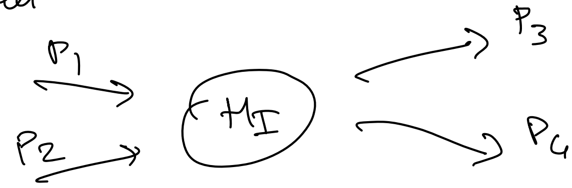
Token: 843 446

potenziale di Yukawa $V(r) = -\frac{g}{4\pi} \frac{e^{-mr}}{r}$

$g > 0$ $[g]$ adimensionale. g : carica forte

$H_I = g V$ g ⊙ $V(r)$ ⊙ g

$= -\frac{g^2}{4\pi} \frac{e^{-mr}}{r}$



$\vec{P}_f = \vec{P}_3 + \vec{P}_4$

$\vec{P}_{in} = \vec{P}_1 + \vec{P}_2$ ψ : onde piane per particelle libere.

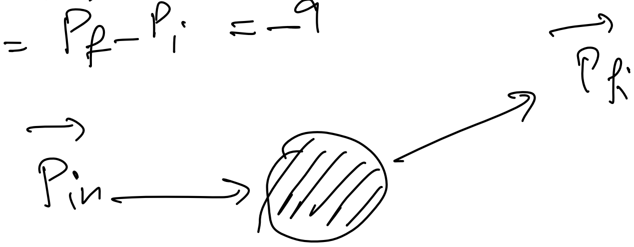
$p + n \longrightarrow p + n$ $\psi \simeq \frac{1}{\sqrt{V}} e^{-i\vec{p}\cdot\vec{r}}$

$\Gamma(i \to f) = 2\pi |M_{fi}|^2 \rho(E)$ $\psi_i = \frac{1}{\sqrt{V}}\frac{1}{\sqrt{V}} e^{-i\vec{p}_1\cdot\vec{r}} e^{-i\vec{p}_2\cdot\vec{r}}$

$M_{fi} = -i \int d^3r \, \psi_f^* H_I \psi_i$ $\psi_f = \frac{1}{\sqrt{V}}\frac{1}{\sqrt{V}} e^{-i\vec{p}_3\cdot\vec{r}} e^{-i\vec{p}_4\cdot\vec{r}}$

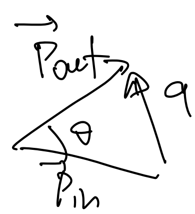
$= -i \frac{g^2}{4\pi} \int d^3r \frac{1}{V^2} e^{+i(\vec{p}_f\cdot\vec{r})} e^{-i\vec{p}_i\cdot\vec{r}} \frac{e^{-mr}}{r}$

$= \vec{P}_f - \vec{P}_i = -\vec{q}$



$\int d^3r \, e^{-i\vec{q}\cdot\vec{r}} \frac{e^{-mr}}{r} \propto \frac{1}{q^2 + m^2}$

$M_{fi} \propto -i \frac{g^2}{4\pi} \frac{1}{q^2 + m^2}$



$q = 2p\sin\frac{\theta}{2}$

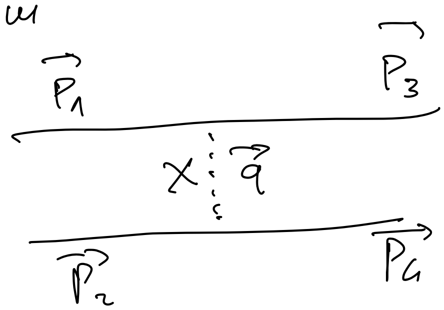
Rutherford: $m=0$. $\quad q = 2p\sin\frac{\theta}{2}$

$$\Rightarrow |M_{fi}|^2 \propto \frac{1}{p^4 \sin^4\frac{\theta}{2}}$$

Teoria di Fermi $\quad H_I = G \quad$ Interazione debole

$M_{fi} \propto -iG \quad$ Fermi $\quad$ mediatore massivo

$$M_{fi} \propto -i\frac{g^2}{4\pi}\frac{1}{q^2+m^2} \quad \text{Yukawa}$$



m: massa del mediatore

q: impulso trasmesso dal mediatore X

$$q^2 >> m^2 \qquad M_{fi}\propto \frac{g^2}{q^2} \qquad \sigma \propto \left(\frac{g^2}{4\pi}\frac{1}{q^2}\right)^2$$

