



Dark matter

Nils-Erik Bomark

April 6, 2017/CERN



Outline

1 Hidden treasures of the universe

- Intergalactic gass-clouds
- Hidden stars and planets
- Black holes

2 Dark matter

- Seeing dark matter
- Wat do we know about dark matter?
- WIMPs

3 What is CERN doing about this?

- Cosmic radiation
- AMS-2
- MET-searches



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Are there more things in the heavens than we can see?

Yes!

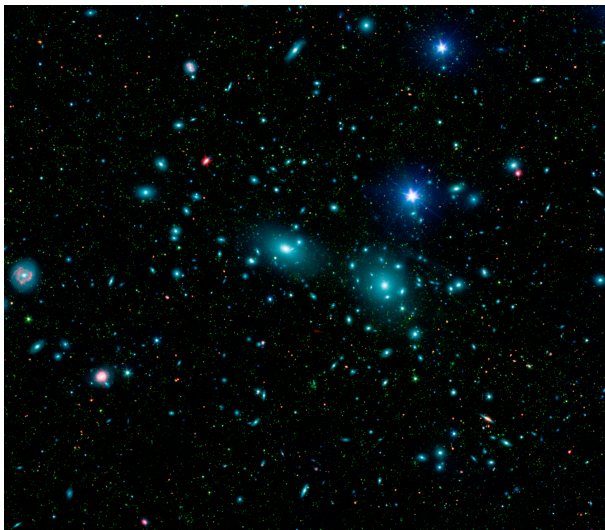


