CERN Retreat 2022

Andrea Caputo

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(2020-2022)

My research

Stars and new physics

Caputo et al., *JCAP* 08 (2022) 08, 045

Caputo et al., *Phys.Rev.Lett.* 128 (2022) 22, 221103 (CCSNe)
Caputo et al., *Phys.Rev.D* 105 (2022) 3, 035022 (CCSNe)

Caputo et al., *Phys.Rev.Lett.* 127 (2021) 18, 181102 (Hypernovae)

Caputo et al., *Phys.Rev.D* 101 (2020) 12, 123004 (Sun)
O'Hare, Caputo, et al., *Phys.Rev.D* 102 (2020) 4, 043019 (Sun)

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Dark Matter and other indirect probes

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Caputo et al., *Phys.Rev.Lett.* 125 (2020) 22, 221303 (CMB)

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Caputo et al., *Phys.Rev.D* 103 (2021) 5, 055017 (sub-GeV DM)

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Gravitational Waves

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Toubiana, Sberna, Caputo, et al., *Phys.Rev.Lett.* 126 (2021) 10, 101105

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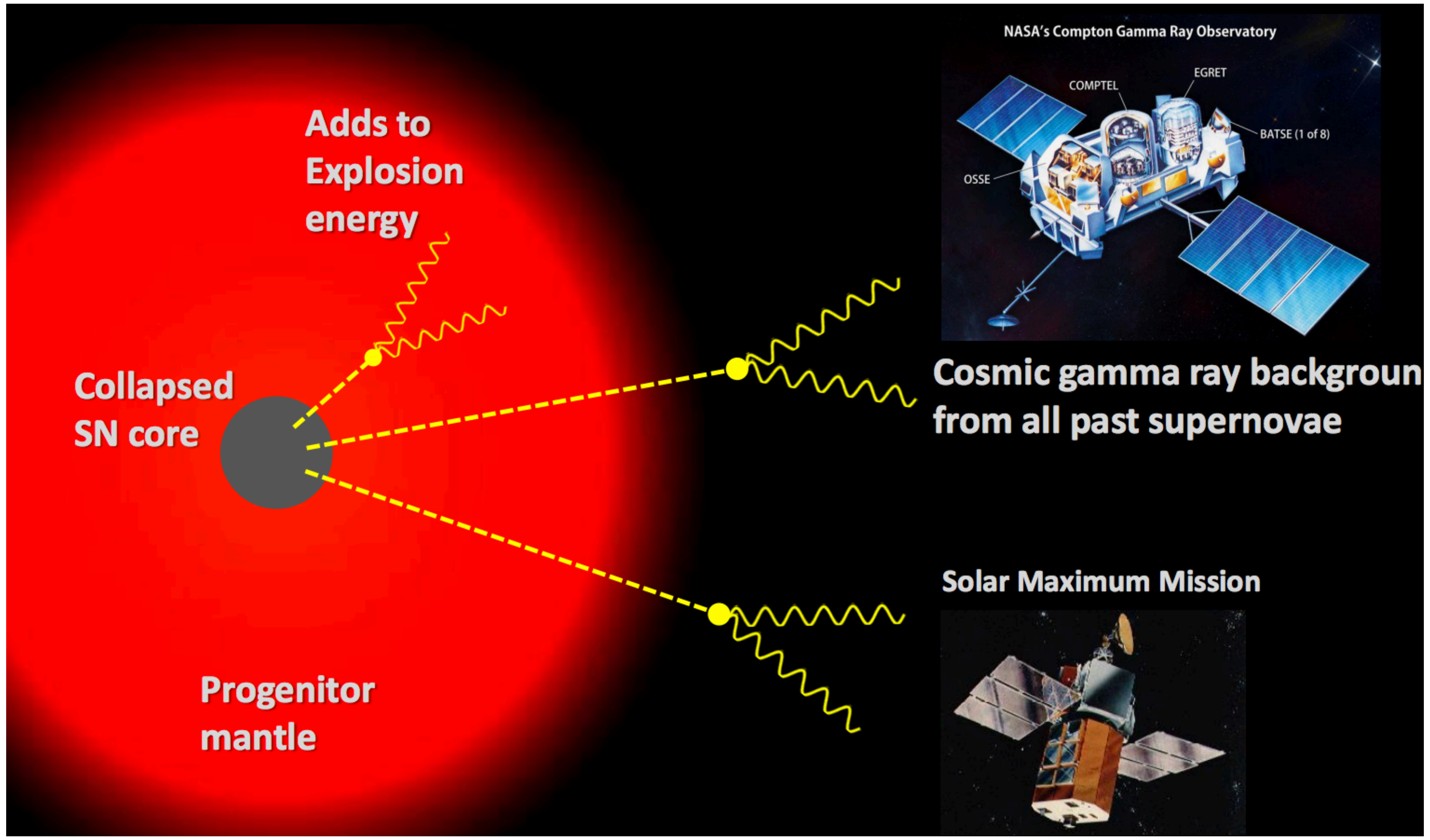
Few Highlights