$$q^2 << m^2 \to M_{fi} \simeq -i\frac{g^2}{4\pi}\frac{1}{m^2}$$

nel limite bassa energia $q<<m$ $\qquad G_F = \frac{g^2}{4\pi^2}\frac{1}{m^2}$

si misura

$G_F \simeq 1.16\times10^{-5}$ GeV^{-2} $\quad$ vite medie $\quad n\to p e^- \bar\nu_e$, $\quad \mu^- \to e^- \nu_\mu \bar\nu_e$

$$\frac{1}{\tau} = \Gamma \propto G_F^2 E_T^5$$

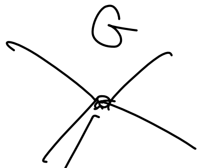
g: carica debole.

$$m^2 = \frac{g_W^2}{4\pi}\frac{1}{1.16\times10^{-5}} \text{ GeV}^2$$

↳ massa del portatore debole.

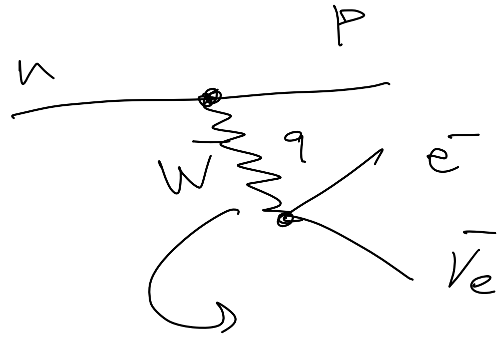
$$m^2 = \left(\frac{g^2}{e^2}\right)\underbrace{\left(\frac{e^2}{4\pi}\right)}_{\frac{1}{137}}\frac{1}{1.16\times 10^{-5}}\ \mathrm{GeV}^2$$

$$\left(\frac{g^2}{e^2}\right) \Rightarrow m \simeq \left(\frac{g}{e}\right)\ 79\ \mathrm{GeV}$$



$q \ll m$

$$\simeq \underbrace{\frac{1}{m^2}\frac{g^2}{4\pi}}_{G_F}$$



$$\frac{g^2}{4\pi}\frac{1}{q^2+m^2}$$

nel lim rel.

$$\frac{1}{|q|^2-m^2}$$

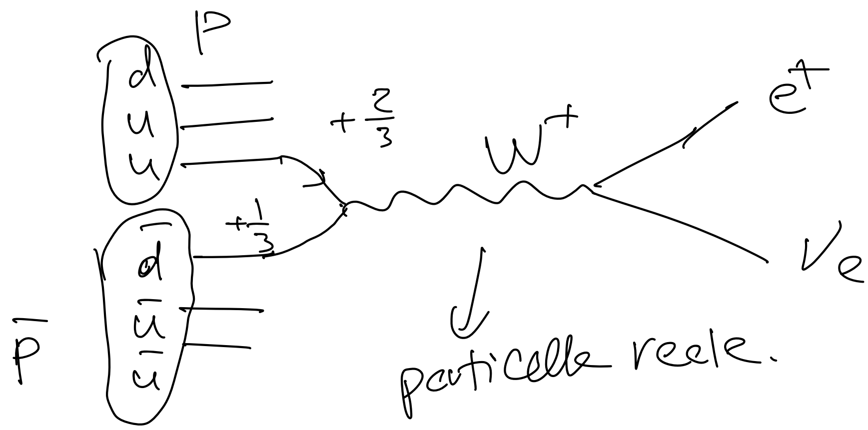
se $\frac{g}{e} \simeq 1 \Rightarrow$ esiste particelle con $m \simeq 80$ GeV

1960 Weinberg, Glashow, Abdus-Salam.

Z^0, W^+, W^- 3 part. di forza debole.

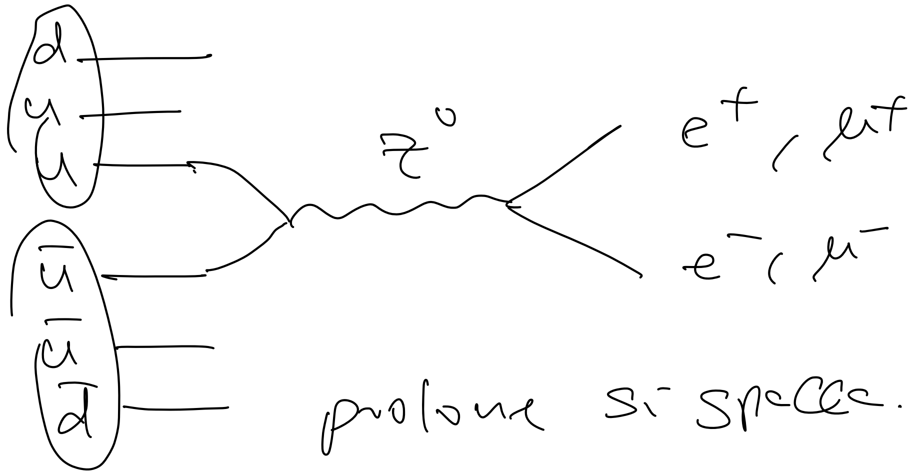
$p+\bar{p} \longrightarrow W^- + X$

$Z^0 + X$



particelle reale.

$Sp\bar{p}S$
CERN



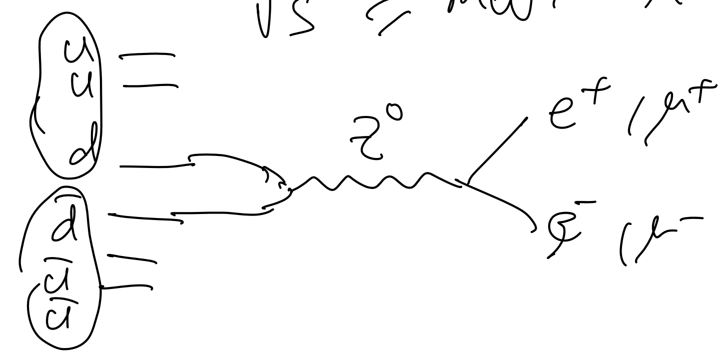
protone si spacca.

