

Highlights from MAGIC

Oscar Blanch Bigas
for the MAGIC collaboration



Barcelona Institute of
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The MAGIC Telescopes

MAGIC is an Imaging Atmospheric Cherenkov Telescope system consisting of two 17m diameter telescopes, located on Canary island La Palma



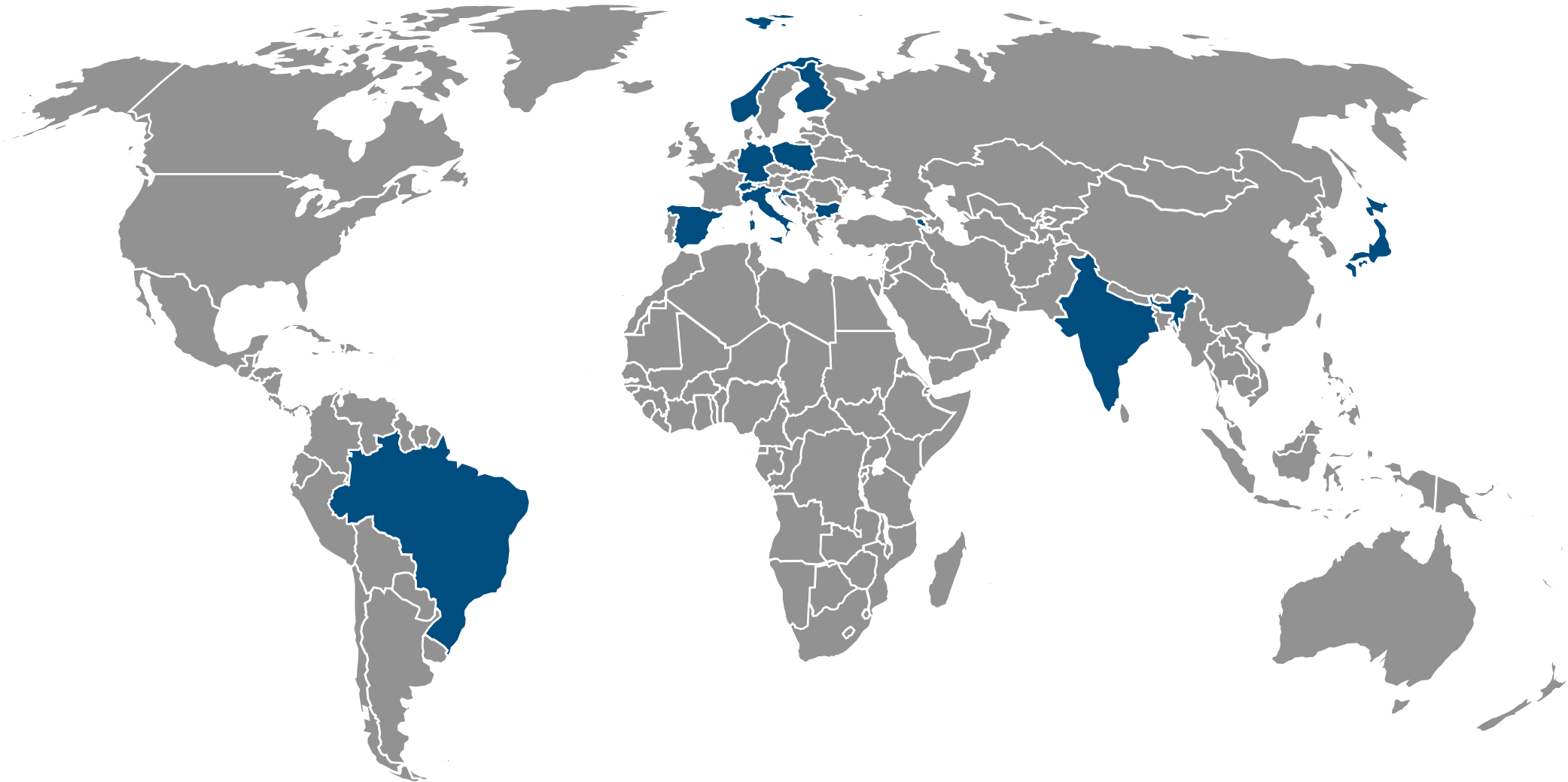
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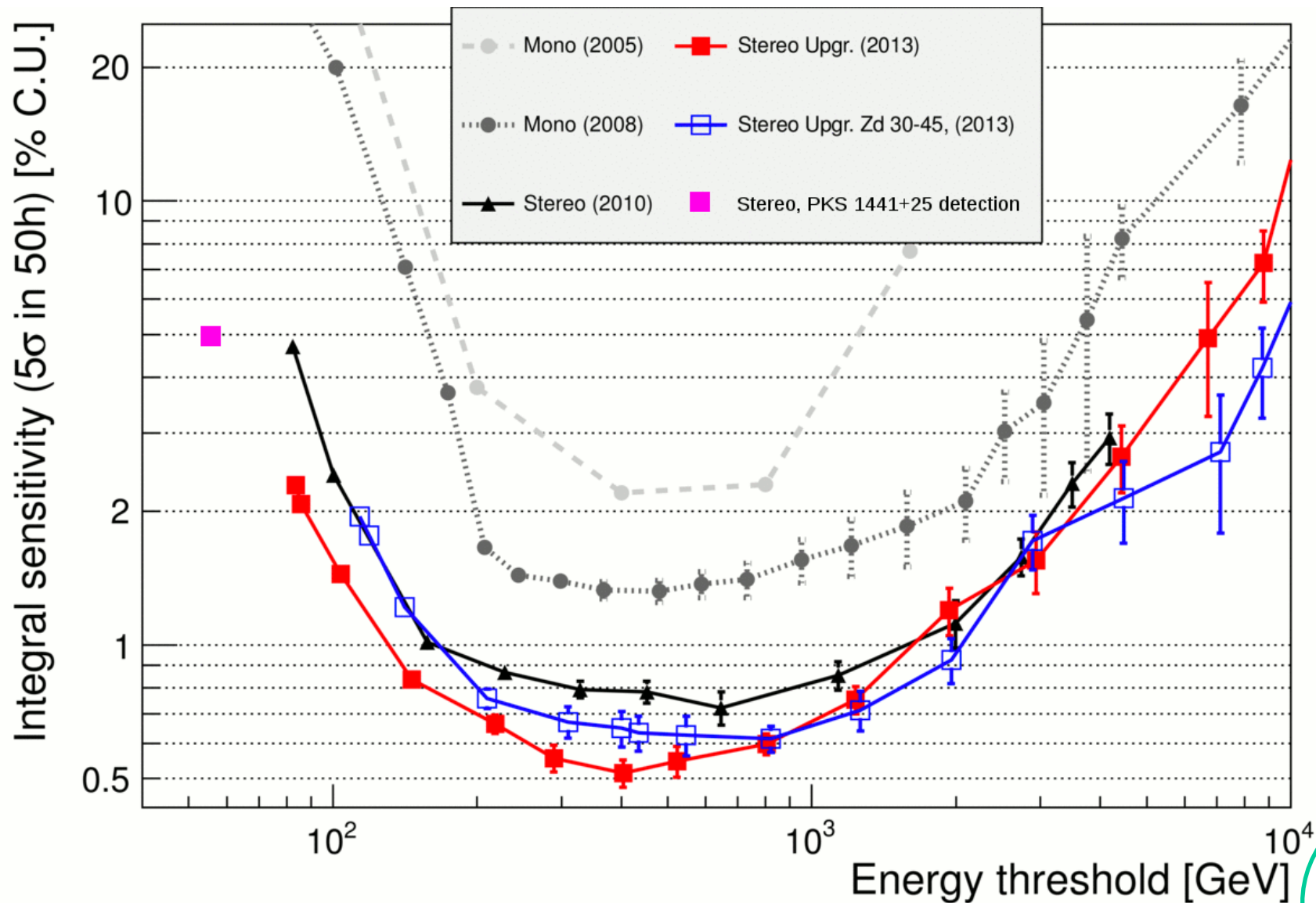


