Detecting the Δ+ 1232 Baryon from an Electron-Proton Inelastic Scattering

Nations' Flying Foxes Proposal presentation

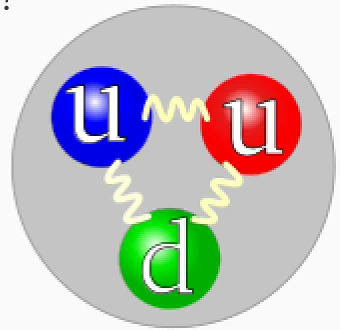
About us

- International school of Geneva-Campus des Nations
- Student body of 1000, with 113 nationalities (8 of which are represented in our team!)

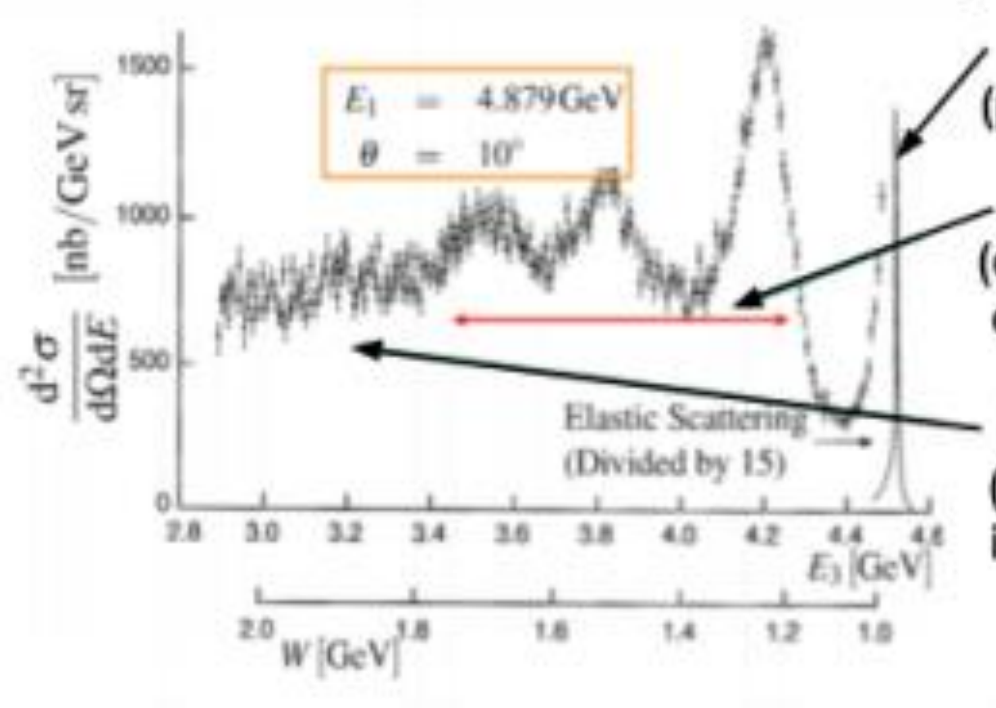
- Born in 2002-2004, currently in our senior year of high school
- University plans ranging from physics and engineering to law and economics

Rationale

1. Detecting short-lived particle by studying less massive particles that come out of high-energy collisions.
2. "Peak" into a proton. What are its properties, otherwise unobservable ?



Background Theory



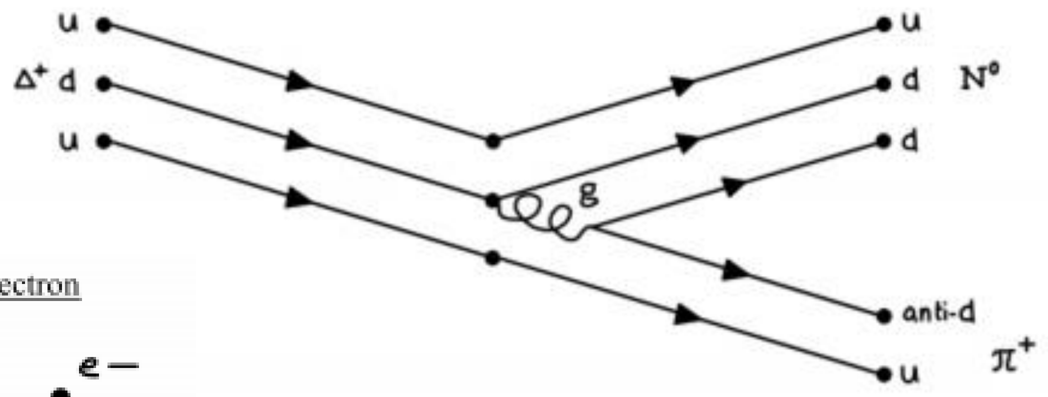
Elastic scattering (proton remains intact)

