Report for admission to the 2nd year

PhD course of National Interest in Technologies for Fundamental Research in Physics and Astrophysics

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INFN TORINO

UNIVERSITÀ DEGLI STUDI DI PADOVA

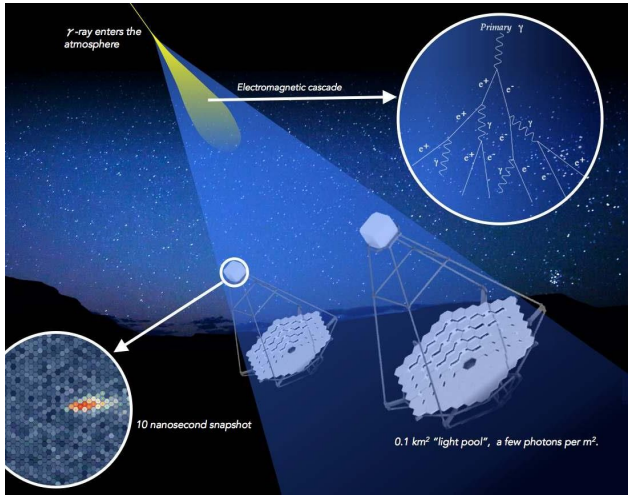
MAX-PLANCK-INSTITUT FÜR KERNPHYSIK

Research topic and goals

- *"Development and characterization of the silicon photomultiplier-based Cherenkov camera for the Small-Sized Telescopes of CTAO"*

- Scientific context
  - Indirect γ-ray astronomy
  - Imaging Atmospheric Cherenkov Telescopes
  - CTAO collaboration → SSTs, LSTs

- INFN and Max-Planck-Institute for Nuclear Physics (MPIK Heidelberg) co-funded scholarship
  - part of work @ MPIK



~ 20 GeV ~ 150 GeV ~ 5 TeV ~ 300 TeV

LSTs MSTs SSTs

Goals

- Development, characterization and commissioning of the first SST Camera
  - Silicon Photomultipliers (2048 pixels)
  - HOW?
    - participate in assembling the device
    - test it in the laboratory
    - test it on-telescope with dedicated campaigns

- Other research topics: contribution in monitoring and maintenance of LST's calibration box

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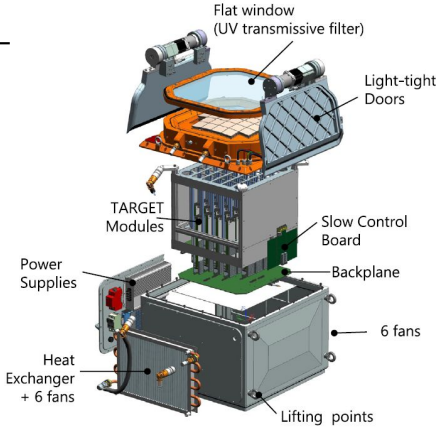


Overall plan

1st year
Hardware assembly of first Quarter of camera (QCAMi)
Tests and characterization of the device (laboratory & on-sky)
Data analysis e.g. study of the trigger system (alternative backplane) e.g. overall response
Familiarize with LST Calibration Box

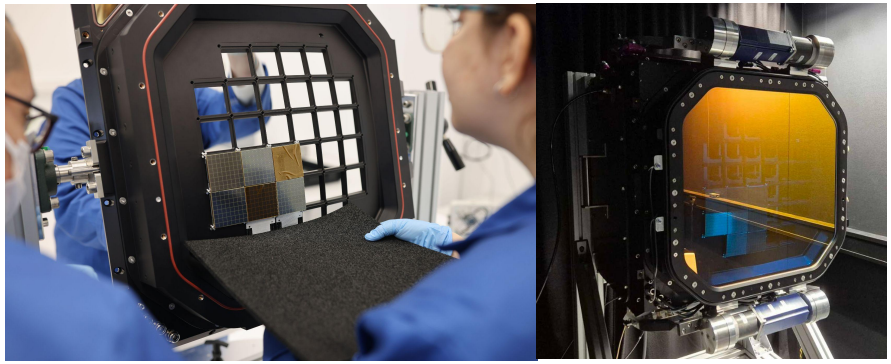
2nd year
Hardware assembly (QCAM and/or SSTCAM)
Overall characterization of device (laboratory measurements)
Trigger system study (q-backplane)

