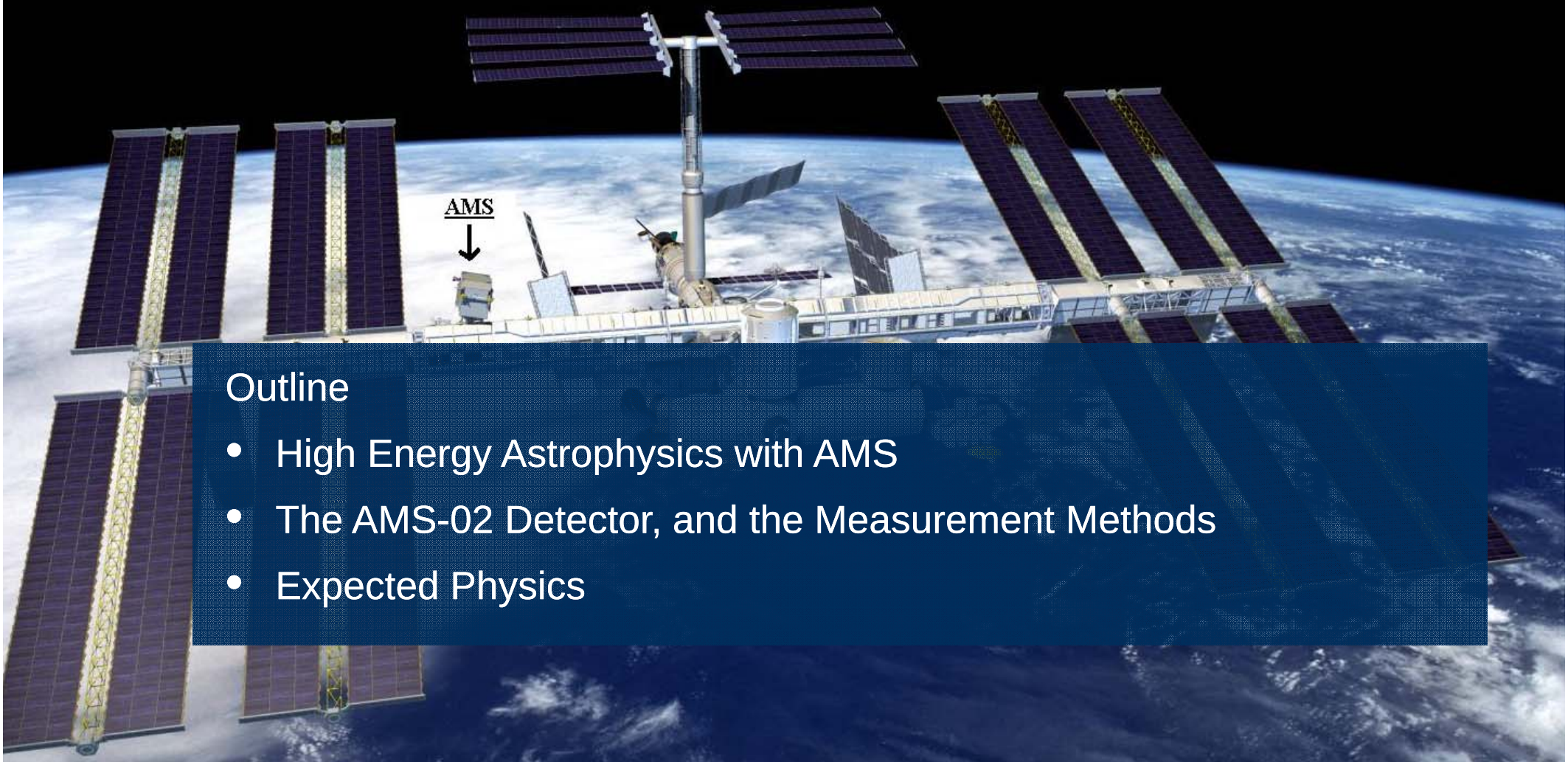
Cosmic-Rays Astrophysics with AMS-02

Alberto Oliva*
on the behalf of the AMS Collaboration

****University and INFN Perugia, Italy***



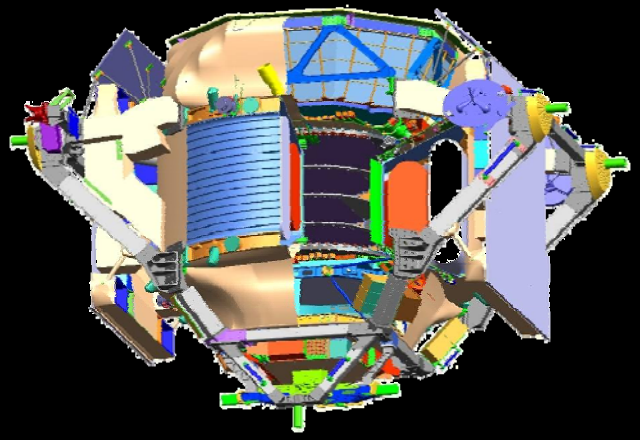
Outline

- High Energy Astrophysics with AMS
- The AMS-02 Detector, and the Measurement Methods
- Expected Physics

AMS-02 experiment

High Energy Particle Physics in Space (ISS):

- Large Acceptance, Long Duration → High Statistics
- Charged Particles & Nuclei Spectra
- High Energy Gamma Rays



Physics goals:

- Search for Primordial Antimatter by Direct Detection of Antinuclei ($\overline{\text{He}}/\text{He}<10^{-9}$)
- Dark Matter Signatures in $\overline{p}$, e^+, $\overline{d}$, γ spectra
- Production, Acceleration and Propagation of Cosmic-Rays
- Solar Modulation

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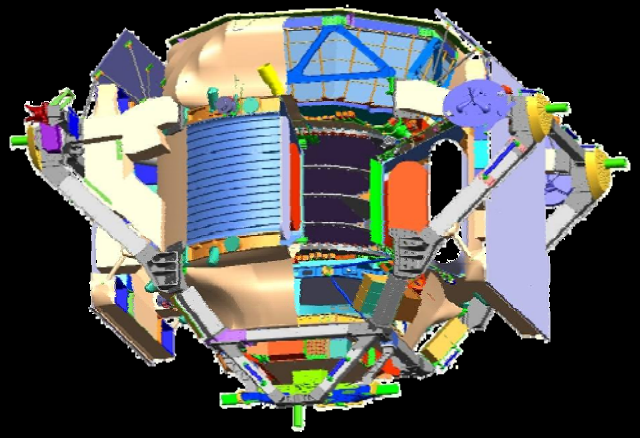

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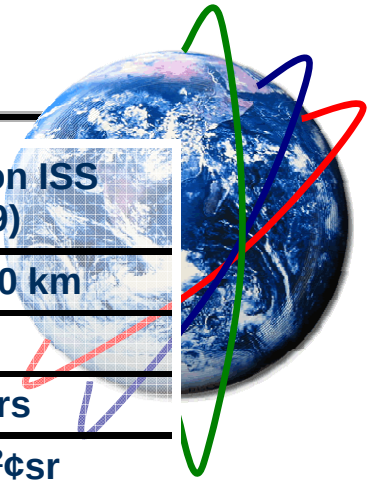
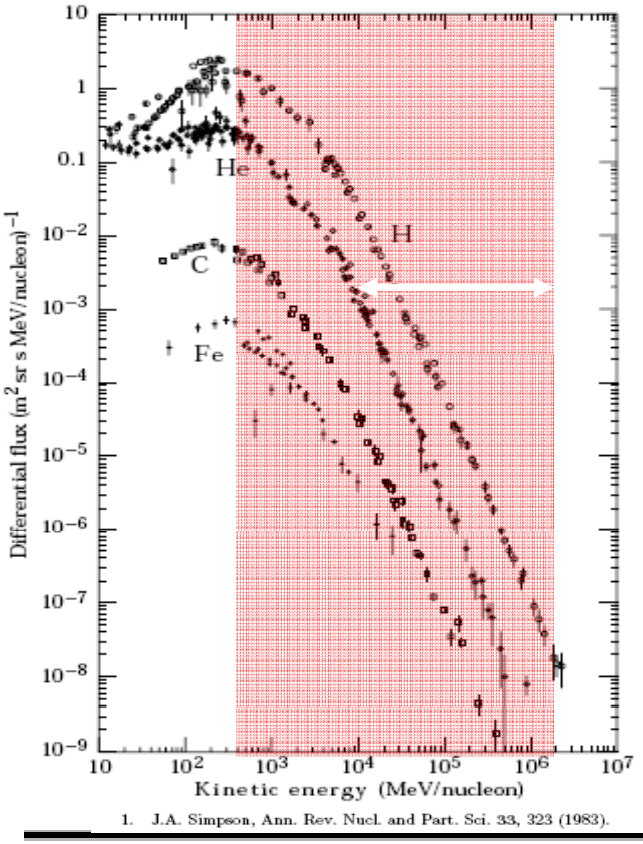
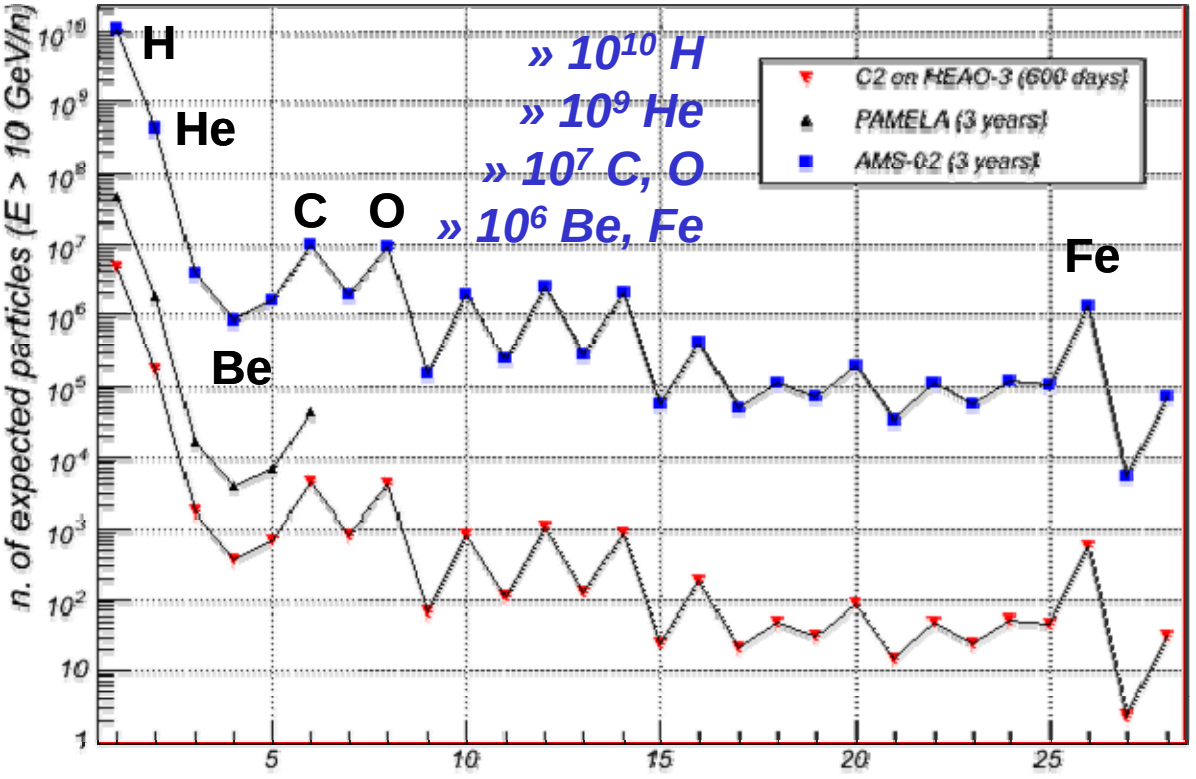
CR spectrum and AMS-02 expectation



