DUNE

Dark UNiverse Explorer

Institut de Ciències de l'Espai ICE/CSIC

Institut de Física d'Altes Energies IFAE

Centro de Investigaciones Energéticas, MedioAmbientales y Tecnológicas CIEMAT

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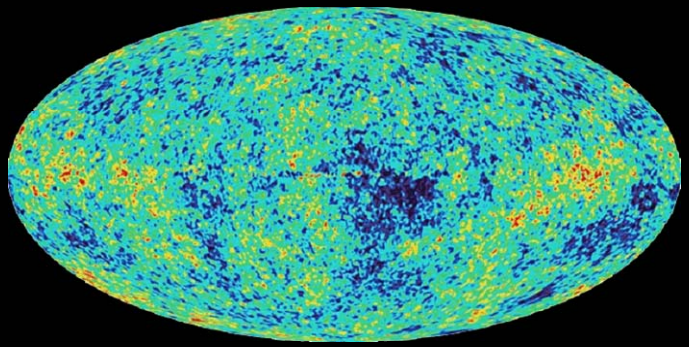
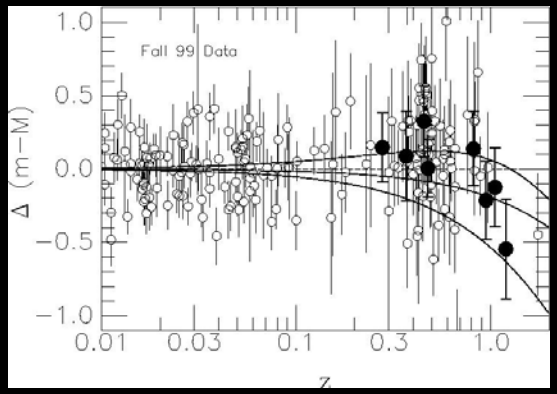
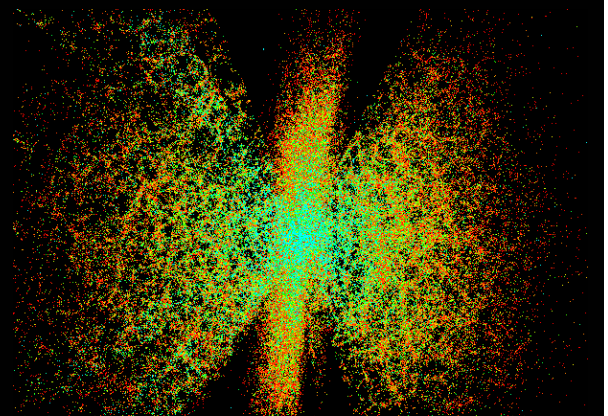
Cosmological Picture



WMAP measures the CMB radiation density field at z=1000



SNe measure the luminosity distance up z~1



Sloan Digital Sky Survey & 2dFGRS measure the galaxy density field at z < 0.3

Combined to measure parameters of cosmology to 10%

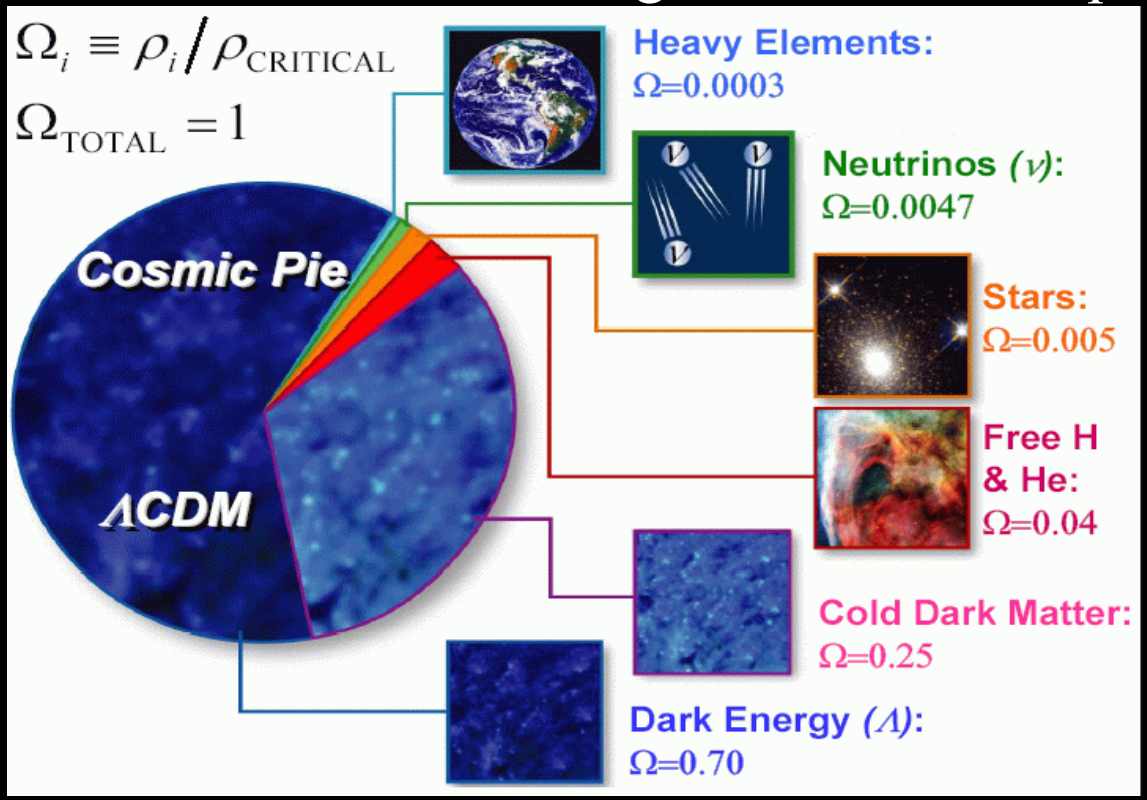
We enter the era of precision cosmology

Confirms dark energy (!)

2003 Science breakthrough of the year

The Big Problems: Dark Energy and Dark Matter

The confirmation of Dark Energy points to major holes in our understanding of fundamental physics



1998 Science breakthrough of the year

95% of the Universe is in forms unknown to us

Probing Dark Energy

- Dark energy is probed through how it influences the expansion rate of the universe H(z) and the rate growth of structure g(z)

$$H^2(z) = H^2_0 \left[\underbrace{\Omega_M (1+z)^3}_{\text{matter}} + \underbrace{\Omega_R (1+z)^4}_{\text{radiation}} + \underbrace{\Omega_K (1+z)^2}_{\text{curvature}} + \underbrace{\Omega_{DE} (1+z)^{3(1+w)}}_{\text{dark energy}} \right]$$

g(z) in general a complicated function of cosmological parameters

Probing Dark Energy

- Geometric test: integrals over H(z):

Comoving distance		$r(z) = F[\int dz/H(z)]$
Standard Candles	Supernovae	$D_L(z) = (1+z)\, r(z)$
Standard Rulers	Baryon Oscillations	$D_A(z) = (1+z)^{-1}\, r(z)$
Standard Population	Clusters	$dV/dzd\Omega = r^2(z)/H(z)$

- Growth of Structure test: g(z)

