Jef Wagner
Nuc Particle Talk
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Intro
*Particle Decayrates and Scattering Cross Sections
*By Jef Wagner

Outline
*Decay Rates
**Multiple Decay Modes
**Theoretical Calculation
**Experimental Measurement
**Setup of Muon Measurement
*Scattering Cross Sctions
**Theoretical Calculation
**Experimental Measurement

Decay Rates
*Probability of a particle decaying
*Heavy Particles Decay into lighter ones
** Muon-> Electron + anti electron neutrino + muon neutrino
*The time of decay is not always the same
*particles have no memory (time until decay does not depend on how long it's been alive)
*If probablity of decay is constant (in the particles rest frame) Sets up differntial equation
*Gives us the equation N(t)=N_0 e^(Gamma t)

Theoretical Calculation
*Use Feynman Diagram for each decay mode, calculate Amplitude
*Use the "Golden Rules" to calculate decay rate for each mode
*Can then calculate total decay rate or Branching Ratios

Expermental Measurement
*Cannot make the measurement from a single particle
*Start with very large number of particles, and measure the number of decays per time
*Measure the lifetimes of many particles put them into bins, match to a exponential

Muon Lifetime Experiment
*typical juniorlab experiment
*Use Cosmic Ray Muons
*Stop them in a scintillator
*Detect the arival and decay with a photomulitplier tube
*Measure the time with a electronic timer
*Many Small details

Cross Sections
*Probabitly of Particles Interacting
*Given as an area (often in the units of a "barn" or 10^-24cm)
*#N of events / time = Crossection * Luminosity
*Detail physical Explanation of what the cross section and differential cross section are
*Hard Sphere scattering example
*Different cross section for each scattering possiblity
*cross section depend upon energy (velocity)
*bumps in the energy vs. cross section curves can indicate short lived partcles
**Example of the Hyperbion and the Top Quark

Theoretical Calculation

*Use feynman Diagram to calculate Amplitude M
*Use Fermi's Golden Rule to calculate crosssections
*Use those results in a monty carlo simpulation to get a sweep of # of events in certain energy ranges

Expermental Measurement
*Use incident beam of particles with known luminosity onto startionary target, Measure #N of events
**Similar to Neutrino observations in the large underground water tanks
*colide two beams of particles, measure the everything you can at all angels. Use the patterns of what comes out to descibe certain events.
** Example a modern particle collider

Works Cited:
Griffiths, David "Introduction to elementary particles"
Bugel, Leonard "Measuring Particle Lifetimes"
Nave, Carl R. "Hyperphysics"

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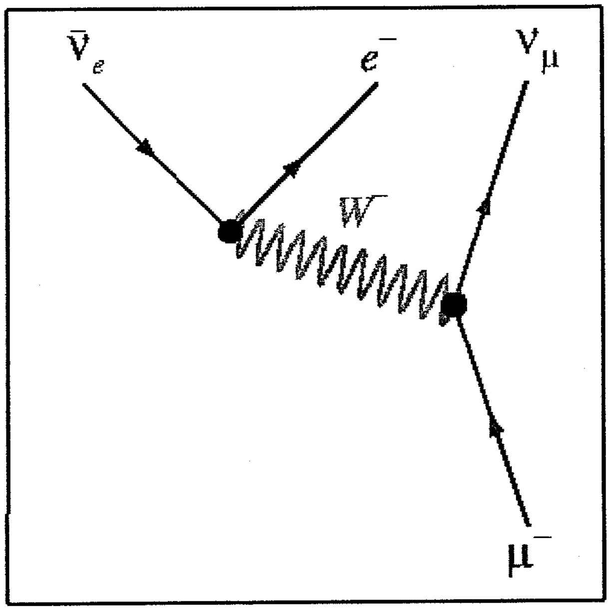
Muon Decay



feynman diagram of a muon scattering event.

