2.5 Origin of masses

Spontaneous breaking of $SU(2)_L$ x $U(1)_Y$ symmetry

↓ **Higgs mechanism**

$$M_Z = \frac{M_W}{\cos\theta_W}$$ **(~ 91 GeV)**

That is: $\sin^2\theta_W = 1 - \frac{M_W^2}{M_Z^2}$ **=> mass measurements M_Z, M_W very important !**

Summary:		**$\lvert V\rvert^2$**	**$\lvert A\rvert^2$**
W coupling-strength:	$\left(\frac{g}{2\sqrt{2}}\right)^2 = \frac{G_F M_W^2}{\sqrt{2}}$	***1**	***1**
Z coupling-strength:	$\left(\frac{g}{2\cos\theta_W}\right)^2 = \sqrt{2}\, G_F M_Z^2$	**$g_V^{f\,2}$**	**$g_A^{f\,2}$**

3. The Z sector

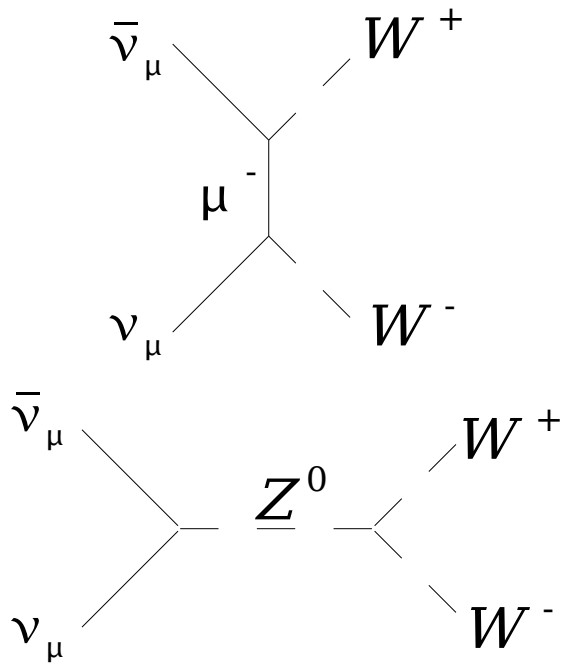
3.1 Z Discovery

a) Theoretical Problems: $\nu_\mu + \bar{\nu}_\mu \rightarrow W^+ + W^-$

$$\frac{d\sigma}{d\Omega} \propto s = (p_{\nu_\mu} + p_{\bar{\nu}_\mu})^2 = E_{CM}^2$$

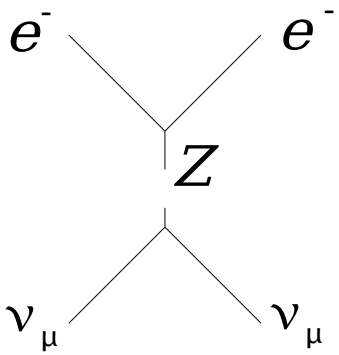
violates unitarity limit at large s

Need additional diagram to avoid cross section rise ∝ s:

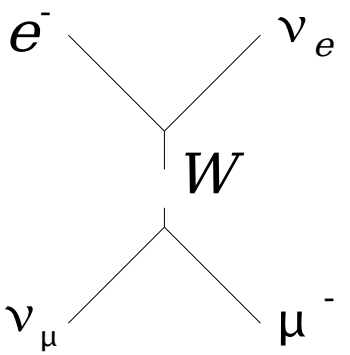


b) Discovery of NC: $\nu_\mu + e^- \rightarrow \nu_\mu + e^-$

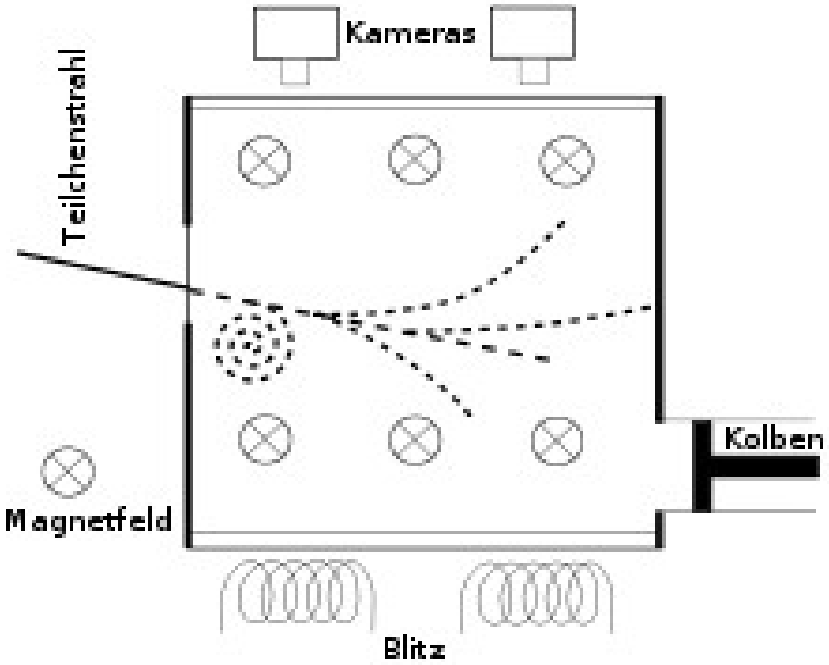
back-scattered e^- (not μ^-)