  Clusters, Weak lensing, clustering

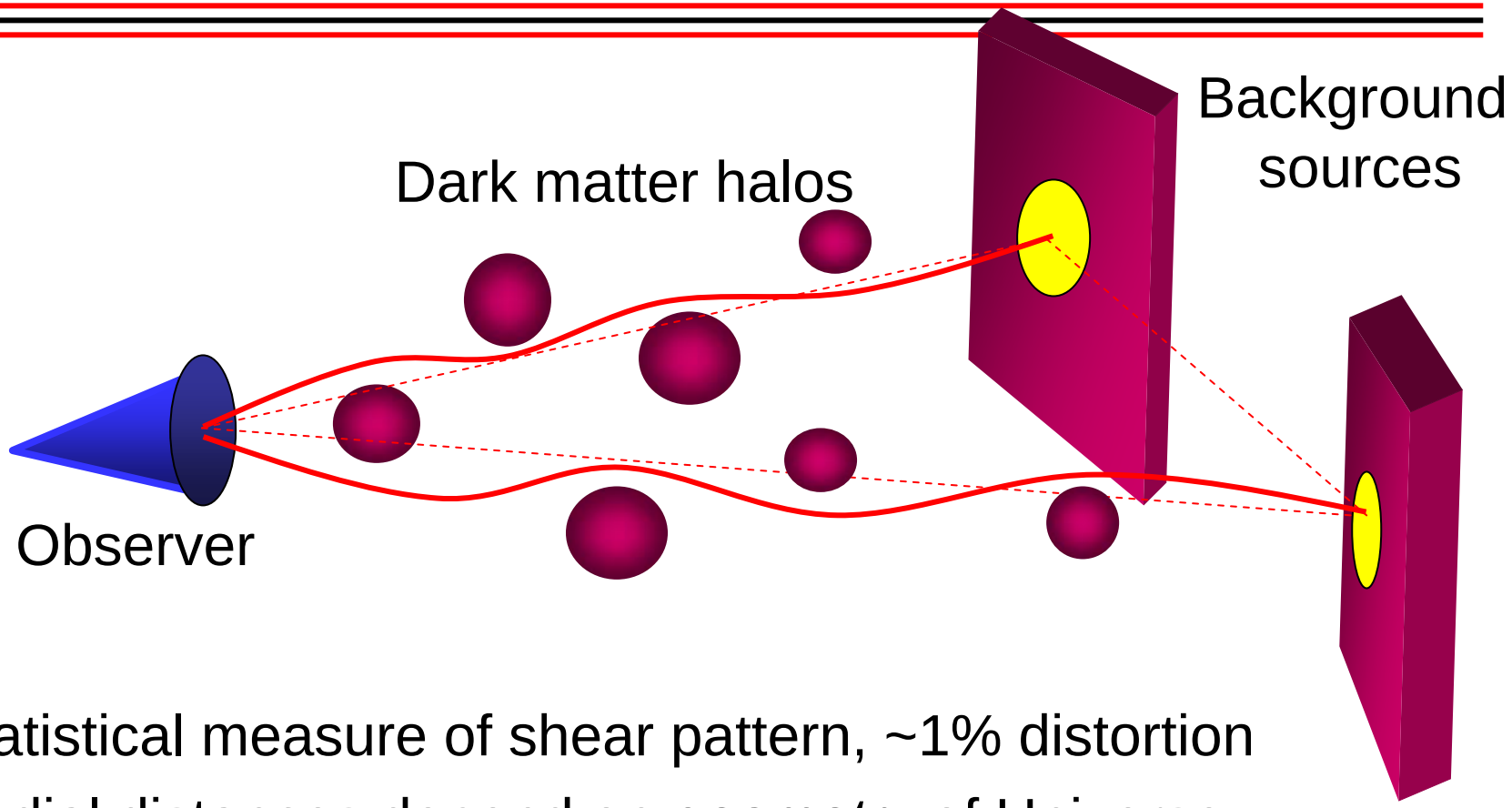
- DE equation of state: $w = P/\rho$
- DE parameterization: $w(z) = w_0 + w_a z/(1+z)$

Probing Dark Energy

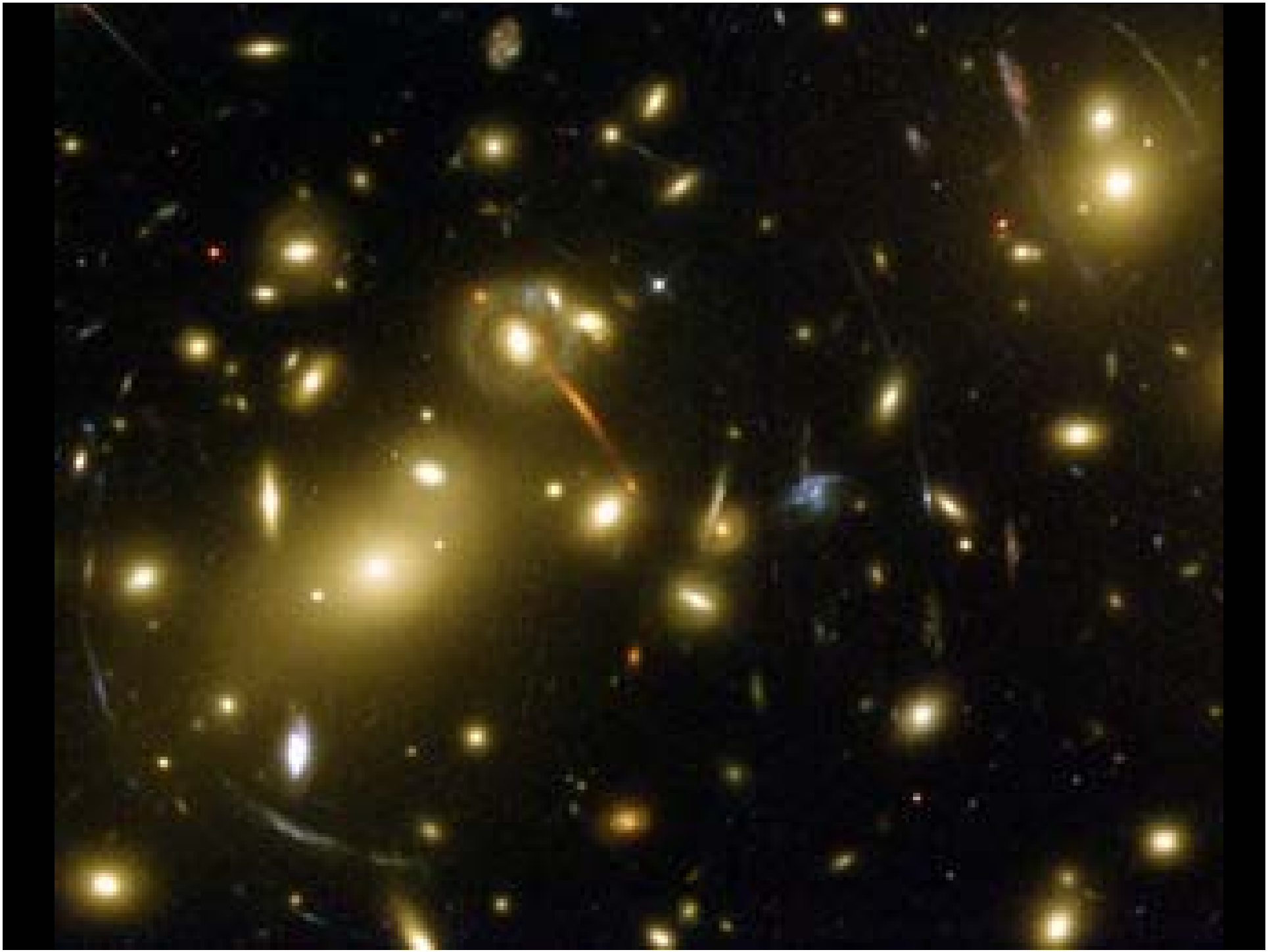
Best observational probes

- Weak lensing (geometrical & growth)
- Baryon acoustic oscillations (geometrical)
- Supernovae (geometrical)
- Clusters of galaxies (growth & geometrical)

Weak Lensing: Cosmic Shear



- Statistical measure of shear pattern, ~1% distortion
- Radial distances depend on *geometry* of Universe
- Foreground mass distribution depends on *growth* of structure



Reviewing Committees

Dark Energy Task Force and ESA/ESO working group on fundamental Cosmology Recommendations

- Strongly recommend an aggressive program to explore dark energy
- Wide Field optical and NIR imaging survey from space

