

# The New York Times

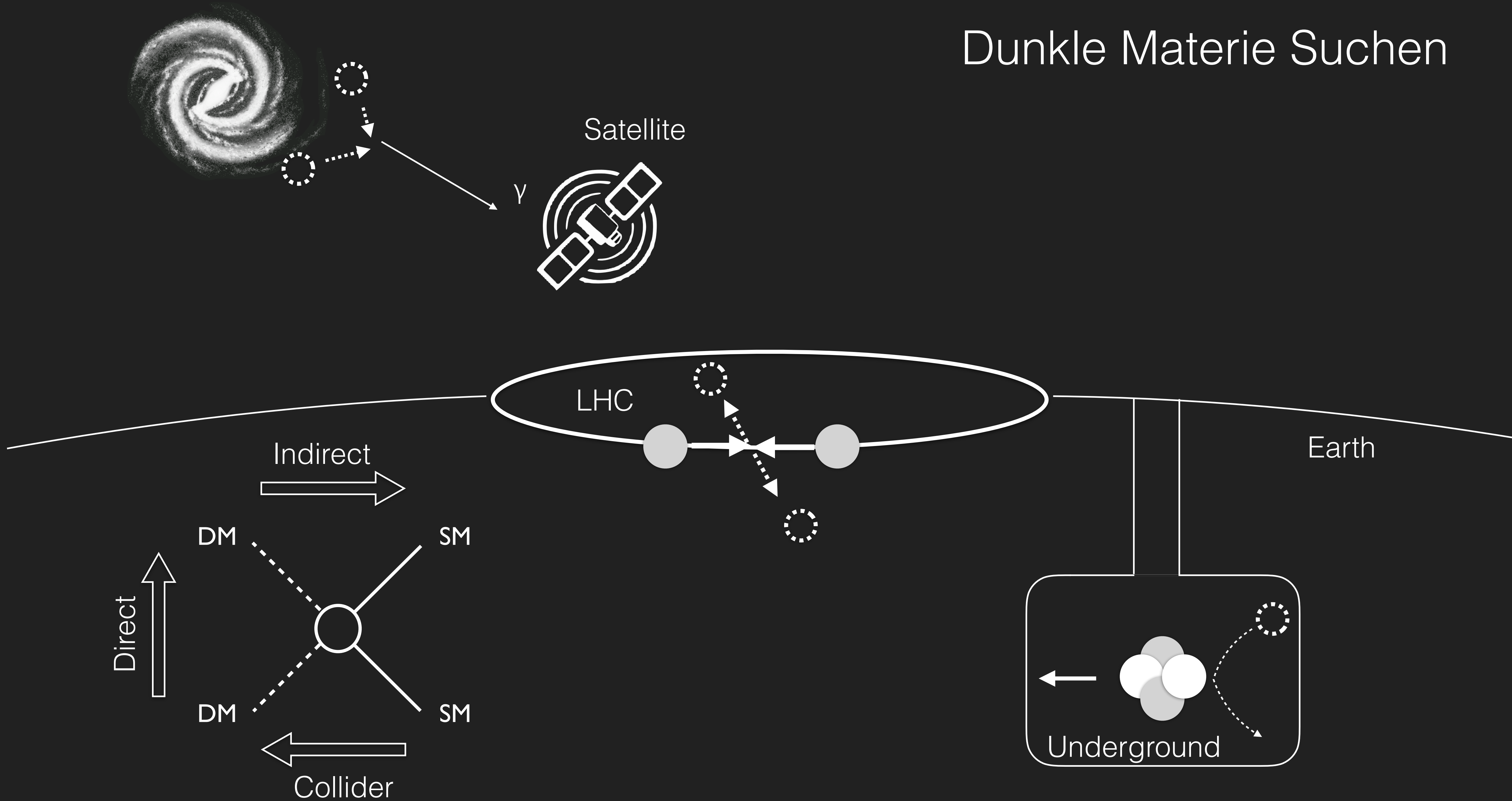
Thursday, July 23, 2020

## The Other Half of the Universe Discovered

Geneva, Switzerland

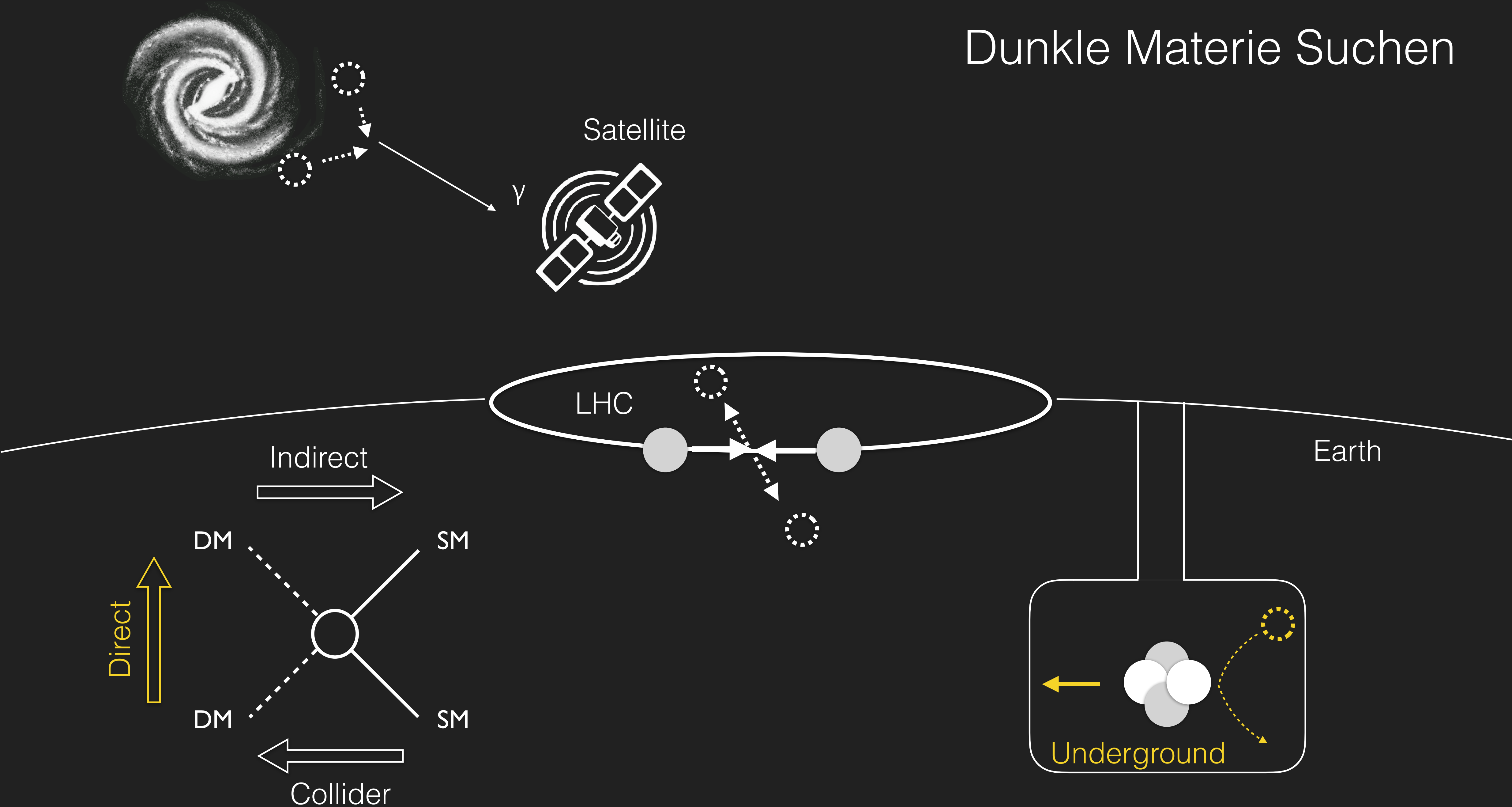


# Dunkle Materie Suchen



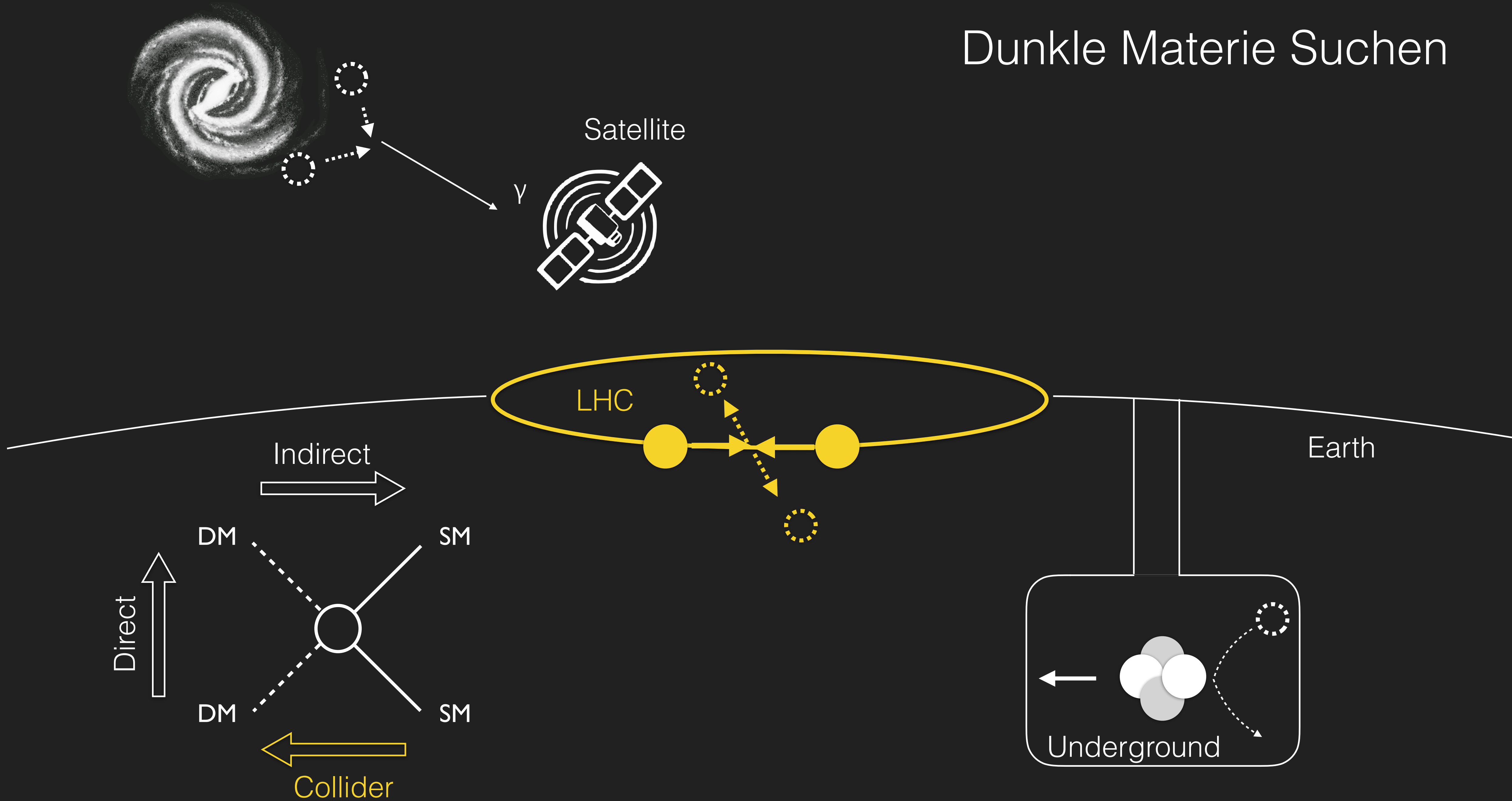


# Dunkle Materie Suchen

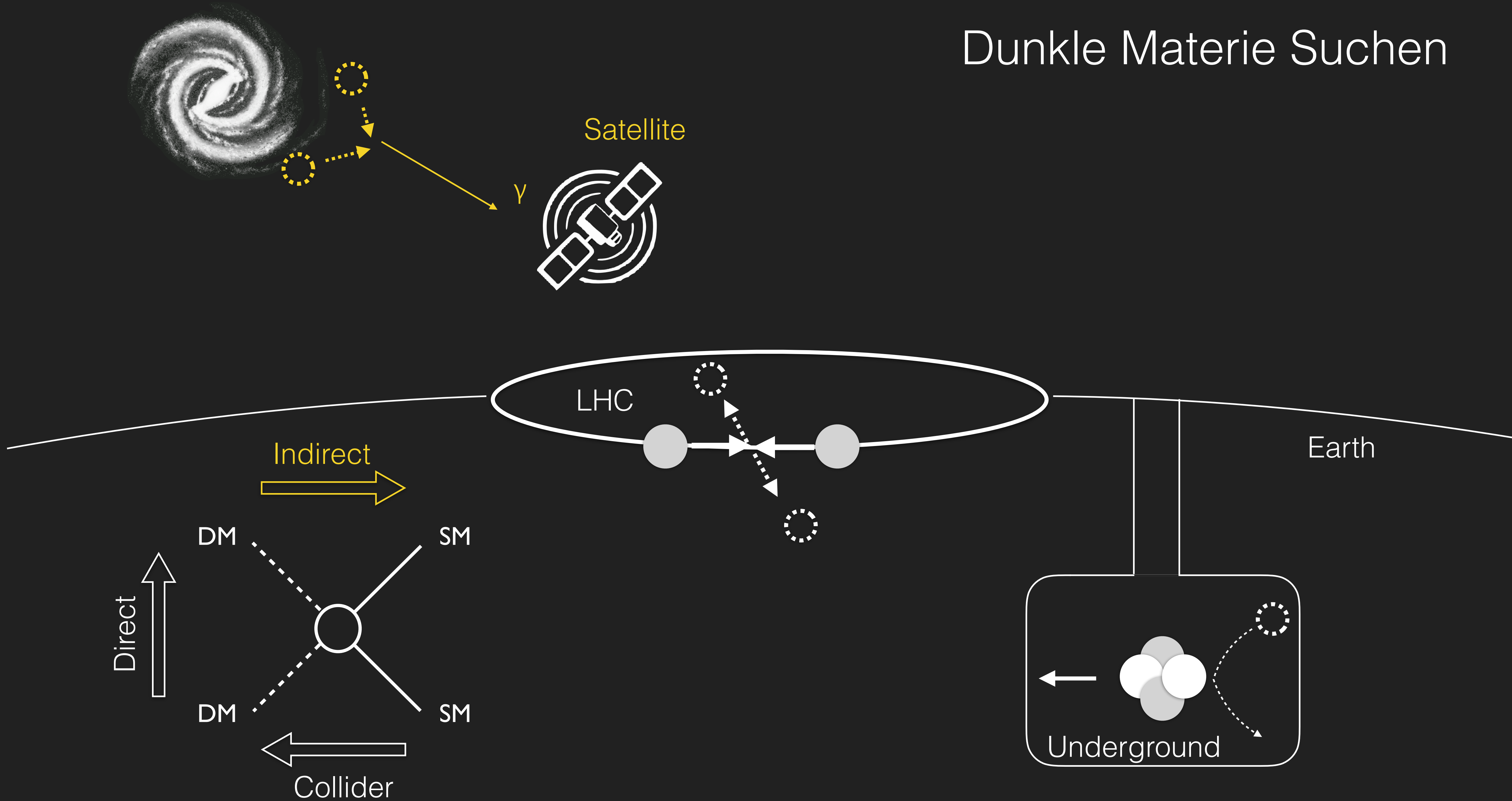




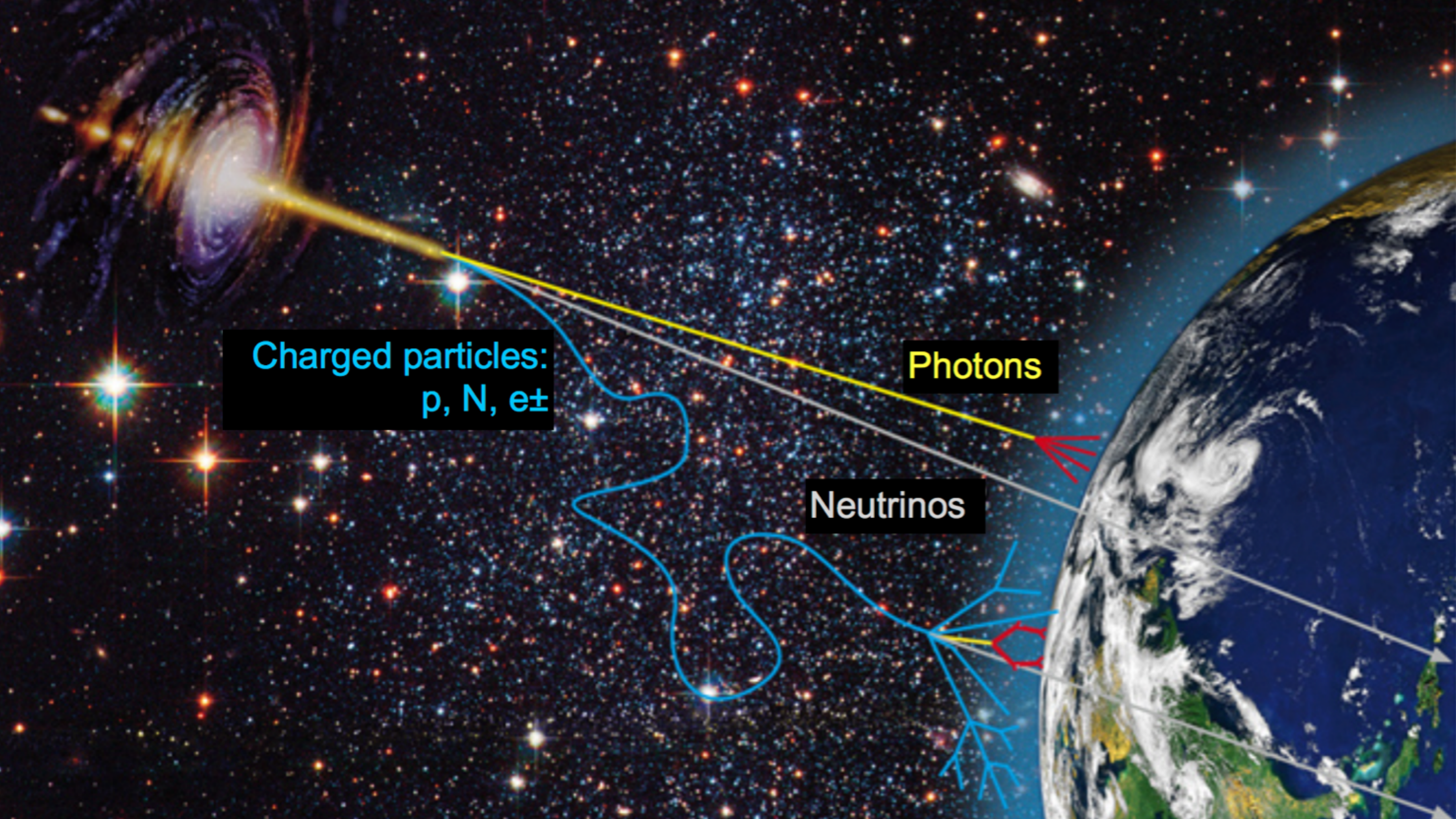
# Dunkle Materie Suchen



# Dunkle Materie Suchen







The diagram illustrates the propagation of cosmic rays from a distant galaxy (top left) towards Earth (bottom right). A yellow beam represents the initial cosmic ray flux. As it travels, it interacts with the cosmic microwave background (CMB), represented by a dense field of small blue and red dots. These interactions produce secondary particles, shown as blue lines branching off the main path. The blue lines represent charged particles (protons, neutrons, and electron-positron pairs) that are deflected by magnetic fields, creating a complex, looping trajectory. The yellow line represents photons, which travel in a straight line. The red lines represent neutrinos, which also travel in a straight line. The Earth is shown on the right, with the atmosphere and surface visible. The background is a deep space filled with stars and galaxies.

