

Methods of Particle Detection


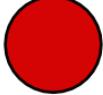
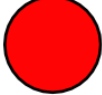






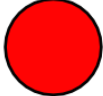

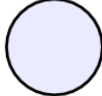
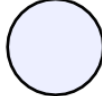
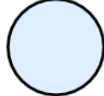


Aaron White

Today

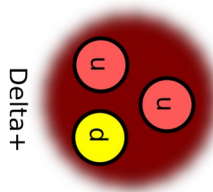
- Review Standard Model
- Particle detection methods slides
- Visit mPandaX

Review the Standard Model

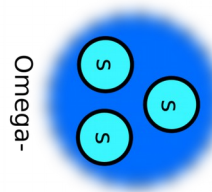
Particles of the Standard Model

Up 	Strange 	Top 	Electron 	Muon 	Tau 	Photon 	Gluon 
Down 	Charm 	Bottom 	Electron Neutrino 	Muon Neutrino 	Tau Neutrino 	W^{\pm}, Z 	Higgs 
<p>Quarks: Three makes a baryon Two makes a meson</p>			<p>Leptons Top three are charged Neutrinos are neutral</p>			<p>Bosons The Gauge bosons carry force The Higgs boson gives some particles mass</p>	

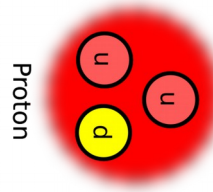
Baryons:



Delta+

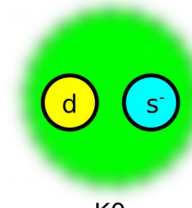


Omega-

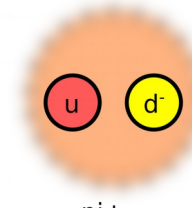


Proton

Mesons:



K0



pi+

Strong Force and Gluons

- Attractive between all quarks
- Confinement:
 - Quarks interact w/ each other
 - Unlike photons carrying electric field
 - Field lines don't spread out
 - **Constant** force over long distance



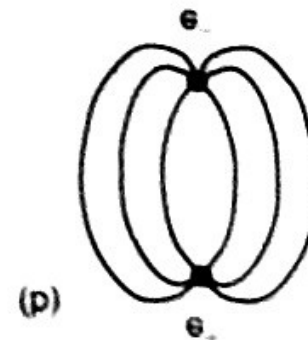
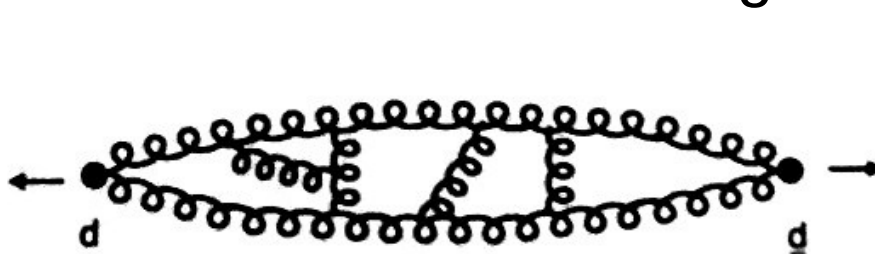
$$V=k*r^2$$



$$V=k*r^{-1}$$



$$V=k*r$$



Modern Particle Physics, Mark Tomson

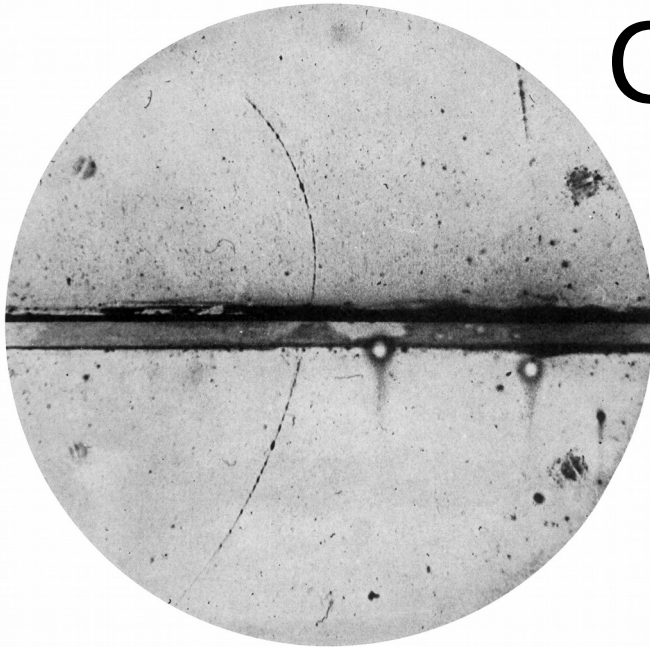
So how do we see them?

(You know one method already)

