

XIPE , IXPE

*Meccanica di volo ed integrazione:
status & plans*

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*XPE - X-ray Polarimeter Explorers
INFN-To 4 May 2016*



Instrument Status

- The DU GPD assembling chain started again: critical steps have been identified

XIPE	IXPE
DU and BEEU configuration trade-off (INFN)	DU configuration freezed (the BEE is part of the DU)
The DU Filter Wheel configuration has been defined and the design phase just started (by MSSL)	The DU Filter Wheel configuration has been defined and the preliminary design has been done (by OHB, eROSITA)
The Focal Plane Support Structure configuration (baseline) and a preliminary design in progress (by UV)	The satellite BUS (BALL) acts as FPS
Critical components of the Back End Electronics Unit have been identified	Critical components of the Back End Electronics Unit have been identified
The Instrument Control Electronics requirements and interfaces with BEE have been selected	The PCU requirements and interfaces with BEE have been selected

GPD-LEP Assembling Procedures (OXFORD, INFN-PI):

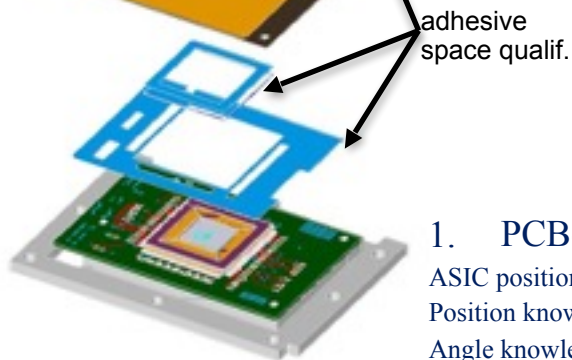
4. Gas filling (OXFORD)



3. Drift subassembly (OXFORD)

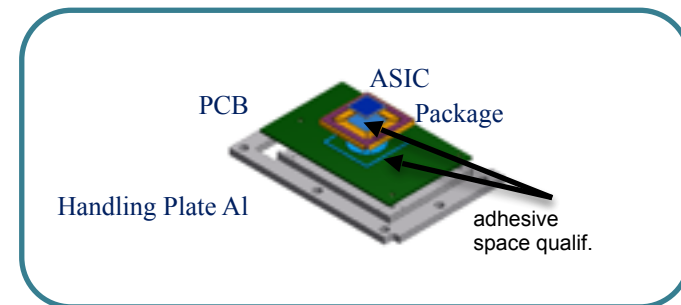
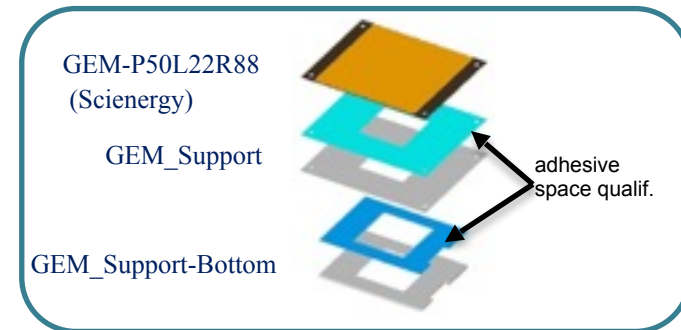
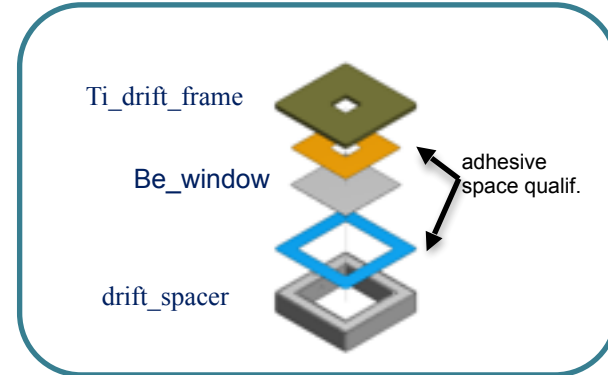


2. GEM subassembly (OXFORD)



1. PCB-ASIC subassembly (INFN-PI)

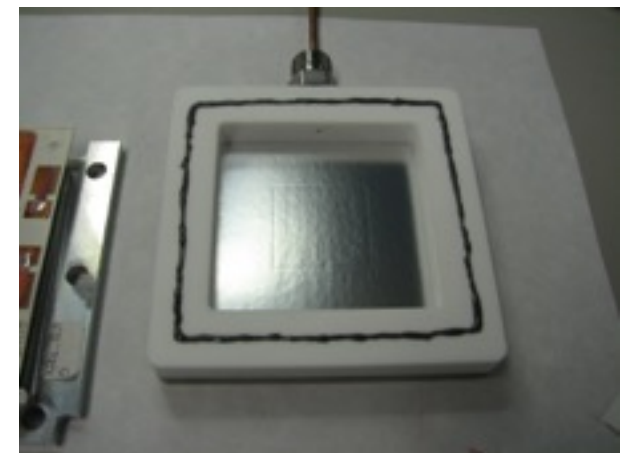
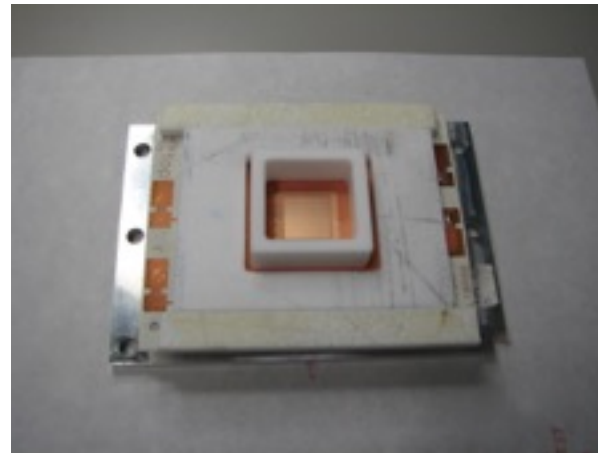
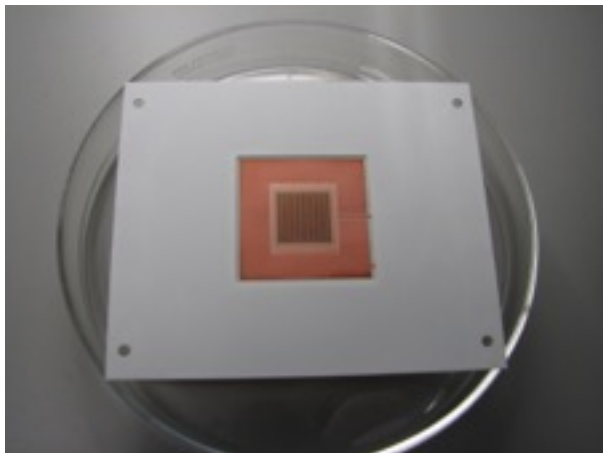
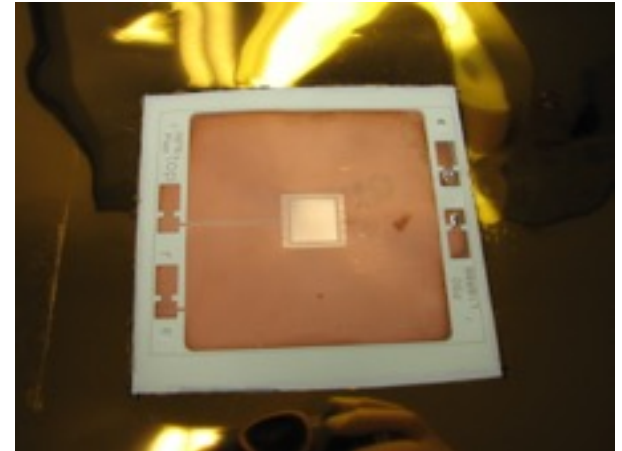
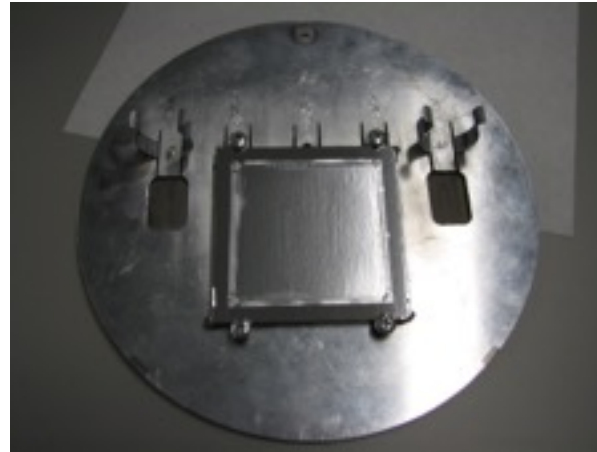
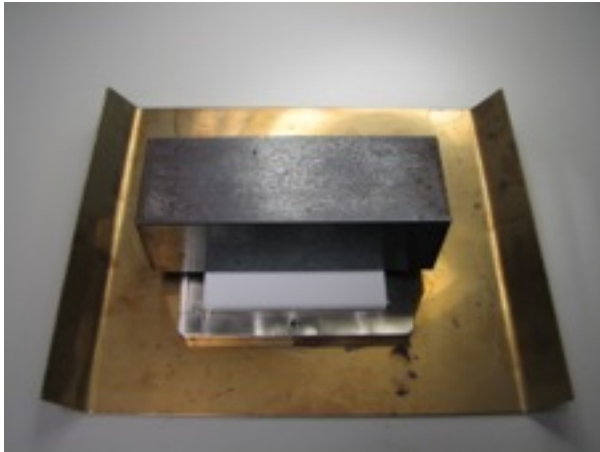
ASIC position references on the Al handling plate.
Position knowledge $\leq 3.5\mu\text{m}$
Angle knowledge $\leq 0.2'$ (150 pixels fit)



