Report from ApPIC to APIF

Michel Spiro

May 15, 2014

ApPIC terms of reference

- Review on a regular basis the scientific status of the field of Astroparticle Physics;
- Engage in a continuous dialogue with "The Astroparticle Physics International Forum (APIF)" of the Global Science Forum (GSF) and provide scientific advice to APIF, whose members are appointed by funding agencies;
- Comment on and liaise with similar national and international organisations on assessment and road-mapping activities as the need may arise, e.g. for promoting the global coherence of plans, priorities and projects in AstroparticlePhysics.

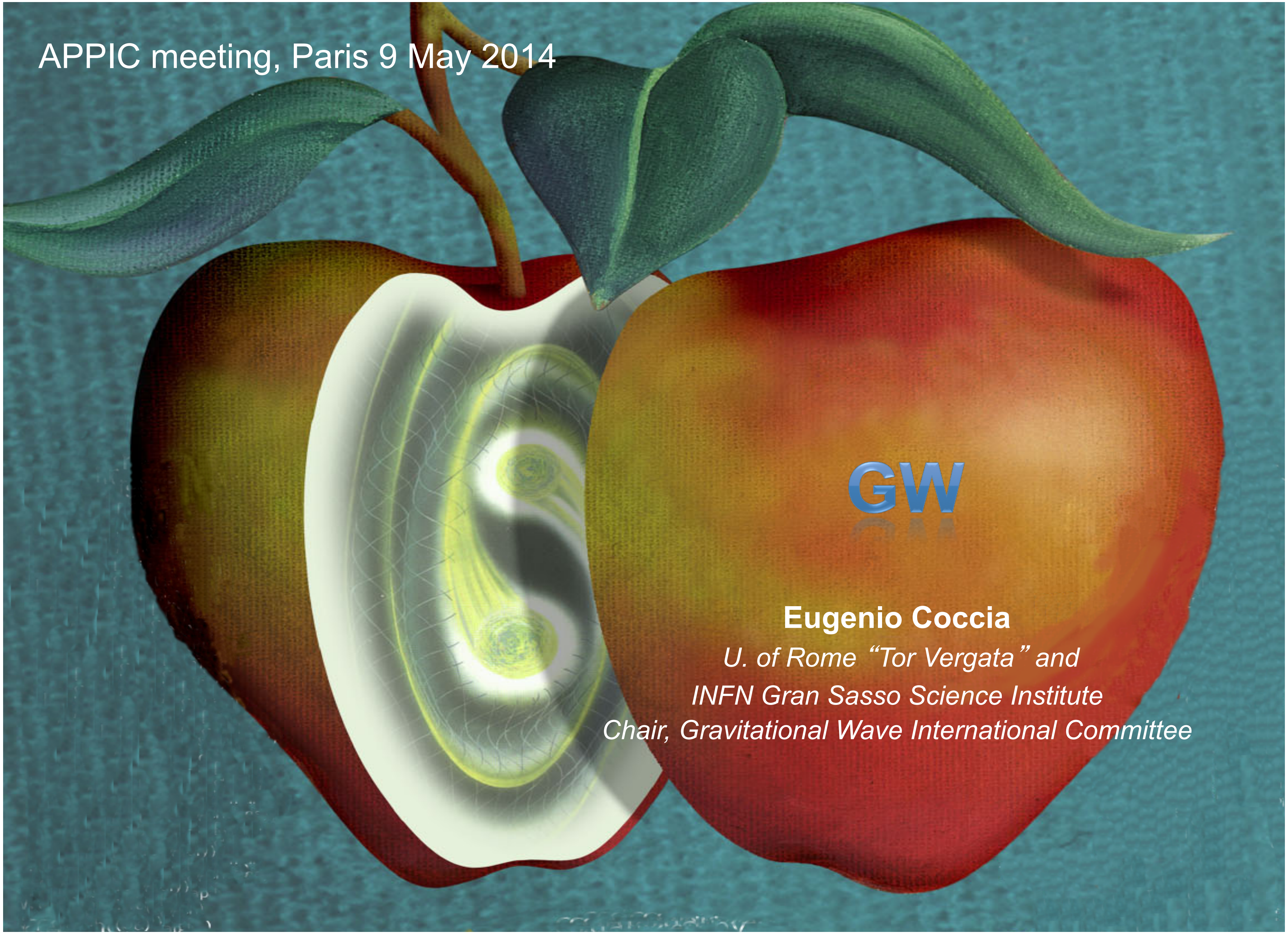
- Here the term « astroparticle physics » is defined in a broad sense to include investigations related to the properties of the high-energy universe as well as the dark universe and issues with cosmic relevance – at the interface of astrophysics, nuclear physics, particle physics and cosmology. It also pursues the relevant research in theory and technology development.

Members of ApPIC

Pierre Binetruy (France)
Roger Blandford (USA)
Zhen Cao (China)
Eugenio Coccia (Italy)
Don Geesaman (USA)
Kunio Inoue (Japan)
Naba Mondal (India)
Angela Olinto (USA)
Natalie Roe (USA)
Sheila Rowan (GB)
Valery Rubakov (Russia)
Bernard Sadoulet (USA)
Subir Sarkar (GB/Denmark)
Christian Spiering (Germany)
Michel Spiro (France) - Chair
Yoichiro Suzuki (Japan)

Agenda of the first ApPIC meeting (May 9, 2014)

- Data policy in AstroParticle Physics (data sharing, data access)
- High energy and ultra-high energy multi-messenger astronomy (neutrinos, gamma rays, cosmic rays, gravitational waves)
- Messages to APIF
- Plans for next meetings

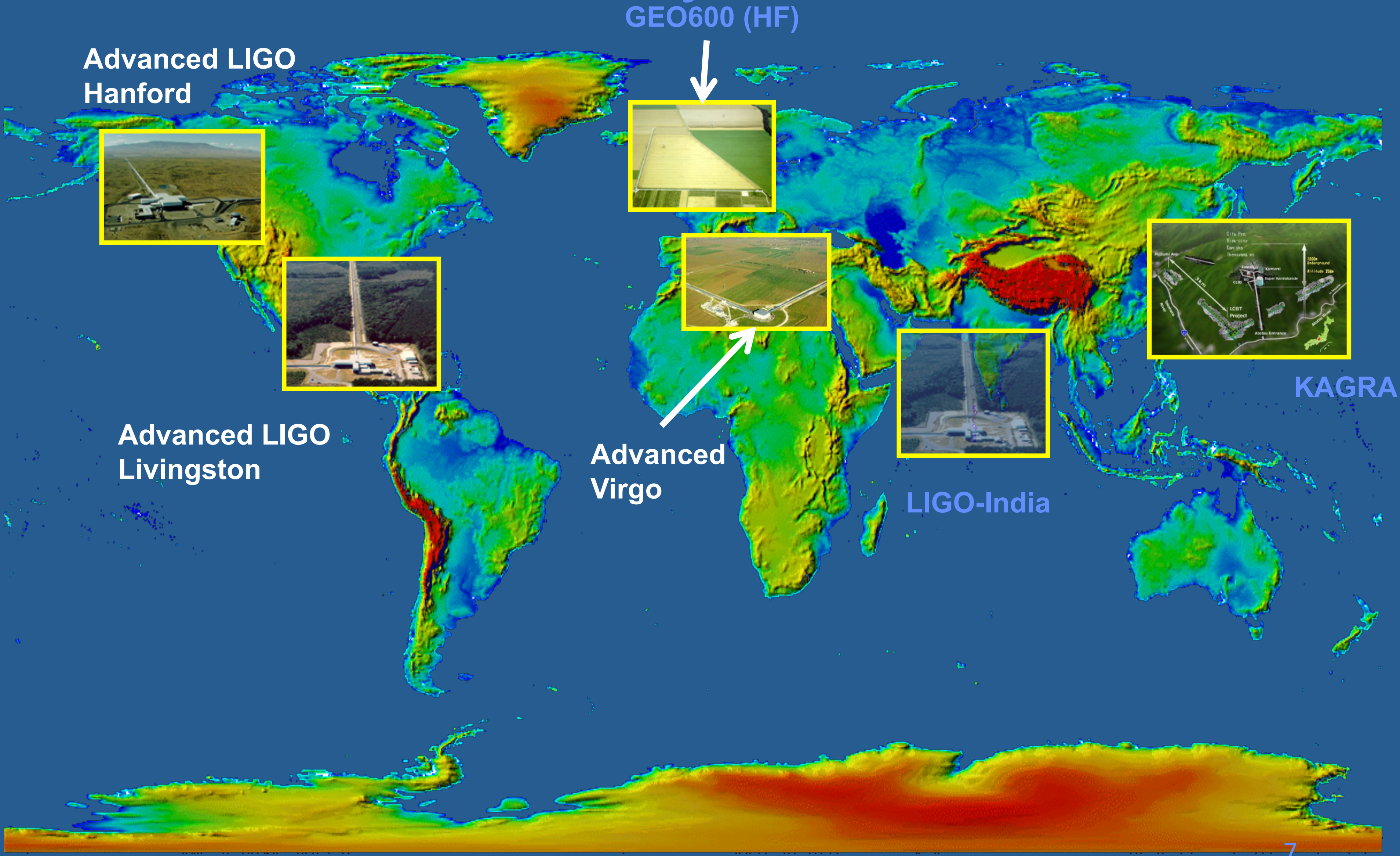


APPIC meeting, Paris 9 May 2014

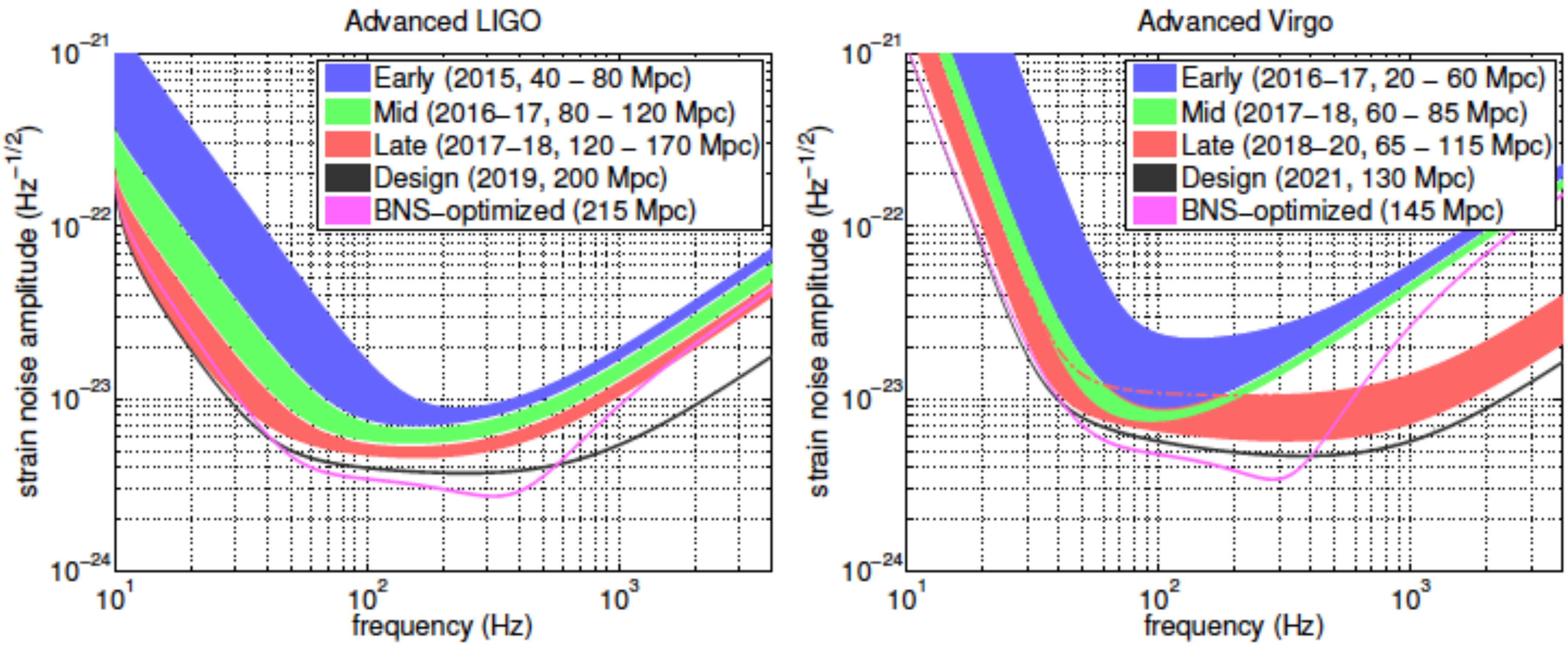
GW

Eugenio Coccia
U. of Rome "Tor Vergata" and
INFN Gran Sasso Science Institute
Chair, Gravitational Wave International Committee

The Advanced GW Detector Network: E. Coccia, chair of GWIC



Plausible scenario
for the operation of the LIGO-Virgo network over the next decade



MoU LSC-Virgo **Purpose of agreement (2007):**

The purpose of this Memorandum of Understanding (MOU) is to establish and define a collaborative relationship between VIRGO on the one hand and the Laser Interferometer Gravitational Wave Observatory (LIGO) on the other hand in the use of the VIRGO, LIGO and GEO detectors based on laser interferometry to measure the distortions of the space between free masses induced by passing gravitational waves.