	C2 on HEAO-3 (1979)	PAMELA on DK1 (2006)	AMS-02 on ISS (2009)
Perigee £ Apogee	490 £ 510 km	350 £ 600 km	360 £ 440 km
Inclination	44°	70°	52°
Δt	600 days	3 years	3 years
Acceptance	4 cm²¢sr	21.5 cm²¢sr	0.45 m²¢sr
Energy	600 MeV/n – 35 GeV/n	100 MeV/n – 250 GeV/n	700 MeV/n – 1 TeV/n
Charge distinction	Z · 26	Z · 6	Z · 26
Mass reconstruction	no	yes	yes

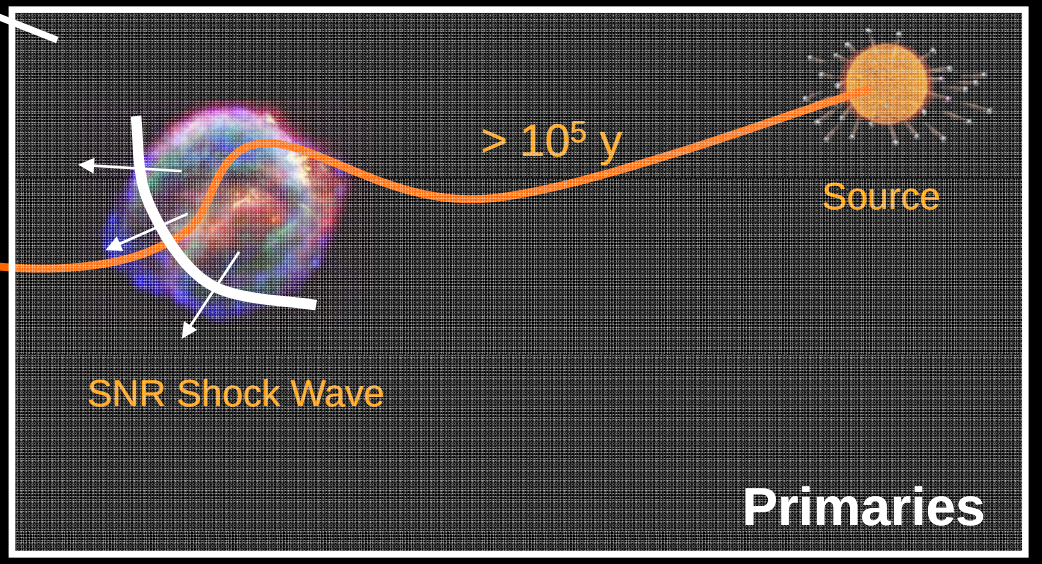


1. J.A. Simpson, Ann. Rev. Nucl. and Part. Sci. 33, 323 (1983).



Cosmic Nuclei Astrophysics

	stable	***β decay***	***K capture***
primary CR	*big bang and stellar nucleosynthesis*	*age of the origin material (U, Pu, Cm, …)*	*Delay between synthesis and acceleration (^{56}Ni, ^{57}Co)*
secondary CR (dependent from ISM)	*diffusion process (B/C, sub-Fe/Fe)*	*galaxy confinement time (^{10}Be, ^{26}Al, ^{36}Cl, ^{54}Mn)*	*Energy changes (decelerations)*



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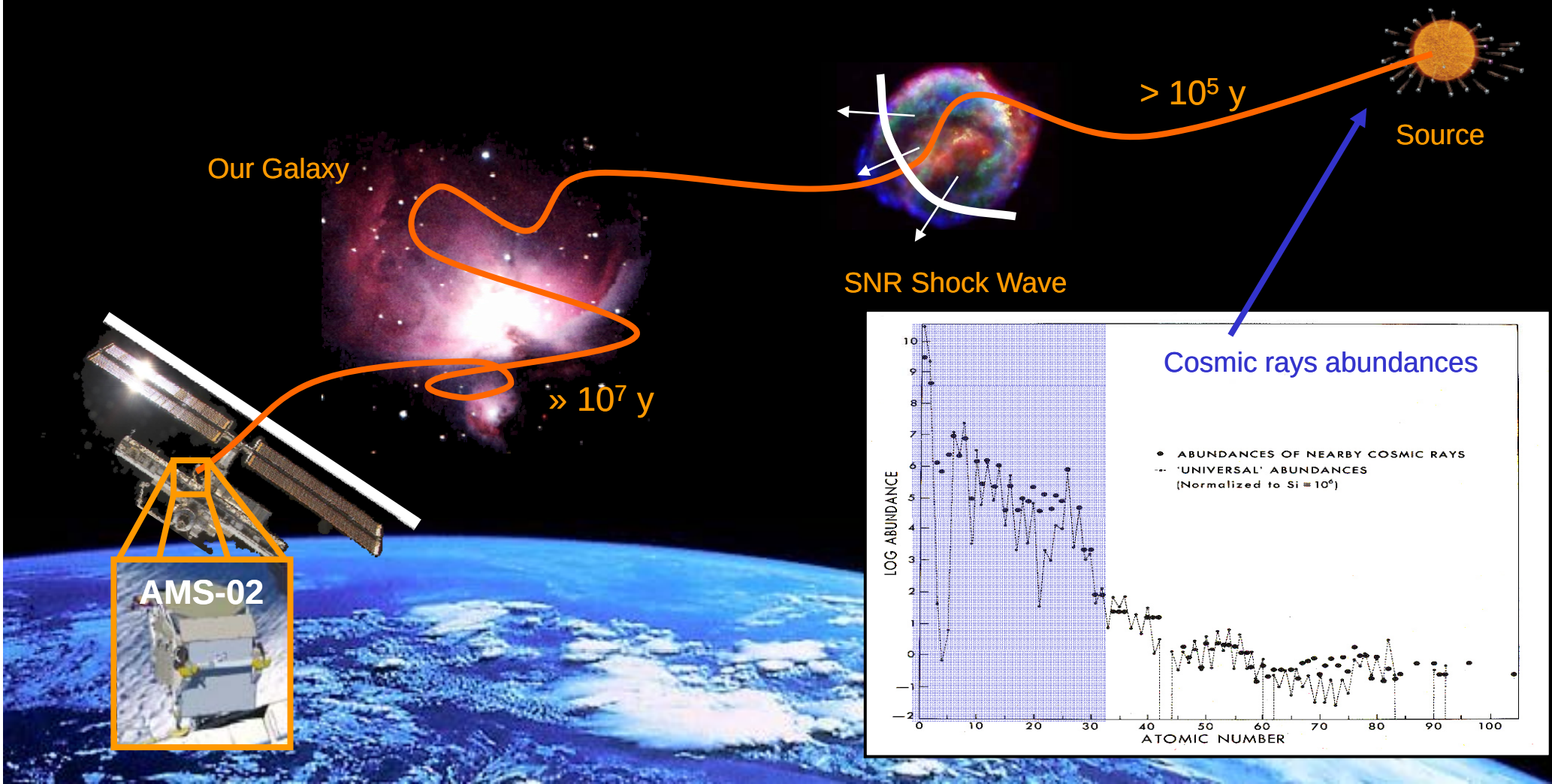

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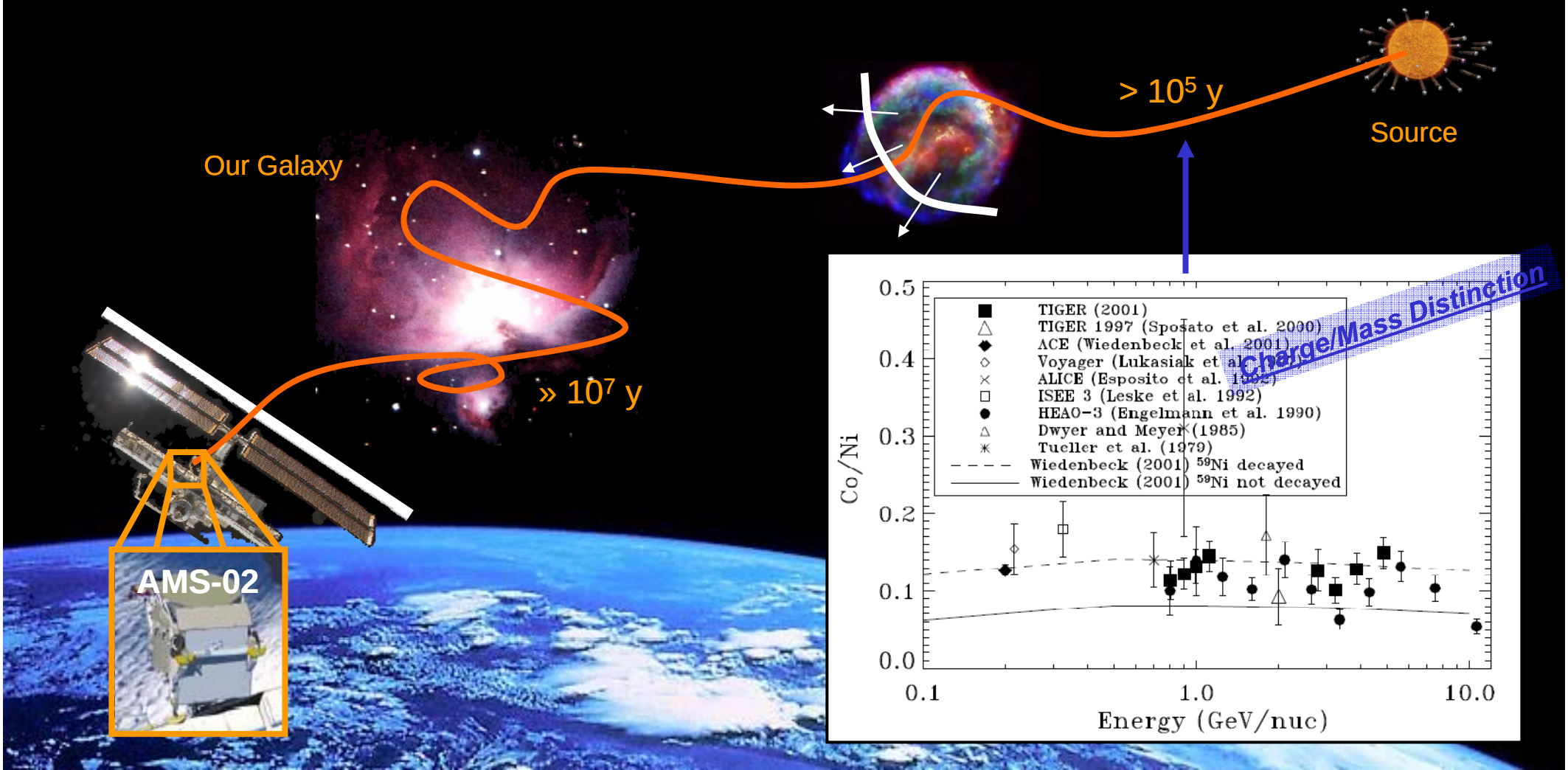

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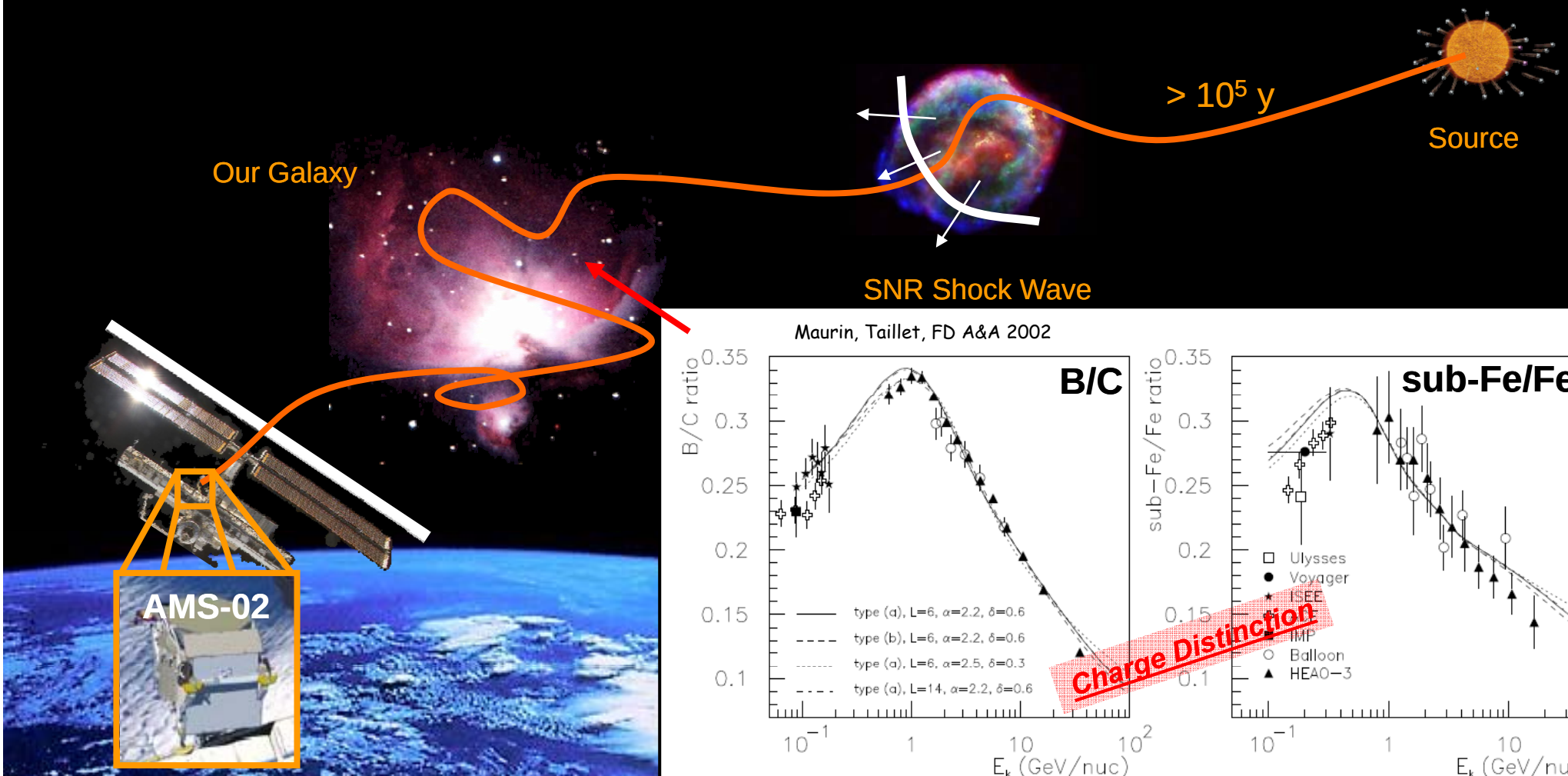

