Analysis of the Galactic diffuse emission with DAMPE

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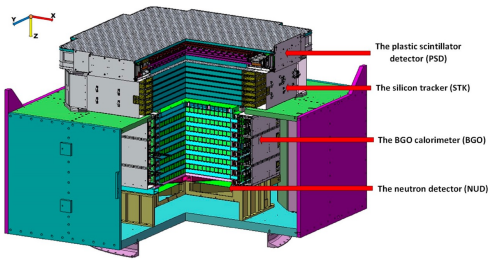
MOTIVATION

Fermi bubbles (FBs) [1] and Galactic center excess (GCE) [2] are distinct diffuse γ-ray components detected by *Fermi*-LAT. Both sources are associated with the processes in the Galactic center (GC), which can help us understand the status and history of GC. The DArk Matter Particle Explorer (DAMPE) is a space-borne high-energy particle telescope capable of detecting γ-ray photons from ~2 GeV to 10 TeV [3]. DAMPE photon events have very low cosmic-ray contamination rate and thereby is suitable for diffuse γ-ray analysis. Here we present the recent progress using 8.5 years of DAMPE photon data.



Fermi bubbles (FBs)

- **Data reduction**
  - ✓ DAMPE γ-ray data: 2016/1/1 – 2024/7/1, 2–500 GeV;
  - ✓ Region of interest (ROI): $5^\circ \leq |b| \leq 60^\circ$ && $|l| \leq 60^\circ$ (Fig.1);
  - ✓ Mask 1.5° around the DAMPE point sources;
  - ✓ γ-ray emitting components:
    Galactic diffuse emission (GDE) model from *Fermi*-LAT 1SC; DAMPE point sources [4]; Loop I template (geometric); Isotropic emission; and the template of FBs.
- **Results**
  1. FBs are significantly detected with TS=757 (26.5σ for 11 dof);
  2. The FBs' morphology from the DAMPE data is similar to that of Fermi-LAT (Fig. 2). The edge of FBs is sharp (boundary width $1.6^\circ \pm 0.9^\circ$, Fig. 3) and the inner region is flat.
  3. The spectrum is curved (3.0σ) and well described by the power law with a cutoff model (Fig. 4):
     $S(E) = N_0 E^\Gamma \exp(-E/E_{\rm cut})$,
     spectral index: $\Gamma = -1.99 \pm 0.06$;
     cutoff energy: $E_{\rm cut} = 210^{+130}_{-60}$ GeV.

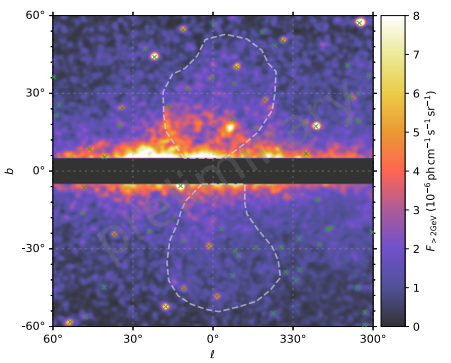


Figure 1. DAMPE flux map for FBs. The point sources in catalog are marked with green crosses.

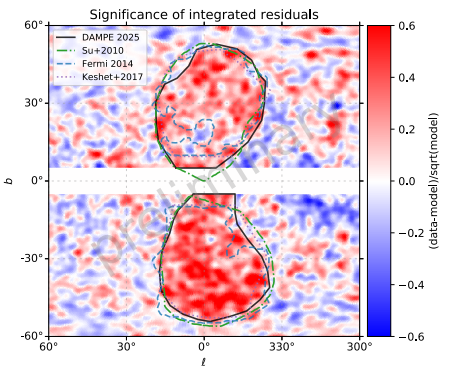


Figure 2. Residual map without the Fermi bubbles in model. The black solid line shows the FBs' boundary.

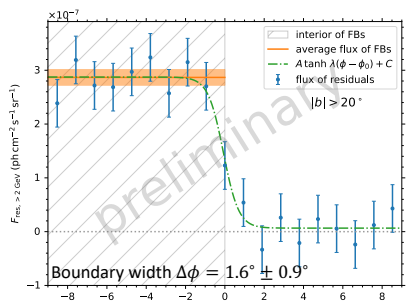


Figure 3. The average flux around the edge of the FBs derived from the residual map.

