Search for Primordial Black Holes with e-ASTROGAM

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Motivation

- Primordial black holes are predicted in some big bang scenarios
- Probe much smaller spatial scales than CMB
  - Can be the only observational tool to put limits on some models at small scales
- Not yet totally excluded as a DM candidate
  - Mass is too large for e-ASTROGAM
- Can be used to explain early SMBH or intermediate mass BH observed in gravitational wave experiments
  - Also not relevant for e-ASTROGAM
- PBHs with initial mass ~ 10^{15} g have lifetime equal to the age of the Universe and temperature ~ 10 MeV
  - Relevant for e-ASTROGAM!

PBH properties

- **Beckenstein (1973)**
  - **Information loss paradox**
  - **BHs have a "temperature" T ~ 1 / M**
- **Hawking (1975)**
  - **Black holes do emit radiation with thermal spectrum with temperature**

$$T = \frac{M_{\mathrm{P}}^2}{8\pi M}$$

- **Lifetime**

$$\tau \sim M^3 \sim T^{-3}$$

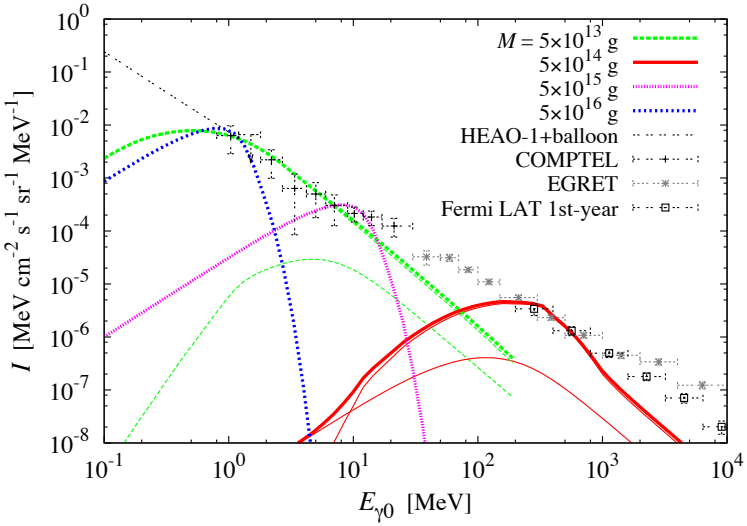
- **10 MeV, 10^{15} g, lifetime of the Universe**
- **10 GeV, 10^{12} g, 30 years**
- **10 TeV, 10^{9} g, 1 second**

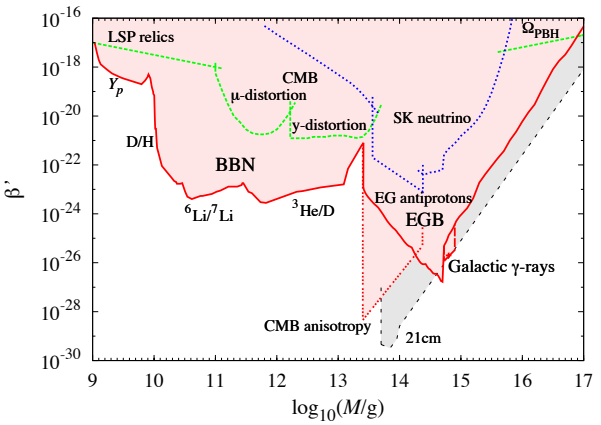
Searches for PBH bursts

- **Hagedorn model**
  - Some theories claim that PBHs evaporate in a microsecond burst when the temperature reaches Hagedorn transition at ~ 160 MeV
  - EGRET has put a limit of 5×10^{-2} pc^{-3} yr^{-1}
  - e-ASTROGAM can improve this limit
- **Standard model**
  - The rate of emission is rather slow until the temperature reaches ~ 1 TeV
  - Lifetime is ~ 10 years for T ~ 10 GeV
  - Typical limits with Cherenkov telescopes and Fermi LAT (in preparation) are ~ 10^4 pc^{-3} yr^{-1}
  - e-ASTROGAM will not improve the limit in the SM scenario

