Cosmic-Ray Antiparticles and Electrons

Discussion Session 16

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THE ASTROPARTICLE PHYSICS CONFERENCE

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Cosmic Ray Conference
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Organization of the Discussion Session

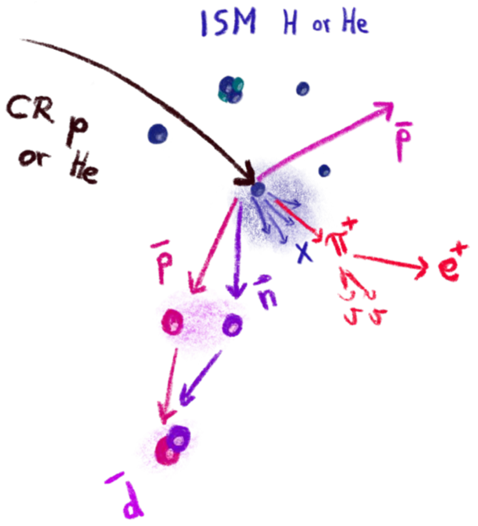
<u>**First half**</u>

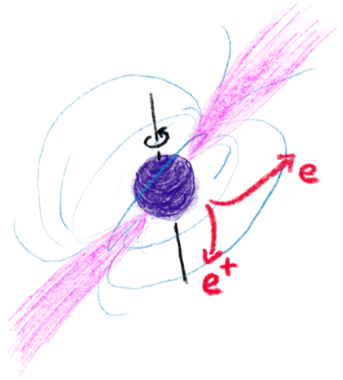
- Very brief **1 min summary** by the author
- **About 2 - 3 specific questions** to each author

<u>**Second half**</u>

- **More general question** that are relevant to multiple contributions
- **Broader discussions**
- Important next steps with **perspectives and outlooks**

Topics of this Discussion Session

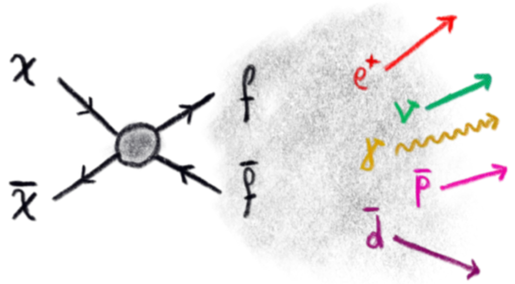


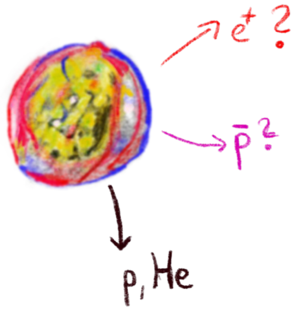


Experimental results &
theoretical interpretations

Particles: Electrons, positrons, antiprotons, antinuclei

Sources: astrophysical (SNR, Pulsars, …), secondary production, Dark Matter

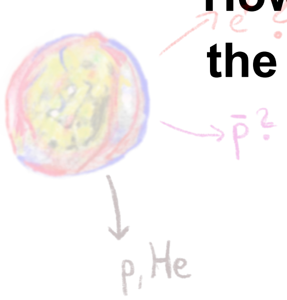


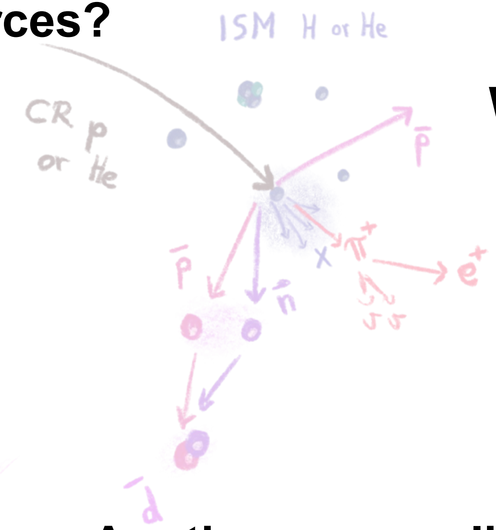


Guiding Questions

What are the new and upcoming experimental data?

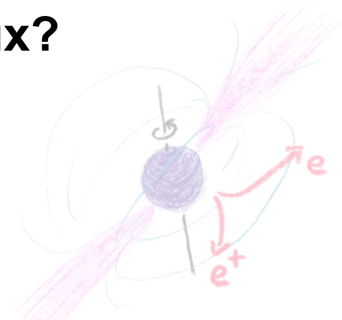
How well do we understand the astrophysical sources?

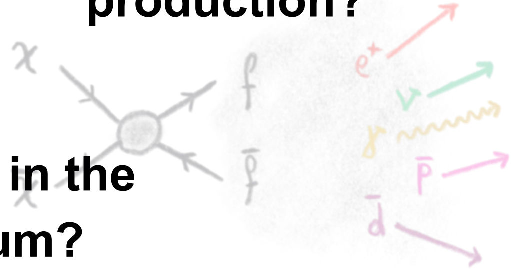




What is the uncertainty in the predicted fluxes of positrons/antiprotons from secondary production?

What is the origin of the hardening of the positron flux?





Are there anomalies in the antiproton spectrum? What causes them?

Related Contributions (experimental)

Antiprotons/Antideuterons

Javier Berdugo	AMS Highlights
Hsin-Yi Chou	Antiproton Flux and Properties of Elementary Particle Fluxes in Primary Cosmic Rays Measured with the Alpha Magnetic Spectrometer on the ISS
Field Rogers	Cosmic Antiproton Sensitivity for the GAPS Experiment
Sean Quinn	The GAPS Instrument: A Large Area Time of Flight and High Resolution Exotic Atom Spectrometer for Cosmic Antinuclei
Dr Mengjiao Xiao	In Search of Cosmic-Ray Antinuclei from Dark Matter with the GAPS Experiment
Nadir Marcelli	Neural Networks aproach to event reconstruction for the GAPS experiment
Alessio Tiberio	Reconstruction of antinucleus-annihilation events in the GAPS experiment
Kenichi Sakai	New result of Antideuteron search in BESS-Polar II
Francesco Nozzoli	An Helium calorimeter for Anti-Deuteron identification in cosmic rays
Achim Stoessl	Searching for cosmic antihelium nuclei with the GAPS experiment
Tsuguo Aramaki	Overview of the GRAMS (Gamma-Ray AntiMatter Survey) Project
P. von Doetinchem	Atmospheric Influence for Low-Energy Cosmic-ray Antinculei Measurements with Balloon-borne Experiments

Positrons

Zhili Weng	Towards Understanding the Origin of Cosmic-Ray Positrons
M. Molero Gonzalez	Anisotropy of Positron and Electron Fluxes Measured with the Alpha Magnetic Spectrometer on the ISS
Maura Graziani	Precision Measurement of low energy positron fluxes by AMS
Shoji Torii	Precise Measurement of the Cosmic-Ray Electron and Positron Spectrum with CALET on the International Space Station
Shijun Lei	Studies of cosmic ray anisotropies with DAMPE

Electrons

D. Krasnopevtsev	Towards Understanding the Origin of Cosmic-Ray Electrons
Weiwei Xu	Precision measurement of daily electrons fluxes by AMS

Unfortunately there is not enough time to feature all contributions in this session. But we encourage you to take a look at all of them.

Related Contributions (theoretical)

Origin of the hard positron flux

Tim Linden TeV Halos: A New Class of TeV Sources Powered by Pulsars
Soheila Abdollahi Systematic search for halos around pulsars in Fermi-LAT data
R. Torres Escobedo Follow-up Analysis to Geminga's contribution to the Local Positron Excess with HAWC Gamma-Ray Observatory
Luca Orusa Constraining positron emission from pulsars with AMS-02 data
Manuel Linares Compact binary millisecond pulsars and the positron excess
Dr Sarah Recchia A local fading accelerator and the origin of TeV cosmic ray electrons
Dr Philipp Mertsch Explaining cosmic ray antimatter with secondaries from old supernova remnants
Agnibha De Sarkar Galactic Molecular Clouds As Sources of Secondary Positrons
Paolo Lipari How well do we understand the properties of the Galactic cosmic ray accelerators and of cosmic ray propagation in the Galaxy ? A critical view.