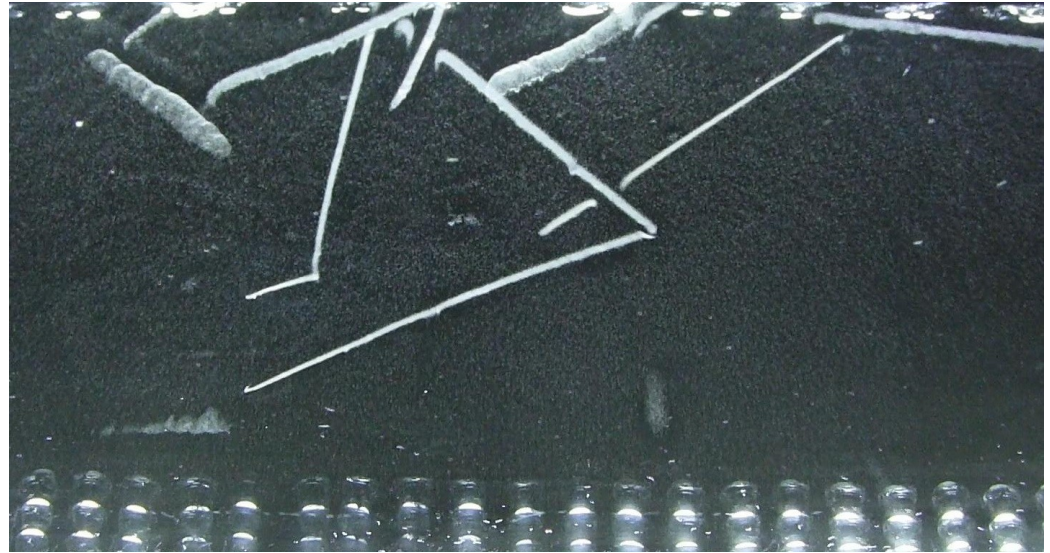
Cloud Chamber

- Super saturated vapor (water, alcohol)
- Charged particle ionizes atoms in path, vapor condenses, creates track
- Portable, experiments carried out in balloons and on mountains
- Magnetic field can allow momentum, charge analysis
- Place lead bar in middle, watch particles interact
- Can ID particles based on track: thickness, etc
- Can see decays
- Discovered: e^+ , muon, K^0 , λ^0 , σ^- , pion

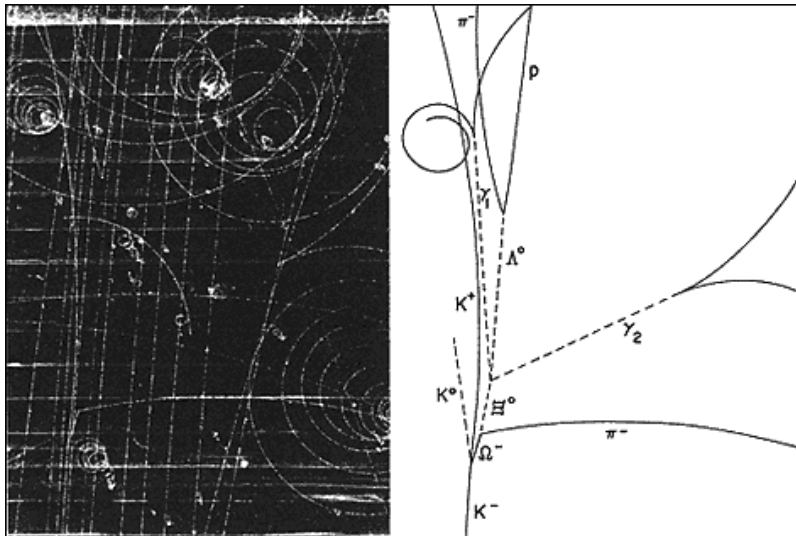
Cloud Chamber



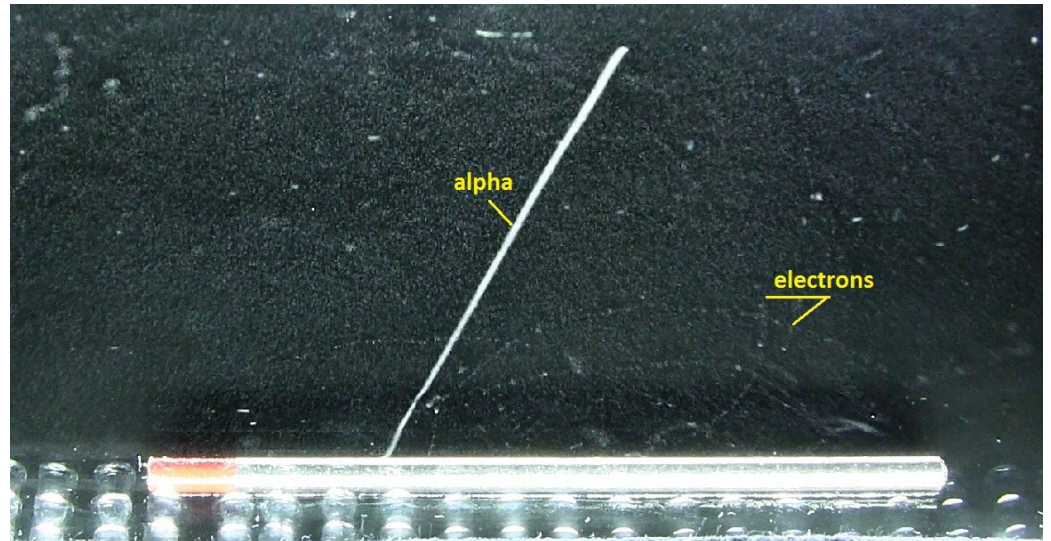
<http://upload.wikimedia.org/wikipedia/commons/6/69/PositronDiscovery.jpg>



[http://upload.wikimedia.org/wikipedia/commons/2/2a/Radon220_decay_in_a cloud_chamber.jpg](http://upload.wikimedia.org/wikipedia/commons/2/2a/Radon220_decay_in_a_cloud_chamber.jpg)



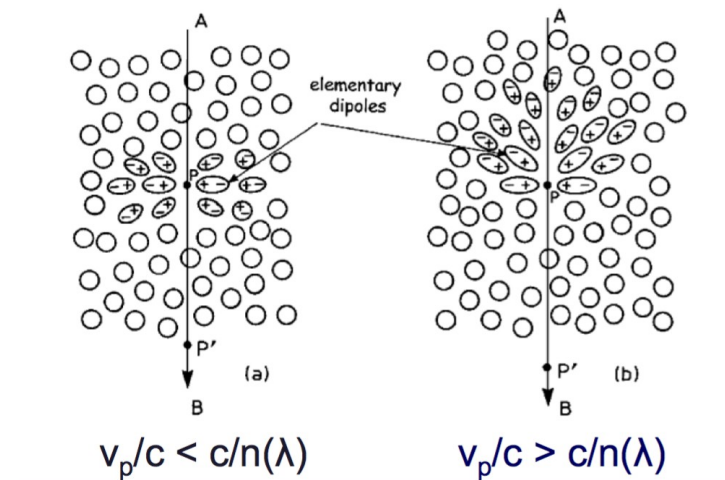
<http://www.pd.infn.it/~dorigo/omega-dia-w.gif>