Inelastic scattering (excited states of proton, e.g. Δ+ 1232, produced)

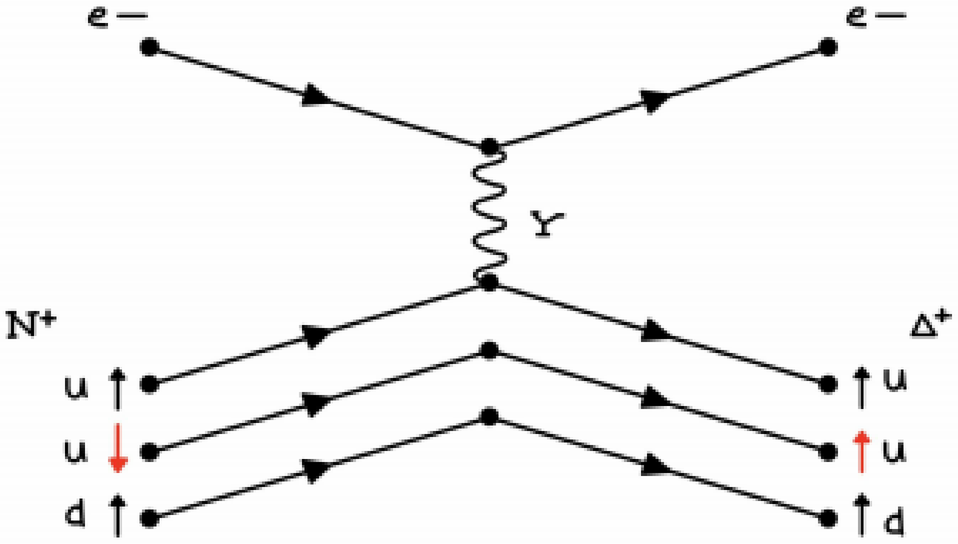
Deep inelastic scattering (proton breaks up resulting in many-particle final state)

(Fig.1) // Source - W. BARTEL, B. DUDELZAKI, H. KREHBIEL, J. MCELROY. U. MEYER-BERKHOUT, W. SCHMIDT, V. WALTHER tt and G. WEBER , *ELECTROPRODUCTION OF PIONS NEAR THE A(1236) ISOBAR AND THE FORM FACTOR C*M(q2) OF THE (γNA)-VERTEX - Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany and II. Institut für Experimentalphysik der Universität Hamburg, Germany*

(Fig.3) Synthesis of a Neutron and a Pion Plus from a decaying Delta plus



(Fig.2) Inelastic scattering of a Proton with an Electron



$$Equation\ 1:\ m_0(N^+) + KE(e^- initial) = m_0(\Delta^+) + KE(e^- final) = m_0(N^0) + m_0(\pi^+) + KE(\pi^+) + KE(e^- final)$$

$$\Rightarrow m_0(\Delta^+) = m_0(N^+) + KE(e^- initial) - KE(e^- final),$$

$$\Rightarrow m_0(\Delta^+) = m_0(N^0) + m_0(\pi^+) + KE(\pi^+),$$ where $m_0(\pi^+) + KE(\pi^+)$ gives the total energy of π^+.

$$Equation\ 2:\ p(e^- initial) = p(\pi^+) + p(e^- final)$$

Hypothesis

Latest Update:

$$\text{Energy gained by } p^{+} \text{ during inelastic scattering} = \mathbf{x - y\ GeV}$$

, where x = initial energy of electron in GeV and y = final energy of electron in GeV

$$\text{As a result, } p^{+} \text{ gains } \mathbf{m(?) - 0.938\ GeVC^{-2}} \text{ of mass}$$

, where $m(?)$ = rest mass of particle created in $GeVC^{-2}$,
and 0.938 = rest mass of proton in $GeVC^{-2}$.

$$\text{KE gained by } ? = \mathbf{x - y - m(?) + 0.938\ GeV}$$

As relativistic KE of $? = \mathbf{m(?)C^2(\gamma - 1)}$, where $\gamma = \frac{1}{\sqrt{1-\frac{v^2}{C^2}}}$ and $C = 1$,

$$v(?) = \sqrt{1 - \frac{m^2(?)}{(x - y + 0.938)^2}} \text{ in } ms^{-1}$$

Now,

$$p(?) = \frac{KE + m(?)C^2}{C^2} \cdot v(?)$$

$$p(?) = (x - y + 0.938)\sqrt{1 - \frac{m^2(?)}{(x - y + 0.938)^2}}$$

, where $p(?)$ = momentum of particle created in $GeVC^{-1}$.

