SOLAR MODULATION OF DEUTERONS IN THE PAMELA EXPERIMENT

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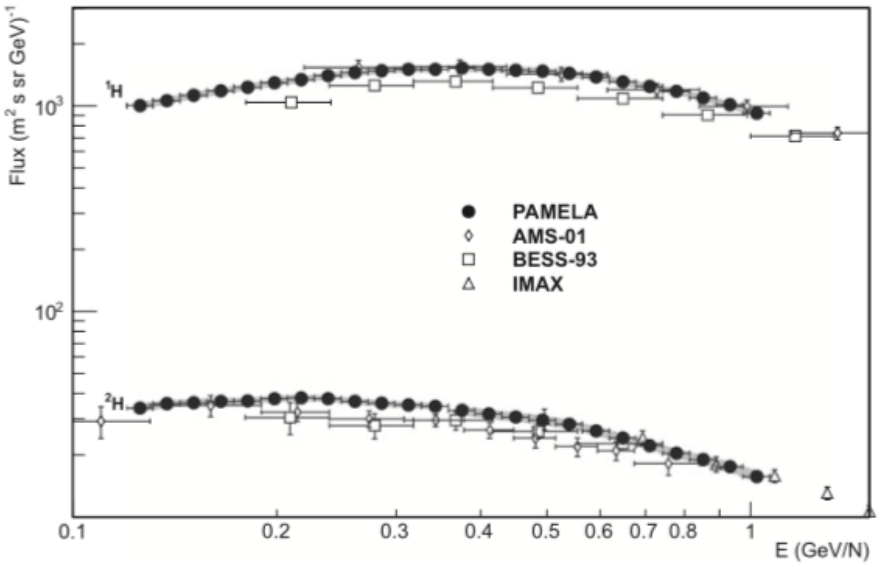
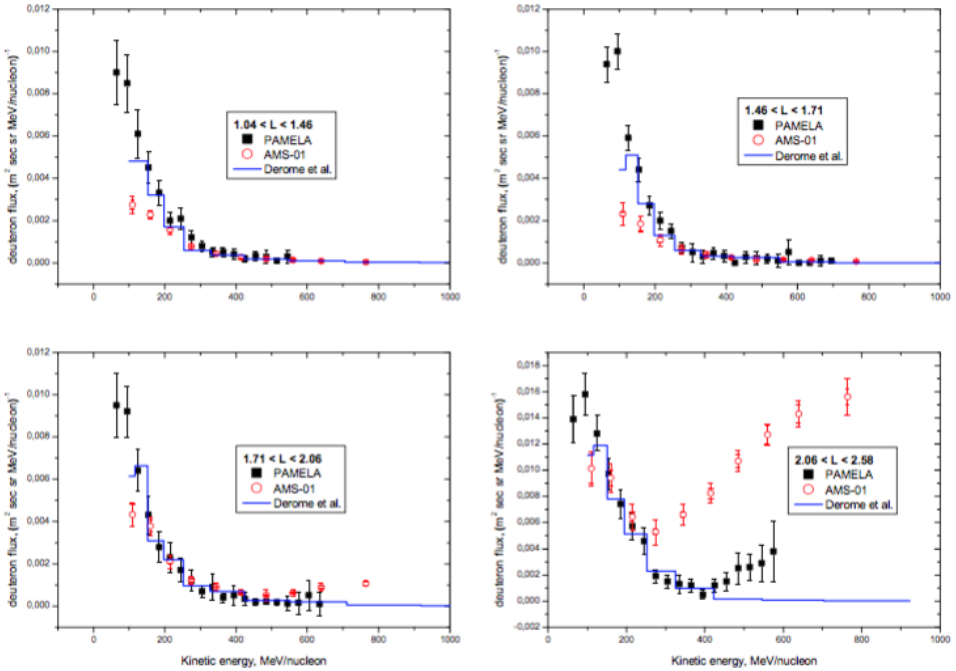
Deuteron spectra measurements in PAMELA





During the analysis of PAMELA experimental data allowed to reconstruct both galactic deuteron spectrum (last work: *O. Adriani et al., Astrophysical Journal, 2016, 818 (1), 68*) and re-entrant albedo deuterons (last work: *Koldobskiy S.A. et al., Nuclear and Particle Physics Proceedings, 2016, 273-275, pp. 2345-2347*)

Why deuterons?

