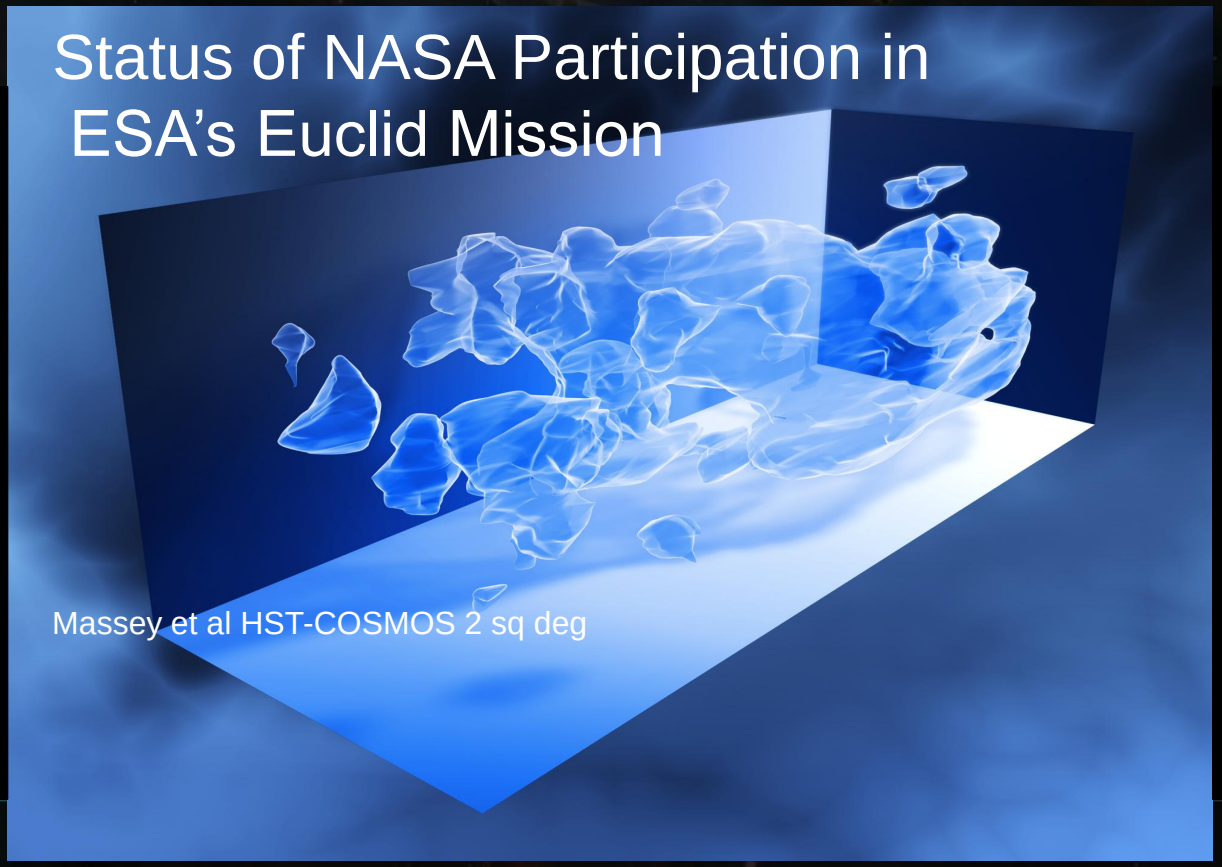
National Aeronautics and Space Administration

Status of NASA Participation in ESA's Euclid Mission



Astrophysics

PhysPAG Meeting

January 6 2013

Richard Griffiths

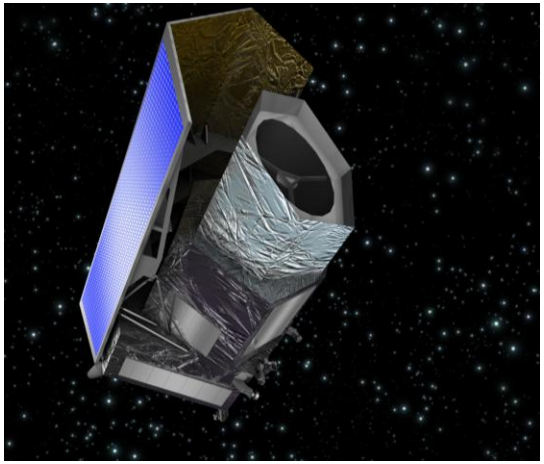
Euclid Program Scientist
Astrophysics Division

