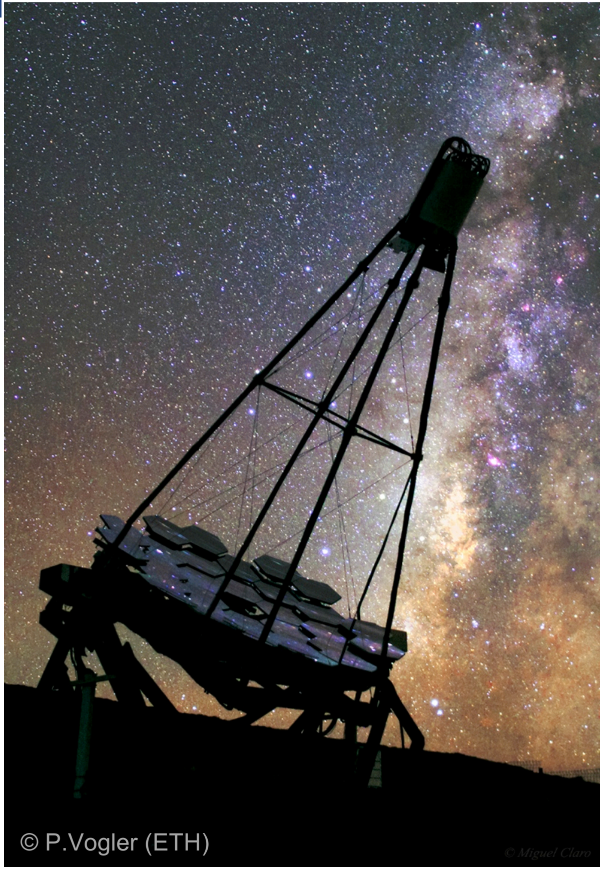
ETH zürich



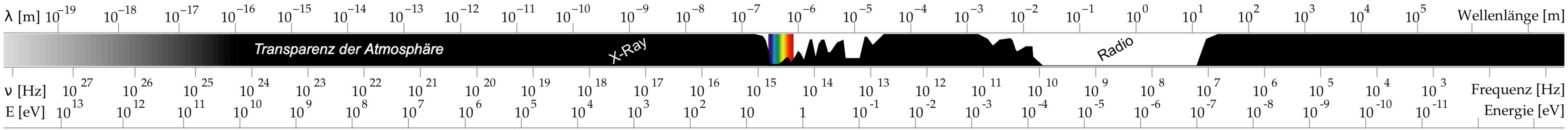
Swiss CTA Day 2020

Nov.24 2020

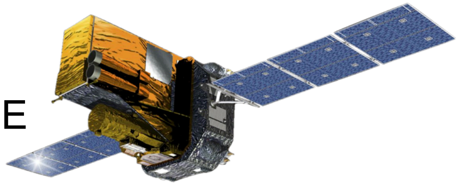
Inheritance of (Very High Energy) Gamma-Ray Astronomy in Switzerland

Adrian Biland, ETH Zurich

Spectrum of Electromagnetic Radiation



'Gamma-ray' is the name for large fraction of the spectrum
There is long legacy of 'gamma-ray' astronomy in Switzerland, e.g. the Science Data Centre for the Integral satellite with UniGE



I will concentrate on the direct precursors to CTA with significant Swiss participation: the Cherenkov telescopes MAGIC and FACT at the Canary Island La Palma


(Roque de los Muchachos, La Palma, 2240m)
LST–1 (23m)
(CTA)
FACT (4m)
MAGIC–II (17m)
MAGIC–I (17m)
© Urs Leutenegger 2020 Nightscape Photography

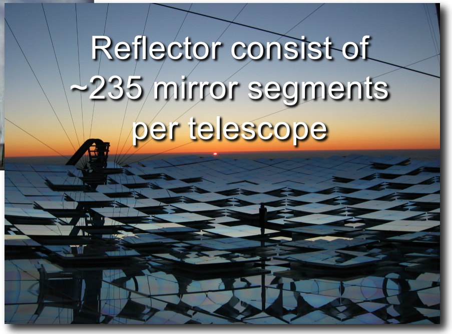
The MAGIC Telescopes

ETHZ joined the MAGIC Collaboration at inauguration of the first telescope in 2003.

