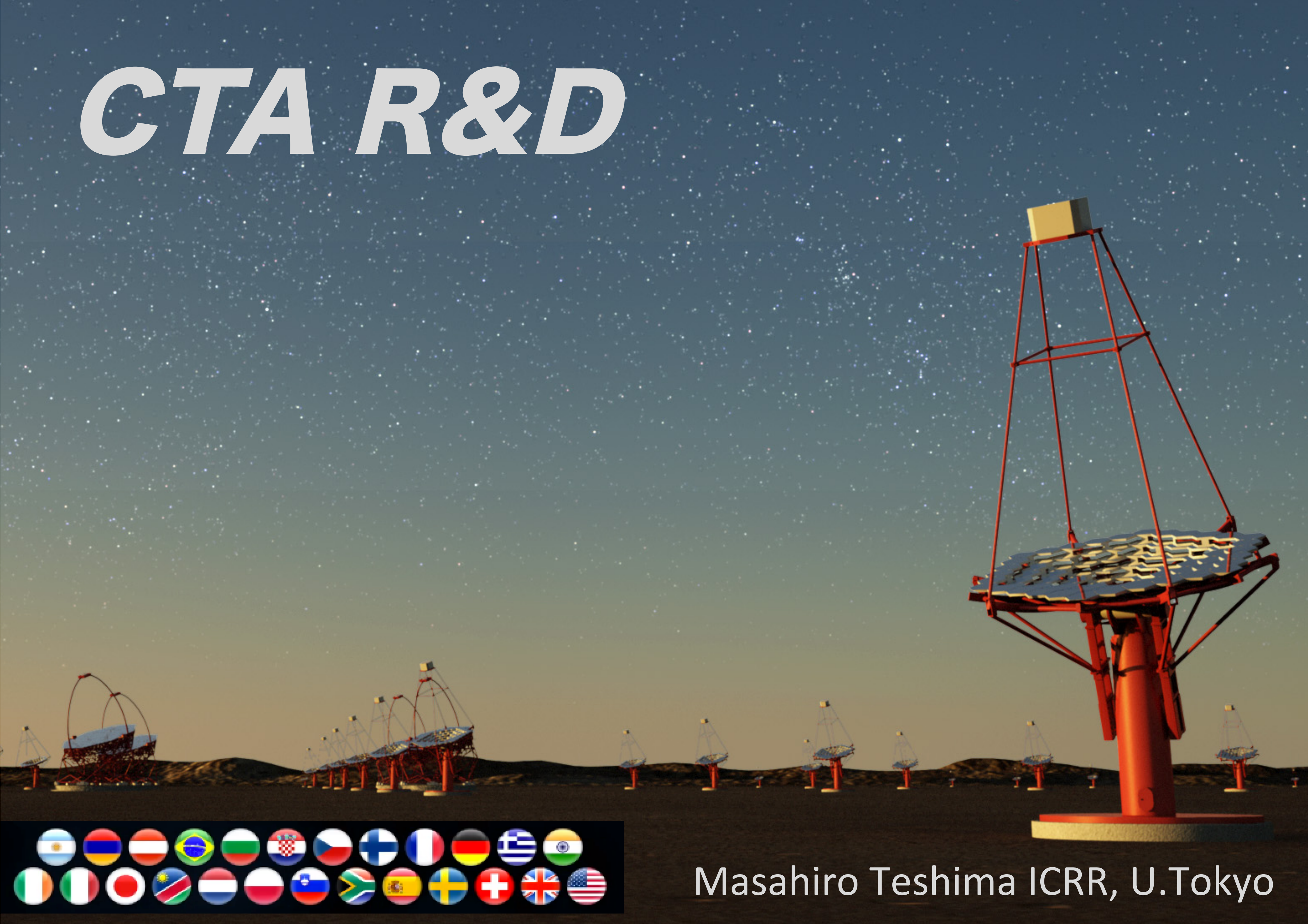
CTA R&D



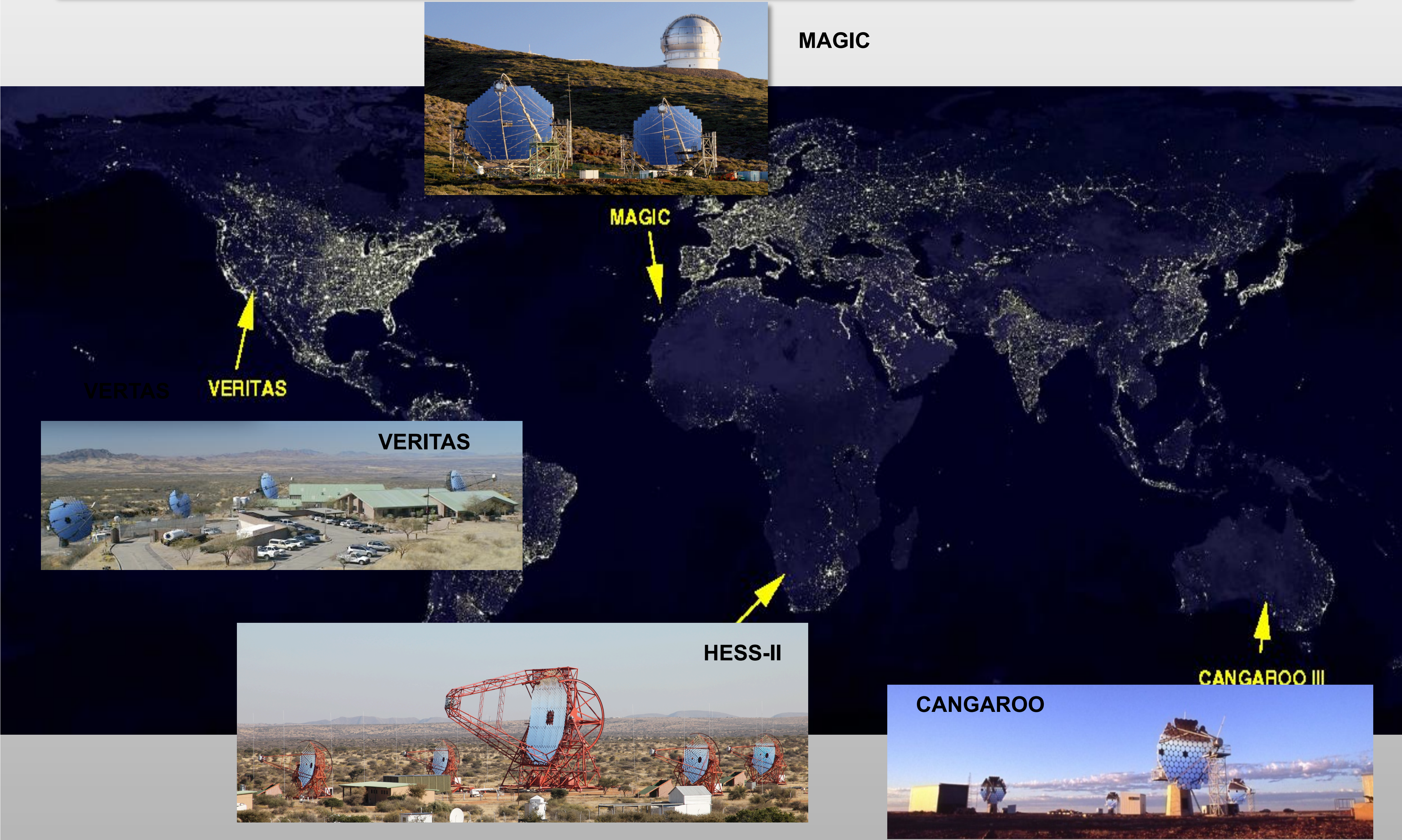
Masahiro Teshima ICRR, U.Tokyo

Scientists in ICRR

- ICRR (5 scientists + 1 Engineer)
  - 1 Professor (M.T.)
  - 1 Assoc. Professor (T. Yoshikoshi)
  - 1 Research Associate (M. Ohishi)
  - 1 Project Research Assoc. (M. Hayashida)
  - 1 Project Researcher (K. Saito)
  - 1 Engineer (H.Ohoka)
- In FY2013
  - a few Project researchers (opening positions)
  - 4 Master course students (2 are from S.S.)

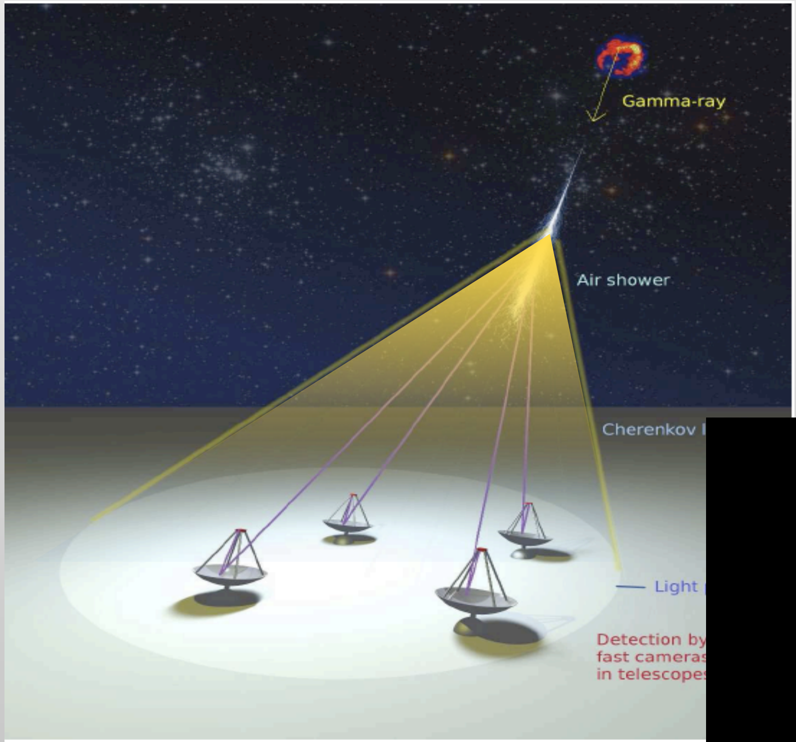
- CTA-Japan Consortium formed in 2009
  - 85 scientists from 27 institutes

Cherenkov Telescope Arrays



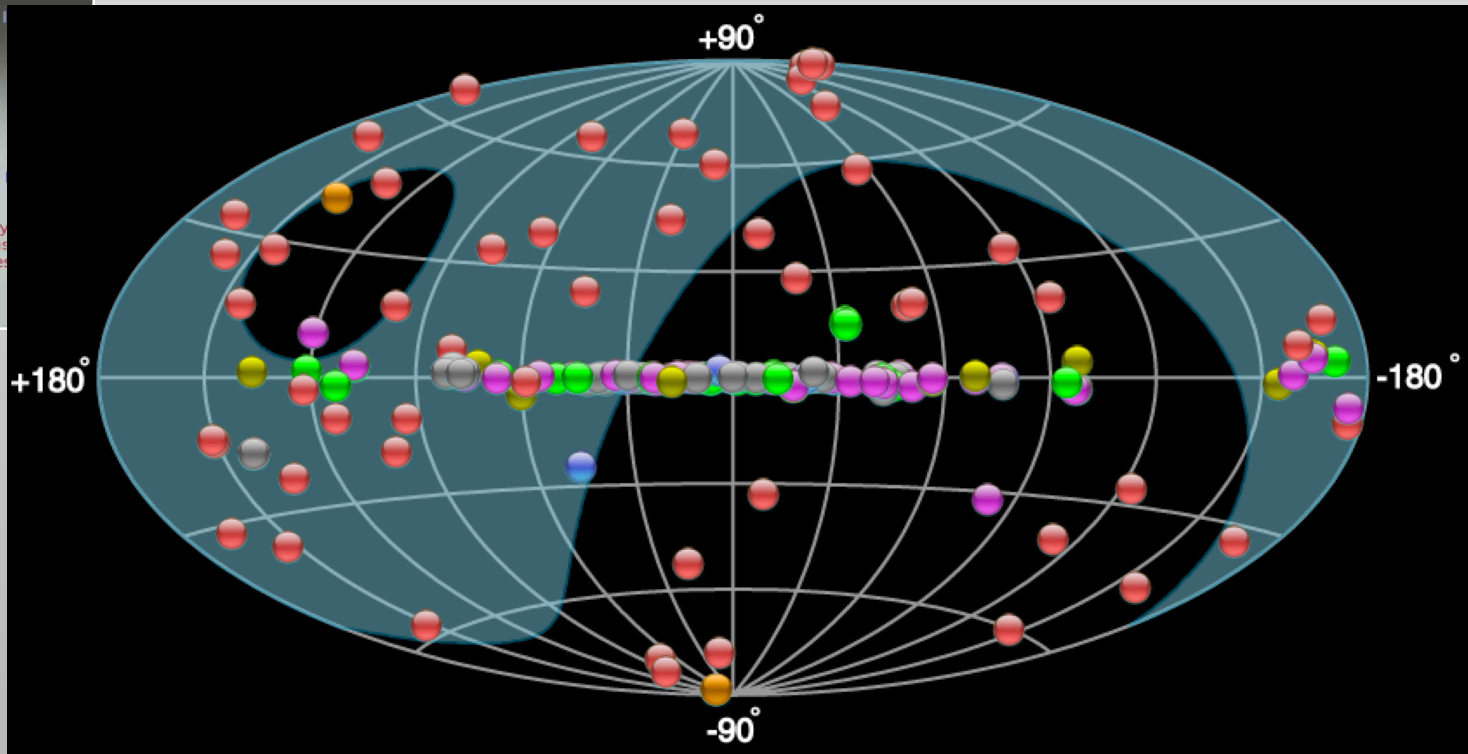
VHE Gamma Ray Astronomy
A New Window to the Universe and Energy Frontier in Astrophysics

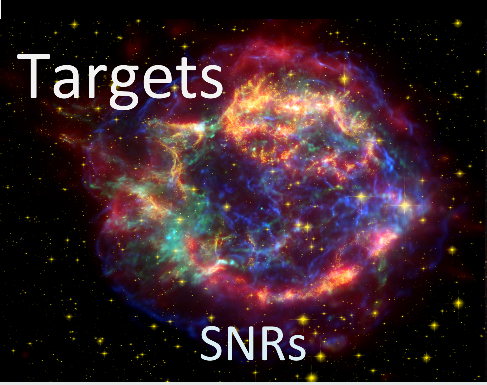
Imaging Air Cherenkov Telescope (IACT) Technique

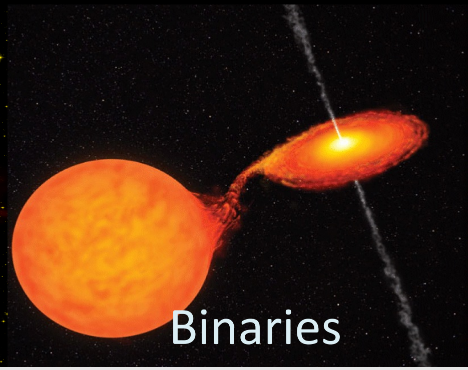


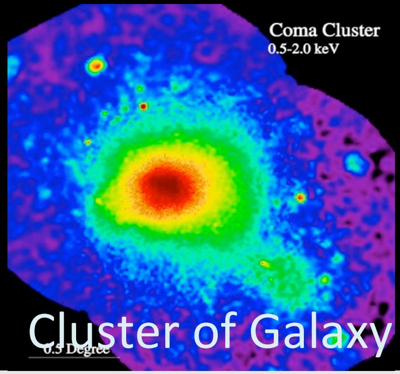
>100GeV Gamma Ray Sources

163 sources (>100GeV) ➔ >1,000 sources with CTA



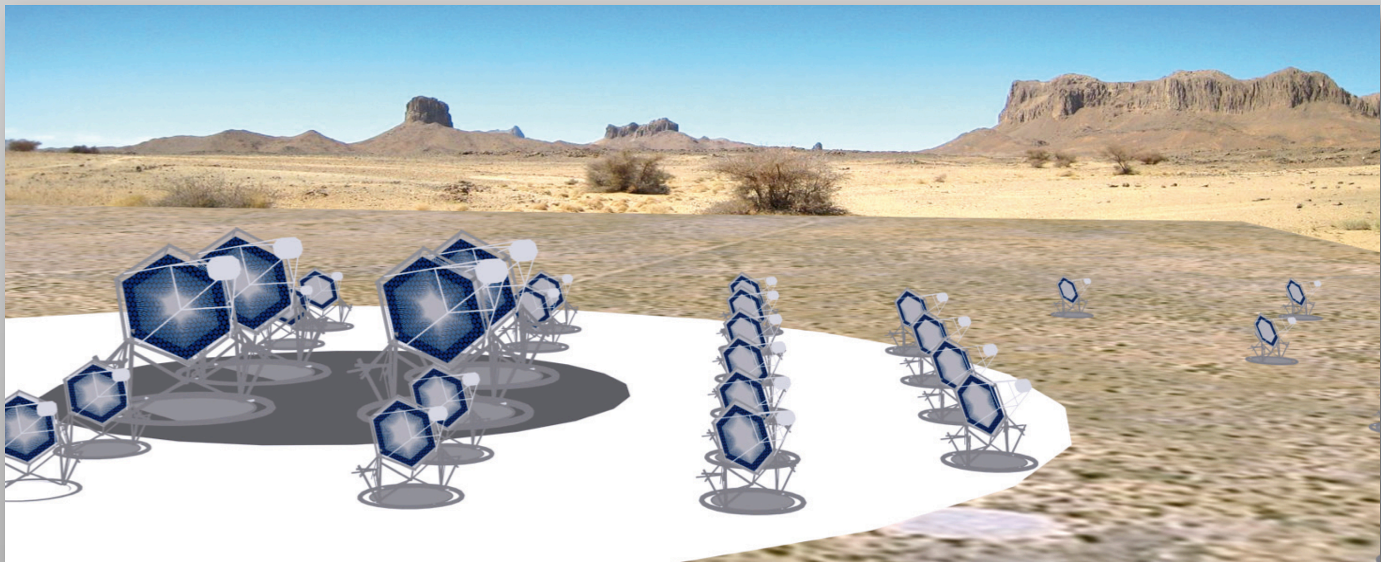




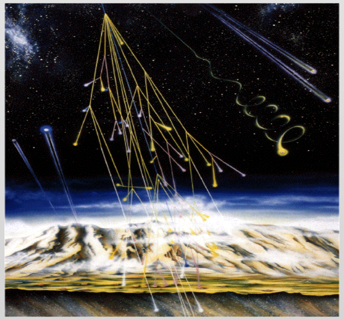


Cherenkov Telescope Array
High Energy Gamma Ray Astronomy

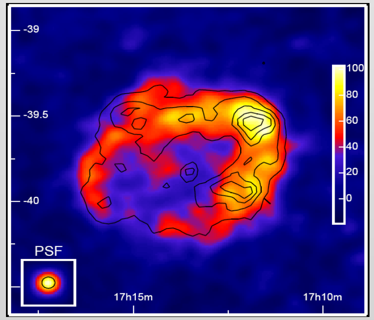
- •Origin of Cosmic Rays
- •Study of High Energy Astronomical Objects
- •EBL Study ➔ Cosmology (Star formation rate
- **•Search for Dar Matter**
- **•Space and Time (test of Relativity) High Precision**