- Different CR species will propagate in the Heliosphere differently due to a lot of different processes inside it.
- These processes depends from different particle characteristics, including sign of charge, magnitude of charge, mass, kinetic energy.
- Therefore we must try to measure modulation for every CR specie we can distinguish (including deuterons)
- These measurements are necessary step when we try to construct modern up-to-date models for propagation processes in Heliosphere.

Solar modulation of GCR deuterons: BESS

Experimental data

A set of flights on balloons:

K.C. Kim et al // Proc. of 30th ICRC, Vol. 2 (OG part 1), pages 71 - 74

- BESS collaboration was able to reconstruct the deuteron spectra in period from 1992 to 2000 and therefore they show the influence of solar modulation to spectrum of galactic deuterons

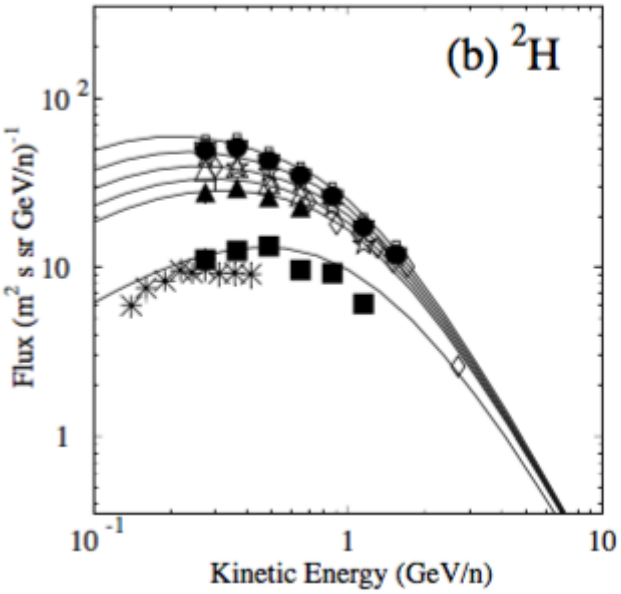
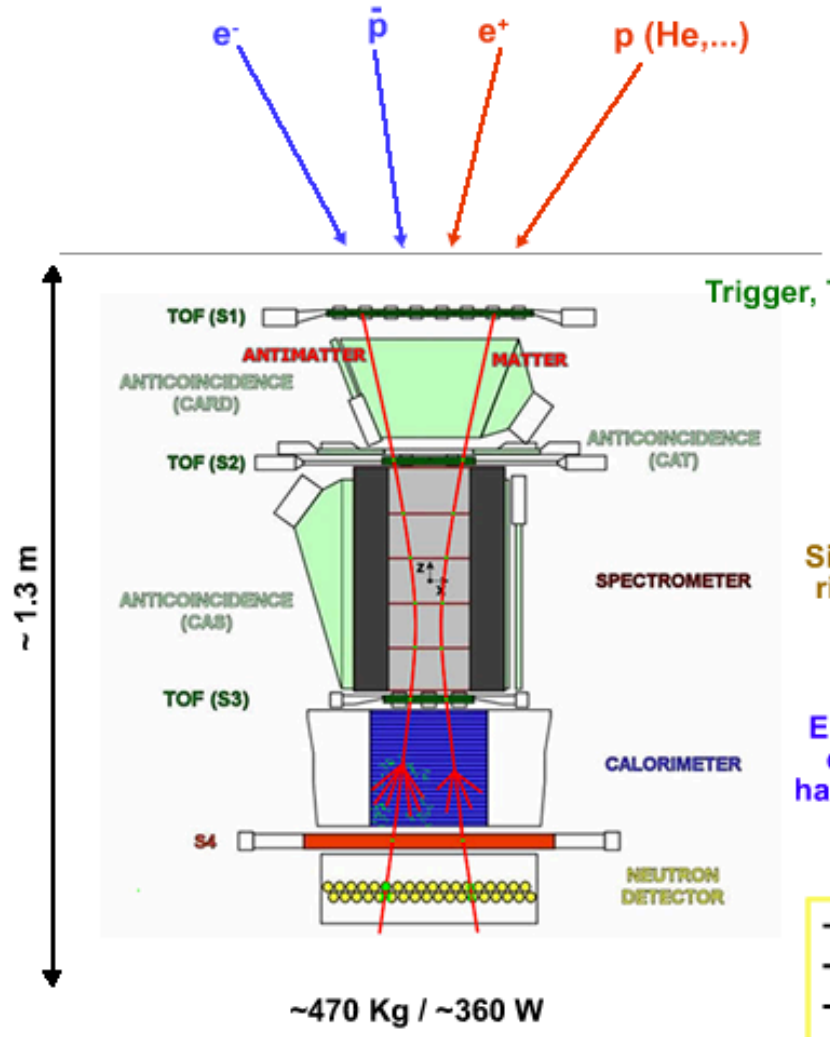


