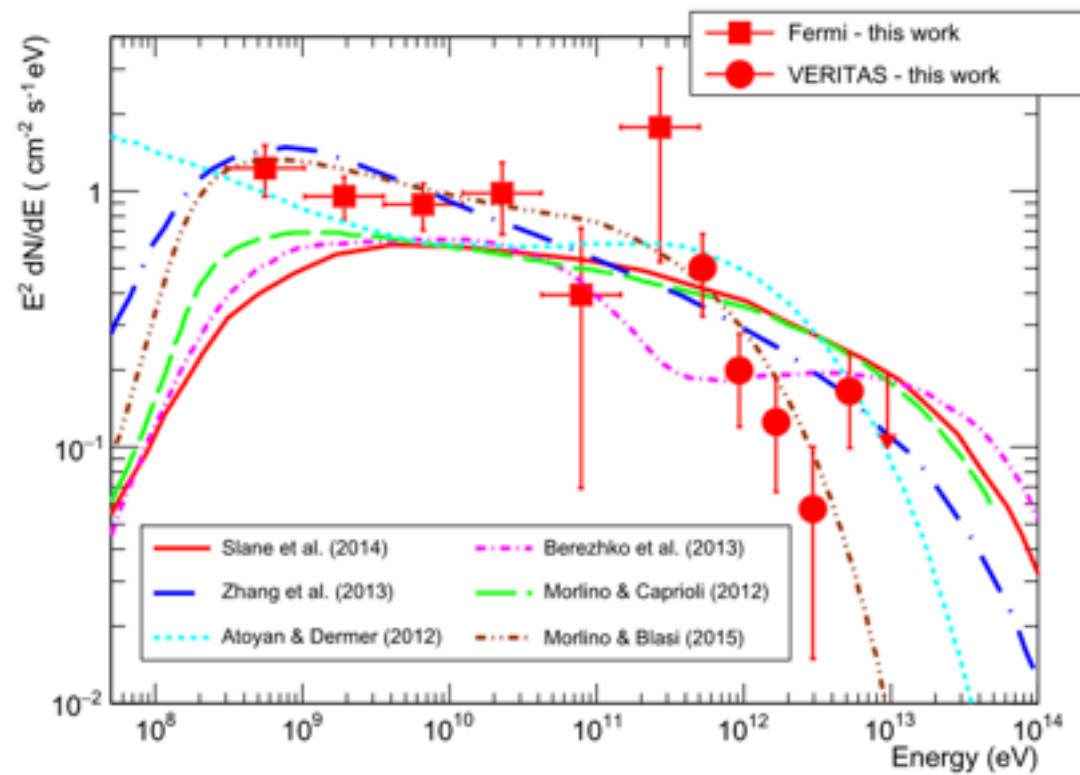
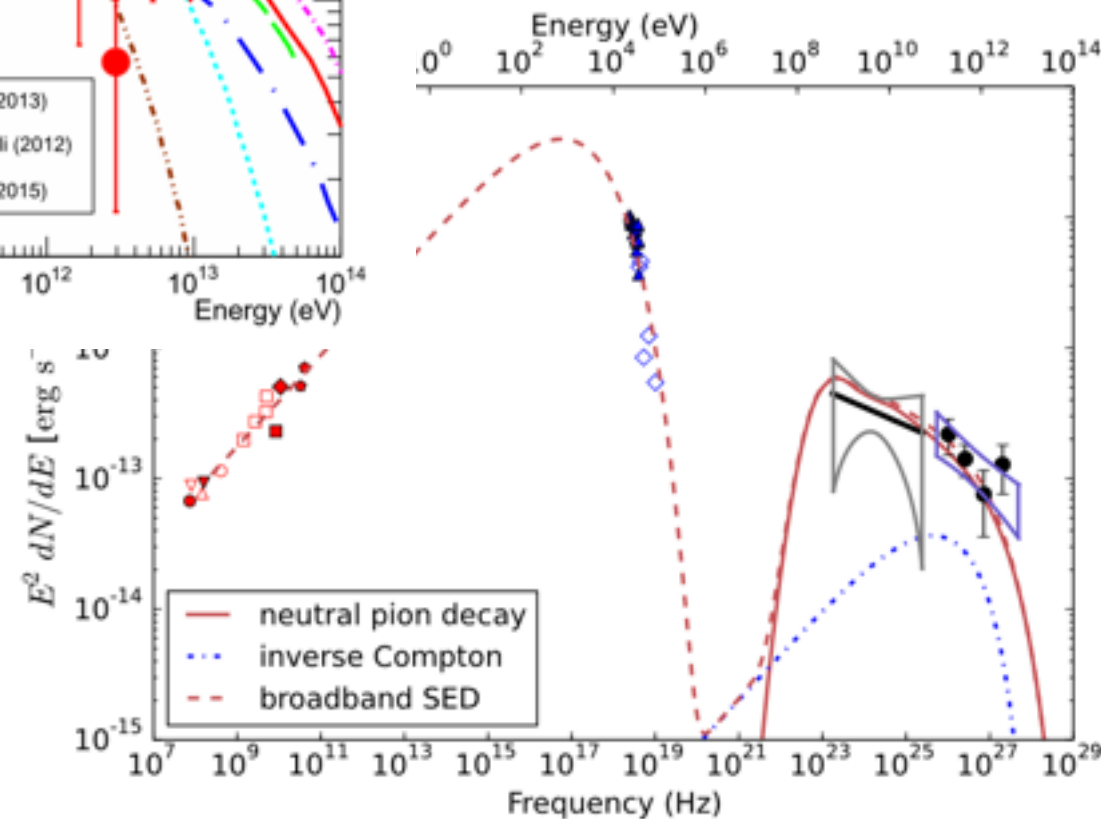
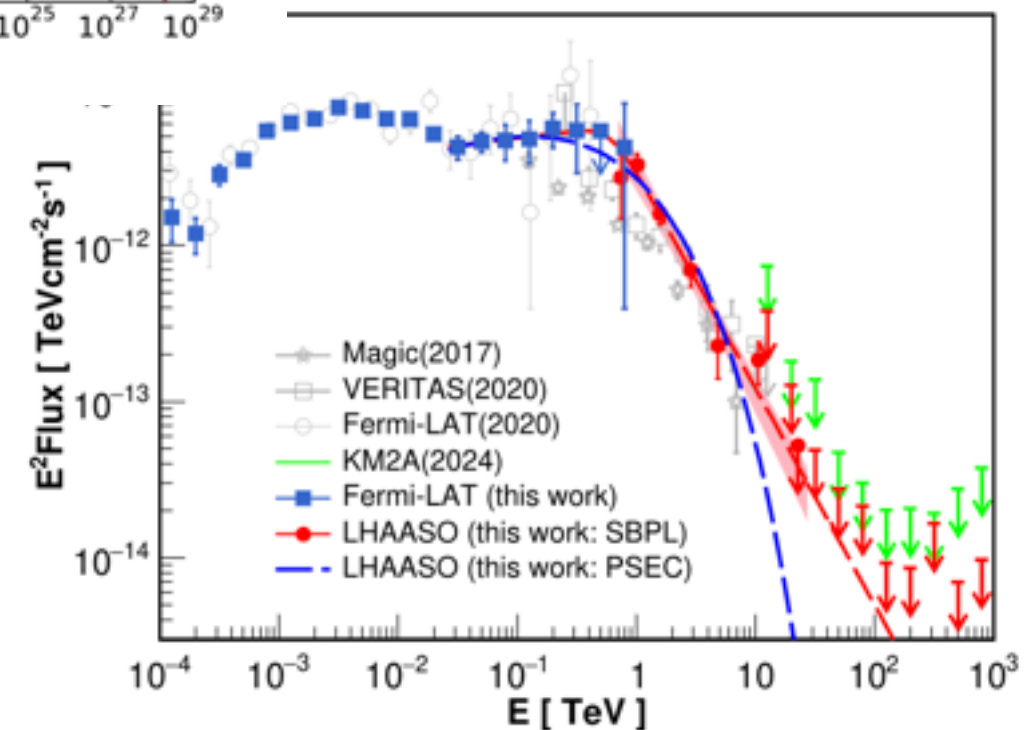




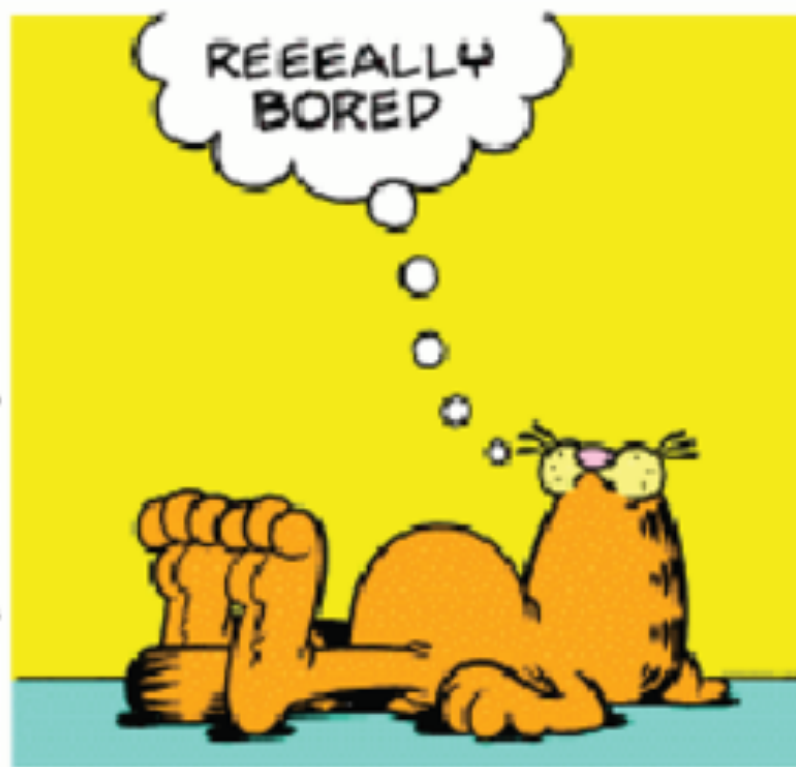
The issue is not "are SNRs PeVatrons?"
(I am quite sure they are), but "can
they accelerate ENOUGH PeV CRs?"



Compare this spectra with
the spectrum of Cyg X-3



Let's start with something boring:
do we need a definition of PeVatron?



Definition(s) of PeVatrons

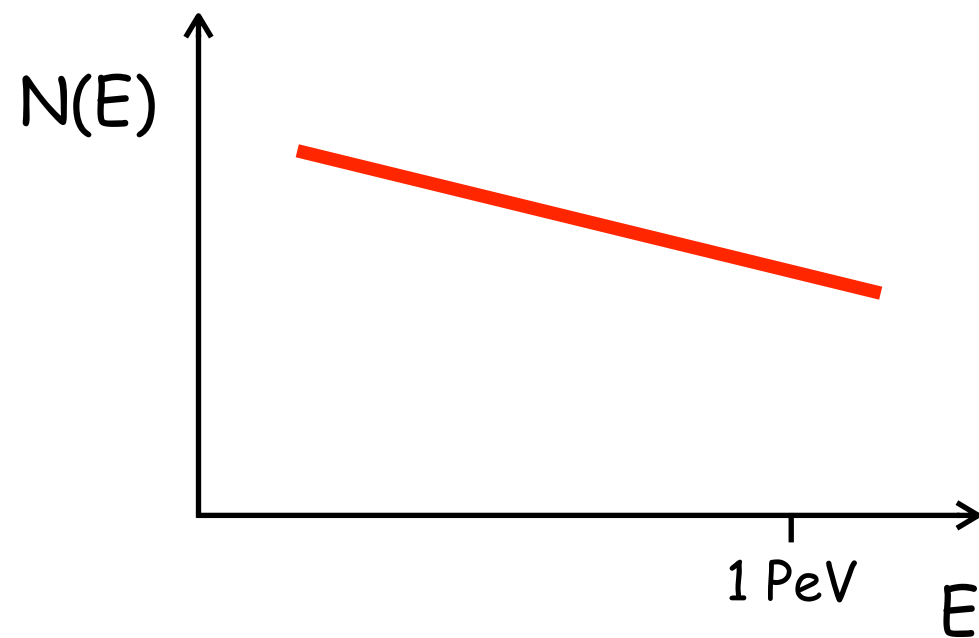
what I normally had in mind (before LHAASO)

any astrophysical object capable of accelerating particles with a spectrum that extends without significant suppression to the PeV energy domain

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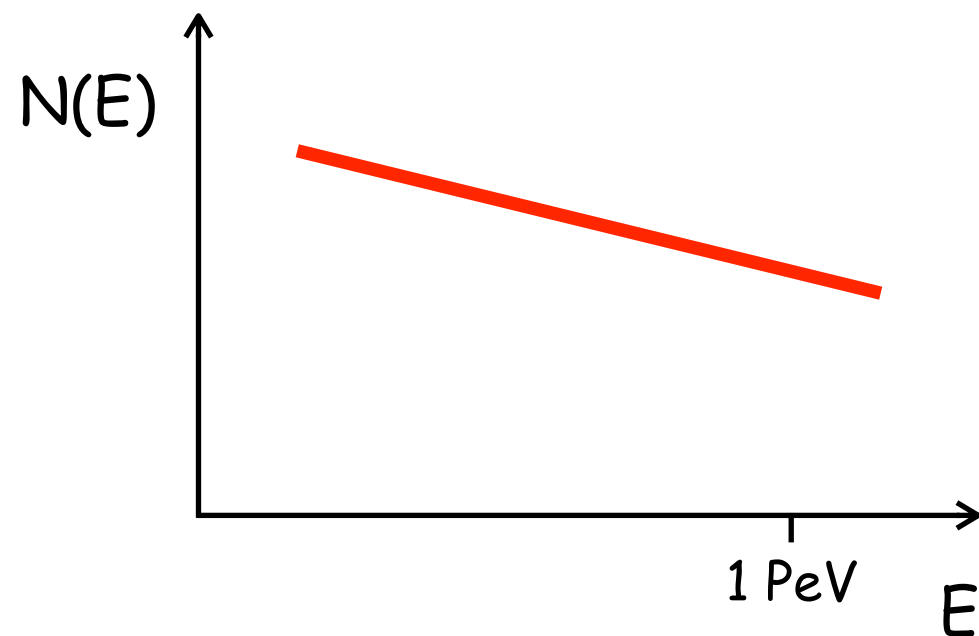
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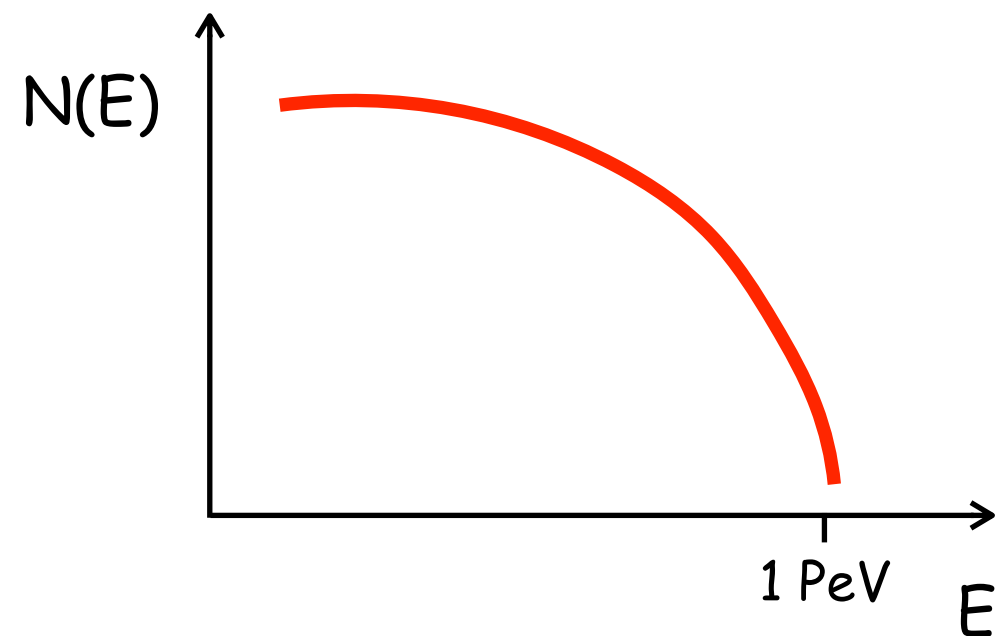
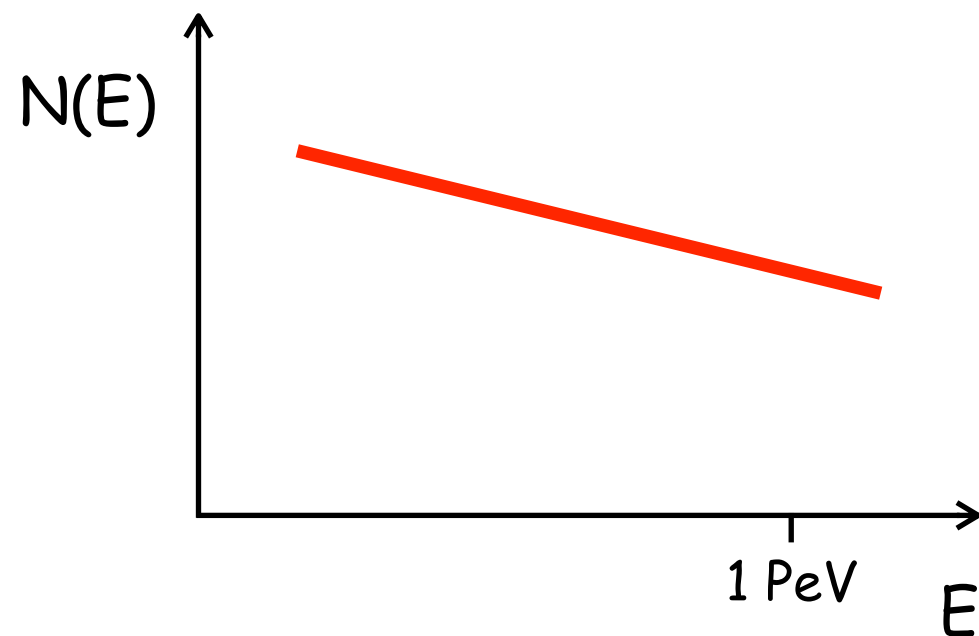


