Cherenkov Telescope Array
CTA

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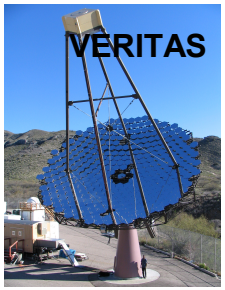
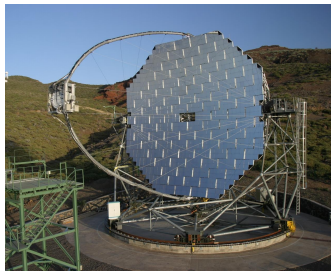
LSW, U. Heidelberg

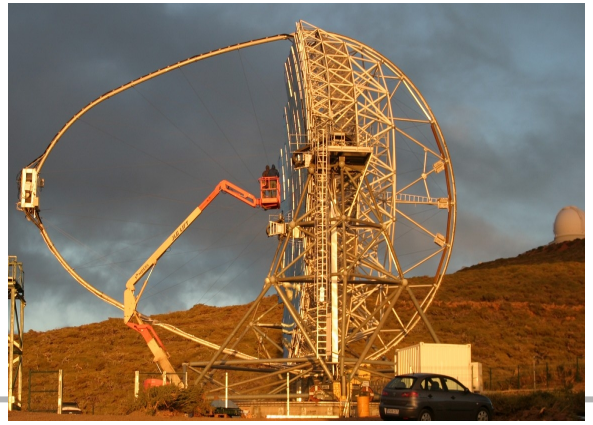
VHE γ-Ray astronomy

1990s: Proof-of-concept:
Whipple, HEGRA

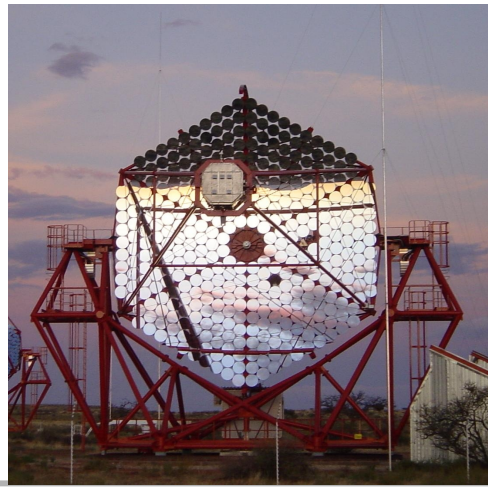




3 major experiments:
HESS (2004+), Namibia, European+,
MAGIC (2005+), La Palma, European+,
VERITAS (2007+), Arizona, US+
demonstrating science
Very high impact!



Current upgrades:
MAGIC: (1 → 2) 17m tel.
HESS: 4 12m + 1 30m tel.

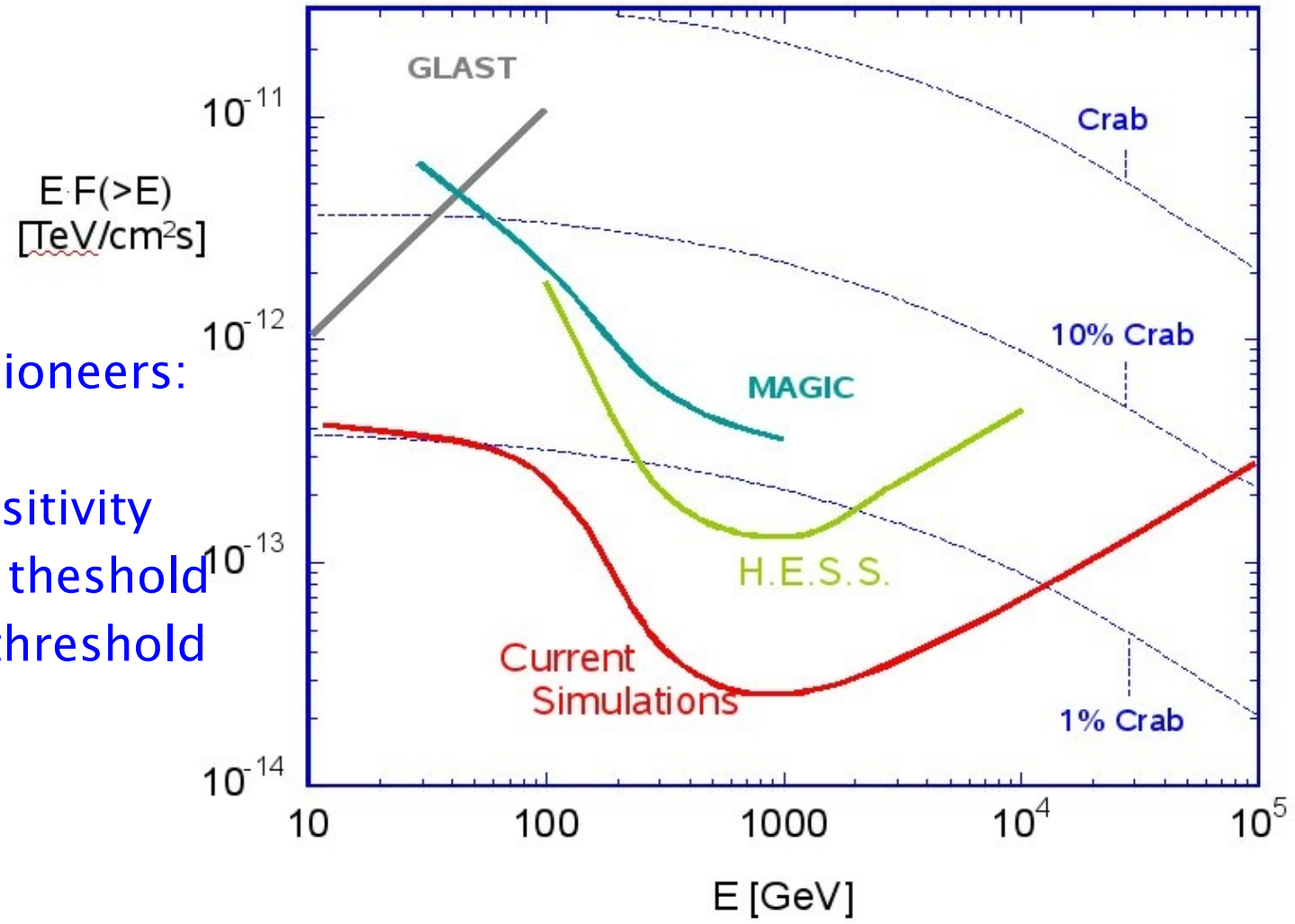


Original suggestion:

Explorers turn pioneers:

Factor 10 in sensitivity
Factor 5 in high theshold
Factor 2 in low threshold

150 ME budget



CTA design goals

Performance goals

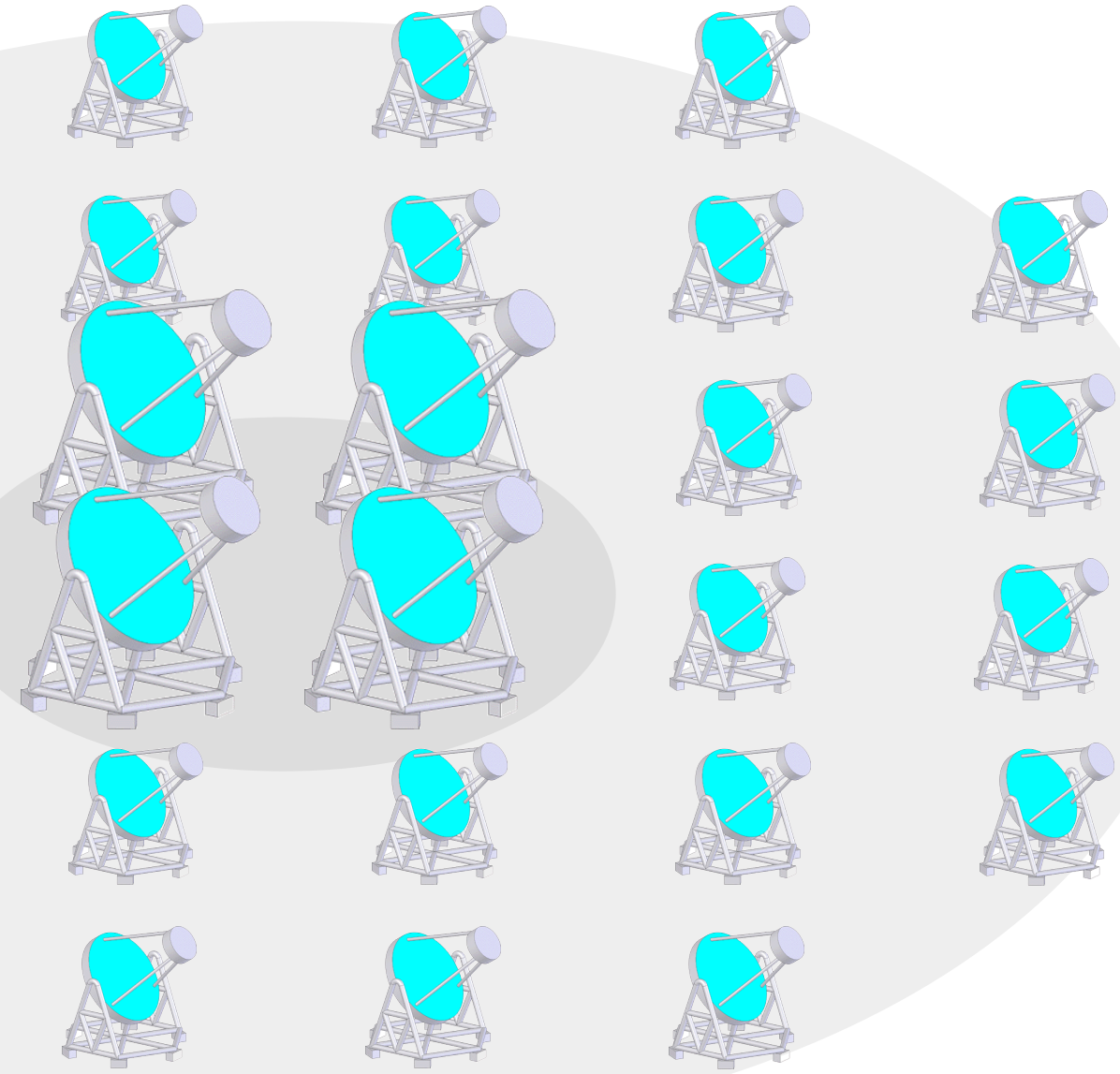
Improved sensitivity (> factor 10)
Increased Energy range (30 GeV – 100 TeV)
Improved Energy Resolution
Improved Angular Resolution
Larger Field-of-view (Survey)

Strategy
Feasibility with current technology & know-how
3 nested arrays of different telescope sizes
High reliability
Observatory operation

CTA Concept

- Large area (1 km^2 @ TeV, 10 km^2 @ multi-TeV energies)
  - Enhanced detection rate and sensitivity at TeV energies
  - Array larger than Cherenkov light pool – for the first time imaging not limited by edge effects
  - Increased high-energy coverage in rate-limited regime above 10 TeV
- Large number of telescopes (50-100)
  - Multiple images per shower result in improved angular reconstruction and improved background rejection
  - Core array serves as cosmic-ray veto for low-energy telescopes
  - Flexibility of operation
- Increased field of view and improved photon detection
  - Multiple objects in fov; increase of effective exposure
  - Improved shower imaging

- Wide simultaneous energy coverage
- Observatory, open to large community



Not to scale !

High-energy section
of halo telescopes
10 km^2 area at
multi-TeV energies

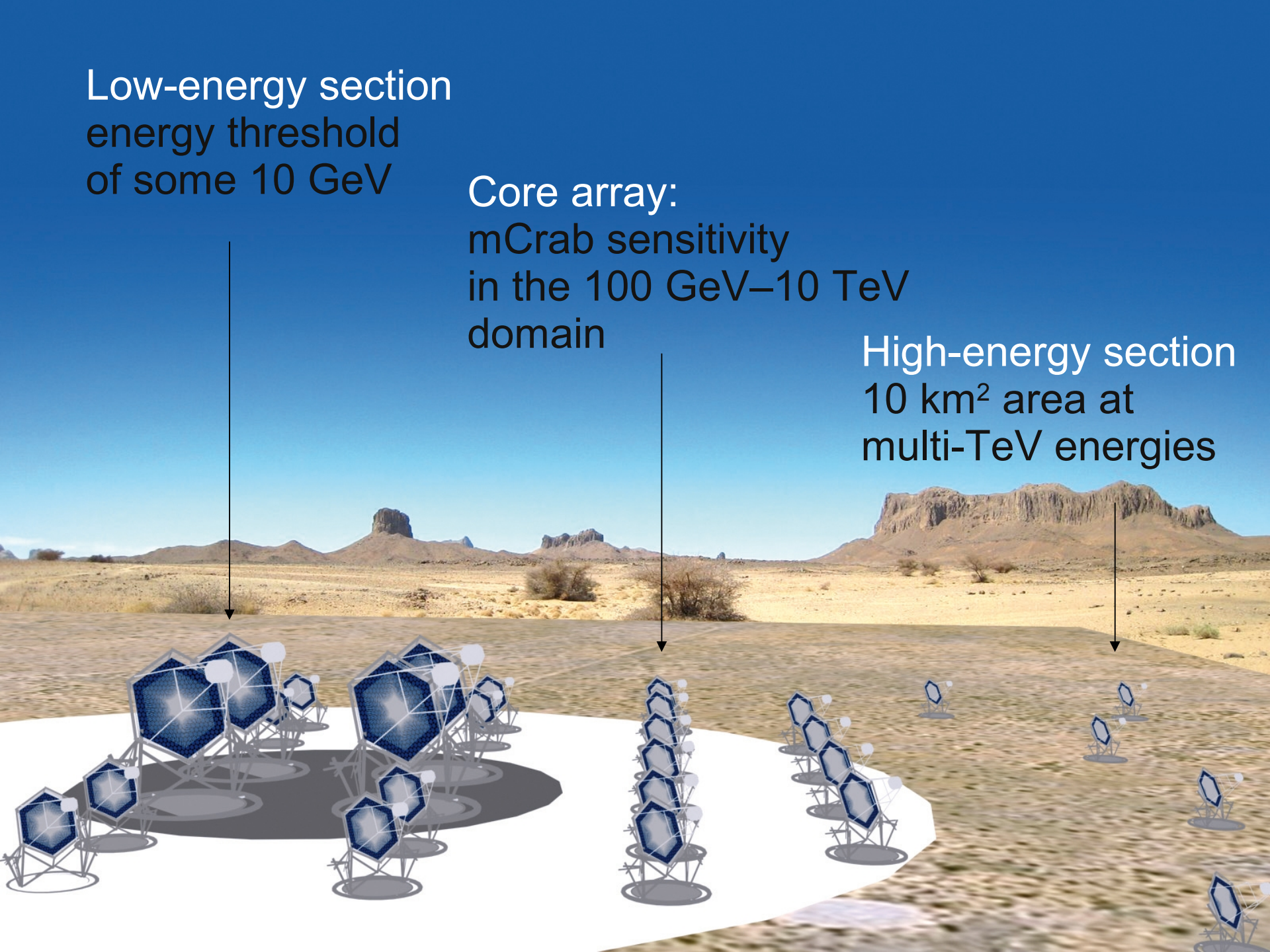
large field of view

Core array of
10 m class telescopes:
mCrab sensitivity
in the 100 GeV-10 TeV
domain

6^o - 8^o field of view

Low-energy section
of large telescopes
energy threshold
of some 10 GeV

smaller field of view


Low-energy section
energy threshold
of some 10 GeV
Core array:
mCrab sensitivity
in the 100 GeV–10 TeV
domain
High-energy section
10 km² area at
multi-TeV energies

Status, Funding, Timeline

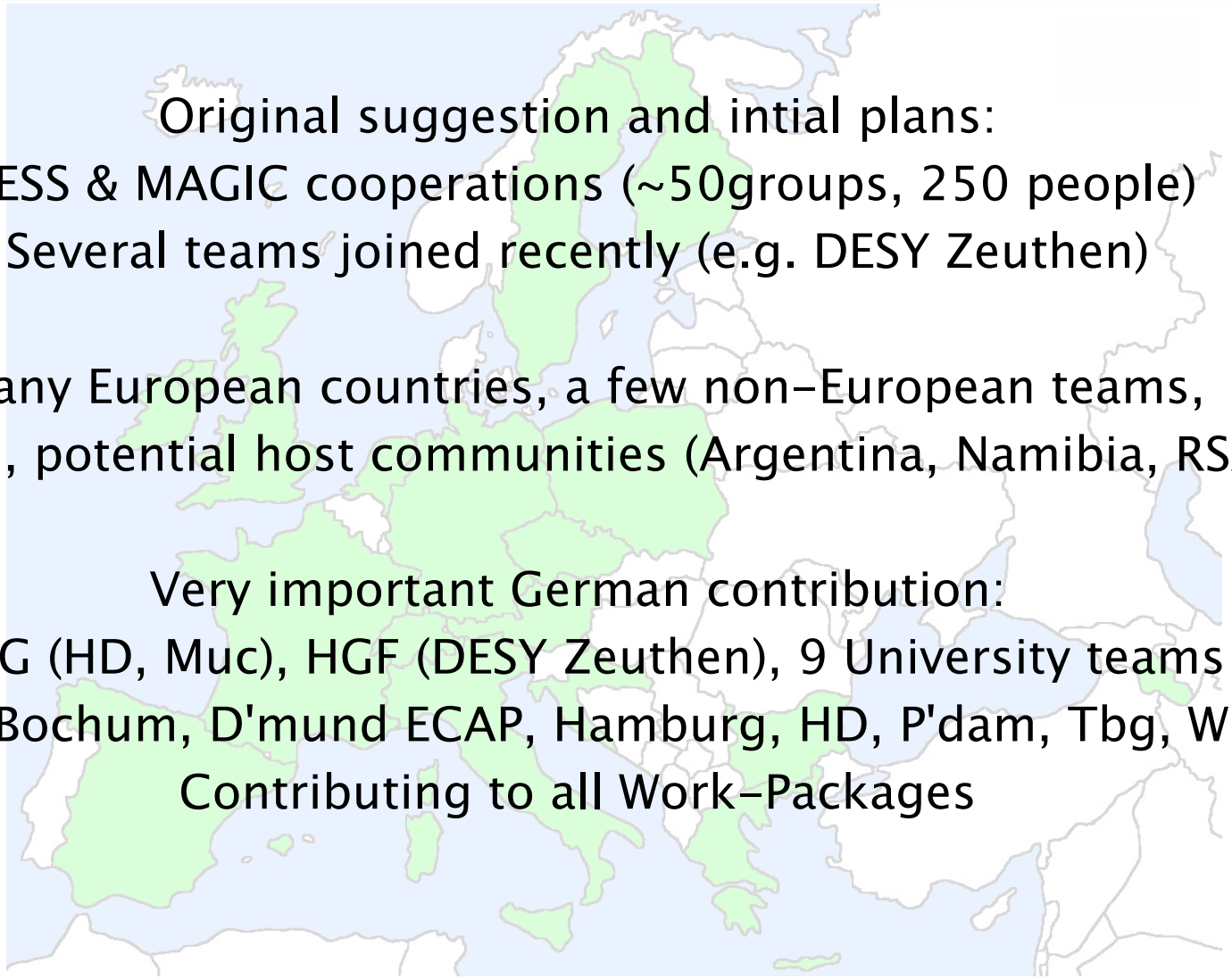
CTA has been very well received
in several reviews:

highly ranked in aspera roadmap,
highly ranked is astronet roadmap,
Included in ESFRI list

Design study ongoing since 2007/2008:
Seed funding from institutes/natl. funding

Attracting more partners along the way

Who are "we"?



Original suggestion and intial plans:
HESS & MAGIC cooperations (~50groups, 250 people)
Several teams joined recently (e.g. DESY Zeuthen)

Many European countries, a few non-European teams,
Japan, potential host communities (Argentina, Namibia, RSA)

Very important German contribution:
MPG (HD, Muc), HGF (DESY Zeuthen), 9 University teams
(HUB, Bochum, D'mund ECAP, Hamburg, HD, P'dam, Tbg, Wbg)
Contributing to all Work-Packages

Work packages

Work Packages (2007–2009) Design Study

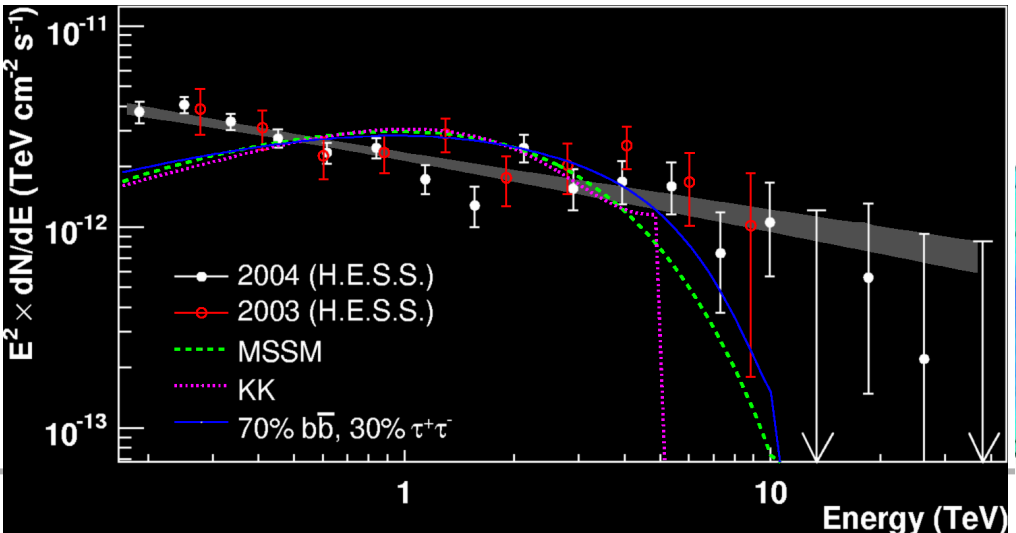
WP1	MNG	Management of the design study
WP2	**PHYS**	Astrophysics and astroparticle physics
WP3	**MC**	Optimization of array layout, performance studies, …
WP4	**SITE**	Site evaluation and site infrastructure
WP5	**MIR**	Telescope optics, mirrors, mirror alignment
WP6	**TEL**	Telescope structure, drive, control, robotics
WP7	**FPI**	Focal plane instrumentation, mechanics and photo detectors
WP8	**ELEC**	Readout electronics and trigger
WP9	**ATAC**	Atmospheric monitoring, associated science & instrument calib.
WP10	**OBS**	Observatory operation and access
WP11	**DATA**	Data handling, data processing, data management and access
WP12	**QA**	Risk assessment and quality assurance, production planning

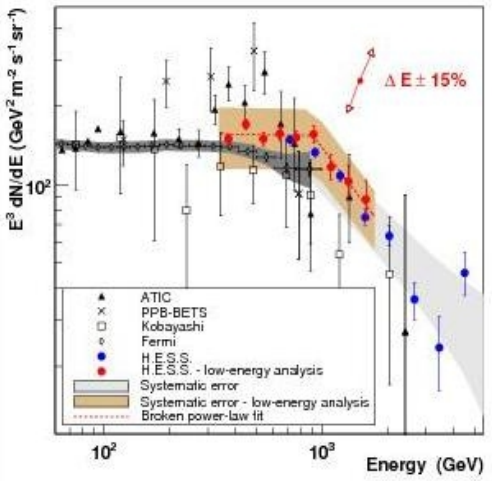
Physics goals

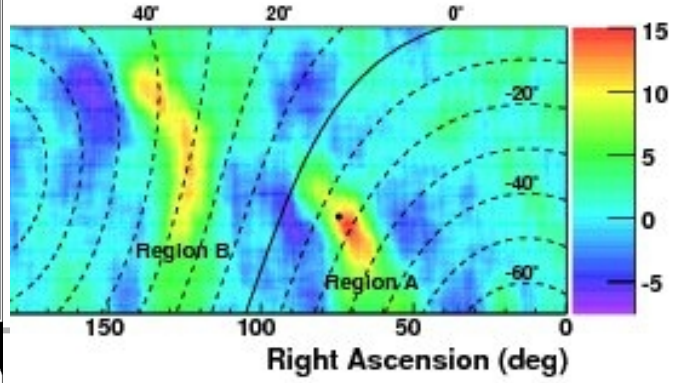
Many experiments testing fundamental physics

CR physics, astrophysics, and cosmology:

- Lorentz Invariance Violation
- Quantum Gravity
- Dark Matter
- Dark Energy
- Galactic Antimatter