[http://upload.wikimedia.org/wikipedia/commons/a/ac/Alpha_particle_and_electrons_from_a_thorium_rod_in_a cloud_chamber.jpg](http://upload.wikimedia.org/wikipedia/commons/a/ac/Alpha_particle_and_electrons_from_a_thorium_rod_in_a_cloud_chamber.jpg)

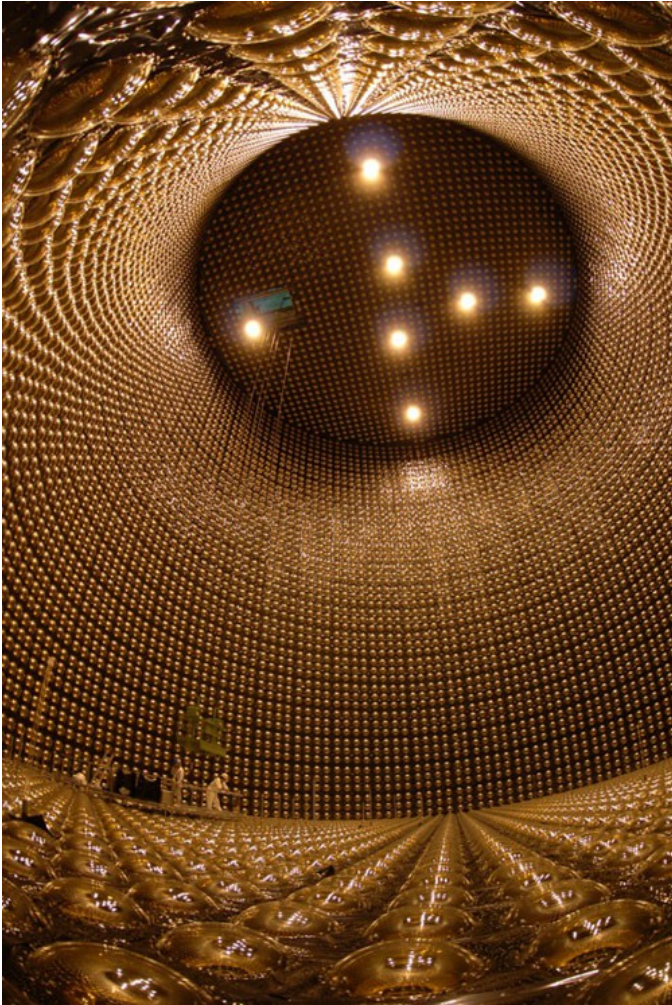
Cherenkov Radiation

- When charged particle passes through medium **faster than the speed of light in that medium**
- Kind of a sonic boom for light
- The particle **polarizes** the media
- Oscillating dipoles radiate (usually visible) light
- Good materials:
 - Transparent
 - Dielectric
 - Lead glass, aerogel, water, etc
- Detect the light (Super Kam)