ESA Cosmic Vision 2015-2025 themes

4. How the universe originate and what is made of?

4.1 The early Universe:

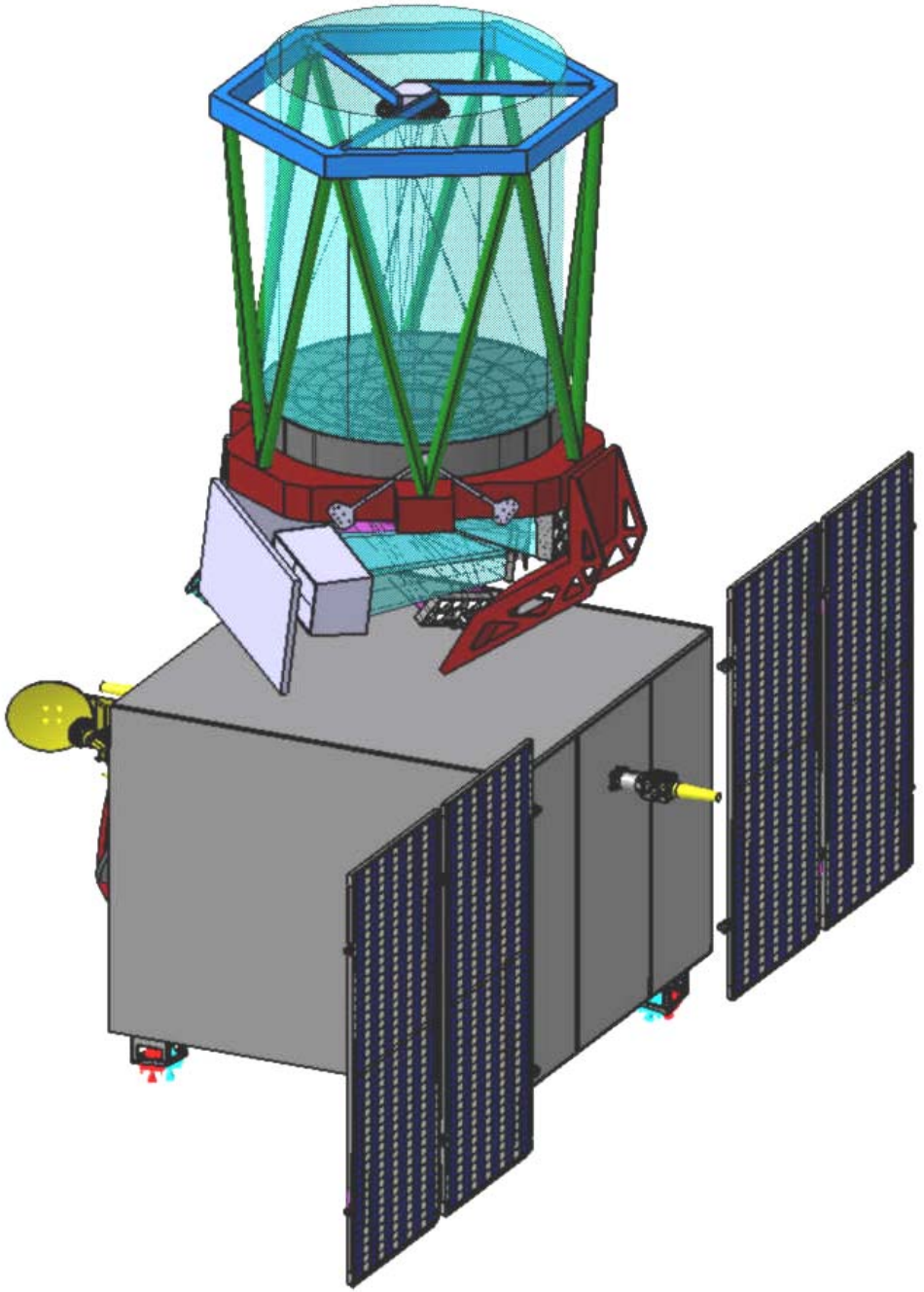
Investigate the nature and origin of Dark Energy that is accelerating the expansion of the Universe

Tool: Wide-field optical-infrared imager

DUNE

Wide Field optical and near infrared imaging survey from space designed to study the dark components of the universe: Dark Energy and Dark Matter

Responds to Cosmic Vision 20015-2025 Themes



DUNE: history

- Lead by France. PI: Alexandre Refregier (Saclay)
- Proposed to CNES
- Funded phase 0 study (led by Astrium)
- Does not fit into CNES budget
- CNES recommends to apply to ESA Cosmic Vision Programme
- A European collaboration has been formed and is working on modifying and redefining the mission concept

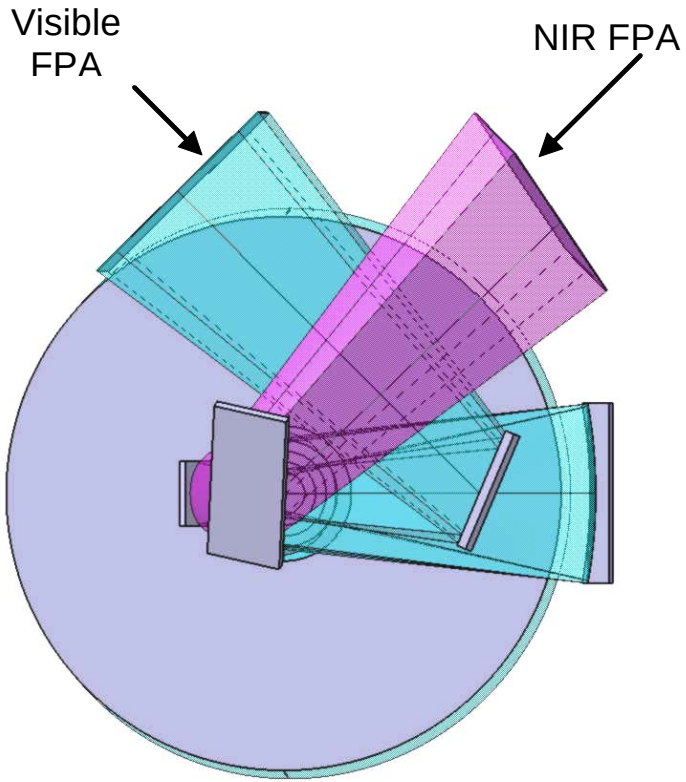
DUNE collaboration

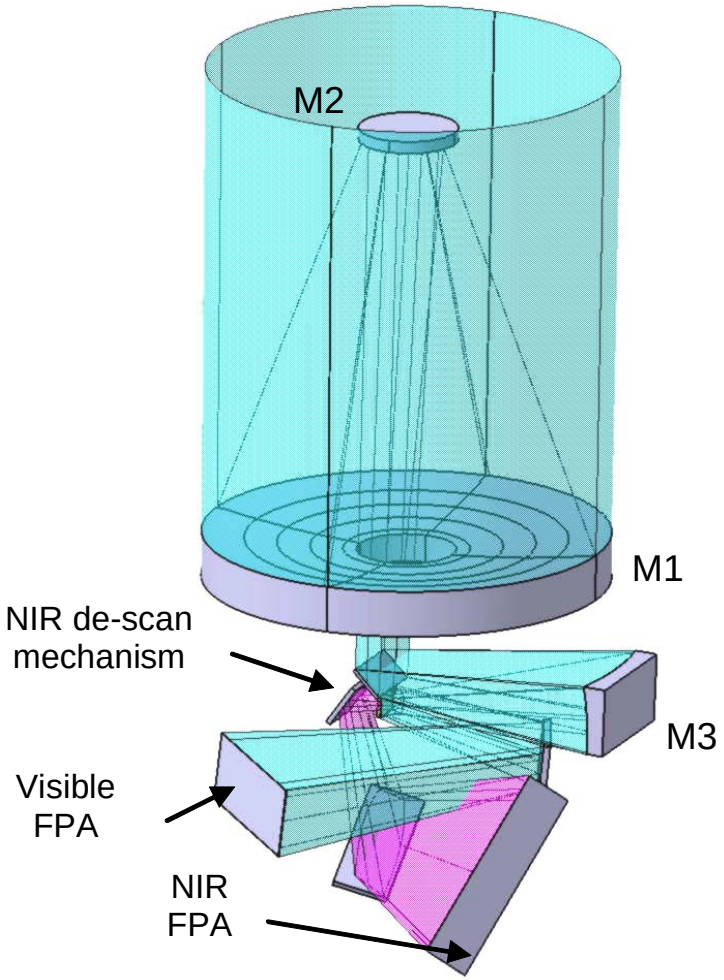
- France (Saclay, IAP, Paris, Marseille, Lyon, CNES, Astrium)
- Germany (Bonn, Heidelberg, Munich, Potsdam)
- Italy (Rome, Padova, Trieste)
- Spain (ICE/CSIC, IFAE, CIEMAT)
- Switzerland (Zurich, Lausanne, Basel)
- United Kingdom (UCL, Edinburgh, Cambridge, Oxford, Durham)
- USA (JPL, NASA)