Solving for $m(?)$ gives:

$$m(?) = \sqrt{(x - y + 0.938)^2 - p^2(?)}$$

Using the law of conservation of momentum,

$$p(?) = \frac{-\beta \sin\theta}{\sin\phi}, \qquad p(?) = \frac{\alpha - \beta\cos\theta}{\cos\phi}$$

, where β = final momentum of the electron in $GeVC^{-1}$, θ = angle of deflected electron, ϕ = angle of particle created, and α = initial momentum of the electron in $GeVC^{-1}$.

Hence equating the expressions for $p(?)$ gives

$$\phi = \arctan\left(\frac{-\beta\sin\theta}{\alpha - \beta\cos\theta}\right)$$

And hence

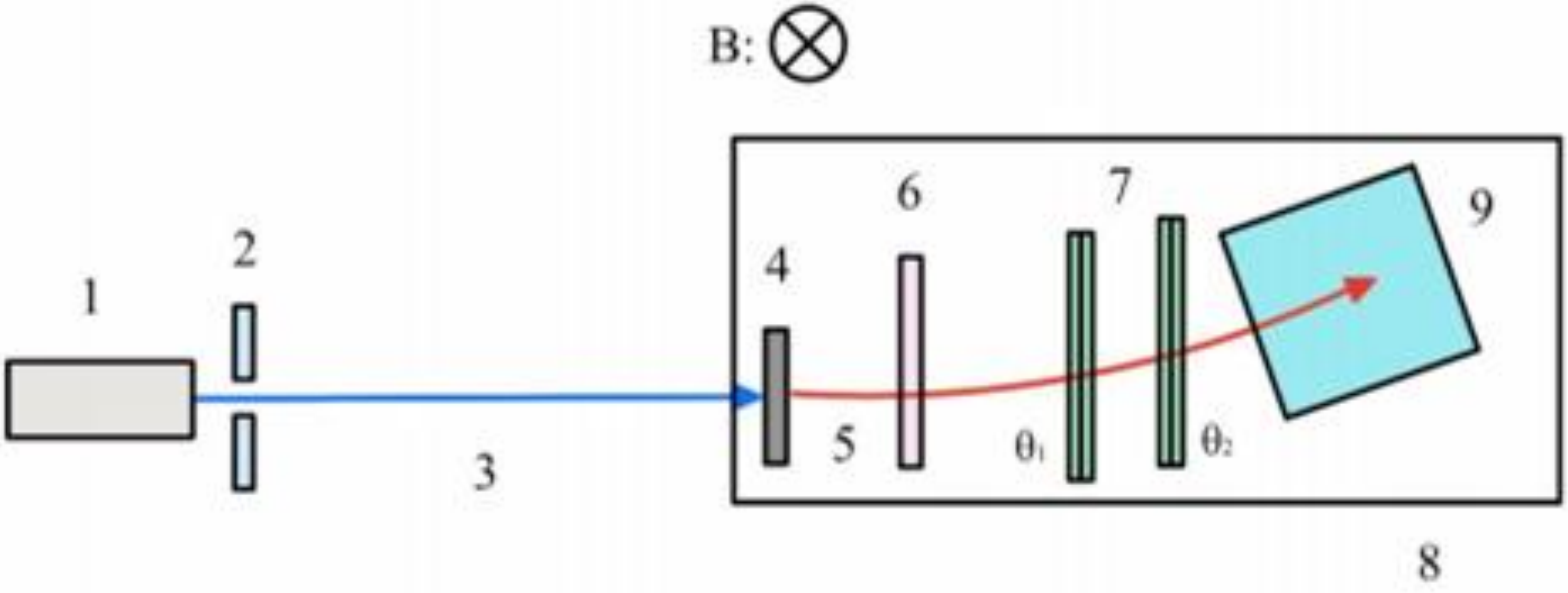
$$p(?) = \frac{-\beta\sin\theta}{\sin\left[\arctan\left(\frac{-\beta\sin\theta}{\alpha - \beta\cos\theta}\right)\right]}$$

