Dark Matter in Cosmic Rays & The Alpha Magnetic Spectrometer (AMS)

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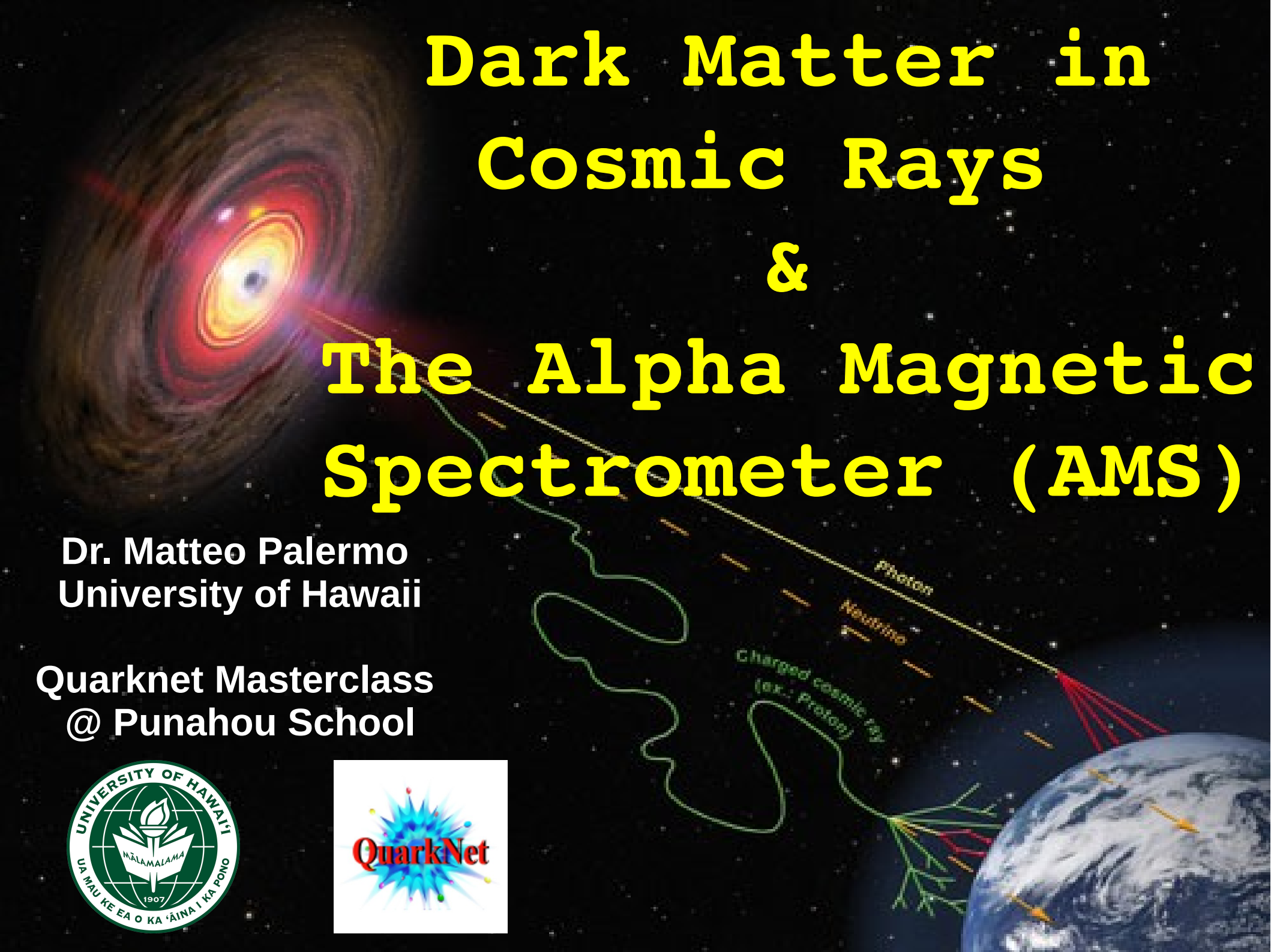
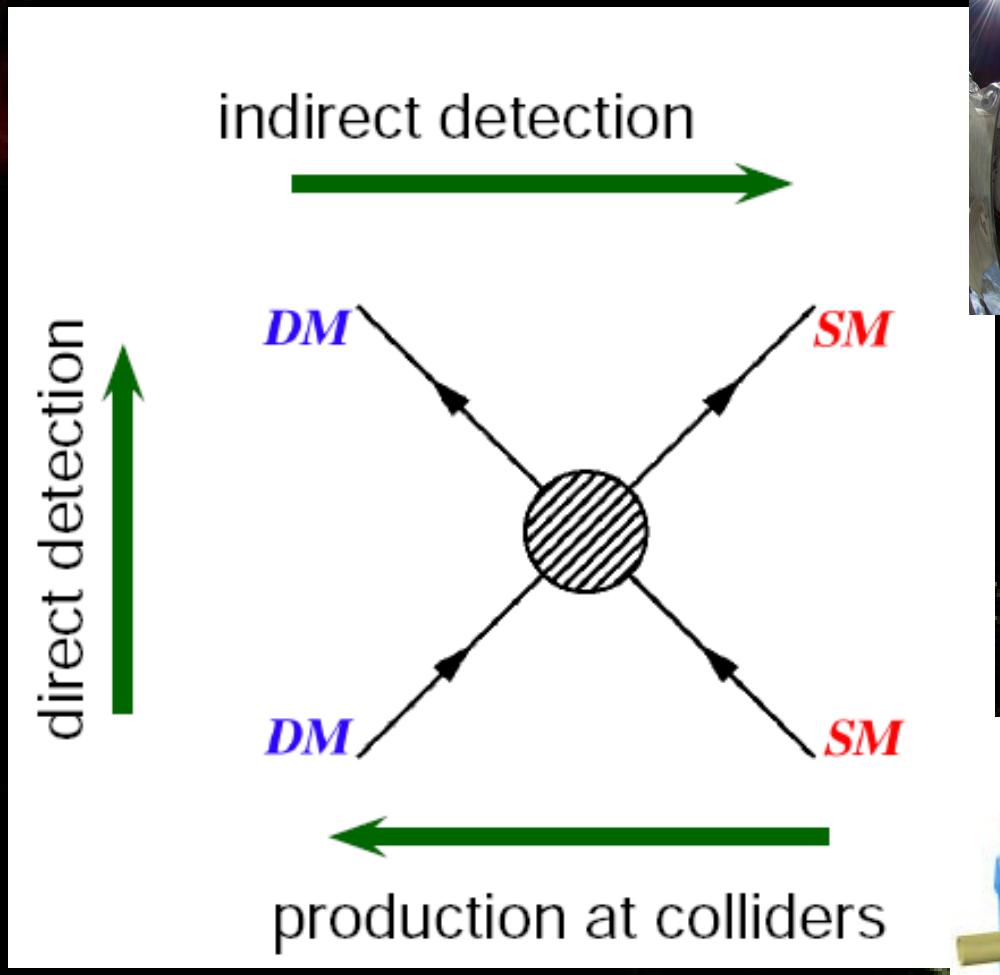
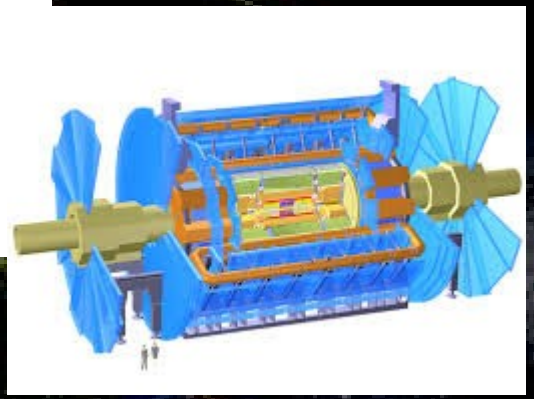