DUNE: instrument summary table

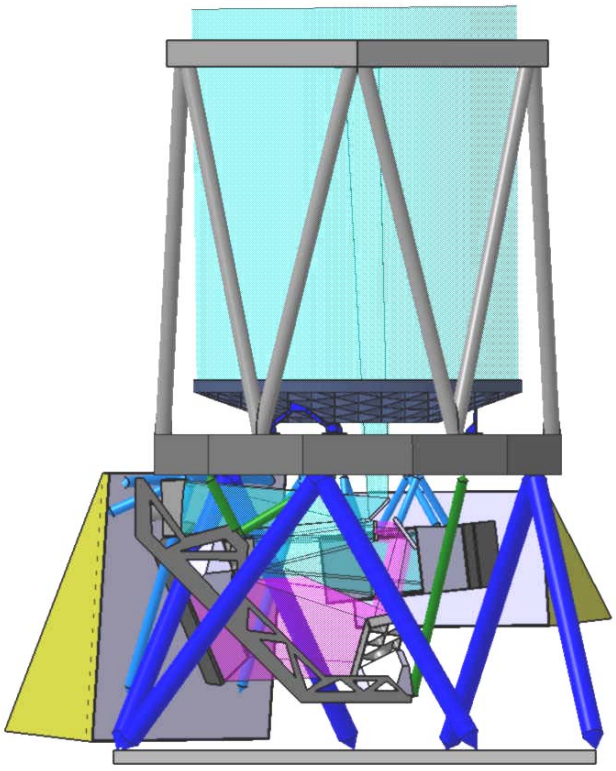
	Parameter	Value / Description	Unit
Instrument definition			
Optical configuration	-	Off-axis Three Mirror Anastigmat (TMA)	-
Pupil diameter	D	1.2	meter
Focal length	Foc	24.2	meter
f-number	n	20	-
Spectral range	VIS-WR	VIS : 500-900	nm
	NIR-WR	NIR : 920-1600 (3 bands)	nm
Spectral separation	-	Dichroic mirror	-
Resolution (pixel size)	VIS-IFOV	0.102	arcsec
	NIR-IFOV	0.15	arcsec
Visible FOV	VIS-FOV	1.08 x 0.48	degree²
		(array of 4 AL x 9 AC matrices / 4096 x 4096 pixels per matrix / 12µm pitch)	
NIR FOV	NIR-FOV	1.04 x 0.44	degree²
		(array of 5 AL x 12 AC matrices / 2048 x 2048 pixels per matrix / 18µm pitch)	
Observation modes			
Visible channel	-	TDI through S/C slow rotation	
		1500s integration time per celestial object	
NIR channel	-	Step&stare through de-scan mechanism	
		300s integration time per celestial object	
Main interface data			
Volume	V	Cylinder : 1900 diameter x 2650 height	mm
Mass	M	454	Kg
Power	P	219	W