1) Use Supernovae to look for new physics



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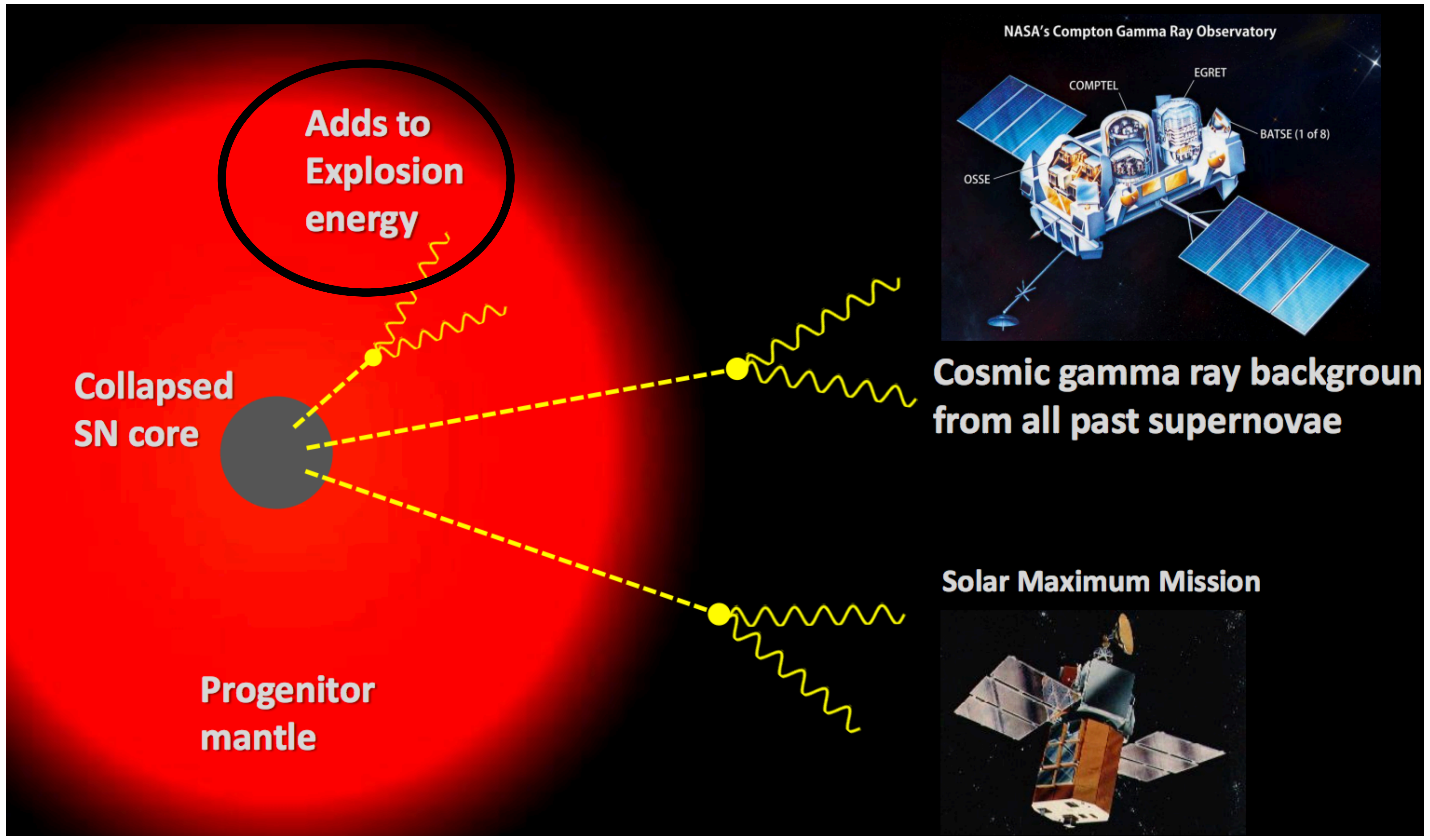
1) Use Supernovae to look for new physics

If new particles, let’s call them axions, are produced in the SN core and they then **decay in the SN mantle**, they can **dump energy** which should then show up either in **kinetic energy or radiation energy**.



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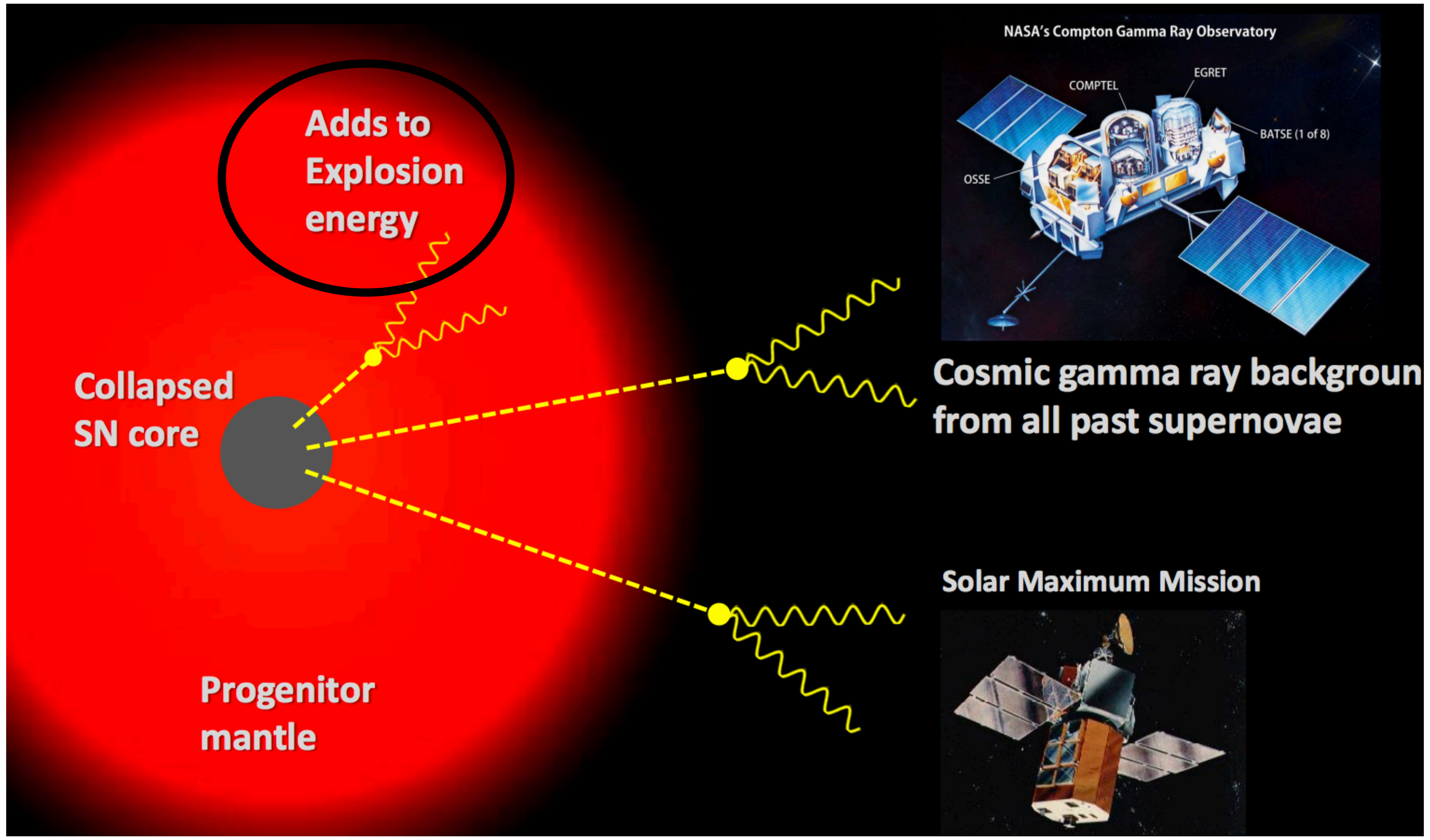

Example model: axion coupling to photons

$$\mathcal{L}_{a\gamma\gamma} = -\frac{1}{4} g_{a\gamma} a \tilde{F}^{\mu\nu} F_{\mu\nu}$$

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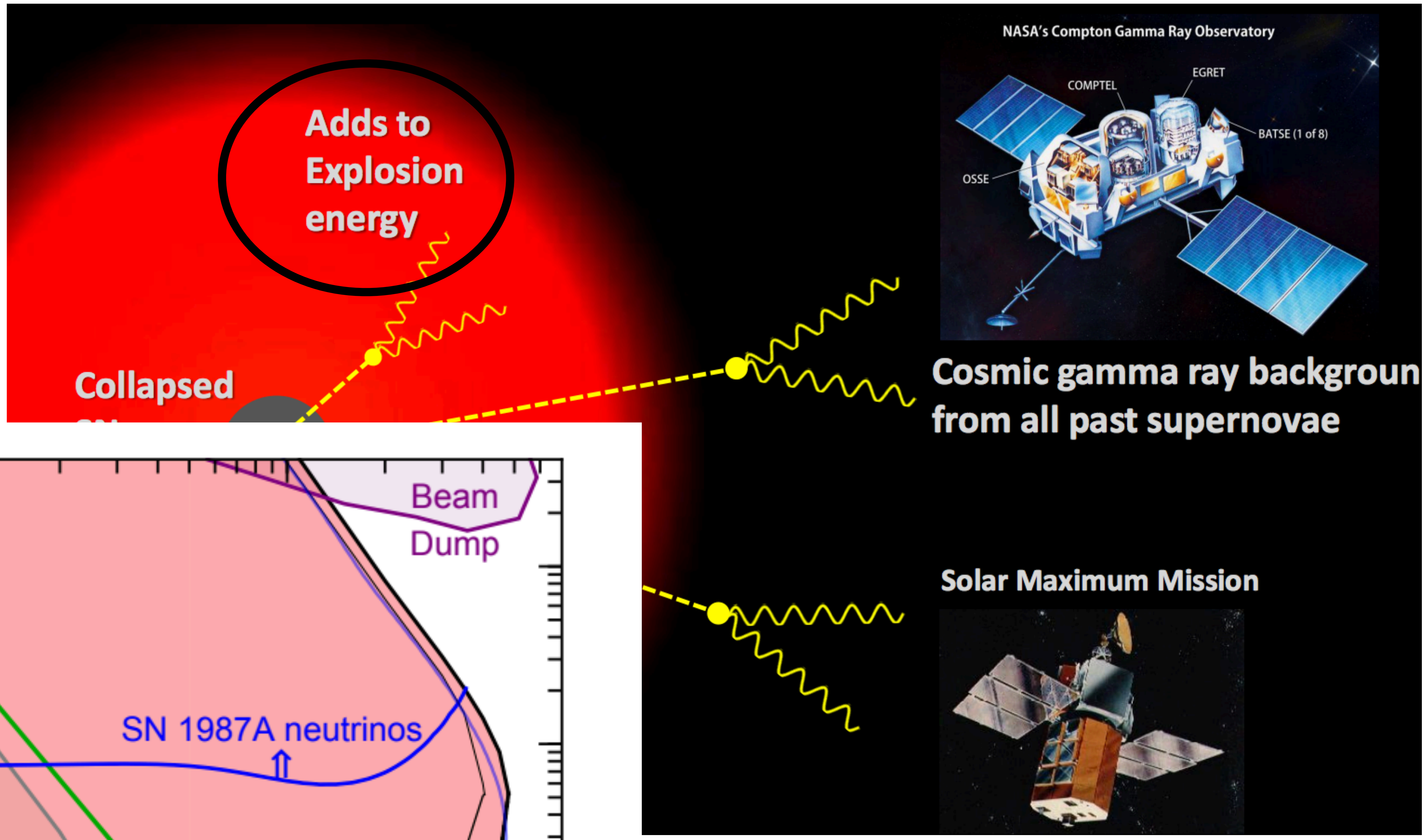

