The Cherenkov Telescope Array
-Status-

J Knapp, U of Leeds

Liverpool, 28 Jan 2010

www.cta-observatory.org

Rich Science in Gamma Ray Astronomy

- Samples of sources without selection biases
- Proof that SNR are sources of galactic CRs
- Propagation of VHE CRs via diffuse emission
- Processes around galactic compact objects
- Energy conversion in pulsar winds
- PWN structure & morphology

...

- Particle acceleration in AGN
- Cosmic rays & VHE gamma rays from starburst galaxies and clusters of galaxies
- VHE gamma rays from GRBs

...

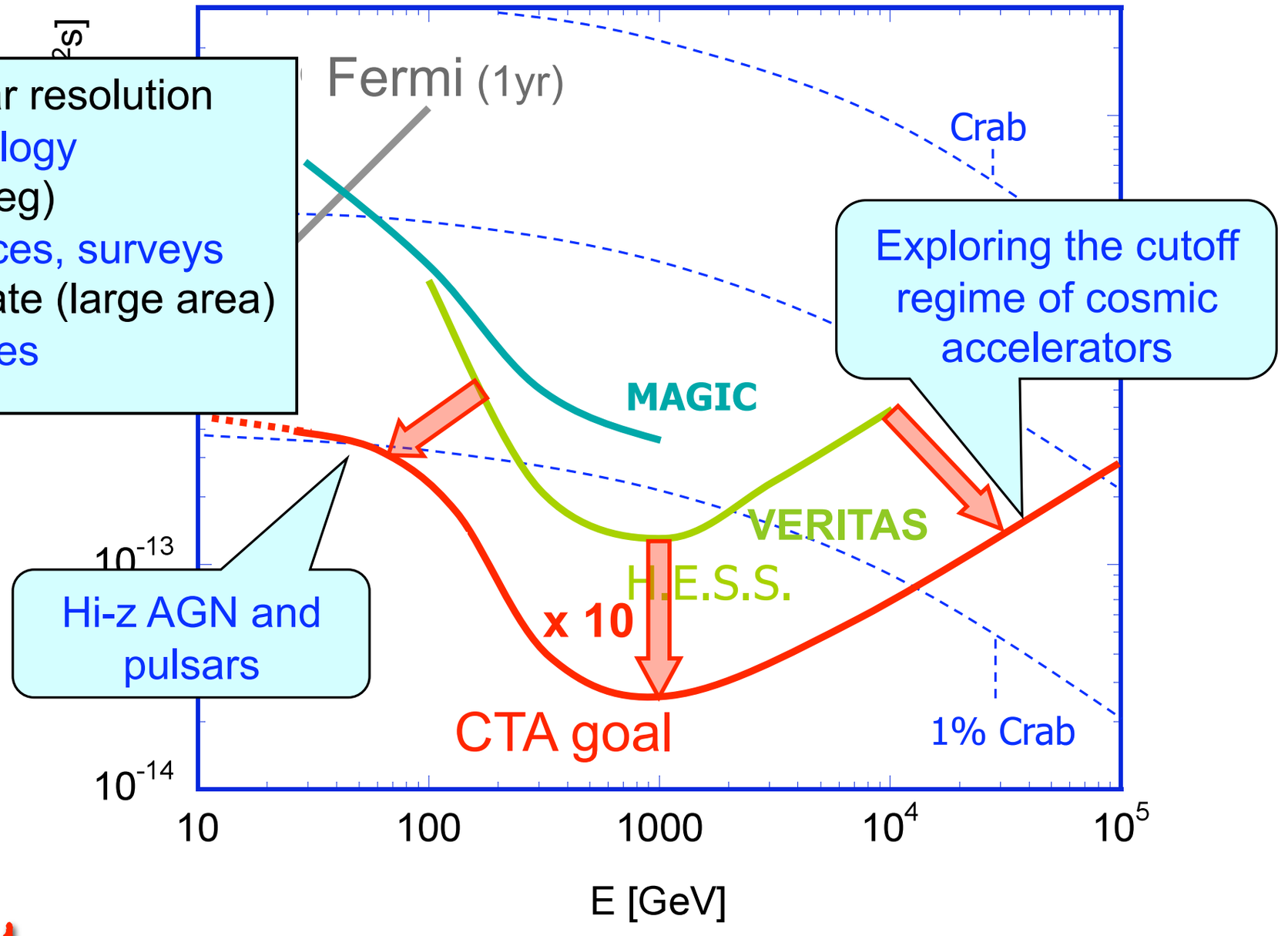
- Cosmology with gamma rays
- Dark Matter Searches
- Violation of Lorenz invariance

...

see Paula's and Jim's talks

The Way Forward:

→ Improved angular resolution
source morphology
→ large FoV (6-8 deg)
extended sources, surveys
→ High detection rate (large area)
transient sources



CTA :

10x more sensitivity
larger energy range
better angular & energy resolution
larger field of view

> 1000 new sources !

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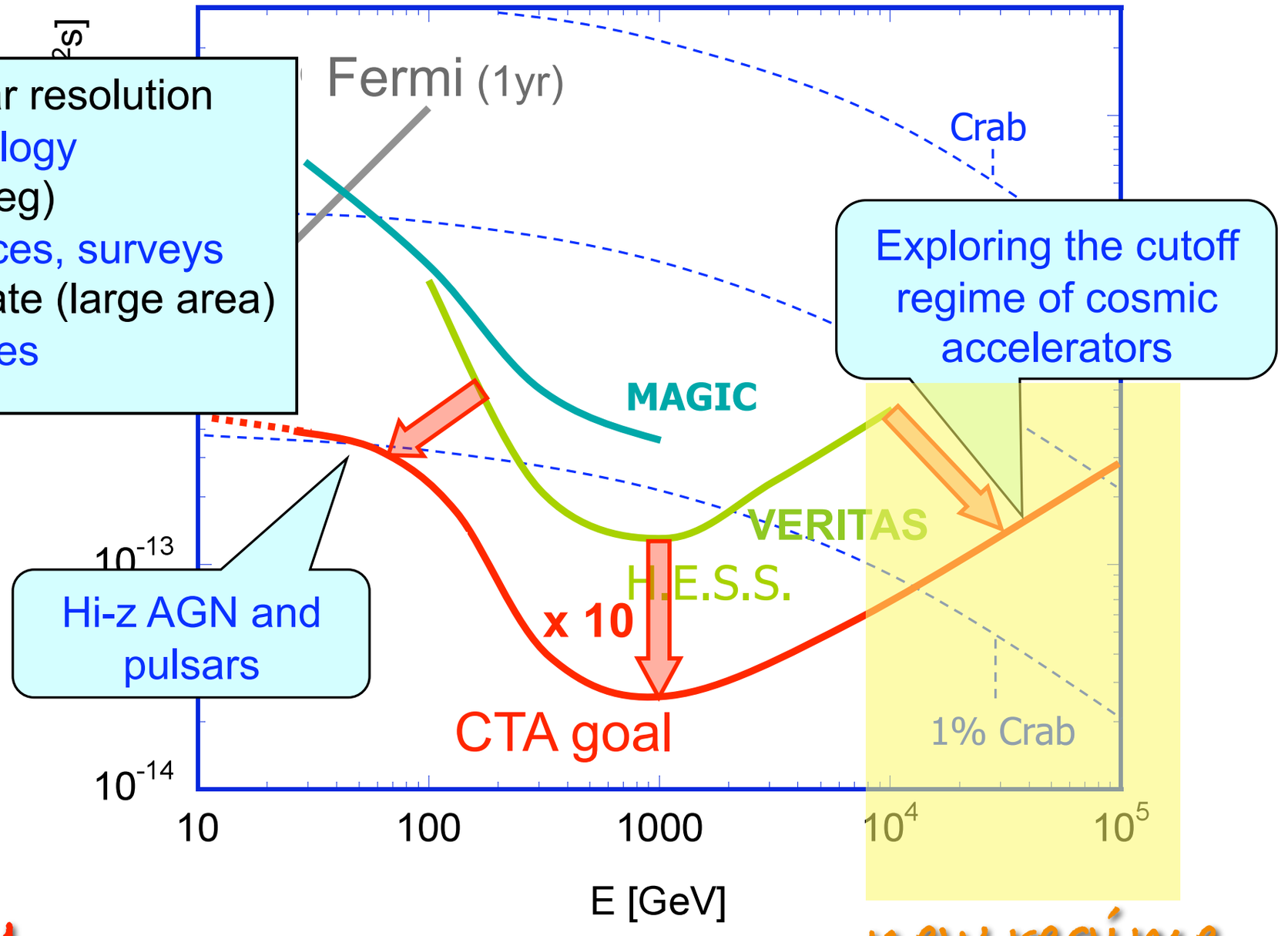