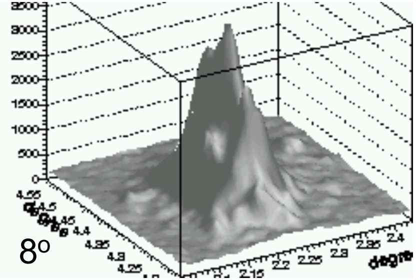
UniGe in process of joining MAGIC

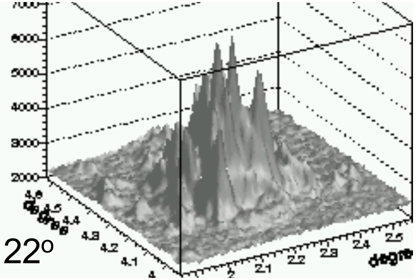
Design principle of MAGIC:
fast repositioning to react on short transient events (e.g. GRB)
➔ low weigth

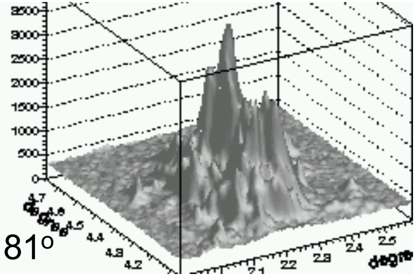
The MAGIC Structure



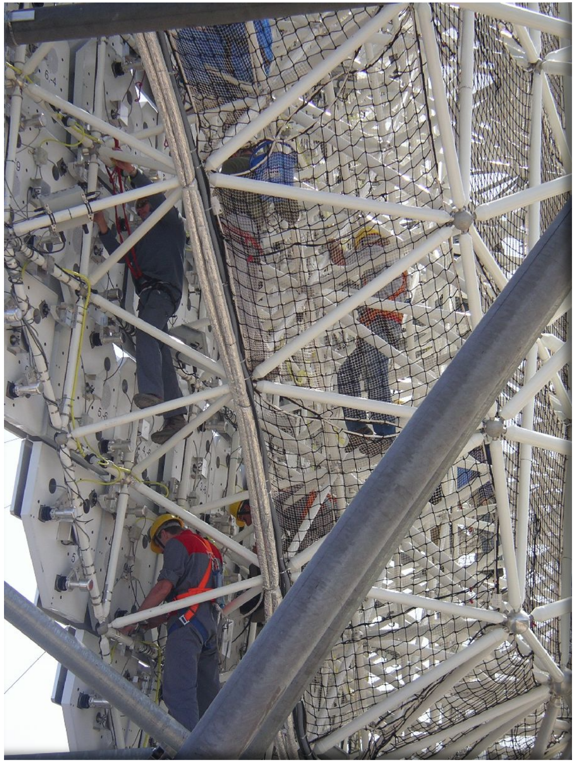
➔ bad optical quality:







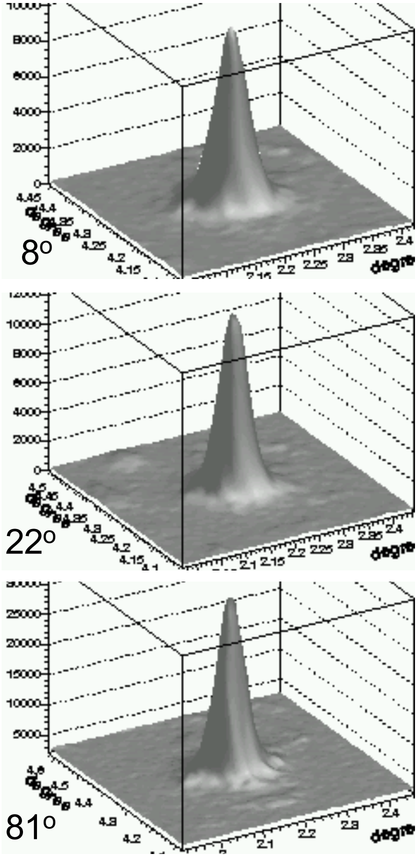
The MAGIC Active Mirror Control



Each mirror segment equipped with two actuators to correct for deformations.

System significantly improved by ETHZ (firmware,software; geometry,procedure) and a further improved version (hardware) was built for MAGIC-II

➔ good optical quality:



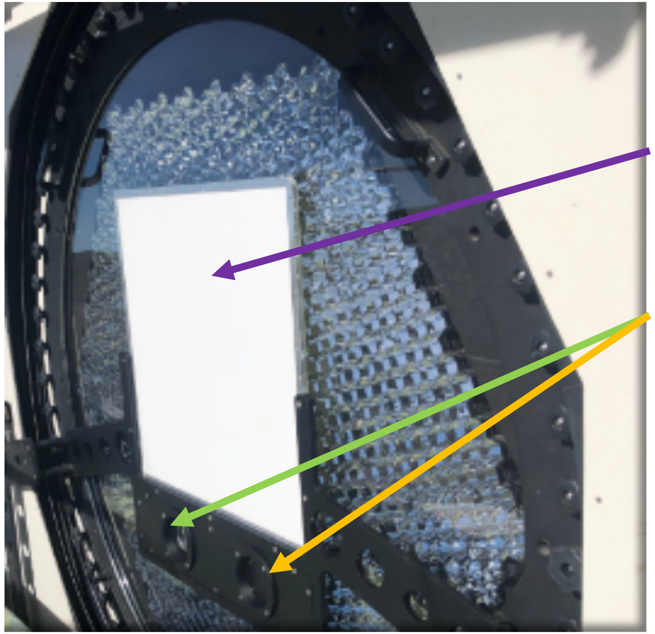
Further improved actuators for CTA developed by UZH

