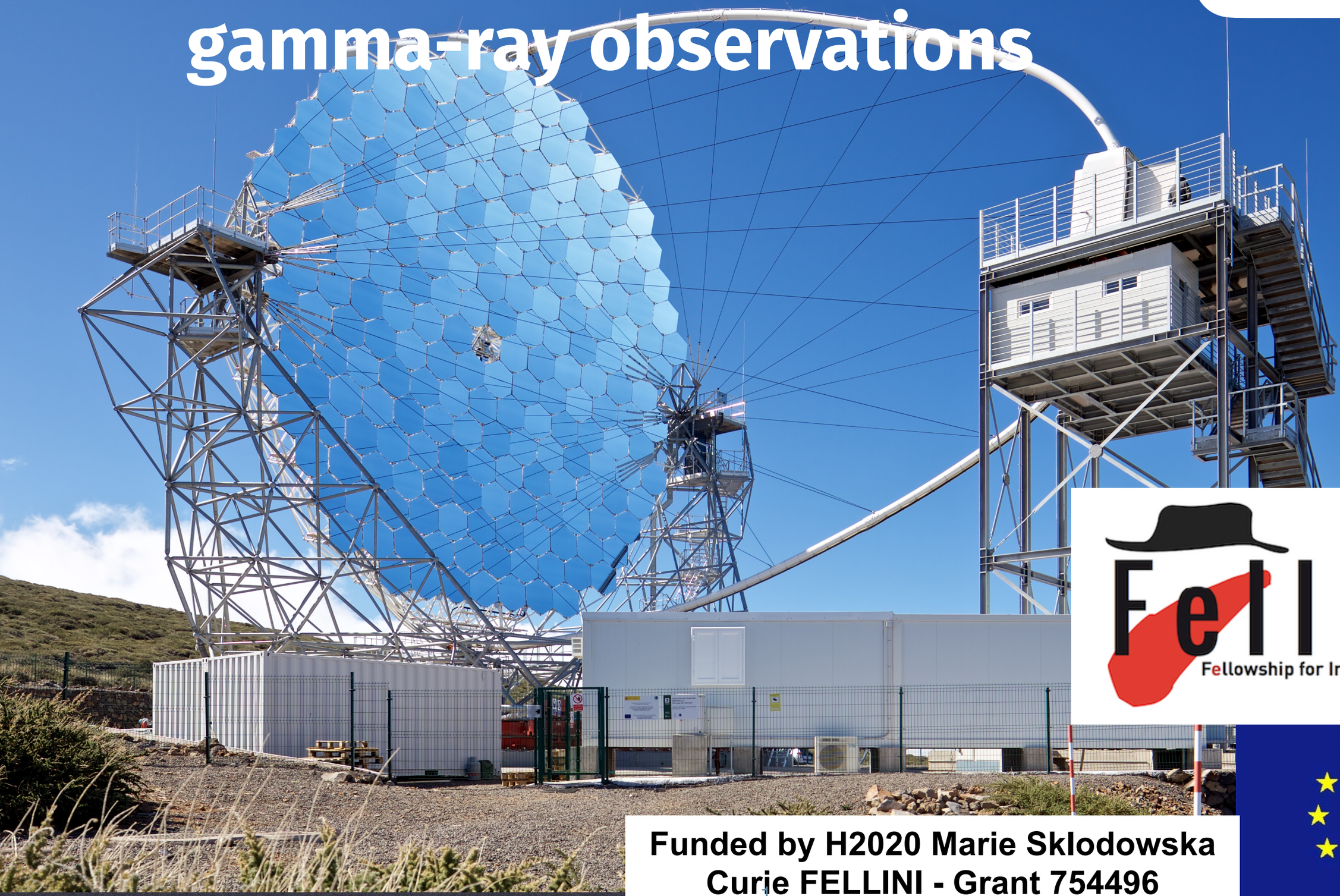
Indirect DM studies using VHE gamma-ray observations



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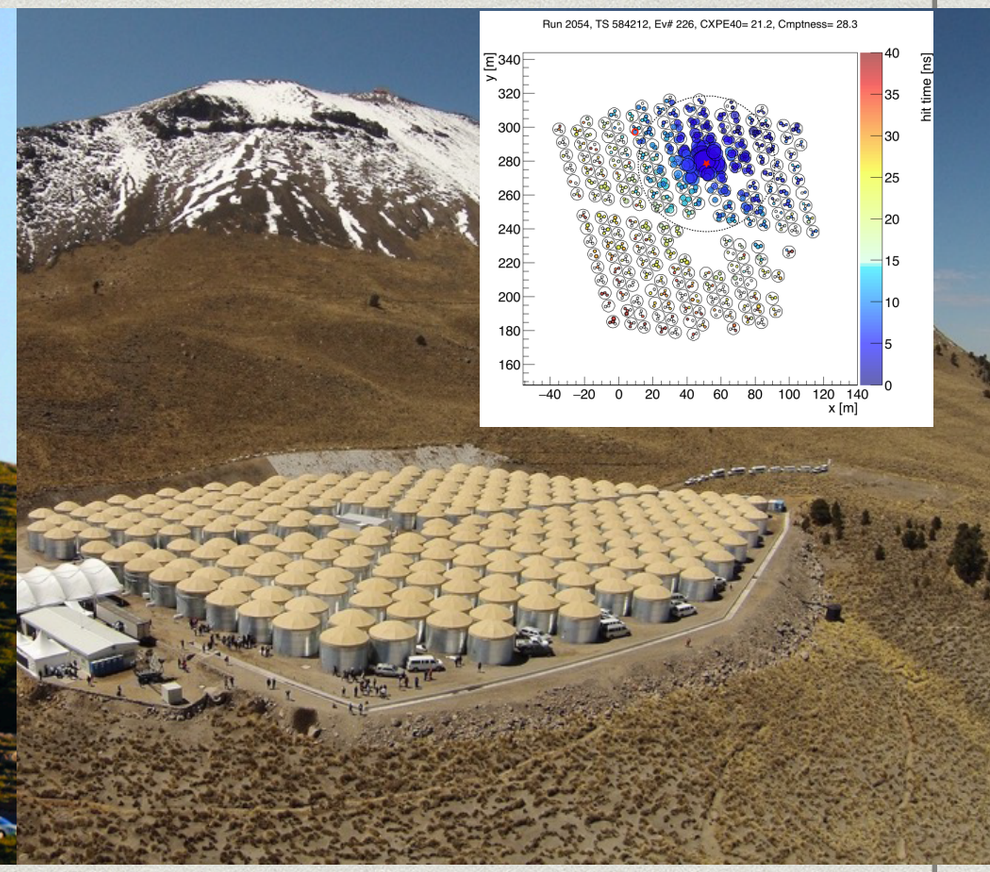
Istituto Nazionale di Fisica Nucleare
Sezione di Padova

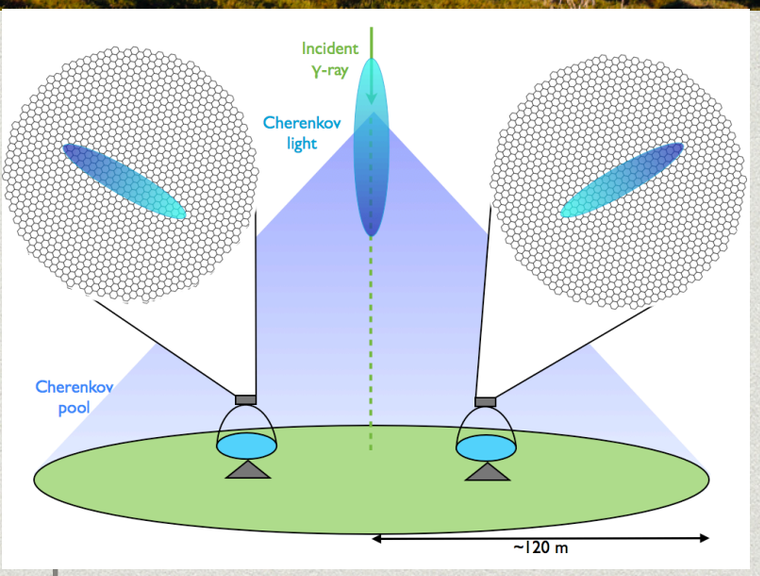
Fellini
Fellowship for Innovation at INFN