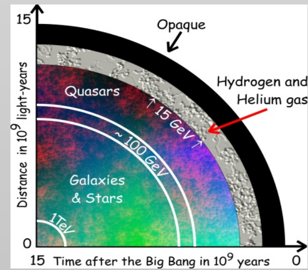
Science Objectives



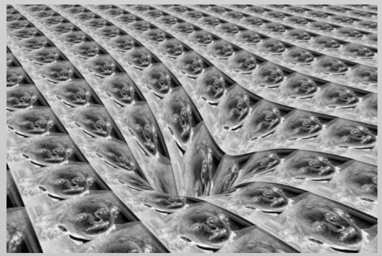
Cosmic Ray Origin



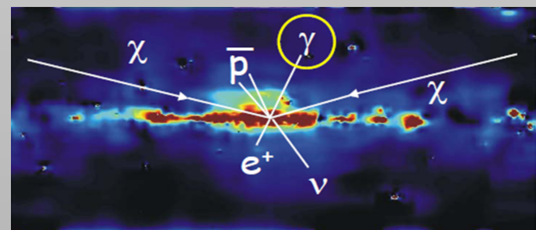
High Energy Objects



Cosmology

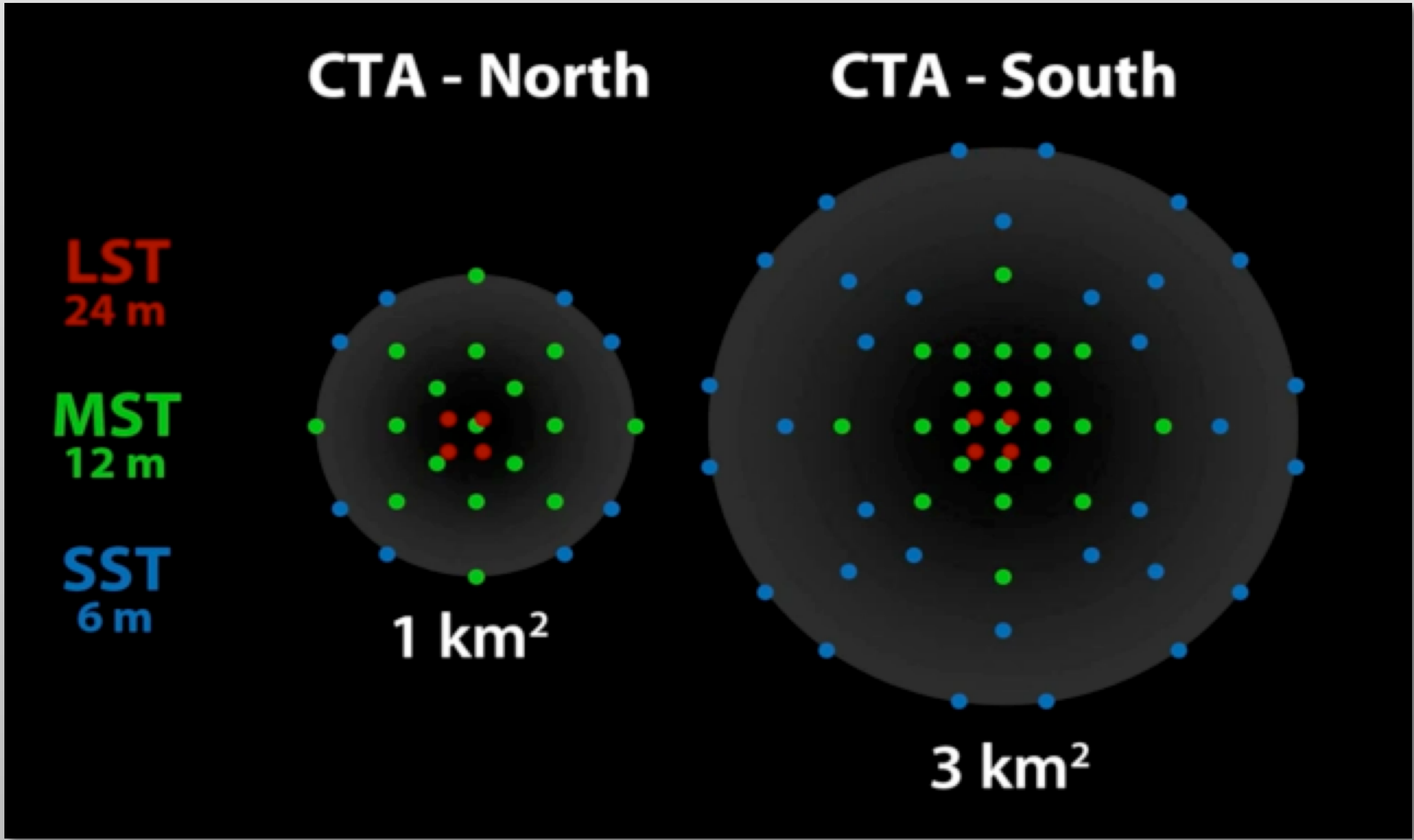


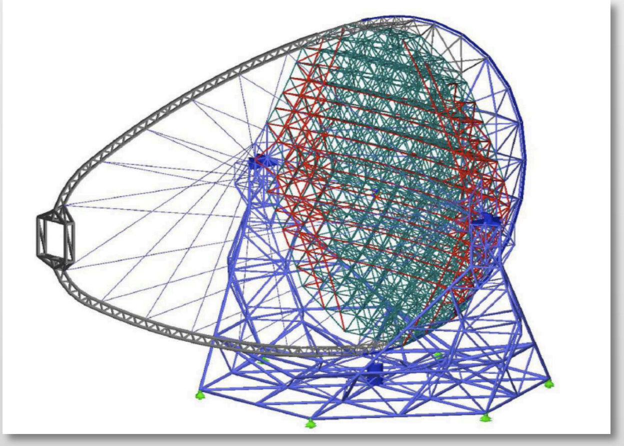
Space & Time



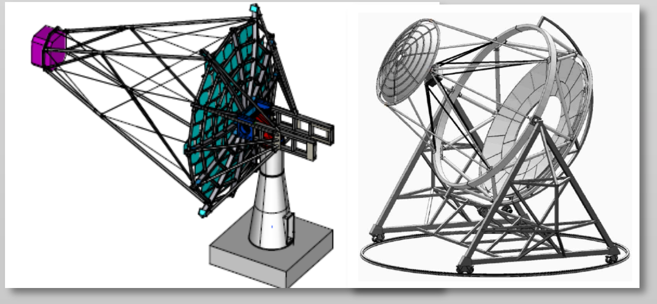
Dark Matter

Possible array configuration

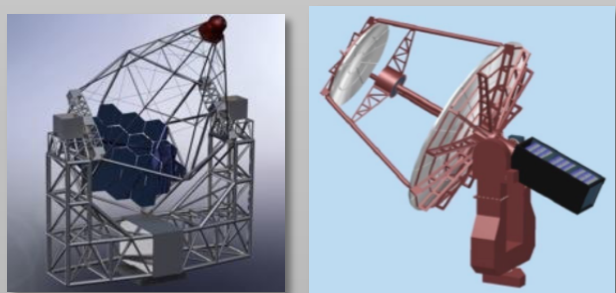




LST 23m



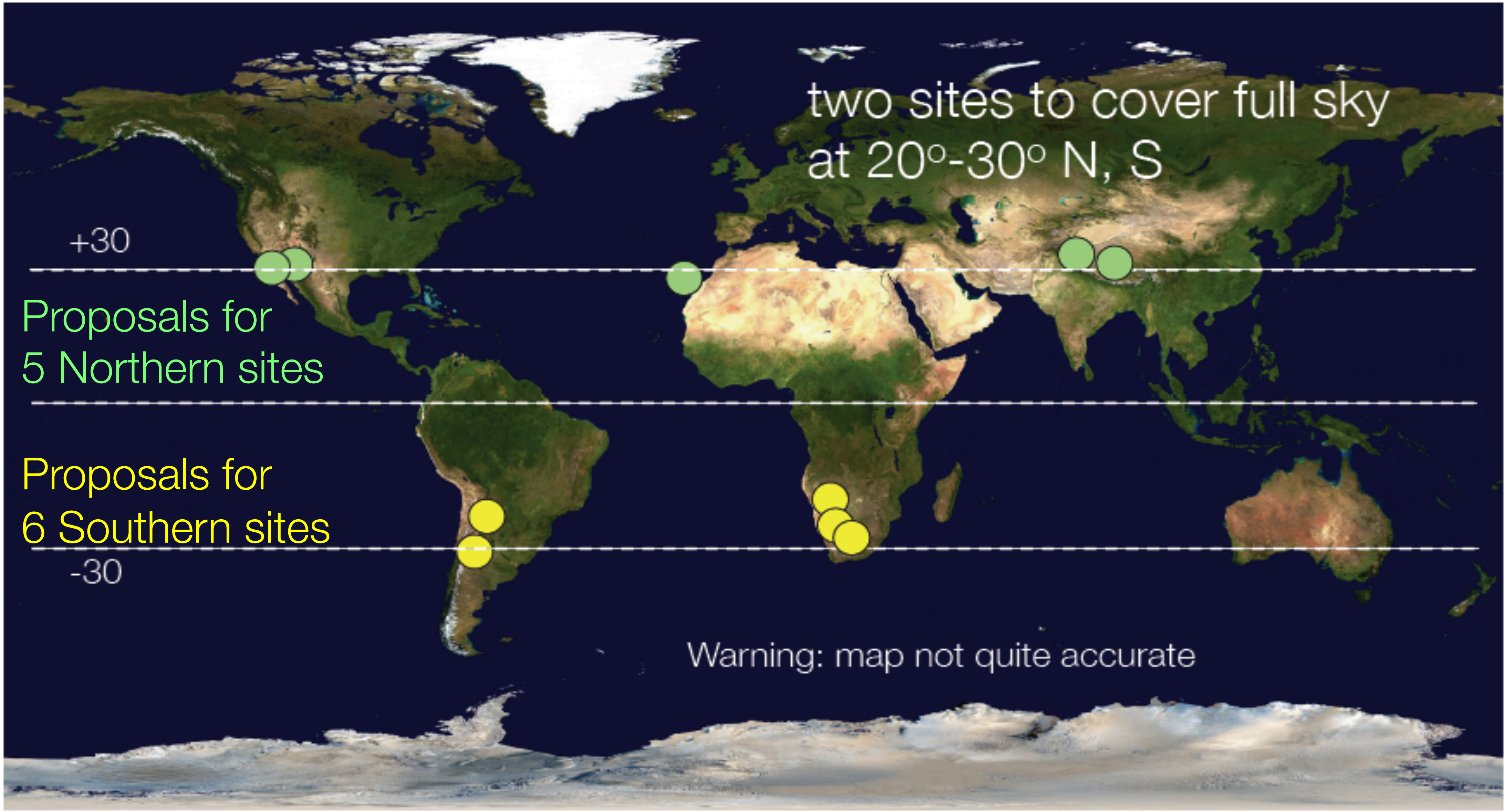
MST 10-12m



SST 4-6m

Site candidates

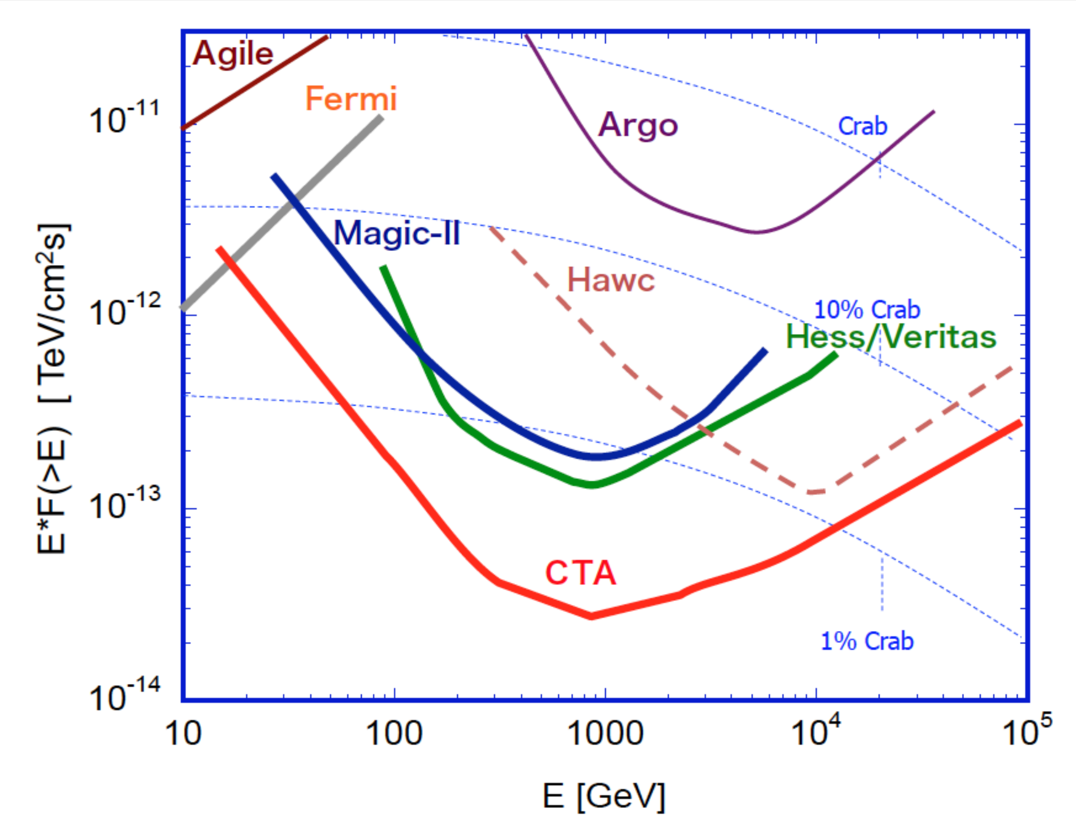
Sites will be selected in the end of 2013