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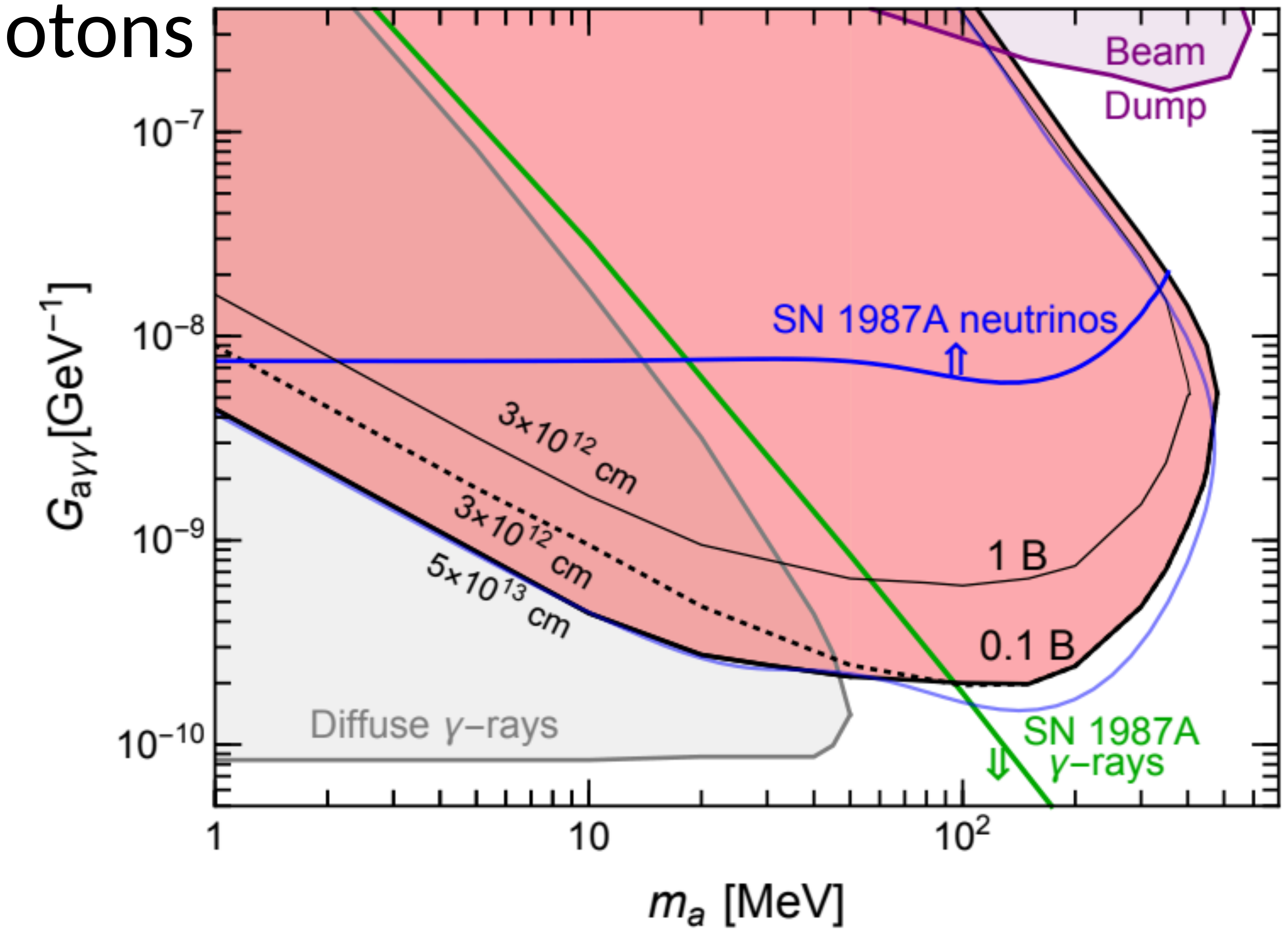

A.C., H.T. Janka, G. Raffelt, E. Vitagliano, PRL 22

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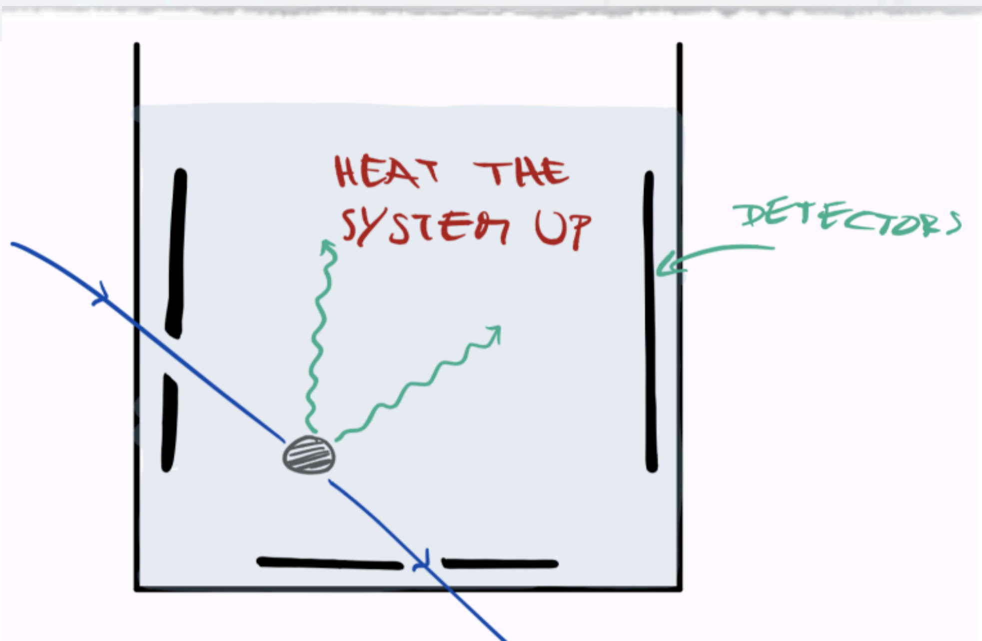
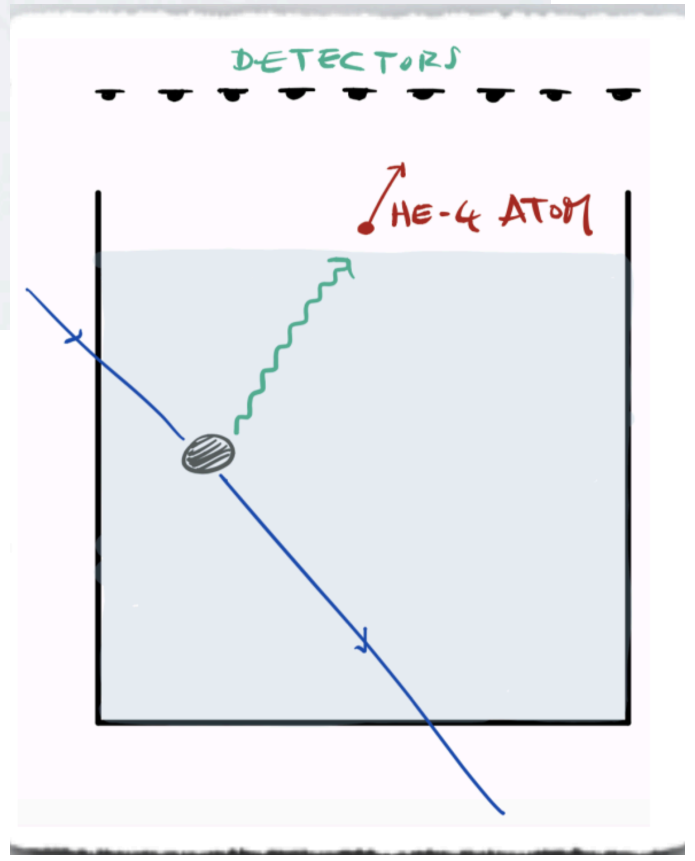
He-4 dark matter detectors, EFT formalism

