

Physics with IACTs

Very high energy gamma rays and optical interferometry

Tarek Hassan

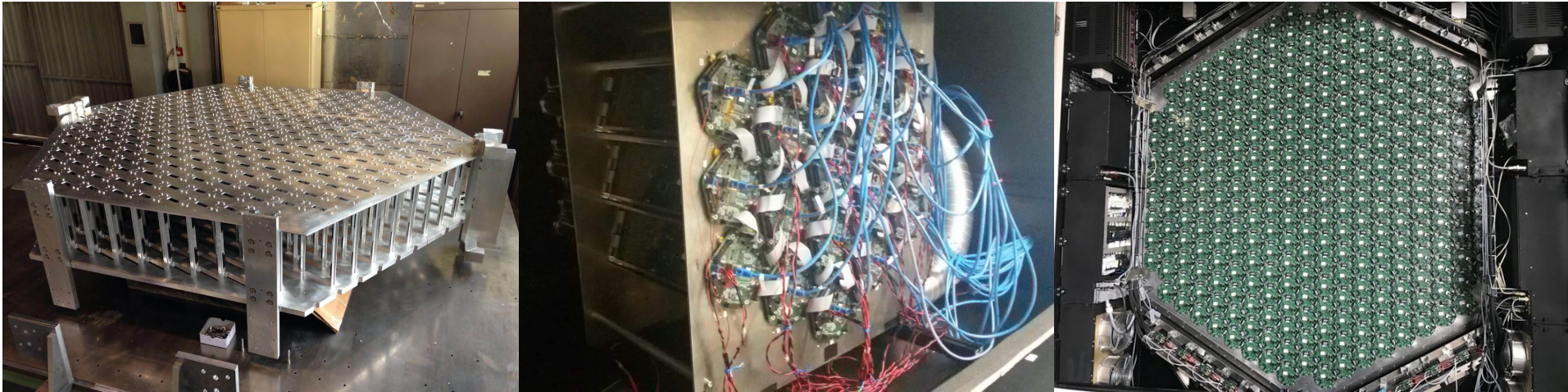
on behalf of the Gamma-rays Group

Description of the line

The line was **created in 2008**, as CTA project was gaining momentum and Spain aimed to play a key role, using MAGIC as a platform to acquire experience.

Established a dual role in Spain which very few groups in the field have:
instrumentation & physics analysis.

During the last few years we have opened a new observation mode: enabling observations for Stellar Intensity interferometry and fast optical transients with IACTs (MAGIC and CTAO-LST1), that resulted in an **ERC** granted to one of ours group members.



Physics goals of the line

Employing VHE cosmic gamma rays as messengers for

Understand galactic cosmic-ray acceleration to the highest energies.

Study extreme environments via VHE gamma rays.

Explore frontiers in fundamental physics (LIV, Dark Matter, Cosmology)

Exploit the fast optical photon detection capabilities of IACTs for astrophysics.

Interferometry: Study the morphology of bright objects in the galaxy

Fast photometry: Study the population of Kuiper Belt objects or fast transients such as GRBs/FRBs

Personnel

Scientific Personnel

Staff: J. Cortina, C. Delgado, T. Hassan, S. Mangano, I. Oya

Postdocs: D. Cuenda, M. Molero, E. do Souto, I. Sushch

Students: A. Cifuentes, A. García, S. García, M. Moró

Hired Physicist: J. Bernete (@ La Palma)

Mechanics

Staff Engineer: C. Diaz

Hired Engineer: M. Polo (on leave)

Electronics

Staff: G. Martínez (from Technology Dept)

Hired Engineer: I. Jorge

Staff Technician: J. Morales

Computing

Staff: J.J. Rodríguez, J. Delgado (PIC)

