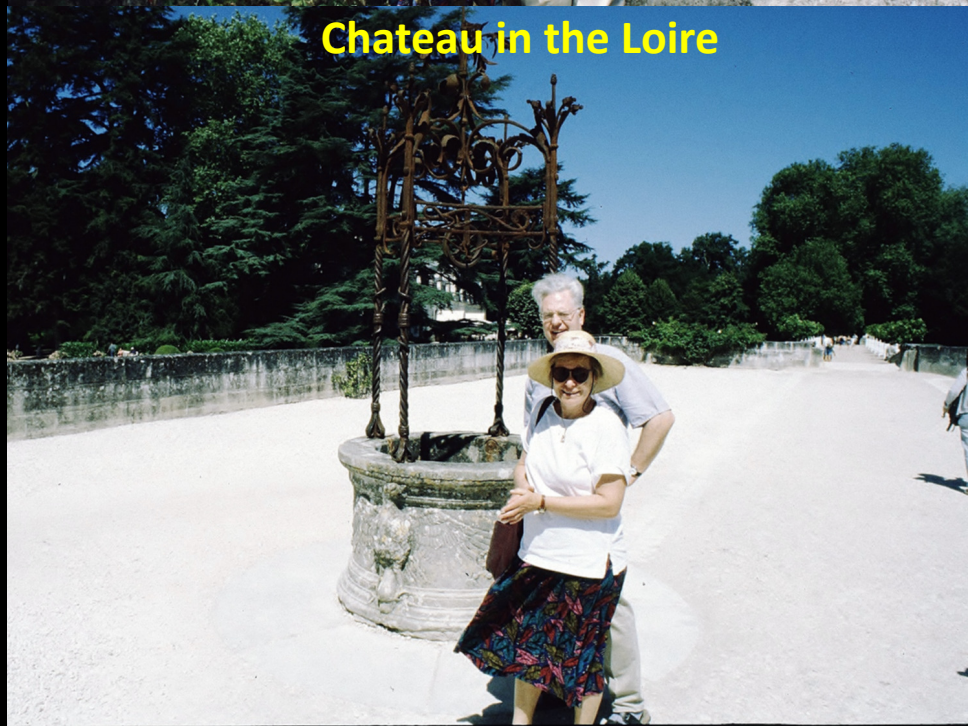
Our collaboration is not only work...

Challex

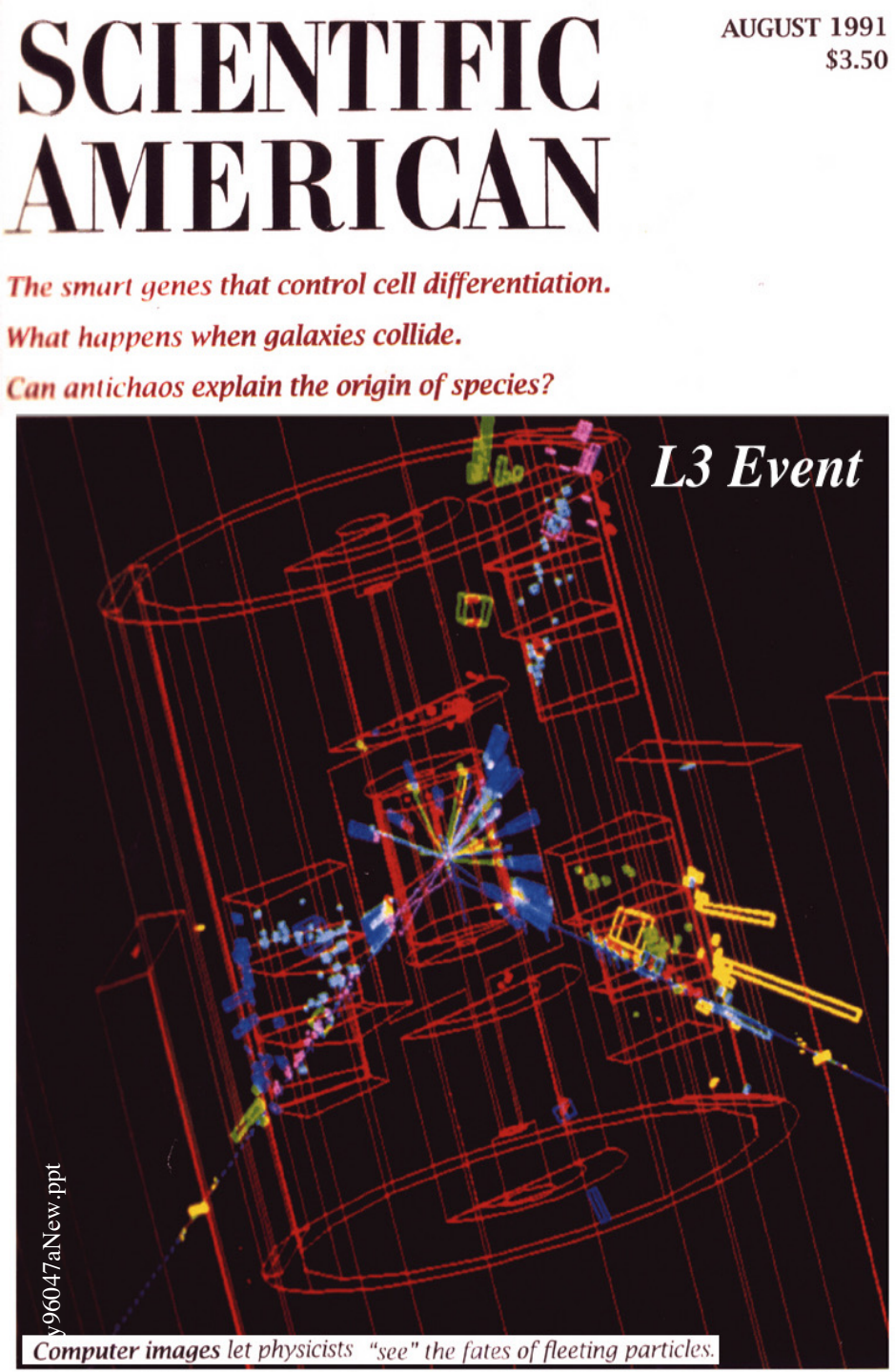
Sicily


Chateau in the Loire

1988: U. Becker 50th Birthday celebration at CERN, Ting's office

Visit of Chuck Vest, Paul Gray, and the MIT Corporation to L3

Christoph Paus at L3 reception with Becker



y96047aNew.ppt

~ 300 Papers

Results:

3 kinds of electrons (e, μ, τ)