We enter into this agreement in order to lay the groundwork for decades of world-wide collaboration. We intend to carry out the search for gravitational waves in a spirit of teamwork, not competition. Furthermore, we remain open to participation of new partners, whenever additional data can add to the scientific value of the search for gravitational waves. All partners in the collaborative search should have a fair share in the scientific governance of the collaborative work.

Among the scientific benefits we hope to achieve from the collaborative search are: better confidence in detection of signals, better duty cycle and sky coverage for searches, and better source position localization and waveform reconstruction. In addition, we believe that the intensified sharing of ideas will also offer additional benefits.

LSC AND VIRGO POLICY ON RELEASING GRAVITATIONAL WAVE TRIGGERS TO THE PUBLIC IN THE ADVANCED DETECTORS ERA (2015)

The LSC and Virgo recognize the great potential benefits of multi-messenger observations, including rapid electromagnetic follow-up observations of GW triggers. Both Collaborations (the LSC and Virgo) will partner with astronomers to carry out an inclusive observing campaign for potentially interesting GW triggers, with MoUs to ensure coordination and confidentiality of the information. They are open to all requests from interested astronomers or astronomy projects which want to become partners through signing an MoU. They encourage colleagues to help set up and organize this effort in an efficient way to guarantee the best science can be done with gravitational wave triggers.

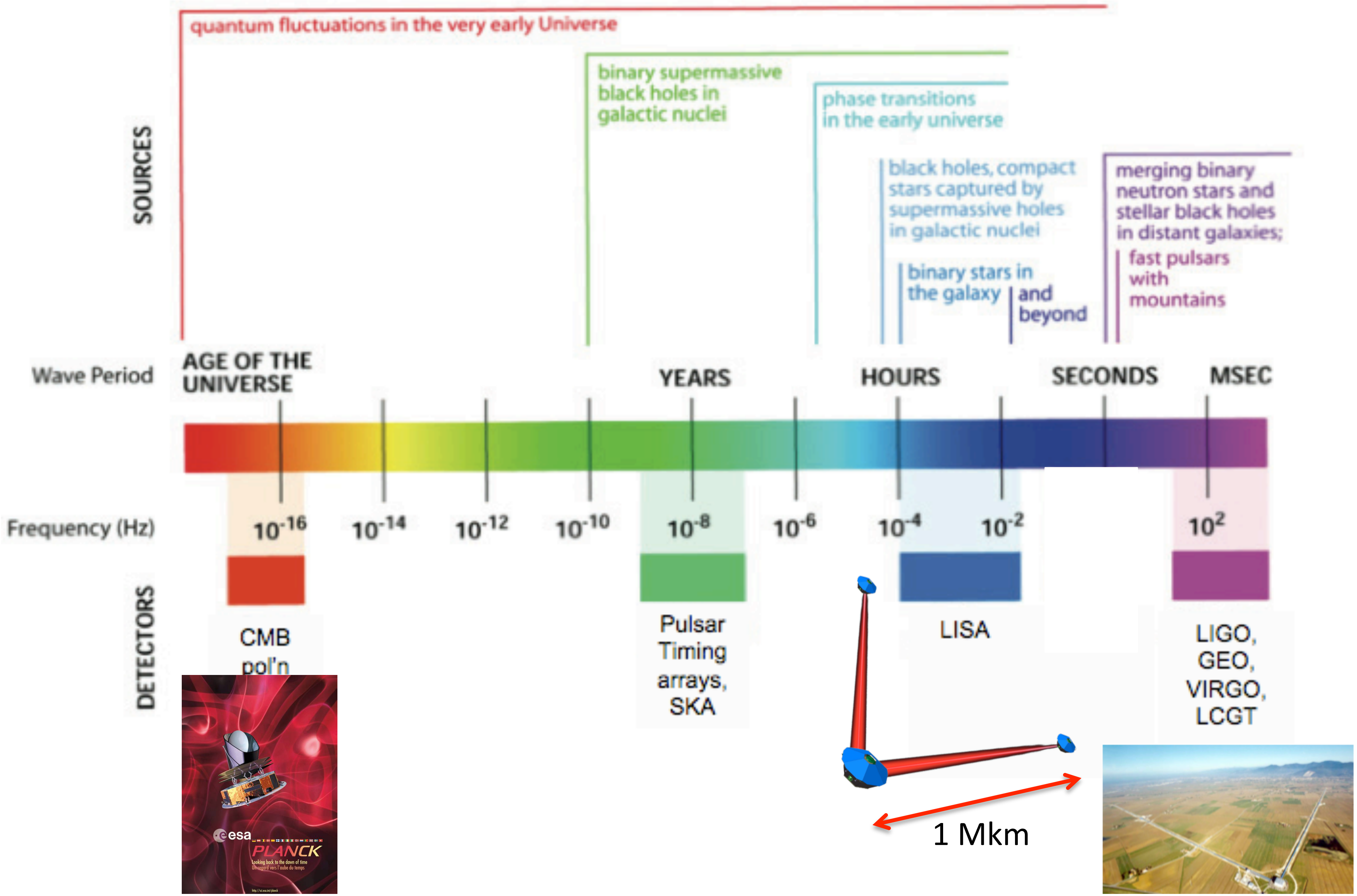
After the published discovery of gravitational waves with data from LSC and/or Virgo detectors, both the LSC and Virgo will begin releasing especially significant triggers promptly to the entire scientific community to enable a wider range of follow-up observations. This will take effect after the Collaborations have published papers (or a paper) about 4 GW events, at which time a detection rate can be reasonably estimated. The releases will be done as promptly as possible, within an hour of the detected transient if feasible. Initially, the released triggers will be those which have an estimated false alarm rate smaller than 1 per 100 years.

Astronomy, physics and data access challenges for the LISA gravitational space mission