Possible alternative definition → any object capable of accelerating PeV particles
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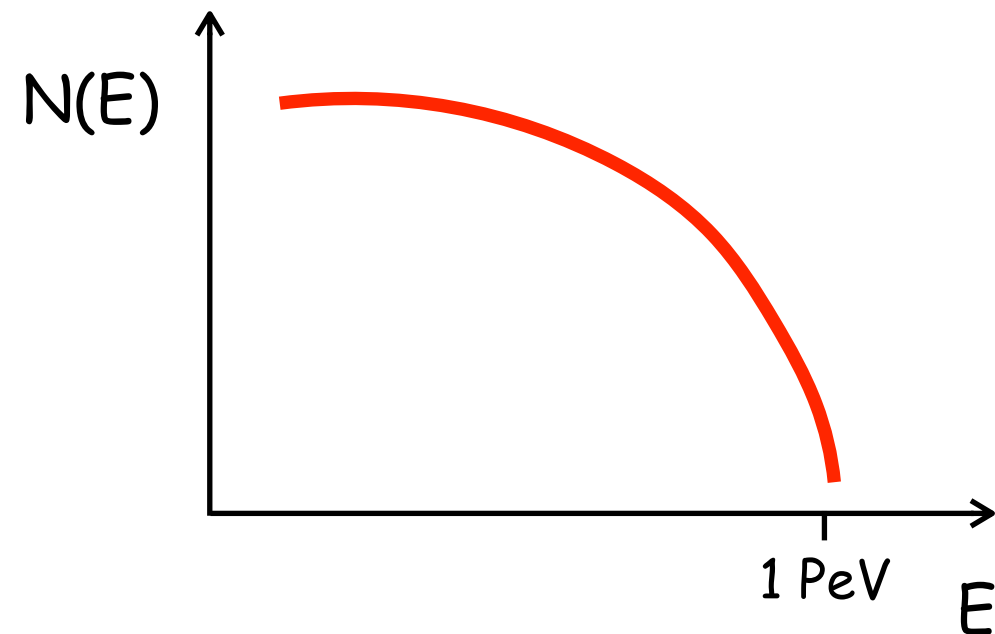
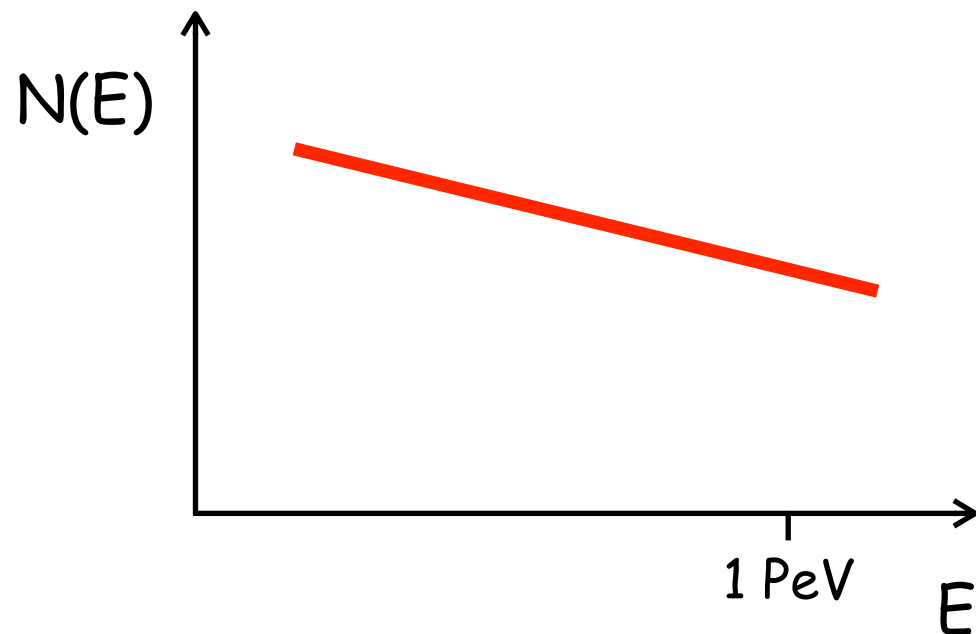
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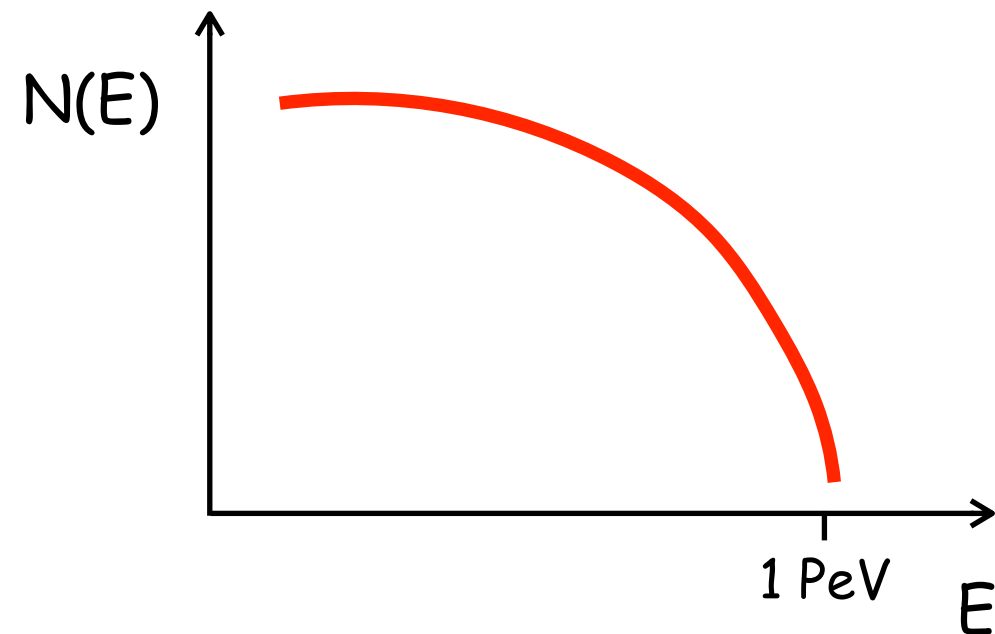
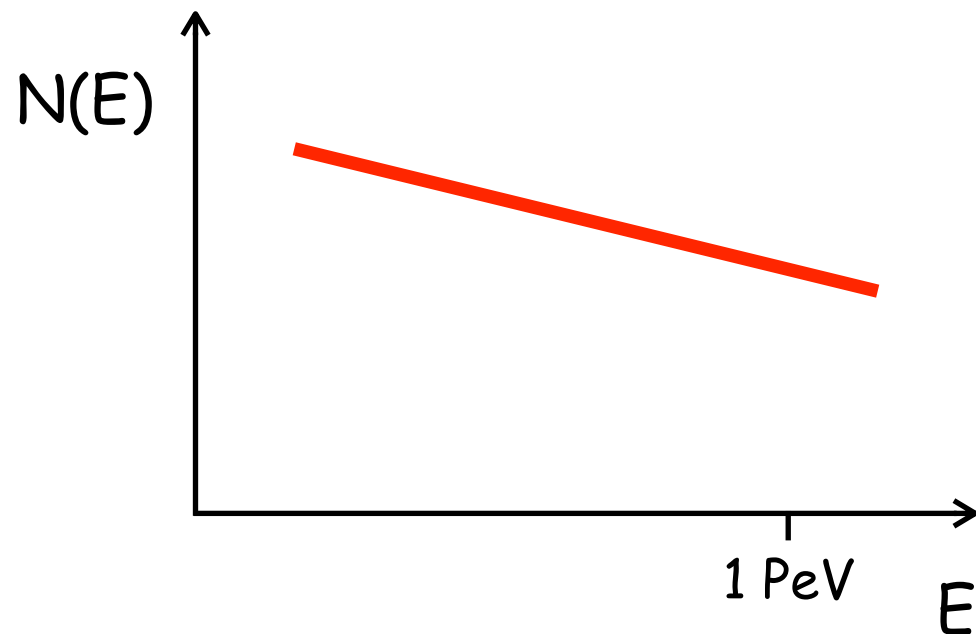
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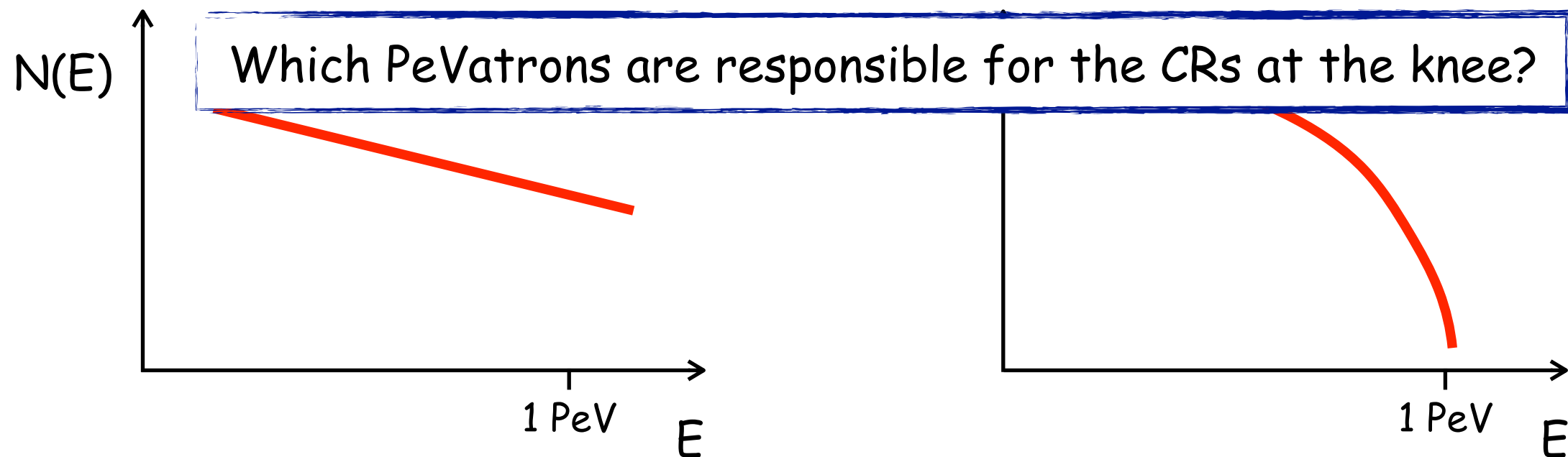
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misleading (?) version

PeVatrons are sources capable of accelerating PeV cosmic rays

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holds for p- γ

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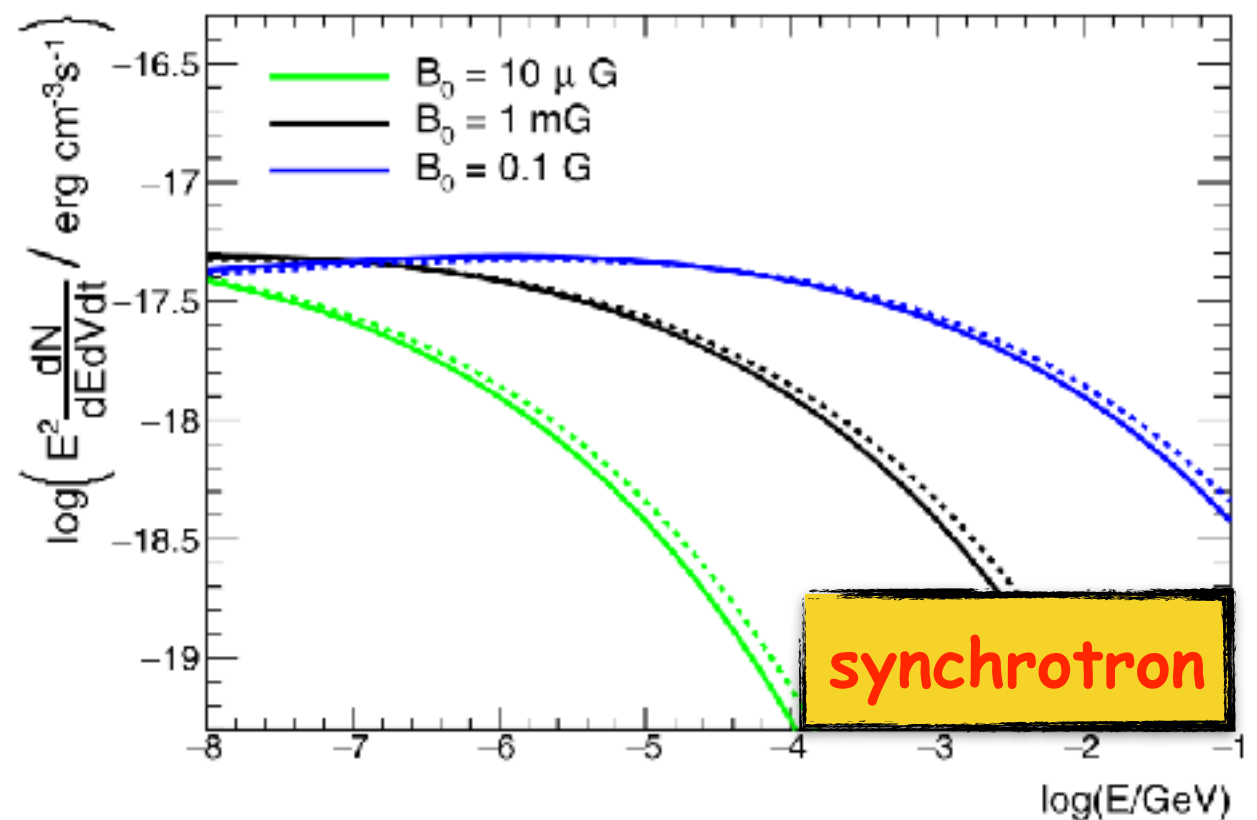
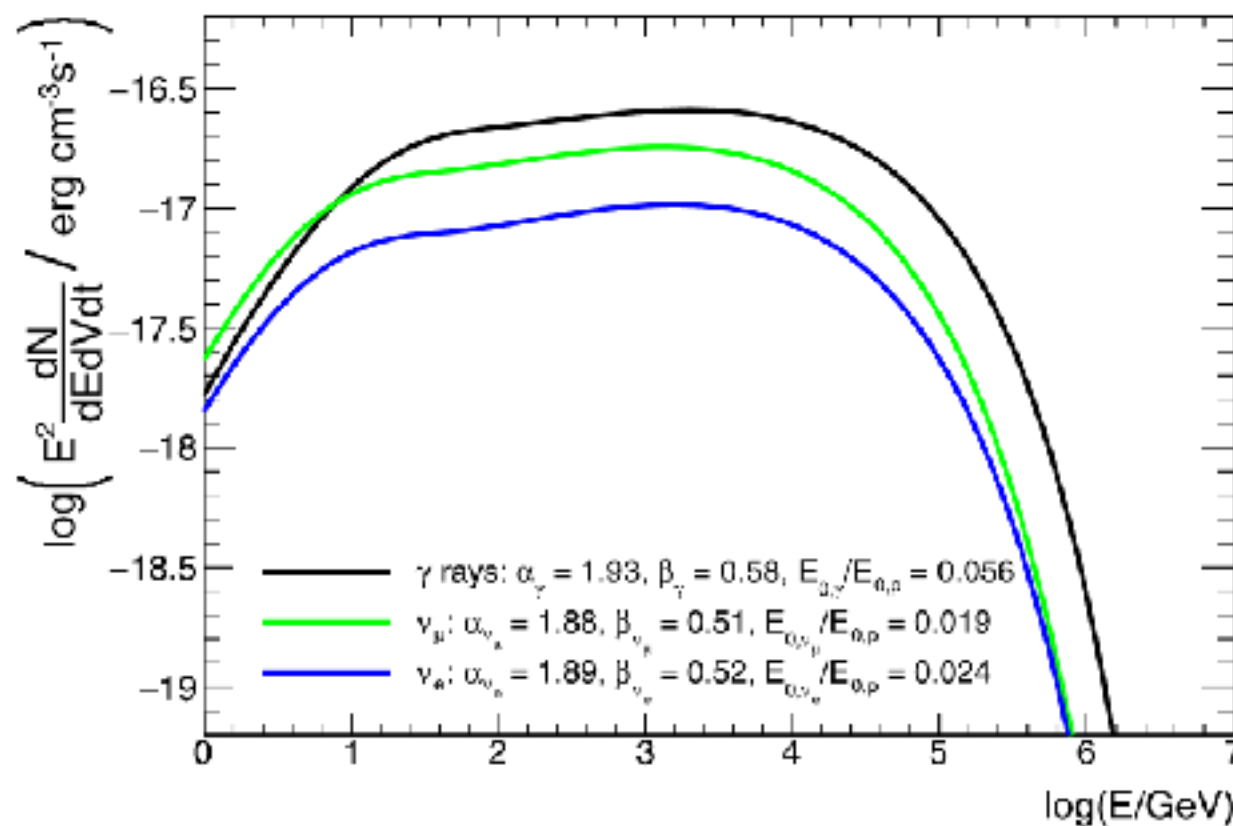
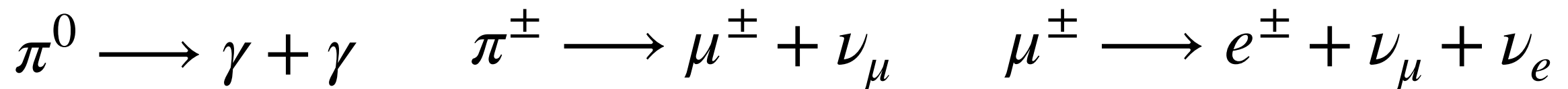
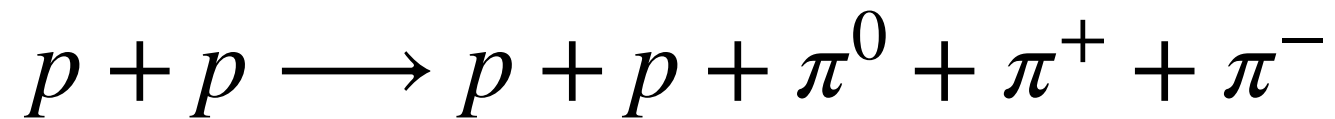
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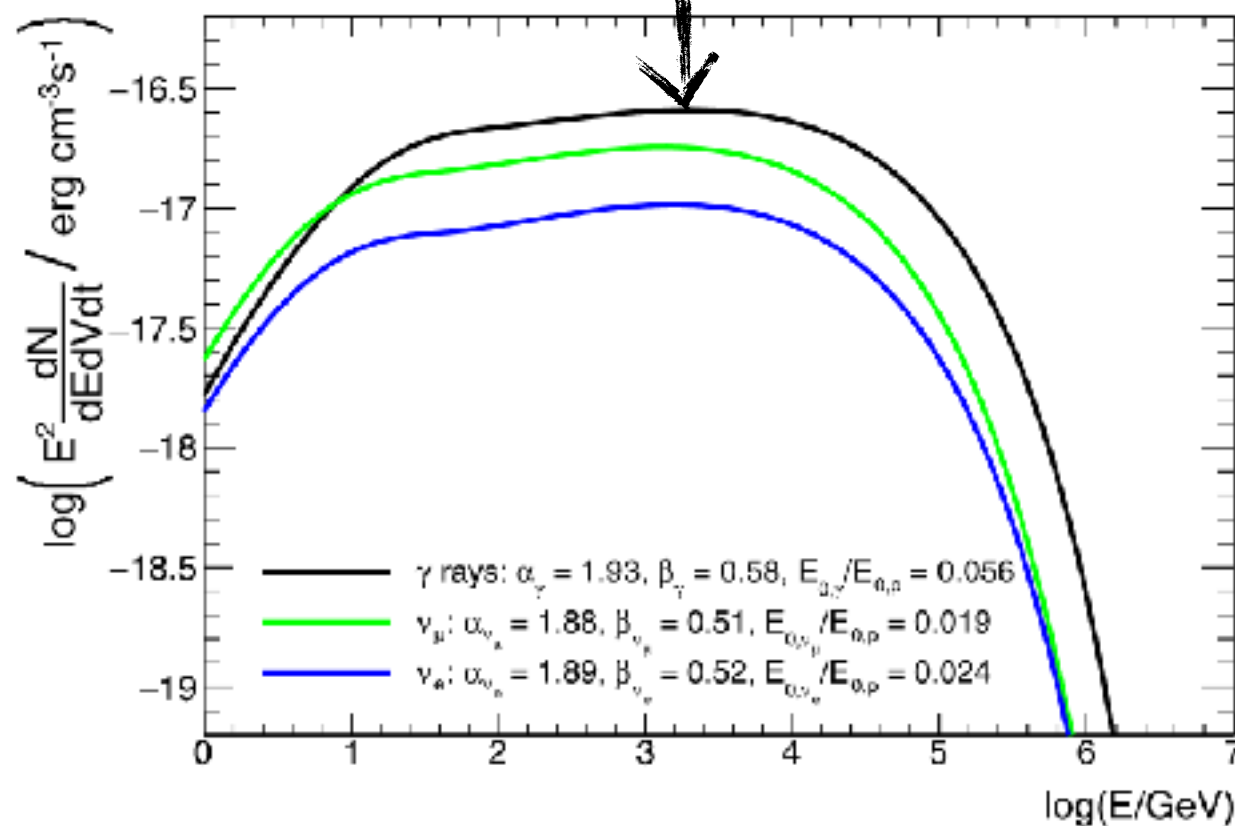
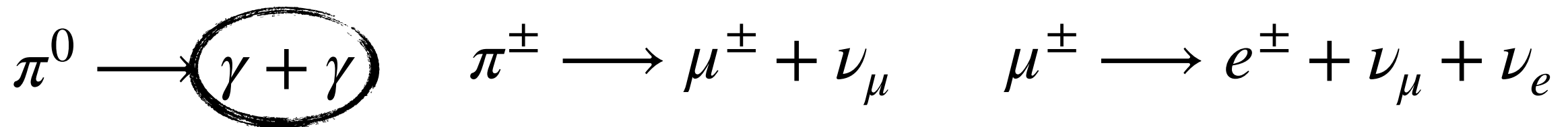
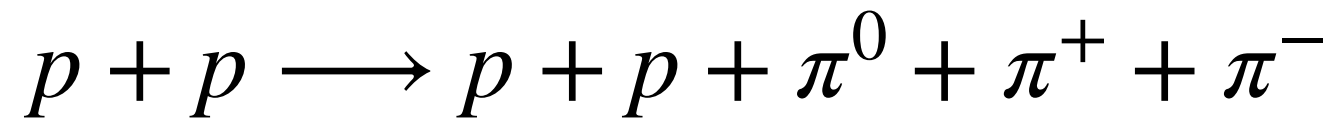
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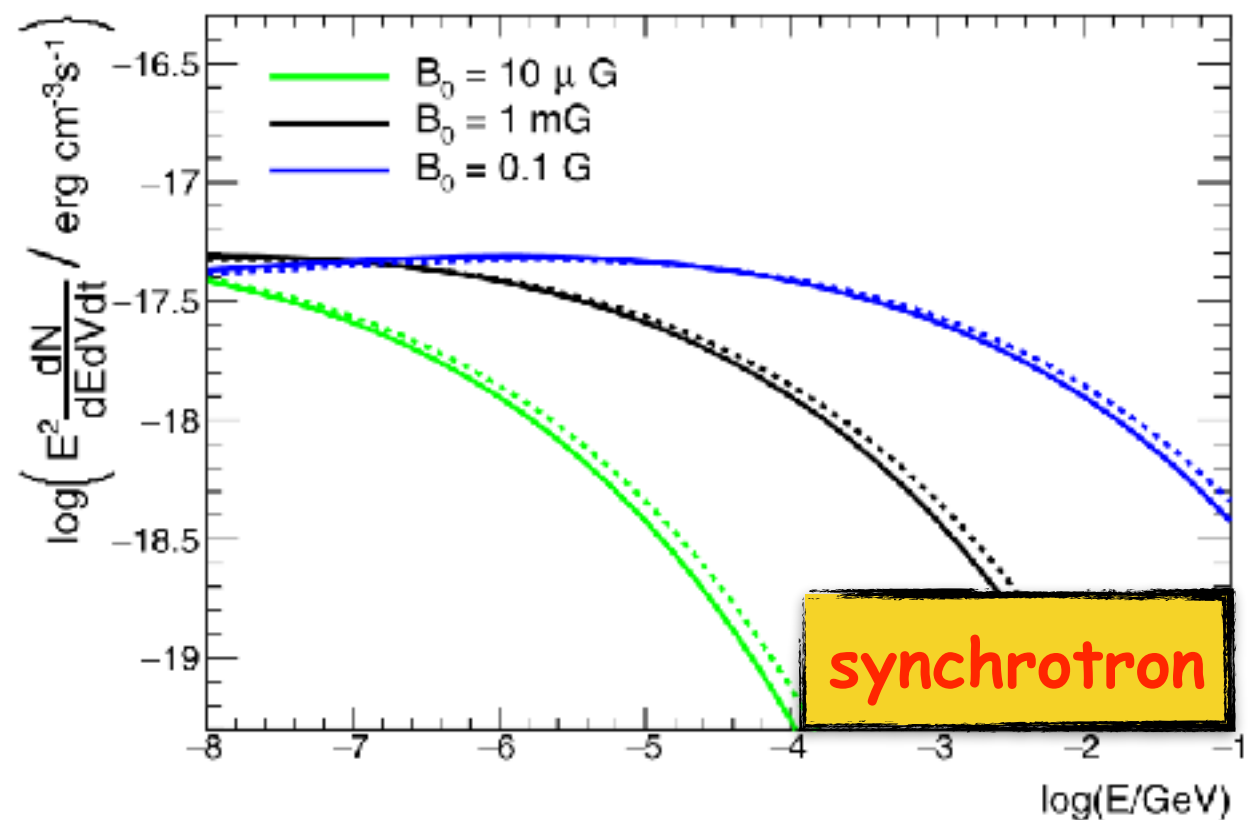
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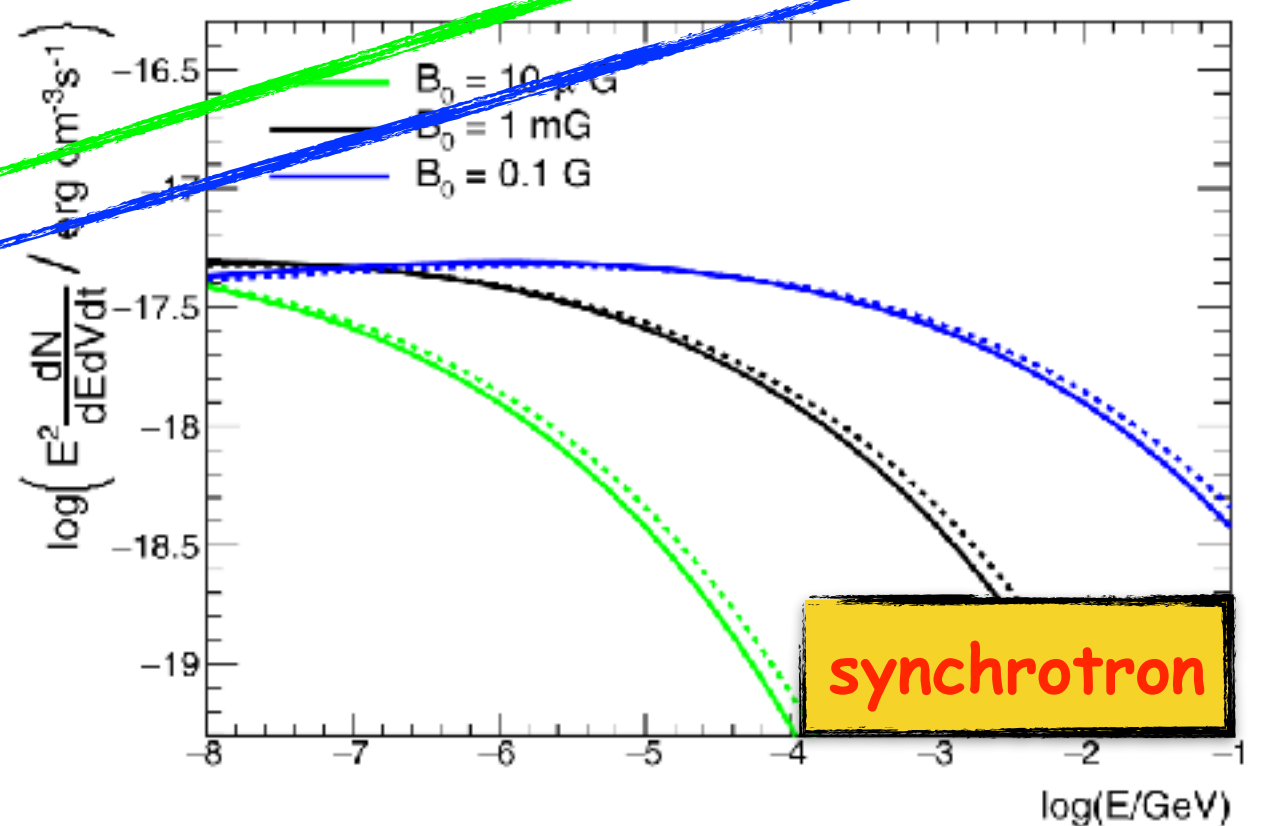