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new regime
UK emphasis

> 1000 new sources !

A real observatory with ≈ 100 telescopes.

Low-energy:
energy threshold
of few 10 GeV

Core array:
mCrab sensitivity at
100 GeV–10 TeV

High-energy:
10 km^2 area at
multi-TeV energies

A real observatory with ≈ 100 telescopes.

Low-energy:
energy threshold
of few 10 GeV

€ 25M

Core array:
mCrab sensitivity at
100 GeV–10 TeV

€ 35M

High-energy:
10 km² area at
multi-TeV energies

€ 20M

CTA observation modes

very deep field

deep field

deep field

monitoring

survey mode

Operations

- Many (≈ 100) telescopes of different sizes
- Operation of varying subsets
- "Observatory" mode
- Long-term stable operation
- Run by local (largely technical) crew
- 2 sites: North and South

- Substantial operating costs (≈ 10 M€ /yr)

CTA is a significant step forward, well beyond the current experiments.

Price Tag: € 100 + 50 M

South

North

What is the best instrument for this money?

Science /€

Design Study:

Optimise performance (within budget),

(parameters: telescope size, type, pixel size, FoV, array layout)

design for mass production, long-term operation

and low maintenance

i.e. cheap, reliable, modular ...

Work Packages

UK well represented

WP1	MNG	Management of the design study	
WP2	PHYS	Astrophysics and astroparticle physics	D Torres
WP3	MC	Optimization of array layout, performance studies, …	J Hinton
WP4	SITE	Site evaluation and site infrastructure	G Vasileiadis
WP5	MIR	Telescope optics, mirrors, mirror alignment	M Mariotti & M Doro
WP6	TEL	Telescope structure, drive, control, robotics	M Panter
WP7	FPI	Focal plane instrumentation, mechanics and photo detectors	R Mirzoyan
WP8	ELEC	Readout electronics and trigger	P Vincent
WP9	ATAC	Atmospheric monitoring, associated science & instrument calib.	S Nolan
WP10	OBS	Observatory operation and access	A Sillanpää & S Wagner
WP11	DATA	Data handling, data processing, data management and access	C Stegmann
WP12	QA	Risk assessment and quality assurance, production planning	M Punch & M Benallou

(acting) Chair of the Consortium Board — J Knapp

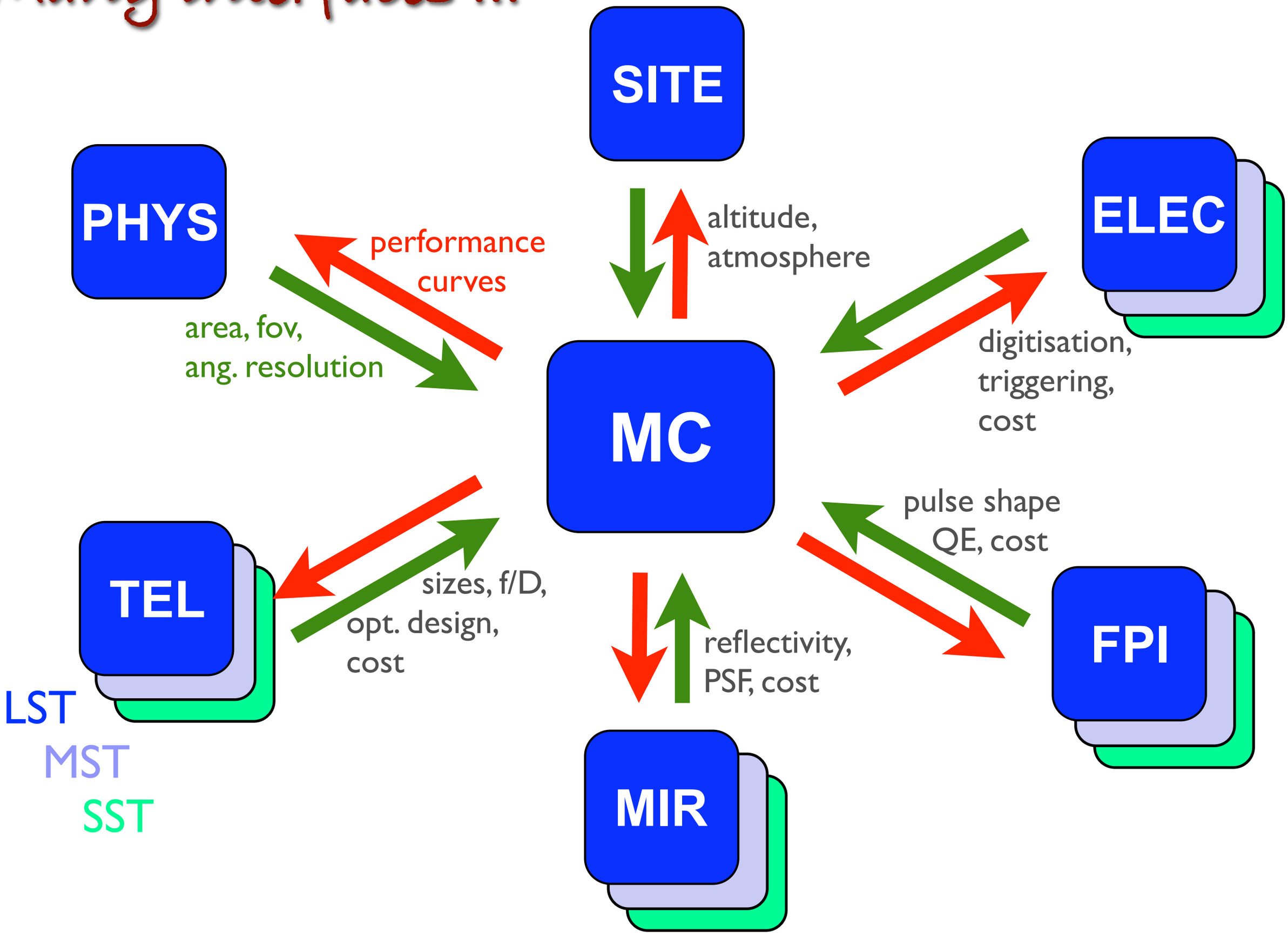
FP7 Preparatory Phase:

SST: small-size telescopes
MST: medium-size telescopes
LST: large-size telescope

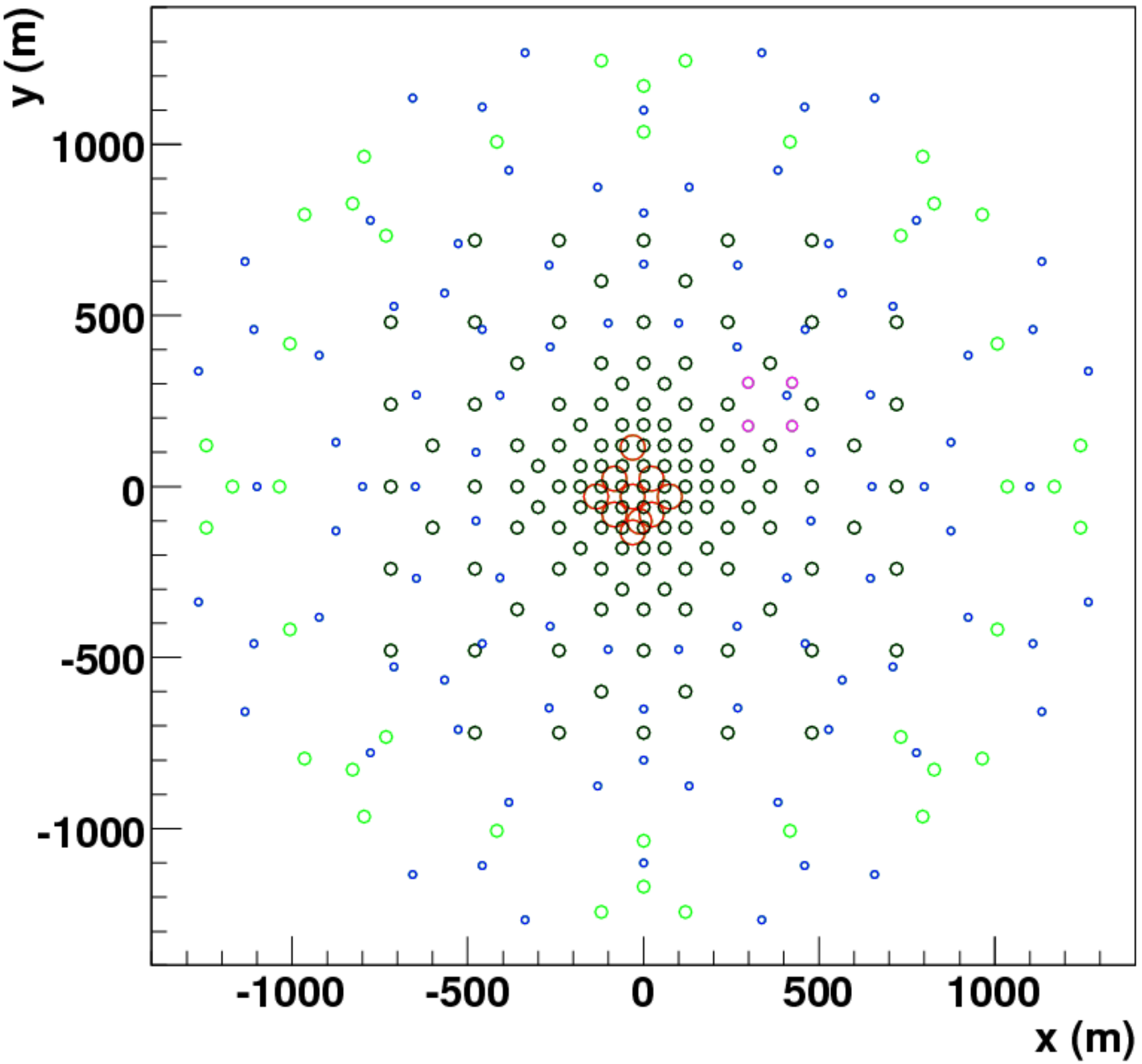
UK emphasis

Opportunities for UK contributions,
Manpower needed everywhere.

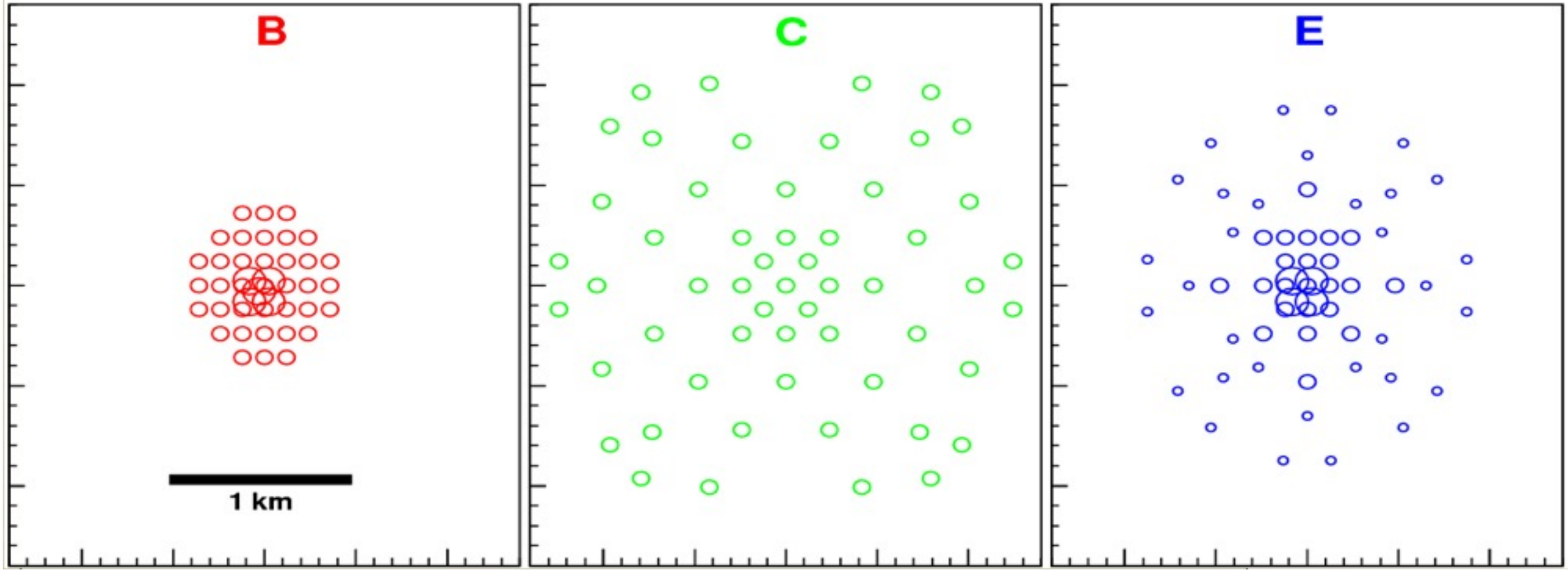
Many interfaces ...