$$\begin{pmatrix} u & +\frac{2}{3} \\ d & -\frac{1}{3} \end{pmatrix}$$

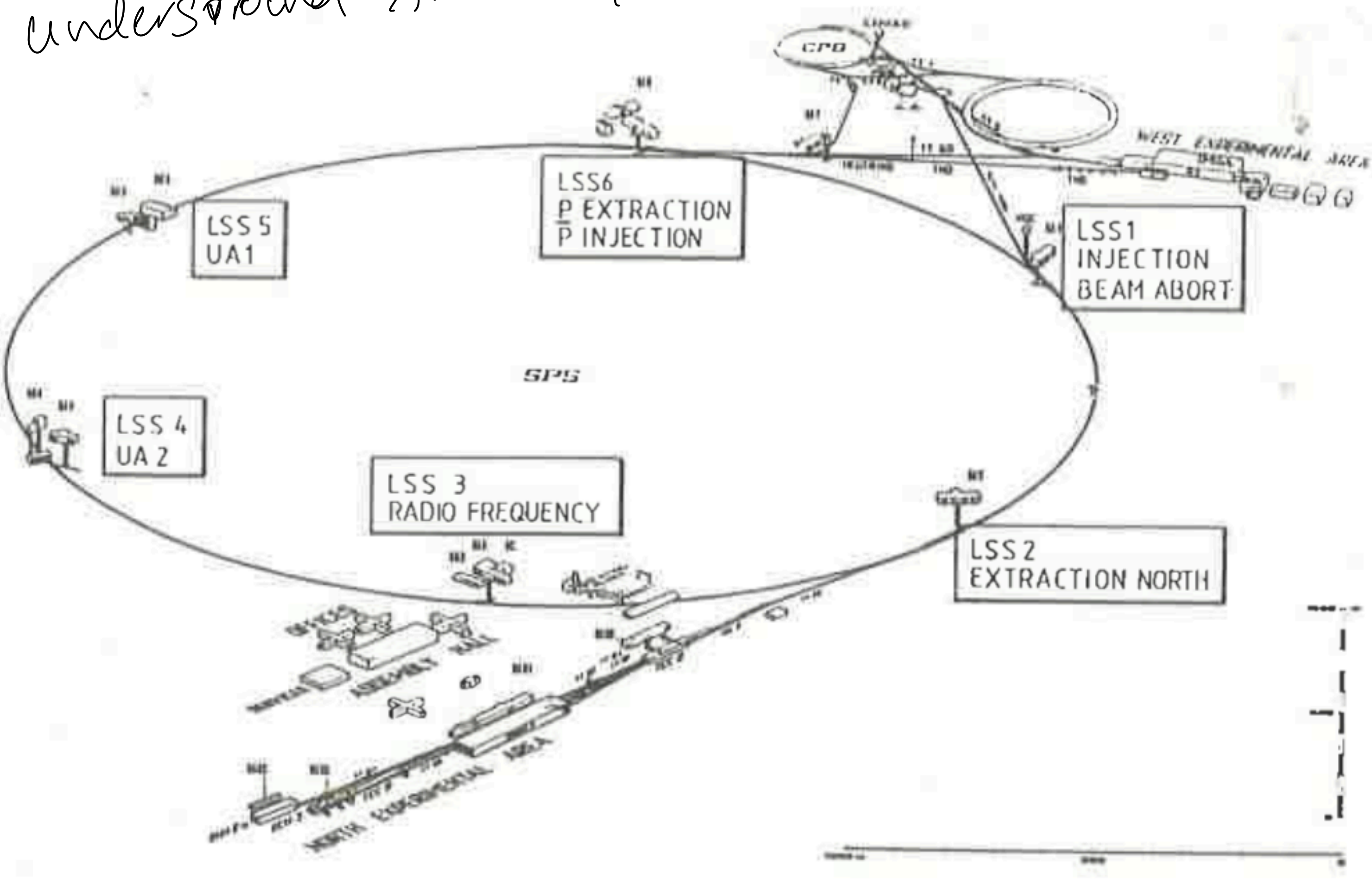
$$\begin{pmatrix} \bar{u} \\ \bar{d} \end{pmatrix} \begin{matrix} -\frac{2}{3} \\ +\frac{1}{3} \end{matrix}$$