The MAGIC Collaboration

~200 scientists working in ~30 institutions from 13 countries around the world: Armenia, Brazil, Bulgaria, Croatia, Finland, Germany, India, Italy, Japan, Norway, Poland, Spain and Switzerland



MAGIC kept Improving



S.Mender

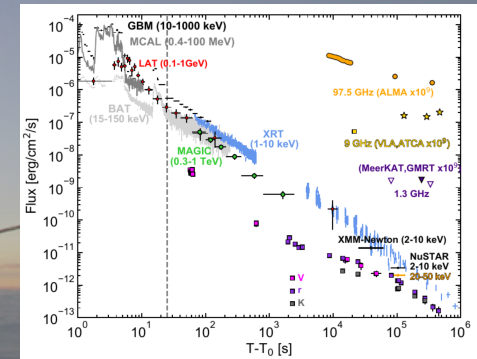
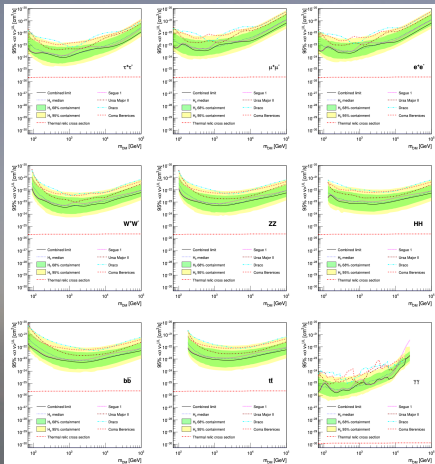
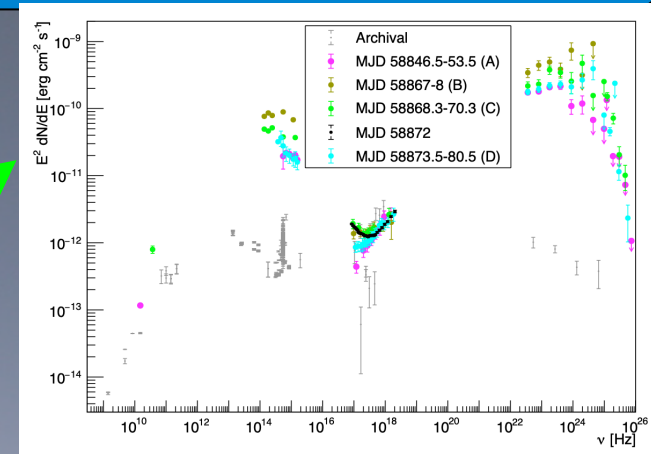
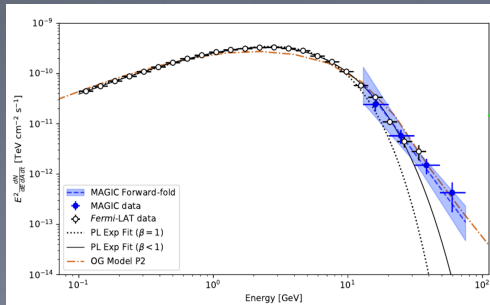
C. Nigro
7/7 at 18:00

- 2004 – MAGIC-I built
- 2007 – upgraded MAGIC-I readout
- 2009 – MAGIC-II built
- 2011-2012 – Major upgrade
- Since then ... maintenance, operation, legacy

Main scientific targets for MAGIC

Galactic sources:
Pulsars, PWN, SNR, Binaries, II

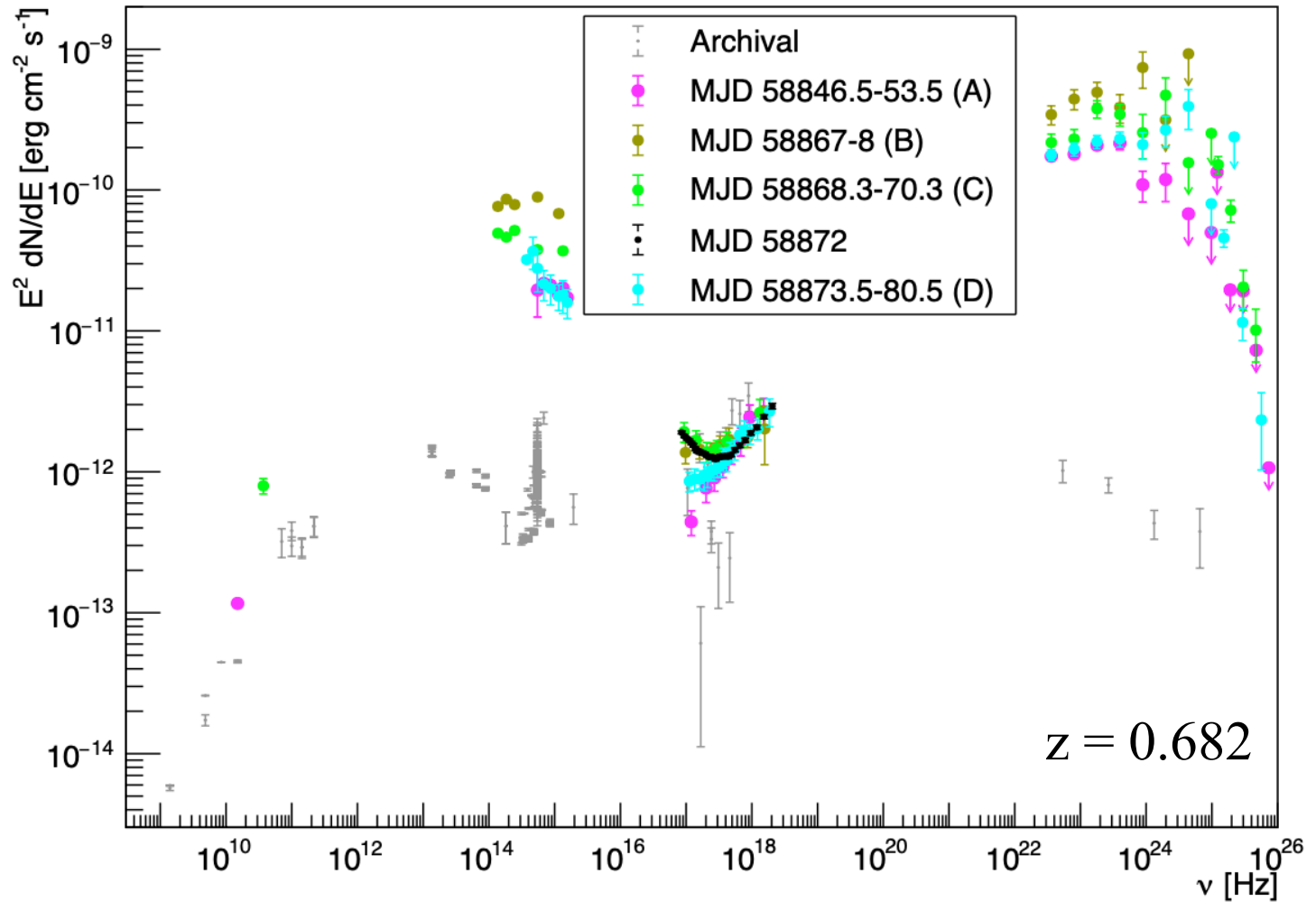
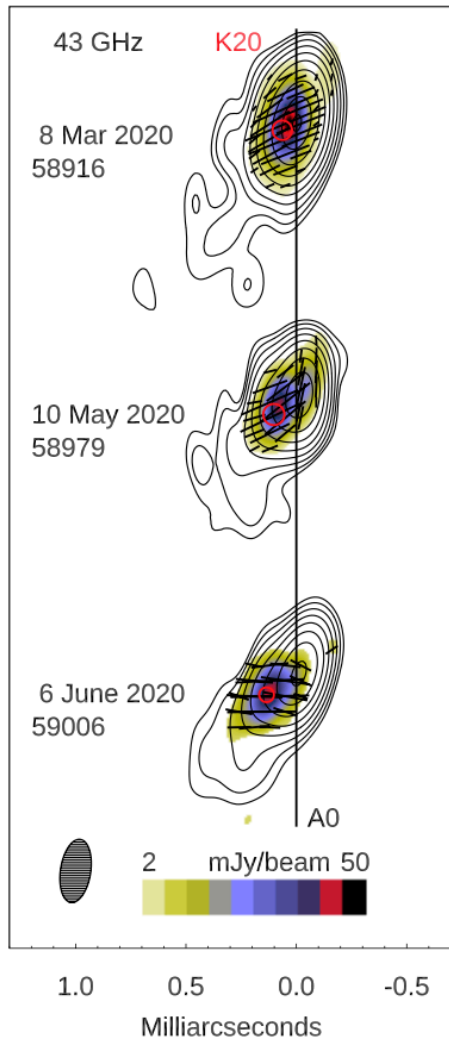
AGNs:
BL Lacs, FSRQs, Radio galaxies



