Gerd Pühlhofer, for the CTA consortium

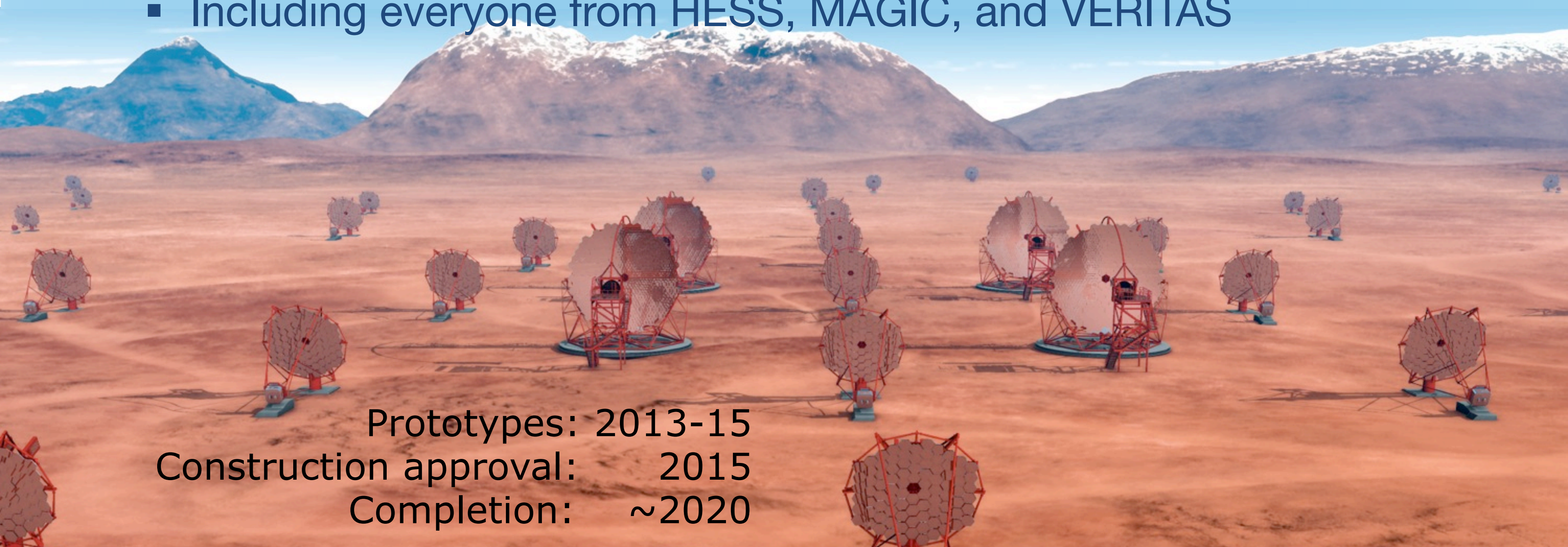
STATUS OF THE CTA PROJECT

EBERHARD KARLS
UNIVERSITÄT
TÜBINGEN

GEFÖRDERT VOM
Bundesministerium
für Bildung
und Forschung

CTA:
THE NEXT GENERATION IACT ARRAY

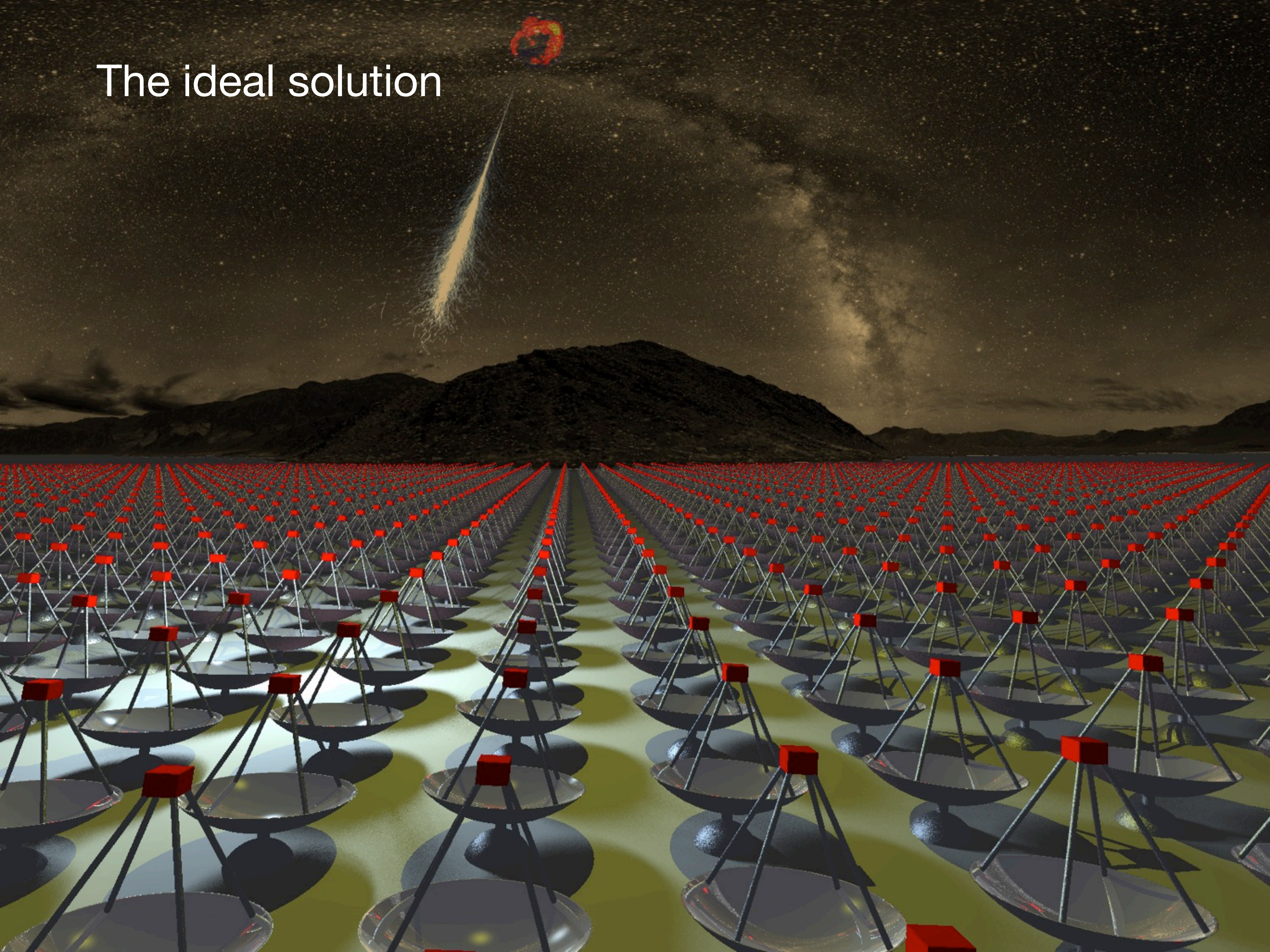
- A huge improvement in all aspects of performance
  - A factor ~10 in sensitivity, much wider energy coverage, better angular resolution, larger field-of-view, full sky, …
- A user facility / proposal-driven observatory
  - With two sites with a total of >100 telescopes
- A 28 nation ~€200M project
  - Including everyone from HESS, MAGIC, and VERITAS



Prototypes: 2013-15
Construction approval: 2015
Completion: ~2020

OUTLINE

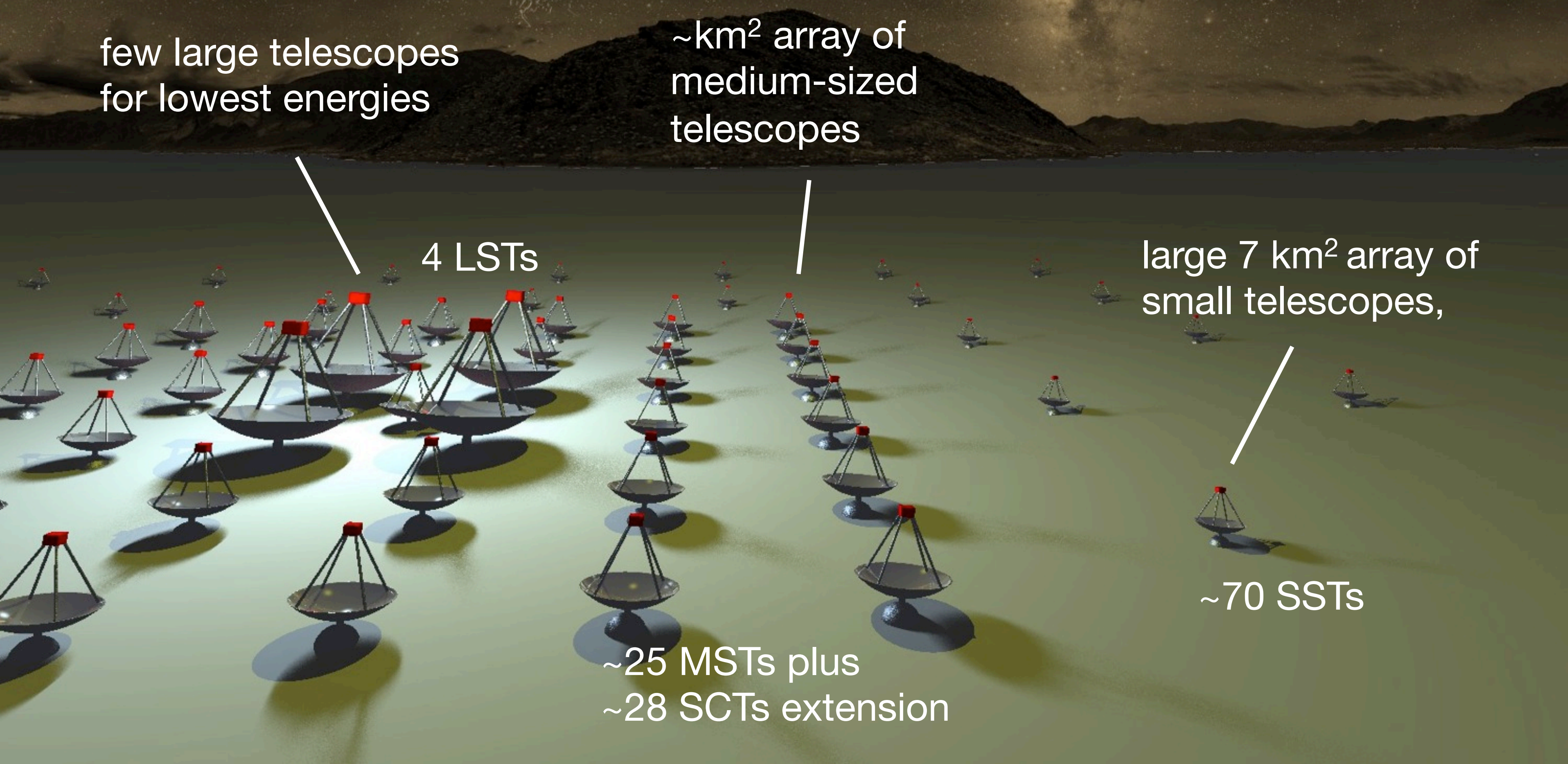
- CTA concept
- Science drivers
- CTA as observatory
- From science drivers to telescopes
- CTA Telescope prototypes
- Towards deployment: site decision



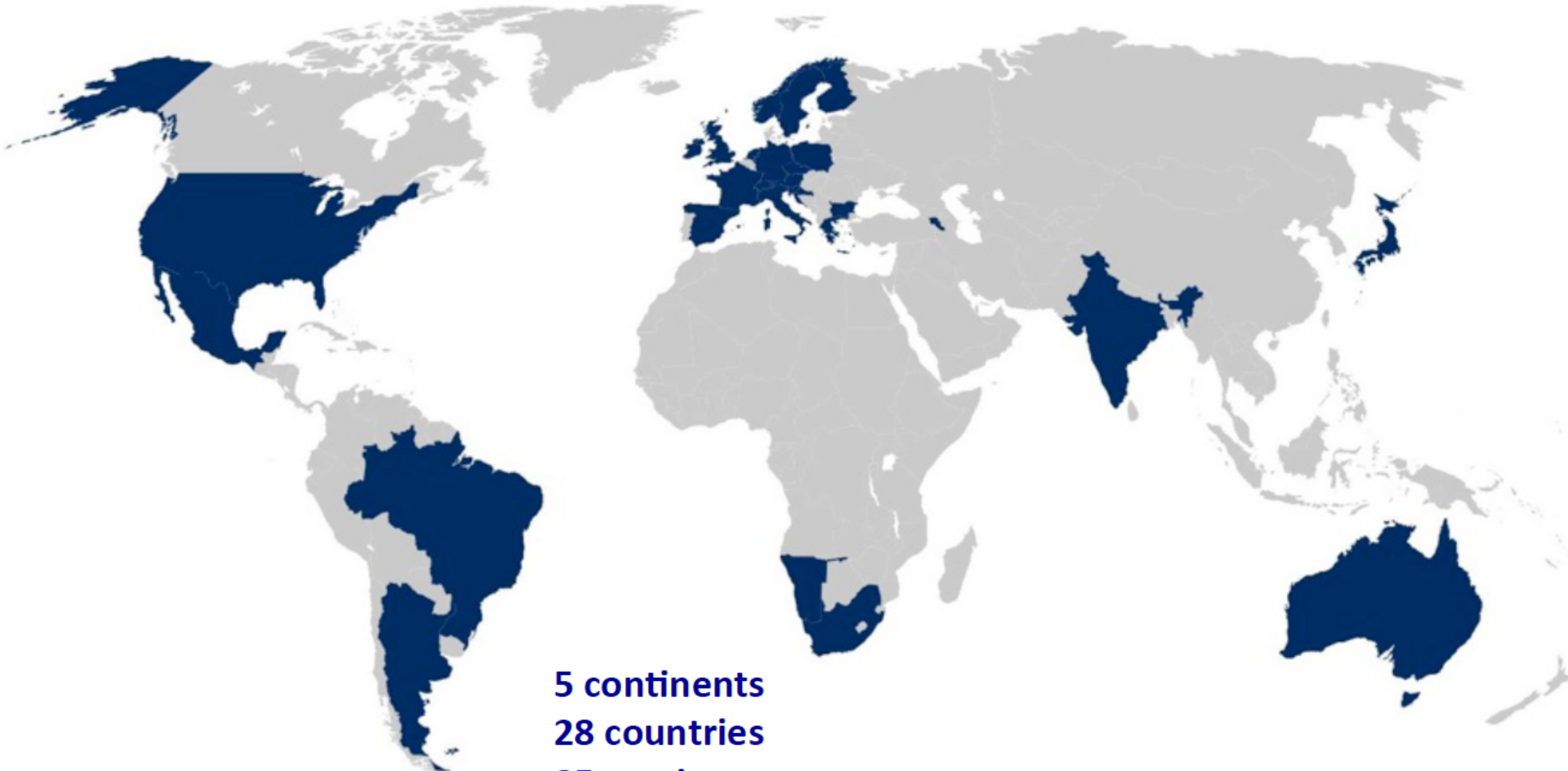
The ideal solution

Science-optimization under budget constraints:

- Low-energy γ high γ-ray rate, low light yield
  ➜ require small ground area, large mirror area
- High-energy γ low γ-rate, high light yield
  ➜ require large ground area, small mirror area



CTA CONSORTIUM



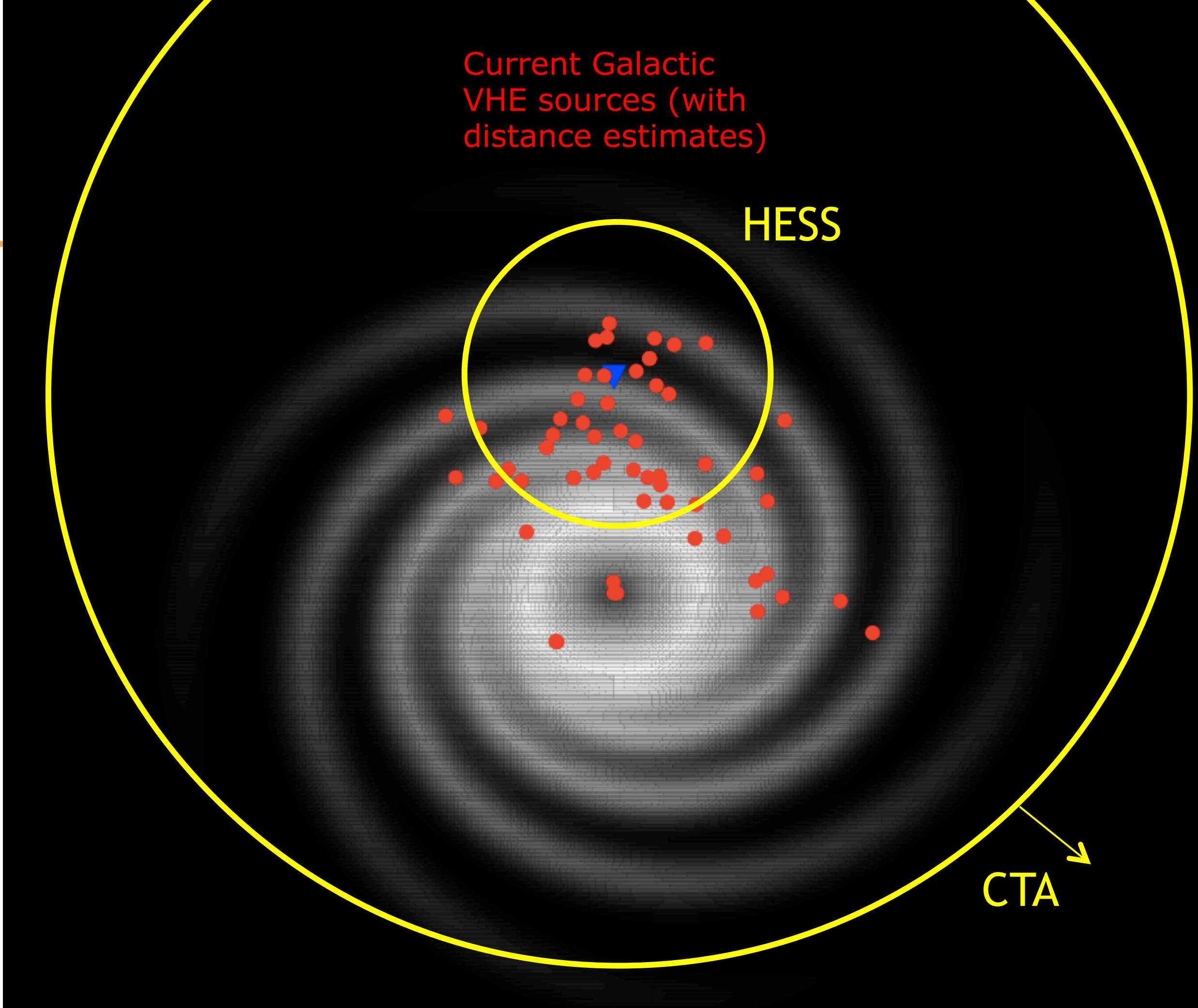
5 continents
28 countries
85 parties
176 institutes
1193 members

