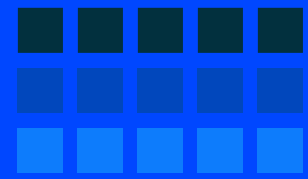
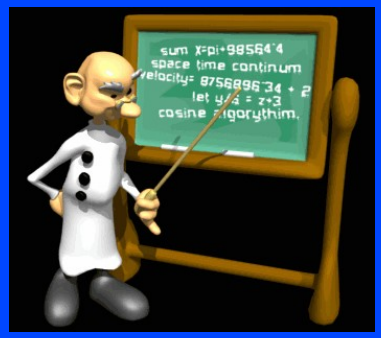
# CTA STATUS DESIGN

M. C. MEDINA





# Outline

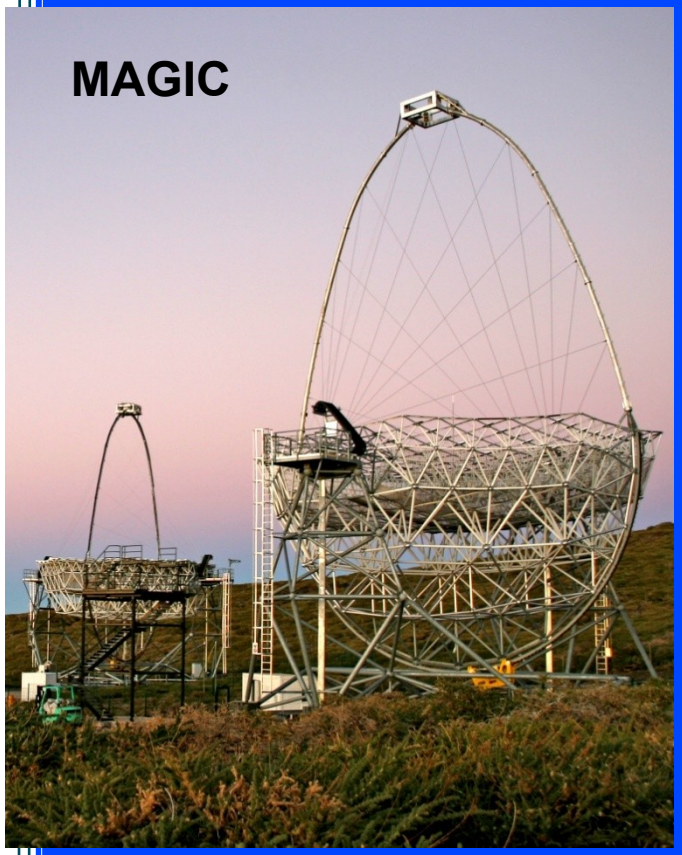



- State of art TeV Astrophysics
- Detecting VHE gamma ray
- CTA  Science Potential
- CTA Wish List
- Possible CTA sensibility
- CTA Concept
- Observation Modes
- Design Studies
- Time Line
- Outlook



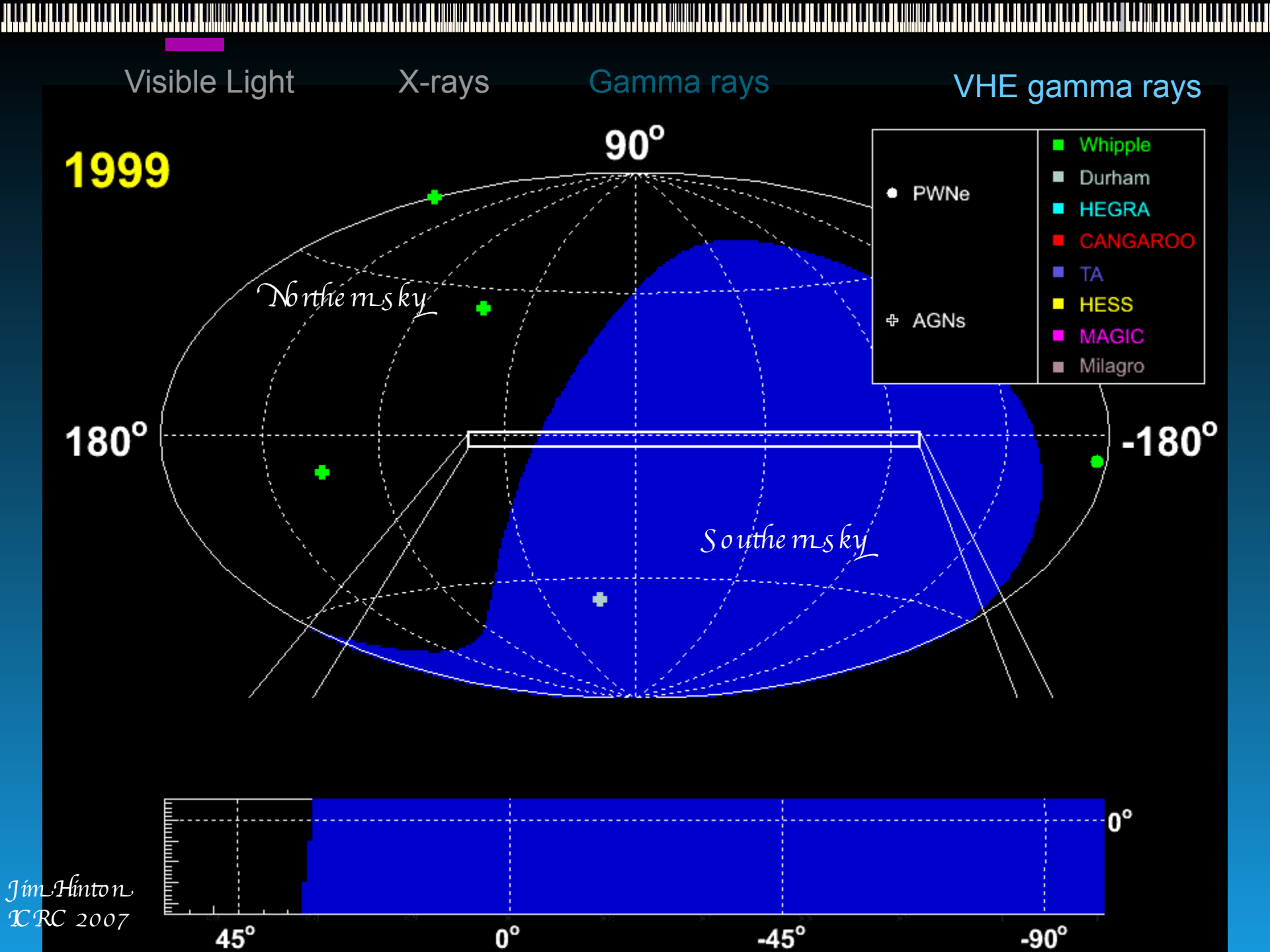
After the pioneers
Whipple, HEGRA, CAT …,
present IACT are revealing
our cosmos at VHE

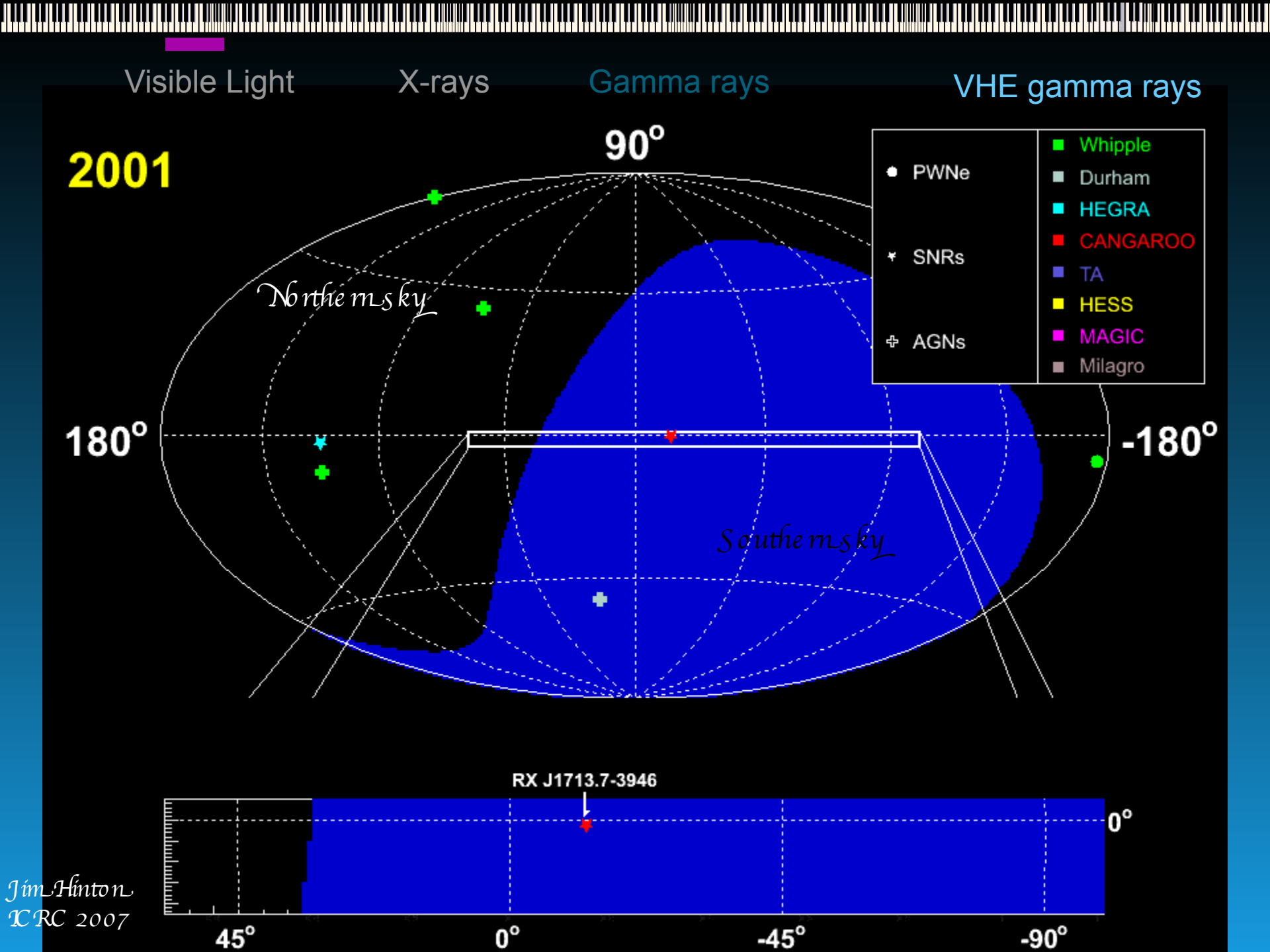

HESS II :
28m tel to add to the HESS 1 array (under construction)
First operations : end of 2009