Funded by H2020 Marie Sklodowska Curie FELLINI - Grant 754496

Research Field

- Particle acceleration using Very-High-Energy gamma rays

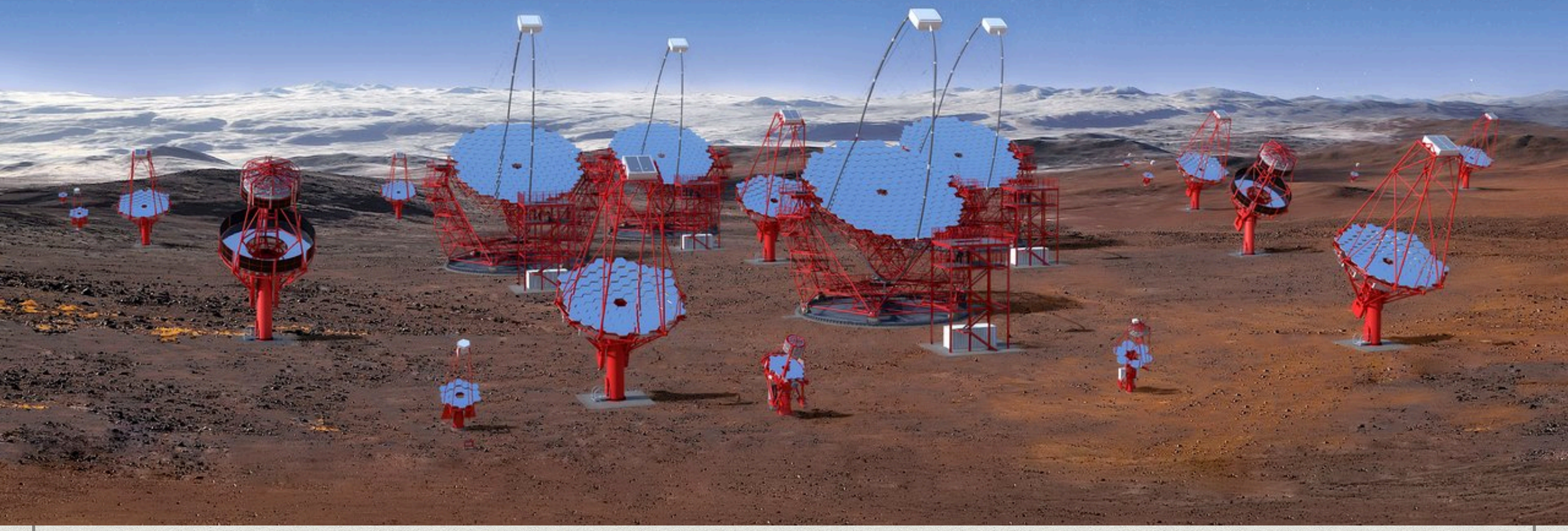




- Two techniques:
  - Imaging Atmospheric Cherenkov Technique (MAGIC, HESS, VERITAS and future CTA)
  - Particle Detection Technique (HAWC, ARGO, LHAASO and future SWGO)

Imaging Atmospheric Cherenkov telescopes

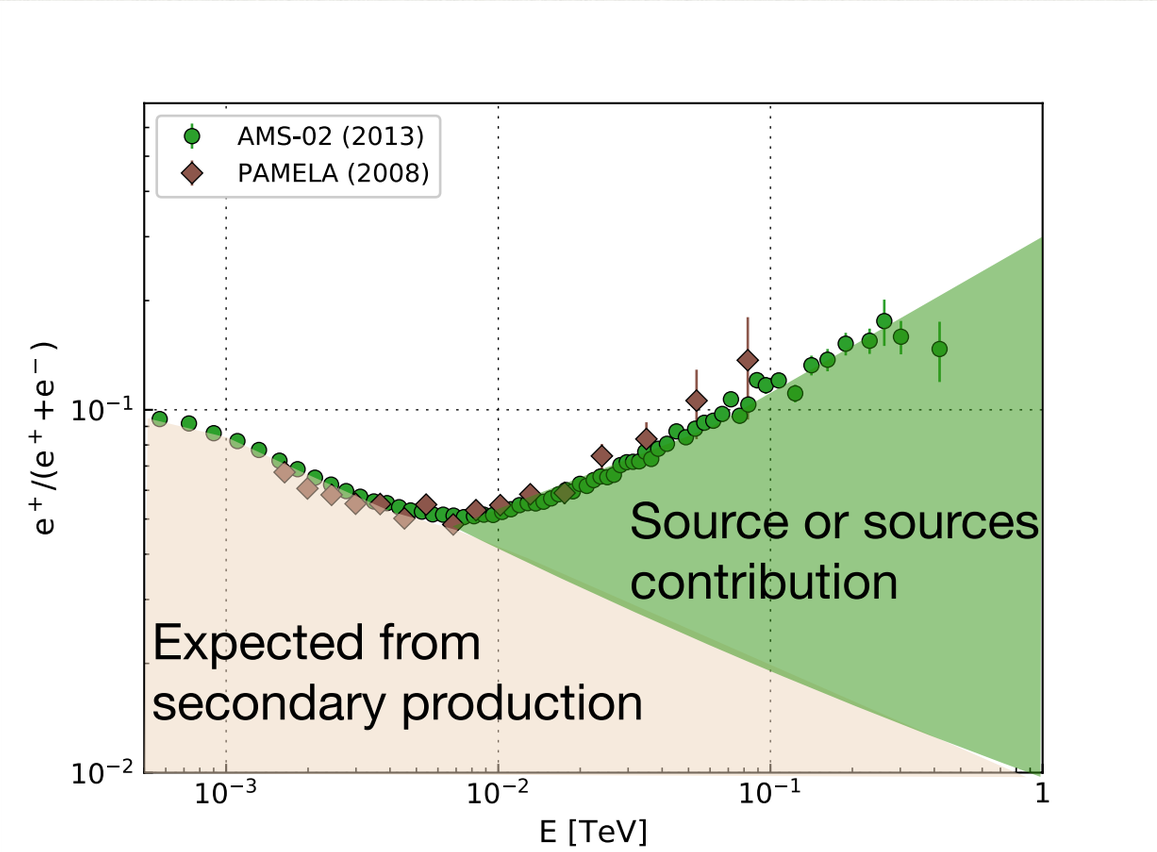
- Energy range: 100 GeV - ~tens of TeV
- Field of View ~ few deg
- Angular resolution ~0.1 deg
- Energy resolution ~15-20%



Water Cherenkov detectors

- Energy range: 1 TeV - ~hundreds of TeV
- Field of View: ~ steradian
- Angular resolution >0.2 deg
- Energy resolution >50%