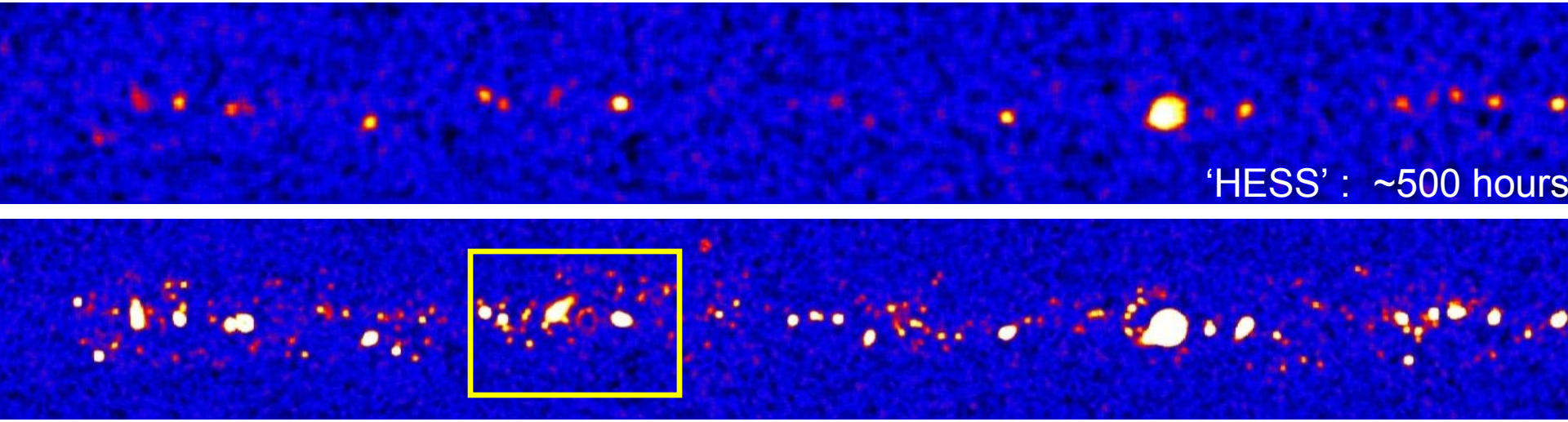




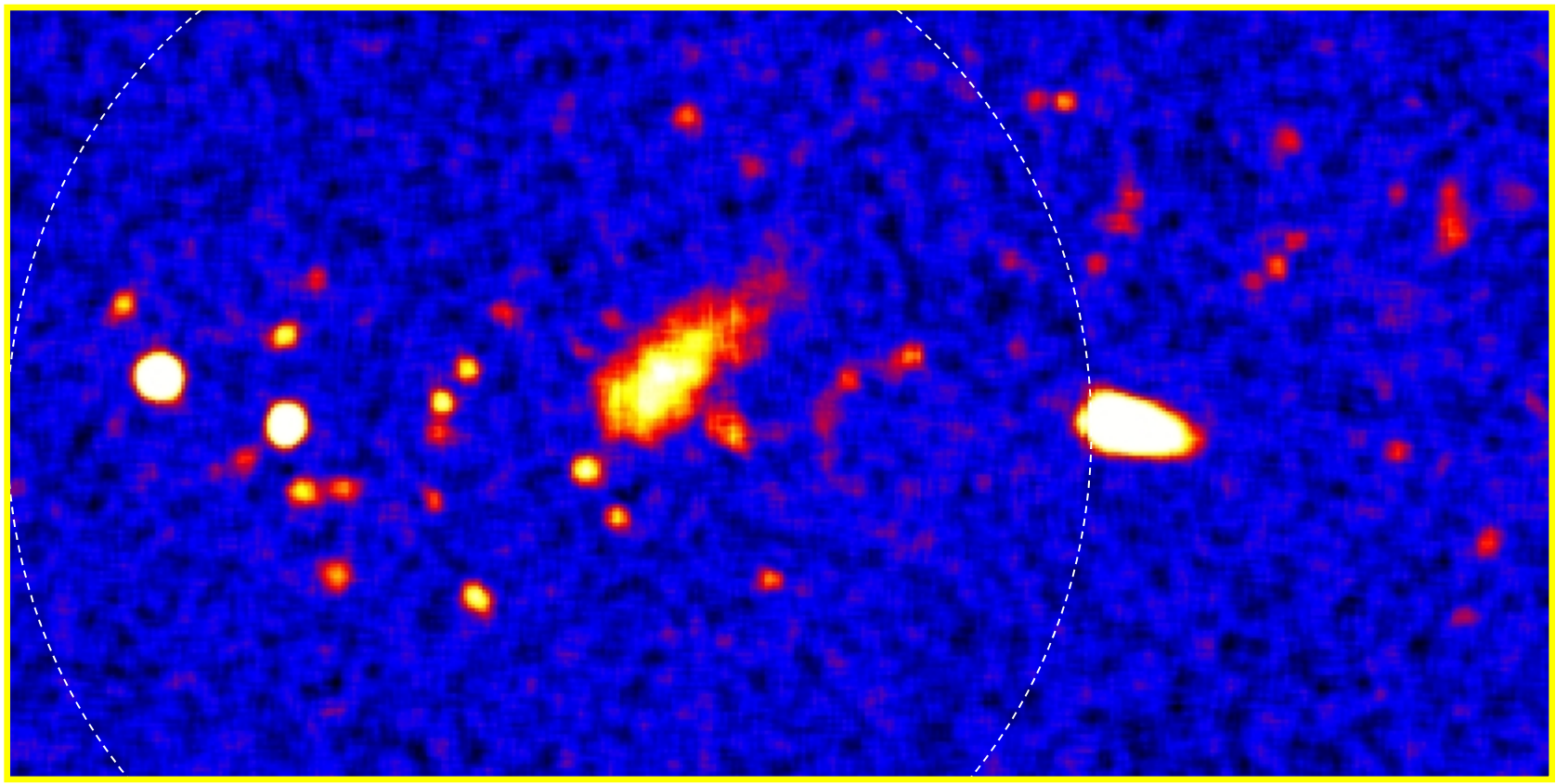


Astrophysics Goals

Gamma-Ray Bursts,
Acceleration of the Universe (Dark Energy)
Detecting all “unpulsed pulsars”
Resolving the myth of dark accelerators:



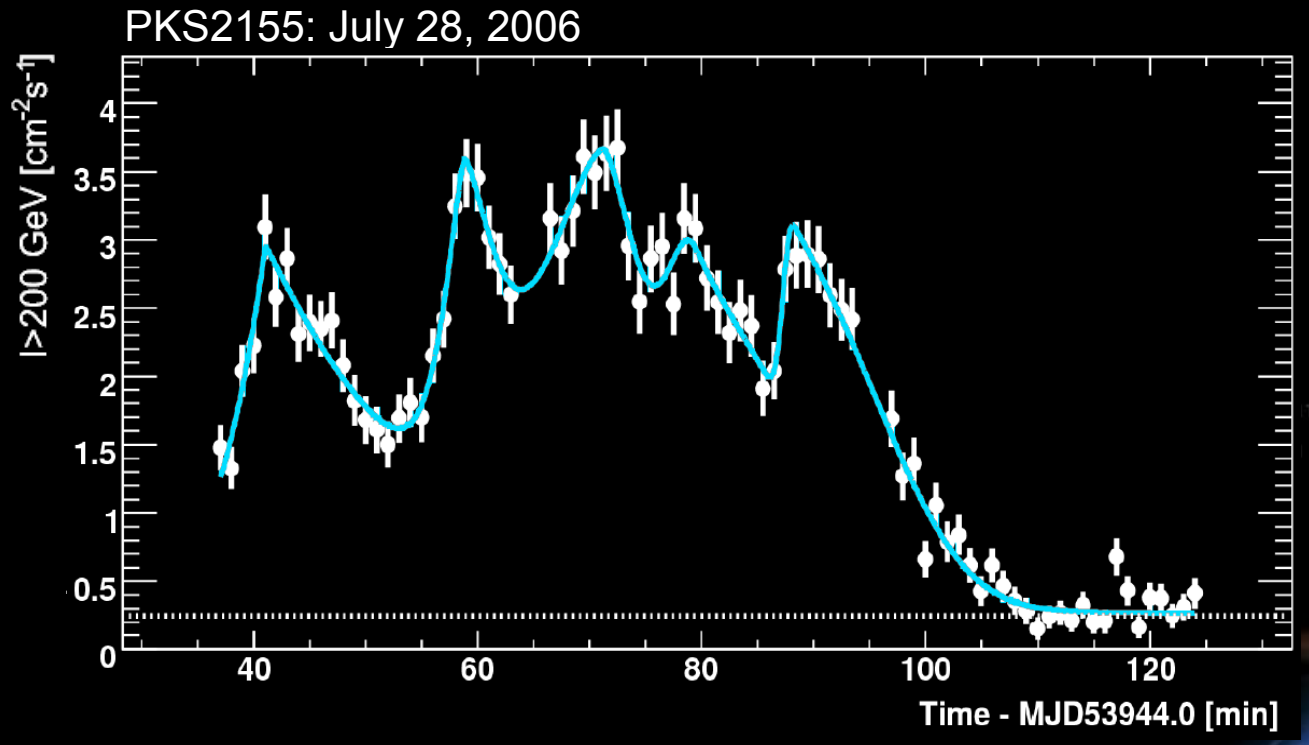
Detailed studies of Galactic sources



6 deg FoV

angular resolution: 0.05 deg (> 1TeV)

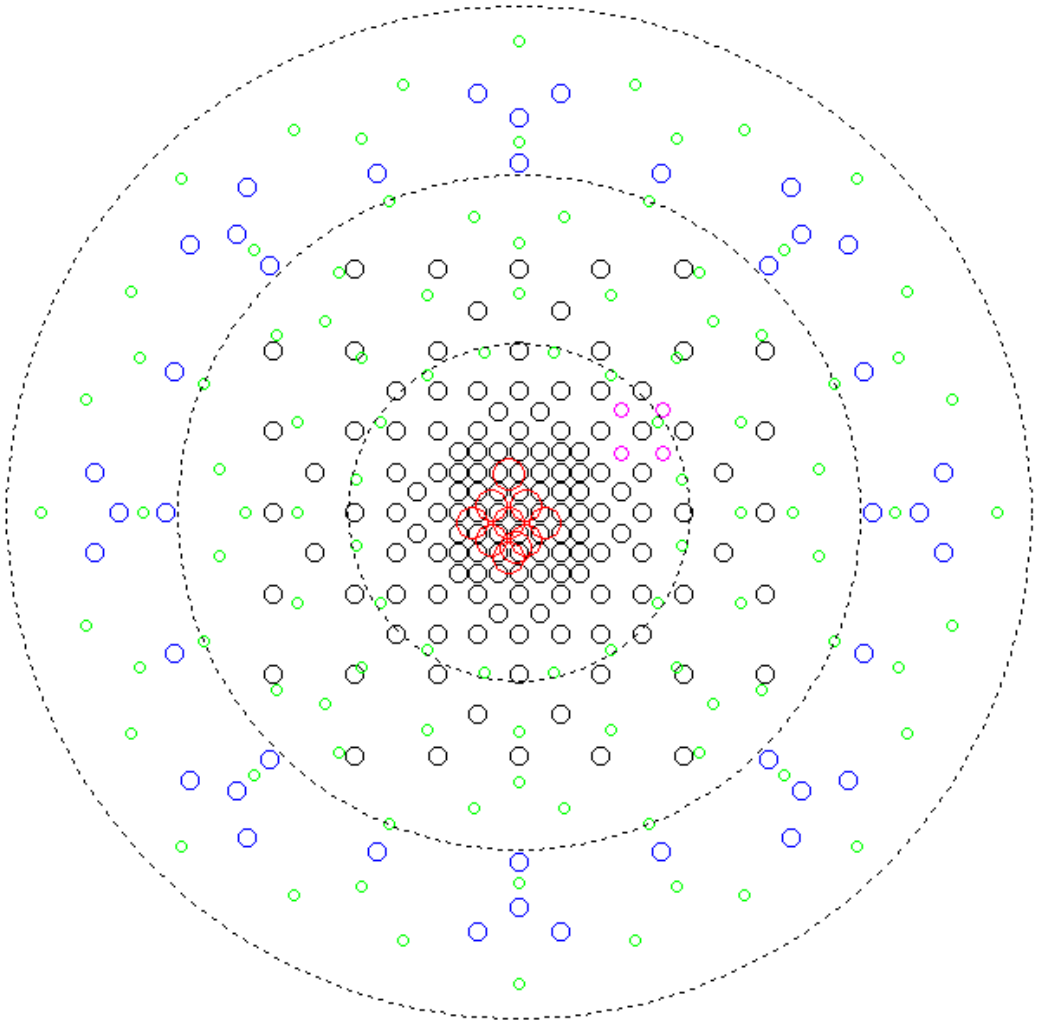
Grazing the horizon?



→ Timescale x c << RS
→ Alternatively: “Nanojets”

HESS, A&A (2007, 2008, 2009)

MC: Large Scale End-to-End Simulations



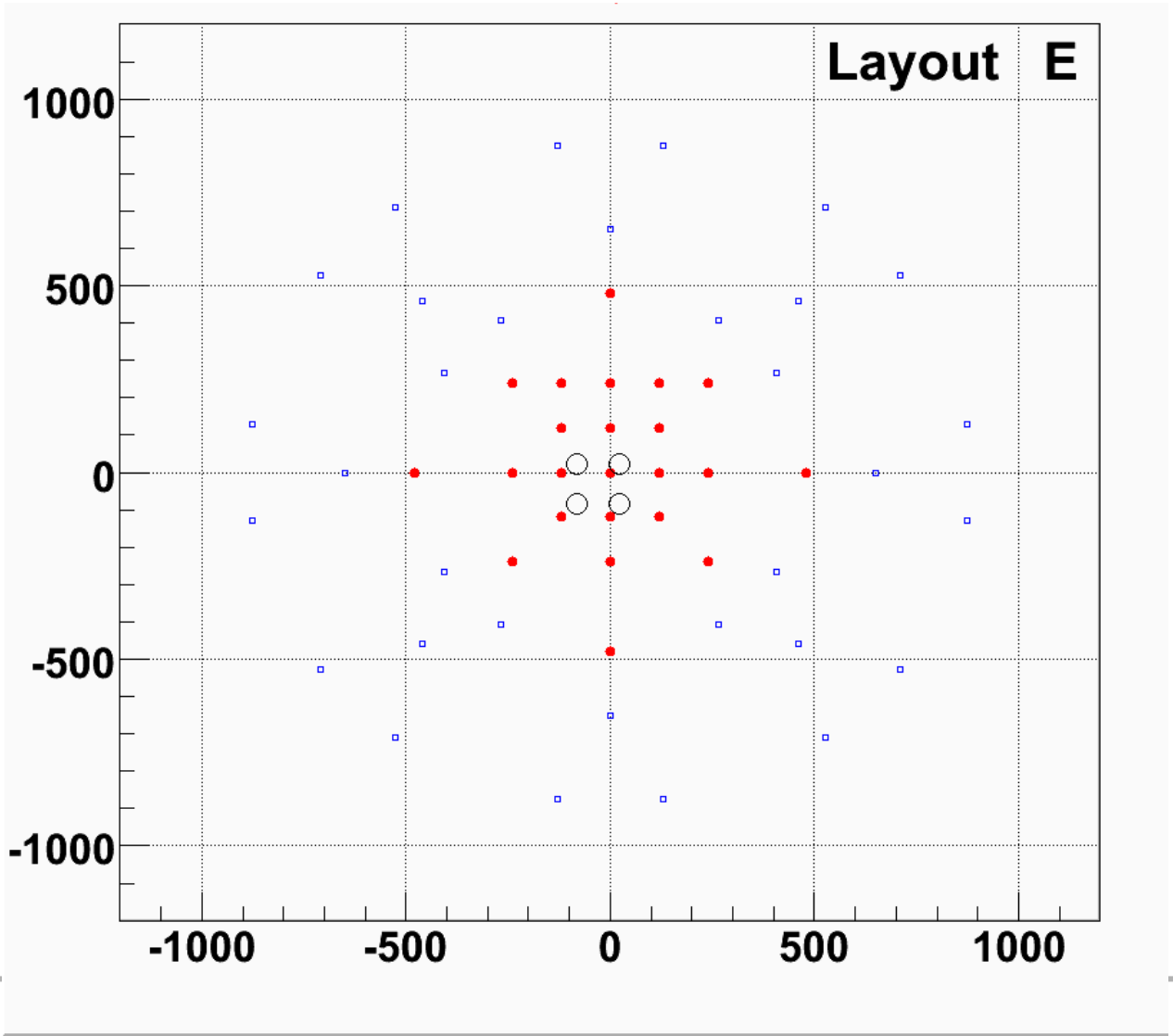
Large scale simulation of "Hyper-Array" with 275 telescopes of 5 different types, sizes, …

→ Selection of candidate arrays under cost constraints
→ Study of performance
→ Assessment within the PHYS work package

~ 10 Billion events generated during last few months, using CTA Grid (Spain, France, Germany, Switzerland, …)

