

**Engineering & Operations in  
Space Mission Design  
Now & Then**

Tübingen July 2010

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A personal view

Experimental High Energy Astrophysics  
- Challenges for the new Decade -

# Four ESA Astronomy Mission now ...



- **Planck**

- Cosmic Microwave Background (CMB)
- Cold Dust

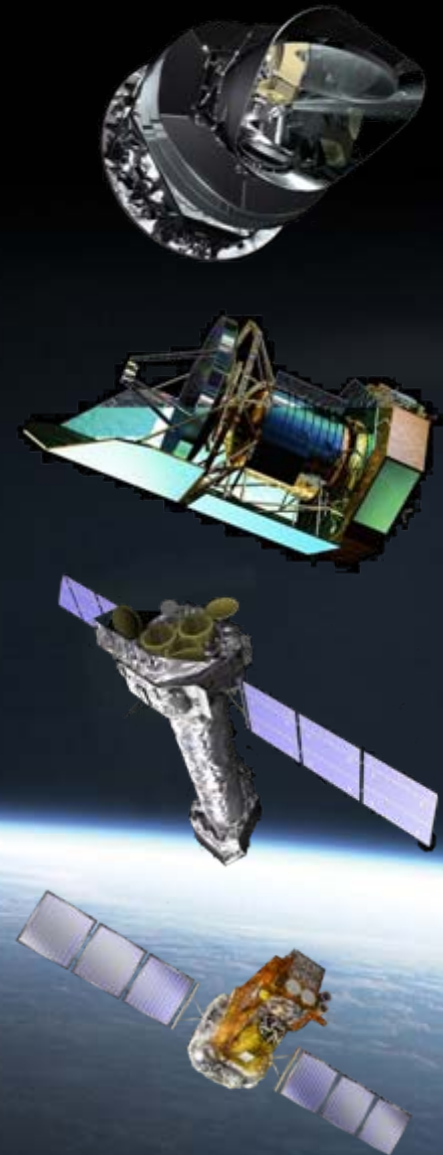
- **Herschel**

- Early galaxies
- Star formation

- **XMM-Newton**

- **Integral**

- **(SIMBOL-X)**



A large, high-resolution image of Earth from space, showing the African continent and surrounding oceans. The image is the background of the slide.

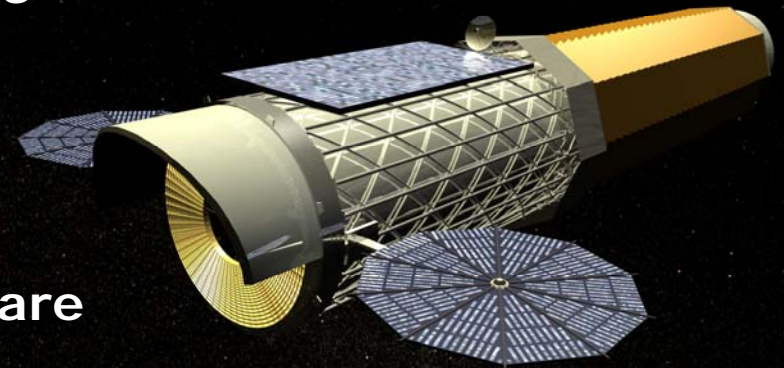
## Viewed from ...

- **On Board Hardware Design**
- **On Board Software Design**
- **Operational Concepts**

# Why interesting for experimental group at IAAT?

- **IXO -> L2**
  - H/P
- **Change in Design**
  - Philosophy & Paradigms
- **Move of**
  - Science Functions
    - GND -> Onboard Software
  - Autonomous Functions:
    - SOC, MOC -> BUS (Payload)

**Lesson learnt from:  
& SIMBOL-X**



- **Resources**
- **Safety**
- **Testability**

Let's start at the beginning...



