

Introductory Concepts behind Particle Detection

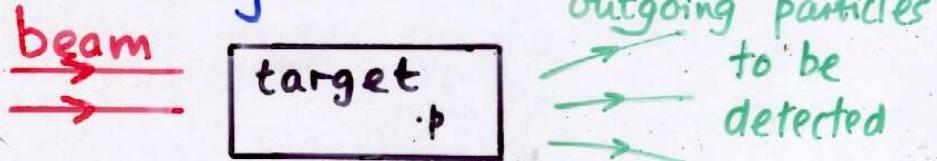
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CERN HST 2009

Particle physics is the study of

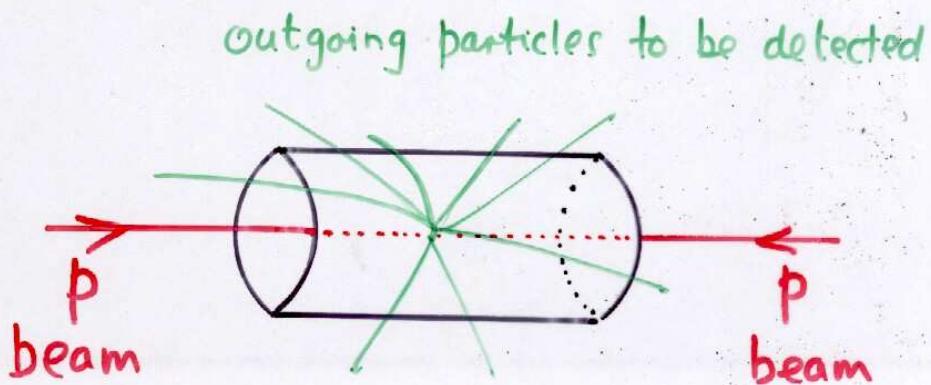
- * the elementary particles of nature
- * the forces they exert on each other

Typical experiments

- * Fixed target



- * Colliding beams



What comes out of a collision is governed by
the rules of

- * QUANTUM MECHANICS
- * RELATIVITY
- * CONSERVATION LAWS .

PLAN

- ① Standard Model Particles
- ② Introduction to how charged particles lose energy as they travel through matter.
- ③ Introduction to decays of heavy particles into lighter particles
- (④ $E^2 = p^2 c^2 + m^2 c^4$)

Standard Model Particles

1968: SLAC <i>u</i> up quark	1974: Brookhaven & SLAC <i>c</i> charm quark	1995: Fermilab <i>t</i> top quark	1979: DESY <i>g</i> gluon
1968: SLAC <i>d</i> down quark	1947: Manchester University <i>s</i> strange quark	1977: Fermilab <i>b</i> bottom quark	1923: Washington University γ photon
1956: Savannah River Plant ν_e electron neutrino	1962: Brookhaven ν_μ muon neutrino	2000: Fermilab ν_τ tau neutrino	1983: CERN <i>W</i> <i>W</i> boson
1897: Cavendish Laboratory <i>e</i> electron	1937: Caltech and Harvard μ muon	1976: SLAC τ tau	1983: CERN <i>Z</i> <i>Z</i> boson

Matter particles

1964: SLAC u up quark	1974: Brookhaven & SLAC c charm quark	1995: Fermilab t top quark	1994: DESY g gluon
1968: SLAC d down quark	1977: Manchester University s strange quark	1977: Fermilab b bottom quark	1943: Washington University γ photon
1962: CERN ν_e electron neutrino	1962: Brookhaven ν_μ muon neutrino	1962: Fermilab ν_τ tau neutrino	1973: CERN W W boson
1953: CERN Laboratory e electron	1953: CERN Laboratory μ muon	1953: SLAC τ tau	1983: CERN Z Z boson

Force carrying particles

gluon
STRONG FORCE

photon
ELECTROMAGNETIC FORCE

W^\pm -boson }
 Z^0 -boson }
WEAK FORCE }

Matter particles

Quarks - cannot be detected directly;
always bound, in HADRONS.

1964: SLAC u up quark	1934: Brookhaven & SLAC c charm quark	1990: Fermilab t top quark	1973: DESY g gluon
1968: SLAC d down quark	1947: Manchester University s strange quark	1971: Fermilab b bottom quark	1923: Washington University γ photon
1957: CERN ν_e electron neutrino	1964: Brookhaven ν_μ muon neutrino	1990: Fermilab ν_τ tau neutrino	1983: CERN W W boson
1953: Caltech Laboratory e electron	1957: Caltech and Harwell μ muon	1990: CERN τ tau	1983: CERN Z Z boson