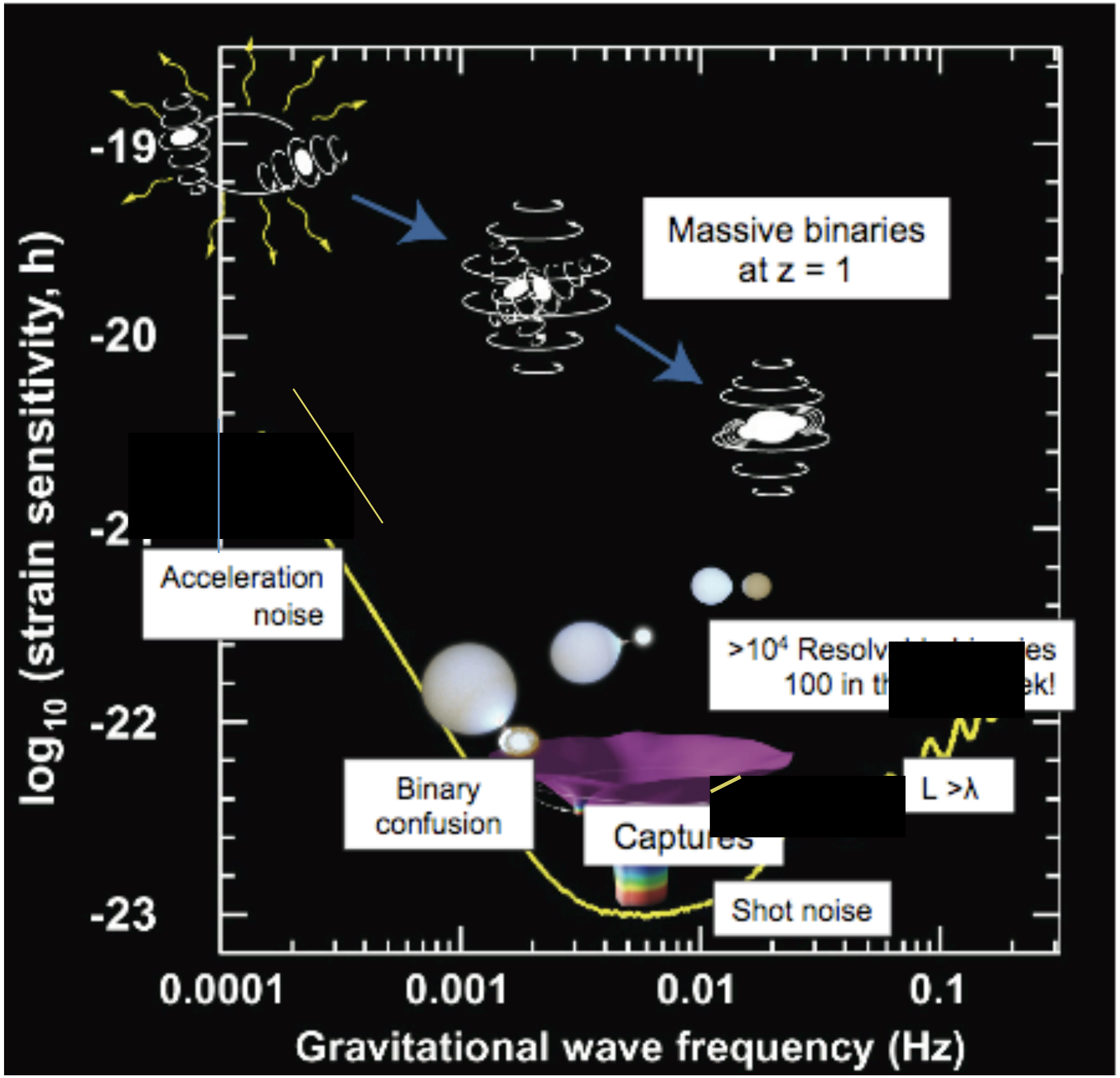
Pierre Binétruy,

APPIC meeting
APC, 9 May 2014

The frequency spectrum of gravitational waves

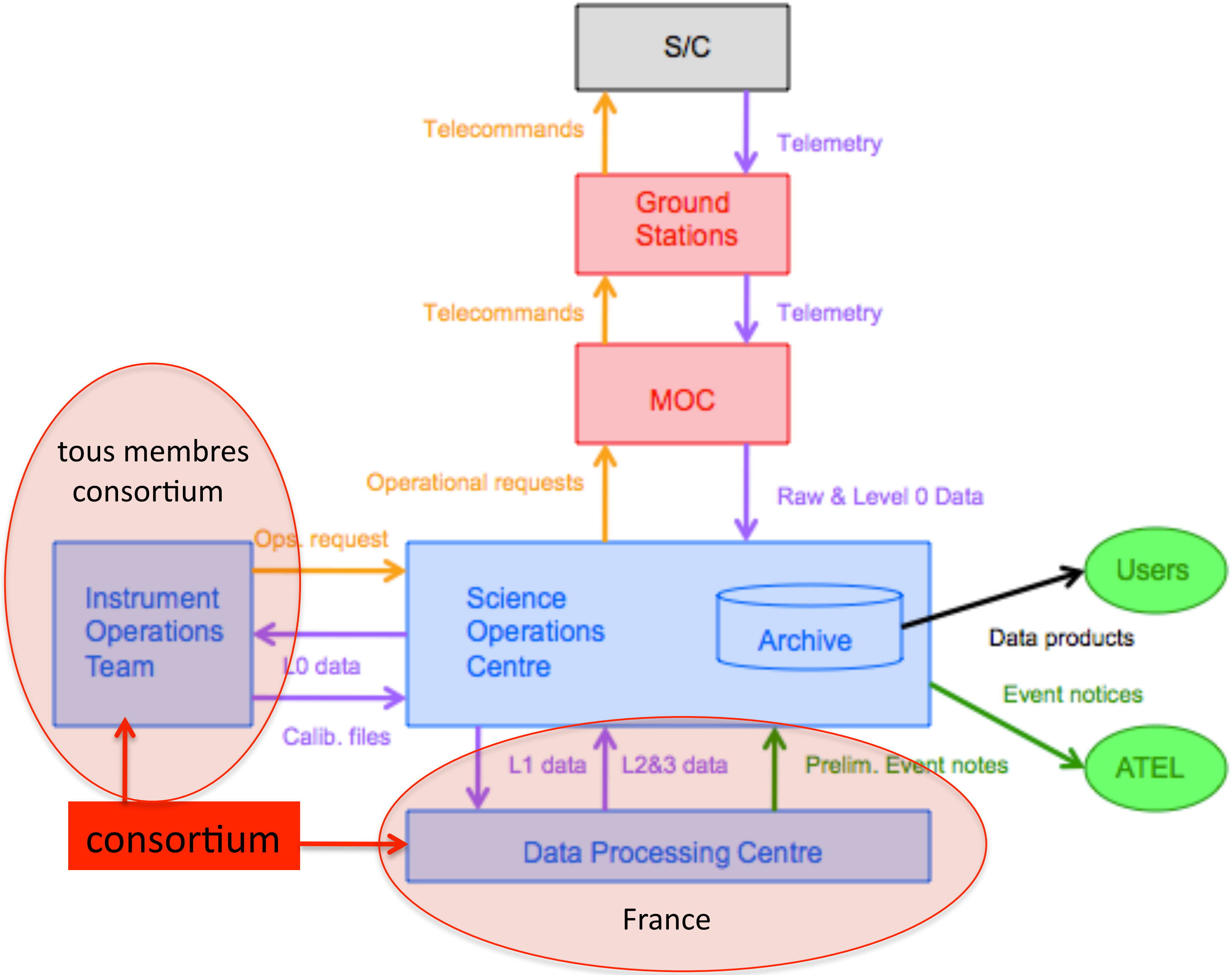


The science of eLISA:
Search for diffuse cosmological background
(phase transition beyond the standard model at 1 to 100 TeV)
Binary star astronomy



Data processing

Data policy: all data publicly released



Why start so early?

• allow as soon as possible the community to develop code in a coordinated way: this is very important if one has to release the data publicly.
• coordinate with the ground interferometers
• the data will address a large community (astrophysicists) which is not used to this kind of data: provide simulated data and associated software to get acquainted with such data. The data may interest particle physicists (physics beyond the standard model up to 100 TeV)
• because this is a discovery mission, the development of code will not stop with the launch: conceive the centre and its development platform in way that allows flexibility and adapt to new discoveries or new theories; better start early to benefit evolution of thinking in coming years.

General conclusions on Data Policy

- Ground gravitational antennas: bottom-up approach, science driven data policy
- LISA (space gravitational antenna): space agency data policy (public funding implies open data policy like in the US)
- General considerations: avoid false discoveries, give proper credit by quoting properly the used data release (collaboration), resources have to be planned from the very beginning with funding agencies

Data policy (5 tempos)

- Data validation (Collaboration)
- First data releases for joint analysis (Collaborations)
  - For combinations and mutual cross-checks
  - For complementary approaches
- Open trigger on or off line (Collaborations)
- Data in open access for the community (get the collaboration and the community prepared, virtual observatory model and help-desk?)
- Data preservation and legacy

How to implement?

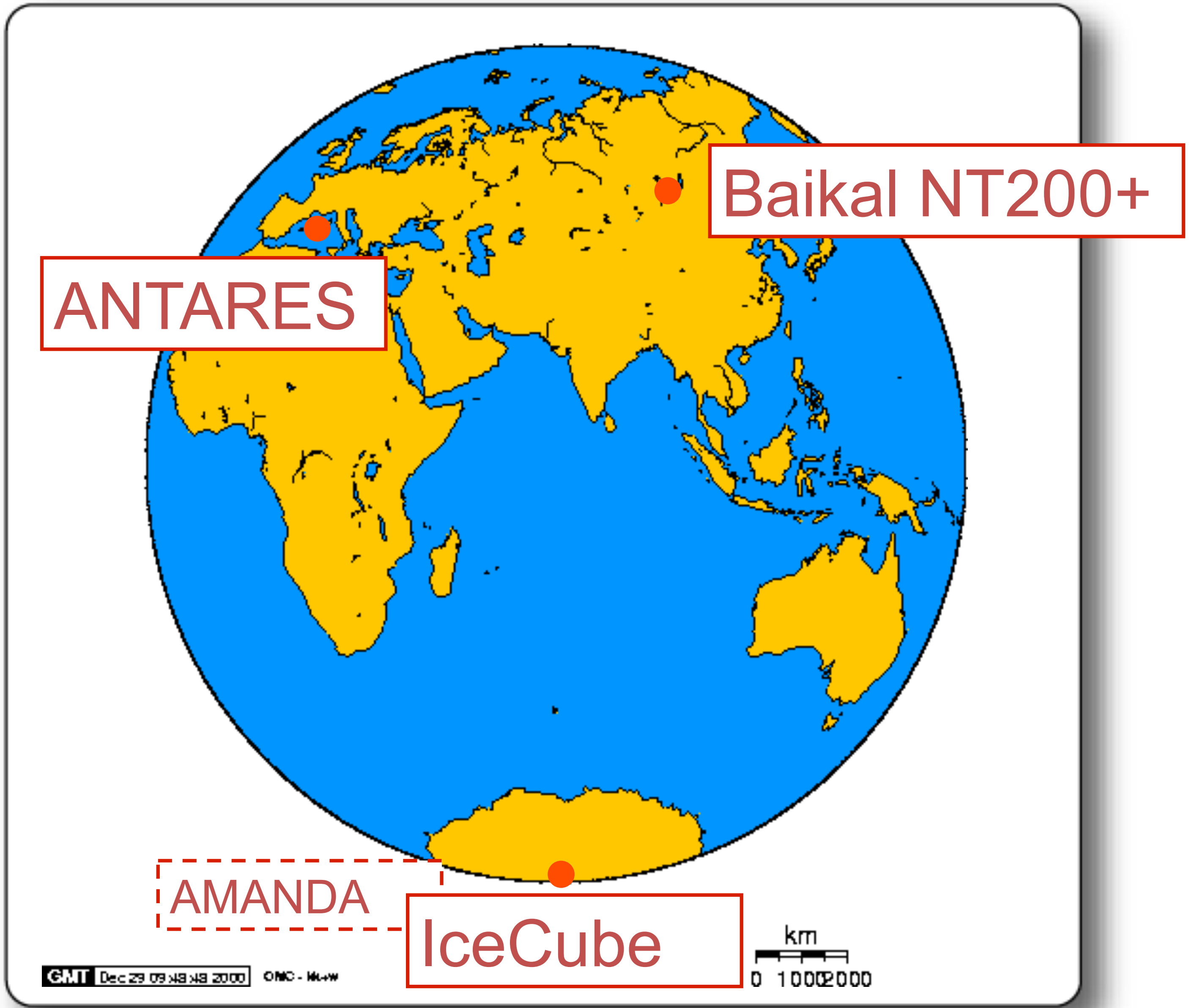
- ApPIC could trigger a session on this topic in the next TAUP 2015 large international conference on Astroparticle Physics
- This would be a discussion with the community on guiding rules for data policy in Astroparticle Physics
- ApPIC would come back to APIF and serve on this item as an interface between APIF and the community (one of the roles of ApPIC)

