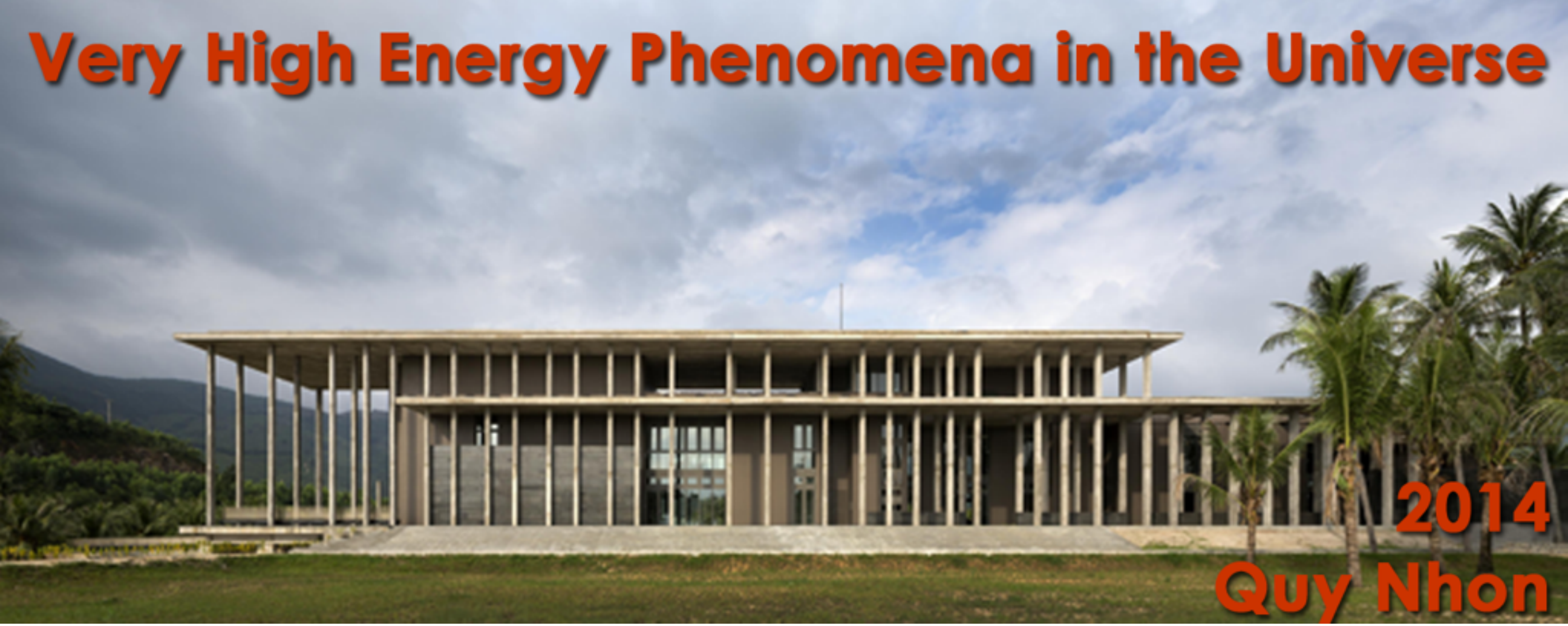


VHEPU Summary

Luke Drury

Preliminaries

- Will follow broad themes of programme; CR, GRA, GRB, Neutrinos, DM, MM.
- Usual caveats and apologies apply:
  - Impossible to cover everything.
  - Views are personal and fallible!
- Key take home messages - exciting times for VHEPU with much promise and some surprises; still many open questions; and a great meeting in a great setting!

Cosmic Rays

- Now know for over a century - one of the few remaining "unsolved" questions in physics that are that old!
- Significant progress in last few years:
  - Definitive proof of proton and electron acceleration in SNRs, but not quite to the energies or spectra expected.
  - `Second order' effects in spectra <1PeV
  - Clearer view of the UHECR sky and spectra from Auger and TA - no GZK problem and hints at source distribution.
  - Hints at high energy composition from modern EAS observations (Kaskade, Auger, TA etc) and interaction models (LHC ground truth helps a lot!).

But many issues remain…

- Where (or when) are the Pevatrons?
- How do the particles escape the accelerator?
- Nature of Galactic propagation - how important are convection and re-acceleration?
- Where is the Galactic/Extragalactic transition?
- How to interpret directional signals at high energies?
- Uncertainties in the HE interaction models (rapidly improving situation?).

COSMIC RAYS FROM SUPER-NOVAE

By W. Baade and F. Zwicky

Mount Wilson Observatory, Carnegie Institution of Washington, and California Institute of Technology, Pasadena

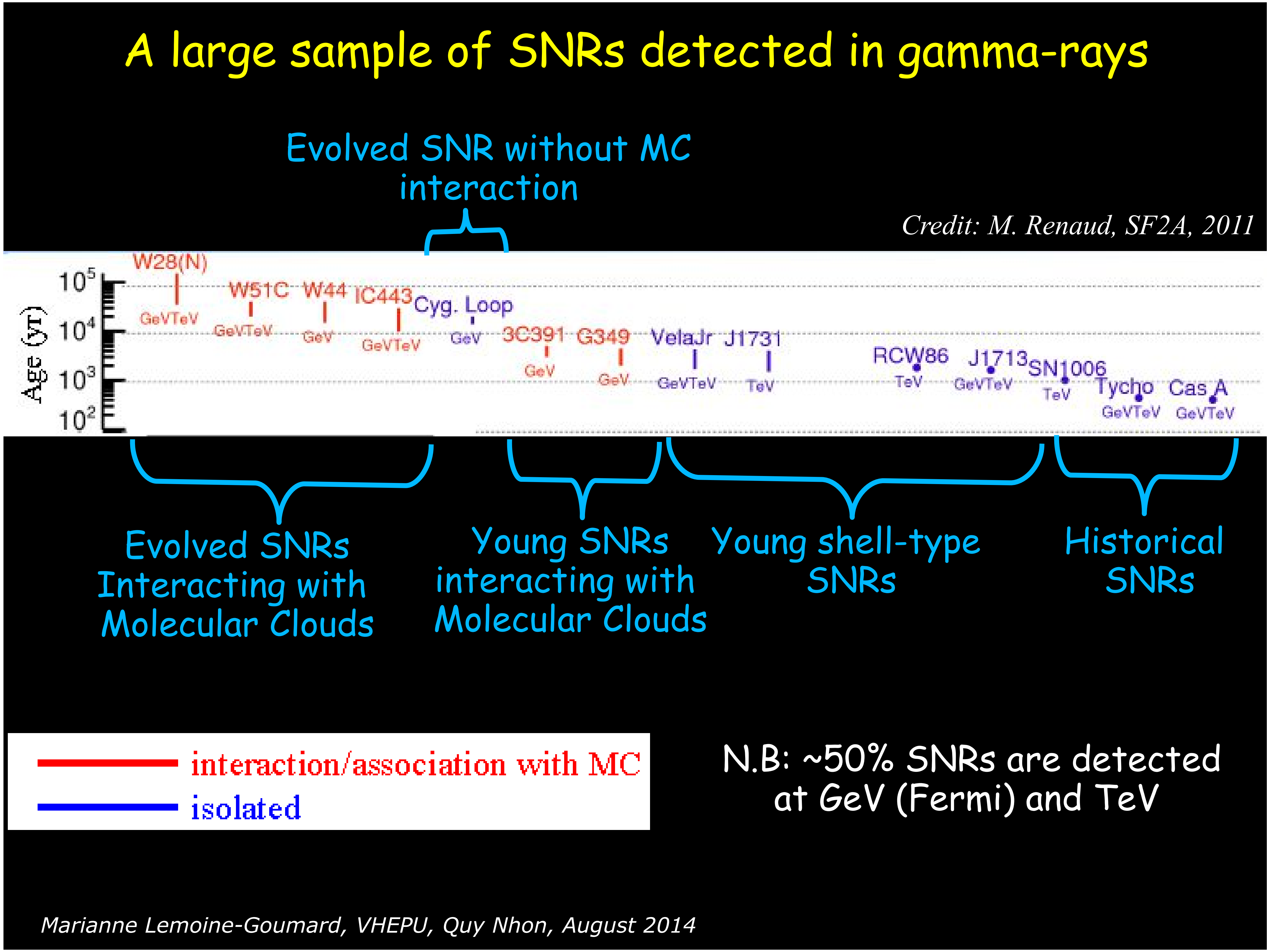
Communicated March 19, 1934

D. Conclusions.—From the data available on super-novae we conclude

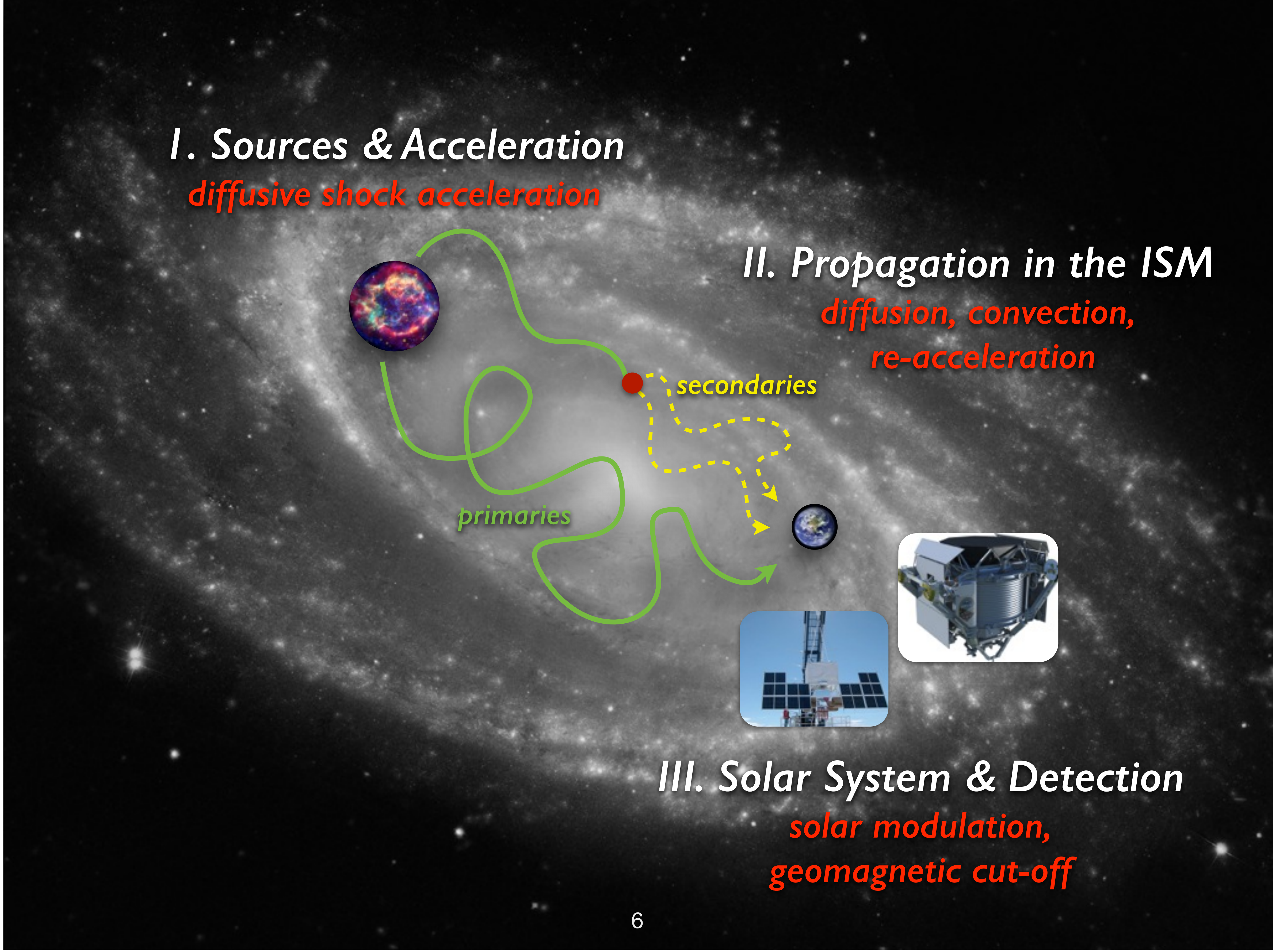
(1) Mass may be *annihilated* in bulk. By this we mean that an assembly of atoms whose total mass is M may lose in the form of electromagnetic radiation and kinetic energy an amount of energy E_T which probably cannot be accounted for by the liberation of known nuclear packing fractions. Several interpretations of this result are possible and will be published in another place.

(2) The hypothesis that *super-novae emit cosmic rays* leads to a very satisfactory agreement with some of the major observations on cosmic rays.

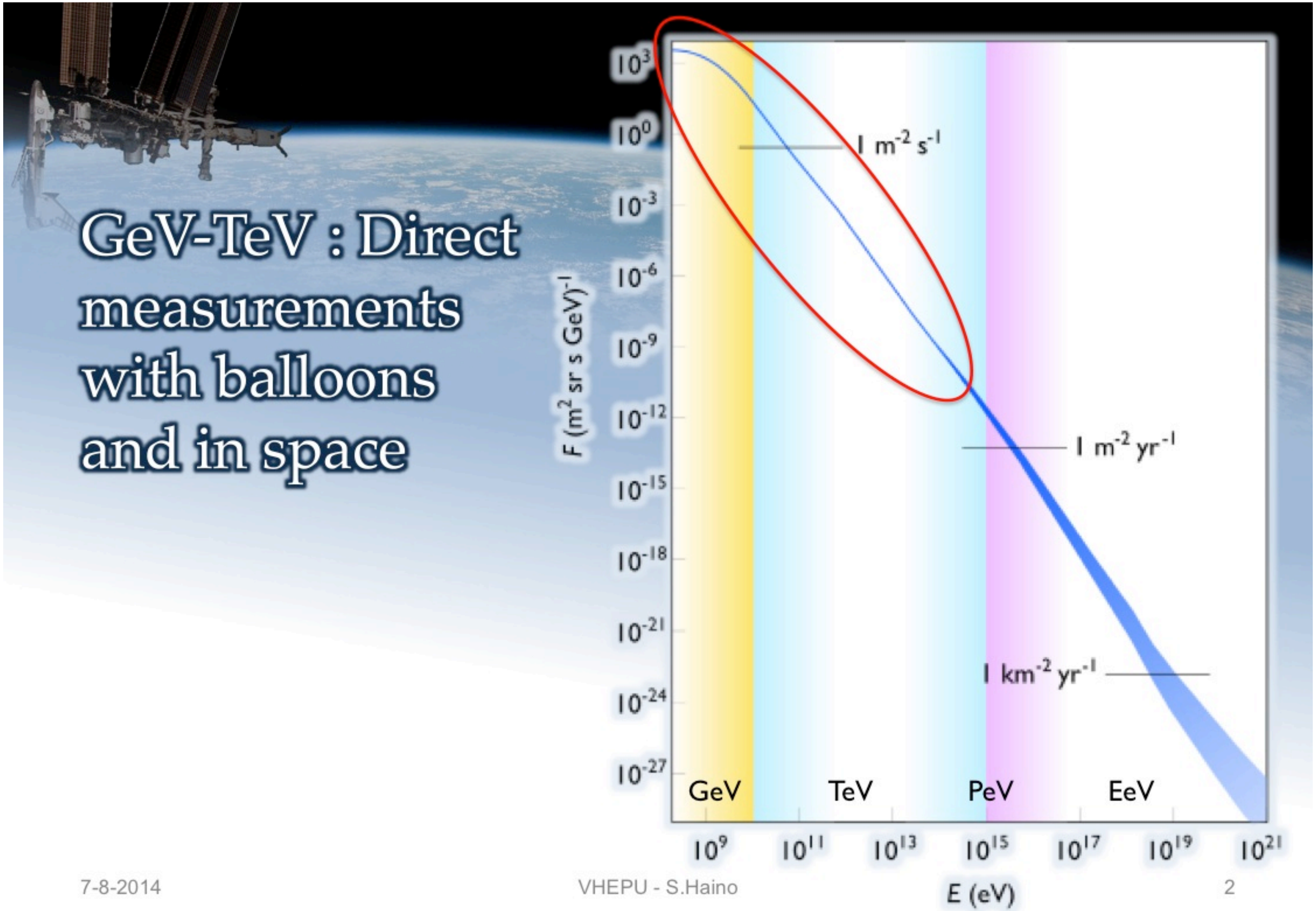
Our two conclusions are essentially independent of each other and should perhaps be judged separately, each on its respective merits.



From Marianne’s talk - confirms SNR link to CRs



A Putze…acceleration, escape, propagation, modulation…

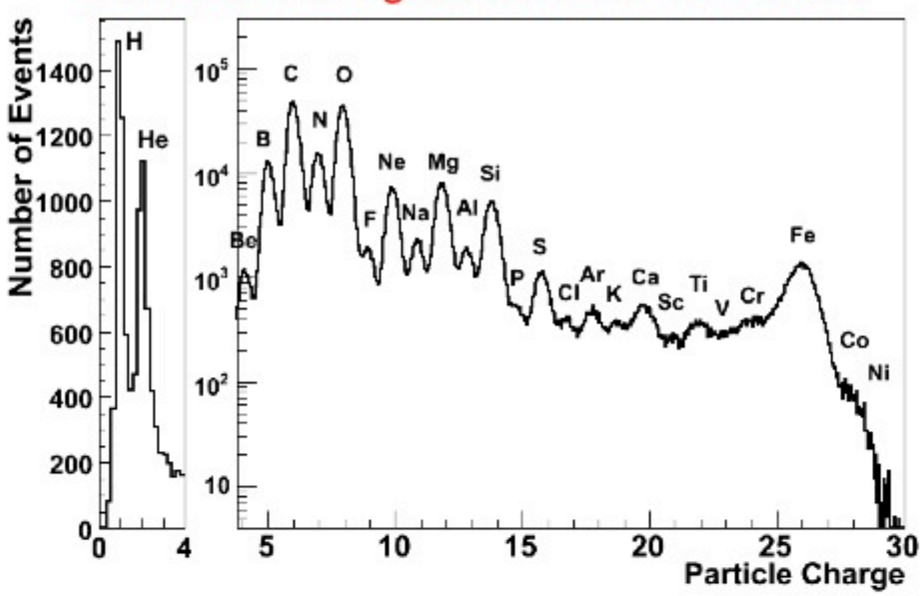


S Haino - relatively easy to measure spectra and composition at low energies

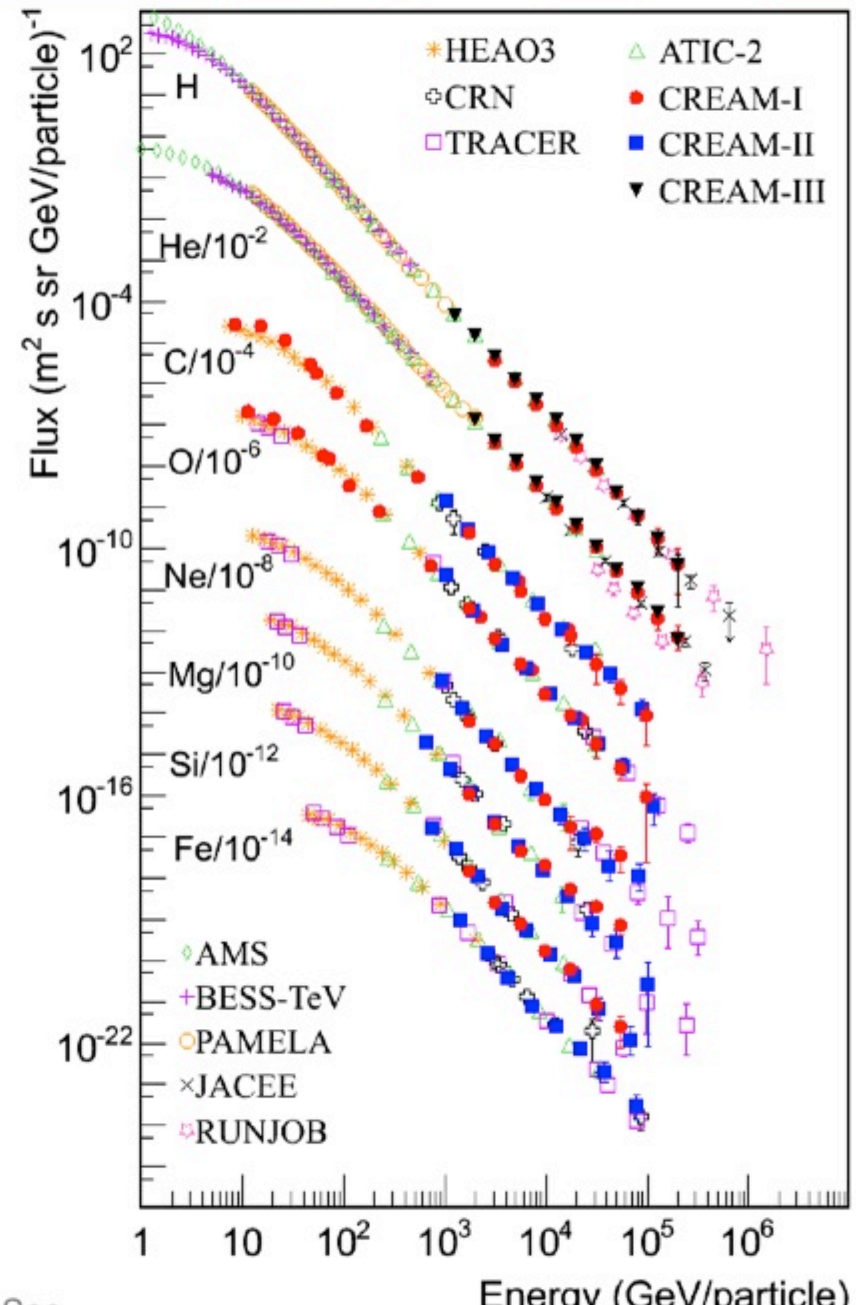
Elemental Spectra over 4 decades in energy

Ahn et al., ApJ **715**, *1400*, 2010; Ahn et al. ApJ **707**, *593*, 2009

Excellent charge resolution from SCD



Distribution of cosmic-ray charge measured with the SCD. The individual elements are clearly identified with excellent charge resolution. The relative abundance in this plot has no physical significance



Aside on spectra < PeV

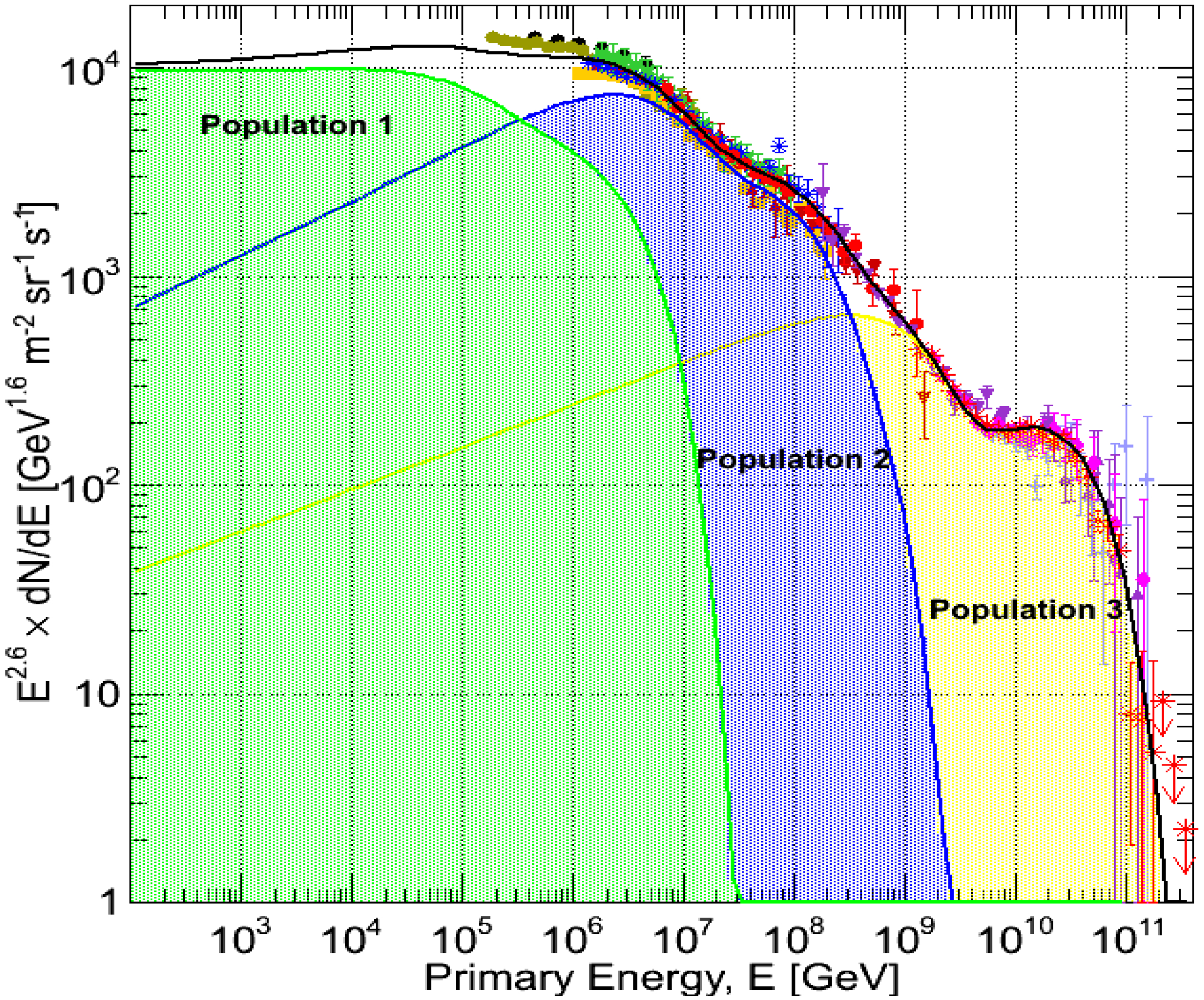
- AMS does not show the `break' at 200GeV seen by Pamela, but may be compatible within systematics.
- However matching CREAM proton spectra to either AMS or Pamela requires a concave bend at about TeV.
- Seems definite that He is harder than H.
- Are we seeing `second order' source effects?

