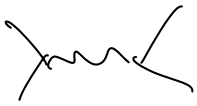
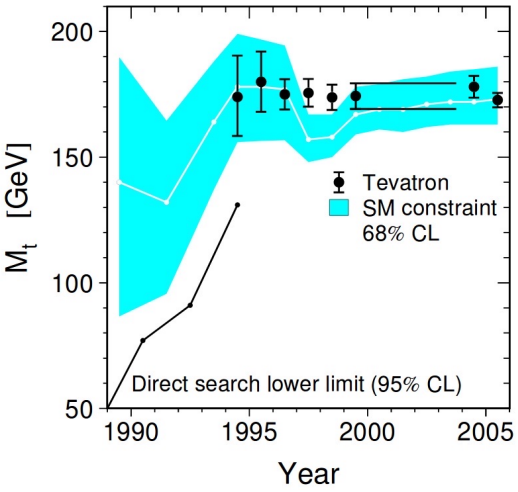
Top Quark

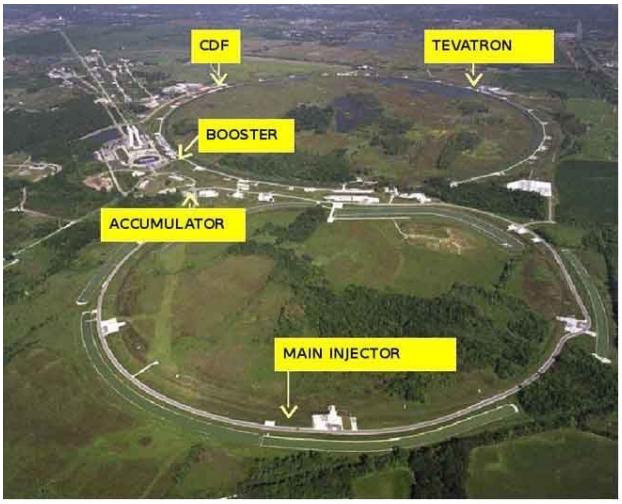
$m_t > m_W$.

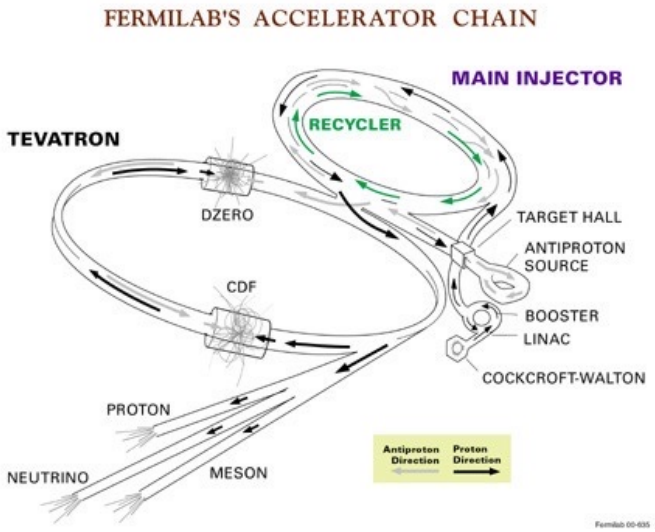
SPPS @ CERN $p\bar{p}$



$\sqrt{s} = 2 m_t$.

