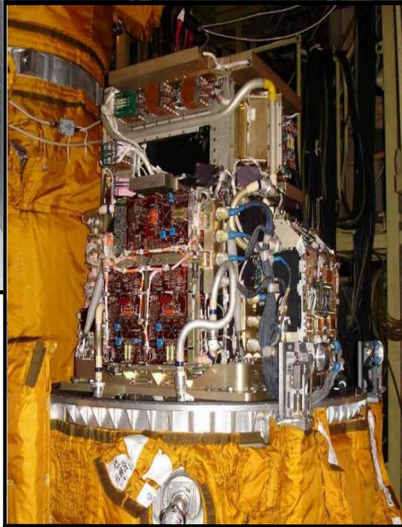


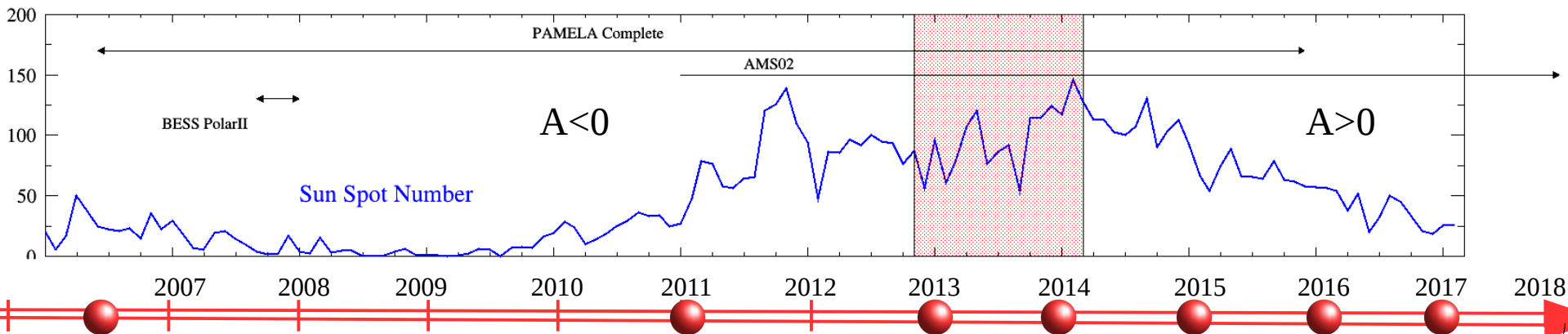
A solar cycle of cosmic ray data measured by the PAMELA experiment.

Riccardo Munini, INFN Trieste
on behalf of the PAMELA collaboration

New opportunities in the AMS Era
25 April 2018 – Washington



Monthly Average



15 June 2006



Успех РН «Союз-У» с КА «Ресурс-ДК1», 15 июня 2006 год

O. Adriani et al., ApJ 742 (2011) 102

The Astrophysical Journal, 742 (2): 102-110 (2011) doi:10.1086/1192129

OBSERVATIONS OF THE 2006 DECEMBER 13 AND 14 SOLAR PARTICLE EVENTS IN THE 30MeV to 51GeV ENERGY RANGE FROM SPACE WITH THE PAMELA DETECTOR

O. Adriani¹, G. C. Barbarino², G. A. Badiereschi³, R. Bellotti⁴, E. A. Besso⁵, L. Borini¹, M. Bongi⁵, M. Cao⁶, S. Di Lorenzo⁷, S. Di Stefano⁸, F. Donato⁹, D. Costantini¹⁰, R. Caviglioli¹¹, P. Carlson¹², M. Cocca¹³, G. Concas¹⁴, L. Costantini¹⁵, P. Di Felice¹⁶, D. Scialò¹⁷, V. Di Felice¹⁸, V. Florio¹⁹, M. Gallorini²⁰, L. Gabriellini²¹, W. Galati²², G. Basilico²³, A. Y. Karimov²⁴, S. V. Krut'ko²⁵, V. Yakovlev²⁶, A. K. Erokhovets²⁷, V. Malakhov²⁸, I. Martucci²⁹, A. G. Orsini³⁰, W. Mann³¹, V. V. Malakhov³², E. Moresco³³, A. Moresco³⁴, N. Masetti³⁵, N. Scopelliti³⁶, G. Orsini³⁷, P. Papini³⁸, M. Pavesi³⁹, P. Panzeri⁴⁰, M. Pavesi⁴¹, P. Perrotti⁴², C. Pizzanelli⁴³, M. Ricci⁴⁴, S. B. Sestini⁴⁵, R. Sakai⁴⁶, L. Brozzetti⁴⁷, M. Sisti⁴⁸, R. Spanu⁴⁹, P. Sestini⁵⁰, Y. I. Izrael⁵¹, A. Vainin⁵², E. Vasconcelos⁵³, G. Vainin⁵⁴, S. A. Vasnetsov⁵⁵, R. U. Y. Yano⁵⁶, G. Zamp⁵⁷, N. Zamp⁵⁸, and G. Zamp⁵⁹

O. Adriani et al., ApJ 765 (2013) 91

The Astrophysical Journal, 765 (2): 91-100 (2013) doi:10.1086/1267202

TIME DEPENDENCE OF THE PROTON FLUX MEASURED BY PAMELA DURING THE 2006 JULY-2009 DECEMBER SOLAR MINIMUM

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O. Adriani et al., ApJ 810 (2015) 142

The Astrophysical Journal, 810 (2): 142-151 (2015) doi:10.1088/00046373/810/2/2

TIME DEPENDENCE OF THE γ FLUX MEASURED BY PAMELA DURING THE 2006 JULY-2009 DECEMBER SOLAR MINIMUM

O. Adriani¹, G. C. Barbarino², G. A. Badiereschi³, R. Bellotti⁴, E. A. Besso⁵, L. Borini¹, M. Bongi⁵, M. Cao⁶, S. Di Lorenzo⁷, S. Di Stefano⁸, F. Donato⁹, D. Costantini¹⁰, R. Caviglioli¹¹, P. Carlson¹², M. Cocca¹³, G. Concas¹⁴, L. Costantini¹⁵, P. Di Felice¹⁶, D. Scialò¹⁷, V. Di Felice¹⁸, V. Florio¹⁹, M. Gallorini²⁰, L. Gabriellini²¹, W. Galati²², G. Basilico²³, A. Y. Karimov²⁴, S. V. Krut'ko²⁵, V. Yakovlev²⁶, A. K. Erokhovets²⁷, V. Malakhov²⁸, I. Martucci²⁹, A. G. Orsini³⁰, W. Mann³¹, V. V. Malakhov³², E. Moresco³³, A. Moresco³⁴, N. Masetti³⁵, N. Scopelliti³⁶, G. Orsini³⁷, P. Papini³⁸, M. Pavesi³⁹, P. Panzeri⁴⁰, M. Pavesi⁴¹, P. Perrotti⁴², C. Pizzanelli⁴³, M. Ricci⁴⁴, S. B. Sestini⁴⁵, R. Sakai⁴⁶, L. Brozzetti⁴⁷, M. Sisti⁴⁸, R. Spanu⁴⁹, P. Sestini⁵⁰, Y. I. Izrael⁵¹, A. Vainin⁵², E. Vasconcelos⁵³, G. Vainin⁵⁴, S. A. Vasnetsov⁵⁵, R. U. Y. Yano⁵⁶, G. Zamp⁵⁷, N. Zamp⁵⁸, and G. Zamp⁵⁹

O. Adriani et al., Space Weather 14 (2016) 210

PAMELA'S Measurements of Magnetospheric Effects on High Energy Solar Particles

O. Adriani¹, G. C. Barbarino², G. A. Badiereschi³, R. Bellotti⁴, E. A. Besso⁵, E. A. Bognomo⁶, M. Bongi⁷, V. Bortolotto⁸, S. Botto⁹, L. Brozzetti¹⁰, A. Bruno¹¹, P. Cadogan¹², D. Capompoli¹³, R. Carlson¹⁴, P. Carlson¹⁵, M. Cauterini¹⁶, G. Castellini¹⁷, R. C. Chiriac¹⁸, C. De Santis¹⁹, G. A. de Santis²⁰, C. De Santis²¹, C. De Santis²², G. A. de Santis²³, V. Di Felice²⁴, V. Florio²⁵, M. Galea²⁶, A. M. Galassi²⁷, A. V. Karimov²⁸, S. V. Krut'ko²⁹, S. V. Krut'ko³⁰, A. N. Kravitskiy³¹, A. Novakova³², V. V. Malakhov³³, I. Martucci³⁴, M. Martucci³⁵, G. Masetti³⁶, A. G. Masetti³⁷, W. Mann³⁸, M. Masera³⁹, G. Orsini⁴⁰, P. Fabbiani⁴¹, B. Fabbini⁴², P. Papini⁴³, M. Pavesi⁴⁴, P. Perrotti⁴⁵, P. Perrotti⁴⁶, M. Ricci⁴⁷, S. B. Sestini⁴⁸, J. M. Sisti⁴⁹, R. Sakai⁵⁰, V. Scialò⁵¹, M. Sisti⁵², M. Sisti⁵³, S. B. Sestini⁵⁴, S. Sestini⁵⁵, V. I. Izrael⁵⁶, A. Vainin⁵⁷, E. Vasconcelos⁵⁸, G. Vainin⁵⁹, S. A. Vasnetsov⁶⁰, Y. T. Yano⁶¹, G. Zamp⁶², N. Zamp⁶³, and M. S. Potgieter⁶⁴

R. Munnini et al., ApJ 853 (2018) 1

EVIDENCE OF ENERGY AND CHARGE STATE DEPENDENCE OF THE RECOVERY TIME FOR THE DECEMBER 2006 FERMI-LAT EVENT MEASURED BY THE PAMELA EXPERIMENT

R. Munnini¹, M. Bongi², A. Bruno³, E. C. Chiavari⁴, G. A. de Santis⁵, V. Di Felice⁶, M. V. Martucci⁷, M. Ricci⁸, L. Brozzetti⁹, R. Bellotti¹⁰, M. Bongi¹¹, V. Bortolotto¹², S. Botto¹³, P. Cadogan¹⁴, P. Carlson¹⁵, M. Cauterini¹⁶, G. Castellini¹⁷, R. C. Chiriac¹⁸, C. De Santis¹⁹, G. A. de Santis²⁰, C. De Santis²¹, C. De Santis²², G. A. de Santis²³, V. Di Felice²⁴, V. Florio²⁵, M. Galea²⁶, A. M. Galassi²⁷, A. V. Karimov²⁸, S. V. Krut'ko²⁹, S. V. Krut'ko³⁰, A. N. Kravitskiy³¹, A. Novakova³², V. V. Malakhov³³, I. Martucci³⁴, M. Martucci³⁵, G. Masetti³⁶, A. G. Masetti³⁷, W. Mann³⁸, M. Masera³⁹, G. Orsini⁴⁰, P. Fabbiani⁴¹, B. Fabbini⁴², P. Papini⁴³, M. Pavesi⁴⁴, P. Perrotti⁴⁵, P. Perrotti⁴⁶, M. Ricci⁴⁷, S. B. Sestini⁴⁸, J. M. Sisti⁴⁹, R. Sakai⁵⁰, V. Scialò⁵¹, M. Sisti⁵², M. Sisti⁵³, S. B. Sestini⁵⁴, S. Sestini⁵⁵, V. I. Izrael⁵⁶, A. Vainin⁵⁷, E. Vasconcelos⁵⁸, G. Vainin⁵⁹, S. A. Vasnetsov⁶⁰, Y. T. Yano⁶¹, G. Zamp⁶², N. Zamp⁶³, and M. S. Potgieter⁶⁴

Submitted to Apj

SOLAR ENERGETIC PARTICLE EVENTS OBSERVED BY THE PAMELA MISSION

A. Bruno¹, M. Bongi², A. Bruno³, E. C. Chiavari⁴, G. A. de Santis⁵, V. Di Felice⁶, M. V. Martucci⁷, M. Ricci⁸, L. Brozzetti⁹, R. Bellotti¹⁰, M. Bongi¹¹, V. Bortolotto¹², S. Botto¹³, P. Cadogan¹⁴, P. Carlson¹⁵, M. Cauterini¹⁶, G. Castellini¹⁷, R. C. Chiriac¹⁸, C. De Santis¹⁹, G. A. de Santis²⁰, C. De Santis²¹, C. De Santis²², G. A. de Santis²³, V. Di Felice²⁴, V. Florio²⁵, M. Galea²⁶, A. M. Galassi²⁷, A. V. Karimov²⁸, S. V. Krut'ko²⁹, S. V. Krut'ko³⁰, A. N. Kravitskiy³¹, A. Novakova³², V. V. Malakhov³³, I. Martucci³⁴, M. Martucci³⁵, G. Masetti³⁶, A. G. Masetti³⁷, W. Mann³⁸, M. Masera³⁹, G. Orsini⁴⁰, P. Fabbiani⁴¹, B. Fabbini⁴², P. Papini⁴³, M. Pavesi⁴⁴, P. Perrotti⁴⁵, P. Perrotti⁴⁶, M. Ricci⁴⁷, S. B. Sestini⁴⁸, J. M. Sisti⁴⁹, R. Sakai⁵⁰, V. Scialò⁵¹, M. Sisti⁵², M. Sisti⁵³, S. B. Sestini⁵⁴, S. Sestini⁵⁵, V. I. Izrael⁵⁶, A. Vainin⁵⁷, E. Vasconcelos⁵⁸, G. Vainin⁵⁹, S. A. Vasnetsov⁶⁰, Y. T. Yano⁶¹, G. Zamp⁶², N. Zamp⁶³, and M. S. Potgieter⁶⁴

