cherenkov telescope array

Institute for Cosmic Ray Research
University of Tokyo

CTA report
Daniel Mazin

Projects to be covered

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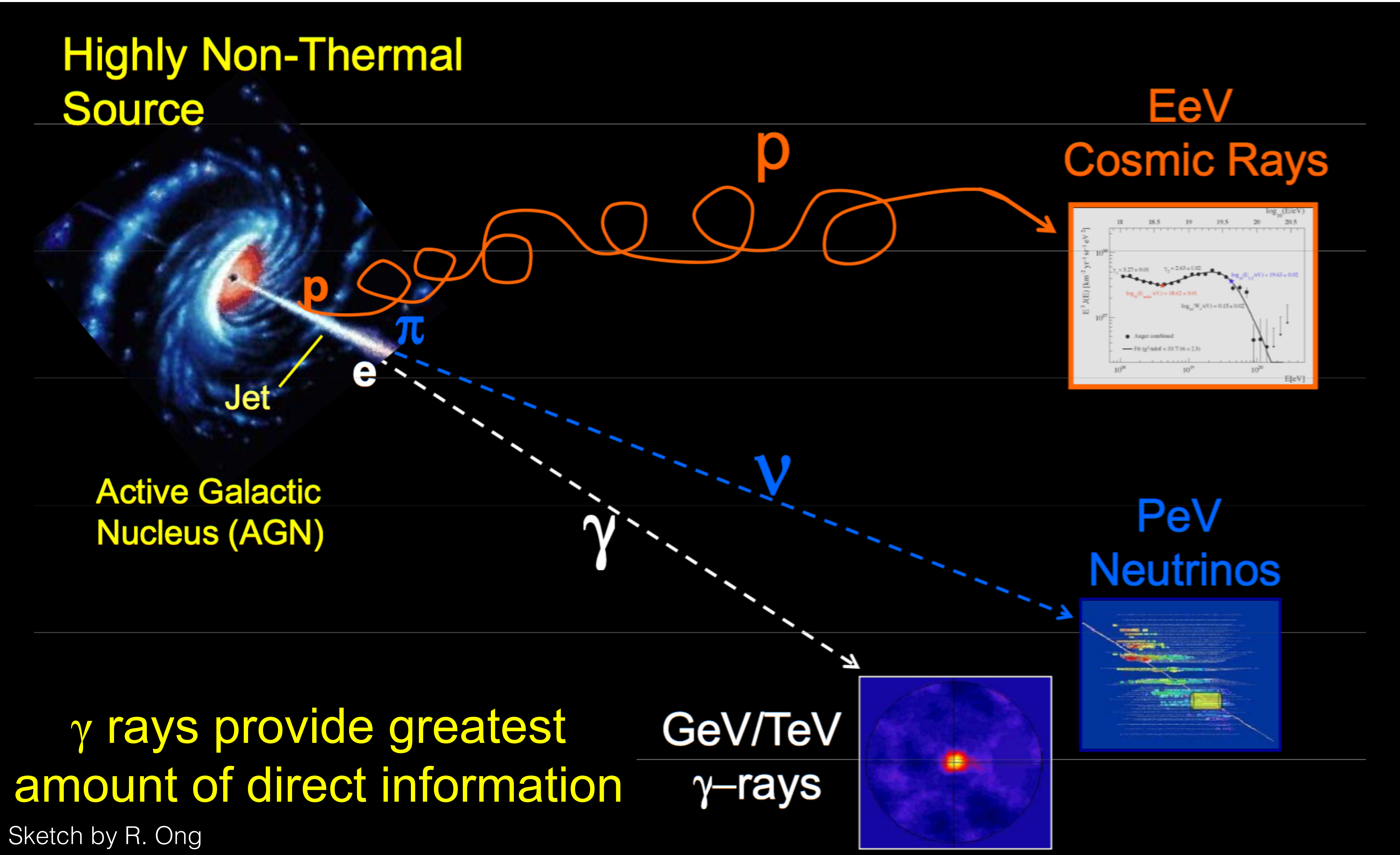
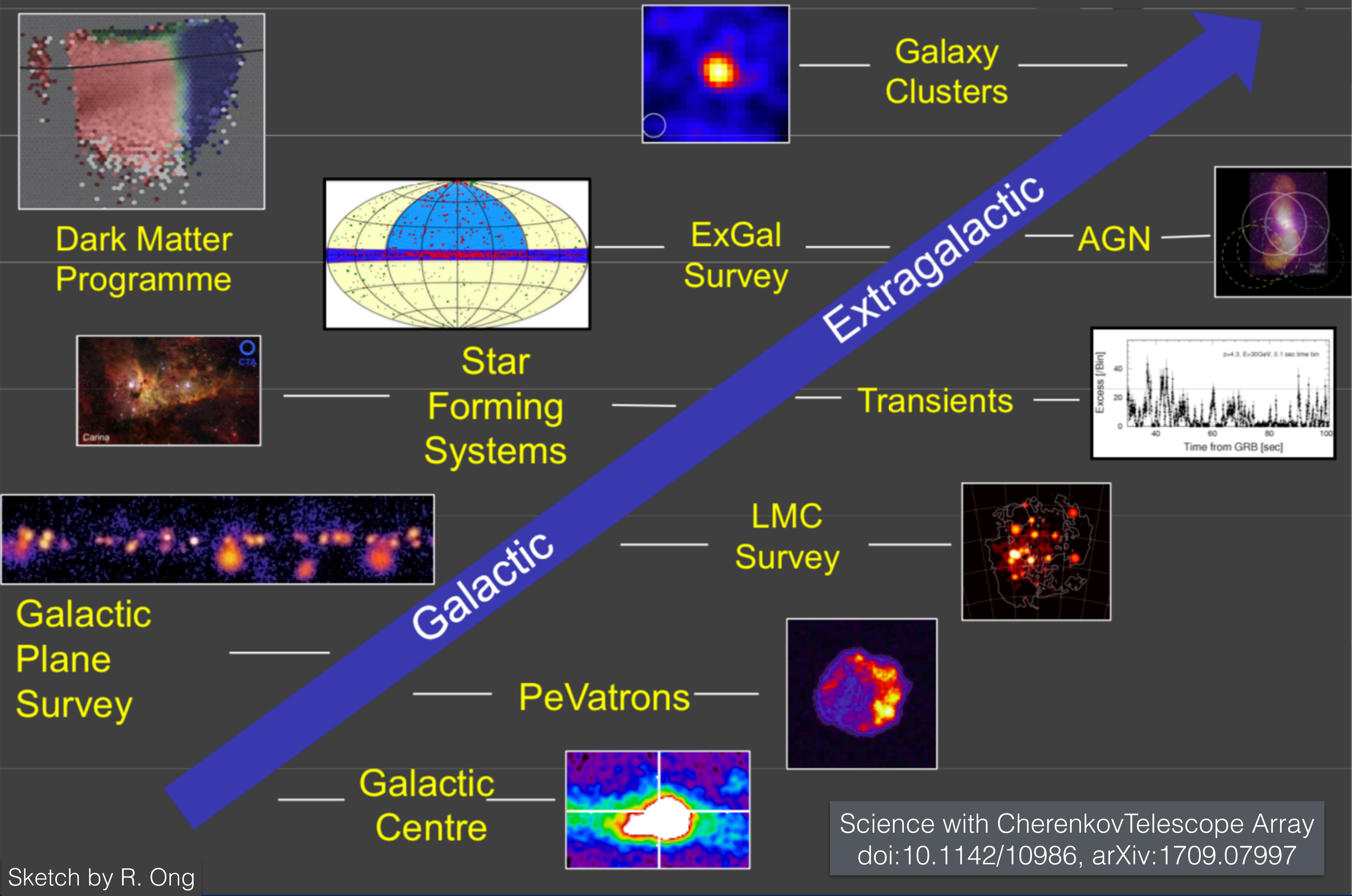
No.	メール番号	所 属 機 関 Affiliation	部局名 Institute	研究代表者 Name	研　究　課　題 Title of the Research	2019 Final (K Yen) Research Fee	 Travel Fee	 Total	備考(事務)(メール番号) 2019/1/8/17:00締切	採択課題可
E01	70	東京大学	宇宙線研究所	Teshima Masahiro	CTA Project	800	1.200	2.000	・ラパルマ ・大型計算機	可
E02	84	京都大学	基礎物理学研究所	Ioka Kunihito	CTA-Japan Physics Research	0	250	250	・大型計算機	可
E03	18	甲南大学	理工学部	Yamamoto Tokonatsu	Development of Focal Plane Instruments for the CTA Large Sized	0	400	400	・ラパルマ	可
E04	97	京都大学	大学院理学研究科　物理学第二教室	Kubo Hidetoshi	Commissioning of the camera on the first LST of CTA	0	800	800	・ラパルマ ・E-97(1位) ・E-98(2位) ・課題名変更	可
E05	69	東京大学	宇宙線研究所	DANIEL MAZIN	Installation and commissioning of the first Large Size Telescope of CTA in La Palma, Canary Islands, Spain	0	500	500	・ラパルマ ・様式3必要なし:CTA−特定事業費	可
E06	2	東京大学	宇宙線研究所	DANIELA HADASCH	Set-up and Commissioning of the onsite data center for CTA North in La Palma,Spain	400	0	400	・ラパルマ ・様式3必要なし:研究所研究員	可
E07	73	名古屋大学	宇宙地球環境研究所	Tajima Hiroyasu	Development of camera for CTA small-sized telescope	300	150	450	・大型計算機	可
E08	96	東京大学	宇宙線研究所	Ohishi Michiko	CTA Monte Carlo Simulation	0	200	200	・大型計算機	可
E09	45	東海大学	理学部	Nishijima Kyoshi	Localization of very high energy gamma-ray emission region in an active galattic nuclei	0	400	400	・ラパルマ	可
E10	98	京都大学	大学院理学研究科　物理学第二教室	Kubo Hidetoshi	Stady of High Energy Gamma-ray Objects with the MAGIC telescope	0	500	500	・ラパルマ ・E-97(1位) ・E-98(2位)	可
E11	112	東京大学	宇宙線研究所	Saito Takayuki	Early phase observations with CTA Large Sized Telescope	0	500	500	・ラパルマ ・様式3必要なし:CTA−特定事業費	可

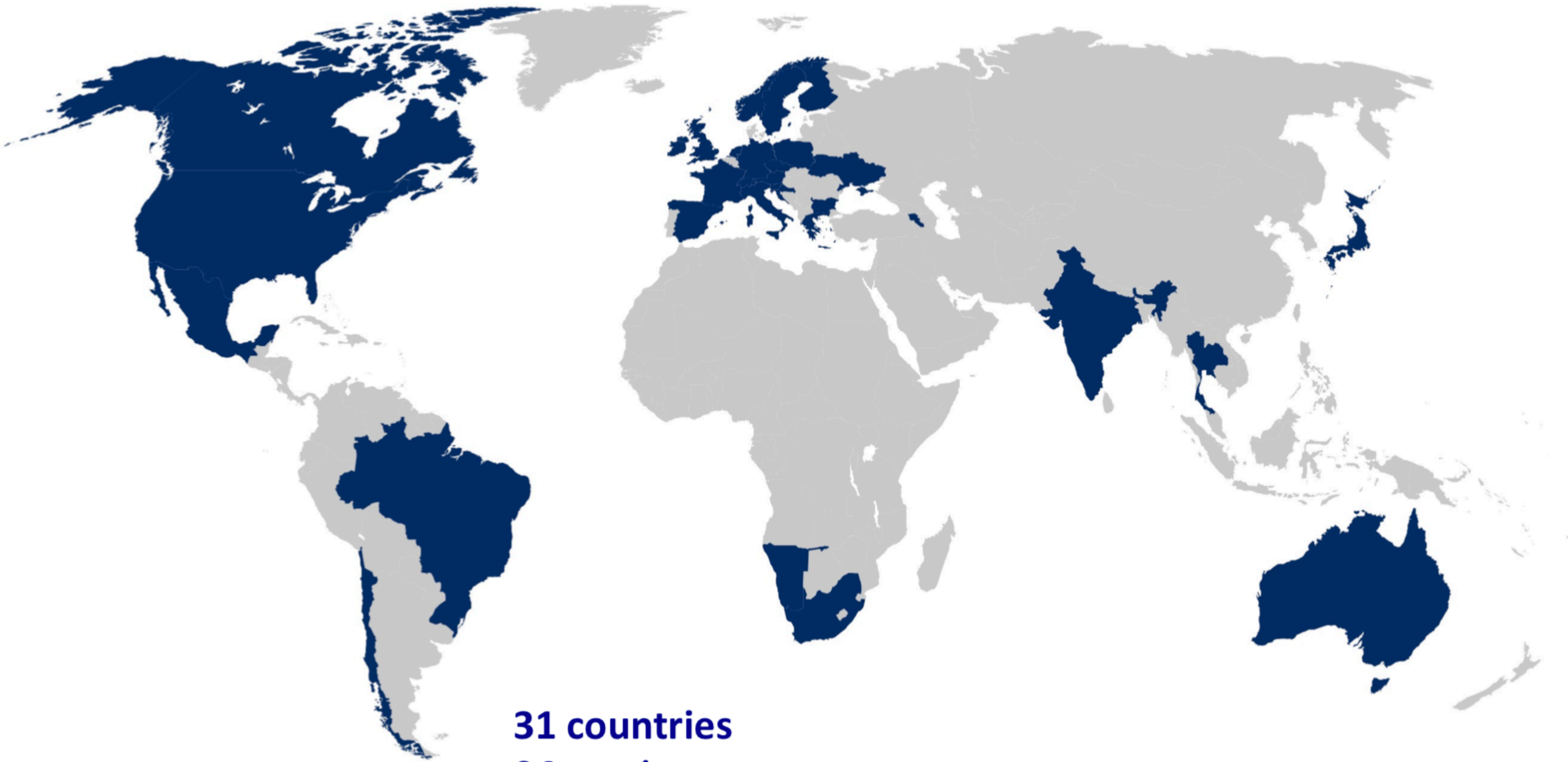
Introduction: perspective



Key Science Topics



CTA Consortium



31 countries
94 parties
206 institutes
1501 members (535 FTE)

as of June 2019

CTA layout

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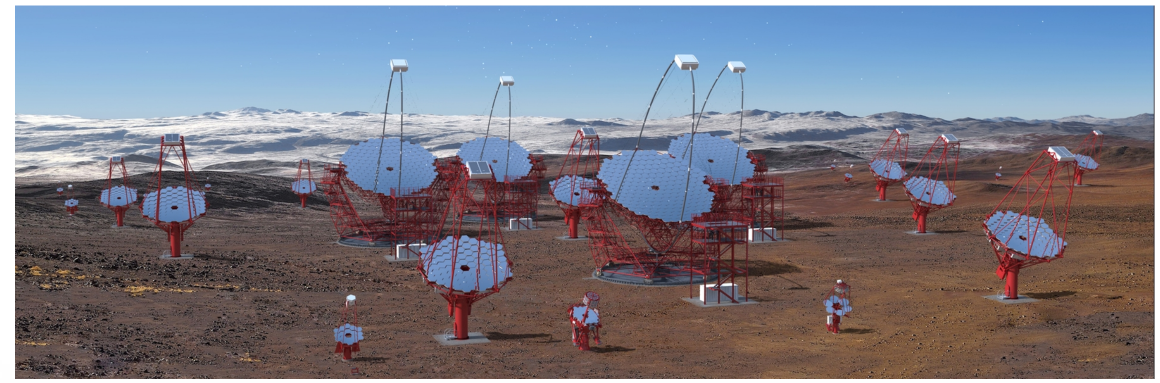
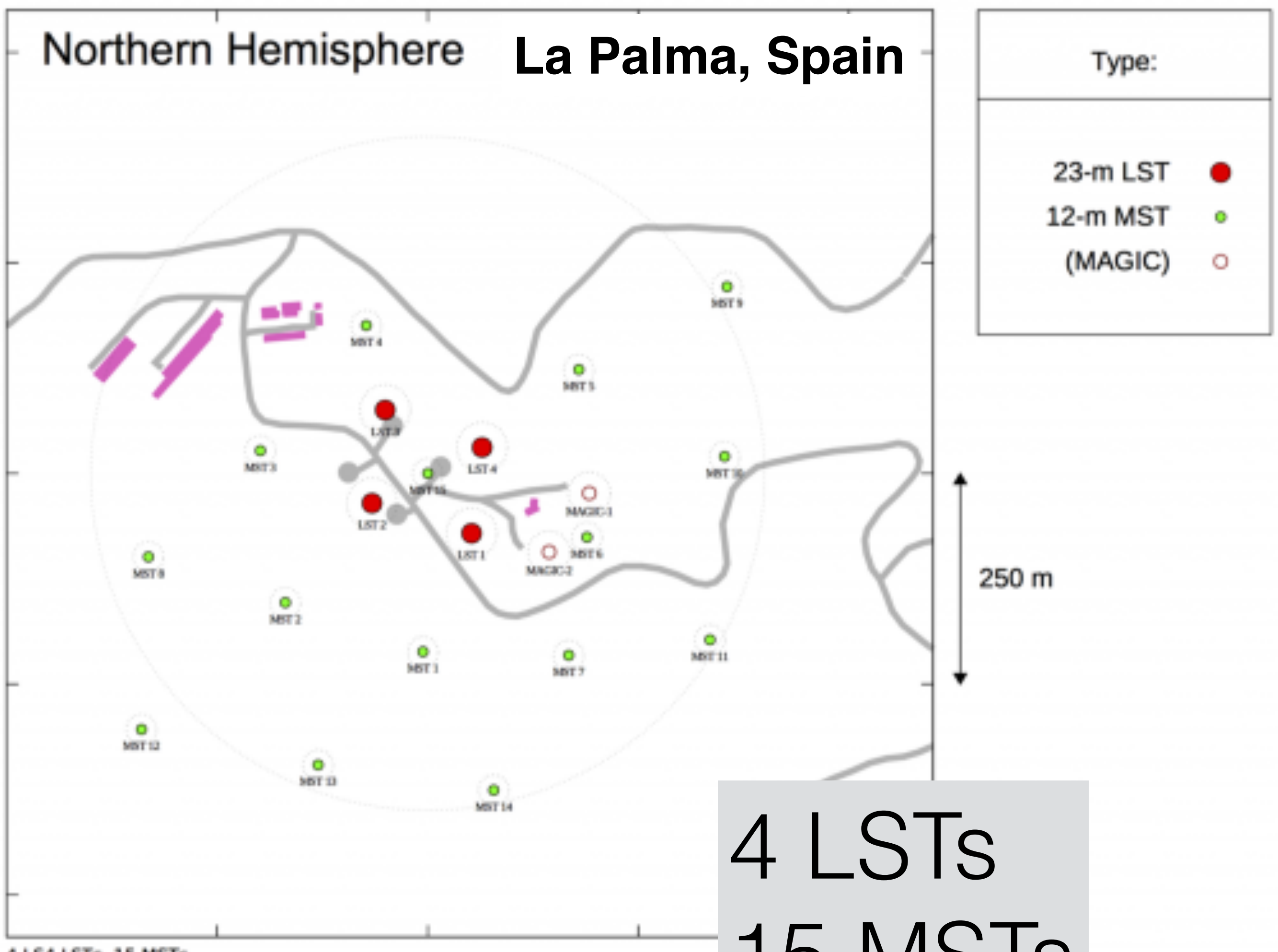
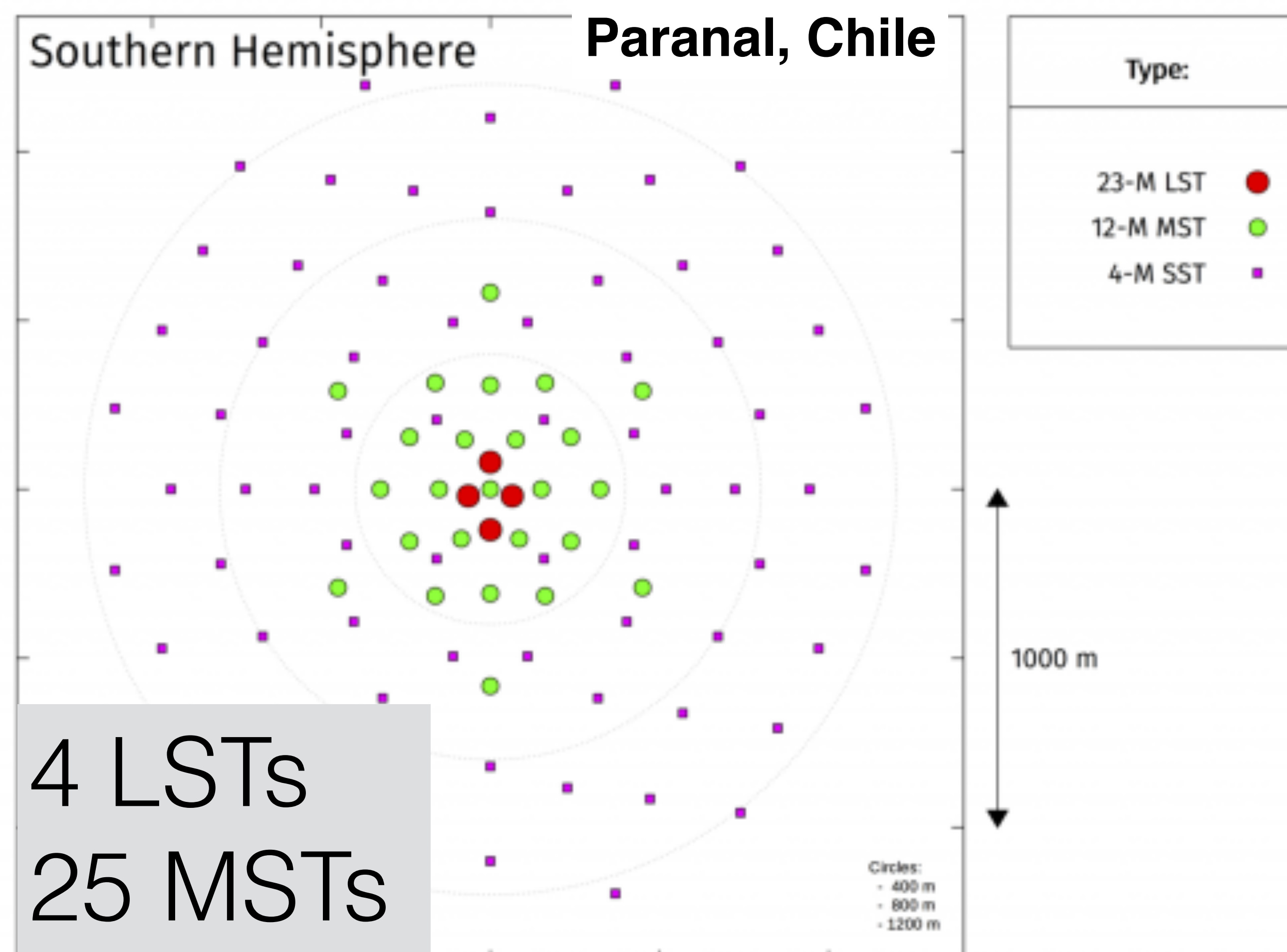