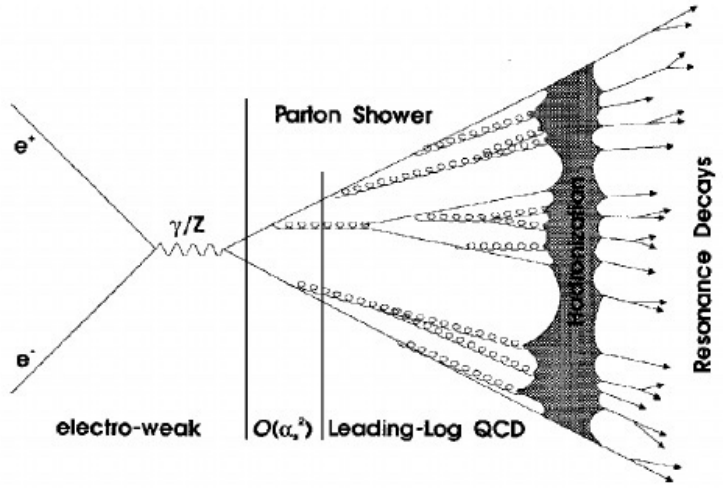




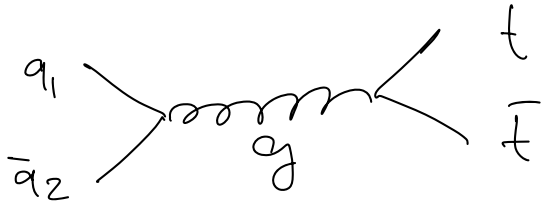


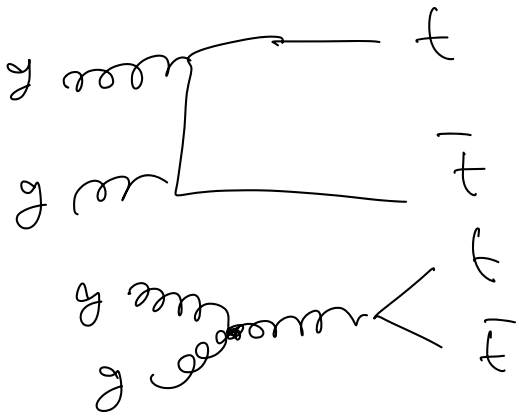
Tevatron @ $\sqrt{s} = 1.96$ TeV

$p + \bar{p} \rightarrow t + \bar{t} + X$

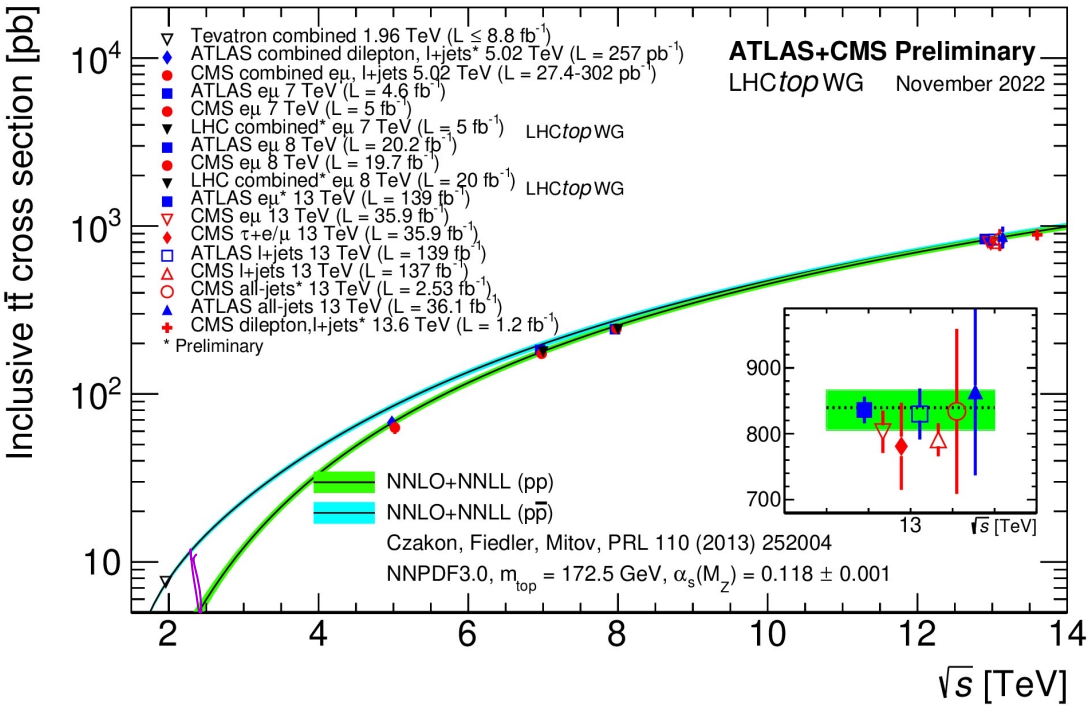


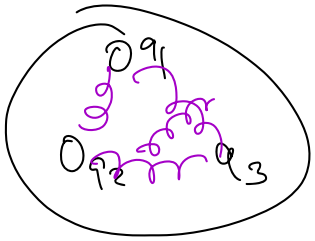
top production in $p\bar{p}$ collision.





gluon – gluon fusion

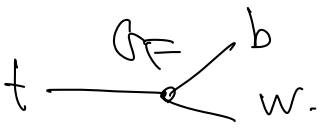




No top meson / baryon.

$t\bar{q}$ tq_1q_2

No quonium ($t\bar{t}$) bound state



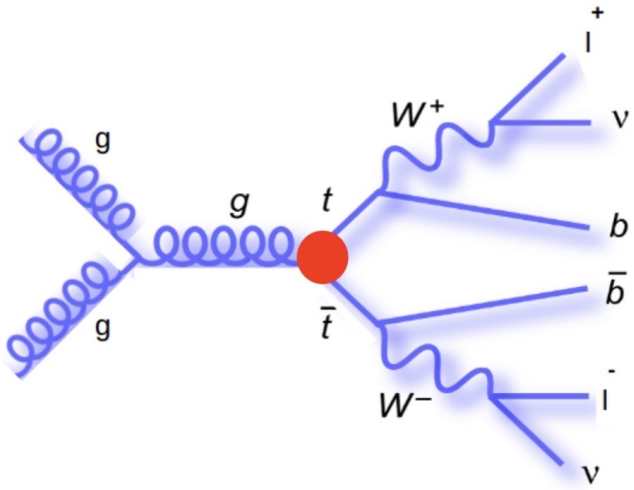
$\Gamma \sim G_F m_t^3$

$m_t = 175$ GeV $\quad G_F = 1.16 \times 10^{-5}$ GeV^{-2}

$\Gamma \sim 2$ GeV. $\quad \tau = \frac{1}{\Gamma} \sim 10^{-25}$ s.

strong interactions $\tau \sim 10^{-23}$ sec.

