The
Cherenkov Cosmic Gamma Ray group
@ICRR

Moritz Hütten on behalf of the group members

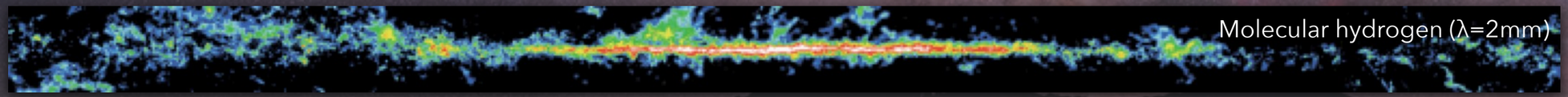
ICRR young researchers' workshop

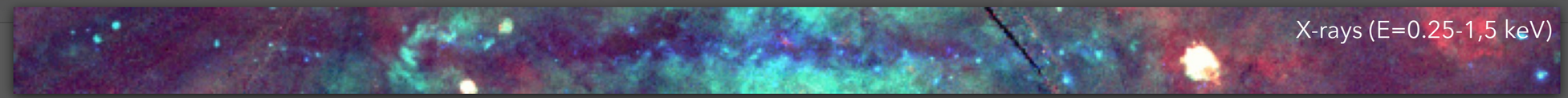
online, 5.11.2020

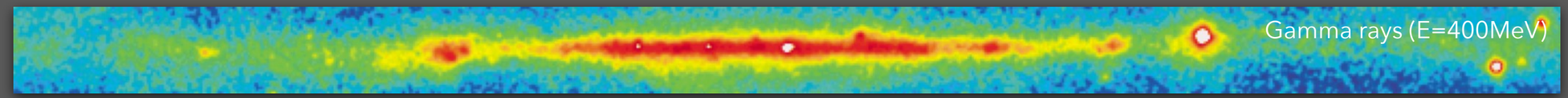
Picture: D. López

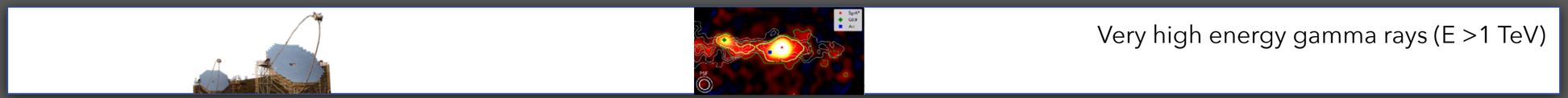
What do we do?

Observe the sky at the highest photon energies









Who are we?







1 professor

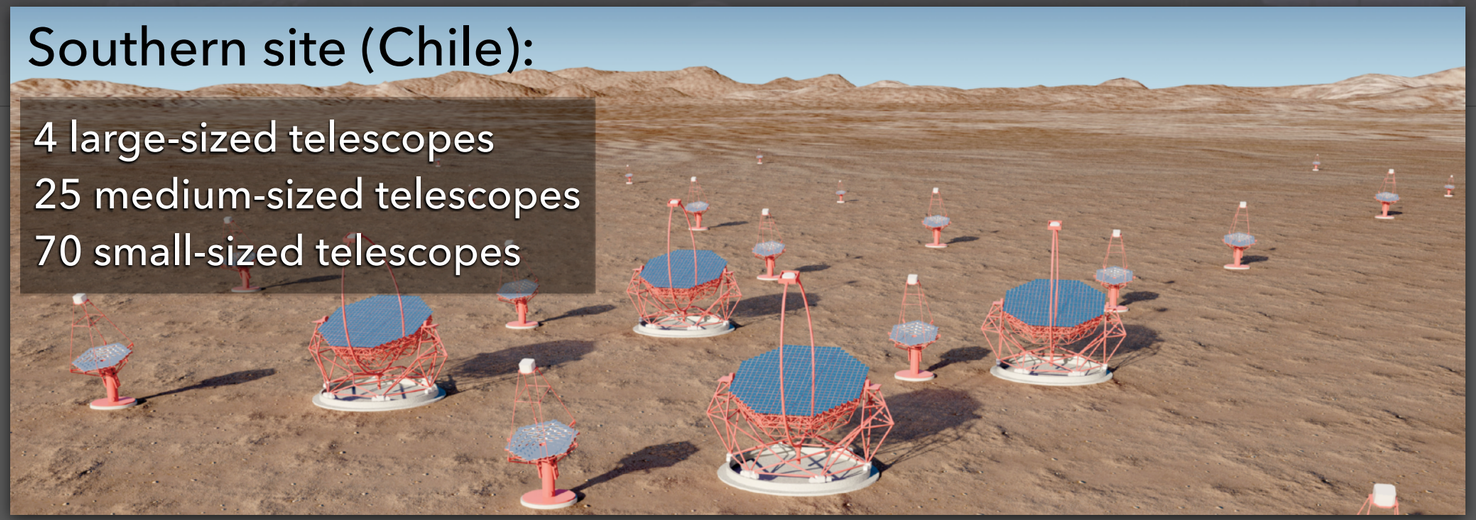
4 assistant professors | 3 associate professors | 2 guest professors

5 researchers | 3 engineers

4 PhD students | 5 Master students

1 secretary

The Cherenkov Telescope Array



The largest Cherenkov observatory every built:

- Two sites
- Over 100 telescopes
- About 1500 scientists and engineers
- About 200 institutes
- 31 countries

The Large-Sized Telescope(s): CTA-LST

- Covers the lower energy range of CTA
- Stereoscopic system of 4 IACTs to be constructed on both in North and South
- On La Palma: First LST (“LST-1”) under commissioning since 2018
- LST 2-4 are under way

Big contribution of Japan and ICRR group

- Mirror diameter: 23 m
- Camera field of view: 4.3°
- Energy range: 20 GeV – several TeV

The MAGIC telescopes

System of two **M**ajor **A**tmospheric **G**amma-ray **I**maging **C**herenkov telescopes

In operation for 18 years (12 years in stereo)

LST-1 (CTA)

MAGIC-2

LIDAR system

MAGIC-1

Picture: L. Heckmann

The MAGIC telescopes

- Mirror diameter: 17 m
- Camera field of view: 3.5°
- Energy range: 30 GeV – 50 TeV (Low zenith ~20°)
- Energy resolution: 15% – 25%
- Angular resolution: 0.05° – 0.10°

LST-1 (CTA)