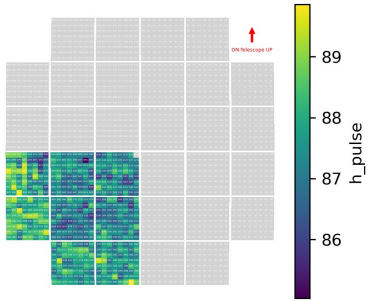
3rd year
Characterization of full SST Camera (on-sky)
Analysis and results
Thesis

\+ courses attendance and exams preparation, participation to schools, conferences, collaboration meetings and data-taking shifts for CTAO telescopes
e.g. LST-1 shift (Dec. 2025) as operator

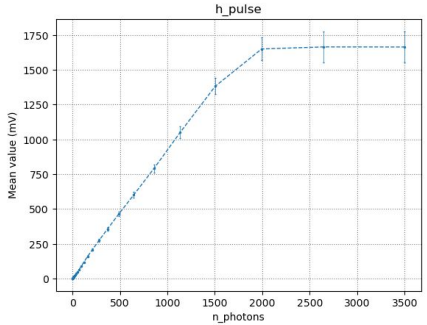
Research activities (1st year)

- Hardware assembly (QCAMi)
  - 8 modules (out of 32)
  - Alternative quarter backplane
- Laboratory tests (in dark room)
  - amplitude matching
  - dynamic range scans
  - trigger threshold scans
  - SPE
  - …
- Participation to on-telescope campaign for QCAMi





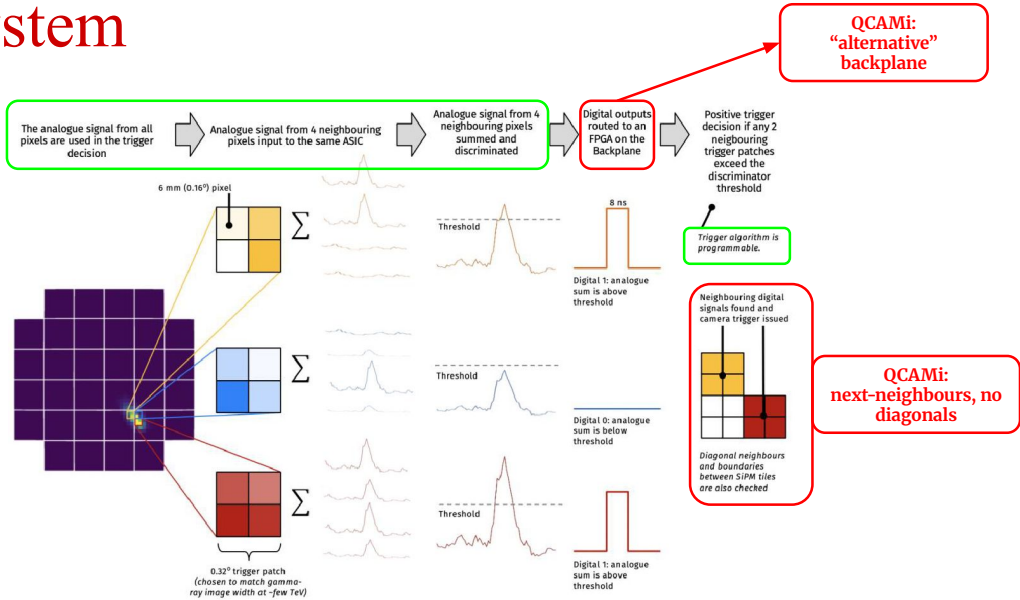
Mean: 87.5 mV, stdev: 0.79,
stdev/mean: 0.9%
(excluding dead pixel)