Charged current: μ^- in final state

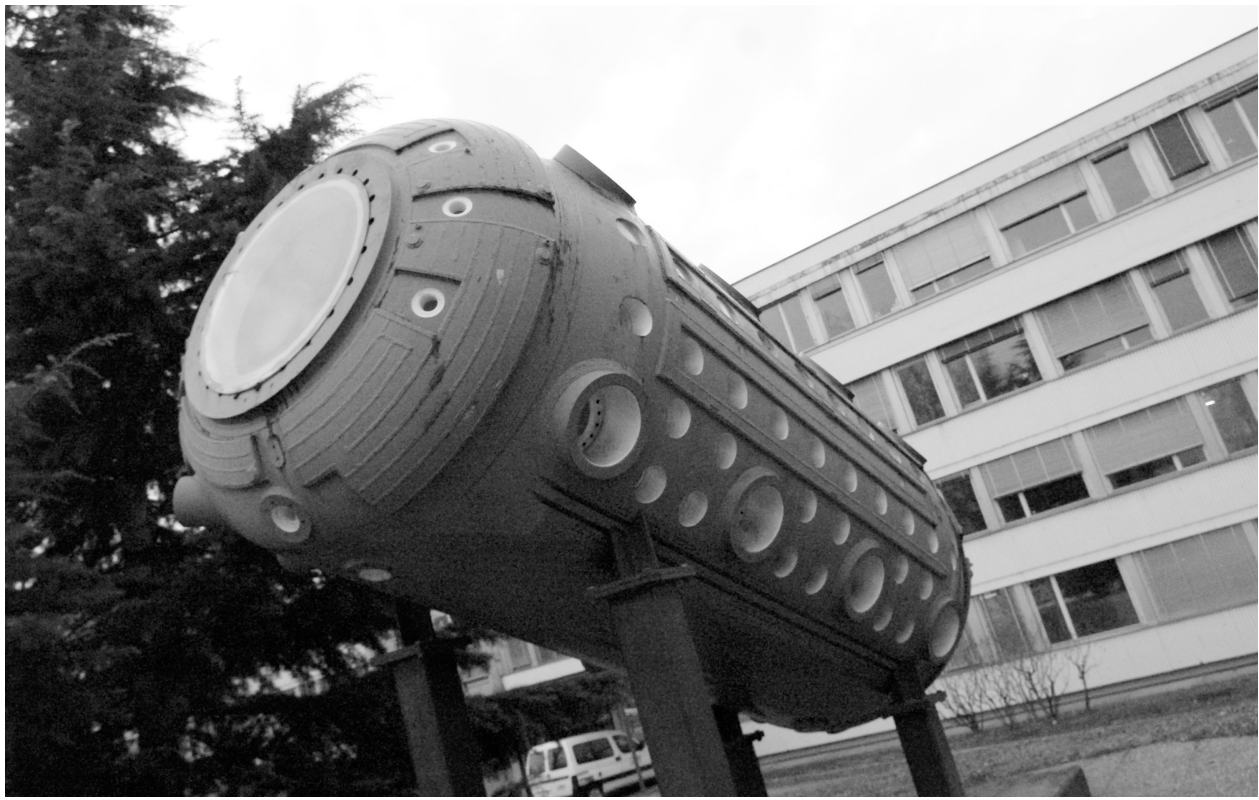


Bubble Chamber Gargamelle @ CERN



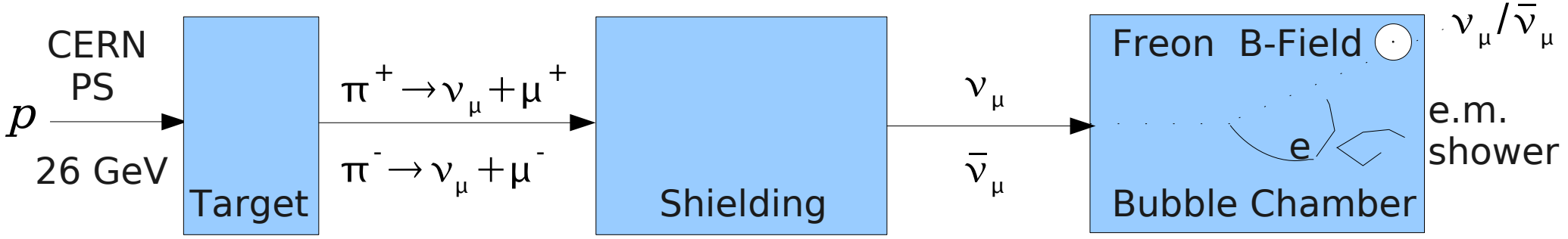
Principle

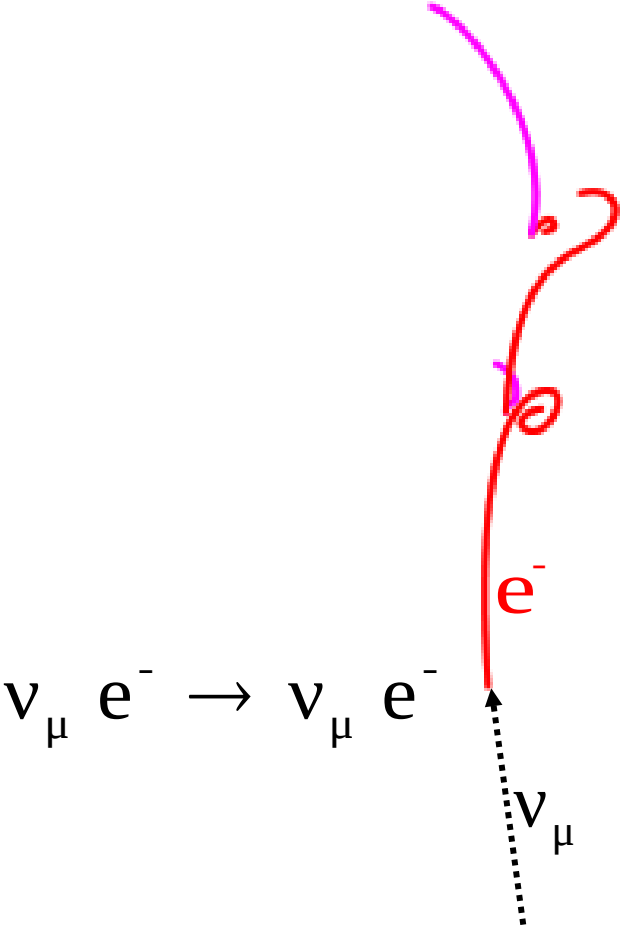
Gargamelle (CERN exhibition)