The MAGIC Active Mirror Control

Unexpected benefit for *Stellar Intensity Interferometry*:

Can make good use of AMC:
- refocusing telescope to infinity (for VHE: focus ~10km)
- repoint reflector to dedicated pixel in the camera
  - can install different optical filters in front of pixels
  - can split full reflector into segments, each pointing to another pixel/filter

Work in progress, significant contribution from UniGE to SII

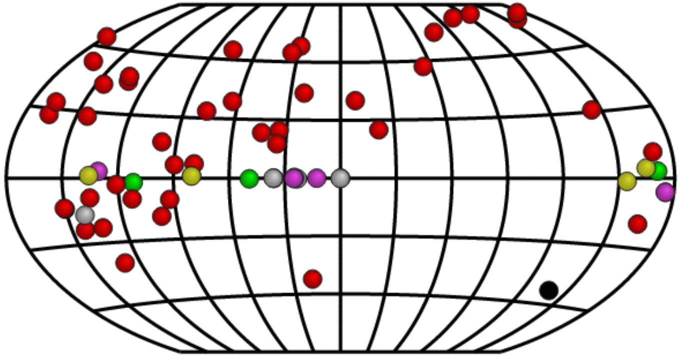


MAGIC camera:

remote controlled reflector to e.g. calibrate AMC

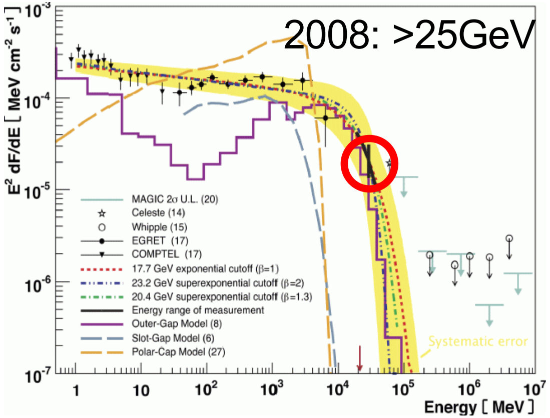
optical filters added in front of selected pixels

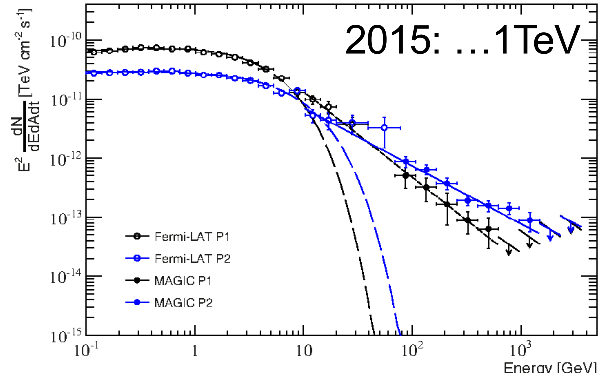
The MAGIC Telescopes: Selected Scientific Results



Measured more than 65 VHE sources, among them:

The MAGIC Telescopes: Selected Scientific Results





Measured more than 65 VHE sources, among them:

- **first** VHE Pulsar (Crab Pulsar)

  (contradicting theories about pulsar emission)

Breaking News:

Highlight Free Access

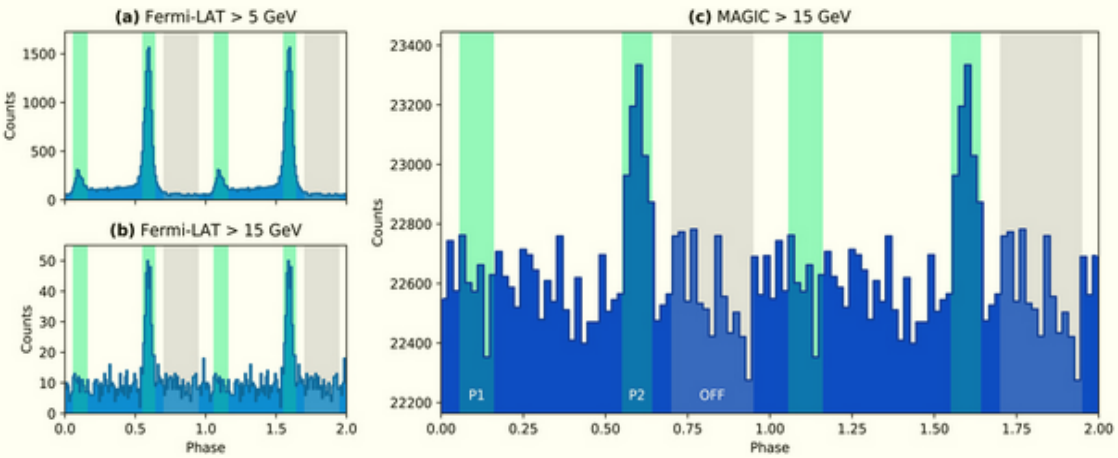
Issue	A&A Volume 643, November 2020
Article Number	L14
Number of page(s)	6
Section	Letters to the Editor
DOI	https://doi.org/10.1051/0004-6361/202039131
Published online	20 November 2020