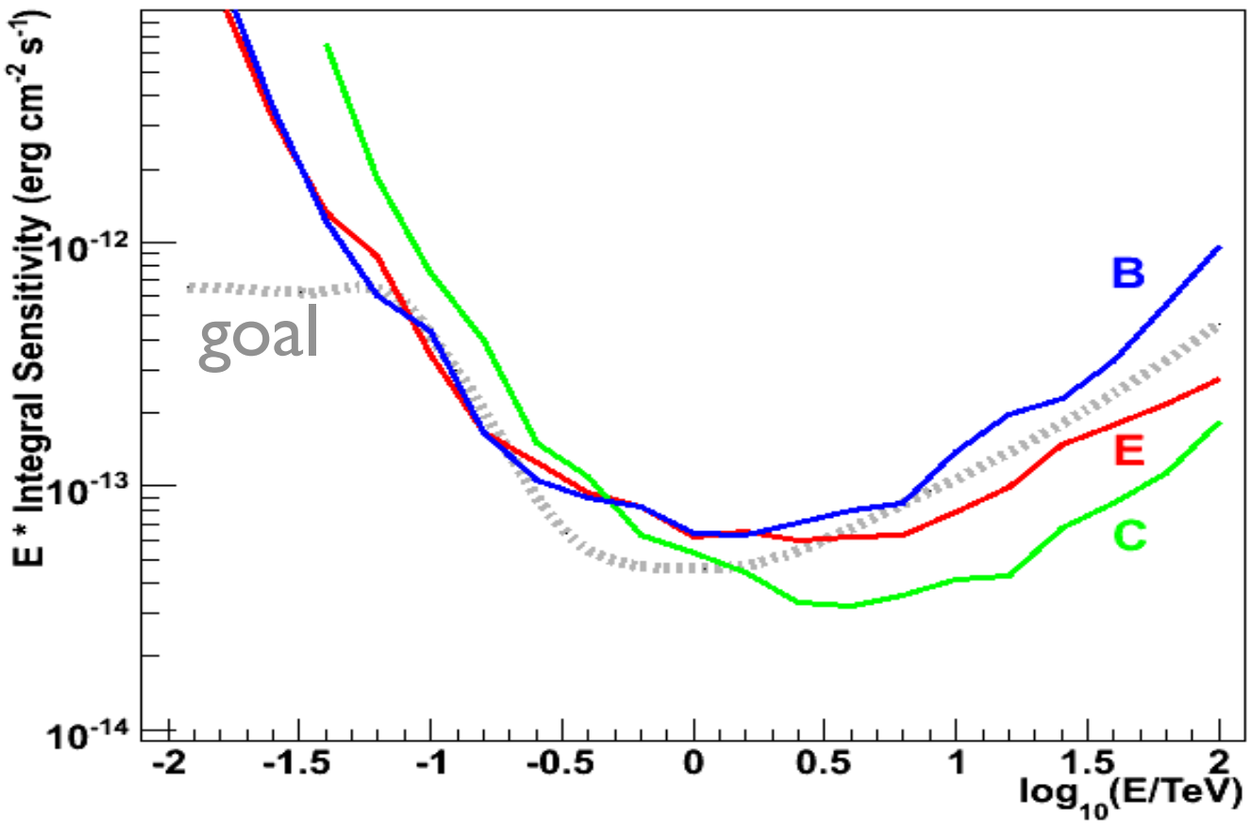
> 40 layouts/options have been investigated ....

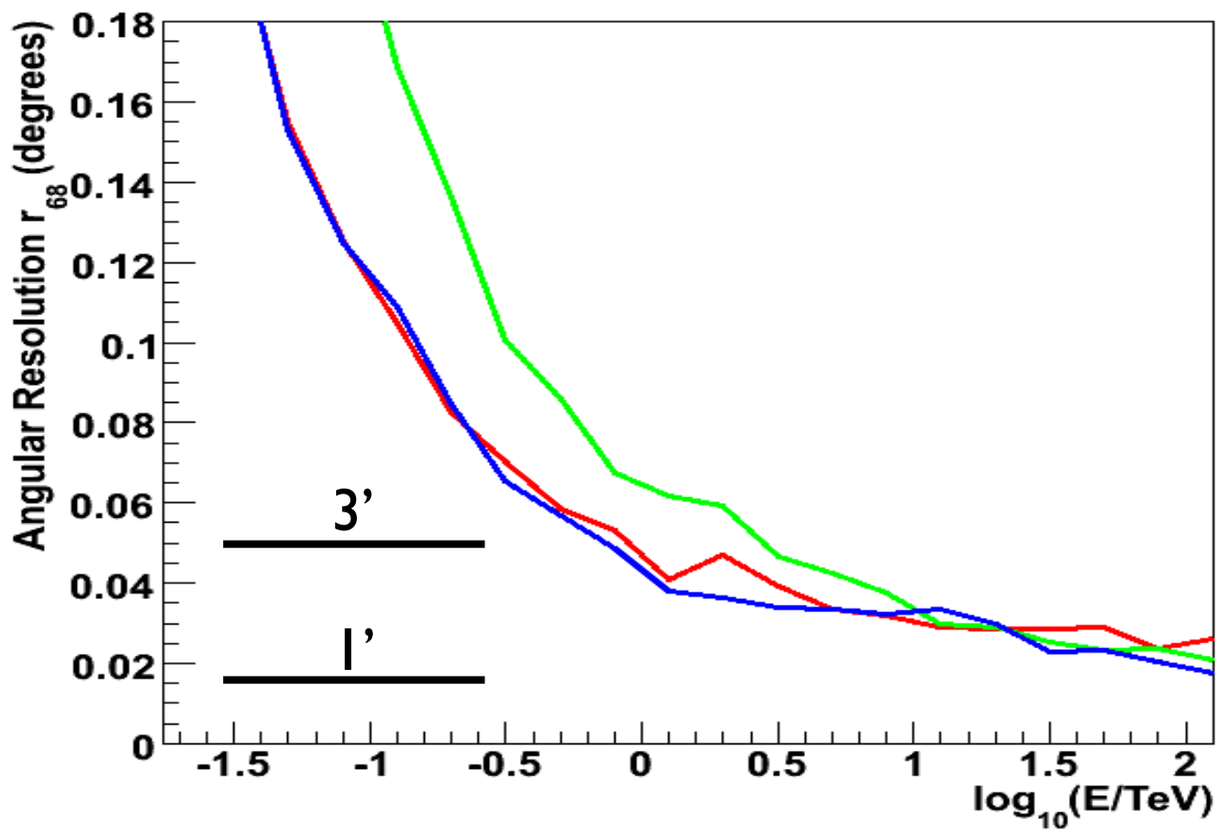


273 tels.



cost for all options: €80M





B

C

E

very soon:
convergence towards
optimised baseline design

goal

B

E

C

E * Integral Sensitivity (erg cm^{-2} s^{-1})

10^{-12}

10^{-13}

10^{-14}

-2 -1.5 -1 -0.5 0 0.5 1 1.5 2

$\log_{10}$(E/TeV)

Angular Resolution r_{68} (deg.)

