LNS Update

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AMS, Antimatter & You...

--Peter Fisher

This talk was recently given to high school students at DOE in Washington, DC.

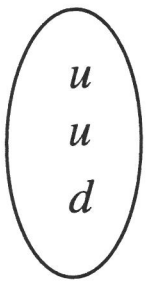
Put your knowledge to the test and take the antimatter quiz at ***www.fnal.gov/directorate/public_affairs/ams/quizhome.html.***

What is antimatter?

- Each matter particle (neutron, proton and electron) has an <u>antimatter</u> partner of opposite electrical charge:

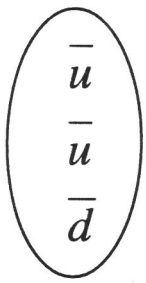
Electron: $e^- \Longrightarrow$ Positron: e^+
(matter) (antimatter)

Proton: (matter)



Charge=+1

Antiproton: (antimatter)



Charge=-1

- Matter-antimatter annihilation to pure energy (light)...

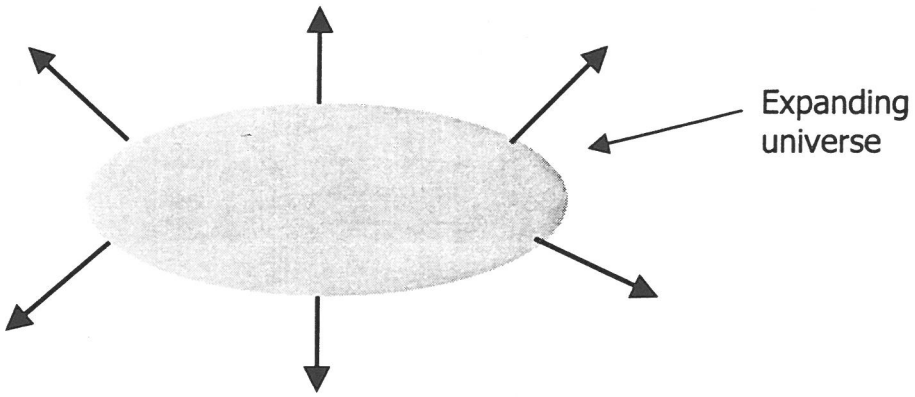
$$e^+ + e^- \rightarrow \gamma + \gamma$$

...creation of matter and antimatter from pure energy

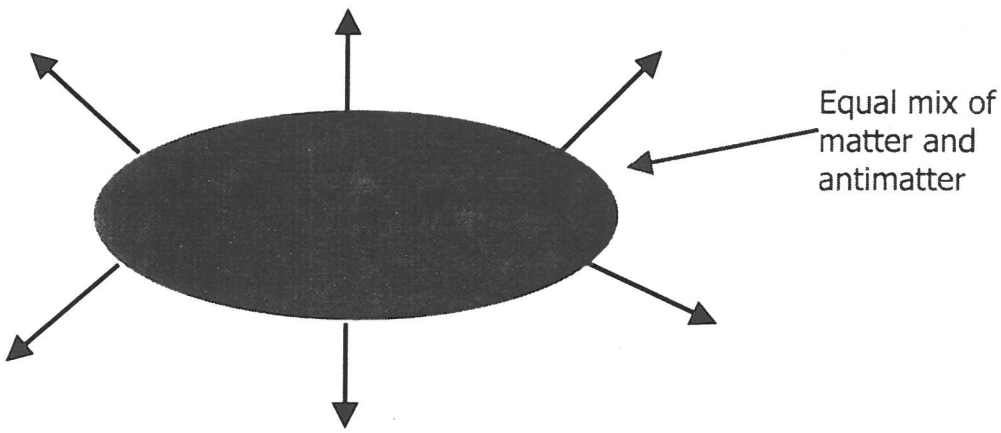
$$\gamma + \gamma \rightarrow e^+ + e^-$$

Why do we expect to find antimatter in space?