6 families of quarks

Electrons and quarks have no size

Their radii are $R < 10^{-17}$ cm

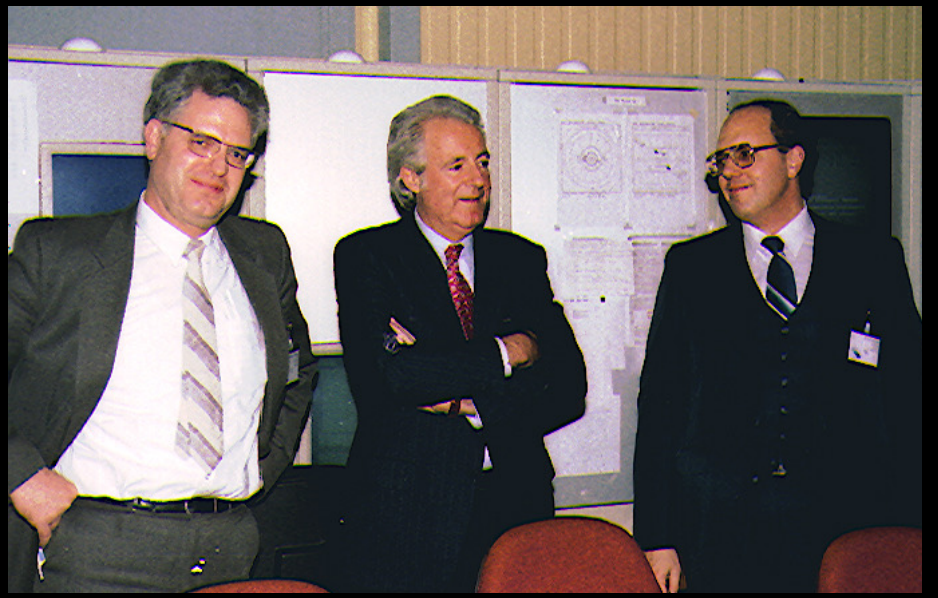
The results are in excellent agreement with

Electroweak Theory

Discussions of L* experiment at SSC

L . Okun

K. Lubelsmeyer H. Newman



M. Vivargent H. Hofer F. Wittgenstein

Z P Zheng

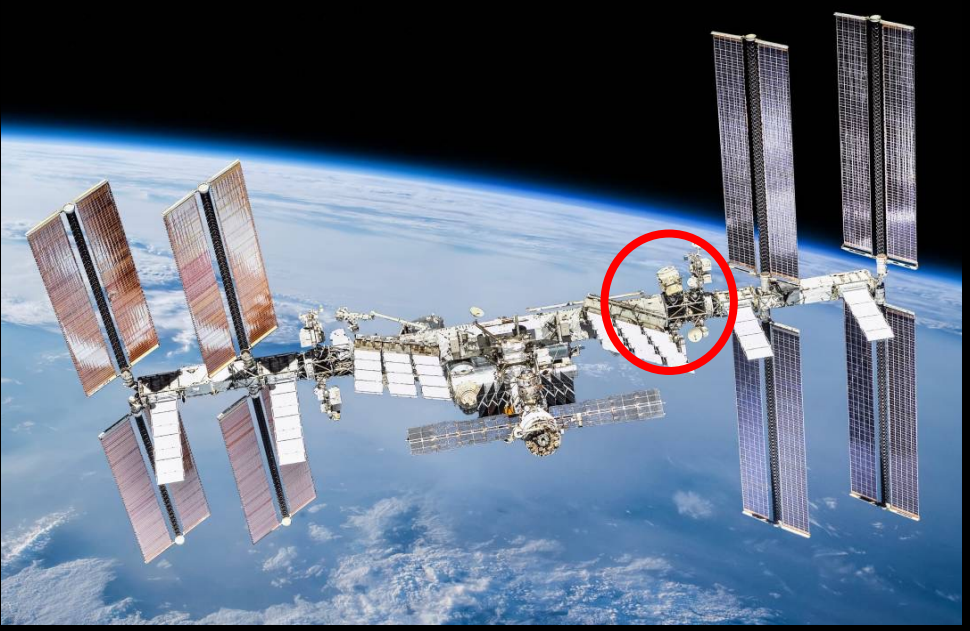
1994, Sixth Experiment with Ulrich Becker
AMS in Space

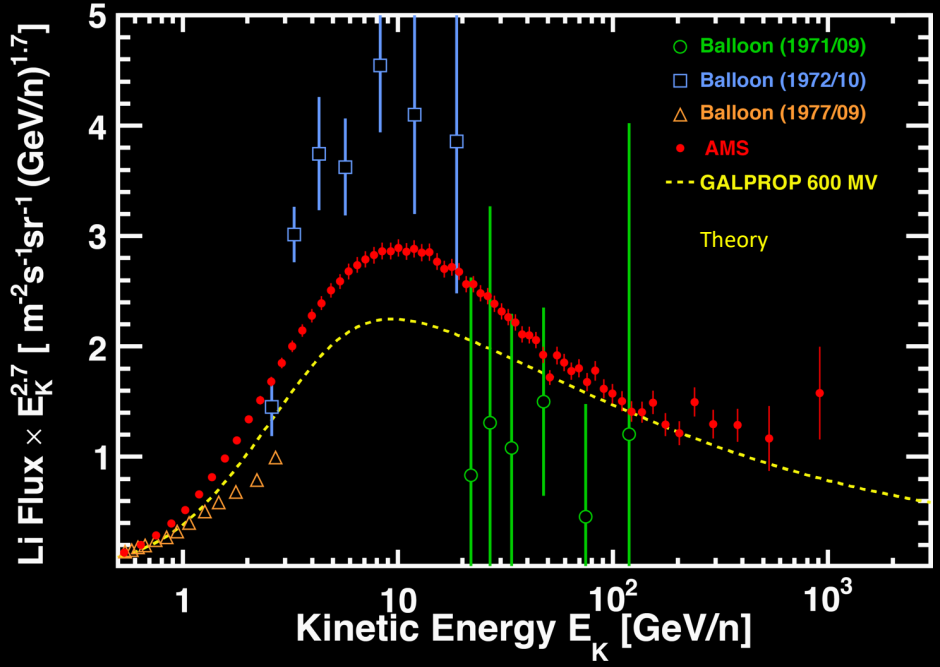
Space is the ultimate laboratory. It provides the highest energy particles.

The Space Station is a unique platform to support the weight and to provide the power for a precision, long duration experiment, AMS.

In the past hundred years, measurements of charged cosmic rays by balloons and satellites have typically had 30% to 50% accuracy.

AMS is providing cosmic ray information with ~1% accuracy.
The improvement in accuracy is providing new insights about the cosmos.

