

today: • TAYLOR - Higgs via top couplings

ANNOUNCE: IEVAL  
ACMI SURVEY

DISCUSS: DARK MATTER COLLOQUIUM /  $W^\pm$  CKM  
(last week)

### THEORY

- symmetry
- particles
- interactions

restricts interactions  
requires particles/interactions

look for these (eg RESONANCES)

using these

### how to look for particles 101

not comprehensive!

USUAL: production & decay

exceptions, eg  
DM,  $\nu$ 's, ...

thing you want to  
study isn't common

probably not common  
b/c it's not stable!

STABLE PARTICLES  
in SM:  
 $e, \gamma$ , lightest  $\nu$ ,

$p^+$ , meson?

n decays

turns out no!

HEAVY MESONS DECAY

→ HIGH SPIN STATES  
CAN RADIATE OFF THE  
ANGULAR MOMENTUM  
(eg emit photon, other meson)

→ HEAVY QUARKS DECAY  
TO LIGHTER QUARKS

not obvious!

LIGHT MESONS

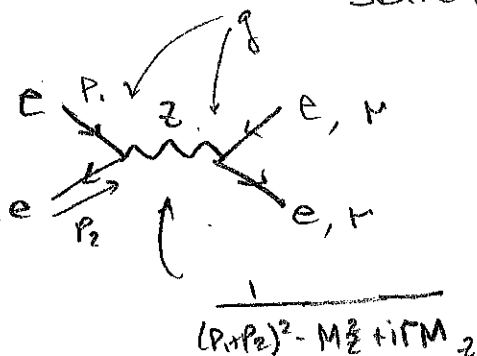
$\pi^\pm \rightarrow \mu^\pm \nu$   
 $\pi^0 \rightarrow \gamma\gamma$

# COLIDER

smash 2 ordinary things together

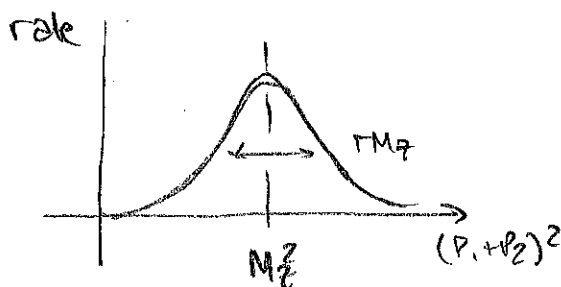
$e^+, e^-, p^+, p^-$

sometimes  $\gamma$ , sometimes  $\mu$

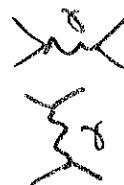
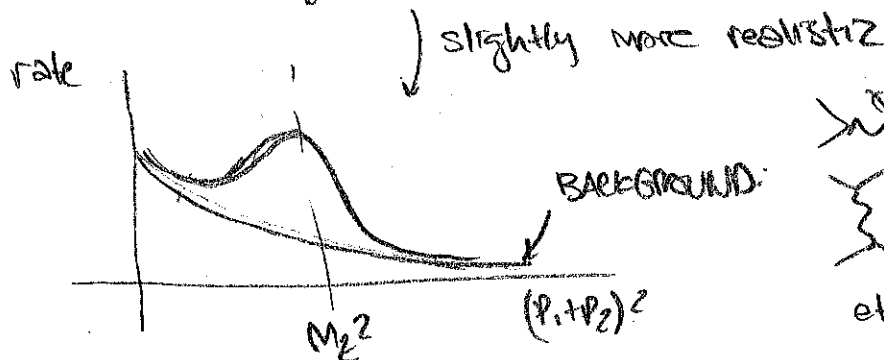


$$\sim \frac{g^2}{(p_1 + p_2)^2 - M_Z^2 + i\Gamma M_Z}$$

↑  
SQUARE THIS,  $\propto$  RATE



"bump hunt"



etc. (experimental junk)

# PROTON COLLIDERS



} bag model

$$\leftarrow \Delta_{\text{QCD}}^+ \rightarrow$$

QCD CONFINEMENT SCALE

① ENERGIES  $\gg \Delta_{\text{QCD}}$  : see free quarks  
(length  $< \Delta_{\text{QCD}}^{-1}$ )

② ENERGIES  $\ll \Delta_{\text{QCD}}$  : see proton

WHEN COLLIDING 2 PROTONS @ HIGH ENERGY ( $\gg \Delta_{\text{QCD}}$ )

↳ really colliding the constituents

- valence quarks (u, u, d)
- gluons

BUT HOW MUCH OF THE  $P^+$  ENERGY/MOMENTUM IS CARRIED BY EACH CONSTITUENT?

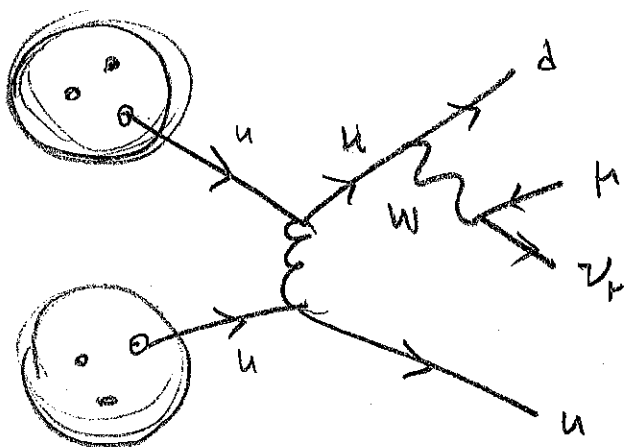
↳ parton distribution function (PDF)

↑  
quark or gluon

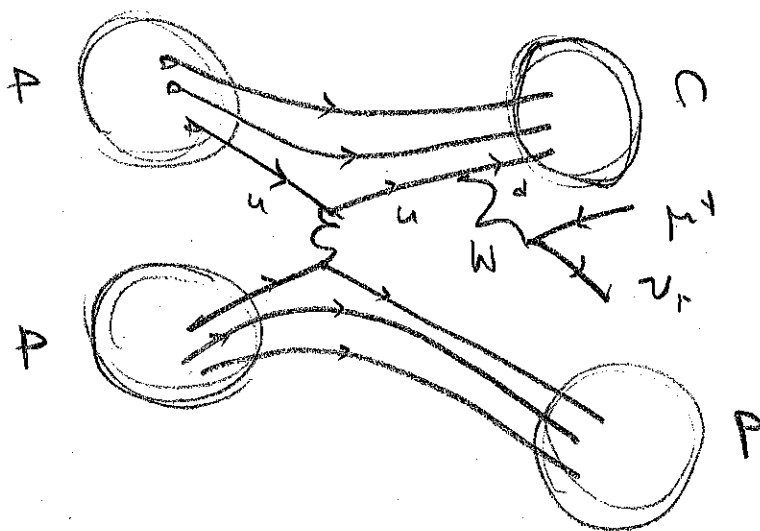
$f_g(x)$  ← "amount of g in  $P^+$   
w/ momentum fraction x"

$$P_g = x P_{P^+}$$

HAVE TO MEASURE EXPERIMENTALLY

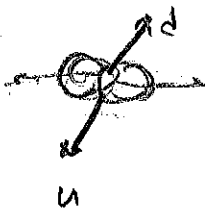


PROBLEM: final state is not color neutral  
maybe "spectator" quarks?

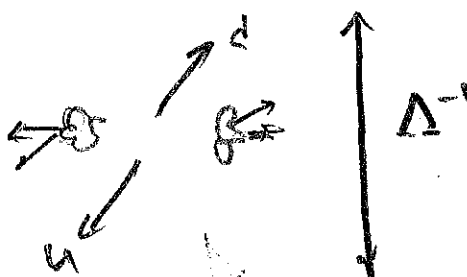


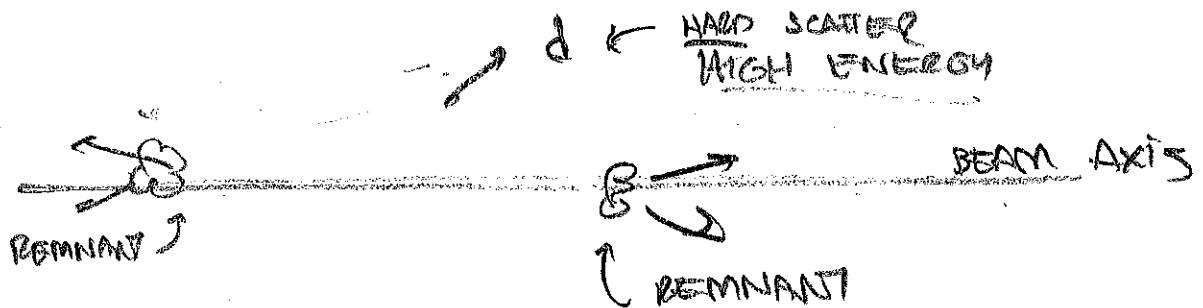
maybe plausible  
(esp @ low energy)

BUT AT HIGH ENERGY,  
SCATTERING CAN HAVE  
HIGH TRANSVERSE  
MOMENTUM



have to color connect  
w/ flux tubes



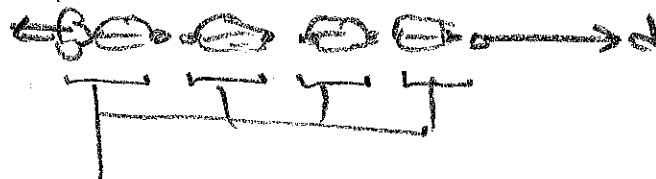
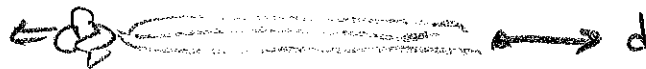


HAVE TO COLOR CONNECT

↳ FLUX TUBES BREAK @ HIGH E. (TRAVELLING FAR APART)

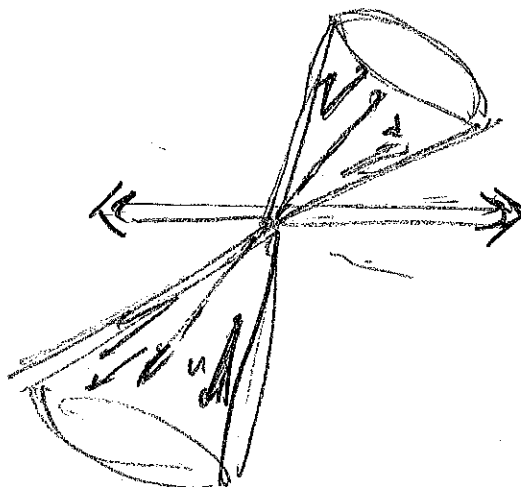
→ BREAKS INTO SMALLER FLUX TUBES

REMNANT



EACH OF THESE IS COLOR NEUTRAL (HADRON)

↑ meson or baryon



SPRAY OF HADRONIC PARTICLES IN A CONE AROUND THE HARD SCATTER FINAL STATES.

↑ we call these jets