Interferometric BIdimensional Spectropolarimeter

INAF
ISTITUTO NAZIONALE
DI ASTROFISICA

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Featuring contributions from: Giorgio Viavattene, Mauro Centrone, Giorgio Frazzoni, Fernando Pedichini, Roberto Piazzesi

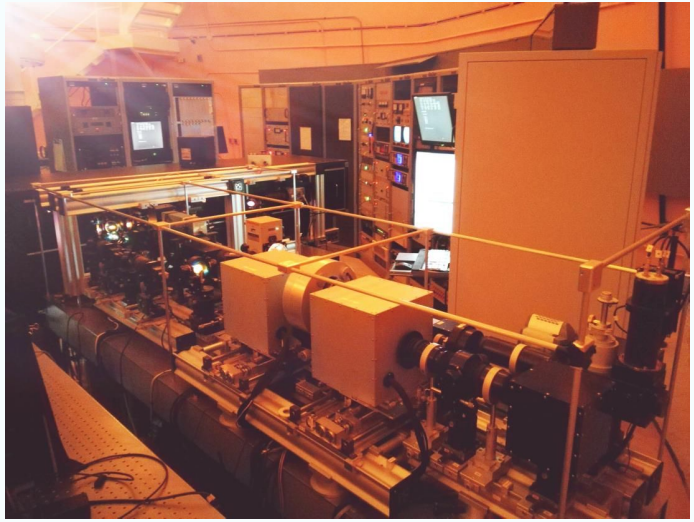
TOR VERGATA
UNIVERSITÀ DEGLI STUDI DI ROMA

Dario Del Moro, Luca Giovannelli

FSLAC International Research Lab
cnrs INSU

Bernard Gelly, Richard Douet, Etienne Pariat

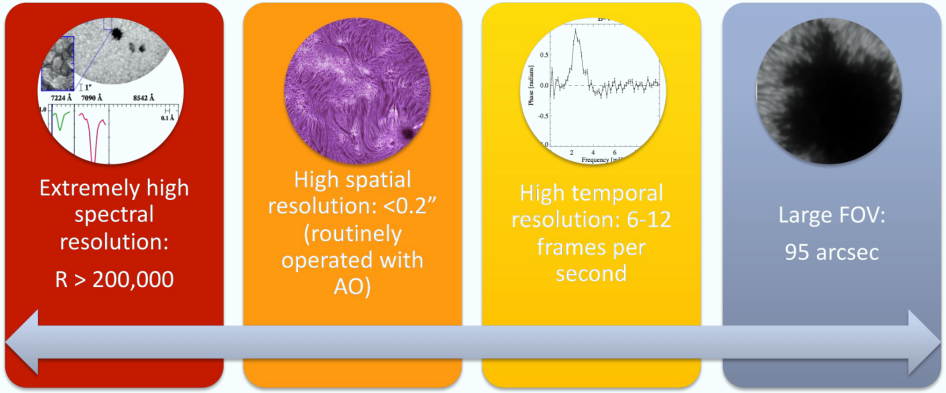
IBIS



IBIS at DST (June 2019)

DST

Credits: IBIS 2.0 Team



2018 - 2025

2018-2021	- Feasibility study at GREGOR and VTT.
early 2022	- Design for Installing IBIS2.0 at VTT.
early 2023	- Feasibility study for Installing IBIS2.0 at THEMIS.
early 2025	- Signing of MoU between INAF, THEMIS and CNRS.

2020 - Assembly of IBIS in the optical laboratory of INAF OAR.

2021 - Test and recovery of components (e.g. ADS100, CS100); procurement of components.

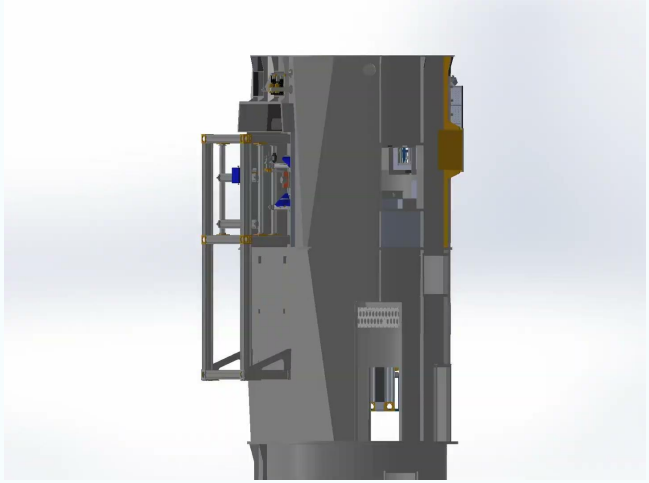
2023 - Optical design completed for installation at THEMIS; laboratory tests.

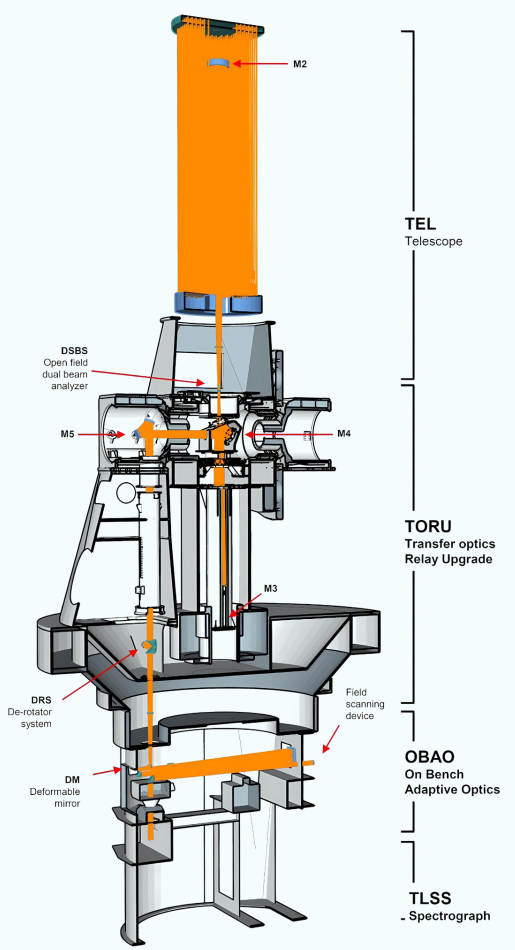
2024 - Mechanical design Finished and Manufacturing of parts started; laboratory tests.