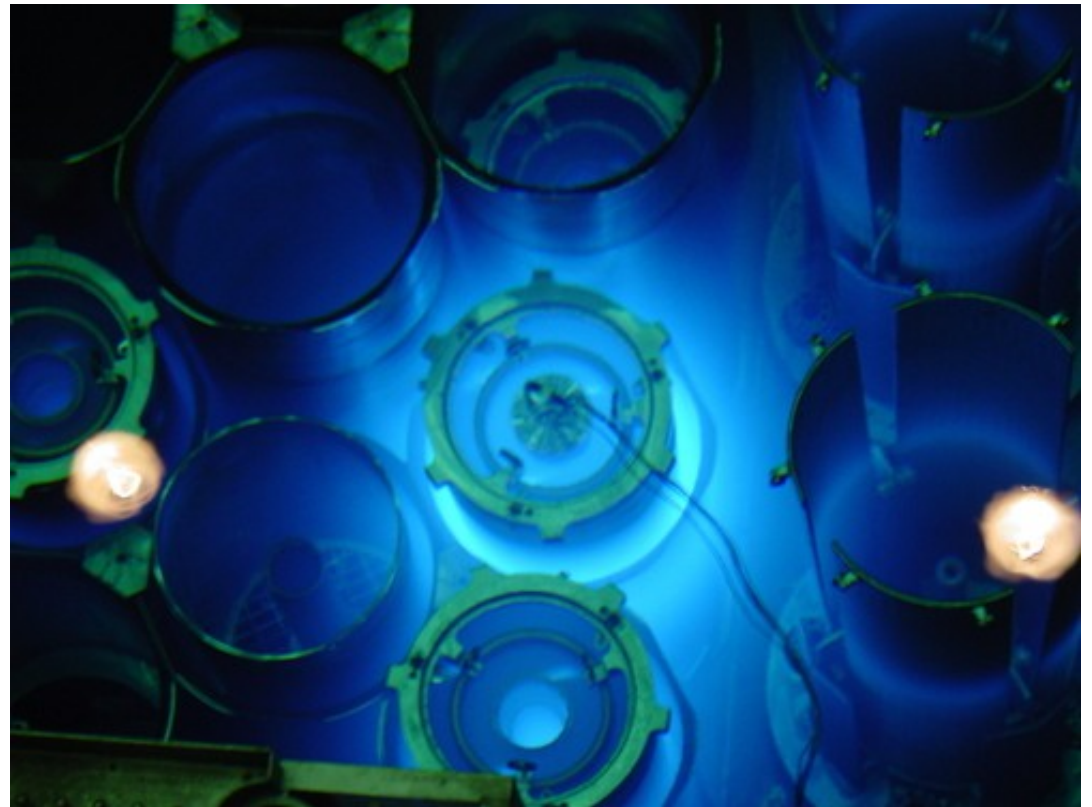


<https://indico.cern.ch/event/318429/material/slides/0.pdf>

Cherenkov Radiation



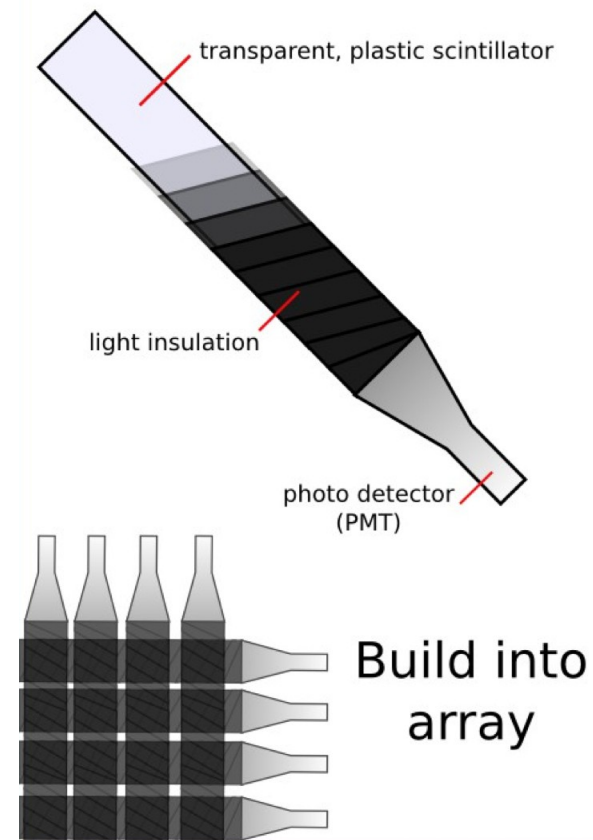
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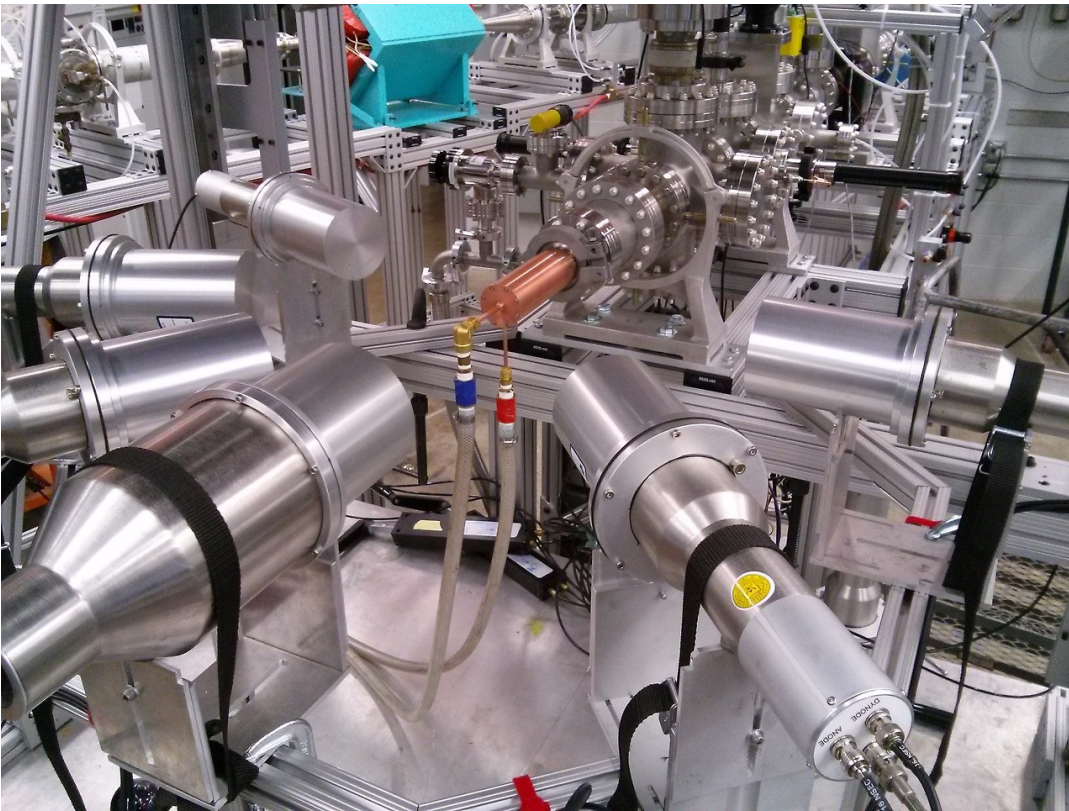
http://images.ookaboo.com/photo/m/HFIR_Gamma_Blue_Glow_m.jpg

