

Towards finalization of CTA-N and exploitation of MAGIC and LSTs

CIEMAT's contribution to the coordinated project

PI-1 and coordinator: Juan Cortina
PI-2: Tarek Hassan

Context

CIEMAT's gamma group have been working in the development of CTA since 2009.

In particular LST camera mechanics, cooling system and camera trigger and clock distribution are designs of CIEMAT, as well as the responsibility of their production for LST-1 and the commissioning for LST-1 to LST-4.

CIEMAT holds the camera engineering and co-spokesperson positions of LST, and held until 2022 the camera coordination position.

CIEMAT manages additional funding for all Spanish communities provided directly through PGE to cover preventive maintenance and operations for LSTs.

- Amounts to 400k/year
- This funding is not guaranteed

Context

Concept	Period	Agency	Funding (k€)
Astronomía de rayos gamma con MAGIC y CTA-Norte, proyecto 1 - Contribución de CIEMAT	06/2020–05/2023	AEI	532
Contribución del CIEMAT a la puesta en marcha y primera ciencia del observatorio CTA-N	01/2018–12/2019	MICIIN	266
Desarrollo de metodos de deep learning para reconstruccion de datos de array de Telescopios Cherenkov	10/2015–10/2018	MINECO	174
Participación en la integración, cualificación, instalación y puesta en funcionamiento del prototipo LST y en su industrialización	1/2016–12/2017	MINECO/FEDER	125
Participación española en el diseño y prototipado del Cherenkov Telescope Array: contribución del CIEMAT	1/2015–12/2015	MINECO	24
Equipamiento de los sistemas de almacenamiento de datos de los telescopios MAGIC en La Palma	1/2013-12/2015	MICINN/FEDER	30
Participación española en el diseño y prototipado del Cherenkov Telescope Array: prototipado en escala completa de la cámara y el trigger de la cámara de los LST	1/2014–12/2014	MINECO	70
Participación española en la fase de preparación de CTA: I+D en nuevos fotodetectores y prototipado de la mecánica de la cámara	1/2011–12/2013	MICINN	194
I+D en nuevos fotosensores para un prototipo de cámara para telescopios de gran tamaño de CTA	1/2010-12/2010	MICINN	41

Context

Successful transfer of knowledge to industry: production of camera mechanics and signal distribution electronics.

- LST2 to LST4 produced in Spanish industry (with CIEMAT as advisor)
- Spanish industry won a tender to produce part of MST mechanics thanks to this technology transfer
- Spanish industry positioned for the production of cameras for CTA-S

We are following the same transfer path with preventive maintenance activities.

Goals of the project

Exploitation of MAGIC+LST-1

Commissioning of LST-2 to LST-4

Development of Intensity interferometry with IACTs and demonstration of its potential for astrophysics

Development of technology for future cameras

Coordination

This project is coordinated with a large group of Spanish institutions through two coordinated projects:

- UCMx2, IFAE, ICCUB, UAB, UJA, IAA
- Coordinated with IAC, although they go through Space program
- Total funding needs amount to 1M per year (including PGE)

Ciencia con MAGIC + LSTs

VHE observations

- Cosmic rays
 - Leptons spectrum: 100 GeV to > 10 TeV
 - Fe spectrum
- Gamma rays
 - CR acceleration within SNRs (pevatrons)
 - Analysis improvement through event types
 - Search for VHE transient phenomena (FRBs)
 - Follow-up of multi-messenger alerts (extragalactic neutrinos)

Optical observations

- Stellar diameters
 - Towards an II catalog of OB stars
 - Improve asteroseismology analysis of β Cephei stars
- Higher order effects
 - Measure the oblateness of fast rotators
 - Determine the orbital parameters of the ι Ori close-by binary systems
- Demonstrate aperture synthesis is possible with MAGIC sub-mirrors

Current project structure

- WP.1 Commissioning of LST-2 to LST-4
 - Trips to IACTEC and La Palma for commissioning
 - Corrective maintenance costs
- WP.2 Scientific exploitation of CTA-LSTs and MAGIC
 - Trips to CTA, LST and MAGIC meetings and conferences
- WP.3 MAGIC data center at PIC and IT management in La Palma
 - Trips and contribution to data center HW along with IFAE
- WP.4 Development of Intensity interferometry with IACTs
 - Production of hardware costs
- WP.5 Future IACTs cameras
 - Under discussion (clock distribution, trigger asic).
- WP.6 Management and services
 - Management trips, common funds of MAGIC and LST, MAGIC and LST shifts costs