2024 - 2025 - Control and Electronic Schematics finalised.

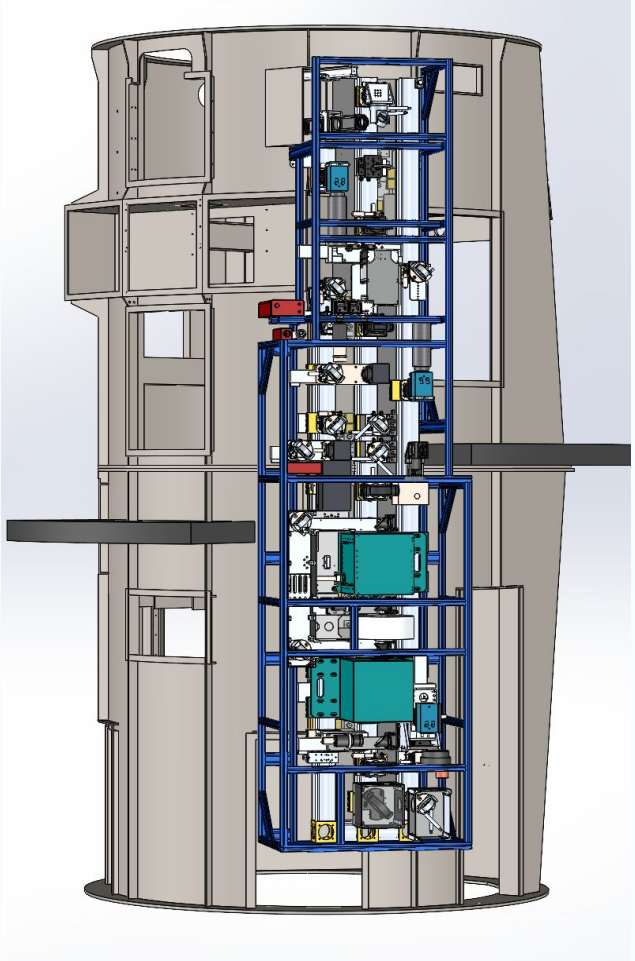
2025 - Major Work on Control Software and Control Electronics finished; procurement of components; start integration in the laboratory.