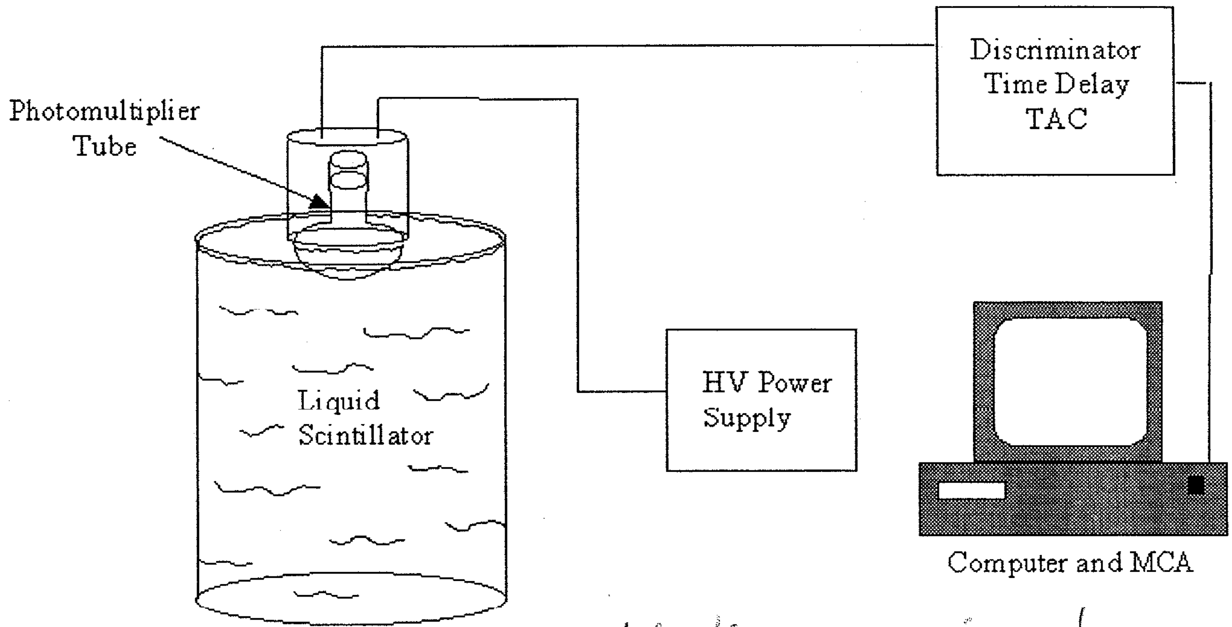
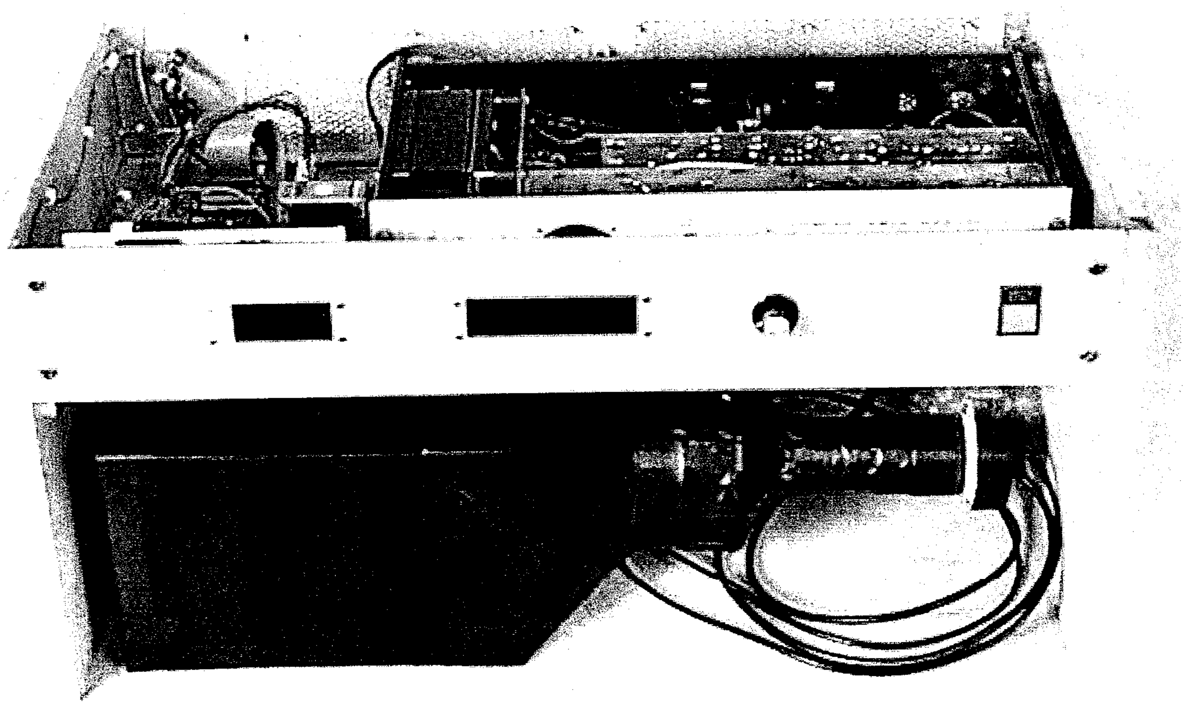


