



HW/SW STRUMENTALE (MONITORING AND CONTROL) @ OATO

SEBASTIANO LIGORI



TEchnologies for Telescopes and
Instrument control Software

THE PEOPLE

- LEONARDO CORCIONE
 - EXPERIENCE IN INSTRUMENT BUILDING, ELECTRONICS DESIGN, DETECTOR OPERATIONS, TELESCOPE CONTROL SW
 - EXAMPLES: PHOTOPOLARIMETER FOR LEONCITO NATIONAL OBSERVATORY (ARGENTINA), GAIA, TNG, FINITO (PROTOTYPE FRINGE TRACKER FOR THE VLT INTERFEROMETER), PRIMA (FRINGE TRACKER FOR THE VLT INTERFEROMETER), AMICA (MID-IR CAMERA FOR ANTARCTICA), TIRCAM (MID-IR CAMERA FOR TIRGO), TC-MIRC (TWO CHANNEL NEAR- AND MID-IR CAMERA FOR TIRGO)
- SEBASTIANO LIGORI
 - EXPERIENCE IN INSTRUMENT BUILDING, IR DETECTOR OPERATIONS, SW ARCHITECTURE, SYSTEM ENGINEERING
 - EXAMPLES: MIDI (MID-IR INSTRUMENT FOR THE VLT INTERFEROMETER), PYRAMIR (IR PYRAMID WAVEFRONT SENSOR), TC-MIRC

THE PEOPLE

- DANIELE GARDIOL
- DAVIDE LOREGGIA



- INSTRUMENT BUILDING, PROJECT MANAGEMENT, PRODUCT & QUALITY ASSURANCE, OPTICAL ENGINEERING, SOFTWARE DEVELOPMENT FOR INSTRUMENT PERFORMANCE ANALYSIS AND OPTIMIZATION.
- MARIO GAI
 - DETECTOR CONTROL ELECTRONICS, OPTICAL ENGINEERING, SW DEVELOPMENT, INSTRUMENT PERFORMANCE EVALUATION
- DONATA BONINO
 - PH.D. IN MATHEMATICS; PREVIOUS EXPERIENCE OF DATA ANALYSIS FOR FINITO AND PRIMA, GAIA, CODING IN C FOR INSTRUMENT CONTROL SW
- VITO CAPOBIANCO (CTER TD)
 - EXPERIENCE IN C, C++ CODING FOR INDUSTRIAL APPLICATIONS, CODING FOR INSTRUMENT CONTROL SW

THE PEOPLE

- GIANALFREDO NICOLINI

- EXPERIENCE IN INSTRUMENT BUILDING, PERFORMANCE VERIFICATION AND OPERATIONS, ELECTRONICS DESIGN, CONTROL SW ARCHITECTURE

- EXAMPLES: METIS (CORONAGRAPH ON SOLAR ORBITER), CORMAG, PRIMA-FSU (FRINGE TRACKER FOR THE VLT INTERFEROMETER), ISAAC, SOFI, IRCAM (FOCAL PLANE INSTRUMENTS FOR VLT AND NTT), IRACE (ACQUISITION & CONTROL ELECTRONICS FOR ESO IR INSTRUMENTS), TIRCAM (MID-IR CAMERA FOR TIRGO), TC-MIRC (TWO CHANNEL NEAR- AND MID-IR CAMERA FOR TIRGO)



