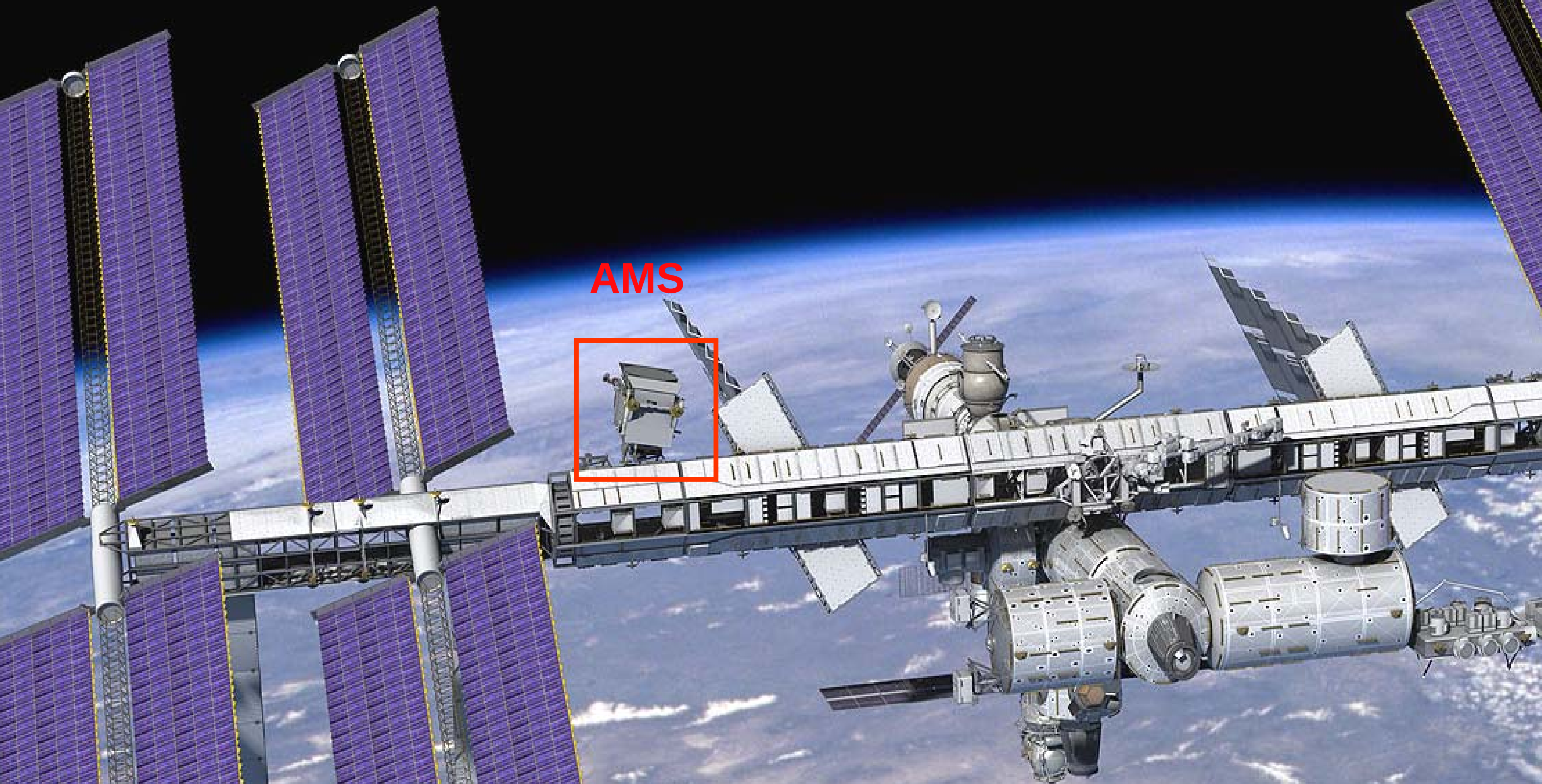
Status of the AMS Experiment



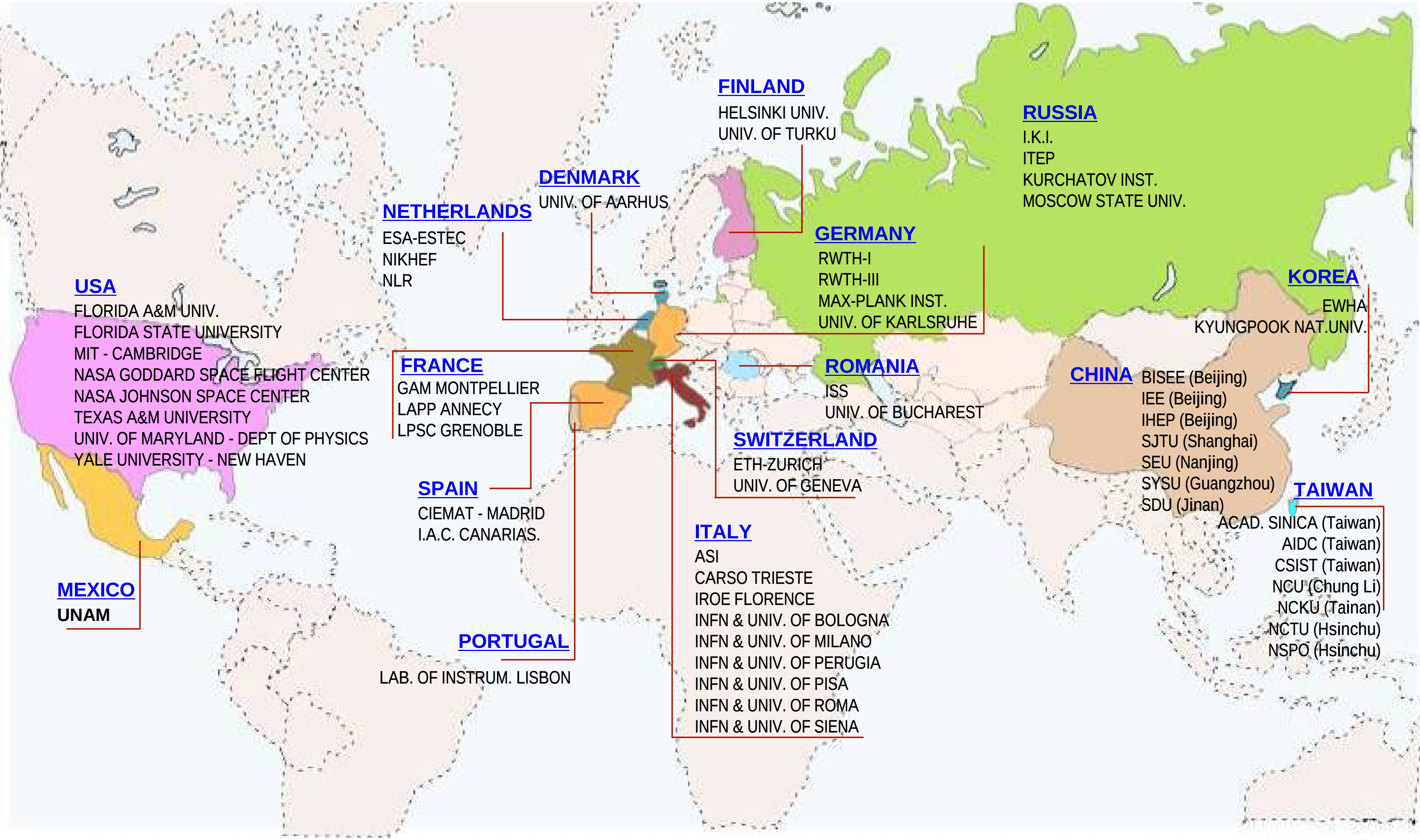
Andrei Kounine / MIT

on behalf of AMS collaboration

ISVHECRI 2010, Fermilab

AMS is a DOE sponsored International Collaboration

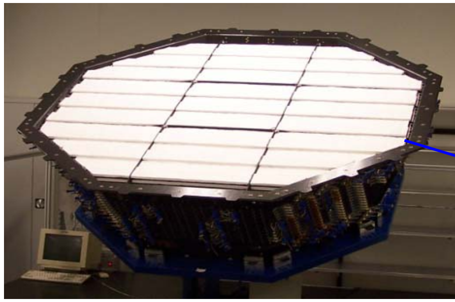
16 Countries, 60 Institutes and 600 Physicists



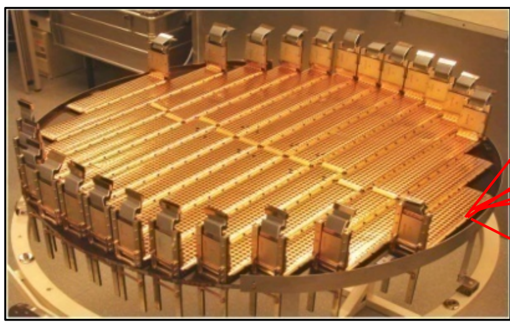
95% of the > $2.0B to build AMS has come from Europe and Asia .

AMS: A TeV precision, multipurpose spectrometer

TRD
Identify e+, e-

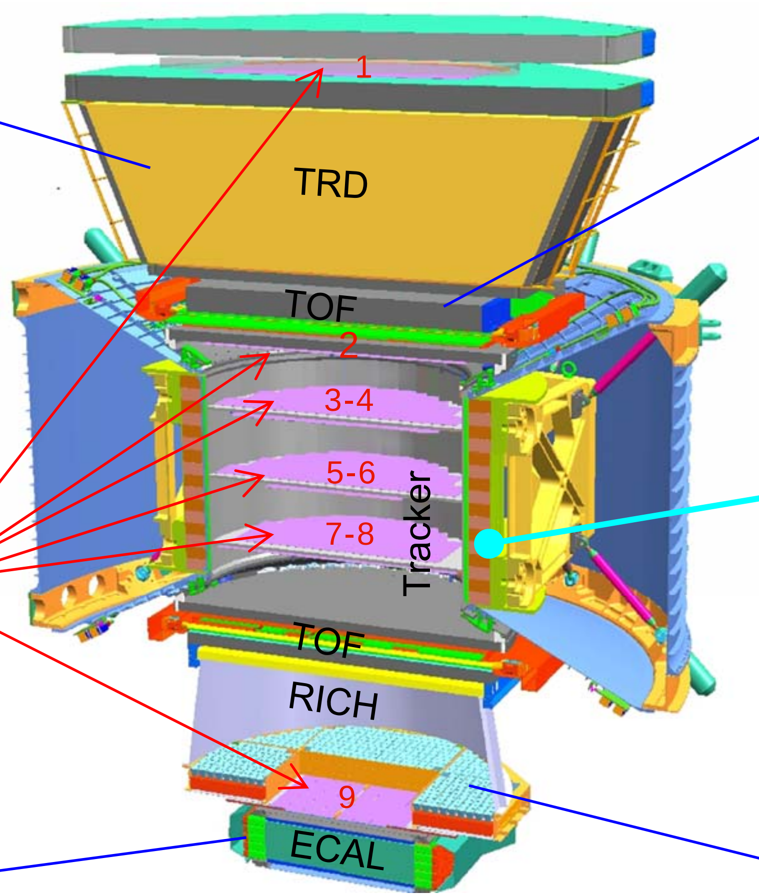


Silicon Tracker
Z, P



ECAL
E of e+, e-, γ

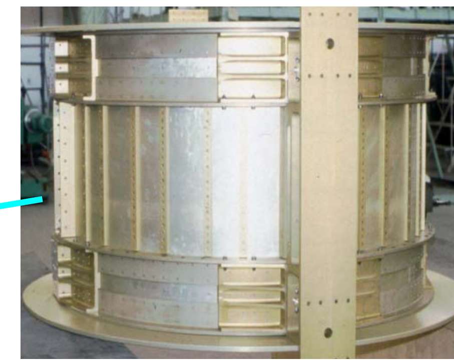
Particles and nuclei are defined by their charge (**Z**) and energy (**E ~ P**)