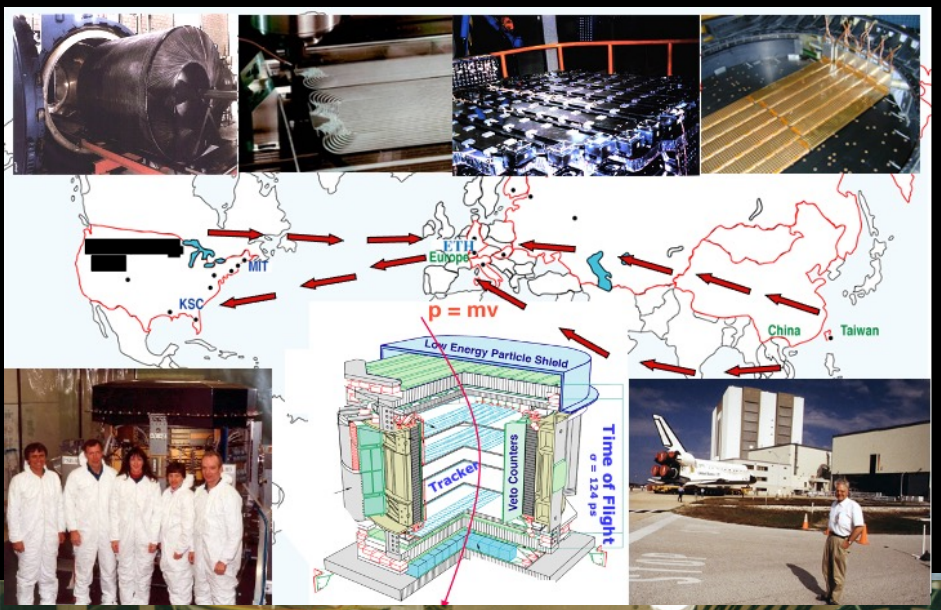


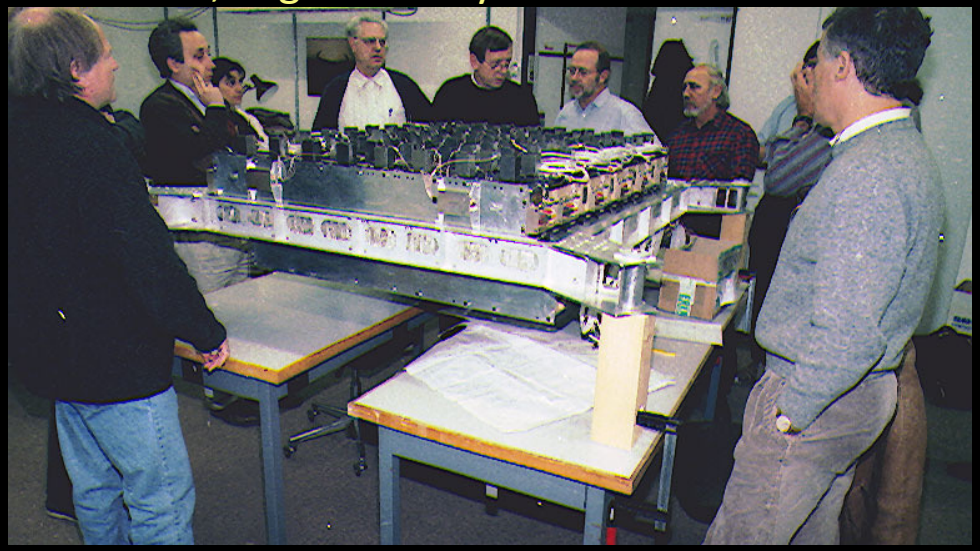


Ph.D. Students: Reyco Henning, Ben Monreal, Yi Jia, Matt Krafczyk, Hai Chen, Matthew Behlmann, …

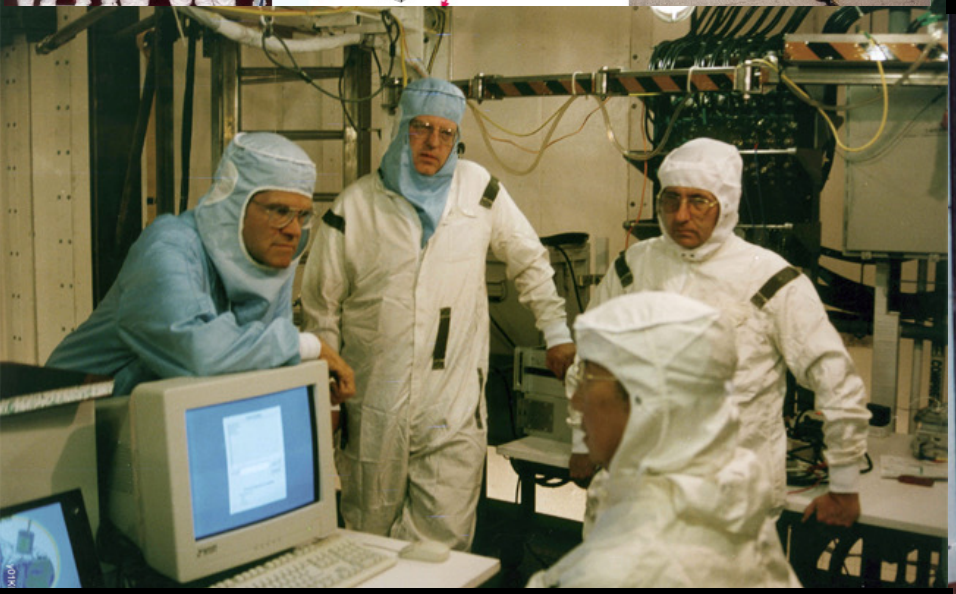
AMS-01 on the space shuttle

Approval: April 1995, Assembly: December 1997, Flight: 10 days in June 1998

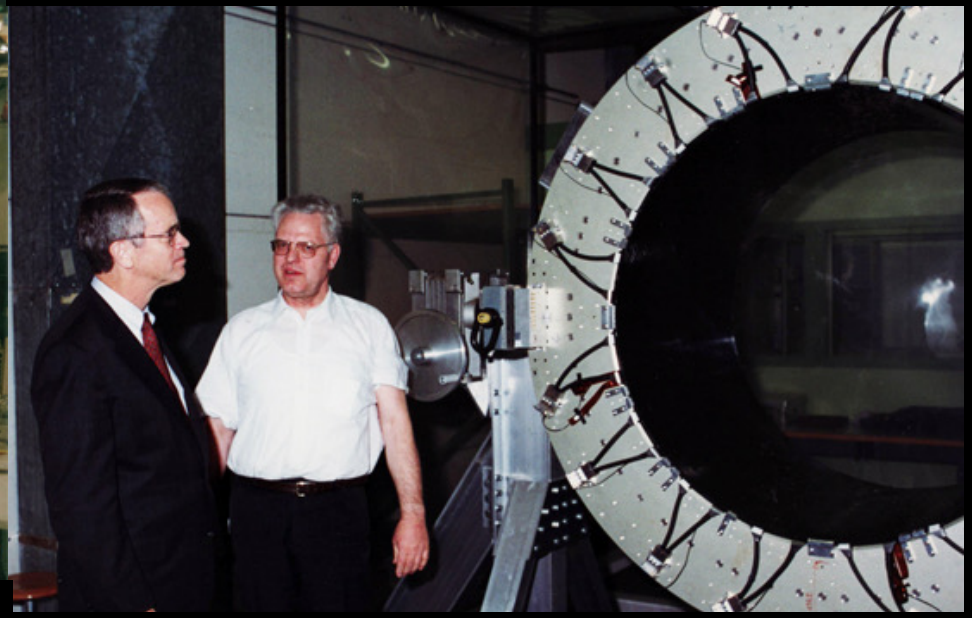




Assembly of AMS-01 at ETH-Zurich.