Figure 1: The absolute fluxes of ^{1}H and ^{2}H. The solid lines are theoretical predictions of the Reacceleration model. Modulation parameters are 500, 600, 700, 800, 900 and 1500 MV from top to bottom. (a) ^{1}H fluxes from BESS (93(solid triangle), 94(open triangle), 95(open star), 97(open cross), 98(solid circle), and 2000(solid square)) and IMAX-92(open diamond) data. (b) The absolute flux of ^{2}H from BESS and MASS-89(snow) data.

PAMELA instrument



Trigger, ToF, dE/dx

- S1, S2, S3; double layers, x-y
- plastic scintillator (8mm)
- ToF resolution ~300 ps (S1-3 ToF >3 ns)
- lepton-hadron separation < 1 GeV/c
- S1.S2.S3 (low rate) / S2.S3 (high rate)

Sign of charge, rigidity, dE/dx

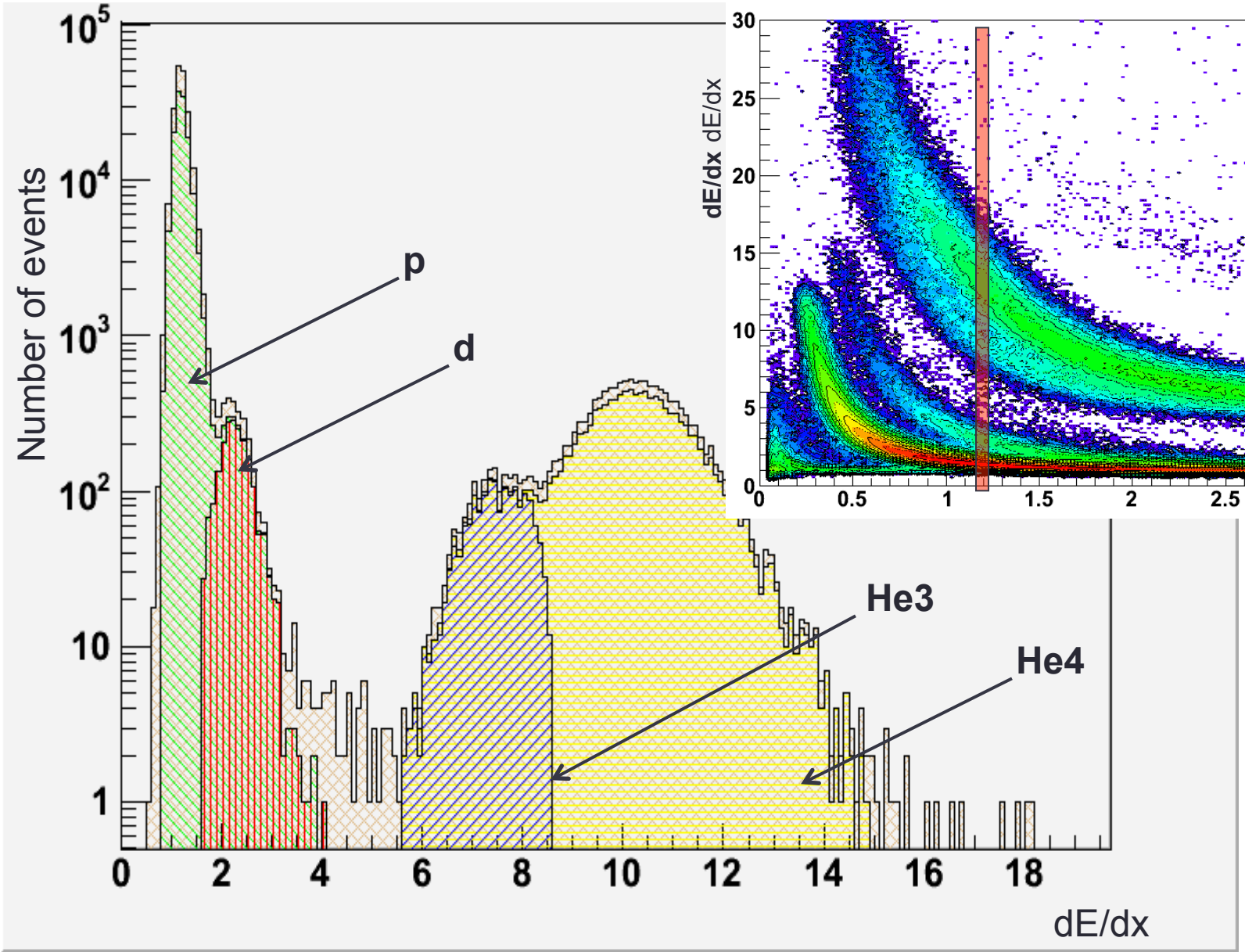
- Permanent magnet, 0.43 T
- 21.5 cm² sr
- 6 planes double-sided silicon strip detectors (300 μm)
- 3 μm resolution in bending view → MDR ~800 GV (6 plane) ~500 GV (5 plane)

Electron energy, dE/dx, lepton-hadron separation

- 44 Si-x / W / Si-y planes (380)
- 16.3 X0 / 0.6 L
- dE/E ~5.5 % (10 - 300 GeV)
- Self trigger > 300 GeV / 600 cm² sr

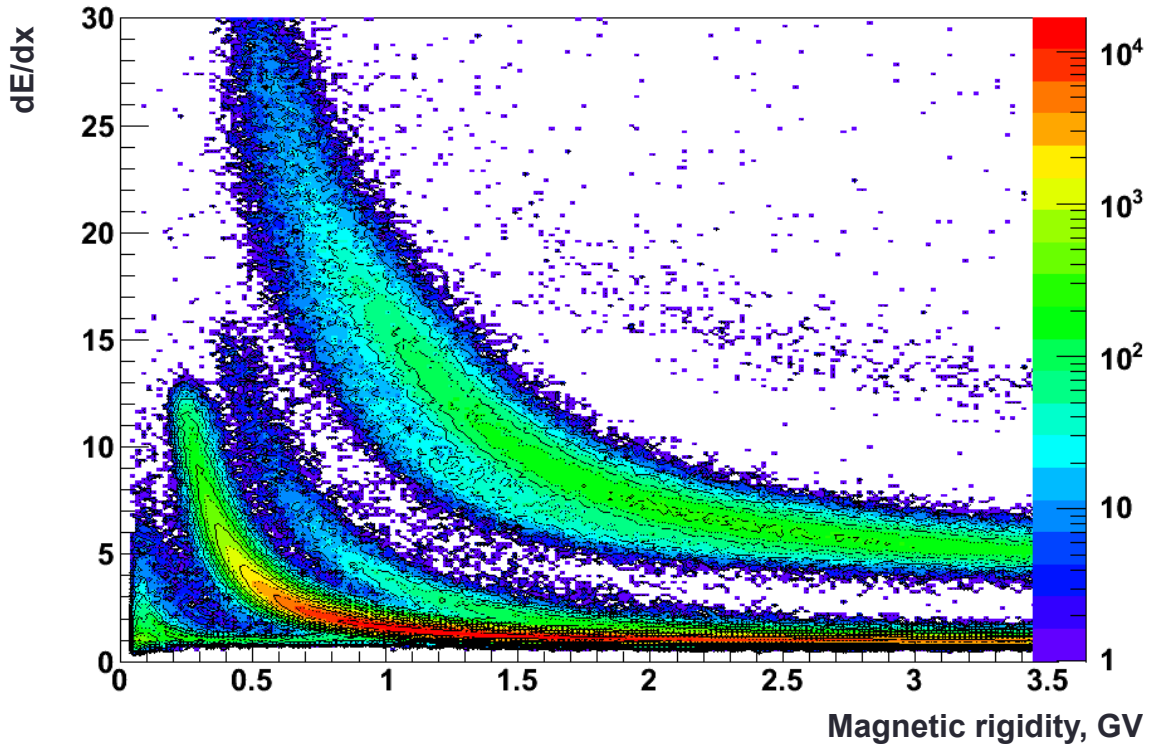
- 36 ^{3}He counters
- ^{3}He(n,p)T; E_p = 780 keV
- 1 cm thick poly + Cd moderator
- 200 μs collection