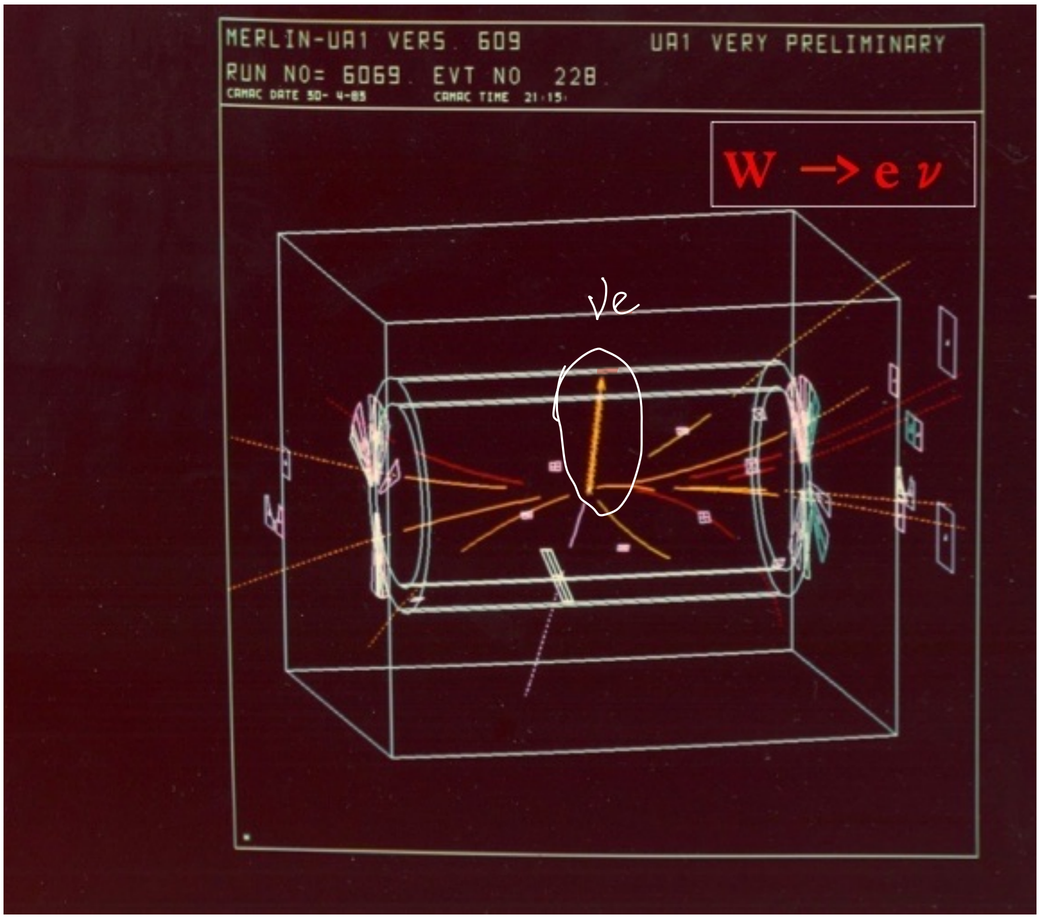
$$p + \bar{p} \longrightarrow W + X$$

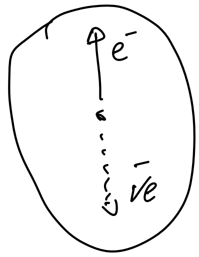
$$\sqrt{s} \geq M_W + m_X$$



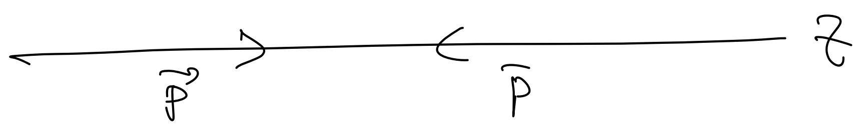
underground Area 1/2



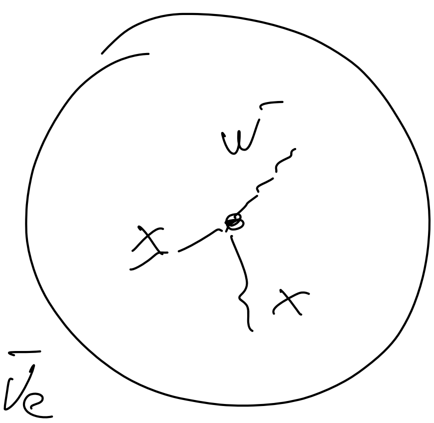




$p + \bar{p}$



$$\vec{P}_{in} \begin{cases} P_z = P_1 - P_1 = \emptyset \\ P_T = 0 \end{cases}$$