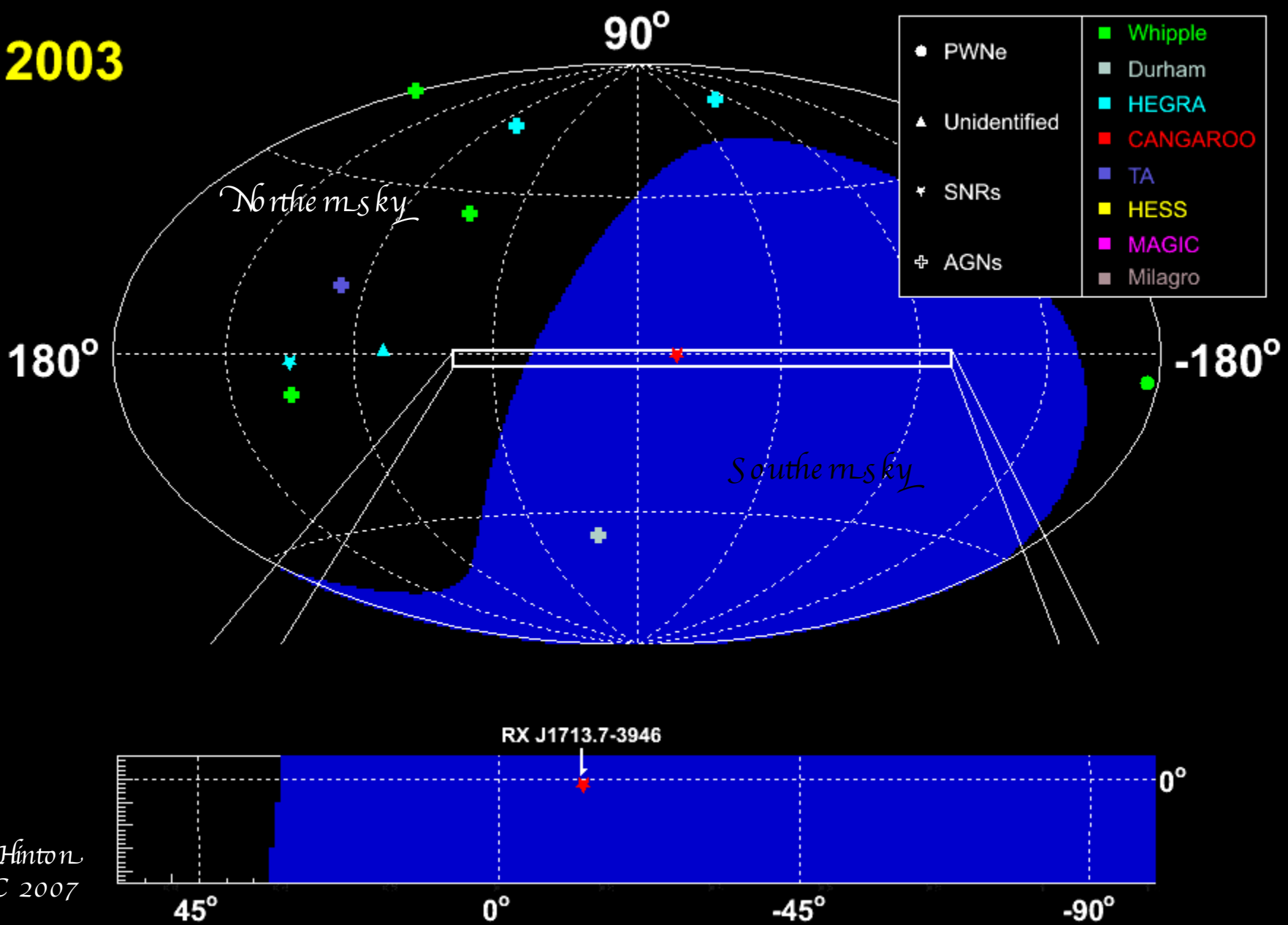

**Next improved performances towards lower energies :**
Extension of present IACT with MAGIC II and HESS II

MAGIC II : 2nd 17m tel
Starts operating in coming weeks/months

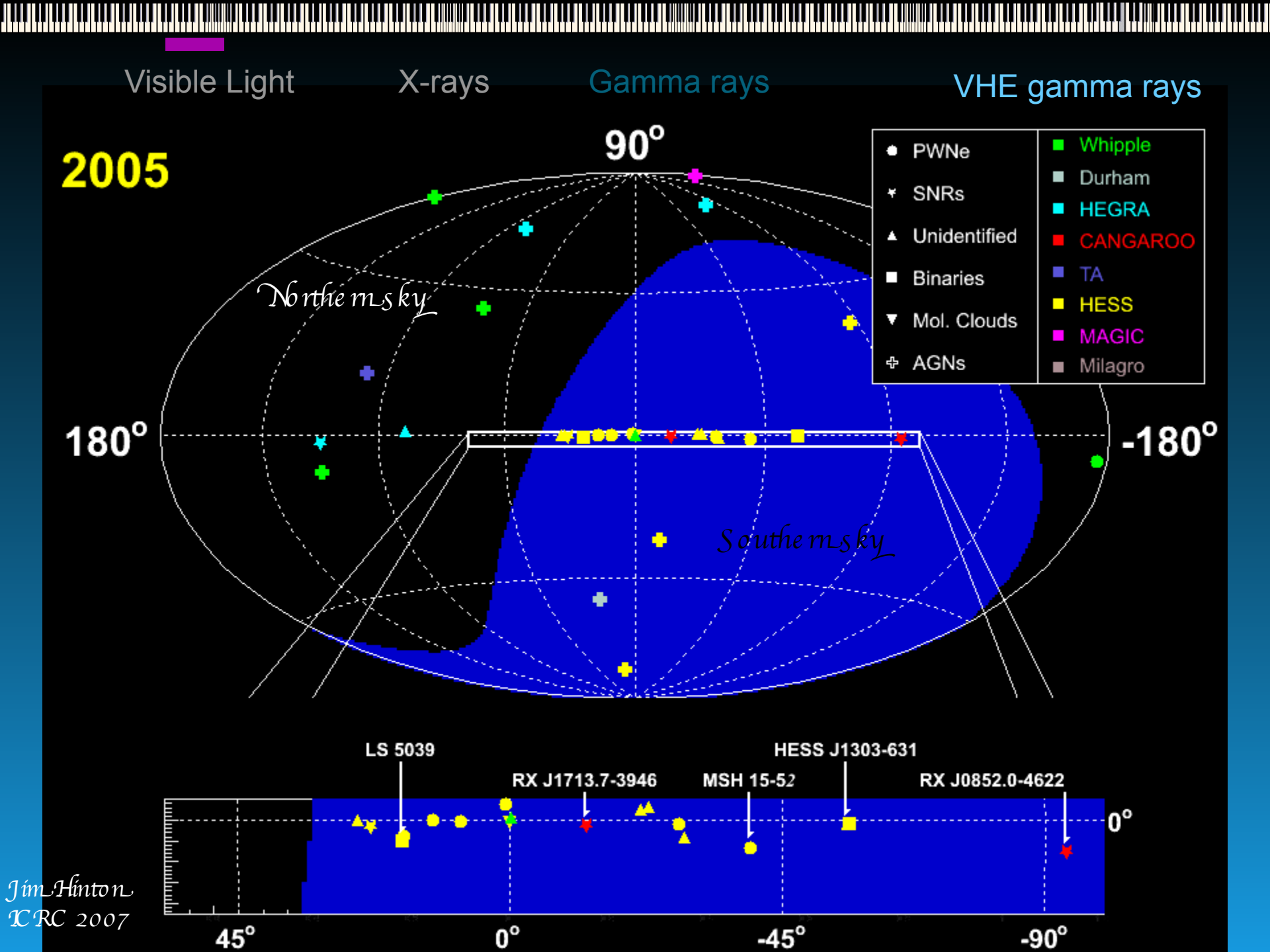

Visible Light
X-rays
Gamma rays
VHE gamma rays
1999
90°
180°
-180°
Northern sky
Southern sky
PWNe
AGNs
Whipple
Durham
HEGRA
CANGAROO
TA
HESS
MAGIC
Milagro
0°
45°
0°
-45°
-90°
Jim Hinton
TRC 2007


Visible Light
X-rays
Gamma rays
VHE gamma rays
2001
90°
180°
-180°
Northern sky
Southern sky
PWNe
SNRs
AGNs
Whipple
Durham
HEGRA
CANGAROO
TA
HESS
MAGIC
Milagro
RX J1713.7-3946
0°
45°
0°
-45°
-90°
Jim Hinton
TRC 2007

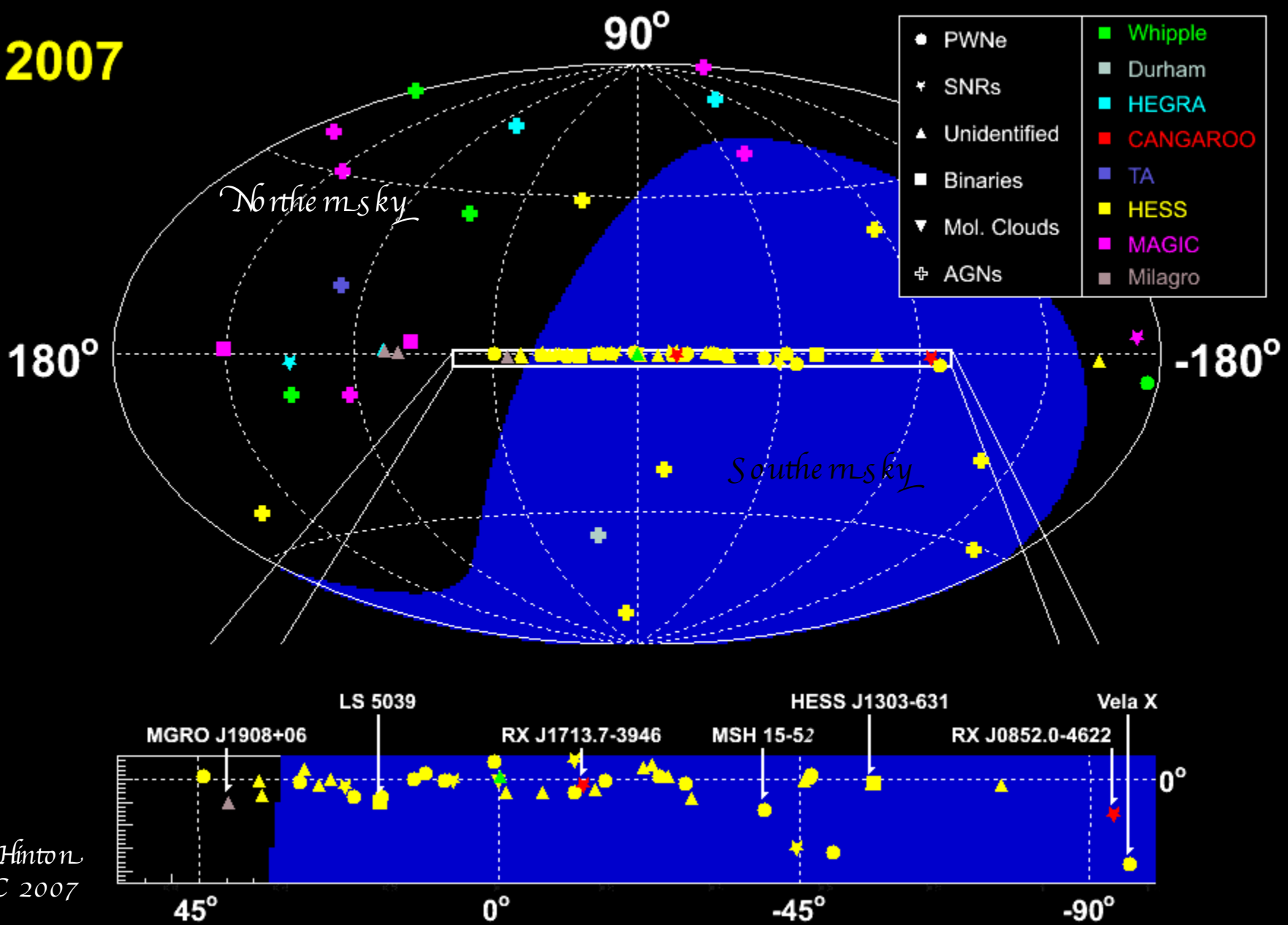
Visible Light X-rays Gamma rays VHE gamma rays




Jim Hinton
TRC 2007


Visible Light
X-rays
Gamma rays
VHE gamma rays
2005
90°
180°
-180°
Northern sky
Southern sky
PWNe
SNRs
Unidentified
Binaries
Mol. Clouds
AGNs
Whipple
Durham
HEGRA
CANGAROO
TA
HESS
MAGIC
Milagro
LS 5039
RX J1713.7-3946
MSH 15-52
HESS J1303-631
RX J0852.0-4622
0°
45°
0°
-45°
-90°
Jim Hinton
TRC 2007

Visible Light X-rays Gamma rays VHE gamma rays



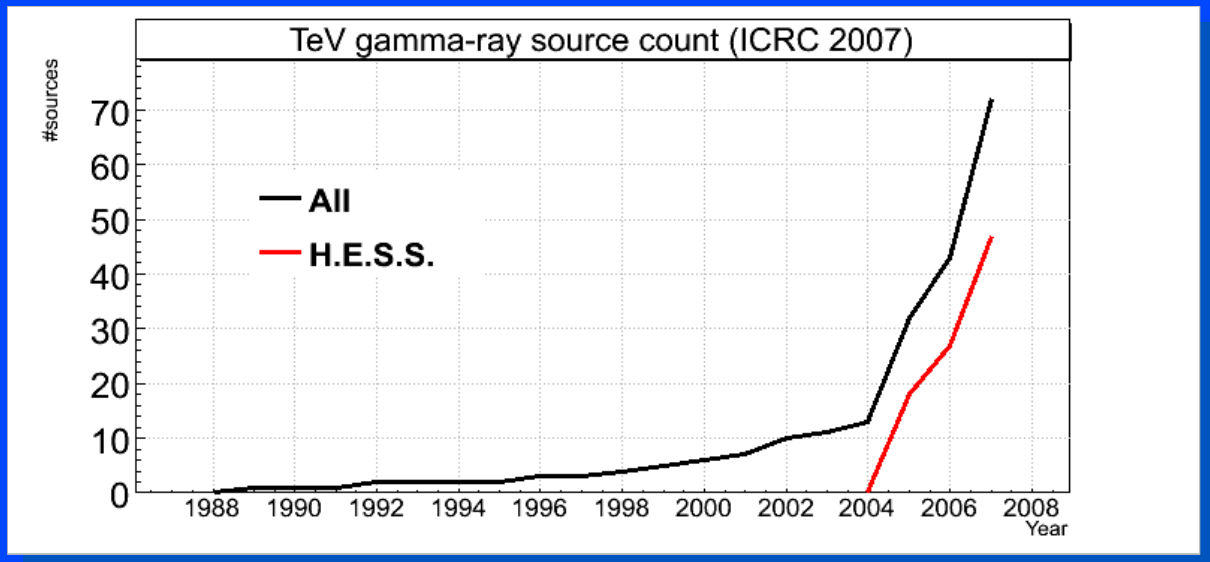

Jim Hinton
TRC 2007

71 VHE sources - each a cosmic particle accelerator, where gamma rays trace primary electrons or nuclei

| | |
|---|---|
| Supernova Remnants (SNR) | 7 |
| Pulsar Wind Nebulae (PWN) | 18 |
| Unidentified Galactic Sources | 21 |
| Diffuse Sources | 2 |
| Binary systems | 4 |
| Active Galactic Nuclei (AGN) | 19 |

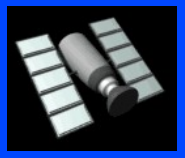
(Hinton, ICRC 2007)