Lia LaPiana Prog Exec

Euclid – M-class ESA Mission : Overview

Summary

- ESA Cosmic Vision 2015-2025 Mission, M-Class
- Optical and NIR Observatory with 1.2-m Telescope (origins in SPACE/DUNE)
- U.S. Providing Characterized NIR Detectors in exchange for 40 EC members and 1 EST/ECB member
- Launch Date: Mar 2020



Cosmology:

- Use two independent probes (weak lensing and galaxy clustering), i.e. imaging survey and redshift survey, to examine:
  - The nature of Dark Energy and Dark Matter
  - The growth of large-scale structure
  - If General Relativity is a correct description of nature

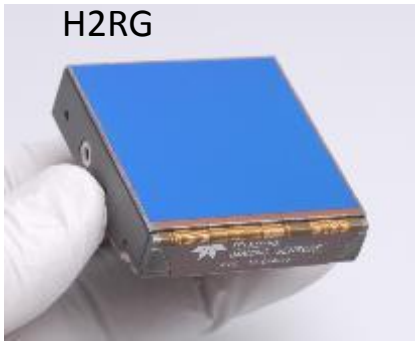
Legacy Science Examples:

- Examine expansion history and star formation history of the Universe through supernovae detections.
- Investigate galaxy formation and evolution
- Conduct a deep NIR survey to explore the high-redshift Universe.

NASA's Minor Partnership Agreement with ESA

- ESA Responsibilities
  - Mission, Spacecraft, Launch vehicle, GDS
    - Spacecraft/Prime contractor ITT underway – selection by June 2013

    Euclid Consortium (EC) responsibilities – 2 Instruments, Science Data Centers, science
- ESA/NASA MOU developed – in final signatures
  - NASA responsible for Sensor Chip Systems (SCS) for Near Infrared Spectrometer and Photometer (NISP) Instrument. ($45M)
    - Teledyne H2RG HgCdTe detector, SIDECAR ASIC, and flexible cryogenic cable. (16 FM and 4 FS)
  - NASA gets 40 new EC member slots, selected through NRA. ($50M lifetime science team cost)
  - JPL Project Office (PM Ulf Israelsson, PS Michael Seiffert)
  - Detector char. at GSFC DCL [PCOS Program Office MM Tom Griffin]



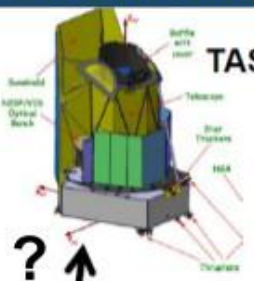
SIDECAR™ (system image, digitizing, enhancing, controlling, and retrieving) ASIC (Application Specific Integrated Circuit)

Contributions of the Euclid Consortium

EUCLID CONSORTIUM

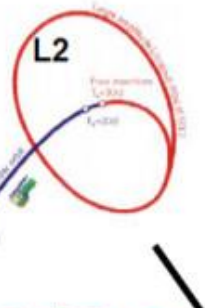
Astrium

TAS



Soyuz@Kourou
Dec. 2019

L2



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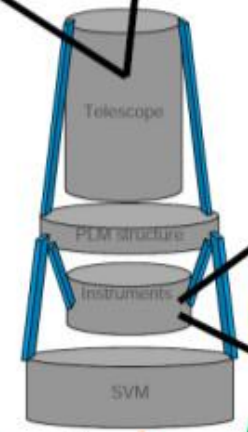
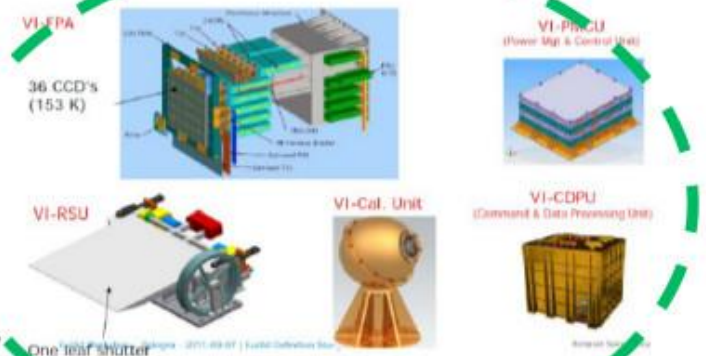
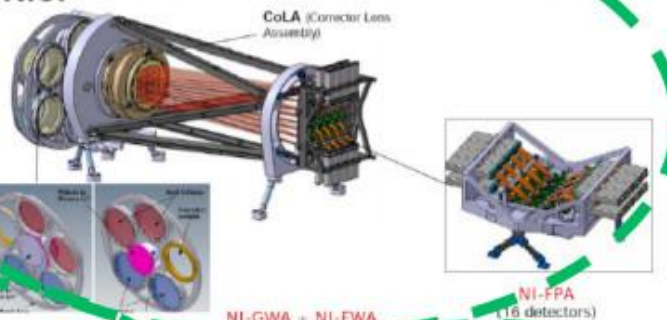