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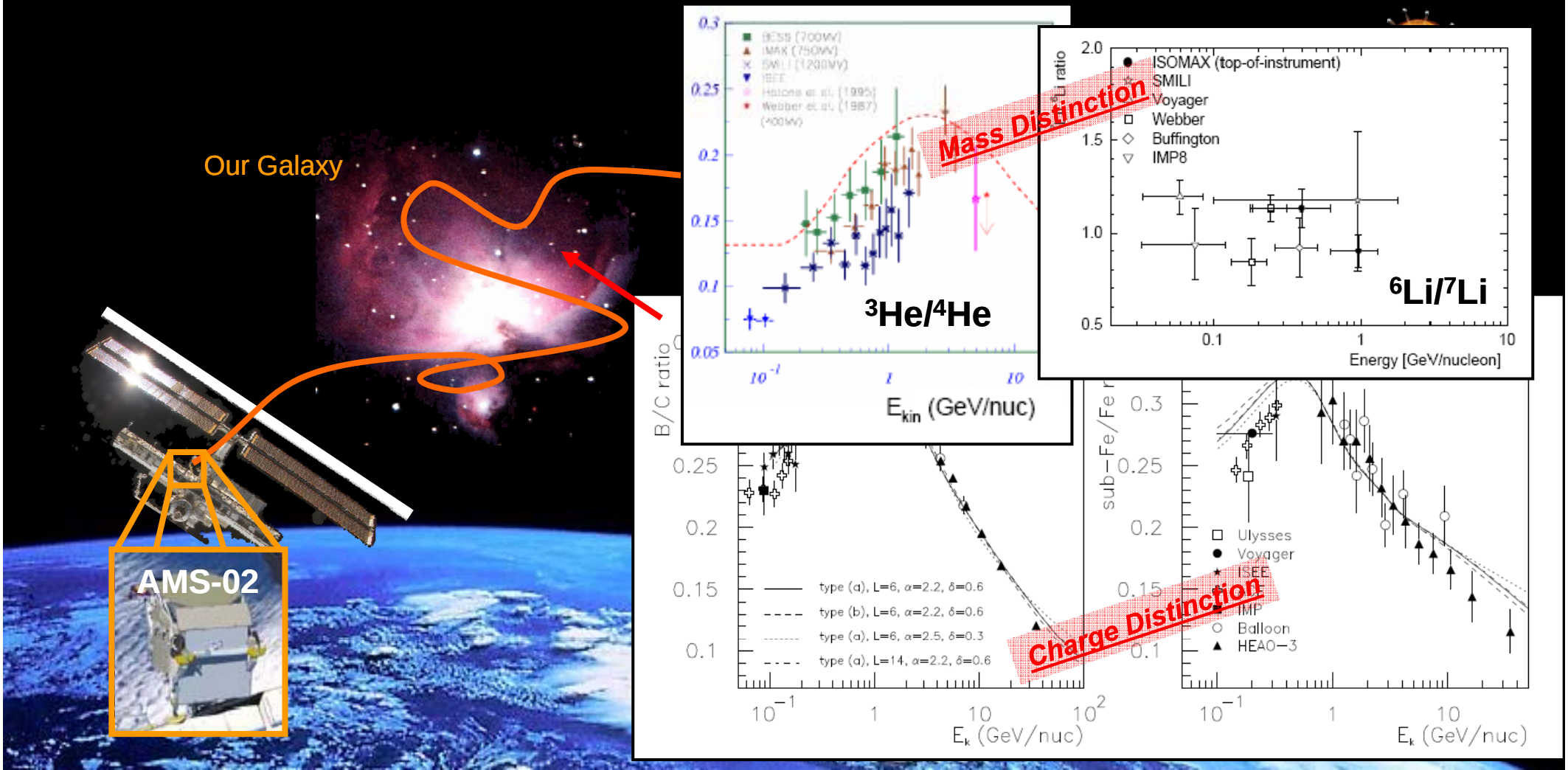

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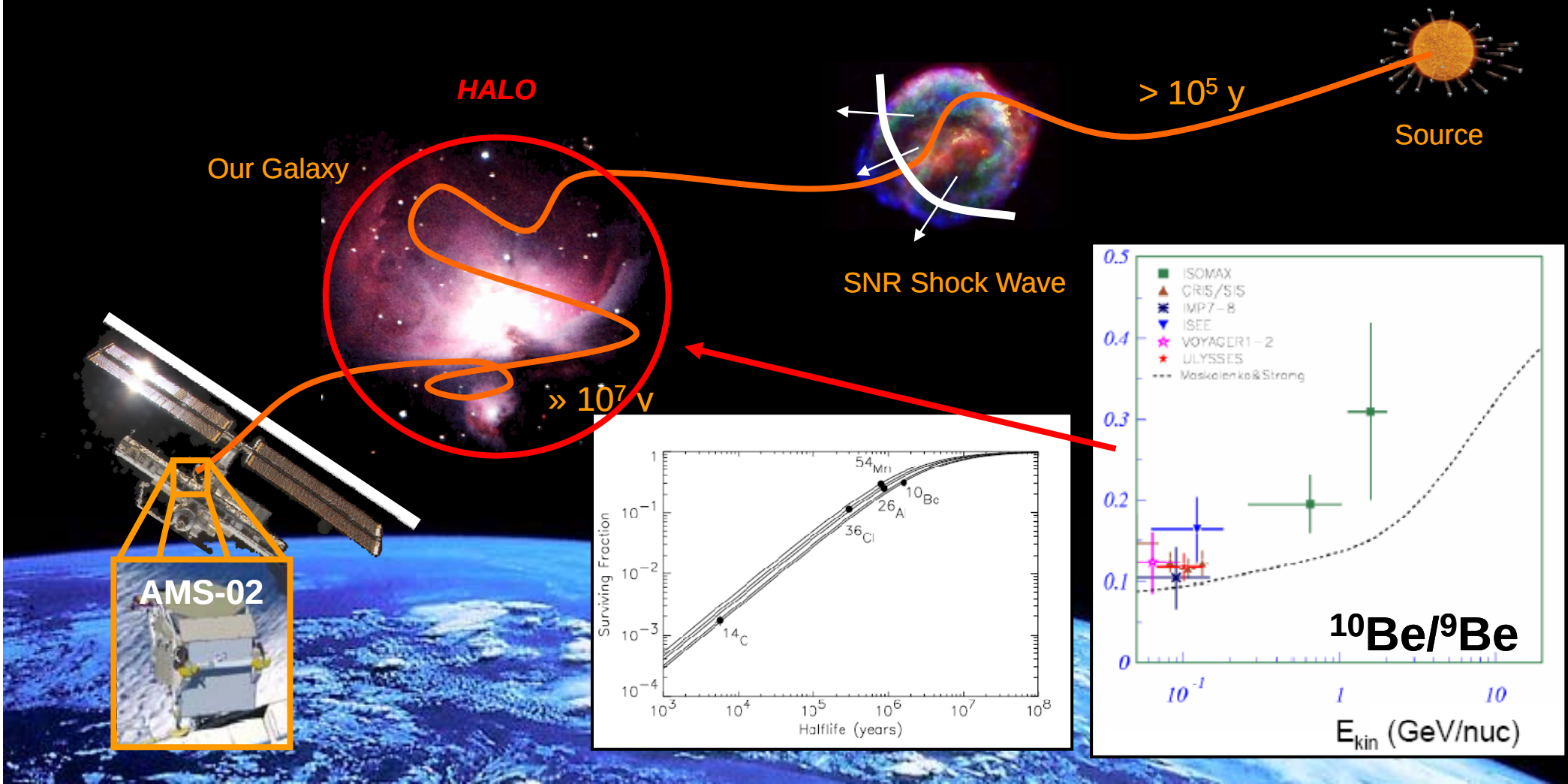
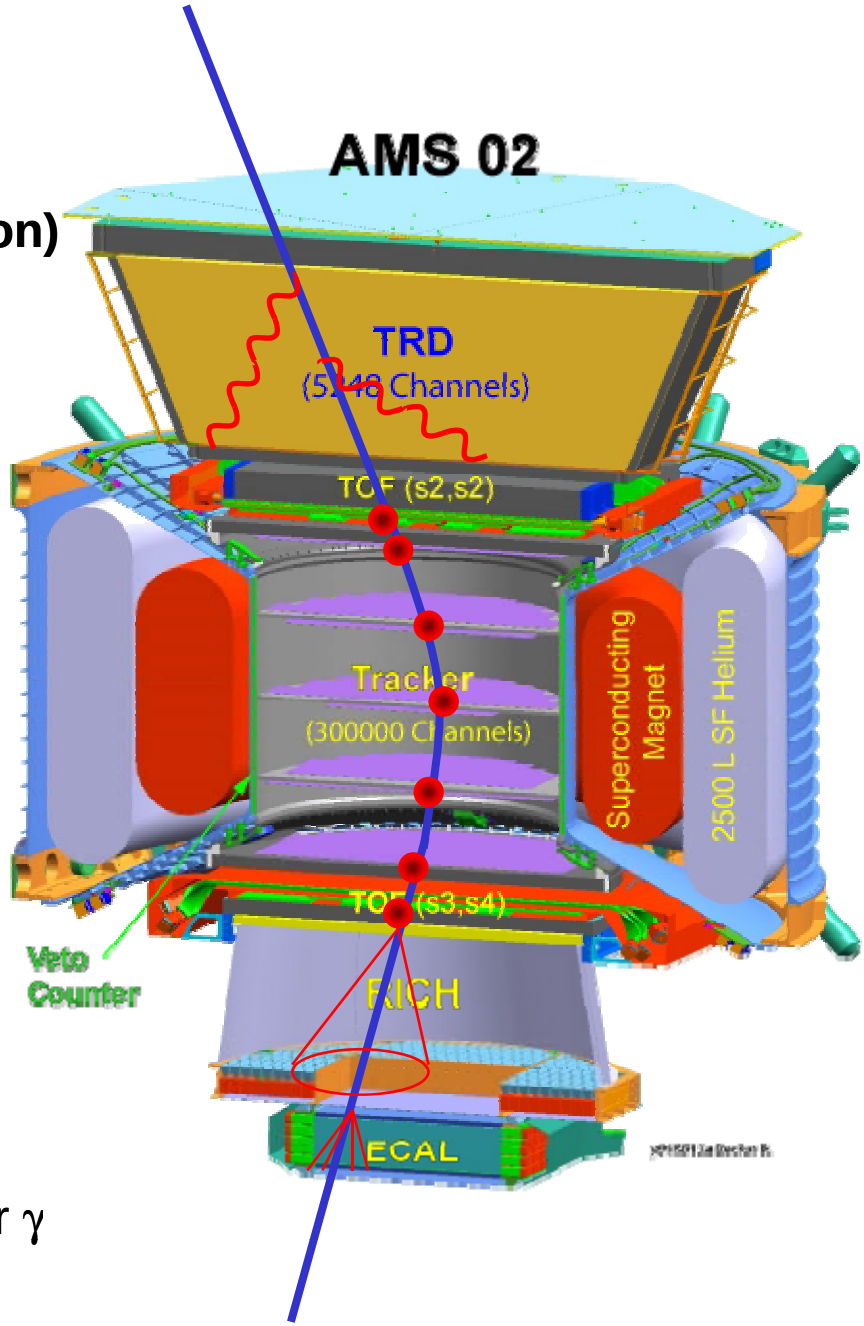