Administration

Hired: E.M. Maldonado

Highlights in the mid2023-mid2025 period

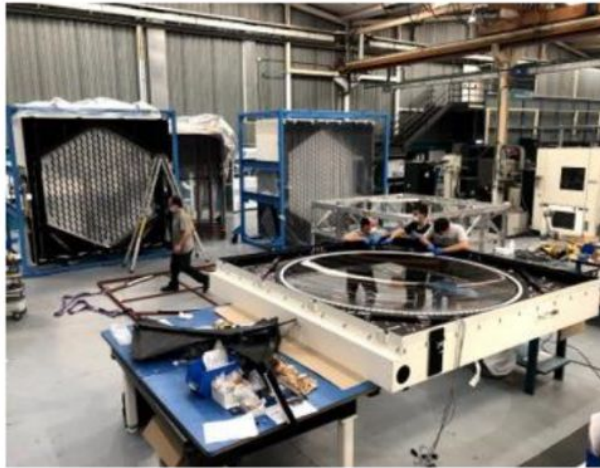
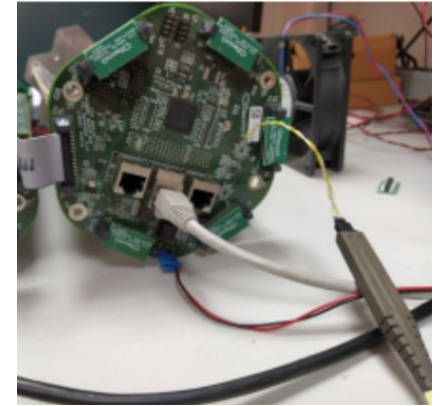
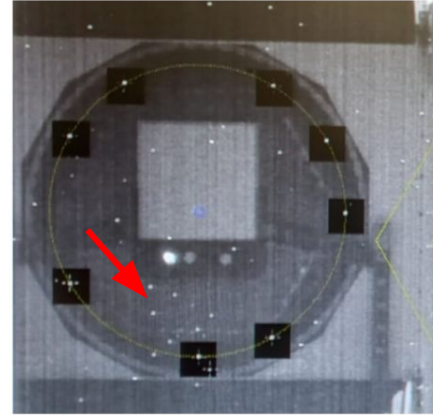
- The Cherenkov Telescope Array Observatory was formally **approved by the European Commission as an ERIC**, granting it official European legal status.
- The CIEMAT-FP team successfully **installed the second camera of LST in La Palma**, marking a key milestone for the CTA-North array of large-sized telescopes.
- CTAO's control and data acquisition software (ACADA) passed its **Critical Design Review**, confirming its technical and operational maturity.
- We demonstrated MAGIC and LSTs are technically suited to routinely acquire competitive optical intensity interferometry data (ERC StG).



Activities: instrumentation

Development of

- Optics & mechanics for MAGIC and LST
- Electronics for LST
- Design and construction of a realtime correlator
- Control & DAQ software
- Advanced camera for the next-gen telescopes



Main responsibilities

Maintenance and commissioning of LST-1 camera

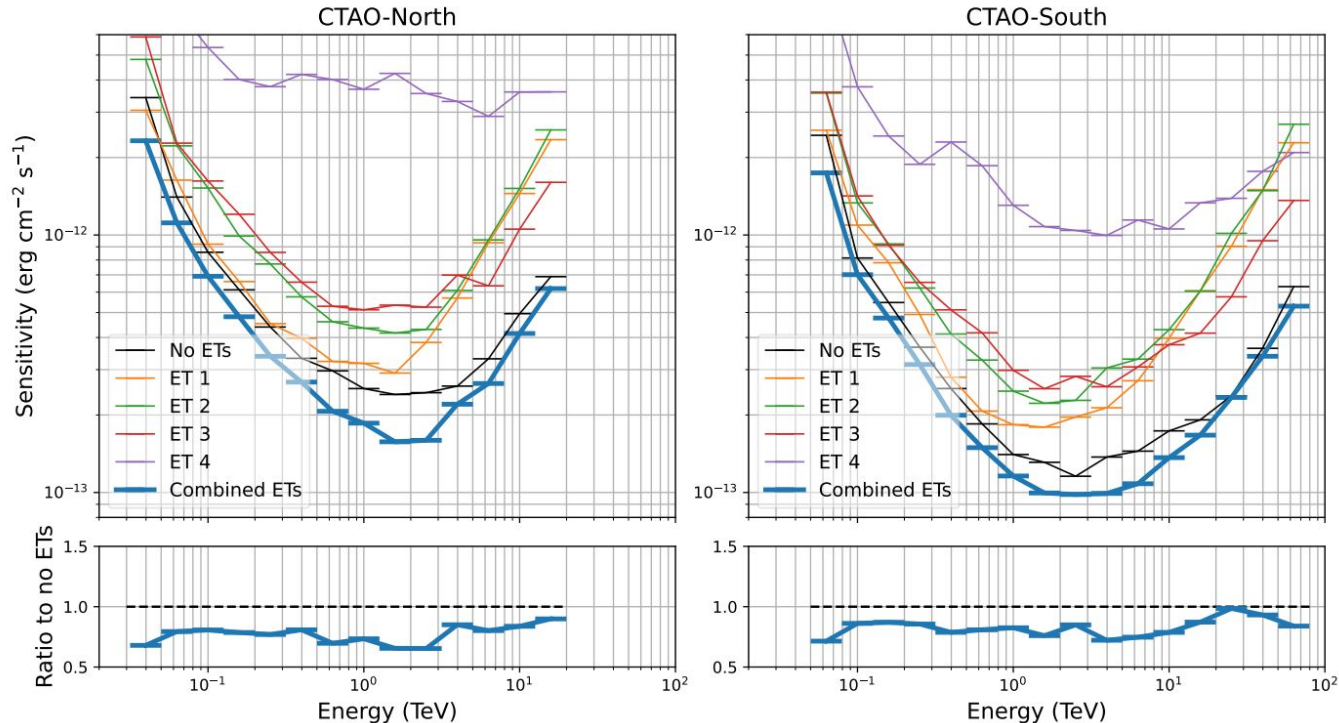
Installation and hardware commissioning of LST-2 to LST-4 cameras

