# CTA_LST status @ INFN

# Outline

LST status

- Intro: LST1 INFN role
- LST1 Commissioning status
- Activity 2020
  - Commissioning and data shifts
  - Reconstruction software and data analysis
- LST 2-4 schedule

# Attività INFN per LST1

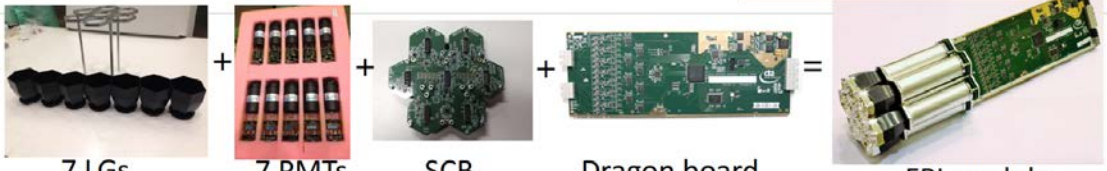
| | |
|---|---|
| • Sampling electronics (LST-CAM) | PI |
| • Calibration box | UD,RM1 |
| • CSS cables | PD |
| • SiPm Cluster (R&D) | PD, TO, PG |
| • Control containers | PD |
| • Drive container | RM2 |
| • Boogie mechanics | PD |
| | |
| • Analysis Software | PD, TO |
| • Analysis Montecarlo | TO, PD,TS |
| • Data analysis | Many |

# LST- CAM

# Camera: Dragon, Pisa

## Pixel module assembly at IAC Tenerife

ICRR, INFN, KYOTO, IAC

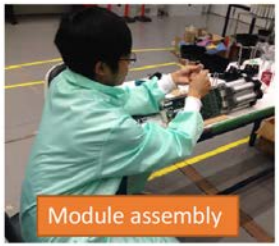


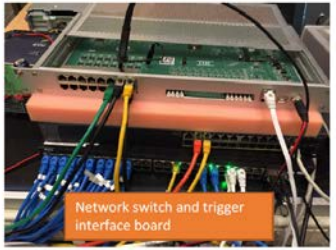




265 modules/ Tel. needed.

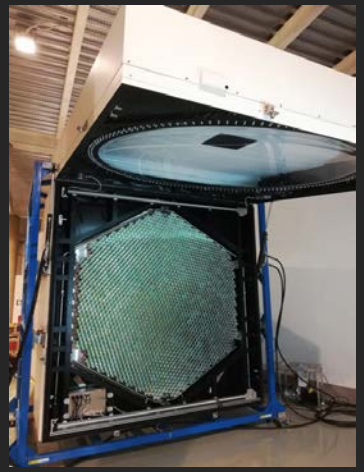
270 modules are assembled @ IAC

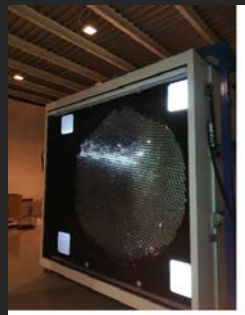



# Camera: Dragon: Pisa

- Installazione dei moduli Dragon di produzione giapponese ed italiana (50-50)
- Camera equipaggiata interamente
- Commissioning della camera presso struttura a S. Cruz (Mirca)
- Calibrazione trigger, FE, DAQ

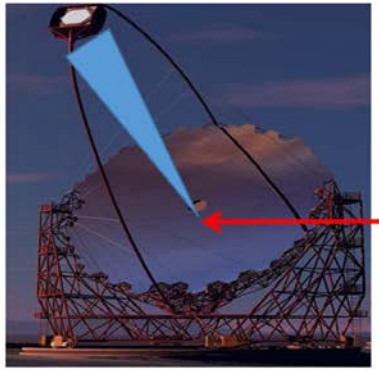




# CALIBOX

# Calibox: Roma, Udine

## Details of the calibox



hermetic filled with dry air

Laser box

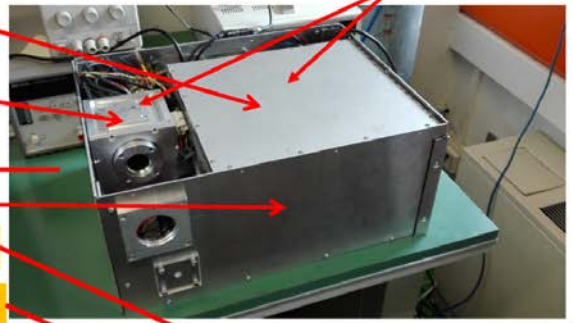
Diffuser box

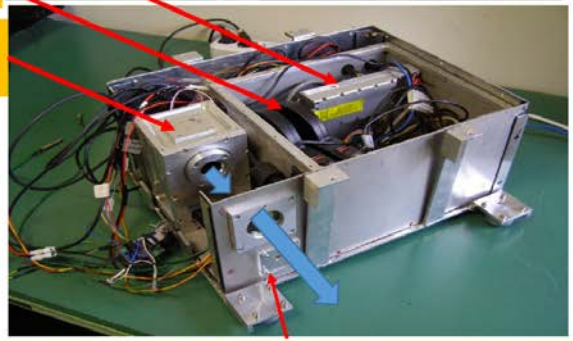
shell

UV Laser

2 Filter wheels

Diffuser and Beam splitter

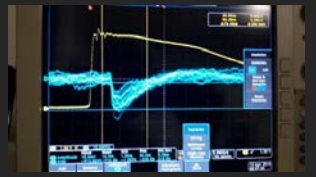




- ✓Calibox frame developed at INFN-RM1
- ✓Test performed in RM1 and UD
- ✓Results PoS(ICRC2017)857 M. Palatiello et
- ✓CTA LST Meeting LaPalma Nov 2017 (talk M.Iori)
- ✓CTA LST Meeting Paris May 2018 (talk M. Iori).
- ✓Calibox controlled by OPC-UA installed on Odroid to set the relay, laser, wheels, weatherboard
- ✓Hermetic laser and diffuser boxes
- ✓Shell protecting from weather conditions
- ✓Inter-calibration by internal SiPM/PD (see design pub in PoS M.Iori et al 2016)

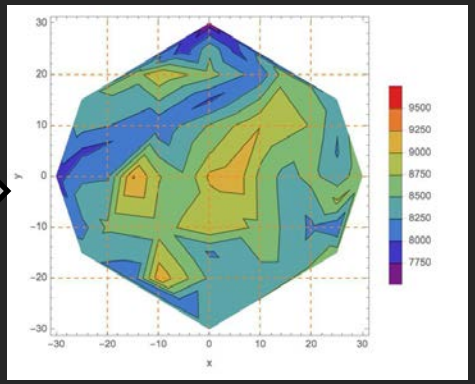
Red laser pointer to align the calibox to the camera

# Calibox: Roma, Udine



## Uniformity of the Calibox output

- The uniformity of the light diffused by the Calibox at the distance of 5 m (asper CTA TDR requirement) has been thoroughly tested at the University of Udine
- A planar fit to the data result sin a uniformity of 1.9% (in agreement with TDR request) on the region of interestat5 m distance from source

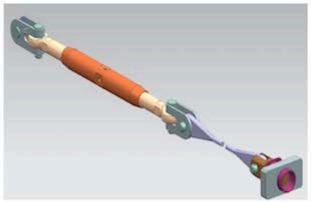


# Carbon fiber ropes

# CF ropes: Padova

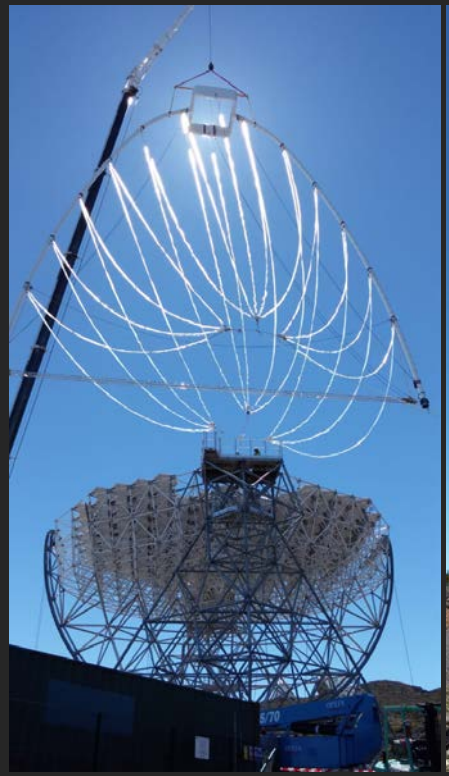
- **Status of the metallic components production.**
  - A first batch of the metallic components of the CF rope, to be integrated in the Arch structure has been delivered to La Palma and integrated at LORIMA.
  - The remaining parts (DUPLEX Mat.) have been completed at FF premises in Sri Lanka and delivered to La Palma