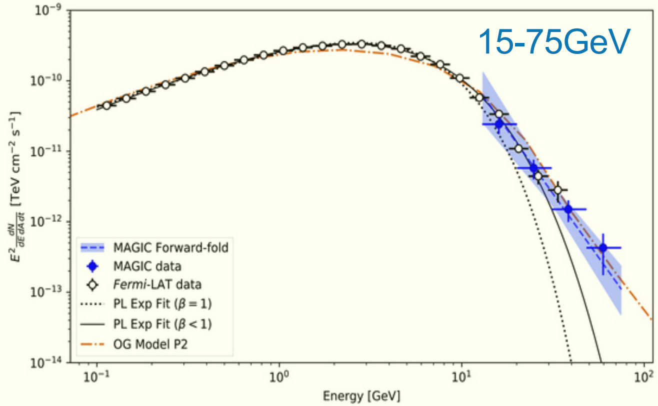
A&A 643, L14 (2020)

Letter to the Editor

Detection of the Geminga pulsar with MAGIC hints at a power-law tail emission beyond 15 GeV

MAGIC Collaboration



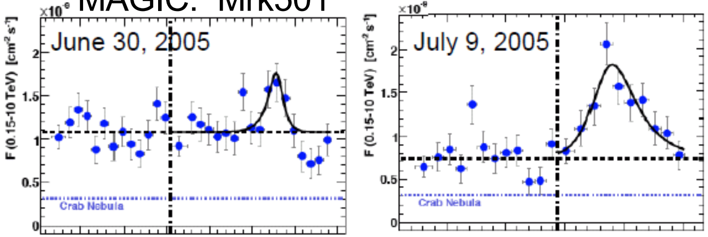


The third IACT Pulsar (Crab[MAGIC] and Vela[H.E.S.S.])

Fermi-LAT: 11 years data, MAGIC: 80 hours data: 15-75GeV

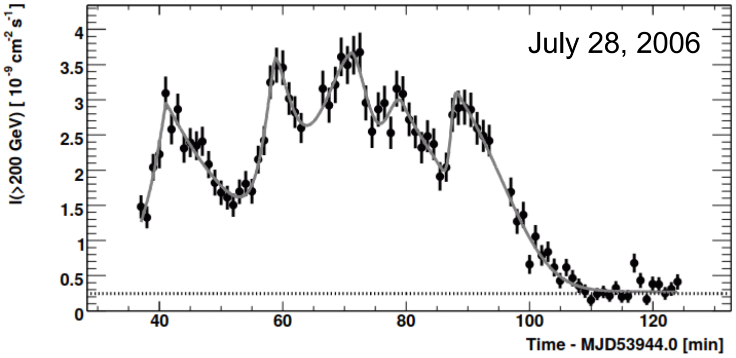
The MAGIC Telescopes: Selected Scientific Results

MAGIC: Mrk501



Time binning: 2 minutes Time binning: 2 minutes

H.E.S.S.: PKS2155



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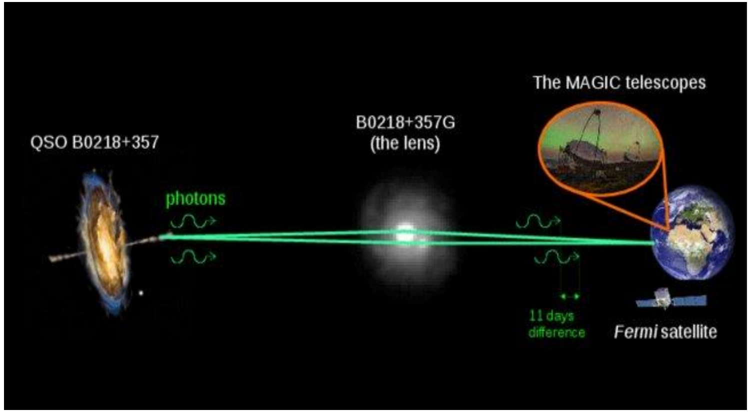
- **first** VHE Pulsar (Crab Pulsar)
  (contradicting theories about pulsar emission)
- **first** detection of fast VHE variability from an Active Galactic Nucleus (supermassive black hole)
  (challenging models about AGN emission)