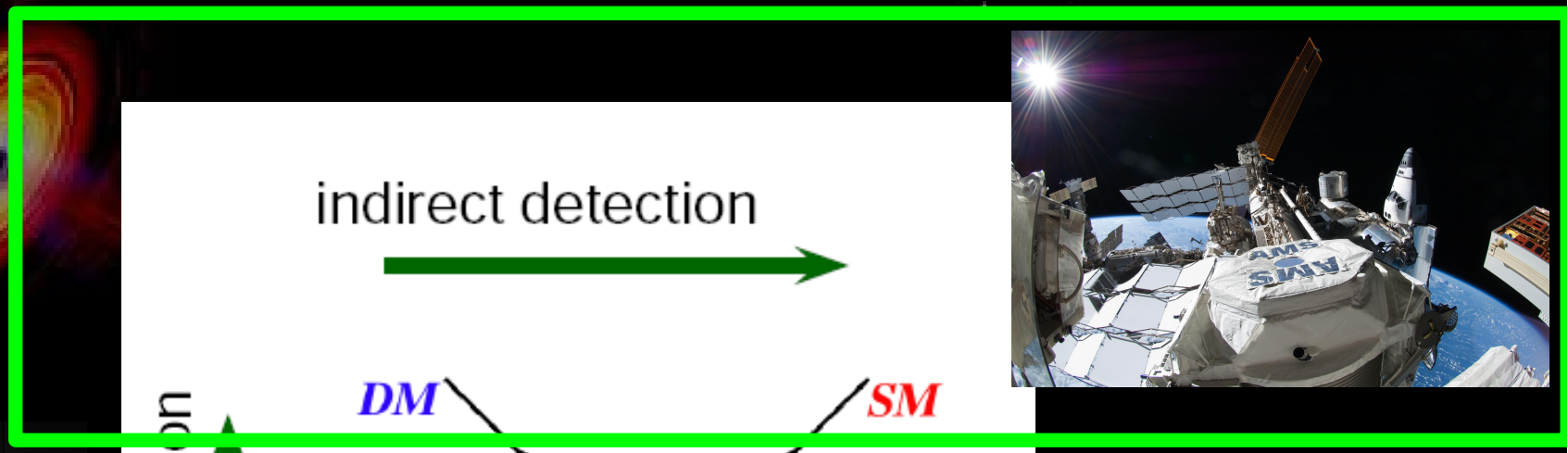
Dark Matter Searches

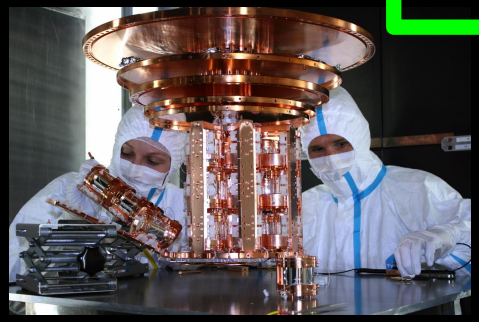


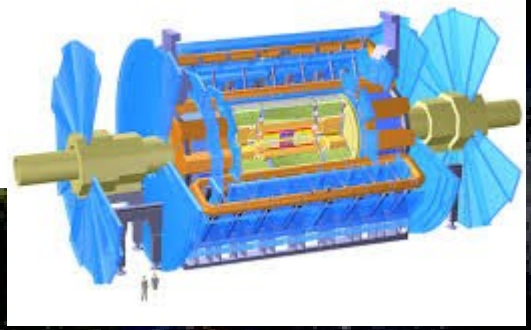


Dark Matter Searches

INDIRECT search

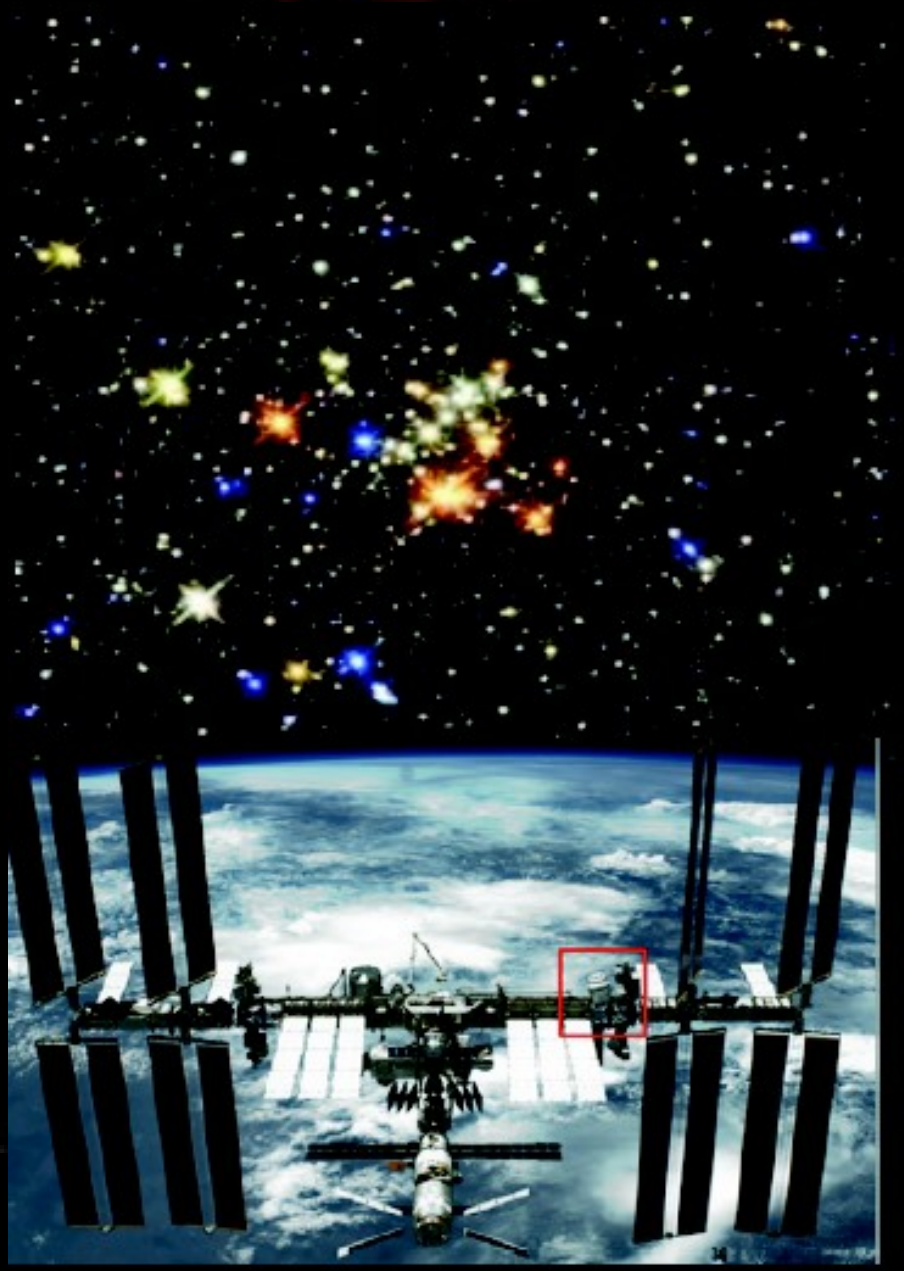


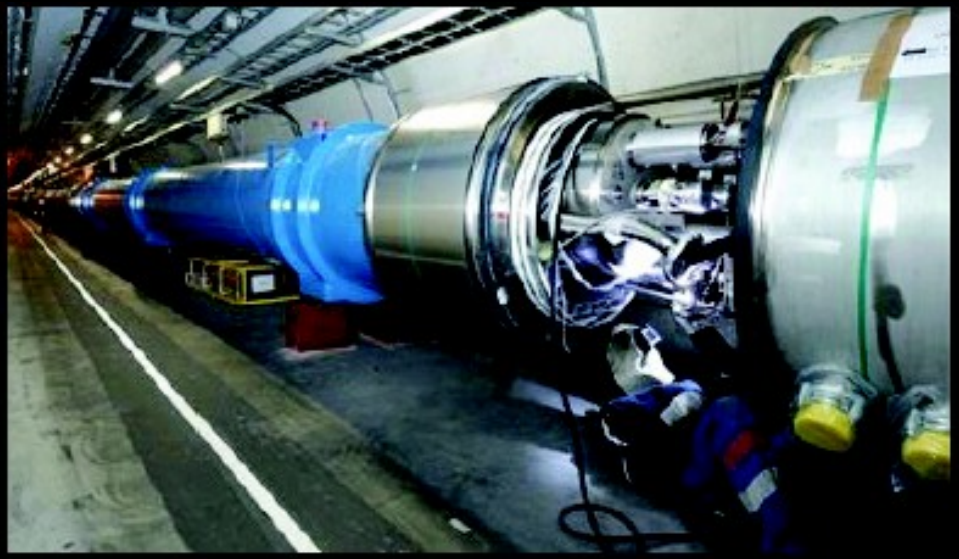




Sven's Talk

The Universe:
The Most Powerful Accelerator



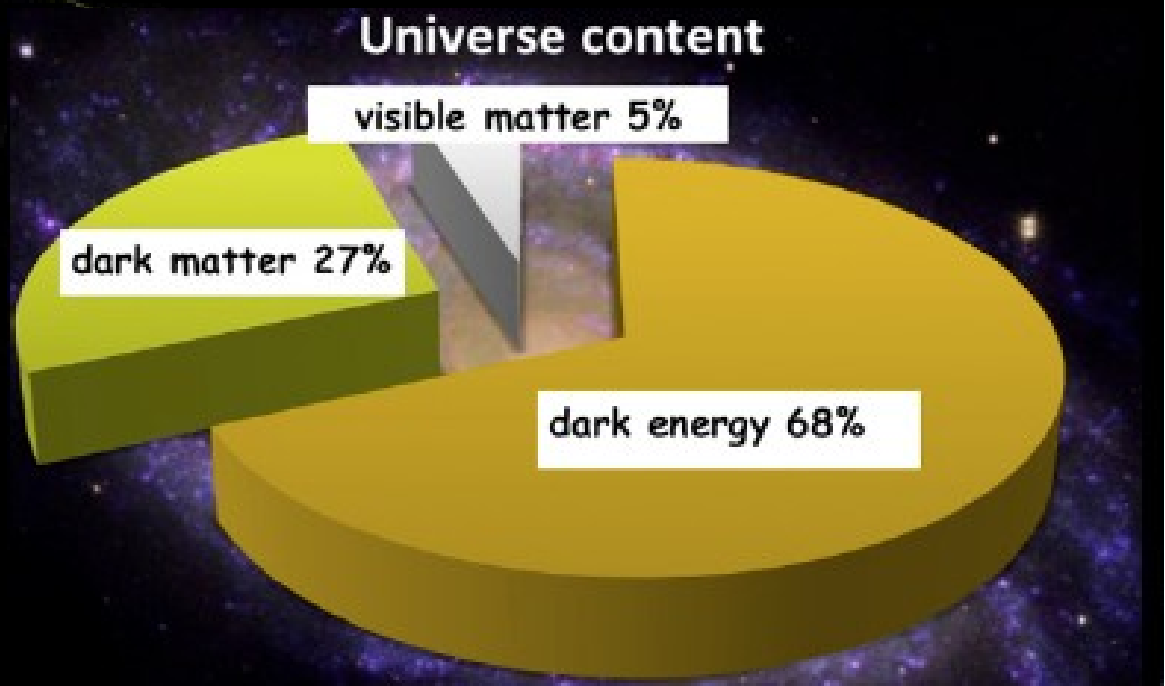


Major Questions:

- Are there forms of matter in the Universe that do not exist on Earth?

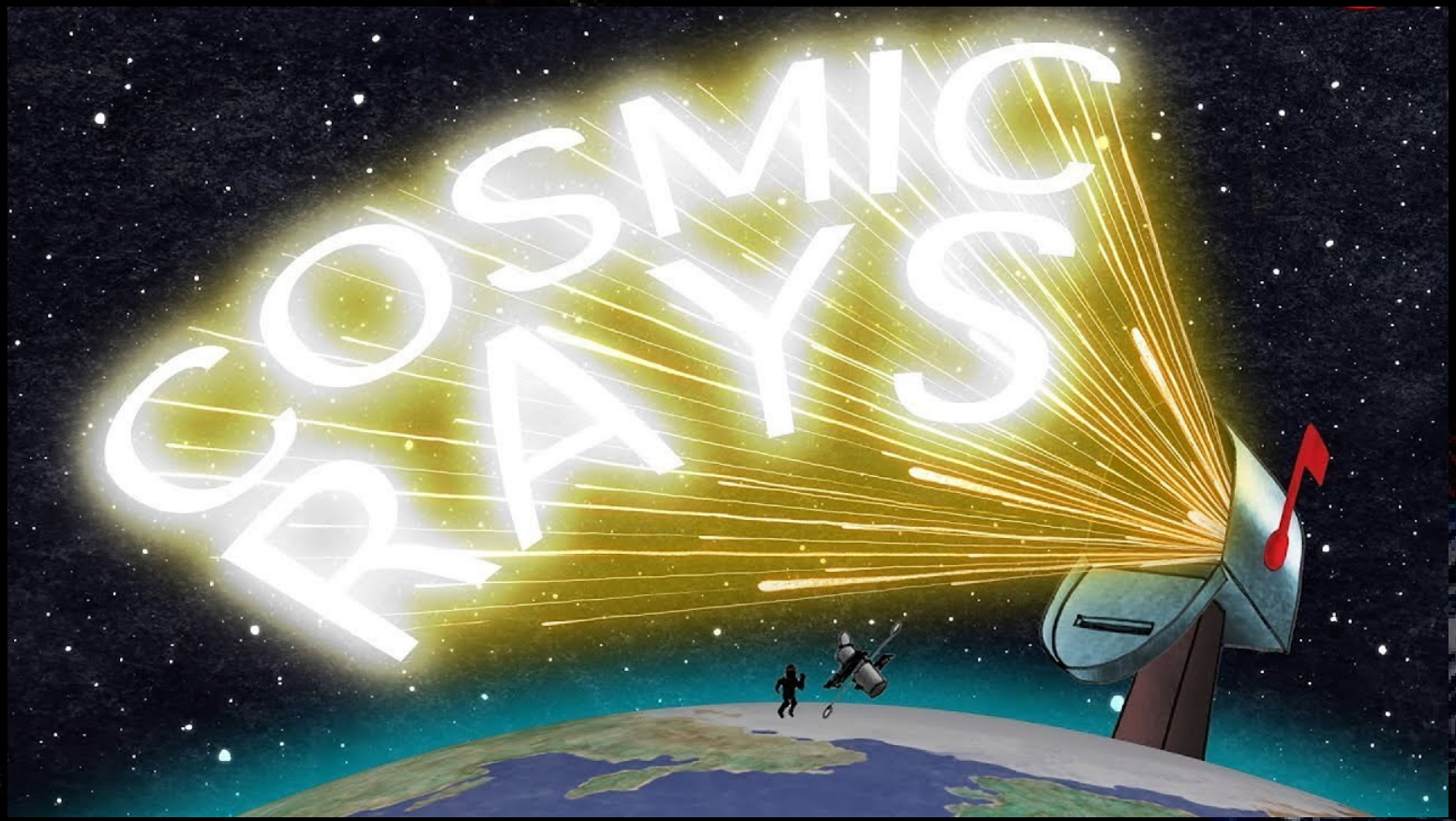
- Do Anti-Stars or Anti-Galaxies exist?

- What is Dark Matter made of?



Answers???

Cosmic Rays!!!



What are Cosmic Rays?

...in simple terms

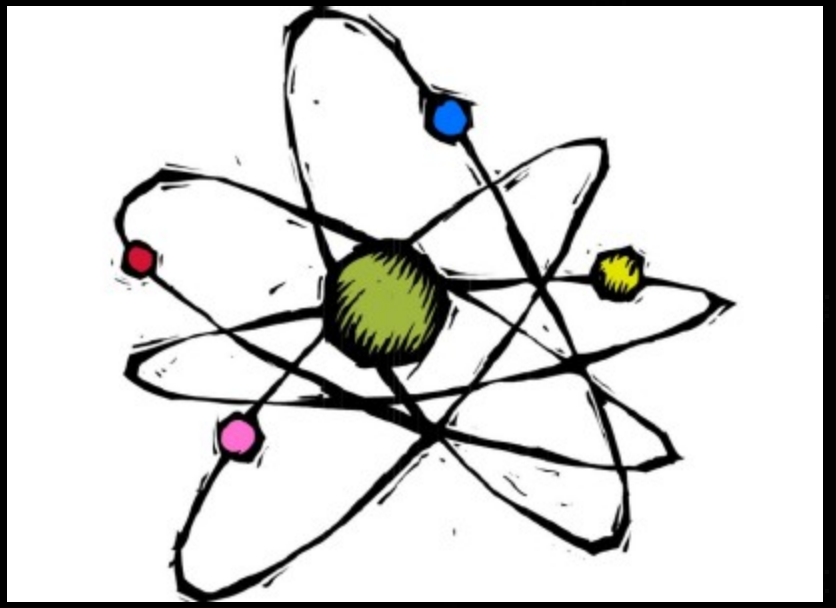
- CRs are tiny particles from outer space

- CRs are invisible to naked eye and carry enormous amount of energy

- CRs travel almost at speed of light.

A Cosmic Ray could zip around the Earth more than 7 times in one second!

