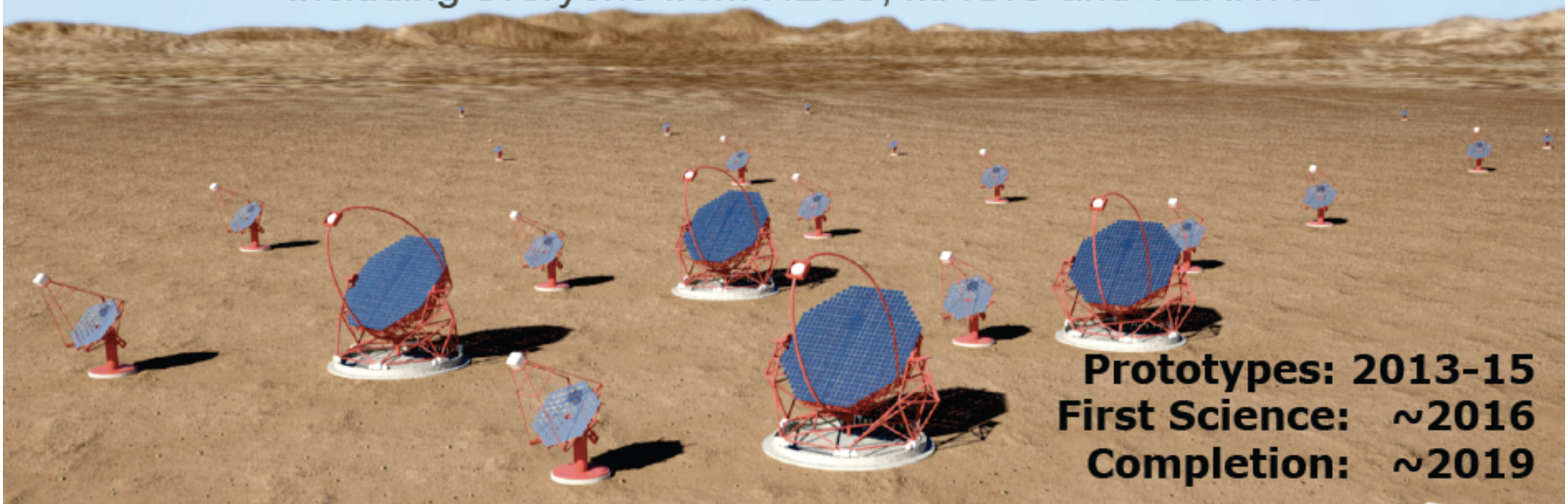
CTA-RD

Alessandro De Angelis, Riccardo Paoletti

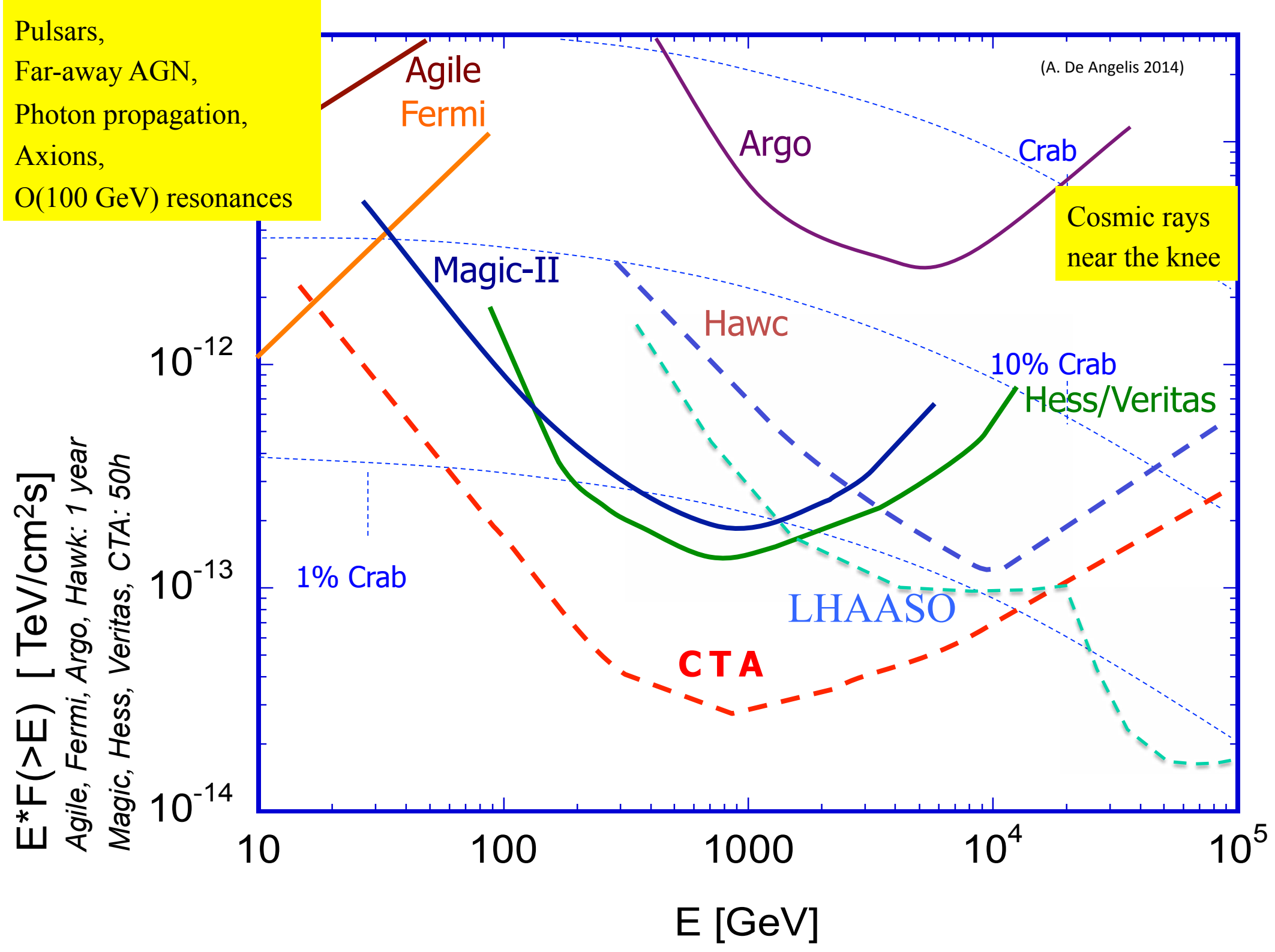
Commissione 2 INFN, 14 Aprile 2014

The Cherenkov Telescope Array

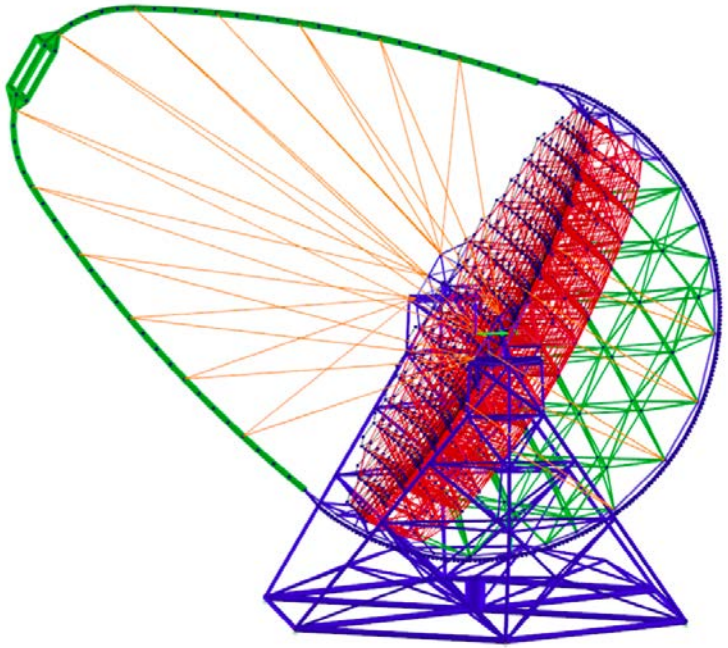
- A huge improvement in all aspects of performance
  - A factor ~10 in sensitivity, much wider energy coverage, much better resolution, field-of-view, full sky, …
- A user facility / proposal-driven observatory
  - With two sites with a total of >100 telescopes
- A 27 nation ~€200M project
  - Including everyone from HESS, MAGIC and VERITAS



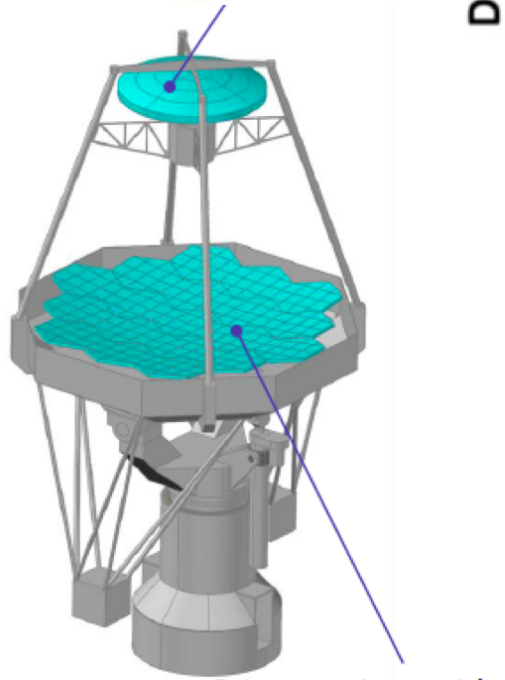
Prototypes: 2013-15
First Science: ~2016
Completion: ~2019

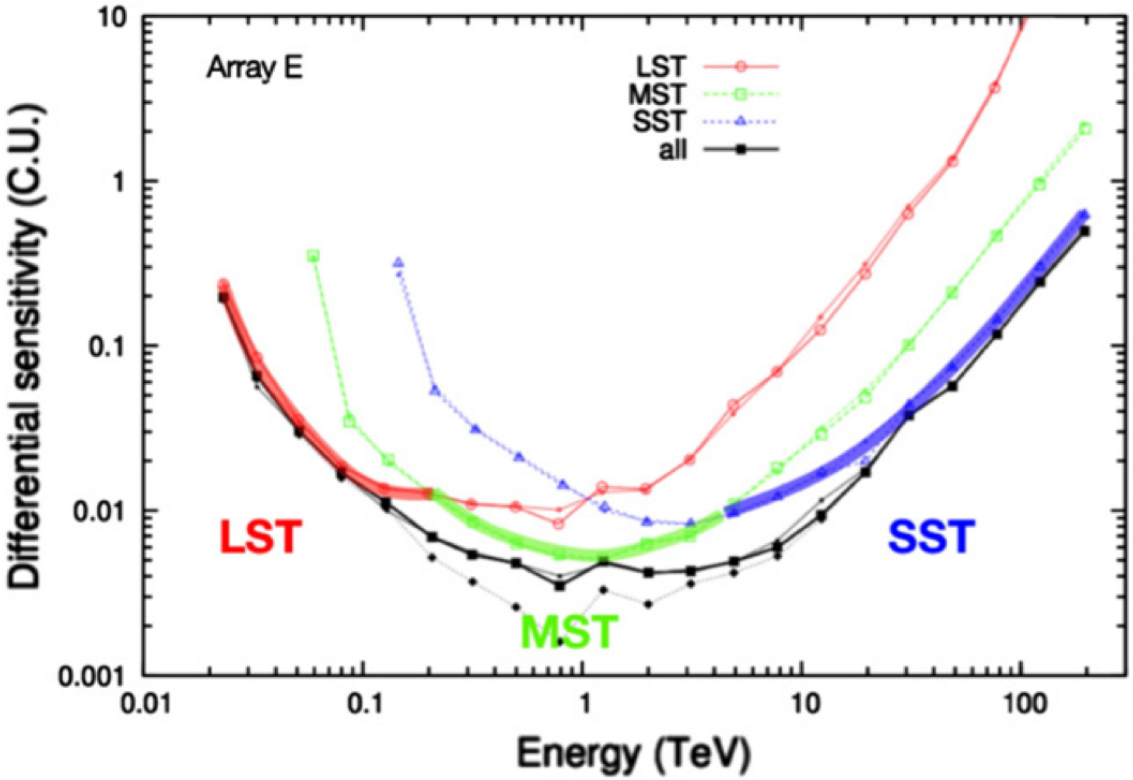

Pulsars,
Far-away AGN,
Photon propagation,
Axions,
O(100 GeV) resonances
(A. De Angelis 2014)
Agile
Fermi
Argo
Crab
Cosmic rays
near the knee
Magic-II
Hawc
10% Crab
Hess/Veritas
1% Crab
LHAASO
CTA
10^{-12}
10^{-13}
10^{-14}
E*F(>E) [TeV/cm^{2}s]
Agile, Fermi, Argo, Hawk: 1 year
Magic, Hess, Veritas, CTA: 50h
10
100
1000
10^4
10^5
E [GeV]

LST: 23 meter diameter, optimized for low E



SST: 4-6 m, optimized for large E





CTA performance below ~100 GeV is given by LSTs and we aim to go down to 20 GeV

New: press release (April 11)

"Gamma-ray Astronomy: Site negotiations for Cherenkov Telescope Array started

On the 10th April 2014, the 12 country delegates mandated by their governments to decide about the start of site negotiations for CTA met in Munich. They took note of the report of the international Site Selection Committee (SSC) […] on the merits of the proposed sites.

The delegates representing Argentina, Austria, Brazil, France, Germany, Italy, Namibia, Poland, Spain, South Africa, Switzerland and the UK decided […] to start the negotiations on the two sites in the southern hemisphere, namely Aar in Namibia and ESO* in Chile, keeping Leoncito in Argentina as a third option. After negotiations finally one site will be selected at the end of the year.

As far as the northern site of the CTA Observatory is concerned – candidate sites are located in Mexico, Spain and the USA - further considerations are necessary. Therefore, the delegates decided to postpone their decision and to ask the CTA board of agency representatives – the Resource Board - to take this forward. The decision for the negotiations about the northern hemisphere site will be taken as soon as possible."

Depending on the status of the negotiations, the LST prototype could be mounted in the Southern site, or in La Palma

PARTE I

Stato di CTA-RD INFN

La partecipazione INFN a CTA

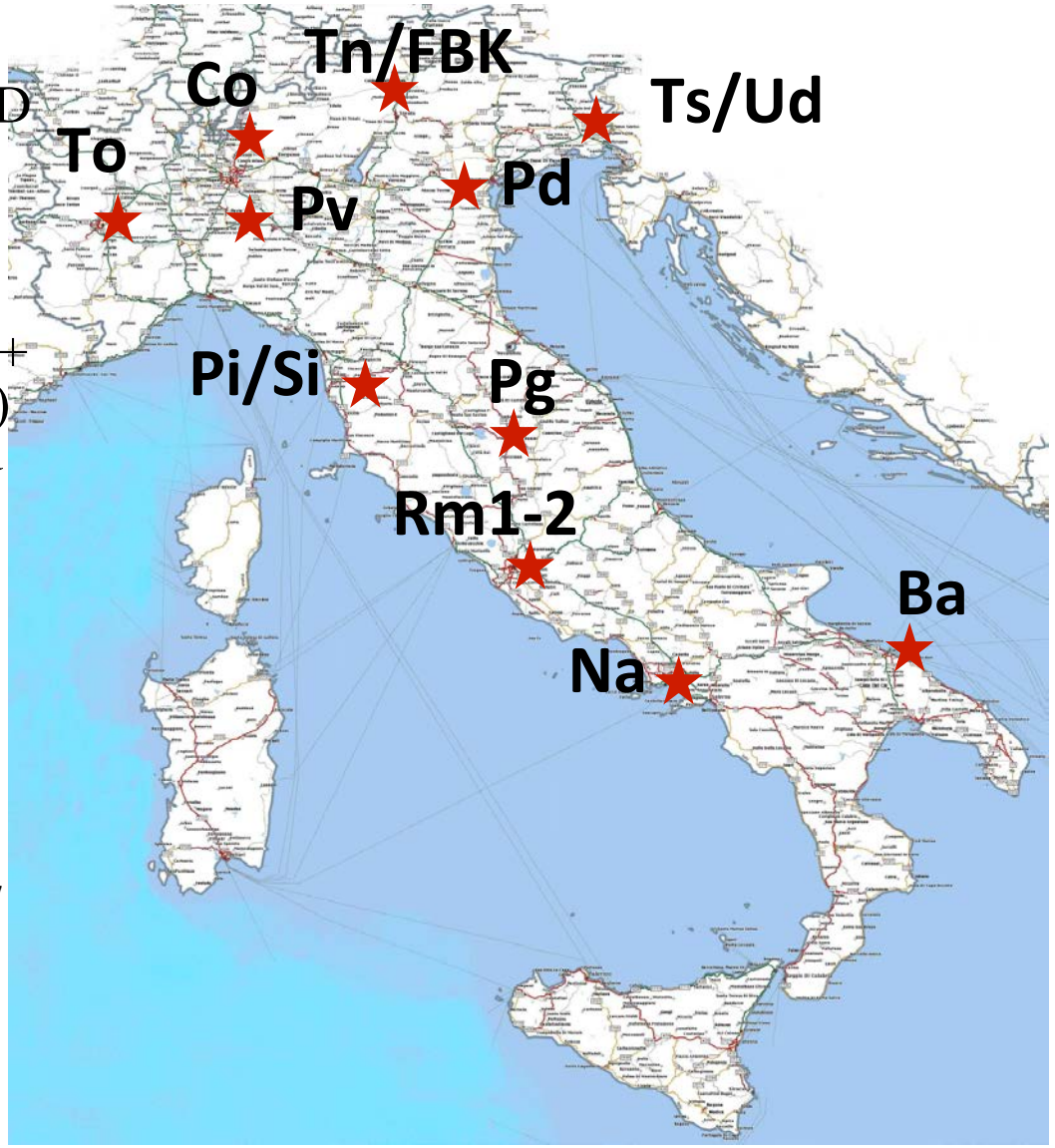
- 3 INFN groups (Pd, Si, Ud) already in CTA since 2008, via national University funding
- ~40 INFN scientists working to INFN CTA-RD since September 2012

  Seevogh meetings every 2nd week, a few physical meetings (Roma, Mestre, Roma, Napoli, Pisa, …)
- January 2013: proposal of a "premiale" INAF + INFN; SiPM (industrial partnership with FBK) + electronics (CAEN, SITAEL); approved end 2013 with a 13% cut
- ~1.5 MEUR-13% for INFN: 2/3 for SiPM, 1/3 electronics
  - After the overhead, a bit more than 1 MEUR

  Sensor ~ few mm for the SST camera (~2000 for a 40 cm detector), where granularity could be the issue

  1" for LST, where sensitivity might be the issue

  Camera demonstrator (SiPM + readout) for SST; cluster of 7 photosensors for LST
- Prototypes for a new mirror technology
- Atmospheric monitoring
- Simulation & science; computing



Premiale TECHE.it
TElescopi CHErenkov con tecnologia .italiana

Premiale diviso in 4 WP

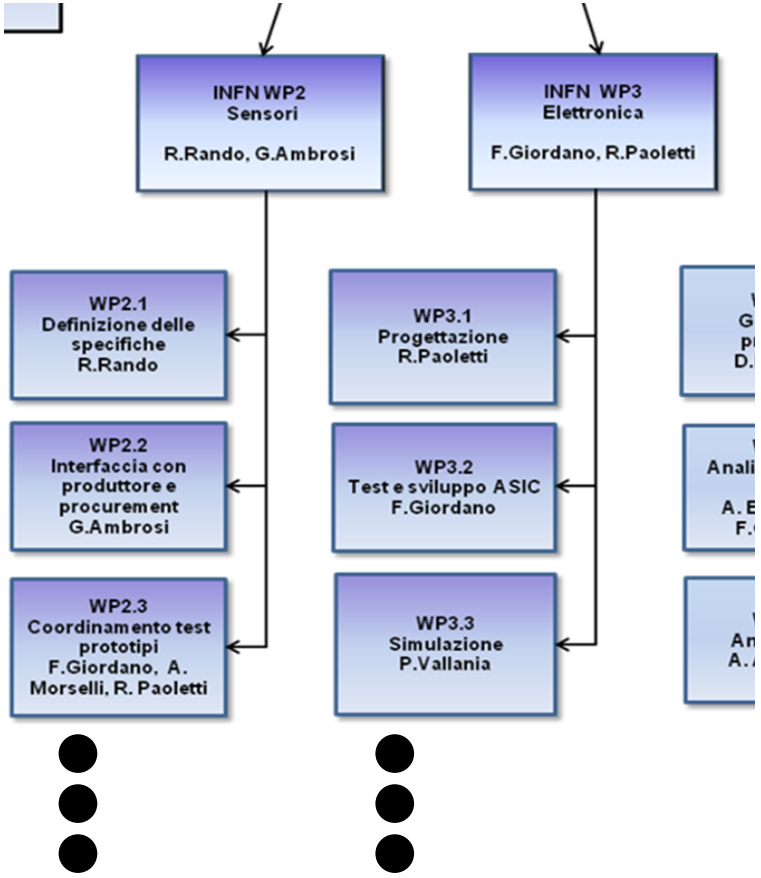
INFN su WP2 e WP3

WP2 - “migliorare le prestazioni di CTA utilizzando nuovissimi sensori al silicio”

- Specifiche sensori
- Interfaccia FBK
- Test sensori

WP3 - “sviluppare una nuova elettronica di front-end e acquisizione dati progettata per i nuovi rivelatori al silicio sviluppati nel WP2”

- Progettazione elettronica
- ASIC (preamplificatore)
- Simulazione (DAQ+trigger)



Il premiale è un'ottima occasione (ben considerata anche in CTA) per consentire all'INFN e all'INAF di lavorare insieme

Consente di finalizzare l'R&D iniziato come INFN e giungere ad una unità ottica basata su SiPM NUV-HD (+elettronica), come dimostratore (tutte le sezioni sono coinvolte)

Vengono finanziati SiPM per ~una camera SST ed elettronica di frontend; per un cluster LST ed elettronica di frontend

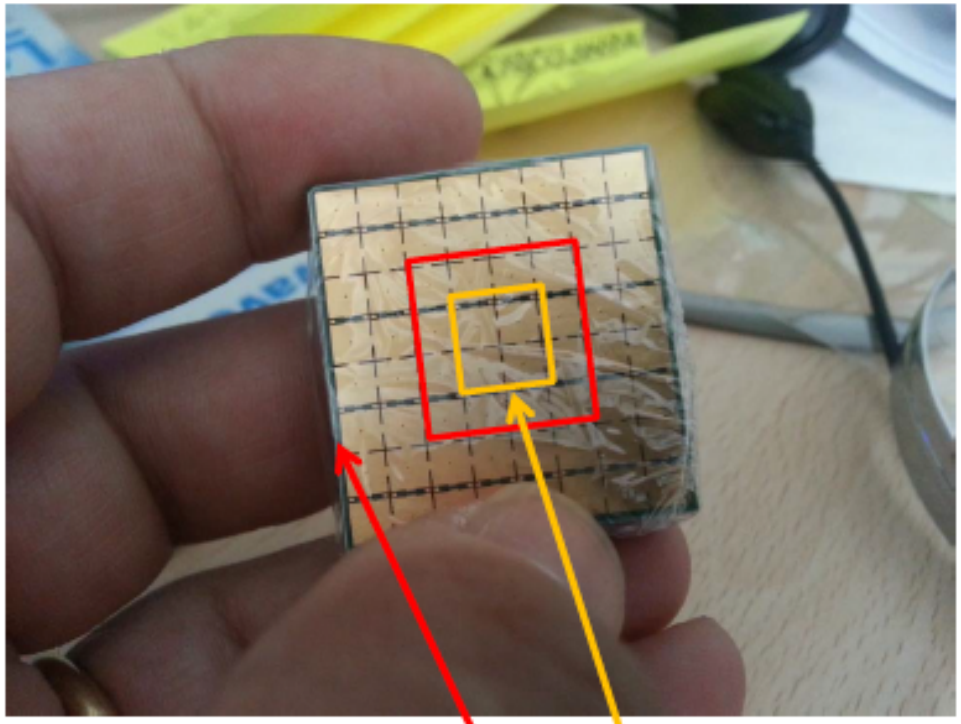
Il finanziamento INFN dell'R&D copre run di produzione SiPM e il setup dei laboratori incaricati dei test sui sensori, e l'inizio di progettazione di parti dell'elettronica (alimentazioni, TARGET, cooling, slow controls, …); missioni; contratti

Sviluppo di simulazioni per guidare la progettazione elettronica

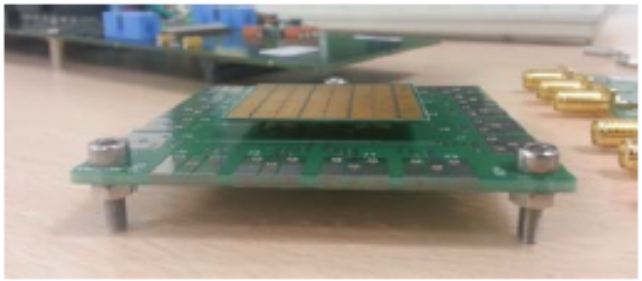
CTA INFN: Sensori

- Test di SiPM sono stati condotto misurandone le prestazioni principalmente con due sistemi di acquisizione: con elettronica “lenta” per integrazione in una finestra temporale (EASIROC) e con elettronica “veloce” per campionamento e successiva analisi del segnale (DRS4). Per misure con impulsi luminosi si sono utilizzati LED con t~ di 100ps e lunghezze d'onda sino a circa 350nm: questo consente di investigare il regime di vicino UV, particolarmente rilevante per la radiazione Cherenkov, e con tempi consistenti con lo sviluppo dello sciame Cherenkov.

- Produced 10 PCBs to hold a matrix of 64 (8x8) SiPM 3mm x 3mm
- 5 PCB sent to PG for NUV sensor bonding
- To be used for
  - SST camera demonstrator
  - Characterization studies
- Can be interfaced to
  - Preamplifier test
  - Readout board

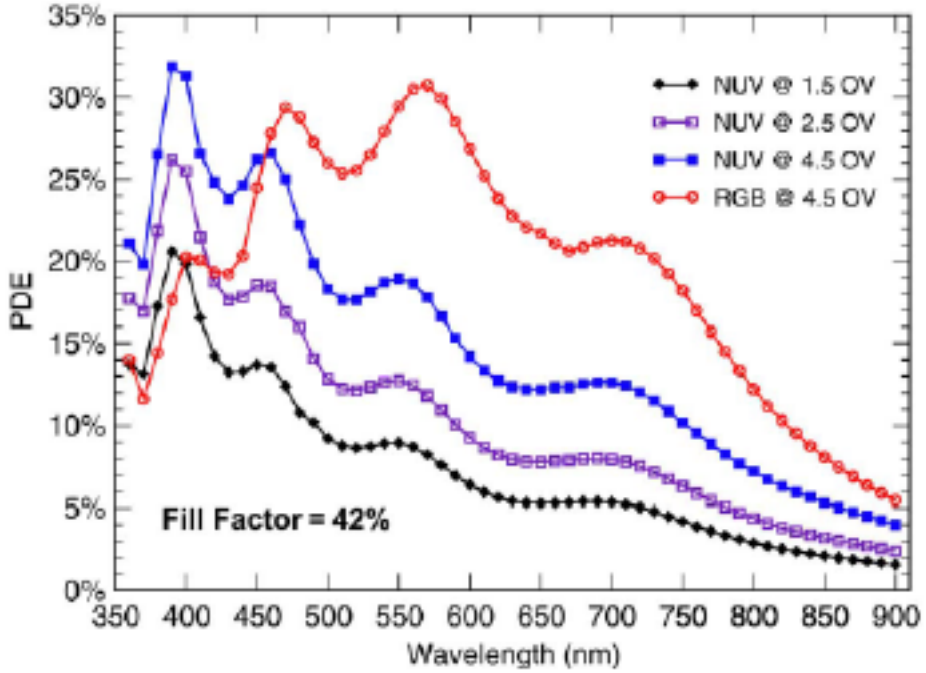


e.g. 50 NUVs = 2 x 16 + 2 x 4 + 10 single



…ma anche come seme per un grande SiPM per LST

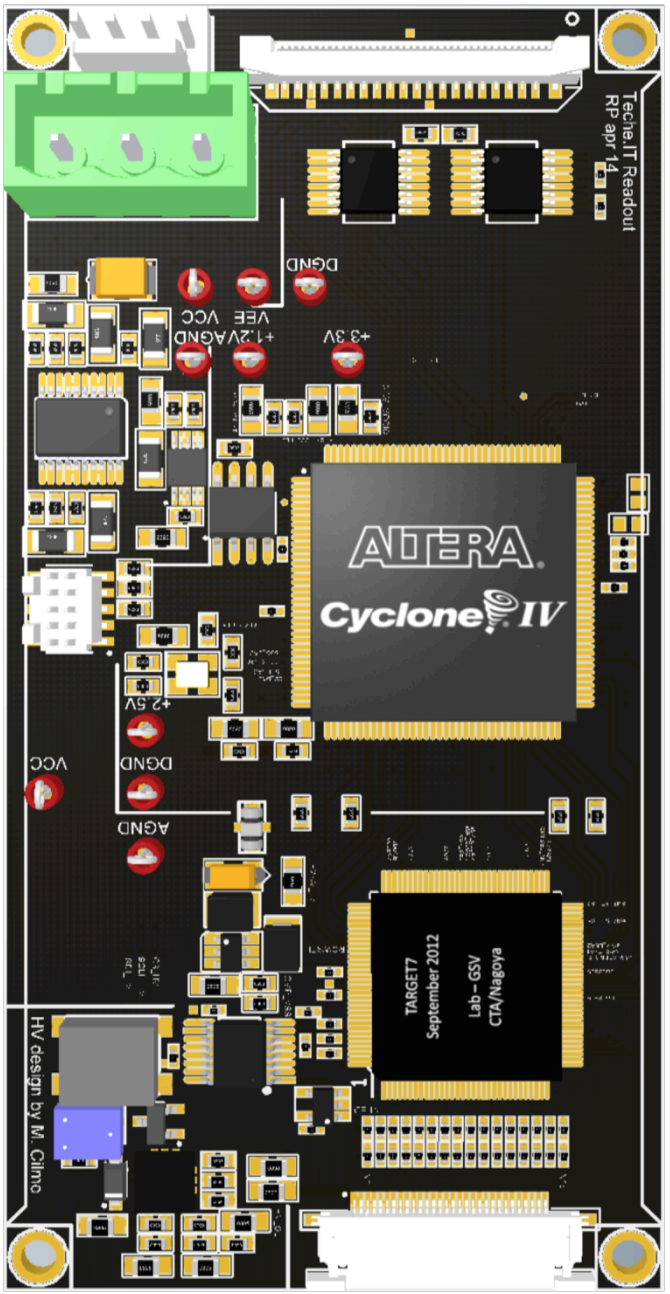
- 2produzioni di SiPM sviluppate con FBK in MEMS; 2 sono in corso con i nuovi wafer da 6”
- PDE: i 3x3 di FBK e Hamamatsu sono confrontabili allo stato attuale
- Anche il Dark Rate, ormai sui livelli di qualche centinaio di kHz/mm^2 , non vede grandi differenze tra prodotti ottenuti in diverse fonderie (NSB: 10 fotoni/mm2/ns full moon)
- Entro fine 2014 FBK potrebbe produrre una nuova generazione di SiPM definiti High Density (HD): il sensore HD prevede un nuovo disegno delle microcelle delle dimensioni di 30 µm x 30 µm => PDE dell’ordine del 50% nel range UV, prestazioni superiori ai SiPM tradizionali. Se i test sono positivi, per luglio potremmo ordinare una produzione di 3x3 pronti per l’uso su SST



(C. Piemonte et al., FBK)

Elettronica “SST”

- La scheda di supporto sensori è collegata ad una scheda di preamplificazione per cui sono state valutate 2 opzioni di preamplificatori (OPA 694 e AD8000).
- I segnali dei SiPM dai preamplificatori sono campionati e digitalizzati in una scheda che alloggia il chip Target (versione 7) sviluppato per CTA da Gary Varner, Hawaii. La progettazione della scheda di readout con chip Target7 è terminata. Il programma di campionamento verra’ perfezionato assieme ai colleghi di SLAC che stanno usando il campionatore Target.
- La scheda di readout alloggia anche la generazione dell'alta tensione per l'alimentazione dei SiPM.



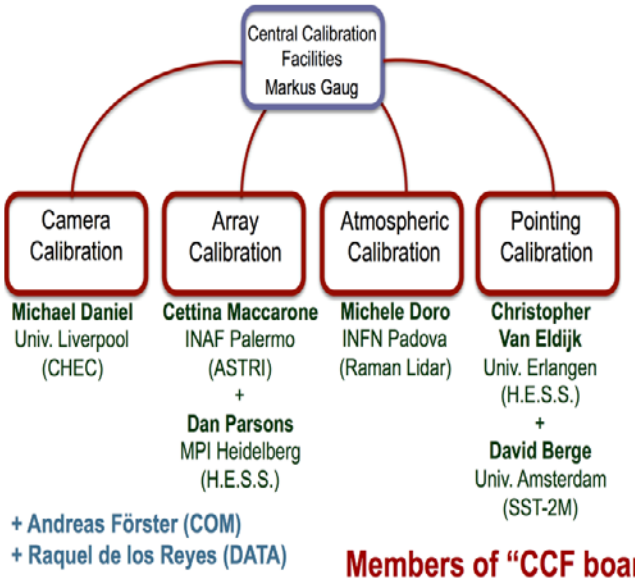
Summary

- We are confident that by end of the year INFN can propose a product (sensors+electronics) appropriate for the SST camera

- In parallel, we work to LST sensors, and to LST electronics in the SiPM and in the standard PM hypothesis (see later)

Calibrazione atmosferica

Implementation Strategy Document:



COM-CCF-ATMO.

Atmospheric Calibration Strategy

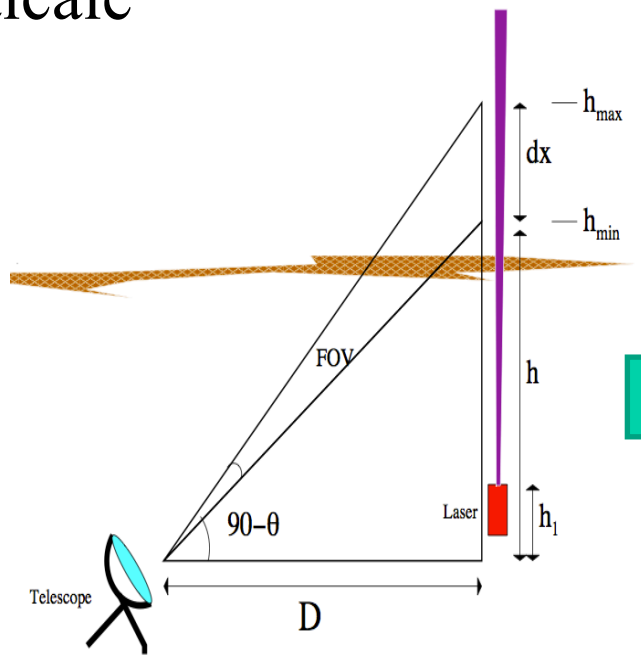
Edited by: Michele Doro michele.doro@pd.infn.it

April 2, 2014

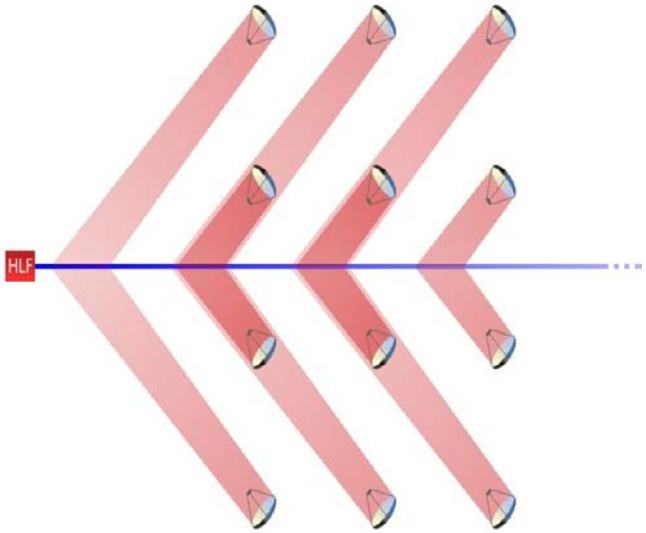
Would like to **start characterizing** atmosphere of the site **as soon as site is available** (with radio-sondes, LIDARs, Ceilometers)

Have the **option** to bring a **cross-calibrated reference LIDAR** from INFN to the site as early as Summer 2015!

Verticale



Orizzontale



ARCADE: Lidar Raman costruito in collaborazione tra i gruppi di Napoli e Torino nel FIRB 2010

Obiettivo di ARCADE : studio delle diverse tecniche attualmente in uso nella comunità degli raggi cosmici per la misura dell'attenuazione da aerosol atmosferici della luce UV

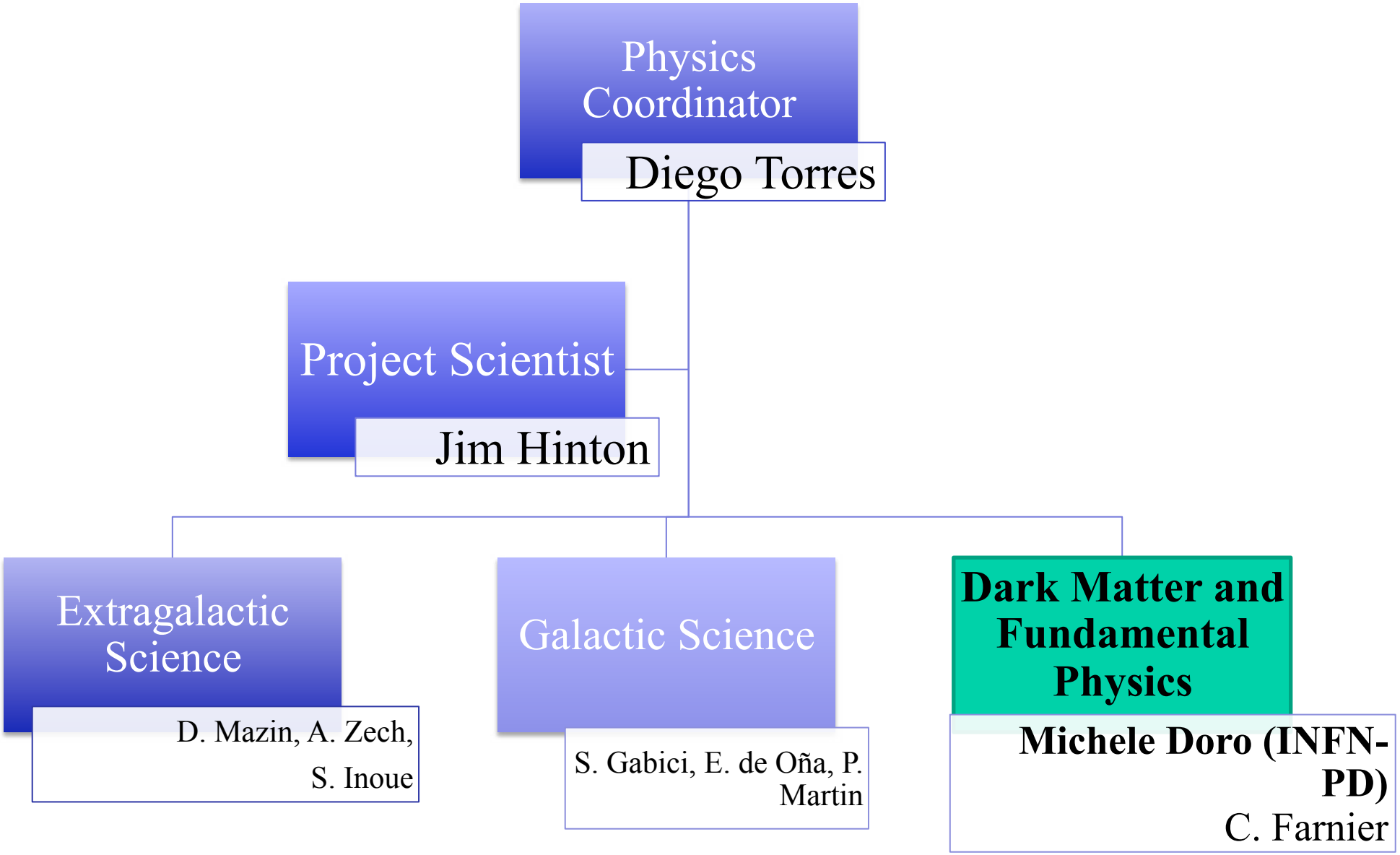
La costruzione è stata appena completata

Al termine del progetto (marzo 2015), la proposta è di riutilizzare il sistema come prototipo per CTA

Sviluppo specchi (prototipo per CTA LST+)

- Due nuovi tipi di prototipi sviluppati (Alluminio-Alluminio-Vetro, AAG, e Vetro-Vetro)
- 2 specchi di prova di tipo 1 montati su MAGIC lo scorso settembre
- 10 specchi di prova di tipo 2 verranno montati su MAGIC quest'estate
- In produzione uno stampo per uno specchio LST (per AAG)

Fisica


Physics Coordinator
Diego Torres
Project Scientist
Jim Hinton
Extragalactic Science
D. Mazin, A. Zech, S. Inoue
Galactic Science
S. Gabici, E. de Oña, P. Martin
Dark Matter and Fundamental Physics
Michele Doro (INFN-PD)
C. Farnier

Fundamental Physics

Dark Matter:

- Galactic center
- Dwarf spheroidal galaxies and dark clumps
- Cluster of galaxies
- Anisotropy in extragalactic gamma-ray diffuse

Axion-like Particles

- Opacity for strong mixing regime
- Spectral wiggles for weak mixing regime

Lorenz-Invariance Limits

- AGN and GRBs
- Pulsars

TaskB
"what results do we obtain with 100h observation with CTA"

Now
Prioritize studies + promote to KP

Goal
"how many hours do we need to investigate this peculiar scientific case"

Astroparticle Physics 43 (2013) 189–214

Contents lists available at SciVerse ScienceDirect

Astroparticle Physics

journal homepage: www.elsevier.com/locate/astropart

Dark matter and fundamental physics with the Cherenkov Telescope Array

M. Doro [k,*], J. Conrad [h,i,*], D. Emmanoulopoulos [l], M.A. Sànchez-Conde [r,s,t], J.A. Barrio [a], E. Birsin [b], J. Bolmont [c], P. Brun [d], S. Colafrancesco [e,f], S.H. Connell [g], J.L. Contreras [a], M.K. Daniel [j], M. Fornasa [m,n], M. Gaug [k], J.F. Glicenstein [d], A. González-Muñoz [m,n], T. Hassan [a], D. Horns [o], A. Jacholkowska [c], C. Jahn [p],

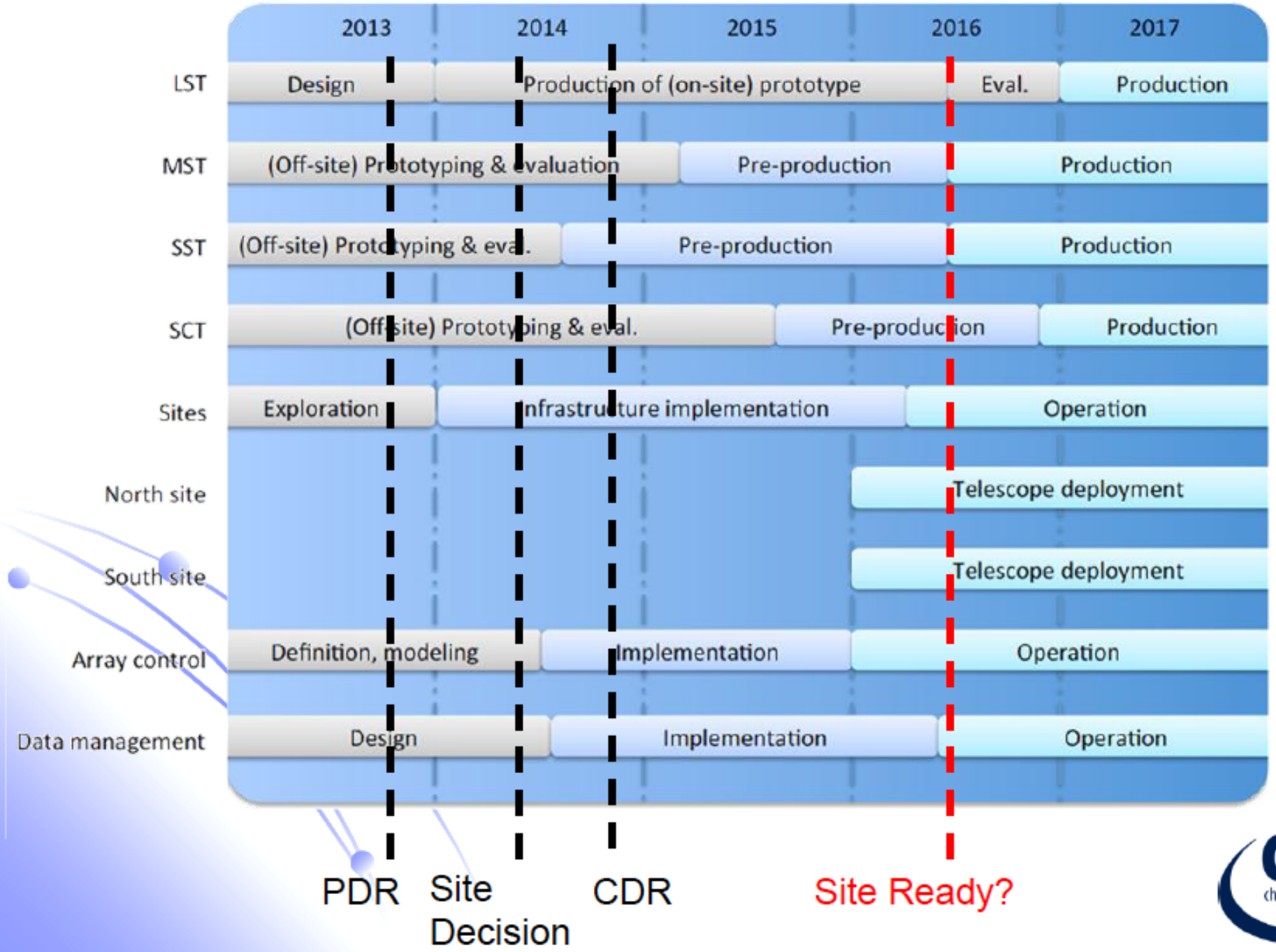
(…)

Key-Science Project definition before end 2014

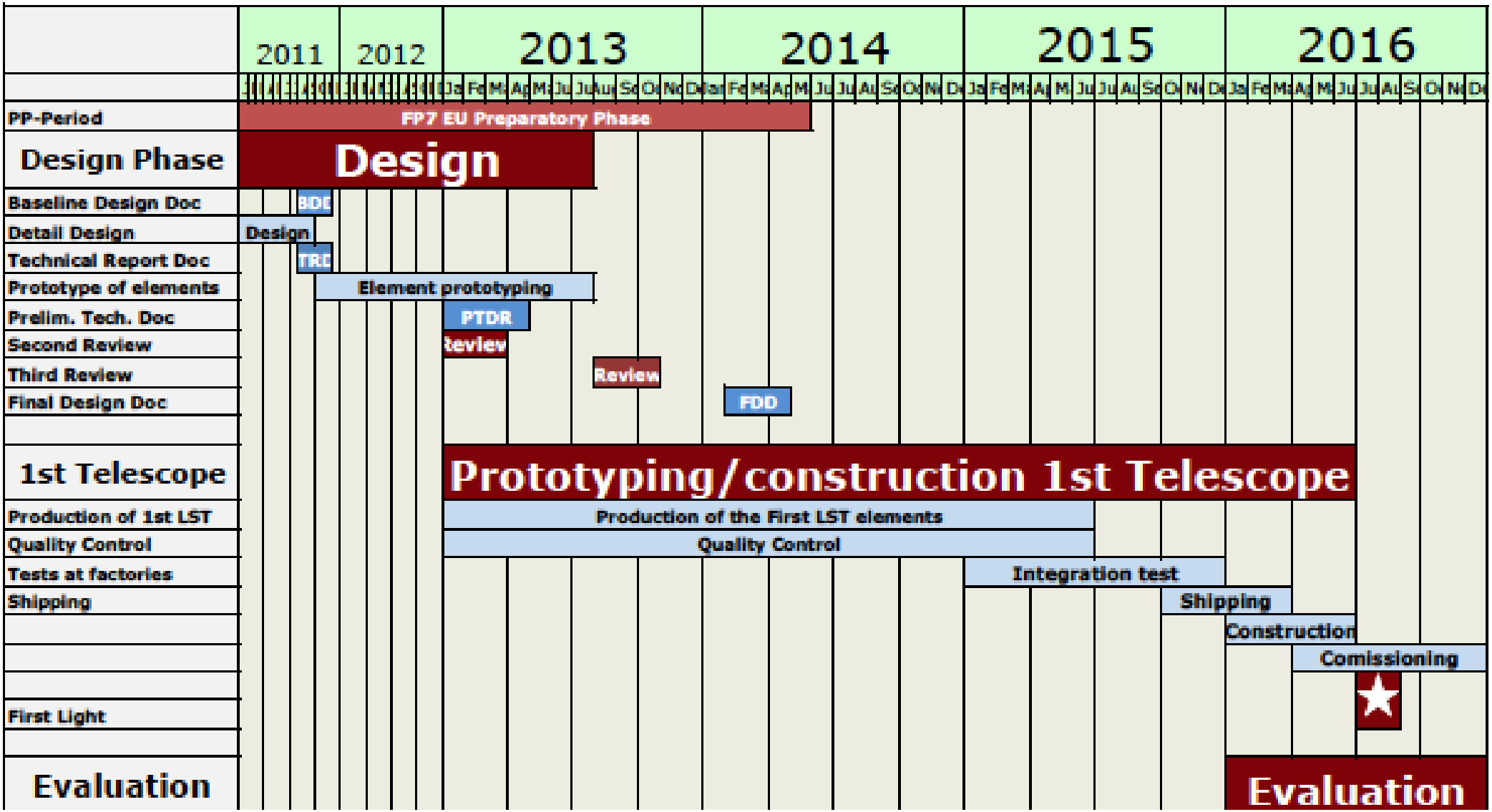
PARTE II

La camera di LST e la sua elettronica

CTA Timeline

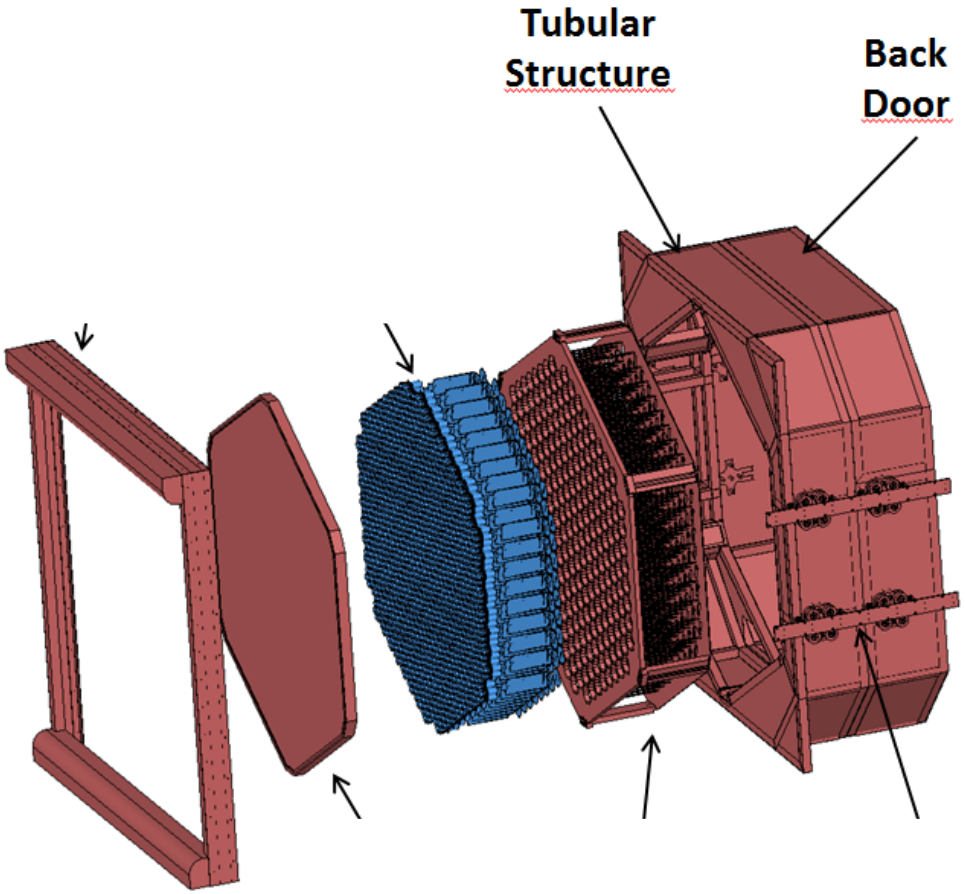


LST construction (Jan 2013)

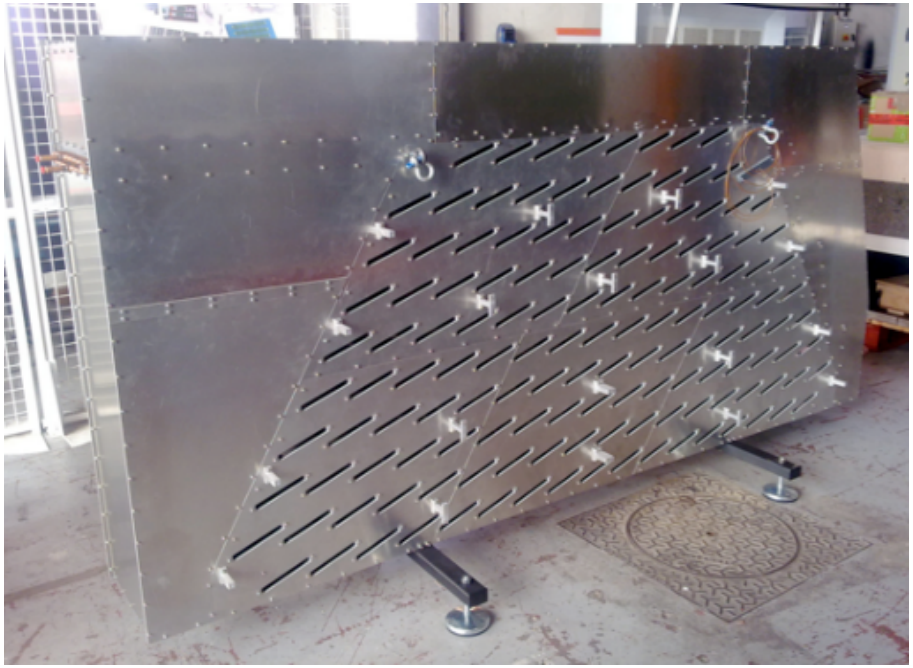


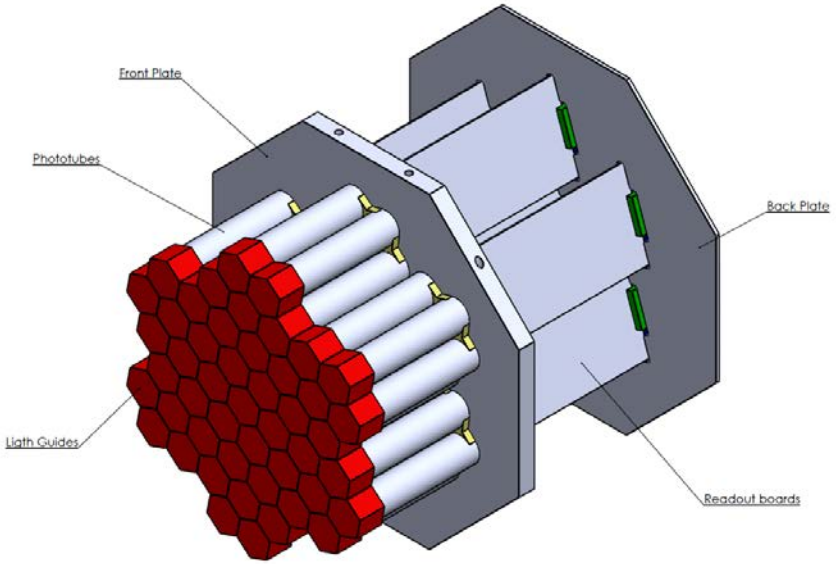
(shift by some 6 months)

Low-weight LST camera



Strong constrain on the weight from the LST structure: 2 tons





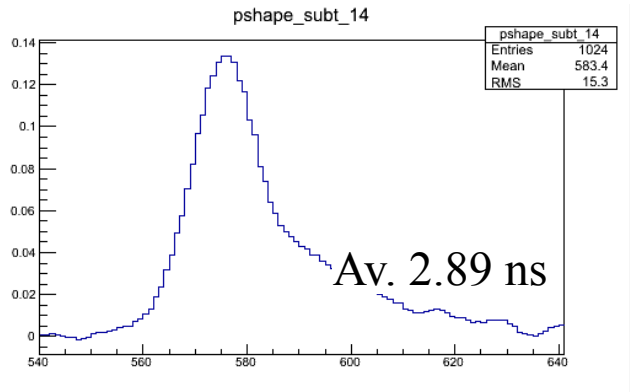
Module mechanics designed and ready for production

Full mechanics not yet final design. It will depend on the outcome of cooling demonstrator (tests ongoing)

PMT MODULE + Readout board

Toko Yamamoto & Daisuke Nakajima

2000 PMTs with HV supplier have been delivered. Calibration of all of these PMTs is underway. Preamplifiers will be on the mass production line in April.

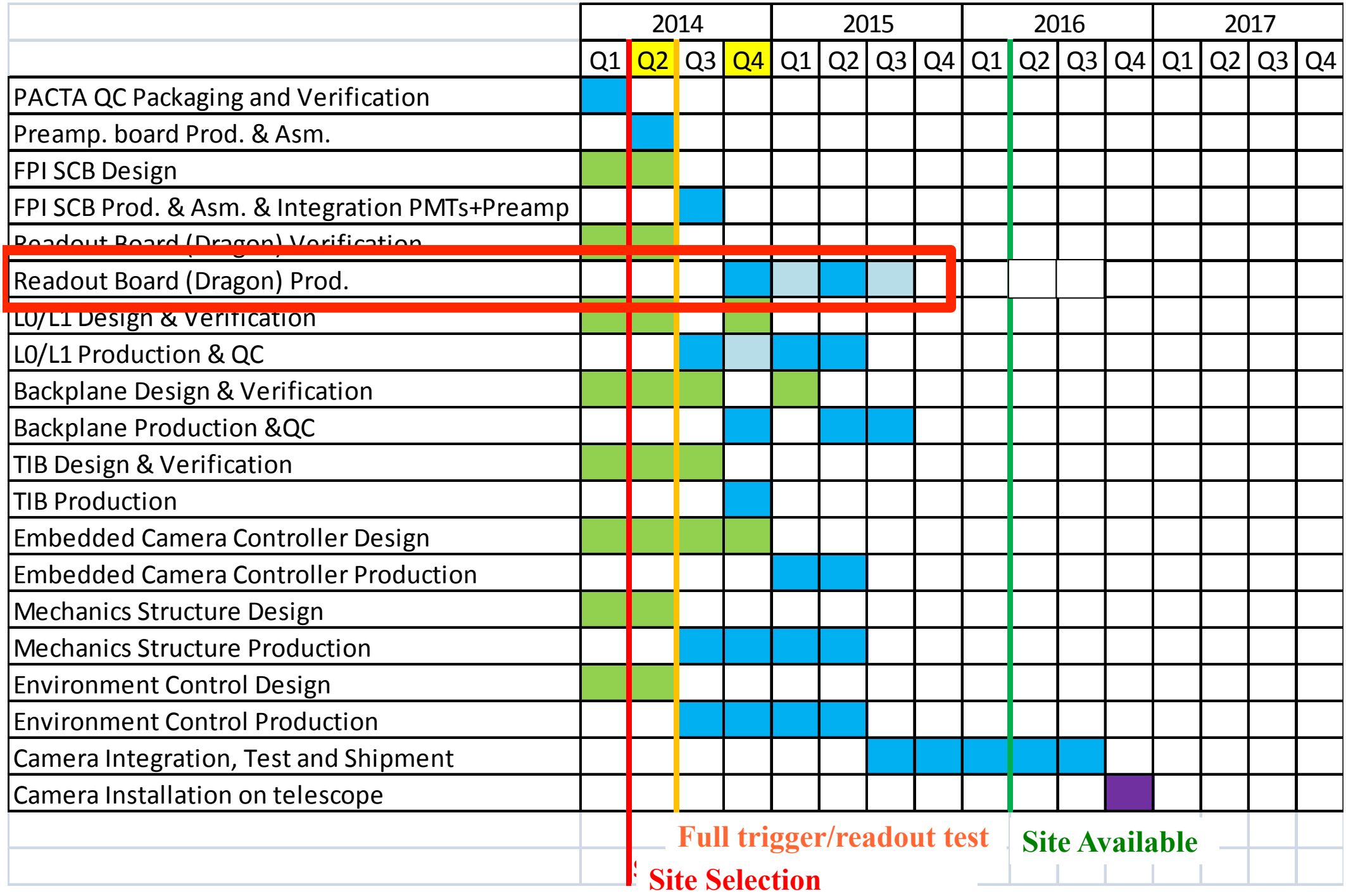


FWHM < 3ns

Nota: Il coordinatore della linea di ricerca LST-SiPM e' Riccardo Rando (INFN PD)

Readout board (down to the event): Dragon4 (project: Kyoto+Pisa; evolution of the MAGIC electronics from INFN Pisa + Padova)

LST camera production schedule (up to date)



Max-Planck-Institut für Physik
(Werner-Heisenberg-Institut)

Prof.Dr. Masahiro Teshima • MPI für Physik • Föhringer Ring 6 • 80805 München

Prof. Alessandro De Angelis
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24.02.2014

Dear Prof. Alessandro De Angelis,

in order to comply with the schedule of the prototype of the Large Size Telescope of the Cherenkov Telescope Array, we need to complete the production of the electronics within Summer 2015. We are able to produce in Japan only 50% of the Dragon boards developed by the Japanese Consortium together with INFN.

The LST Team would thus need the production and commissioning of the remaining 50% of such electronics by INFN. I ask please you and your team if this is possible within the deadline.

Sincerely yours,

Masahiro Teshima

Project Leader of the CTA LST Telescope

Director at Max-Planck-Institute for Physics

PARTE III

Dragon4: l’elettronica di readout per LST

Dragon Collaboration

33RD INTERNATIONAL COSMIC RAY CONFERENCE, RIO DE JANEIRO 2013
THE ASTROPARTICLE PHYSICS CONFERENCE

ICRC 2013

Development of the Photomultiplier-Tube Readout System for the CTA Large Size Telescope

H. KUBO[1], R. PAOLETTI[2], Y. AWANE[1], A. BAMBA[3], M. BARCELO[4], J.A. BARRIO[5], O. BLANCH[4], J. BOIX[4], C. DELGADO[6], D. FINK[7], D. GASCON[8], S. GUNJI[9], R. HAGIWARA[9], Y. HANABATA[10], K. HATANAKA[1], M. HAYASHIDA[10], M. IKENO[11], S. KABUKI[12], H. KATAGIRI[13], J. KATAOKA[14], Y. KONNO[1], S. KOYAMA[15], T. KISHIMOTO[1], J. KUSHIDA[16], G. MARTÍNEZ[6], S. MASUDA[1], J.M. MIRANDA[17], R. MIRZOYAN[7], T. MIZUNO[18], T. NAGAYOSHI[15], D. NAKAJIMA[7], T. NAKAMORI[9], H. OHOKA[10], A. OKUMURA[19], R. ORITO[20], T. SAITO[1], A. SANUY[8], H. SASAKI[21], M. SAWADA[3], T. SCHWEIZER[7], R. SUGAWARA[20], K.-H. SULANKE[22], H. TAJIMA[19], M. TANAKA[11], S. TANAKA[13], L.A. TEJEDOR[5], Y. TERADA[15], M. TESHIMA[7,10], F. TOKANAI[9], Y. TSUCHIYA[1], T. UCHIDA[11], H. UENO[15], K. UMEHARA[13], T. YAMAMOTO[21] FOR THE CTA CONSORTIUM.