M. Martucci et al., ApJ 854 (2018) 1

PHOTON FLUXES MEASURED BY THE PAMELA EXPERIMENT FROM THE MINIMUM TO THE RADIALLY SOLAR ACTIVITY FOR THE 21st SOLAR CYCLE

M. Martucci¹, M. Bongi², M. Bongi³, V. Bortolotto⁴, S. Botto⁵, P. Cadogan⁶, P. Carlson⁷, M. Cauterini⁸, G. Castellini⁹, R. C. Chiriac¹⁰, C. De Santis¹¹, G. A. de Santis¹², C. De Santis¹³, C. De Santis¹⁴, G. A. de Santis¹⁵, V. Di Felice¹⁶, V. Florio¹⁷, M. Galea¹⁸, A. M. Galassi¹⁹, A. V. Karimov²⁰, S. V. Krut'ko²¹, S. V. Krut'ko²², A. N. Kravitskiy²³, A. Novakova²⁴, V. V. Malakhov²⁵, I. Martucci²⁶, M. Martucci²⁷, G. Masetti²⁸, A. G. Masetti²⁹, W. Mann³⁰, M. Masera³¹, G. Orsini³², P. Fabbiani³³, B. Fabbini³⁴, P. Papini³⁵, M. Pavesi³⁶, P. Perrotti³⁷, P. Perrotti³⁸, M. Ricci³⁹, S. B. Sestini⁴⁰, J. M. Sisti⁴¹, R. Sakai⁴², V. Scialò⁴³, M. Sisti⁴⁴, M. Sisti⁴⁵, S. B. Sestini⁴⁶, S. Sestini⁴⁷, V. I. Izrael⁴⁸, A. Vainin⁴⁹, E. Vasconcelos⁵⁰, G. Vainin⁵¹, S. A. Vasnetsov⁵², R. U. Y. Yano⁵³, G. Zamp⁵⁴, N. Zamp⁵⁵, and M. S. Potgieter⁵⁶

M. S. Potgieter et al., Solar Phys 289 (2014)

Solar Phys (2014) 289:391-406
DOI 10.1007/s11207-013-0324-6

Modulation of Galactic Protons in the Heliosphere During the Unusual Solar Minimum of 2006 to 2009

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Modulation of Galactic Protons in the Heliosphere During the Unusual Solar Minimum of 2006 to 2009

M.S. Potgieter · E.E. Vos · M. Bezdade · N. De Simone · V. Di Felice · V. Formato

M. S. Potgieter et al., ApJ 810 (2015) 2, 141.

Modulation of galactic electrons in the heliosphere during the unusual solar minimum of 2006 to 2009: A modelling approach

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O. Adriani et al., PRL 116 (2016) 241105

Time dependence of the electron and positron components of the cosmic radiation measured by the PAMELA experiment between July 2006 and December 2015.

O. Adriani¹, G. C. Barbarino², G. A. Badiereschi³, R. Bellotti⁴, M. Bongi⁵, E. A. Bognomo⁶, M. Bongi⁷, V. Bortolotto⁸, S. Botto⁹, P. Cadogan¹⁰, D. Capompoli¹¹, R. Carlson¹², P. Carlson¹³, M. Cauterini¹⁴, G. Castellini¹⁵, R. C. Chiriac¹⁶, C. De Santis¹⁷, G. A. de Santis¹⁸, C. De Santis¹⁹, C. De Santis²⁰, G. A. de Santis²¹, V. Di Felice²², V. Florio²³, M. Galea²⁴, A. M. Galassi²⁵, A. V. Karimov²⁶, S. V. Krut'ko²⁷, S. V. Krut'ko²⁸, A. N. Kravitskiy²⁹, A. Novakova³⁰, V. V. Malakhov³¹, I. Martucci³², M. Martucci³³, G. Masetti³⁴, A. G. Masetti³⁵, W. Mann³⁶, M. Masera³⁷, G. Orsini³⁸, P. Fabbiani³⁹, B. Fabbiani⁴⁰, P. Papini⁴¹, M. Pavesi⁴², P. Perrotti⁴³, P. Perrotti⁴⁴, M. Ricci⁴⁵, S. B. Sestini⁴⁶, J. M. Sisti⁴⁷, R. Sakai⁴⁸, V. Scialò⁴⁹, M. Sisti⁵⁰, M. Sisti⁵¹, S. B. Sestini⁵², S. Sestini⁵³, V. I. Izrael⁵⁴, A. Vainin⁵⁵, E. Vasconcelos⁵⁶, G. Vainin⁵⁷, S. A. Vasnetsov⁵⁸, R. U. Y. Yano⁵⁹, G. Zamp⁶⁰, N. Zamp⁶¹, M. S. Potgieter⁶², and E. E. Vos⁶³

O. Adriani et al., Space Weather 14 (2016) 210

PAMELA's measurements of geomagnetic cutoff variations during the 14 December 2006 storm

O. Adriani¹, G. C. Barbarino², G. A. Badiereschi³, R. Bellotti⁴, M. Bongi⁵, E. A. Bognomo⁶, M. Bongi⁷, V. Bortolotto⁸, S. Botto⁹, P. Cadogan¹⁰, D. Capompoli¹¹, R. Carlson¹², P. Carlson¹³, M. Cauterini¹⁴, G. Castellini¹⁵, R. C. Chiriac¹⁶, C. De Santis¹⁷, G. A. de Santis¹⁸, C. De Santis¹⁹, C. De Santis²⁰, G. A. de Santis²¹, V. Di Felice²², V. Florio²³, M. Galea²⁴, A. M. Galassi²⁵, A. V. Karimov²⁶, S. V. Krut'ko²⁷, S. V. Krut'ko²⁸, A. N. Kravitskiy²⁹, A. Novakova³⁰, V. V. Malakhov³¹, I. Martucci³², M. Martucci³³, G. Masetti³⁴, A. G. Masetti³⁵, W. Mann³⁶, M. Masera³⁷, G. Orsini³⁸, P. Fabbiani³⁹, B. Fabbiani⁴⁰, P. Papini⁴¹, M. Pavesi⁴², P. Perrotti⁴³, P. Perrotti⁴⁴, M. Ricci⁴⁵, S. B. Sestini⁴⁶, J. M. Sisti⁴⁷, R. Sakai⁴⁸, V. Scialò⁴⁹, M. Sisti⁵⁰, M. Sisti⁵¹, S. B. Sestini⁵², S. Sestini⁵³, V. I. Izrael⁵⁴, A. Vainin⁵⁵, E. Vasconcelos⁵⁶, G. Vainin⁵⁷, S. A. Vasnetsov⁵⁸, R. U. Y. Yano⁵⁹, G. Zamp⁶⁰, N. Zamp⁶¹, and M. S. Potgieter⁶²

V. Di Felice et al., ApJ 834 (2017) 89

NEW EVIDENCE FOR CHARGE-STATE DEPENDENT MODULATION DURING THE SOLAR MINIMUM OF 2006 TO 2009

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O. Adriani et al., ApJ 852 (2018) 1

UNEXPECTED CYCLIC BEHAVIOR IN COSMIC RAY PHOTONS OBSERVED BY PAMELA AT 1 AU

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Solar Mod

Solar Events

8 papers

5 papers

Alessandro Bruno talk

Solar modulation studies



Solar modulation: protons

Adriani, O. et al. 2017, NUOVO CIMENTO, 40, 473

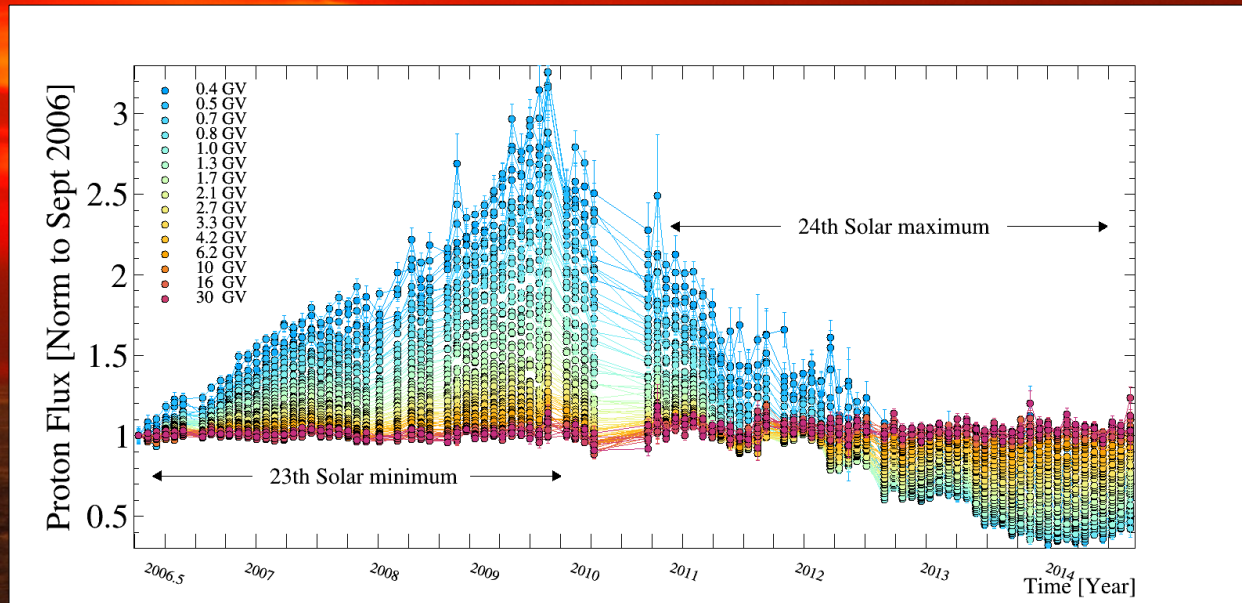
Ten Years of PAMELA in Space

THE PAMELA COLLABORATION

O. ADRIANI^{(1)†}, G. C. BARBARINO^{(3)†}, G. A. BAZILEVSKAYA⁽⁵⁾, R. BELLOTTI^{(6)†}, M. BOEZIO⁽⁶⁾, E. A. BOGOMOLOV⁽⁶⁾, M. BONGI^{(1)†}, V. BONVICINI⁽⁸⁾, S. BOTTAI⁽²⁾, A. BRUNO⁽⁷⁾, F. CAFAGNA⁽⁷⁾, D. CAMPANA⁽⁴⁾, P. CARLSON⁽¹⁰⁾, M. CASOLINO^{(11)†}, G. CASTELLI⁽¹²⁾, C. DE SANTIS⁽¹¹⁾, V. DI FELICE^{(11)†}, A. M. GALPER⁽¹⁴⁾, A. V. KARELIN⁽¹⁵⁾, S. V. KOLDASHOV⁽¹⁵⁾, S. KOLDOBSKIY⁽¹⁵⁾, S. Y. KRUT'KOV⁽⁵⁾, A. N. KVASHNIN⁽³⁾, A. LEBONOV⁽¹⁵⁾, V. MALAKHOV⁽¹⁵⁾, L. MARCELLI⁽¹¹⁾, M. MARTUCCI^{(11)†}, A. G. MAYOROV⁽¹⁵⁾, W. MENN⁽¹⁷⁾, M. MERGB^{(11)†}, V. V. MIKHAILOV⁽¹⁵⁾, E. MOCCHIUCCI⁽⁸⁾, A. MONACO^{(9)†}, R. MUNINI⁽⁸⁾, N. MORI⁽²⁾, G. OSTERIA⁽⁴⁾, E. PANICO⁽⁴⁾, P. PAPERI⁽²⁾, M. PRAROCI⁽¹⁰⁾, P. PICOZZA^{(11)†}, M. RICCI⁽¹⁸⁾, S. E. RICCIAINI^{(13)†}, M. SIMON⁽¹³⁾, R. SPAROLA^{(13)†}, P. SPILLANTINI^{(1)†}, Y. I. STOZHKOV⁽⁵⁾, A. VACCHI^{(8)†}, E. VANNUCCINI⁽¹⁾, G. VASILYEV⁽⁷⁾, S. A. VORONOV⁽¹⁵⁾, Y. T. YURKIN⁽¹⁵⁾, G. ZAMPA⁽⁸⁾ AND N. ZAMPA⁽⁸⁾



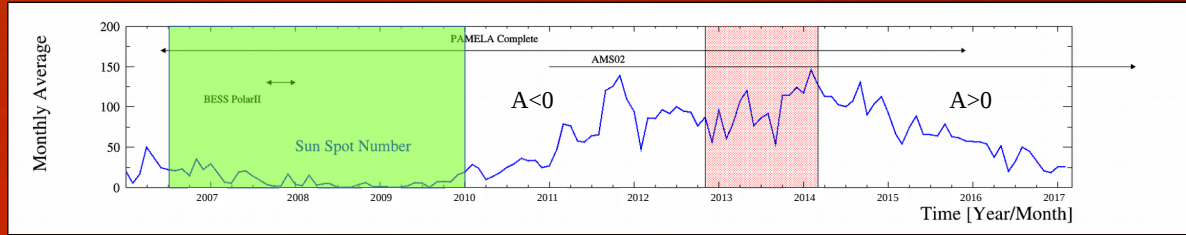
Measurement in a wide energy range of the proton flux time variation with a single apparatus