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Coma cluster



Coma cluster - X-ray

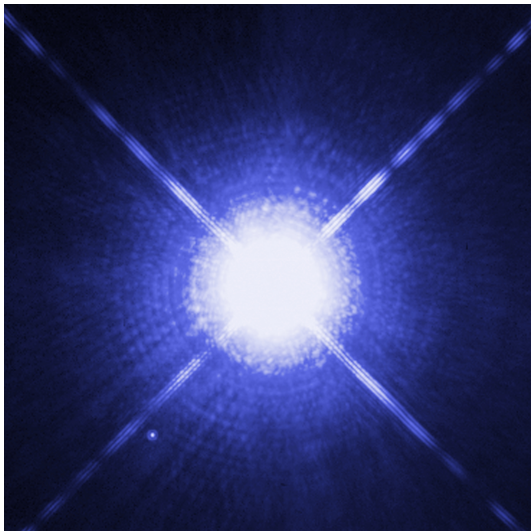


Sirius B

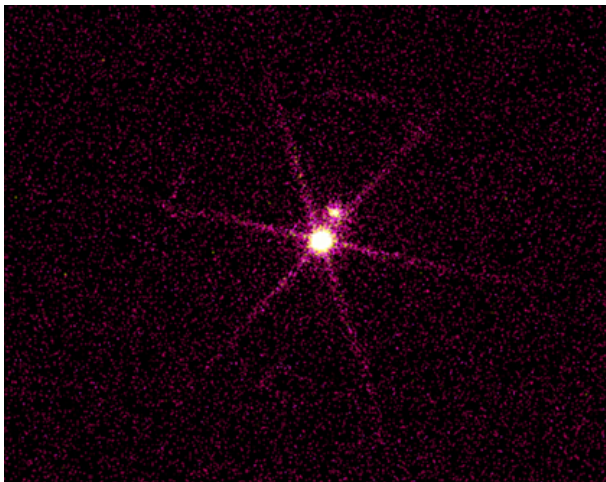




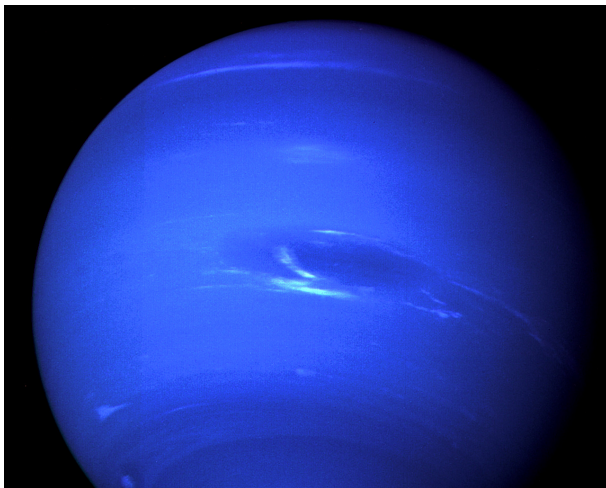
Sirius B



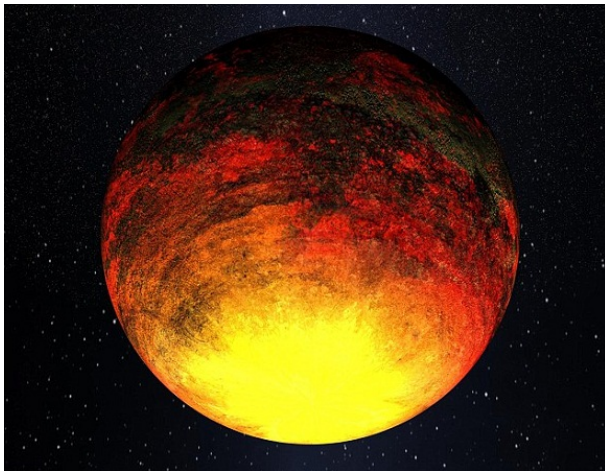
Sirius B



Neptune

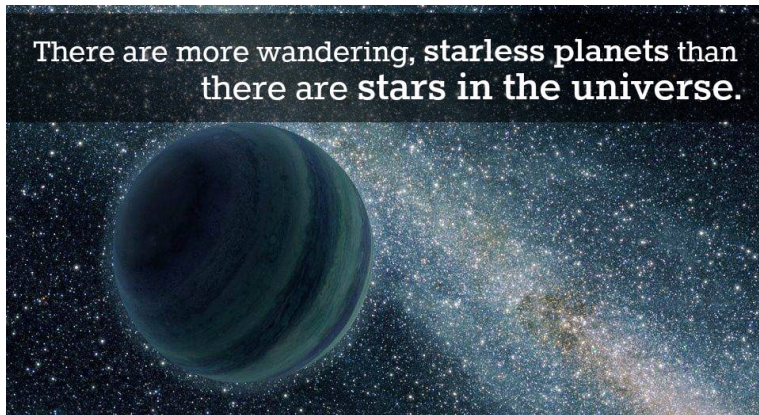


Vulcan

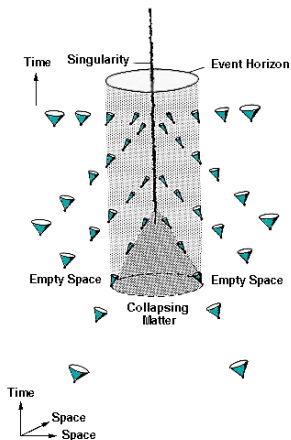




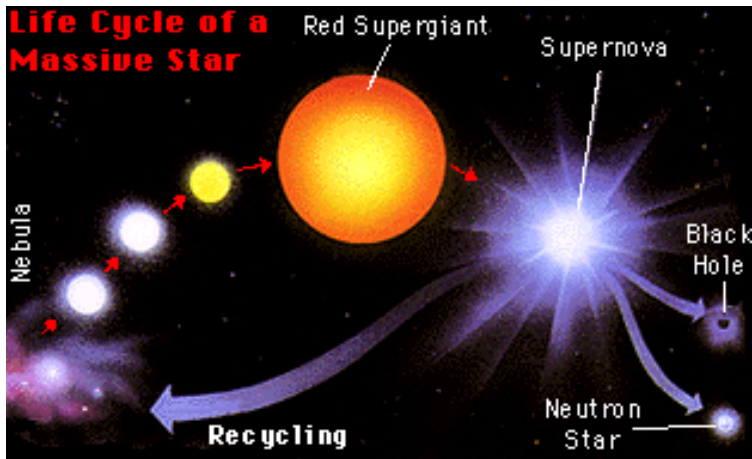
Rogue planets



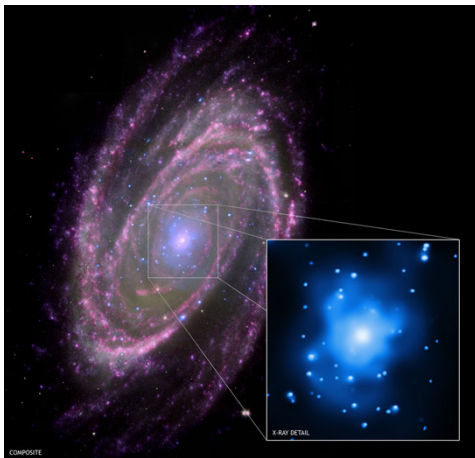
On the event horizon there is no direction "out"