Technology transfer with Spanish industry for the construction of LST-2 to LST-4 for CTA-N, LST-5 and LST-6 cameras for CTA-S, and NectarCAM (MST) mechanics

Activities example: analysis with CTAO

Event types, using machine learning to boost CTAO sensitivity

Point-source sensitivity for 50h of observation

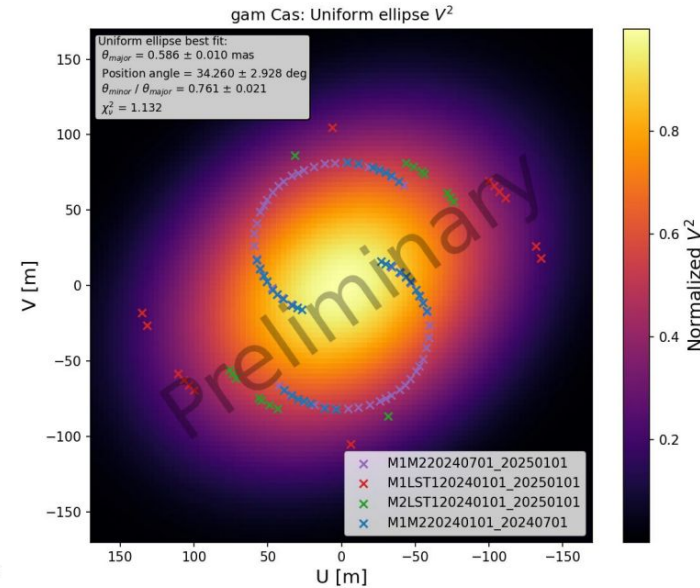
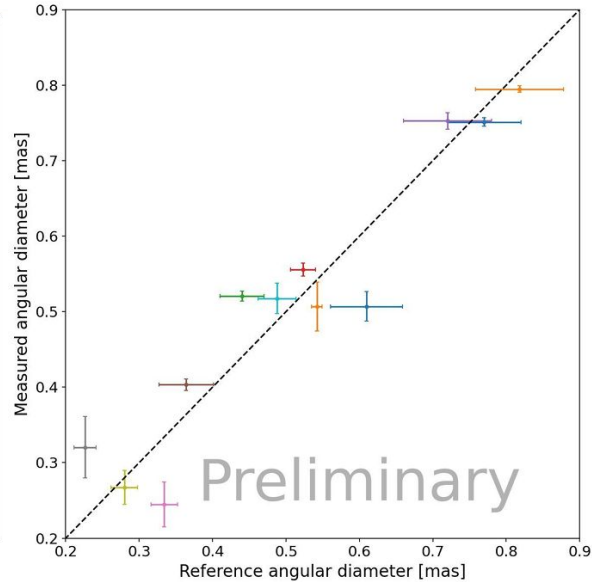
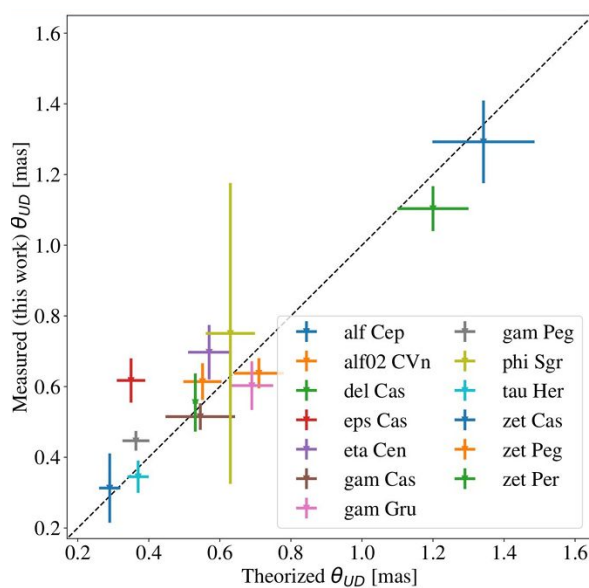