- MAURIZIO PANCRAZZI

- GERARDO CAPOBIANCO

- VALERIA CARACCI



NISP ICU ASW TEAM



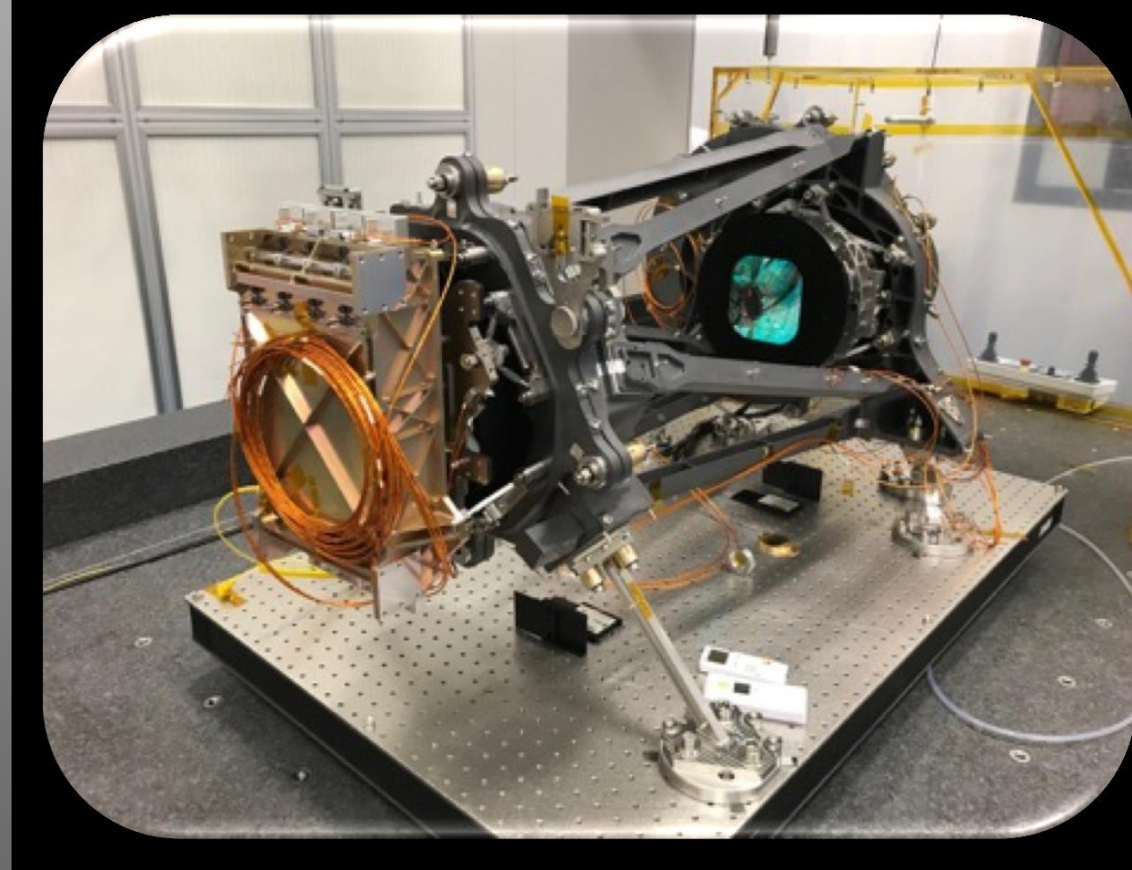
THE PROJECTS: EUCLID

- 1.2 M TELESCOPE IN L2
- 2 INSTRUMENT: VIS (36 4k x 4k CCDs IMAGER); NISP (NEAR-IR SPECTRO-PHOTOMETER, DETAILS IN FOLLOWING SLIDES)
- MAIN SCIENTIFIC GOAL: MAPPING EXTRAGALACTIC SKY, GETTING SPECTRO-Z AND PHOTO-Z INFORMATION AND WEAK LENSING INFORMATION FROM IMAGING IN ORDER TO PROBE THE STRUCTURE OF THE UNIVERSE, COMPARING WITH COMPETING MODELS FOR THE ORIGIN OF THE DARK MATTER AND DARK ENERGY CONTRIBUTION



