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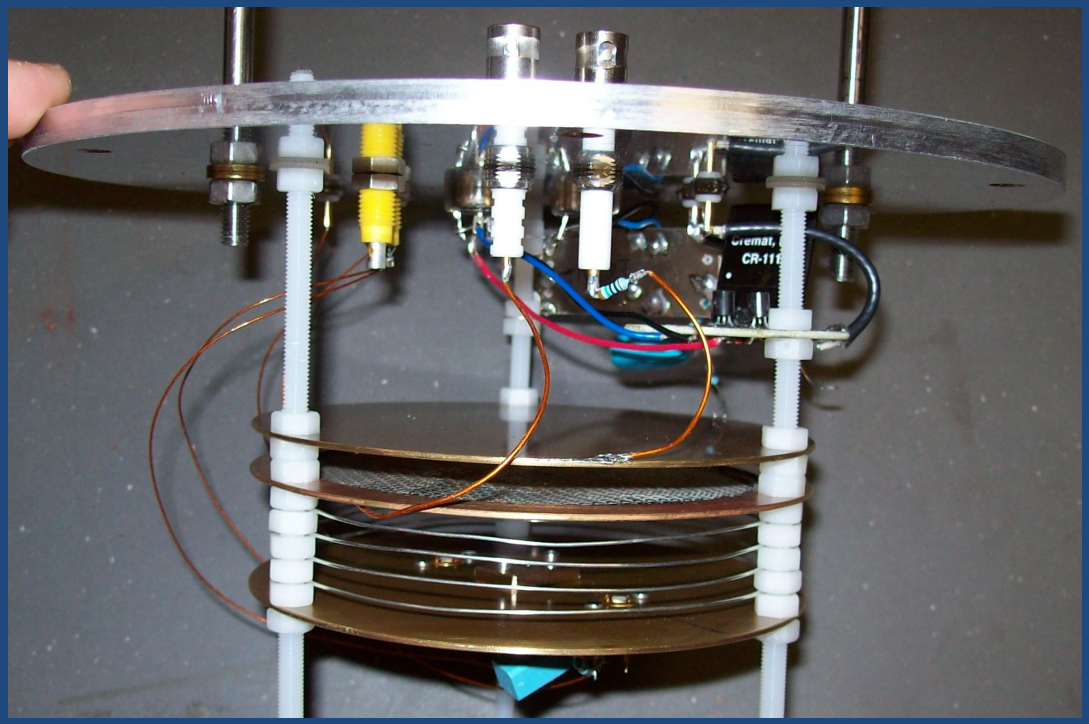
Detecting particles in particle physics



Steve Boyd

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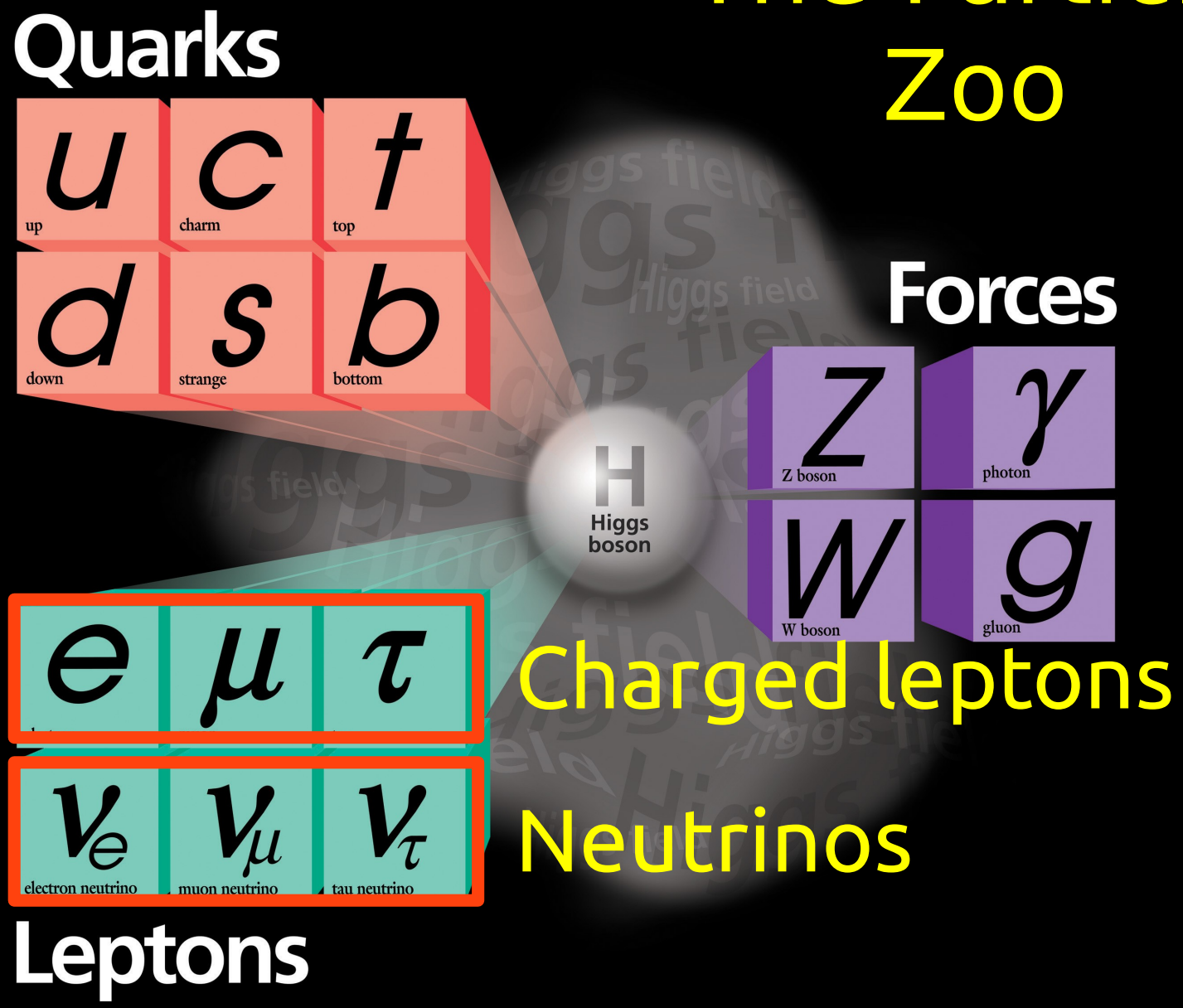
Particle Physics Reminder

The Particle Zoo



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Neutrinos

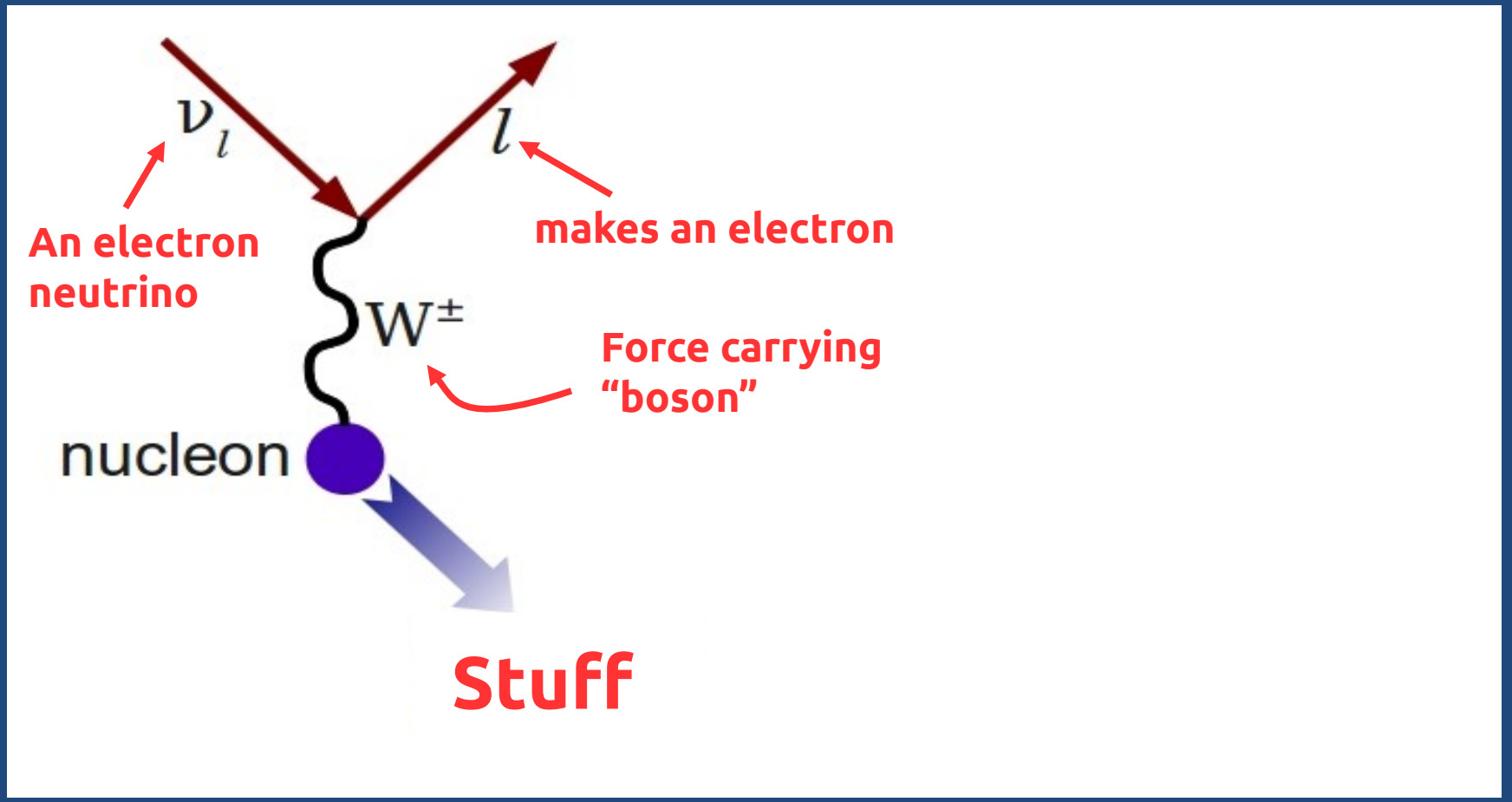
The lightest particle in the universe

No electric charge, so it does not leave a track in our detectors

Three types : electron, muon and tau neutrinos. Each type is associated with the electron, muon and tau particles.