Maybe >100
after Veritas, CANGAROO
MAGIC II and HESS II



# Detection of TeV gamma rays

Gamma - ray



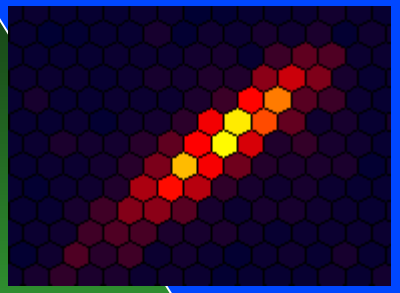
Particle shower

~ 10 km

1°

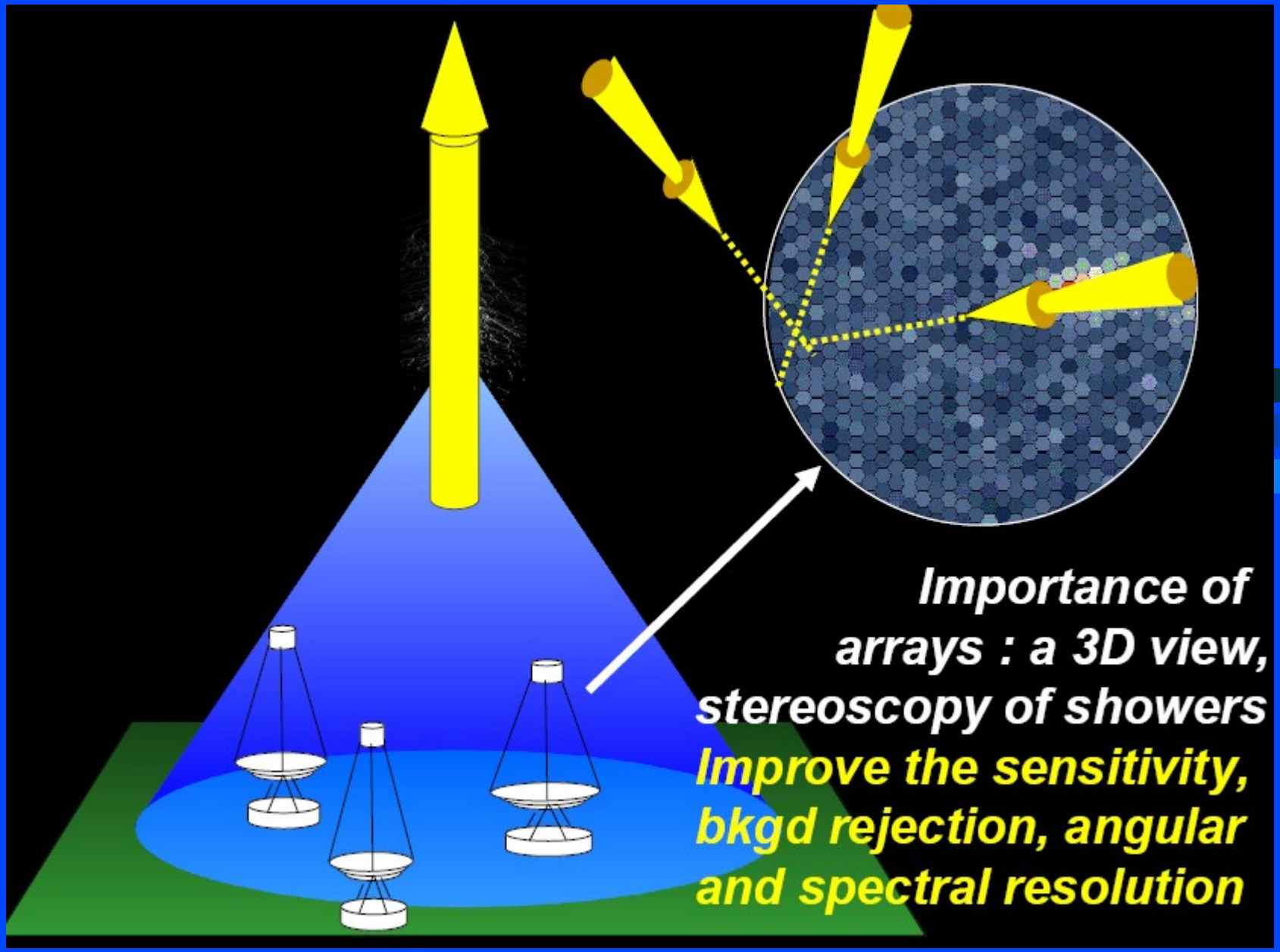
Cherenkov light

~ 120 m

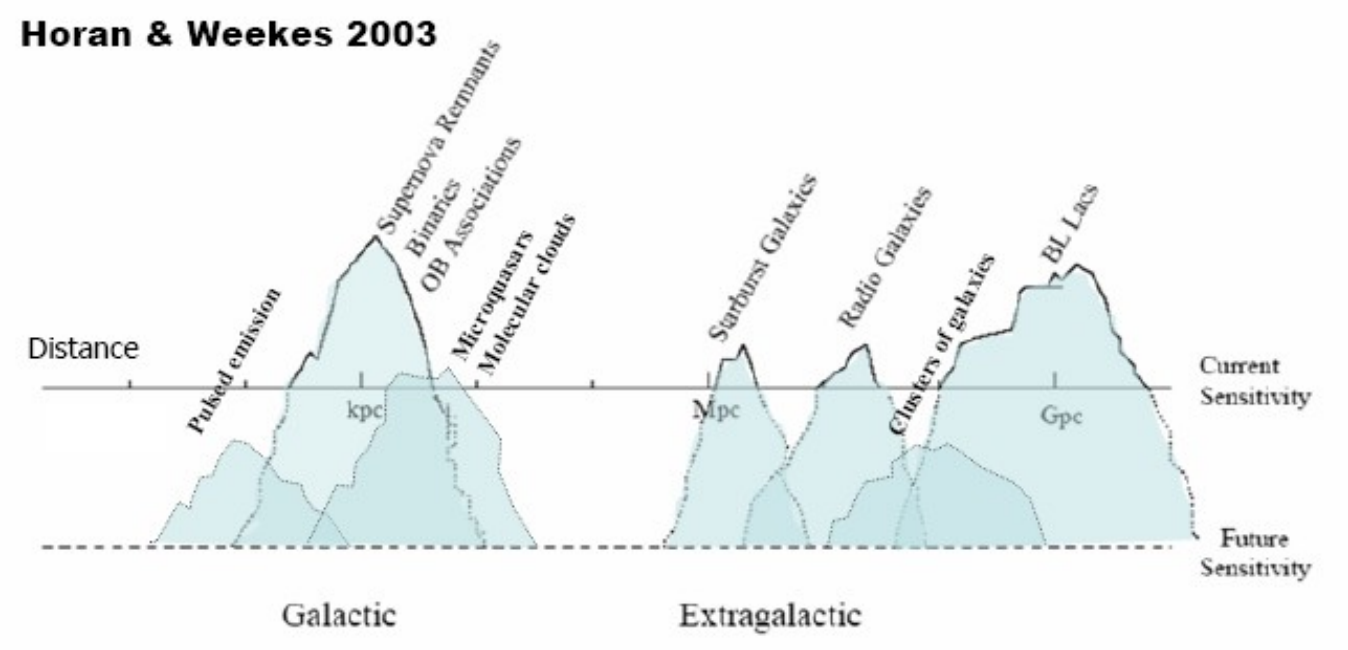


With Cherenkov telescopes

Key issue:
huge detection area
~ $10^5$ $m^2$

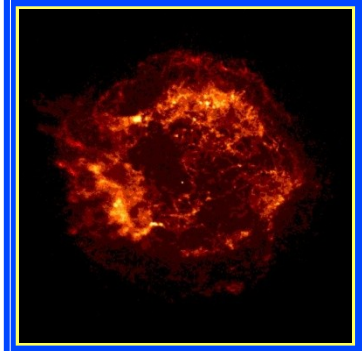

Importance of
arrays : a 3D view,
stereoscopy of showers
Improve the sensitivity,
bkgd rejection, angular
and spectral resolution

# CTA Science Potential

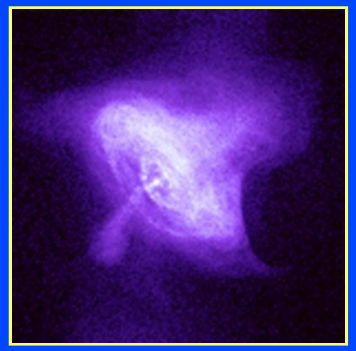



- Current instruments have passed the critical sensitivity threshold and reveal a rich panorama, **but this is only the top of the iceberg**
- Broad and diverse program ahead, **combining guaranteed astrophysics with significant discovery potential**

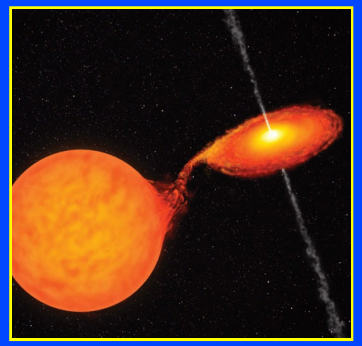
# CTA Science Potential



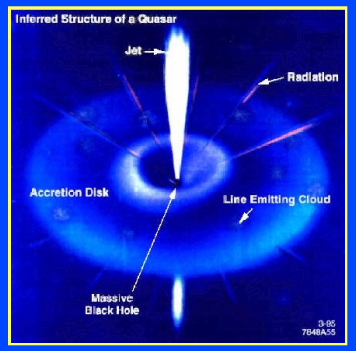
SNRs



Pulsars
and PWN



Micro quasars
X-ray binaries




AGNs

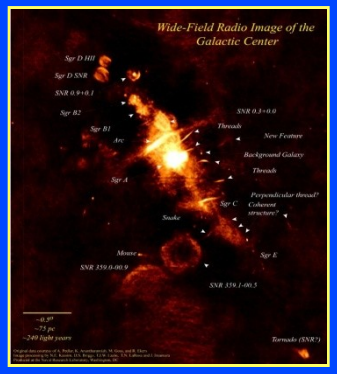
GRBs

Galaxies & stars

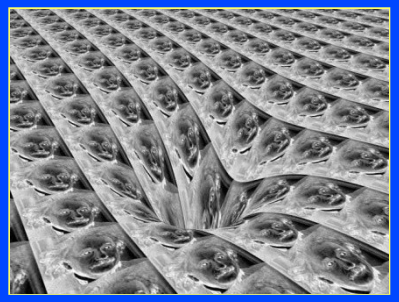
**A guaranteed scientific return** in several astrophysical fields
*(compact objects, stellar physics, physics of ISM, galaxies)*
**Towards thousand VHE sources**

# CTA Science Potential

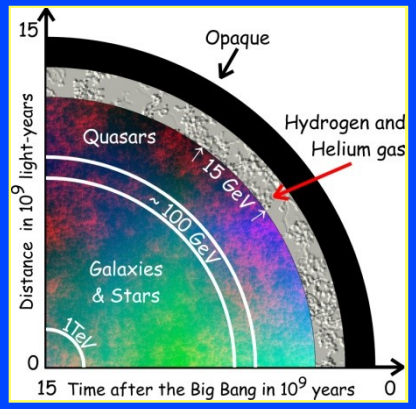
Origin of cosmic rays




Dark matter



Space-time & relativity




Cosmology

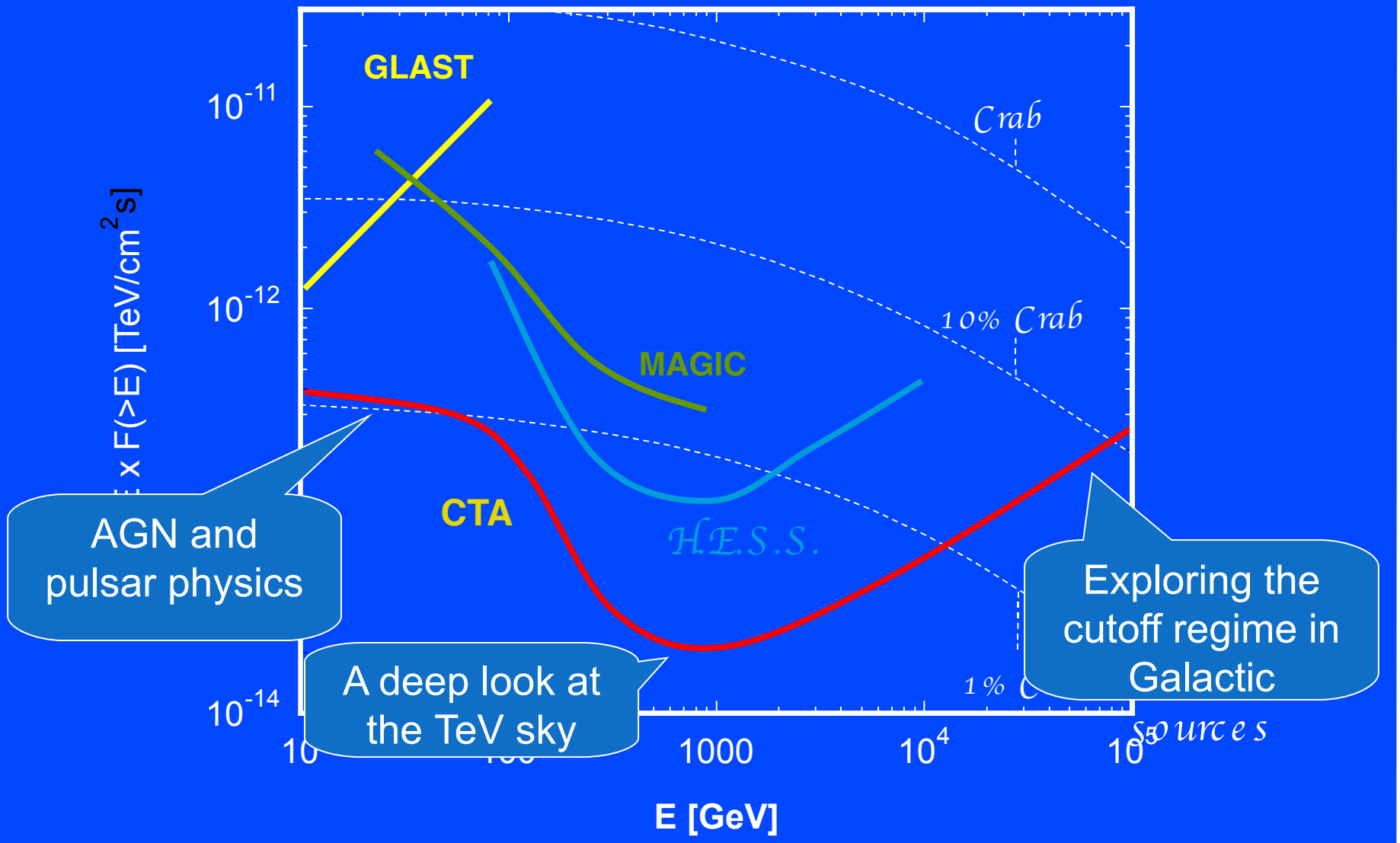
**High discovery potential** in fundamental physics