Astroparticle & Fundamental Physics:
Dark matter, LIV, Cosmic rays

Transients:
GRB, Neutrinos, FRB, GW

AGN: QSO B1420 +326



8th FSRQ detected at VHE gamma rays

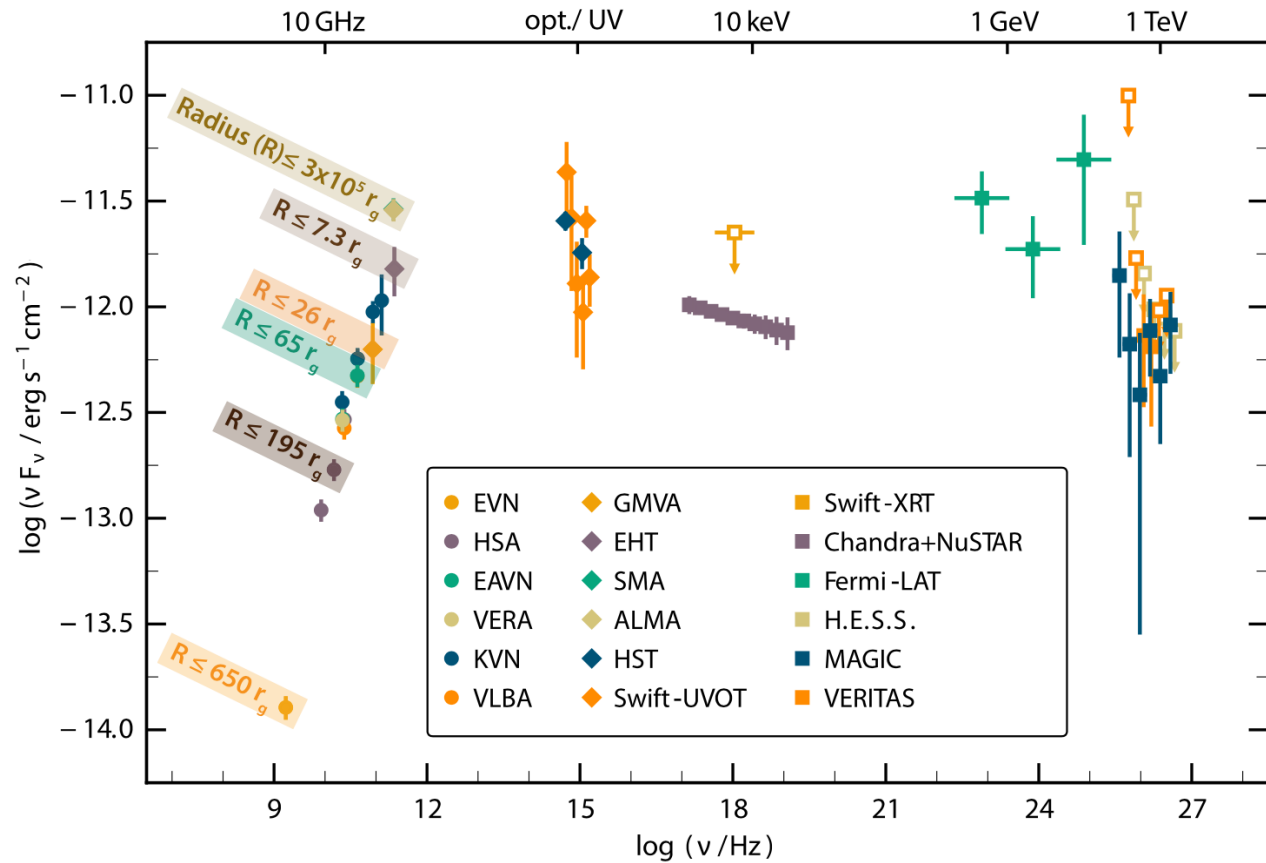
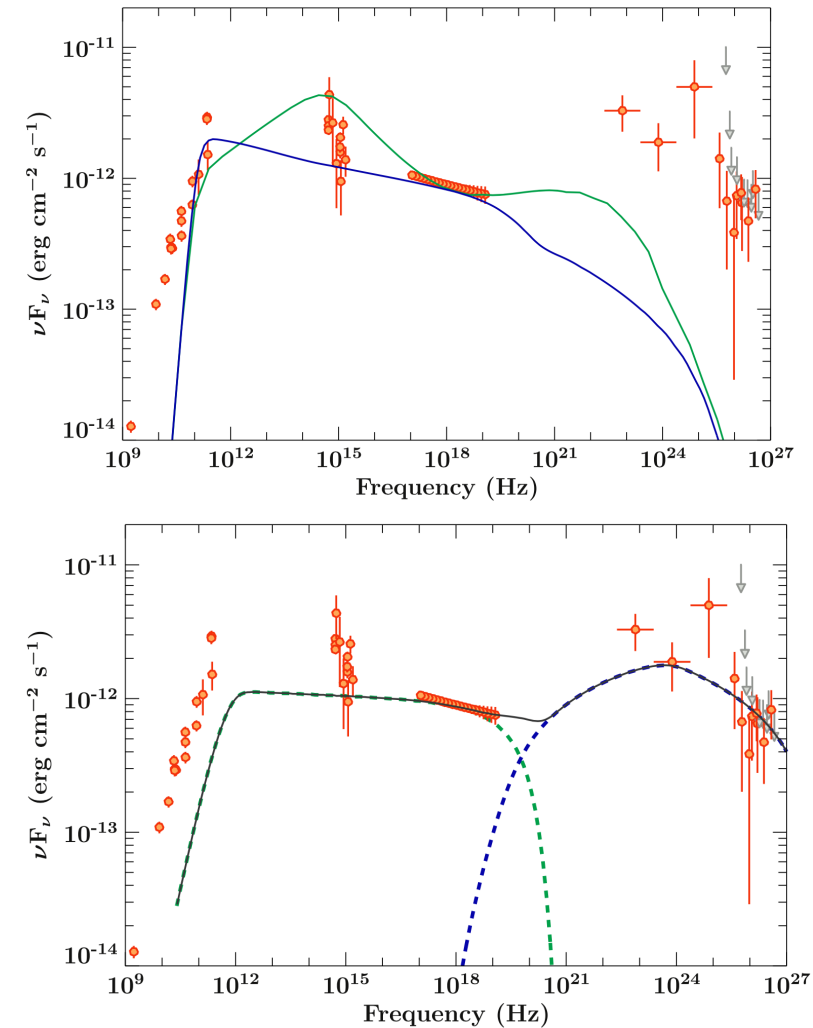
During enhanced state, SED components increased and its peak shifted to higher energies

