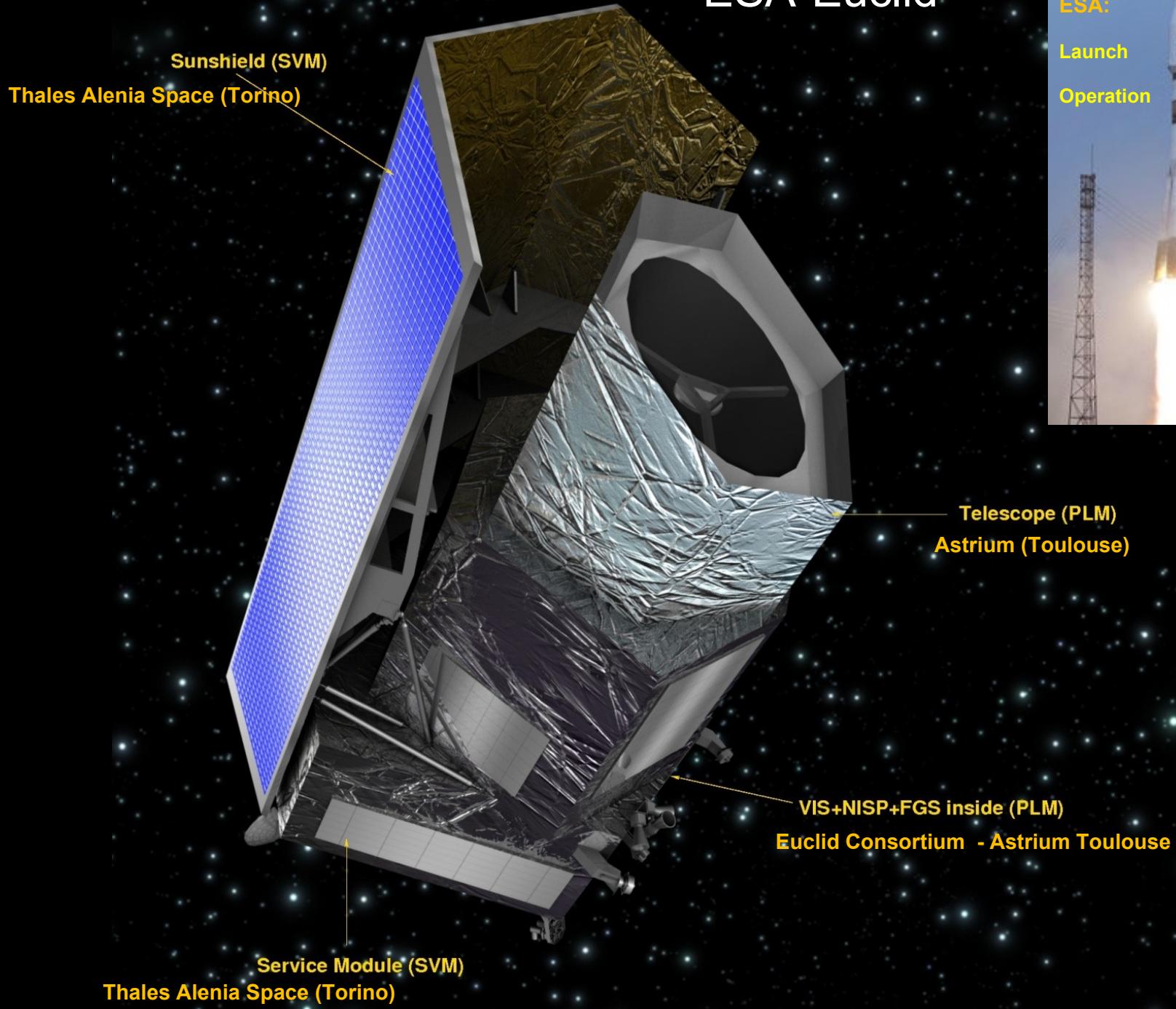
SWG:

2019-2028



Science analyses

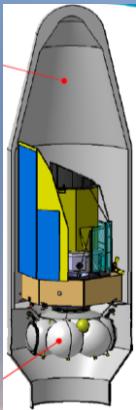
# ESA-Euclid



ESA:

Launch

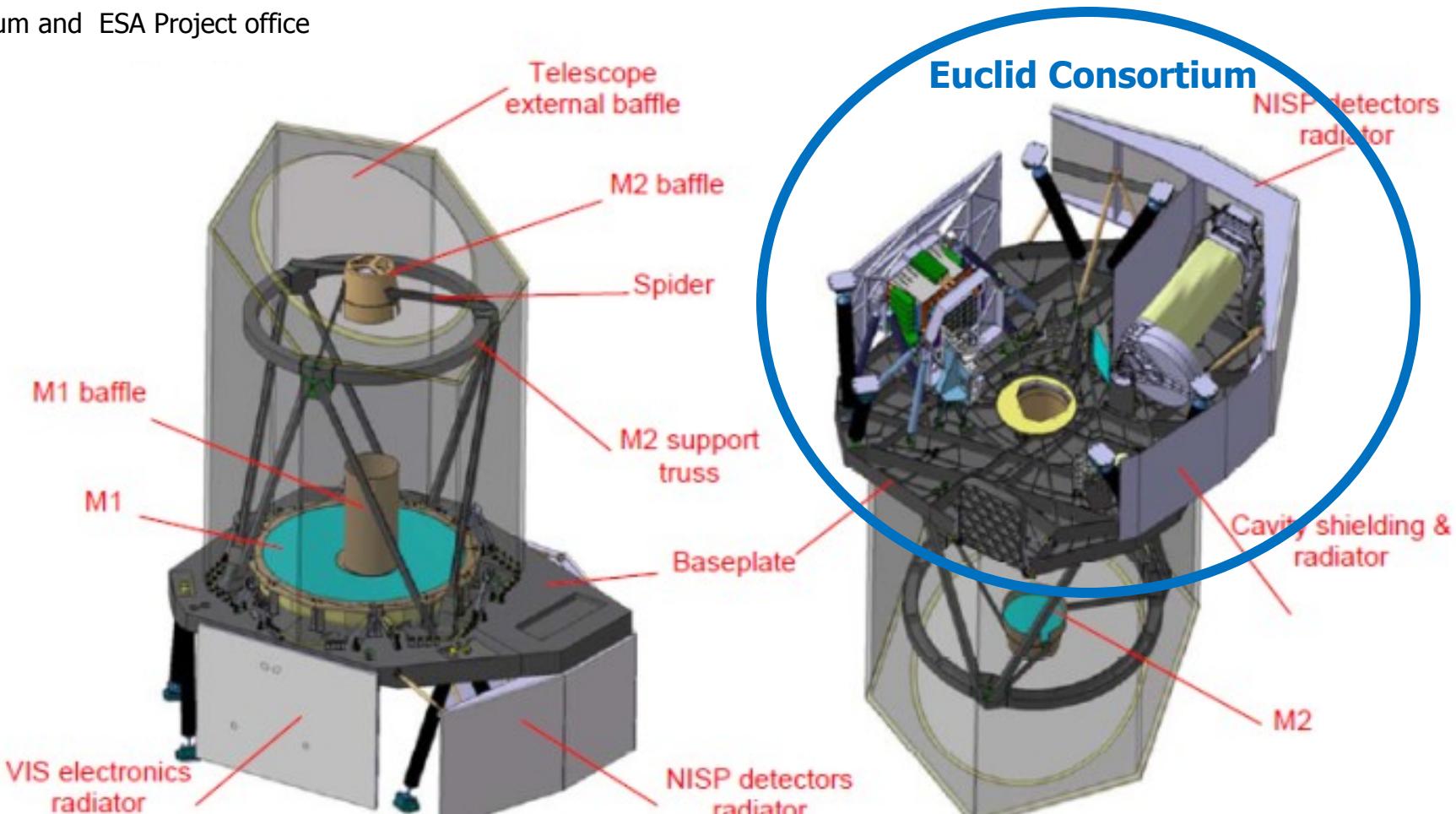
Operation



# PLM and scientific instruments

Courtesy:

Astrium and ESA Project office

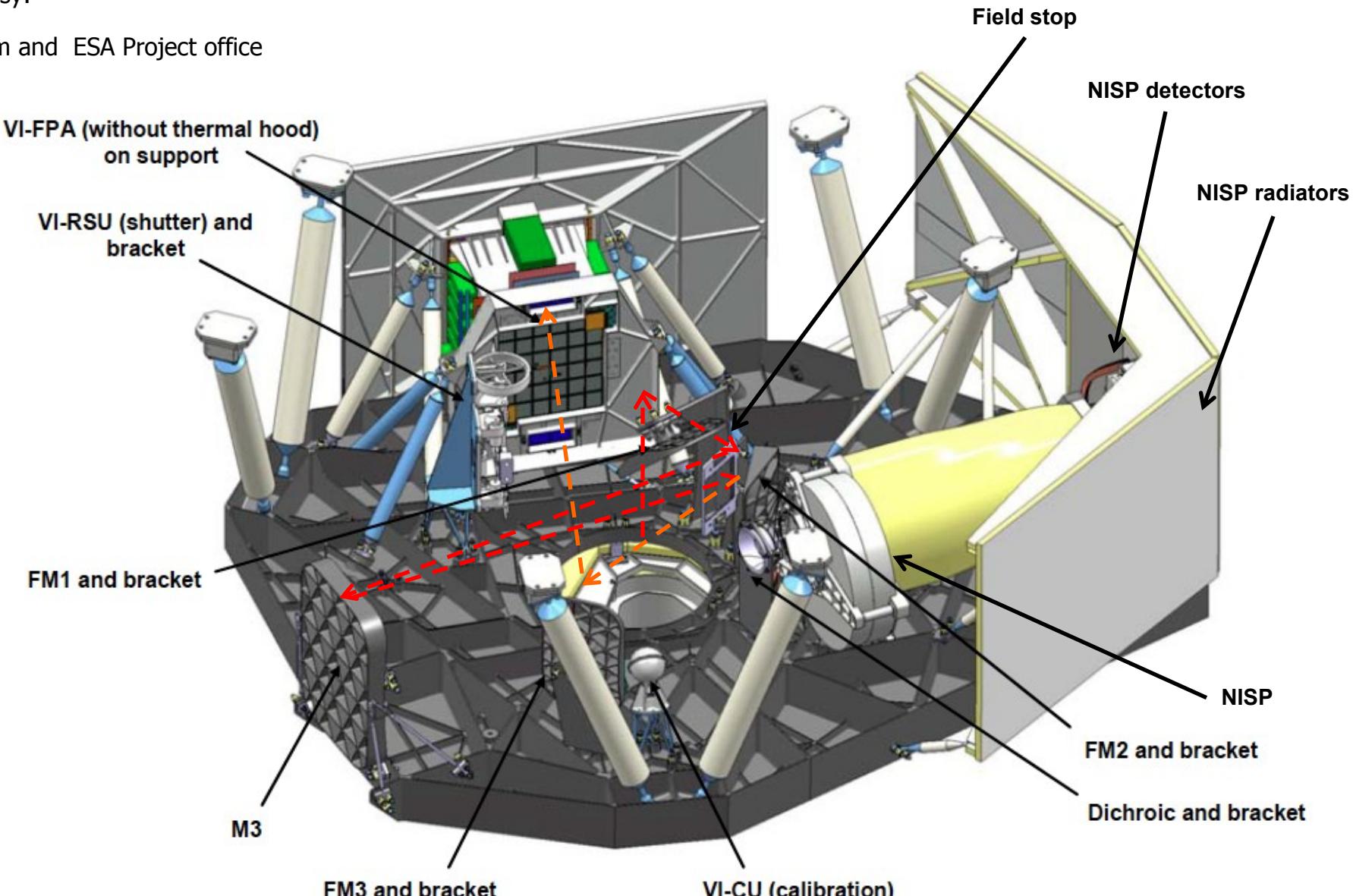


- Stabilisation: Pointing error along the x,y axes= 25mas over a period 700 s.
- FoV: Common visible and NIR Fov =  $0.54 \text{ deg}^2$

# VIS and NISP in PLM

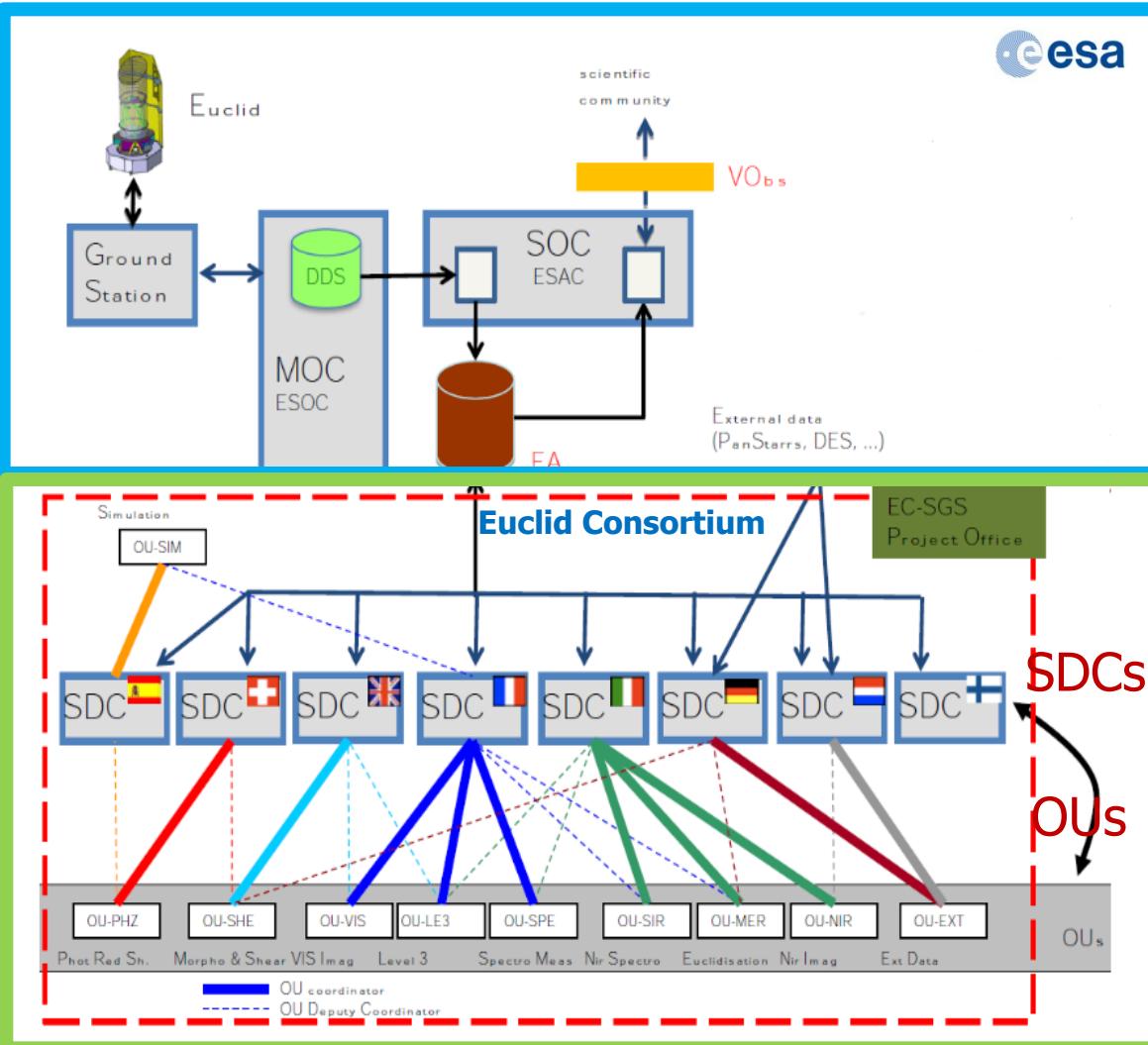
Courtesy:

Astrium and ESA Project office



# Science Ground Segment

Courtesy: F. Pasian, M. Sauvage, J. Hoar, C. Dabin EC SGS and ESAC



## Complex organisation:

- 10 Organisation Units
- 7 Science Data Centers

**Data:** huge volumes, heterogeneous data sets

- imagery and morphometry, photometry , spectroscopy
- data from ground and space
- 20-30 Pbytes
- $> 10^{10}$  sources ( $> 3$ -sigmas)

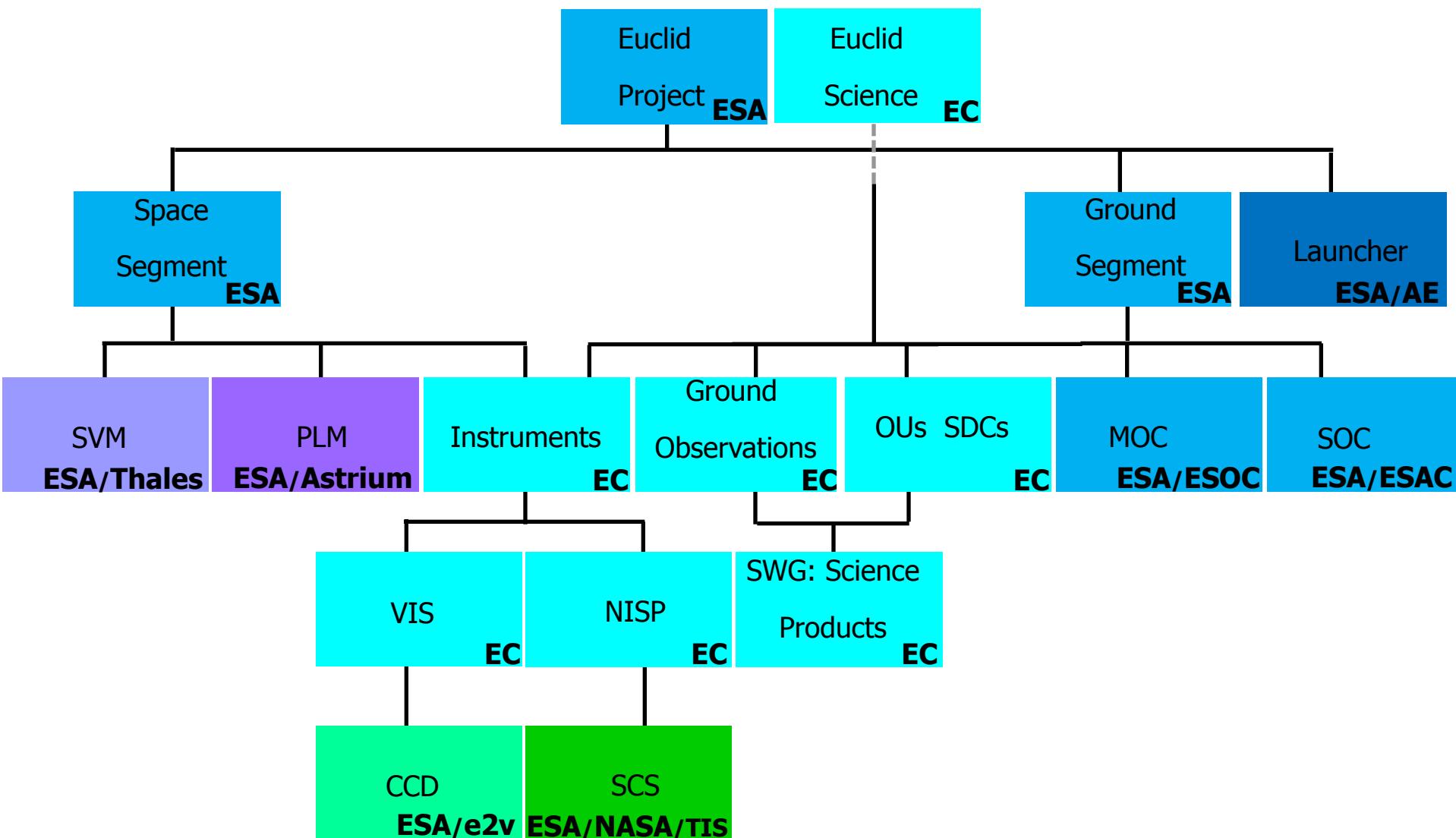
**1st release Level-3:** 26 months after the begining of the survey.

SGS = 50% of Euclid Consortium contributions.

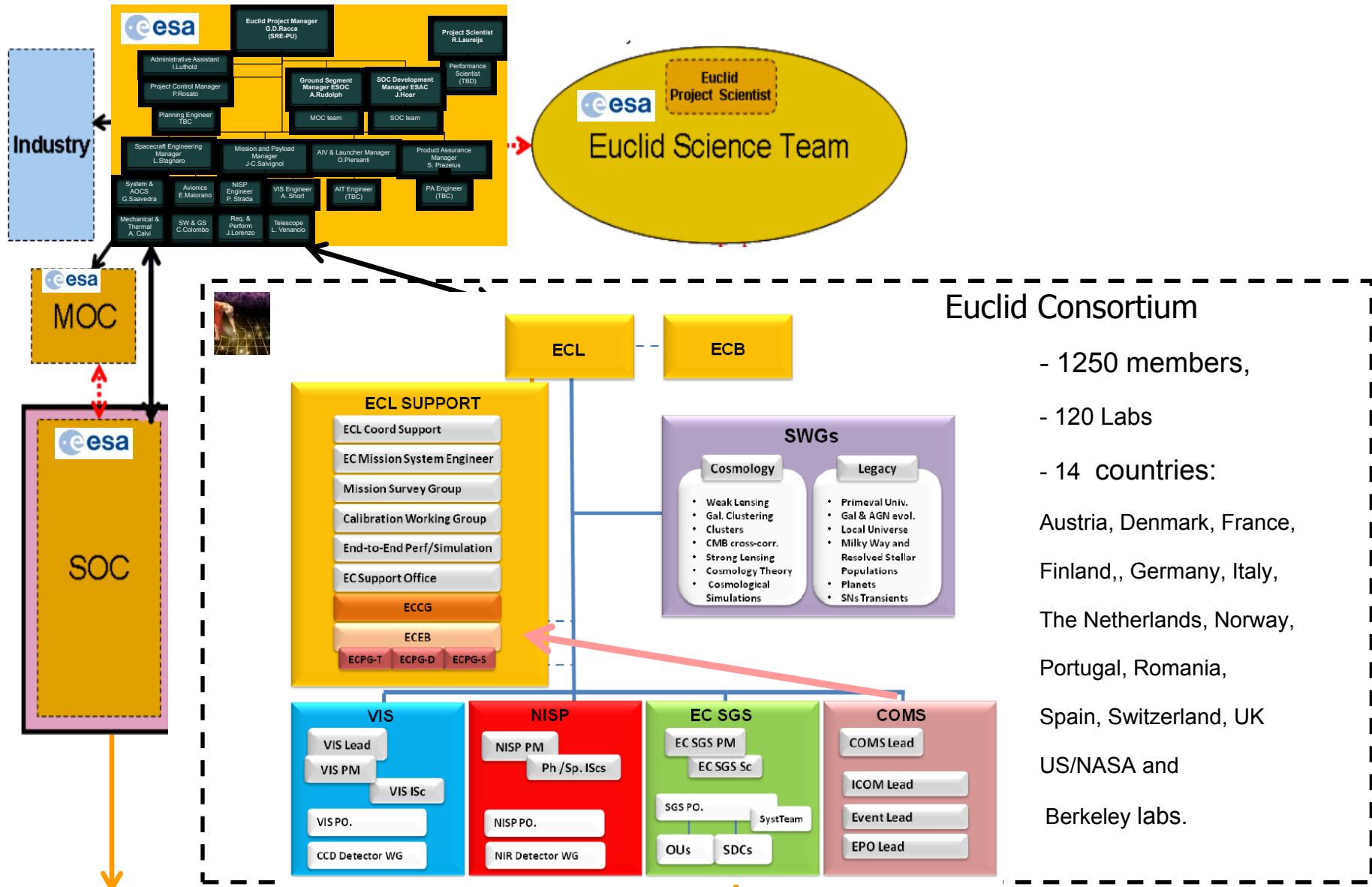
# Issues (discussed during the 2 days)

- ECL/ECL-Support
  - Managing 1250 EC members
  - Registration
  - Publication policy - Set ECEB
  - ECB and ECCG meetings
  - COM
  - Travels
  - New countries (Belgium, Canada)
- Additional science: SN, ExoPI, ...
- EC SGS
  - EXT: ground based data
  - OU-SWG and OU-SDC tasks
  - CC-IN2P3 and SDC-FR
- VIS and NISP Instruments
  - CMU
  - 4 grisms
  - Ghosts
  - FGS EMI
  - Straylight
  - PDRs
- Euclid E2E performances
- Full survey definition
- Cosmology simulations

# Euclid Collaboration



# Euclid Collaboration/Consortium



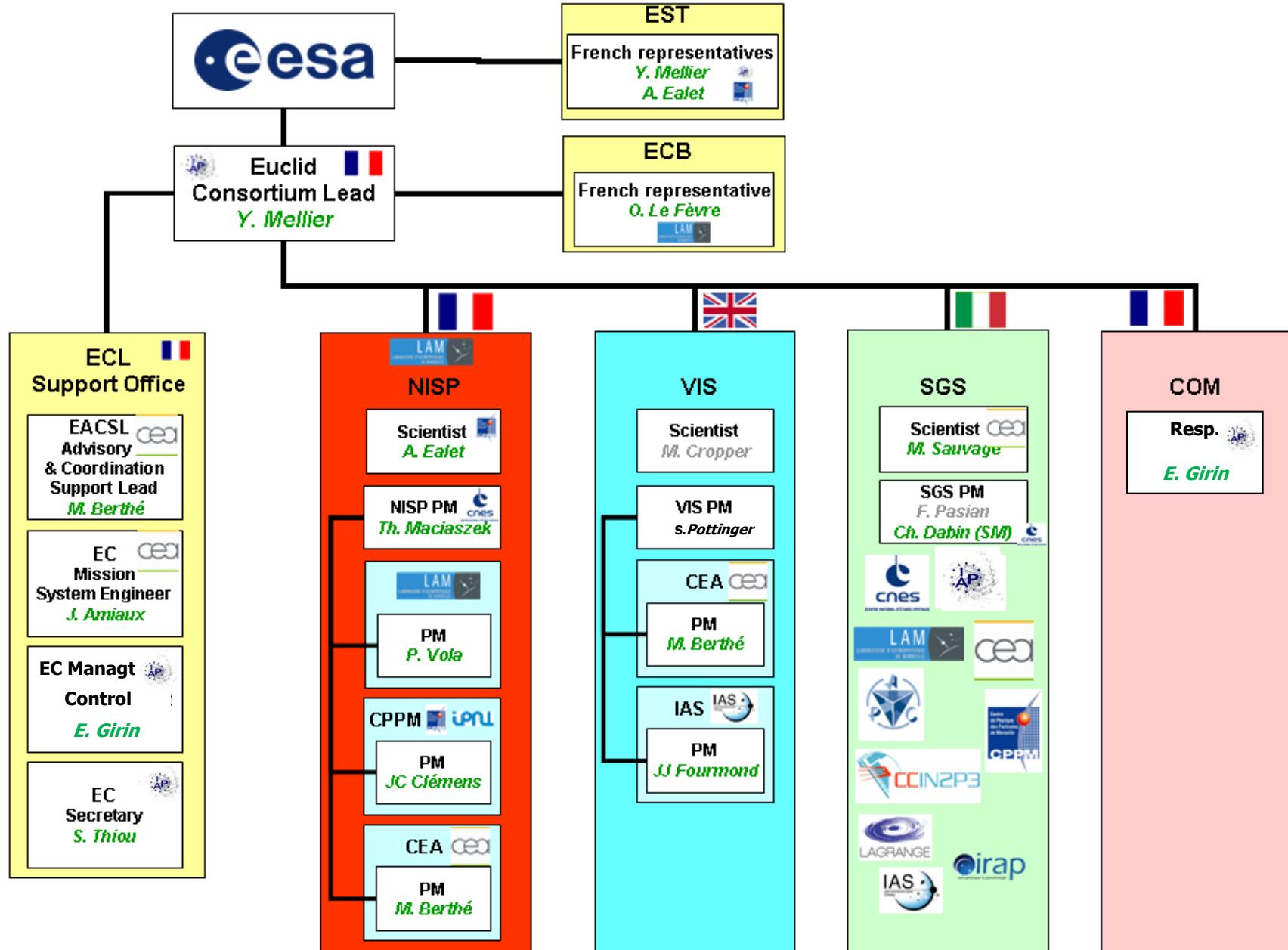
# EC registration process: next in January 2014