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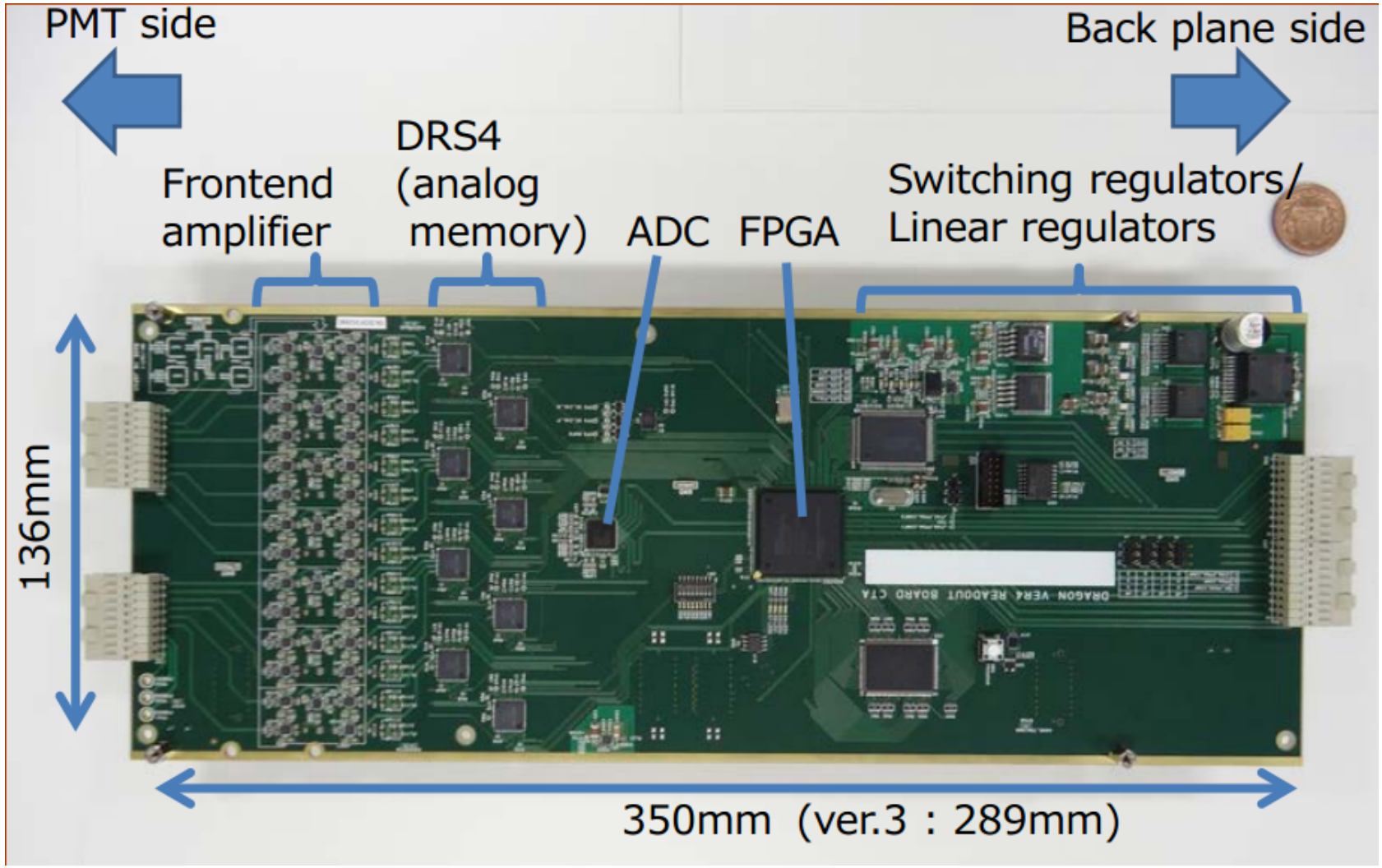
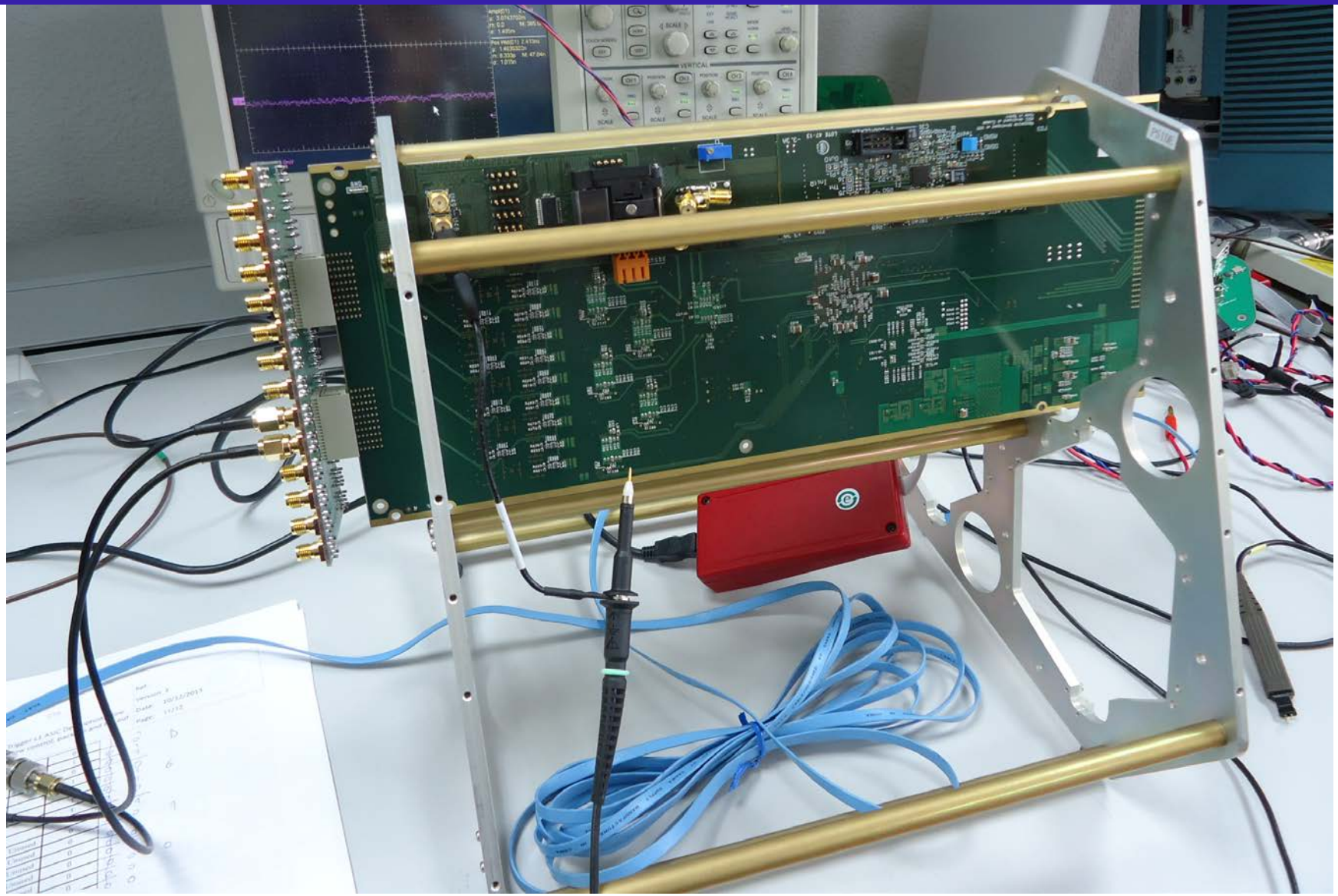
Dragon Readout Board v4

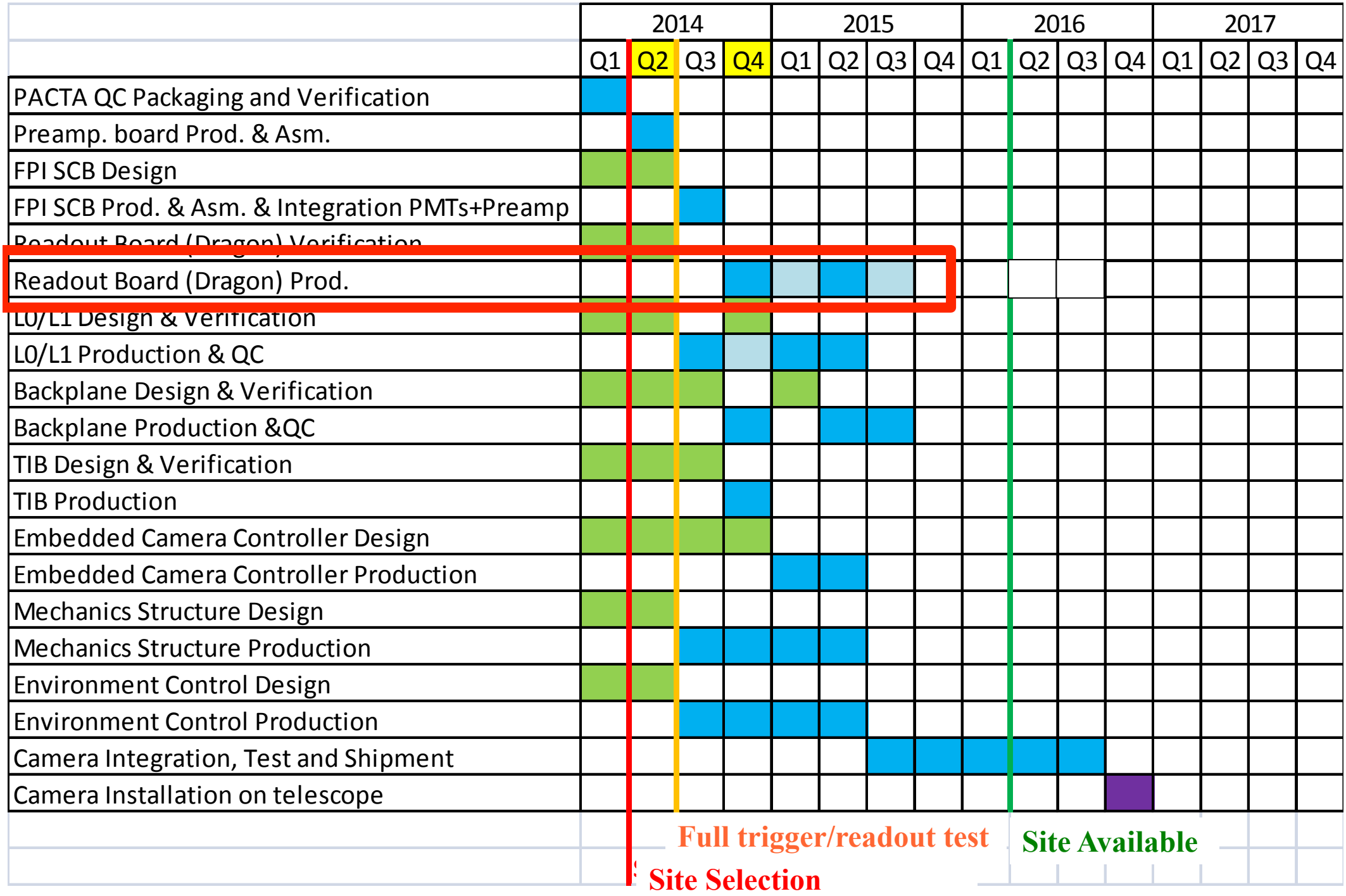


Readout Board & Back Plane



Dragon board V4 (version for 1st telescope, Kyoto+Pisa) has been tested together with trigger and backplane
Characterization being done in Japan

LST prottype camera planning



Budget Planning

Activities in 2014 – batch #1 of 75 boards		
Material procurement	70k€	
PCB production	15k€	
Mount and qualification	25k€	
Quality control	15k€	
		125k€

Activities in 2015 – batch #2 of 75 boards		
Material procurement	70k€	
PCB production	15k€	
Mount and qualication	25k€	
Quality control	15k€	
		125k€