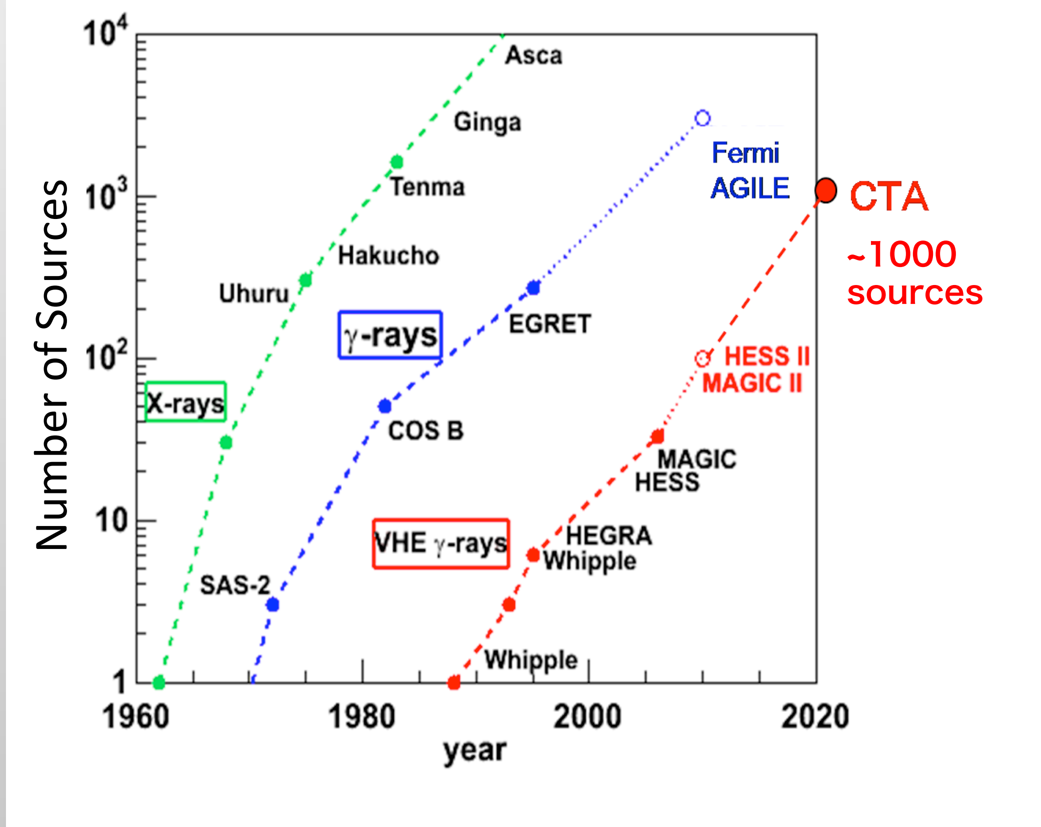


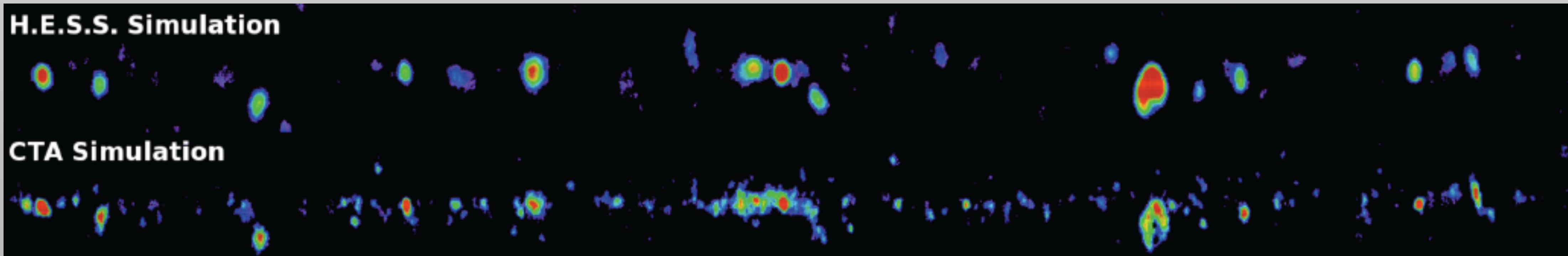
CTA（Cherenkov Telescope Array）

An order of magnitude better sensitivity
Wide energy coverage

More than 1000 sources will be discovered

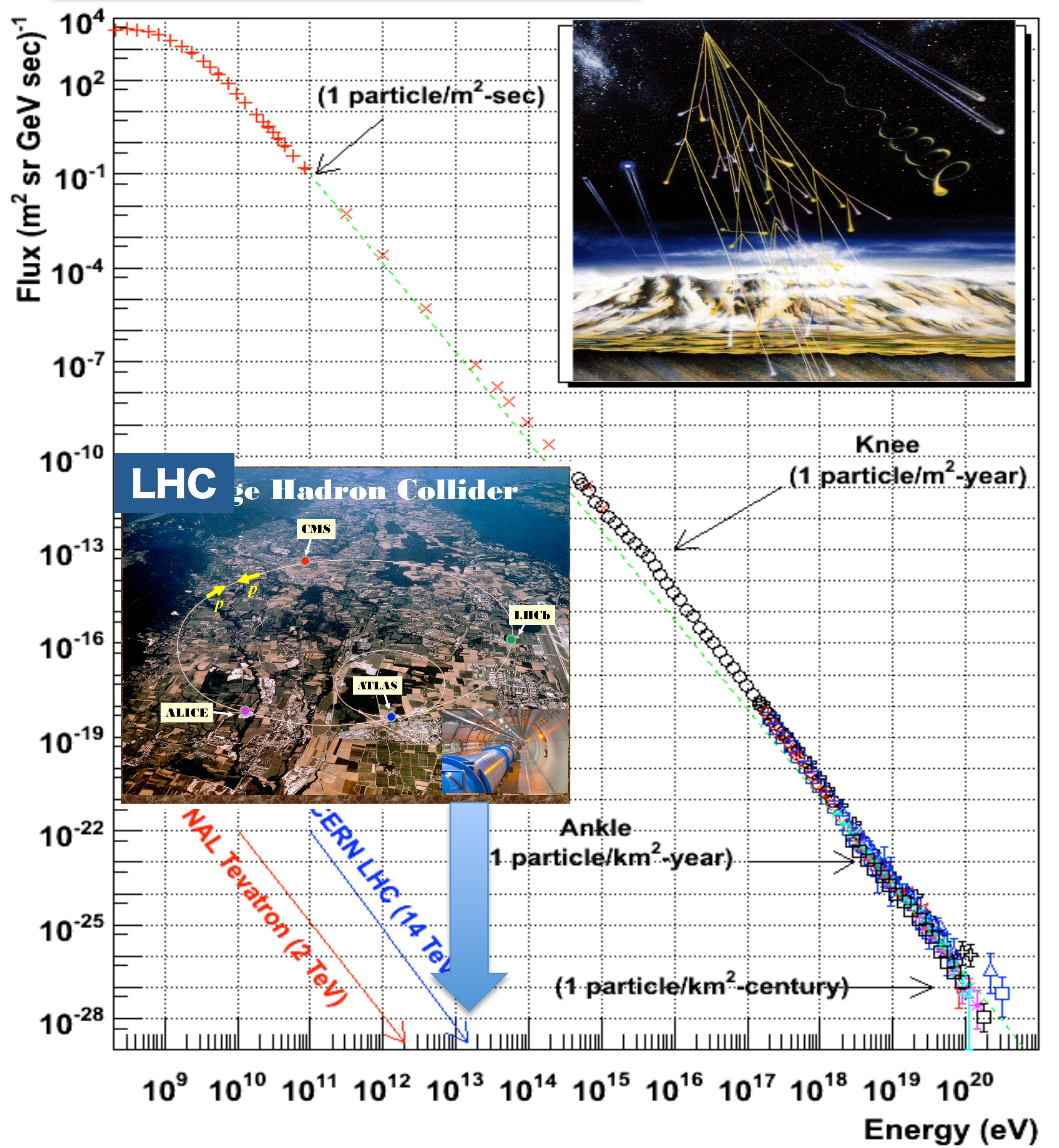




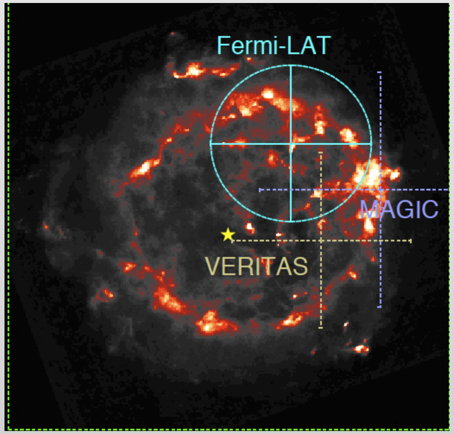


Simulation Galactic Plane scan（HESS and CTA）

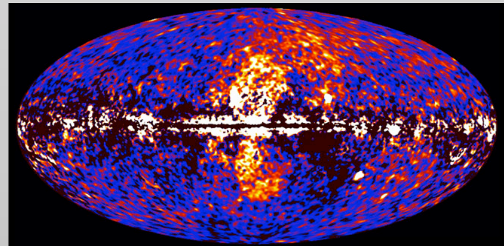
Cosmic Ray Energy Spectrum



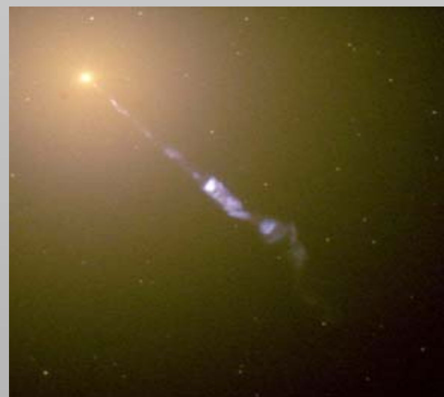
Observe accelerators in the Universe with HE/VHE gamma rays



SNRs
(Cas-A)



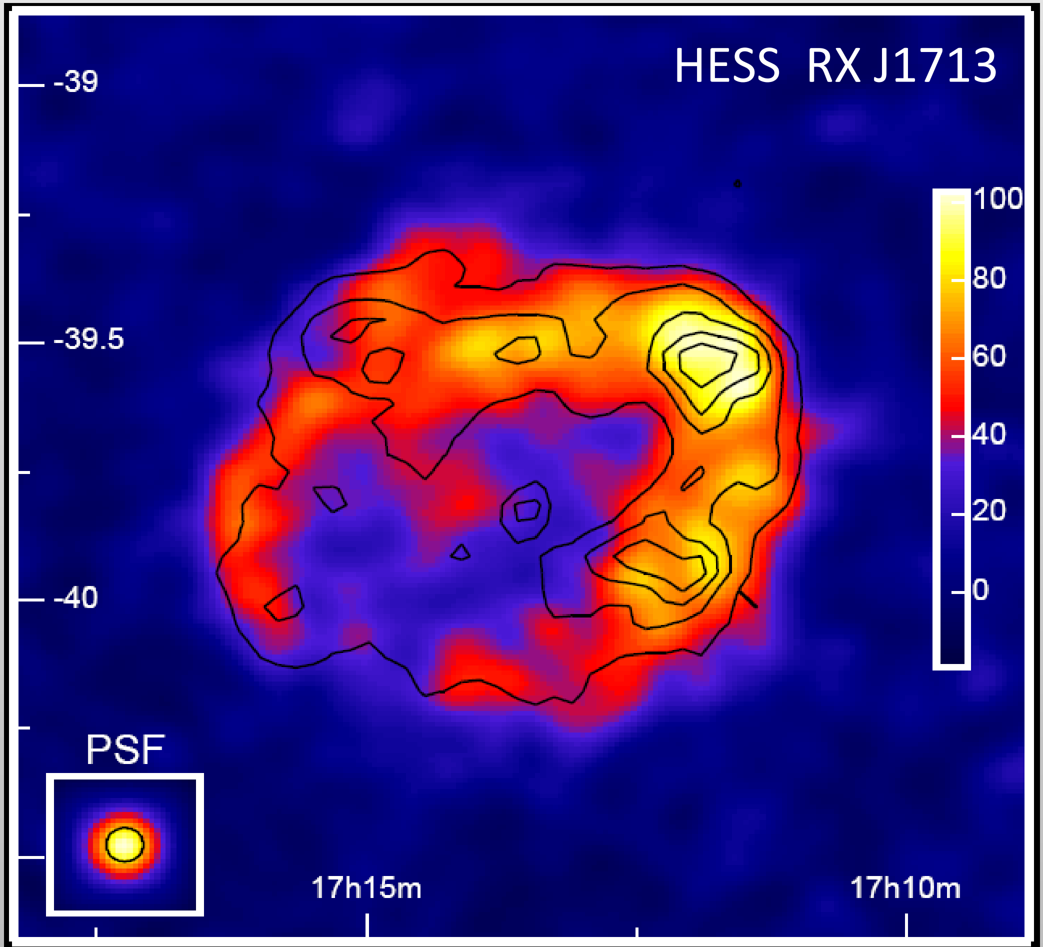
Large Structure in our galaxy
(Fermi bubble)

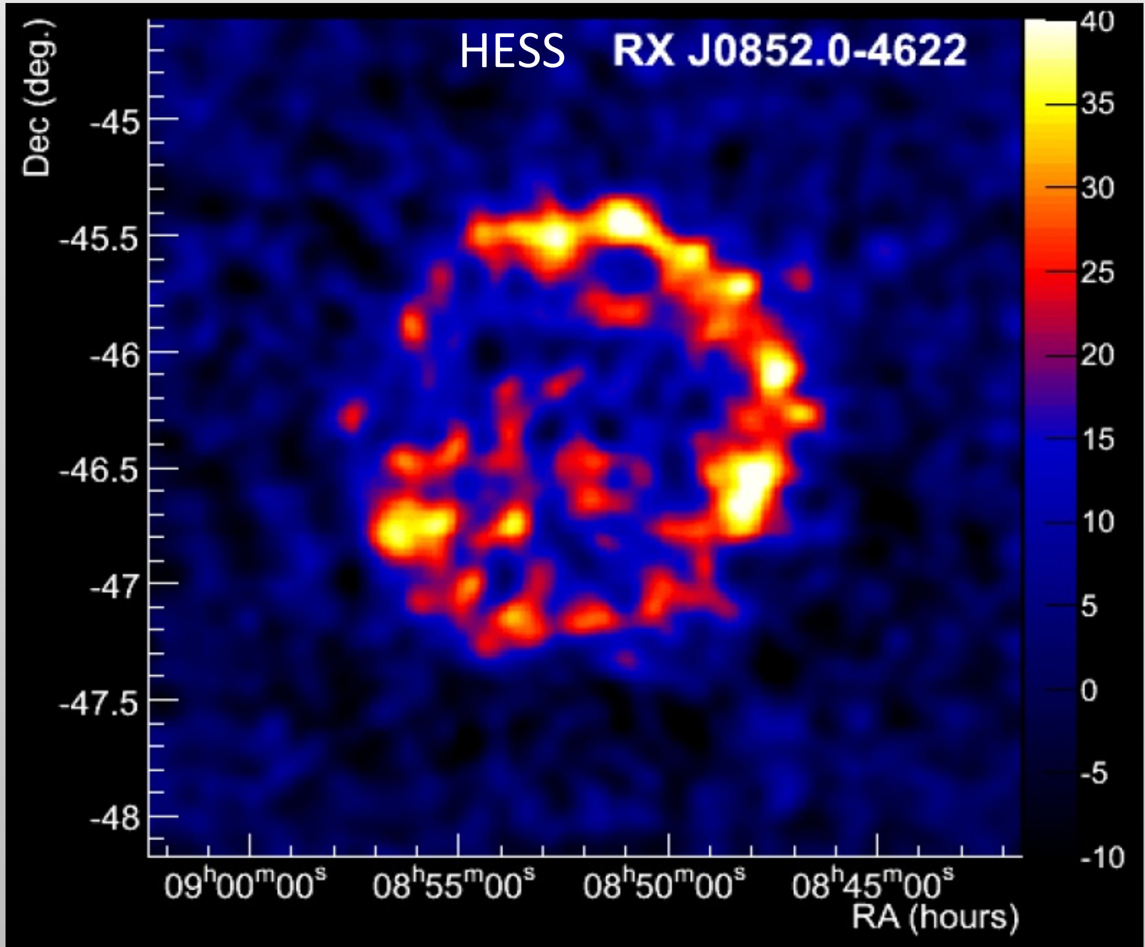


AGNs
(M87)

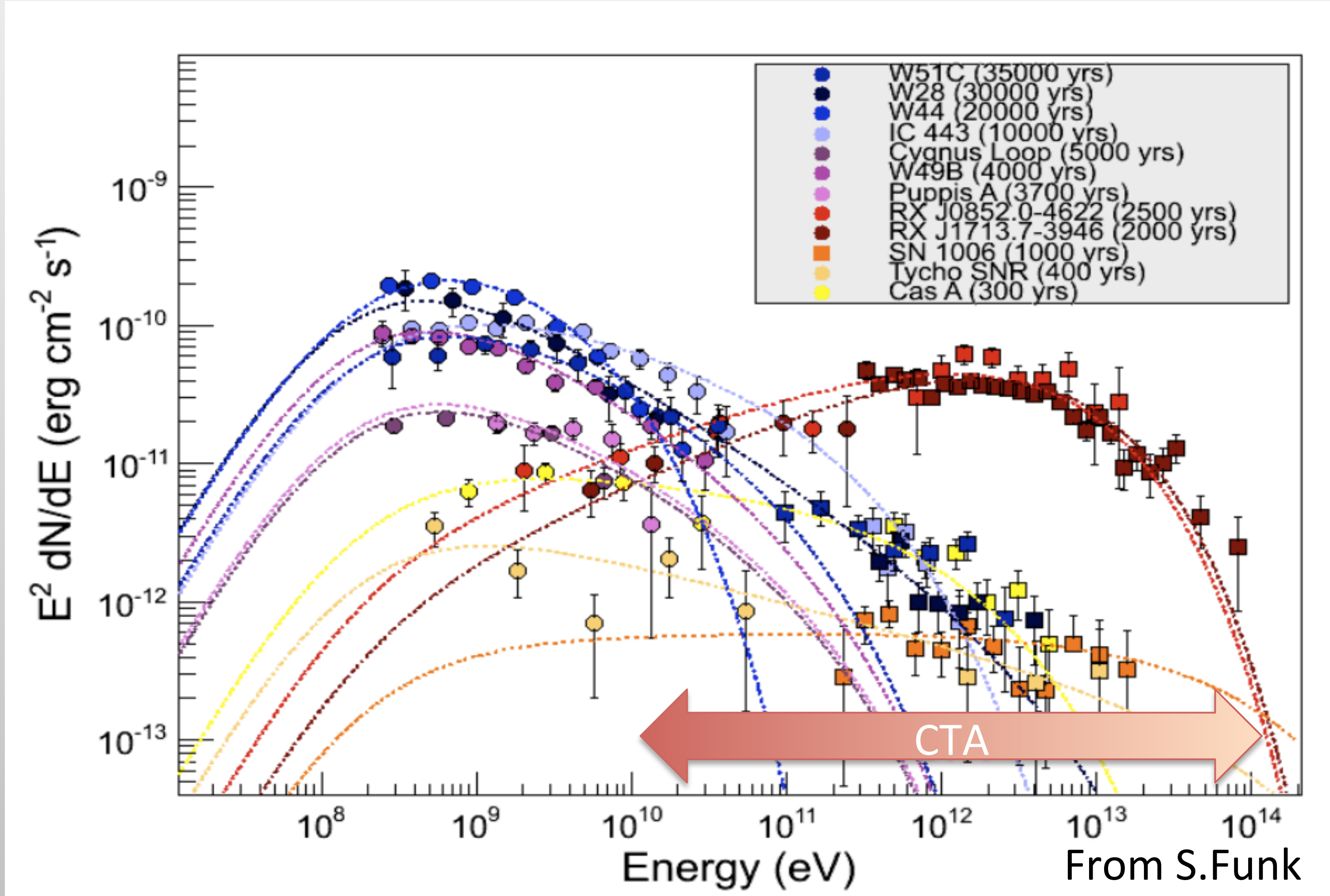
Gamma Ray emission from Shell type SNRs

H.E.S.S. Observation



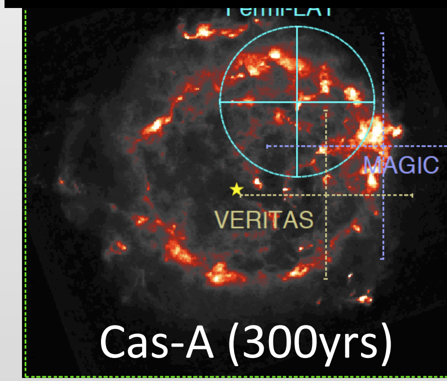


$E<10^{15}$eV Cosmic Rays ←→ Shell type SNRs

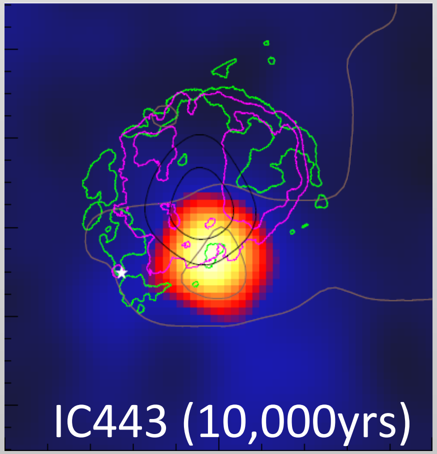


From S.Funk

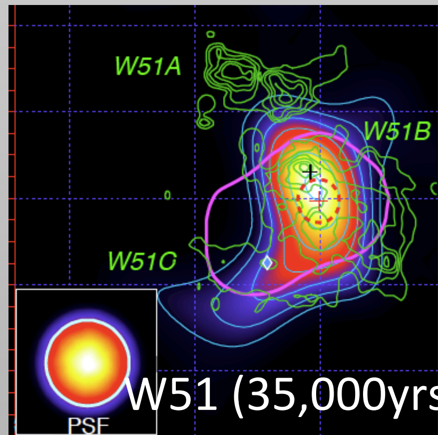
MAGIC Observations



Cas-A (300yrs)



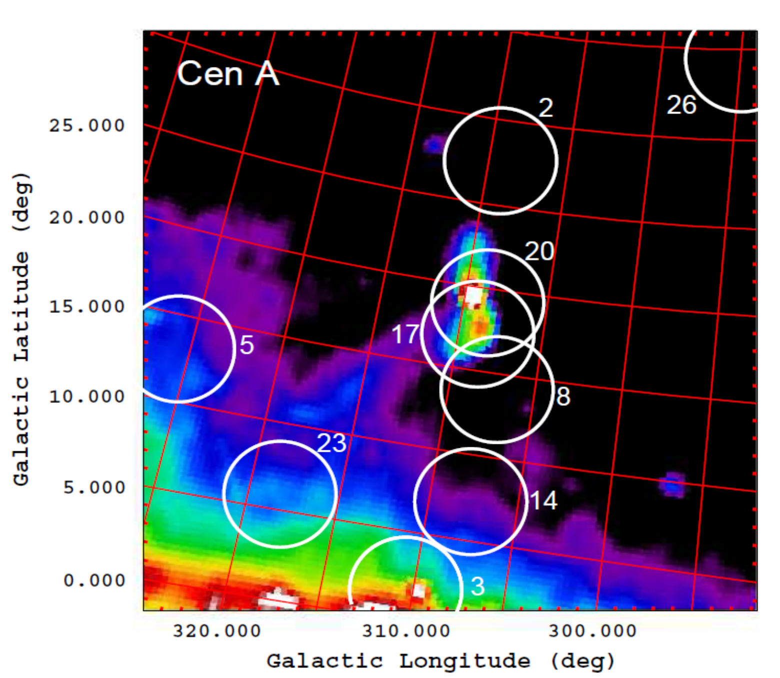
IC443 (10,000yrs)

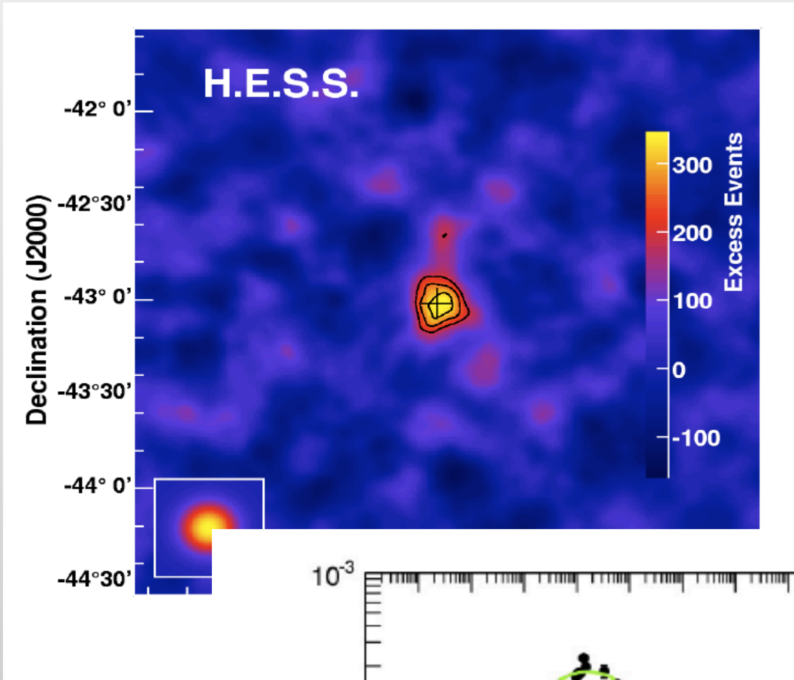


W51 (35,000yrs)

- Different stages of SNRs as cosmic ray accelerator
- CTA will deliver more information on SNRs as cosmic ray accelerators
- We can survey most of SNRs in our galaxy → C.R. energetics

Cen A is hadron accelerator?