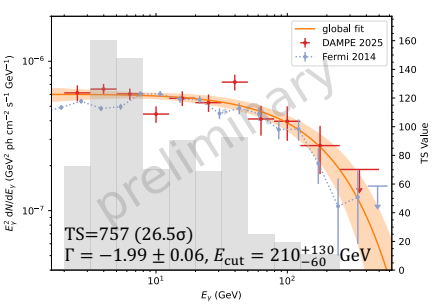


Figure 4. The spectrum of the FBs. The orange line shows the optimal PowerlawExpCut model.

Galactic center excess (GCE)

- **Data reduction**
  - ✓ DAMPE γ-ray data: 2016/1/1 – 2024/7/1, 2–32 GeV;
  - ✓ ROI: $1^\circ \leq |b| \leq 20^\circ$ && $|l| \leq 20^\circ$ (Fig. 5);
  - ✓ Mask 1° around the DAMPE point sources;
  - ✓ γ-ray emitting components:
    Fermi-LAT 1SC GDE model; Fermi bubbles; Isotropic emission; DAMPE point sources [4]; weak point sources in *Fermi*-LAT but not in DAMPE; and the generalized NFW template for GCE.
- **Results**
  1. The GCE is detected with TS=72.8 (7.4σ for 6 dof) with a similar spectrum as *Fermi*-LAT (Fig. 6).
  2. The best-fit inner slope γ of gNFW profile is (Fig. 7):
     $\gamma = 1.25 \pm 0.09$.
  3. γ-ray spectrum from dark matter (DM) annihilation is given by
     $$S(E) = \frac{\langle\sigma v\rangle}{8\pi m_\chi^2}\frac{{\rm d}N_\gamma}{{\rm d}E}\int_{\rm los}{\rm d}s\,\rho^2_{\rm gnfw}(r(s,\psi)).$$
     For $\chi\chi \to b\bar{b}$ channel (Fig. 8):
     $m_\chi = 36 \pm 9$ GeV,
     $\langle\sigma v\rangle = (1.37 \pm 0.21)\times10^{-26}$ cm^3 s^{-1}.

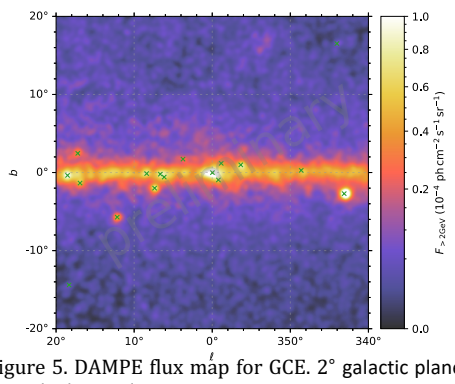


Figure 5. DAMPE flux map for GCE. 2° galactic plane is masked in analysis.

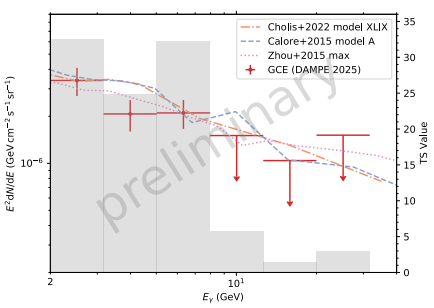


Figure 6. The GCE spectrum at an angle of 5° from the GC. Some Fermi-LAT results are shown.

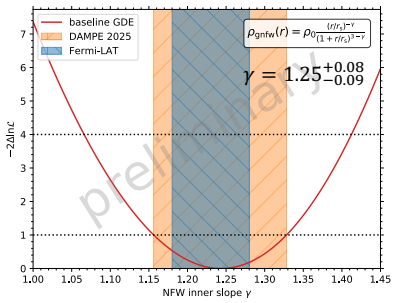


Figure 7. The change of TS value with respect to the gNFW inner slope γ.

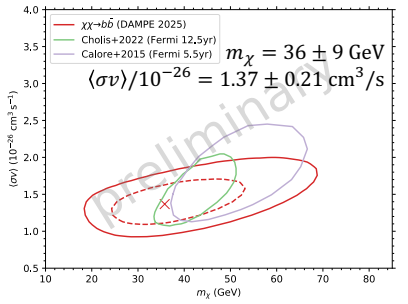


Figure 8. The preferred DM parameter space for the annihilation channel $\chi\chi \to bb$.

Summary

- Both FBs and GCE are significantly detected in DAMPE 8.5-yr data;
- The spectral and spatial parameters are consistent with *Fermi*-LAT.

proceeding

References

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[3] J. Chang *et al.*, APh **95**, 6 (2017)
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ICRC 2025
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Geneva July 15-24, 2025