J. Burger, U. Becker , A. Lebedev and I at the launch pad of AMS-01 at Kennedy Space Center.

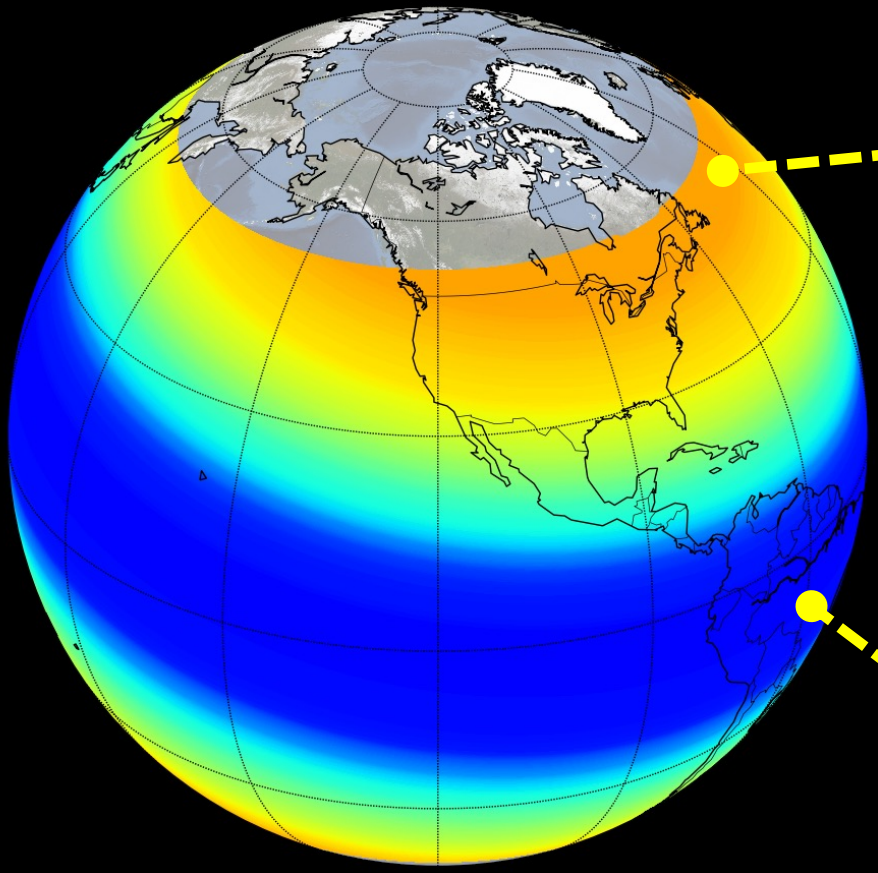


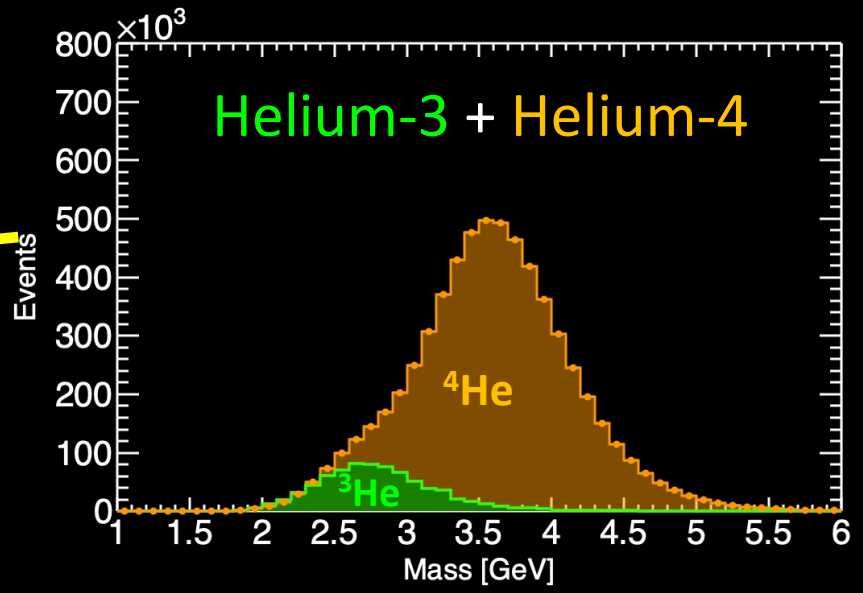
Visit of Chuck Vest to AMS-01 at ETH-Zurich.

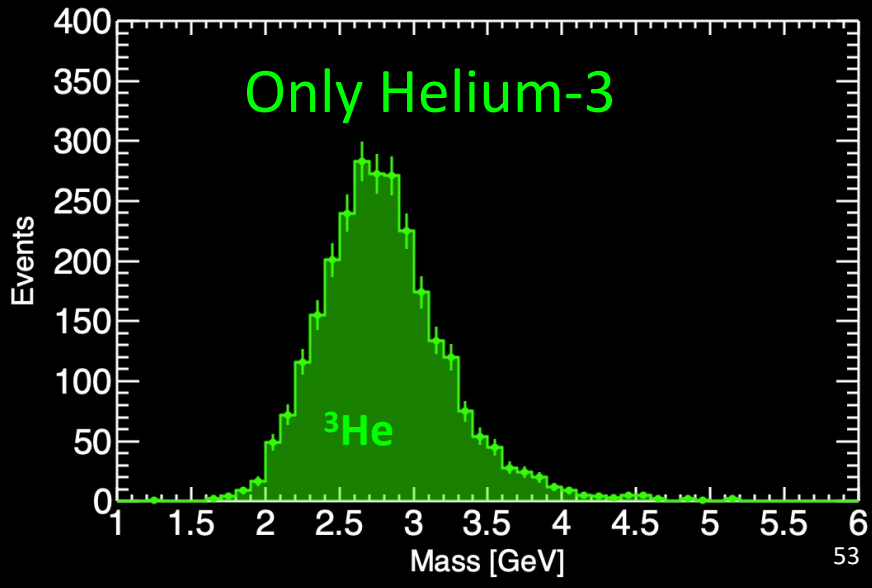
Helium in Low Earth Orbit

In the energy range 100 MeV to 4000 MeV
over a large region, -35°< Θ_M < +35°, only helium-3 isotope exists.