Enabling Grids for E-sciencE

Example – Configuration E

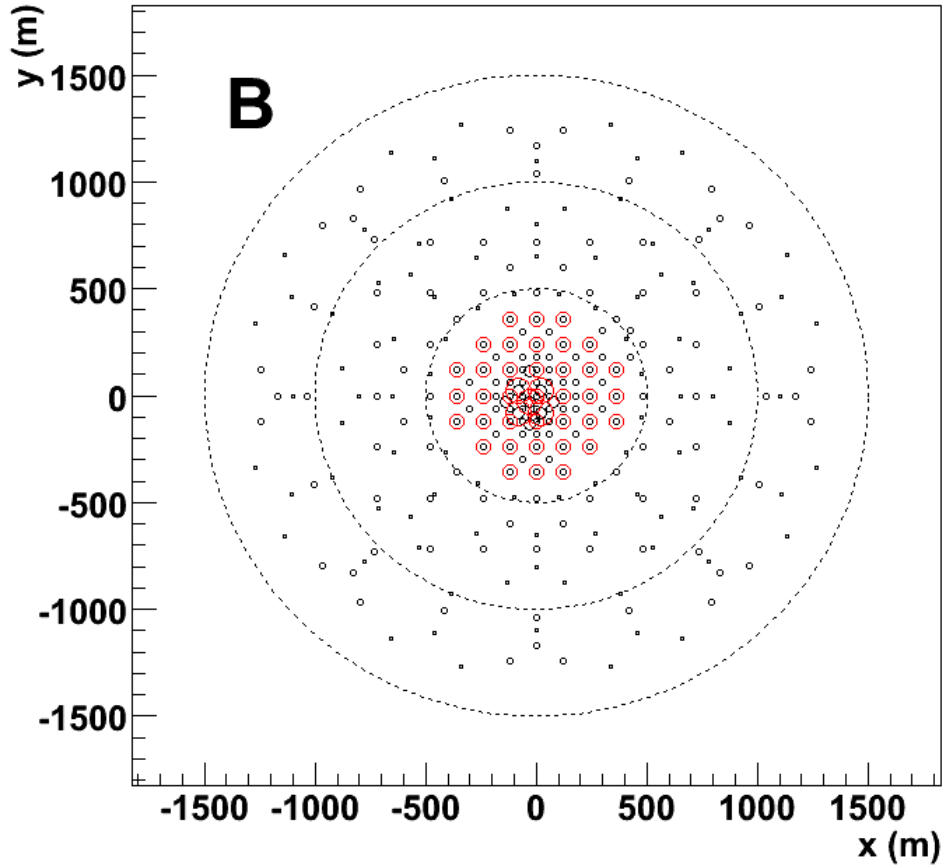


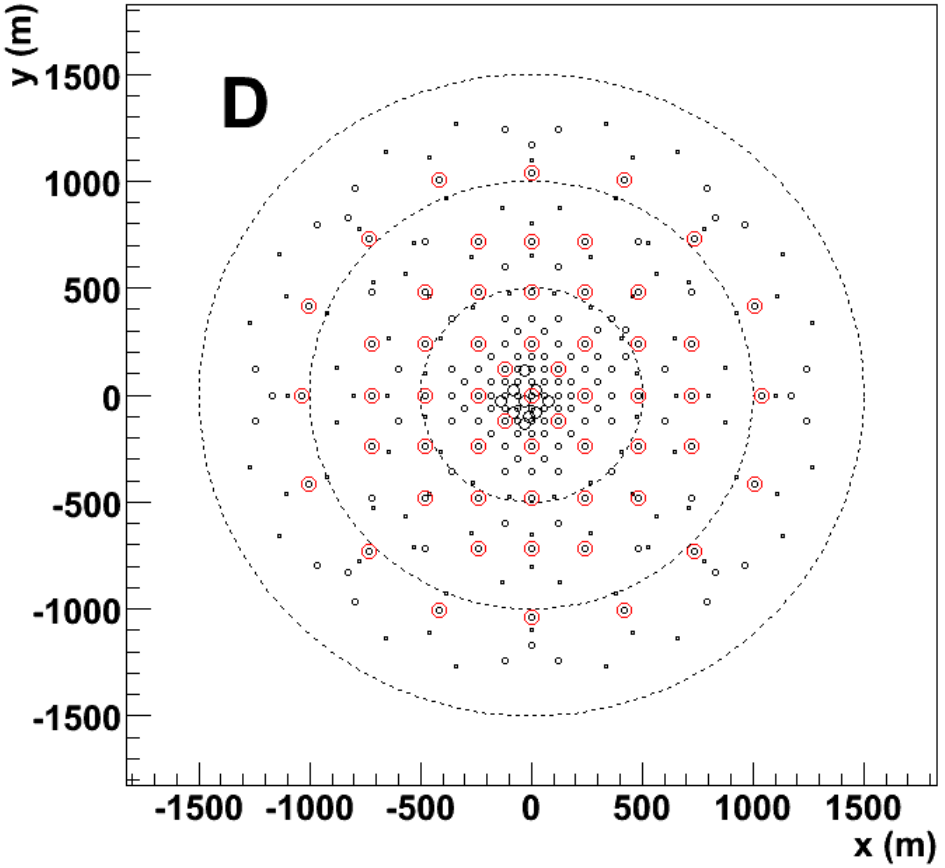
- 23m (x4)
  4.6° FoV,
  0.09° pixels
- 12m (x23)
  8° FoV
  0.18° pixels
- 7m (x32)
  10° FoV
  0.25° pixels

Nominal cost
80Me

Examples: Other configurations

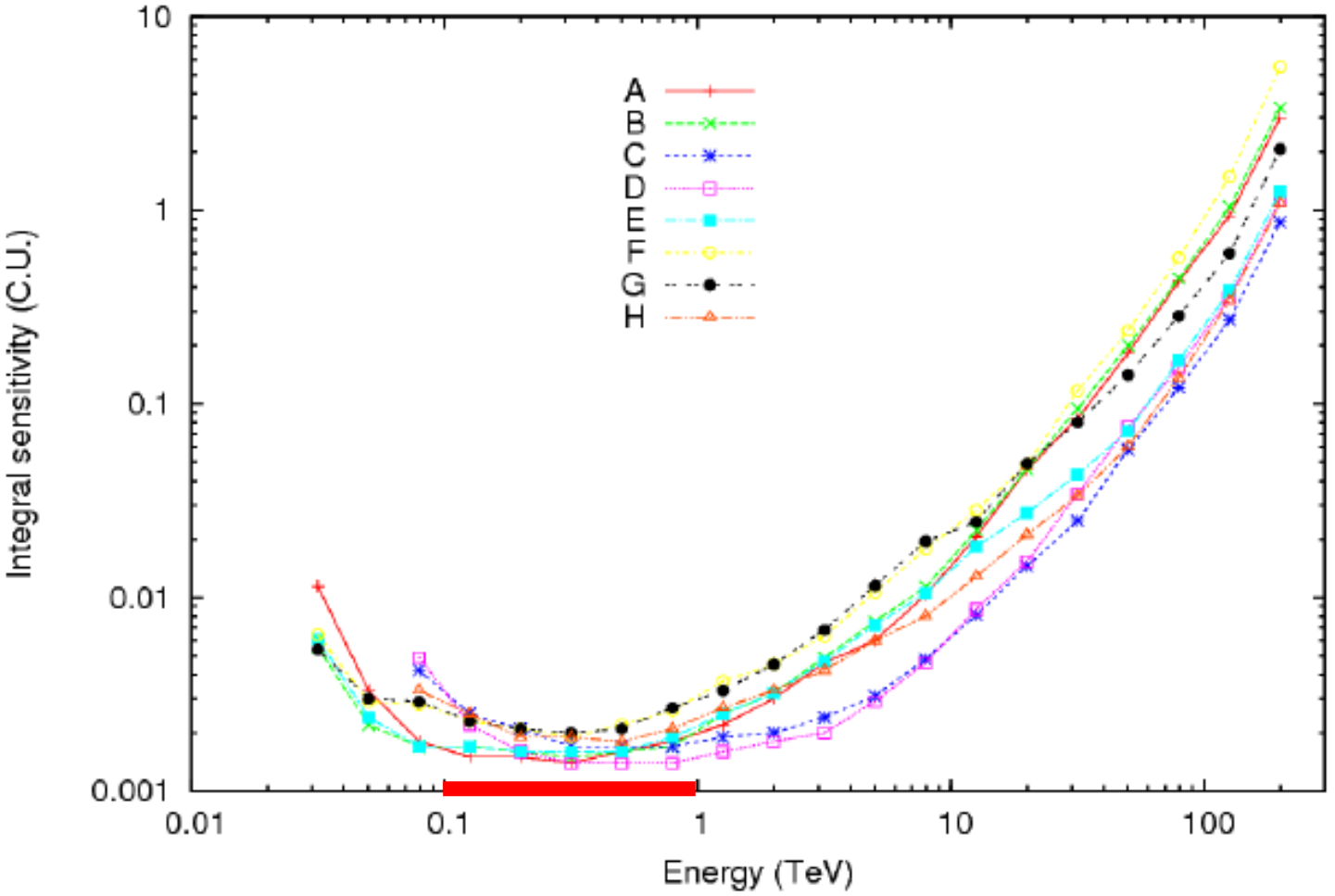
All arrays at
nominal cost of
80 M€





Sensitivity

Preliminary – cuts not optimized !



Building blocks

identical scale

HESS I

HESS II
under construction

The FlashCam Project

A fully digital camera for future Cherenkov telescopes

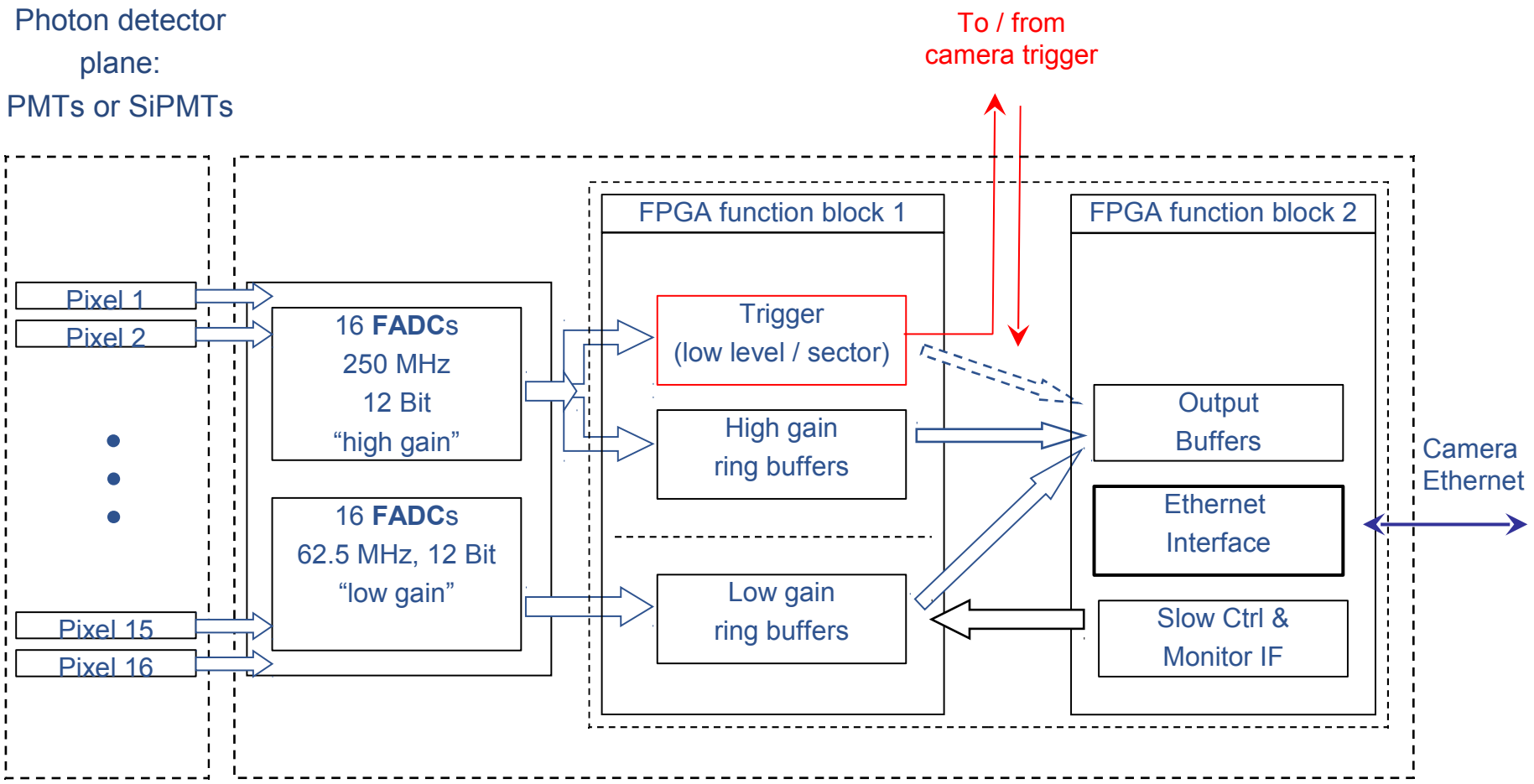
MPIK	Heidelberg
IAAT-KC	Tübingen
ECAP	Erlangen

jointly with groups from

Zurich
Cracow
Leeds, Leicester

- FADC-based system
- Digital FADC/FPGA trigger
- GBit Ethernet front-end R/O
- *Advanced & economic system*

