Max-Planck-Institut für Physik
(Werner-Heisenberg-Institut)

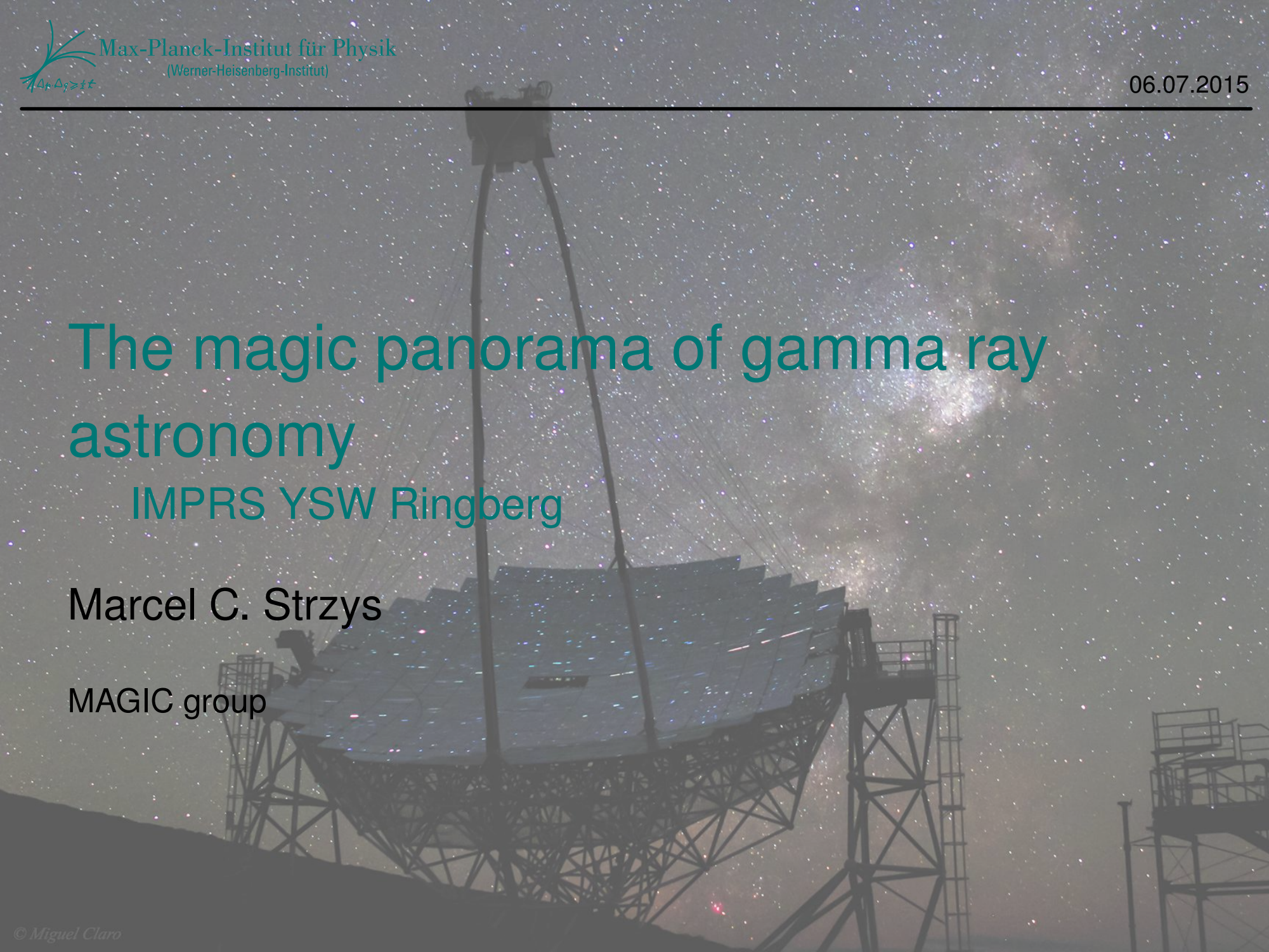
06.07.2015

The magic panorama of gamma ray astronomy

IMPRS YSW Ringberg

Marcel C. Strzys

MAGIC group



MAGIC, cool, but what are they really doing ...

How it started

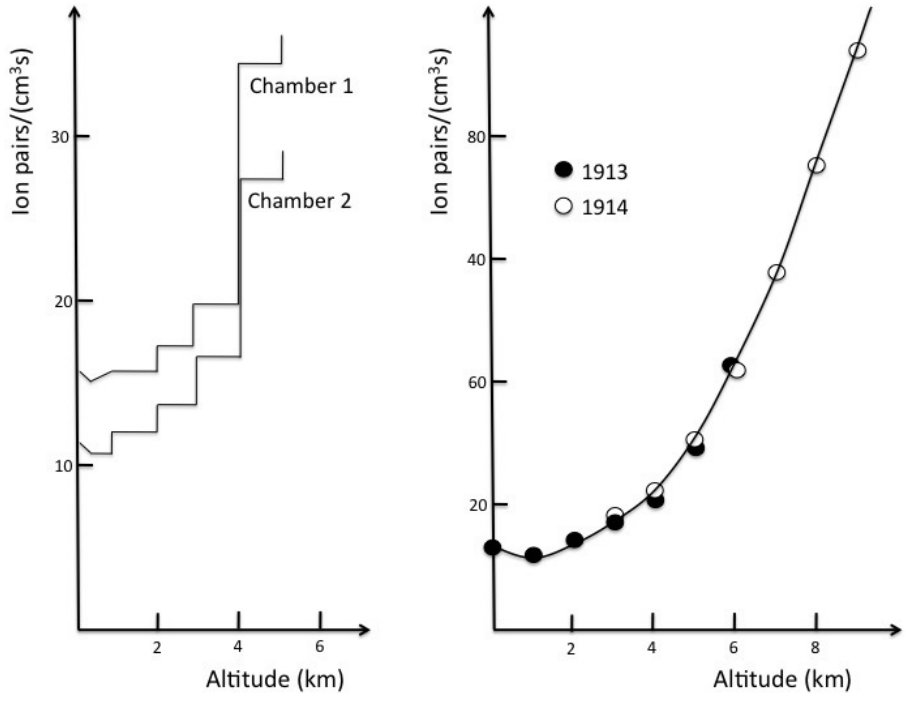
How it started

- 1912/1913 Victor Hess and Werner Kolhörster performed balloon flights to measure ionisation in high altitude

[Wikipedia]

How it started

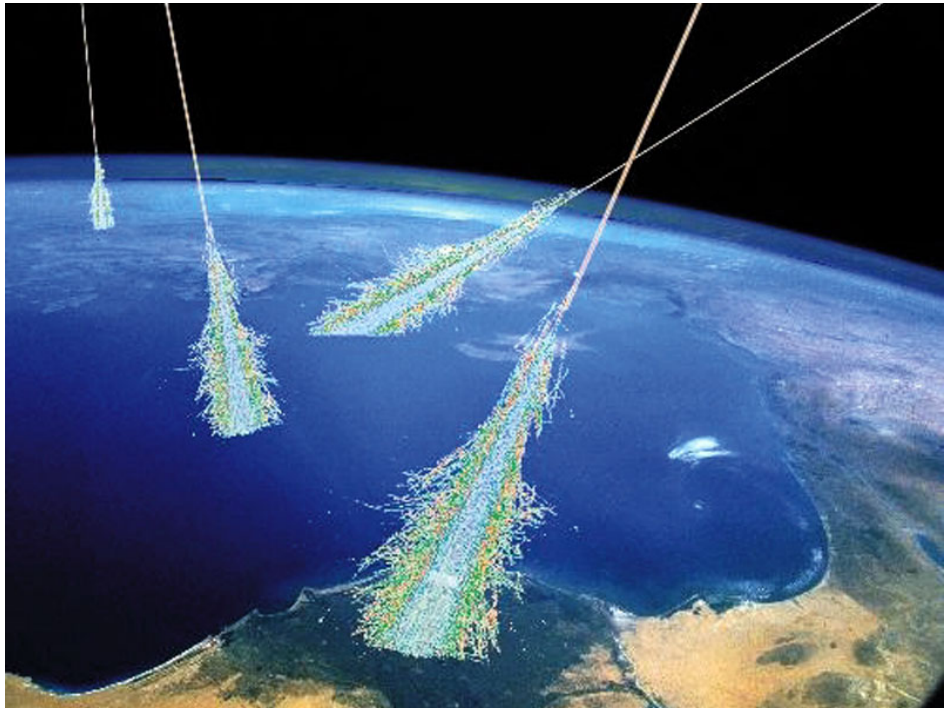
- 1912/1913 Victor Hess and Werner Kolhörster performed balloon flights to measure ionisation in high altitude
- Ionisation increases with altitude $\Rightarrow$ radiation from space



[Wikipedia]

How it started

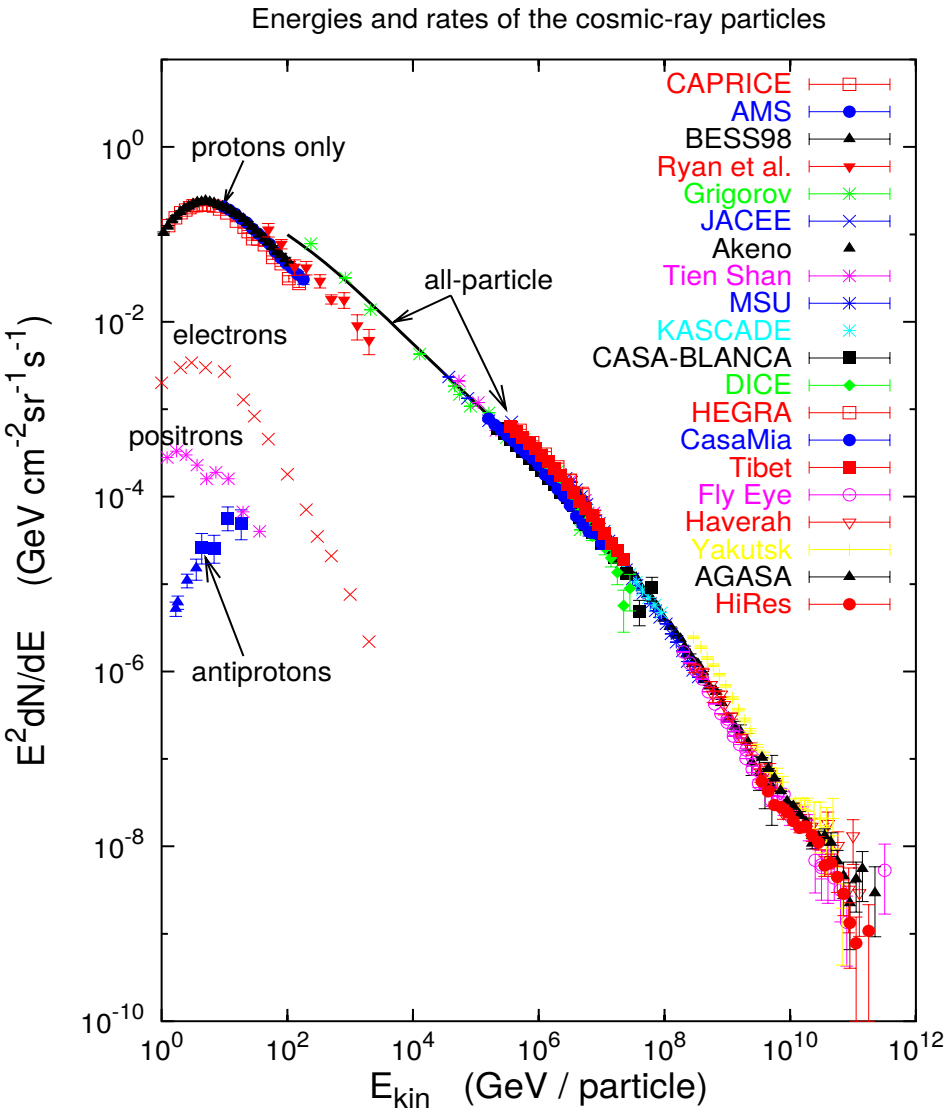
- 1912/1913 Victor Hess and Werner Kolhörster performed balloon flights to measure ionisation in high altitude
- Ionisation increases with altitude $\Rightarrow$ radiation from space
- “While you read this 50 cosmic rays pass through your head.”