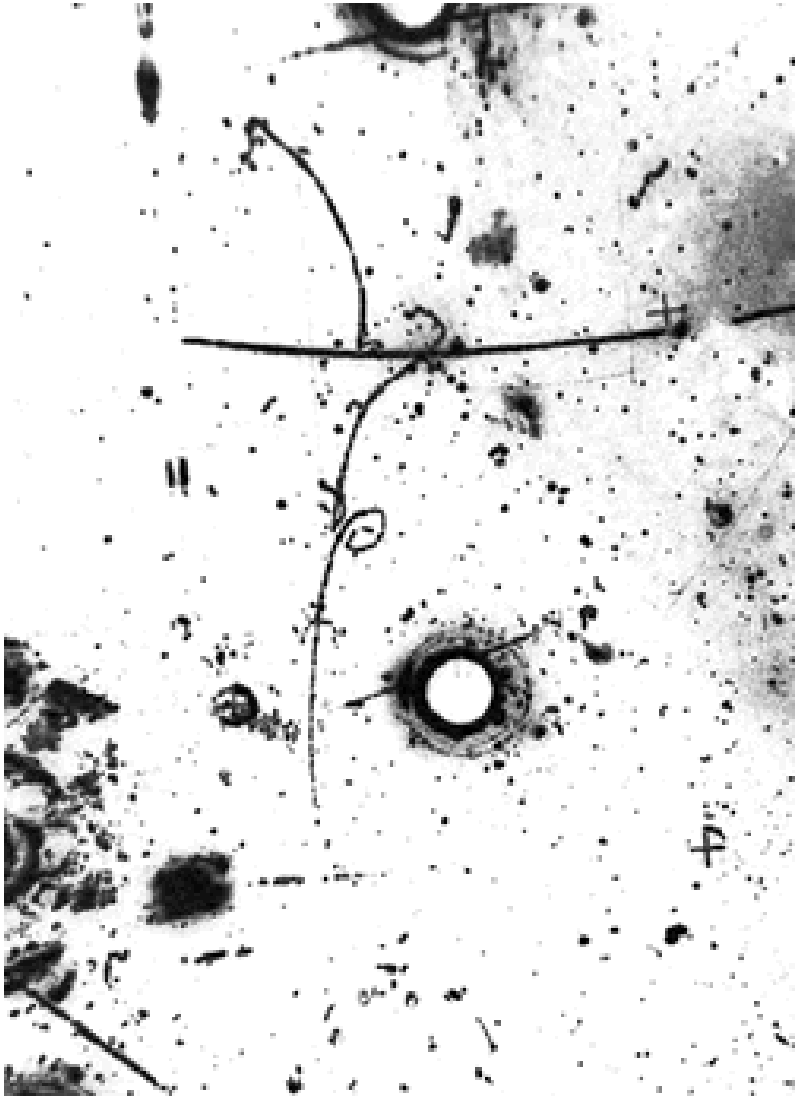


Quelle: Fanny Schertzer

Discovery of Neutral Currents: Gargamelle bubble chamber (1973)

