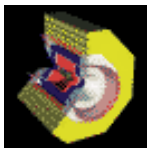
BTEV / CO



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Particle Detectors

Thomas Coan

SMU

- What to detect?
- How to probe?
- What is a “detector?”
- Putting it all together
- Some examples

BTEV Co

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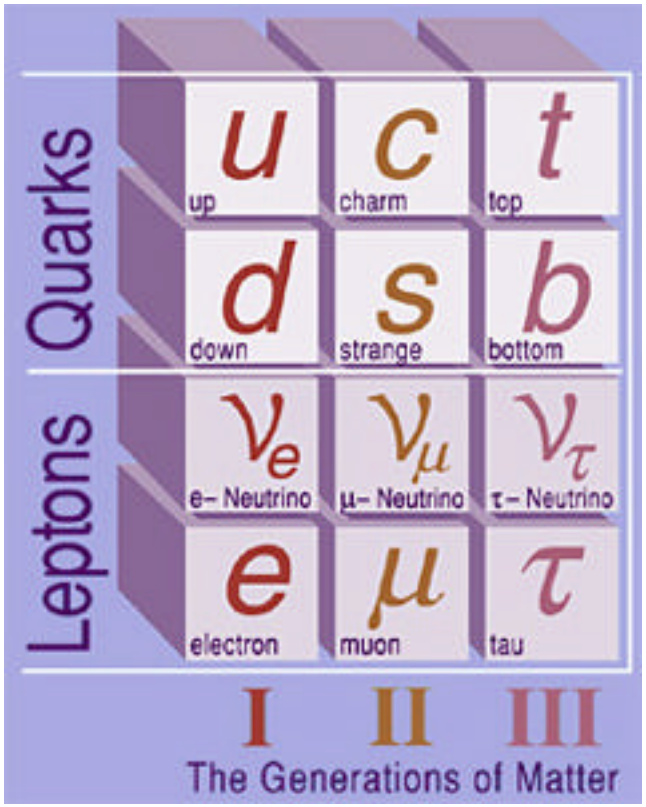
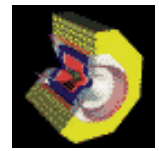
Particle Properties

- mass
- lifetime
- electric charge
- ”spin”





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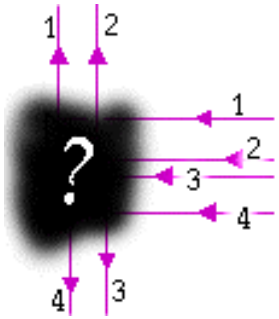
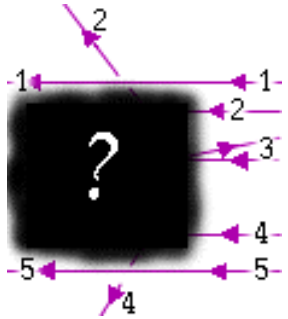
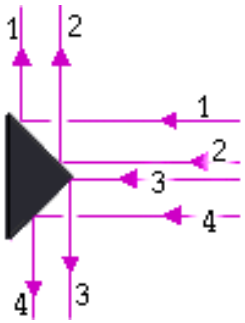
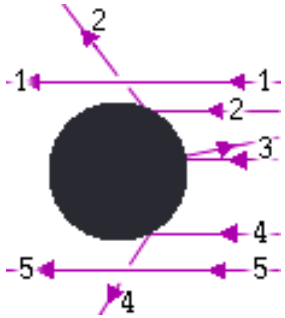
General Idea of Colliding Particle Experiments

- Collide probe particles with target
- Detect particles from collision
- Interpret results









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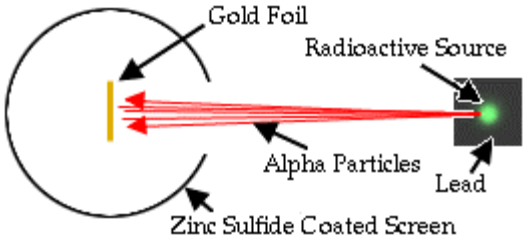
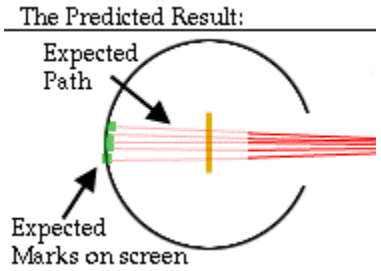
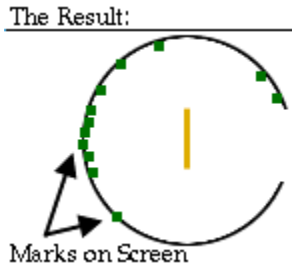
Early Particle Physics Experiment

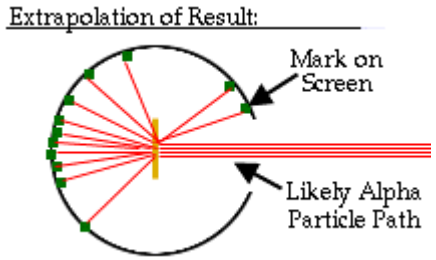
Ernest Rutherford 1909

Set-up:

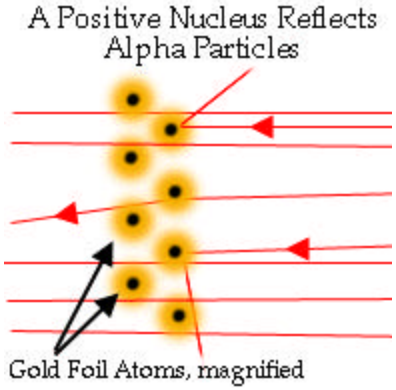






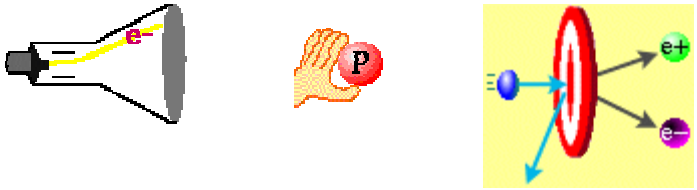


Interpretation:

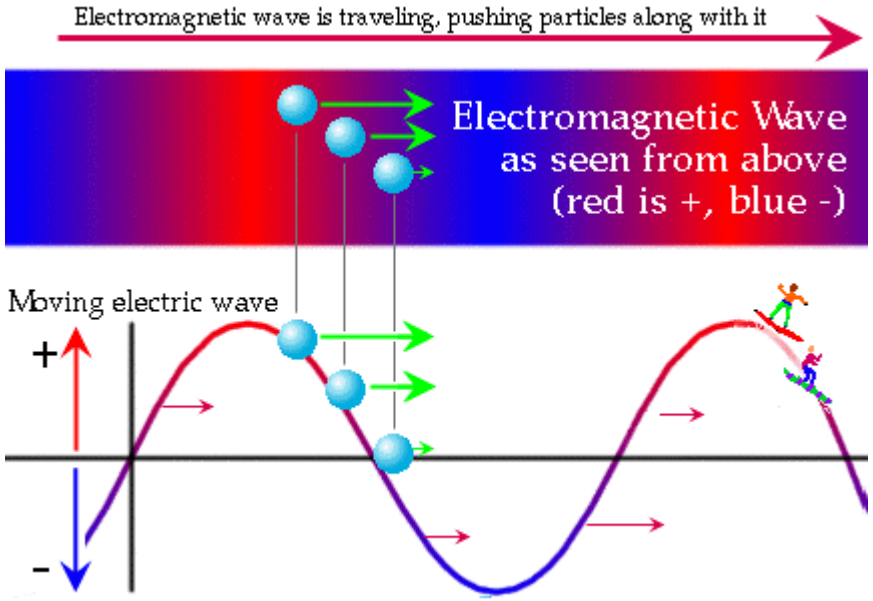


How do we "shoot" probe particles?

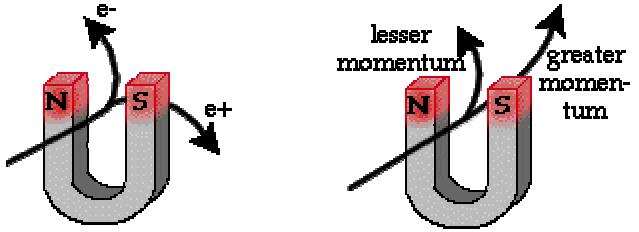
- Acquire some probe particles



- Accelerate the probe particles
  Final speed ~ c



- Steer and aim the probe particles



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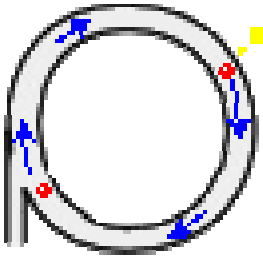
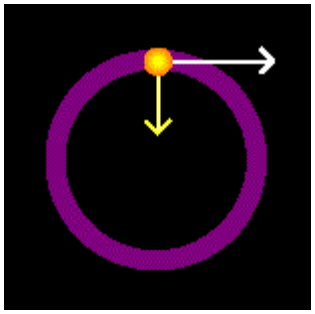
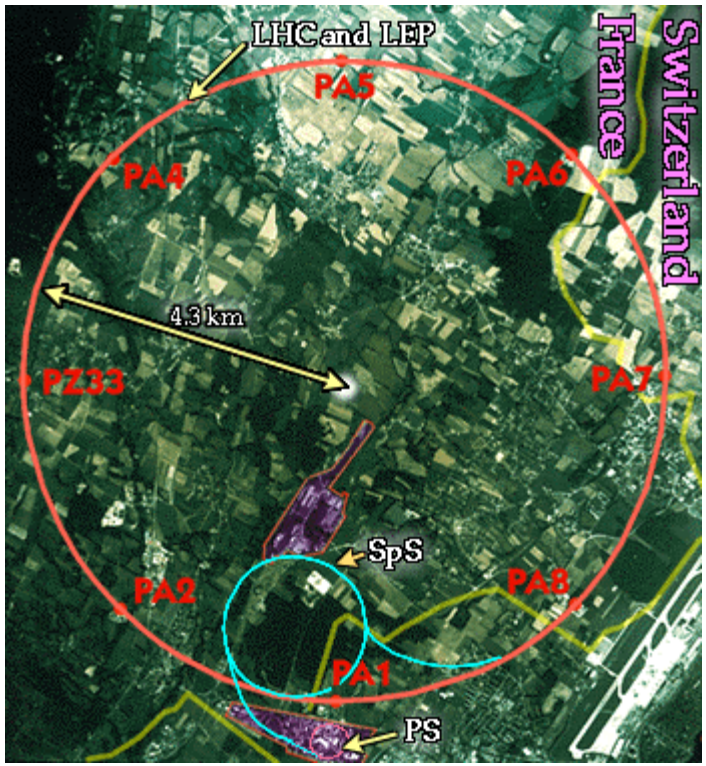
Accelerator Types