[science.nasa.gov]

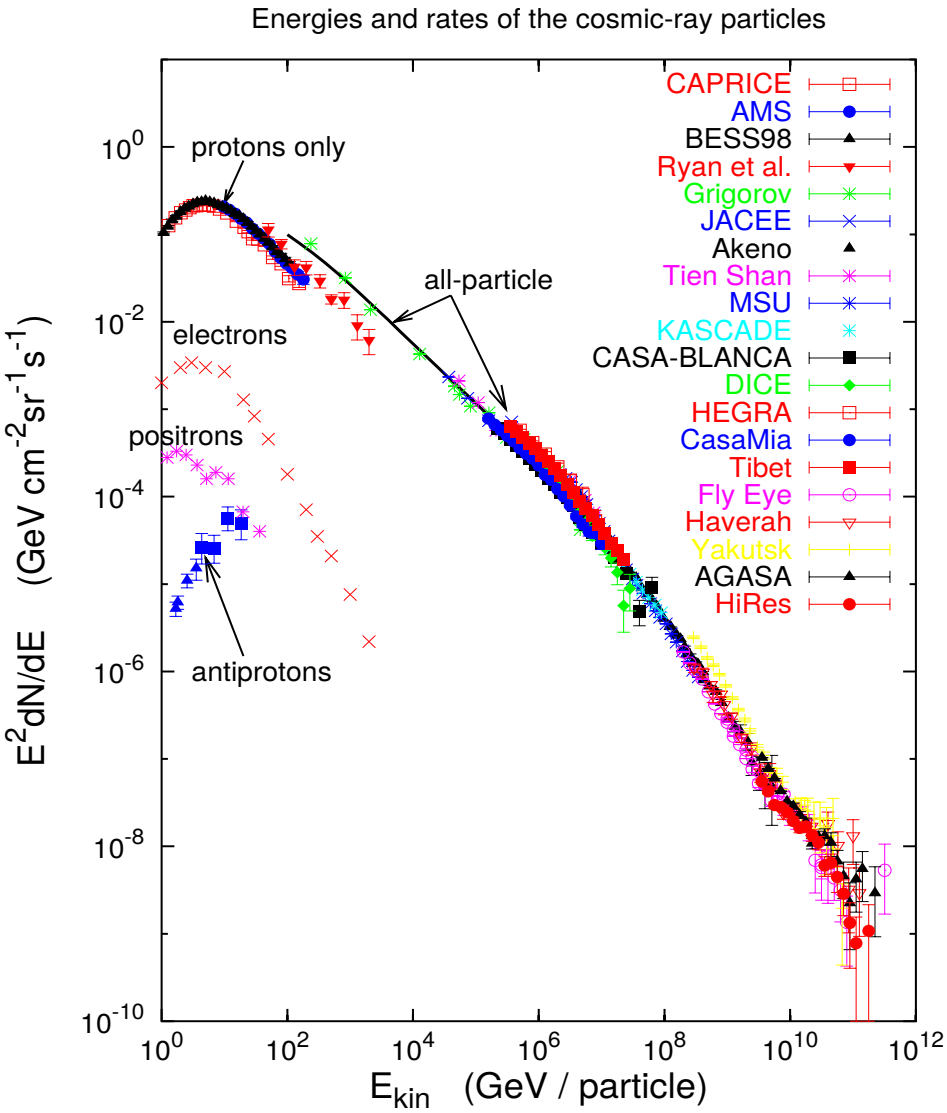
The whole picture

- Which sources provide enough energy to produce particle flux?



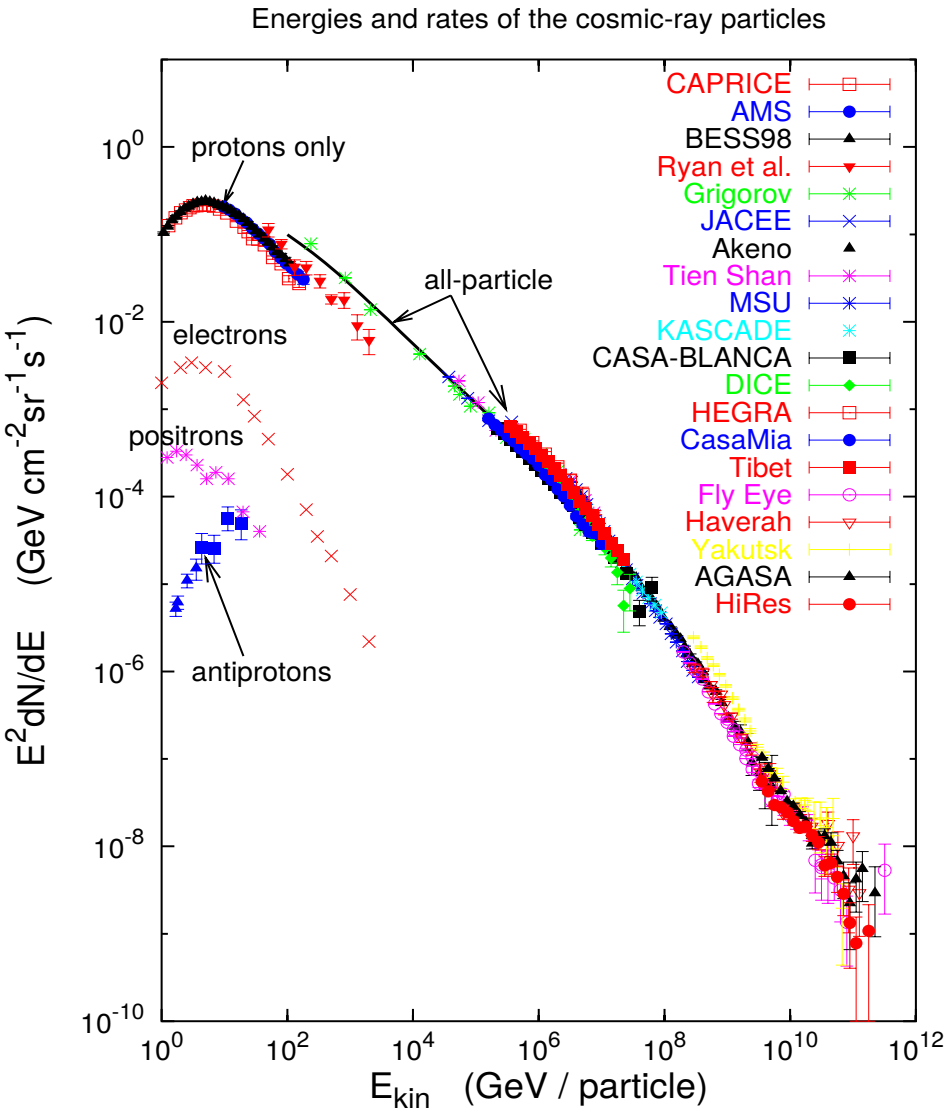
The whole picture

- Which sources provide enough energy to produce particle flux?
- How can the form of the spectrum be produced (power law + max energy)?

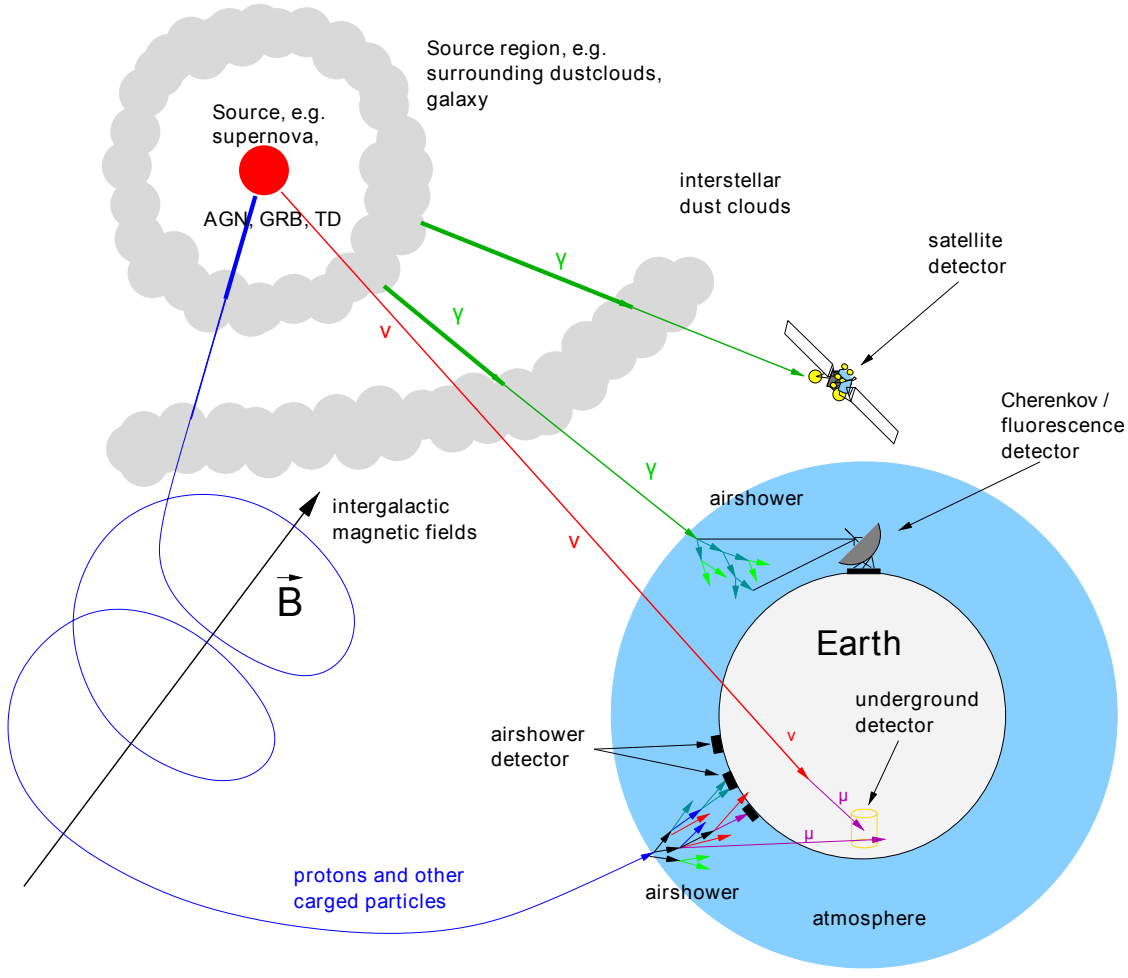


The whole picture

- Which sources provide enough energy to produce particle flux?
- How can the form of the spectrum be produced (power law + max energy)?
- How can the composition of the CRs be met?

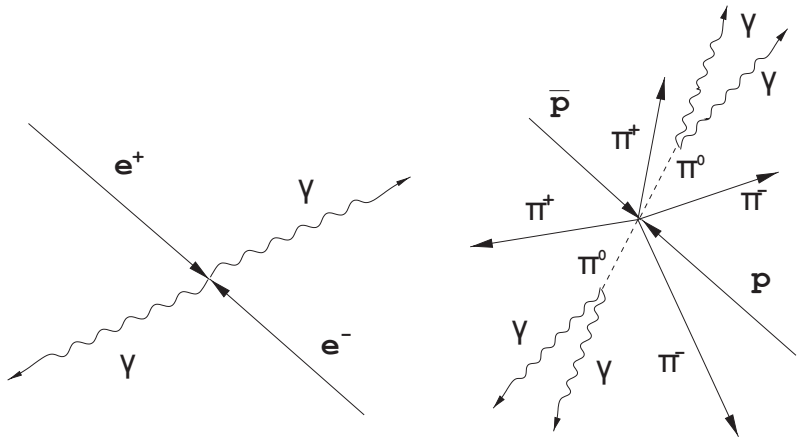


Difficulties with charged Particles

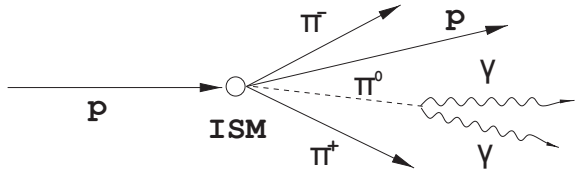


[Wagner2006]

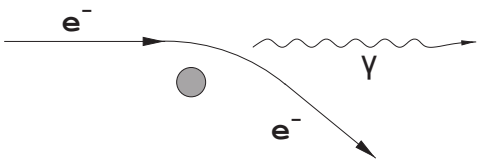
Where CRs, there are γ-rays



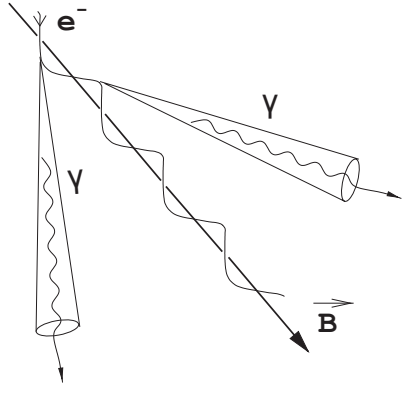
a) Annihilation



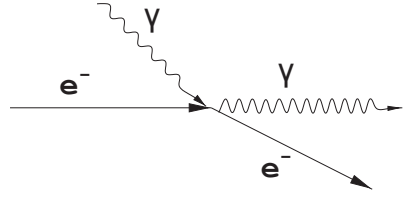
b) CR - ISM scattering



c) Bremsstrahlung



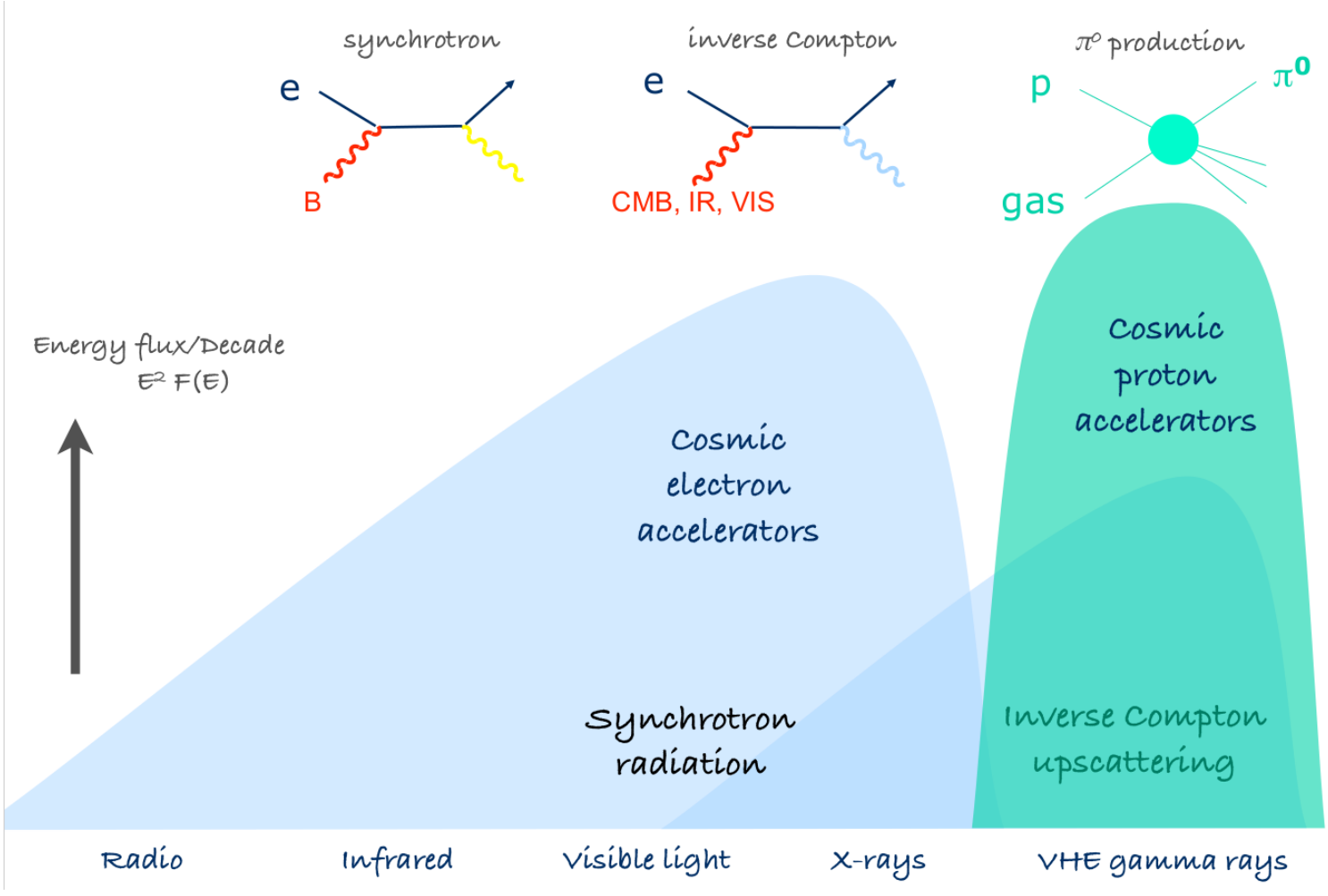
d) Synchrotron radiation



e) Inverse Compton effect

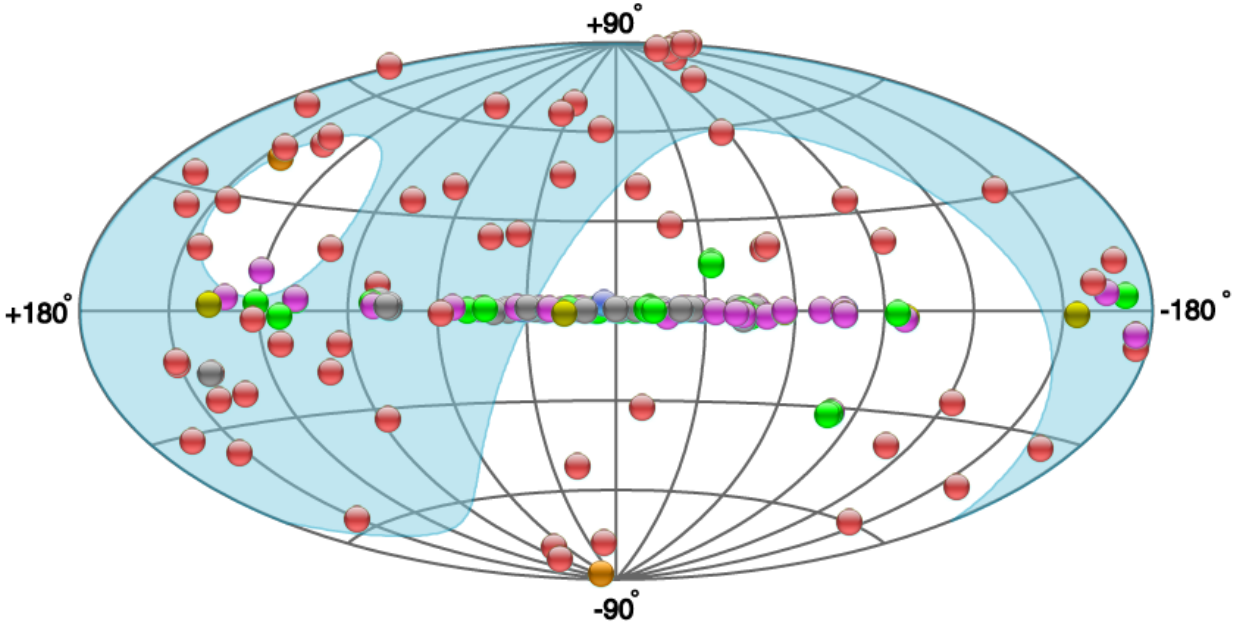
[Tonello2005]

But γ-rays have some difficulties



[Knapp2013]

Today's γ-ray sky



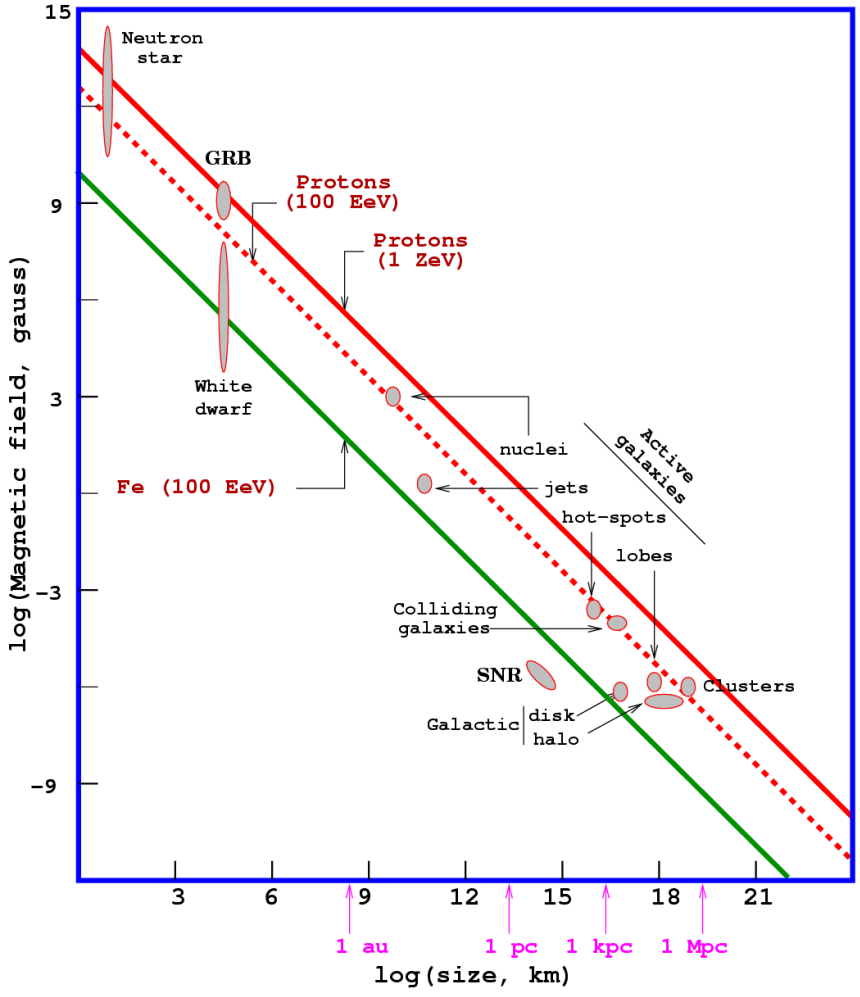
Source Types

- PWN
- Binary XRB PSR Gamma BIN
- HBL IBL FRI FSRQ Blazar LBL AGN (unknown type)
- Shell SNR/Molec. Cloud Composite SNR Superbubble
- Starburst
- DARK UNID Other
- uQuasar Star Forming Region Globular Cluster Cat. Var. Massive Star Cluster BIN BL Lac (class unclear) WR

[http://tevcat.uchicago.edu/]

Which source is the right one?