Recent Results and Prospects of High-Energy Neutrino Astronomy

APPIC Meeting May 8, 2014
Paris

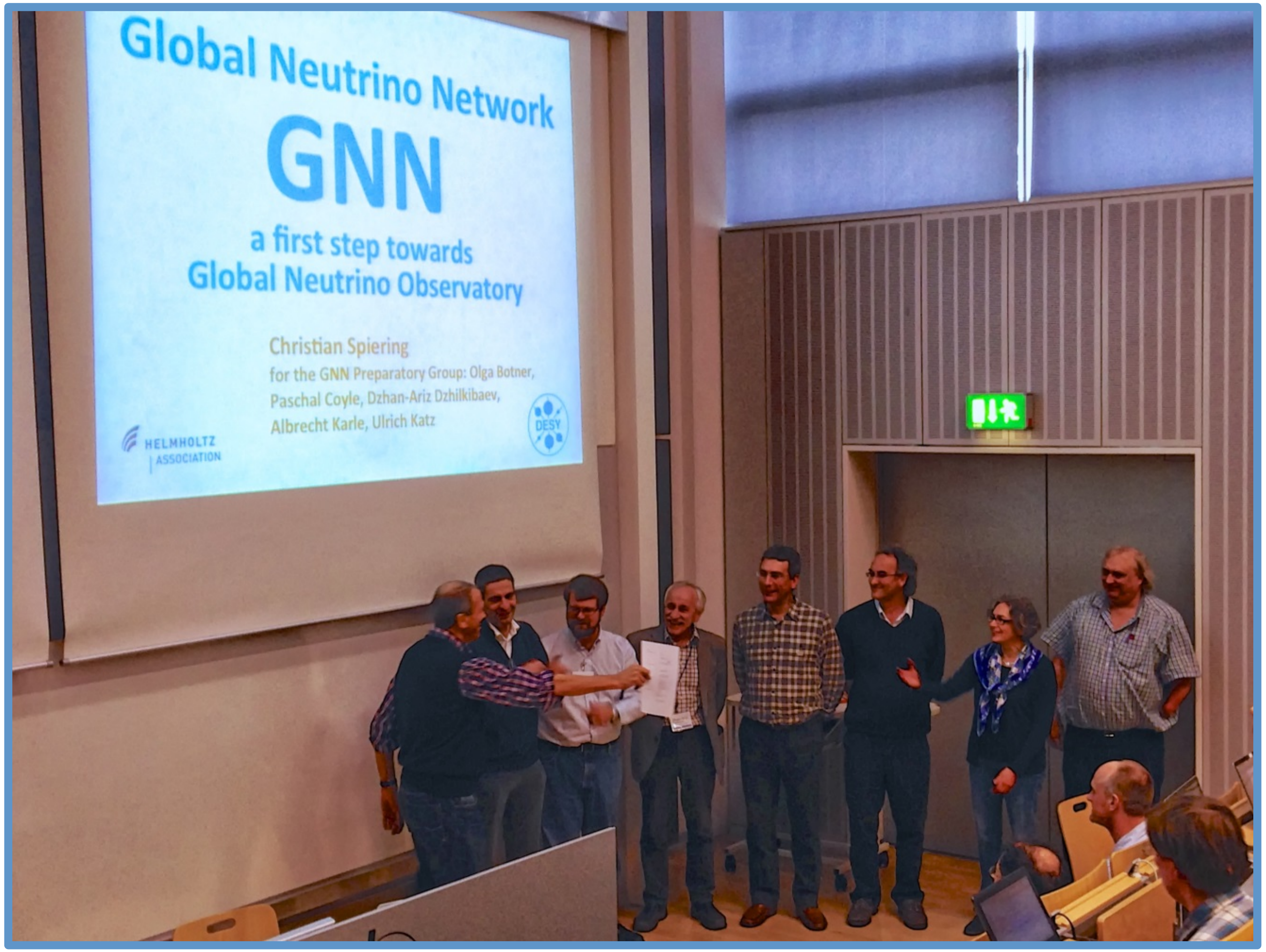
Christian Spiering, DESY Zeuthen

Existing detectors



GNN

The Global Neutrino Network

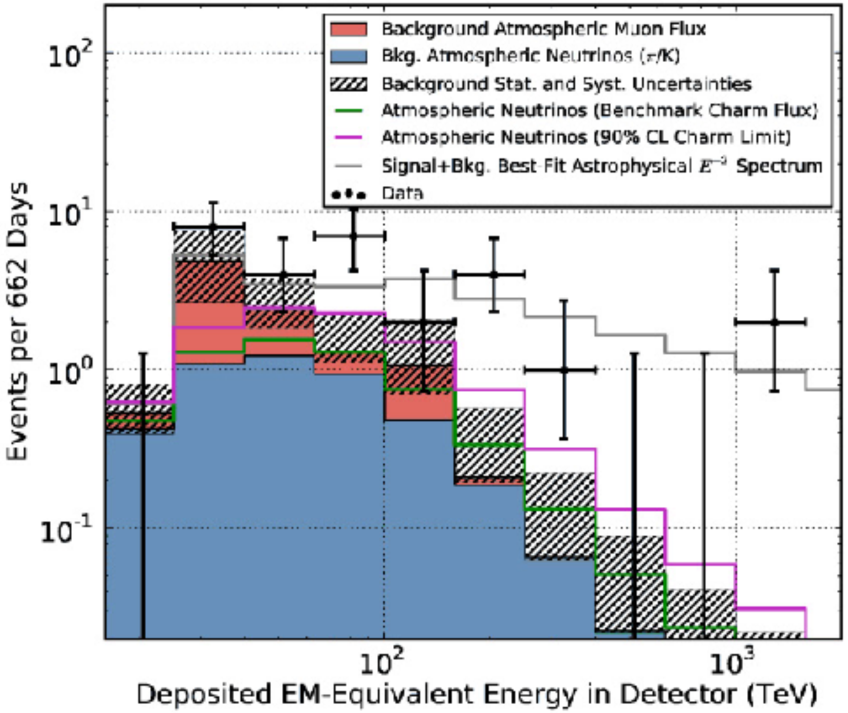


- Oct. 2013, Munich

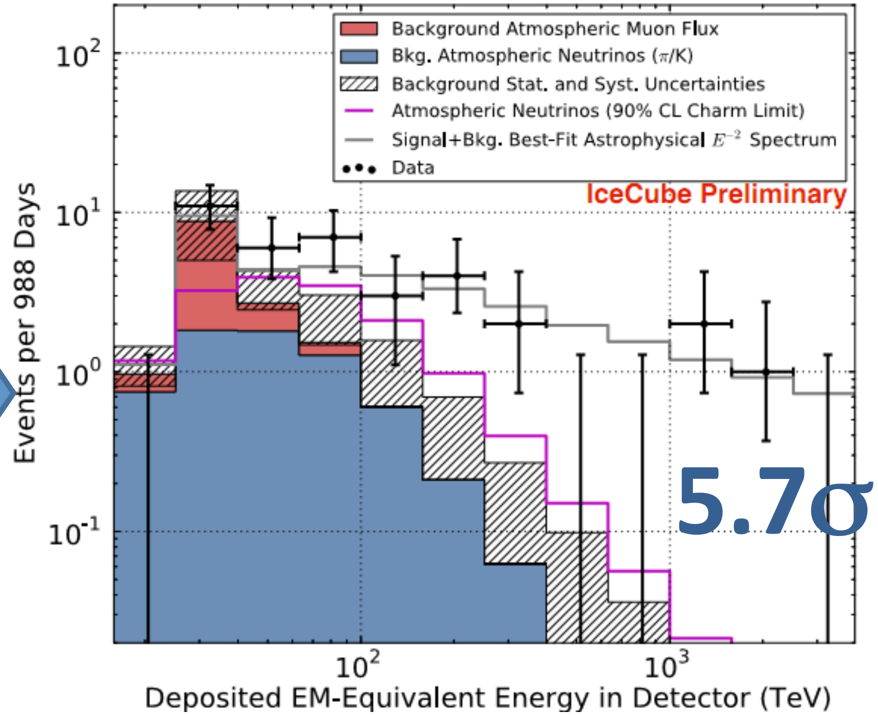
- Antares
- Baikal
- IceCube
- KM3NeT

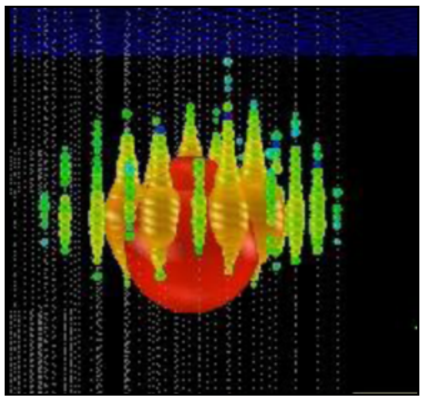
- http://www.globalneutrinonetwork.org/

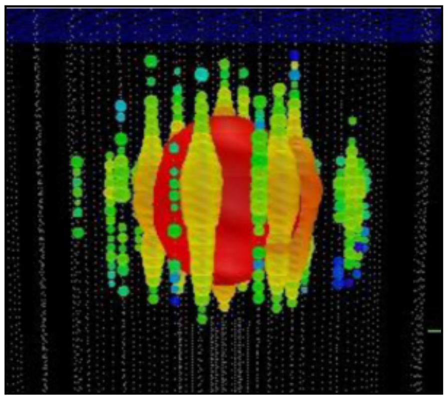
HE neutrino astronomy results IceCube



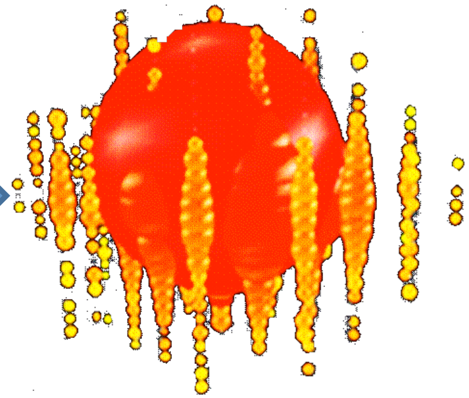
3rd year





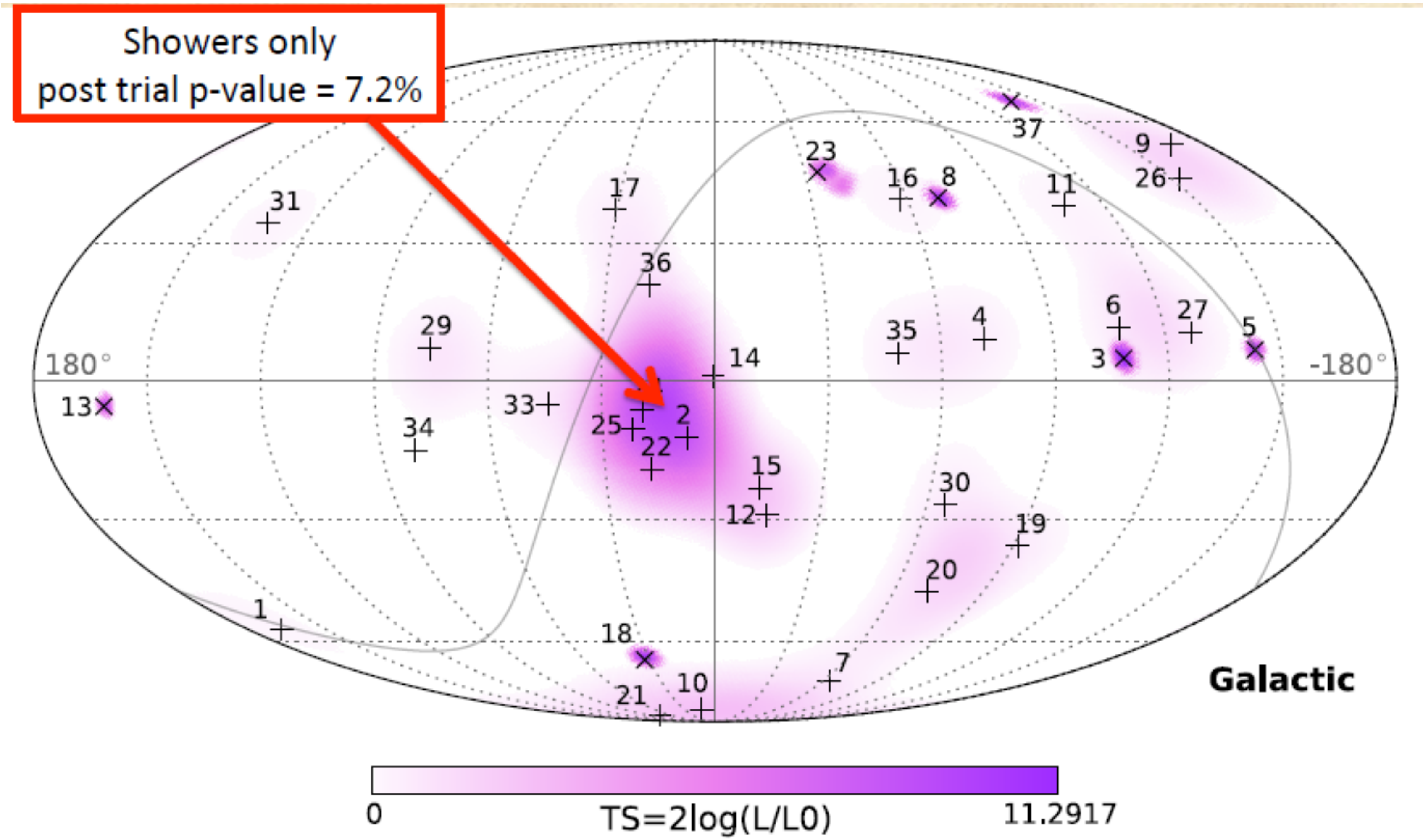


3rd PeV event.



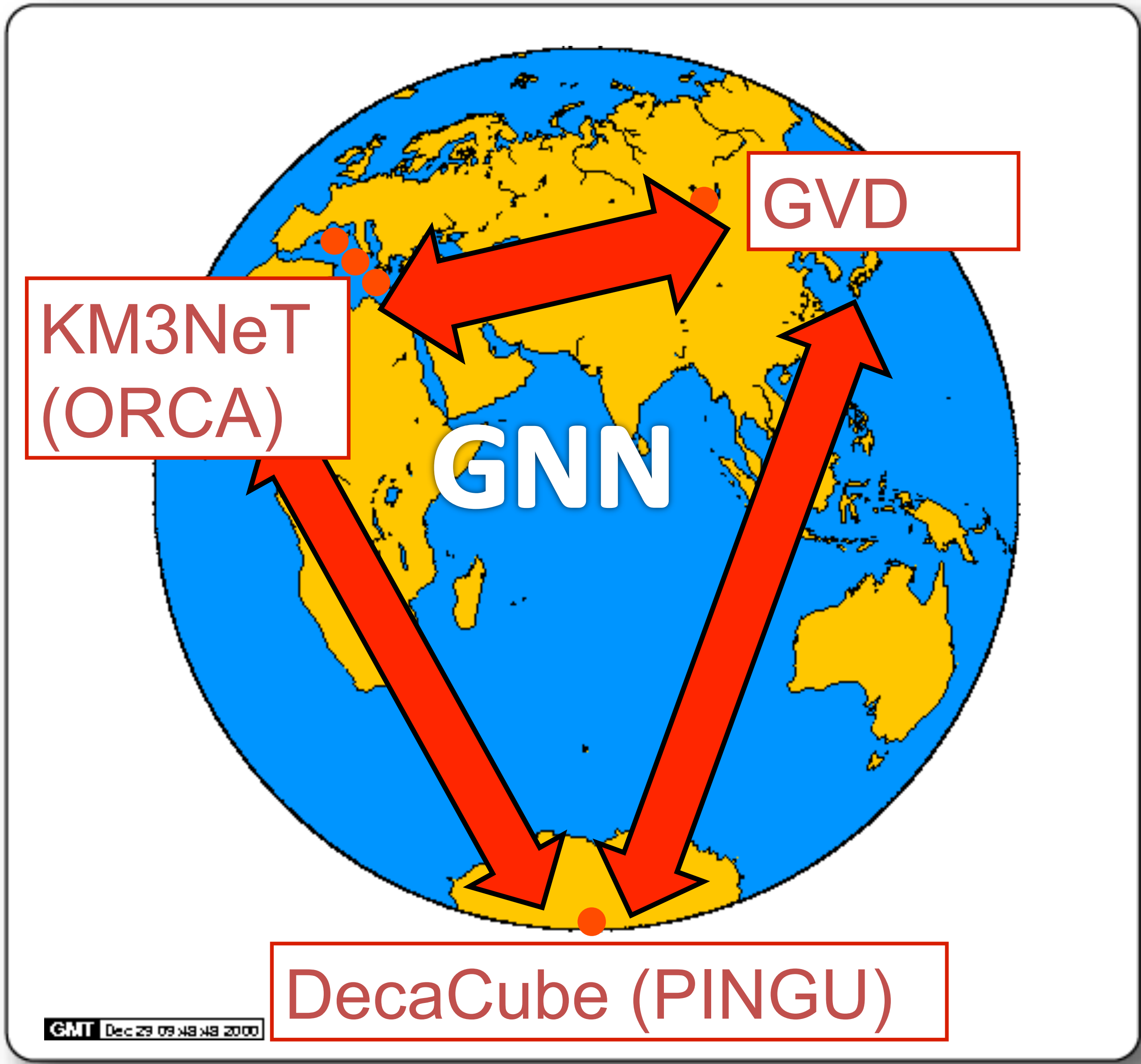

physicsworld
BREAKTHROUGH OF THE YEAR
2013
IceCube
NSF

HE neutrino astronomy skyplot, 3 years



Could that be a point source? – Constraints from ANTARES!