stato finale

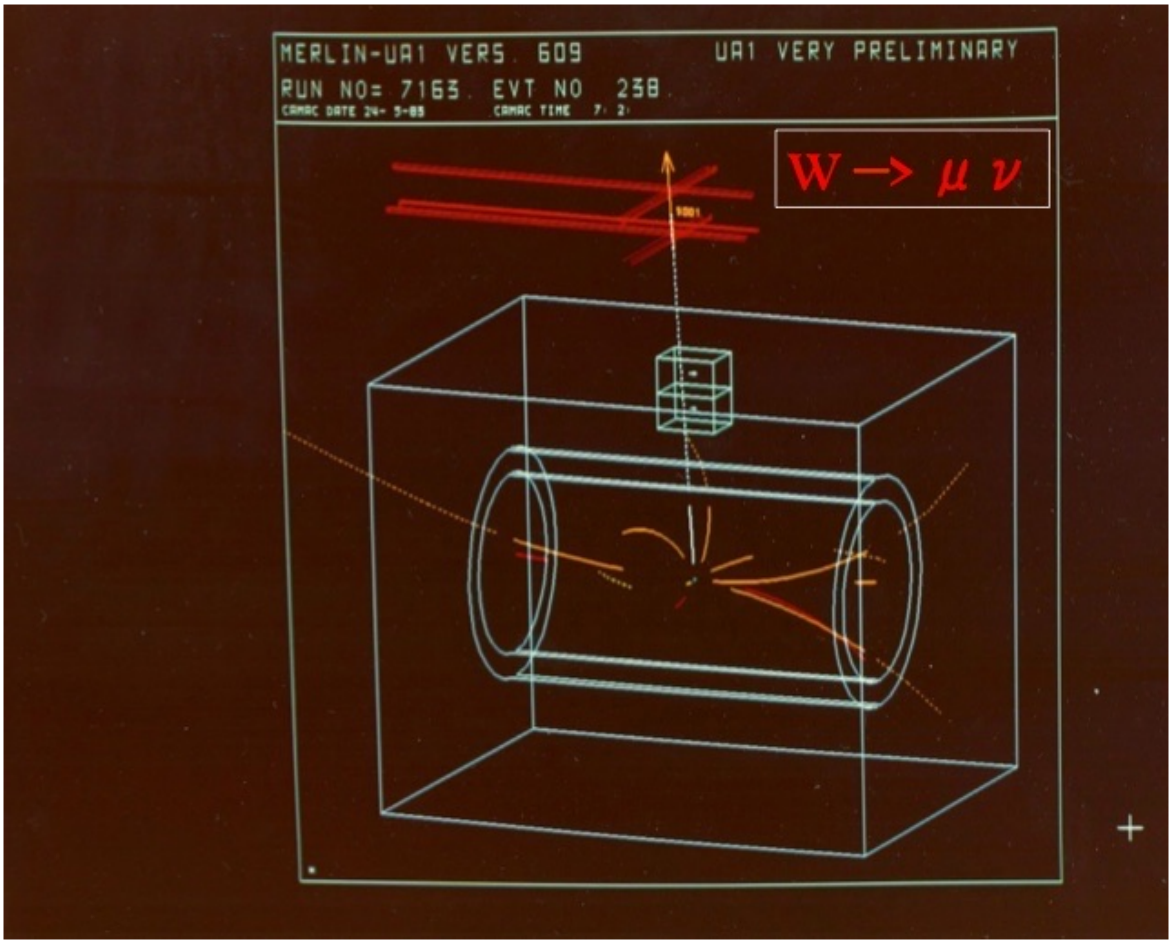
$P_T = 0$

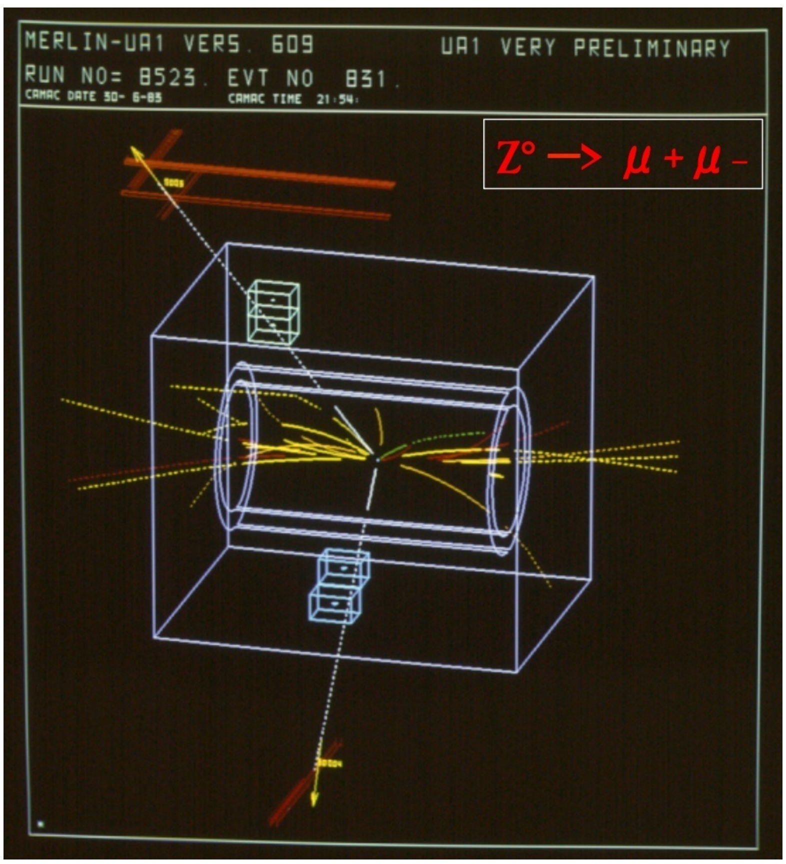
$W^- \to e^- + \bar{\nu}_e$

$p + \bar{p} \longrightarrow W^- + X$

$\qquad\qquad\quad Z^0 + X$

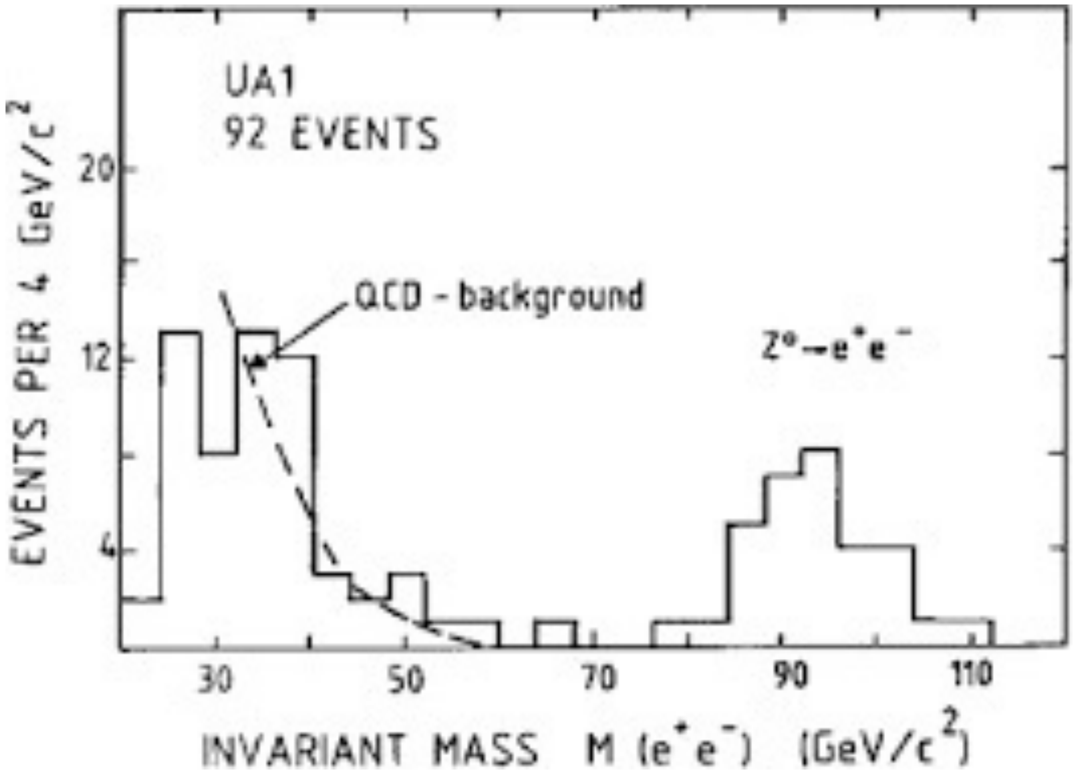
$\sqrt{s} = 540$ GeV

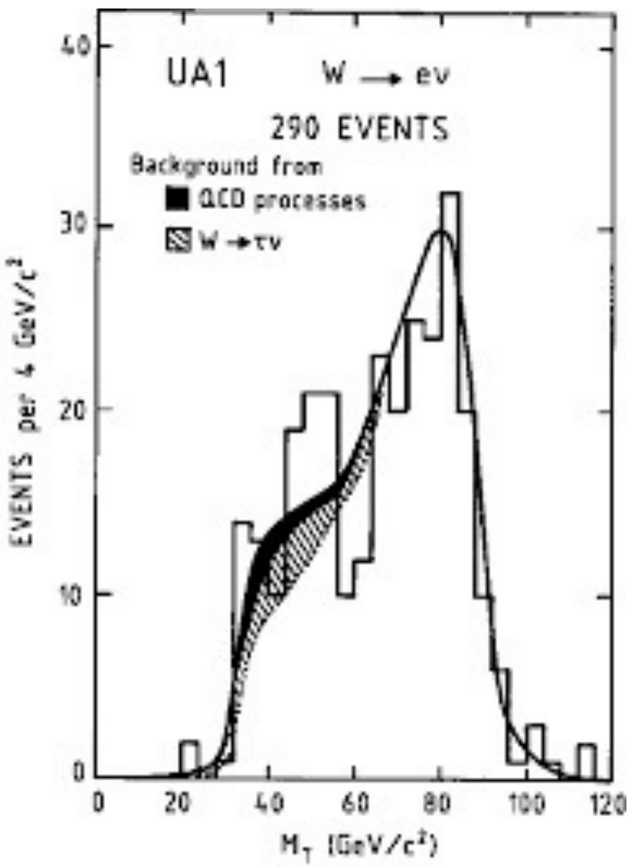




$m_{inv} = \sqrt{(\underline{p}_{\mu}^{1} + \underline{p}_{\mu}^{2})^2}$

bin width





$$m_T^2 = (\underline{p}_T^{\mu} + \underline{p}_T^{\nu})^2$$

Simmetrie, Invarianti, leggi di conservazione

$\langle s | O | s \rangle = a | s \rangle$

$\langle s | O\, T | s \rangle = a | s \rangle$

$\langle A \rangle = \langle \psi | A | \psi \rangle$ valore aspettato.