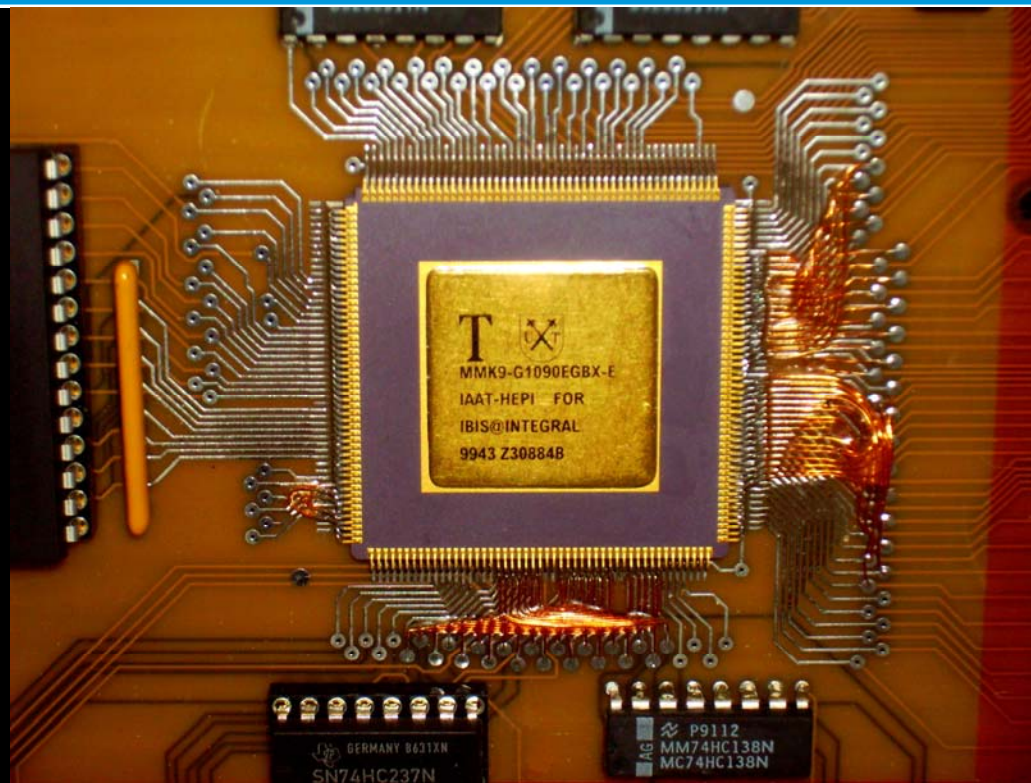
- **Balloon data or FPGA design?**

- **Experimental Heritage**

**E. Kendziorra**



- **Integral IBIS**
  - HEPI
  - FPGA / ASIC
  - GRB Detector & PRE-Burst Buffer
    - NO!
  - Self-Testing
    - NO



- **SIMBOL-X: LEON 3 w/ software [VEGA]**
- **But HERSCHEL RAM, no EDAC!**

- **Integral IBIS IASW [VEGA]**
  - (Almost) no autonomous functions but
    - Noisy pixels handling
    - Broad Cast Package [BCPK] handling (not XMM)
- **SIMBOL-X on Board SW (DPDPA)**
  - Science Data Processing
    - Noisy pixels
    - LED 3 spectra (1 target, 2 background)





- **[Right now @ MOC]**
  - **XMM: 4 wheel drive [life time]**
  - **INT: detector degradation, BG+, compression [science quality]**
  - **H: STR warm pixels, speed bumps [science quality]**
  - **H: no EDAC, CRC [ops]**
  - **P: thermo elastic w/ STR [science quality]**