Baikal, Mediterranean Sea, South Pole



Rationale for the multi-km^3 scale, South & North

- Identify point sources !
- Measure their spectrum !

This is „astronomy“

- IceCube is scratching the point source discovery region at best
- Need larger detectors! (How much larger?)

- Detectors on the North and South look to different parts of the sky (but with some overlap!)
- Can cover different parts of the spectra of the same sources.
- Ice and water have different sytematics. Important for flavor ratios and spectral form, in particular for diffuse fluxes.

Overview on high-energy projects

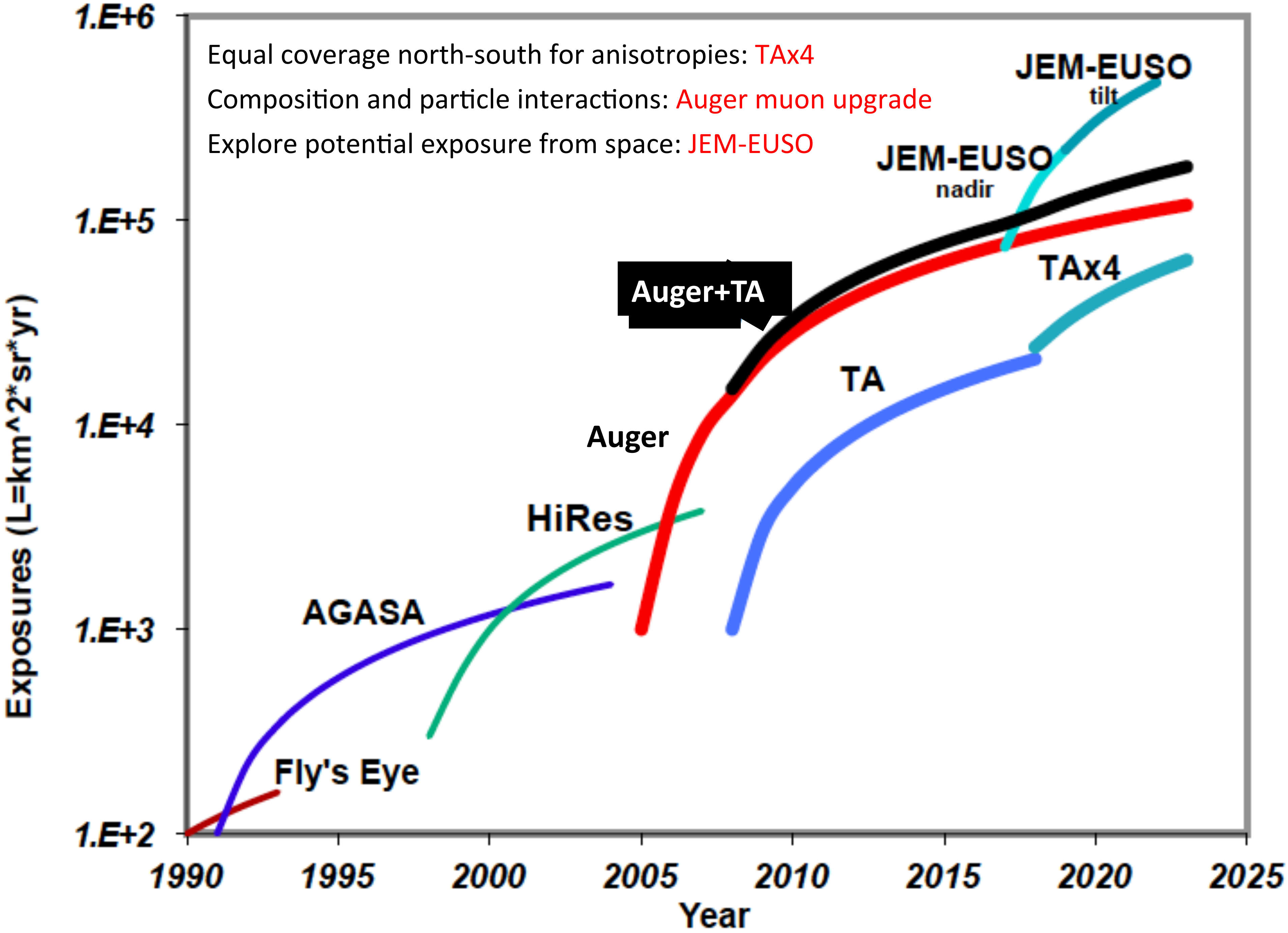
- KM3NeT: **<u>6 x 0.6 km³</u>**
  - Phase 1 (scale ~3 x ANTARES): complete 2016, funded
  - Phase 1.5 (2 x 0.6 km³): complete 2020 encouraging signals for funding
  - Phase 2 (6 x 0.6 km³): complete mid 2020s

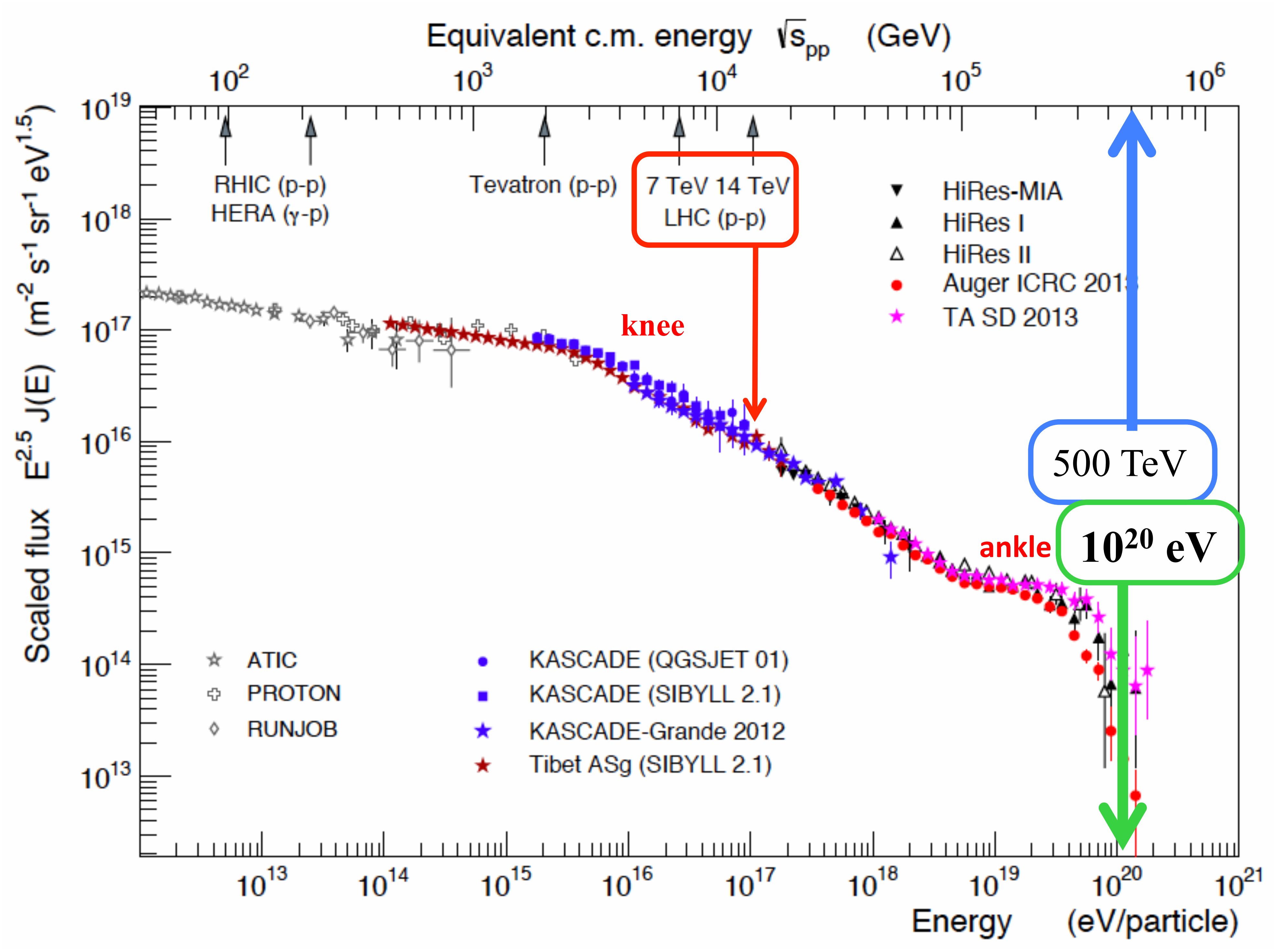
- DecaCube („IceCube High-Energy extension“, HEX) **<u>5-10 km³</u>**
  - Start 2018/19 ?
  - Complete 2027 ? Including PINGU with the 3 first of the 8 seasons
  - Encouraging first responses from NSF

- GVD (Baikal): **<u>0.4 km³</u>**
  - First of 10 clusters in early 2015
  - Full array in 2020

Ultrahigh Energy Cosmic Ray Astronomy!

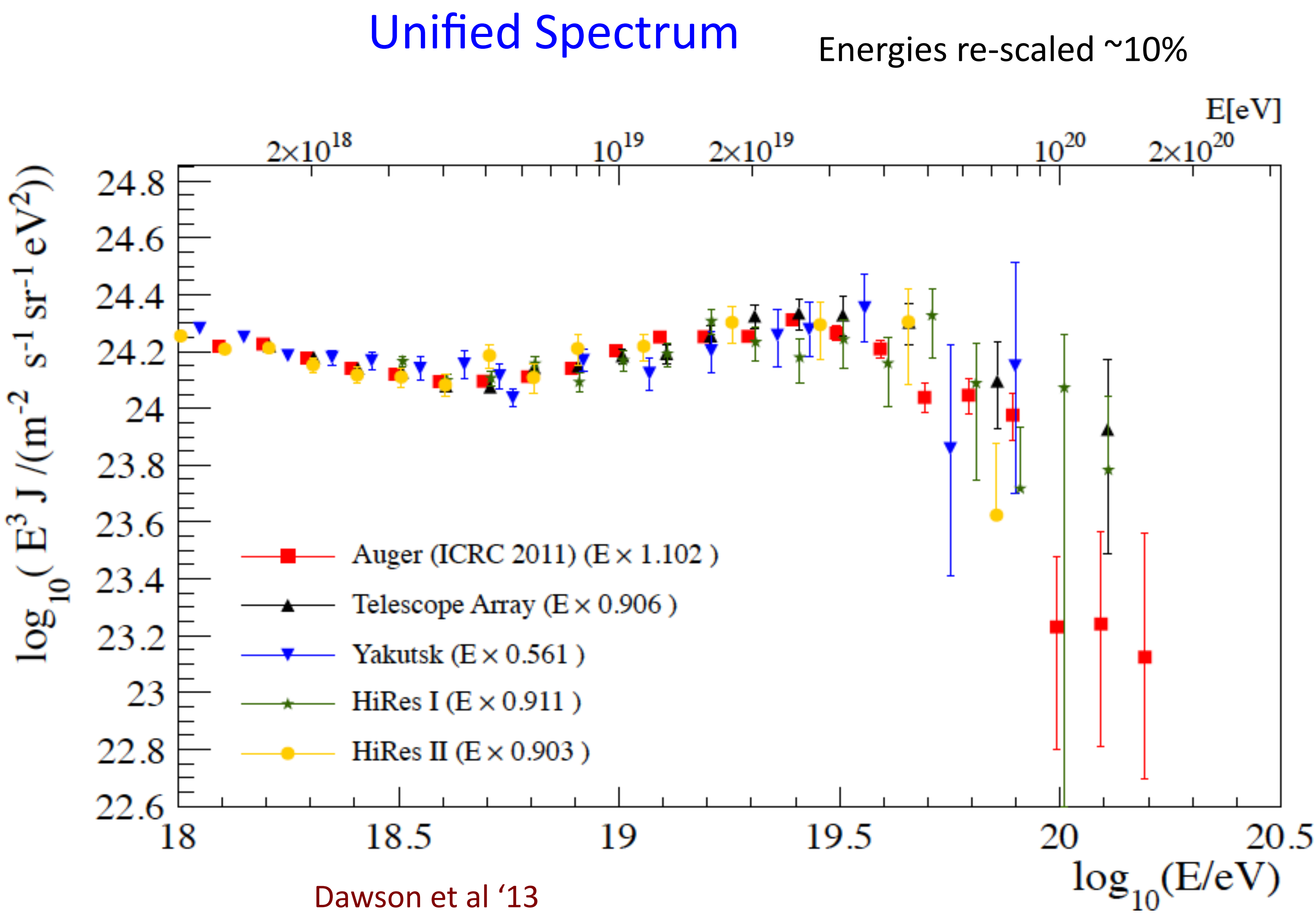
Angela V. Olinto
The University of Chicago