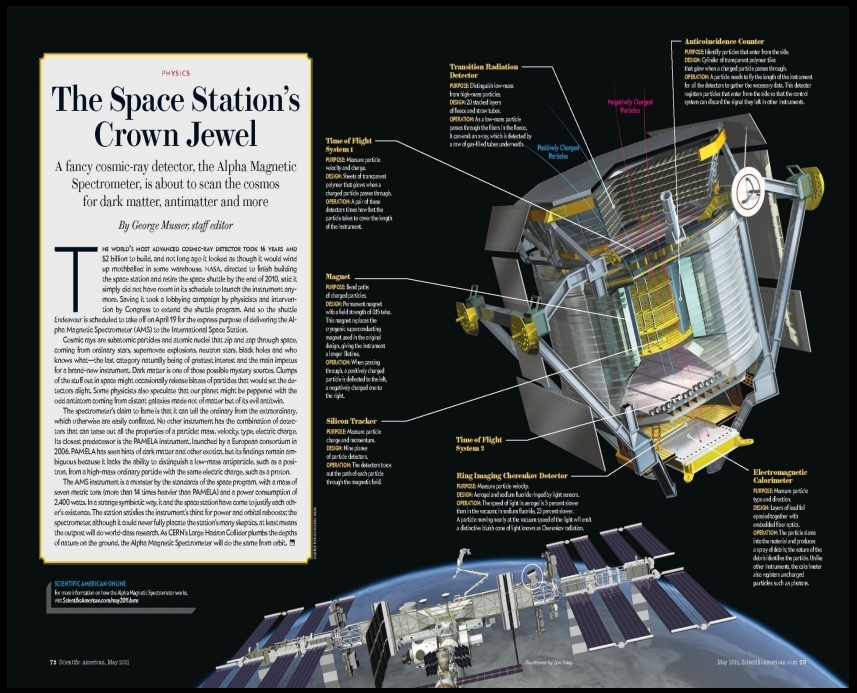
Helium







May 2011



PHYSICS

The Space Station's Crown Jewel

A fancy cosmic-ray detector, the Alpha Magnetic Spectrometer, is about to scan the cosmos for dark matter, antimatter and more

By George Musser, staff editor

THE WORLD'S MOST ADVANCED COSMIC-RAY DETECTOR TOOK 16 YEARS AND $2 billion to build, and not long ago it looked as though it would wind up mothballed in some warehouse. NASA, directed to finish building the space station and retire the space shuttle by the end of 2010, said it simply did not have room in its schedule to launch the instrument anymore. Saving it took a lobbying campaign by physicists and intervention by Congress to extend the shuttle program. And so the shuttle Endeavour is scheduled to take off on April 19 for the express purpose of delivering the Alpha Magnetic Spectrometer (AMS) to the International Space Station.

Cosmic rays are subatomic particles and atomic nuclei that zip and zap through space, coming from ordinary stars, supernovae explosions, neutron stars, black holes and who knows what—the last category naturally being of greatest interest, and the main impetus for a brand-new instrument. Dark matter is one of those possible mystery sources. Clumps of the stuff out in space might occasionally release blazes of particles that would set the detectors alight. Some physicists also speculate that our planet might be peppered with the odd antiatom coming from distant galaxies made not of matter but of its evil antitwin.

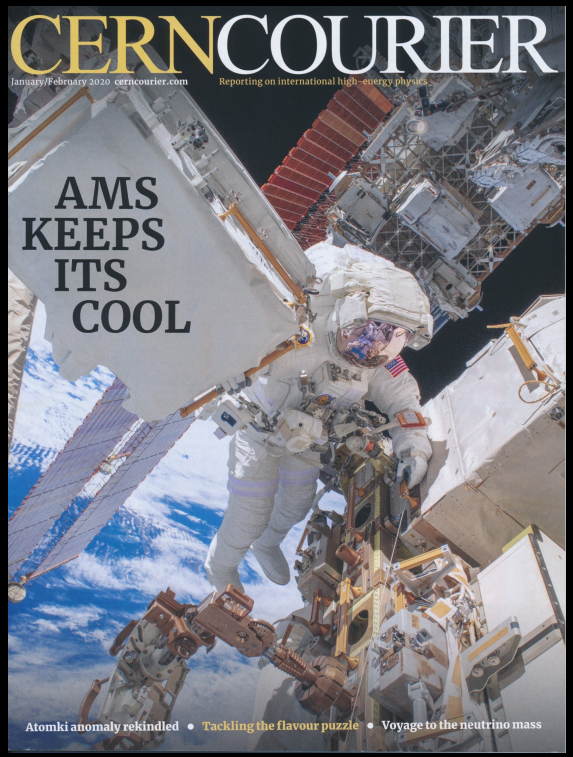
The spectrometer's claim to fame is that it can tell the ordinary from the extraordinary, which otherwise are easily conflated. No other instrument has the combination of detectors that can tease out all the properties of a particle: mass, velocity, type, electric charge. Its closest predecessor is the PAMELA instrument, launched by a European consortium in 2006. PAMELA has seen hints of dark matter and other exotica, but its findings remain ambiguous because it lacks the ability to distinguish a low-mass antiparticle, such as a positron, from a high-mass ordinary particle with the same electric charge, such as a proton.

The AMS instrument is a monster by the standards of the space program, with a mass of seven metric tons (more than 14 times heavier than PAMELA) and a power consumption of 2,400 watts. In a strange symbiotic way, it and the space station have come to justify each other's existence. The station satisfies the instrument's thirst for power and orbital rebooses; the spectrometer, although it could never fully plaster the station's many skeptics, at least means the outpost will do world-class research. As CERN's Large Hadron Collider plumbs the depths of nature on the ground, the Alpha Magnetic Spectrometer will do the same from orbit.