***Z, P** are measured independently from Tracker, RICH, TOF and ECAL*

TOF
Z, E

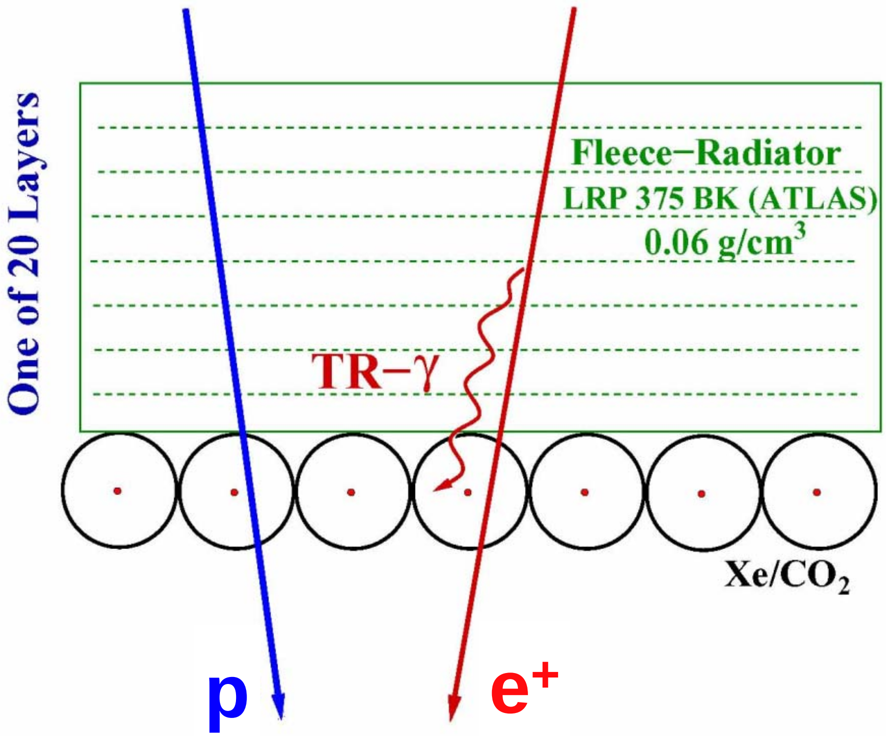
Magnet
±Z

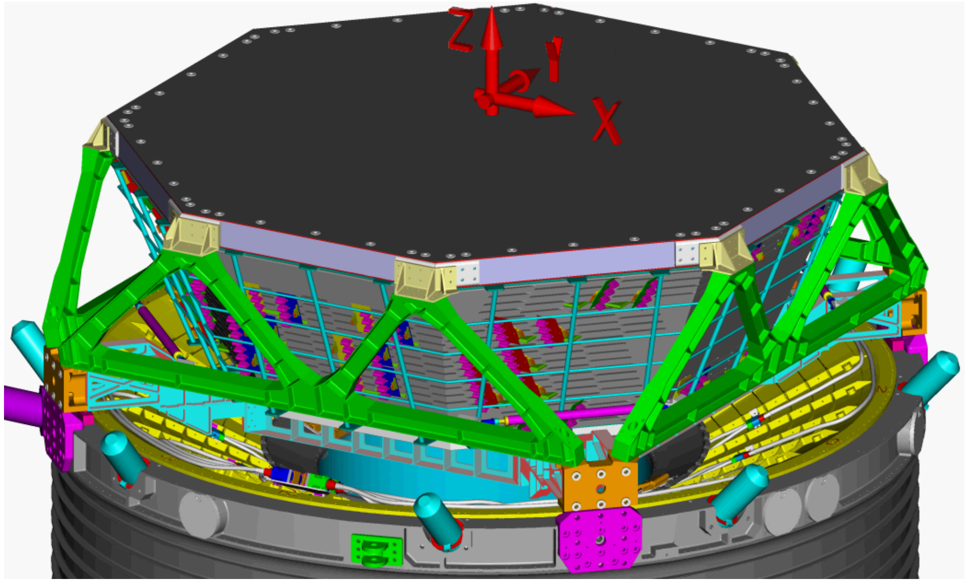


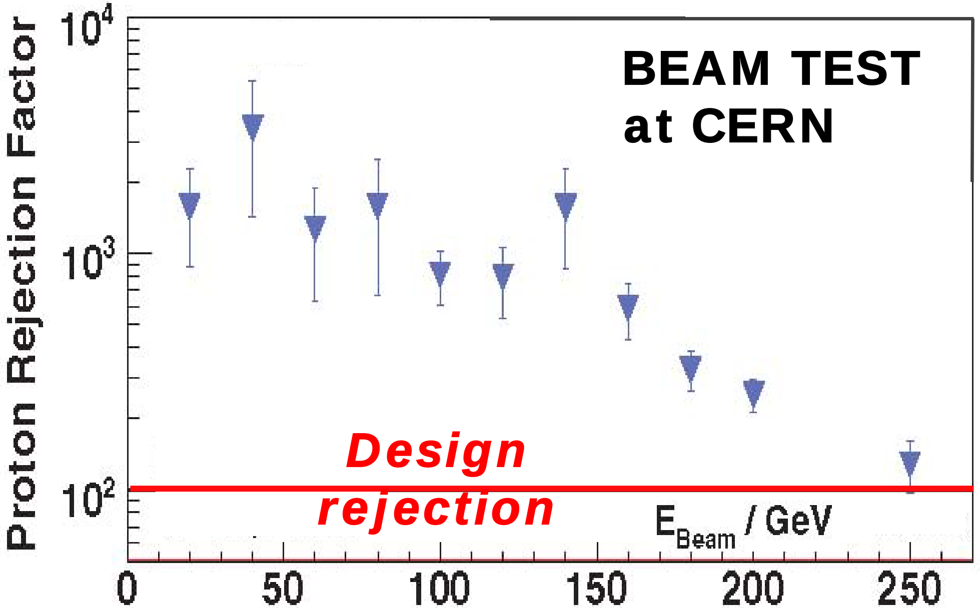
RICH
Z, E

Transition Radiation Detector: TRD

Identify e^+, reject P



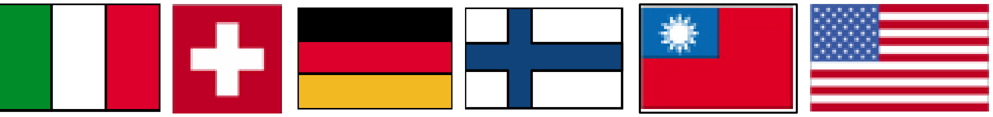




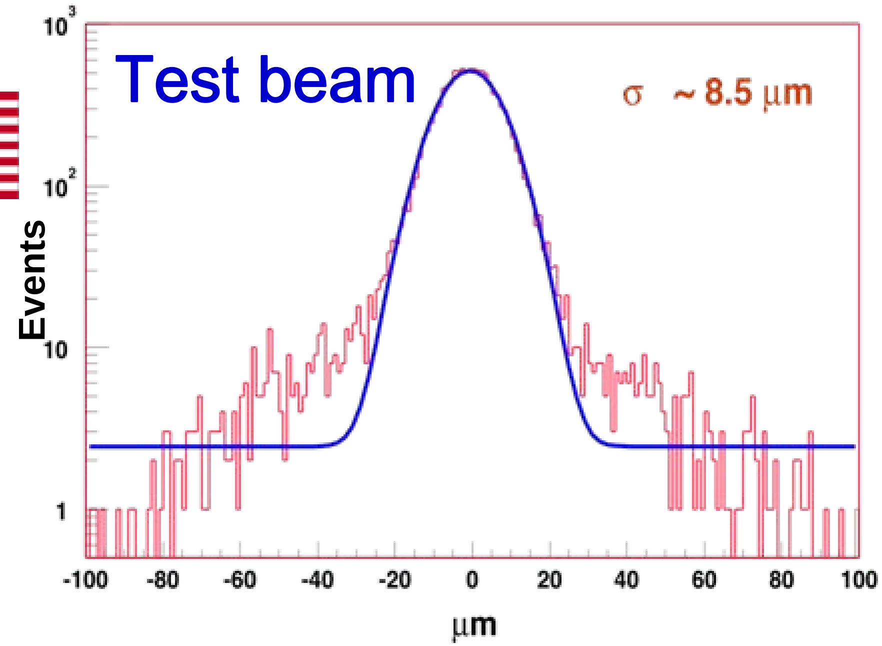
Leakrate: CO_2 ≈ 6 μg/s

Storage: 5 kg – 24 years lifetime

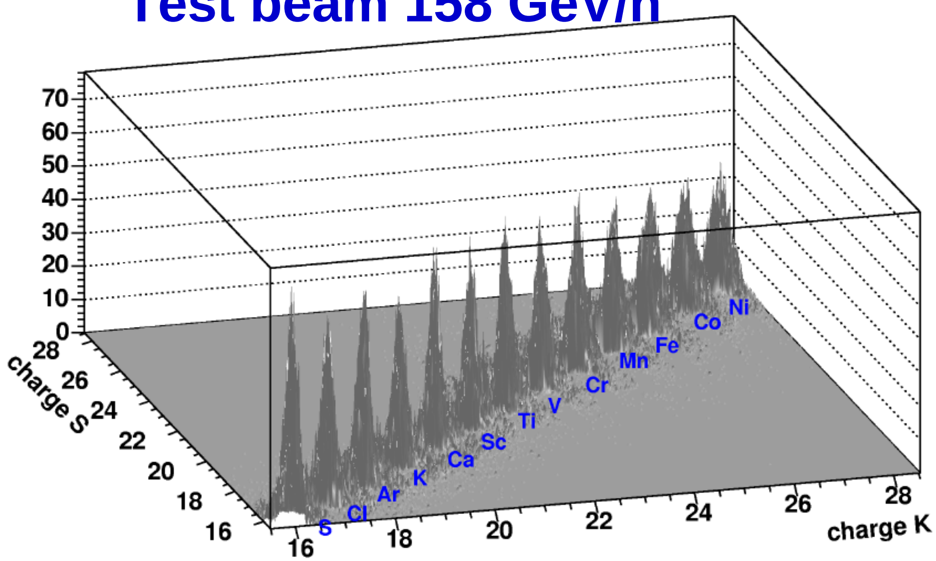
Silicon Tracker

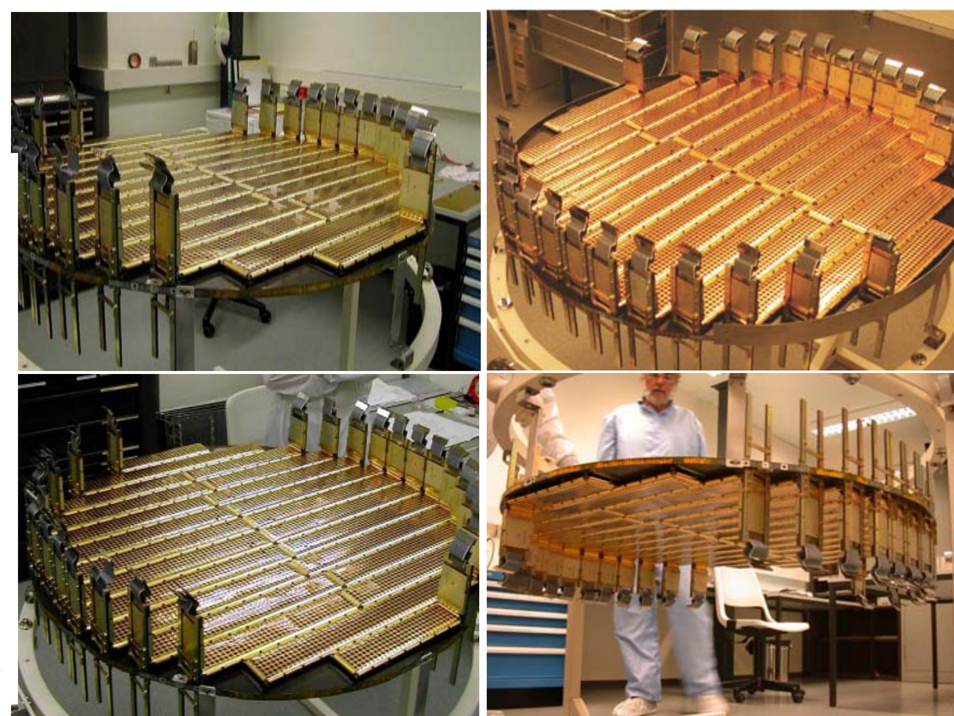


10 mil pitch; 200,000 channels; alignment 3 μm

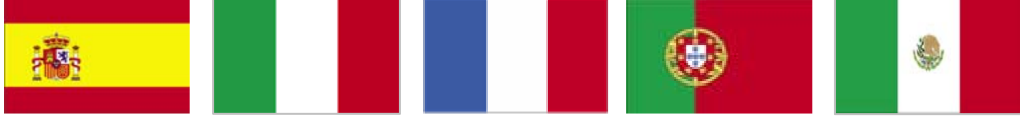


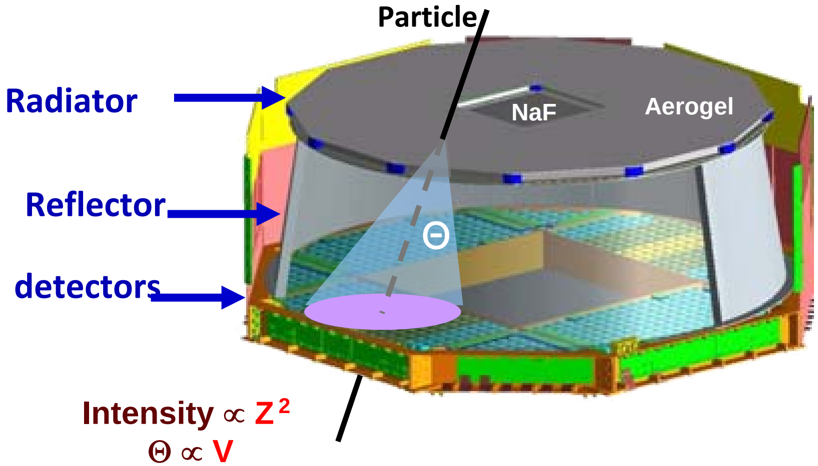
Test beam 158 GeV/n

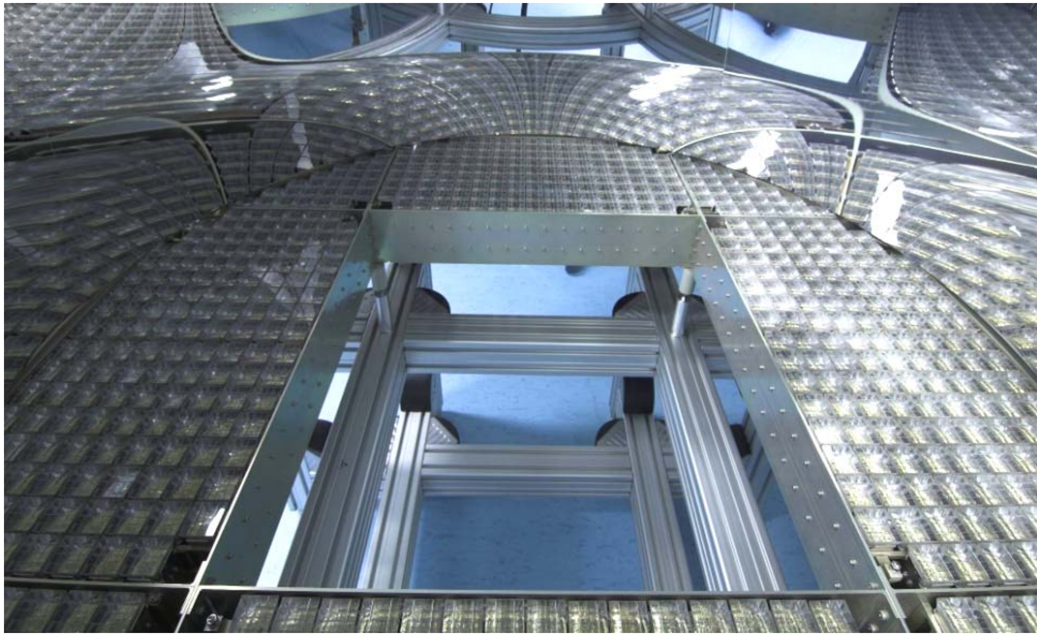




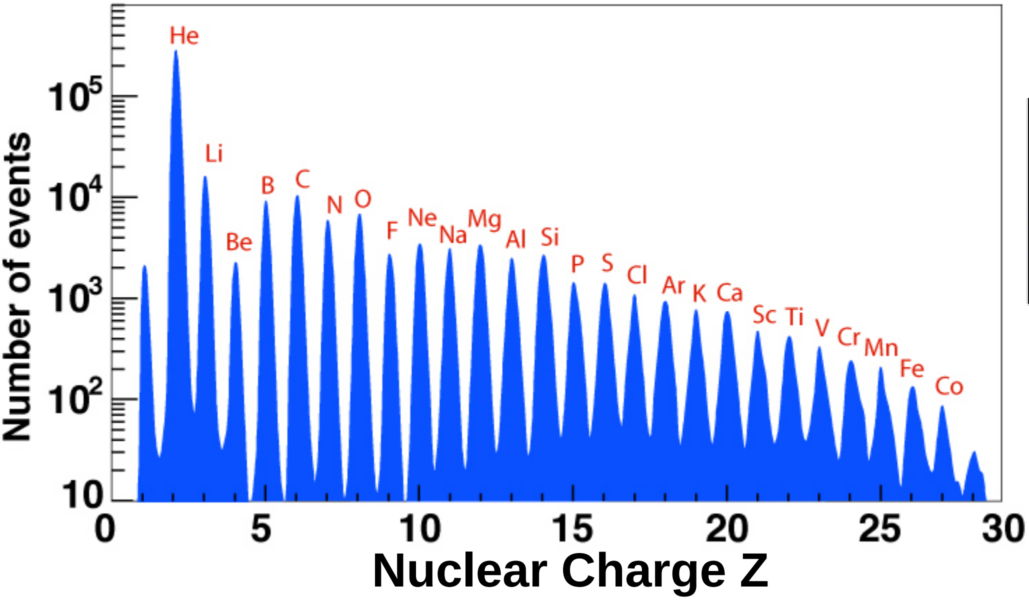
Ring Imaging Cherenkov Detector (RICH)

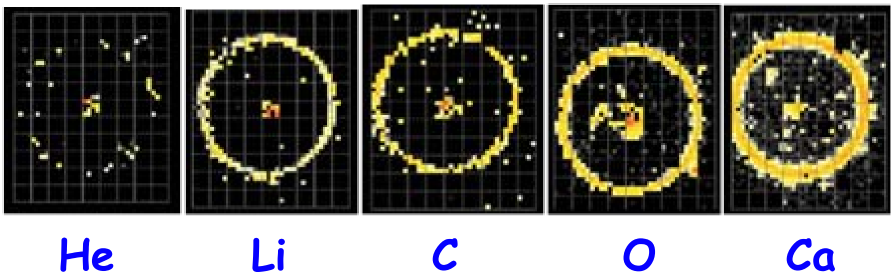






10,880 photosensors



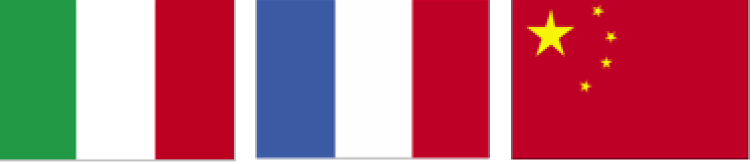


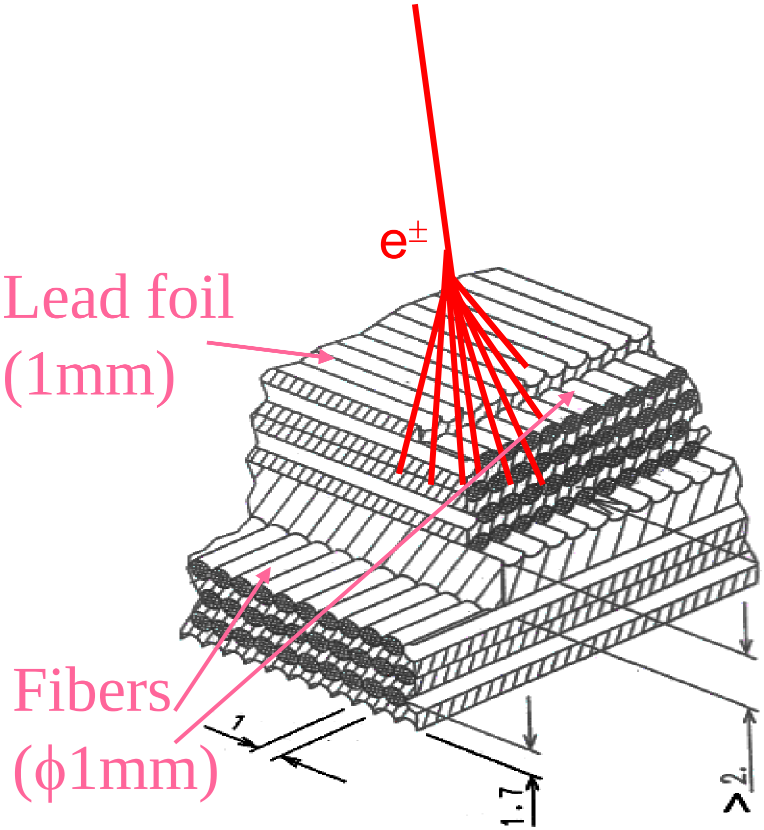
Single Event Displays

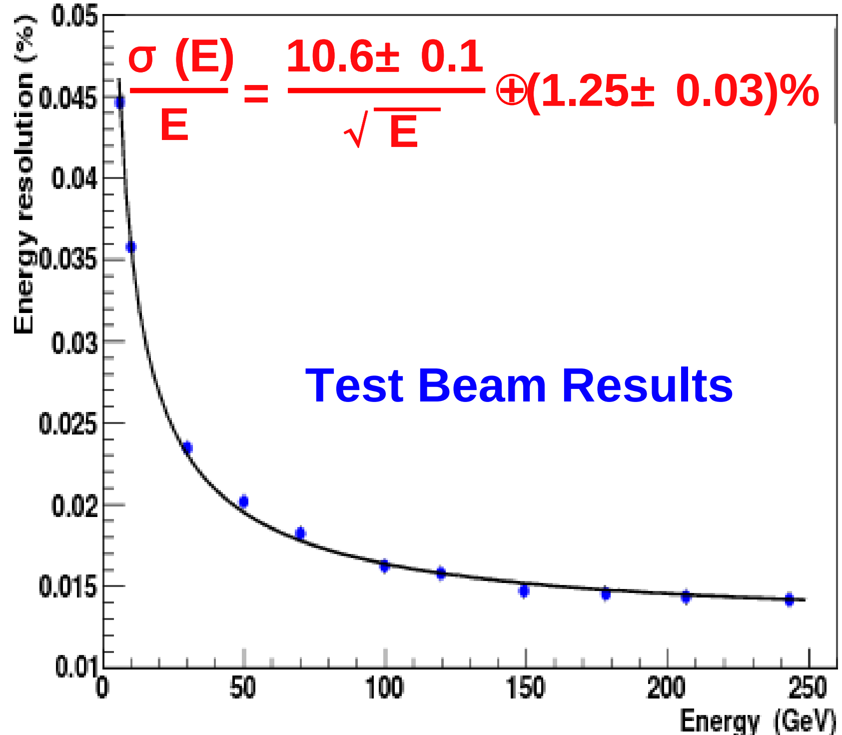
RICH test beam E=158 GeV/n

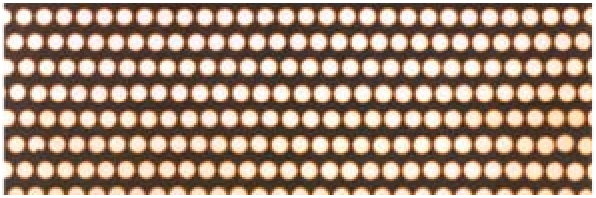
Calorimeter (ECAL)

A precision, 17 X_0, 3-dimensional measurement of the directions and energies of light rays and electrons







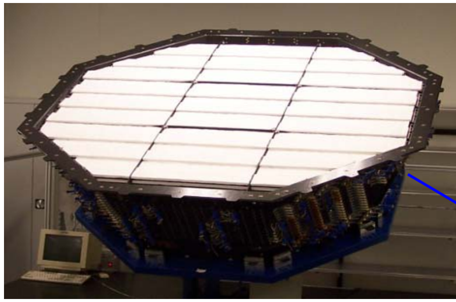


10 000 fibers, $\phi = 1$ mm distributed uniformly Inside 1,200 lb of lead


2009: AFTER 9000 hrs of TVT...THE END OF SUB-SYSTEM TESTS
THE END
SSRMS places AMS on S3 Upper Inboard Payload Attach Site

AMS assembly for 3-year mission on ISS

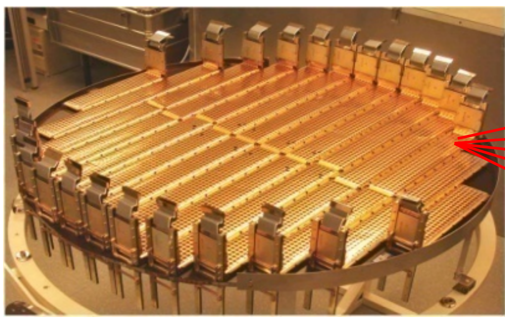
TRD
Identify e+, e-

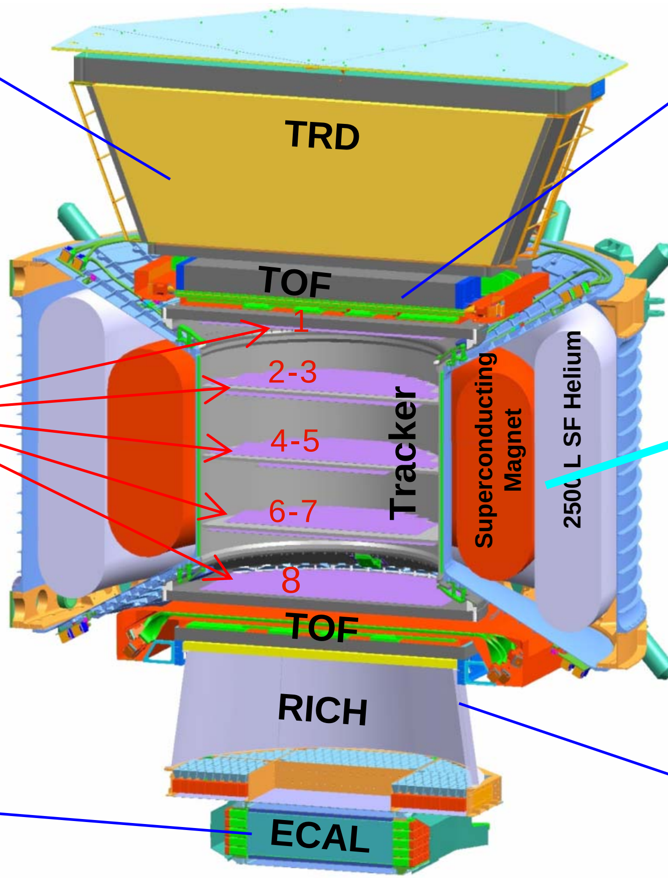


Particles and nuclei are defined by their charge (**Z**) and energy (**E ~ P**)

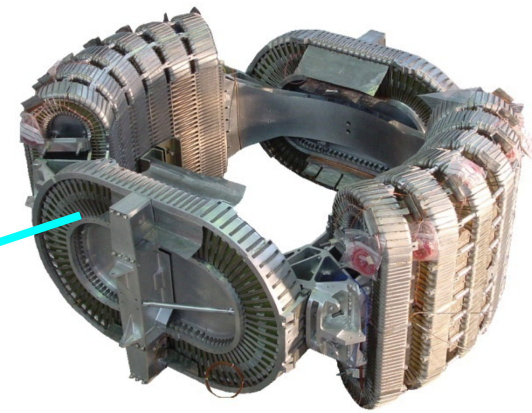
TOF
Z , E

Silicon Tracker
Z , P



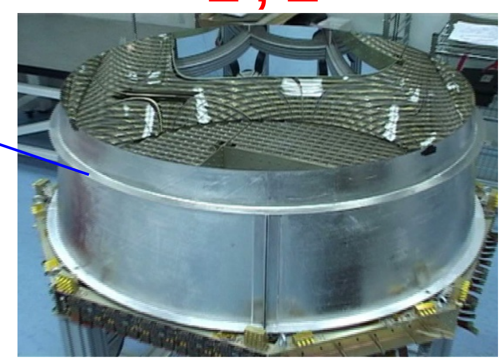


Magnet
±Z



ECAL
E of e+, e-, γ

RICH
Z , E

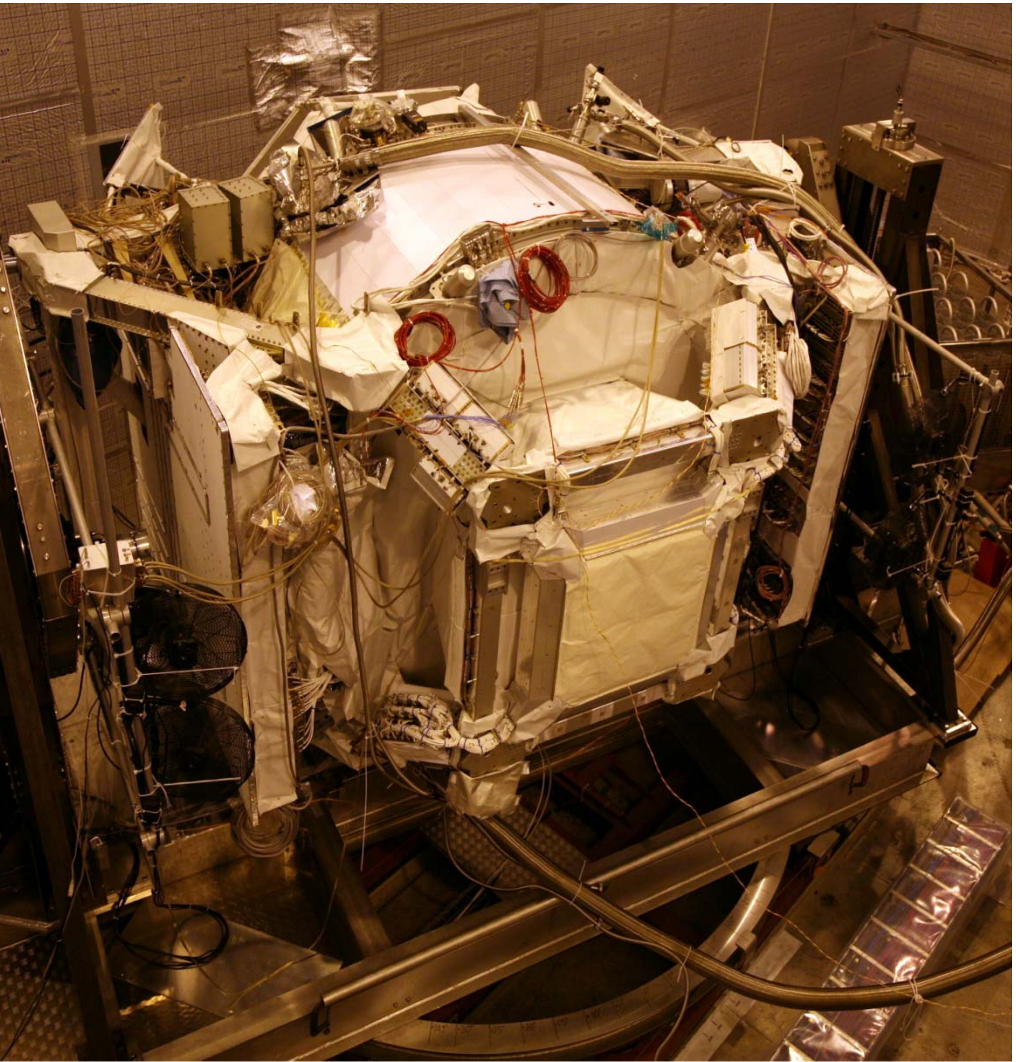


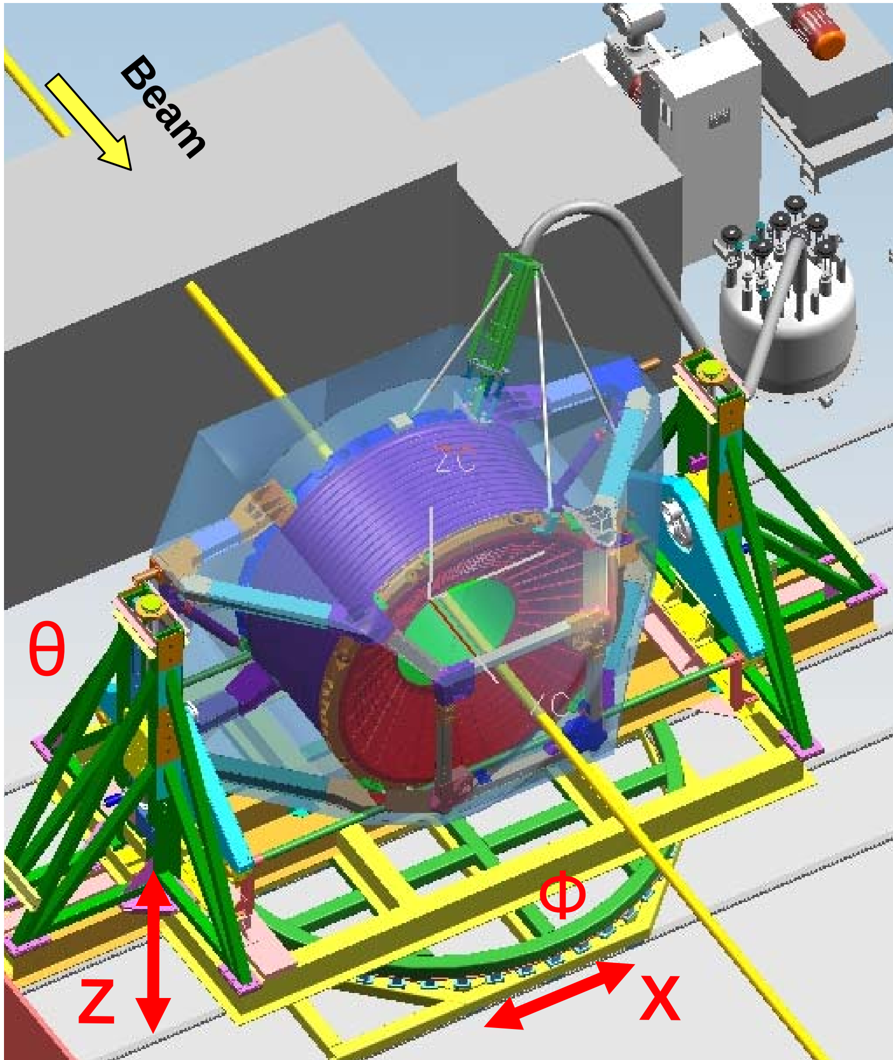
Z, E are measured independently from Tracker, RICH, TOF and ECAL

AMS in Test Beam, Feb 4-8, 2010

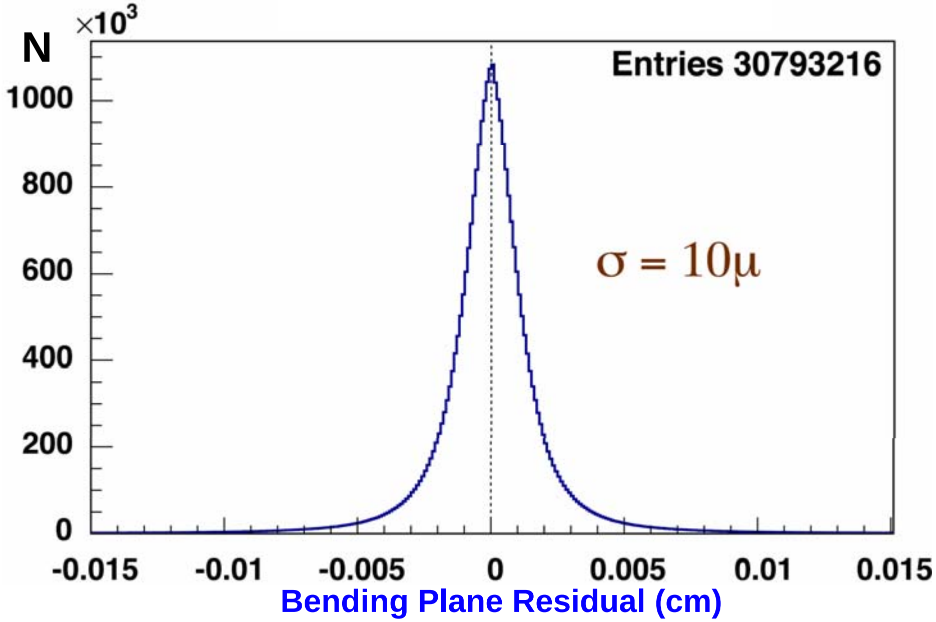
Tests were performed with the superconducting magnet charged to its design current of 400A and to 80A corresponding to the field of the AMS-01 permanent magnet.

