Dark Matter Particle Explorer 7 years in space

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DAMPE collaboration



DAMPE is a satellite-borne particle detector proposed in the framework of the Strategic Pioneer Program on Space Science, promoted by the Chinese Academy of Sciences (CAS).





CHINA



- Institute of High Energy Physics, CAS, Beijing
- National Space Science Center, CAS, Beijing
- University of Science and Technology of China, Hefei
- Institute of Modern Physics, CAS, Lanzhou
- ITALY
 - INFN Perugia and University of Perugia
 - INFN Bari and University of Bari
 - INFN Lecce and University of Salento
 - INFN LNGS and Gran Sasso Science Institute
- SWITZERLAND
 - University of Geneva









>DAMPE mission

>On-orbit performance

>Physical Results

≻Summary



Scientific objectives







DAMPE detector





- PSD: charge measuresument via dE/dx and ACD for photons
- STK: track, charge, and photon converter
- BGO: energy measurement, particle (e-p) identification
- NUD: Particle identification



PSD charge detector









- 2 double-layers (x,y) of **88.4 x 2.8 x 1** cm³ bars
- Active area: 82 x 82 cm²
- Weight: ~ 103 kg
- Power: ~ 8.5 W



Silicon tracker (STK)









- 6 double-layers (x,y)
- 3 W layers (3 mm total) for $\gamma \rightarrow e^+e^-$ conversion
- 192 ladders, 73728 channels, 6.6 m² of silicon
- Active area: 76 x 76 cm²
- Weight: ~ 154 kg
- Power: ~ 82 W



BGO calorimeter









- Outer envelop: 100 cm x 100 cm x 50 cm
- Detection area: 60 cm x 60 cm
- Total weight: ~1052 kg
- Total power consumption: ~ 41.6 W



NUD neutron detector









- $n + {}^{10}B \rightarrow \alpha + {}^{7}Li + \gamma$
- 4 plastic scintillators
- Active area: 60 cm x 60 cm
- Total weight: ~12 kg
- Total power: ~ 0.5 W

A typical event





| Z-X View | Z-Y View |
|---|---|
| | 81 40 40 20 141+06 292+05 606+04 126+04 261e+03 20 1111 223 382 0 691247269 |
| << First < Pre | vious 18438 Next > Last >> Goto |
| Colors: 01 02 | 03 04 05 06 07 08 |
| Stereo Effects: Red Cyan | Red Blue Active Passive No Stereo |
| Advanced Show: Show Traj | Stop Animation Stop Animation |
| ile Name(s): electron.root | 7 6 ToV alactron |
| vent Number: 18438 | |
| Fime Point: 22:23:32.275, 31/01/2016 | |
| Fotal Energy: 7551.083000 GeV | |
| Frack Status: Has BGO Track: Yes. Has Gl | obal Track: Yes. |
| Direction: Theta: 38.4 deg, Phi: -54. | 2 deg |
| | |

Particle identification







DAMPE 7 year exposure map

13+ billion events



Performance

Since the launch on Dec. 17, 2015, DAMPE has operated onorbit for 7.5 years, surveyed the sky for 16 times, and recorded more than 13 billion events



PSD charge measurement







STK direction measurement





Angular resolution calibrated with photons from pulsars and stacked AGNs gives ~0.3 degrees @ 10 GeV



BGO energy measurement



Beam tests at CERN PS & SPS

- Electrons (protons): few GeV 250 (400) GeV, ions: 40 GeV/n, 75 GeV/n
- Energy resolution: ~1% (e/ γ) at 100 GeV and above, 20% 30% for protons/ions



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Good linearity put to ~2.5 TeV with electron events On-orbit energy scale verified with geomagnetic cut-off





Three different PID methods give very consistent results on event-by-event level



Physical Results: proton spectrum DAM



The DAMPE measurement confirms the spectral hardening at a few hundreds of GeVs found by previous experiments, and more importantly, it reveals a spectral softening feature at ~14 TeV.



Physical Results: helium spectrum DA

DARK



The DAMPE measurement confirms the spectral hardening at TeV-energies found by previous experiments, and more importantly, it reveals a spectral softening feature at a few decades of TeVs.







- * The spectra of CR proton and helium measured by DAMPE show a very similar softening feature at tens of TeVs.
- * The softening energies are well consistent with a dependence on particle charge, although a dependence on particle mass can not be ruled out yet.
- * The results implicate a Z-dependent spectral break (e.g. "knee") in CR nuclei, which is likely an imprint of a nearby cosmic ray source.





Independent analysis of p+He spectrum in the collaboration



- Link between direct/indirect CR measurements
- Hint of new spectral hardening at ~150 TeV

| | Proton | Helium | Proton+Helium |
|----------------|----------------------|--|--|
| E_b (TeV) | $13.6^{+4.1}_{-4.8}$ | $34.4\substack{+6.7+11.6\\-9.8-0.0}$ | $28.8^{+6.2+2.9}_{-4.4-0.0}$ |
| γ | 2.60 ± 0.01 | $2.41\substack{+0.02+0.02\\-0.02-0.00}$ | $2.51\substack{+0.021+0.01\\-0.024-0.00}$ |
| $\Delta\gamma$ | -0.25 ± 0.07 | $-0.51\substack{+0.18+0.01\\-0.20-0.00}$ | $0.43\substack{+0.066+0.066\\-0.057-0.00}$ |

Physical Results: B/C, B/O





• A significant hardening at ~100 GeV/n for both B/C and B/O



Physical Results: forbush decrease



Reveal new features of the recovery time

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Physical Results: γ-ray catalog





We also find 303 point sources with TS values larger than 20 in the 7.3 years of DAMPE photon data (more than EGRET now). Source types are found by associating the sources with those in the Fermi-LAT 4FGL-DR3 catalog.

The first 5-year DAMPE photon data are publicly available online (https://dampe.nssdc.ac.cn)



Physical Results: γ-ray sources



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Physical Results: γ-ray line search



The constraints on cross-section or decay time are comparable or stronger than Fermi-LAT's thanks to the high energy resolution

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- DAMPE detector works smoothly for 7+ years, opening a new window to look at the high-energy Universe above TeV
- Precise measurements of the e⁺+e⁻ spectrum show a break at ~TeV energies
- Precise measurements of proton (helium) spectra reveal interesting softening features at ~14 (34) TeV
- Precise measurements of B/C and B/O reveal a unexpected hardening feature at ~100 GeV/n
- More than 300 γ-ray sources are detected, including Fermi bubbles and Galactic center excess
- > Stringent upper limits on dark matter annihilation/decay into monochromatic γ -rays have been obtained
- > More results about cosmic ray nuclei and γ -rays are coming

Thank You!