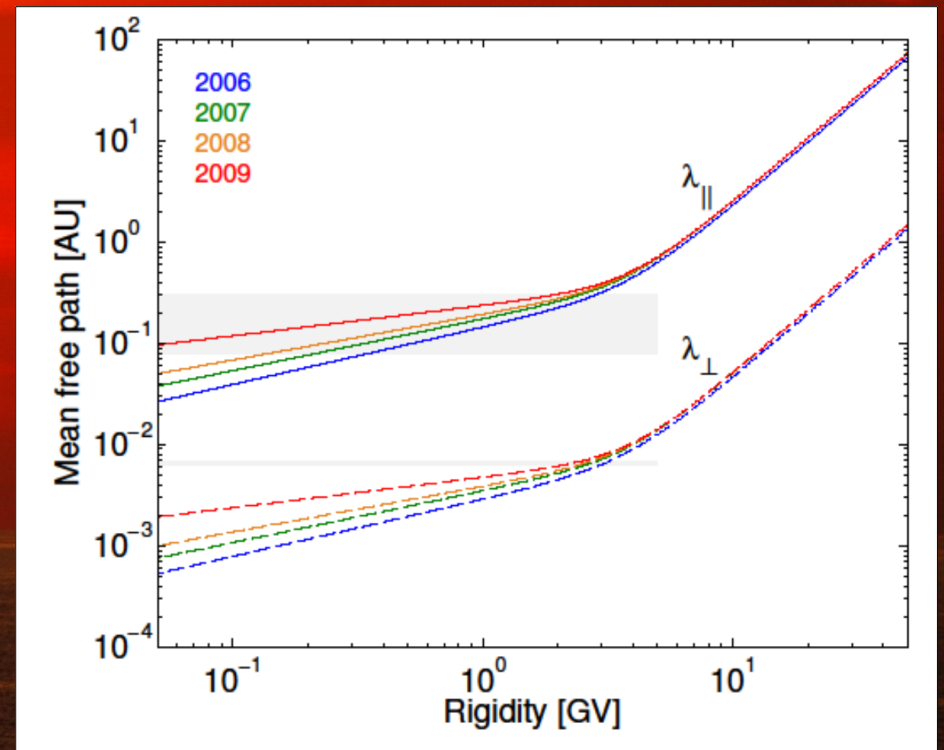
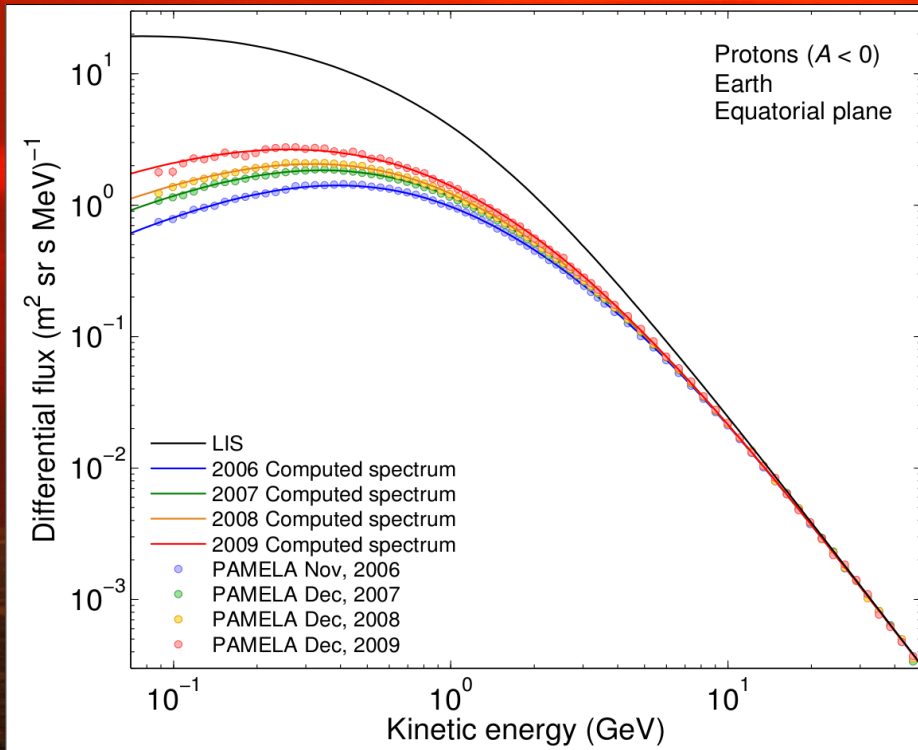
Solar Modulation: protons

O. Adriani et al., ApJ 765 (2013) 91

M. S. Potgieter et al., Solar Phys 289 (2014)



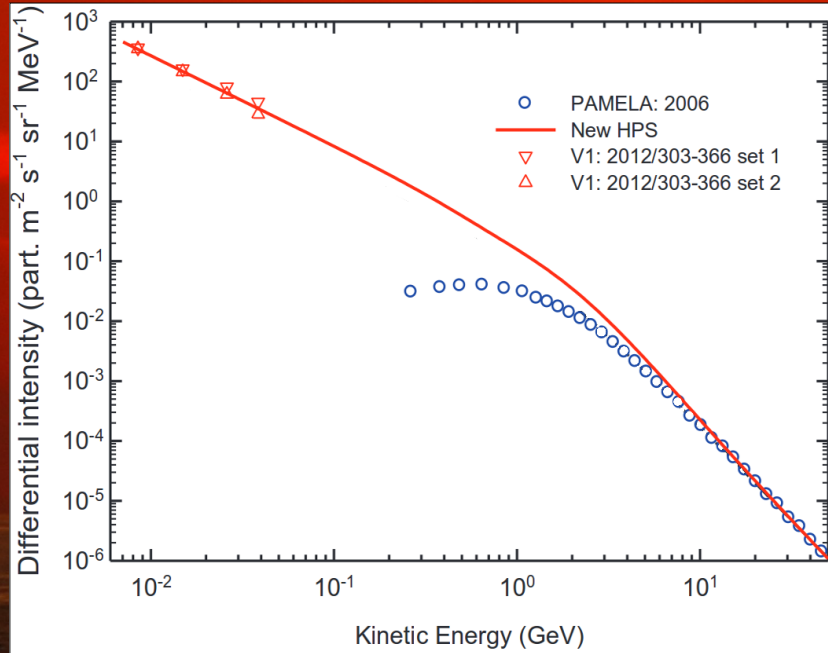
Measurement and modeling during the 23th solar minimum



Solar modulation: modelling

North West University, Potchesfroom
Marius Potgieter, E. Vos, J. L. Raath

3D numerical solution of Parker equation



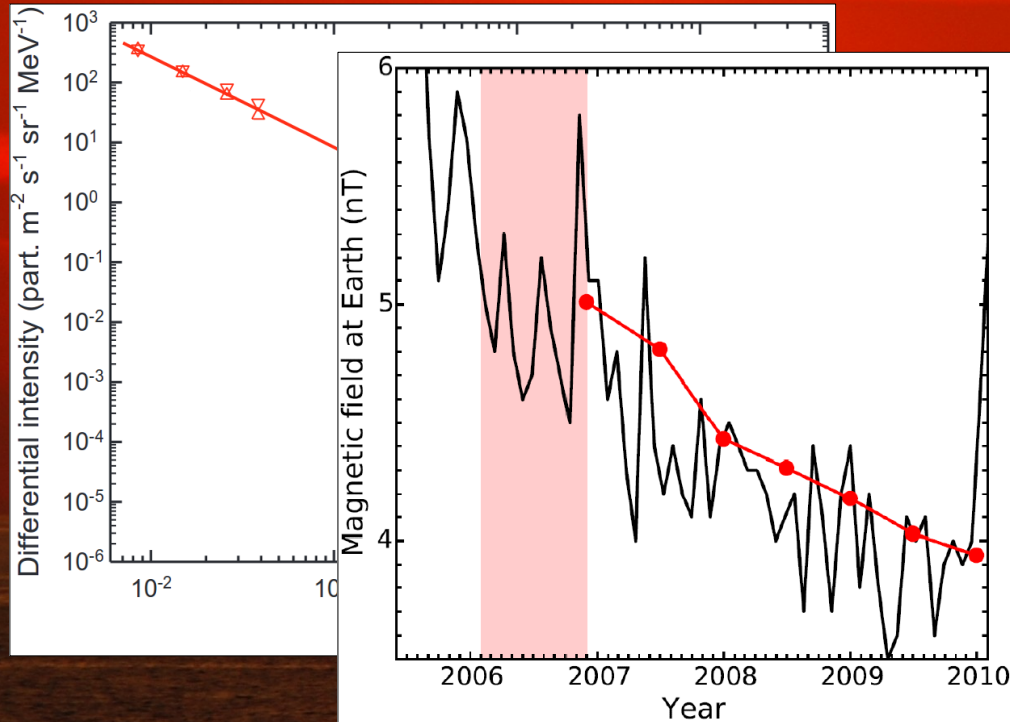
- Local interstellar spectrum (LIS): from numerical simulation or fitting data

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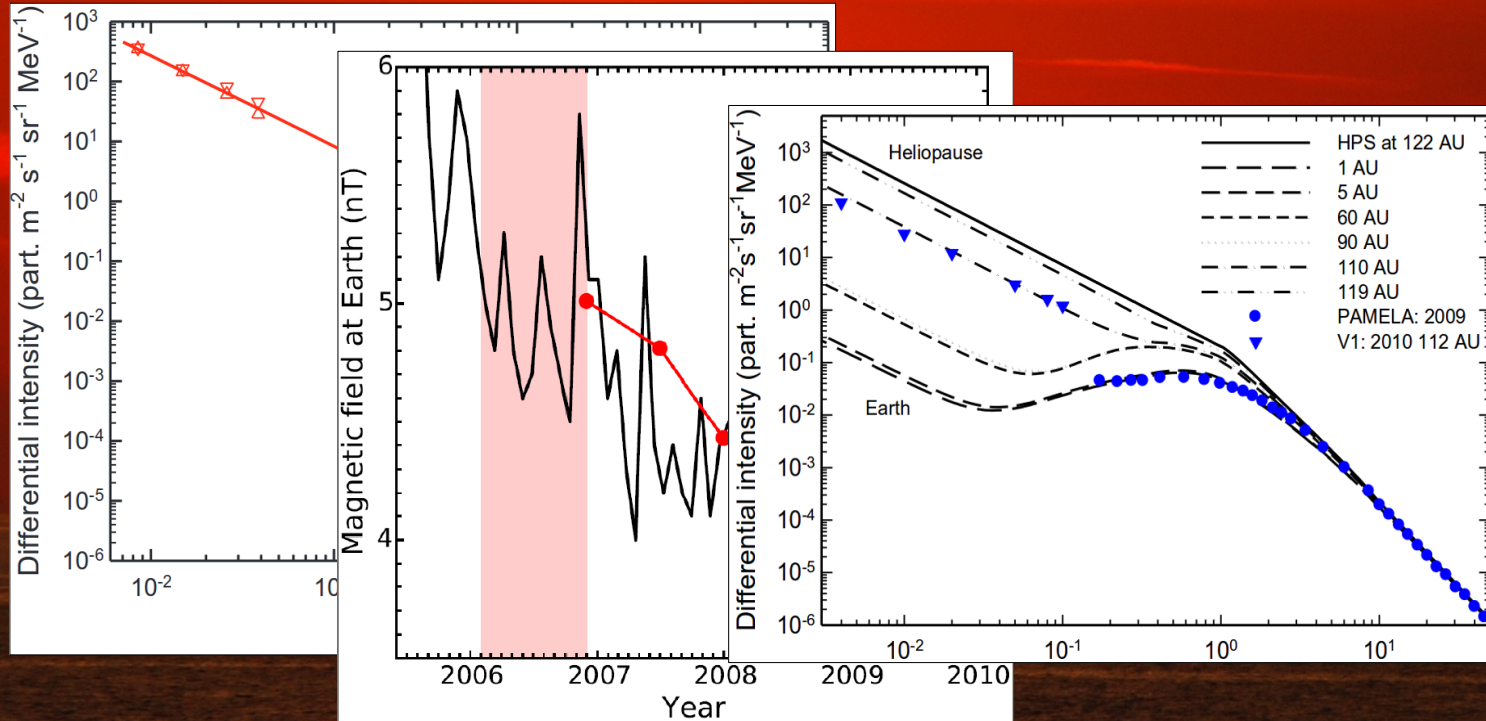


Solar modulation: modelling

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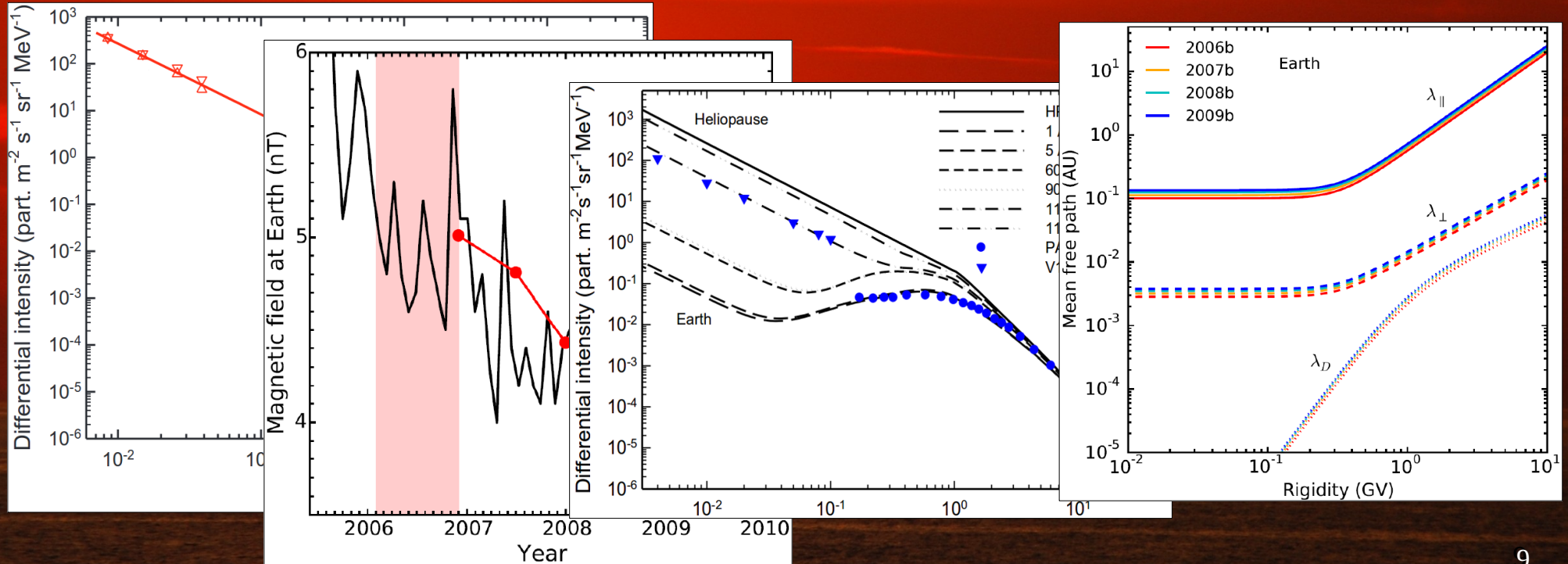