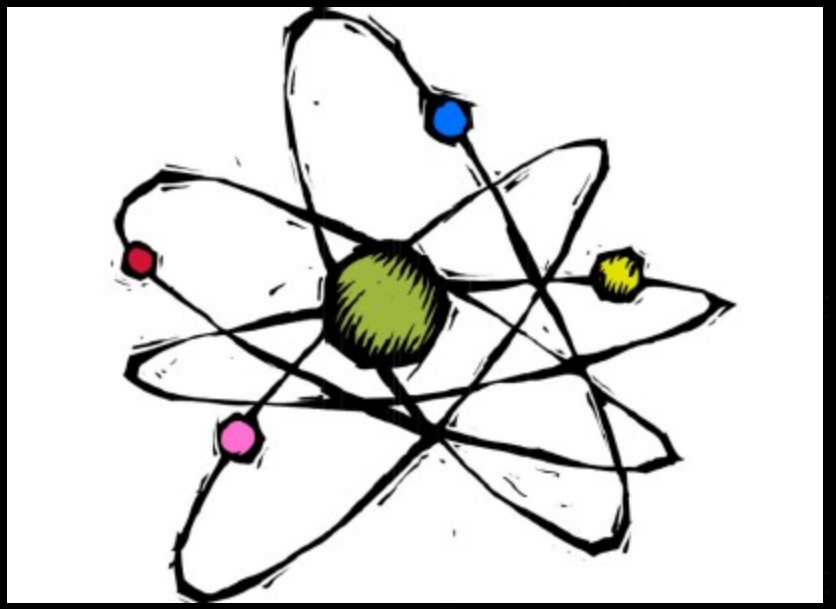
What are Cosmic Rays?



Charged particles

Neutral particles

What are Cosmic Rays?



Charged particles

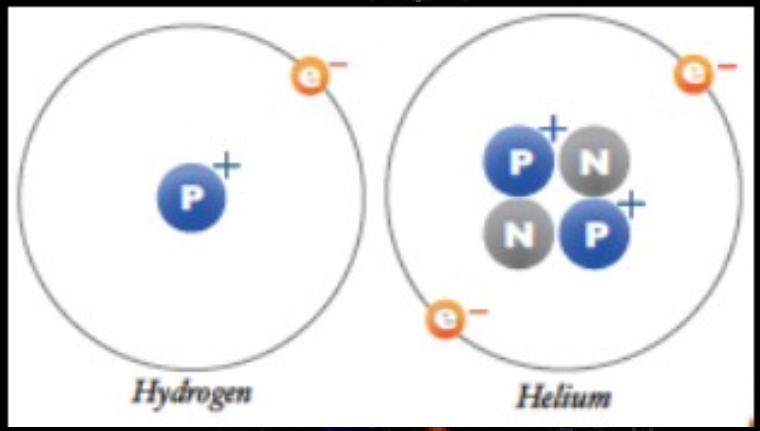
Neutral particles

What are Cosmic Rays?

CRs are **mainly charged particles** composed of the same subatomic particles that make up all matter on Earth (H, He, ions)

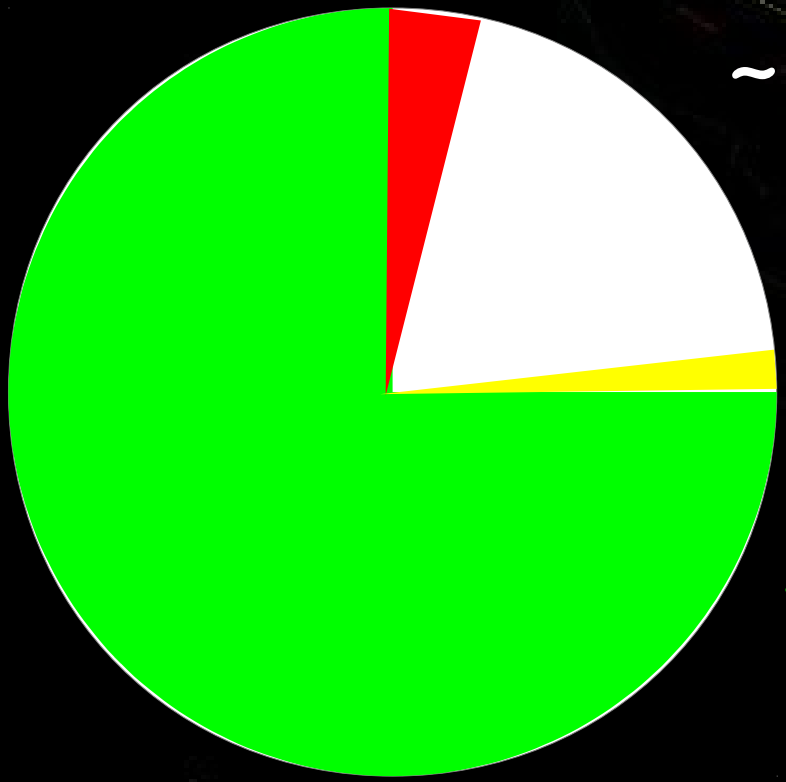
Travel through the Universe/Galaxy/Solar System

and finally reach Earth



Cosmic Ray Composition

~2% Electrons and Antimatter



~12% Helium Nuclei

~1% Heavier Nuclei

~85% Hydrogen Nuclei (protons)

Where do CRs come from?

Where do CRs come from?

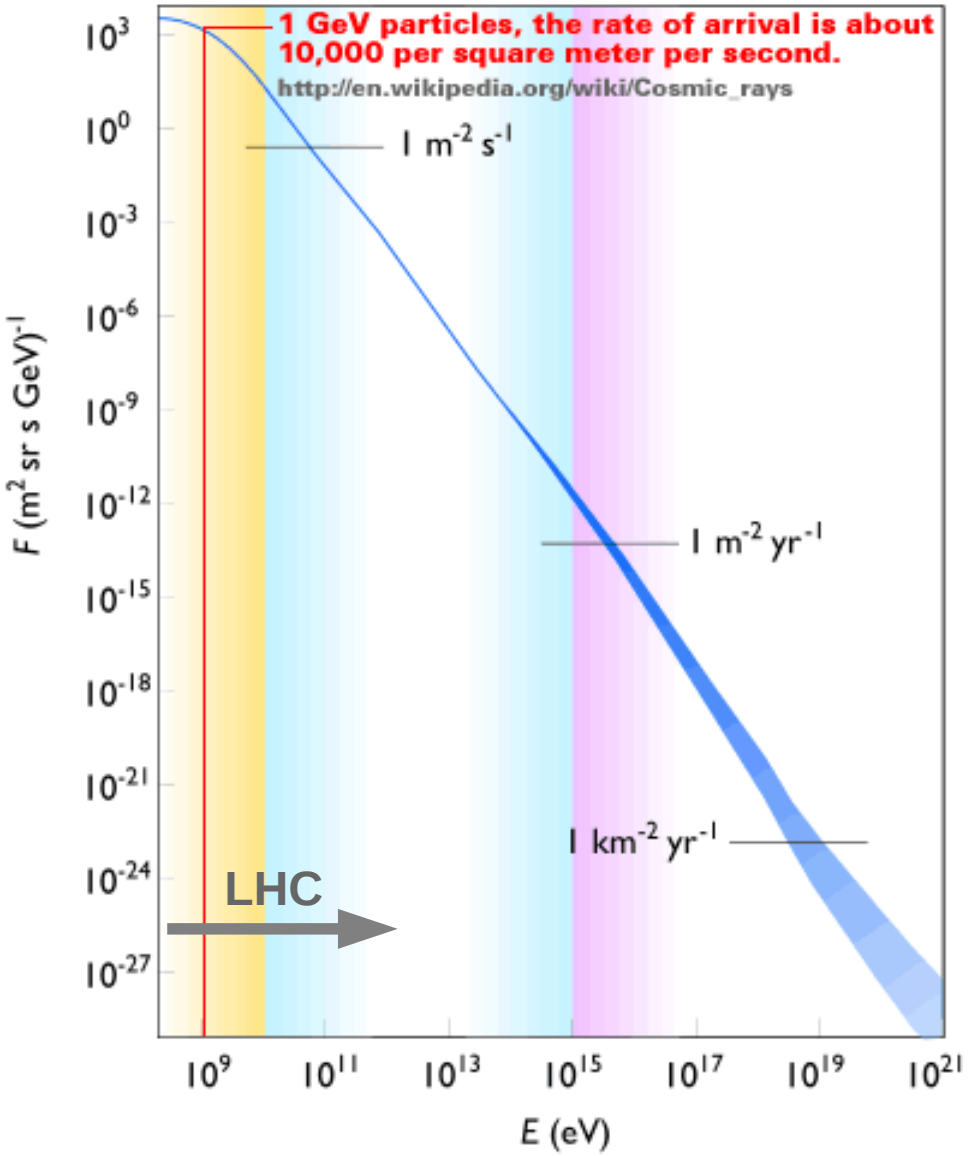
3 main regions:

Solar CR

Galactic CR

Extragalactic CR

Cosmic Ray Flux versus Particle Energy



Yellow Zone
Mainly attributed to Solar cosmic rays

Blue Zone
Mainly attributed to Galactic cosmic rays

Purple Zone
Mainly attributed to Extragalactic cosmic rays

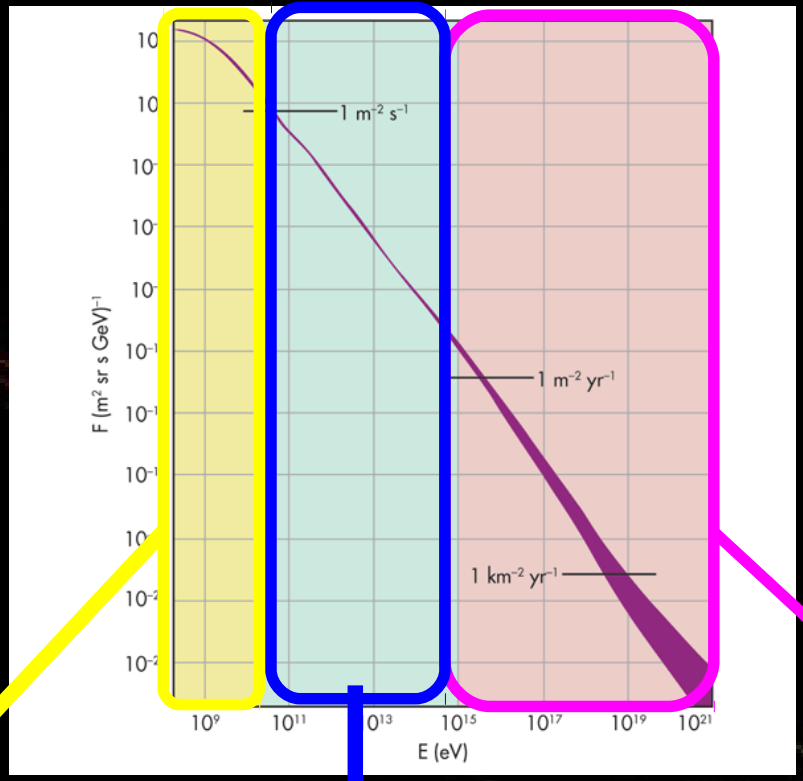
Flux – number of arriving particles per (unit area x unit time)

eV – (very small) unit of energy

- one volt times the charge of a single electron
- 1 eV = 1.609 x 10^{-19} joules

http://en.wikipedia.org/wiki/File:Cosmic_ray_flux_versus_particle_energy.svg

Where do CRs come from?

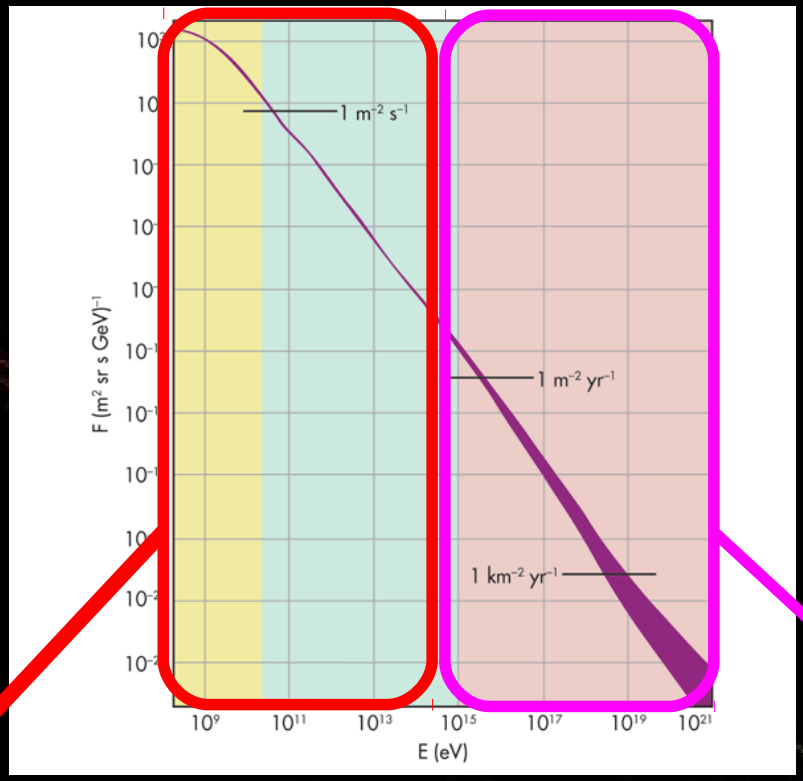


SOLAR origin

Galactic origin

Extragalactic origin

How do we Detect CRs?