The MAGIC Telescopes: Selected Scientific Results



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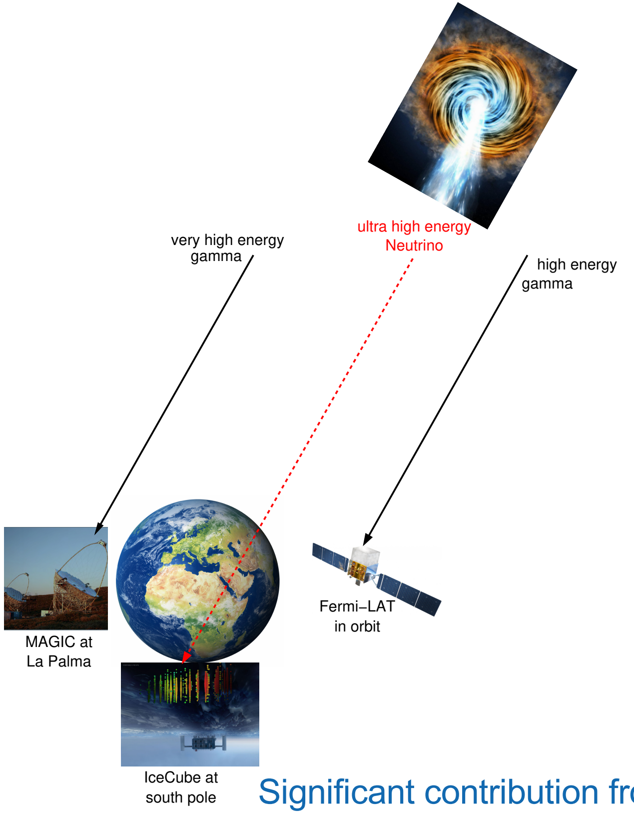

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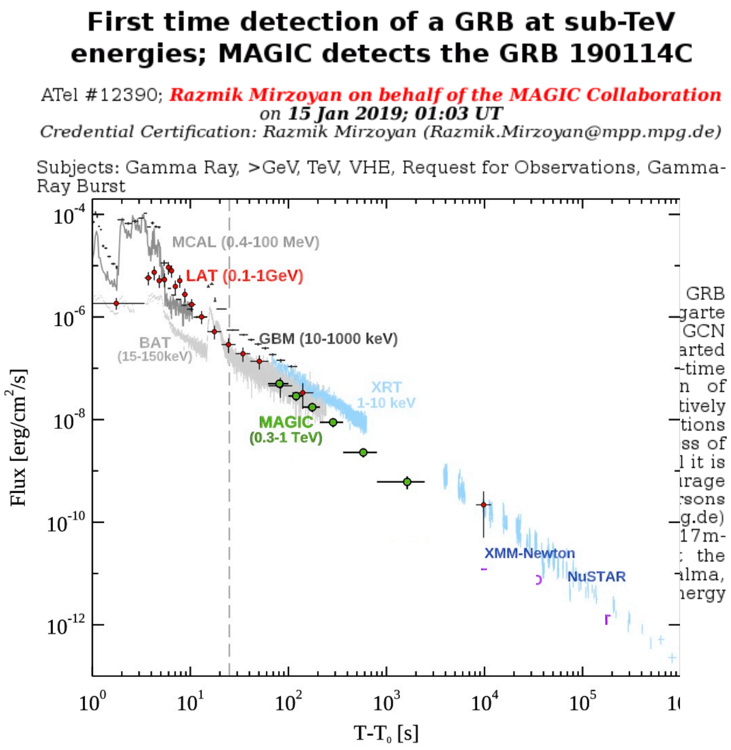
- **first** identification(?) of an AGN as source of Ultra-high energy Neutrino (with IceCube and Fermi)
  ➔ multi-messenger Astronomy

Significant contribution from UniGE in IceCube

The MAGIC Telescopes: Selected Scientific Results



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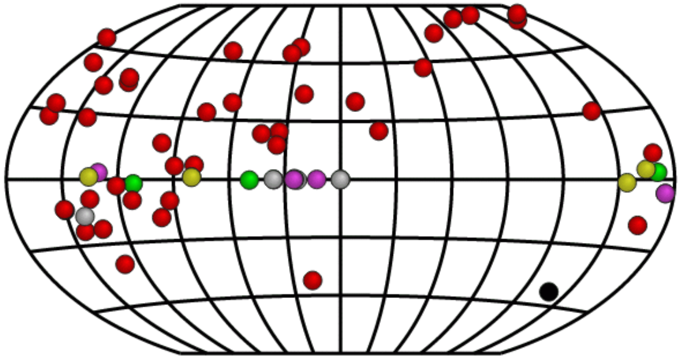
- **first** detection of VHE emission from a GRB
  (birth of a stellar black hole)

After 15 years, the lightweight MAGIG design and AMC did pay off …

The MAGIC Telescopes: Selected Scientific Results



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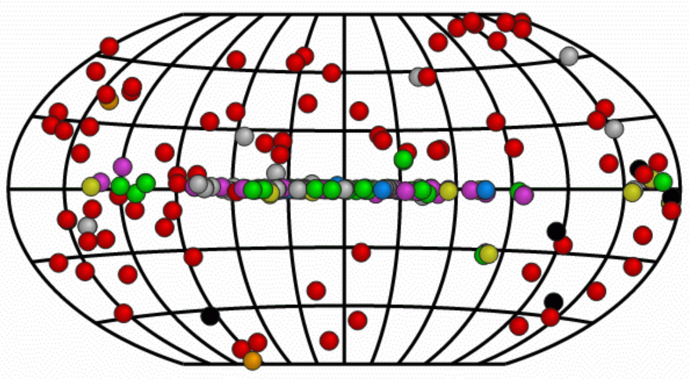
The MAGIC Telescopes: Selected Scientific Results

Also: VERITAS (US), HAWC (Mexico), and H.E.S.S. (Namibia: southern hemisphere ➔ many sources from central part of Milky Way)



2003: <10 VHE sources known
2020: >250 VHE sources known
(far more than expected by experts)

Measured more than 65 VHE sources, among them:

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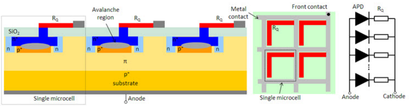
Only tip of the iceberg ➔ need CTA with much better sensitivity

New Technology

??



So far, all Cherenkov Telescopes used Photomultiplier Tubes (PMT) as photo sensors in their cameras.

~2007, solid state photosensors became available: G-APD (now called SiPM)

Most experts were reluctant about SiPM being usable for operation under harsh conditions intrinsic to Cherenkov telescopes

Notable exceptions:

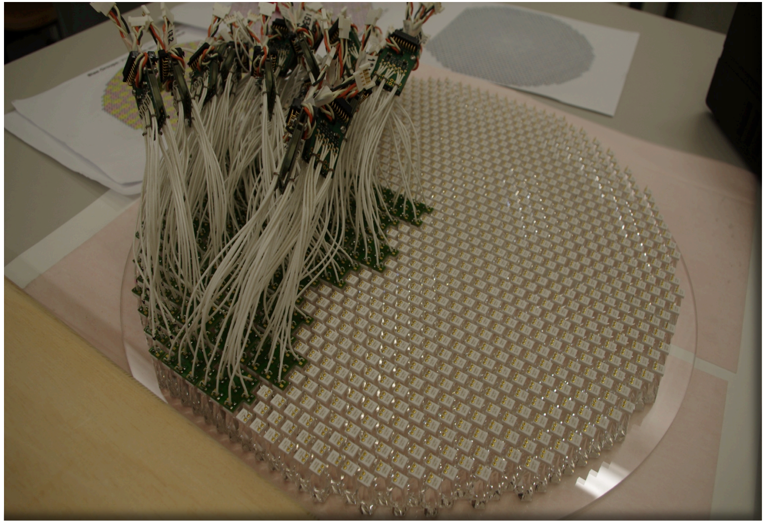
New Technology

Only way to test and finally convince community that SiPM are a viable alternative to PMT: build a camera and operate a telescope with it …

➔ FACT Collaboration (initiated by Felicitas Pauss):
ETHZ(camera), UniGE(datacenter),
Dortmund(telescope),Wuerzburg(analysis)
(of course, all groups helping in all aspects)
some interested large parties did bail out due to strong opposition from community…

Within three years (2008-2011), a novel camera, including electronics, was designed and constructed.