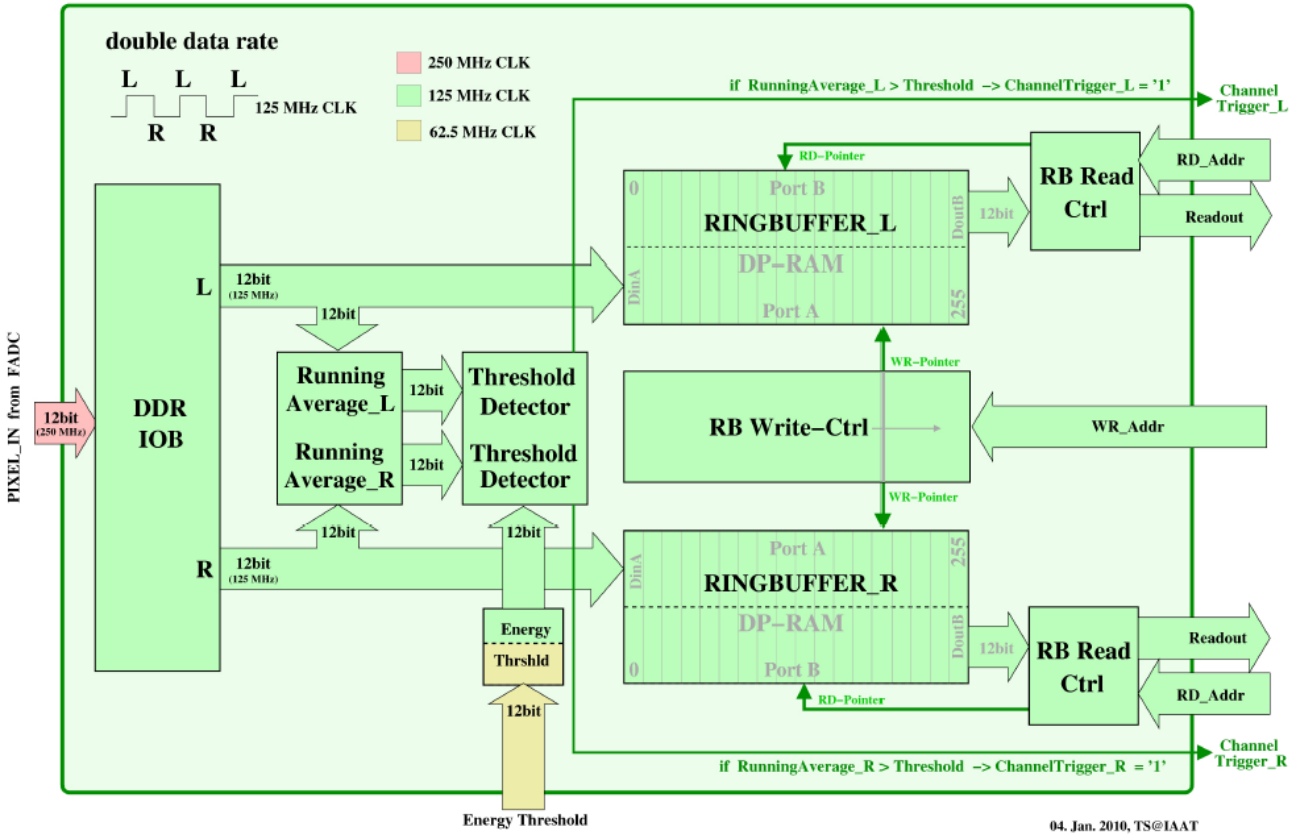
FlashCam: FADC-based front-end



FADC / FPGA based trigger and readout

FlashCam: first fully digital trigger system

SW architecture for digital trigger on FPGA (IAAT)



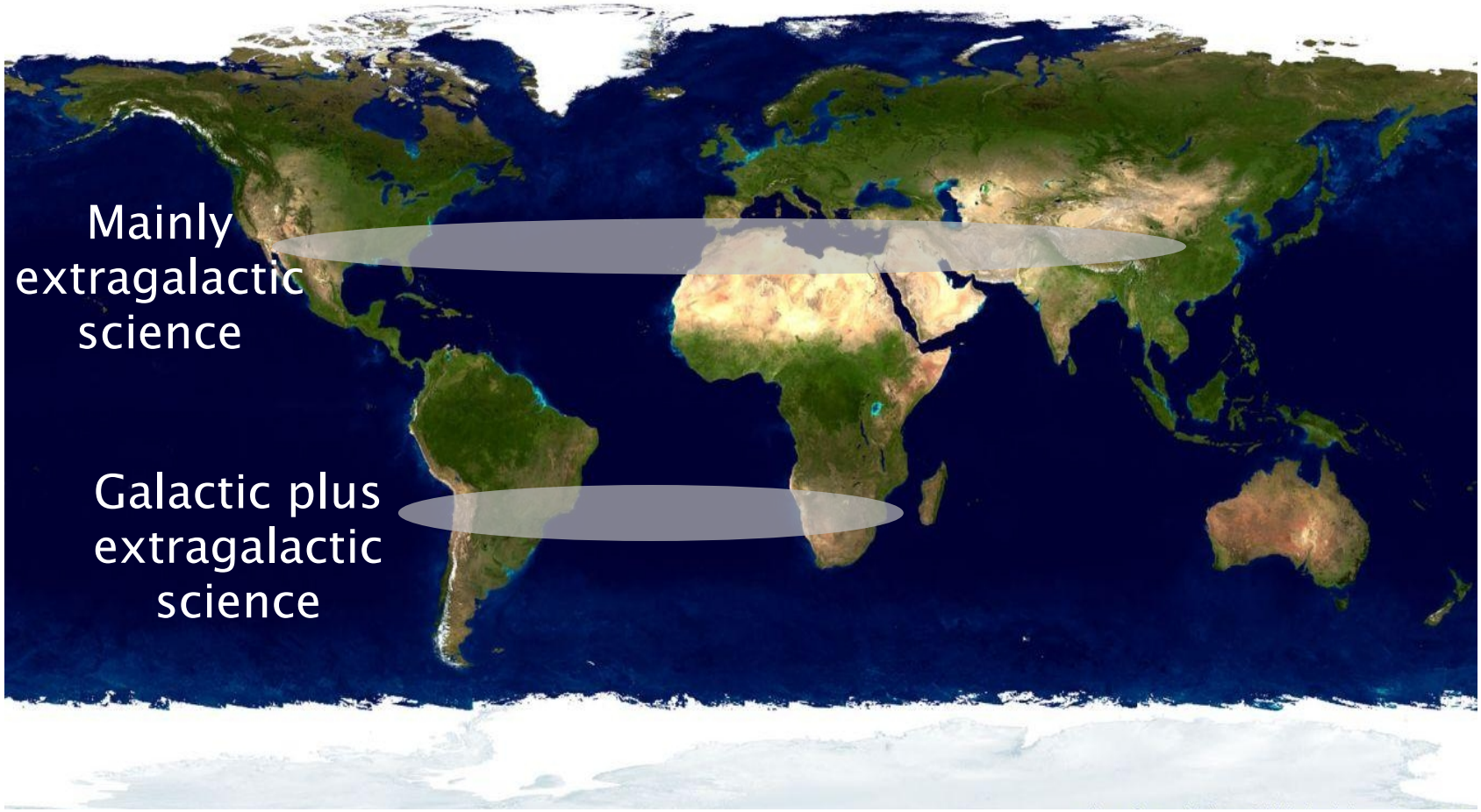
*CTA **Observatory***

CTA has a very broad science programme:
Fundmental Physics, CR Physics, HE Astrophysics, Cosmology
(Surveys, Sources, Diffuse emission, Monitoring)
Not an experiment to measure “the one parameter”.
Best practice: Made available to community.