Charged particles:  
 $p, N, e^\pm$

Photons

Neutrinos



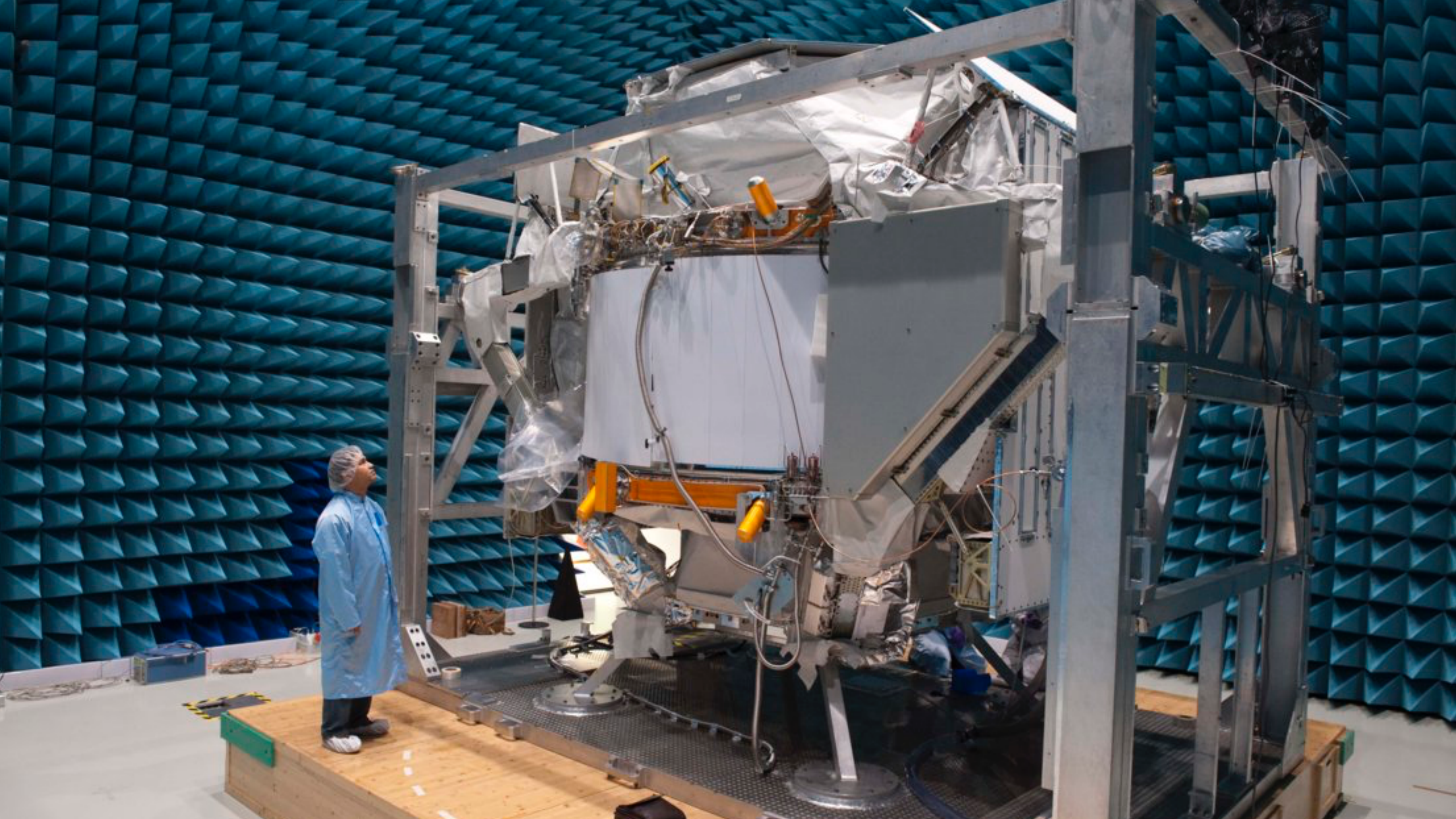
# Cosmic-ray experiments: Alpha Magnetic Spectrometer



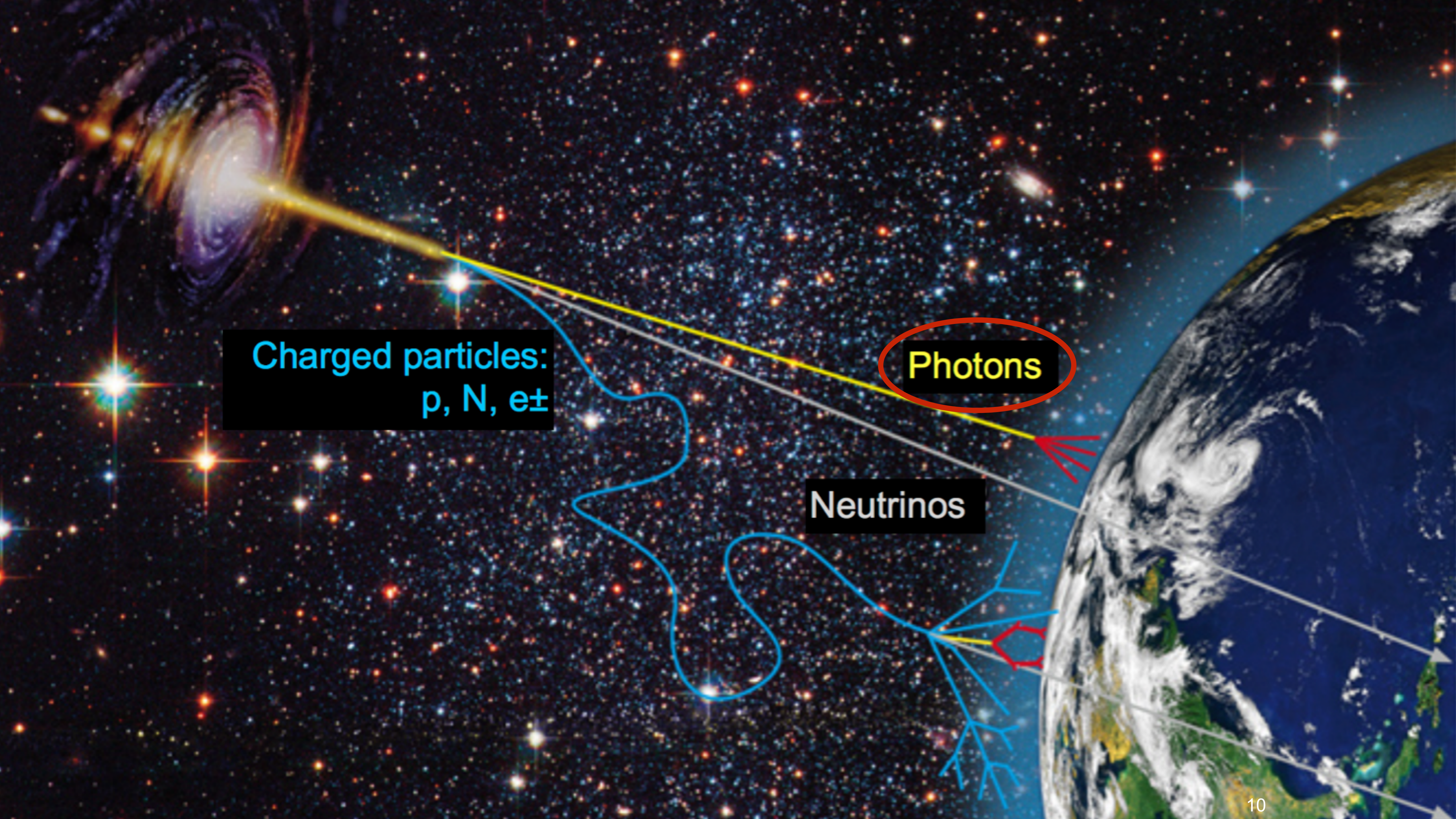












A diagram illustrating the interaction of cosmic rays with Earth's atmosphere. A bright yellow beam of light, representing a cosmic ray, originates from a distant galaxy in the upper left and travels towards the Earth on the right. The beam is labeled 'Photons' in a red oval. As the beam enters the atmosphere, it splits into three paths: a blue wavy line labeled 'Charged particles: p, N, e±', a straight grey line labeled 'Neutrinos', and a red branching structure. The background shows a starry sky with various galaxies and nebulae.

Charged particles:  
 $p, N, e^{\pm}$

Photons

Neutrinos



## Space based:

(Pair conversion detector)

Fermi LAT  
since 2008

20 MeV – 300 GeV  
Effective area:  $1\text{m}^2$   
Obs. time: 10yr



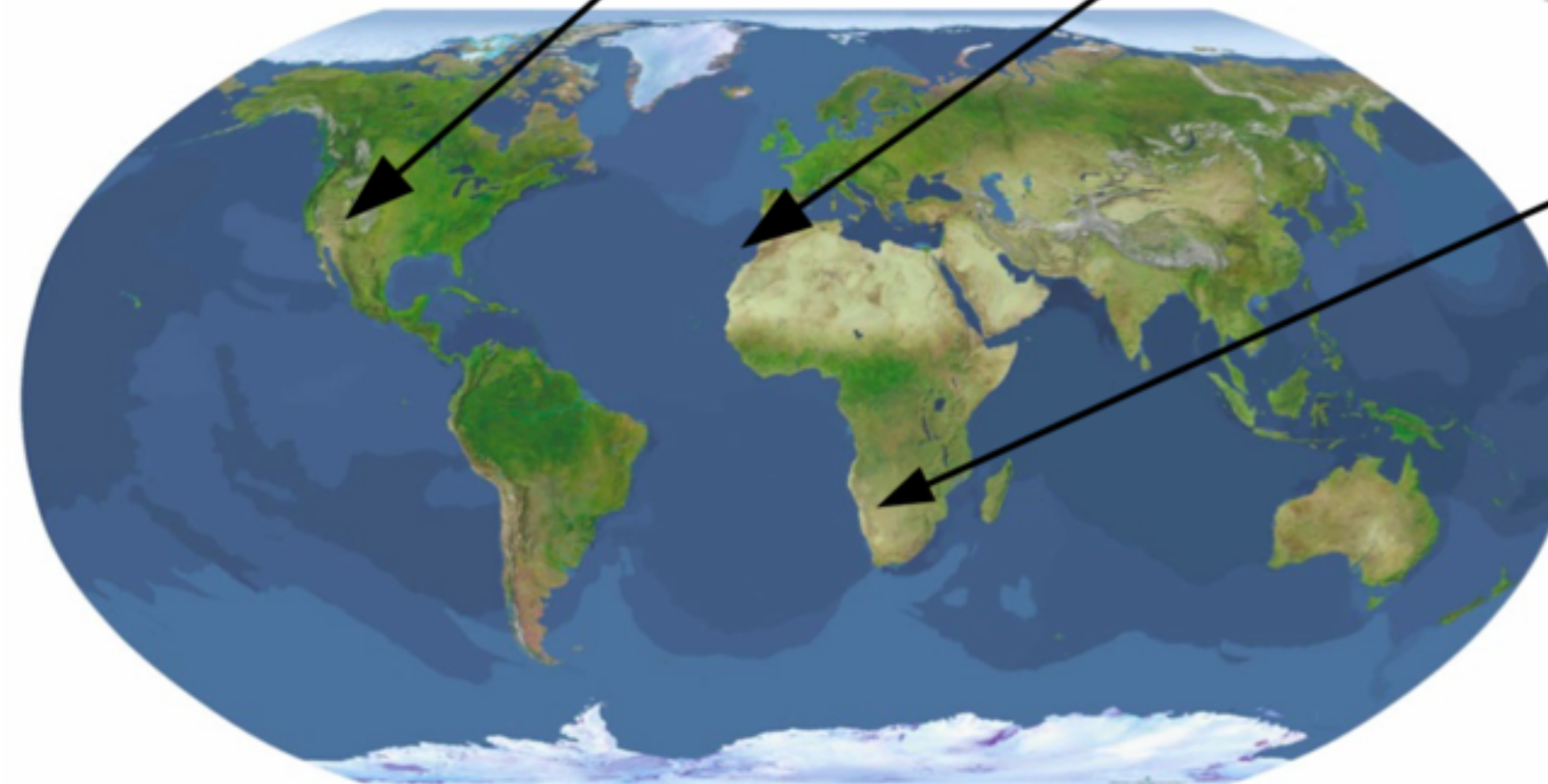
## Ground based:

(Atmospheric Cherenkov Telescopes)

10 GeV – 10 TeV  
Effective area:  $1\text{km}^2$   
Obs. Time: 100h

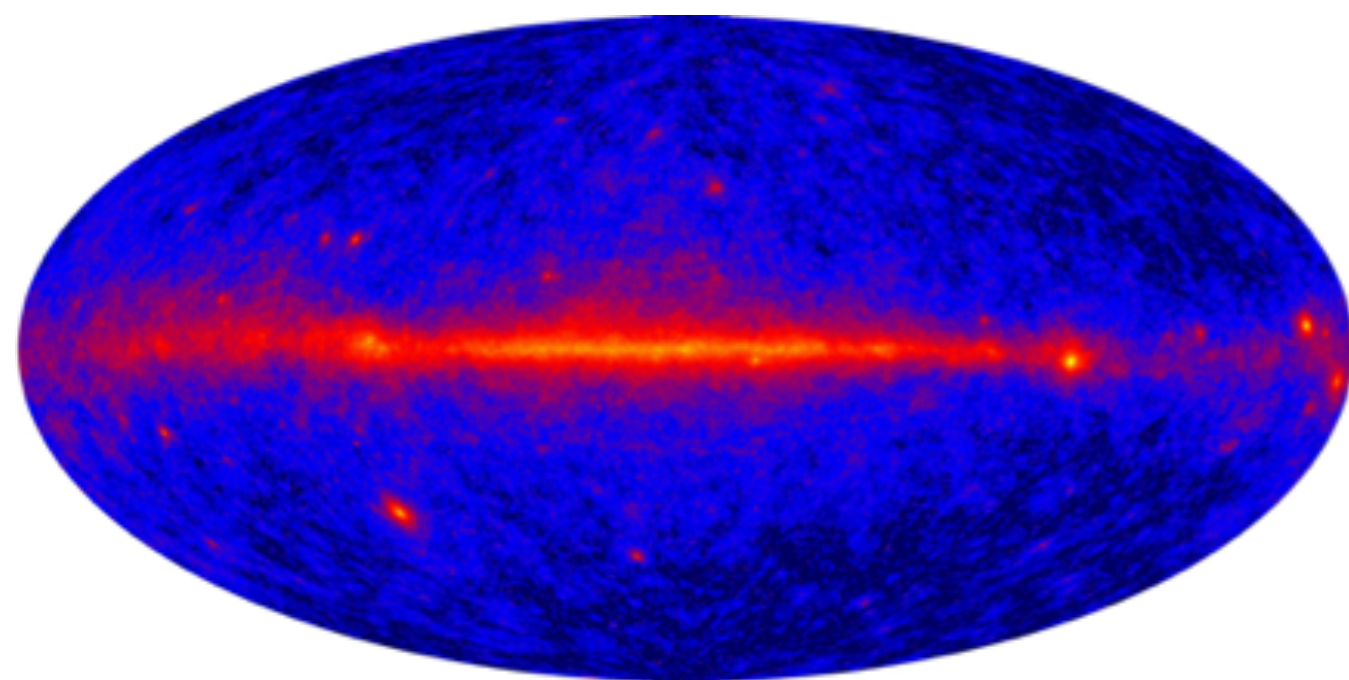
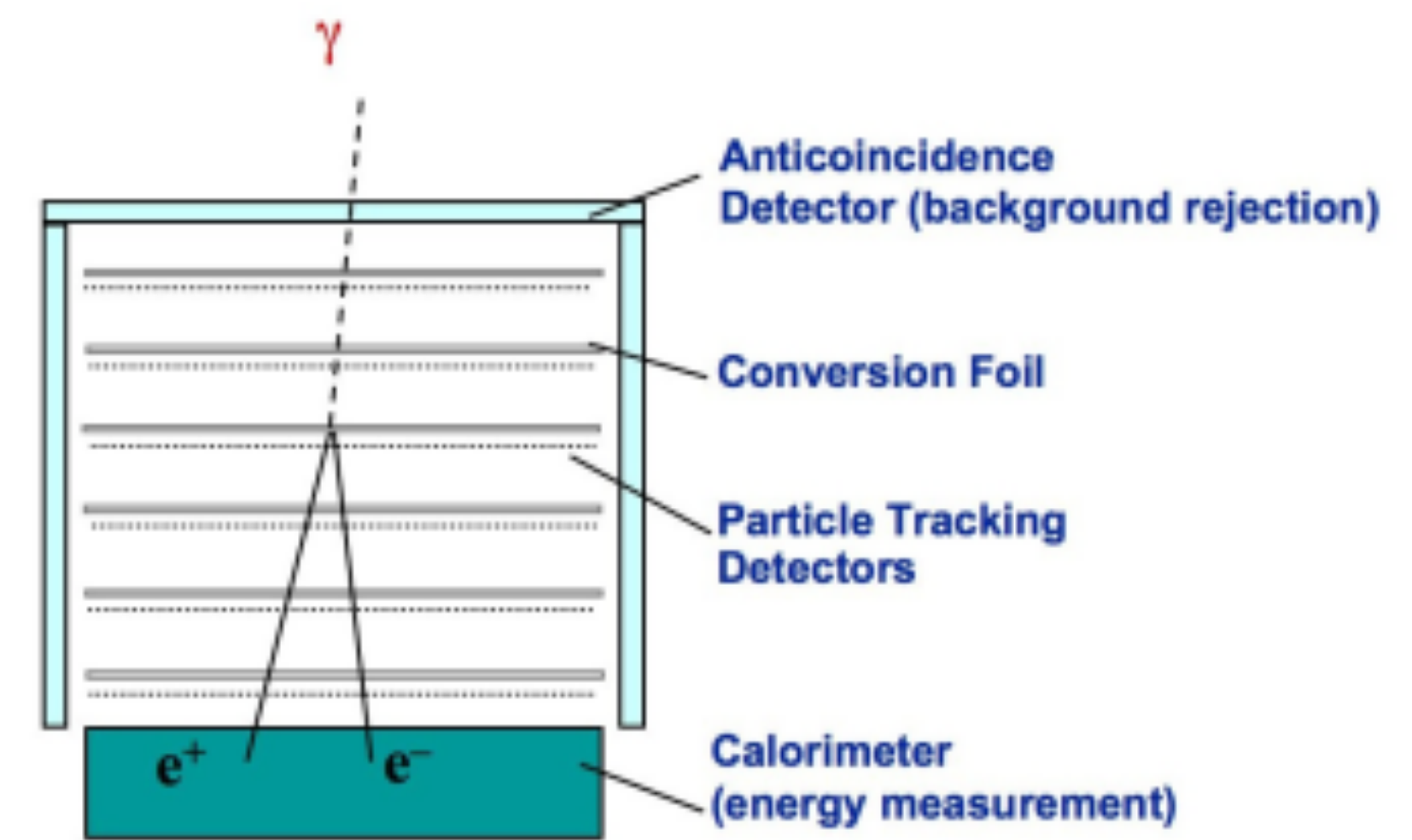


