Deuteron Separation in AMS-02

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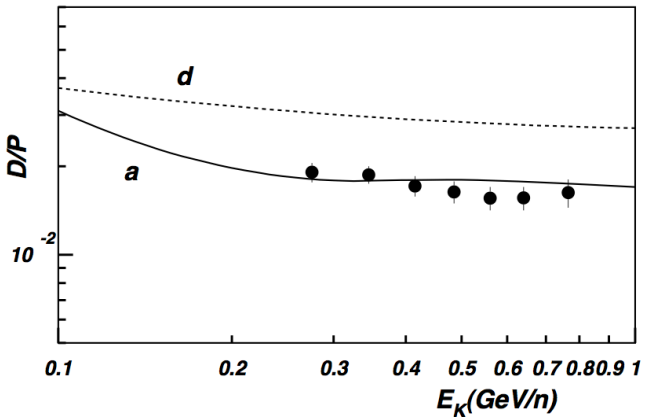
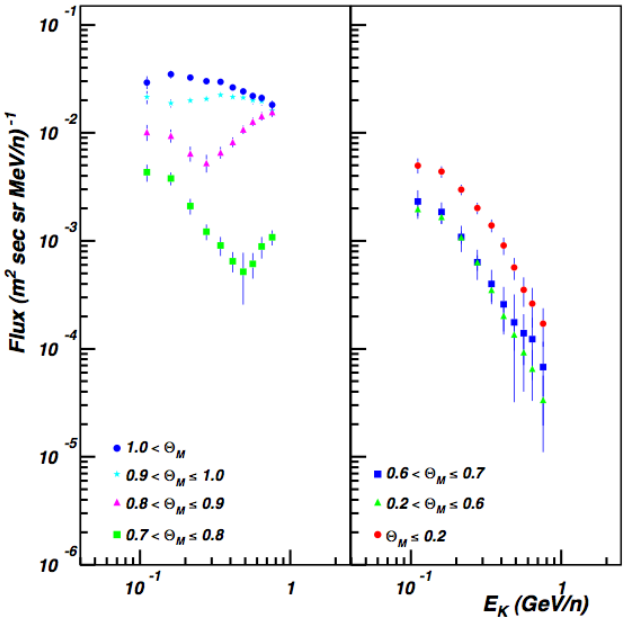
Outline

- ✓ Deuterons
- ✓ Standard Deuteron Separation
- ✓ Geomagnetic Earth Field
- ✓ Deuteron Separation Method
- ✓ Conclusions

Deuterons

- ✓ Rare hydrogen isotopes in cosmic rays that are believed to be of secondary origin.
- ✓ Deuterons results mainly from the nuclear interactions of primary cosmic rays protons and He nuclei with the interstellar medium.
- ✓ It is expected that they provide important information concerning the propagation of cosmic rays in the interstellar space.
- ✓ Constrain propagation models with the study of the D/P ratio (≈ 2%)
- ✓ Achieving a flux of deuterons to higher energies is fundamental.
- ✓ The selection of deuterons is very complex due to the large background consisting by protons



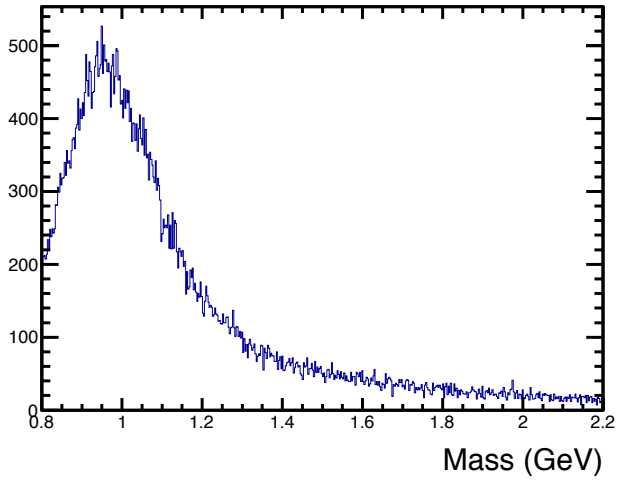


Standard Deuteron Separation

✓ **Classic method**

- Based on the separation of two elements by calculating the mass:

$$M = \frac{p}{\gamma\beta} \qquad \left(\frac{\sigma_M}{M}\right)^2 = \left(\frac{\sigma_p}{p}\right)^2 + \left(\frac{\gamma^2\sigma_\beta}{\beta}\right)^2$$



- Moment – measured by **tracker**: $\frac{\sigma_p}{p} \approx 10\%$
- Velocity – measured by **RICH** $\frac{\sigma\beta}{\beta} \approx 0.1\%$
- Inadequate separation of deuterons from protons at energies above 1Gev

Example: 10 GeV proton

$$\gamma^2 \approx 101$$

$$\left(\frac{\sigma_M}{M}\right) = \sqrt{0.1^2 + (101 * 0.001)^2} \sim 0.14$$

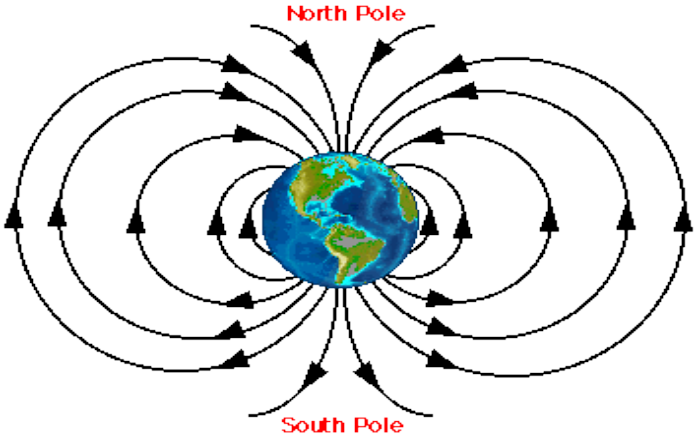
Geomagnetic Earth Field

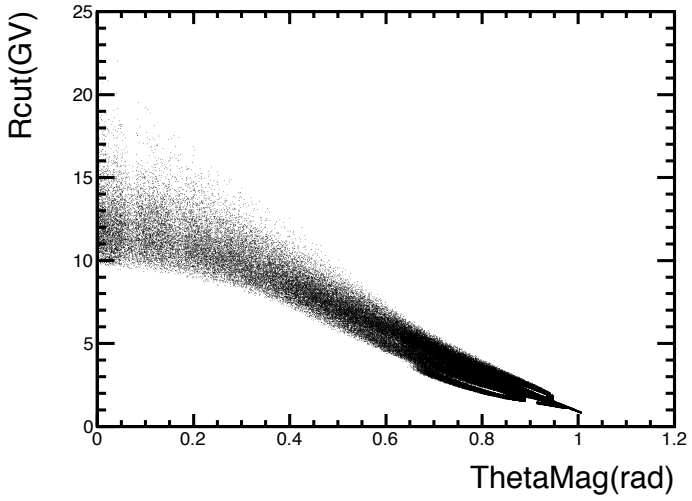
- ✓ The geomagnetic Earth field bends the charged particles that came from the galaxy.
- ✓ Dipole in first approximation, could be corrected at higher orders with multipoles expansion.
- ✓ **Geomagnetic Rigidity Cutoff**

Minimal rigidity ($R = \frac{pc}{ze}$) that a particle coming from the galaxy must have in order to reach a point near the Earth surface

$$R_c(h,\lambda,\alpha) = \frac{60}{\left(1+\frac{h}{R_E}\right)^2}\frac{\cos\lambda^4}{\left[\sqrt{1+\cos\alpha\cos\lambda^3}+1\right]^2}$$

- ✓ We can use the geomagnetic Earth field as a natural selector of deuterons.





Rcut versus Latitude
Computed with particles entering AMS

Deuteron Separation Method

- ✓ Accept only particles that have a rigidity higher than the cutoff one. This allows us to select only primary particles.