Diagram of the muon life time experiment.



Picture of the experimental apparatus.

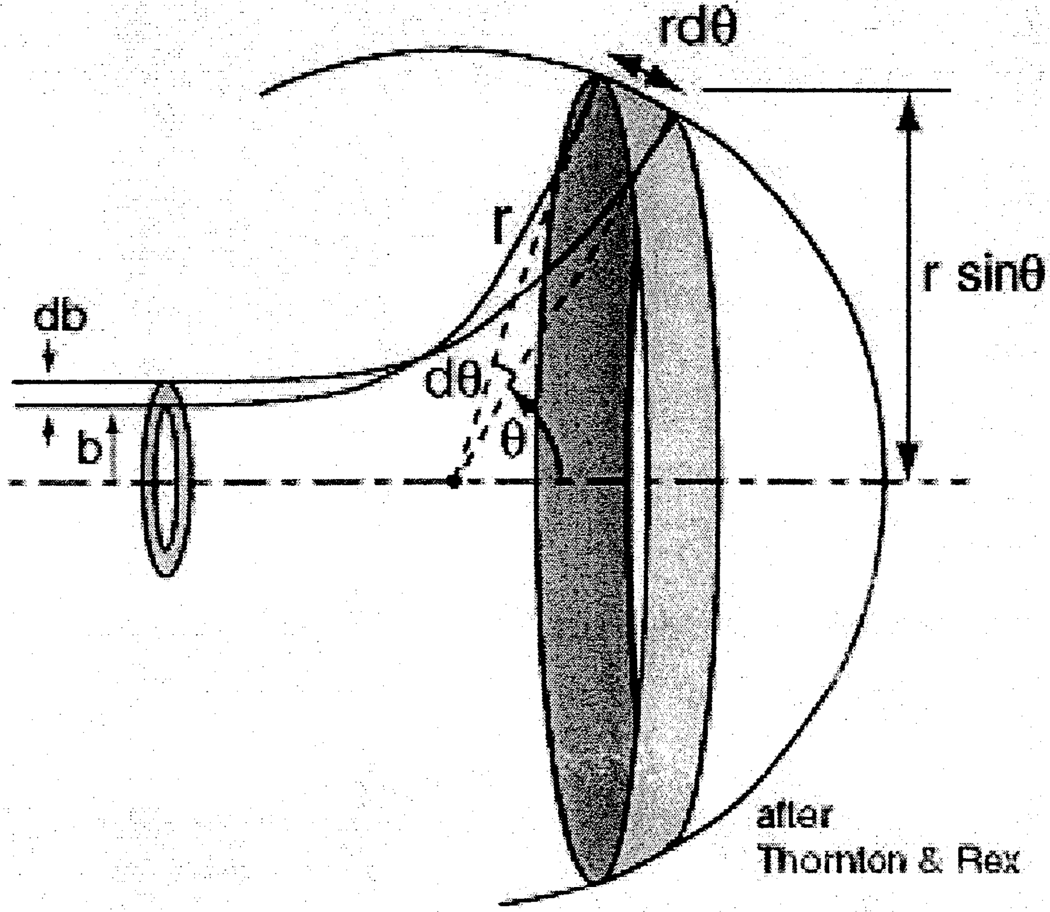


diagram of a classical scattering event

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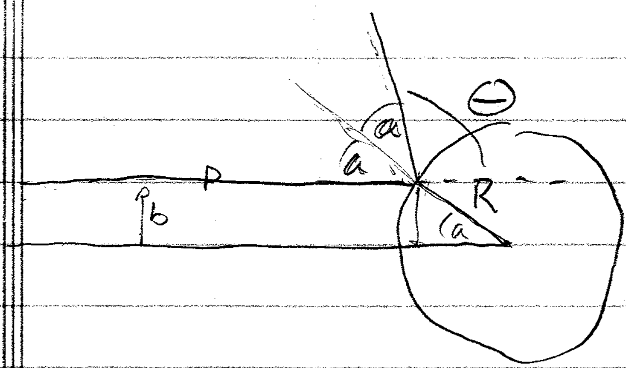

$\theta = \pi - 2a$ or $a = \frac{\pi}{2} - \frac{\theta}{2}$

so $b = R\sin(a) = R\sin\left(\frac{\pi}{2} - \frac{\theta}{2}\right) = R\left(\sin\left(\frac{\pi}{2}\right)\cos\left(\frac{\theta}{2}\right) - \cos\left(\frac{\pi}{2}\right)\sin\left(\frac{\theta}{2}\right)\right)$

$b = R\cos\left(\frac{\theta}{2}\right) \qquad \left(\frac{db}{d\theta}\right) = \frac{R}{2}\sin\left(\frac{\theta}{2}\right)$

dσ find

$$\frac{d\sigma}{d\Omega} = \frac{b\,db\,d\phi}{\sin\theta\,d\theta\,d\phi} = \frac{b}{\sin\theta}\left(\frac{db}{d\theta}\right) = \frac{R^2\cos\left(\frac{\theta}{2}\right)\sin\left(\frac{\theta}{2}\right)}{2\sin\theta}$$

$$\cos\left(\frac{\theta}{2}\right)\sin\left(\frac{\theta}{2}\right) = \frac{1}{2}\sin(\theta)$$

$$\frac{d\sigma}{d\Omega} = \frac{R^2}{4}$$ if we integrate over all solid angle

$$\frac{R^2}{4}\int d\Omega = \frac{R^2}{4}4\pi = \pi R^2 = \underline{\text{Area of a circle}}$$