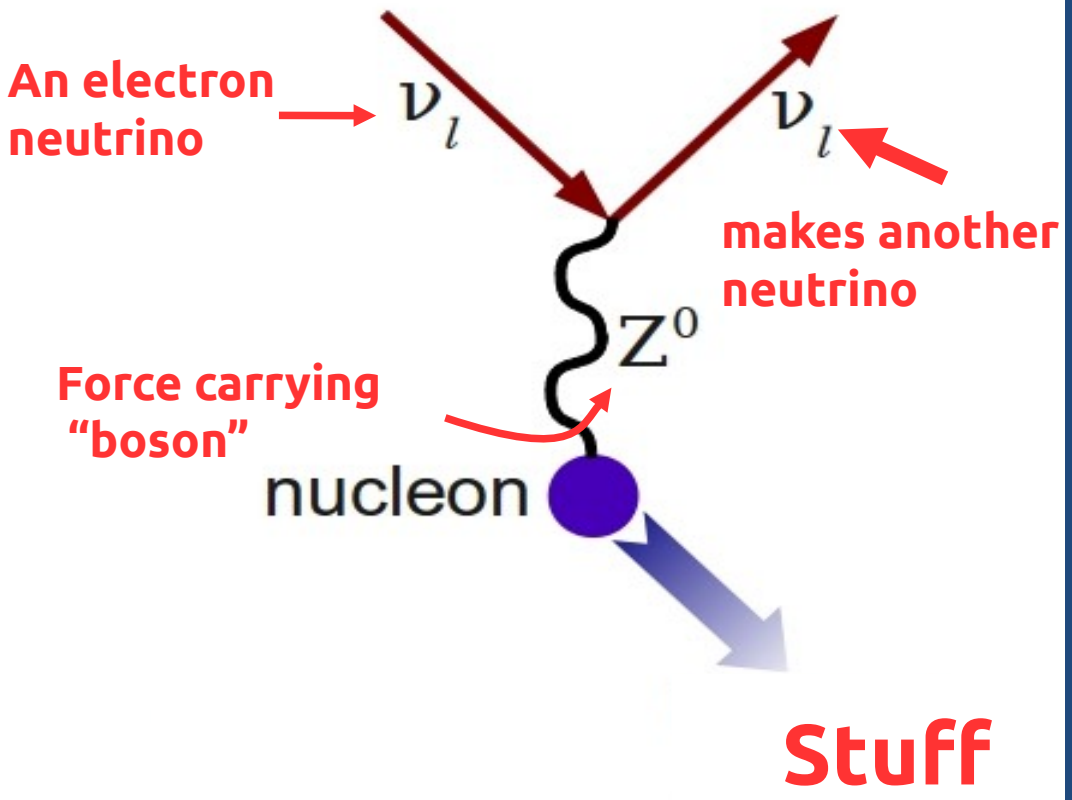
Is critical to make the sun work, to blow up stars and (potentially) to explain why we exist

When neutrinos interact



"Charged Current"

When neutrinos interact



"Neutral Current"

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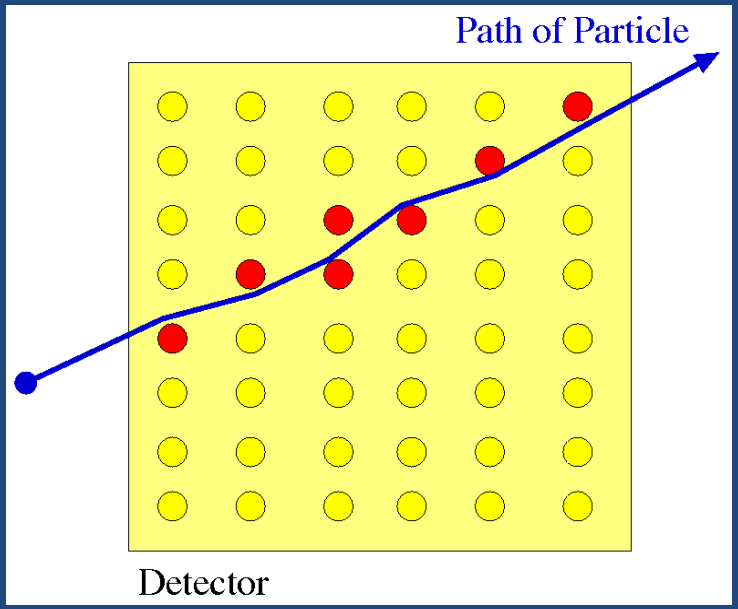
How to detect a particle

Energy Deposition

- Particle enters detector

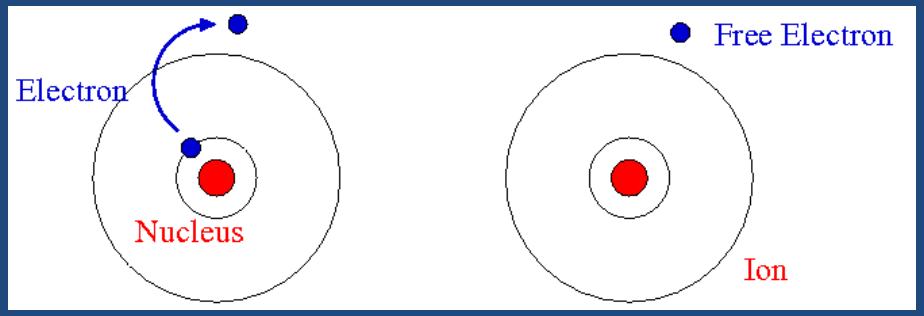
- Particle interacts with detector atoms
  - Ionisation
  - Excitation



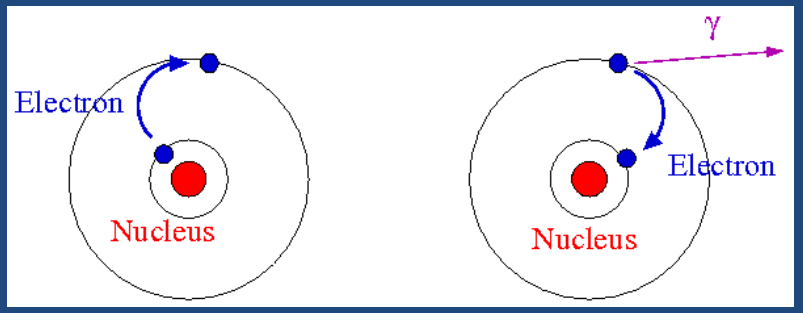
- (Generally only possible if particle is electrically charged)
- Energy left behind where particle has been!