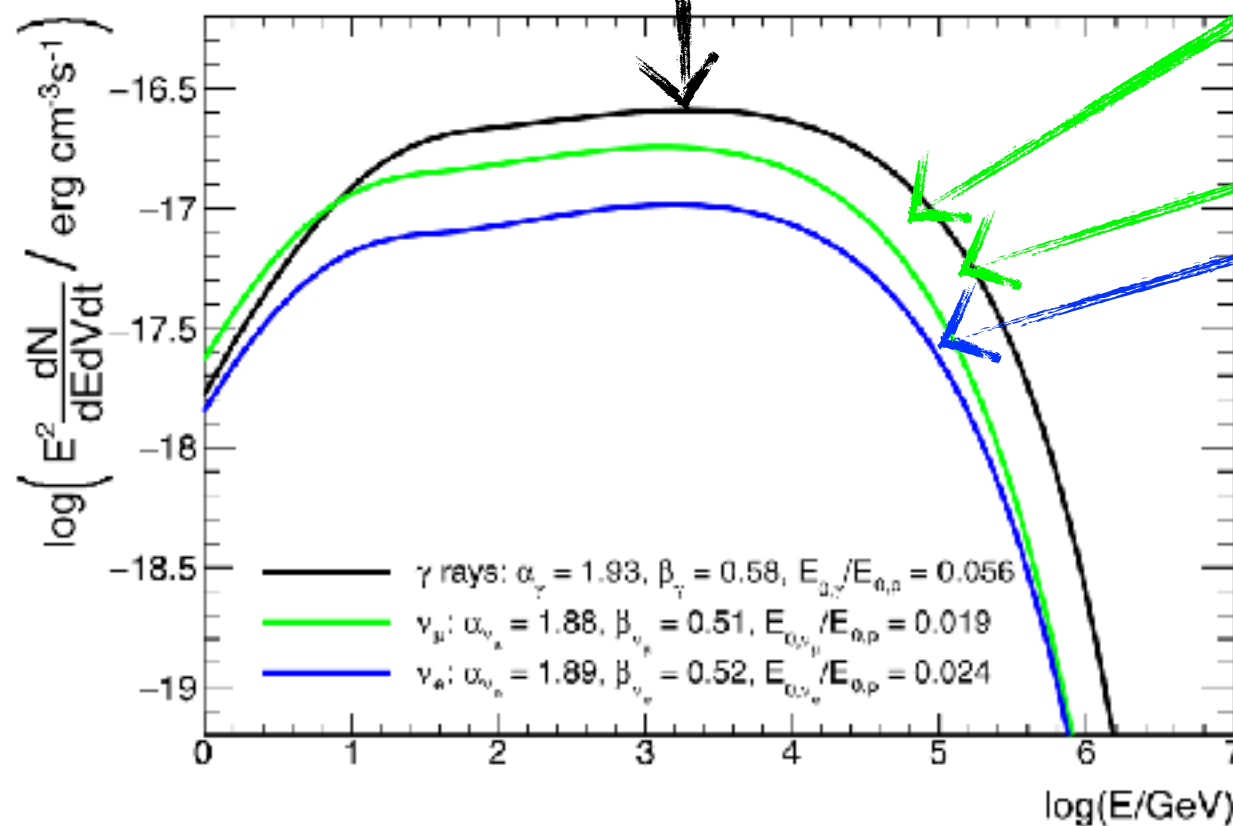
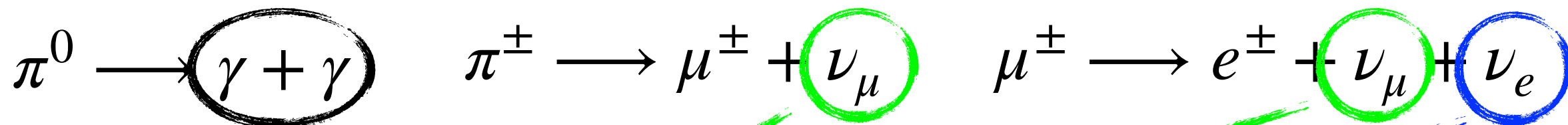
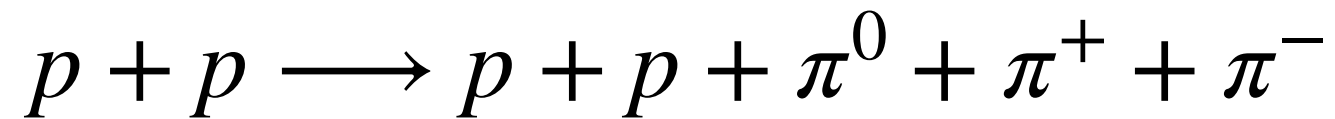
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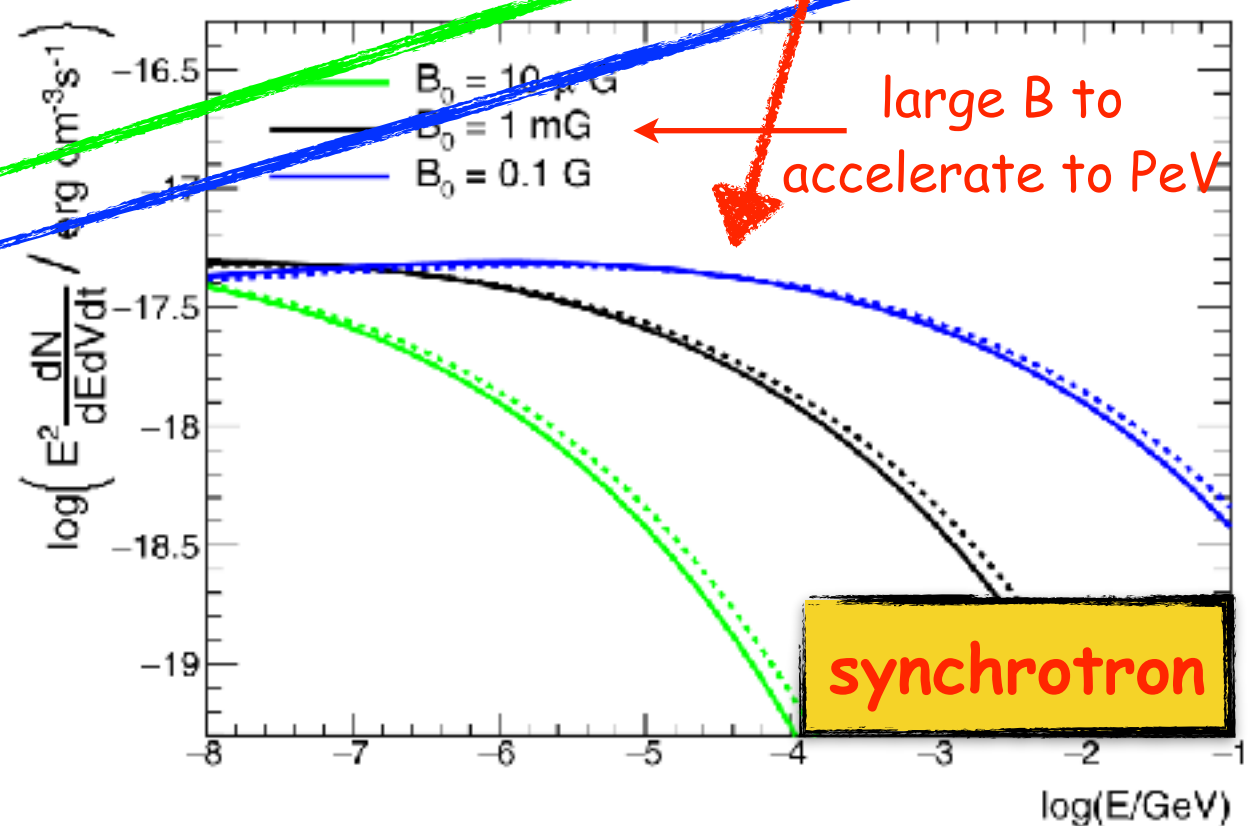
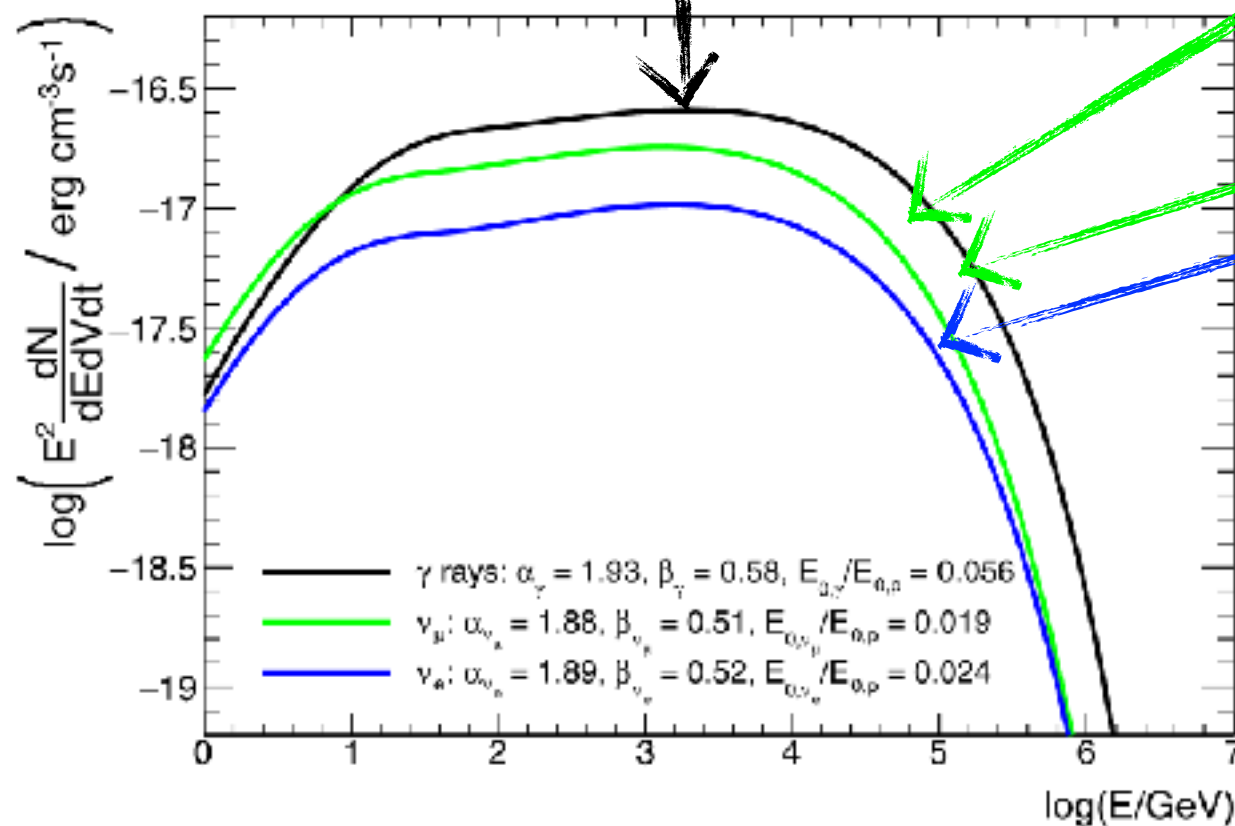
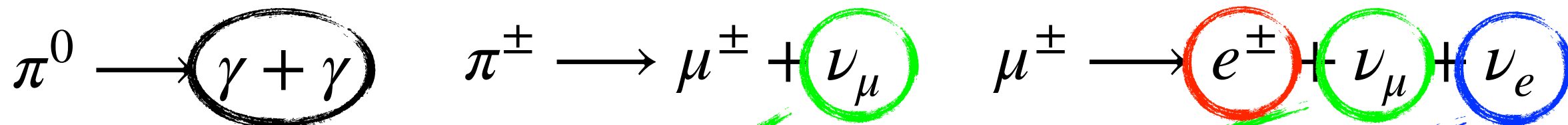
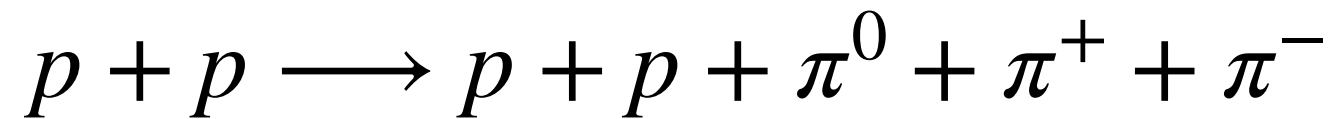
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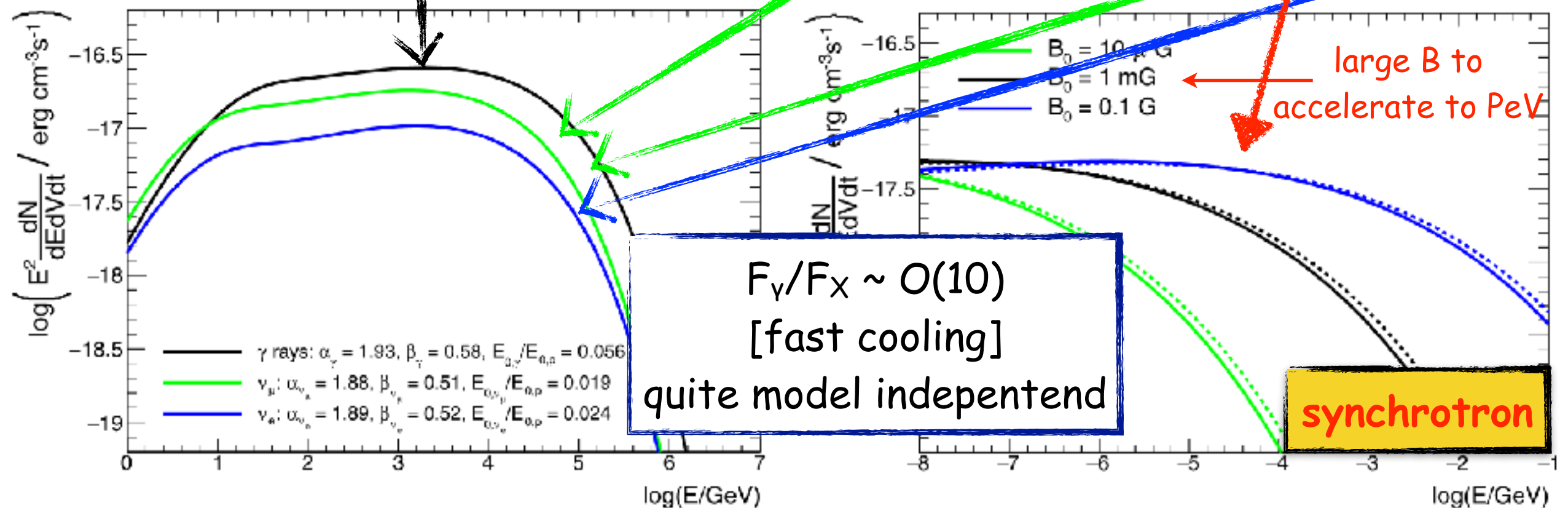
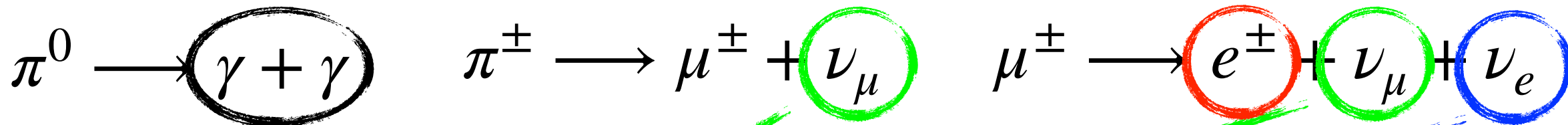
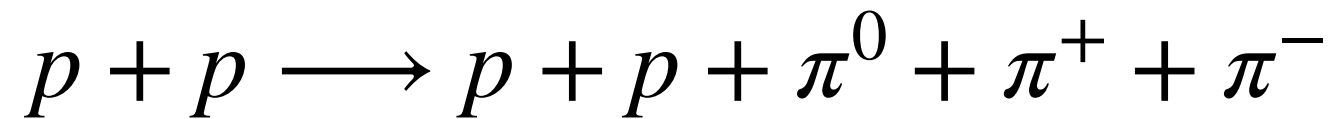
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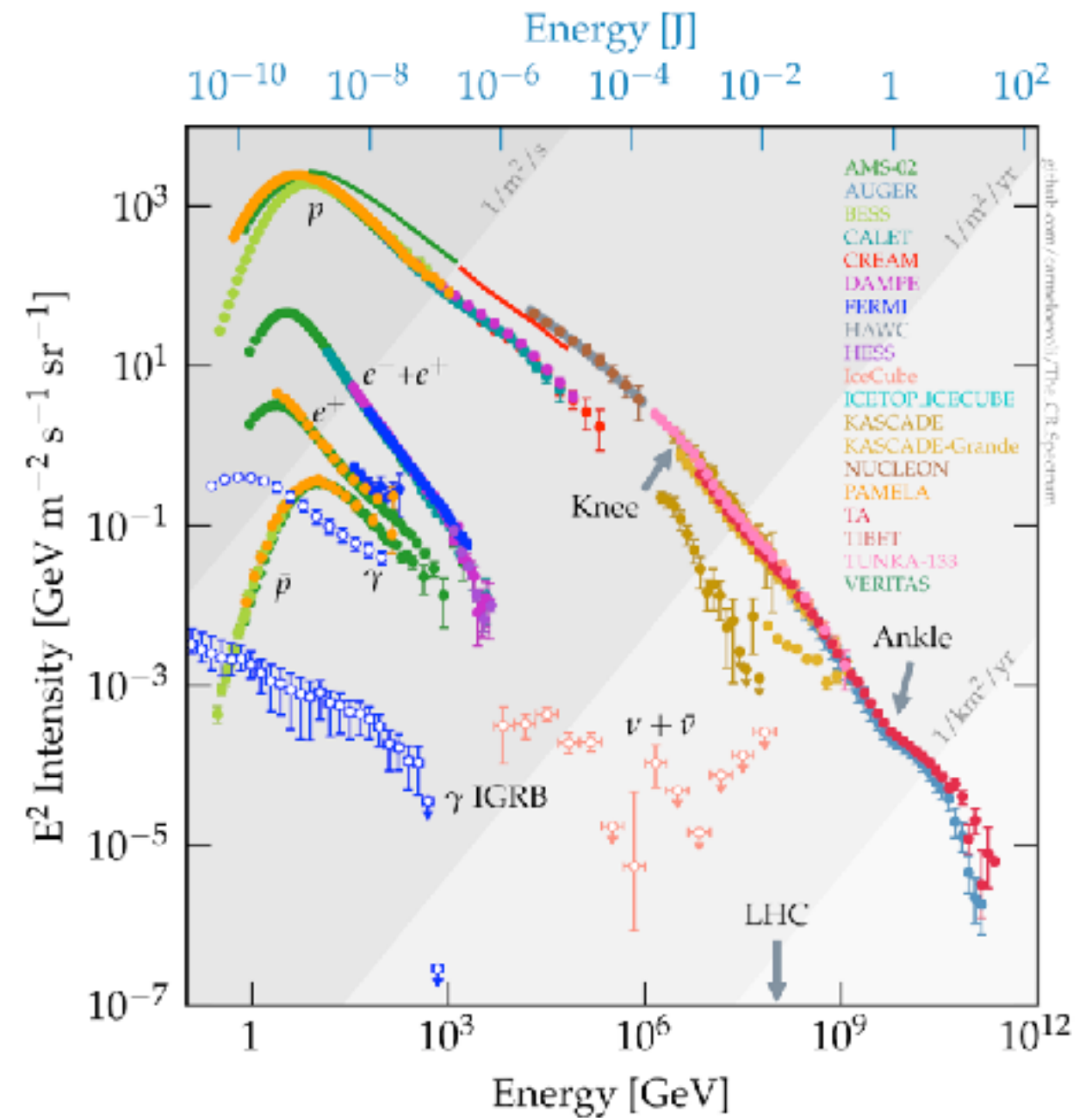
Celli, Aharonian, Gabici 2020

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Origin of PeV particles: 2 possibilities

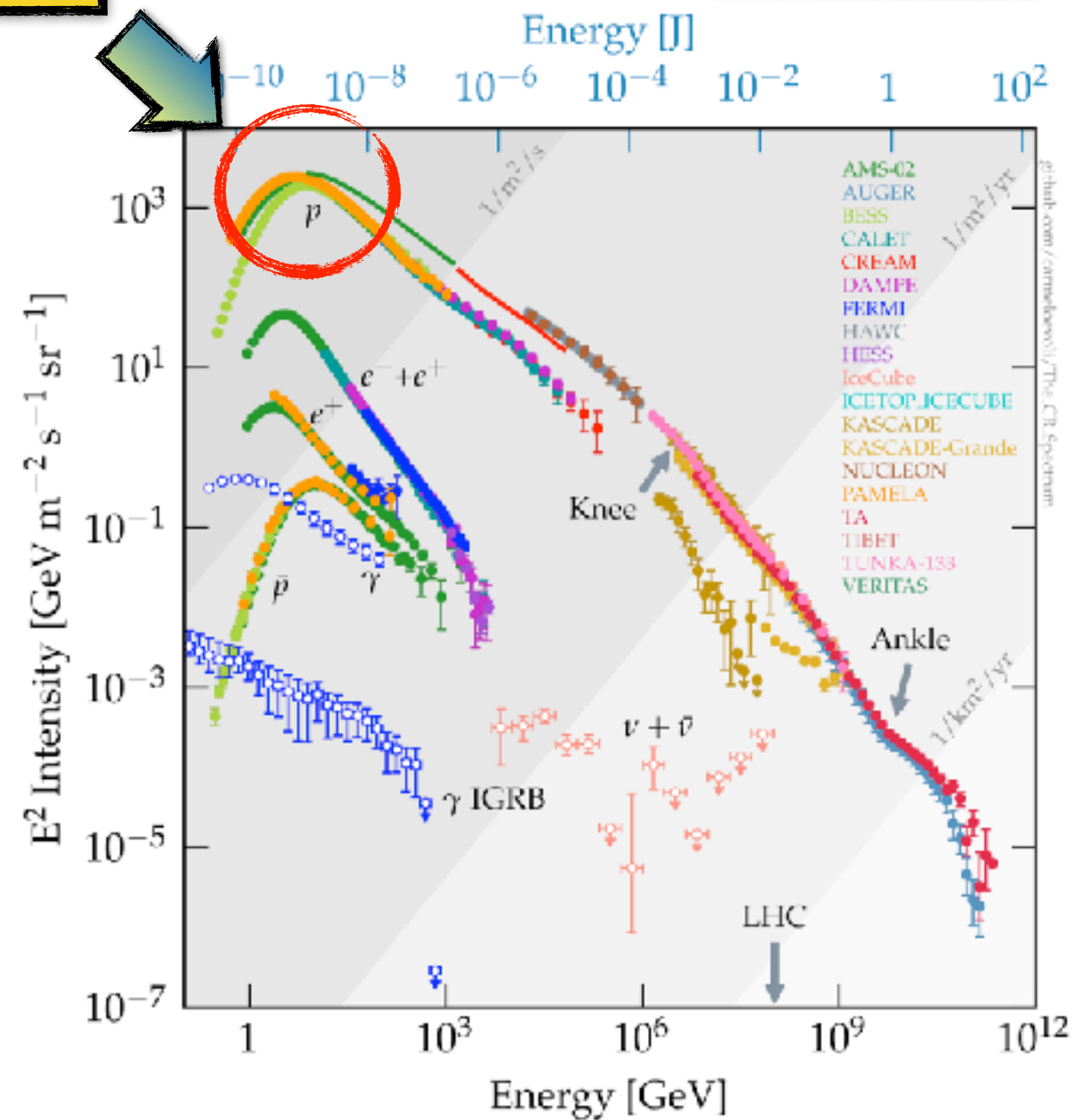


Origin of PeV particles: 2 possibilities

bulk of the energy

$$\approx 10^{41} \text{ erg/s}$$

→ SNaE

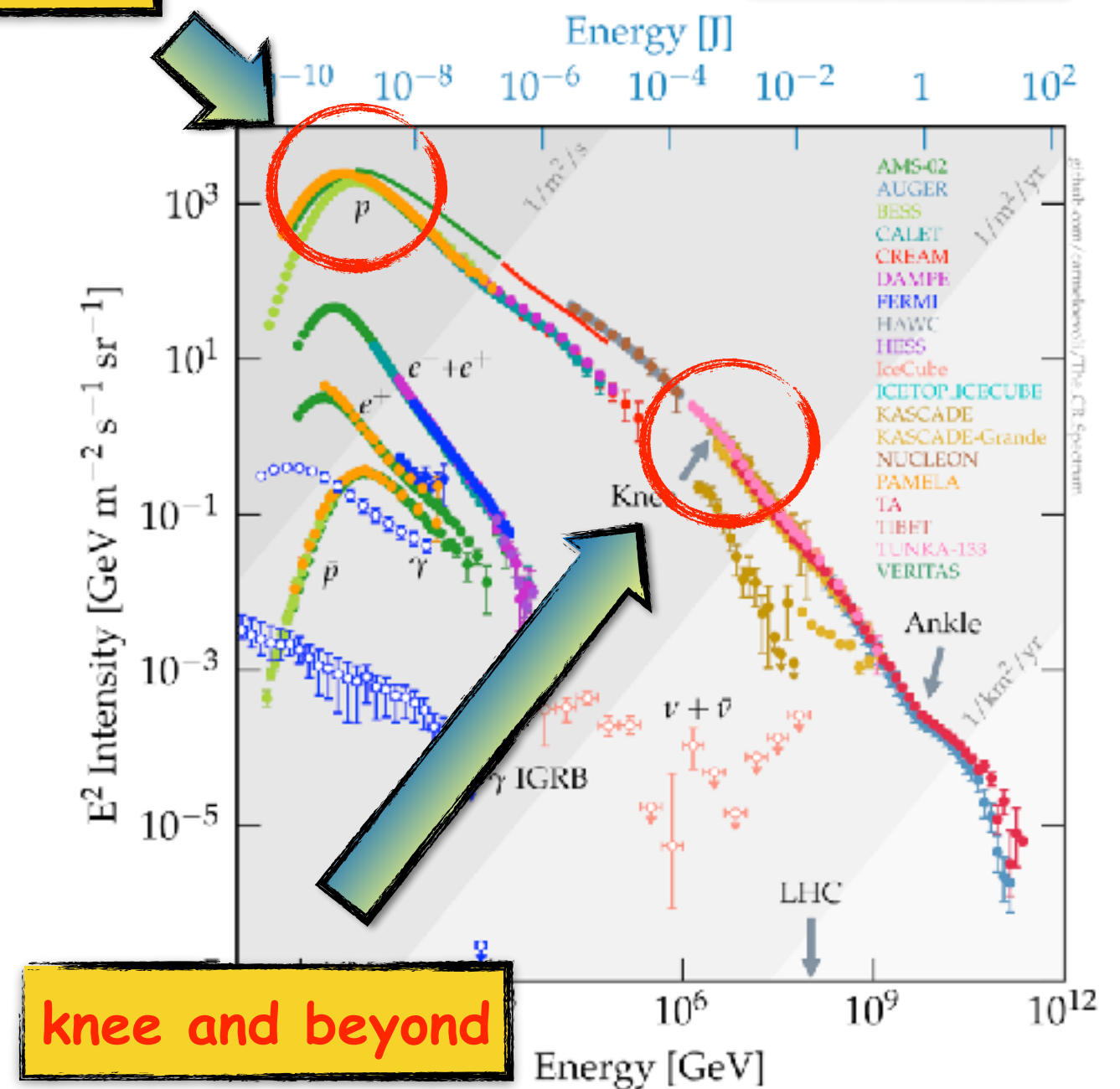


Origin of PeV particles: 2 possibilities

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knee and beyond

$$\dot{W}_{CR}(> 100 \text{ TeV}) \approx 10^{39} \text{ erg/s}$$

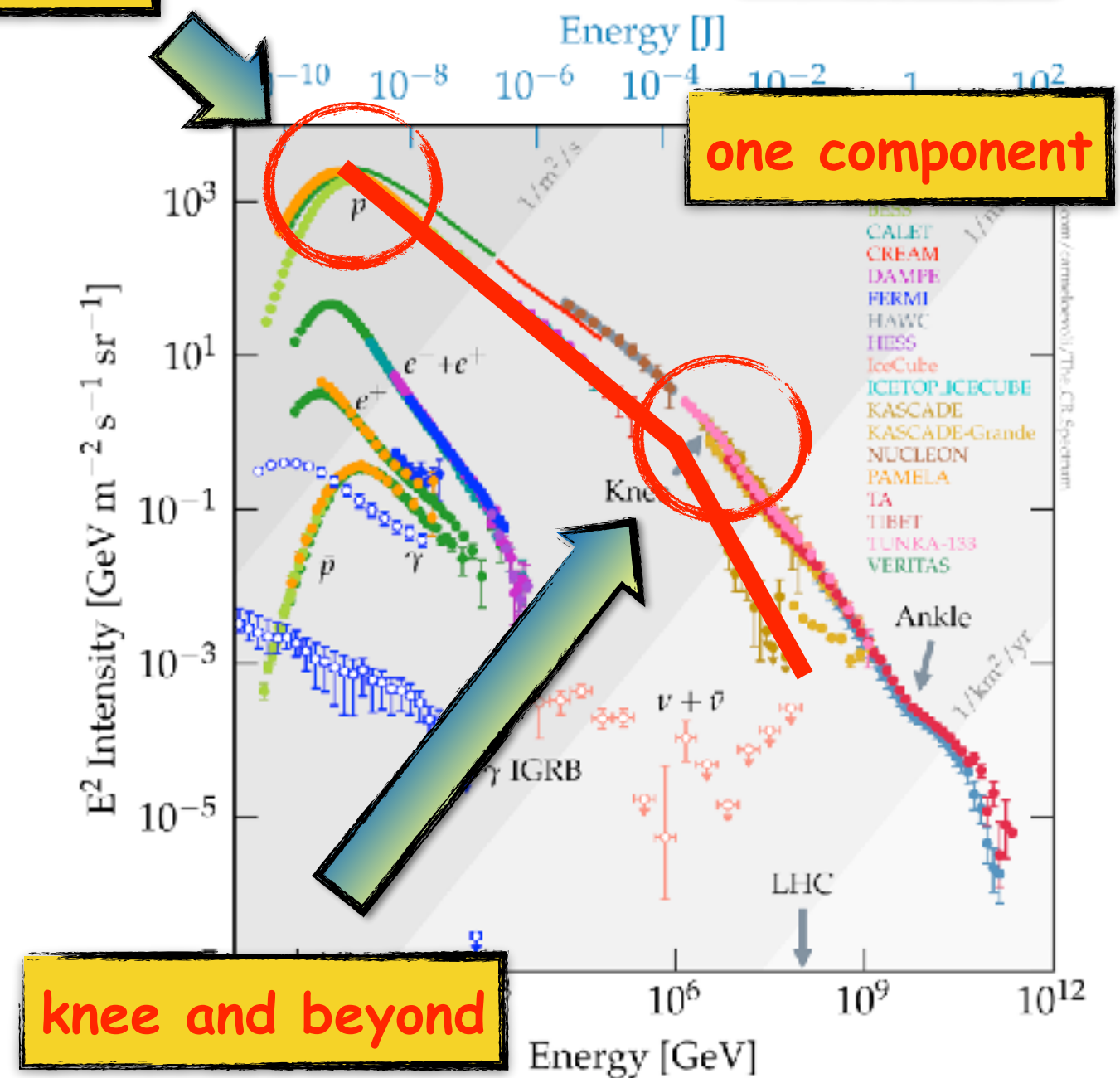
Evoli's plots

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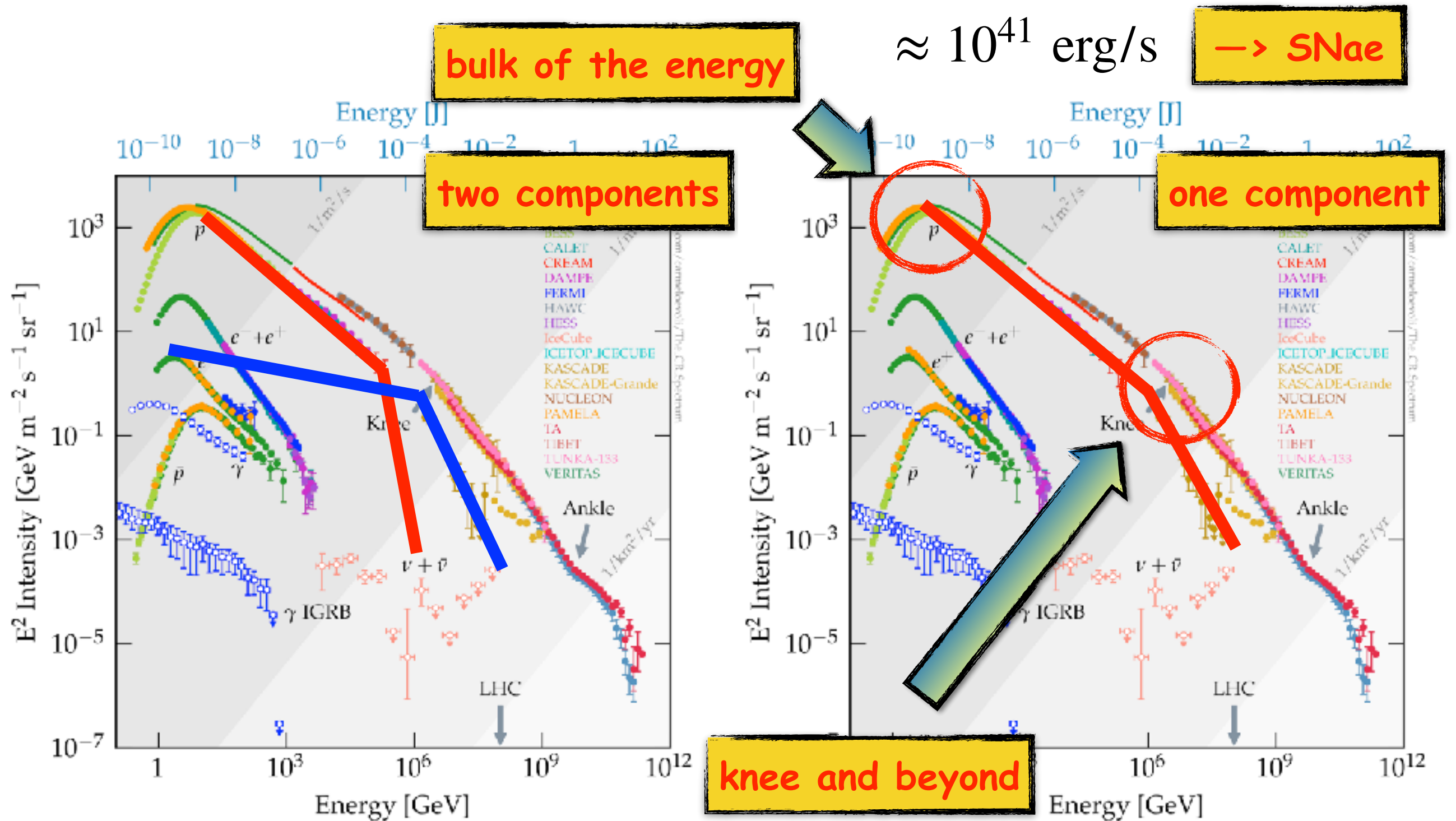
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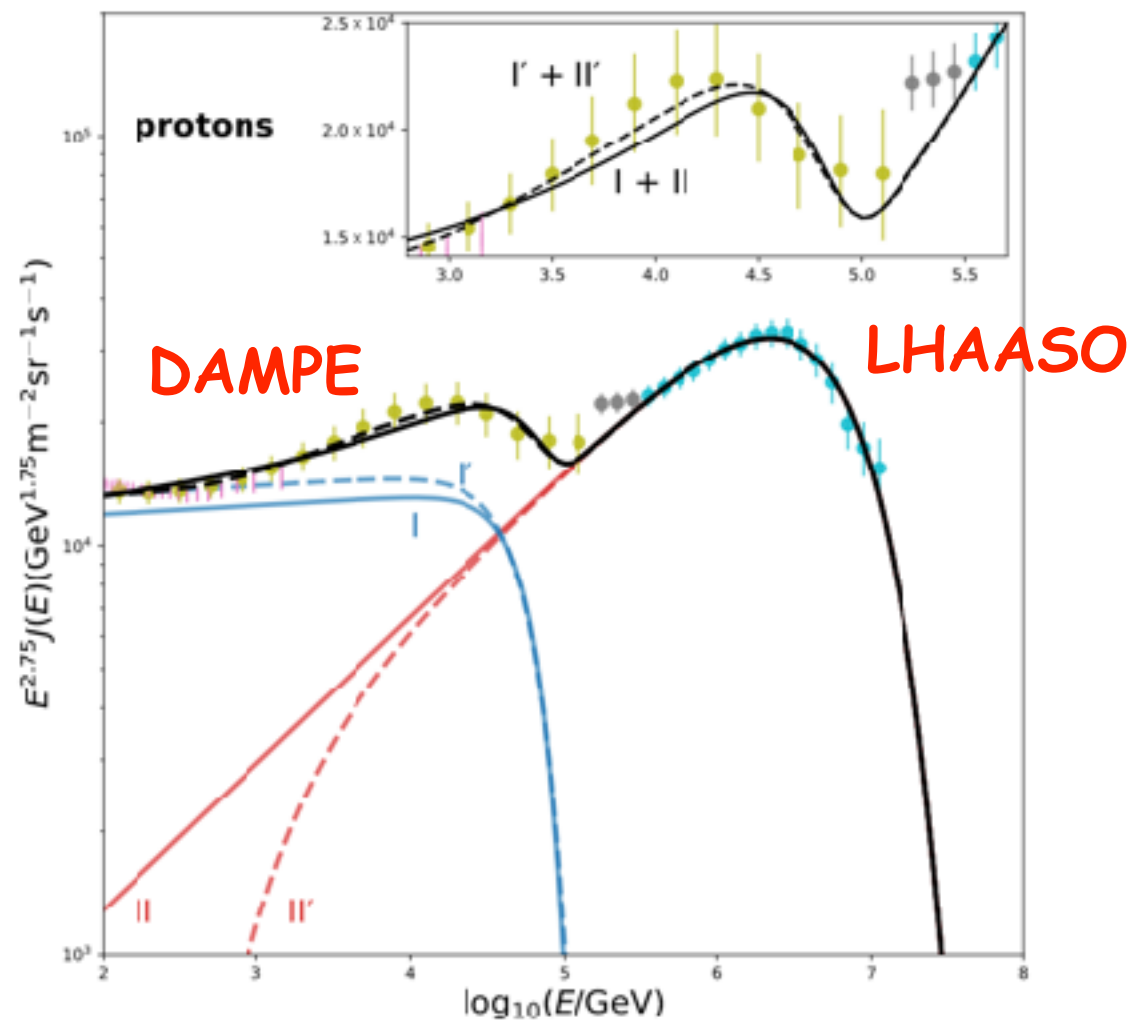
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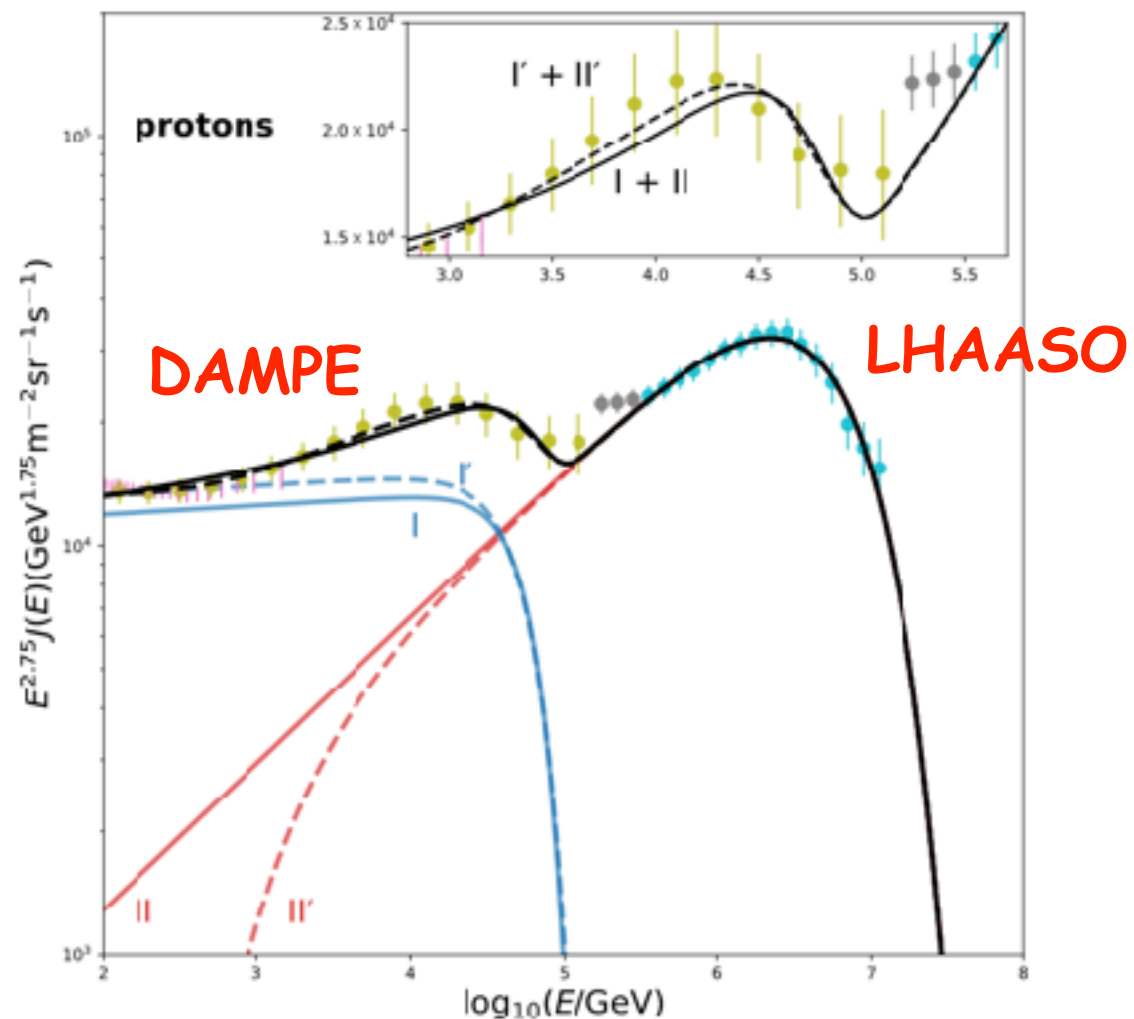


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Super-PeVatrons must exist

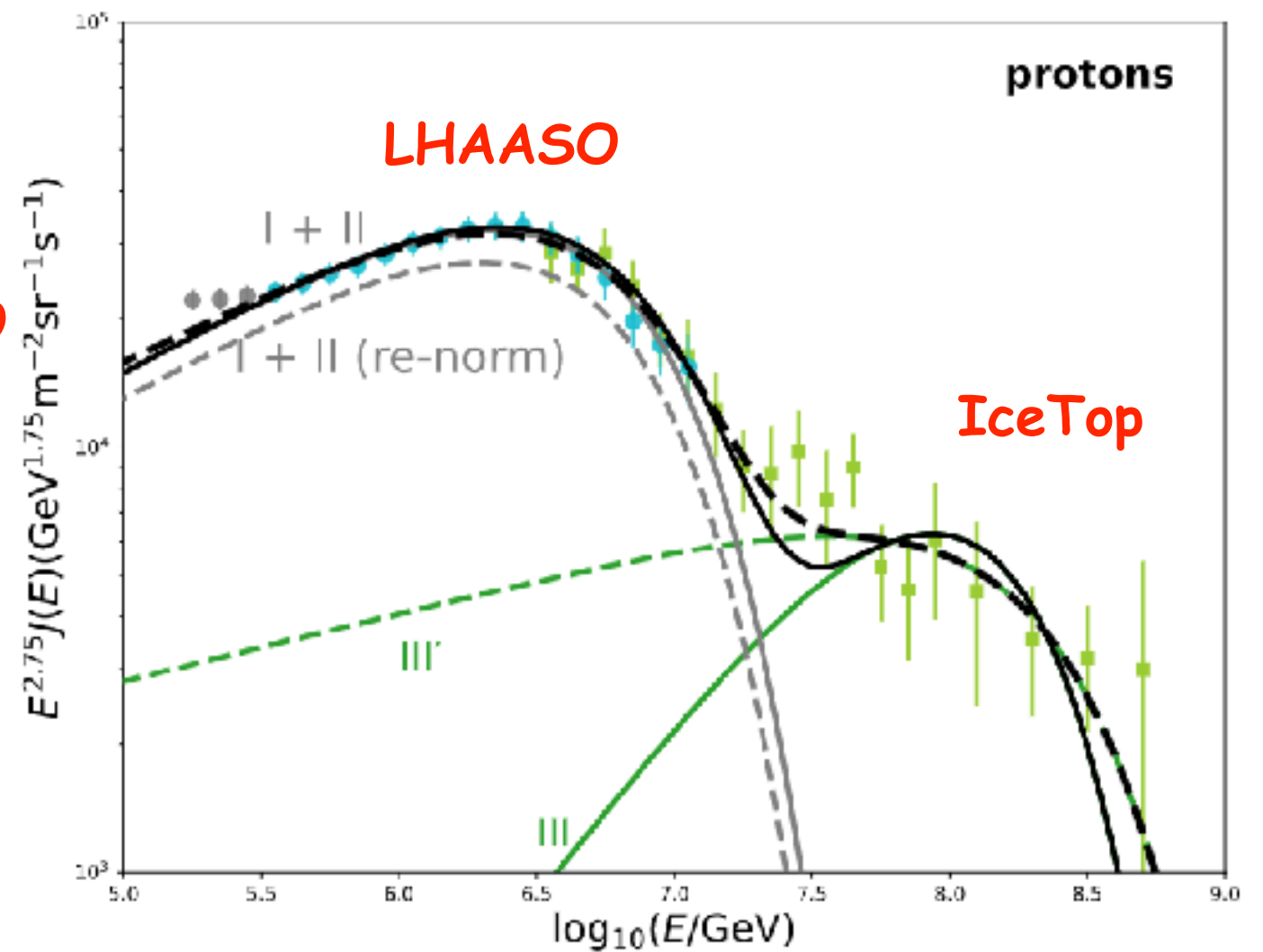
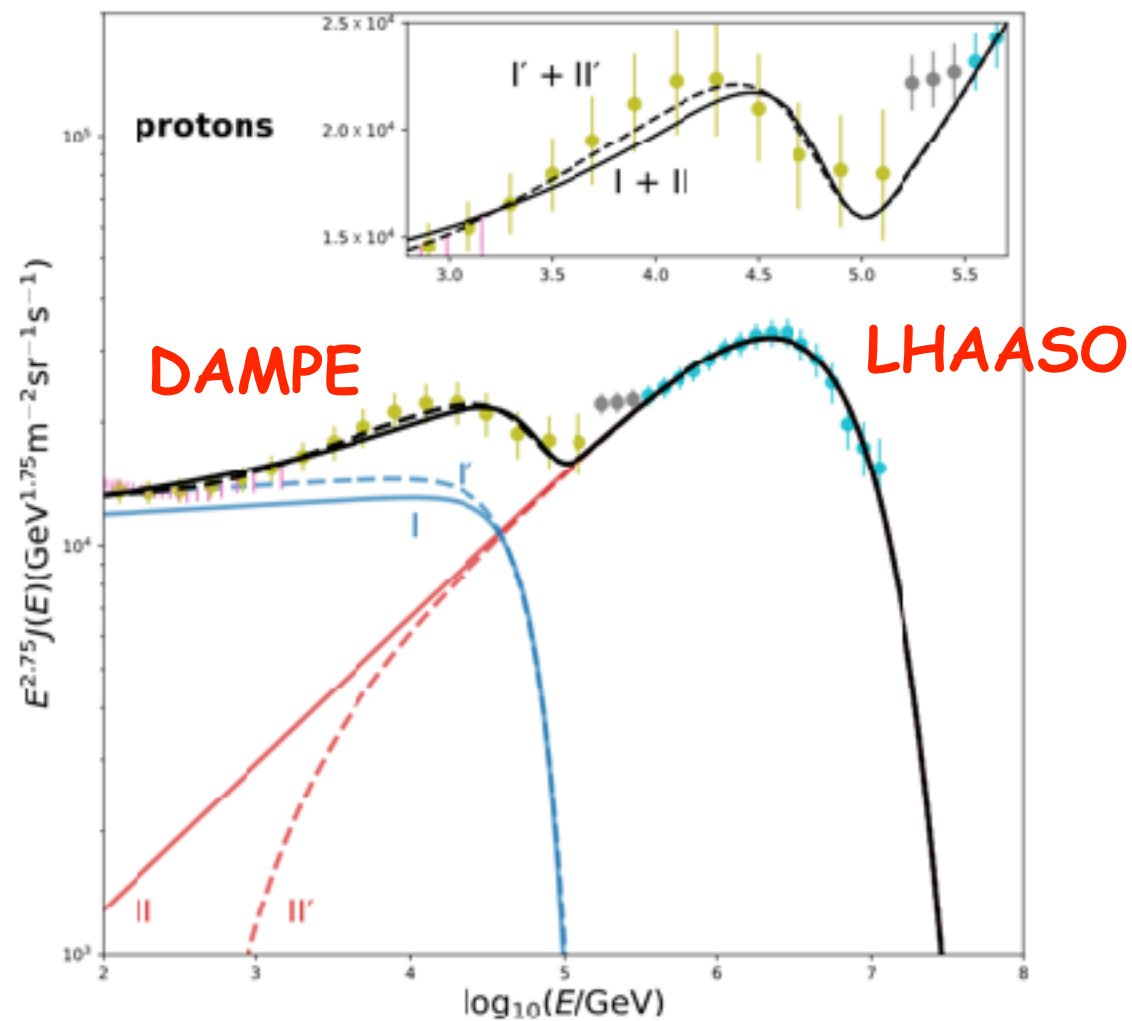


