



**The Abdus Salam
International Centre for Theoretical Physics**



2246-23

**Workshop on Cosmic Rays and Cosmic Neutrinos: Looking at the
Neutrino Sky**

20 - 24 June 2011

The CTA Observatory

Bruno KHELIFI

*Ecole Polytechnique, Palaiseau
France*

CTA

Cherenkov Telescope Array



Trieste, June 2011
Bruno Khélifi, France
(H.E.S.S., CTA)

LM



Outline



- A bit of gamma-ray history
- Science motivation
- The CTA project
- Technical Development

A bit of gamma-ray history...



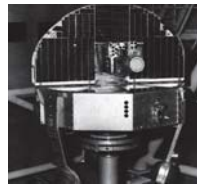
1961



Explorer XI, 31 γ

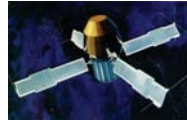
OGO
OSO
Vela
Cosmos

1967



OSO III, 621 γ

1972



SAS II
Geminga
Diffuse em.

1975/82



COS B
25 sces

1991/00



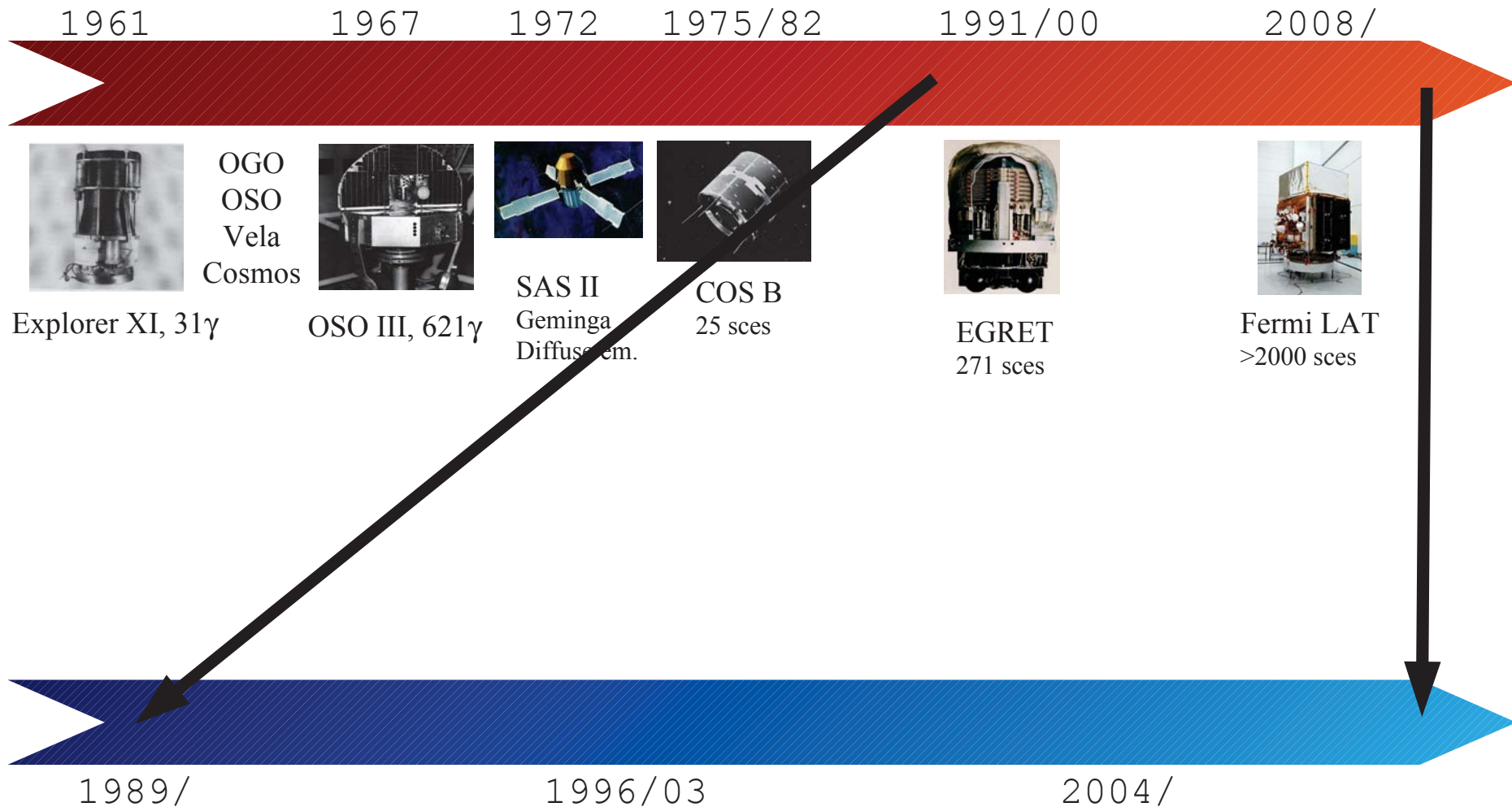
EGRET
271 sces

2008/



Fermi LAT
>2000 sces

A bit of gamma-ray history...



A bit of gamma-ray history...



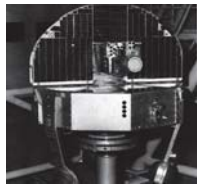
1961



Explorer XI, 31γ

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Diffuse em.

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25 sces

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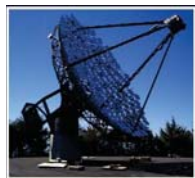
EGRET
271 sces

2008/



Fermi LAT
>2000 sces

Whipple



HEGRA-CT



CAT



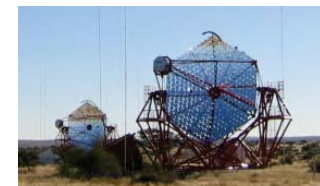
Durham Mark 6



CANGAROO



H.E.S.S.



