

ISDC & CTA

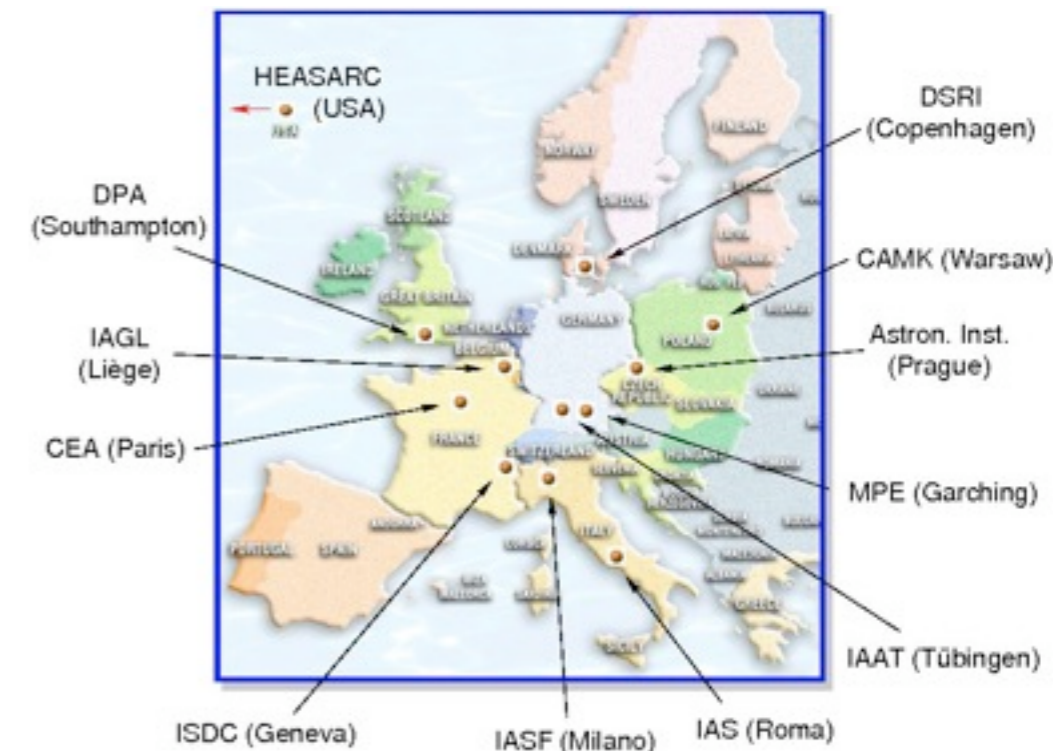
Roland Walter

2009 CHIPP Plenary Meeting

ISDC hosts the high energy astrophysics group of the astronomical department of the Geneva University



Versoix
8 km from CMS



Staff: 45

High-energy projects: 32

Stellar formation: 4

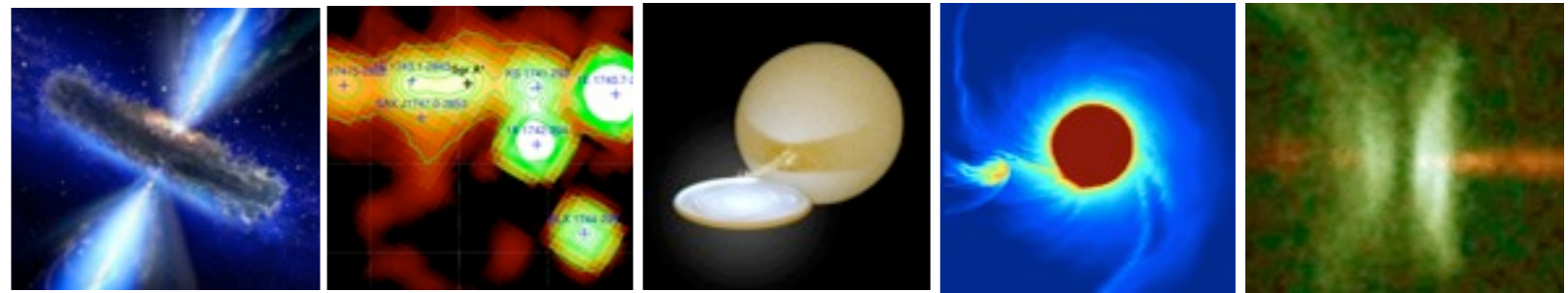
Gaia: 7

Administration: 2

- 1 professor
- 2 SNF professors
- 3 MER
- 14 postdocs
- 9 PhD students
- 16 engineering/technical staff

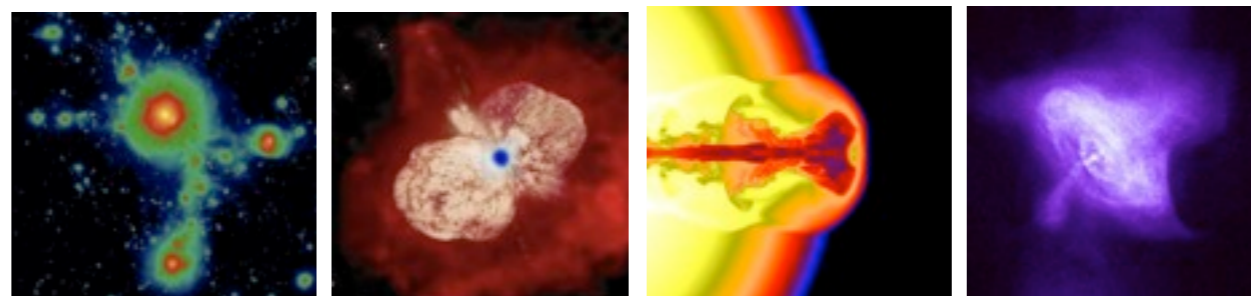
Accretion

- Massive black-holes, Quasars, Blazars
- X-ray binaries in high-mass systems
- Black-hole candidates
- Young stellar objects