Study of CR anomalies through VHE gamma-ray observations

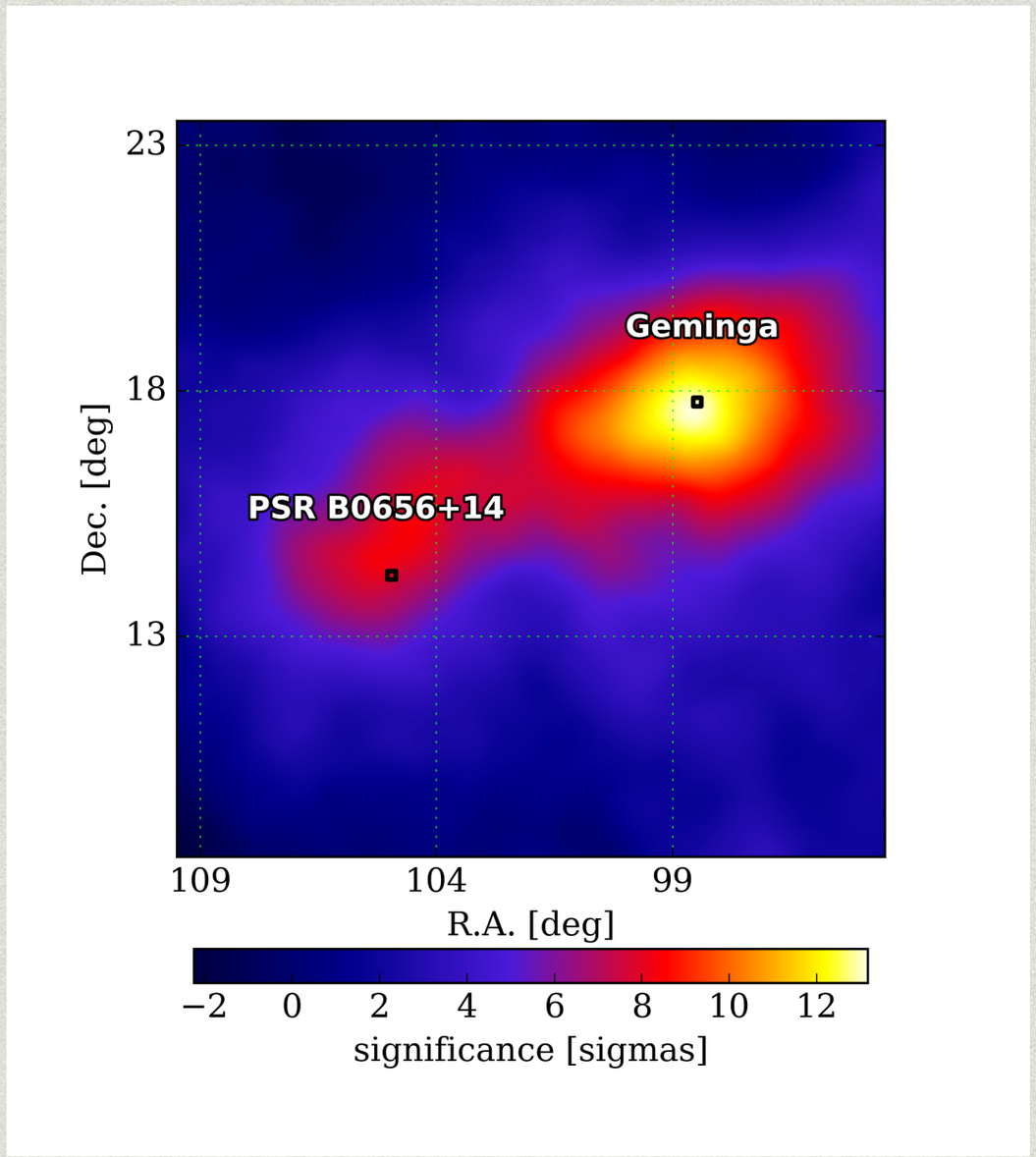


- The positron fraction is expected to decrease with Energy
  - This is the case for energies below a few GeV
- At higher energies the positron fraction increases -> There has to be a source injecting them
- If we take the diffusion coefficient derived from the ratio between secondary to primary cosmic ray species, the highest energy electrons and positrons should come from a nearby source.
- **DM has been proposed as the origin of this excess**, to confirm/rule out this hypothesis, we need to deeply understand the background from cosmic sources.

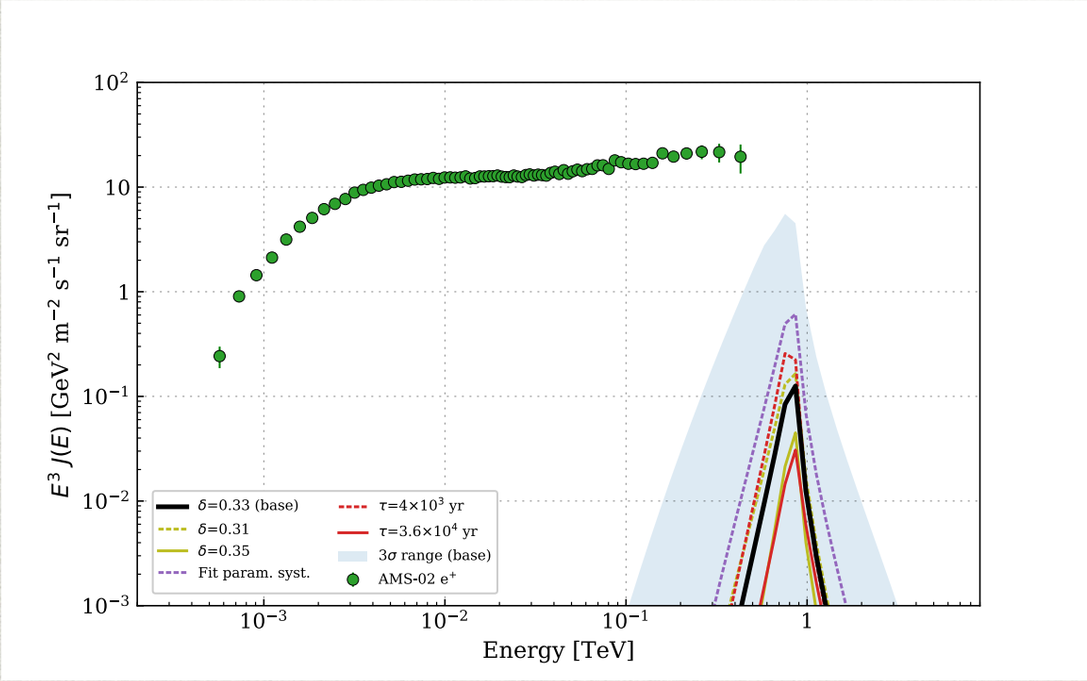
See talk from M. Di Mauro for details about DM searches using Cosmic Rays

Detection of very extended sources

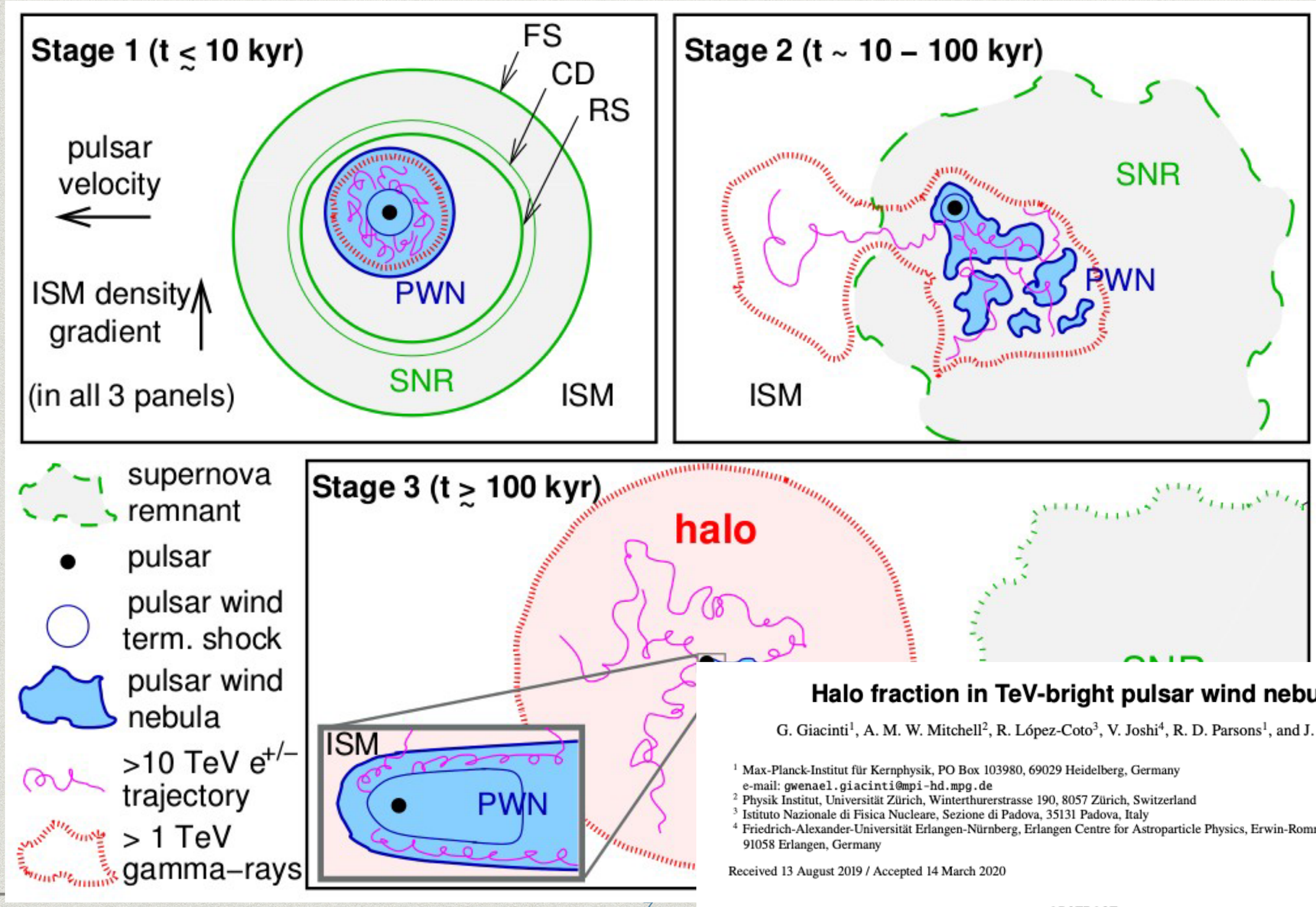
- Detection of two very extended gamma-ray sources coincident with the pulsars Geminga and PSR B0656+14
- We measured the gamma-ray spectrum as a single power-law between 8 and 40 TeV.
- Emission coming from very high energy electrons (~100 TeV) inverse Compton upscattering CMB



HAWC Coll., Science, 358, 911 (2017)



Definition of TeV halos



Halo fraction in TeV-bright pulsar wind nebulae

G. Giacinti[1], A. M. W. Mitchell[2], R. López-Coto[3], V. Joshi[4], R. D. Parsons[1], and J. A. Hinton[1]

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Received 13 August 2019 / Accepted 14 March 2020

International workshop

1st Workshop on Gamma-ray Halos around Pulsars

1-3 December 2020
Europe/Rome timezone

- Overview
- Important Deadlines
- Call for Abstracts
- Timetable
- Contribution List
- Connection details
- My Conference
  - My Contributions
- Registration
- Participant List
- Scientific Organizing Committee
- LOC