Circular



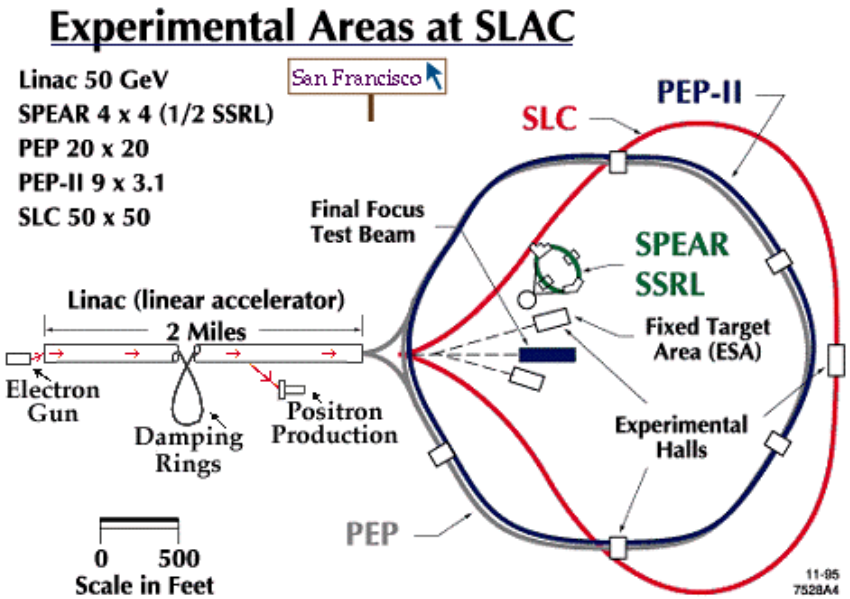


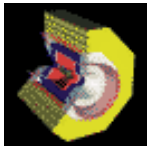


Accelerator Types

CLEO

Linear





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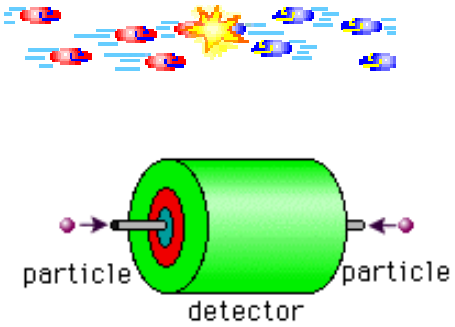
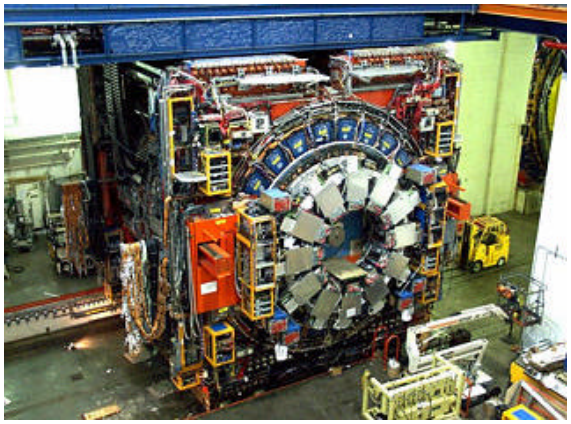
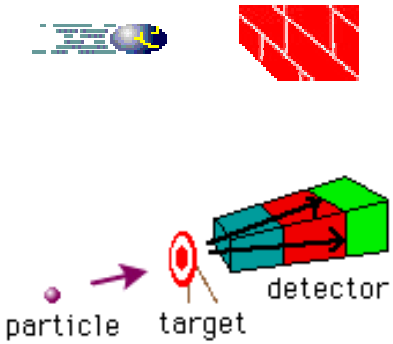
Target Types

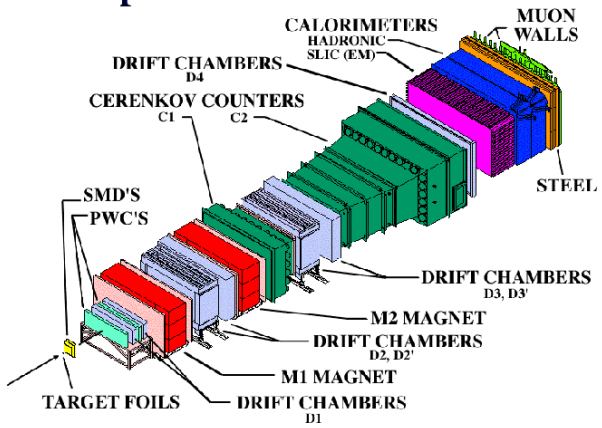
Colliding beam





Fixed target





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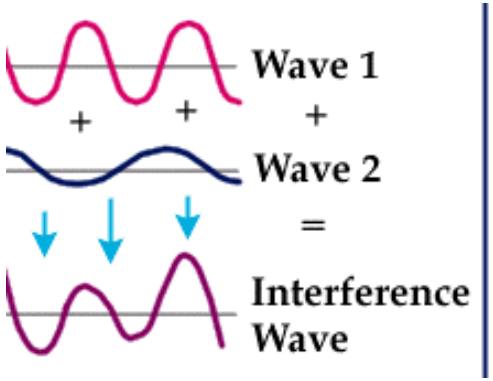
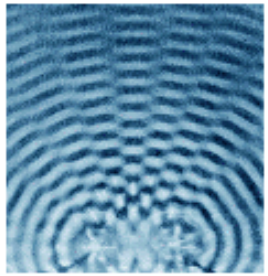
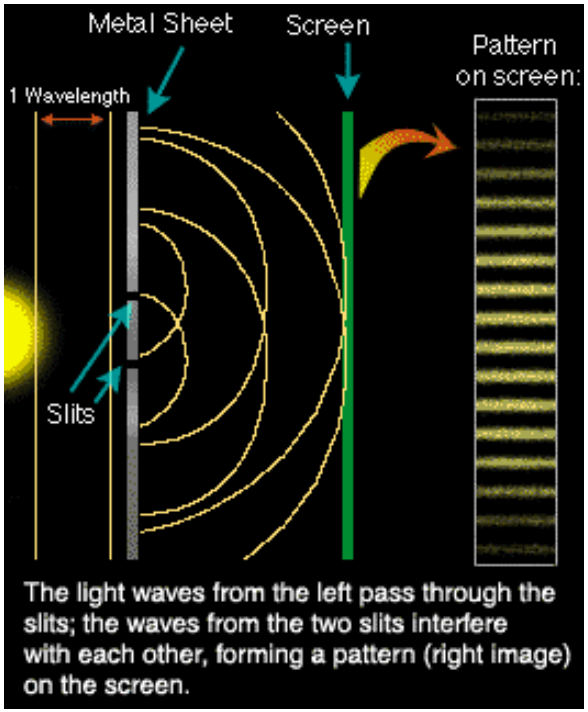
Wave Nature of Particles

Waves interfere:

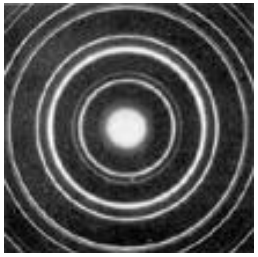


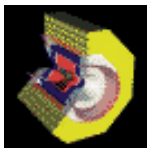


The interference of water waves coming from two sources.



Electron diffraction: particle as wave





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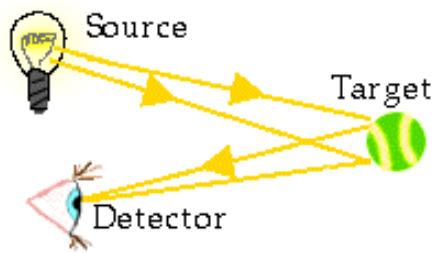
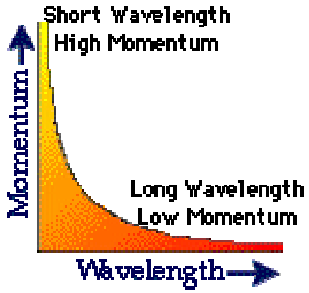
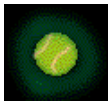
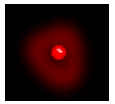
Why use higher and higher energies?

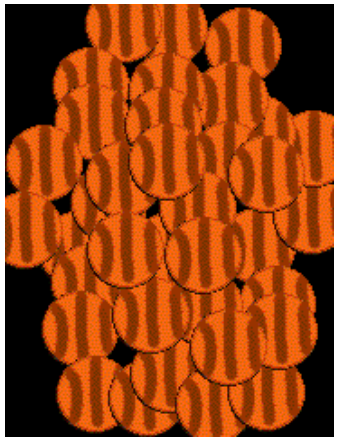


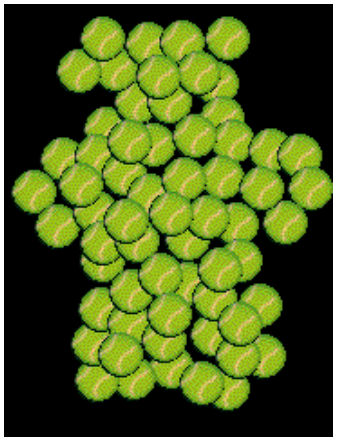
$\lambda = h/p$

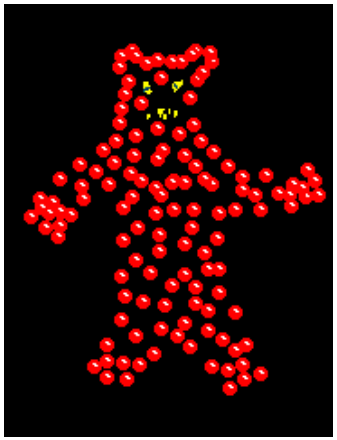






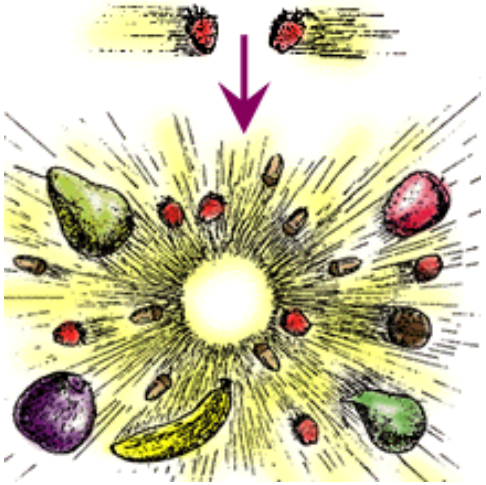


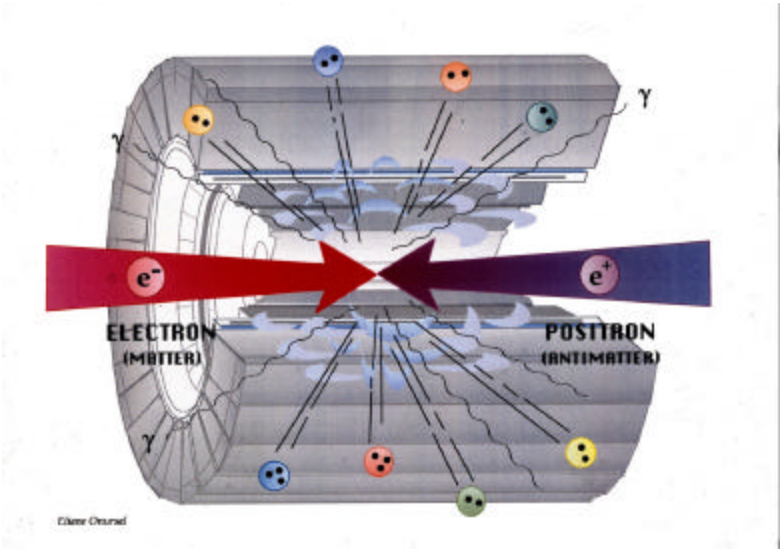


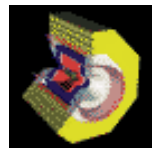


∴ The more energetic the probe, the finer the accessible detail

Collide







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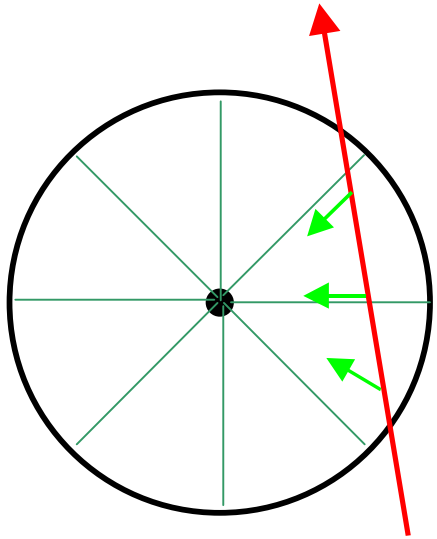
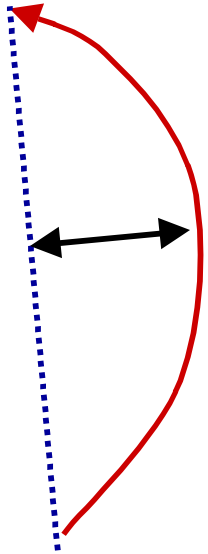
Trajectory measurement

- Charged particle
- Noble "fill gas"
- Electric field
- Drifting ionized e-



∴ "Drift time" ⇒ DOCA

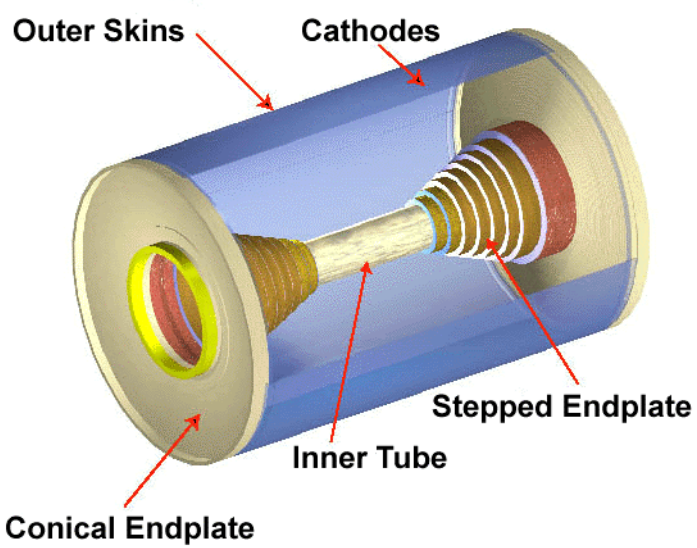


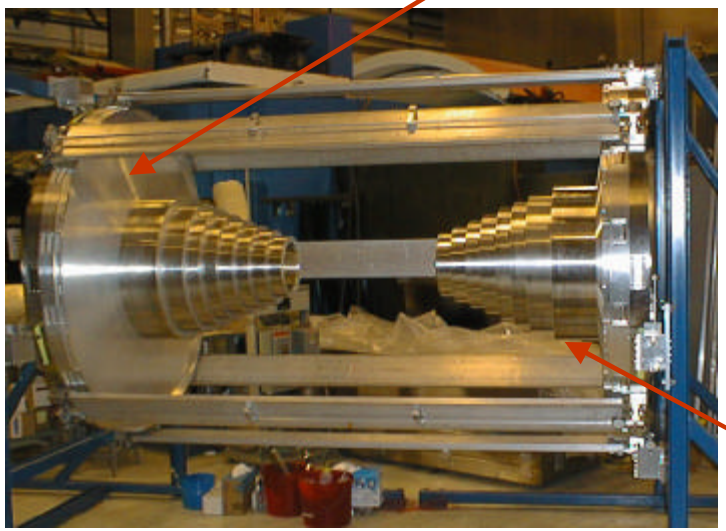
Magnetic field curves trajectory

"curvature" ∝ 1/p

CLEO Drift Chamber

CLEO

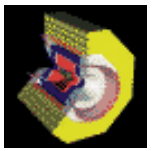




31 stereo layers
8100 cells

16 axial layers
1696 cells

BTEV / Co



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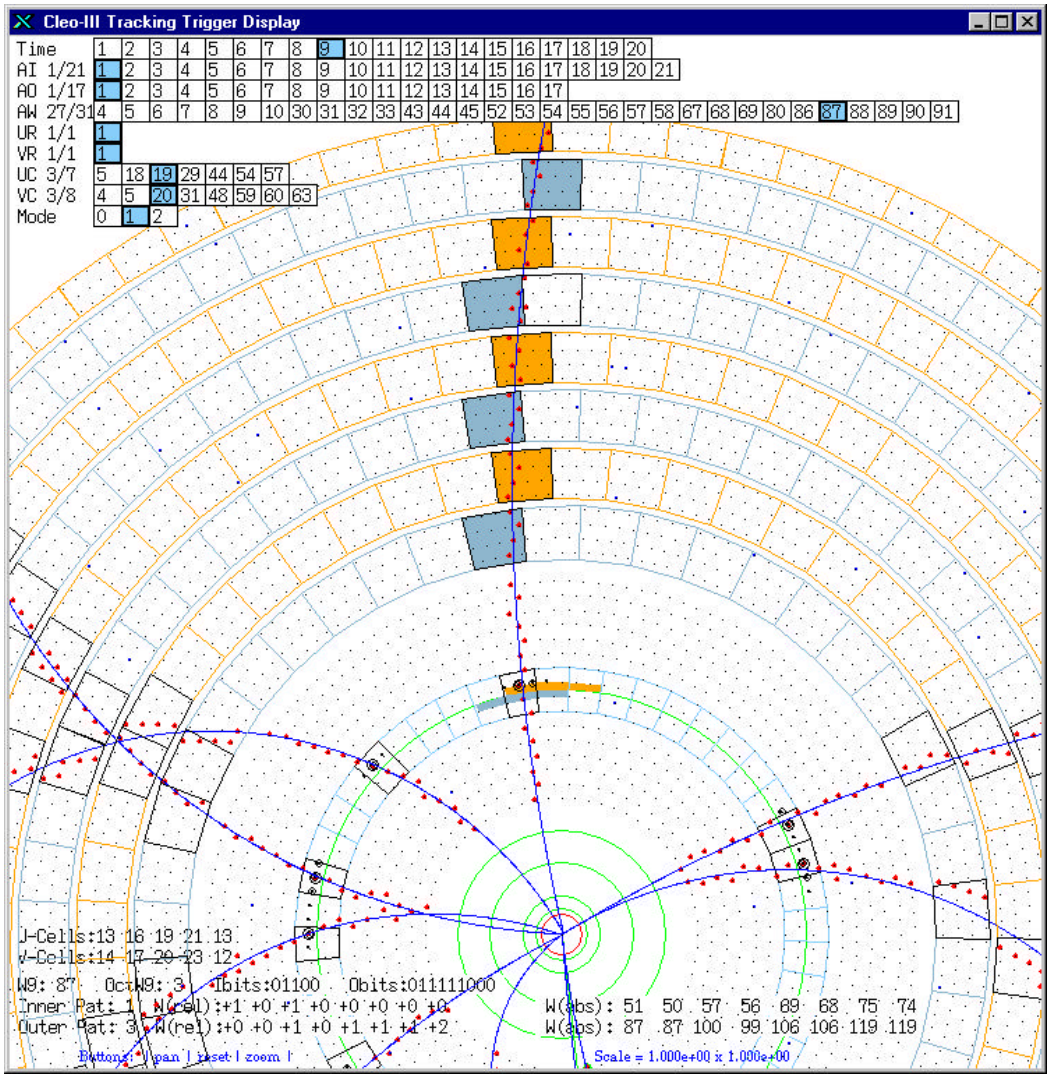
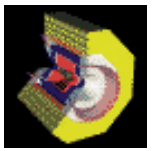
CLEO Drift Chamber





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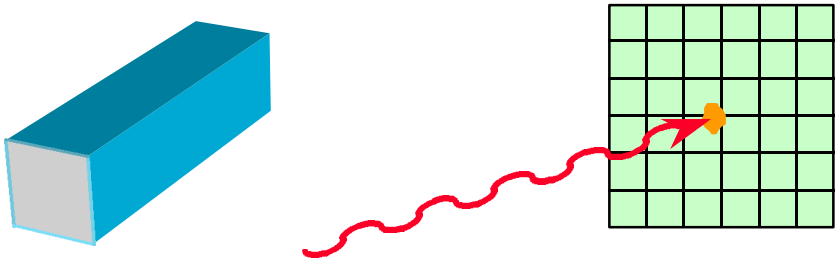
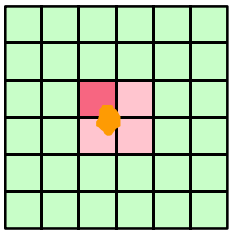
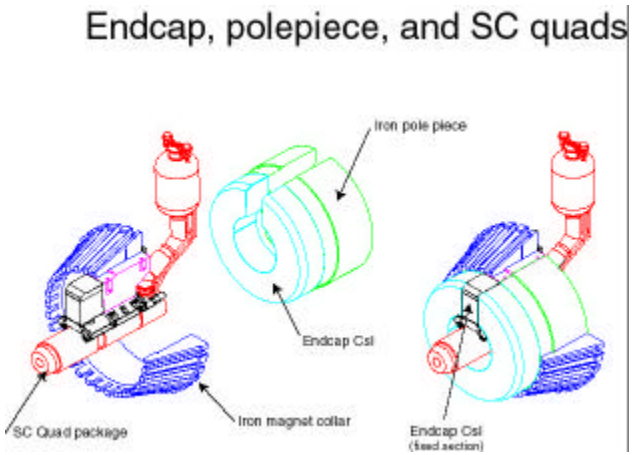
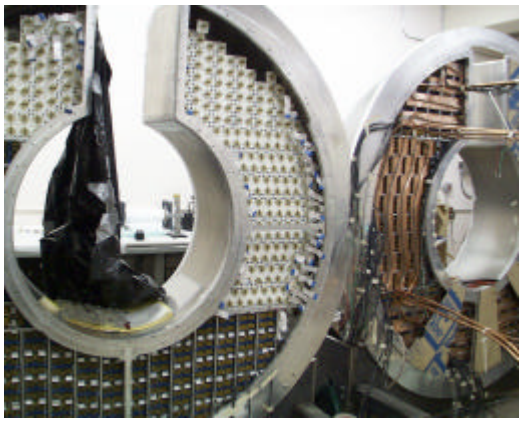
CLEO Calorimeter