- **Highly Elliptical Orbit -> Belts**

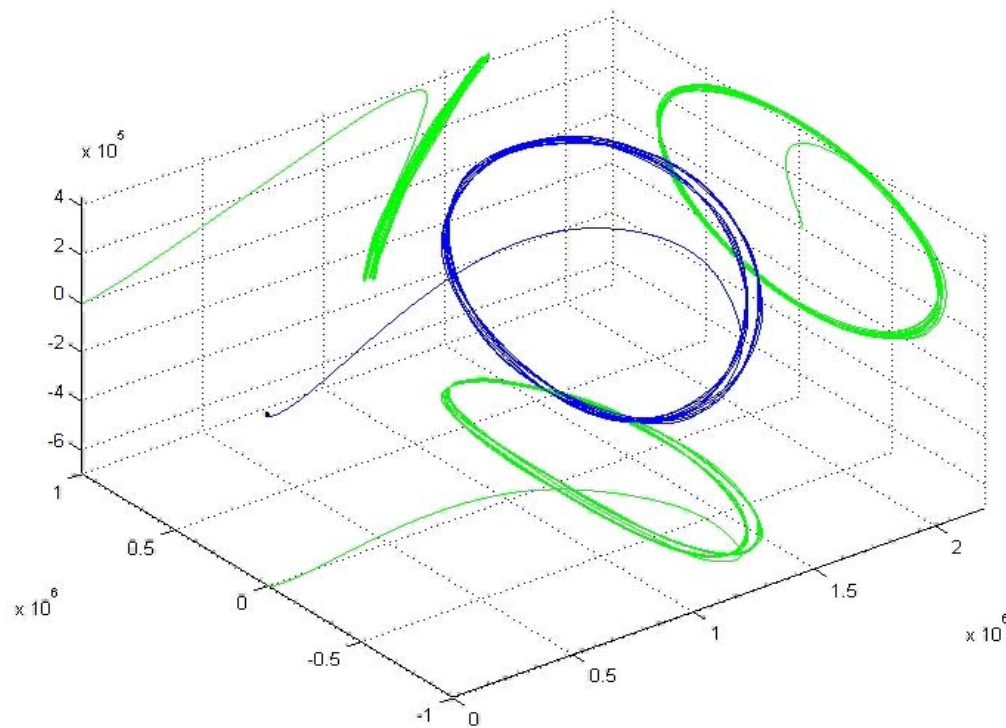
- **INTEGRAL**      Apogee /      Perigee  
                         150.000 /      7.000 km

- **XMM**              Apogee /      Perigee  
                         100.000 /      20.000 km