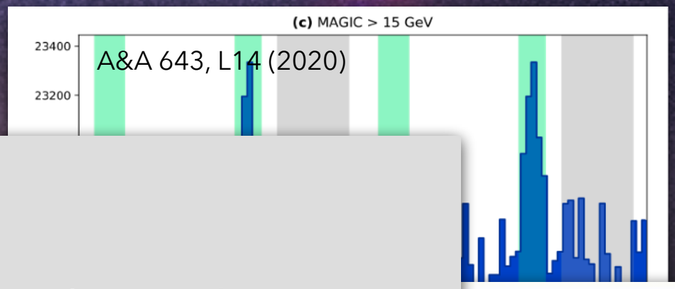
MAGIC-2

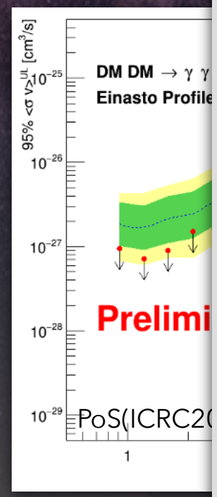
LIDAR system

MAGIC-1

Picture: L. Heckmann

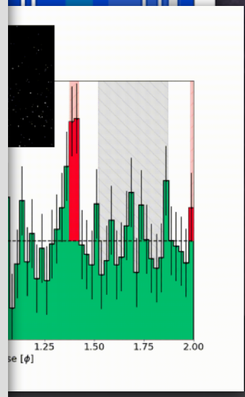
Diverse science with MAGIC and CTA



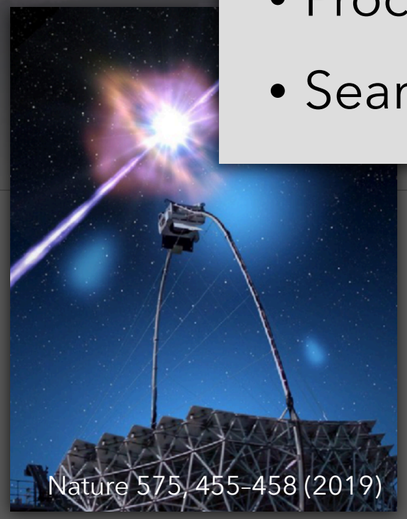


Theory questions of our observations:

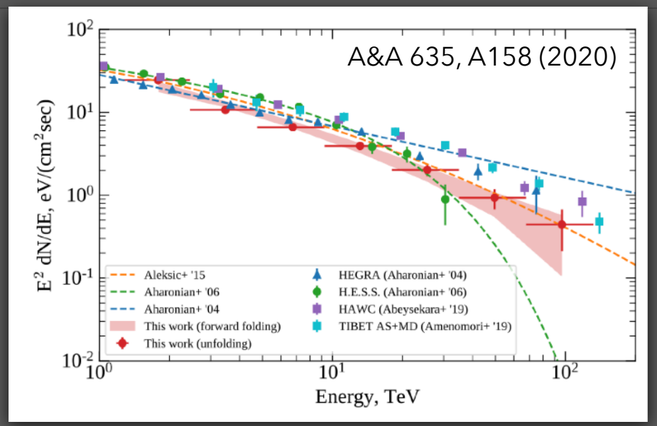
- Particle acceleration and physical processes in extreme astrophysical environments
- What is the origin of the cosmic rays, how are they produced?
- Particle interaction at the highest energies
- Processes behind gamma-ray bursts
- Search for signs for beyond-the-Standard-Model physics



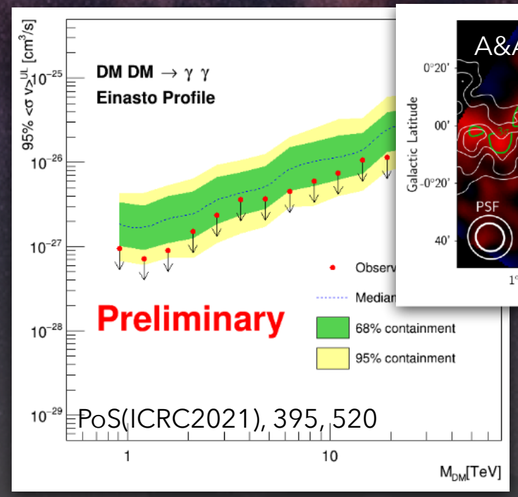
ssion from
o 100 TeV

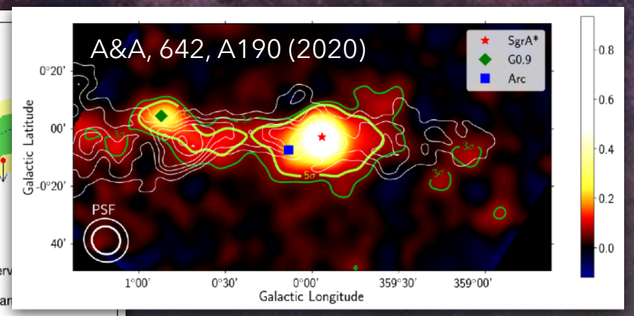

Nature 575, 455–458 (2019)

- Extragalactic: AGN, IGMFs, EBL,…
- Galactic: Pulsars, binaries, Galactic centre,…
- Transients: GRBs, neutrino follow ups,…
- Fundamental Physics: Dark Matter, LIV,…