DIRECT

Measurements:

- SPACE born
- Balloon born

(Primary Cosmic Rays)

INDIRECT

Measurements:

- Ground based

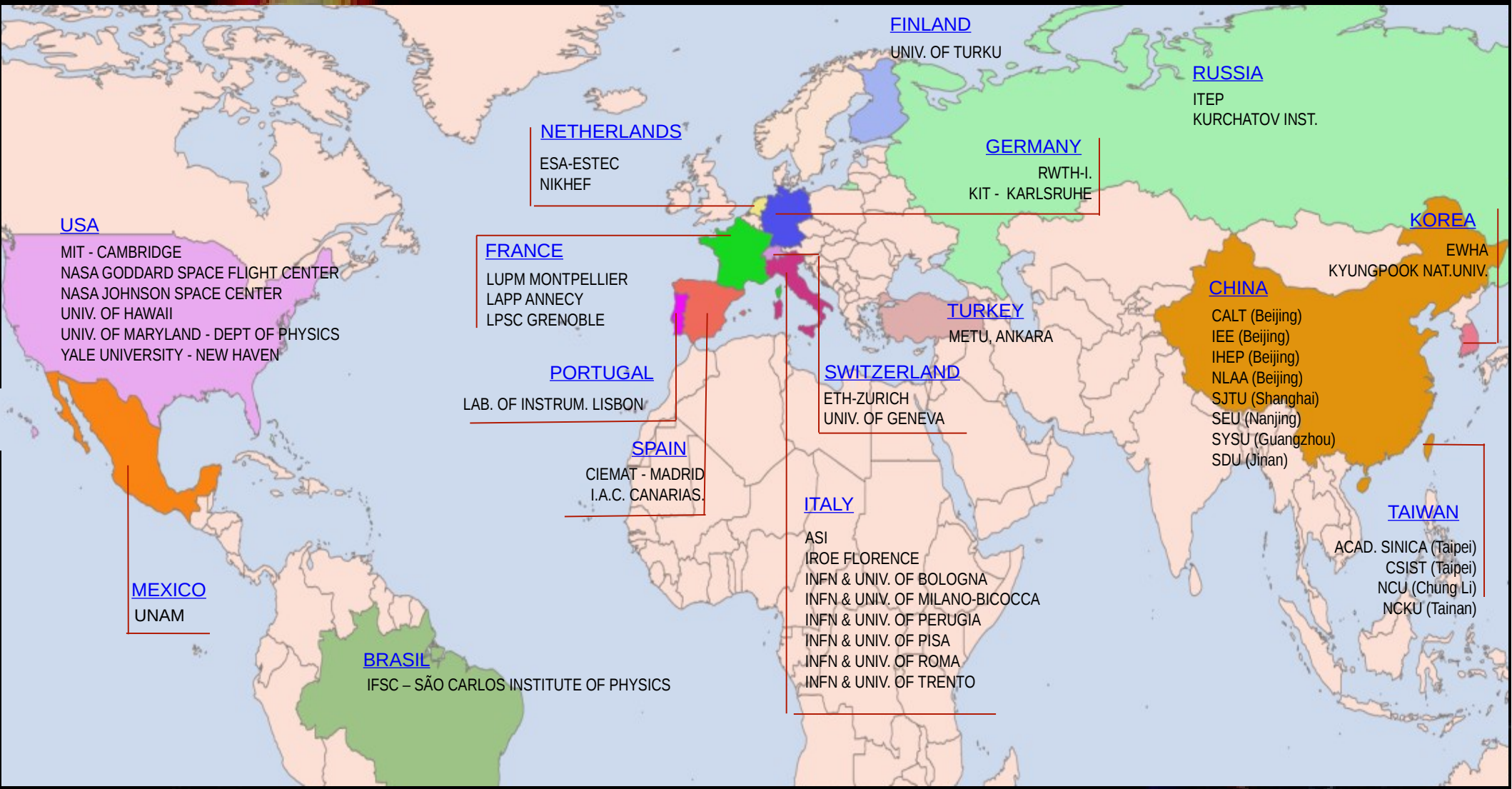
(Atmosphere in between!!)

The Alpha Magnetic Spectrometer

(AMS-02)

...the experiment I am working on at UH Manoa

AMS-02 Collaboration
16 Countries, 57 Institutes

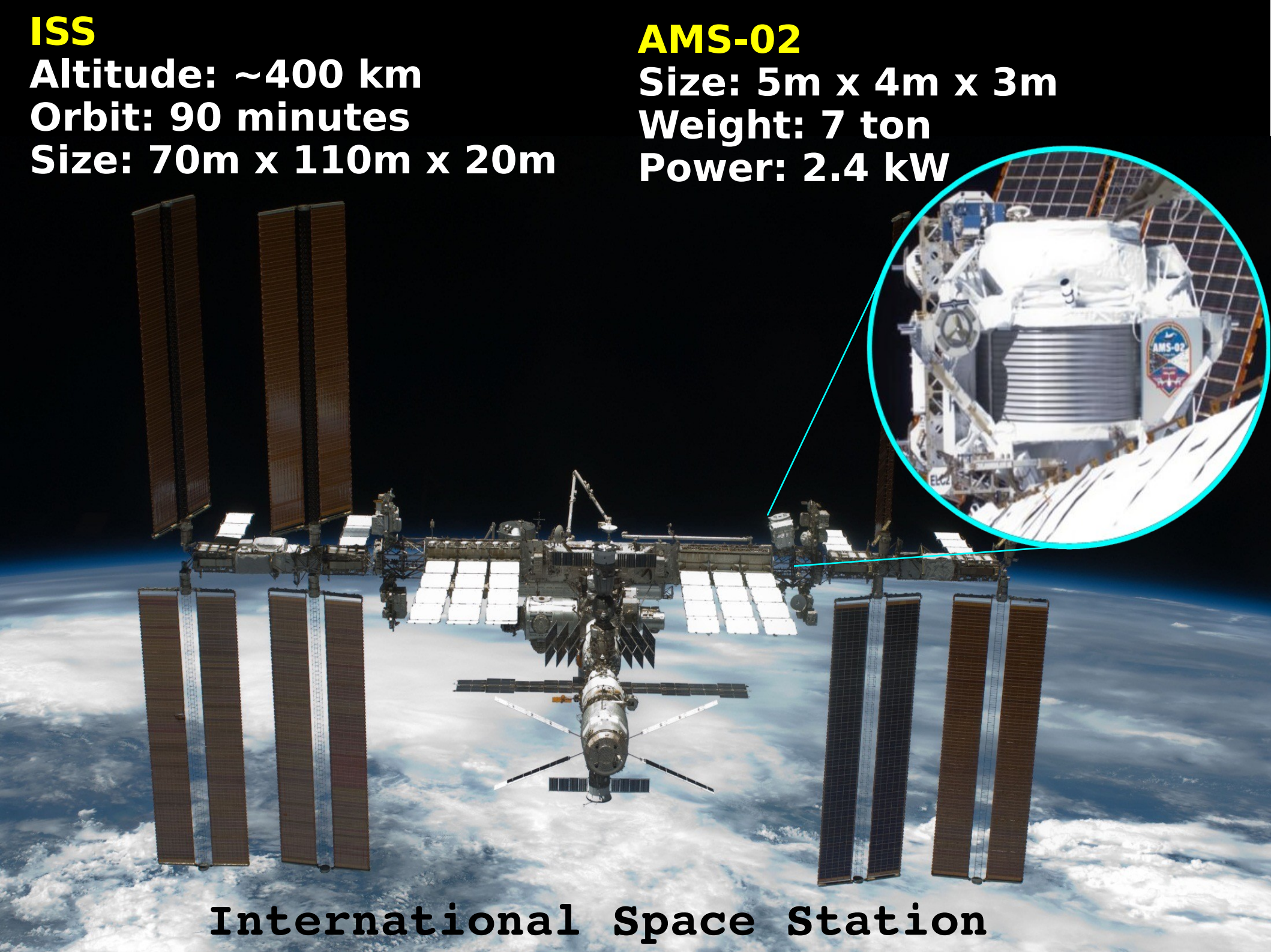


AMS-02 on the ISS

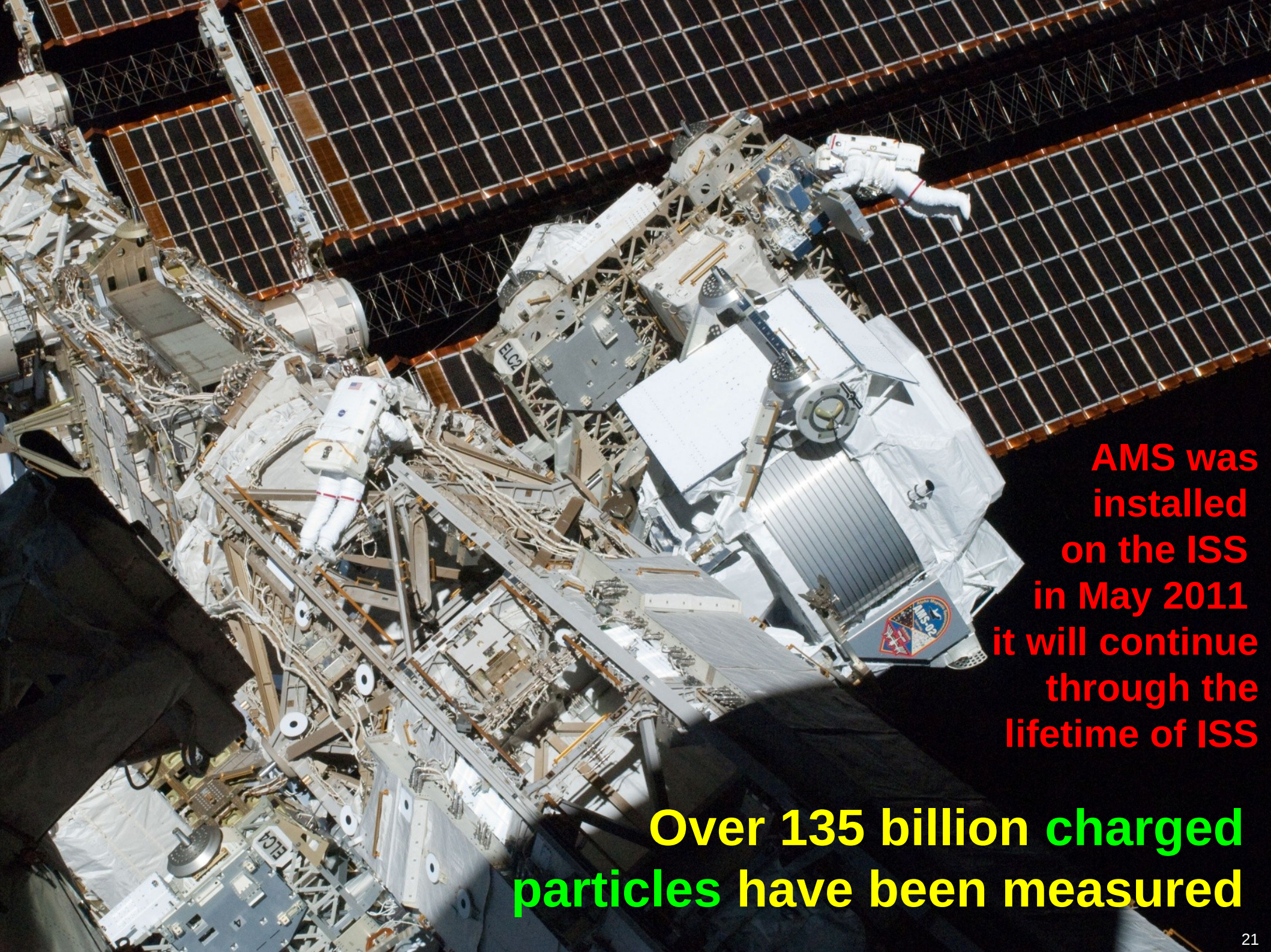
May 16, 2011: AMS Flight, Space Shuttle Endeavor