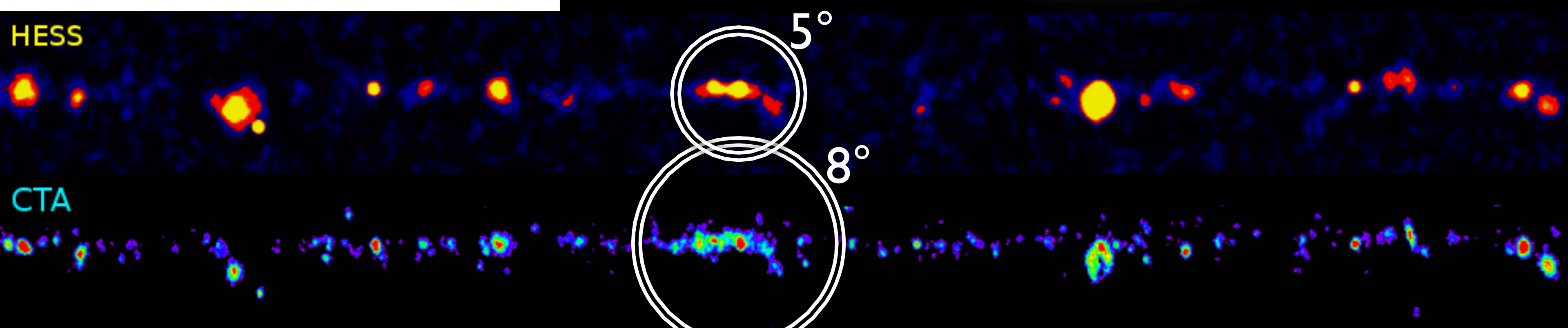
CTA REACH

Example Galactic survey

➡ Field of view + sensitivity

- Survey speed ~300 × HESS
- Survey effective exposure ~5.5 × single exposure time






cta
cherenkov telescope array

Theme 1: Cosmic Particle Acceleration

- How and where are particles accelerated?
- How do they propagate?
- What is their impact on the environment?

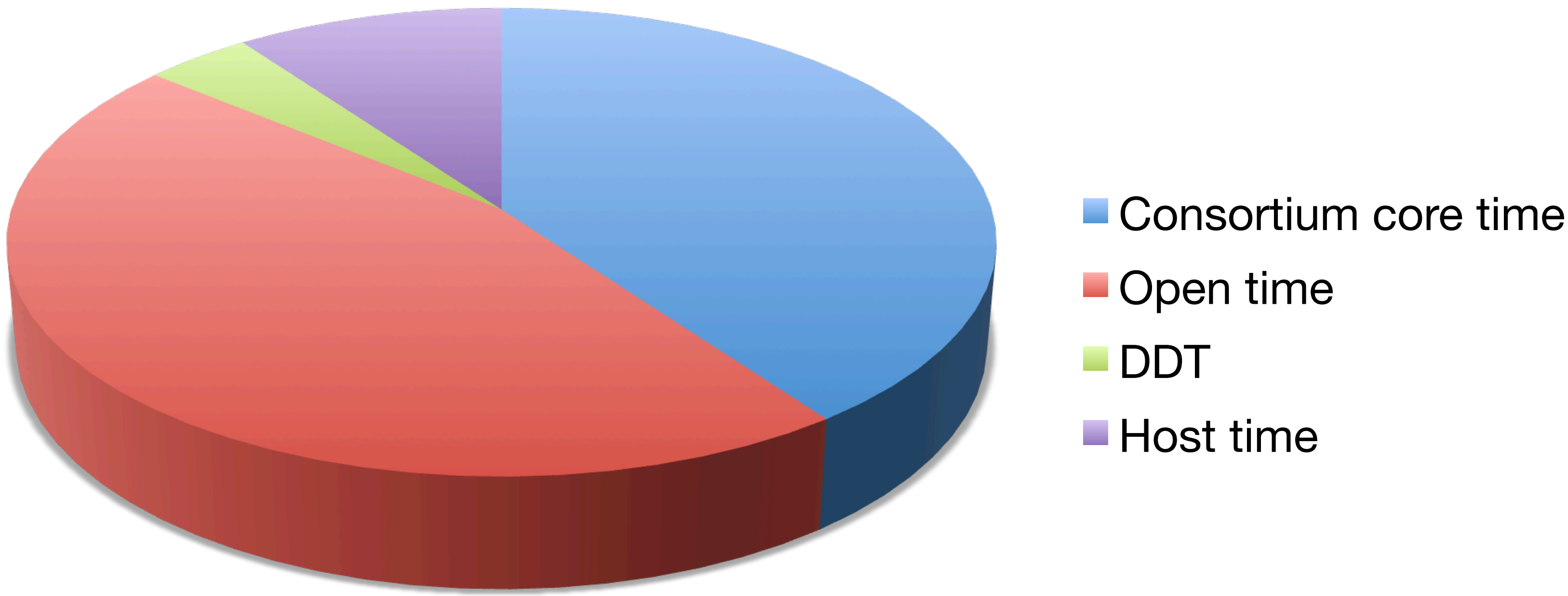
Theme 2: Probing Extreme Environments

- Processes close to neutron stars and black holes?
- Processes in relativistic jets, winds and explosions?
- Exploring cosmic voids

Theme 3: Physics Frontiers – beyond the SM

- What is the nature of Dark Matter? How is it distributed?
- Is the speed of light a constant for high energy photons?
- Do axion-like particles exist?

SHARING OF OBSERVATION TIME



Example; sharing will be time dependent

- Open time: open to participating countries (?)
- Archival data: fully open, 1yr proprietary time (?)

CORE PROGRAMME

Core Programme using Consortium guaranteed time

- Provides legacy data sets (large sky surveys, surveys of object classes)
- Pre-defined deliverables (catalogs, sky maps, …)

- Core Programme fraction time dependent; large in first years, modest later
- Science community is served through both, Core Programme and Open time
- External review in the context of the Critical Design Review in 2015

FORMAL STEPS TOWARDS APPROVAL

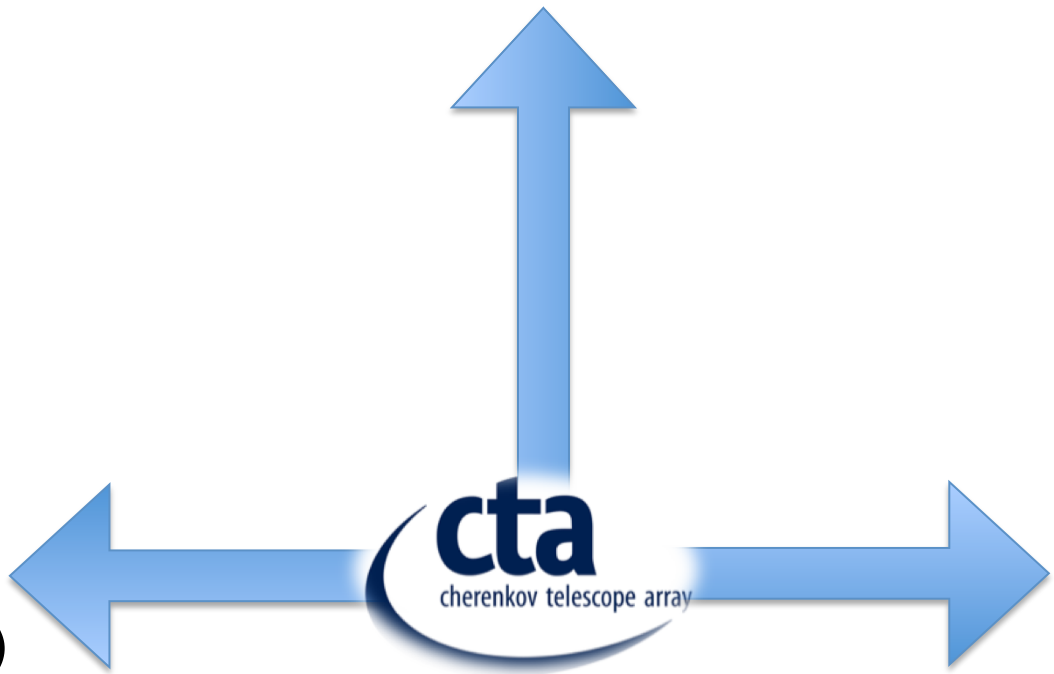
Feb. 2013 ✔

Nov. 2013 ✔

1. Science Performance and Preliminary Requirement Review
2. Preliminary Technical Design Report / Preliminary Design Review
3. Technical Design Report / Critical Design Review

REQUIREMENTS & DRIVERS

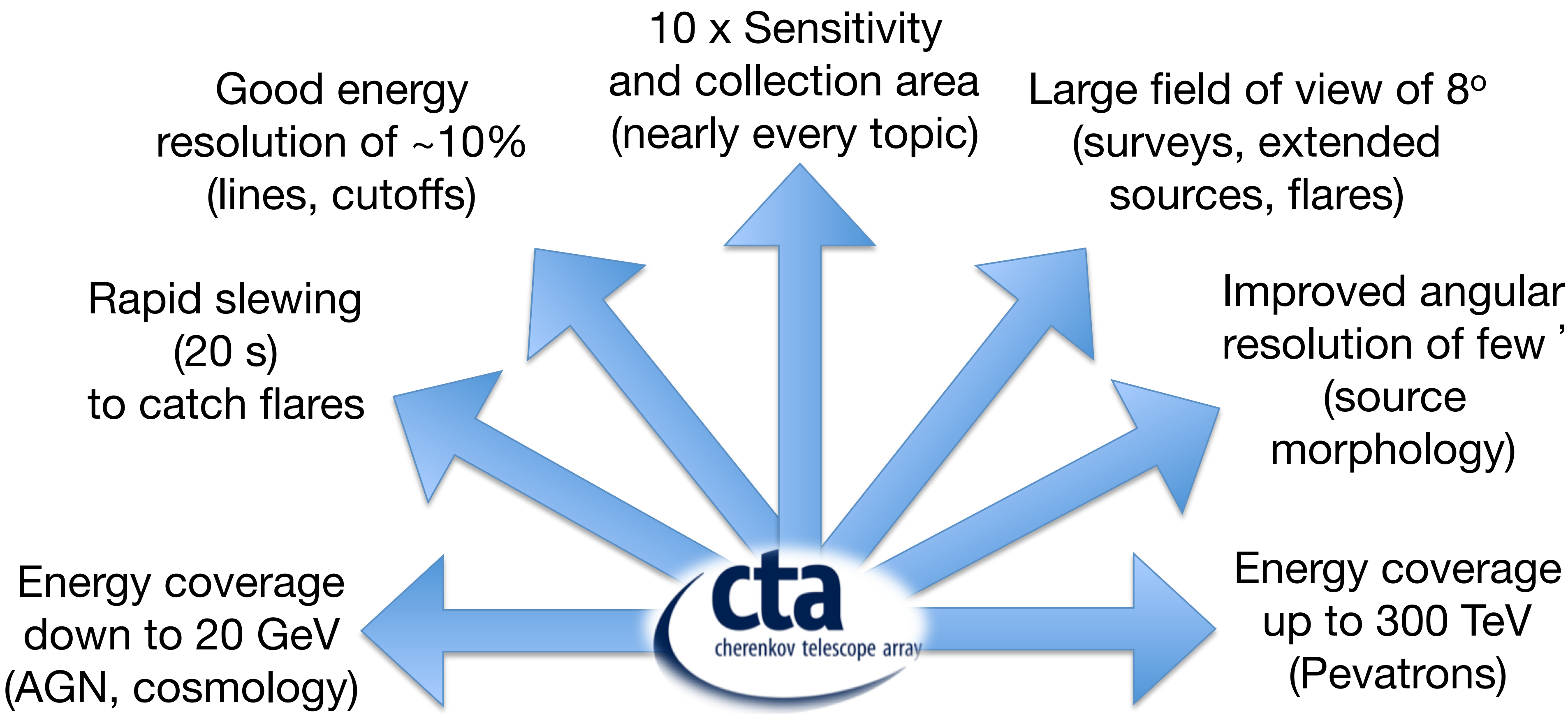
10 x Sensitivity
and collection area
(nearly every topic)



Energy coverage
down to 20 GeV
(AGN, cosmology)

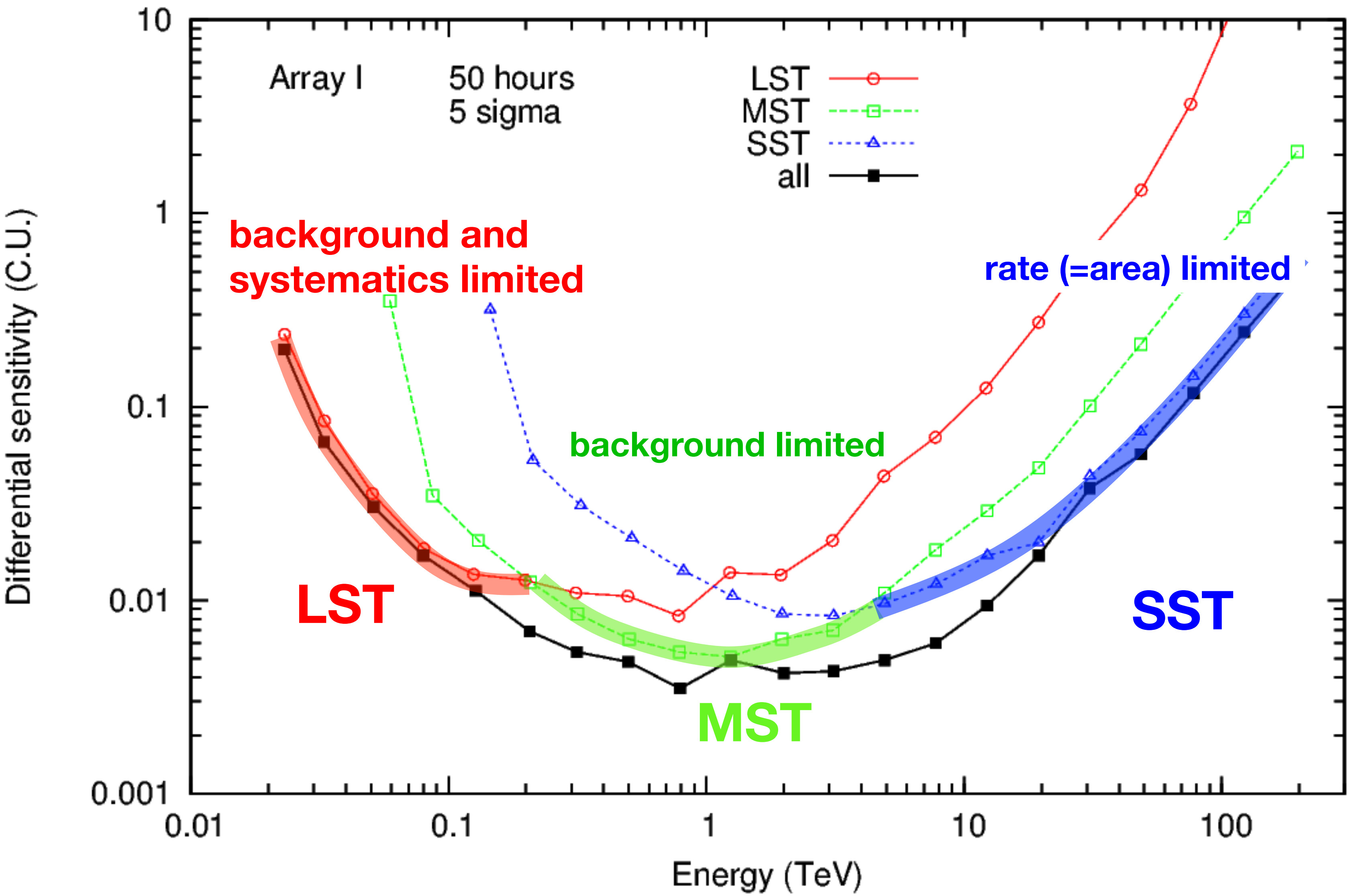
Energy coverage
up to 300 TeV
(Pevatrons)

