An Anomalous Positron Abundance in Cosmic Rays with Energies 1.5-100GeV

PAMELA Collaboration, Nature 2009

Astrolunch – Monday 6th April

Lucy A. Wilcock

Payload for Anti-Matter Exploration and Light-Nuclei Astrophysics

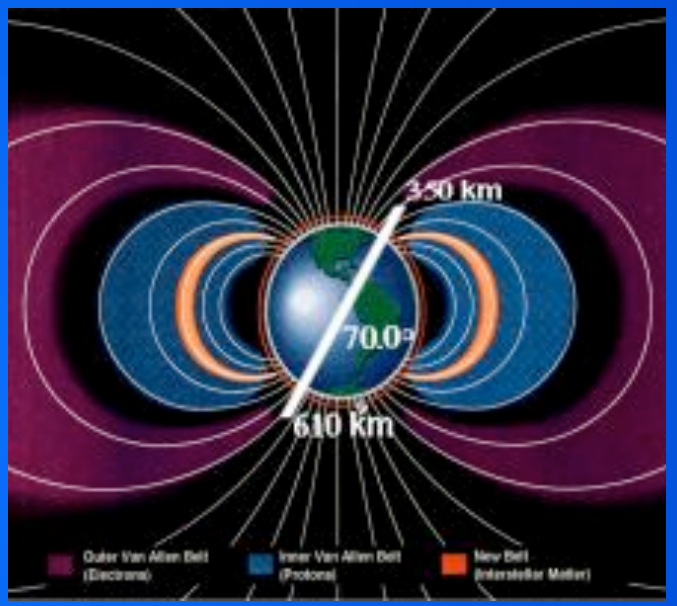
- Built by the WiZard collaboration and is part of the Russian-Italian Mission (RIM) program

- Previous experiments include several balloon-borne instruments launched between 1989 and 1998 and the SilEye Experiments performed aboard MIR and the ISS

- Primary scientific goal is the study of the anti-matter component of cosmic rays

The PAMELA Instrument

- Launched 15th June 2006 and expected to operate for at least three years



- The instrument is installed on the Resurs-DK1 satellite, weighs 420kg and cost £16.8million

- Detects anti-protons, positrons, electrons and protons and provides charge, rigidity and time of flight information for each