Hillas-plot
(candidate sites for E=100 EeV and E=1 ZeV)



$E_{max} \sim$ ZBL (Fermi)

$E_{max} \sim$ ZBL Γ (Ultra-relativistic shocks-GRB)

Pulsars & Pulsar Wind Nebulae

- 38 PWN discovered in γ-rays & 2 Pulsars

[apod.nasa.gov]

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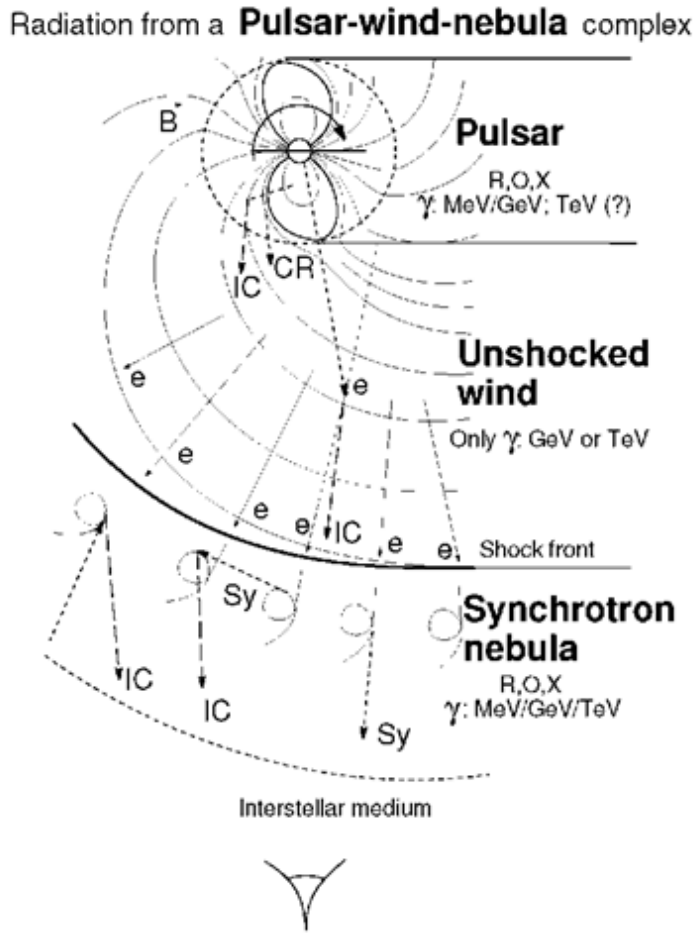
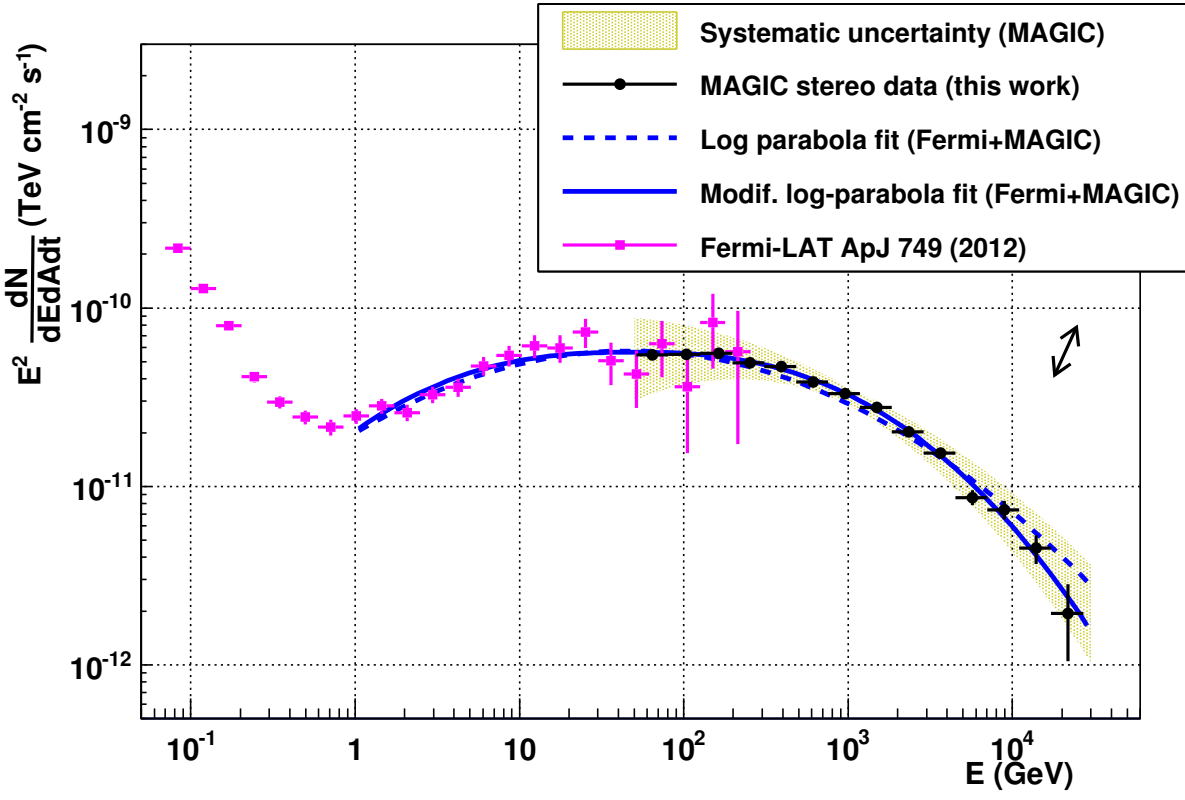
- 38 PWN discovered in γ-rays & 2 Pulsars
- difficult environment



[Aharonian2004]

Pulsars & Pulsar Wind Nebulae

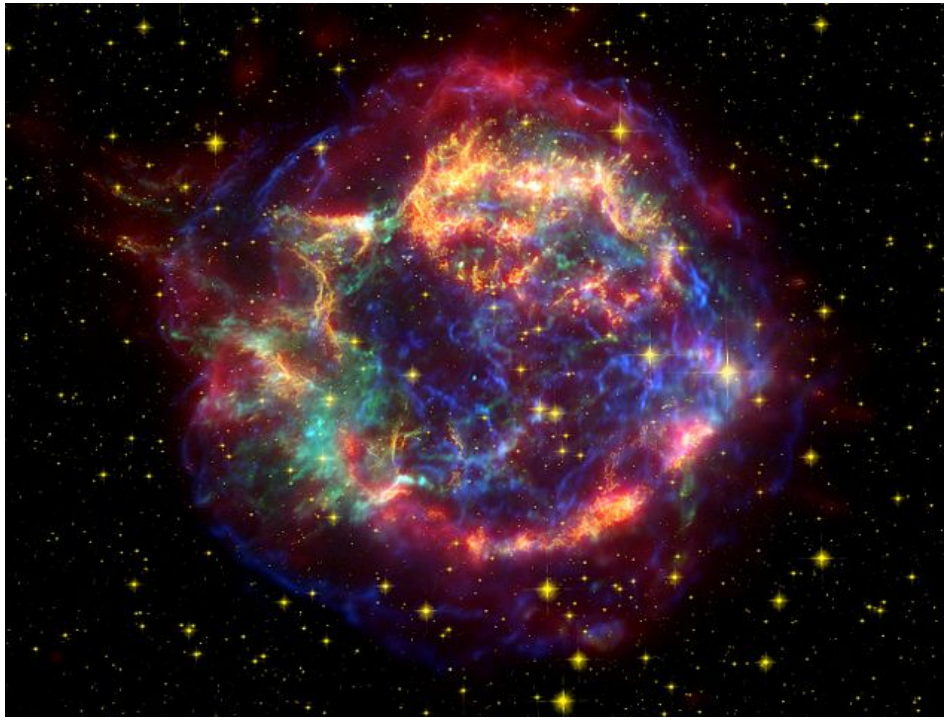
- 38 PWN discovered in γ-rays & 2 Pulsars
- difficult environment
- Very likely leptonic accelerators



[J.High Energ.Phys.2015]

The SNR paradigm

- Baade & Zwicky 1934: SNR provide enough energy (10% of energy into CRs + 3 SN/century)



[NASA/JPL-Caltech]

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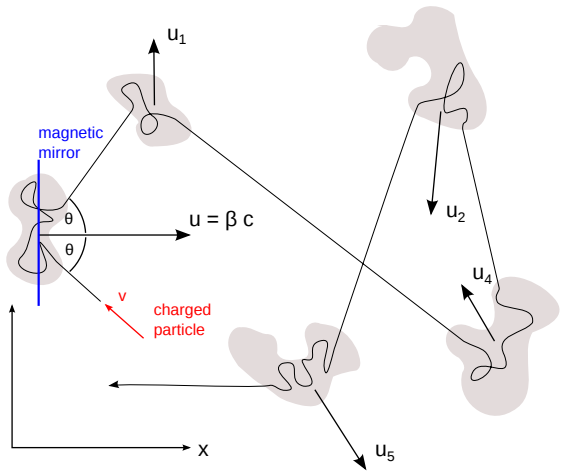

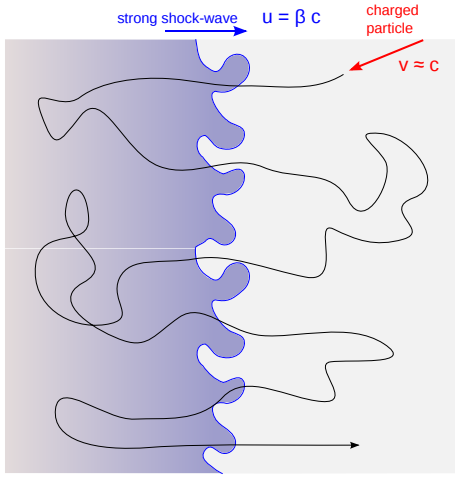

[Fruck2015]

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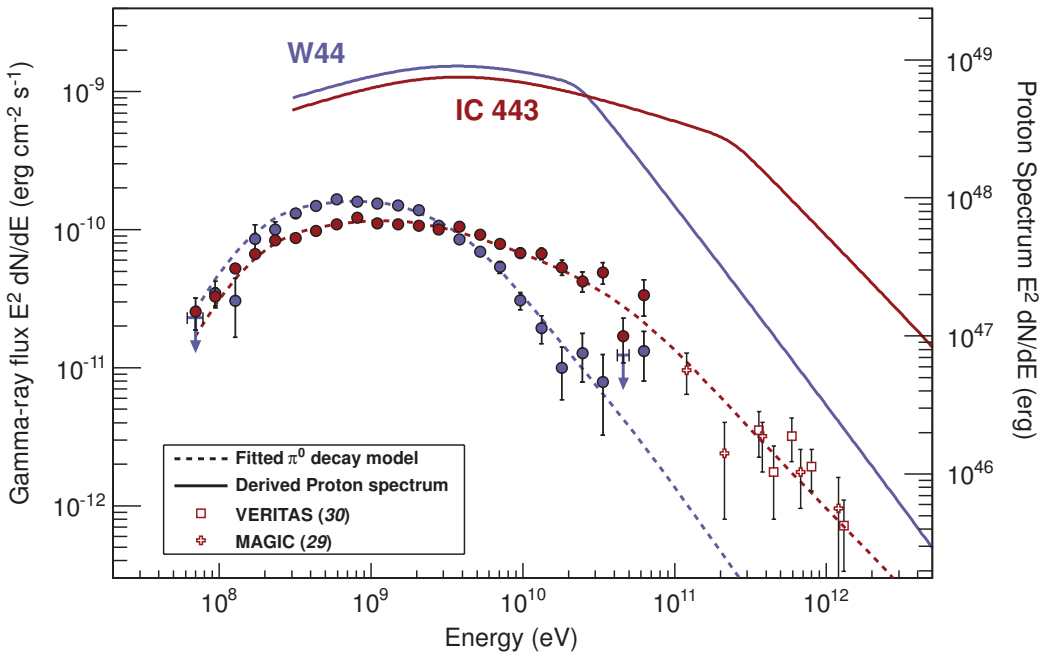
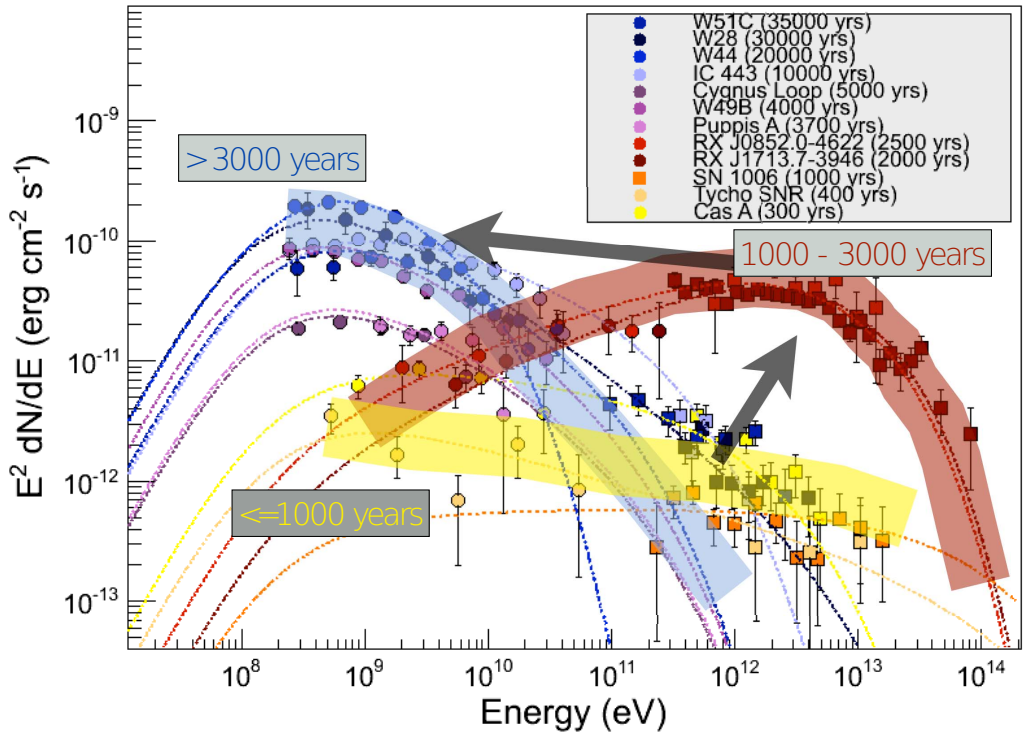