La Palma, Spain



4 LSTs
15 MSTs

Paranal, Chile



4 LSTs
25 MSTs
70 SSTs

CTA telescope prototypes

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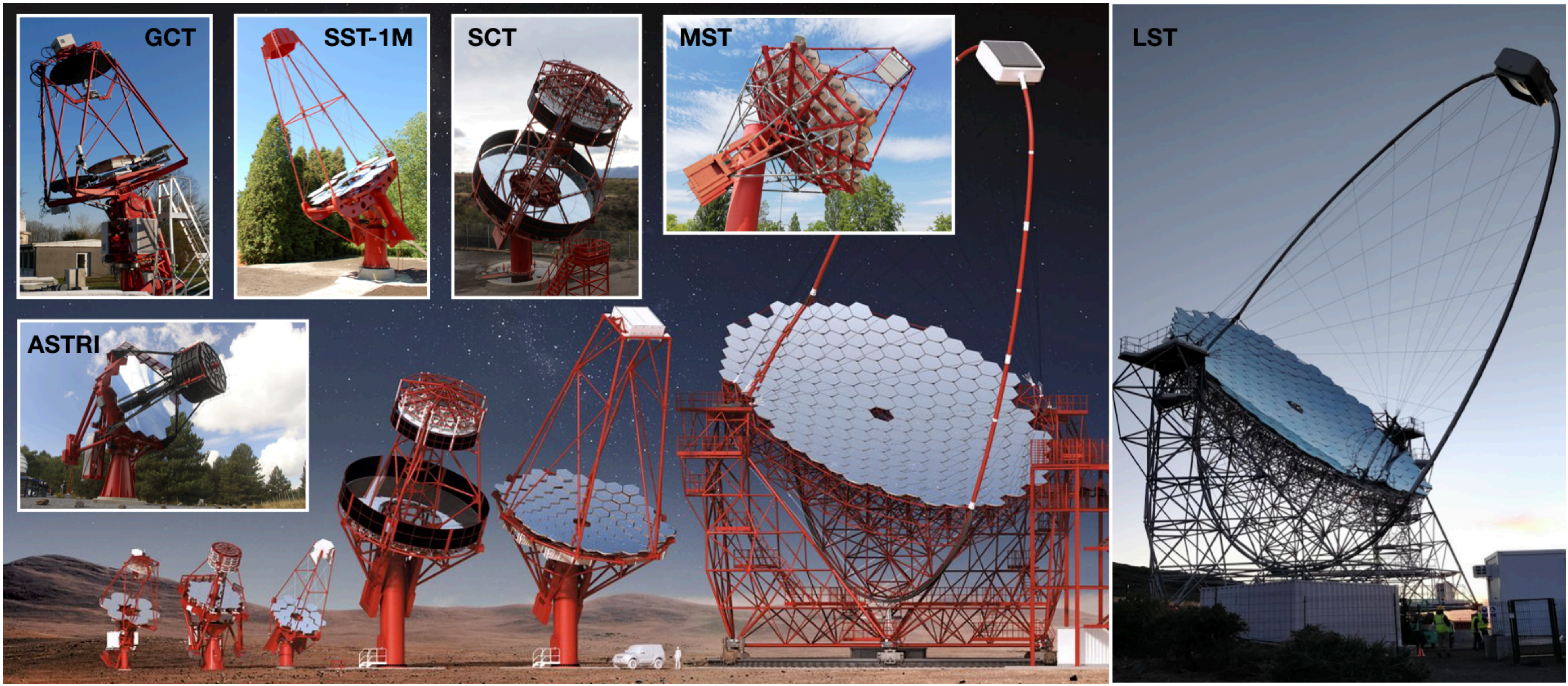
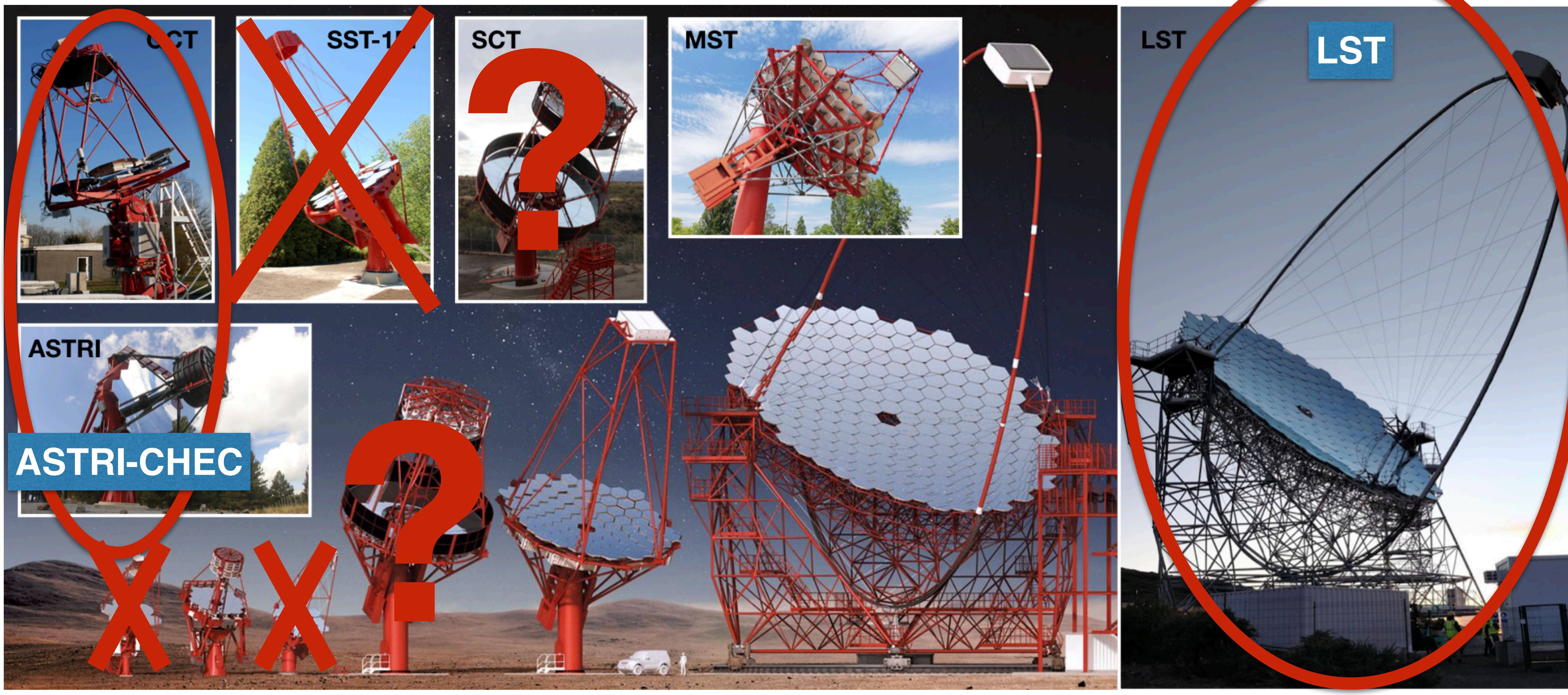
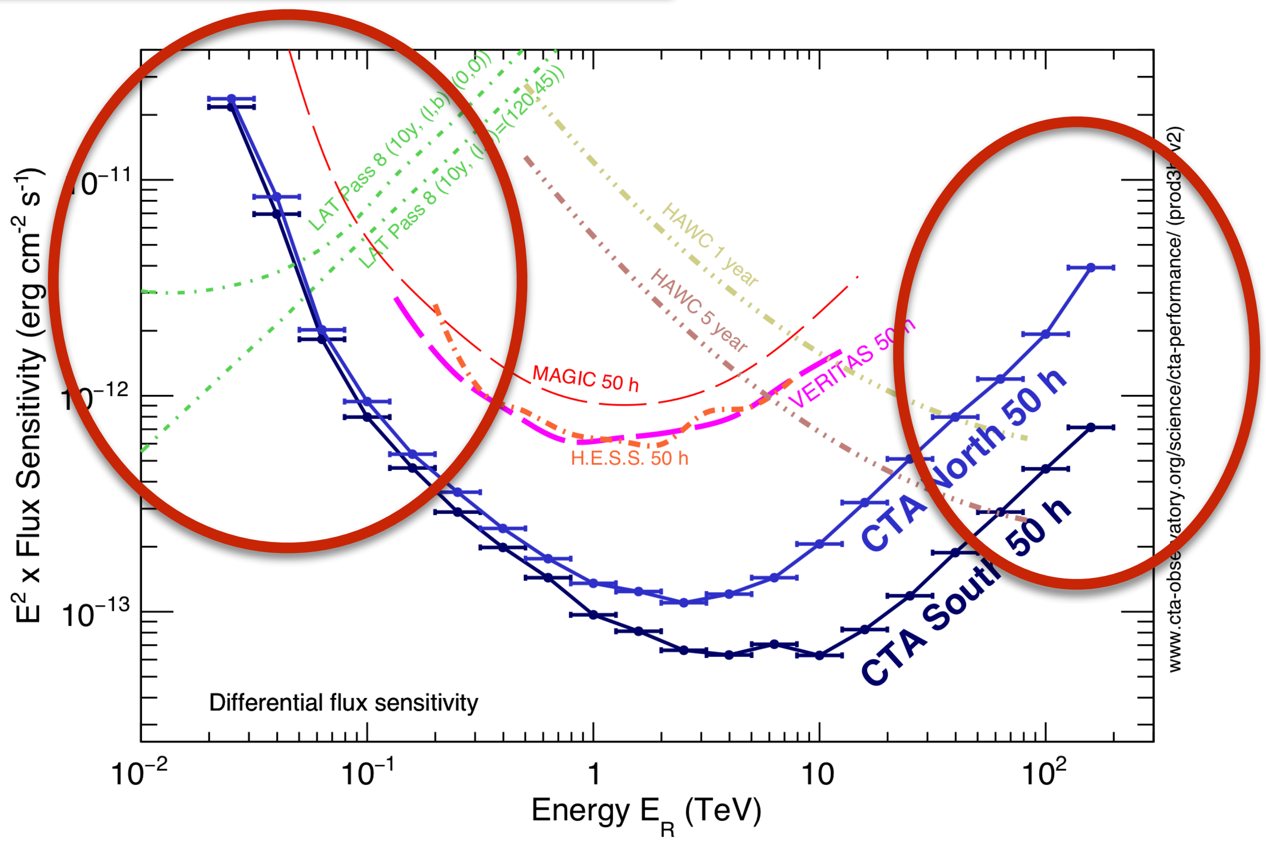


CTA telescope prototypes

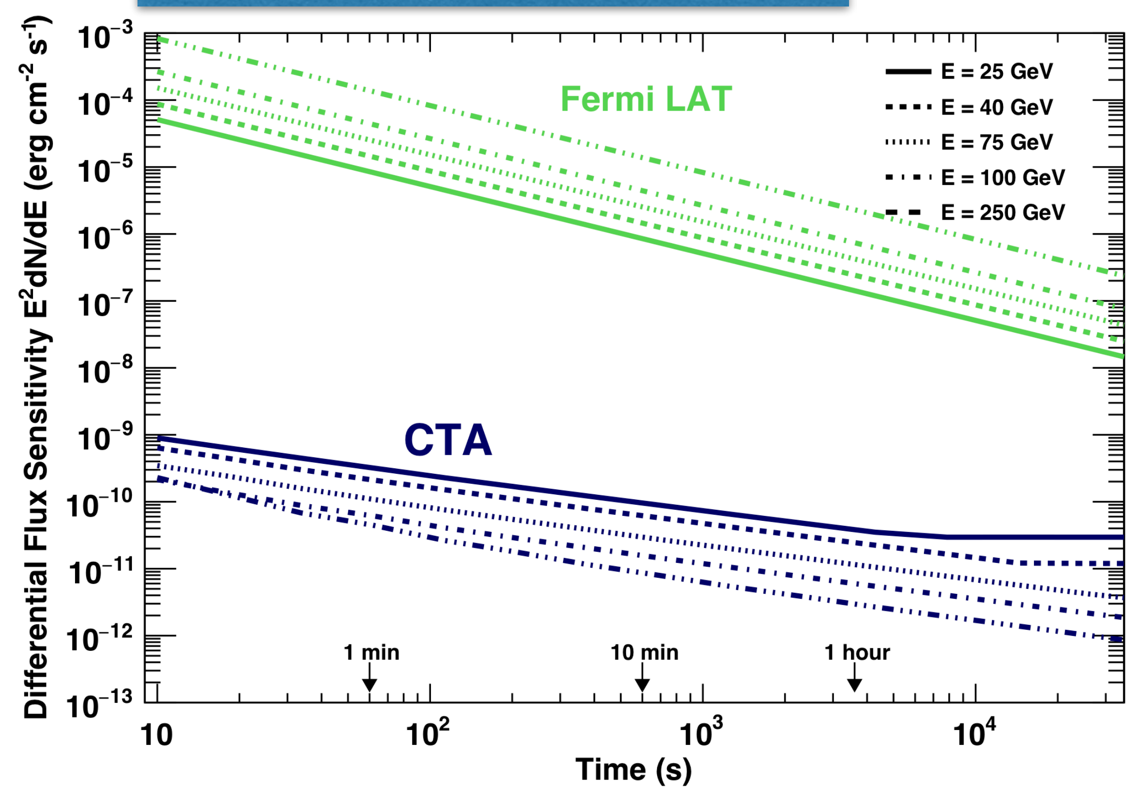


Motivation

energy flux sensitivity

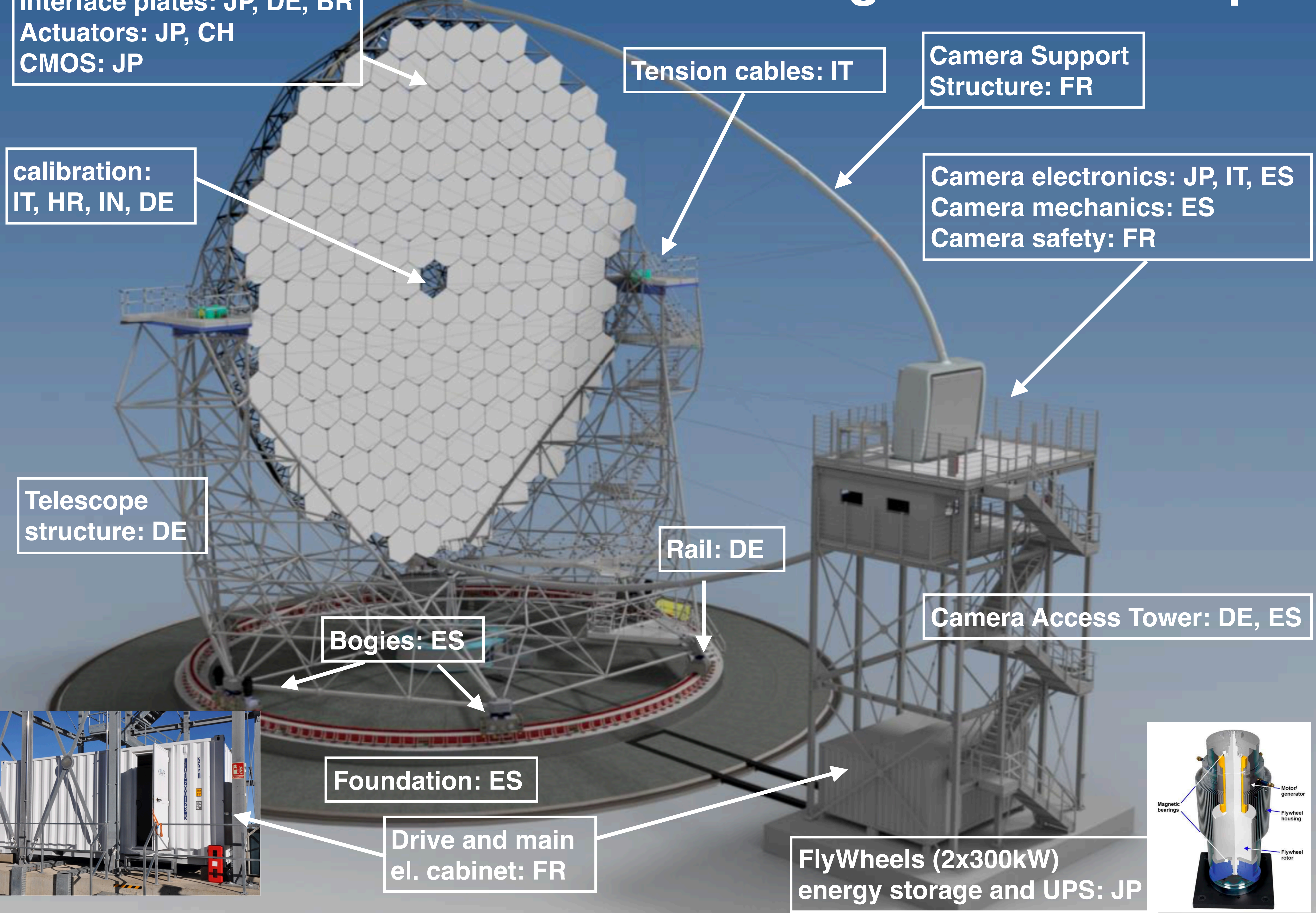


sensitivity versus time



- LST is optimised for
  - low energy gamma rays (increasing accessible volume of the universe)
  - rapid slewing speed (for transients like GRBs)
- SST is optimized for very high energies: Cosmic Rays and PeVatrons!

Large Size Telescope

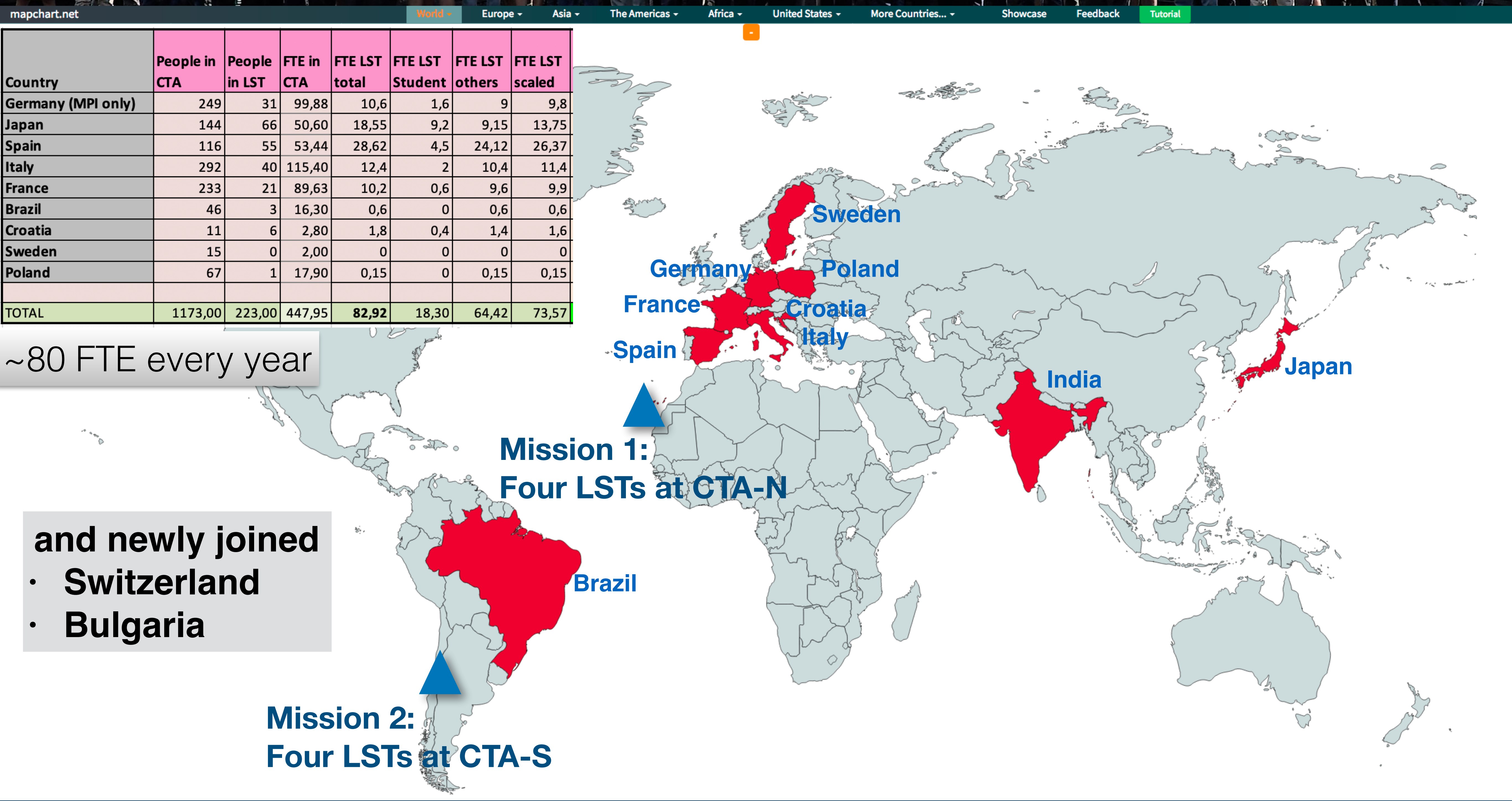


Picture from LST meeting, 2018

LST sub-consortium

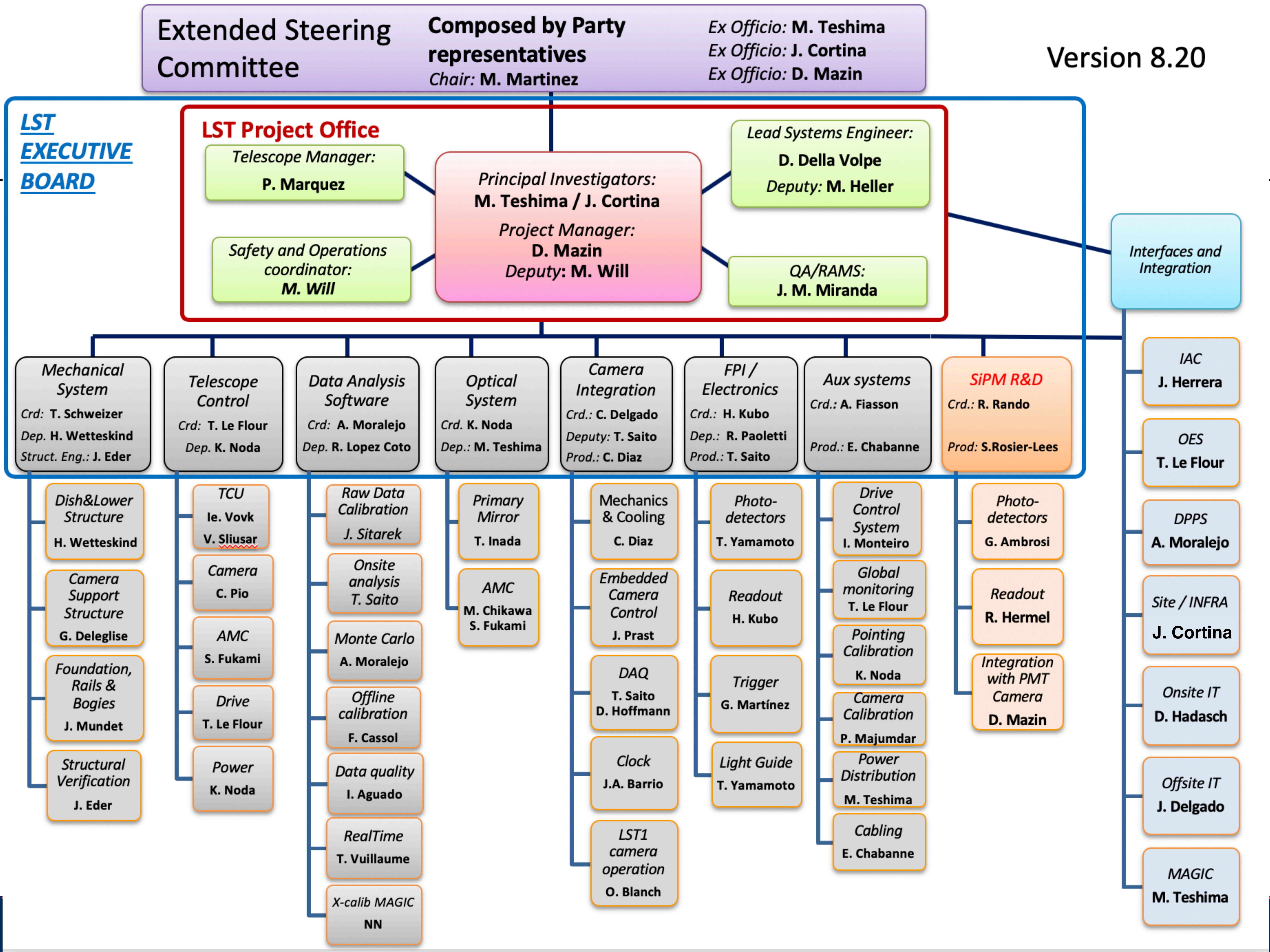
Country	People in CTA	People in LST	FTE in CTA	FTE LST total	FTE LST Student	FTE LST others	FTE LST scaled
Germany (MPI only)	249	31	99,88	10,6	1,6	9	9,8
Japan	144	66	50,60	18,55	9,2	9,15	13,75
Spain	116	55	53,44	28,62	4,5	24,12	26,37
Italy	292	40	115,40	12,4	2	10,4	11,4
France	233	21	89,63	10,2	0,6	9,6	9,9
Brazil	46	3	16,30	0,6	0	0,6	0,6
Croatia	11	6	2,80	1,8	0,4	1,4	1,6
Sweden	15	0	2,00	0	0	0	0
Poland	67	1	17,90	0,15	0	0,15	0,15
TOTAL	1173,00	223,00	447,95	**82,92**	18,30	64,42	73,57