0 0.02 0.04 0.06 0.08 0.1 0.12 0.14 0.16

3’

1’

-1.5 -1 -0.5 0 0.5 1 1.5 2

$\log_{10}$(E/TeV)

Performance:

Energy TeV	Area km^2	Ang.Res arc min	E.Res %	FOV °
0.03	0.003	12	30	4-5
0.3	0.1	4	13	6-8
3	1	2	8	7-9
30	3	1.5	7	8-10

Improvement factors (relative to HESS) :

Diffuse continuum:	≈ x 5
Angular resolution for point sources:	≈ x 2
FoV for surveys:	≈ x 2
Energy resolution for lines:	≈ x 1.5
all-sky survey for point-like emission line sources:	≈ x 30
pointed observation of a 0.5°continuum source:	≈ x 5

Small Size Telescopes for High Energies:

lots of Ch. light,
but very low flux

huge effective area: telescope array (several km²)

for > 100 TeV sources, TeV flares, EBL, ... (Jim's talk)

small mirrors: as there are lots of Ch. photon

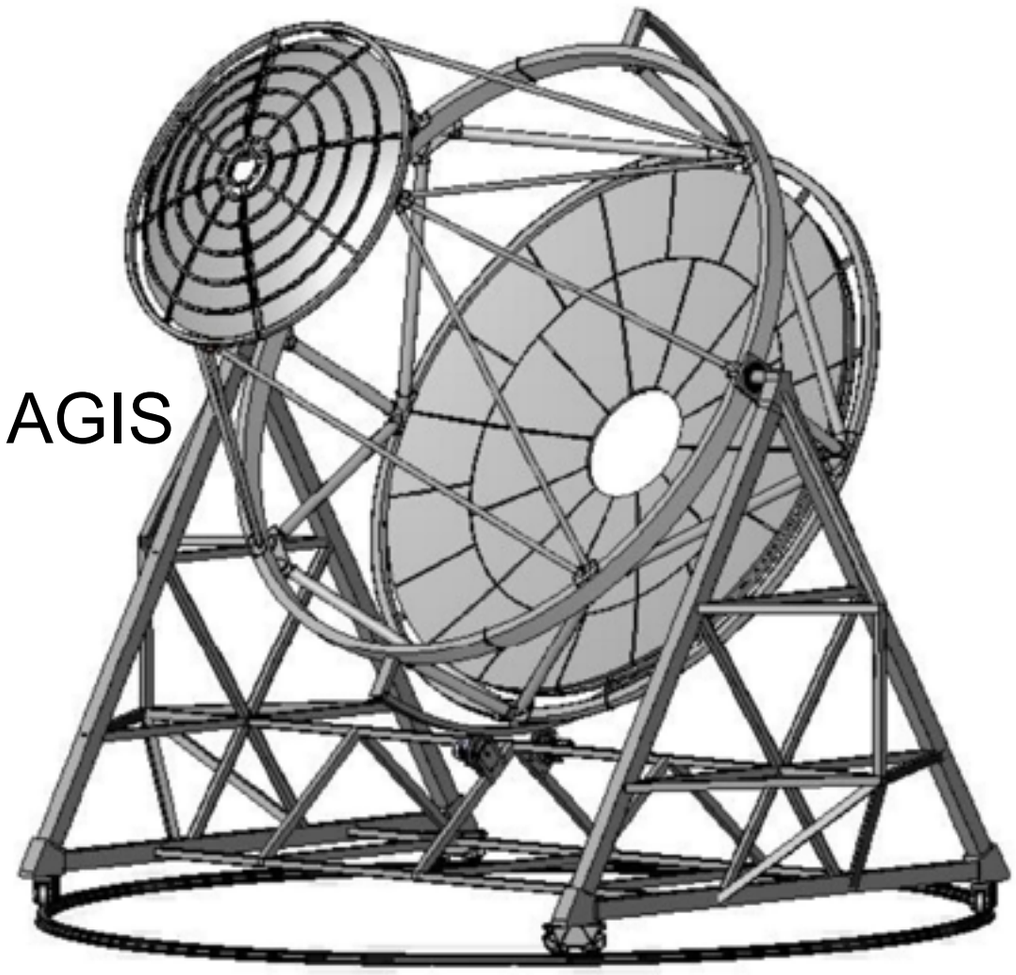
not too far apart: for good angular resolution

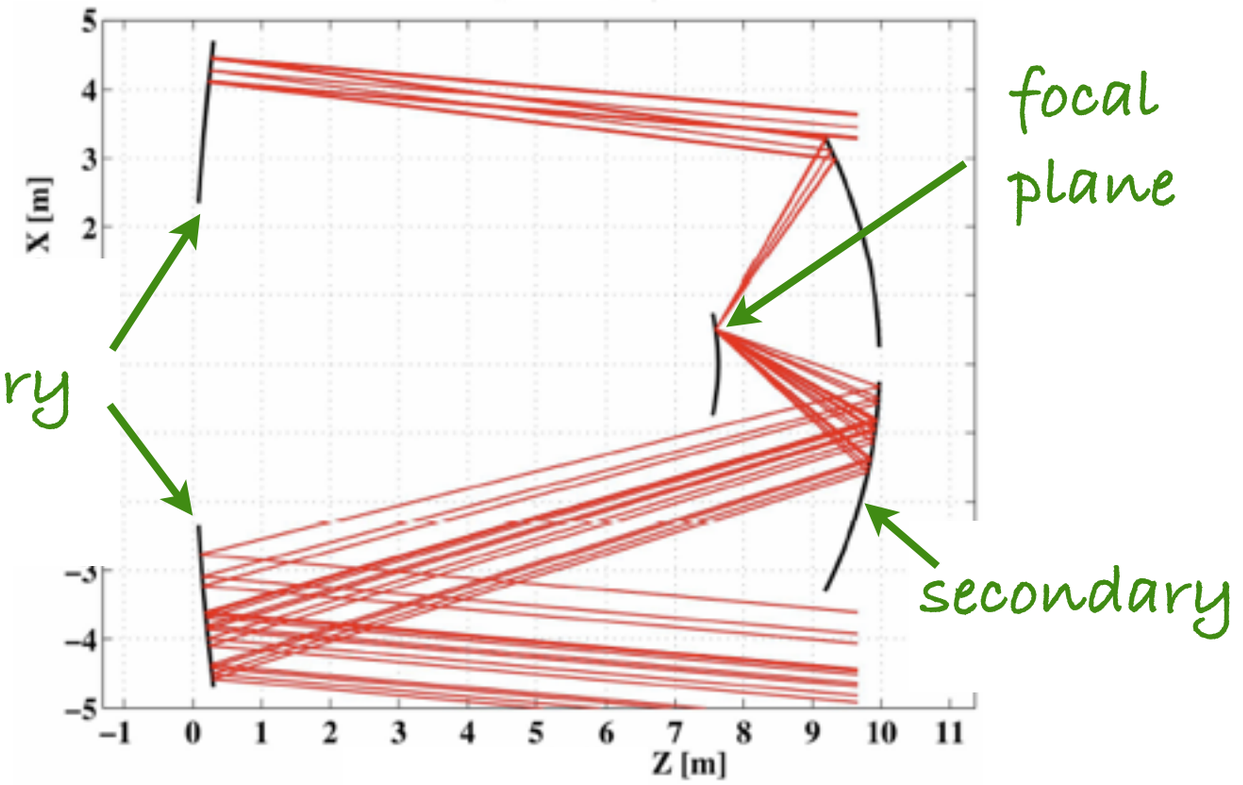
large FOV (≈10°): to see showers far from telescope