Modelling — e- accelerated in shock beyond BLR, gamma-ray from EC Torus, X-ray sync-SSC-EC

Building up FSRQ characteristics (sister of PKS 1510 -089)

AGN: Broadband MWL for M87 with EHT

J.C. Algaba et al, APJ Let. 911, 2021



VHE Gamma-ray emission can not be produced in same region as mm-band
Need of structured jet model including time-dependence

Extensive and deep MWL are key

A.Hahn
5/7 at 15:45

AP&FP: Dark Matter in dSph

MAGIC, Phys.Dark.Univ, 35, 2022

350 hours on 4 dSphs

Most constraining limits from dSphs

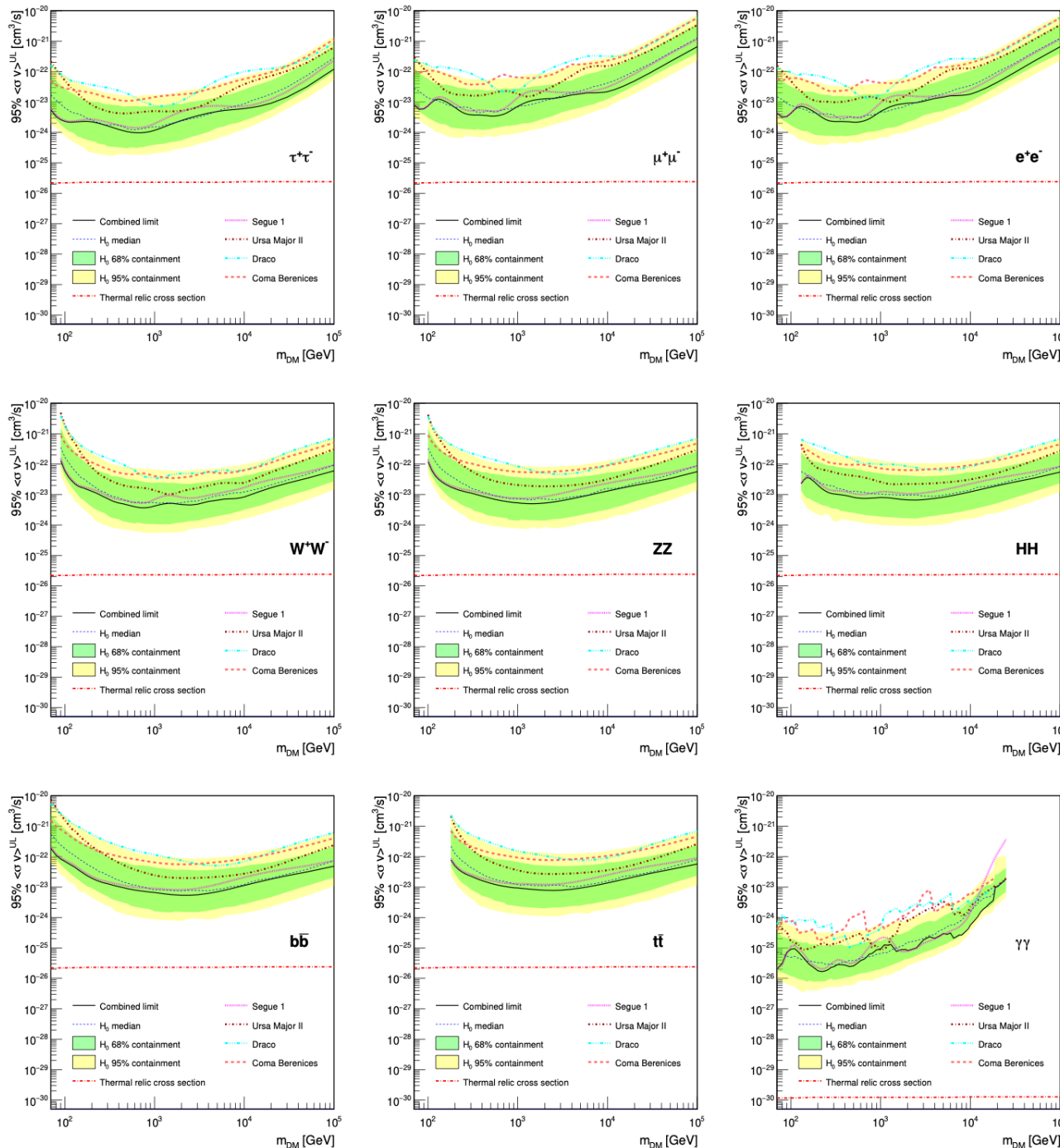
Combination of different observations for DM searches

Keep searching for DM:

- Gamma-ray combination for dSph
- Monochromatic line emission

D. Kerszberg
7/7 at 18:00

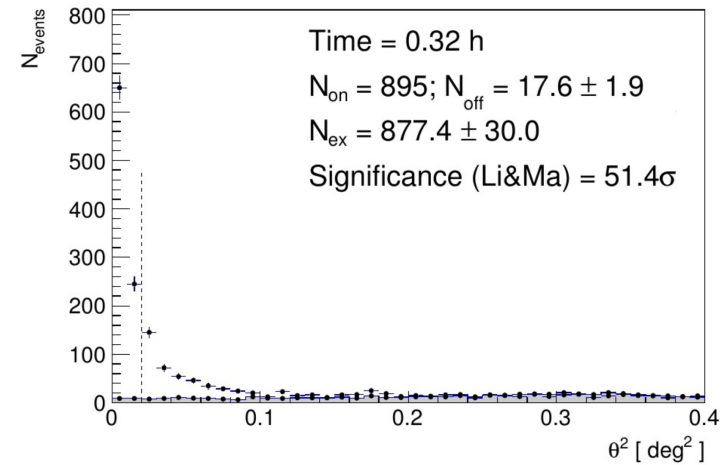
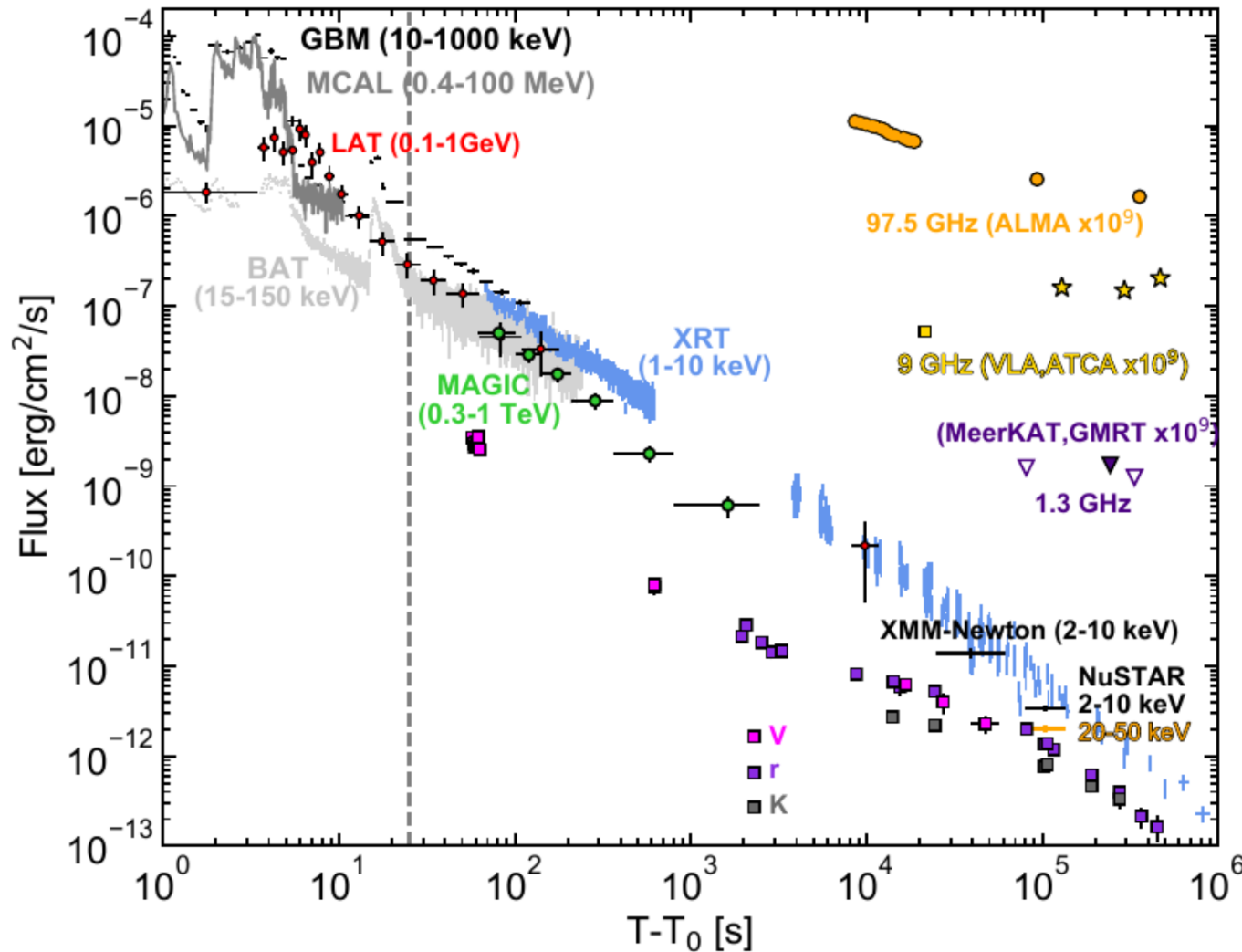
T. Inada
7/7 at 17:45