~80 FTE every year

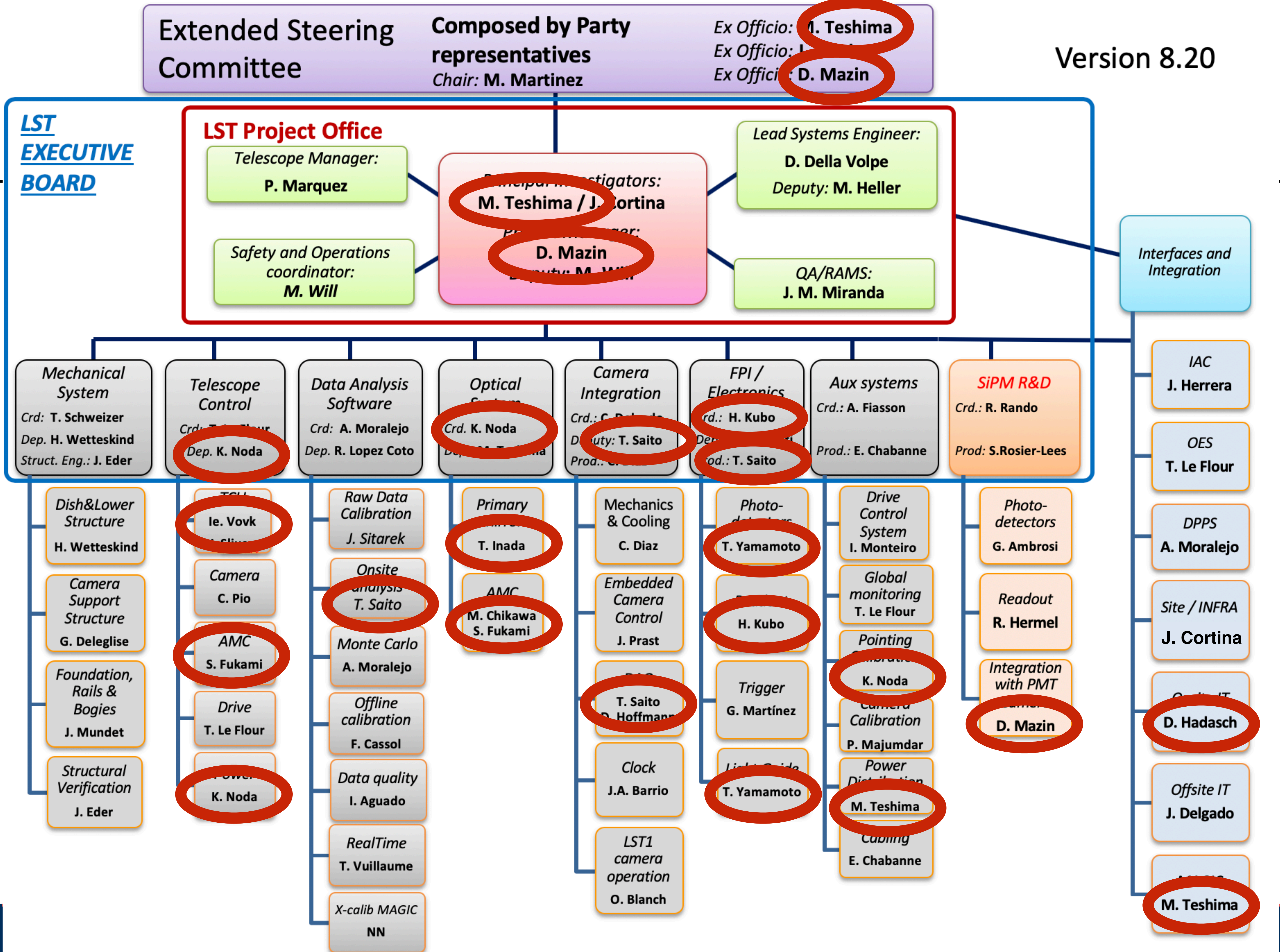


and newly joined

- Switzerland
- Bulgaria



Extended Steering Committee
Composed by Party representatives
Chair: M. Martinez
Ex Officio: M. Teshima
Ex Officio: J. Cortina
Ex Officio: D. Mazin
Version 8.20
LST EXECUTIVE BOARD
LST Project Office
Telescope Manager: P. Marquez
Principal Investigators: M. Teshima / J. Cortina
Project Manager: D. Mazin
Deputy: M. Will
Lead Systems Engineer: D. Della Volpe
Deputy: M. Heller
Safety and Operations coordinator: M. Will
QA/RAMS: J. M. Miranda
Interfaces and Integration
Mechanical System
Crd: T. Schweizer
Dep. H. Wetteskind
Struct. Eng.: J. Eder
Telescope Control
Crd: T. Le Flour
Dep. K. Noda
Data Analysis Software
Crd: A. Moralejo
Dep. R. Lopez Coto
Optical System
Crd. K. Noda
Dep.: M. Teshima
Camera Integration
Crd.: C. Delgado
Deputy: T. Saito
Prod.: C. Diaz
FPI / Electronics
Crd.: H. Kubo
Dep.: R. Paoletti
Prod.: T. Saito
Aux systems
Crd.: A. Fiasson
Prod.: E. Chabanne
SiPM R&D
Crd.: R. Rando
Prod: S.Rosier-Lees
Dish&Lower Structure
H. Wetteskind
Camera Support Structure
G. Deleglise
Foundation, Rails & Bogies
J. Mundet
Structural Verification
J. Eder
TCU
Ie. Vovk
V. Sliusar
Camera
C. Pio
AMC
S. Fukami
Drive
T. Le Flour
Power
K. Noda
Raw Data Calibration
J. Sitarek
Onsite analysis
T. Saito
Monte Carlo
A. Moralejo
Offline calibration
F. Cassol
Data quality
I. Aguado
RealTime
T. Vuillaume
X-calib MAGIC
NN
Primary Mirror
T. Inada
AMC
M. Chikawa
S. Fukami
Mechanics & Cooling
C. Diaz
Embedded Camera Control
J. Prast
DAQ
T. Saito
D. Hoffmann
Clock
J.A. Barrio
LST1 camera operation
O. Blanch
Photo-detectors
T. Yamamoto
Readout
H. Kubo
Trigger
G. Martínez
Light Guide
T. Yamamoto
Drive Control System
I. Monteiro
Global monitoring
T. Le Flour
Pointing Calibration
K. Noda
Camera Calibration
P. Majumdar
Power Distribution
M. Teshima
Cabling
E. Chabanne
Photo-detectors
G. Ambrosi
Readout
R. Hermel
Integration with PMT Camera
D. Mazin
IAC
J. Herrera
OES
T. Le Flour
DPPS
A. Moralejo
Site / INFRA
J. Cortina
Onsite IT
D. Hadasch
Offsite IT
J. Delgado
MAGIC
M. Teshima



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LST1 status

Commissioning Power system

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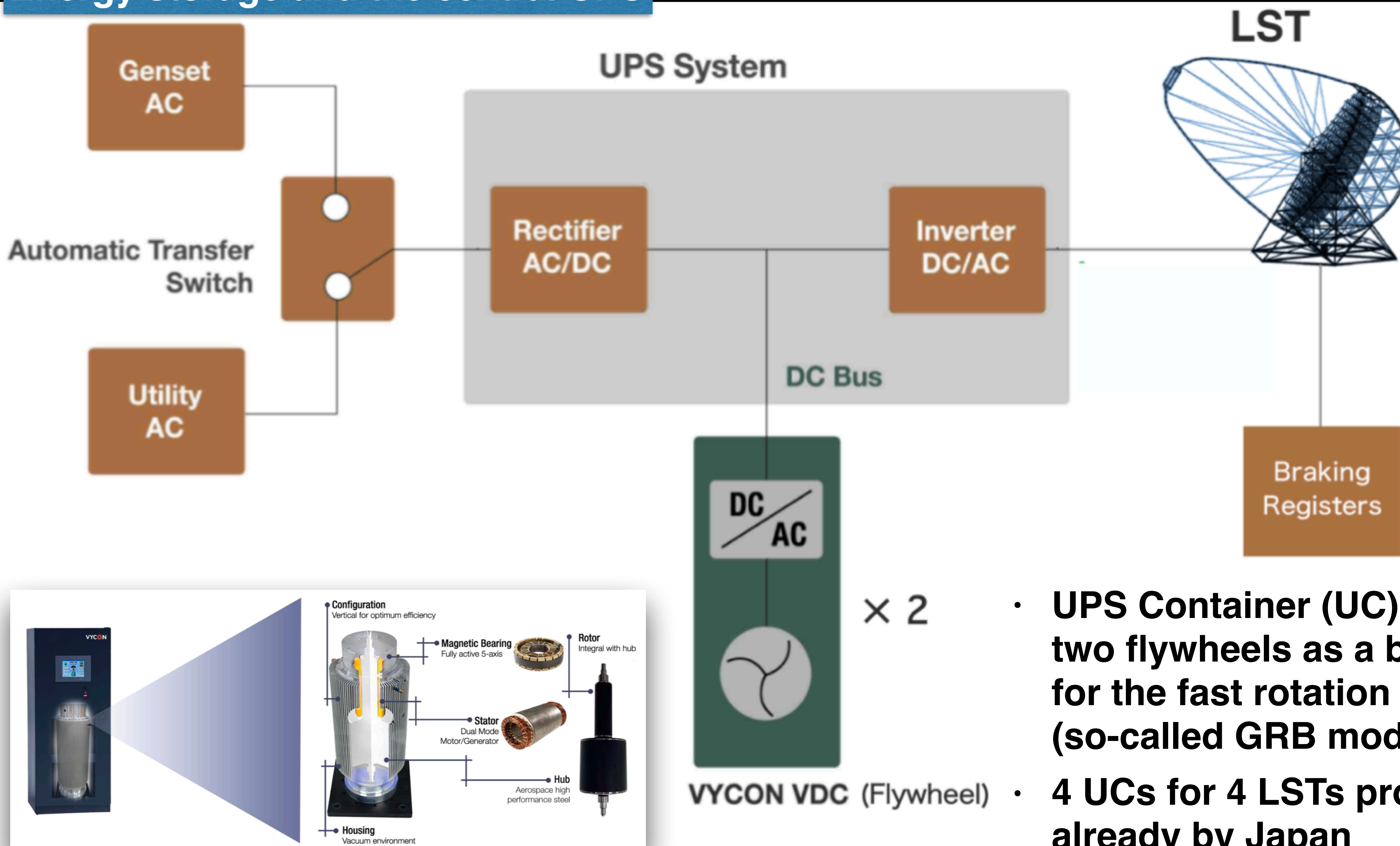
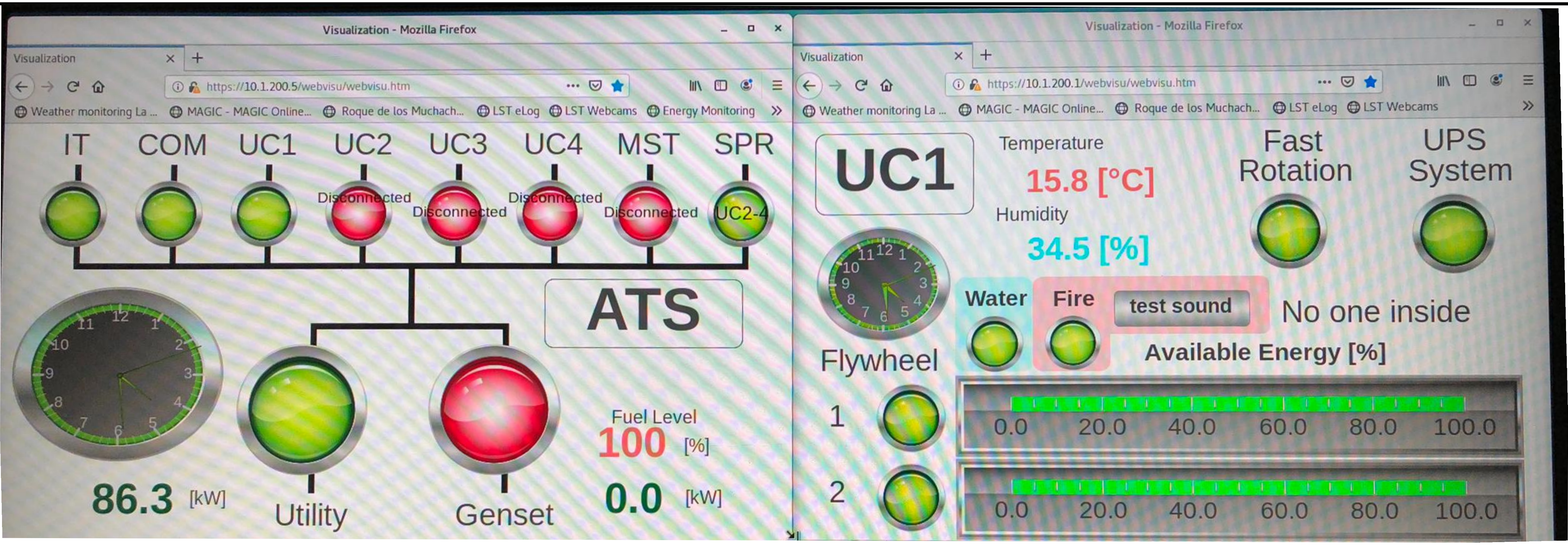
Energy storage and the central UPS



- **UPS Container (UC) with two flywheels as a battery for the fast rotation (so-called GRB mode)**
- **4 UCs for 4 LSTs procured already by Japan**

Commissioning Power system



- Robust monitoring needed for a stable operation of LST1, but also for UC2-4 maintenance
- Improved recently (last week!) for the monitoring UC2-4

Commissioning Power system

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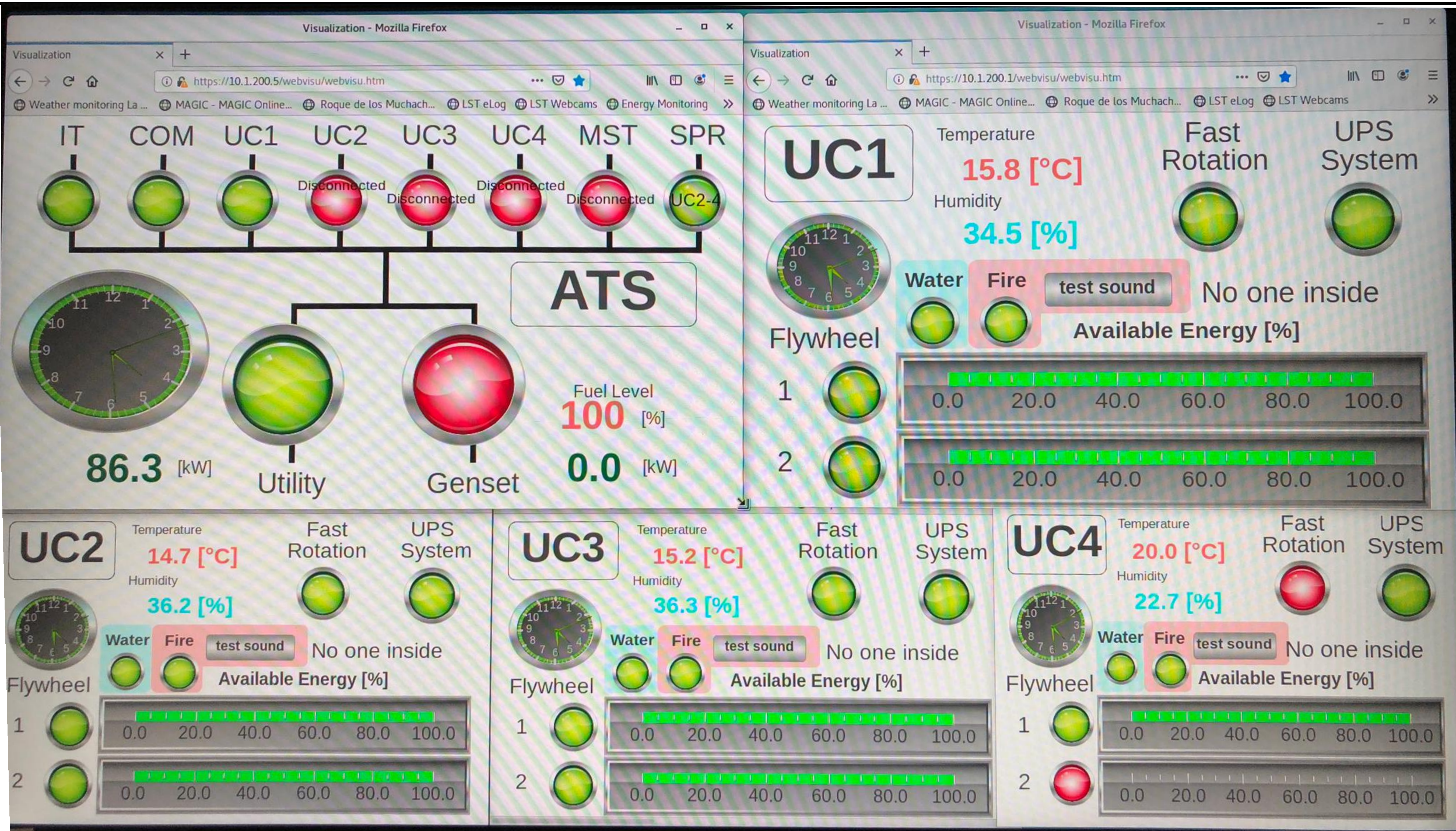

Drive system

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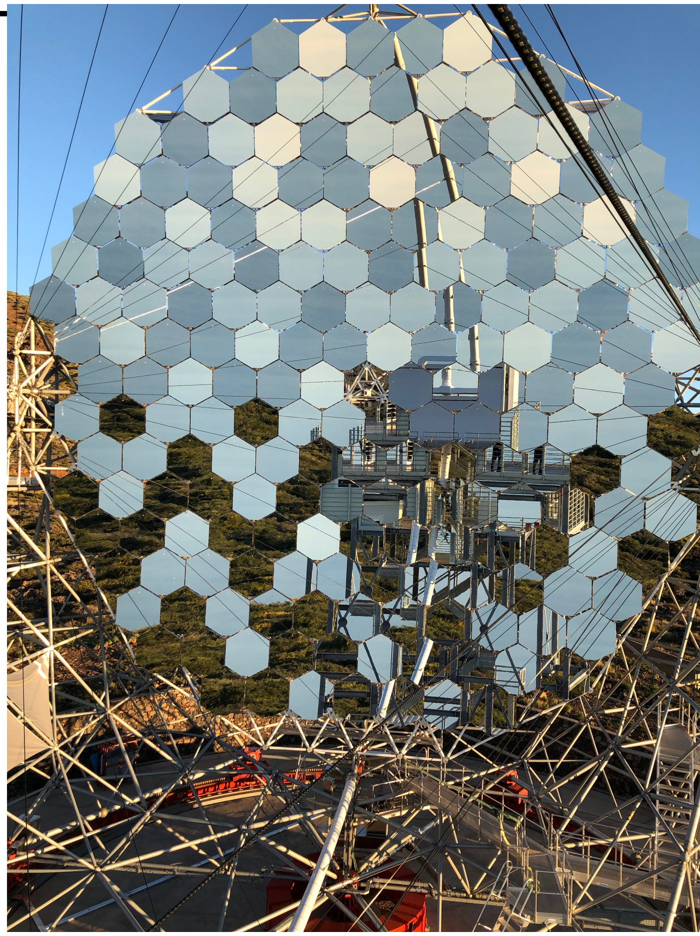
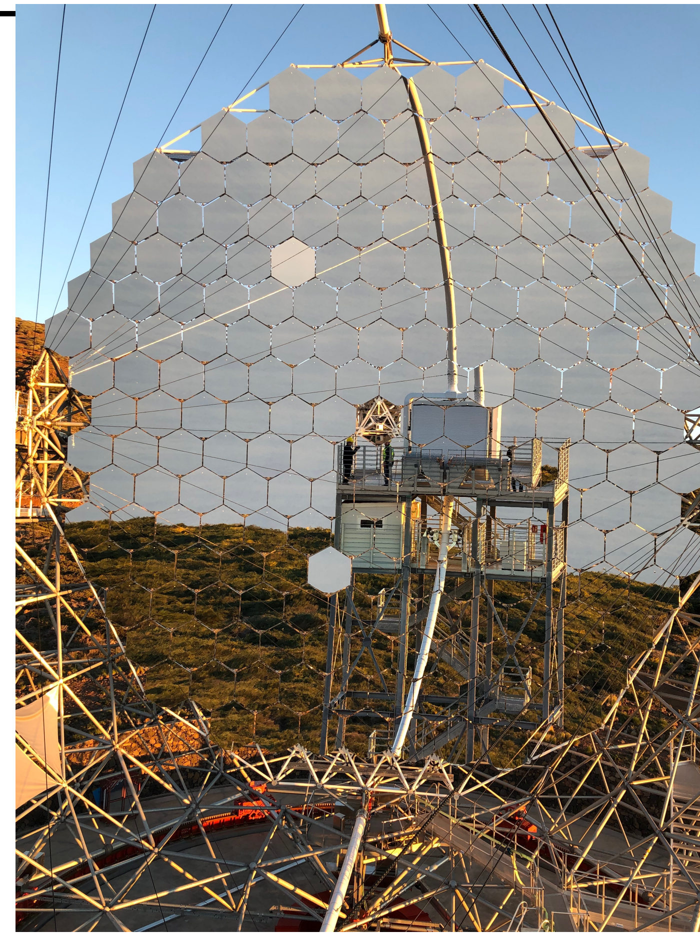
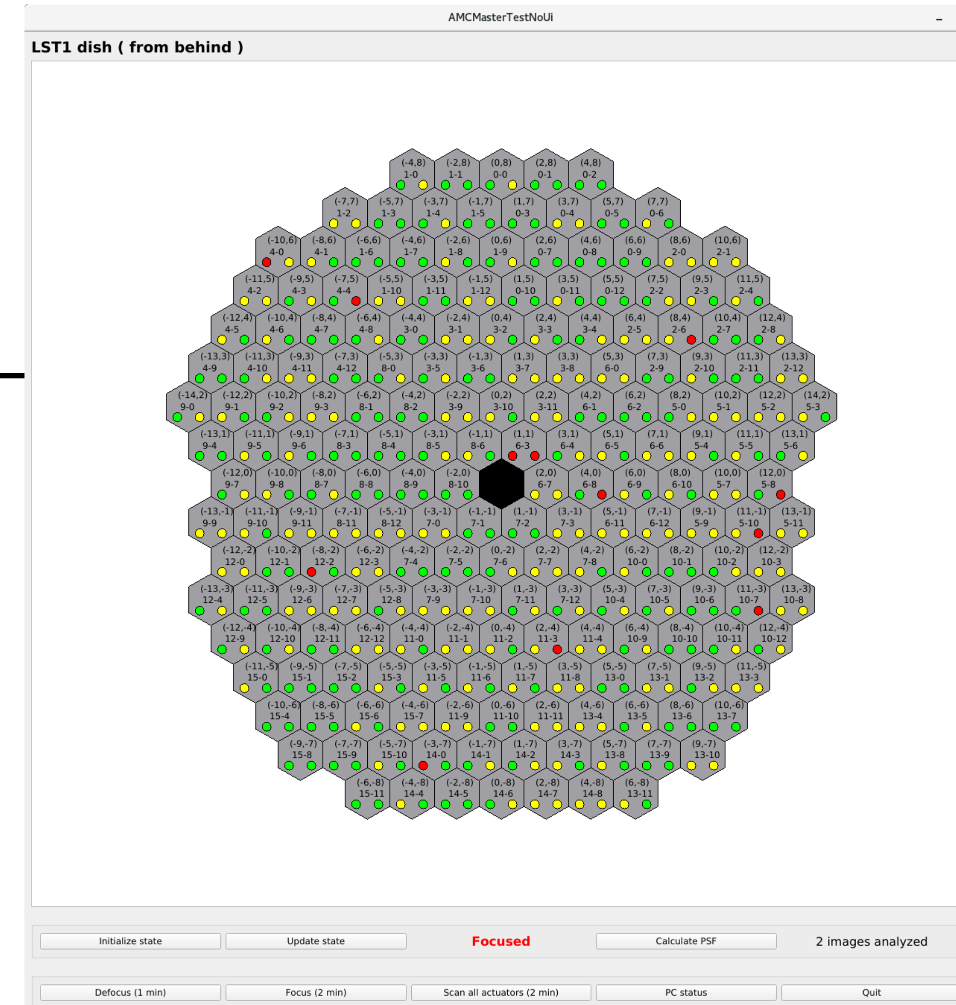
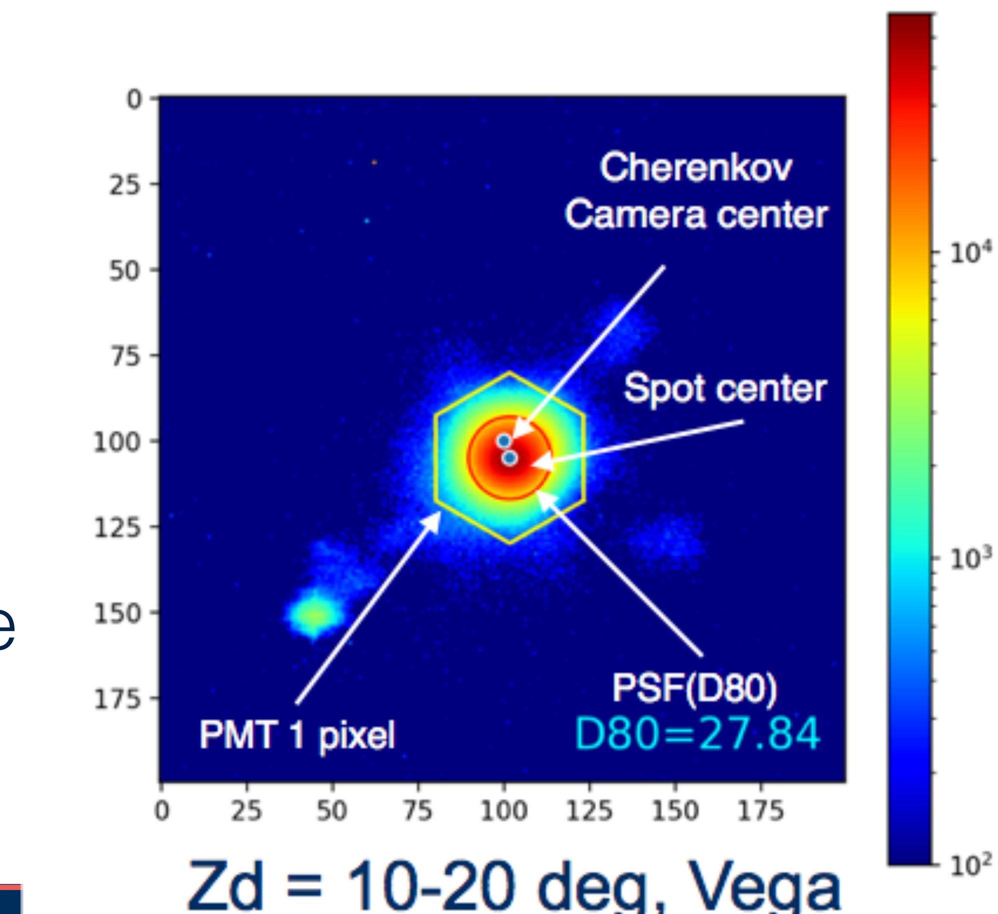
Optics commissioning







- Stable operation with Look-Up Table mode, by an operator-friendly GUI
- PSF within one PMT pixel, close to the requirement. The precision CMOS mode to be implemented
- See Noda talk for details



E04 Camera Commissioning

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Photomultiplier

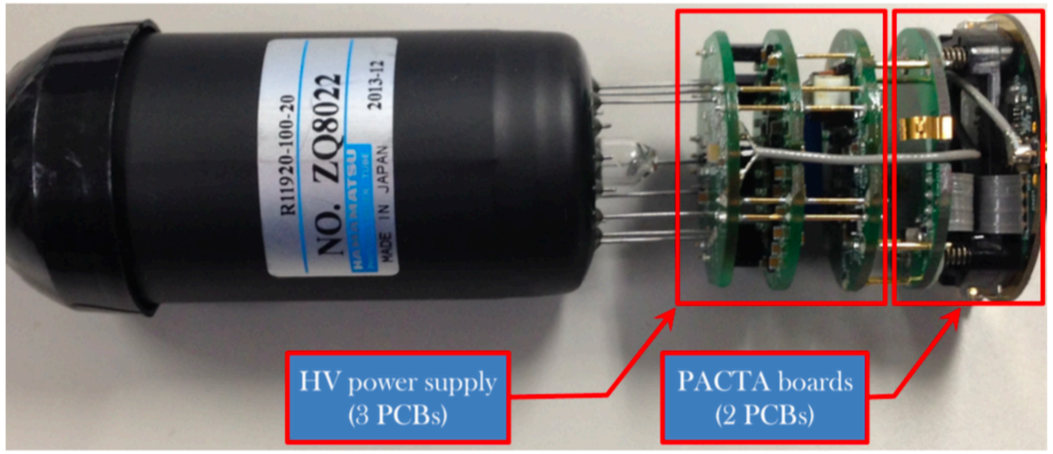
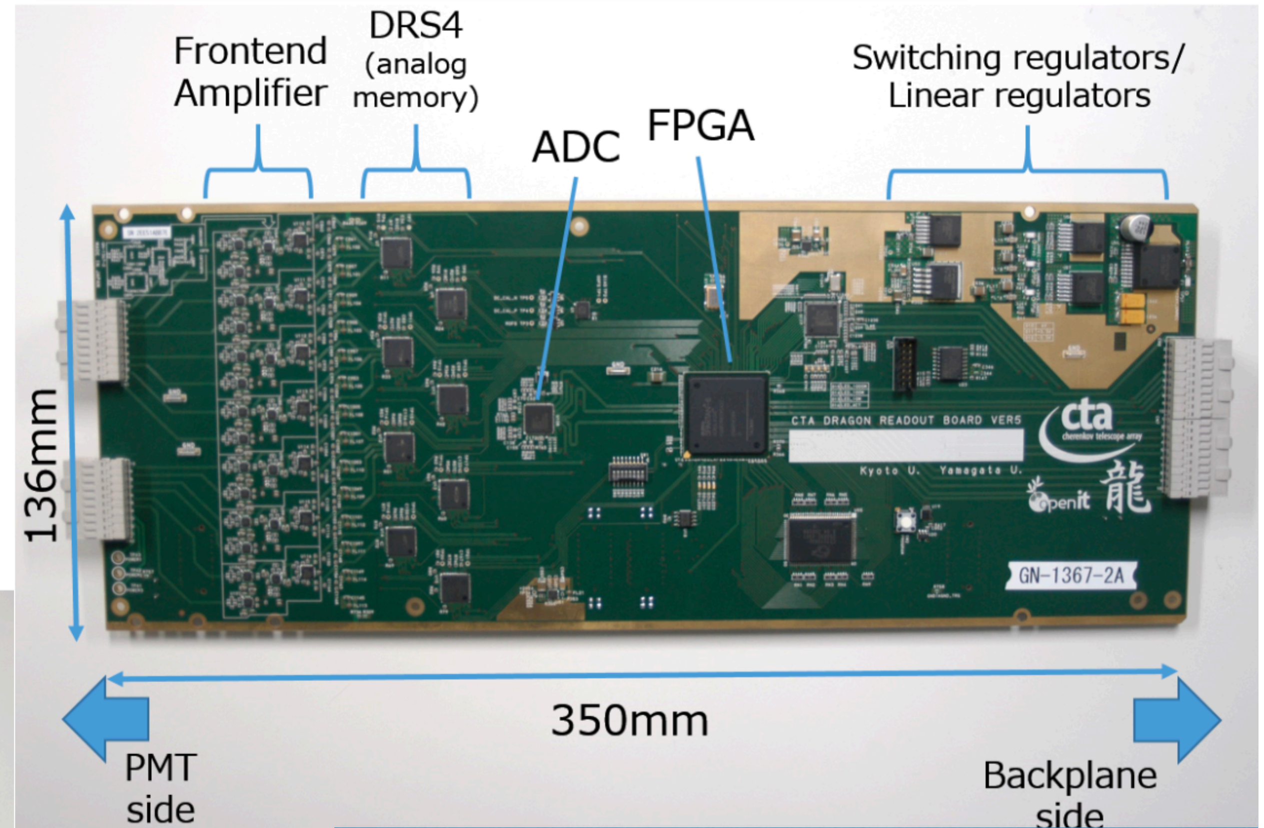
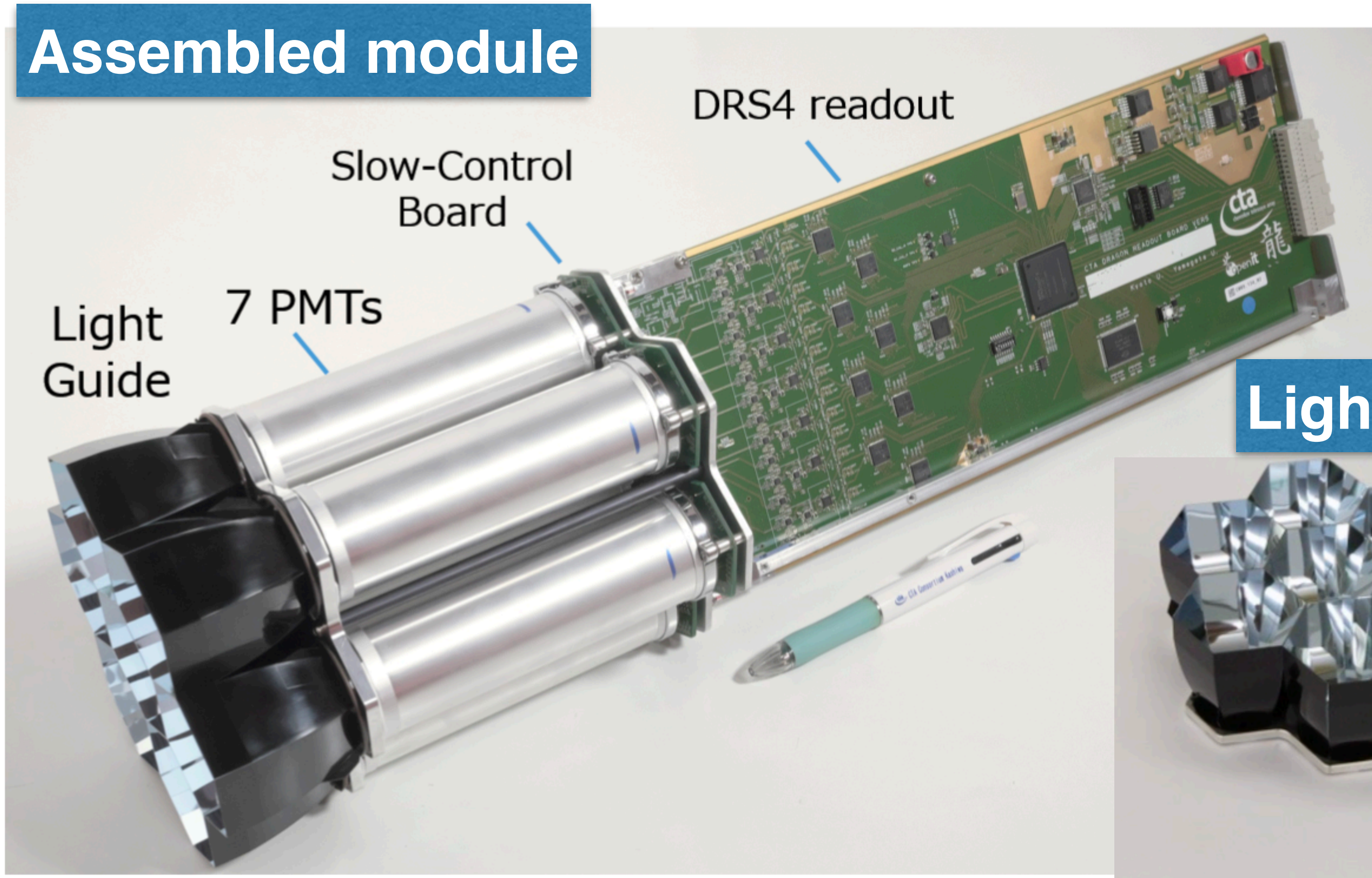


Figure 2.55 – Photo illustrating the arrangement of the *PMT* power supply electronics and *PACTA* boards.

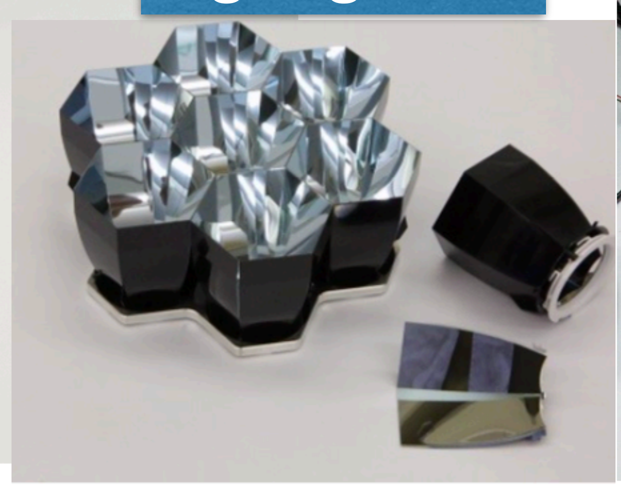
Dragon board (readout board)



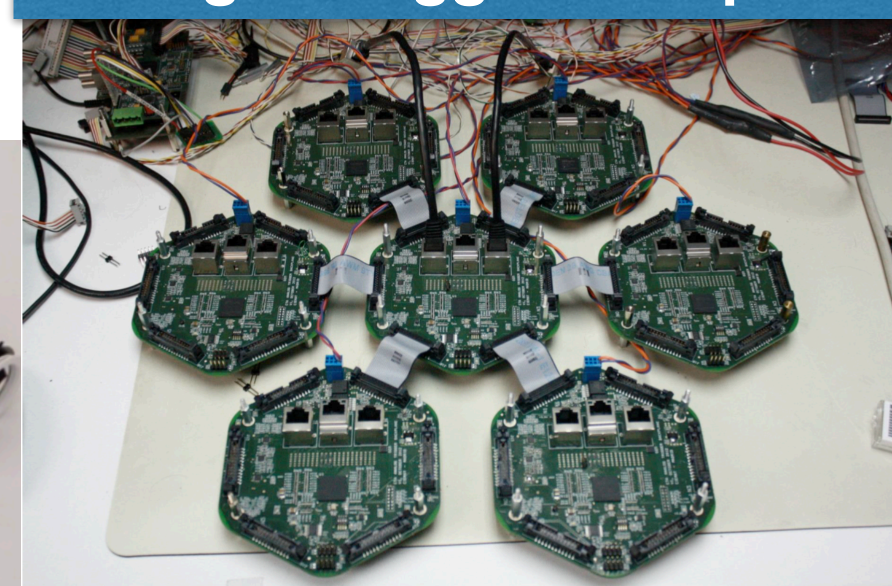
Assembled module



Light guides

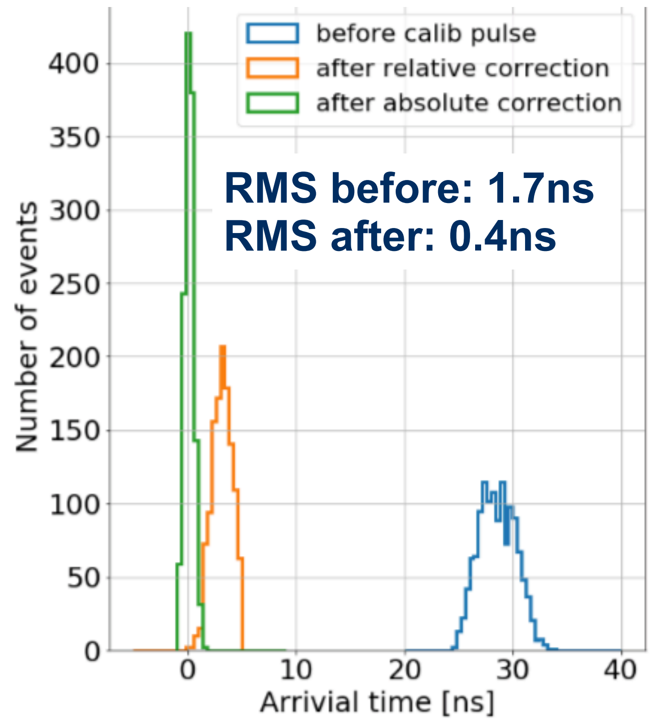


Analogue Trigger Backplanes

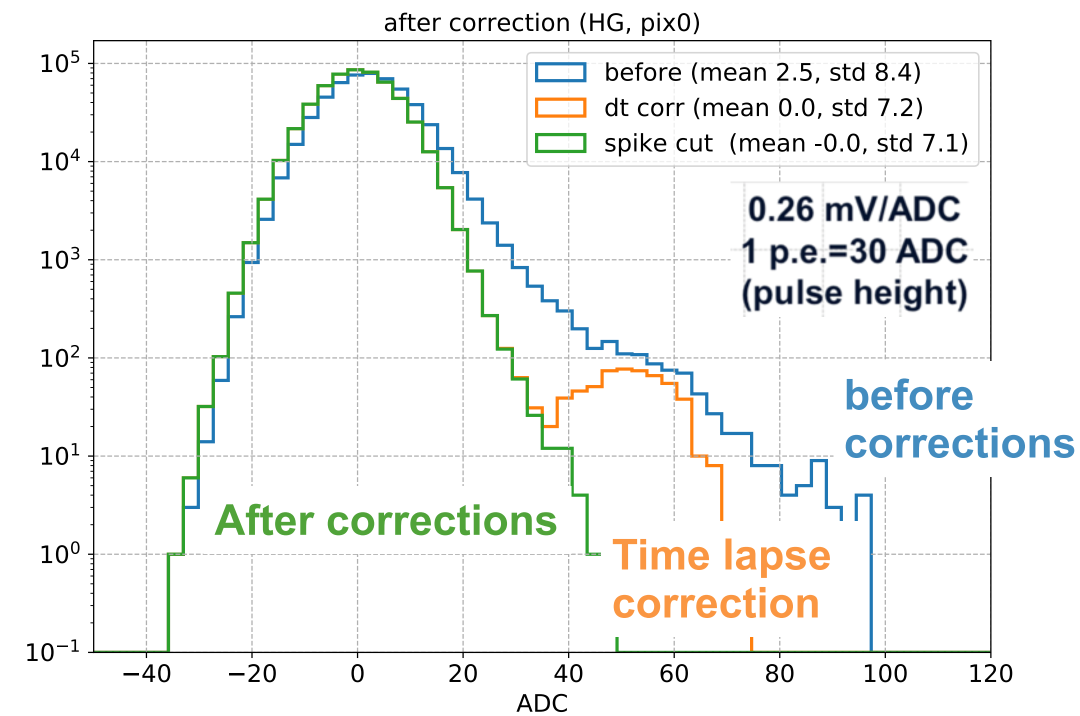


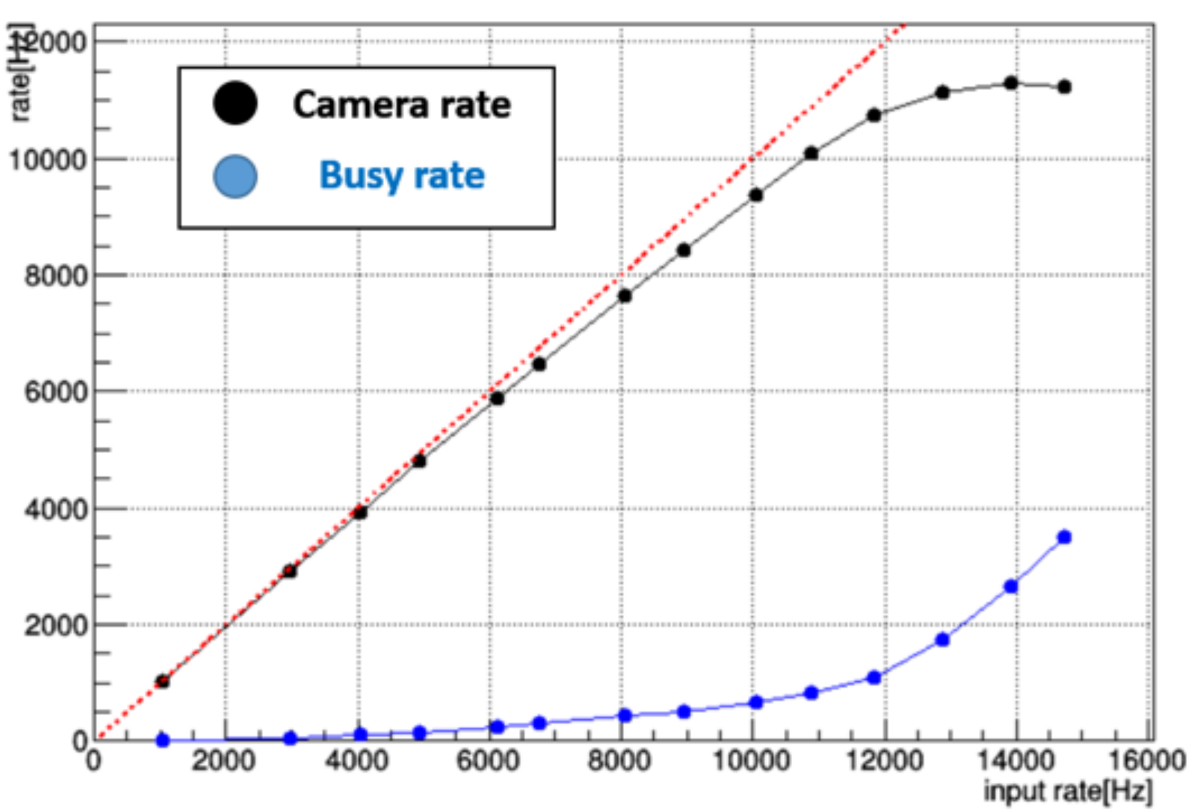
E04 Camera Commissioning

Time resolution, calibration pulses (80p.e)



Electronics noise level





- Noise level
  - 5.9 ADC (0.20p.e.) due to electronics noise
  - 29.5 ADC (0.98p.e.) with HV on in dark patch (dominated by NSB)
- Time accuracy at 400ps level
- Can handle data rates according to specs

E04 Camera Commissioning

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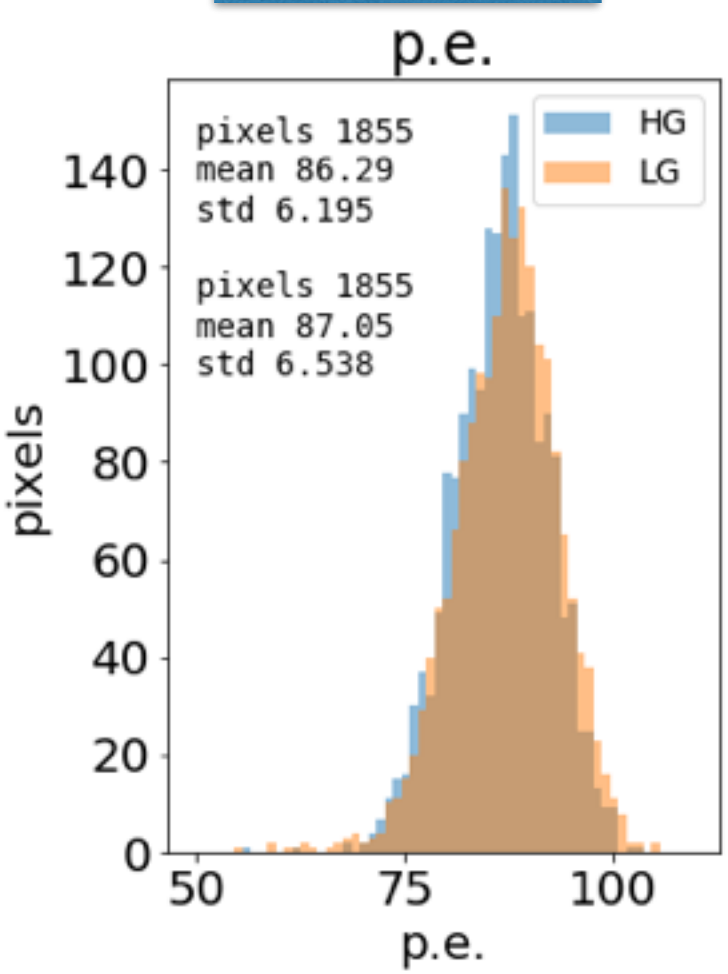
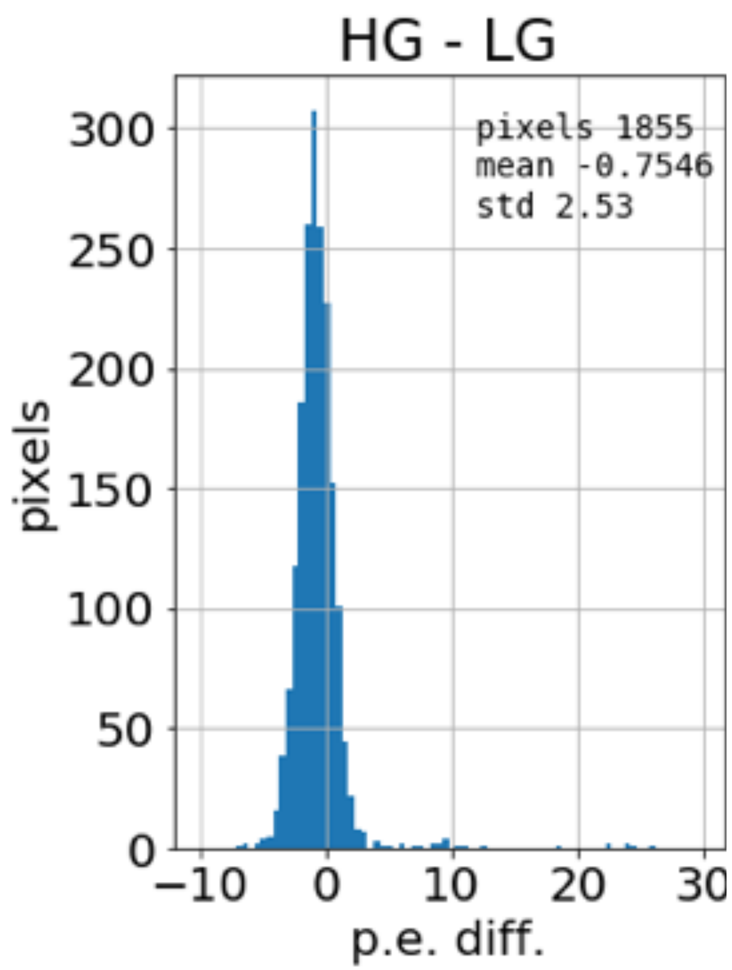
- Camera charge flatfielding (same light intensity produces same signal strength in readout channel) successful and is stable over months
- The readout has two gains — high gain (HG) and low gain (LG) — to increase dynamical range. X-calibration between the HG and LG is achieved on a level of 1% agreement

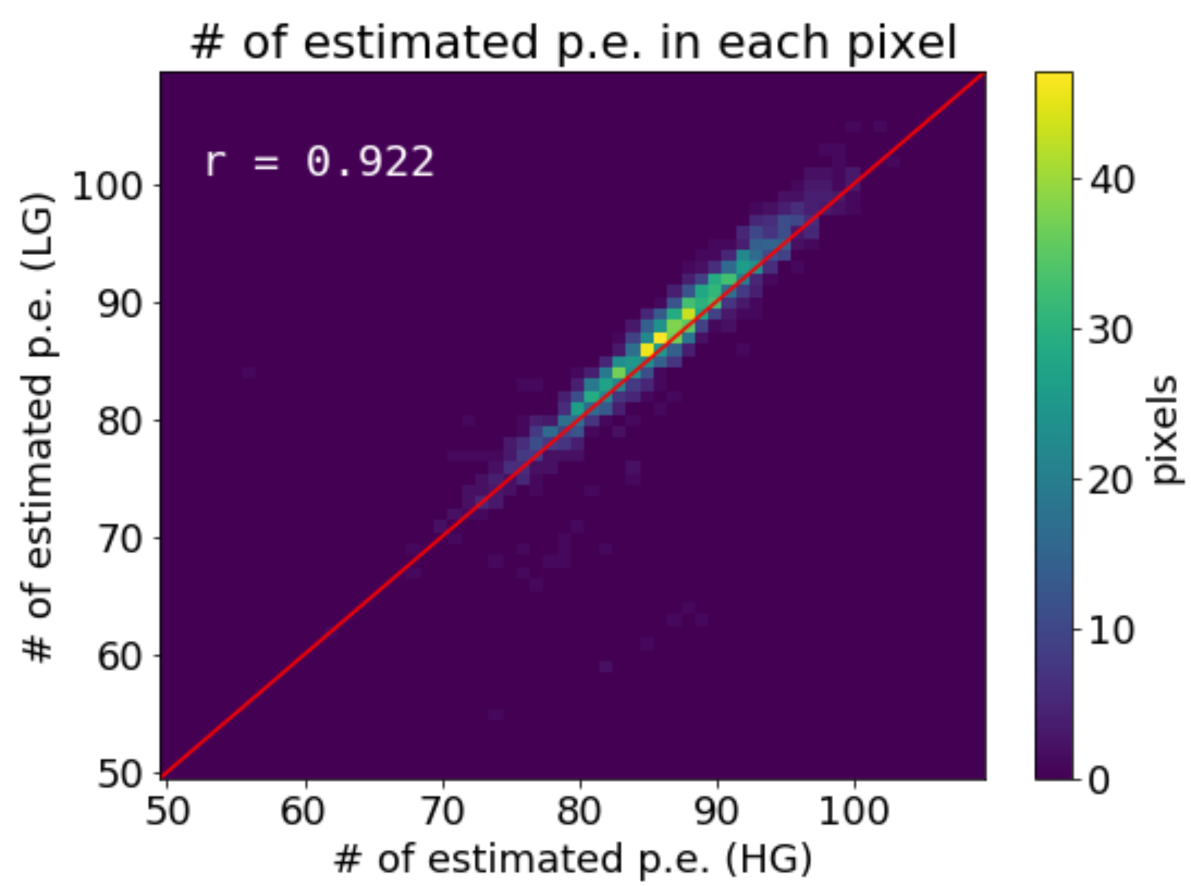
Q flatfielding



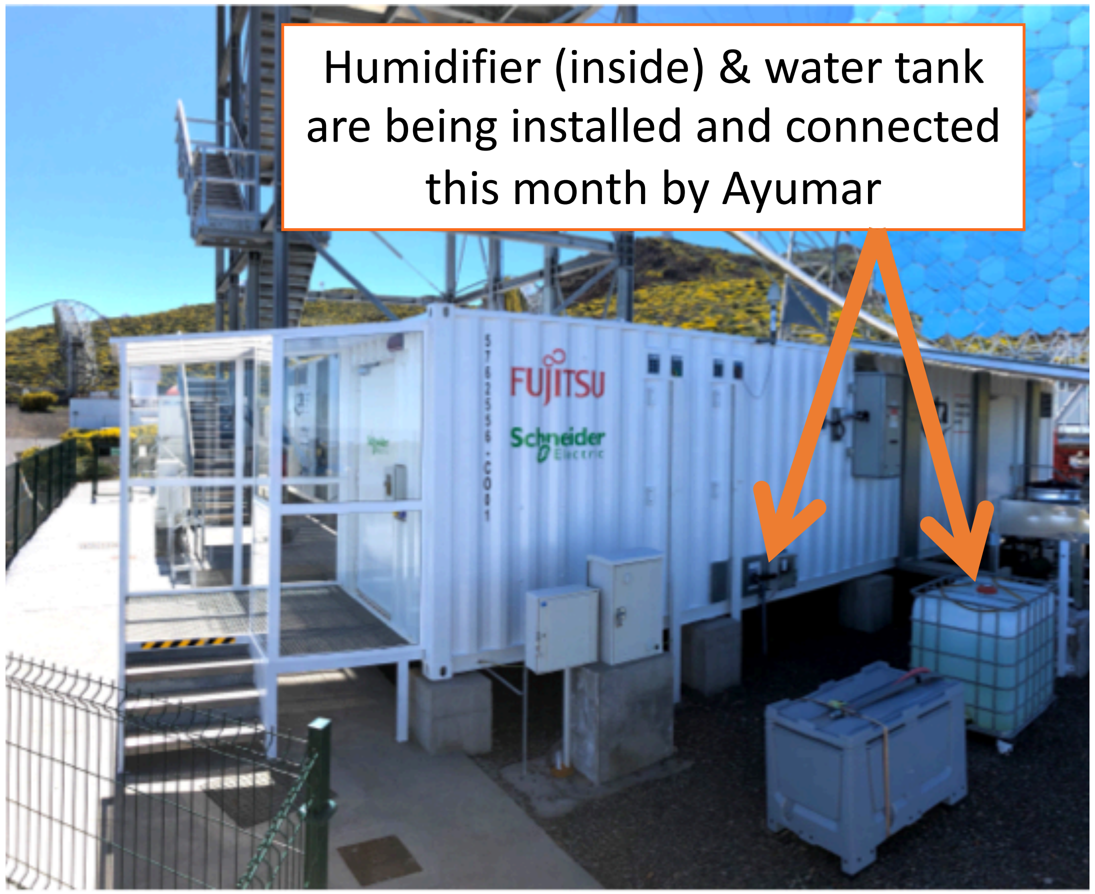
HG / LG calibration

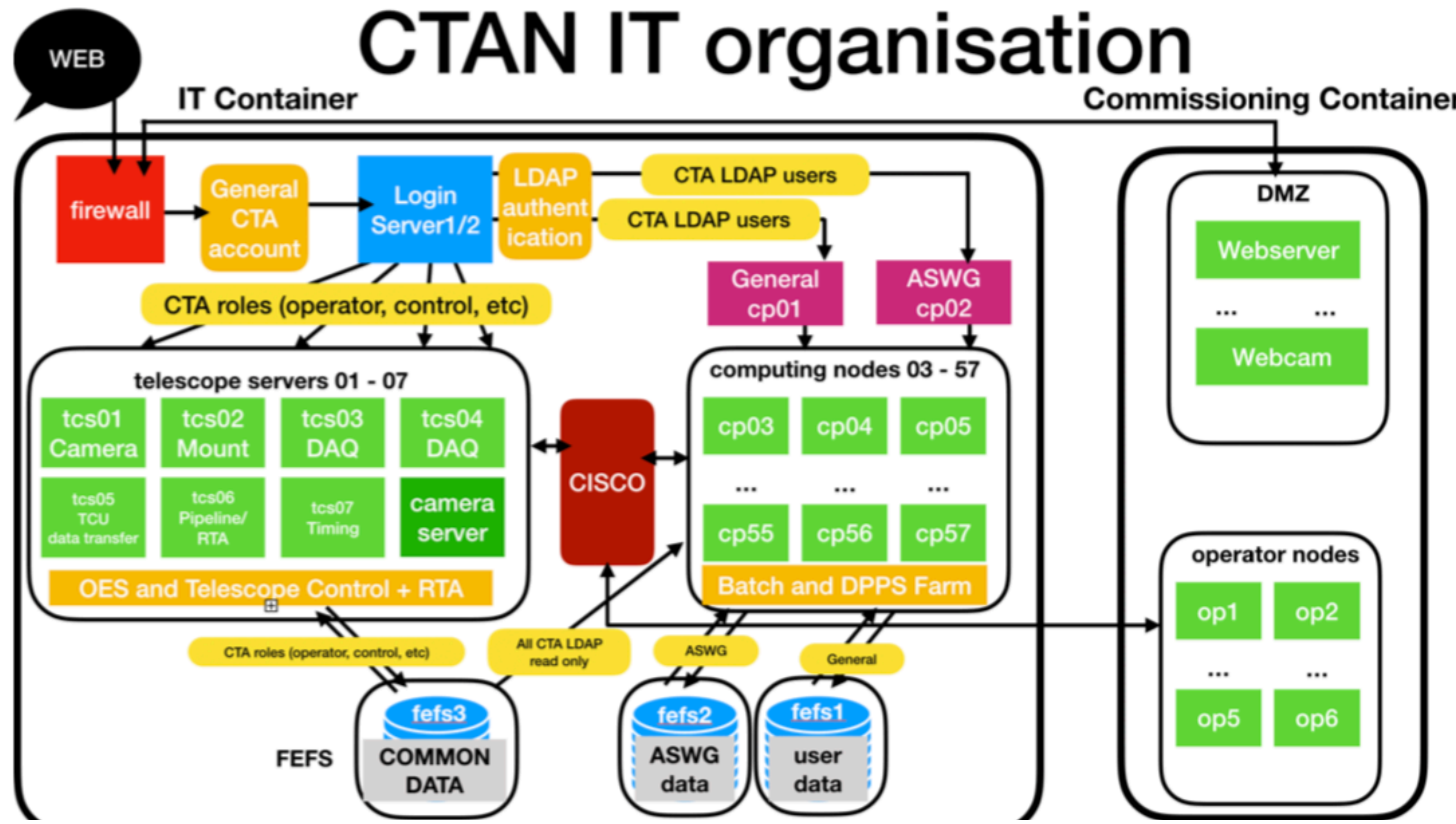


HG / LG correlation



E06 IT centre





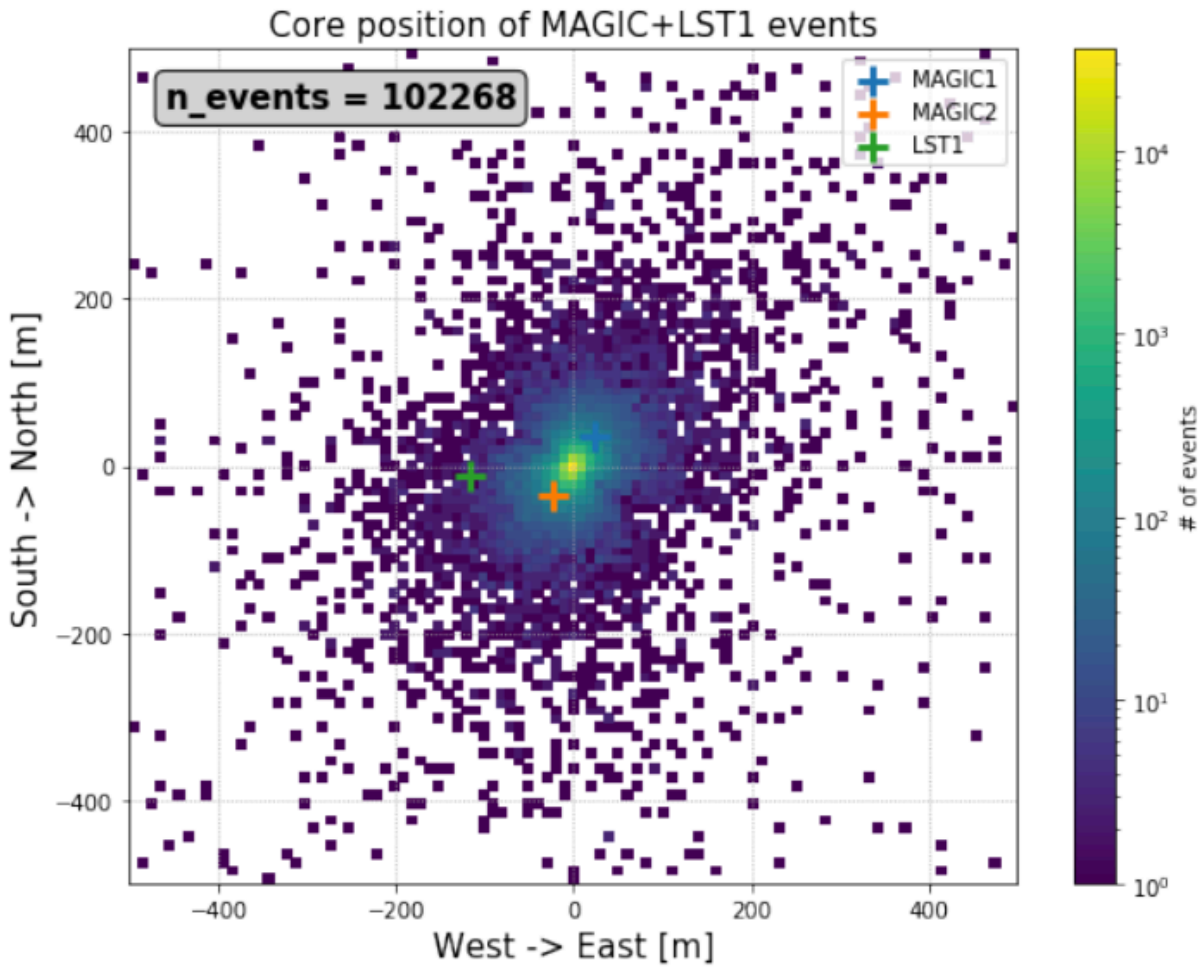
Onsite IT center
Recent activities

- Re-organization of network structure
- Back-up server (RAID10 System) with 100TB installed at CALP
  - Backup of sensitive data offsite
- Erroneous cooling and fire alarm system fixed

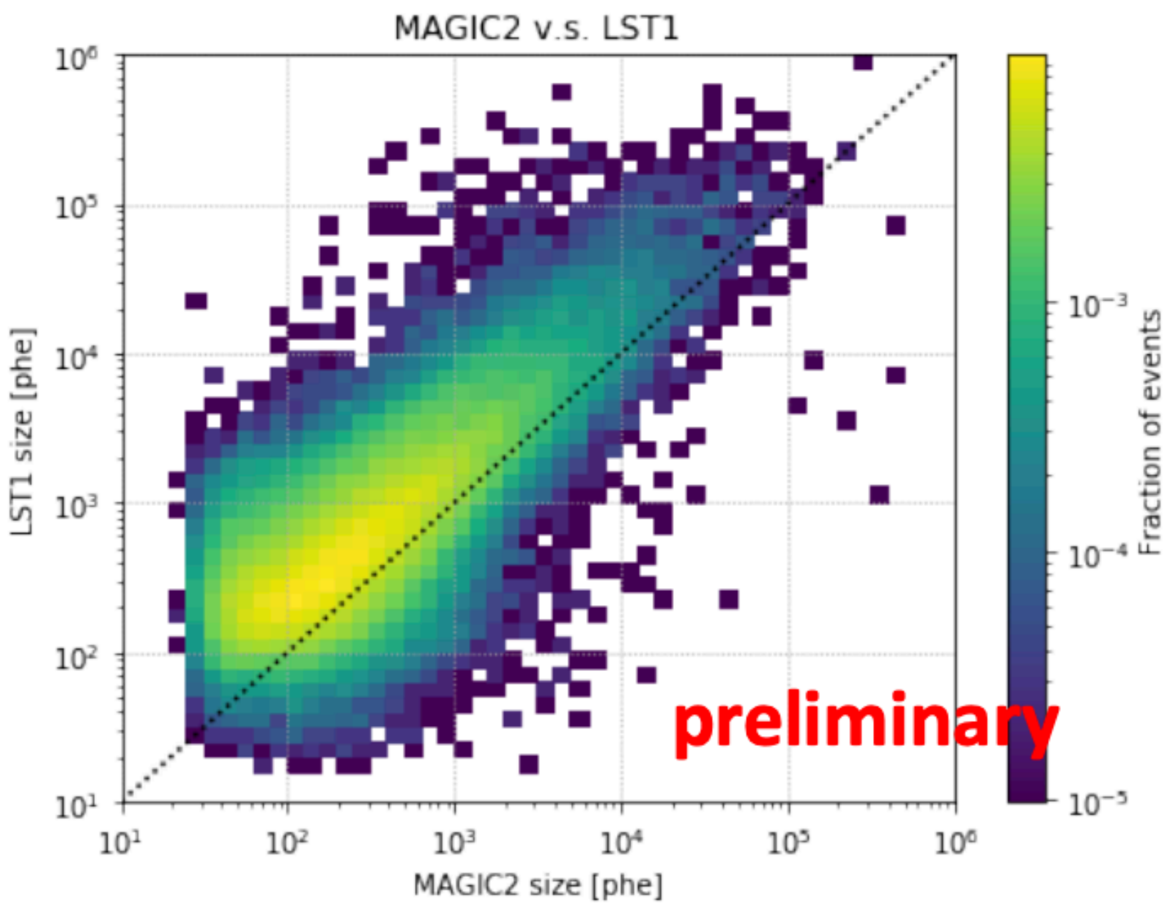
E11 Early phase observations with LST1

- Ongoing cross-calibration between MAGIC and LST1

Core position of coincidence events



Comparison of image intensity of the coincidence events



E11 Early phase observations with LST1

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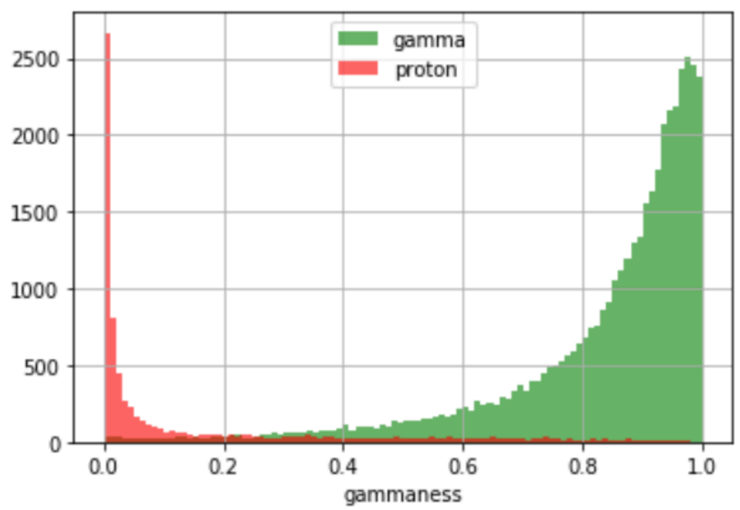
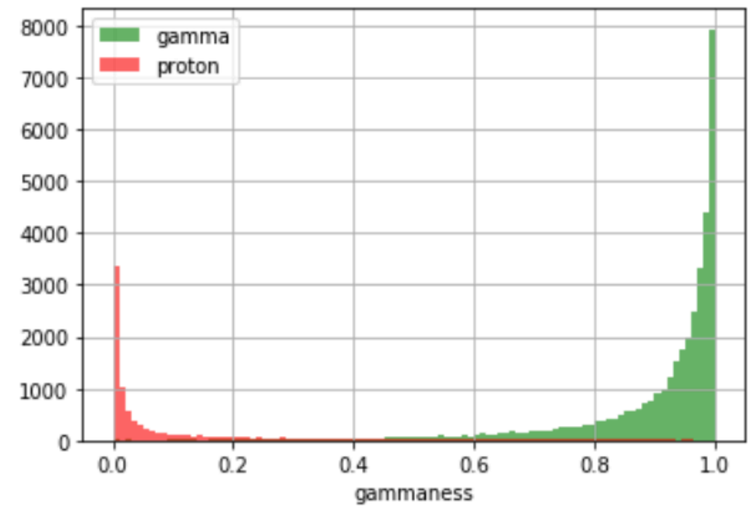
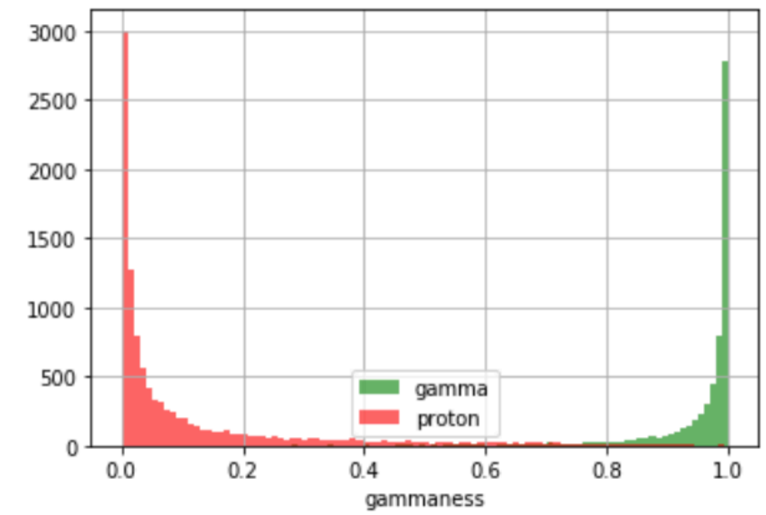
E < 100 GeV



100 GeV < E < 200 GeV

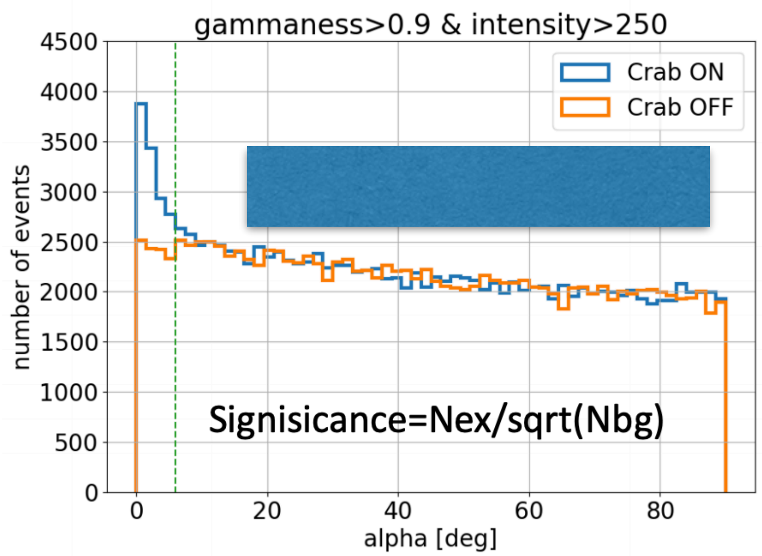


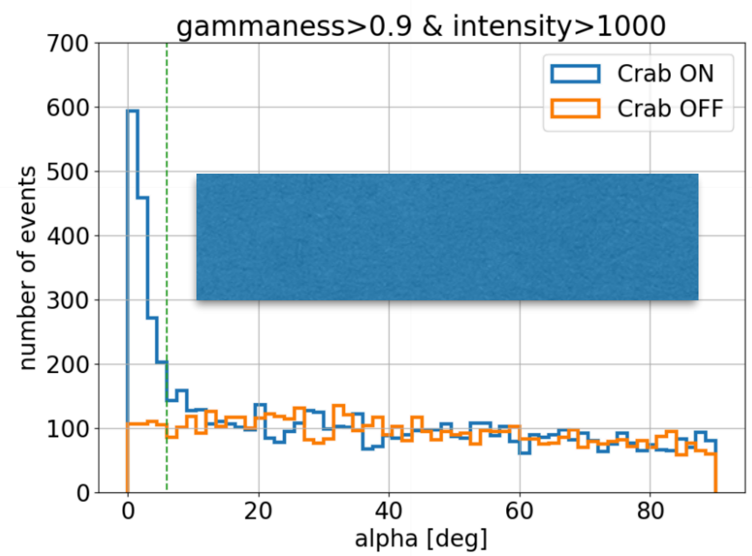
1 TeV < E < 2 TeV



source dependent analysis

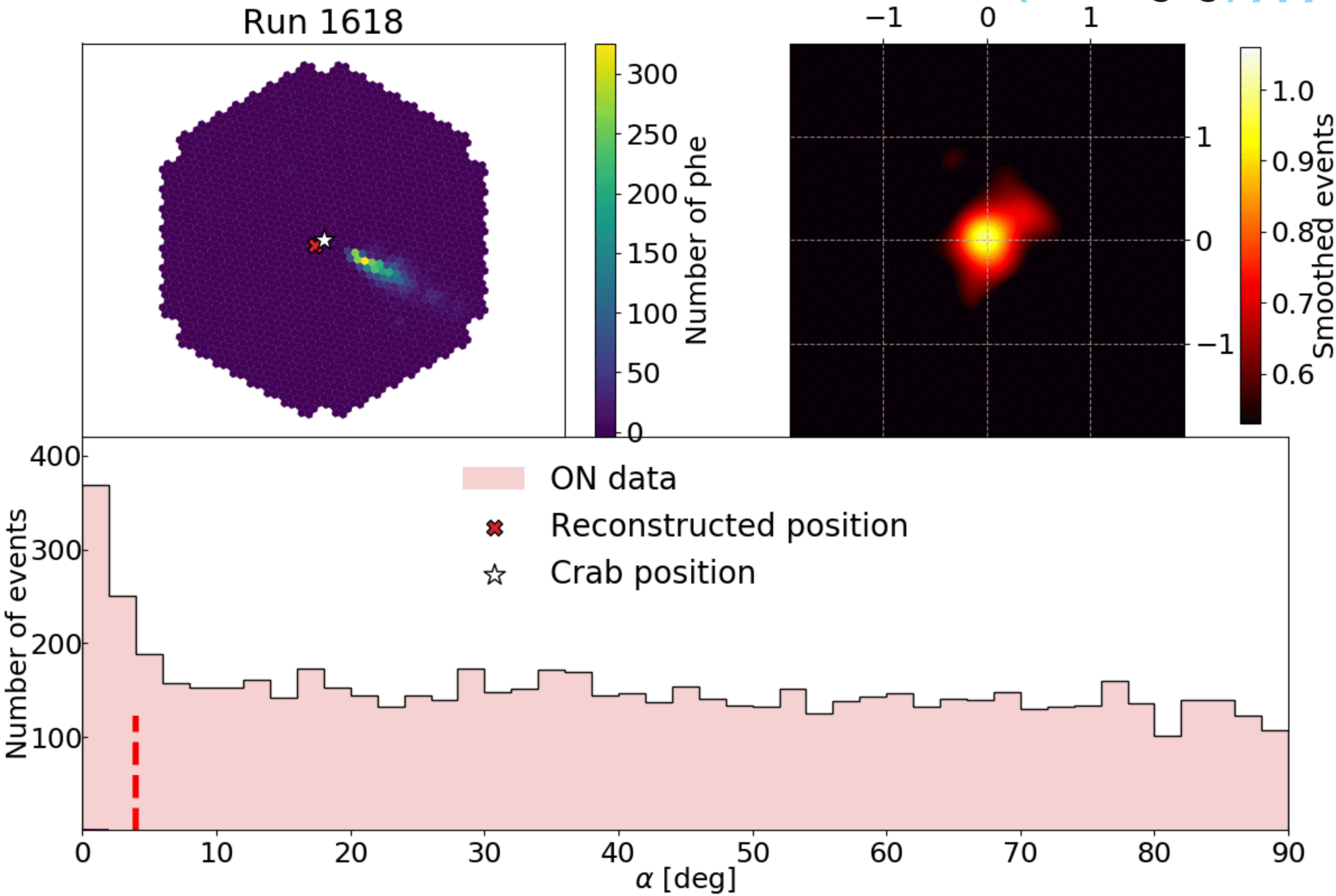
alpha cut = 6deg





- Source dependent analysis
- Appropriate for known point like sources
- **Clear detection of the Crab Nebula first time we pointed to it!**

1 run: 30 min on Crab



LST2-4

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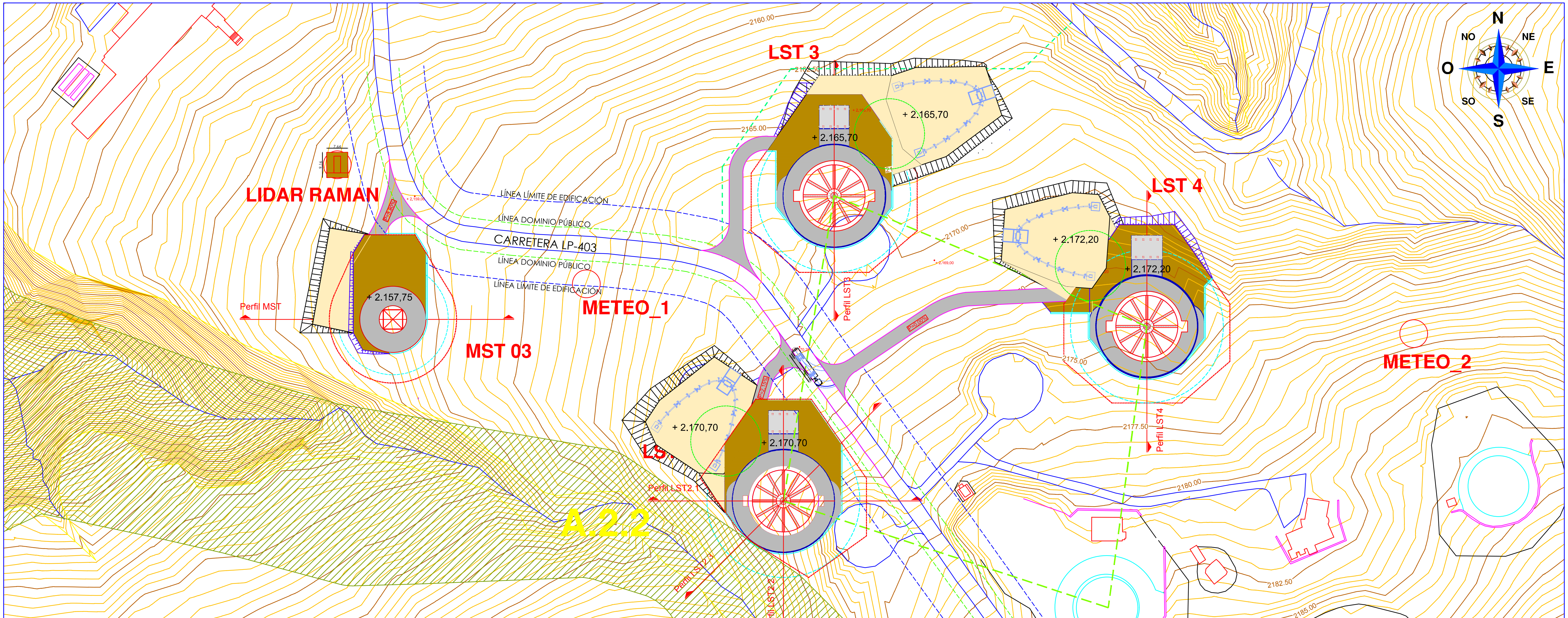
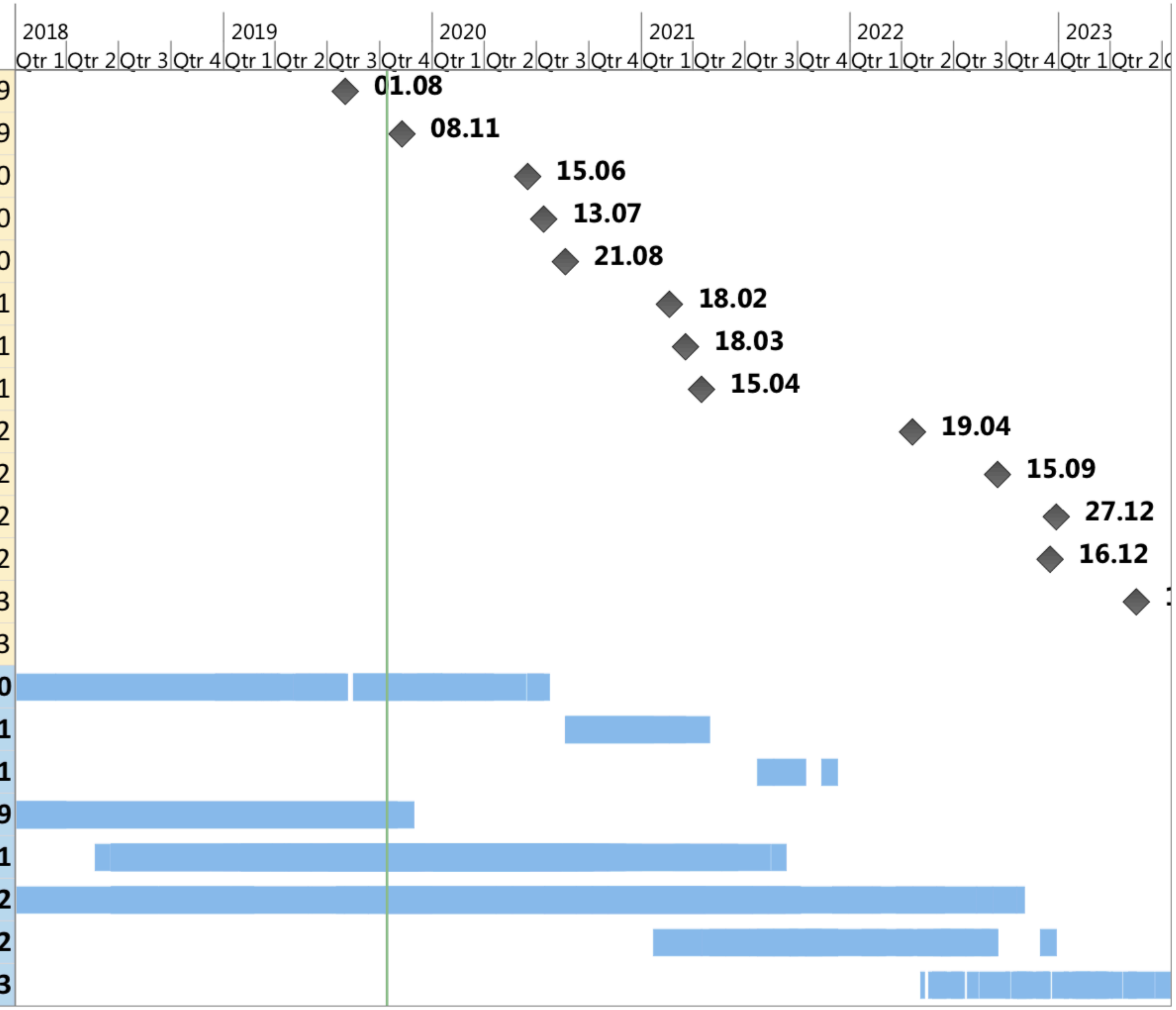


COORDENADAS SISTEMA UTM 28R		
TELESCOPIO	**X**	**Y**
LST-2	217542,210	3185033,610
LST-3	217560,550	3185143,810
LST-4	217673,630	3185096,630
MST-03	217401,117	3185099,180
INSTRUMENTACION AUXILIAR	**X**	**Y**
ESTACION METEO 1	217471,000	3185096,630
ESTACION METEO 2	217770,000	3185094,000
ESTACION METEO 3	217718,000	3184875,000
FRAM	217703,000	3184911,000
LIDAR RAMAN	217381,000	3185155,000

LST2-4

Institute for Cosmic Ray Research
University of Tokyo

ID	Task Name	Duration	Start	Finish
1	Sign Contract for Short Project	0 days	01.08.19	01.08.19
2	Basic project ready for submission	0 days	08.11.19	08.11.19
3	All Permissions granted	0 days	15.06.20	15.06.20
4	Sign civil work contract	0 days	13.07.20	13.07.20
5	Civil Works start	0 days	21.08.20	21.08.20
6	LST2 construction starts	0 days	18.02.21	18.02.21
7	LST3 construction starts	0 days	18.03.21	18.03.21
8	LST4 construction starts	0 days	15.04.21	15.04.21
9	LST2 construction completed	0 days	19.04.22	19.04.22
10	LST3 construction completed	0 days	15.09.22	15.09.22
11	LST4 construction completed	0 days	27.12.22	27.12.22
12	LST2 ready for acceptance	0 days	16.12.22	16.12.22
13	LST3 ready for acceptance	0 days	16.05.23	16.05.23
14	LST4 ready for acceptance	0 days	25.08.23	25.08.23
15	**Project and Permissions LST2-4**	**788 days**	**18.07.17**	**23.07.20**
44	**Civil Works**	**180 days**	**21.08.20**	**29.04.21**
49	**Removal of LST1 assembly platform**	**100 days**	**23.07.21**	**09.12.21**
53	**Optics**	**935 days?**	**02.05.16**	**29.11.19**
58	**Mechanics**	**865 days**	**21.05.18**	**10.09.21**
190	**Camera**	**1697 days**	**02.05.16**	**01.11.22**
236	**Installation**	**503 days**	**22.01.21**	**27.12.22**
264	**AIV (commissioning)**	**343 days**	**04.05.22**	**25.08.23**

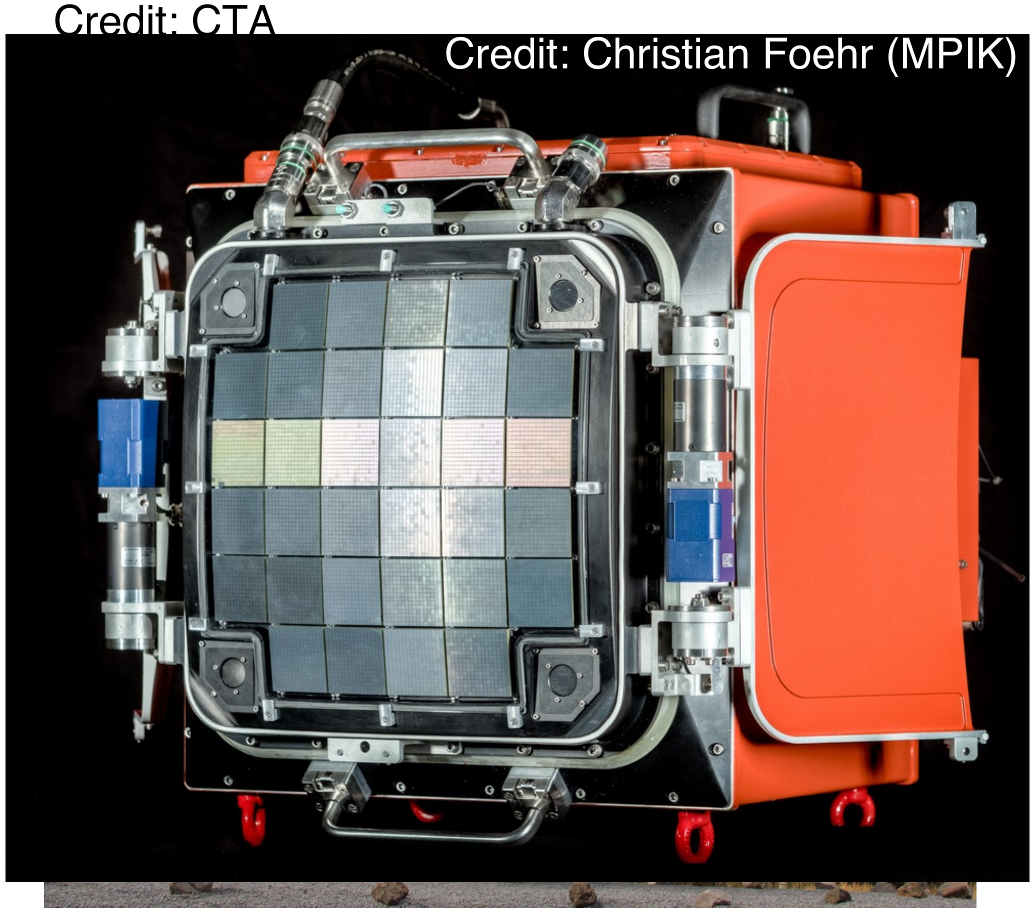


- LST 2-4 construction finished by 2022
- LST 2-4 commissioning finished by 2023

SiPM Camera for SST

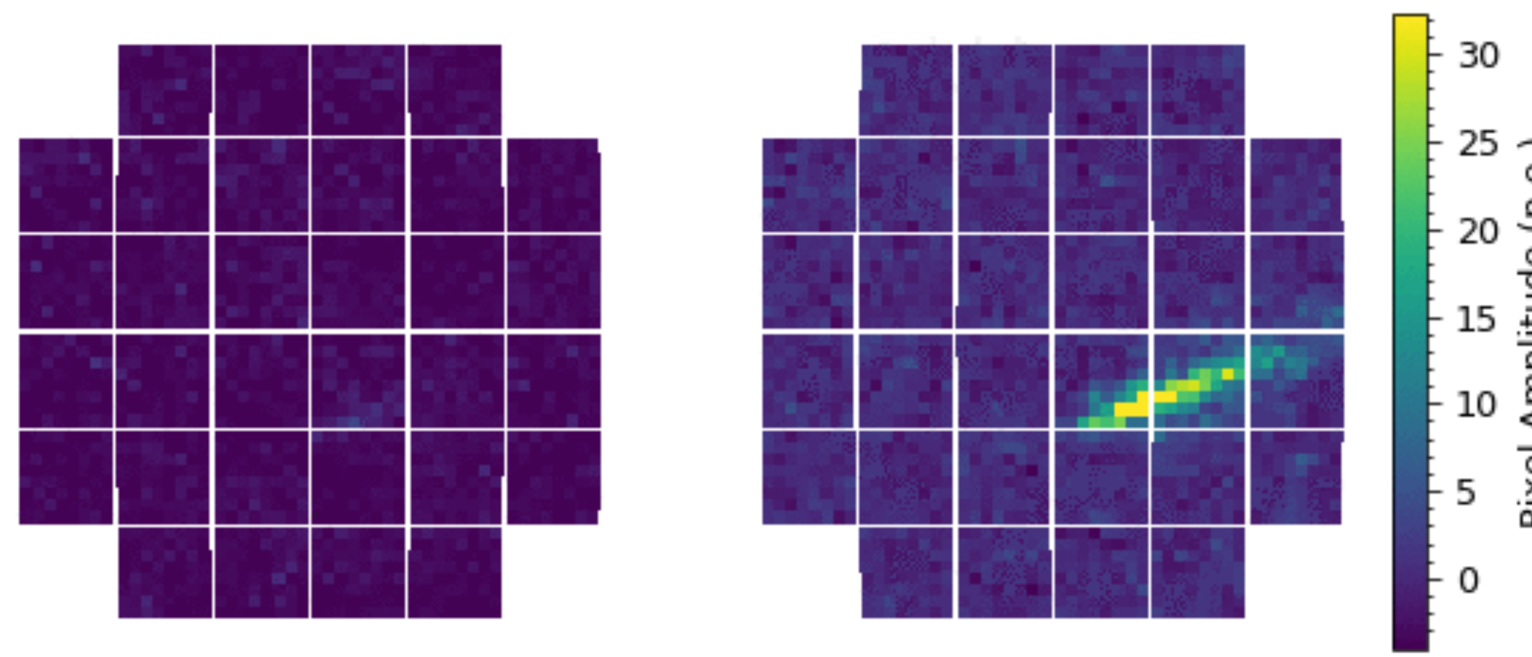
- Nagoya group is in charge of SiPM and software for the Compact High Energy Camera (CHEC)
  - CHEC prototype with SiPM was installed on the ASTRI-Horn telescope (one of SST telescope designs) in April
  - Successfully captured air-shower images
- ASTRI/CHEC was chosen as an SST baseline design

Credit: CTA



Credit: Christian Foehr (MPIK)

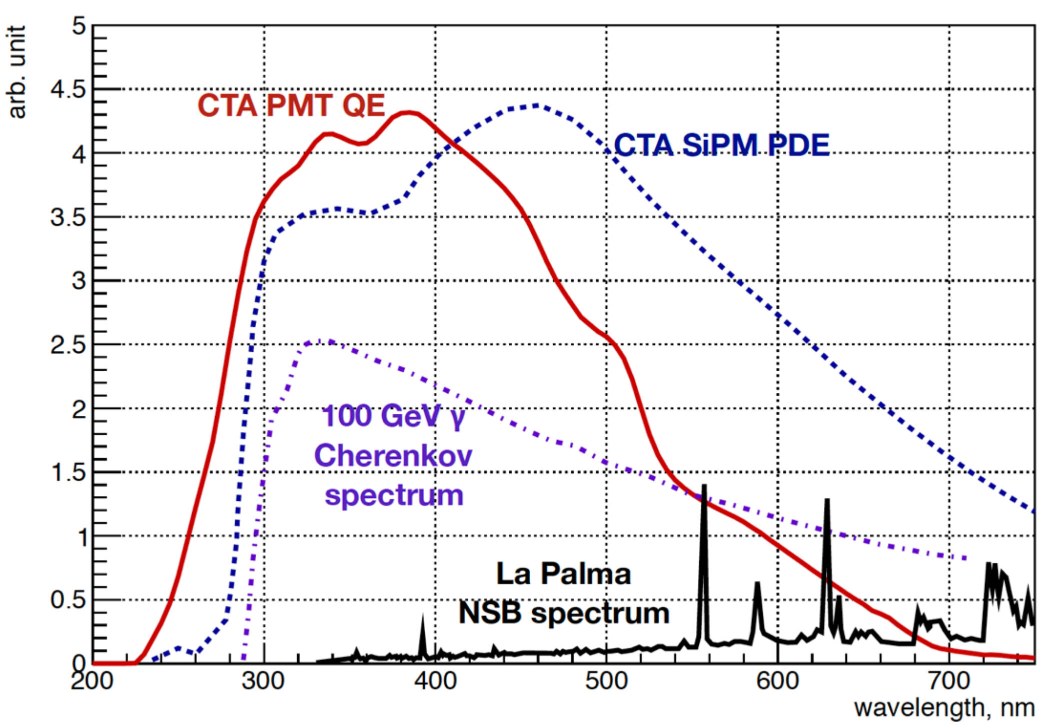
Gamma-ray Cherenkov Telescope



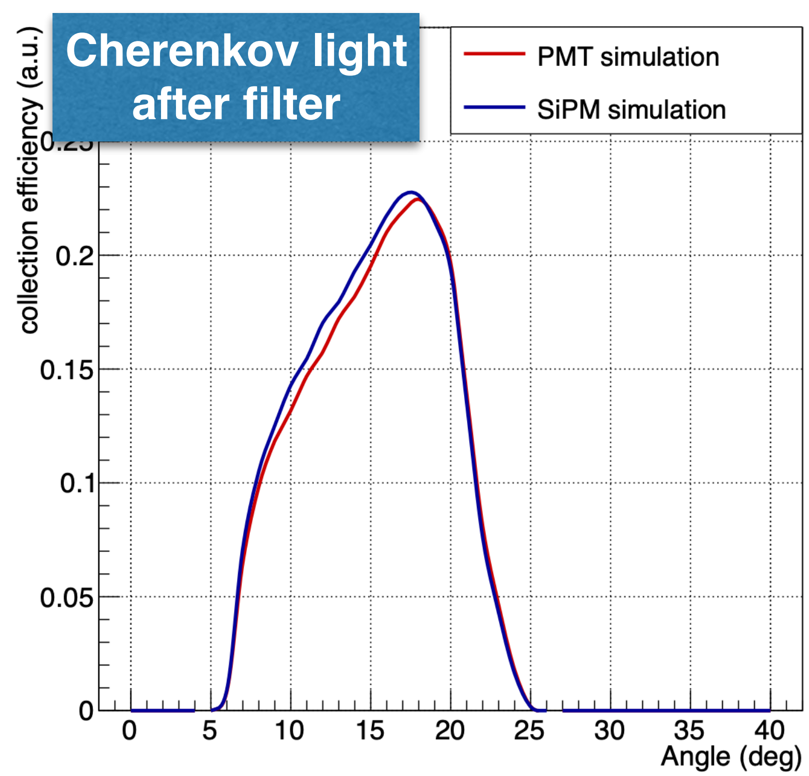
Credit: Jason Watson (Oxford/MPIK)

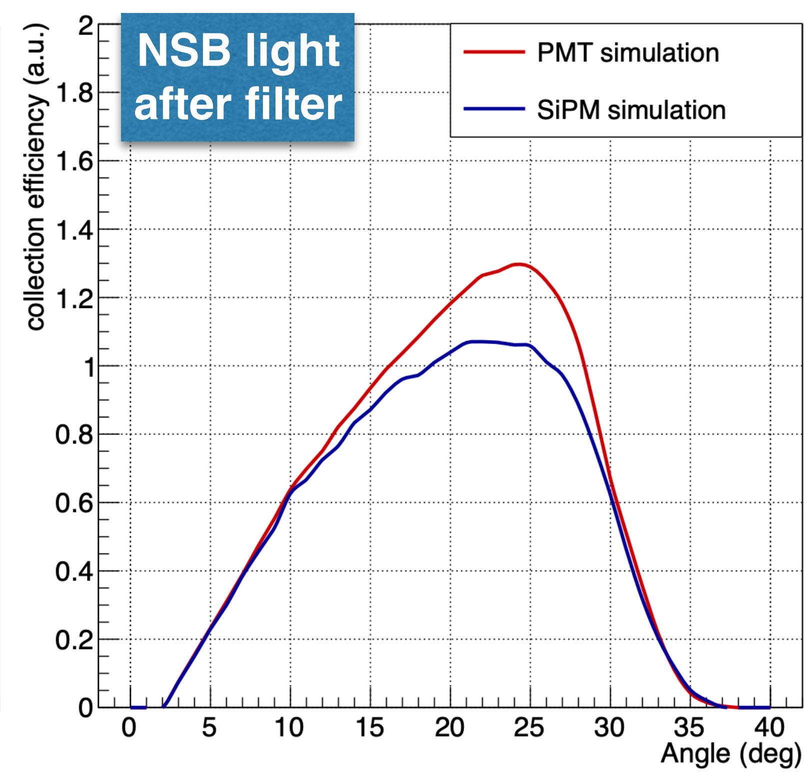
SiPM Camera for MST

- Nagoya group is exploring a possibility to employ SiPM for MST
  - Cost per area was a critical issue for SiPM in MST since total photon sensor area is ~27 m^2 (SST photon sensor area is 6 m^2)
    - Now SiPM cost is comparable with 1 inch PMT used in MST
  - Integrated light yield (LY) over Cherenkov spectrum of SiPM with light concentrator needs to be verified
    - Integrated light yield for Cherenkov signal is similar between SiPM and PMT with a proper filter to cut off NSB peaks above 550 nm
    - NSB light yield is ~10% less (better) for SiPM
    - SiPM is a viable solution for MST camera



Gamma-ray Cherenkov Telescope





E08: CTAモンテカルロシミュレーション
(CTA Monte Carlo Simulation)

Amount of approved budget

Equipment	Domestic Travel
0 k yen	200 k yen (20万円)

Purpose :

Domestic travel money for the participants of F2F meeting, held on 2019-05-27 @ Kashiwa

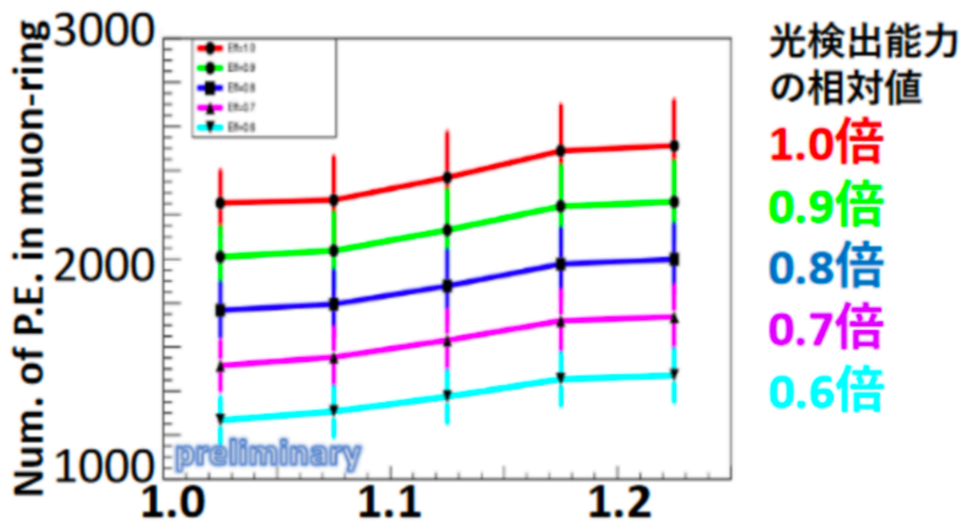
- Annual event mainly targeting newcomers
- Joint host with ODA (**O**nsite **D**ata **A**nalysis, E11) group this year
- 22 participants from 6 institutes
- Includes introductory courses for beginners
  - Usage of ICRR computer system, review of recent analysis methods, etc..
  - One day was not enough to cover all the topics

ご支援ありがとうございます Thank you for your supports

Topics CTA-Japan ASWG covers

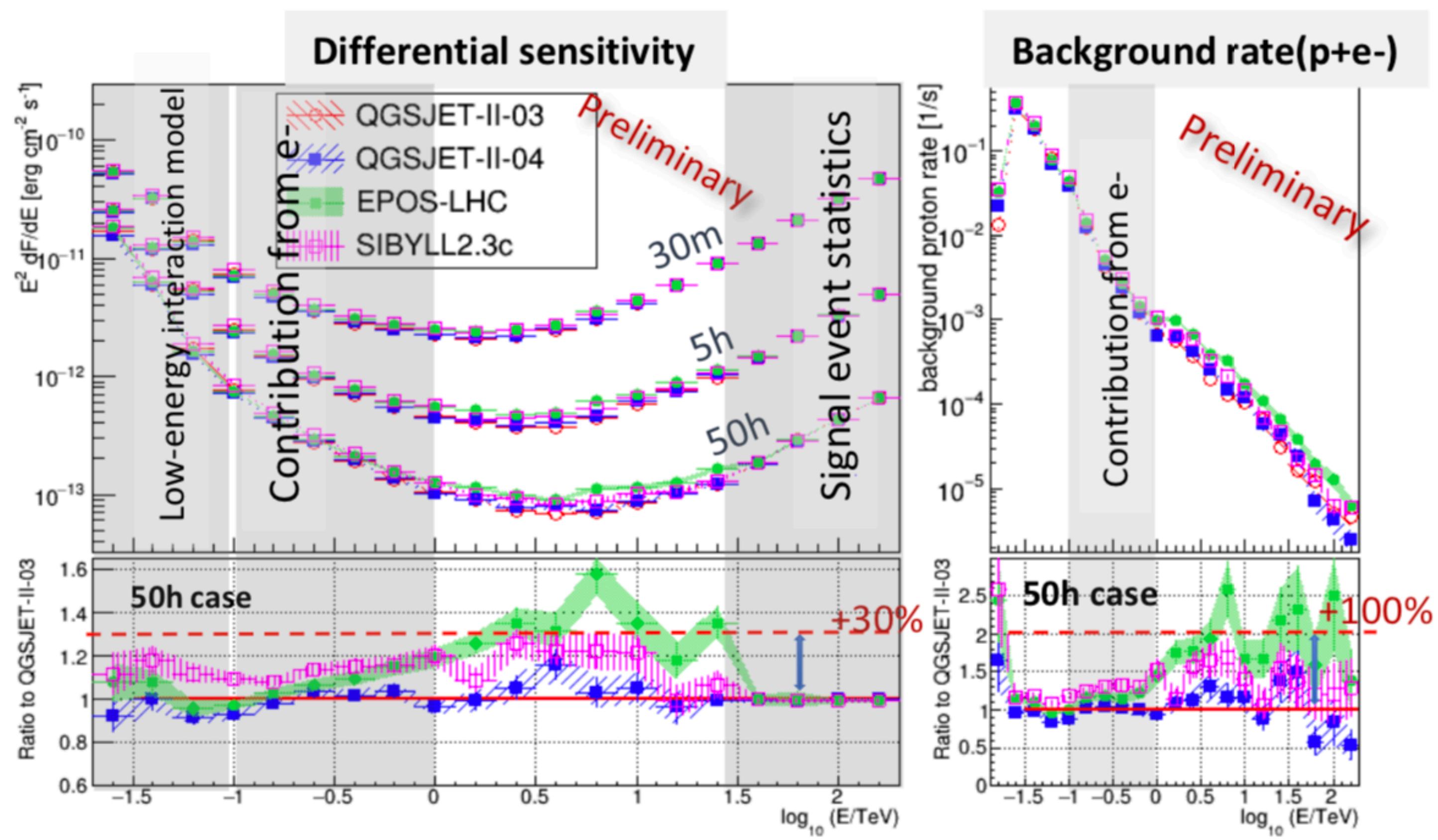
- AS → "**A**nalysis and **S**imulations", here Simulations ≈ **air shower MC**
- Recently some (many) of items are overlapped with **ODA**
  - Muon ring analysis with LST (MC and real data)
  - LST mono analysis (MC and real data)
  - Deep Learning and other Machine Learning techniques (MC)
  - Evaluation of SiPM performance (MC)
  - Investigating influence of the uncertainty of hadronic interaction on the CTA IRF (MC)
  - **…….and more topics…**

望遠鏡集光率の測定



望遠鏡の集光率は、ミューオンイメージの明るさによりモニターできる。1つのミューオンリングにより7%程度の精度。数分程度の観測により1%以下の精度で系統誤差を測定できる。

South site, LST+MST+SST array, z=20deg, average of North+South pointing



μ analysis with CTA-LST
Yamamoto+, JPS meeting (2019 Sp.)

Effect of uncertainty in hadronic interaction
Ohishi+, TAUP2019

MAGIC project

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Radio galaxies: M87

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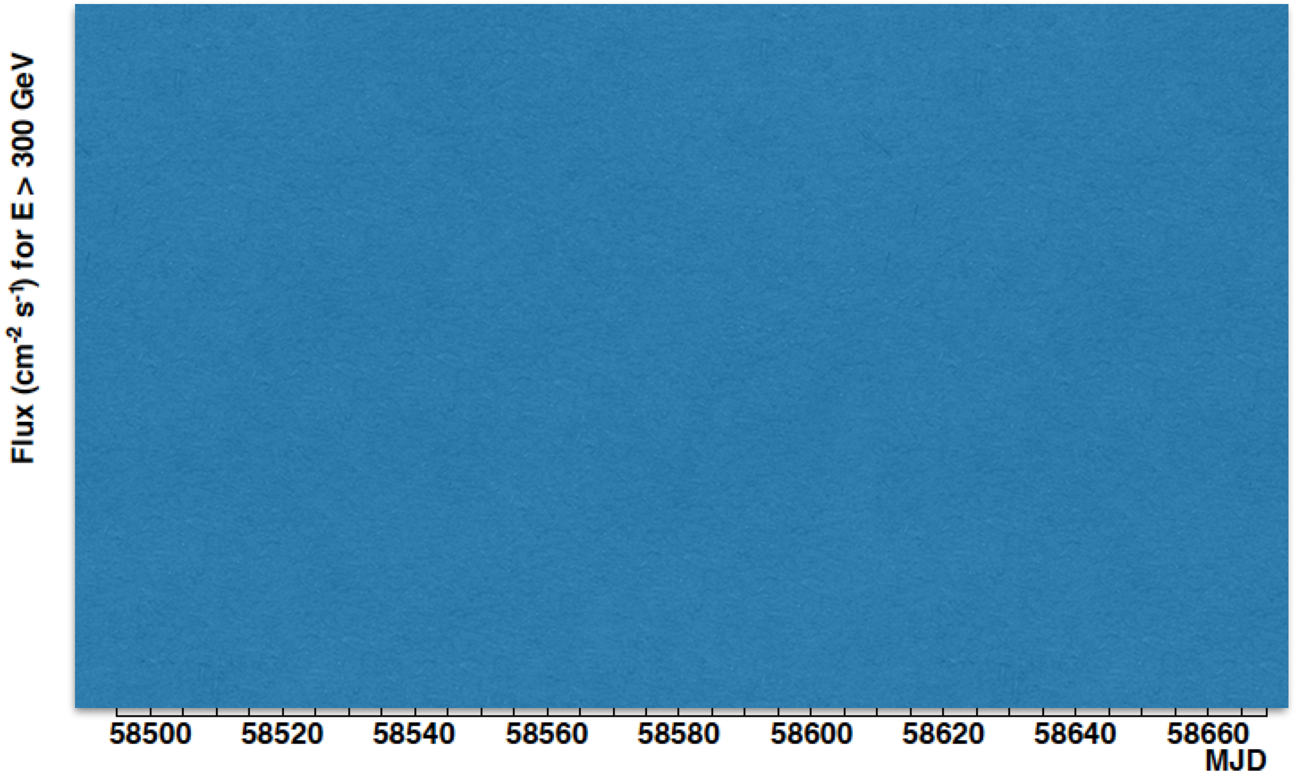
University of Tokyo

Localization of very high energy gamma-ray emission region in an active galactic nuclei (E09)

- **M87 : 2019/1/19 — 6/20(24 nights including 19 moon nights)**
  - **Excess : 4.9σ (> 200 GeV, 32.4 hrs)**
  - **Average integral flux(>300 GeV) : (1.2±0.3)×10-13 ph cm-2s-1**
  - **Light curve**



- K. Nishijima, J. Kushida, S. Tsujimoto, T. Ogata, T. Furuta, Y. Nabatame, Y. Harada (Tokai University)
- M. Teshima, D. Mazin (ICRR, University of Tokyo)

Localization of very high energy gamma-ray emission region in an active galactic nuclei (E09)

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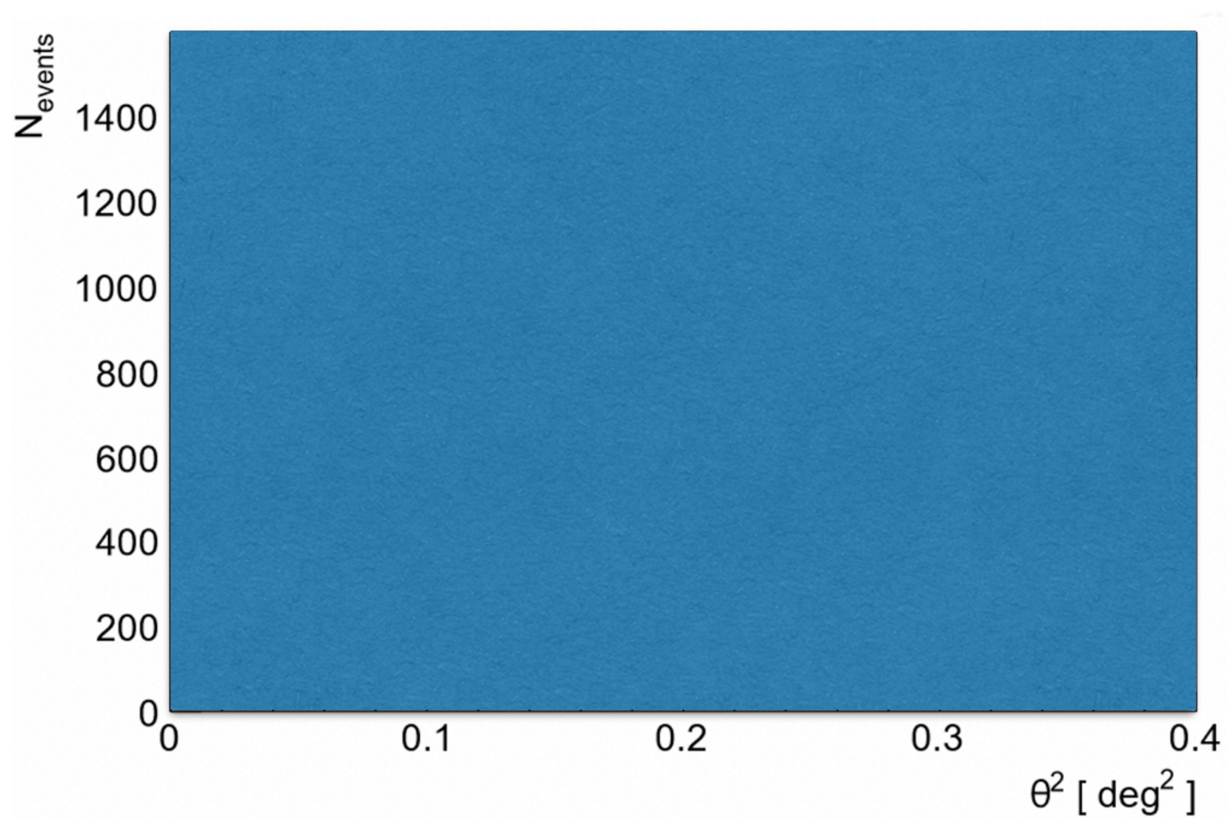
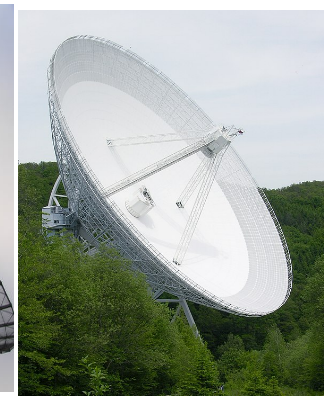
- Ton396, BL Lac, 0.101 < z < 0.36
- 12 out of 16 CLASS (radio survey) High peaked Bl Lacs have been established in TeV
- **Ton 396 is one of the missing 4. Let's check it!**
- 2016/12/28 – 2017/1/29 (11 nights, 11.9 hours after cuts)
- MaTaJu image cleaning to achieve lowest possible threshold

MaTaJu cleaning



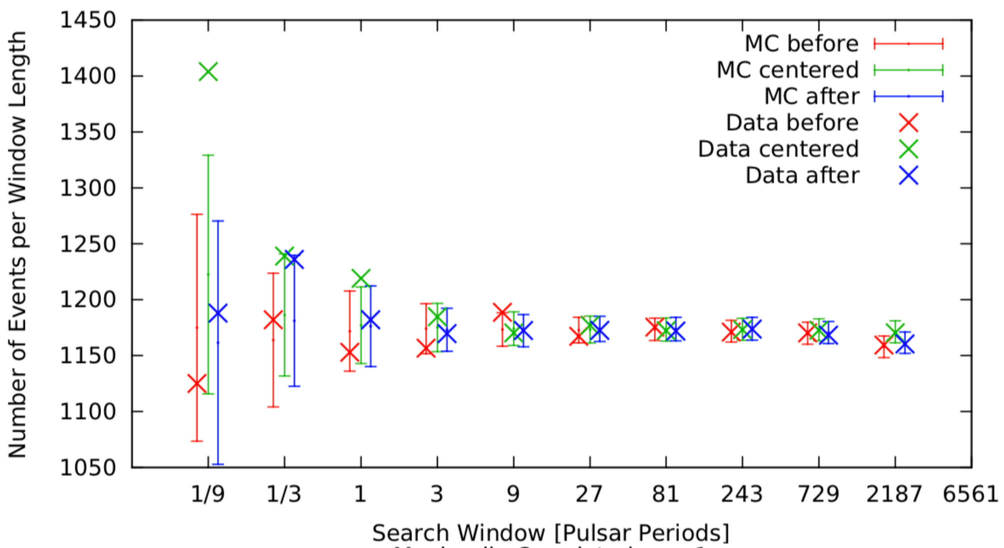
Pulsars:

Crab VHE vs Radio Giant pulse correlation Study



MAGIC

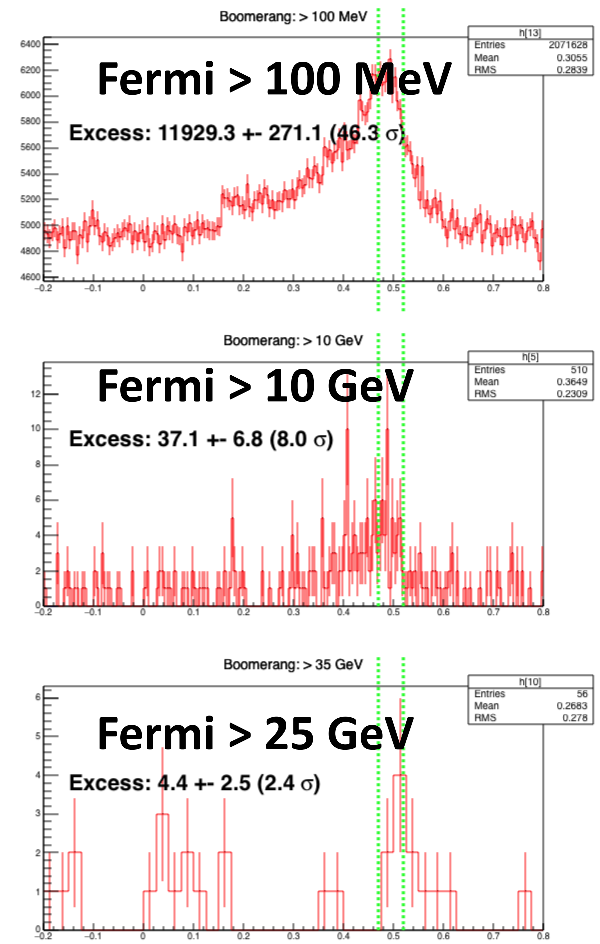
Effelsberg or Westerbork



- 16 hours of simultaneous observation of the Crab pulsar.
- No significant correlation found
- Upper limit on the VHE gamma-ray flux enhancement during GP is estimated to be ~ 740%

- Accepted in MNRAS, arXiv:1911.00634v1

Observation of Boomerang Pulsar



one of the 12 pulsars detected by Fermi above 25 GeV

Gamma-ray binaries

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Binaries with MAGIC

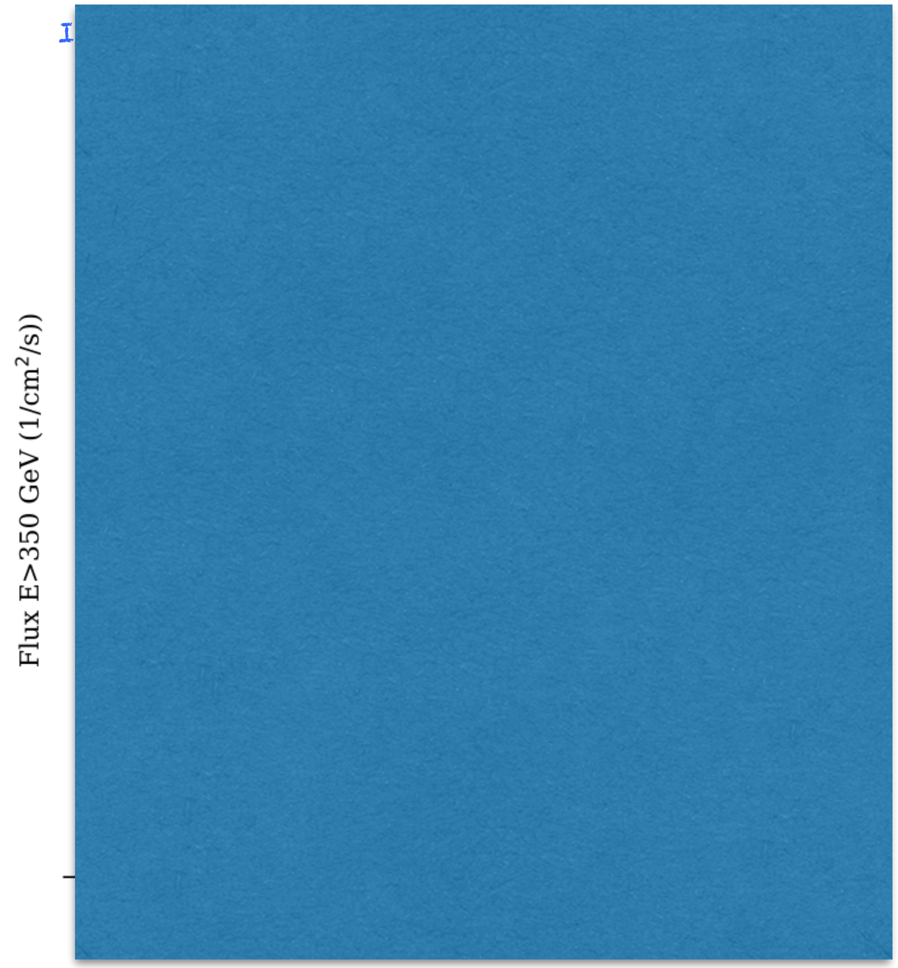
HESS J0632+057

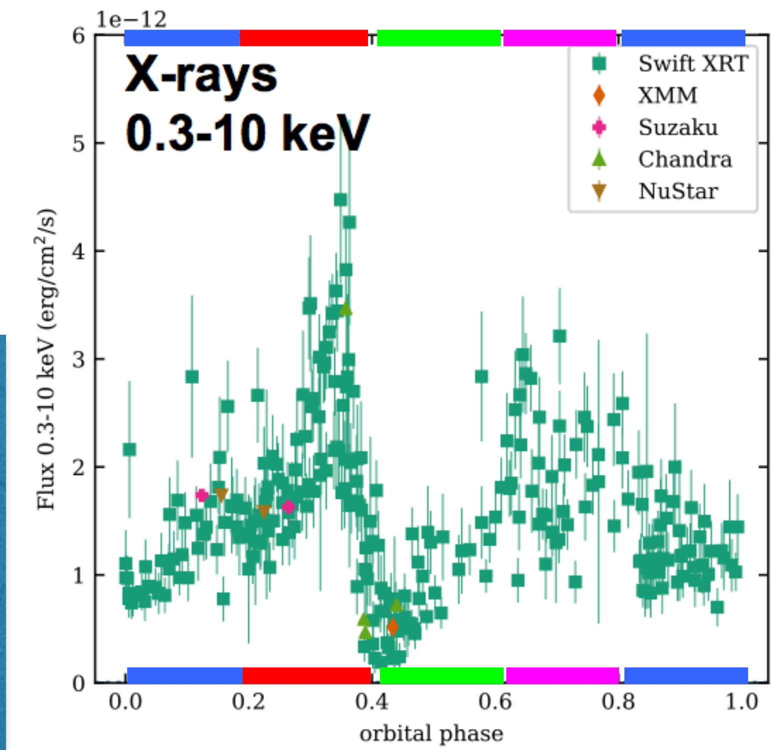
HESS J0632+057 (PI: D. Hadasch)

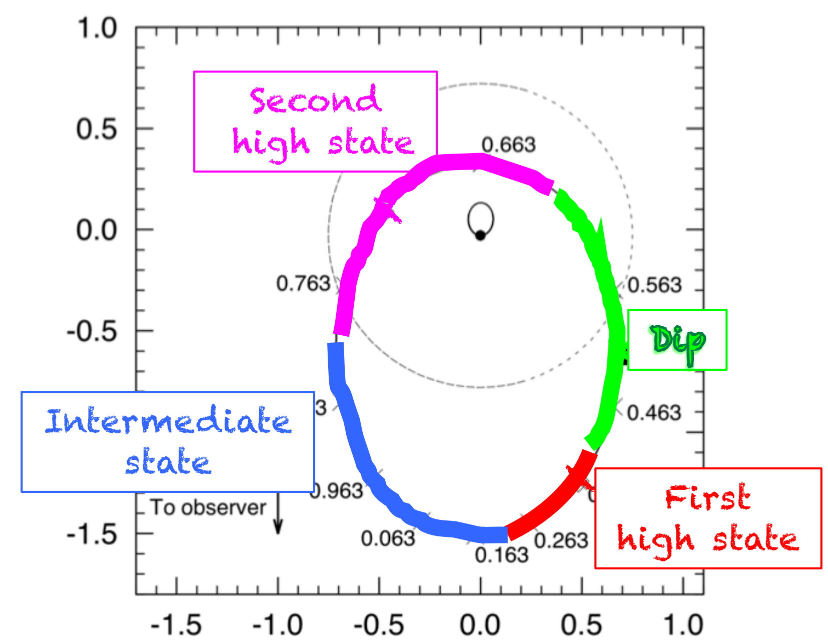
- Joined effort of H.E.S.S., MAGIC & VERITAS and X-ray instruments
- Paper to be published in FY2019

LS I +61 303 (PI: D. Hadasch)

- New observation proposal for 2020 submitted
- 20 hrs of data taken in 2019 within campaign with VERITAS and optical telescope LIVERPOOL on La Palma







First VHE-γ detection of GRB: 190114C

- Bright long GRB by Swift-BAT
- MAGIC observed from 50 s (not the fastest but well within T_{90})
- zenith angle ~55 deg, moderate moon => Eth = ~300 GeV
- z=0.42: 3rd closest in MAGIC
- **>20 sigma online, >50 sigma offline = First clear detection of a GRB in the VHE regime**
- **2 papers in Nature**
  Main contributors from Japan: Inoue, Noda, Fukami, Vovk,,,

ATel #12390 (and also GCN #23701)

[Previous | Next | ADS]

First time detection of a GRB at sub-TeV energies; MAGIC detects the GRB 190114C

ATel #12390; ***Razmik Mirzoyan on behalf of the MAGIC Collaboration***
*on **15 Jan 2019; 01:03 UT***
Credential Certification: Razmik Mirzoyan (Razmik.Mirzoyan@mpp.mpg.de)

Subjects: Gamma Ray, >GeV, TeV, VHE, Request for Observations, Gamma-Ray Burst

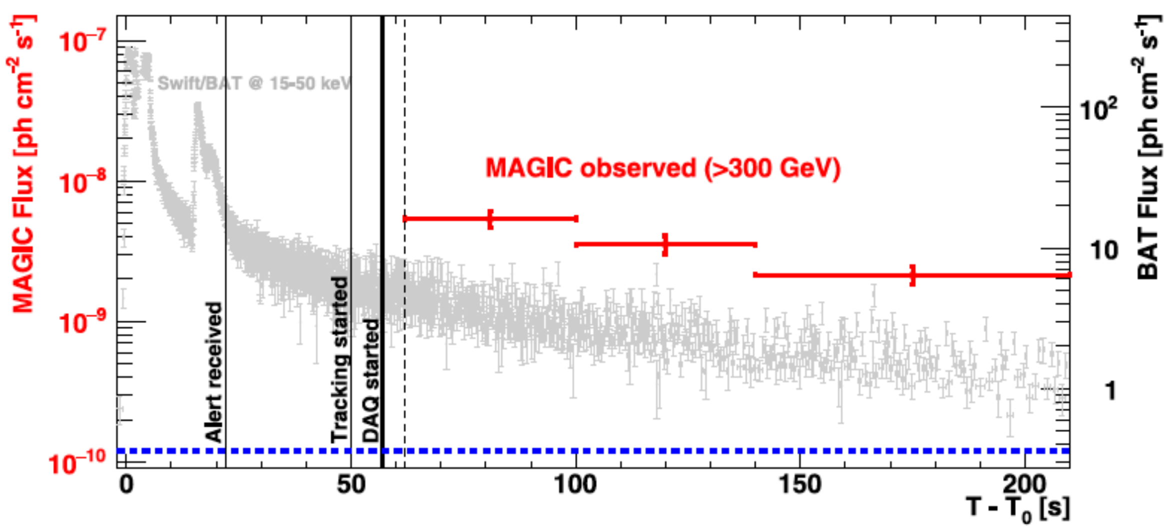
Referred to by ATel #: 12395, 12475

Tweet

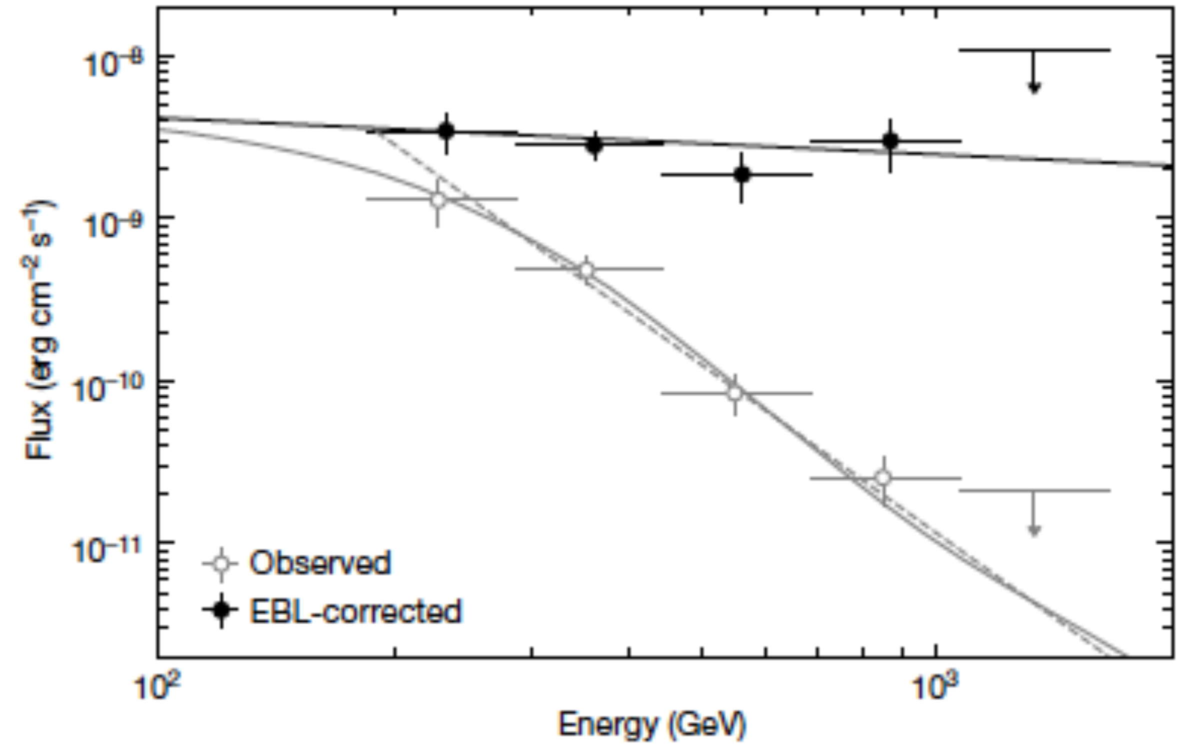
The MAGIC telescopes performed a rapid follow-up observation of GRB 190114C (Gropp et al., GCN 23688; Tyurina et al., GCN 23690, de Ugarte Postigo et al., GCN 23692, Lipunov et al. GCN 23693, Selsing et al. GCN 23695). This observation was triggered by the Swift-BAT alert; we started observing at about 50s after Swift T0: 20:57:03.19. The MAGIC real-time analysis shows a significance >20 sigma in the first 20 min of observations (starting at T0+50s) for energies >300GeV. The relatively high detection threshold is due to the large zenith angle of observations (>60 degrees) and the presence of partial Moon. Given the brightness of the event, MAGIC will continue the observation of GRB 190114C until it is observable tonight and also in the next days. We strongly encourage follow-up observations by other instruments. The MAGIC contact persons for these observations are R. Mirzoyan (Razmik.Mirzoyan@mpp.mpg.de) and K. Noda (nodak@icrr.u-tokyo.ac.jp). MAGIC is a system of two 17m-diameter Imaging Atmospheric Cherenkov Telescopes located at the Observatory Roque de los Muchachos on the Canary island La Palma, Spain, and designed to perform gamma-ray astronomy in the energy range from 50 GeV to greater than 50 TeV.

"Discovery" paper: *MAGIC Collaboration, "Teraelectronvolt emission from the γ-ray burst GRB 190114C", Nature **575** 455 (2019):*
"MWL" paper: *MAGIC Collaboration, Fermi, Swift,,, (>20 instruments), "Observation of inverse Compton emission from a long γ-ray burst", Nature **575** 459 (2019)*

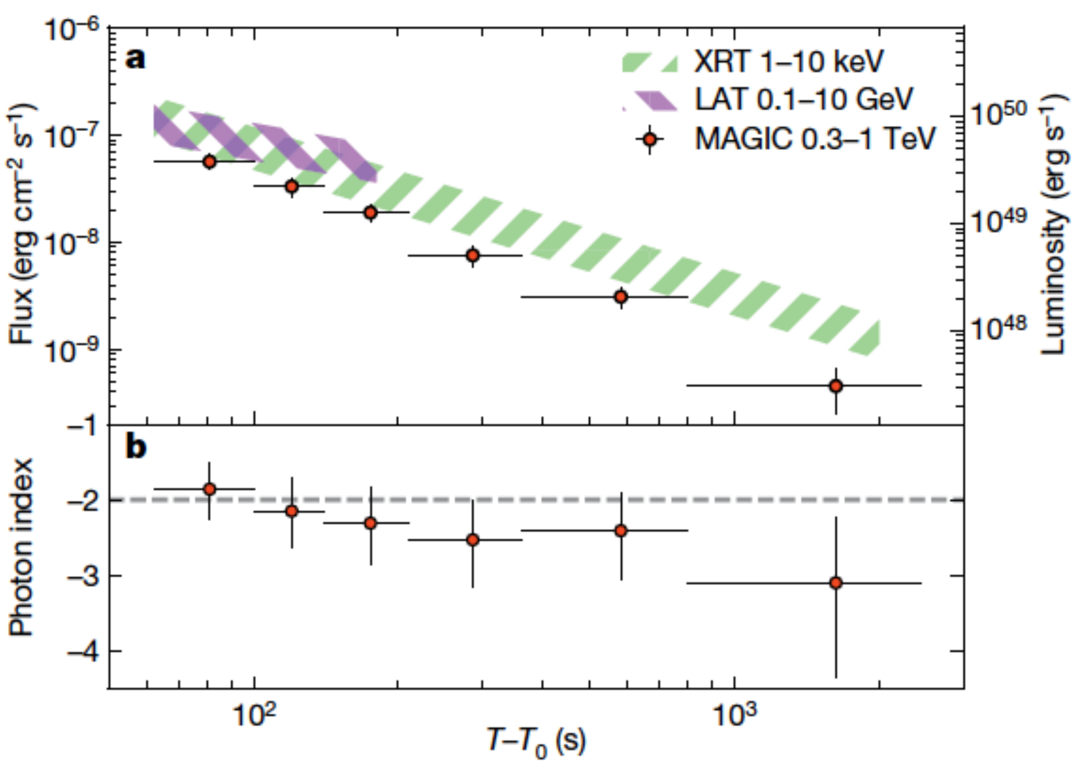
"Discovery" paper (Inoue, Noda, Vovk,,,)

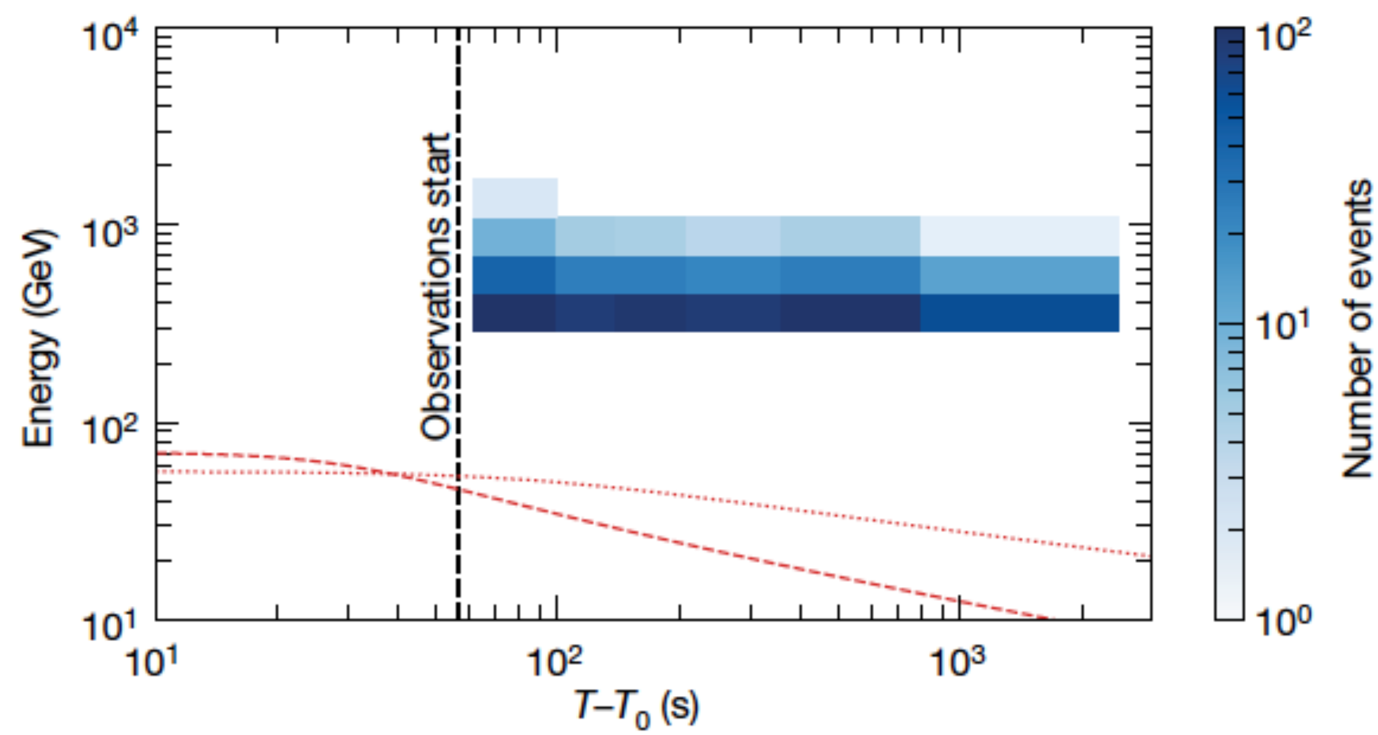


Smooth DAQ, brightest VHE source ever, monotonic decay

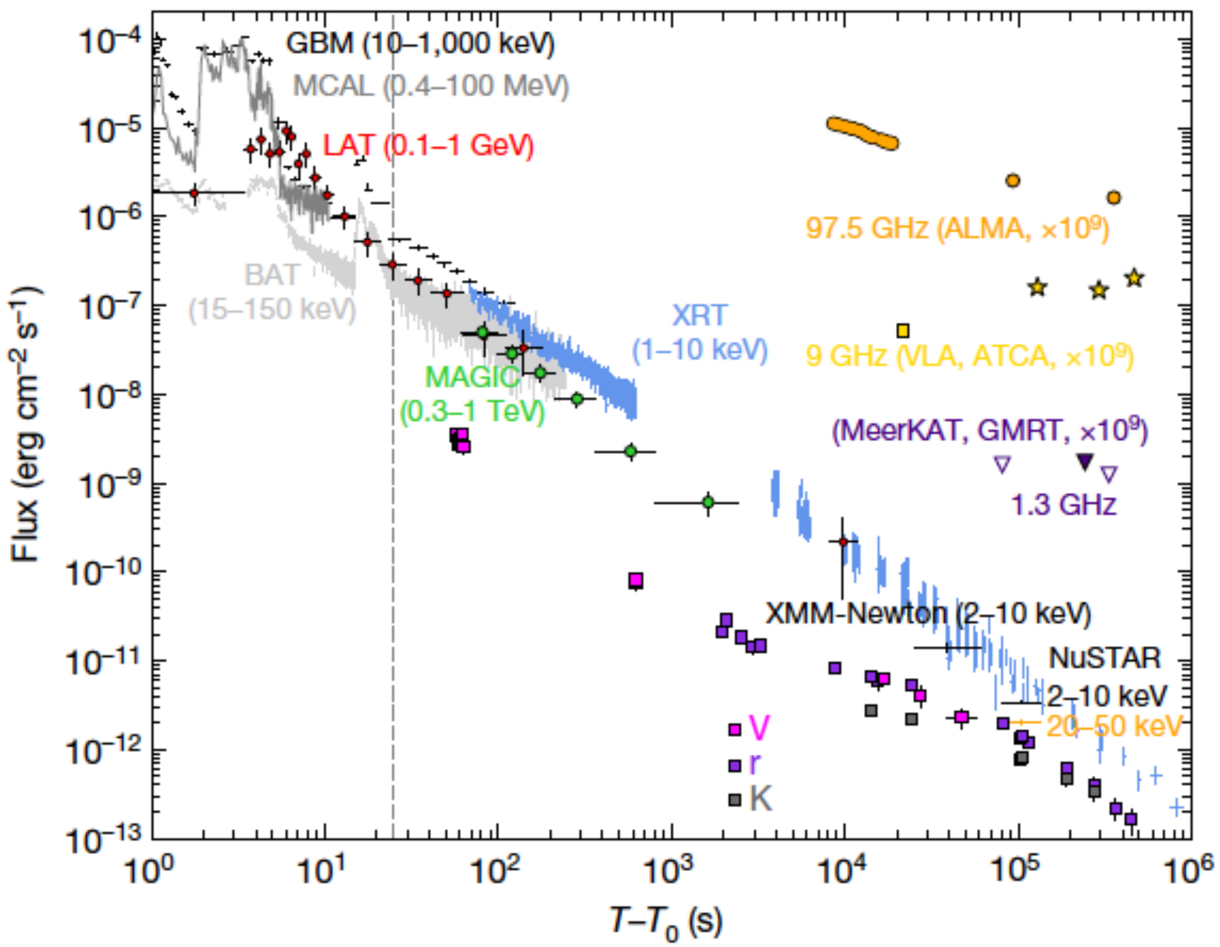


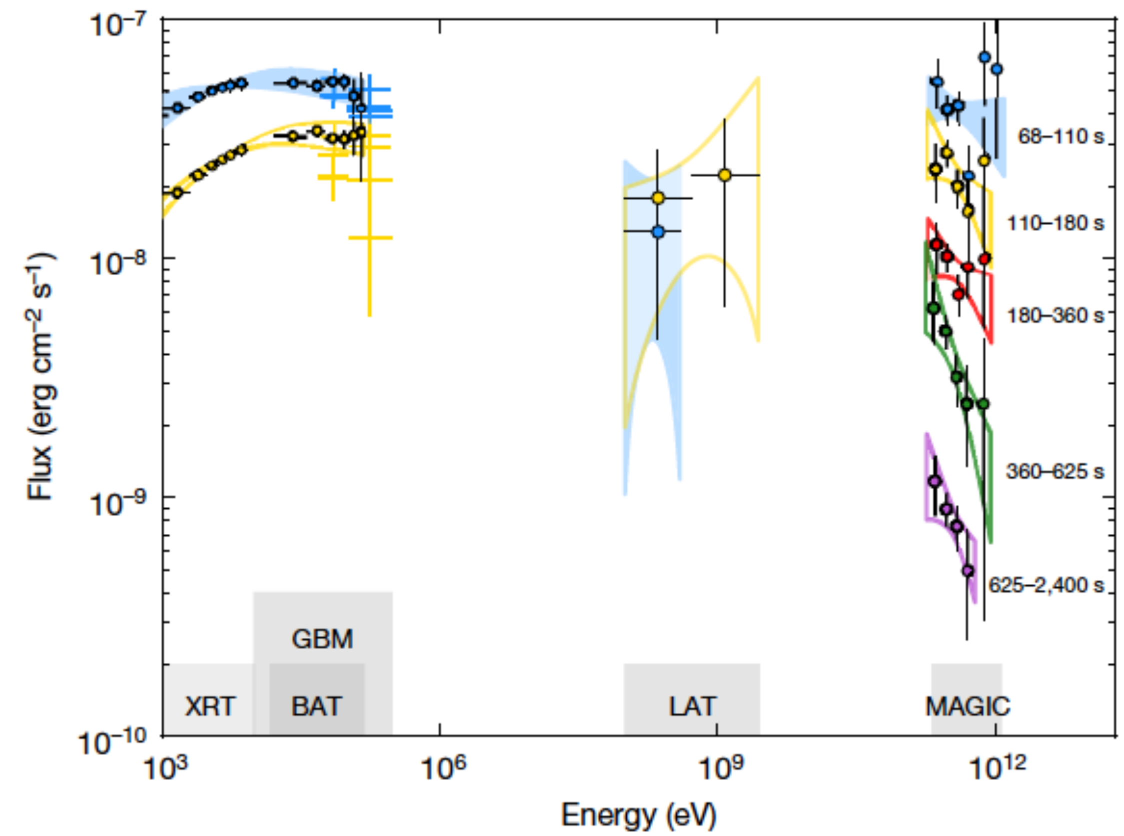
PWL (index -2.2) extended to 1 TeV, clear evidence beyond synchrotron



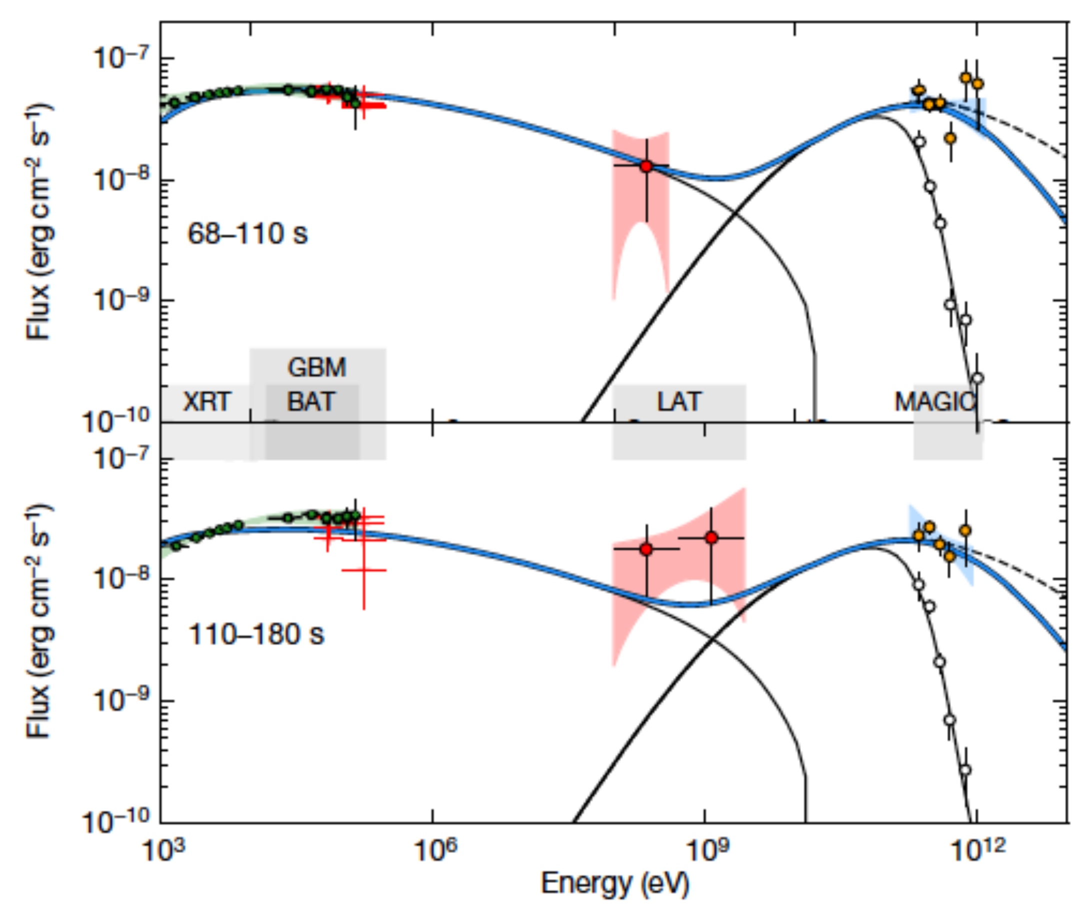


"MWL" paper (Fukami, (Suda),,,)





Large Aeff of IACT dominates.
Modelling consistent with SSC



More to come

- GRB 190114C: LIV, EBL, IGMF,,,
- GRB 160821B
- MAGIC GRB catalog

MAGIC Publications in the last year

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[1] "A fast, very-high-energy γ-ray flare from BL Lacertae during a period of multi-wavelength activity in June 2015"
Astronomy and Astrophysics,623,A175; DOI: 10.1051/0004-6361/201834010

[2] "Discovery of TeV γ-ray emission from the neighbourhood of the supernova remnant G24.7+0.6 by MAGIC"
Monthly Notices of the Royal Astronomical Society,483,4578;
DOI:10.1093/mnras/sty3387

[3] "Deep observations of the globular cluster M15 with the MAGIC telescopes"
Monthly Notices of the Royal Astronomical Society,484,2876;
DOI:10.1093/mnras/stz179

[4] "MAGIC and Fermi-LAT gamma-ray results on unassociated HAWC sources"
MAGIC and Fermi-Lat Collaborations,
Monthly Notices of the Royal Astronomical Society,485,356;
DOI:10.1093/mnras/stz089

[5] "Measurement of the extragalactic background light using MAGIC and
Fermi-LAT gamma-ray observations of blazars up to z = 1"
Monthly Notices of the Royal Astronomical Society,486,4233;
DOI:10.1093/mnras/stz943

[6] "Constraints on Gamma-Ray and Neutrino Emission from NGC 1068 with
the MAGIC Telescopes"
The Astrophysical Journal,883,135; DOI:10.3847/1538-4357/ab3a51

[7] "Teraelectronvolt emission from the γ-ray burst GRB 190114C"
Nature,575,455; DOI:10.1038/s41586-019-1750-x

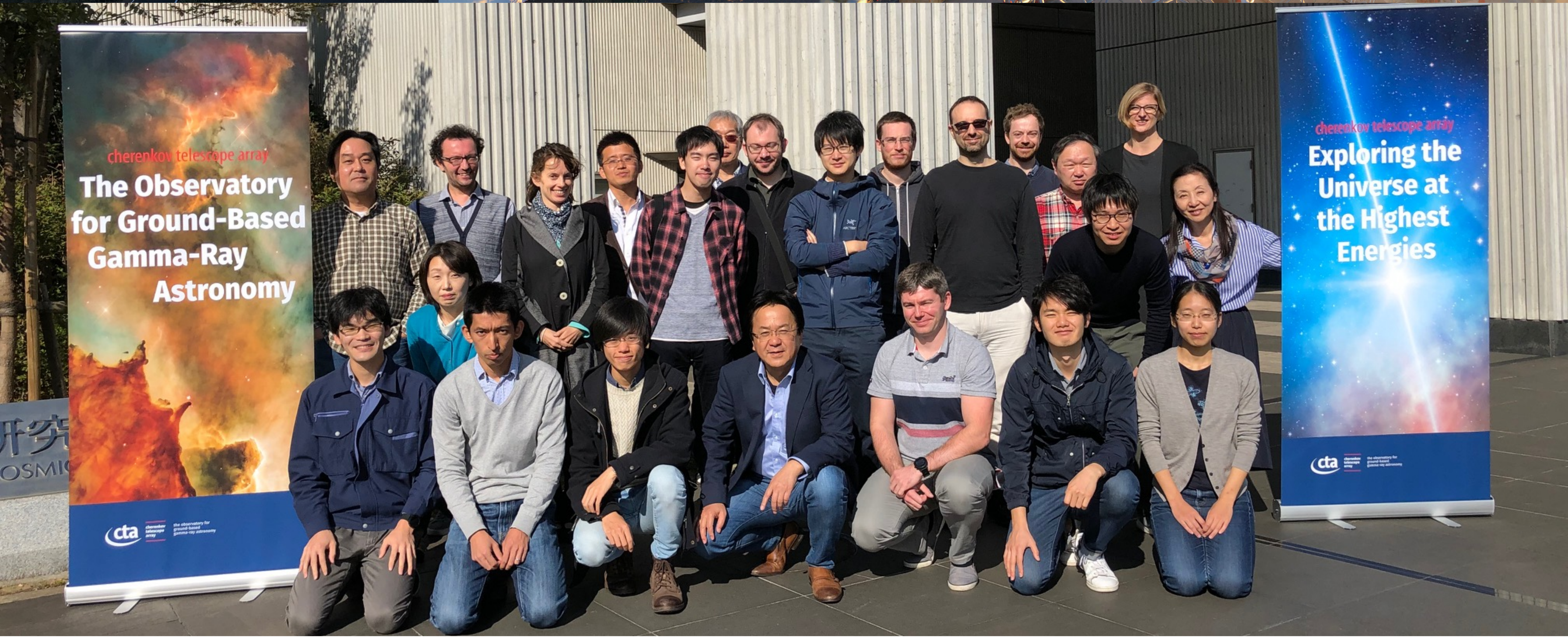
[8] "Observation of inverse Compton emission from a long γ-ray burst"
Nature,575,459; DOI:10.1038/s41586-019-1754-6

[9] "Testing emission models on the extreme blazar 2WHSP J073326.7+515354 detected at very high energies with the MAGIC telescopes"
Monthly Notices of the Royal Astronomical Society,490,2284;
DOI:10.1093/mnras/stz2725

[10] "Statistics of VHE gamma-Rays in Temporal Association with Radio Giant Pulses from the Crab Pulsar"
Accepted for publication by Astronomy and Astrophysics; arXiv: 1911.00634

[11] "New hard-TeV extreme blazars detected with the MAGIC telescopes"
Accepted for publication in Astrophysical Journal Supplement;
arXiv:1911.06680

Thank you for your support!




Thank you
for your support!