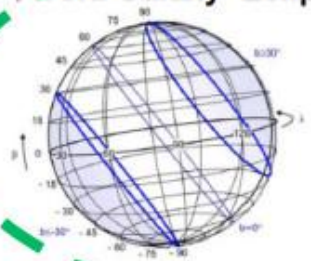
VIS

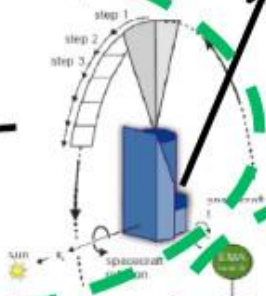


NISP



Avoid Galaxy+Ecliptic





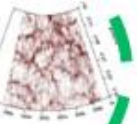
6 yrs mission
Deep+Wide

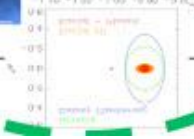
SGS

NI-GWA + NI-FWA

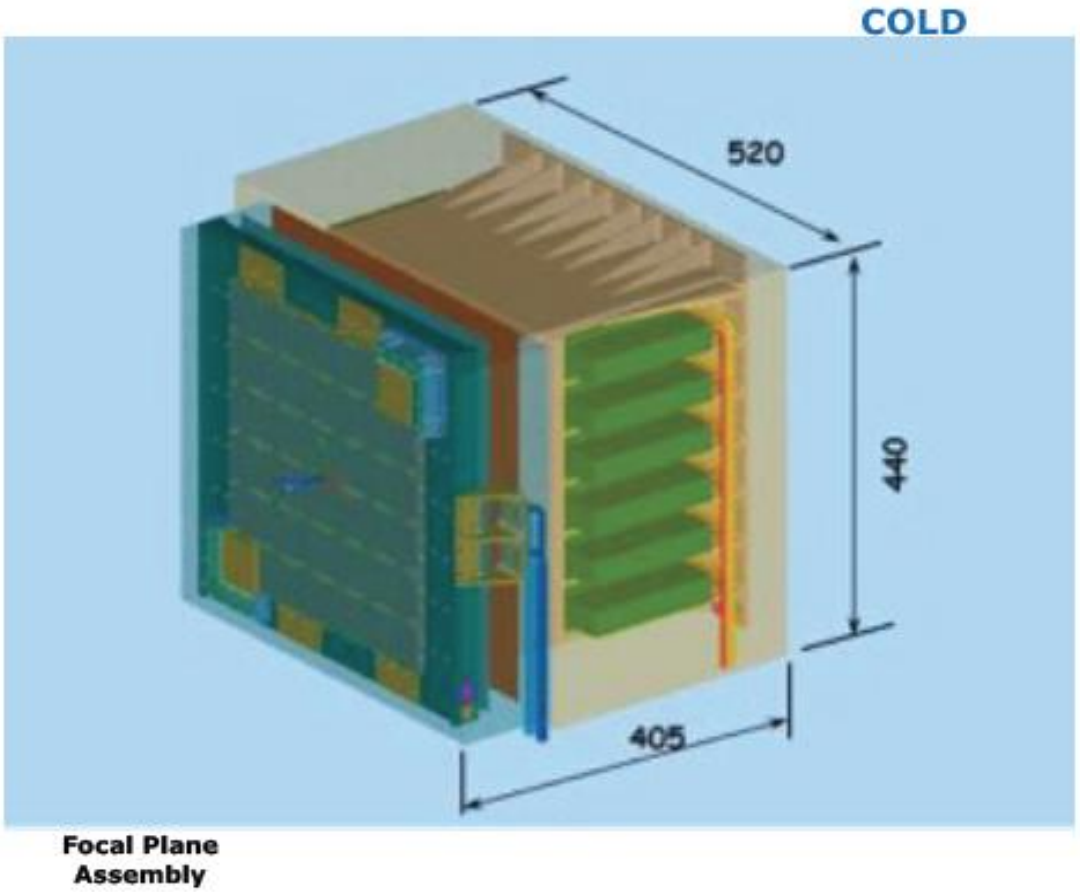
NI-FPA
(16 detectors)