MAGIC



1989/
Crab

1996/03
O(10) sces

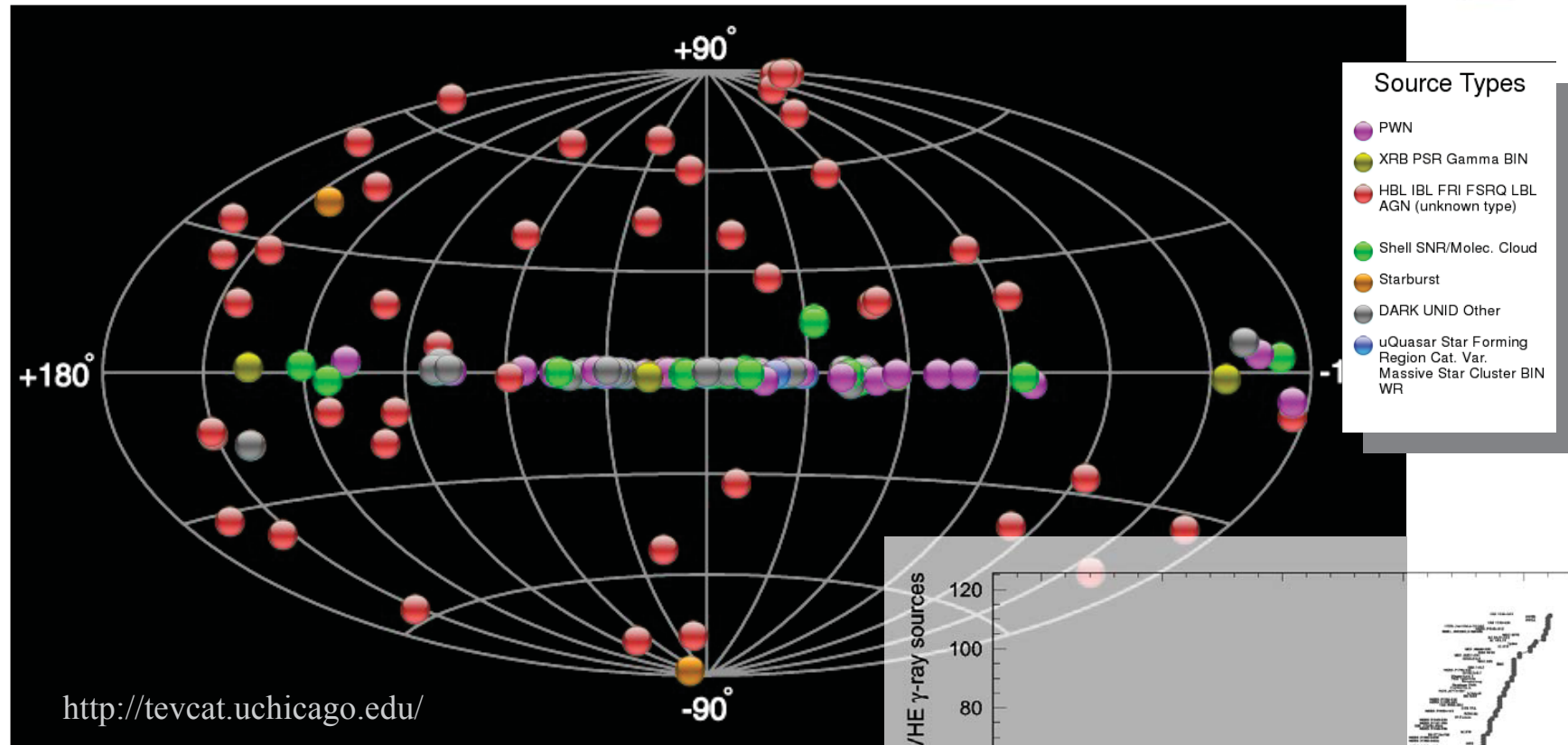
2004/
>100 sces



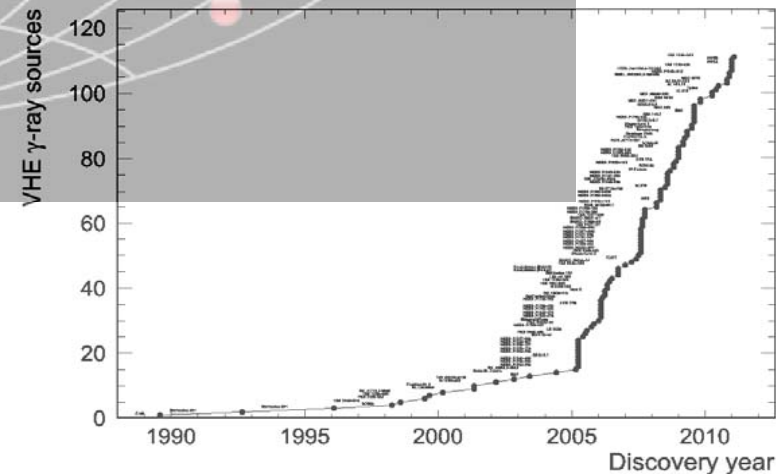
B. Khélifi, LLR

NUSKY 2011 - Trieste

Today gamma-ray sky above 100GeV



Current detections are made at the level of instruments sensitivity

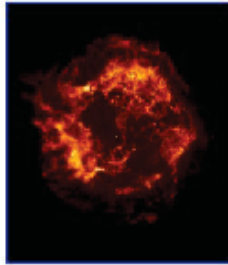


Scienza Motivation

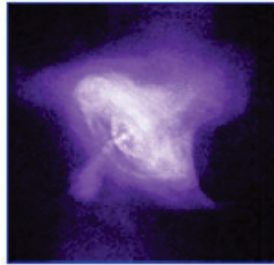


Science Motivation

Galactic



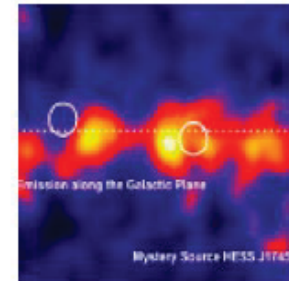
SNRs



Pulsars and PWN

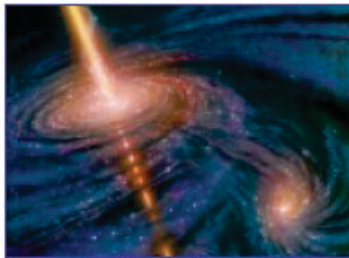


Micro quasars
X-ray binaries

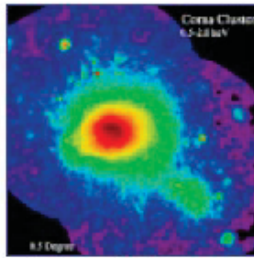


Galactic Center

Extragalactic



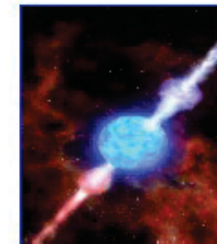
AGNs



Galaxy Clusters



Starburst Galaxies

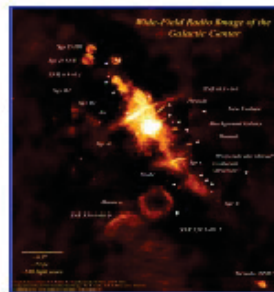


GRBs

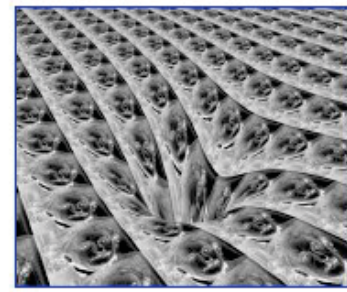
Fundamental Physics



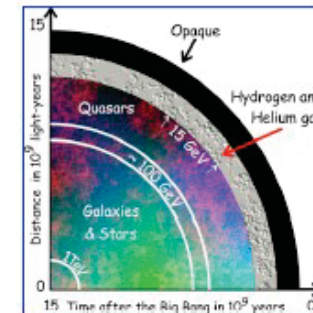
Origin of



Dark matter

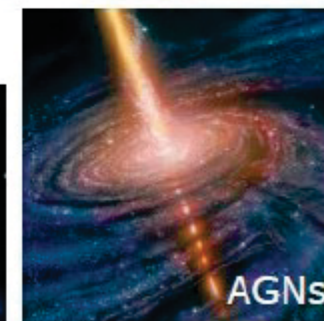
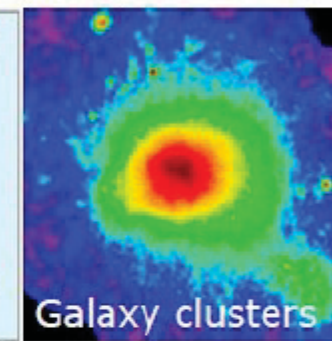
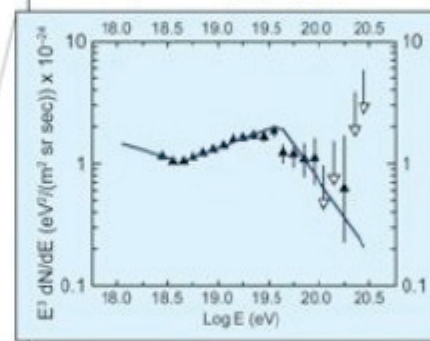
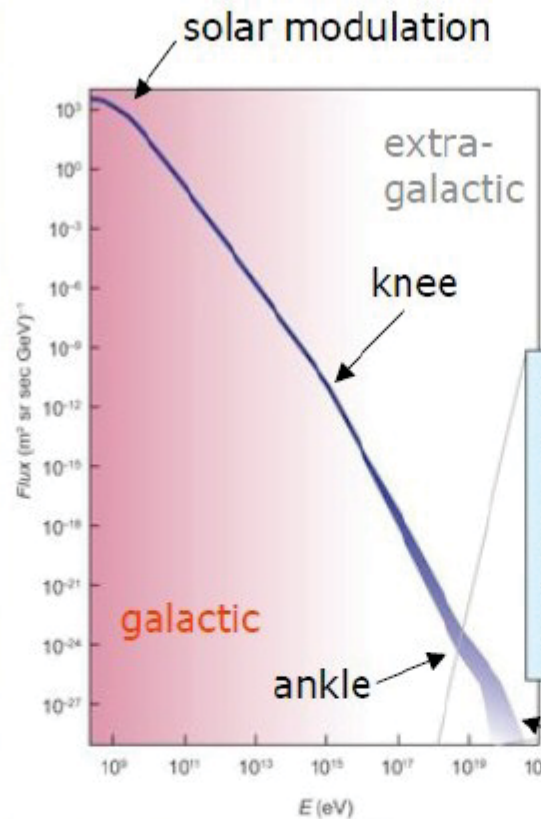
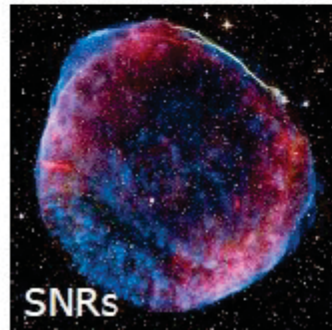
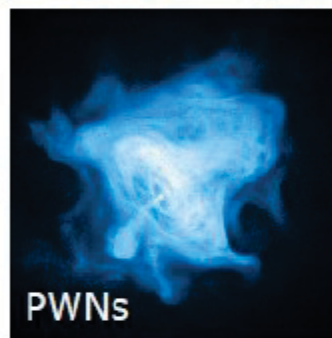


Space-time



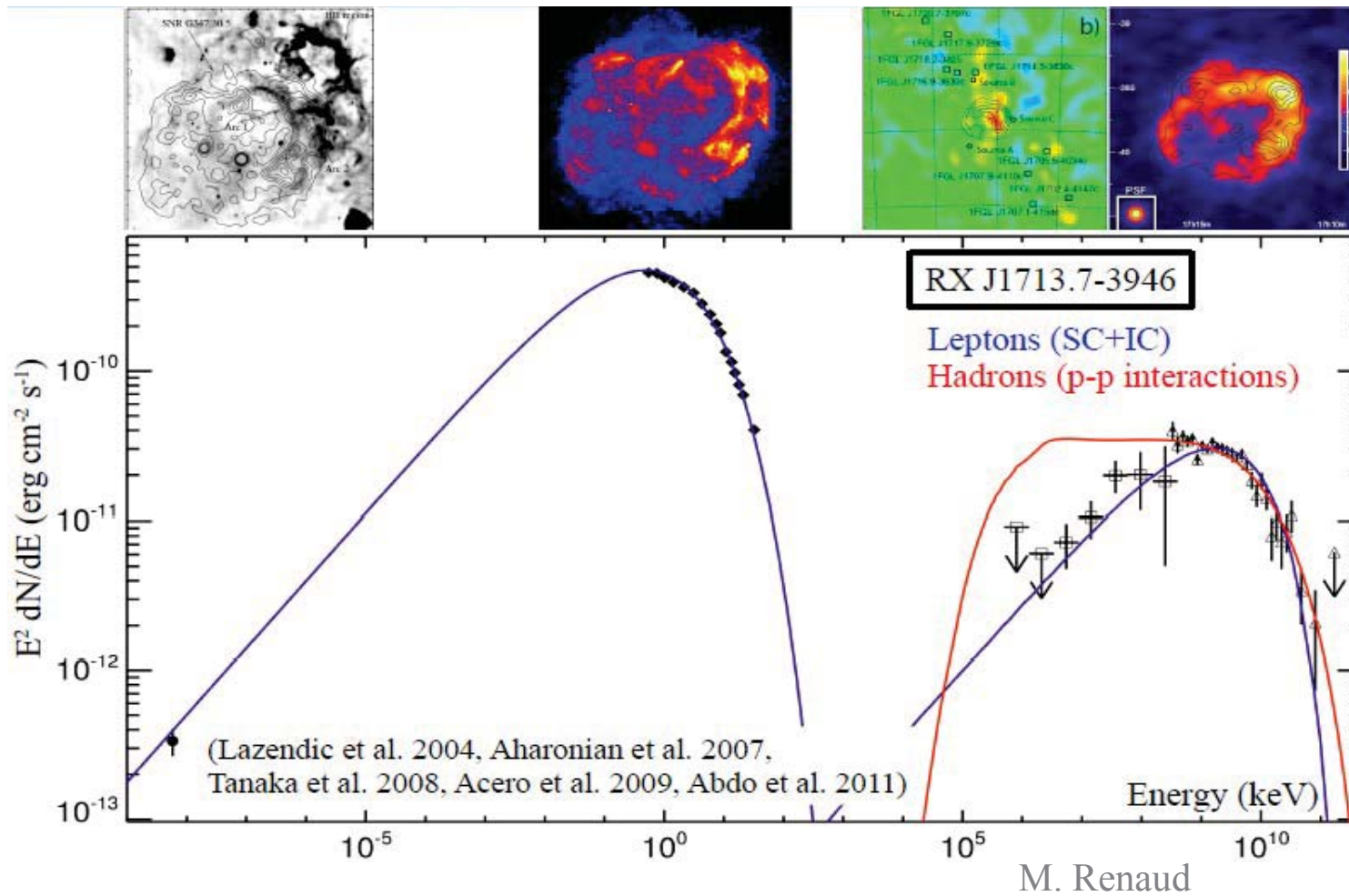
Cosmology

Small focus on possible accelerators of Cosmic Rays



J. Knödlseder

But not alone!