*(physics of cosmic accelerators, non-photonic sources, dark matter, nature of non-identified VHE sources, black holes, check of validity of Lorentz invariance, EBL and formation of cosmic structures 'stars and galaxies')*

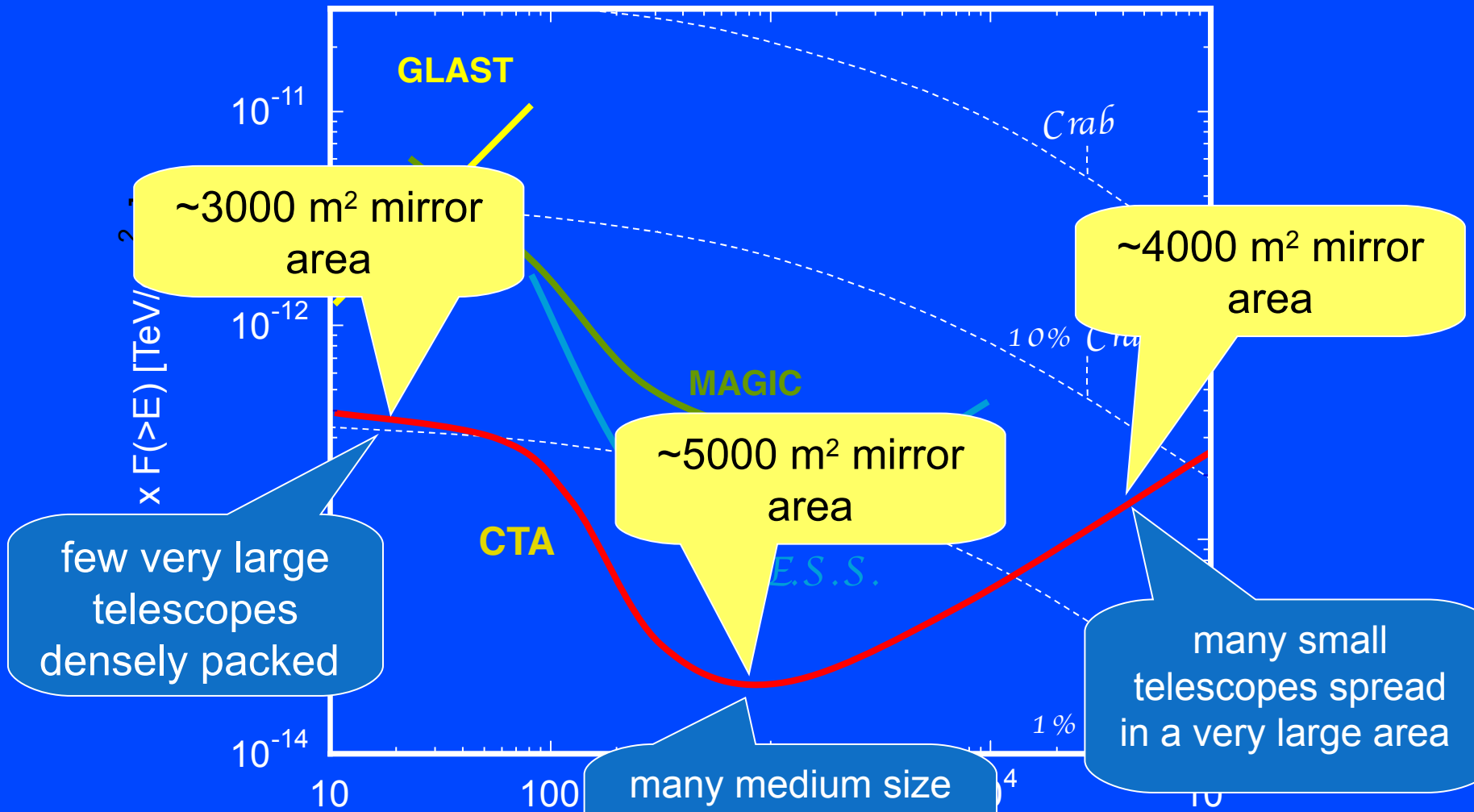
# CTA Wish List

- a) Higher sensitivity at TeV energies (x 10)
  - Deep observations -> more sources
- b) Higher detection area
  - Higher detection rates -> transient phenomena
- c) Improved angular resolution
  - Better morphology -> structure of extended sources
- d) Lower threshold (some 10 GeV)
  - Pulsars, distant AGN, source mechanisms, GLAST
- e) Higher energy reach (PeV and beyond)
  - Cutoff region of Galactic accelerators, MILAGRO
- f) Wide field of view
  - Extended sources, surveys
- g) Full sky coverage

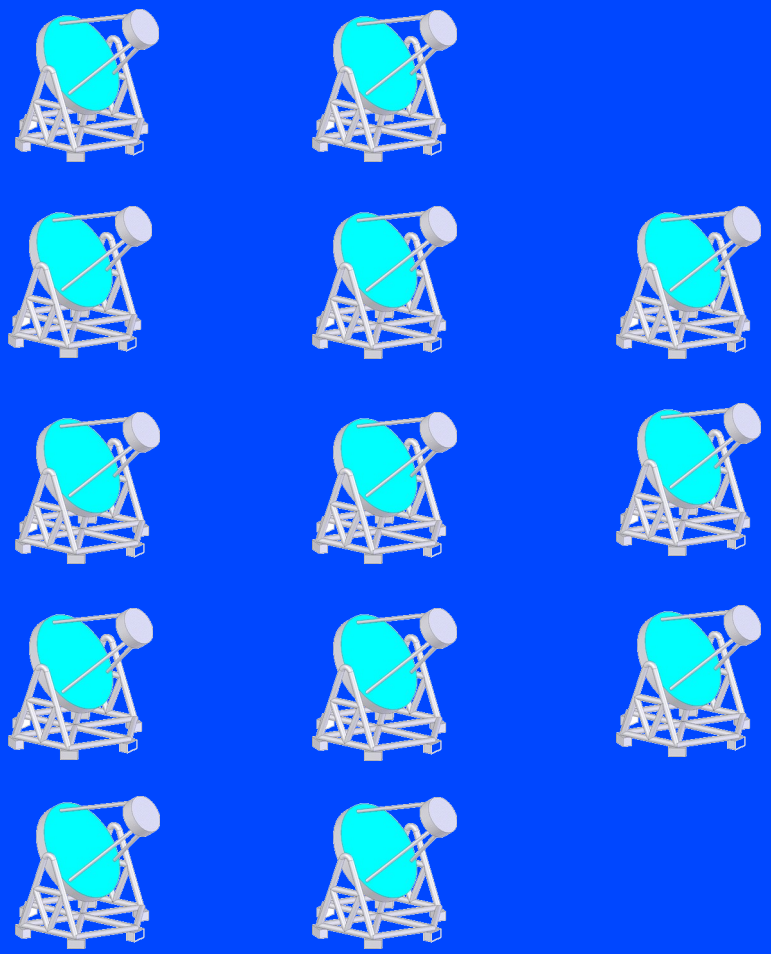
# Possible CTA sensibility



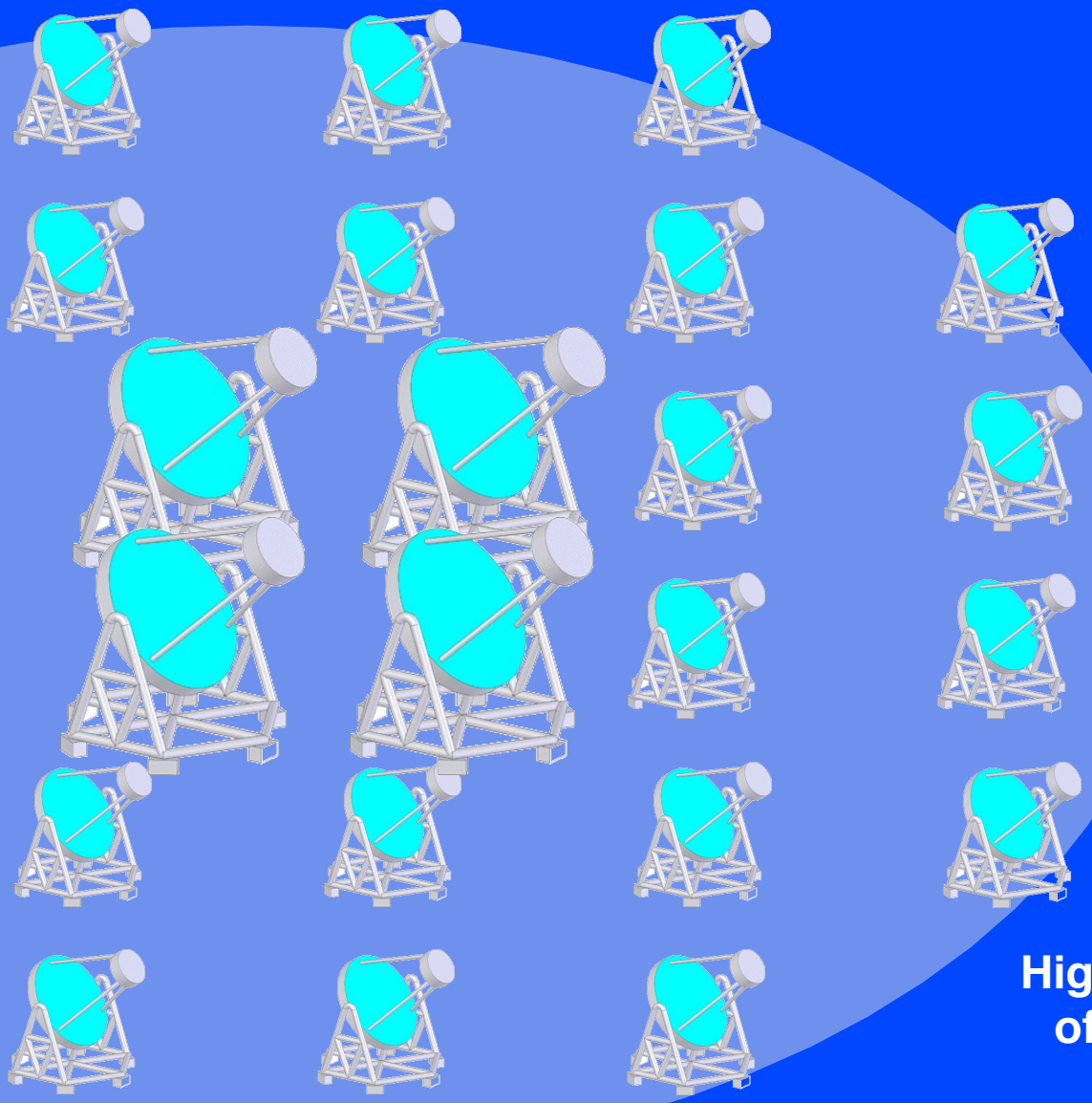
# Possible CTA sensibility I



# The CTA Concept



- Explore the sky in the 10 GeV to 100 TeV energy range
- Builds on demonstrated technologies
- Array of ~ 50 to 100 telescopes of different types