Future: CTA

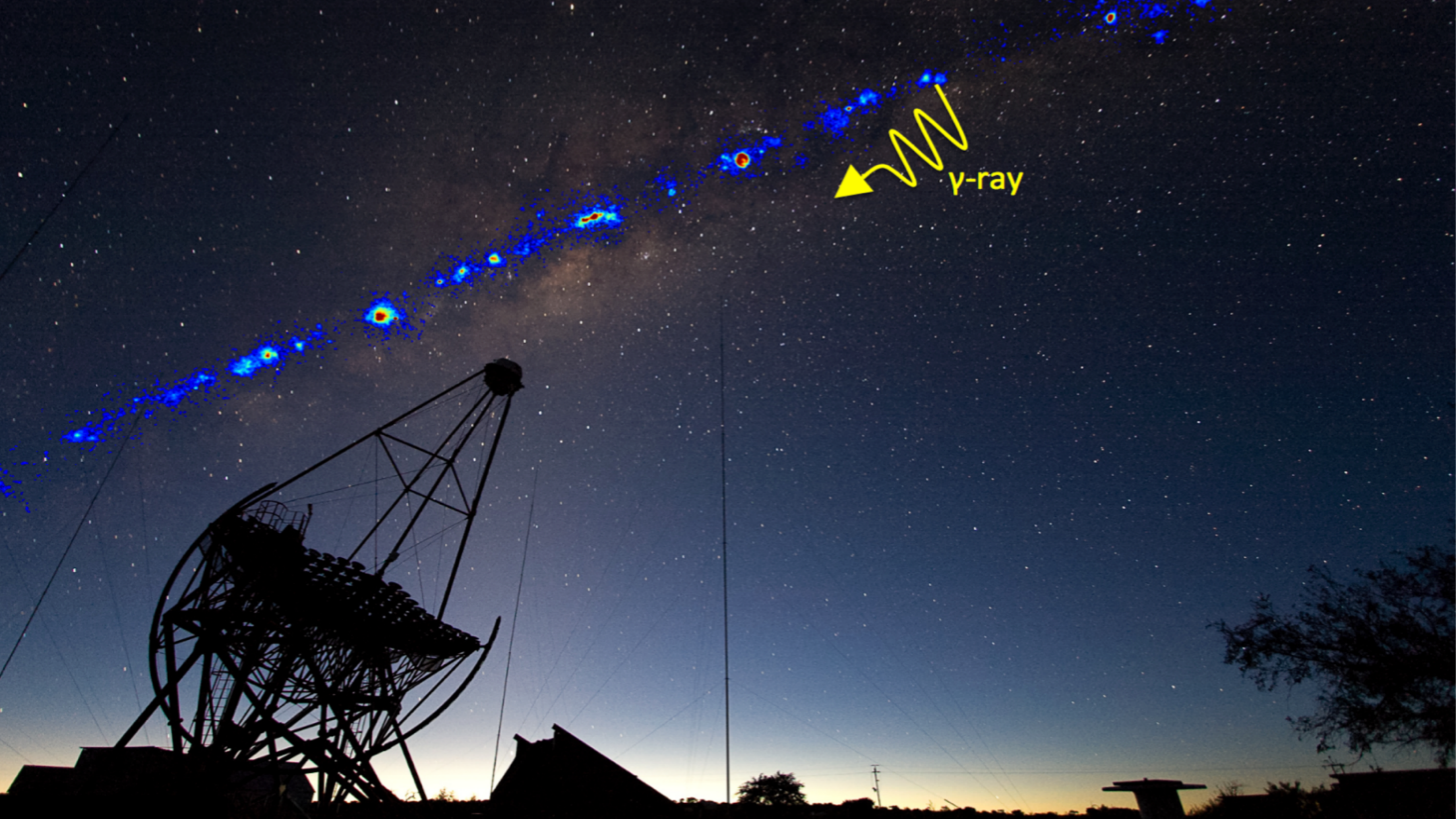




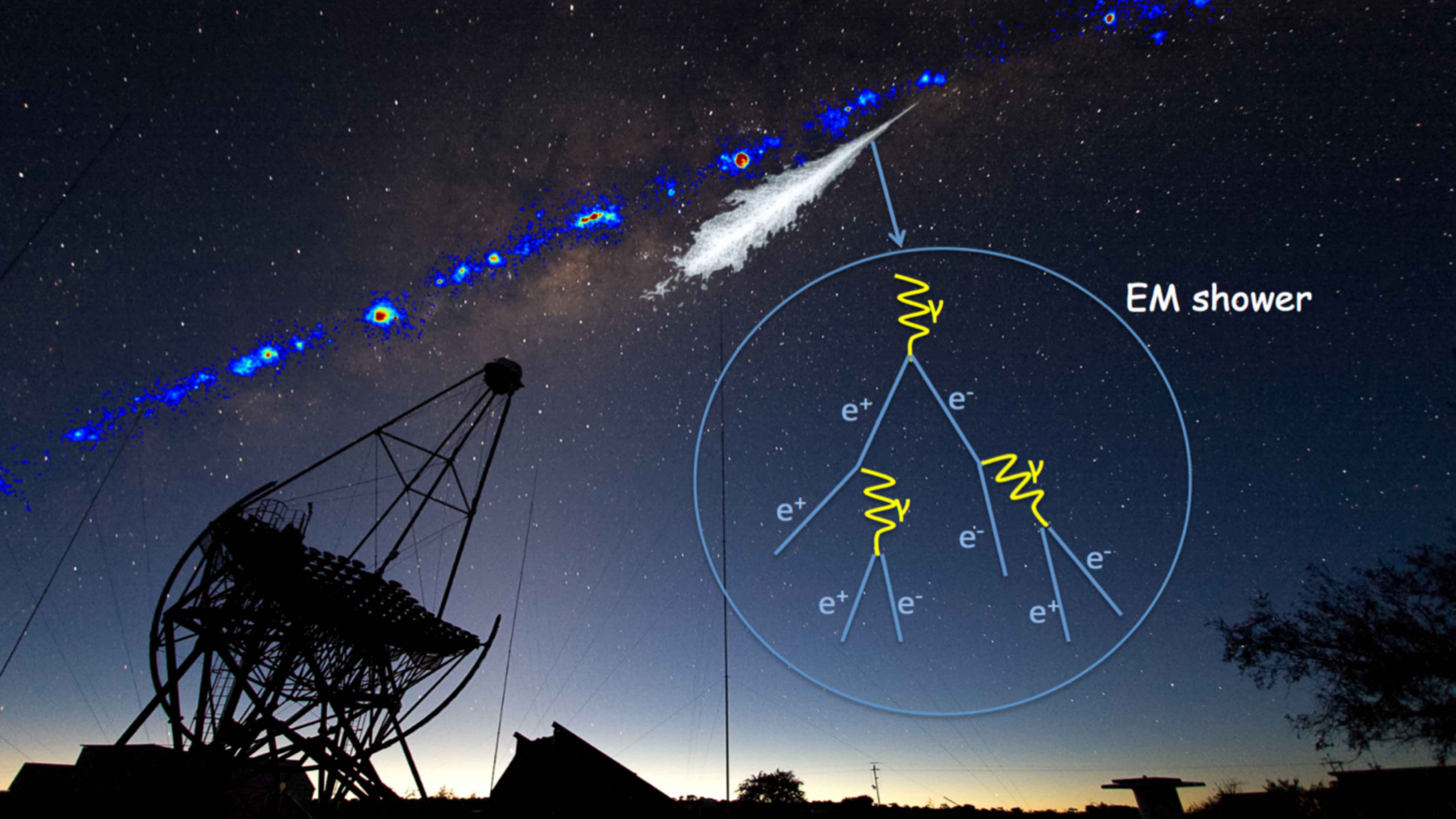
# Fermi Large Area Telescope











EM shower

$e^+$

$e^-$

$e^+$

$e^-$

$e^-$

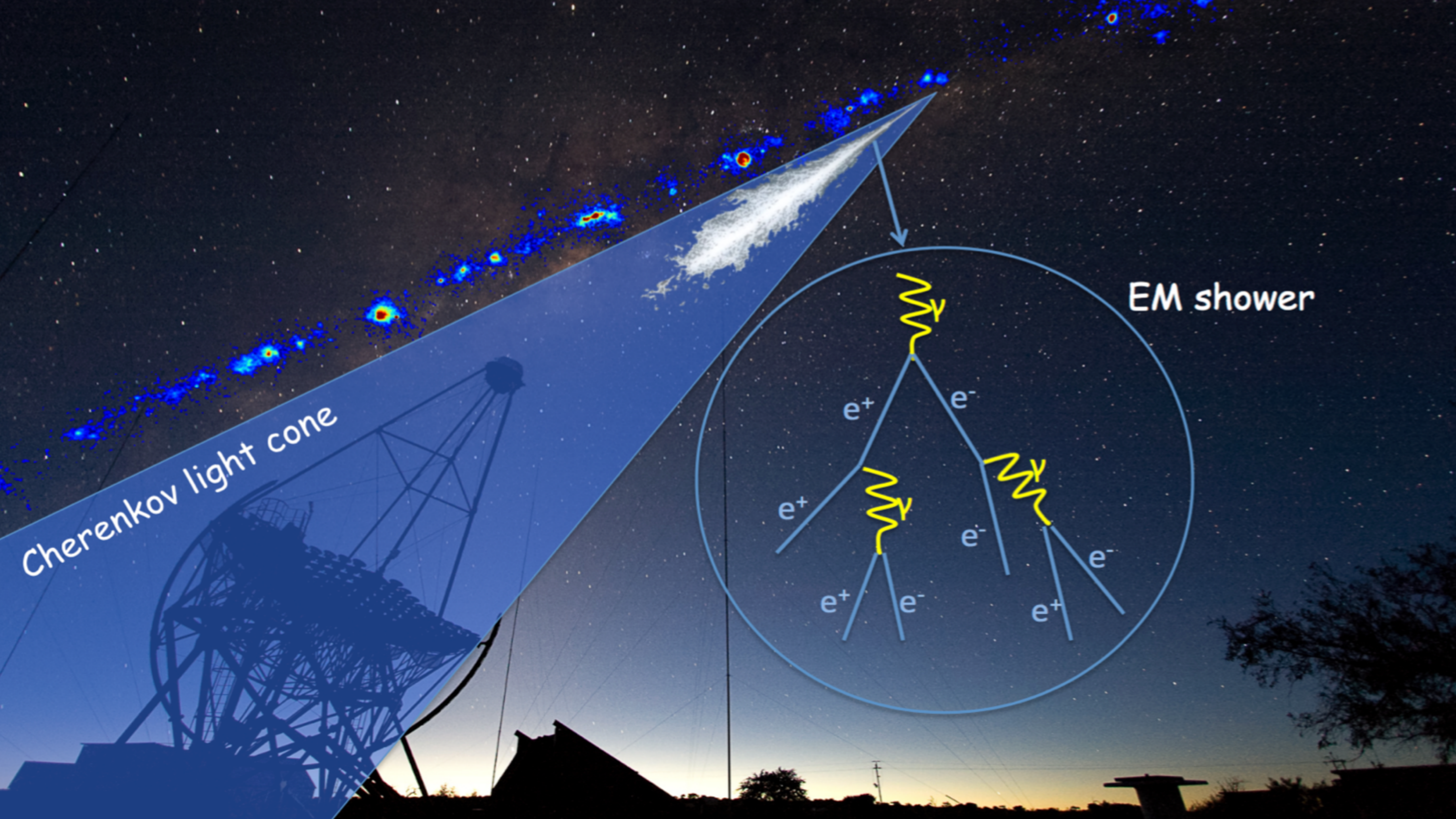
$e^+$

$e^-$

$e^+$

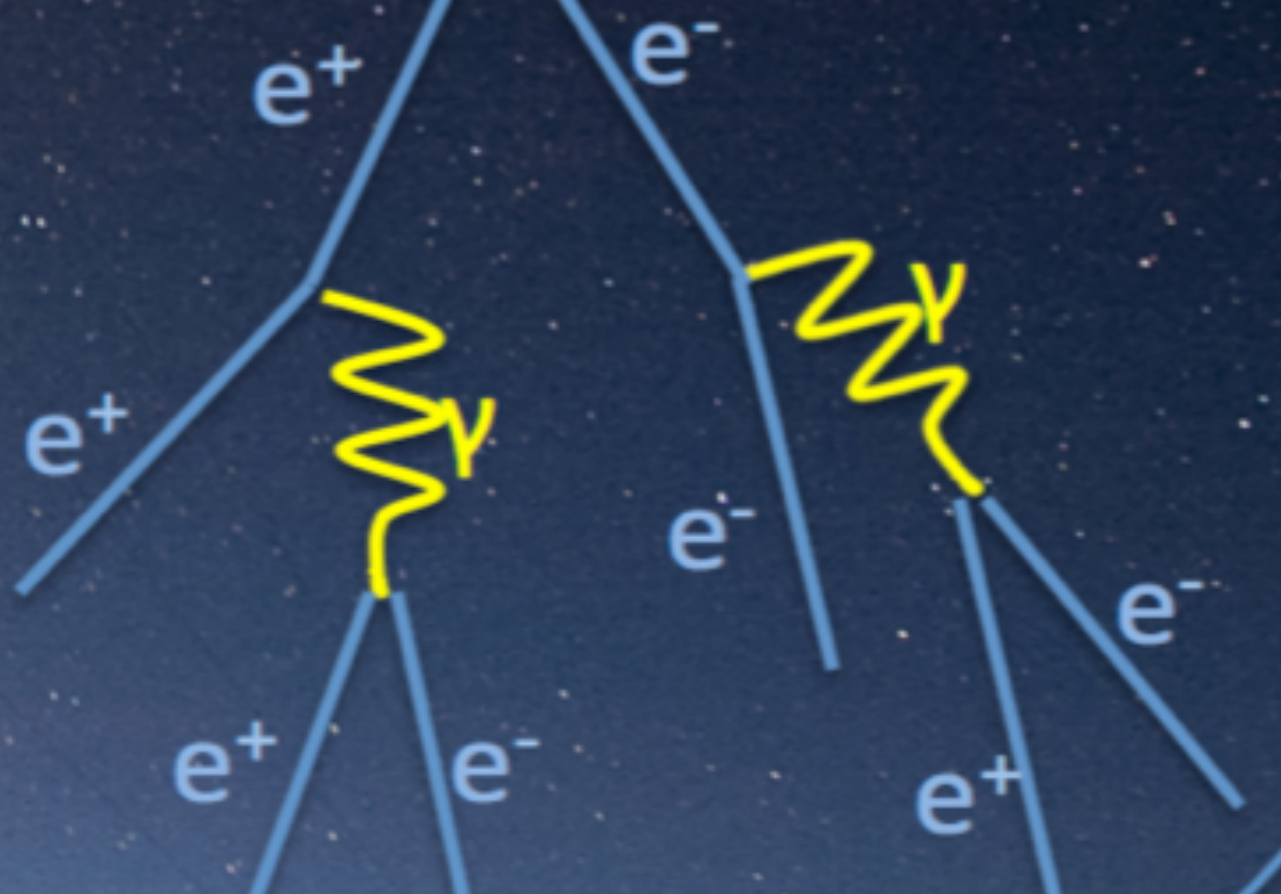
$e^-$





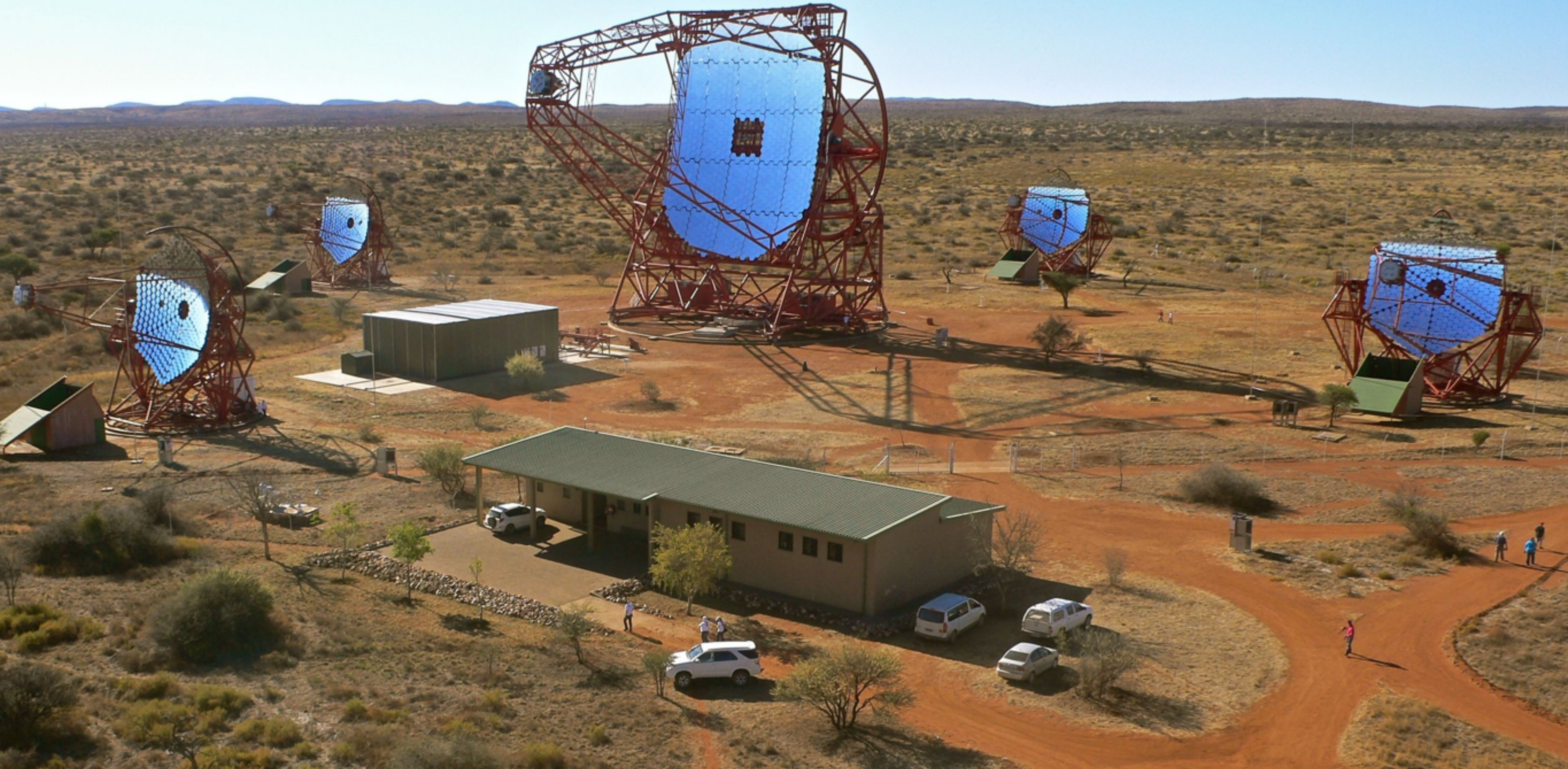
Cherenkov light cone

EM shower

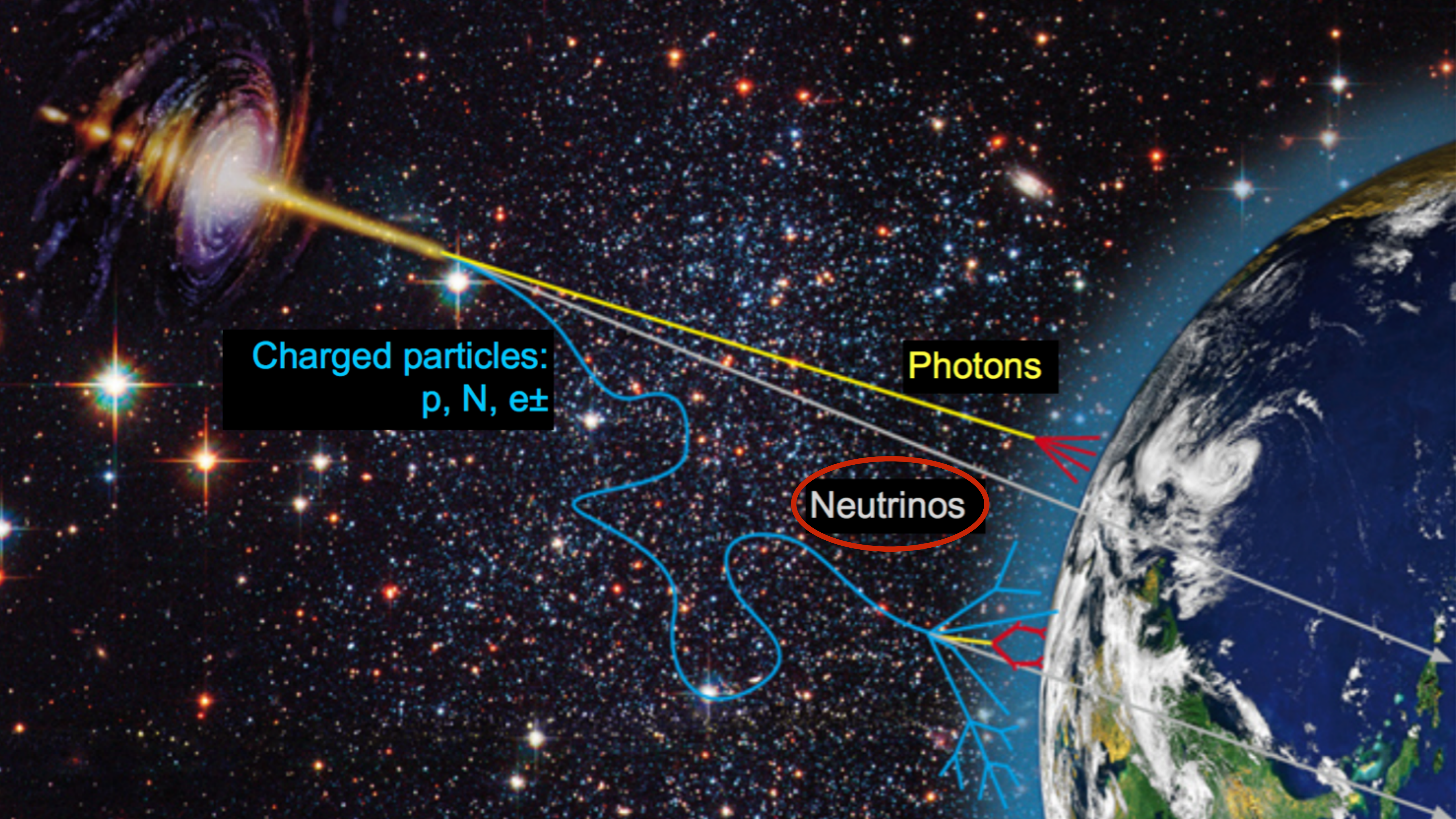




# High Energy Stereoscopic System







A diagram illustrating the interaction of cosmic rays with Earth's atmosphere. A bright yellow beam of light, representing a cosmic ray, originates from a distant galaxy in the upper left and travels towards the Earth on the right. The beam is labeled 'Photons' in a yellow box. As the beam enters the atmosphere, it splits into three paths: a wavy blue line labeled 'Charged particles: p, N, e±' in a blue box, a straight grey line labeled 'Neutrinos' in a red oval, and a red branching structure. The background shows a starry space with various galaxies and nebulae.