[Fermi2013]

The SNR paradigm

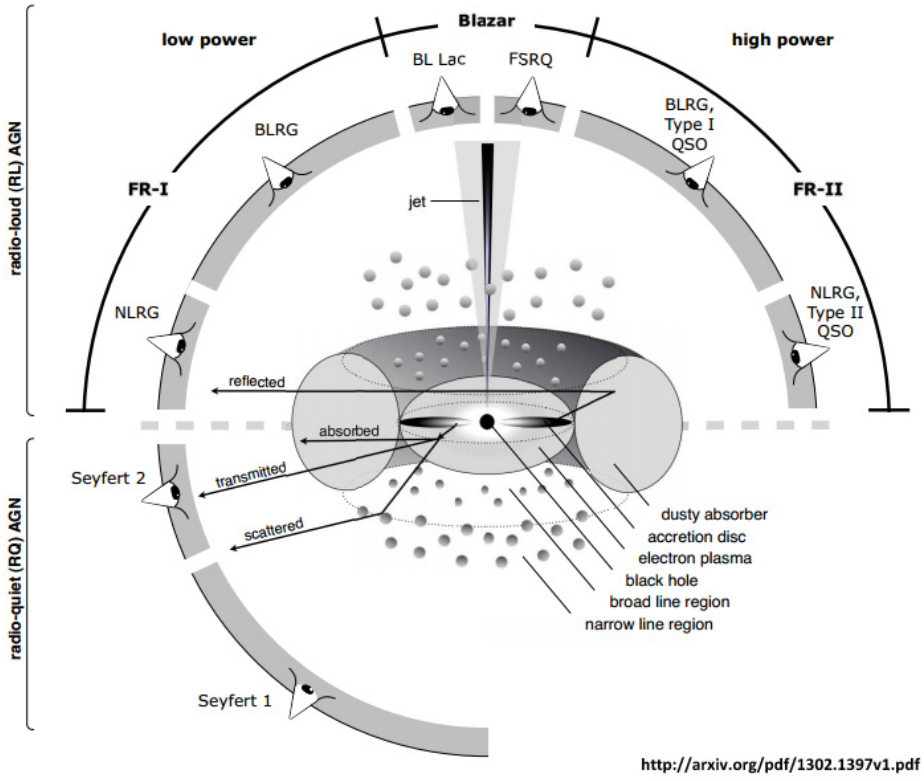
- Baade & Zwicky 1934: SNR provide enough energy (10% of energy into CRs + 3 SN/century)
- Shock acceleration provide “natural” mechanism to create power law
- Extremely like to accelerate CRs
- Not clear if the can energies up to knee



[Funk2011]

Active Galactic Nuclei

- SMBH in the centre of a galaxy accreting matter



http://arxiv.org/pdf/1302.1397v1.pdf

Active Galactic Nuclei

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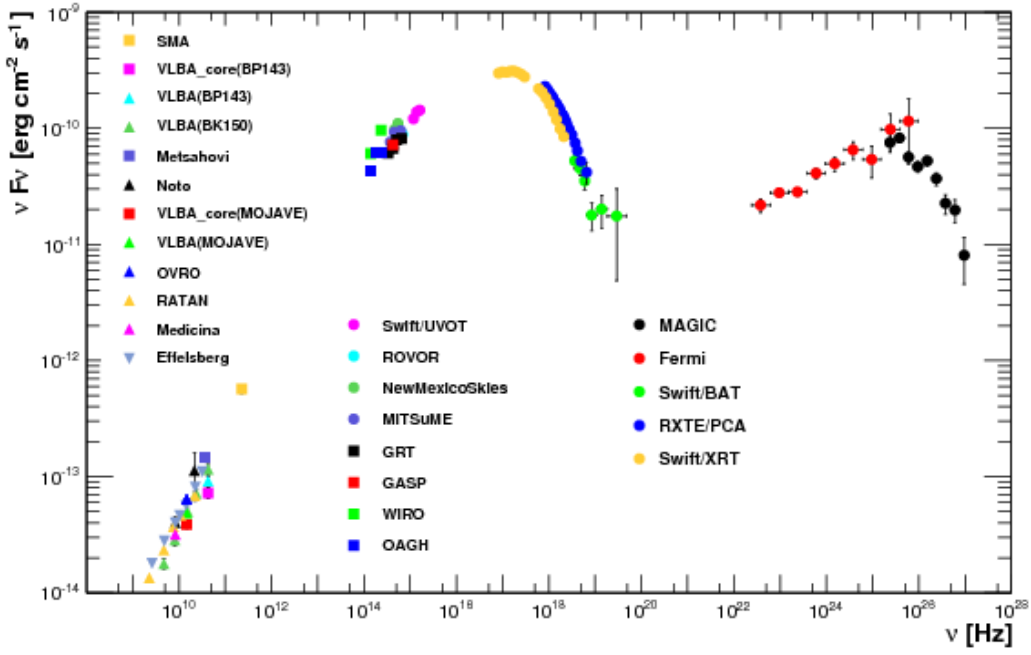
- very variable sources $\Rightarrow$ flares



[Cortina2013]

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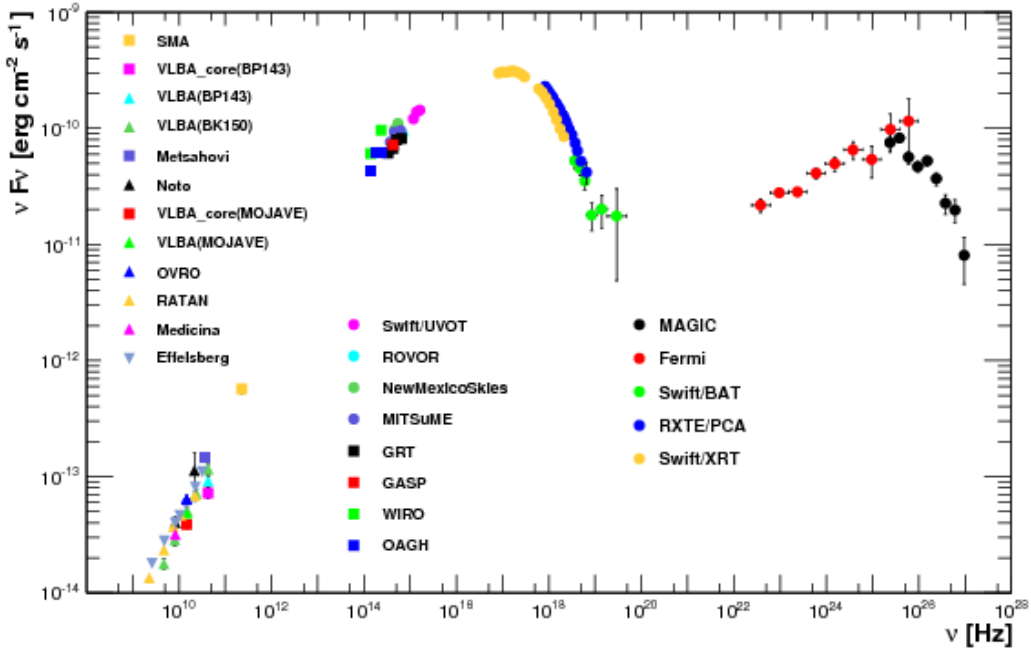

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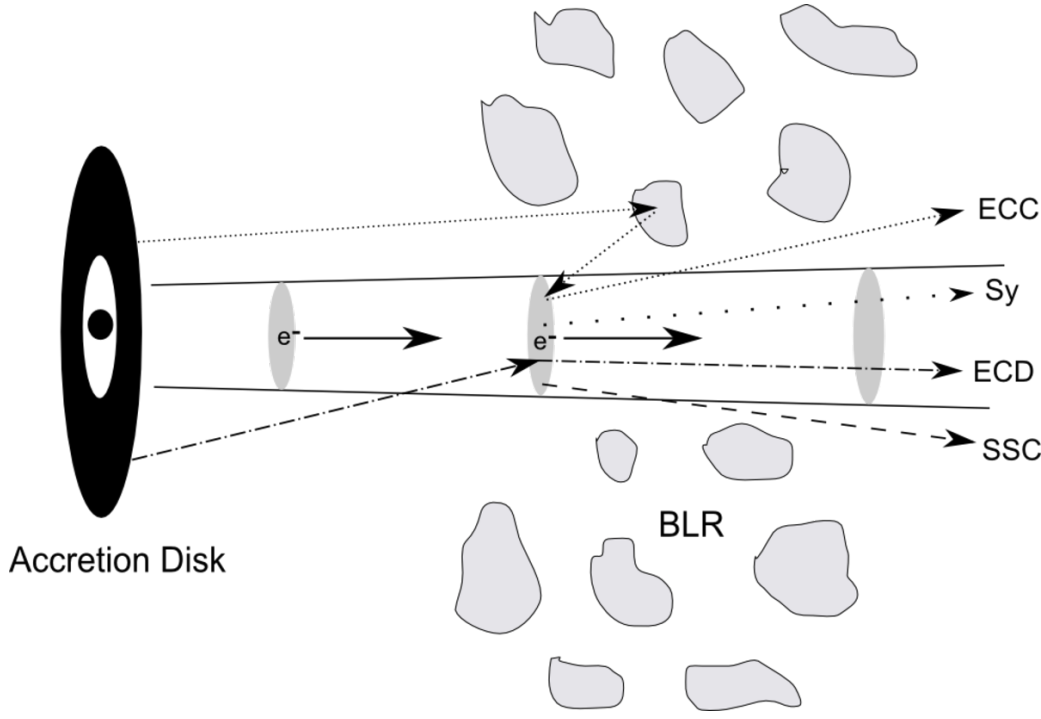
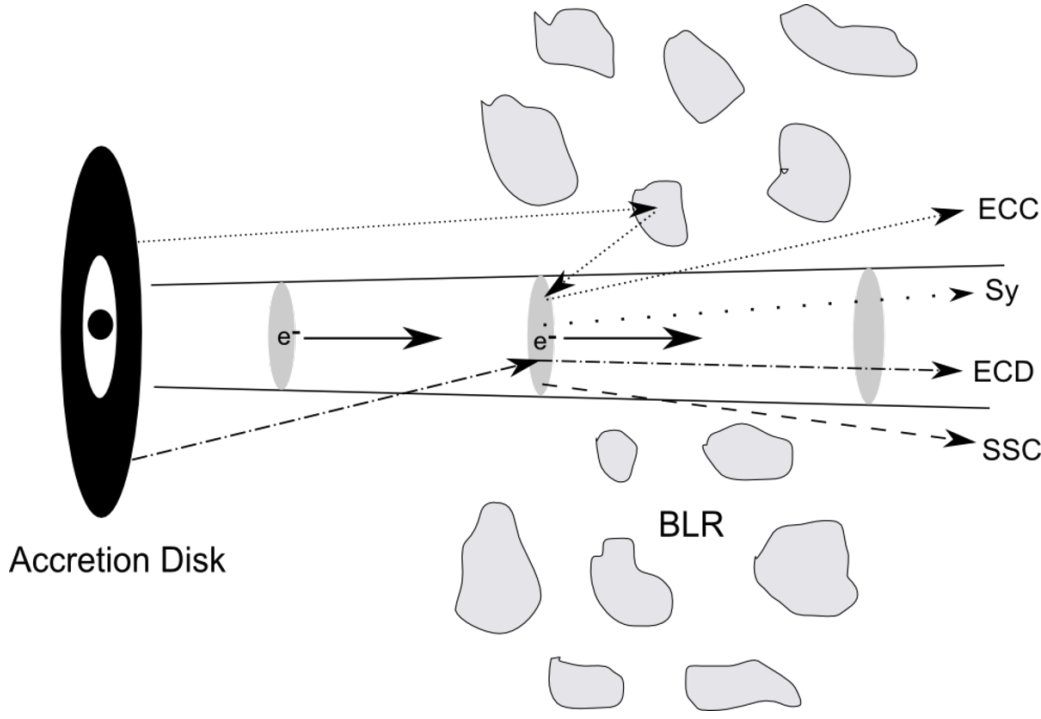


[Eclov2008]

Active Galactic Nuclei

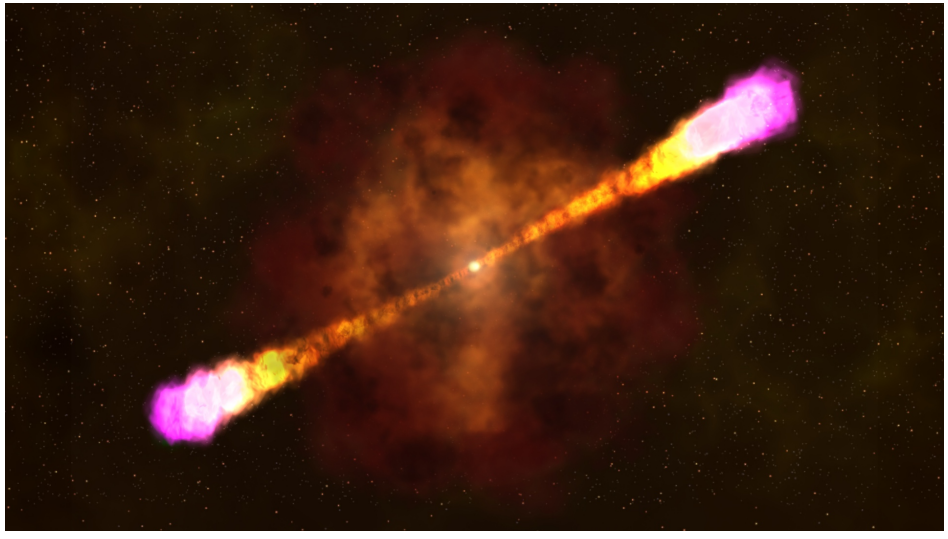
- SMBH in the centre of a galaxy accreting matter
- very variable sources $\Rightarrow$ flares
- leptonic model fit better, most popular SSC
- latest results $\Rightarrow$ radiation created close to BH
- neutrinos could clearly, clarify case



[Eclov2008]

Gamma Ray Bursts

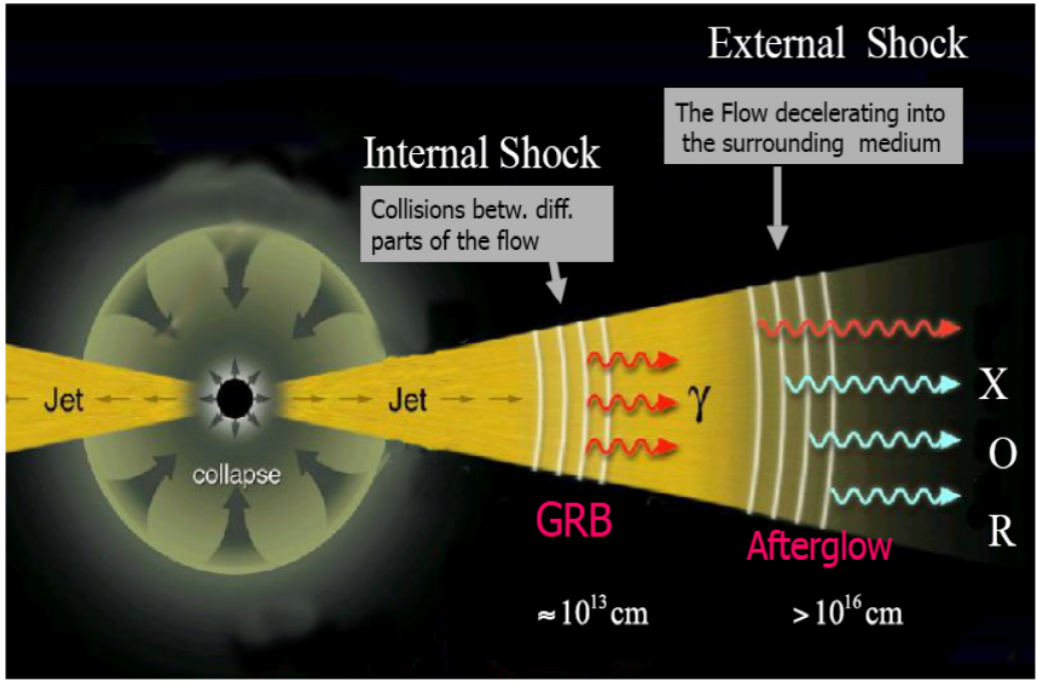
- origin very unclear



[nasa.gov]

Gamma Ray Bursts

- origin very unclear
- short (<2 s, merging BHs) , long (>10 s, extreme core-collapse SN)



[cta-observatory.org]

Gamma Ray Bursts

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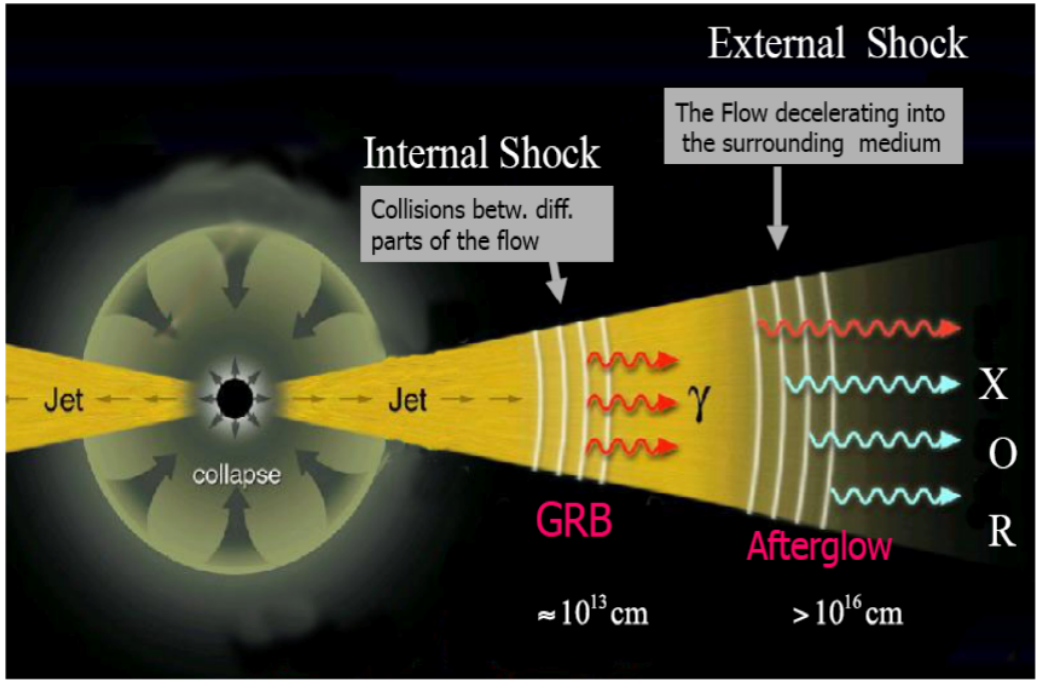
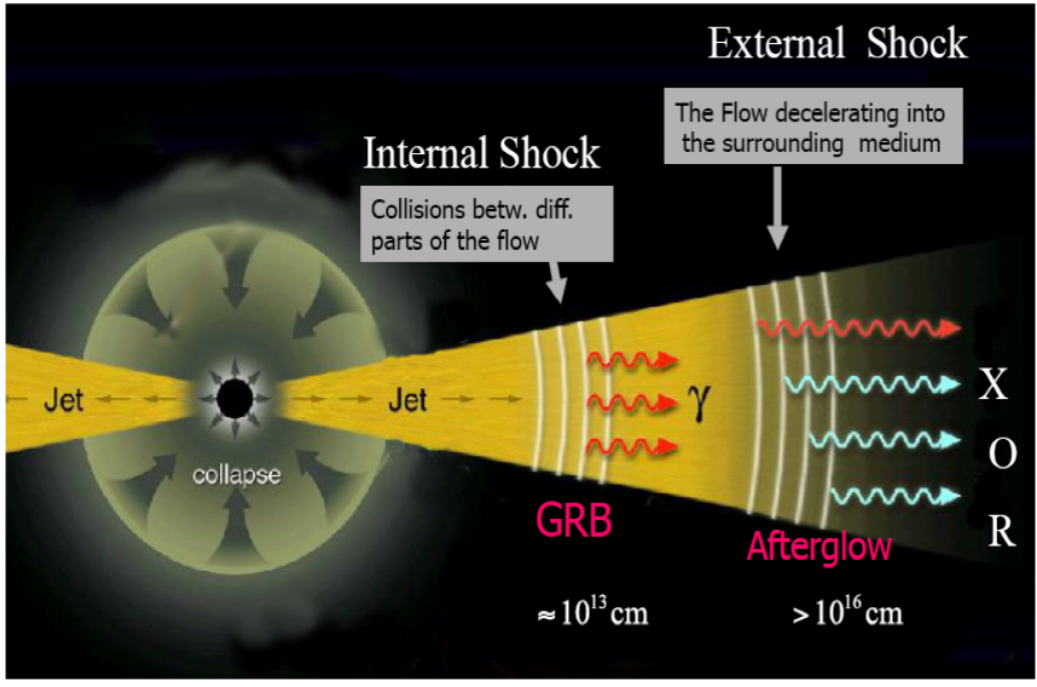
- radiation consists of prompt and afterglow



[cta-observatory.org]