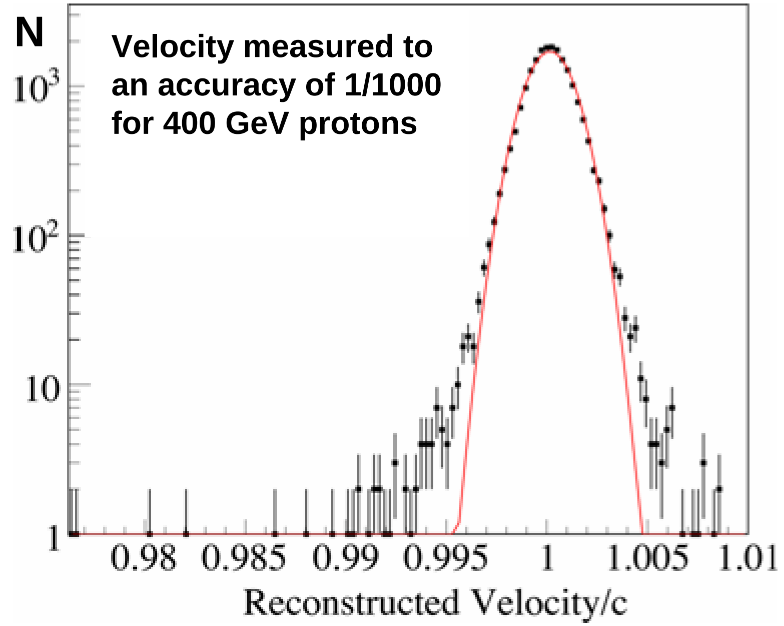
TRD, Tracker, RICH, TOF and ECAL performance was not affected by the change of magnetic field

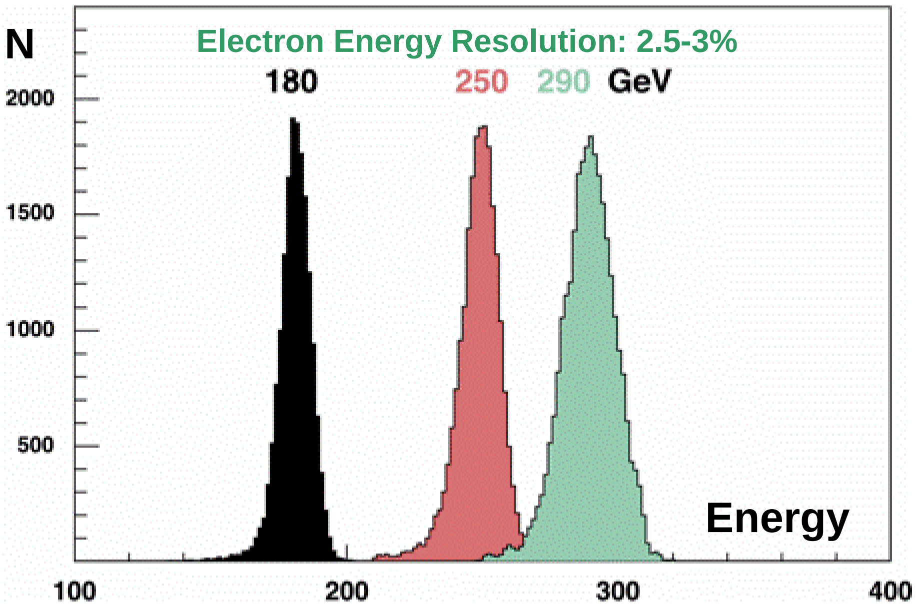


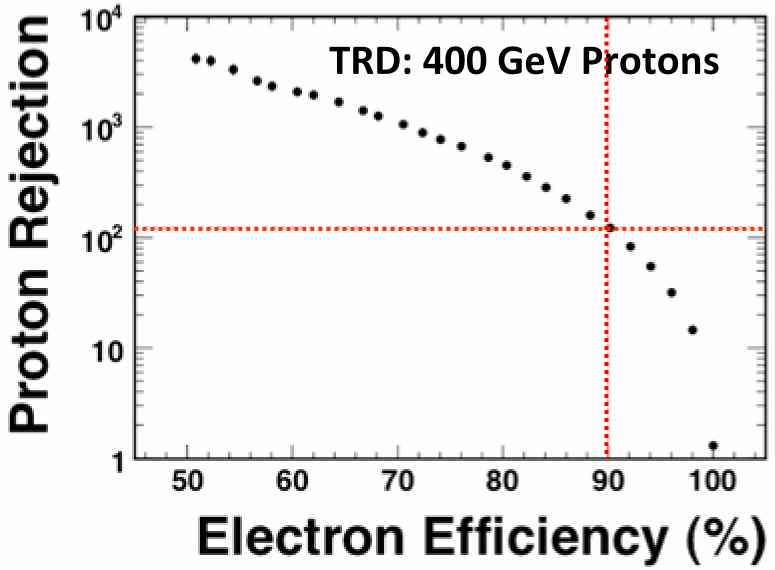


Test Beam Results of integrated detector



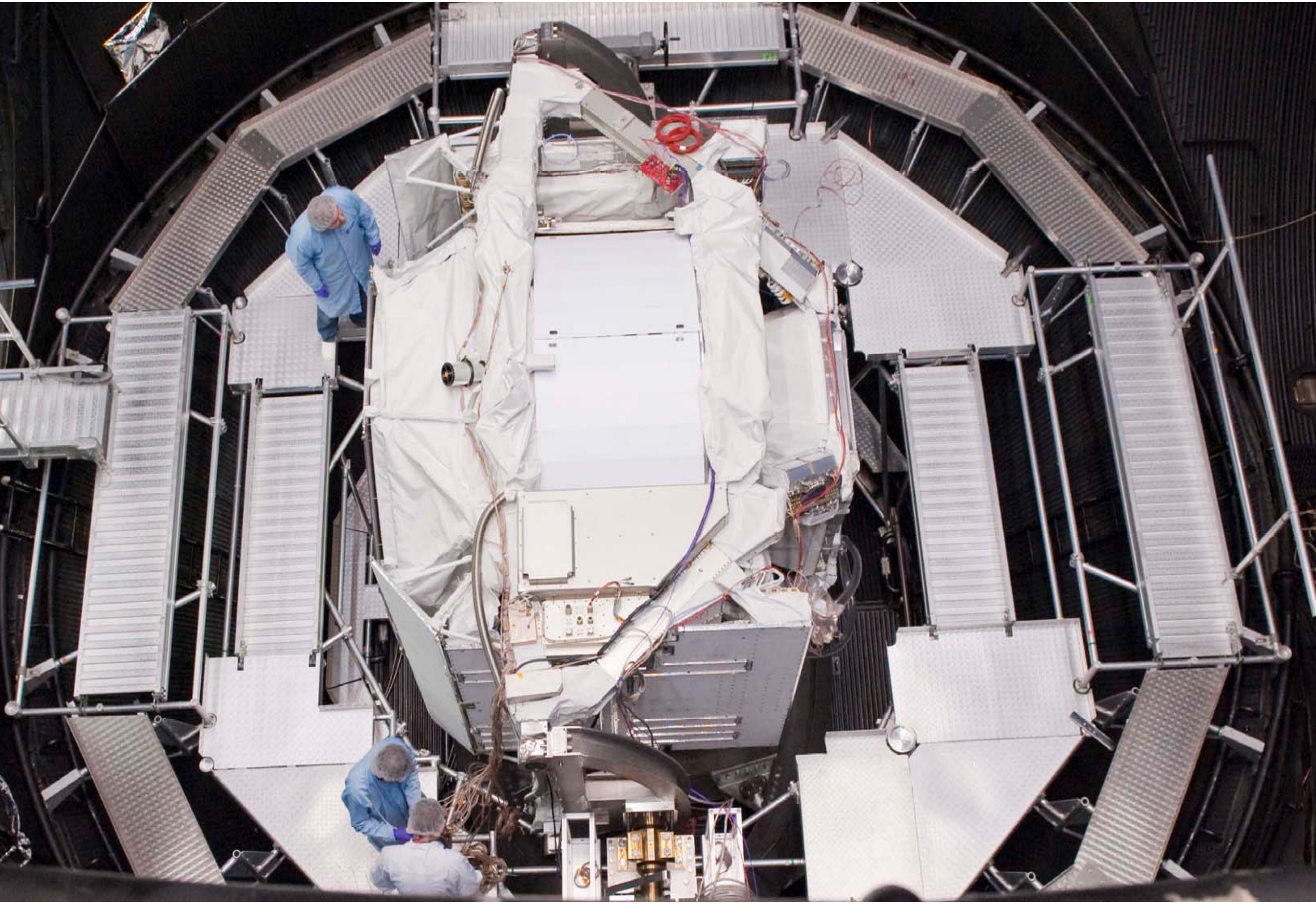




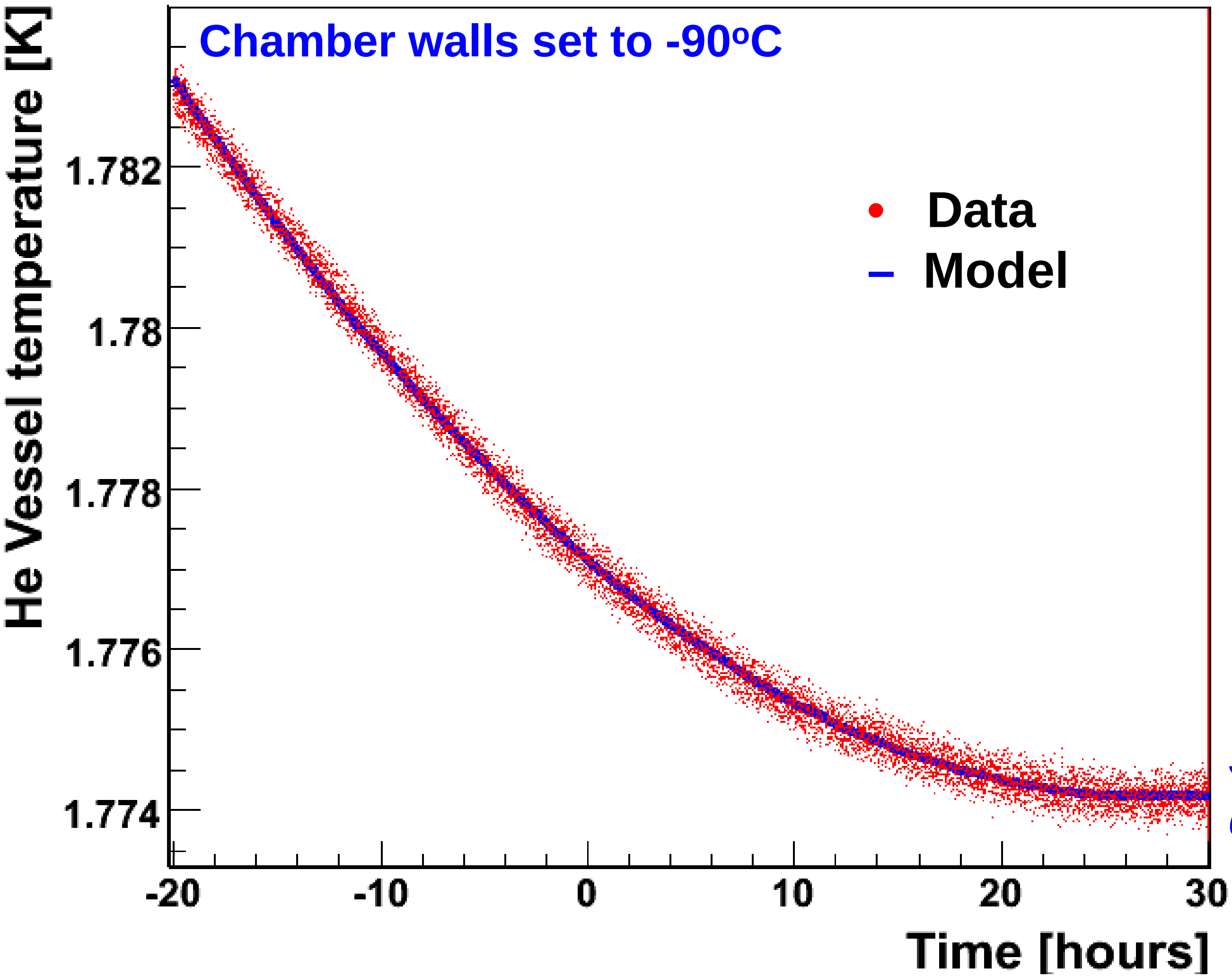


Measured combined rejection power at 400 GeV: $e^+/p = 10^{-6}$

AMS in the ESA TVT Chamber



Stabilization of the He Vessel



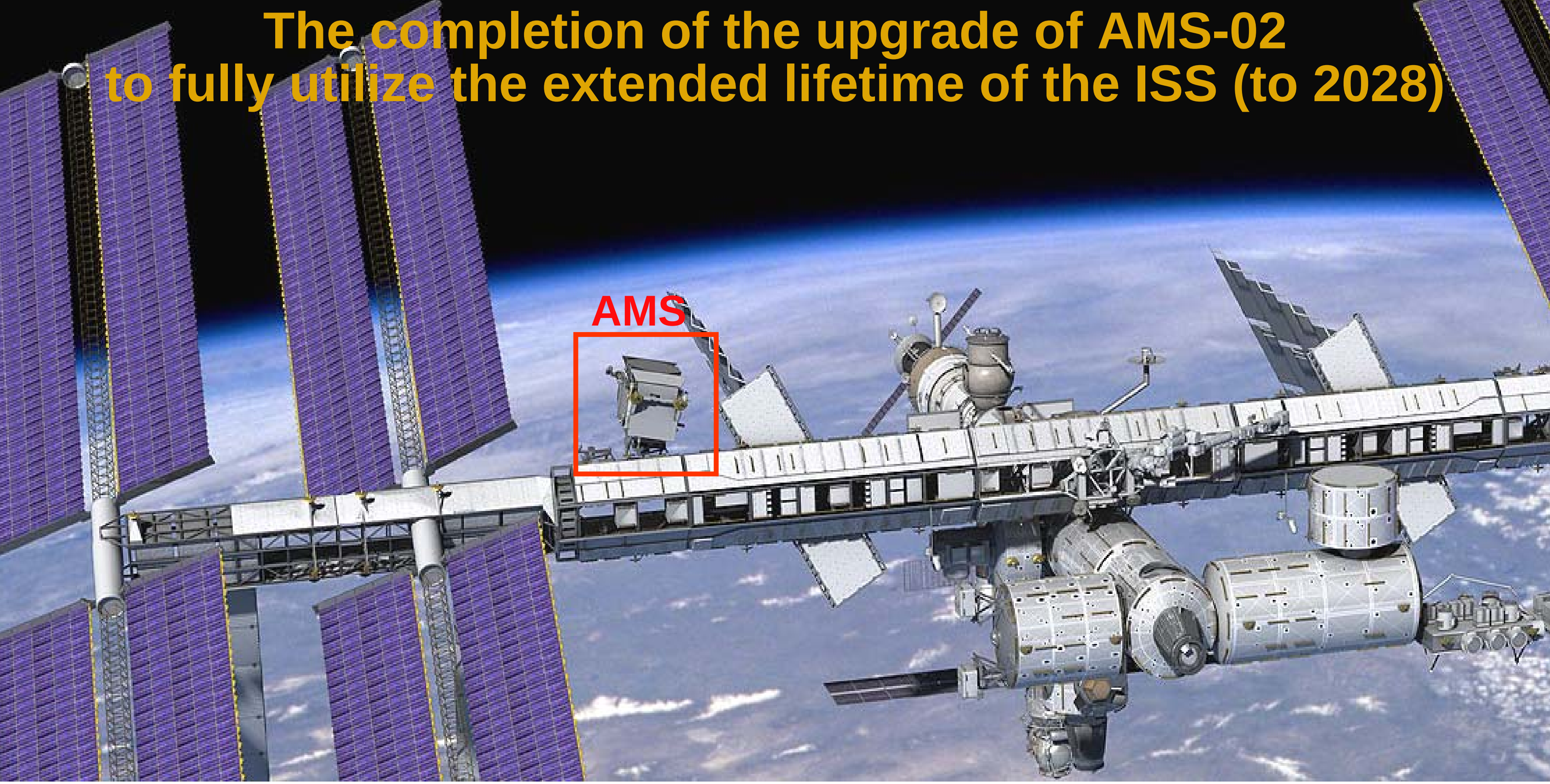
Stability criteria:
dT/dt < 0.0001K/h

Expected life time of the AMS Cryostat on ISS:

20±4 months with M87 cryocoolers (1999)

28±6 months with GT cryocoolers (2010)

The completion of the upgrade of AMS-02 to fully utilize the extended lifetime of the ISS (to 2028)



This upgrade has been supported by agencies from
Italy, Germany, Switzerland, Spain, the Netherlands and the U.S.A.

The European science community realizes the importance of full exploitation of the potential of ISS, to which they have contributed greatly.

Michael Braukus
Headquarters, Washington
202-358-1979
michael.j.braukus@nasa.gov

March 11, 2010

RELEASE : 10-063

Heads of Agency International Space Station Joint Statement

TOKYO -- The heads of the International Space Station (ISS) agencies from Canada, Europe, Japan, Russia, and the United States met in Tokyo, Japan, on March 11, 2010, to review ISS cooperation.

With the assembly of the ISS nearing completion and the capability to support a full-time crew of six established, they noted the outstanding opportunities now offered by the ISS for on-orbit research and for discovery including the operation and management of the world's largest international space complex. In particular, they noted the unprecedented opportunities that enhanced use of this unique facility provides to drive advanced science and technology. This research will deliver benefits to humanity on Earth while preparing the way for future exploration activities beyond low-Earth orbit. The ISS will also allow the partnership to experiment with more integrated international operations and research, paving the way for enhanced collaboration on future international missions.

The heads of agency reaffirmed the importance of full exploitation of the station's scientific, engineering, utilization, and education potential. They noted that there are no identified technical constraints to continuing ISS operations beyond the current planning horizon of 2015 to at least 2020, and that the partnership is currently working to certify on-orbit elements through 2028. The heads of agency expressed their strong mutual interest in continuing operations and utilization for as long as the benefits of ISS exploitation are demonstrated. They acknowledged that a U.S. fiscal year 2011 budget consistent with the U.S. administration's budget request would allow the United States to support the continuation of ISS operations and utilization activities to at least 2020. They emphasized their common intent to undertake the necessary procedures within their respective governments to reach consensus later this year on the continuation of the ISS to the next decade.

In looking ahead, the heads of agency discussed the importance of increasing ISS utilization and operational efficiency by all possible means, including finding and coordinating efficiencies across the ISS Program and assuring the most effective use of essential capabilities, such as space transportation for crew and cargo, for the life of the program.

For the latest about the International Space Station, visit the Internet at: http://www.nasa.gov/station

- end -

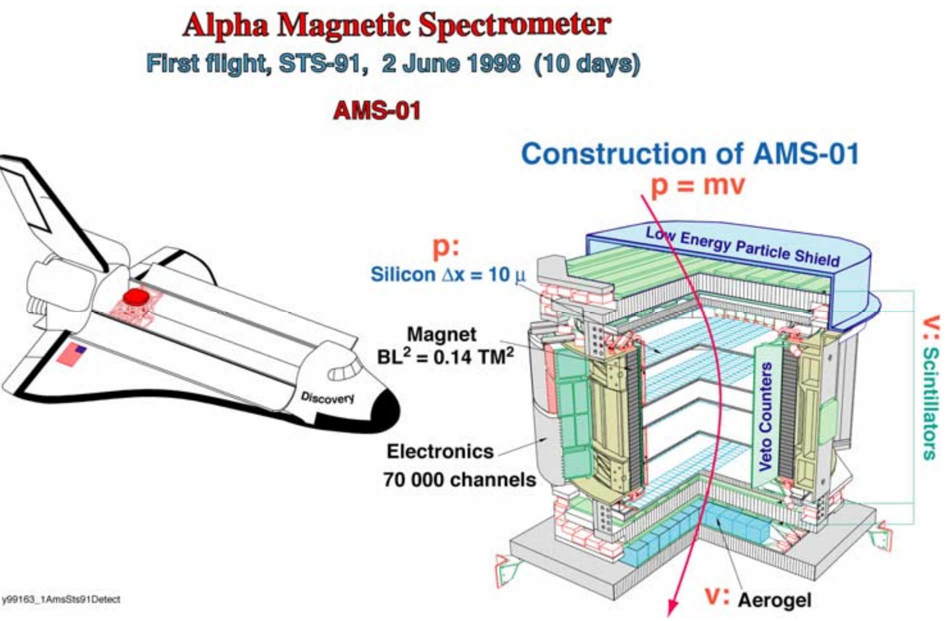
A superconducting magnet was ideal for a three year stay on ISS as originally planned for AMS.

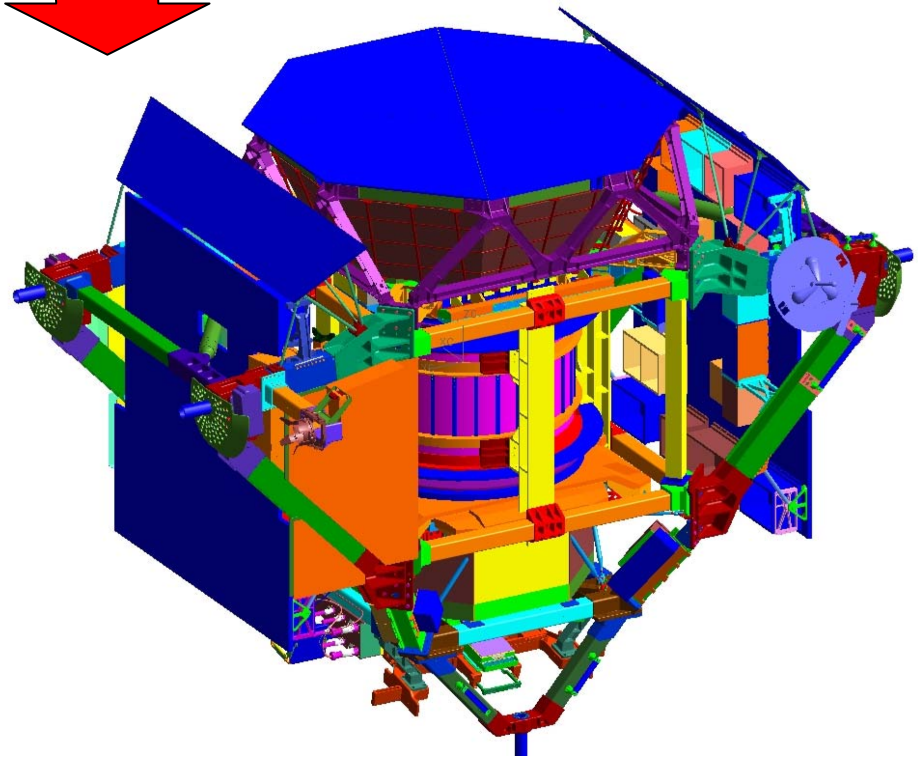
The ISS lifetime has been extended to 2020 (2028), the Shuttle program will be terminated, thus eliminating any possibility of returning and refilling AMS.

A superconducting magnet is no longer the ideal choice.

During the past ten years the AMS-01 Permanent Magnet has been kept as an alternative for AMS-02, and has been reviewed regularly by the Collaboration.