Charged particles:  
 $p, N, e^{\pm}$

Photons

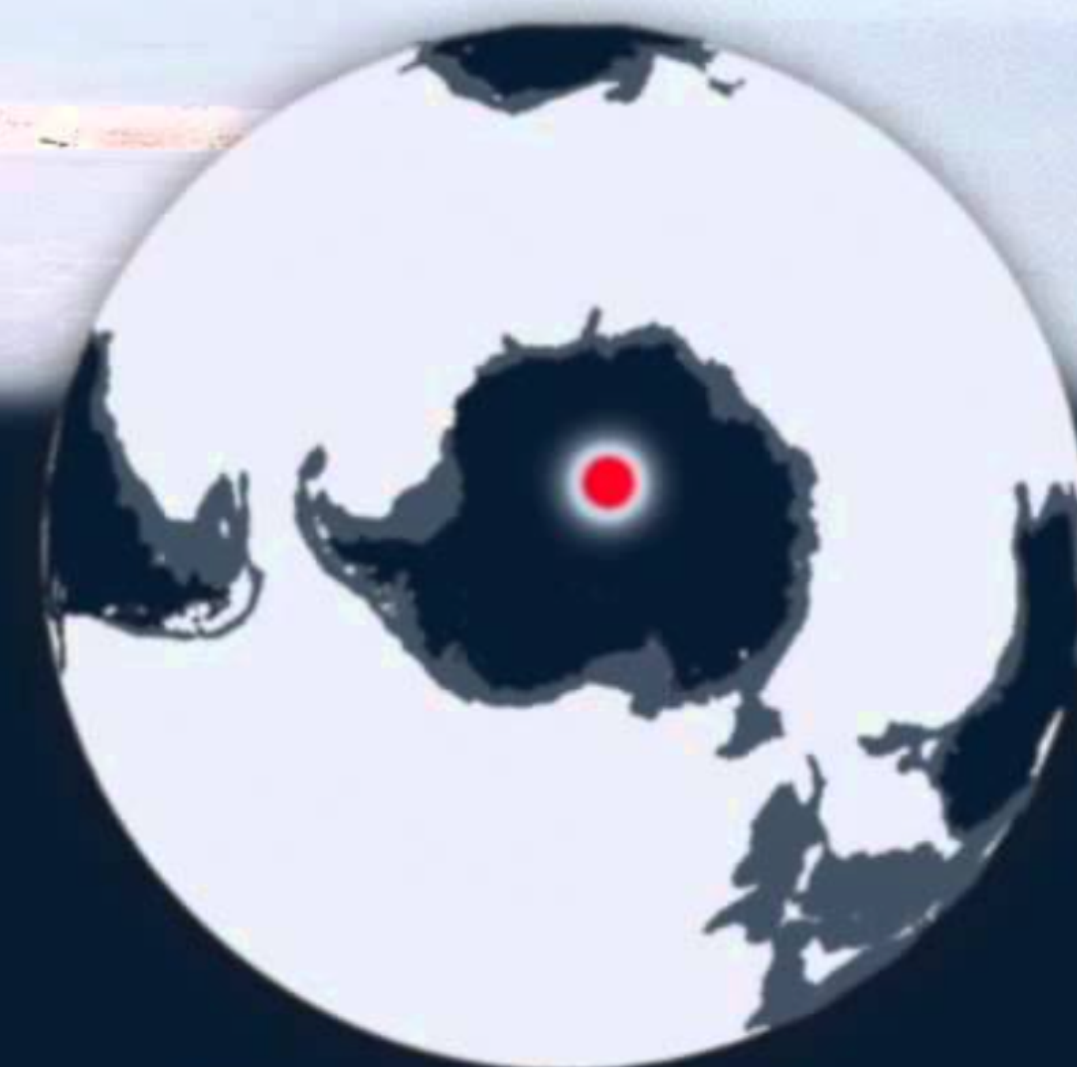
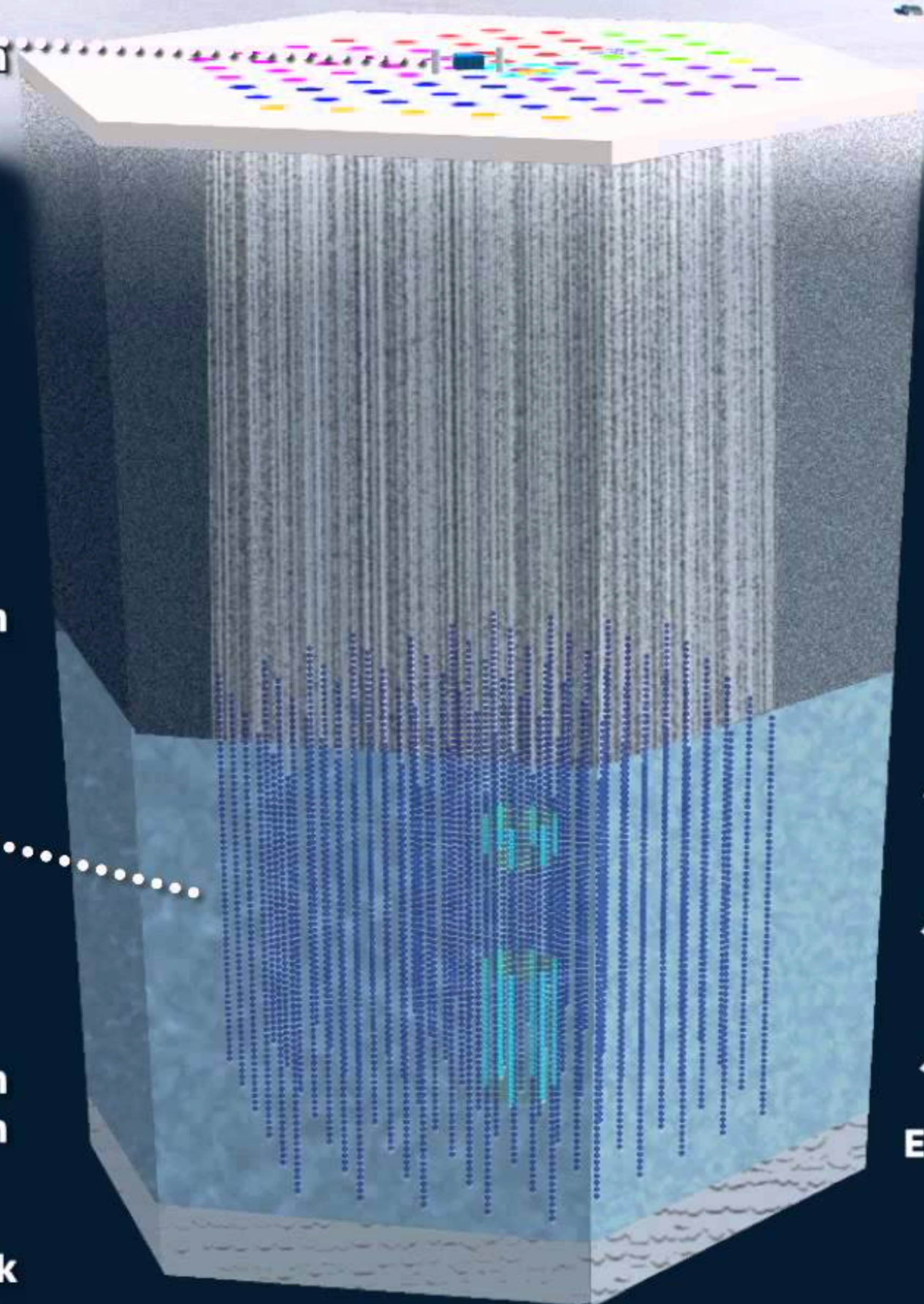
Neutrinos