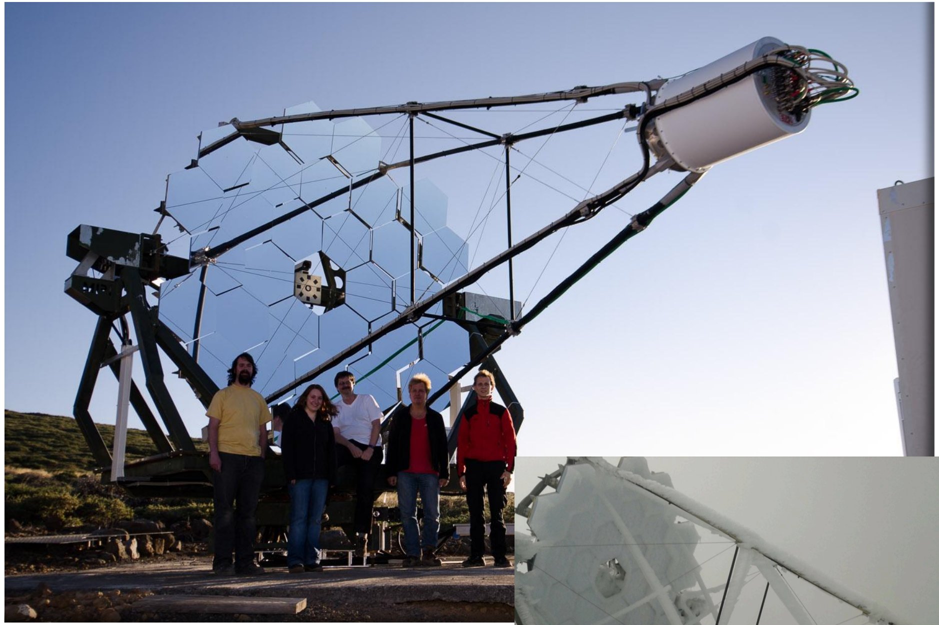
Ready to be installed in refurbished telescope at La Palma in Oct.2011



The FACT Telescope

FACT camera installed in Oct 2011
Since then, successfully taking data whenever conditions permit.

First Cherenkov telescope using SiPM



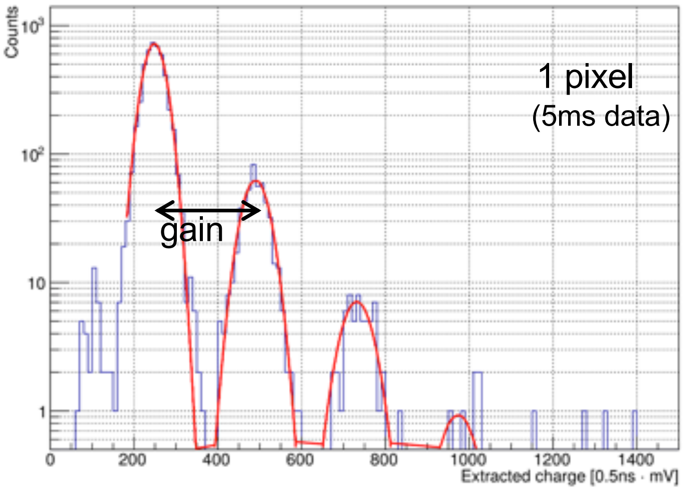
Main goal: identify problems of SiPM under harsh conditions intrinsic to Cherenkov telescopes.

➔ **Total failure?**
no SiPM related problem found in several years of operation

The FACT Telescope

FACT camera installed in Oct 2011
Since then, successfully taking data whenever conditions permit.

First Cherenkov telescope using SiPM advantages:
- having self-calibrating camera



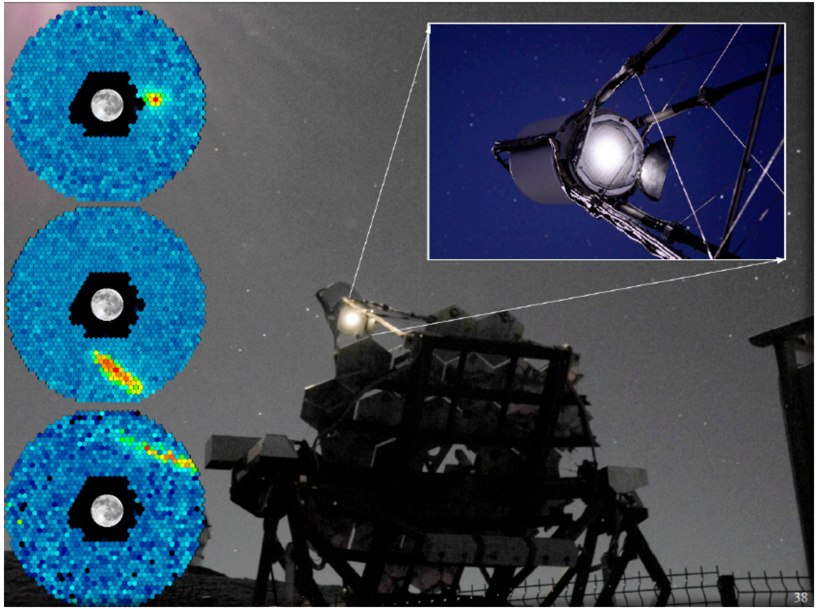
dark noise and crosstalk are usually seen as major nuissance of SiPM, but they form the perfect calibration device for free

Measuring temperature and current and accordingly adjust the Voltage applied to the SiPM is sufficient to keep gain constant. No need for complicated/expensive Temperature stabilisation!