$t \to bW$ 100%



$W^+ \to l^+ \nu_l$

$\bar{q}_2$ $\quad \to q_1 \bar{q}_2$

$p + \bar{p} \to t \; \bar{t}$

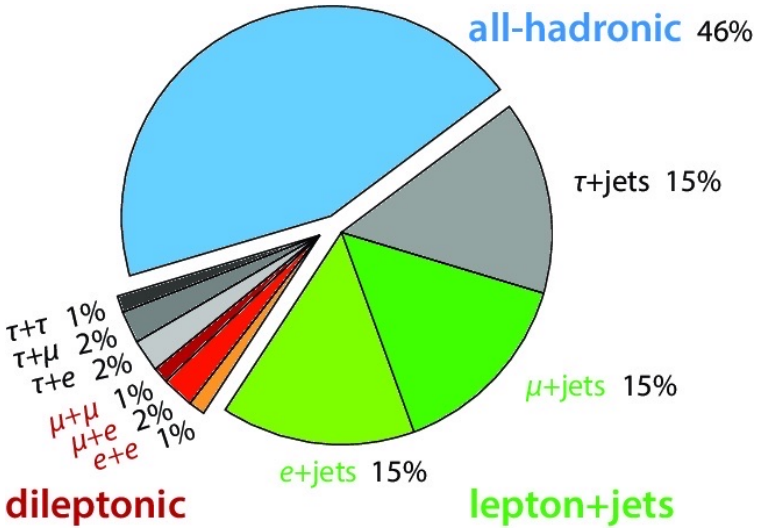
$\hookrightarrow W^- \; b \hookrightarrow$ jets of hadrons.

$\hookrightarrow q_1 \bar{q}_2$ 2 jets of hadrons.

$\hookrightarrow l^- \bar{\nu}_l$

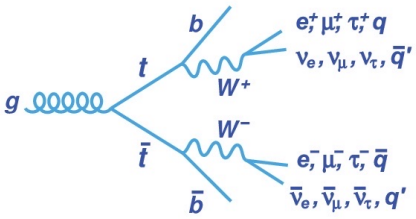
golden mode: 2 b jets + l_1^+ + l_2^- + missing energy.

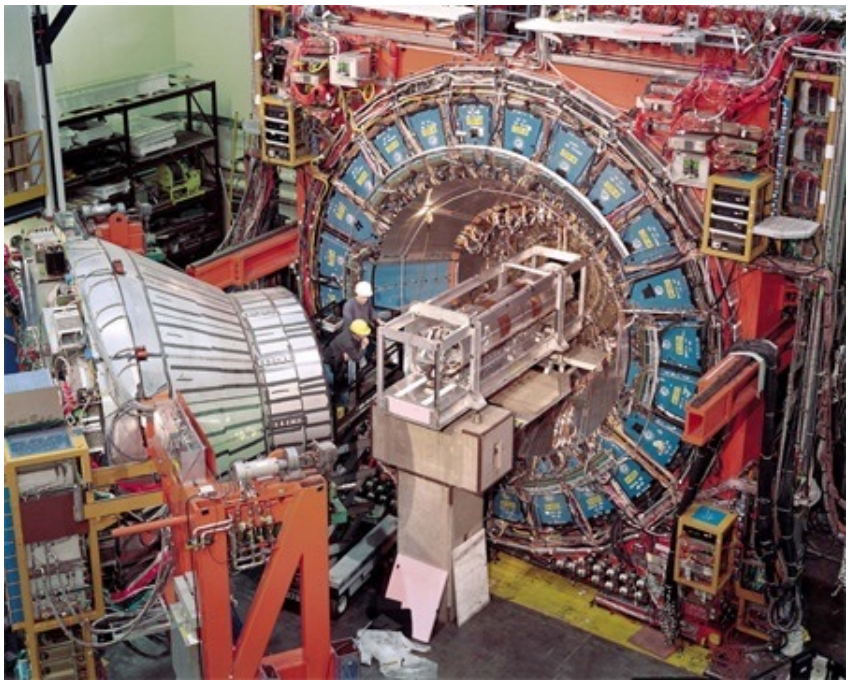
W^+ DECAY MODES		Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$\ell^+\nu$	[b]	(10.86± 0.09) %		–
$e^+\nu$		(10.71± 0.16) %		40189
$\mu^+\nu$		(10.63± 0.15) %		40189
$\tau^+\nu$		(11.38± 0.21) %		40170
hadrons		(67.41± 0.27) %		–