REQUIREMENTS & DRIVERS



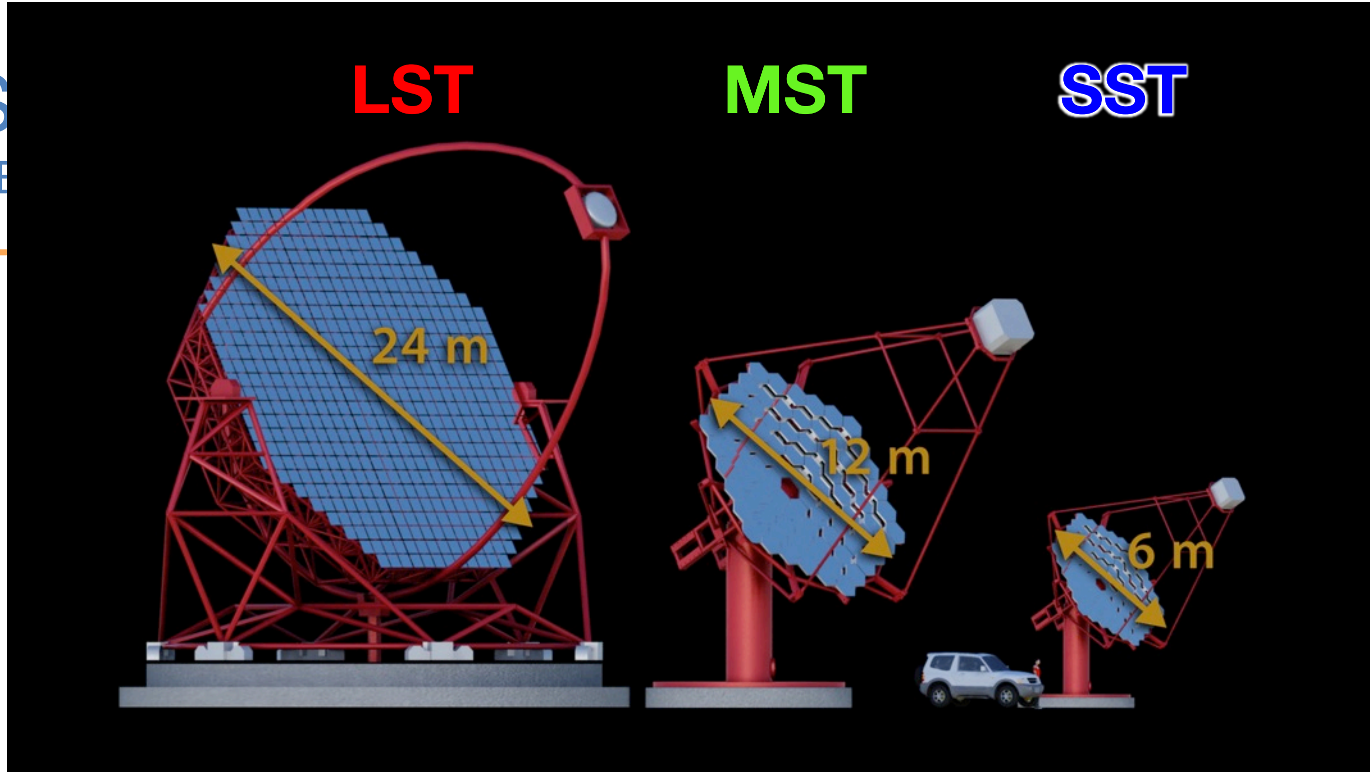
SENSITIVITY (IN UNITS OF CRAB FLUX)

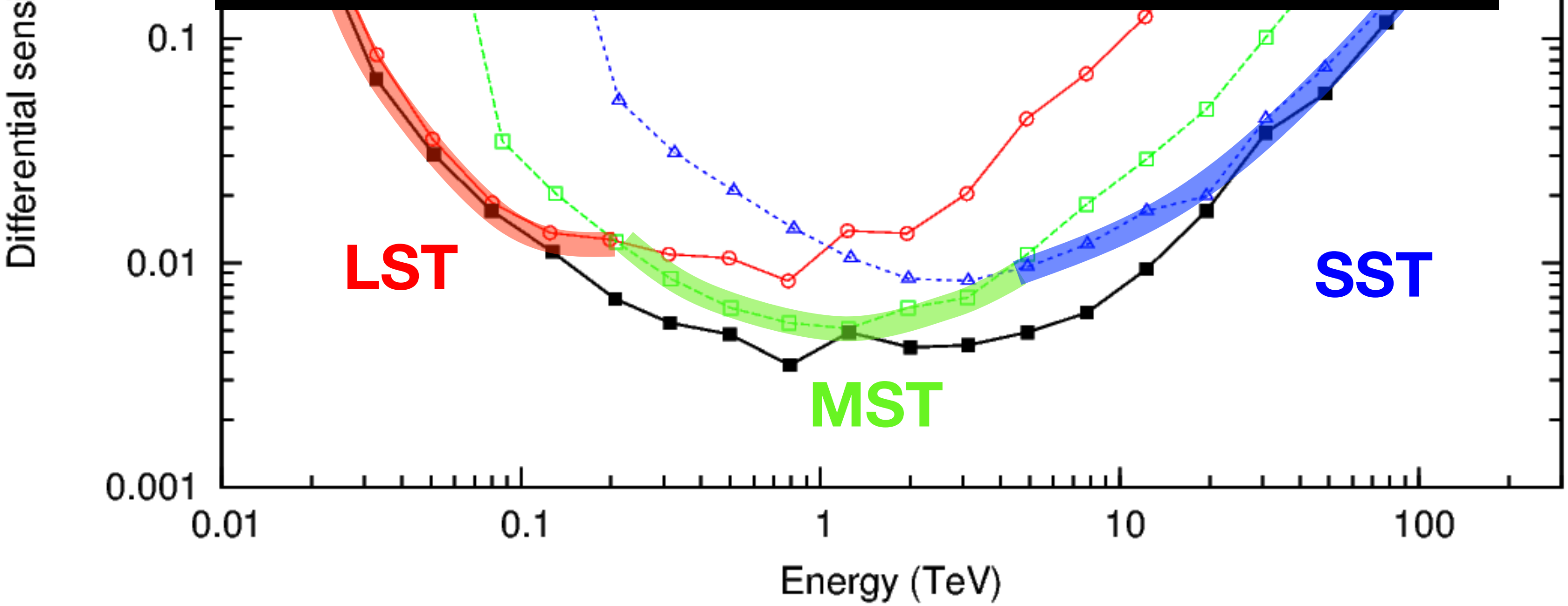
FOR DETECTION IN EACH 0.2-DECADE ENERGY BAND



SENS

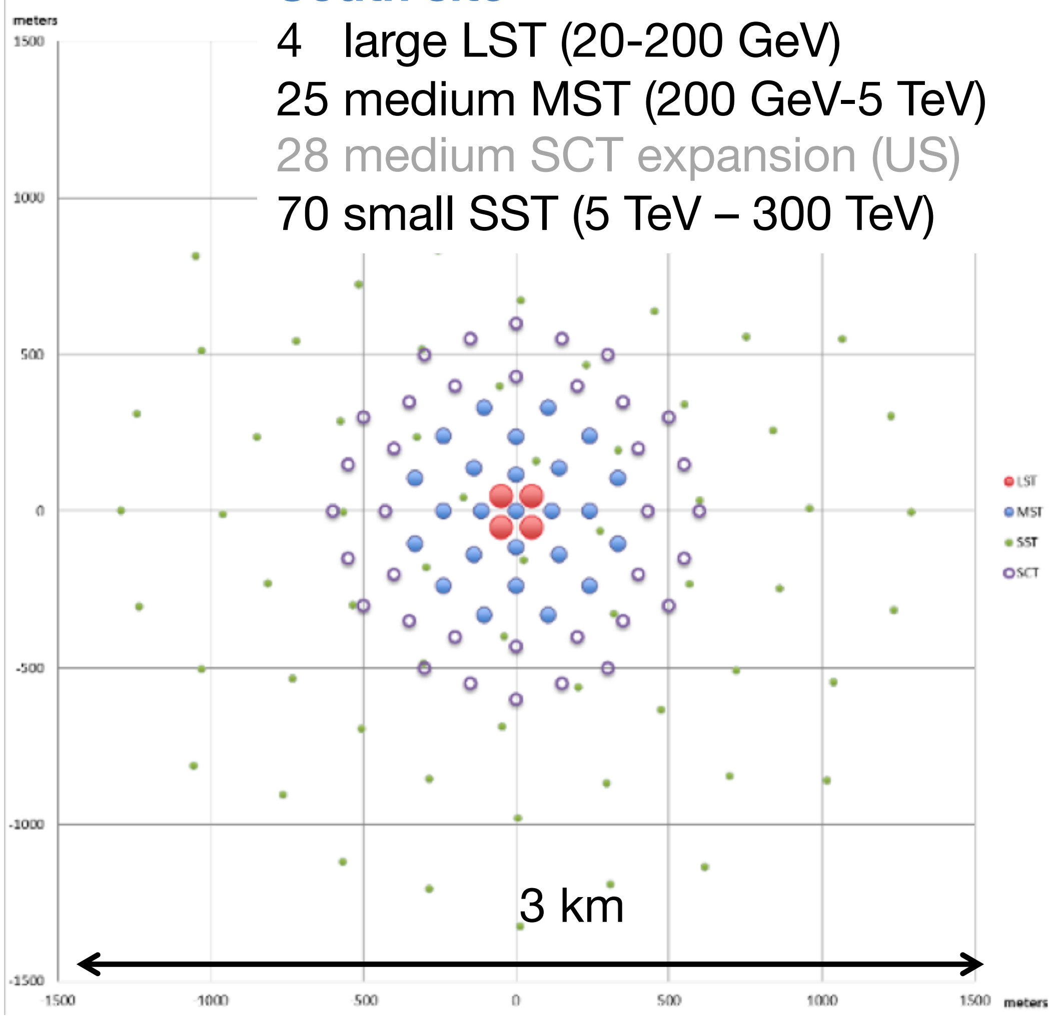
FOR DETE



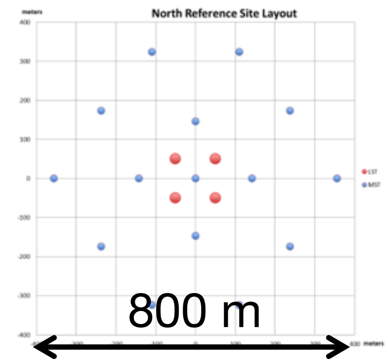


SOUTHERN AND NORTHERN SITES

South site
4 large LST (20-200 GeV)
25 medium MST (200 GeV-5 TeV)
28 medium SCT expansion (US)
70 small SST (5 TeV – 300 TeV)

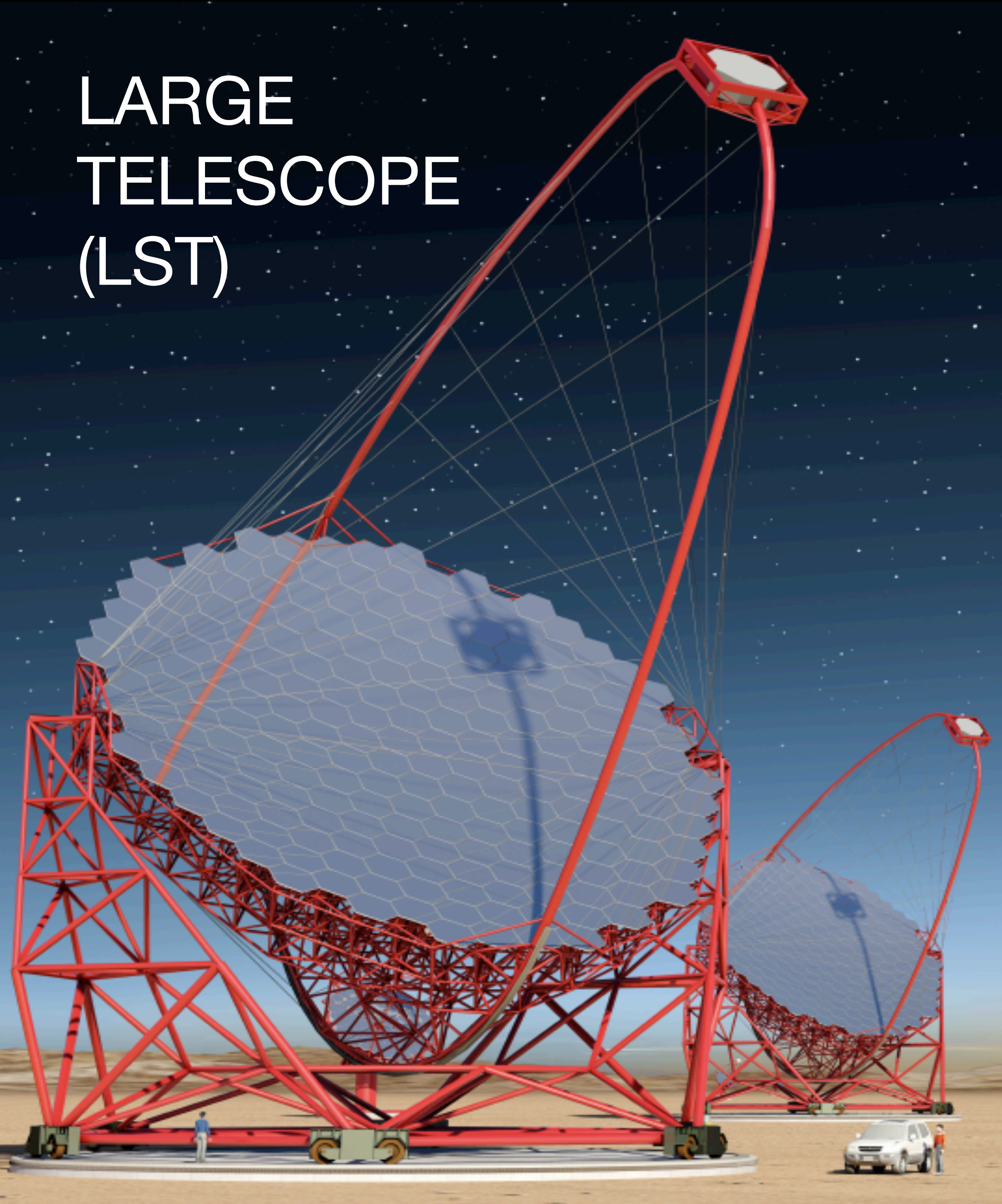


North site
4 large LST
15 medium MST



~2/3 of all current sources in Southern sky

LARGE TELESCOPE (LST)



cta
cherenkov telescope array

23 m diameter
389 m² dish area
28 m focal length
1.5 m mirror facets

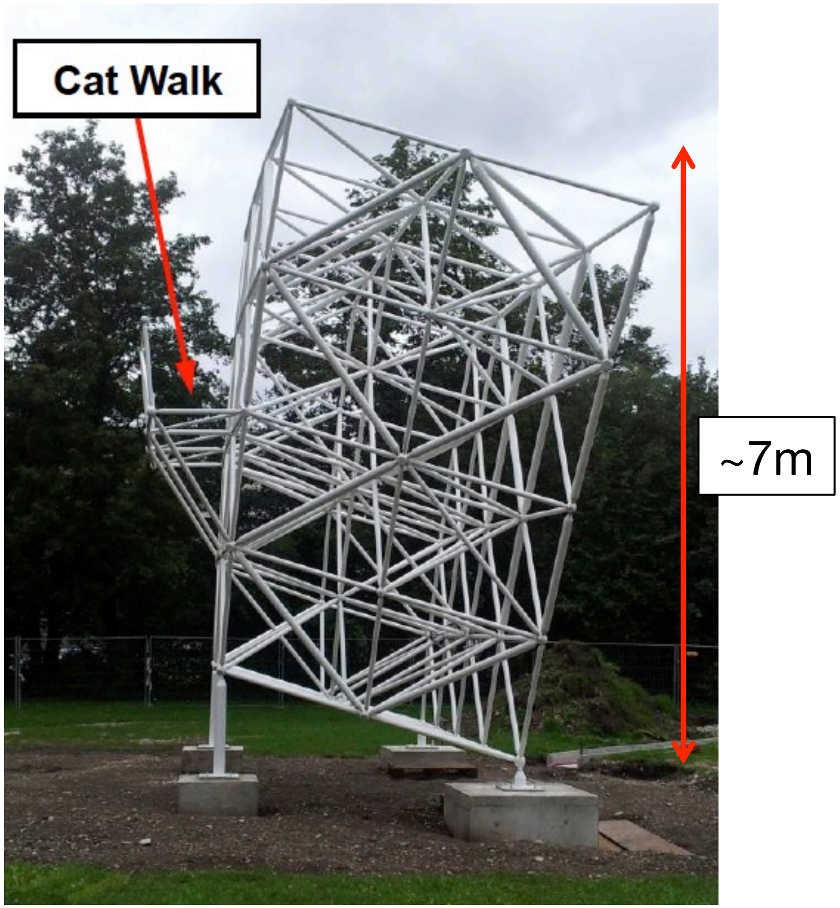
4.5° field of view
0.1° pixels
Camera ∅ over 2 m