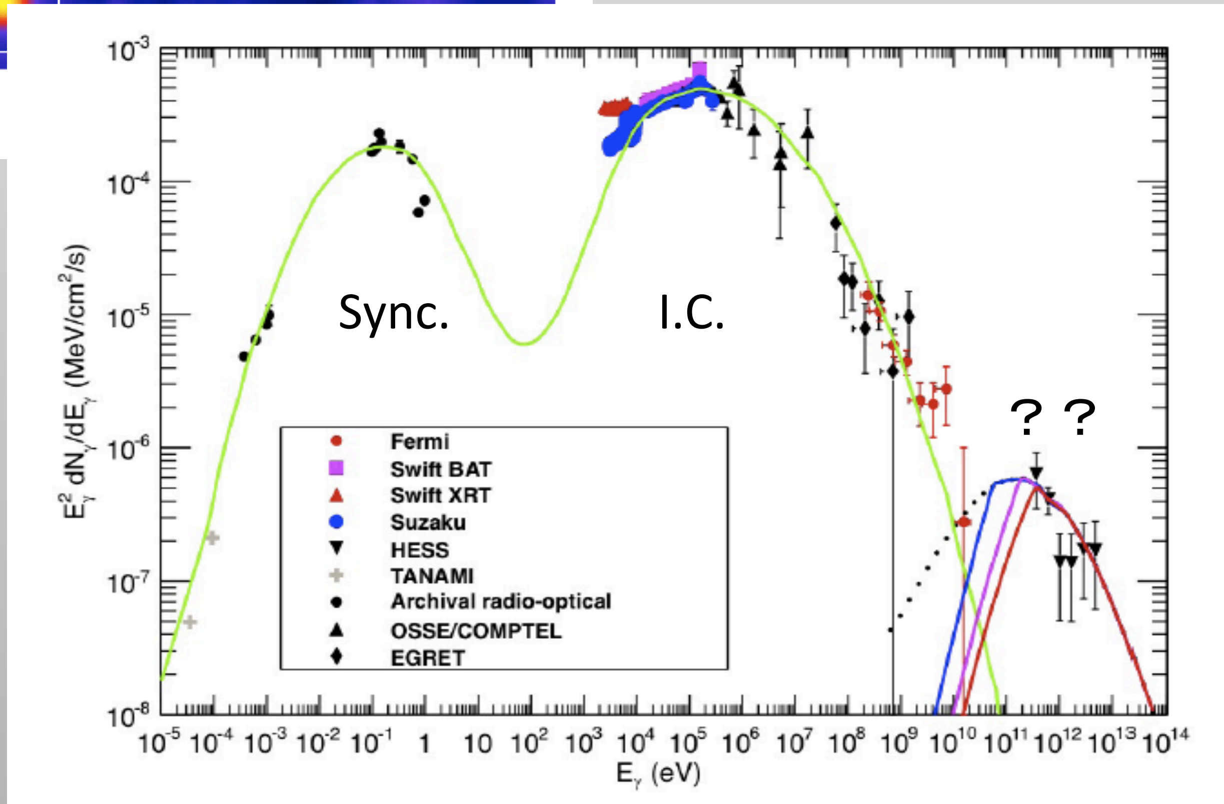




Distance: 3.8Mpc
Flux: 0.8% in Crab Unit
Spectral Index: -2.7

Evidence of P-γ？

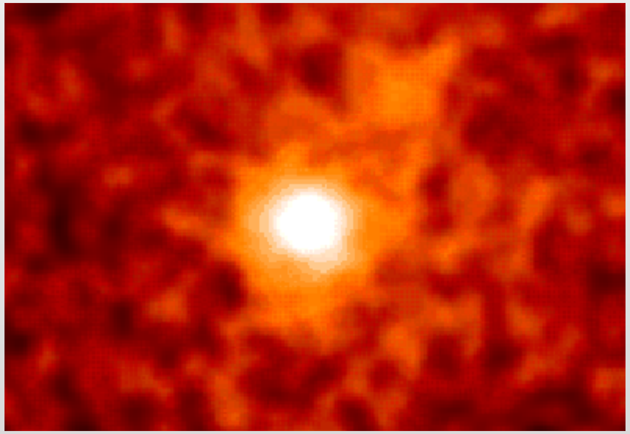
Sahu et al 2012



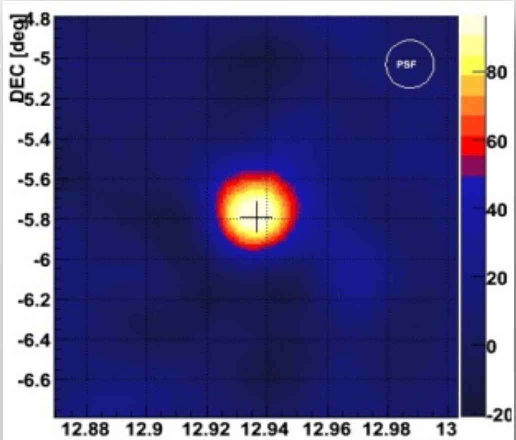
Moskalenko et al.

L_{VHE} ~ 2.6 x 10^{39} erg s^{-1}
L_{UHECR} ~ 10^{40} erg s^{-1}

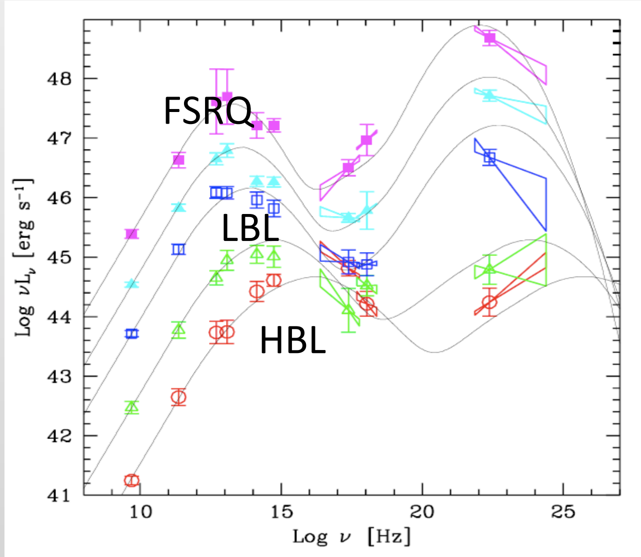
FSRQ 3C279: Hadronic source?

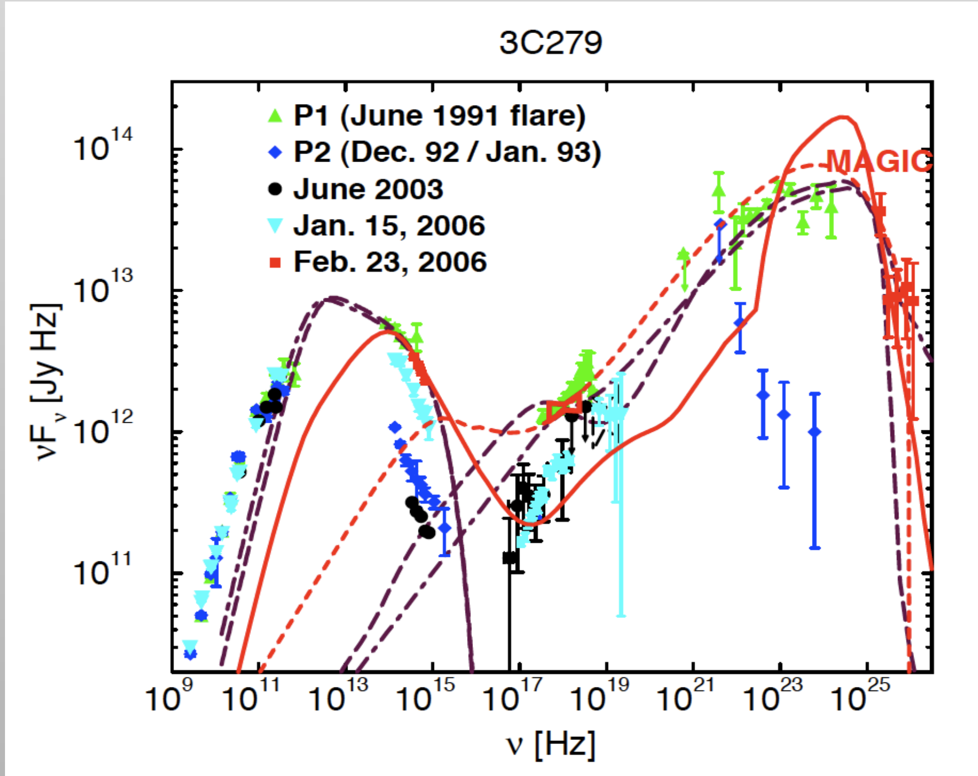


EGRET >100MeV



MAGIC >80GeV





We do not expect Tev emission in Blazar Sequence

Leptonic EC
B is too weak

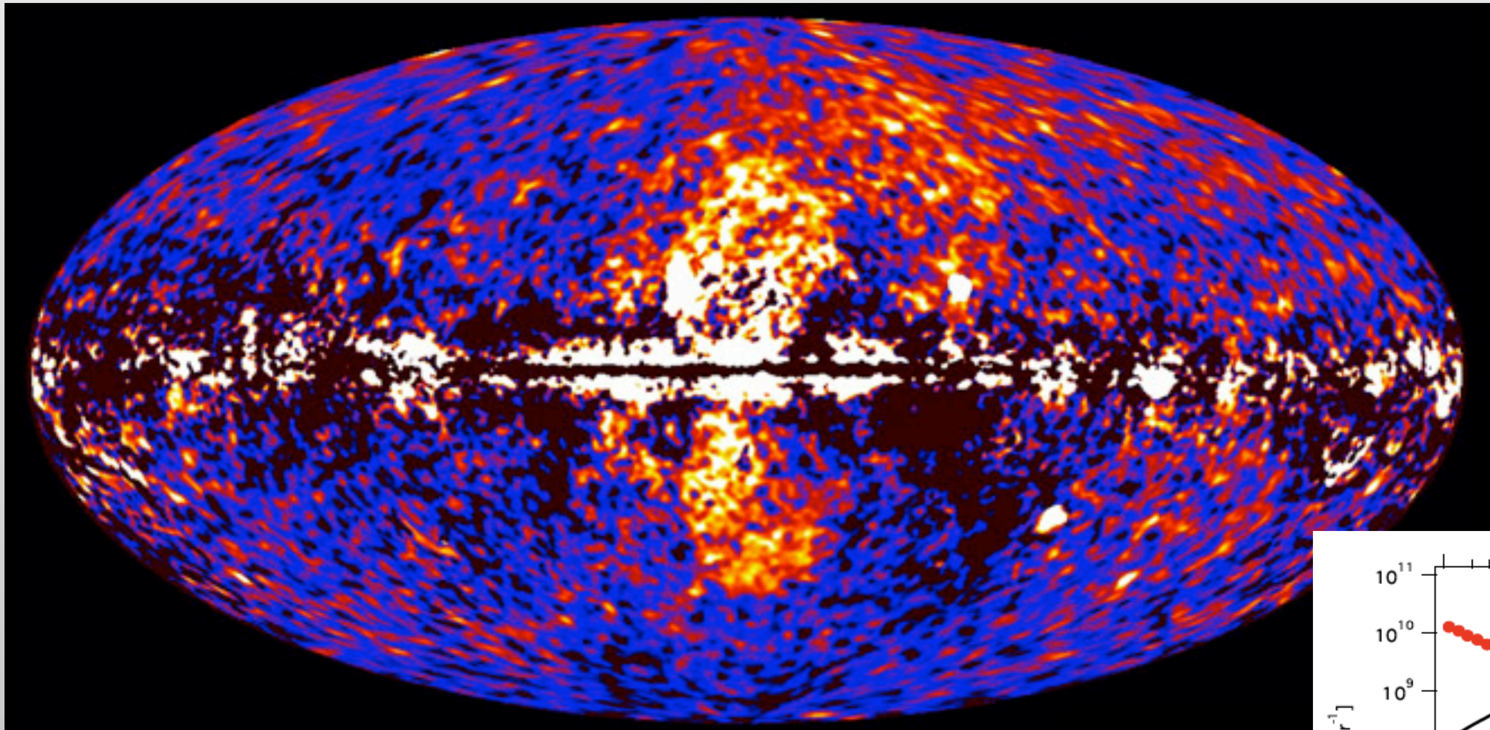
Leptonic SSC
B is too weak

SPB +Sync Pγ
Jet energy 10^{49}erg/s

SPB + Sync, BLR Pγ

Modeling by M.Boettcher et al.

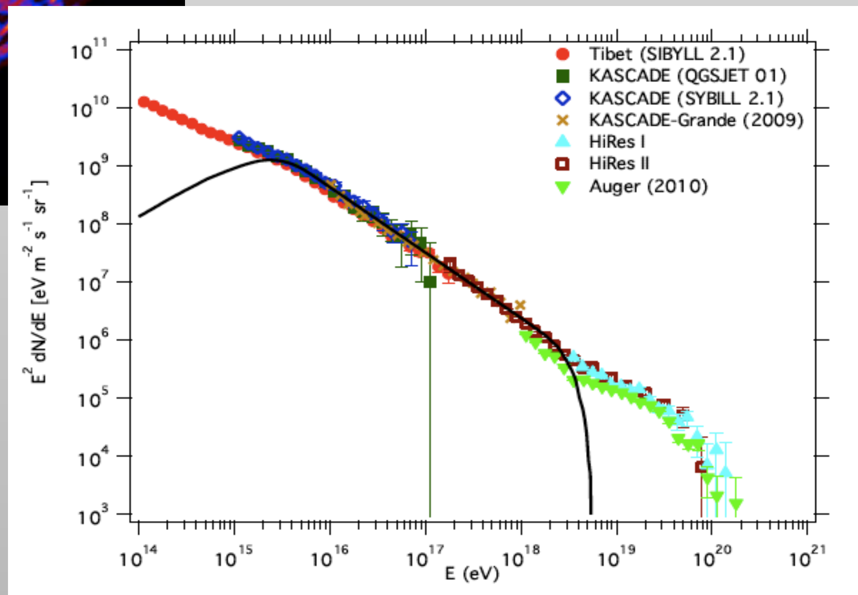
Large structure in our galaxy
Fermi bubble



Source for Cosmic rays above knee??

Re-acceleration of CR?