IBIS2.0 Installation at THEMIS



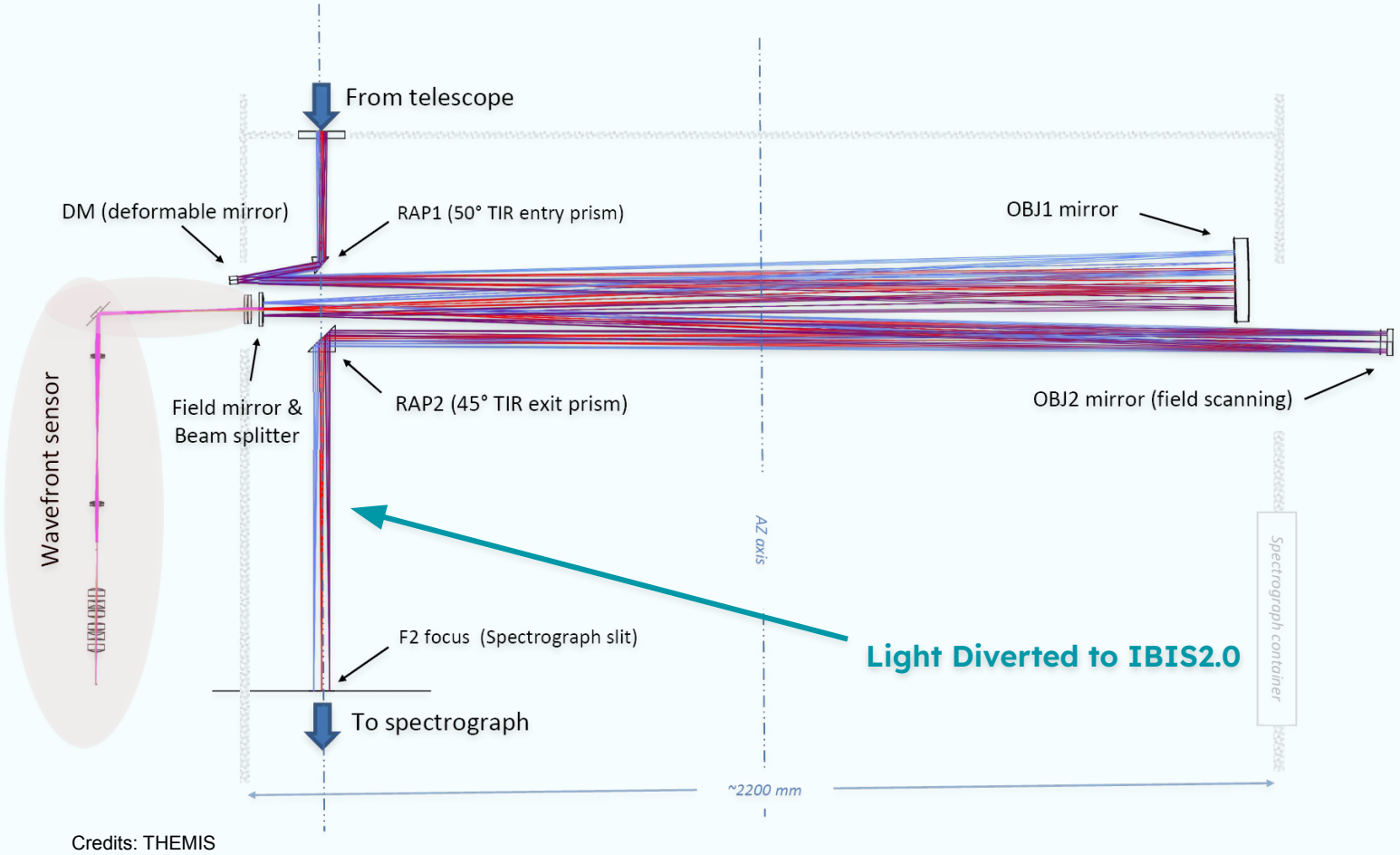


Credits: THEMIS



Credits: IBIS 2.0 Team

Light Injection to IBIS2.0



Credits: THEMIS

Updates in IBIS2.0 Design

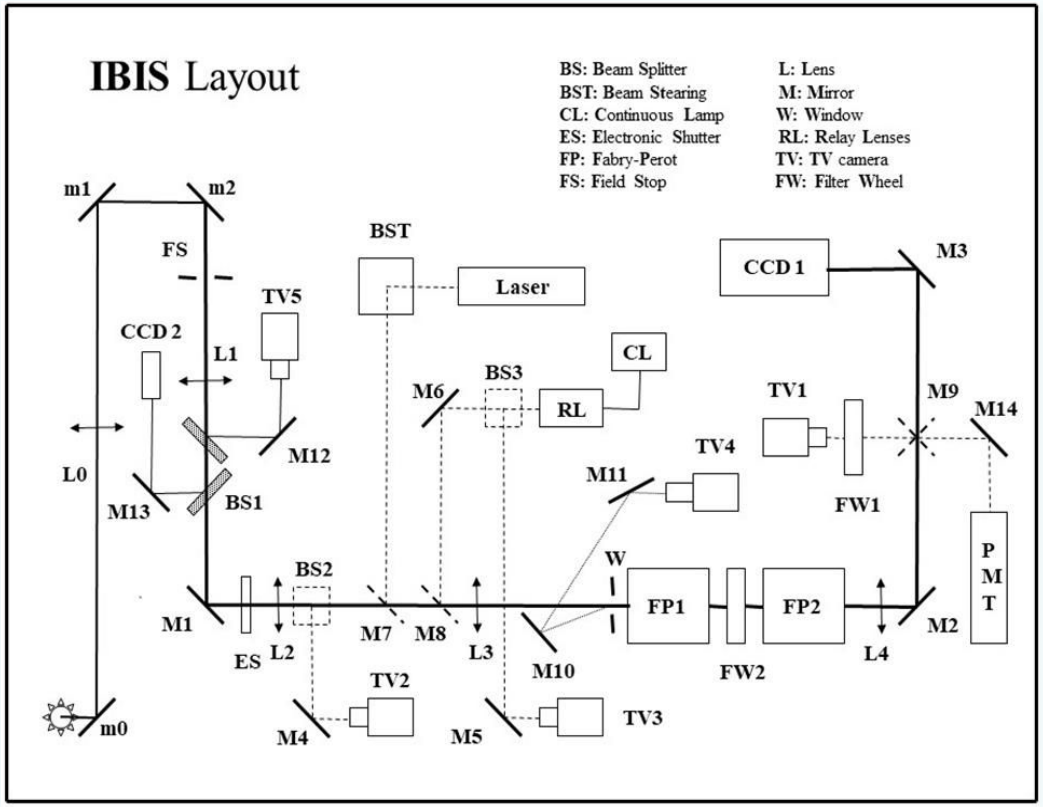
Inherited from IBIS

- Fabry–Pérot etalons (FP) still in the Classical mounting
- FP controllers - CS100
- Mounts for Optical components

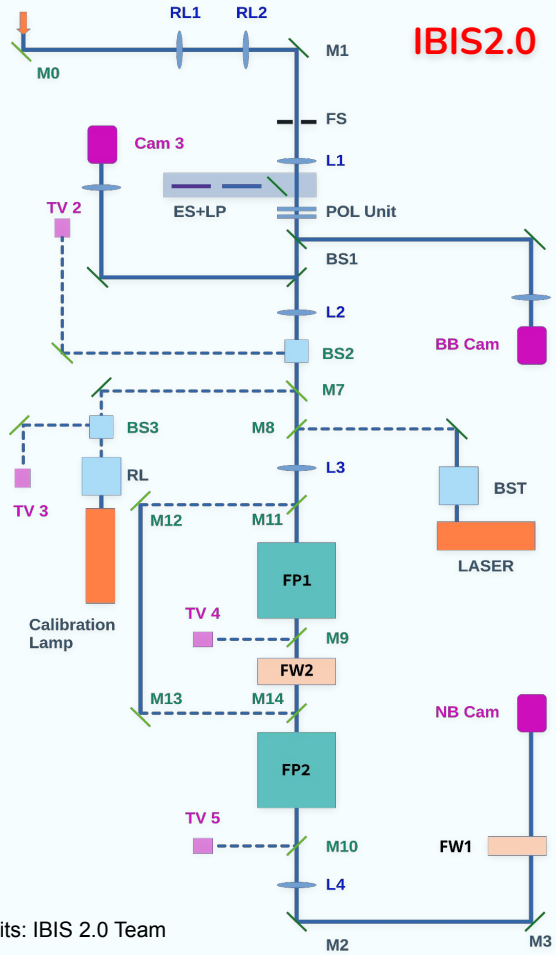
Updated in IBIS2.0

- Optical and Mechanical design
- Polarimetric Modulation Unit
- Detectors (Science and Technical)
- Control Software and Electronics
- Data Acquisition structure
- Data Reduction Pipeline

