Outline:

0- Introduction
1- Why ?
2- How ?
3- Status

Many slides from W.Hofmann and G.Hermann
0- Introduction
State of the Art TeV Astrophysics ...

Europe world-wide leading in the field!
VHE gamma ray window now WIDE OPEN:

AT PRESENT:
About 70 VHE Gamma Ray sources detected so far

-> maybe above 100 after VERITAS, CANGAROO III, MAGIC-II and HESS2
The VHE $\gamma$-ray Physics Program

- SNRs
- Origin of Cosmic Rays
- Galactic
- Pulsars
- Binary systems
- Extragalactic
- GRBs
- Cold Dark Matter
- Cosmological $\gamma$-Ray Horizon
- Test of the speed of light invariance
- AGNs
2- Why ?
Current instruments have passed the critical sensitivity threshold and reveal a rich panorama, but this is clearly only the tip of the iceberg.

Broad and diverse program ahead, combining guaranteed astrophysics with significant discovery potential.
In spite of the big success of the new generation of Cherenkov Telescopes...

...I still haven't found what I'm looking for...

Copyright U2
- 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?
CTA
An advanced facility for ground-based high-energy gamma ray astronomy

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
e) Higher energy reach (PeV and beyond)
   Cutoff region of Galactic accelerators
f) Wide field of view
   Extended sources, surveys
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Possible CTA sensitivity

E\cdot F(>E) [TeV/cm²s]

E [GeV]

AGN and pulsar physics

Explores the cutoff regime in Galactic sources

A deep look at the TeV sky
3- How?
Unifying European Efforts
An advanced Facility for ground-based gamma-ray Astronomy

CTA involves scientists from
Czech Republic
Germany
France
Italy
Ireland
UK
Poland
Spain
Switzerland
Armenia
South Africa
Namibia
...

and from several communities
astronomy & astrophysics
particle physics
nuclear physics

about 250–300 scientists working
currently in the field will be
directly involved,
user community significantly larger

G.Hermann
The Cherenkov Telescope Array facility

- aims to explore the sky in the 10 GeV to 100 TeV energy range
- builds on demonstrated technologies
- combines guaranteed science with significant discovery potential
- is a cornerstone towards a multi-messenger exploration of the nonthermal universe
Possible CTA sensitivity

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- **CTA**
- **Possible CTA sensitivity**

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**Graph:**
- **XTick:** 10, 100, 1000, 10^4, 10^5
- **YTick:** 10^-14, 10^-12, 10^-11

**Axes:**
- **X:** Energy $E$ [GeV]
- **Y:** Event rate $E \cdot F (> E)$ [TeV/cm^2/s]

**Curves:**
- **GLAST**
- **MAGIC**
- **H.E.S.S.**

**Legends:**
- **Crab**
- **10% Crab**

**Telescope Types:**
- **Few very large telescopes densely packed**
- **Many medium size telescopes covering a large area**
- **Many small telescopes spread in a very large area**
How to achieve it

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GLAST

MAGIC

H.E.S.S.

E.F(>E) [TeV/cm²s]

O(10⁷ m²) with low coverage (0.03-0.05%)

~4000 m² mirror area

~3000 m² mirror area

~5000 m² mirror area

few 10⁴ m² with dense coverage (5-10%)

few 10⁵ m² with medium coverage (1-2%)

O(10⁷ m²) with low coverage (0.03-0.05%)
Option:
Mix of telescope types

Not to scale!
Simulations

Systematic studies on how performance changes with single parameters:
- dish size
- field of view
- pixel size
- spacing
- height

Strawman arrays

Example: 97 telescopes
- 3 * 4 tel. with 600 m² (5° f.o.v.)
- 85 tel. with 100 m² (7° f.o.v.)
both 50% higher QE than H.E.S.S.
Sensitivity: 85 + 4 telescopes

1% Crab

0.1% Crab

preliminary

cuts not fully optimized
Technology choices: Readout

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~ 200 ns memory depth

GHz sampling analog memory

ADC

Trigger

μs … ms memory depth

GHz FADC

FPGA/memroy

Trigger
Technology choices: Sensors

5x5mm
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 to outside users
- Data public after certain time (~1 y)

G.Hermann
One observatory with two sites operated by one consortium

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
3- Status
CTA & the ESFRI Roadmap

An advanced Facility for ground-based gamma-ray Astronomy

Emerging proposals

CTA

is an advanced facility for ground based high-energy gamma ray astronomy, based on the observation of Cerenkov radiation. This approach has proven to be extremely successful for gamma rays of energies above few tens of GeV. The facility will consist in an array of telescopes enhancing the all sky monitoring capability.

The Expert and Roadmap Working Groups focussed their discussions more on the mature projects, with the Emerging Proposals deserving attention for the future editions of the Roadmap.

Application submitted end 2005

G.Hermann
- Activity started in spring 2006 in a first meeting in Berlin
  -> creation of Working Groups on different subjects.

- Working Groups have been working and meeting since then
  -> Materials collected into a LoI draft.

- Big meeting in Paris March 2007 with the WG reports and
  preparation of an FP7 DS application.

- Submission of FP7 DS application May 2007
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FP 7 Design Study Prep. Phase?

“Letter of Intent” (100 pages, physics + conceptual design)

Proposal

Design Report

Products of Design Study

GLAST
**Design study structures in Work Packages**

| WP1 | Management of the design study |
| WP2 | Astrophysics and astroparticle physics |
| WP3 | 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 | Instrument calibration and analysis algorithms and atmospheric monitoring and associated science |
| WP10 | Observatory operation and access (TOC + SOC) |
| WP11 | Data handling, data processing, data management and data access (SDC) |
| WP12 | Risk assessment and quality assurance, production planning (?) |
| WP13 | Resource exploration |
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What should we have after design study

- Detailed knowledge of characteristics, availability of (few) good site candidates
- Array layout which optimizes physics performance for a given cost (and which is about 1 order of magnitude better than what we have now)
- Detailed design and (industrial) cost estimates for telescopes and associated equipment
- Plan how to organize, produce, install, commission, operate the facility; estimate for operating cost
- Model and prototype how to handle and analyze the data
- Small prototype series of components such as mirrors (~100), photosensors and electronics (~100-200 channels), probably a few drive systems, possible a secondary mirror, ... to ensure that production issues and costs are understood
Duration: 2008-2010.
Budget: 5 M€.
Participation of 34 institutes from 15 countries, mainly European.

Still waiting for final decision
MEANWHILE:

- ASPERA-ApPEC give full support to CTA.

- CTA also included in the ASTRONET roadmap

- Very explicit support too from important European National Funding agencies.

NEXT STEPS:

- Now submitting a new ESFRI application.

- Next CTA general meeting January 2008 in Barcelona (Spain).
- CONSENSUATED DECISION: The CTA activity will continue independently of the outcome of the FP7 DS application.

-> Our will is to make CTA a reality in a timely fashion.
Status and Outlook

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(Modified) Kifune Plot

Number of sources

10^4

10^3

10^2

10

1

year

1960

1980

2000

2020

X-rays

\( \gamma \)-rays

SAS-2

VHE \( \gamma \)-rays

Uhuru

Hakuchho

Tenma

Asca

Ginga

EGRET

GLAST

HESS

MAGIC

HEGRA

Whipple

CTA

CTA