$\sim 10^{52}$erg / 30,000yrs



Chernyshov et al. 2011

Symmetry suggests relation to Galactic Center
Hard Energy Spectrum ($dN/dE \sim E^{-2}$)
Extends up to 10kpc above the disk (cooling time problem)
Edges are not clear

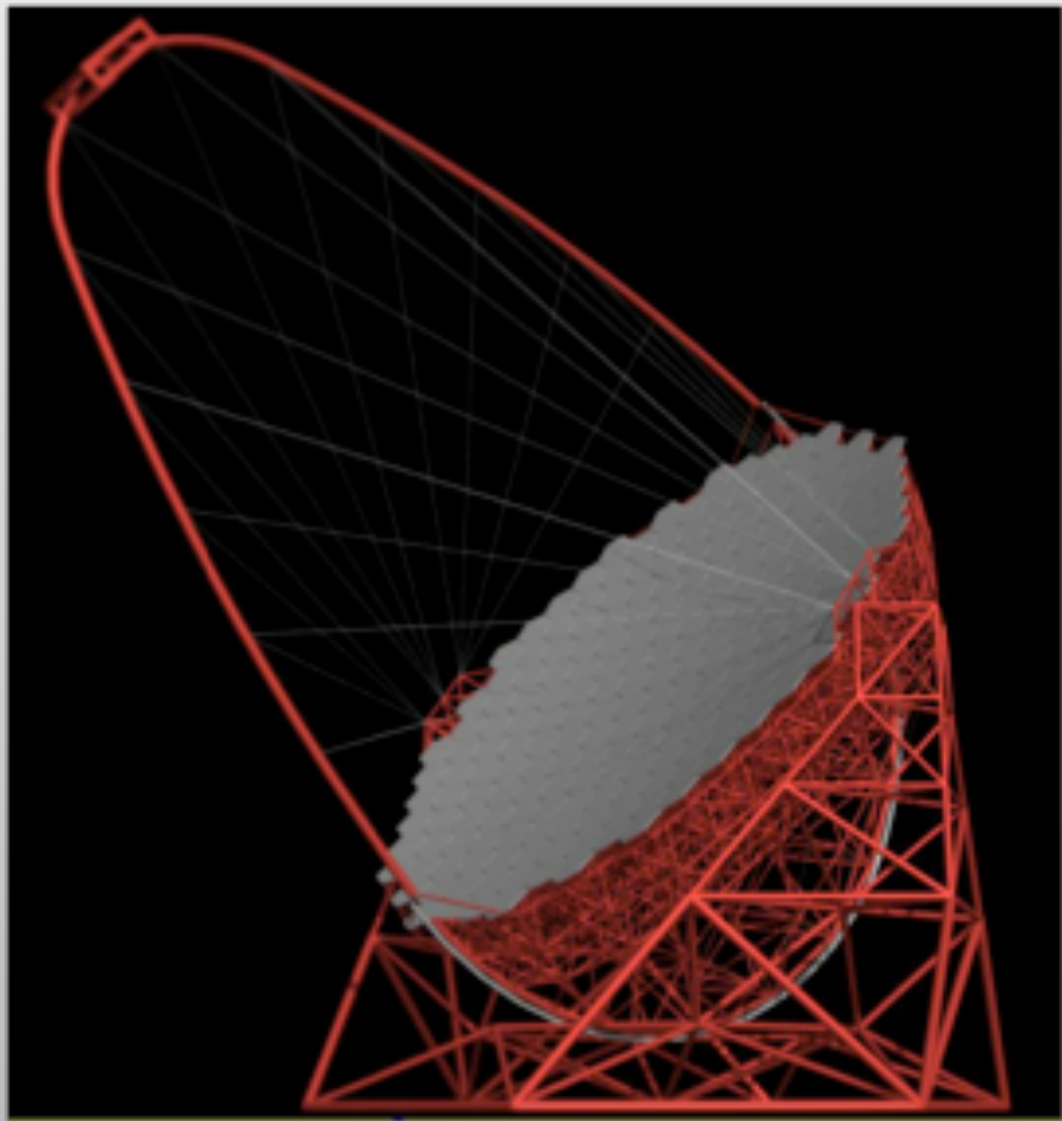
Specifications/Requirements of LST

- Diameter: 23m
- Dish area: 407 m^2
- F/D = 1.2, F=28m
- Dish profile: Parabolic
- Permanent Active Mirror Control

- FOV = 4.5 degrees, Pixel size = 0.1 degrees (1855ch camera)

- Total weight ~ 60 tons
- Fast rotation: <180 deg/20 sec

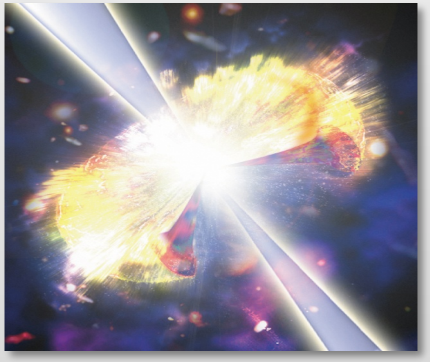
- Dish profile: parabolic ➔ isochronicity: <0.6 ns RMS
- Camera sagging: < 1 pixels
- Camera oscillation in wind gust: <8mm

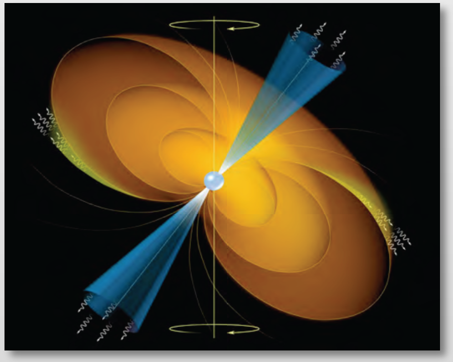


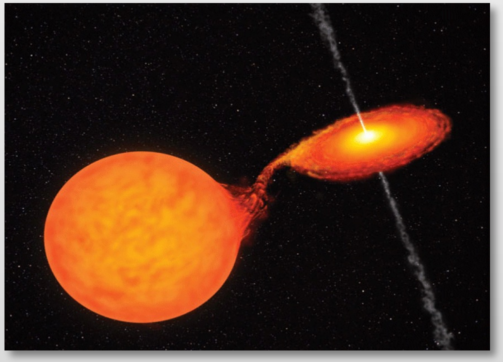
Designed by MPI Munich and MERO

Science case of LST


High redshift AGNs (z<2)


GRBs (z<4)

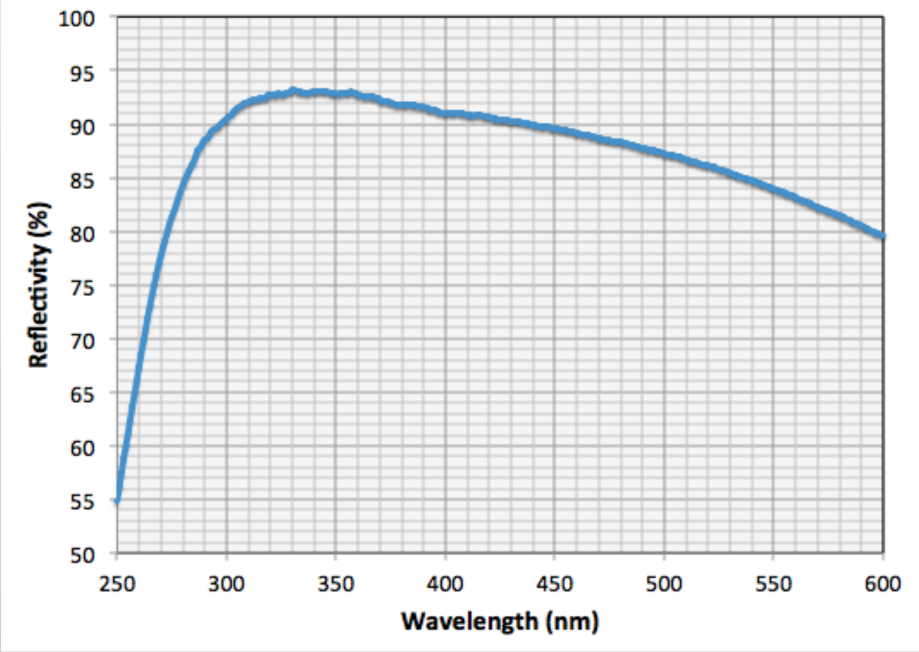

Pulsars


Binaries and transients

- LST should be optimized in the energy range between 20 - 200 GeV
- Low energy threshold
  - Trigger threshold: 15-20 GeV
  - Analysis threshold: 20-30 GeV

- key physics cases:
  - High-redshift AGNs and GRBs, **expand gamma ray horizon**
  - Binaries, Pulsars and other type of transients at low energy

1510mm LST MIRROR prototype at Sanko
2.7mm Glass+60mm Al.Honeycomb+2.7mm Glass

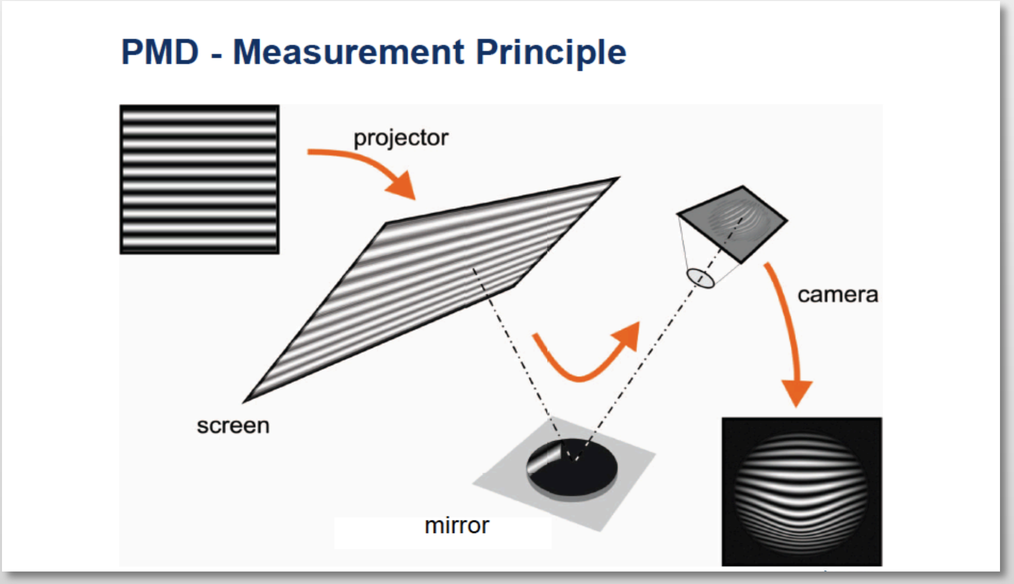


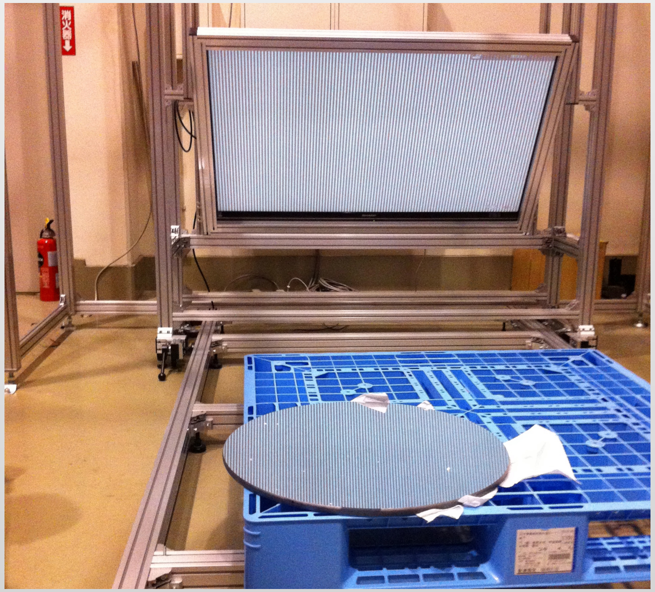
Specifications

- F2F : 1510mm
- Area : $2m^2$
- R: 56.0 – 58.4 m
- D80 : 10mm(1/5 pixel)
- Weight : 45kg

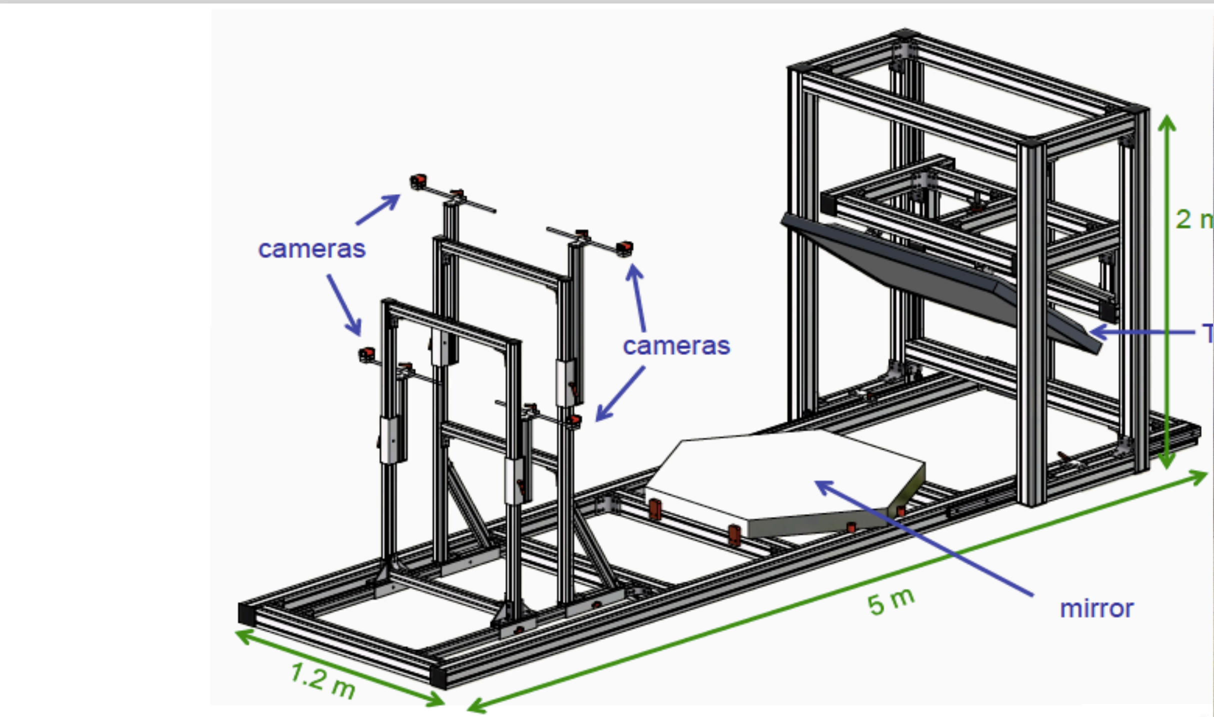
- Sputtering multi layer coat
  - ➔ Cr + Al + SiO2 +HfO2 + SiO2
- Reasonably High reflectivity
- Strong protective surface
  - ➔ Long life time

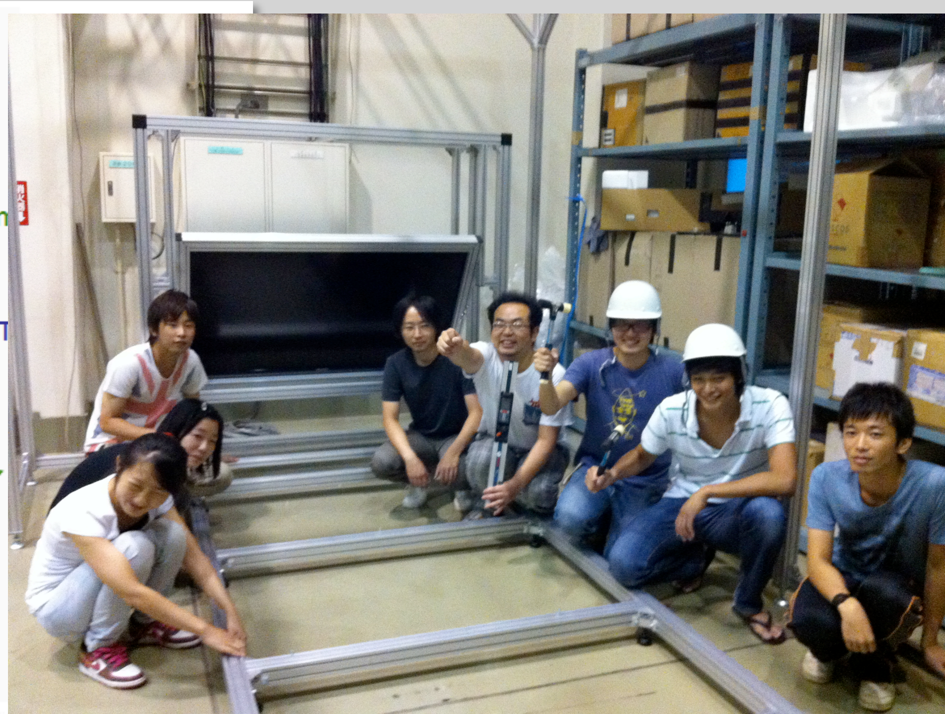
PMD system is installed at ICRR, U-Tokyo (developed by experts of Erlangen optic group)