Acceleration

- Clusters of galaxies
- Stellar winds
- Gamma-ray bursts
- Pulsars, magnetars

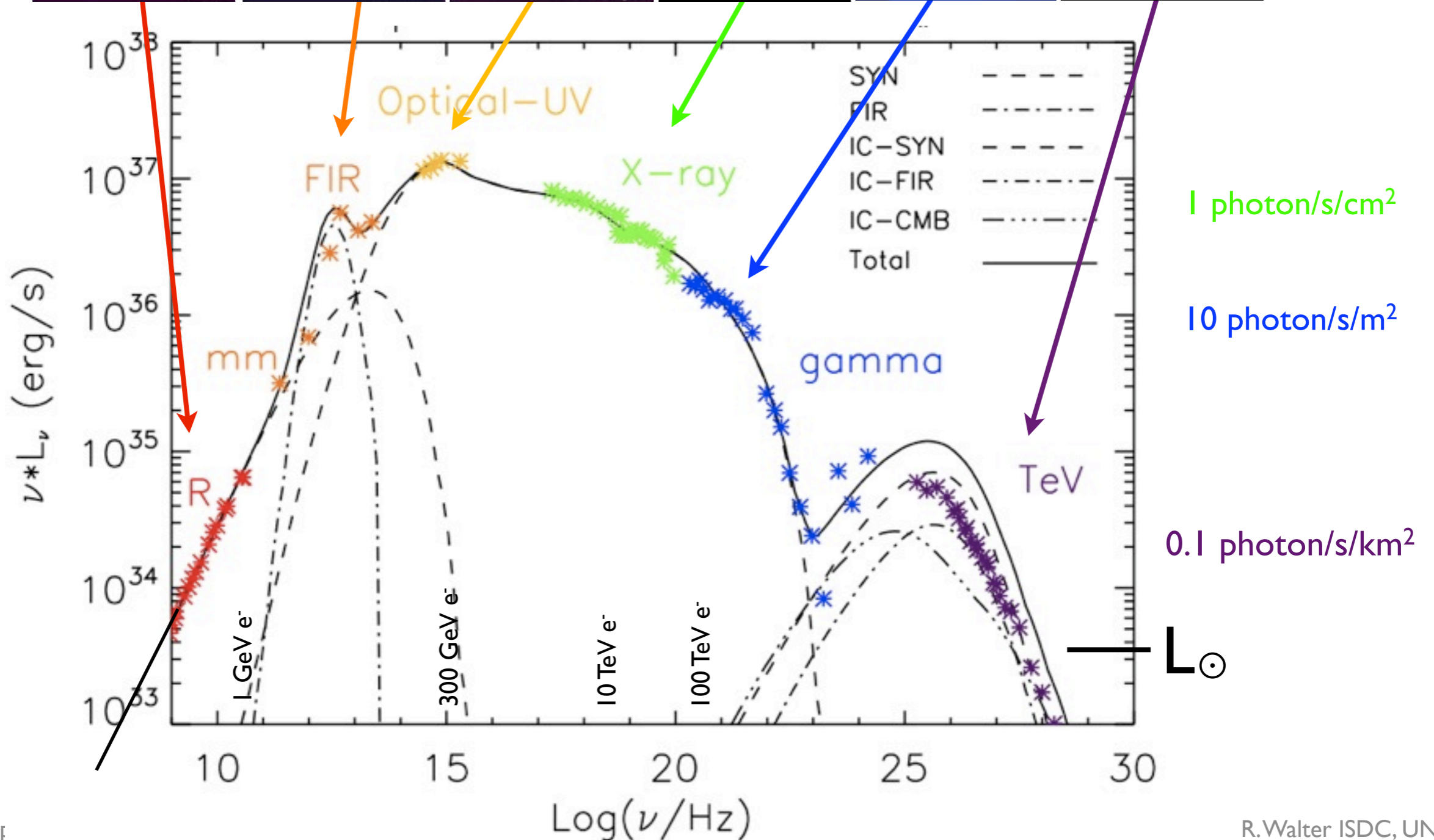
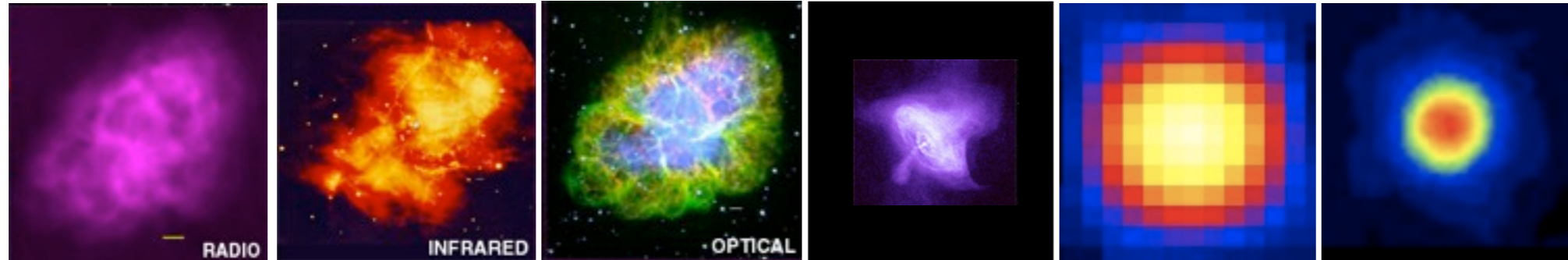