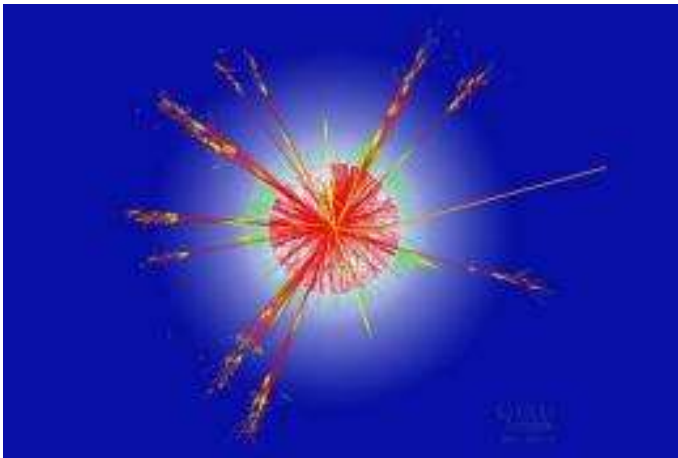
Stellar black holes



Supermassive black holes



Microscopic black holes





Microscopic black holes

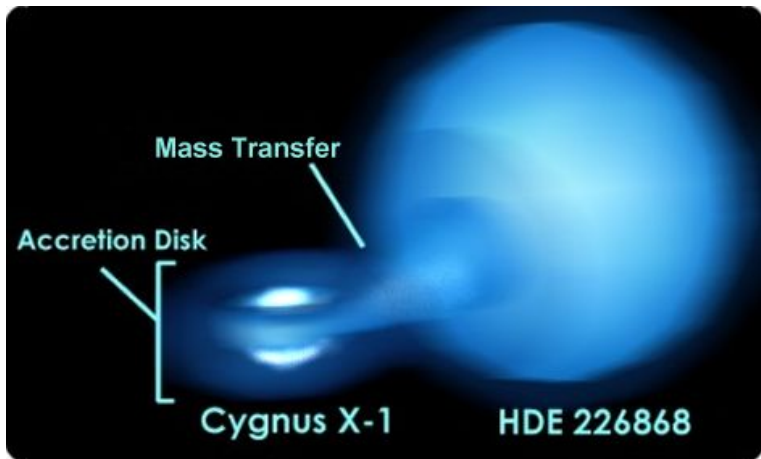




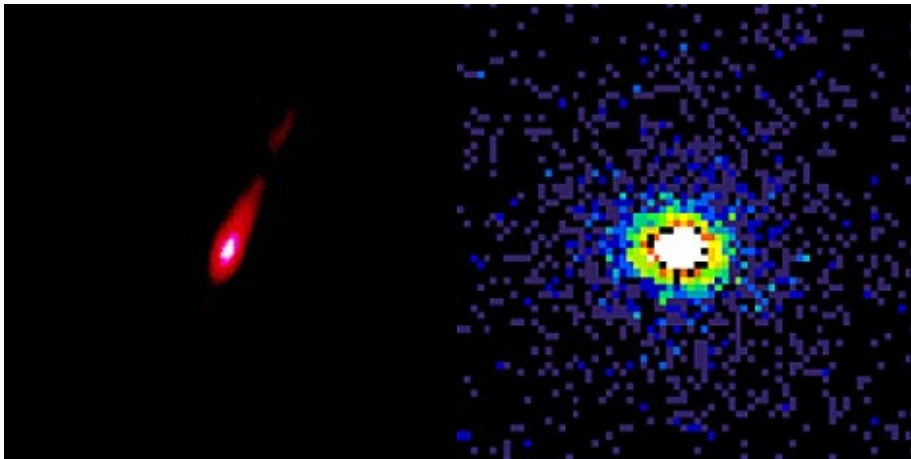
Do they exist?



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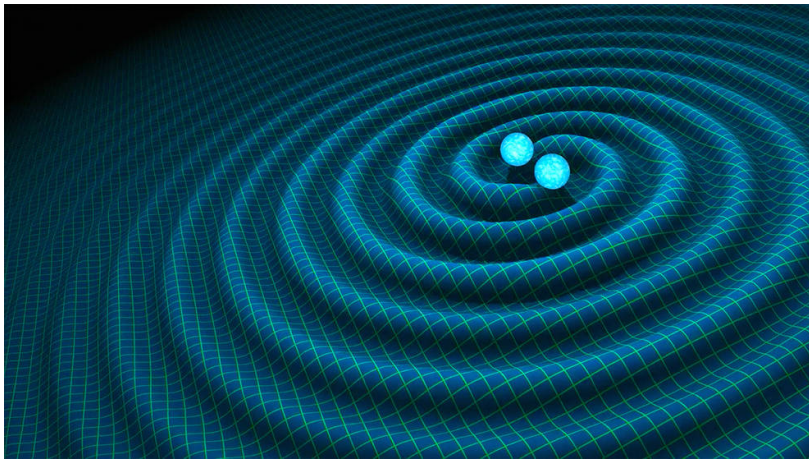


