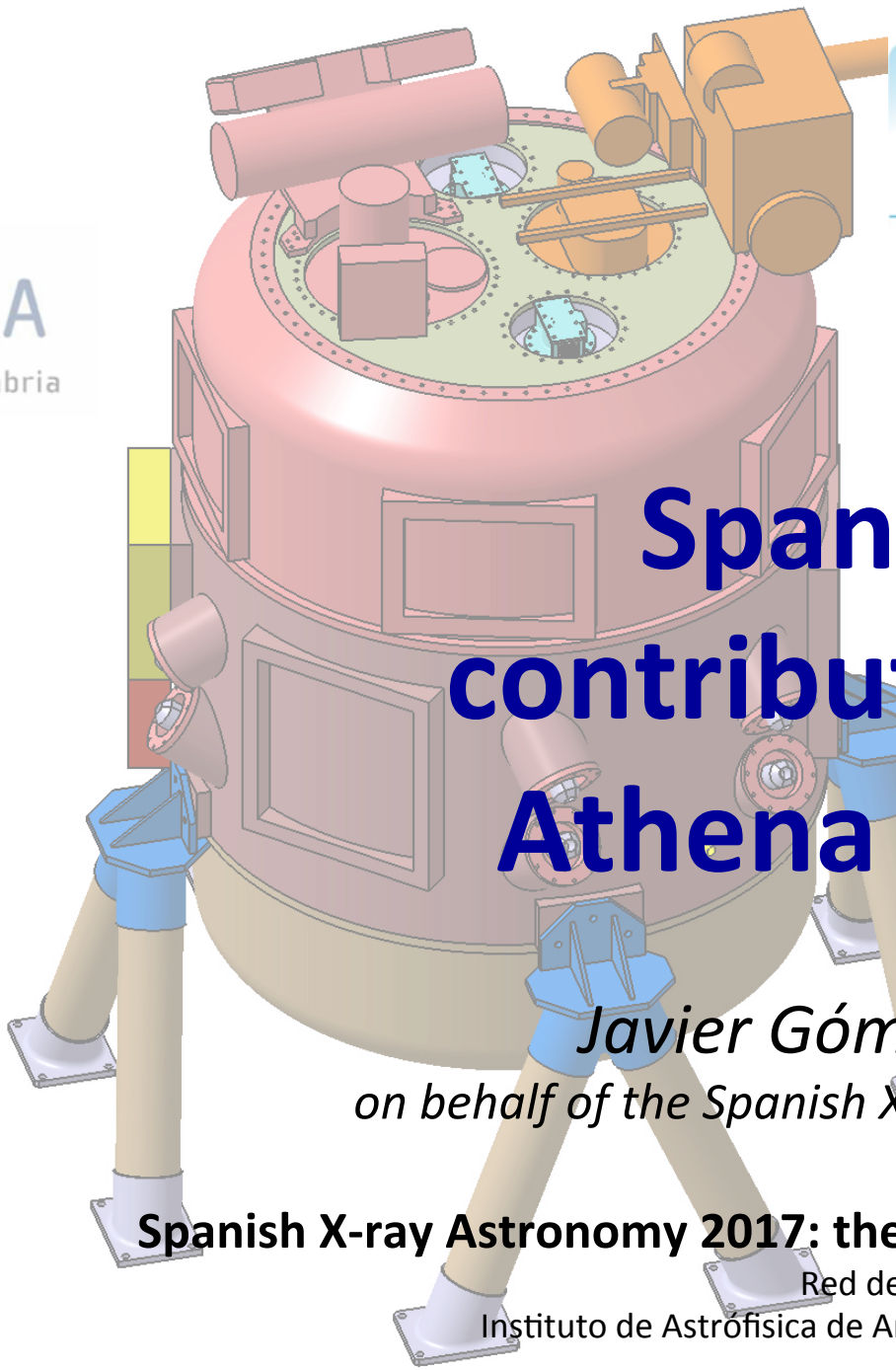


Spanish contribution to Athena X-IFU

Javier Gómez Elvira (INTA)

on behalf of the Spanish X-IFU instrument team

Spanish X-ray Astronomy 2017: the path towards Athena

Red de Infraestructuras de Astronomía

Instituto de Astrofísica de Andalucia - October 23-25, 2017

CONTENTS

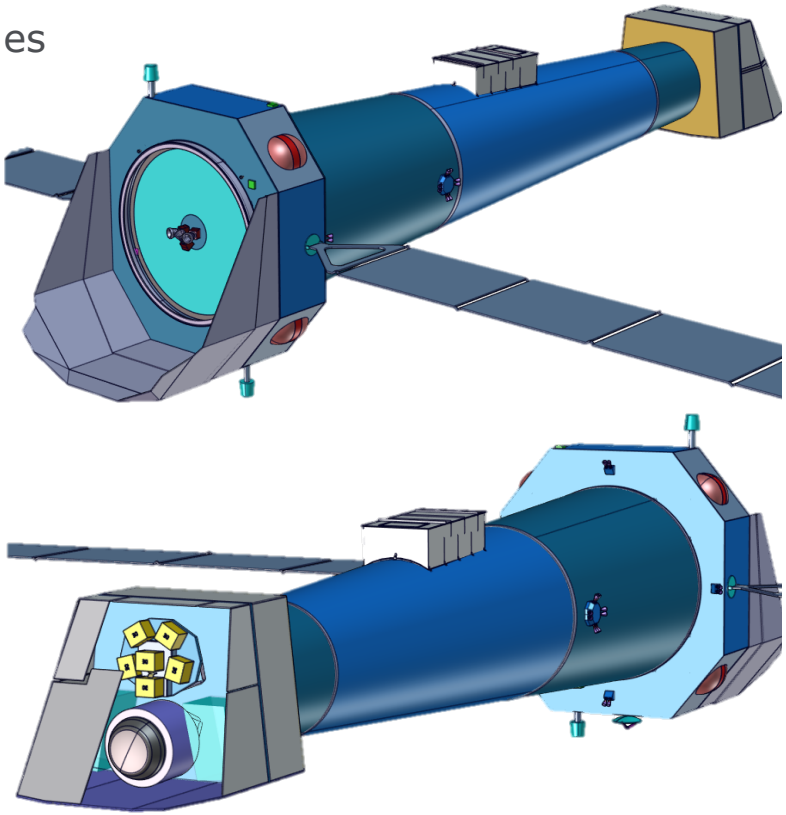
- X-IFU global view
- Spanish contribution to X-IFU flight segment
- Spanish contribution to X-IFU ground segment
- X-IFU instrument development. Spanish team
- TES detector development activities