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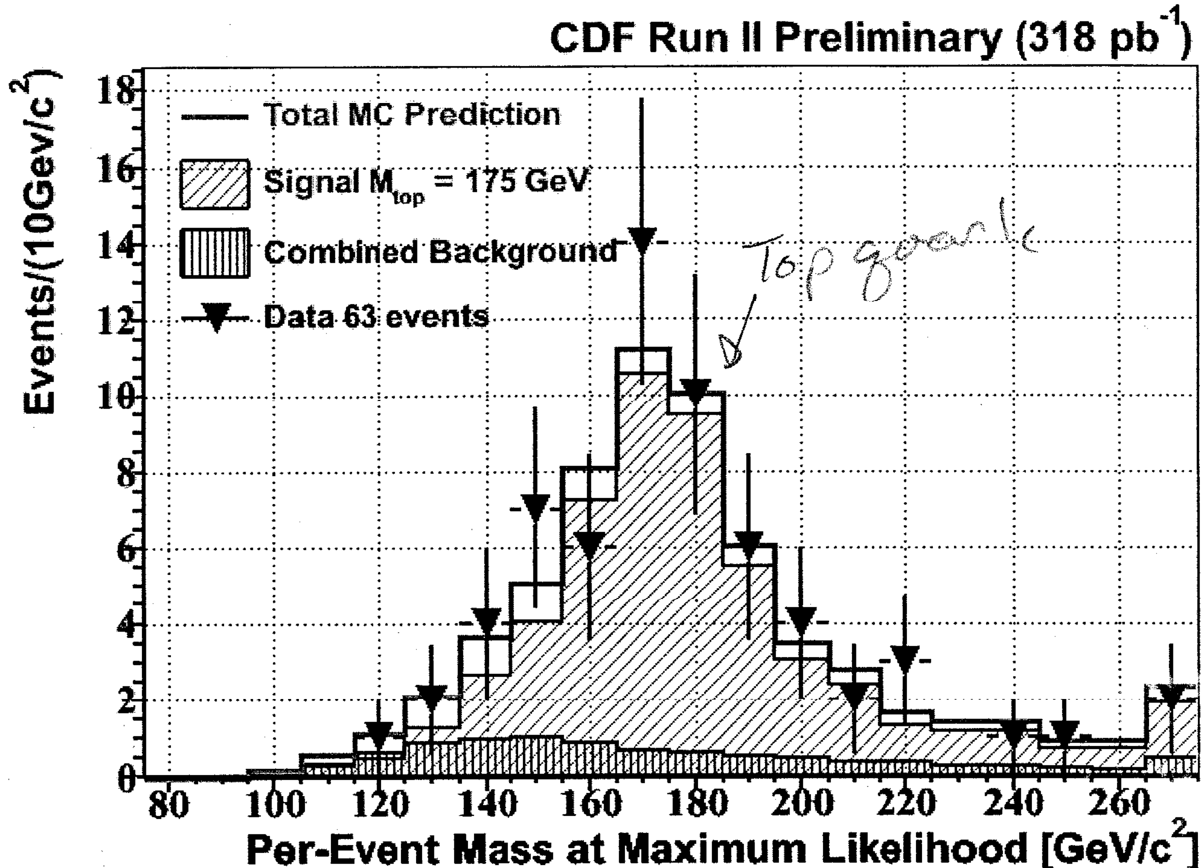
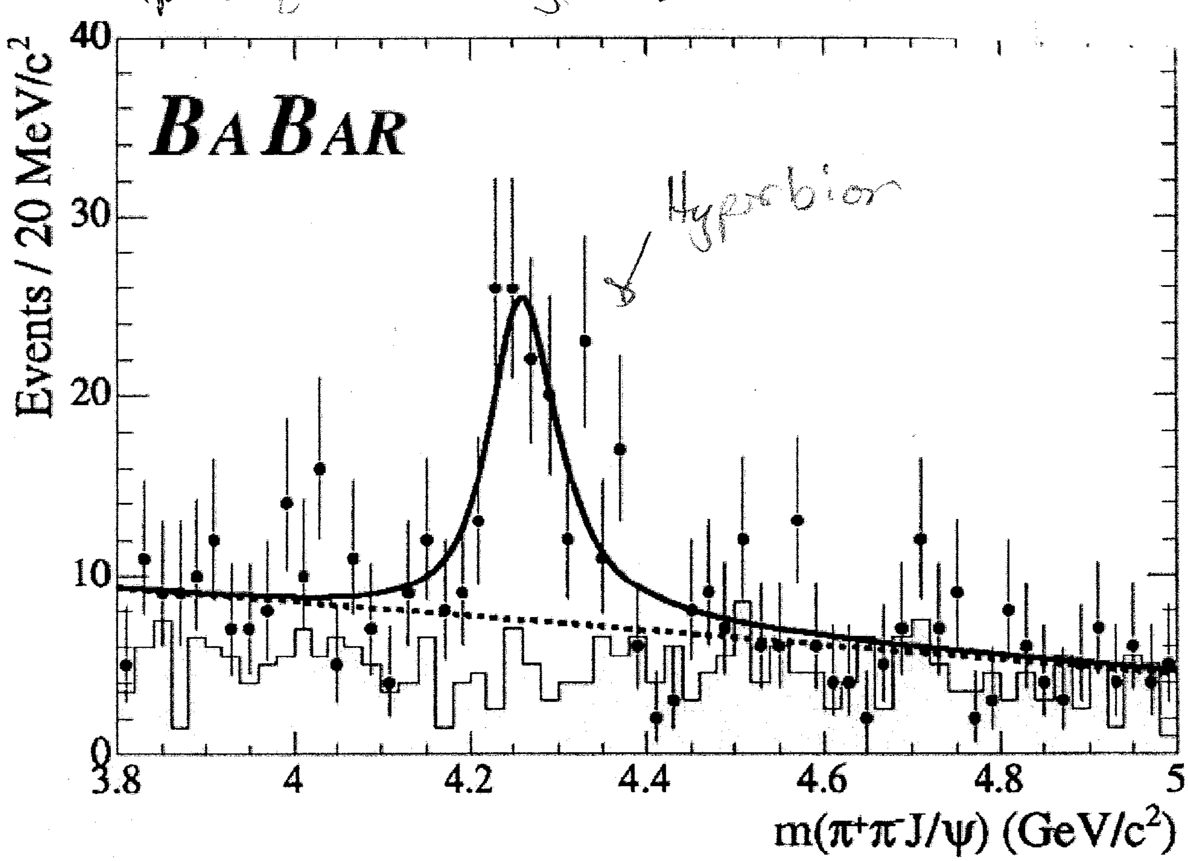