Science motivation: Global approach



- Multi-wavelength observations are mandatory
 - A motivation to have an open access to data



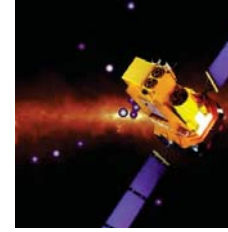
Radio



IR/Optical



X-rays

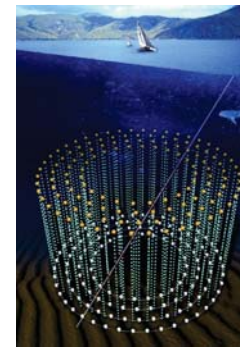
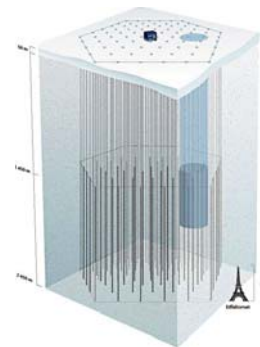


Hard X-rays
Soft γ -rays



Fermi LAT

- Multi-messenger approach
 - Neutrino to trace hadrons



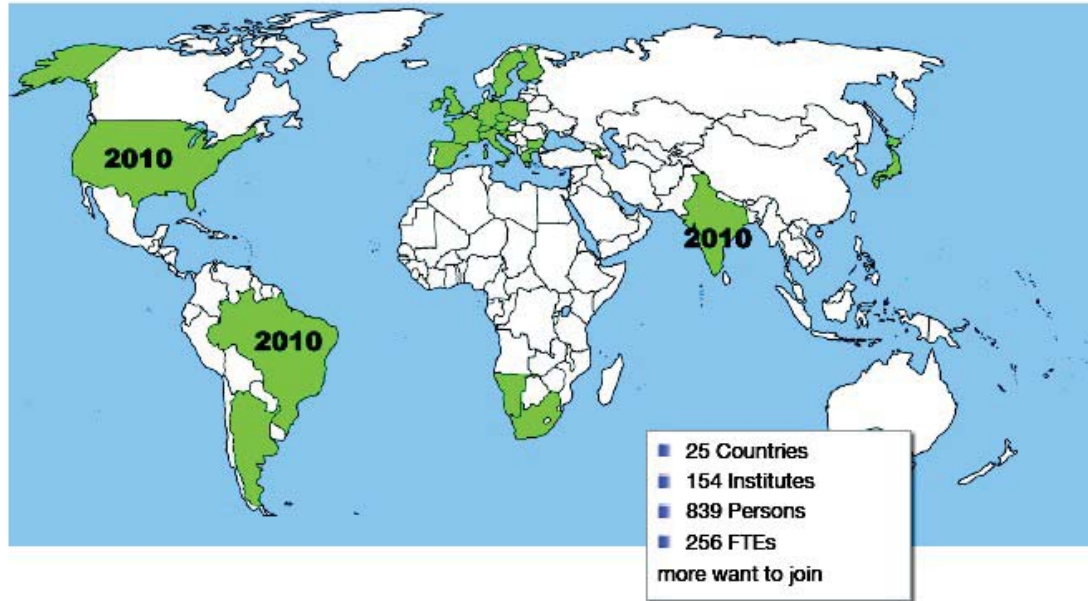
Science motivation: Global approach



The CTA Project



CTA Consortium



- Initiated by H.E.S.S. and MAGIC coll.
- Worldwide project
- US community (AGIS) has joined CTA

- Strongly supported by European Community



- Funding from EU-FP7 program for a Preparatory Phase
 - Oct. 2010 → Oct. 2013

CTA Consortium



- Structure

- Spokes.: [W. Hoffman](#) (MPI-K, Heidelberg)
- Co-Spokes: [M. Martinez](#) (IFAE, Barcelona)



- Preparatory Phase organisation

- Work organised in 27 Working Packages
- Project Manager: [J. Carr](#) (CPPM, Marseille)
- Technical Coordinator: [G. Hermann](#) (MPI-K, Heidelberg)

CTA Consortium

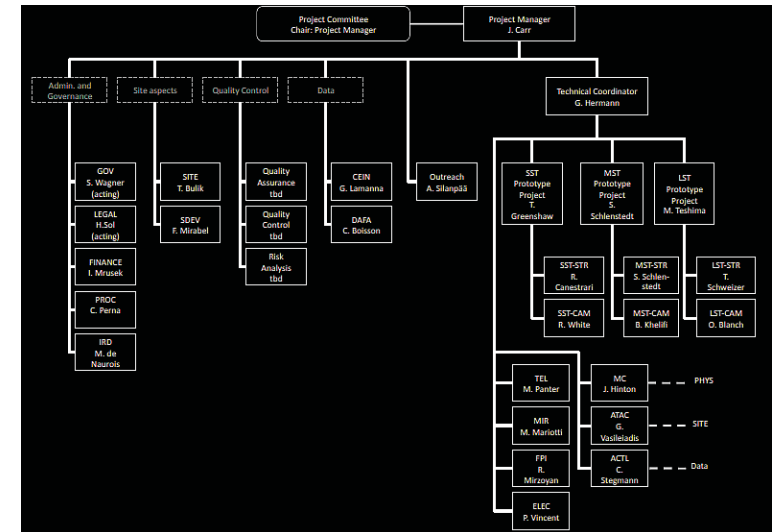


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Scheduled Timeline



	07	08	09	10	11	12	13	14	15	16	17	18
Array Layout	█	█	█	█								
Telescope design		█	█	█	█							
Component prototypes			█	█	█	█						
Telescope prototype					█	█	█					
Array construction								█	█	█	█	█
Partial operation										█	█	█