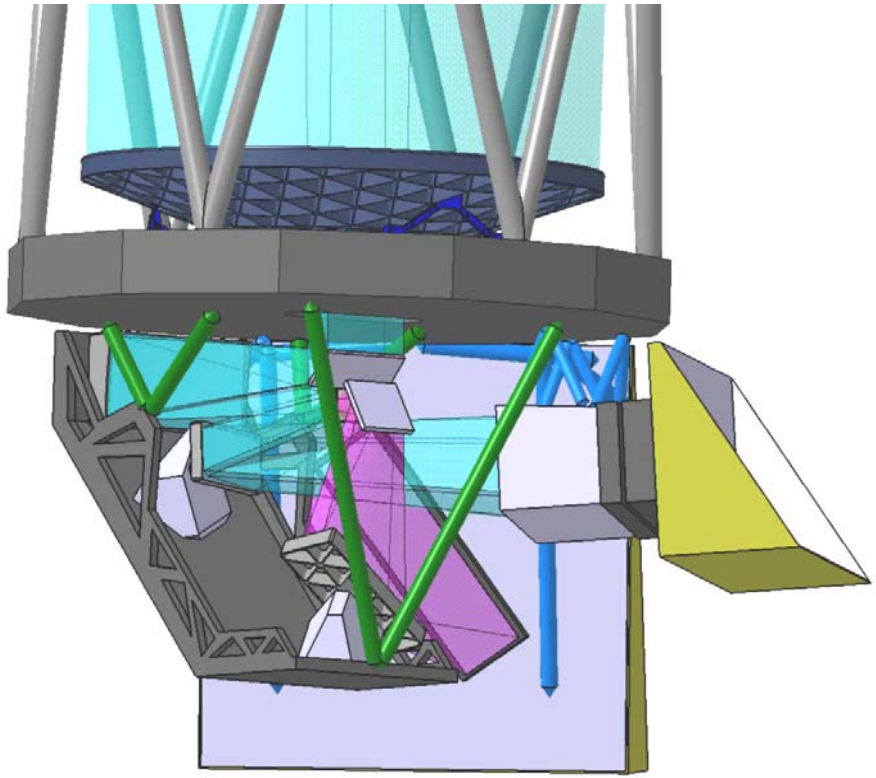
DUNE optical configuration



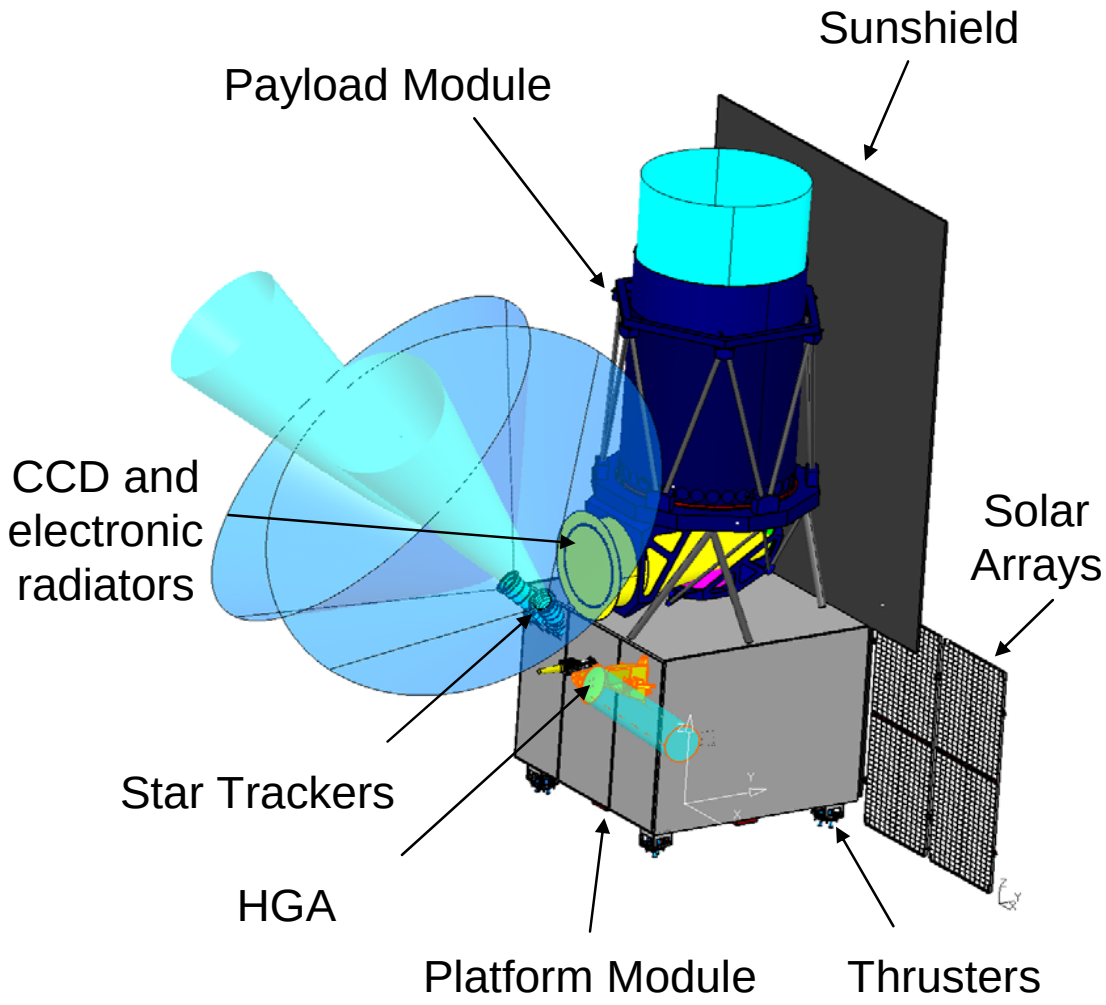


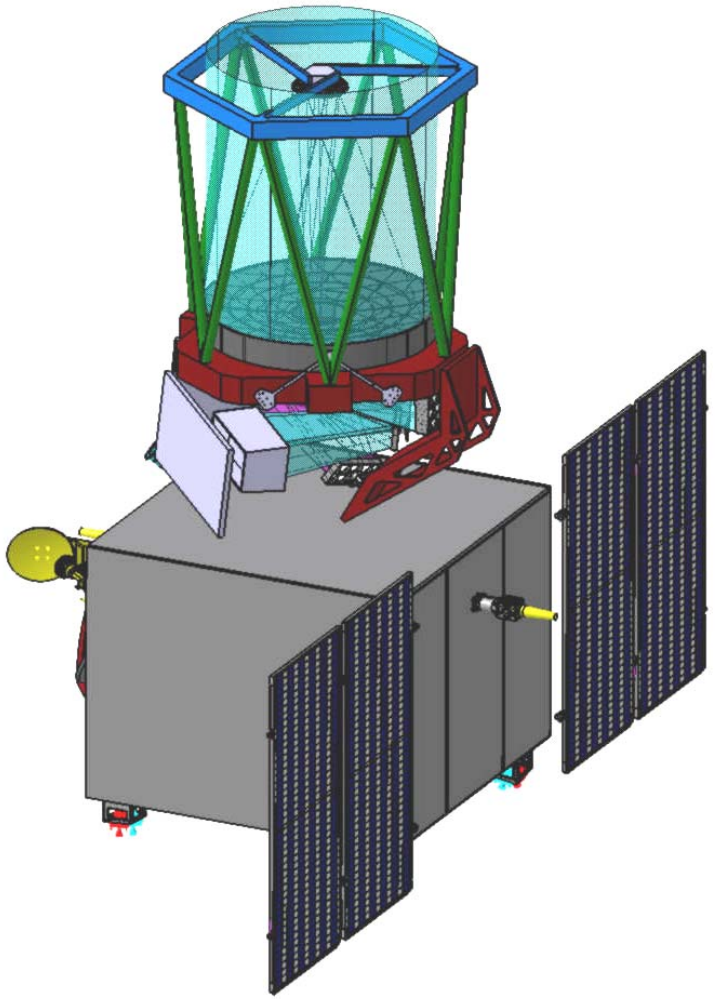
DUNE instrument internal view



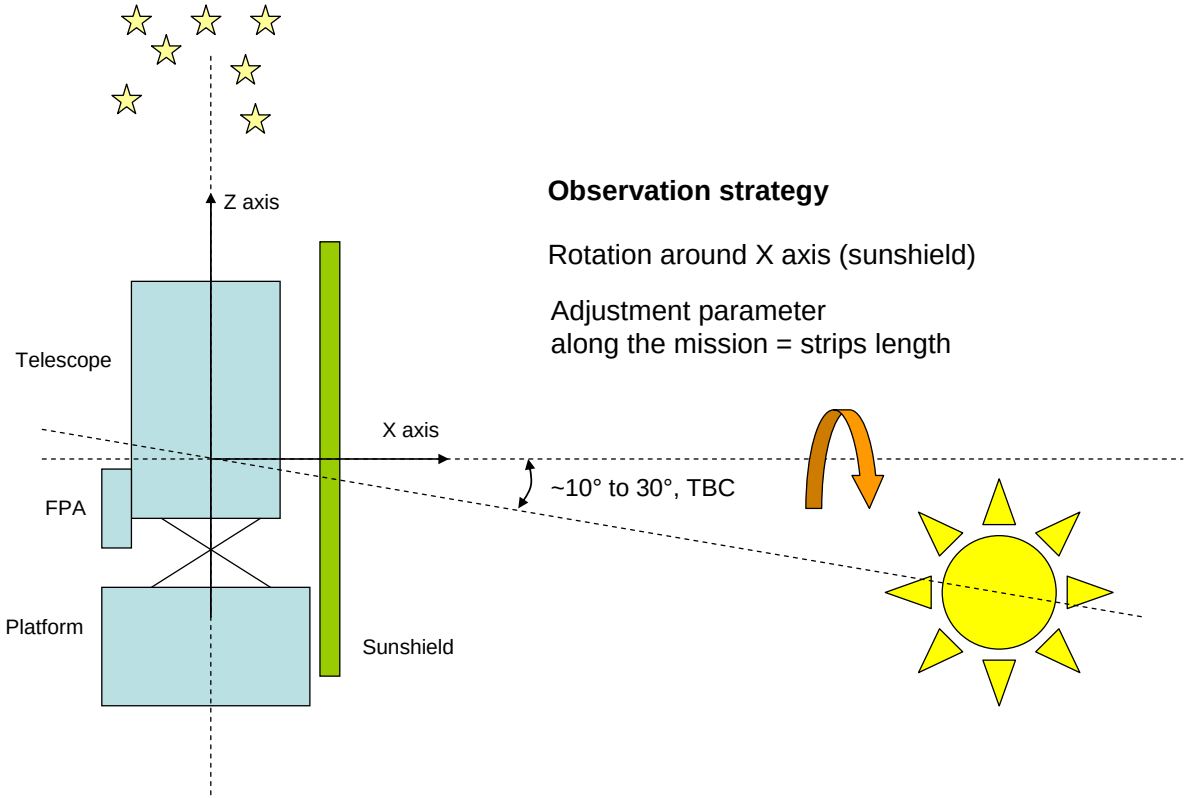


DUNE spacecraft mechanical baseline





DUNE observing strategy



Observation strategy

Rotation around X axis (sunshield)

Adjustment parameter
along the mission = strips length

DUNE spacecraft weight baseline

Equipements

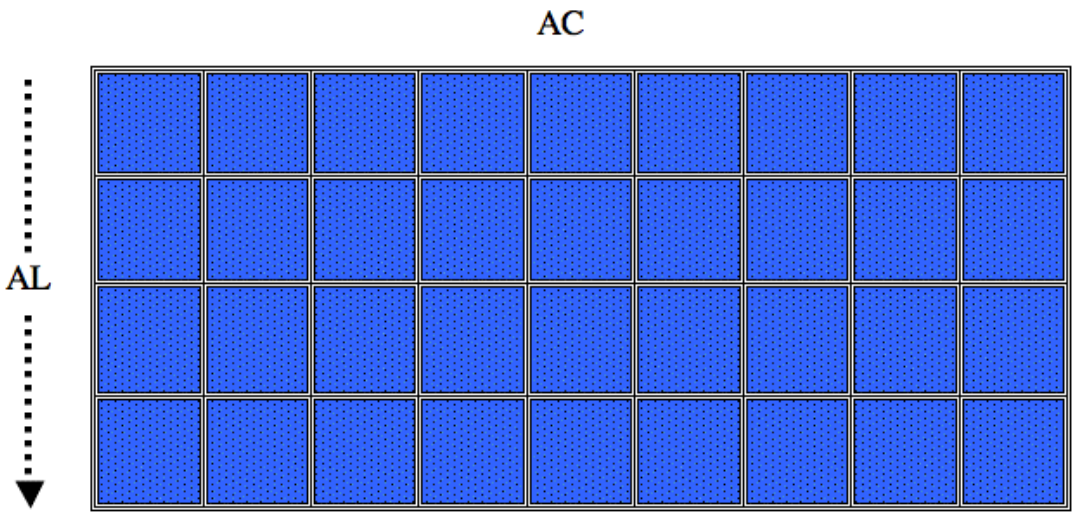
		Mass (kg)			
System	**Equt**	**Unit**	**Margin**	**n**	**Total**
TMI, TTC					**59,4**
	COME	30	20%	1	36,0
	Antenna X band (30 cm)	2	20%	1	2,4
	Modulateur MCTMD	1,4	10%	2	3,1
	Guides	2	20%	1	2,4
	SSPA 25 W	2,4	10%	2	5,3
	Transponder S band	4,3	10%	2	9,5
	LGA	0,37	10%	2	0,8
Data Handling					**26,4**
	OBMU	18	20%	1	21,6
	Electrical Interface Unit	4	20%	1	4,8
Power (w/o SA)					**39,6**
	PCDU	24	10%	1	26,4
	Battery	12	10%	1	13,2
Harness	Harness	50	20%	1	**60,0**
Therm. Control	TCS SVM	30	20%	1	**36,0**
AOCS					**20,4**
	SST - Optical Head	1,2	10%	2	2,6
	SST - Electronics	1,4	10%	2	3,1
	Baffle SST	1	20%	2	2,4
	Gyros (Opt + Elec)	11	10%	1	12,1
	Coarse Sun sensor	0,08	20%	2	0,2
Total SVM equts	wo struct and prop				**242**
microprop	CGT HW	51	10%	1	**56,1**
chemical prop	8x10N Thrusters+ HW	40	10%	1	**44,0**
Payload	All payload	350	20%	1	**420**
Strcture	SVM	135	10%	1	**149**
	SA	26	5%	1	**27**