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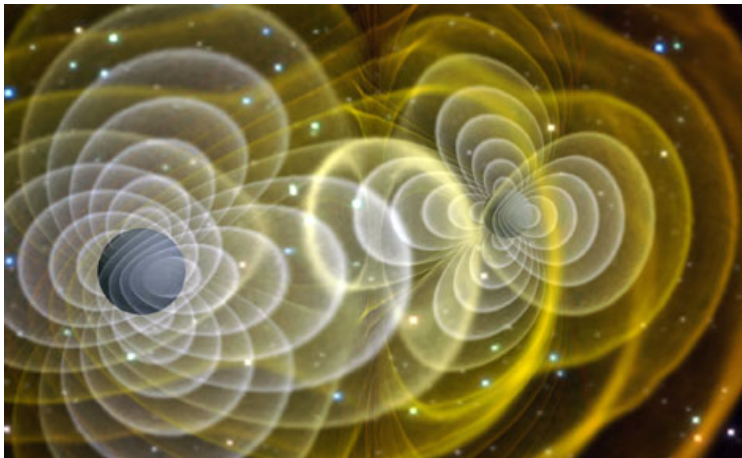




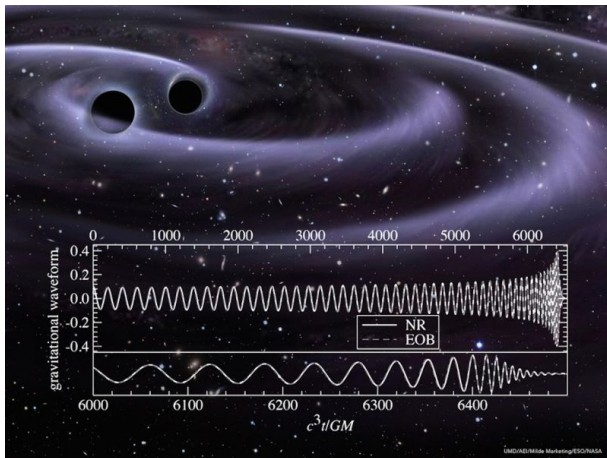
Colliding black holes



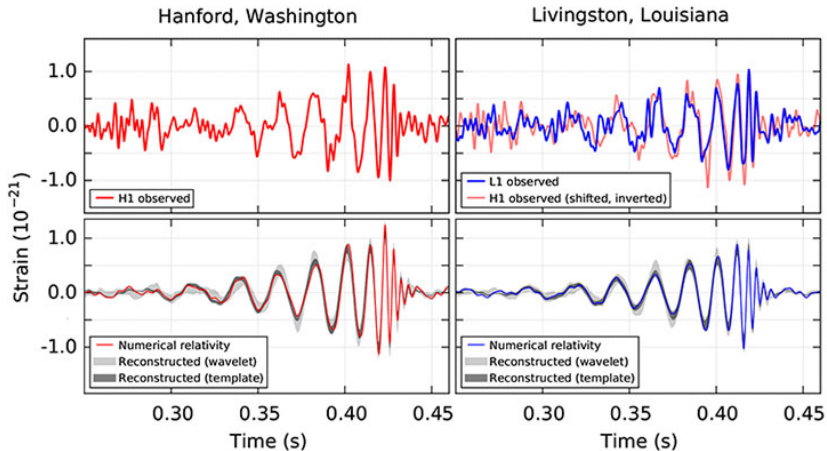
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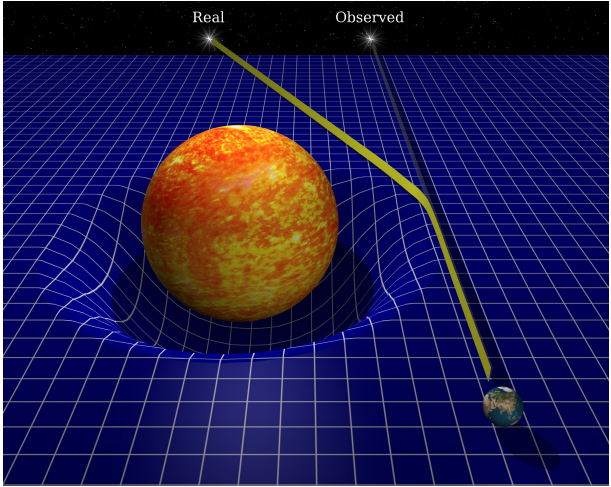
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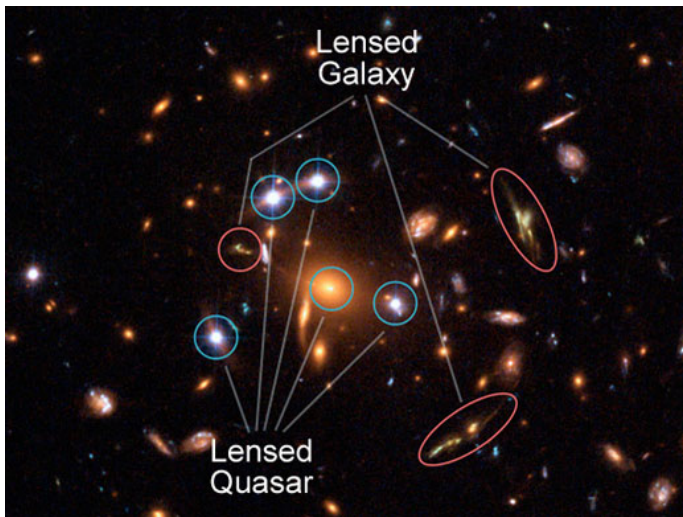
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Gravitational lensing