Gamma Ray Bursts

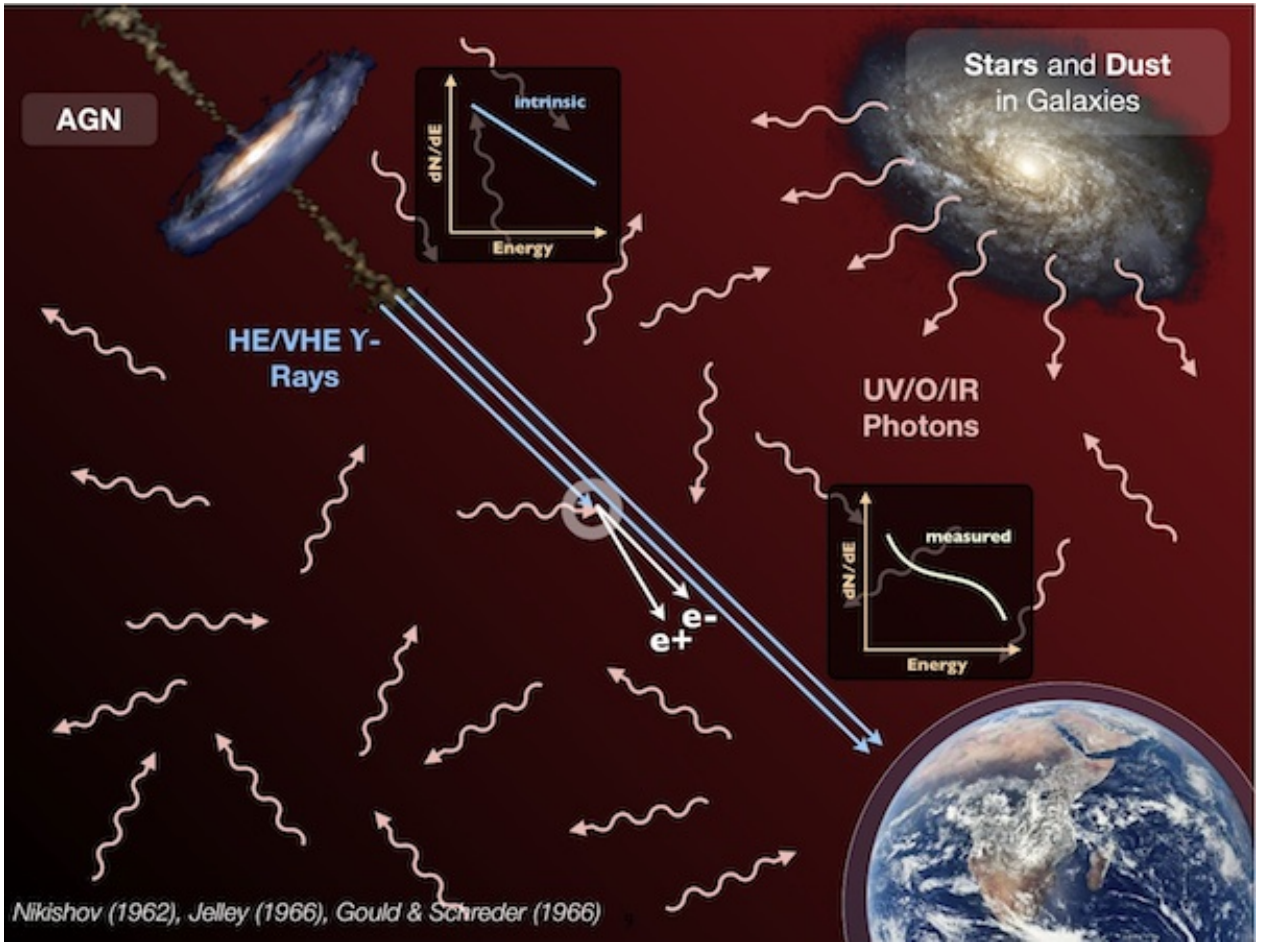
- origin very unclear
- short (<2 s, merging BHs) , long (>10 s, extreme core-collapse SN)
- radiation consists of prompt and afterglow
- fast rotation needed to catch burst (MAGIC <30 s)



[cta-observatory.org]

Issue of HE photons travelling long distances

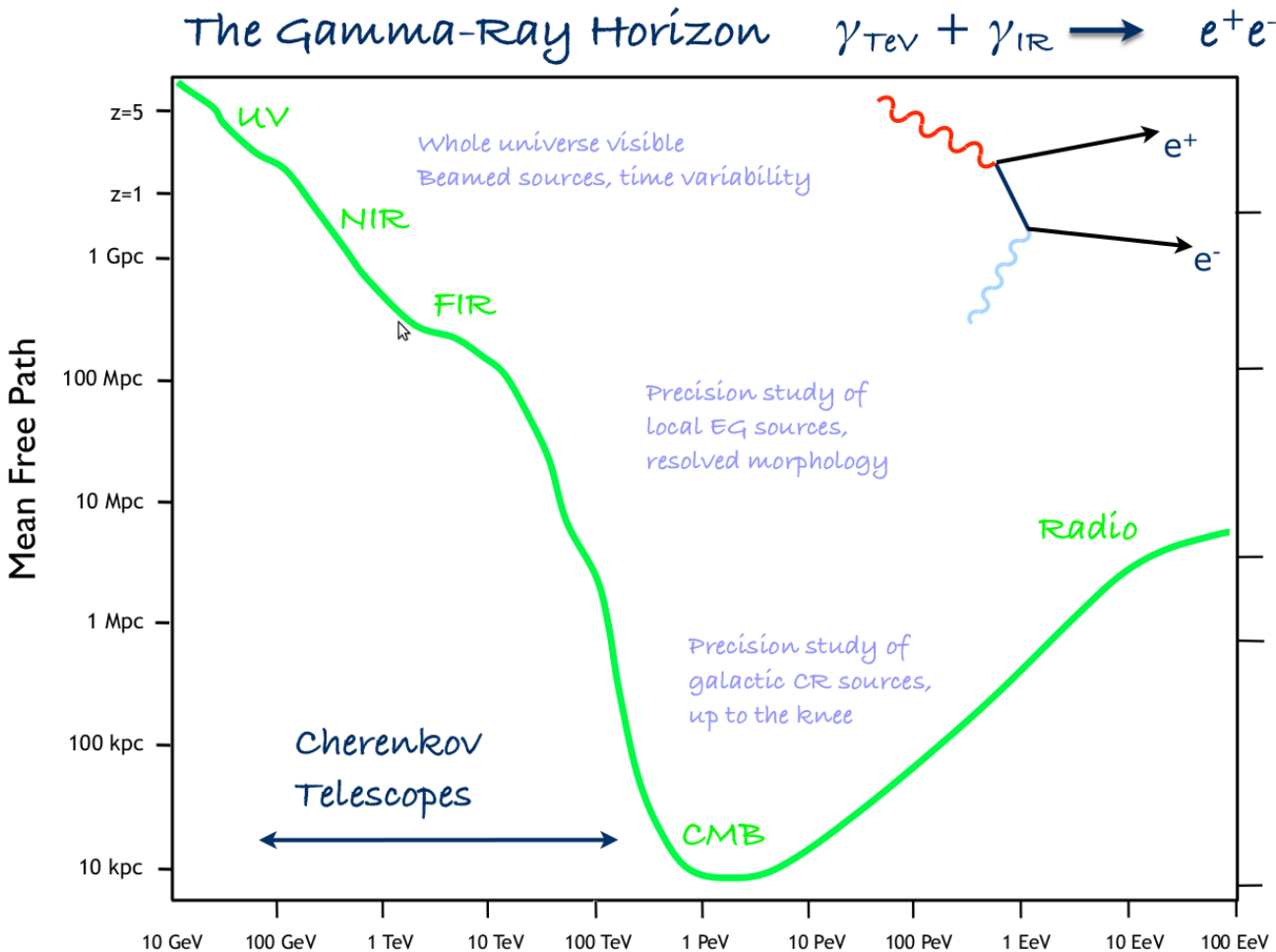
- HE γ-rays get absorbed by EBL



[Raue2011]

Issue of HE photons travelling long distances

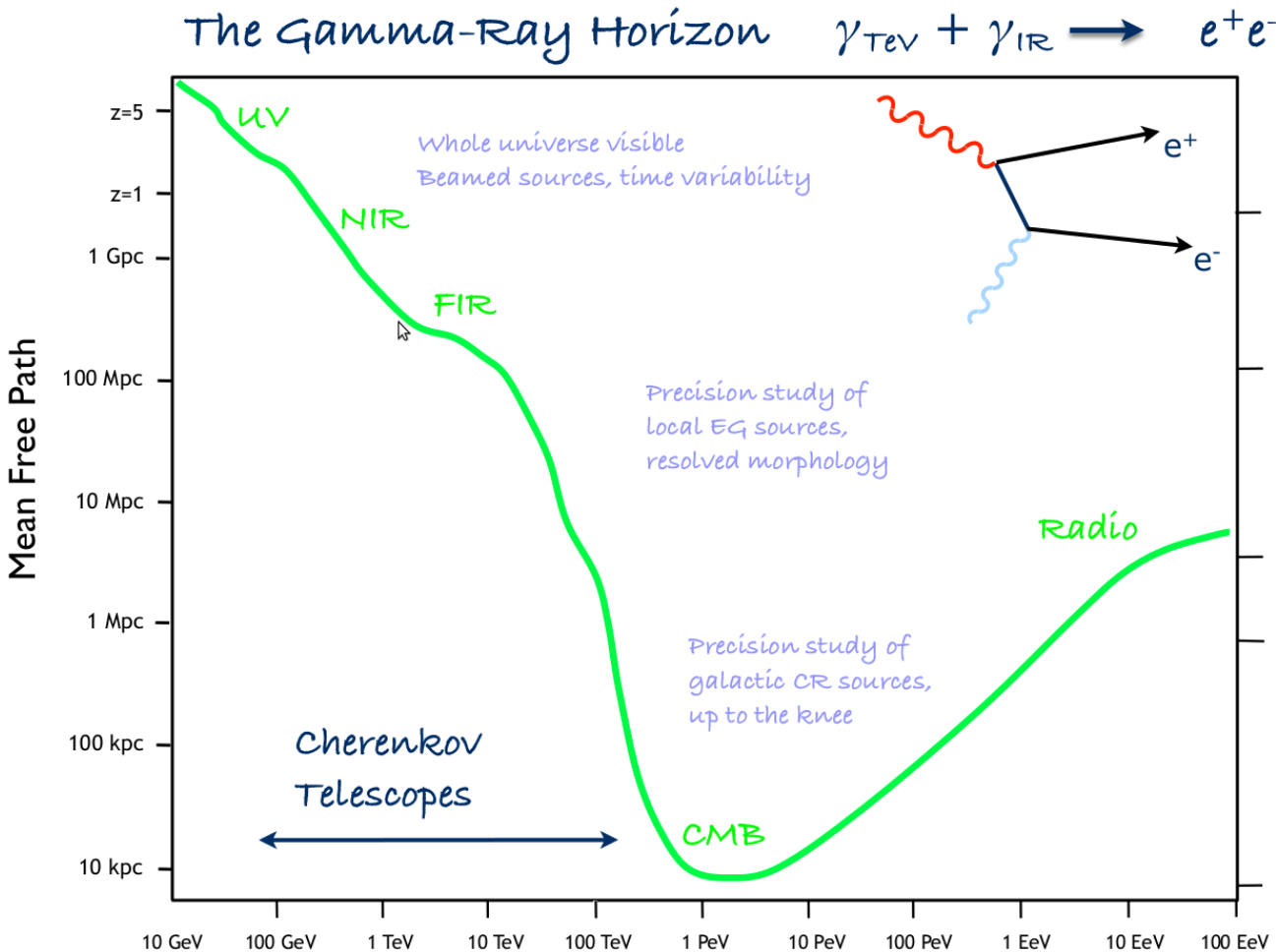
- HE γ-rays get absorbed by EBL
- At short wavelength we can look farther away $\Rightarrow$ low energy threshold needed



[Knapp2013]

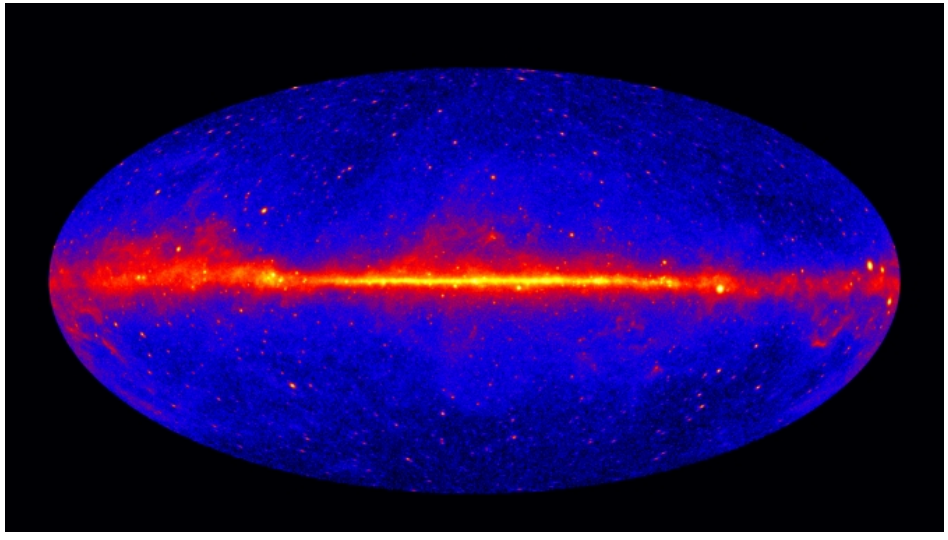
Issue of HE photons travelling long distances