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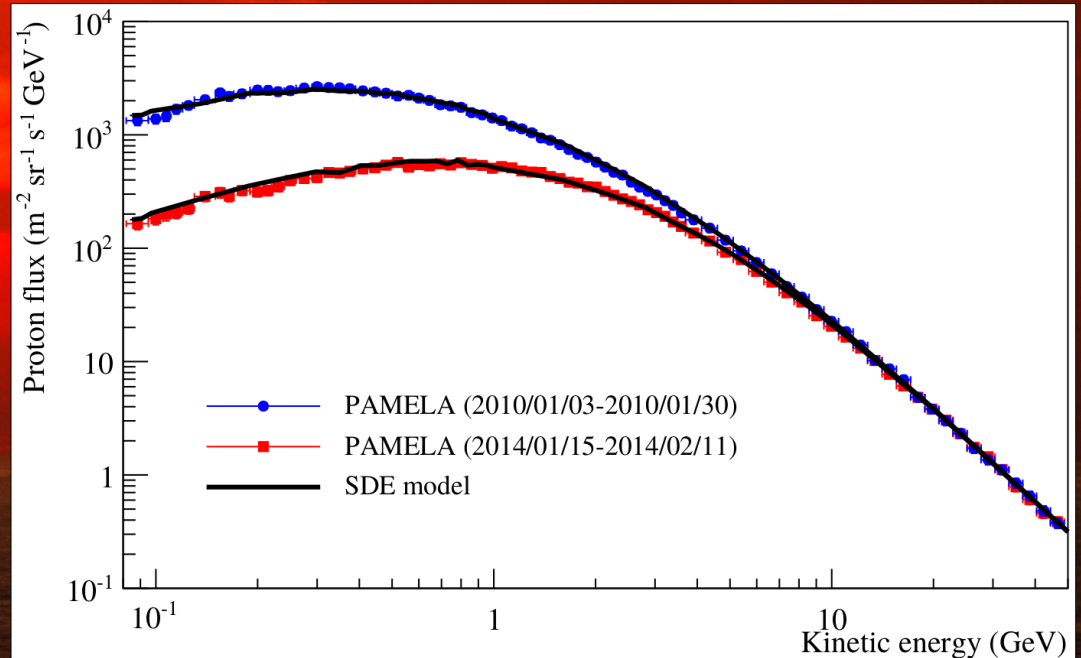
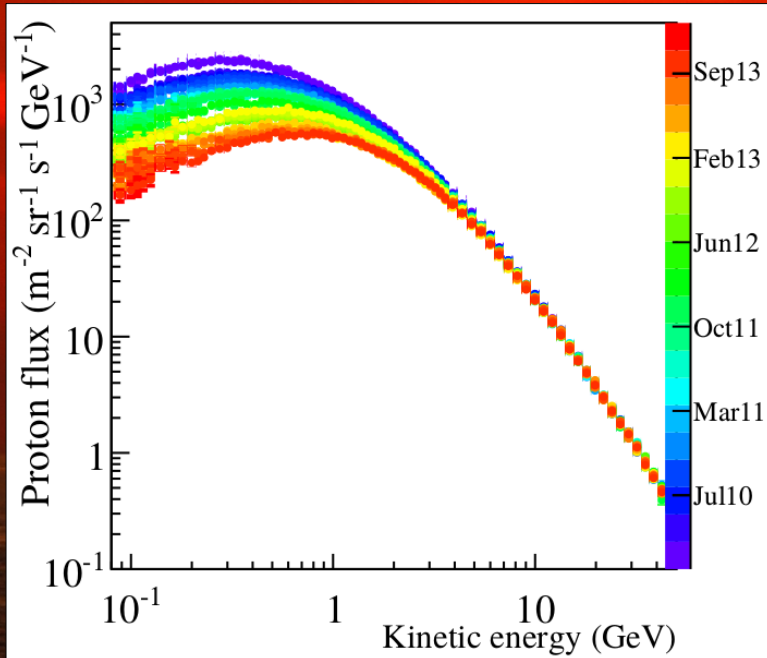


Solar modulation: protons

M. Martucci et al., ApJ 854 (2018) 1

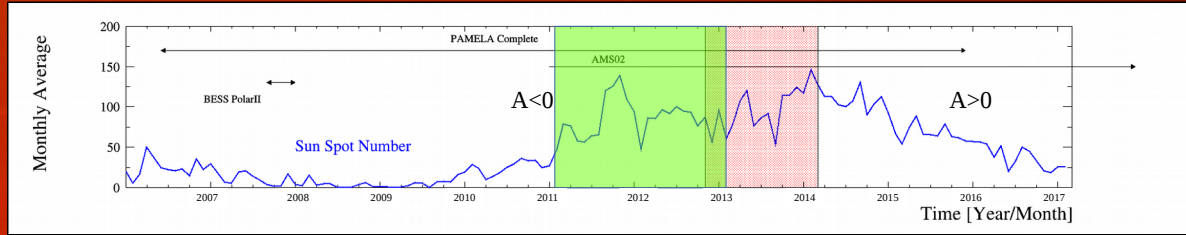


Measure and modeling of the proton spectra during a period of maximum of the solar activity

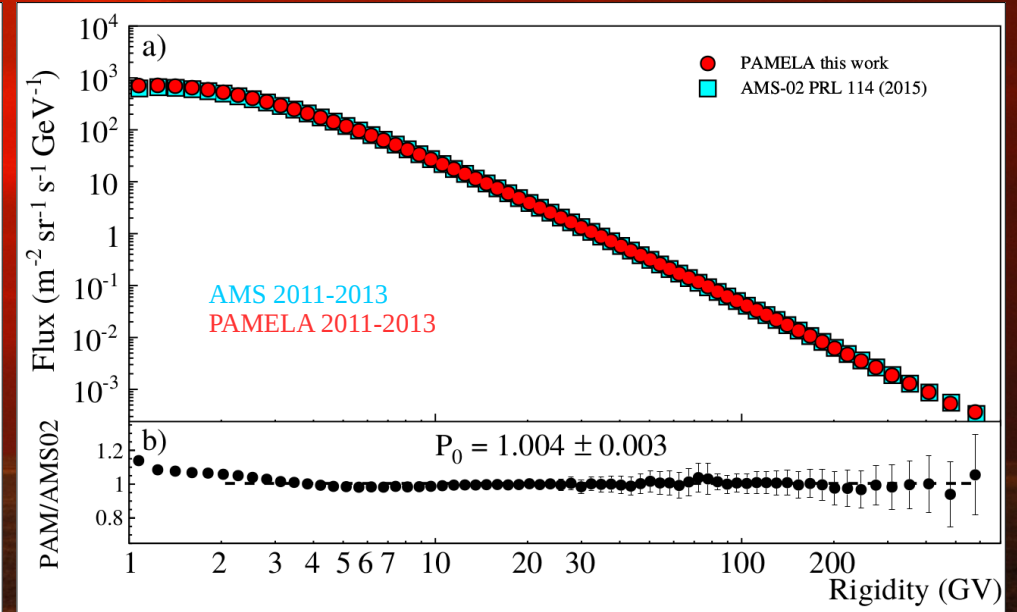
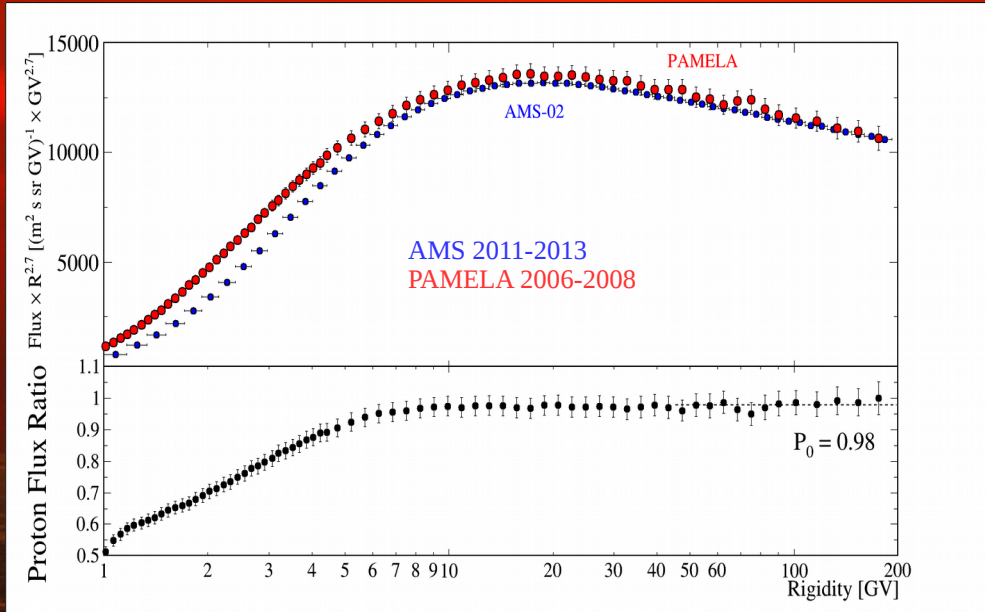


PAMELA – AMS02 comparison

Adriani, O. et al. 2017, NUOVO CIMENTO, 40, 473



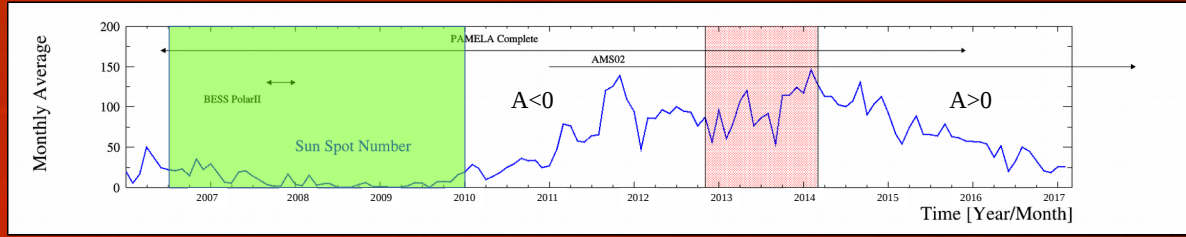
Comparison of the proton flux measured during the same time period of AMS02 published data