Bridging the PeV-EeV Gap

For SNR (Bell 2013 ICRC Review)

$$E_{\mathrm{max}} = 230 \left(\frac{n_e}{1\ \mathrm{cm}^{-3}}\right)^{1/2} \left(\frac{v_{\mathrm{sh}}}{10^7\ \mathrm{m\ s}^{-1}}\right)^2 \left(\frac{R}{\mathrm{pc}}\right)\ \mathrm{TeV}$$

From Gaisser et al. 2013- astro-ph/1303.3565

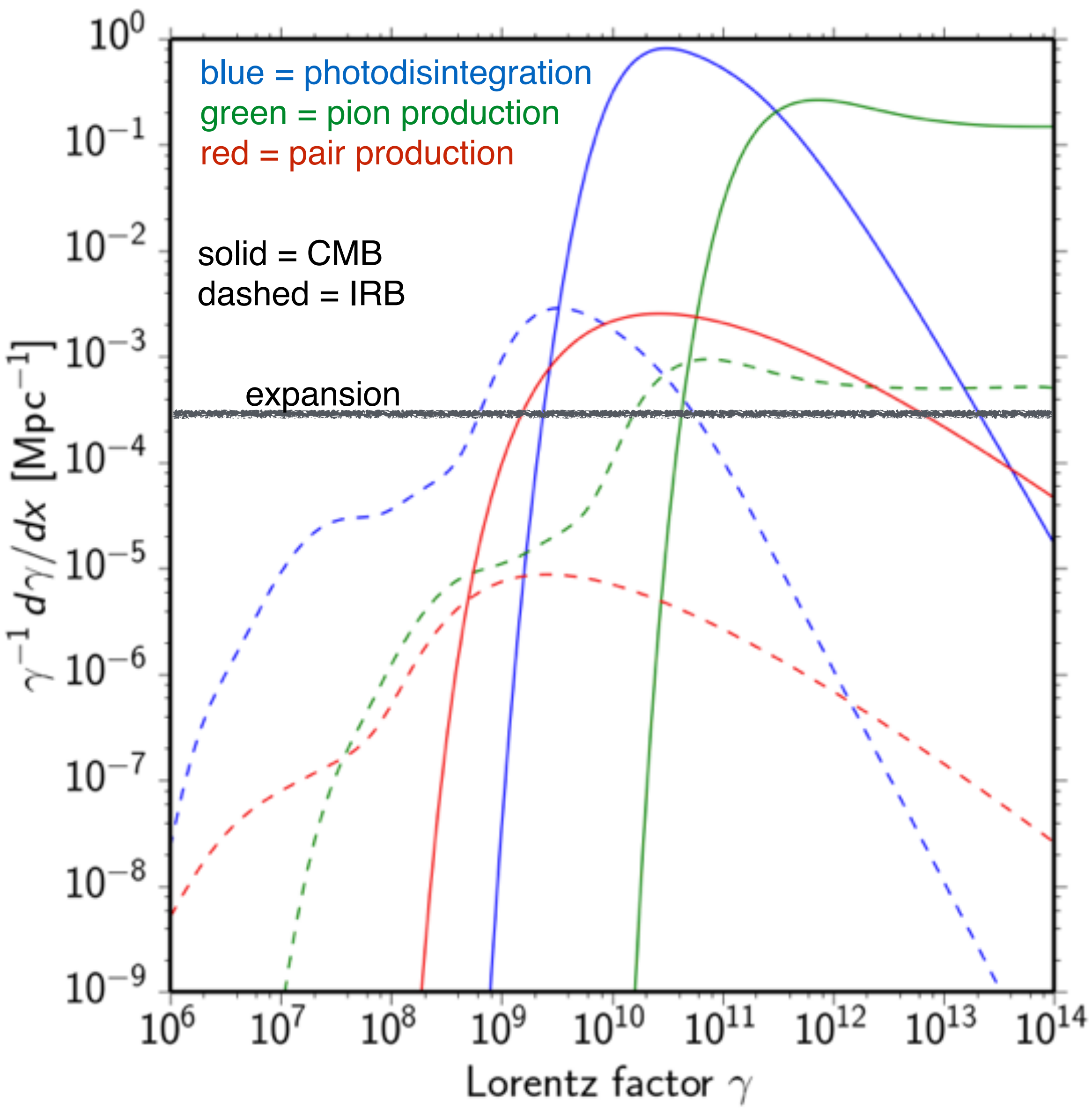


Galactic GeV cosmic rays require a source power output of $\sim 10^{41}$ erg s^{-1}

Naively, source “B” requires a CR proton luminosity of $\sim 10^{39}$ erg s^{-1}

Andrew Taylor

Energy loss rate for Carbon-12

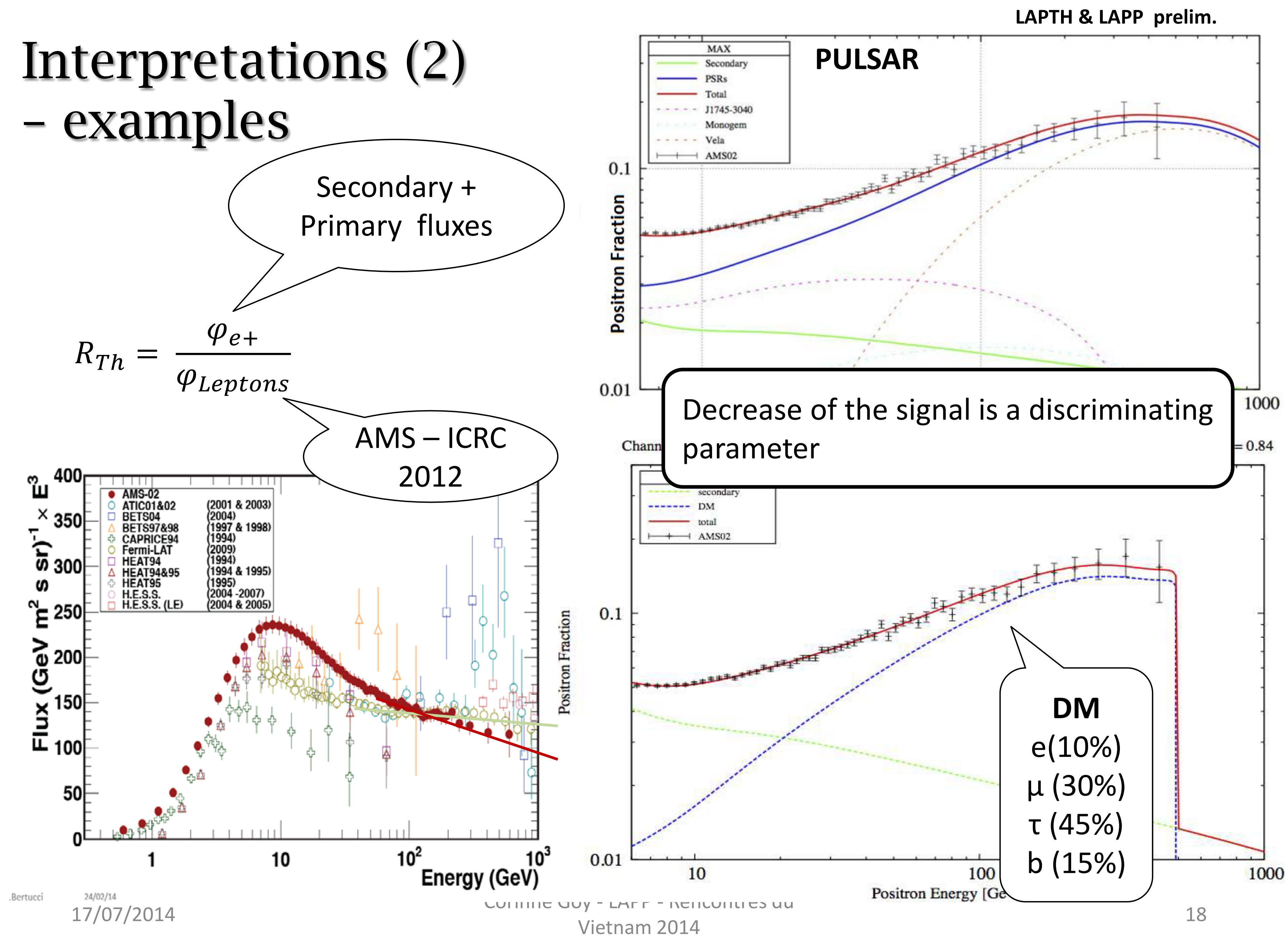


$$E \sim \Gamma\ A\ 10^9\ \mathrm{eV}$$

- **Low energies:**
  energy loss dominated by expansion of the universe
- **Intermediate energies:**
  Most important energy loss is photodisintegration
- **High energies:**
  Pion production on CMB

Daniel Kuempel 10th Rencontres du Vietnam 10

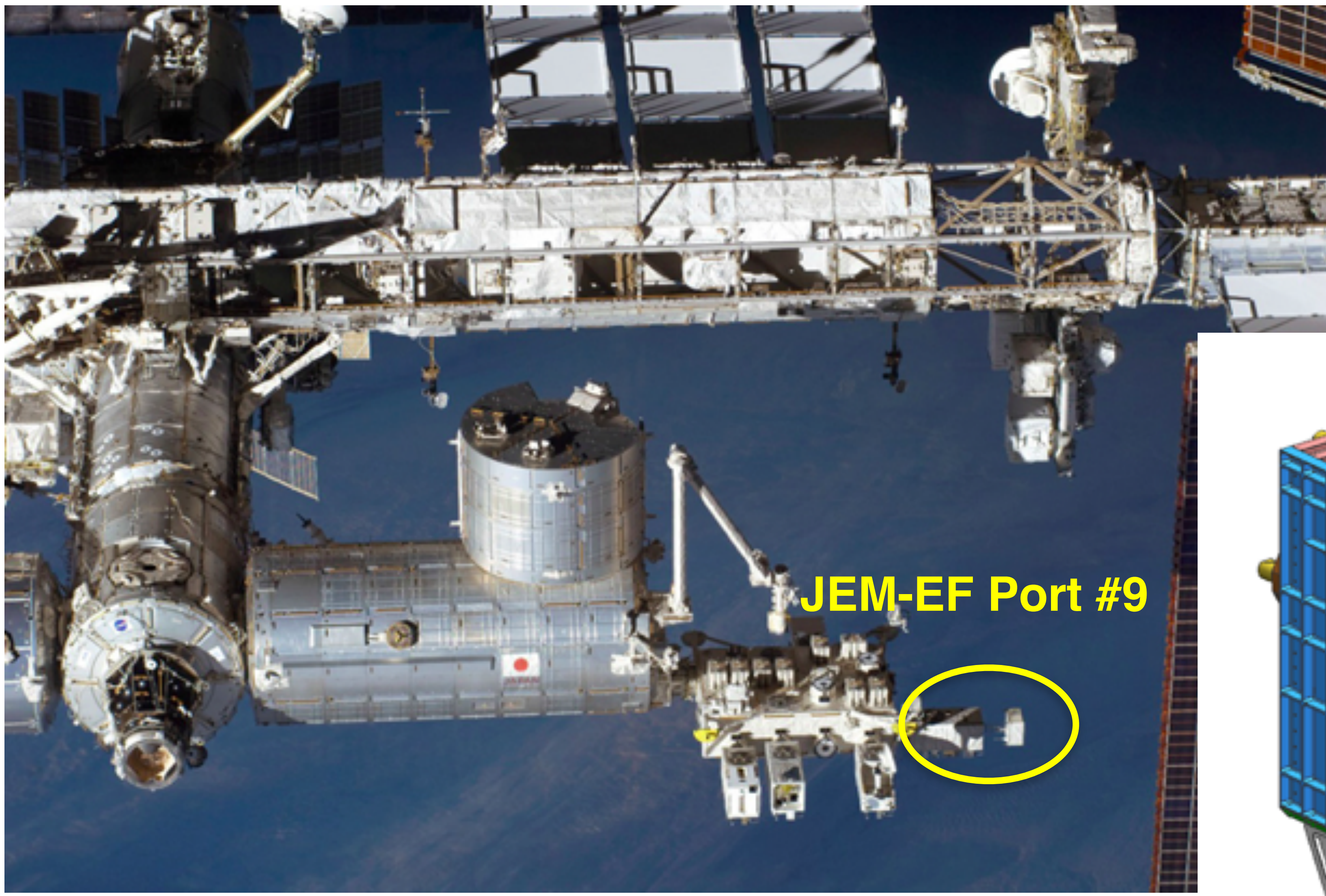
Propagation at UHE energies also complex!



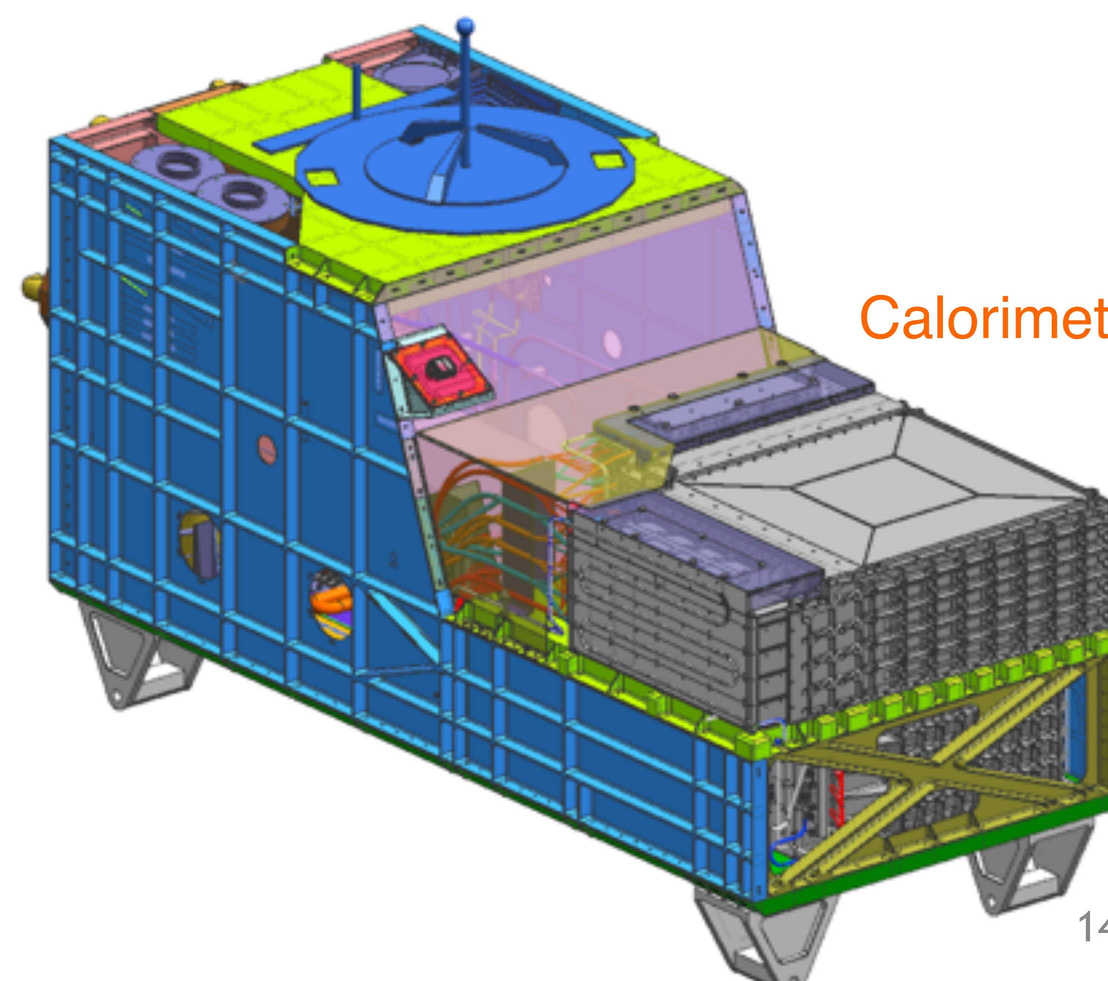
The Pamela positron excess…

CALorimetric Electron Telescope overview

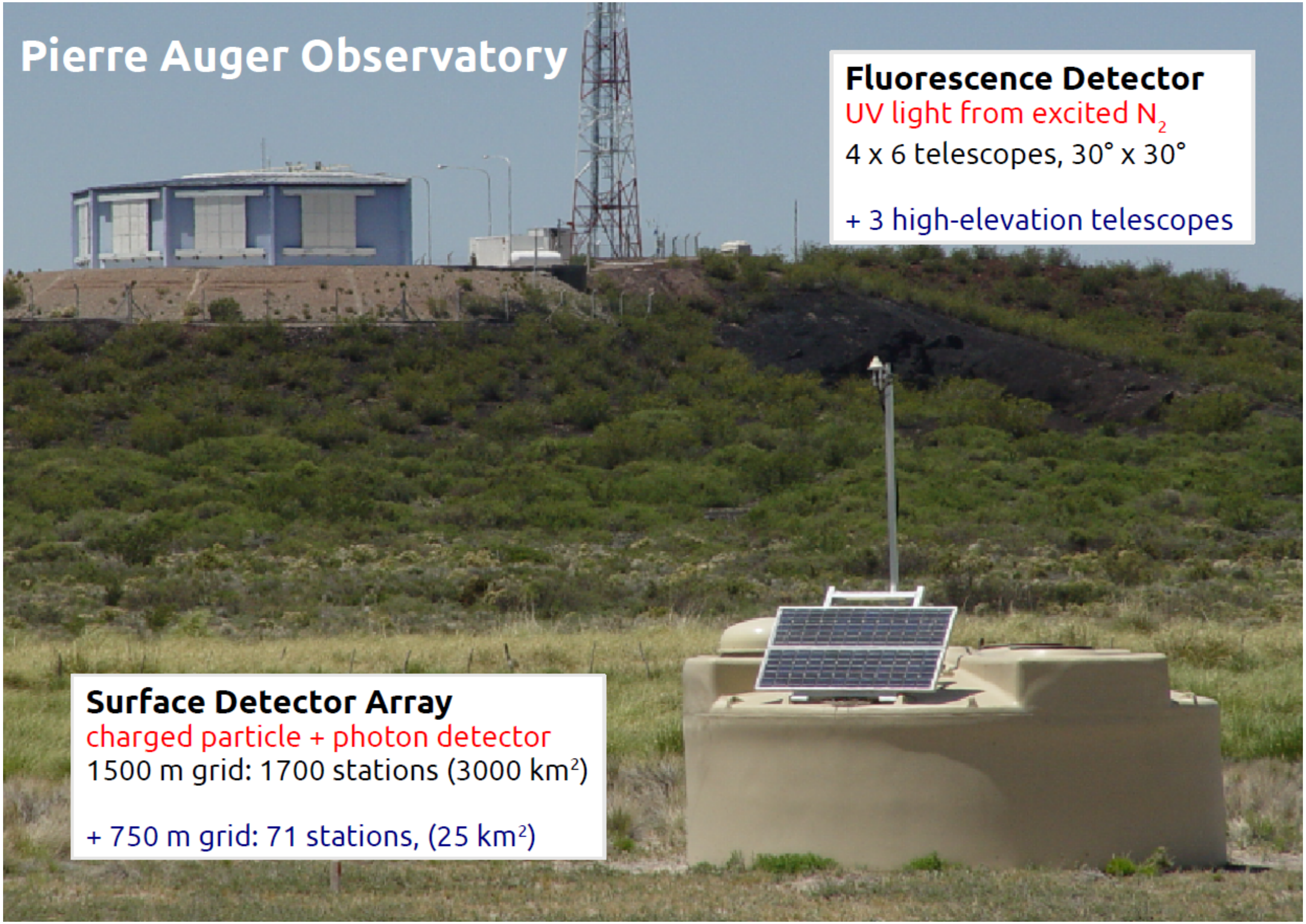
The CALorimetric Electron Telescope, CALET, project is a Japan-led international mission for the International Space Station, ISS, in collaboration with Italy and the United States.



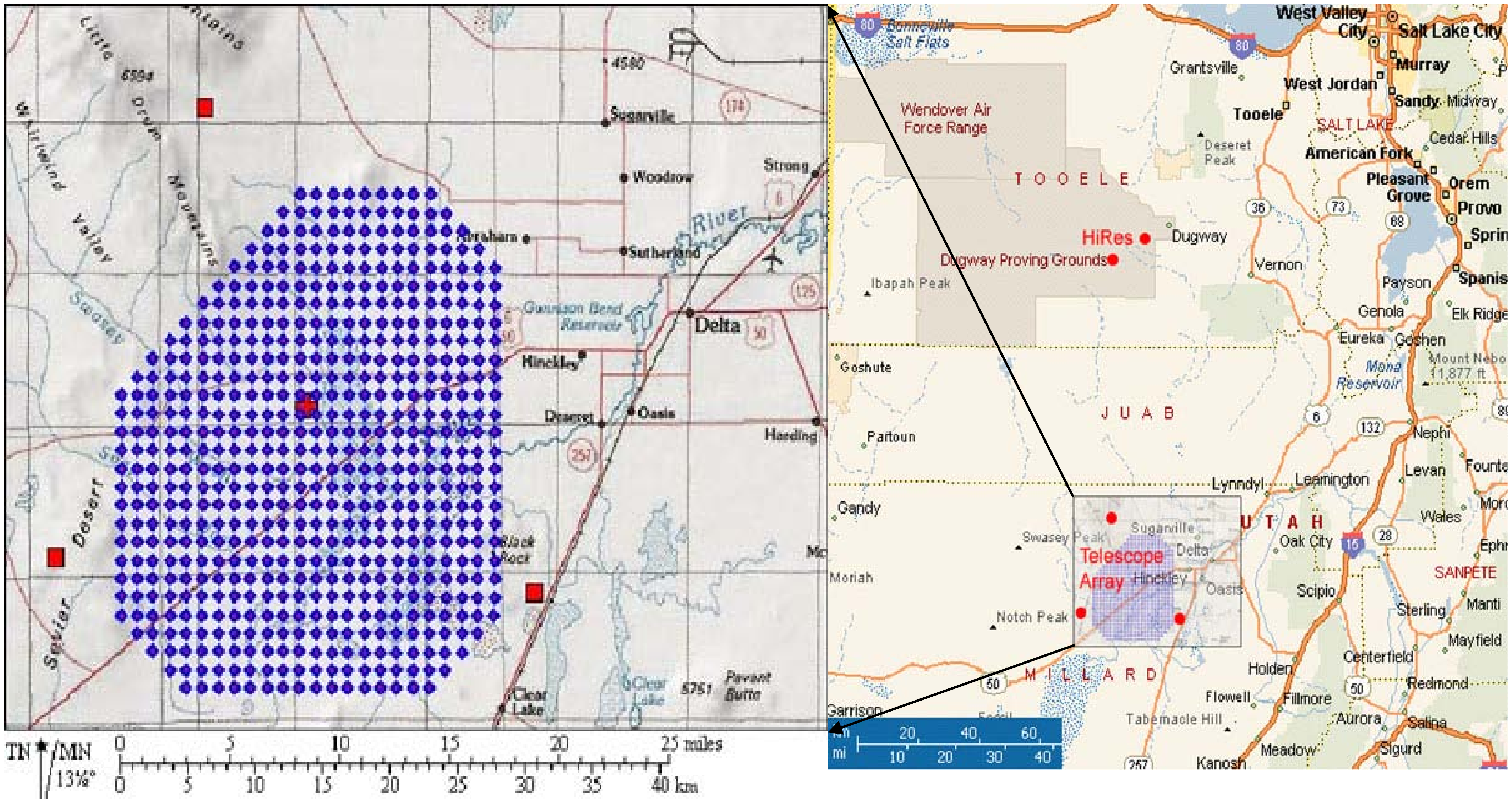
Weight: 650 kg
Mission Life: 5 years
Launch Target: by March, 2015
(Fiscal Year 2014)



The CALET payload will be launched by the Japanese carrier, H-II Transfer Vehicle 5 (HTV5) and robotically attached to the port #9 of the Japanese Experiment Module – Exposed Facility (JEM-EF) on the International Space Station.