Cosmology

- AGN evolution
- DM

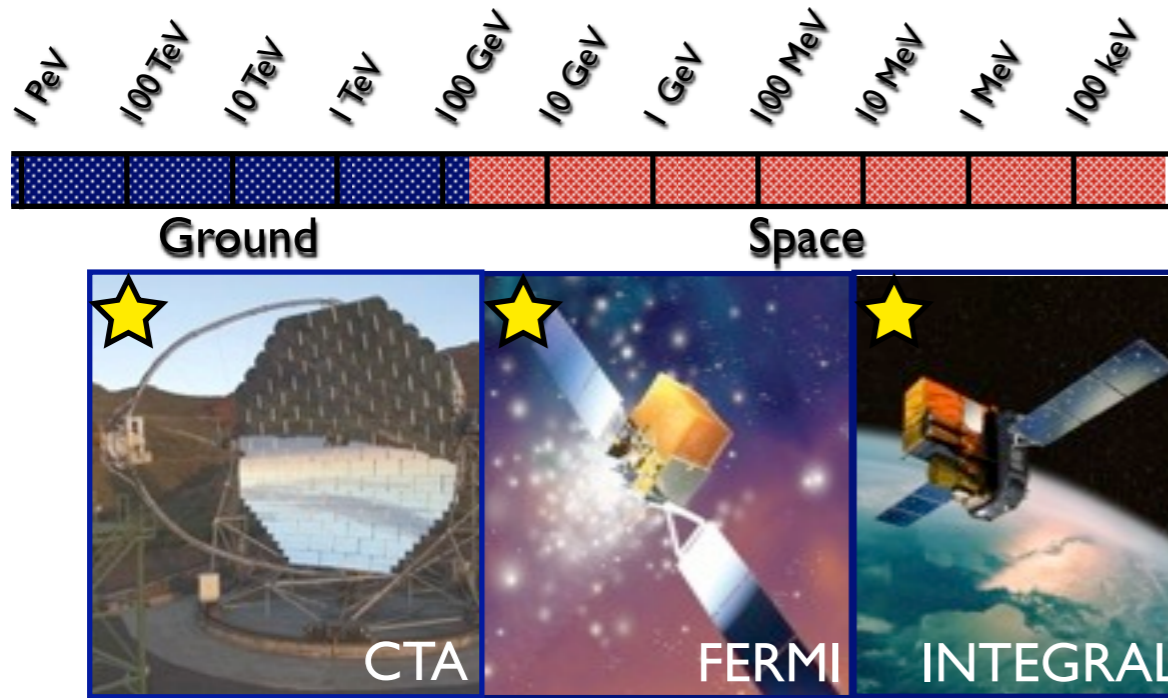


From multi-wavelength...

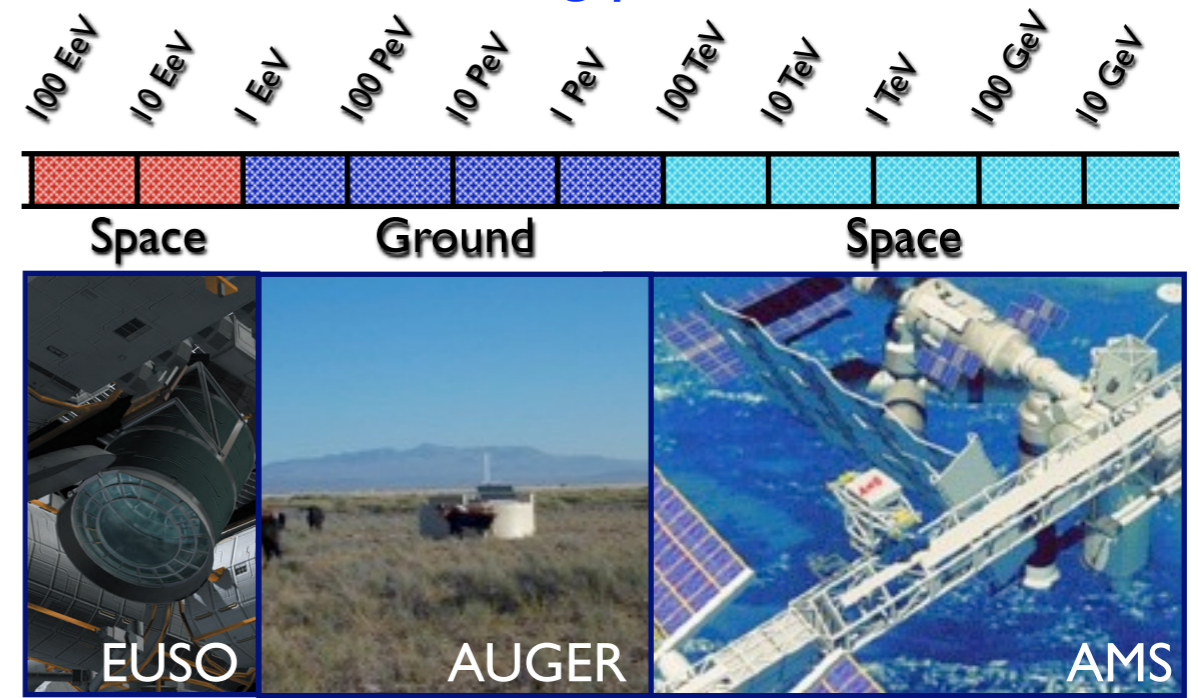


...to multi-messenger

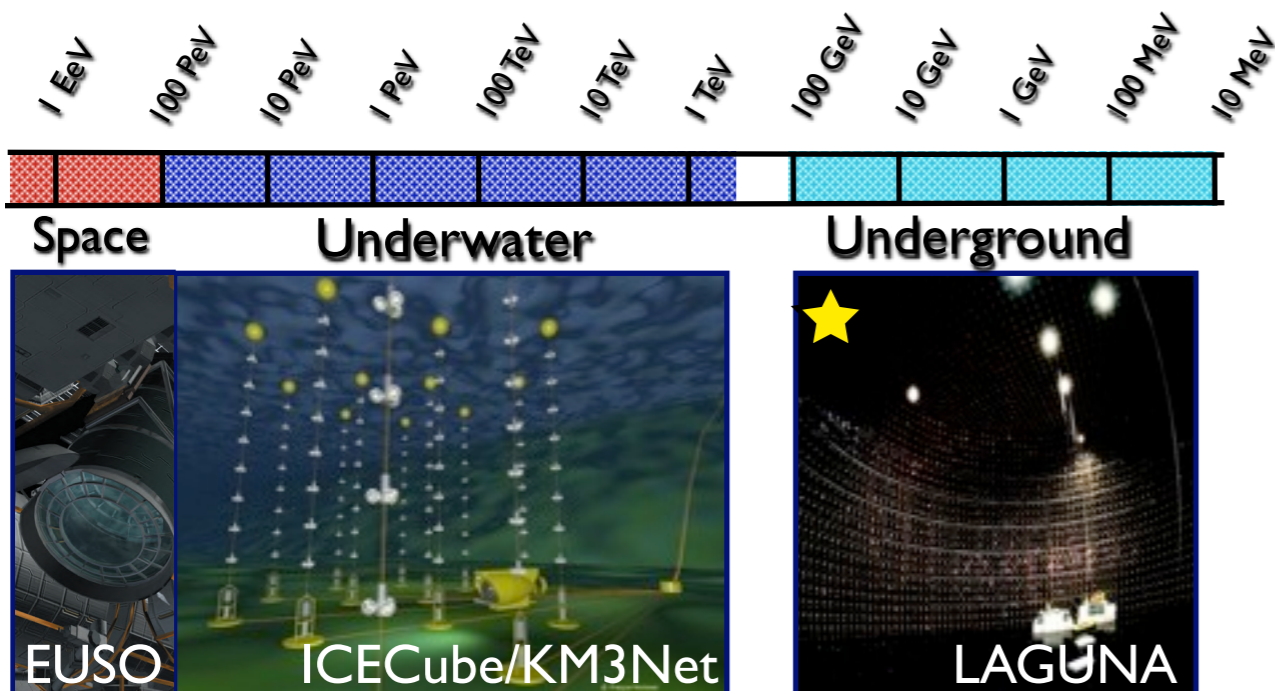
Detecting gamma-rays



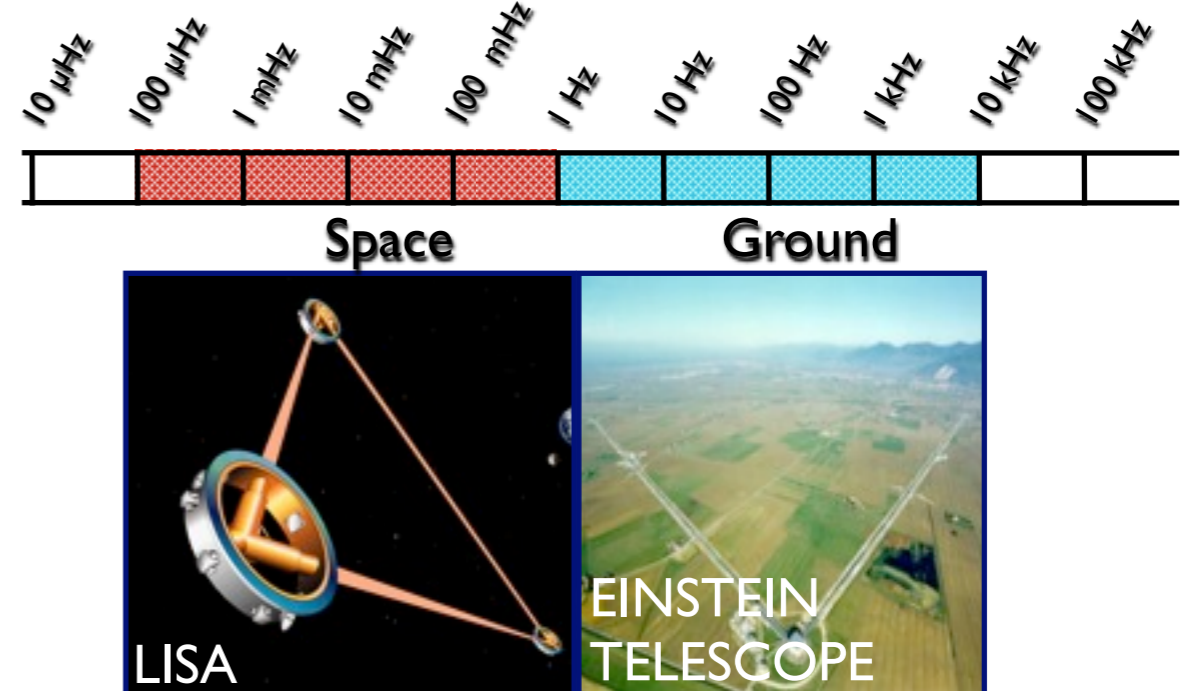
Detecting particles



Detecting neutrinos



Detecting gravitational waves



Running projects

- | | | | |
|------------------------------|------------|----------------------------------------------------------------------------------|--|
| ISDC core
science | • INTEGRAL | strong gravity & magnetic fields, accretion, jets, clusters, nucleosynthesis, DM | |
| | • POLAR | gamma-ray burst polarisation | |
| | • Planck | cosmology, inflation, clusters, jets | |
| | • Gaia | stellar & galactic astronomy | |

Starting projects

- | | | | |
|------------------------------|----------------|------------------------------------------------------------------------------|-------------------------------|
| ISDC core
science | • Fermi | strong gravity & magnetic fields, jets, clusters, particle acceleration, DM | |
| | • CTA | strong magnetic fields, jets, particle acceleration, cosmic ray, DM | Aspera/Astronet/ESFRII |
| | • Astro-H | strong gravity & magnetic fields, jets, clusters, structure formation, stars | |

Some future projects

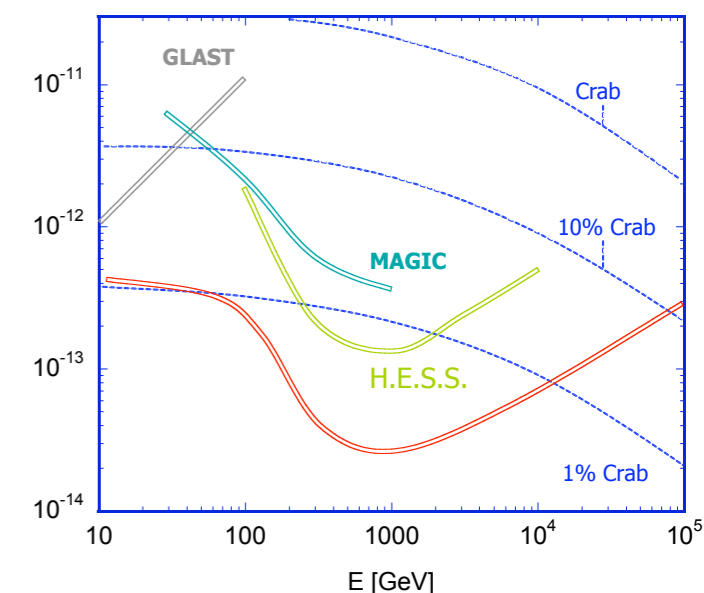
- | | | | |
|------------------------------|-------------------|------------------------------------------------------------------------------|-----------------------------|
| ISDC core
science | • XEUS | strong gravity & magnetic fields, jets, clusters, structure formation, stars | Astronet/ESA |
| | • LISA | strong gravity, structure formation, early universe | (UniZH) Aspera/Astronet/ESA |
| ISDC core
science | • JEM-EUSO | particle acceleration, cosmic rays | JAXA |
| | • Euclid/JDEM | cosmology & galaxies | (ETHZ, EPFL) Astronet/ESA |



Cherenkov Telescope Array

Advanced facility for ground based gamma-ray astronomy

- Provide a next-generation instrument for the user community, to address a wide range of topics in high-energy astrophysics and to explore the full sky.
- Boosts sensitivity by an order of magnitude (mCrab regime)
- Expands energy coverage (few 10 GeV to few 100 TeV, 4 decades in energy)
- Improve angular resolution
- Provide enhanced survey capability and full sky coverage
- Large number (1000) of sources expected implies operation as an open observatory, with appropriate tools for data dissemination and data analysis.
- Expect hundreds of users from astronomy, astro-particle physics, plasma physics, particle physics (DM), cosmology