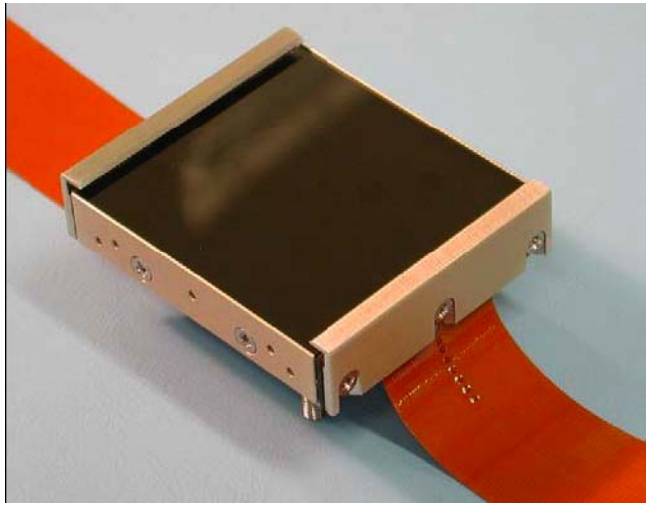
DRY MASS	938
System margin	17%
DRY MASS	**1097**

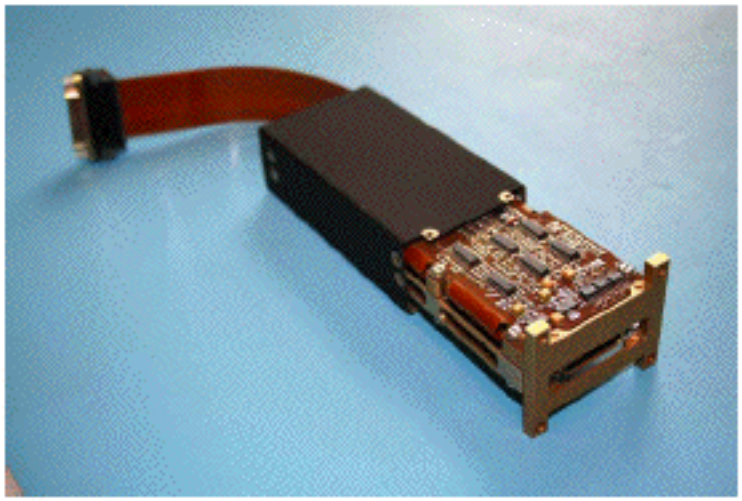
Propellant	Hydrazine	44	50%	1	66,0
Propellant	Cold Gas	24	50%	1	36,0

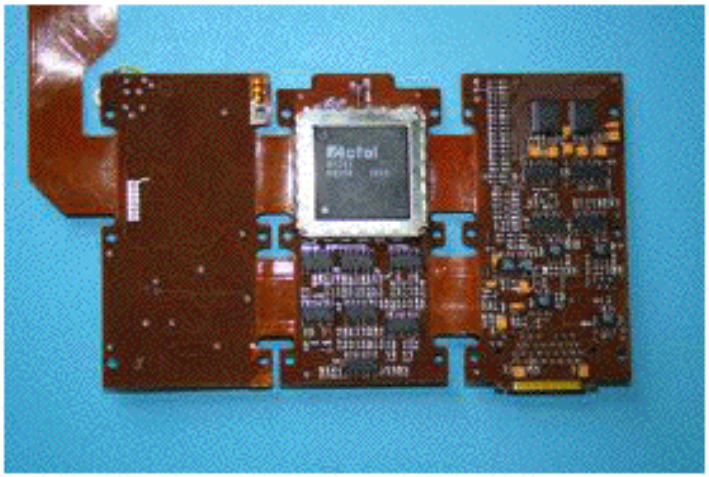
Wet MASS	**1199**

DUNE optical focal plane

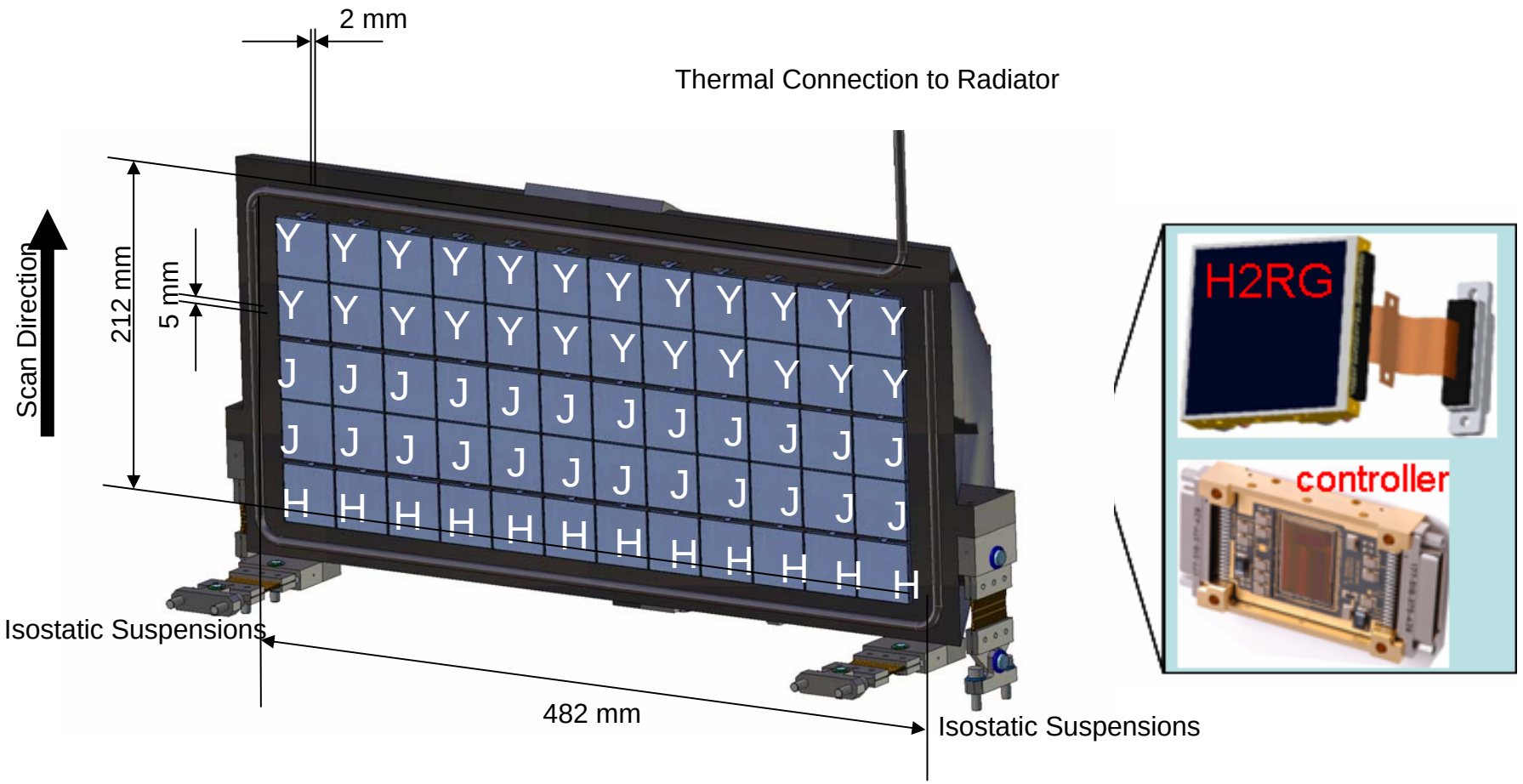




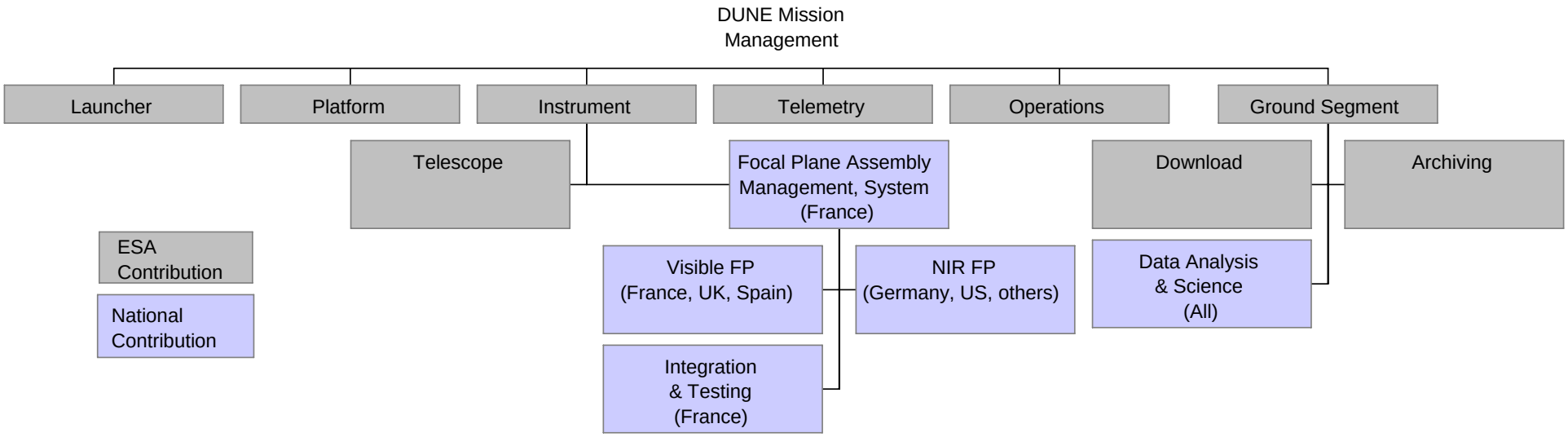




DUNE near-infrared focal plane



DUNE mission management



DUNE Spanish participation

- Two members of the Steering Committee
- Leading one working group (Baryon Acoustic Oscillations)
- Instrumentation: expertise of the participant institutions
- Need man-power and resources to lead an instrumentation area
- Spanish industry involvement is most welcome