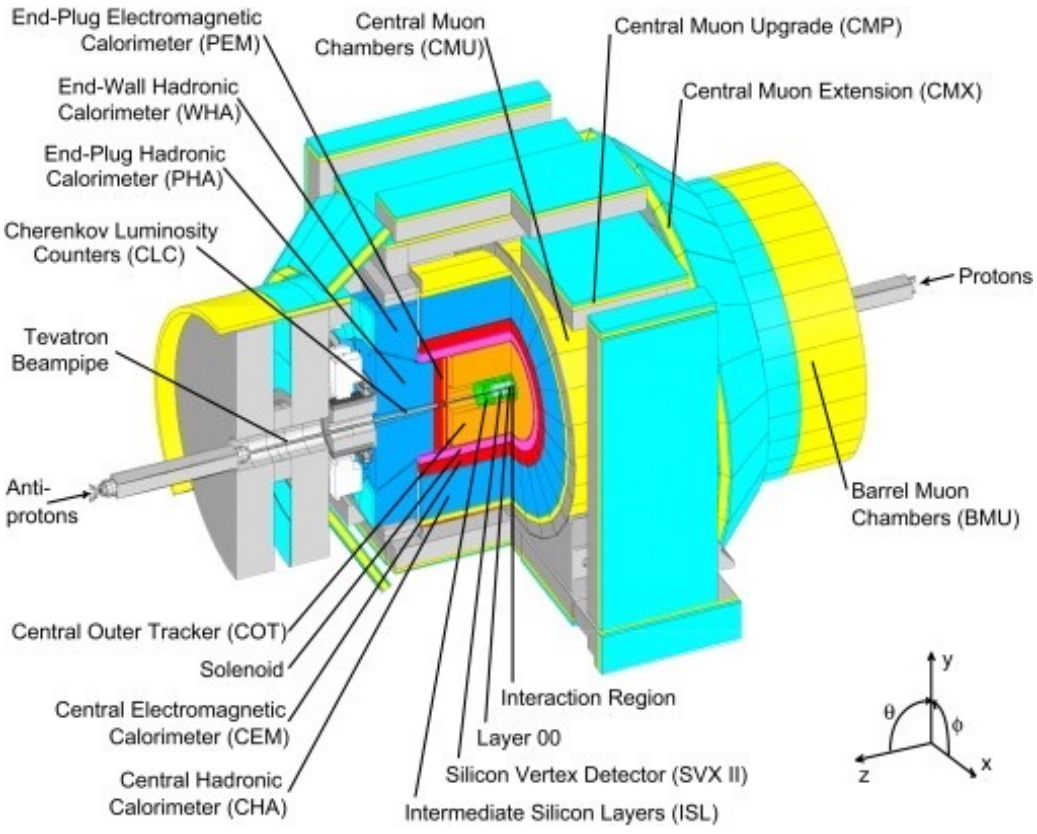


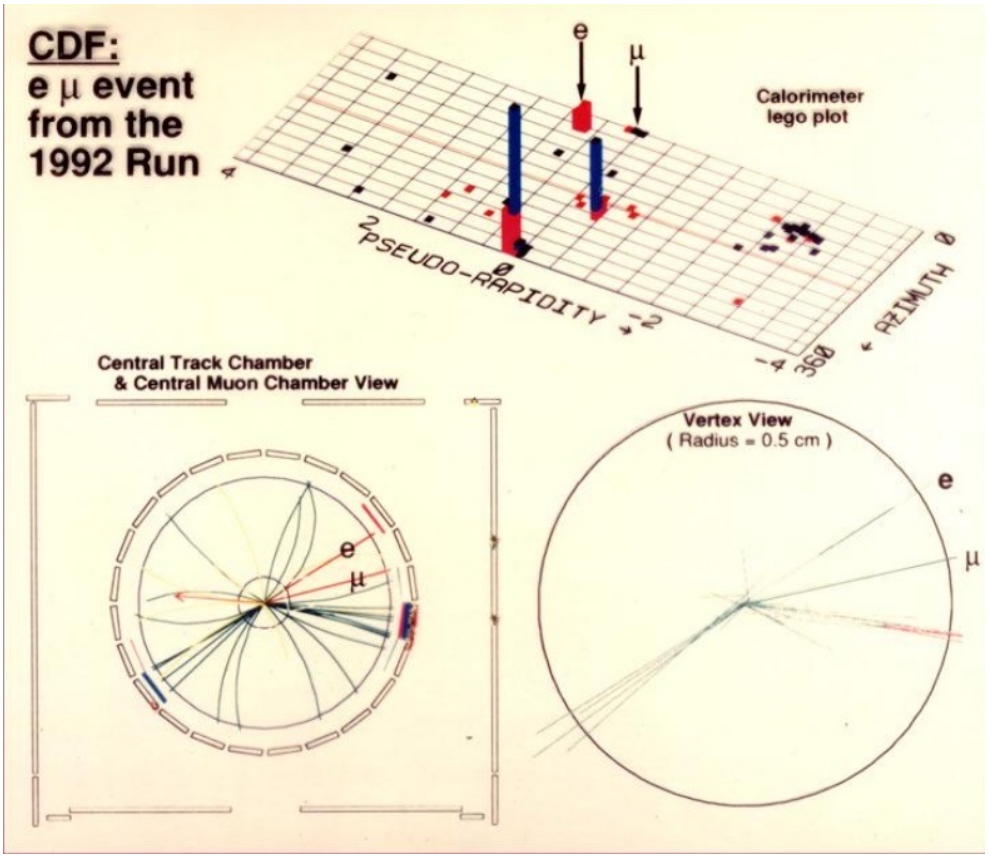
2 bjets + 4 jets from W^+W^-

Topology of $t\bar{t}$








CDF:
e μ event
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1992 Run
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Calorimeter
lego plot