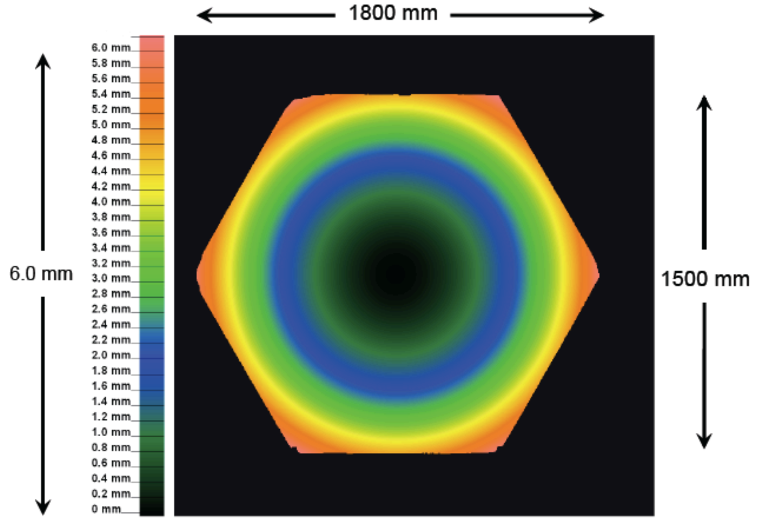


Installed at ICRR
U.Tokyo

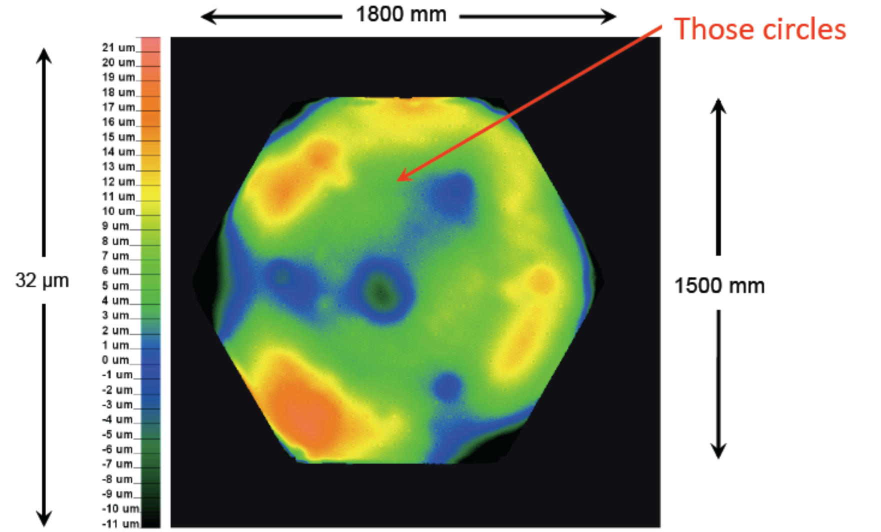




Sanko Mirror #01



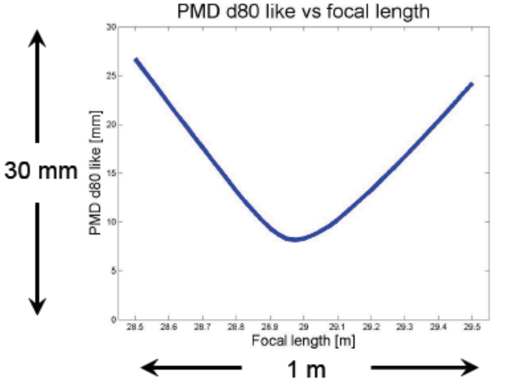
Height [mm] Shape



Height [µm] Shape deviation from sphere

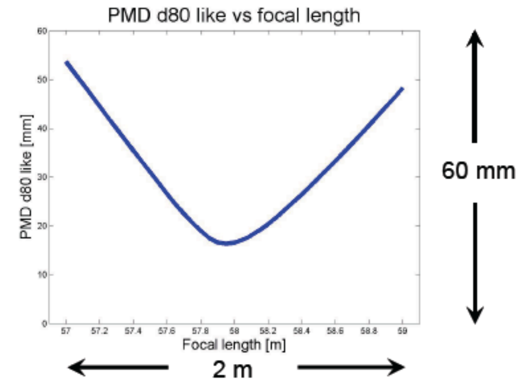
Mean: 5.8 µm
Sigma: 6.6 µm

Parallel light from infinity



minimum @ 28.975 m
d80 = 8.15 mm

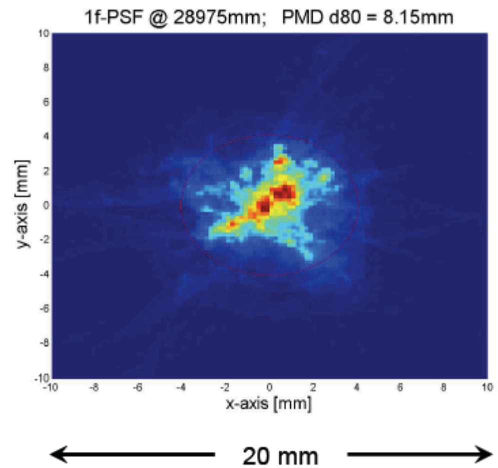
Point source in 2f distance



minimum @ 57.950 m
d80 = 16.35 mm

PSF for parallel light

Minimum @ 28.975 m

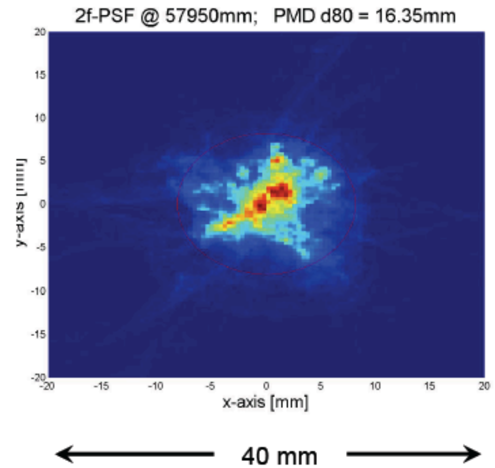


d80 = 8.15 mm

Δz = 25 mm; Δd80 = 0.05 mm

PSF for 2f distance

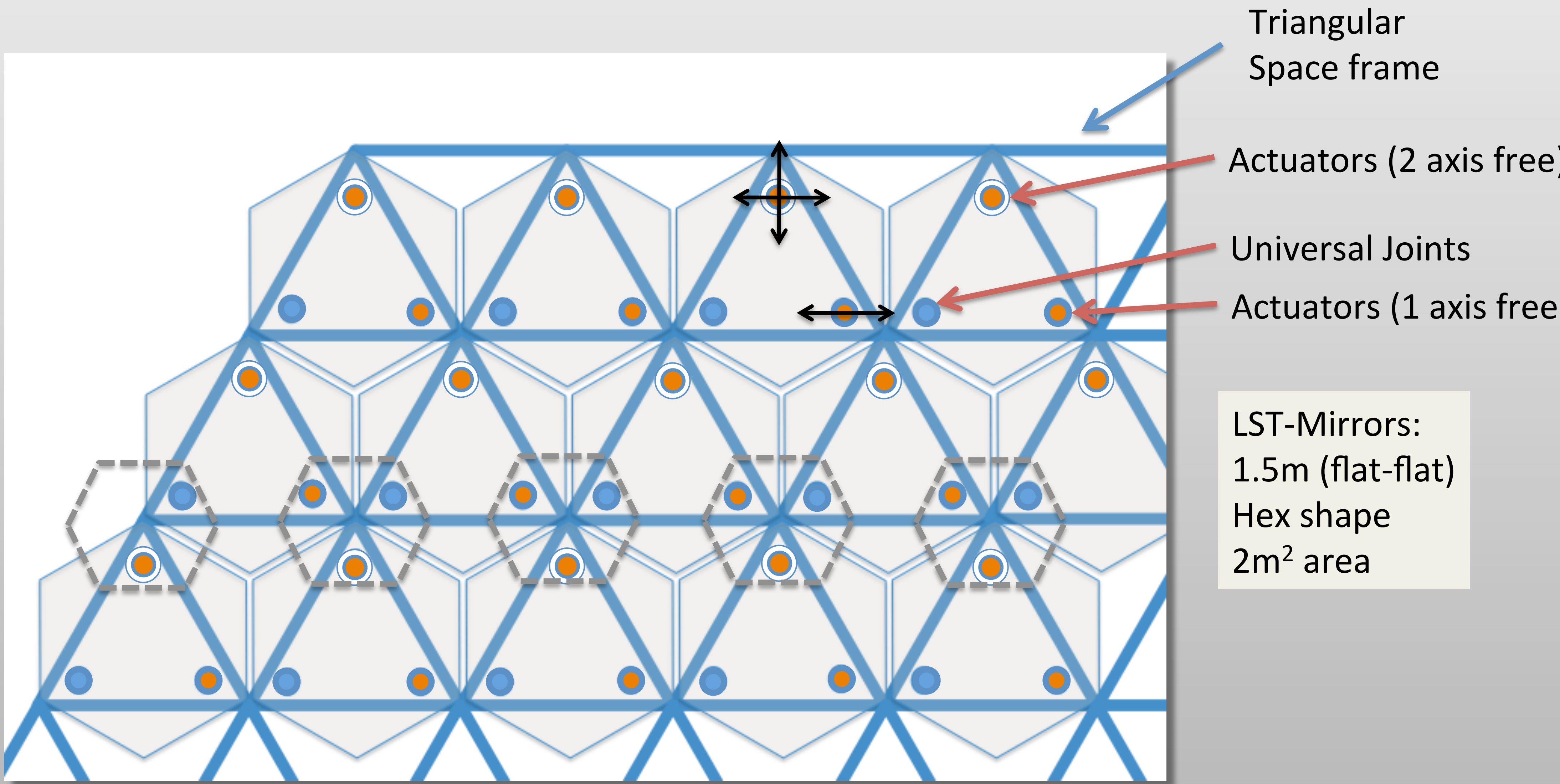
Minimum @ 57.950 m



d80 = 16.35 mm

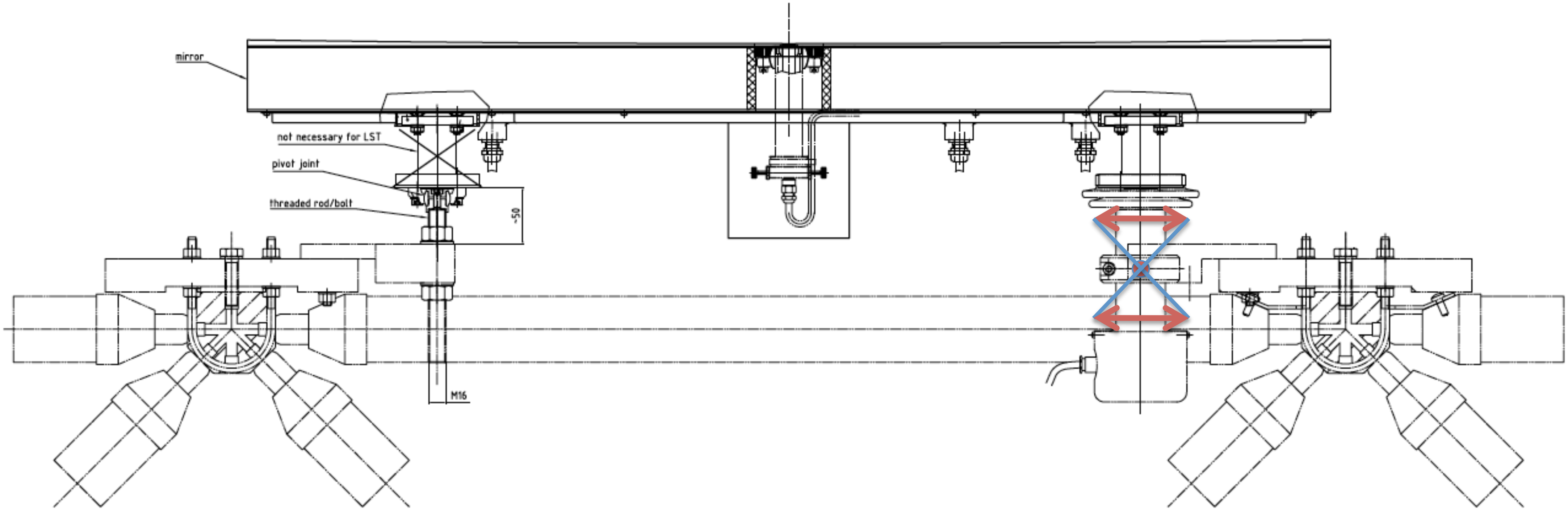
Δz = 50 mm; Δd80 = 0.05 mm

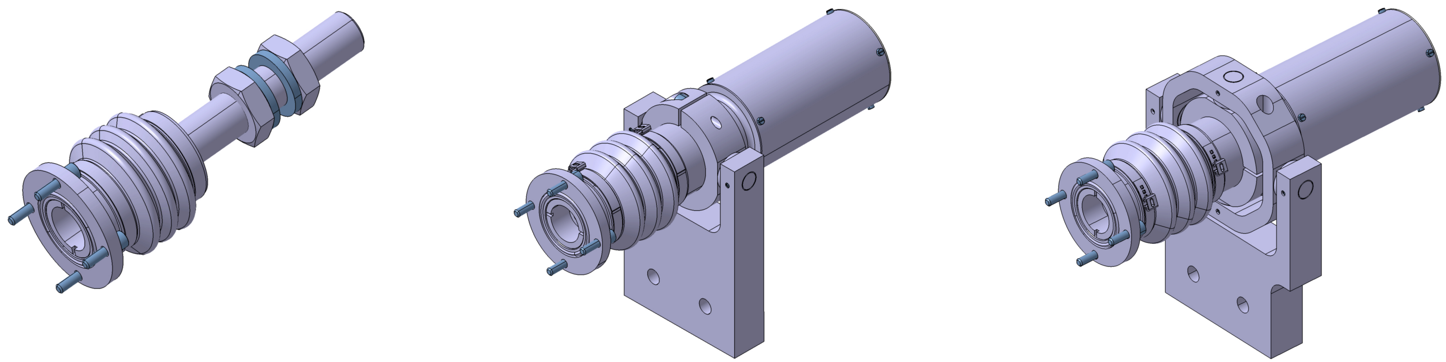
Mirrors and Actuators on Triangular space frame



LST-Mirrors:
1.5m (flat-flat)
Hex shape
$2m^2$ area

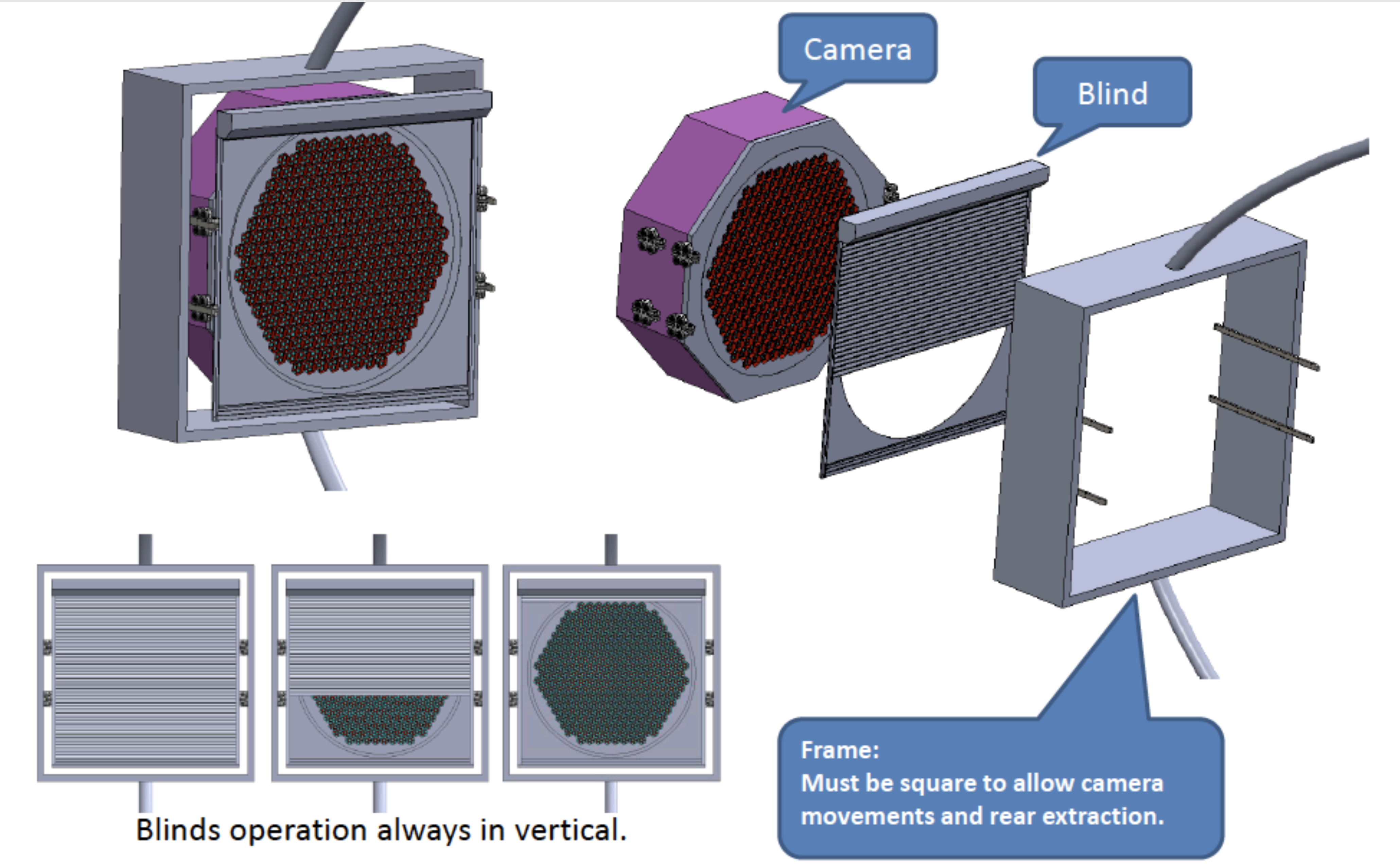
Mirror mounting scheme





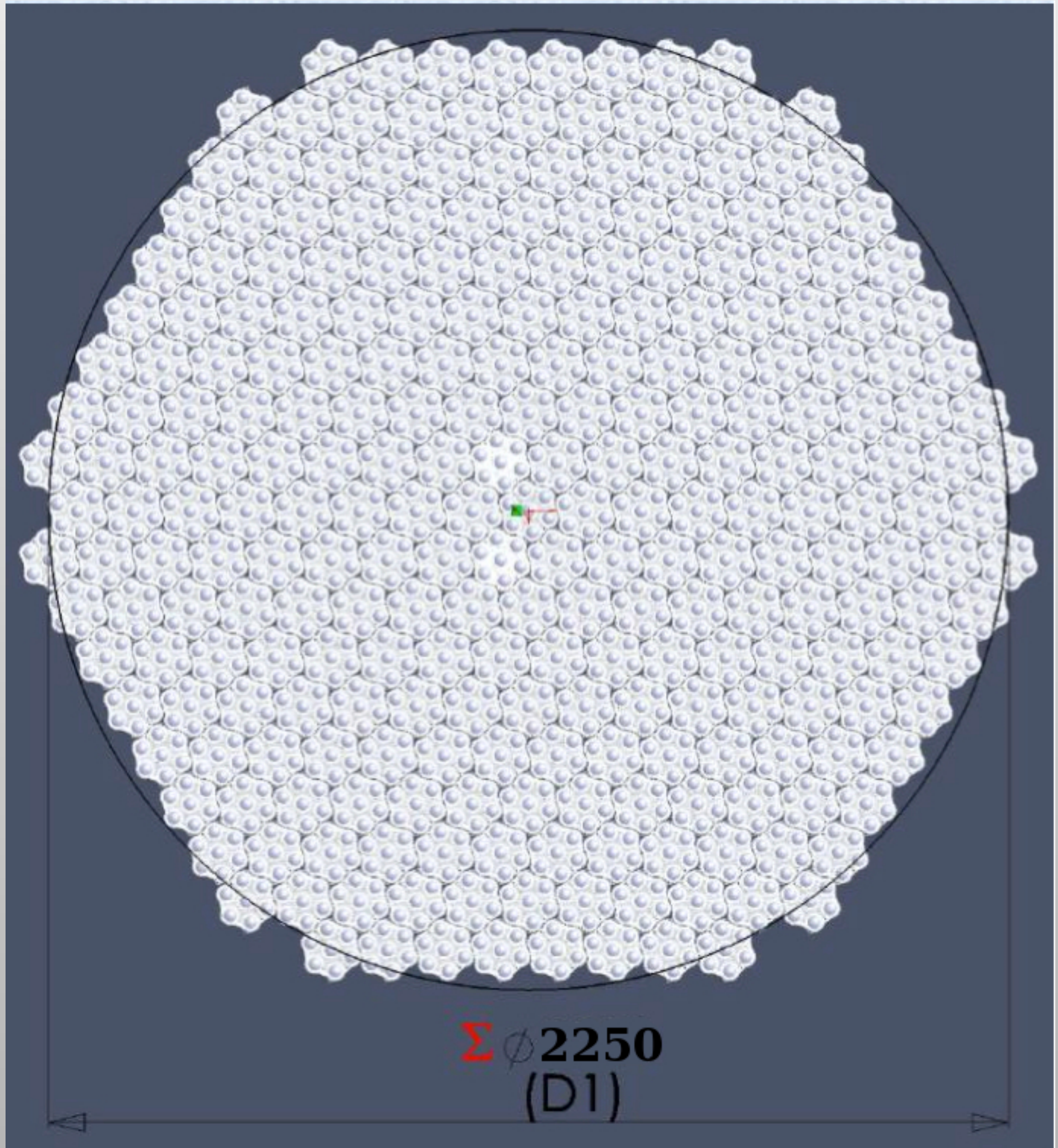
MAX-PLANCK-INSTITUT FÜR PHYSIK
Werner-Heisenberg-Institut
Föhringer Ring 6
80805 München
M 1:5
Datum: 01.12.2010
Projekt: CTA
Zeichnungsnr: Mirror support M-II
Sachbearbeiter: H. Wetteskind
MPI MÜNCHEN

Camera and Blind Structure



LST-Camera 265 clusters/1855 pixels
(0.1°pixel, FOV 4.5°, Weight< 2 ton)