- **L2**

- **Herschel**                      800.000 km Halo

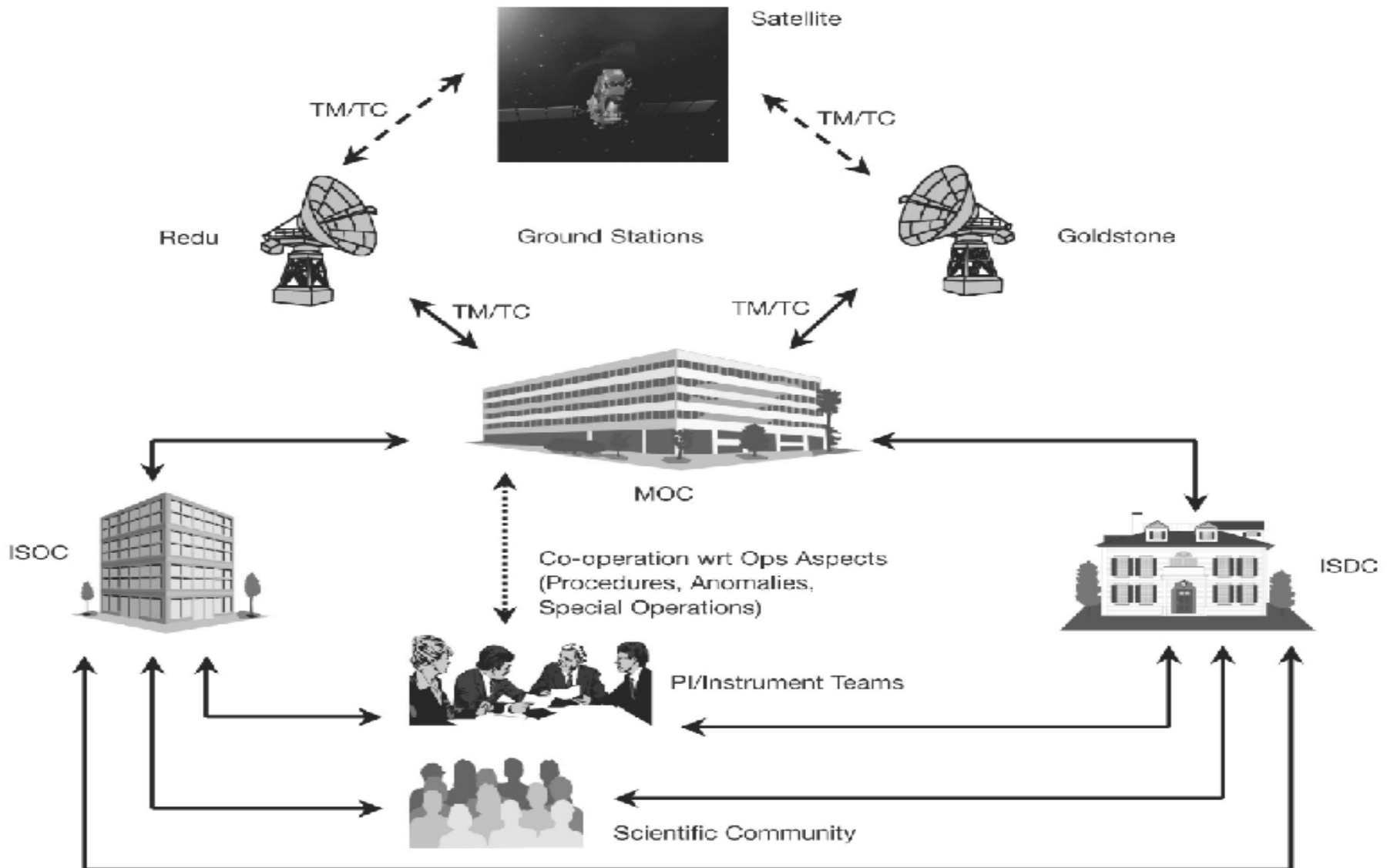
- **Planck**                      400.000 km Lissajou



- **INT / XMM**
  - 24/7
  - 2 GS each
- **H / P**
  - 3/7
  - 1/2 GS each



# TC / TM Flow



|             | <b>XMM/INT</b> | <b>H/P</b>  |             |
|-------------|----------------|-------------|-------------|
| • <b>TM</b> | <b>40</b>      | <b>1600</b> | <b>kbps</b> |
| • <b>TC</b> | <b>1</b>       | <b>4</b>    | <b>kbps</b> |

# TC from to Matrix



| TC               | From       | For PL  | For Bus | For Attitude Control |
|------------------|------------|---------|---------|----------------------|
| Ground TC        | Ground     | X I H P | X I H P | X I H P              |
| Auto stack       | Ground     | X I     | X I     | X I                  |
| CCCF             | Ground     | I       |         |                      |
| Time Tag Command | GND -> BUS | X I H P | X I H P | X I H P              |
| BCKP             | BUS        | I       |         |                      |
| OBCP             | BUS        | H P     | H P     |                      |
| OBCP             | PL         |         |         | <b>FERMI</b>         |

Nikolai von Klusenstern

- **Broadcast packet**
  - -> OBCP
- **3h Daily Telecommunication Period (DTCP )**
  - -> Data recorders
- **Time Tagged Commands**
  - -> MTL 40.000 @ H
  - -> Payload OBCP's?



- **Stick to TM / TC**
- **Functions**
  - **As far away from detector as possible**
  - **As close as necessary**
- **Reduce / Compress Data**

AKARI  
Japanese Infrared  
All-Sky Surveyor

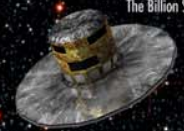
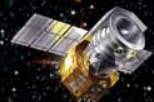
GAIA  
The Billion Star Surveyor



PLANCK  
Looking back to the dawn of time



HERSCHEL  
Unveiling the Universe



ISO  
Infrared Space  
Observatory



HUBBLE SPACE TELESCOPE  
Expanding the frontiers of the visible Universe



JWST  
Striving to observe  
the first light!