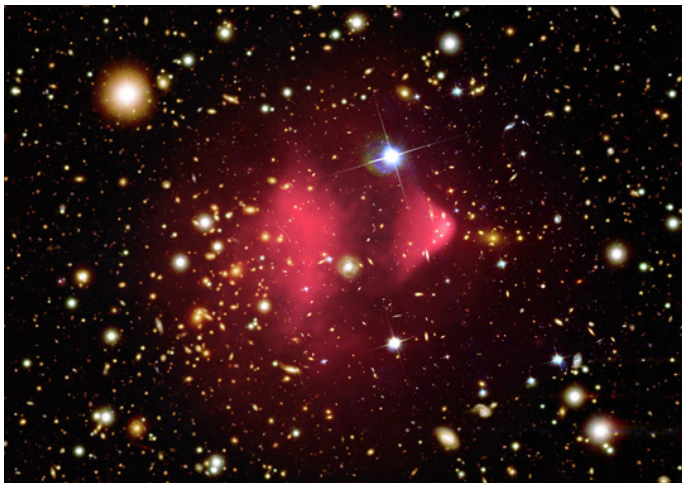
Gravitational lensing



Bullet cluster



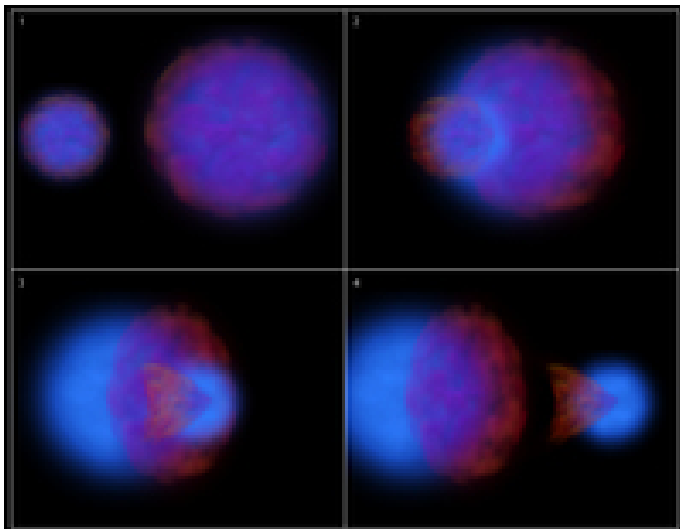
Bullet cluster



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Bullet cluster



What do we know about dark matter?

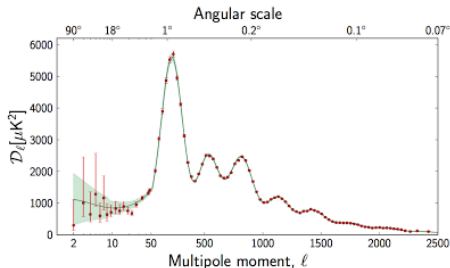
- It exists.
- It is non-baryonic.
- It has a mass less than 10^{50} GeV.
- Its self-interaction is $\frac{\sigma}{m} \lesssim 1 \frac{\text{cm}^2}{\text{g}}$
- It interacts at most weakly with matter.



In conclusion: We know it is hard to detect.

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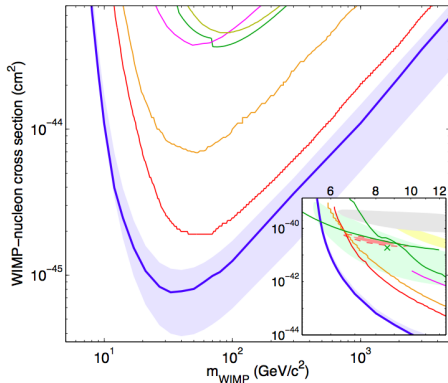
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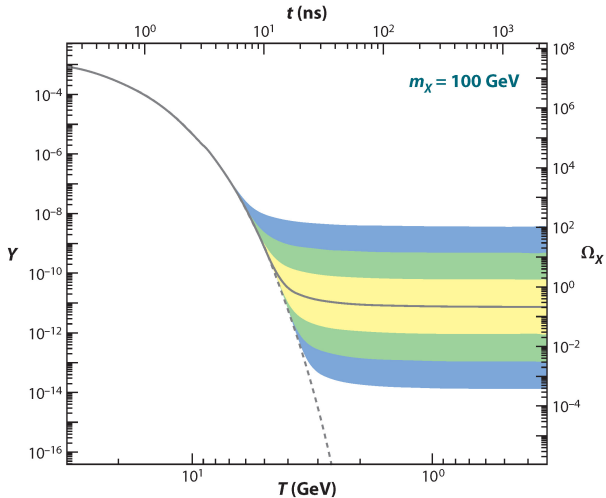