Optical Layout

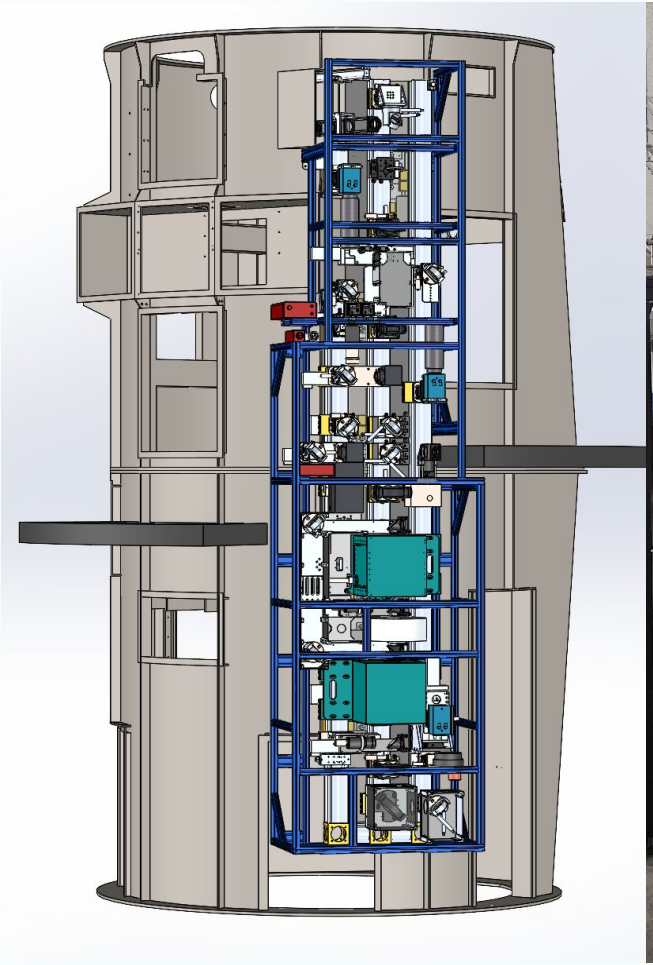


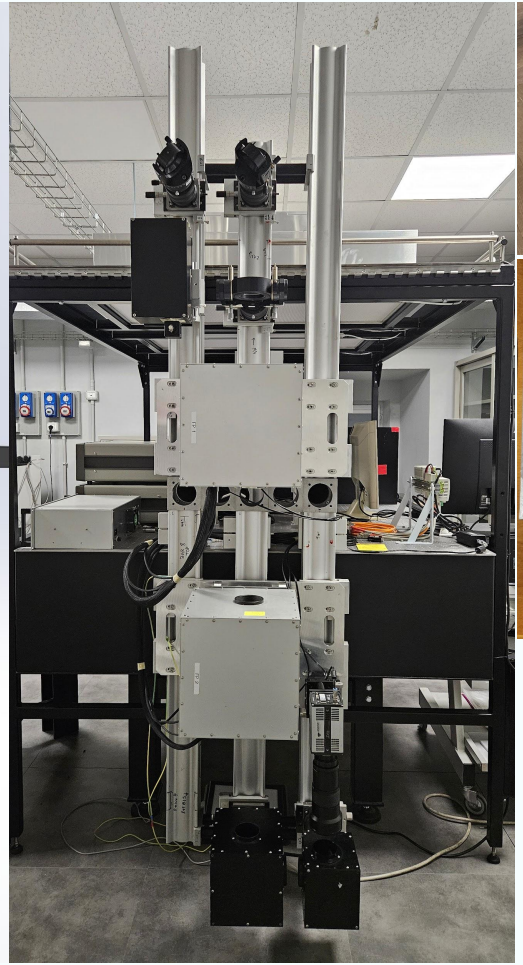
Credits: Adapted from Cavallini 2006, Solar Physics

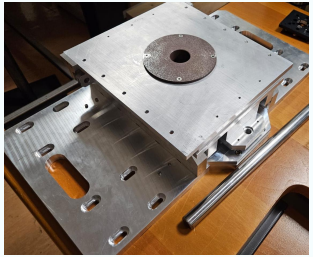


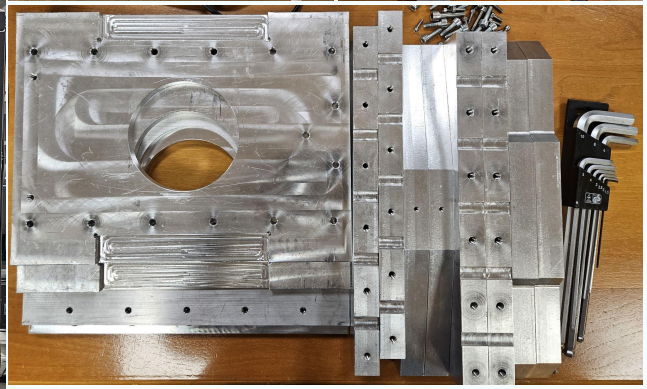
Credits: IBIS 2.0 Team

Mechanical Design







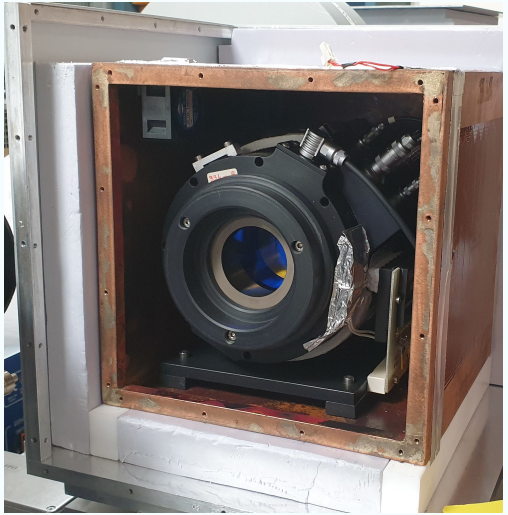


Left: IBIS2.0 Mounting at THEMIS
Centre: IBIS2.0, in the Lab
Right: Some newly manufactured parts for IBIS2.0

Team: Kamal Sant, Giorgio Viavattene, Luca Oggioni, Matteo Aliverti

Credits: IBIS 2.0 Team

Fabry–Pérot



FP

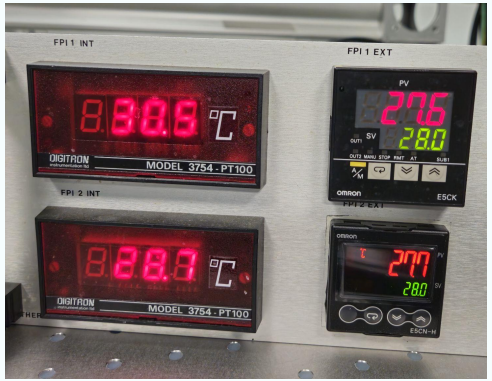
Manufacturer	IC Optical Systems
Type	ET50 FS
Clear aperture (mm)	50
Plate spacing (mm)	2.300 (FPI #1), 0.637 (FPI #2)
Wedge angle	20′
Coating	Multilayer broadband
Dispersion (Å/step)	4.80 (FPI #1), 4.59 (FPI #2)
Wavelength range (Å)	5800 – 8600
Nominal reflectance (@ 6328 Å)	0.942
Nominal absorption coefficient	≤0.002
Estimated cavity errors (@ 6328 Å)	λ/150 (after coating)

Credits: Reardon and Cavallini 2008, A&A

CS100

Credits: IBIS 2.0 Team

Temperature Controller



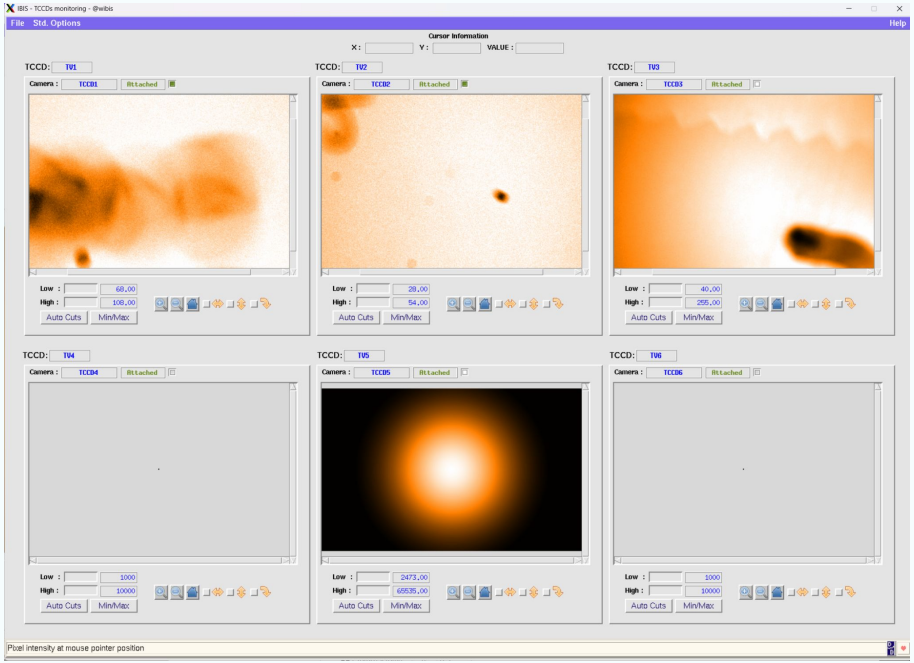
OLD NEW

Detectors

3 - Science cameras - Andor Zyla 4.2

(2 cameras from QUB)

- 2048 x 2048 pixels, with a size of 6.5 µm
- Sensor Cooling upto -10°C (Water Cooled)
- Read noise of ~1 electron
- Full well capacity of 30000 electrons
- Rolling shutter



Credits: IBIS 2.0 Team

6 - Technical detectors - Basler Ace 2

- instrument alignment and calibration

Polarimetric Modulation Unit

- 2 LCVRs (LCC1223T-AB)
- KLC101 - voltage controller
  - Direct voltage control from PLC
  - Removes the need to rely on the USB interface
  - Modified for remote control
- TC300B - Temperature controller

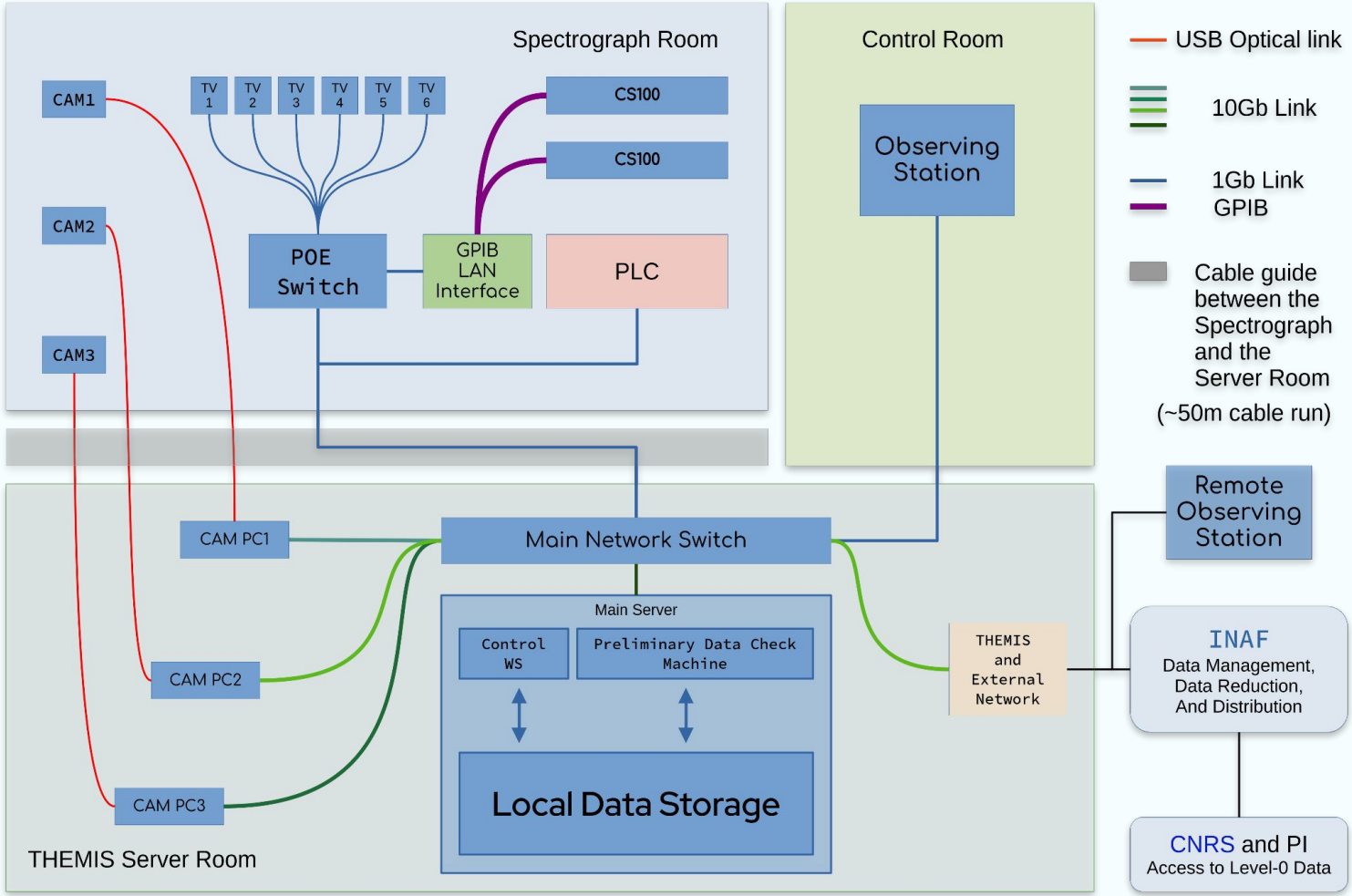
Modulation state	LCVR 1 retardance [deg]	LCVR 1 retardance [wave]	LCVR 2 retardance [deg]	LCVR 2 retardance [wave]
I+Q	360	λ	360	λ
I+V	360	λ	270	¾ λ
I-Q	360	λ	180	λ/2
I-V	360	λ	90	λ/4
I-U	270	¾ λ	90	λ/4
I+U	90	λ/4	90	λ/4