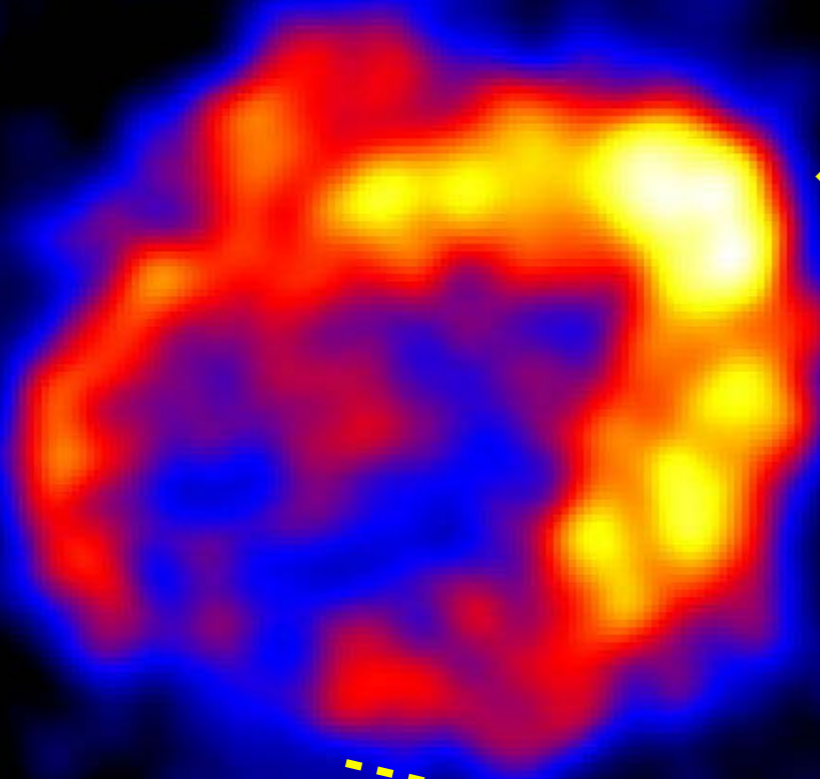




Cosmic rays origin

Cosmic rays from SNR

HESS

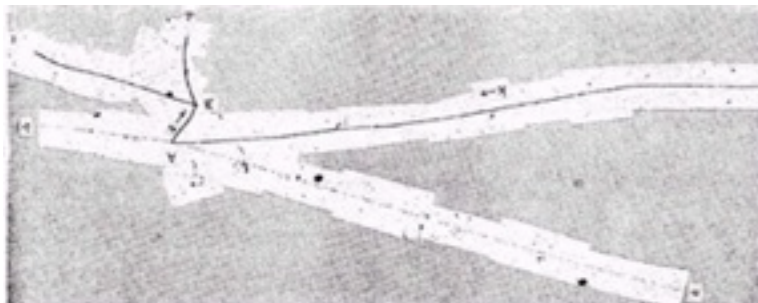
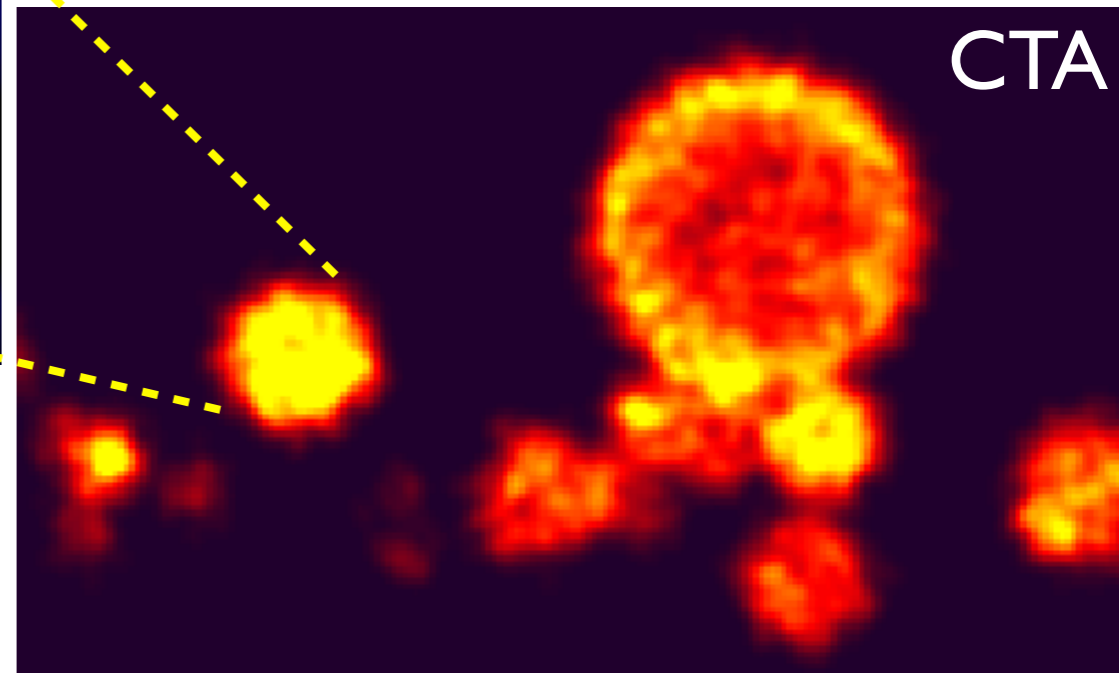


RX J1713.7-3946

- proton or electron origin ?
- Do acceleration reach the knee ?
- Are SNR efficient enough ?
- CR confinement, lifetime, release ?