Carbon-fibre structure
for 20 s positioning

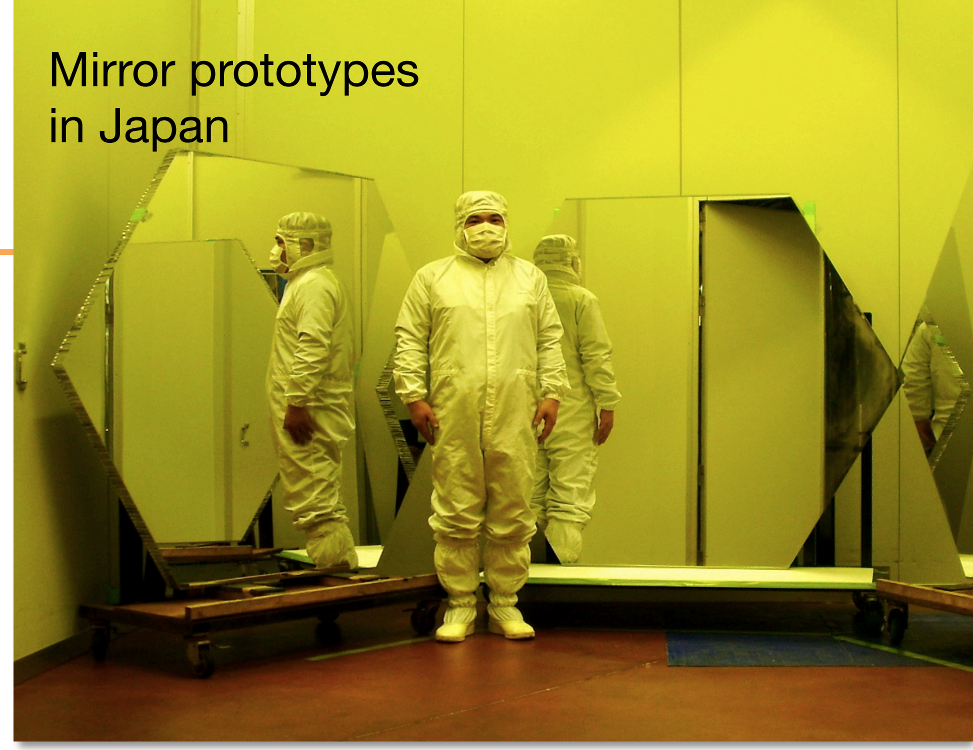
Active mirror control

4 LSTs on South site
4 LSTs on North site

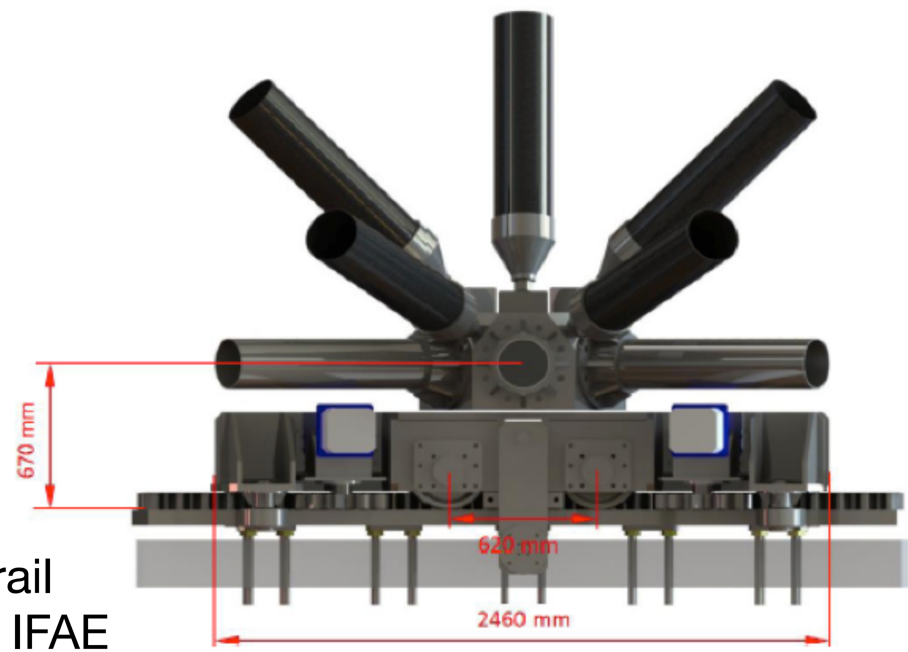
LARGE TELESCOPE PROTOTYPING



Dish segment at Munich



Mirror prototypes in Japan



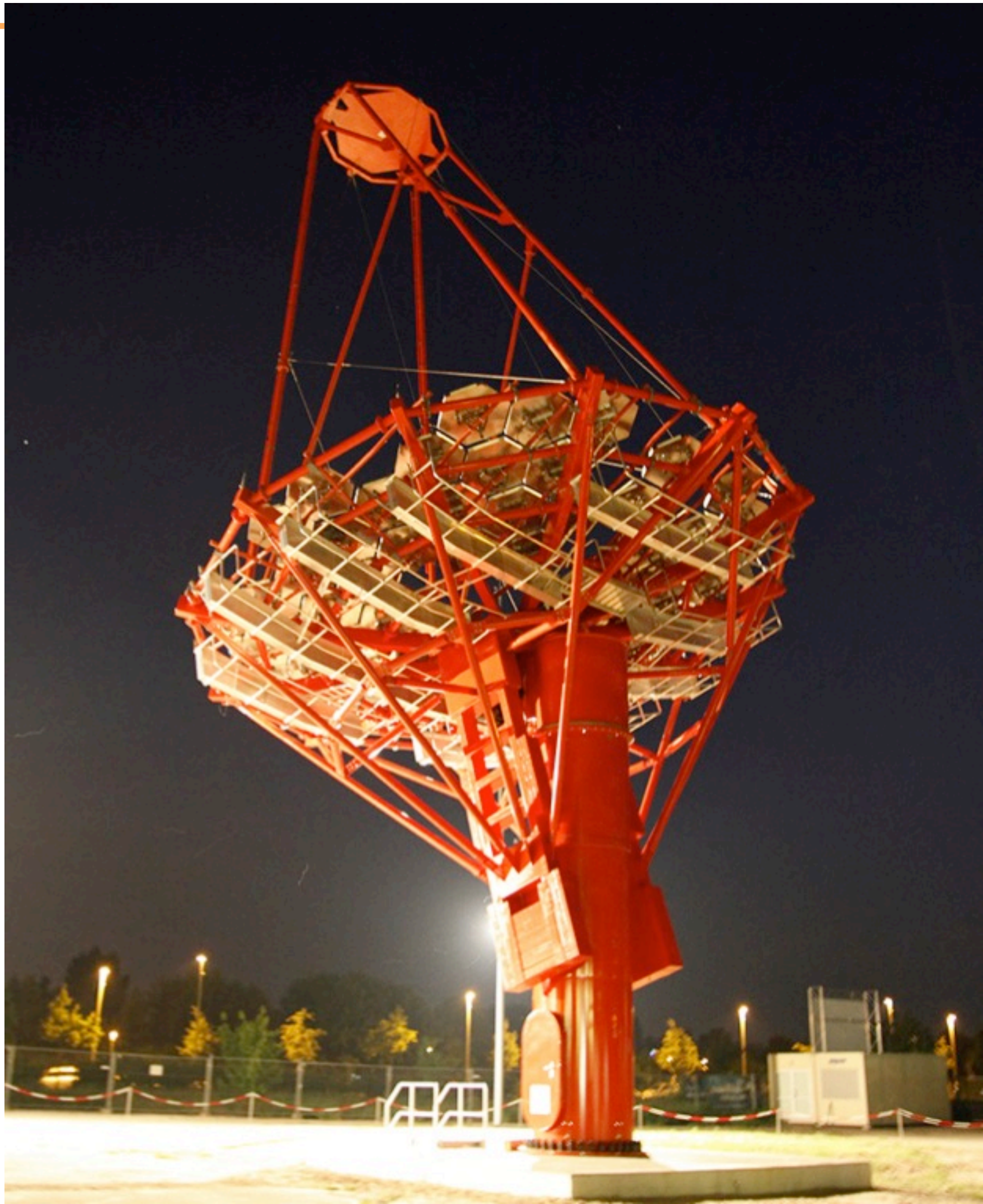
Bogie and rail segment at IFAE

MEDIUM-SIZED 12 M TELESCOPE
OPTIMIZED FOR THE 100 GEV TO ~10 TEV RANGE

100 m^2 dish area
16 m focal length
1.2 m mirror facets

8^o field of view
~2000 x 0.18^o pixels

25 MSTs on South site
15 MSTs on North site



Berlin
MST prototype
operational

MST PROTOTYPE

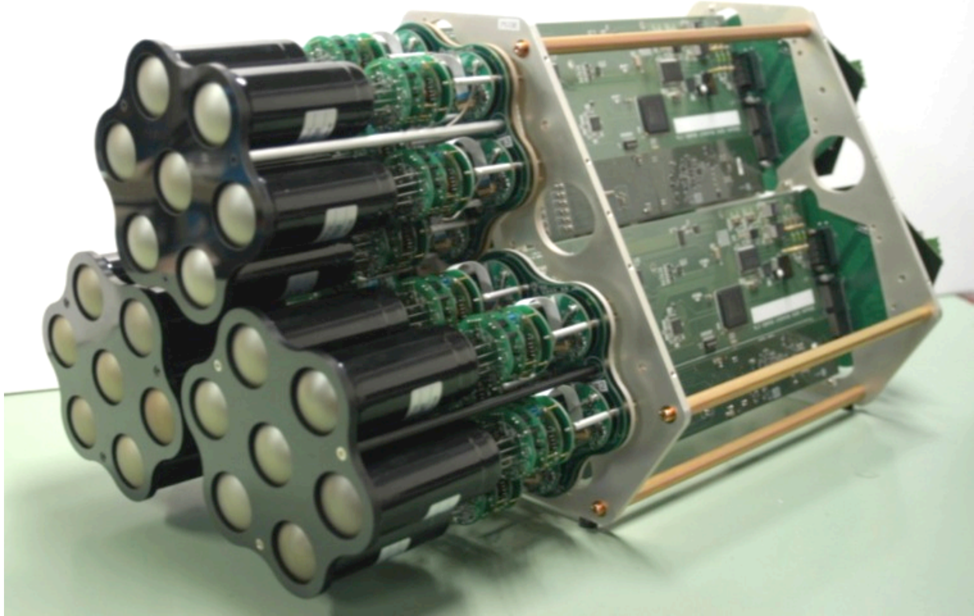
PHOTOMULTIPLIER CAMERAS

cherenkov telescope array

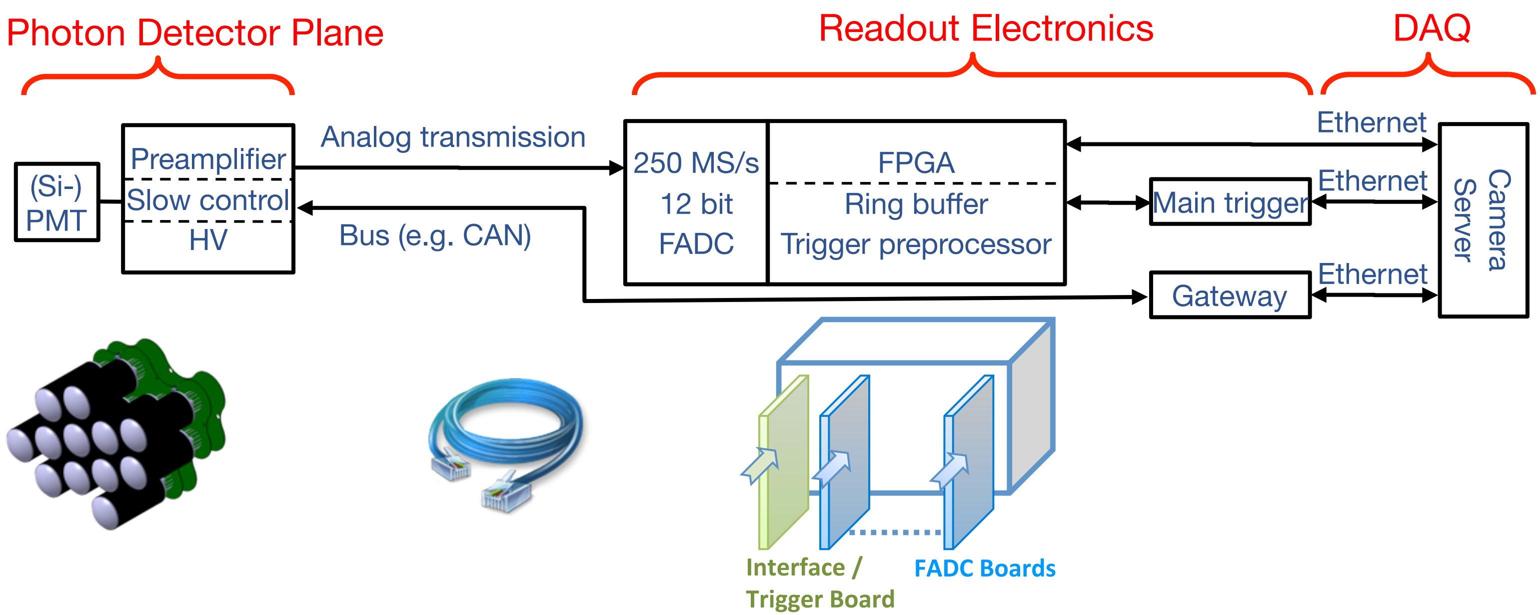
Recording signal waveform for “interesting” (triggered) images

Options:

- Capacitor pipeline + analog trigger + (identical) “drawers”
  - NectarCam (Pixel cluster prototypes operational)
  - DragonCam (Pixel cluster prototypes operational)
- Flash-ADC + digital trigger + rack-based electronics
  - Flashcam (144 pixel prototype operational)



FLASHCAM: A NOVEL CAMERA ARCHITECTURE FOR IACTS



Horizontal architecture:

- **Self-contained PDP**
- **Adaptable for any photosensors**

Fully digital approach:

- **Continuous signal digitization**
- **Digital trigger**

Ethernet-based readout:

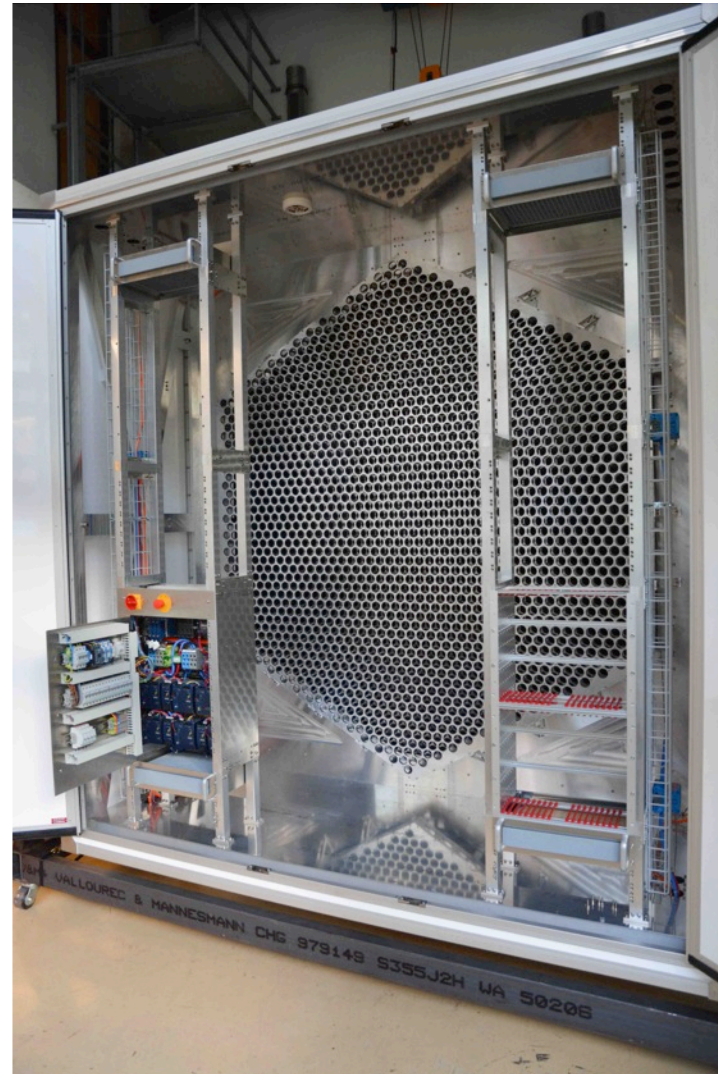
- **Front-end readout**
- **Off the shelf components**