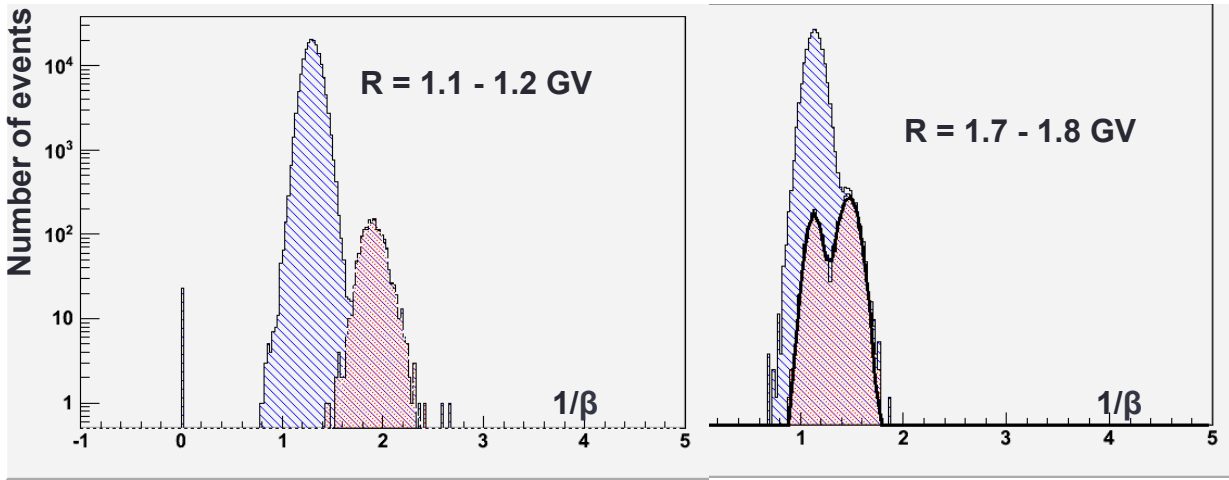
dE/dx distribution (tracker)