Interpretation of CR electrons

Holger Motz Investigating the Vela SNR's Emission of Electron Cosmic Rays with CALET at the International Space Station
Fiorenza Donato On the interpretation of the latest AMS-02 cosmic ray electron spectrum
Alexei Ivlev Rigorous theory for the spectrum of secondary cosmic-ray electrons
Dr Sarah Recchia A local fading accelerator and the origin of TeV cosmic ray electrons

DM Searches/Constraints

Martin Winkler A detectable antihelium flux from dark matter annihilation
Jan Heisig Dark matter or correlated errors? Systematics of the AMS-02 antiproton excess
Pierre Salati New cosmic ray MIN-MED-MAX benchmark models for dark matter indirect signatures
P. De la Torre Luque Cosmic-ray combined analyses to shed light in the antiproton excess and its possible dark matter origin
Isabelle John Dark matter constraints from measurements of cosmic-ray positrons
Mattia Di Mauro Multimessenger constraints on the dark matter interpretation of the Fermi-LAT Galactic center excess

Solar Modulation

Driaan Bisschoff Differences in the solar modulation of protons and anti-protons for 2006 to 2017
Driaan Bisschoff Constraints on the very local interstellar spectrum for cosmic ray anti-protons using solar modulation modeling
Riccardo Munini SOLAR MODULATION OF GALACTIC-COSMIC RAY ANTIPROTONS
Vladimir Mikhailov STUDY OF THE MODULATION OF GALACTIC POSITRONS AND ELECTRONS FROM 2006-2016 WITH THE PAMELA EXPERIMENT

Cross Sections and Coalescence of Antinuclei

Jonas Tjemsland Formation models for cosmic ray antinuclei
Laura Šerkšnytė Antihelium-3 fluxes near Earth using data-driven estimates for annihilation cross section
Michał Naskręt Light (anti)nuclei production cross section studies in p+C collisions at the NA61/SHINE experiment.
Luca Orusa New cross section determination for secondary cosmic ray electron and positrons in the light of new data from collider experiments

Antistars

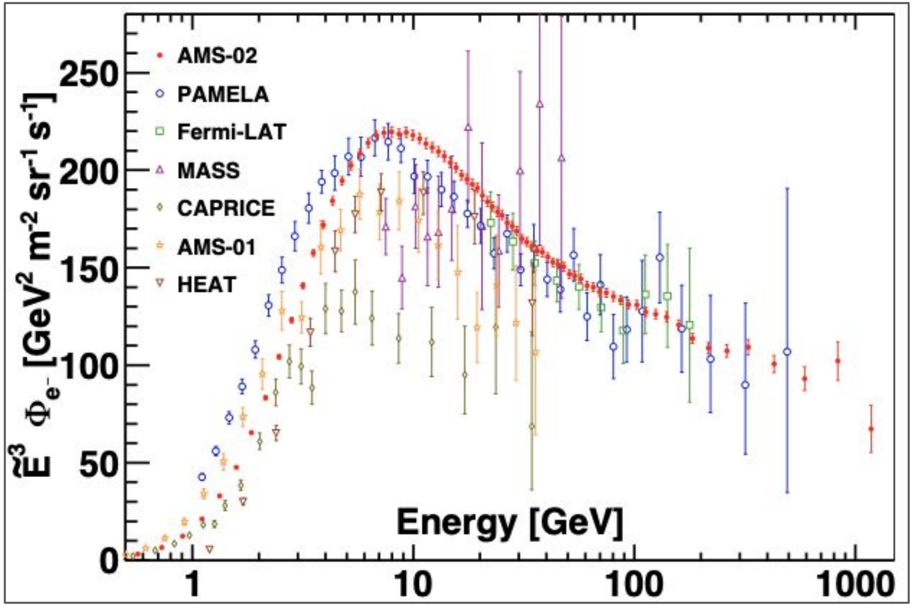
Simon Dupourqué Constraints on the antistar fraction in the Solar System neighborhood from the 10-years Fermi Large Area Telescope gamma-ray source catalog

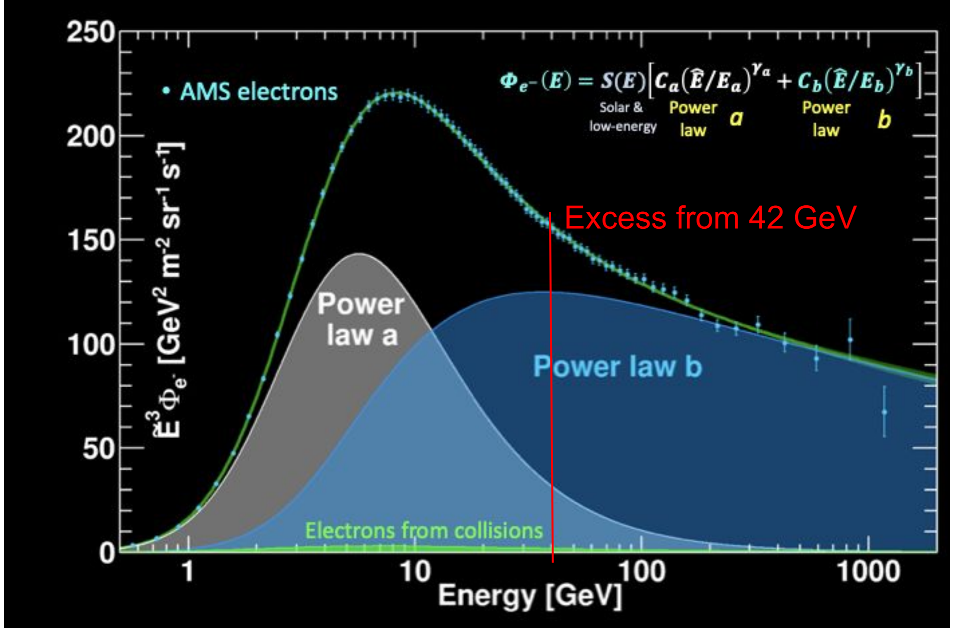
Experimental Results

Towards Understanding the Origin of Cosmic-Ray Electrons

Dimitrii Krasnopevtsev / MIT

on behalf of AMS collaboration

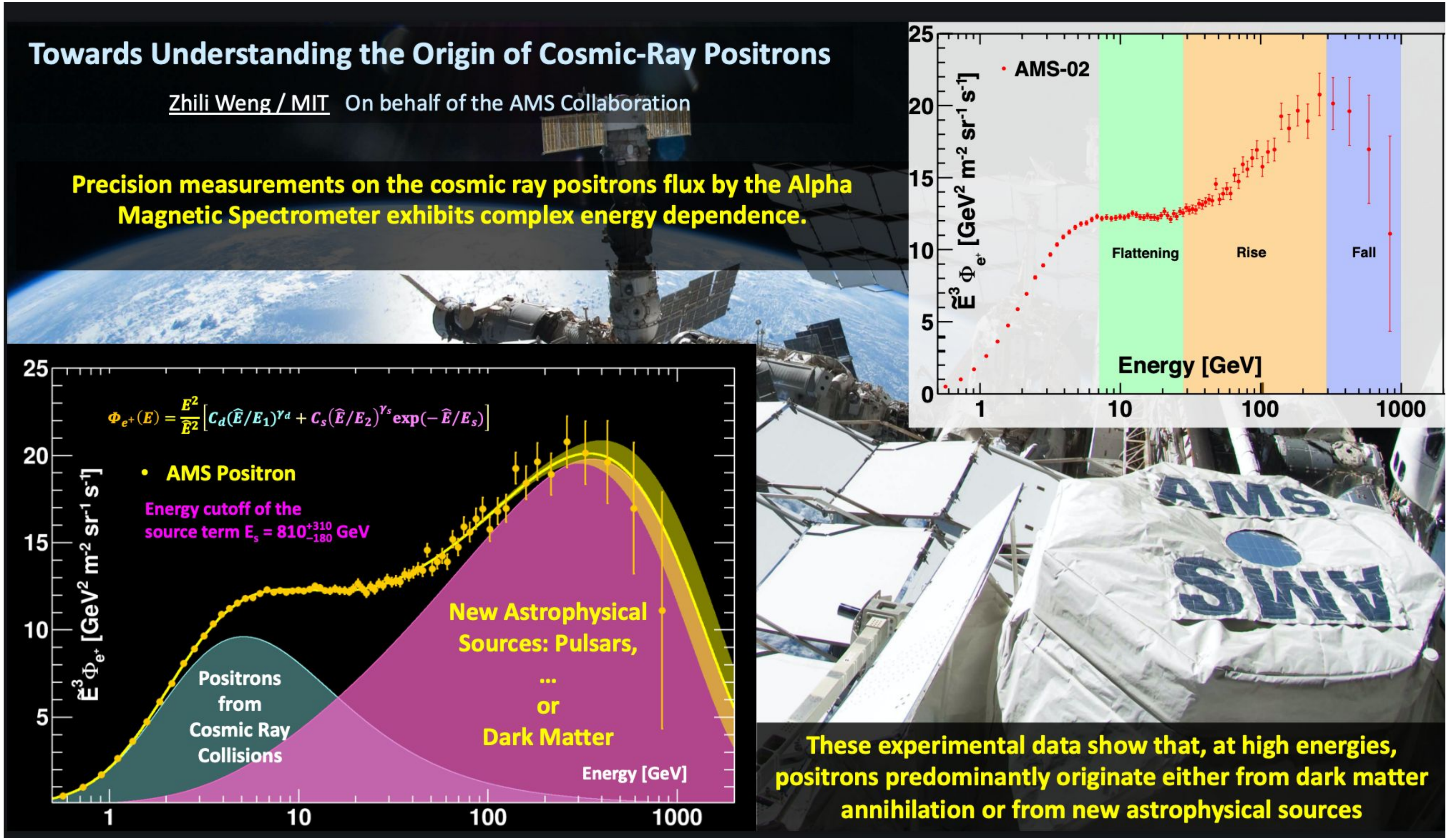




- Electron precision measurement up to 1.4 TeV.
- The electron flux is well described by the sum of two power law components.
- The electron flux exhibits a significant excess starting from 42 GeV and does not show an exponential energy cutoff.
- The contribution from cosmic ray collisions is negligible.

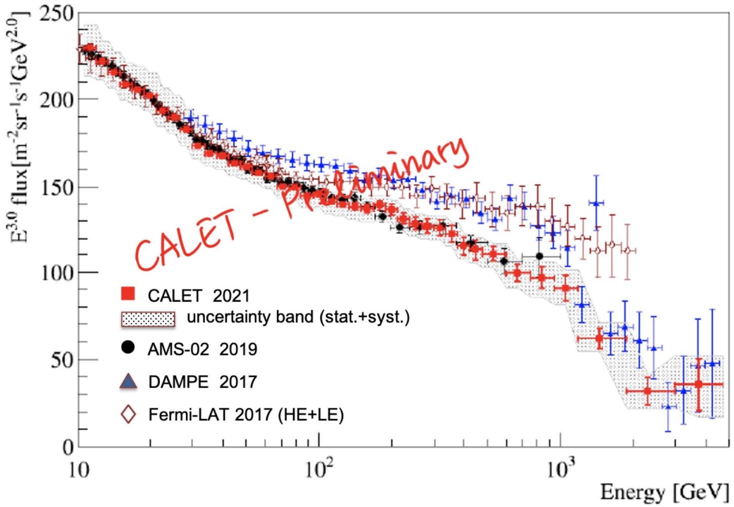
Towards Understanding the Origin of Cosmic-Ray Positrons

Zhili Weng

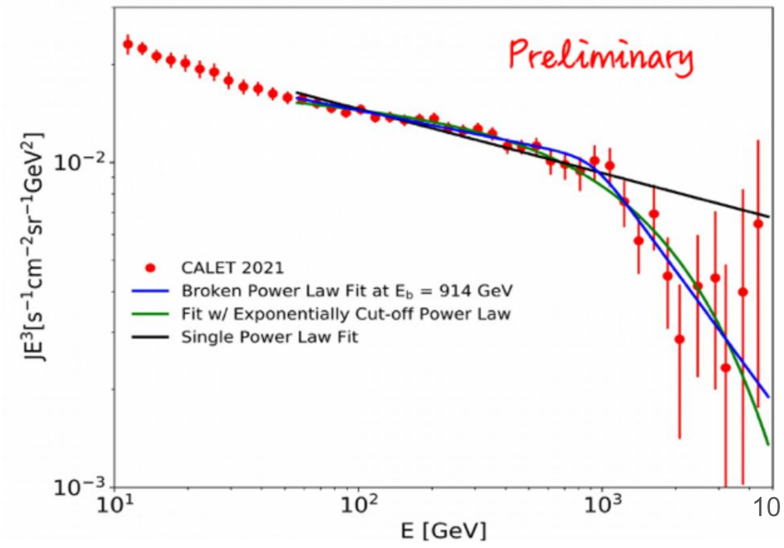


Precise Measurement of the Cosmic-Ray Electron and Positron Spectrum with CALET on the International Space Station

Shoji Torii and Pier Simone Marrocchesi

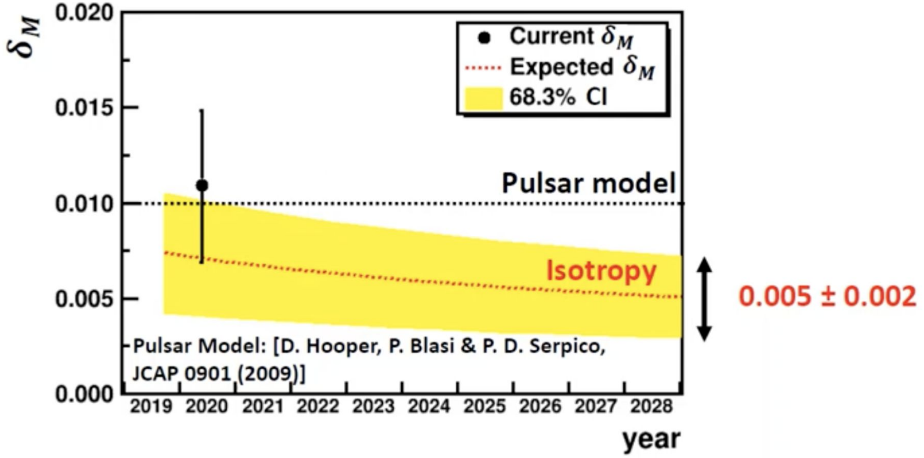


- The all-electron (e++e-) spectrum is observed in the energy range from 11 GeV to 4.8 TeV
- The results at high energies present suppression of the flux above 1 TeV
- The spectrum below 1 TeV is consistent with AMS-02
- Further observations until Dec. 2024 (at least) are approved by JAXA



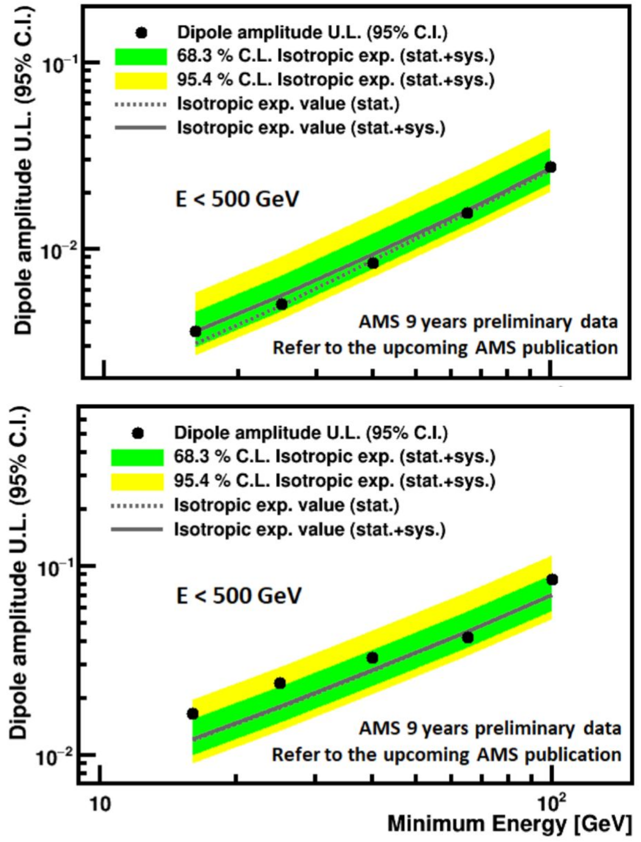
Anisotropy of Positron and Electron Fluxes Measured with the Alpha Magnetic Spectrometer on the ISS