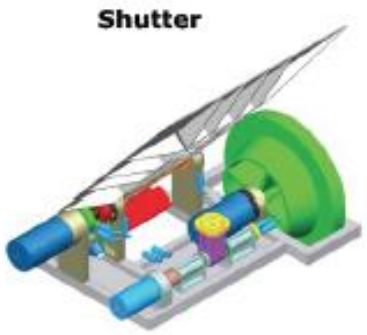
SWG:
2020-2028

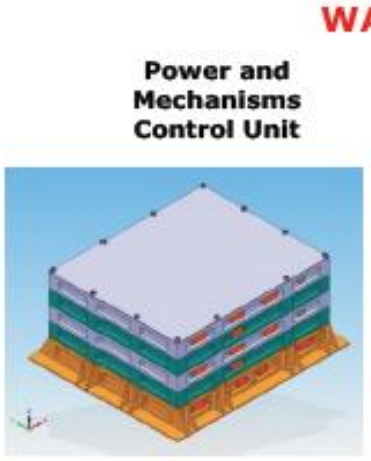




Visible Instrument (VIS)







- 36 4k x 4k CCD arrays cooled to ~150K
- 0.55 – 0.9 um

NISP GENERAL ARCHITECTURE

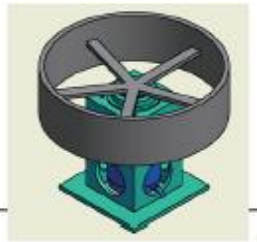
NISP is a Large Field Photometer & Slit Less Spectrograph

MASS < 128Kg ; POWER < 120W; TELEMETRY < 240 Gbit/day

3 main assemblies :

- NI-OMA : Opto Mechanical Assembly in Cold PLM
- NI-DS : Detection System mounted on NI-OMA
- NI-WE ; Warm Electronics in warm SVM

- + NI-CMU : Torque Compensation Mechanism Unit in warm SVM



- **16 2k x 2k HgCdTe arrays cooled to ~100K**
- **0.9 – 2.0 um**

Overview

Euclid Consortium

The Euclid Consortium http://www.euclid-ec.org

See Bologna and Copenhagen EC meeting presentations, Euclid RedBook and EC Newsletters

• EC: ~950 registered members (as of May 2012): ~600 researchers

-in ~110 laboratories/departments

Approval of new members done by the Euclid Consortium Membership Committee (18 members)

• 13 European countries contributing:

• Austria, Denmark, France, Finland, Germany, Italy, Netherlands, Norway, Portugal, Romania, Spain,Switzerland, UK

+ NASA 40 members, subject to MoU

+ Contributions from Berkeley labs.

Data rights: Level1 data released to public 14 months from start,

i.e. year 1 data is released 2 months after end of year 1

Level 2 data are released one year after Level 1 release

NASA: Euclid Science Teams Competition

- **ESA-NASA MoU provides for NASA to nominate**
  - **40 members to Euclid Consortium (EC)**
  - **1 member of the Euclid Science Team (EST)**
  - **1 member of the Euclid Consortium Board (EC)**

ROSES competition for funded teams:
proposals due 31 August 2012; selections 7 December 2012

Fiscal Year	2013	2014	2015	2016	2017	2018	BTC	Total
$M	1.0	1.5	2.0	2.5	3.0	4.0	36.0	50.0

Jason Rhodes (JPL) selected for EST and Euclid Consortium Board

Total of 3 science proposals selected: PIs Rhodes, Kashlinsky, Chary

Selected scientists will join Science Working Groups within Euclid Consortium; they will have same data rights as ESA Consortium members

IPAC study on NASA contributing an US Euclid Science Data Center, due April 2013: this center is NOT included in ESA-NASA MoU
Only the study is funded in current baseline

Science of Selected Proposals

- "Precision Studies of Galaxy Growth and Cosmology Enabled Through a Physical Model for Nebular Emission", PI Chary (Caltech), 3 members

Studies the effect of dust and glowing gas on galaxy spectra, to obtain better distance (redshift) estimates from the measured colors.

- "Looking at Infrared Background Radiation Anisotropies with Euclid", PI Kashlinsky (GSFC), 7 members

Studies unresolved infrared background light from the earliest galaxies, to infer the pace of early star formation.

- "Constraining Dark Energy and Gravity with Euclid", PI Rhodes (JPL), 29 new EC members + 14 current EC members

Measures dark energy and how mass is distributed on the largest cosmic scales, through weak lensing (distortions of galaxy shape), baryon acoustic oscillations (galaxy clustering), and supernova explosions; studies how galaxies form by observing the most youthful (high-redshift) objects.