Instrument Status

GPD Assembling Chain

GPD-LEP Assembling Chain at OXFORD - Critical steps reviewed
FROM this procedure:



Instrument Status

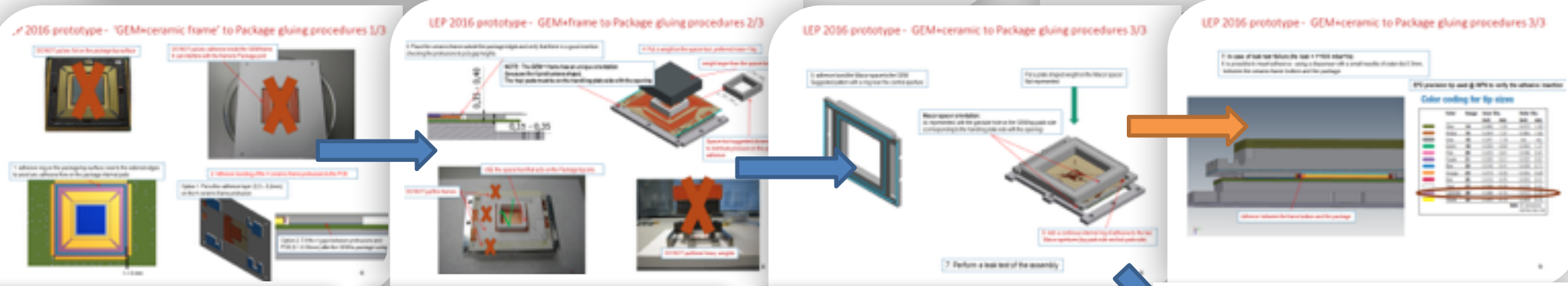
GPD Assembling Chain

TO this one:

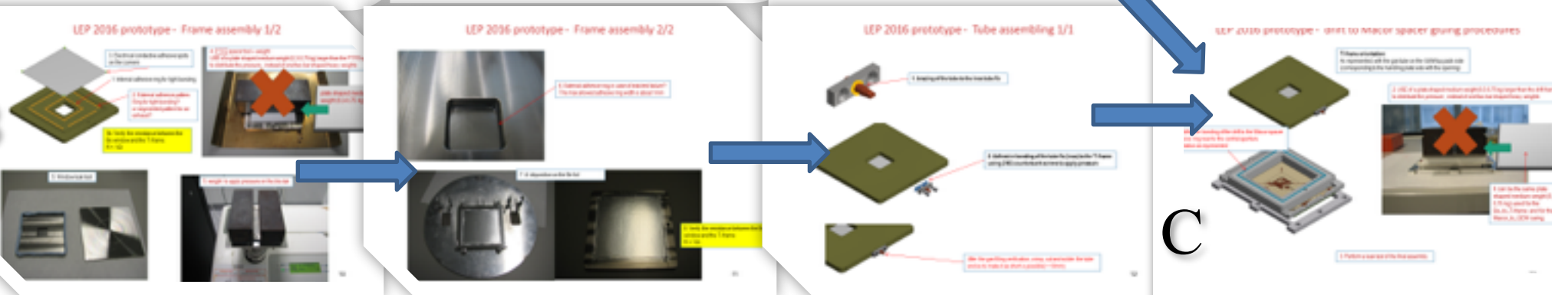
A



B



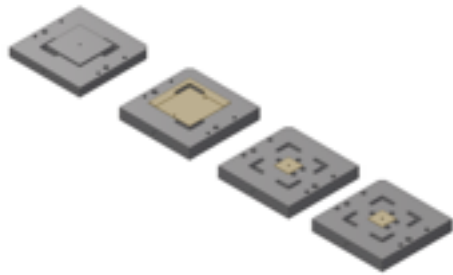
C



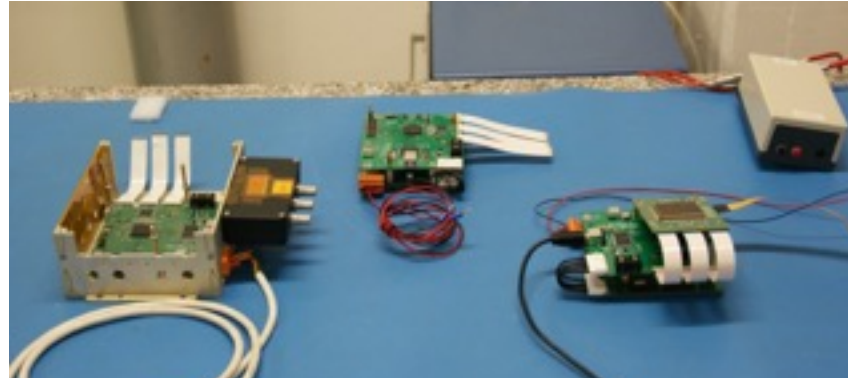
Instrument Status

GPD Assembling Chain

GPD-LEP Assembling and test activities at INFN-Pisa:

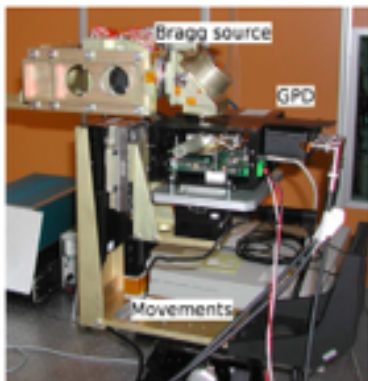


PCB-ASIC Assembling tools production

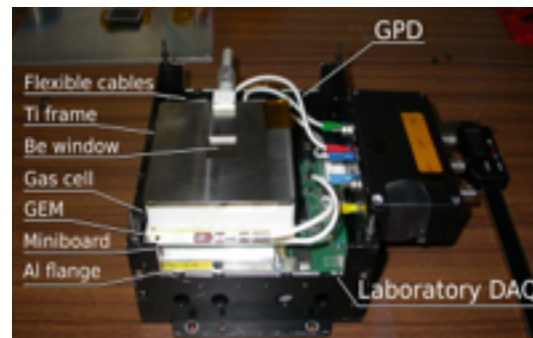


GPD-DAQ 3 available for lab tests (thanks to Hua Feng)

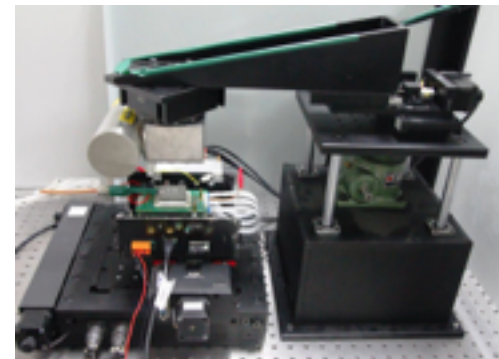
GPD-LEP Test and Calibration activities at IAPS-Rome and Tsinghua:



The polarized X-ray calibration facility at IAPS
Rome



X-ray calibration facility at Tsinghua University (Beijing,
China)





INFN-Pisa Optical METROLOGY SYSTEMS

CMM equipment : Mitutoyo BHN506

max error (from calibration report):

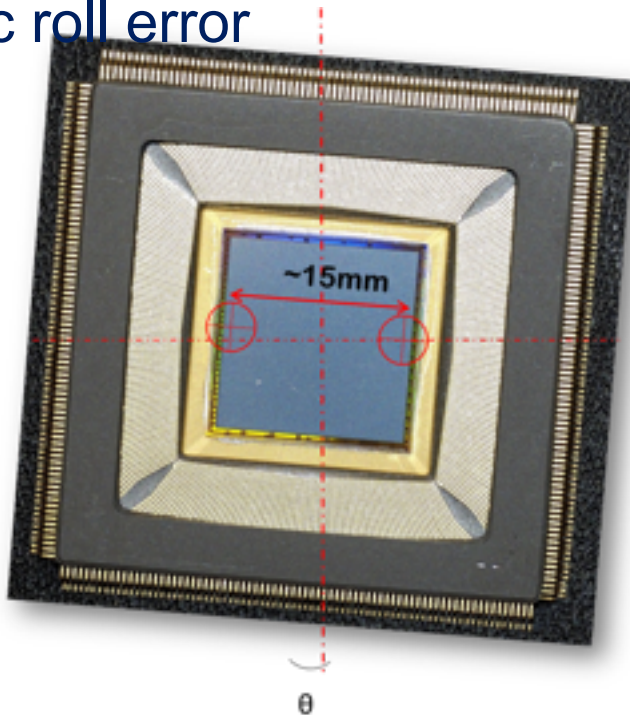
$$3.0 + (4 L / 1000) * \mu\text{m}$$

* dynamic error (L unit=mm)

ASIC measurement error for L= 15mm

- $e = 3.0 + 0.06 \mu\text{m}$
- roll angle error $\leq 0.2'$ (150 pixels fit)

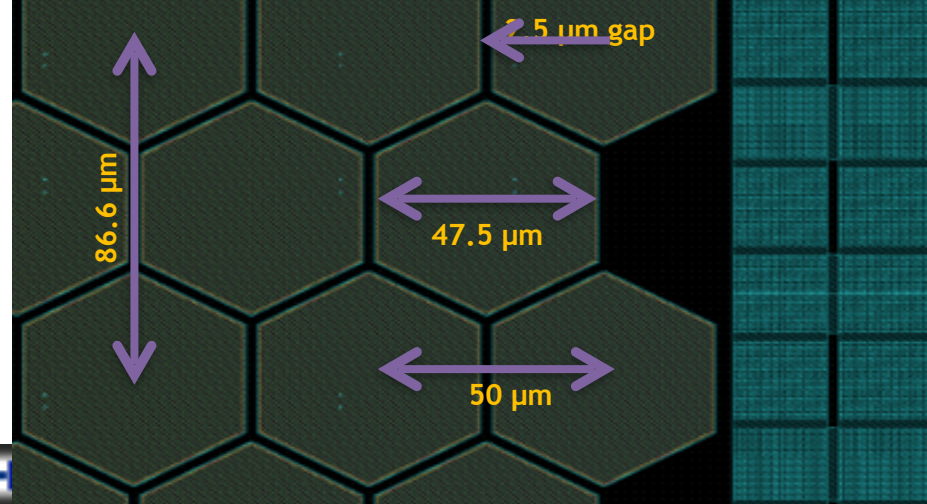
Asic roll error



0.18mm CMOS VLSI (sub-micron precision)

300 x 352 hexagonal pixels, 50 μm pitch

15.023mm x 15.253mm active area



XIPE Payload Module - Instrument

Service Module

Telescope Mirrors

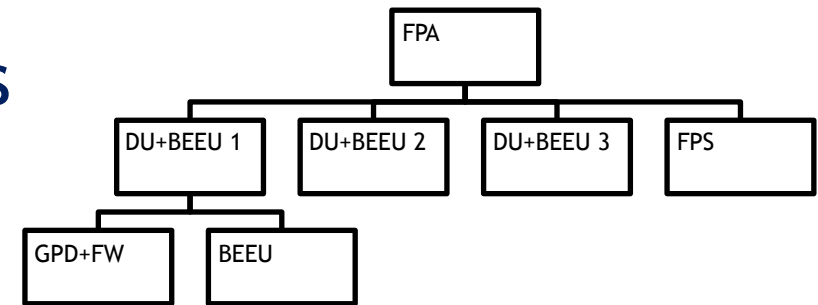
Payload System items

Instrument

Payload Module

FPA = Focal Plane Assembly

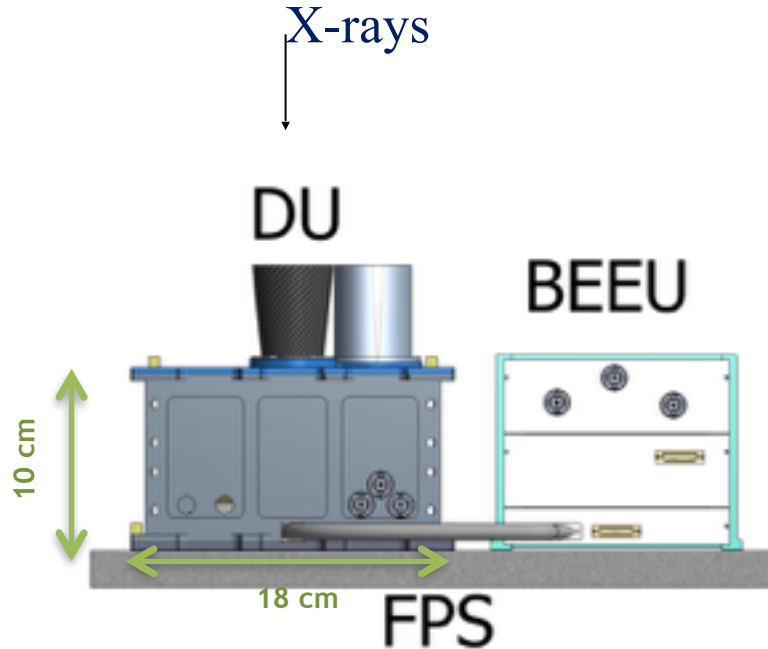
- 3 Detector Units and BEE sets
 - Detector Unit (GPD+FW)
 - Back End Electronics Unit
- Focal Plane Support item



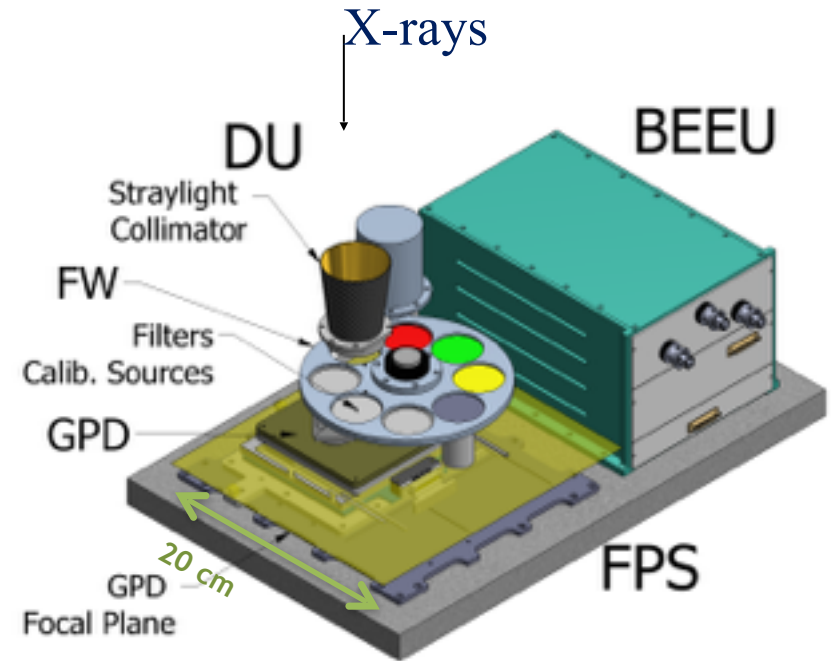
ICE = Instrument Control Electronics unit

XIPE Instrument Design Status

Detector Unit and BEEU Baseline Configuration: side-by-side inside the telescope tube



Detector Unit (baseline config)



Detector Unit and BEEU (baseline config, DU housing omitted)

The Detector Unit (GPD + FW) must stay close to the BEEU (data cable length <20cm).

A short Straylight Collimator can be added to increase the screening of the common baffle.

Units' Dimensions (baseline config)

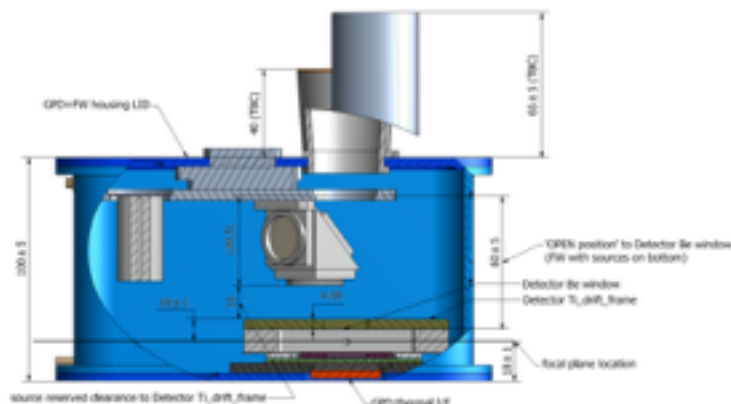
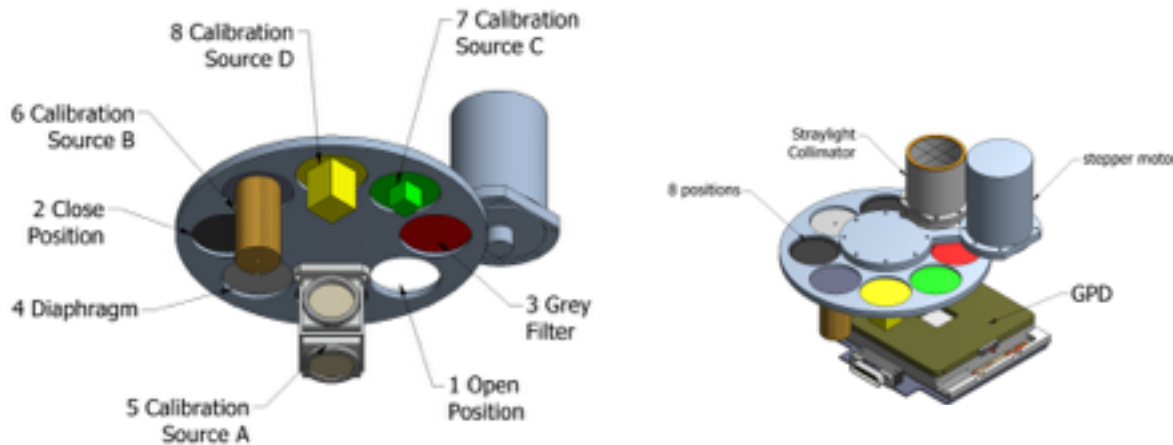
The Collimator can support an electrostatic grid to intercept the slow proton flux.

Unit	Detector Unit GPD+FW	Back-end Electronics
Dimensions (cm)	18 cm	14 cm
	20 cm	19 cm
	17 cm	10 cm

Instrument Status

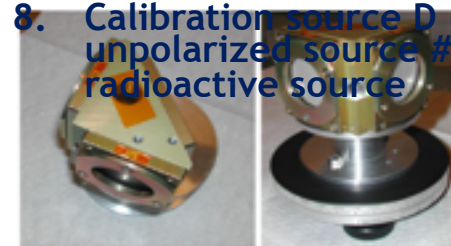
Filter Wheel Design

The DU Filter Wheel configuration has been defined and the design by MSSL(XIPE)-OHB(IXPE) and IAPS (sources) is started



Filter wheel positions (baseline configuration):

1. Open position.
2. Close position. Disk of tungsten 0.5 mm thick, with a multilayer coating
3. Gray filter. Beryllium and 0.25 mm thick
4. Diaphragm, with a hole of 4 mm (TBV). It will be made of tungsten 0.5 mm thick (TBV).
5. Calibration source A (source of polarized photons).
6. Calibration source B (collimated unpolarized source). ^{55}Fe iron radioactive source
7. Calibration source C (isotropic unpolarized source #1). ^{55}Fe iron radioactive source
8. Calibration source D (isotropic unpolarized source #2). ^{109}Cd radioactive source



Polarized calibration source (A) at IAPS

Instrument Status

DU , BEEU budgets

XIPE : FPA Units + ICU POWER BUDGET (from ESA/CDF study)

	Quantity	Total Average Power (incl. maturity margin) (W)	Total Max Power (incl maturity margin) (W)
ICU (Instrument Control Unit)	1.00	31.2	31.2
FPA units			
BEEU (excl. HV)	3.00	15	15
Detector Unit			
HV	3.00	1.8	5.4
Filter Wheel and Baffle	3.00	0	6
GPD	3.00	1.8 (0.6)	1.8
GPD Peltier	3.00	4.2 (1.4)	4.2

IXPE : DU, PLC MASS BUDGET

	GPD+FW	
item	value	unit
GPD	570	g
Peltier	30	g
Filters +Source	263	g
screw+fix	30	g
FW disk	220	g
motor	400	g
sensors	200	g
bearings	140	g
crown	160	g
Housing	1300	g
total	3313	g
margin	20%	
W margin	3976	g

XIPE : Payload MASS BUDGET (mirrors omitted)

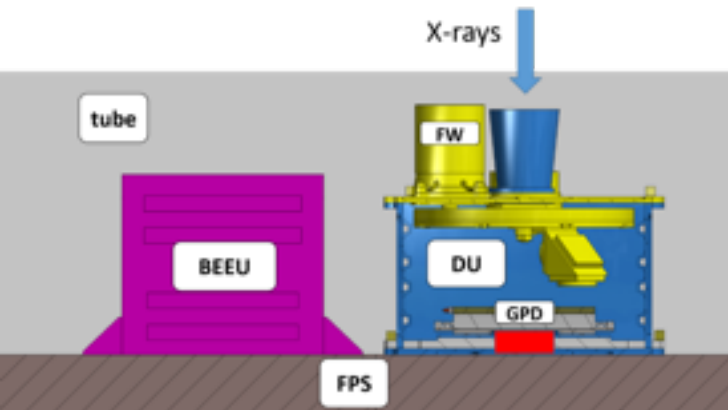
	Equipment masses				
	Estimated Mass (kg)	Qty	Total estimated mass (kg)	Mass margin (%)	Total Mass incl. margin (kg)
Payload					
ICU (Instrument Control Electronics)	6.50	1.00	6.50	20.00	7.80
FPA (Focal Plane Assembly)					
BEEU (Back End Electronics)	1.90	3.00	5.70	30.00	7.41
Detector Unit	3.5				
Filter Wheel and Pre-Baffle	1.50	3.00	4.50	20.00	5.40
GPD (Gas Pixel Detector)	0.60	3.00	1.8	20.00	2.16
GPD+FW Housing	1.4	3.00	4.2	30.00	5.46
Focal Plane Support Structure	8.86	1.00	8.86	20.00	10.64

	BEE	
item	value	unit
mech box	1004	g
DIGITAL	180	g
HV+PWR	225	g
Conn.	16	g
total	1425	g
margin	20%	
W margin	1710	g

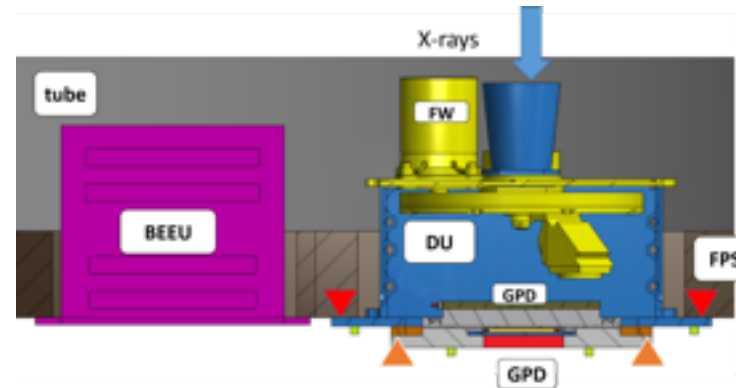
	P/LC	
item	value	unit
mech box	1627	g
2xSBC	828	g
2xPSB	1035	g
1xBKPL	331	g
Conn.	102	g
total	3923	g
margin	20%	
W margin	4708	g