SCIENTIFIC AMERICAN ONLINE
for more information on how the Alpha Magnetic Spectrometer works, visit Scientificamerican.com/may2011/ams

Scientific American 2011

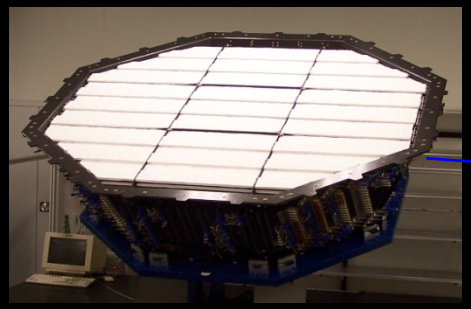
2019 upgrade



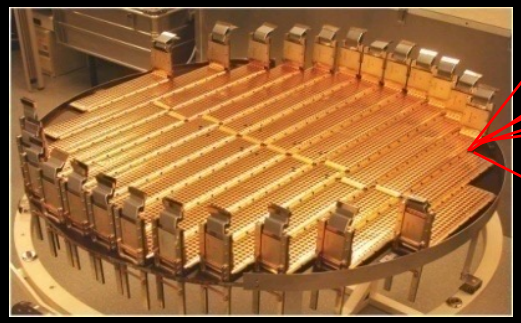
AMS-02 on Space Station

AMS is a space version of a precision detector used in accelerators

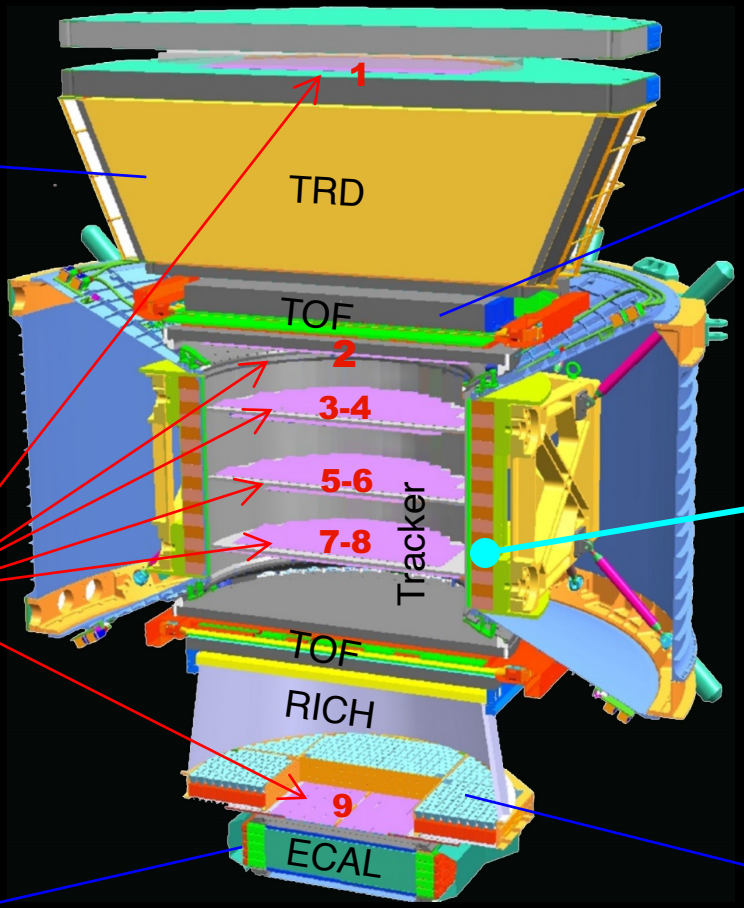
Transition Radiation Detector (TRD)



Silicon Tracker



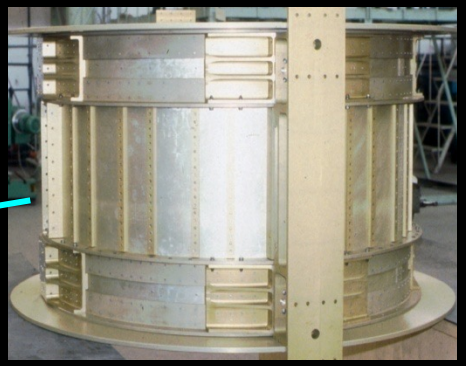
Electromagnetic Calorimeter (ECAL)



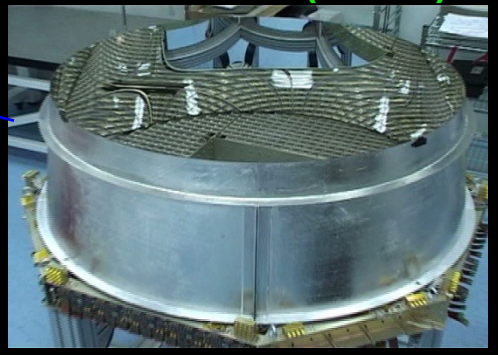
300,000 electronic channels,
650 fast microprocessors
5m x 4m x 3m
7.5 tons

Time of Flight Detector (TOF)