Many more sources needed !
(currently 12 TeV SNR out of 274)

CTA





Science goals

Sources and propagation of high energy particles in the Cosmos, from compact sources to large scale structures

- Pulsars mapping their magnetosphere ?
- Pulsar winds pulsar interaction with ISM
- Stellar winds & clusters particle acceleration by massive stars
- Supernova remnants CR acceleration up to the knee (incl. heavy nuclei)
- X-ray binaries particle acceleration in varying environment
- Galactic plane diffuse emission, molecular clouds, energy budget, ISM chemistry
- Starburst galaxies energy budget
- Cluster of galaxies CR or DM, non thermal energy budget, merger shocks

Black holes and their environment

- Active Galactic Nuclei jets, particle nature, energy distribution, geometry, blazars sequence, UHE CR
- Galactic center high energy protons accelerated in the MBH or PWN (DM contribution ?)
- Stellar-mass black holes jets, micro-quasars

Fundamental physics and cosmology

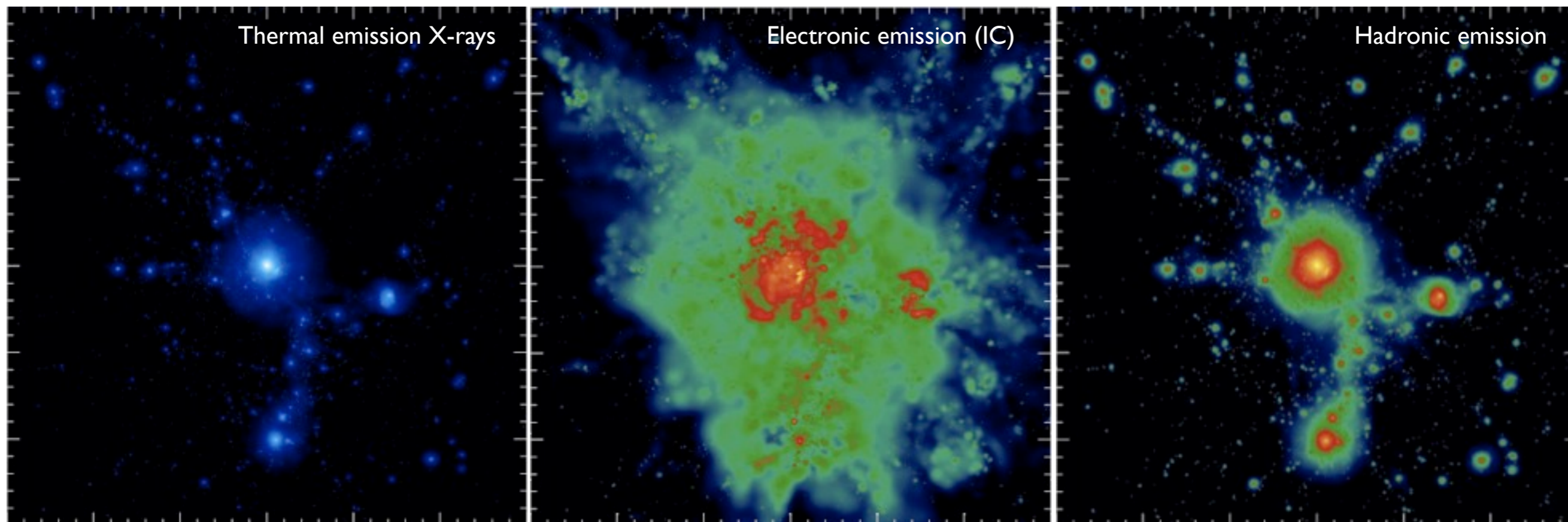
- Dark matter search annihilation in GC/clumps, limit on cross sections.
- Extragalactic background measure of the stellar formation history in the Universe
- Bursts space-time structure and quantum gravity (GRB 080916C)
- Primordial black-holes evaporation

Serendipitous discoveries



probes an important component

In the galaxy: $U_{\text{CR}} (10^{-19} \text{ J/cc}) > U_{\text{CMB}} \approx U_{\star} \approx U_{\text{B}} \approx U_{\text{K}}$



Cosmic rays: up to 30% of the pressure in the cluster central regions

VHE astronomy offers at the moment a unique tool to directly probe the extreme high energy tail of the high energy particle populations, and extremes accelerators which produce them. It reveals the non-thermal universe, out of equilibrium processes, and extreme cosmic events.



Status

Collaboration:

- 70 institutes
- 14 european countries + Japan (USA:AGIS)
- Spokespersons: Werner Hofmann (MPIK) & Manel Martinez (IFAE)
- CH: UniGe, UniZh, ETHZ, EPFL
- Next collaboration meeting: UniZh, October 5-7, 2009

Schedule:

- Design Study & prototype: 2009-2012
- Construction: 2012-2016
- Operations: >10 years, observatory

Medium Scale ^b		2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	
CTA	R&D	€25M										
	Construction			€200M								
	Operations ^c				€4M	€5M	€6M	€7M/yr				

Astronet

Funding:

Design study:

- ASPERA call
- FP7-INFRA-2010-2.2.10 Preparatory phase for CTA
- FP7-INFRA-2010-1.2.3 Virtual Research Communities
- National funding (CH: Sinergia)

Construction & operations: national funding (CH: FOLIS)