Pierre Auger Observatory
Fluorescence Detector
UV light from excited N_2
4 x 6 telescopes, 30° x 30°
+ 3 high-elevation telescopes
Surface Detector Array
charged particle + photon detector
1500 m grid: 1700 stations (3000 km^2)
+ 750 m grid: 71 stations, (25 km^2)

Telescope Array

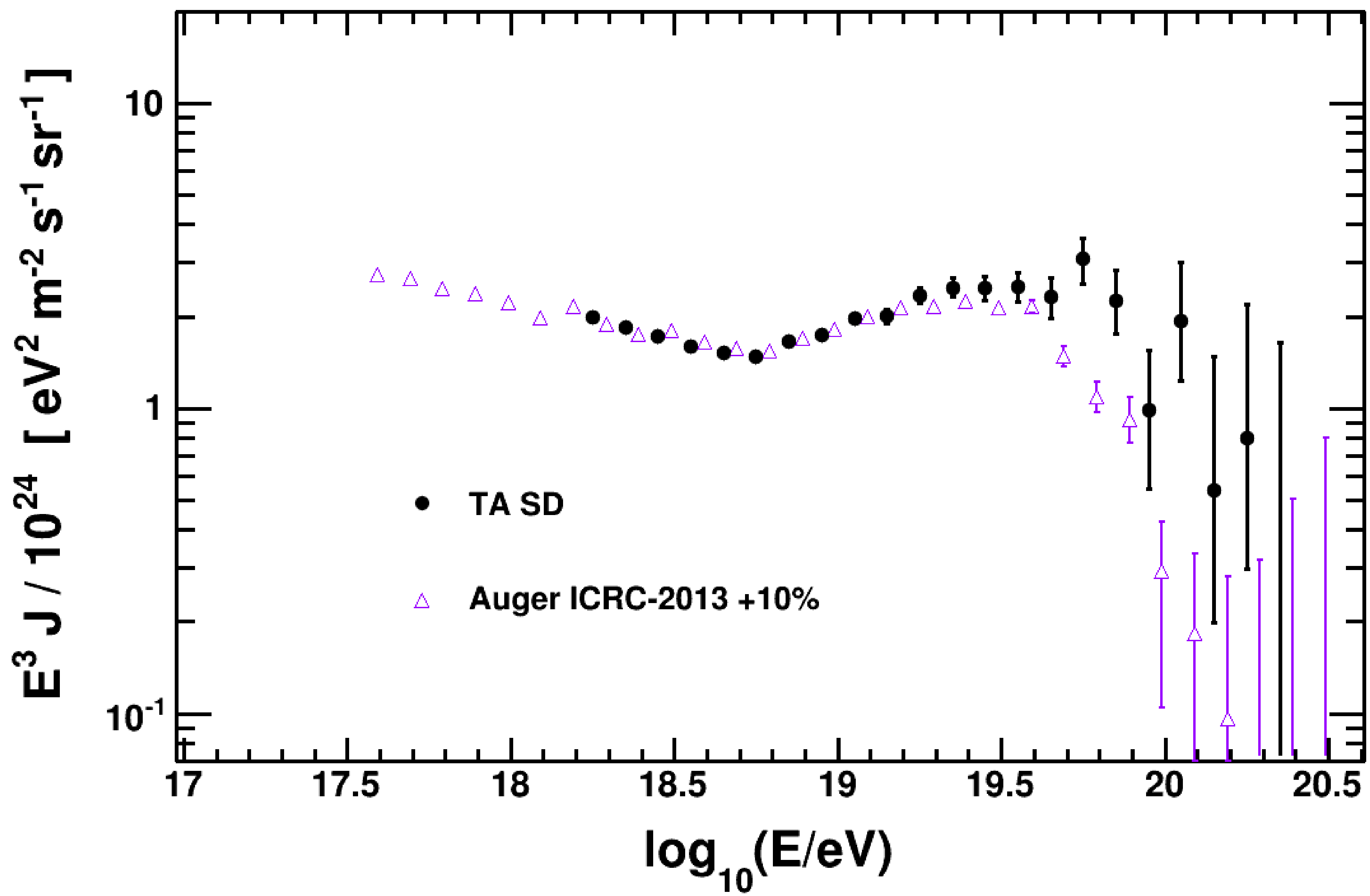


The High Energy component of Telescope Array – 38 fluorescence telescopes (9728 PMTs) at 3 telescope stations overlooking an array of 507 scintillator surface detectors (SD) - complete and operational as of ~1/2008.

CR Spectrum

SD Data (6 Yrs: 20080511-20140511)

Comparison with Auger: ICRC 2013 + 10%



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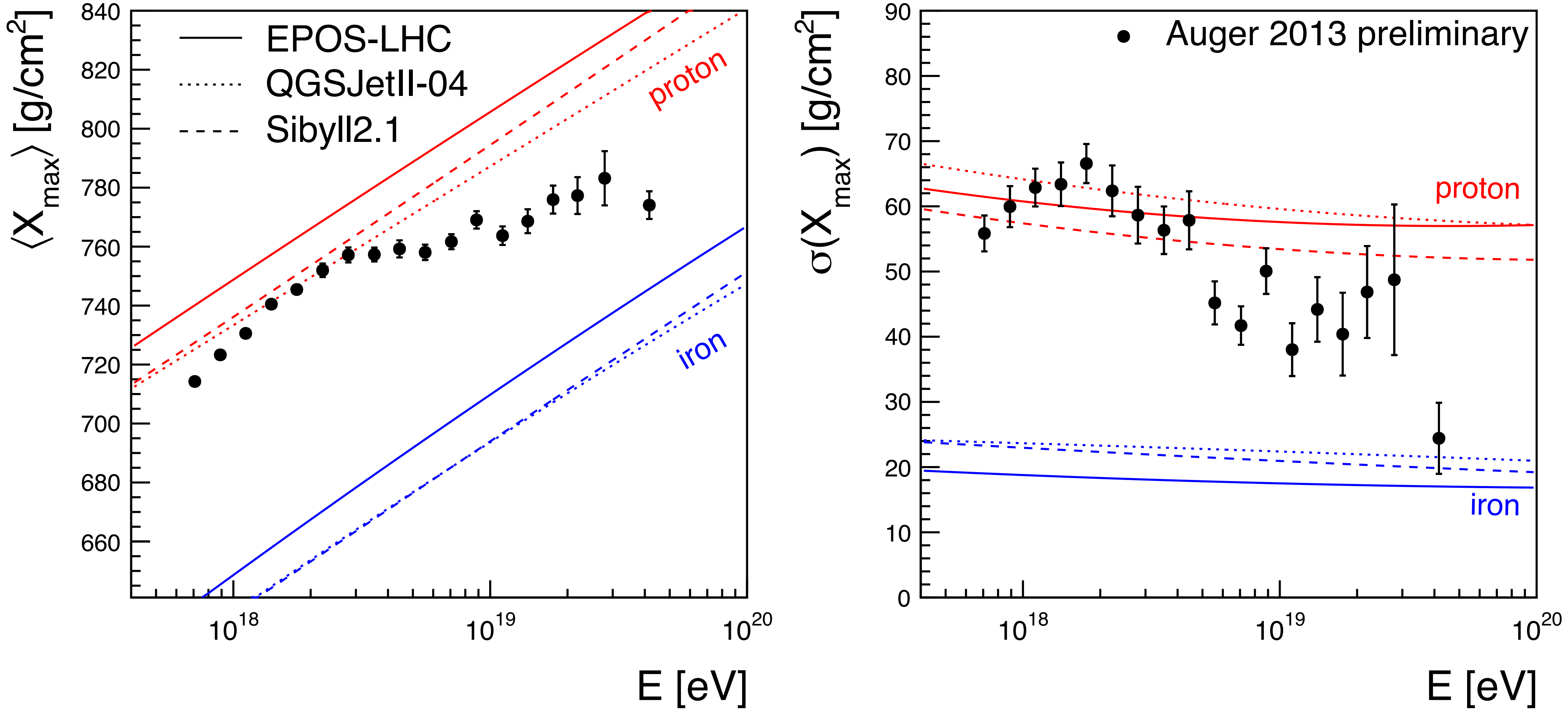
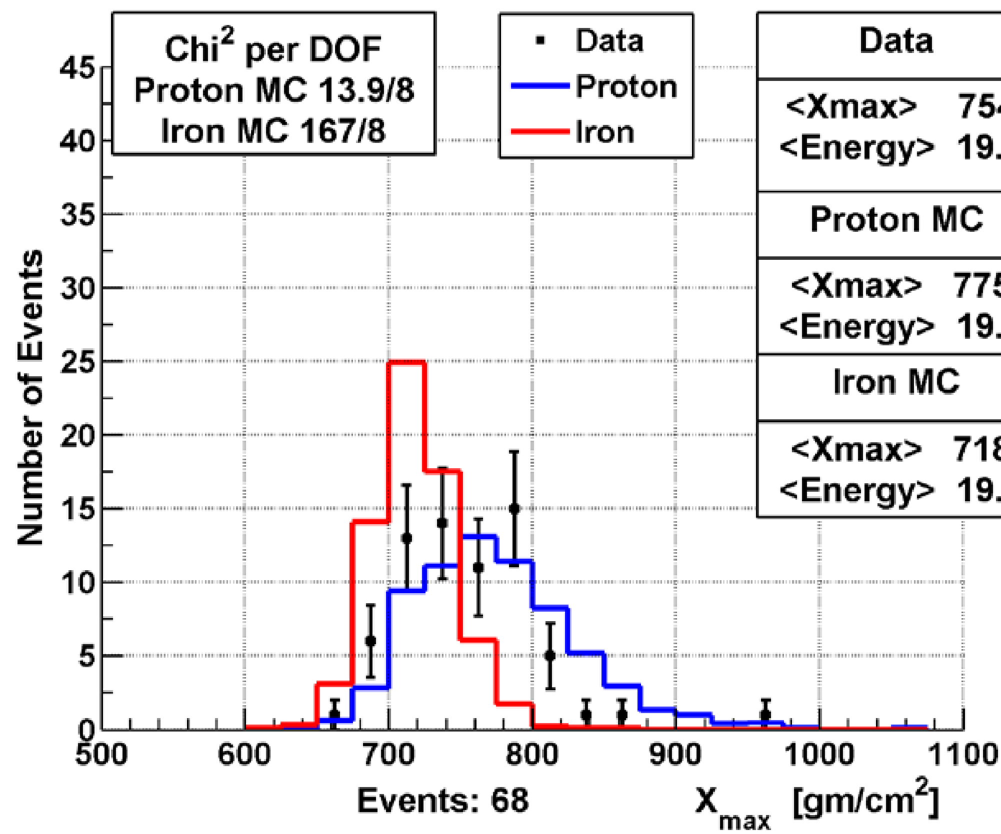
Rather good agreement on spectrum

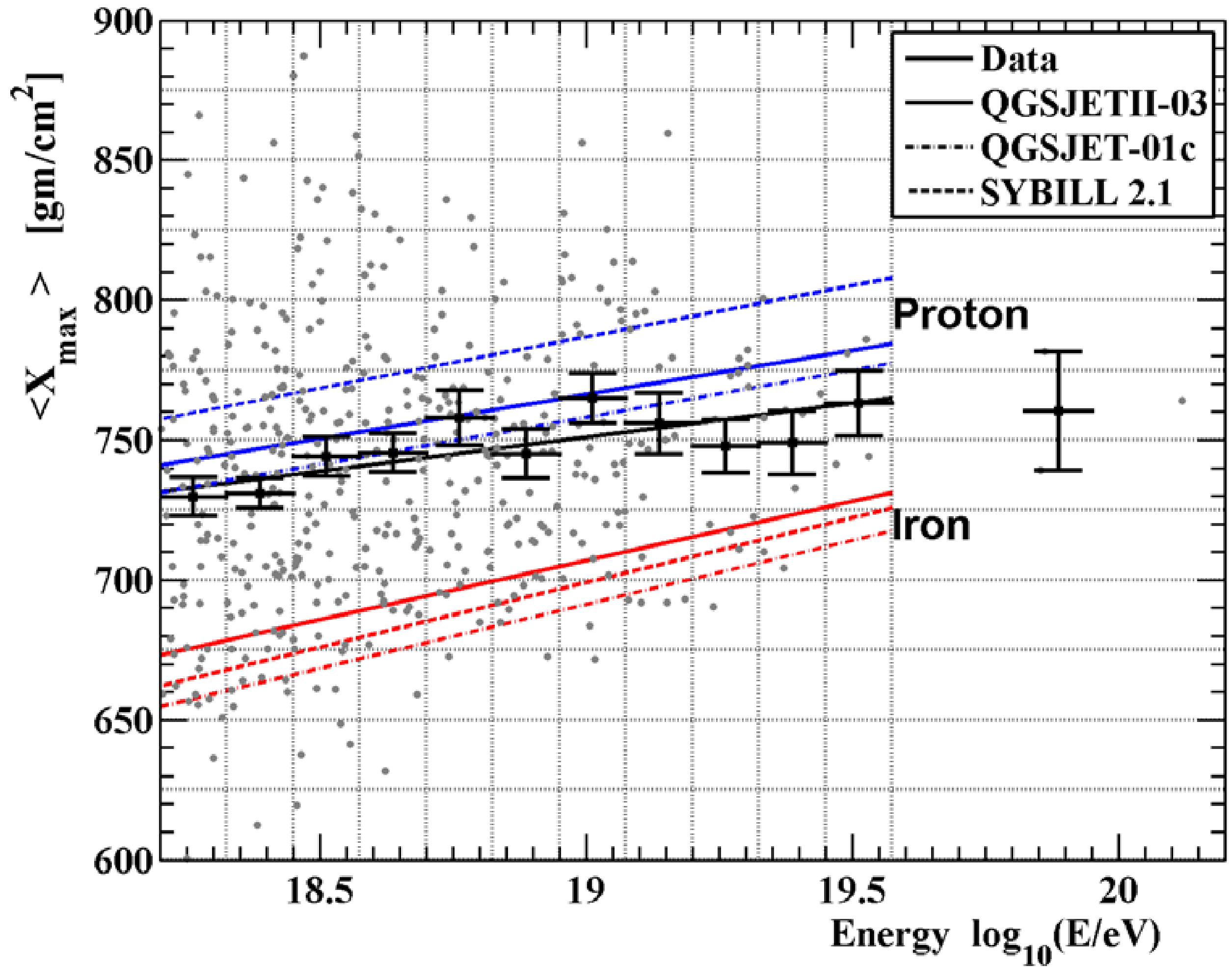
First two moments of $X_{\max}$ distributions



Xmax in Energy Slices Comparison to p/Fe MC



Log10(E/eV) > 19.0



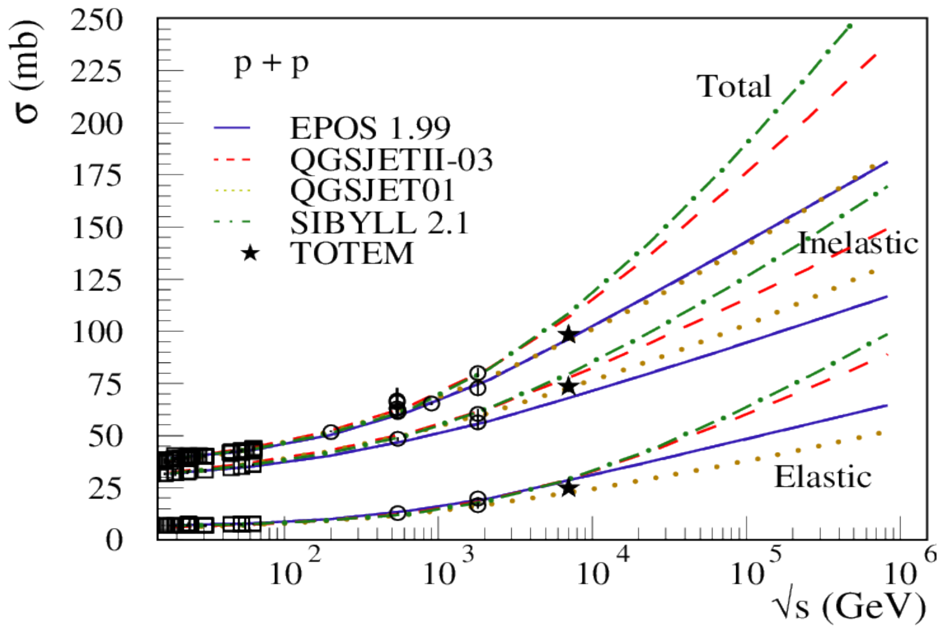
Results are consistent with proton at all energies and inconsistent with iron.

Some tension between TA and Auger on composition

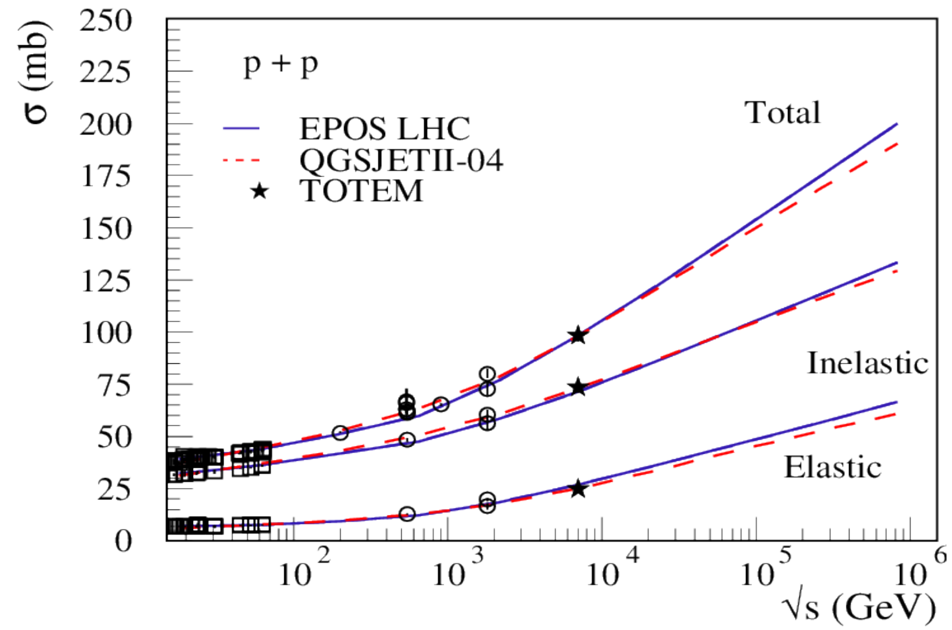
Cross Sections

- Same cross sections at pp level up to LHC
  - weak energy dependence : no room for large change beyond LHC
- other LHC measurements of inelastic cross-section (ALICE, ATLAS, CMS) test the difference between models (diffraction)

Pre - LHC

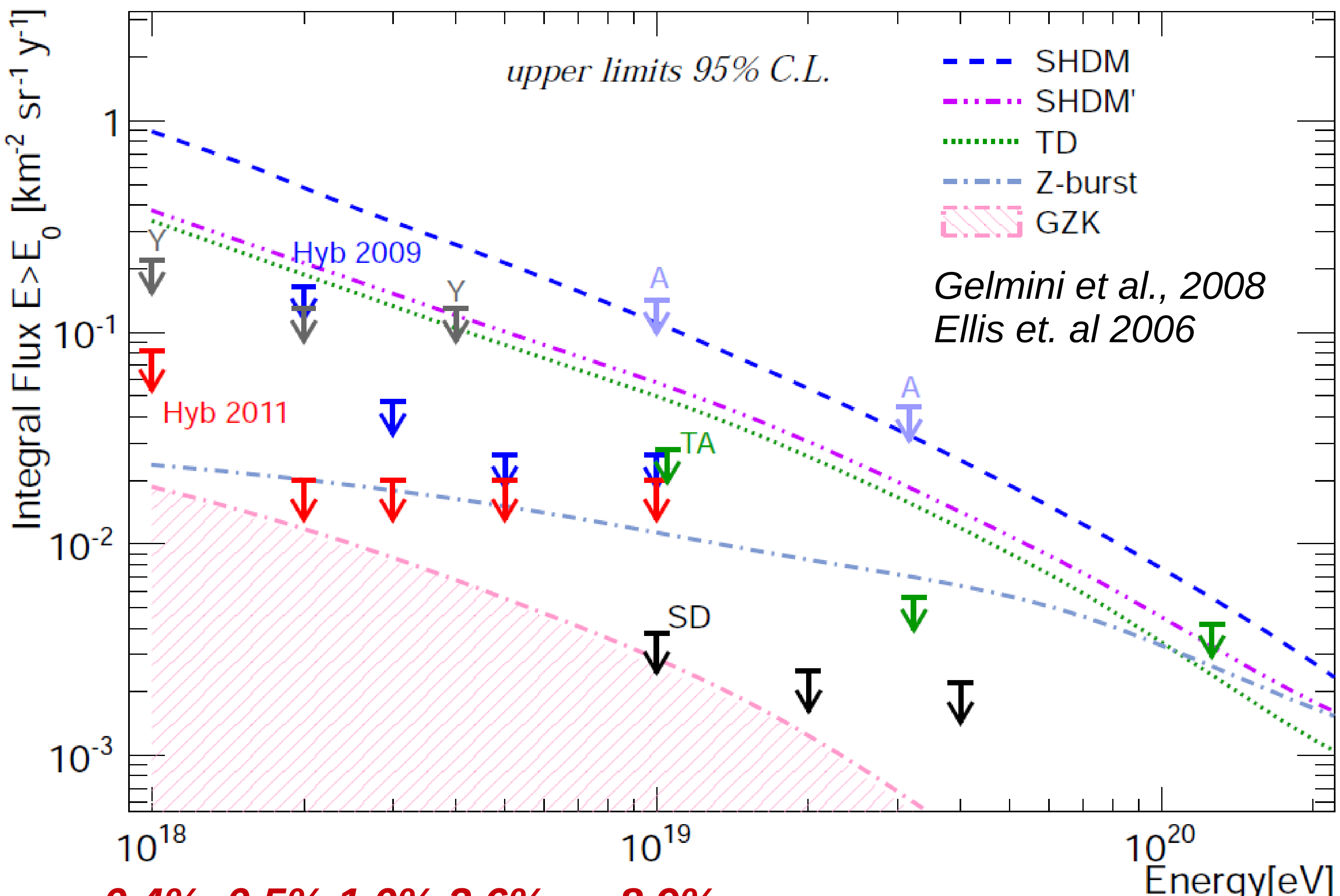


Post - LHC



T Pierog Ground truth from LHC helps a lot!

Upper limits on diffuse fluxes of photons



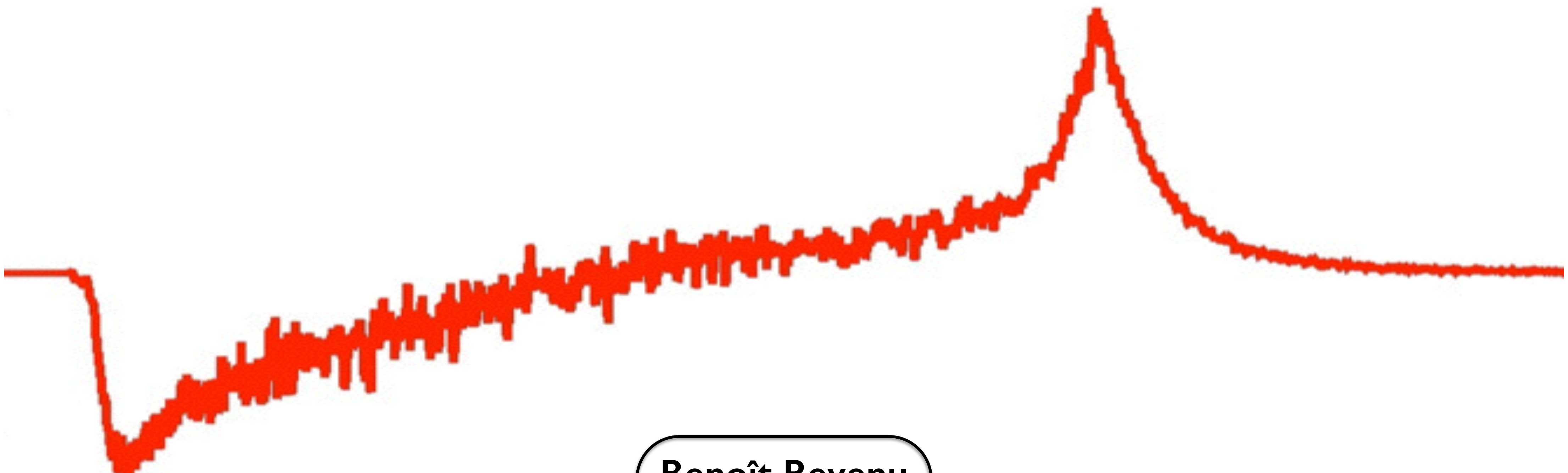
fraction limits **0.4% 0.5% 1.0% 2.6% 8.9%**

2.0% 5.1% 31%

→ Top-down models highly disfavoured
→ Approaching the most optimistic predictions of cosmogenic photon fluxes

C Bleve - limits on UHE photons

Study of ultra-high energy cosmic rays through their radio signal in the atmosphere



Benoît Revenu
SUBATECH
École des Mines de Nantes
Université de Nantes
CNRS/IN2P3

Warning - people have been trying to make this work for decades! But maybe this time is different…

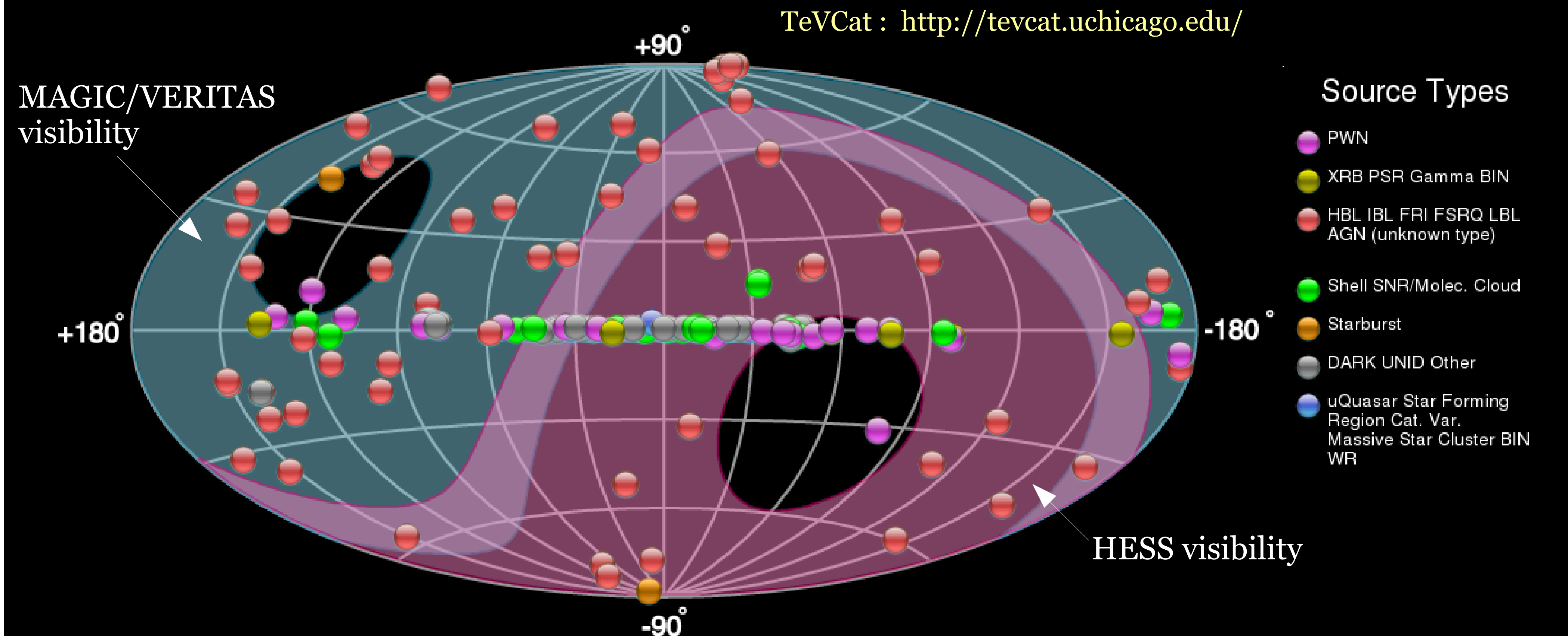
Gamma-Ray Astronomy
1 Galactic

- Currently observationally dominated by Fermi-LAT and Agile at GeV energies and the IACT systems at TeV energies; soon HAWC.
- Interesting to see Integral working as a Compton telescope and a reminder that the sub GeV region is under explored!
- Some real surprises!
    - Dominance of PWNe in TeV Galactic sources.
    - Fermi bubbles - totally unexpected discovery!
    - Classical Novae as GeV sources.
    - Fermi gamma-ray pulsars.
    - Crab flares!