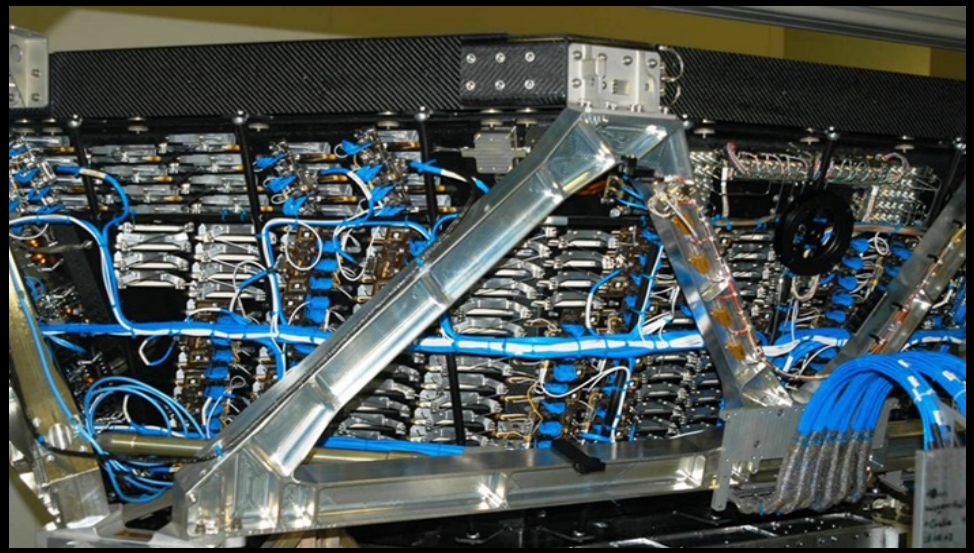
Magnet

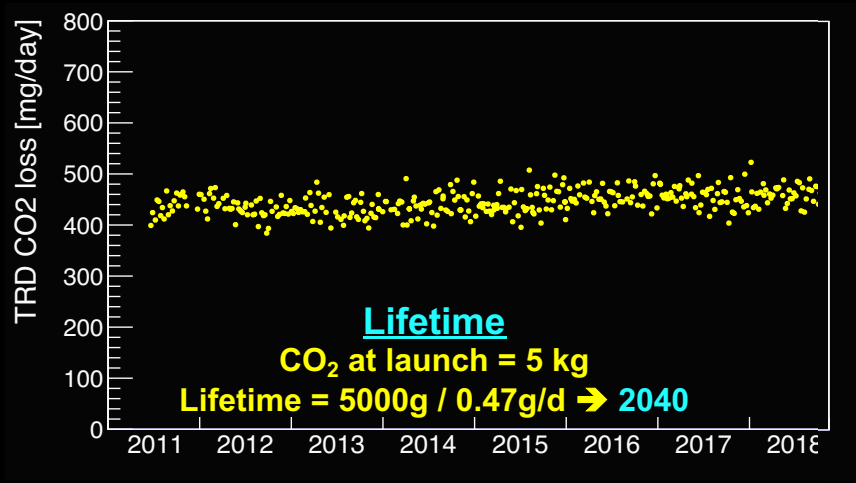


Ring Imaging Cherenkov (RICH)

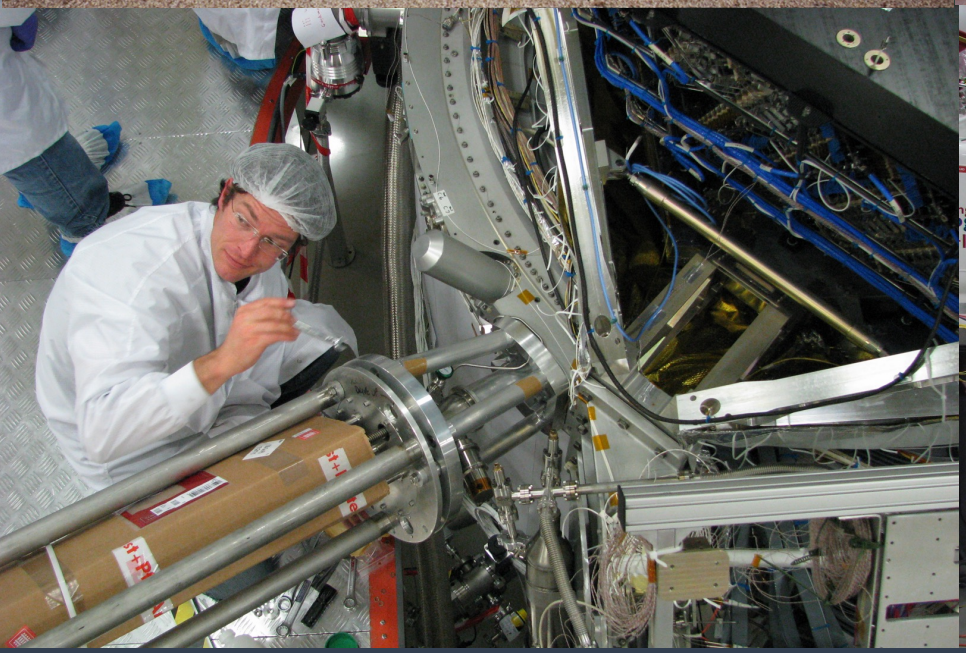


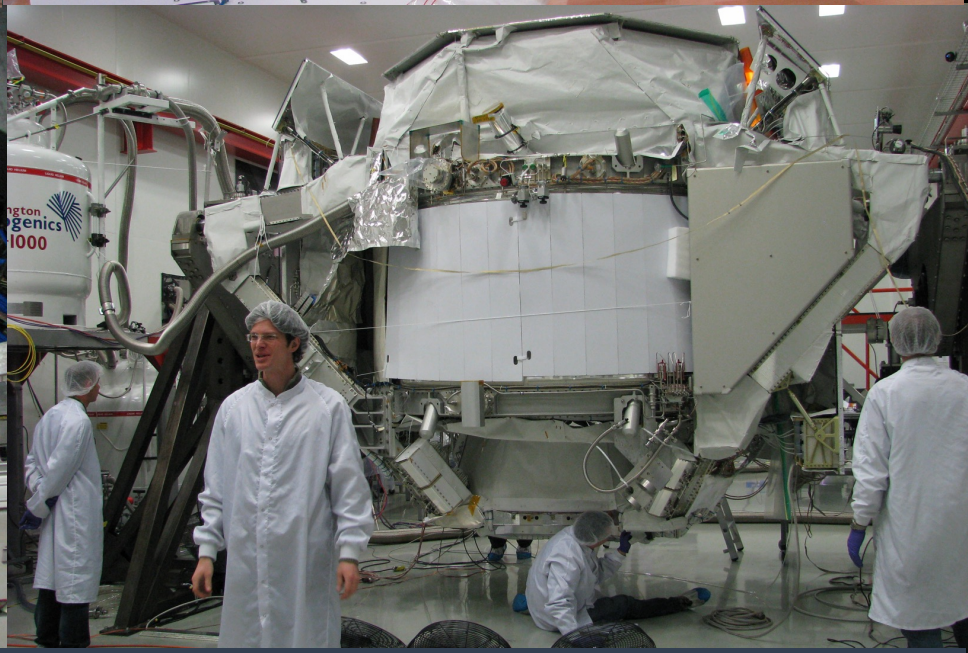
TRD Gas system: U. Becker, J. Burger, P. Fisher





The Beckers in AMS





Robert Becker has made important contributions to AMS

AMS-02 Publications in P.R.L. with U.J. Becker

1) Phys. Rev. Lett. 110, 141102 (2013). Editors' Suggestion. Viewpoint in *Physics*. Highlight of 2013. Ten-Year retrospective.
2) Phys. Rev. Lett. 113, 121101 (2014). Editors' Suggestion
3) Phys. Rev. Lett. 113, 121102 (2014). Editors' Suggestion
4) Phys. Rev. Lett. 113, 221102 (2014).
5) Phys. Rev. Lett. 114, 171103 (2015). Editors' Suggestion
6) Phys. Rev. Lett. 115, 211101 (2015). Editors' Suggestion
7) Phys. Rev. Lett. 117, 091103 (2016).
8) Phys. Rev. Lett. 117, 231102 (2016). Editors' Suggestion
9) Phys. Rev. Lett. 119, 251101 (2017).
10) Phys. Rev. Lett. 120, 021101 (2018). Editors' Suggestion. Featured in *Physics*.
11) Phys. Rev. Lett. 121, 051101 (2018).
12) Phys. Rev. Lett. 121, 051102 (2018). Editors' Suggestion
13) Phys. Rev. Lett. 121, 051103 (2018).
14) Phys. Rev. Lett. 122, 041102 (2019). Editor's Suggestion
15) Phys. Rev. Lett, 122, 101101 (2019).
16) Phys. Rev. Lett. 123, 181102 (2019). Editors' Suggestion
17) Phys. Rev. Lett. 124, 211102 (2020). Editors' Suggestion. Featured in *Physics*.