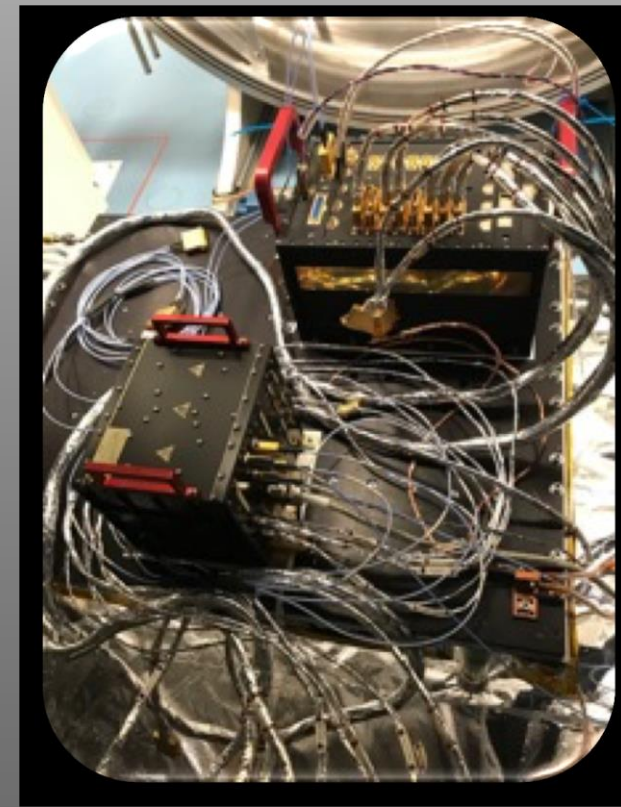
EUCLID NISP

- FOCAL PLANE POPULATED WITH 16 HAWAII2-RG DETECTORS (THE LARGEST IR FOCAL PLANE ON A SPACE MISSION)
- TWO WHEELS TO SELECT BROAD BAND FILTERS OR GRISMS (MOTION COMPENSATED BY A COUNTER WHEEL OPERATED BY THE SPACECRAFT)
- AUTONOMOUS OPERATIONS MUST BE ENSURED FOR UP TO 72 HOURS
- TELEMETRY CONSTRAINTS IMPLY THE IMAGES MUST BE PROCESSED AND COMPRESSED ON BOARD BEFORE BEING STORED ON THE SPACECRAFT MASS MEMORY UNIT (MMU) AND SENT TO EARTH DURING VISIBILITY PERIODS



NISP WARM ELECTRONICS

- THE ITALIAN CONTRIBUTION (BY ASI THROUGH CONTRACTS WITH INDUSTRY AND ACADEMIC INSTITUTIONS) TO THE NISP INSTRUMENT COMPRISES THE DATA PROCESSING UNIT (HW BY OHB ITALIA, APPLICATION SW BY INAF/OAS-OAPD), THE GRISM WHEEL ASSEMBLY (BY OHB ITALIA), AND THE INSTRUMENT CONTROL UNIT APPLICATION SW (THE ICU HW IS PROVIDED BY SPAIN)
- OUR TEAM PARTICIPATED (WITH THE "STAFF" COMPONENT) TO THE EARLY PHASES OF THE PROJECT, CONTRIBUTING TO THE DESIGN OF THE WARM ELECTRONICS, INCLUDING THE HARNESS (A MAJOR SOURCE OF CONCERN IN THIS KIND OF APPLICATIONS) AND IS RESPONSIBLE FOR THE REALIZATION OF THE ICU APPLICATION SW