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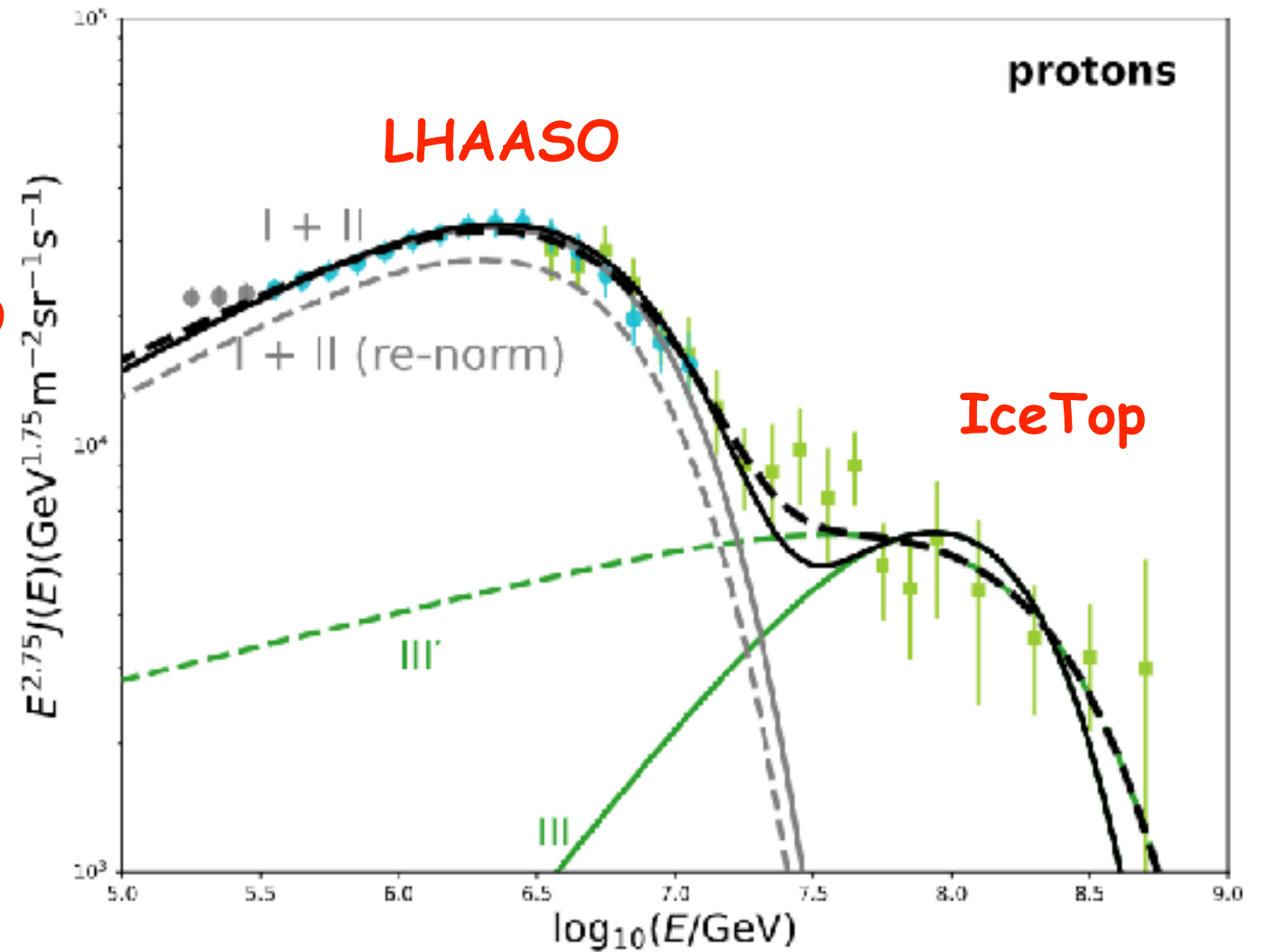
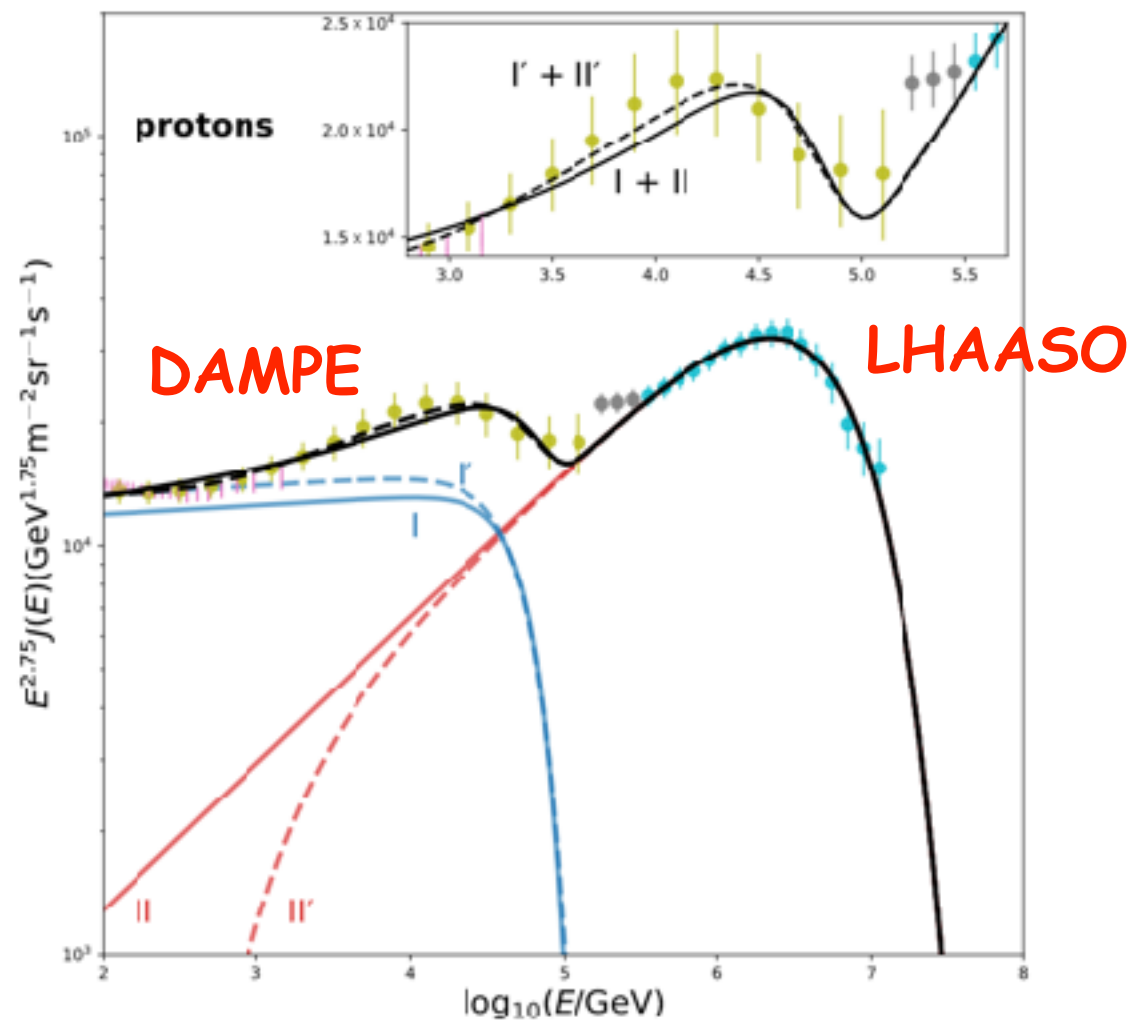
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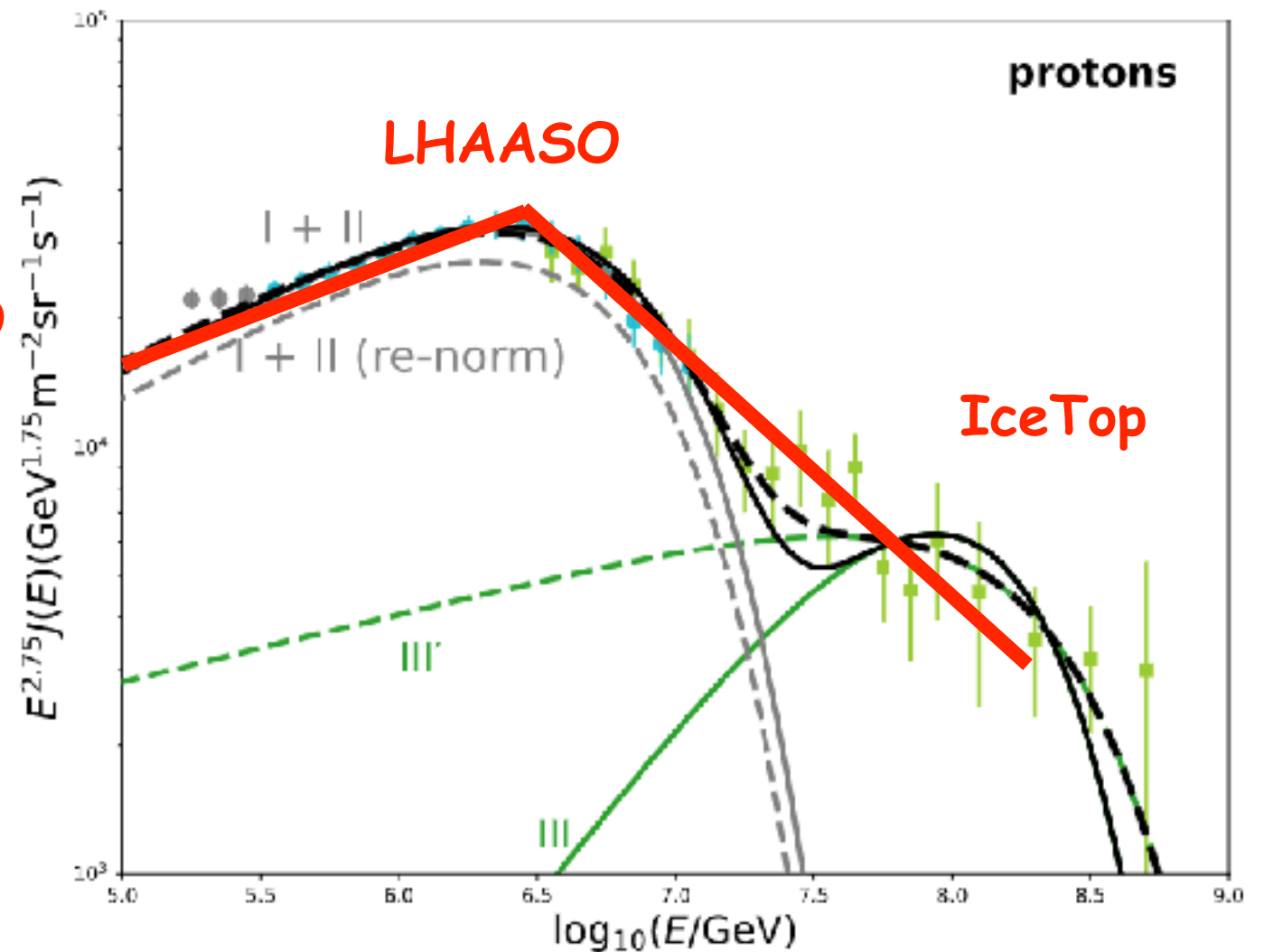
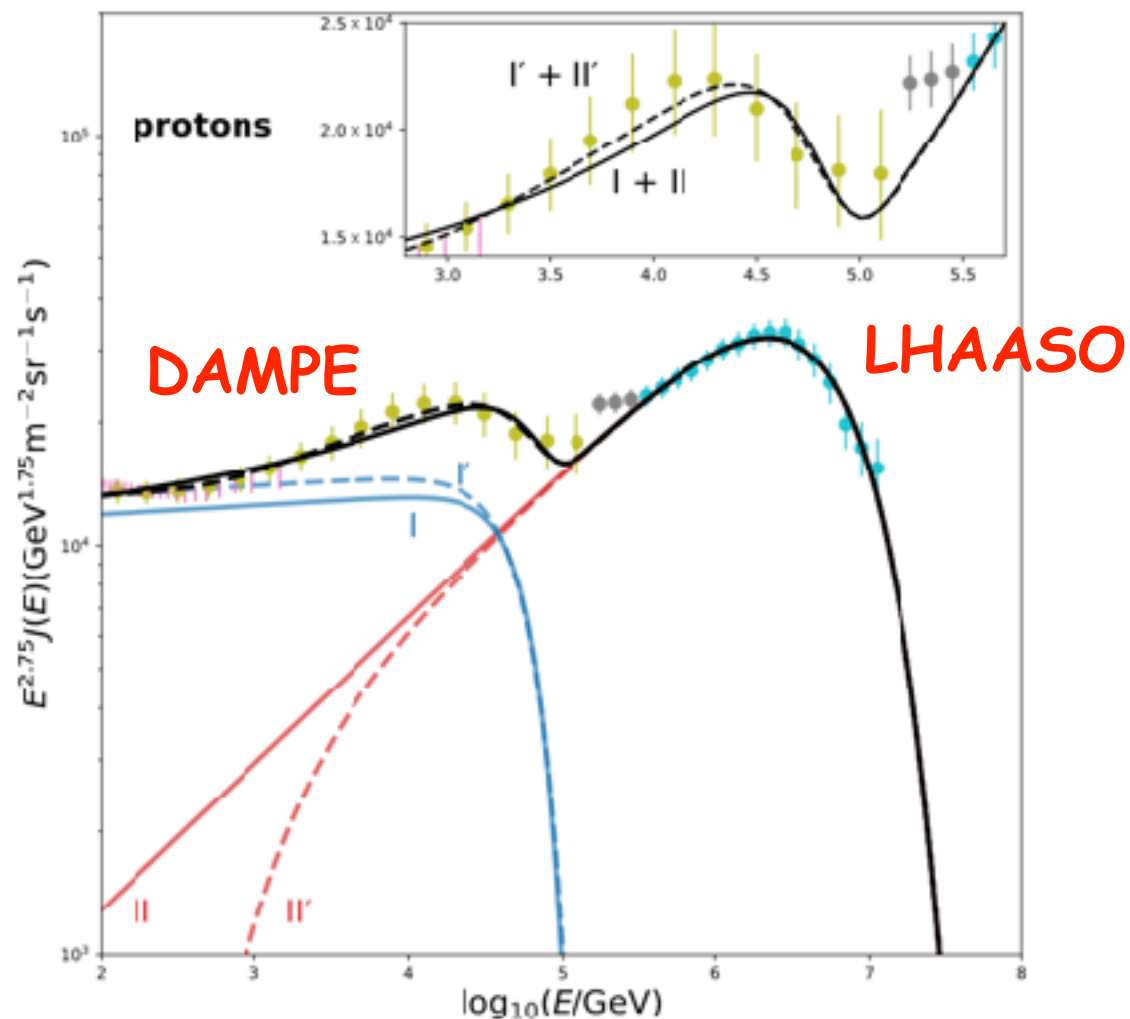
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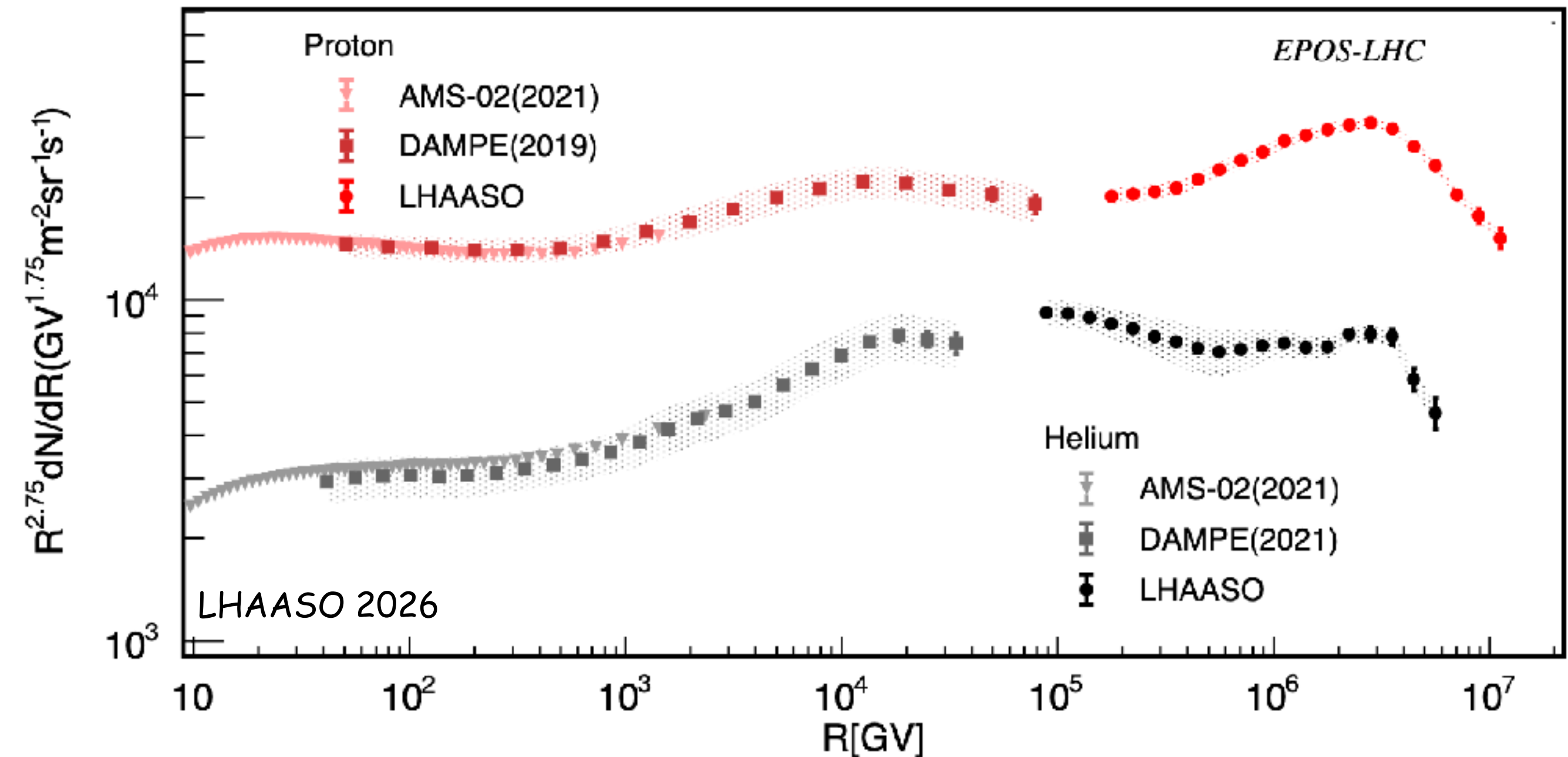
instep $\rightarrow$ new population?