$$S_{eff} = \int d^4x \left[\frac{1}{2}\dot{\pi}^2 - \frac{c_s^2}{2}(\vec{\nabla}\pi)^2 - |\partial\chi|^2 - m_\chi^2|\chi|^2 + \lambda_3\sqrt{\frac{m_{He}}{\bar{n}}}c_s\,\dot{\pi}(\vec{\nabla}\pi)^2 + \lambda_3'\sqrt{\frac{m_{He}}{\bar{n}}}c_s\,\dot{\pi}^3 \right.$$
$$\left. -\left(g_1\sqrt{\frac{m_{He}}{\bar{n}}}c_s\,\dot{\pi} - \frac{g_1}{2}\frac{c_s^2}{\bar{n}}(\vec{\nabla}\pi)^2 + \frac{g_2}{2}\frac{m_{He}c_s^2}{\bar{n}}\dot{\pi}^2\right)|\chi|^2 \right]$$





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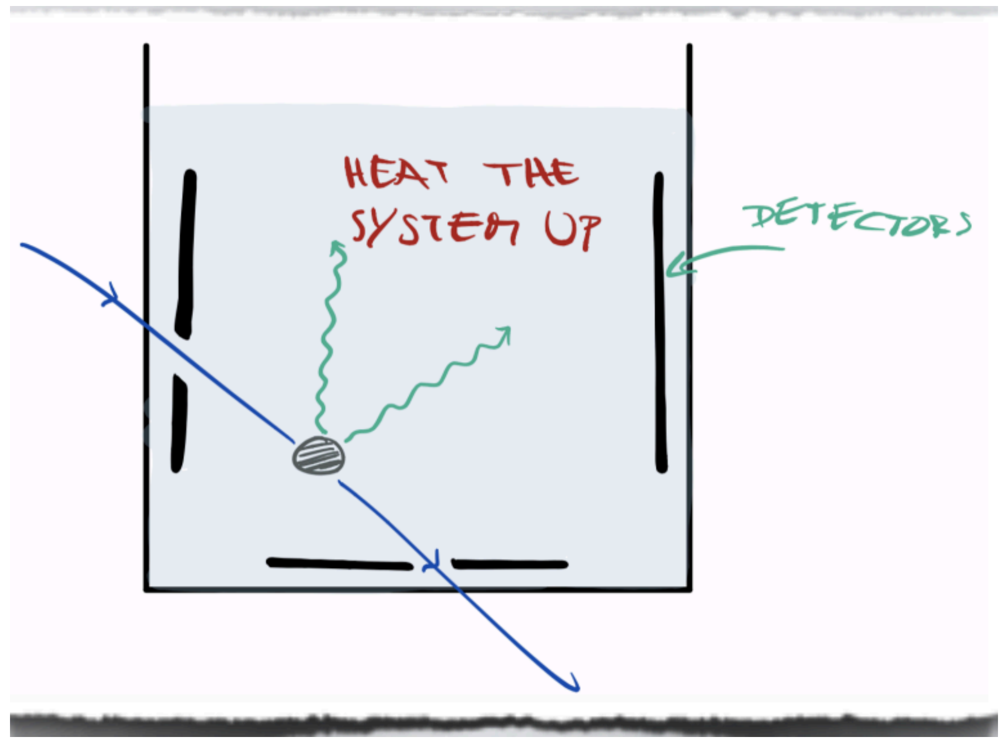
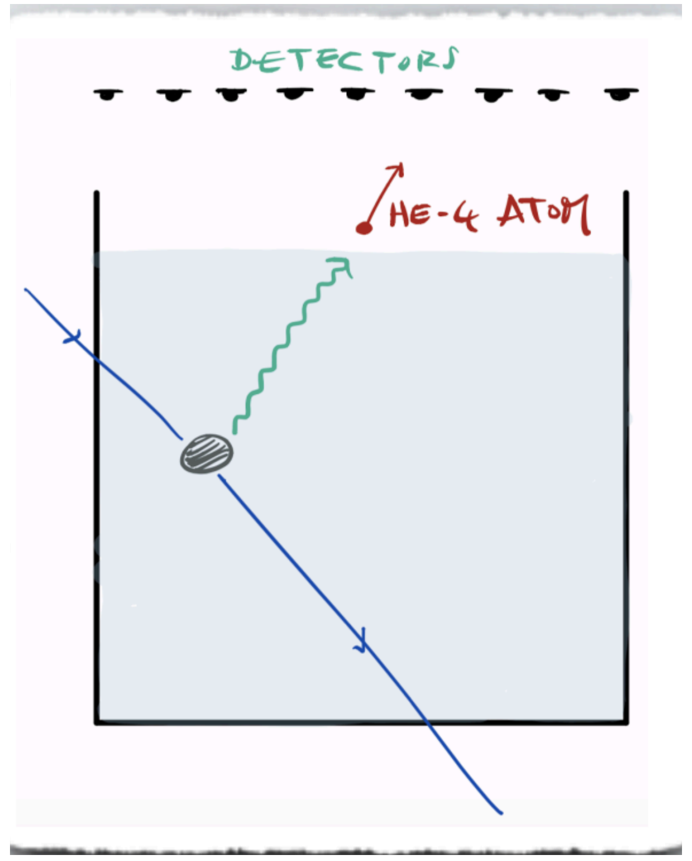
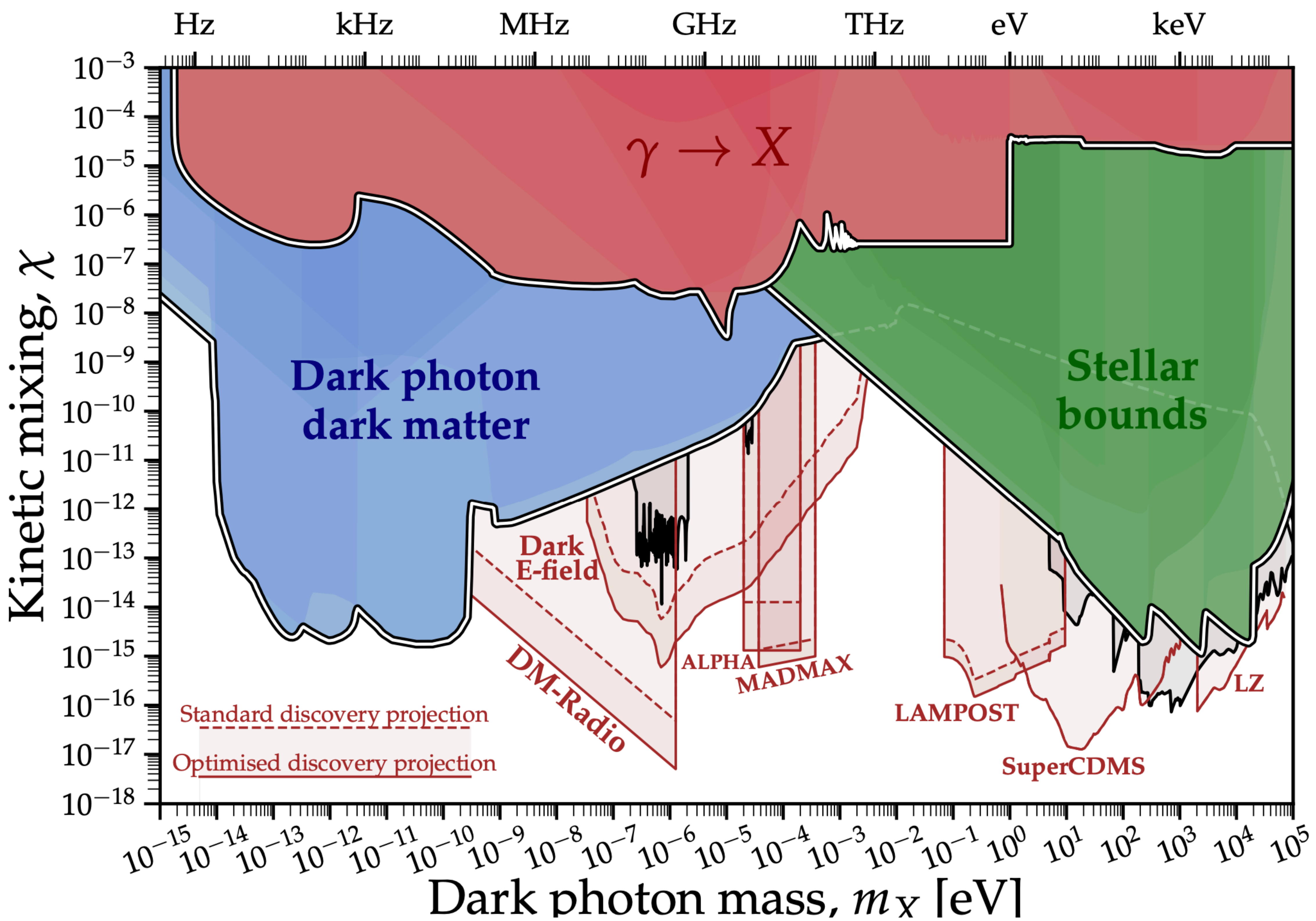