Equal coverage north-south for anisotropies: TAx4
Composition and particle interactions: Auger muon upgrade
Explore potential exposure from space: JEM-EUSO
JEM-EUSO
tilt
JEM-EUSO
nadir
TAx4
Auger+TA
TA
Auger
HiRes
AGASA
Fly's Eye
1.E+6
1.E+5
1.E+4
1.E+3
1.E+2
Exposures (L=km^2*sr*yr)
1990
1995
2000
2005
2010
2015
2020
2025
Year

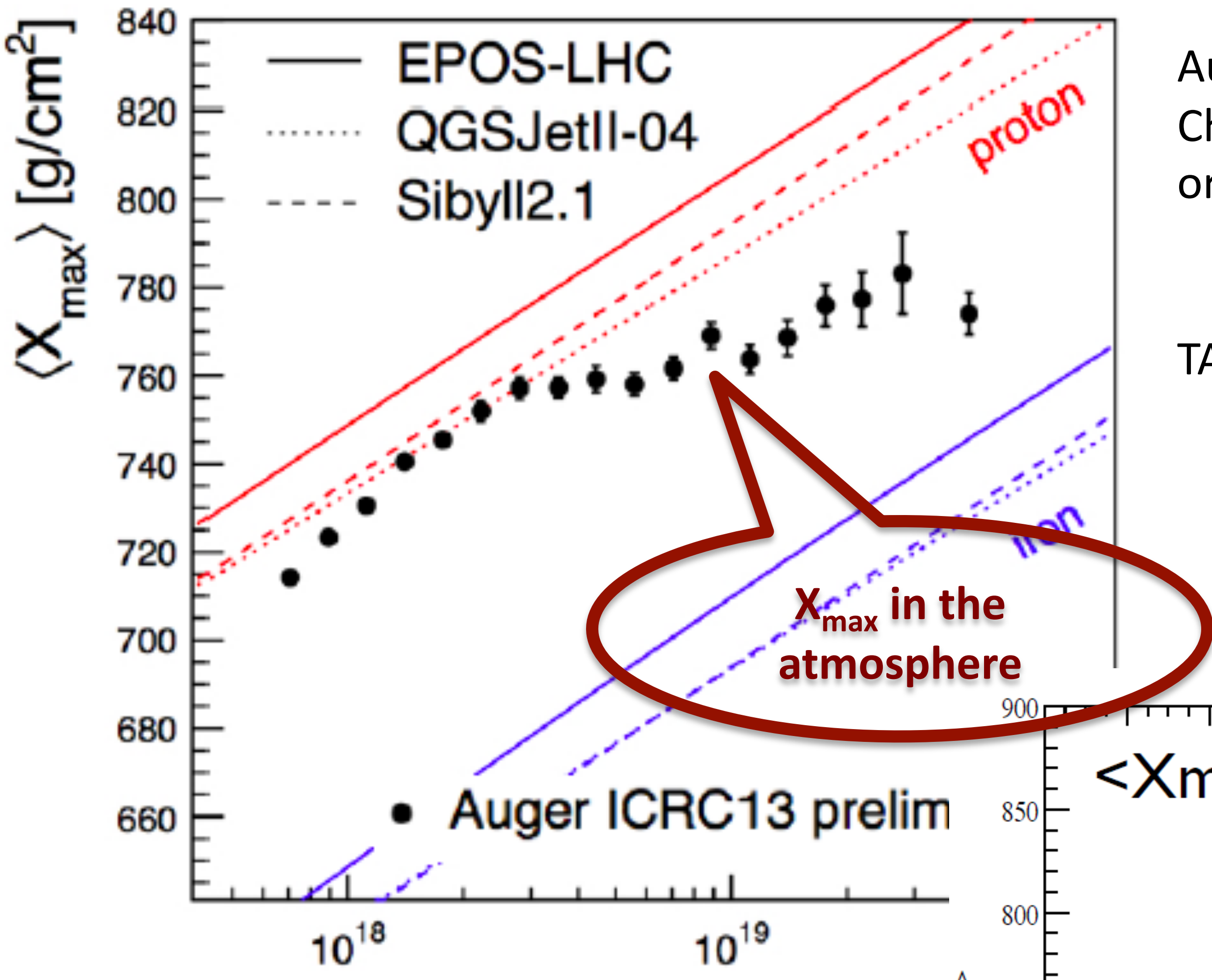


Equivalent c.m. energy $\sqrt{s}_{pp}$ (GeV)
10^2
10^3
10^4
10^5
10^6
RHIC (p-p)
HERA (γ-p)
Tevatron (p-p)
7 TeV 14 TeV
LHC (p-p)
HiRes-MIA
HiRes I
HiRes II
Auger ICRC 2013
TA SD 2013
knee
ankle
500 TeV
10^{20} eV
Scaled flux $E^{2.5}$ J(E) (m^{-2} s^{-1} sr^{-1} $eV^{1.5}$)
ATIC
PROTON
RUNJOB
KASCADE (QGSJET 01)
KASCADE (SIBYLL 2.1)
KASCADE-Grande 2012
Tibet ASg (SIBYLL 2.1)
Energy (eV/particle)

2012 CERN Working Group

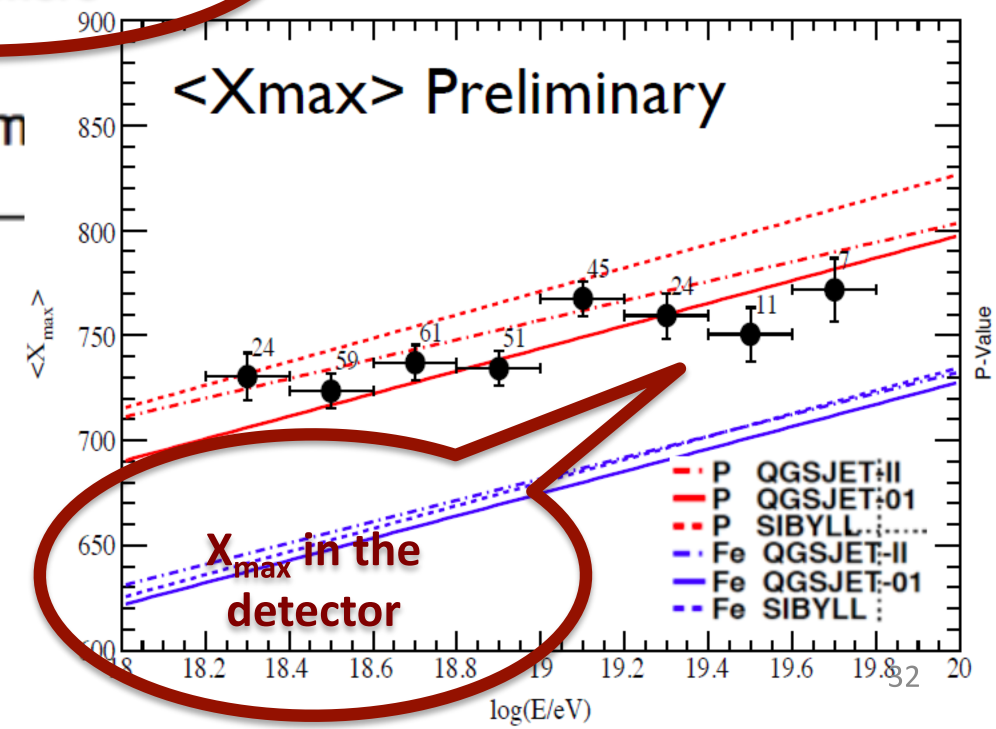


Dawson et al ‘13



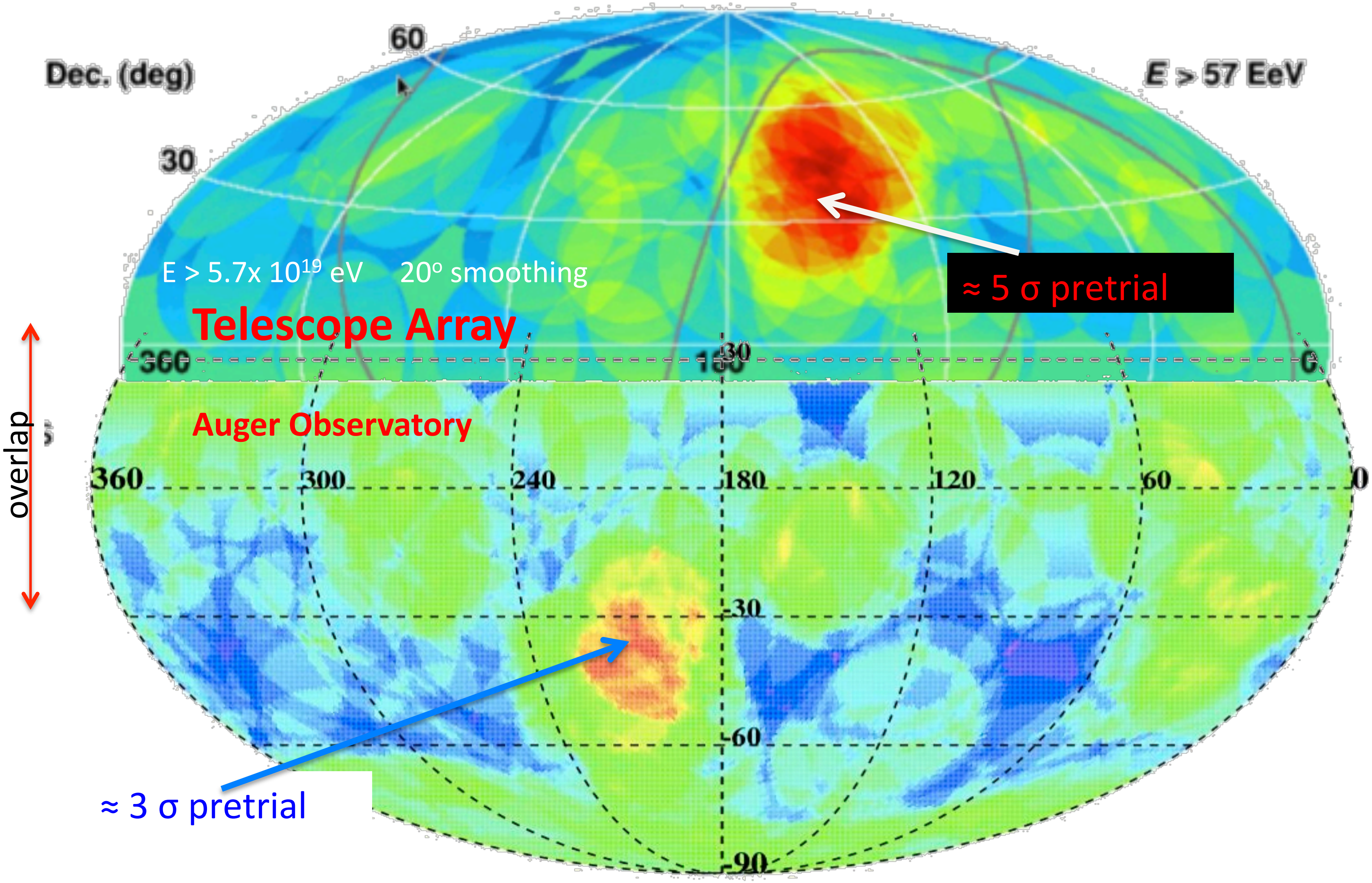
Auger sees change slope:
Change in Composition
or interactions