W = 68kg



Clusters 1.33kg x 265 <400kg
Two cooling plates <500kg

Plex glass < 70kg
Cables, Switching hub < 100kg
Power module <150kg

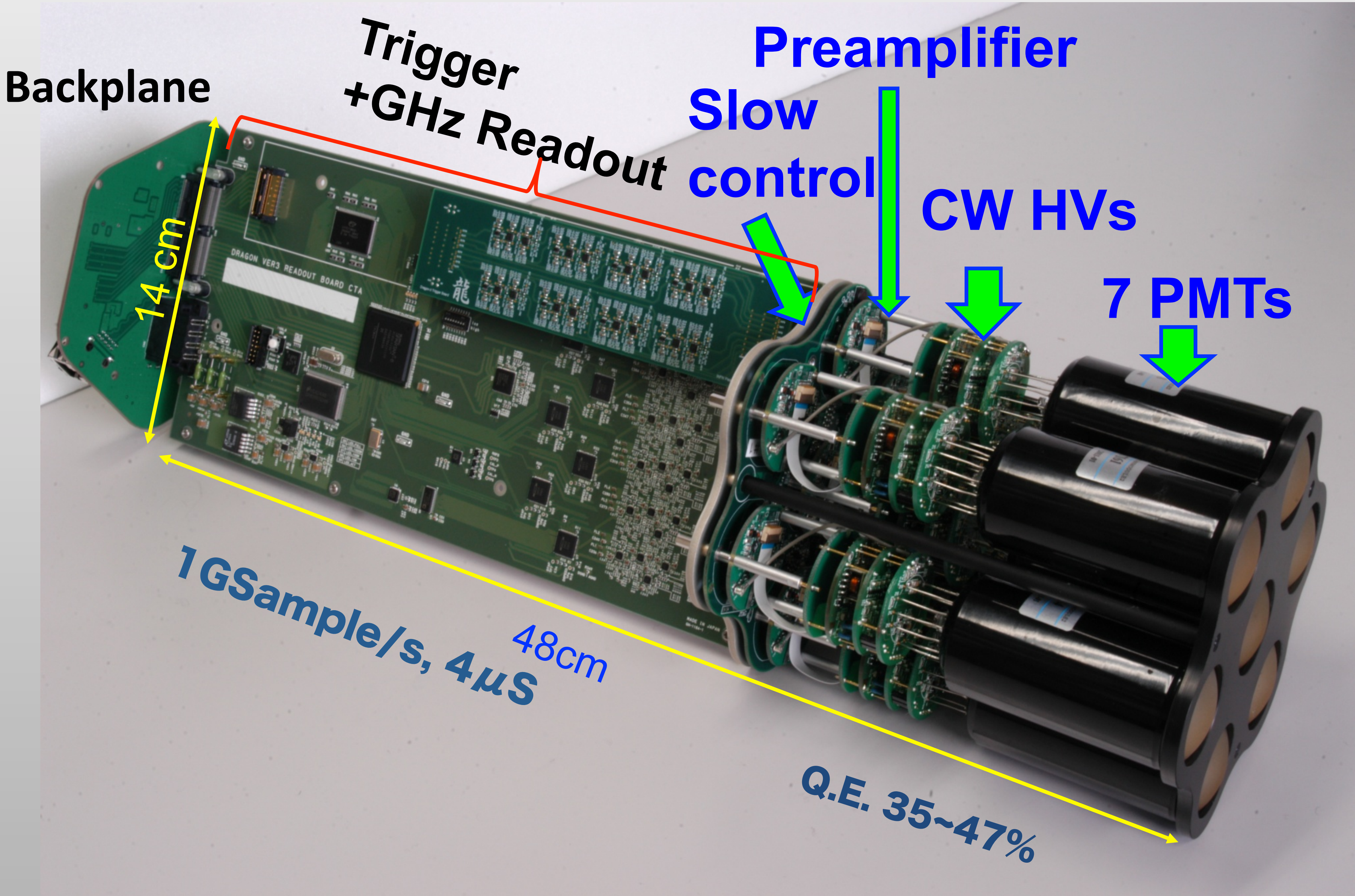
Supporting frame < 100kg
Skin of Camera < 200kg
Interface with Arch < 100kg
Garage door < 200kg

Total <1820 kg

< 2 tons

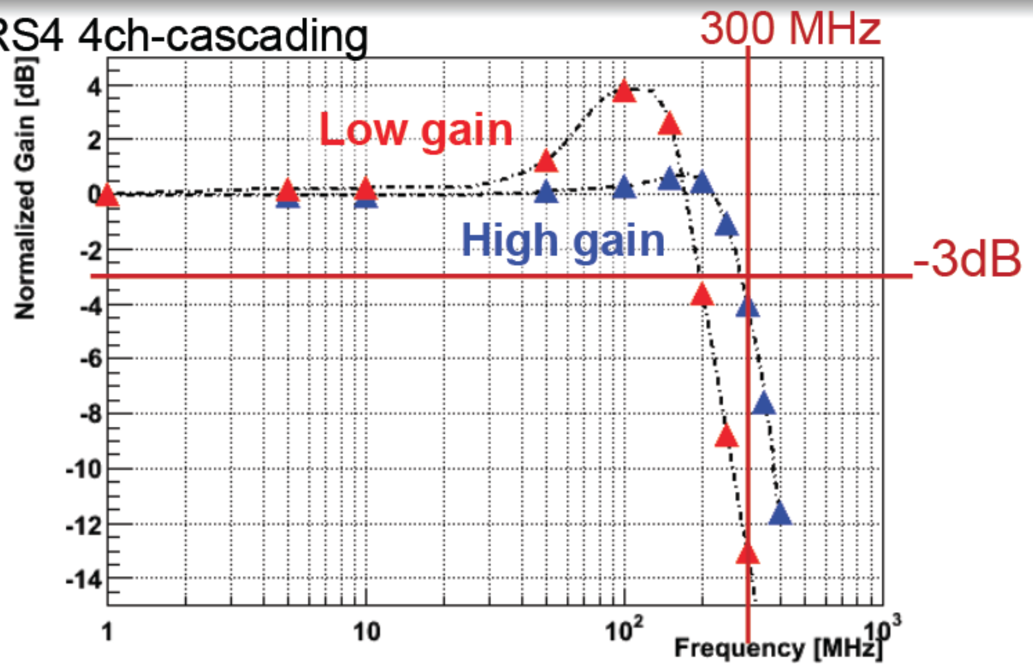
Camera Cluster

(7 PMTs, HVs, Amplifiers, Slow Control, GHz Readout)



Bandwidth of DRS4 Readout Board

with DRS4 4ch-cascading



<u>Bandwidth(-3dB)</u> (requirement is not

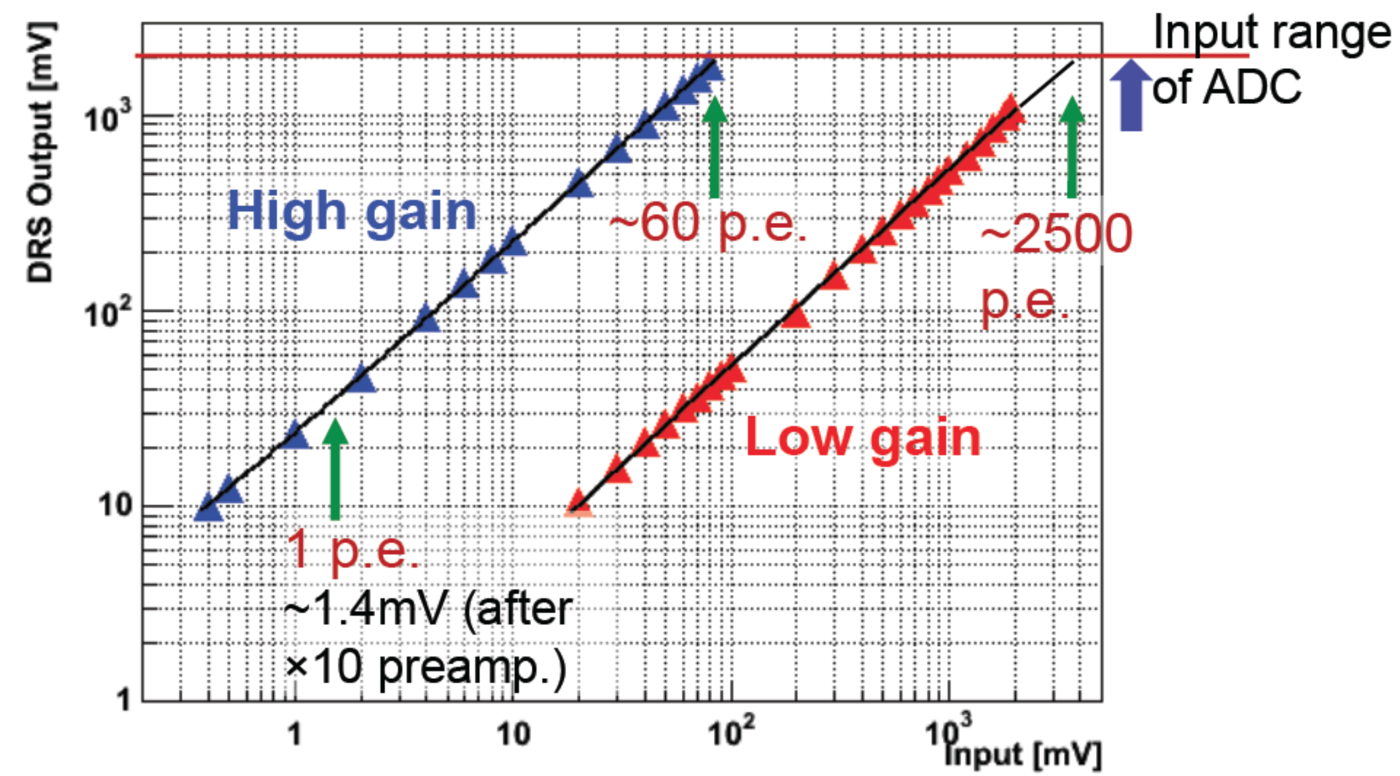
High gain: 275 MHz OK or not

Low gain: 200 MHz OK

Trigger: >350 MHz OK

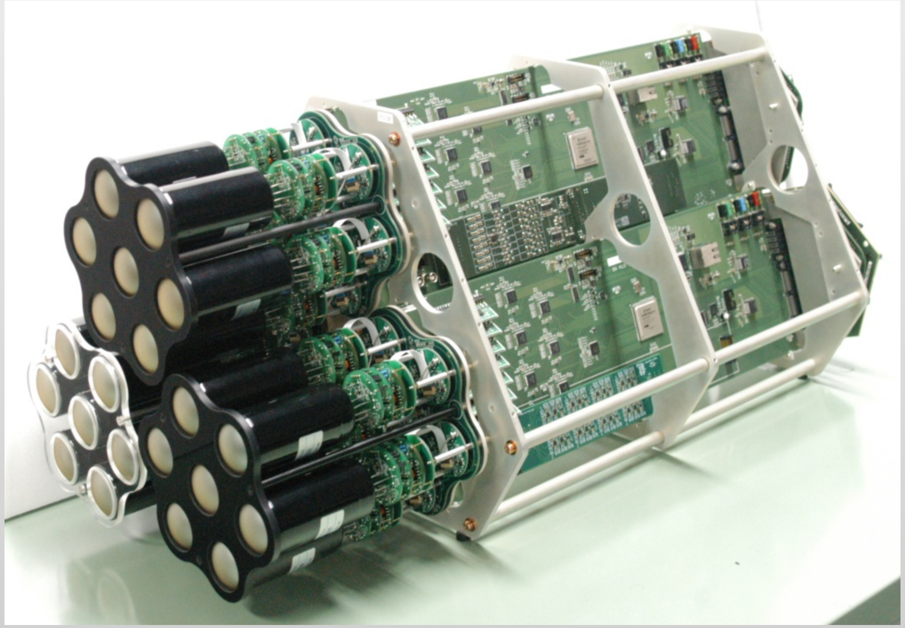
BW is lowe

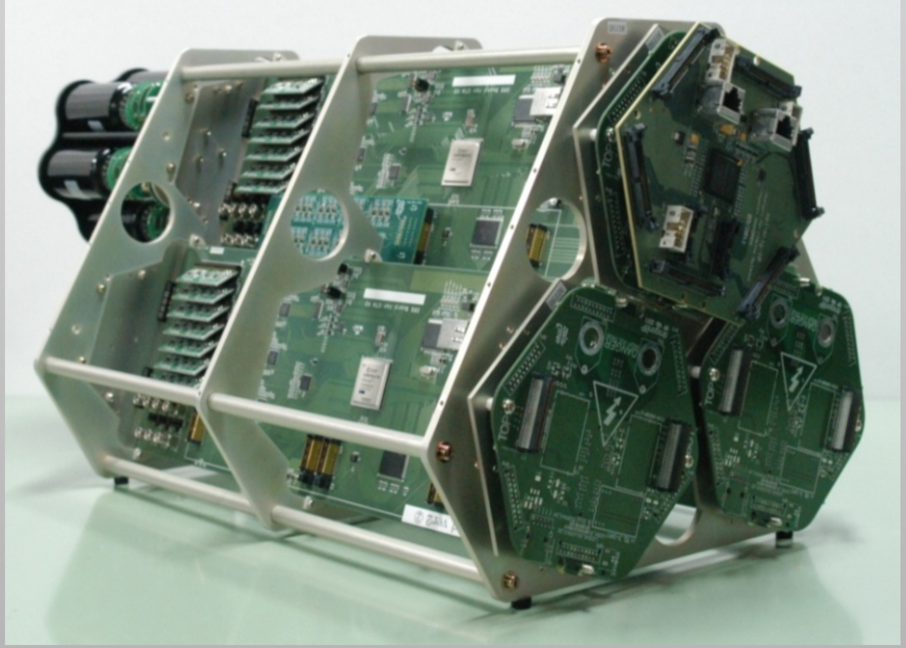
capacitanc



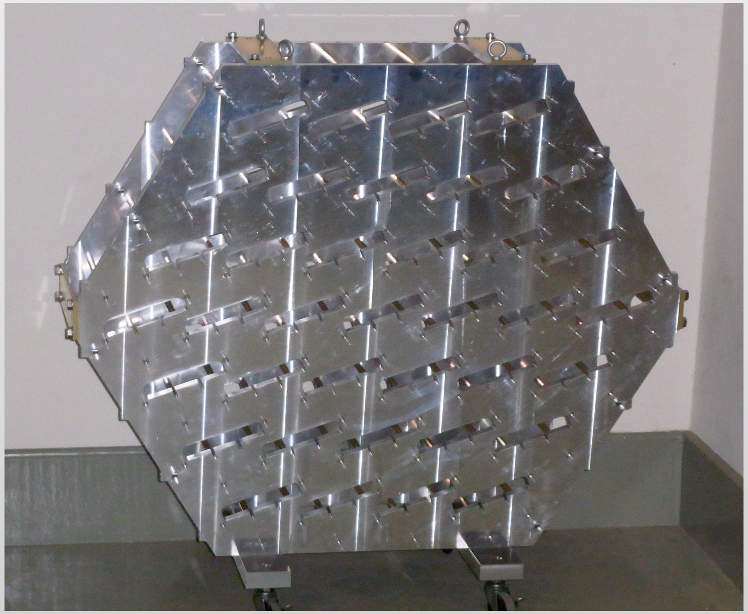
3 Clusters Camera & Water Cooling System