Scintillation

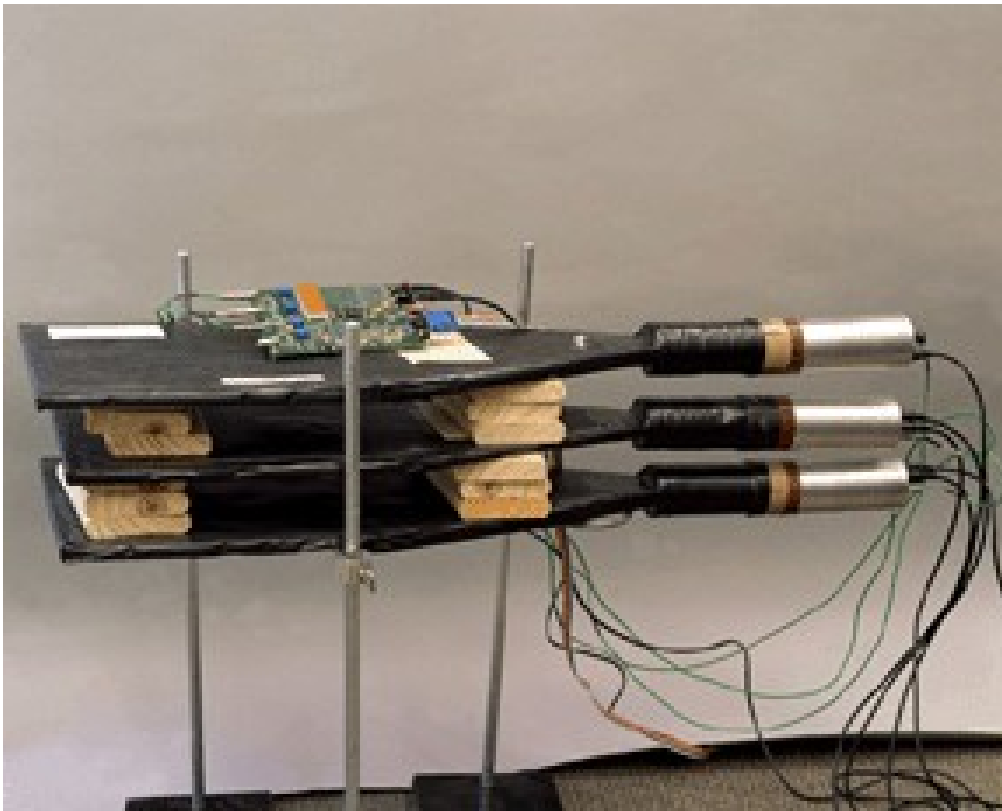
- Charged particle passes through medium
- Excites electrons in medium
- Detection transition radiation
- Photons are detected with photomultiplier tube (PMT)
- Use either
 - a large liquid mass
 - Strips of transparent ig plastic, glass, crystal
- Use to search for:
 - Dark matter – DM decays, produces ionizing radiation
 - Neutrinos – neutrino creates electron, which ionizes media