Weakly Interacting Massive Particles (WIMPs)

- Assume we have a particle with mass $\approx 100 \text{ GeV}$.
- It interacts with the **weak force**.
- Then $\langle \sigma v \rangle \approx 3 \cdot 10^{-26} \text{ cm}^3 \text{ s}^{-1}$



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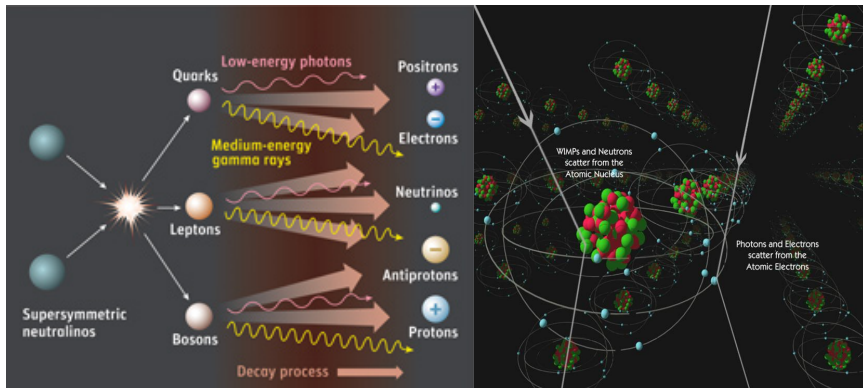




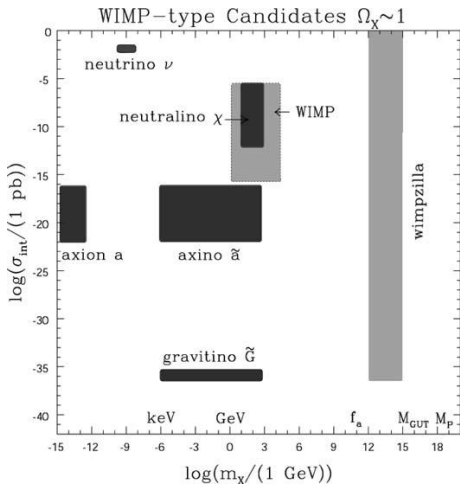
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- Assume we have a particle with mass ≈ 100 GeV.
- It interacts with the weak force.
- Then $\langle \sigma v \rangle \approx 3 \cdot 10^{-26} \text{ cm}^3 \text{ s}^{-1}$
- **WIMPs** give (about) **the right amount!** (“the WIMP miracle”)
- We **expect new particles** with more or less the right properties.

WIMPs are nice — they can be detected!



Other options





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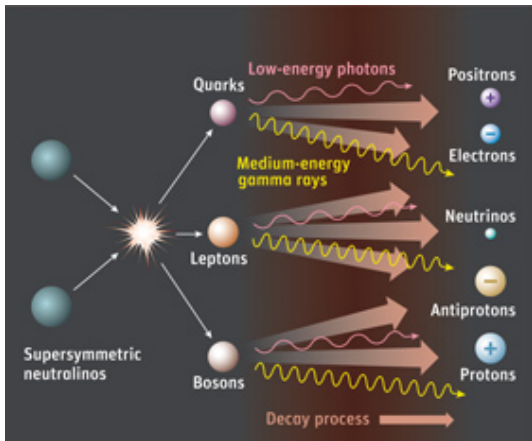
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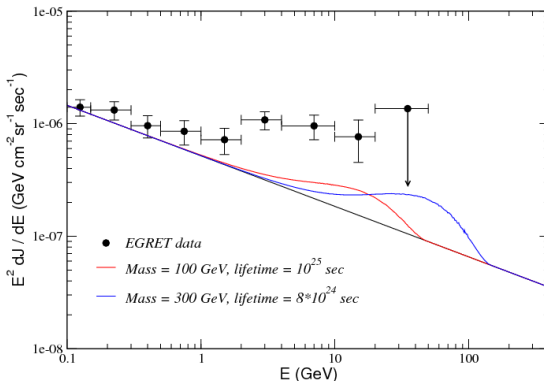
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Cosmic radiation from dark matter

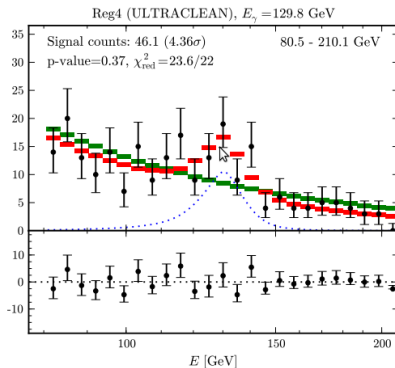


EGRET



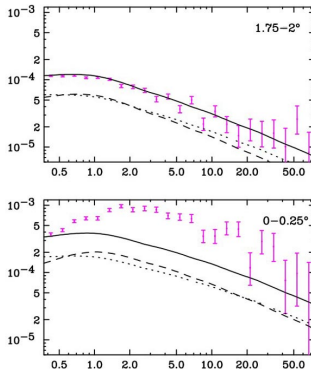
Dark matter? miscalibration.

Fermi LAT



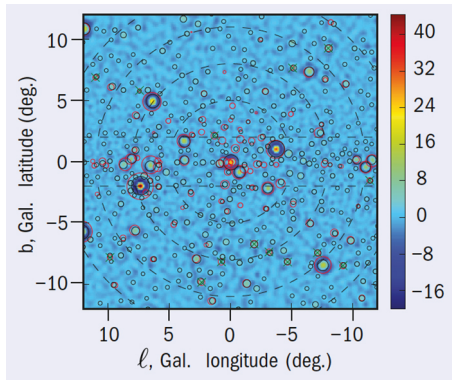
Dark Matter? don't think so.

Fermi LAT



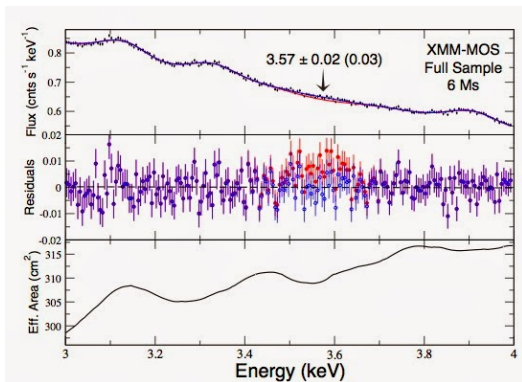
Too much γ -radiation from the galactic centre.

Fermi LAT



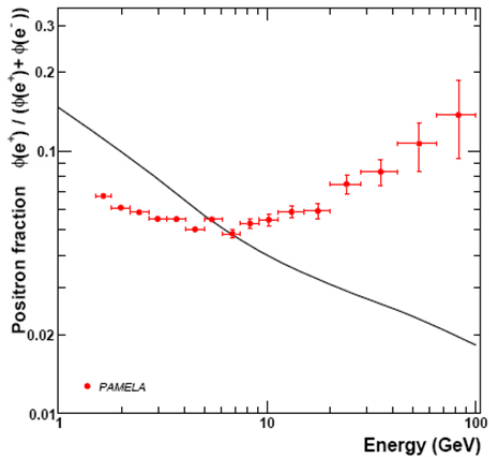
But looks like unresolved point sources.

XMM-Newton

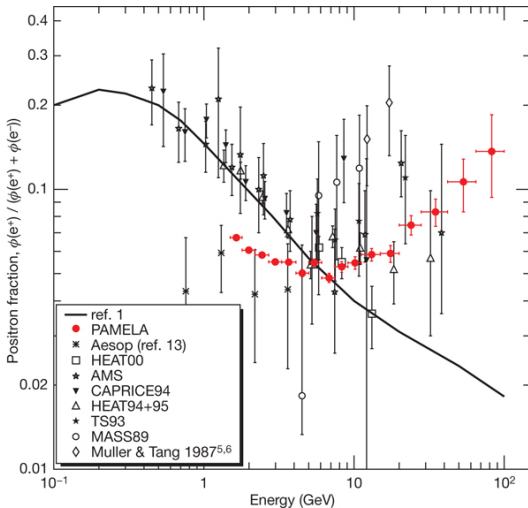


Smoking gun of dark matter?

