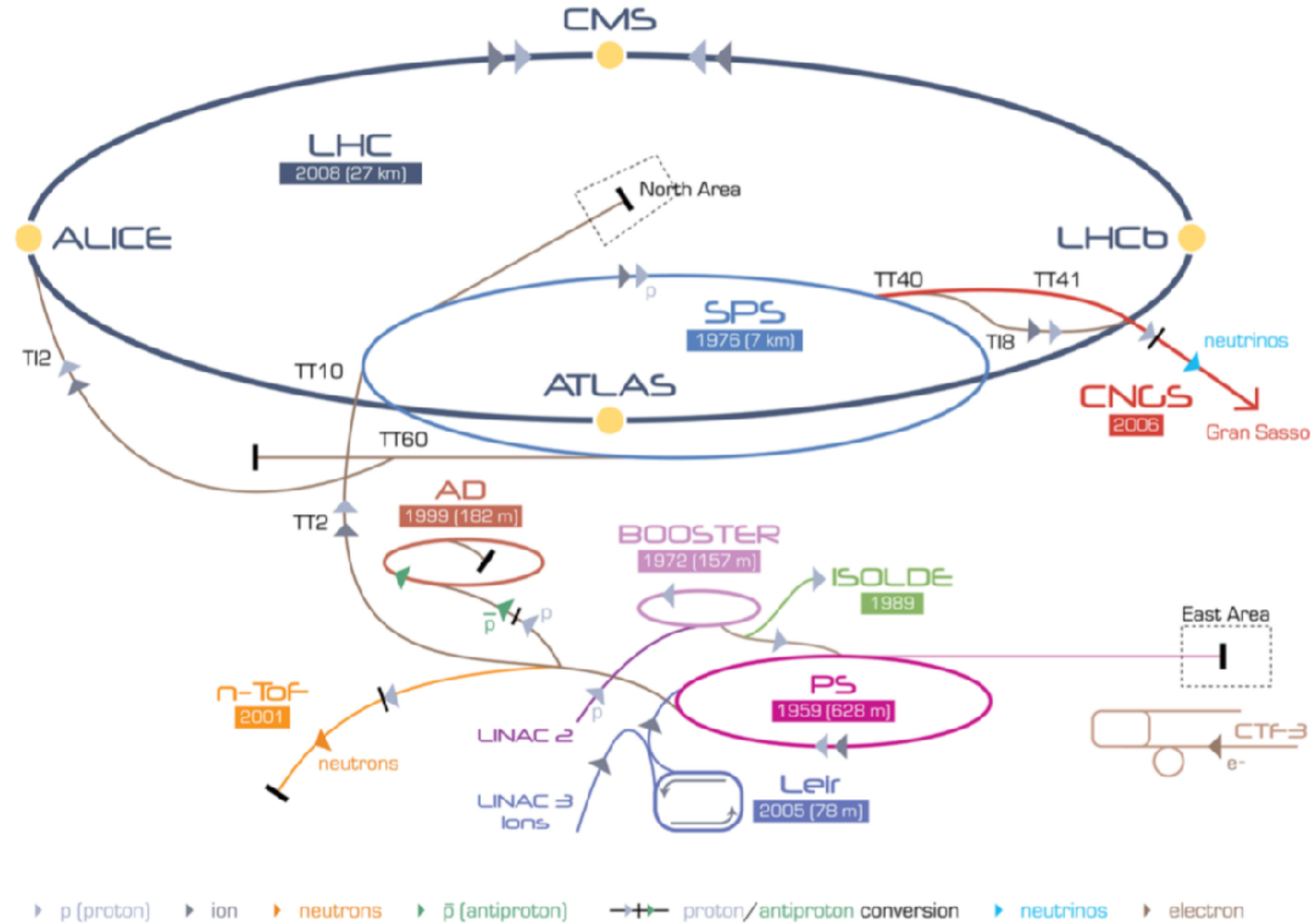


# Particle Detectors

## Introduction

Vinícius Franco





LHC Large Hadron Collider SPS Super Proton Synchrotron PS Proton Synchrotron

AD Antiproton Decelerator CTF-3 Clio Test Facility CNCS Cern Neutrinos to Gran Sasso ISOLDE Isotope Separator OnLine DEvice  
LEIR Low Energy Ion Ring LINAC LINEar ACcelerator n-ToF Neutrons Time Of Flight

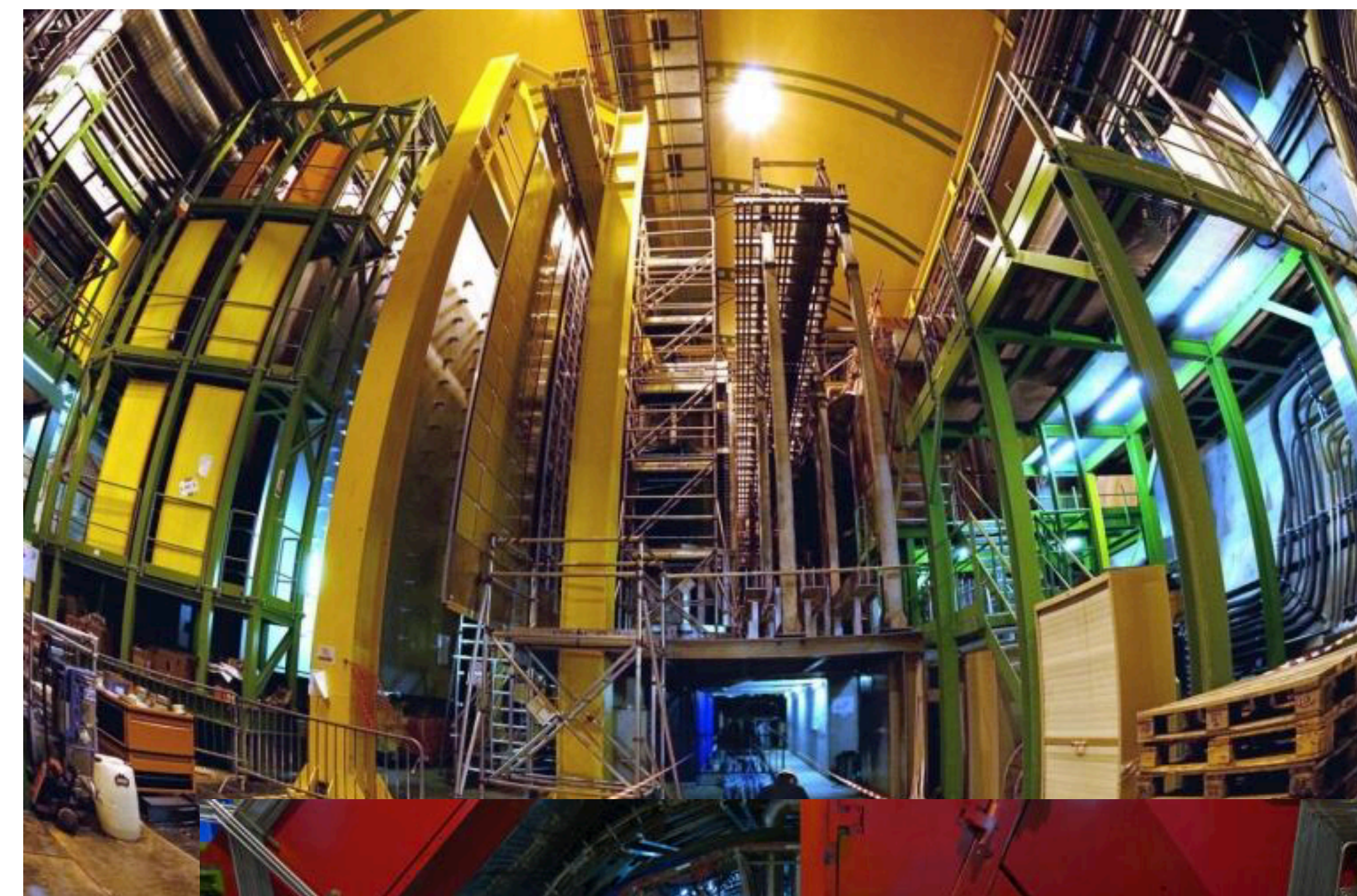
**FARMS!**



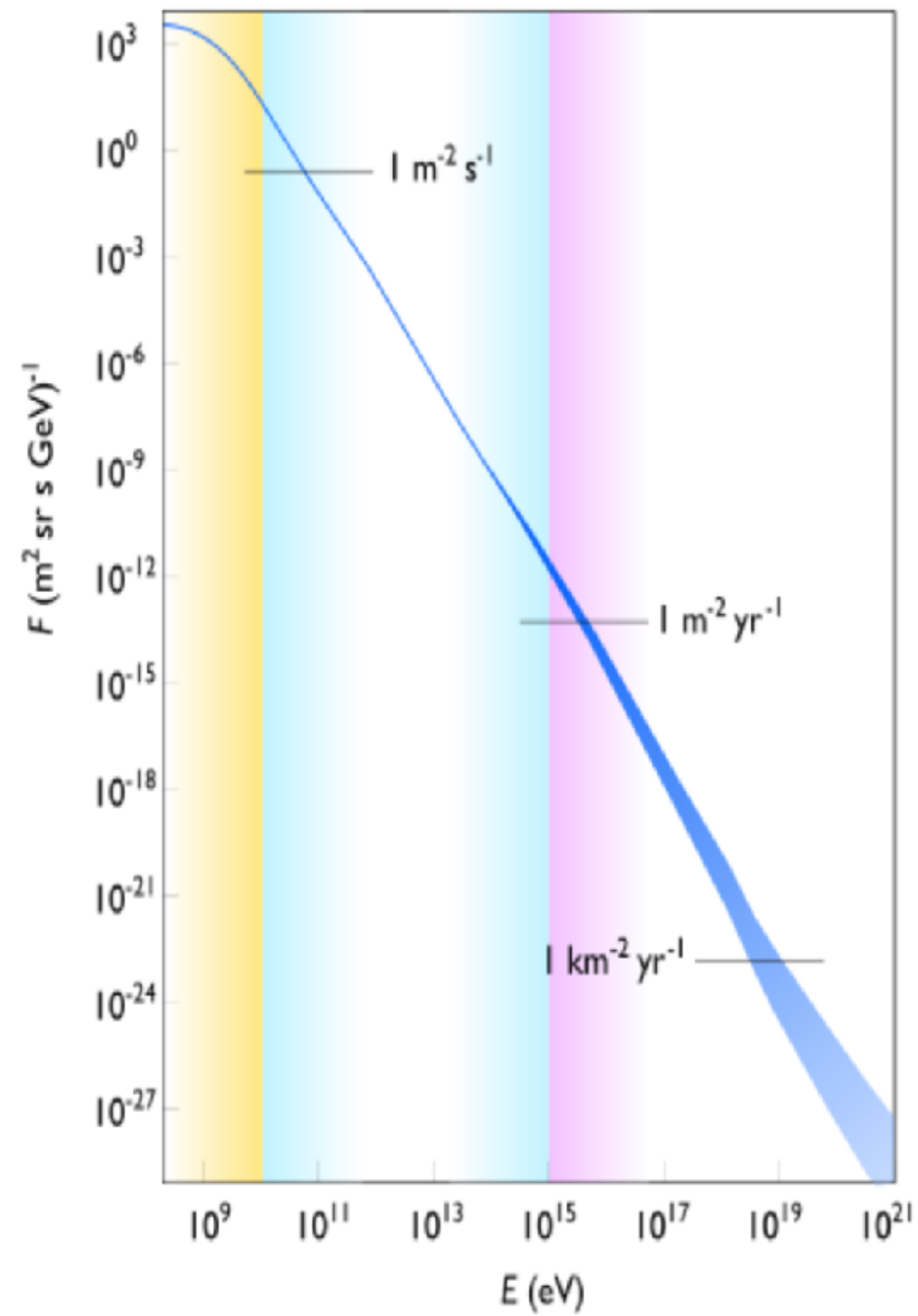
## Hunters



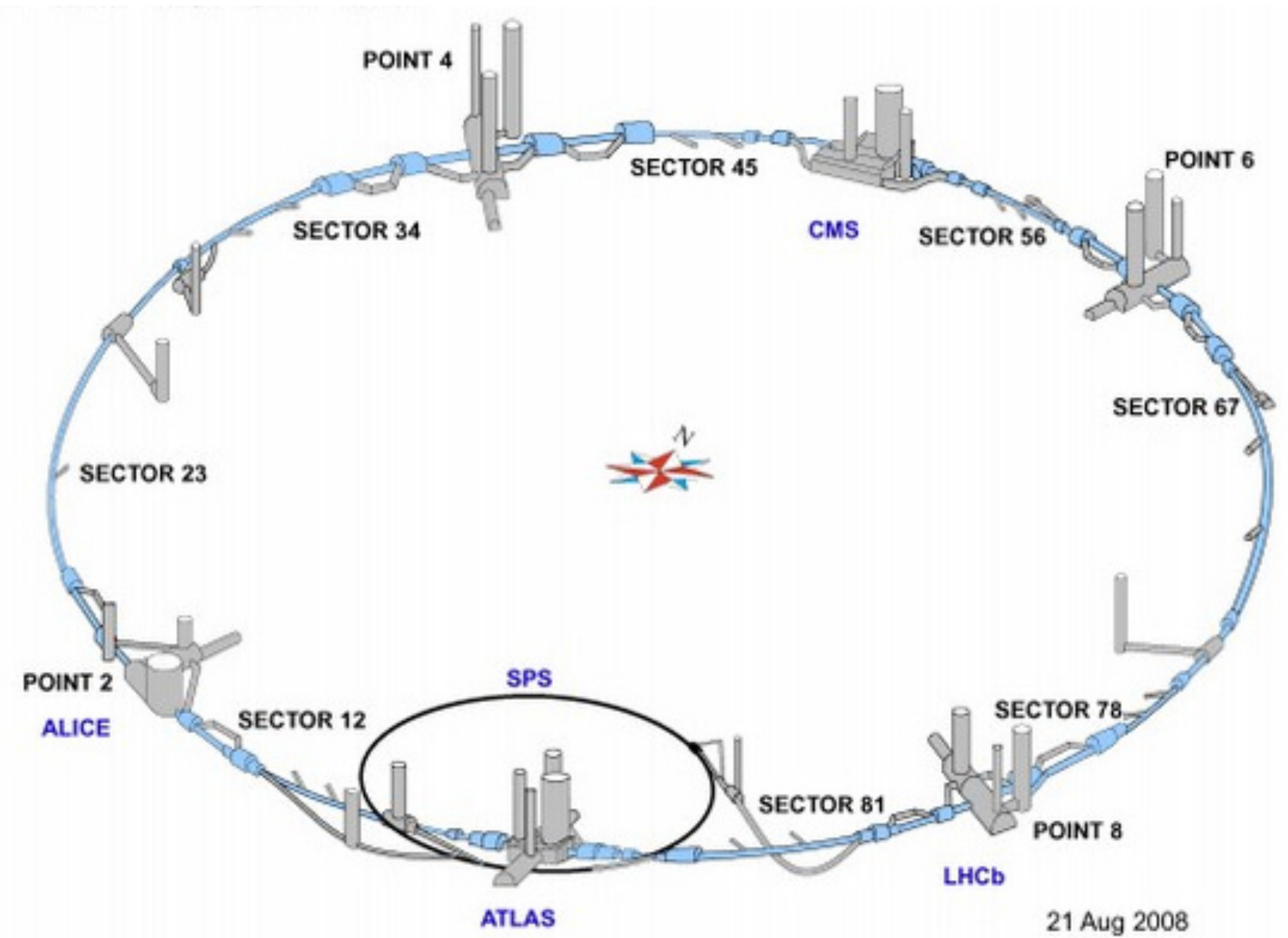
## Farmers



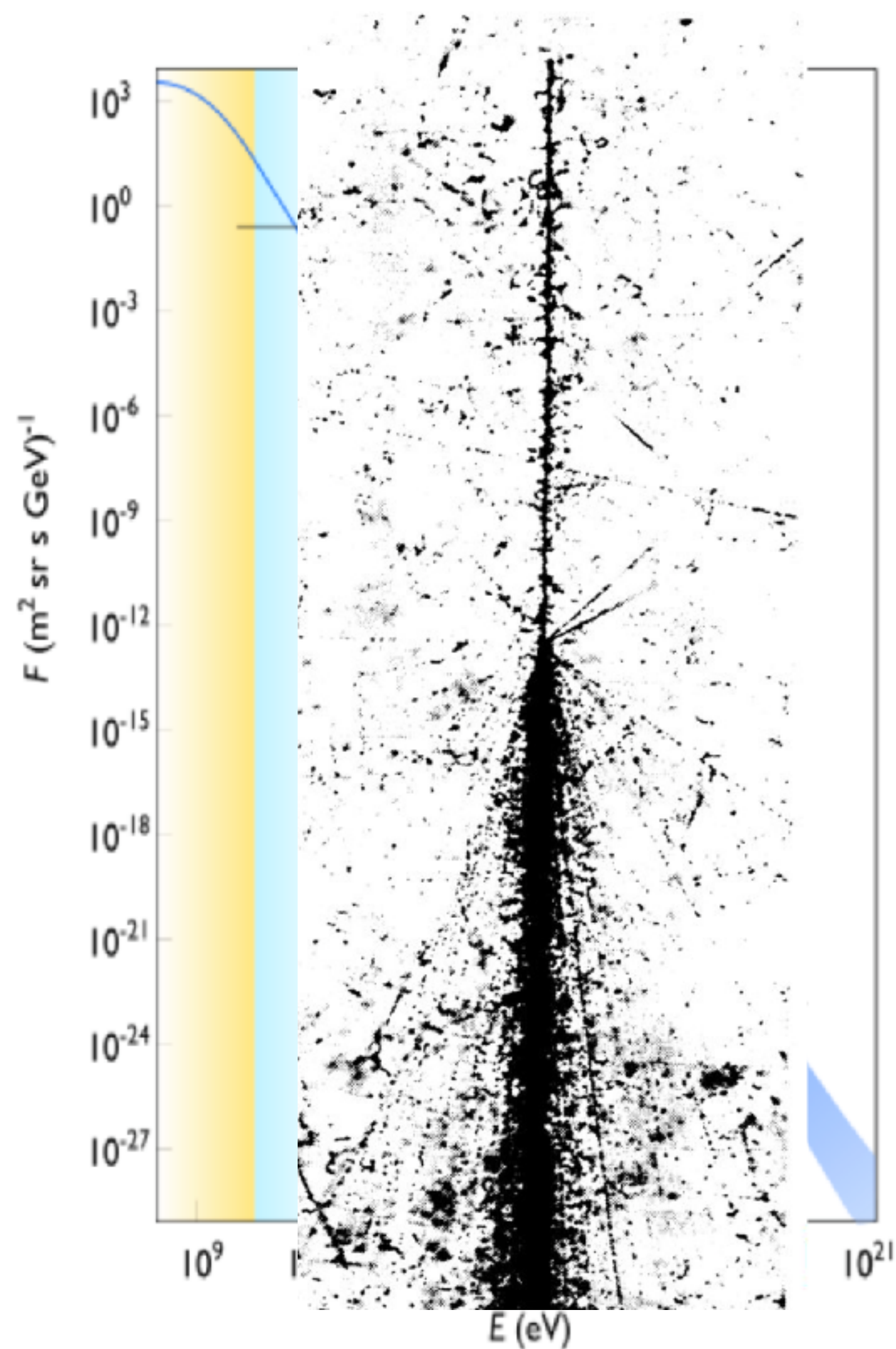
# Hunters



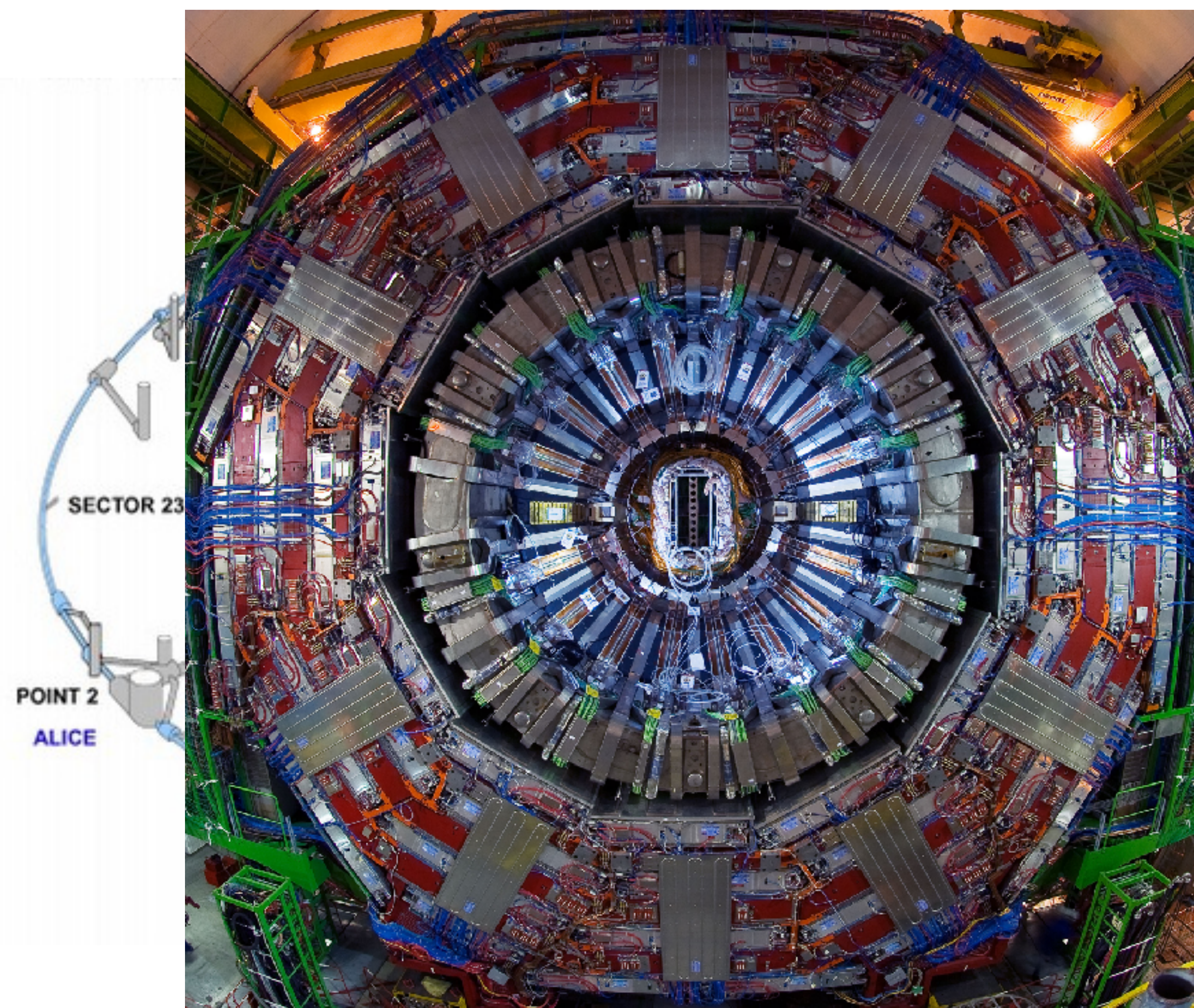
# Farmers



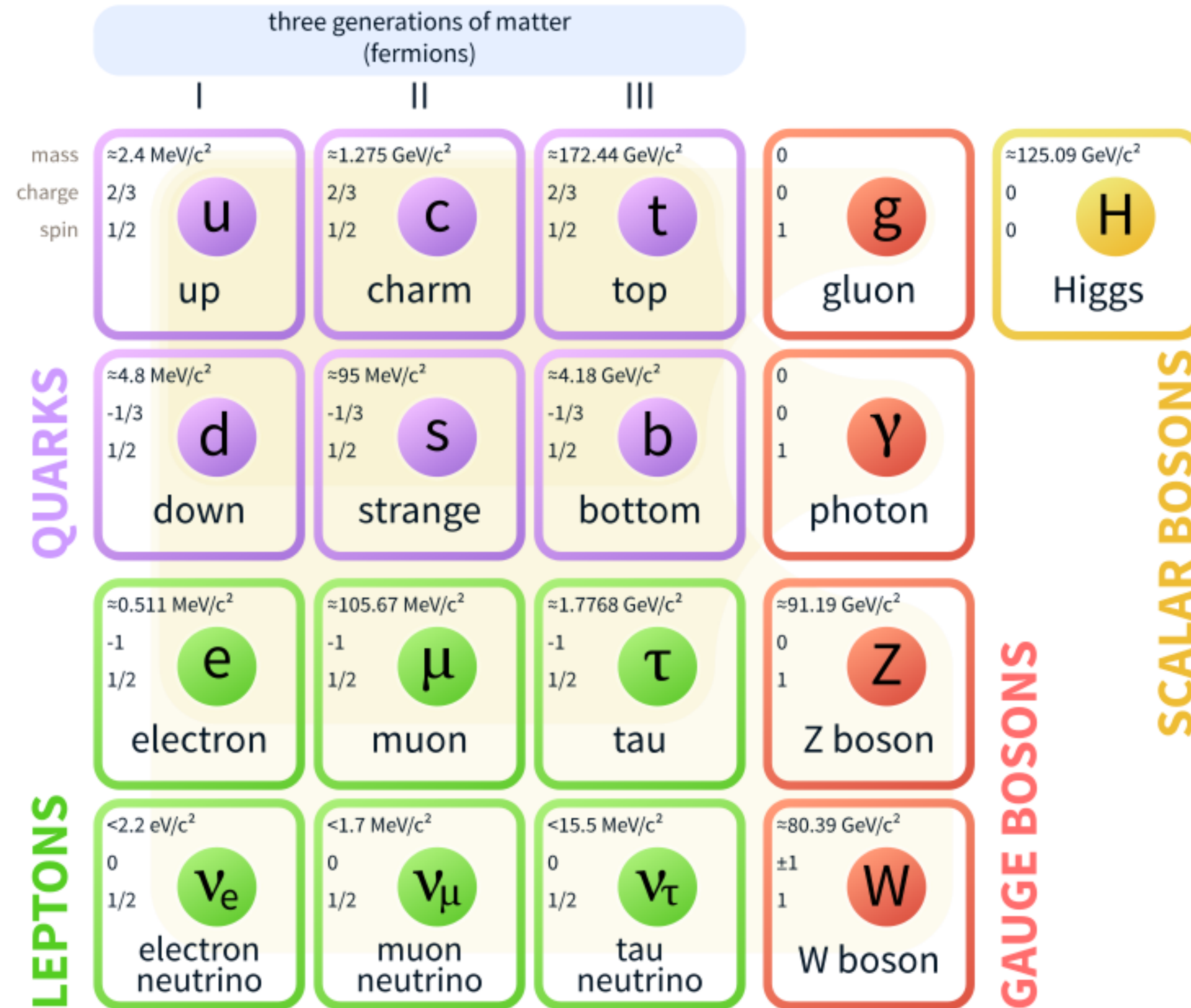
## Hunters



## Farmers

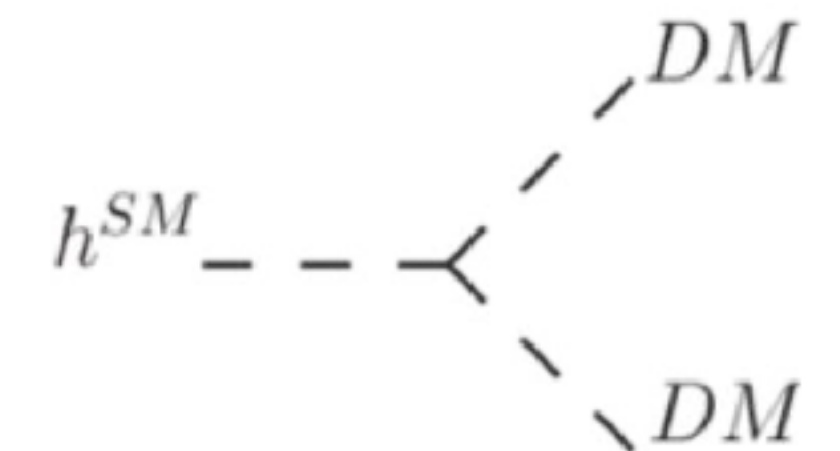
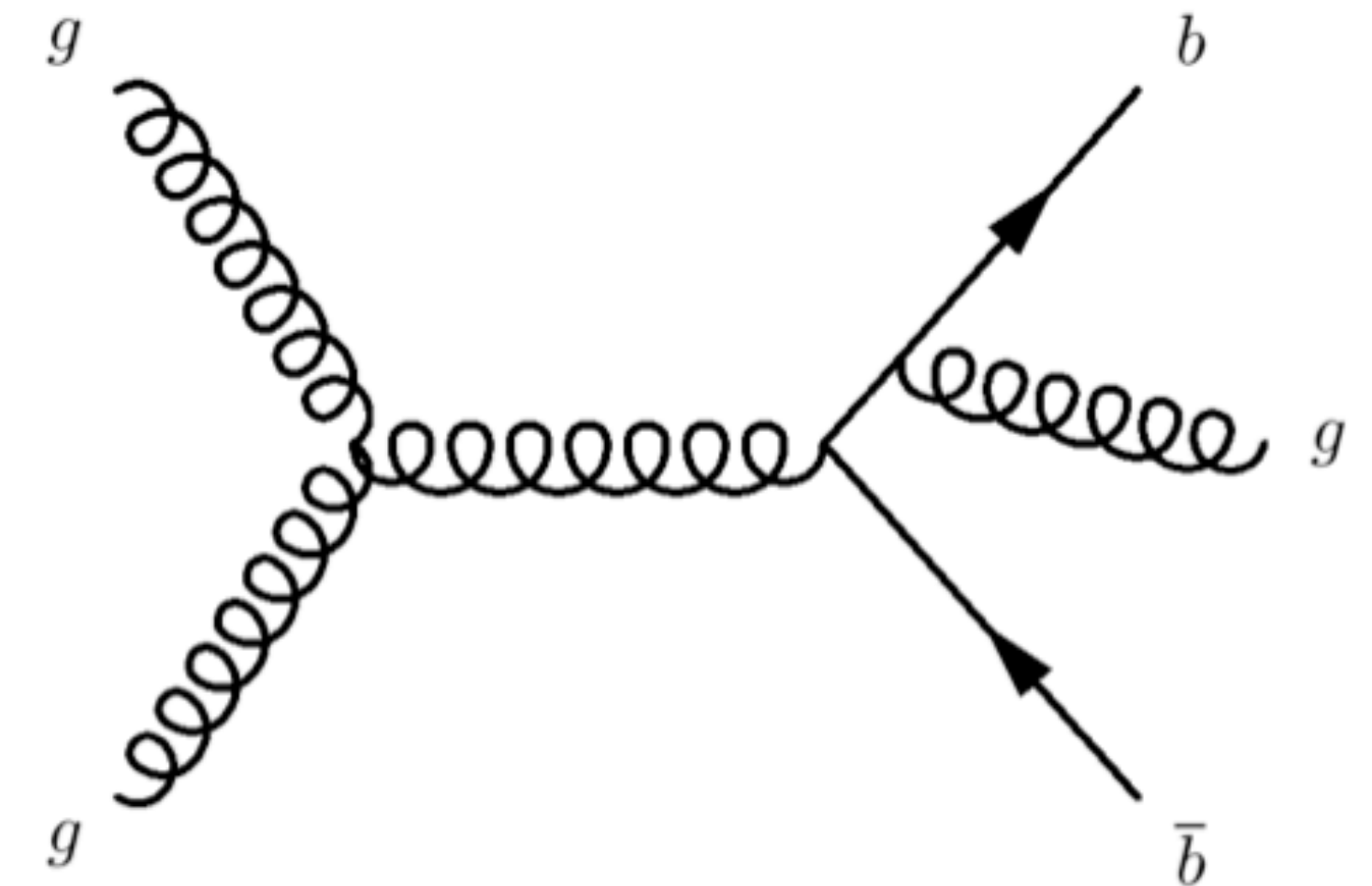
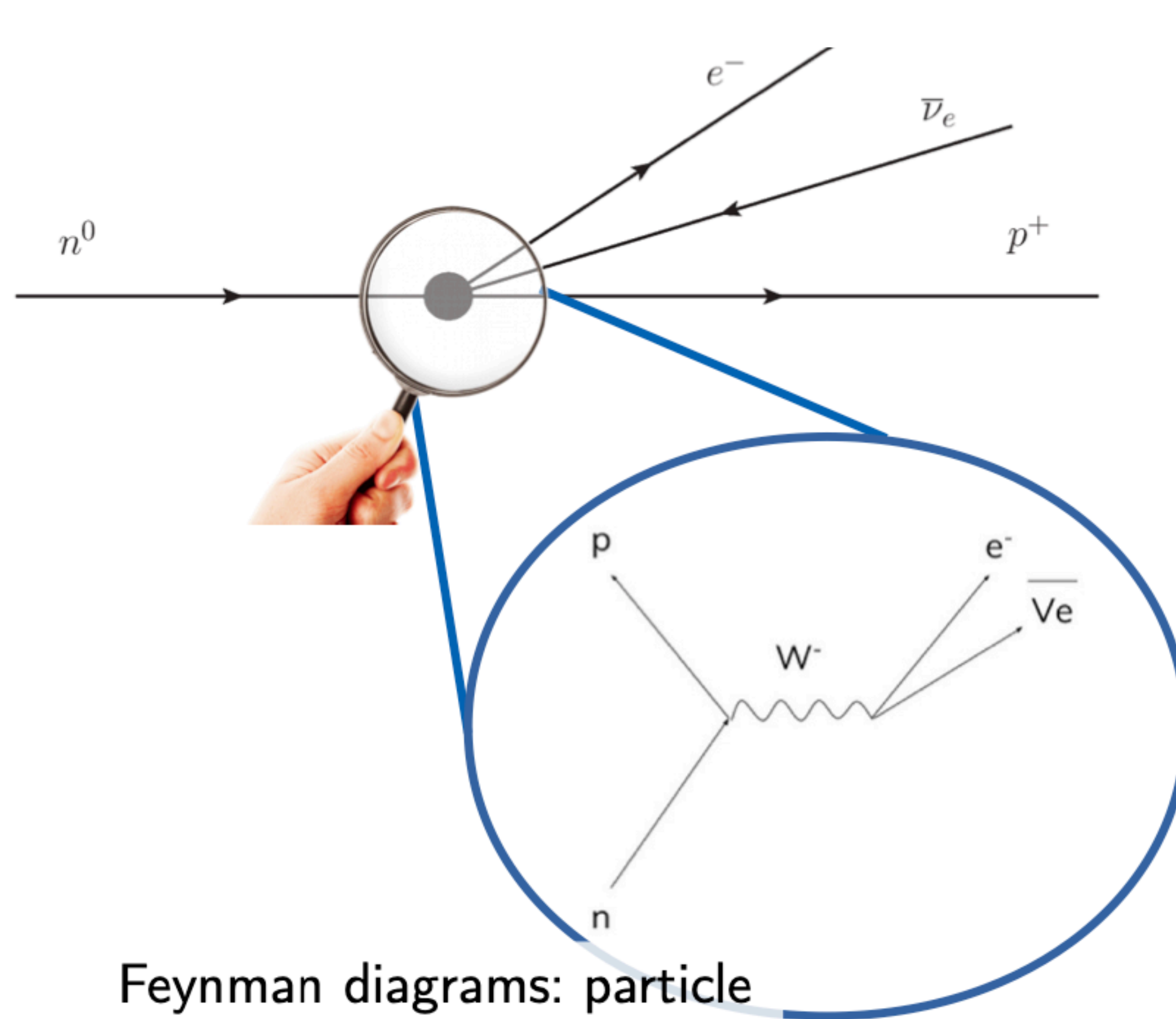