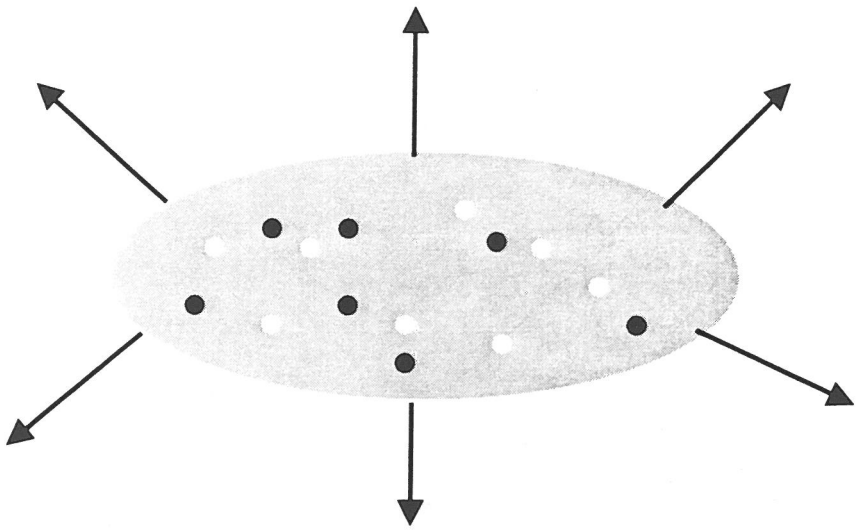
Big Bang: at start, universe filled with pure energy and begins to expand...



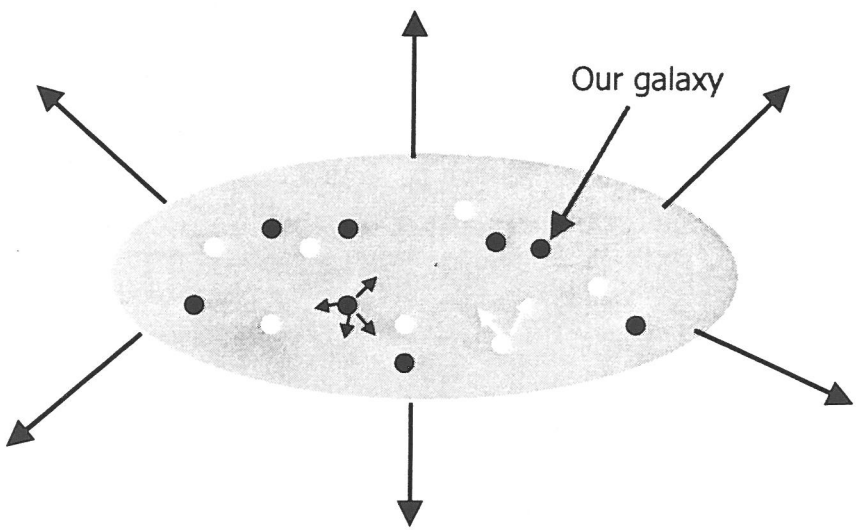
...matter and antimatter created from pure energy uniformly fills the universe...



...gravity begins to pull the matter and antimatter together, most annihilate, but a little of each remains to form galaxies...