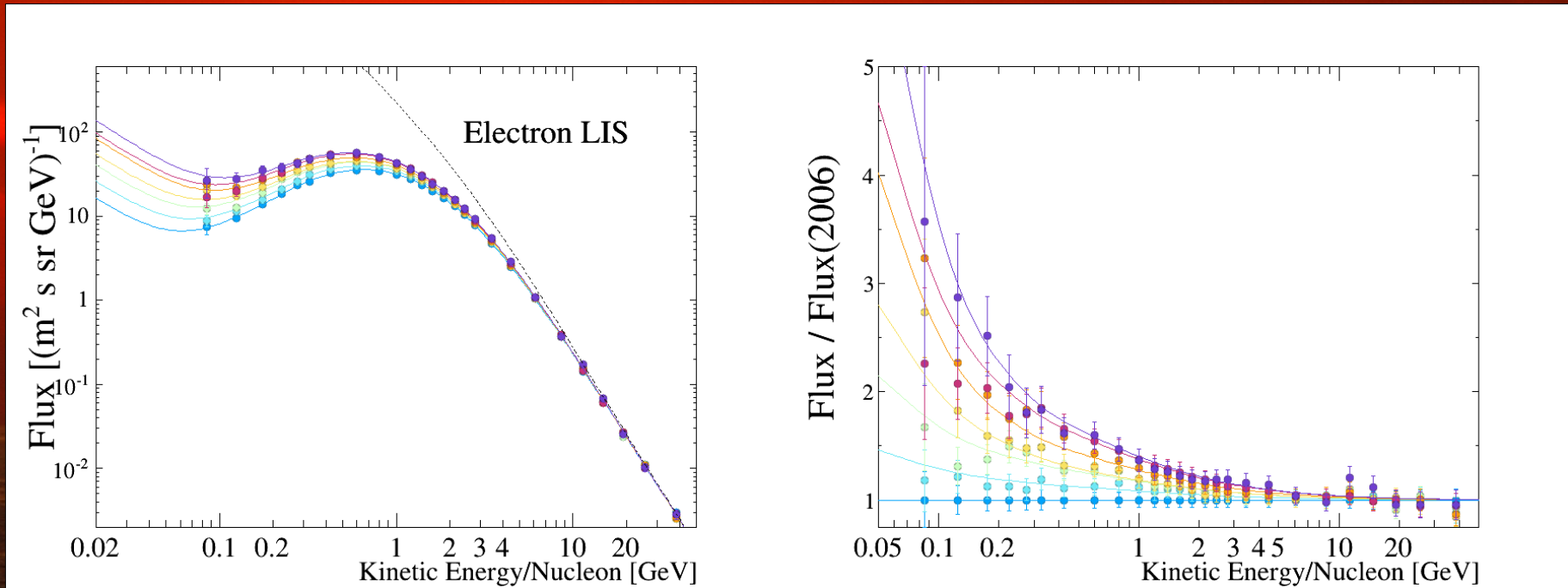
Solar Modulation: electrons

O. Adriani et al., ApJ 810 (2015) 142

M. S. Potgieter et al., ApJ 810 (2015) 2, 141.

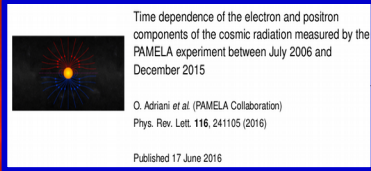


First measurement and modeling between 70 MeV – 30 GeV during a solar minimum



Charge sign dependence: e^+/e^-

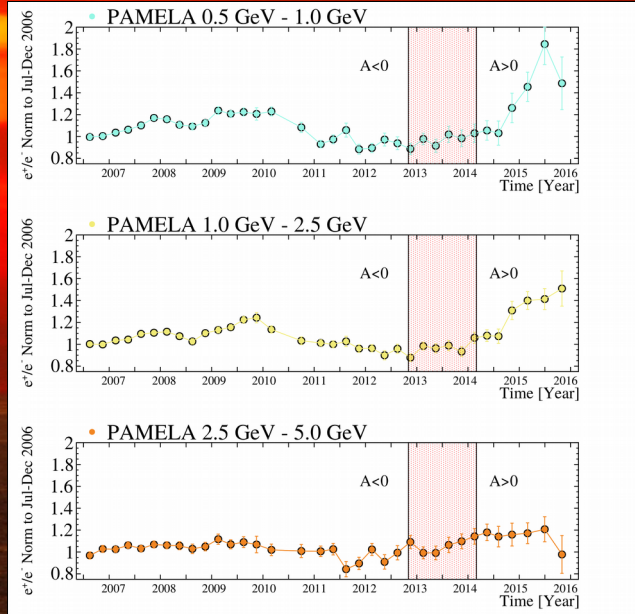
O. Adriani et al., PRL 116 (2016) 241105



Highlighted as editor suggestion

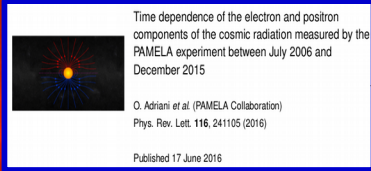


First measurement of the charge dependent effect over an entire solar cycle and through polarity reversal



Charge sign dependence: e^+/e^-

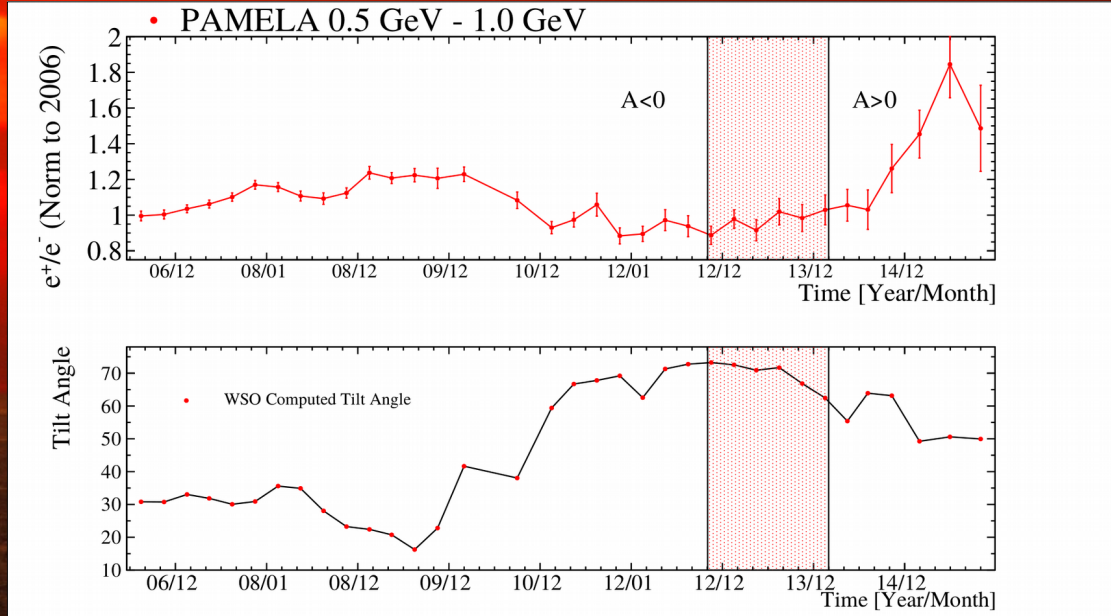
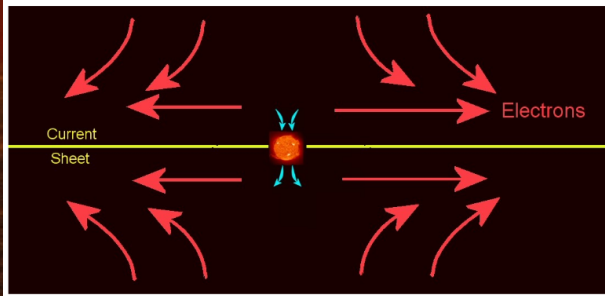
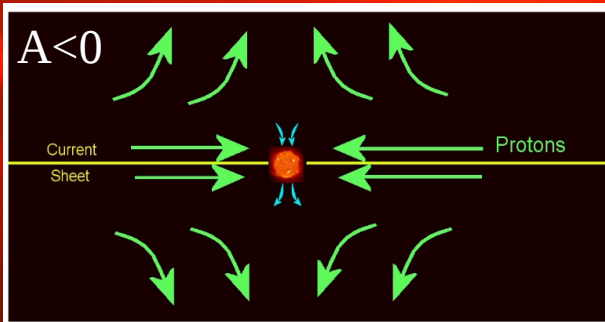
O. Adriani et al., PRL 116 (2016) 241105



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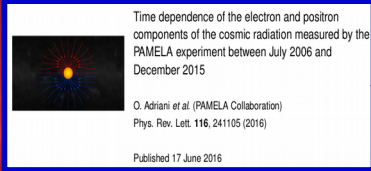


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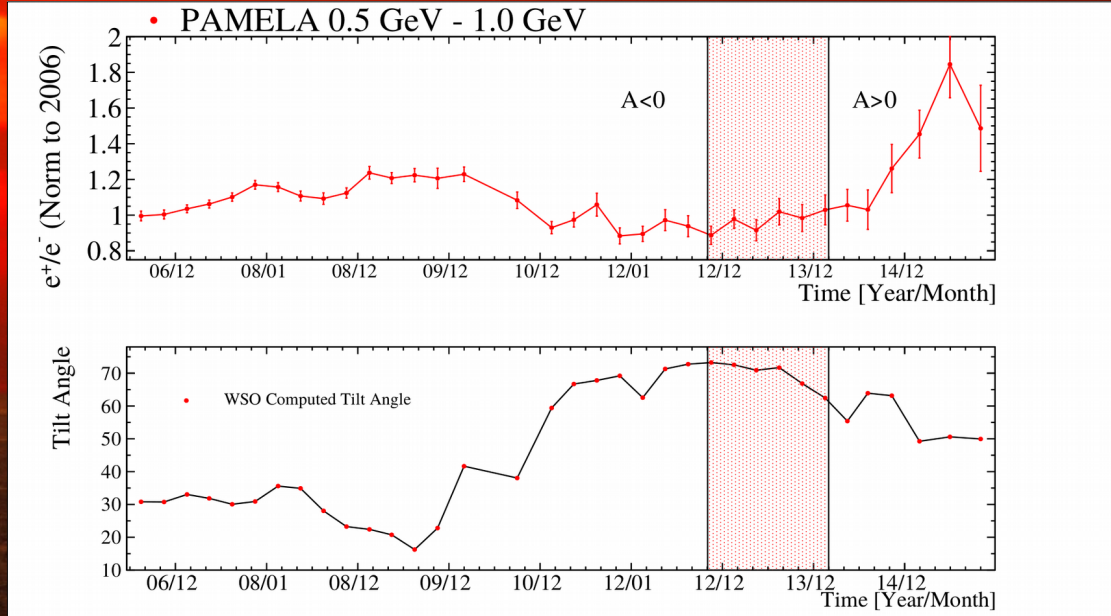
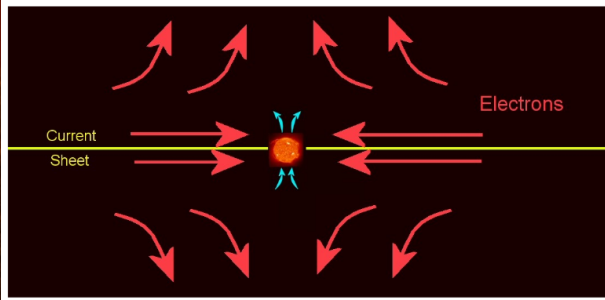
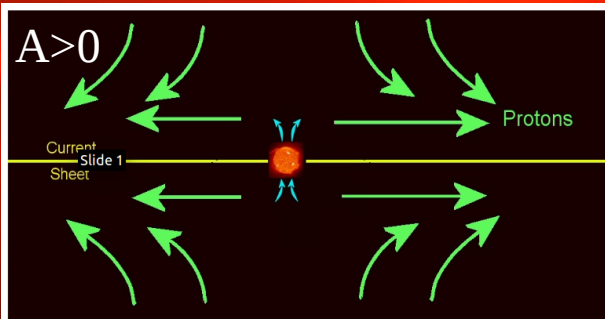
O. Adriani et al., PRL 116 (2016) 241105



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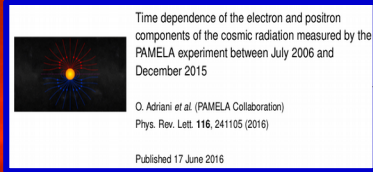


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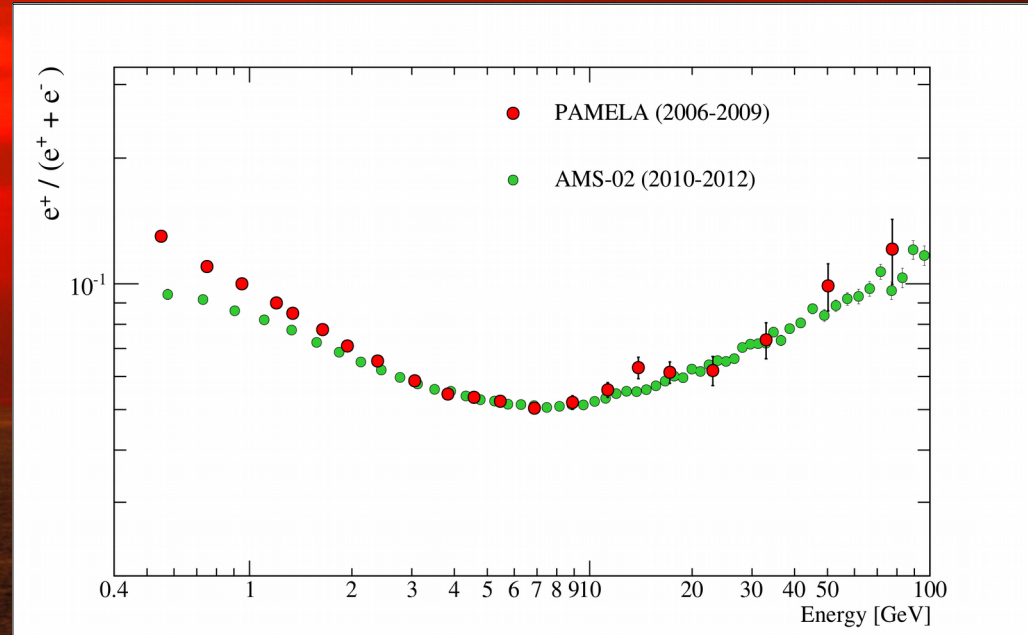
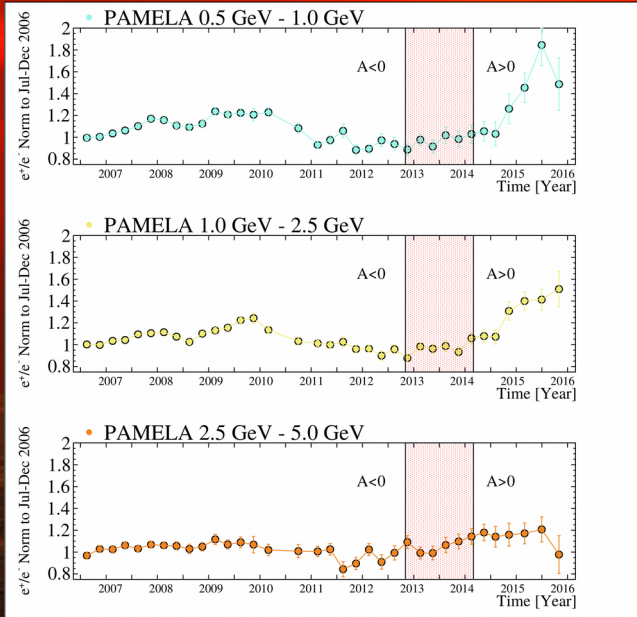
O. Adriani et al., PRL 116 (2016) 241105