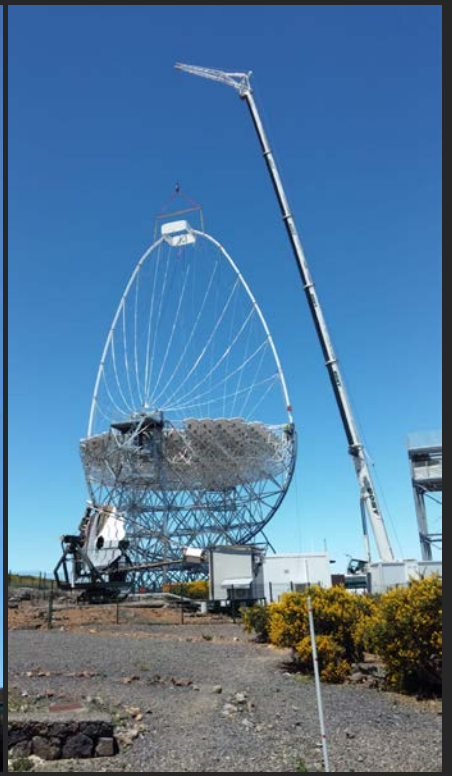
Metallic components of the CF rope.



Some components of the CF rope had to be machined at INFN PD Mechanical Workshop:
- all pins have been delivered to LAPP and should be already in La Palma;
- The CTA04 series are under completion @INFN PD MW and will be delivered to La Palma on W22

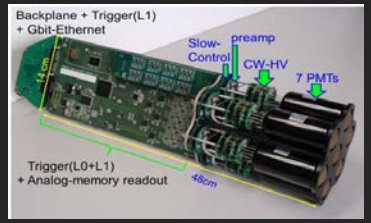
# CF ropes: Padova

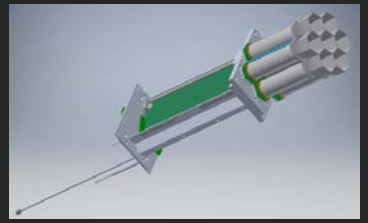


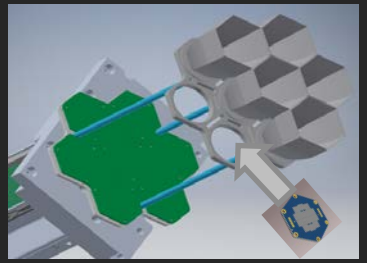


# SiPM clusters-camera

# Camera SiPM: Padova, Torino



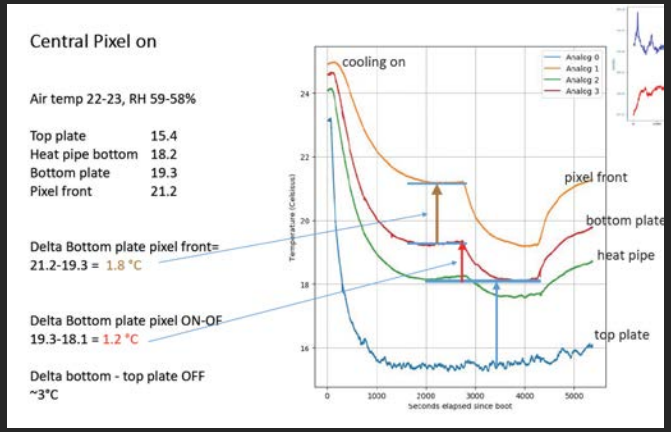



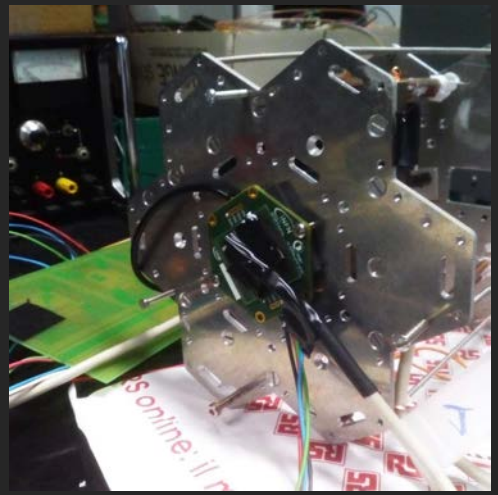


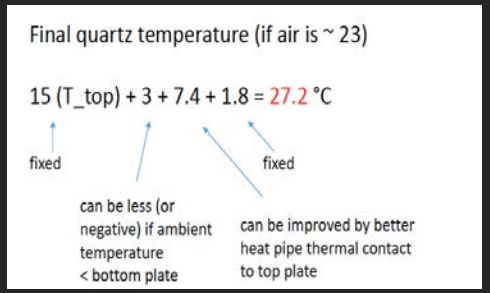
# Camera SiPM: Padova, Torino

## ATTIVITÀ NEL 2018/19

- Versione definitiva Interface Board
- Test termici
- Integrazione del cluster con DRAGON



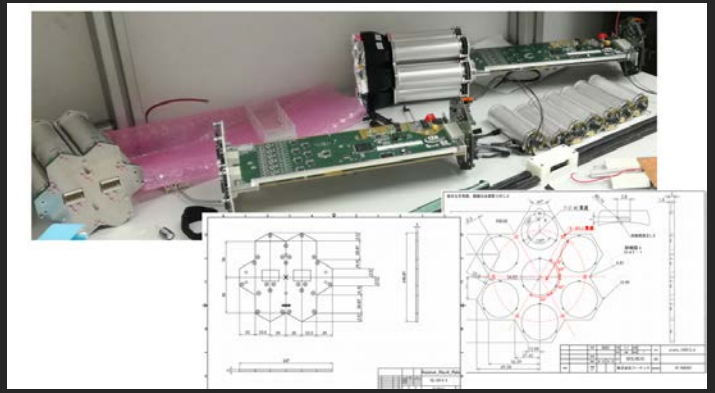



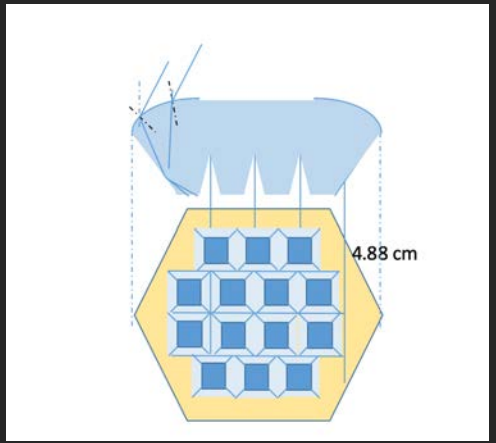


# Camera SiPM: Padova, Torino

## ATTIVITÀ NEL 2020

- Versione definitiva Interface Board
- Realizzazione ottica di piano focale
- Integrazione del cluster con DRAGON
- Progettazione e realizzazione della meccanica
- Realizzazione di 3 moduli di cluster
- Test di un cluster completo





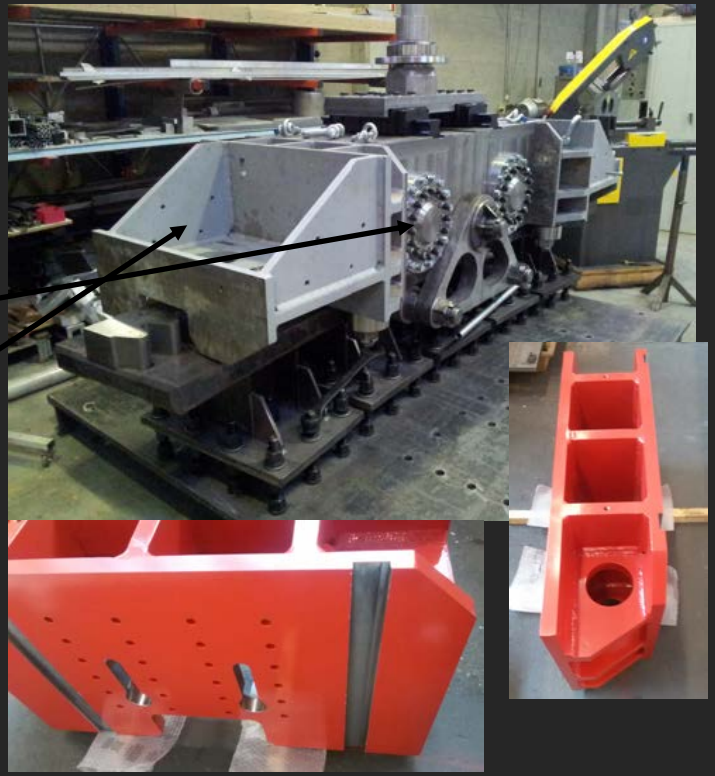
## Commissionig container

# Bogies mechanics

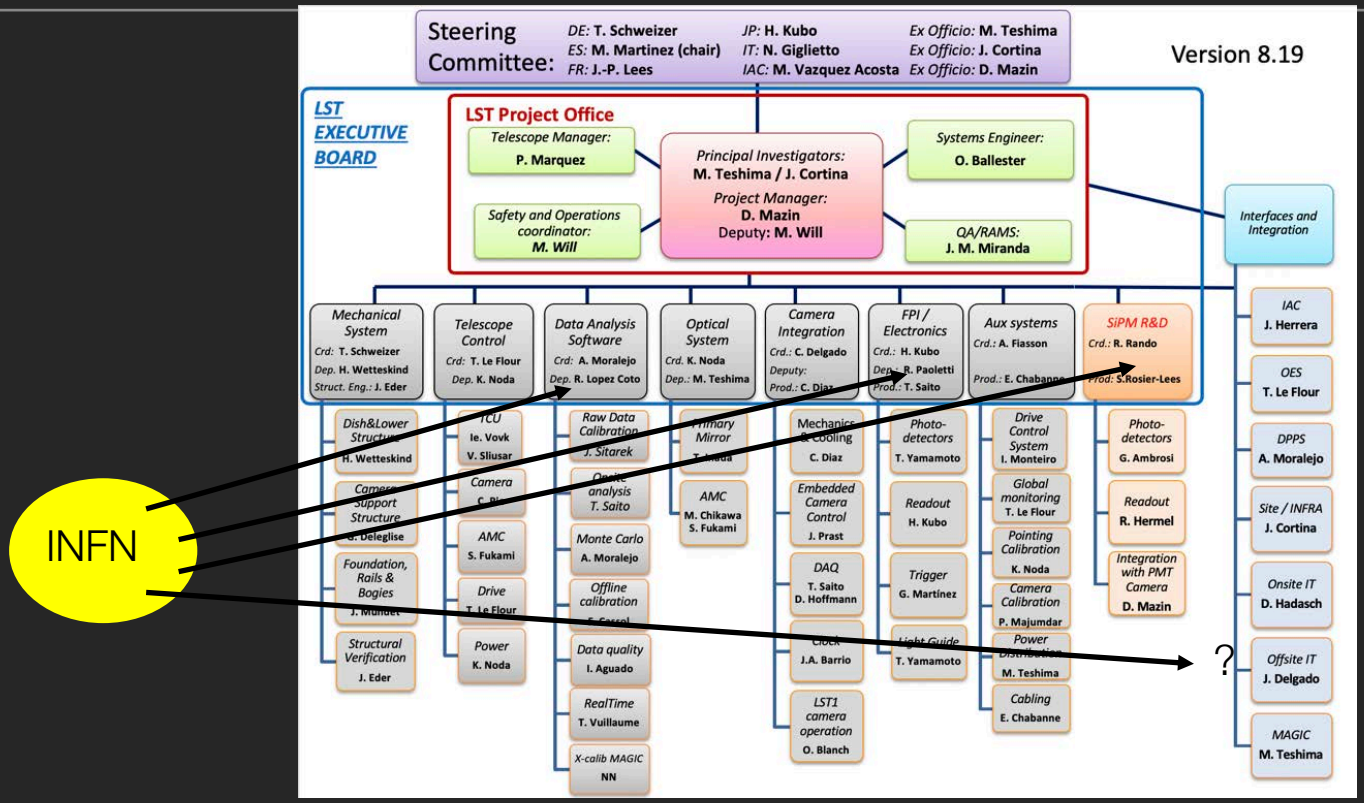
# Carrelli “Bogies” per struttura LST1

Realizzati INFN PD Officina Meccanica (Ramina) importanti elementi per la costruzione dei carrelli portanti del telescopio

-24 assi per ruote
-6 strutture di carpenteria pesante
-3 frames in gara al momento
- Bulloni speciali lavorati in OM



# LST INFN


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
Version 8.19
LST EXECUTIVE BOARD
LST Project Office
Telescope Manager: P. Marquez
Principal Investigators: M. Teshima / J. Cortina
Project Manager: D. Mazin
Deputy: M. Will
Systems Engineer: O. Ballester
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:
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
Foundation, Rails & Bogies
Structural Verification
J. Eder
TCU
Ie. Vovk
V. Sliusar
Camera
AMC
S. Fukami
Drive
T. Le Flour
Power
K. Noda
Raw Data Calibration
J. Sitarek
Optic analysis
T. Saito
Monte Carlo
A. Moralejo
Offline calibration
Data quality
I. Aguado
RealTime
T. Vuillaume
X-calib MAGIC
NN
Primary Mirror
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. Martinez
Light Guide
T. Yamamoto
Drive Control System
I. Monteiro
Global monitoring
T. Le Flour
Pointing Calibration
K. Noda
Camera Calibration
P. Majumdar
Power
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
INFN
?

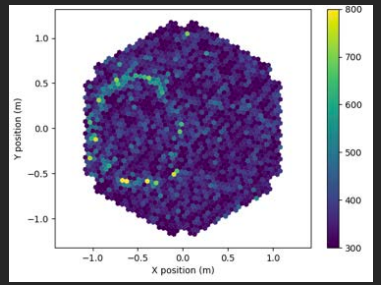
# LST INFN

## LST1 - Status/activity

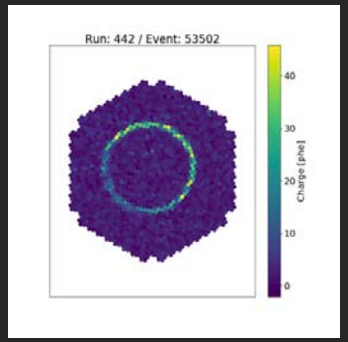
# CTA-LST Status/activity

- LST in commissionig: turni di messa a punto e inizio presa dati
- Workshop sul software ed analisi di LST a Padova organizzato dalla sezione presso LNL. Rubèn Lopez responsabile e coordinatore software ed analisi di LST (Contributo in dettaglio)
- Graduale aumento qualità dei dati: presa dati sistematica con shifts: nella prima fase seguendo le osservazioni MAGIC

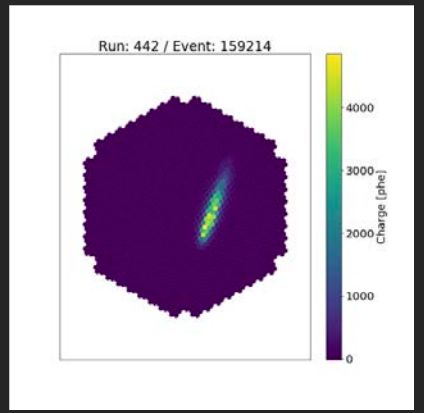
Dicembre 2018




Aprile 2019




Maggio 2019



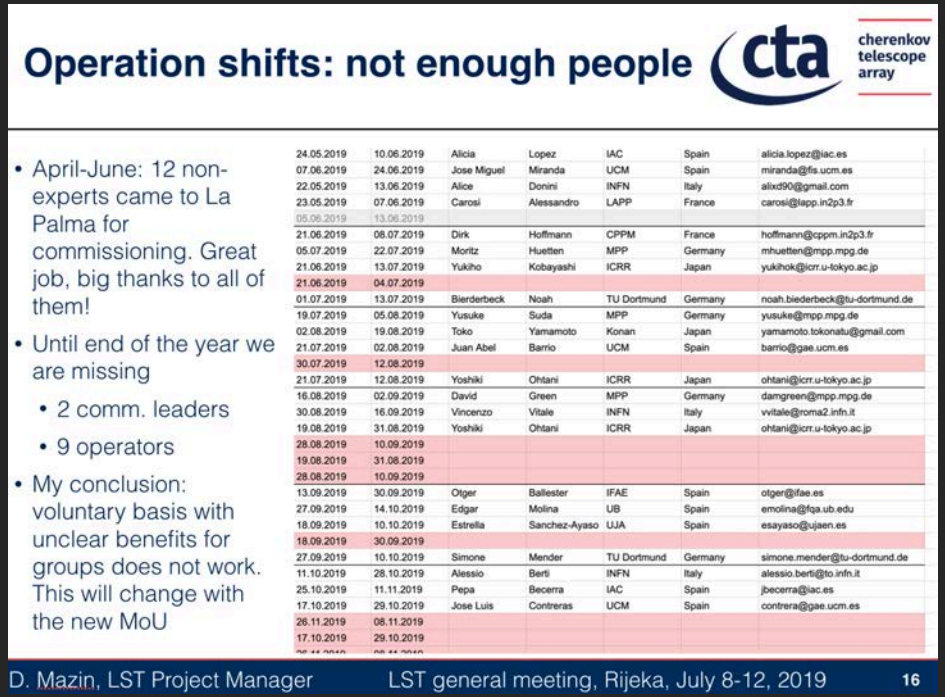
# CTA-LST Status/activity

- LST in commissionig: turni di messa a punto e inizio presa dati

Importante sforzo per coprire l turni di presa dati il prossimo anno. Si stanno valutando diversi schemi di copertura.

Al momento su base volontaria ma si è decisto di assegnare una quota proporzionale al numero di firmatari.

Quota INFN = 40/254



## Operation shifts: not enough people

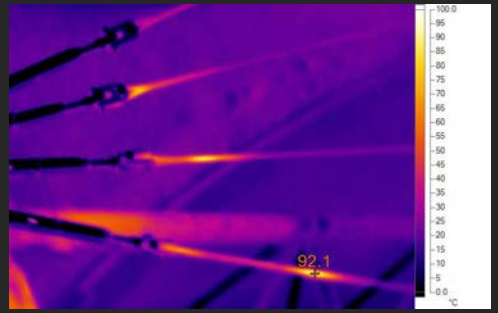
- April-June: 12 non-experts came to La Palma for commissioning. Great job, big thanks to all of them!
- Until end of the year we are missing
  - 2 comm. leaders
  - 9 operators
- My conclusion: voluntary basis with unclear benefits for groups does not work. This will change with the new MoU

| | | | | | | |
|---|---|---|---|---|---|---|
| 24.05.2019 | 10.06.2019 | Alicia | Lopez | IAC | Spain | alicia.lopez@iac.es |
| 07.06.2019 | 24.06.2019 | Jose Miguel | Miranda | UCM | Spain | miranda@fis.ucm.es |
| 22.05.2019 | 13.06.2019 | Alice | Donini | INFN | Italy | alixd90@gmail.com |
| 23.05.2019 | 07.06.2019 | Carosi | Alessandro | LAPP | France | carosi@lapp.in2p3.fr |
| 05.06.2019 | 13.06.2019 | | | | | |
| 21.06.2019 | 08.07.2019 | Dirk | Hoffmann | CPPM | France | hoffmann@cppm.in2p3.fr |
| 05.07.2019 | 22.07.2019 | Moritz | Huetten | MPP | Germany | mhuetten@mpp.mpg.de |
| 21.06.2019 | 13.07.2019 | Yukiho | Kobayashi | ICRR | Japan | yukihok@icrr.u-tokyo.ac.jp |
| 21.06.2019 | 04.07.2019 | | | | | |
| 01.07.2019 | 13.07.2019 | Bierderbeck | Noah | TU Dortmund | Germany | noah.biederbeck@tu-dortmund.de |
| 19.07.2019 | 05.08.2019 | Yusuke | Suda | MPP | Germany | yusuke@mpp.mpg.de |
| 02.08.2019 | 19.08.2019 | Toko | Yamamoto | Konan | Japan | yamamoto.tokonatu@gmail.com |
| 21.07.2019 | 02.08.2019 | Juan Abel | Barrio | UCM | Spain | barrio@gae.ucm.es |
| 30.07.2019 | 12.08.2019 | | | | | |
| 21.07.2019 | 12.08.2019 | Yoshiki | Ohtani | ICRR | Japan | ohtani@icrr.u-tokyo.ac.jp |
| 16.08.2019 | 02.09.2019 | David | Green | MPP | Germany | damgreen@mpp.mpg.de |
| 30.08.2019 | 16.09.2019 | Vincenzo | Vitale | INFN | Italy | vvitale@roma2.infn.it |
| 19.08.2019 | 31.08.2019 | Yoshiki | Ohtani | ICRR | Japan | ohtani@icrr.u-tokyo.ac.jp |
| 28.08.2019 | 10.09.2019 | | | | | |
| 19.08.2019 | 31.08.2019 | | | | | |
| 28.08.2019 | 10.09.2019 | | | | | |
| 13.09.2019 | 30.09.2019 | Otger | Ballester | IFAE | Spain | otger@ifae.es |
| 27.09.2019 | 14.10.2019 | Edgar | Molina | UB | Spain | emolina@fqa.ub.edu |
| 18.09.2019 | 10.10.2019 | Estrella | Sanchez-Ayaso | UJA | Spain | esayaso@ujaen.es |
| 18.09.2019 | 30.09.2019 | | | | | |
| 27.09.2019 | 10.10.2019 | Simone | Mender | TU Dortmund | Germany | simone.mender@tu-dortmund.de |
| 11.10.2019 | 28.10.2019 | Alessio | Berti | INFN | Italy | alessio.berti@to.infn.it |
| 25.10.2019 | 11.11.2019 | Pepa | Becerra | IAC | Spain | jbecerra@iac.es |
| 17.10.2019 | 29.10.2019 | Jose Luis | Contreras | UCM | Spain | contrera@gae.ucm.es |
| 26.11.2019 | 08.11.2019 | | | | | |
| 17.10.2019 | 29.10.2019 | | | | | |

D. Mazin, LST Project Manager LST general meeting, Rijeka, July 8-12, 2019 16

# CTA-LST Status/activity

- LST in commissionig: Issues with sun concentration on several elements: Concerns also on CF ropes:




• Contact with Future Fiber (cable manufacturer)

– Rope itself not very impacted by high temperature
• CF rods epoxy likely damaged around 200 degrees
• CF continuity around the termination
• CF itself will start burning at much higher temperature

– Termination more problematic
• Epoxy cured at lower temperature and may degrade at temperature around 100 deg.

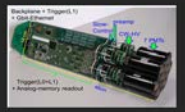
- Only place where epoxy is working in compression
- The company ask to make a check on this termination to insure they will hold on long term

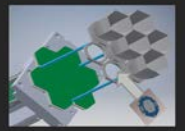
# LST – Activity 2020

# CTA-LST activity 2020

- In preparazione gare per i prossimi 3 telescopi: INFN PD meccanica funi, INFN TS-UD Calibration box,

- Richieste economiche PD 2020: Funi e meccanica ancillare per funi, completamento del cluster R&D a SiPm, Presa dati nel sito ed analisi combinata con dati MAGIC

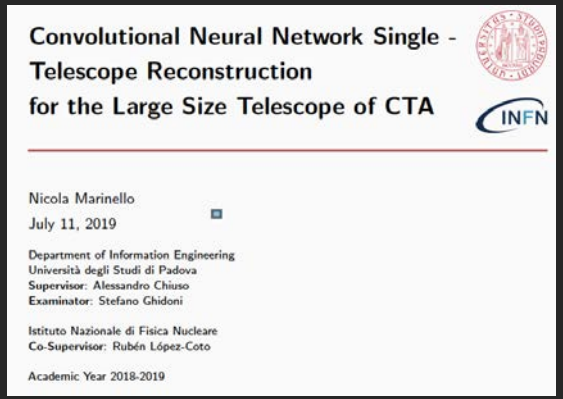




# Impegno INFN Software/data analysis LST

- INFN ha un ruolo chiave nel coordinamento e sviluppo del software per LST (Rubén). Il primo meeting sull'analisi dati è stato organizzato preso strutture INFN

- È nostra intenzione mantenere un ruolo di rilievo in questo settore sia con risorse umane che come investimento "in kind"


Convolutional Neural Network Single - Telescope Reconstruction for the Large Size Telescope of CTA

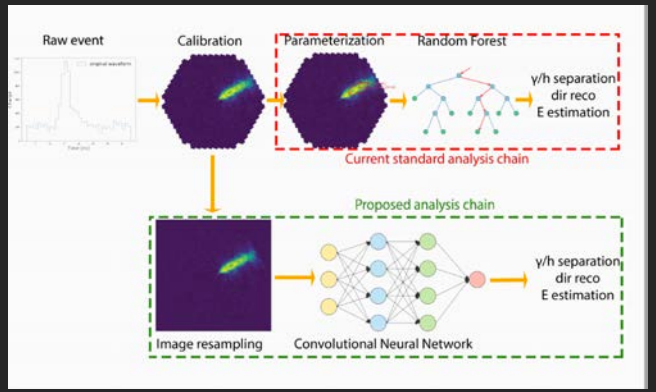
Nicola Marinello

July 11, 2019

Department of Information Engineering
Università degli Studi di Padova
Supervisor: Alessandro Chiuso
Examinator: Stefano Ghidoni

Istituto Nazionale di Fisica Nucleare
Co-Supervisor: Rubén López-Coto

Academic Year 2018-2019



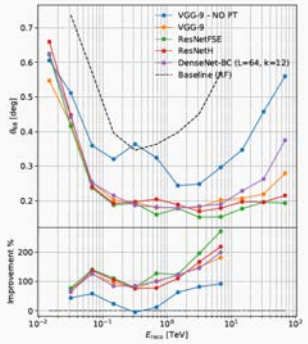
# Impegno INFN Software/data analysis LST

- Sviluppo di metodi CNN per analisi dati LST (mono al momento) estremamente performanti. Vogliamo mentenere la leadership in questo settore

## Direction reconstruction

→ 2D regression problem

→ models comparison by their **angular resolution** (lower is better)




→ We want to reconstruct the vector $\mathbf{d}_i = [\Delta_{az}, \Delta_{alt}]^T$, i.e. the angular delta between the pointing direction of the telescope and the incoming direction of the $\gamma$ ray.

**Training loss function**:
$\mathrm{MAE} = \frac{1}{N}\sum_{i=1}^{N} \|\mathbf{d}_i - \hat{\mathbf{d}}_i\|$

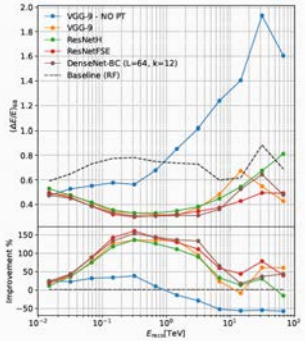
→ resolution improves as the energy increases

→ resolution decreases at the highest energies due to a non-optimal signal extraction

## Energy reconstruction

→ 1D regression problem

→ models comparison by their **energy resolution** (lower is better)




→ We want to reconstruct $E_{\mathrm{gammas}}$, i.e. the true energy of the $\gamma$ ray.

**Training loss function**:
$\mathrm{MAE} = \frac{1}{N}\sum_{i=1}^{N} |e_i - \hat{e}_i|$
where $e_i = \log_{10}(E_{\mathrm{gammas}})$

→ resolution improves as the energy increases

→ resolution decreases at the highest energies due to a non-optimal signal extraction

# Impegno INFN Software/data analysis LST

- Analisi dati MAGIC + LST con forte contributo italiano: le performances dei dati MAGIC ed LST più che raddoppiano la sensibilità di MAGIC soprattutto alle bassse energie! Sarà dedicato un talk di Federico su questo argomento

cherenkov telescope array

## MAGIC + LST simulations

F. Di Pierro[*1], L. Arrabito[2], A. Baquero Larriva[3], A. Berti[1], J. Bregeon[2], D. Depaoli[1,4], D. Dominis Prester[5], R. Lopez Coto[6], M. Manganaro[7], S. Mićanović[5], A. Moralejo[7], Y. Ohtani[8], L. Saha[3], J. Sitarek[9], Y. Suda[10], T. Terzić[5], I. Vovk[10], T. Vuillaume[11] for the CTA Consortium[†]

[1] INFN Sezione di Torino, via P. Giuria, 1 - 10125 Torino, Italy
[2] Laboratoire Univers et Particules de Montpellier, Université de Montpellier, CNRS/IN2P3, France
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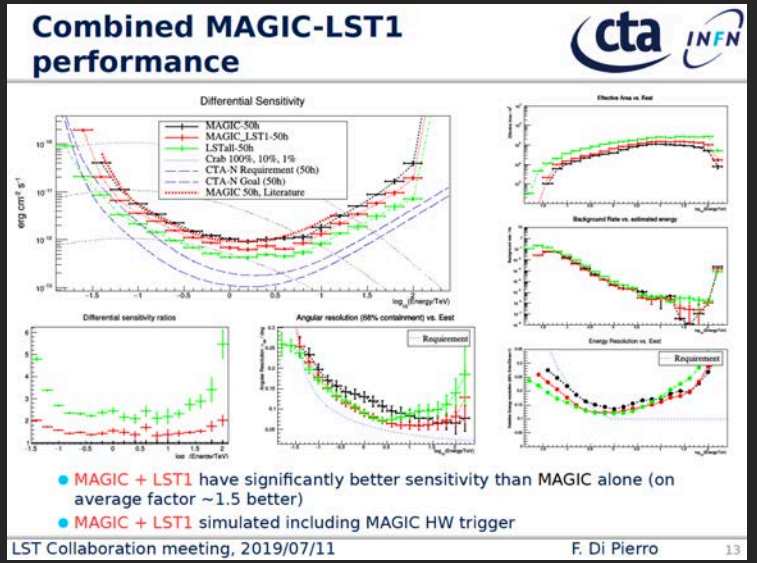
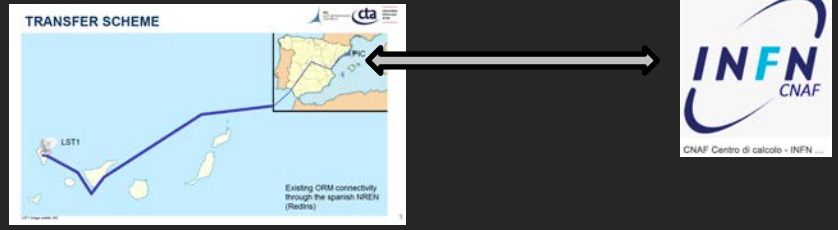
[6] INFN Sezione di Padova, Via Marzolo, 8 - 35131 Padova, Italy
[7] Institut de Física d'Altes Energies (IFAE), The Barcelona Institute of Science and Technology, Campus UAB, 08193 Bellaterra (Barcelona), Spain
[8] ICRR, The University of Tokyo, Japan
[9] Department of Astrophysics, The University of Łódź, ul. Pomorska 149/153, 90-236 Łódź, Poland
[10] Max Planck Institute for Physics, München, Germany
[11] LAPP, CNRS, Université Savoie Mont-Blanc, France

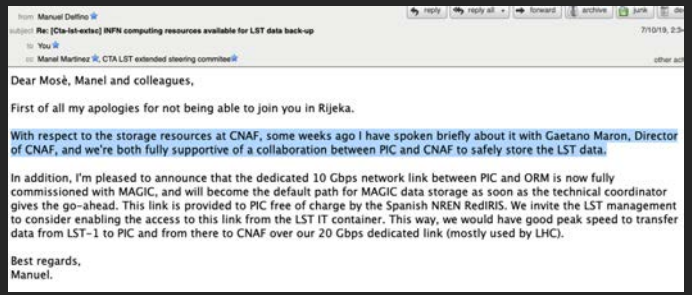


# Impegno INFN Software/data analysis LST

## Data storage LST “offsite”  PIC - CNAF

Raggiunto accordo di coinvolgimento CNAF nella gestione dei dati LST “offsite”: PIC traferisce dati da La Palma e poi si archiviano  al CNAF a Bologna. Lisa Zangrando Tecnologo di Padova incaricata di questa task





Dear Mosè, Manel and colleagues,

First of all my apologies for not being able to join you in Rijeka.

With respect to the storage resources at CNAF, some weeks ago I have spoken briefly about it with Gaetano Maron, Director of CNAF, and we're both fully supportive of a collaboration between PIC and CNAF to safely store the LST data.

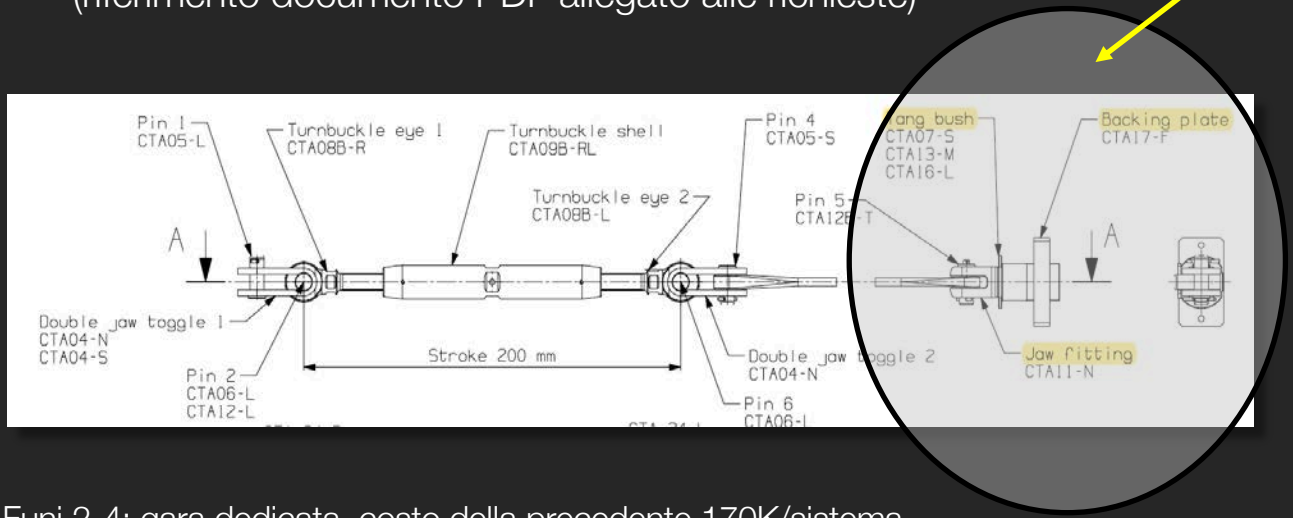
In addition, I'm pleased to announce that the dedicated 10 Gbps network link between PIC and ORM is now fully commissioned with MAGIC, and will become the default path for MAGIC data storage as soon as the technical coordinator gives the go-ahead. This link is provided to PIC free of charge by the Spanish NREN RedIRIS. We invite the LST management to consider enabling the access to this link from the LST IT container. This way, we would have good peak speed to transfer data from LST-1 to PIC and from there to CNAF over our 20 Gbps dedicated link (mostly used by LHC).

Best regards,
Manuel.

# Richieste finanziarie 2020 LST2

## Funi e meccanica ancillare per funi
(riferimento documento PDF allegato alle richieste)

Da inglobare nell'arco
in Fibra CSS




Funi 2-4: gara dedicata, costo della precedente 170K/sistema

Per la prima fornitura LST2, la tempistica è troppo stretta: bisogna realizzare 3 elementi (fuori gara costo ~ 15k Apparati) da realizzare inizio 2020 e da poter essere inglobati nell'arco che sarà in produzione primo quarto 2020

# Richieste finanziarie 2020 LST2

Fig. 3 Cavallotti in acciaio (double jaw taggle) realizzati nell'officine meccaniche di Padova, lavorazione di acciaio speciale tramite elettroerosione

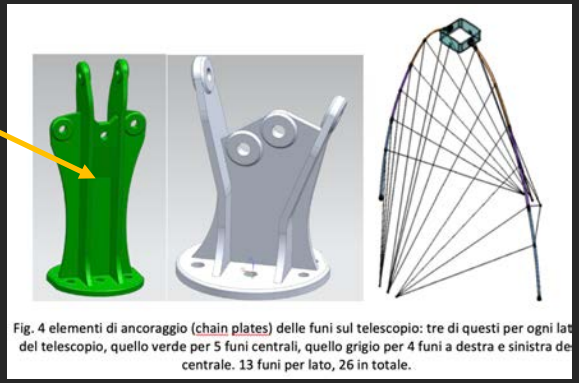


Fig. 4 elementi di ancoraggio (chain plates) delle funi sul telescopio: tre di questi per ogni lat del telescopio, quello verde per 5 funi centrali, quello grigio per 4 funi a destra e sinistra de centrale. 13 funi per lato, 26 in totale.

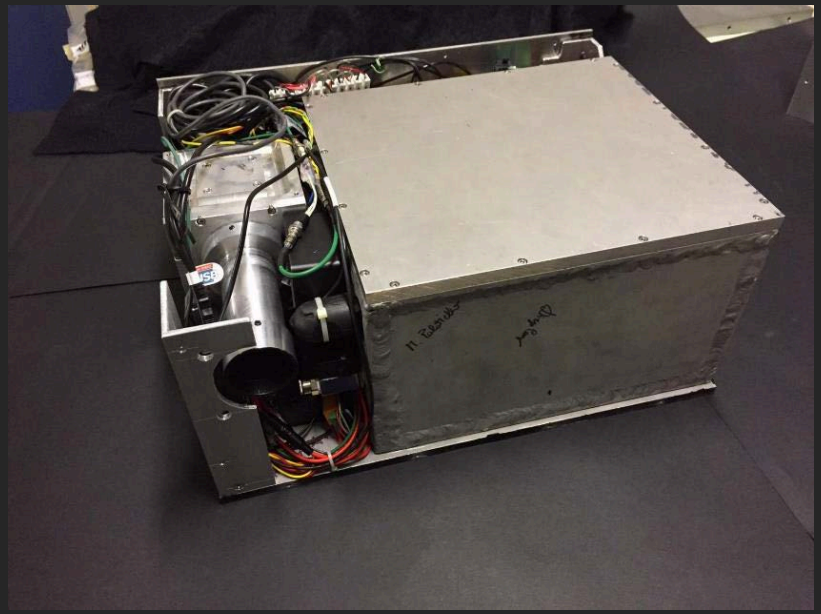
Elementi meccanici ancillari, costo 14 k in consumo PD:

parte per la lavorazione dei cavallotti in elettroerosione (~ 5 K)

Parte per la realizzazione dei 6 elementi "chain Plates" di raccordo funi-struttura (9 k)

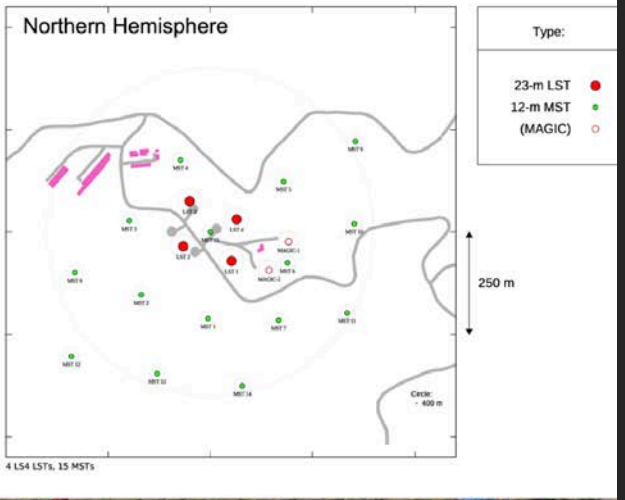
# Richieste finanziarie 2020 LST2

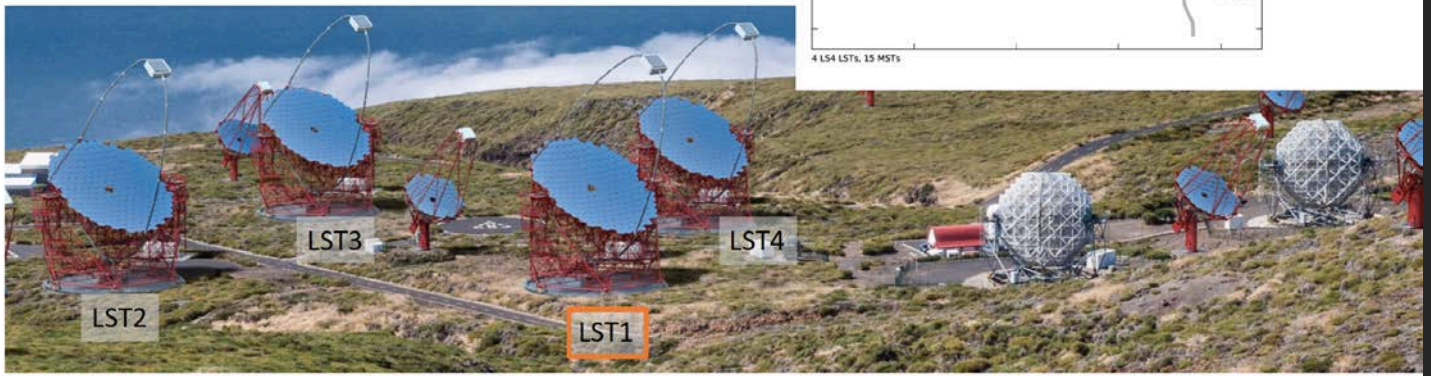
- The second Calibox will be produced soon (starting in within this year) also as to have as soon as possible also as a ‘spare’ for LST1. More details in Maurizio talk: the overall cost around 40k



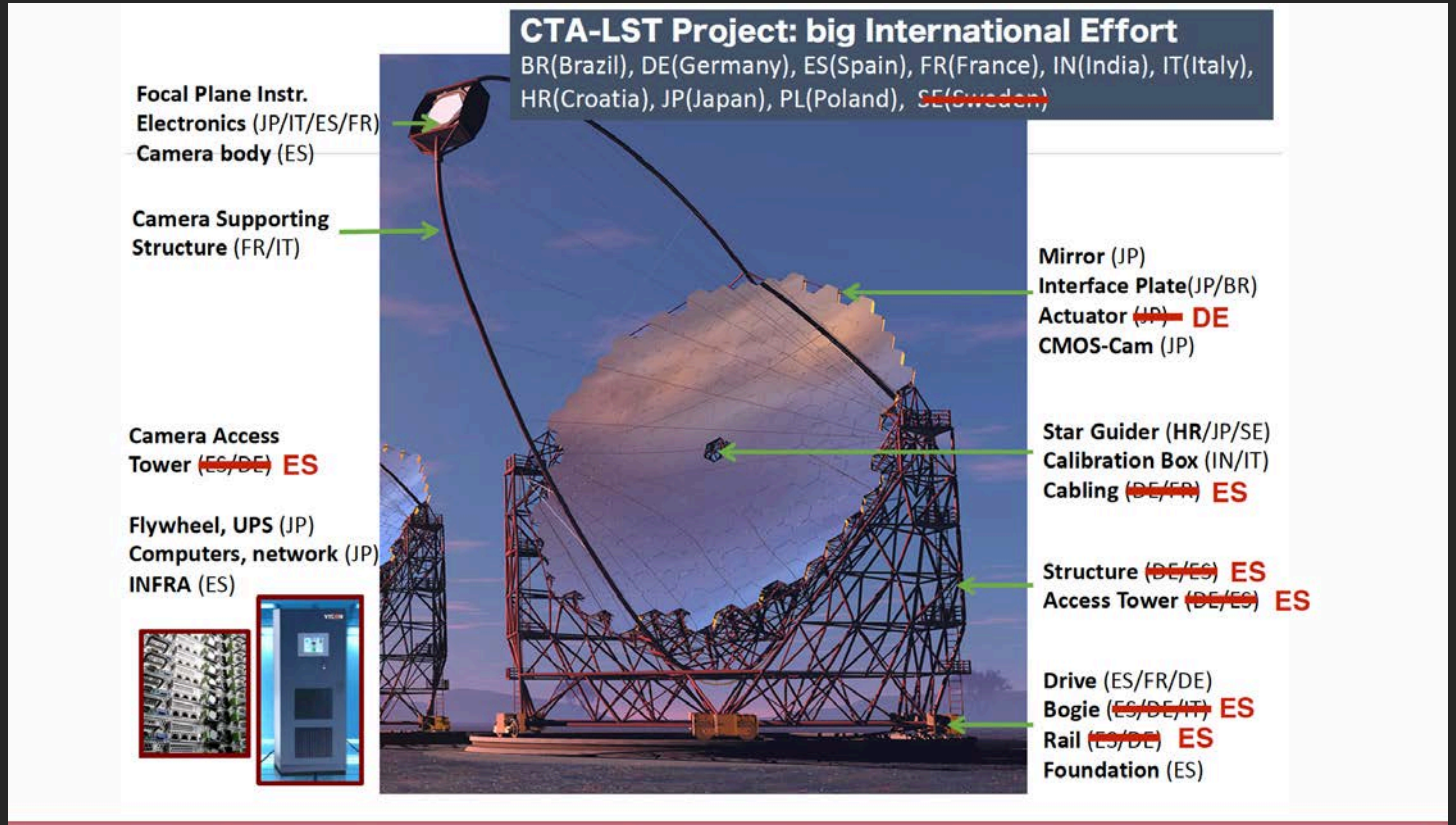
# Prospettiva LST2-4

- We are in the same time
  - commissioning LST1
  - building LST2, LST3 and LST4

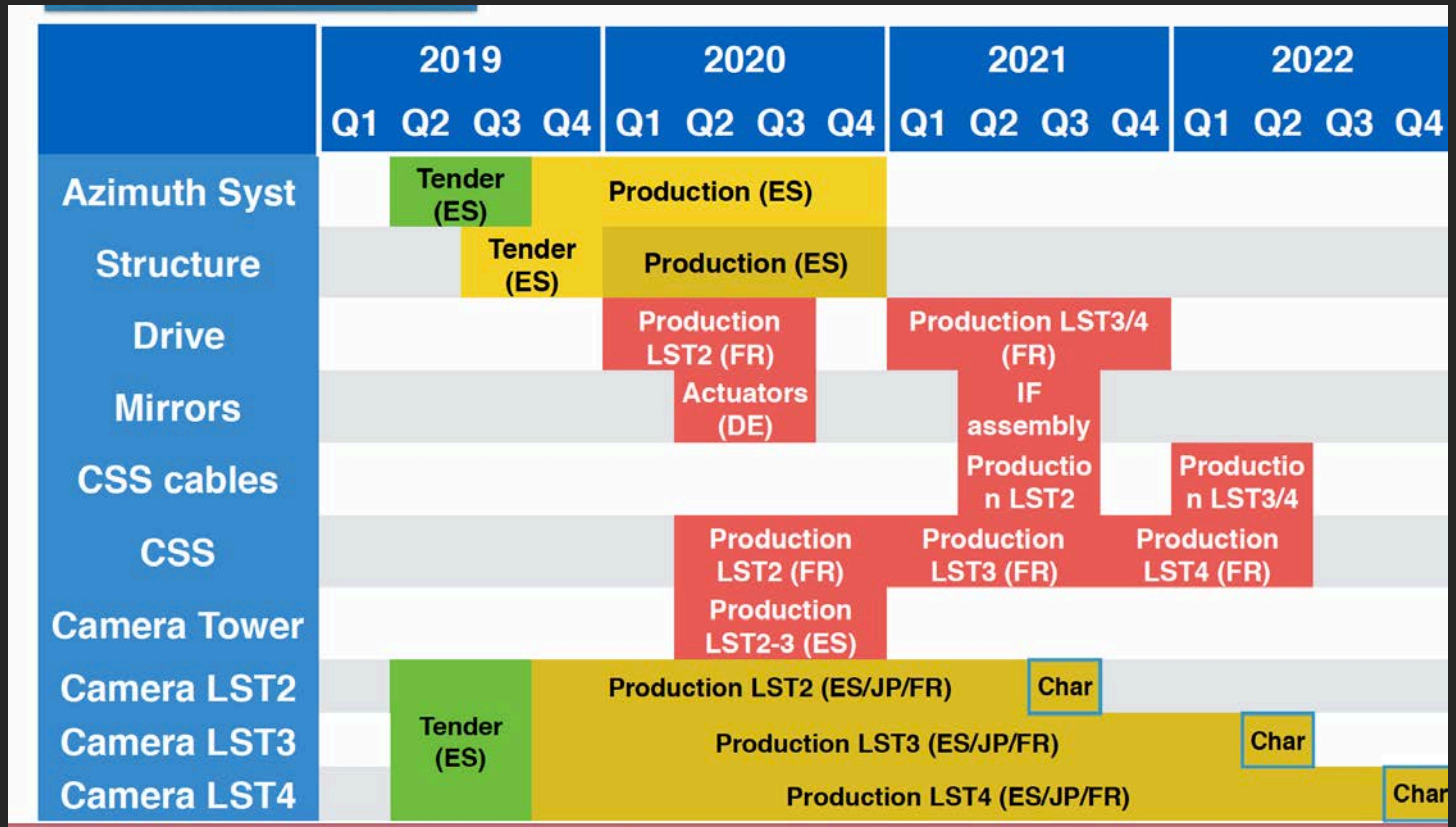


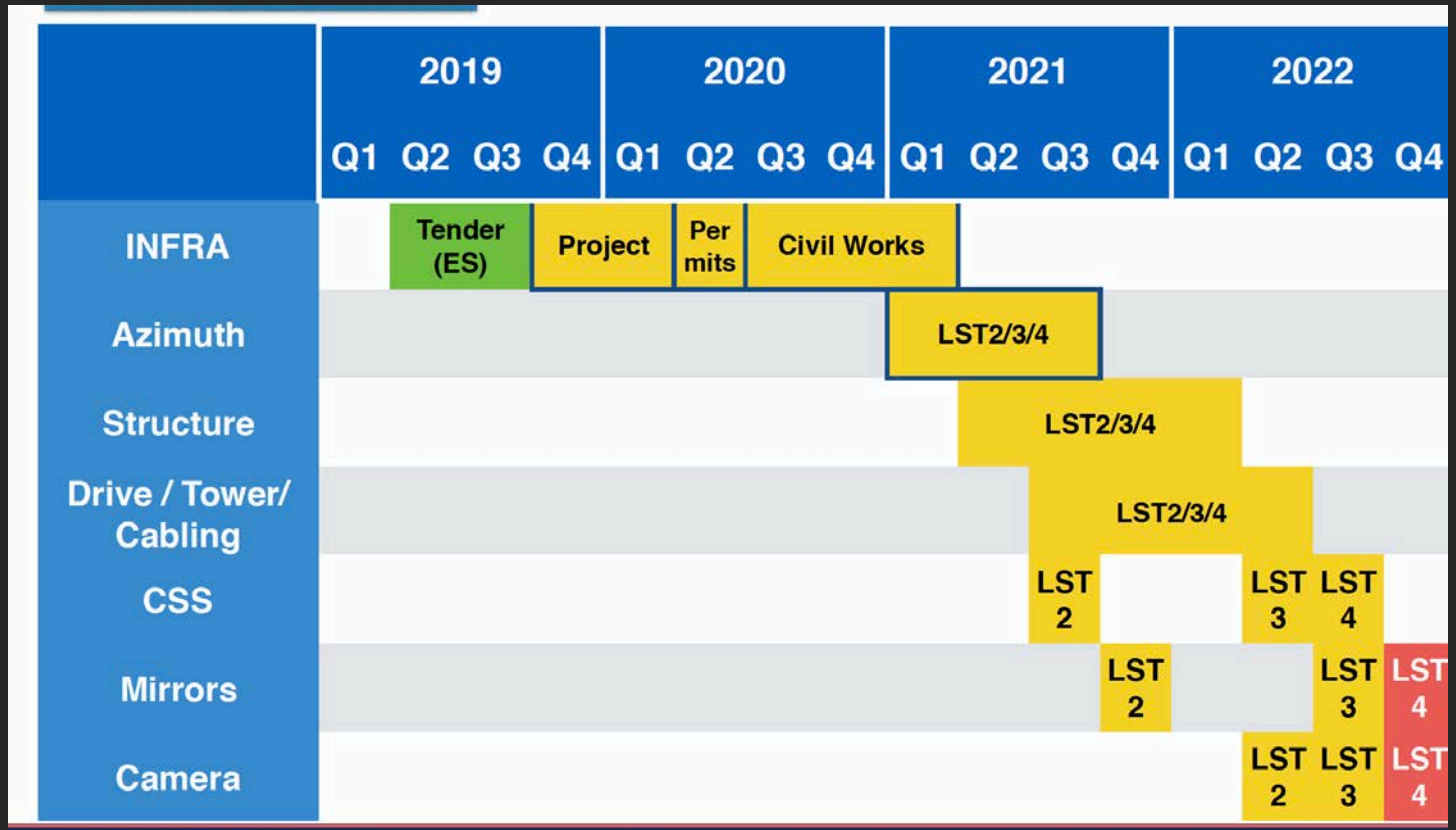
# Prospettiva LST2-4



# Prospettiva LST2-4



# Prospettiva LST2-4



# Budget in prospettiva LST2-4

50 k per far partire gara funi nel 2020, di cui 30 sono per realizzazione di meccanica ancillare per il sistema di aggancio funi al telescopio ed anticipo gara

Problemi con il pagamento dei CF, soldi stanziati ma MoU non passato in giunta ed il nostro direttore (che aveva firmato il pagamento 2 anni stesse condizioni) non vuole firmare

# LST 5-8

Progettazione camera SiPm insieme ai colleghi svizzeri (ETH, uniGE)

Sarà probabilmente una camera di nuova concezione «pizza box»

Riunione preliminare con Teresa e Biland al CERN il 18 dicembre. Se si creano le  condizioni giuste potrebbe essere un contributo rilevante INFN per tutto CTA. Tema comunque delicato……