Study of linear response and saturation

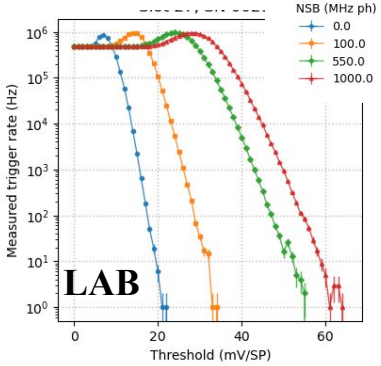
Test and study of the trigger system

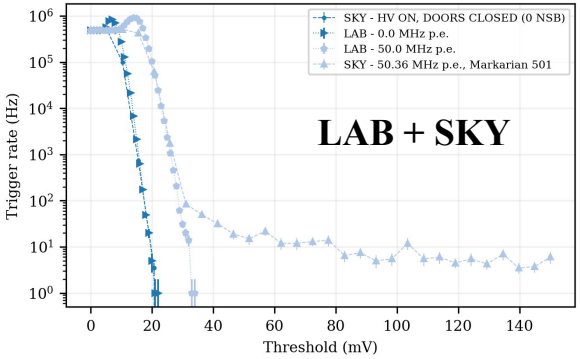
- Analog sum of fast signal in 4 adjacent channels (SPs) □ first level trigger
- Camera trigger managed by the **backplane electronics** (time coincidence from all modules)
- Alternative quarter backplane (QCAMi)
  - trigger board → OR between modules
  - trigger output 20 ns wide
  - different coincidence levels possible
    - 2, 3, 4, … 15 SPs over threshold
    - next-neighbour coincidence
- Tested in laboratory and on-sky

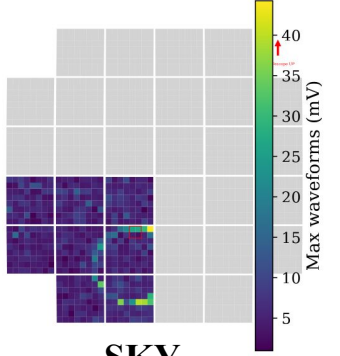


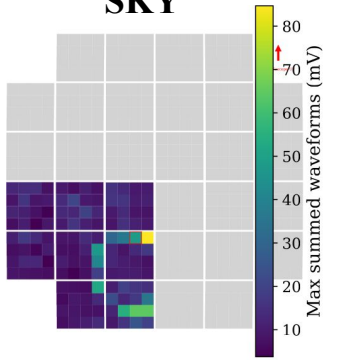
Test and study of the trigger system

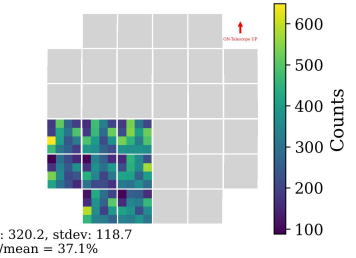
- Measure trigger rate VS trigger threshold
  - coincidence level: next-neighbour (no diagonals)
- Repeat for different simulated NSB levels
- On sky: curve ***from NSB- to CR-dominated***
  - useful to determine threshold to be set
  - higher NSB → higher transition point (mV)
- On recorded data: ***second-brightest SP distribution***
  - assess uniformity of trigger system









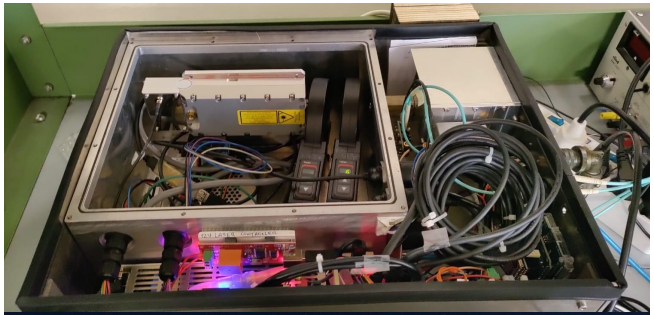


mean: 320.2, stdev: 118.7
stdev/mean = 37.1%

Other research topics: first approach to CaliBox device

- LST-1
- Calibration device
  - uniform illumination of whole PMT camera
  - laser
  - two wheels with ND filters
  - monitoring device: SiPM (and photodiode)