**IceCube  
Laboratory**

50 m



**Amundsen-Scott  
South Pole  
Station  
Antarctica**



**Digital Optical Module  
DOM  
86 strings  
5160 optical sensors**

1450 m

2450 m  
2820 m

bedrock



**Eiffel Tower 324 m**



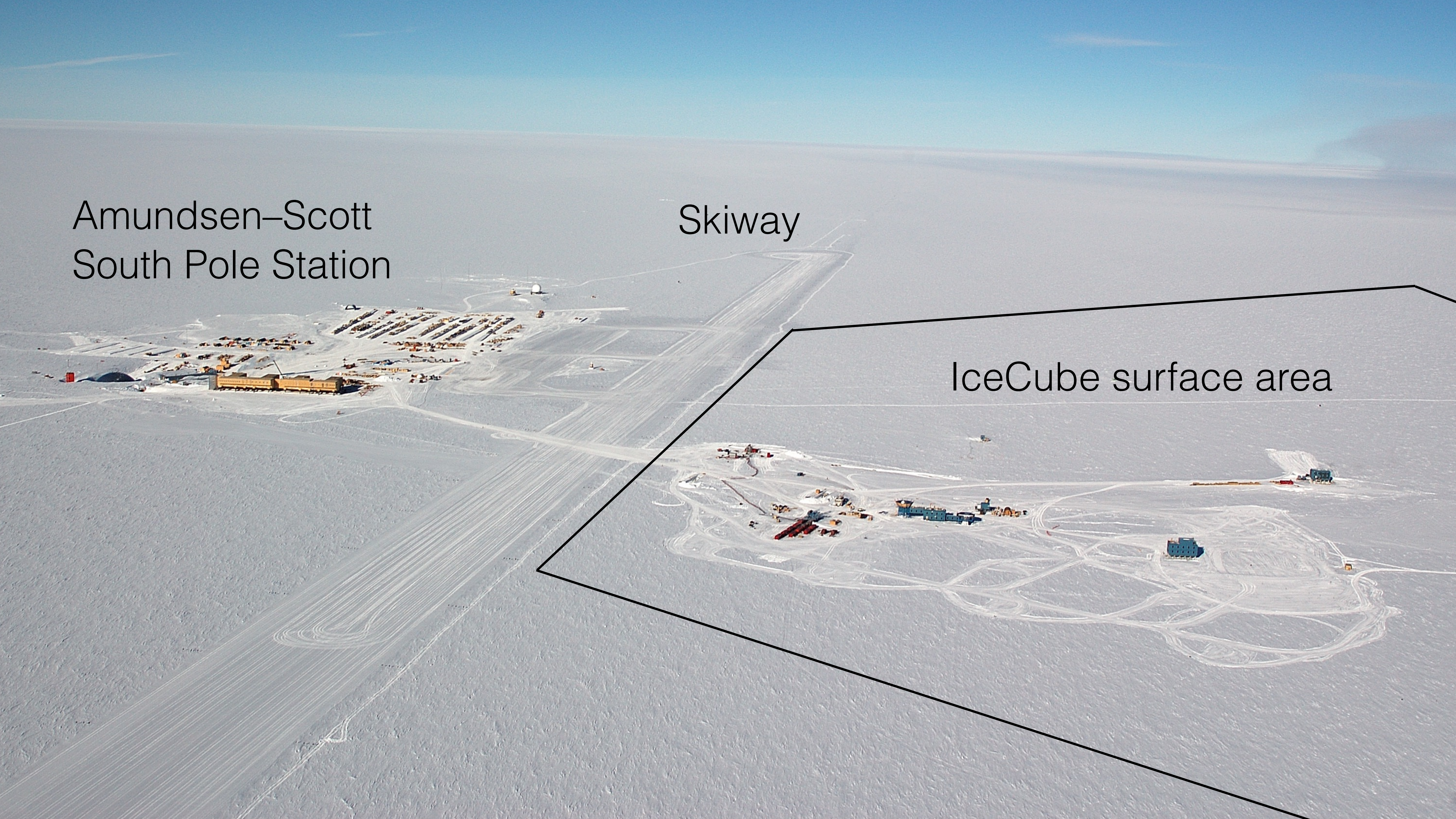




Amundsen–Scott  
South Pole Station

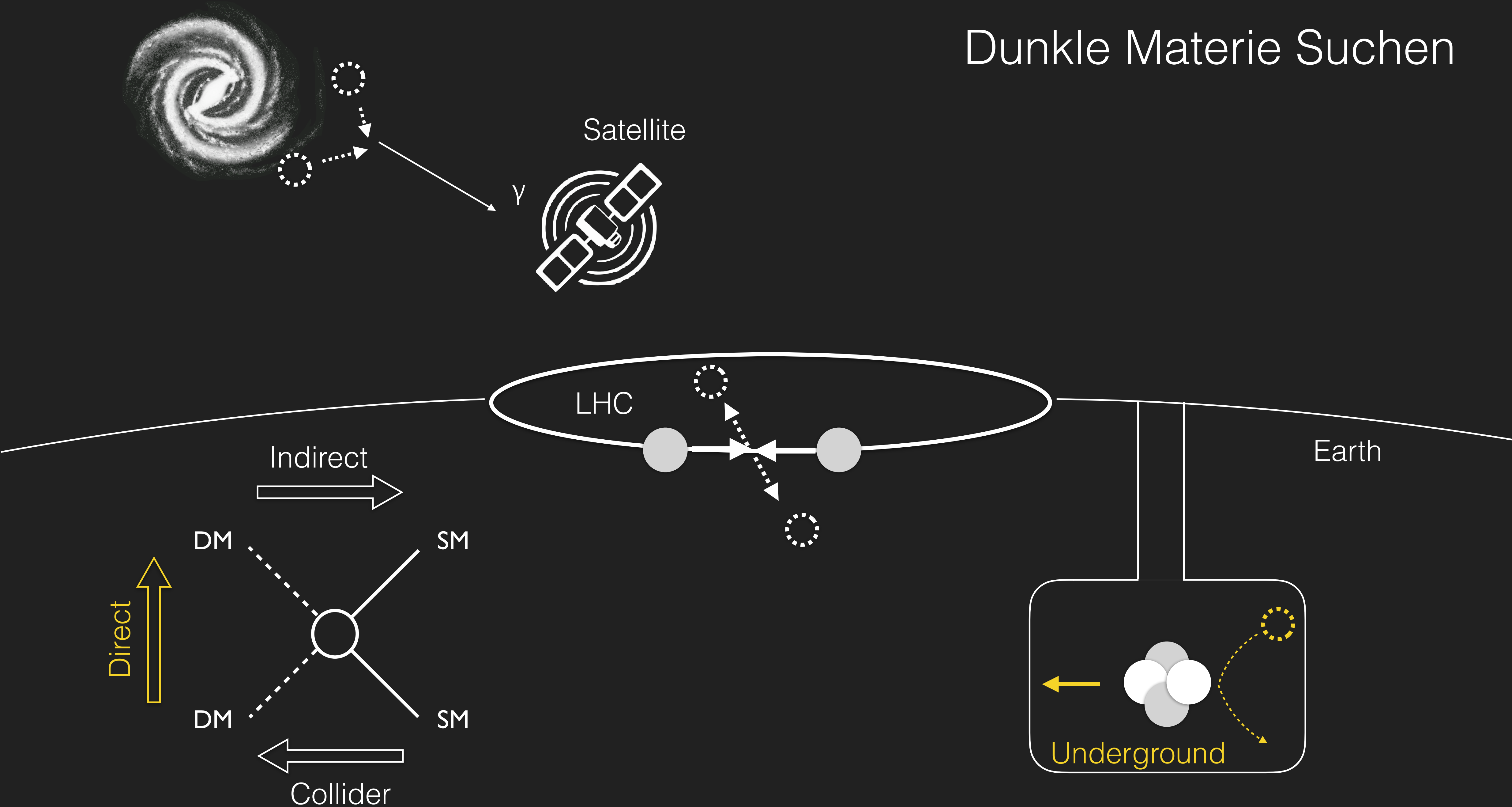
Skiway

IceCube surface area

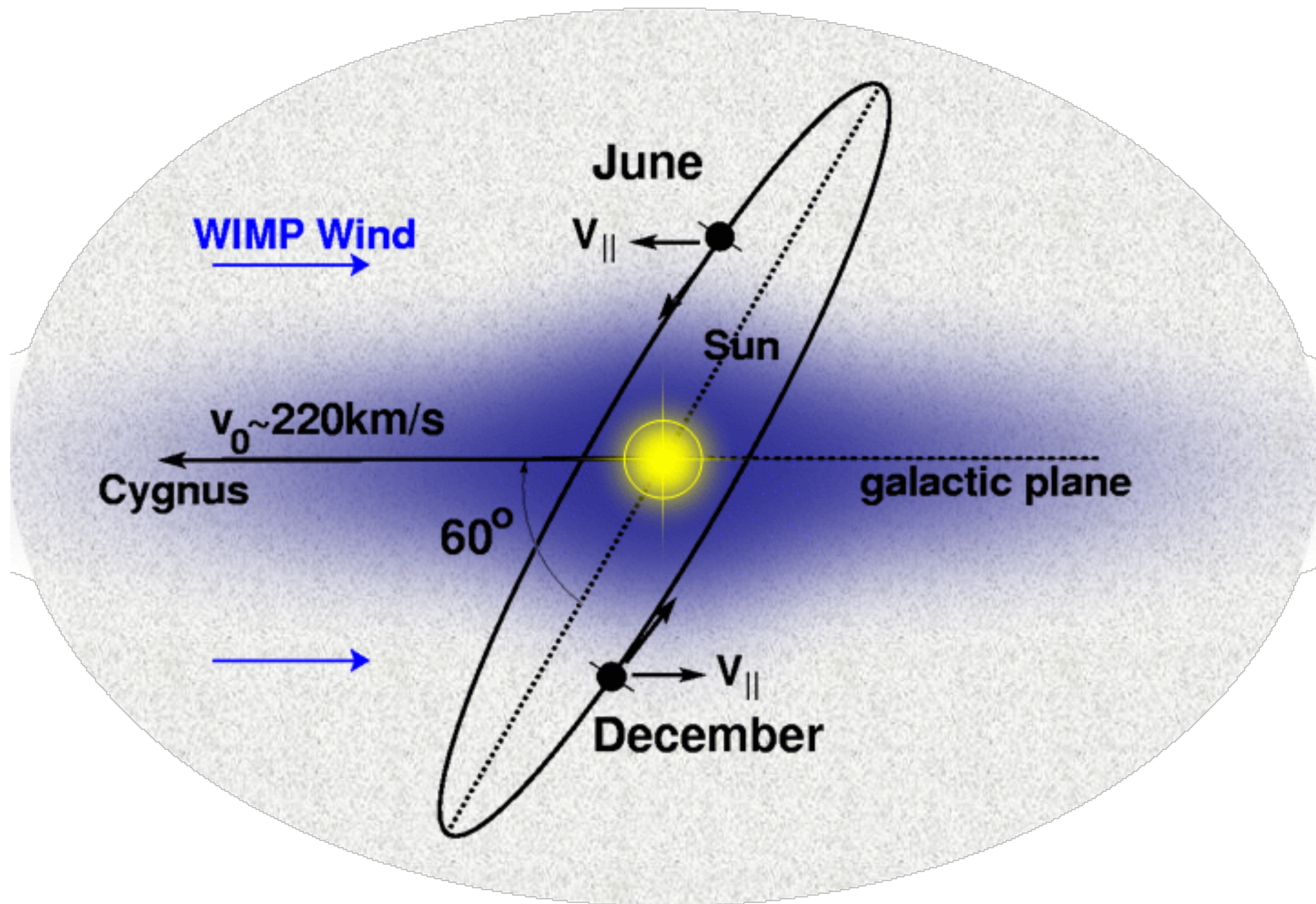




# Dunkle Materie Suchen

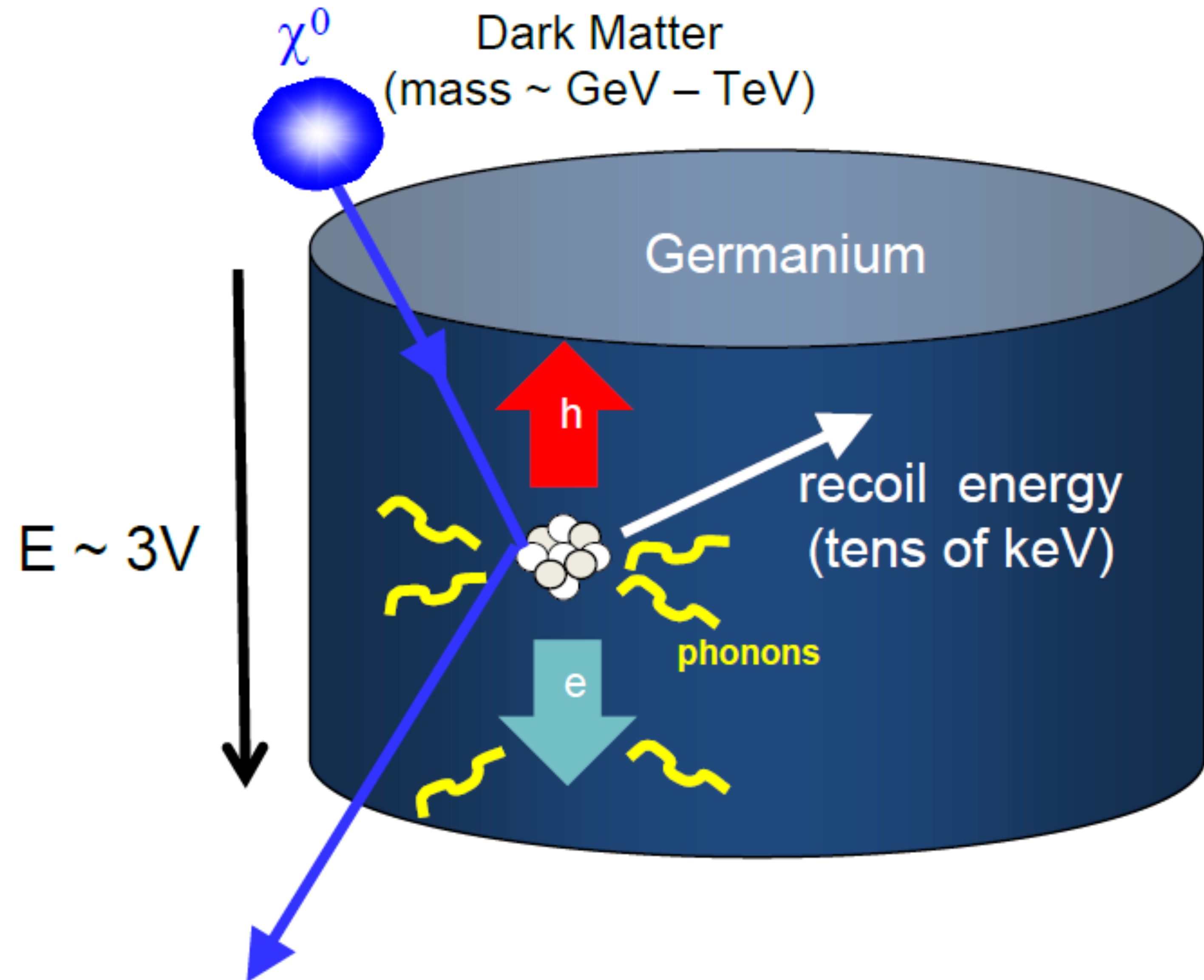








# Direct detection





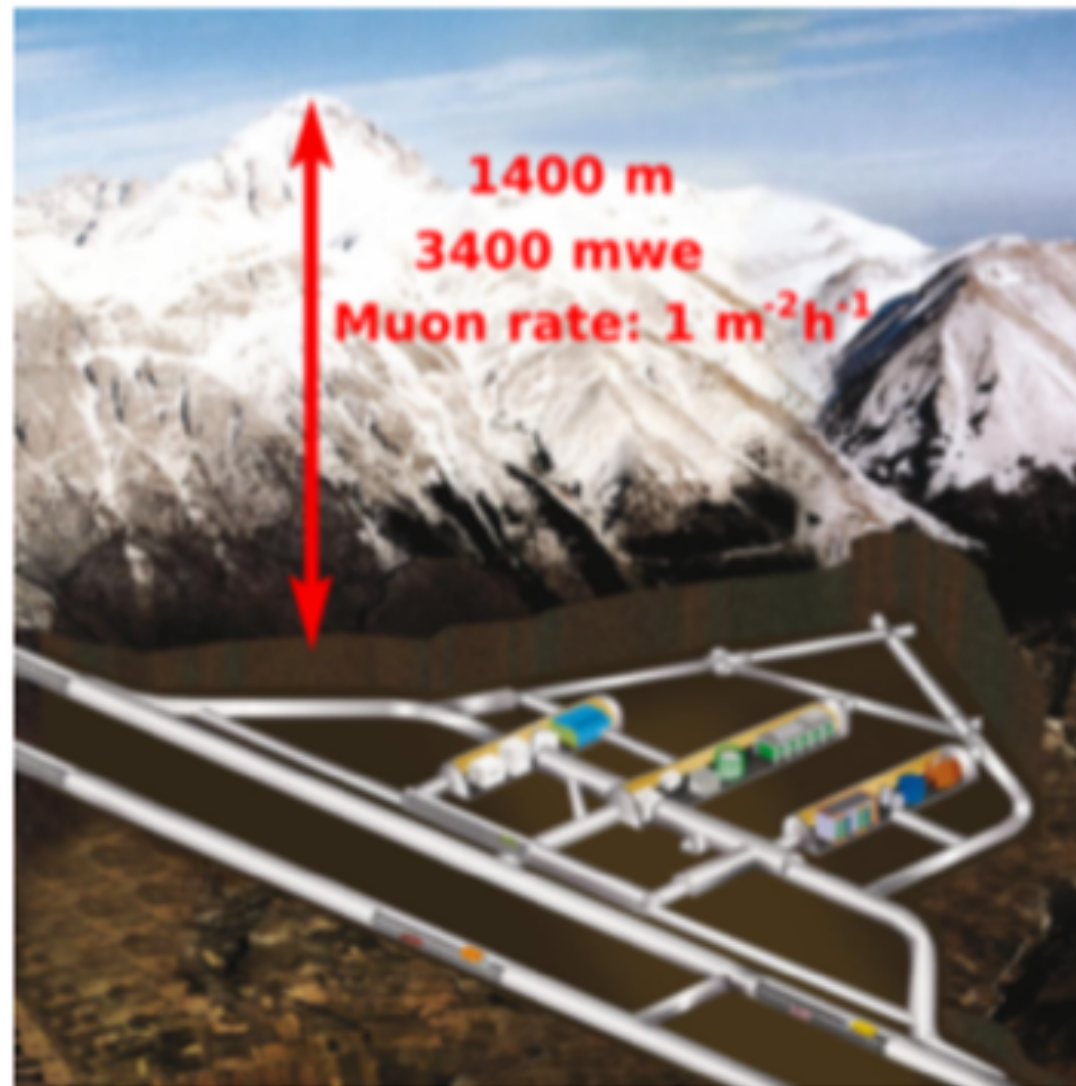
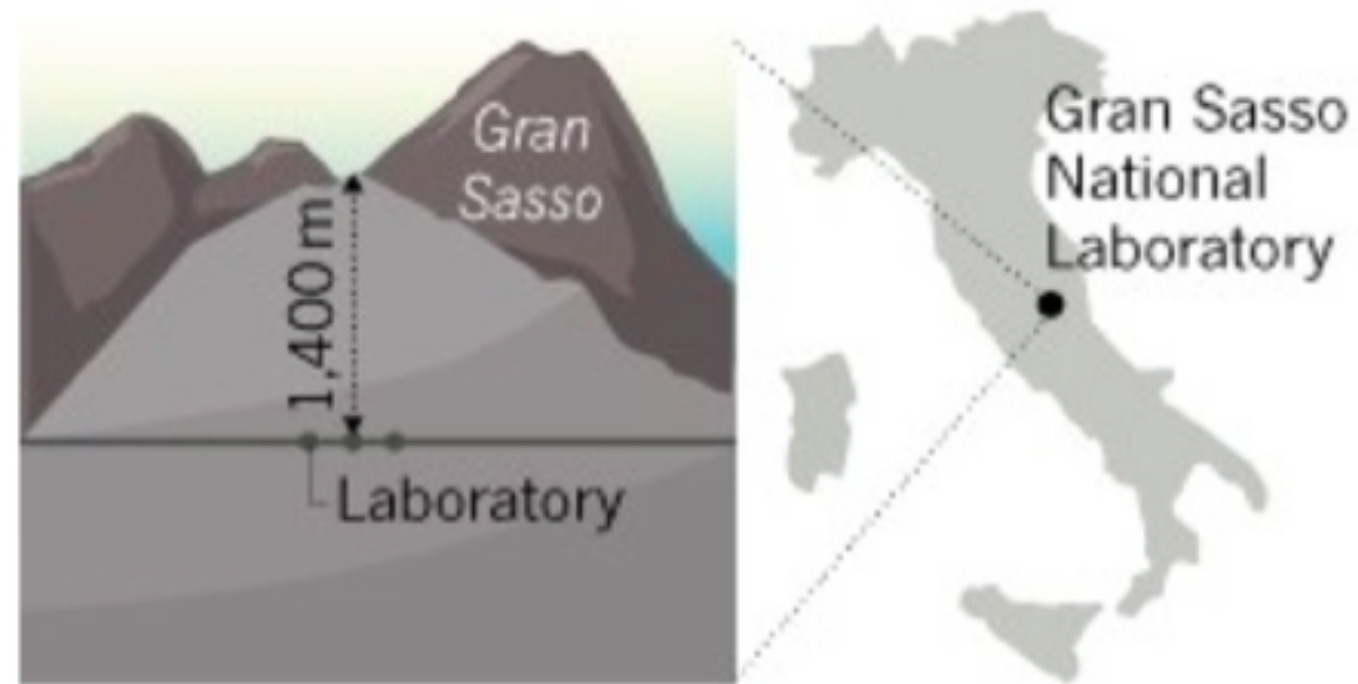
LEVEL NO. 27