Observatory operations: Announcements of opportunity, proposal handling, scheduling (queue, staff observing), observatory operations, data analysis tools and pipelines, archive, access, weather monitoring (WP OBS, ATAC)
Major challenges in software/operations (WP DATA)

CTA: Site search

All-sky coverage from two sites



E.g. aerosols

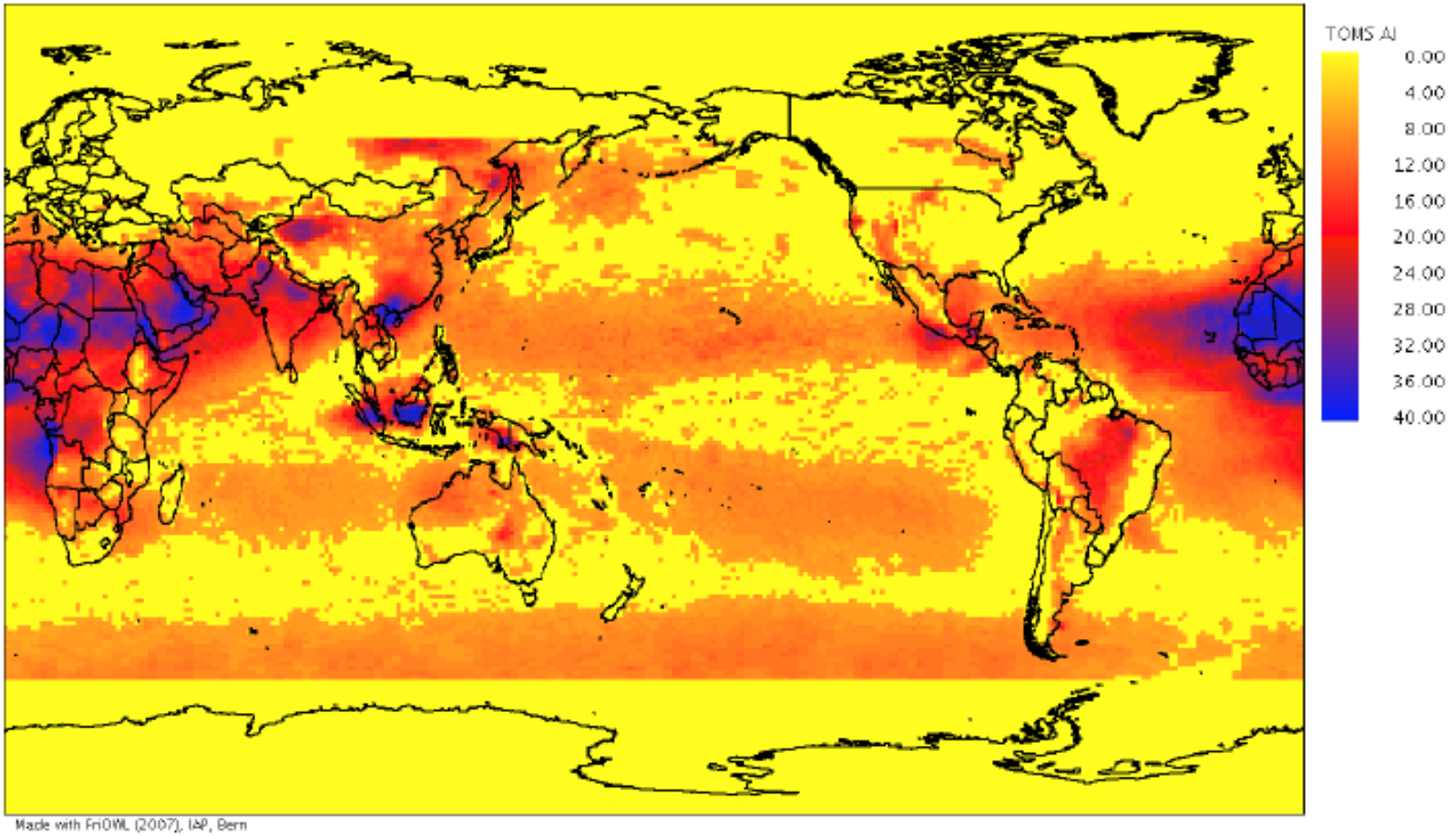
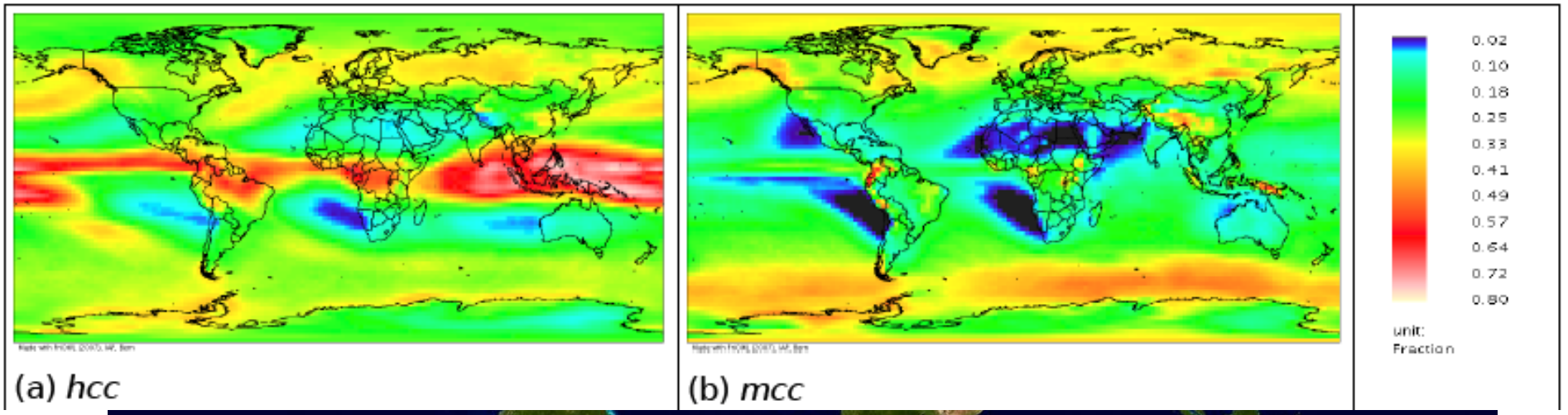


Figure 6.5.2: Maximum mean monthly value of the TOMS aerosol index (X 10) of all months over the period 1980-2002. In addition to the features shown in Figure 6.5.1, this map also shows regions of occasional aerosol contamination.

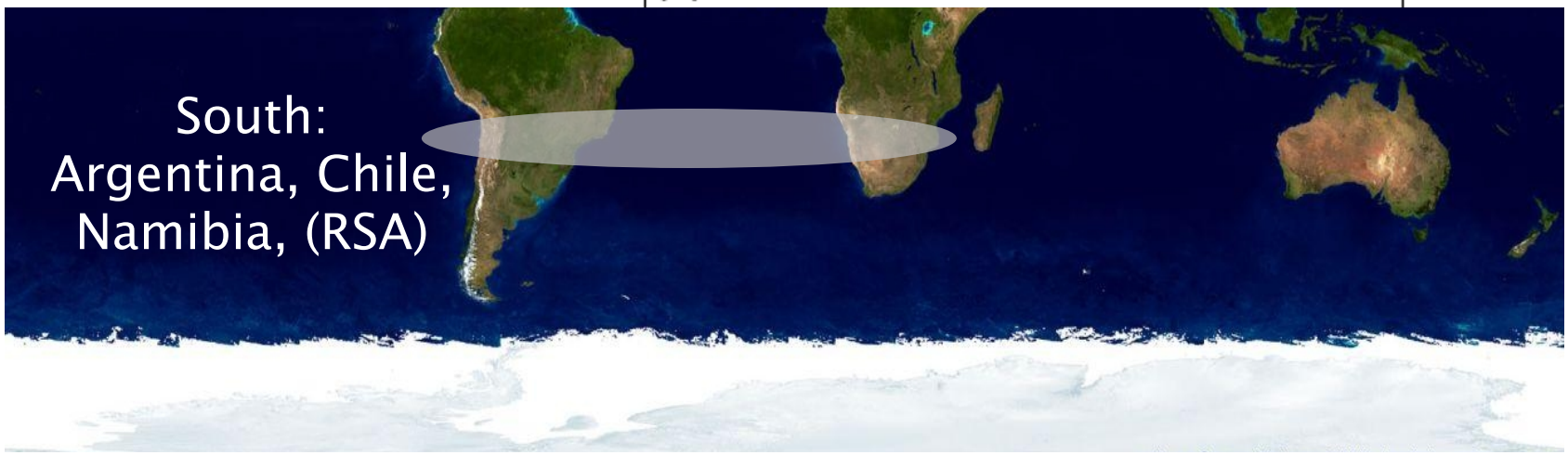
CTA: Site search

Site search: e.g. Cloud coverage



(a) *hcc*

(b) *mcc*



What is happening now?

ASPERA common call 2009

Support for CTA in France, Germany, Poland, Spain, Switzerland (not Italy, not UK); starting now.

Additional financial support in France, Japan, Poland, Switzerland, Spain, in-house support

MOU (130 parties, >350 individuals)

Spokesperson: Werner Hofmann, MPIK/M. Martinez

PDR being drafted

Application "CORE" to *e*-Infrastructure call FP7 Nov. 2009

Application to *Capacities* call FP7 (administration of PP)

CTA Community day

CTA is foreseen to be an observatory.
It will be open to proposals (and provide data for)
to the whole scientific community
served by the supporting funding agencies.
All of you belong to this community if you want to!

We would like to invite you to a CTA Community Day.

Specifically for people who are NOT formally involved (yet)
Astronomy, Underground, Neutrino, CR, ... communities
Share ideas (why do you, why should you care)
Date/venue tbd (~ June 2010)