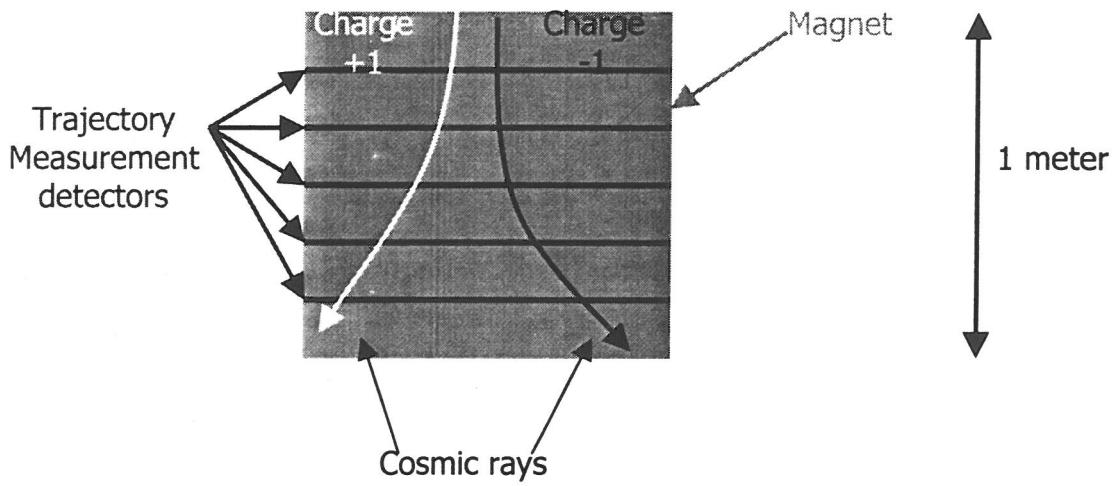
Galaxies spew out matter, antigalaxies spew out antimatter, which travel in between (30 million light years!)...



...and it arrives near Earth (AMS)

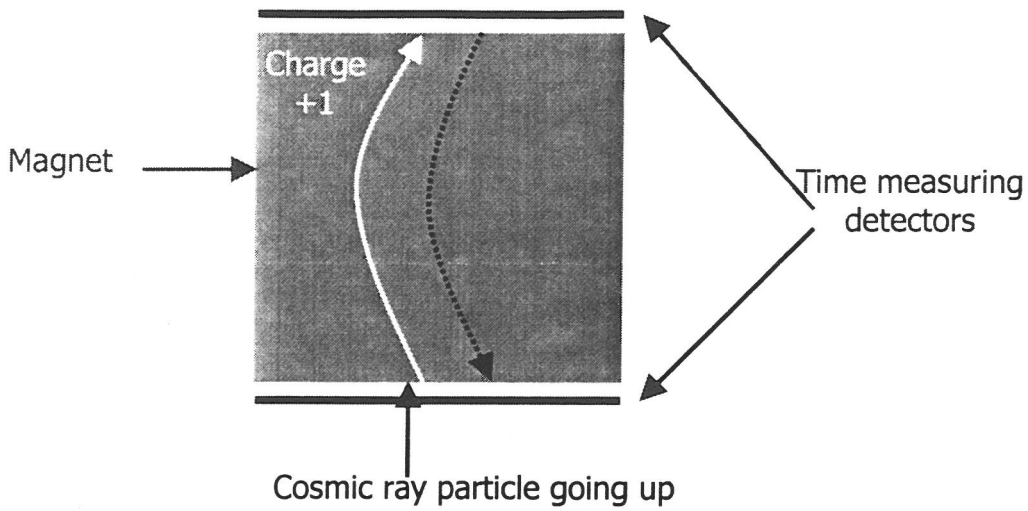
How do we detect antimatter with AMS?

- Need to go into space, atmosphere is *matter!* Will annihilate antimatter.
- Identify charge: measure curvature in a magnetic field:



Must measure *each point* with accuracy of a human hair (25 millionths of a meter)!

- Must measure direction:
  matter going *upward* looks like
  antimatter going *downward.*



Measure time cosmic ray particle enters and leaves the magnet to tell which way it went...