- **Flexible and scalable system based on commercially available chips**

FLASHCAM MST CAMERA PROTOTYPE

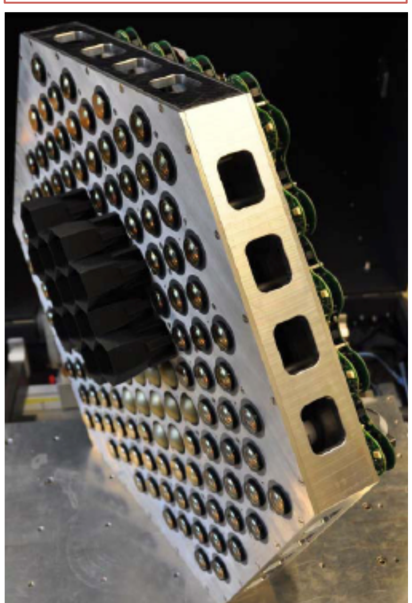
12 pixel PMT PDP module

Prototype Camera front view



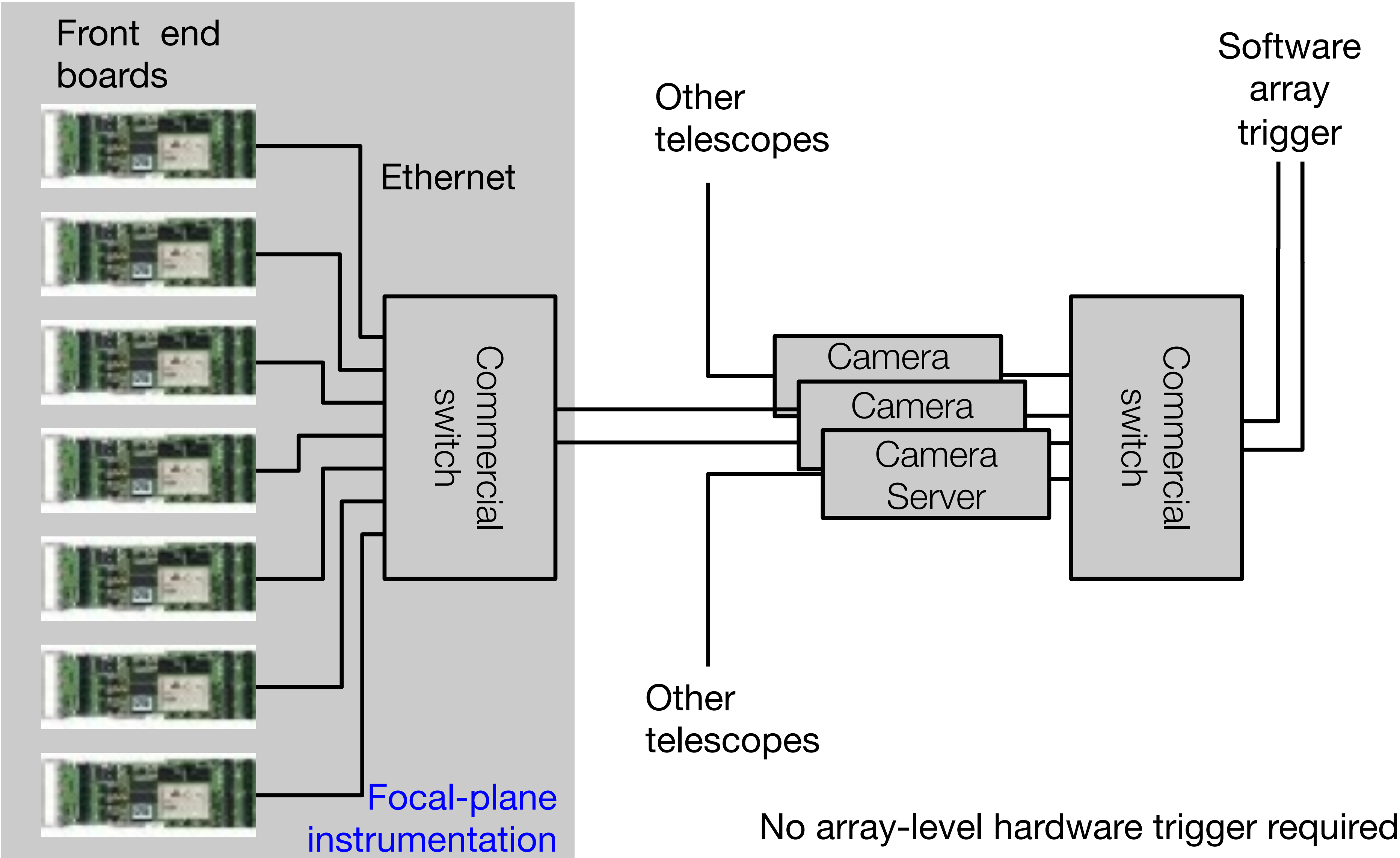
MST camera prototype body (rear view)

144 pixel PDP test setup



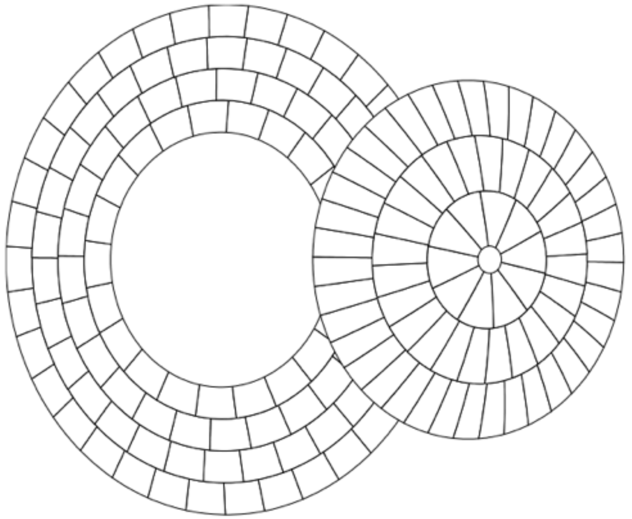
Electronics crate serving up to 192 pixel

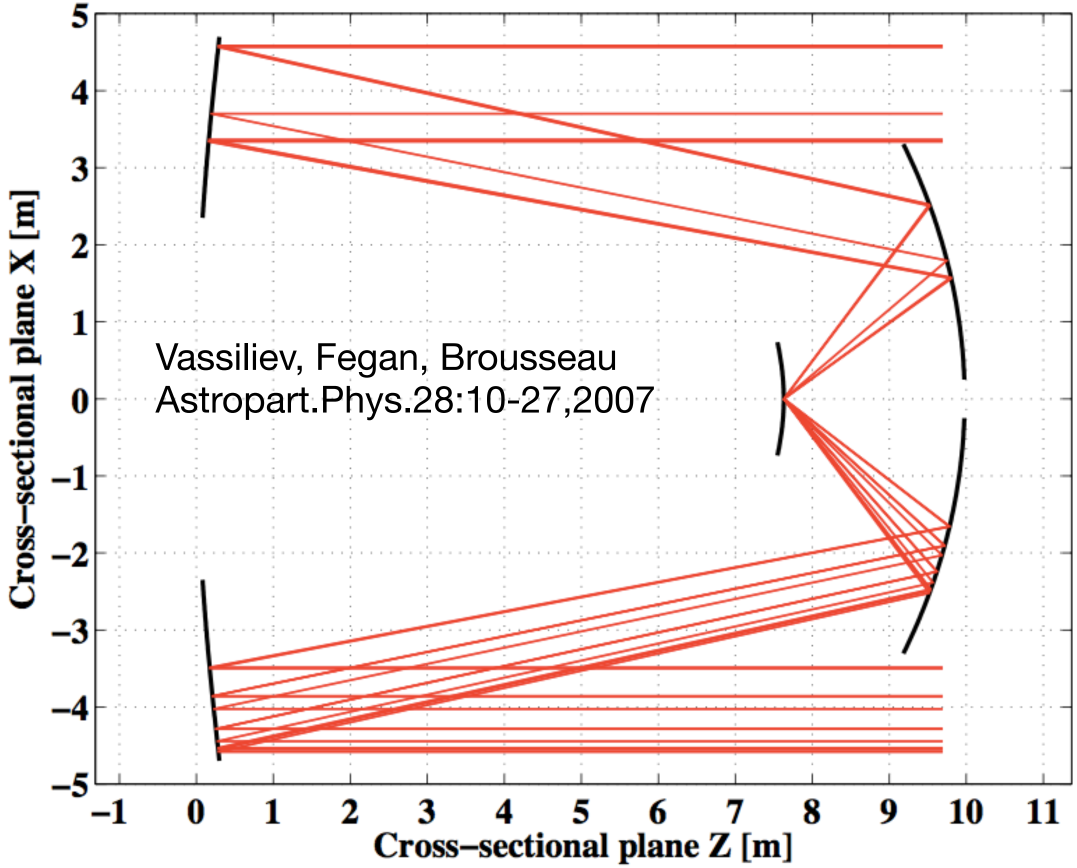
DATA ACQUISITION @ TRIGGER



No array-level hardware trigger required

DUAL-MIRROR TELESCOPES





Vassiliev, Fegan, Brousseau
Astropart.Phys.28:10-27,2007

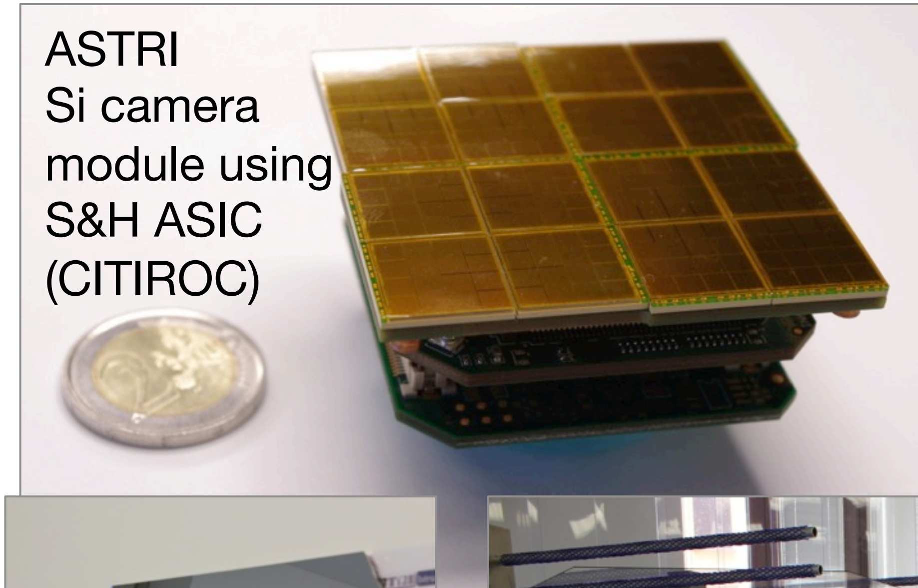
- Reduced plate scale
- Reduced psf
- Uniform psf across f.o.v.

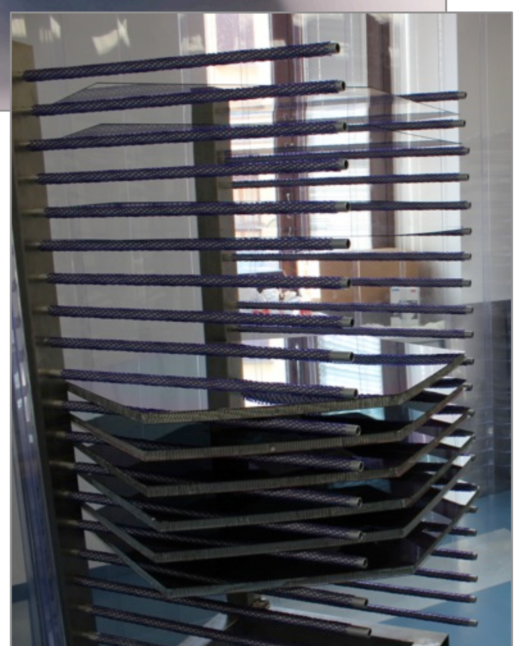
➜ Cost-effective small telescopes with compact sensors (SST-2M)

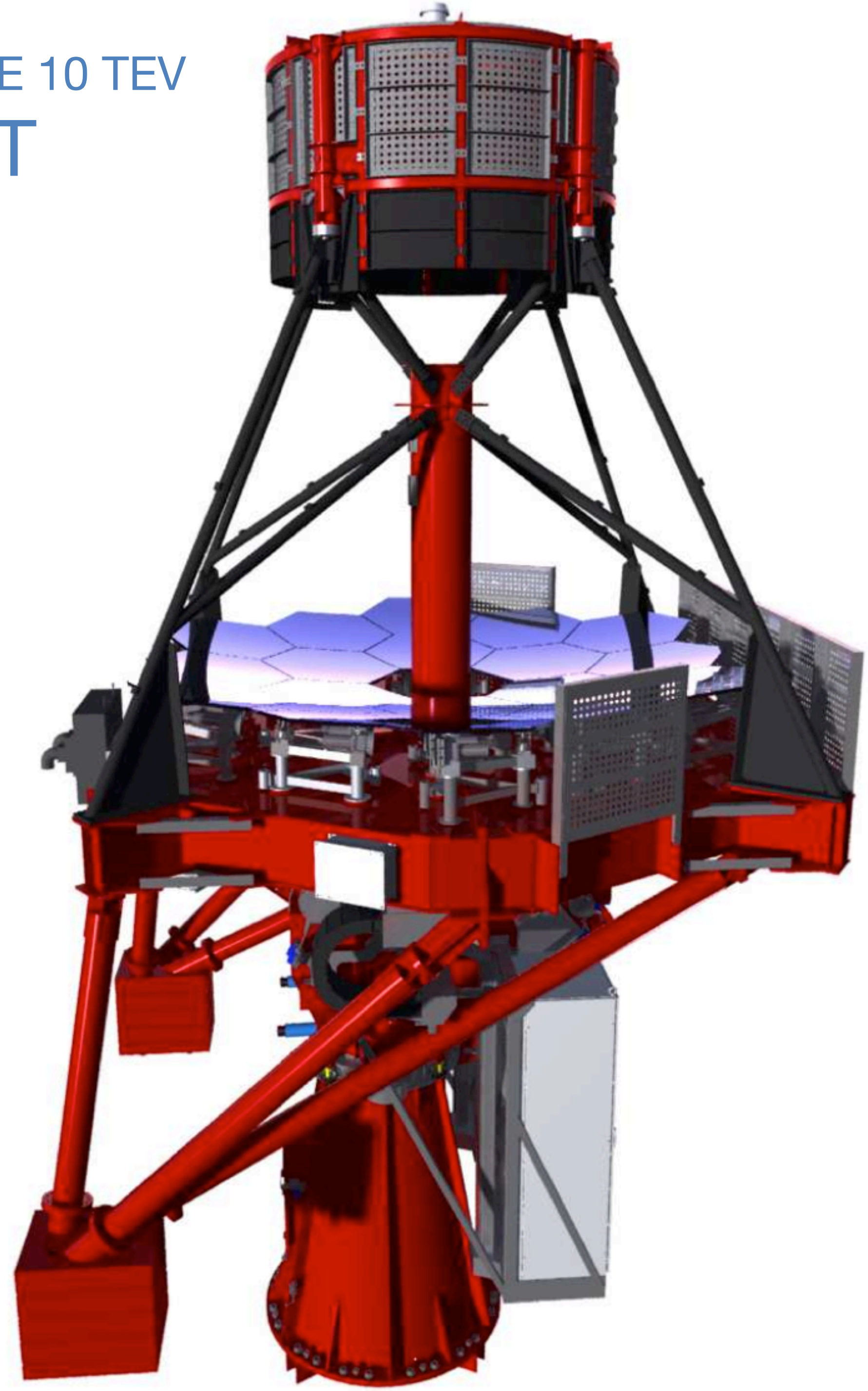
➜ Higher-performance telescopes with small pixels (SCT)

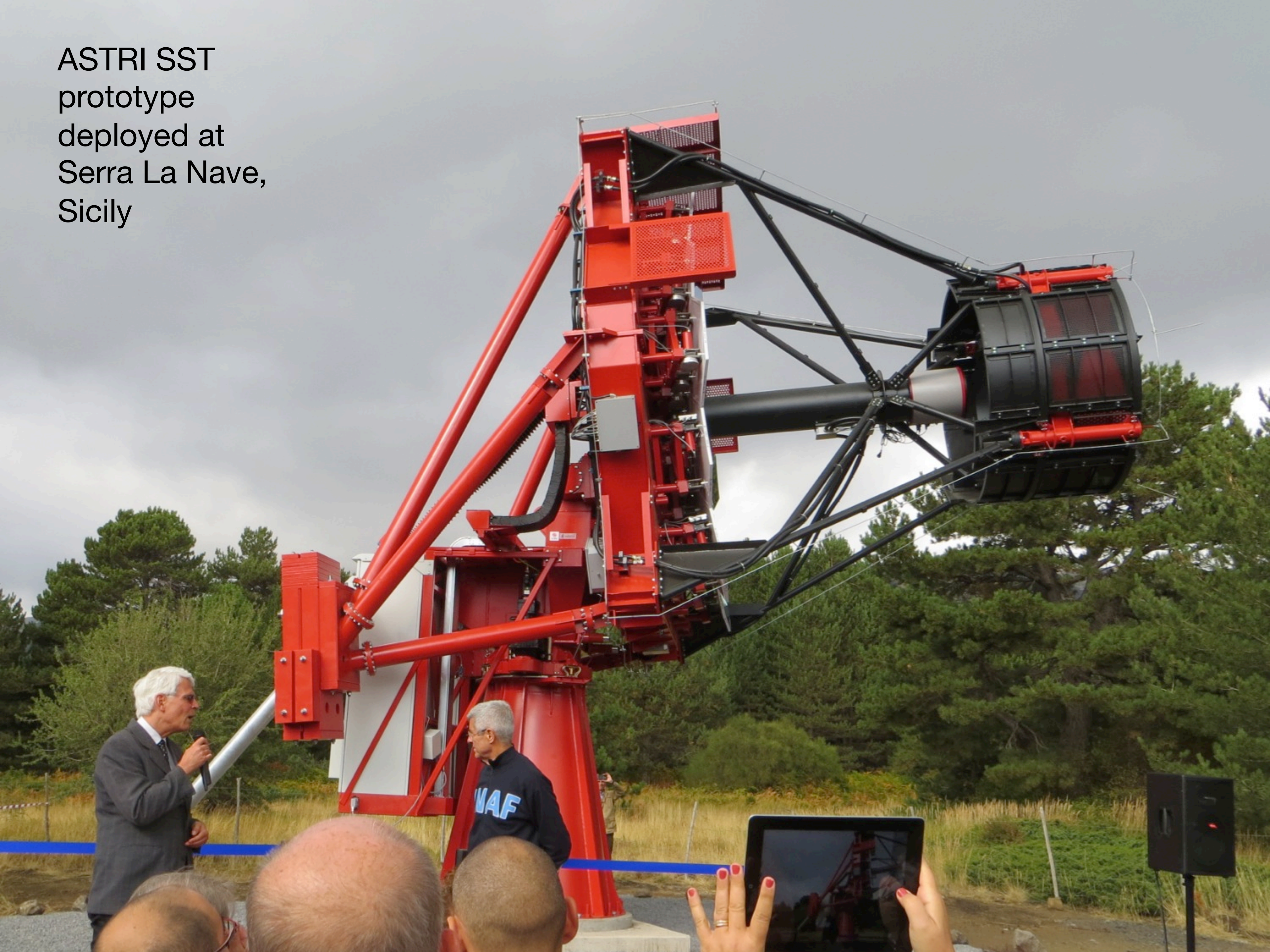
SST - OPTIMIZED FOR THE RANGE ABOVE 10 TEV