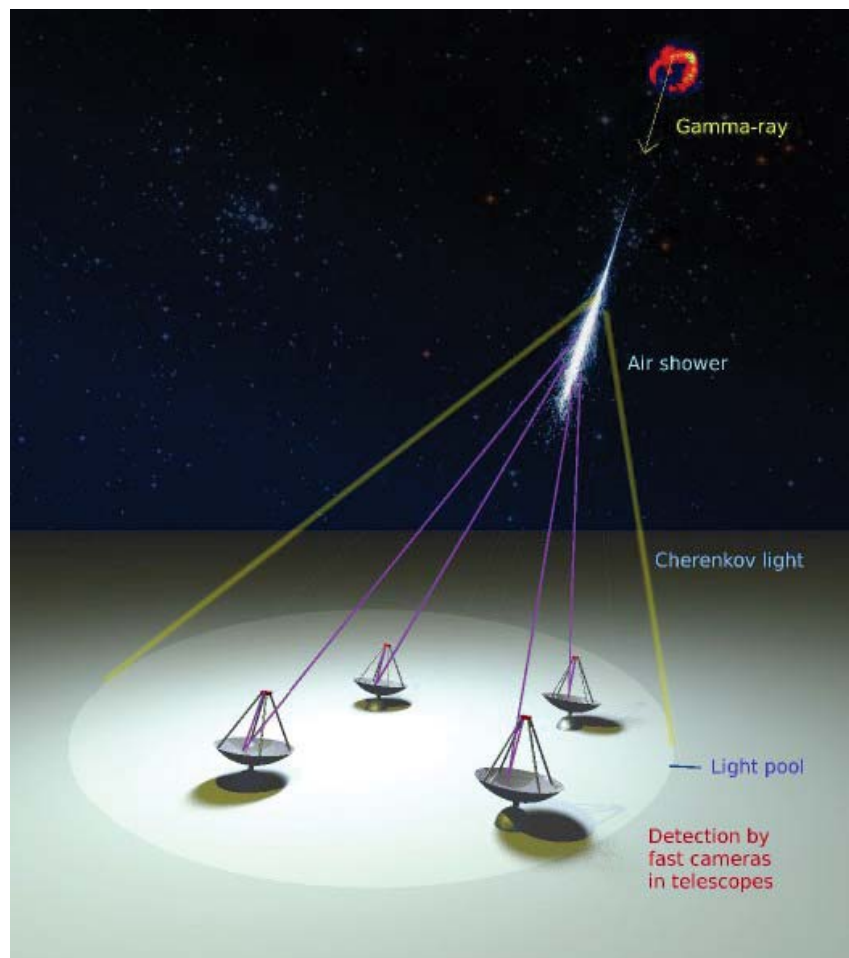


Design Study
2007-2010

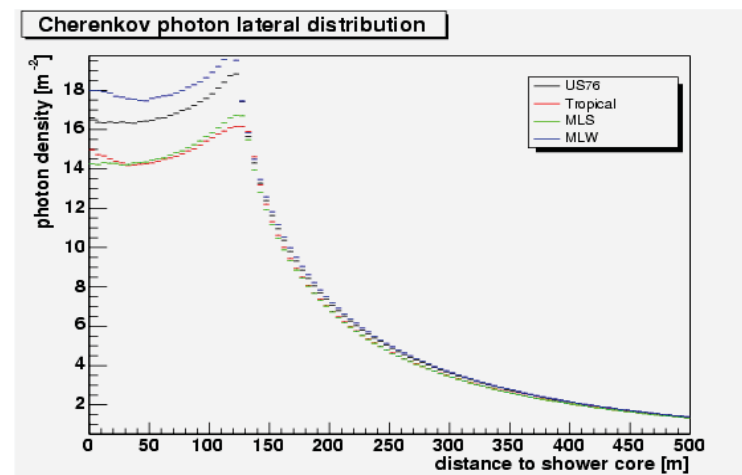
Preparatory Phase
2010-2013

Array Construction
2014-2018

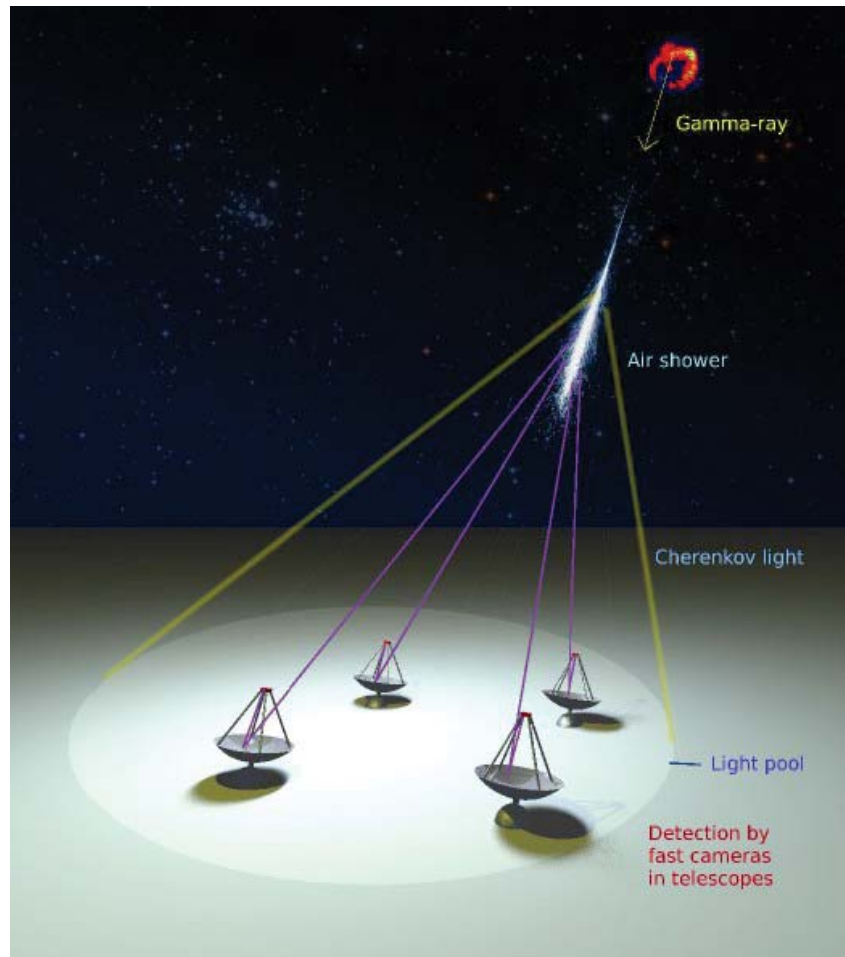
Imaging Atmospheric Cherenkov Technique



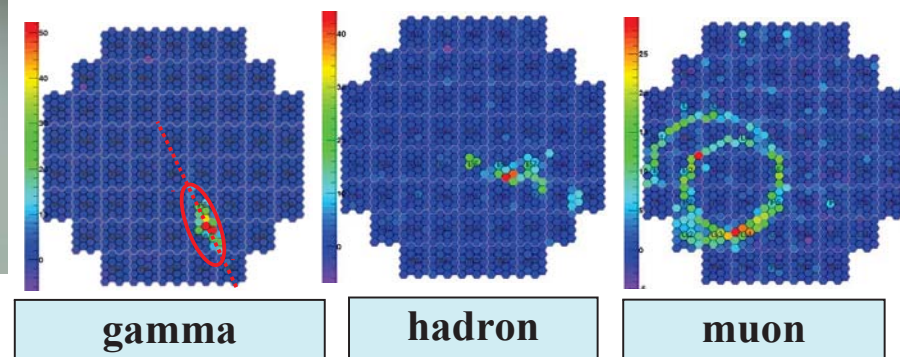
- Cherenkov light detected by optical telescopes
- Large light pool
→ Large collection area



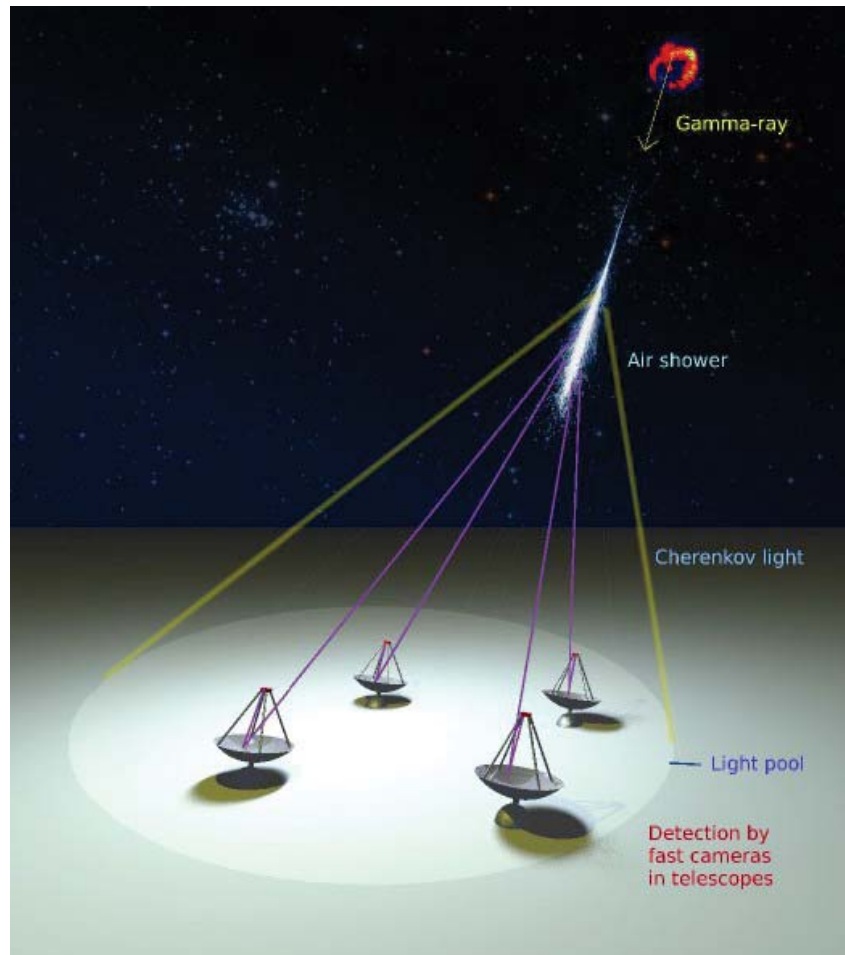
Imaging Atmospheric Cherenkov Technique



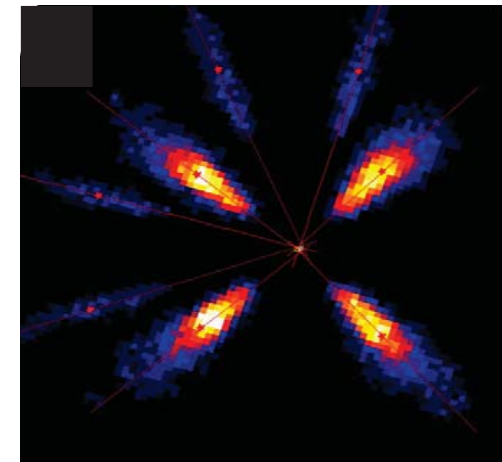
- Cherenkov light detected by optical telescopes
- Large light pool
→ Large collection area
- Fine and fast cameras
→ Good reconstruction (Θ , E)
→ Background rejection



Imaging Atmospheric Cherenkov Technique



- Cherenkov light detected by optical telescopes
- Large light pool
 - Large collection area
- Fine and fast cameras
 - Good reconstruction (Θ , E)
 - Background rejection
- Multiple telescopes
 - Good reconstruction (Θ , E)
 - Background rejection



Low-energy section:

few O(20-30) m tel. (LST)

=> push low threshold

- Parabolic reflector
- FOV: O(3-4) degrees
- f/D: O(1.2-1.5)

Energy threshold
of some 10 GeV

Core-energy array:

many O(10-12) m tel. (MST)

=> workhorse of CTA

-> push cost & reliability

- Davies-Cotton reflector
- FOV: O(6-8) degrees
- f/D: O(1.2-1.5)

mCrab sensitivity
in the 100 GeV-10 TeV
domain

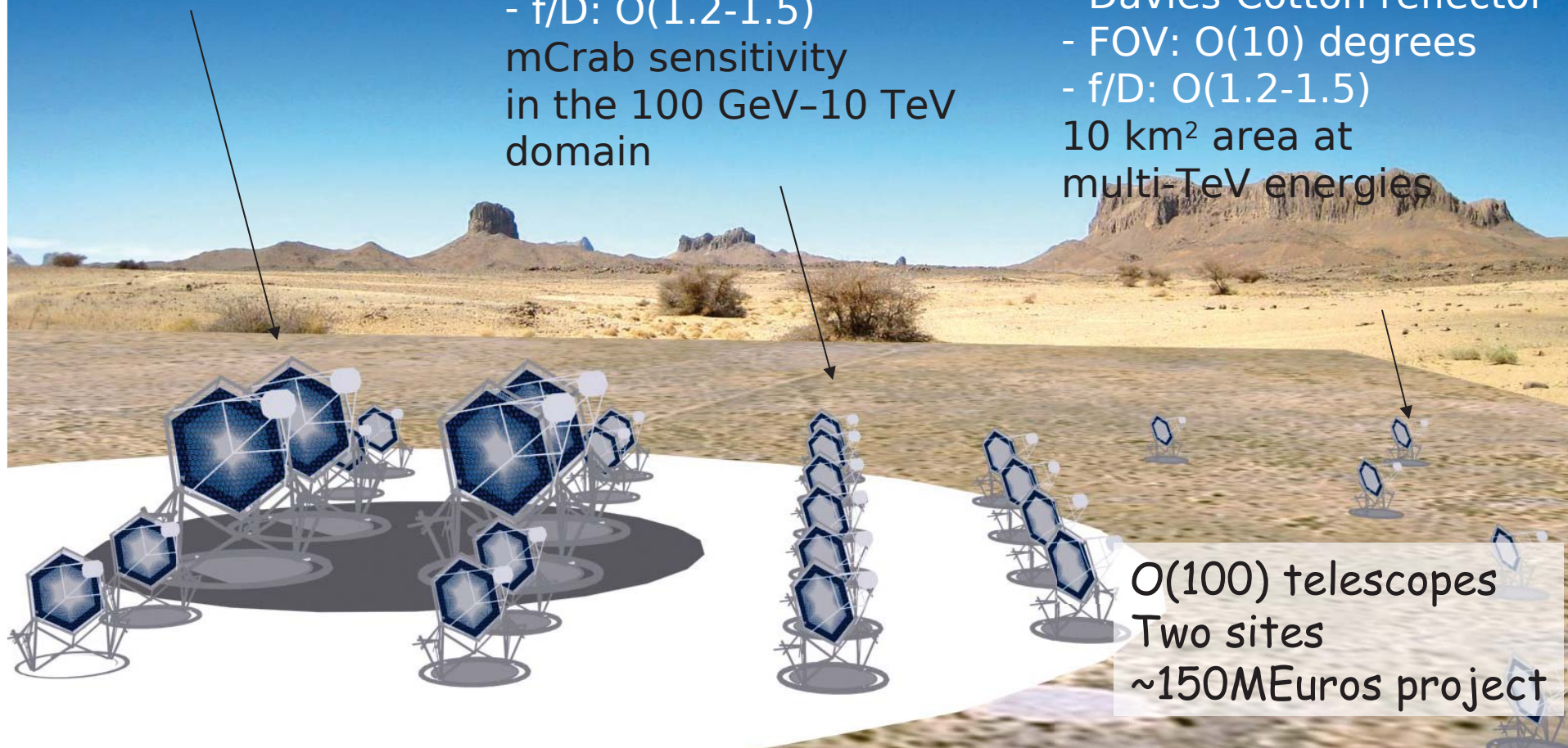
High-energy section:

some O(5-6) m tel. (SST)

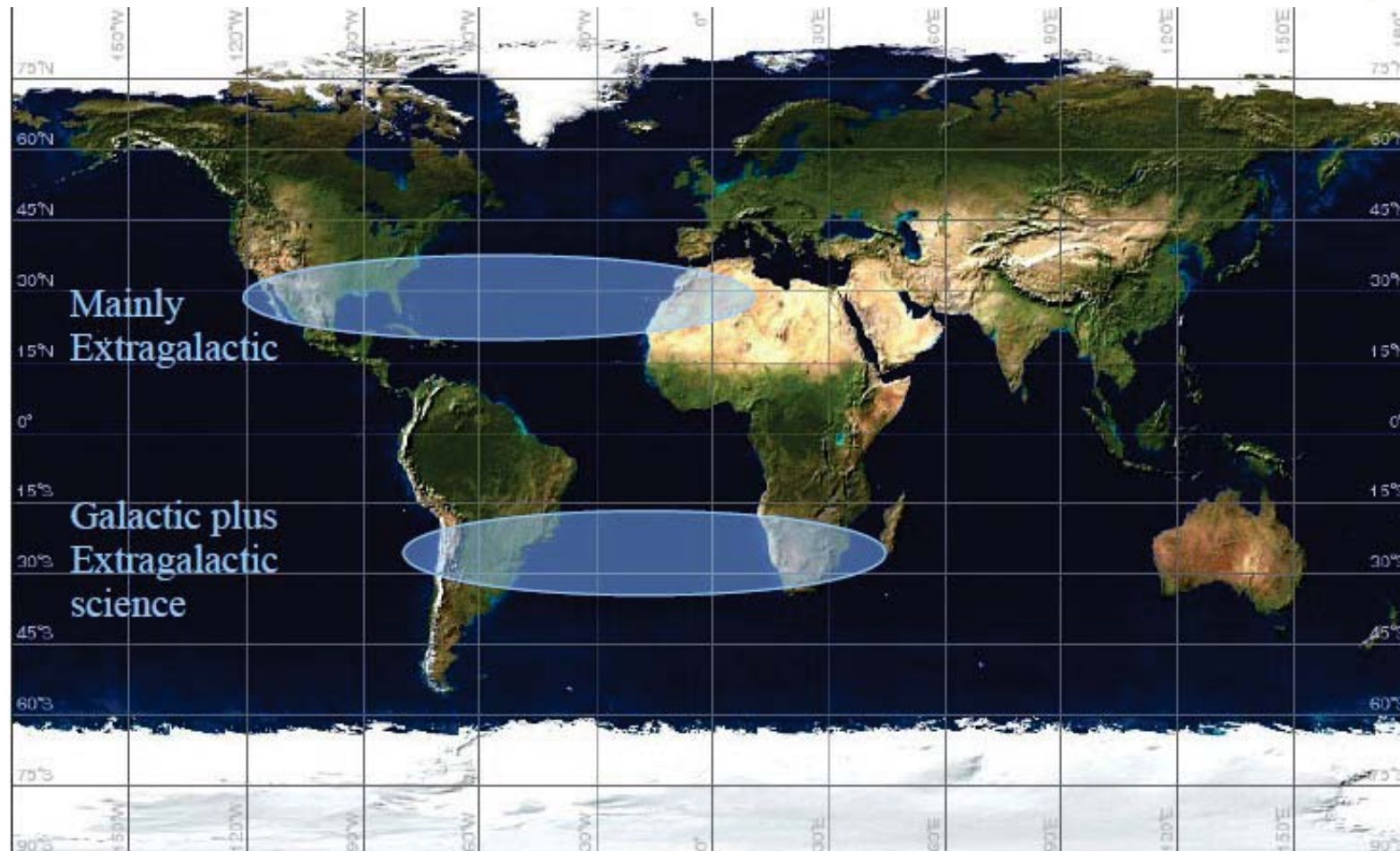
=> push low-cost

- Davies-Cotton reflector
- FOV: O(10) degrees
- f/D: O(1.2-1.5)

10 km² area at
multi-TeV energies

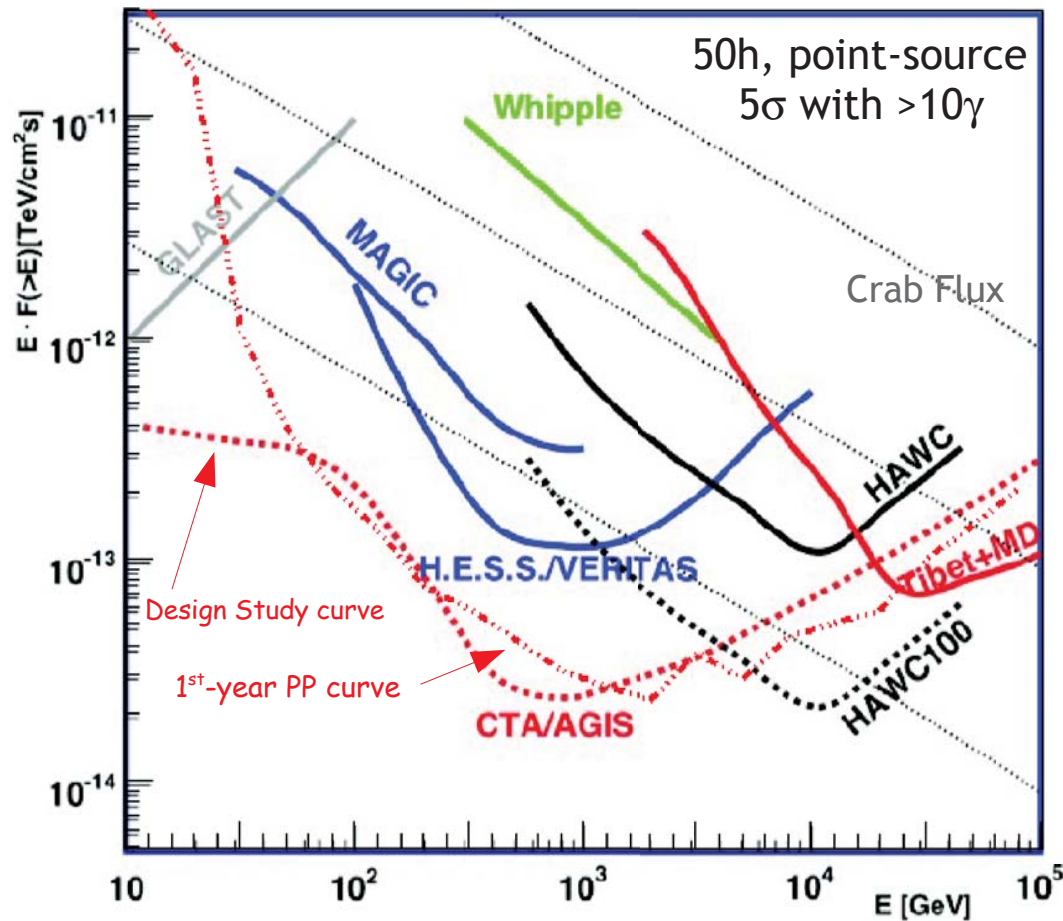


CTA locations



- Search for TWO sites (completeness of our scientific program)
- 10km² flat area, 1.5–3.5 km altitude, minimum cloud coverage, access...