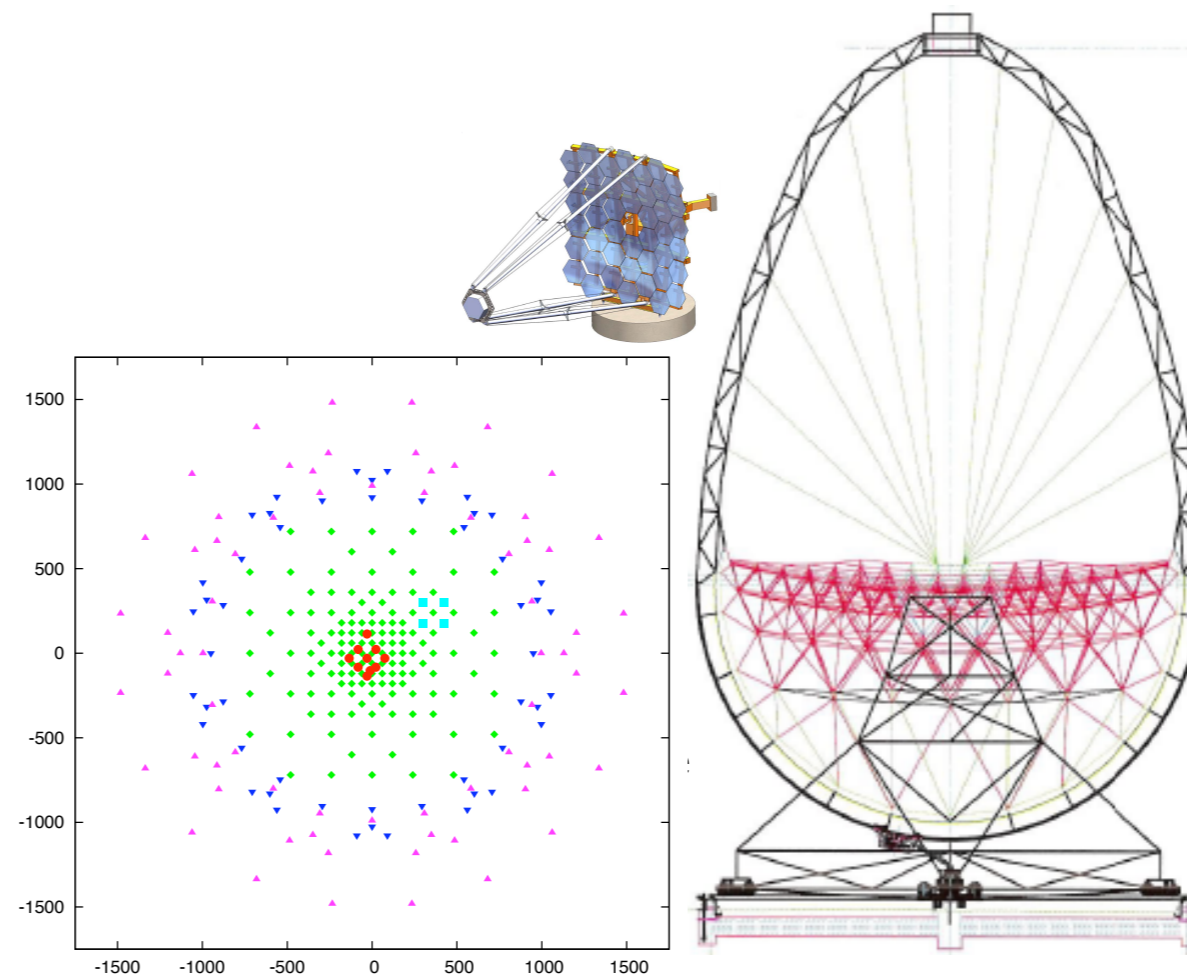
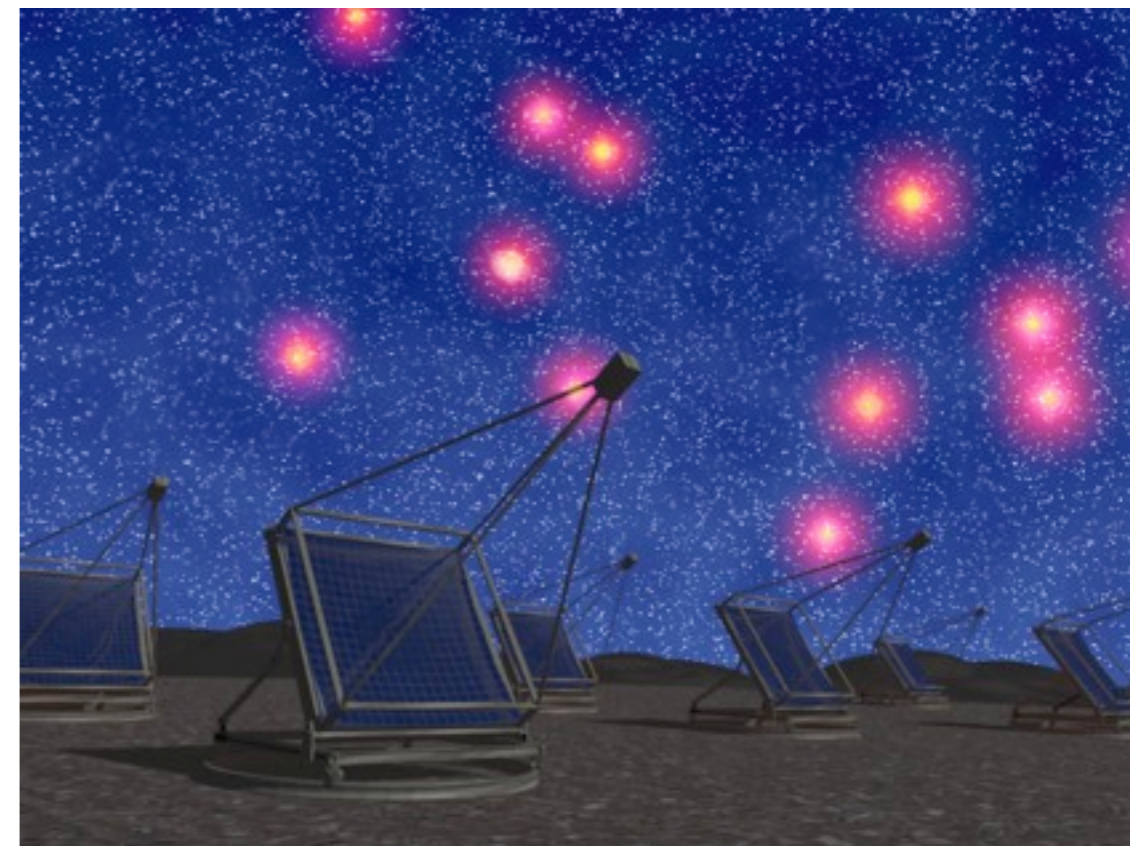


Components

- 2 sites (southern & northern)
- Telescope array \varnothing up to 2.5 km
- Up to 100 telescopes of 2 or 3 kinds (\varnothing : 23, 12 & 6 m)
- $> 10^4$ m² of mirrors
- $\sim 10^6$ camera pixels
- On site operations (x2)
- Operation centre
- Data centre

Many questions:

- Quantitative physics cases
- Site
- Telescope array layout
- Telescope structure
- Pixel size
- Analogue/digitized electronics
- Array trigger
- Improved PMTs, silicon detectors
- Low cost photo sensors + FEE
- Low cost, long life mirrors
- Gb/s data rate; several PB/yr
- Management
- ...