Leptons - can travel individually
and be detected

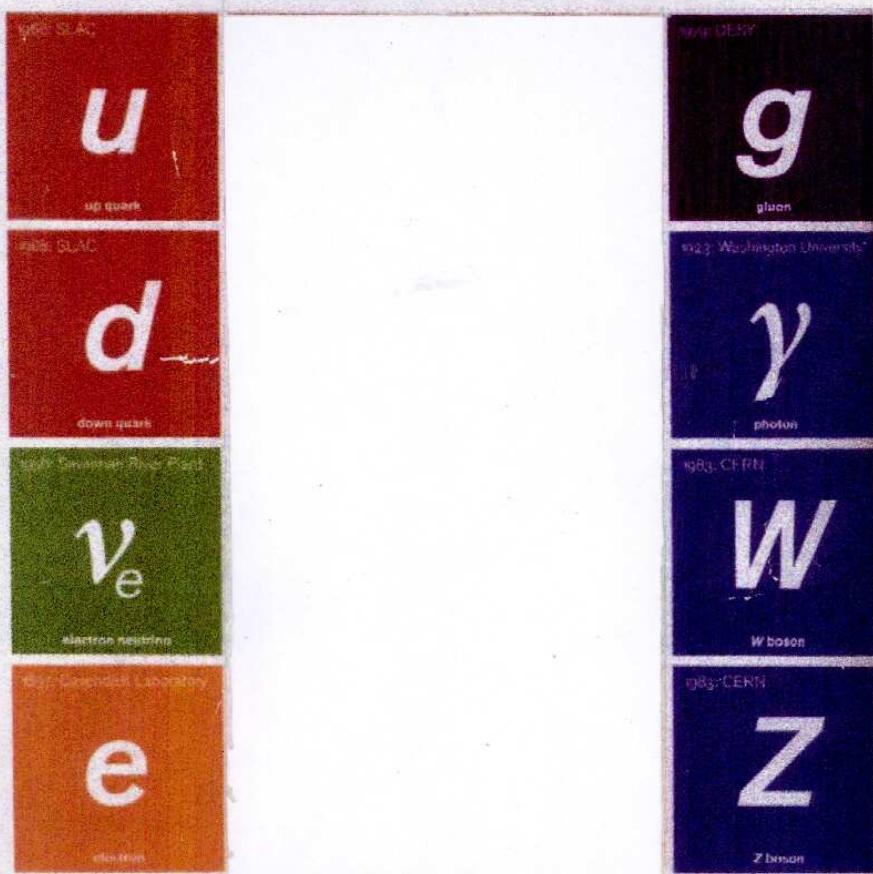
Force carrying particles

gluon - cannot be detected directly; it binds quarks in HADRONS

1969 SLAC u up quark	1973 Brookhaven & SLAC c charm quark	1975 Fermilab t top quark	1976 CERN g gluon
1969 SLAC d down quark	1974 Manchester University s strange quark	1977 Fermilab b bottom quark	1979 Washington University γ photon
1969 CERN, Princeton ν_e electron neutrino	1974 Princeton ν_μ muon neutrino	1974 Princeton ν_τ tau neutrino	1983 CERN W W boson
1969 CERN Laboratory e electron	1973 CERN and INFN μ muon	1976 CERN τ tau	1983 CERN Z Z boson

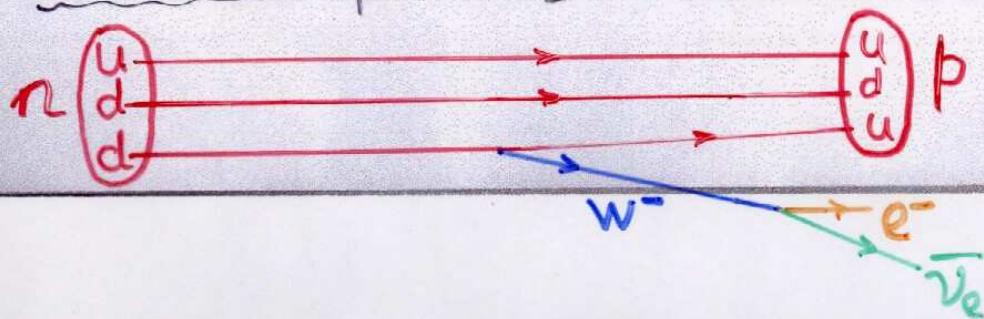
"Vector bosons"
(γ, W^\pm, Z^0)
can travel freely and be detected

3 generations of quarks and leptons



For what we observe we (almost) only need the first generation.

EXAMPLE β -decay $n \rightarrow p e^- \bar{\nu}_e$



We can detect:

• HADRONS

e.g.			MeV/c ²
	π^+	$u\bar{d}$	139.6
	π^-	$\bar{u}d$	139.6
	K^+	$u\bar{s}$	493.7
	K^-	$\bar{u}s$	493.7
	K^0	$d\bar{s}$	497.6
	p	uud	938.3
	n	udd	939.6
	\bar{n}	$\bar{u}\bar{d}\bar{d}$	939.6
	Λ^0	uds	1115.7

mesons

baryons

• LEPTONS

$$e^- \mu^- \tau^- \nu_e \bar{\nu}_\mu \bar{\nu}_\tau$$
$$e^+ \mu^+ \tau^+ \bar{\nu}_e \bar{\nu}_\mu \bar{\nu}_\tau$$

• VECTOR BOSONS

$$\gamma, W^\pm, Z^0$$
$$80.4 \text{ GeV}/c^2 \quad 91.9$$

• Working group