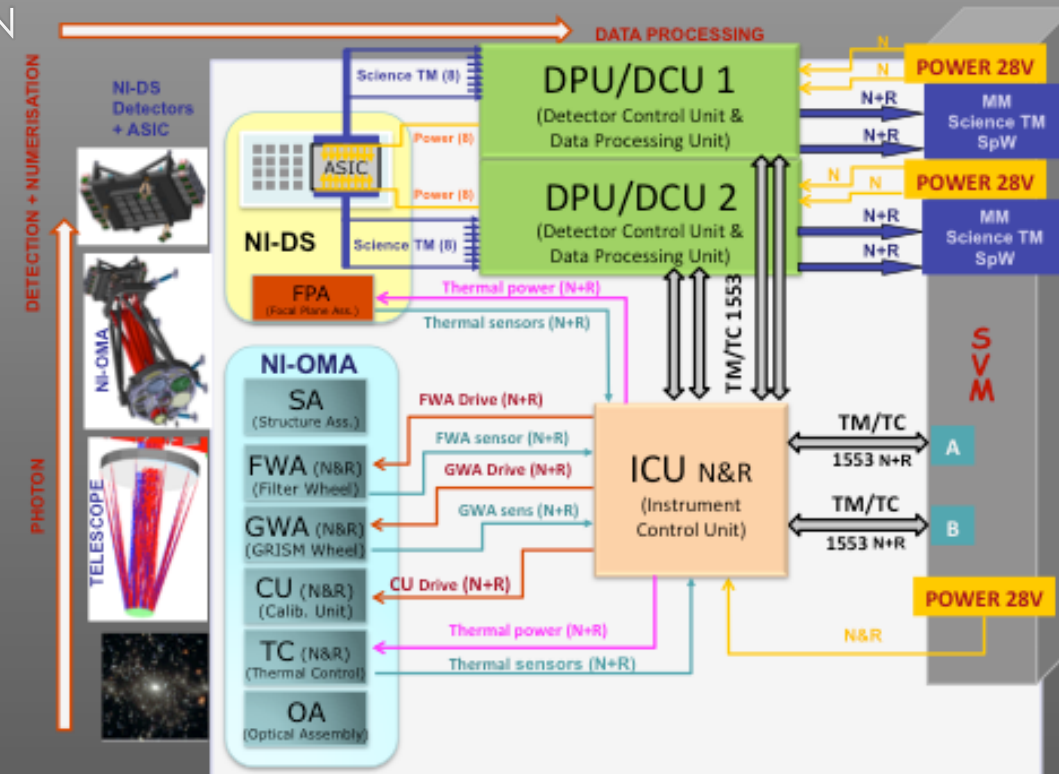


THE NISP INSTRUMENT CONTROL UNIT

- THE ICU IS PRODUCED BY CRISA (AIRBUS), SPAIN, AND IS BASED ON A RADIATION HARDENED LEON2 SPARC V8 PROCESSOR, WITH EDAC PROTECTION
- VERY SMALL EEPROM SIZE (2 MB) AND RAM SIZE (7 MB USABLE); THE CODE MUST NOT HANDLE BIG AMOUNT OF DATA (IN CHARGE TO THE DPU) BUT IT HAS IN ANY CASE TO BE VERY EFFICIENT
- THE APPLICATION SW USES AN OPEN SOURCE REAL TIME OPERATING SYSTEM FOR EMBEDDED APPLICATIONS (RTEMS), WHICH HAS BEEN TAILORED AND QUALIFIED FOR SPACE APPLICATIONS
- A BIG EFFORT HAS BEEN MADE TO LEARN AND APPLY THE RELEVANT STANDARDS FOR THIS KIND OF APPLICATIONS
- PRODUCT ASSURANCE IS A VERY SENSITIVE TOPIC FOR ESA: ALSO IN THIS CASE HEAVY USE OF ECSS STANDARDS HAS BEEN NECESSARY