Transient: Gamma Rays Bursts

MAGIC et al, Nature, 575, 2019

MAGIC, Nature, 575, 2019



Brightest VHE Gamma-ray source ever detected (0.1 kCrab)

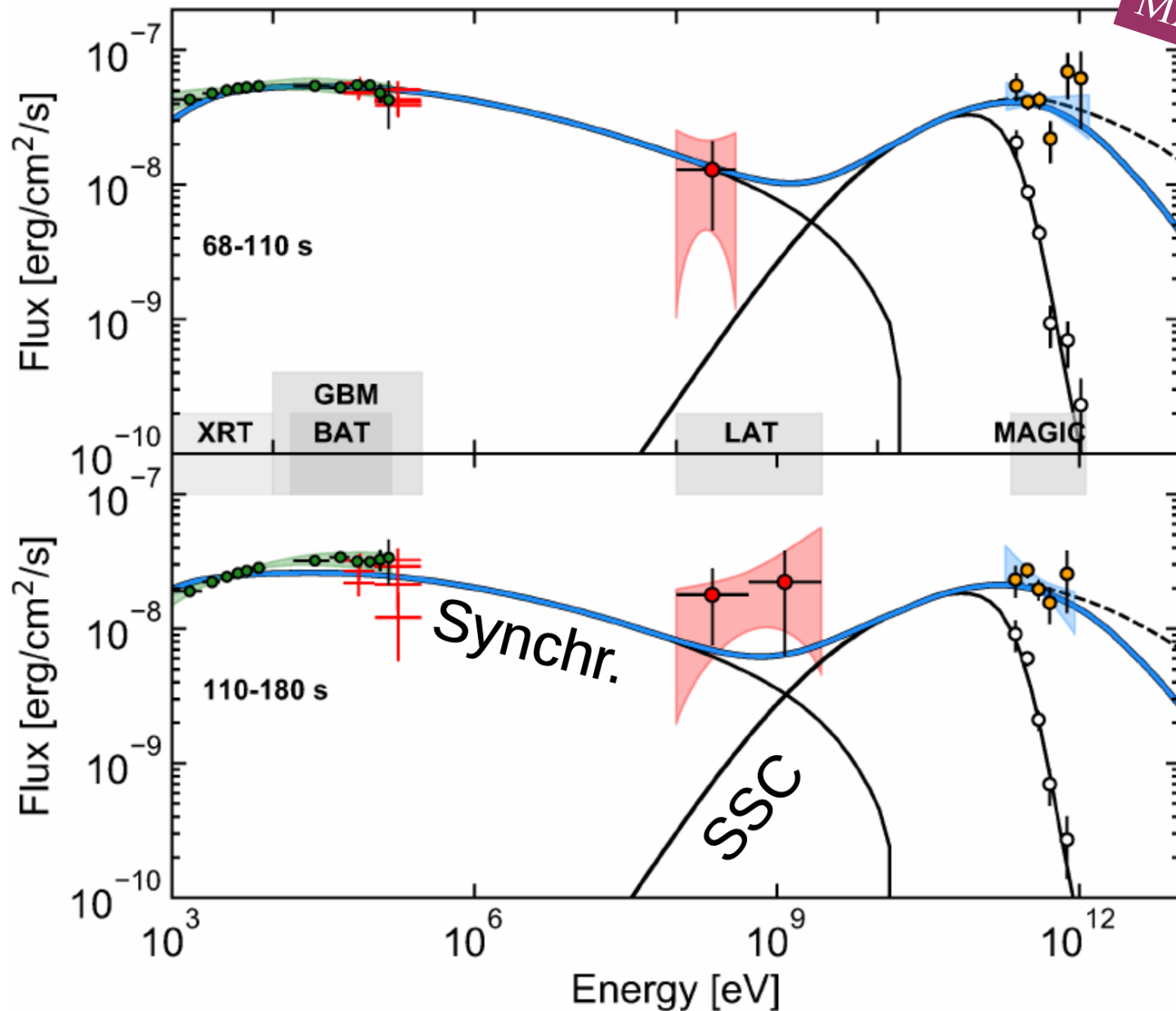
Long GRB (T₉₀=361s)

