Science & Environment

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# Alpha Magnetic Spectrometer to go on Endeavour shuttle

By Jonathan Amos BBC science correspondent, Kennedy Space Center


The long journey: It has taken 17 years to get the Alpha Magnetic Spectrometer to the launch pad

It is the most complex space physics experiment ever built, and it will launch on shuttle Endeavour this week.

The Alpha Magnetic Spectrometer (AMS-02) is also the most expensive, valued at $2bn (£1.2bn) - although no-one is really quite sure how much it has cost.

The 7-tonne machine will sit atop the International Space Station (ISS) and undertake a comprehensive survey of cosmic rays - the storm of high-energy particles (mostly protons and helium nuclei) that are accelerated in our direction from exploded stars, black holes and who knows what other exotic corners of the cosmos.

In analysing the nature of these particles, AMS promises remarkable new discoveries about how the Universe is put together.

There is a chance it could find anti-matter, the mirror of the material from which we are all made; and even identify the mysterious "dark matter" that scientists say makes a bigger contribution to the mass of the cosmos than all the stuff we see through telescopes.

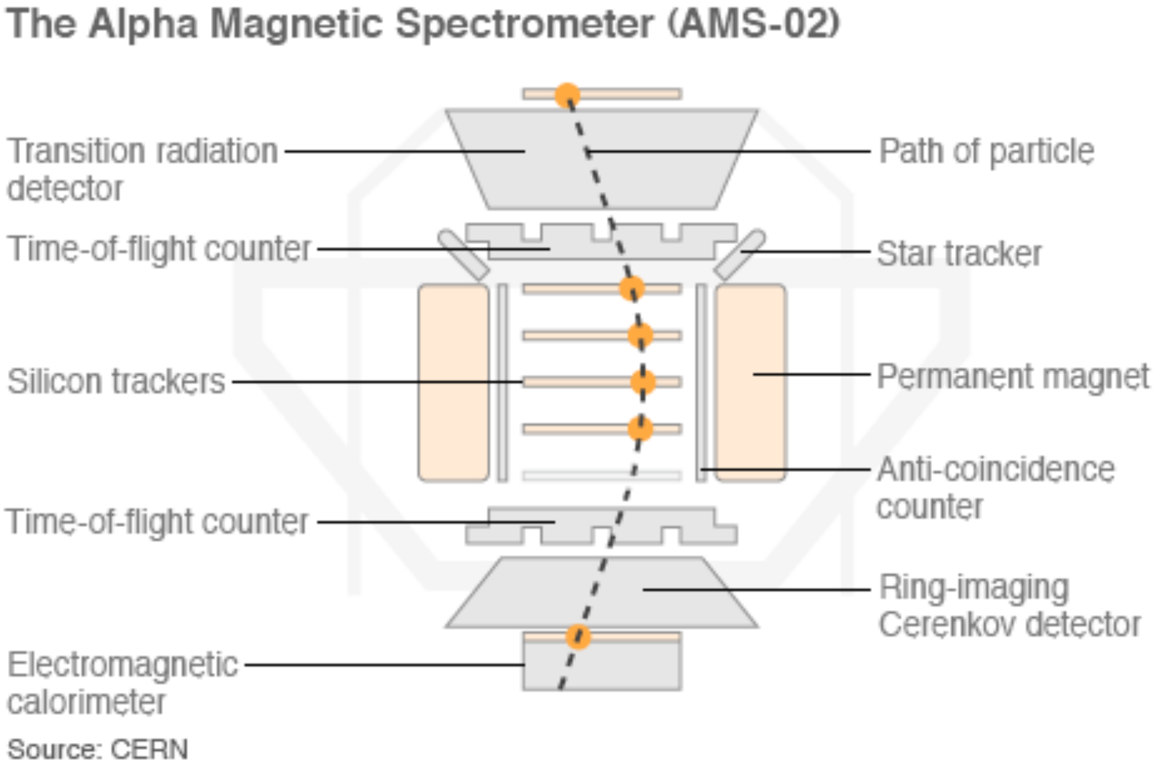
But as exciting as these revelations would be, to Professor Sam Ting, the driving force behind the experiment, it is the knowledge AMS simply stumbles upon that could ultimately shake us.

"The issue of anti-matter and the origin of dark matter really probe the foundations of modern physics, but to my collaborators and me, the most exciting objective of AMS is to probe the unknown, to search for phenomena that exist in Nature but yet we have not the tools or the imagination to find them," the Nobel Laureate said.