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Central Track Chamber
& Central Muon Chamber View
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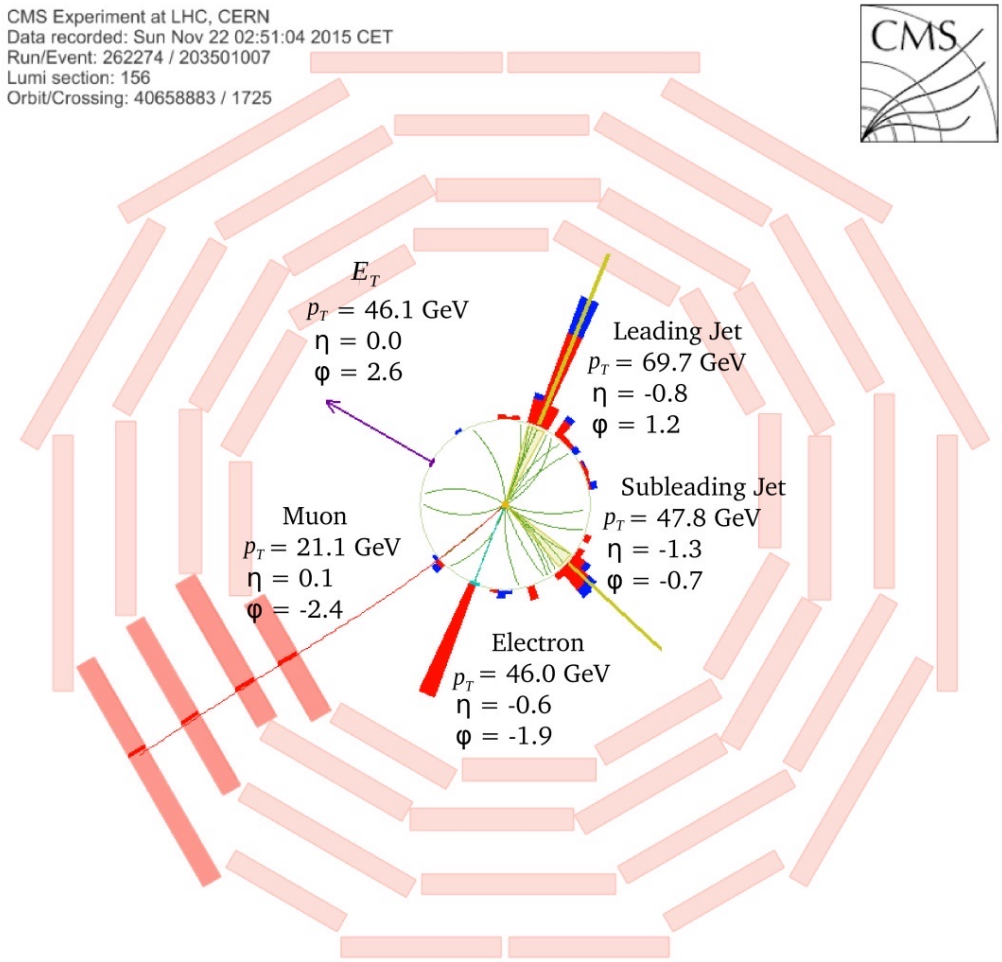
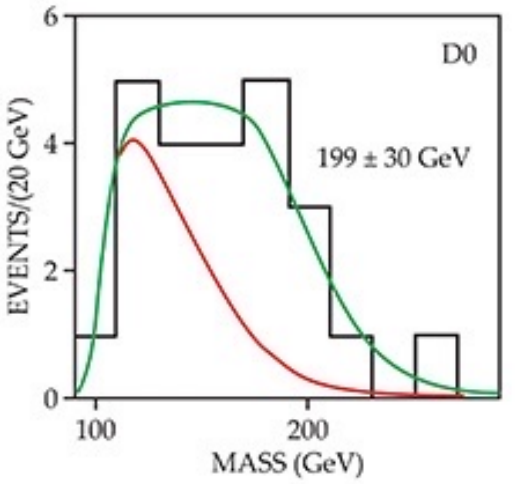
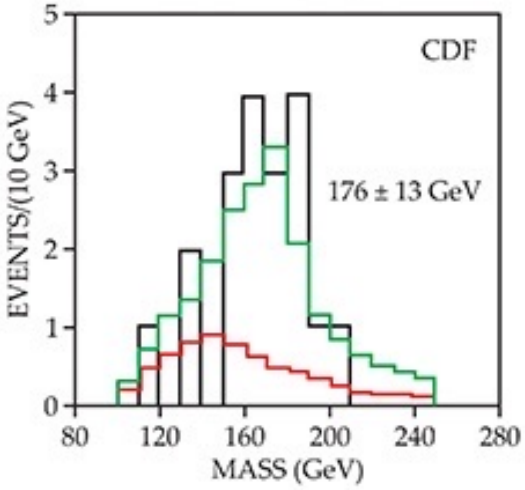
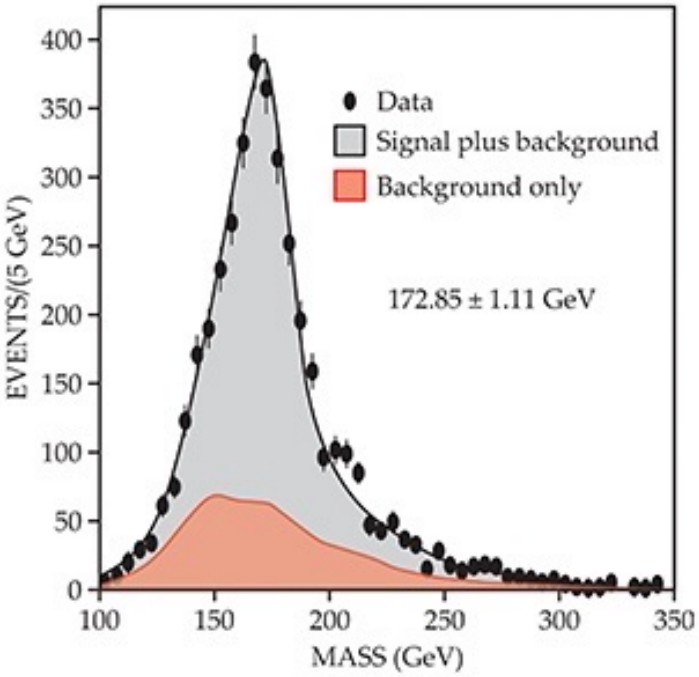
μ
Vertex View
(Radius = 0.5 cm)
e
μ