Budget

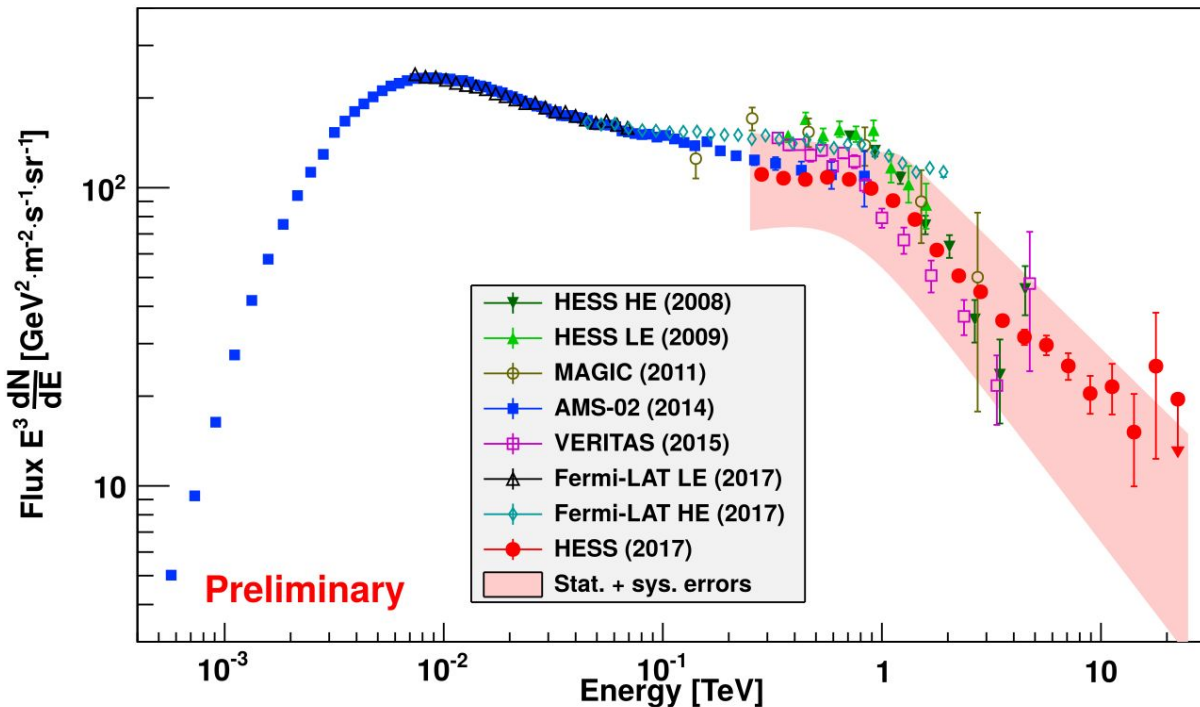
Package	k€
WP.1 Commissioning of LST-2 to LST-4	
Hiring a technician for 3 years (extending current contract, 50% of his time)	67.5
Trips to Tenerife and La Palma (3 personsx3 tripsx2 years)	20
Corrective maintenance budget	30
WP.2 Scientific exploitation of CTA-LSTs and MAGIC	
Hiring one postdoc for 2 years (covers extending current contract)	100
Meetings and conferences (12 trips/year x 3 years + fees)	40
WP.3 MAGIC data center at PIC and IT management in LP	
Contribution to data center HW along with IFAE	120
IT management trips to La Palma (2 per year x 1 person)	6
WP.4 Development of Intensity interferometry with IACTs	
Production of BP & mezzanine hardware for LSTs	10
Production of mechanics and filters	10
Upgrade of the correlator	30
Hiring a technician for 3 years (extending current contract, 50% of his time)	67.5
WP.5 Future IACTs cameras	
Material and production	50
WP.6 Management and services	
Management trips (6 trips x 3 years)	20
CIEMAT LST Common fund, adjusted inflation	21.6
CIEMAT MAGIC Common Fund, adjusted inflation	25.2
Shifts MAGIC (2 trips of 1 months per year x 3 years)	15
Shifts LST (2 trips of 1 months per year x 3 years)	15
TOTAL	647.8