third component or broken
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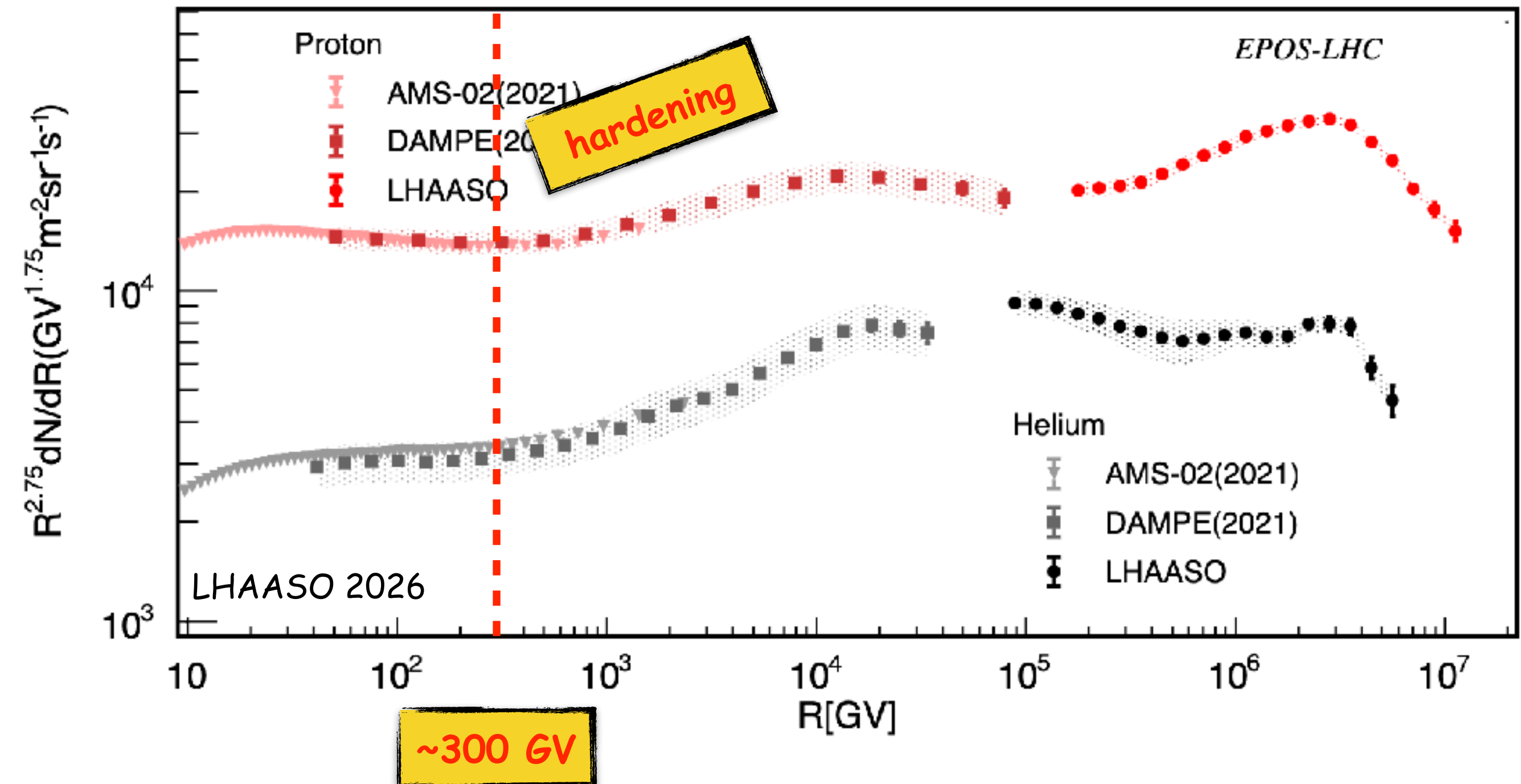
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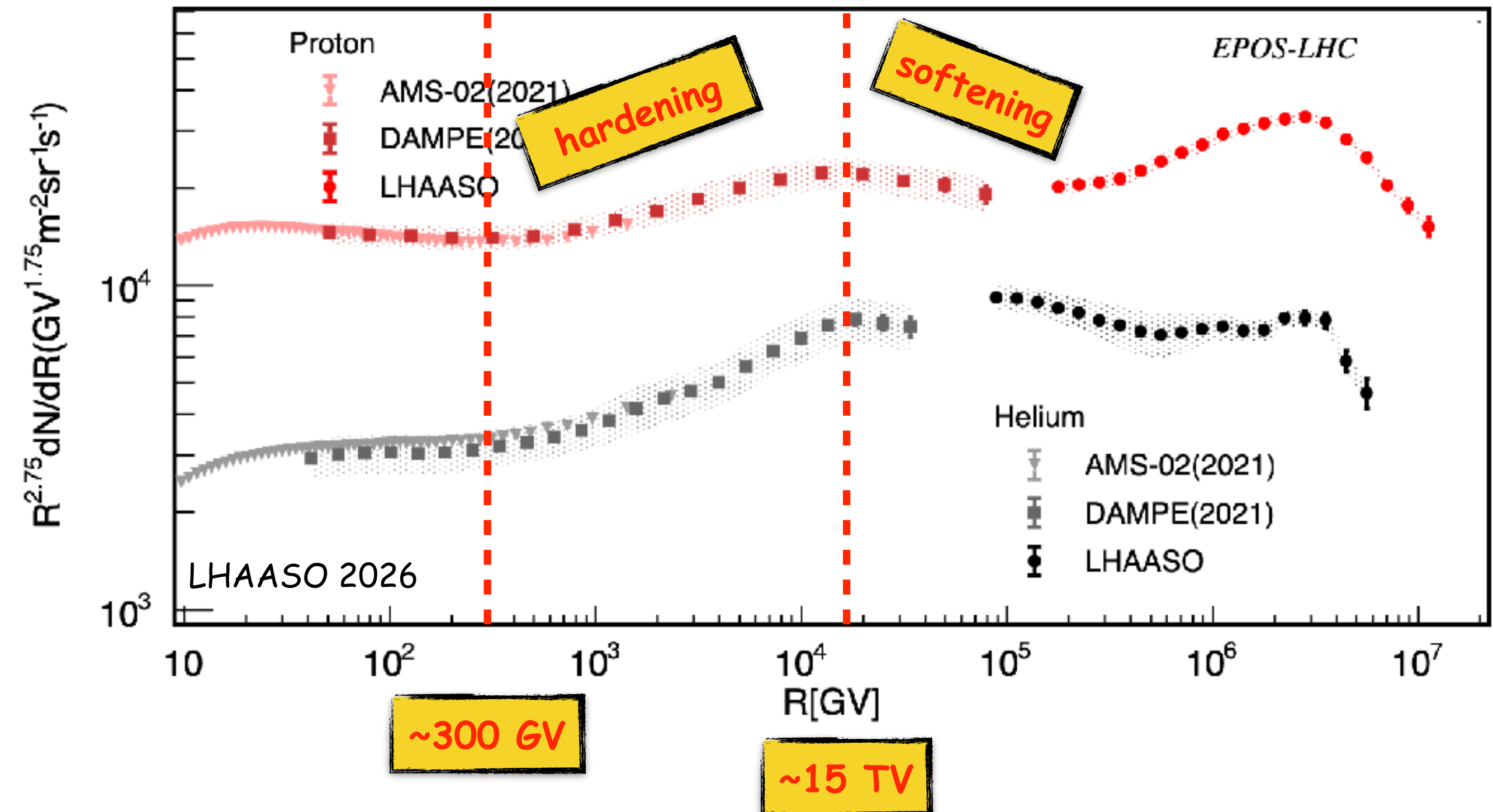
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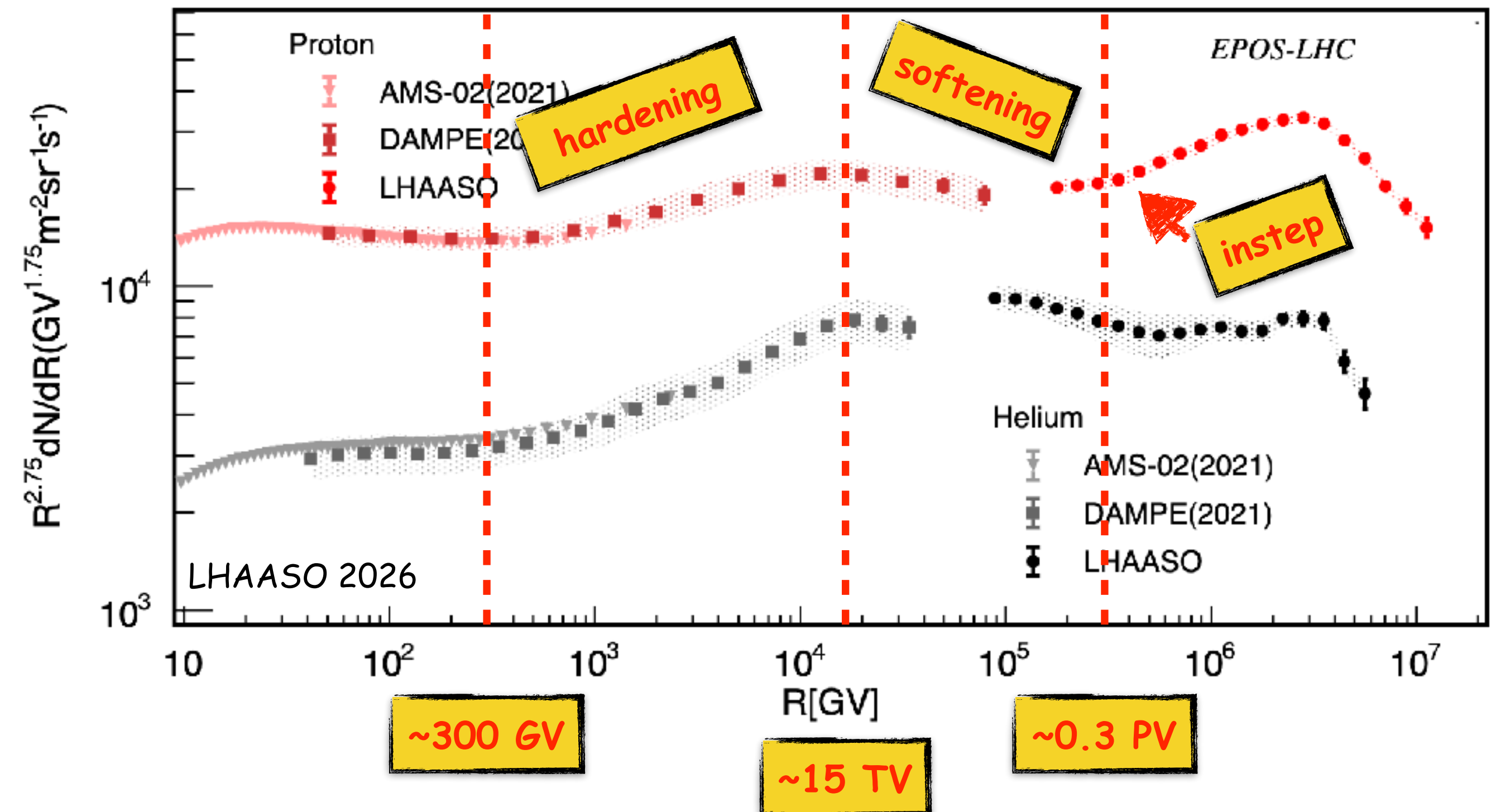
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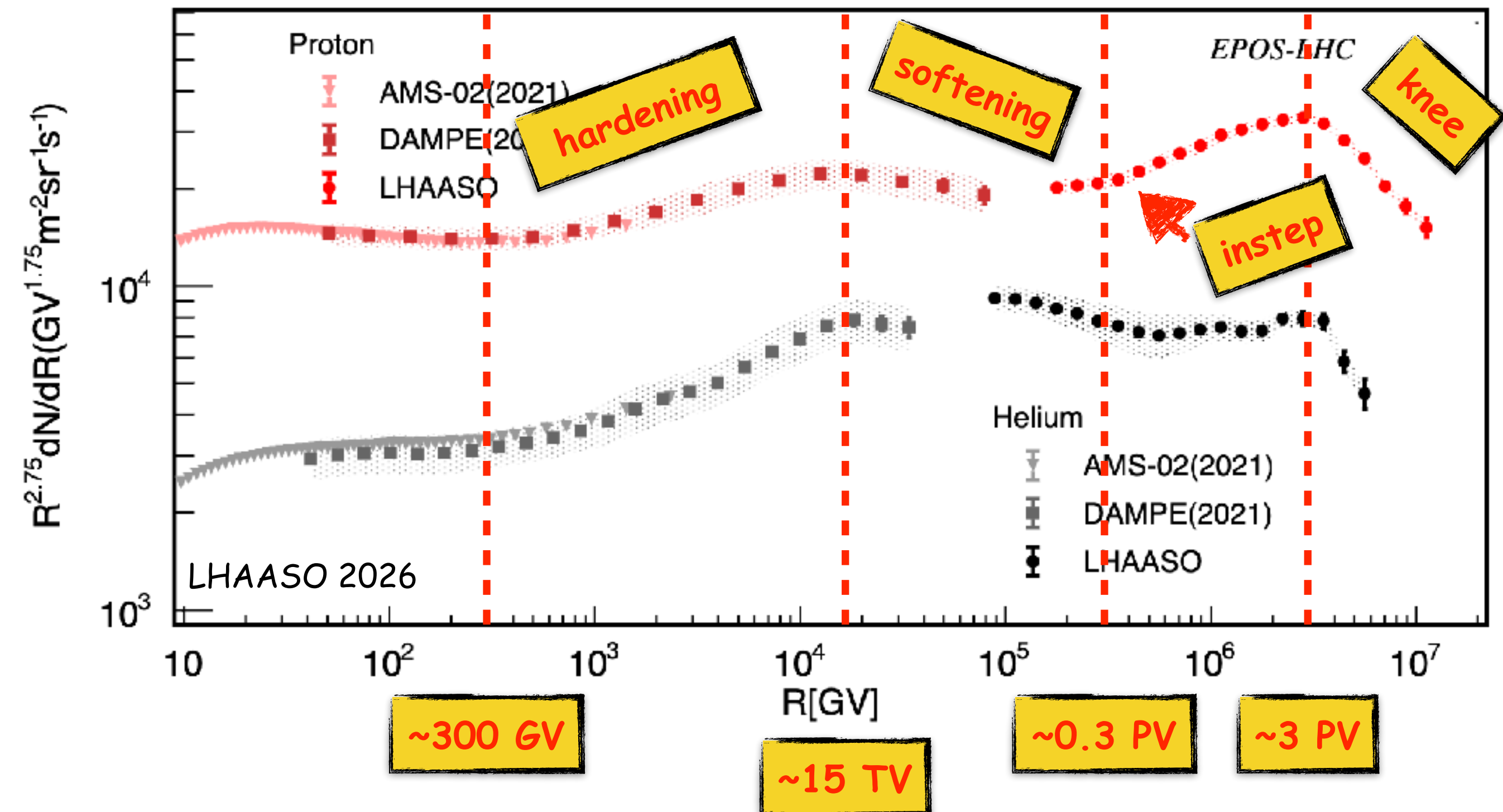
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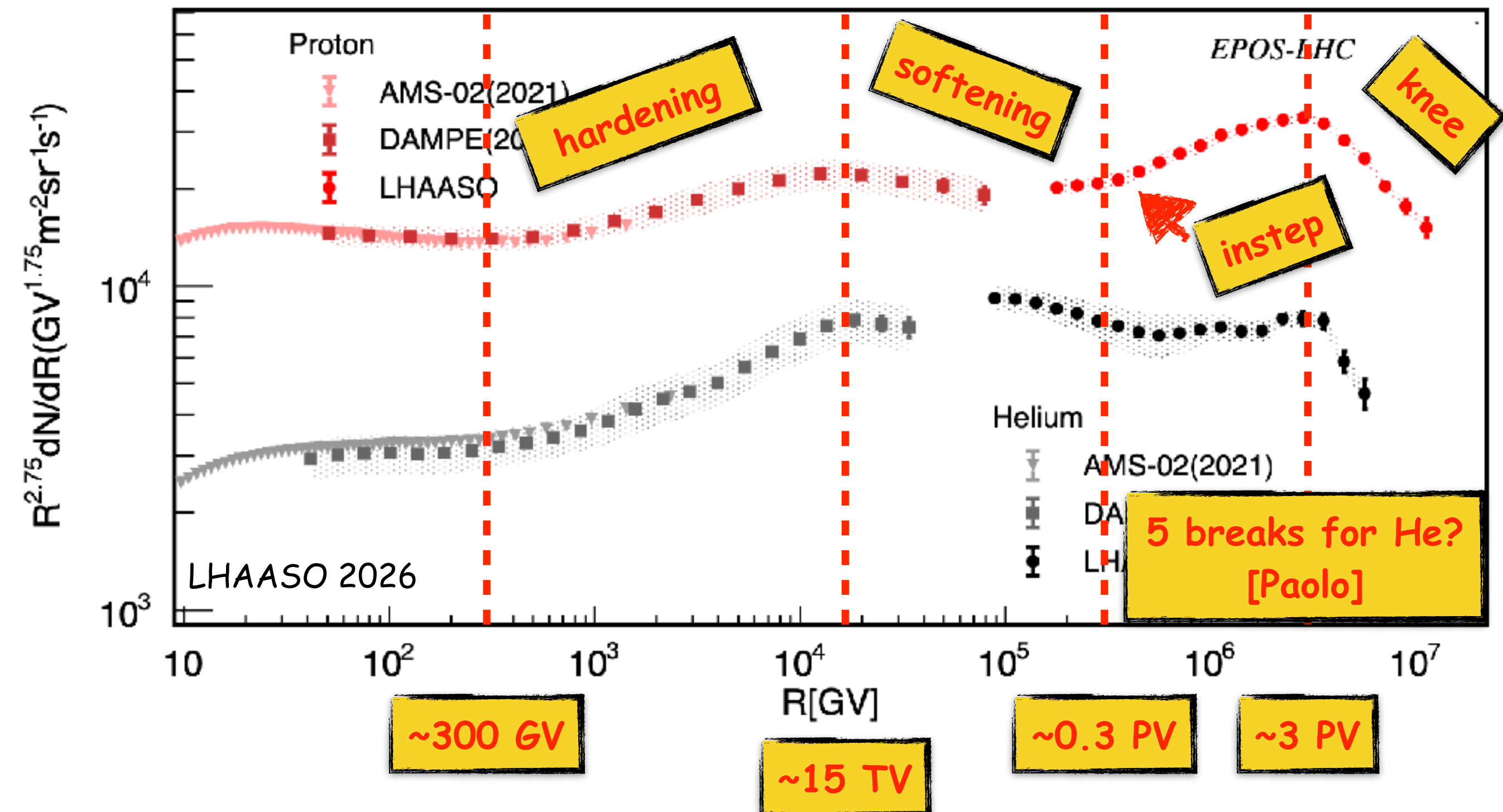
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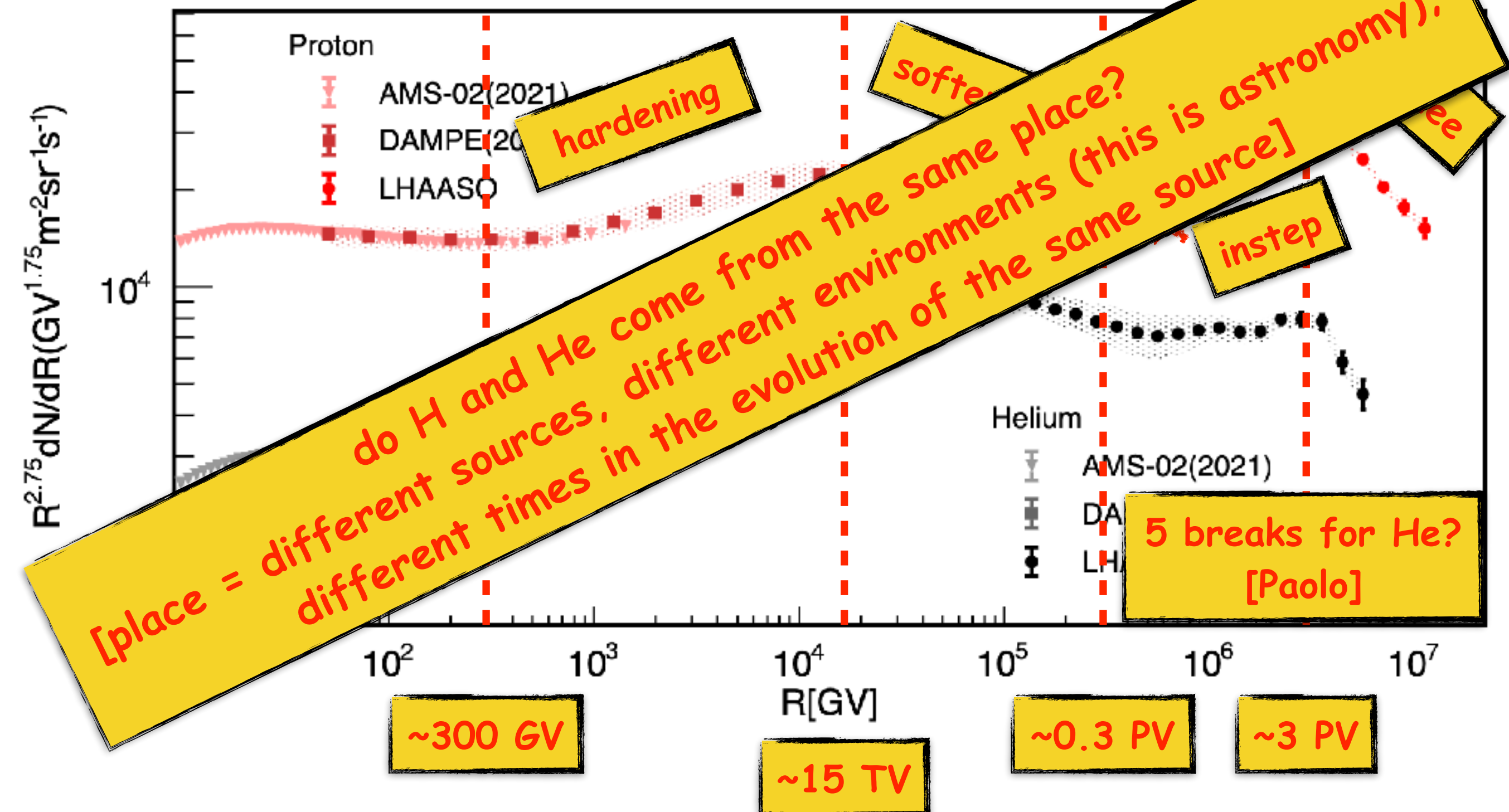
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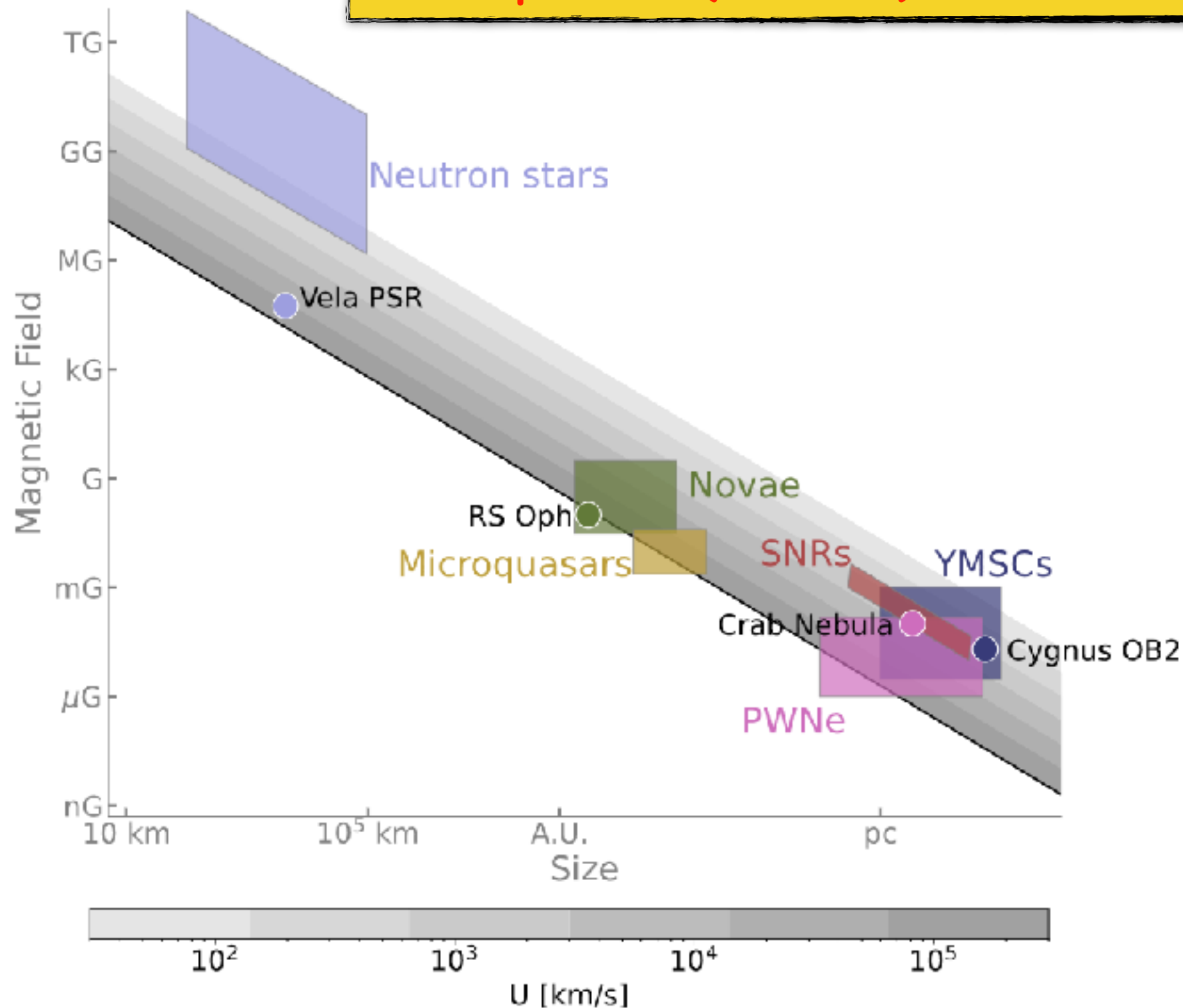
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Theory: how to accelerate to $\gg \text{PeV}$?