Low-energy section
ex : 4 x large telescopes

Main array of 10m class
telescopes over 1 km2 area
100 GeV - 10 TeV
ex : ~ 28 telescopes

High-energy section with a halo
of telescopes on 10 km2 area
ex : ~ 20 telescopes

# CTA observation modes

# CTA observation modes

- Very deep field

**Deep wide-band mode:**
**all telescopes track the same source**

# CTA observation modes

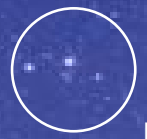
Monitoring
4 telescopes

Monitoring
4 telescope

Deep field
~1/3 of telescopes

Deep field
~1/2 of telescopes

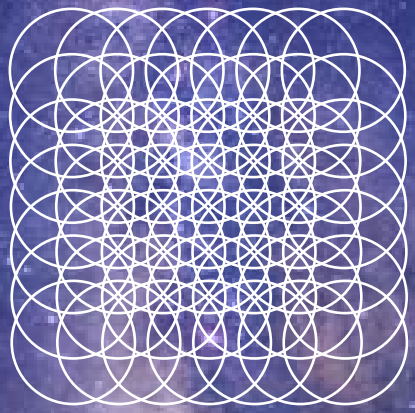
Monitoring
4 Telescopes



Monitoring
1 telescope

**Search & monitoring mode:**
**subclusters track different sources**

# CTA observation modes



Survey mode

**Survey mode**

# CTA Design Studies

- Detailed study of expected science performance of the CTA array
- Optimization of the CTA IACT array(s) on the basis of simulation studies
- Trigger studies
- Design of the telescopes and optimization of photodetectors
- Study of the infrastructure required to operate the CTA array
- Study and exploration of potential sites
- Design and initial implementation of tools to handle observation requests, schedule observations, to process the data and to provide efficient access to data.

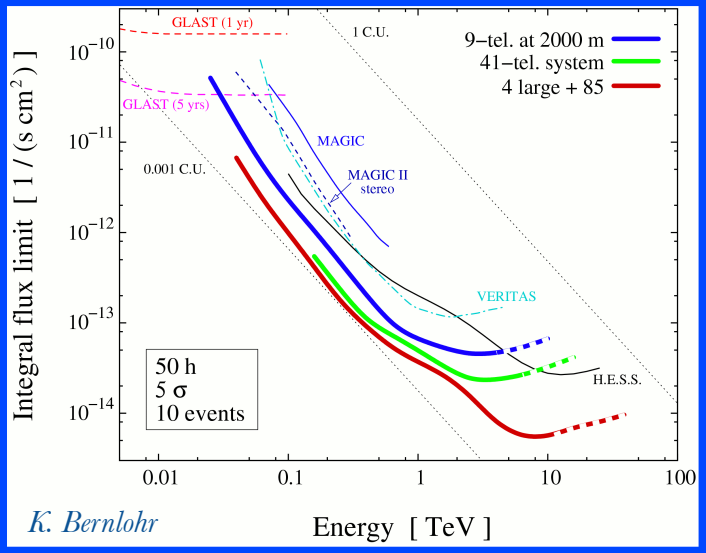
Aims : optimize the performances and reliability, lower the costs (150 M€ class project)

# Design Study and working groups

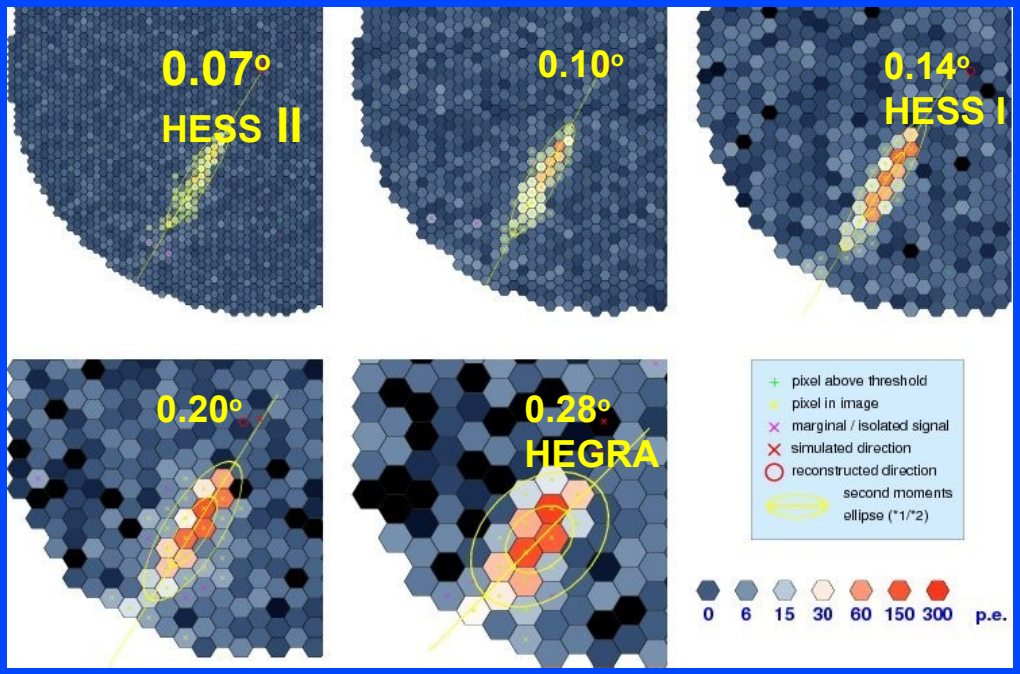
| | |
|---|---|
| **WP1** | Management |
| **WP2** | Physics |
| **WP3** | MonteCarlo Simulations (Optimization of array layout, performance studies and analysis algorithms) |
| **WP4** | Site selection and site infrastructure |
| **WP5** | Telescope optics and mirror |
| **WP6** | Telescope structure, drive, control |
| **WP7** | Photon detectors and focal plane |
| **WP8** | Readout electronics and trigger |
| **WP9** | Calibration and atmospheric monitoring and associated science |
| **WP10** | Observatory operation and access (TOC + SOC) |
| **WP11** | Data handling, management and access (SDC) |
| **WP12** | Risk assessment and quality assurance, production planning (?) |
| **WP13** | Resource exploration |

# Examples

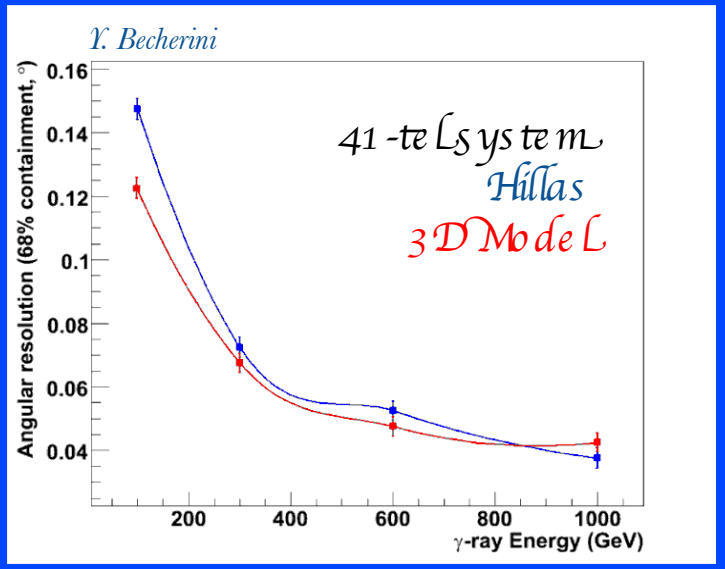
Simulation of the sensitivity of various arrays



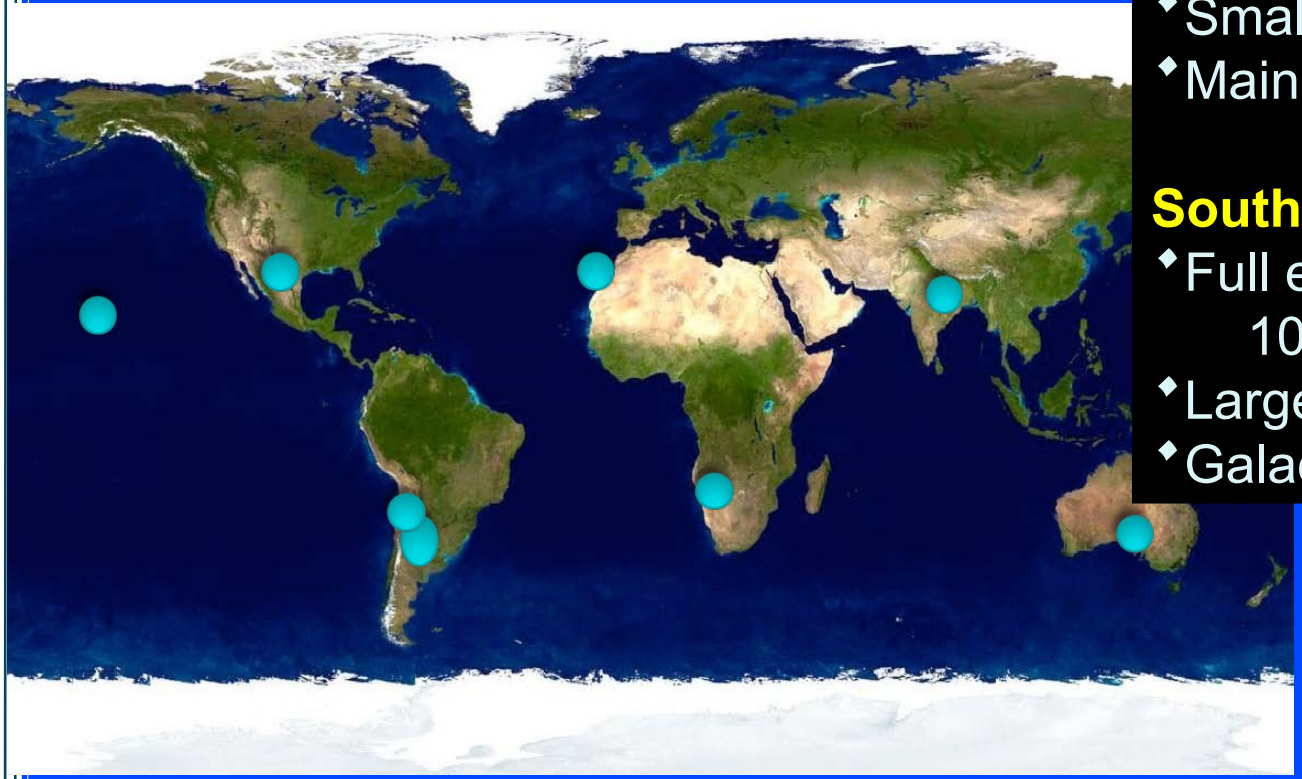

Optimize performances versus costs
choice of pixel size




*Angular resolution improvement at low energies with the 3D model for a 41-telescope array.*