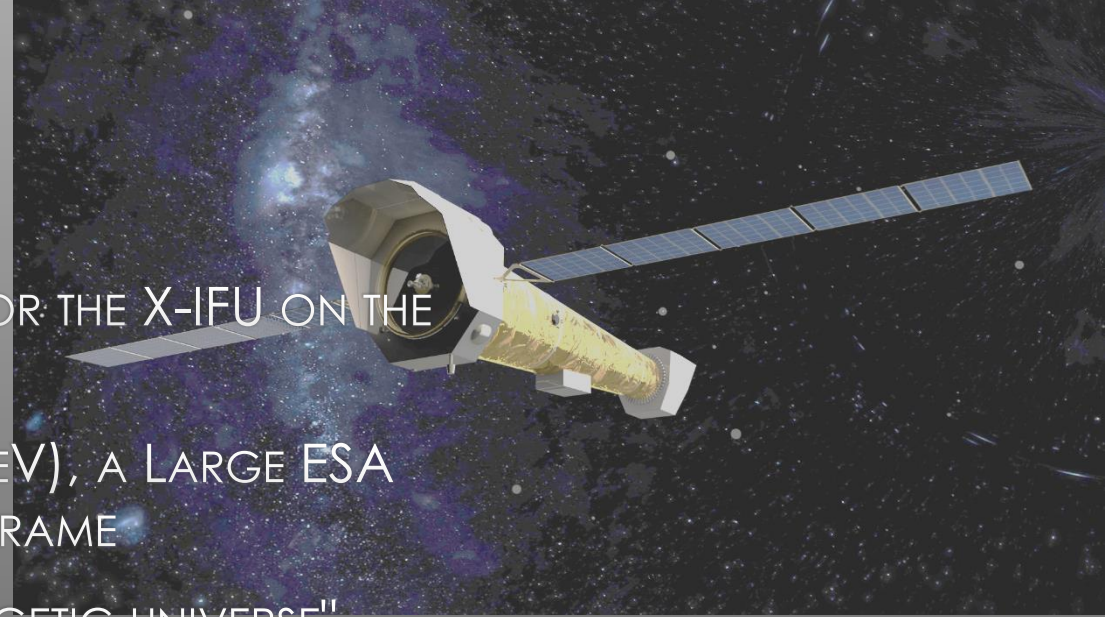
THE NISP INSTRUMENT CONTROL UNIT

- CONTROLS THE NISP SUBSYSTEMS (WHEELS, CALIBRATION UNIT, THERMAL CONTROL)
- DISTRIBUTES TELECOMMANDS TO THE DPU
- MONITORS THE STATUS OF THE SUBSYSTEMS INCLUDING DPU
- COLLECTS HK FROM THE SUBSYSTEMS INCLUDING DPU
- IMPLEMENTS SYSTEM LEVEL FAILURE DETECTION, ISOLATION, AND RECOVERY ALGORITHMS
- THE SYSTEM BEHAVIOR MUST BE COMPLETELY DETERMINISTIC (THE SEQUENCE OF TELECOMMANDS IS EXECUTED AS A TIMELINE FOR UP TO 72 HOURS)



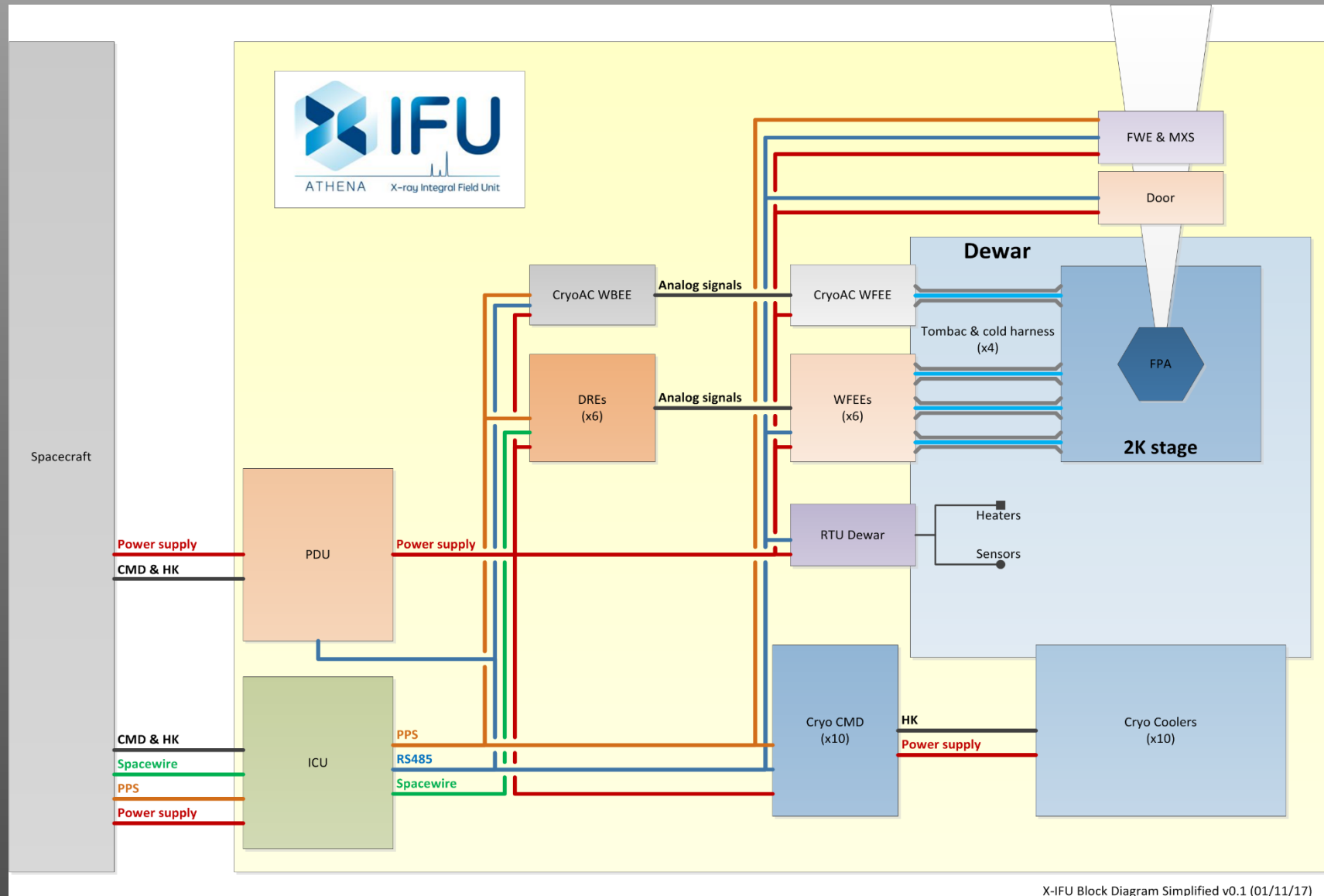
ICU ASW STATUS

- THE ICU ASW HAS COMPLETED THE QUALIFICATION AND ACCEPTANCE REVIEW; THE CURRENT SW VERSION IS THE FLIGHT CANDIDATE
- THE ASW HAS BEEN HANDLED TO THE INDUSTRIES (THALES AND AIRBUS) WHICH WILL USE IT ON DIFFERENT NISP MODELS (INCLUDING THE FLIGHT EQUIPMENT) IN THE NEXT TEST PHASES
- LAUNCH IS FORESEEN IN 202X



- OUR TEAM IS INVOLVED IN THE REALIZATION OF THE ICU SW FOR THE X-IFU ON THE ATHENA MISSION
- ATHENA IS AN X-RAY TELESCOPE (ENERGY RANGE OF 0.2-12KEV), A LARGE ESA MISSION SCHEDULED FOR LAUNCH IN THE "EARLY 2030s" TIME FRAME
- PART OF THE "COSMIC VISION" PROGRAM "THE HOT AND ENERGETIC UNIVERSE"
- THE X-IFU IS ONE OF THE TWO INSTRUMENTS AND IT IS AN INTEGRAL FIELD UNIT, BASED ON AN ARRAY OF CRYOGENICALLY COOLED TRANSITION EDGE SENSORS (TES)
- THE INSTRUMENT CONTROL UNIT WILL BE BASED ON THE NISP HERITAGE, BUT WILL BE MORE COMPLEX AND WILL NEED A MORE PERFORMANT HW
- THE X-IFU COLLABORATION INCLUDE SEVERAL INAF INSTITUTES, THE WORK ON THE ICU IS MAINLY DONE, IN THIS PHASE, BY INAF OAS AND INAF OATo
- THE INSTRUMENT SYSTEM REQUIREMENTS REVIEW IS UNDER WAY, SPC ADOPTION IN 2023?

X-IFU BLOCK DIAGRAM



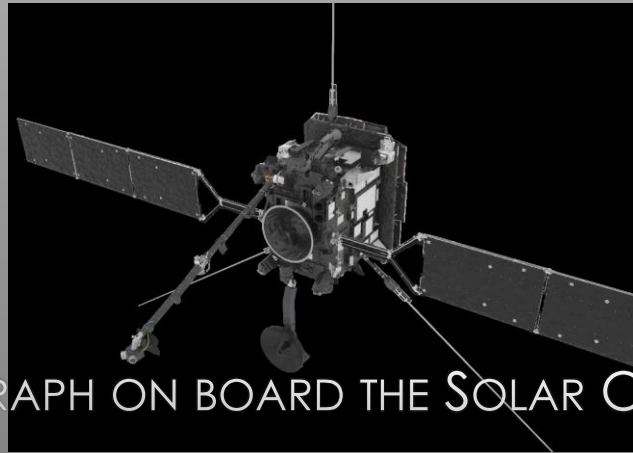
X-IFU Block Diagram Simplified v0.1 (01/11/17)

MULTI CORE PROCESSORS FOR SPACE APPLICATIONS

- IN THE CONTEXT OF THE SPICA STUDY PHASE WE ACQUIRED AND USED A QUAD-CORE LEON4 DEVELOPMENT BOARD BY OCE
- MULTIPROCESSING FOR SPACE APPLICATIONS COULD BE VERY INTERESTING, ALSO TO OPTIMIZE PERFORMANCES AND POWER CONSUMPTION
- TWO APPROACHES HAVE BEEN EXPLORED:
 - 4 DIFFERENT INSTANCES OF SW DEALING EACH WITH A DIFFERENT SET OF CAPABILITIES, AND COMMUNICATING VIA DEDICATED MEMORY AREAS
 - A SINGLE INSTANCE OF RTEMS WITH THE DIFFERENT TASKS ASSIGNED DYNAMICALLY TO THE DIFFERENT CORES
- THIS EXPERIENCE WILL LIKELY BE TRANSFERRED TO THE X-IFU PROJECT