KLC101
Shown with Included Mounting Plate

TC300B

Team: Maurizio Oliviero, Giorgio Viavattene, Fabrizio Giorgi, Kamal Sant

Control and Network Schematics



Controls and Electronics

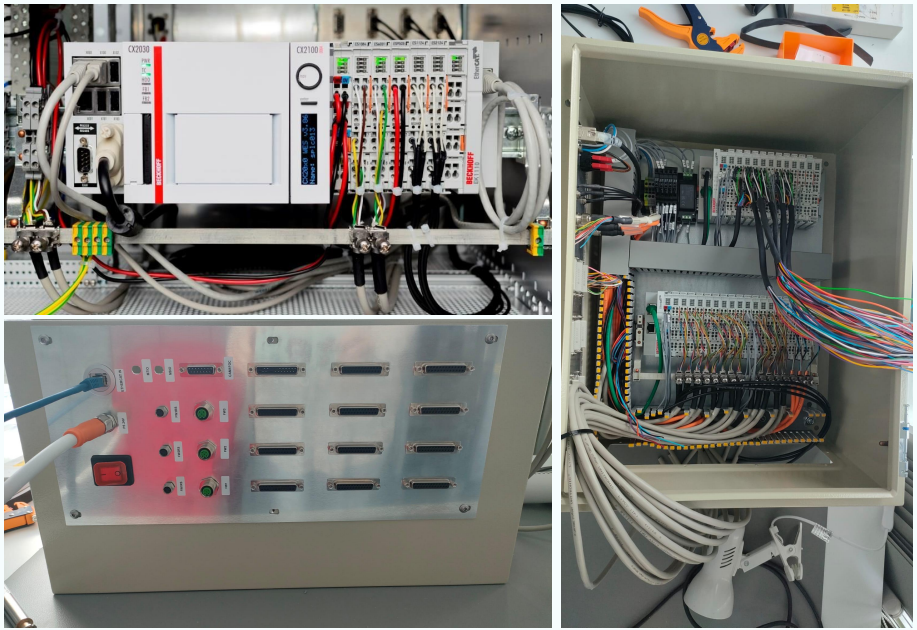
PLC - Beckhoff

- Control motors
- Power Supply Relays
- Temperature Sensors
- Analog signals to CS100
- Analog signals to LCVR controller
- Acquisition Synchronisation

Fabry–Pérot

- CS100, voltage driven
- Updated Temp Controller

LCVRs - ThorLabs, voltage driven



PLC

Credits: IBIS 2.0 Team

Team: Igor Coretti, Veronica Baldini, Antonio Sulich

Control Software

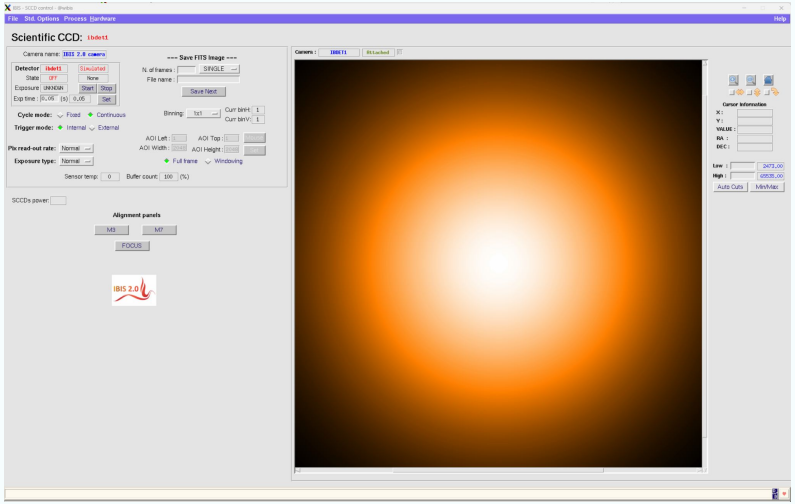
ESO-VLT Software framework for Observation and Instrument Control Software (ICS)

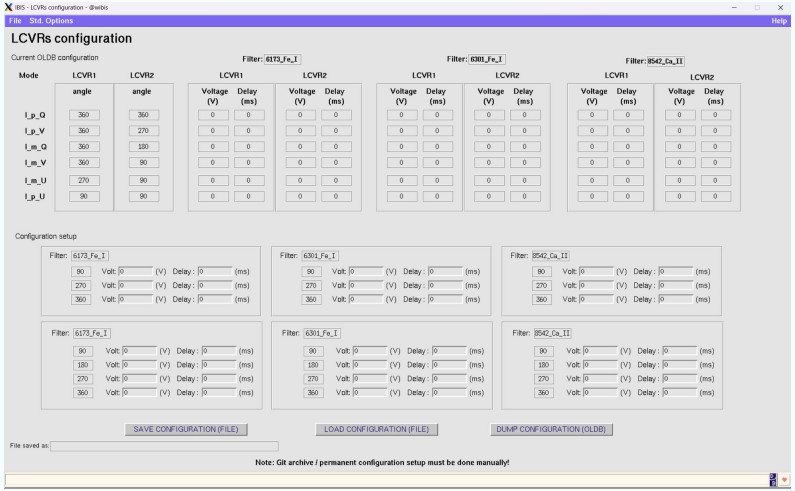
- Already incorporates a lot of the PLC related framework, like
  - Standard drivers for various motors,
  - Communication with the PLC
  - Integrated controls for technical cameras
- Framework for the GUI's and Observation Software

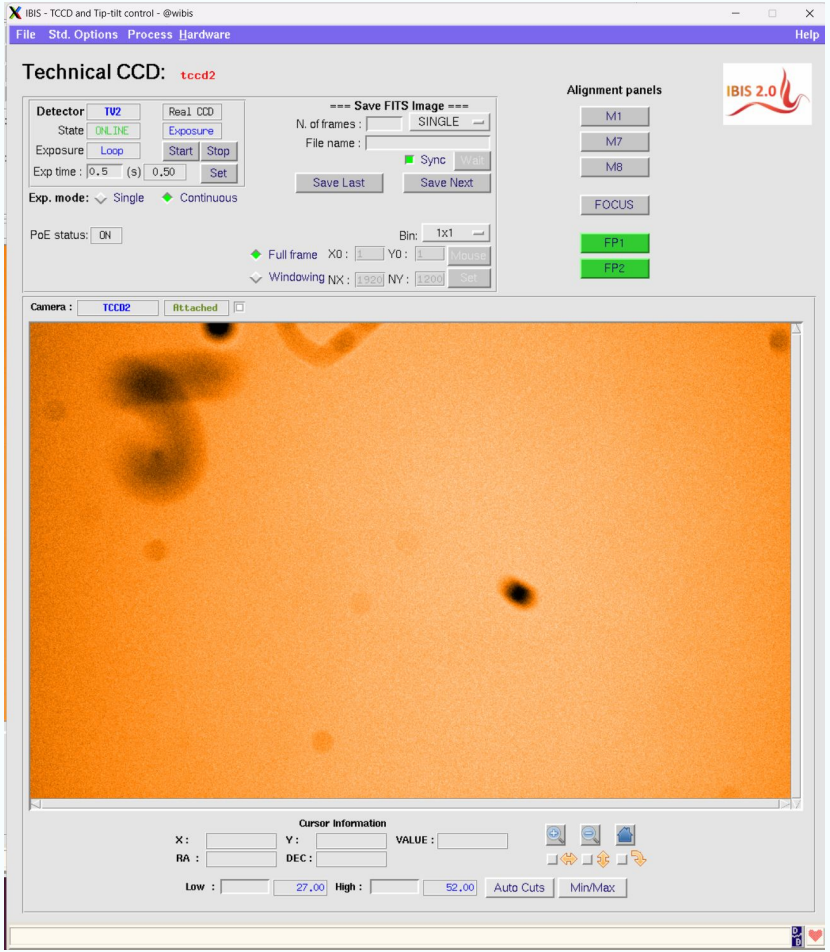
Science Detectors use a custom wrapper(C++) around the Andor SDK to talk to the ICS

Team: Roberto Cirami, Paolo Di Marcantonio, Giorgio Calderone, Valentina Alberti, Igor Coretti, Veronica Baldini, Antonio Sulich, Giorgio Frazzoni, Kamal Sant

Example Instrument Panels







Credits: IBIS 2.0 Team

Changes to the Data Acquisition

FITS structure changed (to simplify file handling)

- Old - 1 FITS file per scan (could contain many spectral lines)
- New - 1 FITS file per Wavelength per scan

Level-0 FITS headers updated to be inline with the SOLARNET standards

Expected Data Volume

- Expected data rate for 3 cameras combined : 0.5 - 1 TB/hr
- For routine observations, there will be data selection.

Data Reduction Pipeline

- Re-written in Python,
  a. For improved modularity
  b. And with more documentation (Read the Docs).
- Plan to apply the following to the raw data,
  a. Alignment between channels
  b. Spectral Calibration
  c. Polarimetric Calibration
  d. Image restoration using TORCHMFBD
- Data Product – Level 1

Team: Giovanna Jerse, Mariarita Murabito, Fabiana Ferrente, Lidia Contarino, Fabrizio Giorgi, Teodora Mihailescu, Dario Del Moro, Kamal Sant

Observation Modes

Basic Requirement / Mode – to scan

- 2 Spectropolarimetric lines (25 spectral points)
- 1 Spectral line (30 points)
- Within 1 minute

Standard (The current Data Reduction Pipeline can handle)

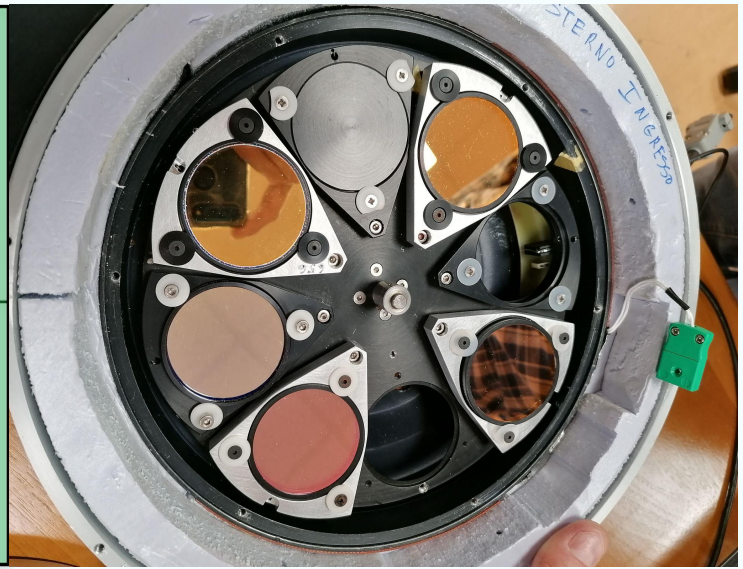
- Spectroscopic with all cameras synced
  - Max frame rate Spectral mode 10-16fps (80ms - 40ms exposure).
- Spectropolarimetric
  - Max frame rate Spectropolarimetric mode 6-7 fps (limiting factor Pol modulation).

Non-Standard

- Multi-point spectral / Spectropolarimetric
  - Max frame rate mode 25fps (40ms exposure).

Available filters

Fe I 543.4 nm (g=0) h^6= 550 km	He I D3 587.6 nm h^8= 1100-1800 km	Na I D2 589.0 nm h^{10}= 600 km	Na I D1 589.6 nm (g=1.33) $h^{4,9}$ = 800-1000 km	Fe I 617.3 nm (g=2.5) h^7= 250-350 km	Fe I 630.1 nm / 630.2 nm (g=1.67/2.5) $h^6_{630.1}$= 340 km $h^6_{630.2}$= 250 km
H I (Hα) 656.3 nm h^{11}= 1500 km	Ni I 676.8 nm (g=1.43) h^1= 200 km	Fe I 709.0 nm (g=0) h^3= 100 km	Fe II 722.4 nm (g=0) h^3= 50 km	K I 769.9 nm h^5= 400 km	Ca II 854.2 nm (g=1.10) h^2= 200-1300 km



Credits: IBIS 2.0 Team

Available filters for observation with IBIS2.0, with the new filters shown in green.

Observation Support and Data Policy

Standard Modes

- Level 1 data corrected for instrumental effects, processed using the Standard Pipeline
- Calibration Data
- Level 1.5 and Level 2 Data

Non-Standard Modes - > Extensive Documentation

Current Schedule - 2026

early 2023 - Feasibility study for Installing IBIS2.0 at THEMIS.

early 2025 - Signing of MoU between INAF, THEMIS and CNRS.

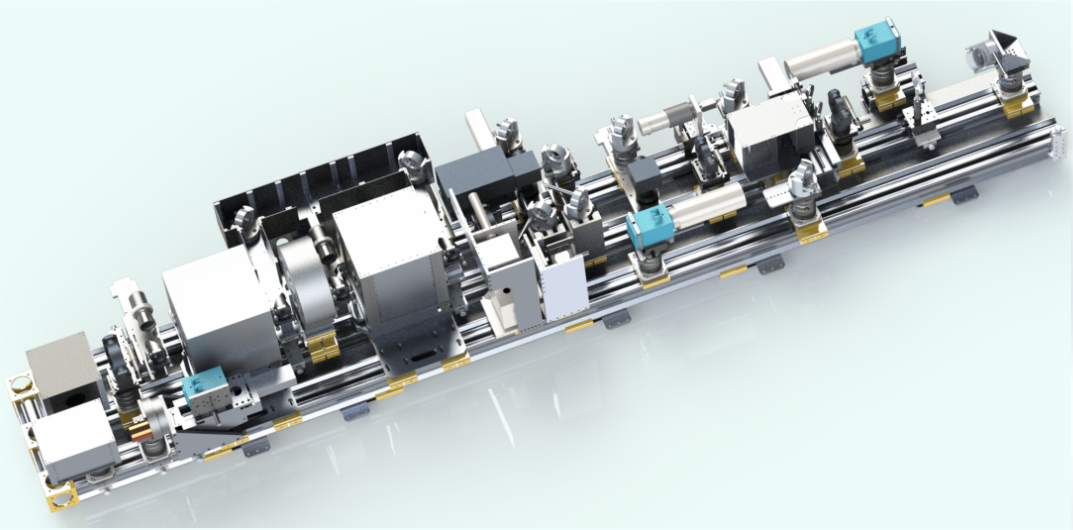
2023 - Optical design completed for installation at THEMIS; laboratory tests.

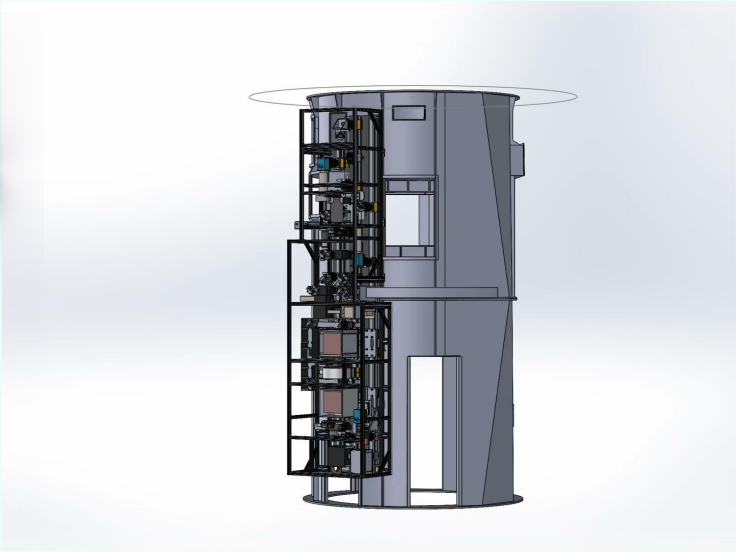
2024 - Mechanical design Finished and Manufacturing of parts started; laboratory tests.

2024 - 2025 - Control and Electronic Schematics finalised.

2025 - Major Work on Control Software and Control Electronics finished; procurement of components; start integration in the laboratory.

May 2026 - Installation at the telescope.





Thank You

www.ibis20.inaf.it