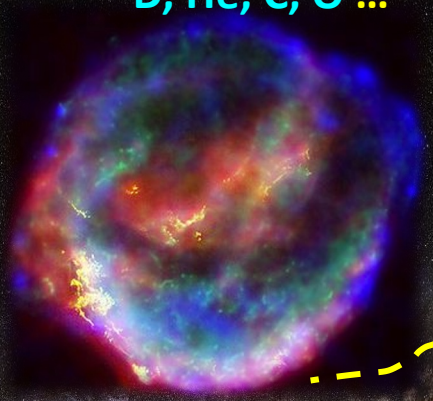
Heavy Antimatter in the Cosmos

Matter is defined by its mass *M* and charge *Z*.

Antimatter has the same mass *M* but opposite charge –*Z*.

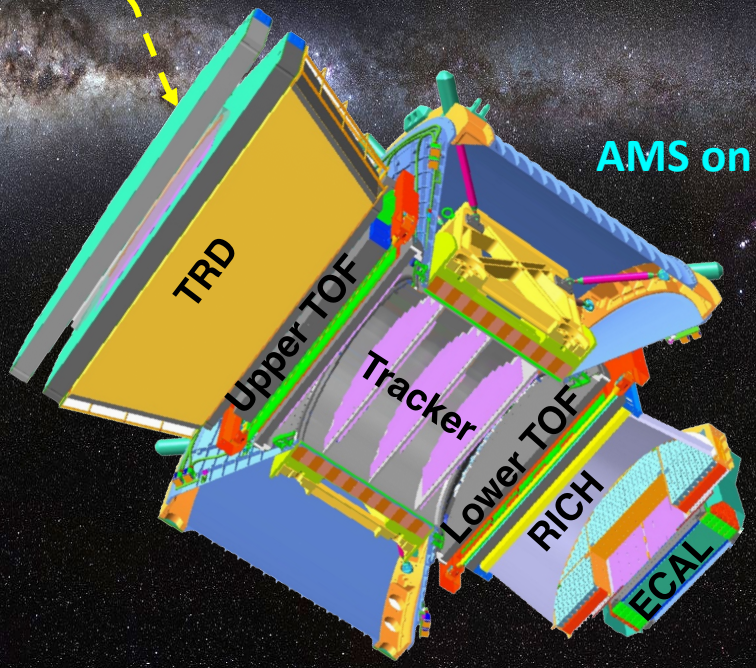
$\bar{D}$, $\bar{He}$, $\bar{C}$, $\bar{O}$ …

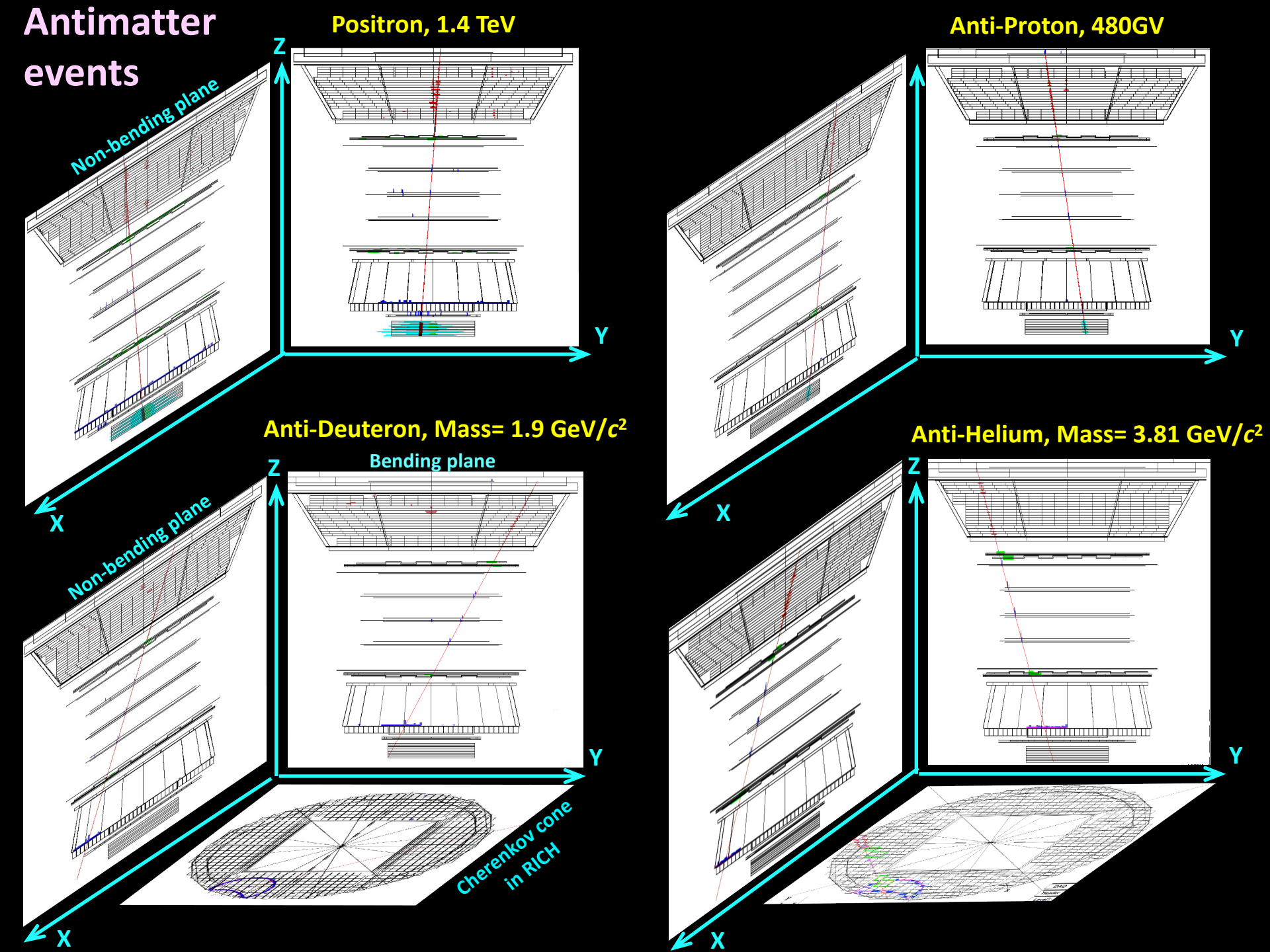
Antimatter Star



$\bar{D}$ may also come from Dark Matter collisions

AMS on ISS



AMS is a unique antimatter spectrometer in space

Antimatter events