The FACT Telescope

FACT camera installed in Oct 2011
Since then, successfully taking data whenever conditions permit.

First Cherenkov telescope using SiPM advantages:
- having self-calibrating camera
- taking data under bright moon conditions



Proof of concept: can identify air-showers ~1 degree from the brightest full moon of the decade. PMTs would have been destroyed by the high photon flux.

The FACT Telescope

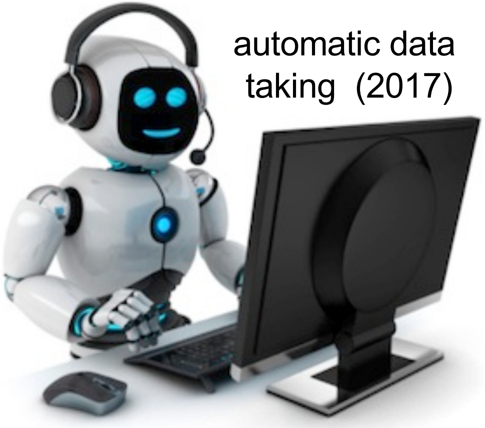
FACT camera installed in Oct 2011
Since then, successfully taking data whenever conditions permit.

First Cherenkov telescope using SiPM advantages:
- having self-calibrating camera
- taking data under bright moon conditions
- remote operation -> automatic operation

on-site data taking (2011)

remote data taking from anywhere (2012)

automatic data taking (2017)



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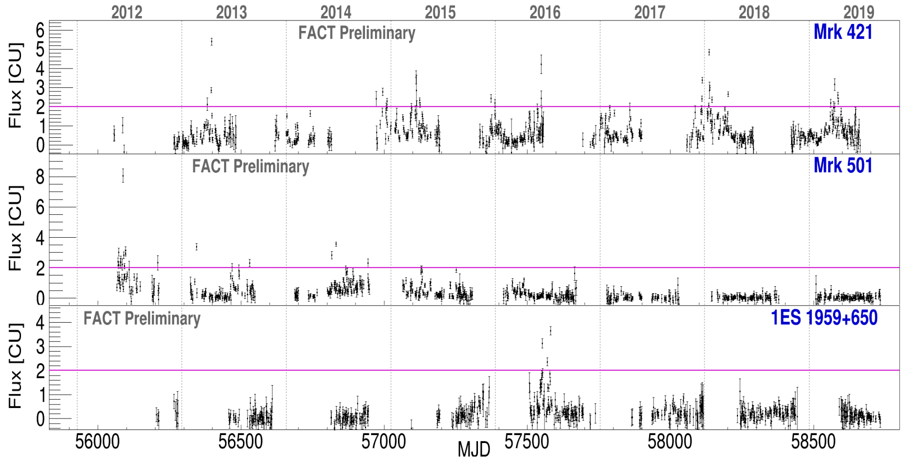
First Cherenkov telescope using SiPM
advantages:
- having self-calibrating camera
- taking data under bright moon conditions
- remote operation -> automatic operation

- first unbiased long-term VHE observation of bright AGNs and send alerts to other instruments in case of exceptional flares (Atel, GNC, AMON, Satellite ToOs, FACT/HAWC/HESS/MAGIC/VERITAS agreement)

publications: Mrk421 submitted, Mrk501 in preparation
individual flares: with MAGIC, HESS, HAWC, IceCube

all lightcurves made public in quasi-realtime



also 1ES2344 and others

➔ **next generation: SST-1M (UniGE)**

FNSNF Swiss National Science Foundation supported projects & State Secretariat for Education, Research and Innovation SERI transitional funding

- Science (all groups)
- operation of MAGIC and FACT (ETHZ)
- development and prototyping SST-1M for CTA (UniGE)
- development of software for CTA operation, datacenter & analysis (UniGE, ETHZ)
- development of improved AMC actuators for CTA (UZH)
- development for MST camera for CTA (UZH)
- …
- Submitted: - development of SiPM camera for LST (UniGE, EPFL, ETHZ)
  - development of SII for MAGIC and CTA (UniGE, UZH)

see also presentations of T.Montaruli, R.Walter, E.Charbon

Swiss Inheritance to CTA

Some Swiss Inheritance to all CTA Projects

AMC (MAGIC) ➔ **LST** (crucial), **MST** (beneficial)

SiPM (FACT) ➔ ***SST-1M*, ASTRI, GCT; SCT** (all crucial)

(… plus Science, Software, Datacenter, Management, …)

➔***Switzerland might be small, but has large footprint***