Detector Signals

- Ionisation signal – signal from charge (electrons/ions)



- Excitation – leads to photon emission – signal from light (photons)



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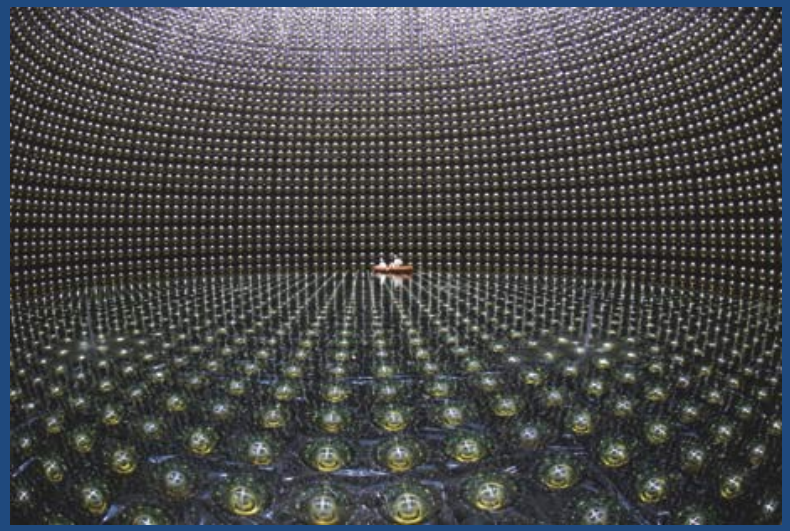
Types of detectors: Light

Liquid / Solid Scintillators

Čerenkov Detectors

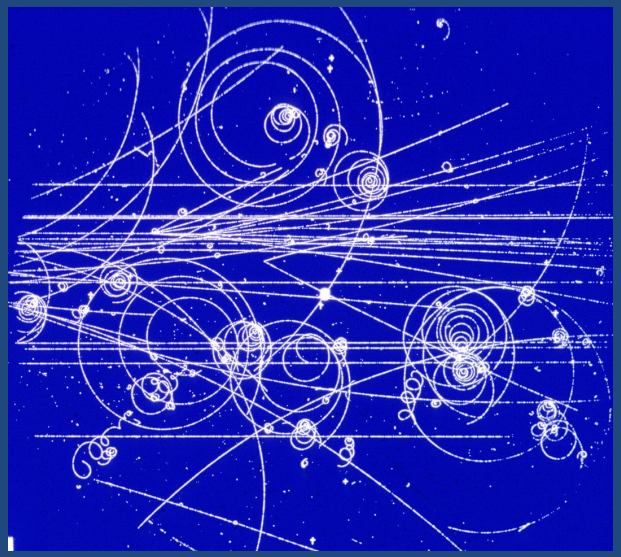


- Light detected by Photosensors

Types of Detectors: Charge

- Solid state detectors
  - Silicon detectors
  - Germanium detectors

- Ionisation Chambers
- Wire Proportional counters



- Bubble Chambers
- Time Projection Chambers

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Measurements

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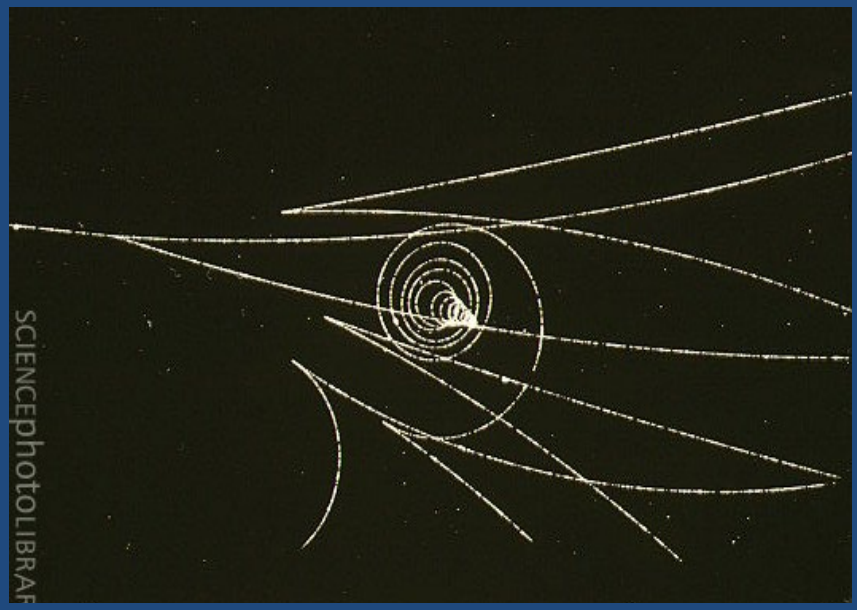
Physics properties

- Energy deposited
- Decay time
- Particle type
- Decay products
- Momentum
- Charge on particle



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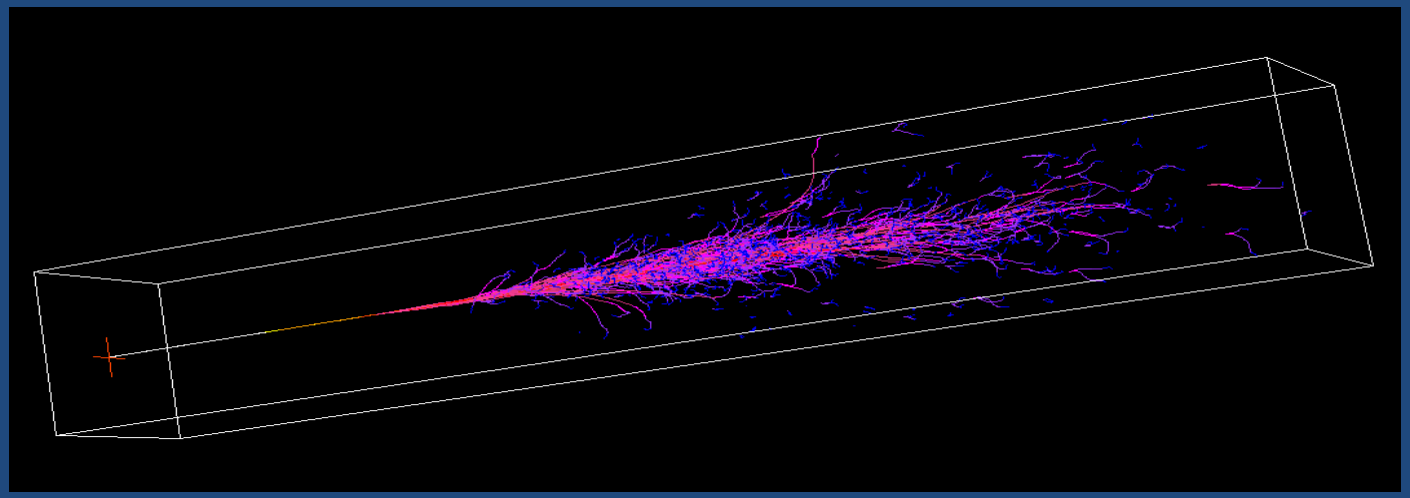
Particle identification

Muons punch straight through everything

Electrons spiral in a magnetic field and shower when they hit something

Photons shower when they hit something



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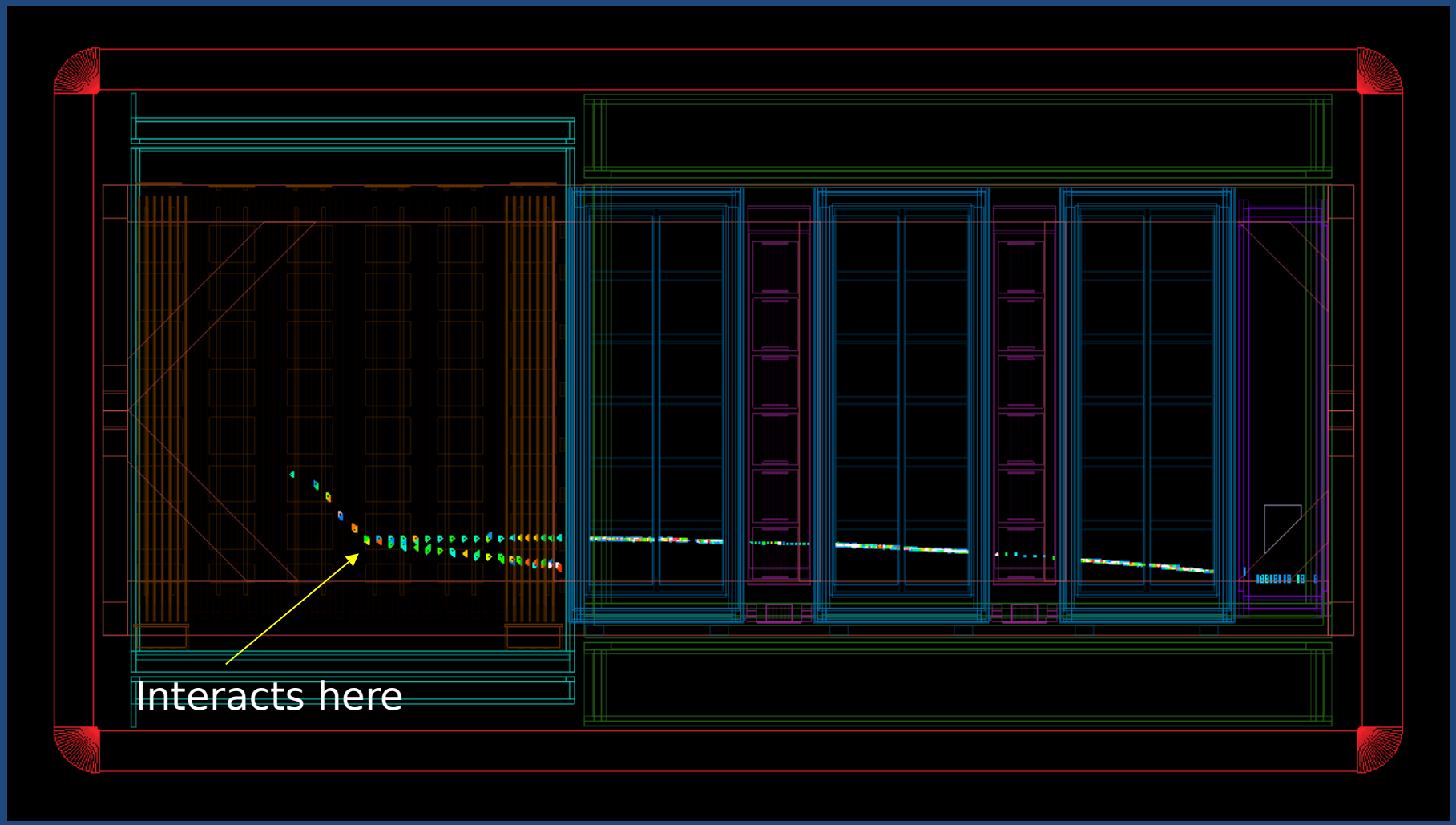
Example of the tracks left by a neutrino interaction



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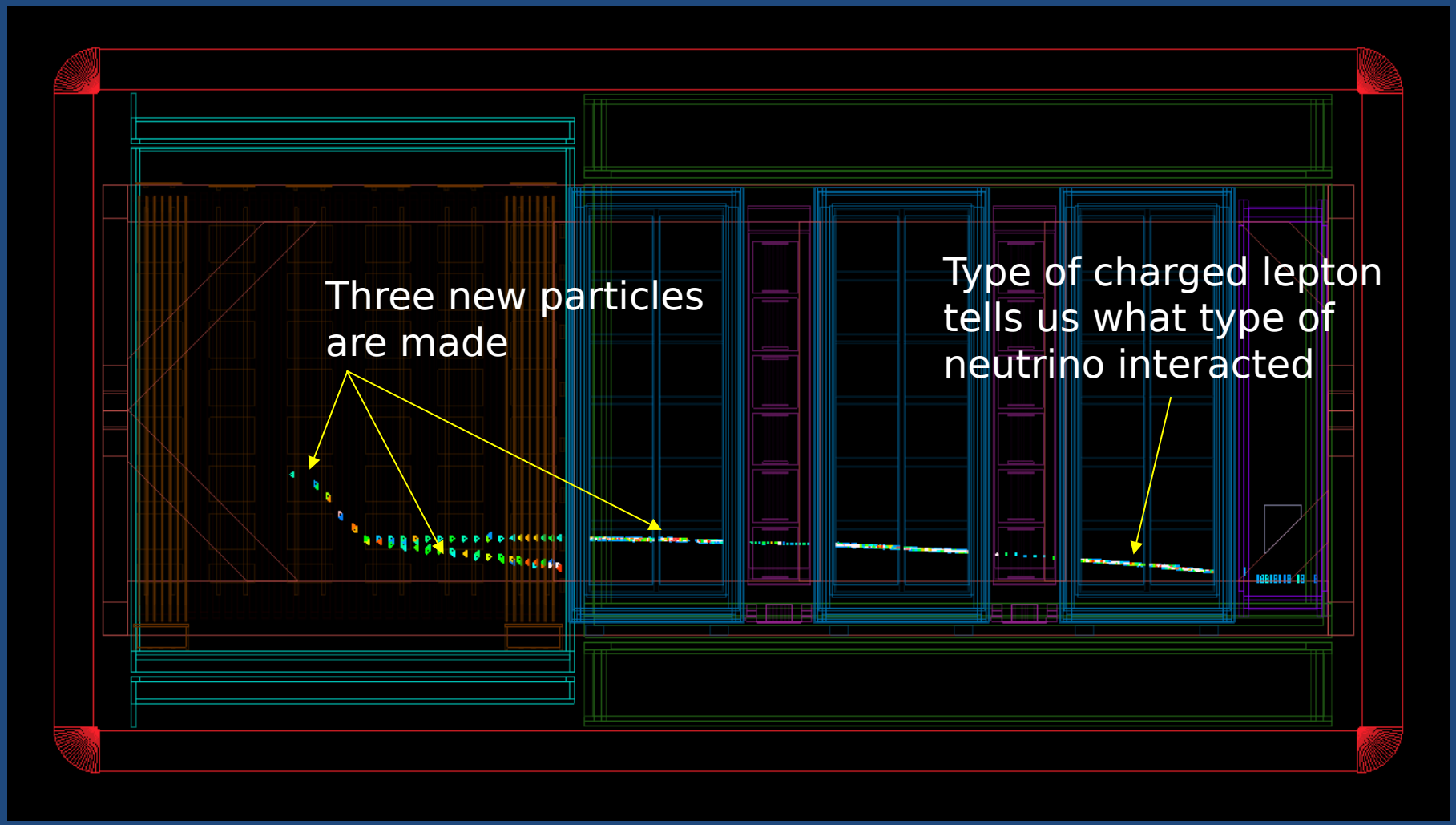
Example of a neutrino interaction



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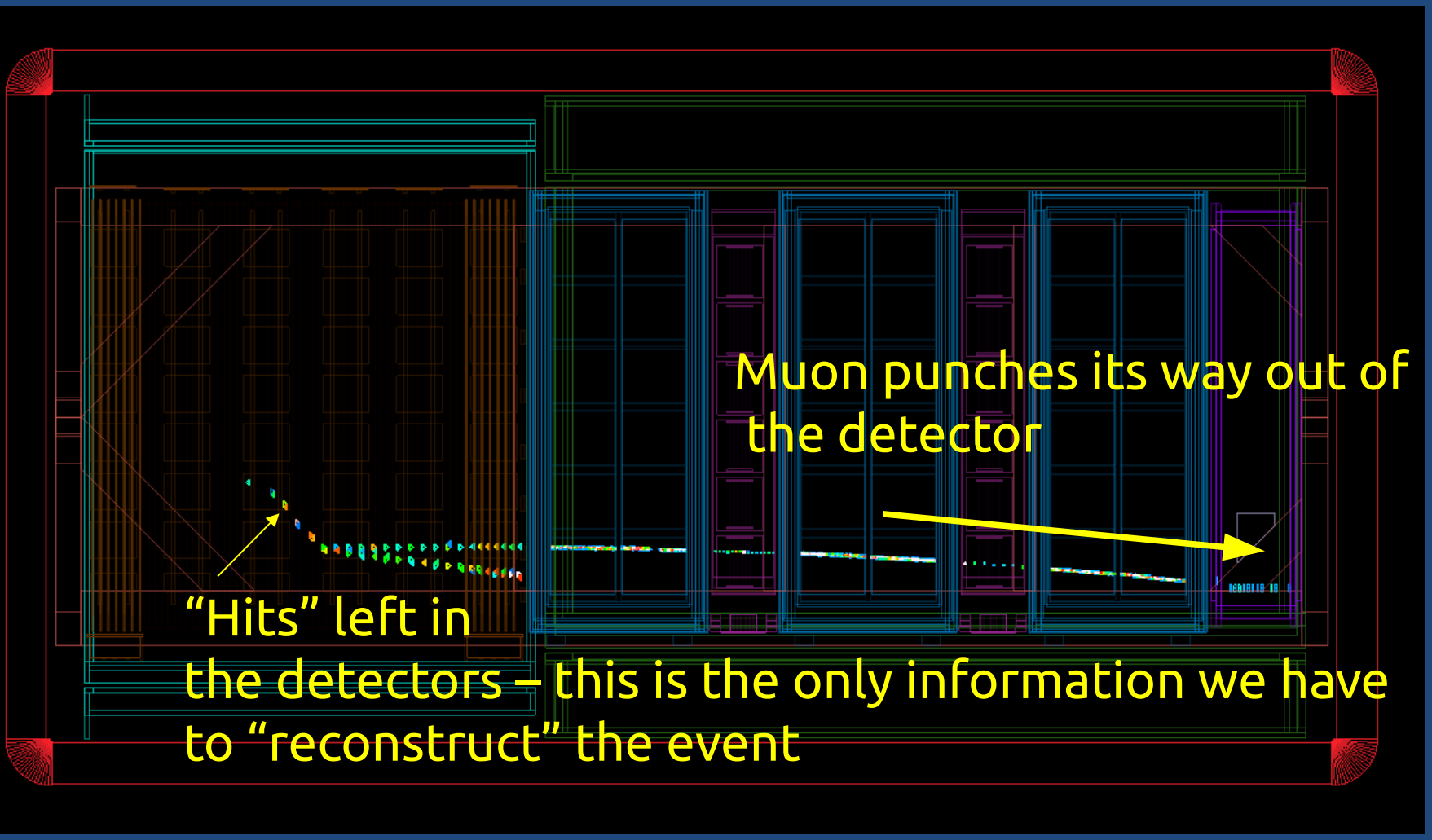
Example of the tracks left by a neutrino interaction