Observations started 50 s after X-ray trigger

GRB 190114C: First detection of VHE emission
Very rich MWL coverage

Transient: Gamma Rays Bursts

MAGIC et al, Nature, 575, 2019



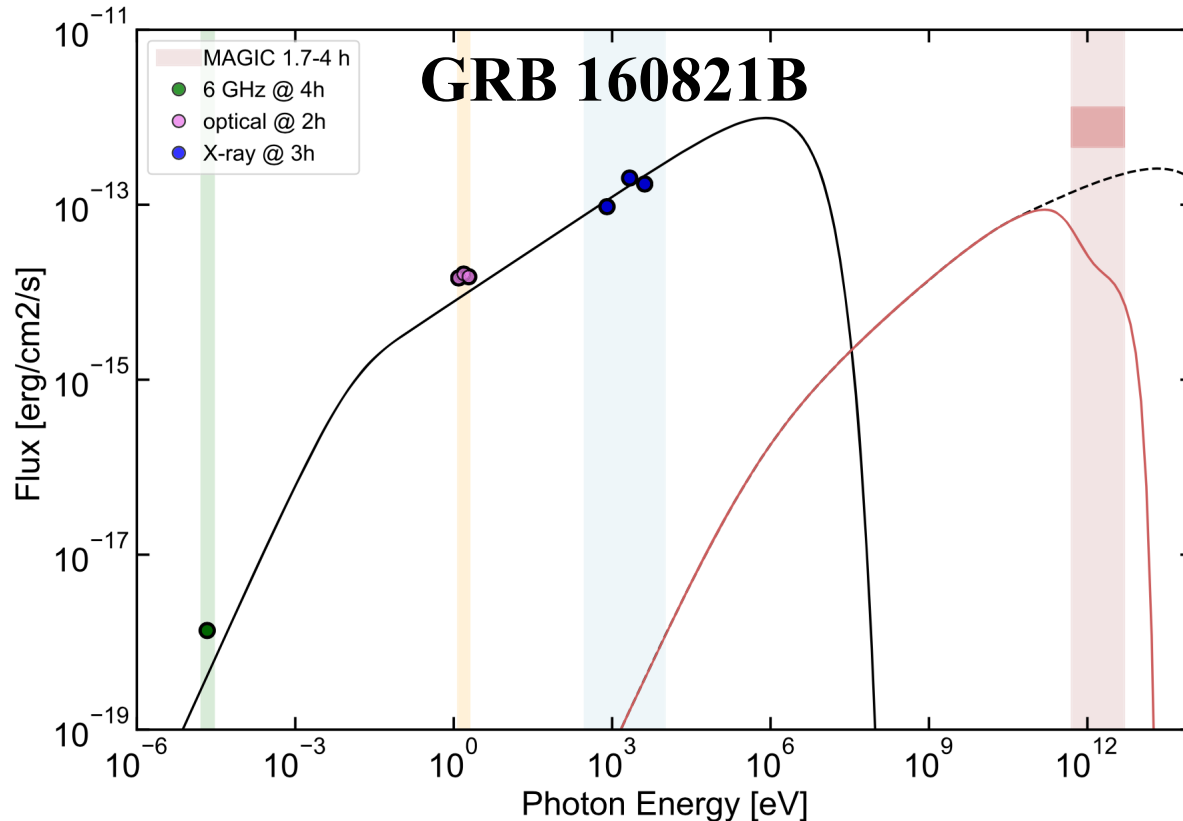
Highest Energy emission strongly absorbed by EBL

VHE Gamma-ray emission can be modelled in SSC scenario

Non-synchrotron origin of VHE gammas, probably SSC

Transient: Gamma Rays Bursts

MAGIC et al, APJ, 908, 2021



GRB 201216C: MAGIC detection in very high energy gamma rays

ATel #14275; *Oscar Blanch (IFAE-BIST) on behalf of the MAGIC Collaboration*
on 17 Dec 2020; 17:23 UT
Credential Certification: Oscar Blanch (blanch@ifae.es)

Subjects: Gamma Ray, >GeV, TeV, VHE, Gamma-Ray Burst

Referred to by ATel #: 14277

[Tweet](#)

On December 16, 2020, the MAGIC telescopes observed GRB 201216C following the trigger by Swift-BAT and Fermi-GBM (Beardmore et al., GCN 29061, Fermi/GBM team GCN 29063). MAGIC started observations under good conditions about 57 seconds after the GRB onset. The preliminary off-line analyses show an excess above 5 sigma, compatible with the GRB position reported by the Swift and Fermi teams. Refined off-line analyses of the data are ongoing.

3 sigma signal for short Gamma-Ray Burst GRB 160821B

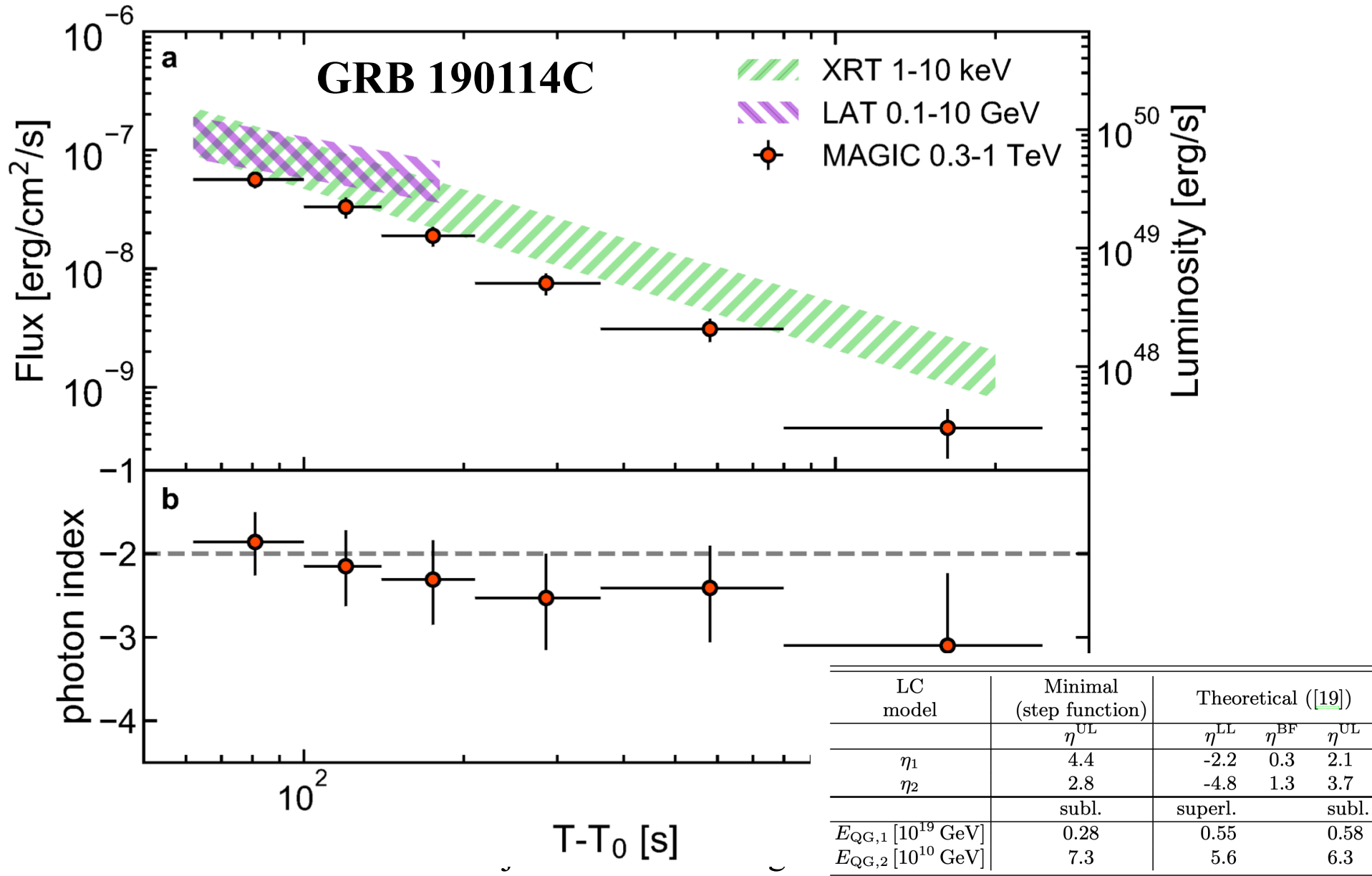
Putative VHE Gamma-ray emission difficult to explain with simple one-zone models of synchrotron-self-Compton emission