NASA's nominations for new EC members (1)

"Constraining Dark Energy and Gravity with Euclid"	PI Jason Rhodes
Rachel Bean, Cornell	Steven Kahn, Stanford
Charles Bennett, JHU	Alina Kiessling (postdoc), JPL
Gary Bernstein, UPenn	Eric Linder, LBNL
Mark Brodwin, UMiss at Kansas City	Robert Lupton, Princeton
Asantha Cooray, UC Irvine	Rachel Mandelbaum, CMU
Francesco DeBernardis (postdoc), UC Irvine	Leonidas Moustakas, JPL
Peter Eisenhardt, JPL	Nikhil Padmanabhan, Yale
Daniel Eisenstein, Harvard	David Spergel, Princeton
Richard Ellis, Caltech	S. Adam Stanford, UC Davis
Cosimo Fedeli (postdoc), U Florida	Daniel Stern, JPL
Jonathan Gardner, NASA GSFC	Michael Strauss, Princeton
Anthony Gonzalez, U Florida	Harry Teplitz, CalTech
Christopher Hirata, CalTech	Ali Vanderveld (postdoc), U Chicago
Shirley Ho, CMU	Risa Wechsler, Stanford
Bhuvnesh Jain, UPenn	Michael Seiffert (JPL Euclid Project Scientist)

NASA's nominations for new EC members (2)

Looking at Infrared Background Radiation Anisotropies with Euclid, PI Kashlinsky	Precision Studies of Galaxy Growth … Physical Model of Nebular Emission, PI Chary
Alexander Kashlinsky, NASA GSFC	Ranga Ram Chary, CalTech
Richard Arendt, NASA GSFC	Daniela Calzetti, UMass, Amherst
Matthew Ashby, SAO	A Postdoctoral Researcher to be named
Volker Bromm, U Texas	
Guenther Hasinger, U Hawaii	
Harvey Moseley, NASA GSFC	
A Postdoctoral Researcher to be named	

Backup Slides

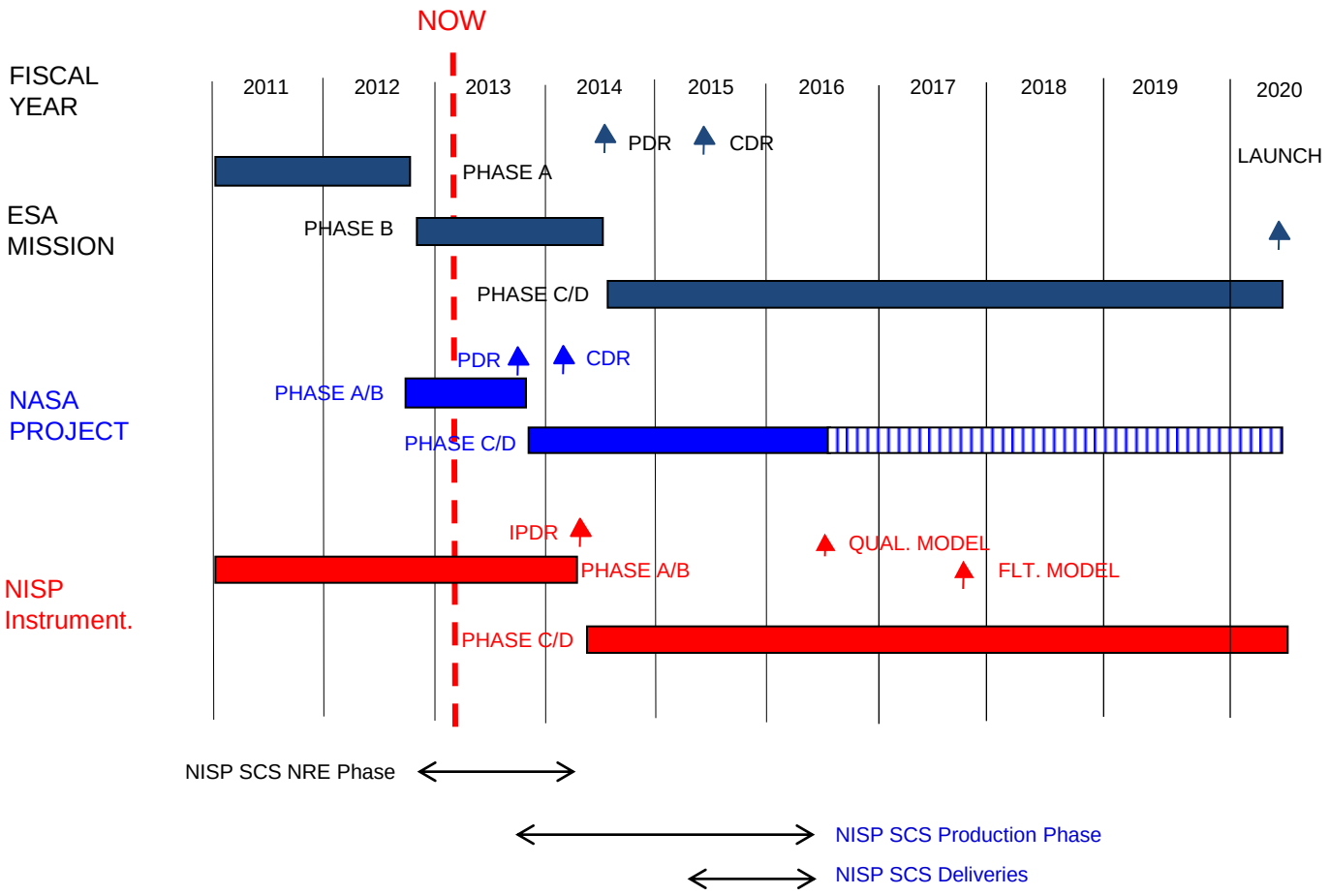
NASA Contributions to ESA's Euclid mission