examples of scattering crosssection resonances



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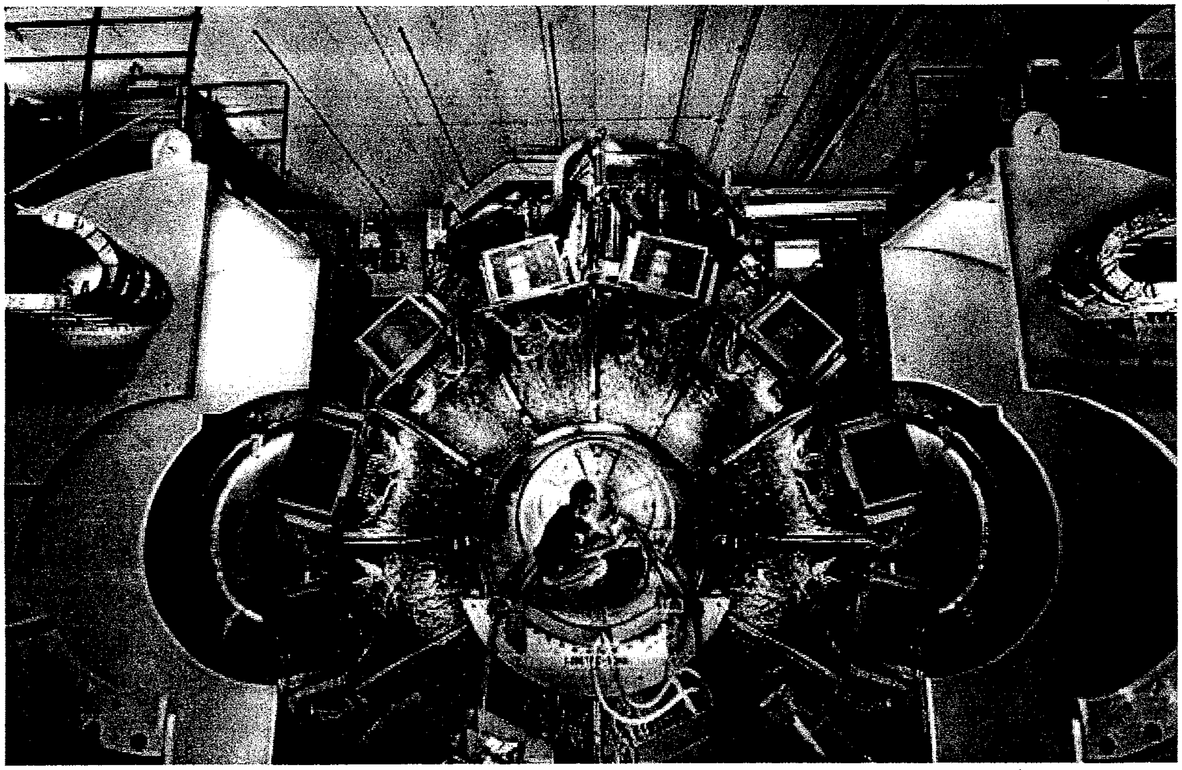