ISS
Altitude: ~400 km
Orbit: 90 minutes
Size: 70m x 110m x 20m

AMS-02
Size: 5m x 4m x 3m
Weight: 7 ton
Power: 2.4 kW



International Space Station

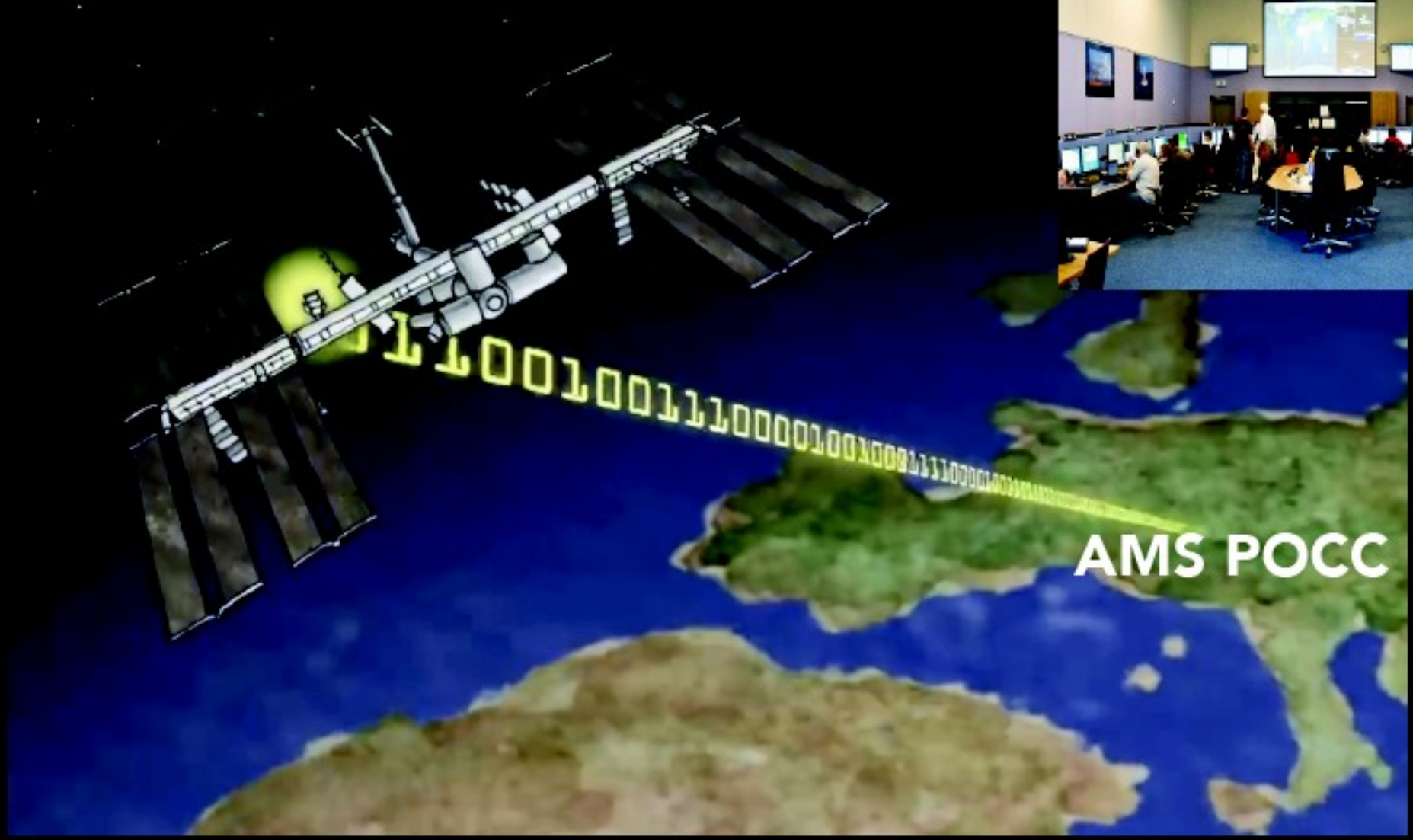


AMS was installed on the ISS in May 2011 it will continue through the lifetime of ISS

Over 135 billion charged particles have been measured

AMS POCC located at CERN

Payload Operation Control Center



AMS Scientific Goals

- Galactic CR Nuclei Spectra
(from H to Fe and above)

- Indirect Dark Matter Search

- Primordial Antimatter
(e.g. Anti-Nuclei)

- Solar Activity

- Space Radiation
(necessary for the future space manned mission to the Moon and Mars)

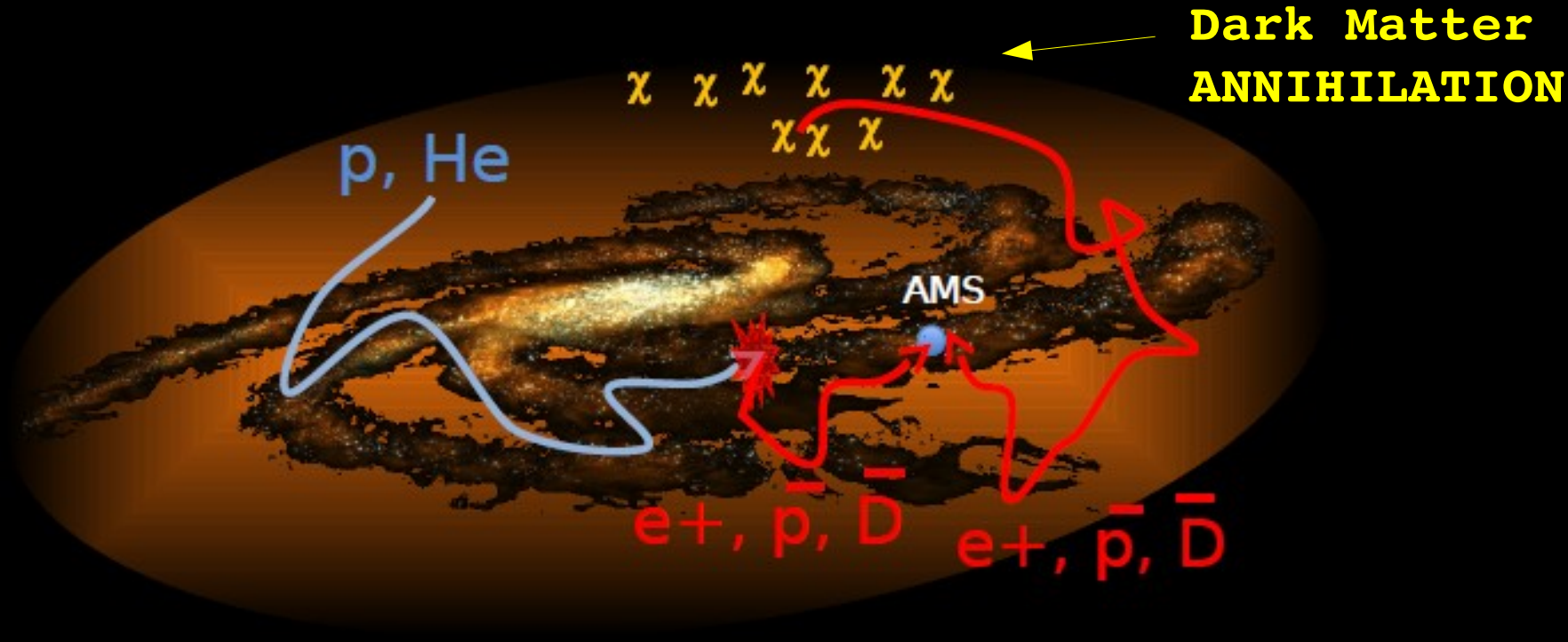
Indirect Dark Matter Search

Indirect Dark Matter Search

Collision of Cosmic Rays with Interstellar Matter produces e+, $\bar{p}$, $\bar{D}$

Dark Matter annihilation also produces light antimatter: e+, $\bar{p}$, $\bar{D}$

The excess of e+, $\bar{p}$, $\bar{D}$ from Dark Matter annihilations can be measured by AMS



What does AMS measure?

- ENERGY or MOMENTUM

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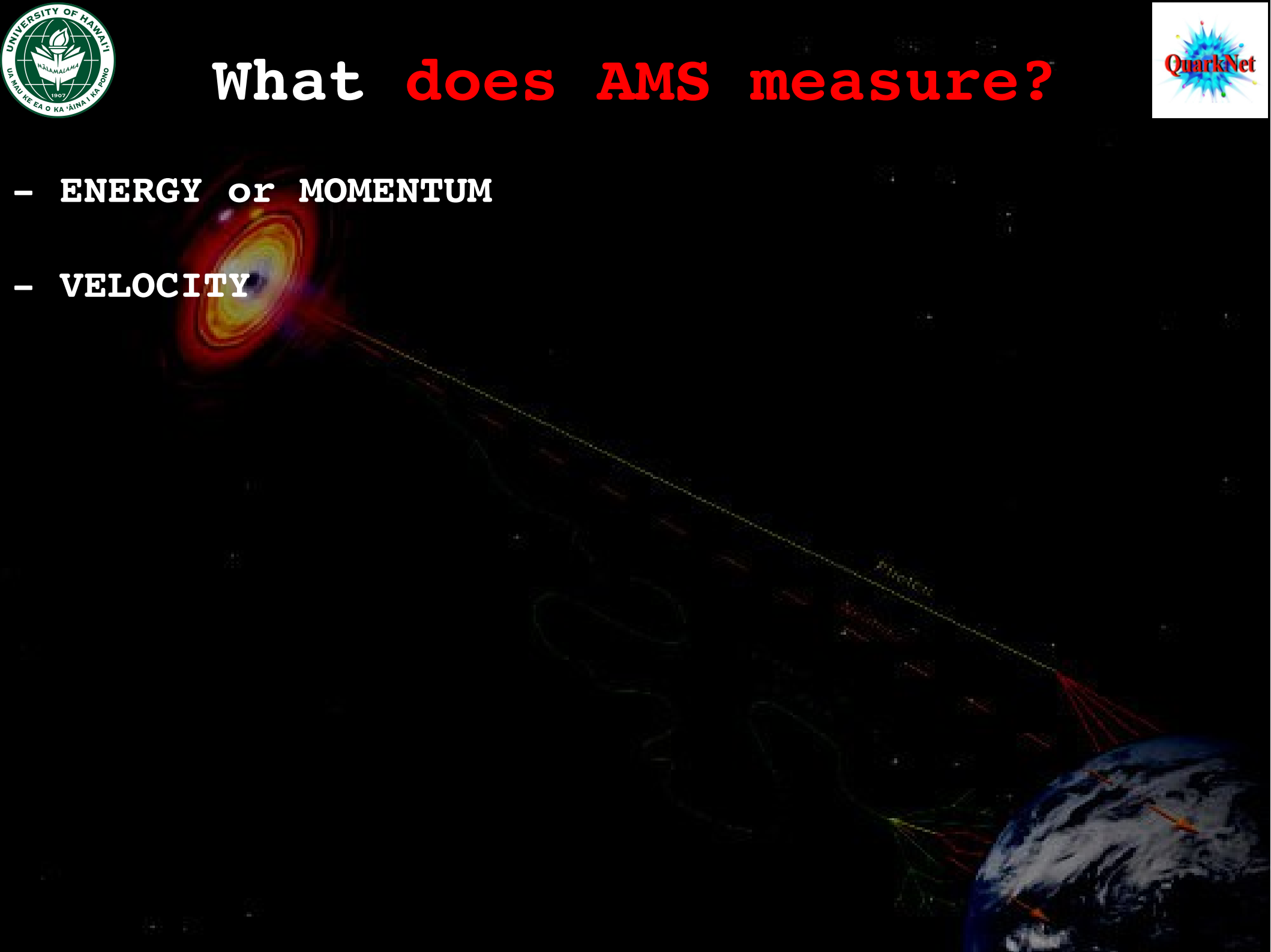
- ENERGY or MOMENTUM