# Full Sky Coverage



**Northern array (50 M€):**

- Energy range 10 GeV – 1 TeV
- Small field of view
- Mainly extragalactic sources

**Southern array (100 M€):**

- Full energy range
  10 GeV – 100 TeV.
- Large field of view
- Galactic + Extrag sources

# CTA consortium

| | |
|---|---|
| Armenia | Yerevan |
| Czech Republic | Prague |
| Germany | HU Berlin, Bochum, DESY, Dortmund, Erlangen, Hamburg, MPI Heidelberg, U. Heidelberg, MPI Munich, Tübingen, Würzburg |
| Finland | Turku |
| France | Annecy, Grenoble, Montpellier, LLR Palaiseau, APC Paris, Obs. Paris-Meudon, U. Paris VI-VII, CEA Saclay, Toulouse |
| Italy | INFN Padova, Pavia, Pisa, Trieste, Rome, Siena, INAF Rome, Brera, Bologna, Padova, Palermo, Torino, … |
| Ireland | DIAS Dublin, … |
| Namibia | U. Namibia |
| Poland | Cracow, NCAC Warsaw, U. Warsaw, Lodz |
| Spain | IFAE, IEEC, UAB, UB Barcelona, UCM Madrid |
| South Africa | Northwest-Univ. |
| Switzerland | ETH Zurich, U. Zurich, Geneva, PSI |
| UK | Leeds, Durham, … |
| more interested | **Argentina, Denmark, Japan, Netherlands, Russia, US (AGIS)** |

# CTA as an observatory

- Combines guaranteed science with significant discovery potential
- Significant  fraction of open time (~50%)
- Guaranteed  time for CTA consortium (~50%)
- Facilities to make data available for outsiders
- Data public after certain time (~ 1 year ?)

# Time Line

- First CTA general meeting
  (January 2008, Barcelona, Spain) → Kick-off
- Second CTA general meeting
  (Novembre 2008, Padua, Italy) → WP Status

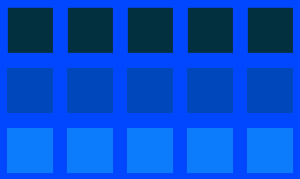
- Design studies : up to 2009-2010
- Prototype construction : 2010-2011
- Array construction : 2012-2018
- Partial operations : starting from 2013
- Complete array : 2018

# Status and outlook

- ASPERA-ApPEC give full support to CTA
- CTA also included in the ASTRONET roadmap
- The European Strategy Forum on Research Infrastructures (ESFRI) lists CTA on its 2008 update of Roadmap for pan-European large research infrastructures.
- Funding…

# Thank you very much

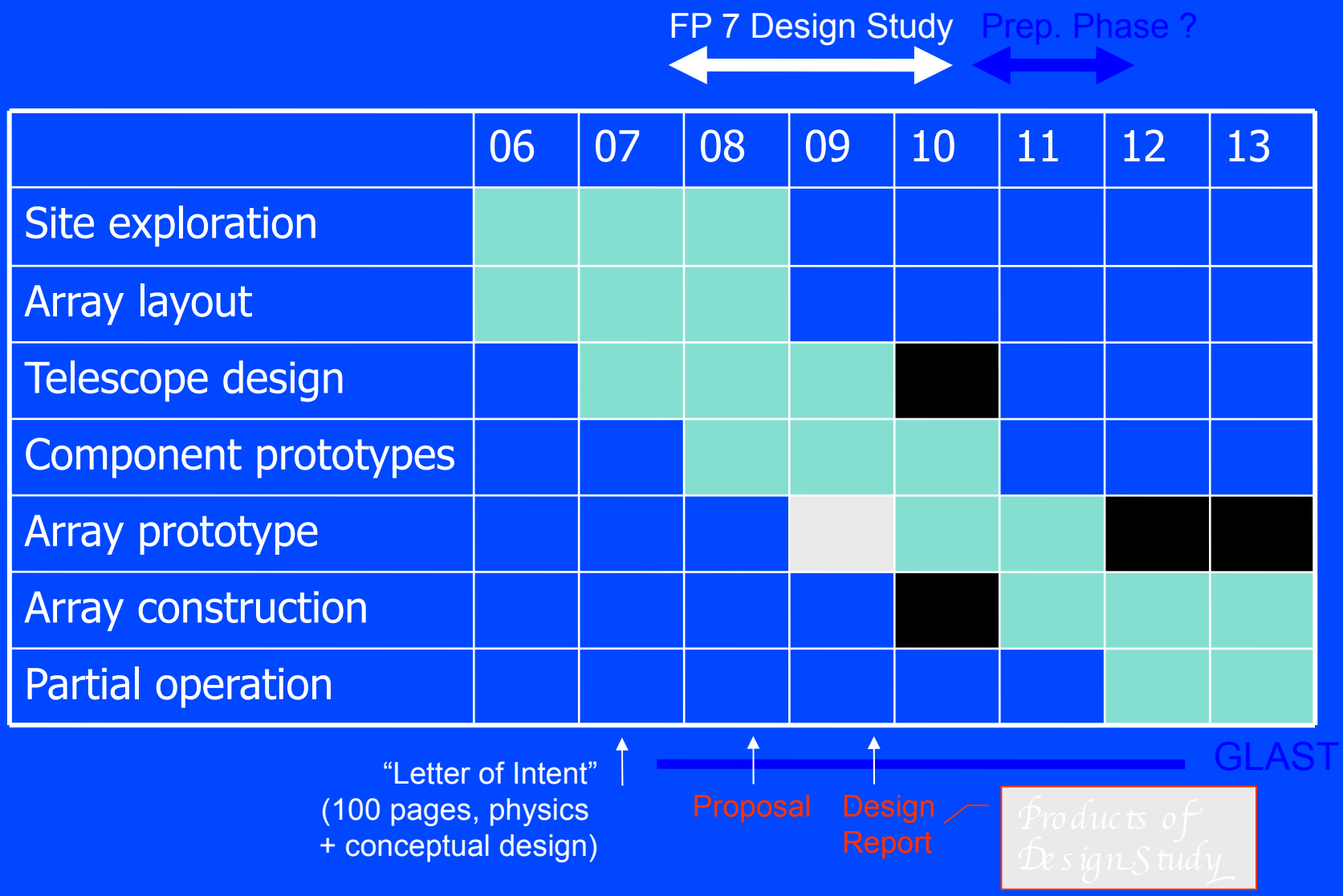
Thanks to H. Sol, W.Hofmann, M. Martinez



# European Coordination

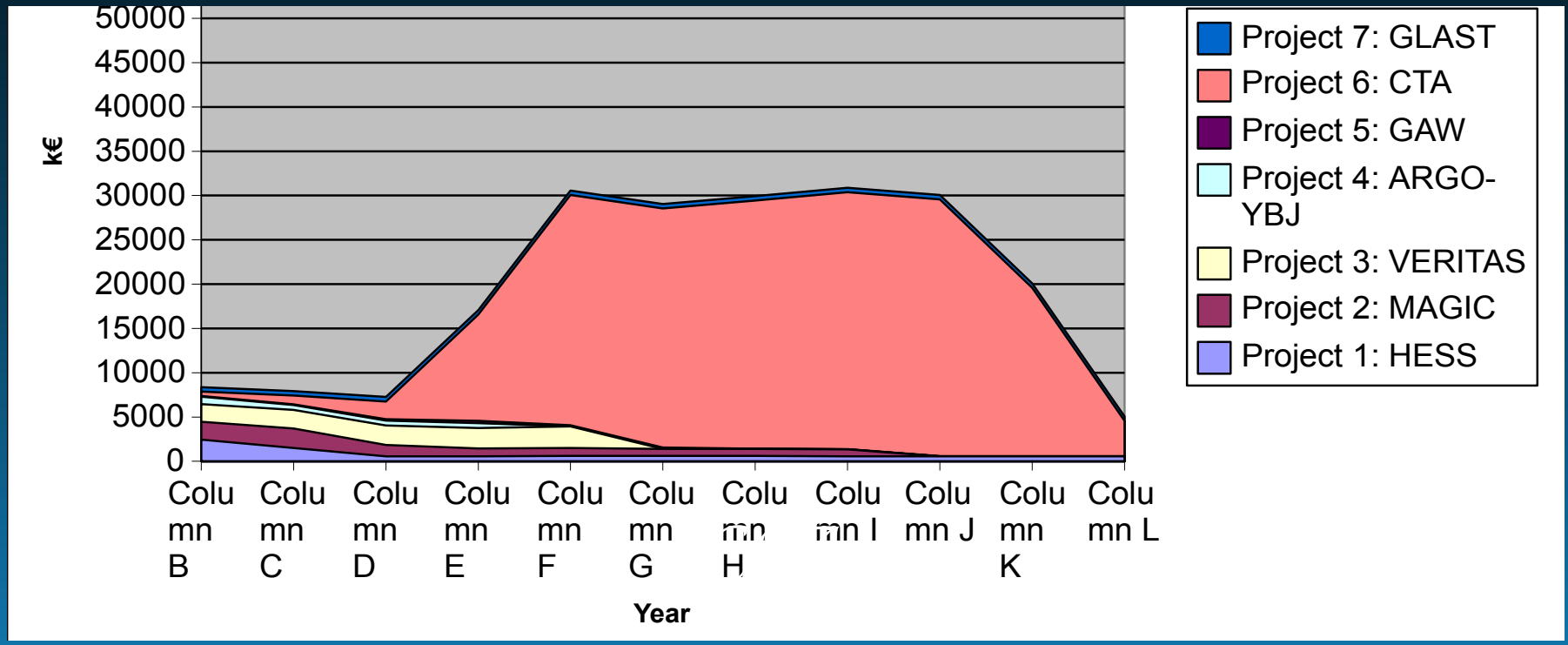

CTA is given very high priority in ASPERA roadmap


CTA included in ASTRONET roadmap


FP 7 Design Study
Prep. Phase ?
06
07
08
09
10
11
12
13
Site exploration
Array layout
Telescope design
Component prototypes
Array prototype
Array construction
Partial operation
"Letter of Intent"
(100 pages, physics
+ conceptual design)
Proposal
Design
Report
GLAST
Products of
Design Study