Instrument Status

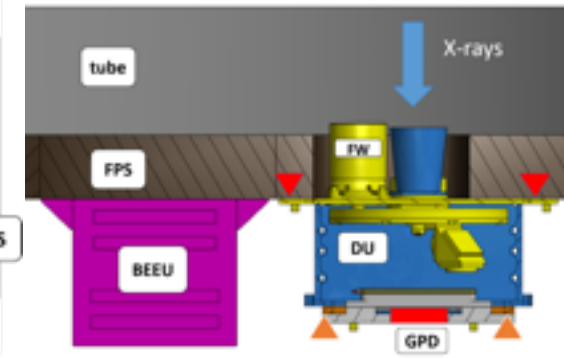
Detector Unit and BEEU trade-off



baseline config: no access for system level alignment and sources mounting

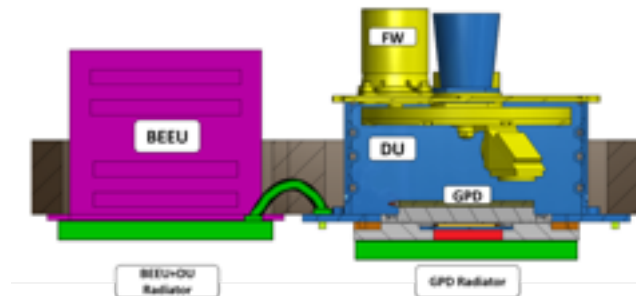
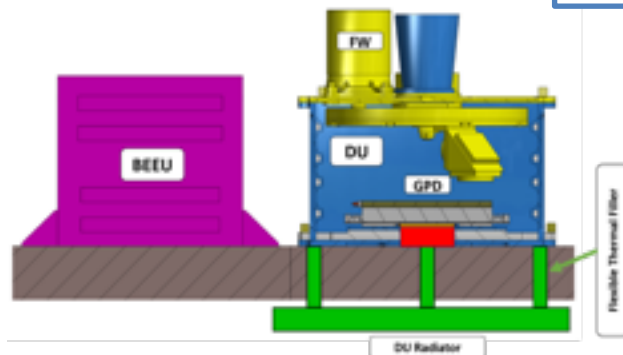


DU and BEEU from FPS cuts:
alignment at system level and access
to the sources



DU and BEEU from a small FPS cut:
alignment at system level and
access to the sources

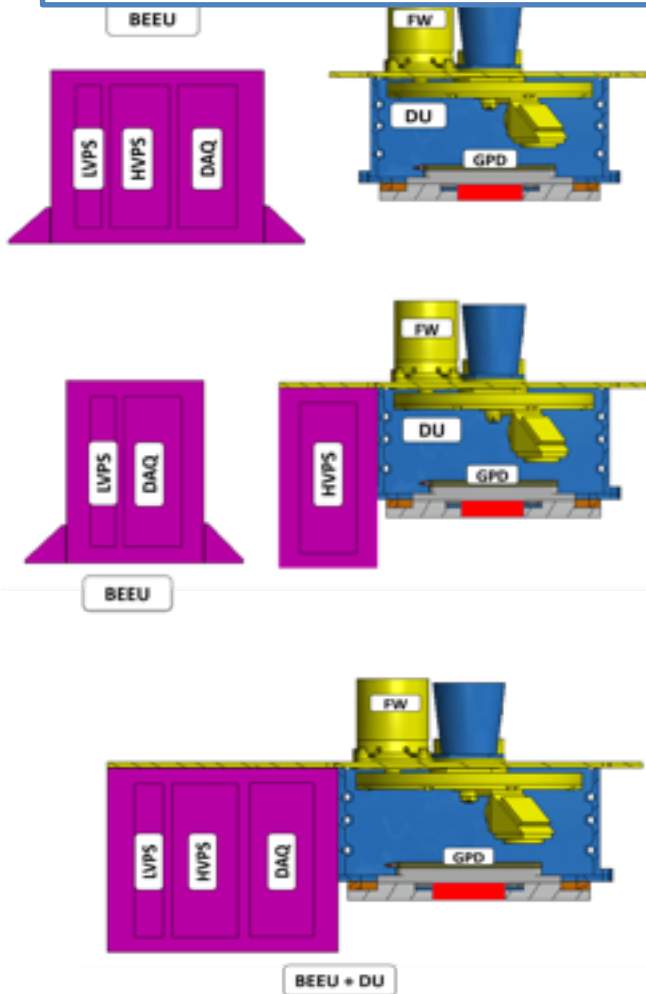
Thermal trade-off



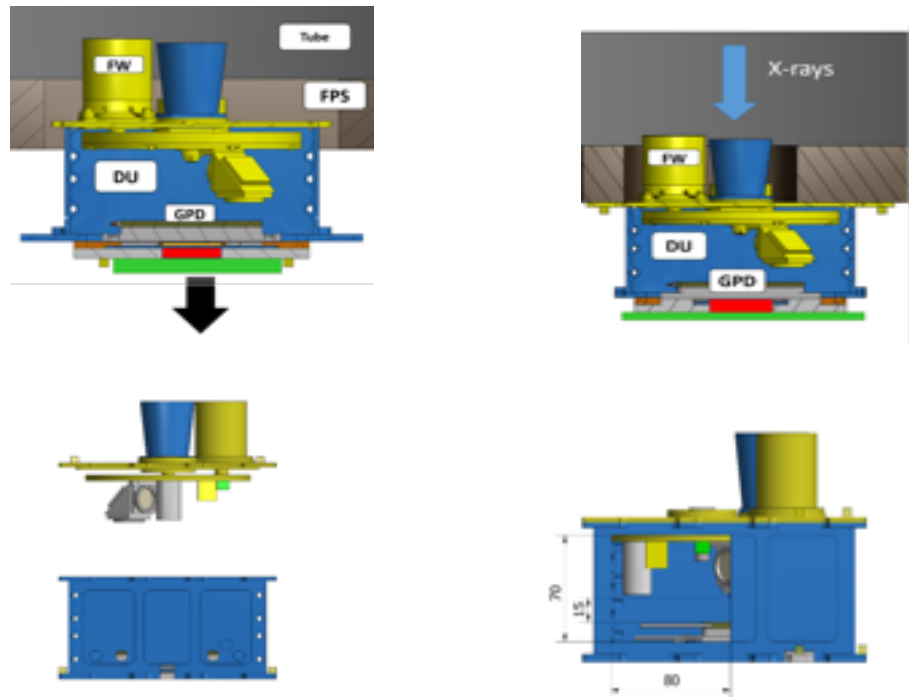
Instrument Status

BEEU-DU merging and Calibration Sources mounting trade-off

BEEU-DU merging trade-off



DU configuration trade-off to permit the sources mounting at system level



IXPE Payload Module - Instrument

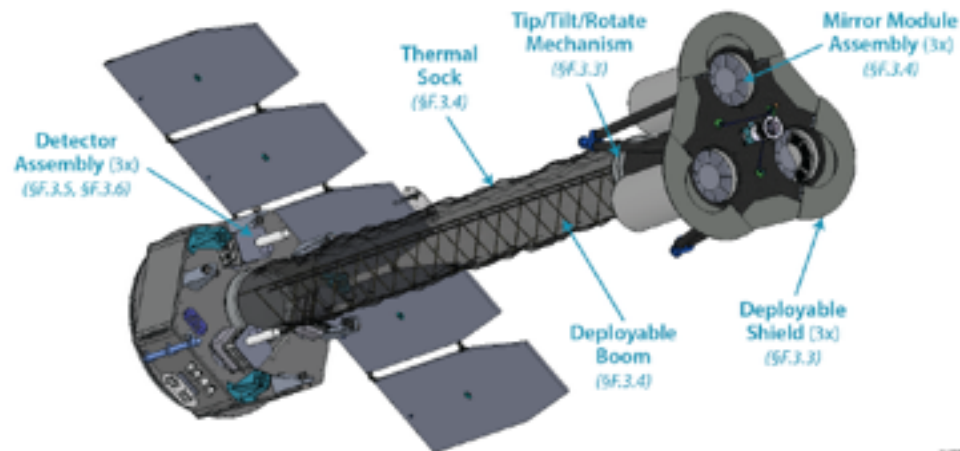


Figure 012. IXPE Observatory in Launch Vehicle Fairing

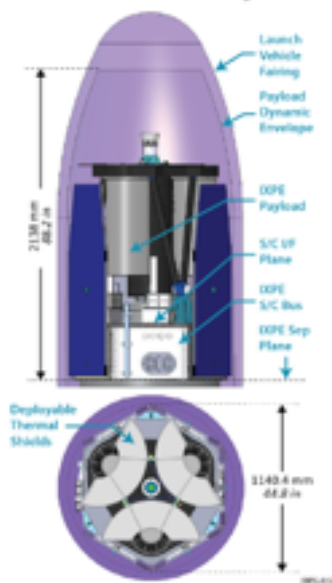


Figure 014. IXPE Spacecraft Components

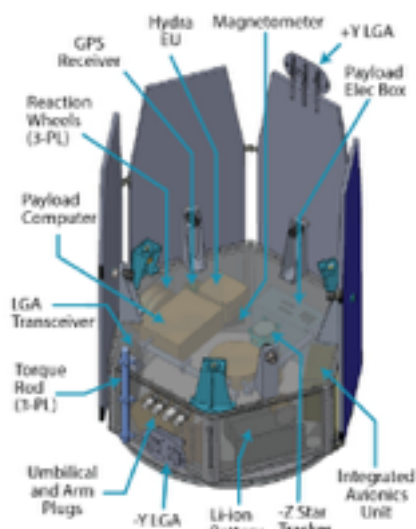
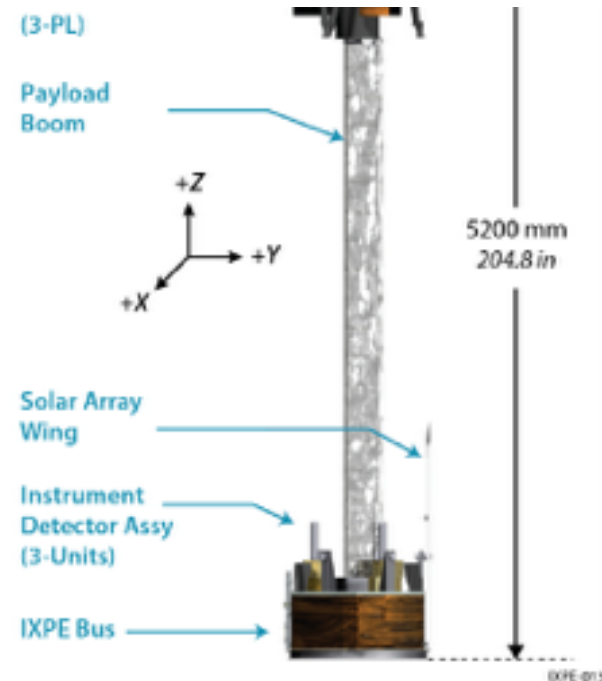


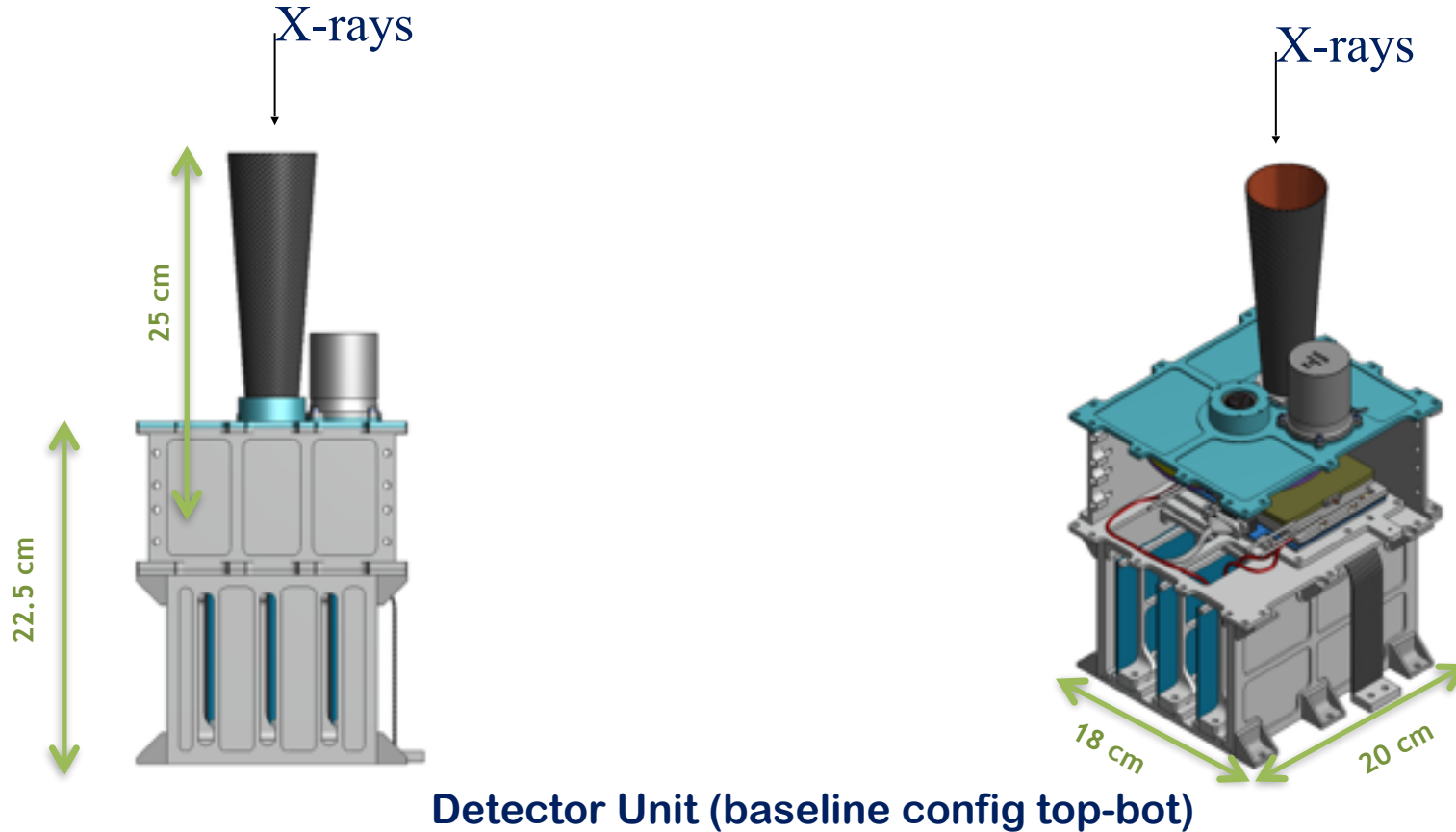
Table F.3-1 Mirror Assembly Properties

Property	Value
Number of telescopes	3
Shells per telescope	24
Outer shell diameter	272 mm
Total shell length	162 mm
Shell Thickness	180 μm (inner), 260 μm (outer)
Shell material	Nickel cobalt alloy
Effective area per module	200 cm^2 (2 keV)
(includes losses due to thermal shields & support mesh)	230 cm^2 (3-6 keV)
Angular resolution	$\leq 25''$ HPD
Detector-limited FOV	12.8'
Focal length	4 m
Mass (3 assemblies)	95 kg with contingency (see 5M.13)



IXPE - Instrument Status

Detector Unit Baseline Configuration



The Detector Unit (GPD + FW+BEE) is accommodated on the Focal Plane Structure (data cable length <20cm).

A short Straylight Collimator is added to increase the screening of the common baffle.

The Collimator can support an electrostatic grid to intercept the slow proton flux.

Instrument Status

TRL status

		Nr	TRL level today
XIPE Instrument			
Detector Unit		3	6
	GPD - Gas Cell	3	6
	GPD - ASIC	3	6
	Peltier	3	7
	Filter Wheel	3	5/6
	Strylight Collimator	3	6
	DU Housing	3	6
Back-End Electronic Unit		3	6
	HV Power Supply	3	6
	ASIC mng, ADC & pre-processing	3	6
	Filter Wheel Control Drivers	3	6
	BEEU Case	3	6
Focal Plane Support Item		1	6
	Focal Plane Structure	1	6
	FP Thermal control set	1	6
	Harness	1	6
Instrument Control Electronic Unit		1	6
	Micro processor board & Memory	1	6
	Power distribution	1	6
	ICU Case	1	6

The TRL status full review is on going

Instrument Status

TRL status - GPD TRL 6 Justification

Environmental test on GPD performed by INFN-Pi			
Enviromenent	Test	Year	Condition
Mechanical	Resonance search	2014	ECSS-E-ST-10-03C Space engineering Testing, June 2012 GPD 9x9 (Xpolvibetest__2014_20141204.pdf)
	Random	2014	GEVS 4/22/2013 two minutes, Table 2.4-4, 6.8 g _{rms} GPD 9x9 (Xpolvibetest__2014_20141204.pdf)
	Sinusoidal	2014	VEGA (Arianspace) User's Manual, Issue 3/Revision 0, March 2006 GPD 9x9 (Xpolvibetest__2014_20141204.pdf)
	Random & Sinusoidal	2008	11.4 _{grms} NASA-GSFC-STD-7000, NASA-MSFC-HDBK-670. GPD 4x4 (IXO-XPOL-TN-006-01.pdf)
Thermal	TV/TC	2014	4 cycles, -15 °C + 45 °C; ⁵⁵ Fe; Acquisition at 10 °C, 15 °C, 20 °C GPD 9x9 + miniboard +DAQ GPD 9x9 (xpol_thermal_report)
	TV/TC	2008	4 cycles, -15 °C + 45 °C; ⁵⁵ Fe; Acquisition at 10 °C, 15 °C, 20 °C . Detector + miniboard +DAQ GPD 4x4, (IXO-XPOL-TN-006-01.pdf)
Thermal vacuum	TV/TC	2014	1 cycle, -15 °C + 45 °C; ⁵⁵ Fe; Acquisition at 10 °C, 15 °C, 20 °C.. Detector + miniboard GPD 9x9 (xpol_thermal_report.pdf)
	TV/TC	2008	1 cycle, -15 °C + 45 °C; ⁵⁵ Fe; Acquisition at 10 °C, 15 °C, 20 °C. Tested detector + miniboard GPD 4x4 (IXO-XPOL-TN-006-01.pdf)
Differential Pressure	Be window Safety Factor	2010	GSFC-STD-7000 Maximum yield stress @ 1.5bar = 249 MPa maximum beryllium strain @ 1.5bar = 7.2 10 ⁻⁴ GPD 4x4 but same window. (IXO-XPOL-TN-004-01.pdf)
Radiation	Heavy ions survivability test	2008	Fe ions, Energy = 500 MeV/nucl, 1.710 ⁴ ions, equivalent to 42 years in LEO orbit. Facility (HIMAC Japan). GPD on during the irradiation. Test facility. (A Polarimeter for IXO, Bellazzini & Spandre, 2010.pdf)

Instrument Status

XIPE Model Philosophy

		Nr	BB	STM (**)	FU.MO . or Sim	EM	El.Mod.	QM (***)	PFM	FM	Spare
XIPE Instrument											
Detector Unit		3	1	1+2D				1		3	1
	Gas Cell	3	1	1+2D				1		3	1
	ASIC	3	1	1+2D				1		3	1
	Peltier	3	1	1+2D				1		3	1
	Filter Wheel	3	1*	1+2D				1		3	1
	Strylight Collimator	3	1	1+2D				1		3	1
	DU Housing	3	1	1+2D				1		3	1
Back-End Electronic Unit		3		1+2D				1		3	1
	HV Power Supply	3	1	1+2D				1		3	1
	ASIC mng, ADC & pre-processing	3		1+2D				1		3	1
	Filter Wheel Control Drivers	3		1+2D				1		3	1
	BEEU Case	3		1+2D				1		3	1
Focal Plane Support Item		1		1				1		1	1
	Focal Plane Structure	1		1				1		1	
	FP Thermal control set	1		1				1		1	1 kit
	Harness	1						1		1	
Instrument Controll Electronic Unit		1		1	1	1 (***)	1 (TBC)		1		1
	Micro processor board & Memory	1		1*D	1	1	1		1		1
	Power distribution	1		1*D	1	1	1		1		1
	ICU Case	1		1	1	1	1		1		1

Instrument Status

XIPE Instrument test matrix

XIPE Instrument Test	B/B	STM	EM	QM	FM	PFM	FS
Functional & Performance	T		T	T	T	T	T
Physical Properties							
Mass		T		T	T	T	T
CoG		A		A	A	A	A
Mol		A		A	A	A	A
Structural Test							
Random Vibration		T _Q		T _Q	T _A	T _P	T _A
Sine Vibration		T _Q		T _Q	T _A	T _P	T _A
Shock				T			
Static		T _Q (1)					
Acoustic	At Satellite level only						
Thermal Test							
TV/TC		T _Q		T _Q	T _A	T _P	
Thermal Balance		T _Q		T _Q	T _A	T _P	
EMC/EMI							
Conducted Em./Susc.			T	T			
Radiated Em./Susc.				T			
Static Magnetic	T			T	T		T
Corona & arcing	T (4)			T	T		T
Mechanism Test							
F&CW Repositioning	T	T		T	T		T
F&CW actuator Life	T						
Others							
Humidity	T						
Alignment Stability (2)		T			T		
Leak (3)	T			T	T	T	T
Pressure (4)	T	T		T			

A = Analysis;

T = Test;

TQ = Test at qualification level;

Tp = Test at proto-qualification level;

TA = Test at acceptance level

AIV/AIT Facility

Item	AIV/AIT Facility
DU & BEEU	INFN-Pisa
ICU	Univ Tubinga
FPA Structure	Univ Valencia
FPA Assembly	INTA-Spain
Instrument Calibration	INAF-IAPS
Telescope Characterization	MPE-Panther

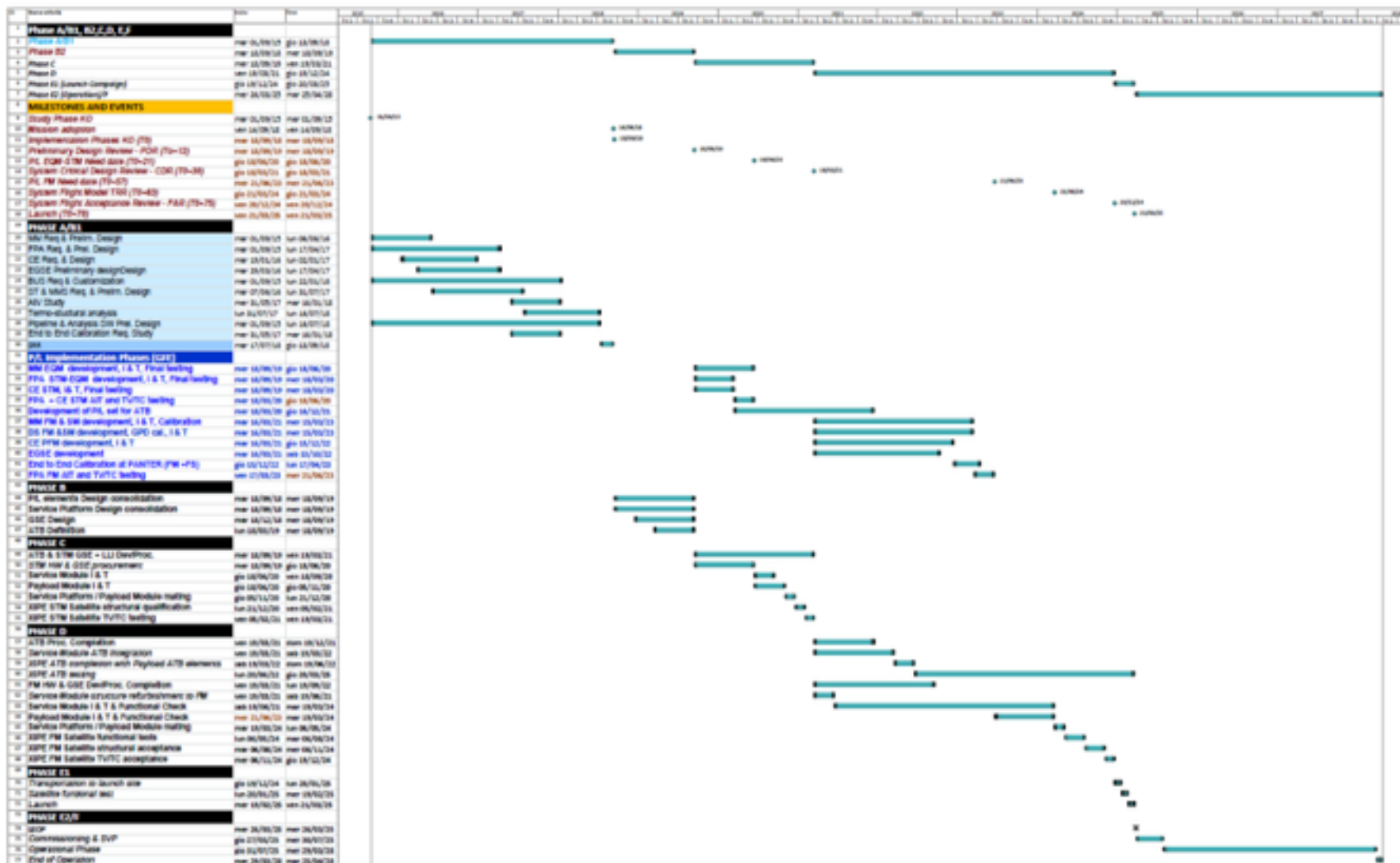
(1) FPA Structure only prior FPA unit integration

(2) Test on integrated FPA prior delivery to prime and at

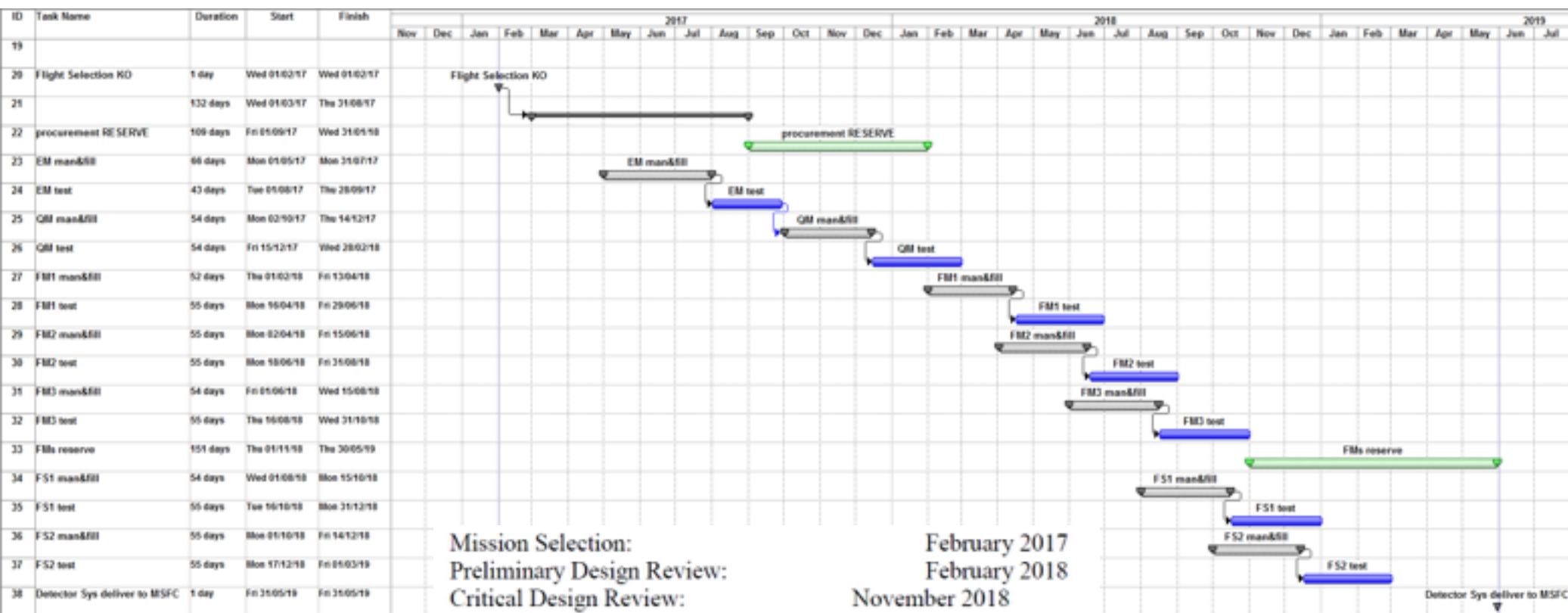
(3) on GPD, DU and Satellite level

(4) HV B/B will be tested at worst pressure and humidity conditions

XIPE Overall Schedule



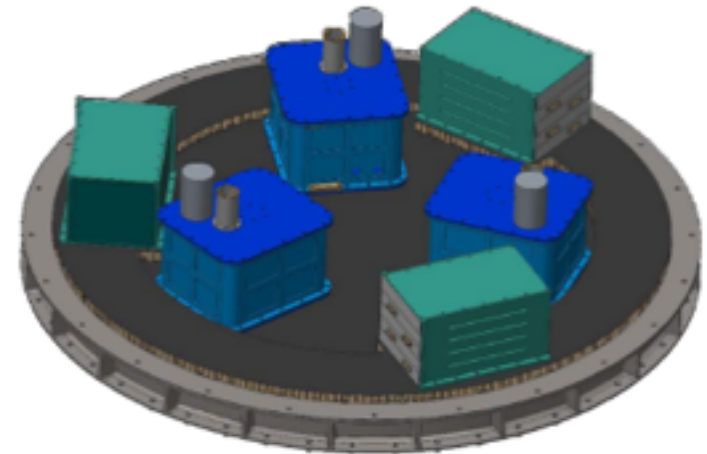
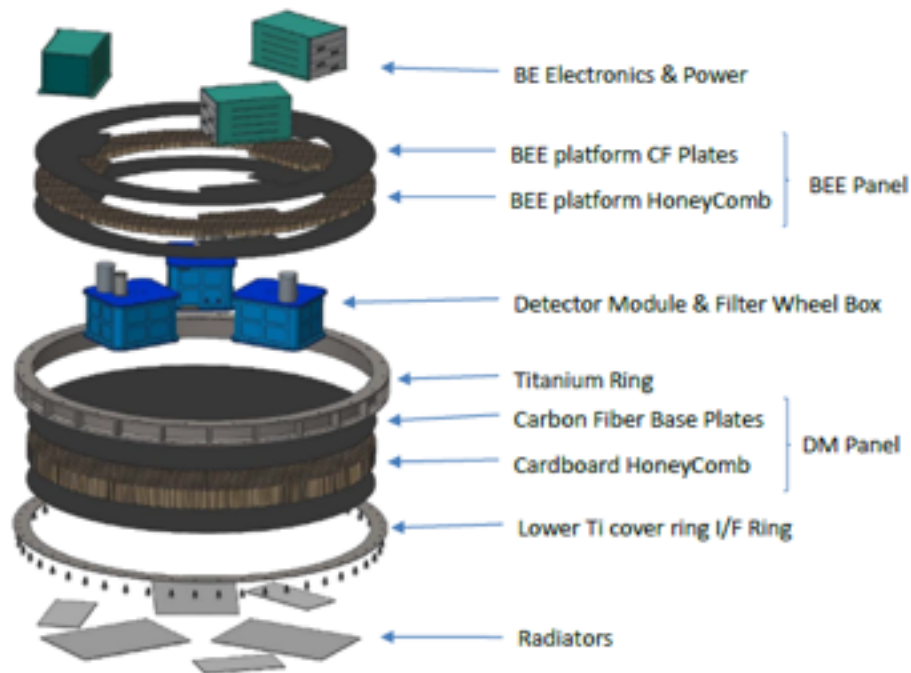
IXPE Instrument and Overall Schedule



Instrument Status

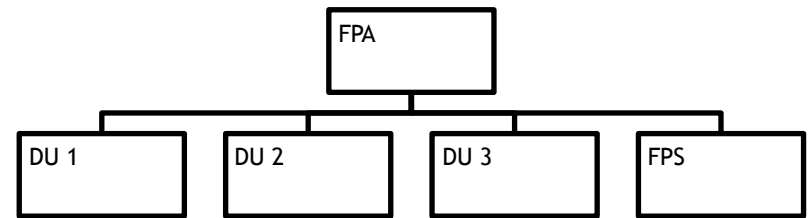
Focal Plane Support item Design

Structural & thermal analysis in progress.
A technical note with a preliminary design has been issued



FPA = Focal Plane Assembly

- 3 Detector Units sets
 - GPD+FW
 - Back End Electronics
 - Housing



PCU= Payload Computer Unit