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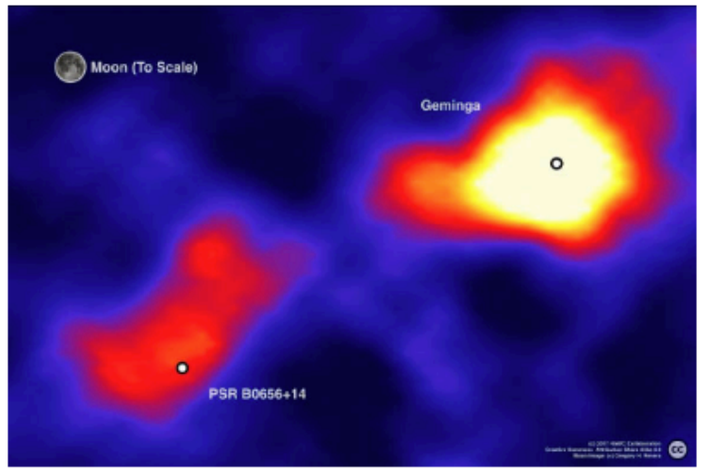
emmadeona@gmail.com



New gamma-ray observations in the GeV and TeV domain have revealed a new class of gamma-ray emission regions: the **gamma-ray halos**. Gamma-ray halos are characterized by regions in which electrons and positrons escape from the Pulsar Wind Nebula and produce a region that is bright in gamma rays. In this Workshop, we aim to discuss the latest results from GeV and TeV instruments, their implications in the current propagation theories and the prospects for future observations. Image credit: John Pretz.

Starts 1 Dec 2020, 09:00
Ends 3 Dec 2020, 13:15
Europe/Rome

Online

Emma de Ona Wilhelmi
Ruben Lopez Coto

There are no materials yet.

More than 180 participants

- Warm welcome from the community

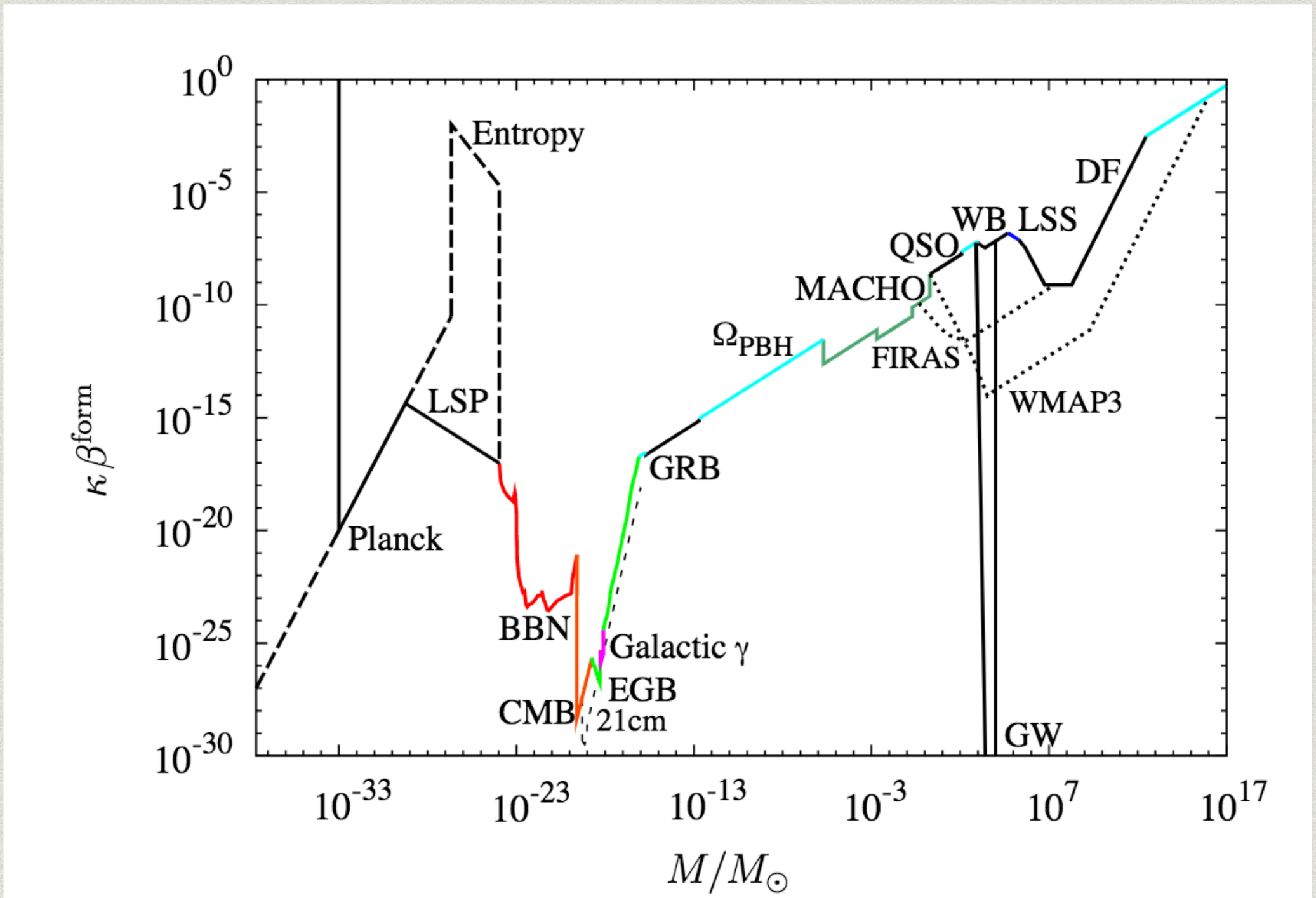
Need to understand these sources to evaluate what is the background for the indirect detection of DM

Primordial Black Holes Definition

For more info, see talks by G. Domenech and M. Leyton

- What are Primordial Black Holes (PBHs)?
  - Predicted by S. Hawking in 1971.
  - Black Holes that were originated in a radiation dominated era.
  - They do not count for the total baryonic mass of the Universe.
  - Their masses can range from the Planck scale up to supermassive BHs.
  - PBH search regained interest after the detection of Gravitational Waves, being proposed as **possible contributors for DM**

Current limits



Limits for evaporation ~now

- Evaporation limits for PBHs evaporating *now*
  - PBHs of mass ~10^{14} g, generated in the Big Bang, should be evaporating ~now $\tau \sim \frac{G^2 M^3}{\hbar c^4}$
  - The Extragalactic Gamma-ray Background (E~100 MeV) gives very good ***Cosmological*** constrains on PBH evaporation [Burst Density < 10^{-6} pc^{-3} yr^{-1}]
  - On **Galactic** scales, clusters of PBHs should produce an anisotropy in the Gamma-ray measurements (E~100 MeV) [Burst Density < 0.42 pc^{-3} yr^{-1}]
  - On **kiloparsec** scales, the antiproton background can be used to derive limits [Burst Density < 10^{-3} pc^{-3} yr^{-1}]