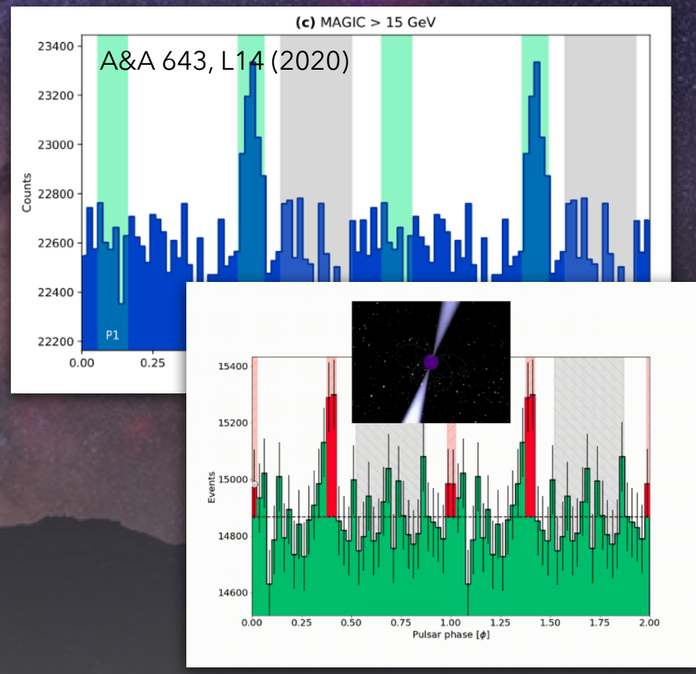
Diverse science with MAGIC and CTA

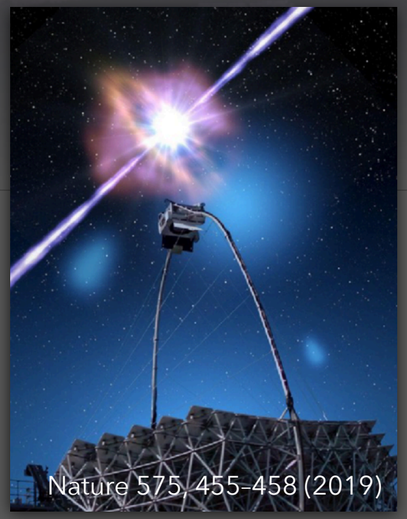




Study of the Galactic centre and search for Dark Matter

LST1 detection of the Crab Pulsar and MAGIC detection of the Geminga pulsar above 15 GeV

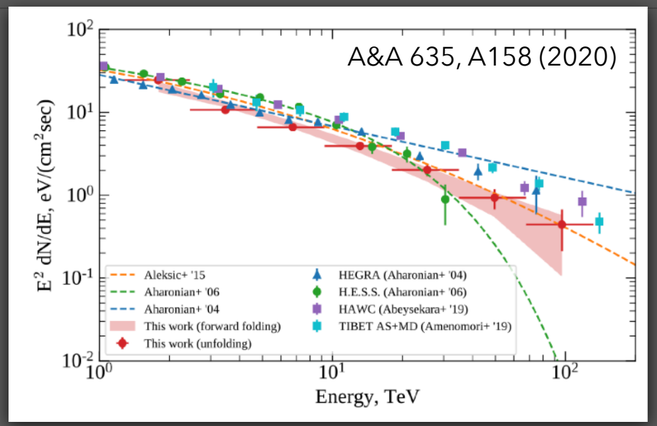




First ever detection of TeV emission from a Gammar-Ray Burst (GRB 190114C) by MAGIC

- Extragalactic: AGN, IGMFs, EBL,…
- Galactic: Pulsars, binaries, Galactic centre,…
- Transients: GRBs, neutrino follow ups,…
- Fundamental Physics: Dark Matter, LIV,…

MAGIC detection of emission from the Crab Nebula up to 100 TeV

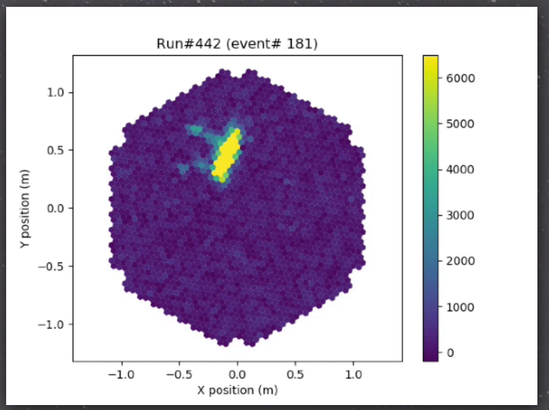


Diverse science with MAGIC and CTA

+ leading involvement in LST-1 construction and commissioning

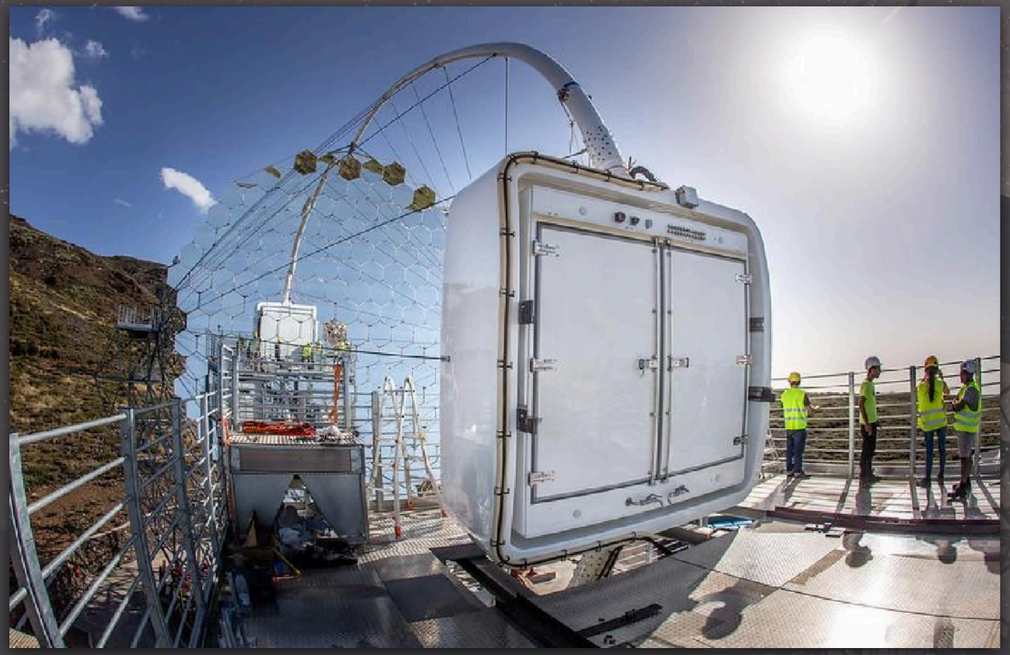
LST activities: camera

Goal: record nanosecond signals from air showers with high efficiency



Quick facts:

- 1855 pixels in 265 modules
- 42% peak QE
- 1 GHz sampling rate
- 10 KHz data acquisition rate
- 4.3 deg FoV



Our group activities:

- big contribution to camera construction
- daily check to monitor PMT camera condition.
- automatic detection of anomalous events
- calibration of the camera pixels signals
- refinement of the MC description

LST activities: active mirror control

Goal: focus light onto the camera + compensate structure deformations

Quick facts:

- 198 mirrors in 16 groups
- ~400 actuators (wireless connection)
- ~200 CMOS cameras
- dedicated PSF camera

Our group activities:

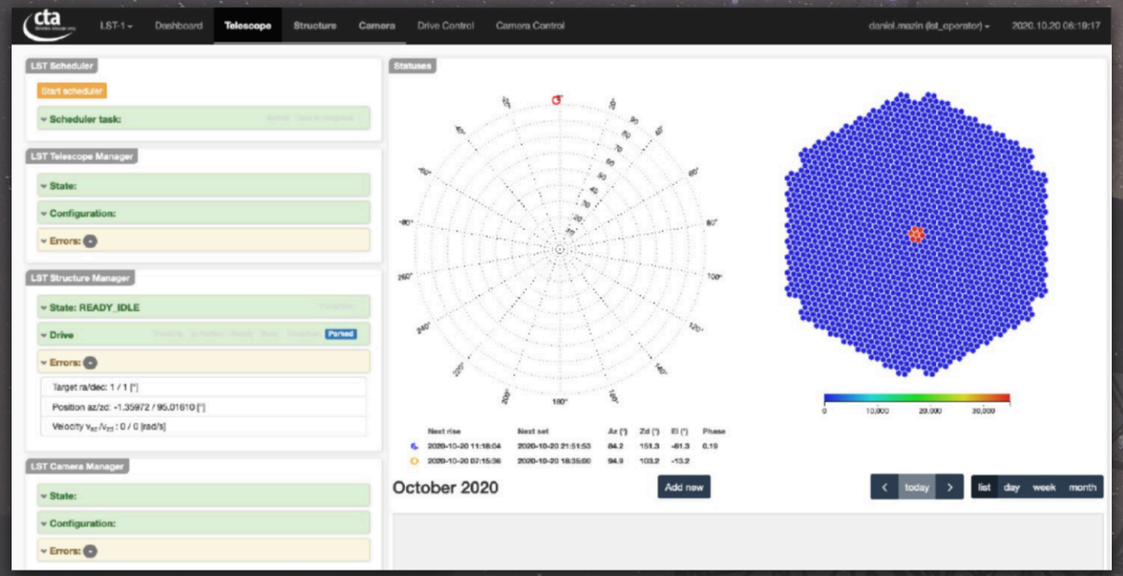
- we are the main responsible for AMC
- development of the mirrors and AMC hardware
- software control and automatization
- monitoring and logging
- remote and on-site maintenance
- fine-tuning for optimal performance

LST activities: telescope control

Goal: control all telescope subsystem from a unified graphic user interface

Quick facts:

- aimed at remote operation
- central control server
- web-based interface
- multi-level access protection



Our group activities:

- are one of the developers of the telescope control software
- camera control integration
- AMC control integration
- central monitoring database

LST activities: IT and data analysis

Goal: ensure smooth LST operation, data acquisition + processing, **obtain first science results**

In our hands:

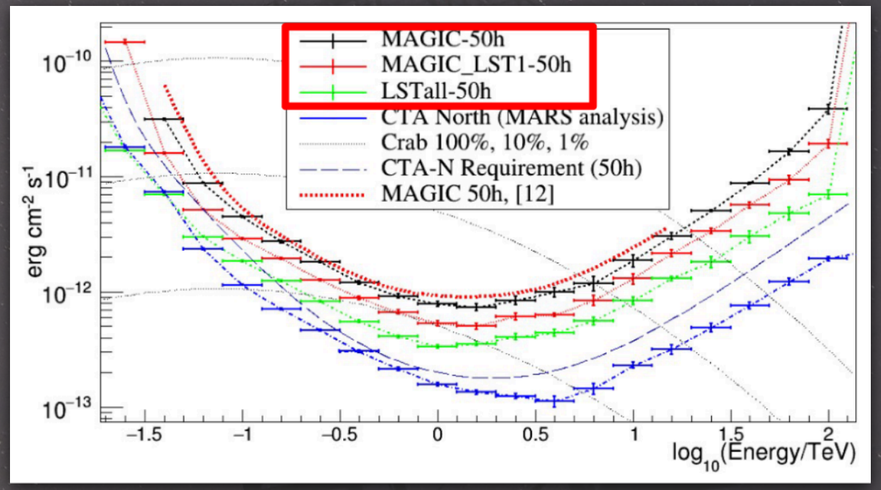
- ~2000 cores
- ~3 Pb of storage
- NVIDIA V100 GPU x 2
- dedicated “telescope” servers
- energy storage

Our group in IT:

- Main responsible for onsite IT center
- cluster management
- backups
- access control
- remote and on-site maintenance

Our group in analysis:

- Science analysis of the data
- Joint analysis with MAGIC
- Monte Carlo refinement
- Generate response functions
- Advanced analysis using Convolutional Neural Networks (CNNs)



Higher sensitivity with MAGIC+LST1 combined (Di Pierro et al., PoS(ICRC2019)659)

Individual research topics of the group members

Koji Noda (野田浩司)

Associate professor (Feb 2018 - Jan 2024).

cannot be an official supervisor/mentor of students

- PhD in ICRR in 2010: Earth-skimming tau neutrino from a GRB
- LHCf experiment (2010-2012), reducing systematic in UHECR experiments.
  Postdoc in Nagoya and in INFN Italy, sometimes in CERN
- MAGIC since 2013. Postdoc in MPP Munich, and IFAE in Barcelona
  - Mrk501 flares (2011, **2013**, 2014): corr. author of a paper for flares in 2013
  - **Neutrino alerts follow-ups** (Tracks, HESEs, NGC 1068)
  - **GRB 190114C "the first (long) VHE GRB" :** main analyzer of the discovery paper, published in Nature
  - **GRB 160821B "hint from a short GRB with kilonova"** main analyzer & editor
  - Convener of Transients Physics Working Group
- CTA since 2013, working on LST1, followed by the construction of LST2-4
  1) **Optics** coordinator, 2) **telescope control**, 3) **power** system, 4) **pointing**, 5) IT
- Interested in multi-messanger physics using CTA LSTs!