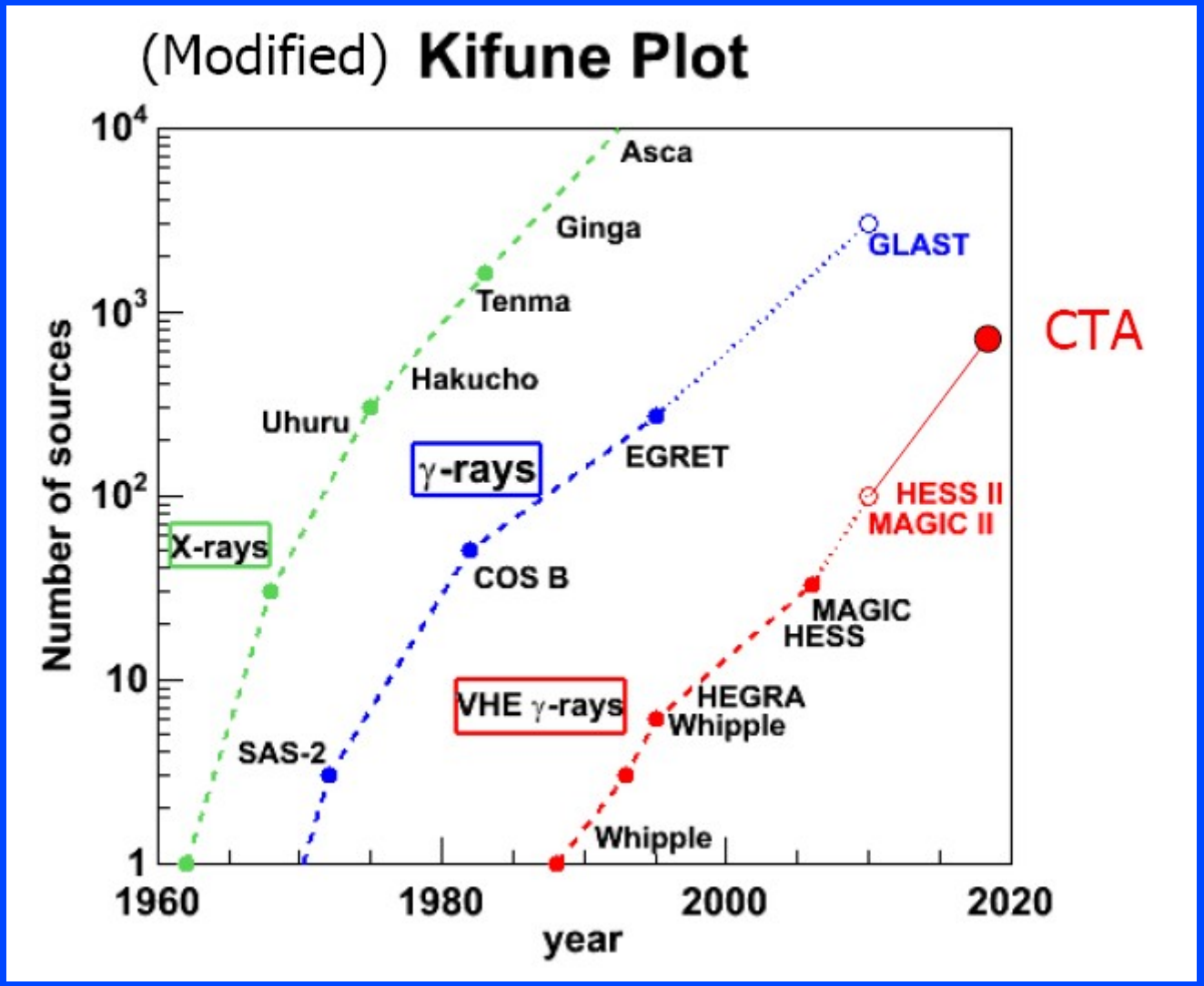
# High Energy Gamma Telescopes

## Clear priority: CTA



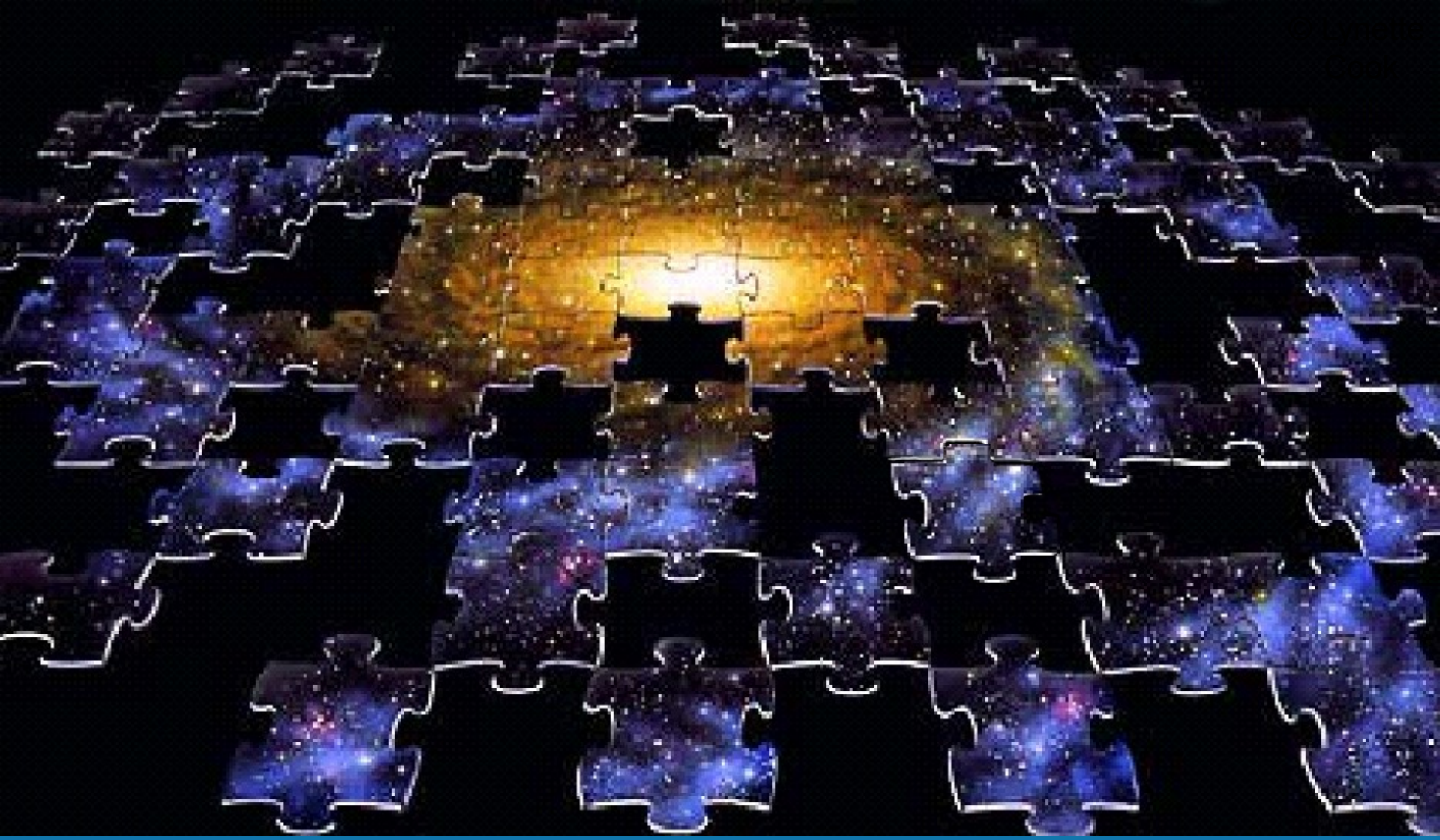

CTA planning at this point shifted by ~1 year compared to the figure

# Status and outlook II



# HE Gamma Astronomy

- **The priority project of VHE gamma astrophysics is CTA.**
- Based on the enormous scientific harvest of the last decade and a demonstrated technological maturity, with the European projects H.E.S.S. and MAGIC being the leading telescopes.
- Will probe production mechanisms and propagation of high-energy particles with unprecedented sensitivity, energy coverage, and spatial and temporal resolution, addressing a wide range of topics in astrophysics, cosmology, and fundamental physics.
- Is on the ESFRI list of emerging projects and has been proposed as a full ESFRI entry. It is also listed as a priority entry in the ASTRONET infrastructure roadmap**.**
- **We recommend design and prototyping of CTA and selection of site(s), and proceeding decidedly towards start of deployment in 2012.**



# *The age of real VHE gamma ray astronomy has started*

# CTA Science Potential

- What is the origin of cosmic rays ?
- How does particle acceleration by accretion into a massive black hole work ?
- Are there strong hadron accelerators which could be good targets for neutrino telescopes ?
  - Do pulsars produce VHE gamma rays ?
- Does Dark Matter annihilate producing gamma rays ?
- Is the origin of EBL completely resolved ?
- What is the impact of the measurements on EBL absorption in the understanding of the history of structure formation ?
- Can the absorption pattern in the spectrum of distant Blazars be used to measure Dark Energy ?
  - Can VHE gammas emitted by flaring AGNs or GRBs tell us something about the quantum structure of gravity ?
- Do GRB produce VHE gamma rays ?