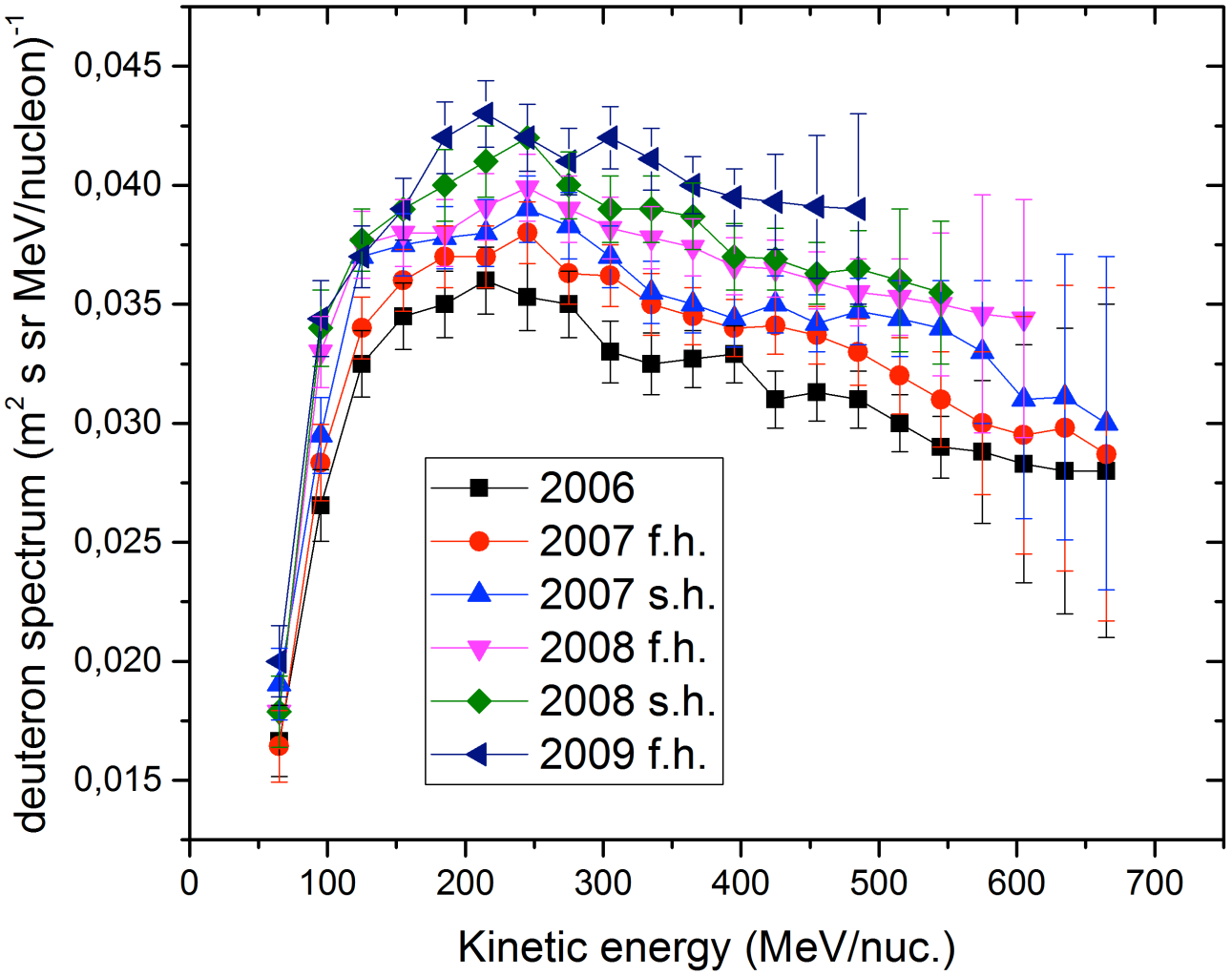
Deuteron selection

- Main problem: enormous background of protons.
- Deuterons were selected via multivariate correlation analysis.
- Rigidity, velocity and energy losses in magnetic spectrometer and detectors of ToF system were used to construct a deuteron selection criteria set
- This set allowed to separate deuterons and protons with energies from 100 MeV/ nucleon to 600 MeV/nucleon.