Julian Sitarek (ユリアン シタレック)

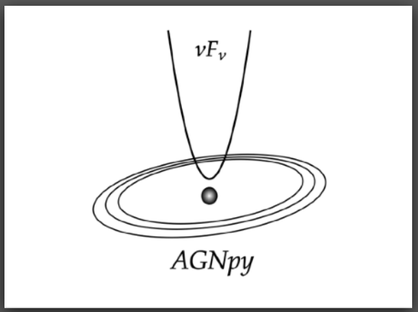
Guest professor (Sep 2021 - Dec 2021)

Gravitationally lensed blazars (QSO B0218+357):

- Unique chance to see a „replay" of blazar flares from the start itself (organizing large multiwavelenght campaigns)
- Possibility to test general relativity at very-high-energy gamma rays
- Possibility to probe the VHE gamma-ray emission at unprecedented angular resolution
- Paper on 2016-2020 monitoring of the source paper submitted to a journal.

agnpy – open source python-based software for modeling radiative processes in active galaxies:

- reliable – continuous tests of all the main parts of the code, comparisons with literature
- easy to use – extensive documentation and examples
- reproducible – open-source, version tagging with zenodo
- Paper submitted to a journal



Daniela Hadasch (ダニエラ ハダシュ)

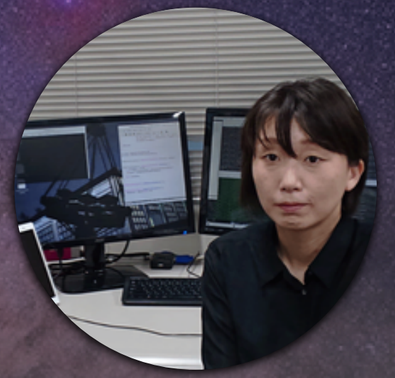
Assistant professor

Research interest

- Transient sources and gamma-ray binaries
  - What is the nature of the compact object in gamma-ray binaries?
  - What are the emission mechanisms in transient objects?
  - Experiments: MAGIC telescopes & Fermi-Large Area Telescope
- Latest result:
  - Deep study of HESS J0632+057 with H.E.S.S., MAGIC & VERITAS analyzing 15 years of TeV & 10 years of X-ray data
  - ➡ Correlation of X-ray and gamma-ray emission
  - ➡ Common origin of the radiation, indicating the existence of a single population of particles
- Currently Galactic Convener within the MAGIC collaboration
- Technical duty: IT management of the CTA computing cluster on La Palma

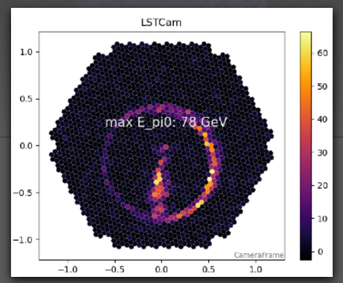
Michiko Ohashi (大石 理子)

Assistant professor

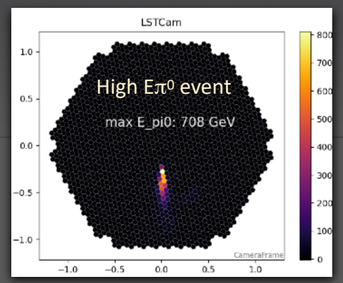


Studies on non-gamma-ray primaries

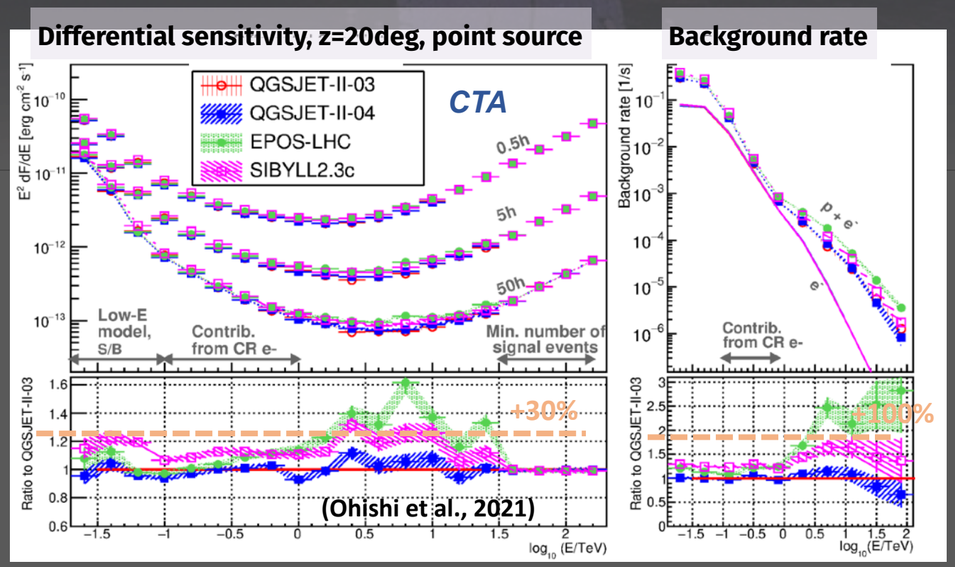
- γ-rays account for a very small fraction (typically order of 10-4) of the triggered events of the IACTs, the rest are CR nuclei
- IACTs are observing hadronic interactions between those CR primaries and nuclei in the air, with fine-pixel imaging cameras



Proton shower images have wide variation



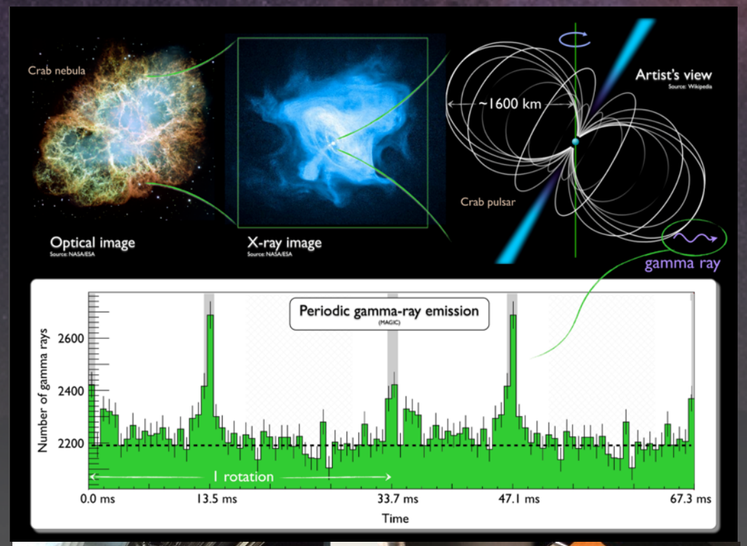
Sub-EM-shower from π0 mimics a g-ray shower