- Measure particle energy (plus position and flight path angle)
- Good for charged and neutral particles
- Particles deposit energy in dense, transparent medium
- Medium produces light, proportional to particle energy



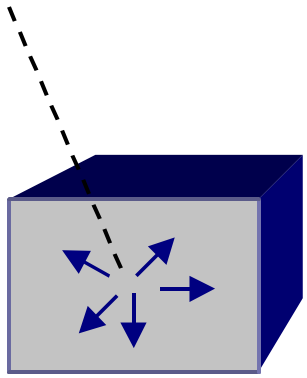




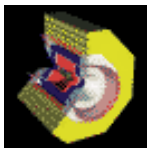


Scintillation

- Complicated phenomenon
- Basic idea: convert particle kinetic energy into light



- Amount of light proportional to particle energy
- Light emission is prompt: scintillators useful as timers
- Scintillators used mostly w/ charged particles



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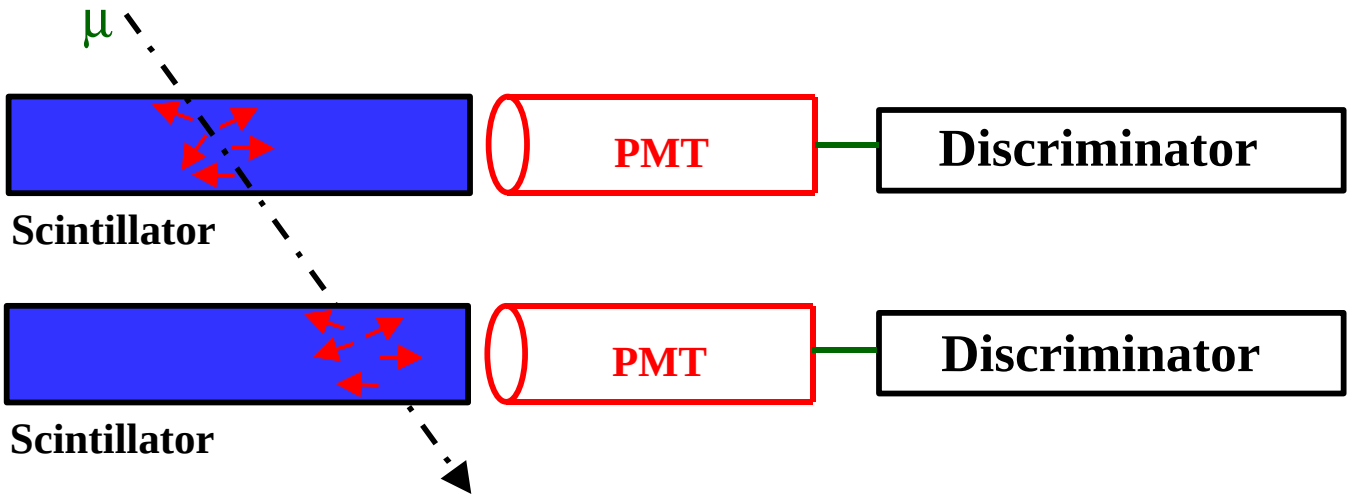
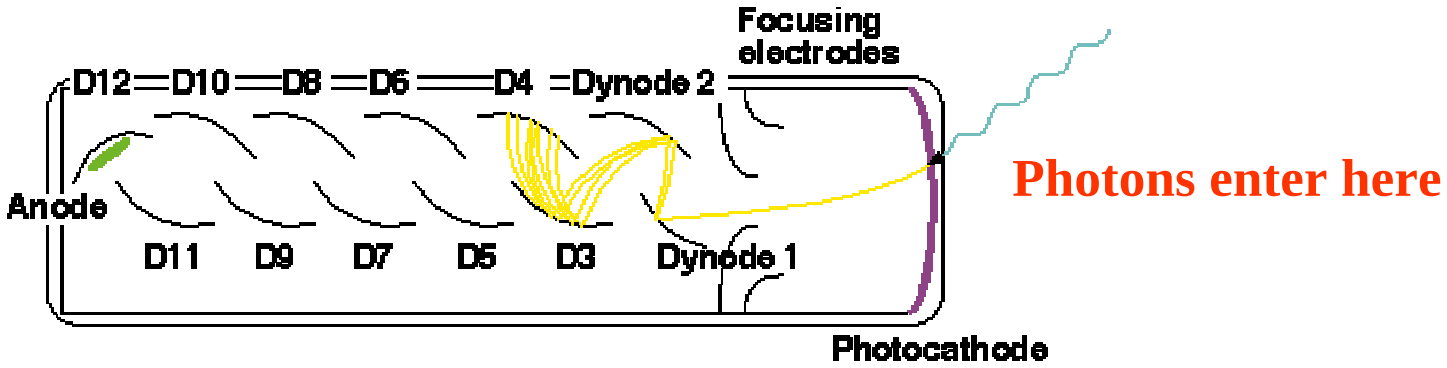
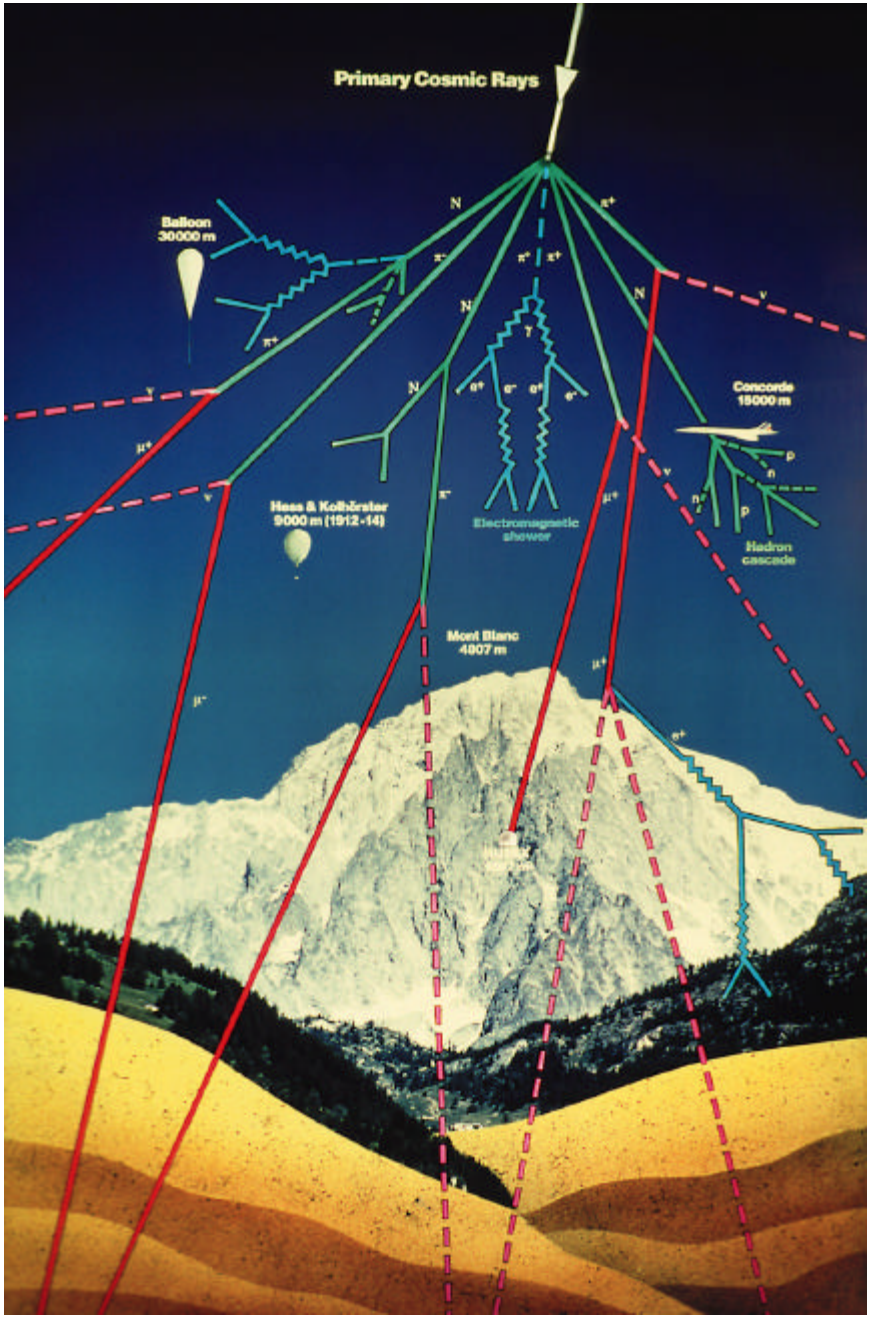
Sea-level muon detector

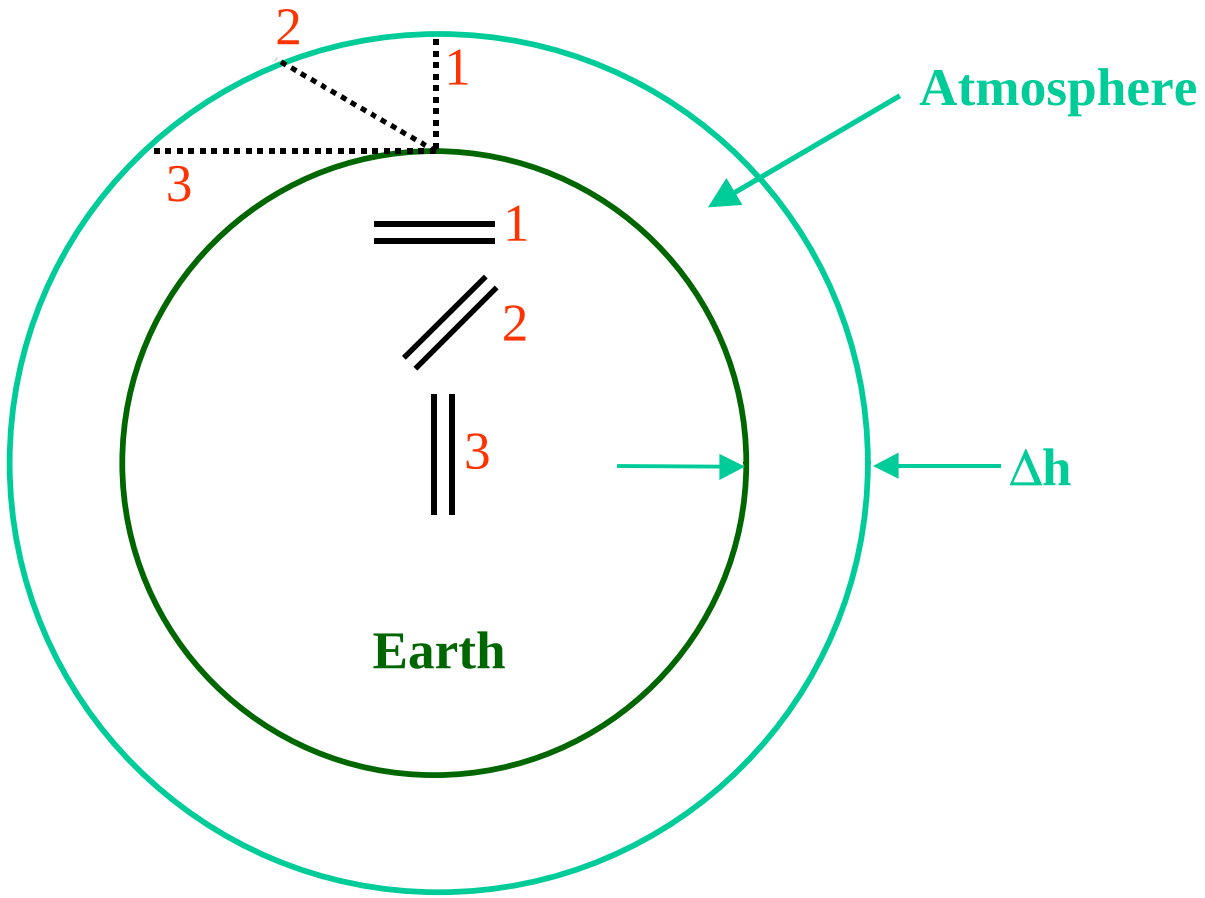




Photomultiplier tube (PMT)


Primary Cosmic Rays
Balloon
30000 m
Hess & Kolhörster
9000 m (1912-14)
Mont Blanc
4807 m
Electromagnetic
shower
Concorde
15000 m
Hadron
cascade