Dark Photon Experiments



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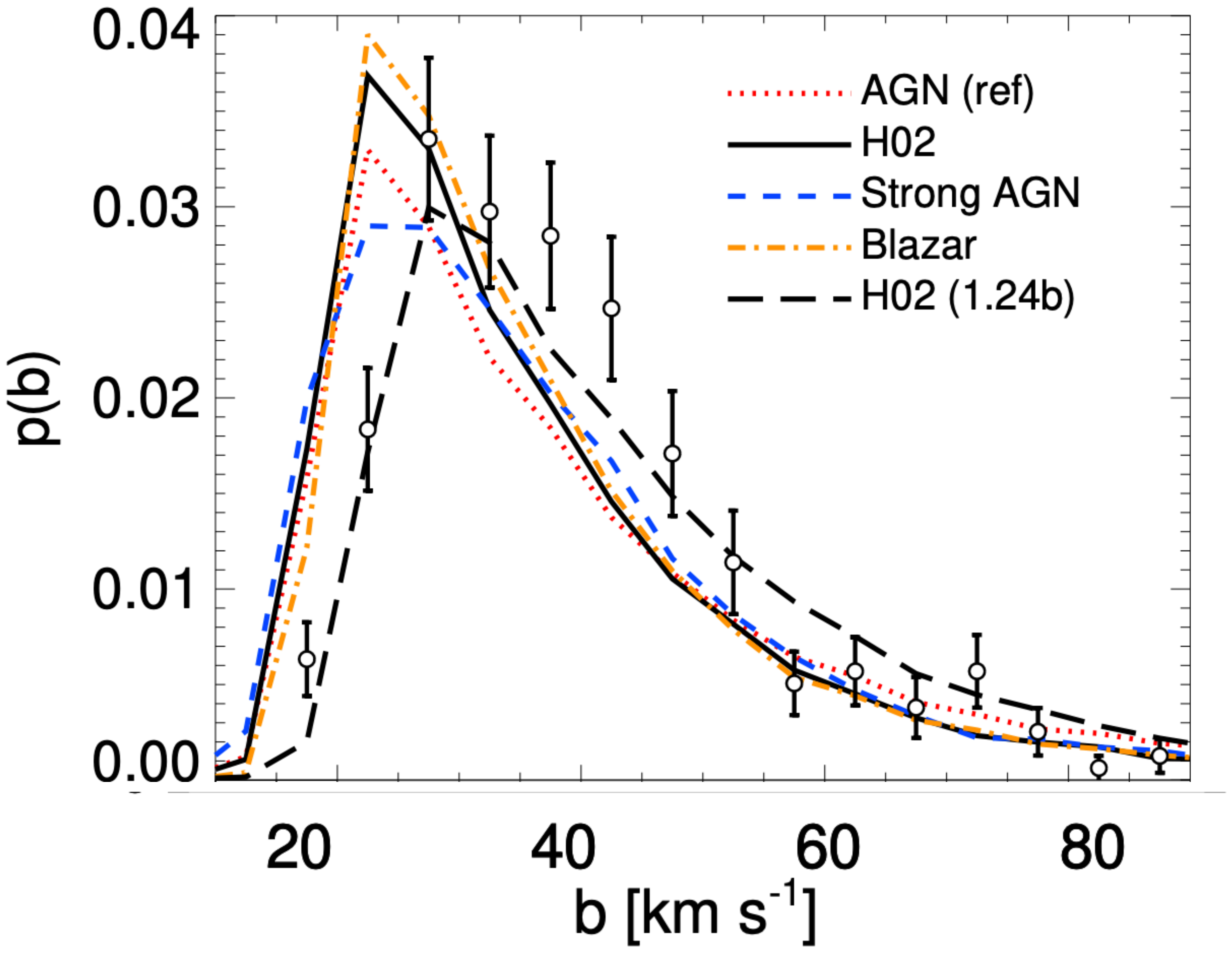
The Lyman-α forest is produced by the absorption of the continuum of a distant source (typically a quasar) caused by the neutral hydrogen present along the line-of-sight that connects the observer to the source.

Interestingly, there seems to be a tension between the observed number of lines with b-parameters in the range 25–45 km/s and the predictions from simulations



Bolton et al., 2021

$$\Delta\nu = \nu_\alpha (b_{\rm th}^2 + b_{\rm nth})^{1/2}/c$$

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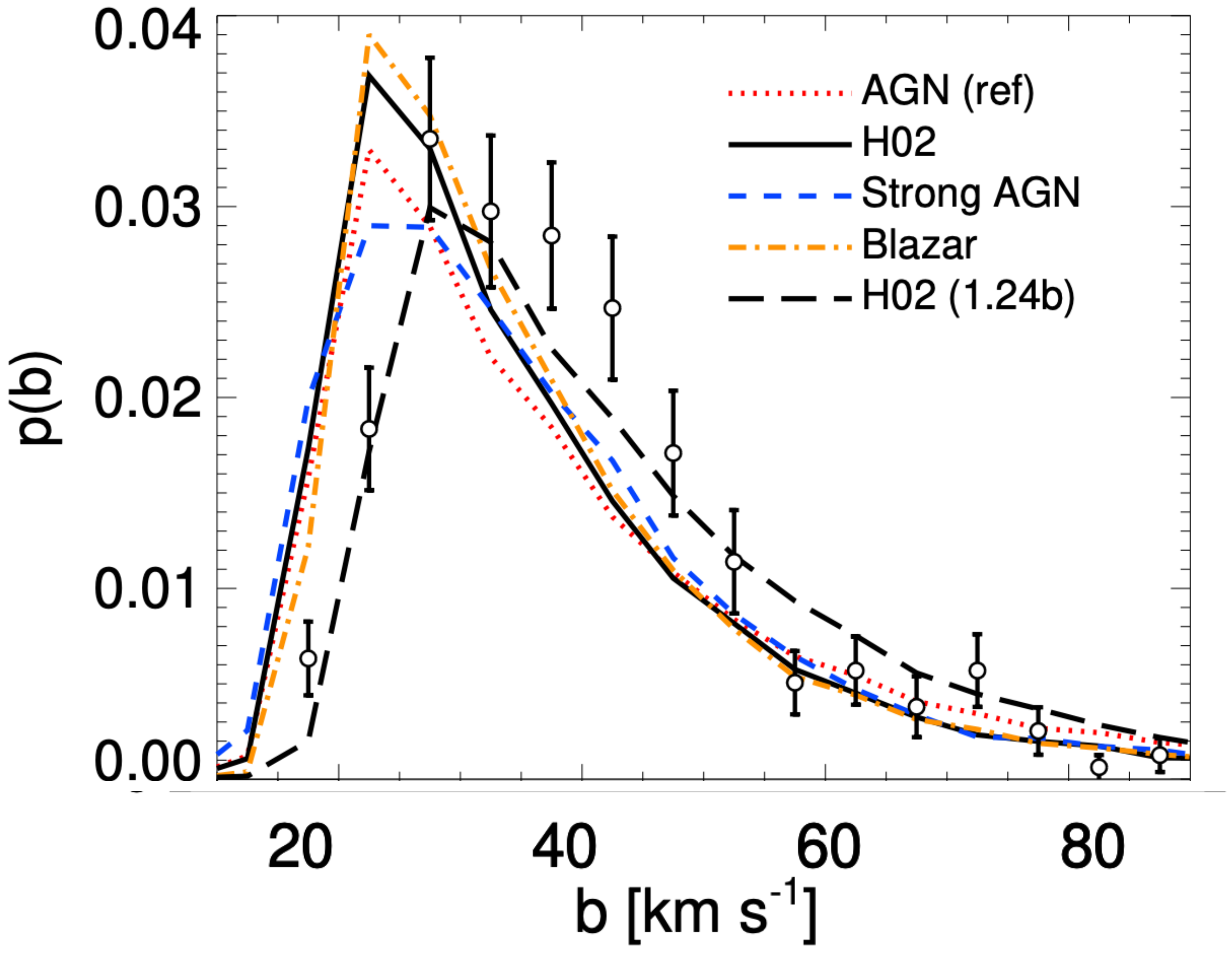