Expected Performance



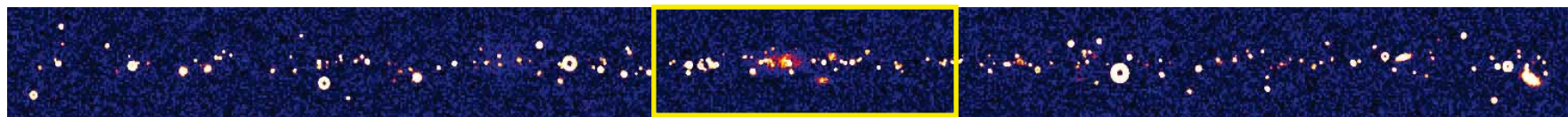
- Increased sensitivity by a factor 10
- Increased energy range: Few 10GeV \rightarrow >100TeV

Expected Performance



- Increased sensitivity by a factor 10
- Increased energy range: Few 10GeV \rightarrow >100TeV
- Increased angular resolution by a factor 3-5
- Larger Field of View

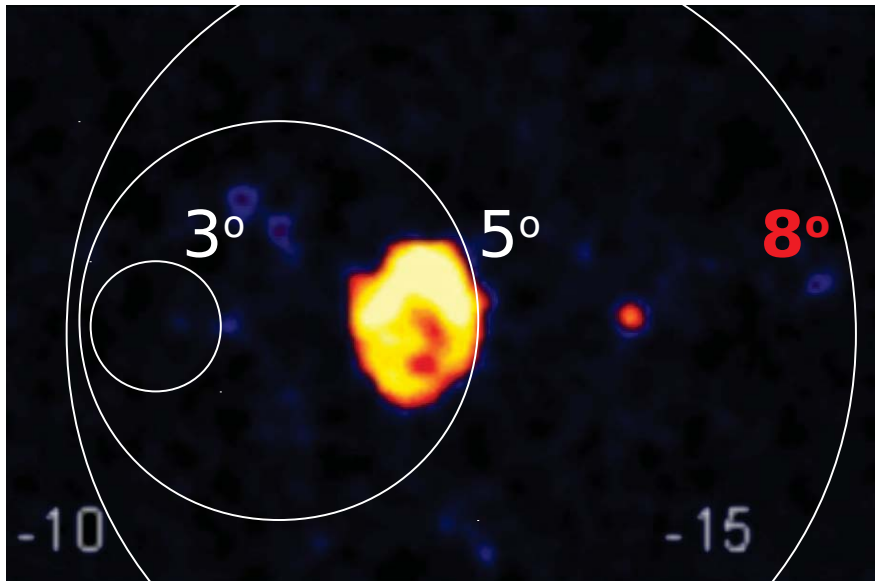
Galactic plane as seen by HESS



Diegel, Funk, Hinton

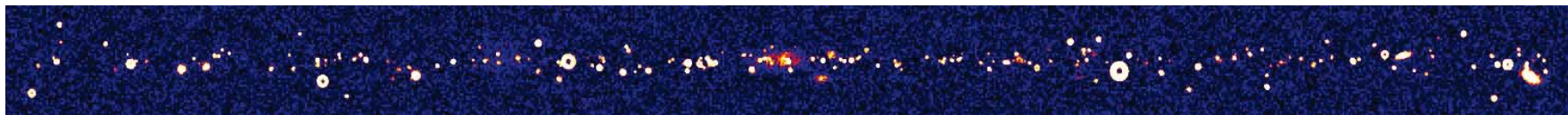
CTA view

Expected Performance



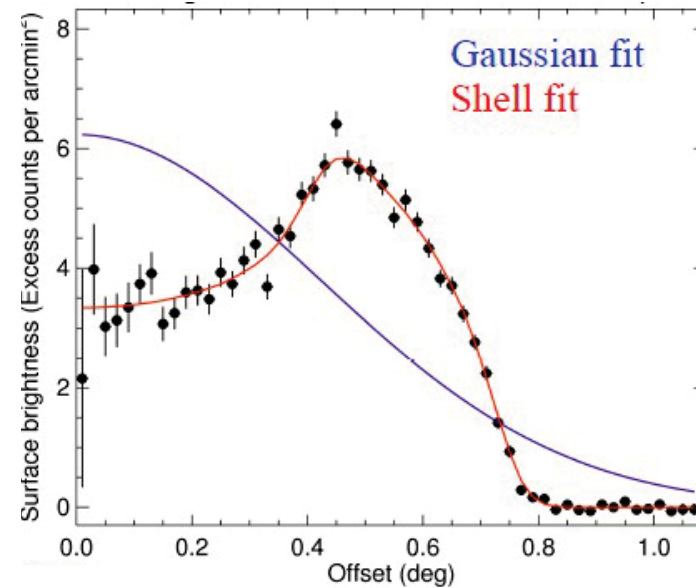
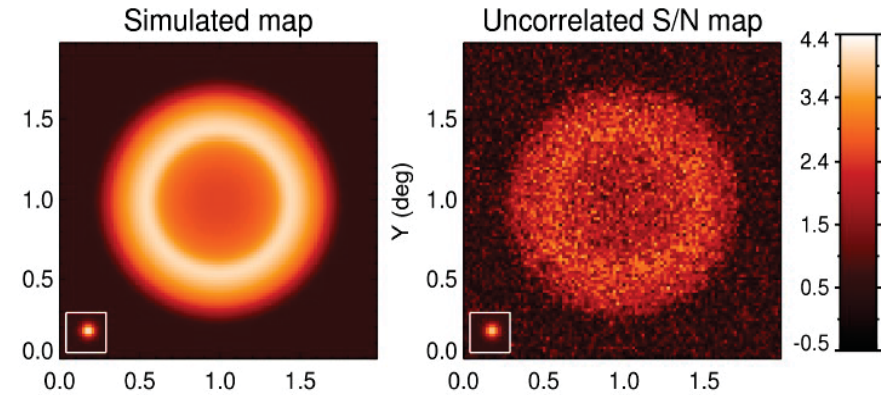
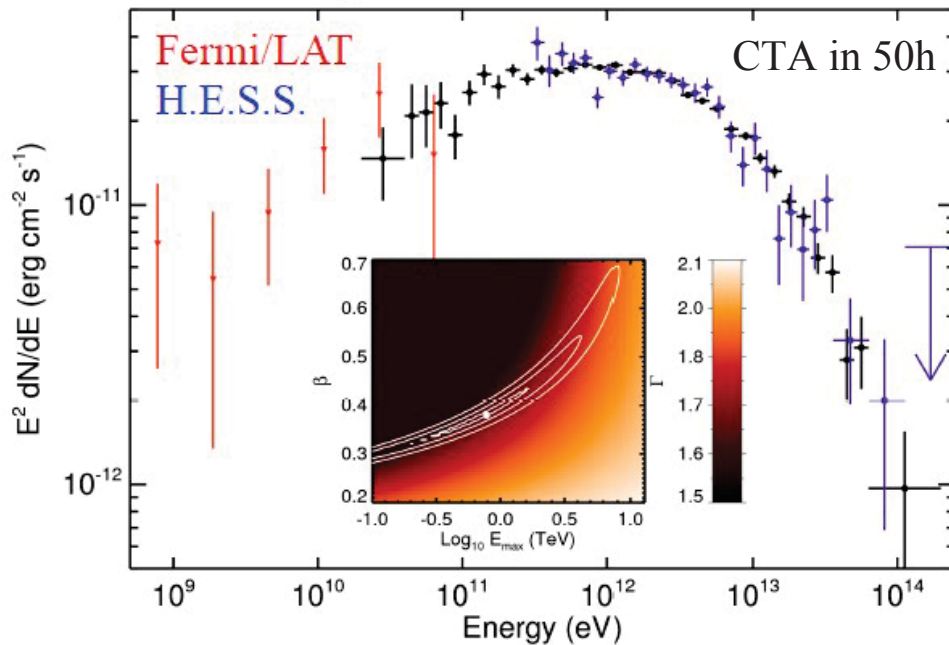
- Increased sensitivity by a factor 10
- Increased energy range: Few 10GeV \rightarrow >100TeV
- Increased angular resolution by a factor 3-5
- Larger Field of View

CTA view



Ex. of expected performance: SNR

RXJ1713-like at d=1kpc, 20h



RX J1713.7-3946 spectral parameters

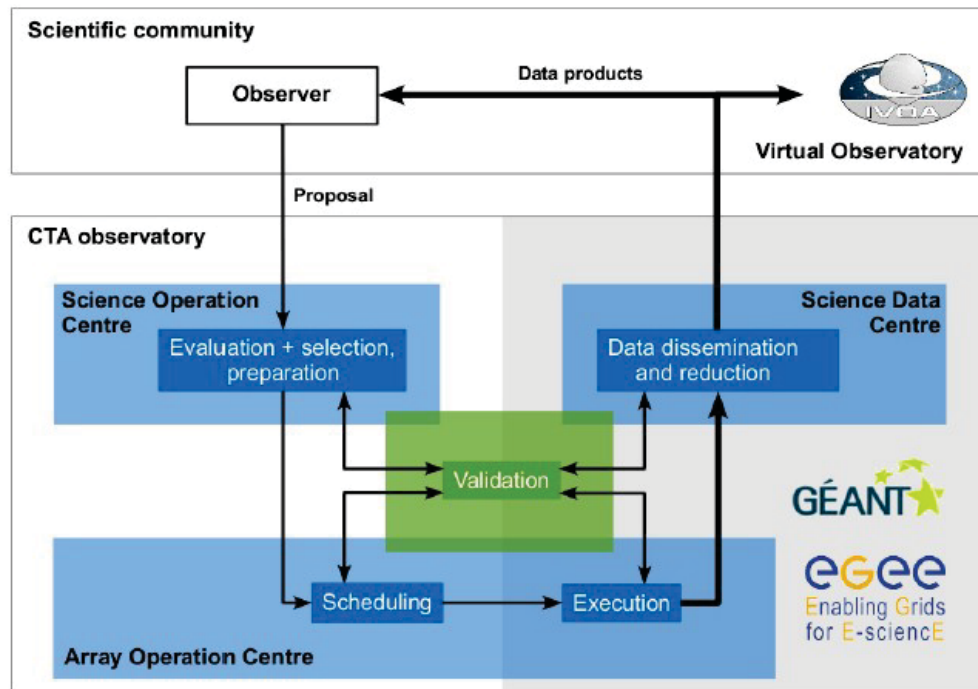
$$dN/dE = N_0 E^{-\Gamma} \exp(-(E/E_{\max})^\beta)$$