i.e. need **many, cheap** telescopes

with normal design (i.e. Davies-Cotton):

wide-FOV: requires large camera,
dominates costs,
limits array size





Secondary optics (Schwarzschild-Couder)

as AGIS

mirror: ø 3.5 m, f/D ~ 0.6

alignment and mirror quality doable

camera: ø 40 cm, 1600 pixels of 0.2°,

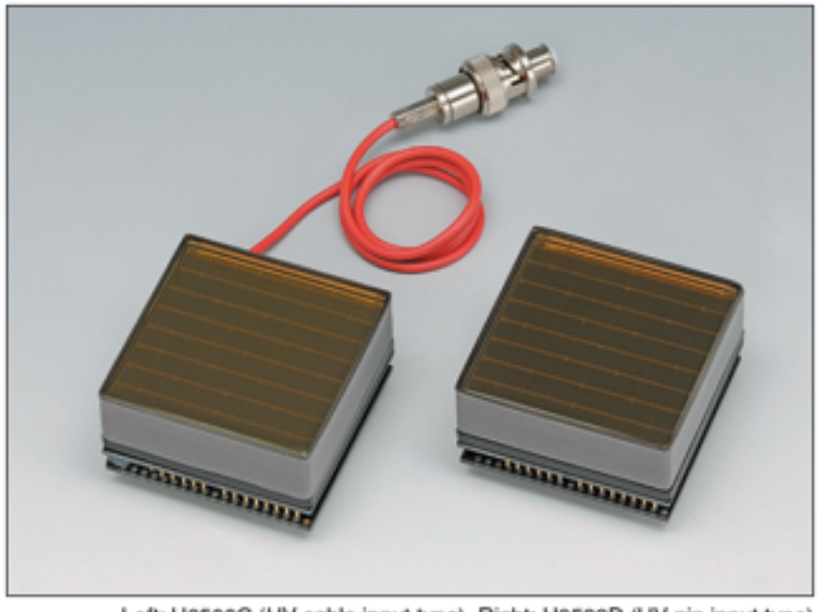
cheap photodetectors (MA, Si PMTs)

cheaper electronics, HV, ...

Camera Cost ≈ Tel Cost

much cheaper than D-C options.

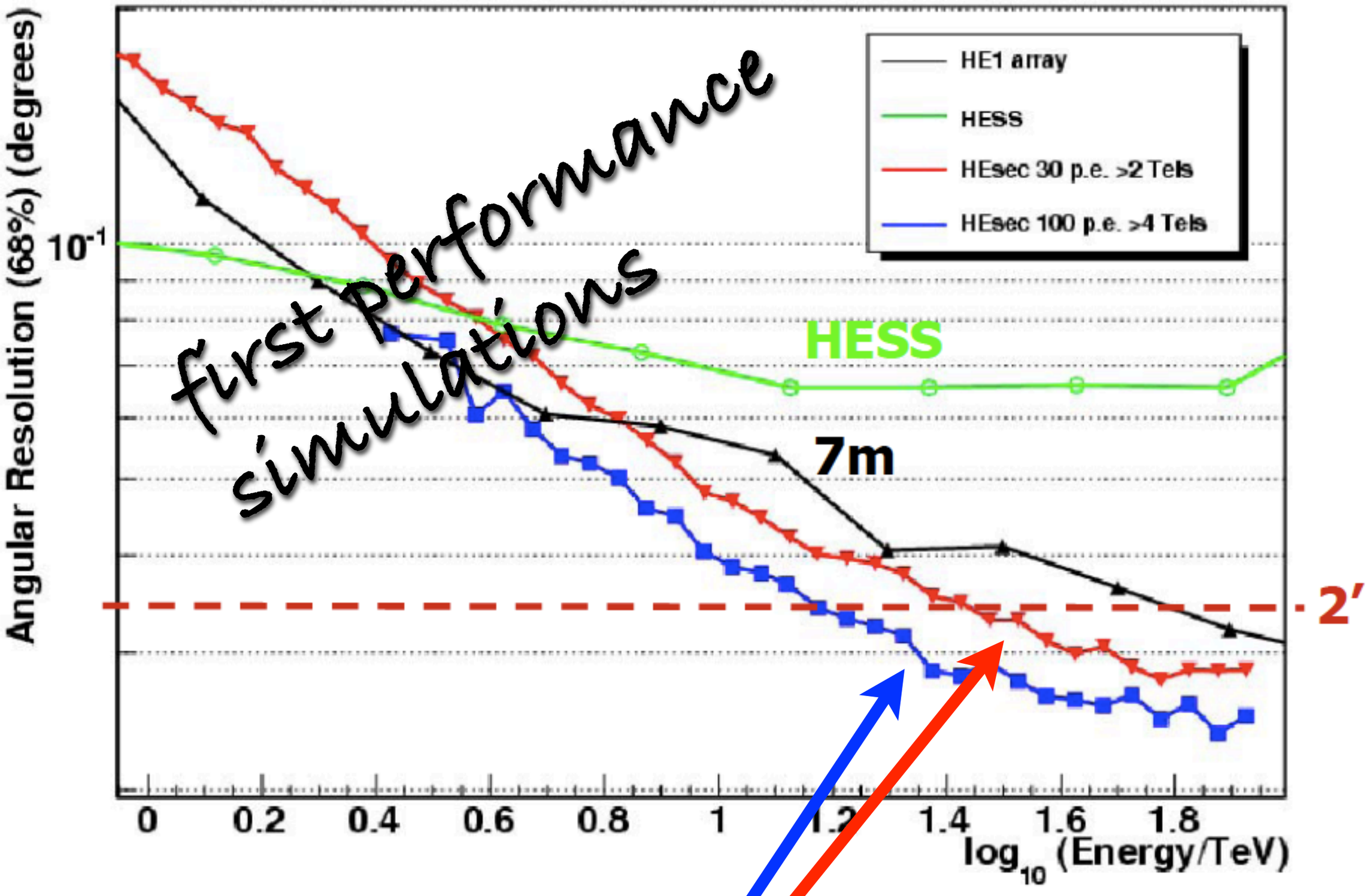
i.e. €20M could buy ≈90 small telescopes



Left: H8500C (HV cable input type), Right: H8500D (HV pin input type)

64 channels

20 € / channel



cheaper and better !