Concluding Remarks

- A DUNE-like mission fits and responds to the Cosmic Vision 2015-2015 themes. It is strongly endorsed by the ESA/ESO WG on fundamental cosmology. Similarly DETF endorses stage IV missions
- DUNE now being re-defined from CNES phase 0 study original design using experience and technology from previous missions, especially GAIA
- Mission duration (nominal 3+1 years)
- Cost within M mission budget
- Spain is a member of the DUNE collaboration
- Significant Spanish industry involvement is welcome and expected

Concluding Remarks

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- Spain is a member of the DUNE collaboration
- Significant Spanish industry involvement is welcome and expected

Reviewing Committees

Dark Energy Task Force

- Established by AAAC and HEPAP as joint subcommittee to advise DOE, NASA & NSF
- Requested white papers from the community

ESA/ESO Working Group on Fundamental Cosmology

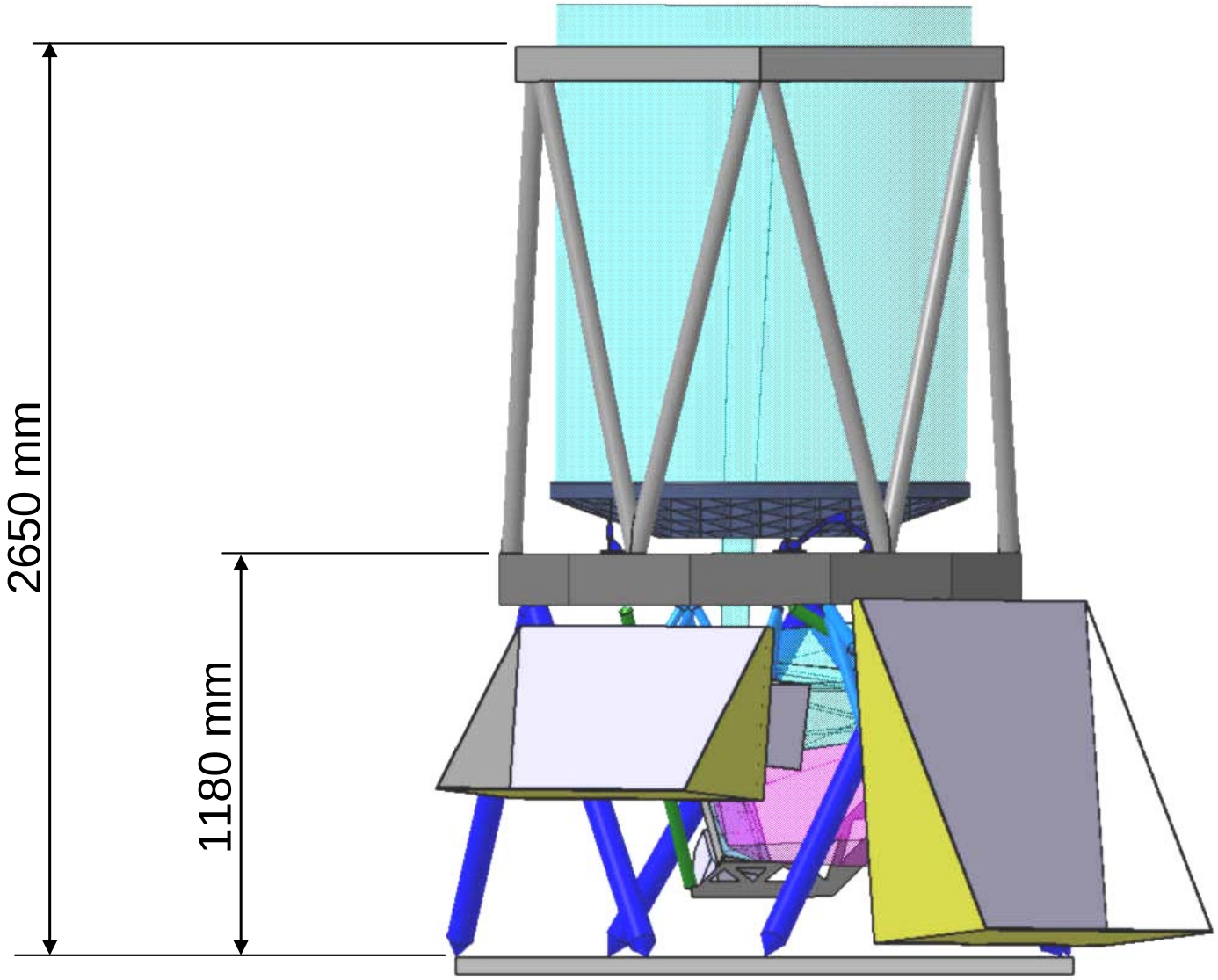
- Explore synergies between ESA & ESO
- mandate: fundamental issues in cosmology, especially the nature of dark matter and dark energy

Reviewing Committees

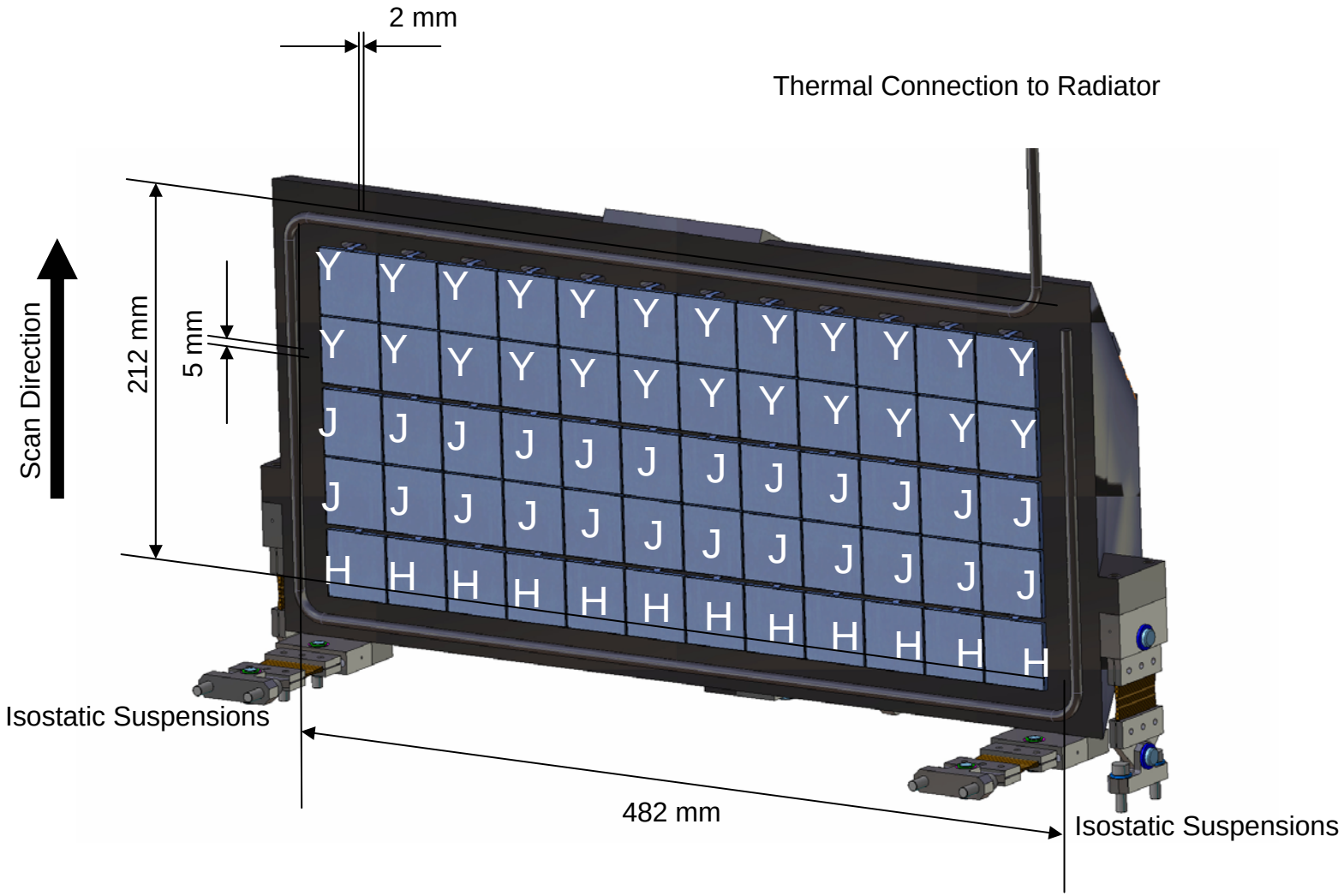
ESA/ESO WG on Fundamental Cosmology Recommendations