PAMELA Measurements of Antiproton-to-Proton Flux

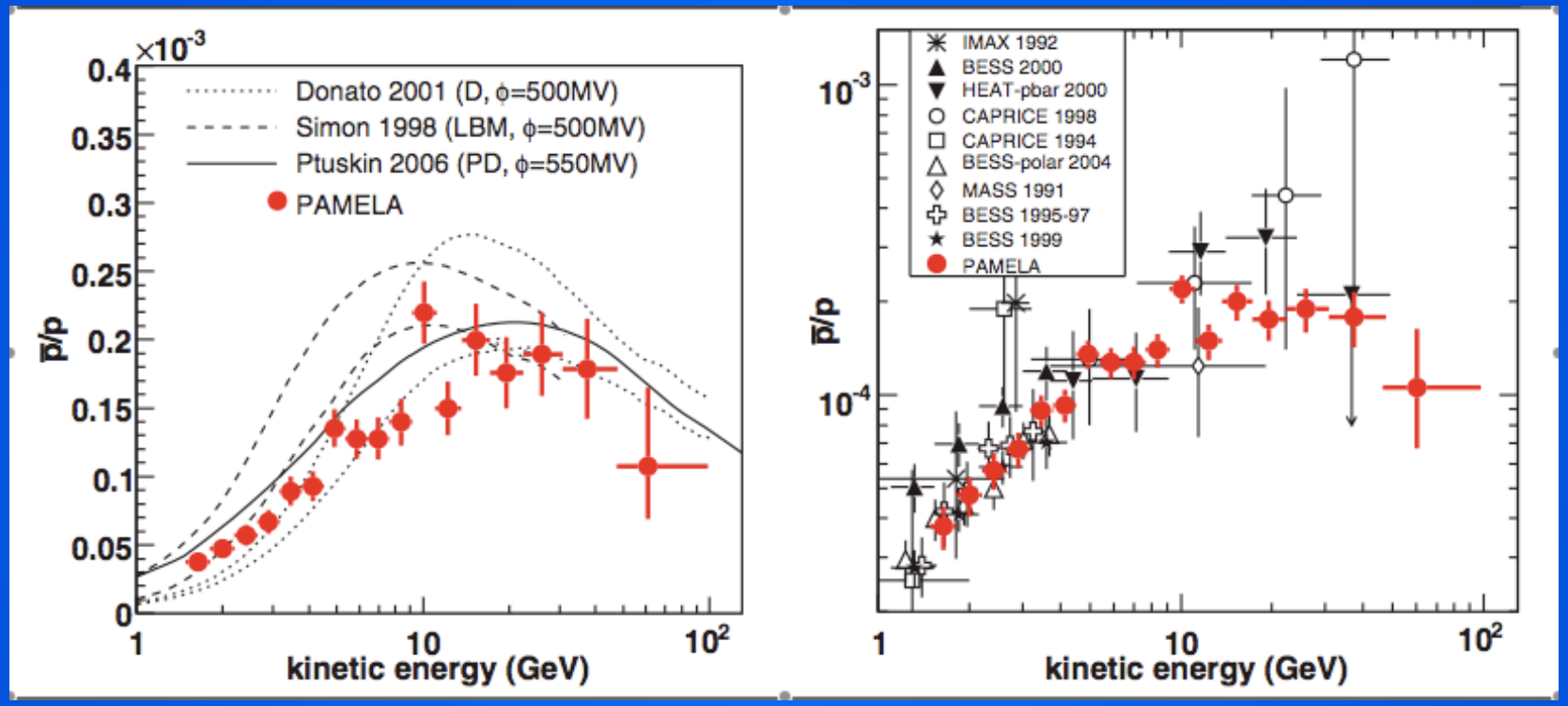


Image from PAMELA Collaboration, Physical Review Letters 2009

- Anti-protons can be produced from 'primary' or 'secondary' sources – measurements agree with predictions for secondary source production

PAMELA Measurements of Positron-Electron Ratio

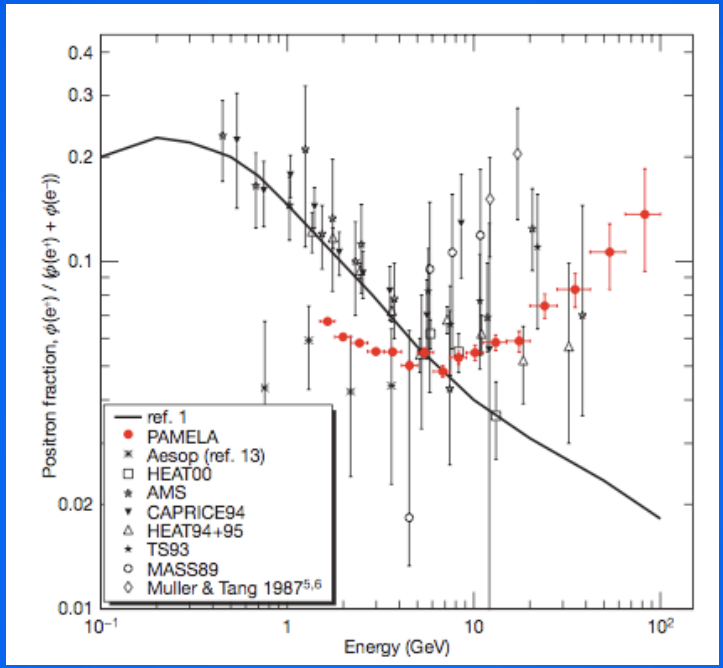
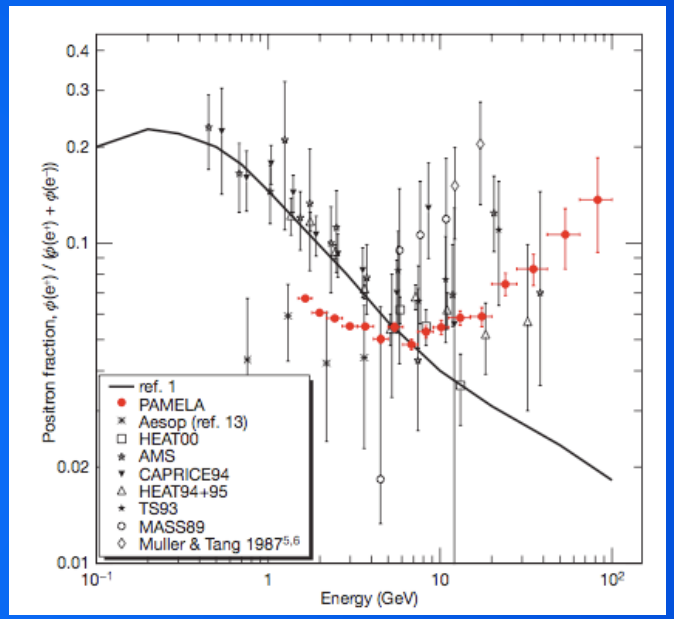


