CTA計画 etc.

野田浩司（東大宇宙線研）
他 共同研究者

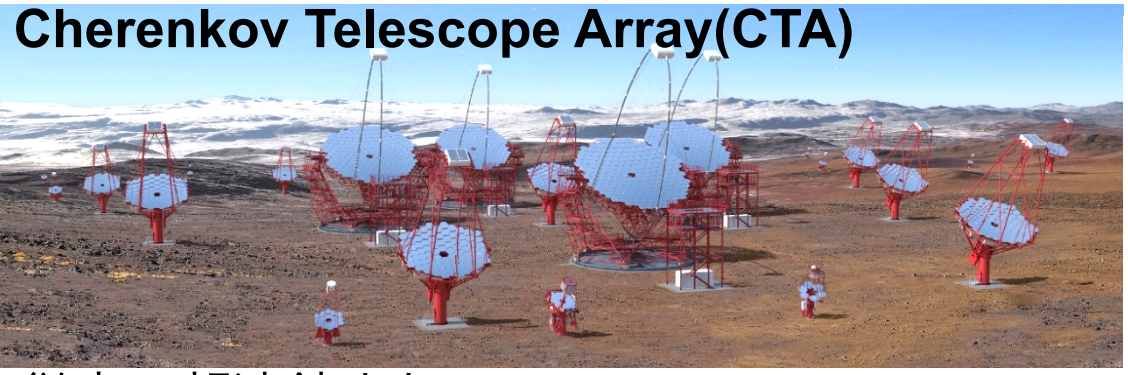
2018年12月21日
共同利用研究成果発表会

研究代表者・課題・査定額

E01	手嶋　政廣	CTA 計画	2,000
E02	井岡　邦仁	CTA-Japan 物理研究	250
E03	山本　常夏	CTA大口径望遠鏡の焦点面検出器開発	500
E04	窪　秀利	CTA大口径望遠鏡用読み出し回路の開発	800
E05	DANIEL MAZIN	CTA大口径望遠鏡初号基の設置建設と初期運用	500
E06	DANIELA HADASCH	CTA北サイト・ラパルマでのオンサイトデータ解析システムの開発	400
E07	田島　宏康	CTA小型望遠鏡用カメラの開発	450
E08	大石　理子	CTAモンテカルロシミュレーション	150
E09	西嶋　恭司	活動銀河核における超高エネルギーガンマ線放射領域の特定	400
E10	郡司　修一	CTAとLEAPによるガンマ線バーストの同時観測可能性に関する研究	150
E11	齋藤　隆之	CTA大口径望遠鏡による初期観測	500
E12	窪　秀利	MAGIC望遠鏡を用いた高エネルギーガンマ線天体の研究	500
E13	吉越　貴紀	明野観測所における小型大気チェレンコフ望遠鏡R&D	100

ありがとうございました。

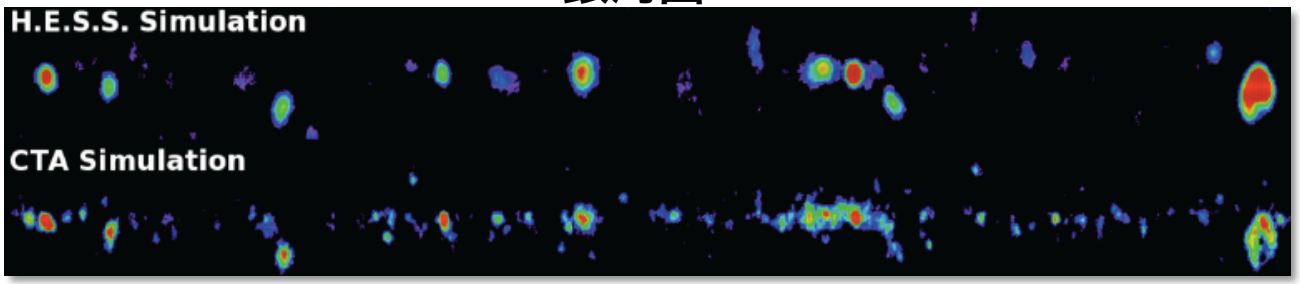
E01, E02: CTA project & physics

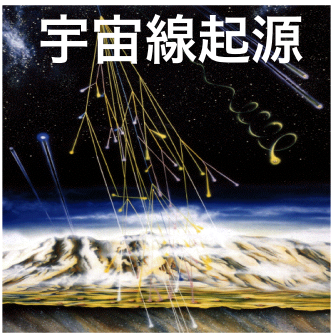


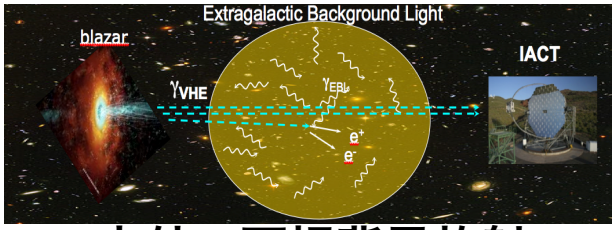
従来の望遠鏡より
- ◆一桁高い感度
- ◆一桁広い帯域(20 GeV-300 TeV)
- ◆角度分解能～2倍(2分角@10TeV)

- ■ 検出天体 200個(現行)
  ⇒1000個以上
- ■ 最遠方 z ～1(現行)
  ⇒ z～4

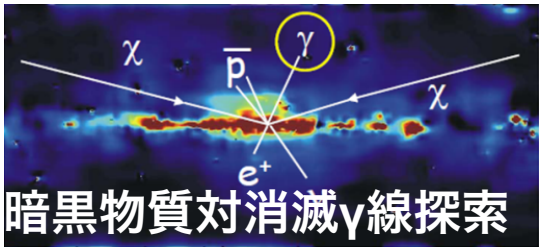
銀河面







赤外・可視背景放射
→宇宙の星形成史



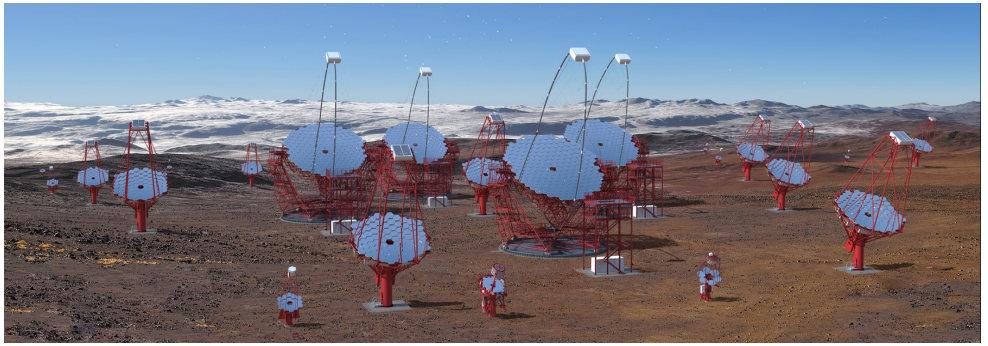
ローレンツ不変性検証

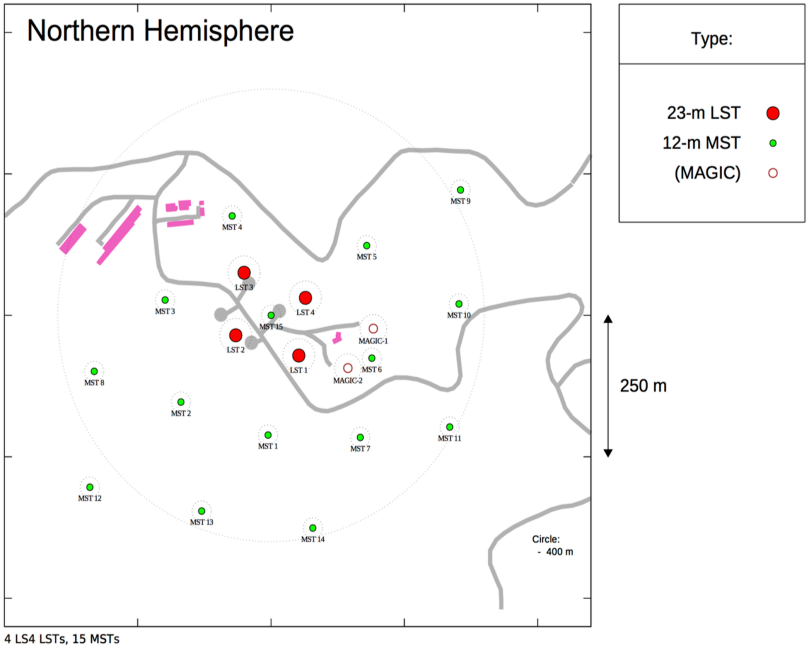
詳細は、Science with CTA , arxiv: 1709.07997

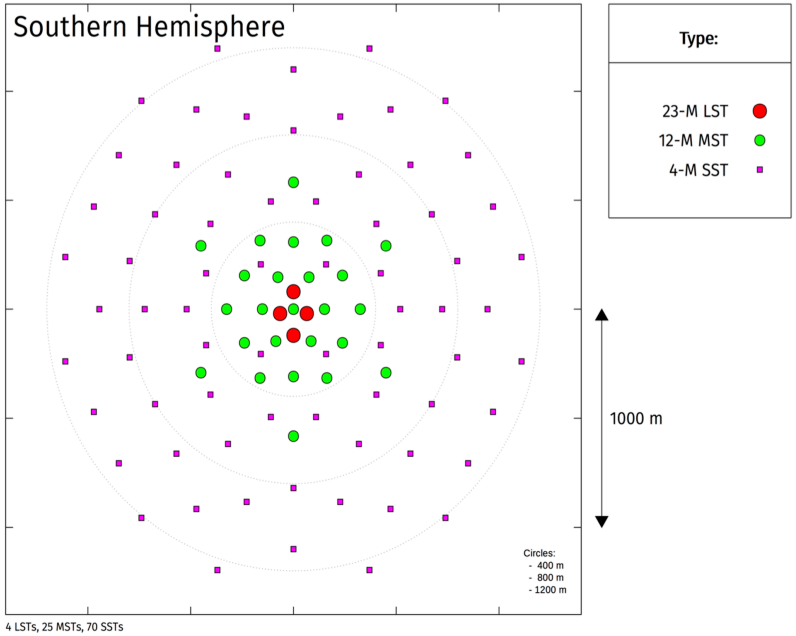
Two sites for all sky observatory

Roque de los Muchachos Observatory
La Palma, Spain

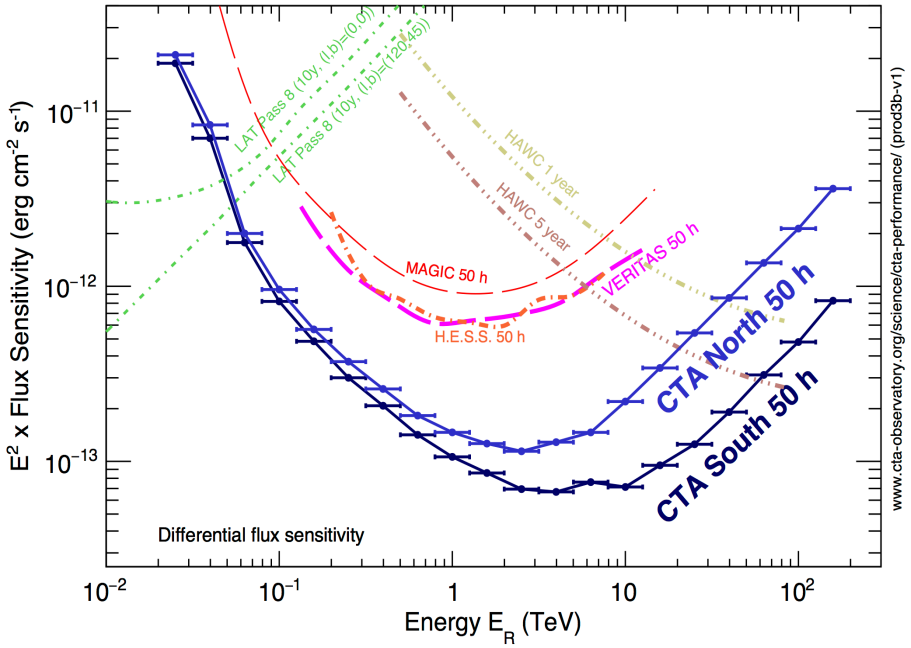
Paranal, Chile

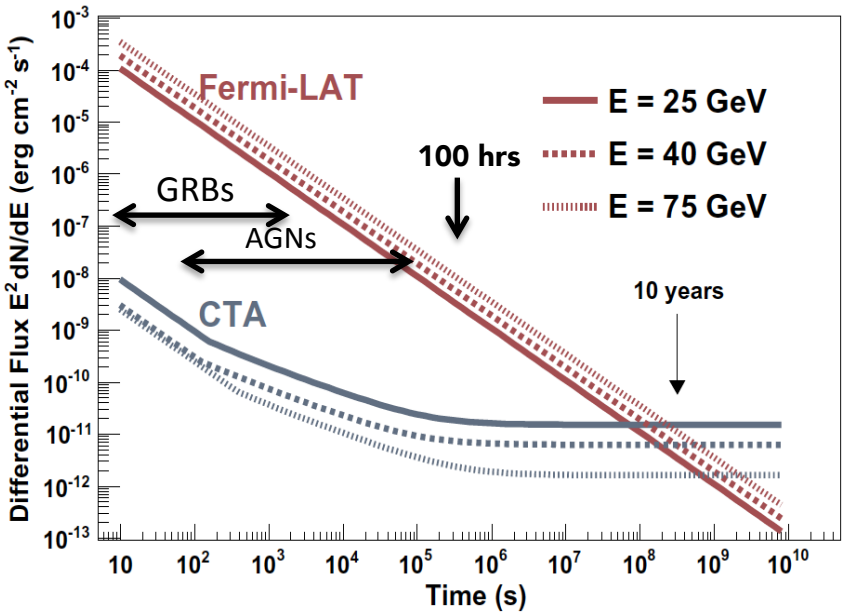






CTAN-LST Array
Sensitivity x3, Angular Resolution x2
Energy Range > 20GeV





- CTA-LST array contributes to the sensitivity in low energies
- >20GeV Threshold Energy
- Distant AGNs are observable up to z=2
- X10000 sensitivity for GRBs and AGN flares than Fermi
- First observation of GRBs from ground