AMS Group Meeting,
CERN - 30Jan.-3 Feb. 2006





AMS-02 with a permanent magnet

CONSIDERATIONS TO UPGRADE AMS-02

Tests of the detectors show their performance exceeds expectations and all the detectors have a lifetime of more than 20 years.

We have maintained 2 magnet options:

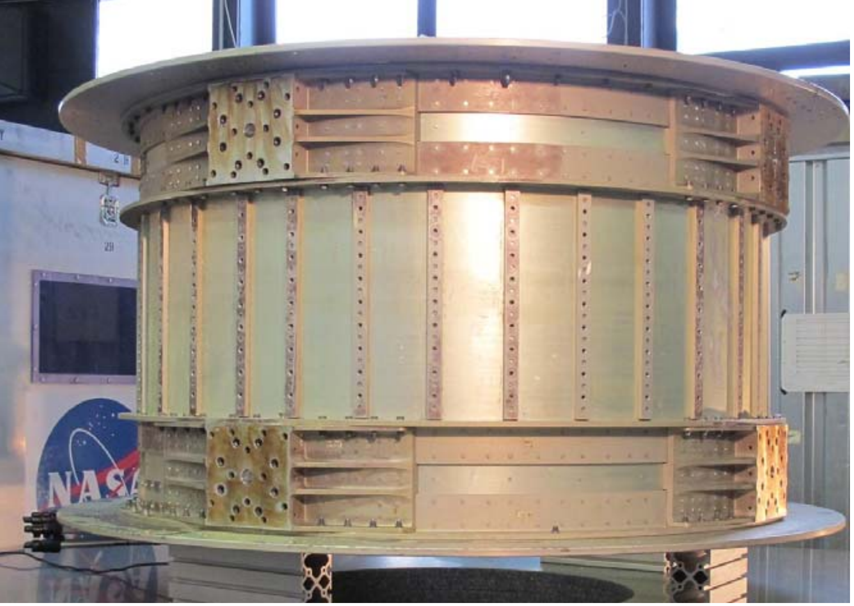
1. **The original AMS-01 permanent magnet and**
2. **A superconducting magnet.**

Two identical support structures were provided by NASA.

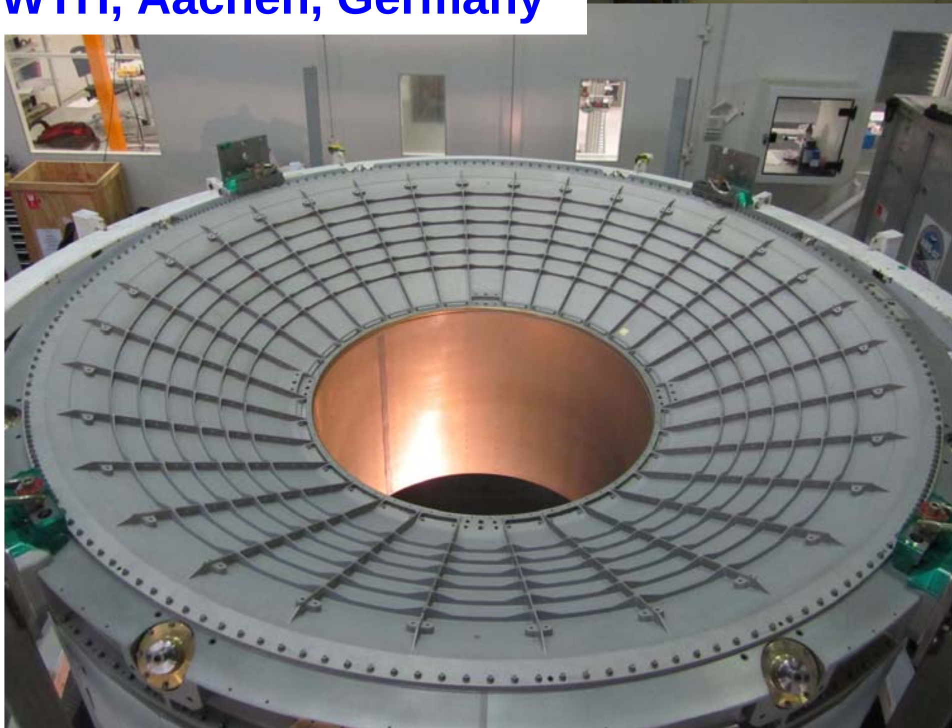
The detectors are compatible with both options.

The two options have comparable momentum resolutions and ranges.

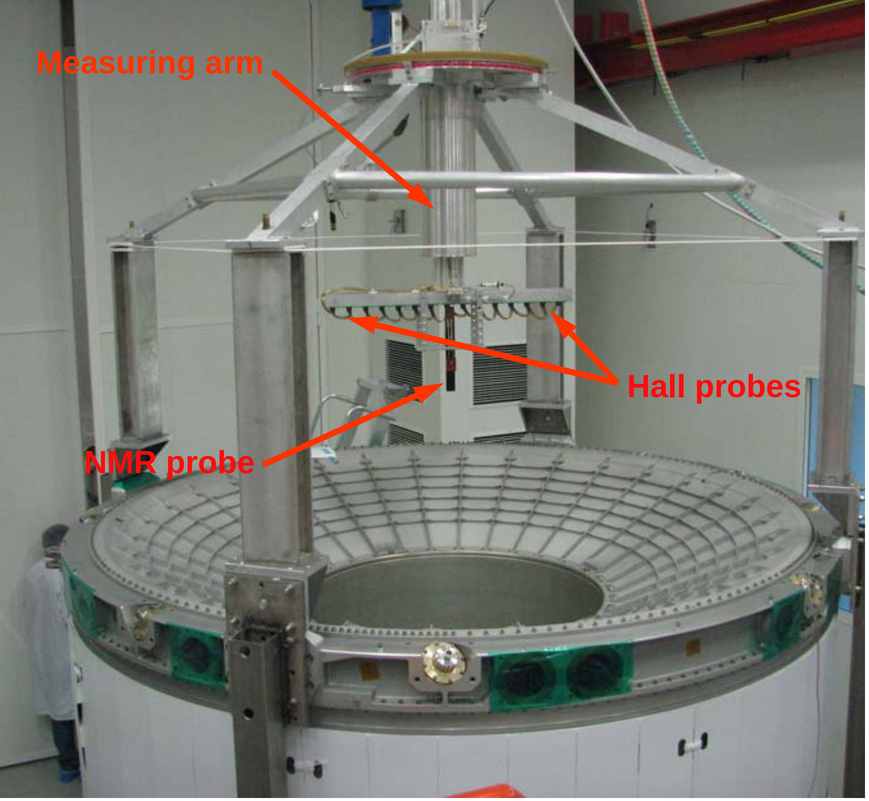
Most importantly, the permanent magnet option will have 10-18 years time to collect data, providing much more sensitivity to search for new phenomena.

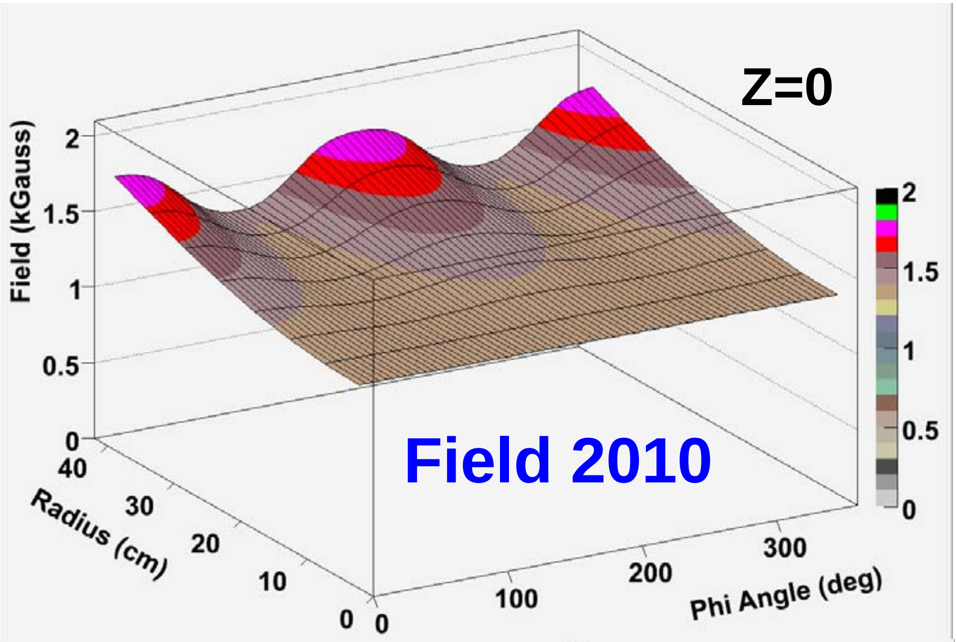


Permanent Magnet installation,
12 May 2010, RWTH, Aachen, Germany

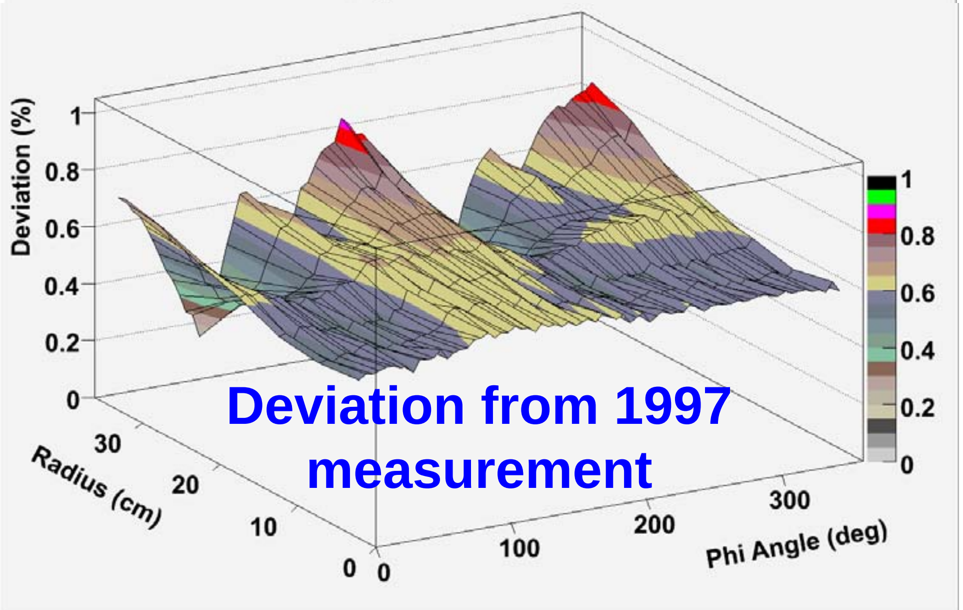


In 12 years the field has remained the same to <1%





The detailed 3D field map (120000 locations) was measured at CERN on 25-27 May 2010



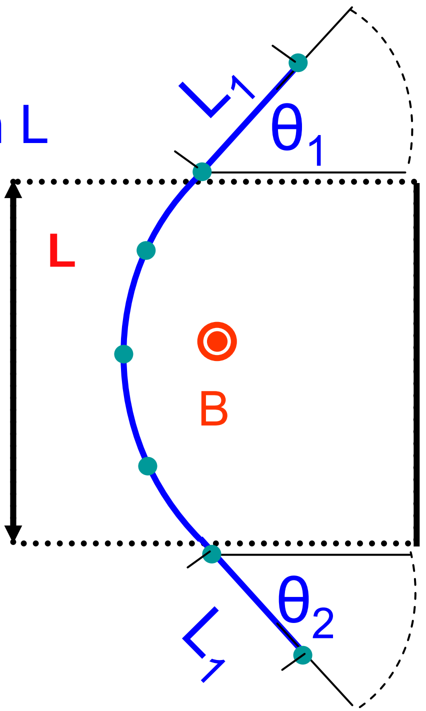
The momentum resolution ($\Delta p/p$) is the sum of two contributions:

1. Measurement inside the magnet with an effective length L

$$(Z/p)\cdot(\Delta p/p) \propto 1/BL^2$$

2. Measurement of the incident (θ_1) and exit (θ_2) angles which depend on the length L_1

$$(Z/p)\cdot(\Delta p/p) \propto 1/BLL_1$$

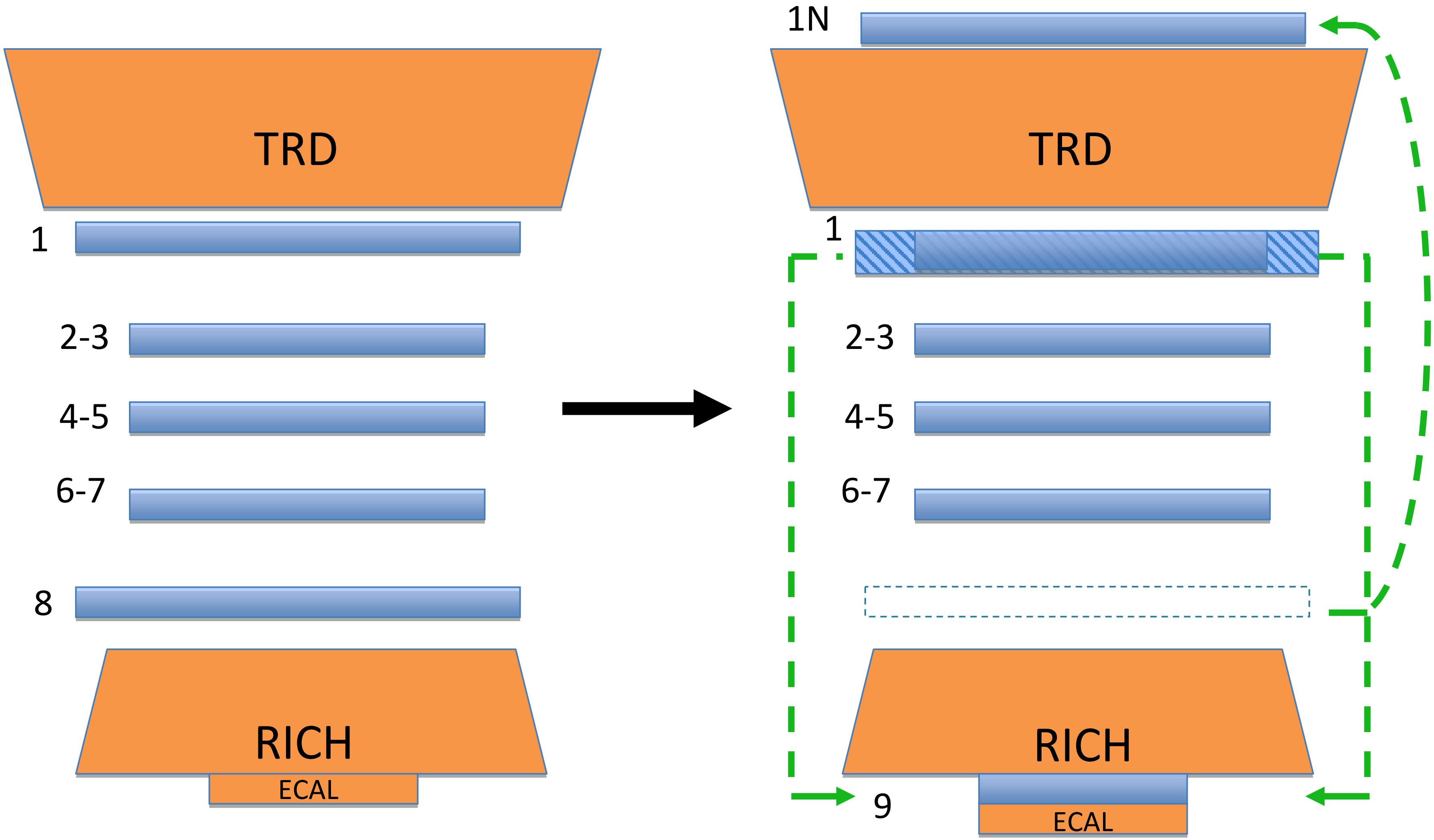


For both magnets, L ~ 80 cm,
but in the permanent magnet B is 5 times smaller

to maintain the same $\Delta p/p$ we increase L1 from ~15 cm (Superconducting Magnet) to ~125 cm (permanent magnet)

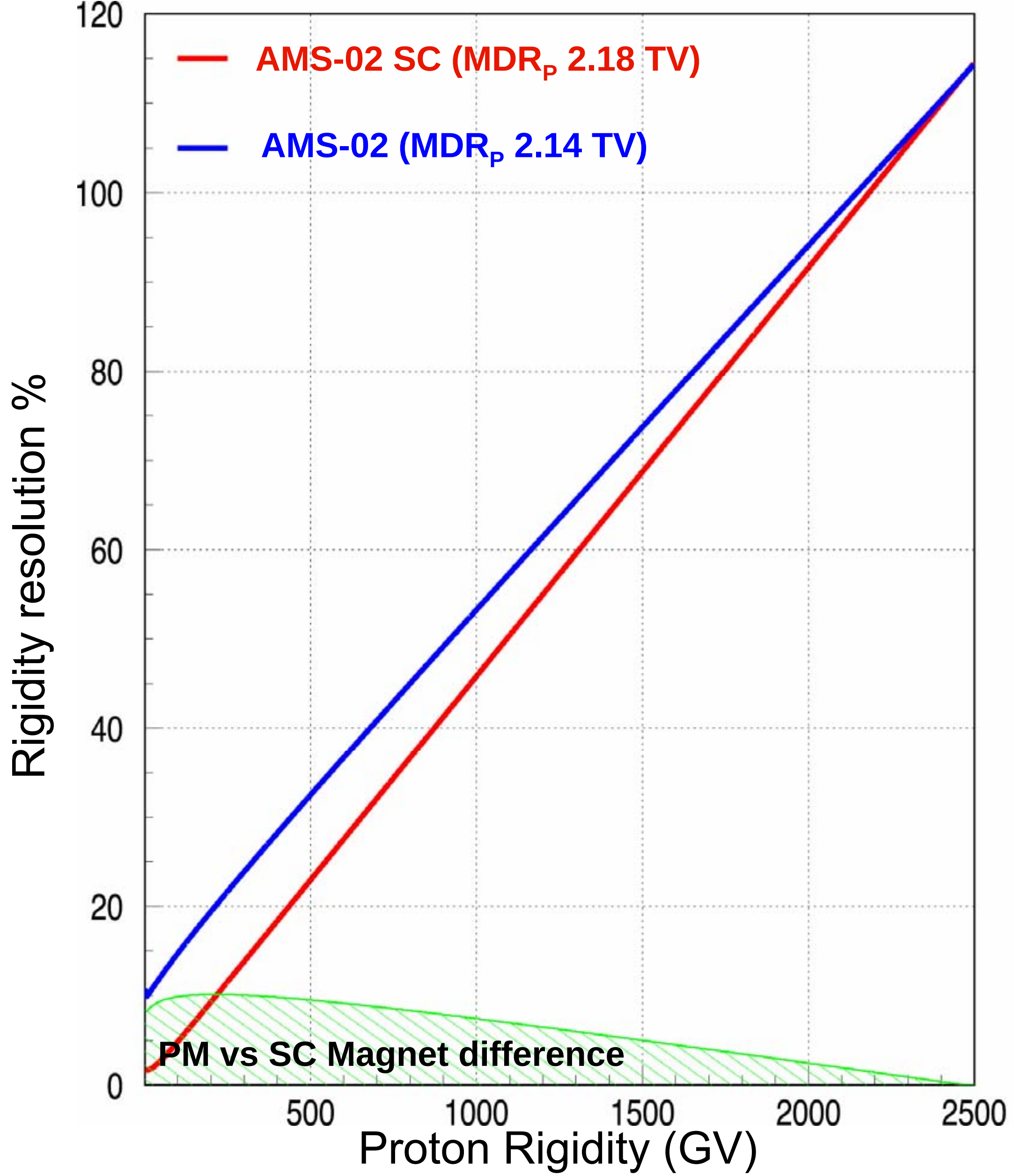
AMS-02 SC (3Yrs) Silicon Tracker Layers

AMS-02 (10 - 18 Yrs) Silicon Tracker Layers



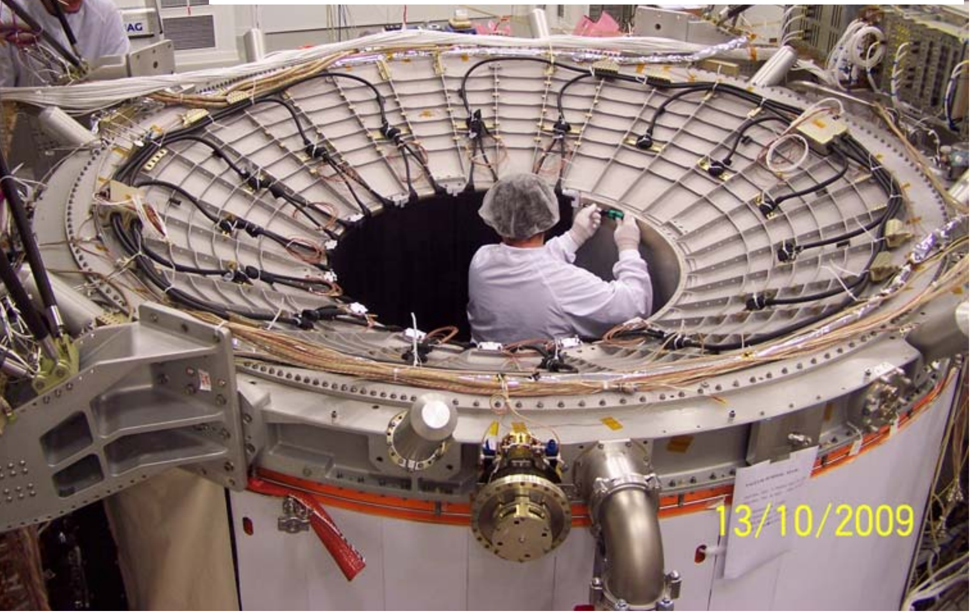
Layer 9 comes from moving the ladders at the edge of the acceptance from layer 1. The layer 8 is moved on top of the TRD to become 1N.

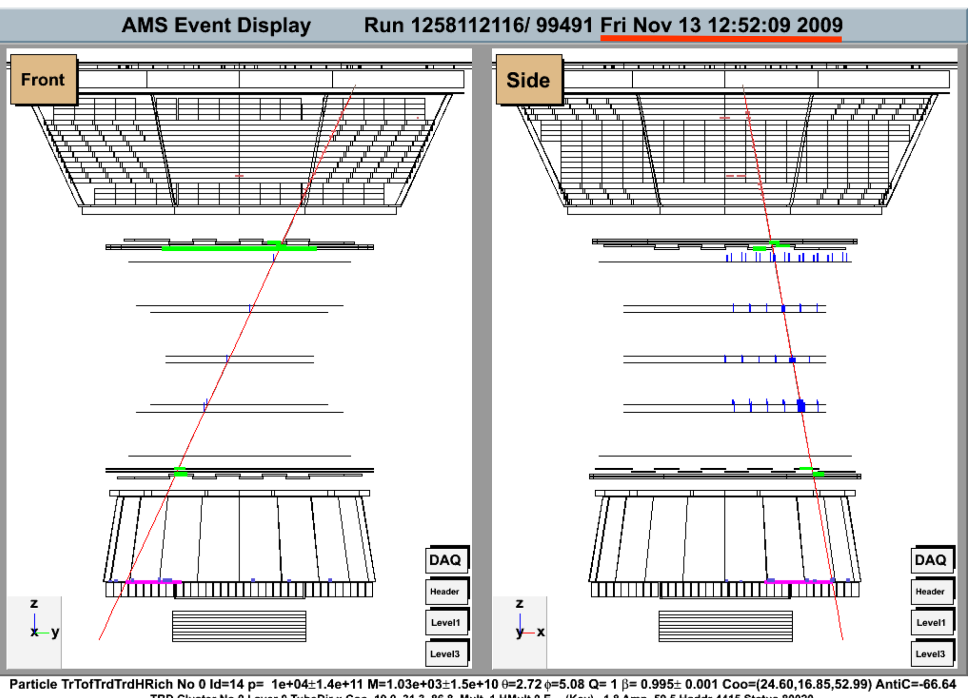
No new silicon and no new electronics are required.