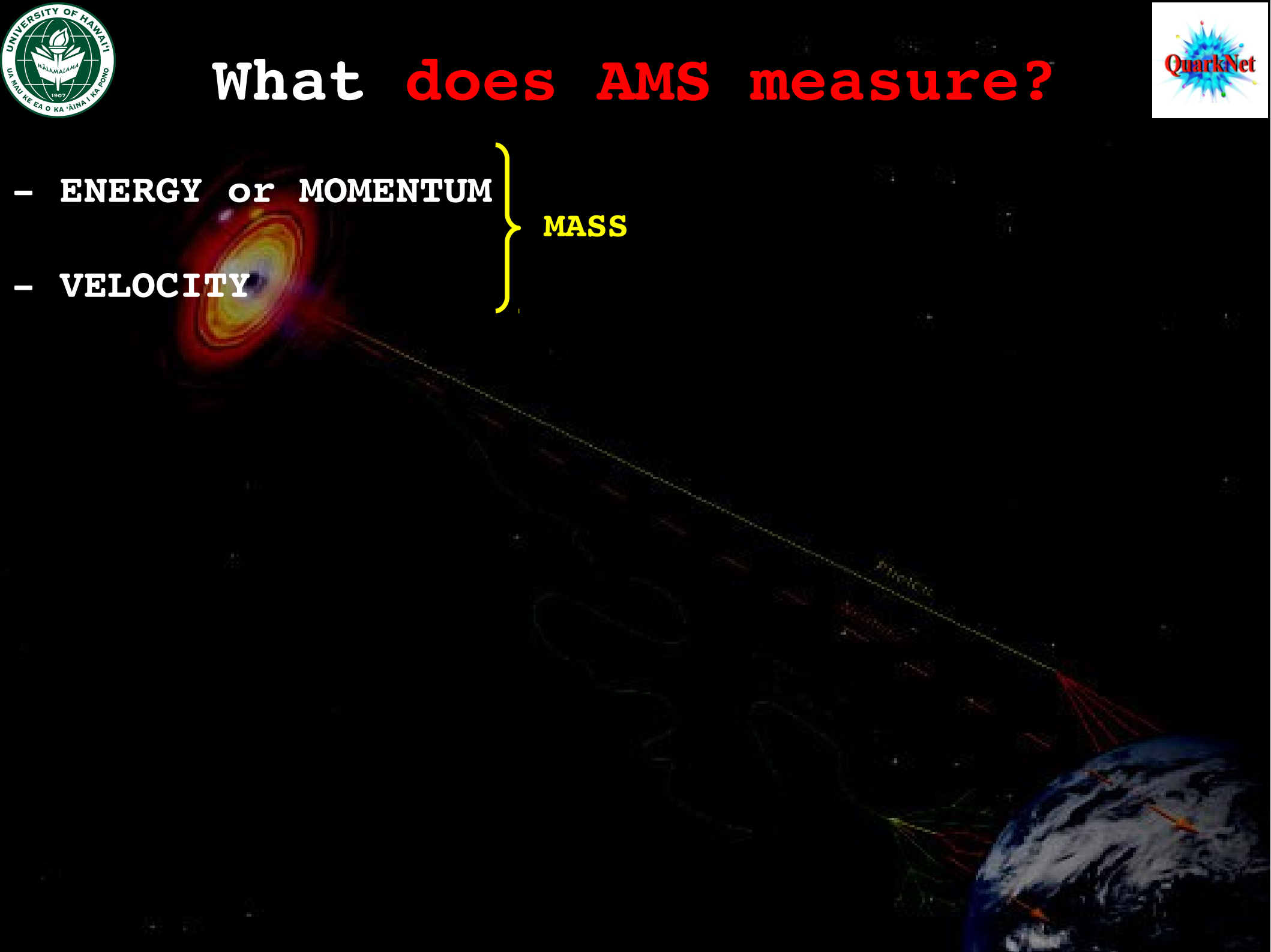
- VELOCITY



What does AMS measure?

- ENERGY or MOMENTUM
- VELOCITY

} MASS



What does AMS measure?

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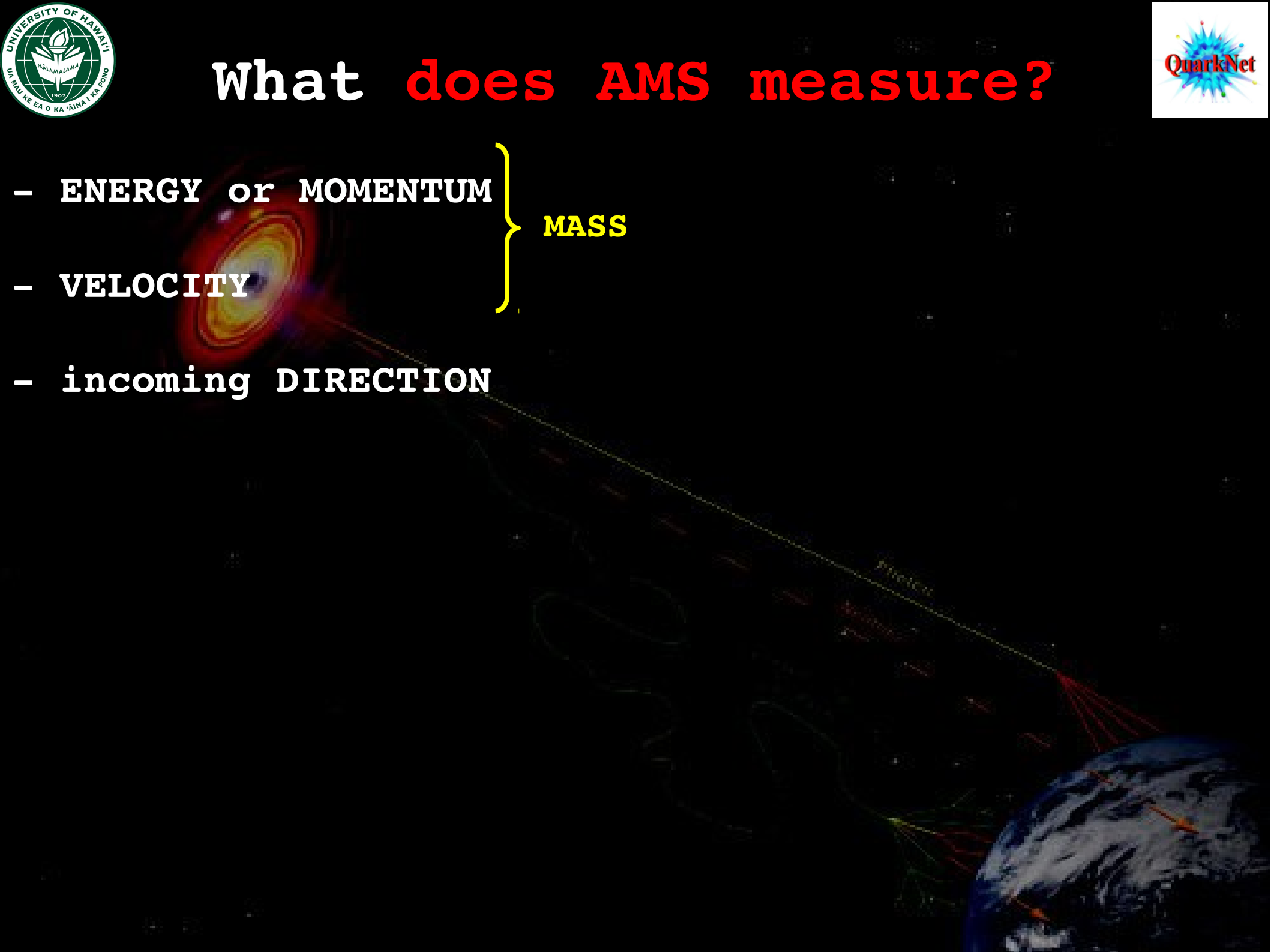
} MASS

- incoming DIRECTION



What does AMS measure?

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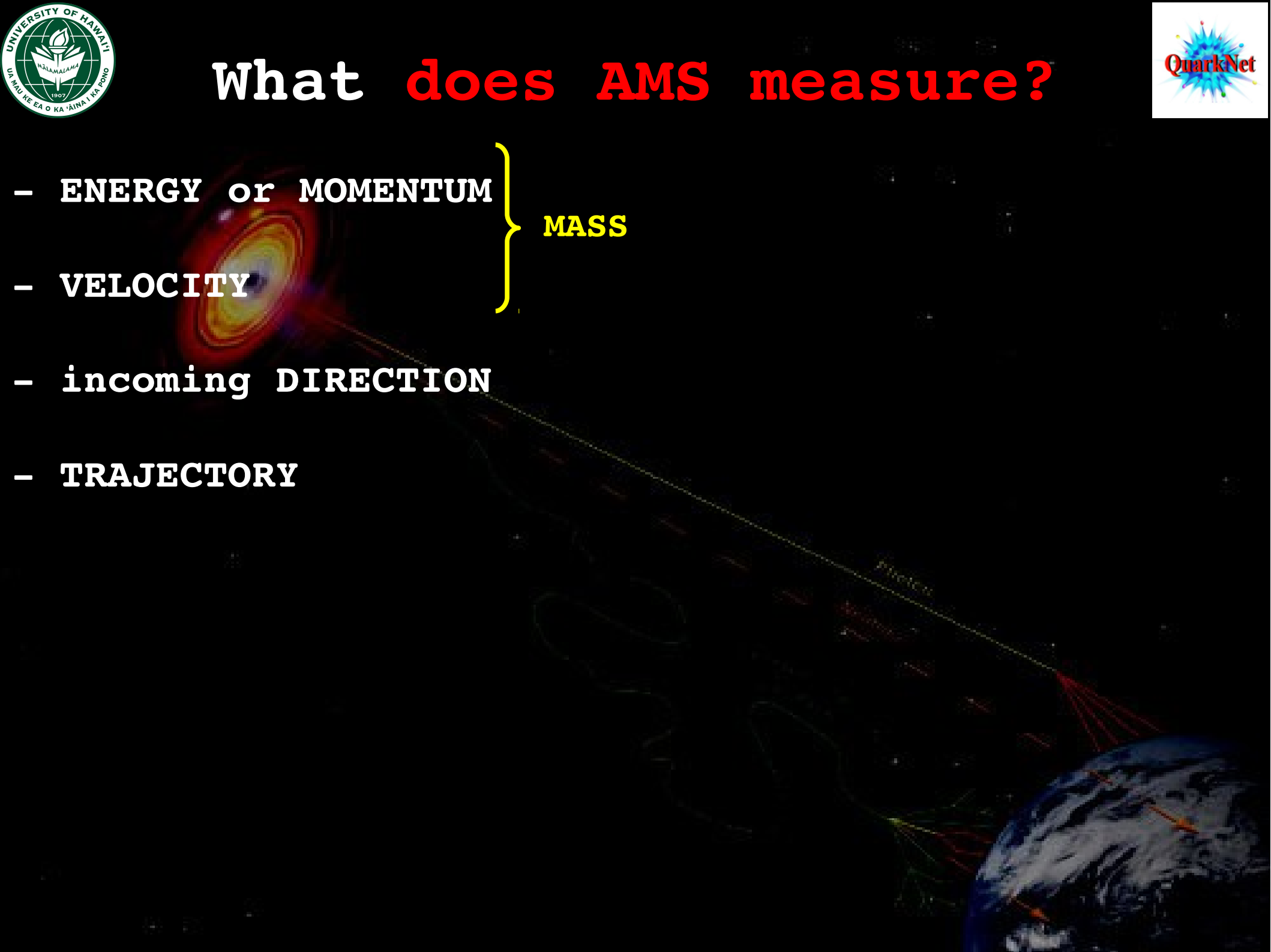
} MASS

- incoming DIRECTION
- TRAJECTORY



What does AMS measure?

- ENERGY or MOMENTUM
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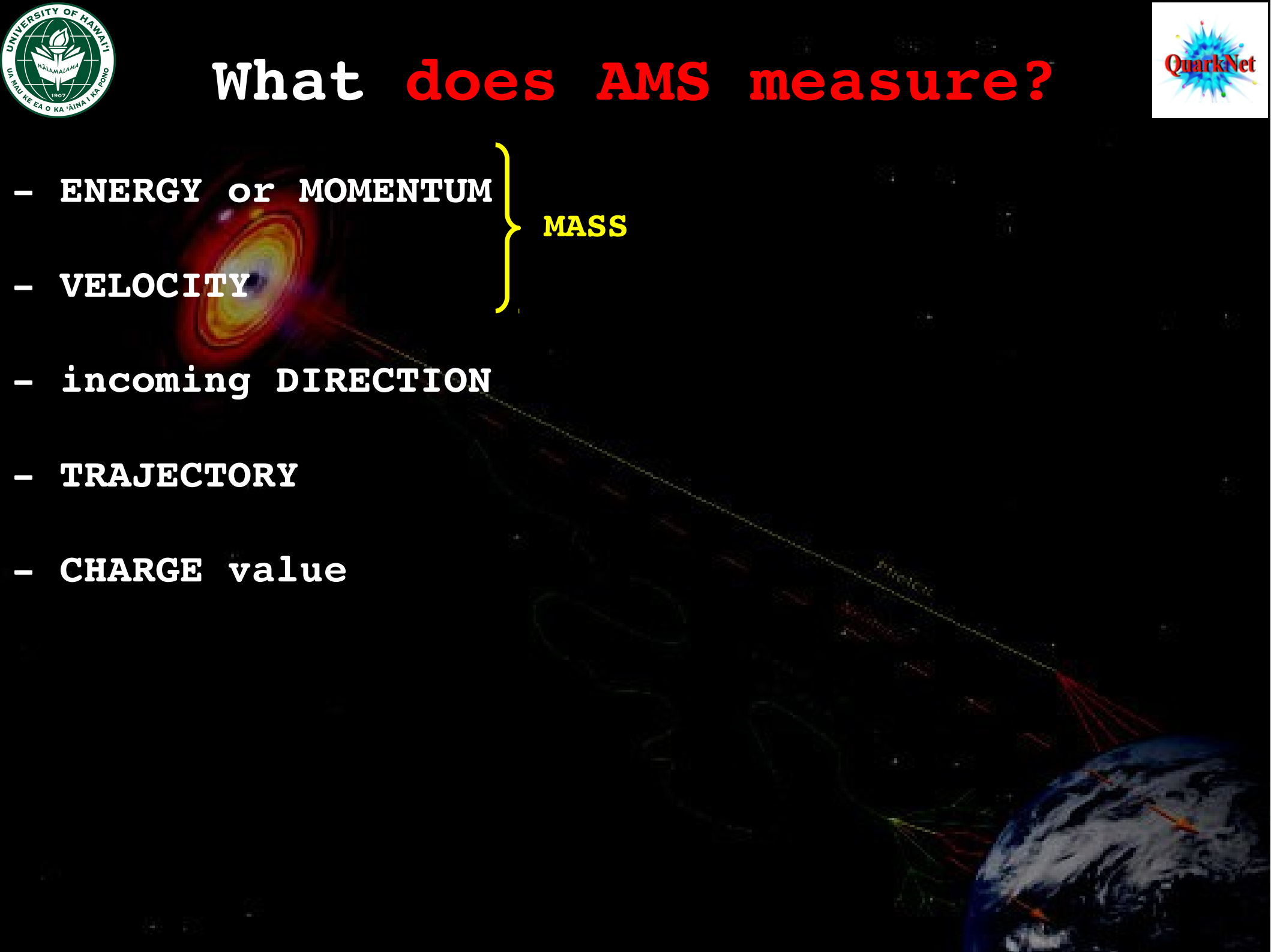
- incoming DIRECTION
- TRAJECTORY
- CHARGE value



What does AMS measure?

- ENERGY or MOMENTUM
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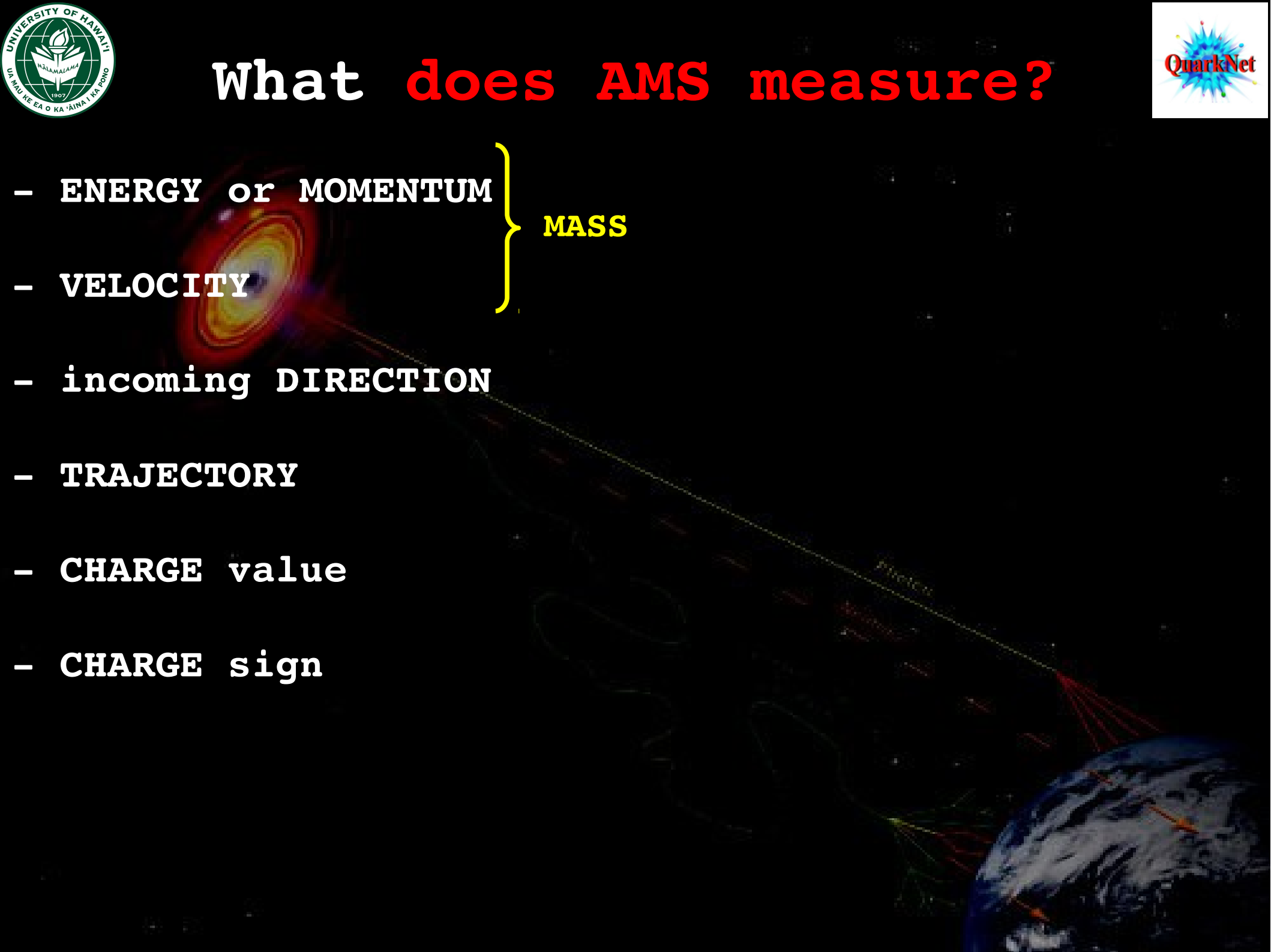
- CHARGE value
- CHARGE sign



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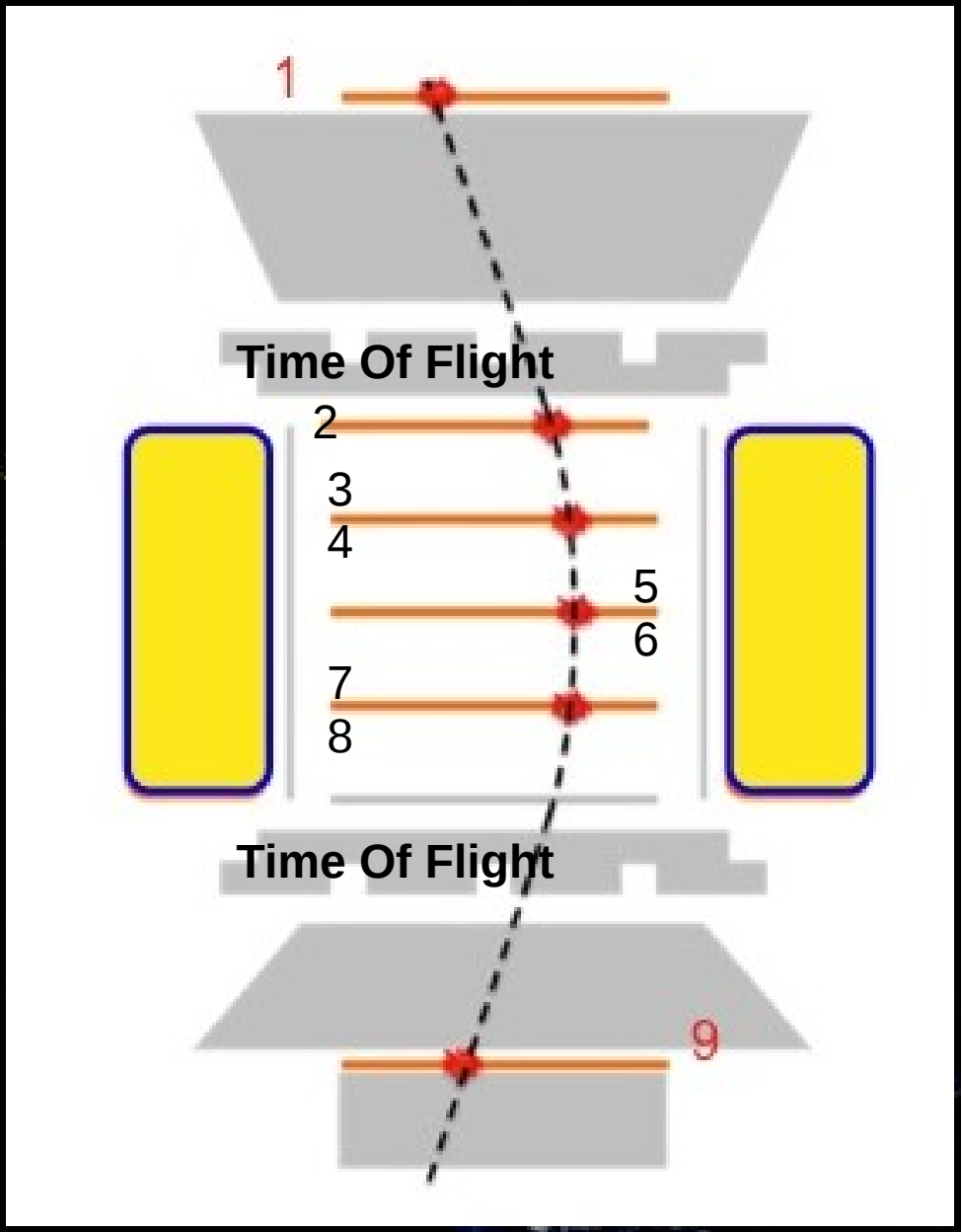

How does AMS measure?

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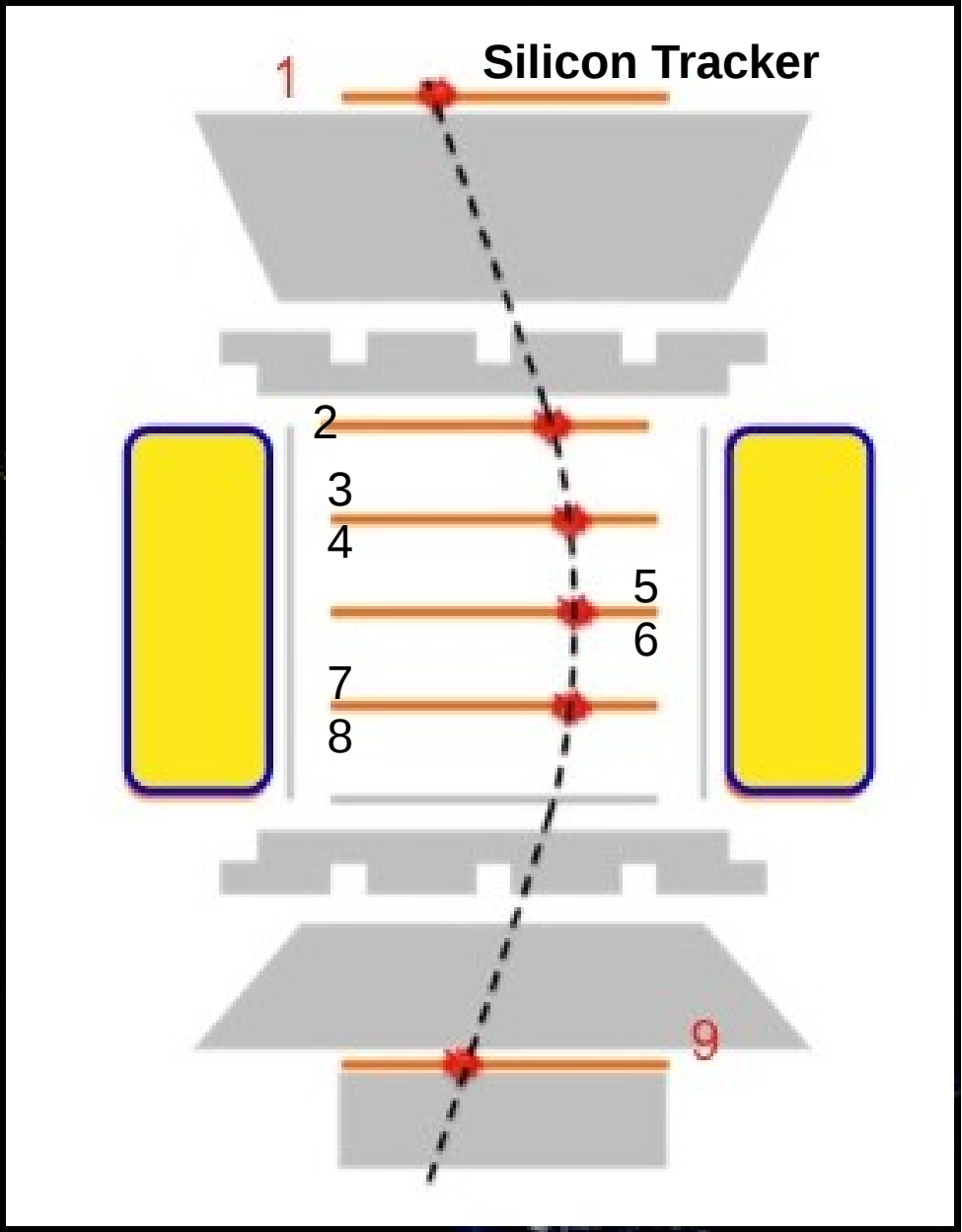

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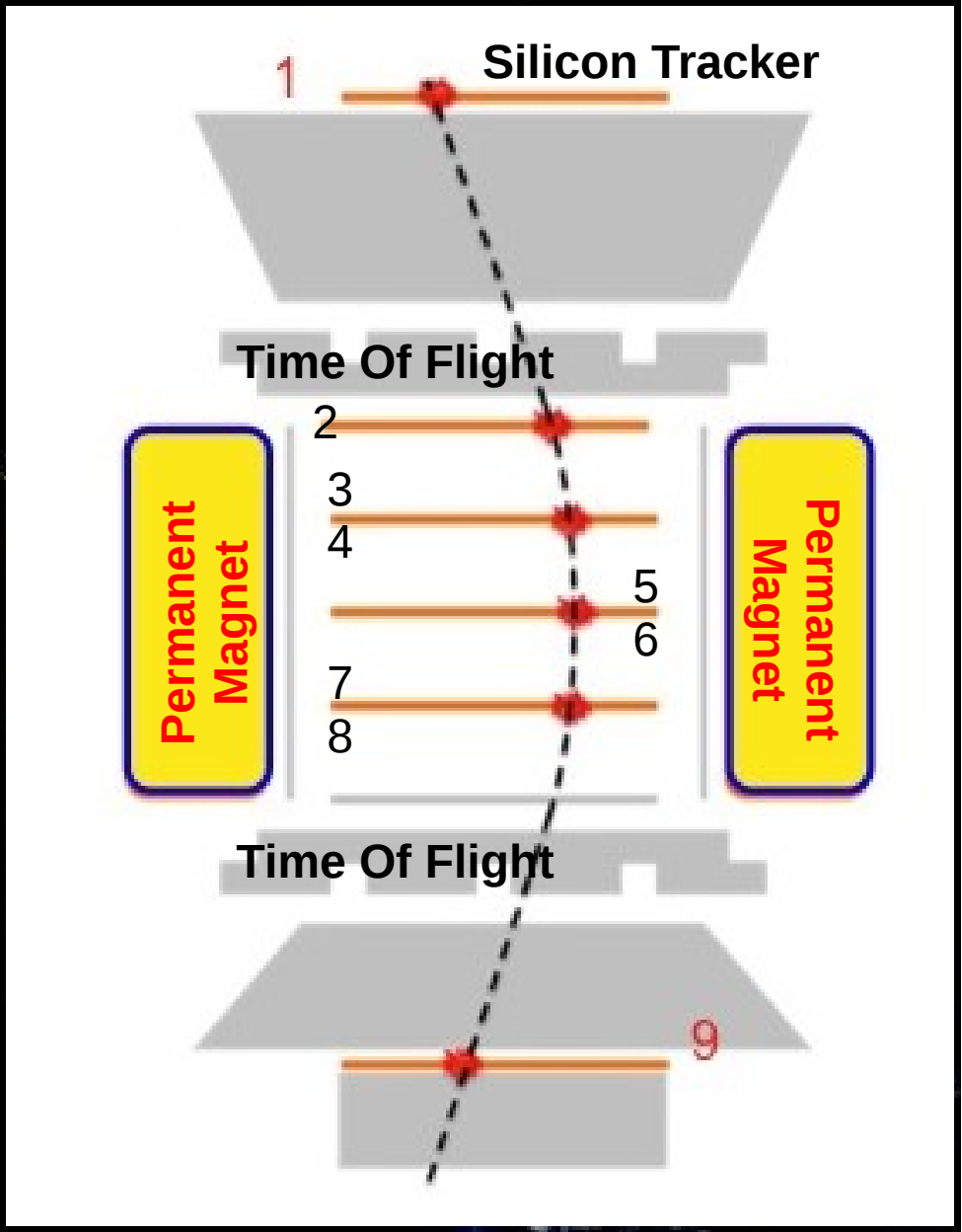

How does AMS measure?

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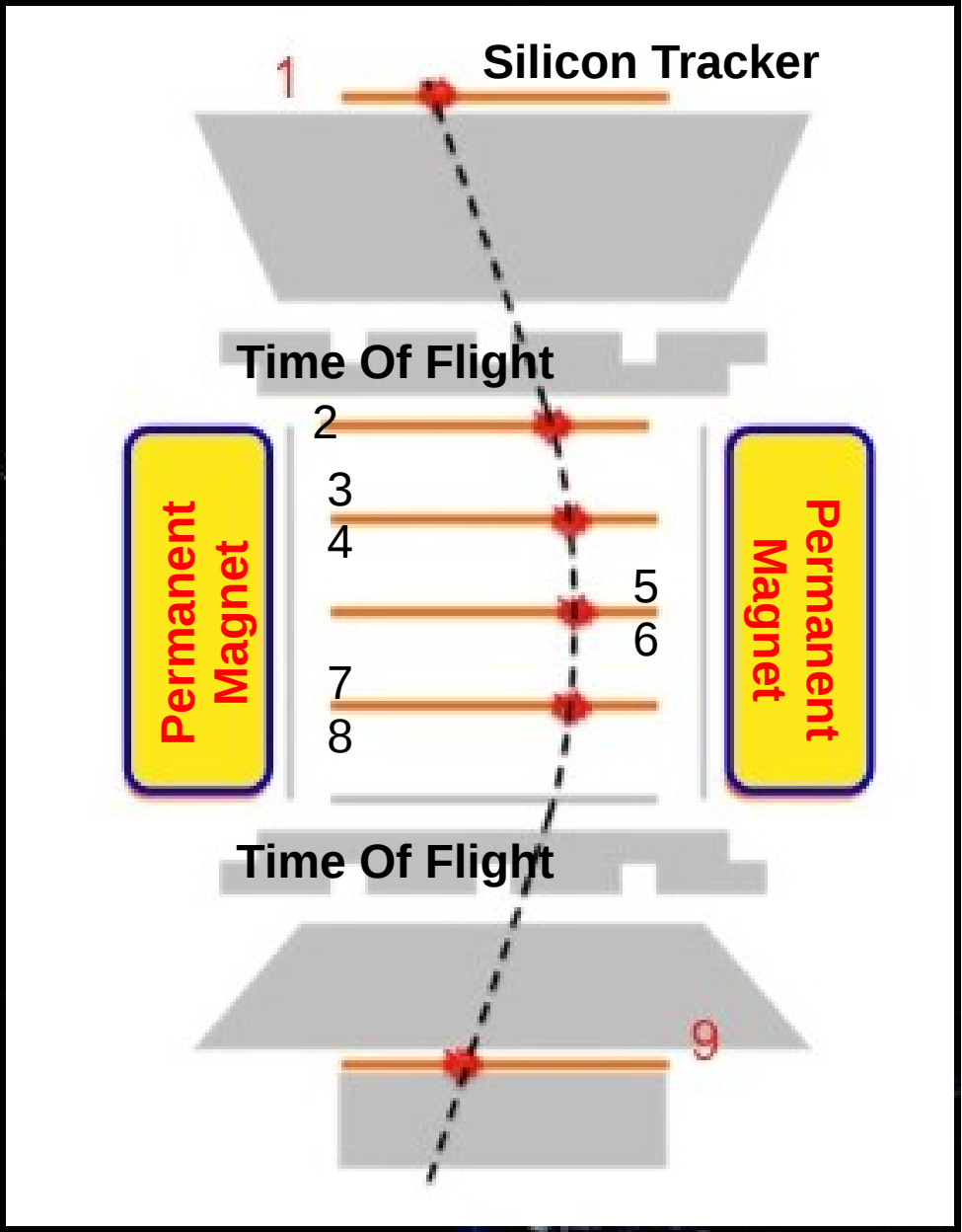
Fundamental to look for Dark Matter

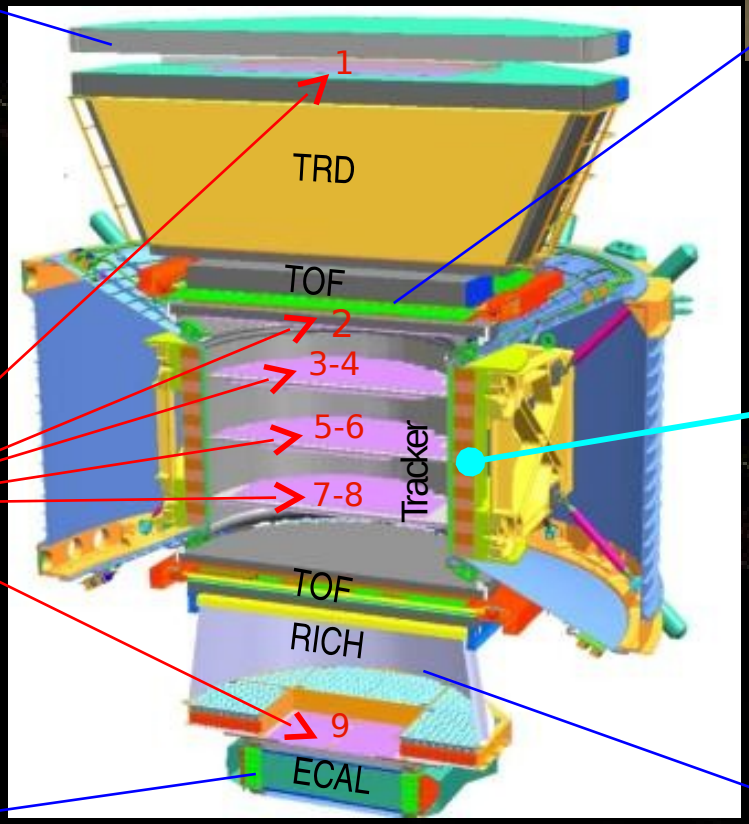


Particle Identification with AMS-02

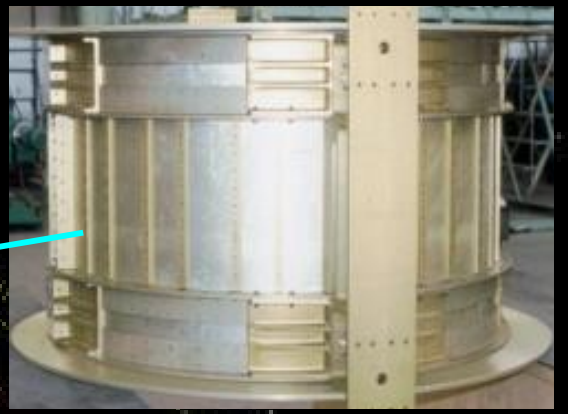
TRD: Identify e+, e-, Z

Particles and nuclei are defined by their charge (Z) and energy (E) or momentum (P). Rigidity R = P/Z

TOF: Z, E

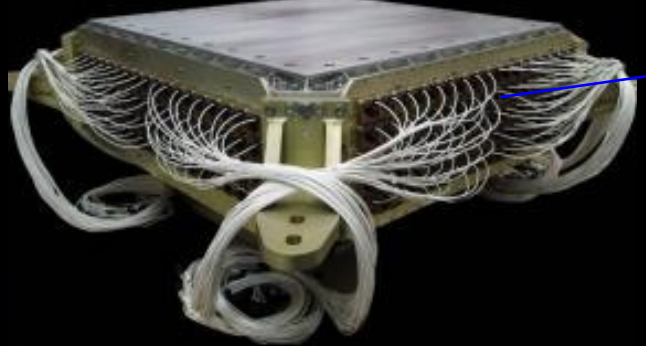


Magnet: ±Z

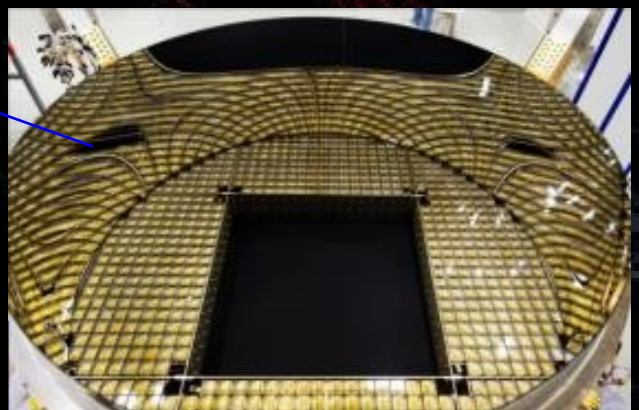


Silicon Tracker: Z, P

ECAL: E of e+, e-



RICH: Z, E



Z and P

are measured independently by the Tracker, RICH, TOF and ECAL