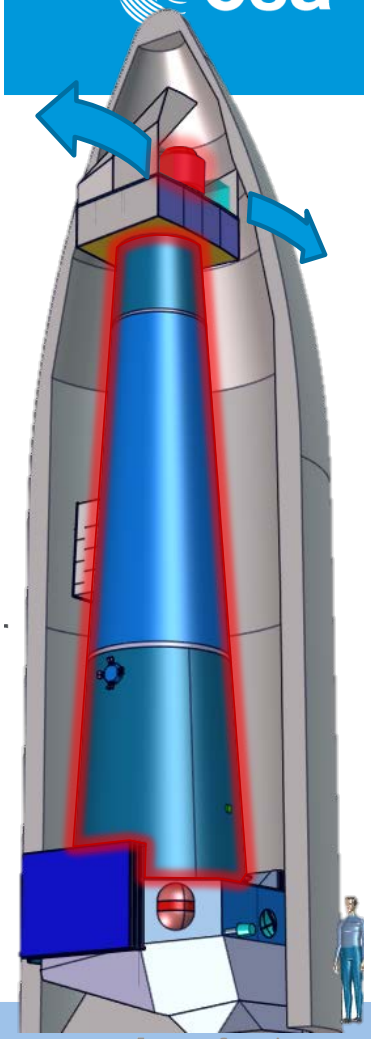
X – IFU Global view

ATHENA Study Outline

ESA ATHENA Phase A Study activities

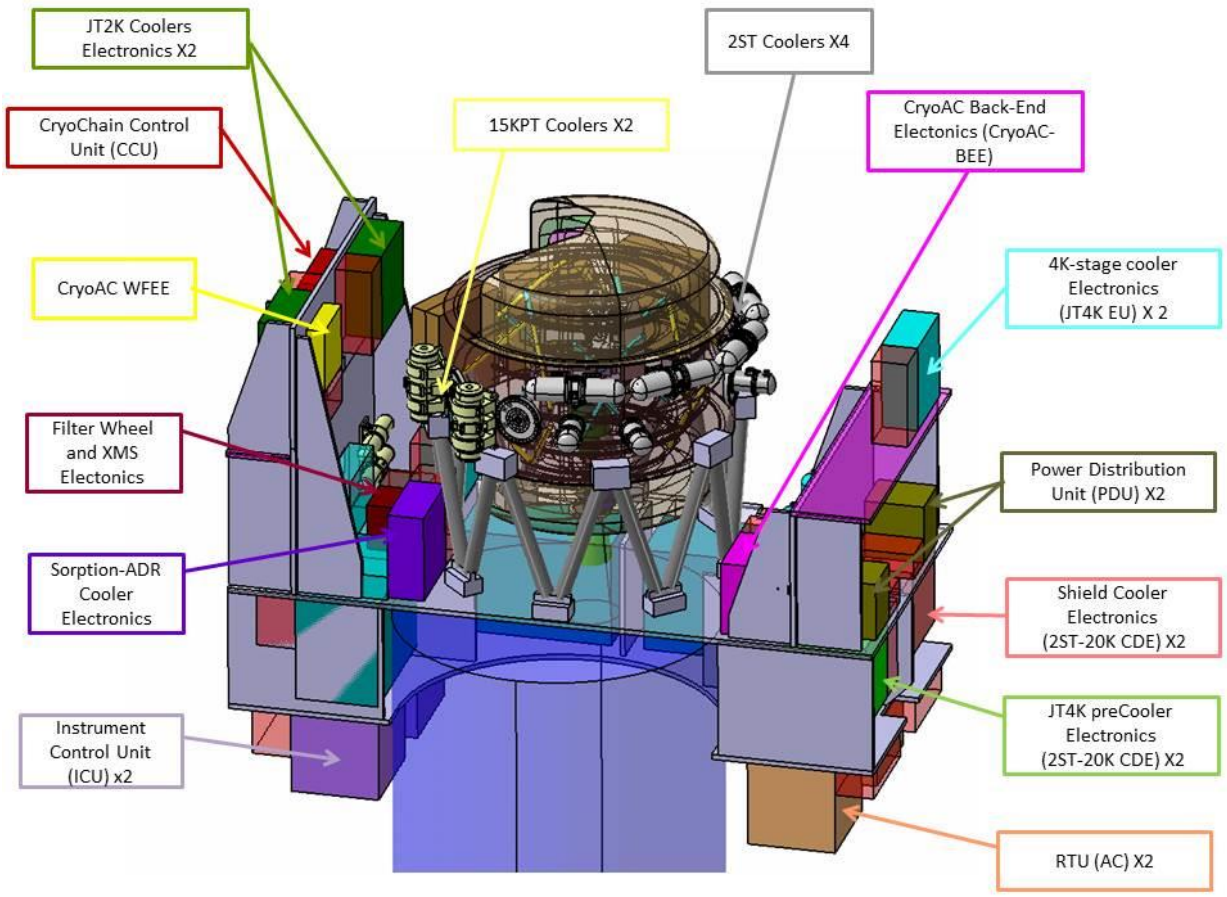
- Two competitive industrial studies
  - S/C configuration
  - Two S/C options: 15 mirror rows and 20 mirror rows
- Instrument studies
  - Instrument configuration
  - Resource and interface requirements





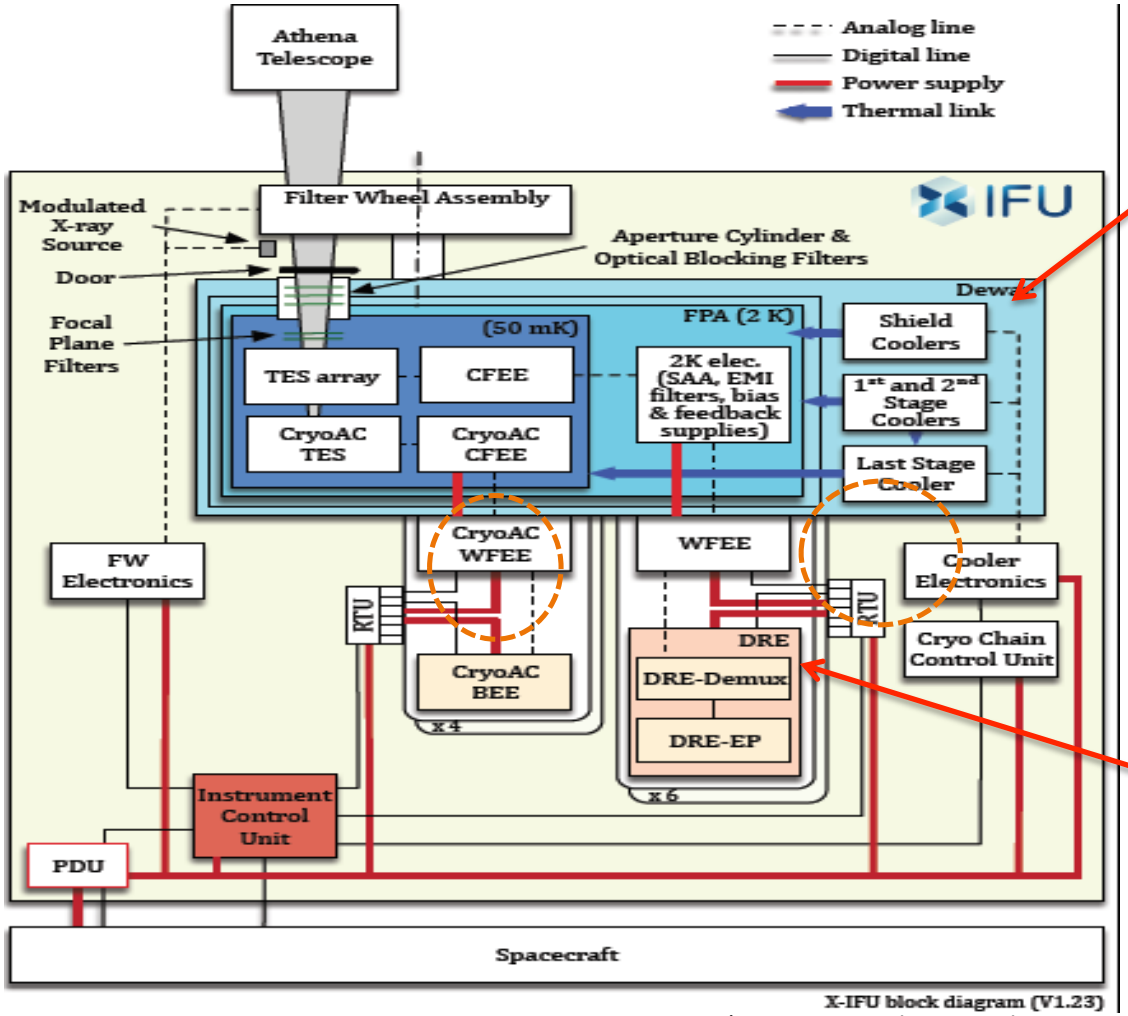
X – IFU Global view

Lay out



One of the major challenge is accommodate the radiators to dissipate all the power generated by the electronics and coolers.