Miguel Molero



Electron

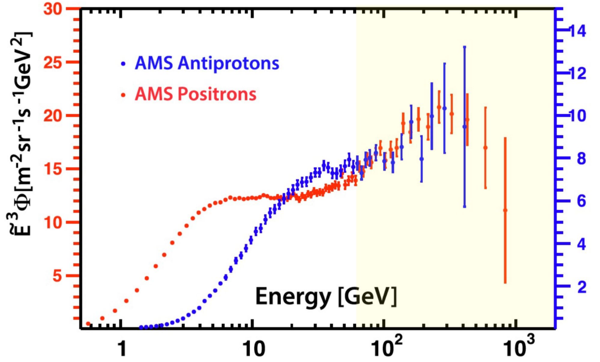
Positron

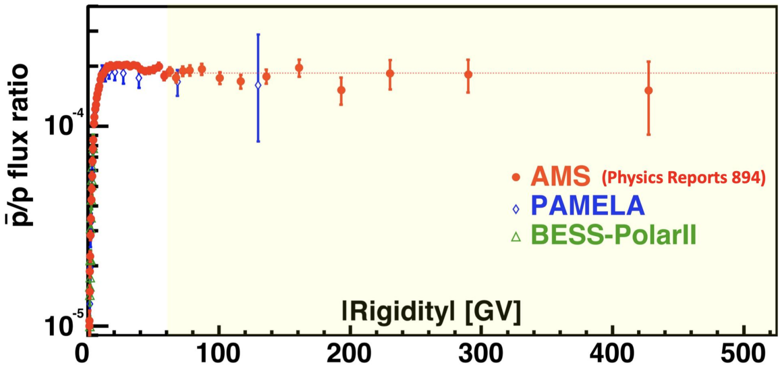


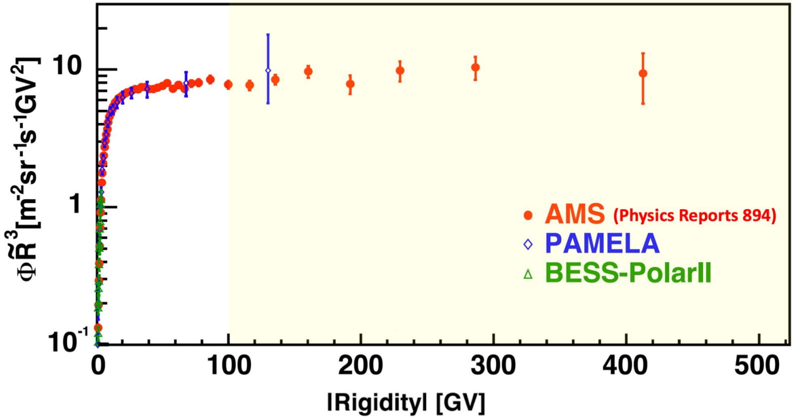
- AMS-02 measures the anisotropy of the electron and positron fluxes
- Measurements are consistent with isotropic expectation
- By 2028 AMS-02 is sensitive to dipole moments at the level of 1%

Antiproton Flux and Properties of Elementary Particle Fluxes in Primary Cosmic Rays Measured with the Alpha Magnetic Spectrometer on the ISS

Hsin-Yi Chou





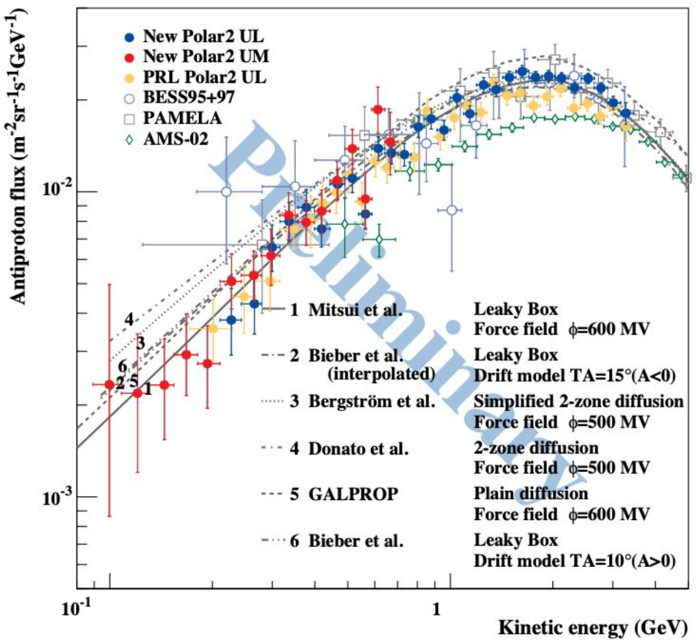


- Starting from 60 GV, antiproton-to-proton flux ratio is a constant up to 525GV.
- Positron flux shows a drop-off at around 280 GeV, proton flux shows progressive hardening towards higher energy.
- Positron and antiproton spectra have similar behavior above 60 GeV.

New result of Antideuteron search in BESS-Polar II

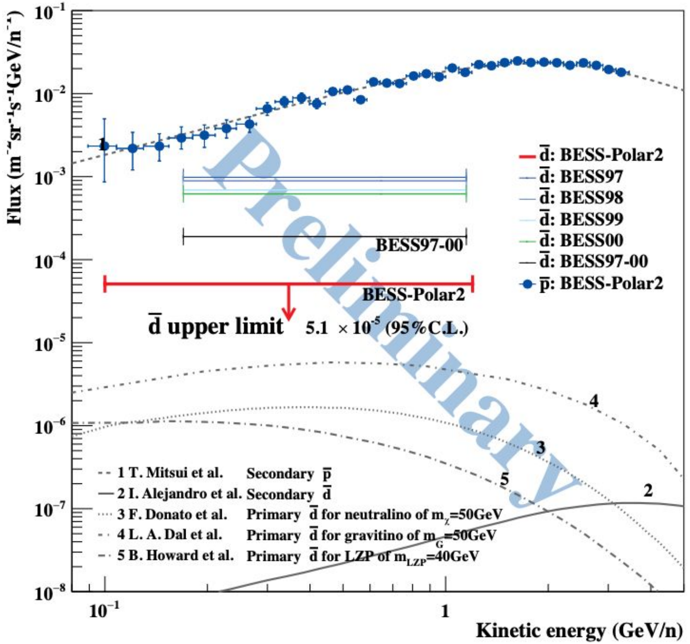
Kenichi Sakai

Antiproton



New UM antiproton flux in the range 0.1 to 0.7 GeV is calculated based on 418 antiprotons.