Personnel

- Equipo (provisional)
 - Equipo de investigación:
 - i. Juan Cortina (IP): Management, Analysis, Hardware coordination
 - ii. Tarek Hassan (IP): Management, Analysis, Computing
 - iii. Total: 5 Doctores + 2 ingenieros
 - Equipo de trabajo:
 - i. 1 postdoc
 - ii. 3 estudiantes doctorado
 - iii. 1 Tecnico
- Colaboradores de otros departamentos del CIEMAT:
 - División de computación
 - Departamento de tecnología del CIEMAT (Workshops y división de instrumentación científica)
 - Colaboración cercana con el grupo de ondas gravitacionales de la división de astropartículas

Cosmic rays with IACTs

Measuring the $e^- + e^+$ spectrum beyond AMS spectrum:



Team currently working on performing a similar measurement with MAGIC

LST's improved systematics will dramatically improve the relevance of this measurement

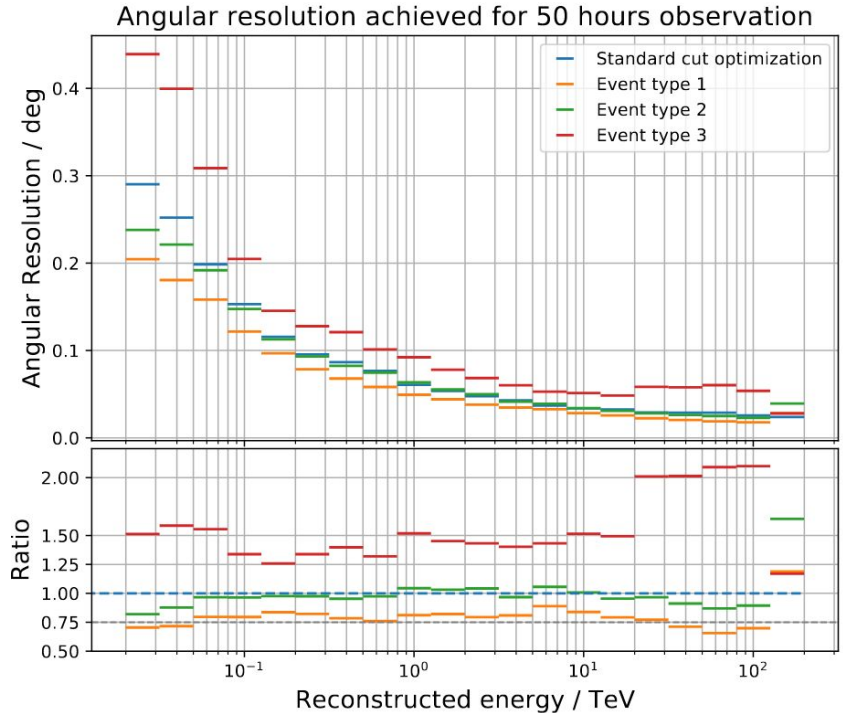
Measurement of Fe under study.