2341 FEET BELOW THE SURFACE  
689 FEET BELOW SEA LEVEL

Soudan mine, northern Minnesota



# Hosted by the Laboratori Nazionali del Gran Sasso (LNGS)



## **XENON10: 2005-07**

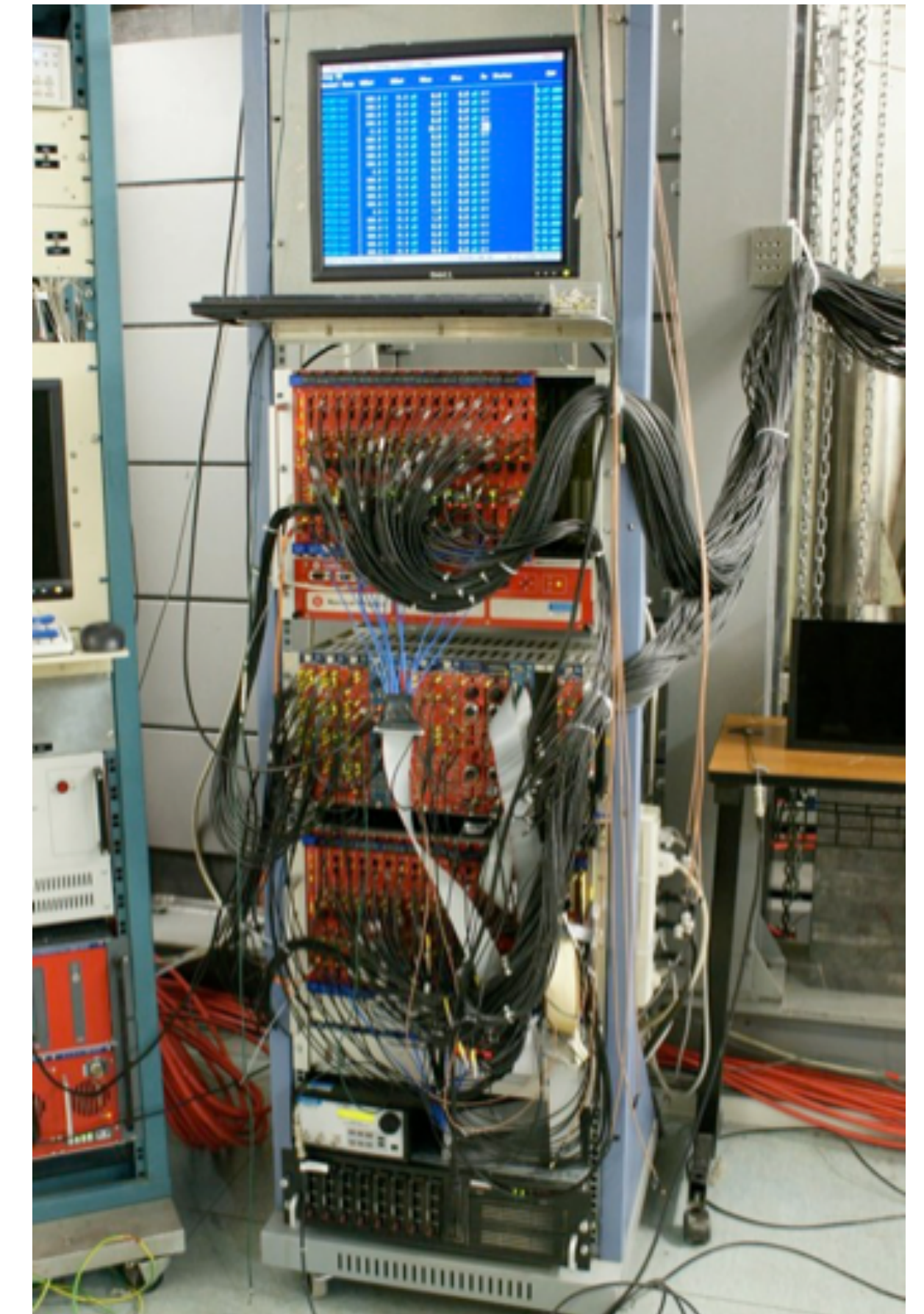
- 14 kg; 15 cm drift

## **XENON100: 2008-11**

- 170 kg; 30 cm drift

## **XENON1T: soon**

- 2,4 t; 90 cm drift

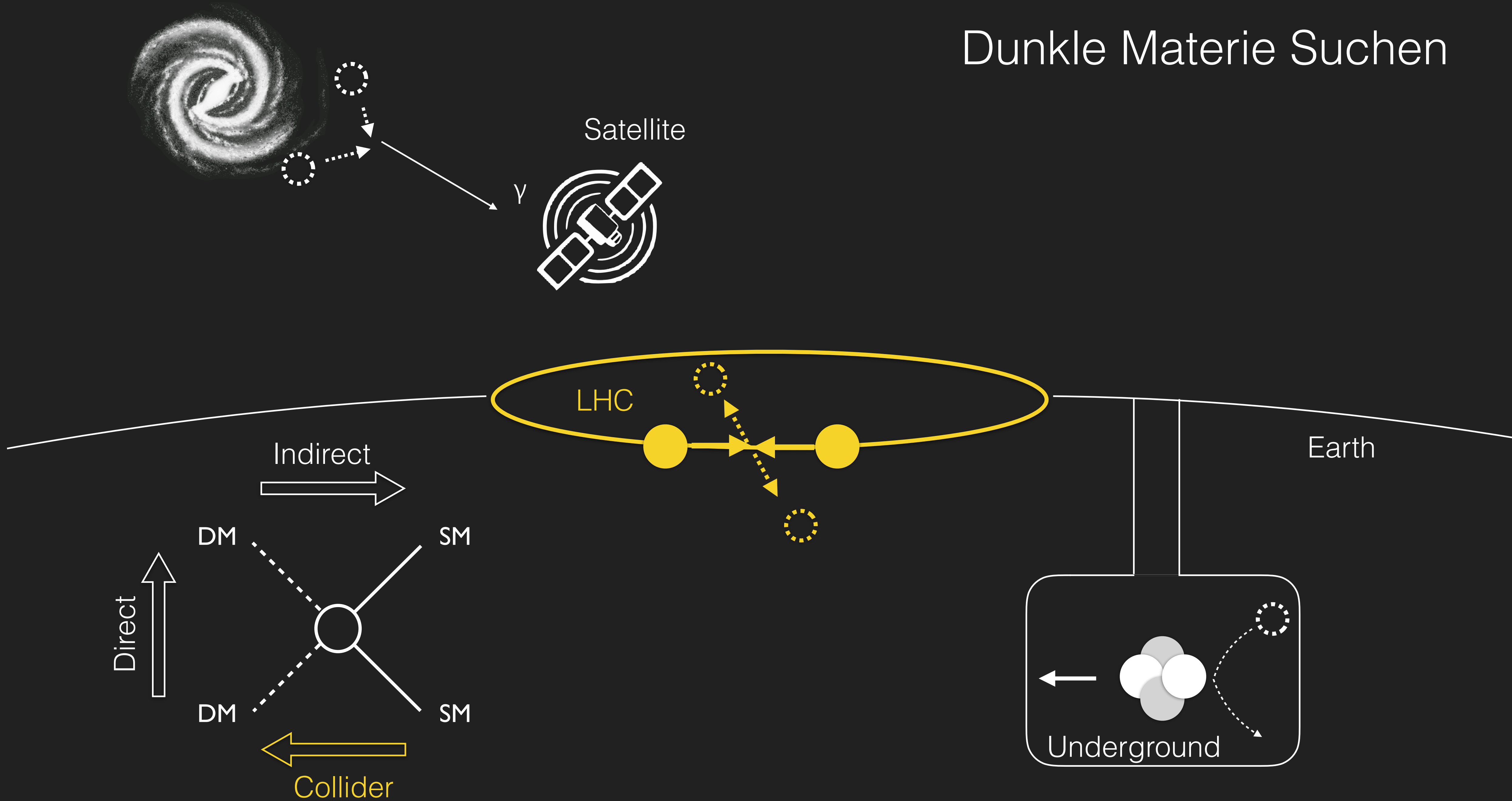






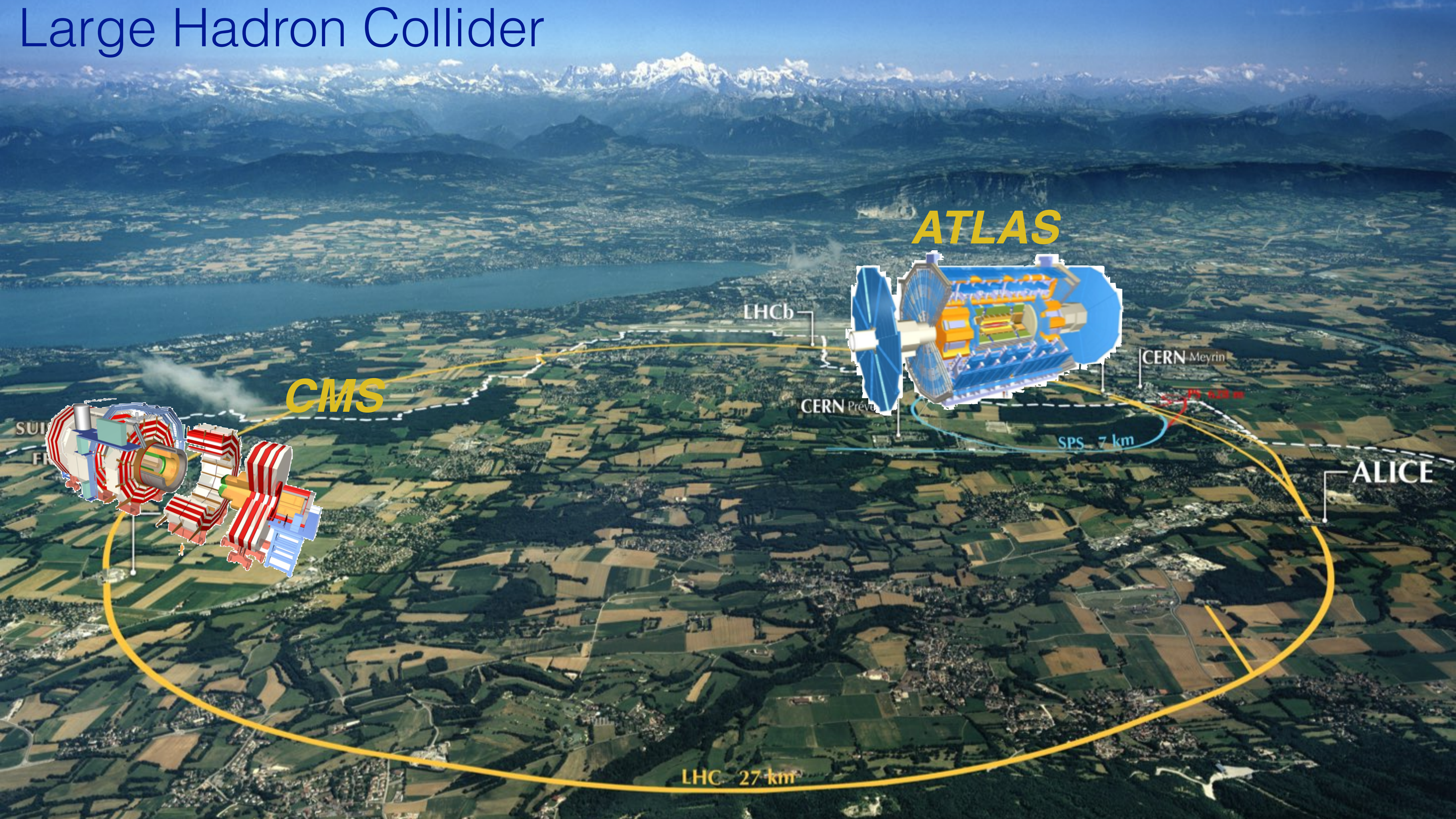


# Dunkle Materie Suchen

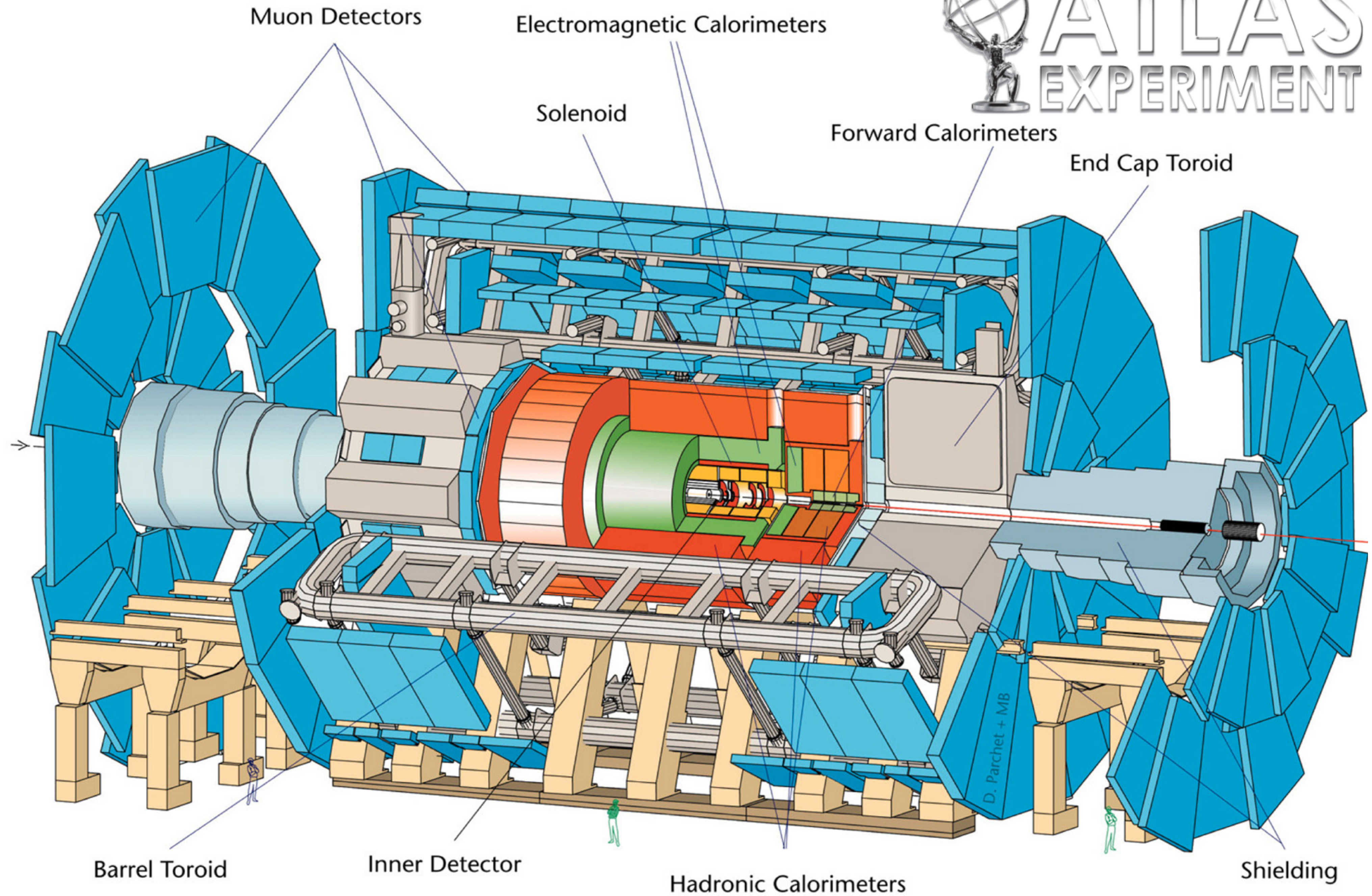




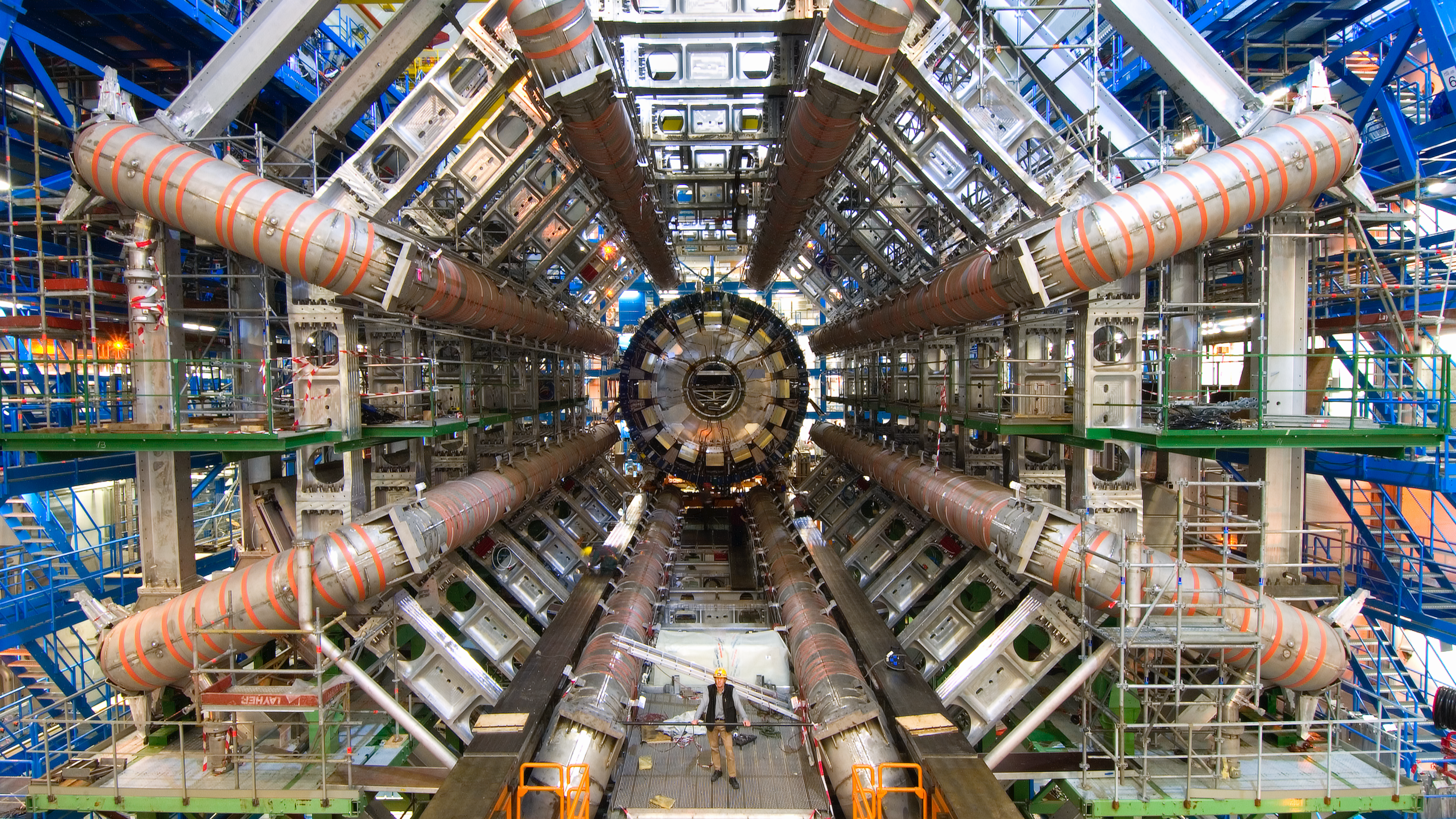
# Large Hadron Collider









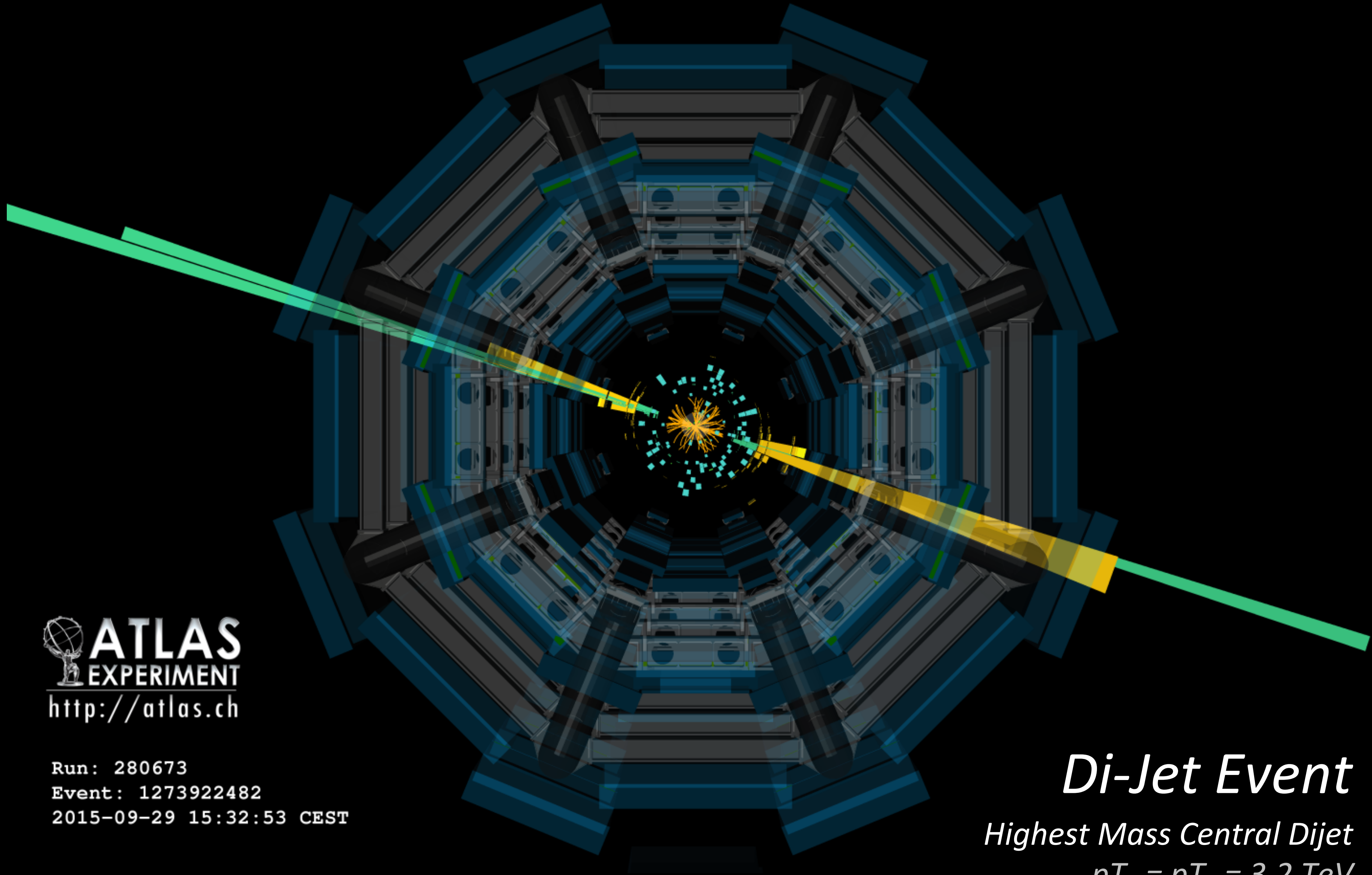






ATLAS  
EXPERIMENT  
<http://atlas.ch>