Scintillation



Liquid Scintillators

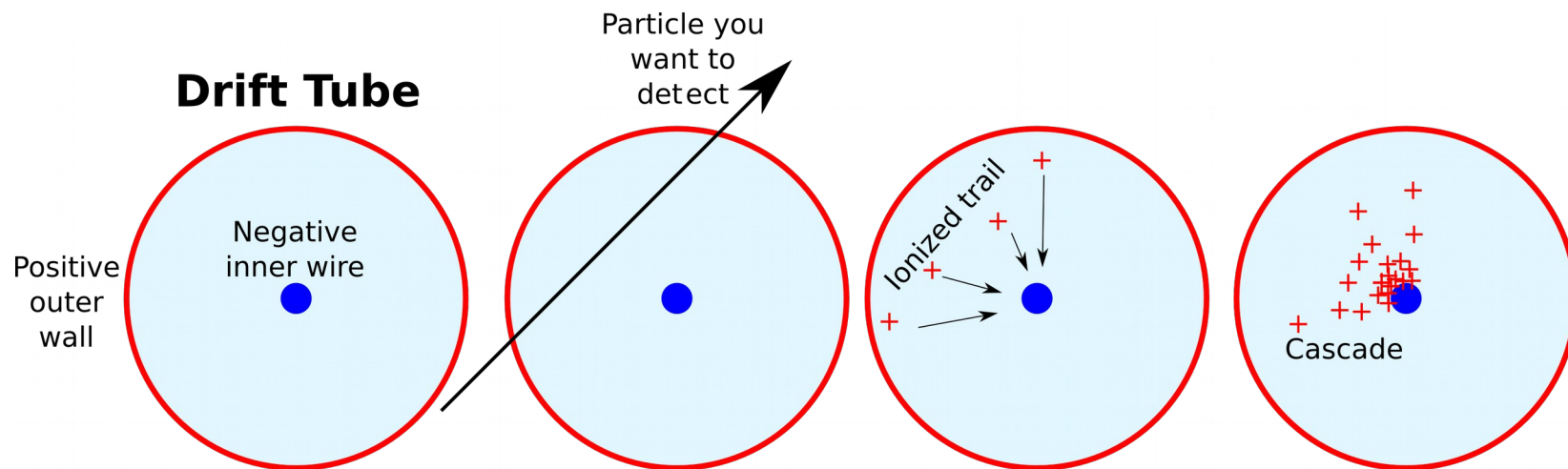


<http://quarknet.fnal.gov/toolkits/new/graphics/muoncount.gif>

Plastic Scintillators

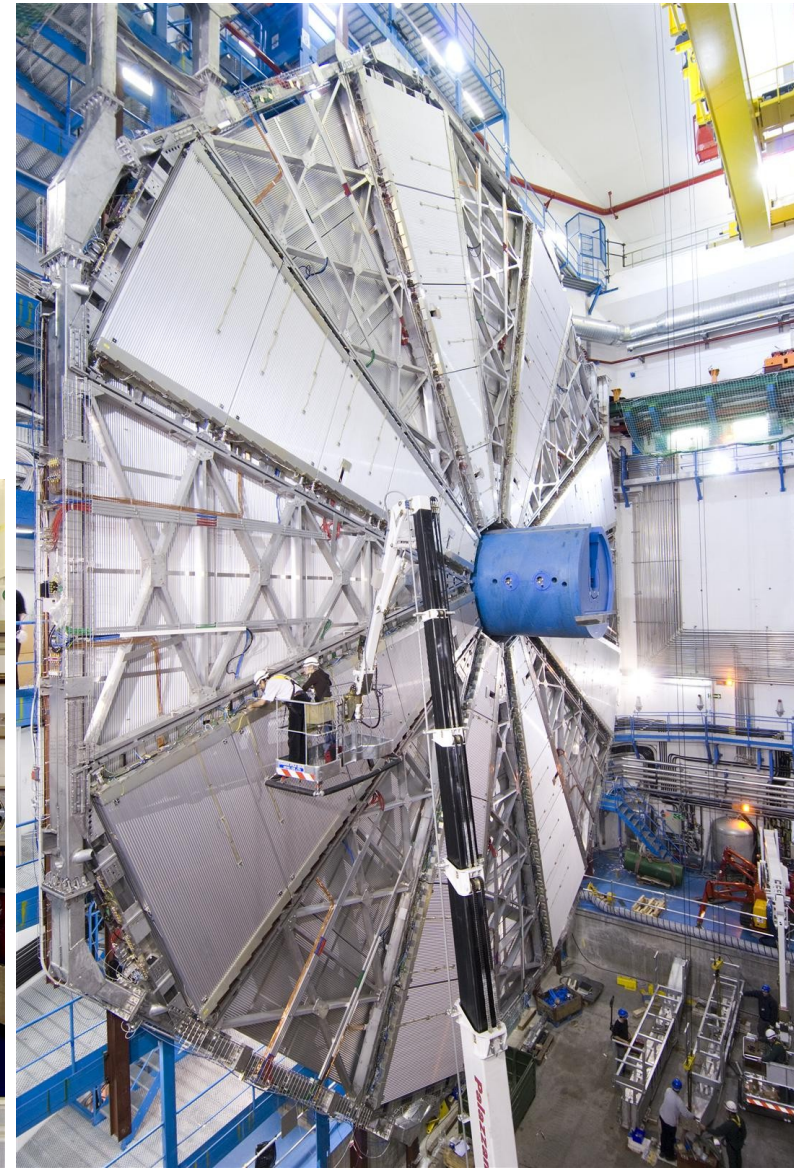
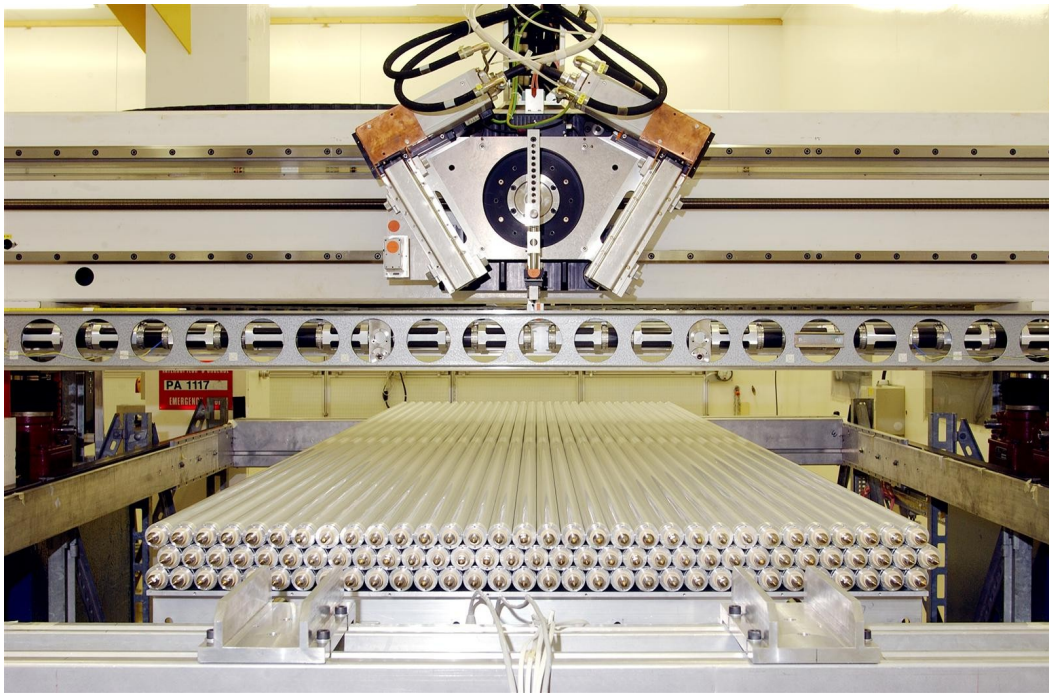
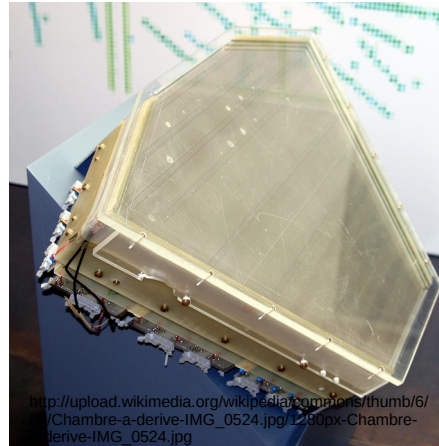
Drift Chamber

- Charged particles ionize gas in chamber
 - Remember ions are electrically **positive**
- Strong electrical field pulls ions towards a wire
- As ion moves towards wire, speeds up and ionizes more gas
- Ions hit wire, detected by electronics



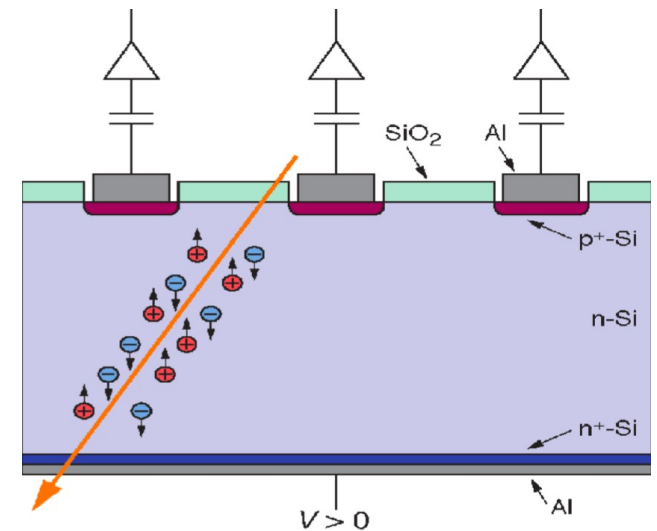
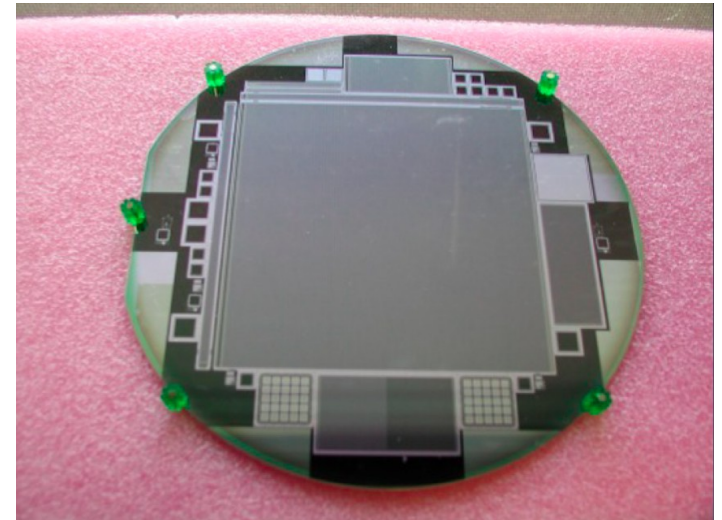
Drift Chamber