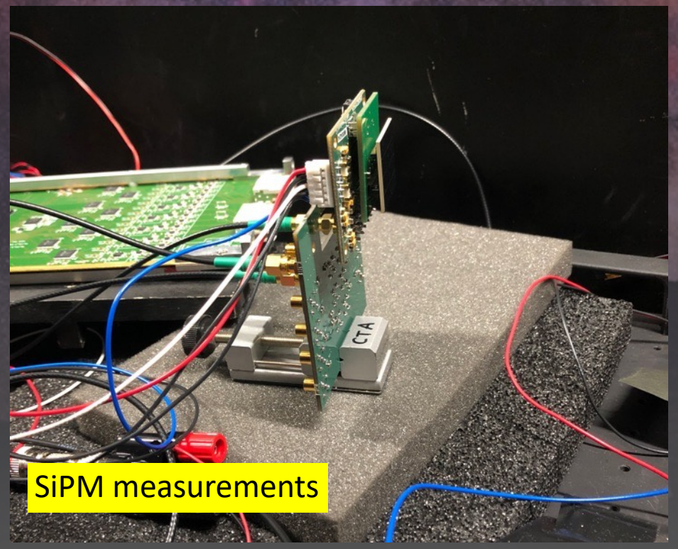


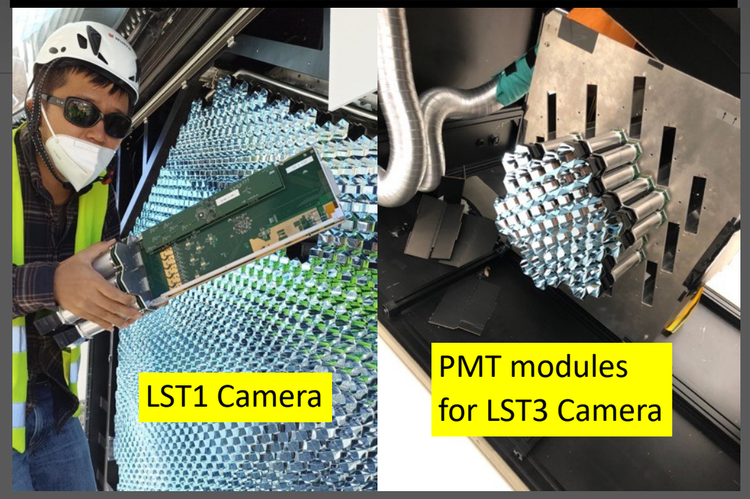
- Difference of the p0 spectrum in the current hadronic interaction models significantly affects the g-ray sensitivity estimation of CTA
- At the same time, CTA and other IACTs are proved to have significant capabilities in validating hadronic interaction models

Takayuki Saito (齋藤 隆之)

Assistant professor







Recent Research activities

- Working mostly on gamma-ray pulsars and other galactic objects
- Maintenance of LST1 Camera
- Quality Check of LST2-4 Camera sensors
- Development of new photosensor modules (SiPM)

Ievgen Vovk (イェブゲン ホフク)

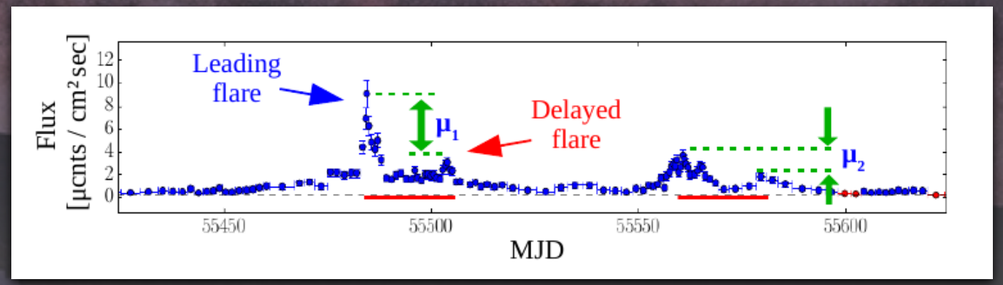
Assistant professor

Research topics

- Intergalactic Magnetic Field
- Gravitational microlensing in γ rays
- AGN physics
- Large zenith angle observations

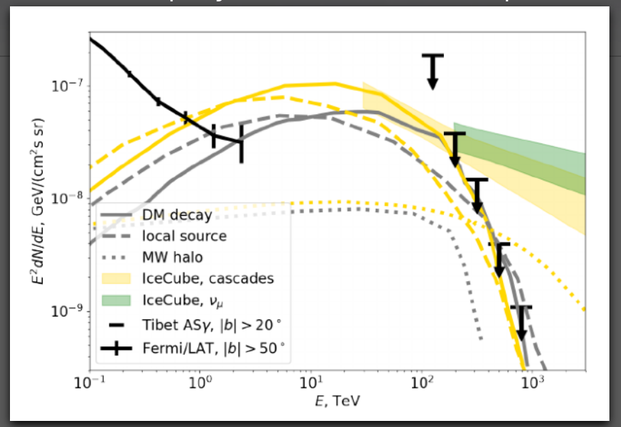
- Latest result:
  - High Galactic latitude PeV gamma-ray flux constraint with Tibet AS-gamma
- Service duties:
  - AMC developement for CTA / LST
  - Control software development for CTA / LST
  - La Palma CTA computing cluster management (consultant)

Microlensing in PKS 1830-211



Neronov, Vovk, Malyshev, Nature Physics, 11, 664 (2015)

PeV γ-ray limits with Tibet ASγ



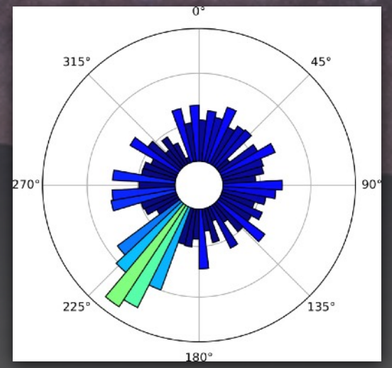
Neronov, Semikoz, Vovk, A&A 653, L4 (2021)