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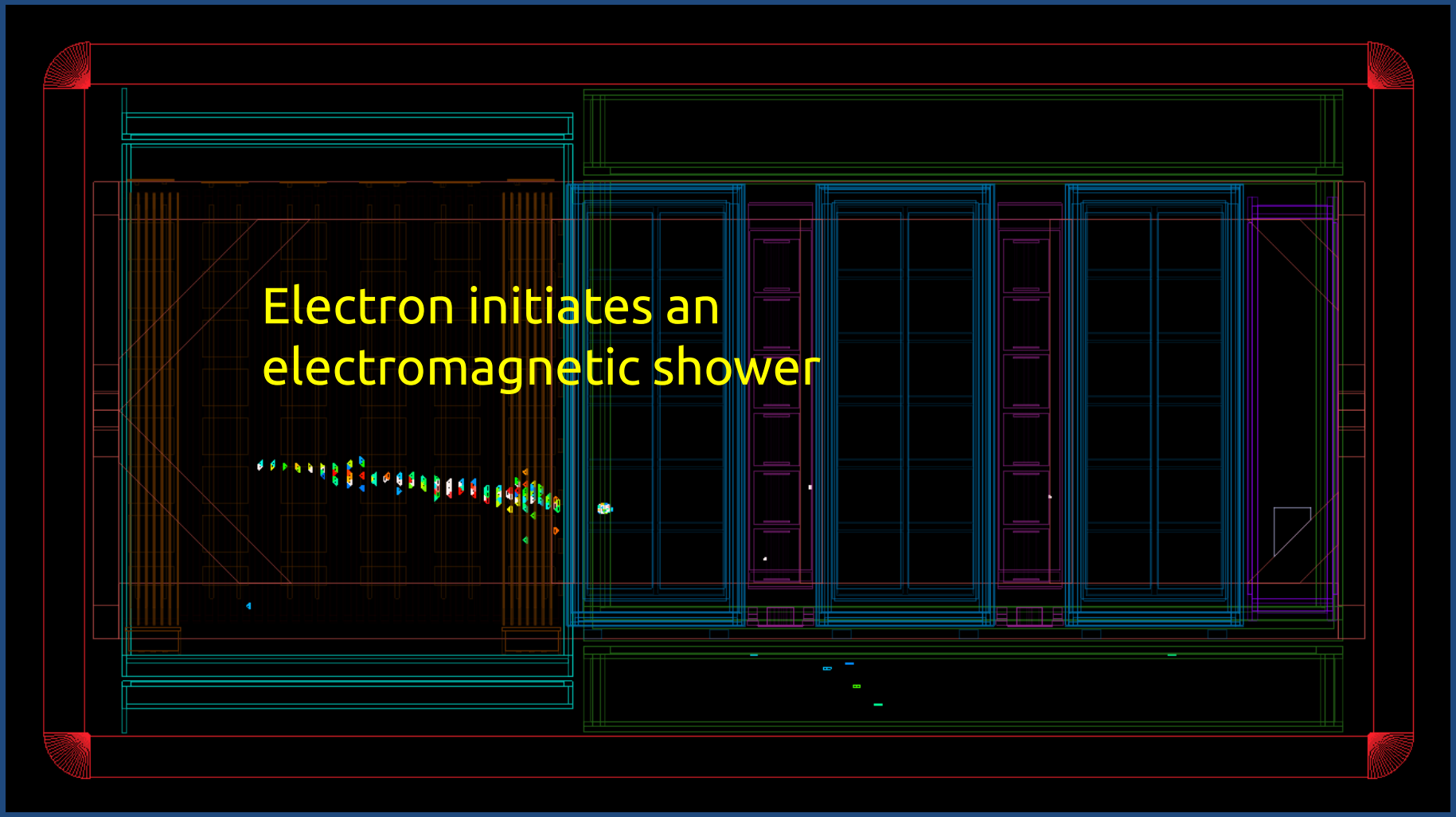
A ν_e interaction



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Summary and Conclusions

- Particle detectors allow us to “see” where a particle has left energy
- Different detectors use light /charge to do this.
- Measurements help us to learn physics properties of particles.

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Exercise

The exercise you are going to do is to try to recognise different types of particles and neutrino interactions using a program

The human brain is one of the best pattern matching machines ever evolved. However, even we will get some of these wrong.

Imagine how much harder it is to ask a computer to do this automatically.