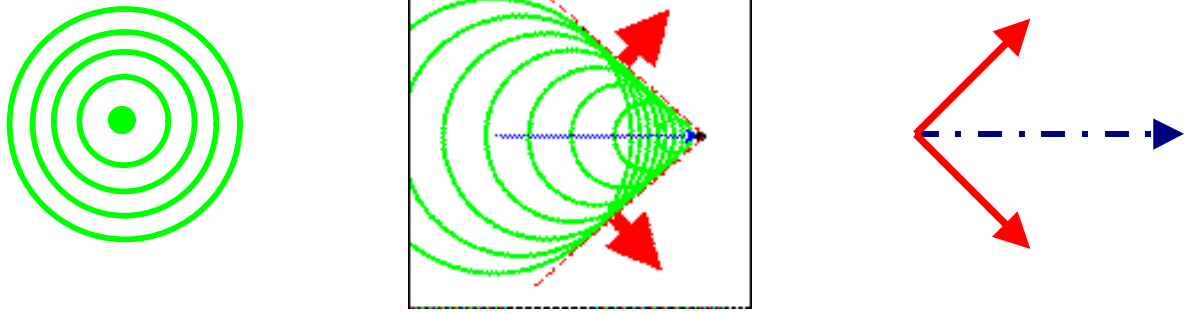
Determine production height of muons



- Sea level μ flux depends on pathlength from production point
- Changing telescope angle changes pathlength
- Flux change ⇒ production height Δh

Cerenkov Radiation

- Emitted by charged particles only
- Emitted only when particle's speed in medium exceeds that of light's
- Pattern of light has cone-like shape:



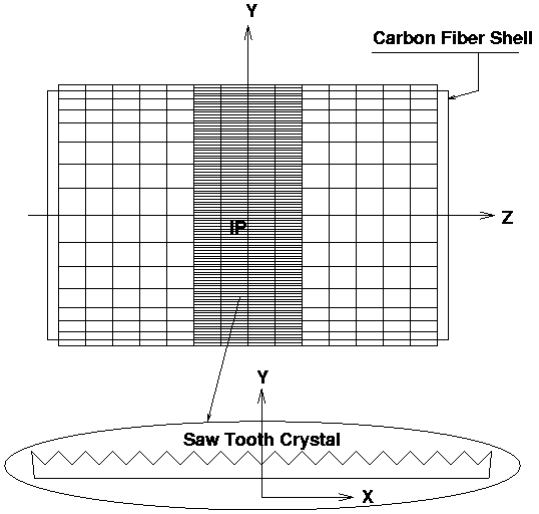
- Particle's speed determines shape of cone
- Cerenkov detectors measure particle speed

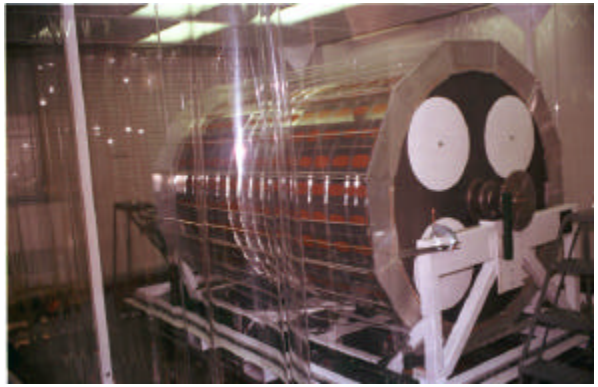
☛ Particle momentum (mv) and speed (v) ⇒ mass

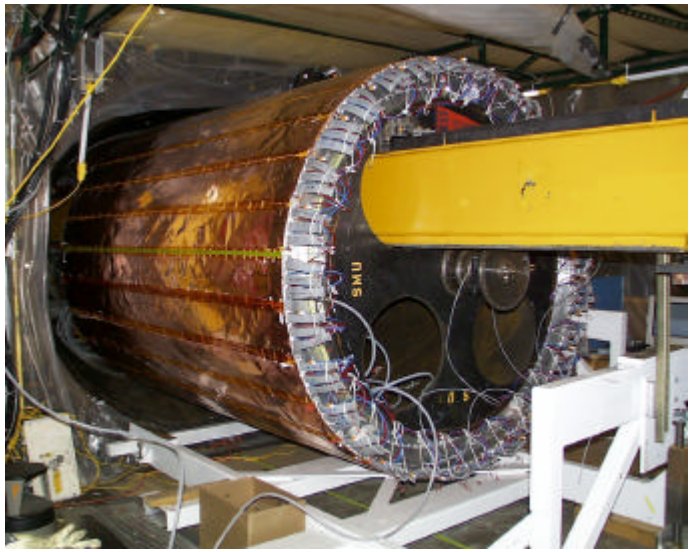
Cerenkov Radiation

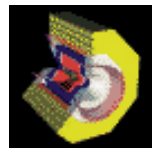
CLEO

Cerenkov radiator built here at SMU for CLEO









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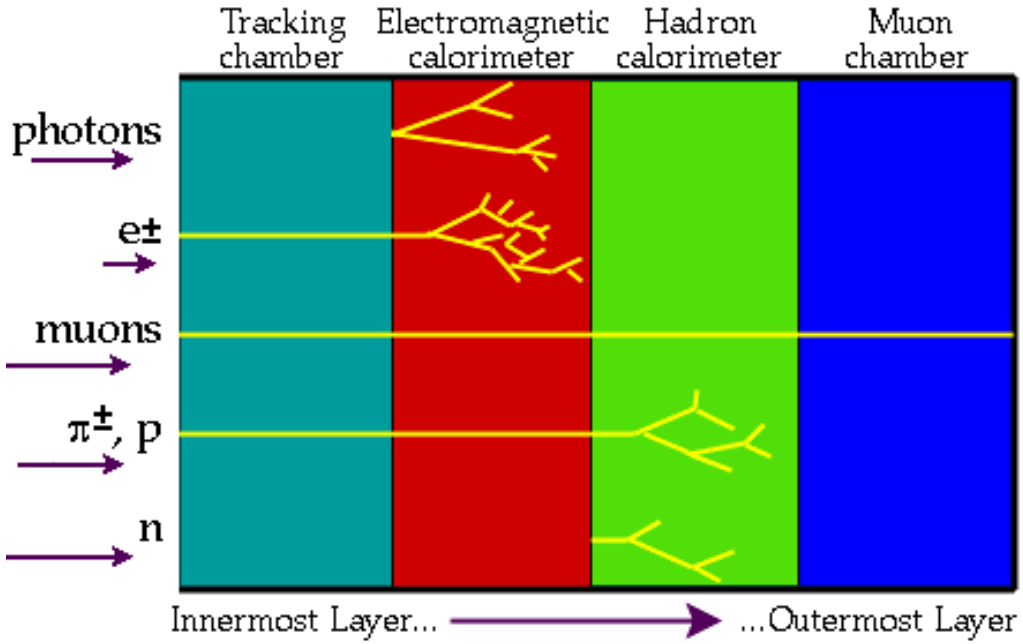
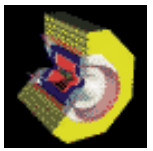
Particle "Fingerprints"





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Russian Dolls

(Anna Kournakova?)