With 9 tracker planes, the resolution of AMS with the permanent magnet is equal (to 10%) to that of the superconducting magnet.
For helium, the MDR for the permanent magnet is 3.75 TV.

2nd integration of AMS,2009
installation of the Veto system





Flight integration, 2010:

begins 7 June,
with installation of veto system

Completion – 7 August

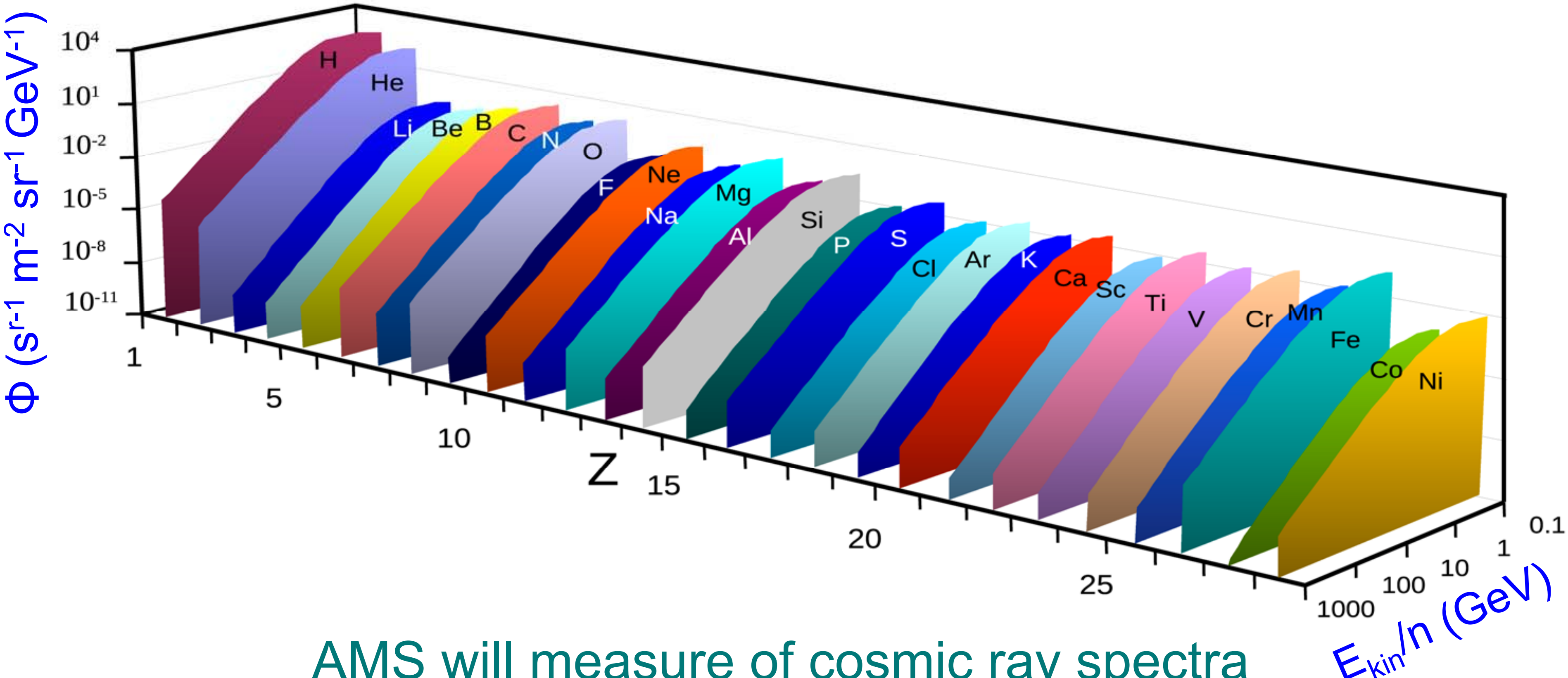
Test beam: 7-14 August

Transport to KSC: 24 August

Launch Ready: Nov 2010

Physics of AMS

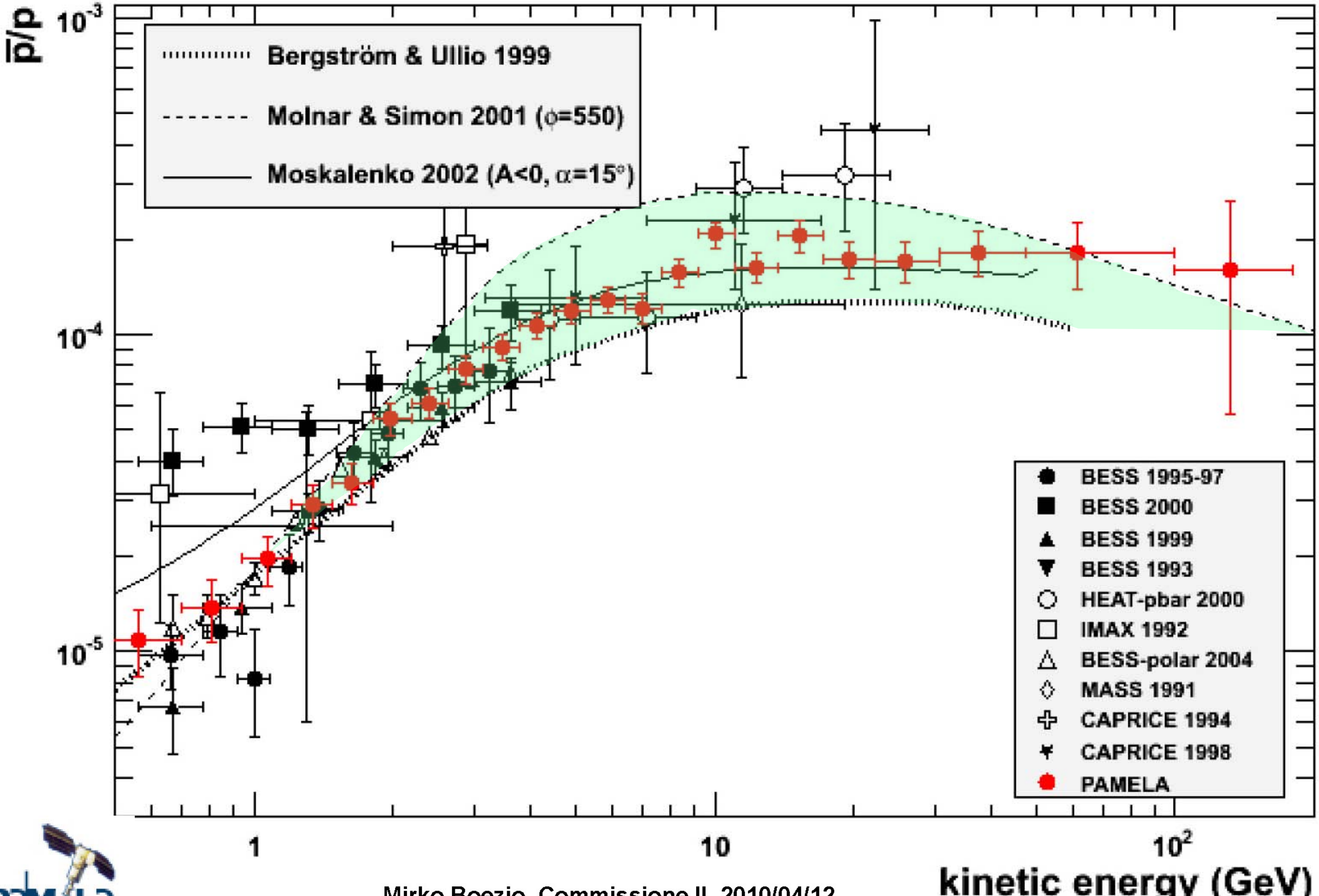
Nuclear Abundances Measurements



AMS will measure of cosmic ray spectra for nuclei, for energies from 100 MeV to 2 TeV with 1% accuracy over the 11-year solar cycle.

These spectra will provide experimental measurements to refine the assumptions that go into calculating the background in searching for Dark Matter, i.e., $p + C \rightarrow e^+, \bar{p}, \ldots$

Rapporto Antiprotoni



Mirko Boezio, Commissione II, 2010/04/12

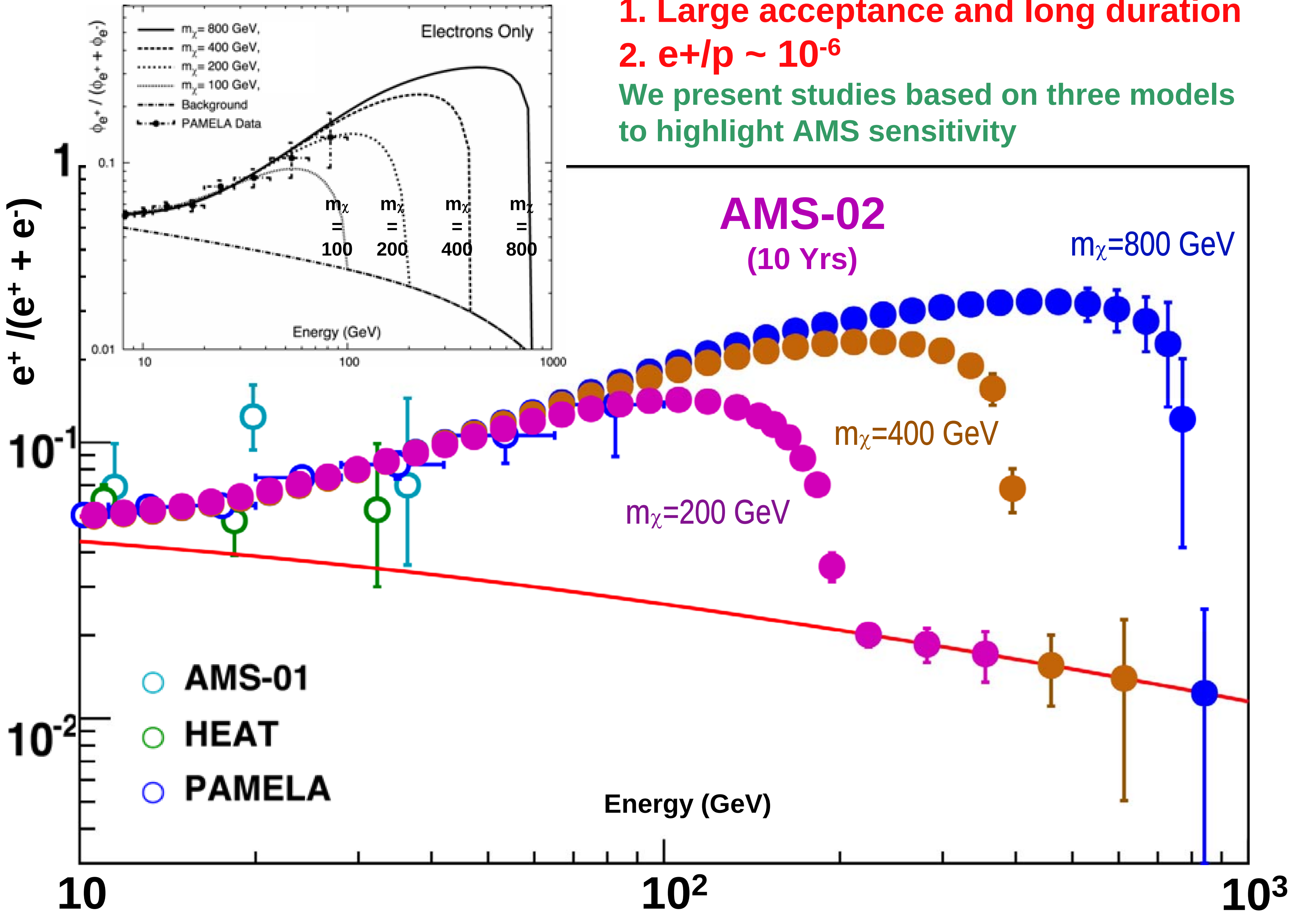
case 1

I.Cholis et al, arXiv:0810.5344v3

AMS – search for DM:

1. Large acceptance and long duration
2. e+/p ~ 10^{-6}

We present studies based on three models to highlight AMS sensitivity

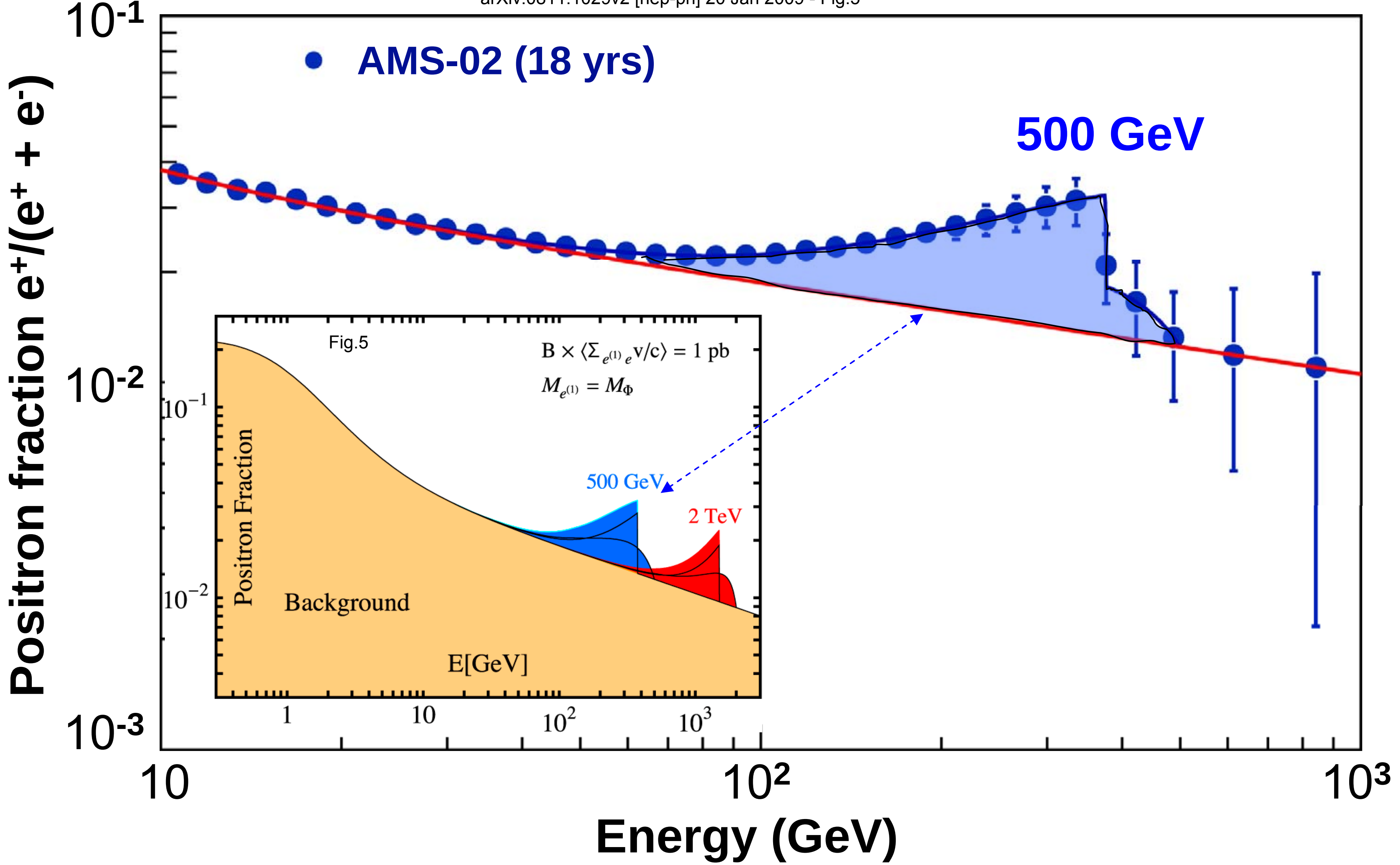


Kaluza-Klein Bosons are also Dark Matter candidates

case 2 TeV Scale Singlet Dark Matter

Eduardo Pontón and Lisa Randall

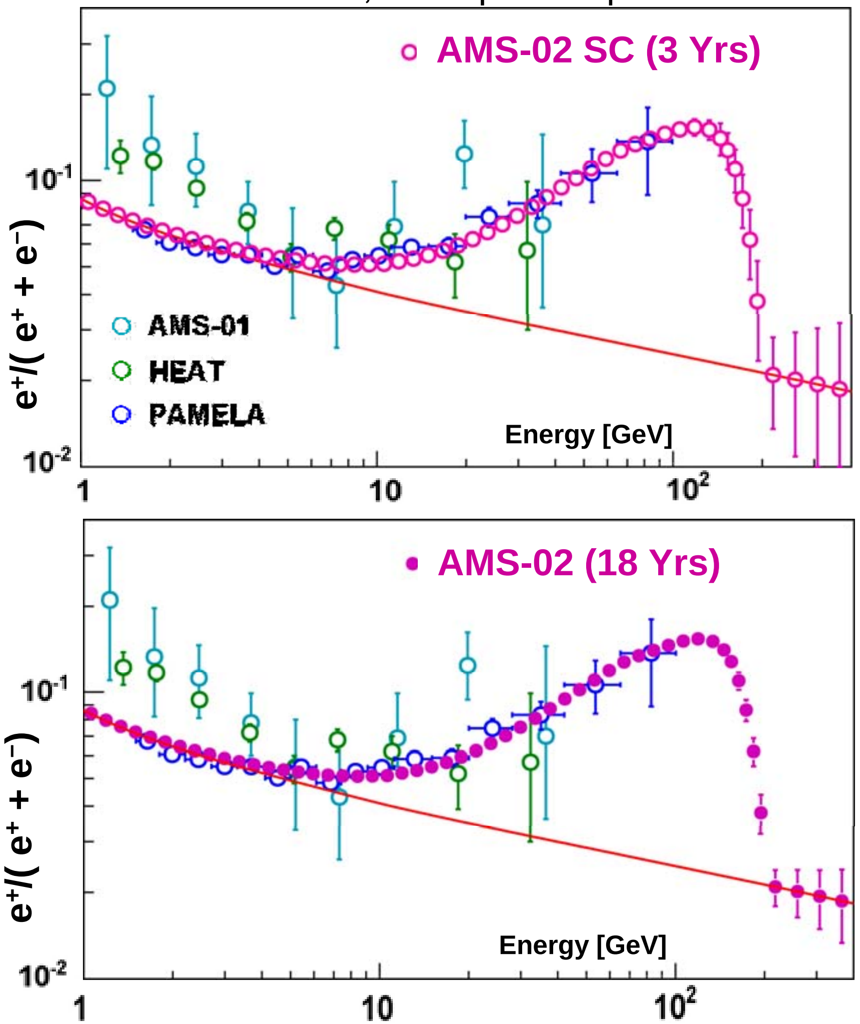
arXiv:0811.1029v2 [hep-ph] 20 Jan 2009 - Fig.5



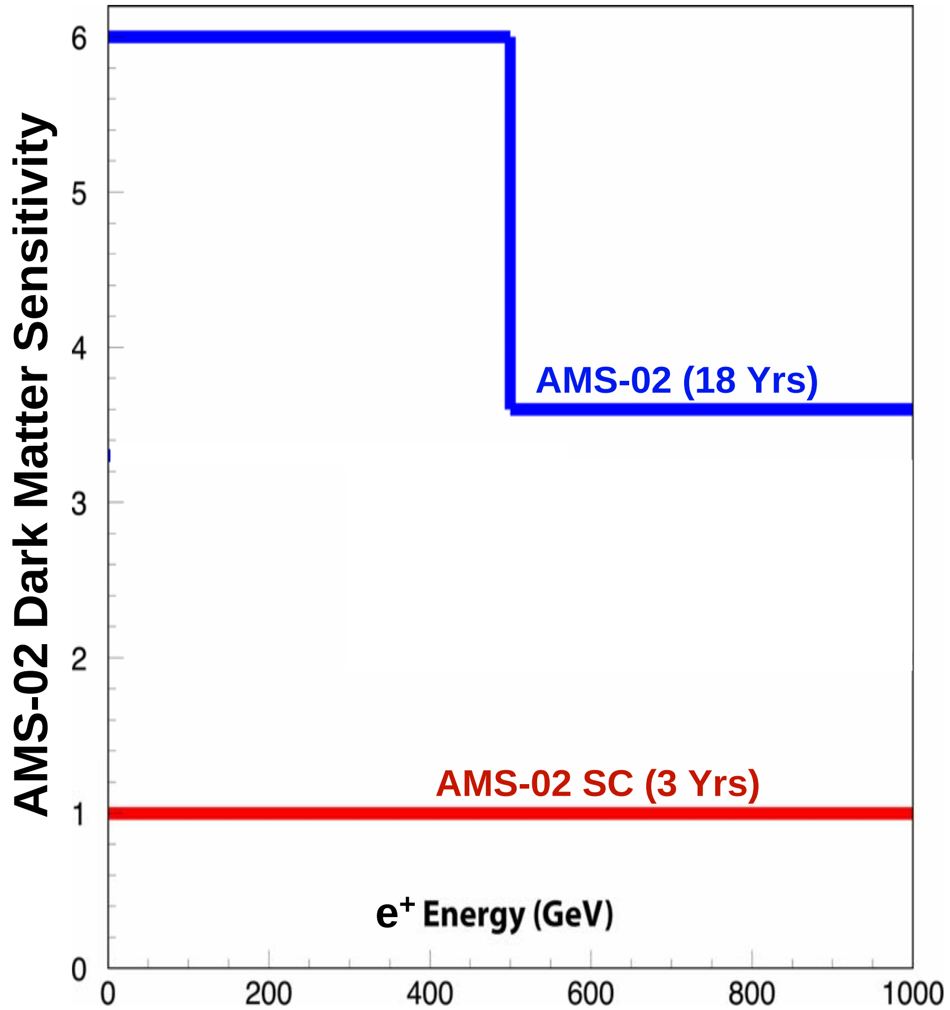
Sensitivity in Dark Matter Searches – large acceptance, long duration

$\chi^0\,\chi^0 \rightarrow e^+, e^-$ for $m\chi^0 = 200$ GeV

I.Cholis et al, astro-ph 30 Apr 2009



normalized to the sensitivity of AMS with superconducting magnet on ISS for 3 years

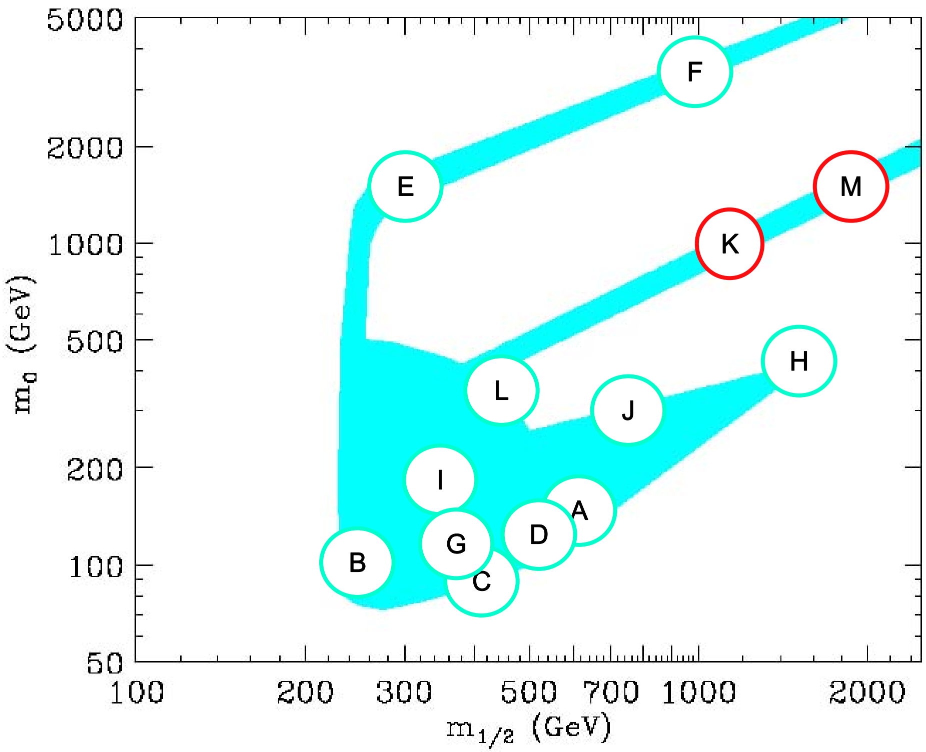


As seen, the permanent magnet upgrade of AMS has a 600-400% improvement in sensitivity in the search for Dark Matter.