CMS Experiment at LHC, CERN
Data recorded: Sun Nov 22 02:51:04 2015 CET
Run/Event: 262274 / 203501007
Lumi section: 156
Orbit/Crossing: 40658883 / 1725
CMS
E_T
p_T = 46.1 GeV
η = 0.0
φ = 2.6
Leading Jet
p_T = 69.7 GeV
η = -0.8
φ = 1.2
Subleading Jet
p_T = 47.8 GeV
η = -1.3
φ = -0.7
Muon
p_T = 21.1 GeV
η = 0.1
φ = -2.4
Electron
p_T = 46.0 GeV
η = -0.6
φ = -1.9



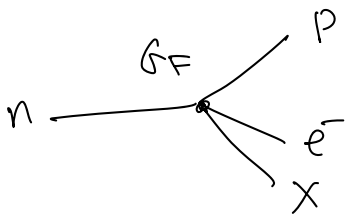




Weak Interactions

β^- decay of nuclei

$${}^{A}_{Z}X \longrightarrow {}^{A}_{Z+1}Y + e^- + \bar{\nu}_e$$



Fermi Theory of weak.

lifetime of some particles ~ 10^{-8} – 10^{-6} sec.

$\mu \sim 10^{-6}$ s

$\pi \sim 10^{-8}$ s

$n \longrightarrow p + e^- + X$

$n \longrightarrow \pi + \pi^-$

$m_n - m_p \simeq 1.5$ MeV

$Q \simeq 1$ MeV

n one of the lightest baryons.

octet with $L = 0$.

$n \to e^+e^-$

Weak interaction conserve Baryon Number ✱

$B = +\frac{1}{3}$ quarks.

$-\frac{1}{3}$ anti quarks

$B = (q_1 q_2 q_3) = +1$

at low energy.

Meson $(q_1 \bar{q}_2) = \frac{1}{3} - \frac{1}{3} = 0$

Lepton Flavor / Family number conserved.

$\begin{pmatrix} \nu_e \\ e^- \end{pmatrix}$ $\begin{pmatrix} \nu_\mu \\ \mu^- \end{pmatrix}$ $\begin{pmatrix} \nu_\tau \\ \tau^- \end{pmatrix}$

$L_e = 1$ $L_\mu = 1$ $L_\tau = 1$

QED, QCD, weak (low energy.) conserve L_e

our world

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

QCD, QED: P conserv, C conserv, CP conserv. ↓

weak: P ✗ ↓ wu experiment; C ✗ ↓ Gold Habe; CP ✗ K Cronin-Fitch B 2002.

CPT theorem.: CPT is a good symm $\Rightarrow$ T ✗ in weak.