TA: does not confirm

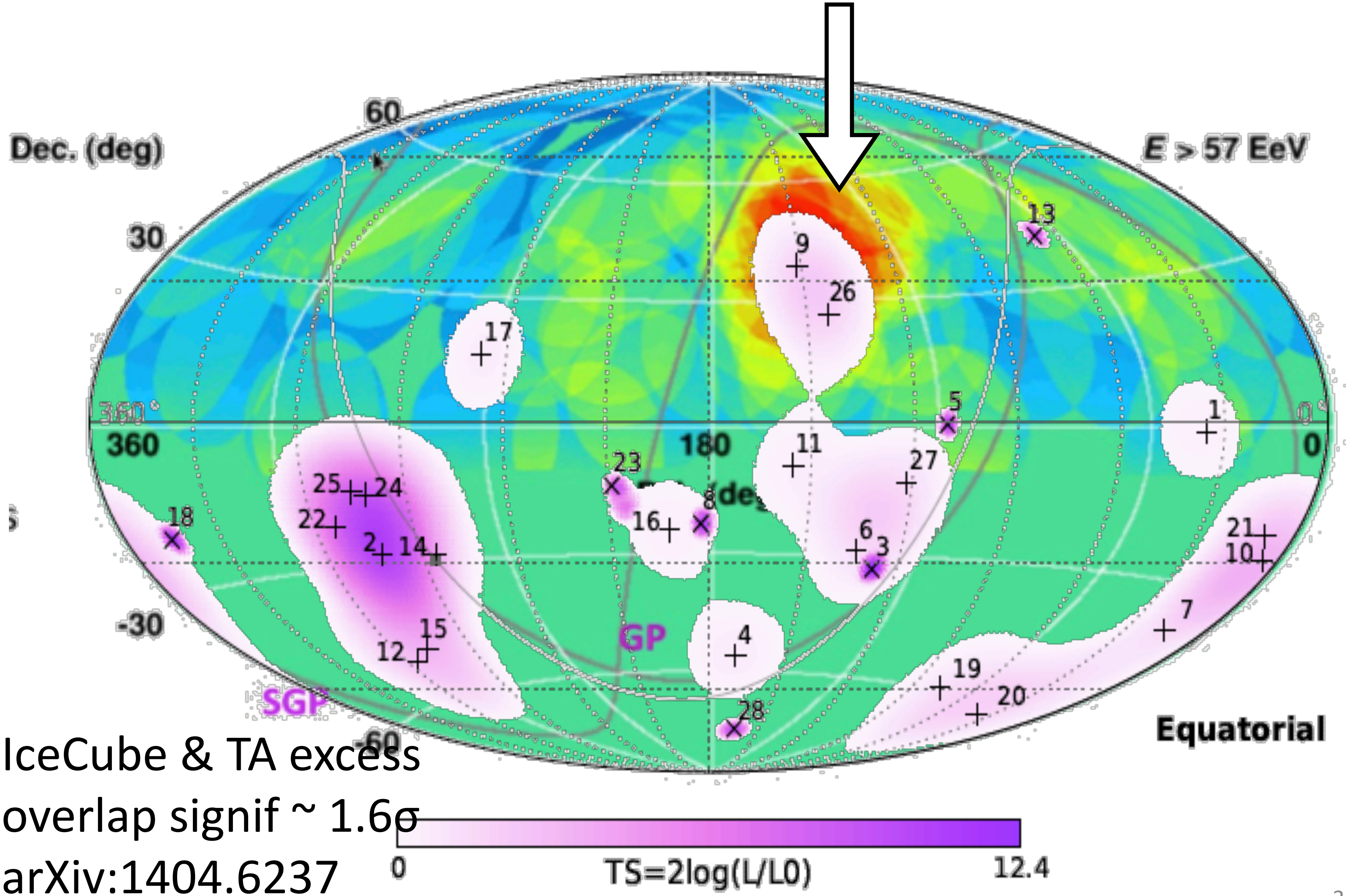


Anisotropy Hints > 60 EeV

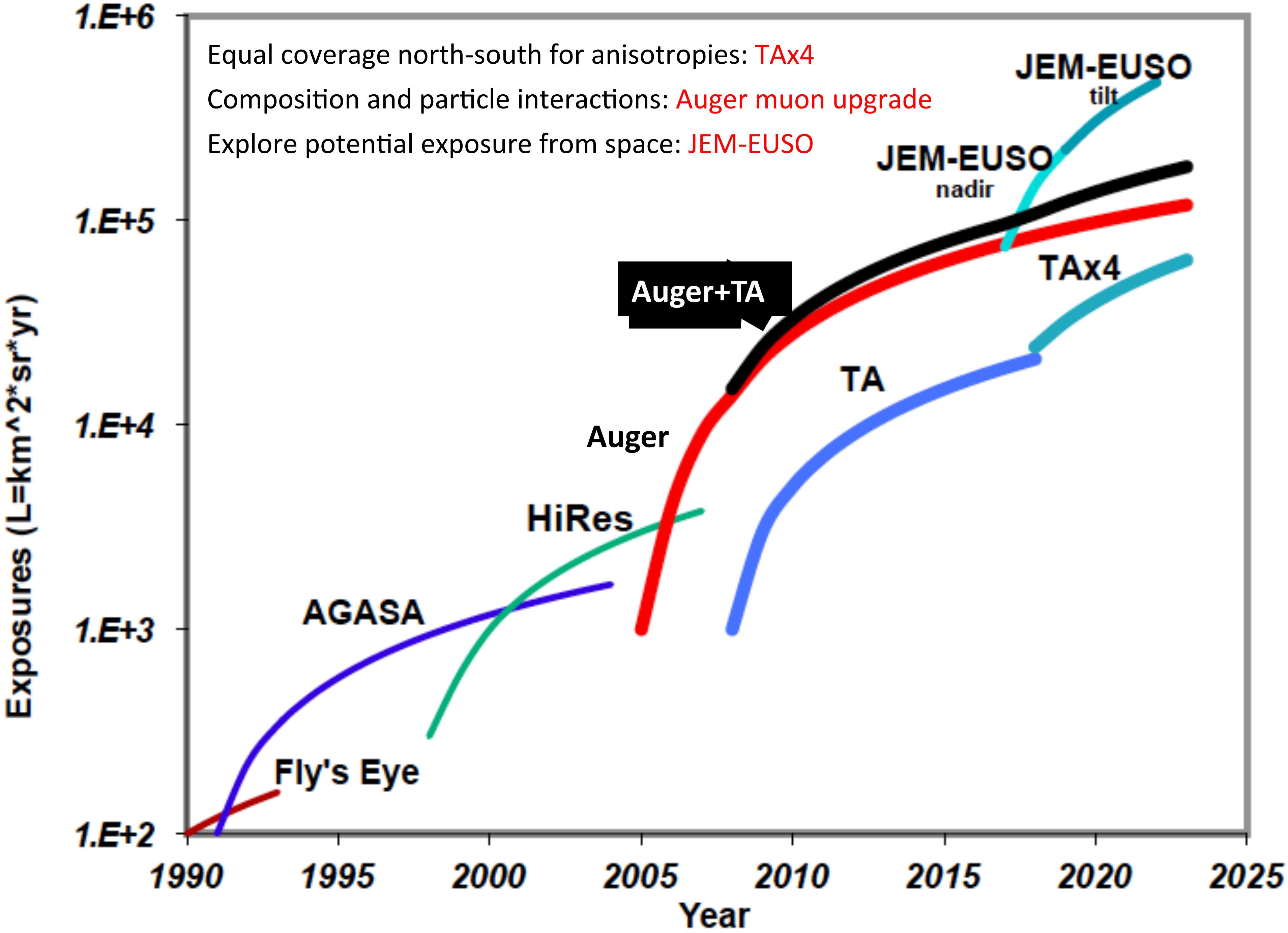
arxiv.1404.5890



Neutrino & UHECR Coincidence



IceCube & TA excess
overlap signif ~ 1.6σ
arXiv:1404.6237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Exposures (L=km^2*sr*yr)
1.E+6
1.E+5
1.E+4
1.E+3
1.E+2
1990
1995
2000
2005
2010
2015
2020
2025
Year

Summary:

- Auger & TA: joint analysis for full sky coverage and resolution of composition differences.
- TA hotspot + Auger Anisotropy hints >57 EeV

imply Sources of UHECRs to be resolved with:

1. Significant increase in exposure at the highest energies (best from Space)
2. Increasing exposure on North 4xTA
2. R&D on improving photo detection (e.g., SiPM) and upgrading muon studies in Auger

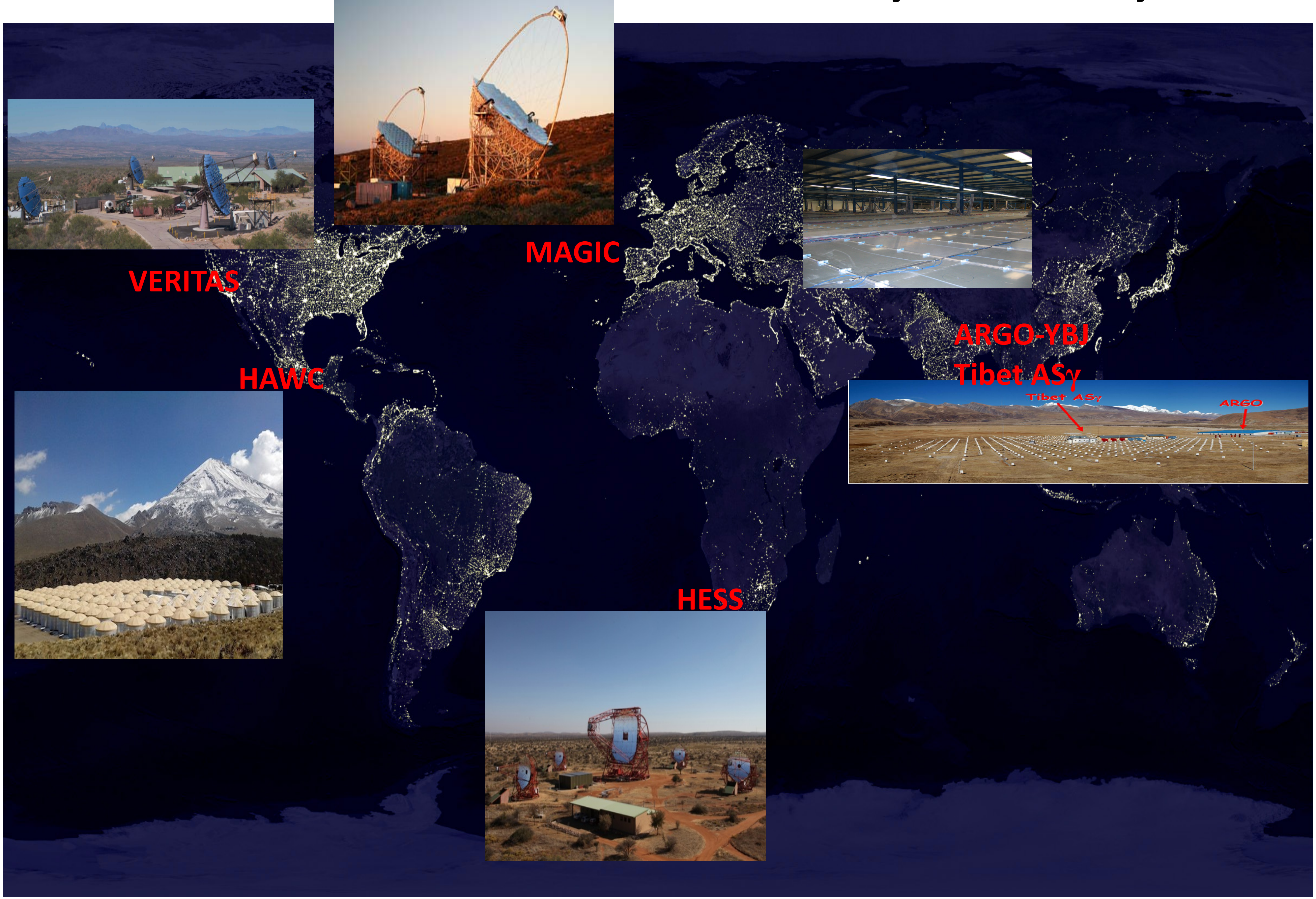
Thanks!