Activities example: intensity interferometry observations

First results on bright stars radius measurement, and shape of fast rotators

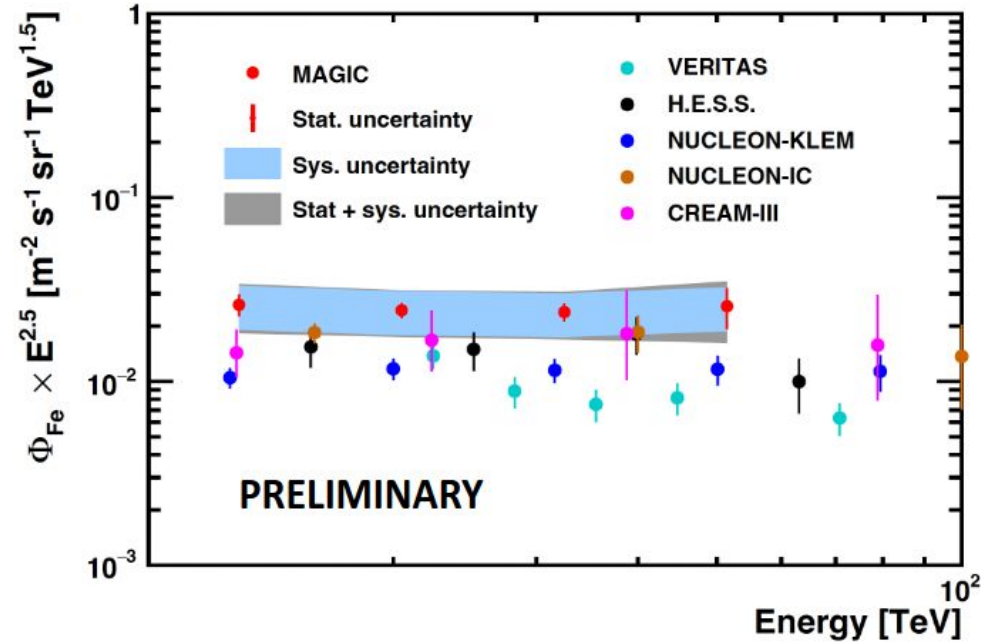
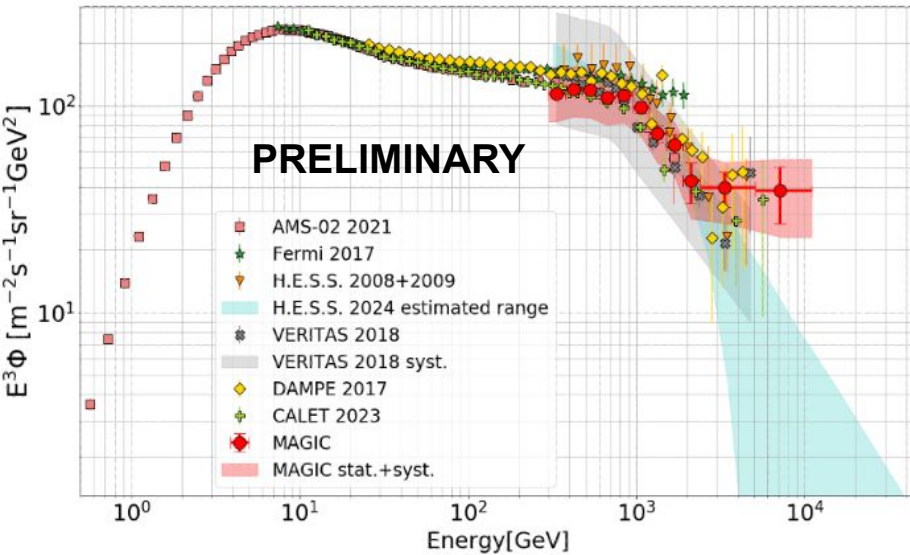
MAGIC