AMS-02 Detector

- **Cryogenic Superconducting Magnet of 0.8 T**
- **TOF: 4 layers of scintillators (150 ps resolution)**
- **Tracker: 8 layers of Si detectors (10 (30) μm)**
- **RICH Detector ($\Delta\beta/\beta$ » 0.1/Z %)**
- **TRD Detector: p/e rejection in 10^3**
- **Pb/Sc EM Calorimeter: p/e rejection 10^4**

- Geometric acceptance of 0.45 m^2¢sr
- Z measurement up to Iron
- A global statistics above 10^{10} particles
- Detector redundancy (charge, velocity)
- Trigger: TOF, ACC (no ACC for ions) or ECAL for γ



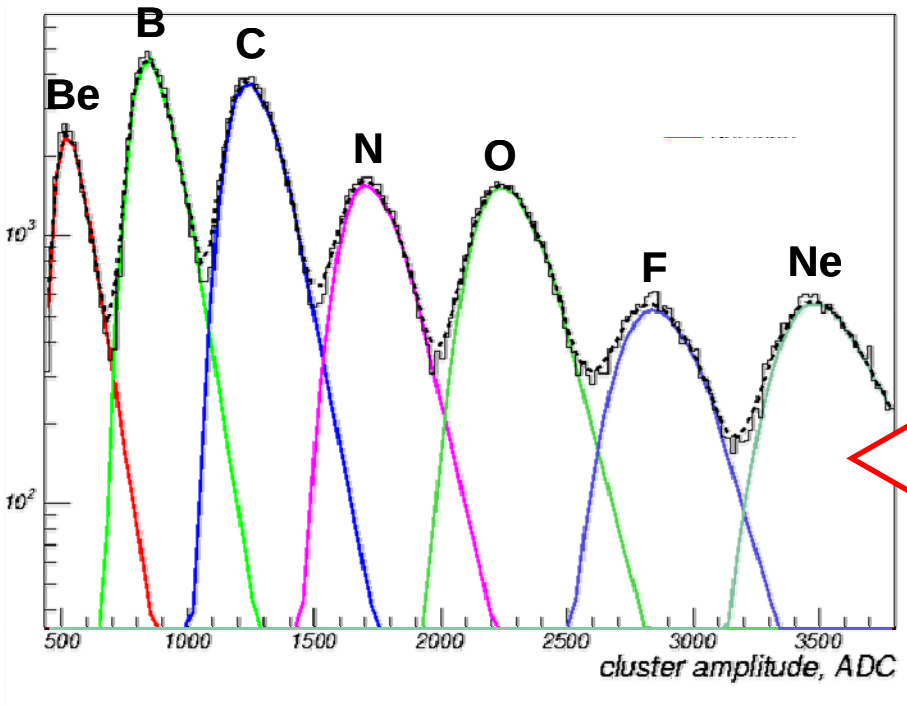
Charge measurement

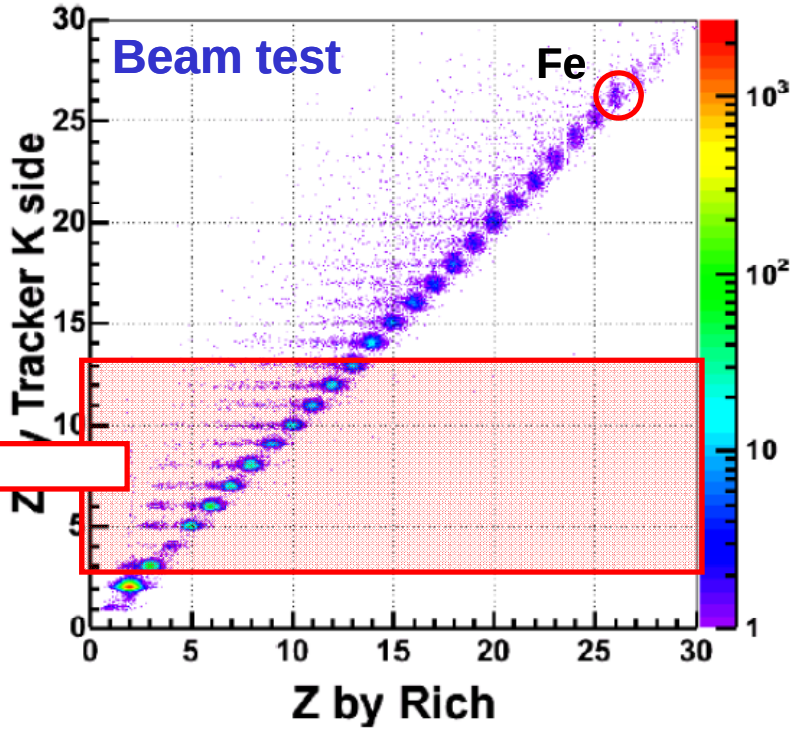
The charge evaluation is redundant

- **Tracker**, TOF: energy deposition by ionization
- RICH: number of photons in the Cherenkov ring

$$\left(\frac{\mathrm{d}E}{\mathrm{d}X}\right)_{\mathrm{bethe}} \propto Z^2$$

$$N_\gamma \propto Z^2 \Delta L \left[1 - \frac{1}{\beta^2 n^2}\right]$$



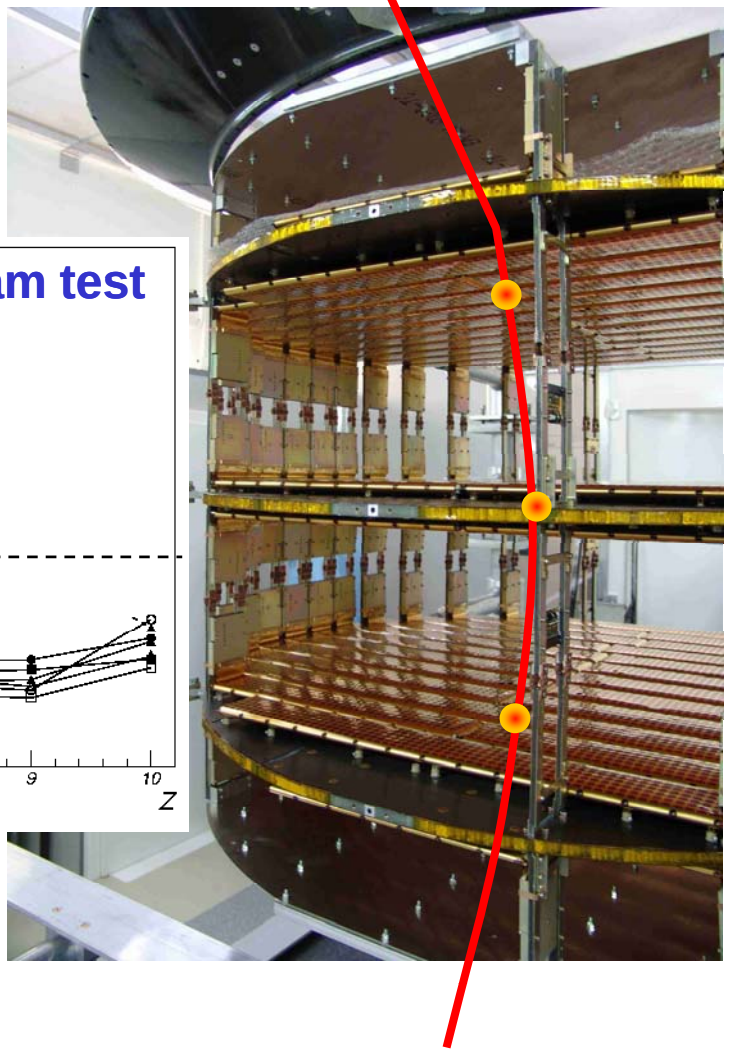


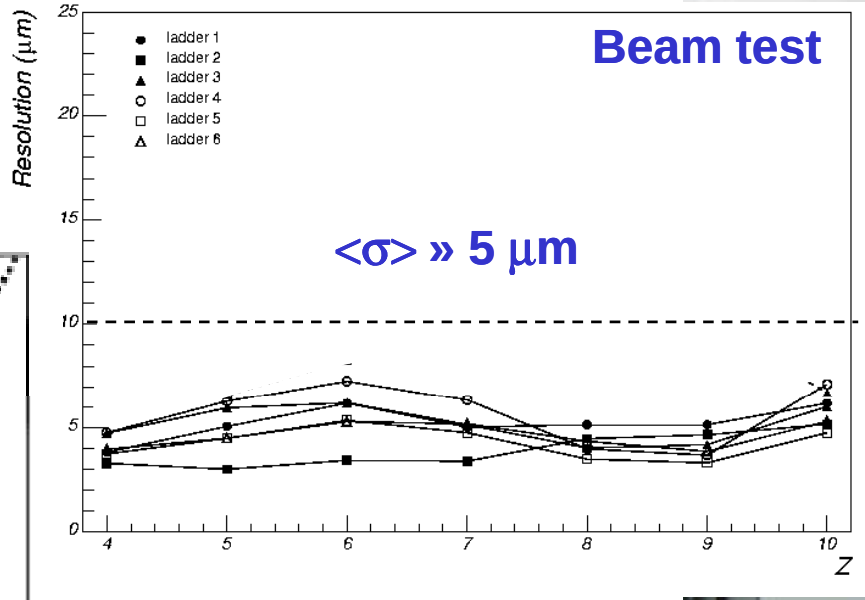
Rigidity measurement

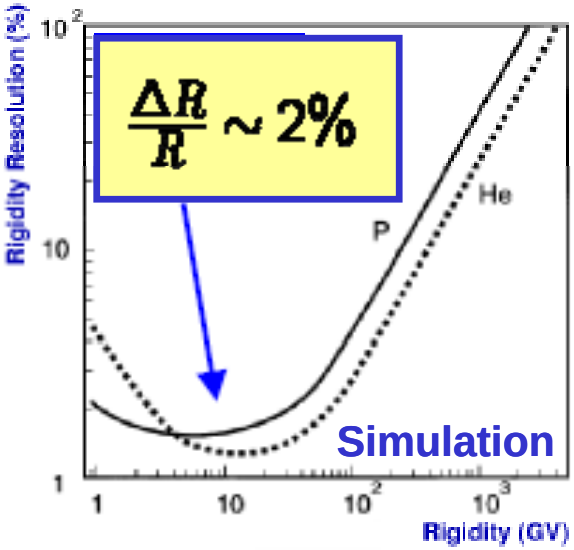
The AMS-02 Si Tracker:

- Silicon double-sided sensors
- 8 layers arranged in 5 planes
- Resolution < 10 μm in the bending direction
- A rigidity determination of 2% at 10 GV

$$R = B\rho = \frac{p}{eZ}$$



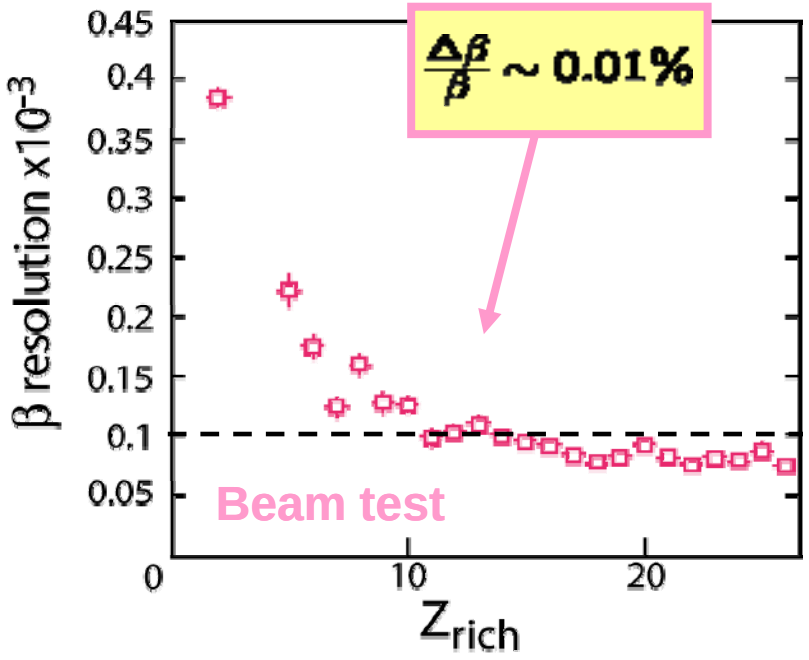


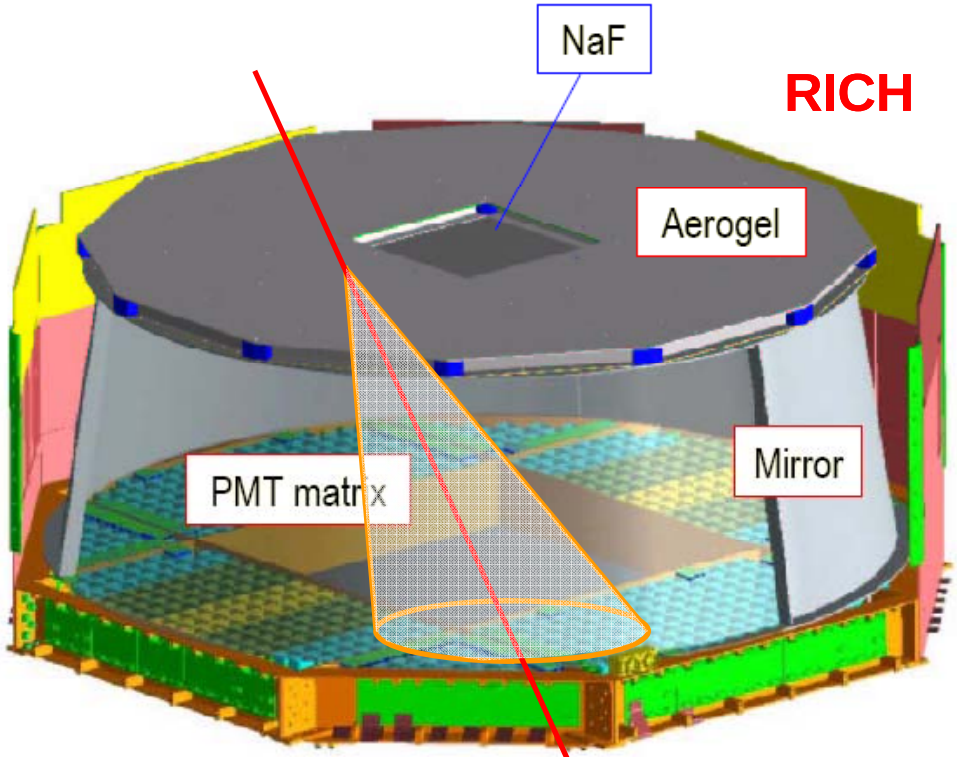


Velocity measurement

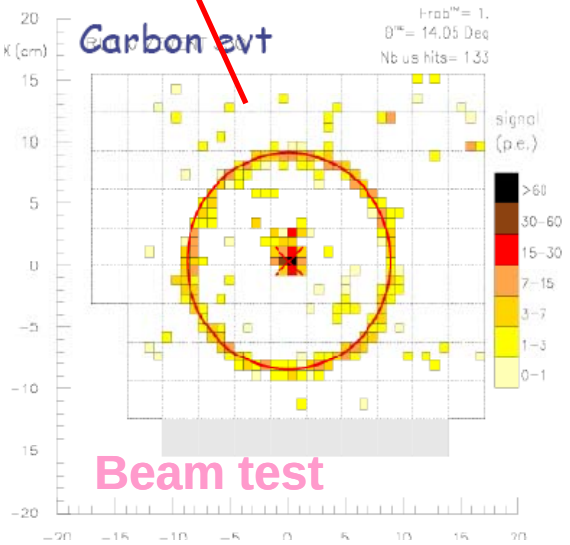
Redundant measurements

- TOF: $\beta = \Delta L/\Delta t$ with $\Delta\beta/\beta \approx 1\%$
- **RICH**: β with $\Delta\beta/\beta \approx 0.01\%$