CTA North

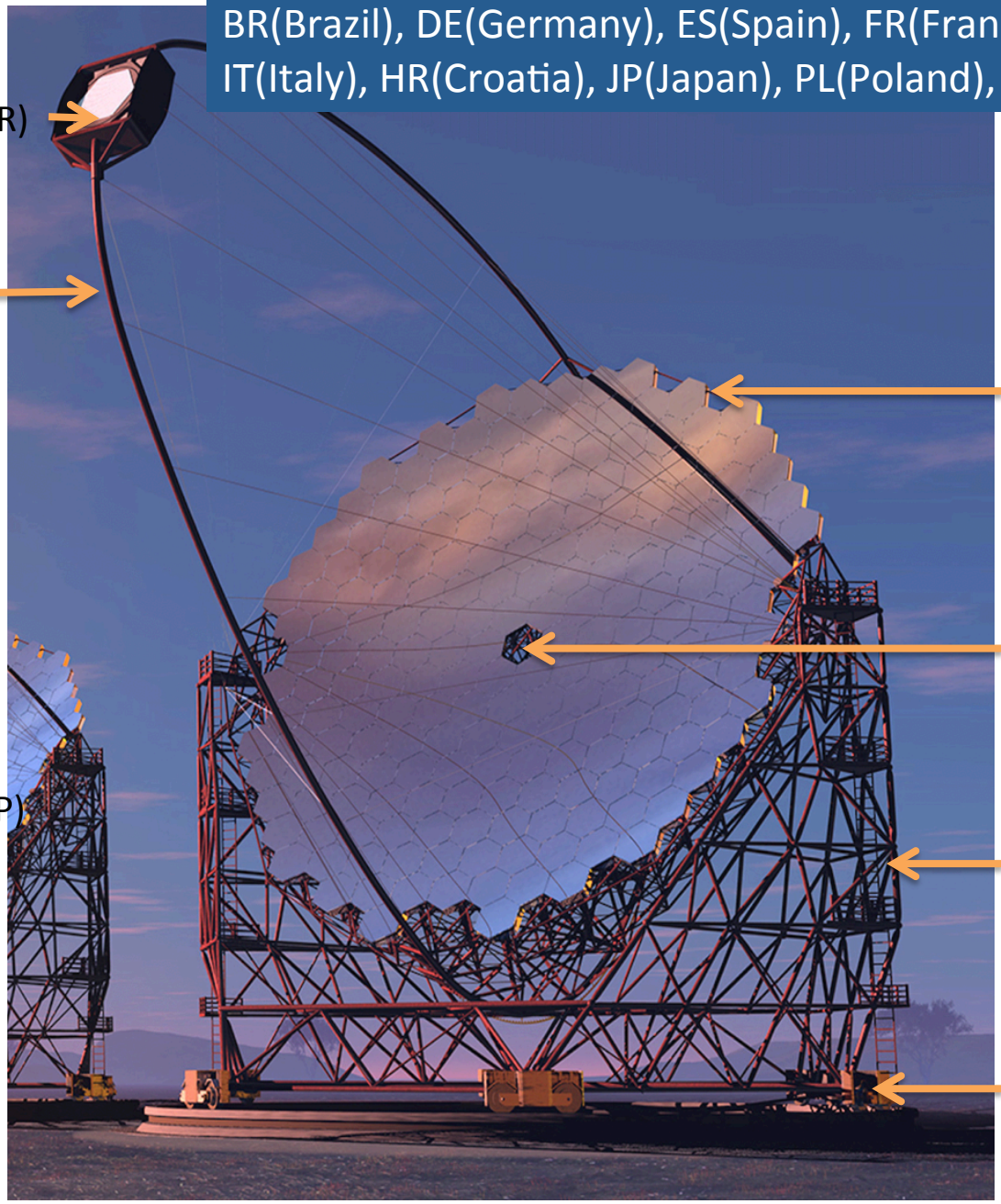
Observatorio del Roque de los Muchachos

CTA-LST Project: big International Effort

BR(Brazil), DE(Germany), ES(Spain), FR(France), IN(India), IT(Italy), HR(Croatia), JP(Japan), PL(Poland), SE(Sweden)

Focal Plane Instr.
Electronics (JP/IT/ES/FR)
Camera body (ES)

Camera Supporting Structure (FR/IT)



Mirror (JP)
Interface Plate(JP/BR)
Actuator (JP)
CMOS-Cam (JP)

Star Guider (JP/SE)
Calibration Box (IN/IT)
Cabling (DE/FR)

Structure (DE/ES)
Access Tower (DE/ES)

Drive (ES/FR/DE)
Bogie (ES/DE/IT)
Rail (ES/DE)
Foundation (ES)

Camera Access Tower (ES/DE)

Flywheel, UPS (JP)
Computers, network (JP)
INFRA (ES)

LST collaboration

Version 7.10

Steering Committee:
DE: **T. Schweizer** | *ES:* **M. Martinez (chair)** | *FR:* **J.-P. Lees** | *JP:* **H. Kubo** | *IT:* **N. Giglietto** | *IAC:* **M. Vazquez Acosta** | *Ex Officio:* **M. Teshima** | *Ex Officio:* **J. Cortina** | *Ex Officio:* **D. Mazin**

LST EXECUTIVE BOARD

LST Project Office
- *QA/RAMS:* **J. M. Miranda**
- *Systems Engineer:* **O. Ballester**
- *Telescope Manager:* **P. Marquez**
- *Principal Investigators:* **M. Teshima / J. Cortina**
- *Project Manager:* **D. Mazin**, Deputy: **NN**

prototype only

- **Site / INFRA** — *Crd.:* **J. Cortina**, *Dep.* **J. Herrera**
  - *Geological survey*
  - *Concrete foundation*
  - *Power / Network*
- **Data Analysis Software** — *Crd.:* **A. Moralejo**, *Dep.* **R. Lopez Coto**
  - *MonteCarlo*
  - *Data manage-ment*
  - *Data analysis*
- **Mechanical System** — *Crd:* **T. Schweizer**, *Dep.* **H. Wetteskind**, *Struct. Eng.:* **J. Eder**
  - *Dish&Lowe r Structure* — **H. Wetteskind**
  - *Camera Support Structure* — **G. Deleglise**
  - *Foundation , Rails & Bogies* — **J. Mundet**
  - *Structural Verification* — **J. Eder**
- **Optical System** — *Crd.* **K. Noda**, *Dep.:* **M. Teshima**
  - *Primary Mirror* — **T. Inada**
  - *AMC* — **M. Chikawa**, **S. Fukami**
- **Camera Integration** — *Crd.:* **O. Blanch**, *Deputy:* **C. Delgado**, *Prod.:* **C. Diaz**
  - *Mechanics & Cooling* — **C. Diaz**
  - *Slow Control* — **J. Prast**
  - *DAQ* — **T. Saito**, **D. Hoffmann**
- **FPI / Electronics** — *Crd.:* **H. Kubo**, *Dep.:* **R. Paoletti**, *Prod.:* **T. Saito**
  - *Photo-detectors* — **T. Yamamoto**
  - *Readout* — **H. Kubo**
  - *Trigger* — **G. Martínez**
  - *Light Guide* — **A. Okumura**
- **Auxiliary systems** — *Crd.:* **A. Fiasson**, *Prod.:* **E. Chabanne**
  - *Drive Control System* — **I. Monteiro**
  - *Global monitoring* — **T. Le Flour**
  - *Pointing Calibration* — **K. Noda**
  - *Camera Calibration* — **P. Majumdar**
  - *Power Distribution* — **M. Teshima**
- **R&D – Cam. SiPM** — *Crd.:* **R. Rando**, *Prod:* **S.Rosier-Lees**
  - *Photo-detectors* — **G. Ambrosi**
  - *Readout* — **R. Hermel**
  - *Integration with PMT Camera* — **D. Mazin**

- *Interfaces and Integration*
  - *ACTL* — **T. Le Flour**, **K. Noda**
  - *Data* — **NN**
  - *Site / INFRA* — **J. Cortina**
  - *Common Test Facilities* — **M. Doro**
  - *MAGIC* — **O. Blanch**

- Project led by M. Teshima (ICRR)
- Project manager: D. Mazin (ICRR)

LST1: Concrete foundation, bogies and rail

After the long delay of the construction permission

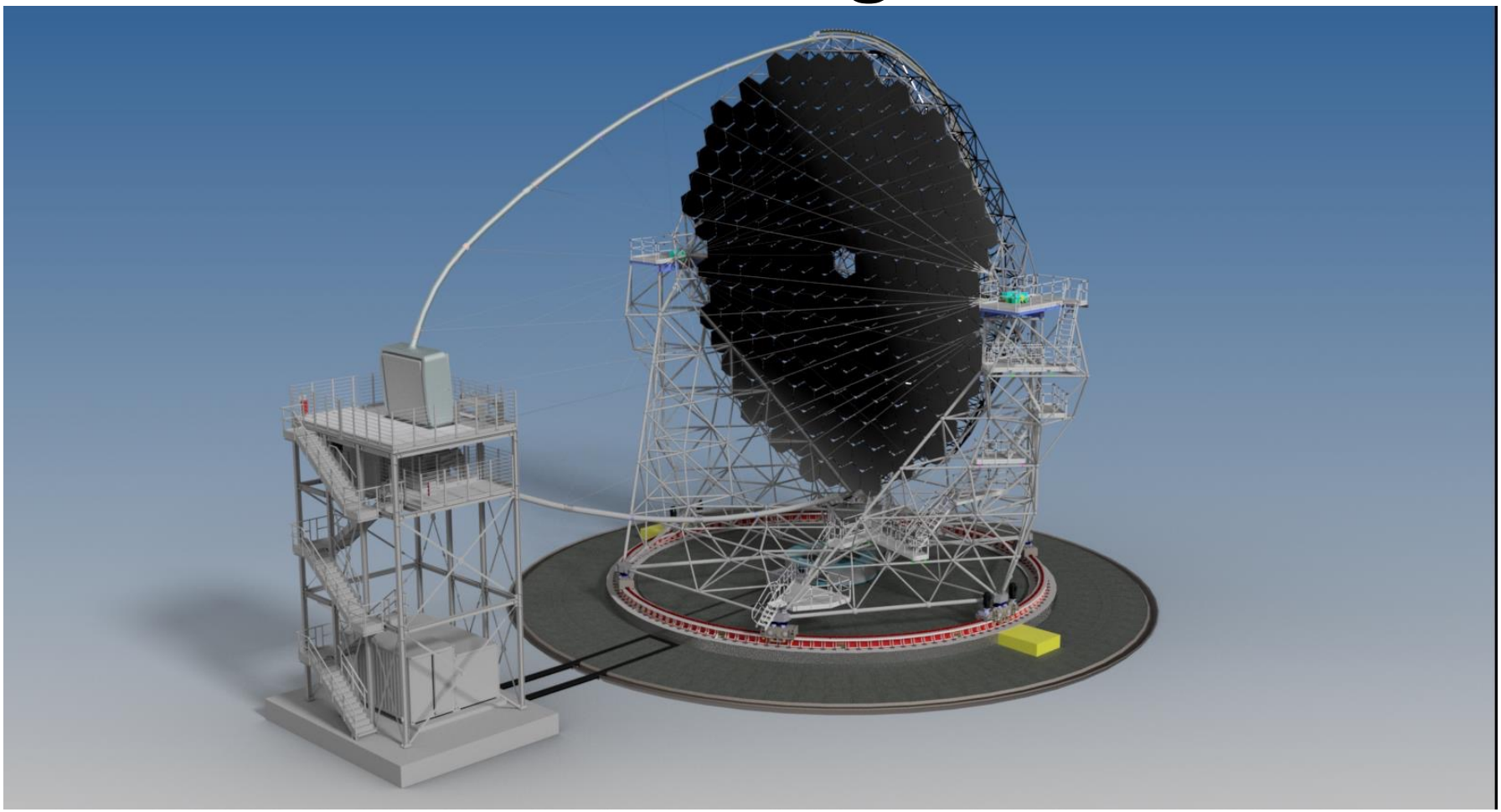
LST1: completion of Azimuth str.

https://www.cta-observatory.org/project/technology/lst/

Nov 2017
CTA General Meeting

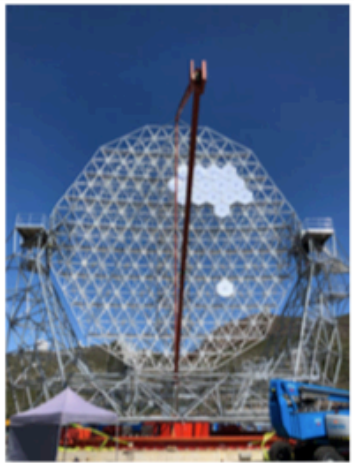
LST1: Mirror dish installation

From April 2018
E05: Construction & commissioning of LST1

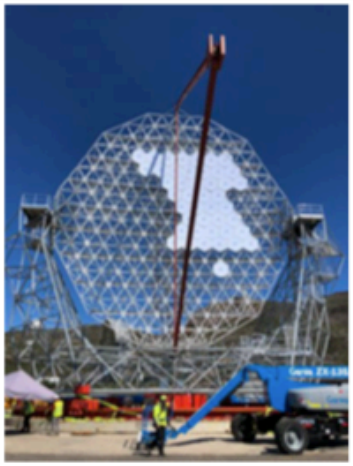


LST1 construction in 2018

- Mirror Installation

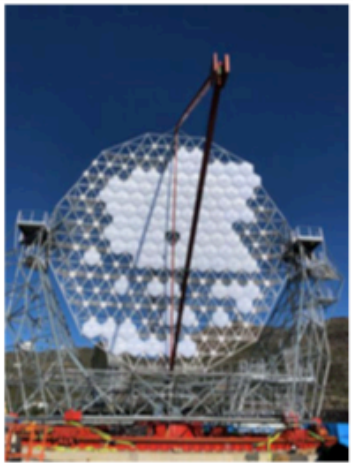


April 26



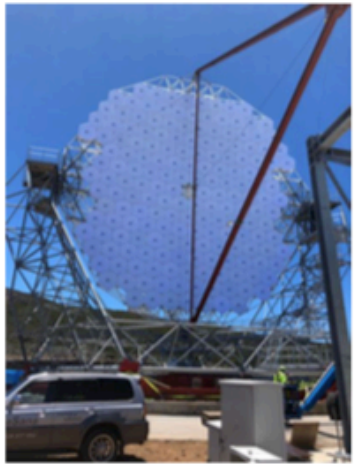
April 28

May 4

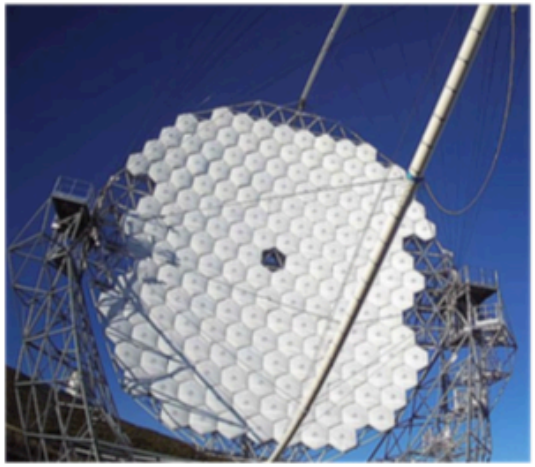


May 10

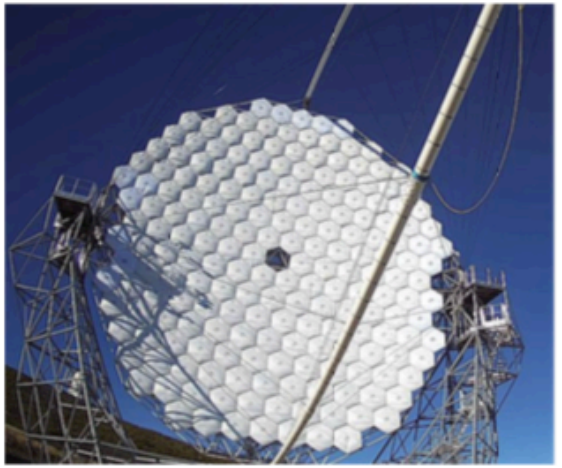
May 15



May 23

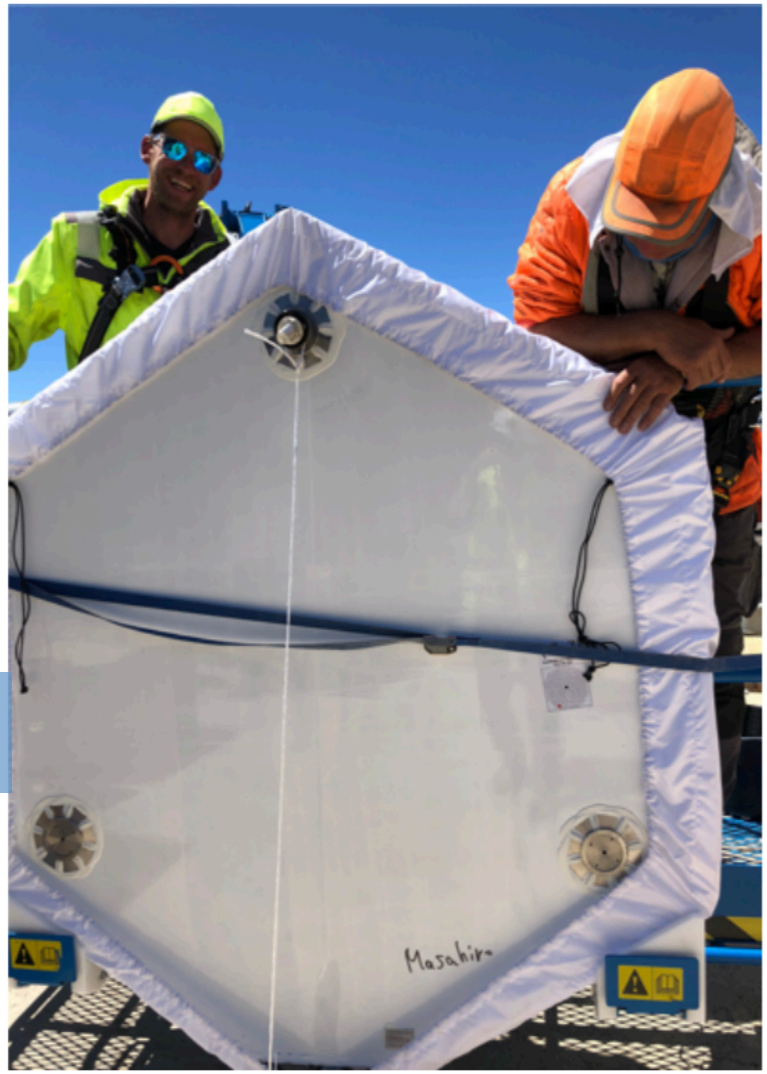


Aug 9



Aug 11

LST1: Mirror installation



There is 'Martin' mirror as well ;)

LST1 construction in 2018

- CSS installation

Assembly of CSS, camera frame, CF cables and spreader on the ground,

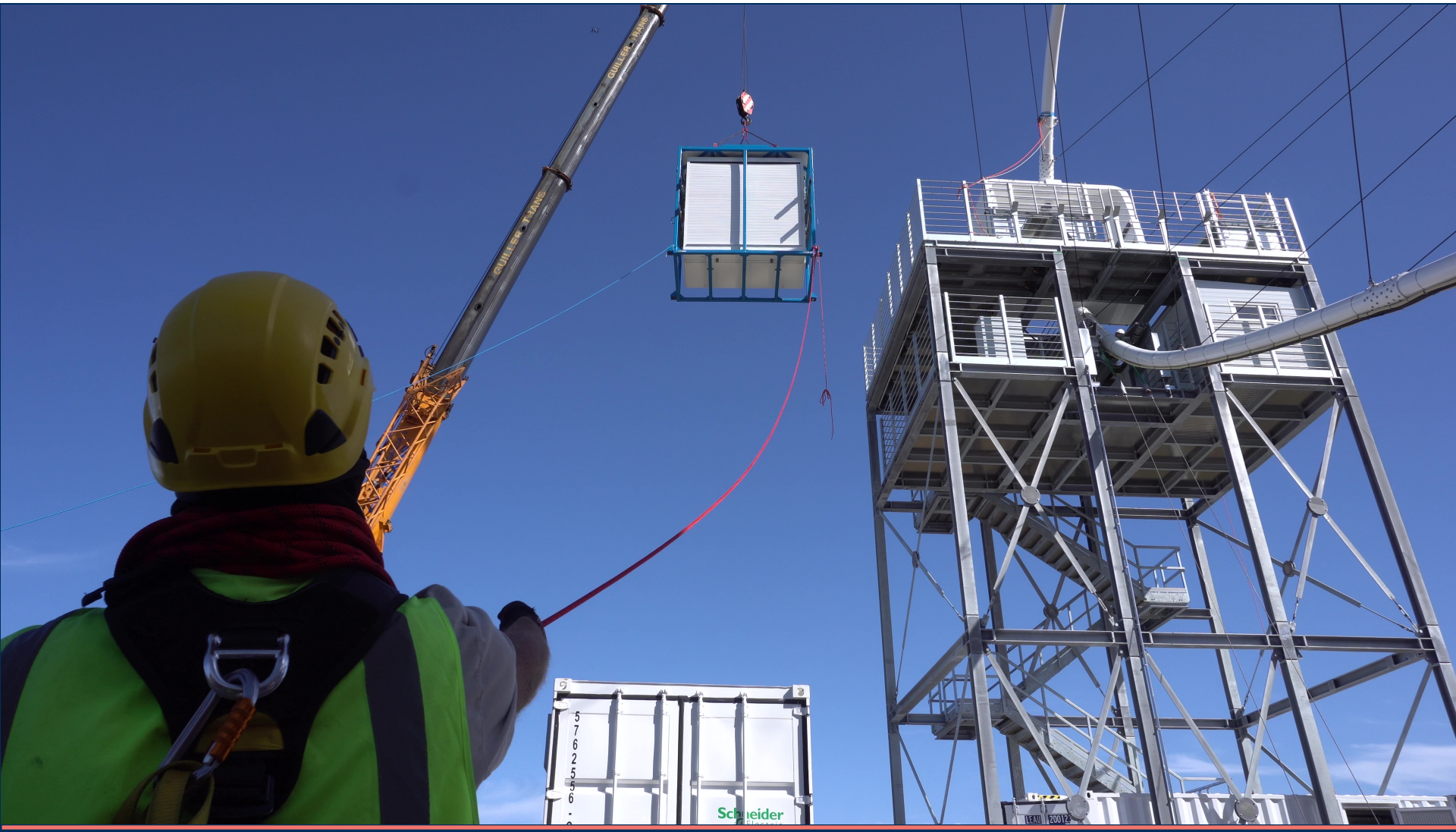
LST1 construction in 2018

- lifting with 70t crane

- CSS installation

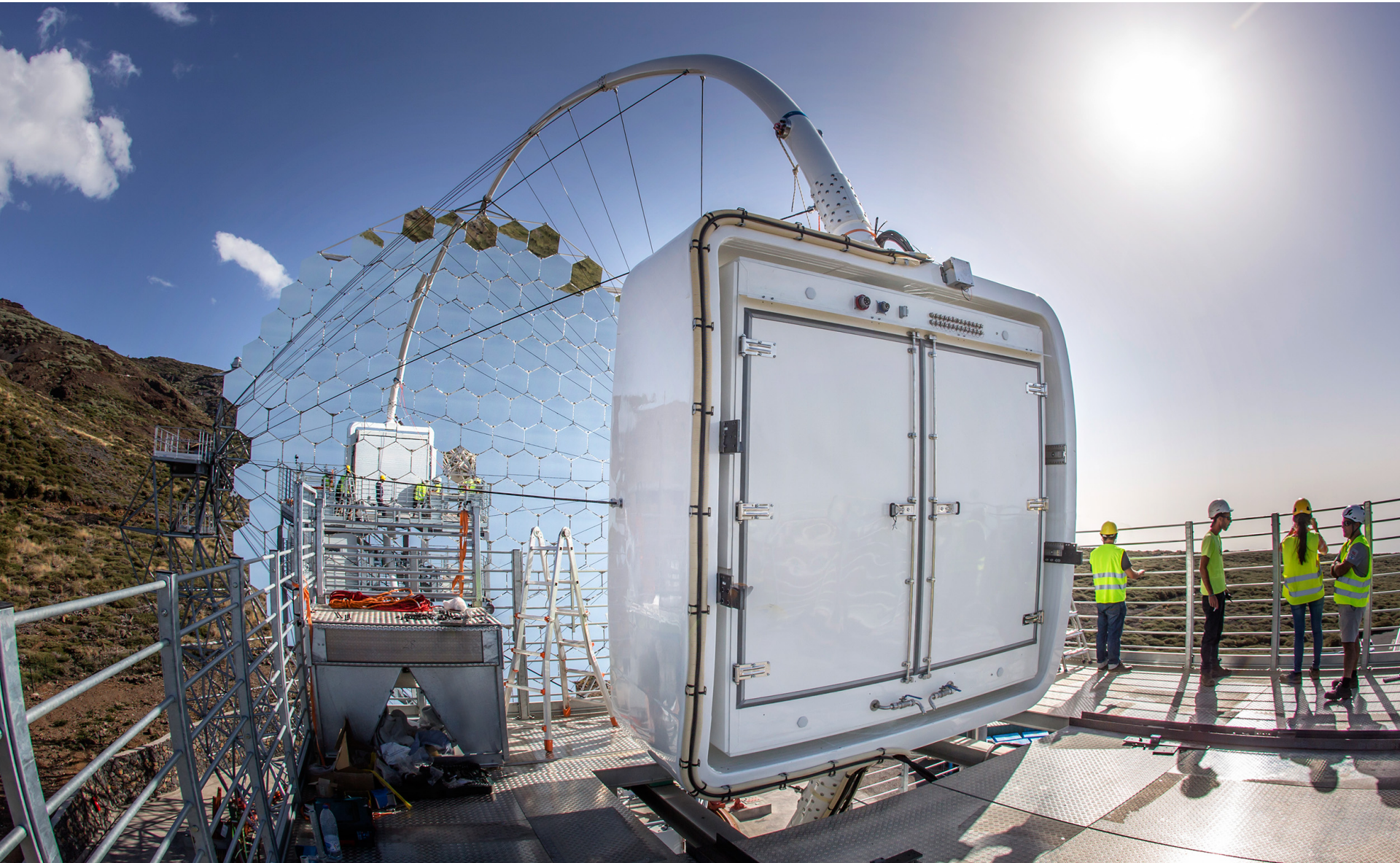
LST1 construction in 2018

- Camera installation



LST1 construction in 2018

- Camera installation



LST1 construction in 2018

- Inauguration

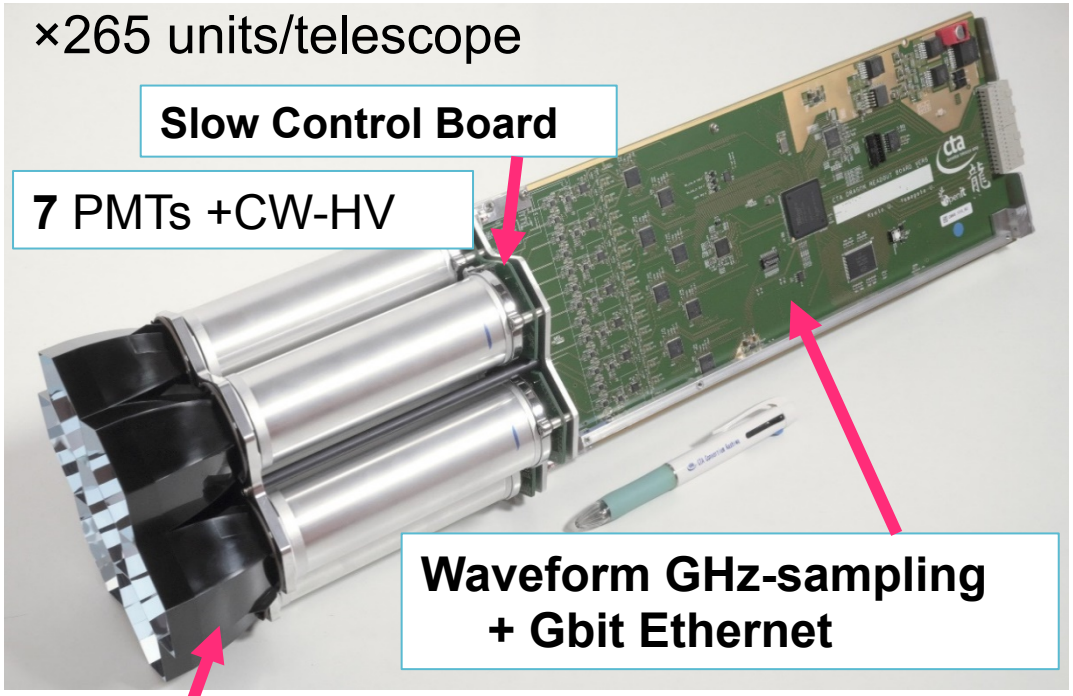
The LST1 is ready

J. Jimenez, Picture taken on October 3, 2018

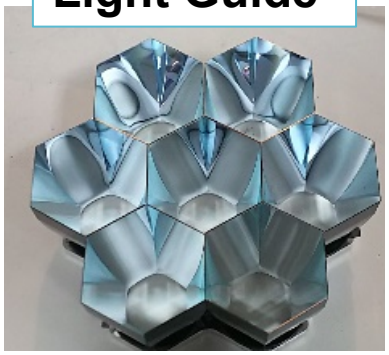
LST-1 Camera

[E03] Development of Focal Plane Instrument (Yamamoto)
[E04] Development of Camera Readout Electronics (Kubo)

×265 units/telescope



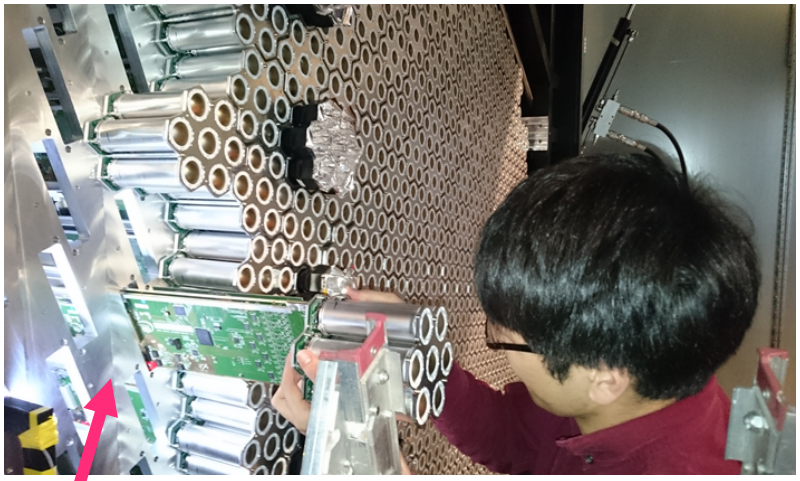
Light Guide



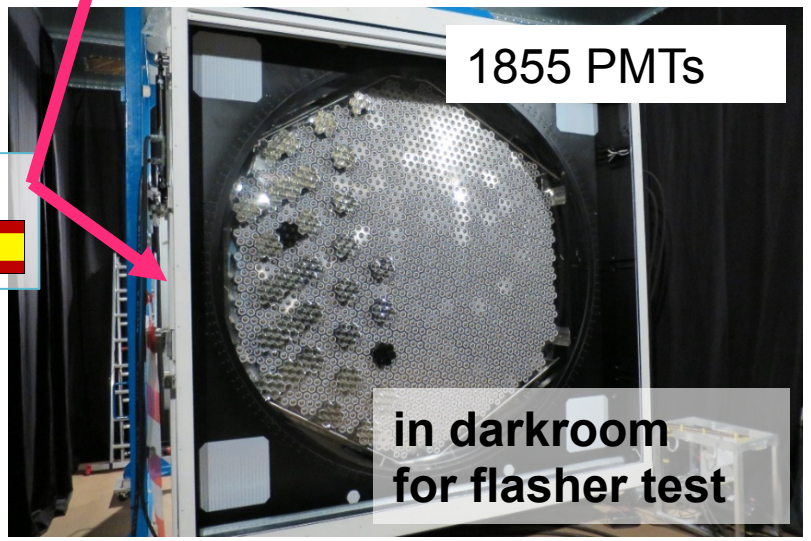
The design was changed from ESR reflective film to direct coating to plastic cone. Mass production was done in Q2 2018.

Integration & Test

@IFAE(Barcelona) in Apr. to Jul.



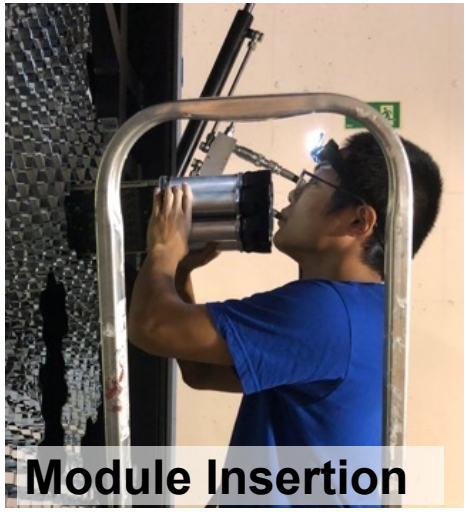
Camera body

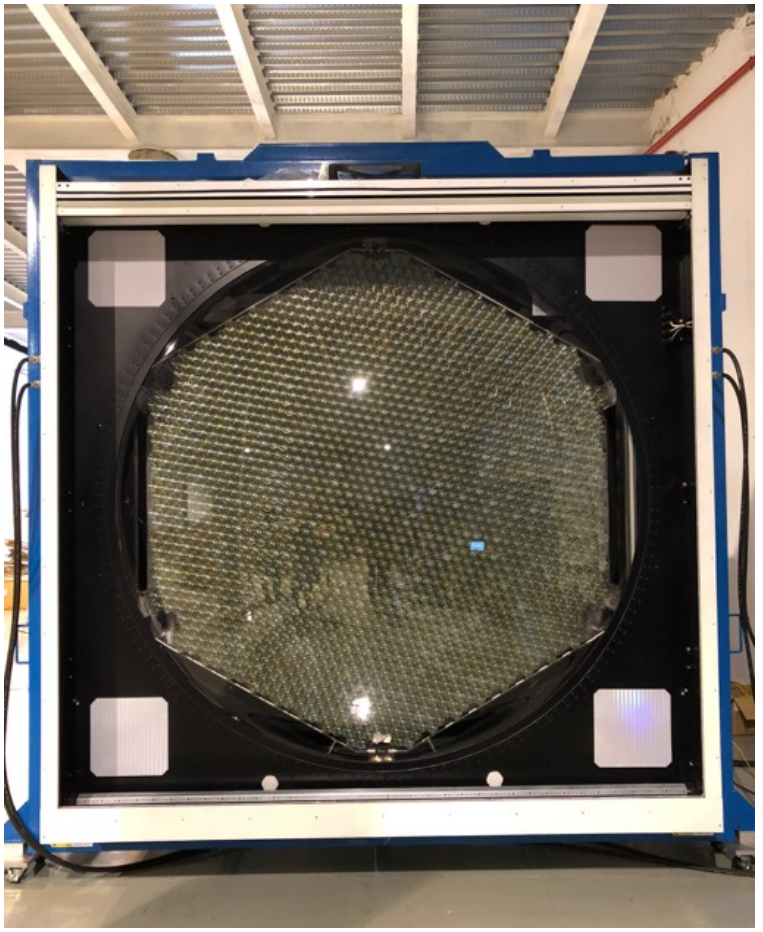


After tests, PMT-modules were removed from the body for shipping to La Palma.

LST-1 Camera

Integration and Tests at La Palma in Aug. to Sep.



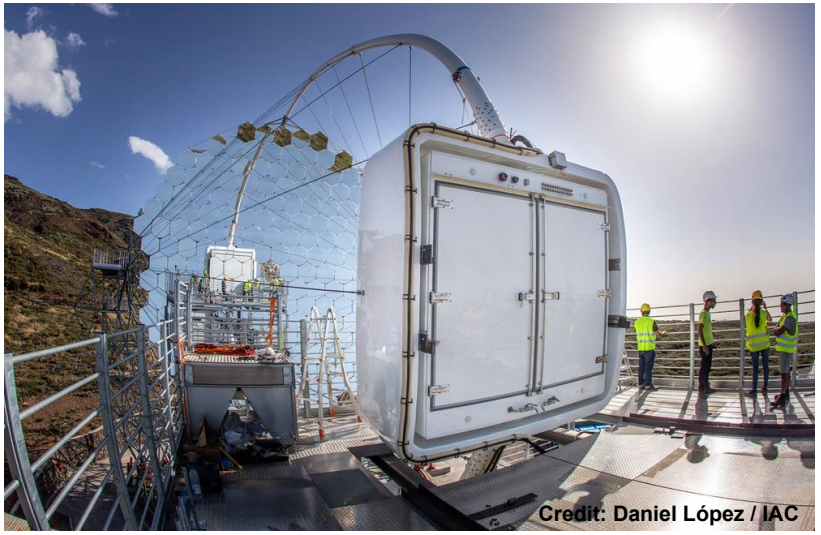


Finally perfect camera completed!

In collaboration with Spanish and French groups

LST-1 Camera

Installation to telescope on Sep. 25



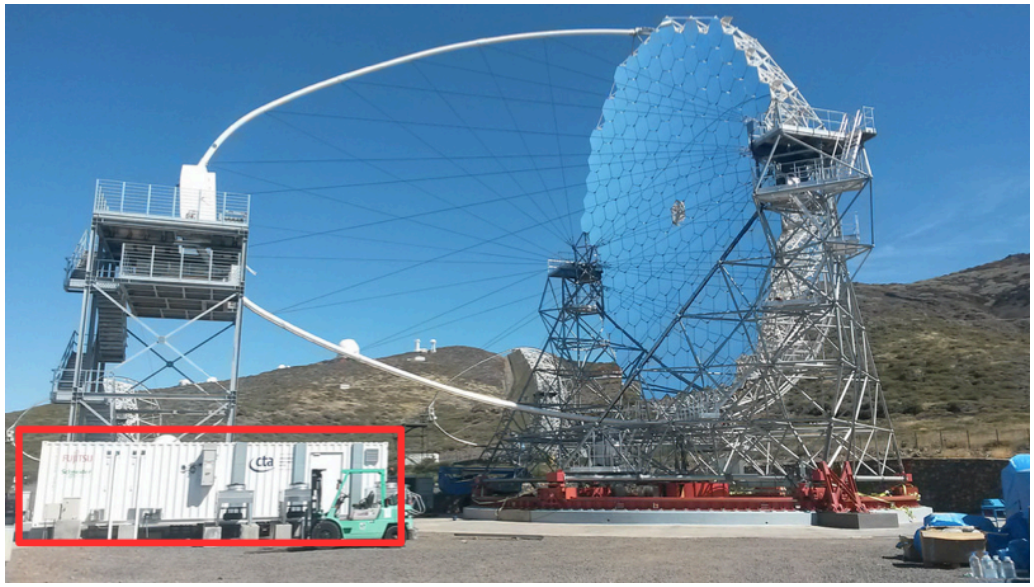
Production of LST 2-4 Cameras

- Mass-productions of PMT-module elements except light guides were done.
- QC of the elements and assembly of PMT modules are ongoing at ICRR and La Palma

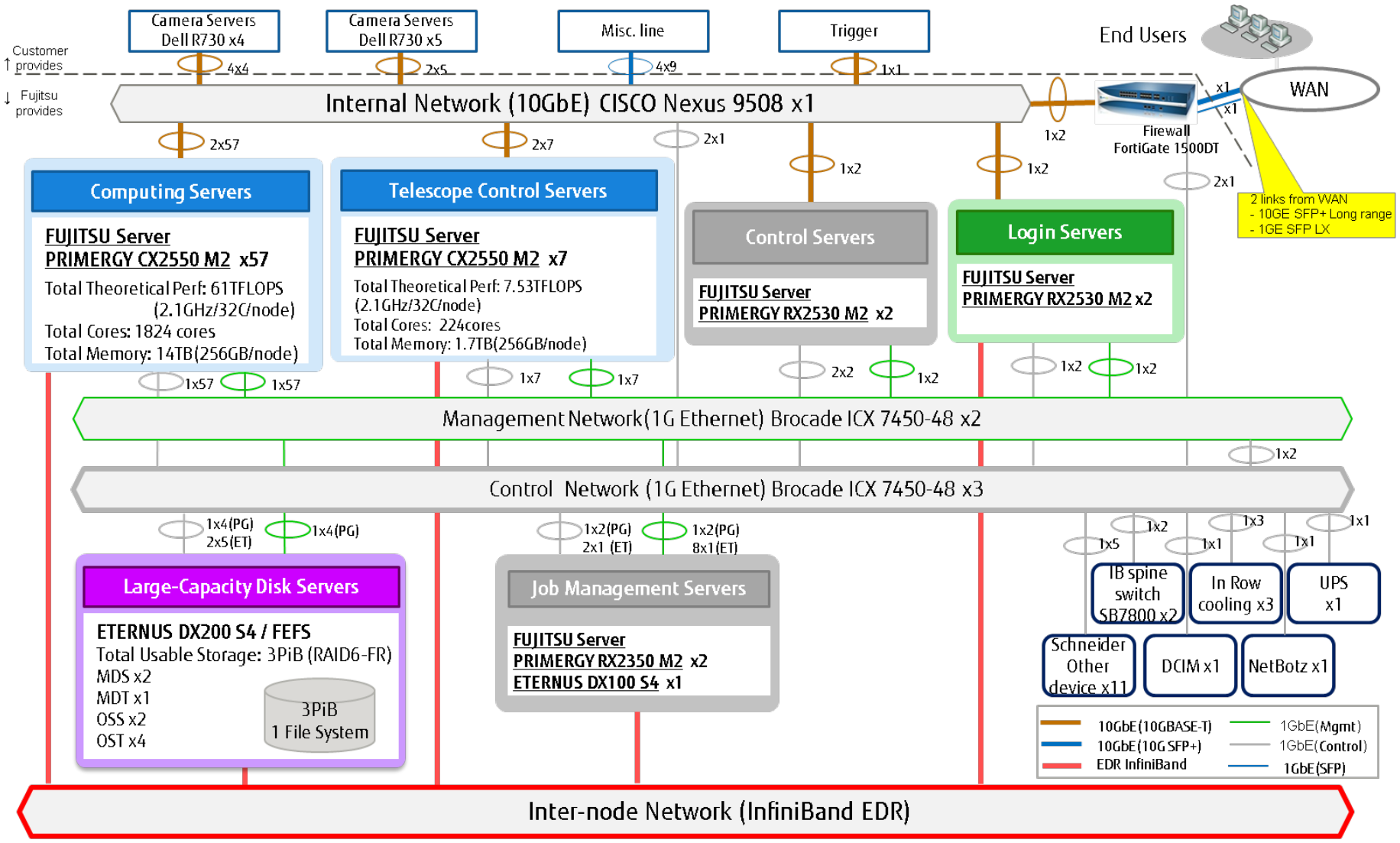
We could take the waveform data from almost all PMTs.

E06: IT onsite Computing Container

- Located on LST-1 site: onsite data center for CTAN with a capacity enough for 4LSTs+5MSTs
- Infrastructure & components provided by Fujitsu
  - Infiniband & Ethernet network configurations
  - 2000 CPU cores
  - 3.4 PB of disk space
  - Nexus 9508 Router
  - Lustre file system
  - SLURM batch system



General Architecture

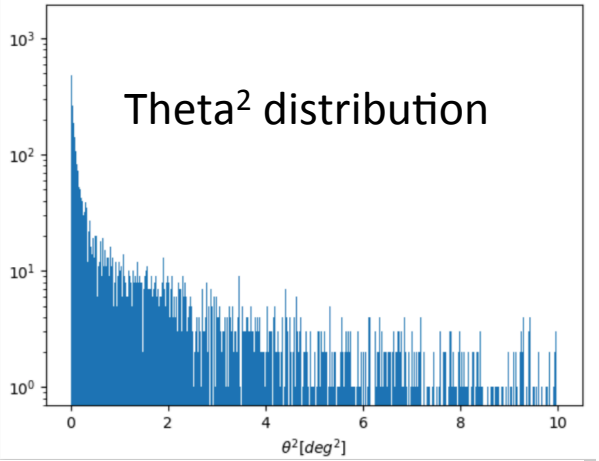


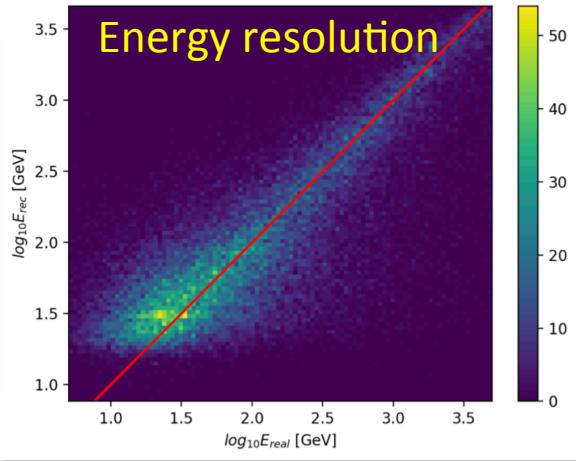
IT center Administration team

PIs: Masahiro Teshima, Daniel Mazin, Koji Noda
Network/Infrastructure: Takayuki Saito, P. Márquez
IT manager (Japan): Daniela Hadasch
Low-level system admin: Rafael Morizawa (Fujitsu)
High-level system admin: J. Delgado (LDAP Integration, Data Transfers, Singularity)

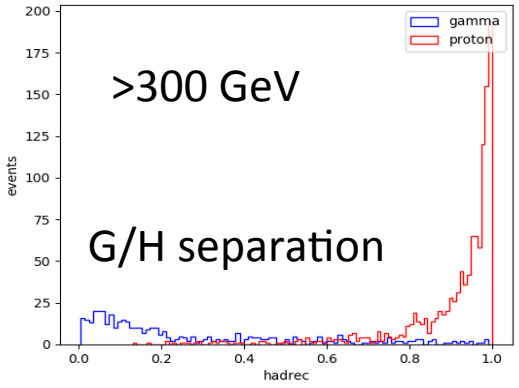
Advisers & technical help): R. Lindemann, F. Krack, P. Wegener (DESY Zeuthen)

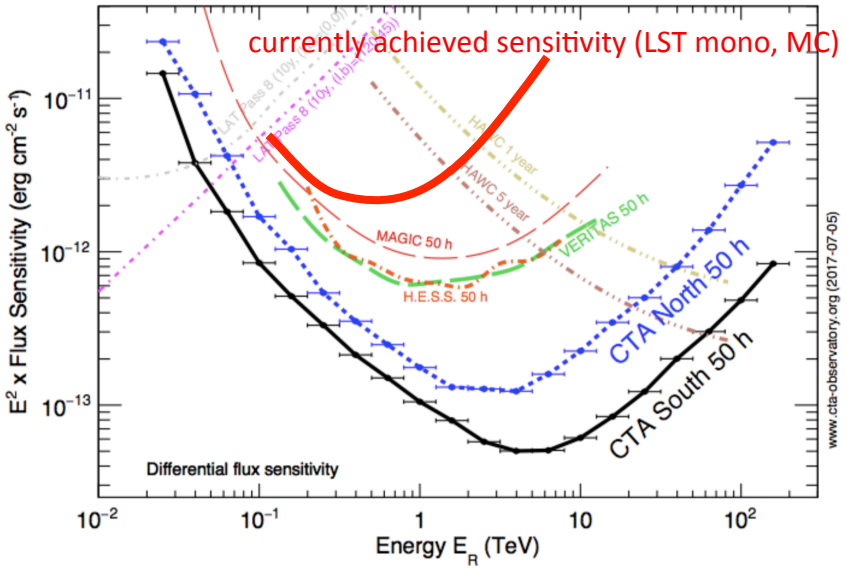
E:11 Early phase observations with CTA Large Sized Telescopes





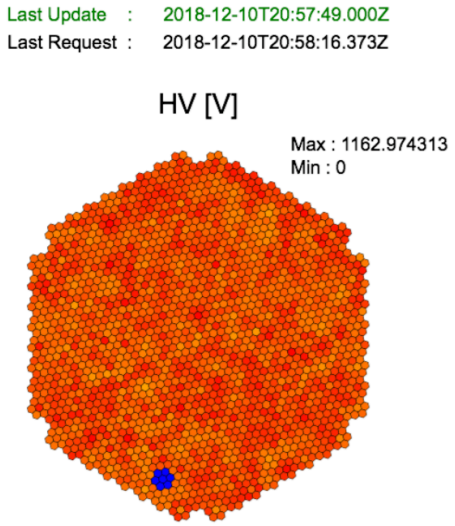
- LST1 mono analysis is being developed using MC simulations.
- Software is called “cta-lstchain” and it is based on python.
- Large room for improvements in
  - G/H separation at low energies
  - Head-tail decision



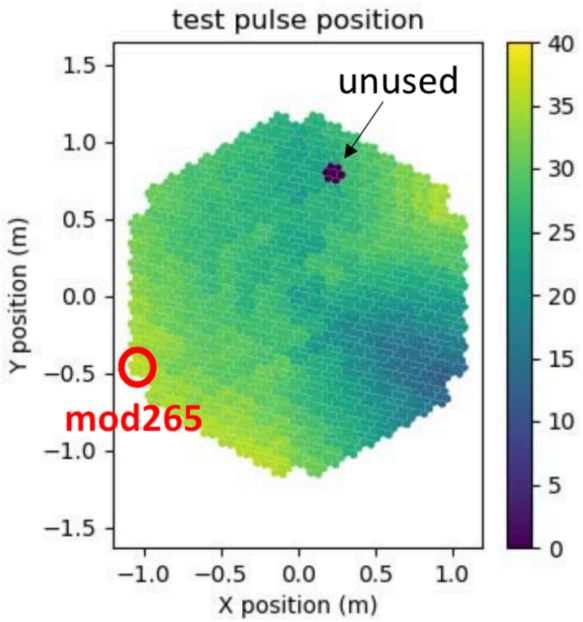


PI	TSaito
Approved Budeget	500k Yen
Purpose	Travel

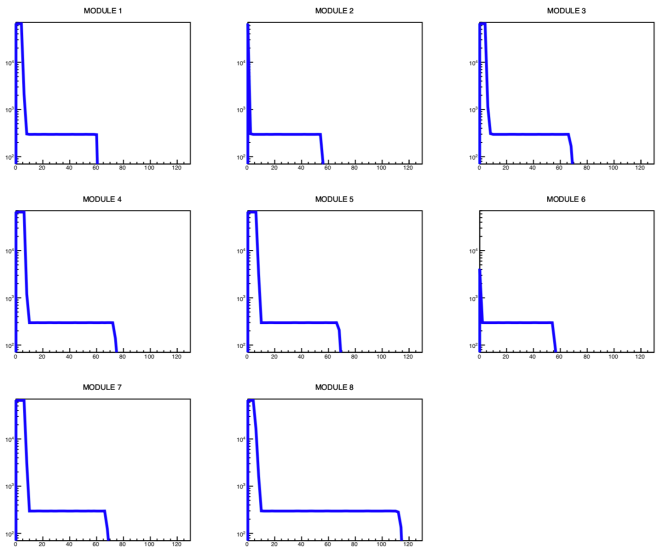
Early phase observations with CTA Large Sized Telescopes



HV are applied



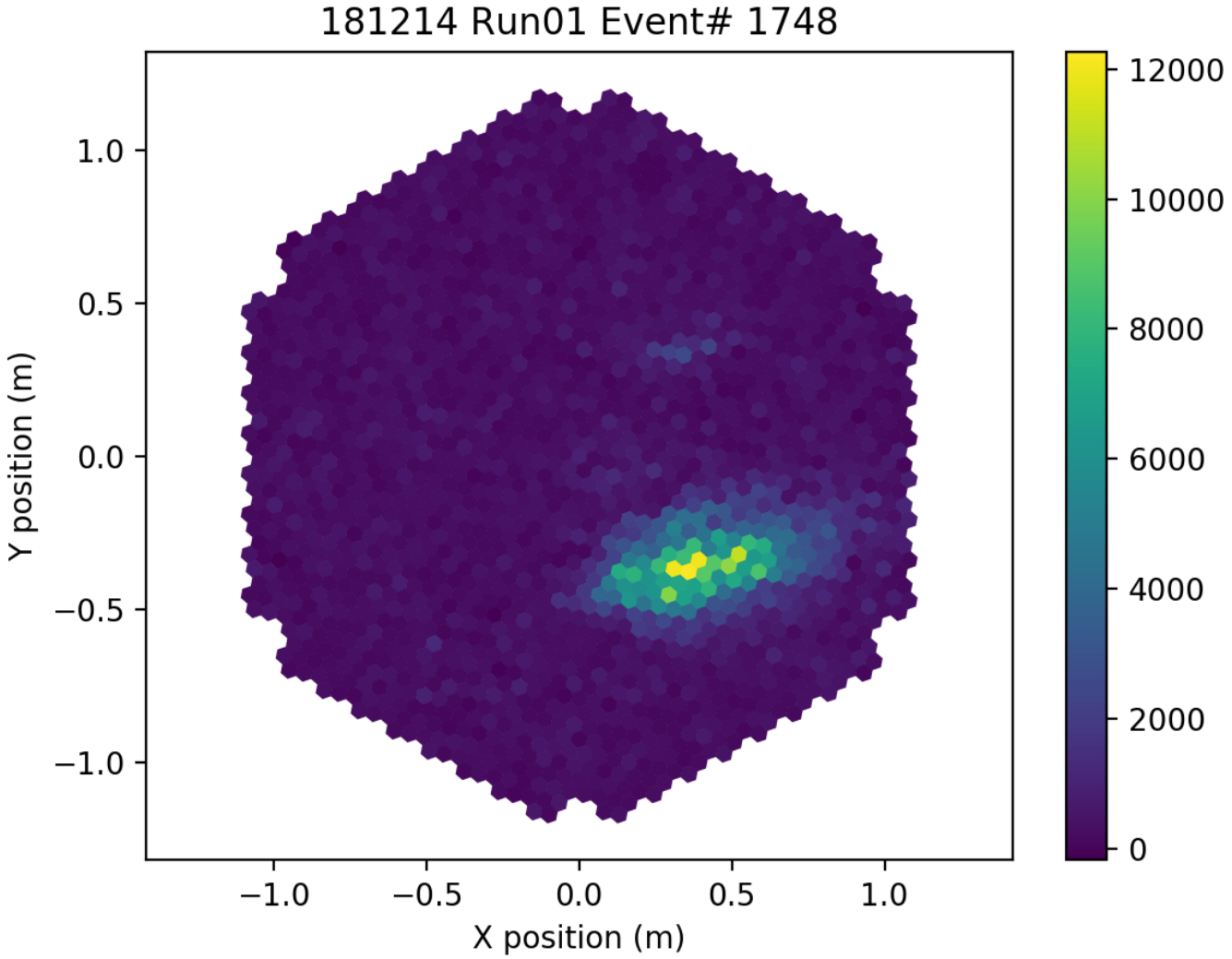
PMT modules are synchronized



Trigger is ready.

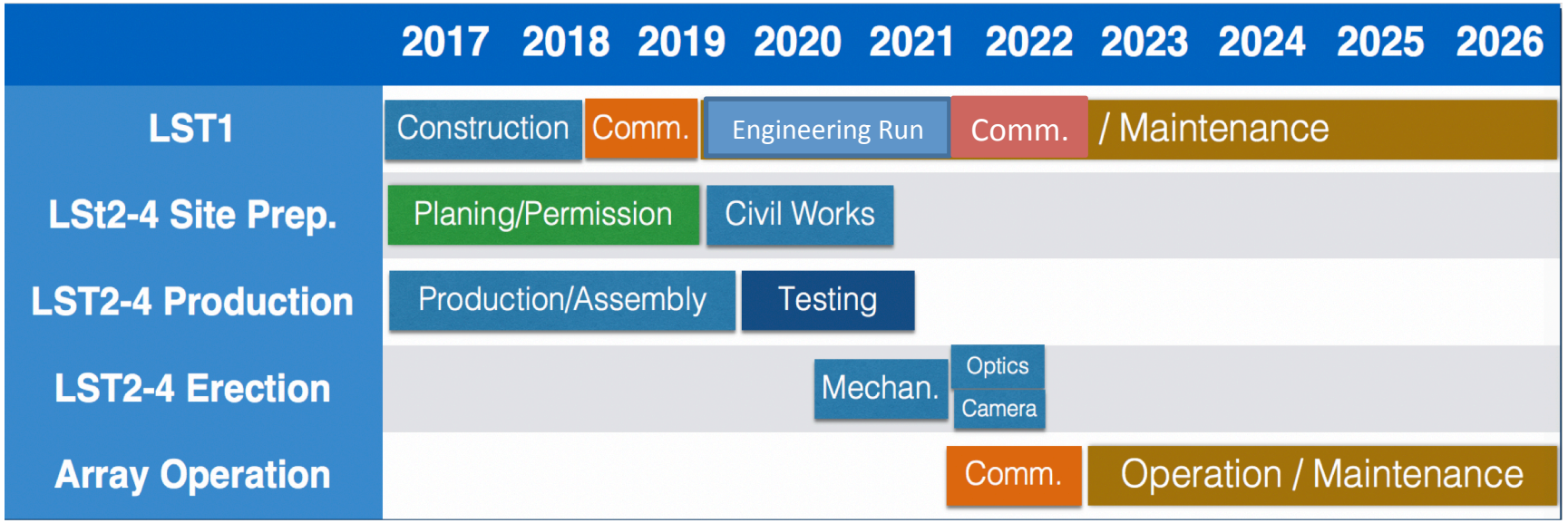
DAQ is also ready.
Real data is coming very soon!

NEW: event examples



Time schedule of LSTs in CTA North

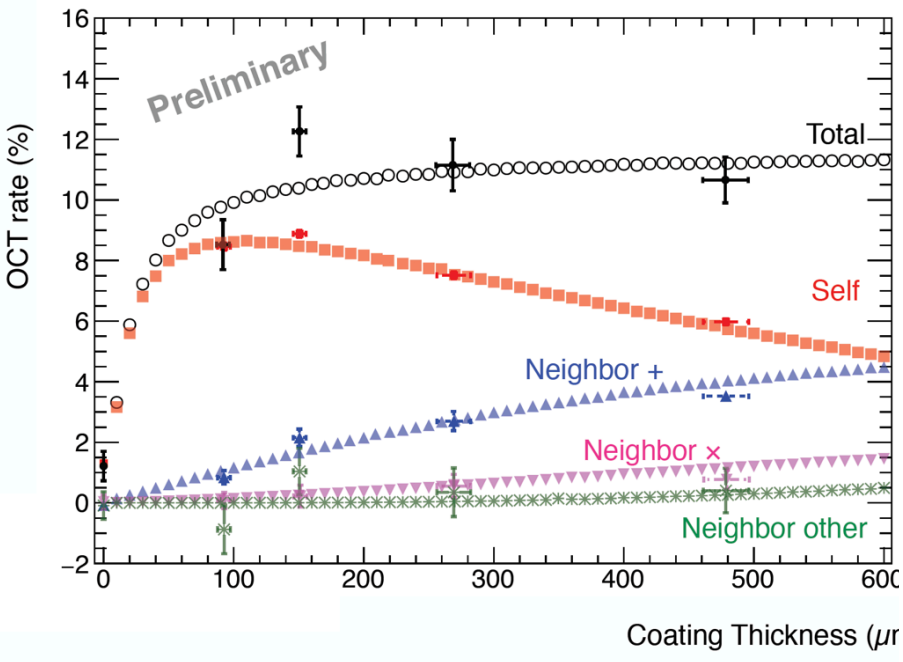
- The final tuning of the system is still ongoing
  - The commissioning (tune the system) may take at least one year (until end of 2019).
  - Engineering run after commissioning may continue to understand better the performance and characteristics of the telescope in 2020 and 2021 (technical observations and technical publications)
  - If scientifically important results are obtained during eng. run, paper shall be signed by all CTAC members
  - In 2022, we may complete LST2-4, and then start the commissioning of the LST stereo system
  - In 2023, we can transfer LST1-4 to CTAO as IKC, CTAO shall operate them
- In 2022/2023, we want to start the construction of LST5-8, if the finance is continued

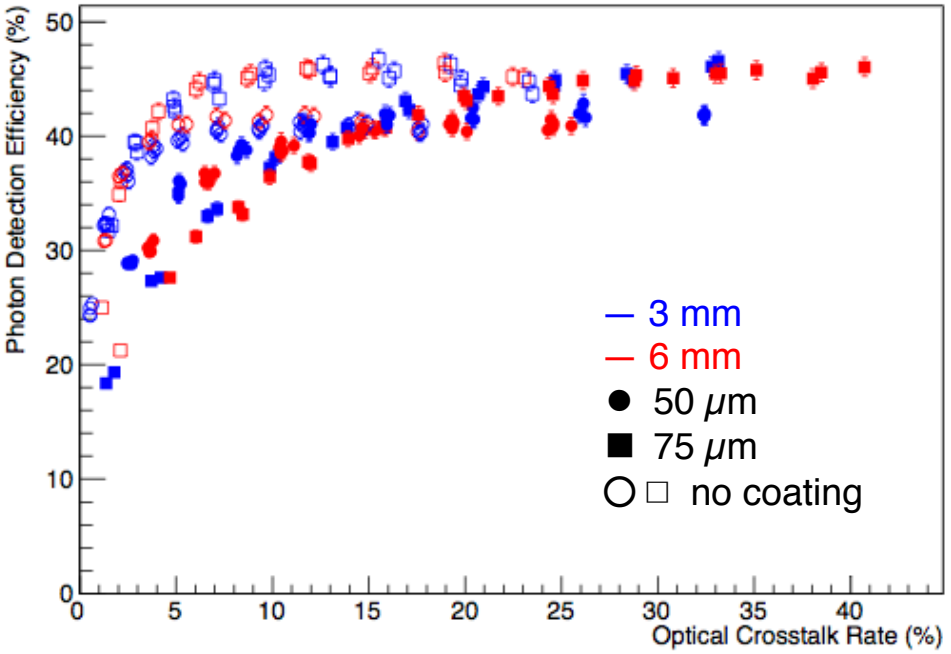


Other research projects for CTA

E07: SiPM Camera for GCT (SST)

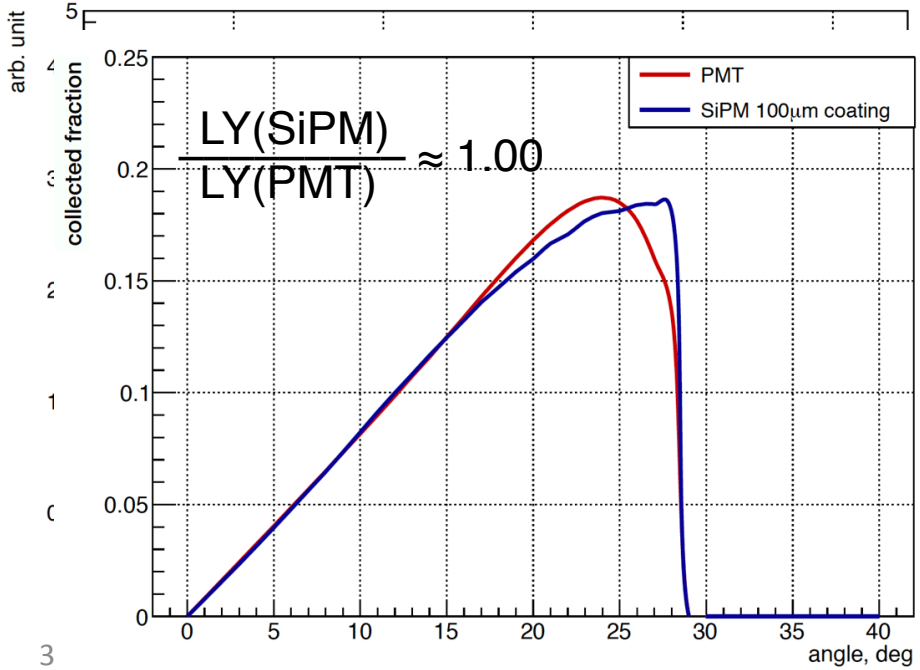
- Nagoya group is in charge of SiPM and GCT camera software
  - CTA prefers SiPMs with high photon detection efficiency (PDE) and low optical crosstalk (OCT)
    - Thicker protection resin can reduce crosstalk for single SiPM, but total crosstalk including neighboring SiPM are constant
    - Removing protection resin gives best optical crosstalk
      - 6 mm SiPM with 75 µm cell without protection resin is recommended

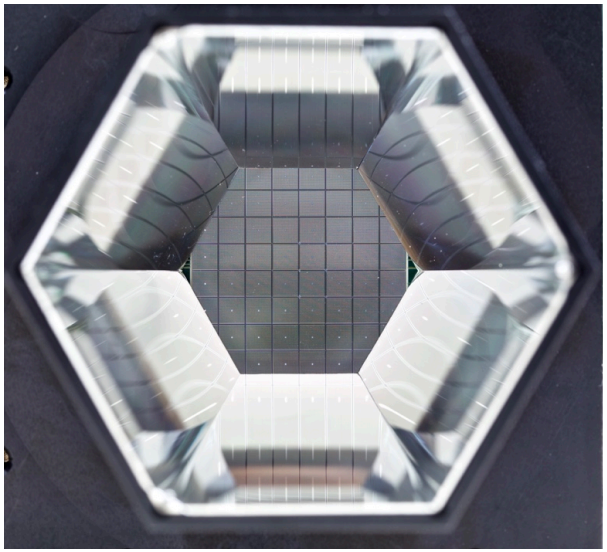




SiPM Camera for MST

- Nagoya group is also 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 is similar between SiPM and PMT





E08 : "CTA Monte Carlo simulation"

Budget:

	Domestic travel	Material&Supplies	Total
Amount of money	150k JPY	0 JPY	150k JPY

Thank you for your support

With usage of ICRR computer cluster at Kashiwa

Purpose: Travel money for F2F meeting

Activity:

- **F2F meeting in Kashiwa (Jun 5th, joint with ctapipe/IT center lecture)**
  annual events mainly for beginners, including instructions of ICRR computer cluster usage
- **Members are working on their own research topics, forming small teams**

North 4-LST high NSB sensitivity study (Ibaraki-U team) / hadronic interaction study (expansion from CR electron study, ICRR) / SiPM related studies (Nagoya ISEE team) / muon-ring studies (Kinki-U team) / ODA activity (there will be an independent report on this) etc.

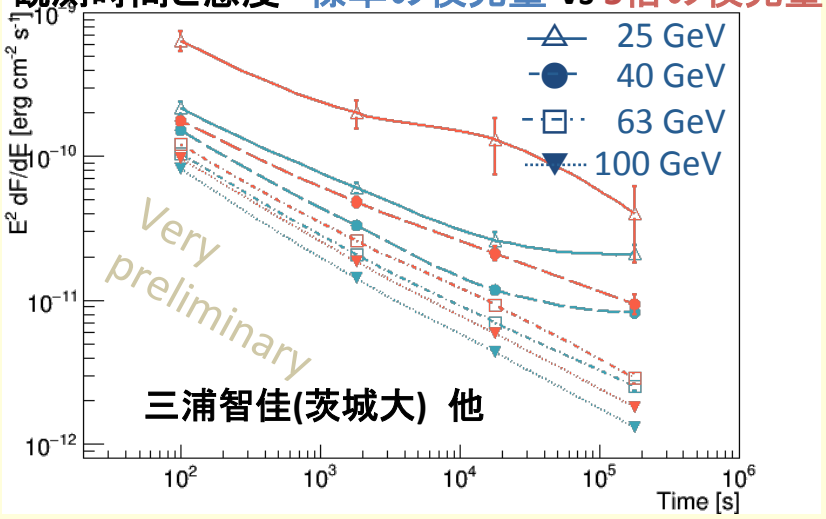
E08 : “CTA Monte Carlo simulation”

- **2018Sep** : 2 presentations for JPS meeting
- **2018Mar** : 3 presentations for JPS, 1 for ASJ meeting
- **(2019Mar)** : 2 presentations are planned

Pickup: Slides from the last JPS meeting at Matsumoto

North LST-4 high NSB case studies

観測時間と感度　標準の夜光量 vs 5倍の夜光量



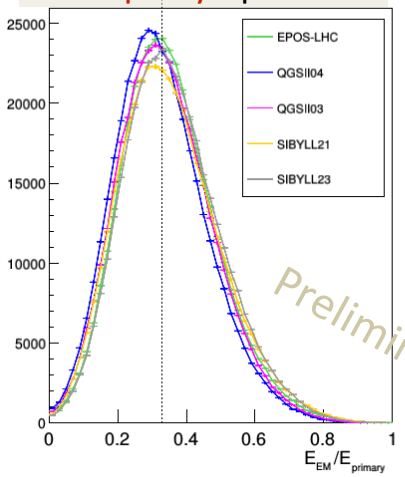
- CTA公式の結果と同等の結果が得られ、おおよそ$T^{-1/2}$ に比例している。
- 5倍の夜光量では25 GeVで約3倍程度感度が落ちる。
- 40 GeVであれば5倍の夜光量でも標準の夜光量とほぼ同等 (ファクター2以下) の観測ができる。

Hadronic interaction model studies

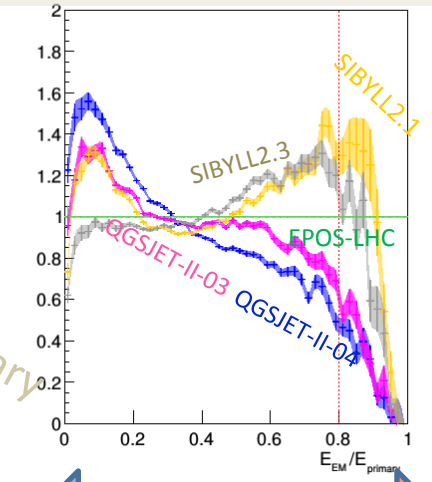
第三次反応時点で電磁成分粒子(e^+, e^-, gamma)で運ばれるエネルギーの入射エネルギーに対する比率

（初段反応ではまだ核子が有意なエネルギー比率を占めており、
πにエネルギーが渡され切っていない）

$E_{EM}/E_{primary}$　E_p= 1 TeV



EPOS-LHCを基準にしたときの比率



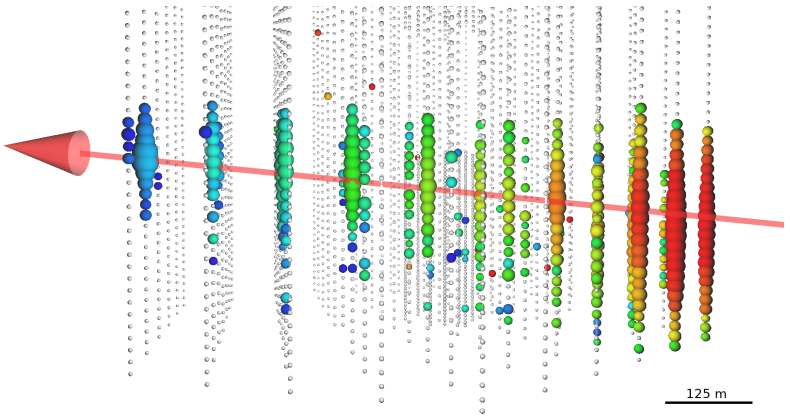
大石理子(ICRR) 他

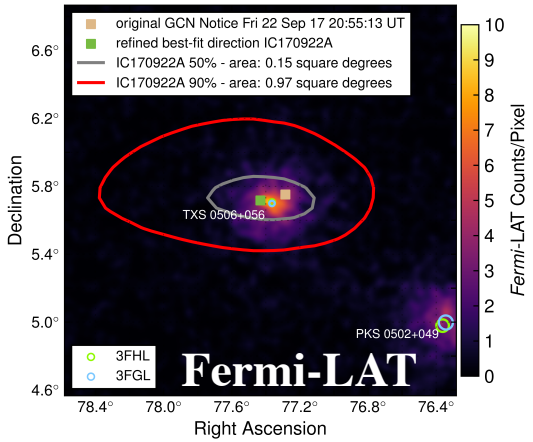
陽子らしい ⟷ ガンマ線らしい

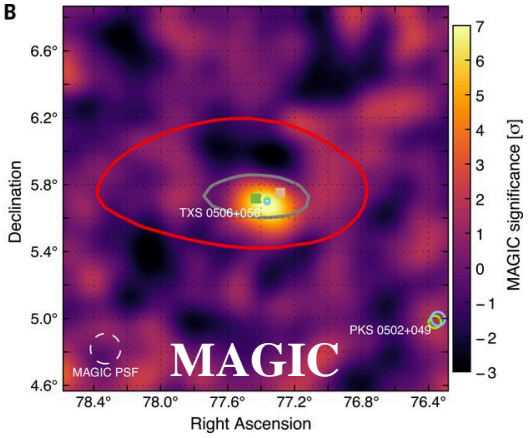
電磁成分でのE消費率はモデル間で有意な違いがある

Other projects
(E:12 MAGIC, etc.)