ASTRI DUAL MIRROR SST





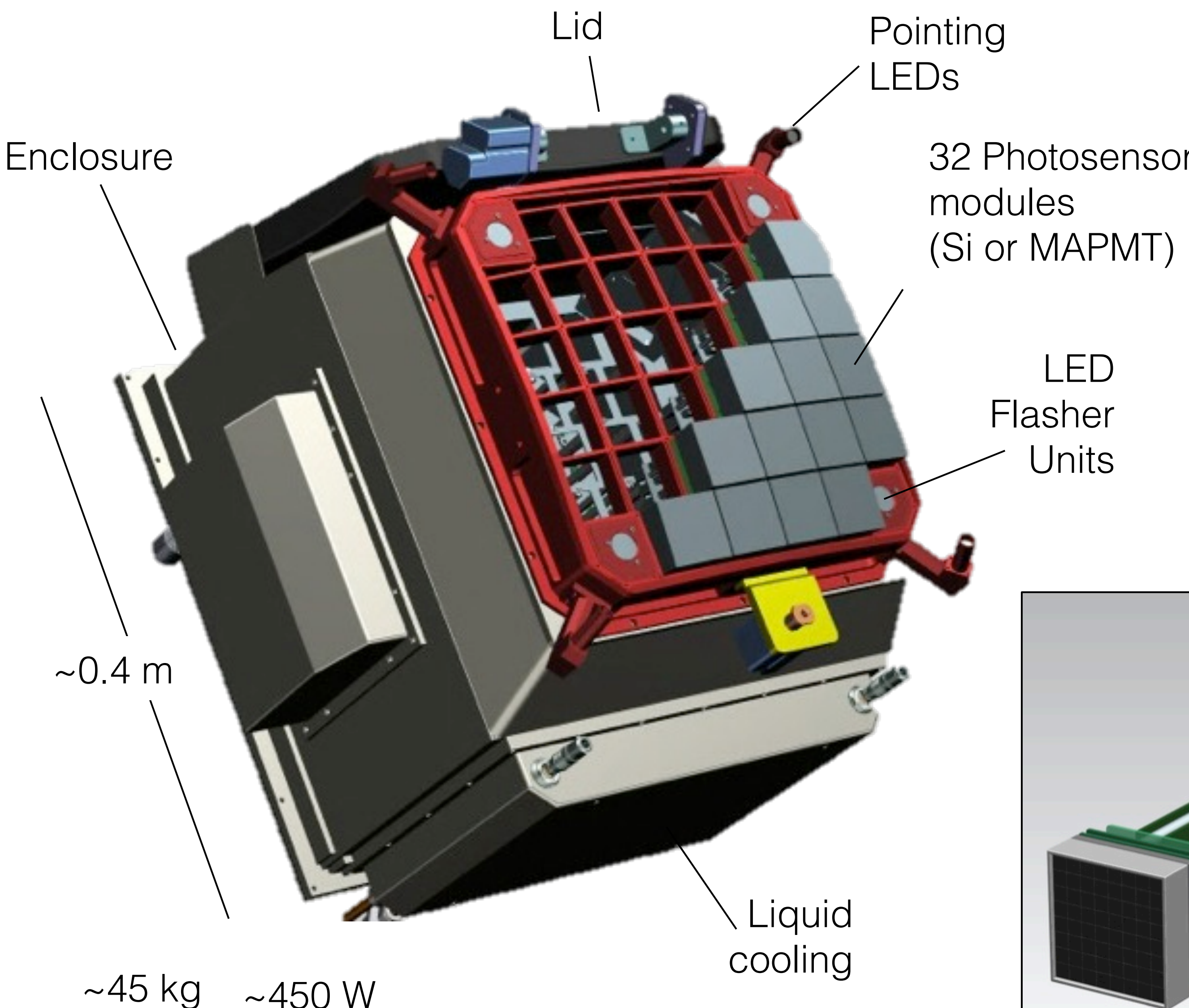


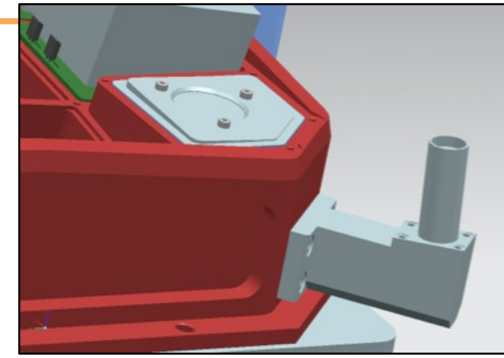


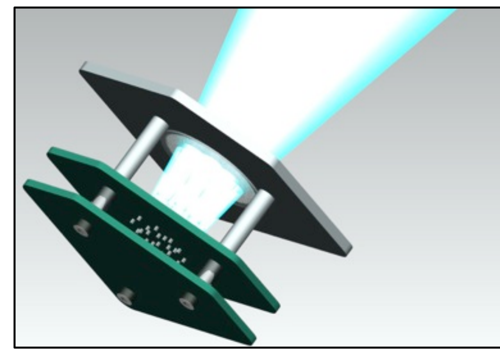
ASTRI SST prototype deployed at Serra La Nave, Sicily

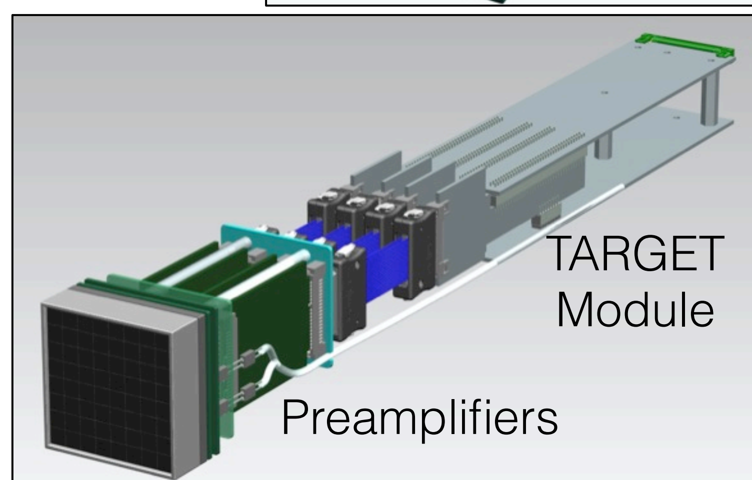
CHEC SST CAMERA

Prototypes ready:
CHEC-M: 10/2014
CHEC-S: Spring 2015









GATE DUAL MIRROR SST

Prototype under construction at Paris

SMALL TELESCOPES

Several options under prototyping

Dual-mirror telescopes

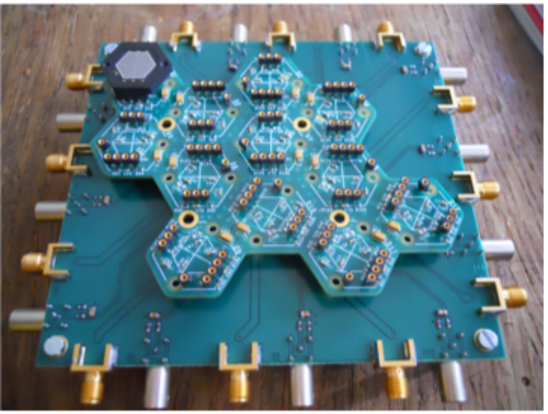
- ASTRI telescope structure (prototype under constr.)
- GATE telescope structure (prototype under constr.)

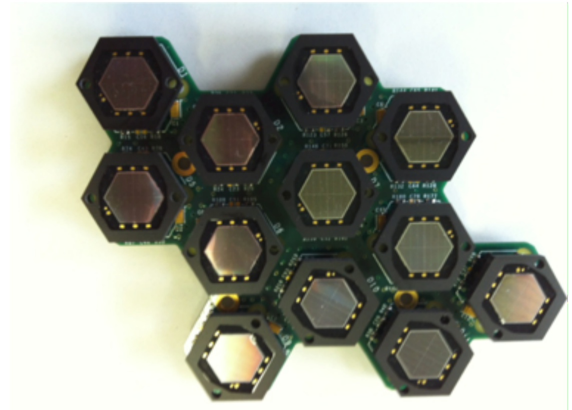
with camera options

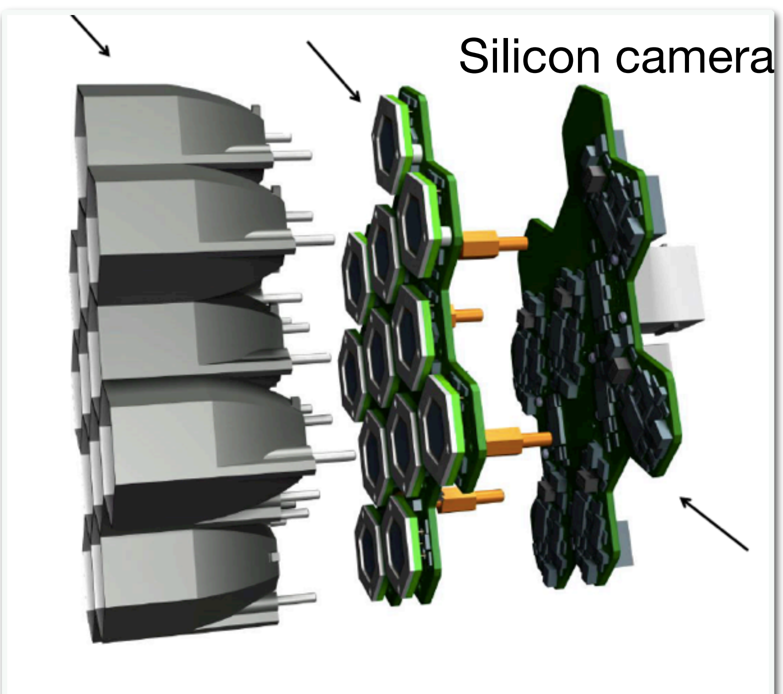
- ASTRI (Silicon, S&H ASIC) (prototype under constr.)
- CHEC (Silicon or MAPMT, Pipeline ASIC) (prototype under constr.)

Single-mirror telescope with Silicon camera (prototype under constr.)

SINGLE-MIRROR SST PROTOTYPE







IMPLEMENTATION

Prototypes

- MST @ Berlin
- SST-1M @ Cracow, SST-2M @ Sicily, Paris
- LST @ La Palma

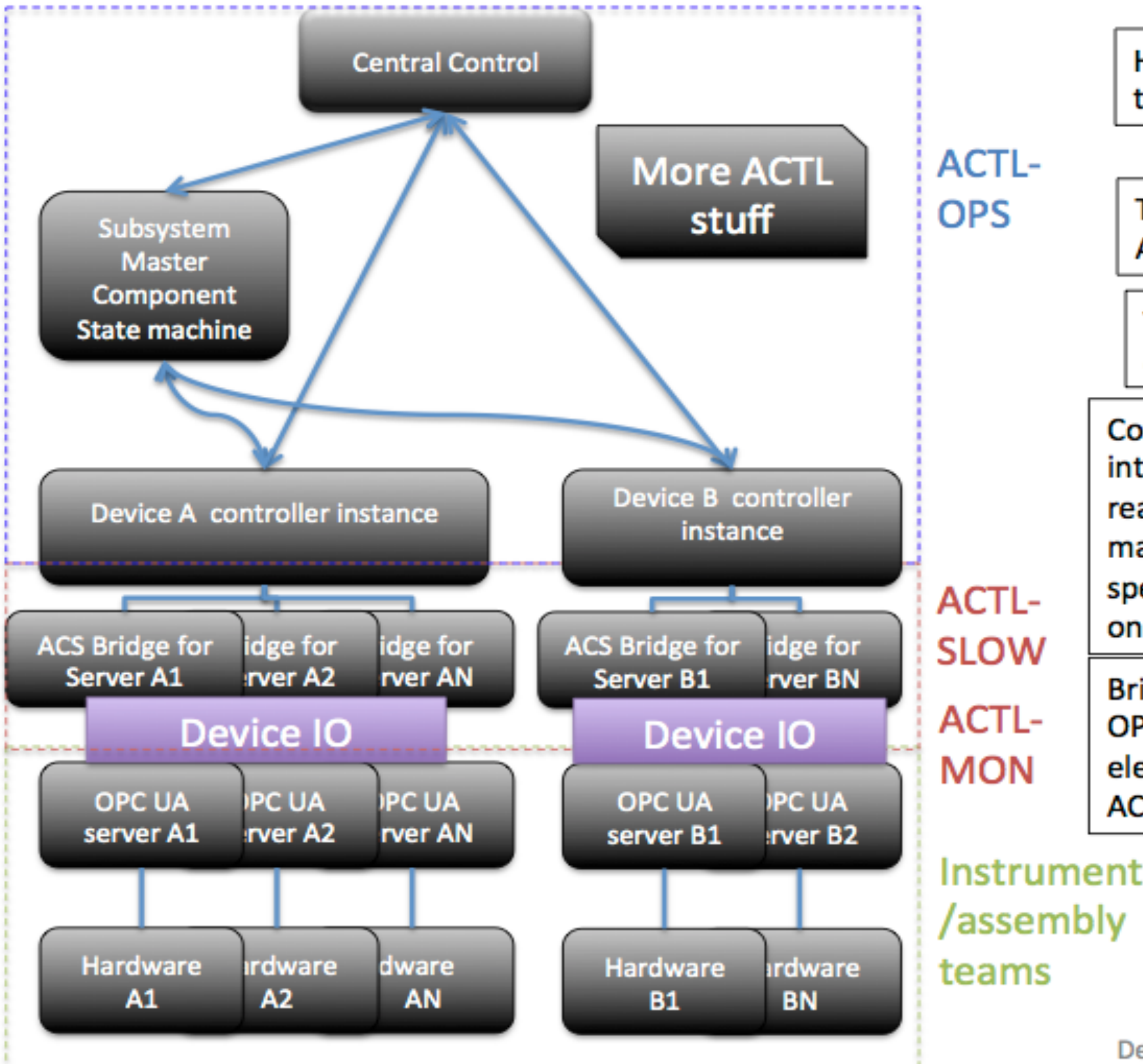
Pre-production telescopes:

- to verify mass production and deployment
- “Mini-arrays” at final sites, used in final arrays
- ~3 MSTs
- ~5 SST-1M
- ~5 SST-2M

Mass production and deployment

ARRAY CONTROL

CONTROL FRAMEWORK



High level ACTL, will not deal with this here. Many boxes missing

The subsystem here would be AUX, or array of telescopes

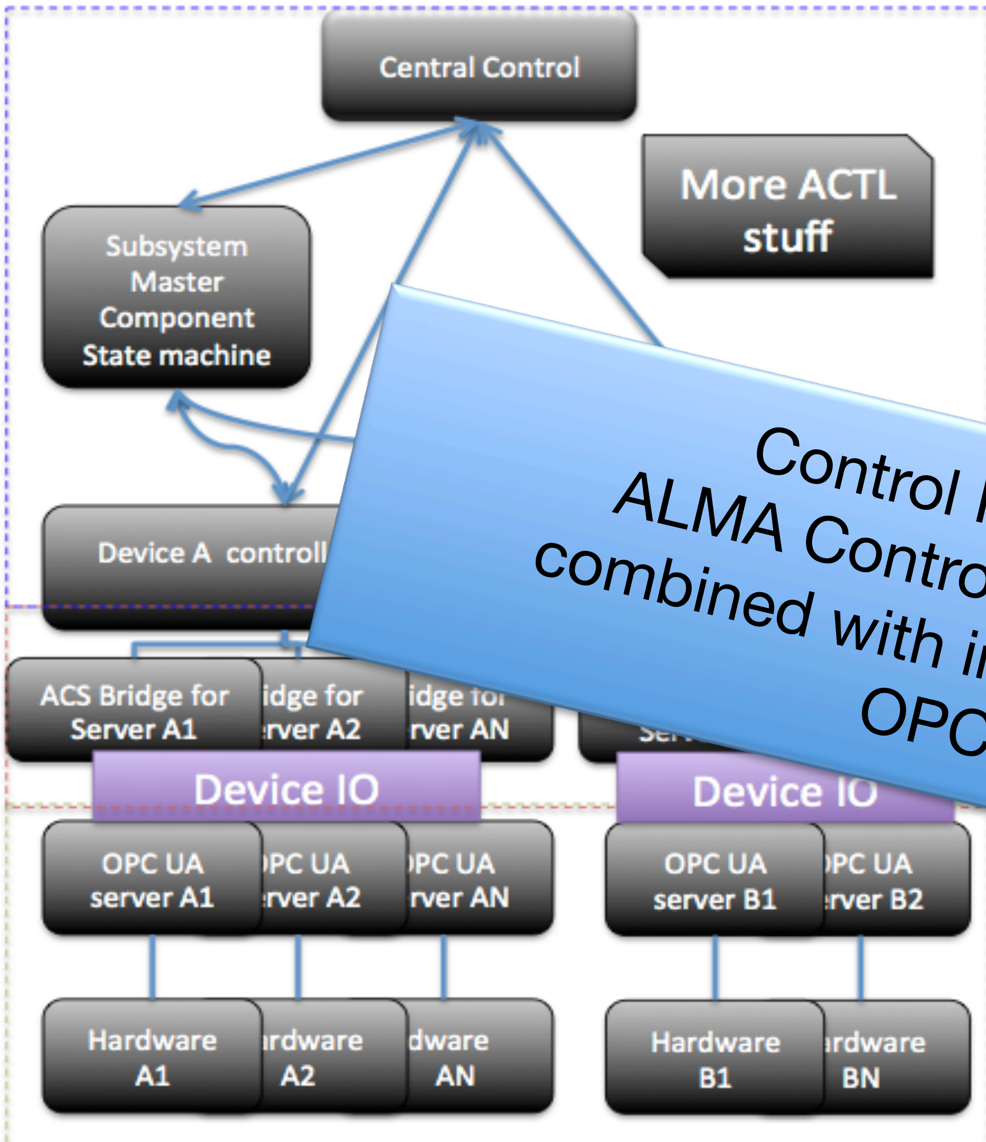
The master deals with the startup and state of software components

Controller implements the same interface with standard methods (e.g. get ready, start) and perhaps a state machine. Translates device/assembly specific functionality to ACTL standard one.