- Wide Field optical and NIR imaging survey (space & ground)
- multi-colour SN survey
- Extremely Large Telescopes (ELT)
- Cosmic Microwave Background (CMB) & Polarization
- Gravitational Waves

DUNE instrument overall view



DUNE near-infrared focal plane



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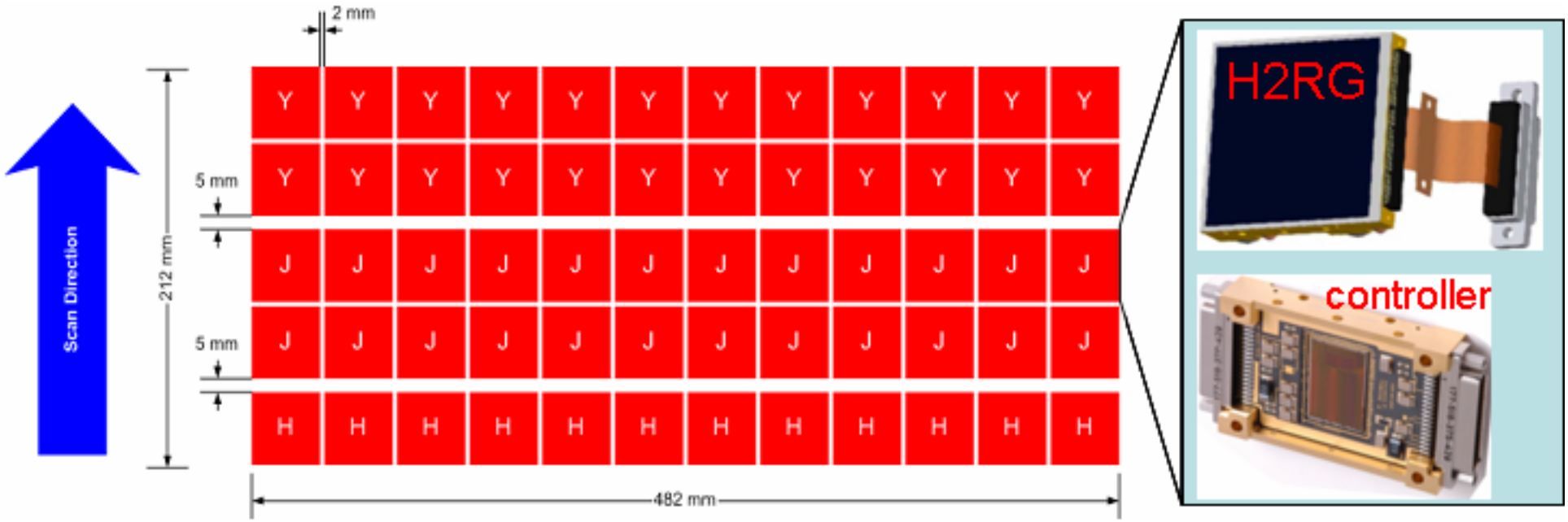
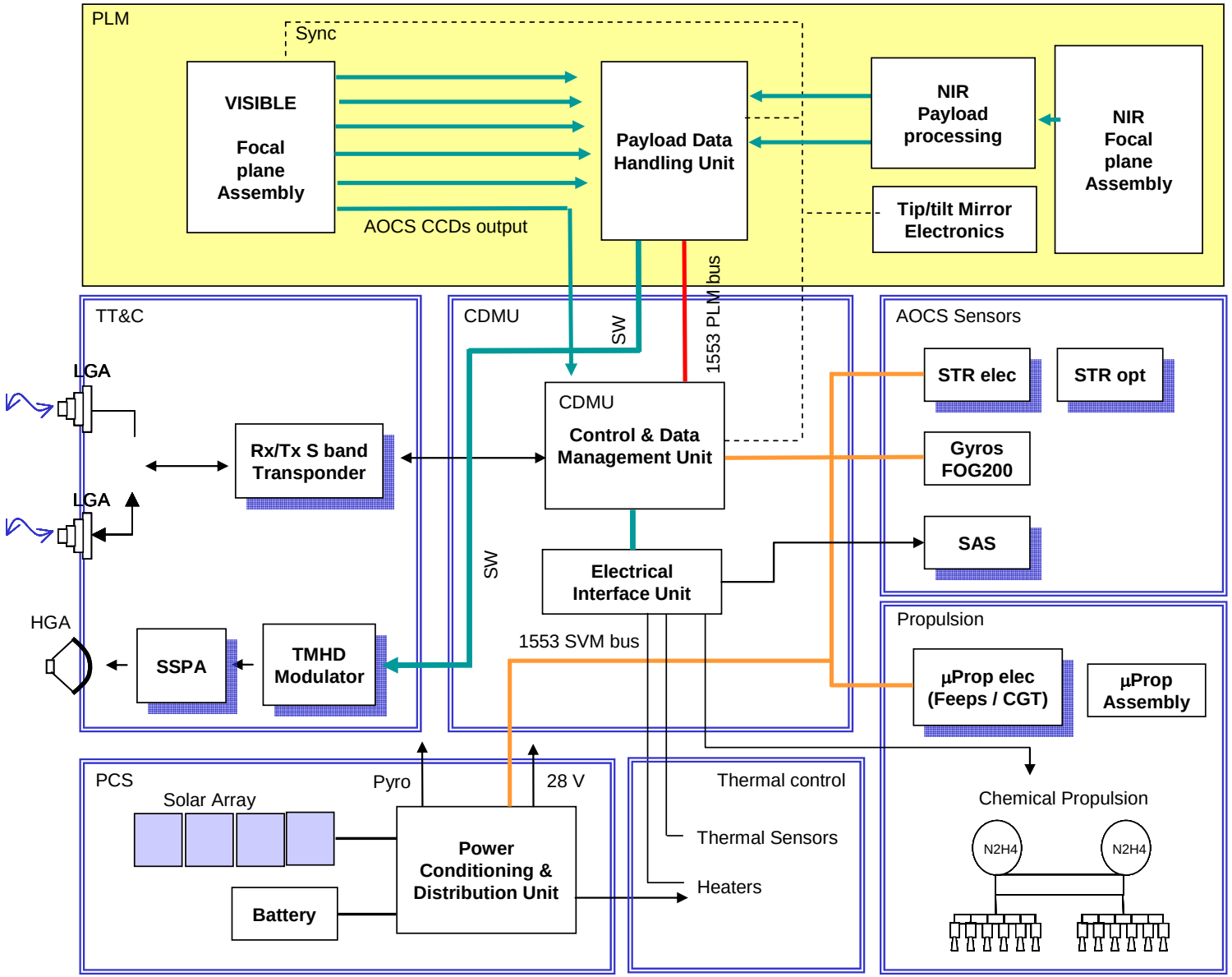


DUNE spacecraft electrical baseline



Reviewing Committees

Dark Energy Task Force Recommendations

- Established by AAAC and HEPAP as joint subcommittee to advise the 3 agencies
- ``Strongly recommend…an aggressive program to explore dark energy”
- Considered 4 main techniques to study DE (those above)
- Defined stages of projects: Stage I=completed; II=on-going; III=near-term, medium-cost, proposed; IV=LST, SKA, JDEM