PBH contribution to diffuse emission

- EGB gives the most limiting constraints in the mass range $10^{14} – 10^{17}$ g
- For PBHs with lifetime ~ the age of the Universe the SED peaks around 200 MeV
- If one assumes a reasonable distribution of initial PBH masses and a concentration of PBHs in the Galaxy similar to DM, then the diffuse limit can be expressed as a local evaporation rate limit ~ 10^{-2} pc^{-3} yr^{-1}, which is 6 orders of magnitude more constraining than the limit from direct searches of bursts (in SM scenario)
- e-ASTROGAM – better resolution of EGB between 1 MeV and 1 GeV



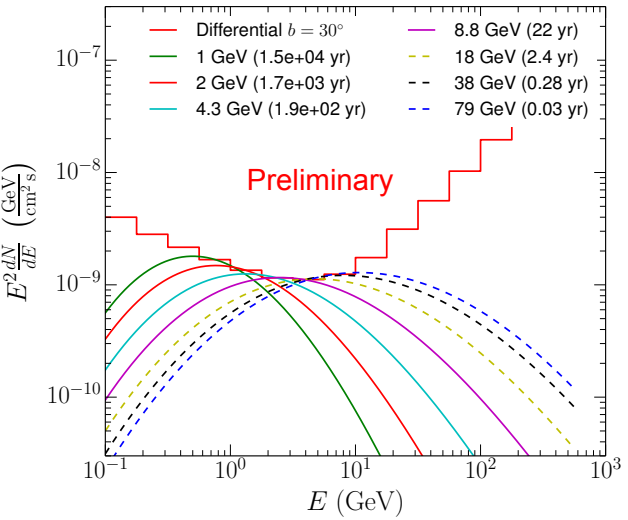


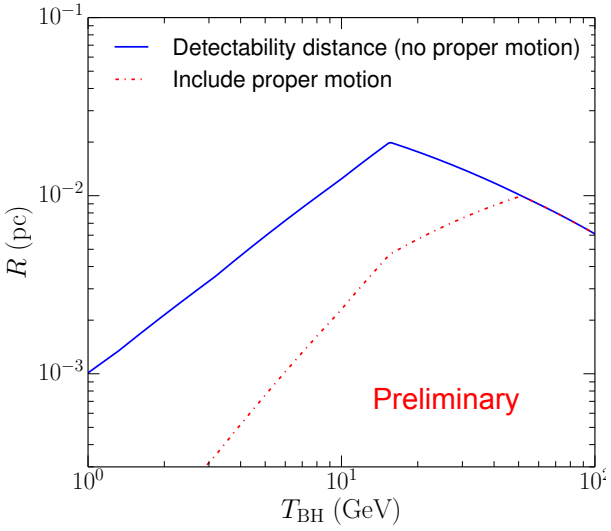
Carr et al, PRD 81, 104019 (2010)

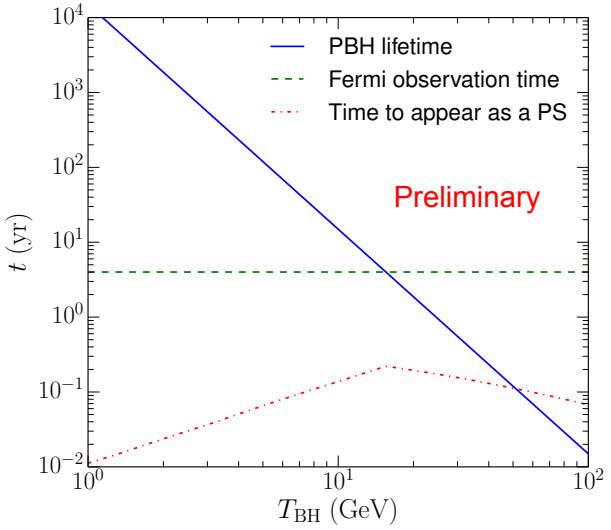
Backup slides

Fermi LAT sensitivity to PBHs

- **We use the differential Fermi LAT sensitivity to estimate the detectability radius and the characteristic lifetime of a PBH that can be detected by the LAT**
  - **The typical radii are less than ~ 0.01 pc**
  - **Temperature ~ 10 – 50 GeV**
  - **Lifetime ~ few months to few years**







Fermi LAT limit