Bridges are device specific and convert OPC UA elements into ACS standard elements (properties, methods, alarms). ACTL-MON system listens to bridges

OPC UA servers provide device specific functionality and expose it following some rules.

CONTROL FRAMEWORK



ACTL-OPS

High level ACTL, will not deal with this here. Many boxes missing

The subsystem here would be AUX, or array of telescopes

The master deals with the startup and state of software components

Controller implements the same ... with standard methods (e.g. get ... haps a state ... mbly ... ndard

MON

... convert ... ndard ... s, alarms). ... bridges

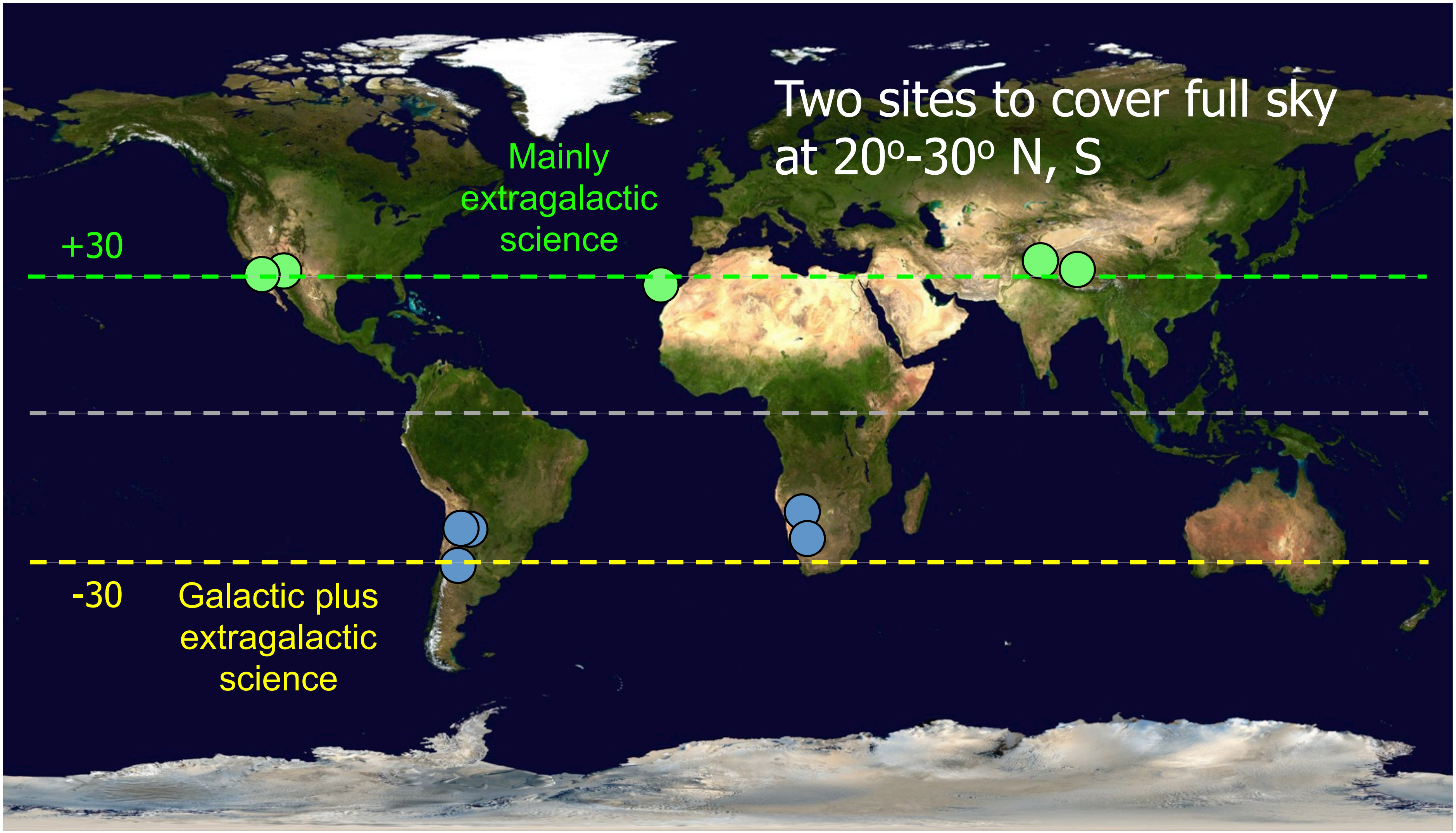
ACTL

Instrument /assembly teams

OPC UA serve... ovide device specific functionality and expose it following some rules.

Control Framework: ALMA Control System (ACS) combined with industry-standard OPC UA

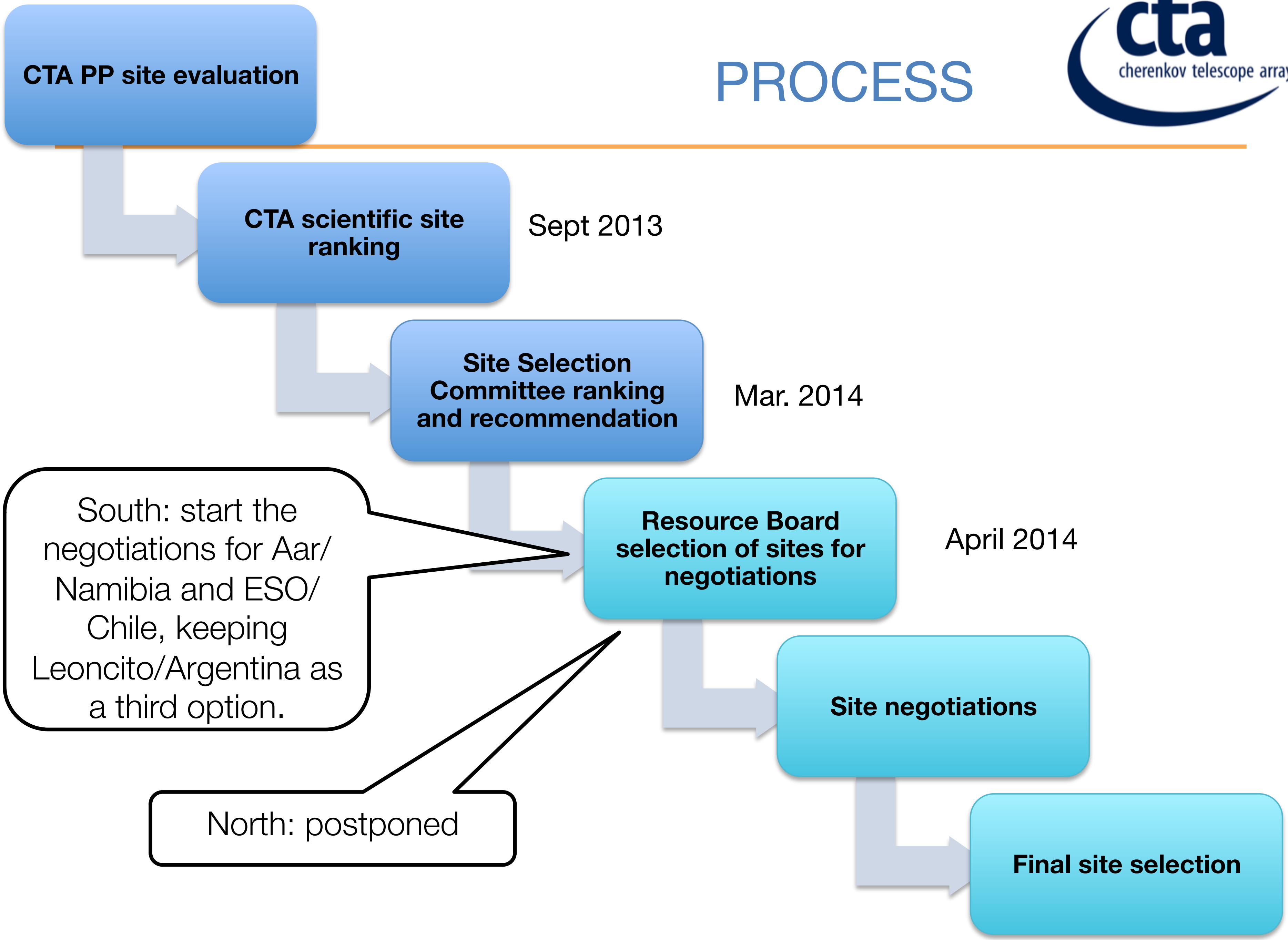
CTA SITES



Two sites to cover full sky
at 20°-30° N, S
Mainly
extragalactic
science
+30
-30
Galactic plus
extragalactic
science

SITES: CANDIDATES

PROCESS



CTA PP site evaluation
CTA scientific site ranking
Sept 2013
Site Selection Committee ranking and recommendation
Mar. 2014
Resource Board selection of sites for negotiations
April 2014
Site negotiations
Final site selection
South: start the negotiations for Aar/ Namibia and ESO/ Chile, keeping Leoncito/Argentina as a third option.
North: postponed

CONCLUSIONS

- Extend sensitivity compared to current instruments by a factor ~10
  - Huge physics potential
    - Cosmic Particle Acceleration
    - Probing Extreme Environments
    - Physics Frontiers – beyond the SM
  - International collaboration with ~thousand scientists
- Open Observatory
  - Guaranteed time for CTA Consortium for Key Science Projects
  - Regular open call for proposals - time allocation based on scientific competition

CONCLUSIONS

- Site selection
  - Site evaluation and scientific ranking by CTA consortium
  - Recommendation by agency-appointed Site Selection Committee
  - Decision by agency board (Resource Board / LE Council)
  - South: start negotiations for Aar/Namibia and ESO/Chile, keeping Leoncito/Argentina as a third option.
  - North: decision on negotiations on hold
- Approval/construction
  - Prototyping ongoing
  - Aim for construction approval in mid-2015 (CDR)
  - Estimated 5 year construction period
  - Early operation of partial arrays
  - Investment cost 150 M€ (2006), escalates to ~200 M€; updated cost estimate in preparation

cta
cherenkov telescope array

BACKUPS

CTA TELESCOPES: SPECS

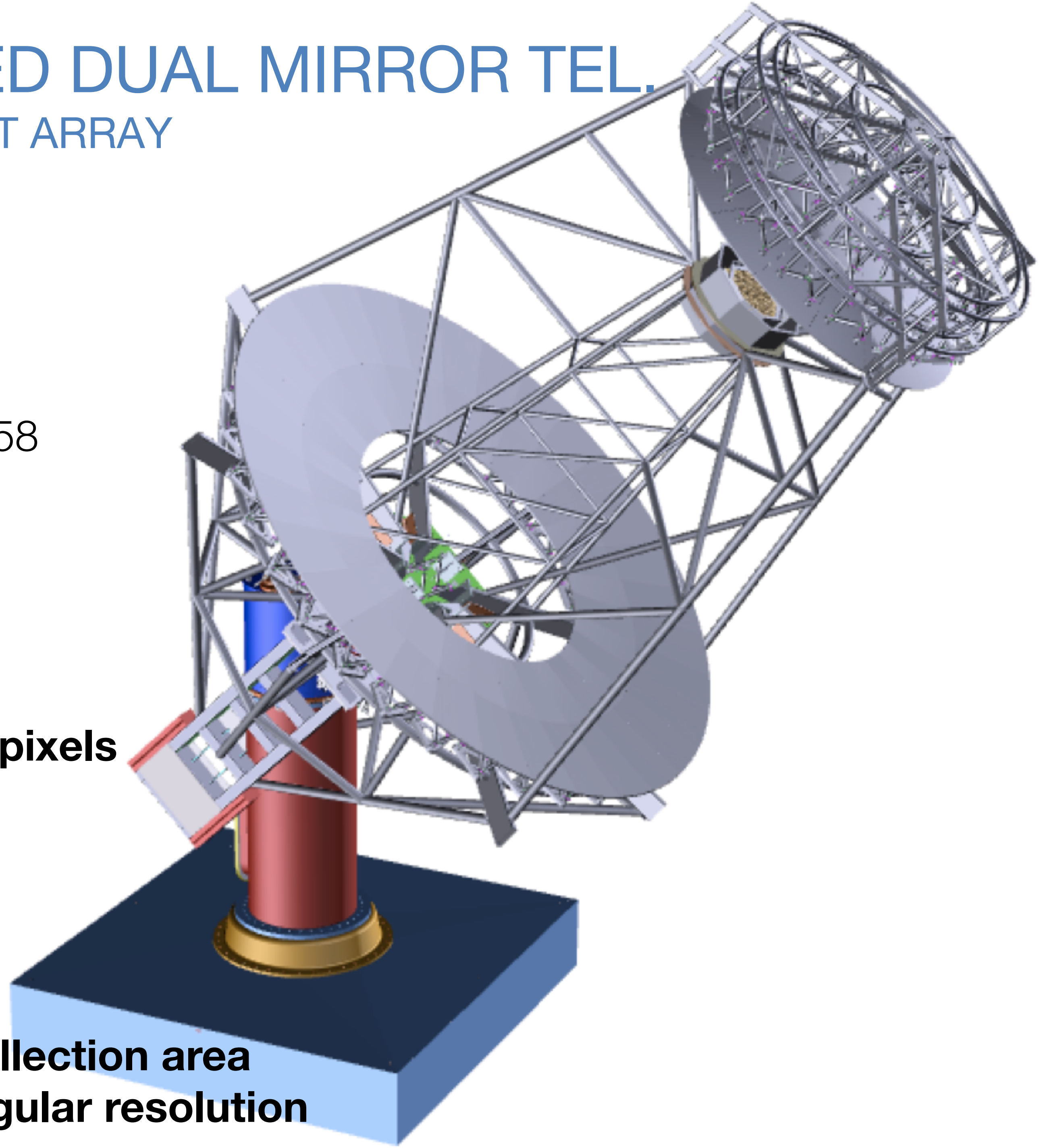
	SST "small"	MST "medium"	LST "large"	SCT "medium 2-M"
Number	**70 (S)**	**25 (S) 15 (N)**	**4 (S) 4 (N)**	**24 (S)**
Spec'd range	> few TeV	200 GeV to 10 TeV	20 GeV to 1 TeV	200 GeV to 10 TeV
Eff. mirror area	> 5 m^2	> 88 m^2	> 330 m^2	> 40 m^2
Field of view	> 8°	> 7°	> 4.4°	> 7°
Pixel size ~PSF θ_{80}	< 0.25°	< 0.18°	< 0.11°	< 0.075°
Positioning time	90 s, 60 s goal	90 s, 60 s goal	50 s, 20 s goal	90 s, 60 s goal
Availability	> 97% @ 3 h/week	>97% @ 6 h/week	>95% @ 9 h/week	>97% @ 6 h/week
Target capital cost	420 k€	1.6 M€	7.4 M€	2.0 M€

MEDIUM-SIZED DUAL MIRROR TEL.