Status in the TeV range

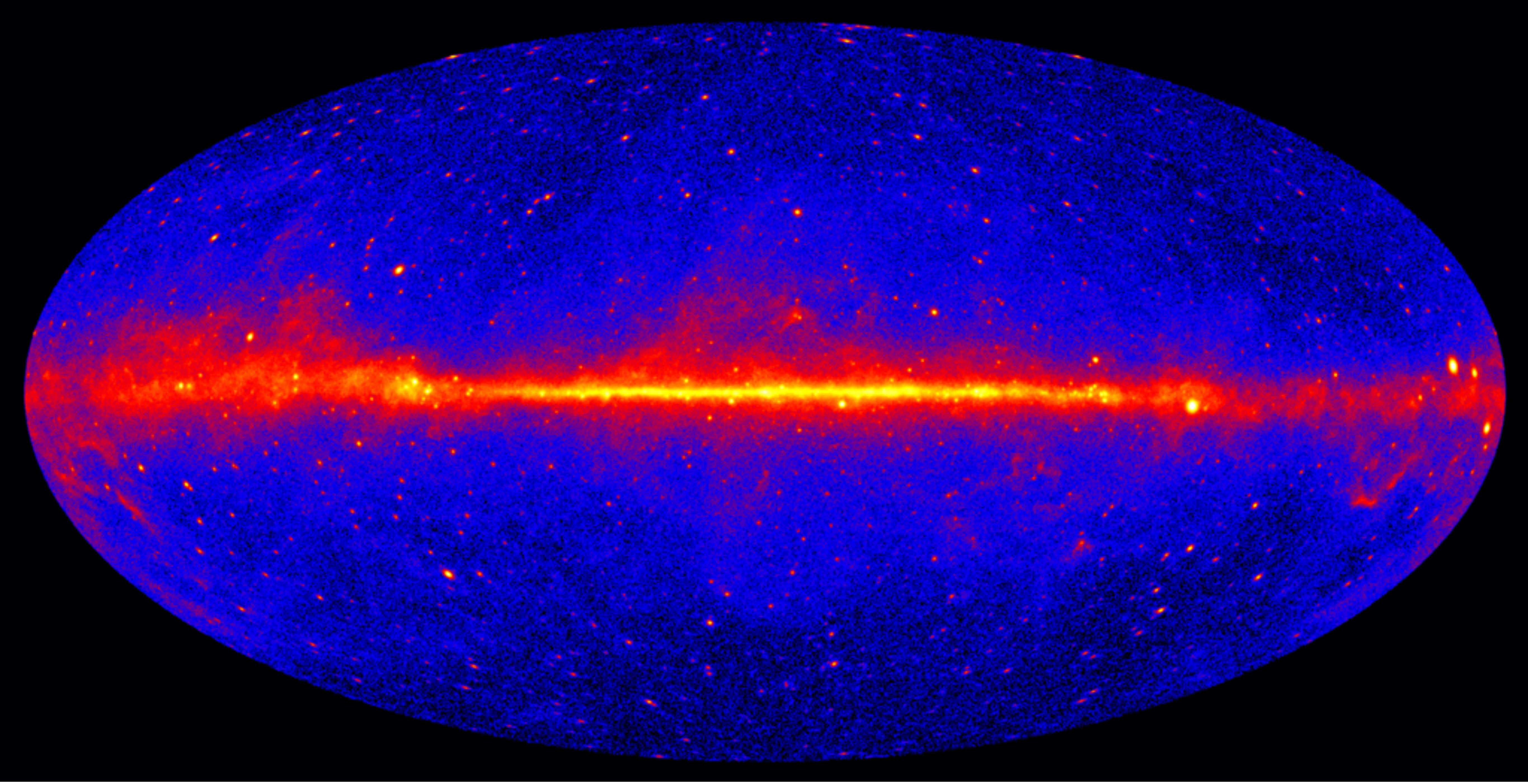
Improved sensitivity of current generation of Imaging Atmospheric Cherenkov Telescopes (IACTs)

→ *detection of ~145 VHE sources*



Marie-Helene Grondin, VHEPU 2014, Quy Nhon, 04/08/2014

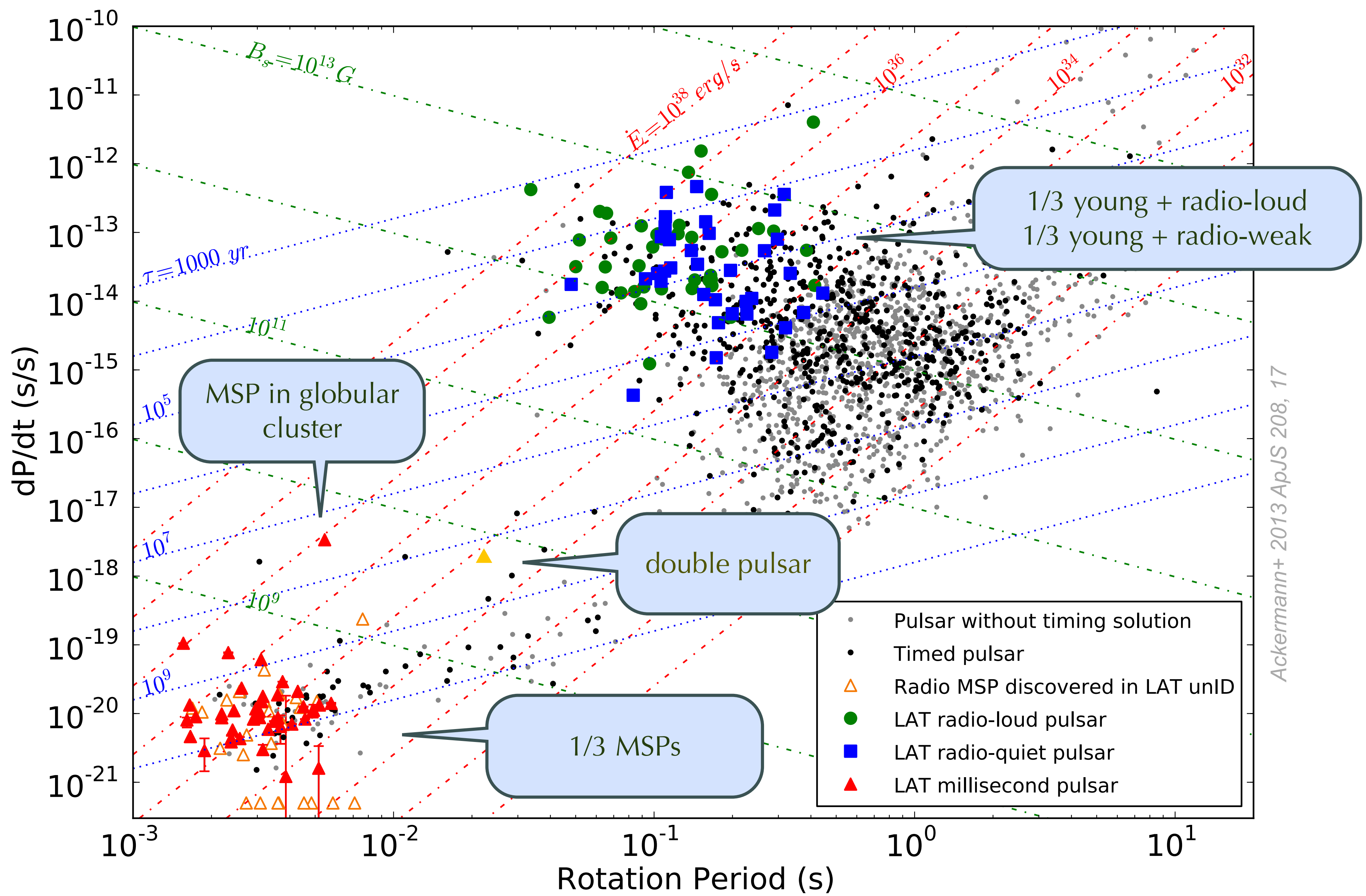
M-H Grondin - Already well populated TeV gamma-ray sky!
Many more sources soon…..



And at GeV energies (Fermi-LAT 5 year map)

γ-ray pulsar families

- 2PC catalogue: 117 pulsars and 3 years of data

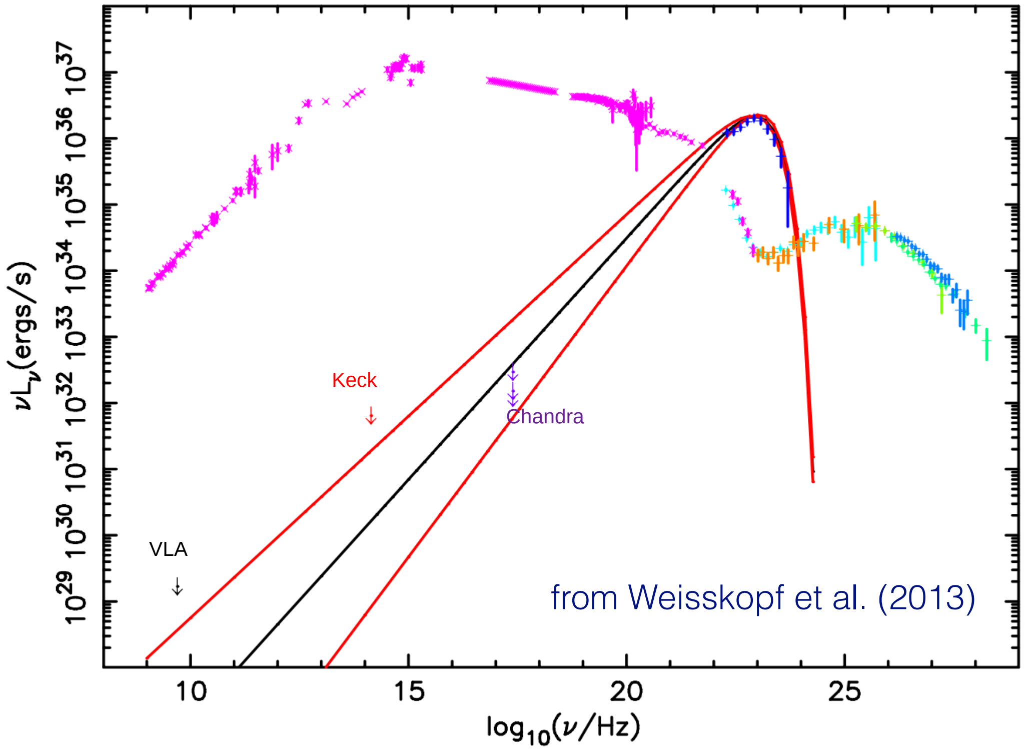


I Grenier - surprising numbers of Fermi pulsars

Crab flares

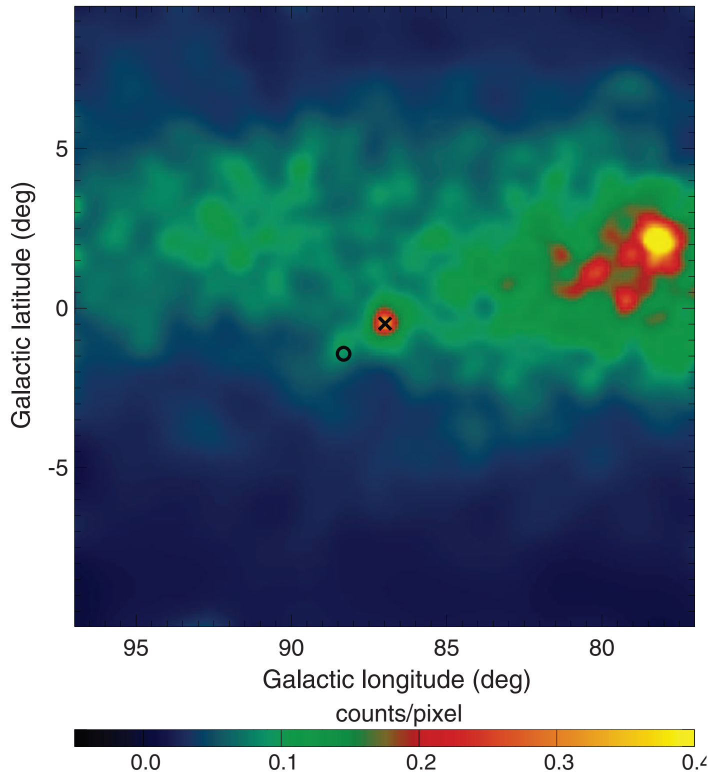
➤ origin of the flares?

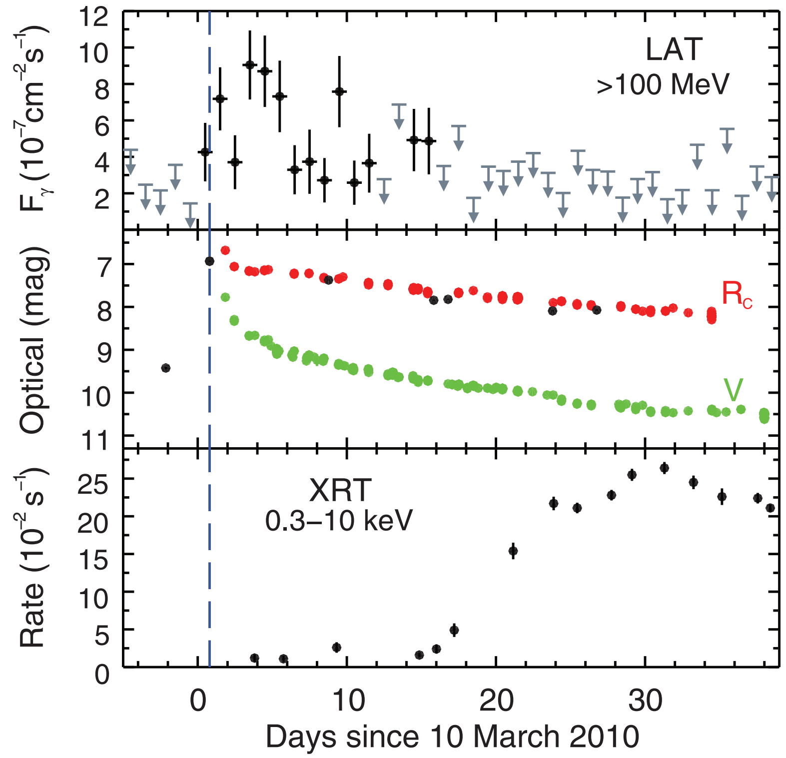
- Synchrotron emission from hard, ~mono-energetic electrons at $\gamma_e \sim 4 \times 10^9$ (Buehler et al. 2011)
- rise-times of ~few hours: very efficient acceleration mechanism!
  - magnetic reconnection? shock-acceleration not enough (Uzdensky et al. 2011, Sironi et al. 2011, Cerutti et al. 2013)
  - related to magnetic dissipation (sigma problem)? (Begelman 1998, Komissarov 2012, Porth et al. 2013)
- compact region ($< 10^{-3}$ pc) delivering ~ 1% spin-down power
  => anisotropy/doppler-boosting? (Bednarek et al. 2011, Clausen-Brown et al 2012, Lyutikov et al 2012)
- emitter: knot1? base of the jet/kink instabilities?



Very mysterious and totally unexpected!

V407 Cyg





Abdo et al. (2010)

- New gamma-ray source in Cygnus: *Fermi J2102+4542*
    - High-significance detection March 13th and 14th 2010 (> 100 MeV: 10^{-6} ph cm^{-2} s^{-1})
    - spatially coincident with symbiotic star V407 Cyg
    - optical outburst in V407 Cyg on March 10th + only *Swift*-XRT counterpart
    - *Fermi*-LAT reanalysis: (fainter) emission from March 10th
- First Nova detected at HE gamma-rays

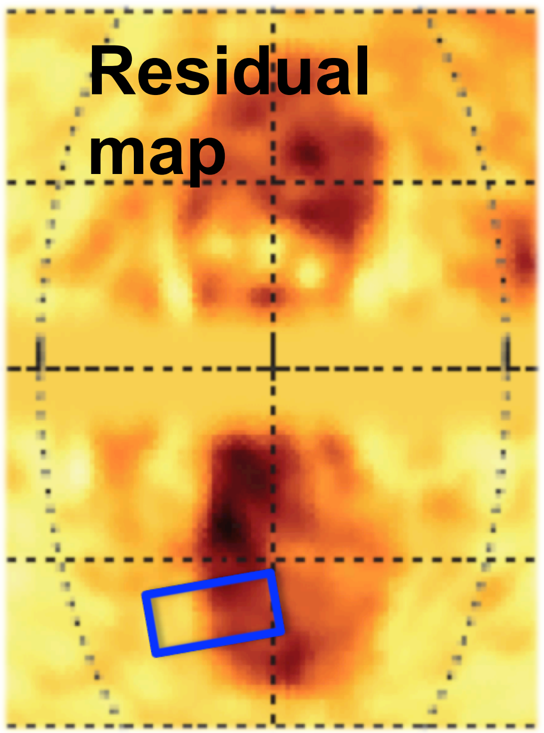
P Bodas - classical nova in gamma-rays!

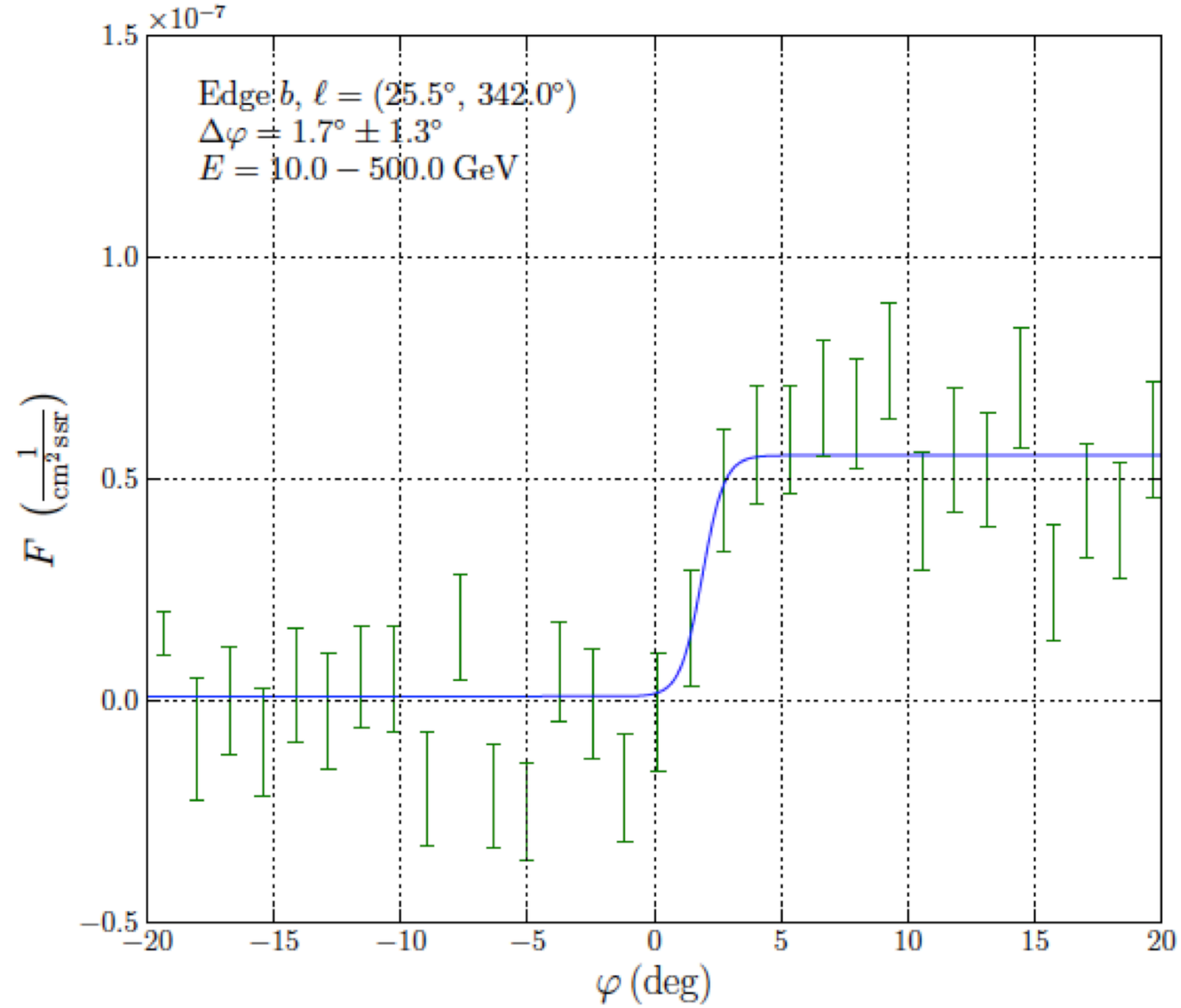
Exotic/Remarkable Non-Thermal Phenomena of the GC/Inner Galaxy:

- (Quasi) point-like GeV and TeV γ-ray source coincident with Sgr A* (= radio source coincident with SMBH)
- Extended (few degrees) GeV & TeV emission
- Non-Thermal Radio (and X-ray) Filaments (NTFs)
- 130 GeV 'line'
- Few GeV γ-ray spectral bump
- 511 keV positron annihilation line
- Non-thermal microwave 'haze'
- Fermi Bubbles

R Crocker - The GC is complicated!

Boundary of the Bubbles



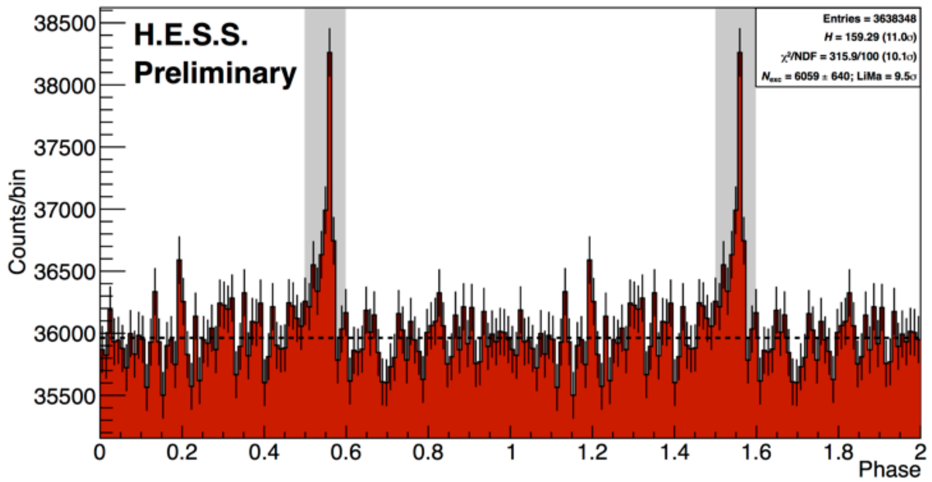


A. Franckowiak

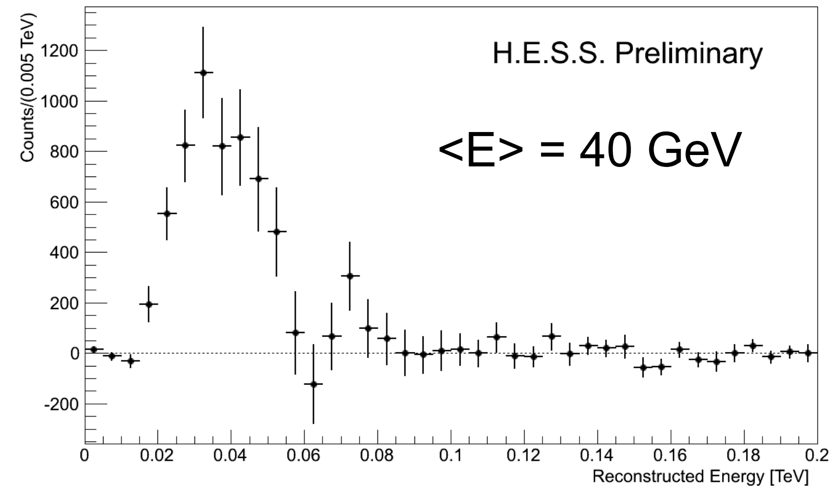
15

A Franckowiak - What are the Fermi “bubbles”???