Flavor violation: QED $\mu \to e^- \gamma$. Cannot happen.

$\Omega \longrightarrow X + \gamma$

$S = -3$ $S = -3$

weak int. $\Delta S = 1$, $\Delta C = 1$, $\Delta B = 1$ processes.

$\begin{pmatrix} u \\ d \end{pmatrix}\begin{pmatrix} c \\ s \end{pmatrix}\begin{pmatrix} t \\ b \end{pmatrix}$

Experimental prob of weak interactions

1) production of neutrinos.
2) flavor variation (s, c, b)
3) long lifetime $\qquad \Gamma \propto |M|^2 \rho$

Neutrino Flavors

$\begin{pmatrix} \nu_e \\ e^- \end{pmatrix}\begin{pmatrix} \nu_\mu \\ \mu^- \end{pmatrix}$

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

$\mu^- \to e^- \bar{\nu}_e \nu_\mu$

$\mu^- \to e^- + X$ $\qquad$ $\pi^+ \to \mu^+ + \nu_e$?

1) How do we know $\nu_\mu \neq \nu_e$?

2) How $\nu \neq \bar{\nu}$?

β^- decay $\quad n \to p + e^- + \bar{\nu}_e \qquad Q \simeq$ MeV

1956 Reines-Cowen. $\quad \bar{\nu}_e + p \to n + e^+$

$n + \mu^+$?

Lederman, Schwartz, Steinberger 1962.

$\pi^+ \to \mu^+ + \nu_\mu \longrightarrow \quad \nu_\mu + X \to \mu^- + Y$ OK.

$e^- + Y$ absent.

Fixed target exp @ AGS

Brookhaven.

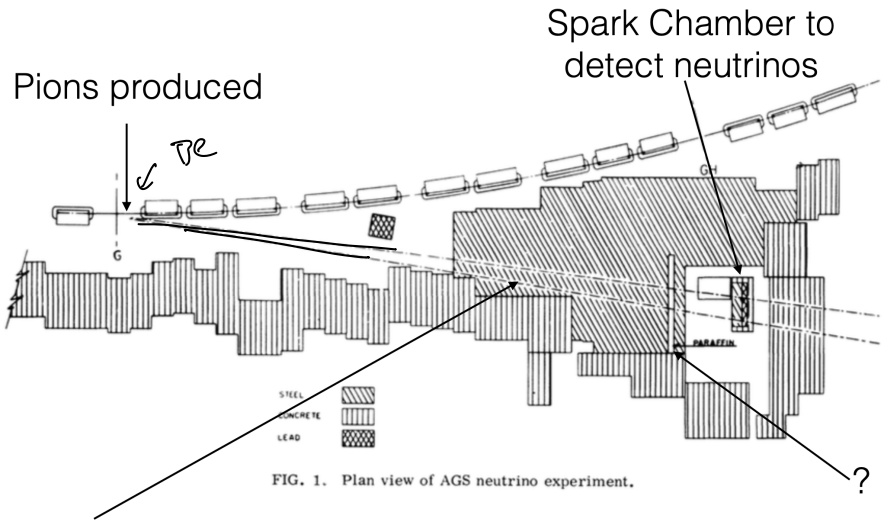


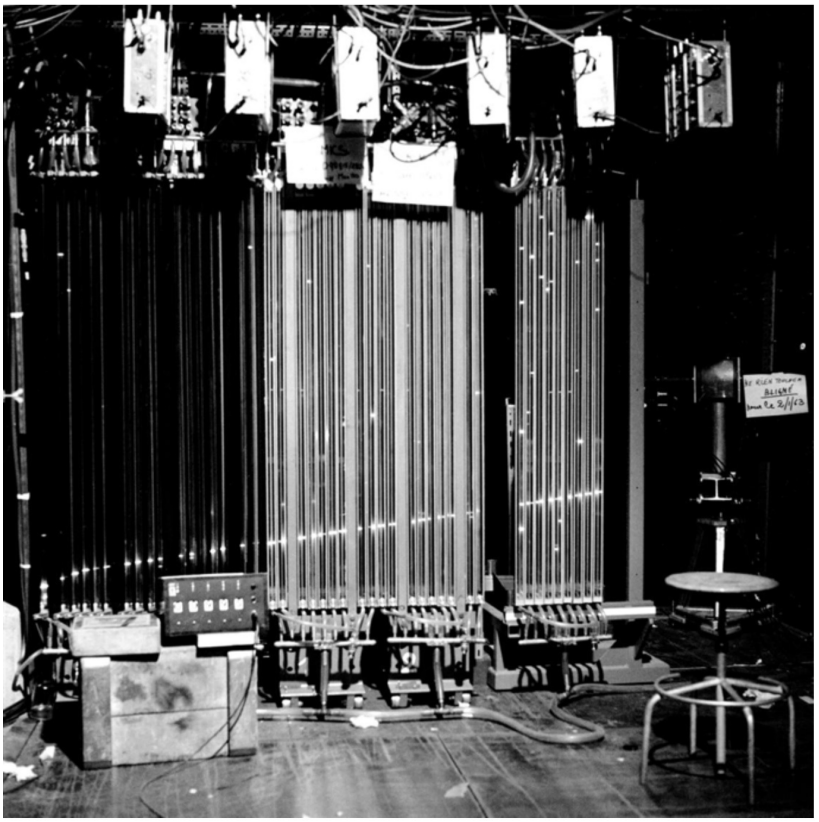
FIG. 1. Plan view of AGS neutrino experiment.