{ Γ , β , E_{max}} well constrained

$$S/N_{>35\text{TeV}} \sim 7\sigma$$

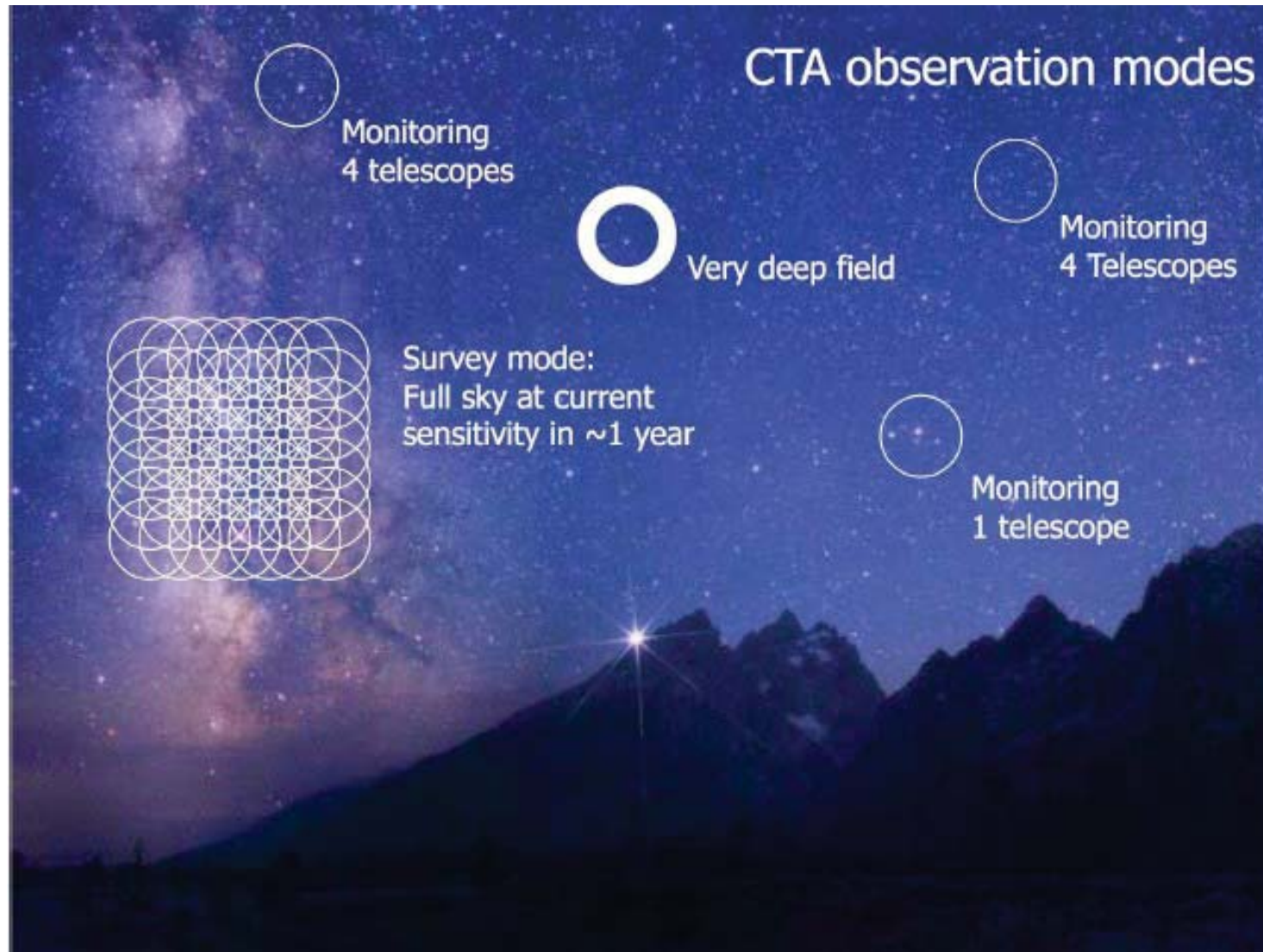
M. Renaud

CTA as Observatory



- Operated as “open” Observatory
- Peer-reviewed process on submitted proposals
- Observations made by Consortium experts
- Foreseen “legacy” data: Galactic Plane, full-sky survey, ...
- Data access via Virtual Observatory
- Software Tools releases

CTA Observation Modes





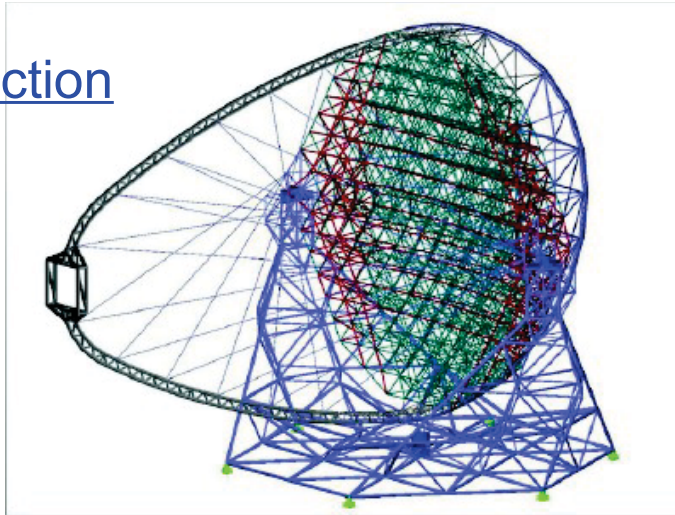
Technical Developments

Telescopes Designs

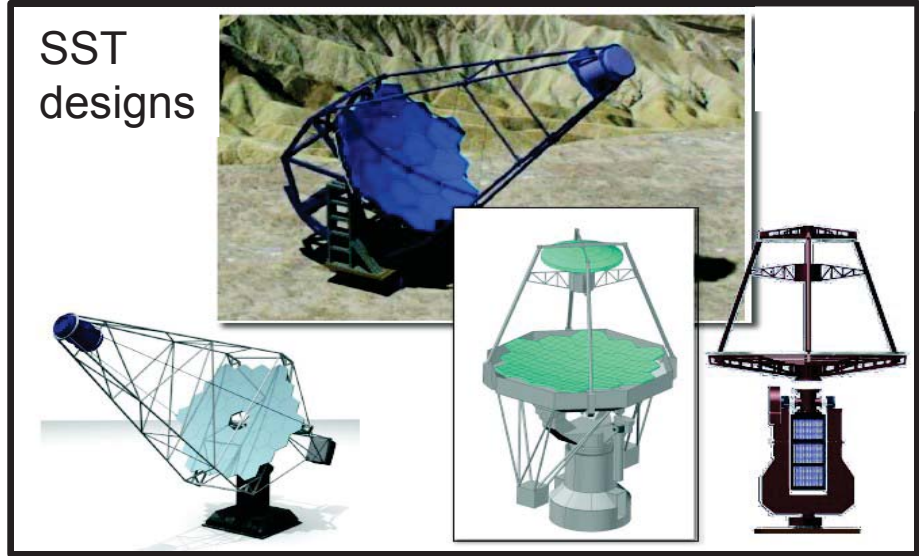
HE section



LE section

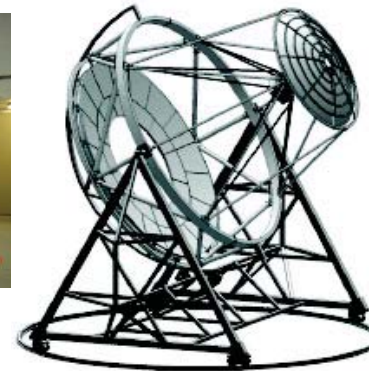
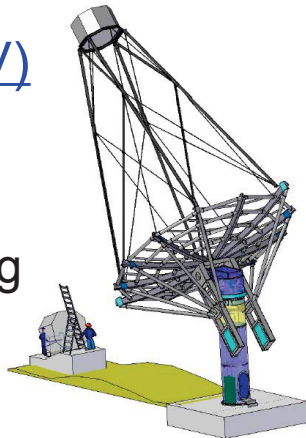


SST designs



Core Range (TeV)

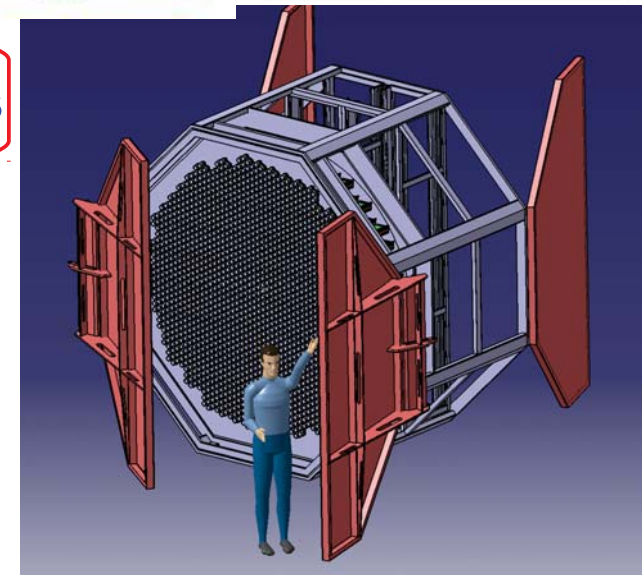
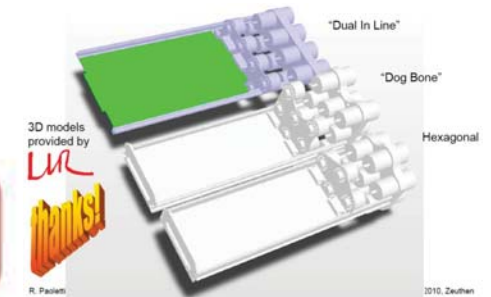
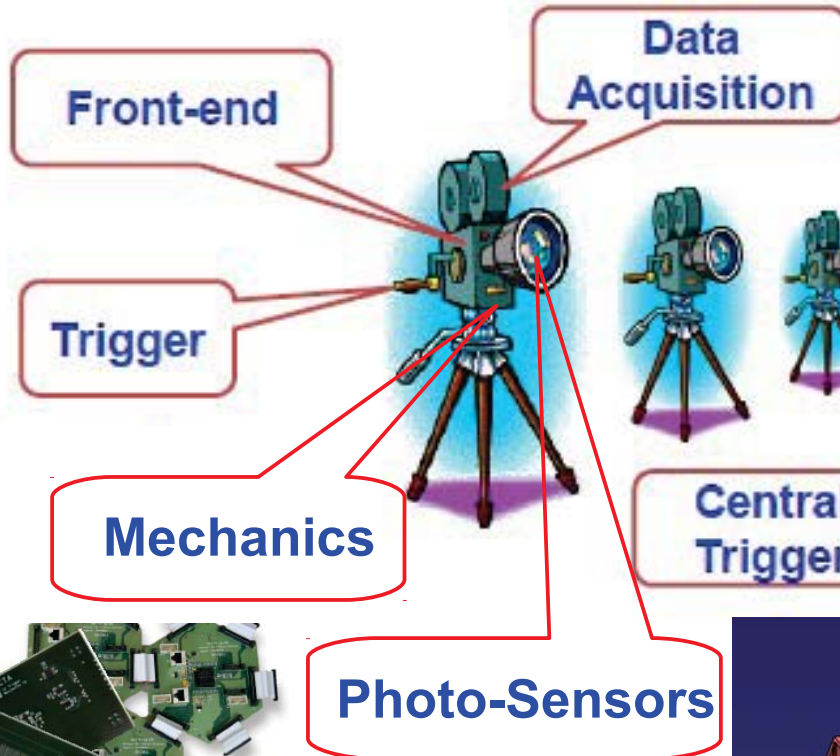
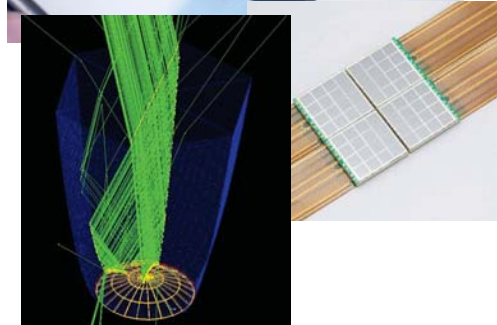
DC-MST
under prototyping