Exploring the performance of event types with CTA

CIEMAT is leading the implementation of a event-type based analysis within CTA

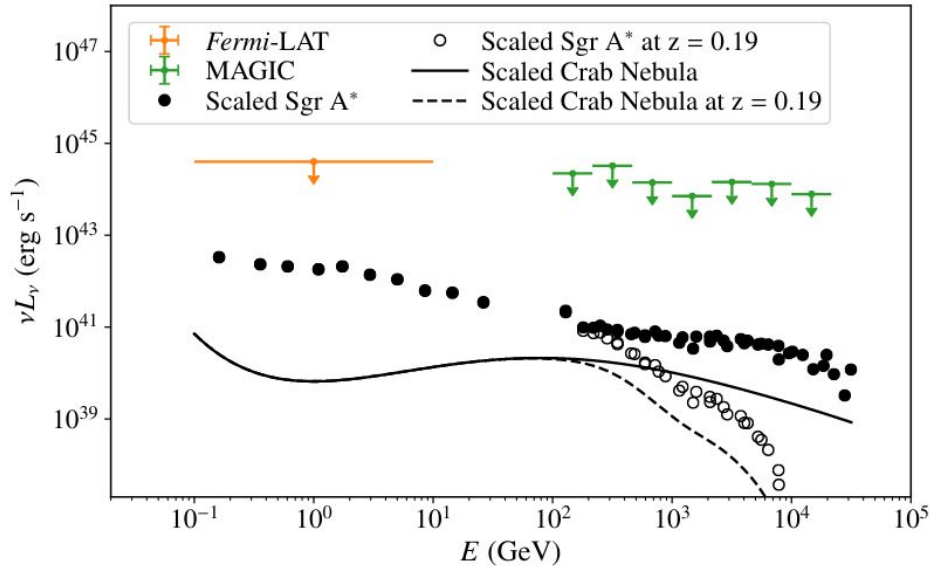
Machine learning evaluates the reconstruction quality of individual events

By considering these event types in the high-level analysis, we boost angular and energy resolution by ~25%



Constraining optical and VHE emission of FRBs

Irene Jimenez (lead analyzer) and Tarek Hassan (PI of MAGIC proposal)



Fast Radio Bursts have been recently associated with transient extremely-energetic events in magnetars

Both VHE gamma-ray and optical counterparts are plausible, and will constrain emission models

MAGIC is suitable to constrain both

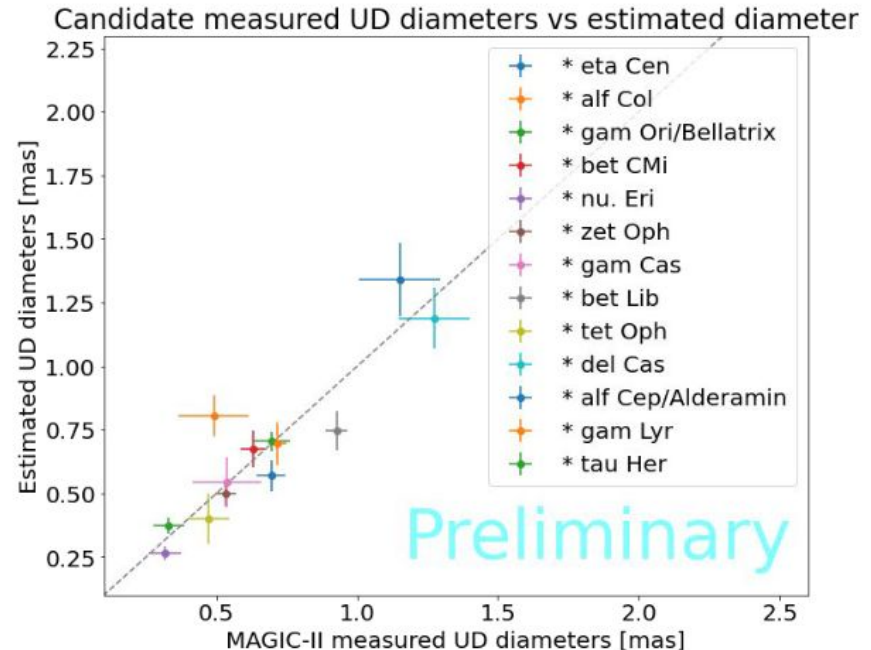
Imaging stars with Intensity interferometry

CIEMAT lead the upgrade of MAGIC into an optical interferometer. Now, we are leading the observation scheduling and scientific analysis:

Demonstrated x10 sensitivity than previous generation of intensity interferometers

Already working on a scientific program aiming to provide a catalog of stellar diameters and to study the oblateness of fast rotators

Upgrade of the correlator and addition of LST-1 is part of the program towards imaging stars



MAGIC as follow-up instrument of AMON alerts

Real-time multimessenger alerts to find most energetic sources

Magic as follow-up instrument of gamma-rays and neutrinos

AMON alerts based on sub-threshold coincidences of gamma-rays and neutrinos

Data taken from HAWC observatory and IceCube

Coincidences defined by temporal and spatial criteria