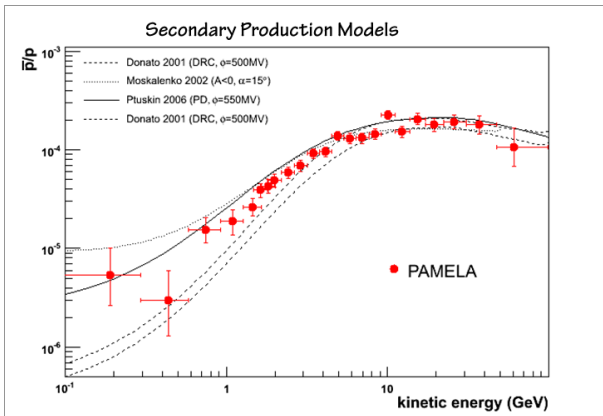
PAMELA



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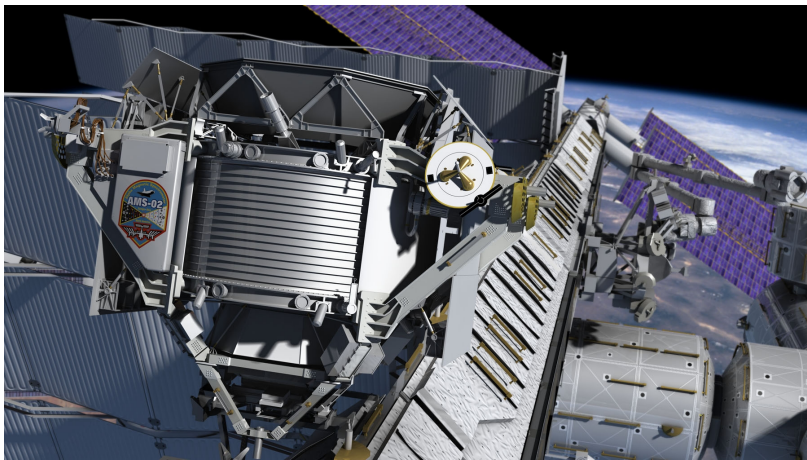


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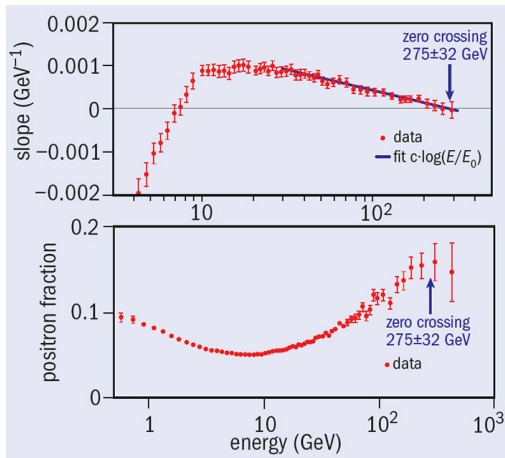




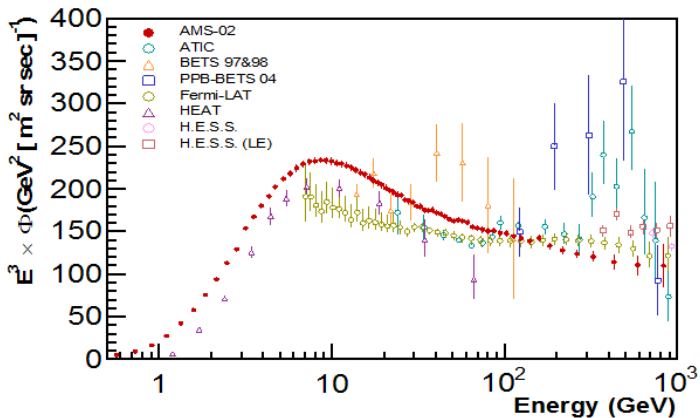
AMS-2 — particle detector in space



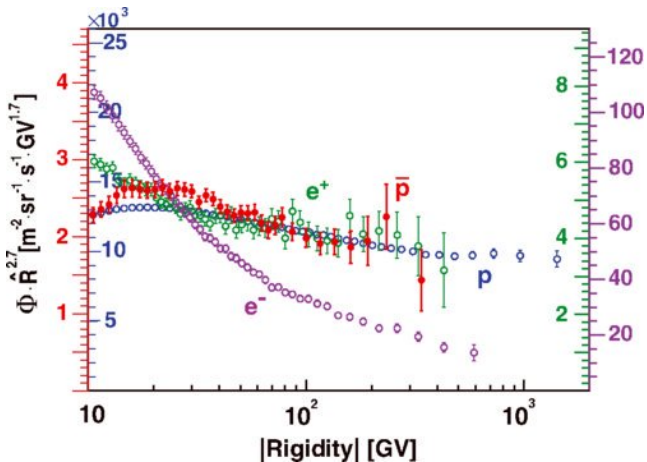
AMS-2



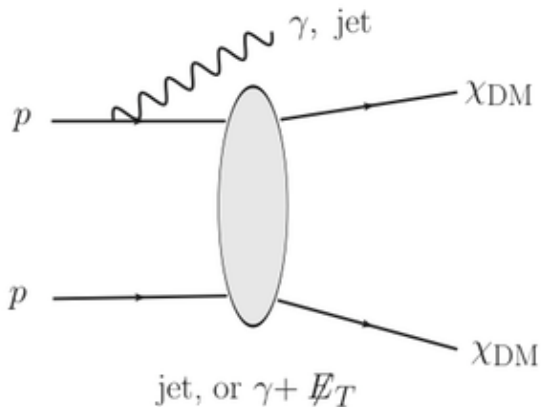
AMS-2



AMS-2



MonoPhoton



MonoPhoton