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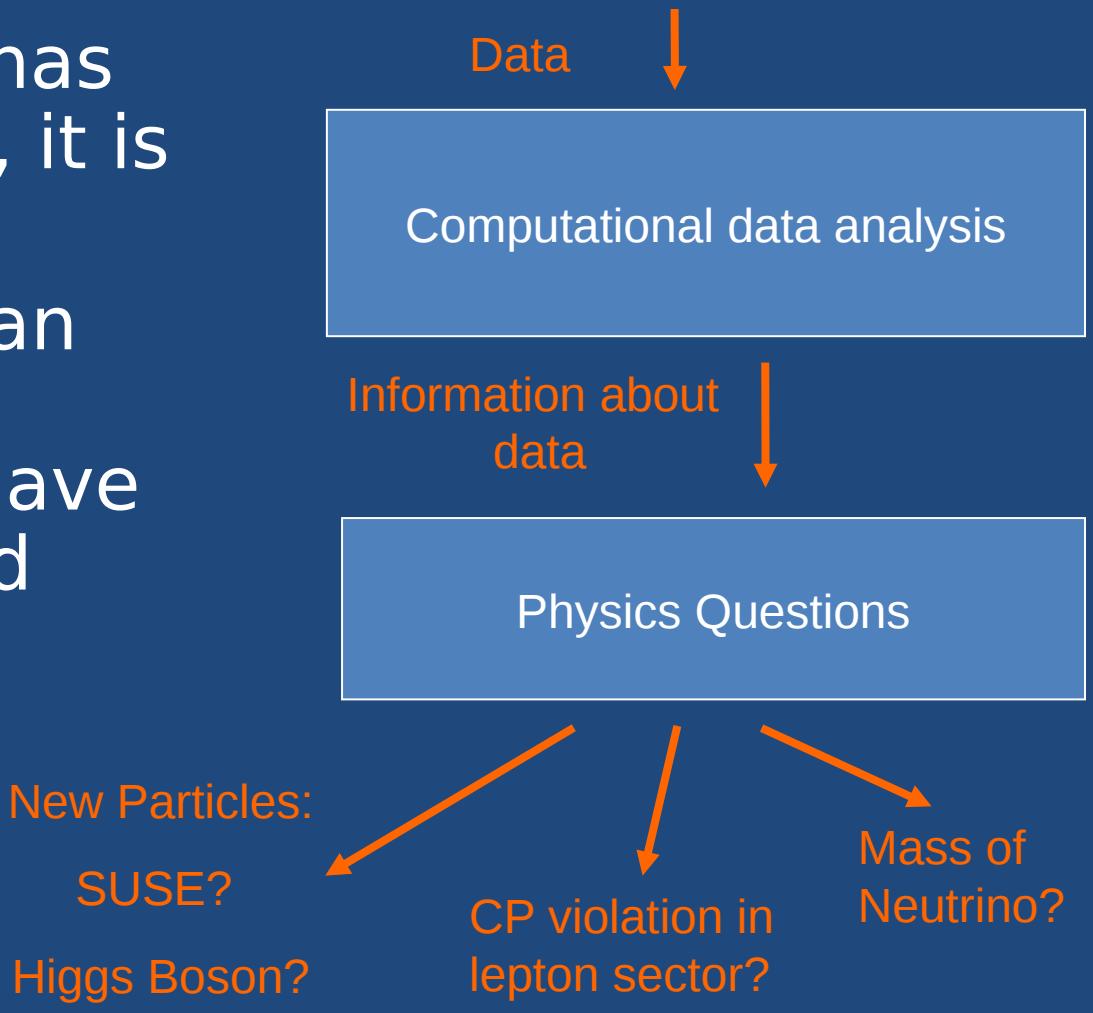
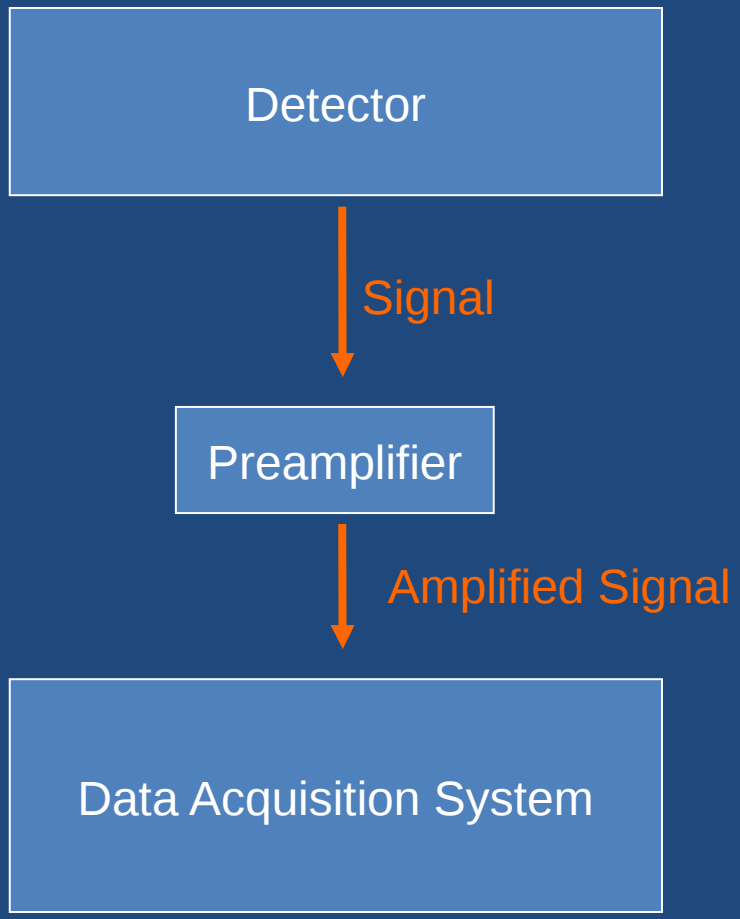
Offline – data processing

- After the data has been collected, it is analysed.
- This analysis can help to answer questions we have about the world around us.



Online – in real time



- Data is collected, amplified, and written to disk in real time.
- Amplification close to the detector allows better signal to noise.