# Standard Model of Elementary Particles





# Physics experiments are interested in particular processes



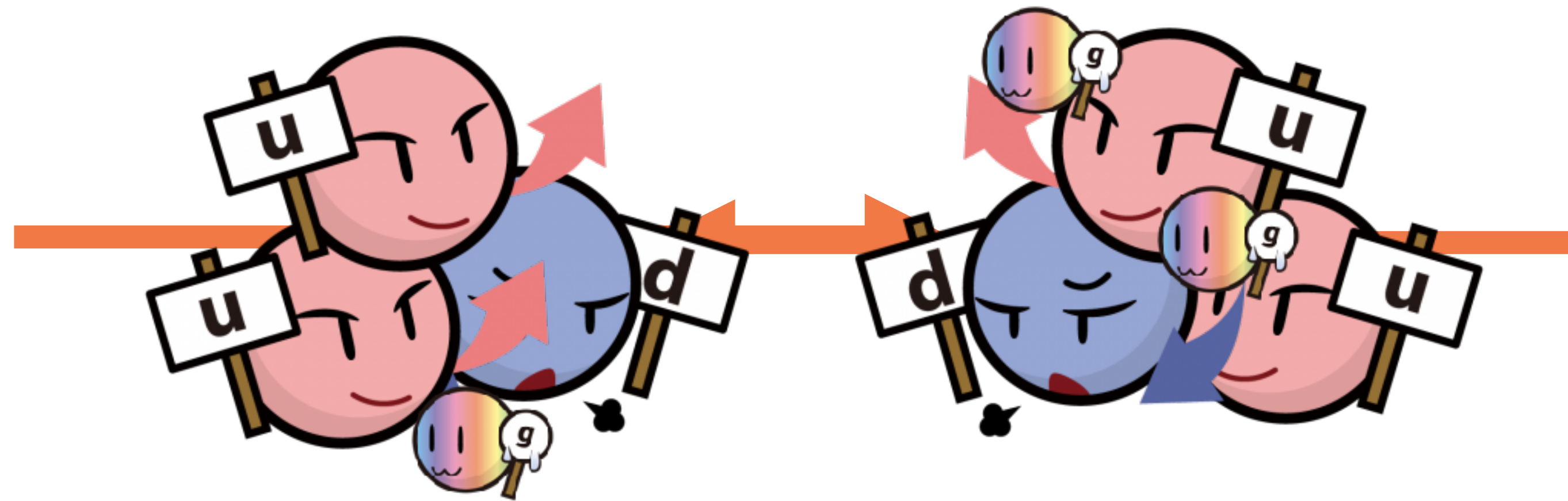
Feynman diagrams: particle physicists' best friends to understand interactions