Steel shield stops strongly interacting particles

$$\text{proton} + Be \longrightarrow \pi^+ + X.$$

$$\pi^+ \longrightarrow \mu^+ + \nu_\mu.$$

$$\nu_\mu + X \longrightarrow \mu^- + Y$$



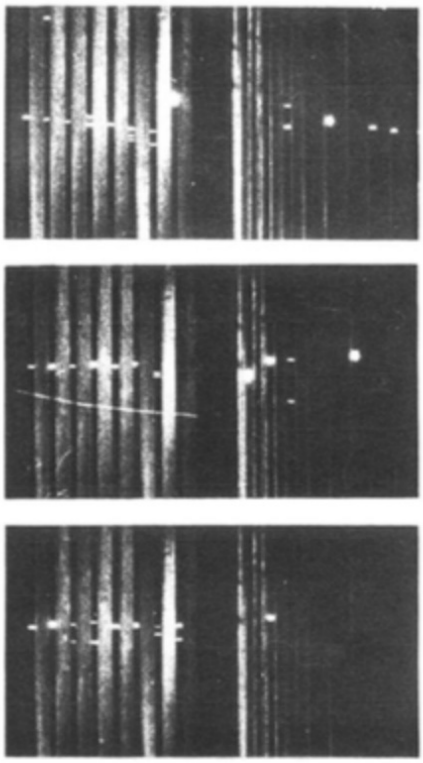


FIG. 8. 400-MeV electrons from the Cosmotron.

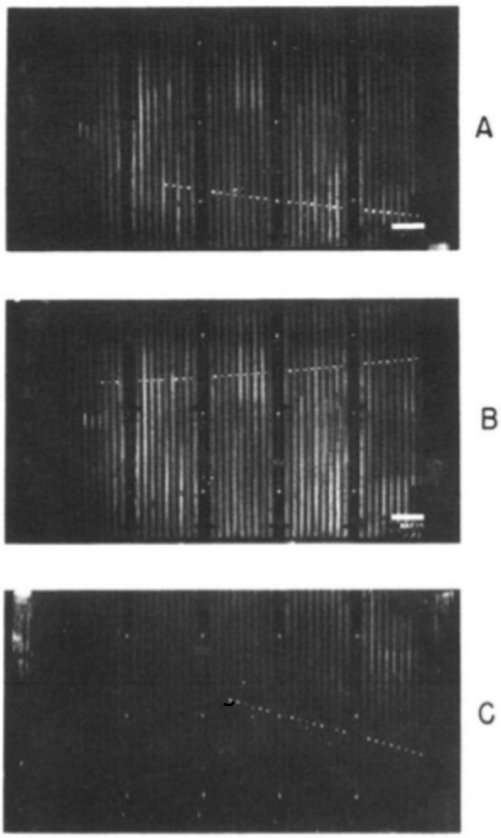


FIG. 5. Single muon events. (A) $p_\mu > 540$ MeV and δ ray indicating direction of motion (neutrino beam incident from left); (B) $p_\mu > 700$ MeV/c; (C) $p_\mu > 440$ with δ ray.

10^{17} protons on Be target

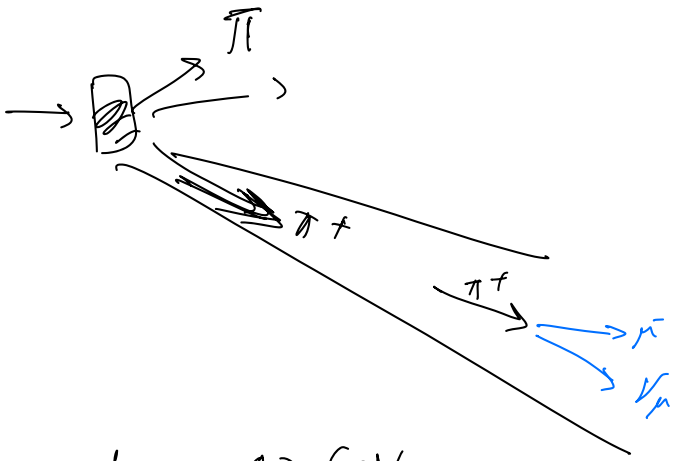
34 single μ track.

6 e^- showers.

ν_μ produces only μ^-

$\Rightarrow \nu_\mu \neq \nu_e$

ν_τ @ DONUT exp. @ Fermilab. 1998



if $p \geq 10$ GeV. π

Compute $\beta/\beta\sigma$.