Serendipitous events

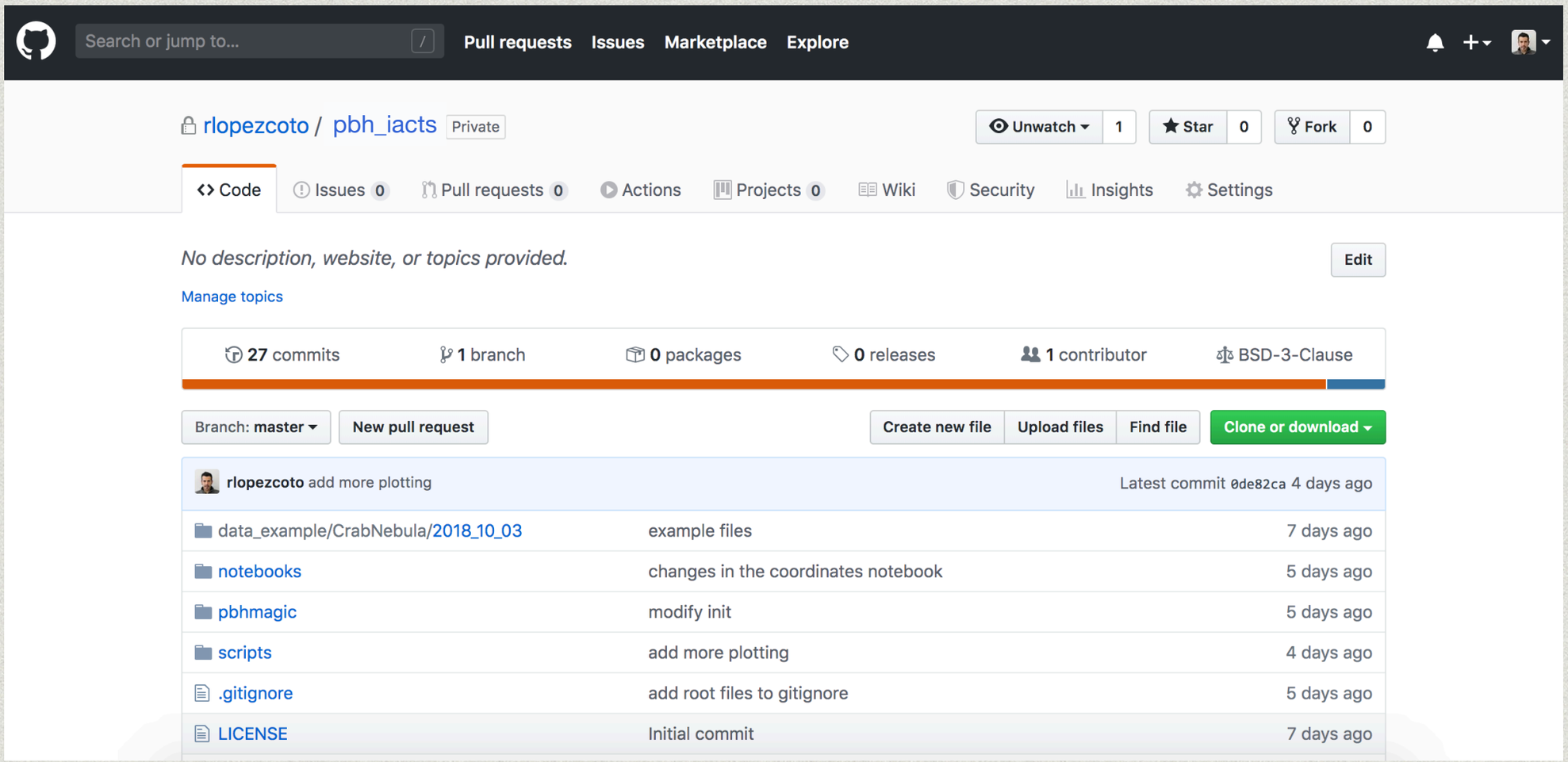
- VHE gamma-ray experiments have sensitivity to detect single events occurring at ~parsec distances

- Wide FoV detectors (Milagro/HAWC/SWGO)
  - Thanks to their large FoV and exposures, cover a large *Volume* and therefore can establish the best limits nowadays

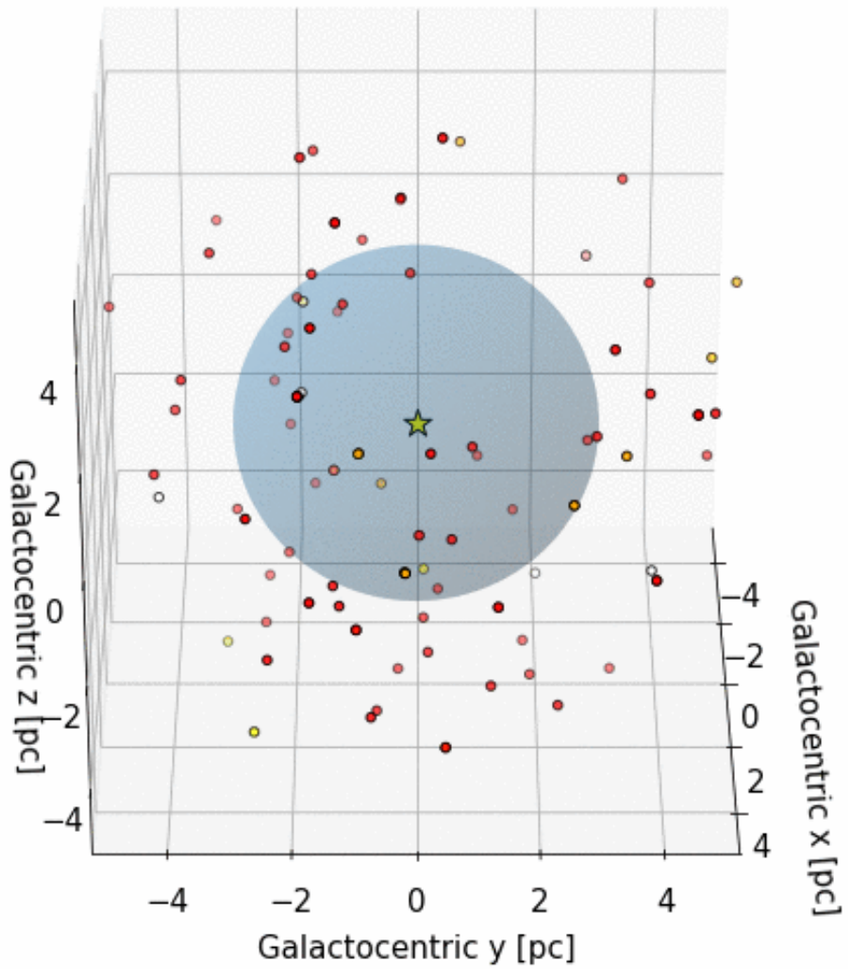
- IACTs (MAGIC/HESS/VERITAS)
  - Thanks to their very good background rejection and the low expected signal, they are able to have the longest *reach.*

Open source code for PBH search

- **pbh_iacts:** Public code for burst search already in place. Entirely written in python, only reading high level files.
- In the era of Open-Source software/science, it is essential to provide open-source tools to make analysis reproducible.



Limits foreseen



*** 1 pc ~ 3 light-years**

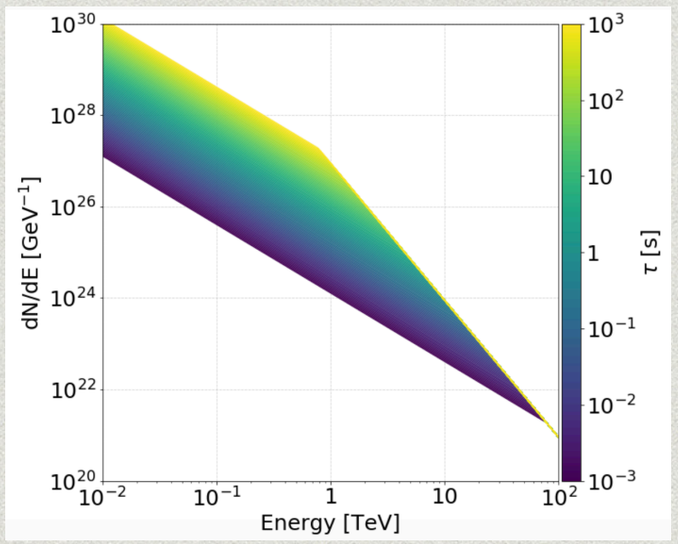
Estimations with SWGO

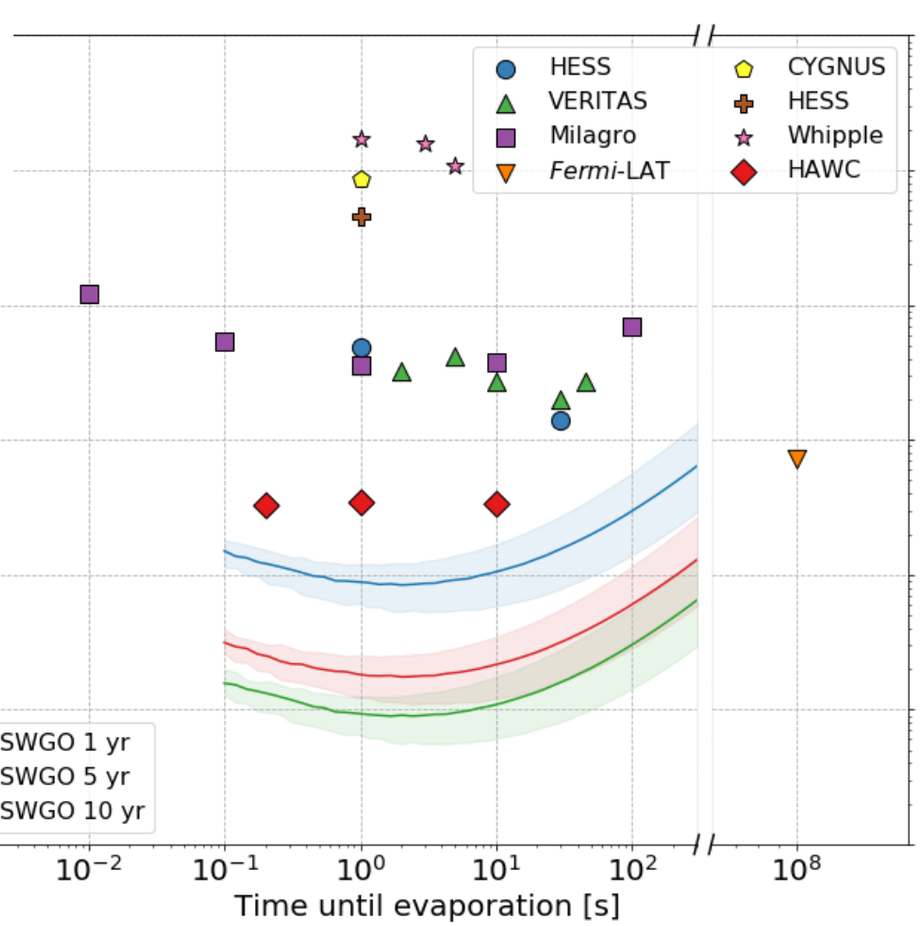
Prospects for the Observation of Primordial Black Hole evaporation with the Southern Wide Field of View Gamma-ray Observatory

R. López-Coto[a] M. Doro[a,b] A. de Angelis[a,b] M. Mariotti[a,b] J. P. Harding[c]

[a]Istituto Nazionale di Fisica Nucleare, Sezione di Padova, I-35131, Padova, Italy.
[b]Università di Padova, Dipartimento di Fisica, I-35131, Padova, Italy.
[c]Los Alamos National Laboratory, Los Alamos, USA.