Spanish Contribution to the Instrument Flight Segment

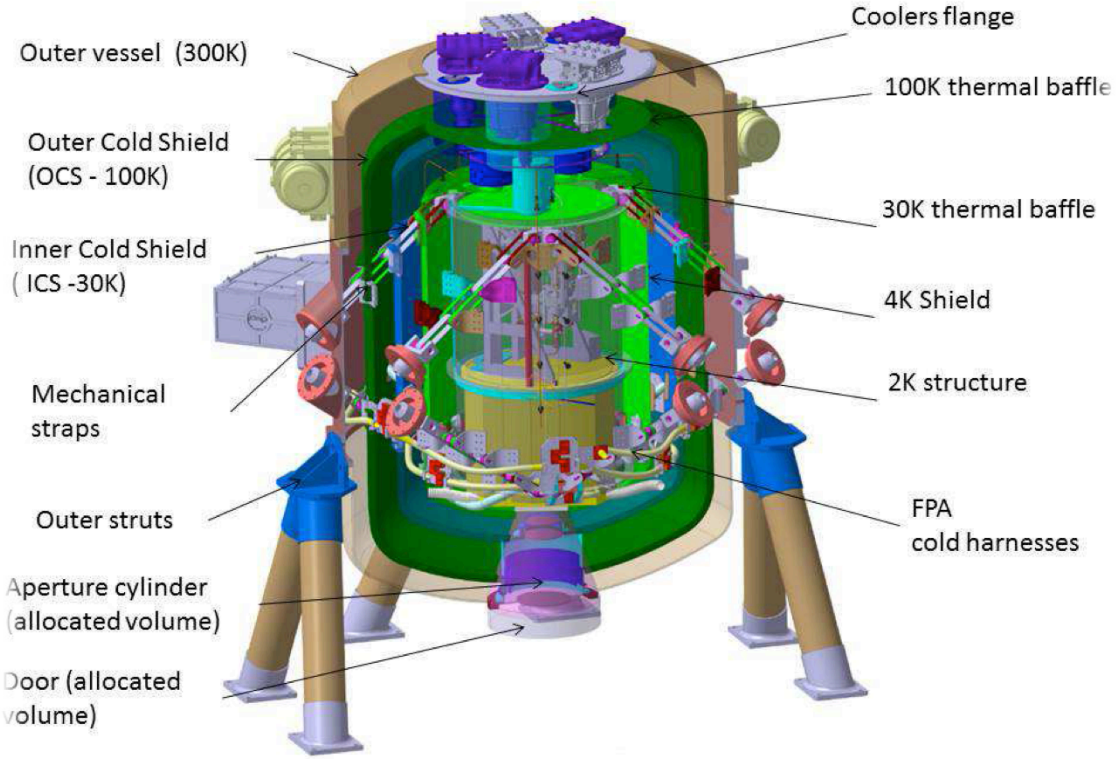


INTA contributes to the Dewar. In charge of cryostat.

IFCA contributes to the DRE

Source: X-IFU Status. Th. Lam Consortium Meeting, May 2016

DEWAR CONCEPT



Source: X-IFU Instrument Status Report. F. Delcelier-Douchin Consortium Meeting, September 2017

Some functions:

- Give support, thermal protection and electromagnetic isolation to the Focal Plane Assembly (Structure 2K and Mechanical straps).
- Isolation from external environment, support to the coolers and warm electronics, joint to the spacecraft (Outer vessel).
- Thermal accommodation. (Thermal baffles 100, 30, 4K).

Cryostat. Dewar without cryocoolers and FPA

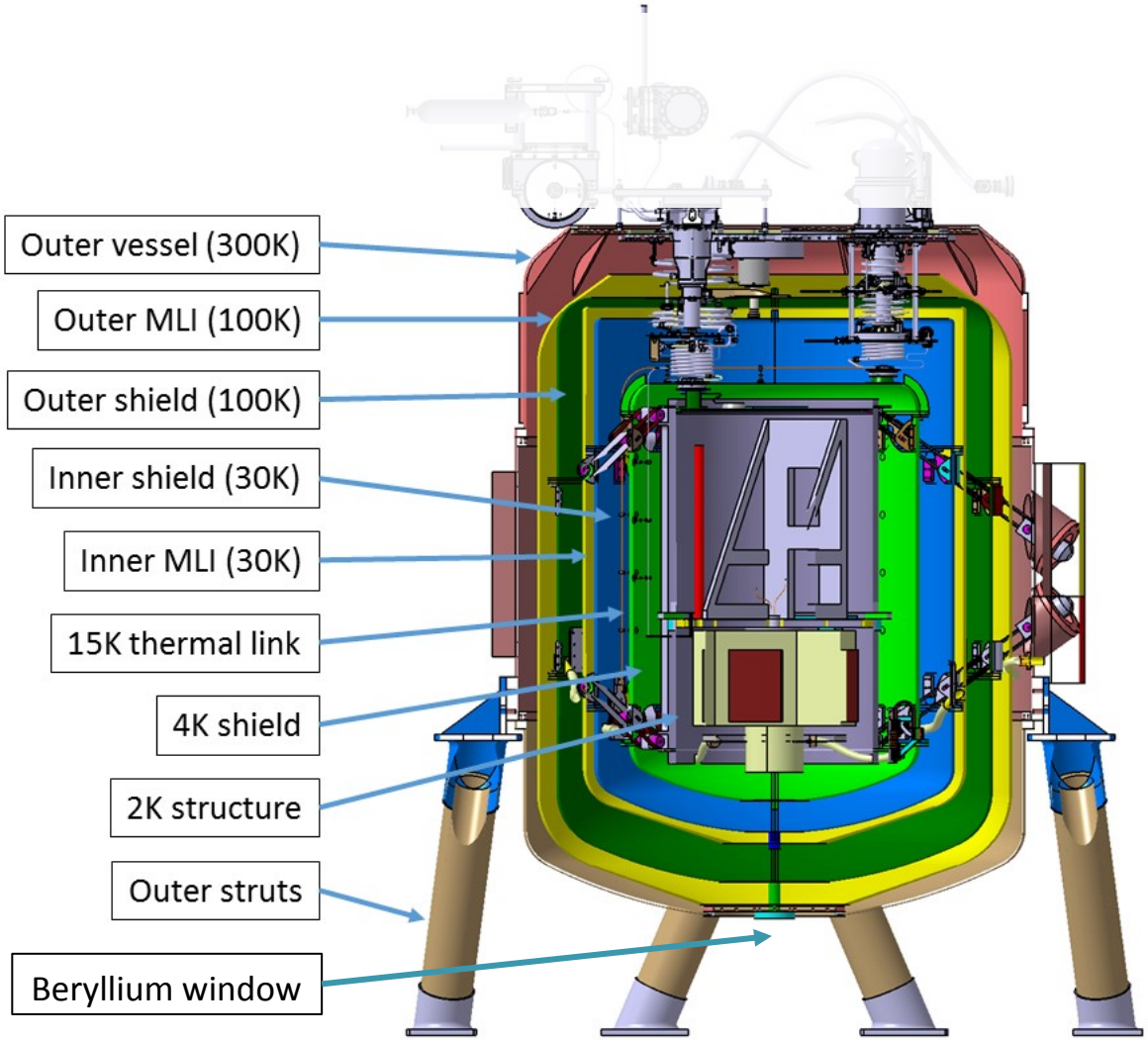
Cryostat design challenges

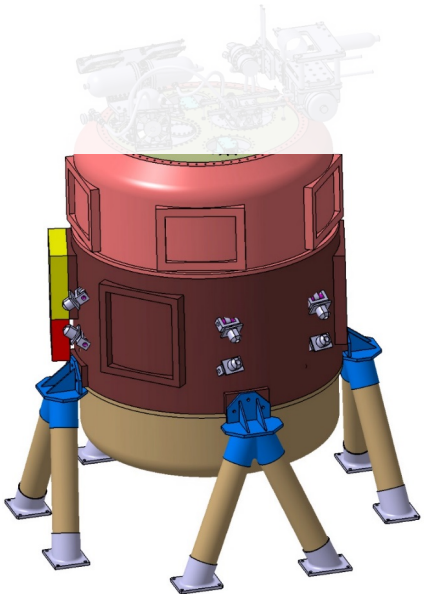
- FPA mechanical perturbations should be minimize:
  - Mechanical support should guarantee survive the launch -> dynamical isolation.
  - Mechanical support should minimize microvibrations transmission from external cryocoolers to the FPA support structure.
  - Mechanical support should manage a large temperature gradient from external 300 K to internal 2 K.
- FPA thermal isolation
  - Thermal design should guarantee its working temperature based on a set of internal barriers (thermal shield or thermal buffers).

Cryostat design challenges

- Mechanical support to many cryocoolers and warm electronics.
- Harness.
  - More than 1000 wires should be properly isolated from electromagnetic point of view and thermalized to minimize heat transmission.
- Beryllium window accommodation and isolation
- Minimize mass
- Integration

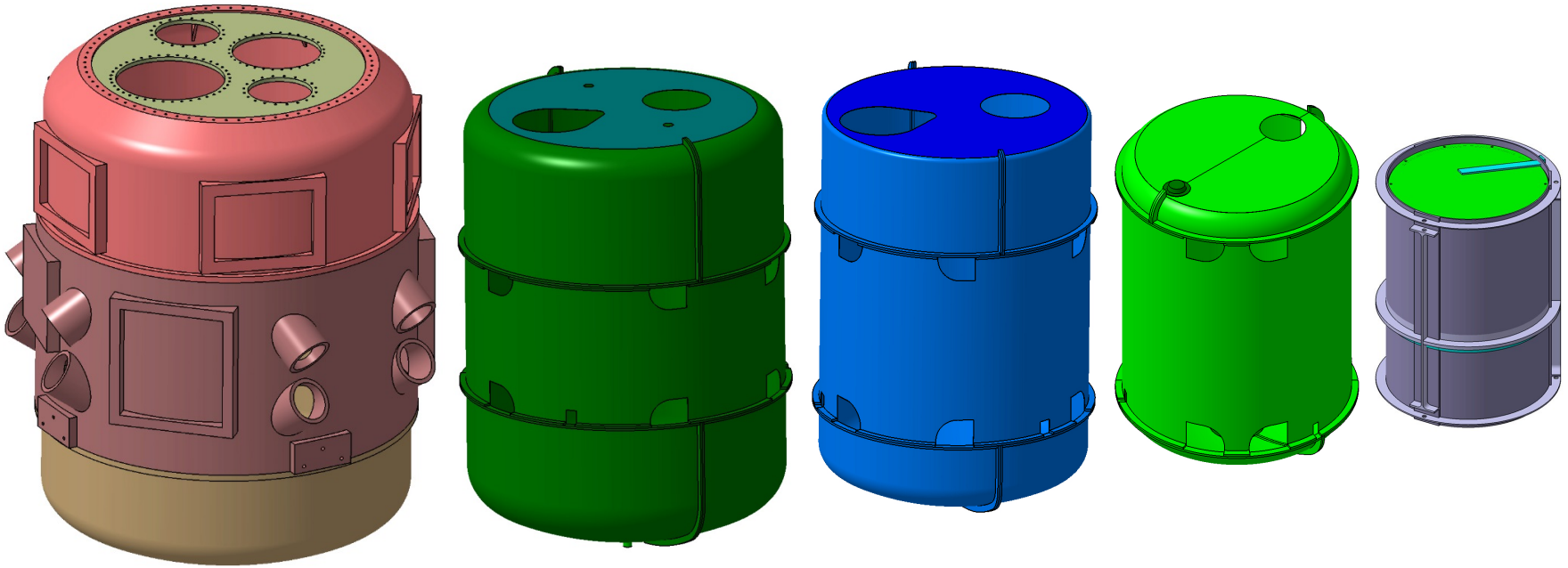
Cryostat
Detector Cooling System (DCS)





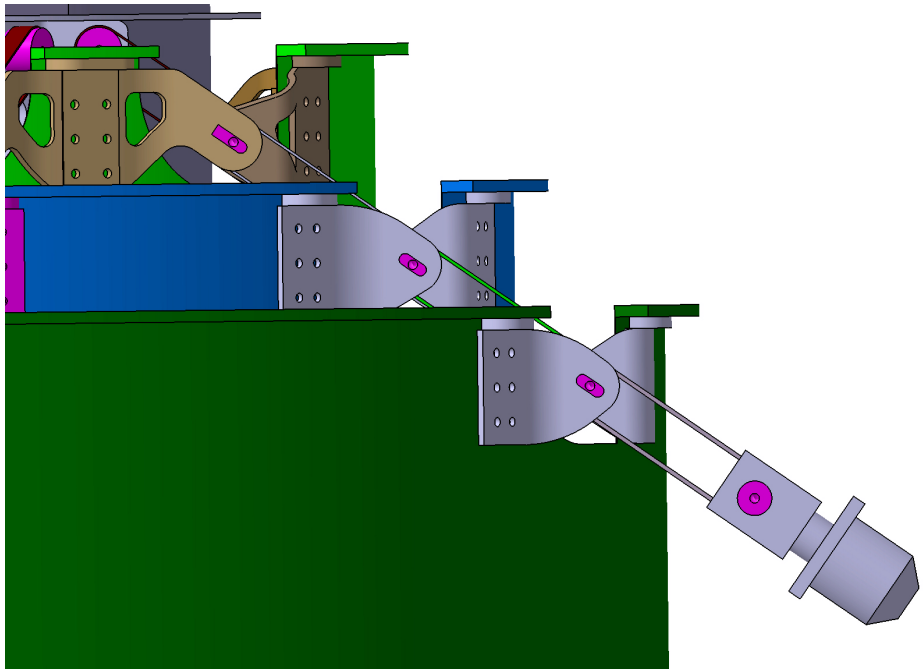
DCS is a ESA contract to develop the technologies required for X-IFU.

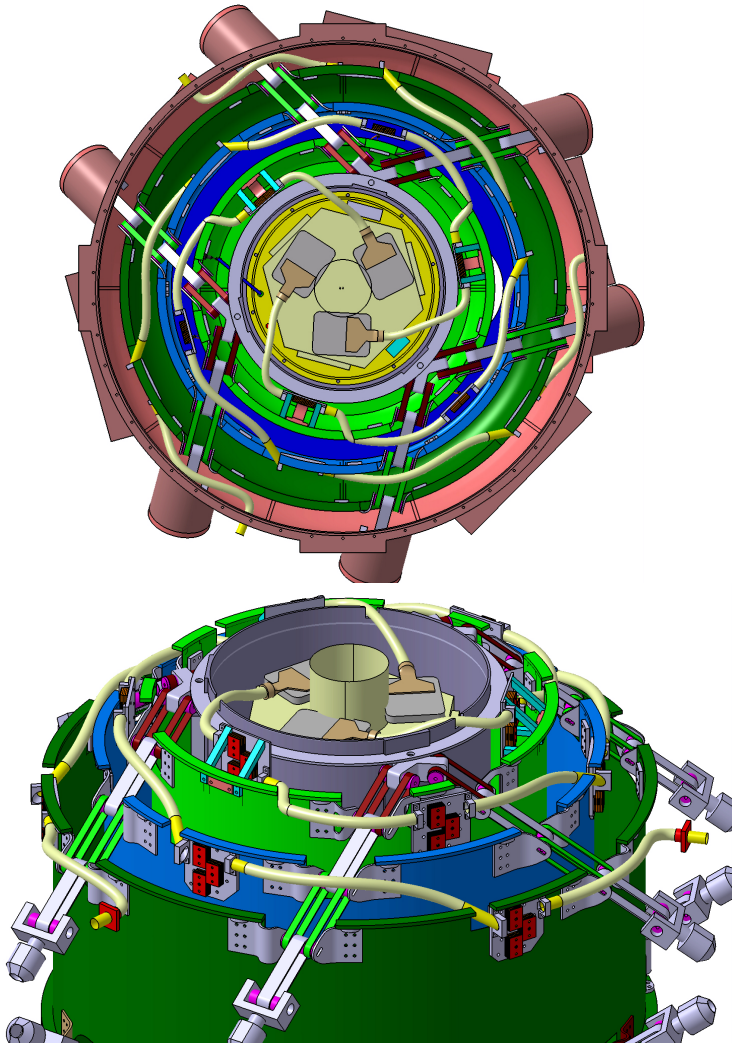
DCS
Thermal shields



Outer Vessel (300K)	Outer Shield (100K)	Inner Shield (30K)	4K Shield	2K Structure