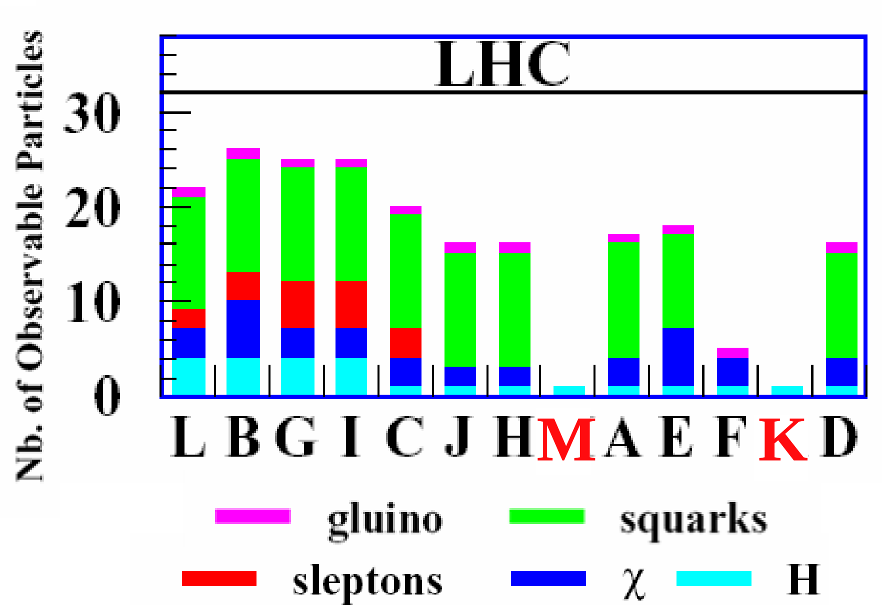
AMS is sensitive to SUSY parameter space that is difficult to study at LHC (large m_0, $m_{1/2}$ values)

J.Ellis, private communication

Shaded region allowed by WMAP, etc.



Post-WMAP Benchmarks



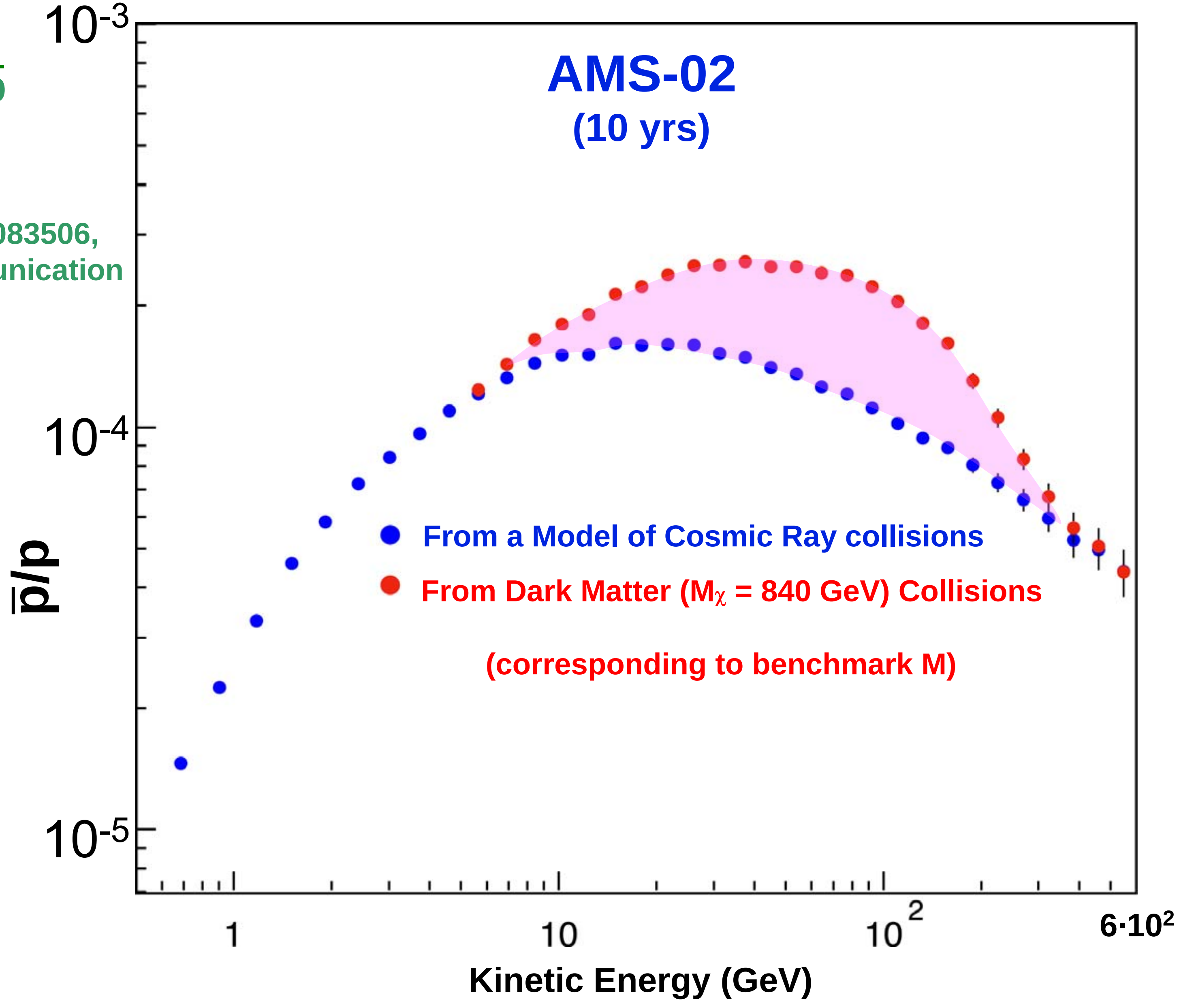
At benchmarks "K" & "M" Supersymmetric particles are not visible at the LHC.

M. Battaglia et al., hep-ph/0112013
M. Battaglia et al., hep-ex/0106207
M. Battaglia et al., hep-ph/0306219
D.N. Spergel et al., astro-ph/0603449

case 3:

DM signal from $\bar{p}$

P. Brun, Phys.Rev.D76:083506, 2007 and private communication



Experimental work on Antimatter in the Universe

Direct search

Search for Baryogenesis

New CP

BELLE

BaBar

(sin 2β= 0.672±0.023 consistent with SM)

FNAL KTeV

(Re(ε'/ ε) = (19.2±2.1)*10^{-4})

CERN NA-48

CDF, D0

Proton decay

Super K

(τ_p > 6.6 * 10^{33} years)

AMS

Increase in sensitivity: x 10^3 – 10^6

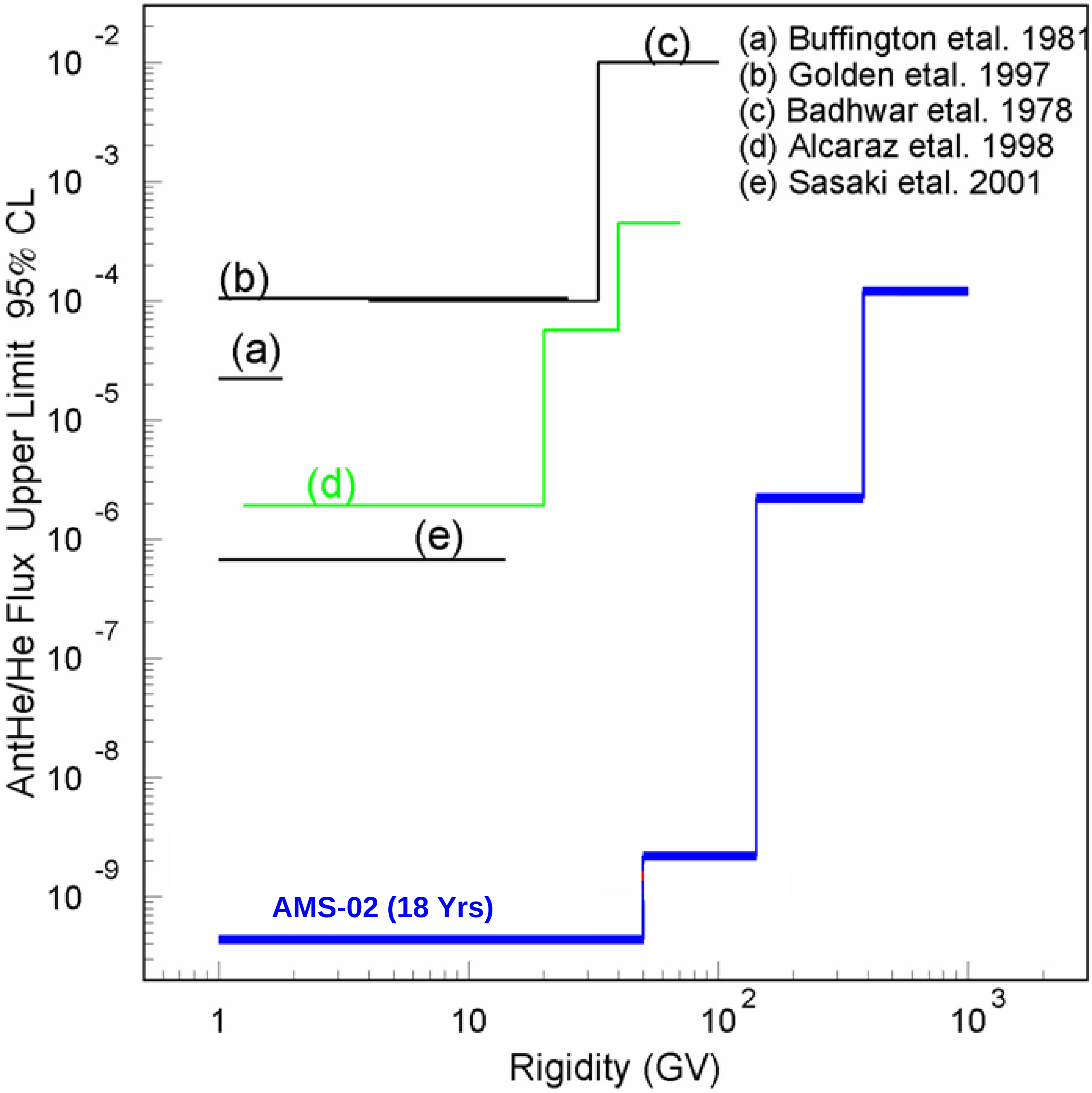
Increase in energy to ~TeV

LHC-b

ATLAS

CMS

y06K299a



(a) Buffington etal. 1981
(b) Golden etal. 1997
(c) Badhwar etal. 1978
(d) Alcaraz etal. 1998
(e) Sasaki etal. 2001
(a)
(b)
(c)
(d)
(e)
AMS-02 (18 Yrs)
AntHe/He Flux Upper Limit 95% CL
Rigidity (GV)

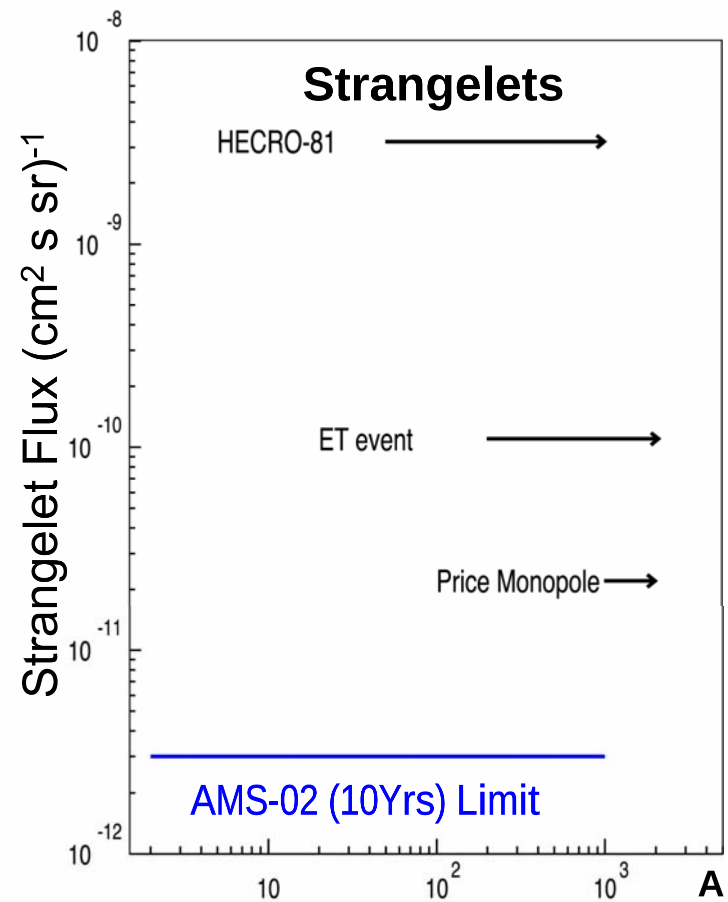
Strangelets

E. Witten, Phys. Rev. D,272-285 (1984)
J.Sandweiss, J.Phys. G30, 551 (2004)

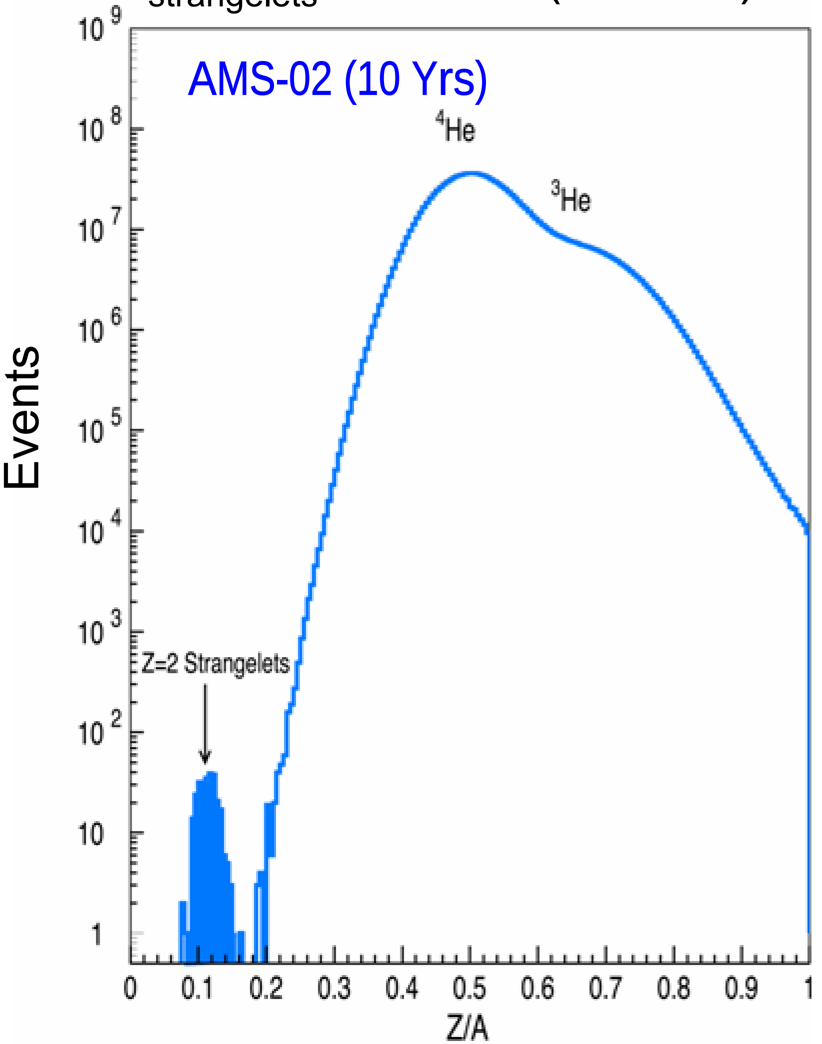
All the known material on Earth is made out of u and d quarks

Is there material in the universe made up of u, d, & s quarks?

Z/A~0.1



$\Phi_{strangelets} = 5x10^{-10}(cm^2 s\ sr)^{-1}$



This can be answered definitively by AMS.

AMS will be launch ready at KSC by November 2010

STS-134 Mission Information

Image above: Pictured clockwise in the STS-134 crew portrait are NASA astronauts Mark Kelly (bottom center), commander; Gregory H. Johnson, pilot; Michael Fincke, Greg Chamitoff, Andrew Feustel and European Space Agency's Roberto Vittori, all mission specialists. Image credit: NASA

The STS-134 crew members are Commander Mark Kelly, Pilot Gregory H. Johnson and Mission Specialists Michael Fincke, Greg Chamitoff, Andrew Feustel and European Space Agency astronaut Roberto Vittori.

Endeavour will deliver spare parts including two S-band communications antennas, a high-pressure gas tank, additional spare parts for Dextre and micrometeoroid debris shields. This will be the 36th shuttle mission to the International Space Station.

Overview

Launch Target:
Nov. 2010
Orbiter:
Endeavour
Mission Number:
STS-134
(134th space shuttle flight)
Launch Window:
10 minutes
Launch Pad:
39A
Mission Duration:
10 days
Landing Site:
KSC
Inclination/Altitude:
51.6 degrees/122 nautical miles
Primary Payload:
36th station flight (ULF6), EXPRESS Logistics Carrier 3 (ELC3), Alpha Magnetic Spectrometer (AMS)

Backup slides

THE DIRECTOR GENERAL

DG/146

Paris, 3 February 2010

Samuel C.C. Ting
CERN, Physics Department
CH-1211 GENEVA 23

Ref. My letter DG/137 dated 29 January 2010

Dear Professor Ting,

A I wrote to you in my referenced letter, and following the positive outcome from the visit of the ESA team at CERN to evaluate the readiness of AMS-02, I confirm that I grant the highest priority to AMS-02 in providing it access to the ESTEC Test Centre as soon as possible in order that you meet your targeted launch date.

. . . .

Yours sincerely,

Jean-Jacques Dordain

From: Steve Myers Sent: Mon 2/8/2010 7:58 AM To: Dimitri Delikaris; Dietrich Schinzel

Dear Dimitri,

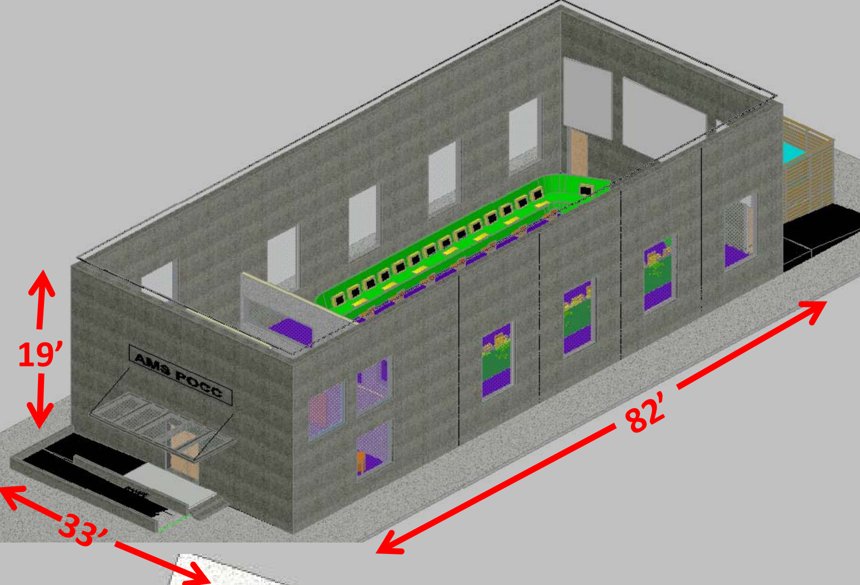
There is a decision from the Directorate level to give the maximum possible amount of help to AMS.

I really appreciate your aid. If there are any “legal” problems please let me know right away.

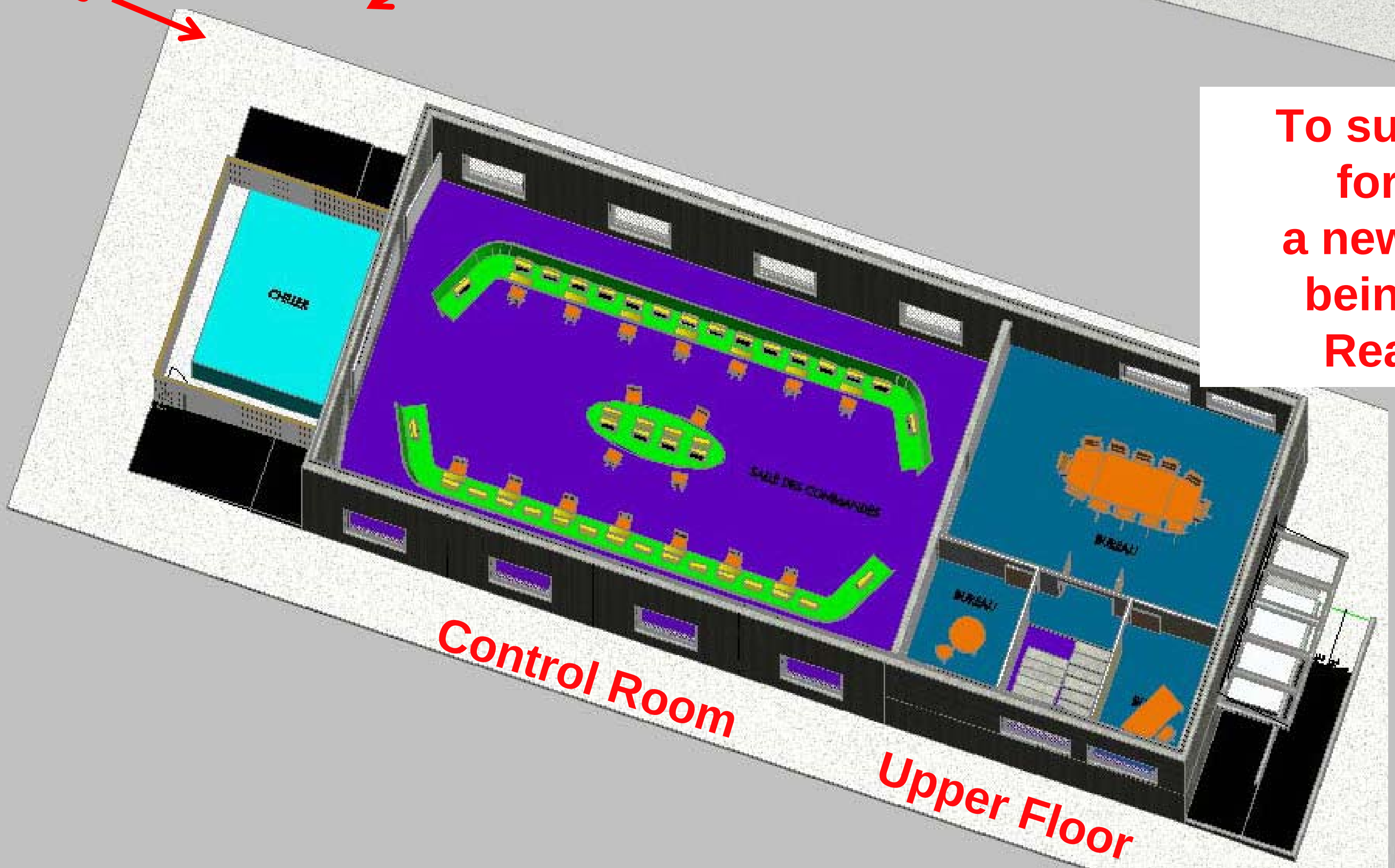
Regards,

Steve

Steve Myers
Director of Accelerators and Technology
European Organisation for Nuclear Research (CERN)
CH-1211 Geneva 23
Switzerland