- Many configurations of same principle
 - Box with many cross-hatched wires
 - Tubes with a single wire
 - Plates – resistive pad chambers

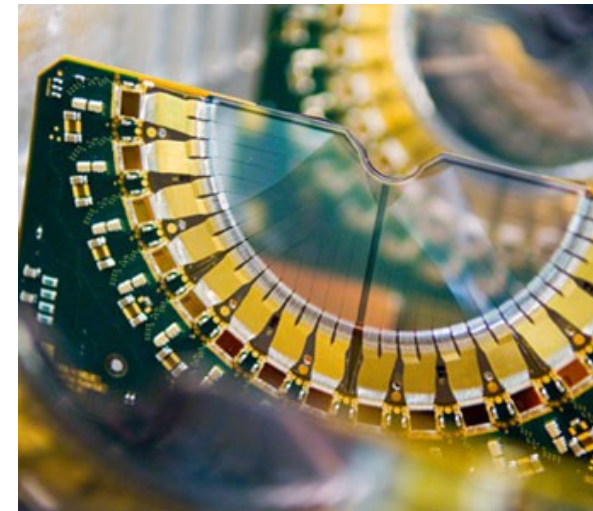
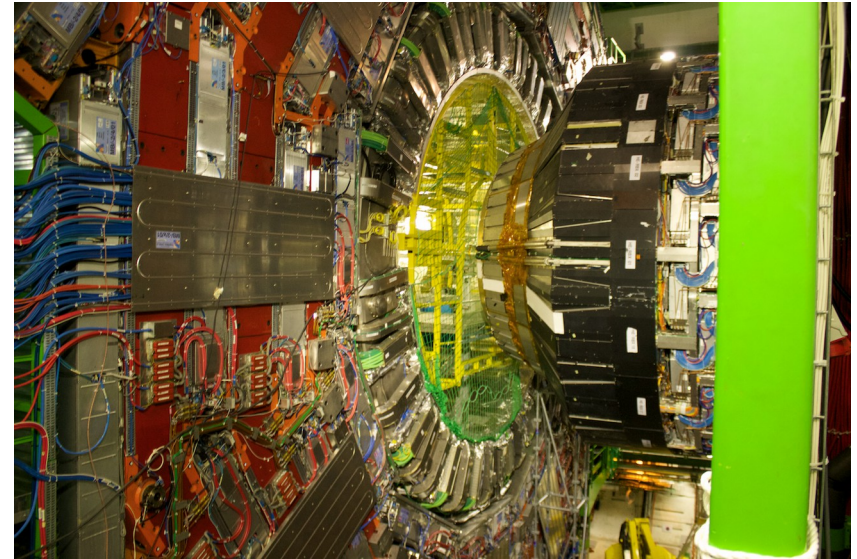
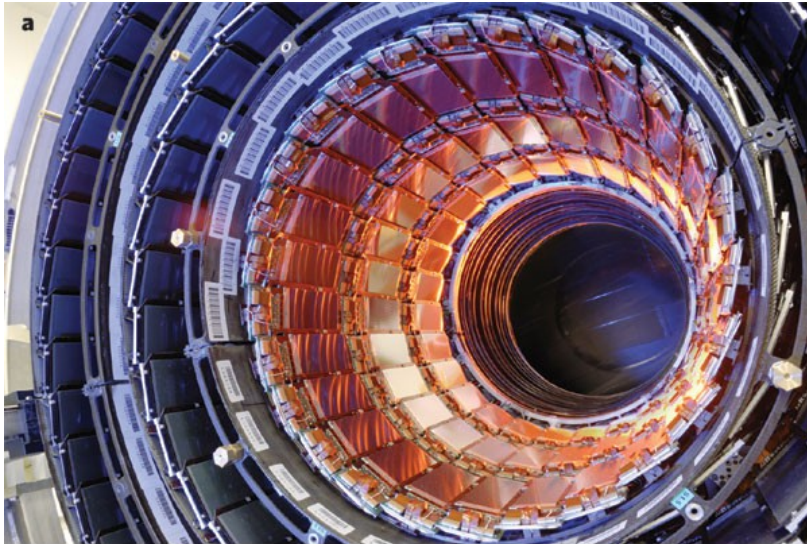


Silicon

- “We have all these computer chips, can we use them to detect particles?
 - **Yes**
- Silicon detectors use the same manufacturing used make a CPU to make microscopic particle detectors
- Very good for precise, high resolution particle tracks



Silicon

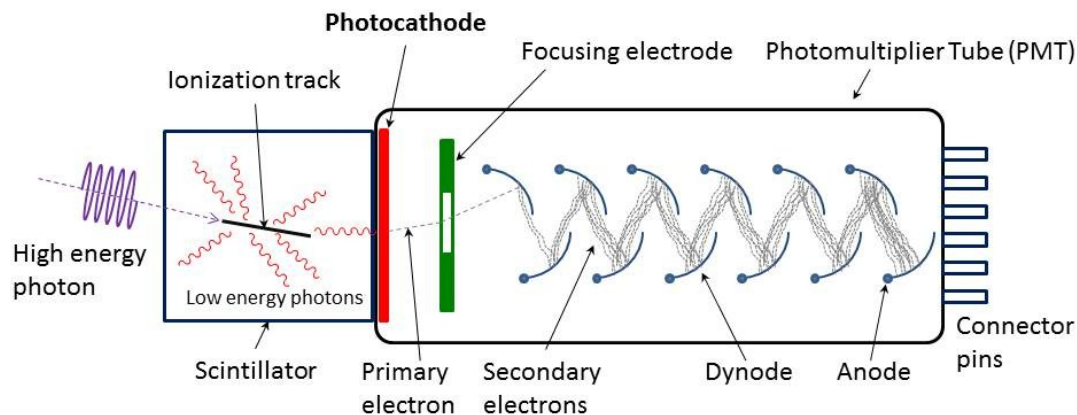


<http://www.nature.com/nature/journal/v448/n7151/images/nature06078-f2.2.jpg>

<http://www.liv.ac.uk/particle-physics/Velo-340x300.jpg>

Photomultiplier

- Detects individual photons



<http://upload.wikimedia.org/wikipedia/commons/5/5f/PhotoMultiplierTubeAndScintillator.jpg>

ro-optics : detector modules

Components

Modules

CS

Meters

Section

al

Hamamatsu Photomultiplier Tube Modules



- Wide Spectral Response
- Fast Time Response
- Low Dark Noise
- High Sensitivity

Photomultiplier Tube (PMT) modules combine a PMT with a high voltage and often other signal processing electronics. A variety of PMT modules is available which differ in output signal format (current or voltage), spectral response, amplifier gain and bandwidth, as well as the size of the active area. 8mm Voltage and Current Output types feature 8mm head-on photomultiplier tubes, 1V/ μ A 20kHz low noise amplifiers, and can be fiber-coupled using #57-567 SMA Adapter or #57-568 FC Adapter. 8mm Current Output types feature low ripple noise and fast settling times. 15mm Voltage Output types feature 15mm head-on photomultiplier tubes and 0.1V/ μ A 200kHz amplifiers. #5 x 20mm Current Output type is a high gain (10^7) PMT module suitable for broadband spectrophotometers and other precision photometric instruments. Rectangular active area PMT modules deliver high sensitivity with gains $\geq 10^7$ and fast response times. The recommended power supplies for the PMT modules are #57-987 or #84-956.

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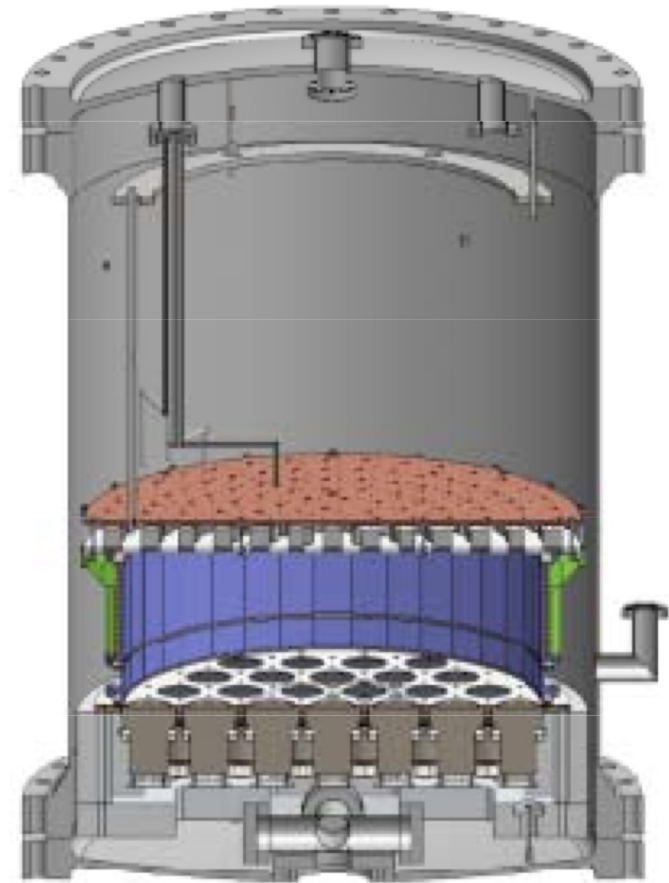
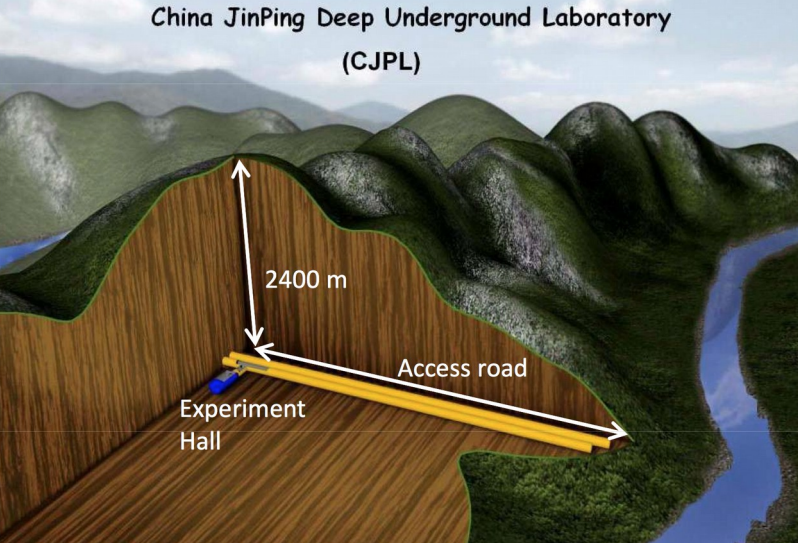
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