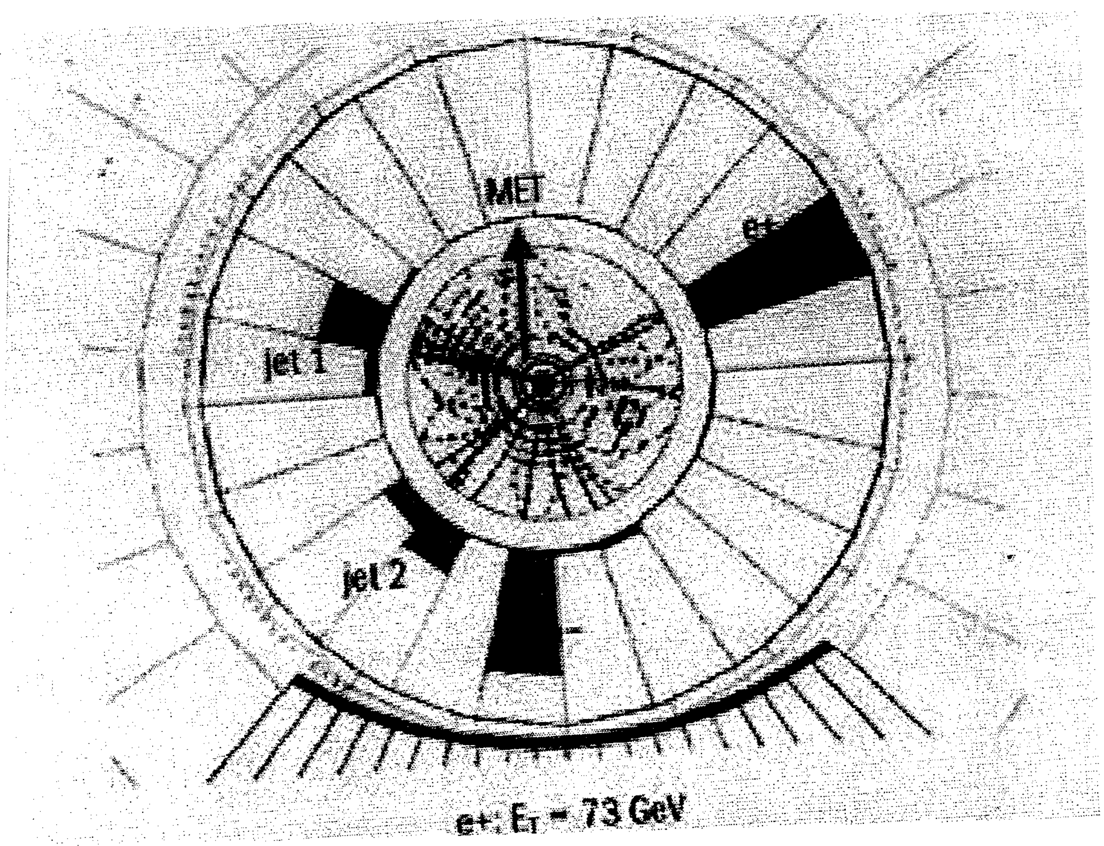


Example of a collision exprimental apparatus.



example of a collision event.