Image from PAMELA Collaboration, Nature 2009

- Solid black line shows the theoretical positron fraction due to secondary sources, there is significant deviation in the PAMELA results below 5GeV and above 10GeV

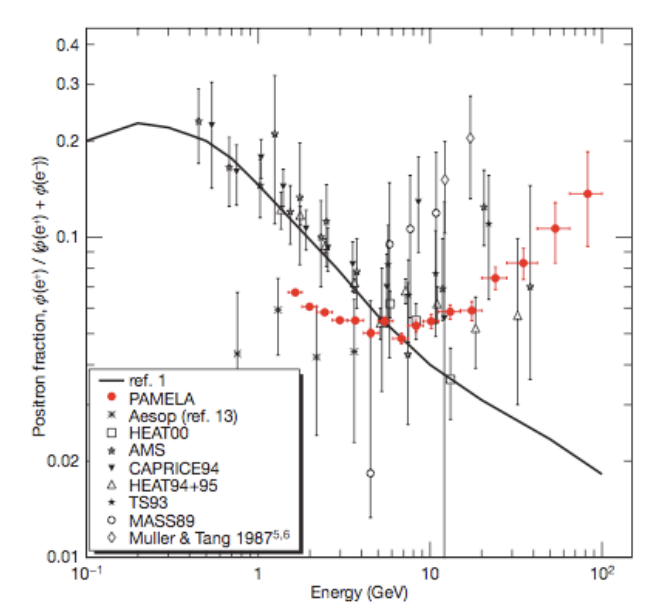
Discrepancy at Energies <5GeV

- Low energy data from previous experiments match the calculated secondary fraction
- The PAMELA data are much lower than previous experiments



- Can be interpreted as a consequence of charge dependent solar modulation effects

Discrepancy at Energies >10GeV



- PAMELA data show the positron fraction increases significantly at higher frequencies
- If positrons are of secondary origins they are expected to fall as a smooth function with increasing energy
- Positrons are from a primary source

Candidates for a Primary Source of Positrons

- Positrons and antiprotons can be produced during the annihilation or decay of dark matter particles
- Pulsars and micro-quasars can contribute to the high energy positron spectrum
- Future PAMELA results (on positron fraction up to 300GeV and cosmic ray energy spectrum) will help clarify source of high energy positrons

Conclusions

1. PAMELA has shown that high energy antiprotons are mostly from secondary sources
2. The positron fraction at high energies can not be explained by production from secondary sources
3. These results can be explained by decay of non-thermal WIMPs or by astrophysical phenomena
4. Future results from PAMELA looking at the positron fraction up to 300GeV will help clarify these results

Questions?