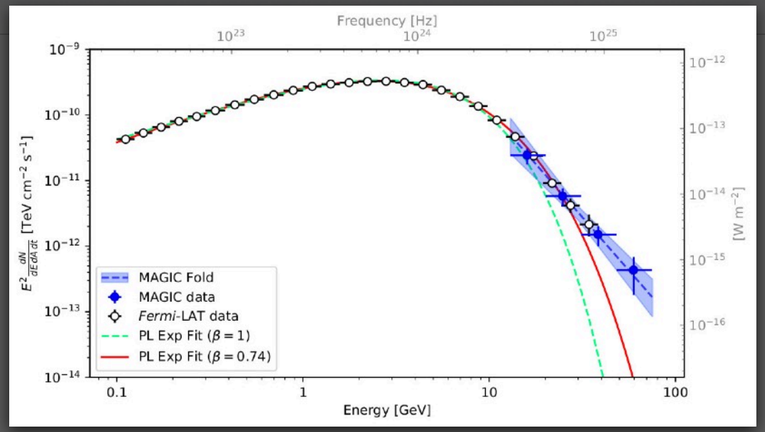
Giovanni Ceribella (ジョヴァンニ チェリベッラ)

Project researcher

VERY-HIGH-ENERGY PULSARS

- Energetic rotation-powered pulsars producing gamma-rays beyond 50 GeV
- Only 4 (!) known up to date:
  - Crab and Geminga discovered by MAGIC
- Emission mechanisms still poorly understood
- Pulsar hunter:
  - Technical development for E<100 GeV observations (HW/SW)
  - Production of rotation models for pulsars with Fermi-LAT data
  - MAGIC (and LST1) pulsar data analysis
- LST construction and commissioning



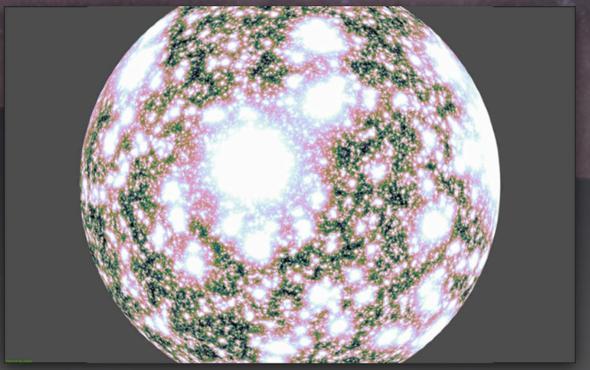


Moritz Hütten (モリッツ ヒュッテン)

Project researcher

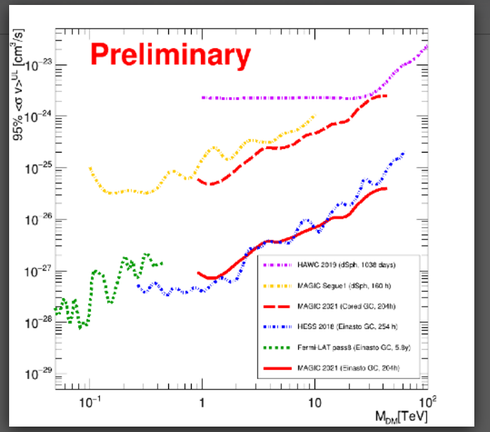
Research interests

- Indirect searches for dark matter: Galactic Centre & galaxy clusters
- Cosmology & structure formation
- LST1+MAGIC combined data analysis



Latest results

- Search for gamma-ray line emission from Dark Matter annihilation in the Galactic Centre with MAGIC (w./ T. Inada, D. Kerszberg)



Responsibilities

- Convener of the MAGIC Astroparticle and Fundamental Physics Working Group
- Chair of the Kashiwa Dark Matter Symposia

Marcel Strzys (マーセル ストゥルース)

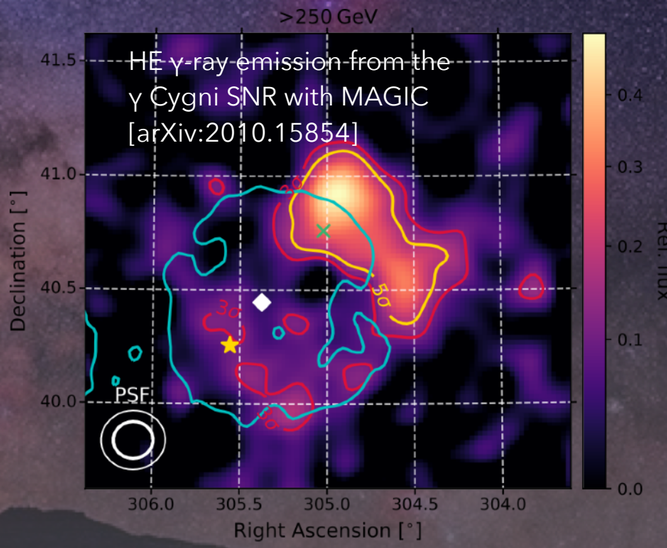
Project researcher

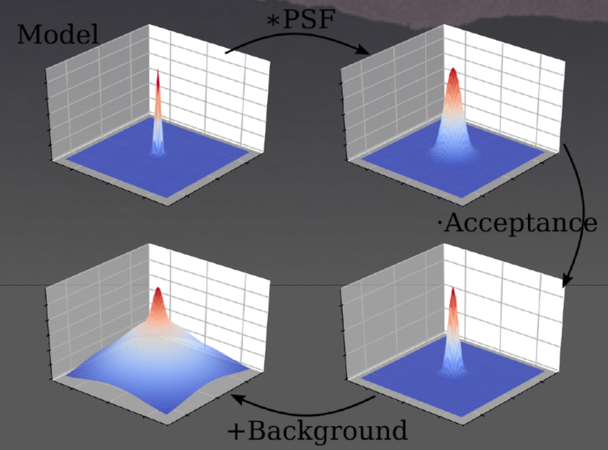
Research interests

- Galactic CR sources & PeVatron candidates:
- Supernova remnants, starforming regions, Gal. Center
- Image analysis:
  - how can we better disentangle different source components?
  - Methods to determine the irreducible CR background for Cherenkov telescopes

Latest results

- Study of gamma-ray emission in the vicinity of the SNRs γ Cygni (G78.2+2.1) and Boomerang (G106.3+2.7), the unidentified source HESS J1809-193, and Gal. Center





Principle of the Spatial likelihood technique used in MAGIC
A&A 619, A7 (2018)

Collaboration responsibilities

- Member of the MAGIC software board, source scheduling team, and safety committee
- La Palma CTA/LST computing cluster administration (together with D. Hadasch, D. Mazin, and I. Vovk)