E-mail: rlopez@pd.infn.it

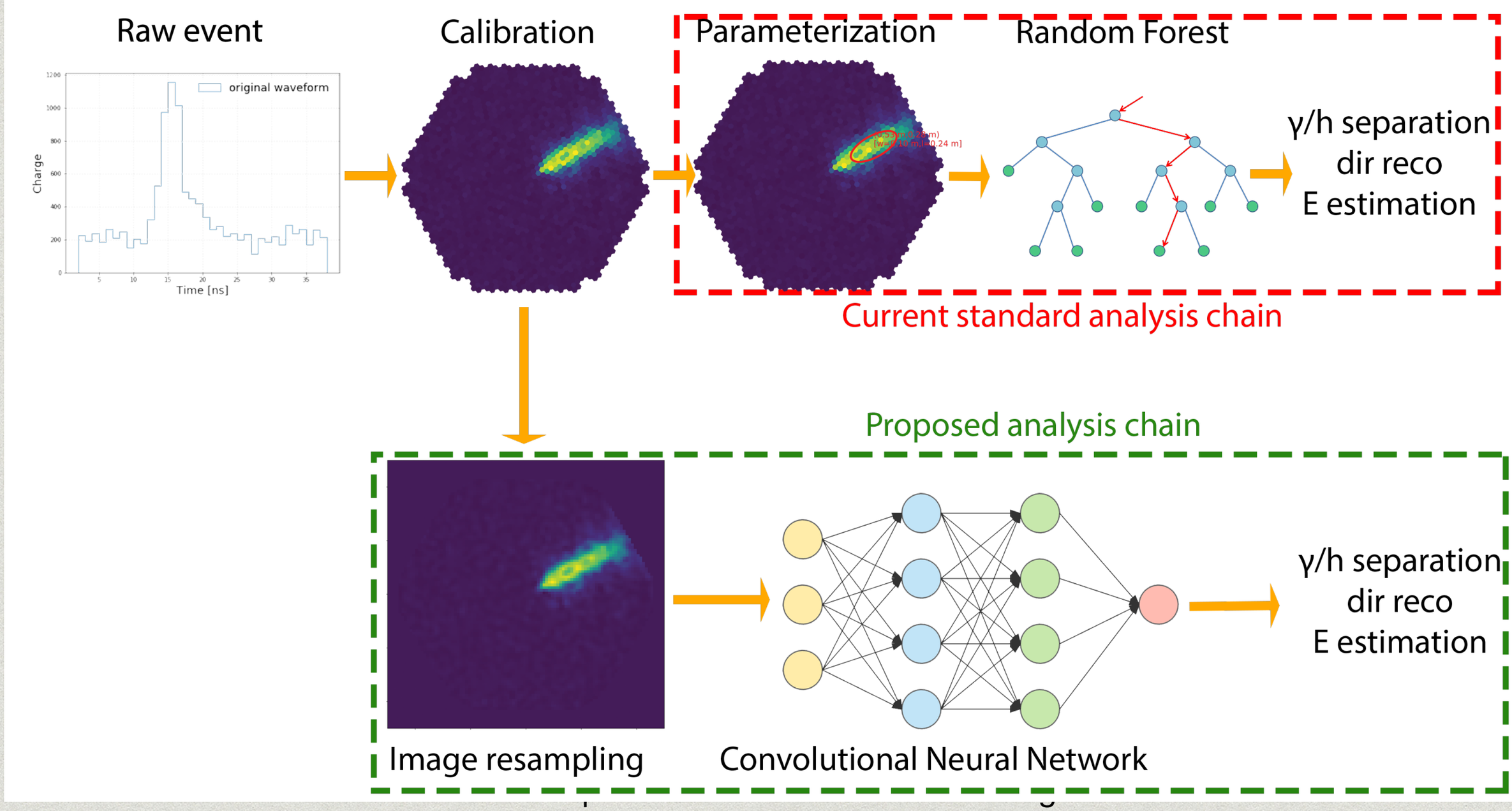




Large Sized Telescope (LST)

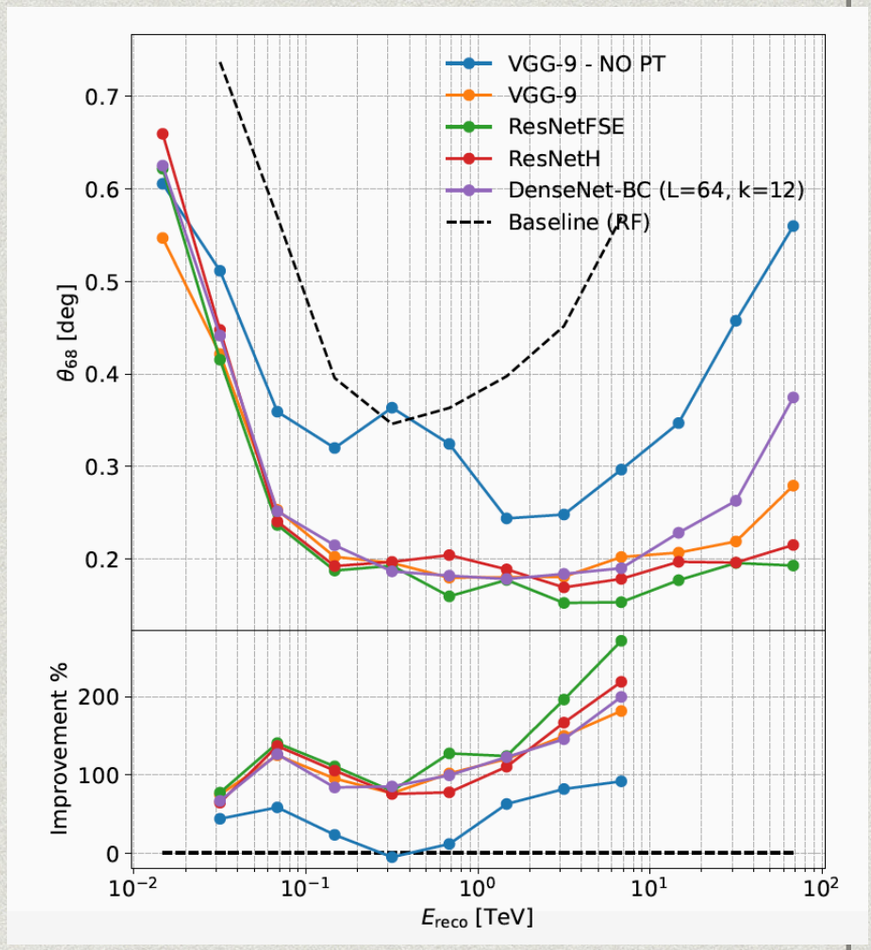
- Largest telescope of the Cherenkov Telescope Array
  - 23 meter diameter. Fast movement to catch transient phenomena.
  - First prototype already in place in La Palma. Currently under commissioning.
  - Reaches the lowest energy threshold from ground-based instruments -> largest energy range.
  - 4 in each hemisphere. LST 2, 3 and 4 already being constructed in la Palma.
  - Important INFN contribution.
  - Leadership role in the construction and commissioning as **Analysis Software Coordinator of the LST**