**To support AMS on ISS
for 10 to 18 years,
a new control center is
being built by CERN.
Ready 15 Nov 2010**



Characteristics of AMS

AMS was constructed with emphasis on

a) Precision:δx=10μm, δt =150 ps, δv/v =1/1000, $\delta E/E=10^{-2}$, $e^+/p=10^{-6}$.

b) Redundancy: 200% to 400%.

c) Reliability: Each detector was tested in specially built space simulation facilities in Italy, Germany, Spain, Taiwan. The entire AMS detector was then tested at ESA-ESTEC, Holland. The AMS-01 detectors have been operating for over ten years to study cosmic rays at SEU, China.

d) Lifetime: TRD consumables will last more than 20 years.

e) Readily assembled, disassembled for modification before lift-off:

2008

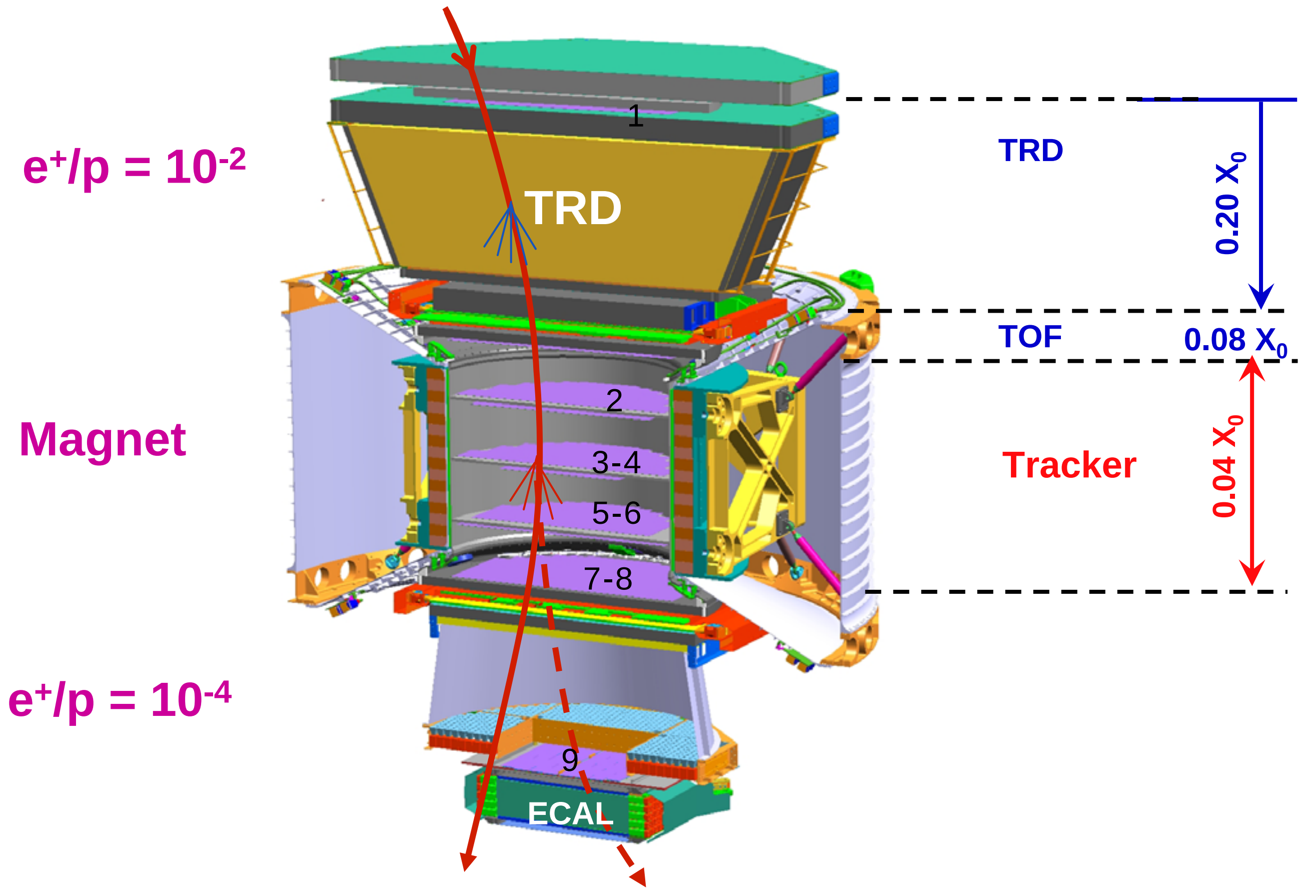
1^{st} integration – 6 months

1^{st} de-integration – 1 month

2009

2nd integration – 1 month

AMS goals: $\overline{He}/He = 1/10^{10}$, $e^+/p = 1/10^6$ & Spectra to 1%



a) Minimal material in the tracker, so that it does not become a source of background nor of large angle scattering

b) Repetitive measurements of momentum, to ensure that particles which had large angle scattering are not confused with the signal.

c) $e^{\pm}$ detectors are separated by magnetic field, so that particles from TRD do not enter into ECAL.

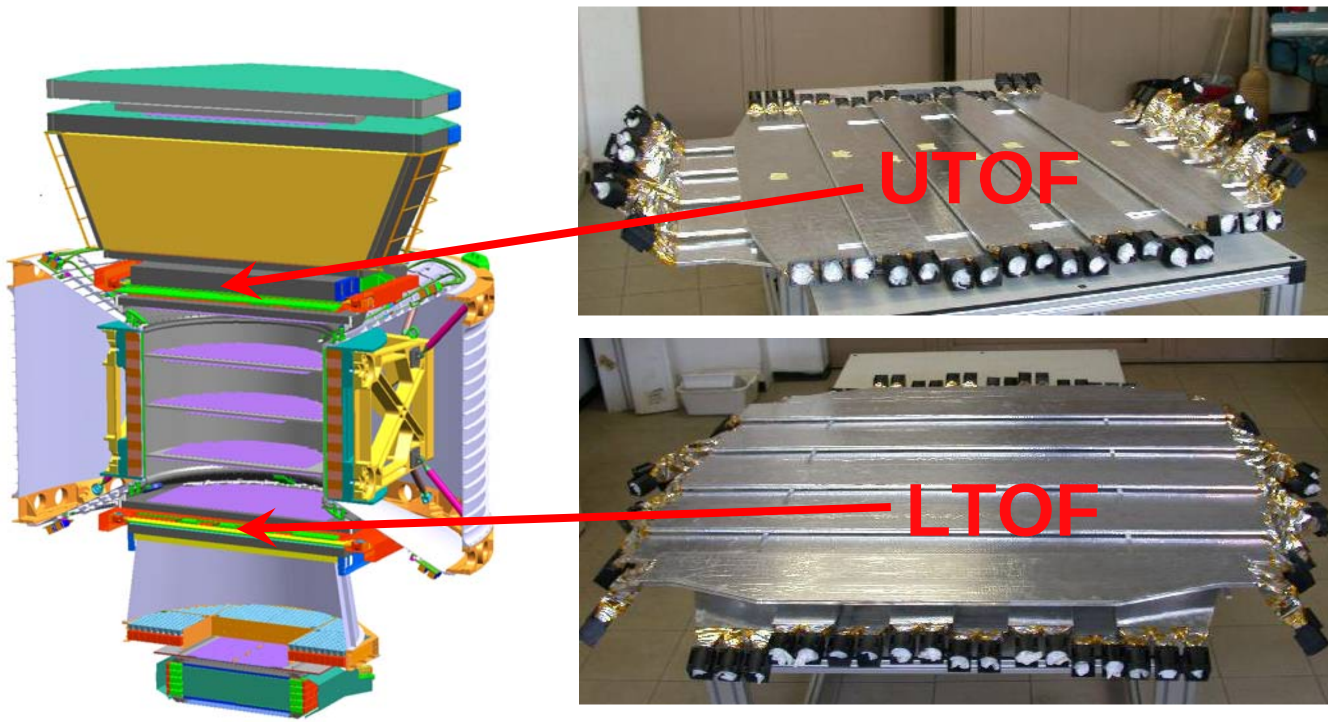
Measured rejection at 0.4 TeV $e^+/p = 10^{-6}$

Time of Flight (TOF)

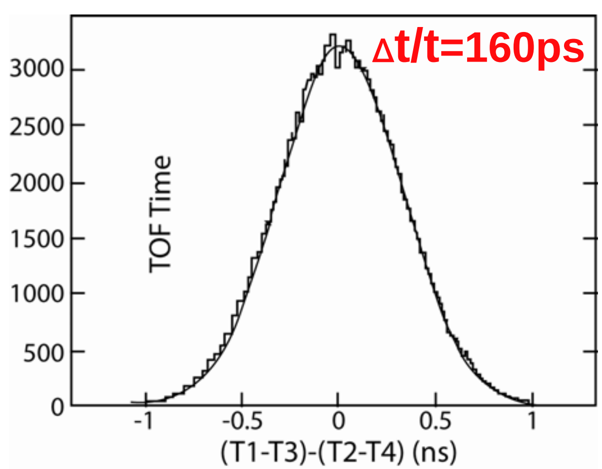
4 scintillator planes

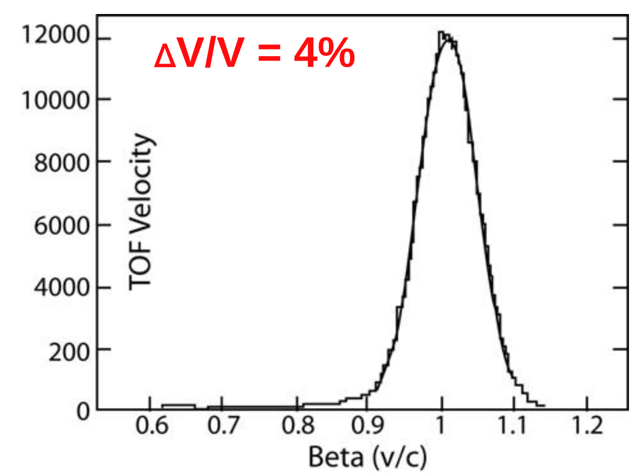
Provides trigger for charged particles

Trigger time is synchronized to UTC time to 1μs



Measures the time of relativistic particles to 160 picoseconds





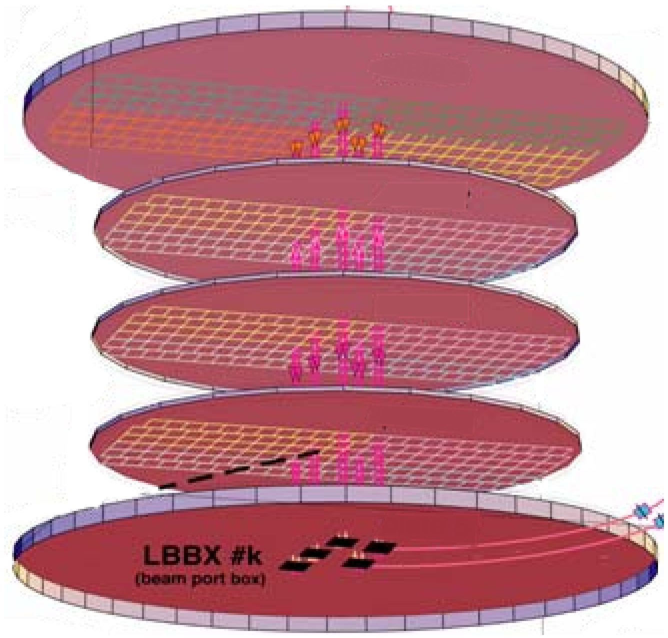
Two identical vacuum cases

One to support the permanent and one for the superconducting magnet

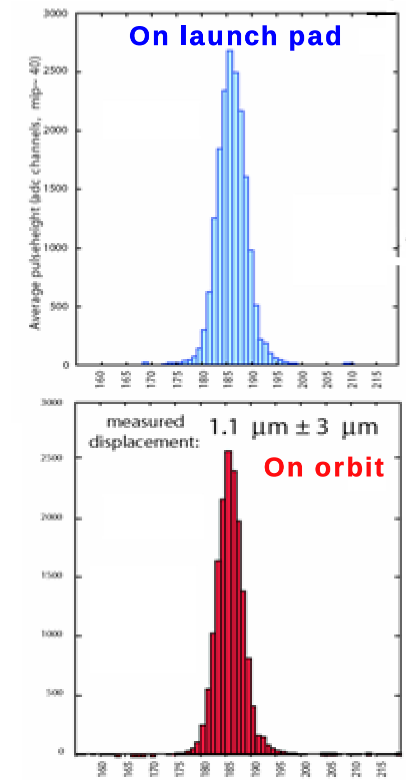
Alignment of the entire Tracker System

Inner tracker alignment

In space, the inner tracker alignment of 3 μm will be continuously monitored by 20 Laser beams.



AMS-01



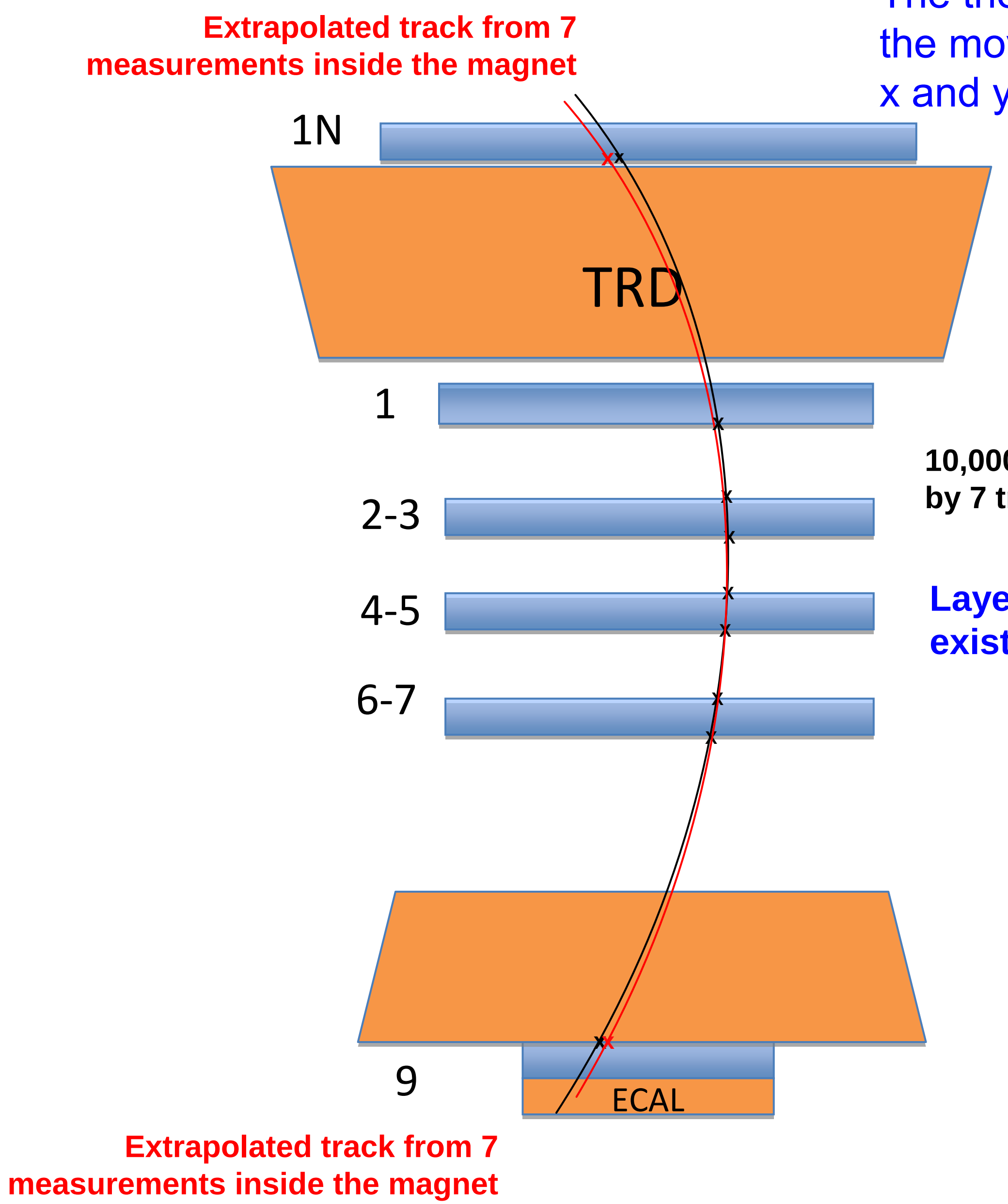
Alignment of the entire System

1. **With CERN Test beam on 7-14 Aug 2010 using 400 GeV protons.**

2. **With 10,000 cosmic rays every minute in every orbit**

AMS-02 (10 to 18 Yrs)
Silicon Tracker Alignment with Cosmic protons

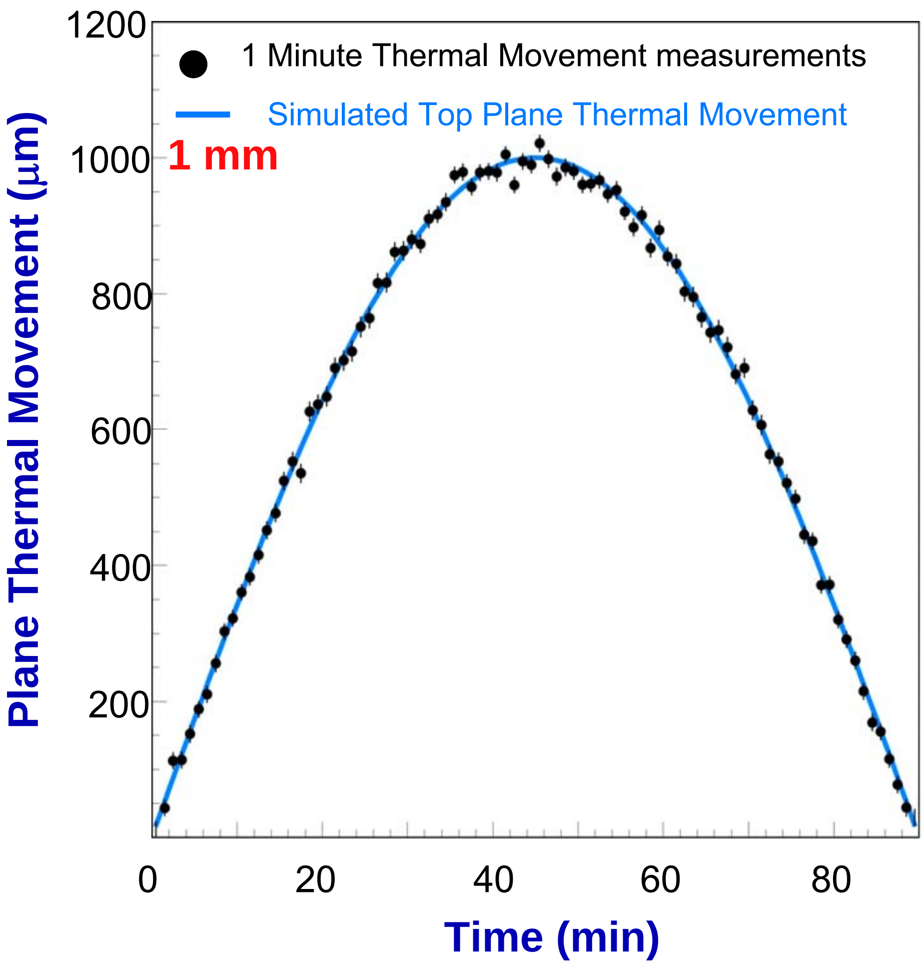
The thermal model predicts the movement of 1N and 9 in x and y are both less than 150 μm.

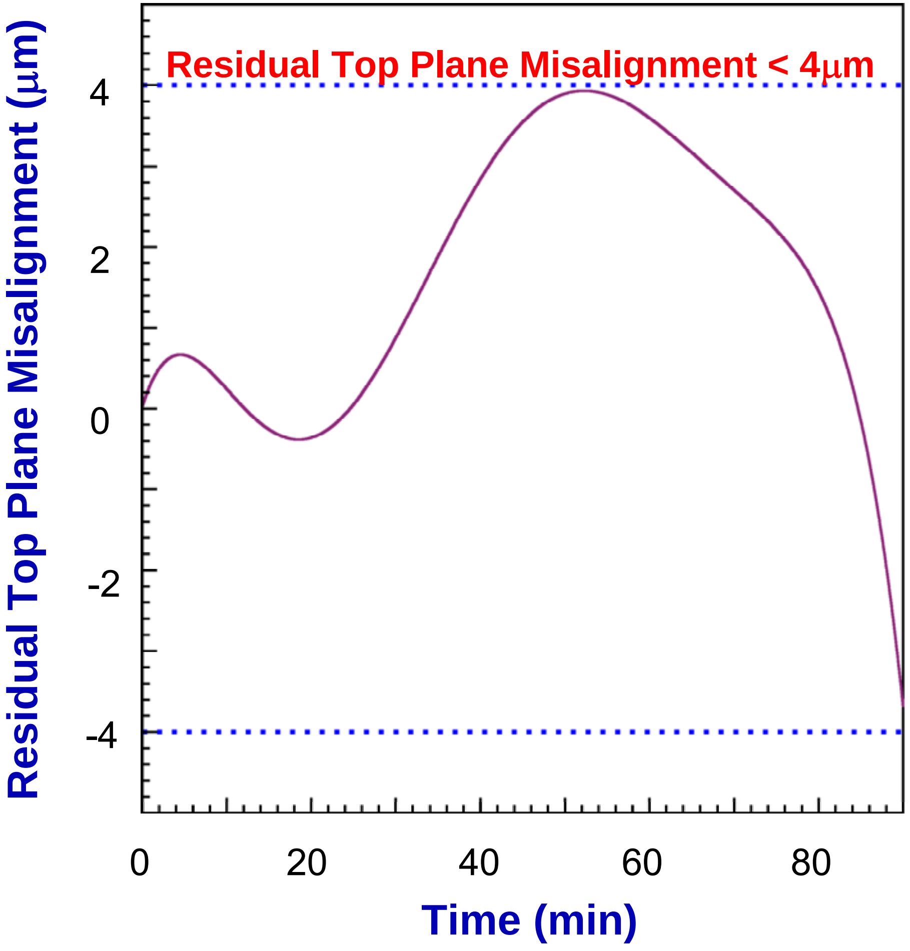


10,000 cosmic protons / min measured by 7 tracker layers in the magnet

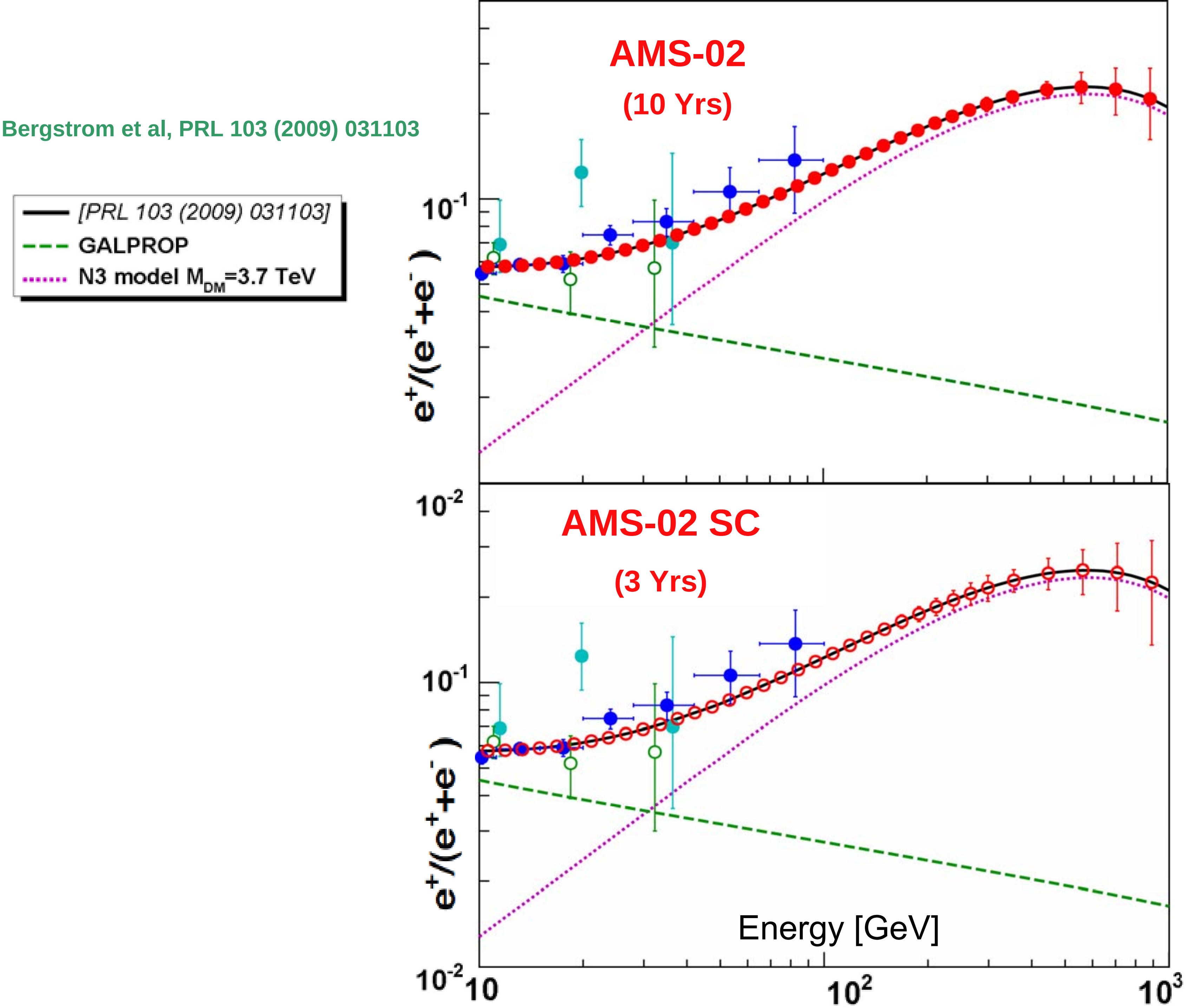
Layers 1 to 7 are aligned with existing laser system