The Highest Energy Gamma Sky

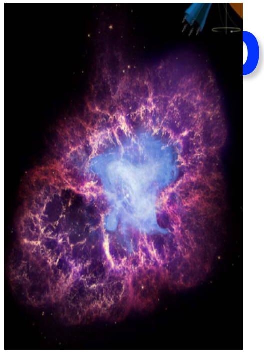
Zhen Cao
IHEP, China, Beijing

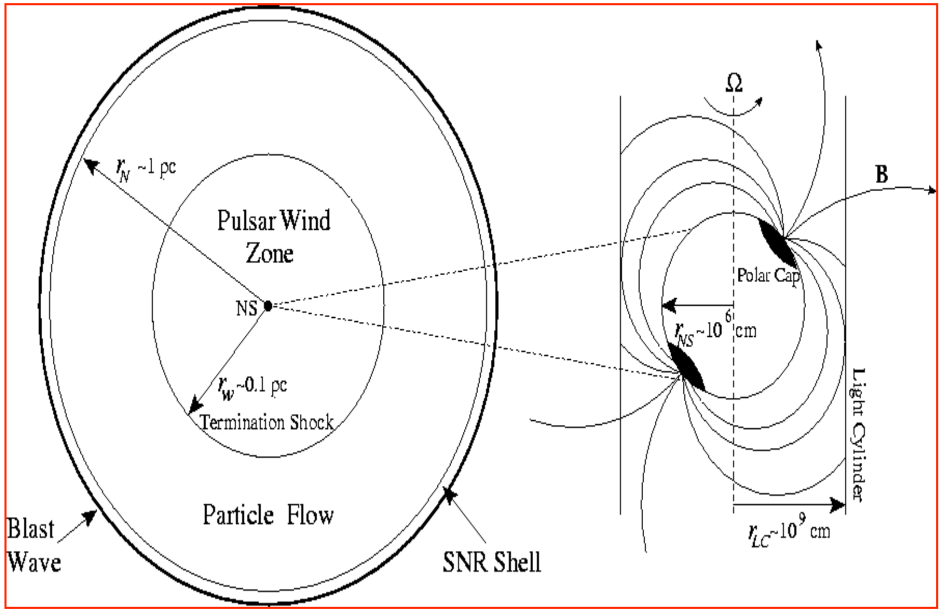
1st APPIC Meeting at APC, Paris, May, 2014

1. Global Instruments of VHE Gamma Ray Astronomy

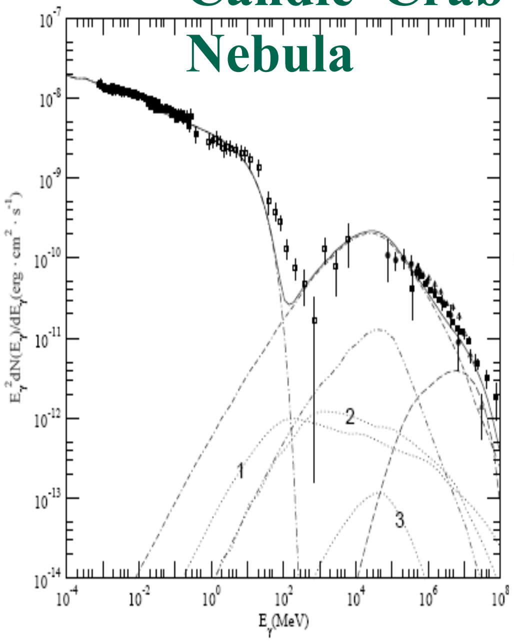


34 Pulsar Wind bula

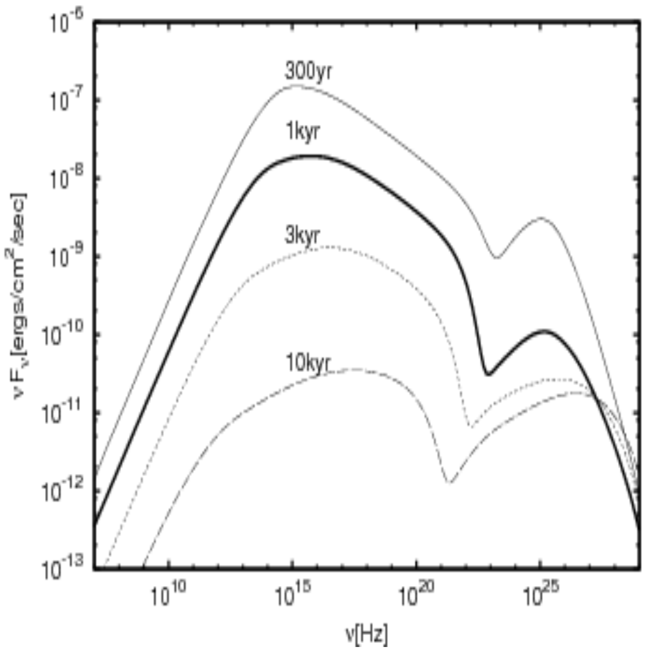




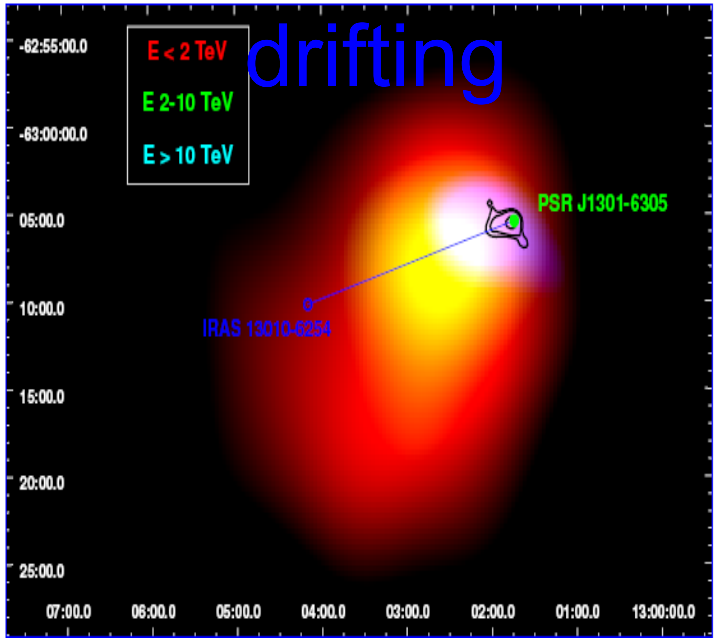
Standard Candle Crab Nebula



Evolutio



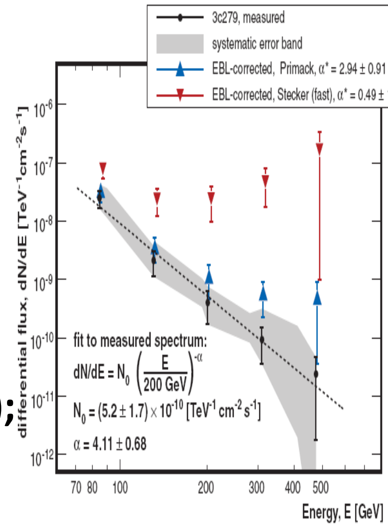
Spatial drifting



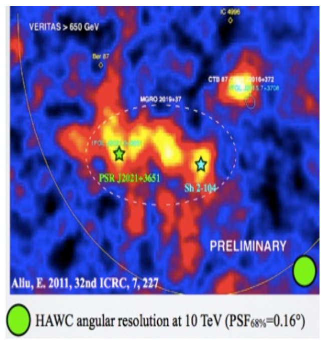
A&A 548, A46 (2012)

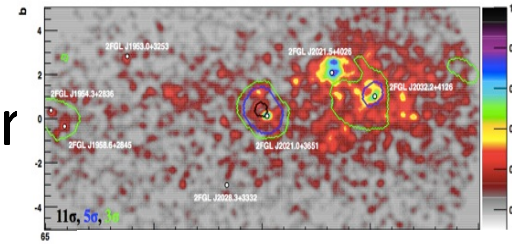
Summary of the status

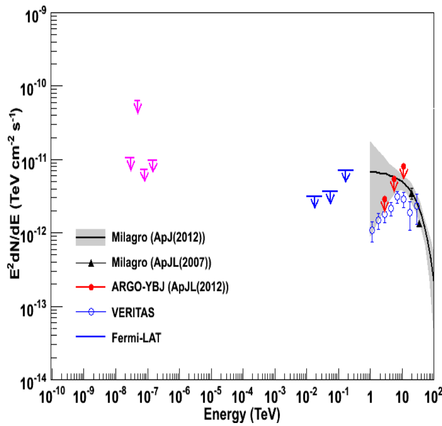
- The most fascinating discoveries in TeV gamma ray astronomy
  - RXJ 1713: a possible hadronic source
  - Fast transient AGNs: PKS 2155-304,Mrk501,…
  - Very remote Quasar: 3C279 (z=0.5362)
  - Very hard spectrum of very extended sour Cygnus region
  - Cygnus Cocoon
  - ….



3C279
Science **320, 1752 (2008); MAGIC**







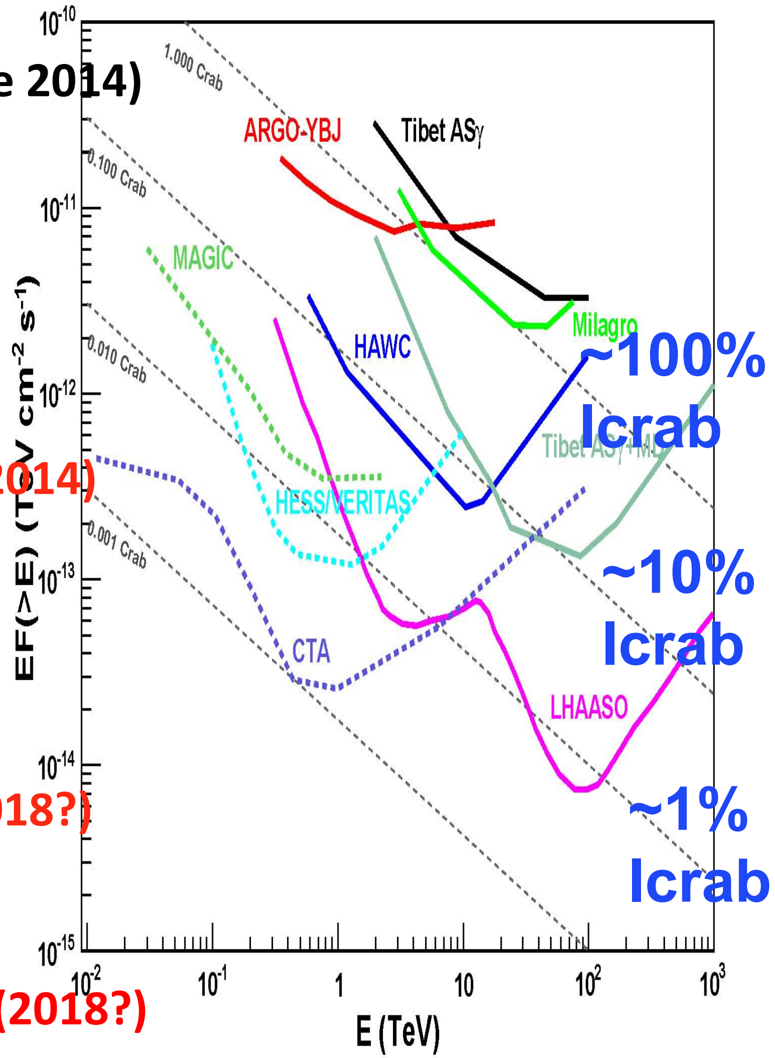
outlook

1 yr for Ω ~ 2 sr

- Past EAS arrays (before 2014)
  Tibet ASr: 1990-2008
  Milagro: 1999-2008
  ARGO-YBJ: 2006-2013
  50~200% Icrab

- Currrent EAS arrays (~2014)
  Tibet ASr+MD,
  HAWC
  ~10% Icrab

- Future EAS arrays (~2018?)
  LHAASO
  ~1% Icrab, 0.3~1000 TeV
  HiSCORE (2016) / TAIGA(2018?)



50 hrs for single source

- Past IACT arrays (before 2014)
  few percent of Icrab

- Current IACT arrays (~2014)
  HESS (I + II)
  MAGIC (I + II)
  VERITAS (upgraded)
  ~1% Icrab

- Future IACT arrays (~2018?)
  CTA
  ~0.1% Icrab, 10GeV~10 TeV

High and ultra high energy astronomy

- Gamma ray astronomy paves the way: reference map of the high energy sky
- Strong evidence for extraterrestrial TeV to PeV neutrinos. Origin unknown.
- Cut-off of the cosmic ray high energy spectrum seen: composition near the cut-off debated. Origin unknown.
- Gravitational waves will enter the game soon and open new questions (this is already the case with BICEP2)

Conclusions in high and ultrahigh energy astronomy

- Many recent achievements and open questions
- Huge discovery potential
- Multi messenger approach crucial, including gravitational waves and conventional astronomy (open data policy, virtual observatories including these new messengers will help)
- We could also trigger a discussion on this subject in TAUP 2015, looking at the global coherence and at priorities

Plans for next meeting

- Coherence and priorities in high and ultrahigh energy astronomy (follow-up of this meeting)
- Cosmology, dark matter and dark energy: review, coherence and priorities