$$\cos\theta_c = \frac{1}{\beta n}$$



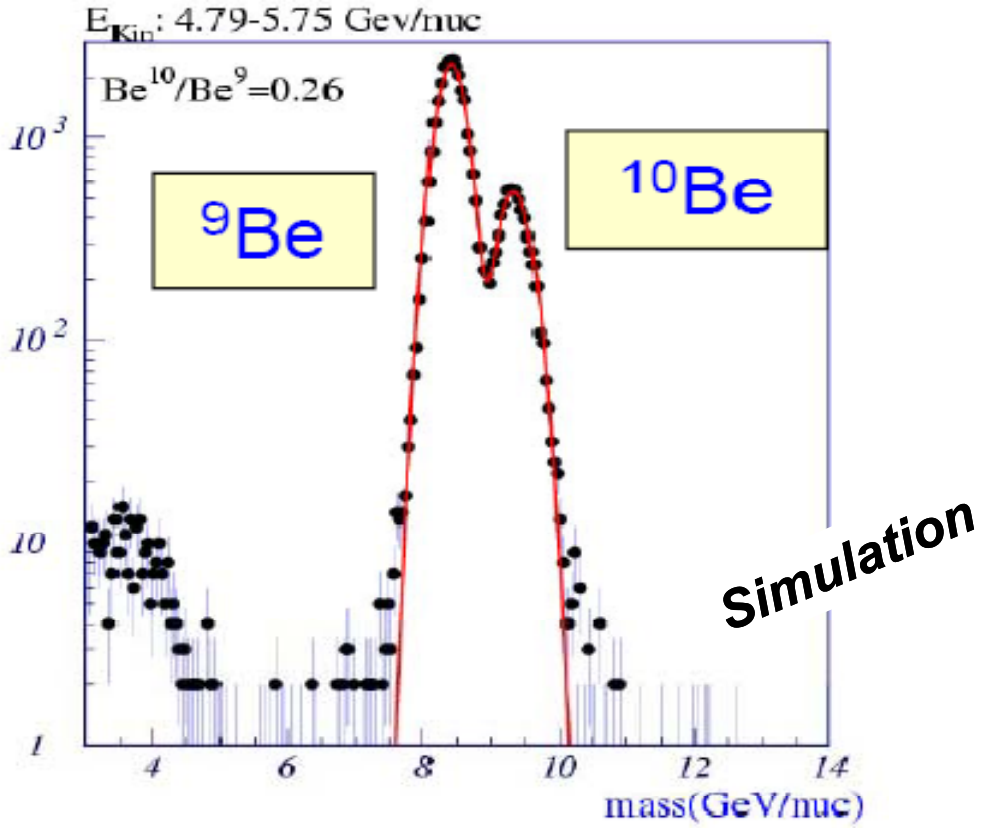
Mass measurement

The AMS-02 spectrometry

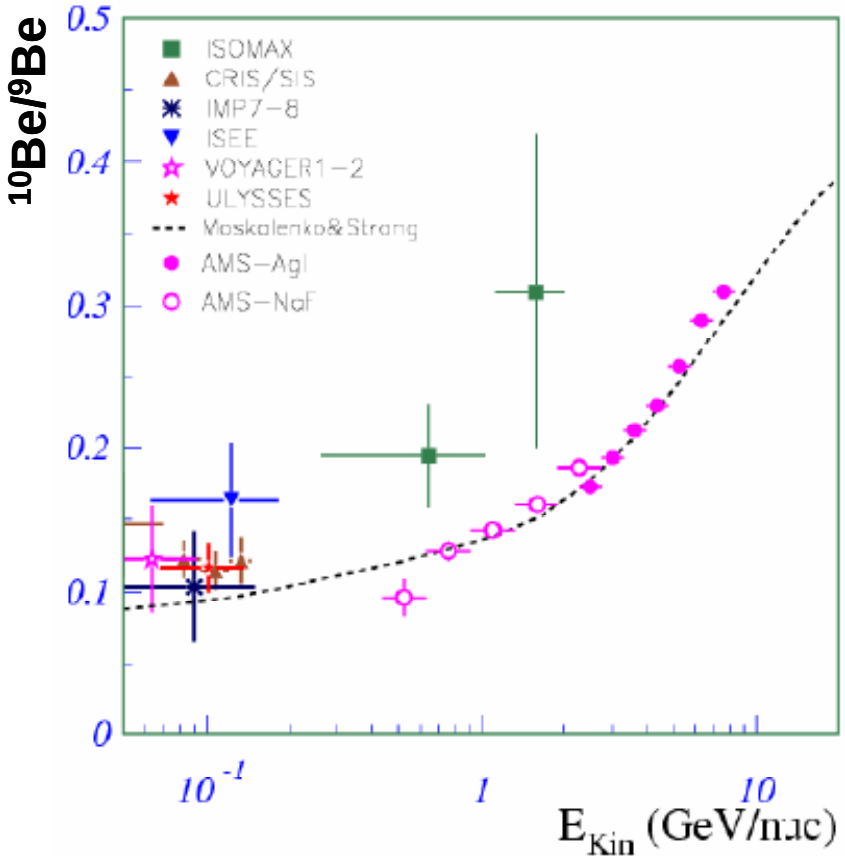
- Tracker for rigidity and charge
- RICH for velocity and charge
- Isotopic distinction up to » 10 GeVn

$$m = \frac{e}{c} \cdot \frac{RZ}{\beta\gamma}$$

$$\left(\frac{\Delta m}{m}\right)^2 = \left(\gamma^2 \frac{\Delta\beta}{\beta}\right)^2 + \left(\frac{\Delta R}{R}\right)^2$$



Simulation



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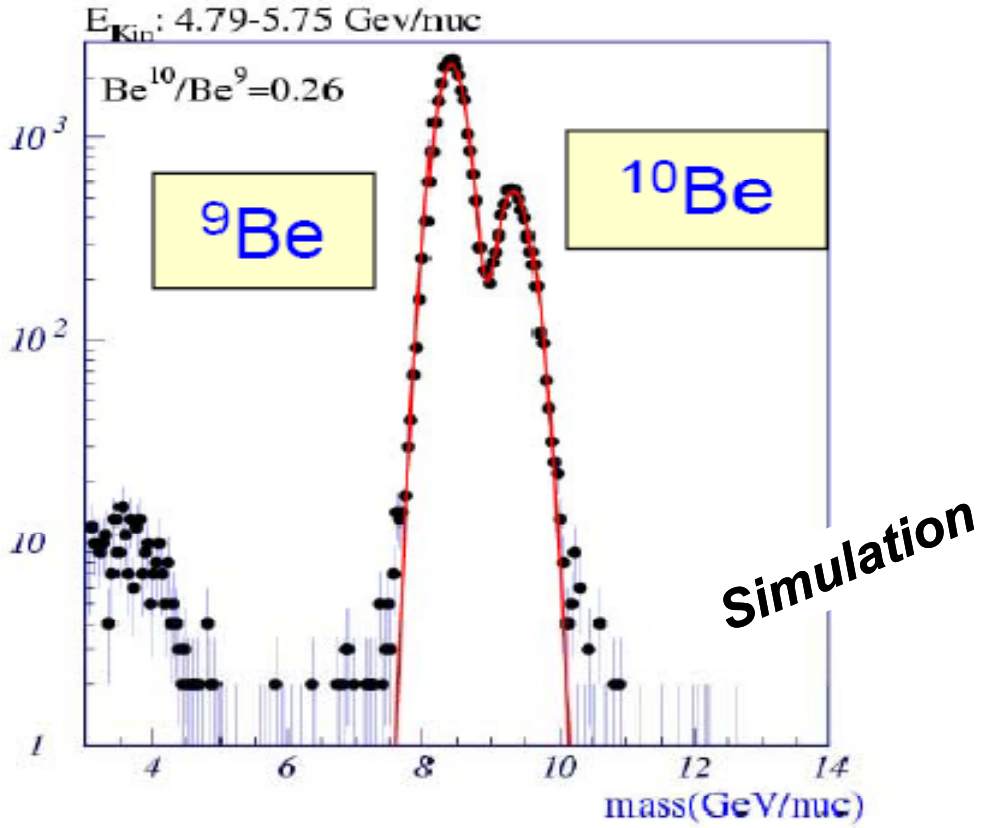
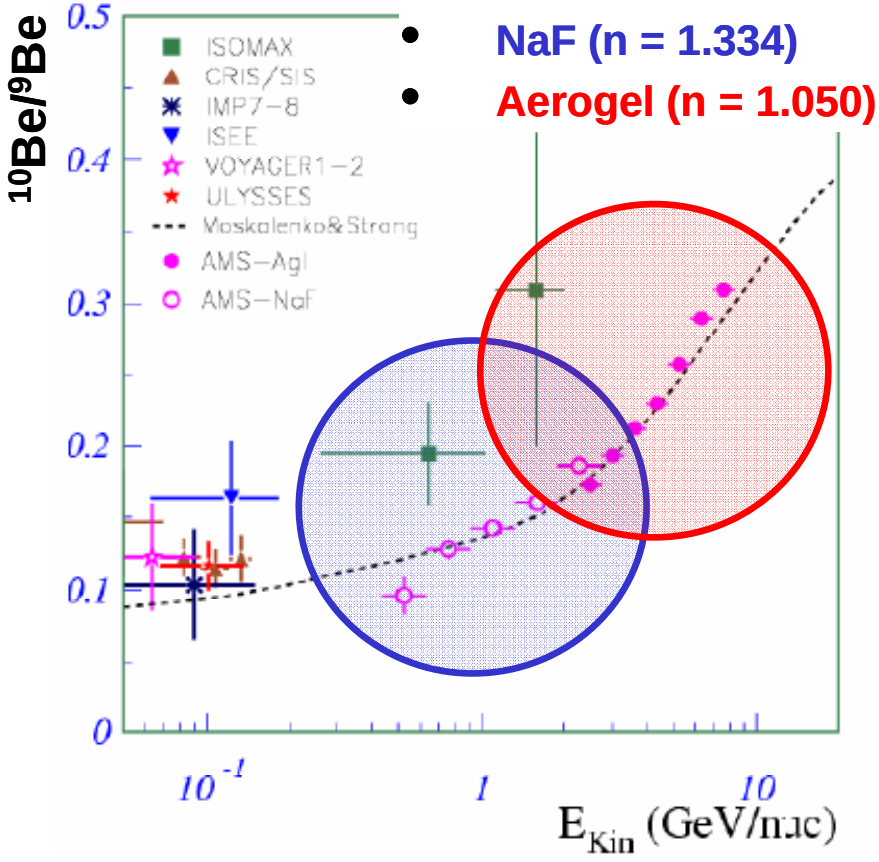


Simulation

Two radiators:

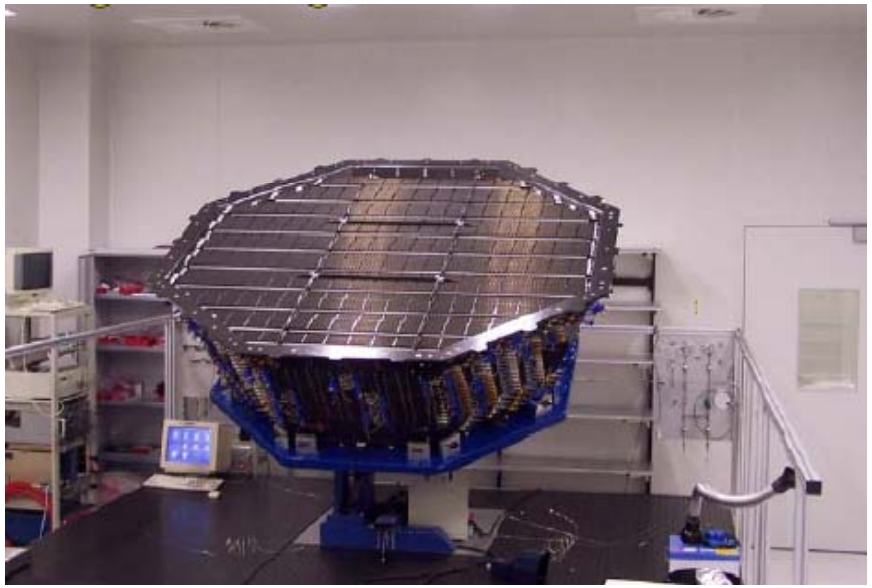
- NaF (n = 1.334)
- Aerogel (n = 1.050)