Secondary optics with small cameras for SST is a very promising idea (... but needs still more R&D)

proposed/driven by UK

allows for interesting Science at high energies

new - clever - affordable - potential for industry

optics - mechanics - photo detection - electronics

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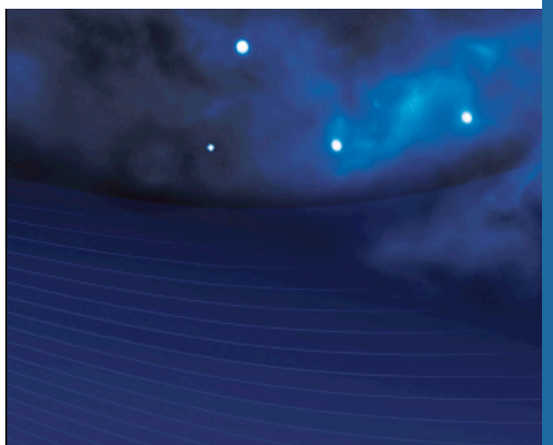
Would be an ideal UK contribution to CTA

... if we could afford working on it.

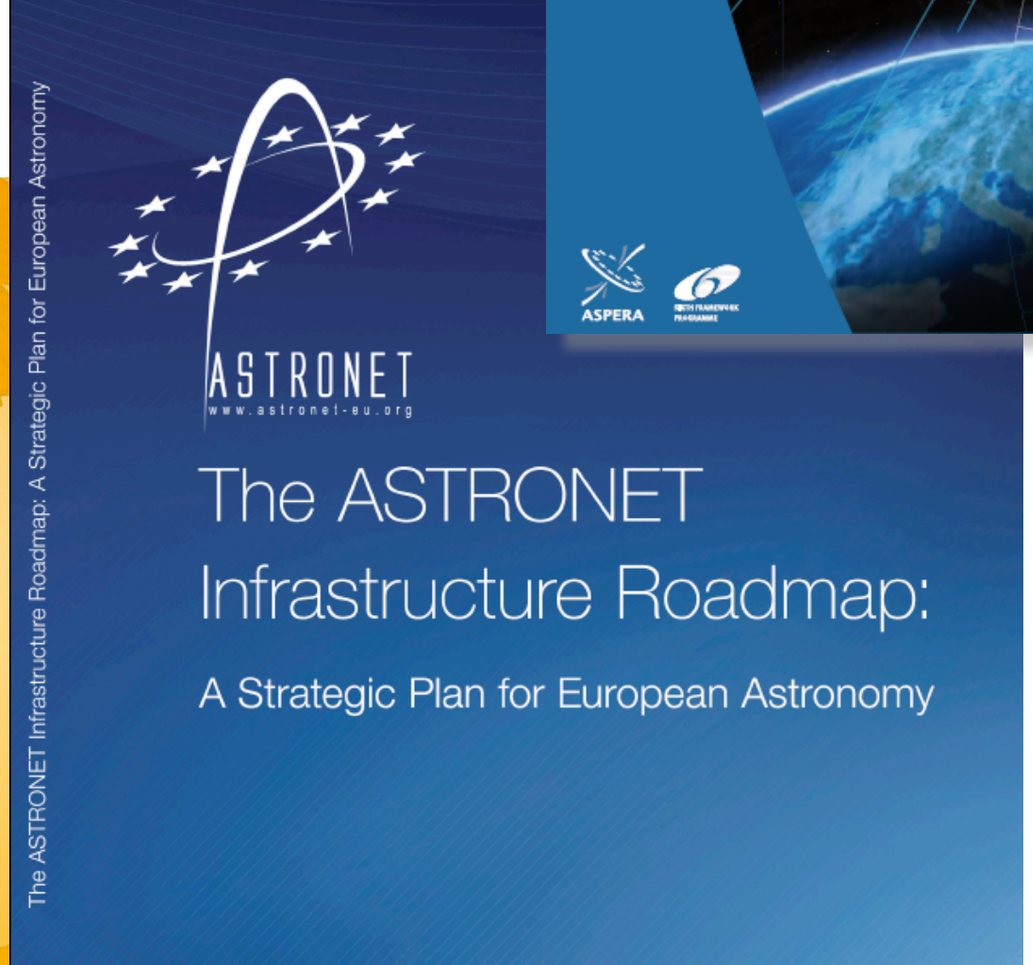
Very Good reviews for CTA:

ASPERA:

ASTRONET:



ESFRI:



Funding:

"guaranteed"