Design Study

Short name

PHYS

MC

SITE

MIR

TEL

FPI

ELEC

ATAC

OBS

DATA

QA

Work package title

Astrophysics and astroparticle physics

Optimisation of array layout, performance studies and analysis algorithms

Site evaluation and site infrastructure

Design of telescope optics and mirror

Design of telescope structure, drive and control systems

Focal Plane Instrumentation

Readout electronics and trigger

Atmospheric monitoring, associated science and instrument calibration

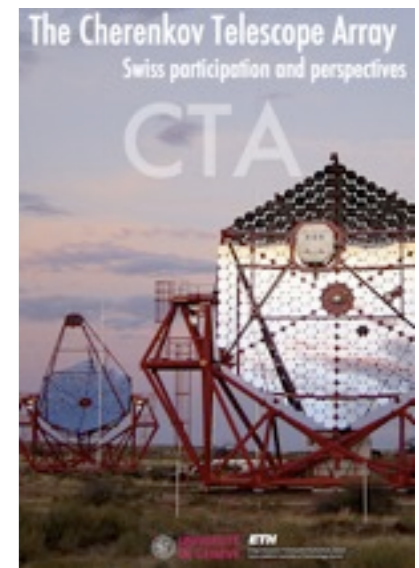
Observatory operation and access

Data handling, processing, management and data access

Risk assessment and quality assurance



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CTA data center activities

- Observatory and science operations
- On-site data activities
- Raw data archive
- Calibrate, process and archive data
- Off-line scientific analysis & user support

- Legacy data from Cherenkov arrays

Υ -ray science (based on Fermi data)

Funding for design study

SNF Sinergia + ASPERA
UniGe
CH-PL cohesion fund ?

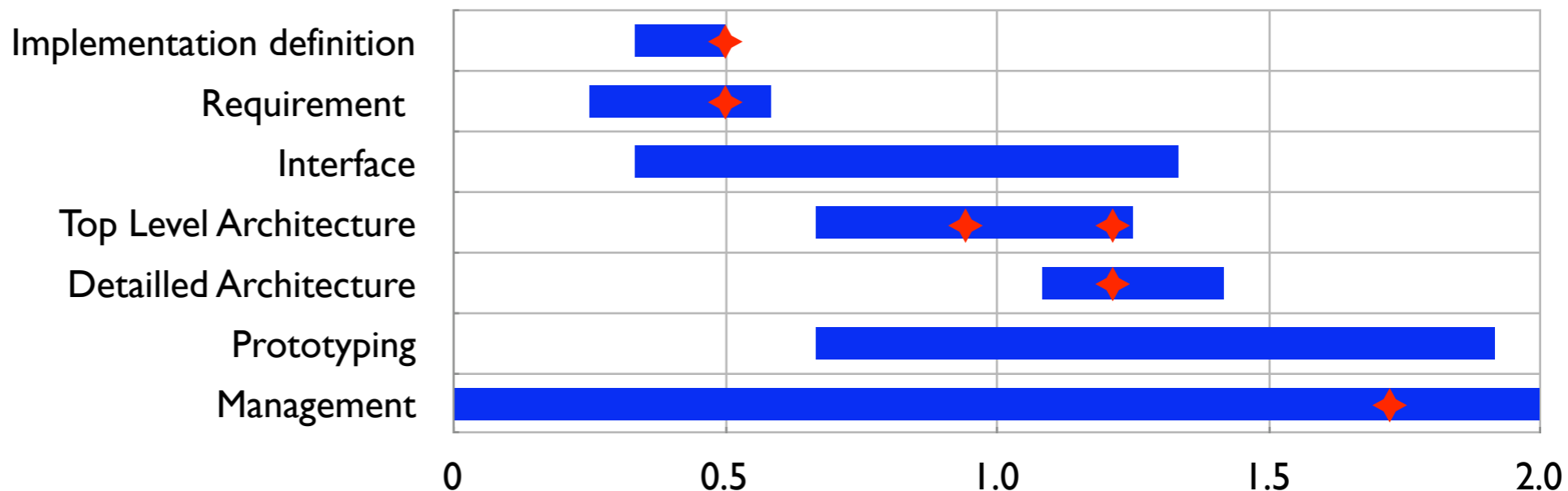
FP7-INFRA-2010-1.2.3

SNF Sinergia



CTA data center activities

Design study



and prototype development

γ-ray science

Follow-up on current subjects: AGNs, HMXB, colliding winds, transients, particle acceleration

Develop: Pulsars, DM

Astrophysics at Very-High Energies

15-20 March 2010, Les Diablerets, Switzerland

Lecturers:
Prof. Felix Aharonian
Prof. Lars Bergström
Dr Charles Dermer



You are all invited to participate !

The sky at very-high energies

Prof. Felix Aharonian (DIAS, Dublin & MPIK, Heidelberg)

1. The TeV sky: introduction
2. TeV instrumentation
3. The TeV source populations
4. Supernova remnants and the origin of Galactic cosmic rays
5. Star forming regions and giant molecular clouds
6. Pulsar winds and nebulae
7. Gamma-ray loud binaries (pulsars and microquasars)
8. TeV blazars
9. Exploring extreme cosmic accelerators with hard X-rays, gamma-rays and neutrinos
10. Gamma-rays from large scale cosmological structures (clusters of galaxies, pair halos, etc.)

Multi-messenger astronomy and dark matter

Prof. Lars Bergström (Stockholm University)

1. The particle universe: introduction
2. Basic cross sections for neutrinos and gamma-rays; IceCube
3. The dark matter problem: Particle candidates, relic density, cosmological parameters
4. Dark matter: Direct and indirect detection methods; the galactic centre
5. Backgrounds: Diffuse galactic and extragalactic gamma-rays
6. Particular dark matter candidates (WIMPs, Kaluza-Klein particles, sterile neutrinos)
7. Super-symmetric dark matter, Sommerfeldt enhancement
8. Primordial black holes, Hawking radiation
9. Gravitational waves

Sources of GeV photons and Fermi results

Dr Charles Dermer (U.S. Naval Research Laboratory)

1. GeV instrumentation and the GeV sky with Fermi
2. Non-thermal radiation processes (synchrotron, Compton, bremsstrahlung, secondary nuclear, photo-pion, photo-pair, photo-ion)
3. Fermi acceleration (first- and second-order, maximum particle energies)
4. Relativistic jet physics (relativistic flows, transformations, gamma-gamma opacity constraints, microquasars)
5. Neutron stars and pulsars
6. Radio galaxies (equipartition field, power, Compton-scattered CMB in lobes, Fermi results)
7. Nonthermal radiation from galaxy clusters and AGN (Fermi results and multi-wavelength modeling, population studies)
8. Gamma ray bursts I (introduction, pre-Fermi observations, relativistic jet model, quantum gravity)
9. Gamma ray bursts II (Fermi results and new theoretical developments; summary)