- **NASA providing 16 flight "triplets" – 2Kx2K HgCdTe array (H2RGs) + flex cable + SIDECAR ASIC control electronics – the complete focal plane for the NISP instrument plus 4 flight spares**
  - **Arrays to be fabricated at Teledyne with requirements and recipe demonstrated in ESA-funded NRE phase currently underway**
  - **NASA responsible for characterization, selection, and delivery of flight devices**
  - **NASA expecting receipt of several NRE phase devices for early start on testing**
  - **First delivery to ESA planned for late CY2014**
- **NASA-funded science teams to participate in Euclid mission**
  - **Selected PIs (3) have been notified**
  - **NASA HQs has sent letter nominating their teams to ESA HQs**
- **Study underway by IPAC to define possible NASA-funded Euclid Science Data Center.**
  - **Funding for implementing an US Euclid Science Data Center is currently not in the baseline.**

Mission Overview

- Euclid Mission Objective: dark energy probe of Weak Lensing and Baryonic Acoustic Oscillation (BAO)
  - Euclid is not exploring Type Ia Supernova
- Mission Specifics
  - Sun-Earth L2 orbit
  - Launch in 2018 on Soyuz
  - Survey 20,000 deg^2 of the sky beyond $|b|>30^o$ in a step-and-stare mode
    - Each Field views 0.5°x 0.5°
    - 4 dithered Pointings for each Field
  - Simultaneous observations with VIS and NISP instruments
- Instrument Configuration
  - Visible Channel (VIS) for measuring the distortions of galaxy shapes due to Weak Lensing
  - Near IR Spectrometer/Photometer (NISP)
    - Photometric measurements required to bin the galaxies by redshift
    - Spectroscopic measurements for BAO observations
  - NISP will sequentially image each pointing with 3 NIR filters and a grism
    - 3 Filters: Y=920-1146nm, J=1146-1372nm, H=1372-2000nm
    - Grisims cover 1.0-2.0 micron