The Vela pulsar seen with H.E.S.S.



Energy distribution



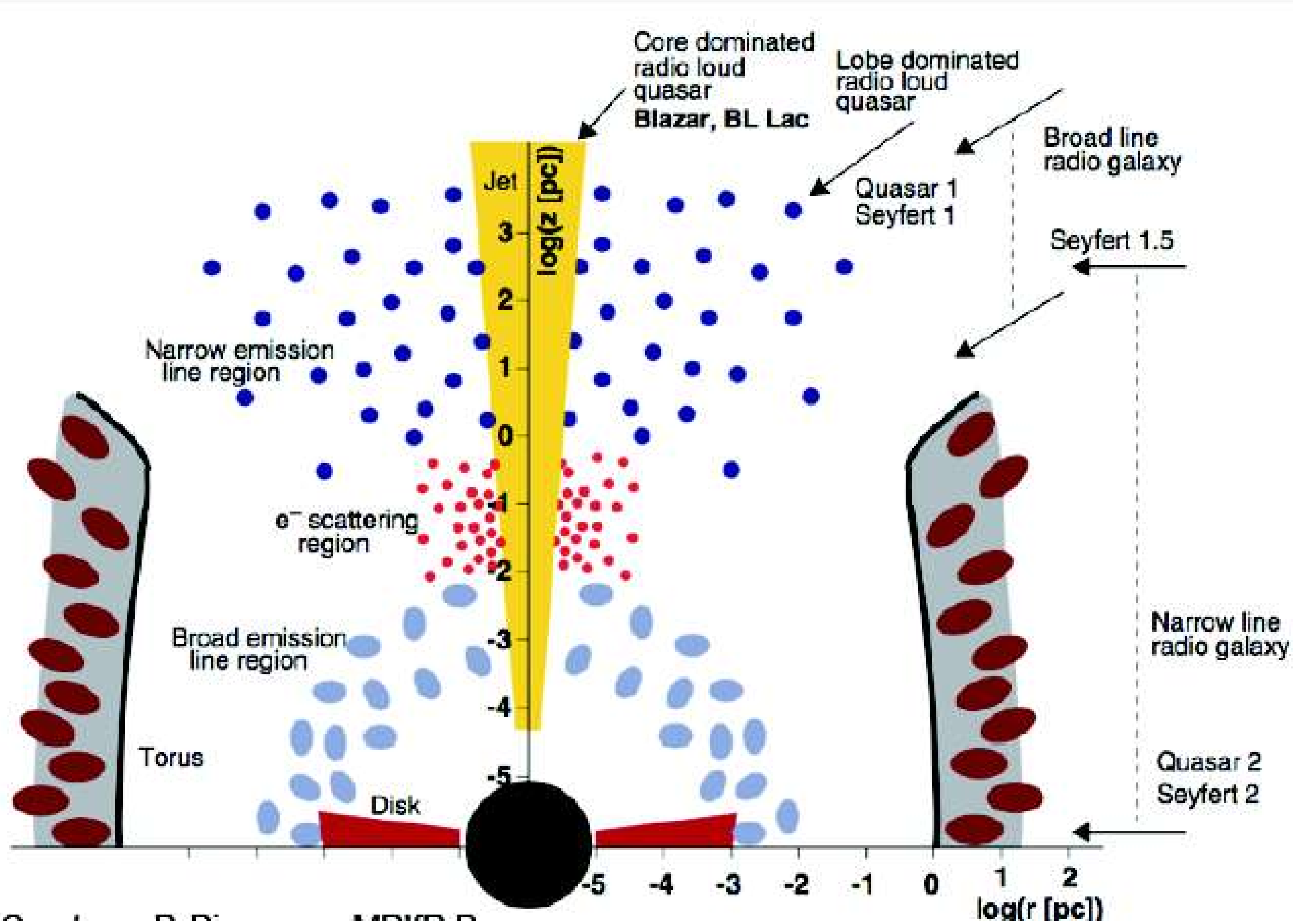
- For H.E.S.S.
  - Calibration source at the threshold in standard observation mode
  - Well prepared for GRB search

P Brun - First science from HESS-II.

Gamma-Ray Astronomy
II - Extra-galactic

- Mostly AGNs
  - Dominated by blazars
  - But also a few other AGNs
- And a few starburst galaxies
- Diffuse Background
- (And of course GRBs - in separate theme)

Blazars



- Highly variable at all frequencies
- Highly polarized
- Radio core dominance
- Superluminal speeds
- Relativistic boosting, high Doppler factors

Observed at small angle to the jet,
thus rare AGN : 5-8% of all AGN
(but only at optical or X-ray frequencies!)

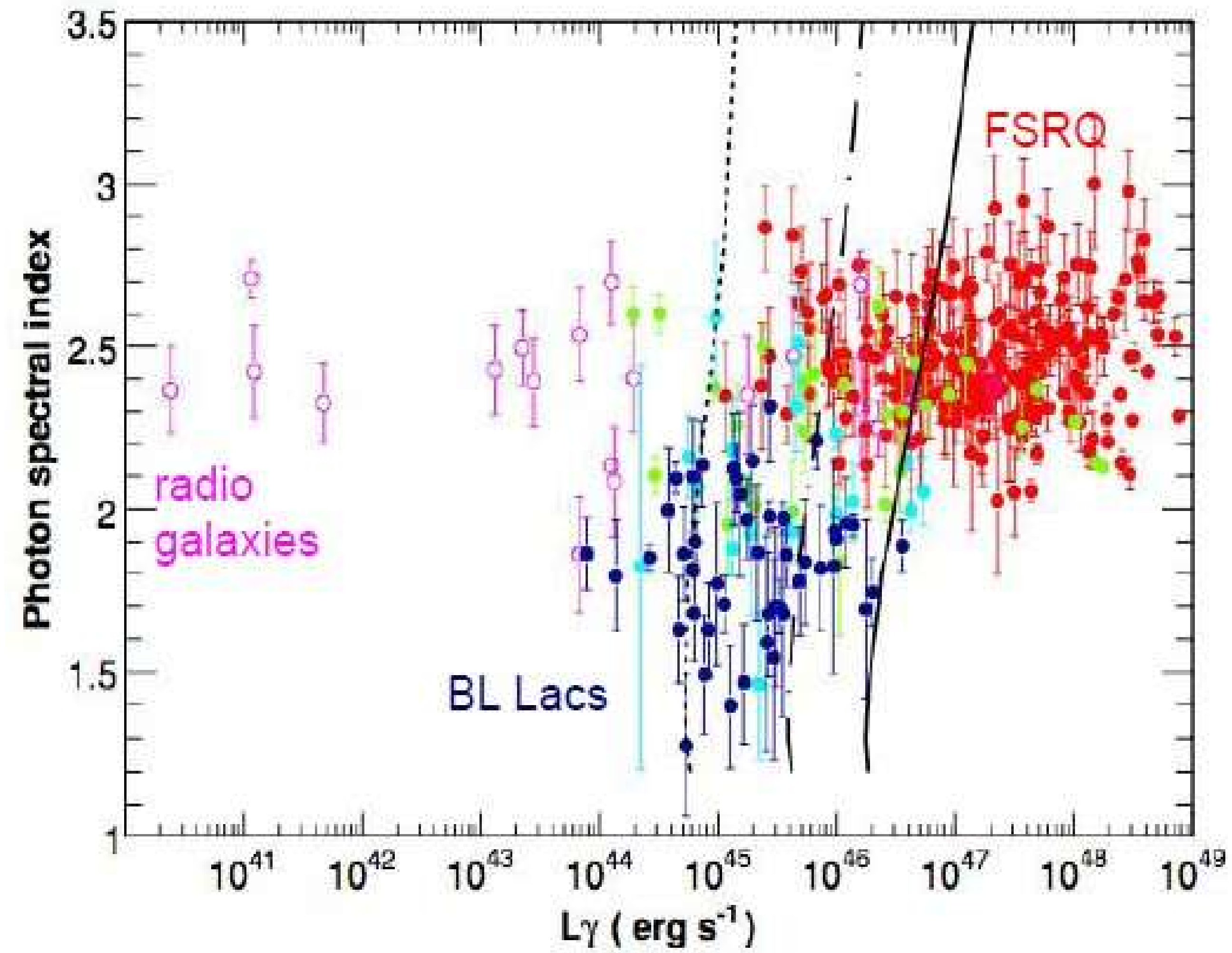
Blazars are the dominant population of extragalactic point sources at

- Gamma-ray
- TeV
- Microwave frequency

@ Biermann

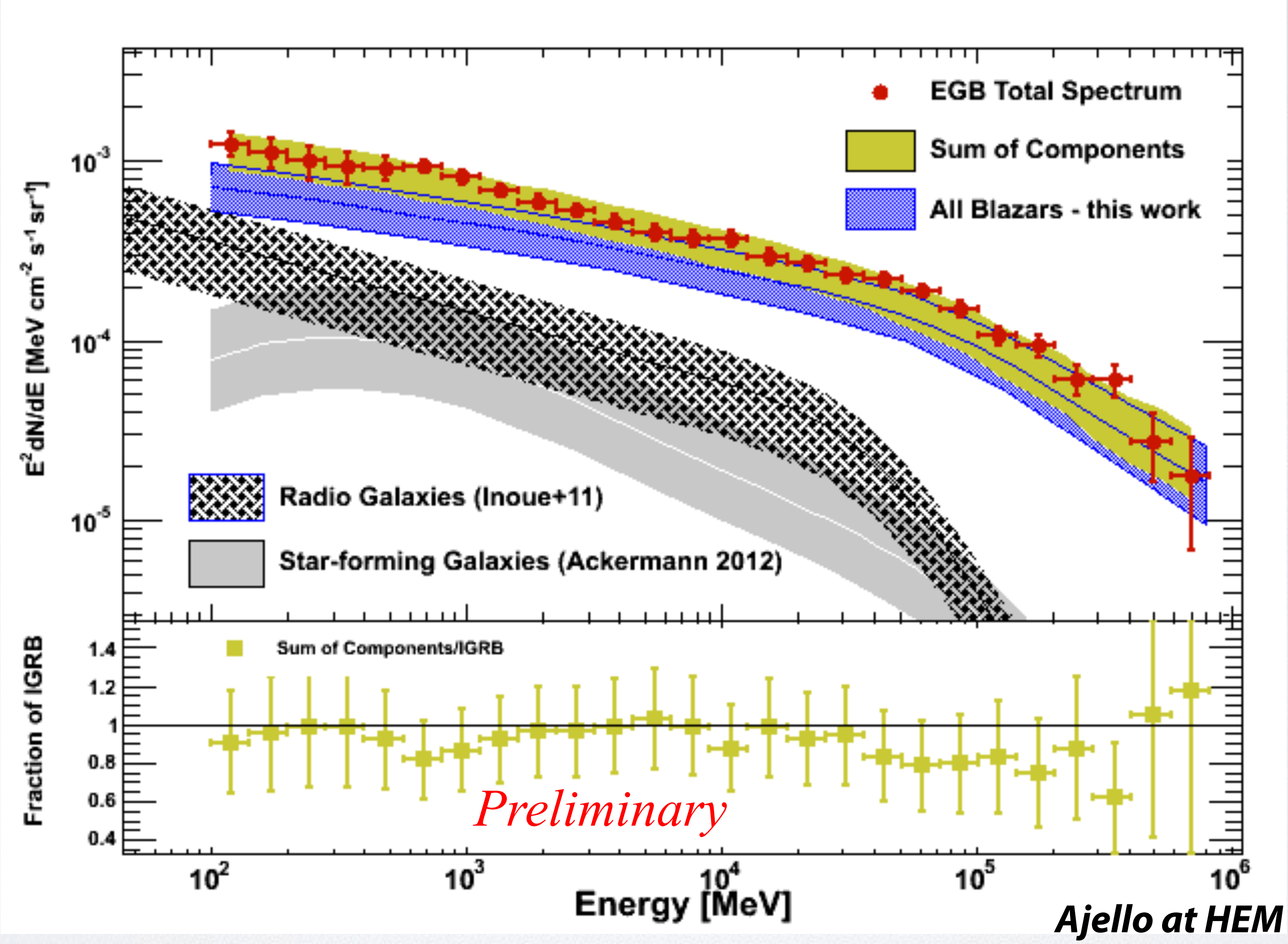
FERMI census

- ~ 1000 AGN
- Only a few non blazar detected
- No radio-quiet Seyfert detected at a level of 1% of their bolometric luminosity
- Luminosity is correlated with photon index (and blazar class):
  higher luminosity ↔ steeper spectrum
  → consistent with blazar sequence



C Boisson - GRA crucial for Blazar physics

Components of Cosmic Gamma-ray Background



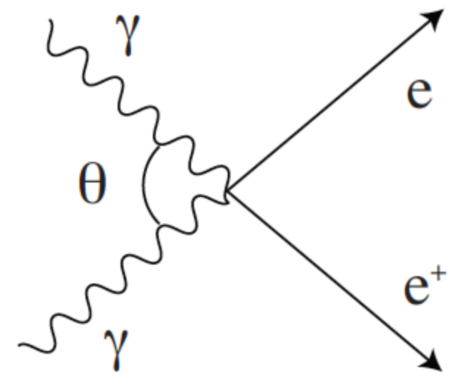
Ajello at HEM14

- FSRQs (Ajello+'12), BL Lacs (Ajello+'14), Radio gals. (YI'11), Star-forming gals. (Ackermann+'12) are guaranteed.
- little room for dark matters?

Y Inoue - blazers dominate diffuse background.

EBL Constraints – Related Issues

- **EBL constraints are based on pair production via photon-photon interactions along the gamma ray's path!**

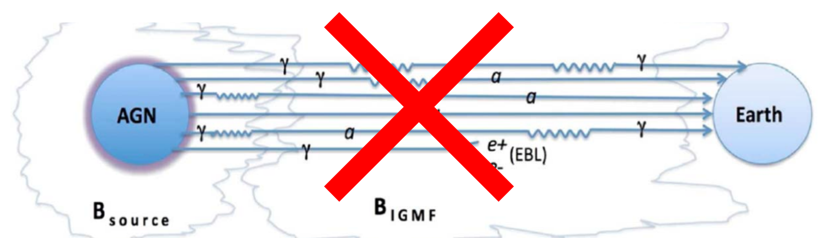


- **Secondary gamma rays from other (hypothetical) processes**

  → 10^{17} eV proton-induced cascades (UHE cosmic rays):

  $$\cancel{p + \gamma_{EBL}} \rightarrow \pi^{\pm}, \ldots \rightarrow e^{+} + \gamma_{EBL} \xrightarrow[\text{inverse Compton}]{} \gamma_{TeV}$$

  → Axion-Like-Particle – Photon conversions in IGMF (Dark matter searches)



Aug 8 2014 Frank Krennrich 10th Rencontres du Vietnam

F Krennrich - GRA sensitive probe of EBL

PASS 8 EVENT ANALYSIS OF THE FERMI LARGE AREA TELESCOPE

Carmelo Sgrò
INFN–Pisa
carmelo.sgro@pi.infn.it

on behalf of the Fermi LAT collaboration

10^{th} Rencontres du Vietnam on Very High Energy Phenomena in the Universe

C Szego - Improvements to analysis of Fermi soon….

To sum up...

Telescopes in good shape to continue producing scientific results for several years. System with a better performance than ever.

Currently running more ambitious Key Science Programs → They will be the MAGIC legacy for the scientific community.

We are currently having very **exciting** and **novel** results:

- Source discoveries: 3C 58, S3 0218+357, MS1221.8+2452, RBS 0723, RX J1136.5+6737.
- Deep studies of known sources: Crab nebula, LS I +61° 303, Mrk 421, Mrk 501, DM searches...
- Surprises as IC 310 extreme variability...

What has the future waiting for us?

- GRB detection?
- → Stay tuned!!

R Lopex-Coto - Magic upgrades

The H.E.S.S. telescope array
H.E.S.S.-2 phase: 2012

Array of FIVE Imaging Atmospheric Cherenkov Telescopes

located in Namibia (1800m a.s.l.)

and HESS phase 2 is now working!

Gamma-Ray Detectors

HAWC is a wide field of view (~2 sr), continuously operating (>90% duty cycle), TeV observatory.

⇒Unbiased search for transients to initiate multi messenger observations

⇒ Highest energy observations with ~100 km^2 hr exposure after 5 years operation on > ½ the sky

Wide Field of View, Continuous Operations

TeV Sensitivity

Fermi
AGILE
EGRET

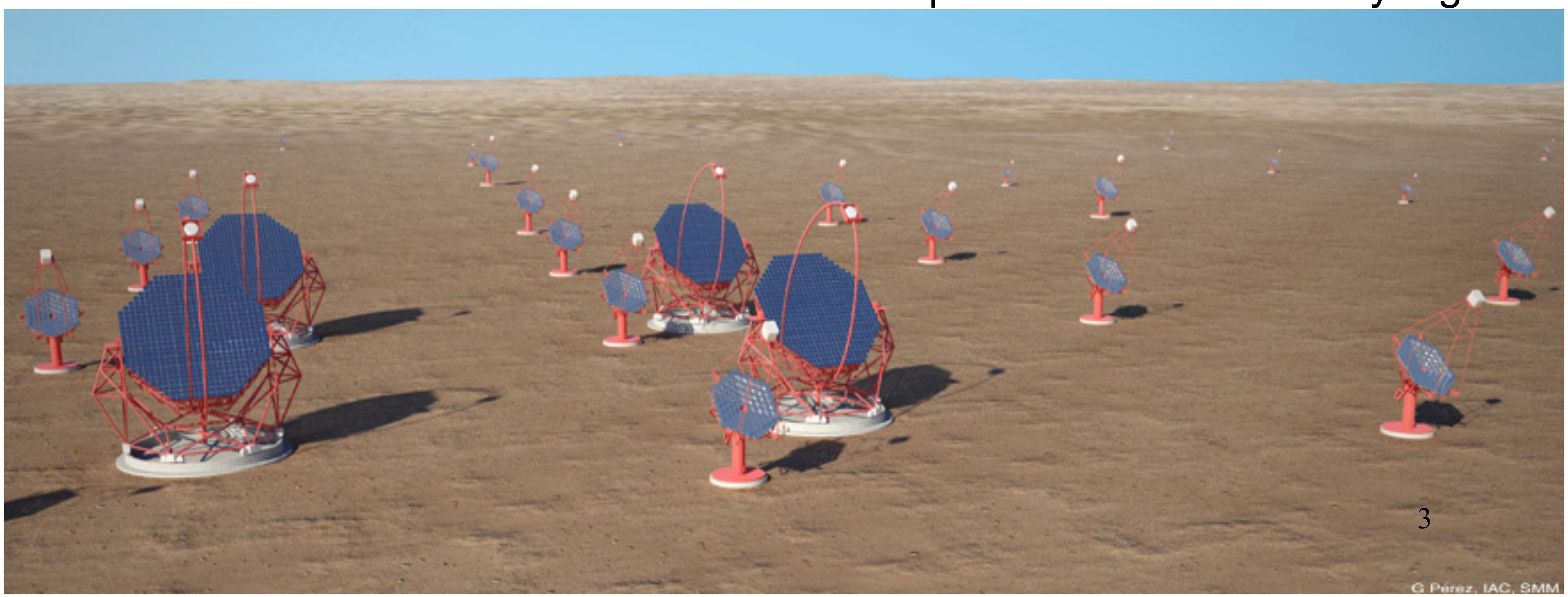
HAWC
ARGO
Milagro

VERITASH
ESS
MAGIC

The Cherenkov Telescope Array (CTA): the future in VHE gamma-ray astronomy

The CTA project is an initiative to build the next
generation ground-based
very high energy gamma-ray instrument

http://www.cta-observatory.org



Gamma-Ray Bursts

- Discovered serendipitously by military satellites monitoring the atmospheric test ban treaty!
- Afterglows localised by BeppoSAX satellite (also a bit serendipitous).
- To everyone's surprise turned out to be at cosmological distances and ultra-relativistic.
- Most powerful and extreme explosions in the universe!

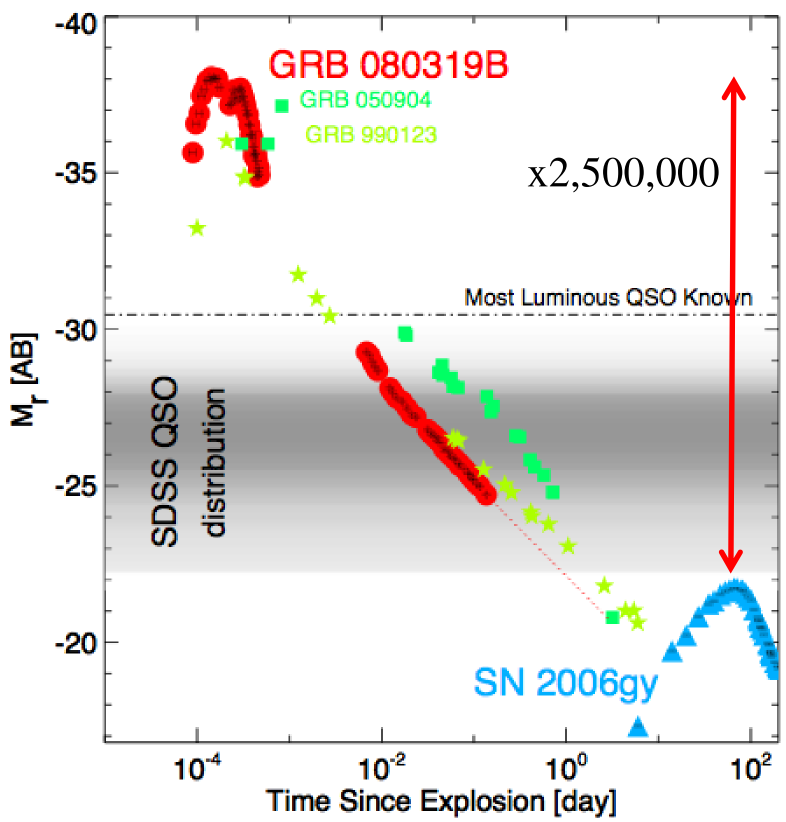
- Predicted to be powerful sources of gravitational waves.

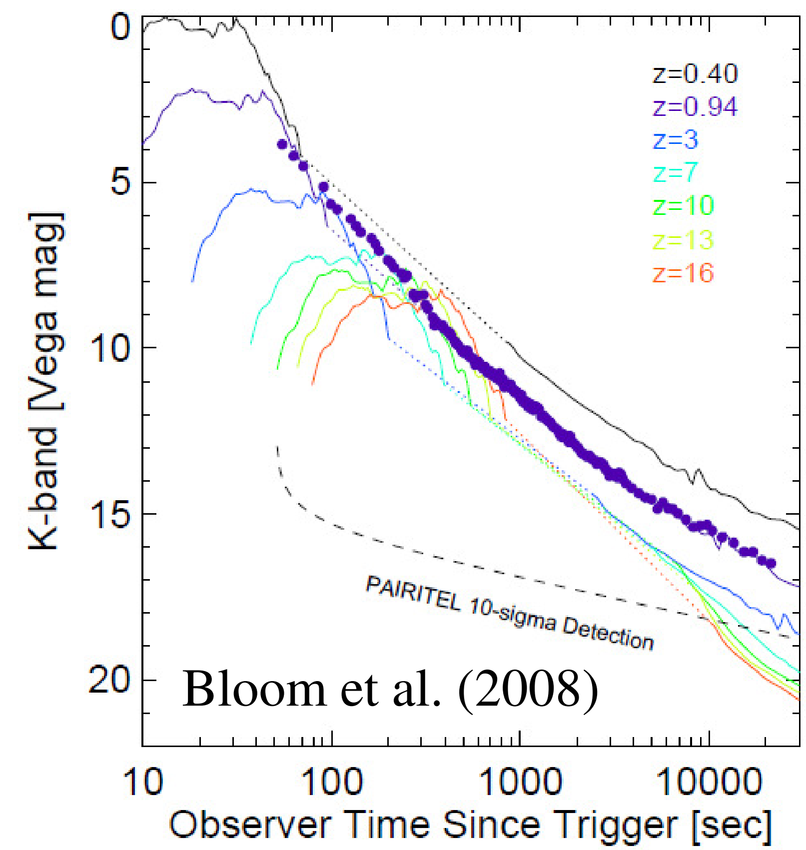
- Possible sources for the UHCREs?