Preliminary results for GCR deuteron spectrum modulation in PAMELA experiment



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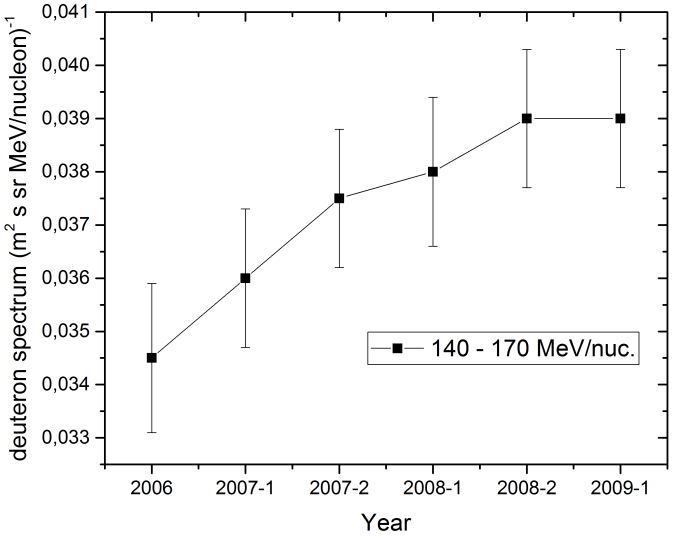

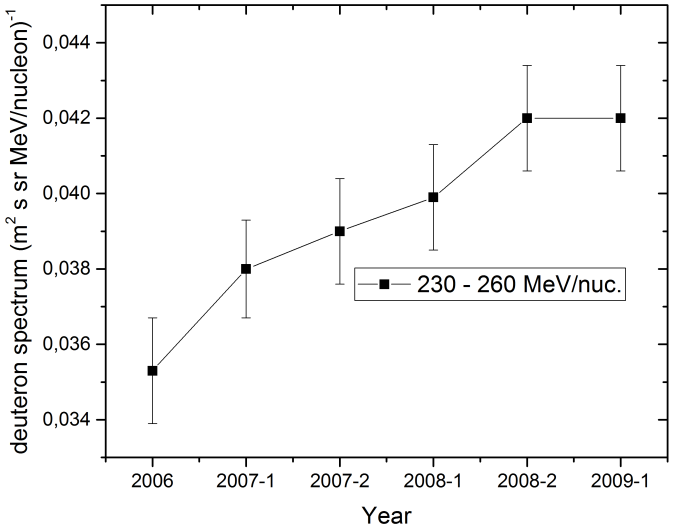

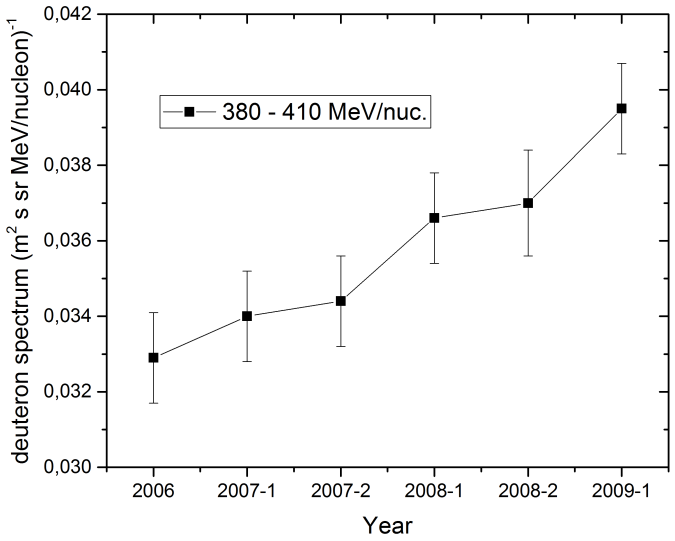

Conclusion

- PAMELA experimental data from June 2006 to June 2009 was analyzed and GCR deuteron spectra were reconstructed for this period with bin size in half year.

- The deuteron spectrum dependence from solar modulation is clearly seen.

- Work not finished, some additional efficiency evaluations are needed, moreover the main goal is to reconstruct the spectra for period from 2006 to 2015. For this task new criteria set is developed.

Thank you for attention!