Hillas plot for (hadronic) PeVatrons*



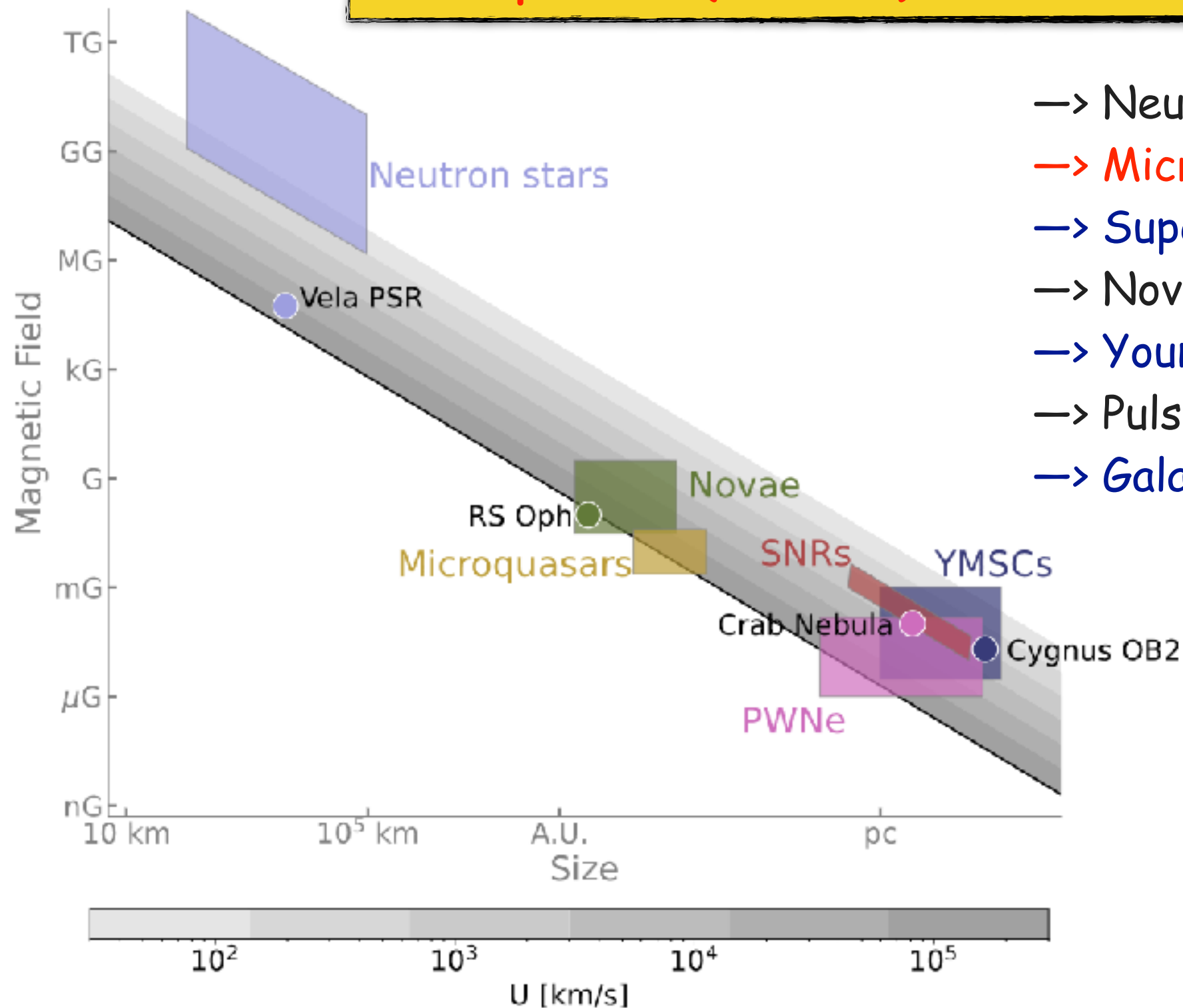
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direct
[acceleration]

indirect
[escape]

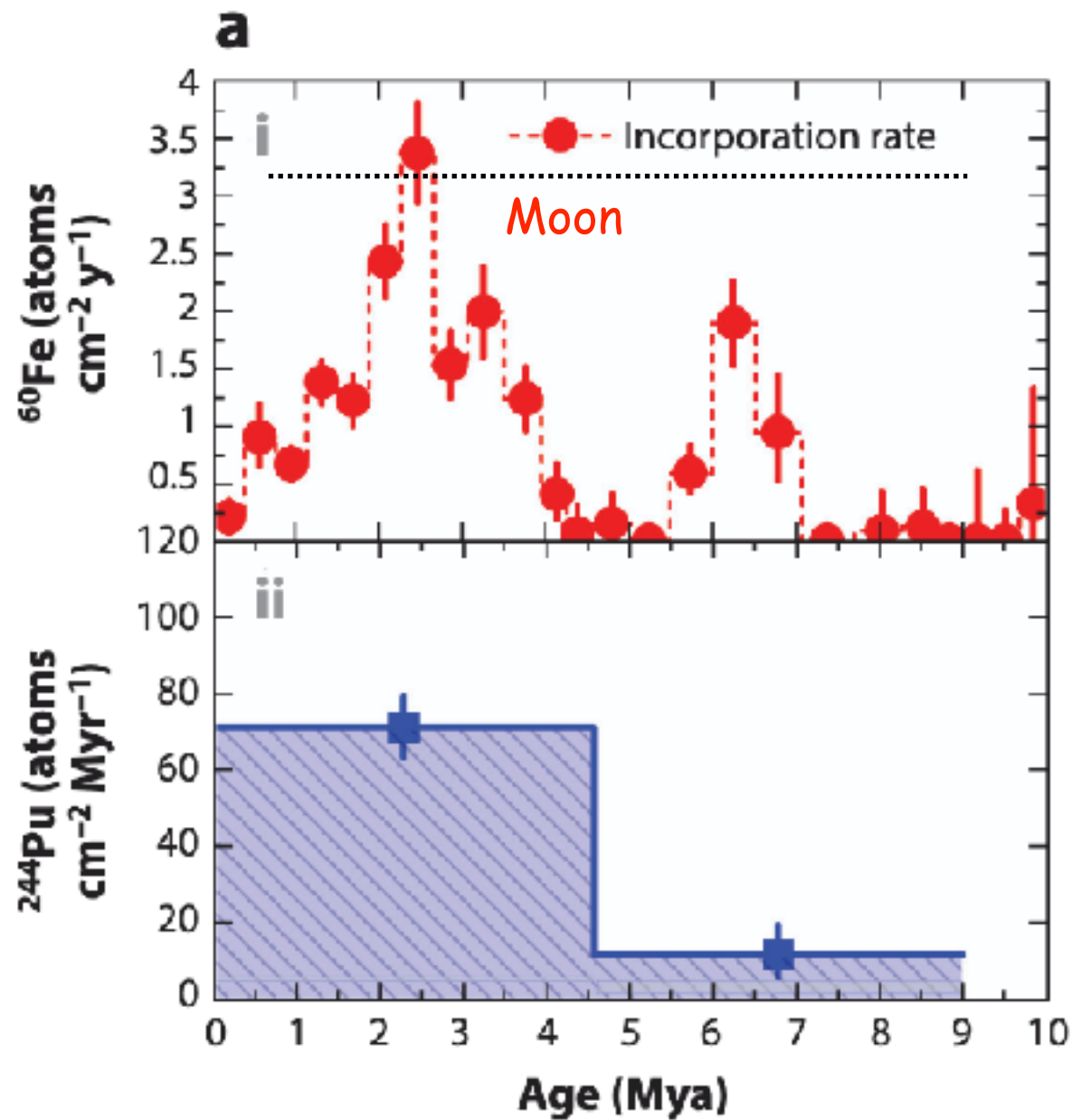


- Neutron stars
- Microquasars
- Supernova remnants
- Novae
- Young Massive Star Clusters
- Pulsar Wind Nebulae
- Galactic centre (?)

*remember that the Hillas criterium indicates the maximum energy one can achieve without violating electrodynamics

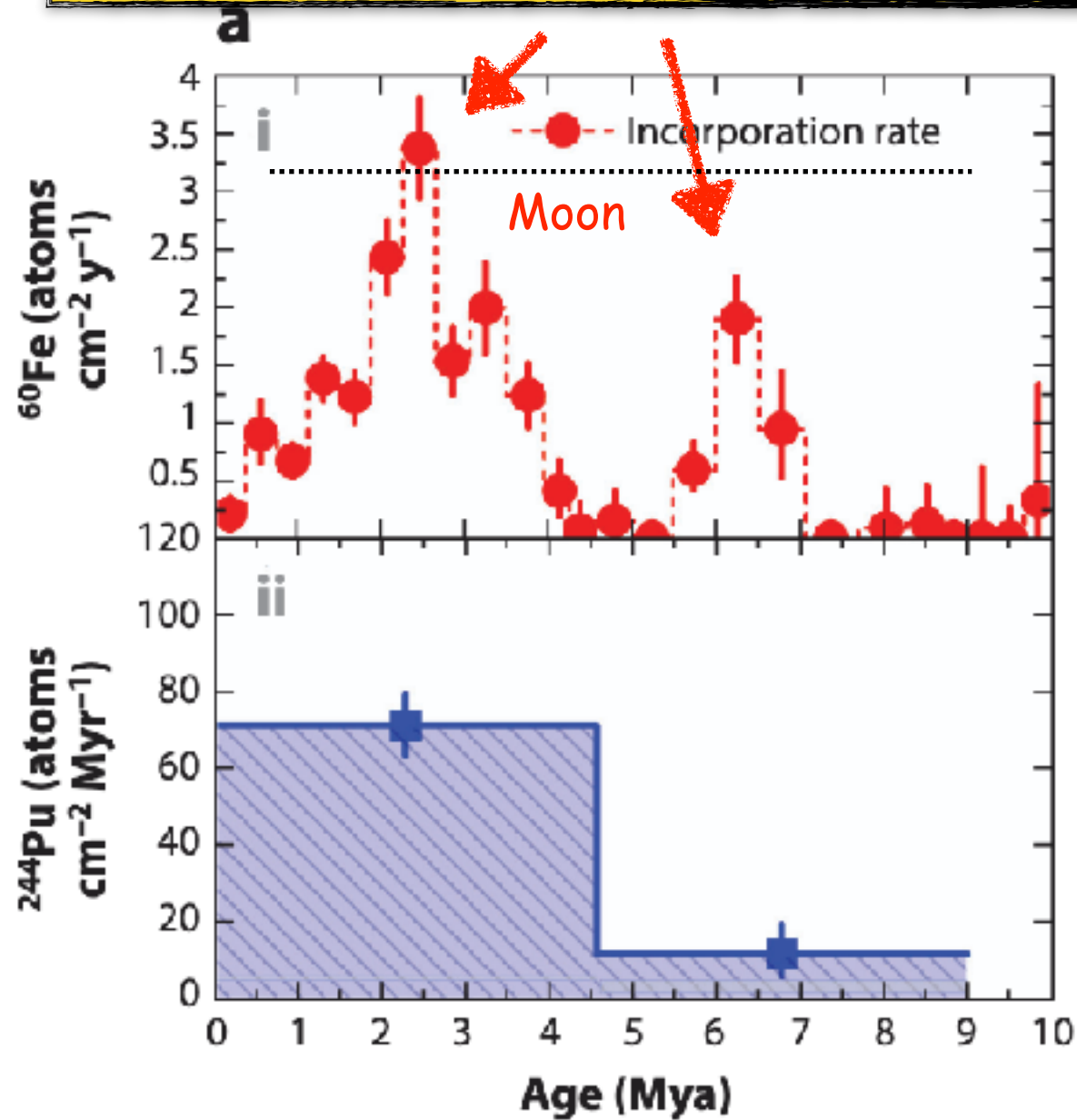
Look down! ^{60}Fe and ^{244}Pu in the bottom of the ocean, paleo-detectors...

Knies 2004 ... Wallner+ 2021, Fields&Wallner 2023



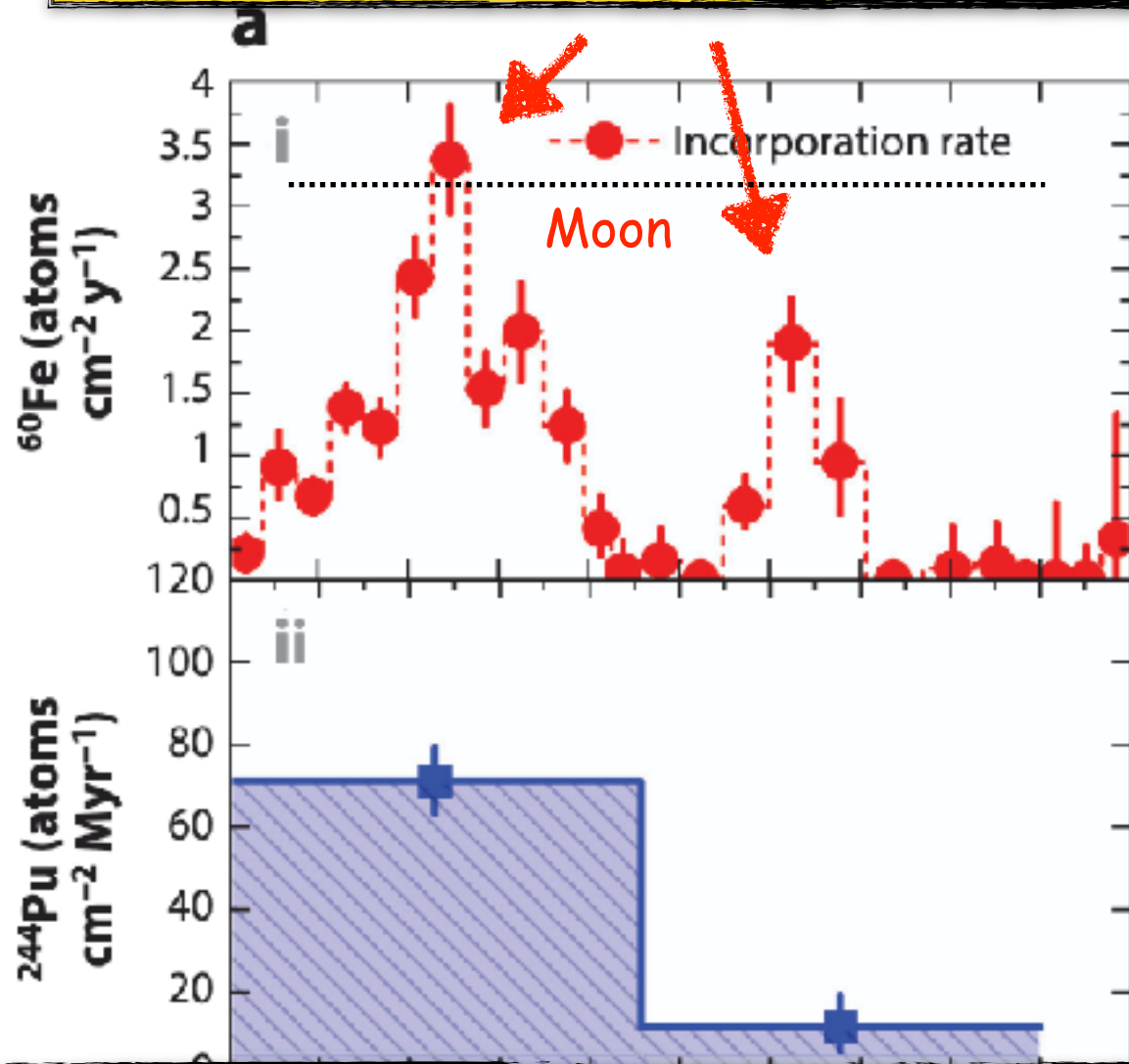
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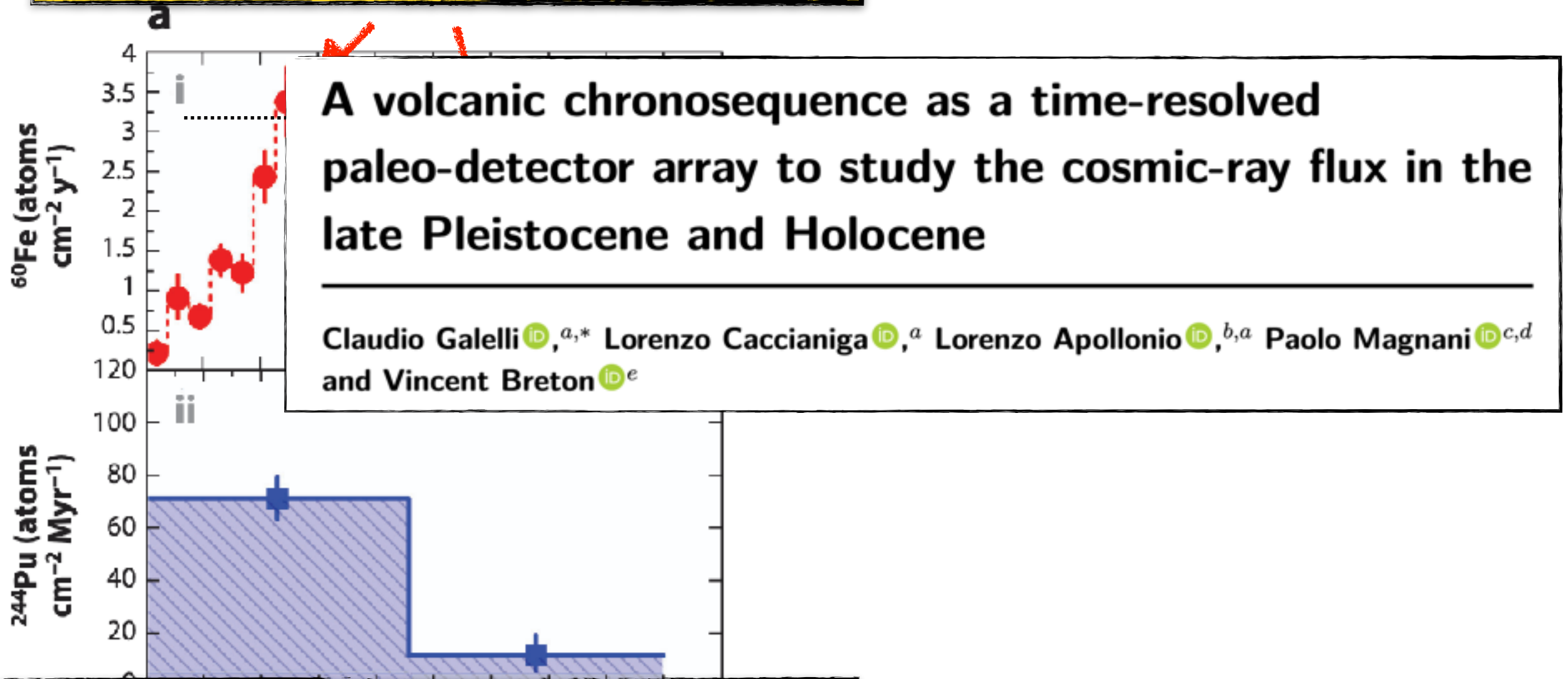
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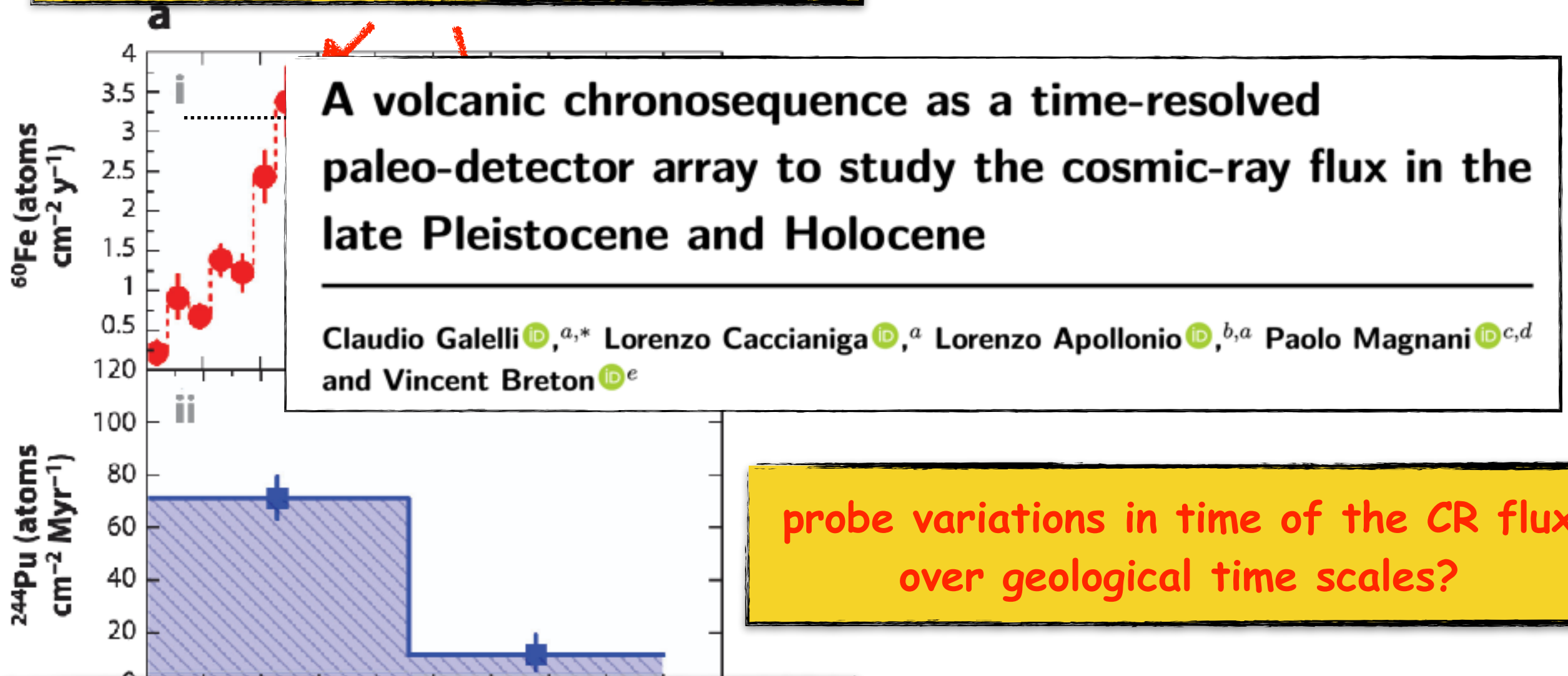
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probe variations in time of the CR flux over geological time scales?

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One component

- SNRs $\rightarrow$ $\gg 1$ sources do the knee
- Theory: PeV phase = 10 yr $\rightarrow$ 0 active PeVatrons now $\rightarrow$ it's normal not to see them $\rightarrow$ sadness/despair
- Indirect detections $\rightarrow$ model dependent
- "boosted" DSA?

Questions

do the same sources produce CRs from GeV to >PeV, or is a new component required?

- Which (how many) class(es) of sources?
- What does it mean "one class of sources"? (SNRs in different environments count as one or two? are μ QSOs very different from each other a single class?)
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Few (1?) sources scenario possible

Erlykin&Wolfendale
1997

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be brave/lucky

- Another SN 1987A? (not too close please)
- Tracers of CRs @ Earth?