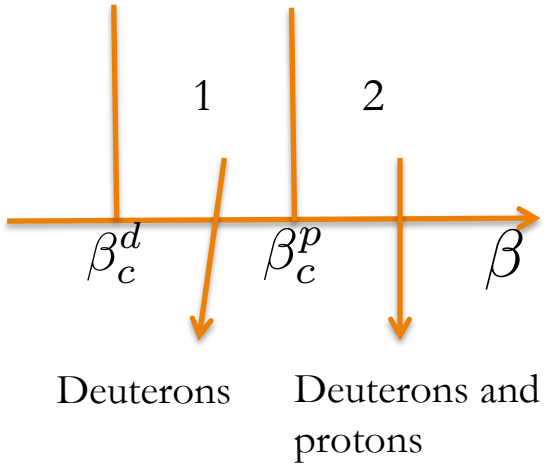
- ✓ The cosmic ray particles have a cutoff velocity that depends on the mass of the particle for every orbit position.

$$\beta_c^{-2} = 1 + \left(\frac{A}{Z} \frac{m}{R_c(h, \lambda, \alpha)} \right)^2$$

- ✓ There is a velocity region where is possible to separate the deuterons from the protons.

- ✓ This region decreases with the increase in energy. **Higher cutoff energies correspond to lower geomagnetic latitudes.**

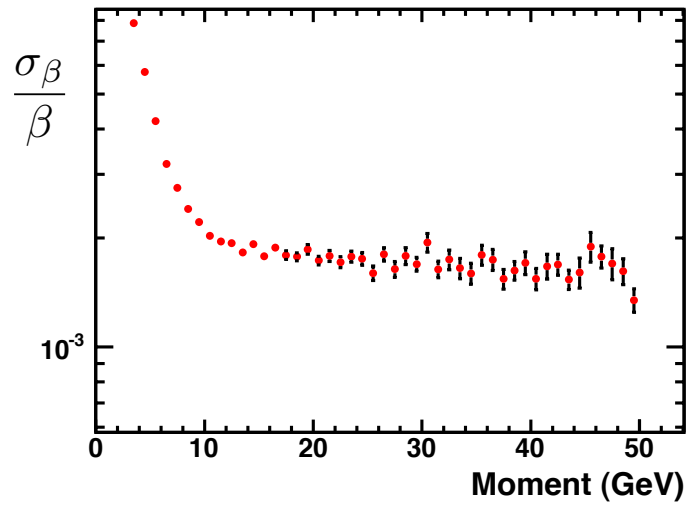
$$M_d > M_p \rightarrow \beta_c^p > \beta_c^d$$

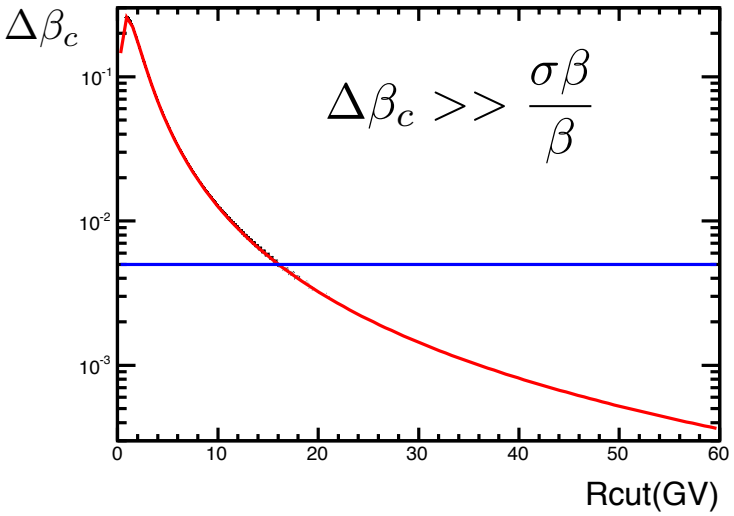


$$\Delta\beta_c = \beta_c^p - \beta_c^d$$

Deuteron Separation Method

- ✓ Advantages of this method:
  - Direct use of the good velocity measurement to do the separation
  - High statistics collected by AMS-02
- ✓ Steps to the deuteron separation:
  1. Accept only particles with Z =1.
  2. Quality cuts in the rigidity and beta measurements
  3. Accept particles that have a rigidity higher than the cutoff rigidity.
  4. Use the RICH resolution velocity to separate primary deuterons from primary protons.