- Target for large IACTs and HAWC

GRB080319B; z=0.935

"The naked-eye Burst" (Racusin et al. 2008)





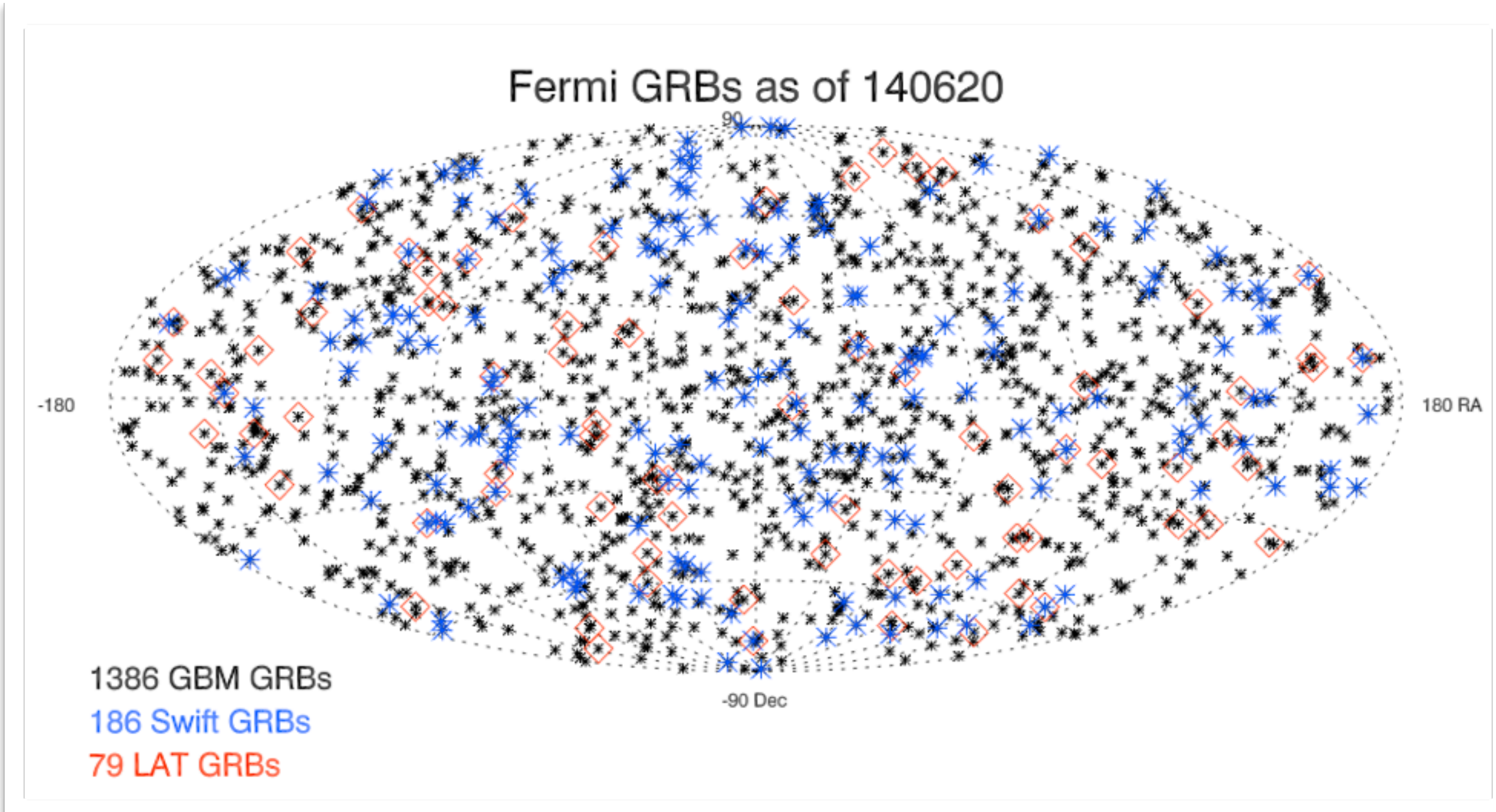
Such bursts can be seen to very high z in both IR and X-ray (re-ionisation era targets for JWST, E-ELT, Athena…)

Finding high-z GRBs is a major science driver for future facilities (e.g. SVOM)

8

P O'Brien - review of SWIFT

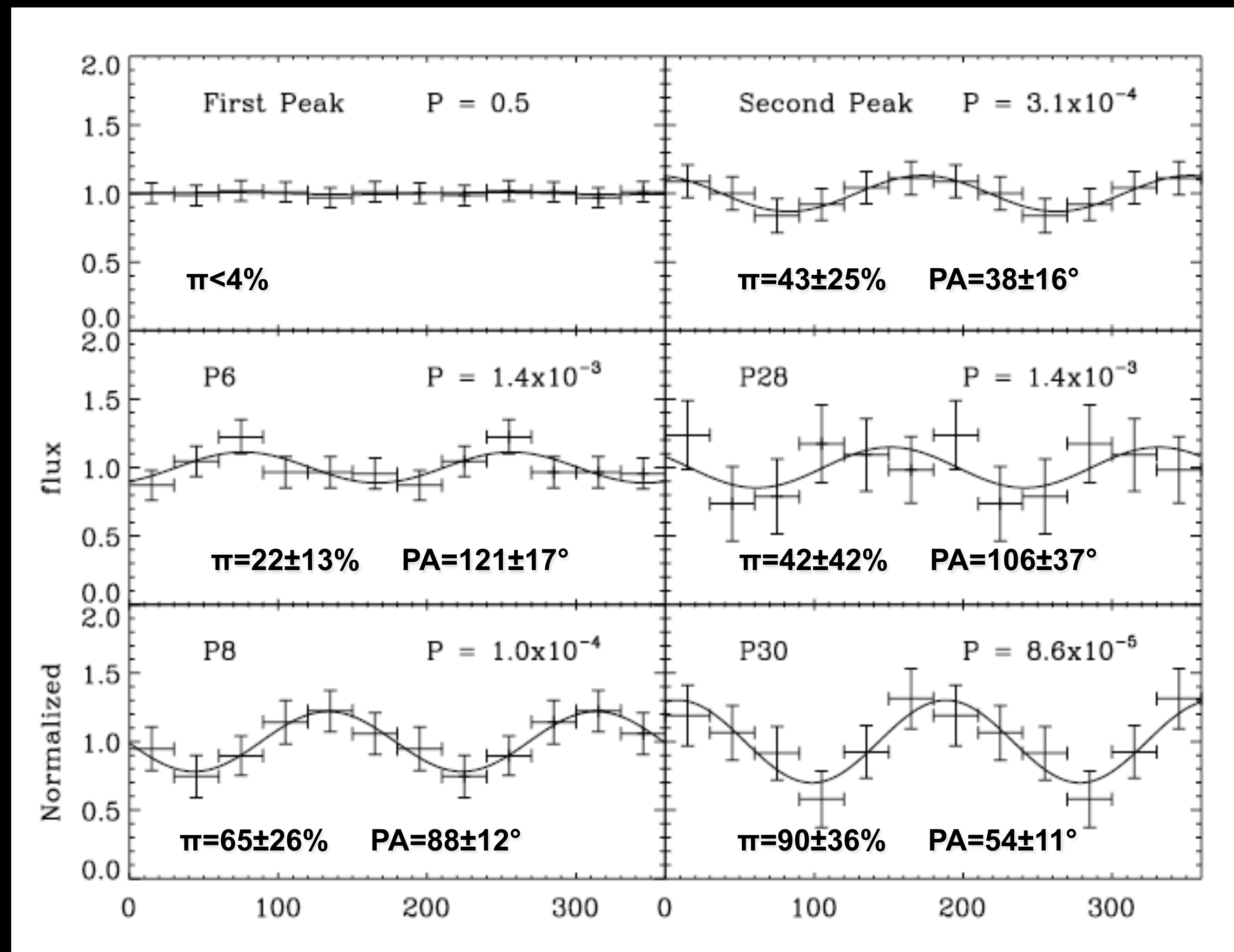
Common GBM-Swift GRB sample and Swift follow-up of LAT-detected GRBs have been the best-studied GBM-detected GRBs because of difficulties of observing GBM-only detected GRBs with sensitive follow-up instruments



V Connaughton - Fermi GRB studies


The SVOM GRB mission
J-L Atteia – IRAP – Toulouse
On behalf of the SVOM consortium
NAOC, Beijing
XIOPM, Xi'an
CEA-Irfu, Saclay
APC, Paris
LAM, Marseille
CPPM Marseille
GEPI meudon
MPE, Garching
IHEP, Beijing
SECM, Shanghai
IRAP, Toulouse
IAP, Paris
LAL Orsay
LUPM Montpellier
University of Leicester
CNES, Toulouse

GRB 041219A: polarization results



Götz+09

SPI: π=68±29% PA=$70^{\circ+19^\circ}_{-27^\circ}$

McGlynn et al. (2007)

Integral in Compton telescope mode!

tl;dr

- GRB130427A was really bright and should be detectable at VHE (>100 GeV) under favorable conditions.

- VERITAS looked at it about 1 day after the burst went off.

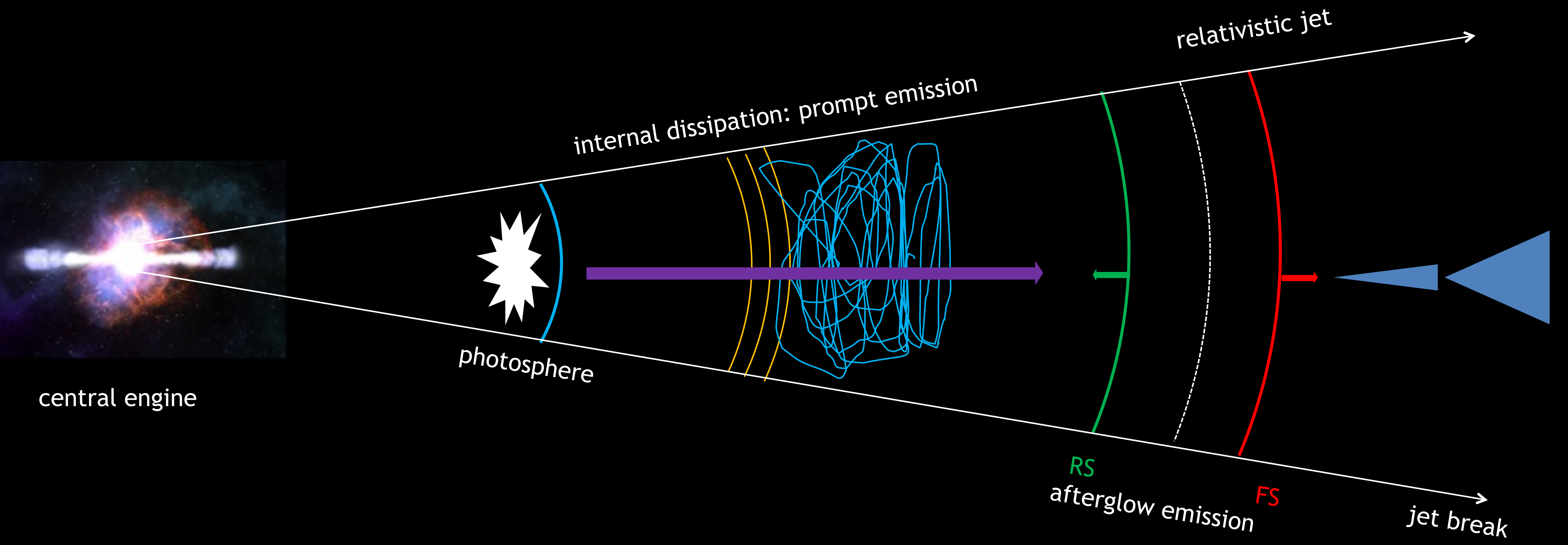
- No VHE emission was seen:

    - this disfavors additional components and

    - there's probably a cut off.

J Perkins - expect to see VHE emission from GRBs

What we know for (almost) sure….



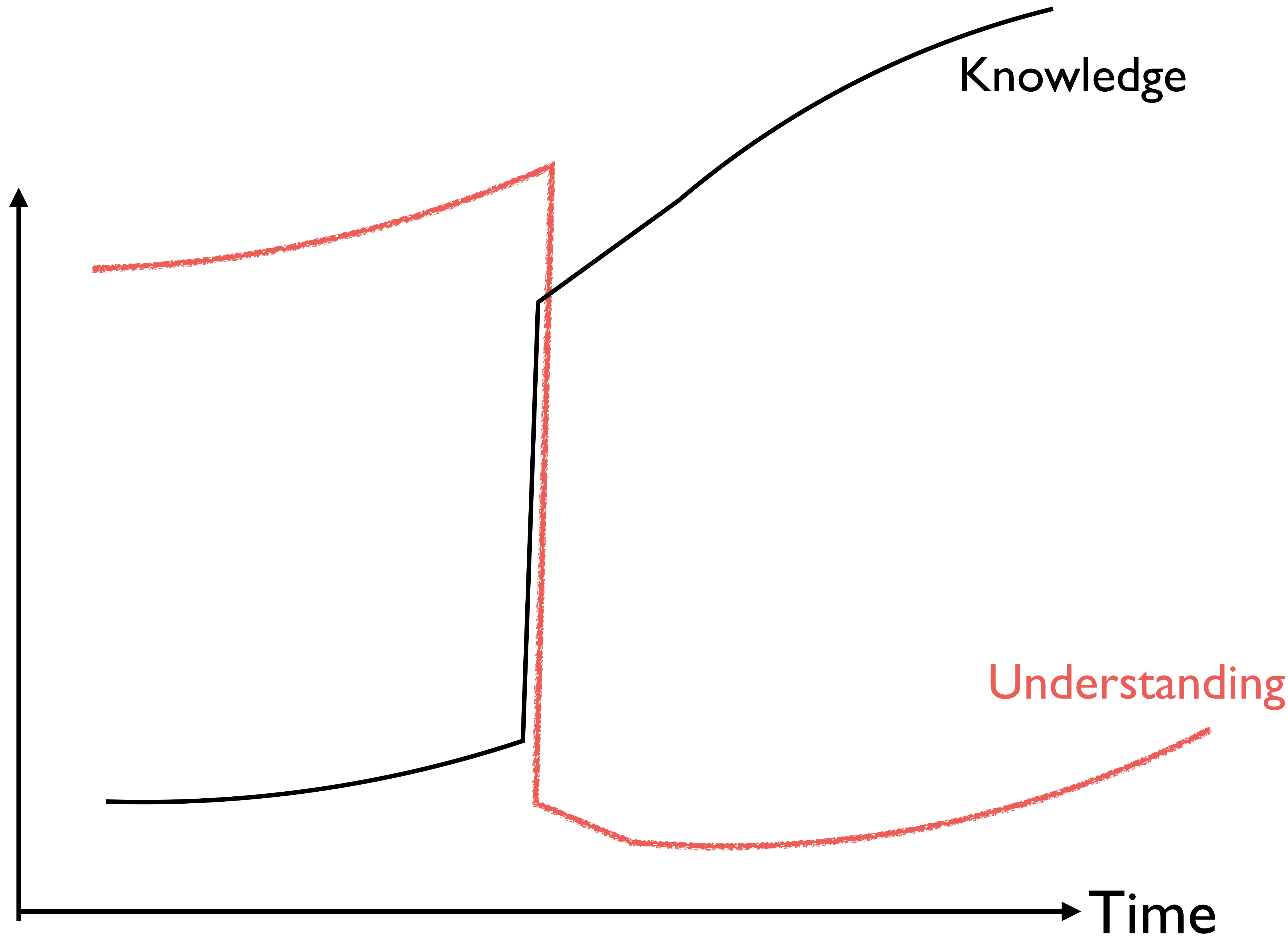
<u>Unsettled issues</u>:

- acceleration/energy content of the jet: thermal/magnetic?
- dissipation mechanism at work?
- respective contributions of the forward and reverse shocks to the afterglow
- surprises in the early afterglow

Wonderful dataset challenges the current "standard" model for GRBs

All in all, the "standard" model works decently well, but:

- Internal shocks model for prompt emission not quite right
- LAT observations are especially hard to account for
- Quite a bit of ad-hoc work to get all the other pieces together, with some values for parameters quite hard to digest
- Other solutions can be explored (other acceleration mechanisms? or a whole different picture?)

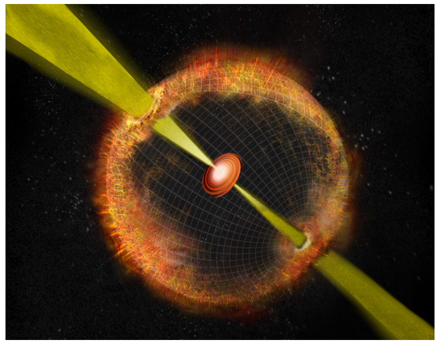


Progress in GRB science - copied from M. Rees

Summary

- Long and short GRBs progenitors may produce large amounts of GWs
- Some relevant exclusions: GRB070201, GRB051103
- Good prospects for first detection with advanced detectors $\gtrsim$ 2015
- Joint GW-γ observation will determine the nature of GRB progenitors
- Full sky γ-ray coverage essential in 2015-2020

Swift/BAT	10% of sky
SVOM/GRM	20% of sky
Fermi/GBM	60% of sky
IPN	most of the sky?



M Was - GRBs as sources of GWs

Why Gamma-Ray Bursts?

Long-duration (> 2 s) GRBs are the most luminous objects in the gamma-ray sky

$L_\gamma \sim 10^{51}\ \mathrm{erg/s}$

Non-thermal

Isotropic-equivalent

particle acceleration

GRBs as sources of UHECRs: Waxman 1995; Vietri 1995

Energy injection rate in UHECRs

Baryon loading>1

$$\dot{E}_{\rm CR} \sim 10^{51}\ \frac{\rm erg}{\rm GRB} \cdot \frac{20\,{\rm GRB}}{{\rm Gpc^3\ yr}} \eta_{\rm bol}\eta_p \sim 2\times 10^{43} \eta_{\rm bol}\eta_p\ \frac{\rm erg}{\rm Mpc^3\ yr}$$

Local true GRB rate

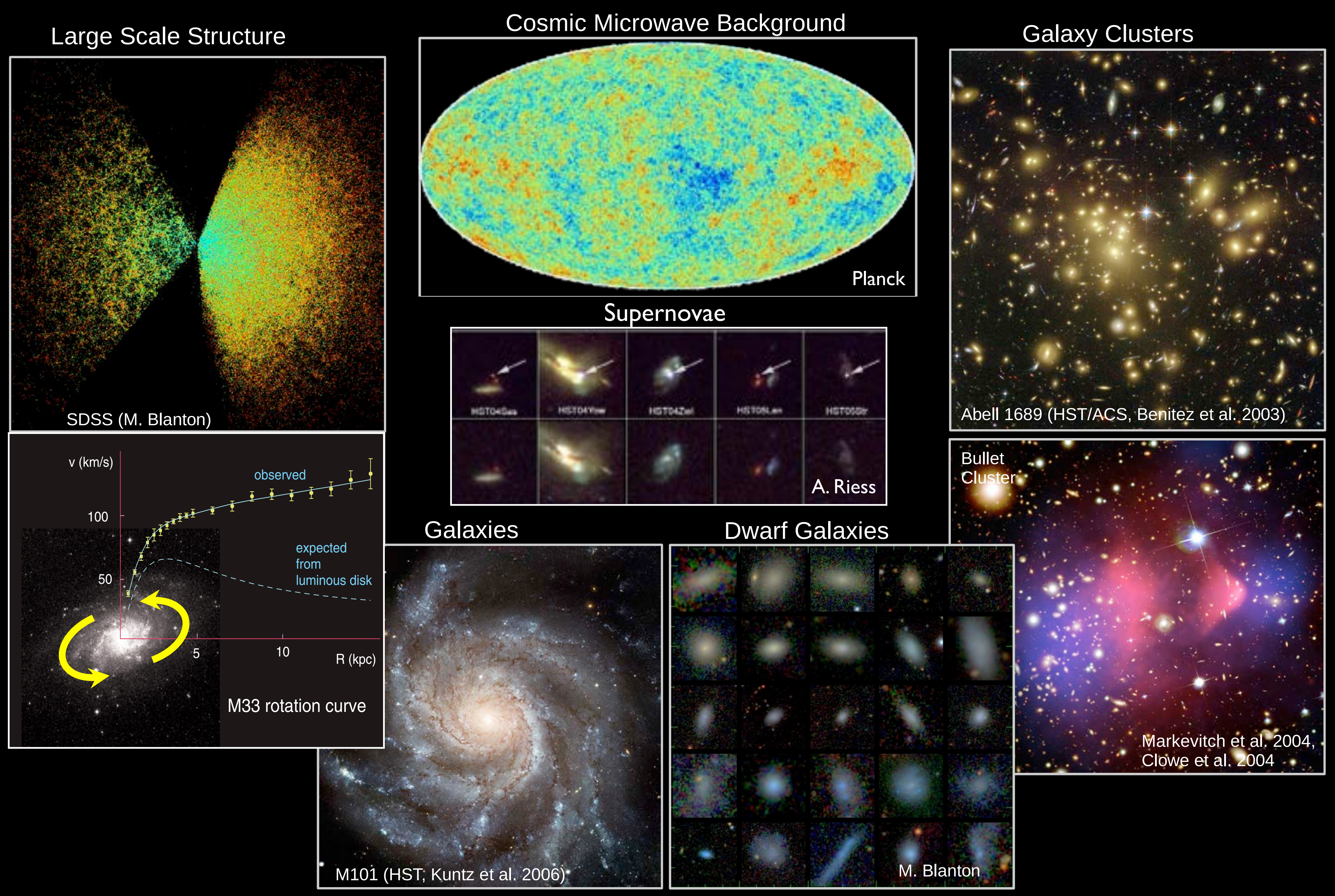
Bolometric factor<1

S Razzaque - GRBs as sources of UHE CRs?

Dark Matter

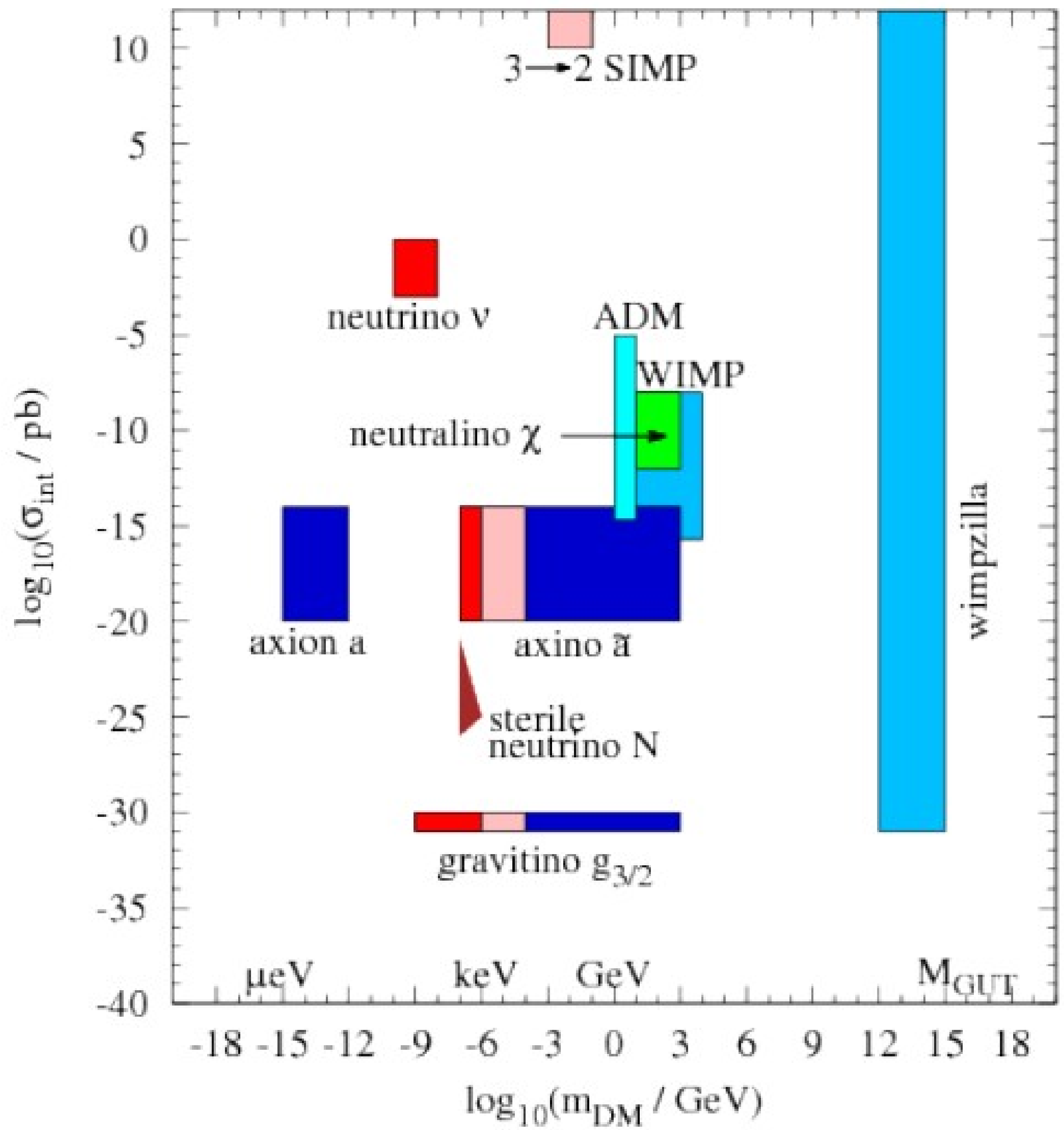
- CRs are particles that we observe, but which shouldn't be there; DM consists of particles that should be there, but which we don't see!
- Evidence for DM from cosmology and astrophysics is overwhelming - not modified gravity (bullet cluster, structure formation, Planck data etc…).
- But what is it…..
- Strong links to Neutrino and CR physics.

Evidence for cold dark matter



Not modified gravity! Real “stuff”

Dark matter candidates



G Belanger - Many candidates from particle physics!

Axions

INSTITUT FÜR THEORETISCHE PHYSIK
Heidelberg University

- Classical flatness from symmetry
- Quantum corrections are small
- New light particle: The Axion
  (it's a Weakly Interacting Sub-eV Particle)

Dark matter candidate

Good motivation
for axion/WISP experiments

J Jaeckel - Not just wimps - axions?

Summary

1. Investigating the nature of Dark Matter is a leading problem of our times. The LHC program brings an entirely new dimension to the problem.

2. ATLAS and CMS have produced early results within a framework defined by some choice of operators.

3. The LHC is beginning to have an impact. In the spin-independent case, low DM masses are being excluded. In the spin-dependent case, the limits are better than direct search experiments.

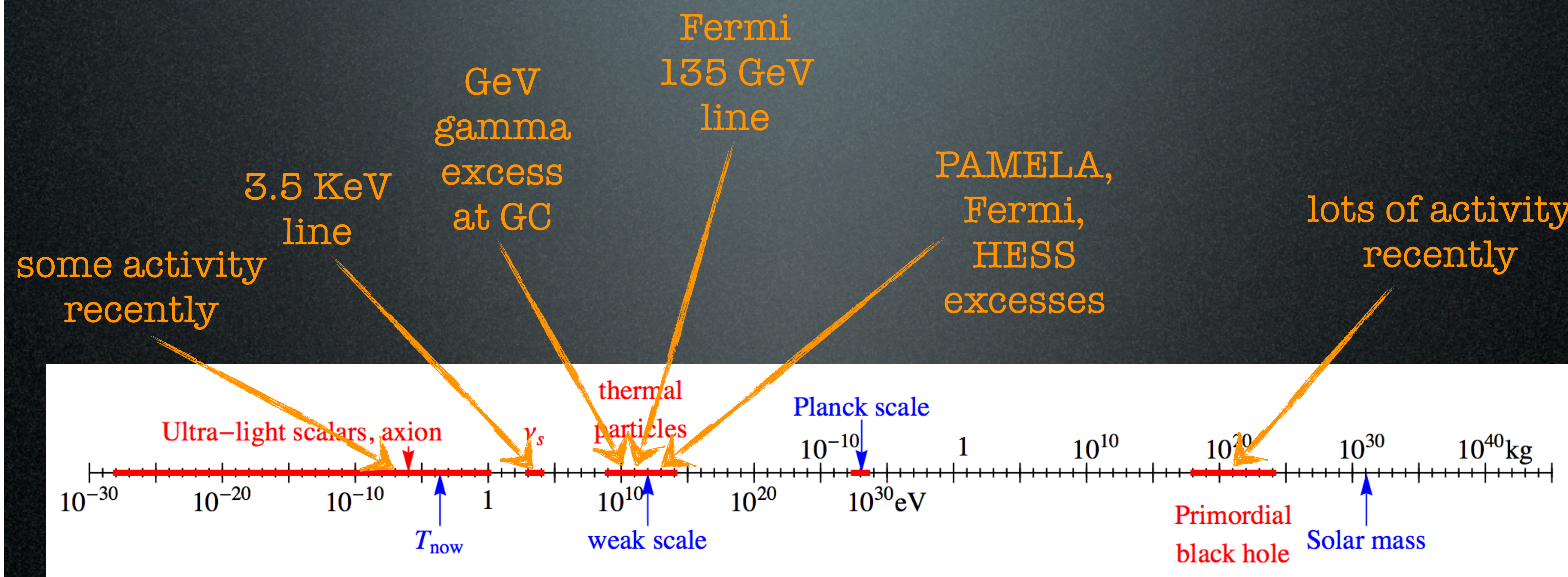
4. Besides the Mono-X channels, new Higgs modes are being investigated.

5. With the planned LHC upgrade, there are interesting times ahead for dark matter searches.

M Tripathi - direct production at LHC?

Candidates

A matter of perspective: plausible mass ranges



'only' 90 orders of magnitude!

Theorist's reaction

1. the 'PAMELA frenzy'

The PANDAX laboratory

Ge counting station

Storage bottles with Gas Xenon

Xe detector

K Pushkin

Current dark matter experiment by liquid xenon

double phase

Xenon100/1t

Xenon100 :
161kg xenon
50kg FV
Continue data taking 2014
Xenon1t:
Commissioning phase 2014May-

LUX

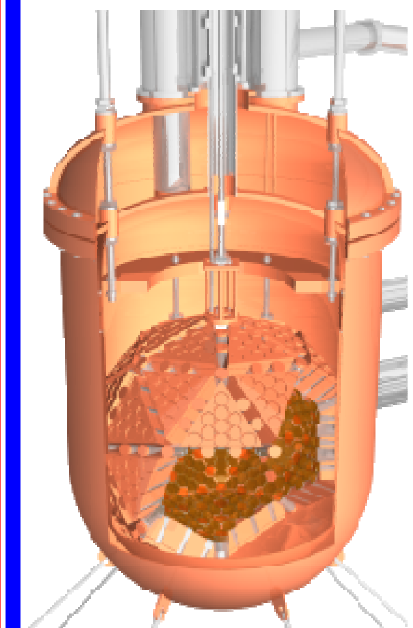
350kg xenon
118kg FV
First result :
arXiv:1310.8214v2
Using Apr-Aug 2013

PANDA-X

DM search run planned :
Phase1a :
25kgFV x 60days
Phase1b :
300kgFV x 180days

single phase

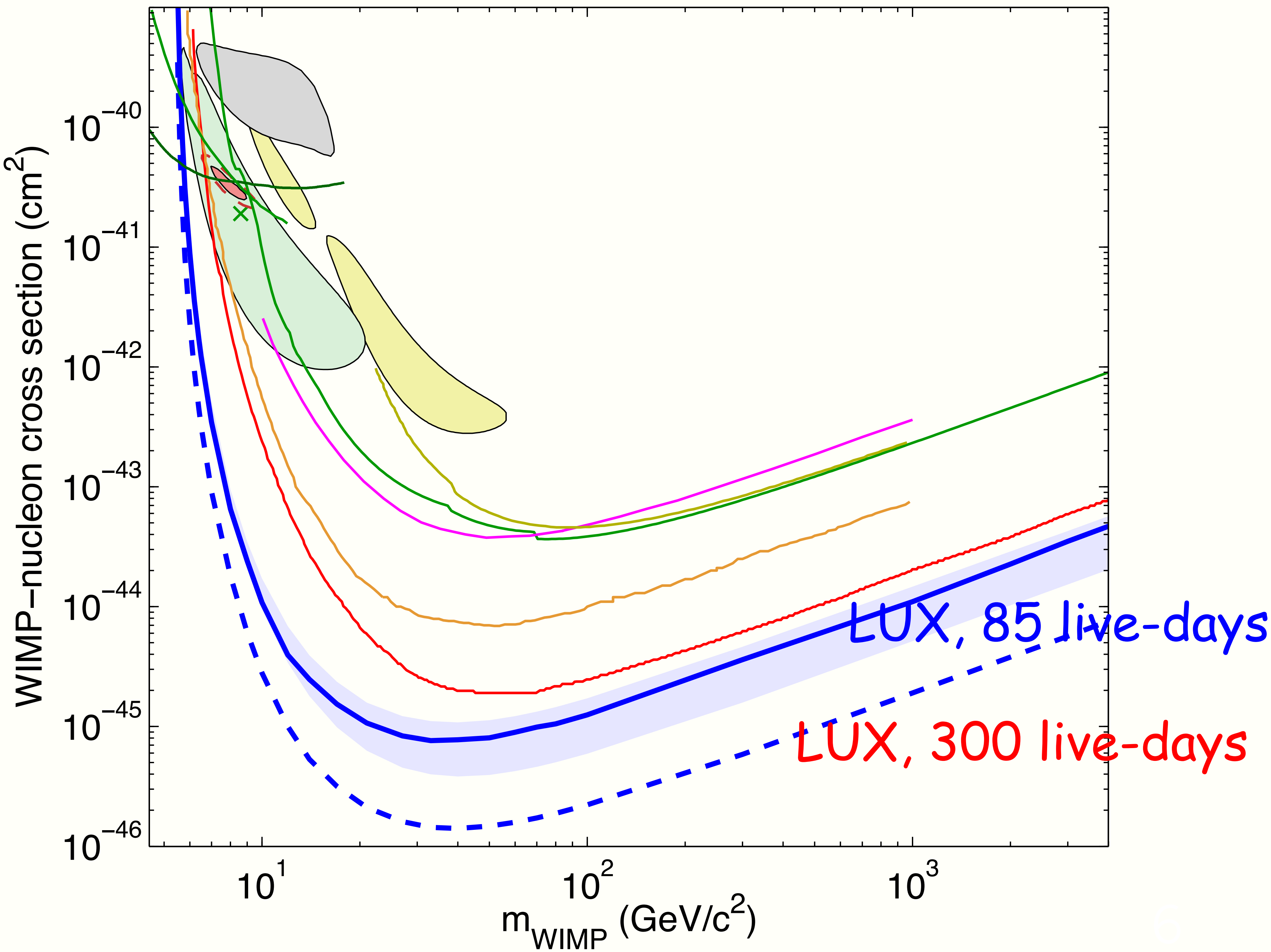
XMASS



XMASS-I is ongoing since 2010
835kg xenon
100kgFV

H Ogawa - 3+1 liquid Xe experiments

Current Limits: the LUX experiment

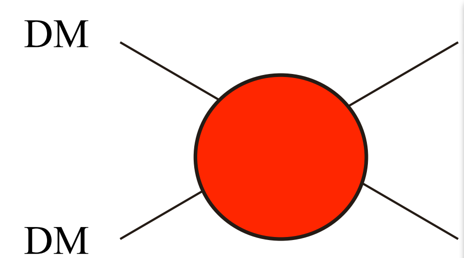


Mani Tripathi

Indirect dark matter searches through gamma-rays

DM self-annihilation rate :

$$\Gamma_{\rm DM} \approx \sigma v \frac{\rho^2_{\rm DM}}{m^2_{\rm DM}}$$



SM: b, W^+, Z, μ^+

Primary channels

SM: $\bar{b}$, W^-, Z, μ^-

Hadronisation and/or decay

=> γ, $e^\pm$, p, ν

Final states

=> γ, $e^\pm$, $\bar{p}$, $\bar{\nu}$

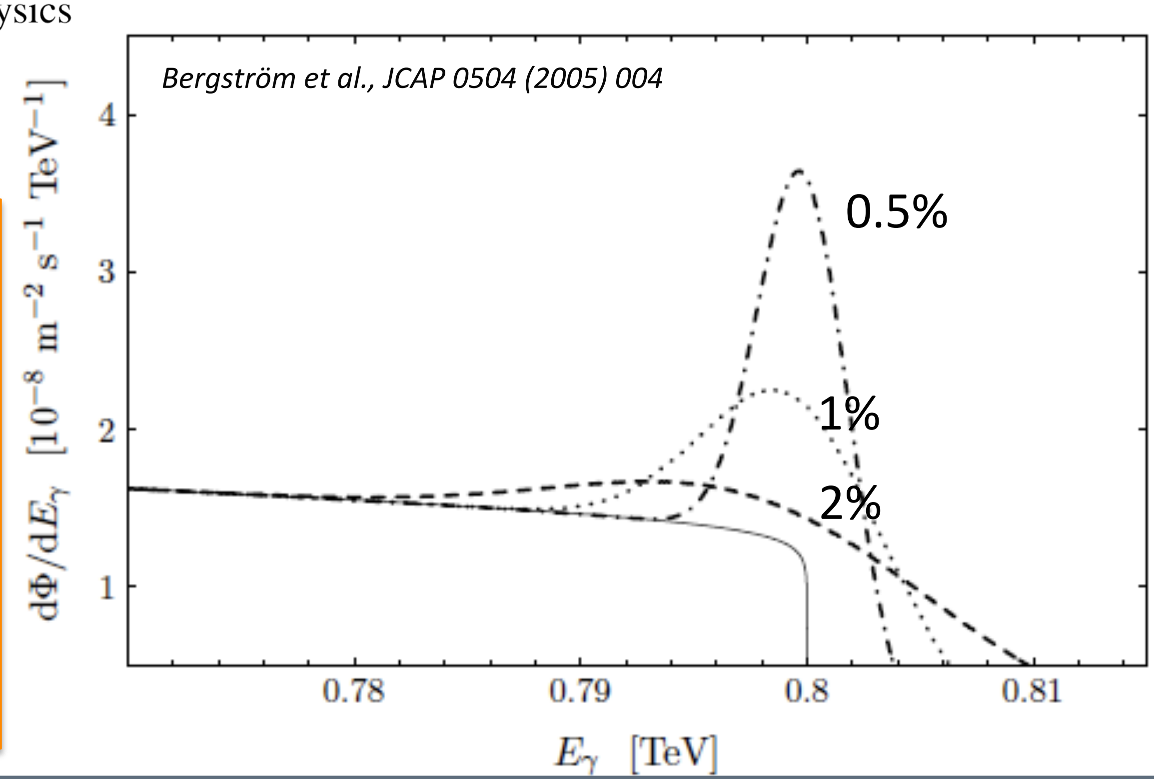
Gamma-ray flux from annihilation of a WIMP:

$$\frac{d\Phi_\gamma(\Delta\Omega, E_\gamma)}{dE_\gamma} = \frac{1}{8\pi} \underbrace{\frac{\langle\sigma v\rangle}{m^2_{\rm DM}} \frac{dN_\gamma}{dE_\gamma}}_{\text{Particle Physics}} \times \underbrace{\bar{J}(\Delta\Omega)\Delta\Omega}_{\text{Astrophysics}} \quad {\rm cm^{-2}s^{-1}GeV^{-1}}$$

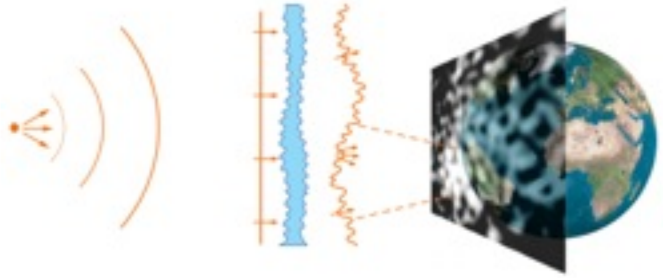
where

Gamma spectrum:

- typically a continuum with an energy cut-off at the DM particle mass
- Mono-energetic line signal :
  - $\chi\chi \rightarrow \gamma\gamma$, γZ : line at or close to DM particle mass
  - $\chi\chi \rightarrow$ ll, WW: Internal Bremsstrahlung



A Viana - link DM to GRA



Search for missing baryons through interstellar scintillation

A&A 412, 105-120 (2003):
Does Transparent Hidden Matter Generate Optical Scintillation?
A&A 525, A108 (2011):
Results from a test with the NTT-SOFI detector
A&A 552, A93 (2013) :
Simulation of Optical Interstellar Scintillation

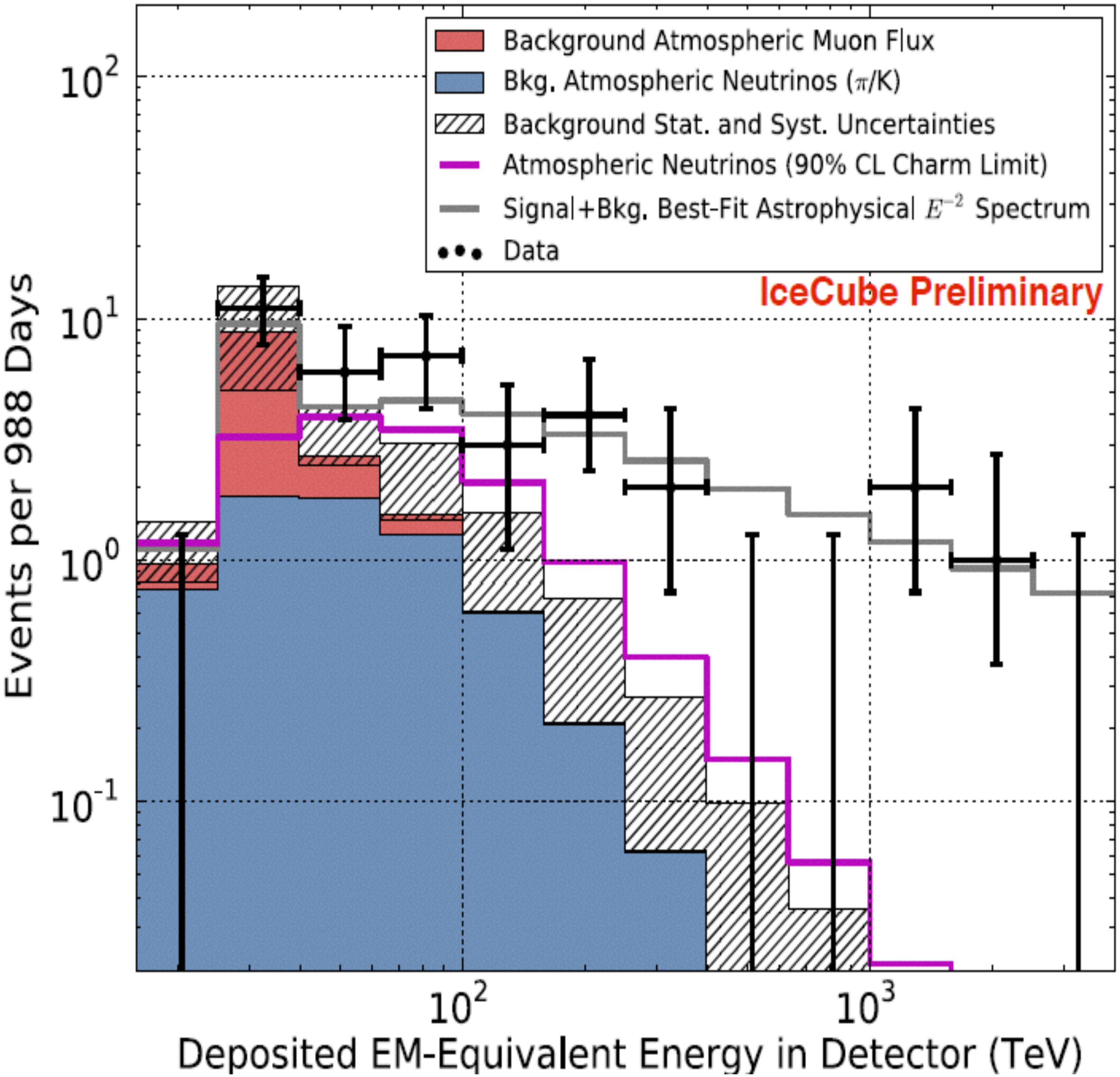
Marc MONIEZ, IN2P3, CNRS
Farhang HABIBI, IPM
Reza ANSARI, IN2P3, P11 U.
Sohrab RAHVAR, Sharif U.

Quy Nhon
8 august 2014

Neutrinos

- Two identified astronomical sources at low energies - our Sun and SN1987a
- Recent detection of VHE neutrinos of extraterrestrial origin by Icecube - very exciting!
- Interesting limits on GZK neutrinos already
- Cosmological bounds on neutrino masses
- Technique works and is well understood - just need bigger experiments!

Extraterrestrial neutrino search with starting events



- atmospheric background $13.0^{+7.2}_{-4.5}$
- **Inconsistent with background only model** at 4.1σ with 28 events (science 2013) and 5.7σ with additional 7 events (preliminary)
- Event features (reconstructed energy, zenith angle and topology) **consistent with background + astrophysical ($\phi_{astro} \propto E^{-2}$) fluxes**

- **Best fit flux** $E^2\phi$=**(**0.95±0.3)x10^{-8} [GeV cm^{-2} s^{-1} sr^{-1}] with a hard cut off around 2.0 PeV or a softer spectra with a spectral index γ=2.3±0.3

Conclusions and plans

- ANTARES – the first undersea Neutrino Telescope. It is in its 7th year of operation.
- Despite its moderate size, but thanks to its location and excellent angular resolution it is yielding:
  - Diffuse flux sensitivity in the relevant range
  - Best limits for the Galactic Centre and the Fermi bubble regions
- The measurements can be improved:
  - It is planned to run during 2015 and, probably, longer
  - More data are already collected and not analyzed yet
  - Joint track and shower analyses are in development
- Prepare for the next generation Mediterranean neutrino telescope – KM3NeT

ANTARES diffuse flux searches (V. Kulikovskiy) VHEPU 3-9 August 2014 16

V Kilikovskiy - status of Antares

Conclusions

- A Galactic origin of the neutrinos observed by IceCube cannot be ruled out

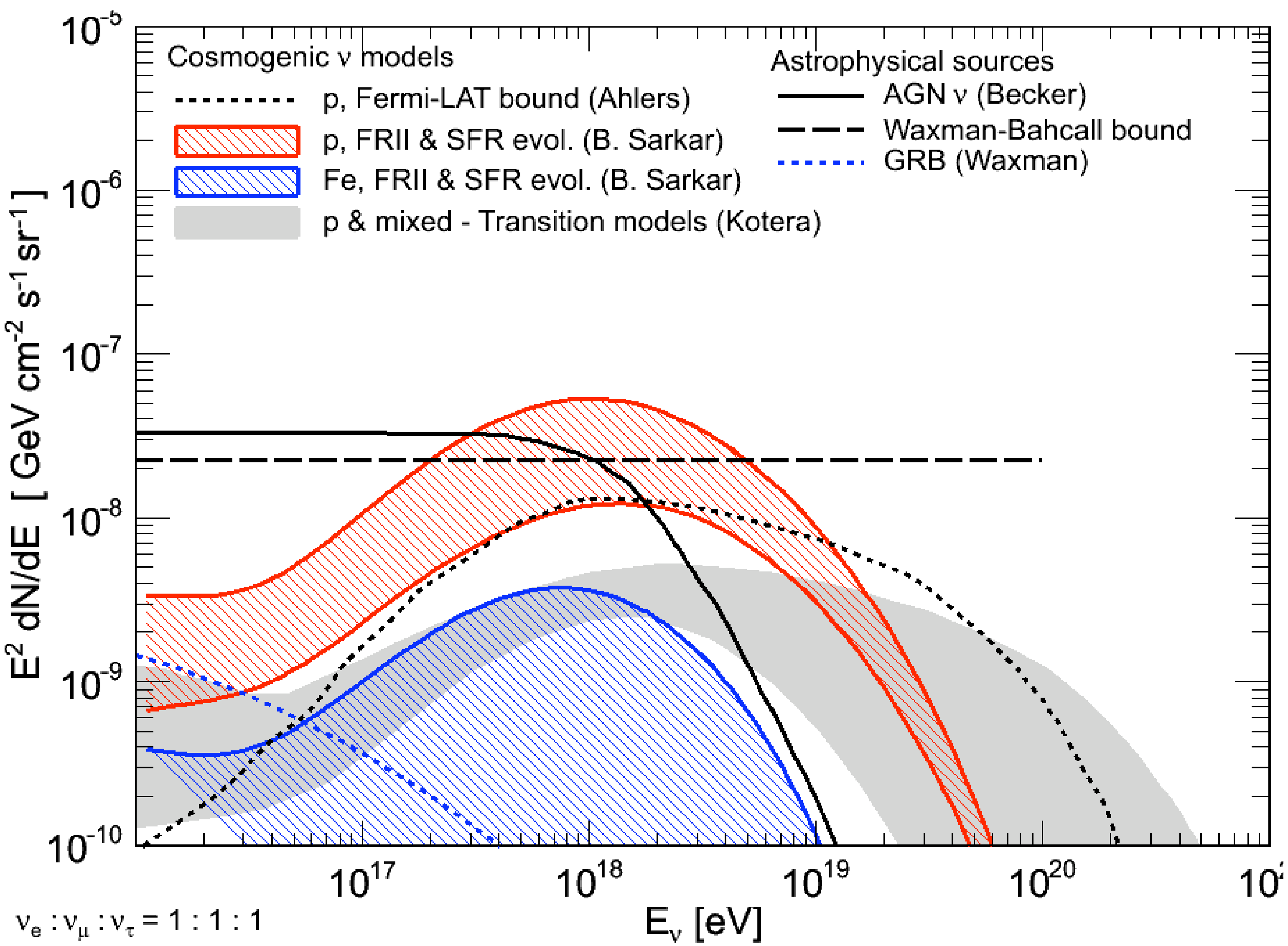
- The expected Galactic plane emission can be outshone by the Galactic halo, provided the halo is sufficiently big and contains sufficient target material

- The Fermi bubbles may be an indicator of cosmic ray outflow following Galactocentric activity

- Such a scenario leads to the dumping of cosmic rays into the halo for them to live out their days

Andrew Taylor

UHECR Composition and UHE Neutrinos



- Strong dependence of the EeV-cosmogenic flux with the CR composition at UHE
- Observation or non-observation of EeV-neutrinos would be an indirect tool to understand the CR composition at UHE

O Deligny - search for UHE neutrinos

Summary and perspectives

✓ANTARES : Most sensitive neutrino telsecope in the TeV-PeV range seeing the southern sky

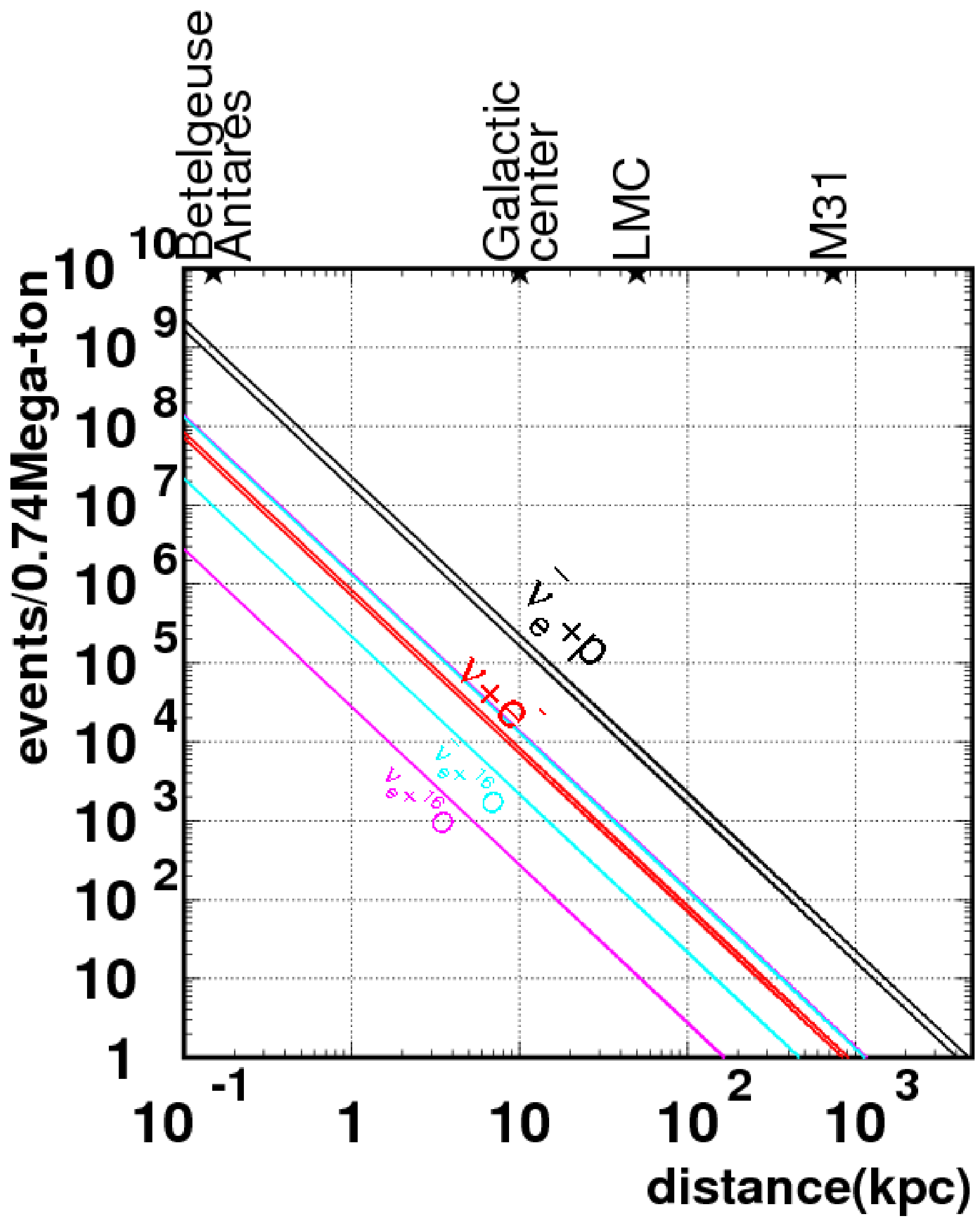
⇒ No cosmic signal yet (but taking data until end 2016)

✓ Many coincident searches with other messengers (E.M., G.W., ...)