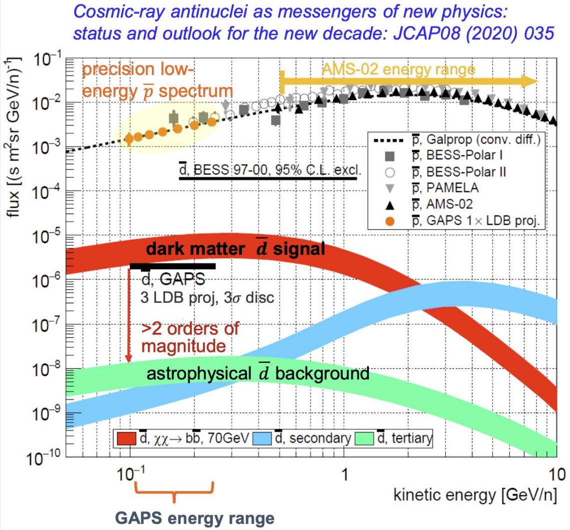
Antideuteron

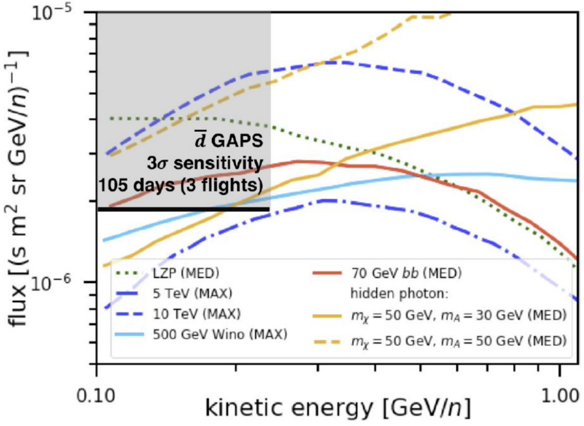


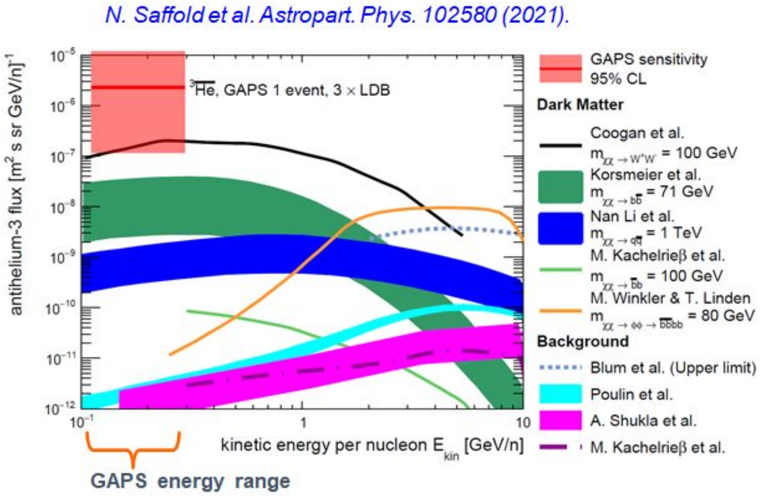
New preliminary upper limit in antideuteron flux is $J(\bar{d}) < 5.1 \times 10^{-5}$ $(m^2 sr\ sec\ GeV/n)^{-1}$ (95%C.L.)

In Search of Cosmic-Ray Anti-nuclei from Dark Matter with GAPS

Mengjiao Xiao





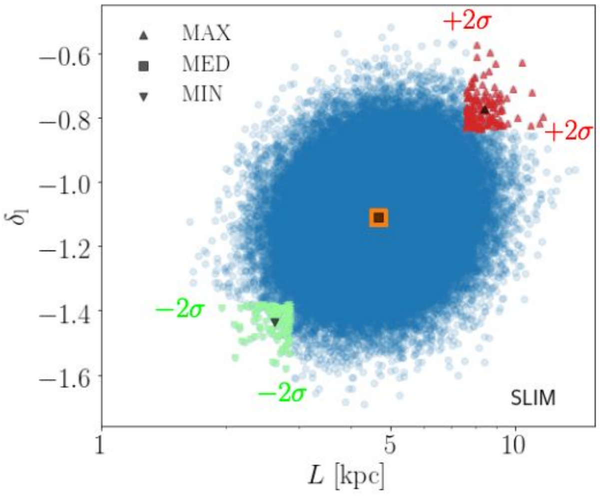


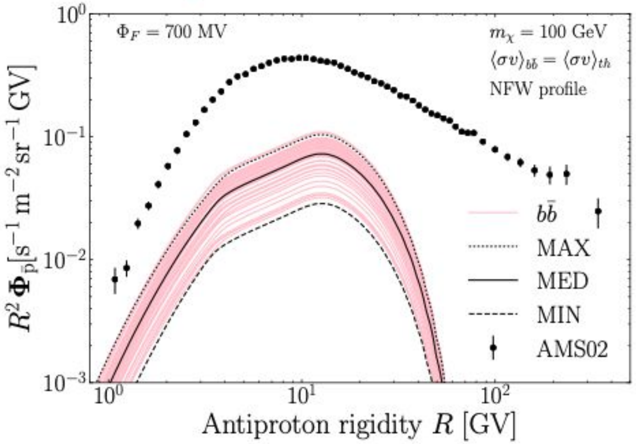
- GAPS is the first experiment optimized specifically for low-energy (<0.25 GeV/n) cosmic antinuclei searches, aims to deliver:
  - the first-time detection of low-energy ***antideuterons*** with the unprecedented sensitivity.
  - a precision measurement of low-energy ***antiprotons***, and the potential detection of ***anti-He***.
- Instrument integration has begun, on schedule for the ***first science flight from Antarctica in late 2022.***

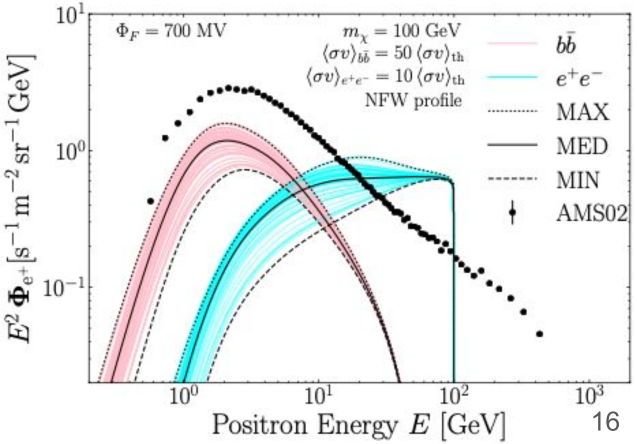
Theoretical Interpretation

New cosmic ray MIN-MED-MAX benchmark models for dark matter indirect signatures

Pierre Salati





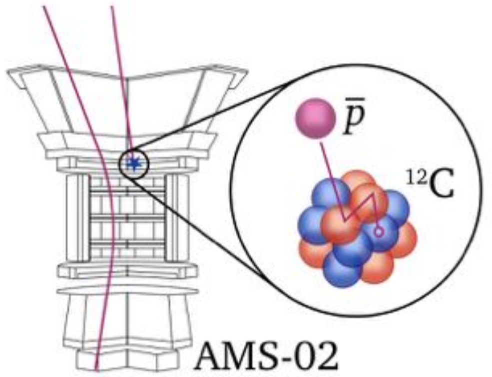


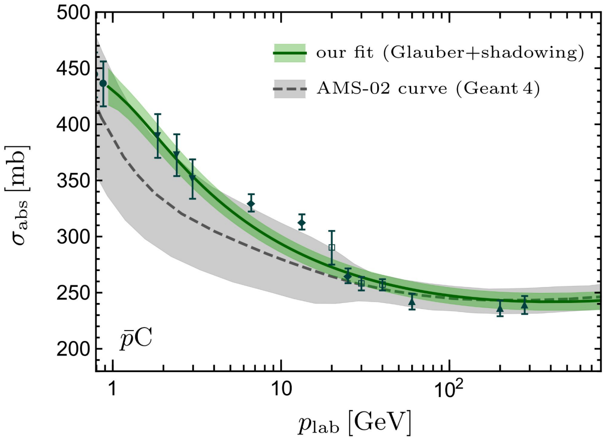
- NEW MIN-MED-MAX benchmarks for BIG, QUAINT and SLIM propagation model
- *L* is a crucial quantity for the intensity of primary antiprotons and positrons fluxes
- Uncertainties are reduced by a factor 3-4 for positrons and 5 for antiprotons

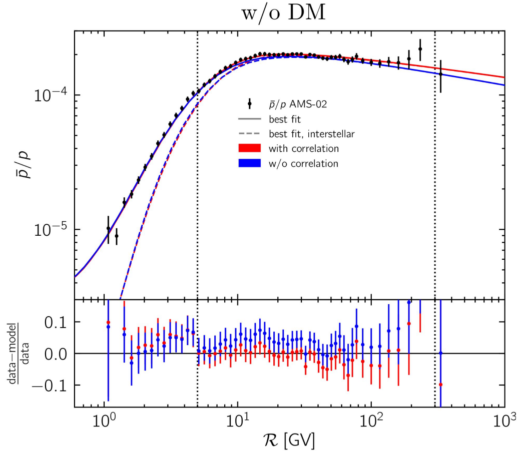
Dark matter or correlated errors: Systematics of the AMS-02 antiproton excess

Jan Heisig

- Excess in AMS-02 antiprotons around 10-20GV found by several groups
- Study systematics that could have 'faked' the signal
- Unaccounted error correlations in measurements have large effect
- Dominant error: cross sections for cosmic-ray absorption in the detector
- First-time computation in global fit using Glauber-Gribov theory
- Questions robustness of excess but increases sensitivity
- Reveals strong dependence on diffusion model at low rigidities.







Explaining cosmic ray antimatter with secondaries from old supernova remnants

Philipp Mertsch

What is this contribution about?

Secondary cosmic rays are produced and accelerated in the shocks of supernova remnants.

Why is it relevant / interesting?

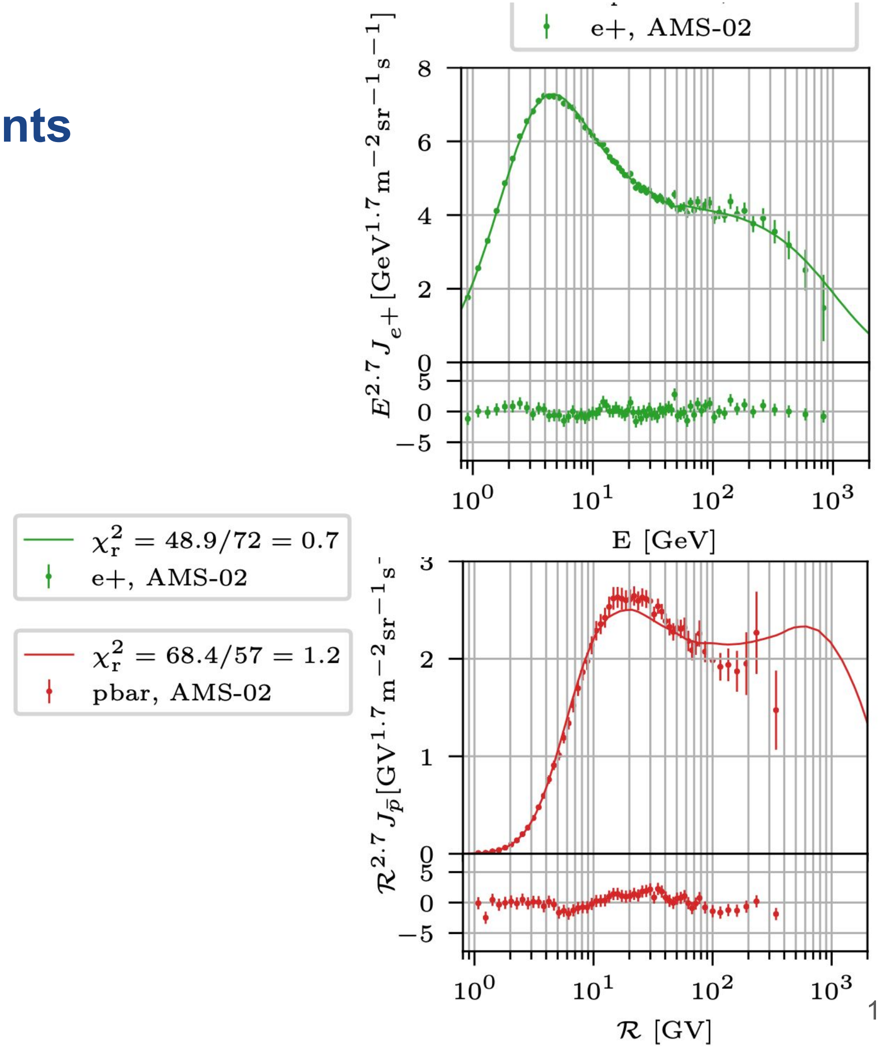
This can explain the positron excess and accommodate the measured antiproton flux.

What have we done?

We have computed the shock-accelerated secondaries and studied the parameter space.

What is the result?

Good fit of proton, helium, carbon, oxygen, boron, nitrogen, positrons and antiprotons!

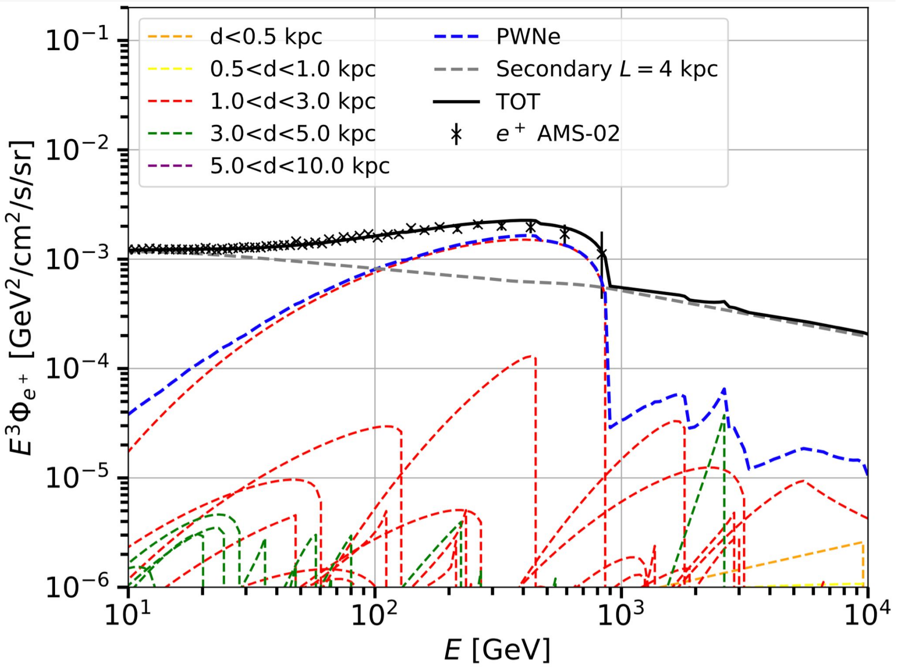


Constraining positron emission from pulsars with AMS-02 data

Luca Orusa

	$\chi^2_{red} < 2$	$\chi^2_{red} < 1.5$	$\chi^2_{red} < 1$
ModA	15.	8	4
ModB	30.	19	6
ModC	15.	10	3
ModD	42.	25	10

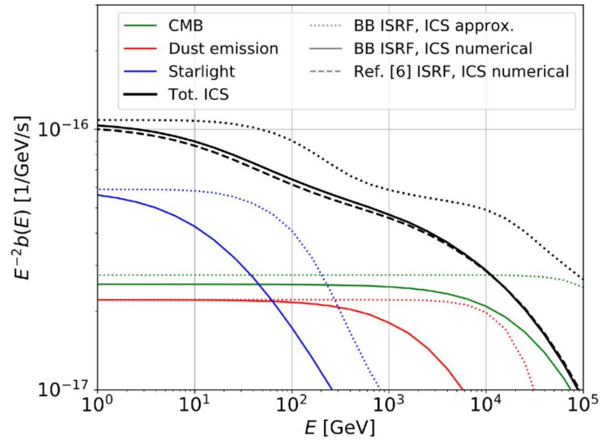
Number of simulations (out of 1000) that produce a reduced chi square smaller than 2, 1.5 or 1 in the fit to AMS-02 data, for each simulation setup.

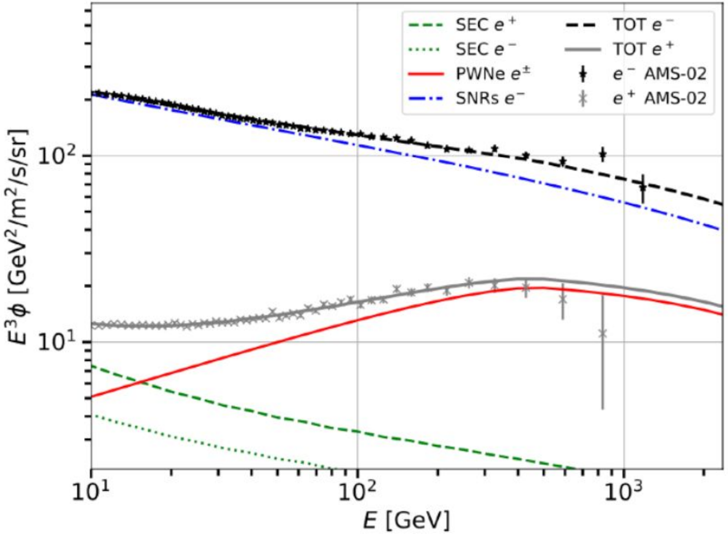


- Pulsar catalogs might not be complete ⟶ Simulation of pulsar populations
- The smooth trend of the AMS-02 data disfavors scenarios with a huge number of bright sources

On the interpretation of the latest AMS-02 cosmic ray electron spectrum

Fiorenza Donato

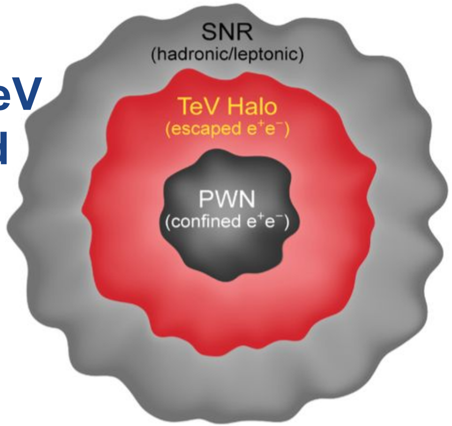


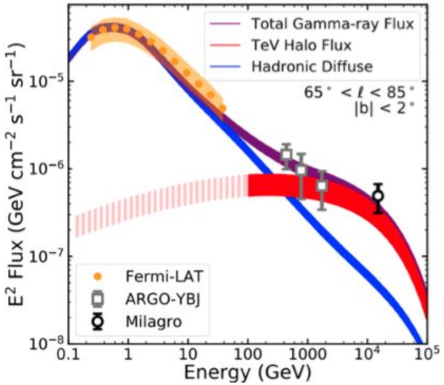


- We have demonstrated that the approximated ICS cross section gives a bad description in AMS-02 energy range
- Full numerical ICS does not predict e^- slope change
- The break measured by AMS-02 in the e^- flux at about 40 GeV is very likely due to the interplay between SNR and PWN emission

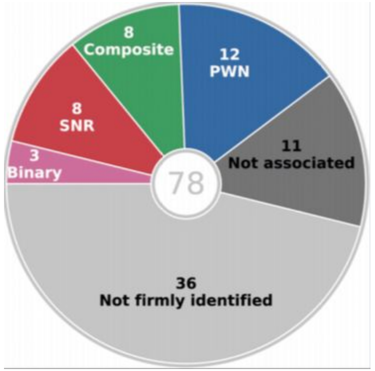
TeV Halos: A new class of TeV sources powered by pulsars

Tim Linden

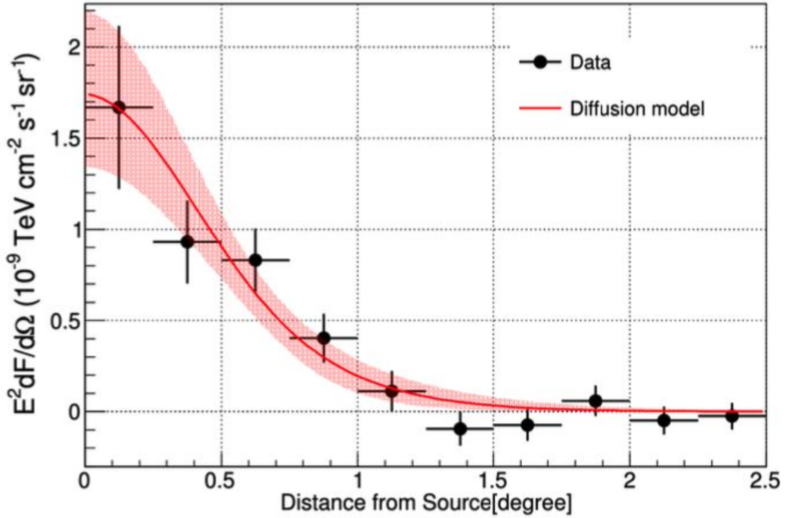


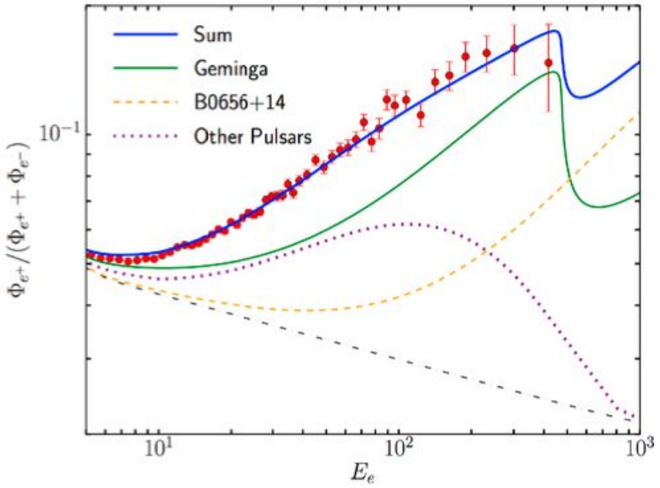


Diffuse TeV Flux



TeV Source Counts

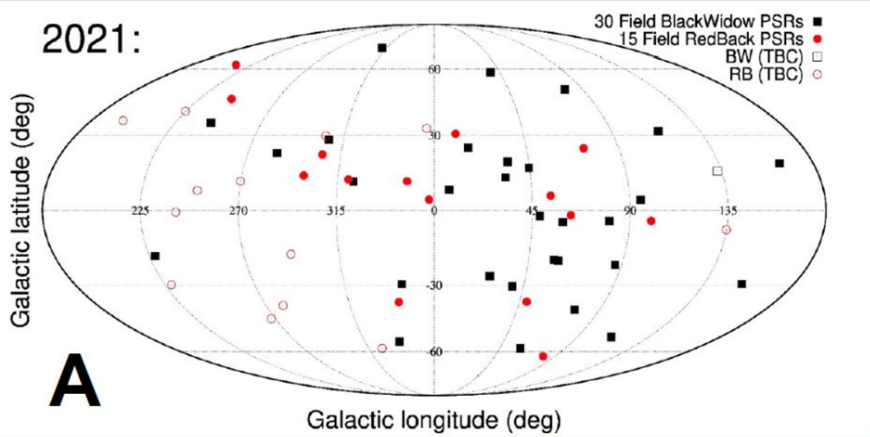




Positron Excess

Compact binary MSPs and the e^+ excess

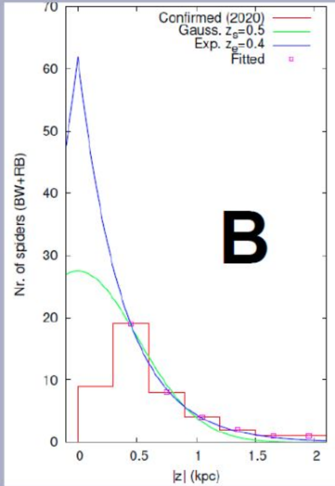
Manu Linares (GAA@UPC & IEEC, Barcelona) & Michael Kachelriess (NTNU, Trondheim): 2021JCAP...02..030L

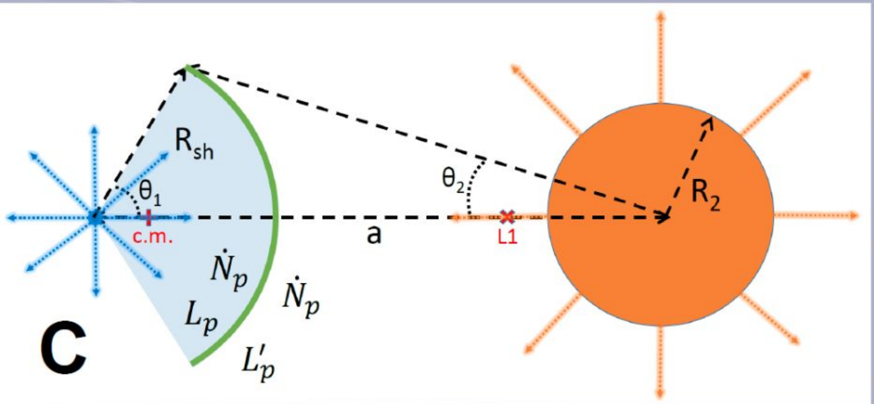


>50 spiders discovered in a decade!
(d ~ **0.5**-5 kpc; L_{sd} ~ 10^{34}-10^{35} erg/s)

Exp. scale height: z_e = 0.4+/-0.1 kpc
(2-3 "hidden nearby": d<1kpc; |ℓ|<5º)

Total: 2-7 thousand spiders in the Galaxy
(we simulate 5000)

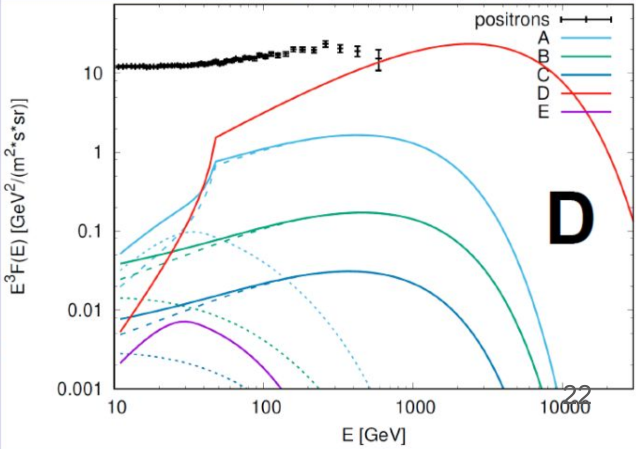




Intrabinary shock (re)acceleration:
10% L_{sd}, up to ~10 TeV

Currently known spiders:
Minor contribution e^+ flux

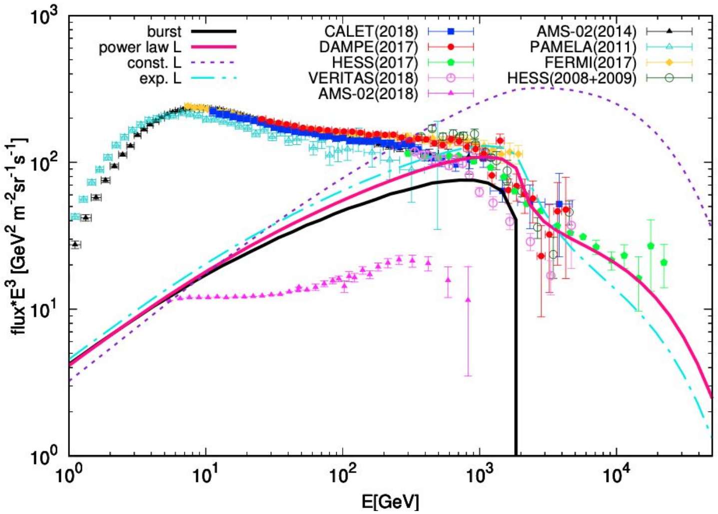
Nearby spider || GMF:
Major contribution e^+ flux

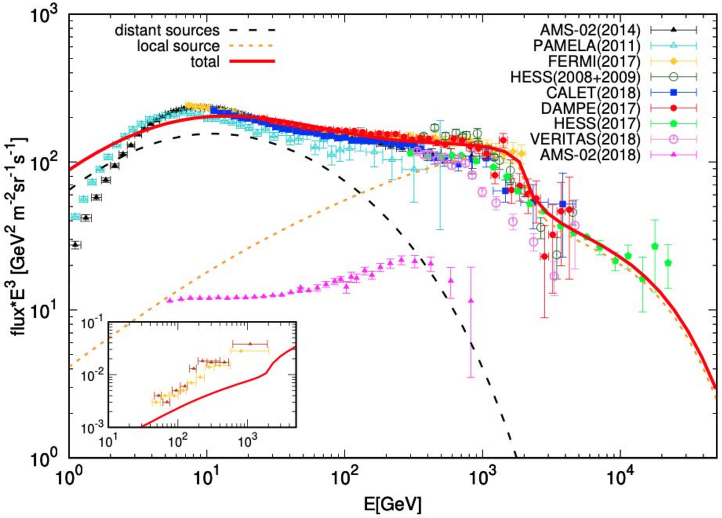


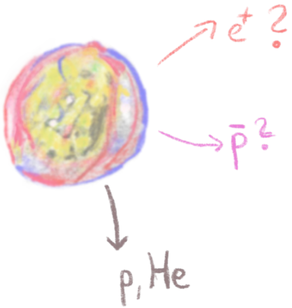
A local fading accelerator and the origin of TeV cosmic ray electrons

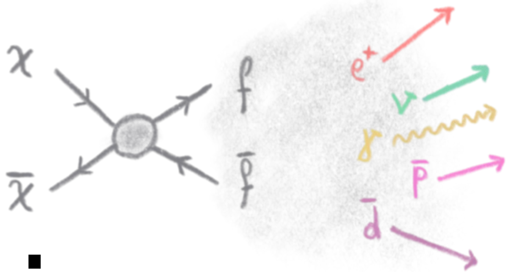
Sarah Recchia

- A local fading accelerator can account for the entire multi-TeV electron spectrum, from the ~1 TeV break up to 20 TeV
- Such accelerator should produce preferentially electrons over positrons, its age should be ~100 kyr and it fading timescale should be τ~10 kyr
- The nature of such accelerator should be investigated (SNR, stellar winds...?)



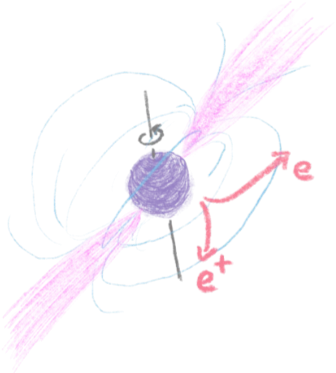


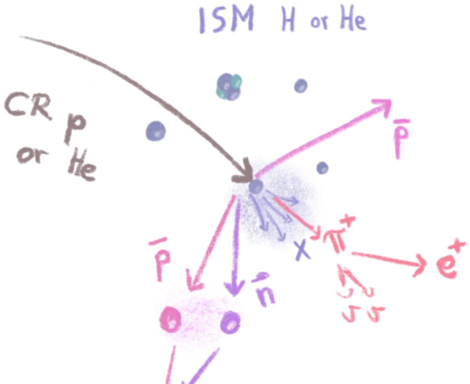




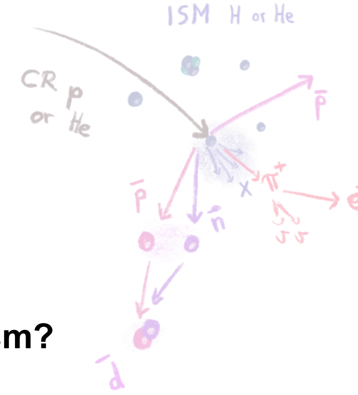
Broader Discussion

More general questions and perspectives





Guiding Questions



How well can we predict the fluxes of positrons
and antiprotons from the secondary production mechanism?

Is the positron spectrum inconsistent with the standard, secondary production mechanism?

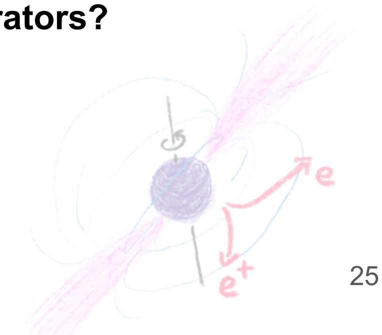
If positrons have an additional (non-standard) source,
what is its spectral shape, and what is its origin?

Are there anomalies in the antiproton spectrum? What causes them?

How do propagation effects modify the source spectra of protons and nuclei,
and the source spectra of electrons and positrons?

Which spectra are generated by the electron accelerators? Are there positron accelerators?

Do we understand the features in the electron and positron energy spectra?



Multi-TeV electrons and positrons: What do we see, and what do we expect?

Antinuclei: Waiting for new results, what do we expect?