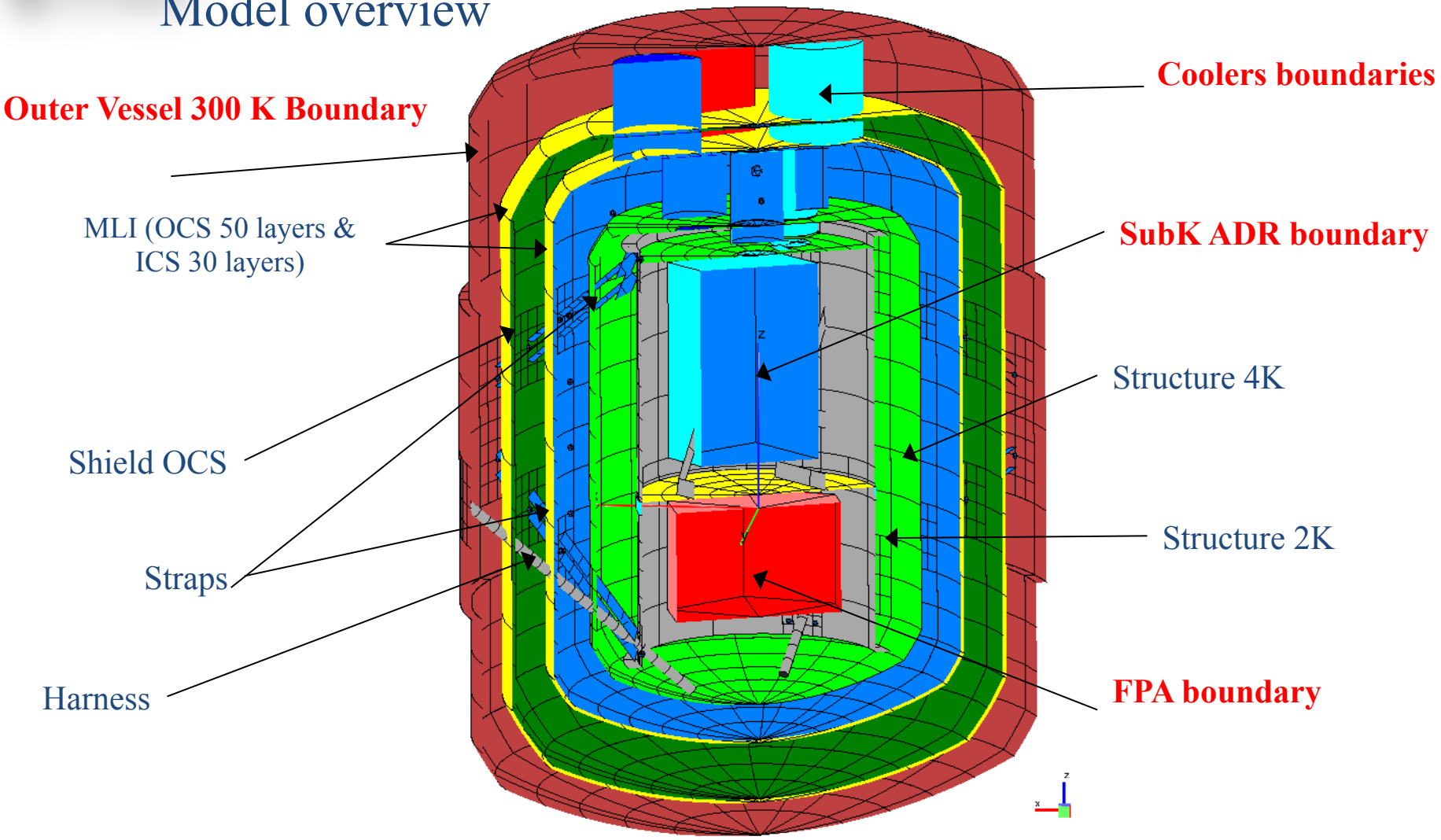
DCS
Straps and harness



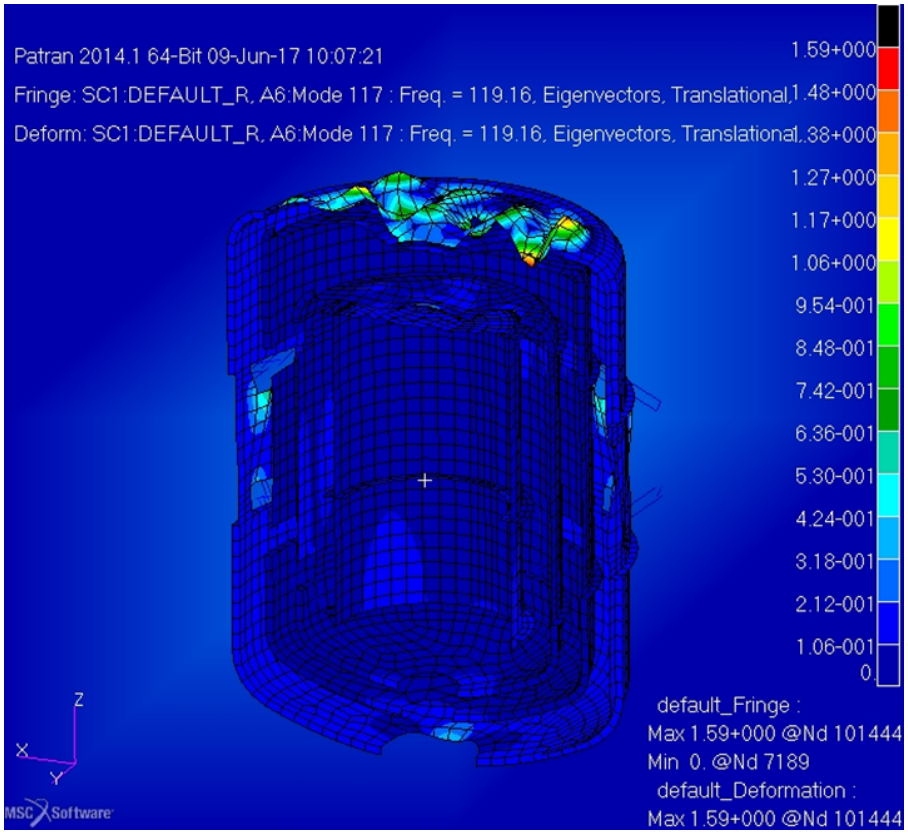


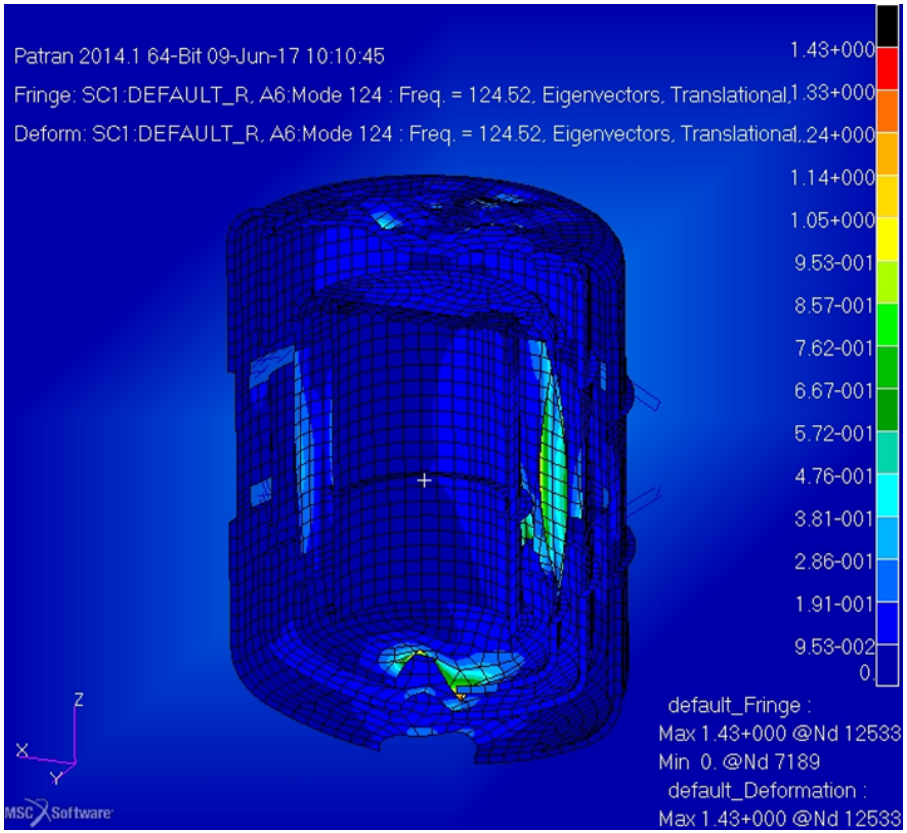
DCS
Thermal modelization

Model overview



DCS
Mechanical Analysis





DCS
Materials tests

- Materials properties at cryogenics temperatures are not available.
- A test campaign is on going to determine mechanical and thermal properties of the cryostat materials : CFRP and GFRP mainly. An components, like fatigue test of straps.

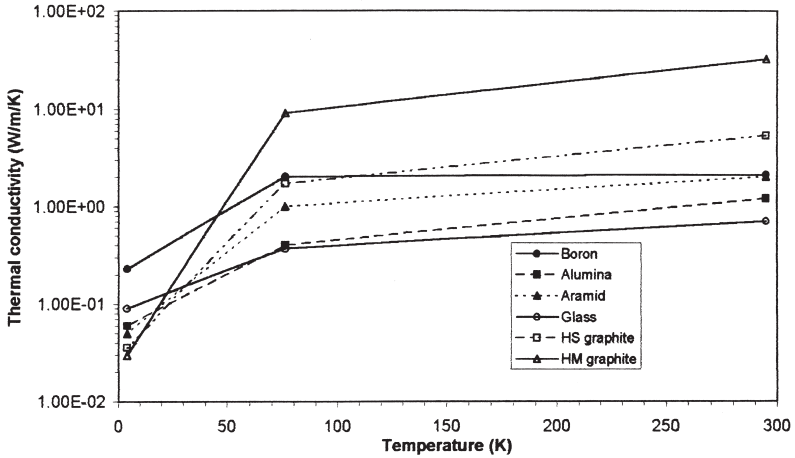


Figure 7 Thermal conductivity of unidirectional composites (data from reference [3])

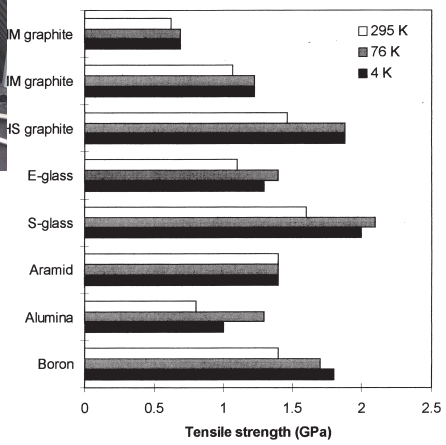


Figure 4 Tensile strength of unidirectional epoxy matrix composites (data from reference [3])

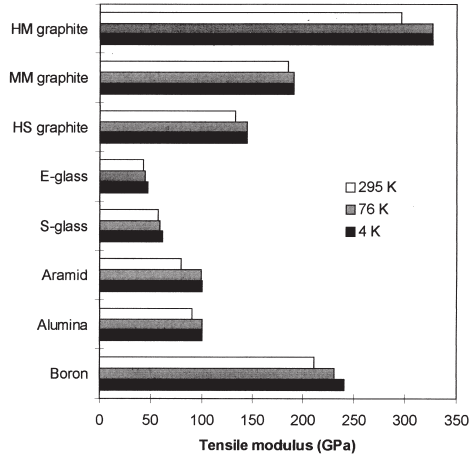


Figure 5 Tensile modulus of unidirectional epoxy matrix composites (data from reference [3])

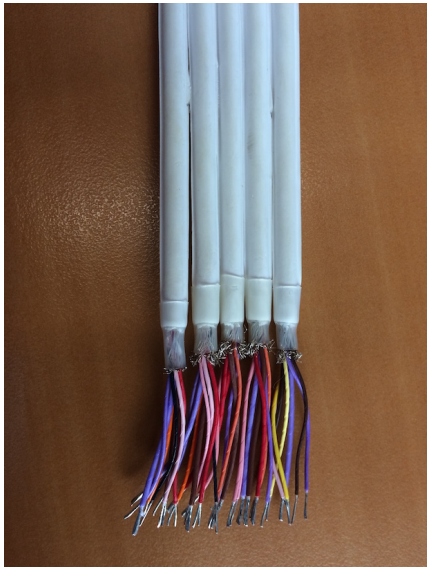
Properties of composites materials for cryogenic applications
Schutz J.B., Cryogenics 38 (1998)

DCS
Thermal tests

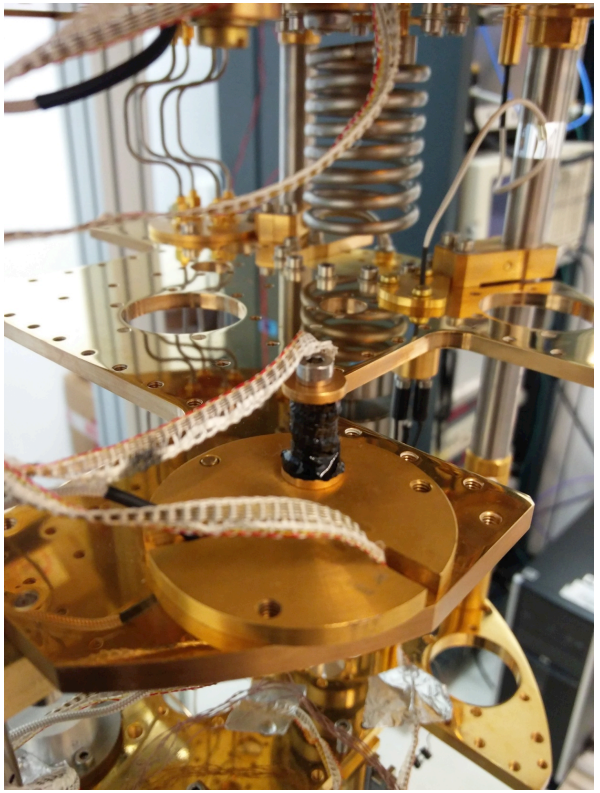
- One of the key aspect of the cryostat design is the need of properly modelling the thermal behaviour of the flight instrument. There are a lot of details that need to be tested well in advance: MLI properties at low temperatures, thermal conductivities, radiation, thermal couplings, etc. INTA is in charge of defining and performing those tests in collaboration with CNES and CEA.

DCS Harness

- DCS harness is a compromise of electronics, thermal, EMI and mechanics.
- Harness thermal, EMI and mechanical characterization is part of the INTA activities. Wire selection and bundle configuration is a work managed by CNES with SRON, CEA and INTA participation.
- Test will be performed in the futures for characterization.



An example of potential harness configuration.



Harness configuration of laboratory cryostat based on a loom which is thermalized in different steps.

Digital Read-out Eletronics Event reconstruction

Definition of:

- pulse detection & reconstruction algos.

- method to acquire DB for on-board processing

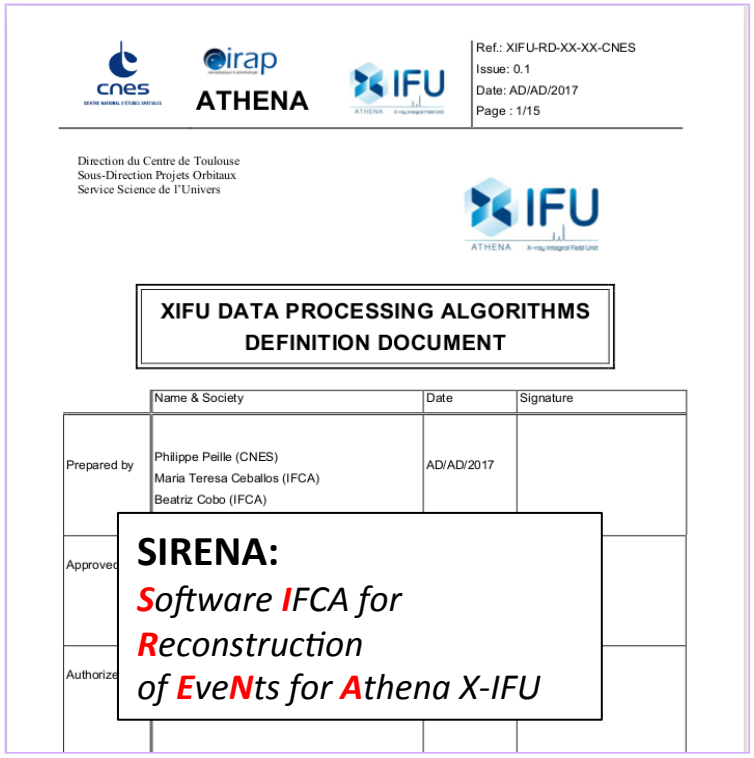
- post-processing corrections to deal with potential biases

BASELINE

Event processor algorithms

Collaboration with CEA Saclay (DRE HW/SW) and Bamberg University

w/ CNES: First Draft of Definition Document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Ref.: XIFU-RD-XX-XX-CNES
Issue: 0.1
Date: AD/AD/2017
Page : 1/15

Direction du Centre de Toulouse
Sous-Direction Projets Orbitaux
Service Science de l'Univers

XIFU DATA PROCESSING ALGORITHMS DEFINITION DOCUMENT

	Name & Society	Date	Signature
Prepared by	Philippe Peille (CNES) Maria Teresa Ceballos (IFCA) Beatriz Cobo (IFCA)	AD/AD/2017	
Approved			
Authorized			

SIRENA:
Software IFCA for Reconstruction of EveNts for Athena X-IFU

Working on:

* Alternative detection methods (less computing cost) → effect of missing pulses in energy resolution?

* Effect of reducing the sampling rate

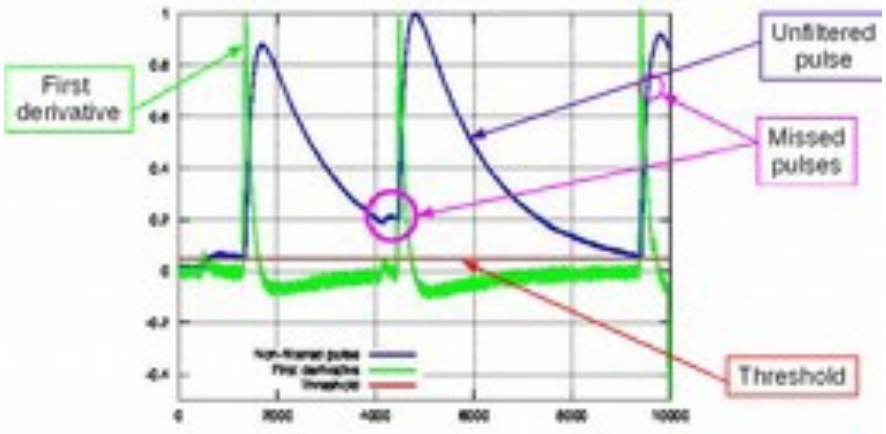
* Effect of time jitter in the pulse detection

* Exploring Neural Network approach to event reconstruction

EP splinter (CM #6 Madrid) M.Ceballos et al.