EXTENDING THE MST ARRAY

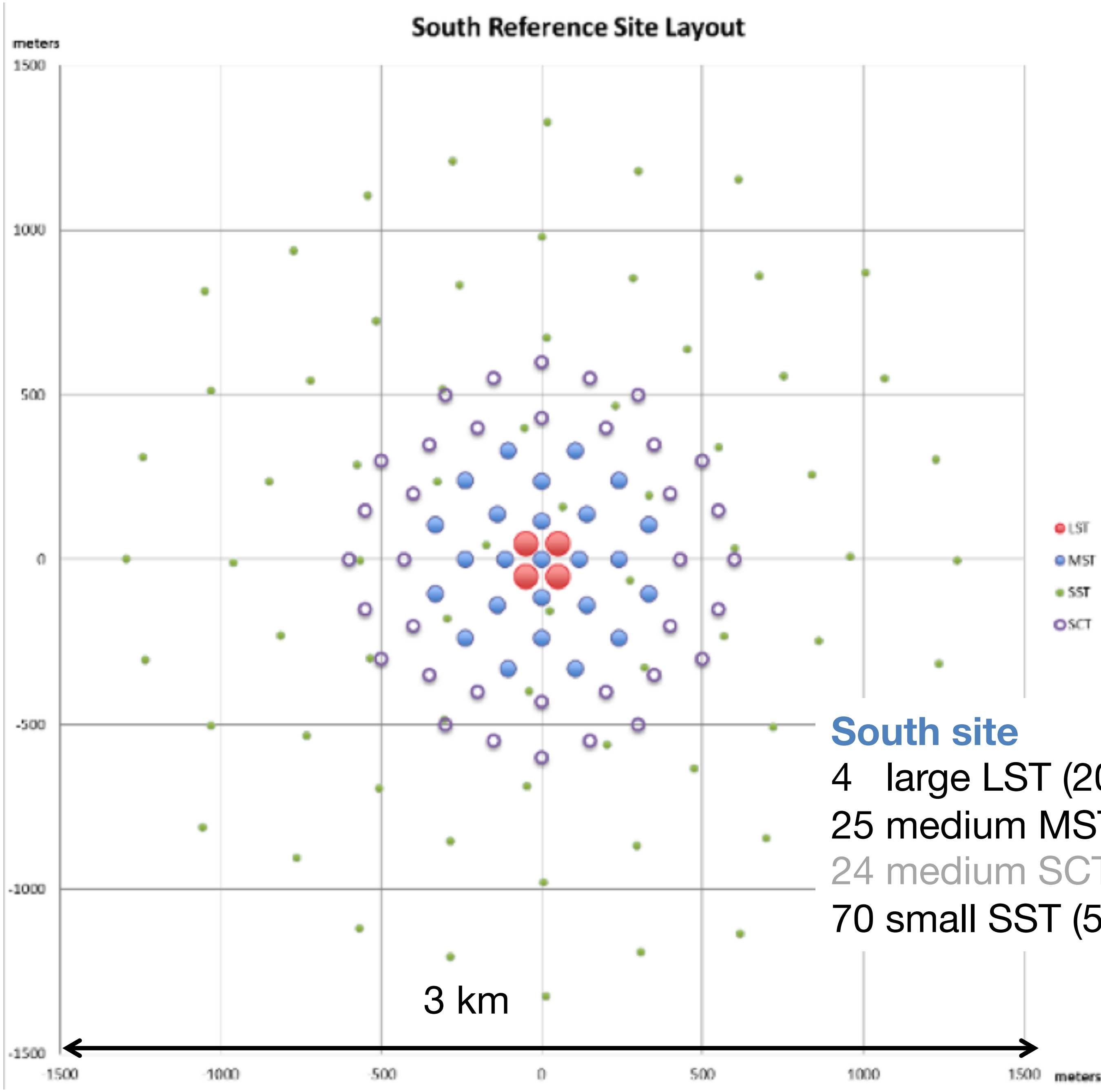
9.7 m primary
5.4 m secondary
5.6 m focal length, f/0.58
40 m^2 eff. coll. area
PSF better than 4.5'
across 8^o fov

8^o field of view
11328 x 0.07^o SiPMT pixels
Target readout ASIC



Extend South array
by adding 24 SCTs

➜ increased γ-ray collection area
➜ improved γ-ray angular resolution



Reference layout, not final

South site

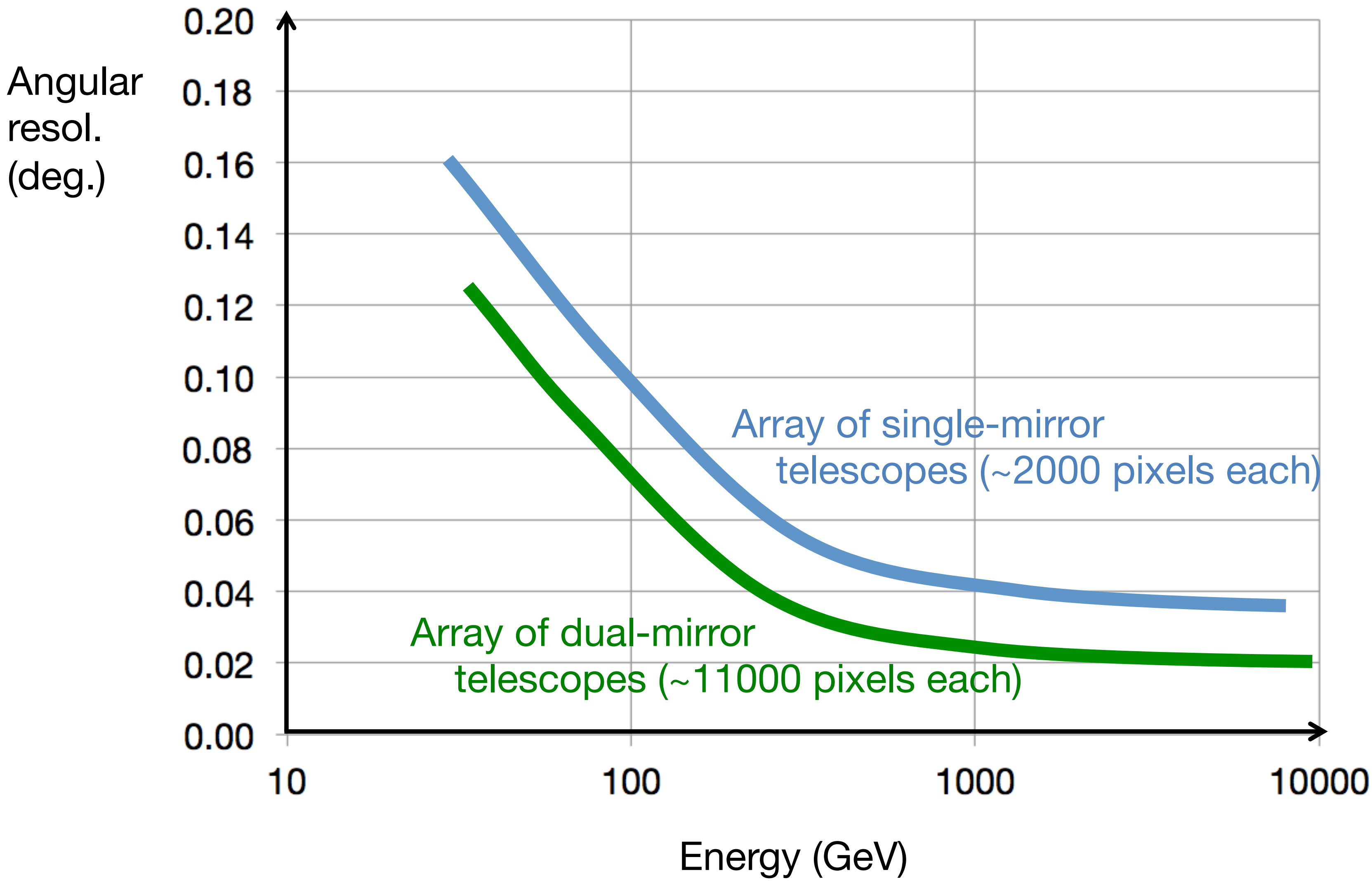
4 large LST (20-200 GeV)

25 medium MST (200 GeV-5 TeV)

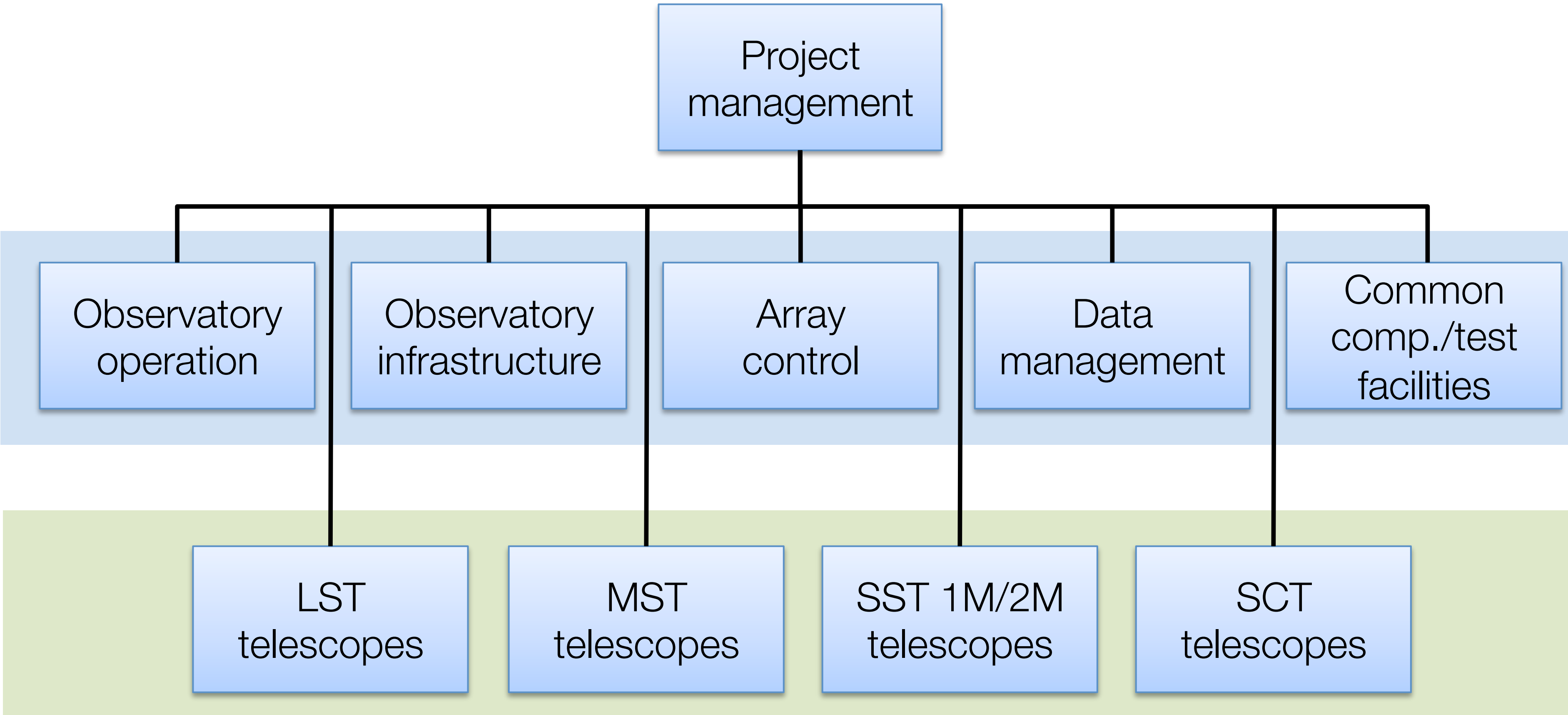
24 medium SCT expansion (US)

70 small SST (5 TeV – 300 TeV)

ANGULAR RESOLUTION



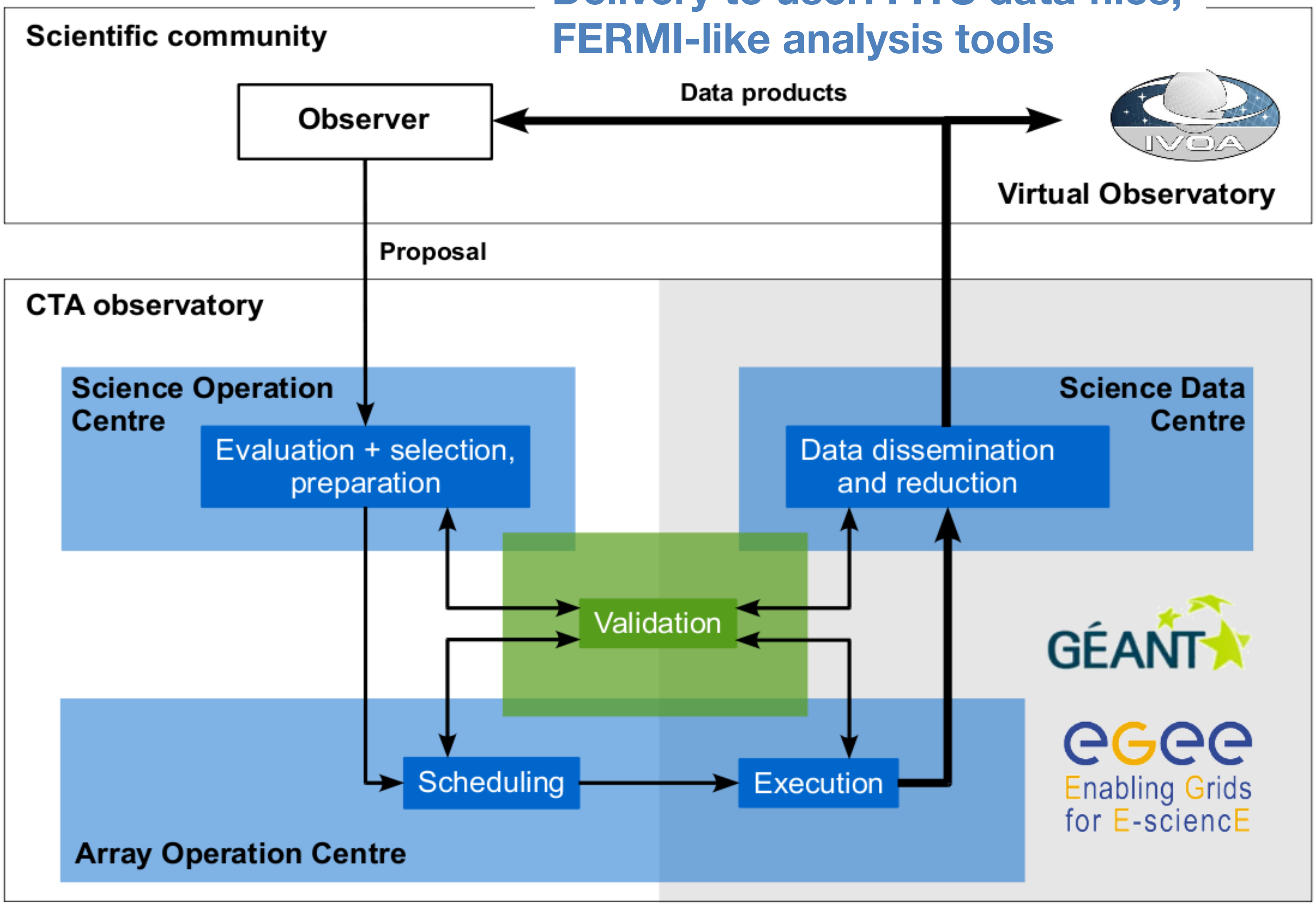
STRUCTURE



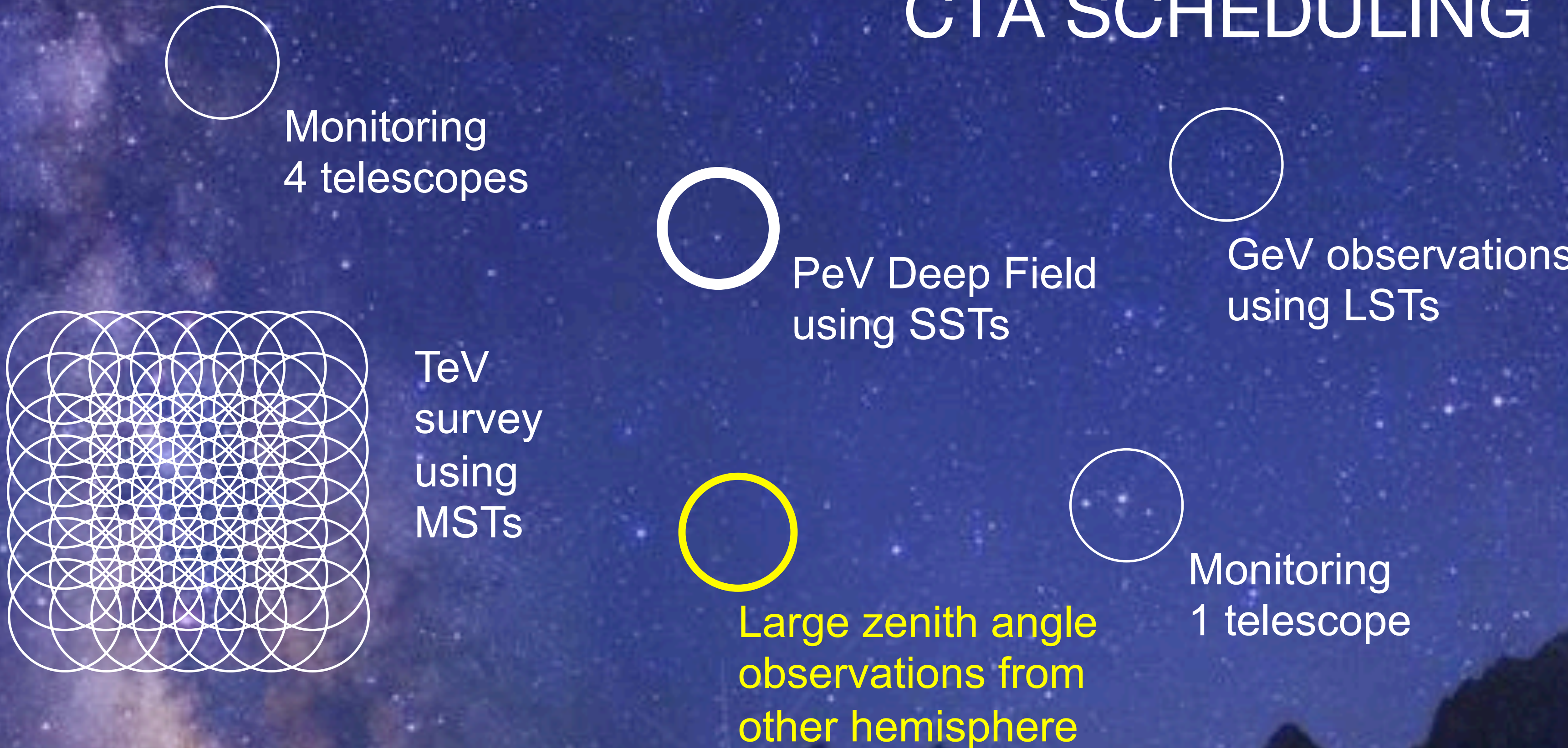
- CTA components will mostly be provided as in-kind contributions by CTA Consortium parties

FOR THE FIRST TIME IN THIS FIELD: OPEN ACCESS

Delivery to user: FITS data files, FERMI-like analysis tools



CTA SCHEDULING



- CTA North and South through single portal, AO, identical tools
- Queue mode scheduler taking into account actual sky conditions, sub-arrays & conditions requested in proposal, priorities, TOOs

TIME LINE
CTA OBSERVATORY