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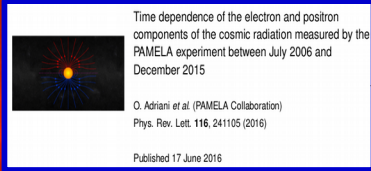


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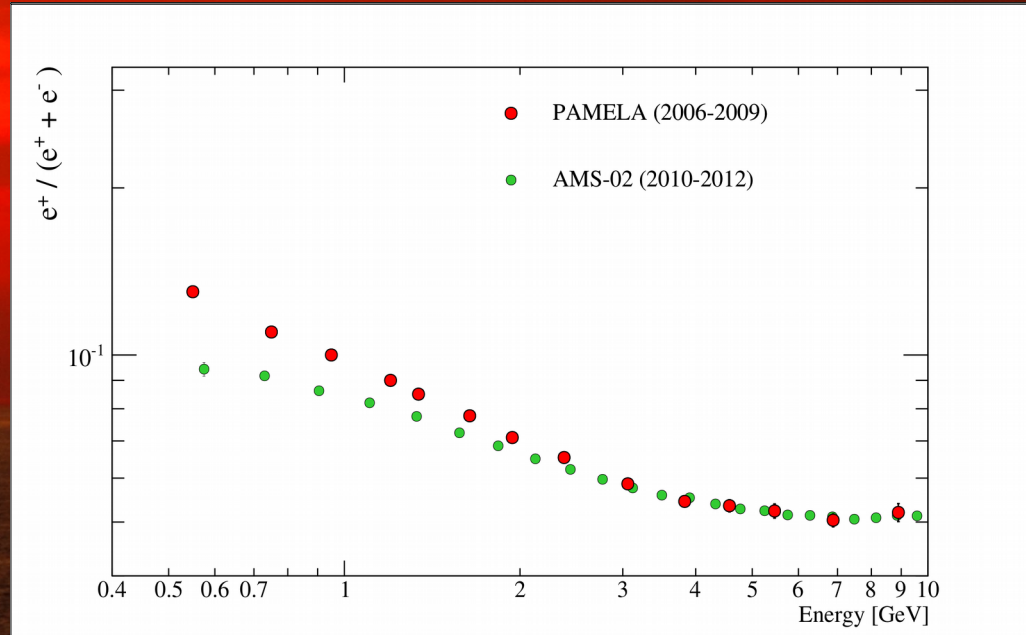
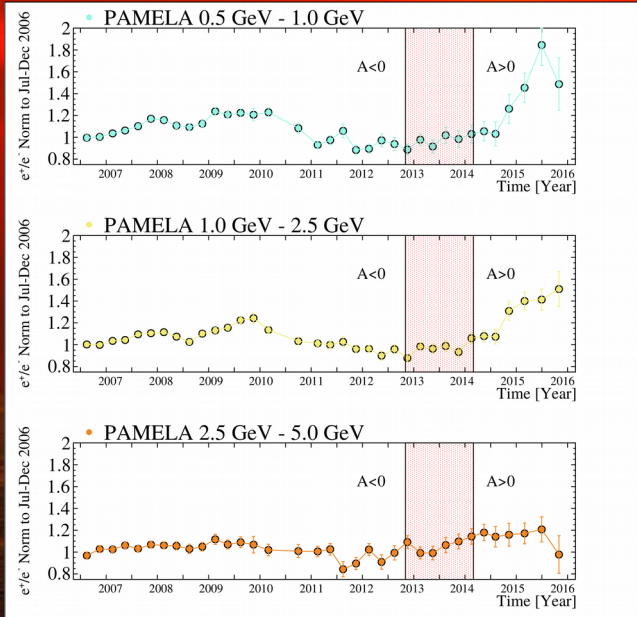
O. Adriani et al., PRL 116 (2016) 241105



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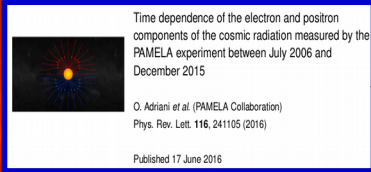


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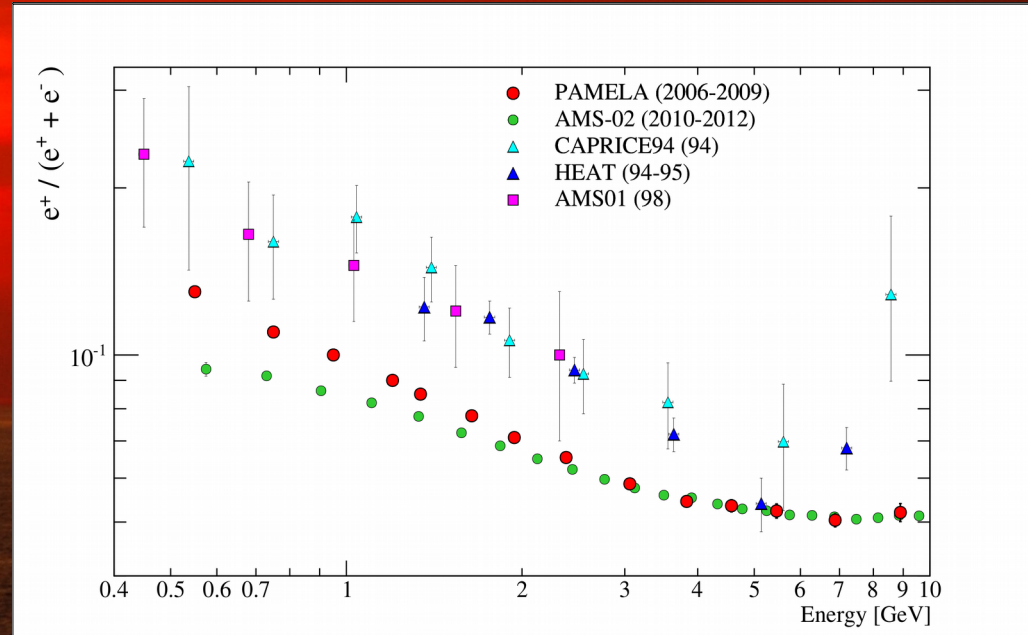
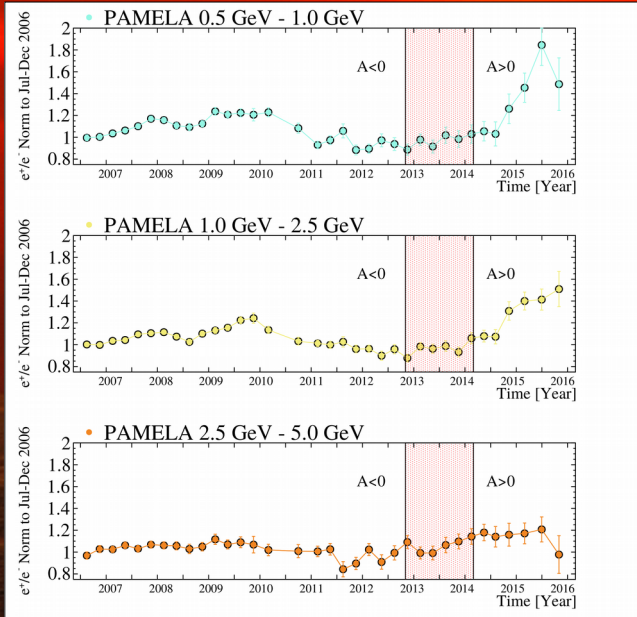
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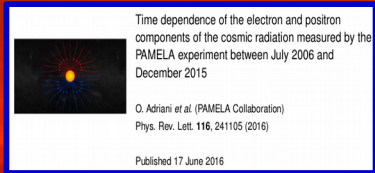


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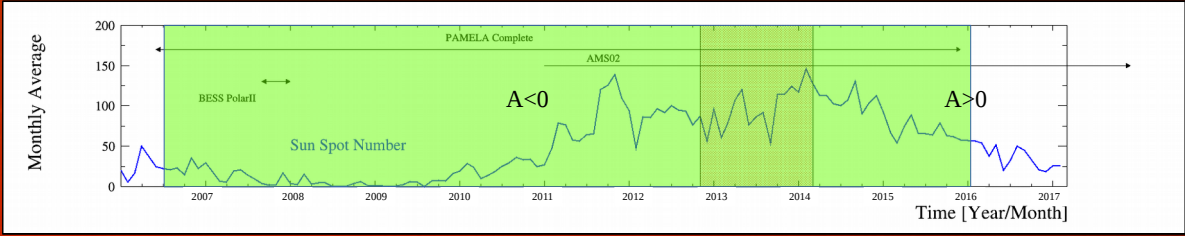


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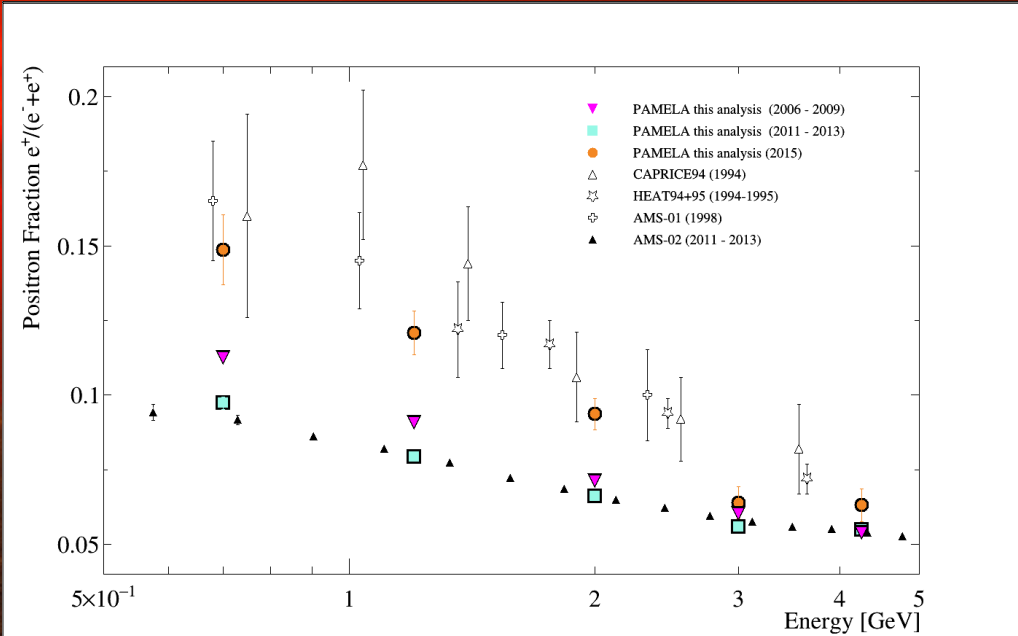
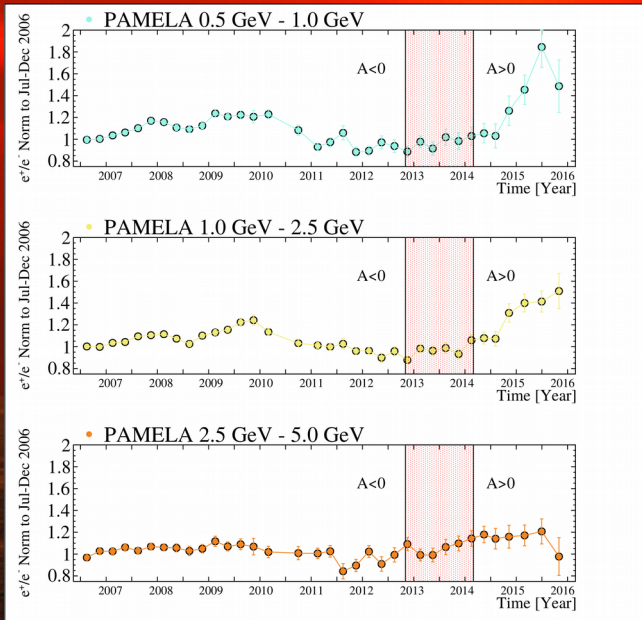
O. Adriani et al., PRL 116 (2016) 241105



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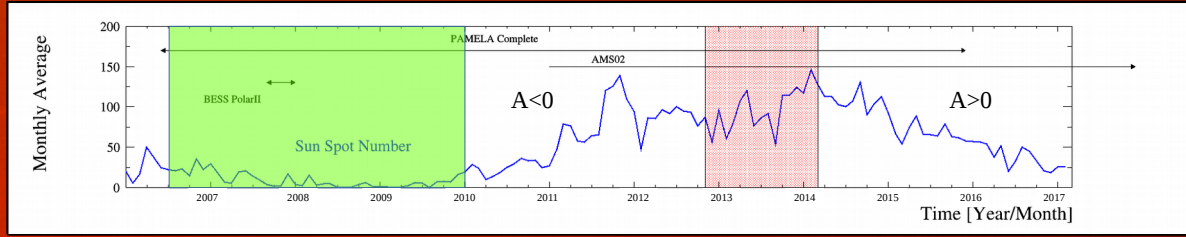