ν / EM observations of IC-170922A / Blazar TXS 0506+056





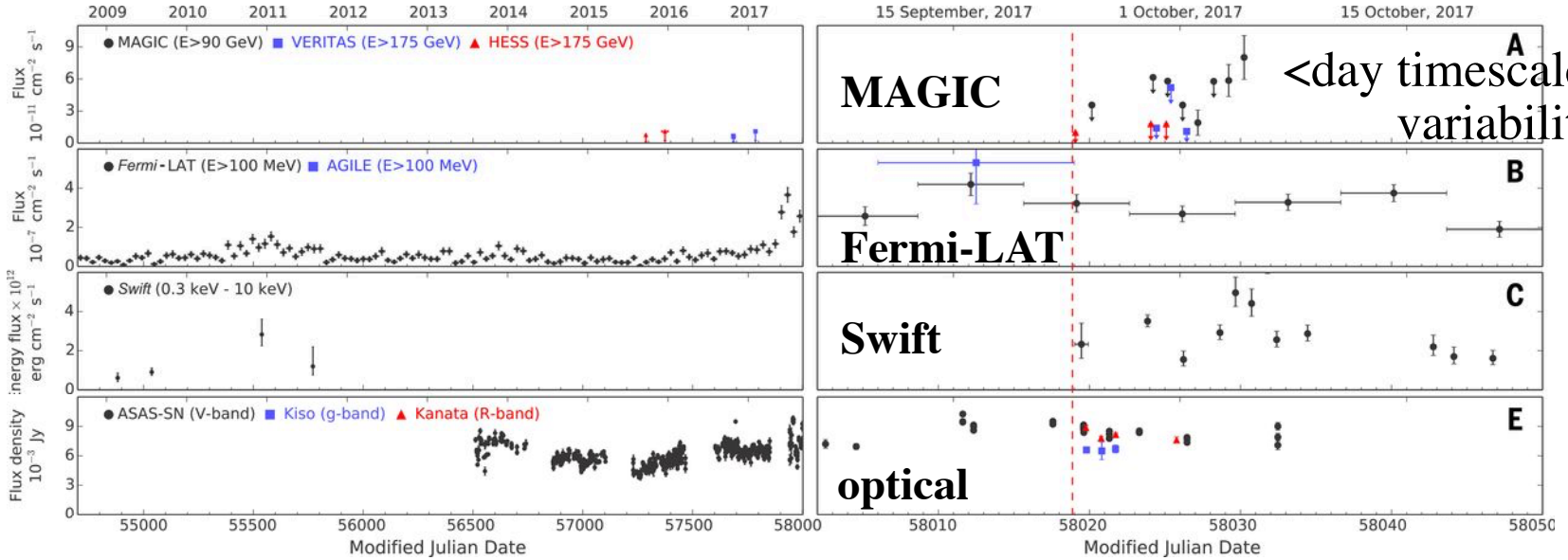


P(astrophysical) ~56.5%

E_ν~290 TeV (183 TeV - 4.3 PeV 90% CL)

significance of association ~3σ

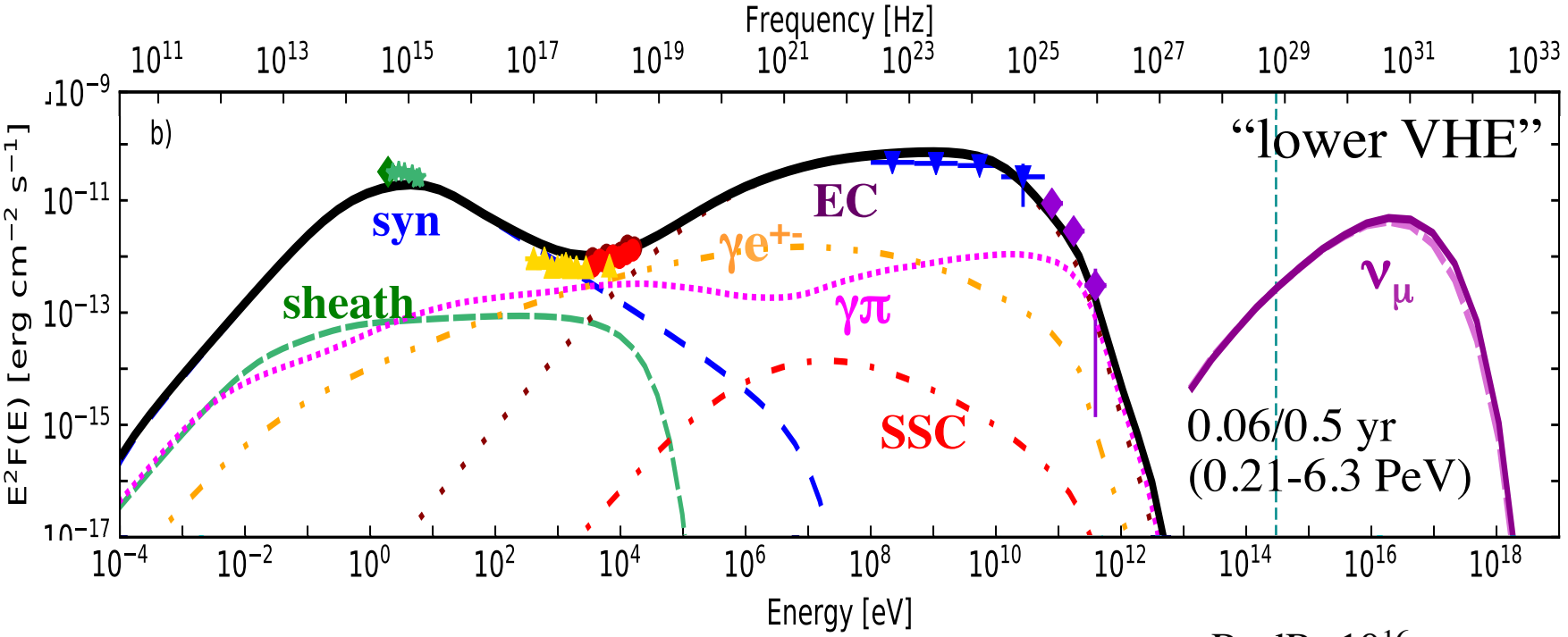
possible source of possible astrophysical high-energy neutrino



IceCube, Fermi, MAGIC+, 2018, Science 361, eaat1378; Press Conference at MEXT on 20th July

MAGIC collaboration, ApJ, 863, L10

jet-sheath model for electroweak emission



- large no. of parameters but reasonably constrained
- SED predominantly leptonic, γ-rays EC (not SSC)
- photopion+photopair cascade subdominant
  but non-negligible in X (+VHE)
  -> crucial constraint on proton population
- photopion efficiency $f_{p\gamma}(E_p\sim 6\ \mathrm{PeV})\sim 10^{-4}$
  -> $\tau_{\gamma\gamma}(E_\gamma\sim 12\ \mathrm{GeV})\sim 0.1$ -> $\tau_{\gamma\gamma}(E_\gamma\sim 100\ \mathrm{GeV})\sim 1$
  consistent with observed GeV-TeV break

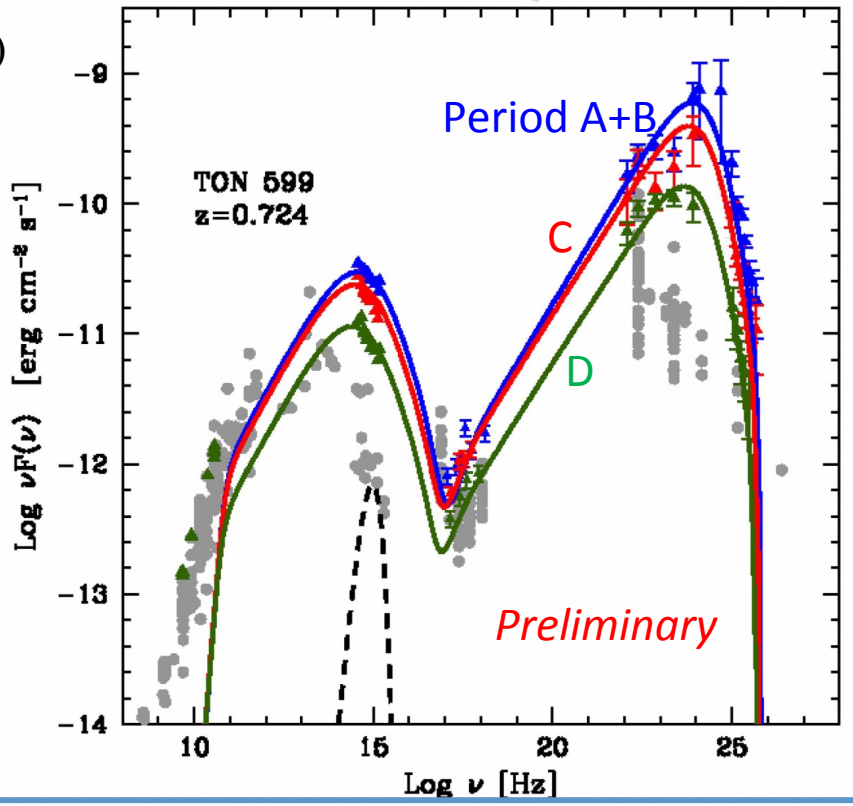
$R=dR=10^{16}$ cm
$B=2.6$ G
$\Gamma_j=22$, $\Gamma_s=2.2$
$\theta_v=0.8°(\delta_j=40)$
$E'_{pmax}=10^{16}$ eV
$L_e=1.6\times10^{42}$ erg/s
$L_p=3\times10^{45}$ erg/s(?)
($L_B=1.2\times10^{45}$ erg/s)

Inoue+

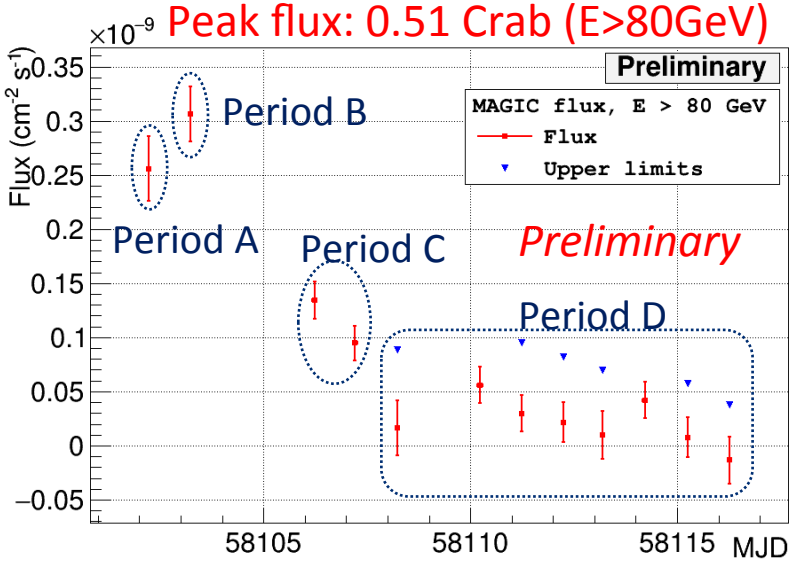
Detection of VHE γ-ray emission from the FSRQ Ton 0599

third farthest source ATel #11061(15 Dec 2017)

Source	Redshift	Year	Discovered by
B2 0218+357	0.954	2014	MAGIC
PKS 1441+25	0.939	2015	MAGIC
TON 0599	0.725	2018	MAGIC
3C 279	0.536	2006	MAGIC
PKS 1222+216	0.432	2010	MAGIC
PKS 1510-089	0.361	2009	H.E.S.S.
PKS 0736+017	0.189	2016	H.E.S.S.



Peak flux: 0.51 Crab (E>80GeV)



Leptonic model

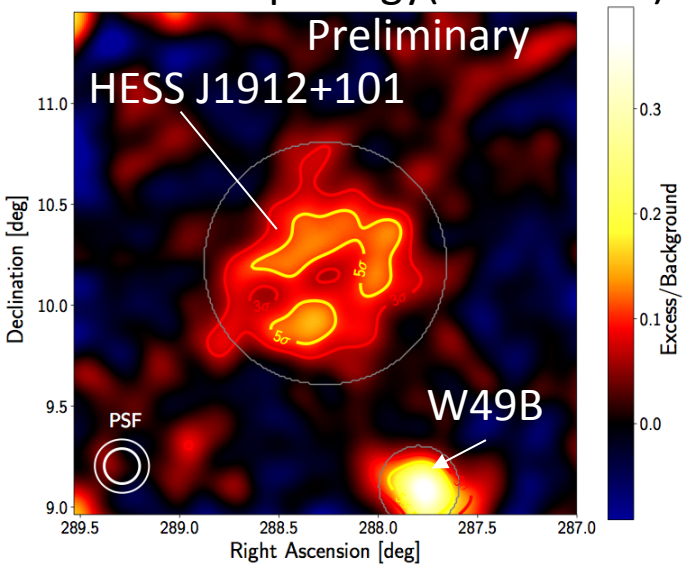
- Synchrotron emission dominant to the low-energy bump
- Synchrotron-Self-Compton emission contributes ~50% in X-ray
- High-energy: External Radiation Compton of the torus photons
- Jet slowing down as flare fades out

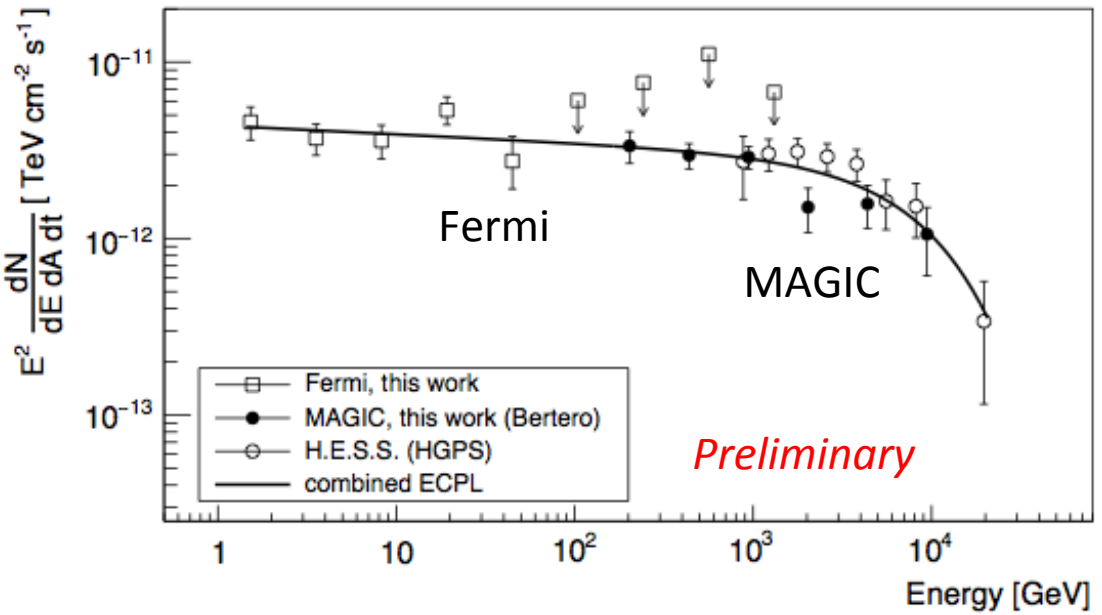
presented at BHCB2018 conference Hirako+

HESS J1912+101

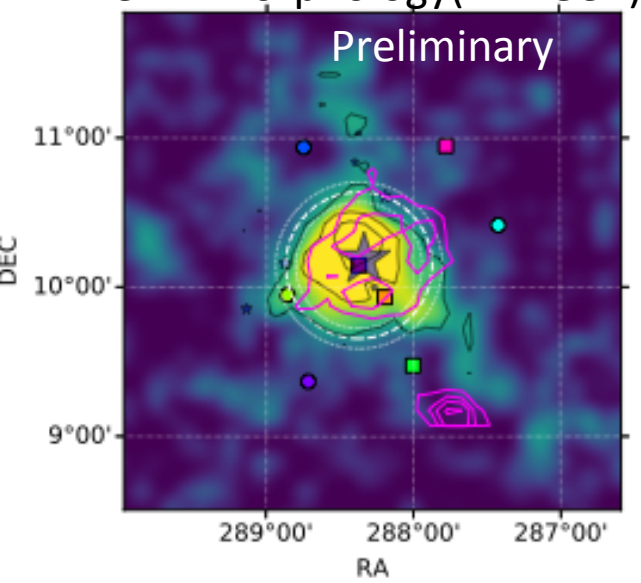
- unID discovered by H.E.S.S Galactic Plane Survey
- shell-like structure -> labeled “SNR candidate”

MAGIC morphology(E>200 GeV)





Fermi morphology(E>1 GeV)



- Extended emission in the GeV energy range as well as the TeV energy range. Fermi-LAT and MAGIC show consistent results both morphologically and spectrally.
- MAGIC morphology (>200 GeV) prefers a shell-like structure, but Fermi morphology (>1 GeV) prefers the gaussian-like structure.
- Energy spectrum in gamma-ray range (1 GeV – 10 TeV) do not have any contradiction with DSA if the gamma-ray emission is dominated by hadronic process.

presented at 8th Fermi symposium 2018 Nagayoshi+

Binaries with MAGIC

HESS J0632+057

- Joined effort of H.E.S.S., MAGIC & VERITAS to publish last paper on this source with current generation of Cherenkov telescopes

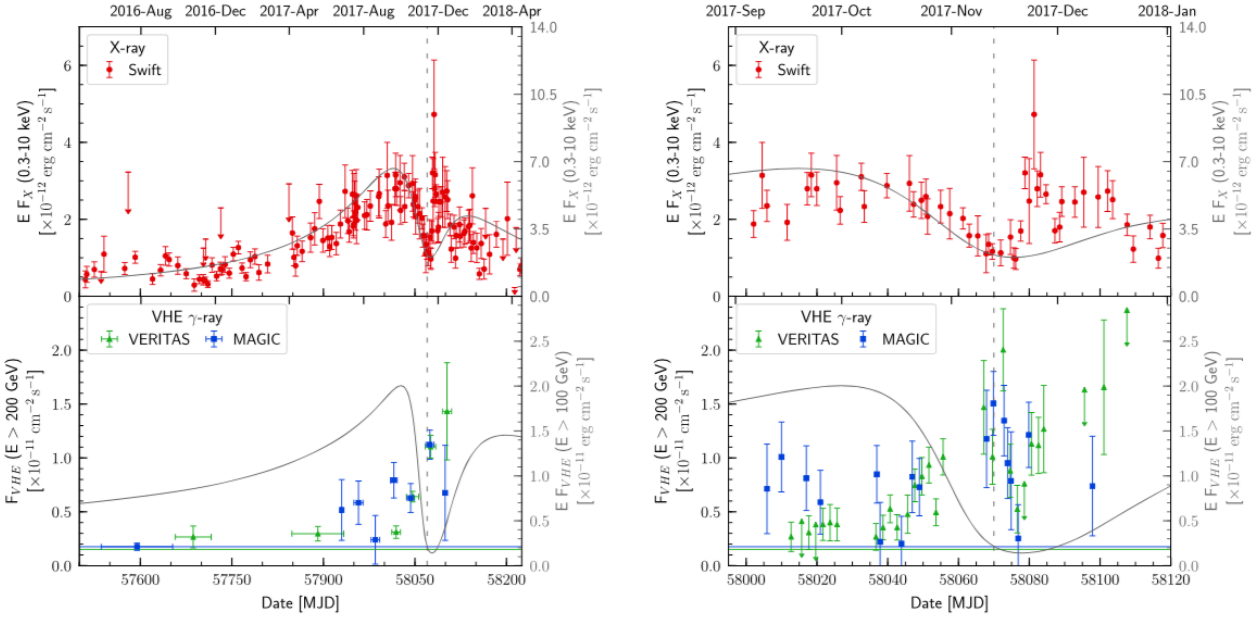
HESS J0632+057

LS I +61 303

- 20 hrs of data taken in 2018 within campaign with VERITAS and optical telescope LIVERPOOL on La Palma

PSR J2032+4107

- New binary in TeV range discovered through joined campaign of MAGIC & VERITAS
- Paper published: ApJL, 867:L19(8pp) 2018



(a) Full Dataset

PSR J2032+4107

(b) Periastron

Hadasch+

GRB 160821B
multi-wavelength afterglow modeling

- good overall description with reasonable parameter values
- f_e<<1 required (only a fraction of electrons accelerated): first observational indication; physically expected but was unproven for relativistic shocks; important for correctly deriving energetics

Modeling: Inoue+
MAGIC analysis: Noda, Fukami

Publication in refereed journals (2018)

13 papers:

The blazar TXS 0506+056 associated with a high-energy neutrino: insights into extragalactic jets and cosmic ray acceleration
MAGIC collaboration, Max Ludwig Ahnen *et al.*
ApJL **863** (2018) L10

Multimessenger observations of a flaring blazar coincident with high-energy neutrino IceCube-170922A
IceCube collaboration, Aartsen *et al.*
Science **361** (2018) eaat1378

Limits on the flux of tau neutrinos from 1 PeV to 3 EeV with the MAGIC telescopes
MAGIC collaboration, Ahnen *et al.*
Astroparticle Physics **102** (2018) 77-88

The broad-band properties of the intermediate synchrotron peaked BL Lac S2 0109+22 from radio to VHE gamma rays
MAGIC collaboration, Ansoldi *et al.*
Monthly Notices of the Royal Astronomical Society **480** (2018) 879–892

Multi-wavelength characterization of the blazar S5~0716+714 during an unprecedented outburst phase
MAGIC collaboration, Ahnen *et al.*; Fermi-LAT collaboration, : *et al.*
A&A **619** (2018) A45

The detection of the blazar S4 0954+65 at very-high-energy with the MAGIC telescopes during an exceptionally high optical state
MAGIC collaboration, Ahnen *et al.*
A&A **617** (2018) A30

Indirect dark matter searches in the dwarf satellite galaxy Ursa Major II with the MAGIC Telescopes
MAGIC collaboration, Ahnen *et al.*
Journal of Cosmology and Astroparticle Physics 03 009 (2018)

Constraining Dark Matter lifetime with a deep gamma-ray survey of the Perseus Galaxy Cluster with MAGIC
MAGIC collaboration, Acciari *et al.*
Physics of the Dark Universe 22 38 (2018)

Constraining very-high-energy and optical emission from FRB 121102 with the MAGIC telescopes
MAGIC collaboration, Acciari *et al.*
MNRAS 481 2479 (2018)

Detection of persistent VHE gamma-ray emission from PKS 1510-089 by the MAGIC telescopes during low states between 2012 and 2017
MAGIC collaboration, Acciari *et al.*
A&A 619 159 (2018)

Gamma-ray flaring activity of NGC 1275 in 2016-2017 measured by MAGIC
MAGIC collaboration, Ansoldi *et al.*
A&A 617 91 (2018)

Periastron Observations of TeV Gamma-Ray Emission from a Binary System with a 50-year Period
VERITAS collaboration, Abeysekara *et al.*; MAGIC collaboration, : *et al.*
ApJL 867 L19 (2018)

Limits on the flux of tau neutrinos from 1 PeV to 3 EeV with the MAGIC telescopes
MAGIC collaboration, : *et al.*
Astropart Physics 102 77 (2018)

E09: VHE gamma-ray emission regions in AGN

K. Nishijima, J. Kushida, Y. Taneda, T. Kamimoto, S. Tsujimoto, T. Ogata, T. Furuta
Tokai University
M. Teshima, D. Mazin
ICRR, University of Tokyo

- M87 : MWL monitoring observations with H.E.S.S., VERITAS, Fermi-LAT in gamma rays and with VLBA, EVN, EHT in radio to identify the location of gamma-ray emission regions and to understand their emission mechanisms.

Preliminary

- 2018/1/10～6/18(19 nights)
- E > 350 GeV
- No significant variations were found with MAGIC

Preliminary

- But, a possible increase of VHE gamma-ray flux during MWL campaign period.
- We are waiting for H.E.S.S., VERITAS, and EHT data.

?

E09: VHE gamma-ray emission regions in AGN

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M. Teshima, D. Mazin
ICRR, University of Tokyo

- Extreme HBL source hunting : EHBLs are interesting object not only from the aspect of gamma-ray astrophysics but also from cosmological aspect.
  - We found one of the EHBL candidates expected from the spectrum in GeV regions shows a significant excess.

    DISCOVERY!

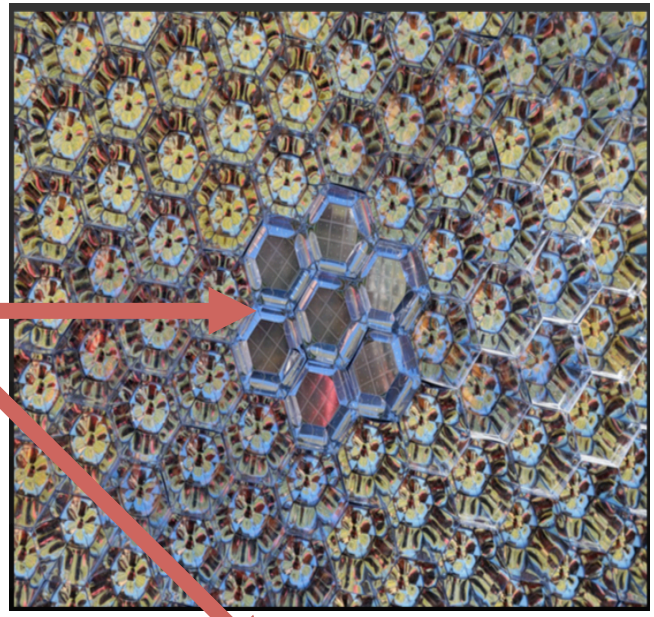
    - 2018/1/10～6/18(19 nights)
    - E > 350 GeV

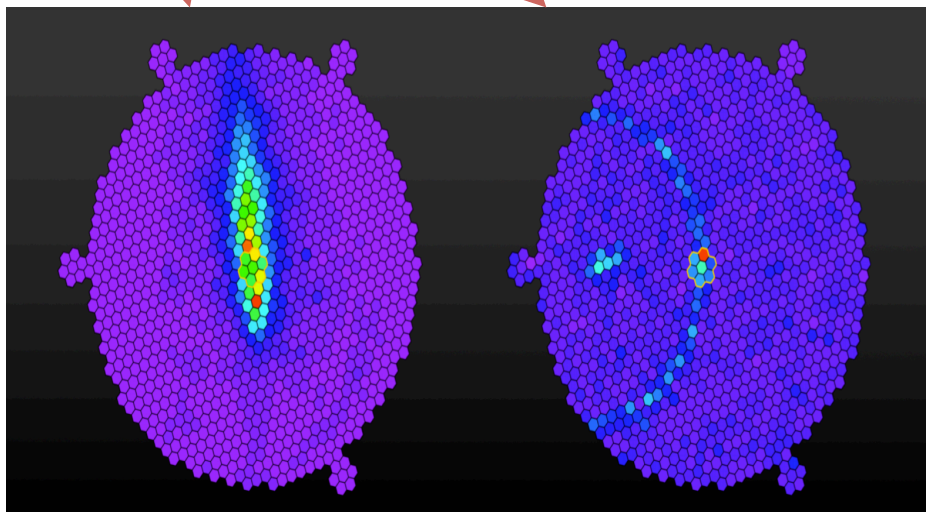
    Preliminary

- HBL : TON396(HBL at z=0.101). Fermi source, and VERITAS reported 3.5σ hint of signals in 11.7 hour observations.
  - Only an upper limit was derived from MAGIC observations.
- We developed a moon-adapted analysis method to save the data observed under moonlight, which improves the duty cycle.
- Our assessed amount : ¥400K for travel expense.

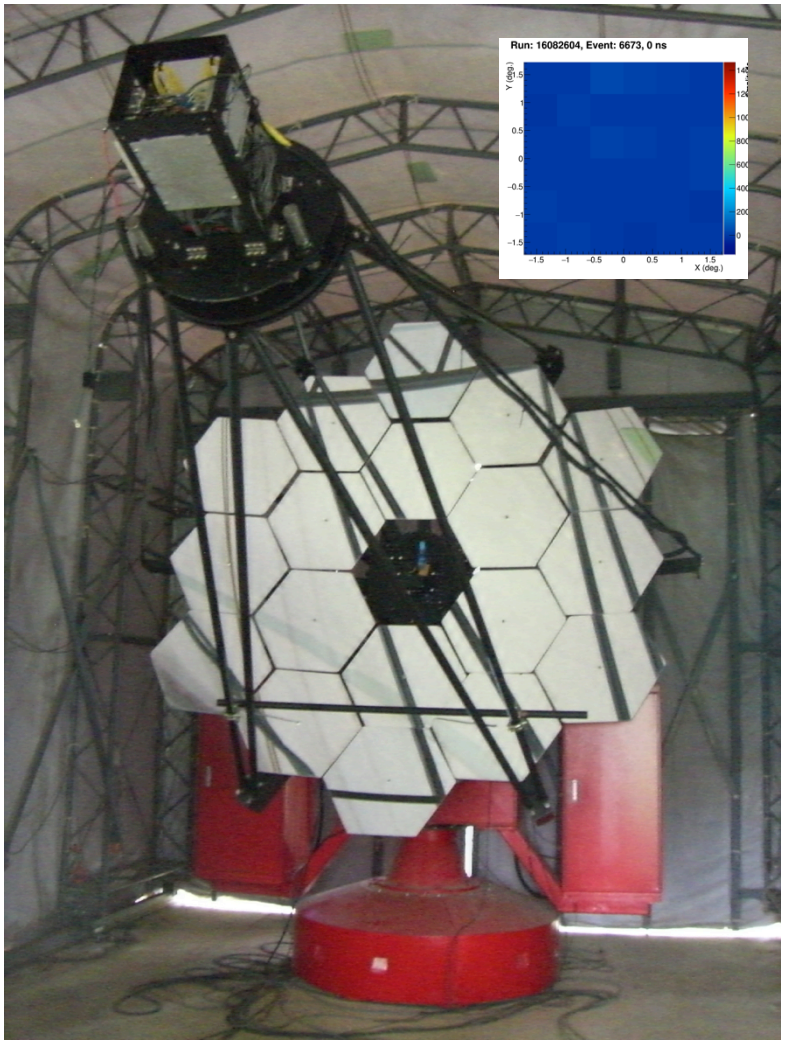
SiPM clusters installed in MAGIC

- 4 SiPM clusters installed (2xHamamatsu, 1xExcelitas, 1xSensl
- Long term: SiPMs are in edges of the camera
- 1 night: Hamamatsu cluster in camera center
- Paper PMT vs SiPM in preparation





E13: 明野観測所における小型大気チェレンコフ望遠鏡R＆D



- 明野観測所施設利用（E13）
- 代表者：吉越貴紀
- 目的：明野観測所に設置した3ｍ口径大気チェレンコフ望遠鏡を整備・維持し、地上ガンマ線天文台将来計画等の各種R＆Dに利用する
- 査定額：旅費10万円
- 最近の活動：
  - 平成29年度にCrab Nebulaを観測、データ解析中
  - 可視光Crabパルサー観測用システム開発中（武岡＠立命館大）

Summary

- CTA-N : finally the construction of telescopes has started, and IT center is ready
- LST1: successful construction and first light!
  - Stable operation will start soon
- Other activities are going on (SiPM, MC,,,)
- MAGIC “Full of physics” The neutrino blazar, far FSRQ, other AGN, SNR, Binaries, GRB,,,
- Etc. etc.

backup