If some of what AMS does sounds similar to the activities of the Large Hadron Collider (LHC) at Europe's Cern laboratory, you would be right. The association is a rich one.

AMS was assembled and tested at Cern, and when it is working on the back of the ISS, it will talk to an operations control room at the laboratory.

But the details of the two great machines are really quite different, and AMS is doing something that is simply impossible on Earth.



In the LHC, a ring of super-cooled magnets are used to accelerate and corral particles that have energies of 7 trillion electron volts (TeV). The cosmos-accelerated particles AMS will catch in its detectors may have energies of 100 million TeV. The Earth's atmosphere works to filter out such high-energy objects, so AMS has to go into space if it wants to study them directly.

**Transition Radiation Detector** determines highest-energy particle velocities

**Silicon trackers** follow particle paths; how they bend reveals their charge

**Permanent magnet** is core component of AMS and makes particles curve

**Time-of-flight counters** determine lowest-energy particle velocities

**Star trackers** scan star fields to establish AMS's orientation in space

**Cerenkov detector** makes accurate velocity measurements of fast particles

**Electromagnetic calorimeter** measures energy of impacting particles

**Anti-coincidence counter** filters signal from unwanted side particles

AMS does carry a magnet - a very big one. But this is used just to bend the particles as they pass through the machine. The way they bend reveals their charge, a fundamental property that, together with information about the particles' mass, velocity and energy, garnered from a slew of detectors, tells scientists precisely what they are dealing with.

In the overwhelming majority of cases, it will be just a boring proton that is observed. But there is a good chance that some colourful form of matter never witnessed before turns up in AMS.

This confidence may stem from a shuttle flight in 1998 when a much less sensitive test version of the machine (AMS-01) recorded one fascinating event in the course of 10-day journey into space.

The event was speculated to be the impact on the detectors of a so-called strangelet, a type matter composed of a different mix of elementary particles to that of normal matter.

"OK, it was a single event and a single event doesn't mean much - we would have to gather far more statistics," conceded Professor Martin Pohl of Geneva University, a team leader for one of the detector teams on the machine.

Our only obligation is to make sure the instrument is correct - what you get is the truth”

End Quote Professor Sam Ting AMS project leader
"But if strangelets really exist, there will be no way to miss them on this next flight. Their source would be supernova explosions. It would revolutionise our understanding of the physics of what a supernova is," he told BBC News.

Asymmetric cosmos

One of the key quests for AMS, though, is to tie down the thorny issue of anti-matter.

Theory holds that for each basic particle of matter, there exists an anti-particle with the same mass but the opposite electric charge. For example, the negatively charged electron has a positively charged anti-particle called the positron.

Physicists believe the Big Bang should have produced equal amounts of matter and anti-matter, and yet when we look around our galaxy and beyond, all we seem to see is normal matter. Where has the anti-matter gone?