Convolutional Neural Networks on IACTs

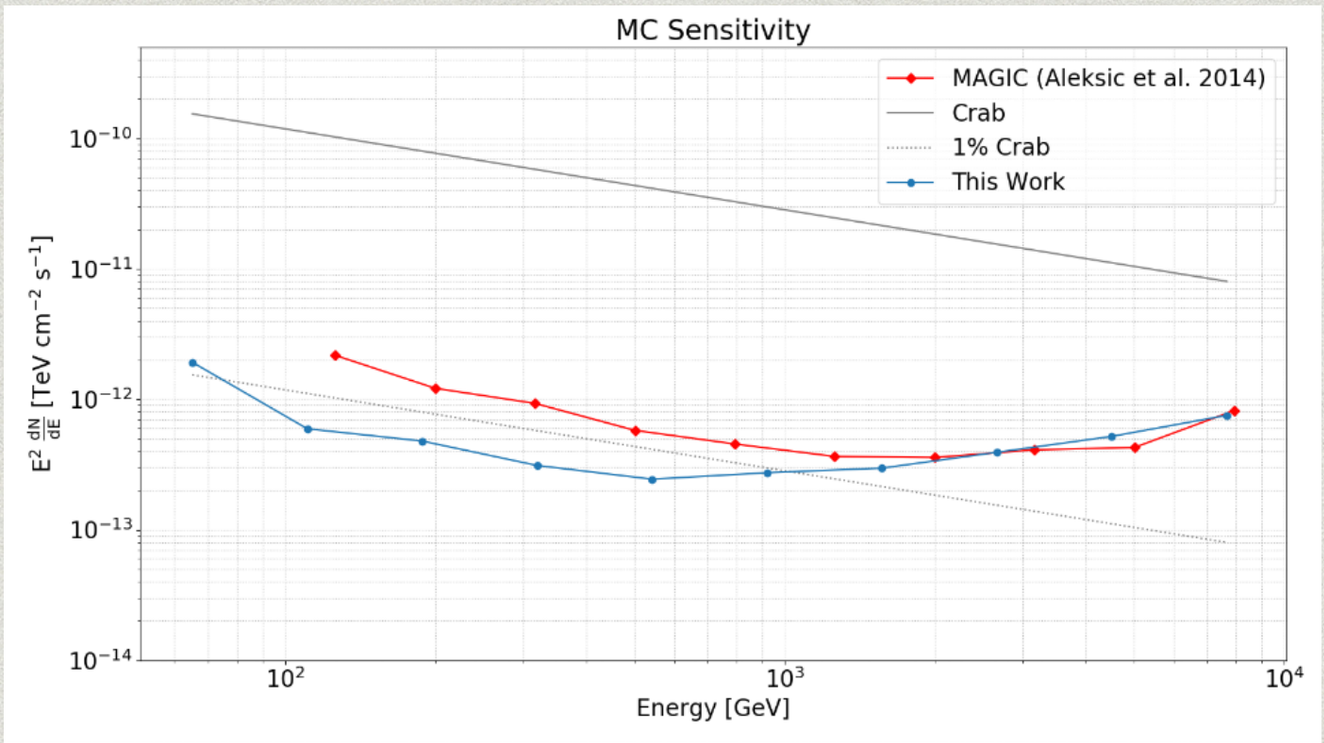


Preliminary results

- LST first results on MC simulations
  - Significant improvement in angular and energy reconstruction with respect to the algorithms currently in use



- Testbench using MAGIC real data



Communication

- LST First astronomical light
  - led by the FELLINI project

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RE ESPERIMENTI PROGETTI COMUNICAZIONE OPPO

13 DICEMBRE 2019

LA PRIMA SORGENTE GAMMA DI LST-1

LST-1, il primo grande telescopio del Cherenkov Telescope Array, ha rivelato la sua prima sorgente gamma puntando la famosa Nebulosa del Granchio, considerata dai cosmologi la "candela standard" dell'astrofisica delle alte energie. LST-1 è stato inaugurato nell'ottobre 2018 ed ha rilevato la sua "prima luce" la sera del 14-15 dicembre 2018, ma questa è la prima rilevazione da una reale sorgente a raggi gamma ottenuta Il 23 novembre. Già dalle prime analisi dei dati raccolti è stato possibile evidenziare un chiaro segnale di fotoni di alta energia provenienti dalla sorgente.

"Dopo aver sviluppato e raffinato gli strumenti di analisi per più di un anr su simulazioni Monte Carlo è stato molto emozionante vedere il primo segnale "reale" confermare la bontà di un lungo lavoro di squadra" ha commentato Rubén Lopez-Coto, ricercatore della sezione INFN di Padova

"Questo importante risultato ha confermato che lo strumento e la catena di analisi, a cui l'INFN ha contribuito in maniera significativa, funzionano correttamente e siamo pronti ad ottenere i primi risultati scientifici", ha sottolineato Federico Di Pierro, ricercatore dell'INFN

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International

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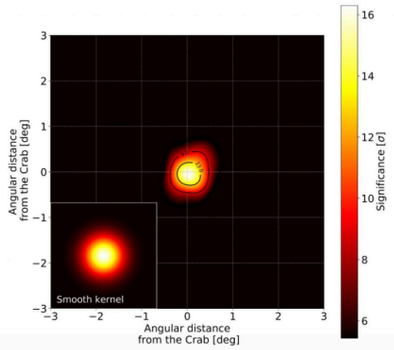
cta cherenkov telescope array

Announcement

The LST-1 Detects its First Gamma-Ray Signal

In its first attempt to detect a gamma-ray source, the Large-Sized Telescope prototype (LST-1) successfully detected its first gamma-ray signal on 23 November 2019 when it pointed to the Crab Nebula, which is considered the standard candle in very high-energy astronomy. Preliminary analyses show a very clear detection of a gamma-ray signal coming from the source, reassuring the team's expectations that the telescope is performing as designed. These results are being discussed at the LST General Meeting that is taking place this week in Marseille, France. Right: the two-dimensional excess map of the gamma-ray excess from the direction of the Crab Nebula at an exposure of 269 min. (Credit: Rubén López-Coto, LST Collaboration)



Local

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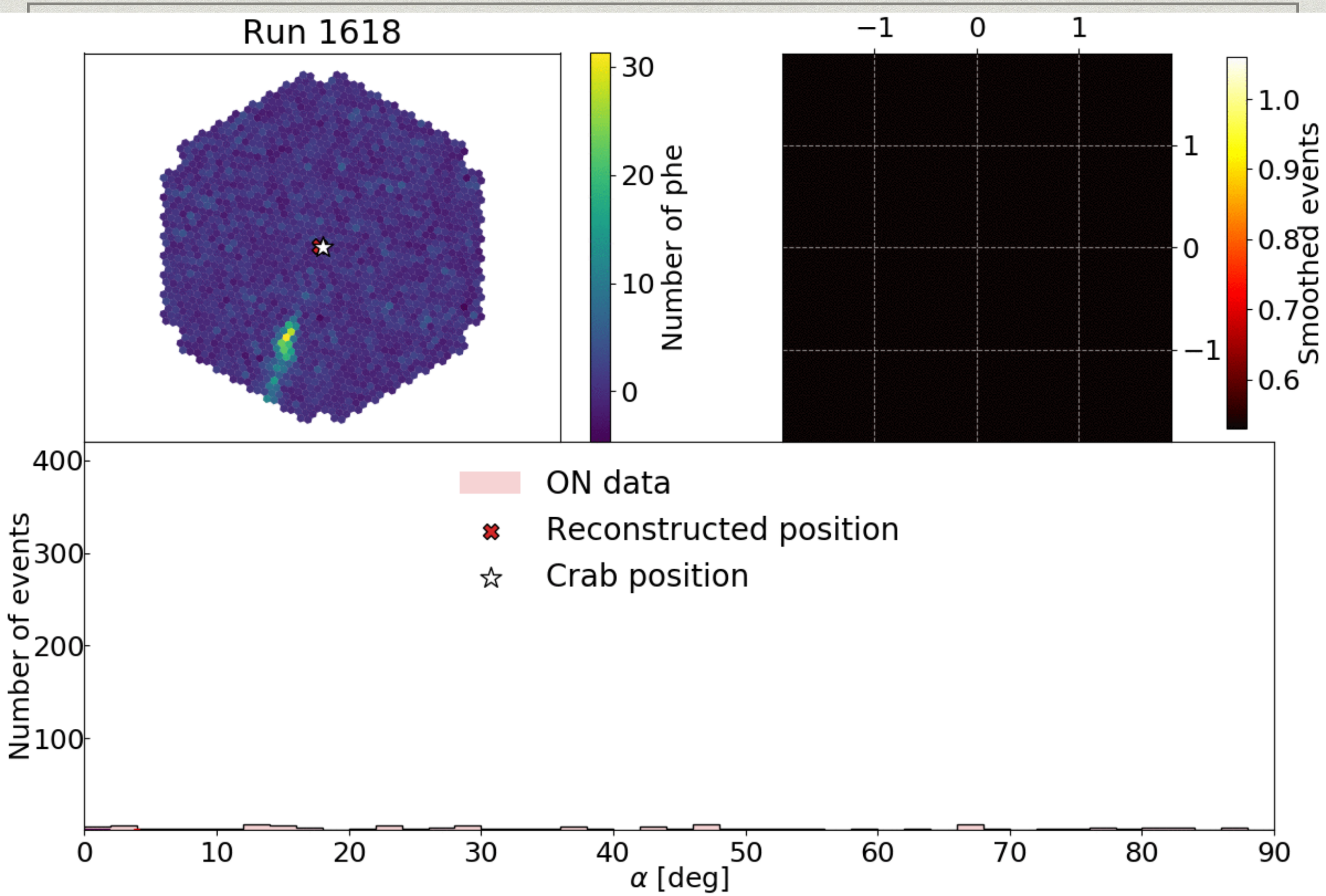
o dei quattro telescopi di grandi dimensioni (Large Size Telescopes), che saranno presenti in ciascuno dei due siti osservati ciascun emisfero, sull'isola di La Palma (Canarie, Spagna) e nei pressi del sito ESO del Paranal in Cile. I telescopi LST amentali per rivelare i raggi gamma tra 20 e 200 GeV e grazie anche