**Many squiggly lines yesterday!**

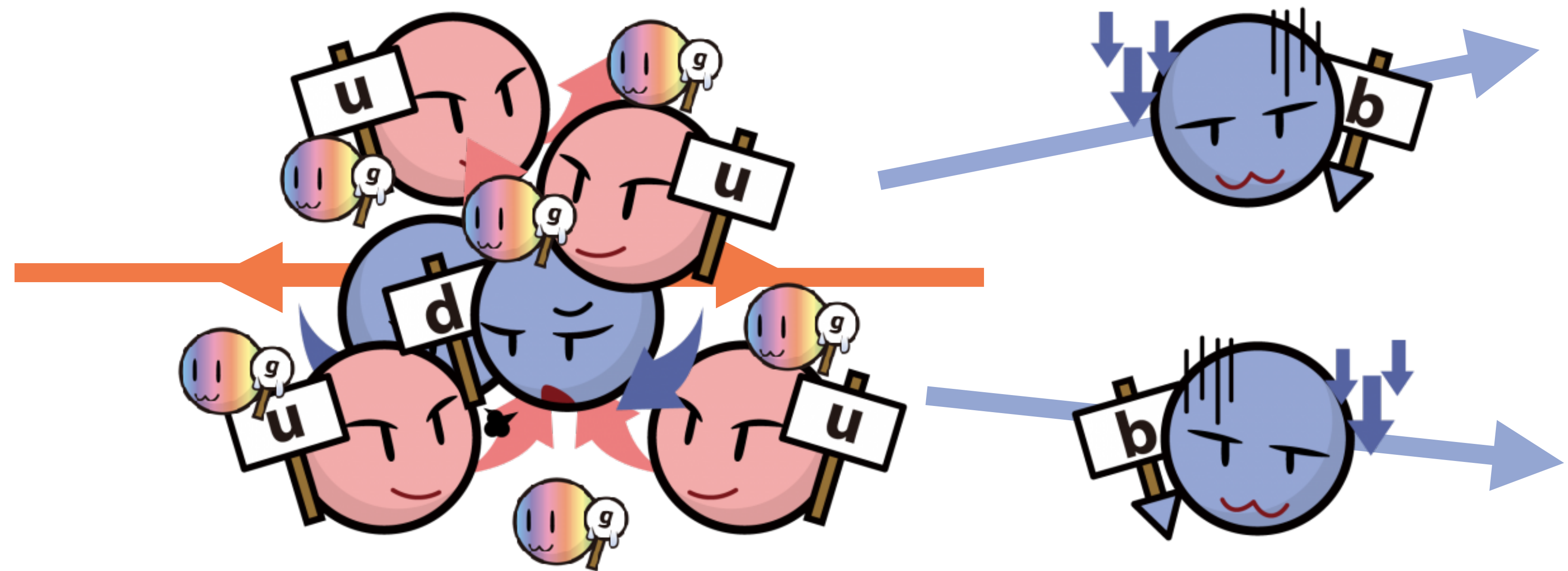
*In LHC...*

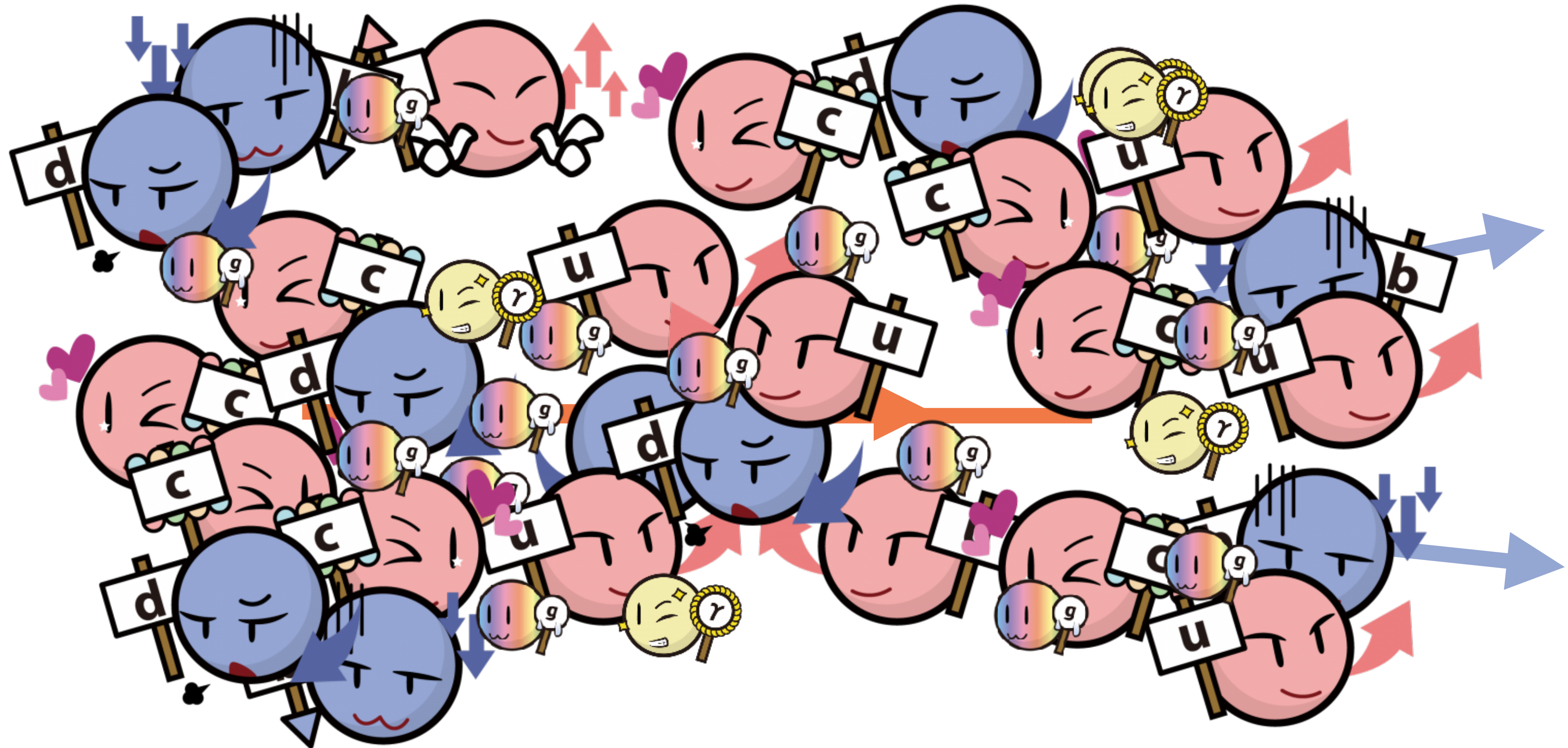


# In LHC...

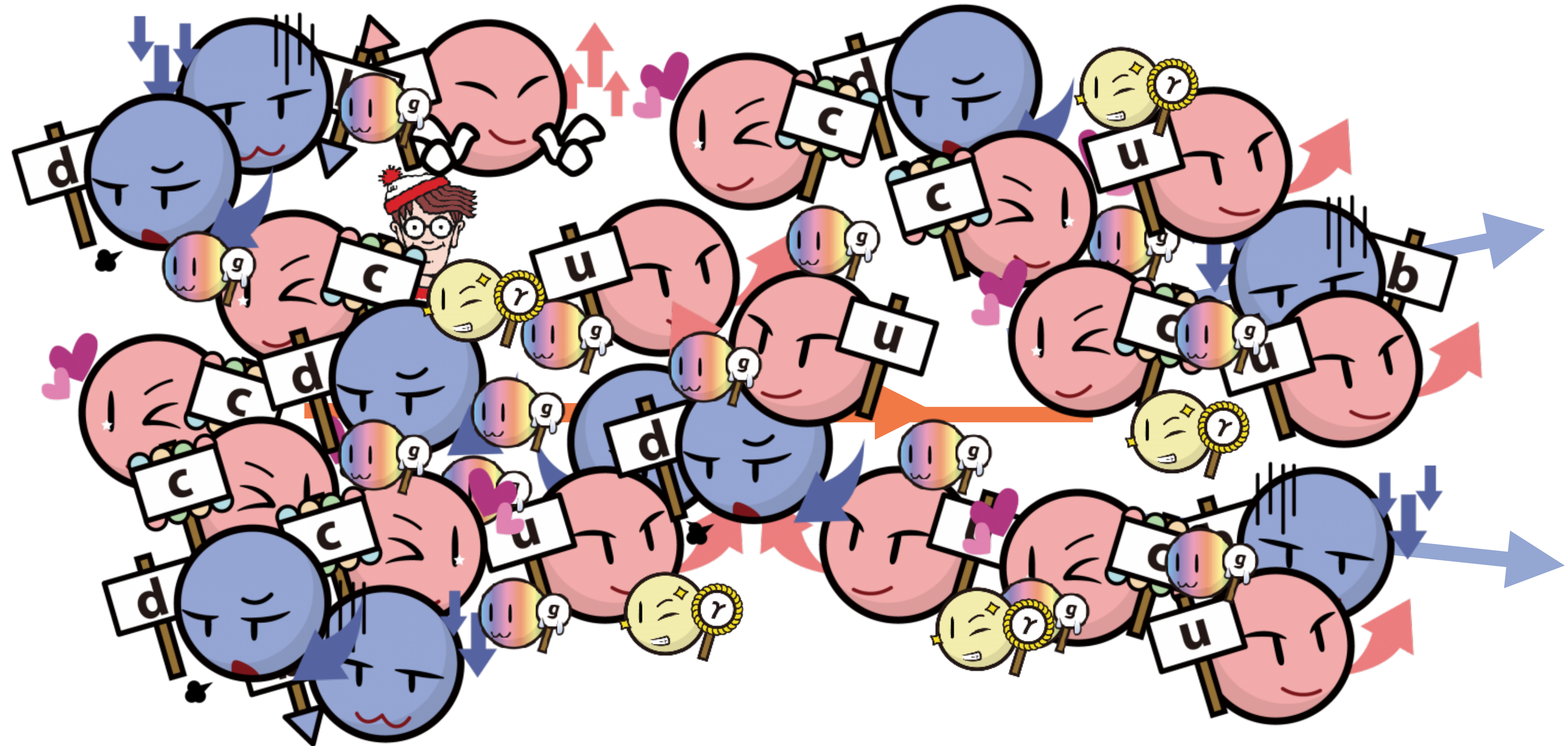


# In LHC...

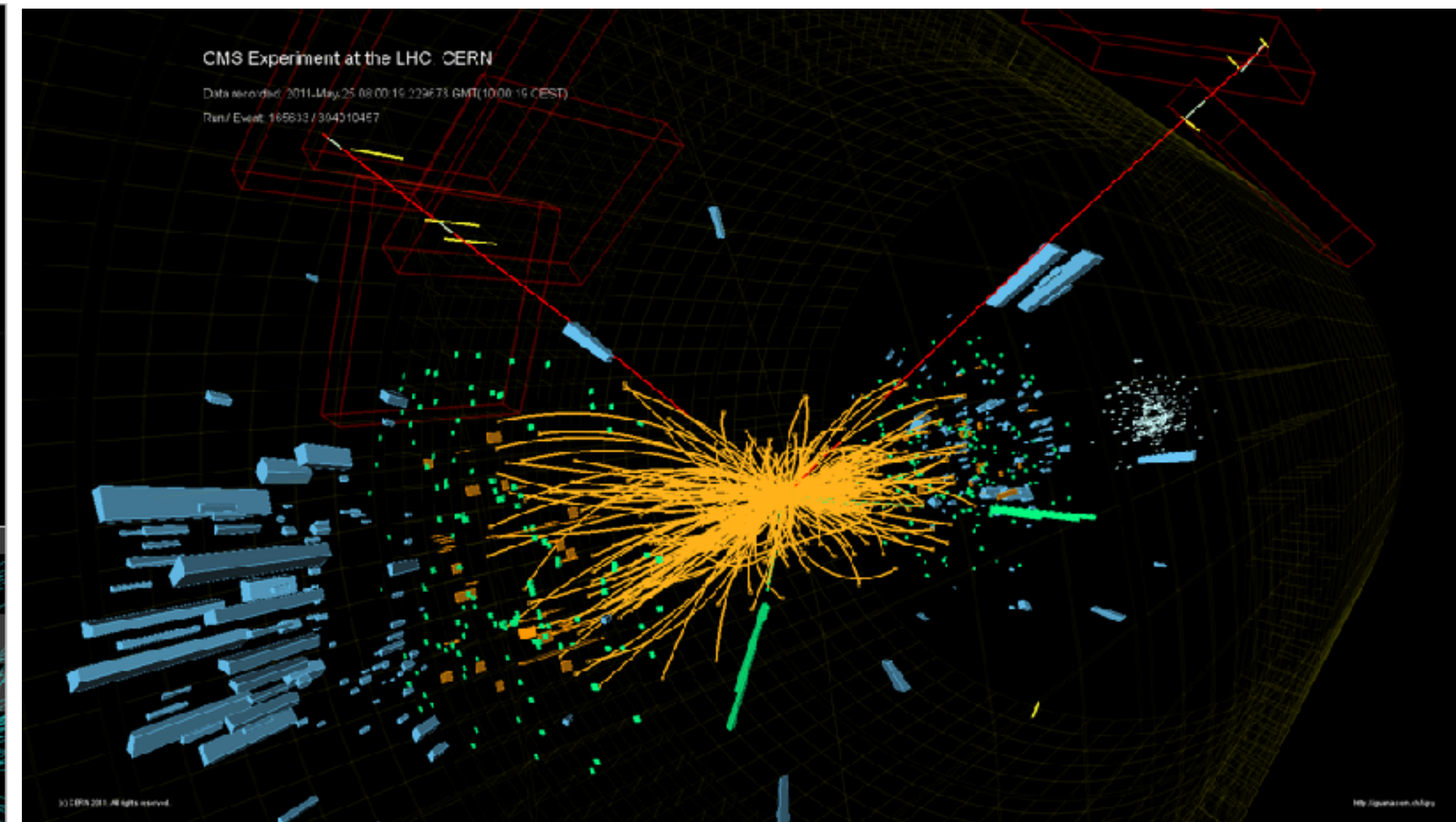
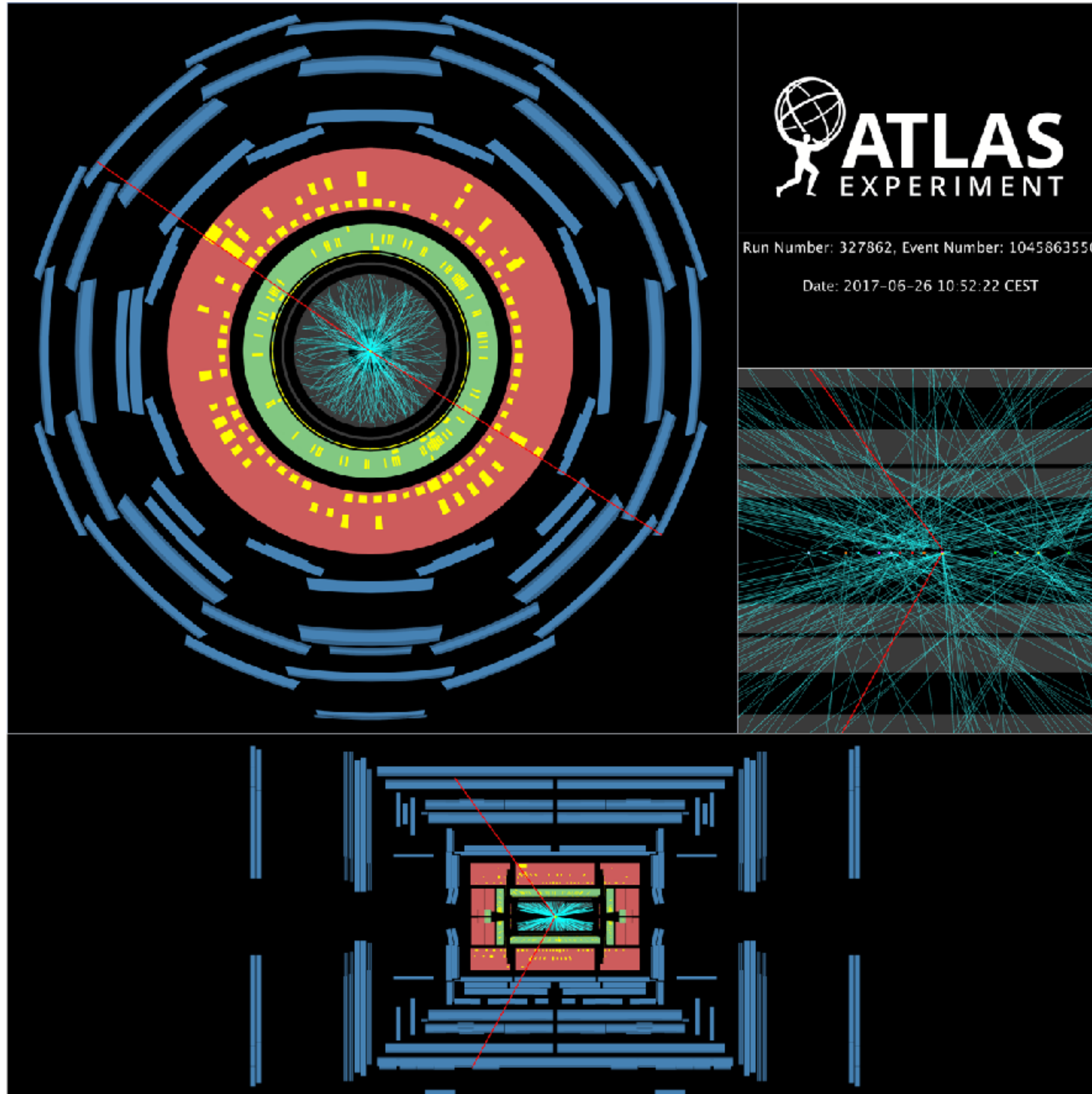




***It really looks like this!***

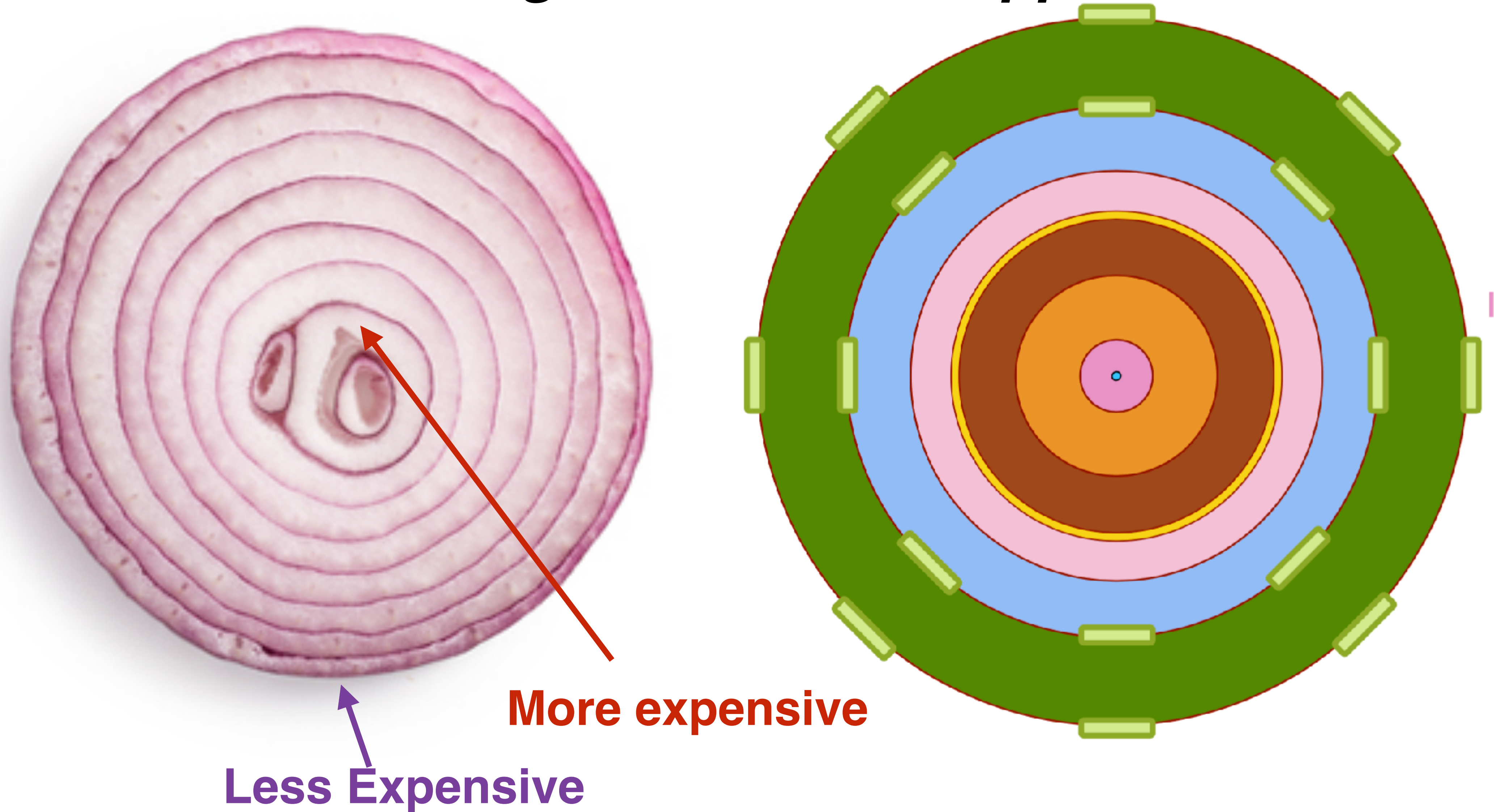


*It really looks like this!*

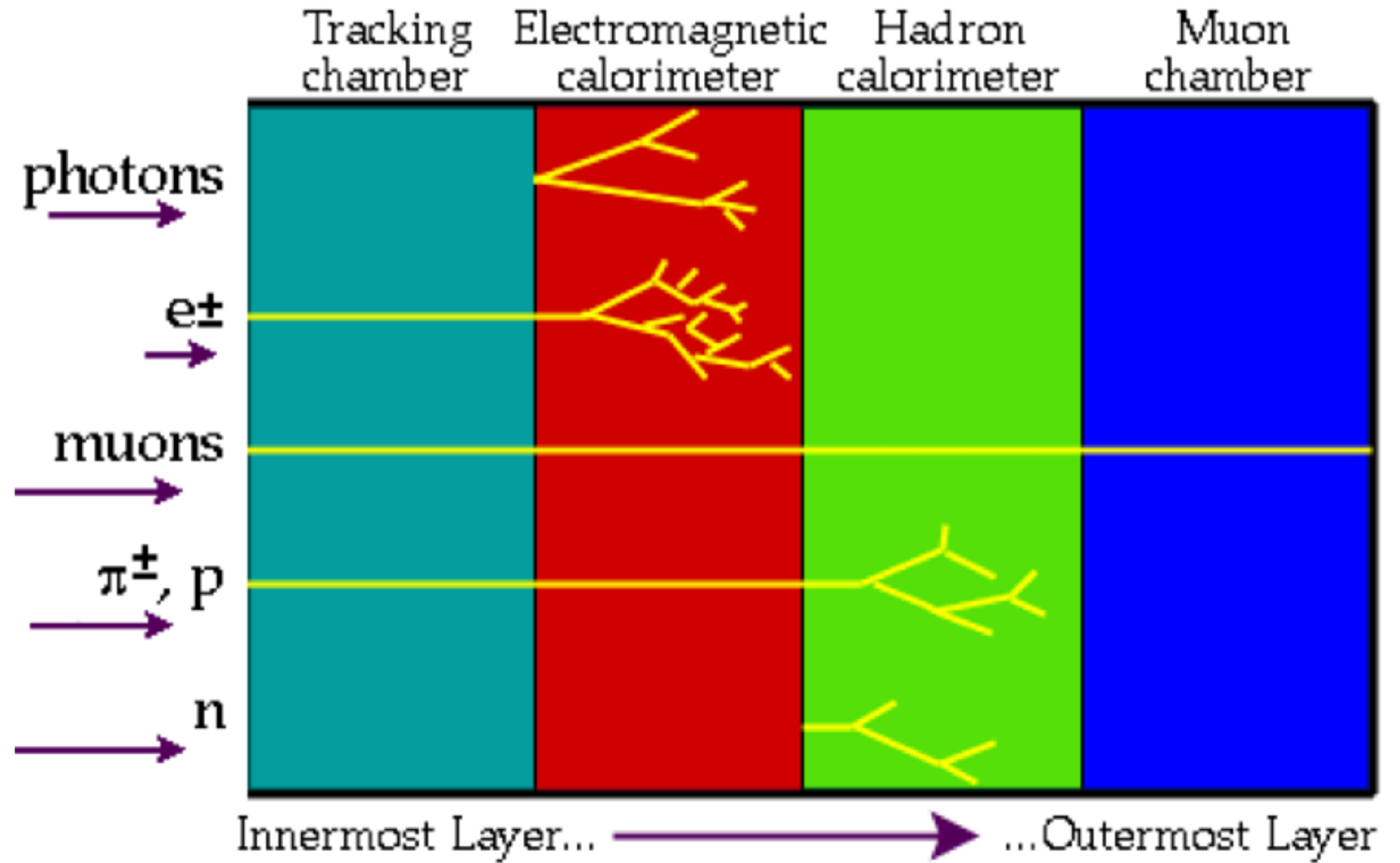


*It really looks like this!*

# *Detectors allow us figure out what happened*

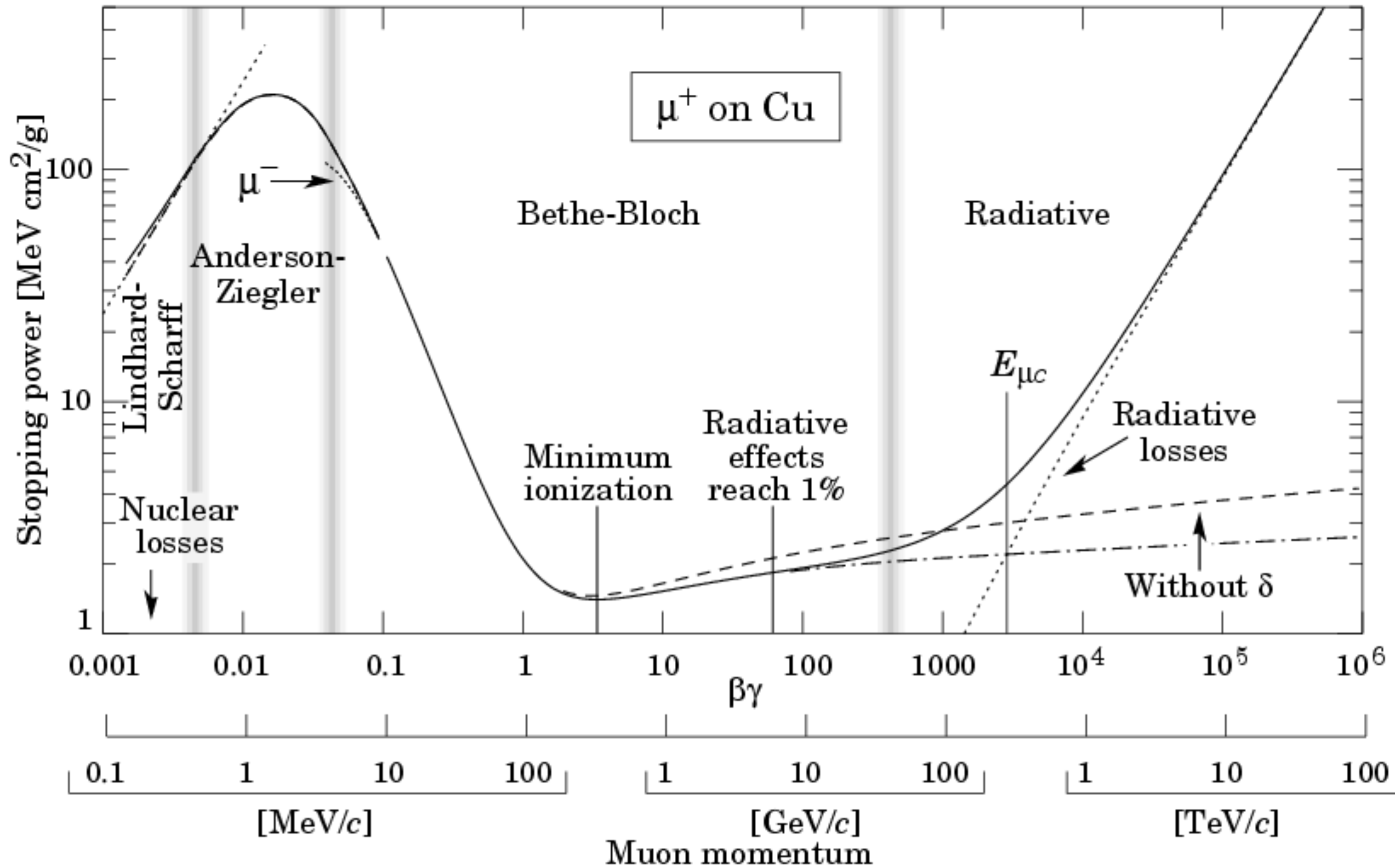






**7 Different “stable” particles leave signals.**

# The Bethe-Bloch Equation



*How do charged particles interact with matter?*

*Ionisation!*

$$-\frac{dE}{dx} = \frac{4\pi e^4 z^2 N Z}{(4\pi\epsilon_0)^2 M_e v^2} \left[ \ln\left(\frac{2M_e v^2}{I}\right) - \ln(1 - \beta^2) - \beta^2 \right]$$

***Did a particle pass through here?***

***Did it generate any charge ?***

***We have to collect this  
charge to figure it out!***



***Detector Volume***

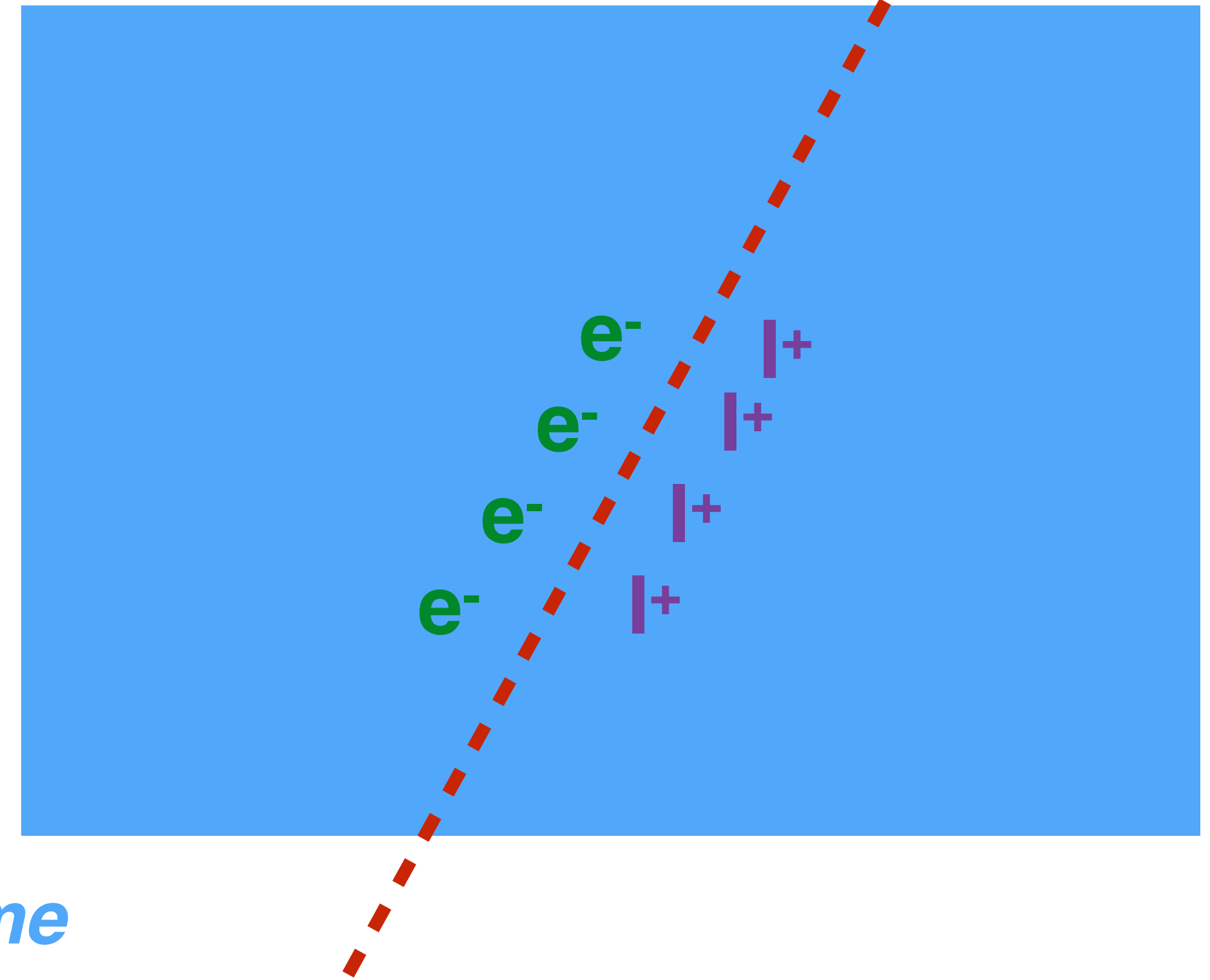
# *Did a particle pass through here?*

*Did it generate any charge ?*

*We have to collect this charge to figure it out!*

*Detector Volume*

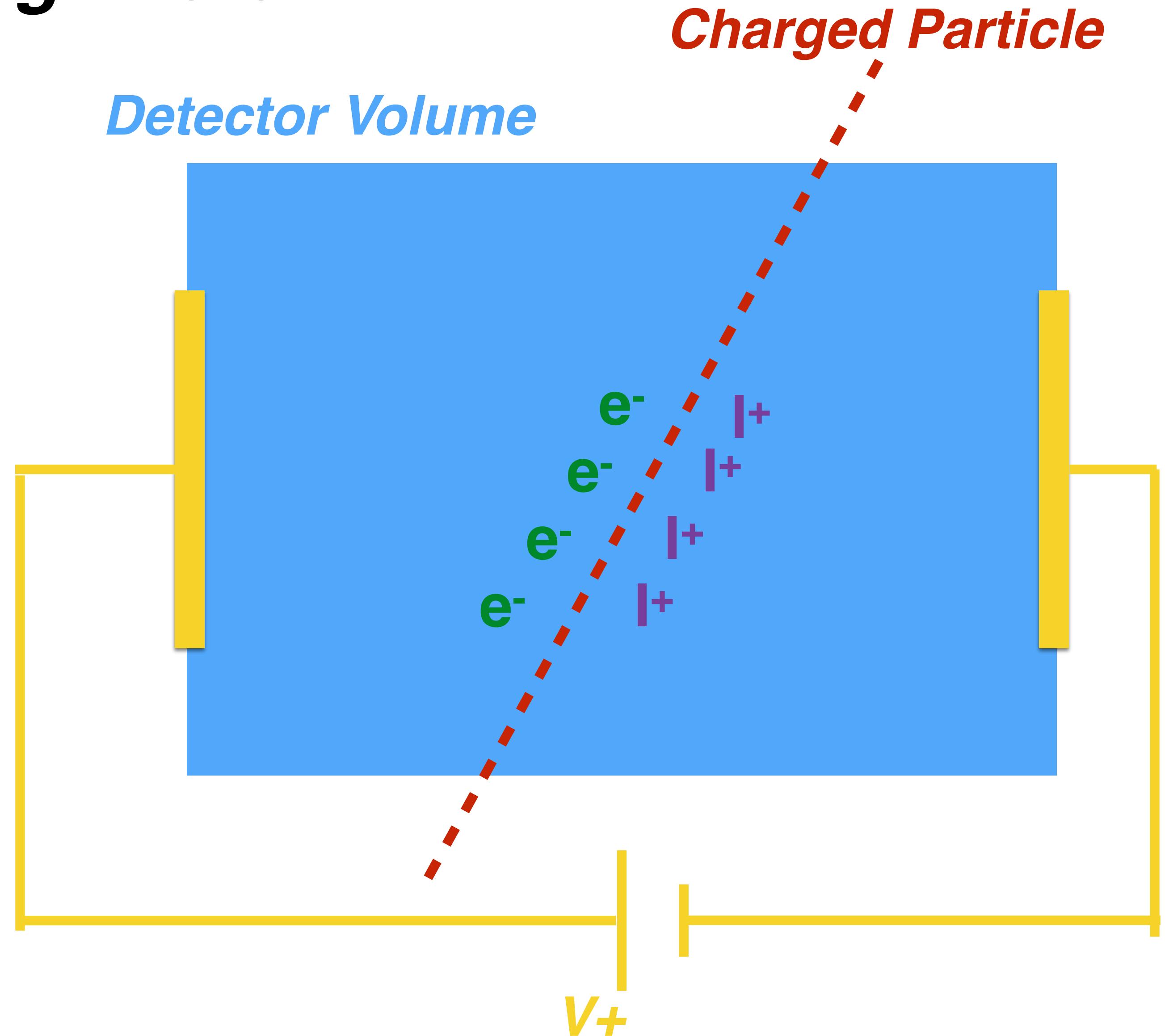
*Charged Particle*



# Did a particle pass through here?

Did it generate any charge ?

We have to collect this charge to figure it out!



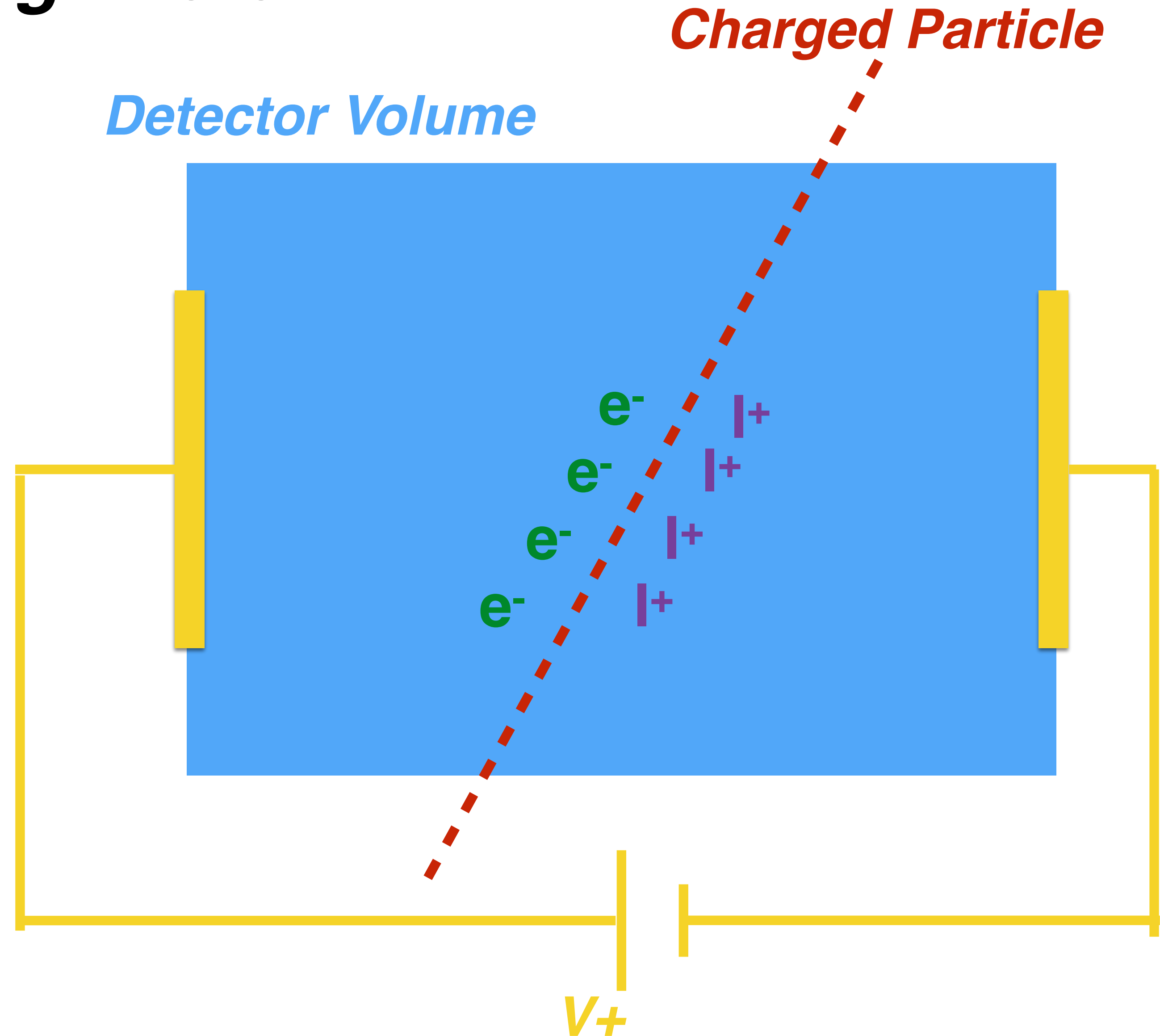
# Did a particle pass through here?

Did it generate any charge ?

We have to collect this charge to figure it out!

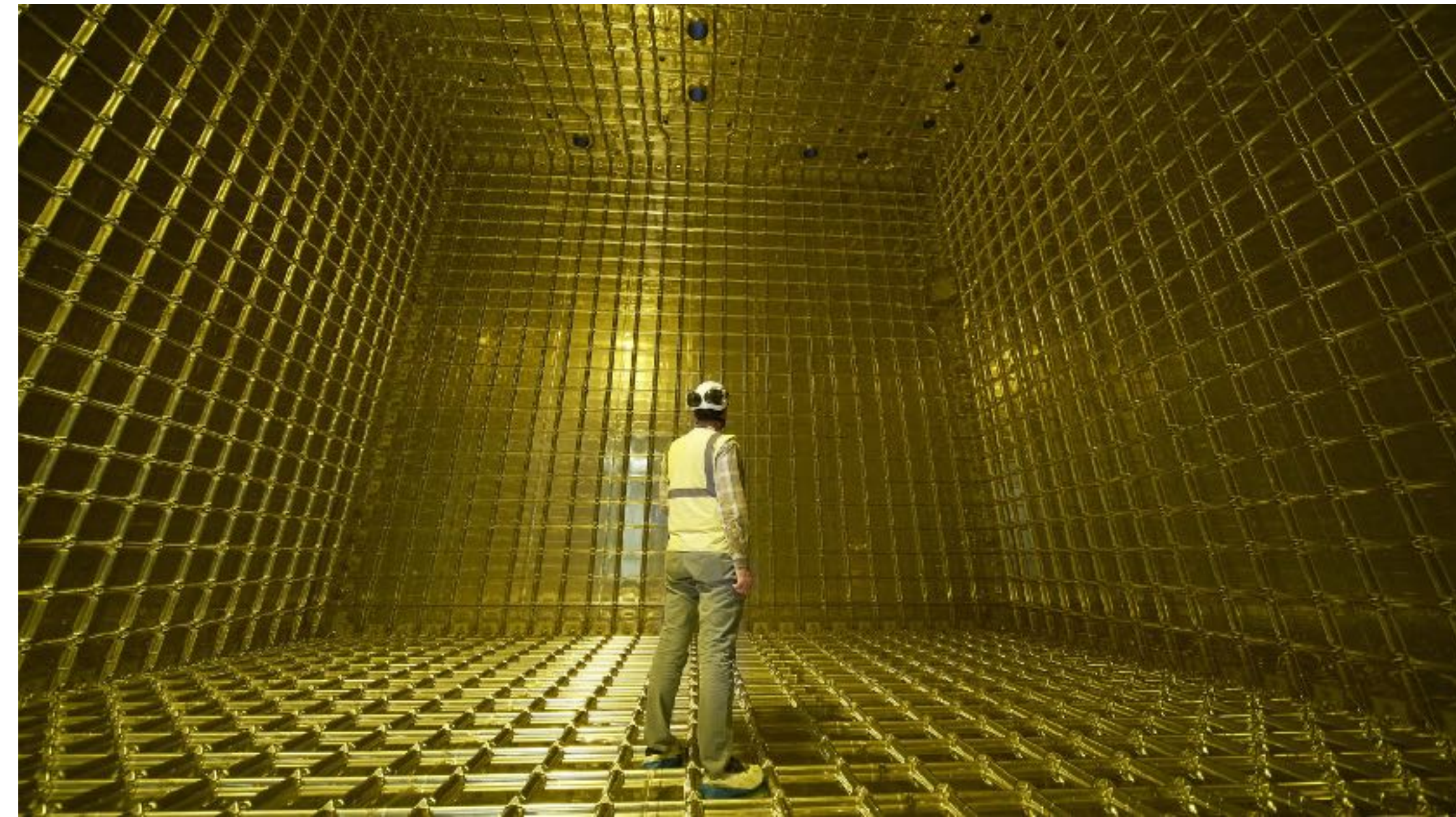
Electric field drifts free charges away.

Electronics measure how much charge drifted at any point in time.



# *Did a particle pass through here?*

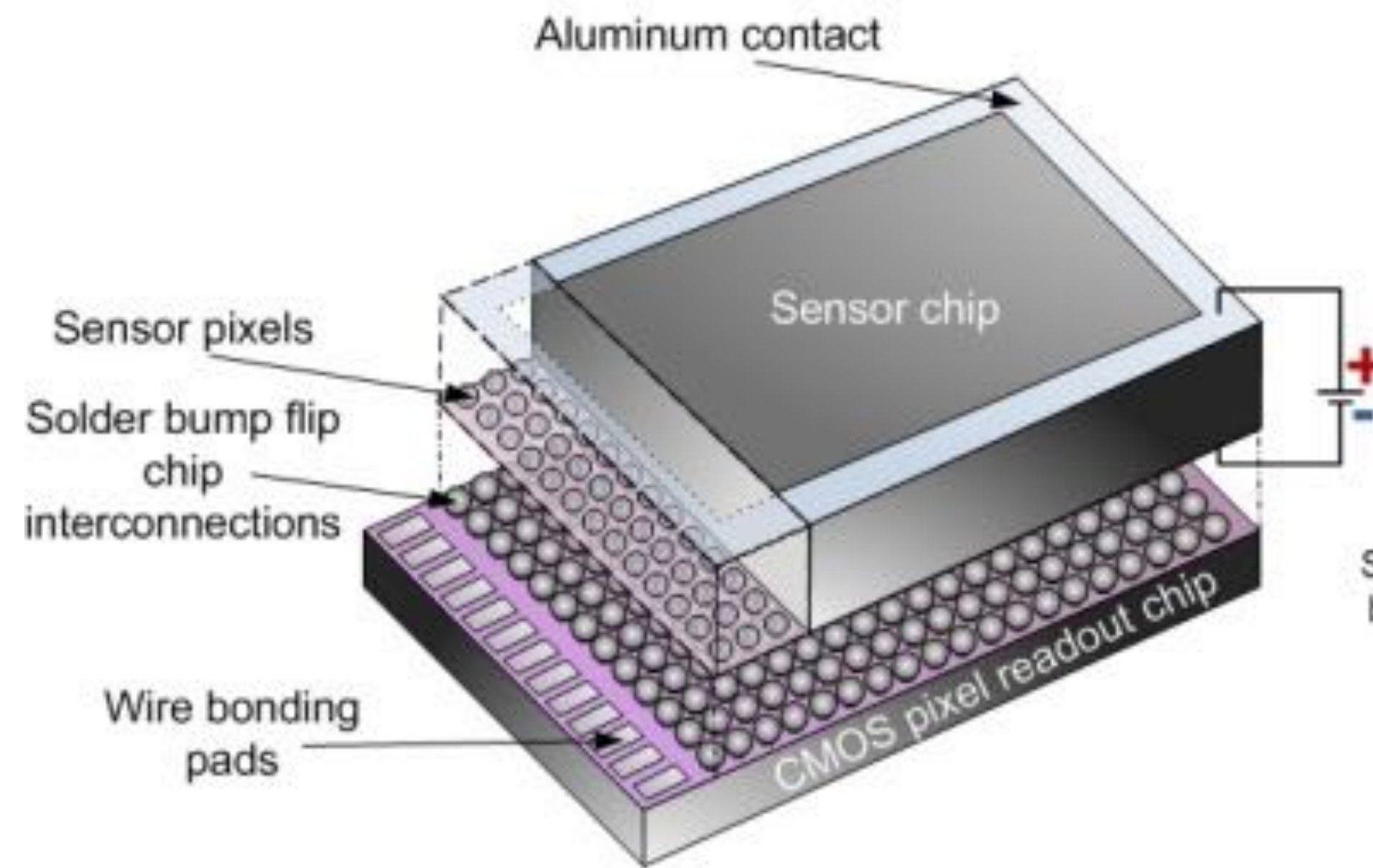
*Now you know how to make  
a tracking detector!*



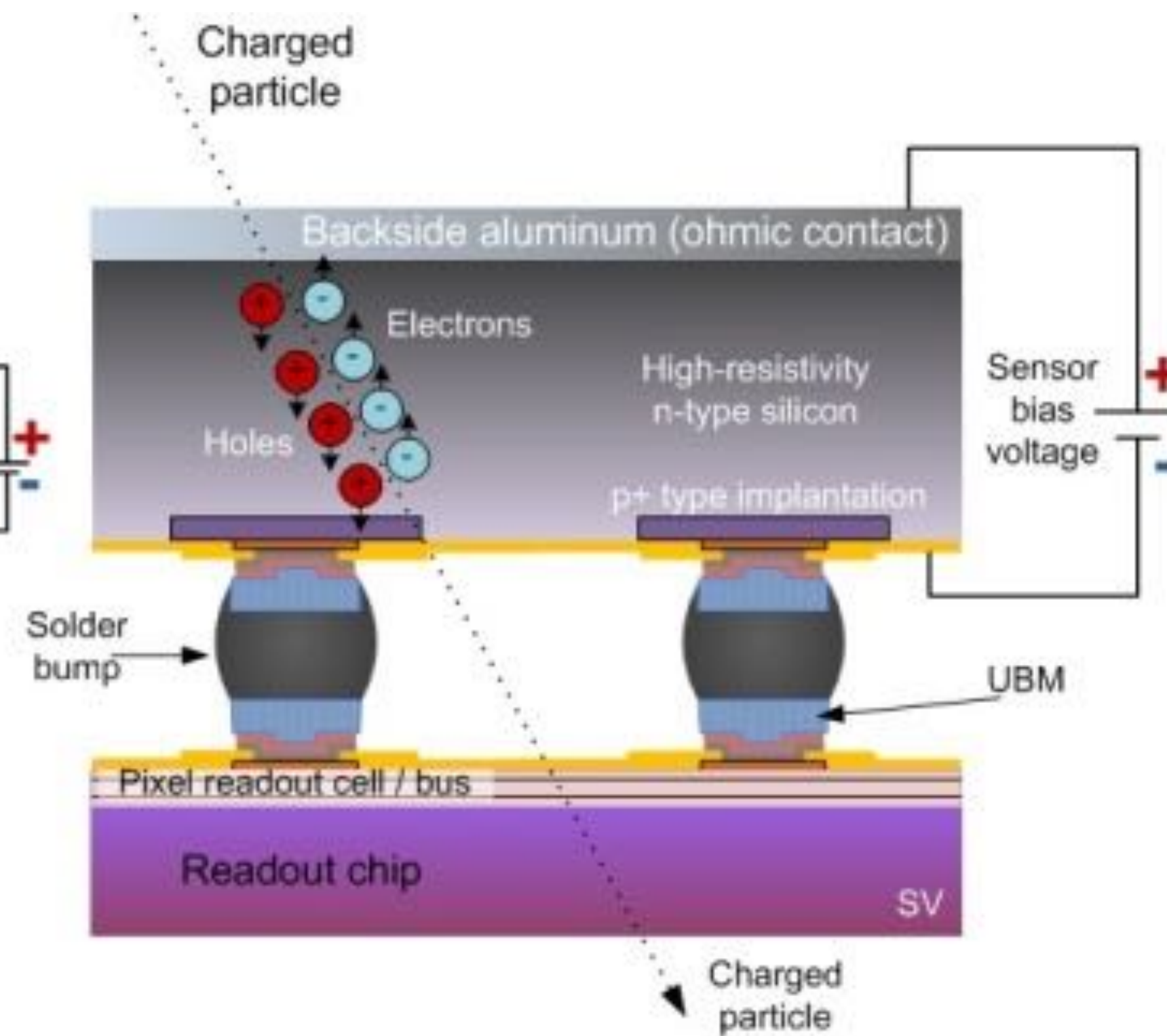
*Choose an appropriate  
volume, and the correct  
density of channels, design  
special readout electronics,  
probably cry at some point.*

# Did a particle pass through here?

*State of the art: Silicon Pixel detectors.*



Generic pixel detector

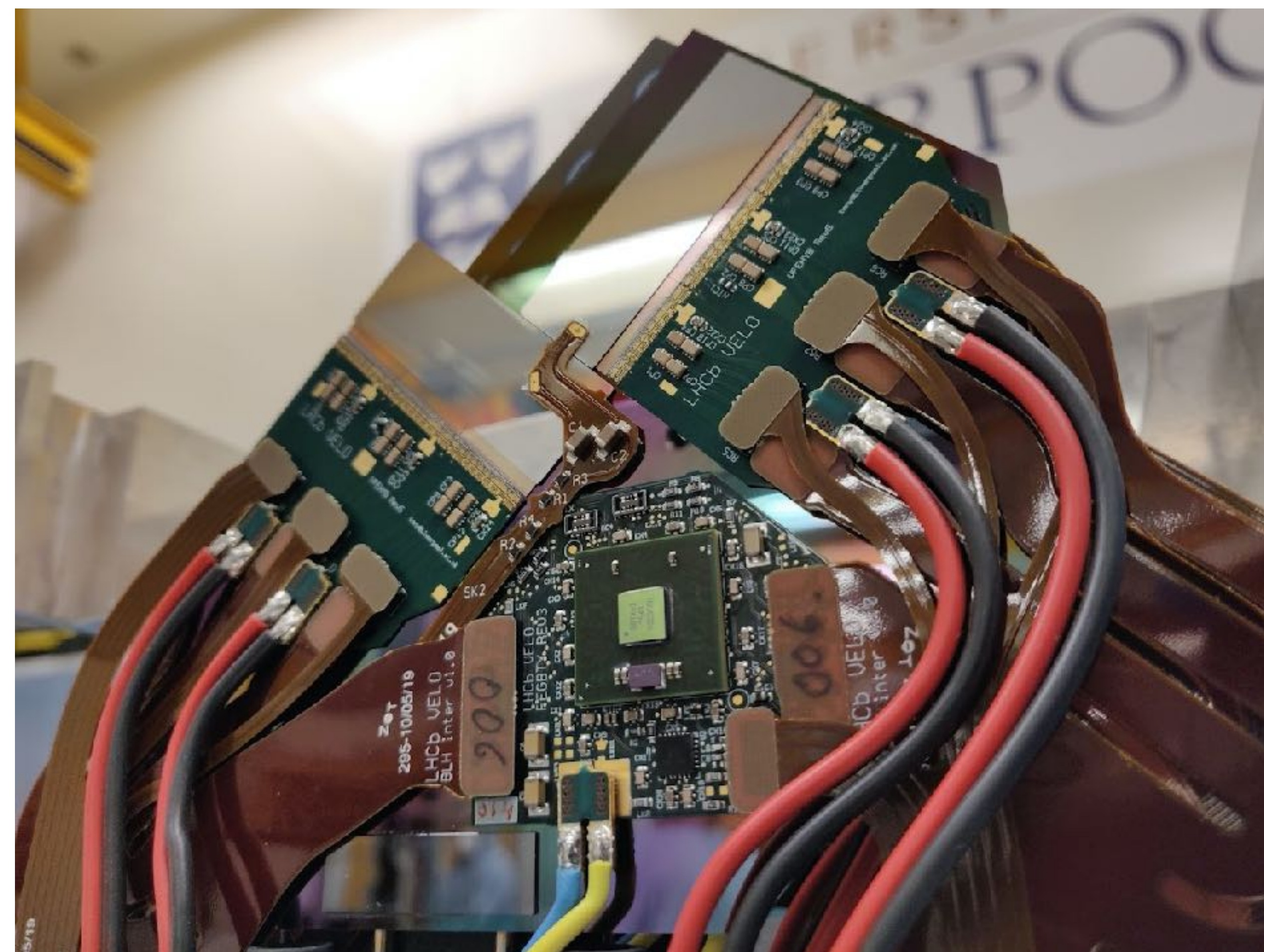


Cross-sectional cut



# *Did a particle pass through here?*

*State of the art: Silicon Pixel detectors.*



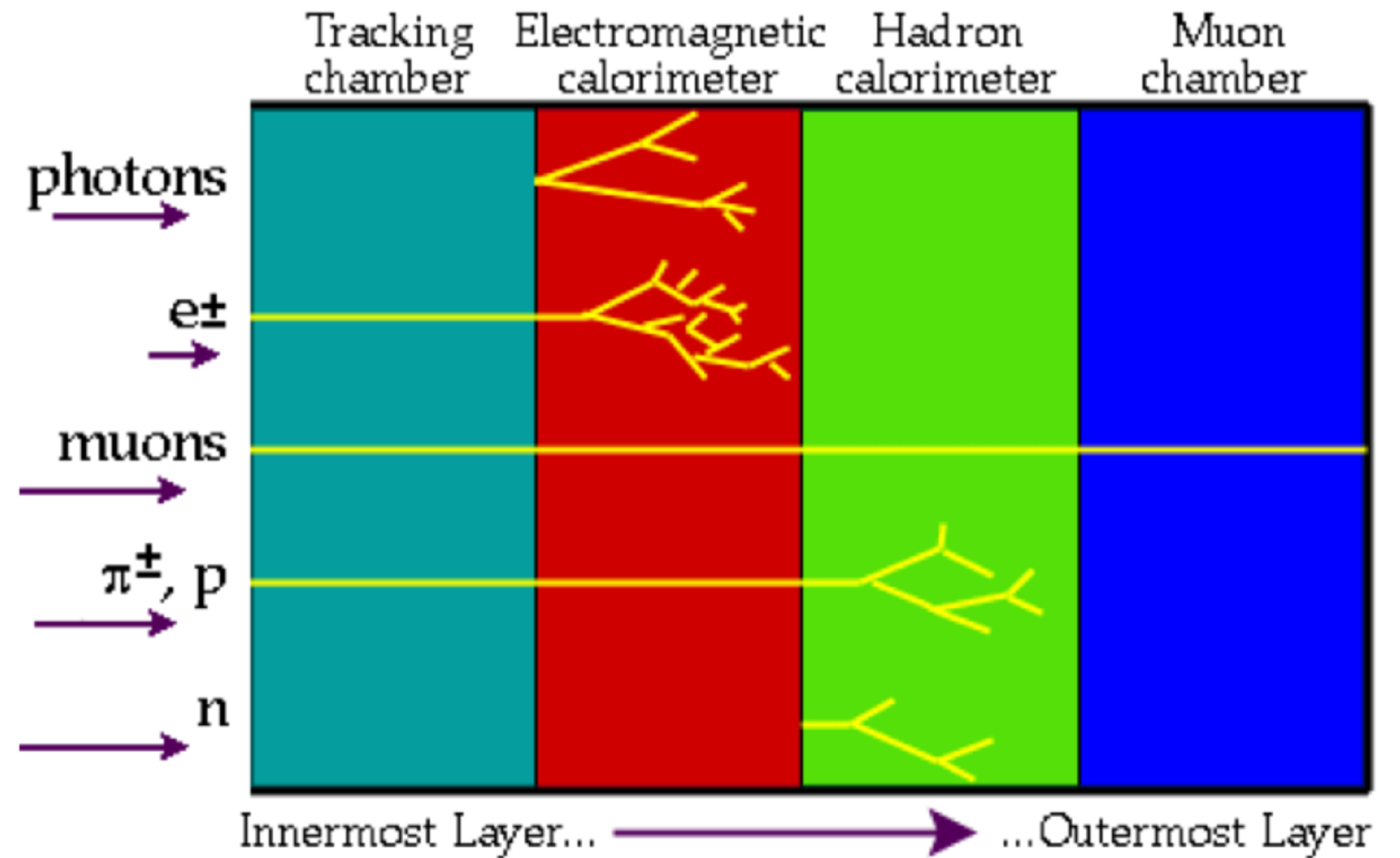
*Me, looking proud :)*

# Which particle passed through here?

Once you reconstructed a trajectory, you need to know its identity!

Calorimeters identify particles by stopping them.

Cherenkov detectors identify particles by looking at their Cherenkov light.