ESA/NASA Project Top-Level Schedule



JWST H2RG Yield Model used for Euclid

- JWST Yield Model: 1/3 of detectors making it to test are science grade

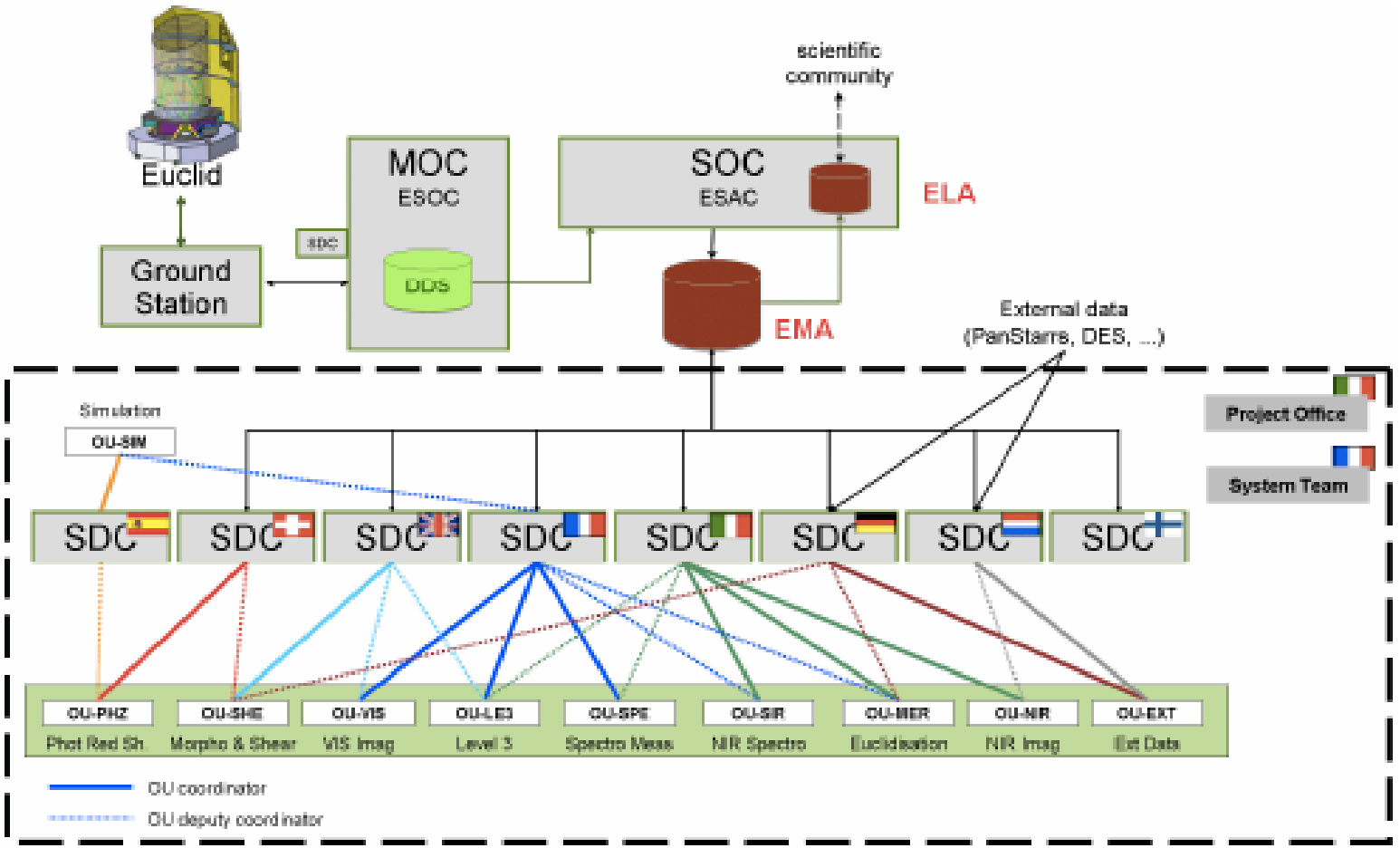
- EUCLID is buying 72 Detectors (6 Lots) to get 20 detectors. (28% yield)
  - 20 - Detectors Pass
  - 12 - Detectors Fail in Production
  - 40 - Detectors Tested Not Meeting Reqts.