ASPERA Common Call CTA — € 2.6M — UK: ~~£0.5M~~ £0.00

mostly personnel

FP7 CTA Prep Phase call (EU) (€ 6M) — UK: ≈ € 0.78M

announcement spring 2010

mostly organisational

matching funds: € 2.93M — UK: ≈ € 0.26M

FP7 Virtual research infrastructures (EU) (€ 4.2M) — UK: ≈ 4 PD yrs

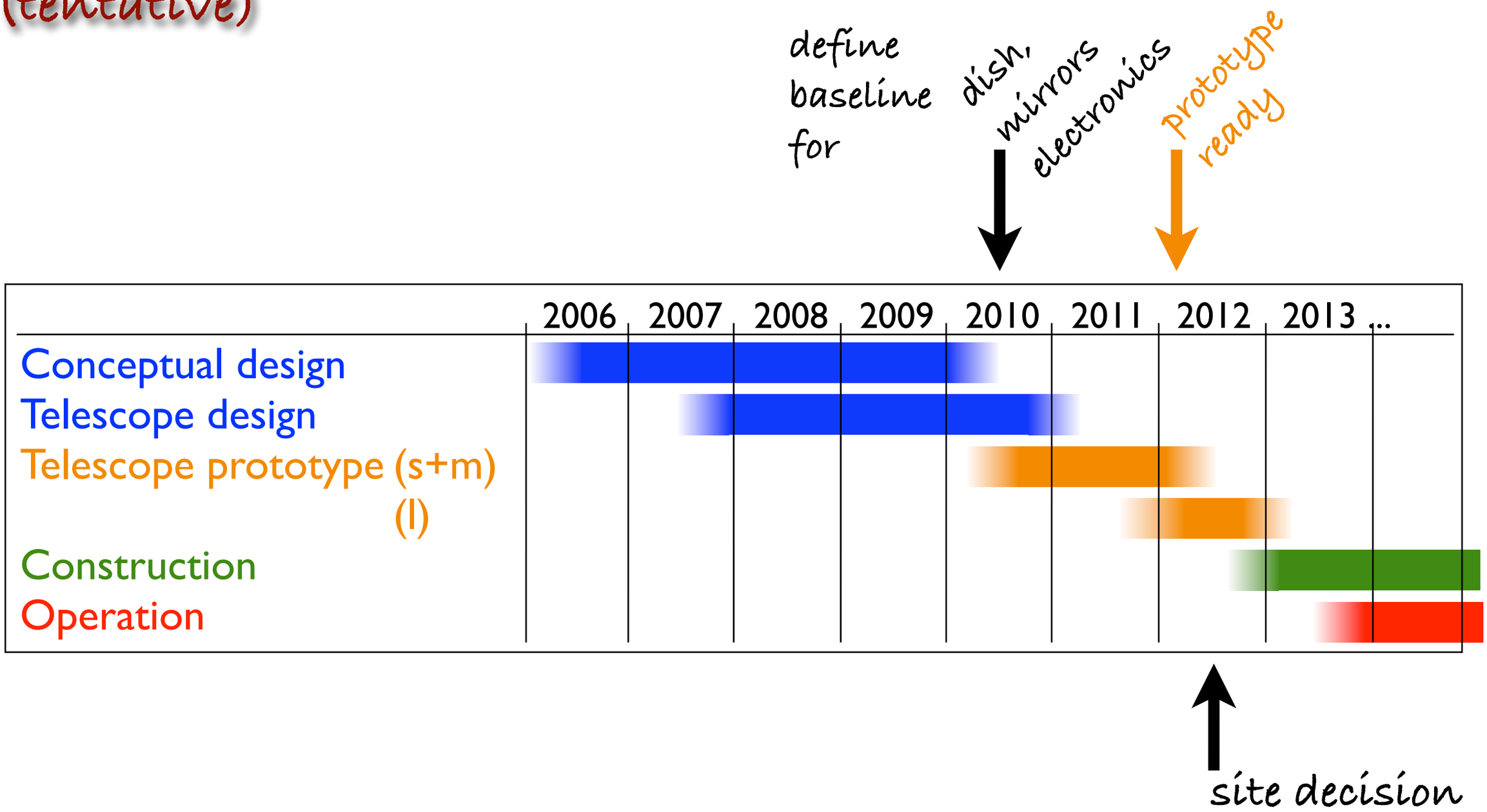
announcement spring 2010

GRID, archiving, data handling, ...

other funding : € 2.76M — UK: ≈ € 0.24M

Time Line

(tentative)



now: convergence towards optimised baseline design

Large telescopes:
prototype = first telescope

CTA Consortium: (status Jan 2010)

22 countries,
114 groups (full & associate)
524 persons

Argentina
Instituto de Astronomía y Física del Espacio (CONICET-UBA)
UID GEMA - UN La Plata
Centro Atómico Bariloche
CEILAP - CITEFA / CONICET)
Inst de Technologias en detection y astroparticulas UNSAM
Instituto Argentino de Radioastronomía La Plata
Lab. Pierre Auger, UTN Mendoza

Armenia
Yerevan Physics Institute

Austria
Leopold-Franzens-Universität Innsbruck

Bulgaria
Lab. of Particle and Astroparticle Physics, INRNE, BAS
Inst. of Astronomy, BAS
Astronomy Depart. of Faculty of Physics, Sofia University

Croatia
Rudjer Boskovic Institute
University of Rijeka-Physics Department
FESB-University of Split

Czech Republic
Charles University

Finland
University of Turku

France
Centre National de la Recherche Scientifique (CNRS)
Université Denis Diderot (Paris 7)
Université de Savoie
Ecole Polytechnique
Université Pierre et Marie Curie (Paris 6)
Université de Montpellier 2
Université Paul Sabatier de Toulouse
Université Joseph Fourier
Commissariat à l'Energie Atomique (CEA)
Observatoire de Paris

Germany
Humboldt-Universität Berlin
Ruhr-Universität Bochum
DESY
Technische Universität Dortmund
Universtät Hamburg
Max Planck Heidelberg
Max Planck München
Friedrich-Alexander-Universität Erlangen-Nürnberg
Landessternwarte Heidelberg
Universität Tübingen
Universität Potsdam
Universität Würzburg

Greece
Aristotle University, Thessaloniki
National & Kapodistrian University, Athens
National Technical University of Athens

Ireland
Dublin Institute for Advanced Studies

Italy
IASF-Palermo /INAF
Osservatorio di Brera /INAF
IFSI-Torino /INAF
Osservatorio di Padova /INAF
Osservatorio di Bologna /INAF
IASF-Roma /INAF
Osservatorio di Roma /INAF
Osservatorio di Catania /INAF
Telescopio Nazionale Galileo/INAF
University and INFN Padova
University of Siena
University and INFN Udine

Japan
Institute of Cosmic-Ray Research (ICRR), University of Tokyo
Dept of Physics and Mathematics, Aoyama-Gakuin University
Dept of Physical Science, Hiroshima University
Faculty of Science, Ibaraki University
Ibaraki Prefectural University of Health Sciences
Inst. of Space and Astronautical Science / Exloration Research
Institute of Particle & Nuclear Studies, KEK
School of Allied Health Sciences, Kitasato University
Dept of Astronomy, Kyoto University
Dept of Physics, Kyoto University
Dept of Applied Physics, University of Miyazaki
Graduate School of Science and Engineering, Saitama University
Dept of Physics, Tokai University
Dept of Physics, Graduate School of Science, University of Tokyo
IPMU, University of Tokyo
Dept of Physics, Tokyo University of Science
Dept of Basic Physics, Tokyo Institute of Technology
Dept of Physics, Yamagata University
Faculty of Management Information, Yamanashi Gakuin University

Netherlands
University of Amsterdam
University of Utrecht

Namibia
University of Namibia (UNAM)

Poland
Copernicus Astronomical Center, Polish Academy of Sciences
Institute of Nuclear Physics, Polish Academy of Sciences
Space Research Centre, Polish Academy of Sciences
Faculty of Physics, Astronomy and Applied Computer Science, Jagiellonian University
Faculty of Physics and Applied Informatics, University of Lodz
Faculty of Physics, University of Warsaw
Faculty of Physics, Astronomy and Informatics, Nicolaus Copernicus University

Spain
IFAE Barcelona
Grupo de Altas Energías, Universidad Complutense de Madrid.
Grupo de Electronica, Universidad Complutense de Madrid
CIEMAT, Madrid
Grup de Fisica de les Radiacions, Universitat Autonoma de Barcelona
Grup d'Astrofísica d'Altes Energies, Universitat de Barcelona (ICC-UB), Barcelona
Institut de Ciencies de l'Espai (IEEC-CSIC)
Instituto de Astrofisica de Canarias, IAC, Tenerife

South Africa
North-West University

Sweden
Lund University
Royal Institute of Technology
Stockholm University
Uppsala University

Switzerland
University Geneva
University Zurich
EPF Lausanne
ETH Zurich

United Kingdom
University of Leeds
Durham University
University of Southampton
University of Edinburgh
University of Hertfordshire
University of Leicester
University of Northumbria
University of Nottingham
Rutherford Appleton Laboratory, STFC
University of Liverpool
University of Sheffield

USA
Argonne National Lab
University of California Davis

+ India, Brazil, Slovenia
+ US groups (AGIS)

Summary:

CTA will be built

Design - Prototyping - Construction - Science

UK ought to be part of it !

Good science, good part of project,

many interested groups.

Durham, Edinburgh, Hertfordshire, Leeds, Leicester, Liverpool, Northumbria, Nottingham, Oxford, RAL, Sheffield, Southampton

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Chance of funding in future?

??? ... but we have a brilliant science case,

We need to stay involved,
bridge the gap with 3rd party funding,
convince the PP and AP communities ....

Next CTA Meeting: Zeuthen 10-12 May 2010