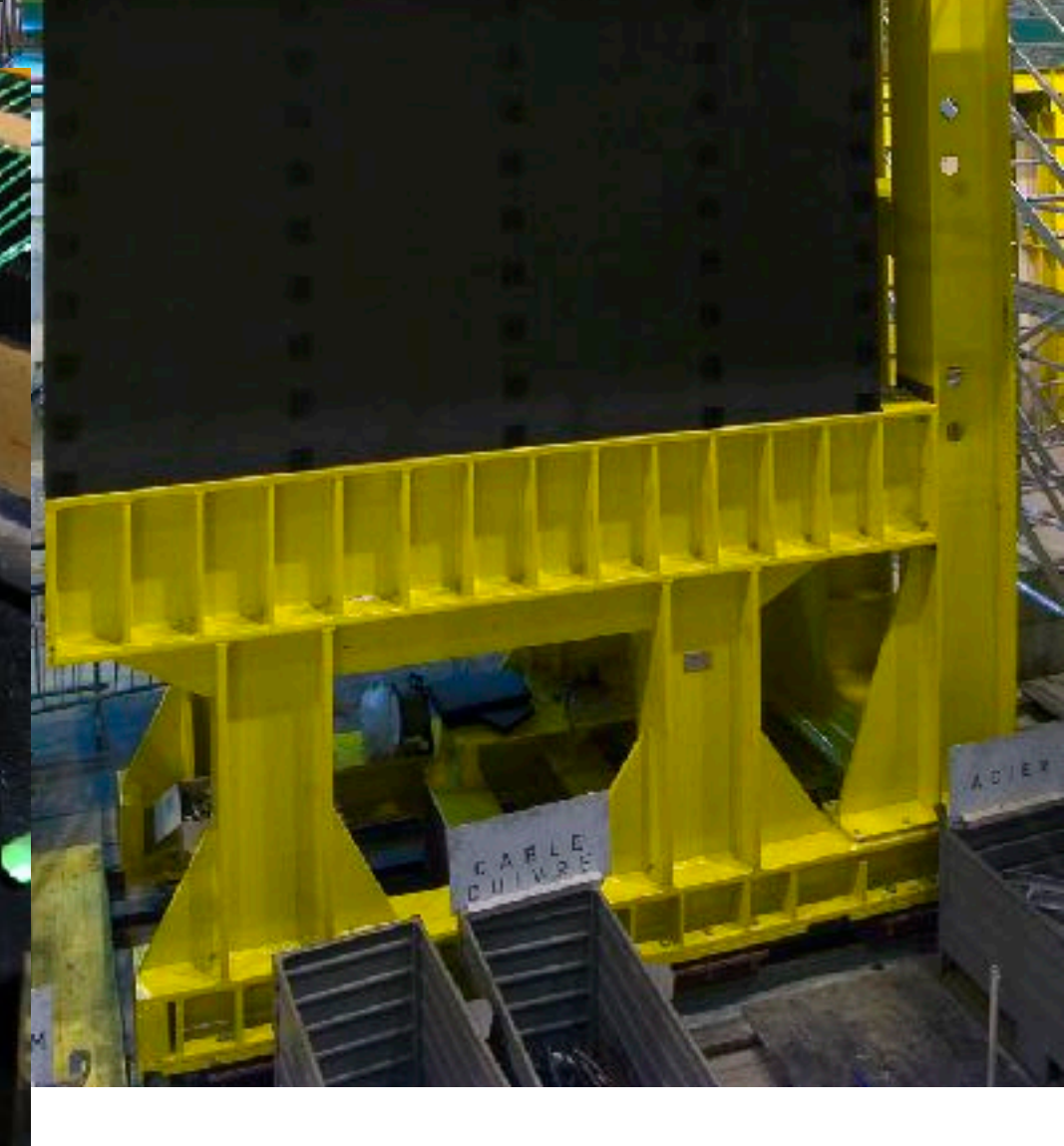
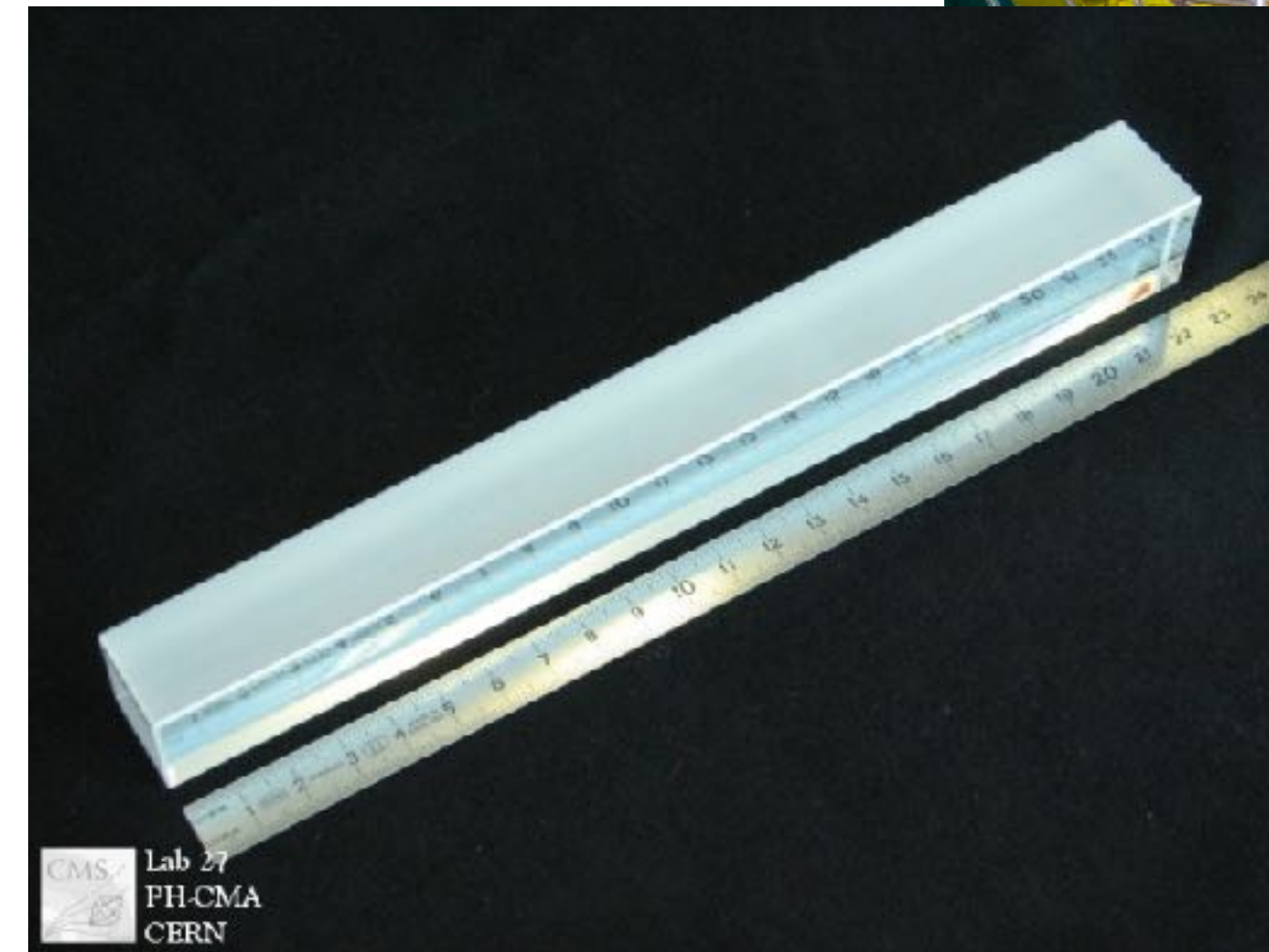


# *Which particle passed through here?*

*Calorimeters identify particles by stopping them.*

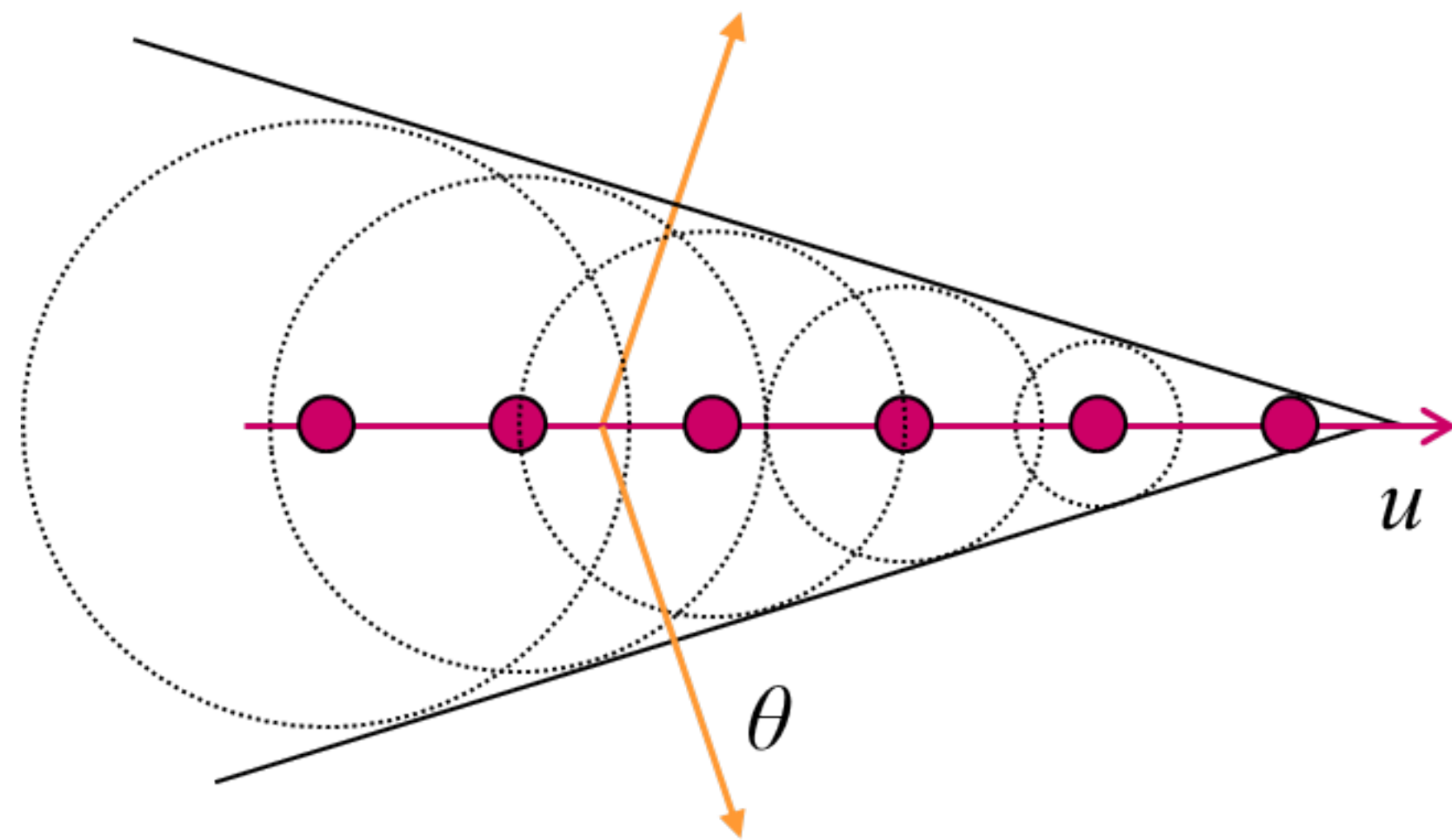
*Main different between electromagnetic and hadron calorimeters is their density.*

*In general hadrons penetrate much deeper and will leave signals in both EM and Hadron calorimeters.*



# *Which particle passed through here?*

*Cherenkov light for particle identification.*



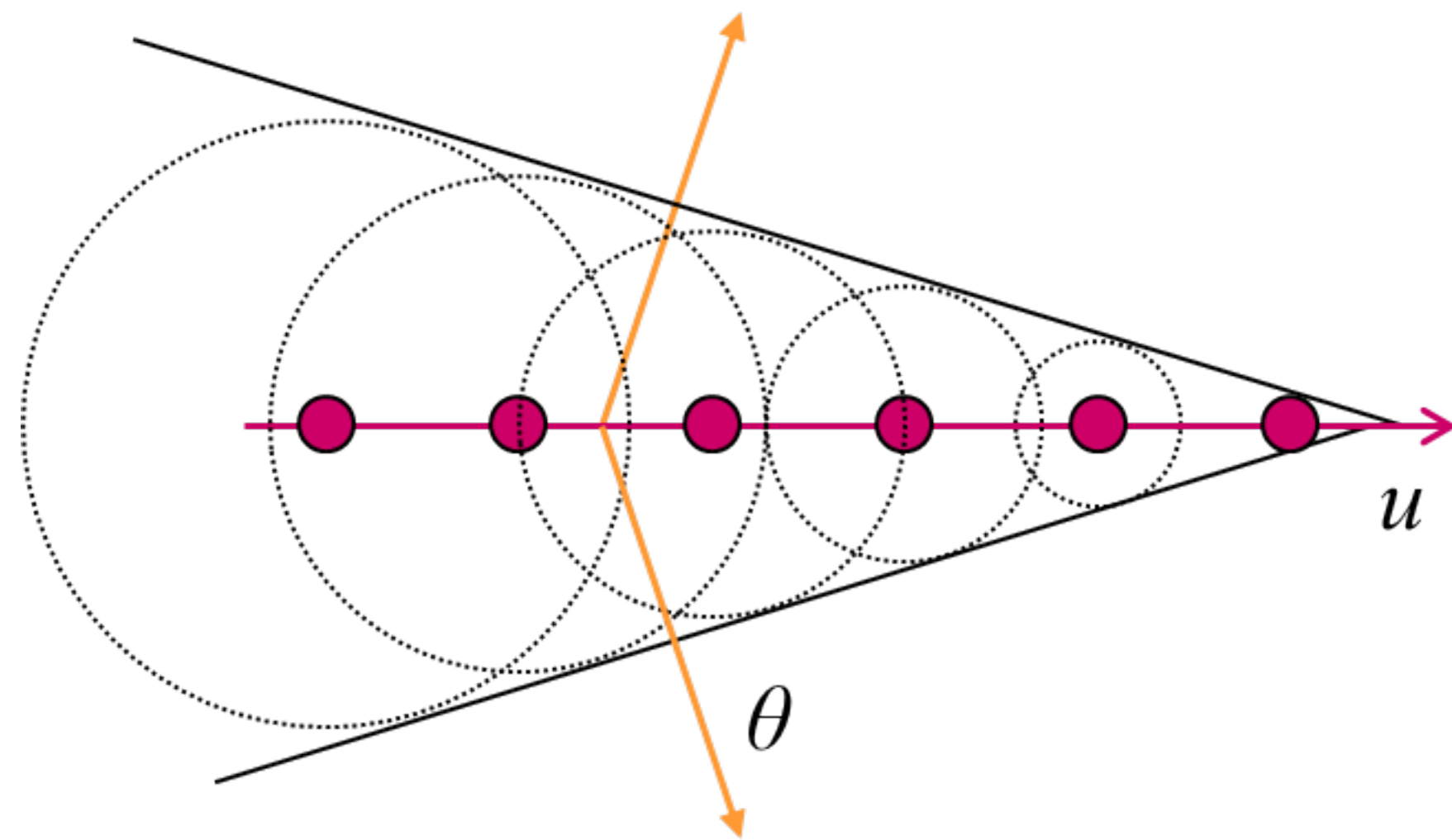
*Generated by particles traversing a medium at a speed higher than the speed of light in that medium.*



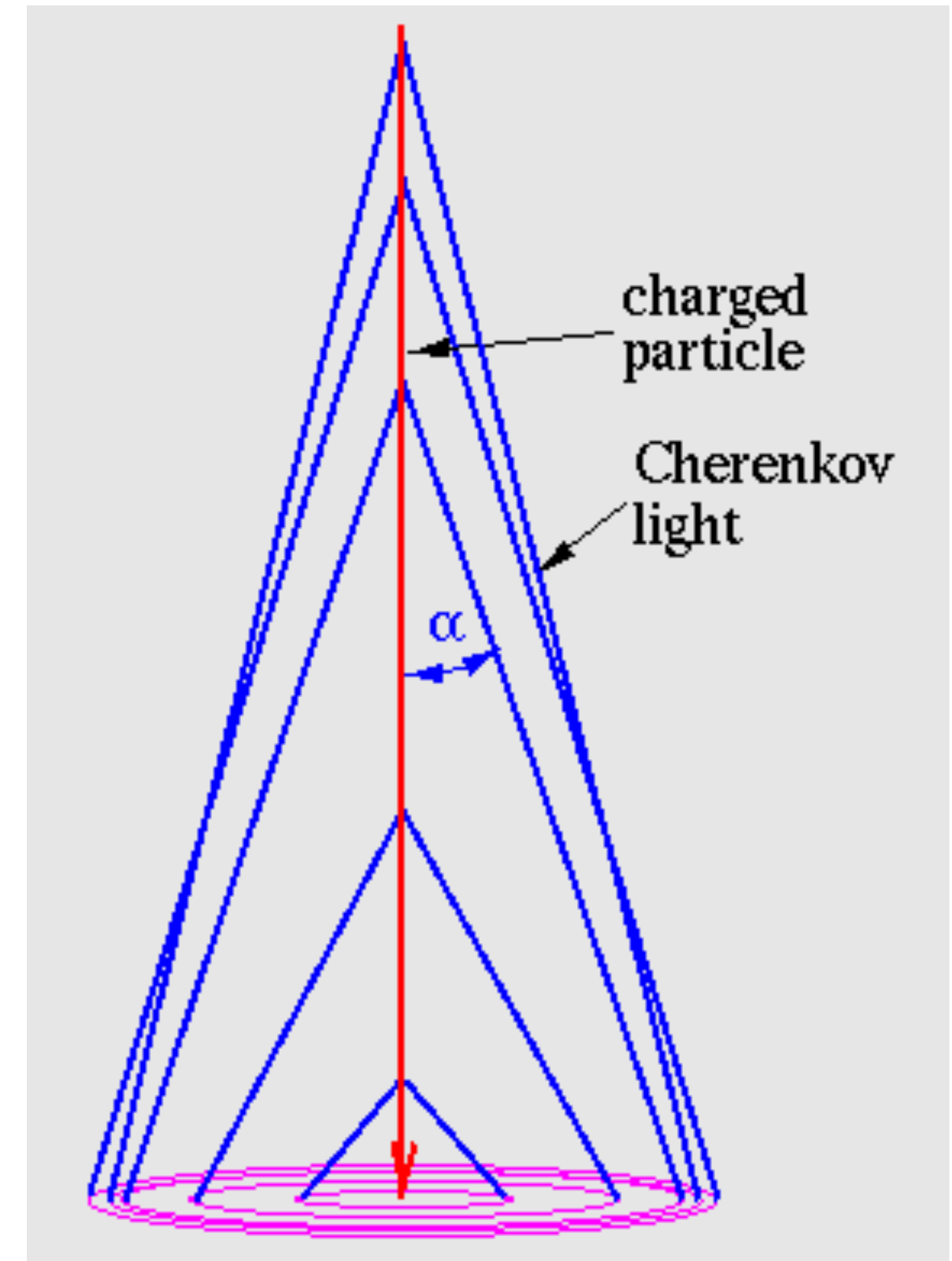
*Angle of the wake depends on the speed of the particle.*