Digital Read-out Eletronics
Event reconstruction

Event processor algorithms



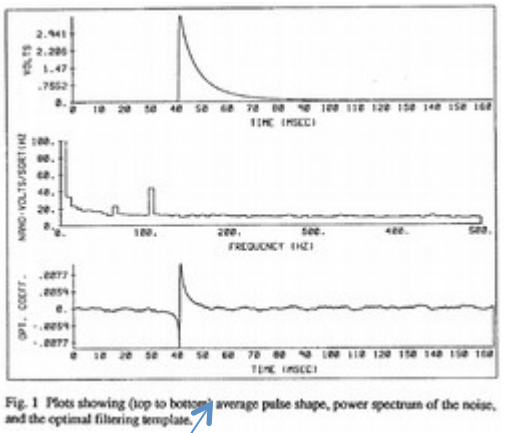
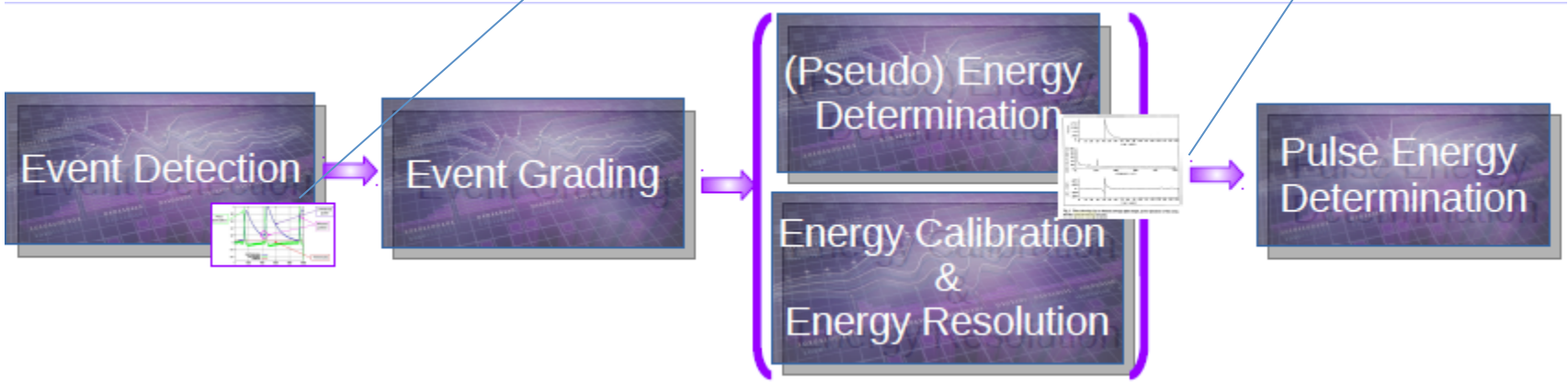


Fig. 1 Plots showing (top to bottom) average pulse shape, power spectrum of the noise, and the optimal filtering template.



Spanish Contribution to the Instrument Ground Segment

X-IFU Science Advisory Team/X-IFU Instrument Science Center

- Assessing the impact of Be filters of several thicknesses on the He like triplets spectral diagnostics of bright point sources at low energies.
- Hundreds of science simulations to study the X-IFU capabilities to recover the spectra of close sources in crowded fields.

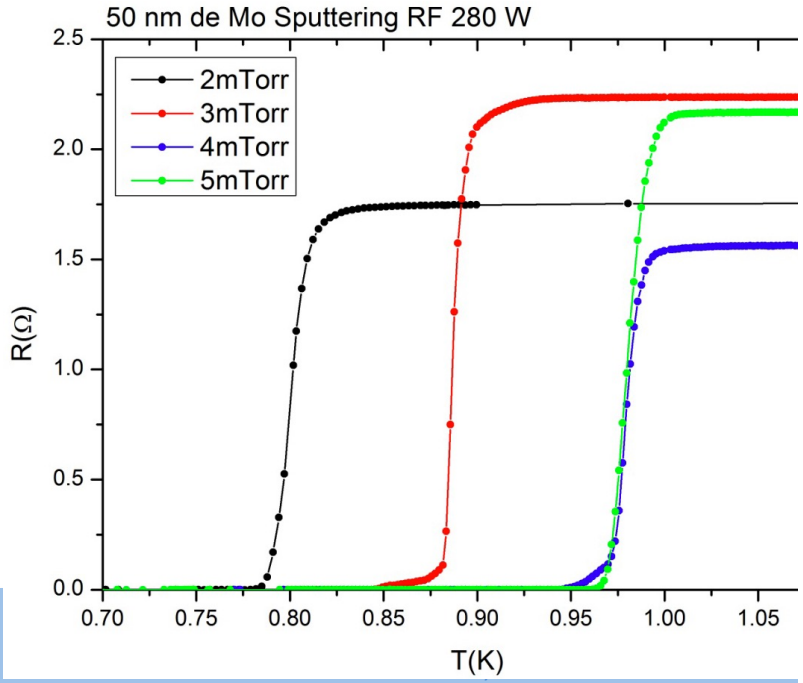
X-IFU instrument development Spanish team

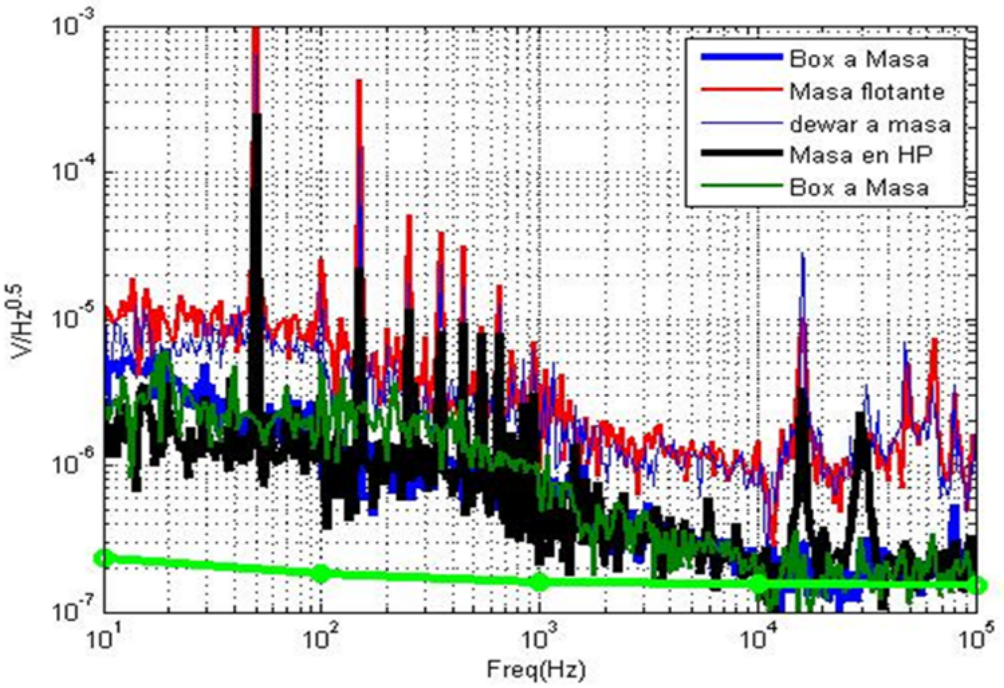
- Cryostat (not including cryocoolers)
  - INTA. J. Azcue, A. Balado , F. Cabrerizo, J.M. Encinas, J. Gómez-Elvira, J.M. Pintado, M. Reina, J.Sanmillan.
- Cryogenic harness (2 K → 300 K)
  - INTA. A. Balado, D. Escot, J. Gómez-Elvira, M. Pajas, D. Poyatos
- Event processing algorithms
  - Maite Ceballos and Beatriz Cobo (IFCA)
- X-IFU Instrument and Science Center
  - J. Miguel Torrejón (UAlicante) + IFCA

ICMAB/ICMA activities

Transition Edge Detectors (TES)

- Development in parallel. **Not for flight**.
- Fabrication of Mo and Au thin films by off-axis sputtering
- Nb pads: fabricated, lithographed and tested
- Lithography tests fully performed
- Noise characterization tests performed





ICMAB/ICMA activities

Transition Edge Detectors (TES)

- Pixels manufactured and tested with Bi absorbers:
  - Parameters close to state of the art. Very good prospects.
- Successful tests of electrodeposited Bi/Au and pillar-cantilevered Bi absorbers.