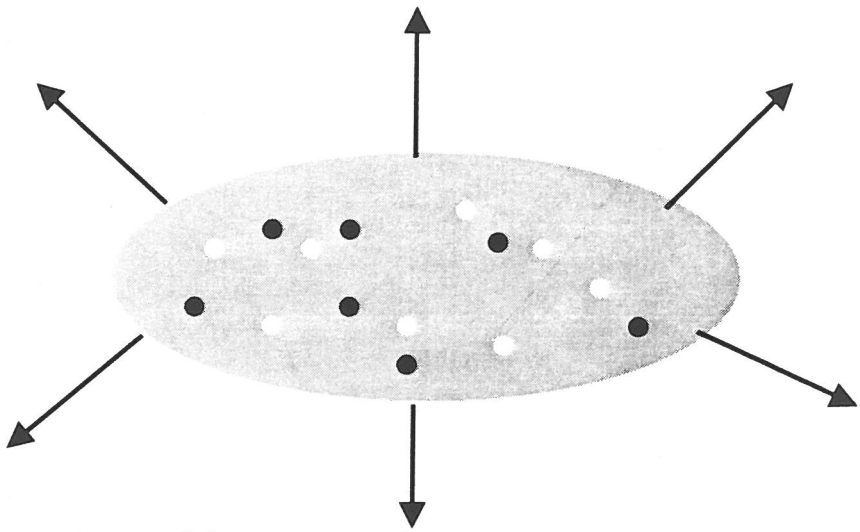
...must measure time to an accuracy
of 1 billionth of a second!

AMS is one of the most advanced, accurate detectors ever built.
What is dark matter?

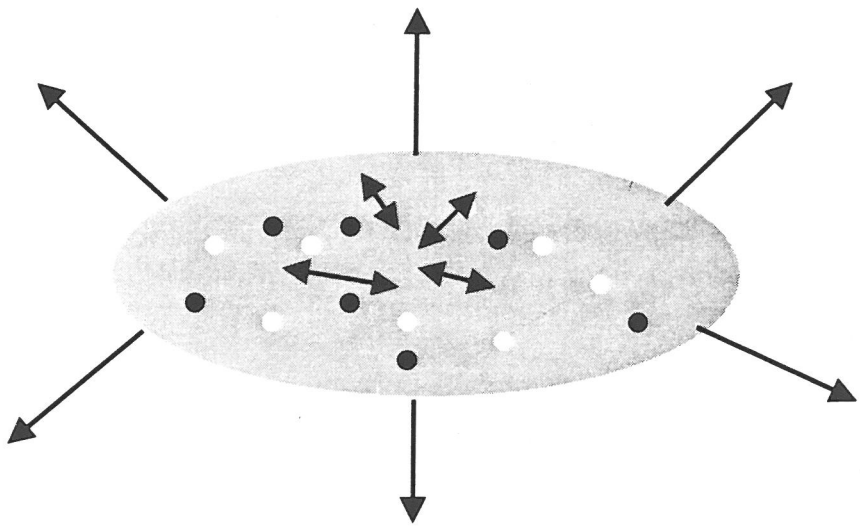
- By studying the Sun, we know how much matter is needed to produce a certain amount of light by a star. This is the same for matter and antimatter stars.
- Some particles do not participate in the production of light in a star, for example:
  - Neutrinos (known to exist)
  - Axions (not yet observed, may exist)
  - WIMPS (not yet observed, may exist)
- If there are many of these particles, their presense may lead to the production of antimatter in our galaxy $\Rightarrow$ by looking for antimatter, we can look for these new particles.

Why is this important to you?

- The universe is expanding...



...but the gravitation pull between galaxies tries to stop the expansion...



...if there is enough matter, the expansion will stop !
The end of the universe

- If the expansion stops, the universe will collapse into a Big Crunch, followed by another Big Bang.
- If we count all the stars we can see and determine the total mass from the study of the sun, there is only 10% of the mass need to stop the expansion.

- There *may be* enough dark matter to stop the expansion. Results for the AMS shuttle measurements will tell us of certain kinds of dark matter exist.

Will the universe expand forever, making it possible for civilization to continue forever?

Or will everything collapse into a blaze of pure energy in a few billion years?

Are there antigalaxies in the distant corners of the universe?

We do not know, but AMS and other experiments will tell us the answer in the next few years.

Perhaps you would like to join in this exciting adventure!