Ryuji Takeishi (武石 隆治)

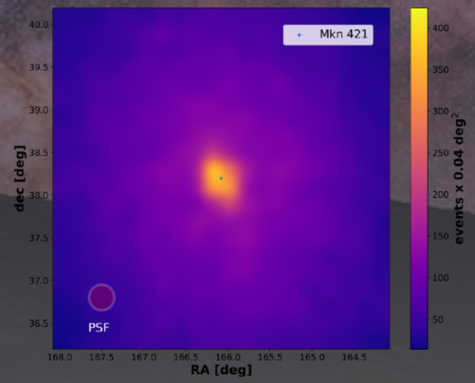
Project researcher

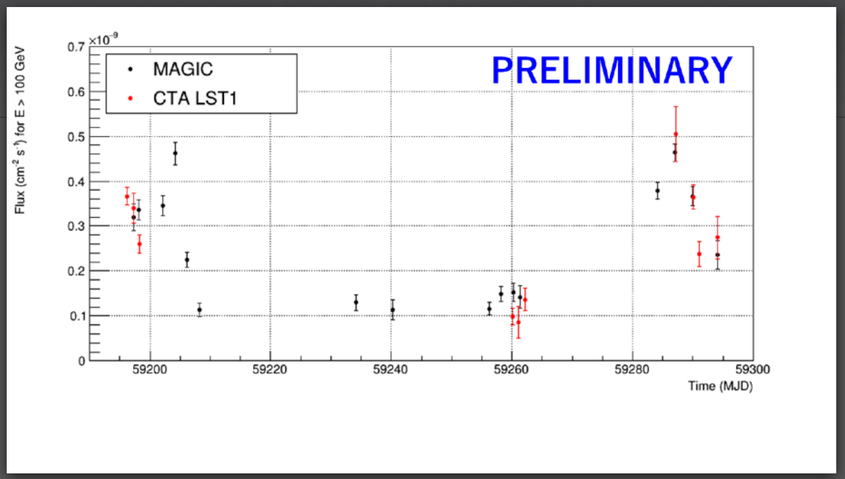
Analysis of Mrk421

- AGN with jets, one of the nearest blazars
- There is gamma-ray flux variability (about 0.3 - 5 Crab unit)
- For evaluating LST-1 performance, it is useful to measure light curve of gamma-ray sources with flux variability and compare it with MAGIC.
- We measured Mrk421 light curve and compared it with MAGIC same period data.
- LST-1 plots are within about 1 sigma from MAGIC same time period data, which indicates that LST-1 works normally.

Mrk 421 sky map detected with LST-1

R. López-Coto, PoS (ICRC2021) 806

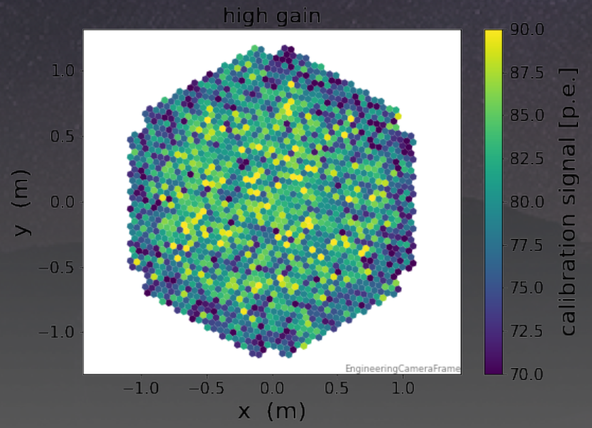




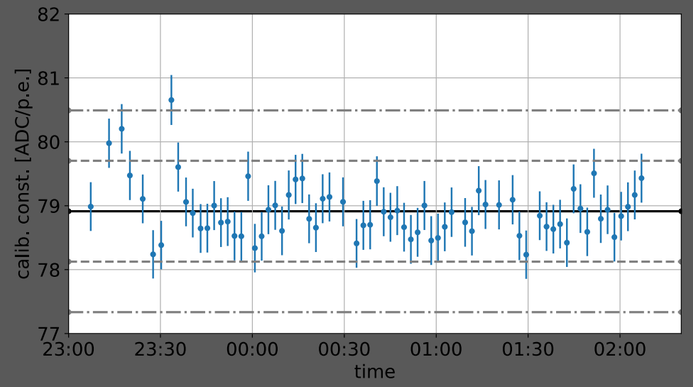
Yukiho Kobayashi (小林 志鳳)

2nd year PhD student

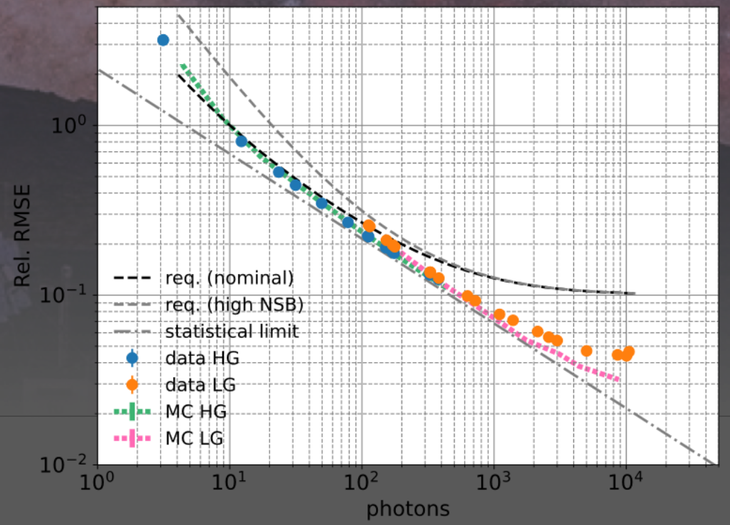
LST-1 Camera Calibration



The camera can be illuminated by a pulse laser placed at the dish center for charge calibration.
The figure shows the average number of photoelectrons detected in each PMT from the laser.



The PMT gain in each pixel estimated by the calibration is confirmed to be stable within 1%.
The figure shows time stability of the PMT gain.



The figure shows the charge resolution evaluated with the camera and the current analysis pipeline. It is confirmed that the data meet the CTA requirement for the charge resolution.

Thanks for listening

Please feel free to drop by (we are in 3rd, 5th and 6th floor) and let's discuss about how to collaborate!