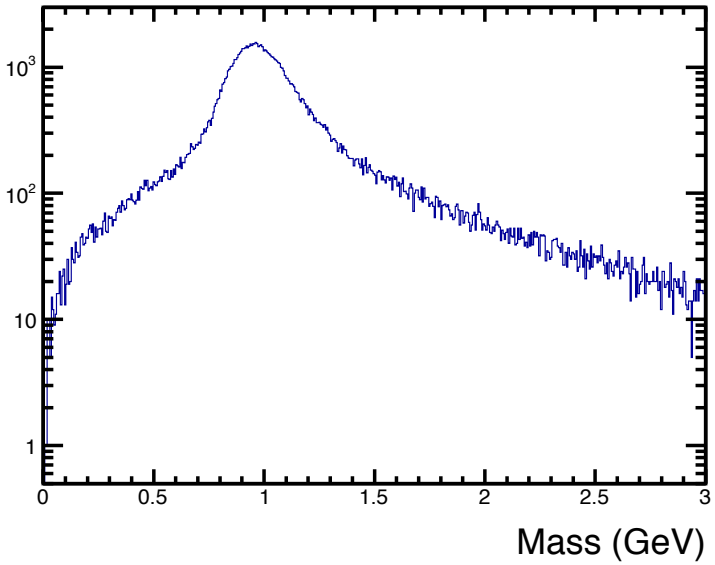




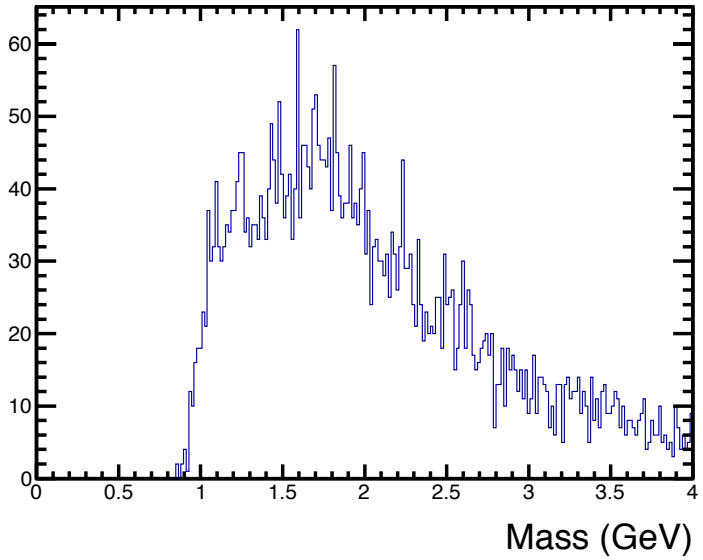
Conclusions

- ✓ Obtain a deuteron mass distribution (We show in the next two plots two **preliminary mass distributions**)

$\beta > \beta_c^d$

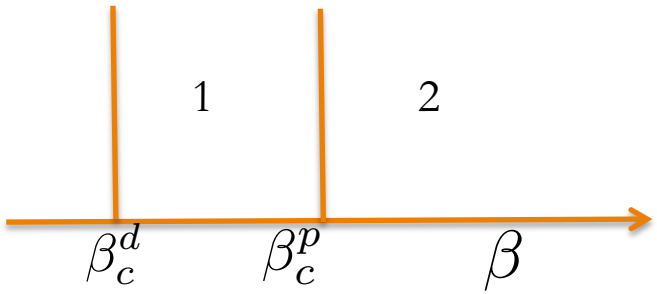


$\beta_c^d < \beta < \beta_c^p$



- ✓ Expect to measure a deuteron flux and a D/P ratio up to 10-12 GeV

- ✓ Comparison of D/P ratio results with models predictions



Thank You !