$\frac{d}{dt} \langle A \rangle = \emptyset \iff [A, H] = \emptyset$

$\frac{\partial A}{\partial t} = 0$

parole magiche: mom. angolare $\vec{L} = \vec{r} \times \vec{p}$

$\vec{p}$

E

si conservano

Inv.

Traslazione $\delta \vec{x} \to \vec{p}$ si conserva

Rotazioni $\delta \vec{r} \to \vec{L} = \vec{r} \times \vec{p}, \vec{J}$

Traslazione $\delta t \to E$ si conserva

Trasf. continue $\to$ legge di conserv.

leggi additive

Teorema Nöther 1917

Simmetria
Inv. sotto trasf. $\longleftrightarrow$ esiste quantità conservata

Simmetrie accidentali:
si conserva qualcosa senza apparente simm. nella lag. $\mathcal{L}$

$$n \to p + e^- + \nu_e$$

numero barionico
numero leptonico.

$$n \to p + \bar{\mu} + \nu_e \qquad Q < 0$$

$$(\bar{\nu}_e)X + p \to e^+ + n$$

$$X^0 + p \to e^- + n \qquad \text{carica non si conserva}$$

$$X + p \to \mu^+ + n$$

$$L_\mu \quad 0 \quad 0 \qquad 1 \quad 0 \qquad \Delta L_\mu \neq 0.$$

$$n \to p + \mu^- + \bar{\nu}_\mu$$

$$\mu^- \to e^- + \gamma \qquad Q > 0$$

$$\mu^- \to e^- \bar{\nu}_e \nu_\mu \qquad Q > 0$$

num lep. si conserva $L_e \neq L_\mu$

flavor violation L_e, L_μ, L_τ

Baryon numb. violation $\Delta B \neq 0$.

Finora non ci sono prove sperim.

$$p + p \longrightarrow p + \bar{p} + p + p$$