Finally,

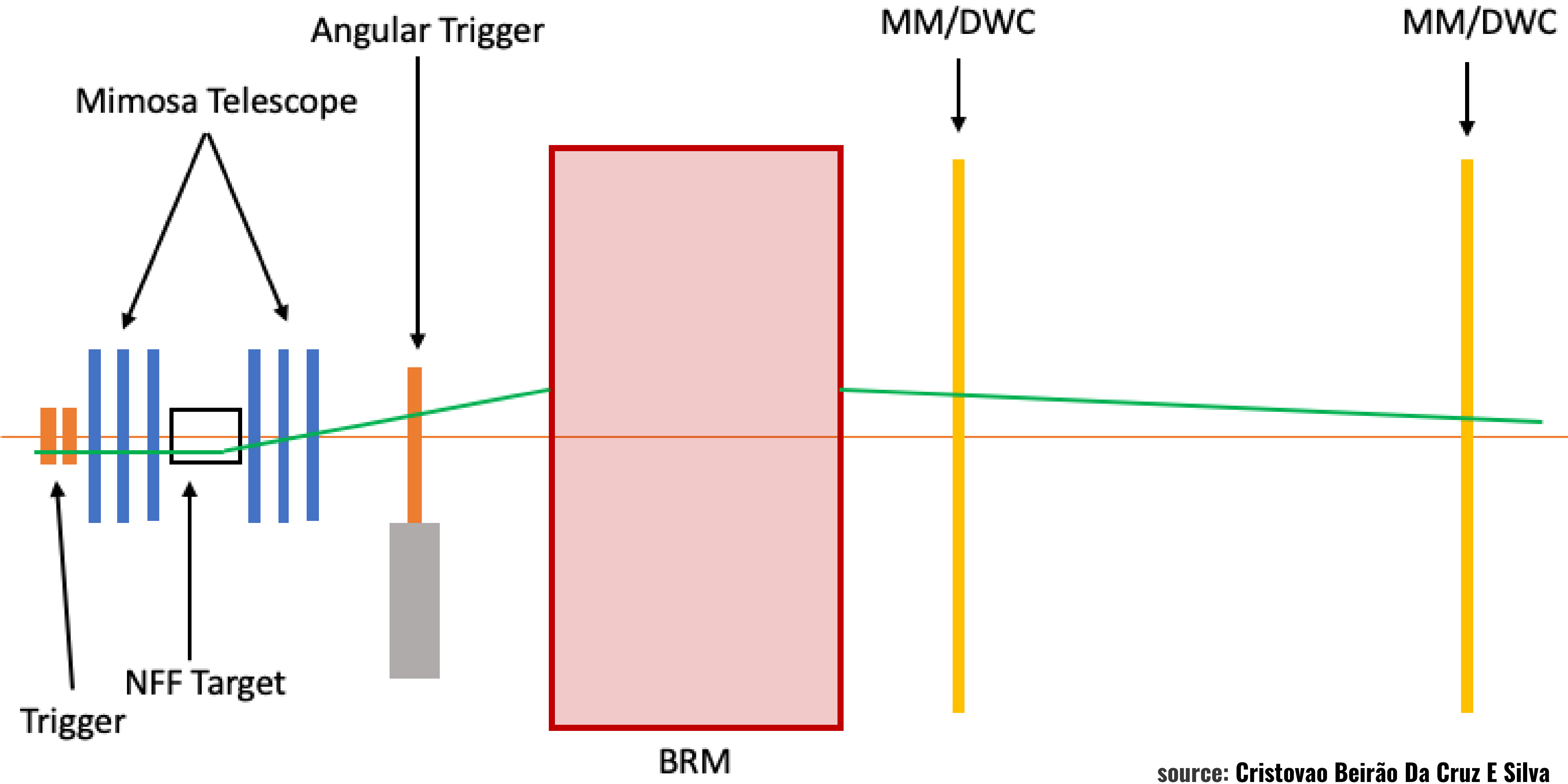
$$m(?) = \sqrt{(x - y + 0.938)^2 - \left[\frac{-\beta\sin\theta}{\sin\left[\arctan\left(\frac{-\beta\sin\theta}{\alpha - \beta\cos\theta}\right)\right]}\right]^2}$$

So, measuring x, y, α, β, and θ of the electron gives us the rest mass of the particle created.

If $m(?) = 1.232\text{GeV}C^{-2}$, we have found Δ^+ 1232 baryon!



1: Electron beam shaft
2: Collimator
3: Electron beam trajectory
4: Lead panel (proton source)
5: Pi-plus projected trajectory
6: Scintillator (trigger mechanism)
7: Two pairs of MicroMegas detectors
8: PCMAG
9: Lead crystal calorimeter



source: **Cristovao Beirão Da Cruz E Silva**