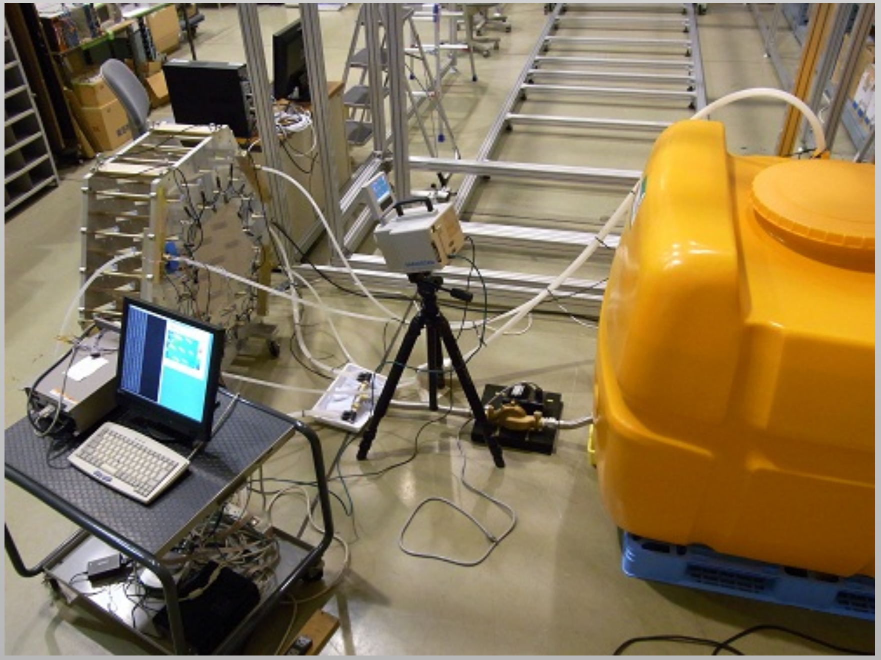
Trigger test with 3 clusters



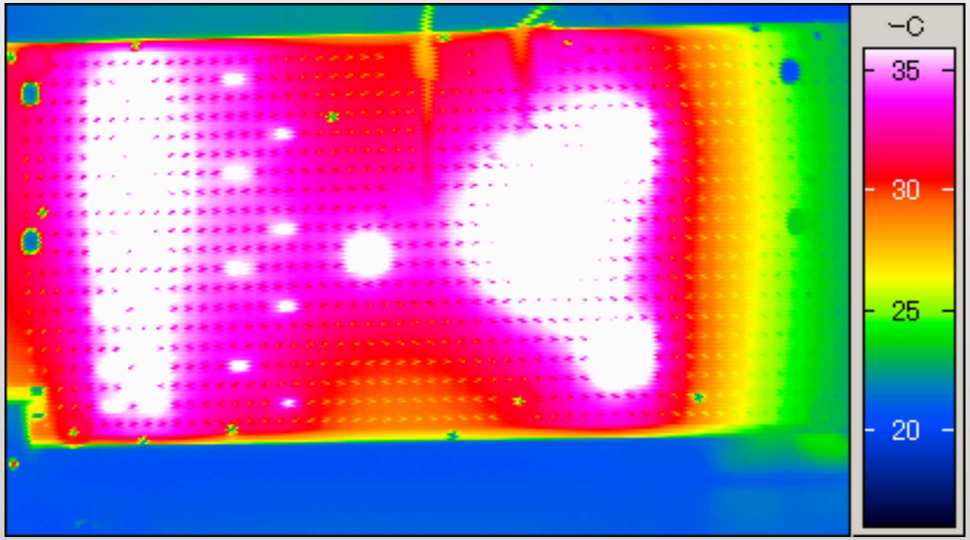


Cooling plate 1/8 model





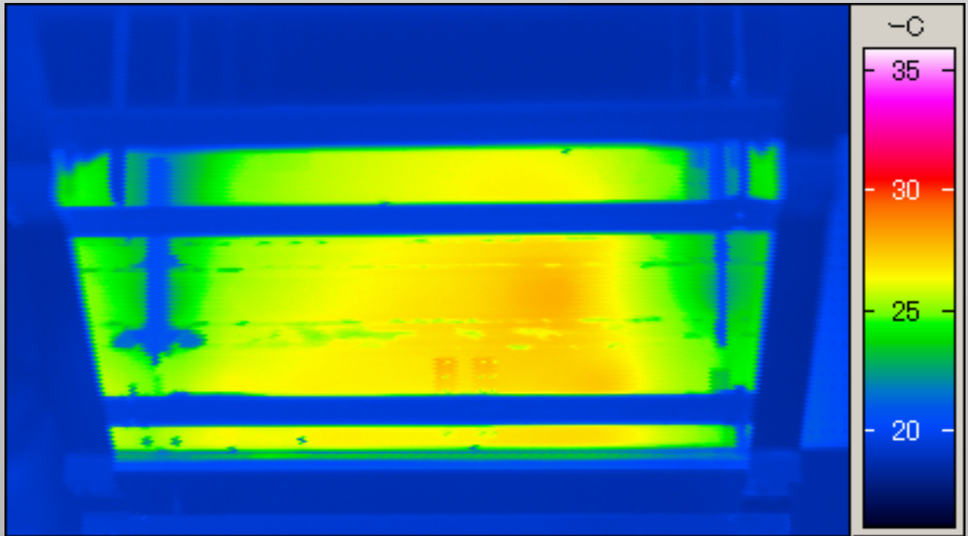
Testing cooling of DRS4-sim-PCB



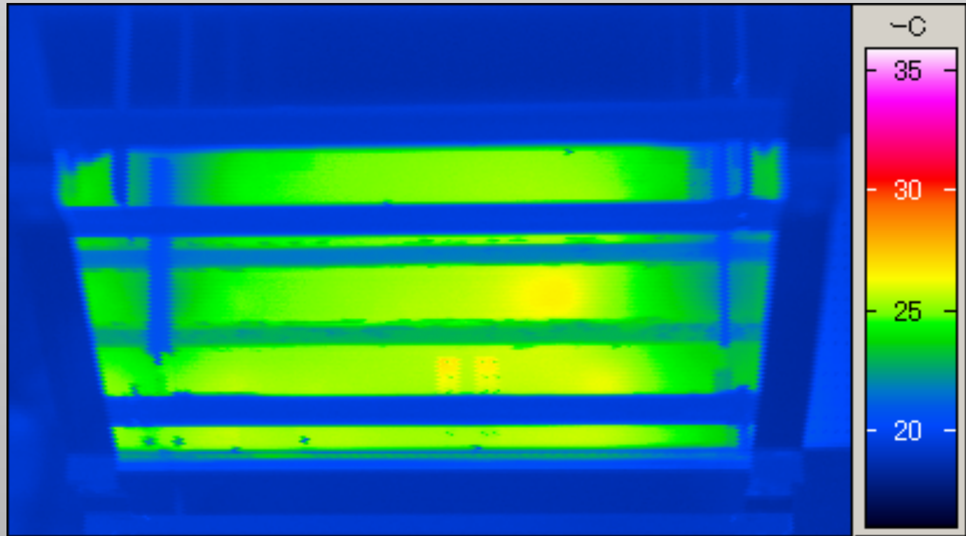
w/o Aluminum plate, heat pipes, floating

The location of FPGA shows 70 degreees.

Just with Al. Plate is not so bad.
With Al. plate + cooling pies looks better



w Al. plate, contact to Water C.P.



w Al. plate, heat pipes, contact to Water C.P.

CTA Japan Organization (85 scientists)

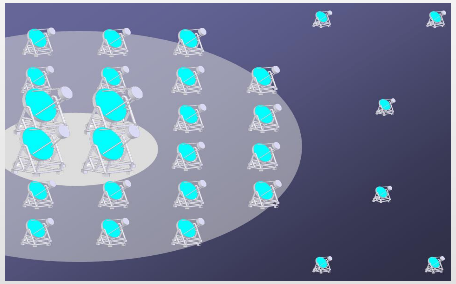
PHYSICS WG
IOKA（KEK）
KEK, Kyoto, Aoyama, Ibarak

CTA-Japan PI
M.Teshima（ICRR）

Management

CTA Japan PI	M.Teshima (ICRR)
CTA Japan Co-PI	H.Kubo（Kyoto）
CTA Japan Chair	T. Totani（Tokyo）
CTA Japan SBO	T.Yoshida（Ibaraki）

MC WG
T.Yoshikoshi(ICRR)
ICRR, Konan, Tokai



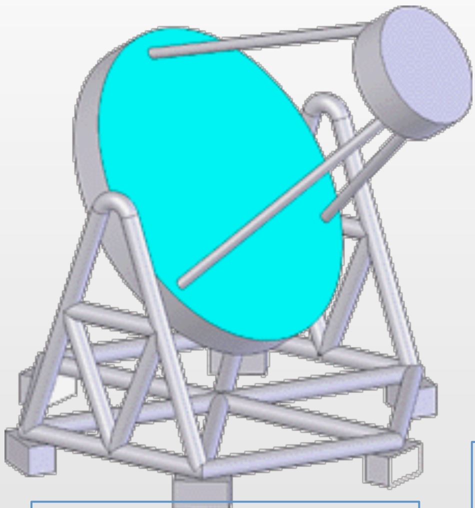
CTA LST Prototyping
Project Coordinator
M. Teshima（ICRR）

MIR WG
M. Teshima (ICRR)
ICRR, Kinki, Konan, Ibaraki, Sanko, etc.

FPI / CAL WG
T. Yamamoto（Konan）
ICRR, Ibaraki, Konan, Saitama, Aoyama, Hamamatsu, etc.

Ampl./Slow Control
ICRR, Tokushima, Kyoto, Ibaraki

Dual Mirror Cam
H. Tajima (Nagoya)



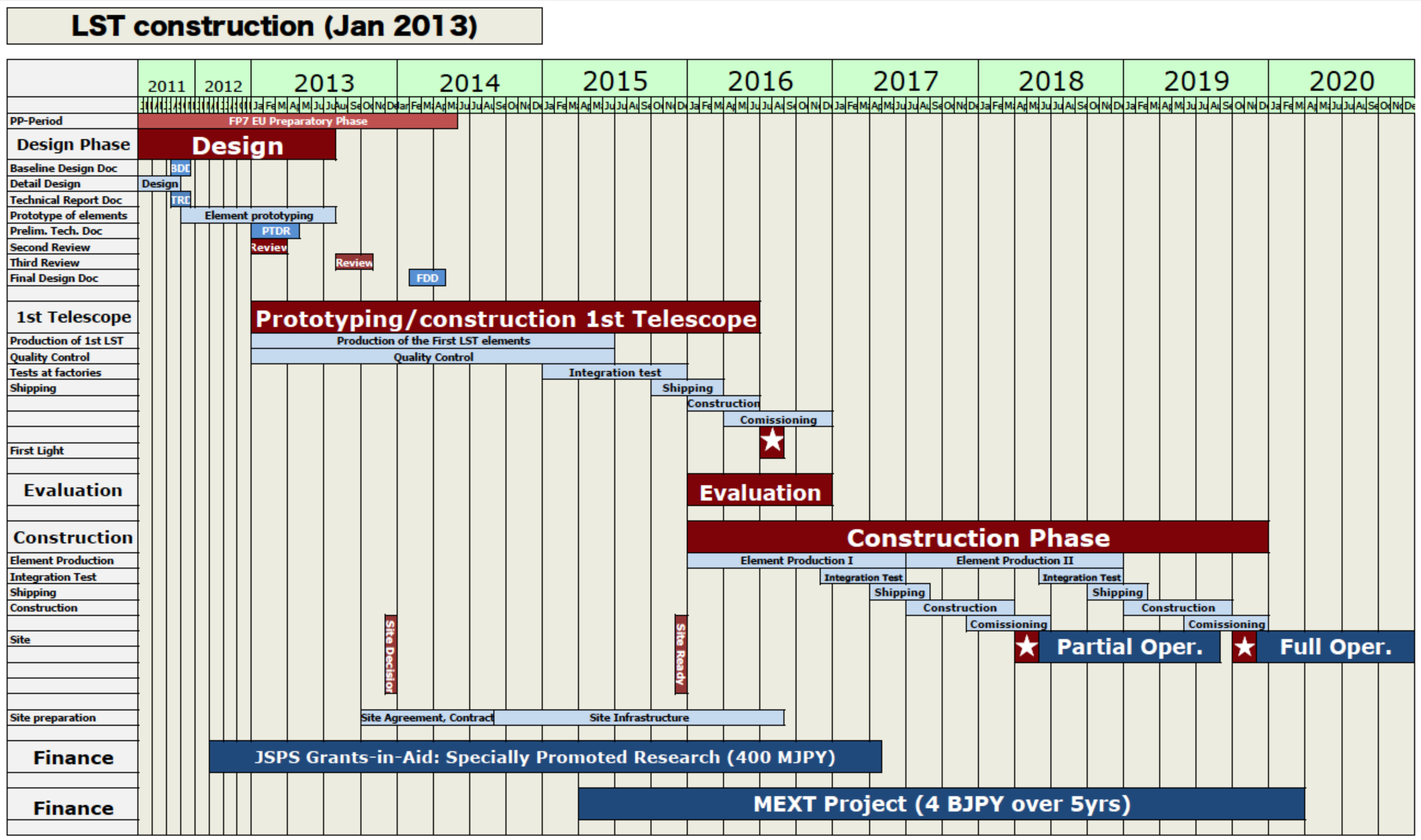
ELEC WG
H.Kubo（Kyoto）
Kyoto, KEK, Yamagata, etc.

Telescope Drive
Spain

Telescope Structure
Germany, MPI

CAMERA Supporting Arch
France, IN2P3, LAPP

Time Schedule for LST construction



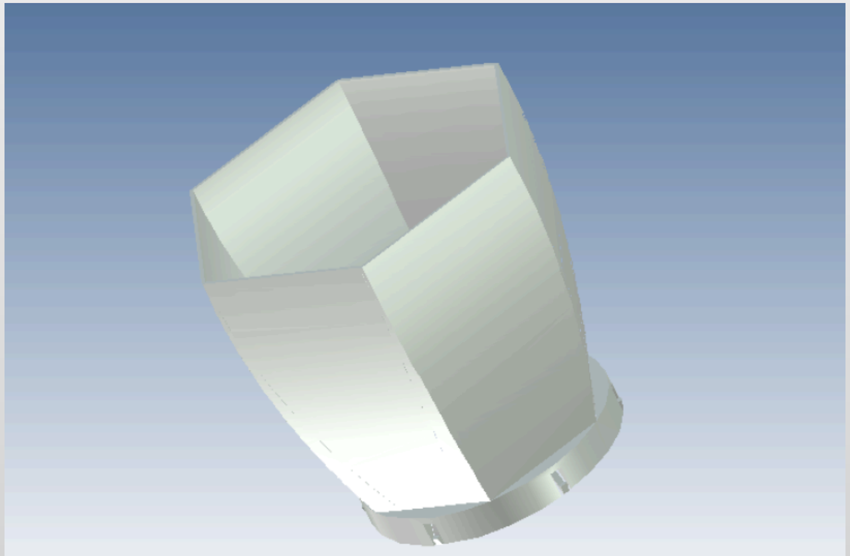
Summary

- CTA is an international ground-based gamma ray observatory
- CTA will expands the visible Universe
  - Science of CTA is very wide
    - Origin of Cosmic Rays, Study of High Energy Objects, Cosmology, Dark Matter
  - New Classes of sources
  - Deep Universe

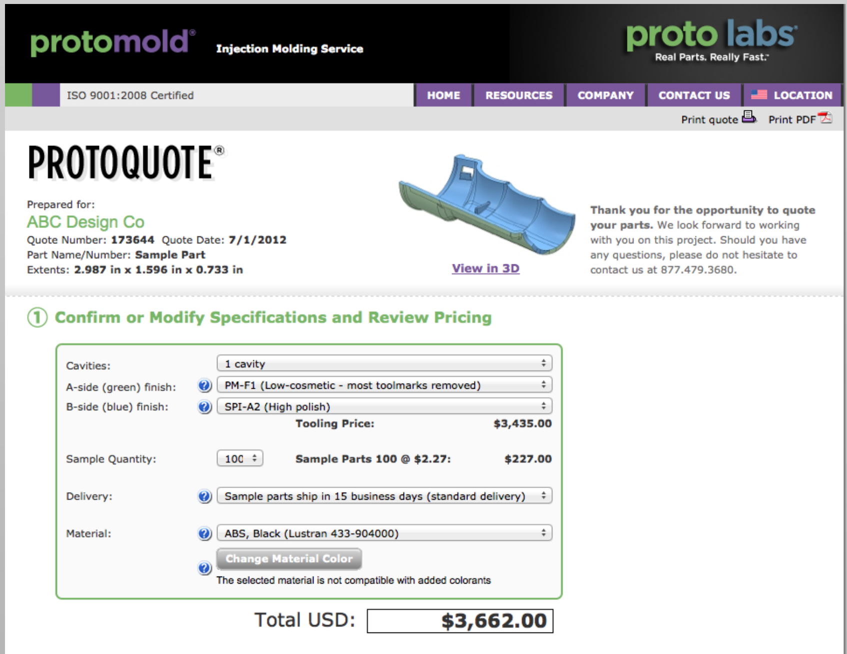
- **CTA Japan Consortium** will make a significant contribution to the CTA construction
  - Prototype / first LST ← Grants-in-Aid
  - Construction of LSTs ← Finance from Government (more efforts)

- Increase (doubling) of manpower in ICRR is really desired
- The first LST will be built and commissioned in 2016 at CTA Site

Winston Cone Prototyping in Japan
4Euro/pcs in mass production



Designed in ICRR, Ibaraki-U and Nagoya-U



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PROTOQUOTE®

Prepared for:
ABC Design Co
Quote Number: 173644 Quote Date: 7/1/2012
Part Name/Number: Sample Part
Extents: 2.987 in x 1.596 in x 0.733 in

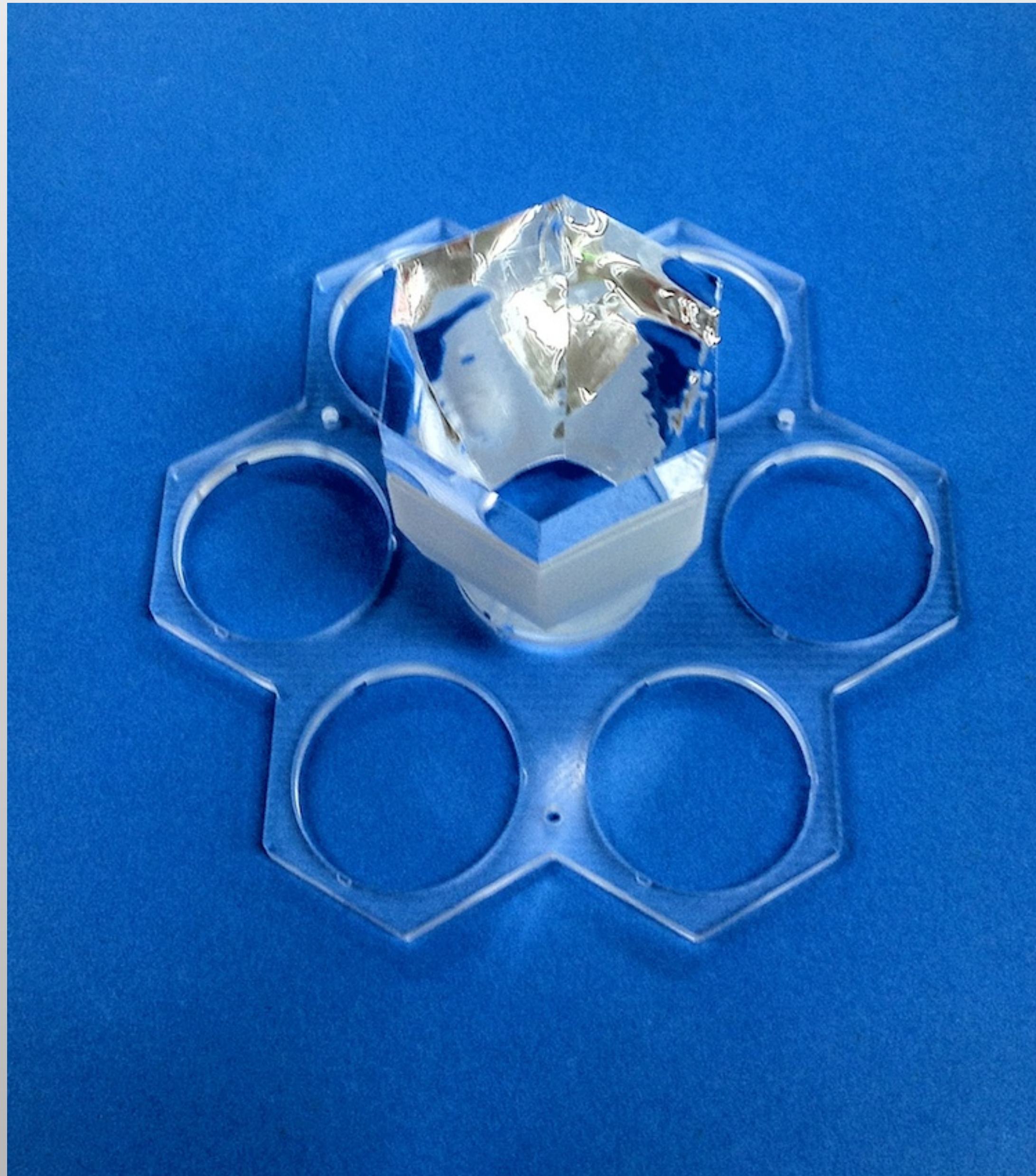
View in 3D

Thank you for the opportunity to quote your parts. We look forward to working with you on this project. Should you have any questions, please do not hesitate to contact us at 877.479.3680.

① Confirm or Modify Specifications and Review Pricing

Cavities:	1 cavity	
A-side (green) finish:	PM-F1 (Low-cosmetic - most toolmarks removed)	
B-side (blue) finish:	SPI-A2 (High polish)	
	Tooling Price:	$3,435.00
Sample Quantity:	100 Sample Parts 100 @ $2.27:	$227.00
Delivery:	Sample parts ship in 15 business days (standard delivery)	
Material:	ABS, Black (Lustran 433-904000)	
	Change Material Color	
	The selected material is not compatible with added colorants	

Total USD: $3,662.00



CAMERA Cluster Design