- Goals
  - monitoring and maintenance of device
  - installation of new one on LST-4

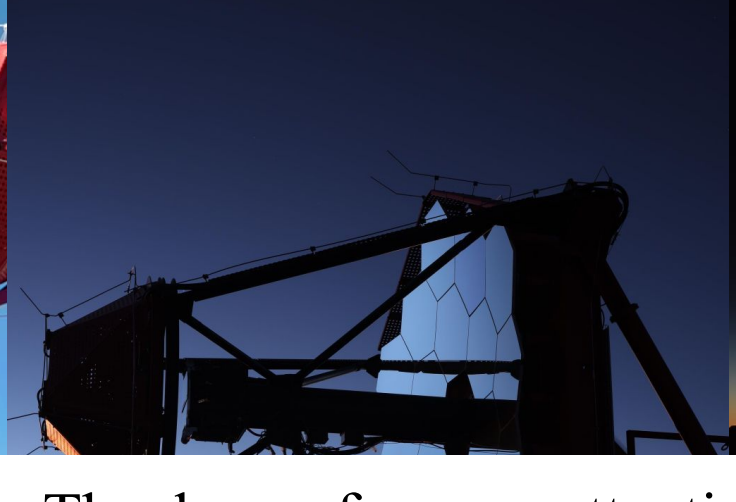
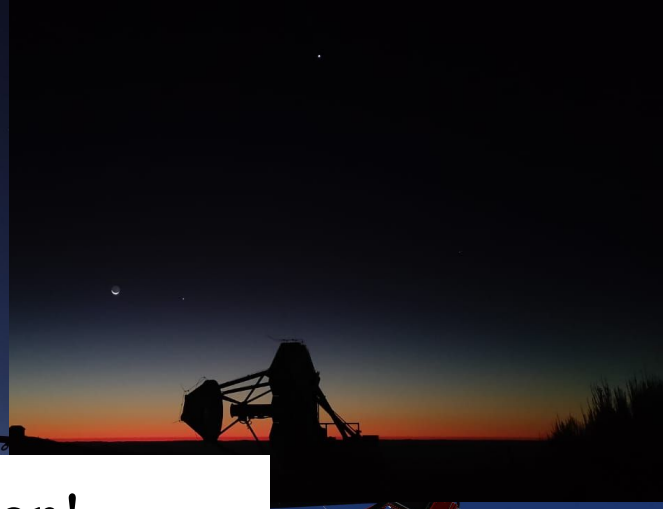


Courses, exams and training activities

- Courses
  - Project Management in science (2 cfu) [PASSED]
  - New technologies for Cherenkov Telescopes (2 cfu) [PASSED]
  - Photodetection: scintillators and silicon photomultipliers (2 cfu) [PASSED]
  - Statistical methods and techniques for data analysis (in particle and astroparticle physics) (2 cfu) [ATTENDED]
- Training activities
  - LST General Meeting in Rome, Italy, 18-22 November 2024
  - TECH-FPA PhD Retreat 2025 in L'Aquila, Italy, 17-21 February 2025
  - XXXIII Bonaudi-Chiavassa school on particle detectors in Cogne, Italy, 23-27 June 2025
  - Research period abroad of ~ 6 months at Max-Planck-Institute for Nuclear Physics
  - Participation to the on-telescope campaign for SST's QCAMi at Observatorio del Teide, Tenerife, Spain

Planned courses and training activities (2nd year)

- Courses
  - Machine Learning for Physics (TECH-FPA PhD academic offer, 3 cfu)
- Workshops, conferences and meetings
  - 2nd SST meeting in Catania, Italy (24-26 September 2025)
    - presentation of QCAMi trigger system on-sky performance
  - conferences (e.g. ECRS2026)
- Training activities
  - Research period abroad (up to 6 months) at MPIK
  - LST-1 data taking shift at Observatorio Roque de los Muchachos, La Palma, Spain (December 2025)
  - Participation to the commissioning of the Calibration Box on LST-4 at ORM, La Palma, Spain (December 2025)

Thank you for your attention!