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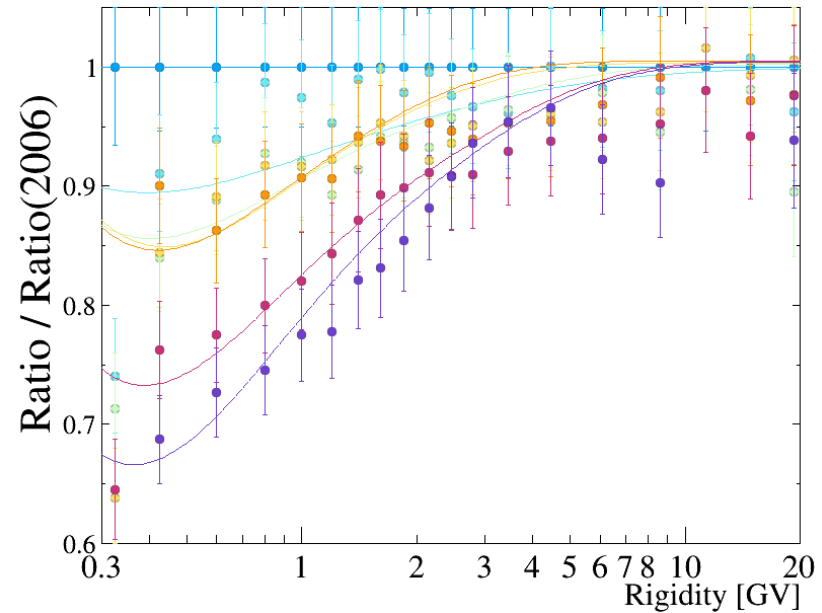
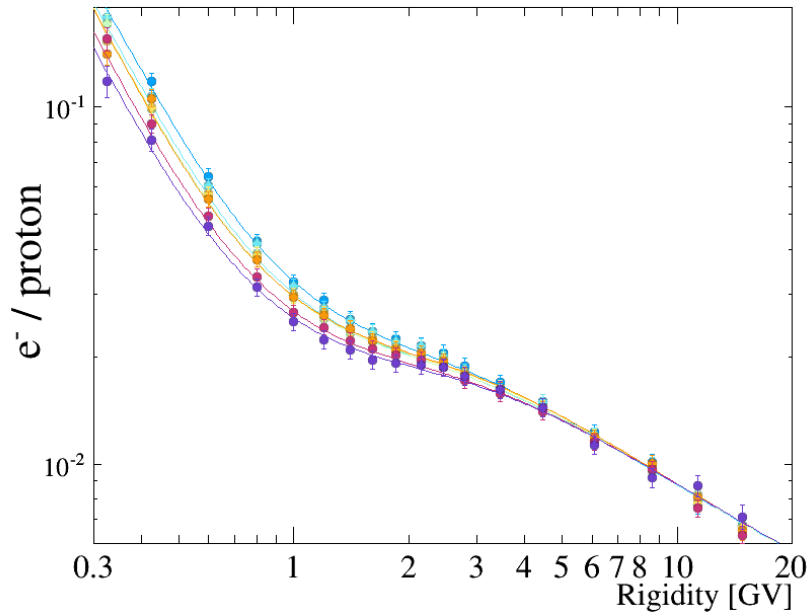


Charge sign dependence: e-/p

V. Di Felice, R. M., E. E. Vos. M. S. Poggieter, ApJ 834 (2017) 89



Measure and modeling of the charge sign dependence as a function of the energy.



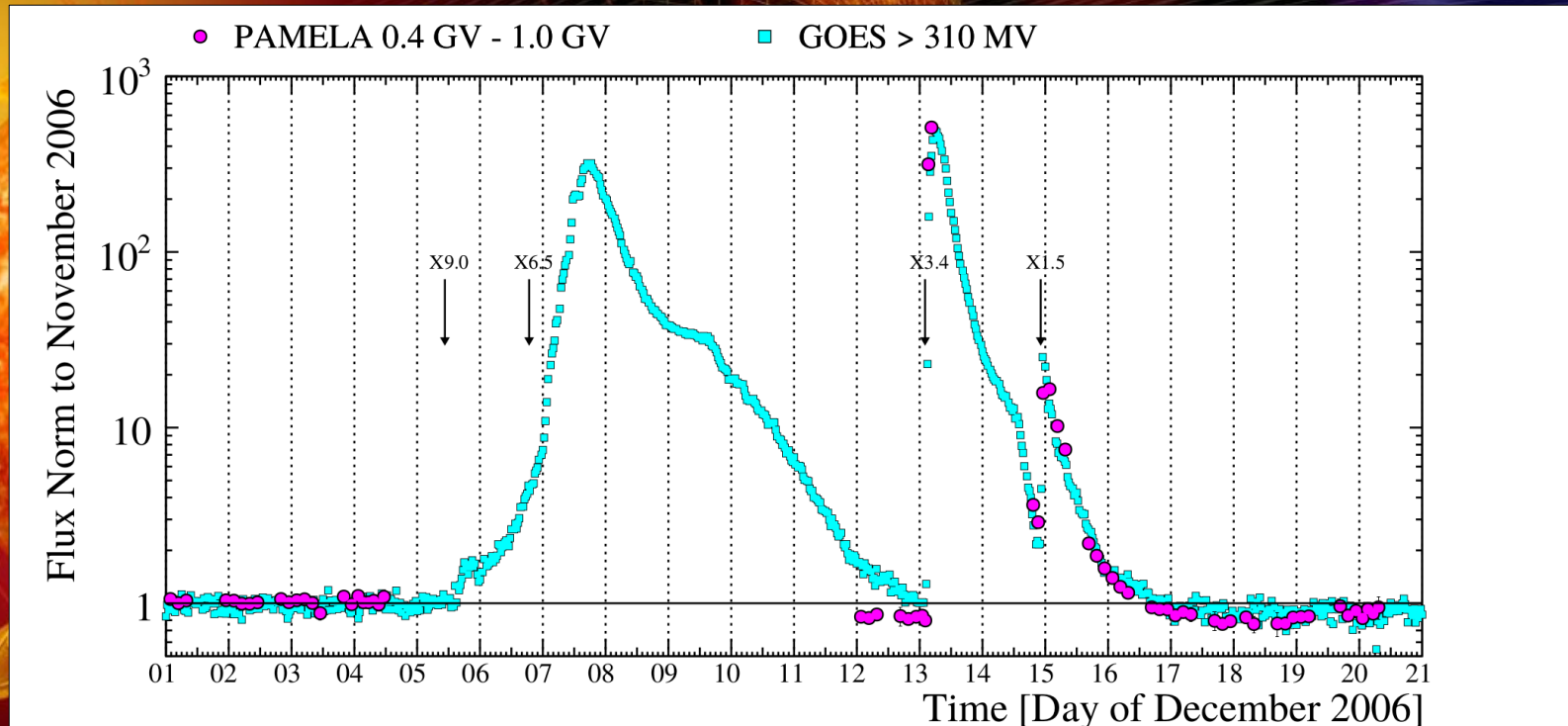
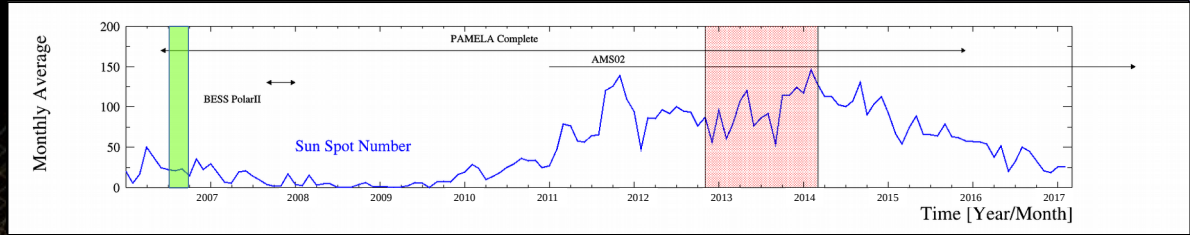
Forbush decrease



December 2006 Forbush decrease

R. Munini et al., ApJ 853 (2018) 1

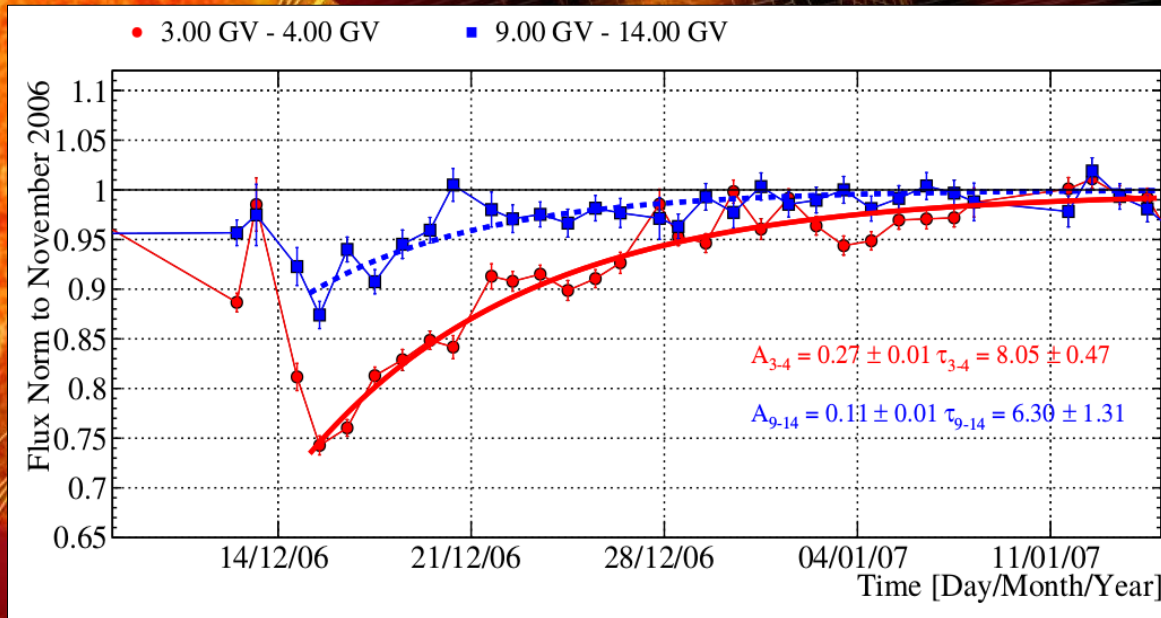
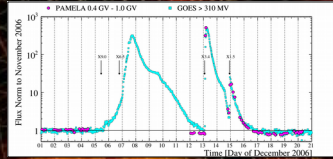
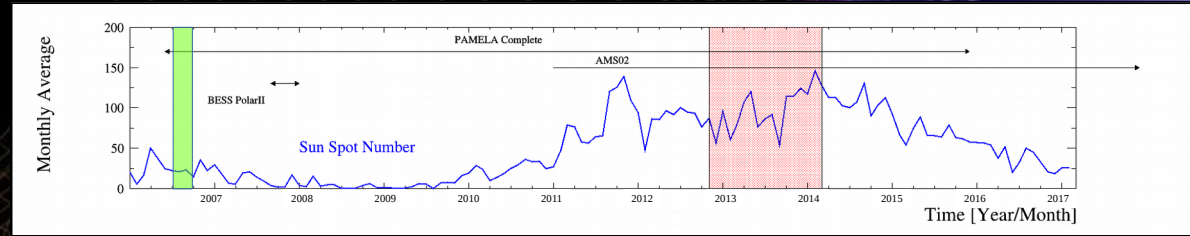
- Uncommon event: solar minimum



December 2006 Forbush decrease

R. Munini et al., ApJ 853 (2018) 1

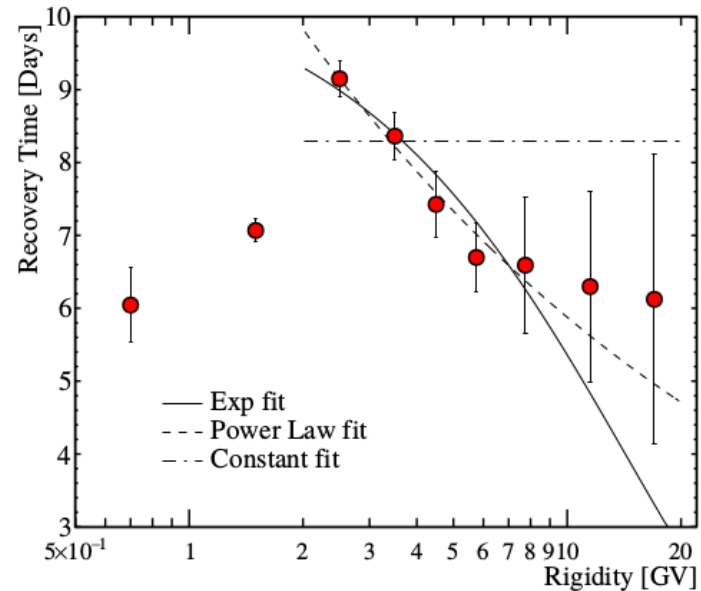
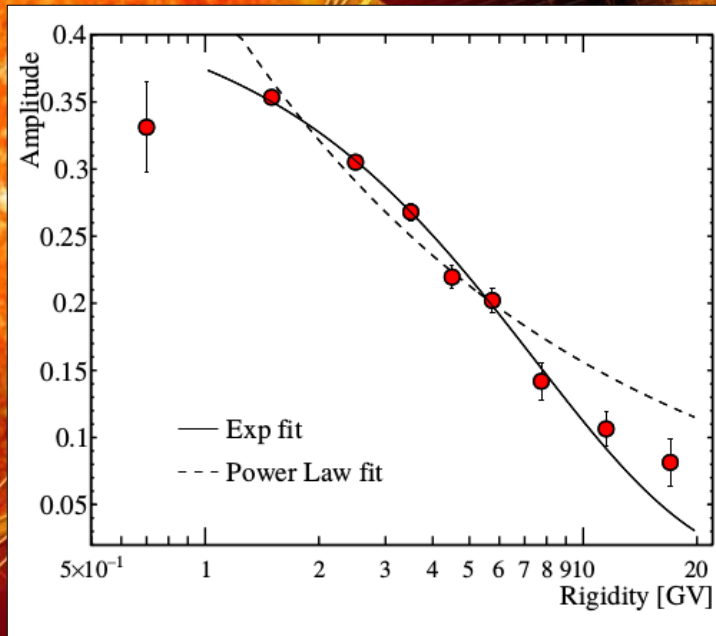
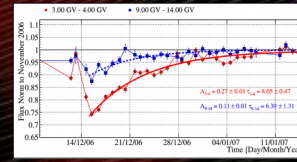
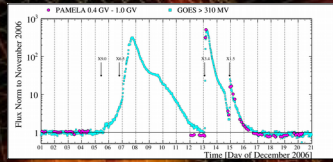
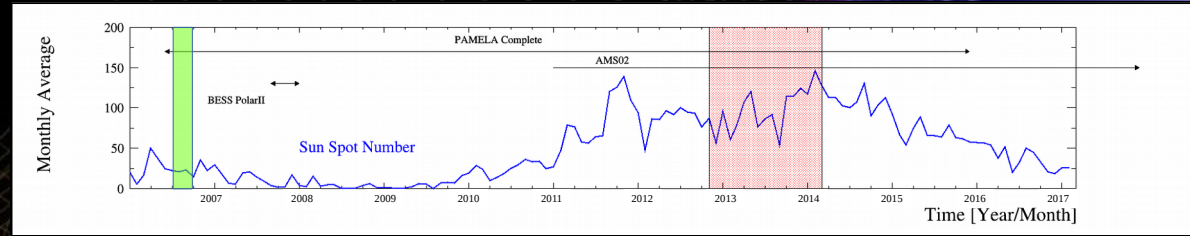
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R. Munini et al., ApJ 853 (2018) 1

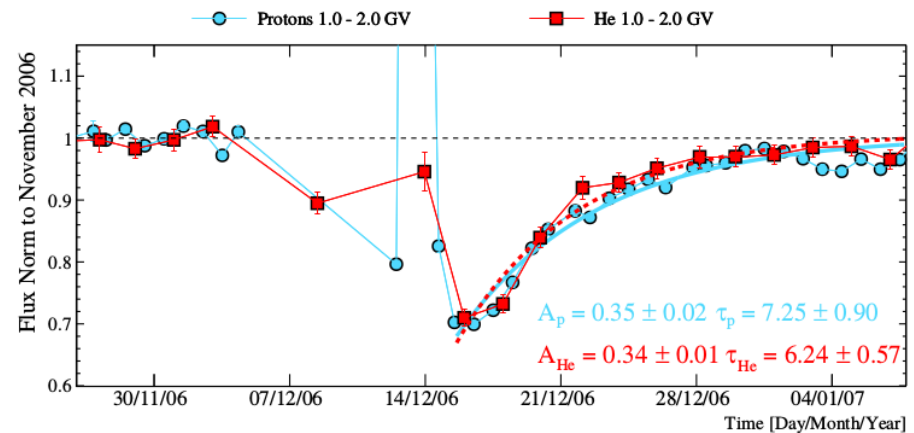
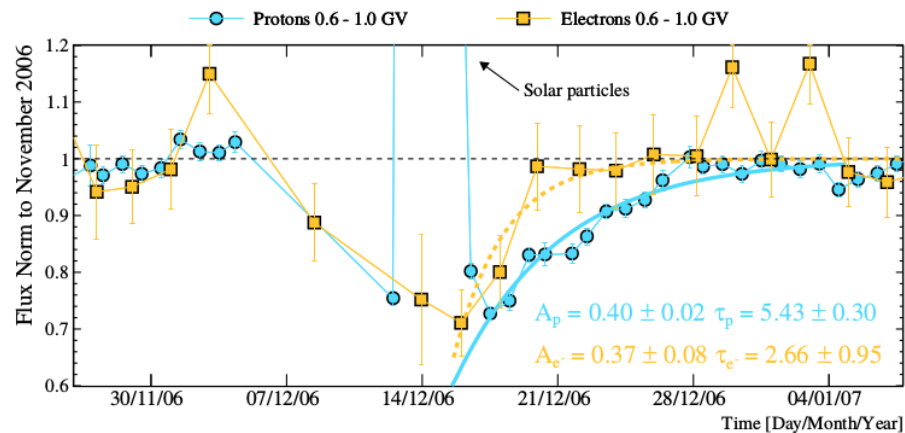
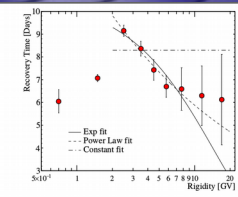
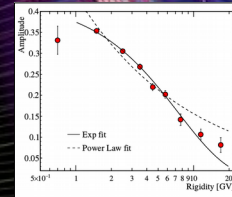
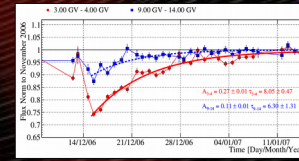
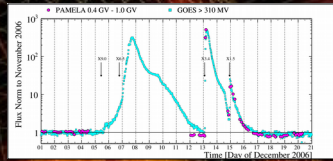
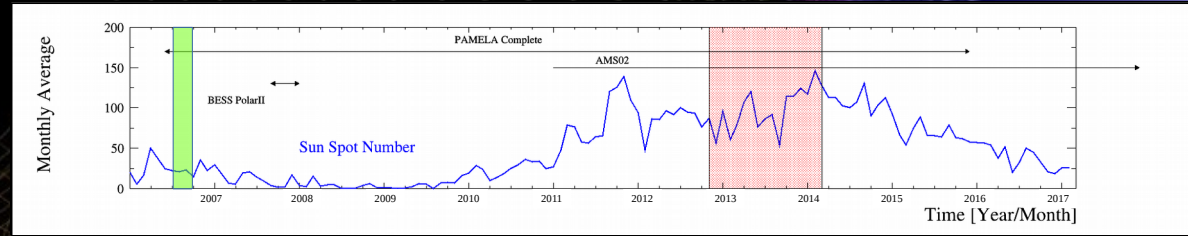
- Uncommon event: solar minimum
- First measurement of a Forbush decrease with a space apparatus over a wide energy range
- Amplitude and recovery time energy dependence observed



December 2006 Forbush decrease

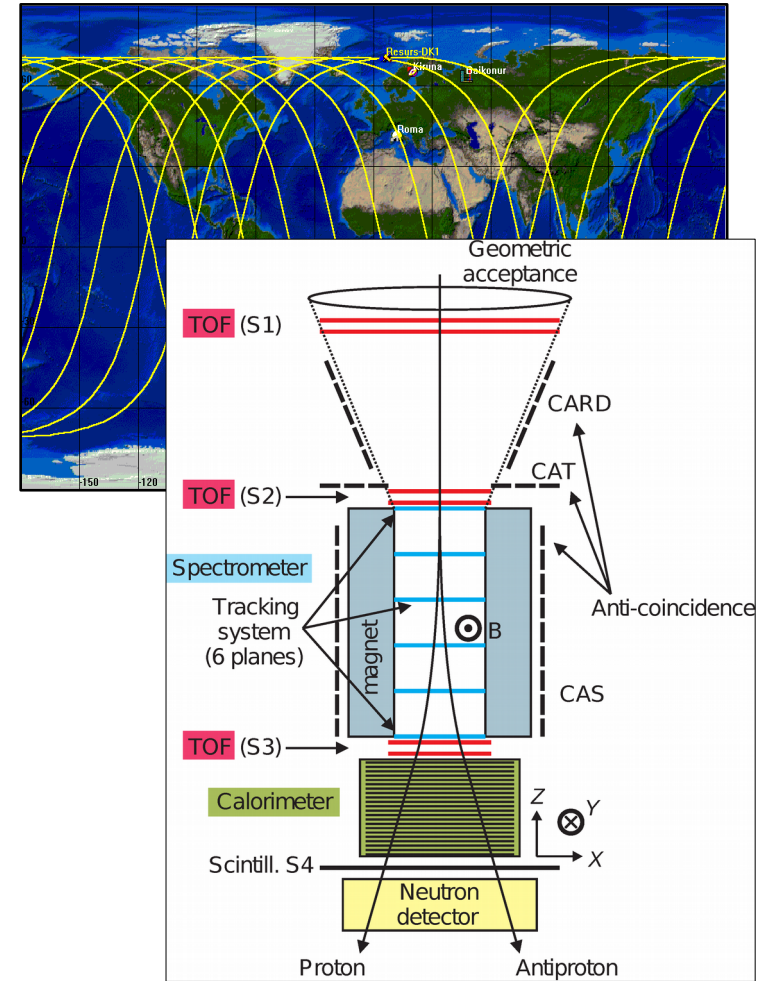
R. Munini et al., ApJ 853 (2018) 1

- Uncommon event: solar minimum
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- Charge sign dependence of the recovery time due to drift effects



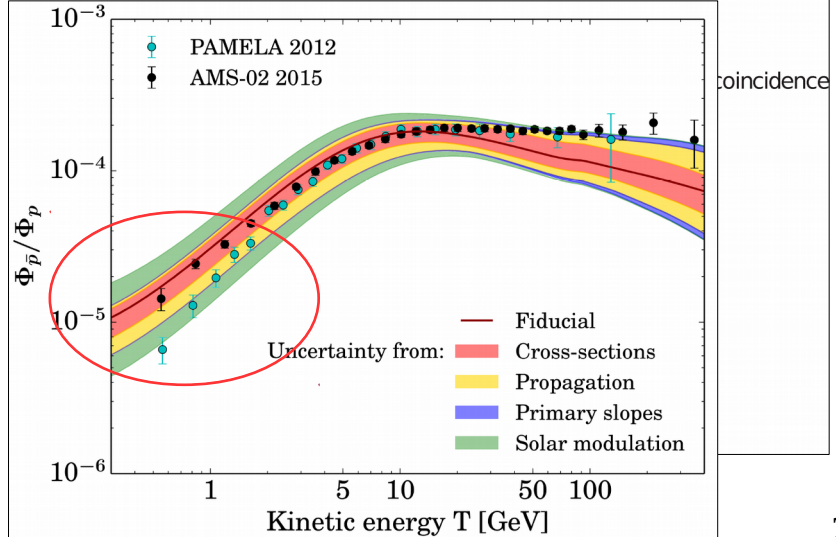
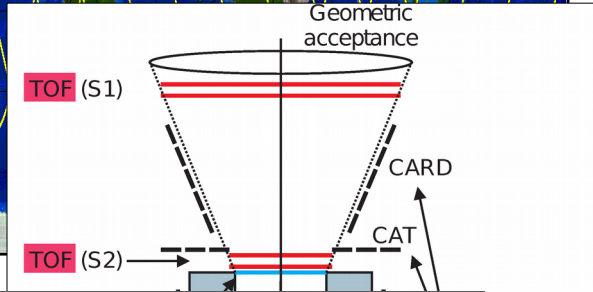
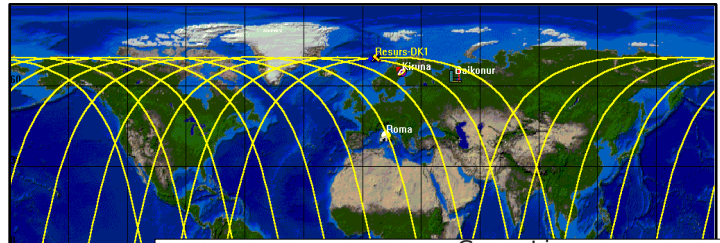
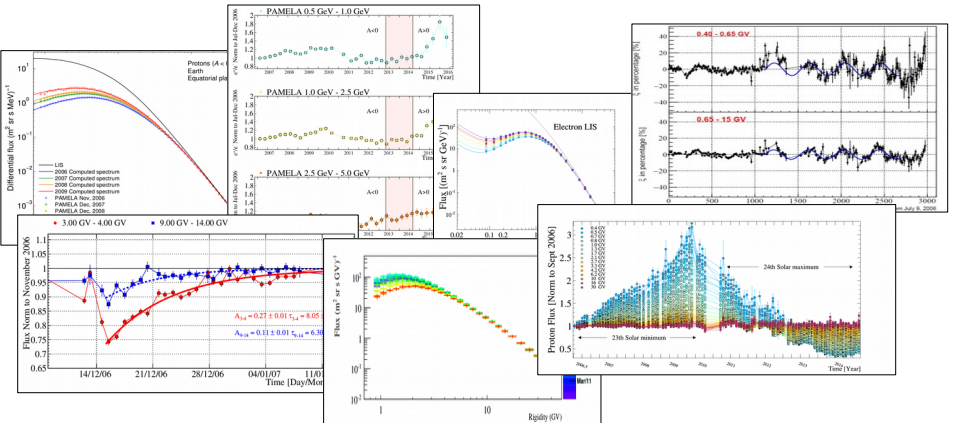
Conclusions I

- PAMELA provided excellent data for solar modulation studied: low geomagnetic cutoff, low energy threshold
- Multiparticle studies, charge sign dependence



Conclusions I

- PAMELA provided excellent data for solar modulation studied: low geomagnetic cutoff, low energy threshold
- Multiparticle studies, charge sign dependence
- Improve the understanding of propagation inside heliosphere (and galaxy): decrease uncertainties at low energies, indirect search of dark matter.
- Solar modulation, forrush decrease, cyclic variation (400-27 days)



G. Giesen et al., JCAP 1509 (2015) 023;