45 metri e pesi circa 100 tonnellate, è estremamente agile, avendo la poss rsi in 20 secondi per catturare segnali gamma da eventi transienti. La possi ento rapido e la bassa soglia in energia dei grandi telescopi LST sono e fondamentali per lo studio di sorgenti di raggi gamma transienti galattiche ma anche per lo ei galattici attivi e lampi di raggi gamma (GRB – gamma-ray bursts) in galassie molto lontane. el grande telesocopio LST-1 dovrebbe diventare il primo telescopio di CTA una volta competata la ica del progetto che decreta lo strumento "formalmente accettato" dall'Osservatorio CTAO

taliano a LST è significativo ed articolato. Il Gruppo di Padova (INFN e Dipartimento di Fisica e ha contribuito alla progettazione concettuale del telescopio LST in particolare nella messa a egno ottico e della superficie riflettente con il Prof. Mosè Mariotti e il prof. Michele Doro del di Fisica ed Astronomia dell'Università di Padova insieme al gruppo del Max Plank Institute di

zione del primo telescopio Padova ha costruito parte della meccanica di movimentazione azimutale (carrelli), le funi in fibra di carbonio per il sostegno e l'ancoraggio dell'arco che supporta la camera. Ha anche dato (e sta dando tuttora) un forte contributo alla realizzazione del software e alle strategie di analisi dati, è padovano infatti il coordinatore del software di analisi dati di LST: Dr. Rubén Lopez-Coto, ricercatore del progetto "Fellini" della Sezione INFN di Padova (Marie Skłodowska-Curie grant n. 754496).


Run 1618
Number of phe
30
20
10
0
−1
0
1
Smoothed events
1.0
0.9
0.8
0.7
0.6
ON data
Reconstructed position
Crab position
Number of events
400
300
200
100
0
10
20
30
40
50
60
70
80
90
α [deg]

Crab pulsar

- INFN contribution highlighted in the Press Coverage thanks to Deep involvement in data analysis

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22 GIUGNO 2020

IL PRIMO TELESCOPIO DI CTA RIVELA FOTONI GAMMA DALLA PULSAR DEL GRANCHIO

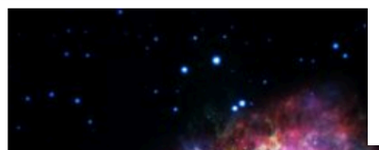
L'osservazione di un'emissione pulsata di fotoni di alta energia provenienti dalla nebulosa del Granchio conferma le enormi potenzialità di LST-1 (Large Size Telescope), il primo dei quattro telescopi Cherenkov di grandi dimensioni (23 metri di diametro) che, insieme a una decina di telescopi medi (12 m di diametro), andranno a comporre la schiera di rivelatori del sito nord del Cherenkov Telescope Array (CTA), l'osservatorio terrestre di prossima generazione per l'astronomia dei raggi gamma a energie molto elevate. Al progetto collaborano per l'Italia l'INFN e l'INAF Istituto Nazionale di Astrofisica. Già pochi giorni dopo l'installazione della camera a fotomoltiplicatori, lo scorso novembre LST-1

CTA Prototype LST-1 Detects Very High-Energy Emission from the Crab Pulsar

International

22 June 2020

Between January and February 2020, the prototype Large-Sized Telescope (LST), the LST-1, observed the Crab Pulsar, the neutron star at the centre of the Crab Nebula. The telescope, which is being commissioned on the CTA-North site on the island of La Palma in the Canary Islands, was conducting engineering runs to verify the



INFN PADOVA

HOME LA SEZIONE RICERCA DIVULGAZ

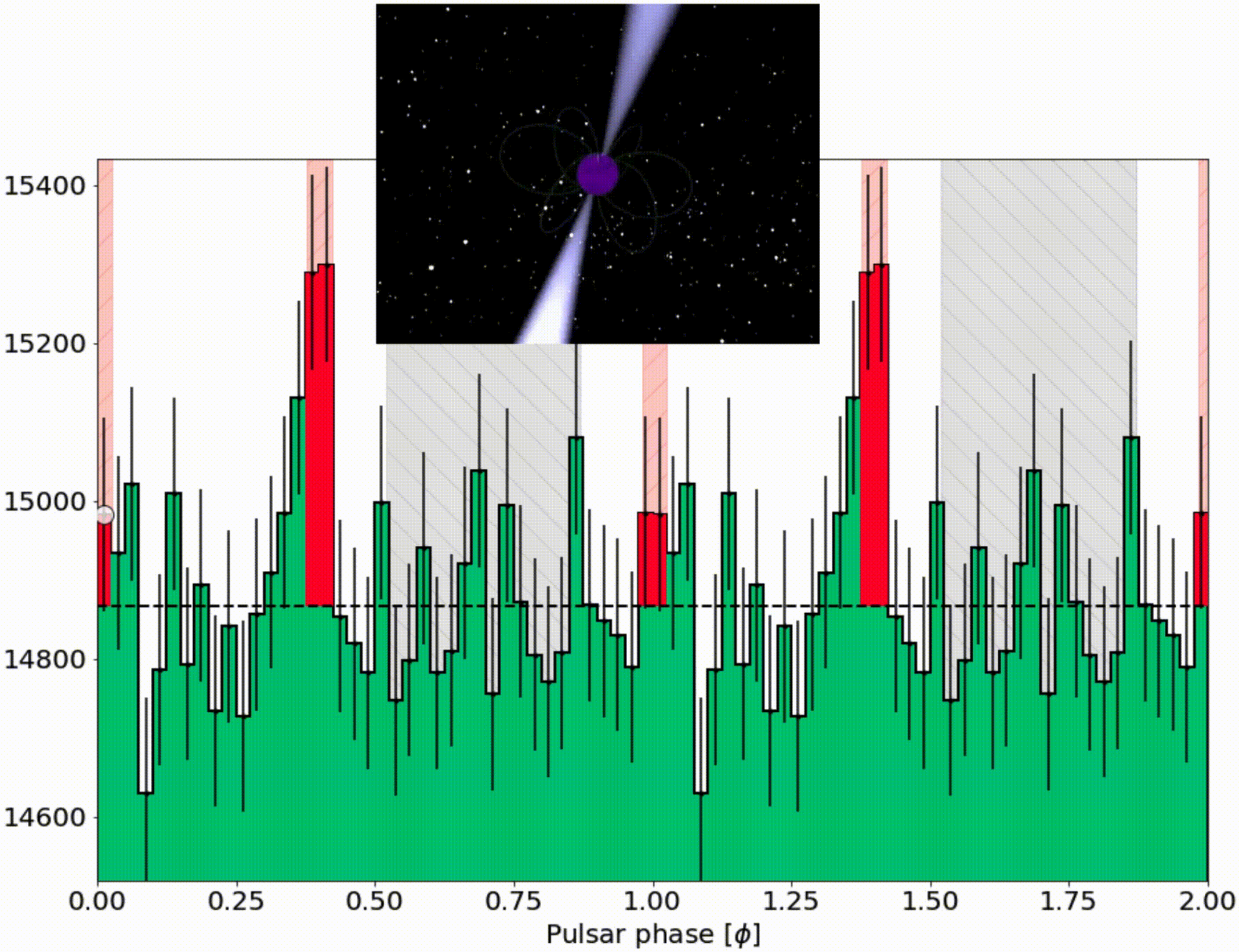
22 GIUGNO 2020

LST-1, il prototipo del primo telescopio di CTA, rivela emissione gamma di alta energia da parte della Pulsar del Granchio

Local

0

La Palma, Isole Canarie, Spagna – Tra gennaio e febbraio 2020, il prototipo del Large Sized Telescope di CTA, LST-1, ha osservato la pulsar del Granchio, la stella di neutroni al centro della nebulosa del Granchio (Figura 1). Il telescopio è nella fase di messa a punto nel sito CTA-Nord sull'isola di La Palma, nelle Isole Canarie.


15400
15200
15000
14800
14600
Events
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
Pulsar phase [ϕ]