External Plane Alignment with Cosmic Rays Minute by Minute





L.Bergstrom et al, PRL 103 (2009) 031103



Discoveries in Physics

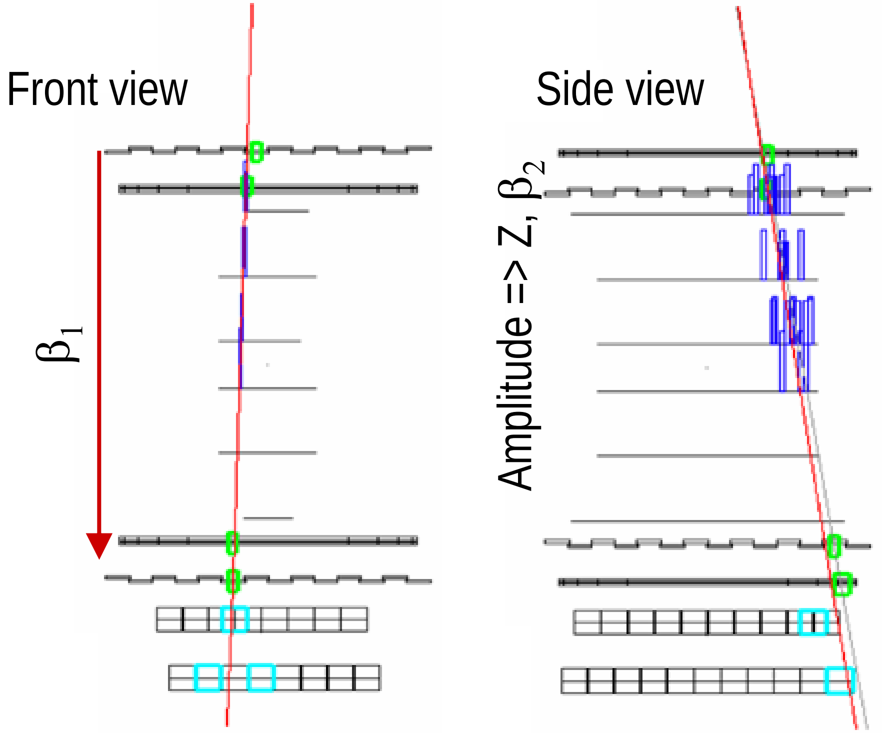
Facility	Original purpose, Expert Opinion	Discovery with Precision Instrument
P.S. CERN	π N interactions	Neutral Currents -> Z, W
Brookhaven	π N interactions	ν_e, ν_μ CP violation, J
FNAL	Neutrino physics	*b, t quarks*
SLAC Spear	ep, QED	Scaling, Ψ, τ
PETRA	t quark	*Gluon*
Super Kamiokande	Proton decay	Neutrino oscillations
Hubble Space Telescope	Galactic survey	*Curvature of the universe, dark energy*
AMS on ISS	Dark Matter, Antimatter Strangelets,…	*?*

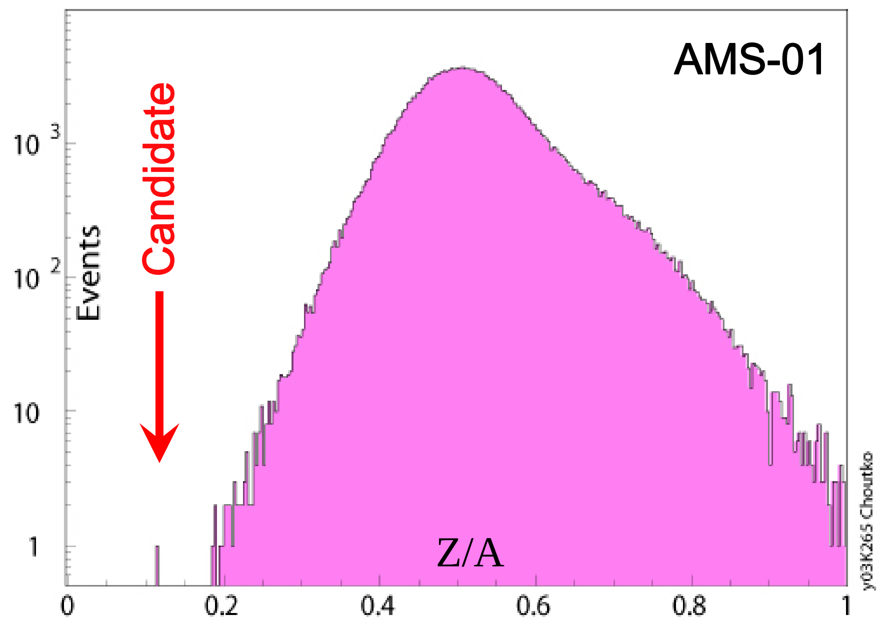
Exploring a new territory with a precision instrument is the key to discovery.

Strangelet candidate from AMS-01

Observed 5 June 1998 11:13:16 UTC

Lat/Long= -44.38°/+23.70°, Local Cutoff 1.95±0.1 GV, Angle= 77.5° from local zenith





Rigidity = 4.31 ± 0.38 GV

Charge Z = 2

$\beta_1 = \beta_2$ = 0.462 ± 0.005

Mass = 16.45±0.15 GeV/c^2

Z/A = 0.114 ± 0.01

Flux (1.5 < E_K < 10 GeV) = 5×10^{-5} (m^2 sr sec)$^{-1}$

Background probability < 10^{-3}

Professor Roberto Battiston
President

II National Committee of INFN on Astroparticle Physics.

This Committee is responsible for reviewing, approving, and funding of experiments in astroparticle physics:

Neutrino: Opera, Borexino, ICARUS....

Space Born: Fermi, Pamela, AMS, LISA....

Direct Dark Matter: Dama, Warp, Xenon...

Ground based: Argo, Magic,....

Presented at HEPAP meeting, 4 June 2010, Washington

A statistical procedure for the identification of positrons in the PAMELA experiment

O. Adriani[a,b], G. C. Barbarino[c,d], G. A. Bazilevskaya[e], R. Bellotti[f,g,*], M. Boezio[h], E. A. Bogomolov[i], L. Bonechi[a,b], M. Bongi[b], V. Bonvicini[h], S. Borisov[j,k,l], S. Bottai[b], A. Bruno[f,g], F. Cafagna[g], D. Campana[d], R. Carbone[j,d], P. Carlson[m], M. Casolino[k], G. Castellini[n], L. Consiglio[d], M. P. De Pascale[j,k], C. De Santis[k], N. De Simone[j,k], V. Di Felice[j,k], A. M. Galper[l], W. Gillard[m], L. Grishantseva[l], P. Hofverberg[m], G. Jerse[h,o], S. V. Koldashov[l], S. Y. Krutkov[i], A. N. Kvashnin[e], A. Leonov[l], V. Malvezzi[k], L. Marcelli[k], W. Menn[p], V. V. Mikhailov[l], E. Mocchiutti[h], A. Monaco[f,g], N. Mori[b], N. Nikonov[j,k,i], G. Osteria[d], P. Papini[b], M. Pearce[m], P. Picozza[j,k], M. Ricci[q], S. B. Ricciarini[b], L. Rossetto[m], M. Simon[p], R. Sparvoli[j,k], P. Spillantini[a,b], Y. I. Stozhkov[e], A. Vacchi[h], E. Vannuccini[b], G. Vasilyev[i], S. A. Voronov[l], J. Wu[m], Y. T. Yurkin[l], G. Zampa[h], N. Zampa[h], V. G. Zverev[l], D. Marinucci[r]

[a] *University of Florence, Department of Physics, Via Sansone 1, I-50019 Sesto Fiorentino, Florence, Italy.*
[b] *INFN, Sezione di Florence, Via Sansone 1, I-50019 Sesto Fiorentino, Florence, Italy.*
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[d] *INFN, Sezione di Naples, Via Cintia, I-80126 Naples, Italy.*
[e] *Lebedev Physical Institute, Leninsky Prospekt 53, RU-119991 Moscow, Russia.*
[f] *University of Bari, Department of Physics, Via Amendola 173, I-70126 Bari, Italy.*
[g] *INFN, Sezione di Bari, Via Amendola 173, I-70126 Bari, Italy.*
[h] *INFN, Sezione di Trieste, Padriciano 99, I-34012 Trieste, Italy.*
[i] *Ioffe Physical Technical Institute, Polytekhnicheskaya 26, RU-194021 St. Petersburg, Russia.*
[j] *University of Rome "Tor Vergata", Department of Physics, Via della Ricerca Scientifica 1, I-00133 Rome, Italy.*
[k] *INFN, Sezione di Roma "Tor Vergata", Via della Ricerca Scientifica 1, I-00133 Rome, Italy.*
[l] *Moscow Engineering and Physics Institute, Kashirskoe Shosse 31, RU-11540 Moscow, Russia.*
[m] *KTH, Department of Physics, and the Oskar Klein Centre for Cosmoparticle Physics, AlbaNova University Centre, 10691 Stockholm, Sweden.*

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*Corresponding author. Tel: +390805443173
Email address: roberto.bellotti@ba.infn.it (R. Bellotti)

A statistical procedure for the identification of positrons in the PAMELA experiment

arXiv:1001.3522v1 [astro-ph.HE] 20 January 2010

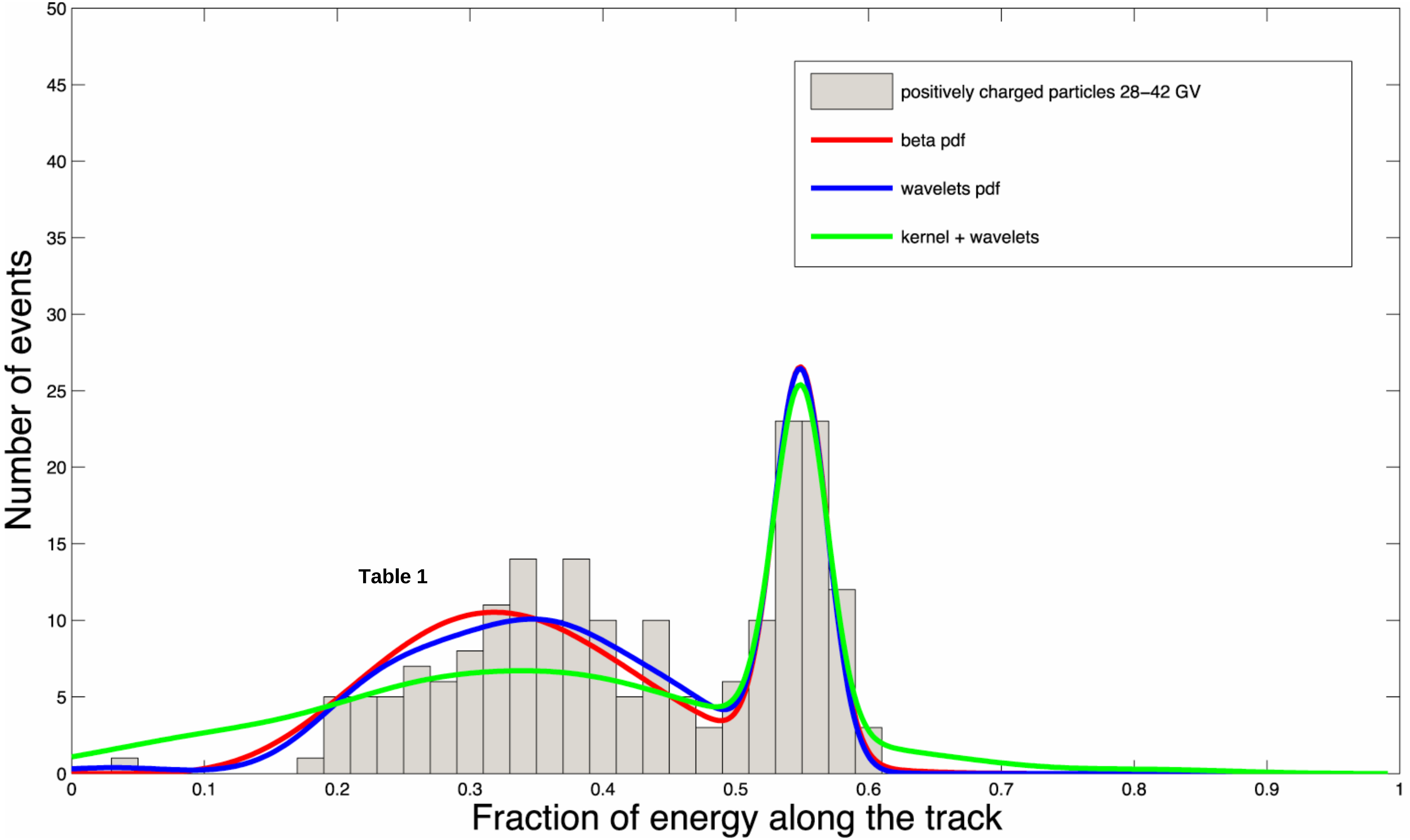


Figure 8: The distribution of positively charged particles for the rigidity bin 28-42 GV showing 3 pdf fits.

Rigidity at spectrometer (GV)	Percent error (beta)	Percent error (wavelets)	Percent error (kernelwith wavelets)
1.5–1.8	3.2%	2.6%	2.6%
1.8–2.2	2.6%	2.9%	2.6%
2.2–2.7	2.7%	2.6%	2.6%
2.7–3.3	2.9%	3.1%	3.1%
3.3–4.1	3.1%	3.9%	3.9%
4.1–5.0	3.6%	3.8%	4.3%
5.0–6.1	3.9%	5.7%	5.3%
6.1–7.4	4.7%	4.8%	4.4%
7.4–9.1	4.9%	4.9%	5.0%
9.1–11.2	4.7%	5.7%	5.9%
11.2–15.0	5.3%	5.0%	5.6%
15.0–20.0	6.1%	5.4%	6.3%
20.0–28.0	8.1%	7.5%	8.2%
28.0–42.0	10.1%	9.5%	11.2%
42.0–65.0	13.4%	12.4%	13.0%
65.0–100.0	25%	29.5%	25.3%

Table 1: Statistical errors on the positron fraction R for all rigidity bins.

New Measurement of the Antiproton-to-Proton Flux Ratio up to 100 GeV in the Cosmic Radiation

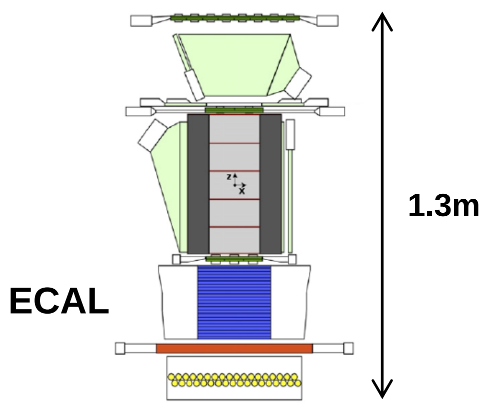
O. Adriani,[1,2] G. C. Barbarino,[3,4] G. A. Bazilevskaya,[5] R. Bellotti,[6,7] M. Boezio,[8] E. A. Bogomolov,[9] L. Bonechi,[1,2] M. Bongi,[2] V. Bonvicini,[8] S. Bottai,[2] A. Bruno,[6,7] F. Cafagna,[7] D. Campana,[4] P. Carlson,[10] M. Casolino,[11] G. Castellini,[12] M. P. De Pascale,[11,13] G. De Rosa,[4] D. Fedele,[1,2] A. M. Galper,[14] L. Grishantseva,[14] P. Hofverberg,[10] A. Leonov,[14] S. V. Koldashov,[14] S. Y. Krutkov,[9] A. N. Kvashnin,[5] V. Malvezzi,[11] L. Marcelli,[11] W. Menn,[15] V. V. Mikhailov,[14] M. Minori,[11] E. Mocchiutti,[8] M. Nagni,[11] S. Orsi,[10] G. Osteria,[4] P. Papini,[2] M. Pearce,[10] P. Picozza,[11,13] M. Ricci,[16] S. B. Ricciarini,[2] M. Simon,[15] R. Sparvoli,[11,13] P. Spillantini,[1,2] Y. I. Stozhkov,[5] E. Taddei,[1,2] A. Vacchi,[8] E. Vannuccini,[2] G. Vasilyev,[9] S. A. Voronov,[14] Y. T. Yurkin,[14] G. Zampa,[8] N. Zampa,[8] and V. G. Zverev[14]

(PAMELA Collaboration)

TABLE I. Summary of proton and antiproton results.

Rigidity at spectrometer GV	Mean Kinetic Energy GeV	Observed number of events $\bar{p}$	p	Extrapolated $\frac{\bar{p}}{p}$ at top of payload
2.23–2.58	1.64	39	119 803 9	$(3.92 \pm 0.63) \times 10^{5}$
2.58–2.99	1.99	48	114 401 4	$(4.92 \pm 0.71) \times 10^{5}$
2.99–3.45	2.41	55	107 177 8	$(5.91 \pm 0.80) \times 10^{5}$
3.45–3.99	2.89	60	988 666	$(6.89 \pm 0.89) \times 10^{5}$
3.99–4.62	3.46	74	903 708	$(9.2 \pm 1.1) \times 10^{5}$
4.62–5.36	4.13	71	827 521	$(9.6 \pm 1.1) \times 10^{5}$
5.36–6.23	4.91	93	738 028	$(1.40 \pm 0.14) \times 10^{4}$
6.23–7.27	5.85	78	653 736	$(1.31 \pm 0.15) \times 10^{4}$
7.27–8.53	6.98	69	573 172	$(1.32 \pm 0.16) \times 10^{4}$
8.53–10.1	8.37	67	505 503	$(1.44 \pm 0.18) \times 10^{4}$
10.1–12.0	10.1	94	449 261	$(2.27 \pm 0.23) \times 10^{4}$
12.0–14.6	12.3	58	405 583	$(1.54 \pm 0.20) \times 10^{4}$
14.6–18.1	15.3	58	301 314	$(2.05 \pm 0.27) \times 10^{4}$
18.1–23.3	19.5	46	270 068	$(1.80 \pm 0.27) \times 10^{4}$
23.3–31.7	25.9	39	211 249	$(1.94 \pm 0.31) \times 10^{4}$
31.7–48.5	37.3	24	136 858	$(1.82 \pm 0.37) \times 10^{4}$
48.5–100.0	61.2	6	57 613	$(1.07^{+0.58}_{0.39}) \times 10^{4}$

PAMELA



<u>Acceptance</u>

21.5 cm^2sr

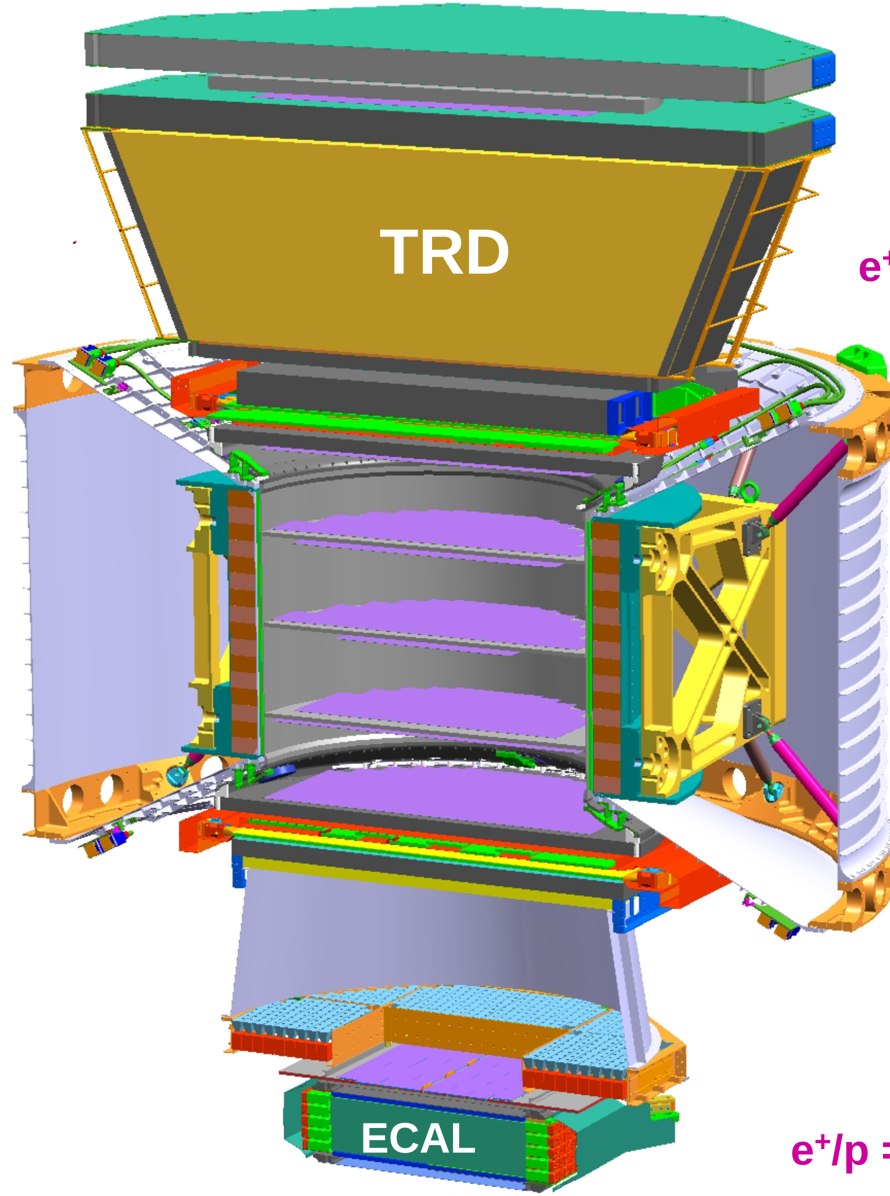
Astroparticle Physics
27 *(2007) 296–315*

<u>Exposure (5yrs)</u>

2006-2011

Published e^+ data up to ~ 100 GeV

AMS-02



$e^+/p = 10^{-2}$

Magnet

$e^+/p = 10^{-4}$

<u>Acceptance</u>

e^+	950 cm^2sr
$\bar{p}$, He, $\overline{He}$, …	4,500 cm^2sr

Measured rejection at 0.4 TeV
$e^+/p = 10^{-6}$

<u>Exposure (10 to 18 yrs)</u>

e^+ energy > 1 TeV