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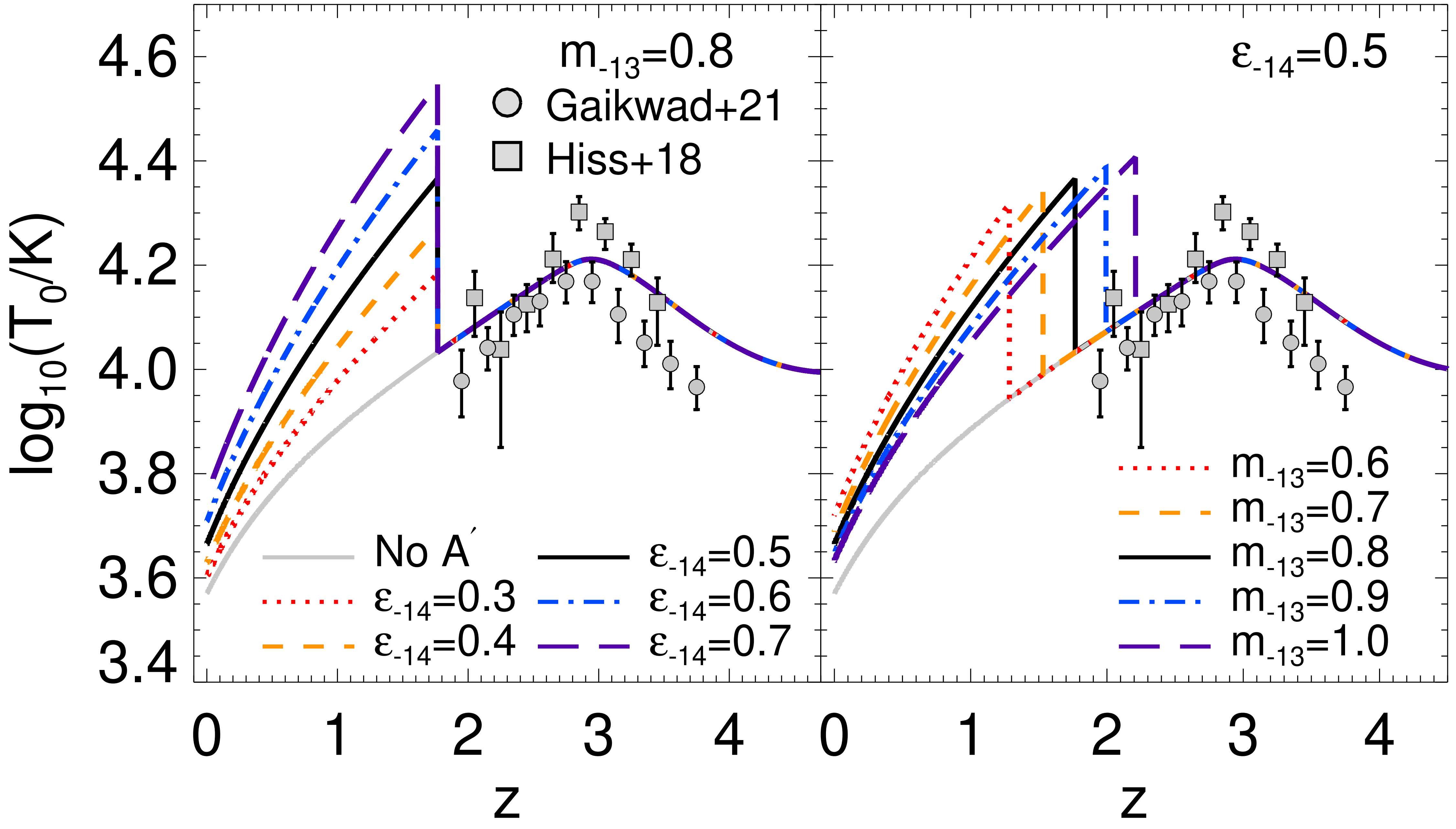
What if dark matter is responsible for this?

Dark Photon Dark Matter can be efficiently converted into photons!

$$\mathcal{L} = -\frac{1}{4}F_{\mu\nu}F^{\mu\nu} - \frac{1}{4}\tilde{F}_{\mu\nu}\tilde{F}^{\mu\nu} + \frac{m^2}{2}\tilde{A}_\mu\tilde{A}^\mu - \frac{e}{(1+\varepsilon^2)^{1/2}}J^\mu\left(A_\mu + \varepsilon\tilde{A}_\mu\right)$$

$$E_{A'\to\gamma} \sim 2.5\,\mathrm{eV}\left(\frac{\epsilon_{-14}}{0.5}\right)^2\left(\frac{3}{1+z_{\mathrm{res}}}\right)^{3/2}\left(\frac{m_{-13}}{0.8}\right)$$

Energy injected per unity baryon via dark photon to photon conversion



J. Bolton, A.C, H. Liu, M. Viel, PRL in press

Physics Magazine Focus

Thermal histories for baryons at the mean background density

Thanks for the attention!