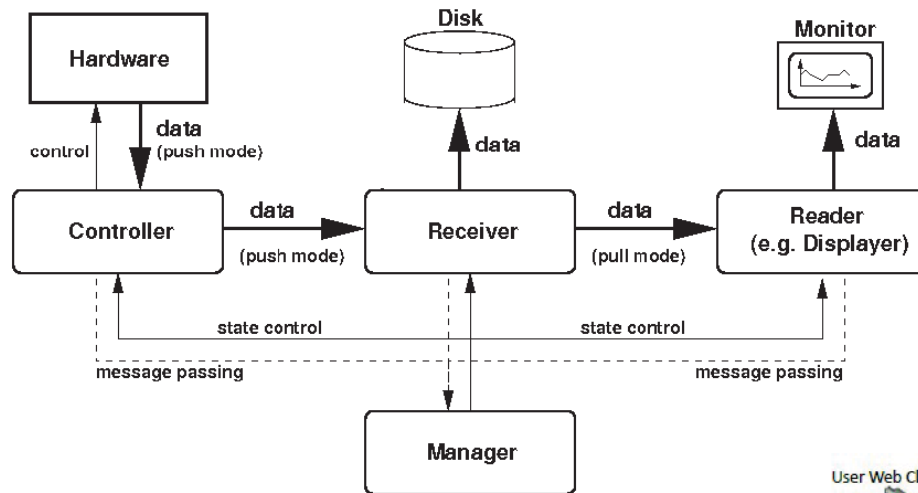
SC-MST
possible designs



Camera Instrumentation



Array Control and Data Management

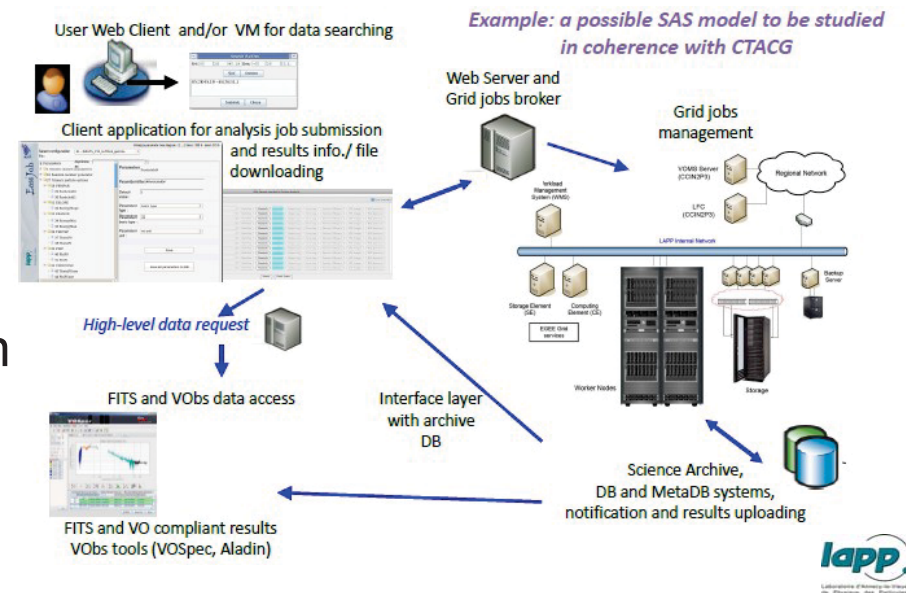


- On-site Software

- Array Control
- Data Transfert

- Offline Software

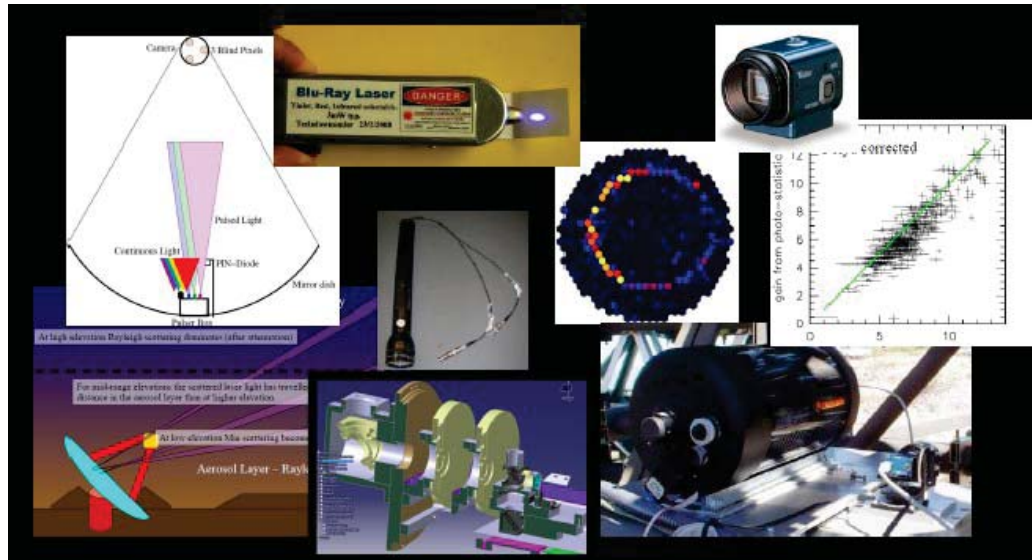
- Data dissemination
- Calibration & Reconstruction
- High-Level analysis
- VO



Site Infrastructure



- Calibration tools



- Tooling



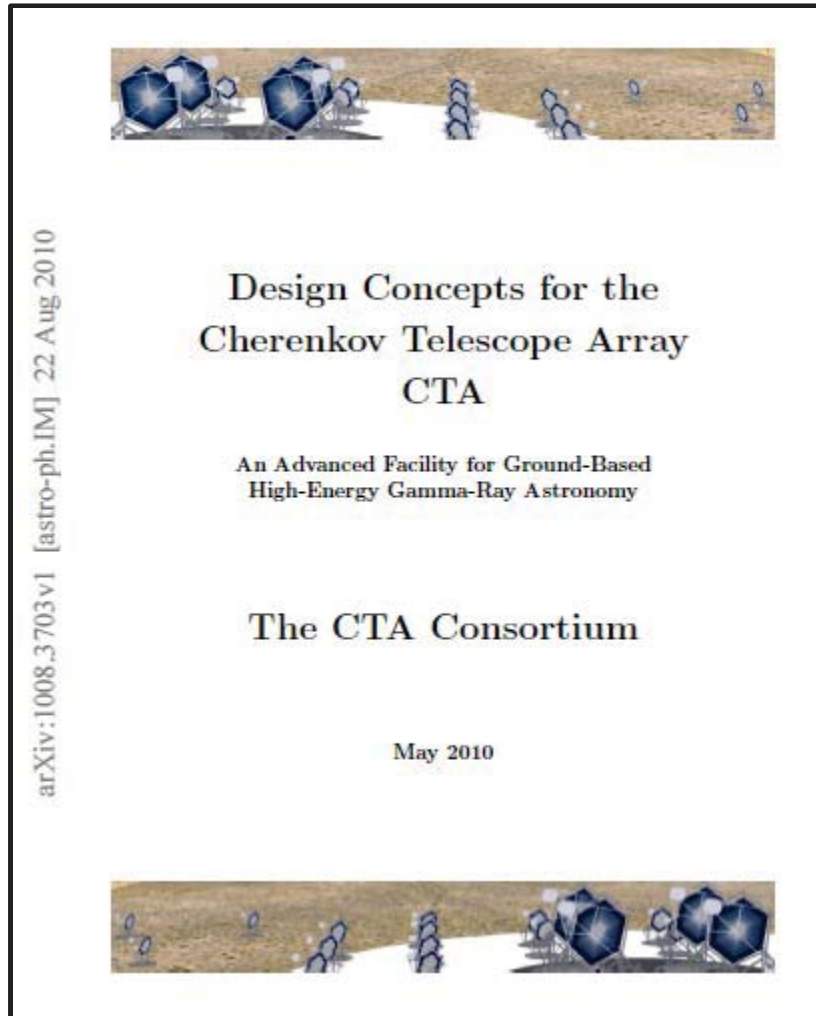
- Control rooms and workshops



- Services



Summary and CTA info



VHE astronomy provides a unique tool to study particle acceleration throughout the Universe and to probe physics beyond the establish horizon

CTA will take up the challenge!

- <http://www.cta-observatory.org/>
- Speaker's And Publication Office
cta-sb@cta-observatory.org
(Chairman: BK)