Run: 280673  
Event: 1273922482  
2015-09-29 15:32:53 CEST



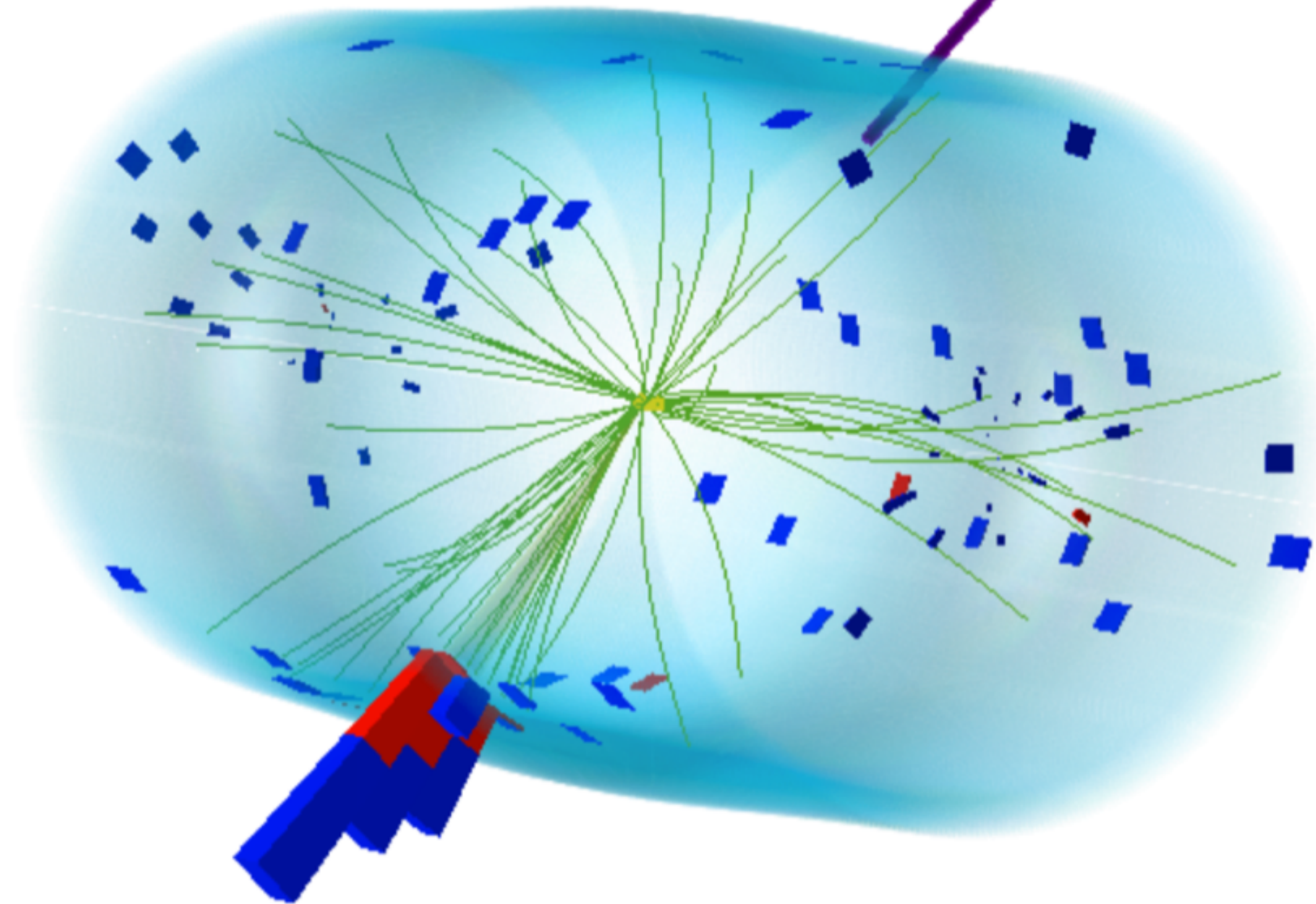
*Di-Jet Event*  
*Highest Mass Central Dijet*  
 $pT_1 = pT_2 = 3.2 \text{ TeV}$   
 $m_{jj} = 6.9 \text{ TeV}$   
 $MET = 46 \text{ GeV}$





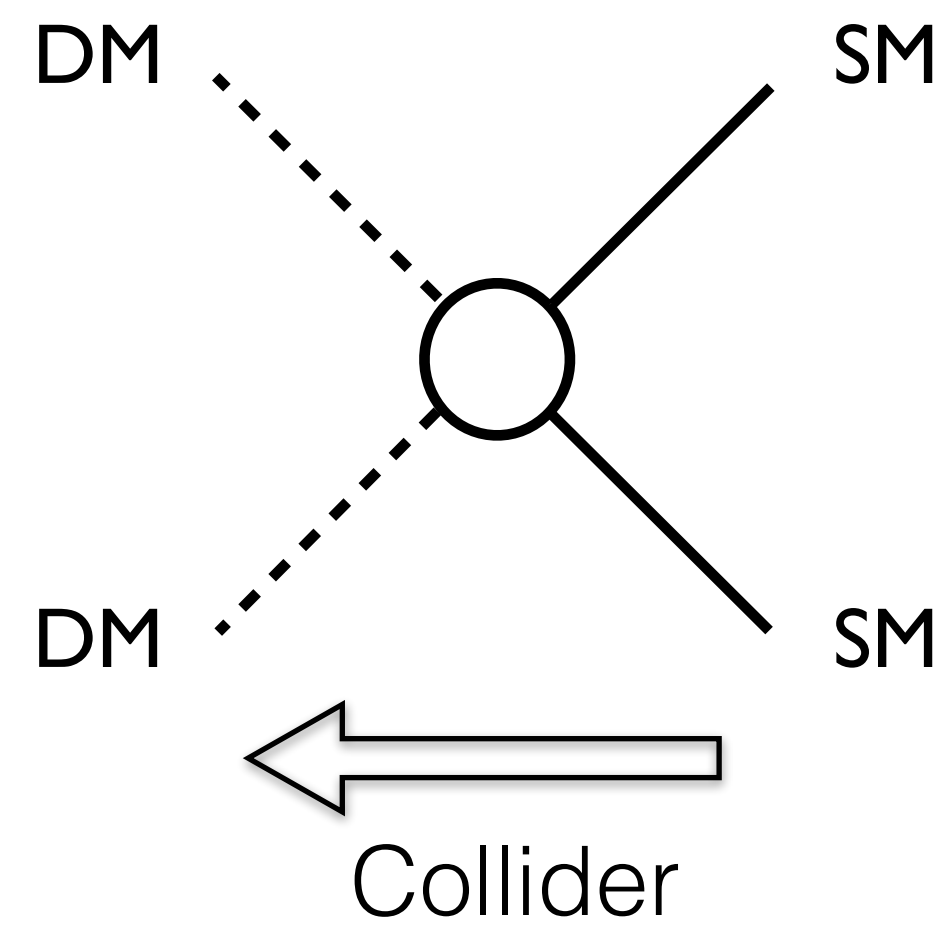
CMS Experiment at LHC, CERN  
Data recorded: Mon Jun 13 17:44:28 2016 CEST  
Run/Event: 274999 / 1837785290  
Lumi section: 1029

$E_{T}^{\text{miss}} = 1.05 \text{ TeV}$



$p_{T}^{\text{jet}} = 1.04 \text{ TeV}$

Mass = 79 GeV







CMS Experiment at LHC, CERN  
Data recorded: Mon Jun 13 17:44:28 2016 CEST  
Run/Event: 274999 / 1837785290  
Lumi section: 1029