MAGIC+LST1



Activities example: iron flux with MAGIC

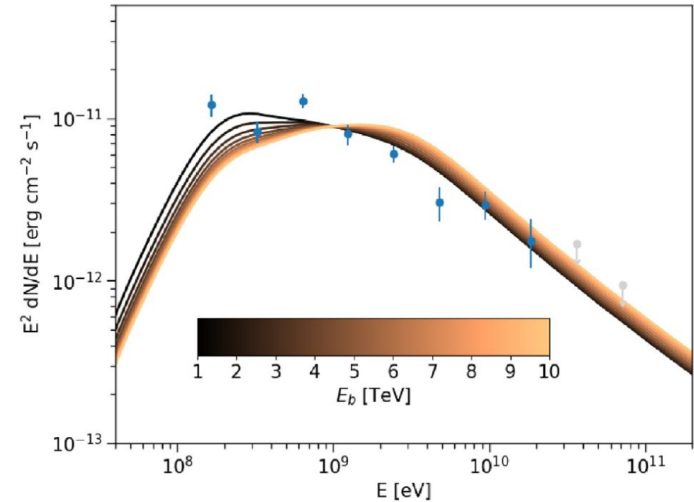
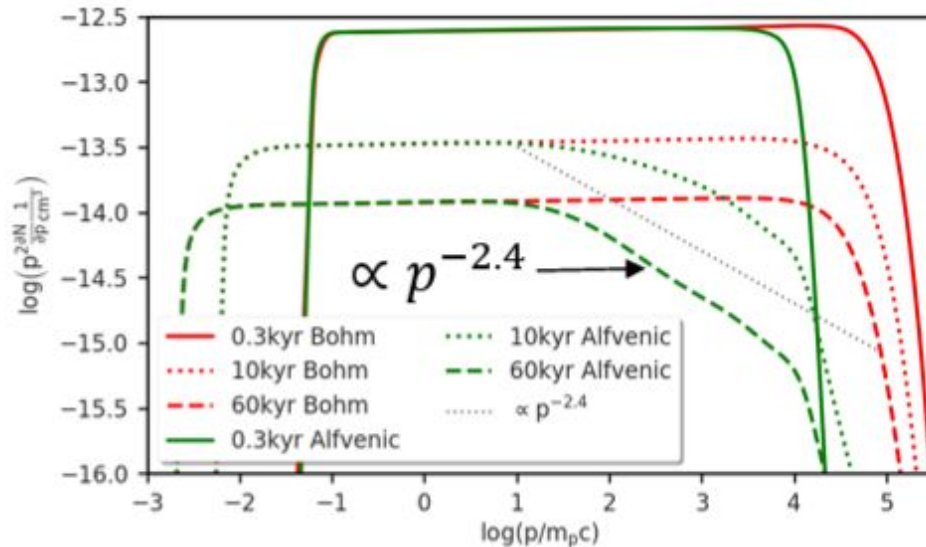
Using the Cherenkov light emitted before interaction to identify iron nuclei
Exploring the possibility of using a discriminator based on the shower image.



Activities example: cosmic rays from SNRs with numeric simulations

Detailed characterization of the **total contribution from SNRs to cosmic rays** - spectral shape, maximum energy, composition:

- modelling of SNRs accounting for pre-explosion evolution
- population synthesis, modelling non-thermal emission from individual sources
- propagation of CRs in the Galaxy, comparison with the observed spectrum of CRs
- possibility to model neutrino fluxes



Major responsibilities

- Co-PI of LST-North project.
- Coordinator of LST camera engineering activities.
- Deputy coordinator of LST 2 - LST 4 construction.
- CTAO Deputy Computing coordinator.
- Delegate of Spanish Ministry in Advisory Finance Committee of CTAO.
- Coordinator of CTAO's Array Control and Data Acquisition development.
- Scientific coordinators of multiple physics groups in MAGIC and LST.
- Managers of funding for the Spanish operation and maintenance of CTAO-N.