## 11.5. ECMC Members

- New registration interface in progress,
- Registration process tested
- Works with IE10, Opera, Safari, Firefox, Chrome, Samsung S IV

| <b>Names</b>    | <b>Role</b>                                       | <b>Country</b> | <b>Institute</b> | <b>Note</b>             |
|-----------------|---|----------------|------------------|-------------------------|
| J. Bartlett     | Sc. Coord. Add. Cosmo                             | FR             | APC              | Rotating                |
| R. Bender       | ECB   | DE             | MPE, USM         |                         |
| M. Berthé       | EACSL   | FR             | CEA              |                         |
| J. Brinchmann   | Sc. Coord. Legacy                                 | NL             | U. Leiden        |                         |
| F. Castander    | ECB, EST  | ES             | IEEC             |                         |
| A. Cimatti      | ECB, EST  | IT             | U. Bologna       |                         |
| R. Cole         | First VIS PM                                      | UK             | MSSL             |                         |
| M. Cropper      | ECB, EST, VIS Lead                                | UK             | MSSL             |                         |
| A. Da Silva     | ECB   | PT             | U. Porto         |                         |
| A. Ealet        | NISP-S IS, EST                                    | FR             | CPPM             |                         |
| E. Girin        | Study engineer in charge of EC management control | FR             | IAP              | ECMC management control |
| L. Guzzo        | Sc. Coord. Cosmo GC                               | IT             | U. Brera         |                         |
| H. Hoekstra     | Sc. Coord. Cosmo WL                               | NL             | U. Leiden        |                         |
| K. Janhke       | NISP-P IS   | DE             | MPIA             |                         |
| T. Kitching     | Sc. Coord. Cosmo WL                               | UK             | MSSL             |                         |
| H. Kurki-Suonio | ECB   | FI             | U. Helsinki      |                         |
| O. Le Fèvre     | ECB   | FR             | LAM              |                         |
| P. Lilje        | ECB   | NO             | U. Oslo          |                         |
| T. Maciaszek    | NISP PM   | FR             | CNES             |                         |
| Y. Mellier      | ECL, ECB, EST                                     | FR             | IAP              | ECMC Chair              |
| G. Meylan       | ECB   | CH             | EPFL             |                         |
| B. Nichol       | ECB, EST, COM Lead                                | UK             | ICG              |                         |
| S. Niemi        | VIS IS  | UK             | MSSL             |                         |
| F. Pasian       | SGS PM  | IT             | INAF OA Trieste  |                         |
| K. Pedersen     | ECB   | DK             | DTU              |                         |
| W. Percival     | Sc. Coord. Cosmo GC                               | UK             | U. Portsmouth    |                         |
| L. Popa         | ECB   | RO             | ISS              |                         |
| S. Pottinger    | VIS PM  | UK             | MSSL             |                         |
| R. Rebolo-Lopez | ECB   | ES             | IAC              |                         |
| J. Rhodes       | ECB, EST  | US             | Caltech/JPL      |                         |
| H.-W. Rix       | ECB, EST  | DE             | MPIA             |                         |
| H. Rottgering   | ECB   | NL             | U. Leiden        |                         |
| M. Sauvage      | SGS Scientist                                     | FR             | CEA              |                         |
| R. Scaramella   | ECB, EST, SSWG Lead                               | IT             | INAF OA Roma     |                         |
| S. Thiou        | ECL Assistant Secretary                           | FR             | IAP              | ECMC Secretary          |
| S. Wachter      | CalWG Lead  | DE             | MPIA             |                         |
| S. Warren       | Sc. Coord. Legacy                                 | UK             | Imperial         |                         |
| W. Zeilinger    | ECB   | AT             | U. Wien          |                         |

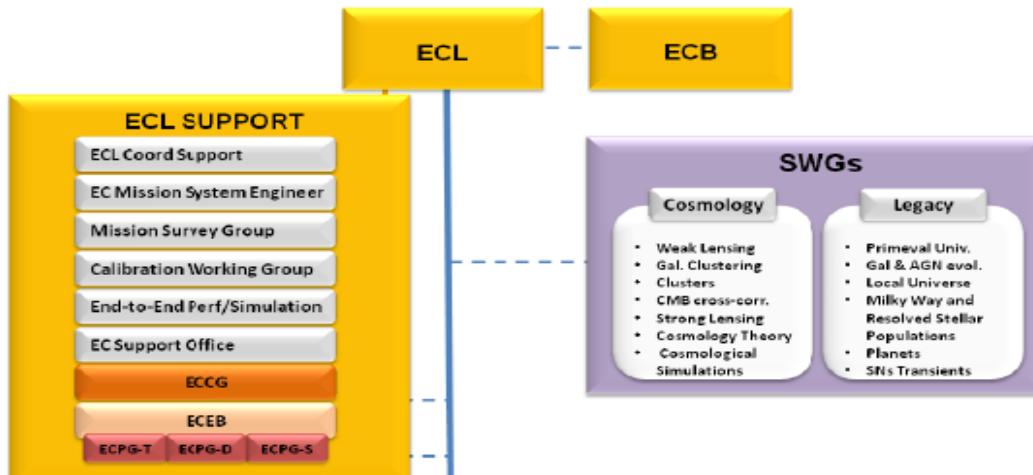
# French contributions (end 2013)



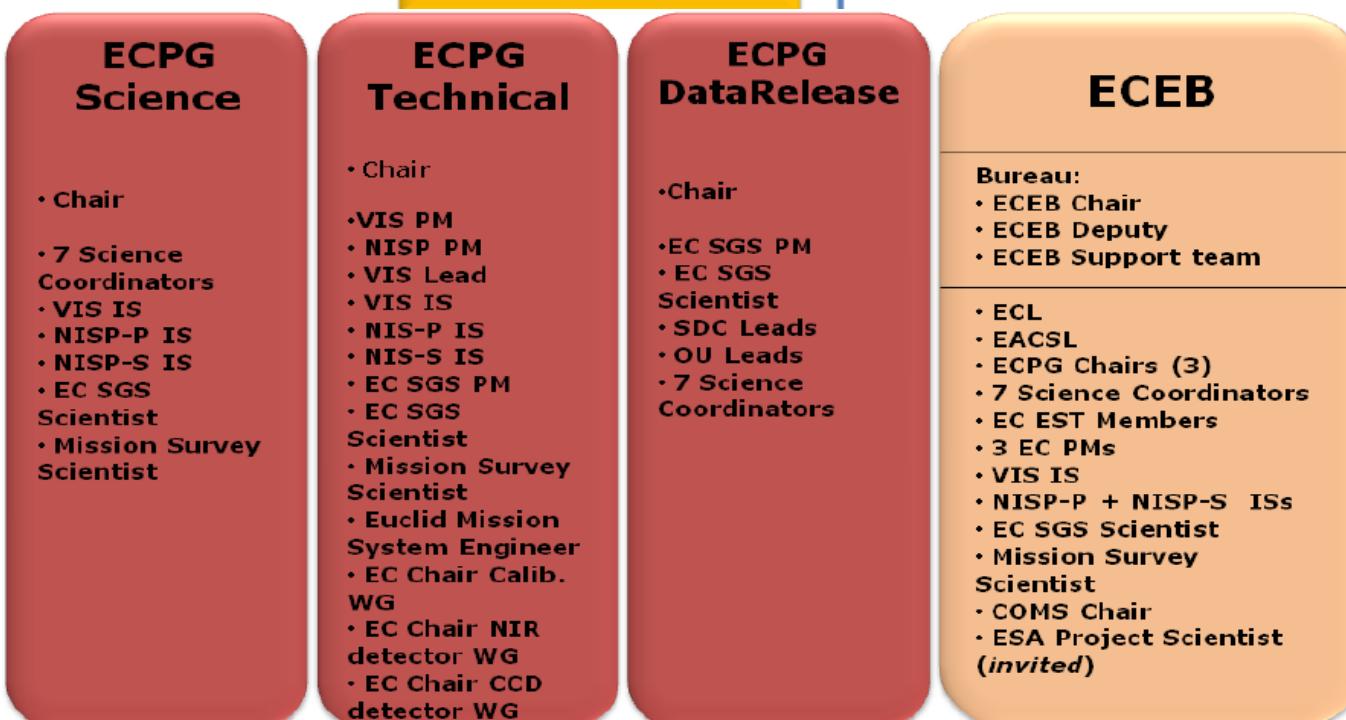
# SWG - French leads ?

| Coordination      | WGs                            | Country            | Names                                  |
|-------------------|--------------------------------|--------------------|--|
| COSMOLOGY         | Leads                          | I / UK / NL        | Guzzo / Percival / Hoekstra / Kitching |
|                   | Weak Lensing                   | UK / NL / F        | Kitching / Hoekstra / Benabed          |
|                   | Galaxy Clustering              | UK / I             | Percival / Guzzo                       |
|                   | Clusters                       | I / G / F          | Moscardini / Weller / Bartlett         |
|                   | CMB x-correlations             | F / I              | Aghanim / Baccigalupi                  |
|                   | Strong Lensing                 | F→CH / I           | Kneib / Meneghetti                     |
|                   | Theory                         | G / CH             | Amendola / Kunz                        |
|                   | Additional science             | F -> DE (rotating) | Bartlett (rotating)                    |
| LEGACY            | Leads                          | UK / NL            | Warren / Brinchmann                    |
|                   | Primeval Universe              | F / DK             | Cuby / Fynbo                           |
|                   | Galaxies/AGN evol.             | NL / F / I         | Brinchmann / Elbaz / Cimatti           |
|                   | Local Universe                 | I / UK             | Poggianti / Warren                     |
|                   | MilkyWay/Resolved stellar pop. | NL / UK            | Tolstoi / Warren                       |
|                   | Planets                        | F / SP / UK        | Beaulieu / Zapatero / Kerins           |
|                   | Sne & Transients               | UK(I) / F / IT     | Hook / Tao / Capellaro                 |
| COSMO SIMULATIONS |                                | F→CH / SP          | Teyssier / Fosalba                     |

# EC publication policy: organisation

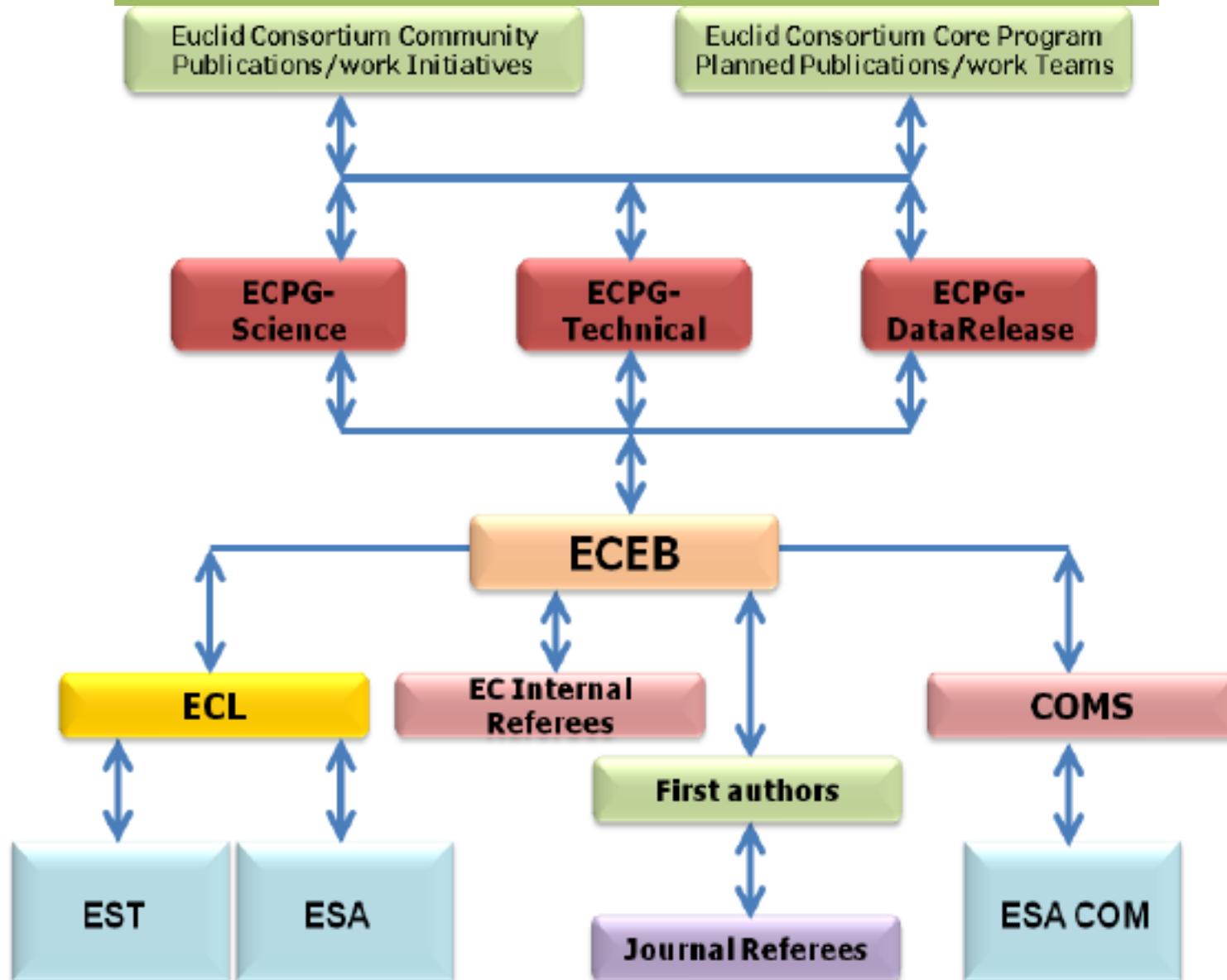


ECEB, ECPGS ... not set



# EC publication policy: publication process

All works and relevant papers announced in advance on an EC web page



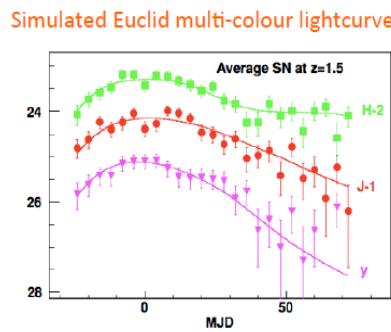
# EC publication policy: contribution level

| Level                                   | Typical Contribution of EC full members work-years (WY) counts starting from the beginning of the project until mission completion.  | Publication Rights  |
|---|--|---|
| L4: Associate                           | . 0.5-2.0 WYs – Anyone who was or is currently EC full members lightly interested (small fraction of time) or post-doc working for a period, then leaving. L4 associate selected by ECMC.  | . Only papers they effectively contribute to/write.   |
| L3: Member                              | . >2.0 WYs – Anyone who was or is currently EC full members strongly interested (devoting a significant fraction of their time). May had or has some responsibilities in the project. L3 members selected by ECMC.   | . All Primary Programme papers regardless the scientific, data or technical nature.<br>+ a fraction of papers (TBD) they wish in their scientific or technical areas (e.g. additional cosmology, legacy, SGS, Payload, COMs) in the current non-primary paper list; |
| L2: Long Term Contributors              | . >4.0 WYs – Anyone who was or is currently EC full members who have Euclid as main project (spend a large fraction of time) and bear quite relevant responsibilities in the project. L2 contributors are selected by ECMC.<br><br>. Include all past or present EC members with responsibilities in Euclid for at least 3 WYs since beginning of Phase-A. Selected by ECMC.                     | . All Primary Programme papers, regardless the scientific, data or technical nature;<br>+ all non-Primary papers of the current paper list they wish in their scientific or technical areas.  |
| L1: Founder + LongTerm KEY Contributors | . Founders include past or present members with sustained positive contributions critical to the Euclid mission during the selection period. Founders will be decided by ECB members only.<br><br>. Past or present Long Term KEY Contributors having at least 4.0 WYs of activity critical to the Euclid mission. May also include anyone the ECB would select. Can be proposed to ECB by ECMC. | All papers.   |

# Example survey

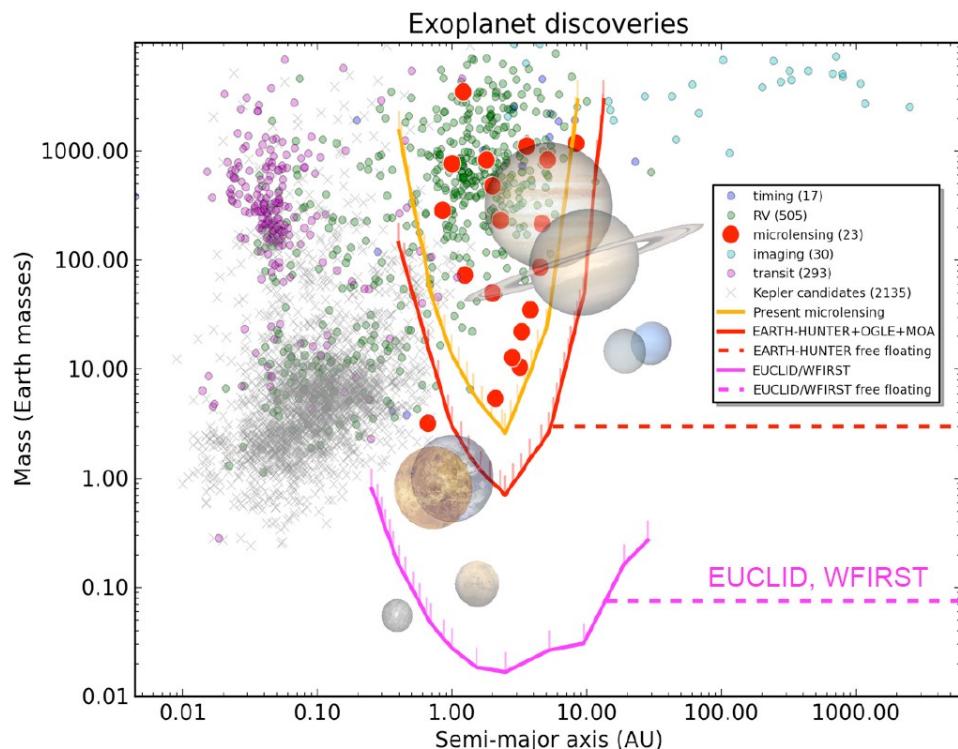
Simulations by P. Astier, K. Maguire, S. Spiro  
Astier et al, in prep

- Starting assumption: 6 months total Euclid time
- Euclid Survey outline:
  - 10 sq deg x two seasons (references)
  - 4 day cadence
- I and z- band observations from the ground
  - Aids photo-classification
  - Provides consistent rest-frame wavelength coverage over full z range
  - (Euclid's own broad optical band is not suitable)
- Real-time spectroscopic confirmation for a subset of SNe (8ms, JWST + ELTs)
- Accurate redshifts obtained later from the host galaxies
  - wide-field MOS instrument on 8m telescope



# Euclid SN survey? ...

... or Exoplanet/mu-lens with Euclid?



Wait for

Mission PDR in April 2015

→ Selection in 2015

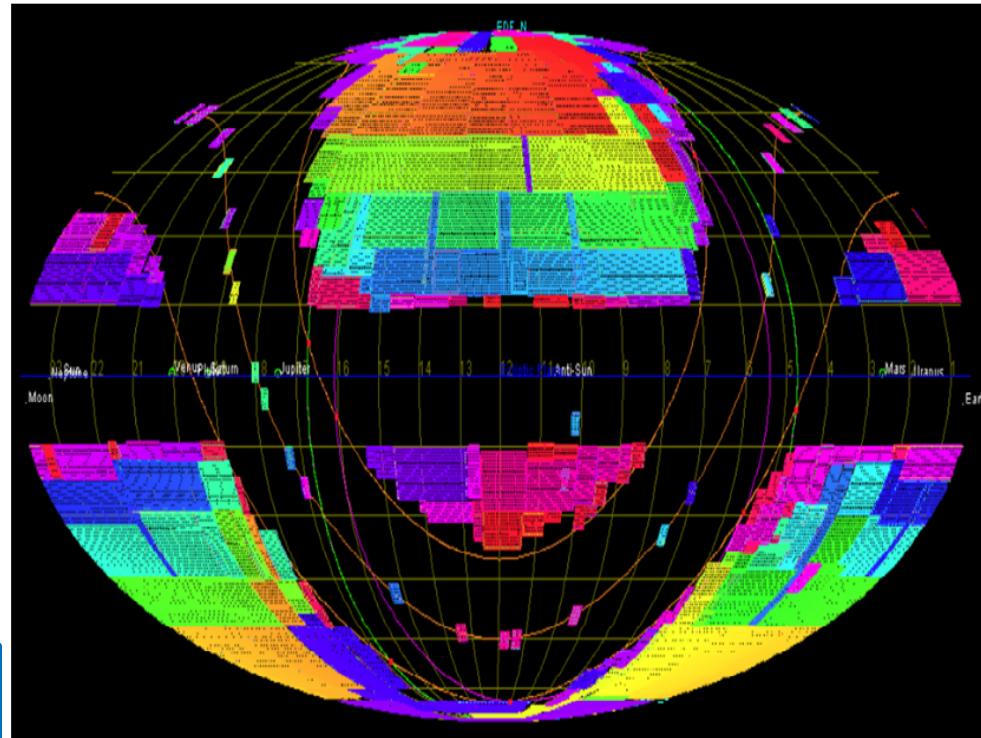
# Ground based imaging data for photo-z

- South:

- DES (5000 deg<sup>2</sup>) data deep enough in g,r,i,z . Suits Euclid needs; : consolidated
- Part of south missing (LSST?): if LSST no strong need: I=24.5 and 5000 deg<sup>2</sup>: not all LSST data.

- North:

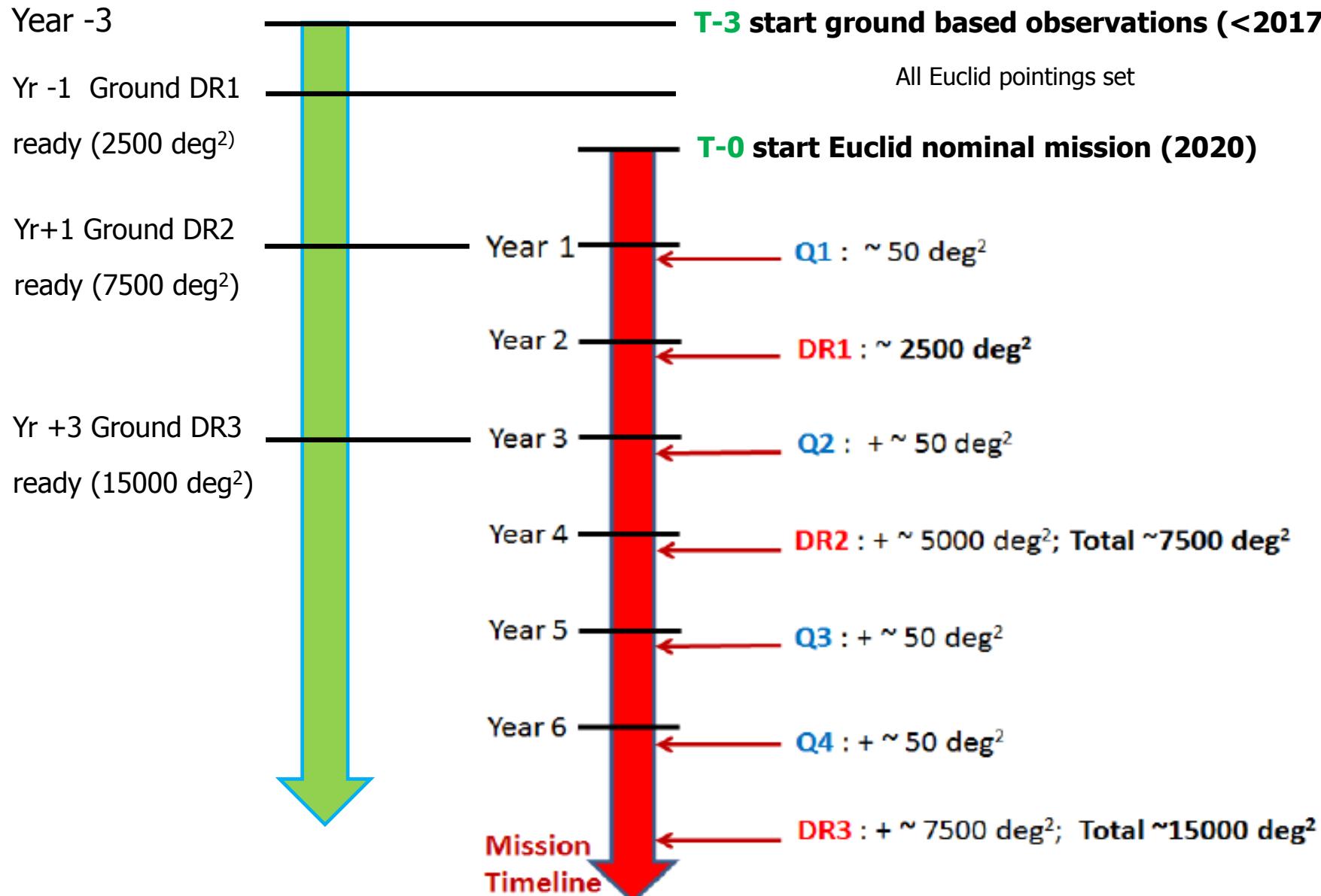
- Pan-STARRS: not clear if ok.
- **MegaCam-RED at CFHT: proposal submitted: g,r,i,z (+ u) →ugrz??**
- **MegaCam-RED at CFHT+WHT?**
- **HSC baseline:1400 deg<sup>2</sup> g,r,i,z consolidated: public after 2 yrs**
- e-HSC/Subaru→ PFS ?
- LSST intermediate south-north?



Sky covered by the Euclid mission at completion (6 year) in ecliptic coordinates – Courtesy Euclid Consortium/ESA/Science Survey Working Group

| SURVEYS          |                                 |                           |  |                           |   |
|------------------|---------------------------------|---------------------------|--|---------------------------|---|
|                  | Area (deg <sup>2</sup> )        |                           | Description  |                           |   |
| Wide Survey      | <b>15,000 deg<sup>2</sup></b>   |                           | Step and stare with 4 dither pointings per step.                                       |                           |   |
| Deep Survey      | <b>40 deg<sup>2</sup></b>       |                           | In at least 2 patches of > 10 deg <sup>2</sup><br>2 magnitudes deeper than wide survey |                           |   |
| Wavelength range | 550– 900 nm                     | Y (920-1146nm),           | J (1146-1372 nm)   | H (1372-2000nm)           | 1100-2000 nm  |
| Sensitivity      | 24.5 mag<br>10σ extended source | 24 mag<br>5σ point source | 24 mag<br>5σ point source  | 24 mag<br>5σ point source | $3 \cdot 10^{-16}$ erg cm <sup>-2</sup> s <sup>-1</sup><br>3.5σ unresolved line flux<br>$z$ of $n=5 \times 10^7$ galaxies |

# Ground based + Euclid imaging data: plans



# Spectro surveys: VIMOS+MOONS

## submitted on Oct. 15

ESO Public Spectroscopic Surveys

Letter of Intent

### 1 Title: Enabling Precision Cosmology with Euclid with high colour completeness spectroscopy at faint magnitudes

PI: F.J. Castander, ICE, Spain

co-PI: Y. Mellier, IAP, France

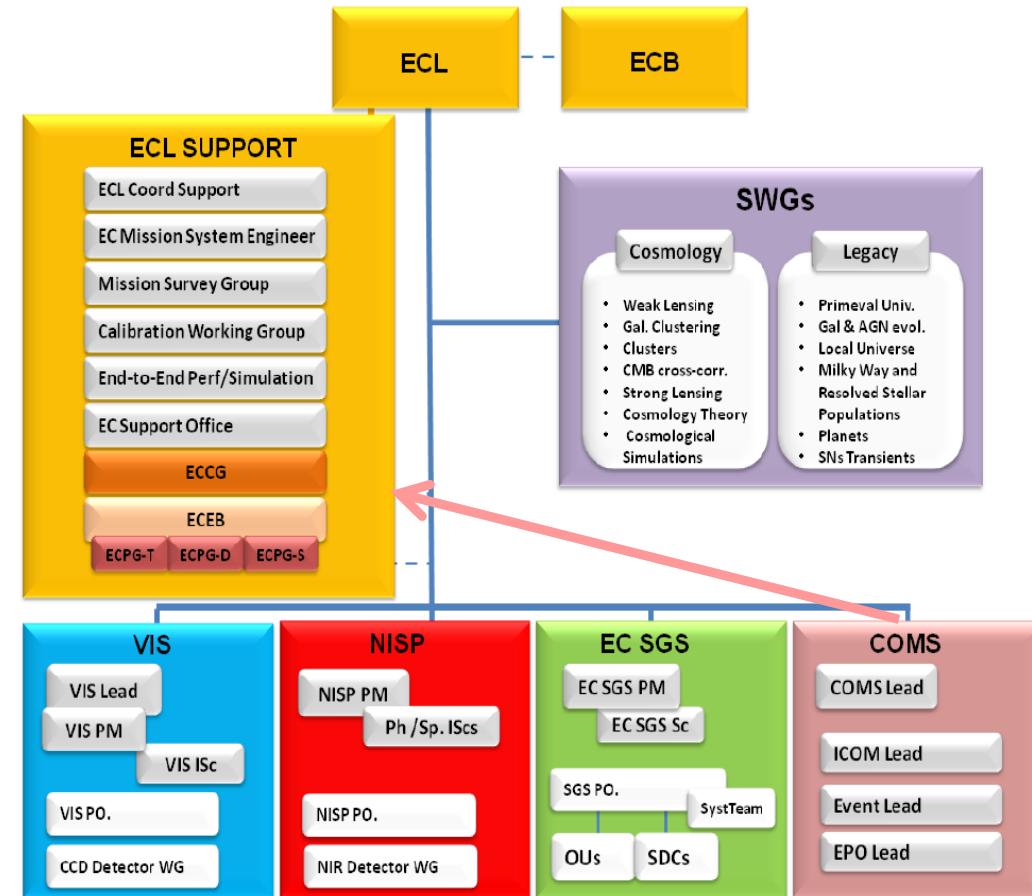
CoIs: F. Abdalla, London, UK; S. Arnouts, Marseille, France; R. Bender, Munich, Germany; M. Bolzonella, Bologna, Italy; J. Brinchmann, Leiden, Netherlands; P. Capak, CalTech, USA; A. Cimatti, Bologna, Italy; A. da Silva, Porto, Portugal; P. Franzetti, Milano, Italy; B. Garilli, Milano, Italy; H. Hoekstra, Leiden, Netherlands; H. Hildebrandt, Bonn, Germany; O. Ilbert, Marseille, France; M. Jarvis, Oxford, UK; H. Kurki-Suonio, Helsinki, Finland; O. LeFèvre, Marseille, France; P. Lilje, Oslo, Norway; C. Maraston, Portsmouth, UK; G. Meylan, Lausanne, Switzerland; B. Nichol, Portsmouth, UK; P. Norberg, Durham, UK; S. Paltani, Geneva, Switzerland; K. Pedersen, Copenhagen, Denmark; L. Popa, Bucharest, Romania; R. Rebolo, Tenerife, Spain; J. Rhodes, JPL, USA; H.-W. Rix, Heidelberg, Germany; H. Rottgering, Leiden, Netherlands; R. Saglia, Munich, Germany; M. Salvato, Munich, Germany; R. Scaramella, Rome, Italy; M. Scodéglio, Milano, Italy; L. Tresse, Marseille, France; W. Zeilinger, Vienna, Austria

#### 1.1 Abstract:(10 lines max)

We propose a deep spectroscopic survey to calibrate the photometric redshifts that enable the weak lensing experiment of Euclid, the most ambitious dark energy probe in the next decade and highly supported by the European community. We will obtain redshifts for 30,000 galaxies with the highest levels of completeness ever achieved, systematically sampling colour space down to a magnitude limit of  $I_{AB} \sim 24.5$ , and covering an area of  $2.5 \text{ deg}^2$  in 40 VIMOS pointings and sampling the redshift range  $0.2 < z < 2.5$ . The survey represents a step forward compared to previous large surveys carried out with VIMOS in terms of depth, spectral type coverage and completeness. The sample gathered when combined with the photometry will provide an invaluable data set with high legacy value. The later addition of Euclid data will provide sampling of the galaxies spectral energy distributions from the optical to the near infrared allowing us to explore the frontiers of science.

Summarizing, we are requesting deep spectroscopic observations for 40 fields, with a total on-target exposure time of 25 hours per field, split up between the LR-Blue and LR-Red grisms. In addition, we request deep 1.5h pre-imaging in the I-band filter of our fields. Taking into account a 30% overhead for spectroscopy and 20% for pre-imaging, the observations amount to a total of  $(25h * 1.3 + 1.5h * 1.2) * 40 \sim 1350$  hours time. For a mean night length of 8.5 hours that amounts to 160 nights. As our observational strategy depends on re-observing the same fields in  $\sim 5$  hours slots in different semesters to re-design the masks to eliminate already secure redshifts, we plan to run our survey for 5 years or 10 semesters.

# EC communication reorganised



- Under ECL responsibility
- New team created with 15 members out of which 11 have no activities today in the EC  
→ new resource : Total FTE: 3.00
- 5 main tasks
  - Presence on the scientific International stage (F. Combes, S. Mei)
  - Presence on the Aerospace International Stage (M. Berthé, JL Auguères)
  - Presence on Internet (F. Magnard, E. Girin)
  - Education and Public Outreach (A. Fuzfa, JP Uzan)
  - Euclid Consortium Alumni (R. Holmes)
- Include Web 1.0, Web 3.0 and Wikipedia
- New COM plan document released soon

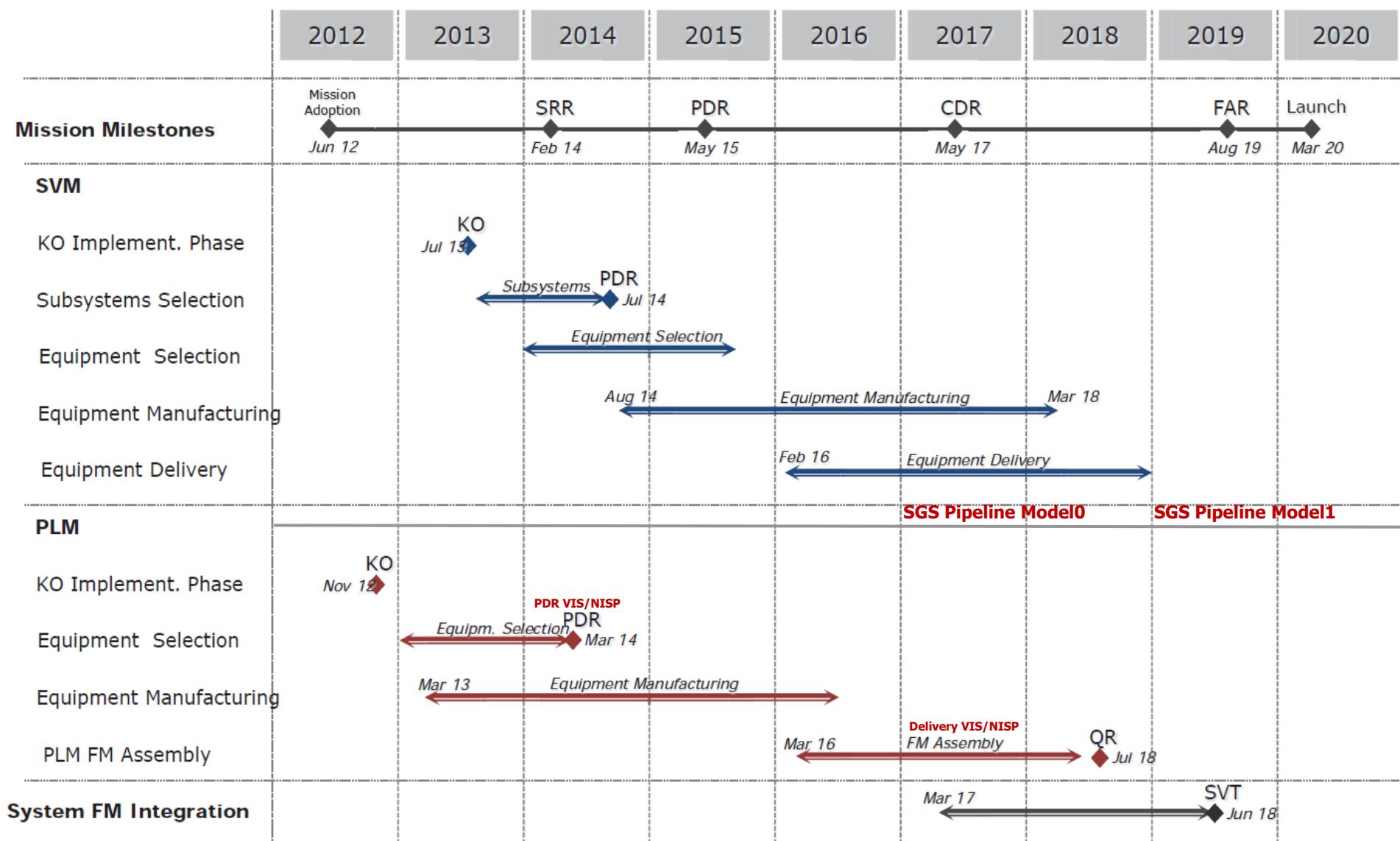
# EC communication activities

- Euclid web site considerably expanded: maintained daily
  - <http://www.euclid-ec.org>
  - <http://internal.euclid-ec.org>
  - Includes jobs announcements and PRs
  - Web 3.0 under development , extra-funds (not taken to EC funds)
- Wikipedia controled by EC: maintained monthly with explicit reference to EC as authors
  - <http://fr.wikipedia.org/wiki/Euclid>
  - [http://en.wikipedia.org/wiki/Euclid\\_\(spacecraft\)](http://en.wikipedia.org/wiki/Euclid_(spacecraft))
  - [http://pt.wikipedia.org/wiki/Euclid\\_\(telescopio\\_espacial\)](http://pt.wikipedia.org/wiki/Euclid_(telescopio_espacial))
  - Other languages in progress
- PRs have already been issued by EC or jointly with ESA. EC COM office in contact with ESA COM office. PRs coordinated with national COM offices.

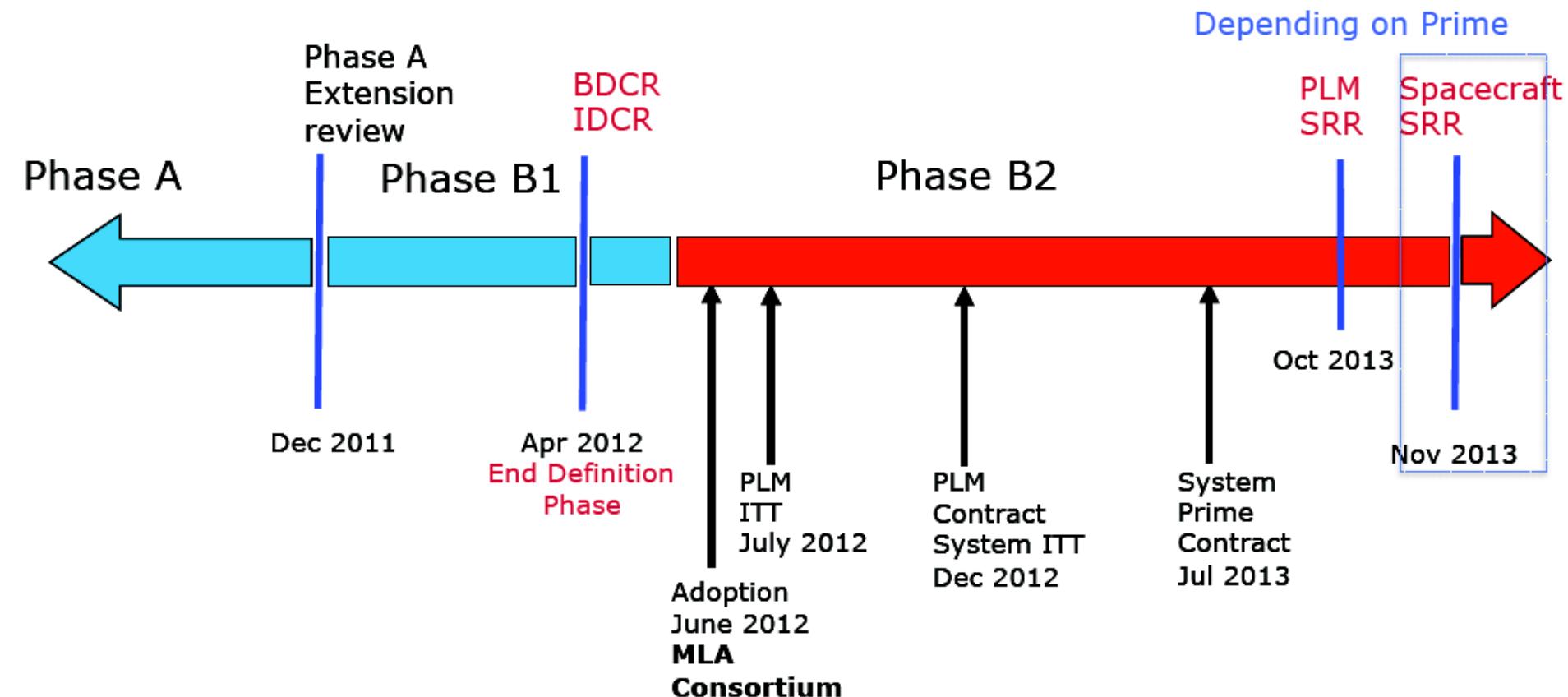
# Challenges for Euclid

- **EC Management:** managing 1250 persons: registration, keep lists updated, monitoring evaluation of activities and movements of EC members
- **Data processing:** huge volume, heterogeneous data, 10 SDCs
- **Shape measurements/systematics**
  - Control multiplicative and additive biases, shape measurement algorithms
- **Photometric redshifts:**
  - Ground based photometry in 4 bands :  $15,000 \text{ deg}^2$  (i.e. north and south)
- **Numerical simulations** with power spectrum to a 1% accuracy :
  - Underlying physics: e.g. numerical simulations with baryons
  - Numerical simulations of a large number of DE, GR models
  - $10^3$  to  $10^5$  simulations to estimate covariance matrices
- **End-to-End performances**
- **Spectroscopic surveys to:**
  - Calibrate deep photo-z and
  - Understand BAO and RSD samples

# Schedule



# Euclid planning overview



# EC important dates

- EC Annual Meeting in May 2013 in Leiden
- VIS passed SSR in June with success
- NISP Partially passed SRR in July but with go ahead to PDR
- SGS passed PRR in July
- NIR detectors passed PDR in July
- MRR : data pack delivered on Nov 18
- Nov 28 MLA signed...

# Nov. 28 : Euclid MLA signed



# EC important dates

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- MRR: data pack delivered on Nov 18
- Nov 28 MLA signed...
- MRR and S/C SRR Board meeting on Feb. 3 2014
- VIS PDR in February 2014
- NISP PDR in March 2014
- **May-June 2014: CFHT SAC+BoD MegaCam RED survey**  
→need Euclid-FR full support
- Next EC Annual meeting in June 2014 in Marseille
- SGS SRR in December 2014
- COSPAR Moscou in Aug 2014

# MegaCam–RED & the CFHT Northern Extragalactic Survey (Red Enhanced Detectors)

Jean–Charles Cuillandre, Kevin Ho  
*Canada–France–Hawaii Telescope*

Rémi Granelli, Olivier Boulade  
*CEA IRFU*

Ray Carlberg  
*University of Toronto*

Yannick Mellier  
*Institut d'Astrophysique de Paris*

Joe Mohr  
*Ludwig–Maximilians–Universität*



# CFHT: a legacy 3.6m telescope still relevant after 34 years



Mauna Kea (4,200m)



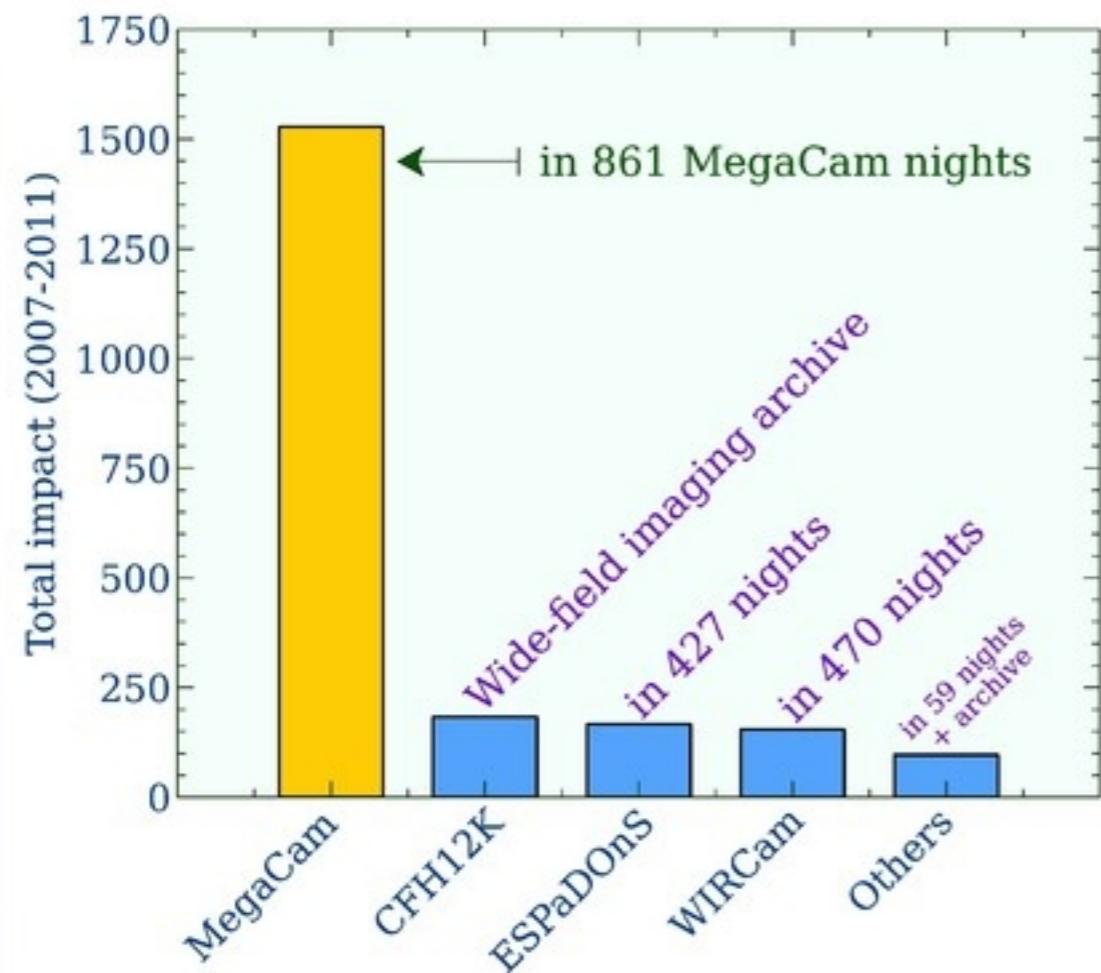
Equatorial mount with prime focus cage



CFHT dome atop Mauna Kea (first light 1979)

# CFHT total bibliographical impact (Crabtree 2011)

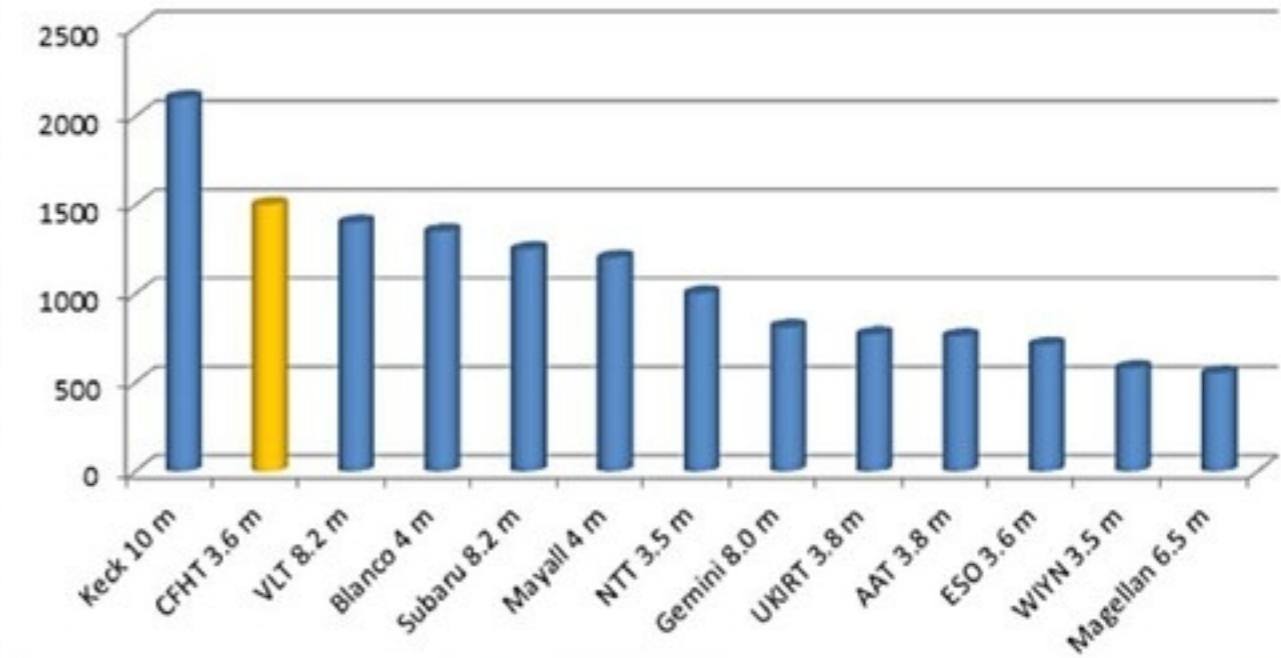
Total impact per CFHT instrument



CFHT instruments (2007–2011)

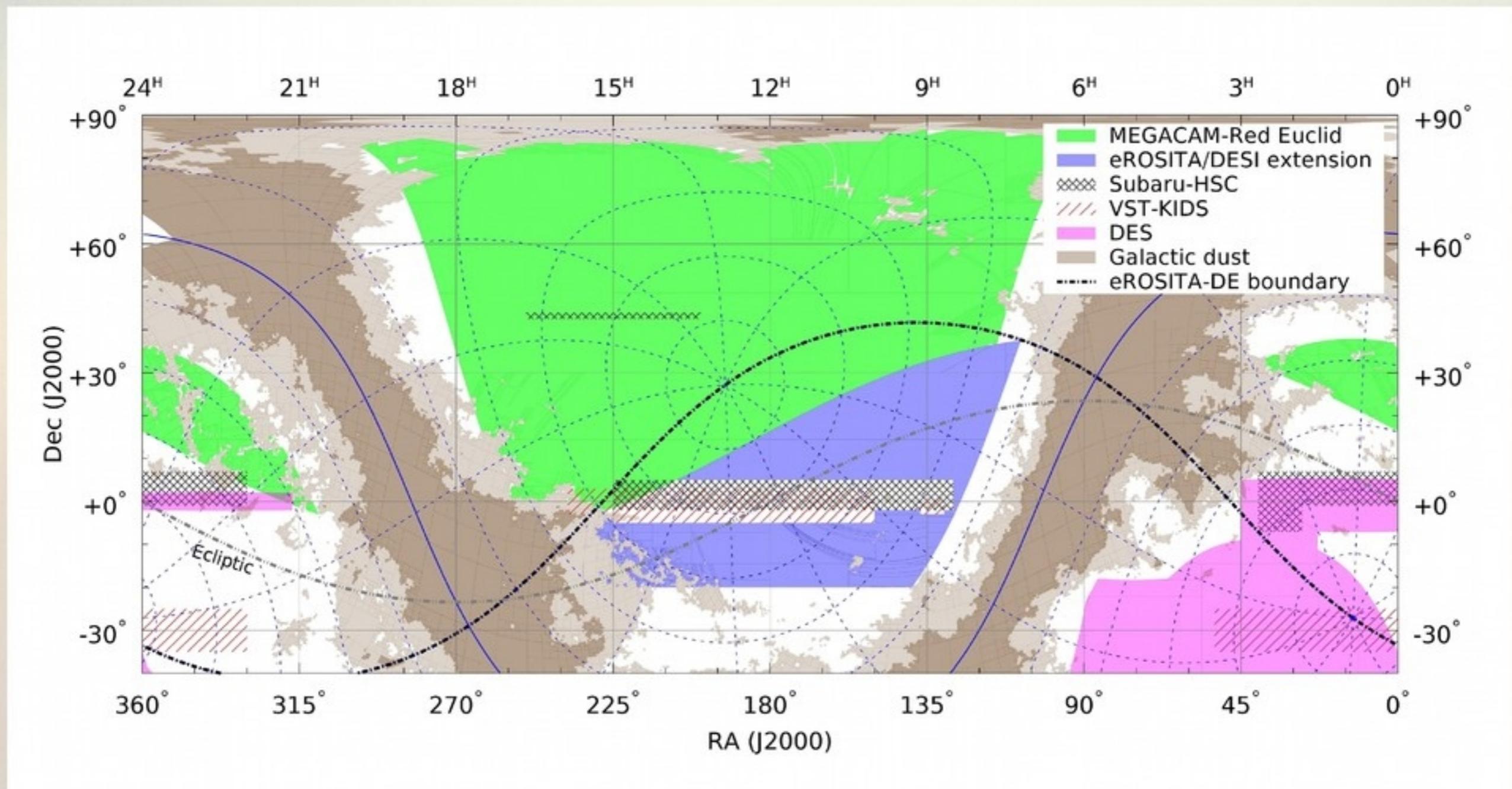
**CFHTLS = ~2/3 of MegaCam impact  
for 1/3 of all telescope time (03–08)**

Total impact per telescope (excluding Sloan)



CFHT vs. other optical/IR versatile facilities

# CFHT Northern Extragalactic Survey: Euclid&eROSITA/DESI

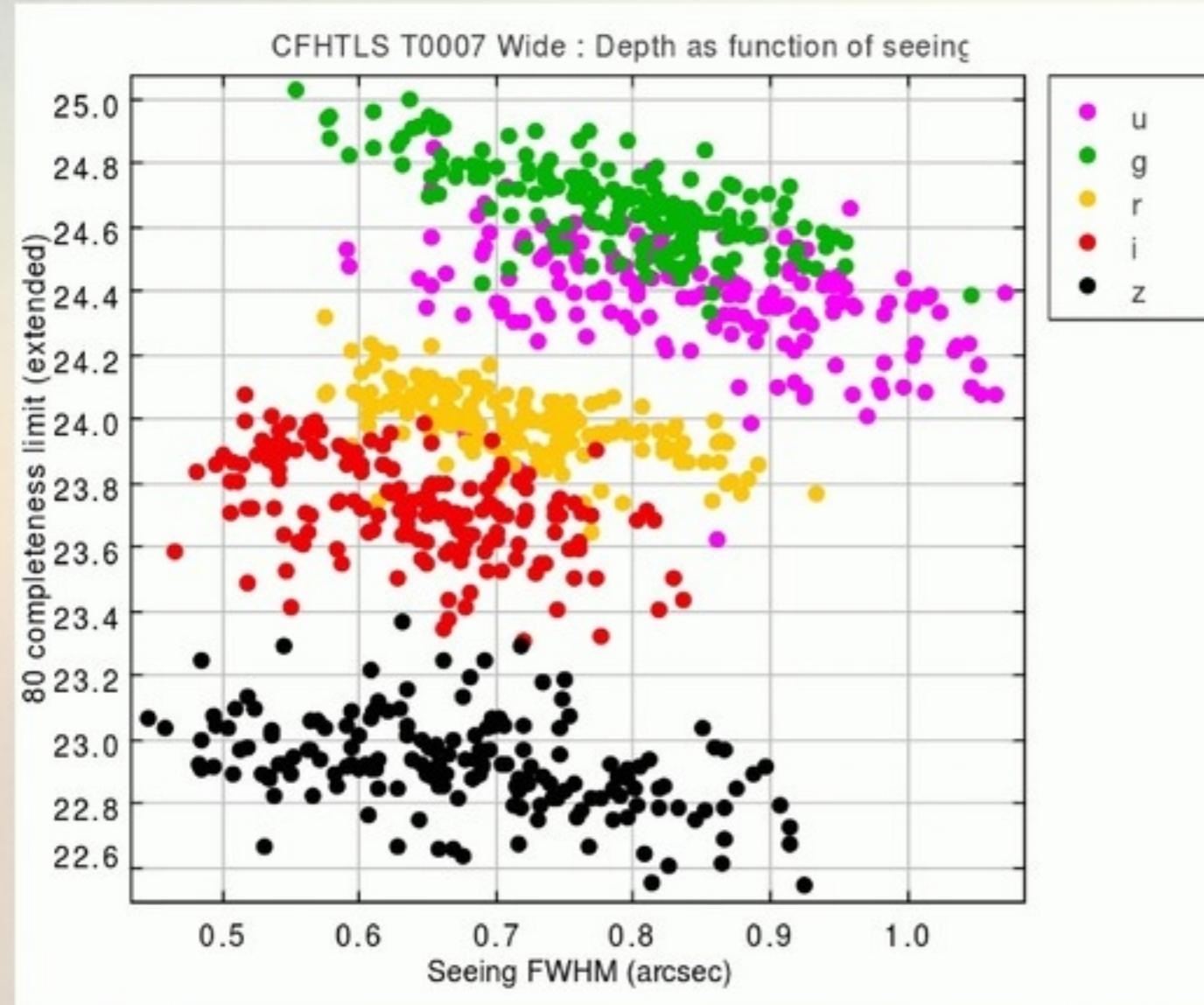


The sky visible from Hawaii

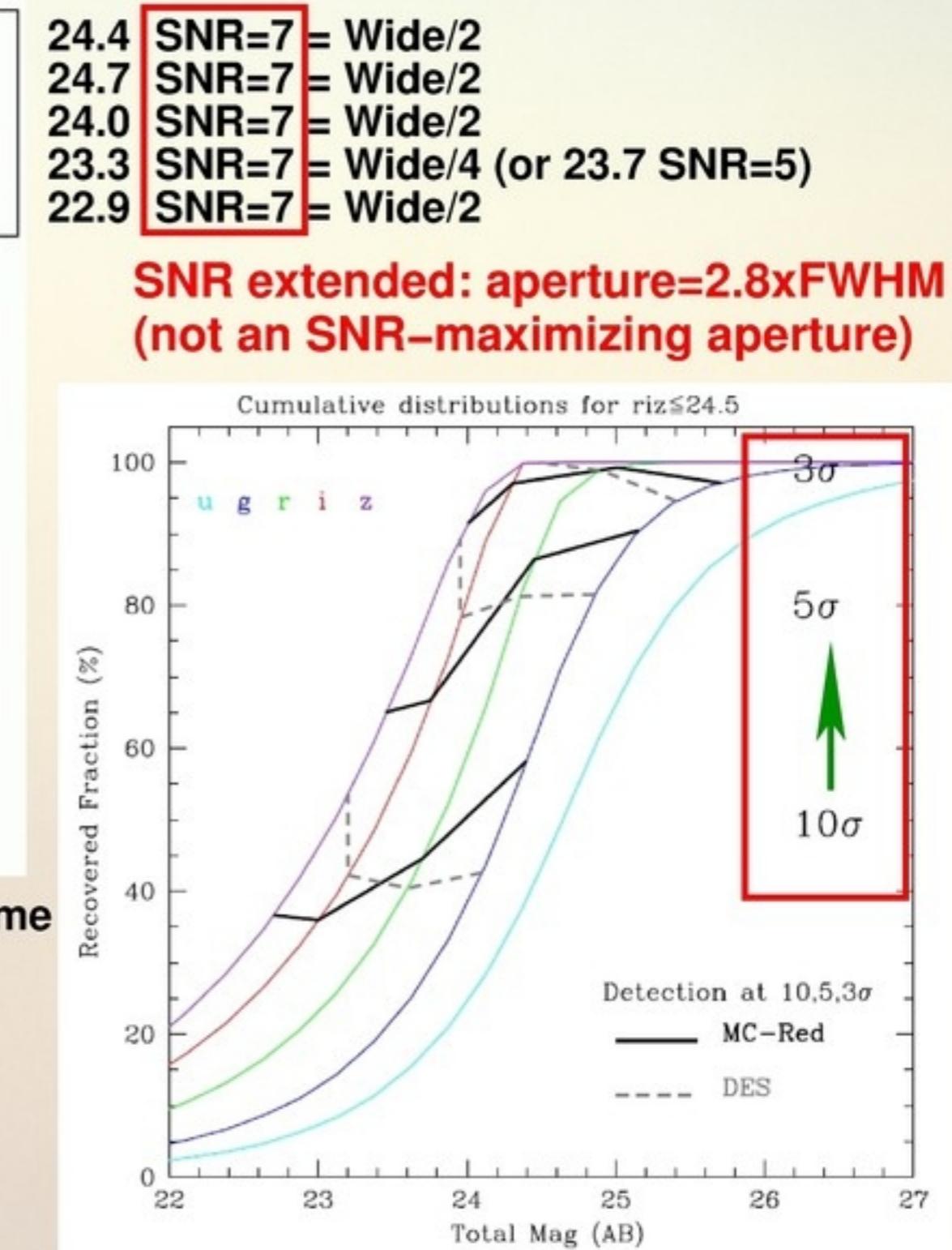
**CFHT NES-Euclid: 7500 sq.deg. (4 bands)**

**CFHT NES-eROSITA/DESI shallow extension: 3000 sq.deg. (3 bands)**

# CFHT NES Euclid: a "blue" Dark Energy Survey = CFHTLS Wide/2



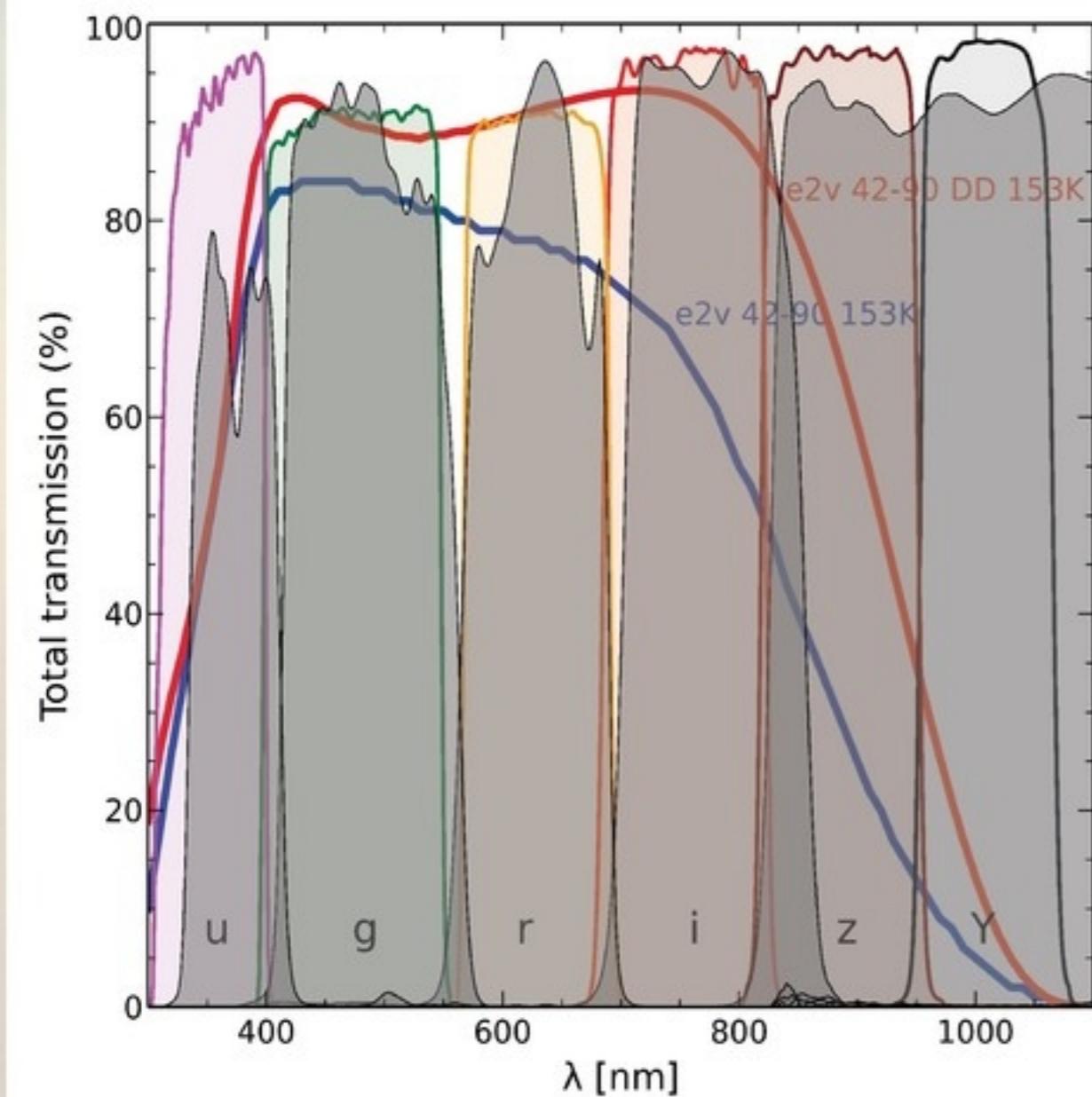
CFHTLS-Wide depth\* vs image quality at fixed intg. time



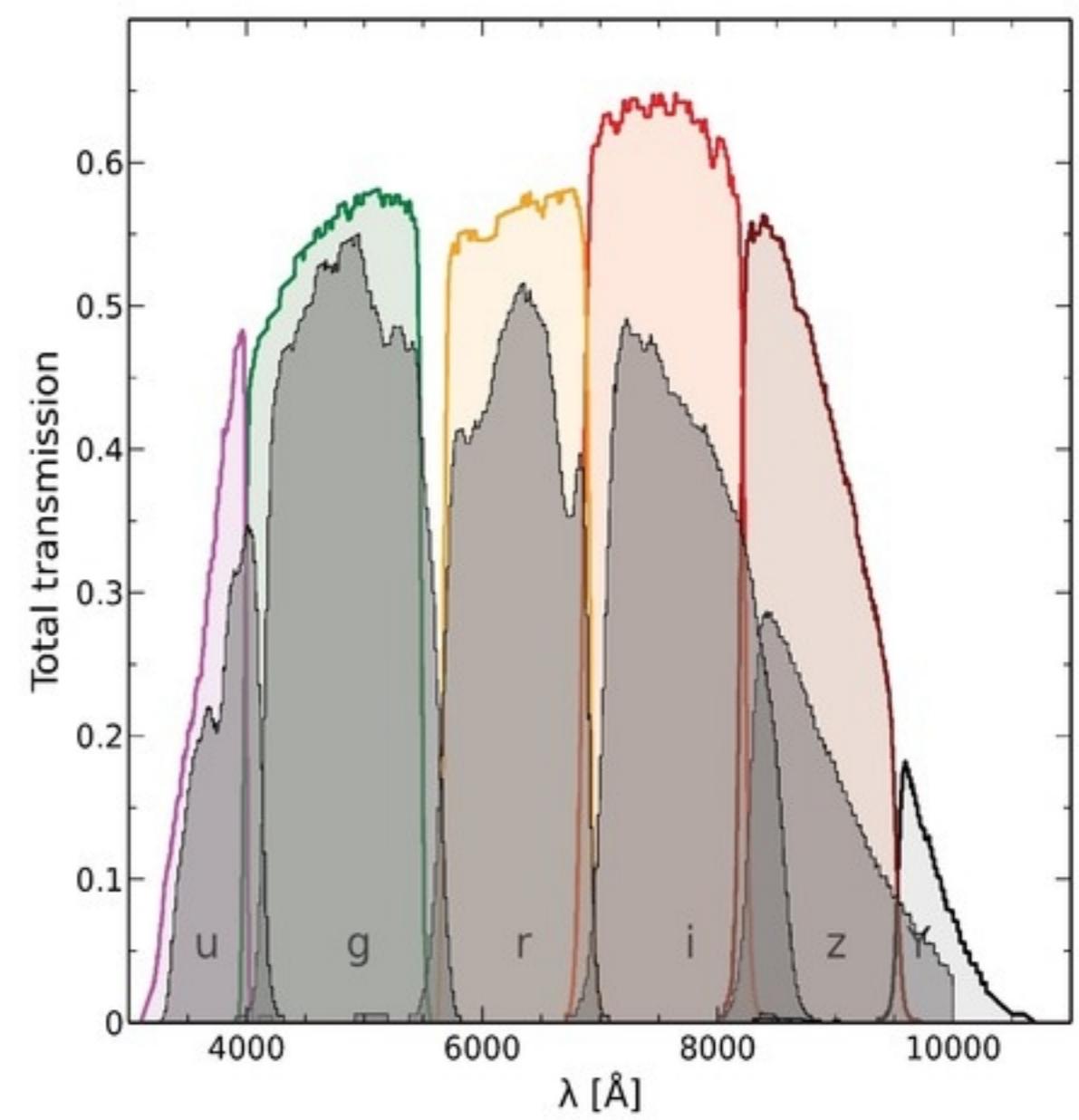
Matching Euclid: DES and NES (MC-Red)

\*CFHT now offers a SNR based dynamic integration ensuring a uniform depth for a survey

# MegaCam upgrade: new detectors, new filters, faster readout



Current MegaCam (blue) vs RED (red)



Total transmission (including atm.)

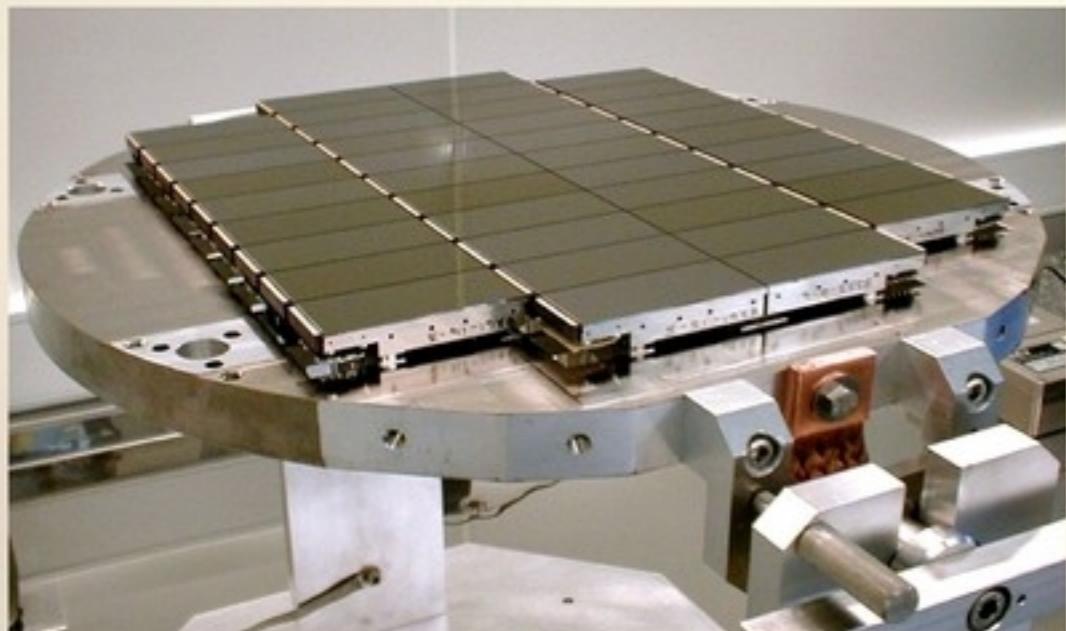
New CCDs: e2v 42–90 deep depletion with "Astro Multi–2" coating

New filters: higher transmission, steeper, larger (expose MegaCam "ears")

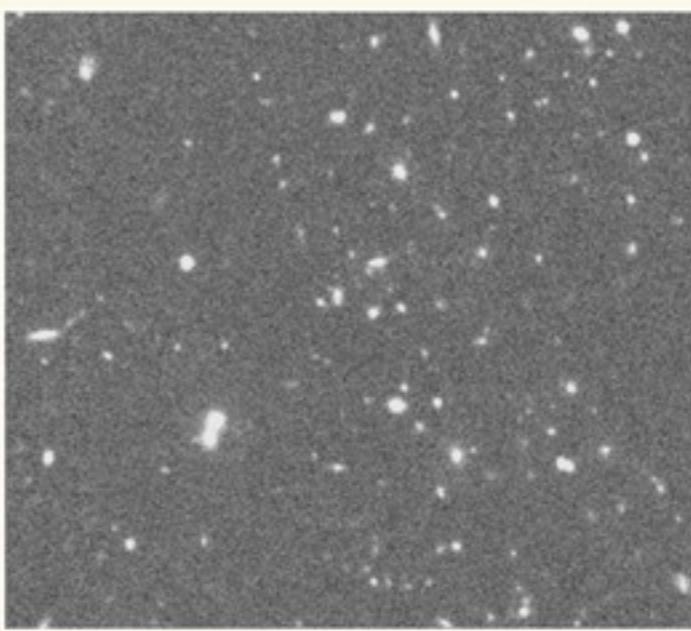
Faster readout: replace ADCs, optimize code and data processing (ringing)

**Key benefits from the e2v 42–90 deep depletion device:**

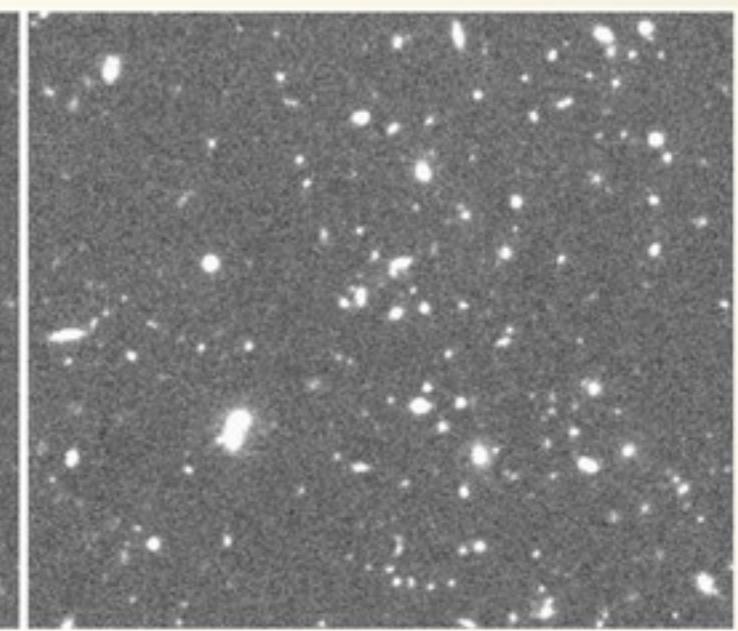
- Superior QE with DD silicon and lower fringing because of lower reflectivity
- Improves the near-UV response (300–400nm) with new coating "Astro Multi-2"
- 100% pin and voltage compatible with original version of the 42–90 (1998)



MegaCam focal plane (40 e2v 42–90)



Gemini GMOS 2011 swap: before/after (1hr, 0.5", z)



## The MegaCam upgrade (RED) in numbers:

Total budget identified: \$2.5M (with two test benches, excluding all in-kind FTE)

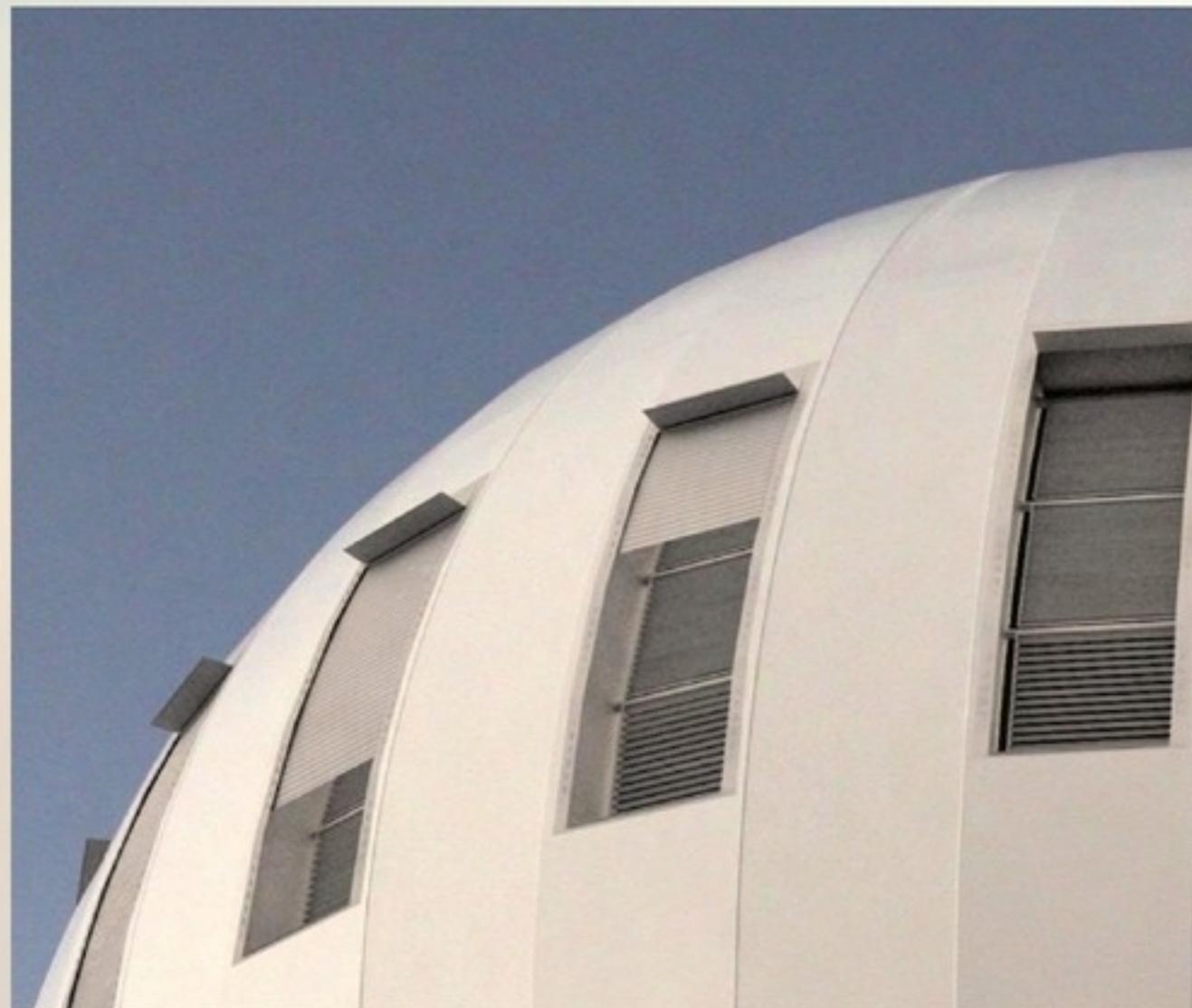
Funds: Dunlap (Toronto, \$1M), German eROSITA group (\$1M), CFHT (\$0.5M)

Instrumental effort: CEA and CFHT (original MegaCam partners)

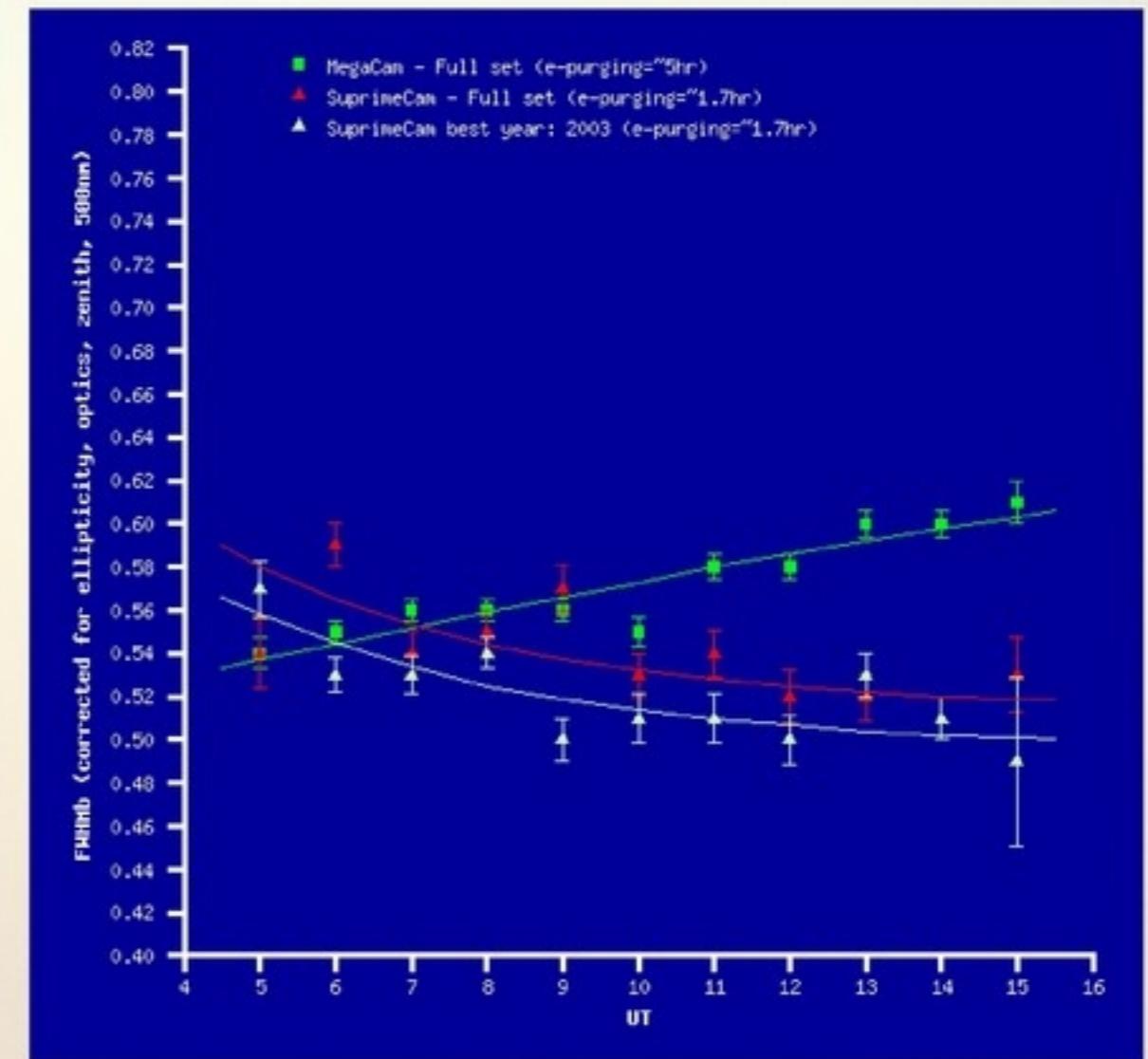
Schedule: Jan. 2014 to first light early 2016 (set by e2v delivery over 15 months)

Pending a 1200 nights survey decision by CFHT's board in Dec. 2013 & Jun. 2014

# Dome venting: boosting the Northern Extragalactic Survey (NES)



Full integration: fall 2013



Matching Subaru's performance: 0.1" gain

Not just a gain in absolute: the IQ will get far more uniform throughout the night

CFHT could possibly reclaim its title of best in the class for image quality

Tremendous potential for lensing with CFHT NES (0.6") versus DECam DES (1")

# Milestones for a CFHT–NES Euclid&eROSITA/DESI approval

- Dec. 2013: CFHT boards approves the strategic approach
- Jan. 2014: CFHT director appoints a CFHT–NES Steering Group
- Jan. 2014: The CCD test bench effort starts at CEA
- Feb. 2014: Preliminary contract discussion with e2v for 40 CCDs
- Mar. 2014: CFHT NES national meetings in France and Canada You!
- Mar. 2014: Mapping the CFHT–NES into the INSU prospective You!
- Apr. 2014: Submission of a survey plan to CFHT (SAC) You!
- May 2014: Approval of the survey plan by SAC
- Jun. 2014: Approval of the survey plan by CFHT board (1,200 nights, 2016–2022)
- Jun. 2014: Access to the Toronto and German funds (\$2M)
- Jul. 2014: CCD contract with e2v starts
- Dec. 2014: CCD testing starts at CEA
- Oct. 2015: MegaCam cryostat ships to CEA for CCD replacement
- Dec. 2015: MegaCam cryostat ships back to CFHT
- Jan. 2016: MegaCam–RED first light
- Feb. 2016: Northern Extragalactic Survey starts! You!