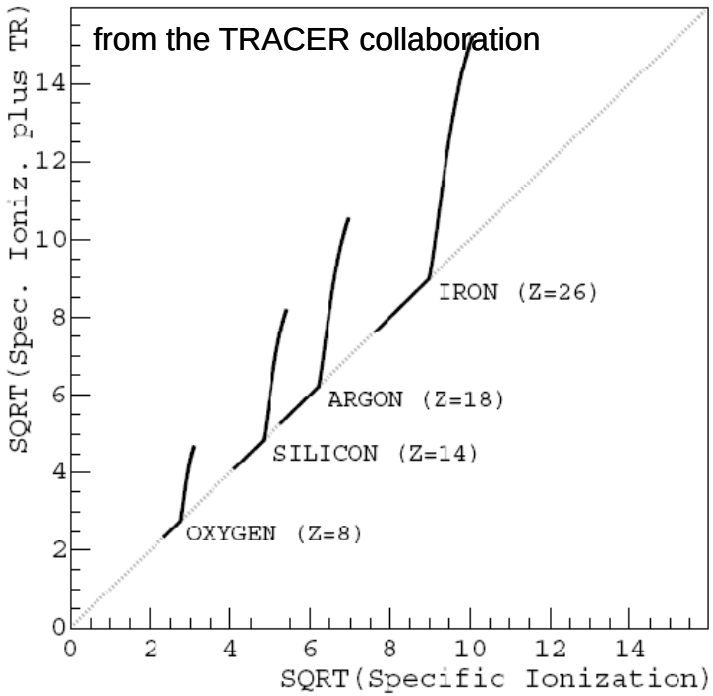


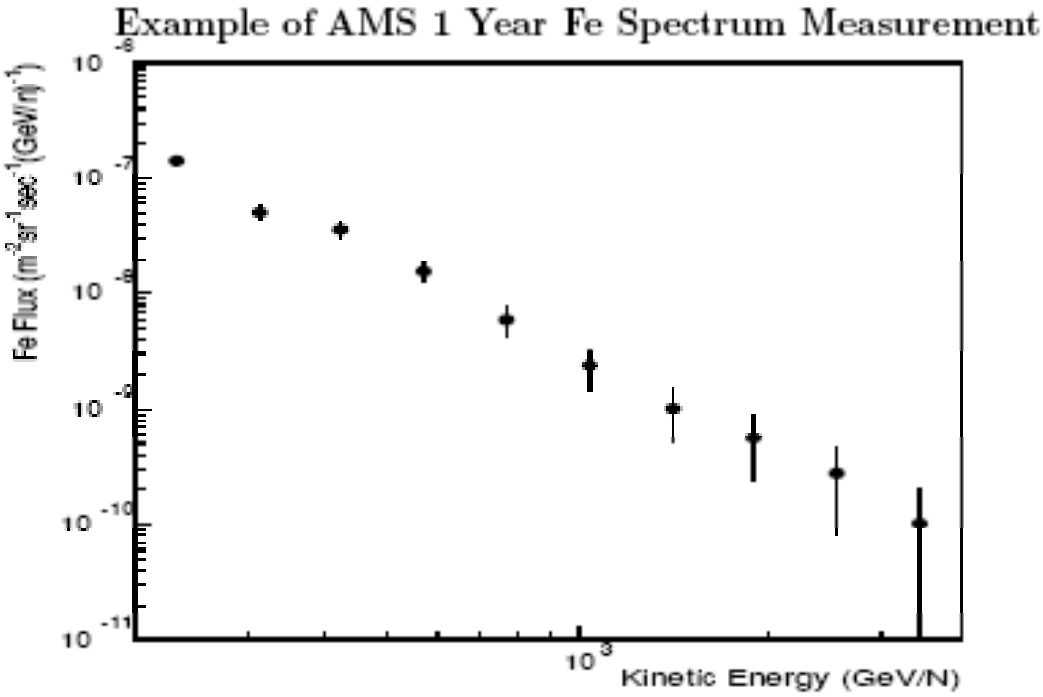
Long term measurement

After 3 years of “full“ magnetic spectrometry:

- Lowering TRD gain by a factor 20
- Measure γ for charges up to Iron
- 10 – 30 % energy resolution
- From 200 to 4000 GeV/n

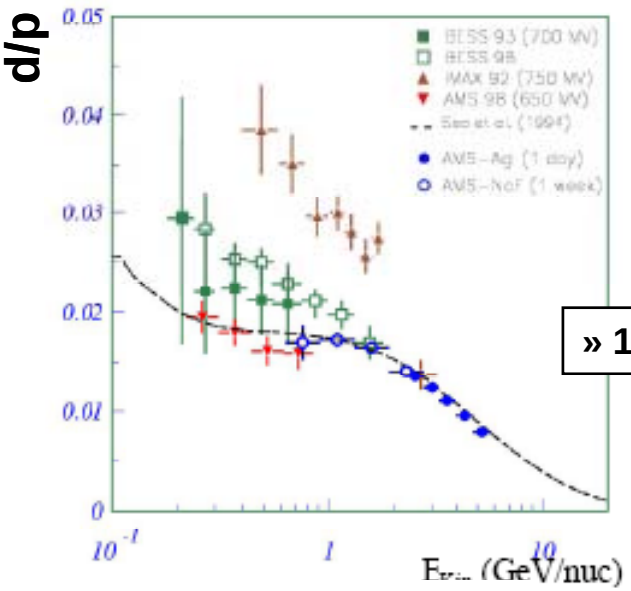






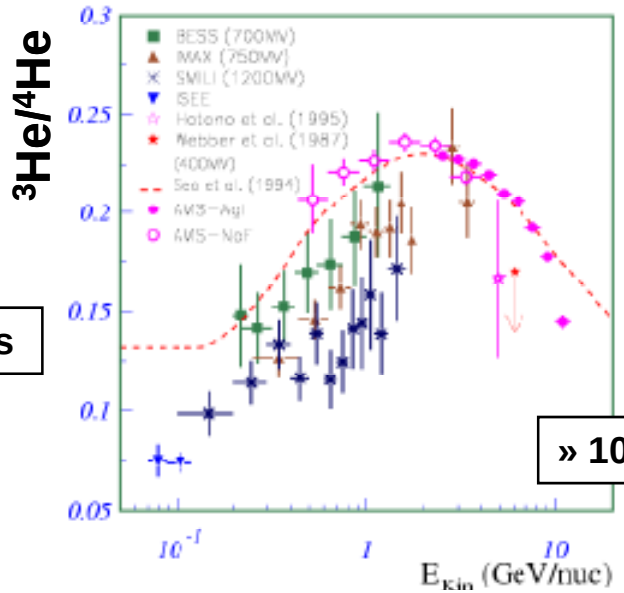
Expected

1 week



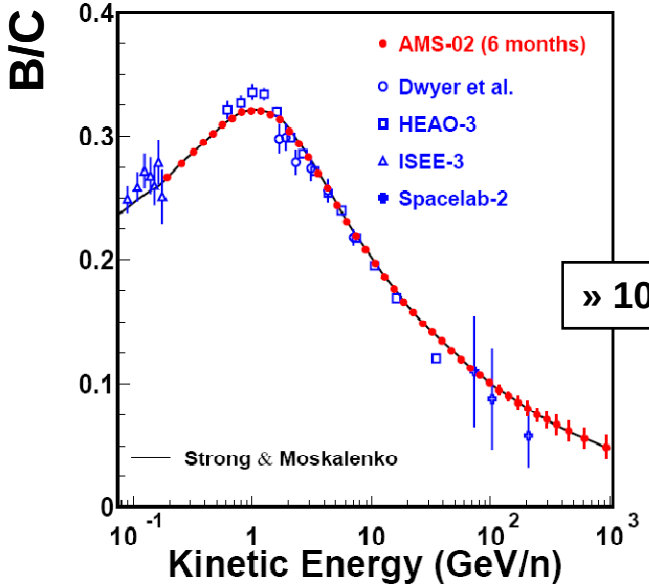
» 10^7 particles

1 day



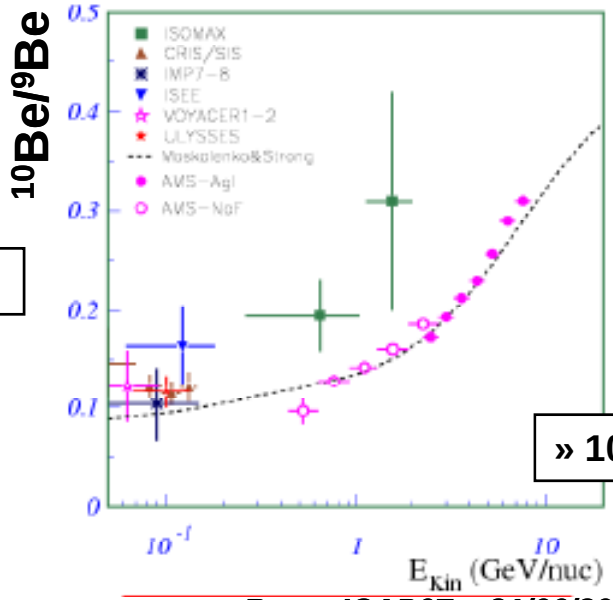
» 10^6 particles

6 months



» 10^7 particles

1 year



» 10^7 particles

Conclusions

- AMS-02 in the integration phase and will be installed on the ISS in 2009
- AMS-02 will perform high statistic measurement of all chemical species up to Iron in CR in a wide energy spectrum
- AMS-02 will play a key role in the CR Astrophysics studies

THANK YOU