Off-line : GRBs, X-ray binaries, blazars, unknowns

On-line : optical and gamma follow-up

Supernova events at Hyper-Kamiokande



~200,000 $\bar{\nu}_e$+p events
7,000~8000 ν+e events
~10,000 $\overset{(-)}{\nu}_e$+^{16}O events

for 10 kpc supernova

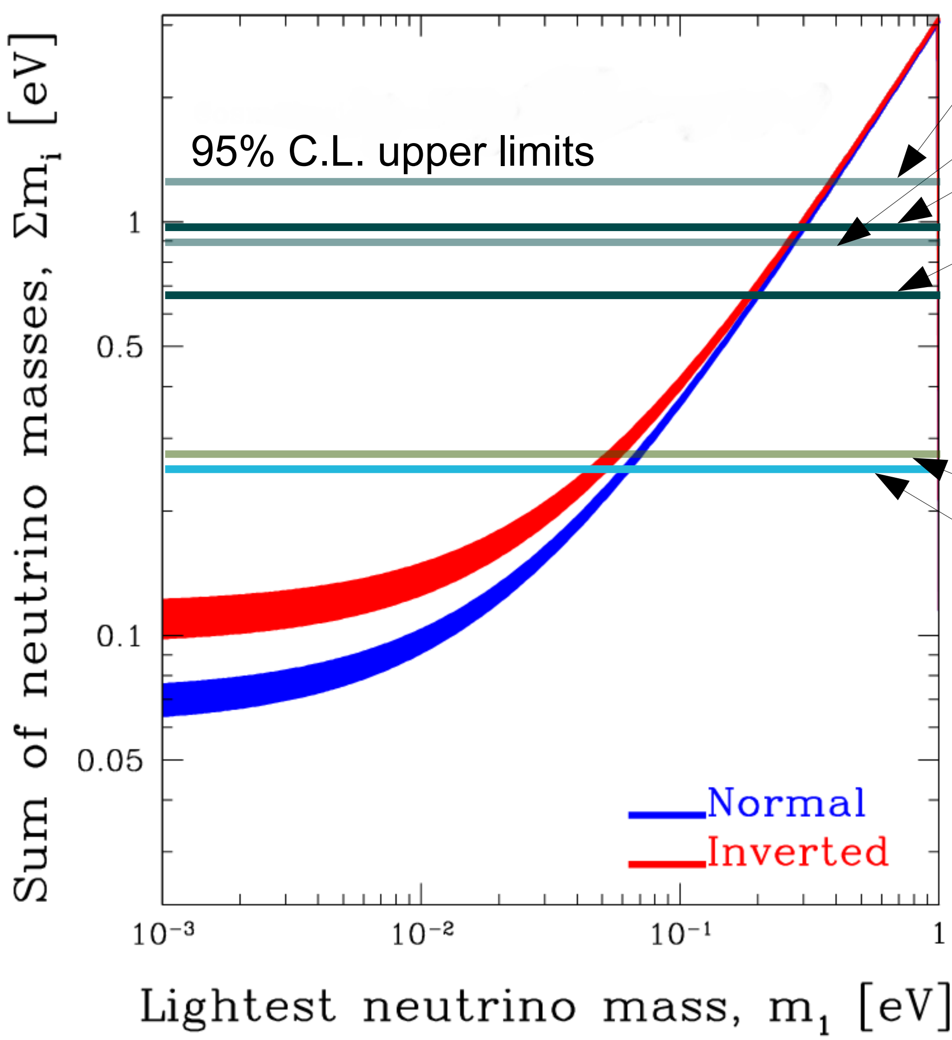
30~50 events even for M31 supernova

Each band covers, no osc., N.H. and I.H. cases

M Nakahata - SN detection potential

Post-Planck...

Ade et al.[Planck] 2013



ΛCDM+neutrino mass (7 parameters)

WMAP (9 years)

W9 + ACT

Planck + WMAP Polarisation

Planck + WP + ACT ℓ > 1000 + SPT ℓ > 2000

$$\sum m_\nu < 0.66 \text{ eV} \quad (95\% \text{C.L.})$$

Best CMB-only bound

W7+ matter power spectrum + HST H_0

Planck + WP + (ACT ℓ > 1000 + SPT ℓ > 2000)
+ baryon acoustic oscillations

$$\sum m_\nu < 0.25 \text{ eV} \quad (95\% \text{C.L.})$$

Best minimal bound

Dropping assumption of spatial flatness:

$$\sum m_\nu < 0.32 \text{ eV} \quad (95\% \text{C.L.})$$

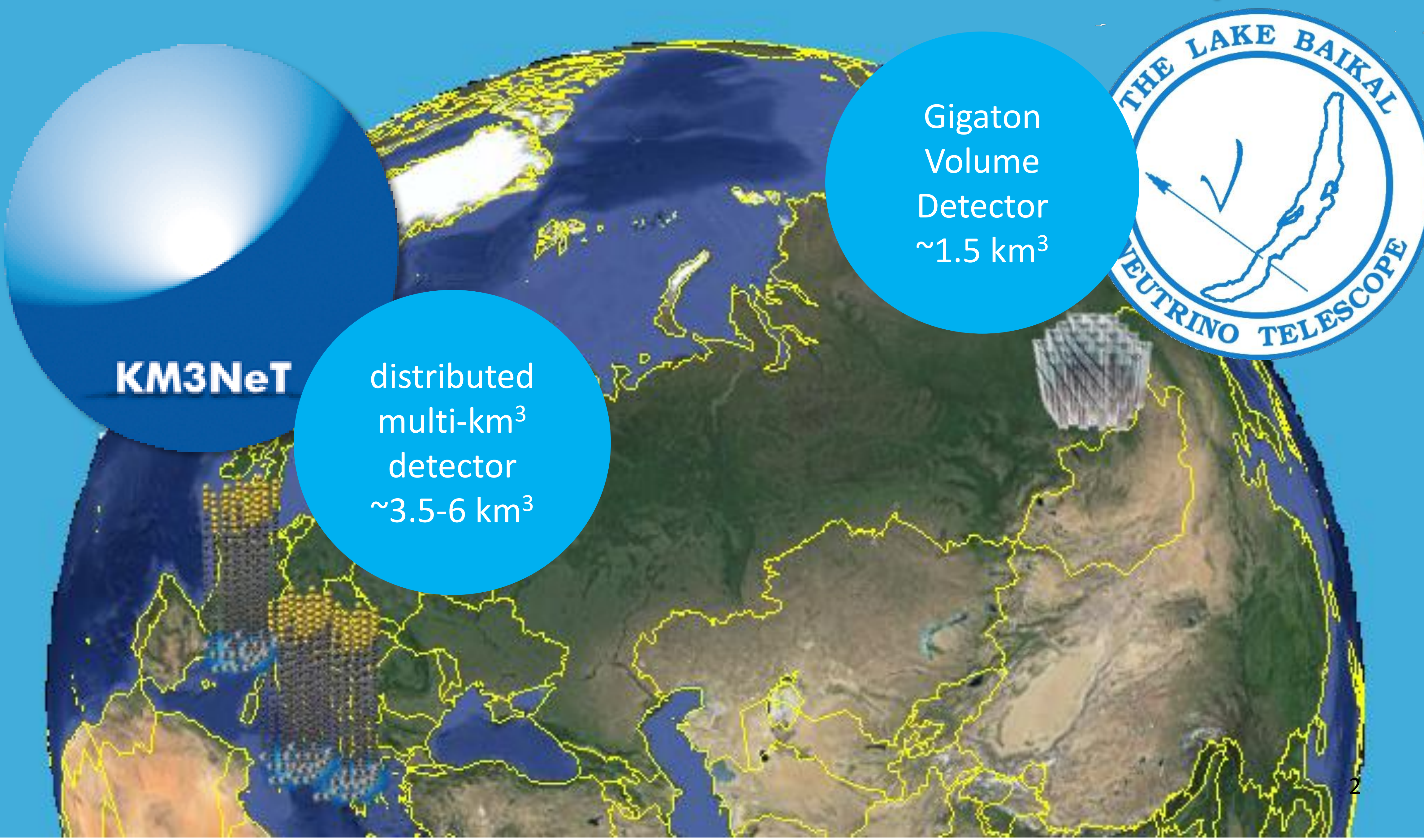
Other extensions?? Still to be checked!

Y Wong - links to precision cosmology

The Future…

- KM3NeT
- GVD
- ORCA
- PINGU

KM3NeT and GVD
New Northern Neutrino Telescopes

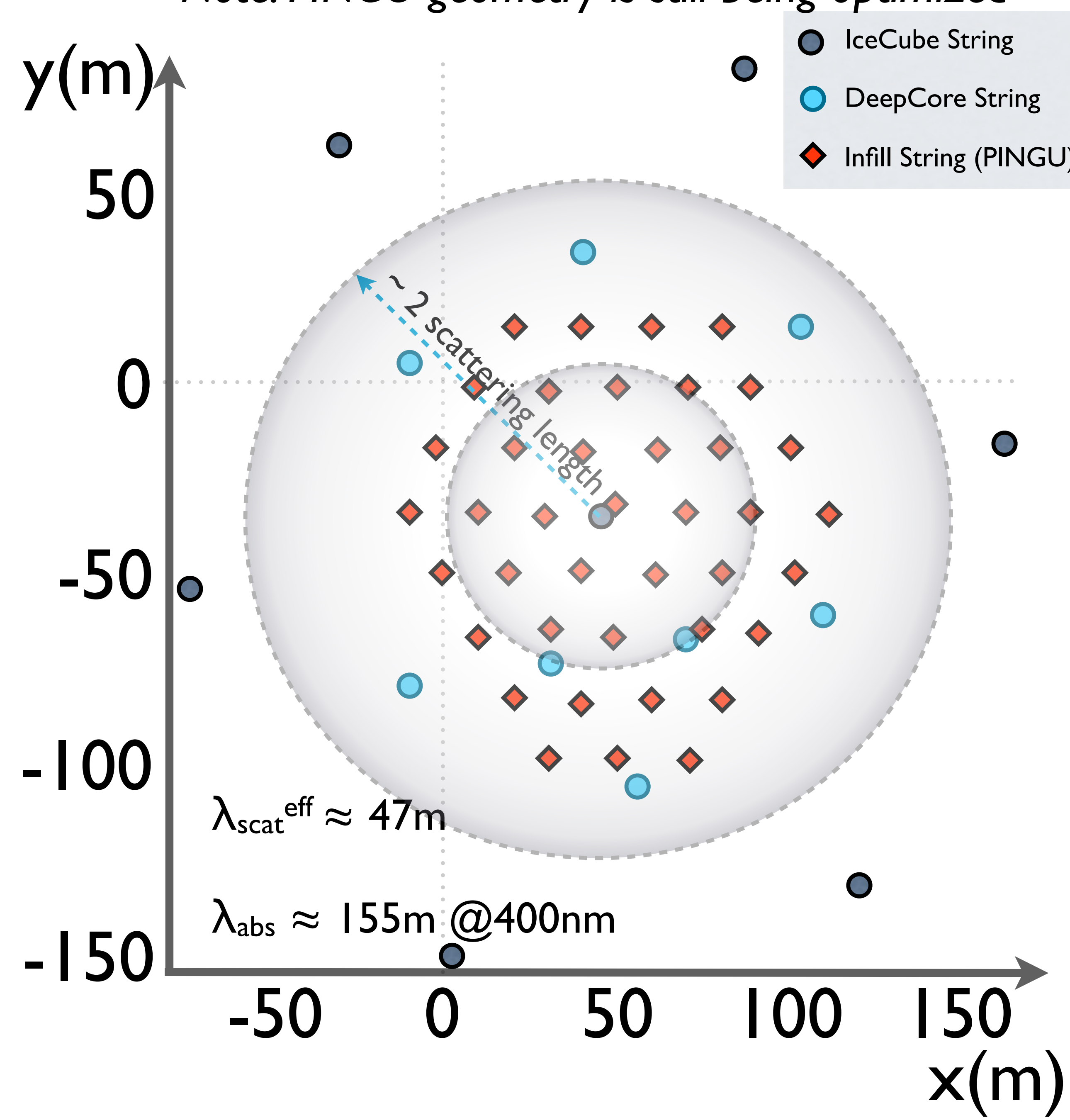


PINGU - Precision IceCube Next Generation Upgrade

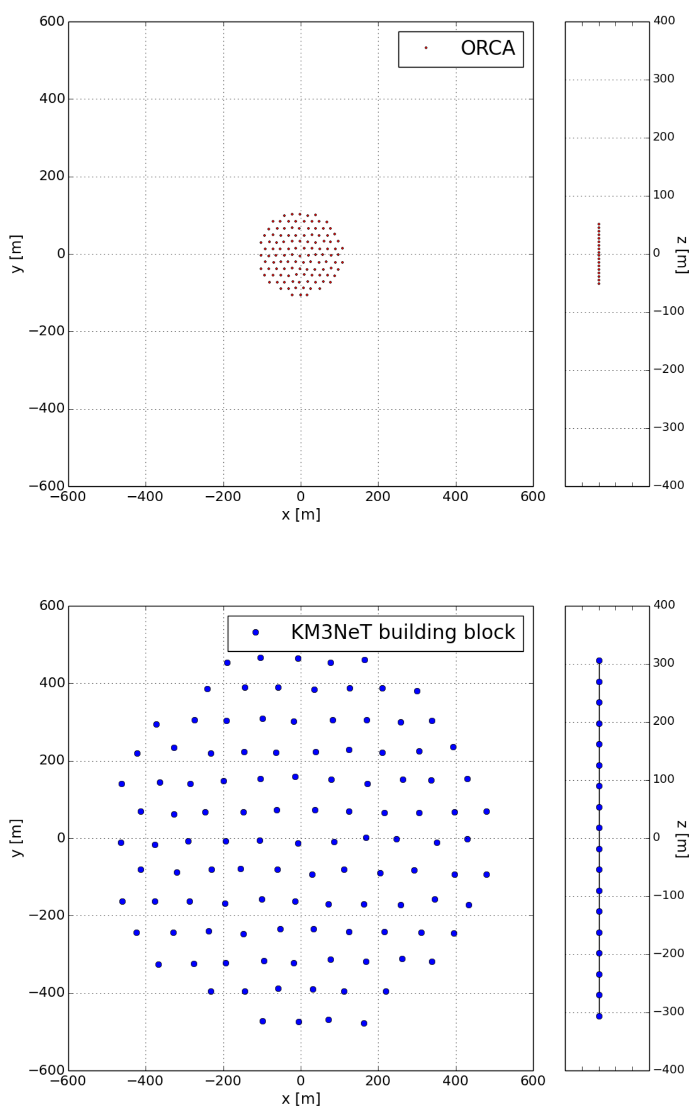
- PINGU upgrade plan
  - Instrument a volume of about 5MT with ~40 strings each containing 60-100 optical modules
  - Rely on well established drilling technology and photo sensors
  - Create platform for calibration program and test technologies for future detectors
- Physics Goals:
  - Precision measurements of neutrino oscillations (mass hierarchy, ...)
  - Test low mass dark matter models

An example PINGU geometry (40 strings)

Note: PINGU geometry is still being optimized



ORCA within KM3NeT



ORCA is part of the KM3NeT research infrastructure:

- Same technology
- (Much) more compact detector
- Few GeV energy threshold

Aimed at studying neutrino properties through oscillations:

- neutrino mass hierarchy
- mixing parameters

But also supernovae, dark matter, …

07/08/2014 Salvatore Galatà VHEPU, Quy Nhon 2

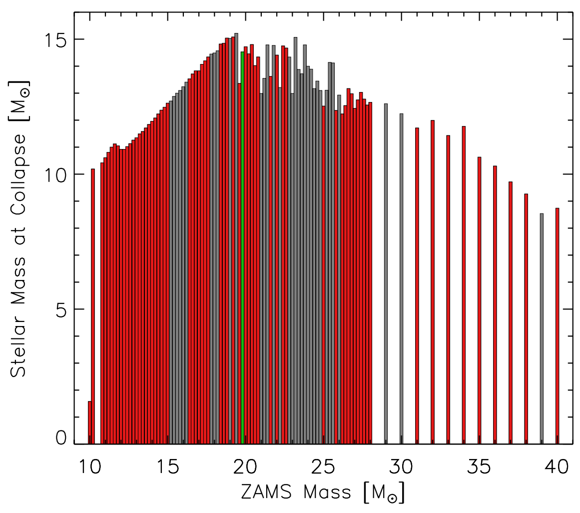
S Galata

Multi-Messenger

- Eclectic mix of talks
  - Numerical simulations
    - Core collapse SNRs
    - Neutron star coalescence
  - GRW observatories
  - Time-like extra dimensions?
  - Bring back the ether?

Open questions...

- Why / How do massive stars explode?
- What are the properties of the final compact object at the center?
- How / Where do heavy elements form?
- What are observable signals?
- What can we learn for fundamental physics?



Ugliano et al. 2012

Growing number of groups:

MPA Garching (H.-T. Janka), Princeton (A. Burrows), Oak Ridge (T. Mezzacappa), Univ. Basel (M. Liebendörfer), Tokyo (S. Yamada), NAOJ/Fukuoka (K. Kotake), Caltech (C. Ott), Los Alamos (C. Fryer), France (T. Foglizzo), Univ. Valencia (M.-A. Aloy), ...

l'Observatoire de Paris | LUTH
Laboratoire Univers et Théories

Conclusions

- NR can reliably evolve compact binaries
- PN results good for early inspiral of BHs, NSs
- NR needed for merger
- BHs, NSs important source of GWs
- Some goals of GW physics:

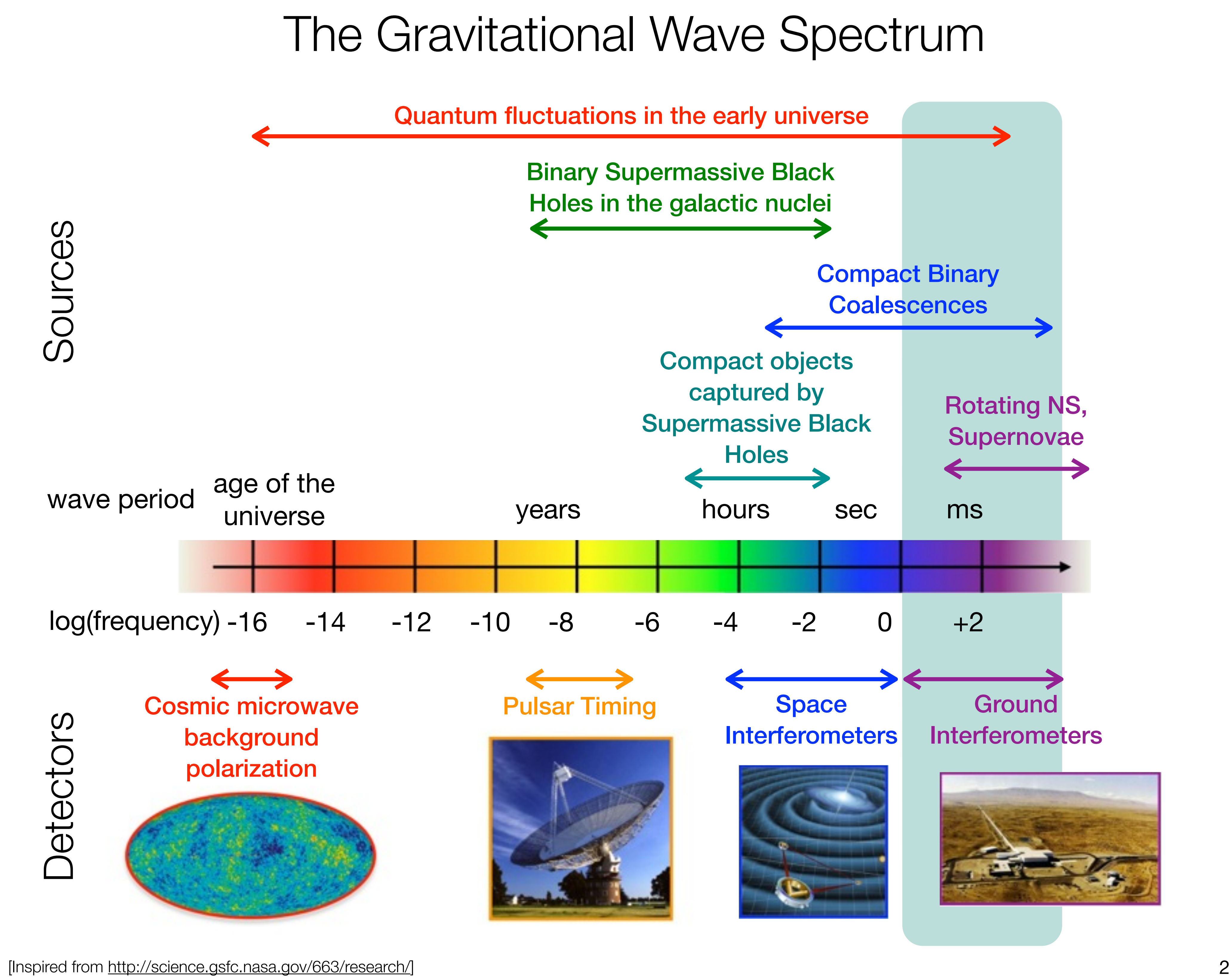
  EOS of NS matter, Standard Sirens, BH formation
- Astrophysical studies: BH Kicks, Elm. signatures
- Other physics: *TeV* Gravity, AdS/CFT, Fundamental physics

U Sperhake - Merging BHs now accessible to NR

Concluding Remarks

- LIGO-Virgo instrument progress is accelerating!
  - One instrument functioning beyond previous sensitivity limits
  - Next observing run planned for next year!
- Multi-messenger astronomy with gravitational waves will be a challenging but rewarding prospect: Gravitational-wave astronomy looks to partner observations with electromagnetic and particle observatories; joint observations to explore questions in current astrophysics as well as open new avenues
- **Given current understanding/uncertainty of standard candle sources (like binary neutron stars) a detection(s) is ≤ 3 years away**

C Pankow



V Raymond - Good discovery potential

VERY HIGH ENERGY PHENOMENA IN THE UNIVERSE 2014

A duality between the emission of micro-gravitational waves and Quantum Mechanics

Vo Van Thuan

Vietnam Atomic Energy Institute (VINATOM)
and
The Office of the State NEPIO for NPP

thuanvova@gmail.com & thuanvv@moit.gov.vn

Quy Nhon, August 3rd - 9th, 2014.

Conclusions

- Exciting results and potential in all thematic areas
- Strong cross connections
- Very good and useful conference

The warning

"For any complex physical phenomenon there is a simple, elegant, compelling, wrong explanation."

Thomas Gold, 1920-2004, Austrian-born astronomer at Cambridge University and Cornell University

From talk by Paolo Gondolo

Rất cám ơn đã tổ chức một cuộc họp tốt và khoa học thú vị!