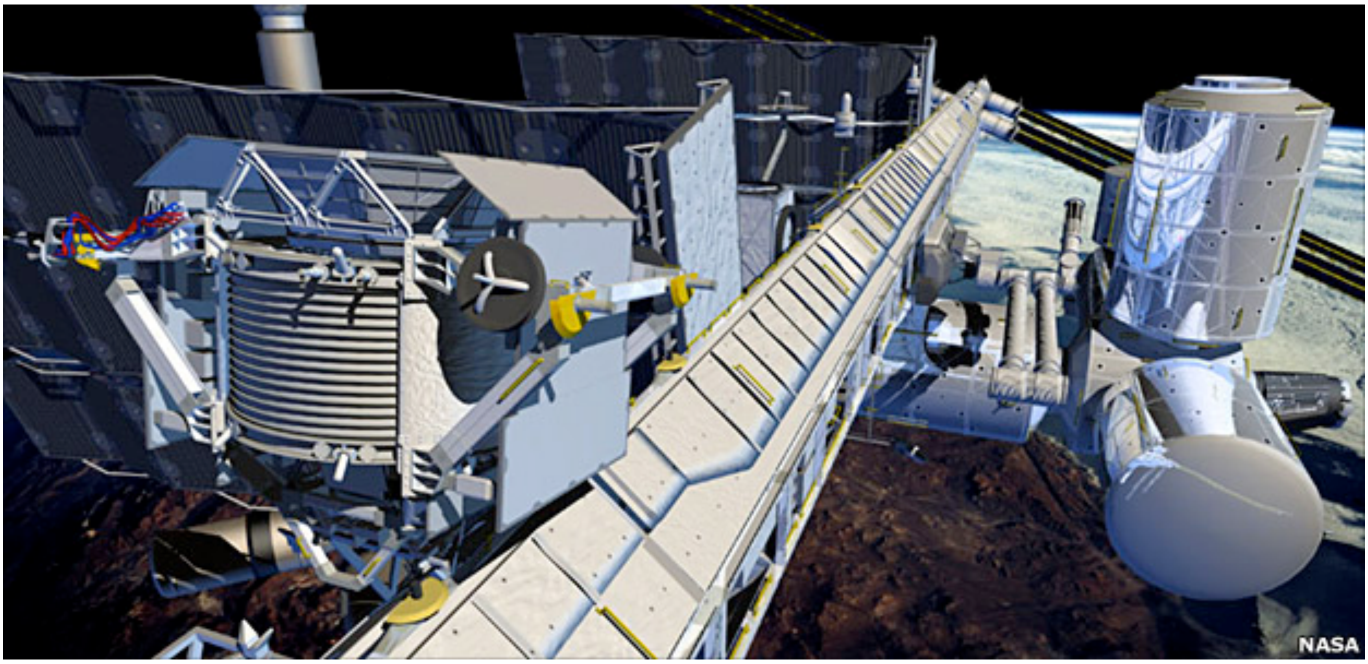
This asymmetry sits uncomfortably with some other experimental observations, and so establishing whether or not anti-matter still exists in the Universe is really quite a pressing question for today's physicists.

Professor Ting says that detecting just one anti-helium nucleus, for example, would provide good evidence for the existence of a large amount of anti-matter somewhere in the Universe.

"The reason we have designed this experiment with such a large size, with so many layers of repetitive precision detectors, is to search for the existence of anti-matter to the age of the observable Universe - for anti-helium, anti-carbon; and we can distinguish these particles from billions of ordinary particles," the Massachusetts Institute of Technology (MIT) researcher explained.

AMS colleague Roberto Battiston, a professor of physics at the University of Perugia, describes the necessary sensitivity thus: "It's basically similar to the following example: Imagine it is raining over London - which often happens - and there is one drop which is red. We want to catch it without any hesitation.

"It is an experiment capable to get out one particle out of ten billion, to find out this one is very special and carries information the other particles don't," he told BBC News.




The AMS will sit on the station's truss, or backbone, slightly tilted to look past the giant solar wings

Although it is riding into orbit on the US space agency's Endeavour shuttle and being hosted at the ISS, the machine is not actually a Nasa project. The agency is really just a facilitator.
The main sponsor is the US Department of Energy. MIT has the science lead and heads a collaboration that comprises some 600 researchers at 60 institutions across 16 nations.

That AMS has even arrived at the launch pad is remarkable in itself given the history of the project. It has been near to cancellation on a few occasions, and after the Columbia shuttle accident was even dropped from the ISS assembly plan altogether.

But the commitment of the team and the financial backing of the US Congress, which mandated Nasa to find a shuttle to fly AMS, have ensured the "LHC in space" will get to do its science.

This is likely to begin within minutes of the machine being connected to the power supply of the orbiting platform.

Responsibility to science

It will sit at one of six fixed-payload attach-points, tilted slightly so that it can have a view of the cosmos unobstructed by the station's giant solar wings.

"We'll be gathering data at seven gigabits per second," explained Trent Martin, the Nasa project manager appointed to advise the collaboration.

"We can't send that huge amount of data down through the space station data systems - it's just too much. So the onboard computers actually go through a process of condensing that data down to just the data we're truly interested in, compressing it as much as possible. We'll be sending down data on average at about six megabits per second, constantly for the whole time that AMS is on."

There will be no rush to announcement, warns Professor Ting. The AMS experiment relies on good statistics so the collaboration will want to run it for a good length of time before they start making assessments about the presence or not of anti-matter, and the like.

And if one science team thinks it has a eureka moment, the finding will be assessed first by another, independent team - a practice well established at the LHC.

"Given the enormous difficulty we have had in building this experiment, I think in the next 10 to 20 years nobody will be foolish enough to repeat this," the professor joked; and then in more serious tone: "It is very important we do it correctly, because otherwise it is certainly going to mislead the direction of science. Our only obligation is to make sure the instrument is correct - what you get is the truth."