# Which particle passed through here?

*Cherenkov light for particle identification.*

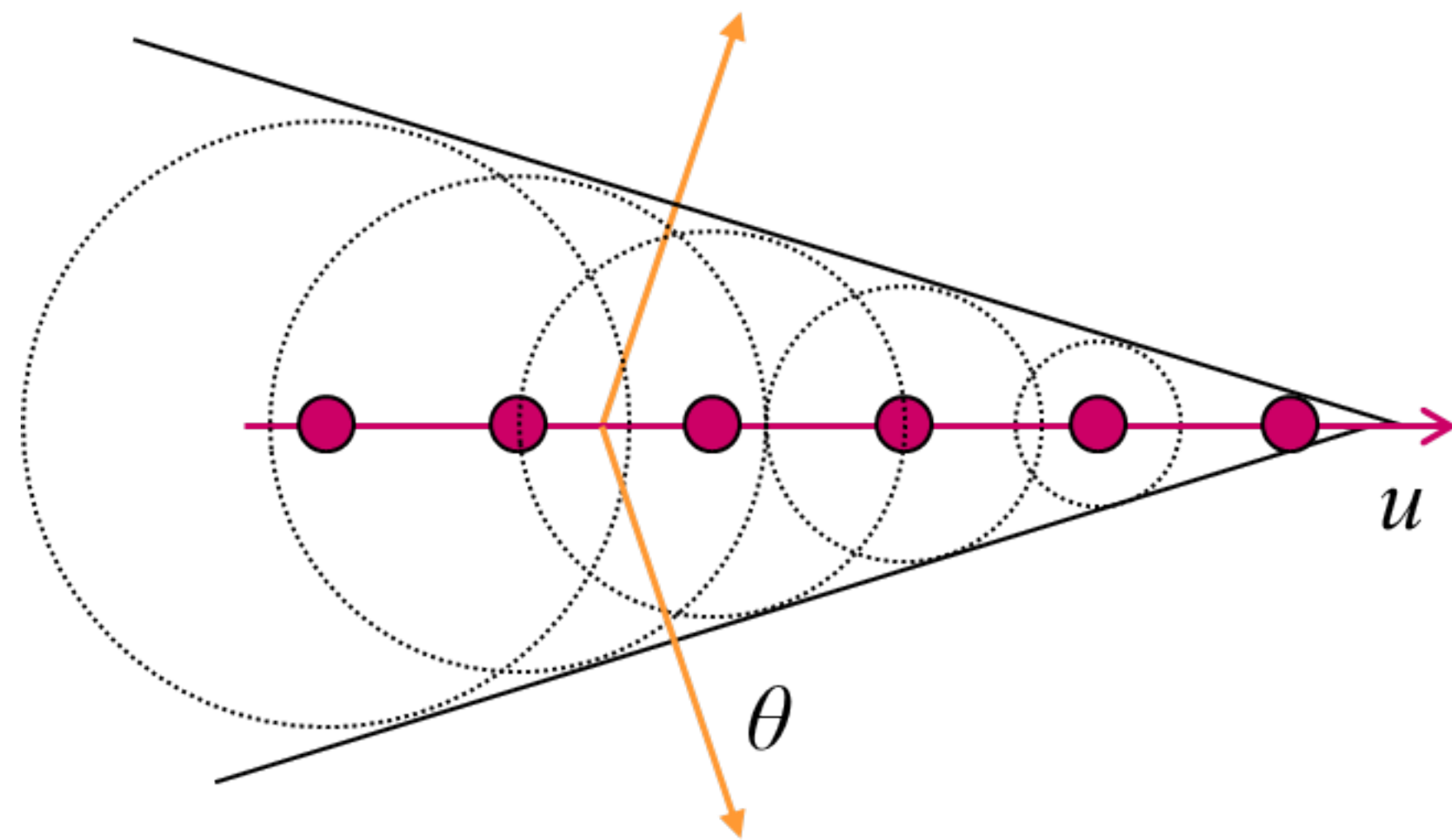


*Different angles project different ring sizes on a detector.*

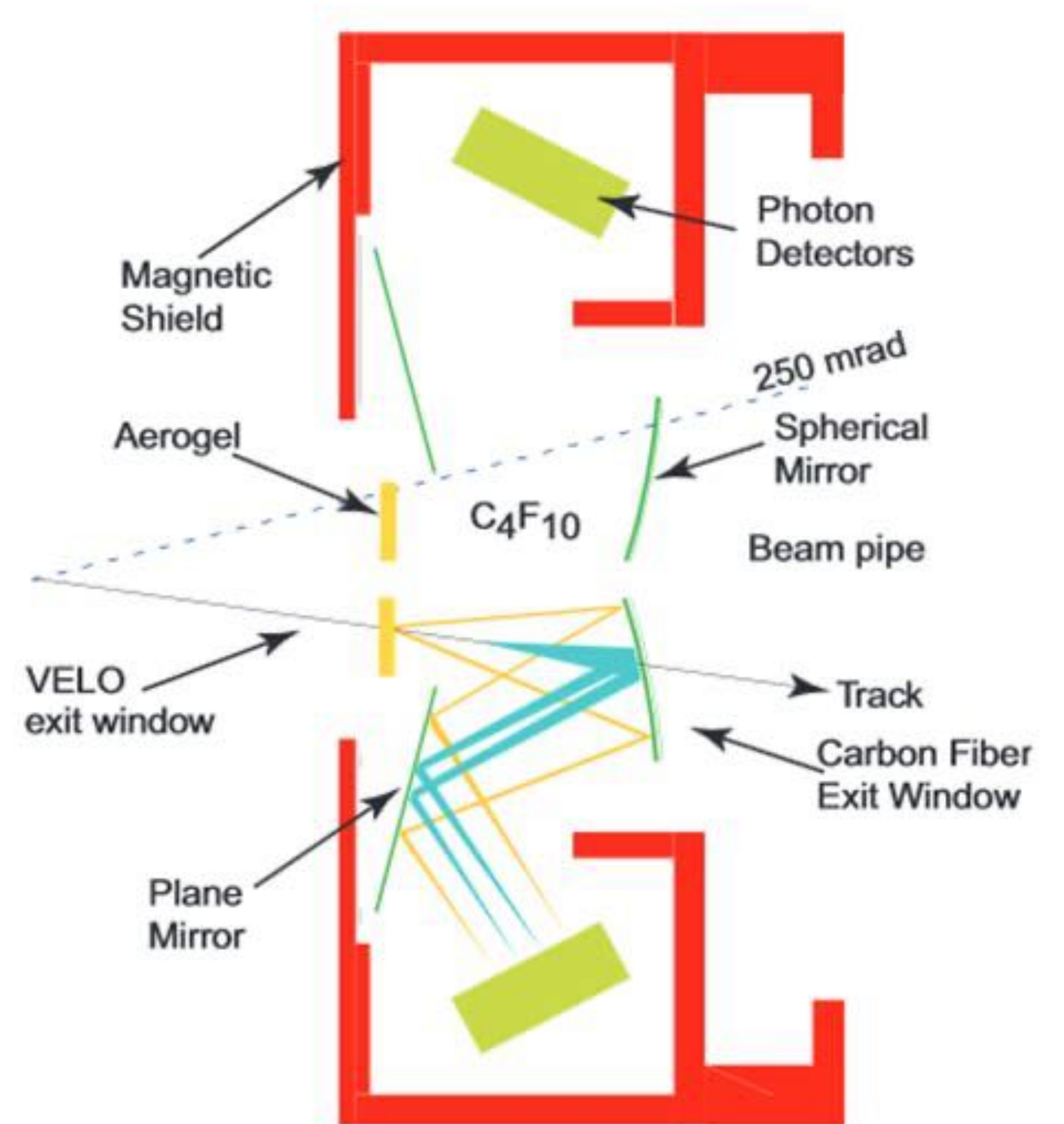


# Which particle passed through here?

Cherenkov light for particle identification.



Different angles project different ring sizes on a detector.



# Which particle passed through here?

How to detect light ?

PMTs : Photomultiplier tubes!

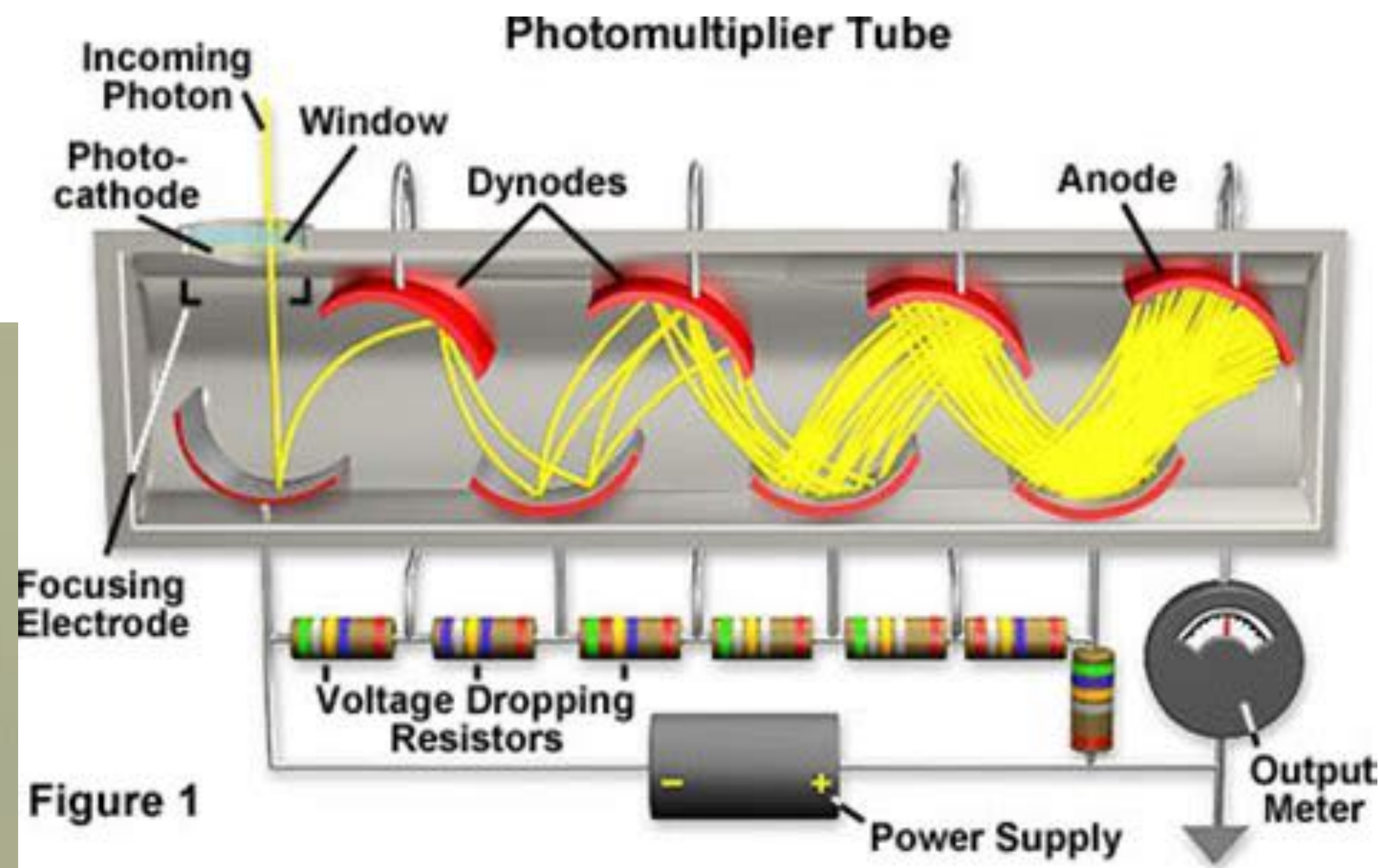


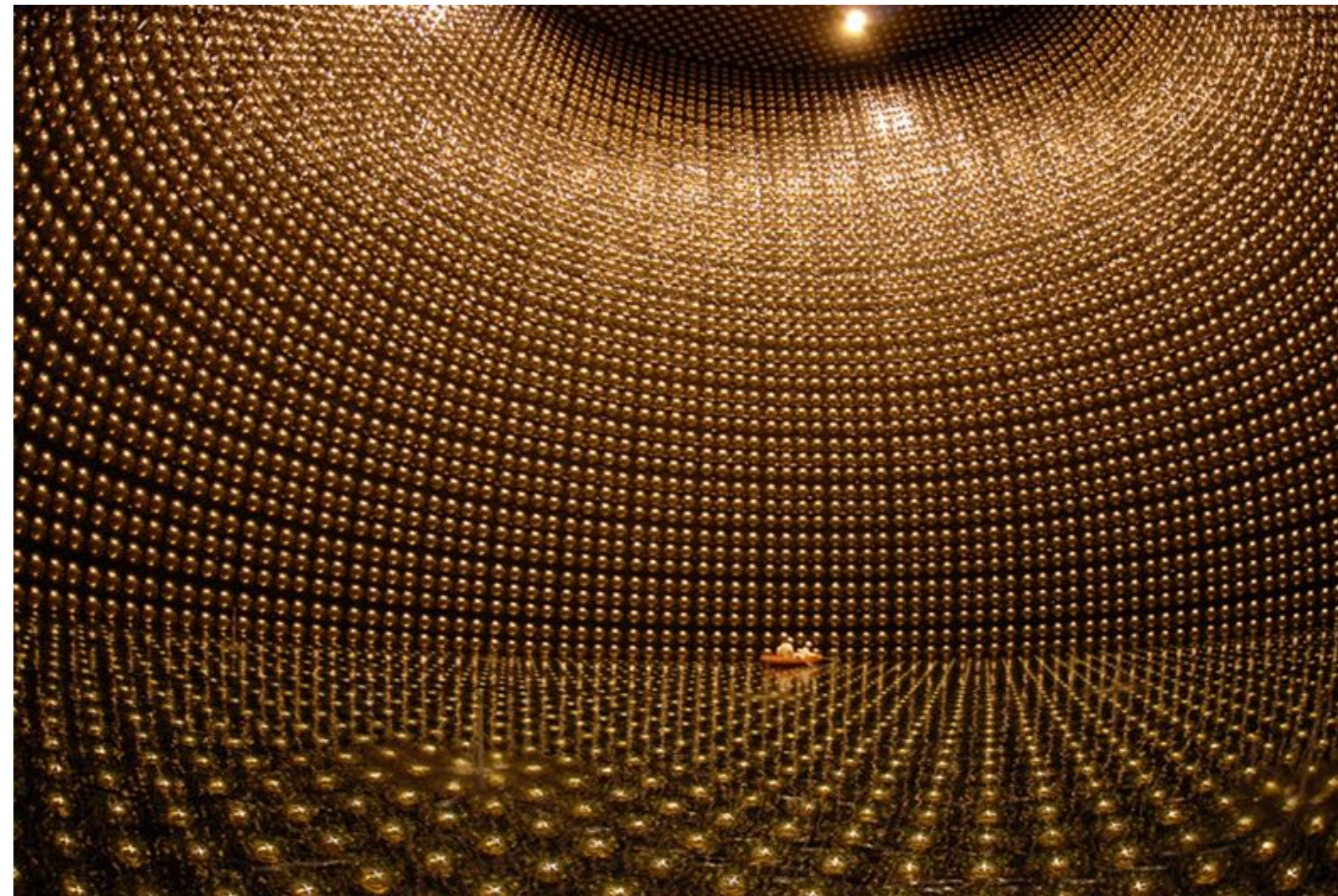
Figure 1

# *Which particle passed through here?*

*How to detect light ?*

*PMTs : Photomultiplier tubes!*

*Sometimes, many of them....*



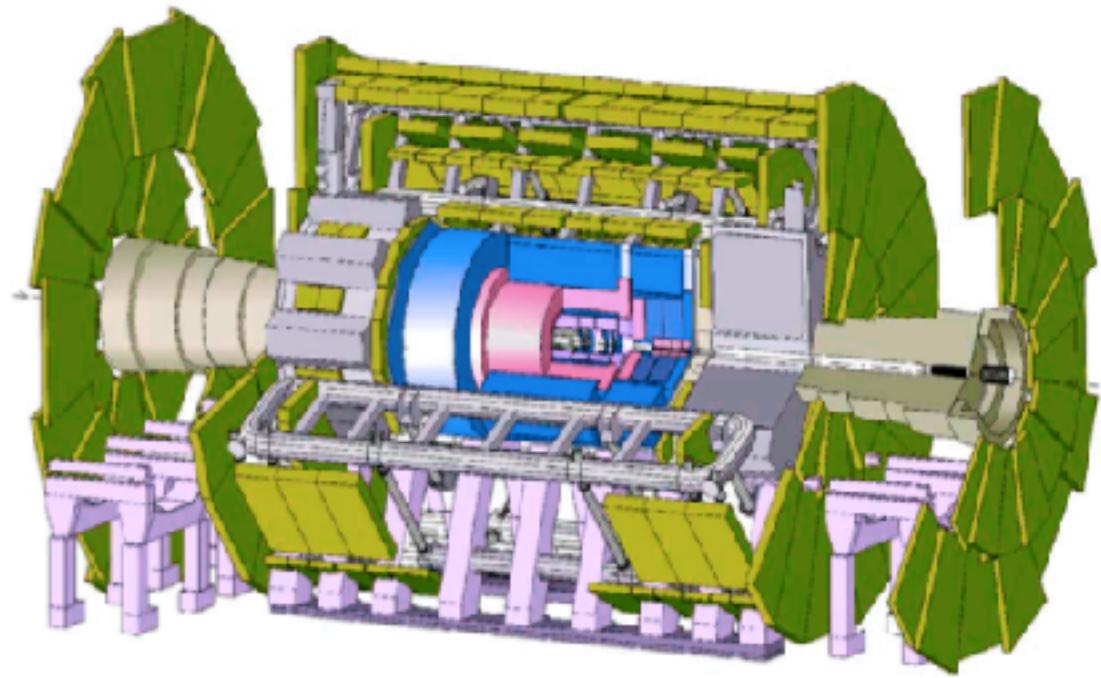
Super - Kamiokande, Japan



***I think for today this might be enough.***

***Interested to head all your new detector designs!***

***Questions ?***



## Simplified Detector Transverse View