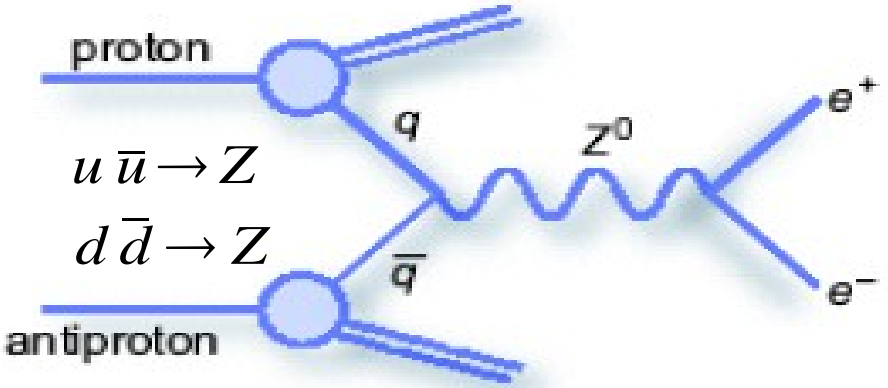






3.1 Z discovery

c) First observation in Drell-Yan production (CERN, $Sp\bar{p}S$, 1983: UA1 and UA2)

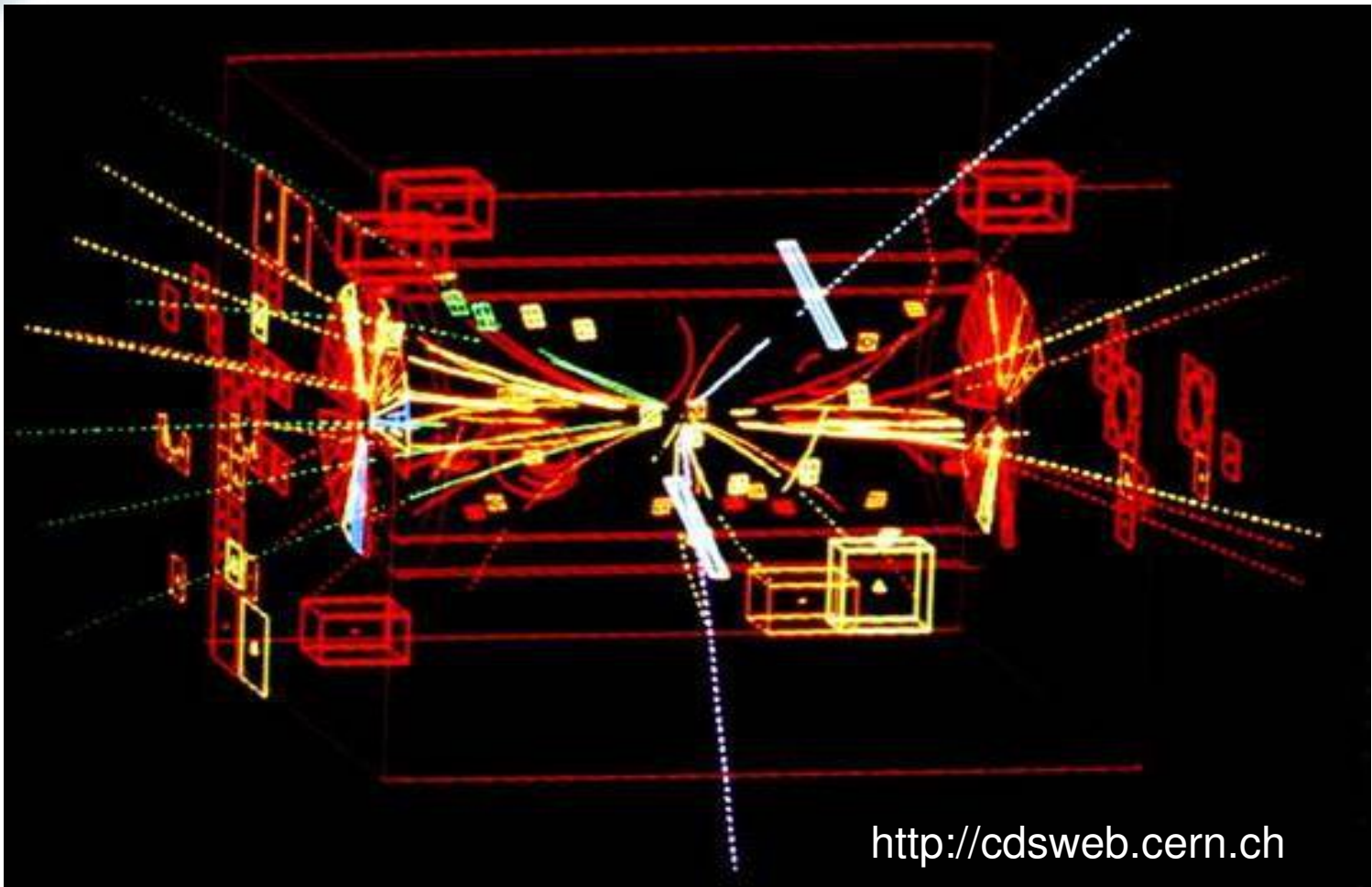


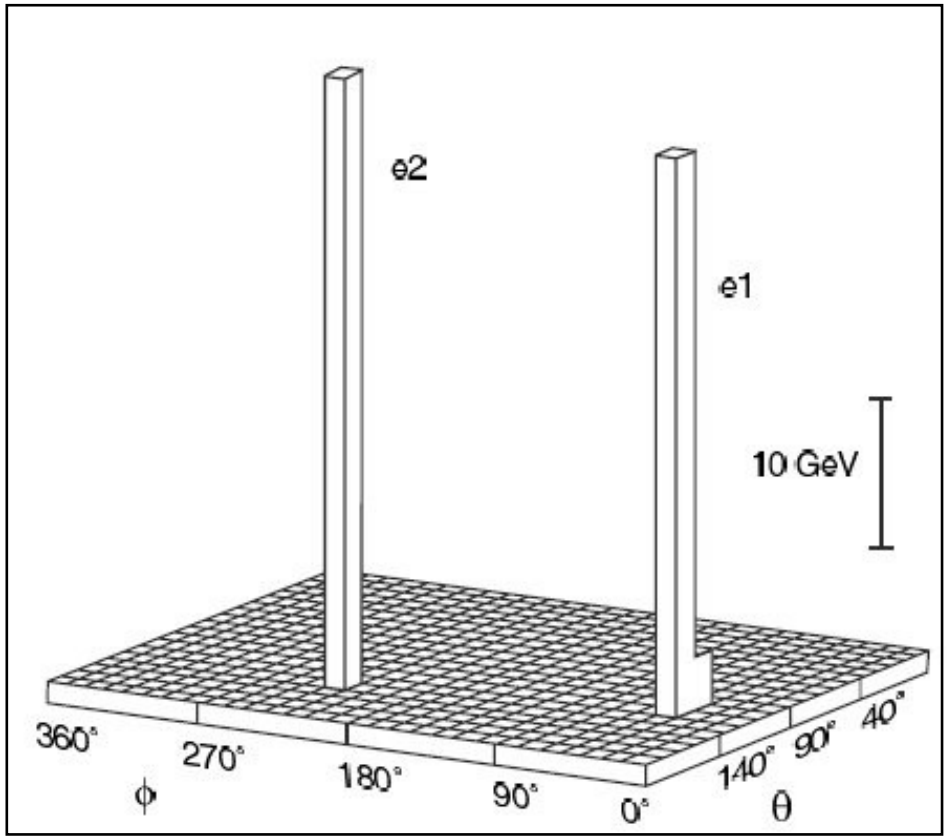
$$Z \to e^+ e^- , \mu^+ \mu^- \qquad (p_{e^+} + p_{e^-})^2 \approx M_Z^2$$

First Z boson candidate in UA1 detector

(CERN)

$$Z \to e^+ e^-$$





Energy deposition in EM-Calorimeter

Distribution of invariant di-lepton mass: