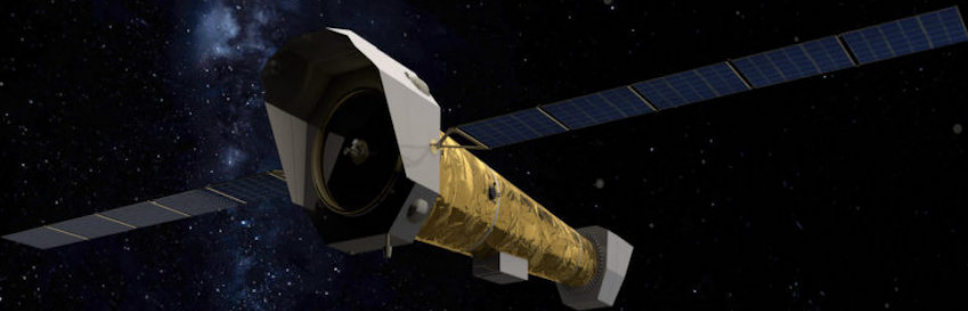




ATHENA

Cosmo group meeting - APC

Damien PRÊLE - 29 Mars 2021

ATHENA in the ESA Cosmic Vision

Space science programme of the European Space Agency (ESA)
2015–2025/35... [L class](#) :

L1 Jupiter Icy Moon Explorer - JUICE

Jupiter system (Laplace heritage) launch planned 2022

L2 Advanced Telescope for High Energy Astrophysics - ATHENA

X-ray observatory launch planned 2031

L3 Laser Interferometer Space Antenna - LISA

Gravitational waves at lower frequencies than Earth-bound
detectors launch planned for 2034



Athena project development - current status

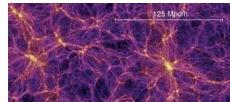
Athena selected in 2014 by ESA ...after ATHENA+ IXO XEUS proposals ...

- ▶ The **WFI and X-IFU instruments consortia** officially endorsed by ESA in December 2018 → successful **Instrument Preliminary Requirements Review** - IPRR in 2018/2019
- ▶ **Phase A ended on Nov. 2019** with Mission Formulation Review → Phase B1
- ▶ X-IFU currently **moving to phase B2**
- ▶ next key milestone **Mission Adoption by ESA's Science Programme Committee - SPC - end 2022**
- ▶ ... **launch (Ariane 6) in the early 2030s**



ATHENA science case

The Hot and Energetic Universe



- ▶ *How ordinary matter assemble in the large-scale structures?*

large scale structure map → hot gas ($>50\%$ baryons $> 10^6\text{K}$; $> 10^7\text{K}$ in clusters as in the stars) evolution : chemical enrichment

- ▶ *How black holes grow and shape galaxies?*

around supermassive black holes conditions
accretion of compact objects

Cosmic feedback : black holes $\leftrightarrow$ cosmic structures

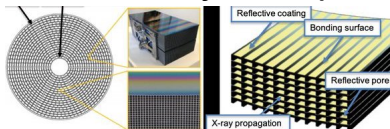
and

- ▶ Fast ToO capability → **transient** sources
- ▶ Powerful **general-purpose observatory** → current astro. topics
- ▶ + multi messenger astronomy conjunction with ALMA, ELT, JWST, SKA, CTA, LISA ...



Advanced Telescope for High ENergy Astrophysics

- ▶ single large-aperture **grazing-incidence X-ray telescope**

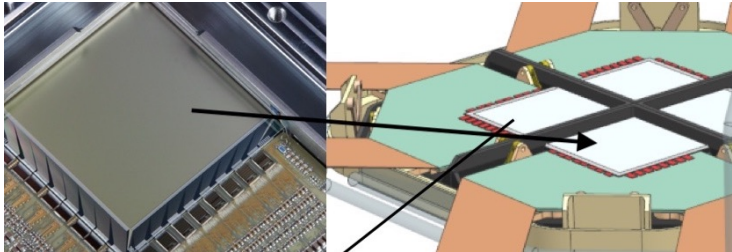


ESA Si pore optics mirror ef area 1.4m^2 @ 1 keV

- ▶ **12m focal length** and 5 arcsec on-axis angular resolution
- ▶ 0.2-15 keV X-ray focal plane contains 2 instruments :
 - ▶ **Wide Field Imager - WFI**
40'x40' field of view / spectroscopy 170 eV @ 7 keV / high count-rate capability (DEPFET detector)
 - ▶ **X-ray Integral Field Unit - X-IFU**
spatially resolved high-resolution X-ray spectroscopy over 5 arc minutes - 5"/pixel (TES)

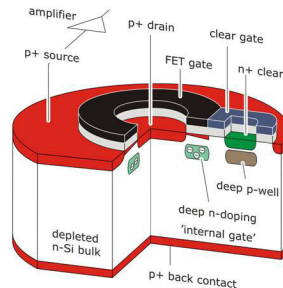


Wide Field Imager - WFI



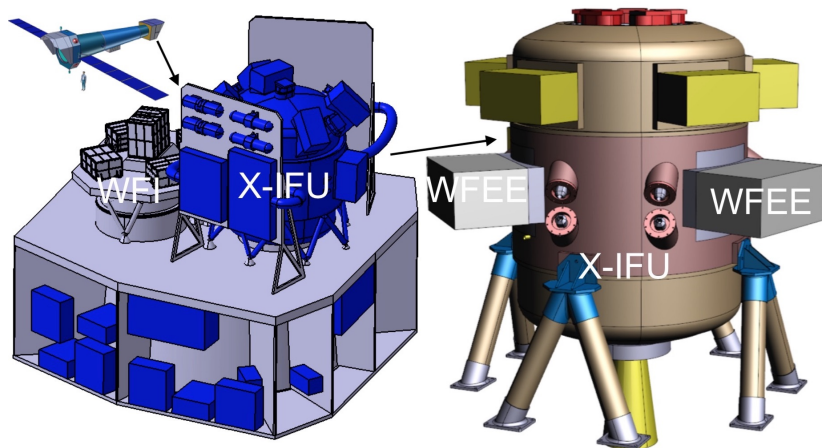
4 x 512 x 512 DEPFET
13cm side
+ TDM ASIC based readout

Depleted P-channel FET →



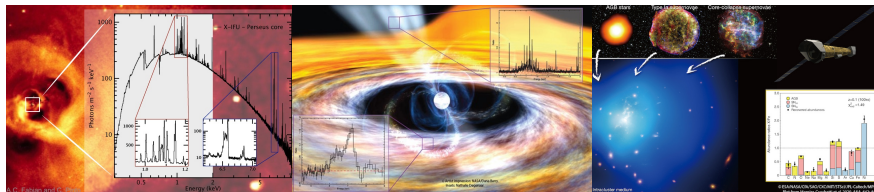
The Athena X-ray Integral Field Unit

3-4 k TES micro-calorimeters cooled to 50 mK $\rightarrow$ look like a big *cryostat* (about 1 m side) with Adiabatic Demag. Refrigerator ADR + Joule Thompson & Pulse Tube coolers

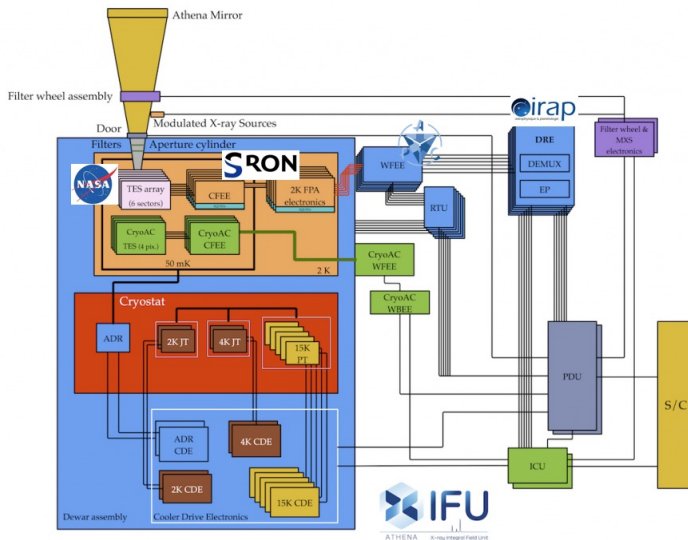


Key performance requirements for X-IFU

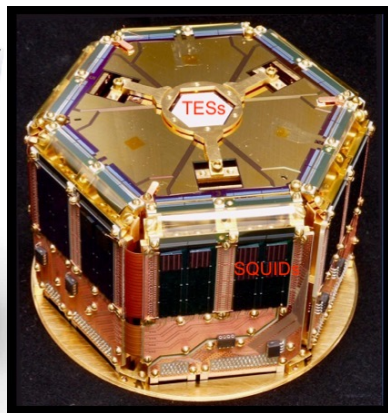
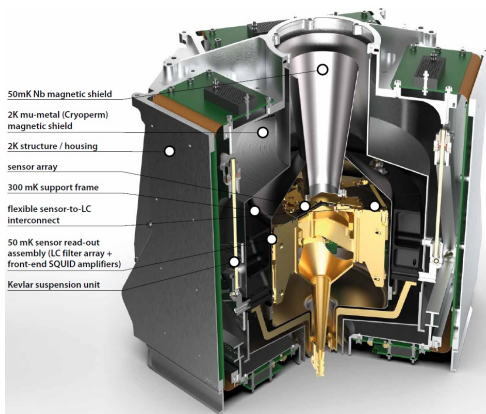
Energy range	0.2-12 keV
Energy resolution	2.5 eV @ 7 keV ($E/\Delta E = 2800$)
Field of View	5' (diameter) (3840 TES)
Effective area	1.5 m ² @ 1 keV
Gain error (RMS)	0.4 eV
Count rate capability	1 mCrab(HighRes) - 1 Crab
Time resolution	10 μ s



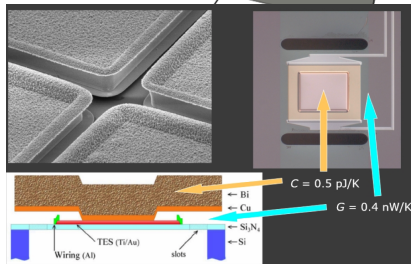
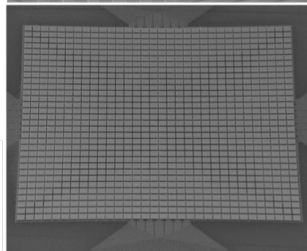
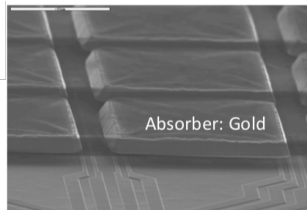
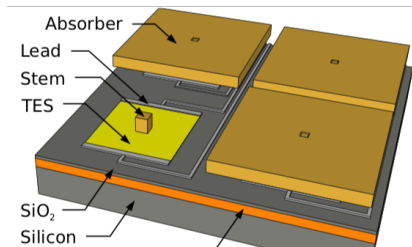
X-IFU Functional block diagram



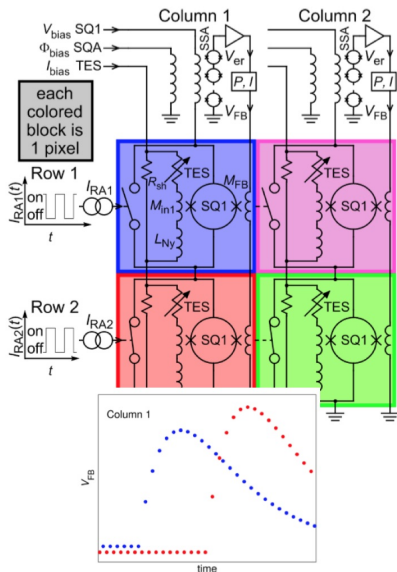
X-IFU Focal Plane Assembly - FPA



Transition-Edge Eensor - TES



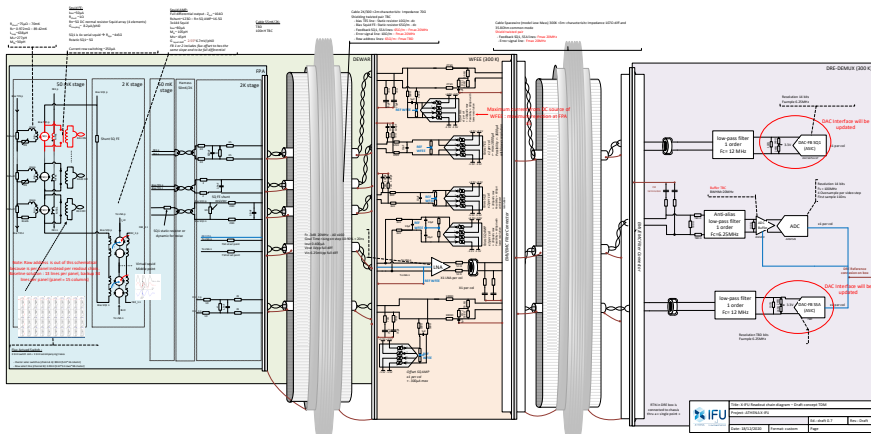
Time Domain Multiplexing - TDM (move from FDM to TDM in 2019/2020)



- ▶ 34:1 mux factor
- ▶ SQUID MHz switch ON/OFF
- ▶ Each pixel sampled at 180 kHz
- ▶ Interleaved signals demux@ 300 K
- ▶ Linearize SQUID feedback generated with 1 frame delay
- ▶ 96 readout channels
- ▶ Ground-based demo 8x32 demo ΔE 2.23 eV @ 7 keV



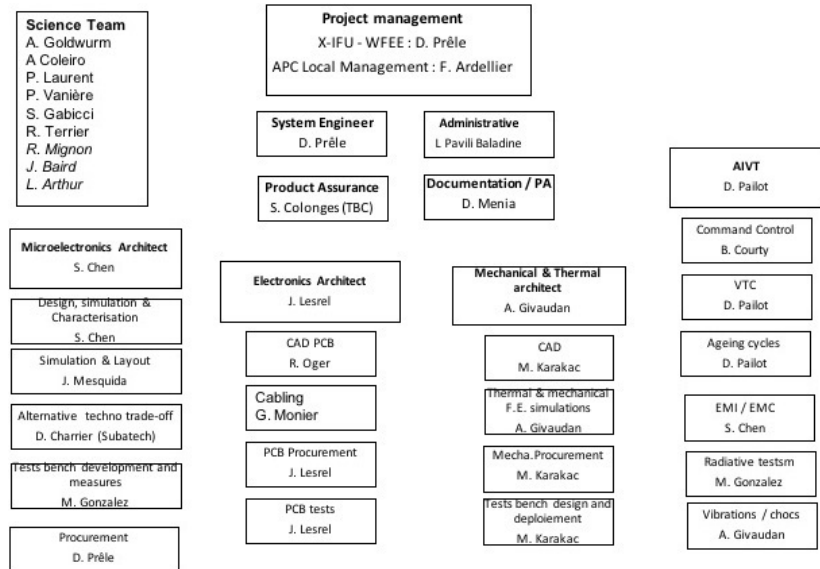
Warm Front End Electronic - WFEE in the X-IFU TES Readout



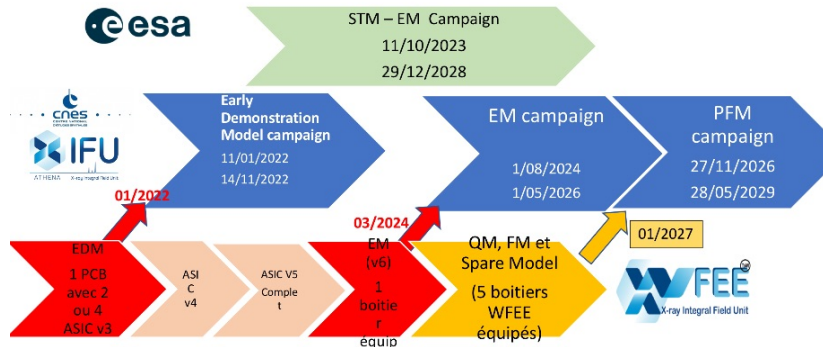
FPA (TES+SQUIDmux@50mK+SQUIDamp@2K) $\rightarrow$ WFEE (LNA+bias TES&SQUID) $\rightarrow$ APC $\rightarrow$ DRE (Demux+Row@+EP) $\rightarrow$ IRAP



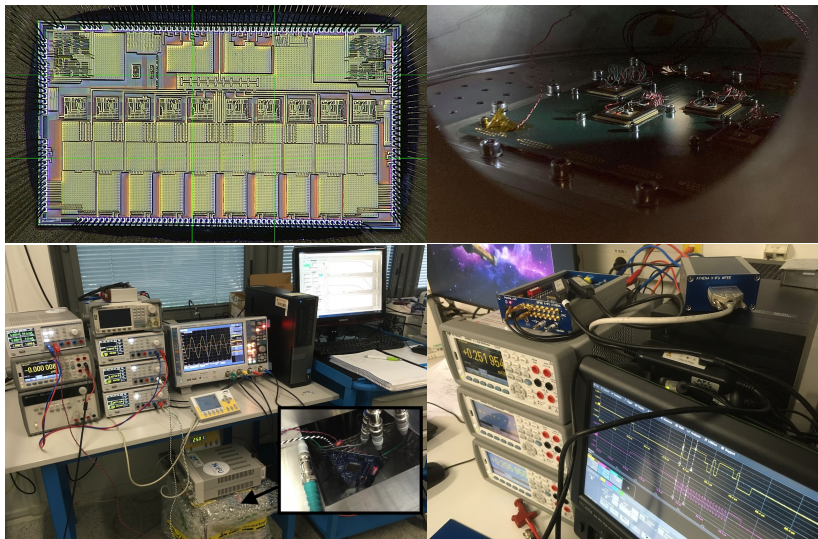
Equipe projet WFEE @ APC



Schedule and model philosophy



some activities about WFEE ... at APC



X-IFU consortium @ APC (2018)