    = 72
- Total cost per lot for Euclid: $1.6M
- Independent Validations of Model

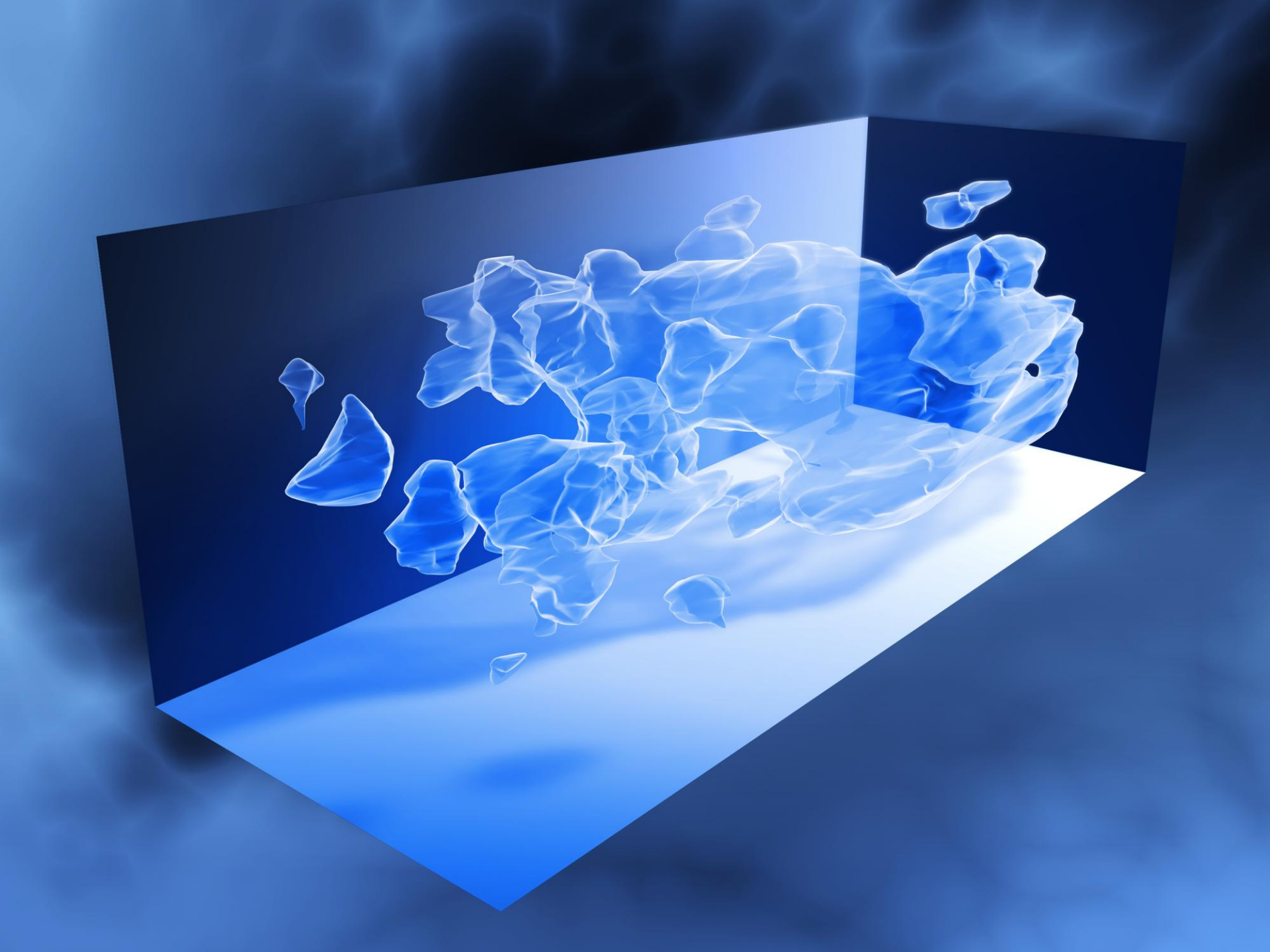
Mission Elements

- Spacecraft
  - Service Module
  - Payload Module
    - Telescope
    - NISP instrument (JPL contributes detectors, cables, and readouts)
    - VIS instrument
- Launch vehicle
  - Soyus ST-2.1 B from Kourou
- Ground Stations
  - Kourou (French Guiana), Malargue (Argentina), Cebreros (Spain), New Norcia (Western Australia)
- Data Processing
  - Mission Operations Centre (ESOC, Darmstadt, Germany)
  - Science Operation Centre (ESAC, Madrid, Spain)
  - Numerous Science Data Centers

Ground Segment



- **IPAC is performing a Study to determine a potential role for a NASA Euclid Science Data Center.**
- **Recommendations to NASA by ~February, 2013**



Instrument Requirements / Constraints

Item	Requirement / Constraint
Mission Duration	• 4 years/*5 years goal*
Orbit	• Sun-Earth L2
Operating Power	•Goal is less than 65 W
Mass	• Goal is less than 160 kg
Volume Allocation	• Initial allocation is 2.1 m diam x 450 mm height
Operating Temp / Stability	• Hawaii 2RG Detectors / ROIC: 100 K +/- 10mK • SIDECAR ASIC: 150K +/-1K • All other items in Instrument volume: 150 K • Electronics Boxes on Spacecraft Bus: -10 to 40 C (+/- 2C)
Data Storage &Compression	• Performed by spacecraft • Instrument will perform Correlated Double Sampling (CDS) • Raw instrument data will be time tagged and send to SC
Radiators	•FPA and ASIC and Mechanism radiators housed outside instrument volume •Electronic box radiators located on spacecraft
Coordination	• Simultaneous measurements with Visible Imaging Instrument (VIS)
Optical Bench	• Shared Optical Bench; Cost of the bench is not NISP's responsibility

Instrument Requirements / Constraints

Item	Requirement / Constraint
Mechanisms	(1) Filter Wheel (F/W) Mechanism • 5 positions • 3 filter, 1 filter window, 1 closed / shutter (2) Grism Wheel (G/W) Mechanism • 6 positions • Two 0 deg, two 90 deg, Open "A", Open "B"
Electro Optics	• Photometry bandwidth: Y (920-1146nm), J (1146-1372nm), and H (1372-2000nm) • Spectroscopy bandwidth: 1.0-1.5 microns and 1.5-2.0 microns • Throughputs for each of the optics: 5 mirrors at 98% efficiency; 4 lenses at 97% transmission; Dichroic at 94% transmission; Filters at 85% transmission in band; Grism at 75% transmission at peak with blazed response; Detector QE of 85% (input was 90%)