- HE γ-rays get absorbed by EBL
- At short wavelength we can look farther away $\Rightarrow$ low energy threshold needed
- Maybe Axions play a role here



[Knapp2013]

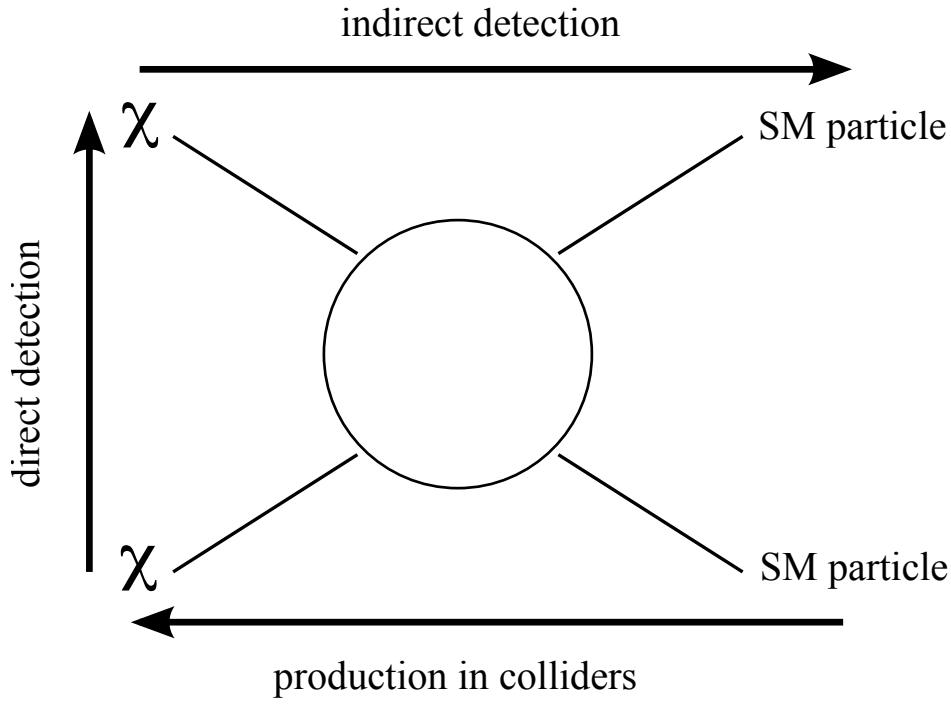
You like more crazy stuff?



[nasa.gov]

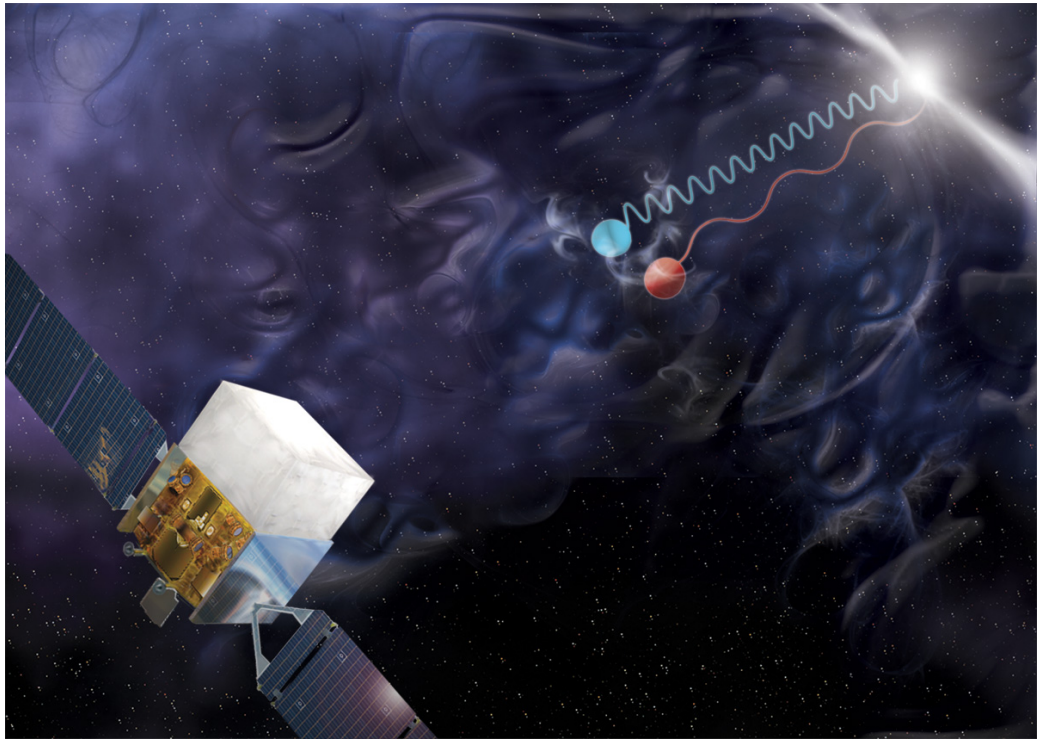
Finally some candies

- Annihilating DM can emit γ-rays



Finally some candies

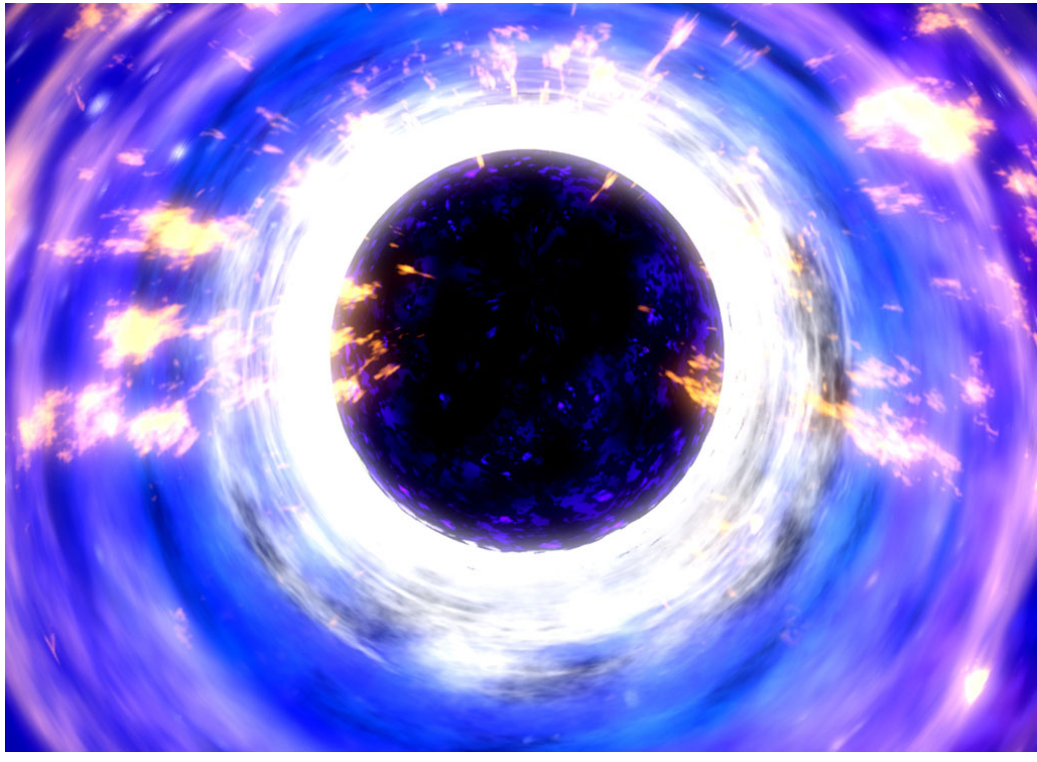
- Annihilating DM can emit γ-rays
- LIV may let photons travel at different speed



[cta-observatory.org]

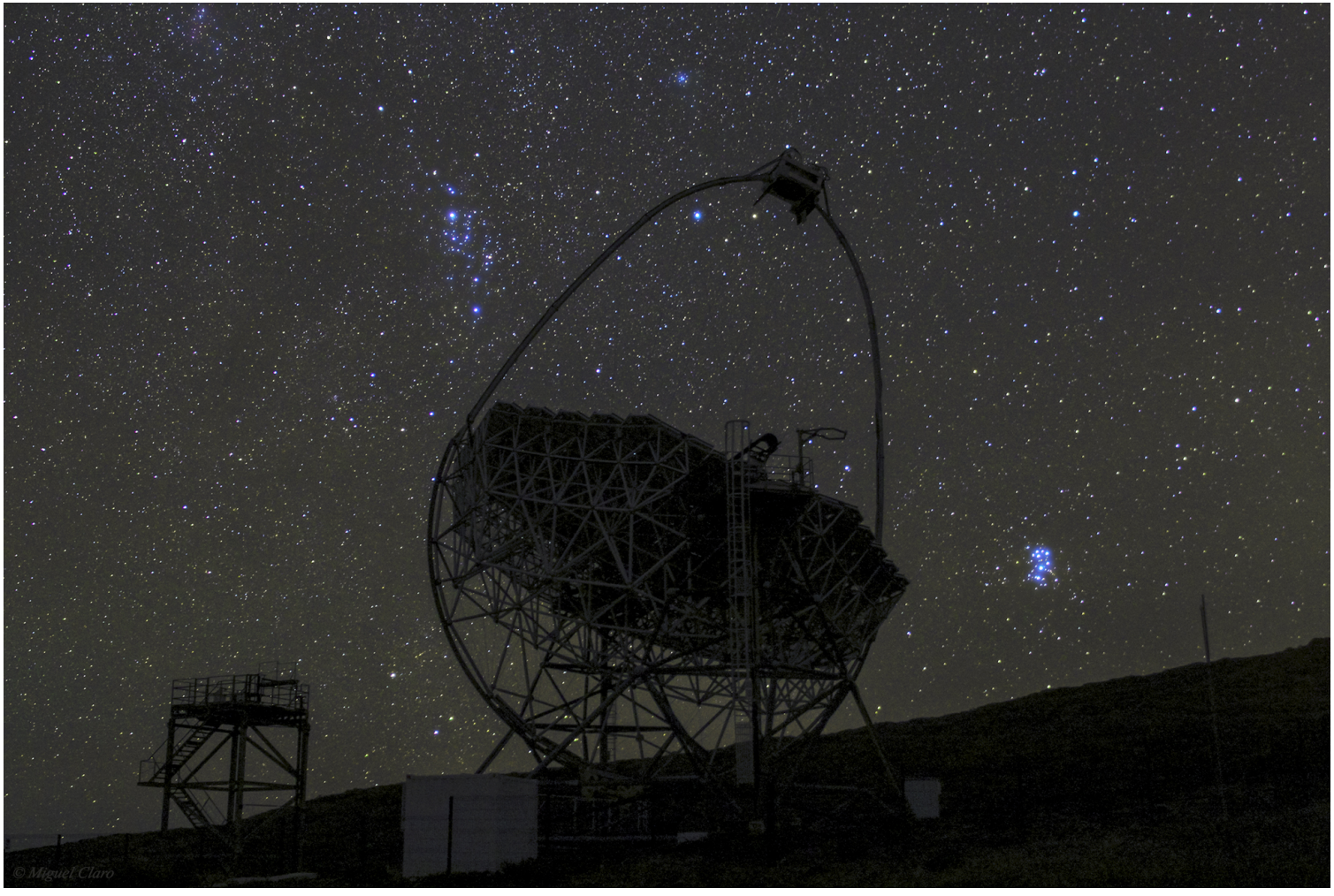
Finally some candies

- Annihilating DM can emit γ-rays
- LIV may let photons travel at different speed
- Evaporating primordial BHs may radiate γ-rays



[Wikipedia]

Or what else might be out there



[Miguel Claro]

Thank you for your attention and interest!