GRB 201216C detection above 5 sigmas

Since GRB 190114C, several signal of VHE emission from GRBs reported

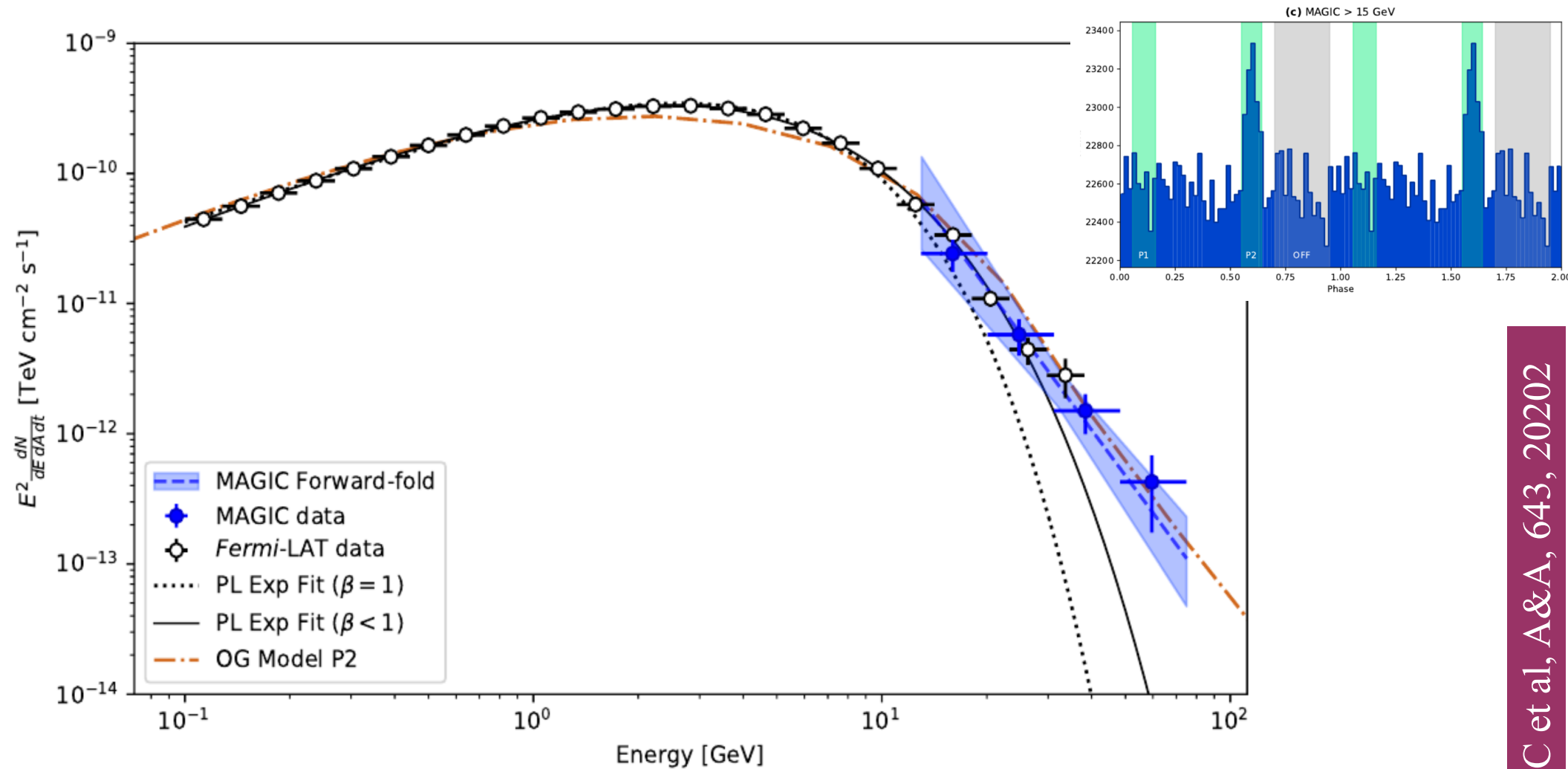
AP&FP: LIV in VHE GRBs

MAGIC et al., PRL, 125, 2020



Competitive lower limits on quadratic leading order

Galactic: Geminga Pulsar



80 hours of low energy trigger option (SumTrigger II) — 6σ detection

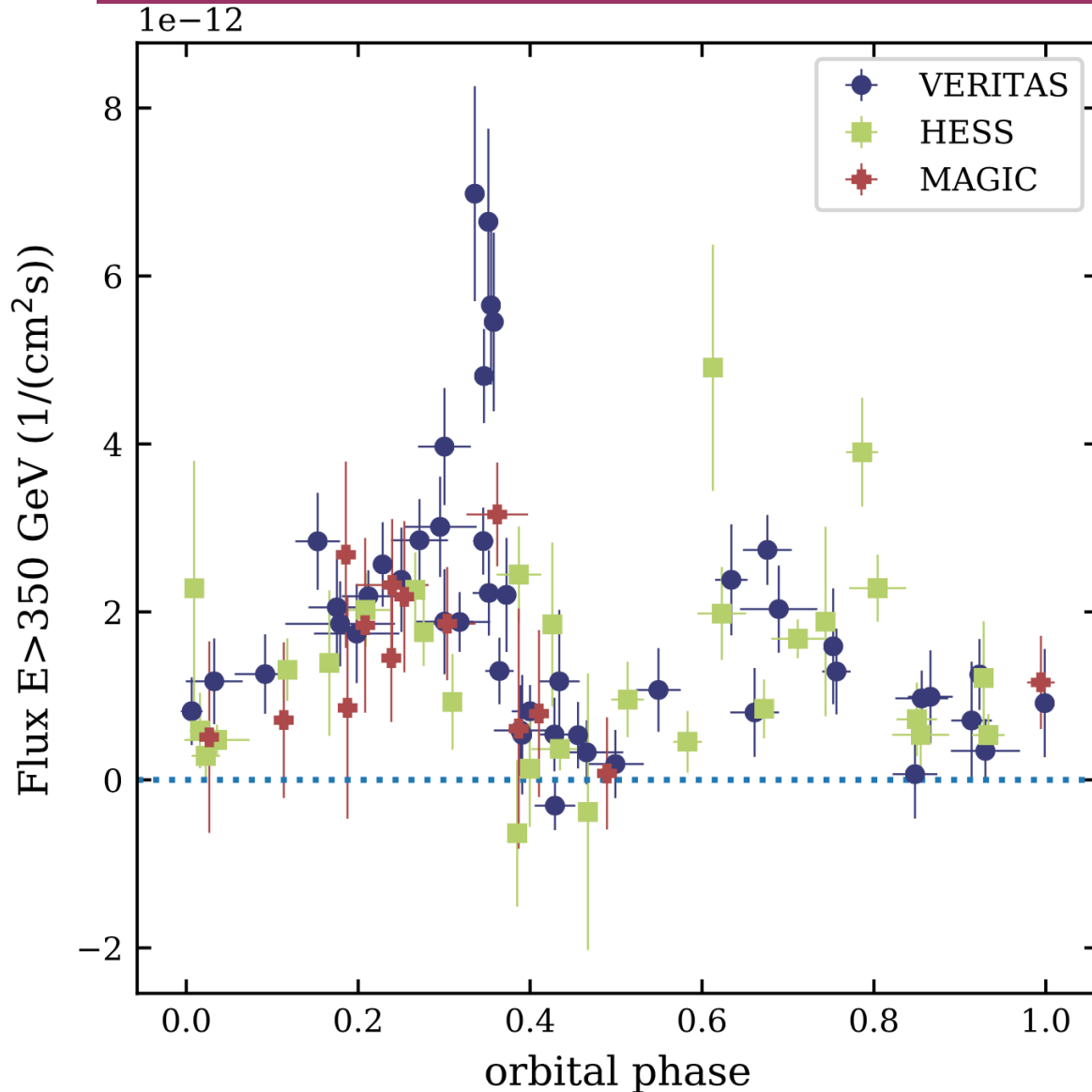
Hint of power low tail above 15 GeV

Modelling: IC scattering of soft X-rays from NS surface (inward electrons)