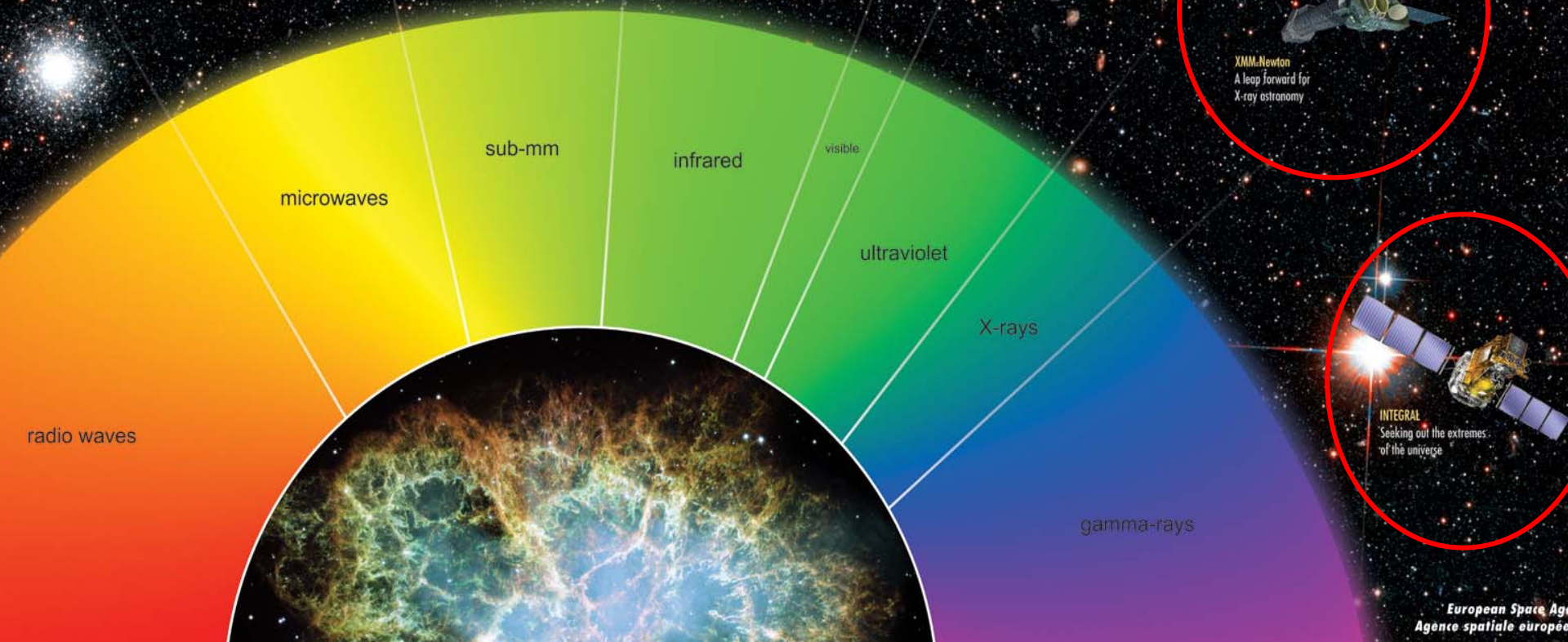
IUE  
Taking the measure of  
Massive Black holes



XMM-Newton  
A leap forward for  
X-ray astronomy



INTEGRAL  
Seeking out the extremes  
of the universe



# Use all four ESA Astronomy Missions



- **Now and parallel**
- **H / P 2.5 a**
  - -> No
- **GAI A, maybe LISA**
- **XMM / INT > 10 a** (w/ 4 wheel drive)
- **IXO 2025!**
  - Cross calibration
  - w/ XMM hibernation?

- Thank you ...