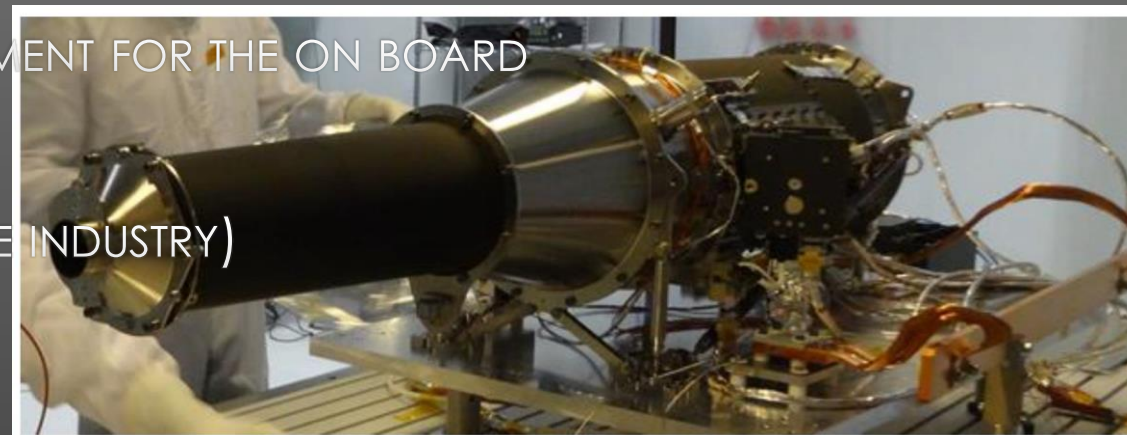
METIS



METIS IS THE CORONAGRAPH ON BOARD THE SOLAR ORBITER ESA MISSION THAT IS ABLE TO PERFORM IMAGING IN THE UV LYMAN ALPHA LINE (121 nm) AND IN THE VISIBLE LIGHT (590-640 nm) ; METIS HAS BEEN DESIGN BY THE INAF STAFF LEAD BY THE OATo SOLAR GROUP.

CONCERNING THE SW, INAF OATo (G. NICOLINI, M. PANCRAZZI) HAS BEEN INVOLVED IN:

- DEFINITION OF THE SPECIFICATION AND THE REQUIREMENT FOR THE ON BOARD PROCESSING
- SUPPORT TO THE DEVELOPMENT (CARRIED OUT BY THE INDUSTRY)
- TEST VERIFICATION





CORMAG (Coronal Magnetograph)

Stratospheric-altitude, 1-day duration experiment for the study of the topology of solar coronal magnetic fields.

Internally occulted coronagraph with active pointing and tracking of the sun, remotely commanded by ground.

Design, electrical interfaces, control sw (ground, control unit and pointing and tracking unit): OATo

ANTARCTI-COR (Antarctic Coronagraph)

Ground-based coronagraph for the study of the coronal electron density; demonstrator for ASPIICS-PROBA 3.

Internally occulted coronagraph with active tracking of the sun.

Design, electrical interfaces, control sw: OATo



Donata Bonino: Control Unit SW developer (CORMAG)

Francesco Amadori: Astronomy student at Bologna University, sw developer for solar experiments (CORMAG, METIS @Solar Orbiter, PROBA 3)

Gerardo Capobianco: HW and electronics (Antarcti-cor, CORMAG), control and data acquisition sw (Antarcti-cor), ground sw (CORMAG, ASPIICS @PROBA 3)

Salvatore Caschera: fellow, Software developer for solar experiments (ASPIICS, CORMAG)



Maurizio Pancrazzi: Hw and electronics (CORMAG, SCORE), data acquisition sw (SCORE)

Valeria Caracci: CAD designer (Heliantus, Cormag)