Transition from Curvature Radiation to IC scattering

Galactic: HESS 0632 +057

VERITAS, MAGIC, HESS et al, ApJ 943, 2021



450 hours over 15 years from
VERITAS, HESS and MAGIC

Modulation of the VHE gamma-ray
fluxes with a period of 316.7 ± 4.4 days

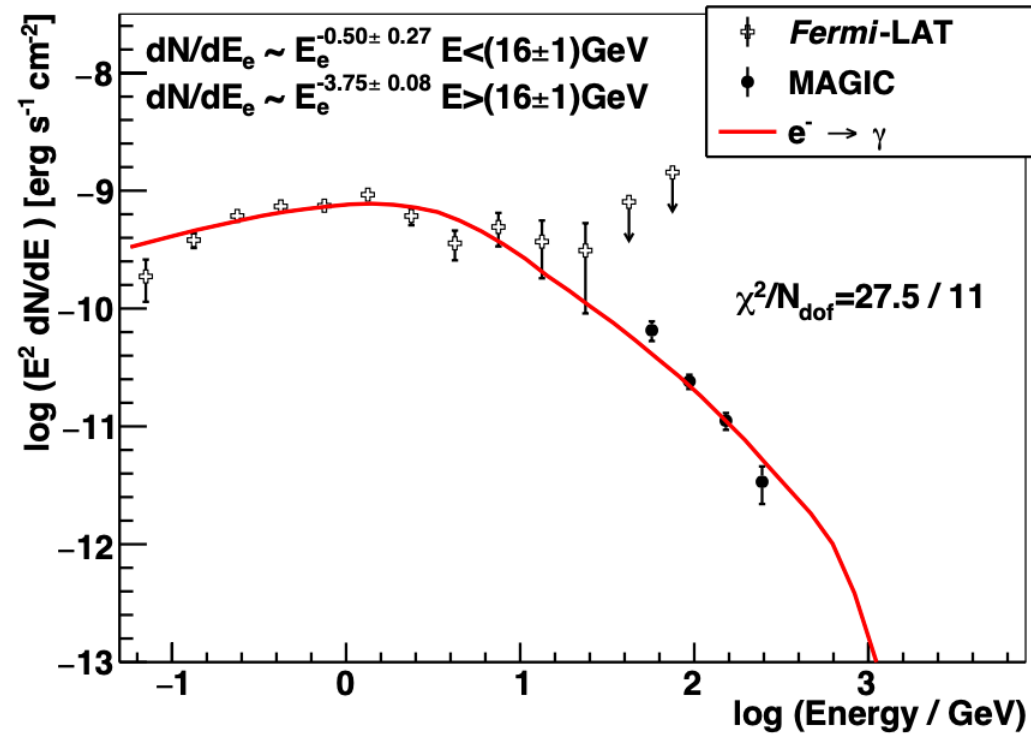
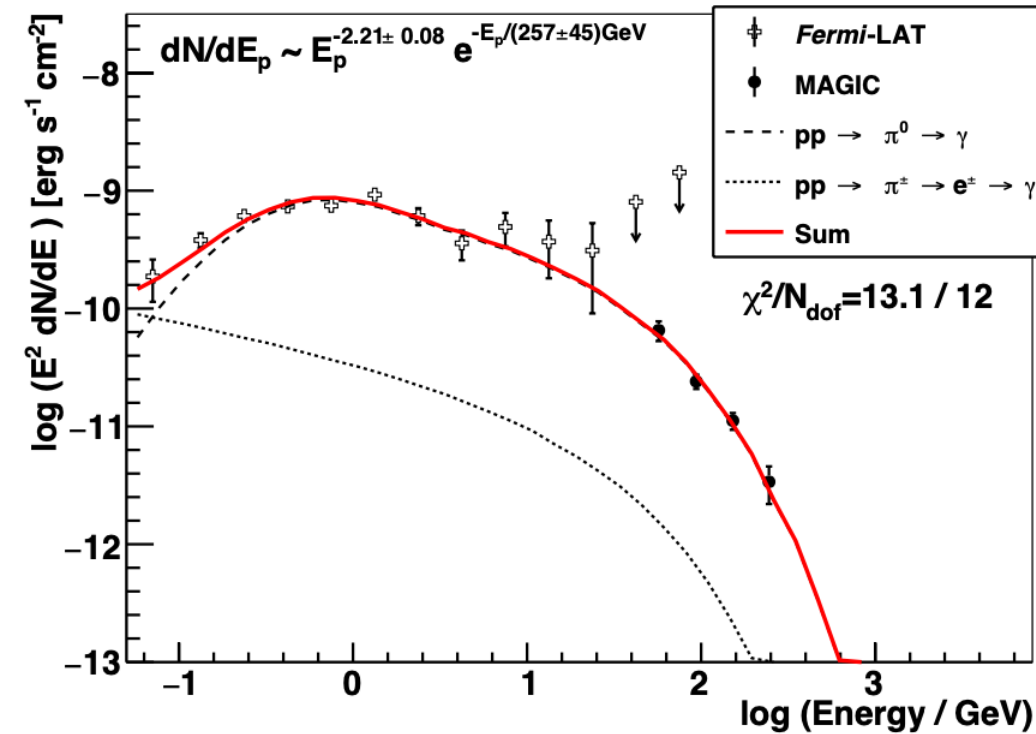
Extensive Multi Wavelength data

Correlation Gamma-ray and X-ray, but
no correlation with H α parameters

**HESS J0632+057 highly variable on different time scales
(X-ray & Gamma-ray)**

Galactic: Proton Acceleration in RS-Ophiuchi

MAGIC et al, Nat.Ast. 6, 2022



VHE Gamma-ray emission from a recurrent symbiotic Nova following outburst observed in optical and High Energy gamma-rays (*Fermi-LAT*)

Data suggests proton acceleration to hundreds of GeV in the nova shock

Local enhancement (13 pc) of Cosmic Ray density

New type of source emitting VHE gamma-rays

A.Lopez-Oramas
6/7 at 15:00

And many more ...

- [Putative PeVatron SNR G106.3+2.7 in the proximity of the Boomerang PWN](#), T.Saito, 4/7
- [1ES 0647+250: 10 years of multiwavelength observations](#), J. Otero-Santos, 4/7
- [Neutral pion bumps in TeV spectra of X-ray flaring blazars](#), M. Petropoulou, 4/7
- [Cosmic Rays origin studies in the W 44 region](#), R. di Tria, 5/7
- [Multi-wavelength view of M87](#), A. Hahn, 5/7
- [MWL view of the transitional blazar OT081](#), M. Manganaro, 5/7
- [Gamma-ray emission of hadronic origin from nova RS Oph](#), A. Lopez-Oramas, 6/7
- [Multi-messenger characterization of Mrk501 during historically low activity](#), L. Heckmann, 7/7
- [Search for Dark Matter annihilation with a combined analysis of dSph](#), D. Kerszberg, 7/7
- [Monochromatic line emission search from dark matter annihilation](#), T. Inada, 7/7
- [Establishing the MAGIC data legacy](#), C. Nigro, 7/7
- [Testing LIV on Observations of Energy-dependent Time Delays](#), S. Caroff, 7/7
- [Combined search for branon dark matter annihilation signatures](#), T. Miener, Poster
- [Sky maps using the open-source package Gammapy and MAGIC data](#), S. Mender, Poster
- [Search for axion-like particles in the Perseus galaxy cluster](#), I. Batkovic. Poster
- [The performance of the MAGIC telescopes using deep CNN](#), T. Miener, Poster

Summary

- MAGIC is operating smoothly since the latest major upgrade in 2011 – 2012
- We keep thinking about the future of MAGIC: simplify operation, automatise analysis, ...
- MAGIC keeps producing high impact scientific results
 - Acceleration mechanism for **VHE gamma-rays in Gamma Ray Bursts**
 - **Proton acceleration** in Novae
 - Building up **characteristics of FSRQ**
 - Unveiling the nature of **acceleration mechanism in pulsars**
 - **Long term behaviour** of astrophysical sources
 - **Dark matter searches** on joint observations and line searches
 - Limits on **Lorentz Invariance Violation**
- Many (most of them) **multi-messenger, multi-wavelength or multi-collaboration** projects
- Magicians are very important: Early Career Committee, DEI task force, Code of Conduct, Ombudsperson, ...

THANKS !!

The end