Funding

- ERC grant for “MicroStars: Extreme time and angular resolution in the optical with Cherenkov telescopes”
 - 2.5M€ from 2023 to 2028
- AEI project “Astronomía de rayos gamma con CTA-Norte y MAGIC - Contribución del CIEMAT”
 - 4 institutions, coordinated by CIEMAT
 - CIEMAT granted with 460k€ from 2023 to 2026
 - New project submitted
- Direct line from the Spanish Government Budget for Operation and Construction of CTA-N
 - 500k€ yearly since 2023
- Other sources (Atracción de Talento, Consolidación Investigadora...)

Landscape

~2030

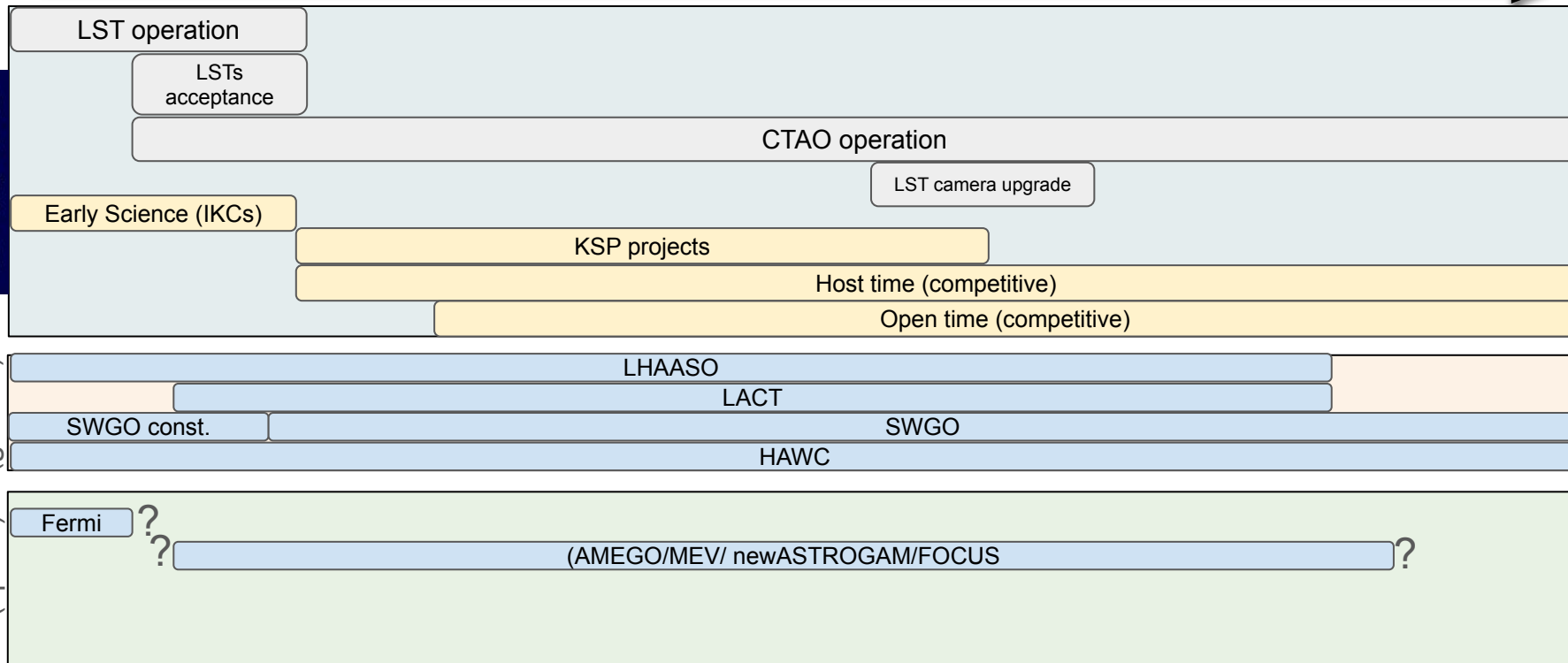
~2040

~2050

CTAO

Other
(ground)

Other
(space)



Vision

~2030

~2040

~2050

CTAO

LST operation

LSTs
acceptance

CTAO operation

LST camera upgrade

Maintenance knowledge
transfer & support

Design of digital camera for LST

Construction, deployment and comm.

Design & prototyping of SII
butterfly camera

CTAO's development program

Stars, Novas & FRB with
II and fast optics

Stars, Novas & FRB with II and fast optics

LHAASO-like PeV
sources

LHAASO-like PeV sources

AGN KSP

Nuclei flux measurement at VHE

Transients(fast optics
and gammas) /
Multimessenger

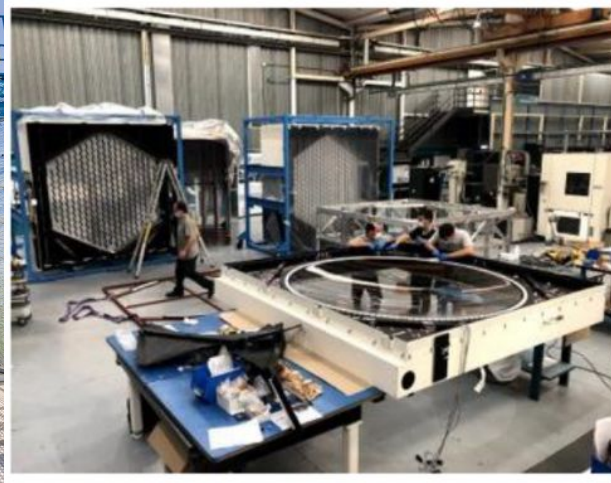
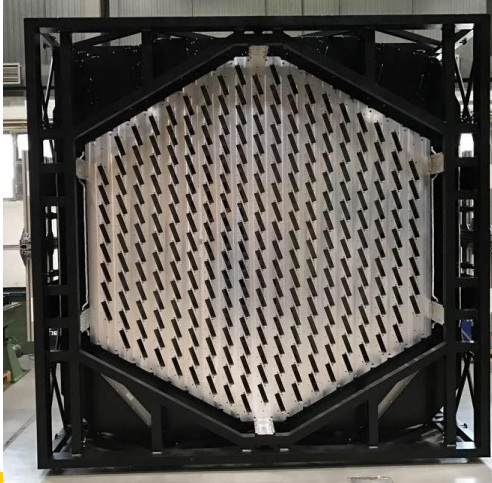
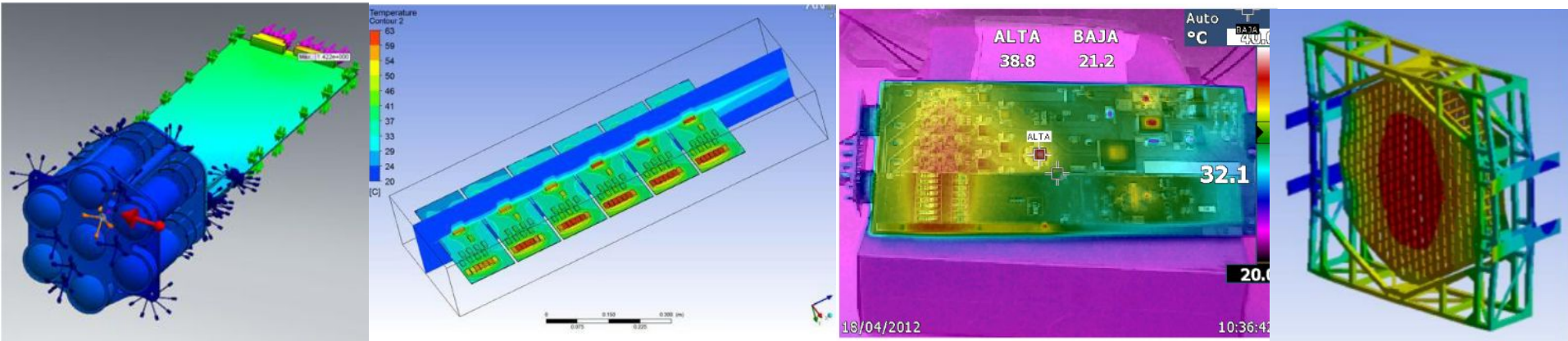
Transients(fast optics and gammas) / Multimessenger

15



Thank you

Activities: instrumentation



Activities: instrumentation

