Introductory Concepts behind Particle Detection

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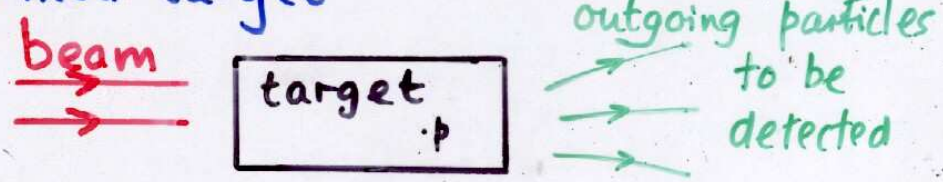
Particle physics is the study of

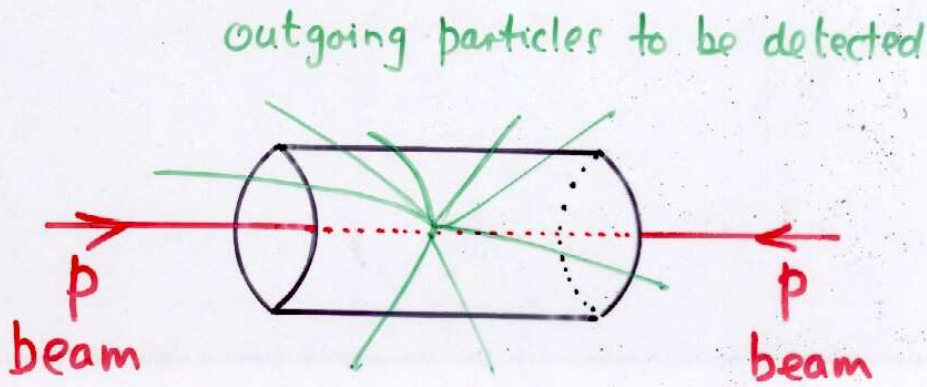
* the elementary particles of nature
* the forces they exert on each other

Typical experiments

* Fixed target



* Colliding beams



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

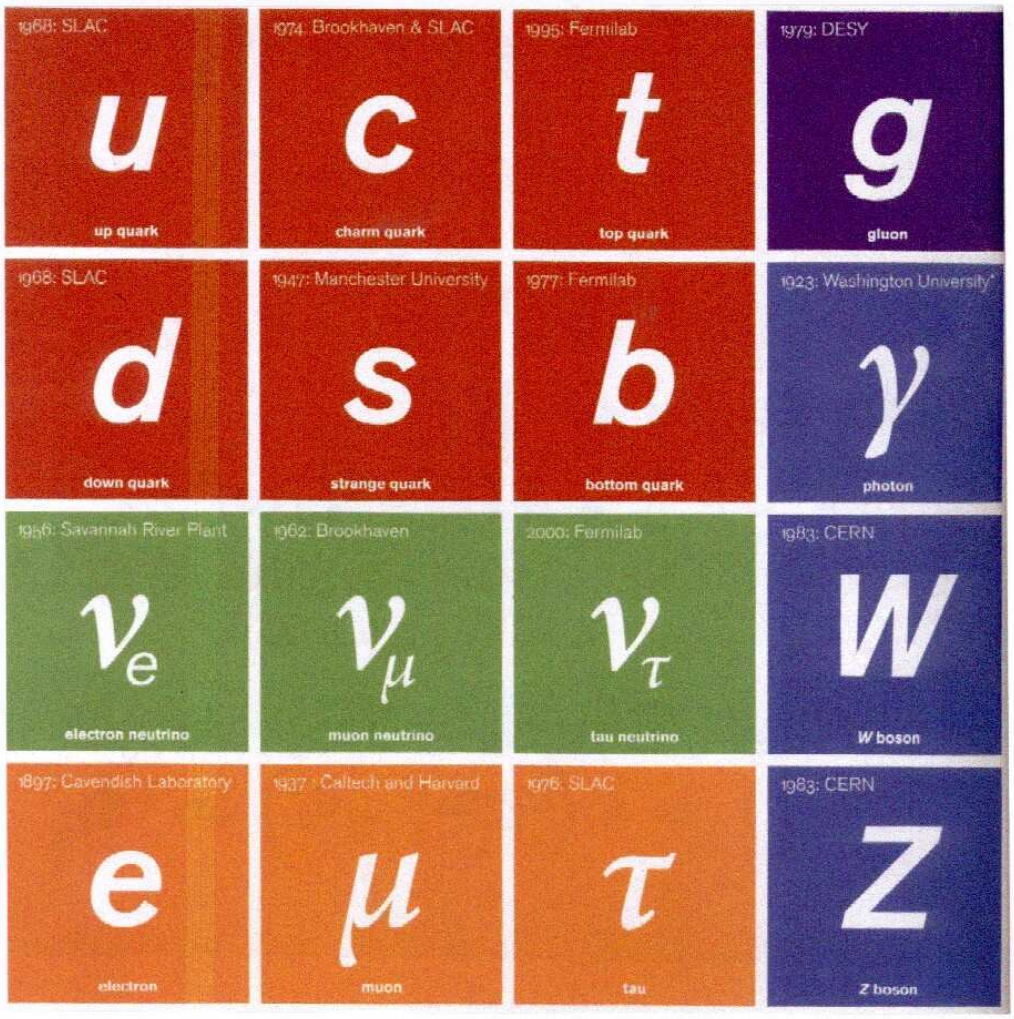
* QUANTUM MECHANICS
* RELATIVITY
* CONSERVATION LAWS .

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

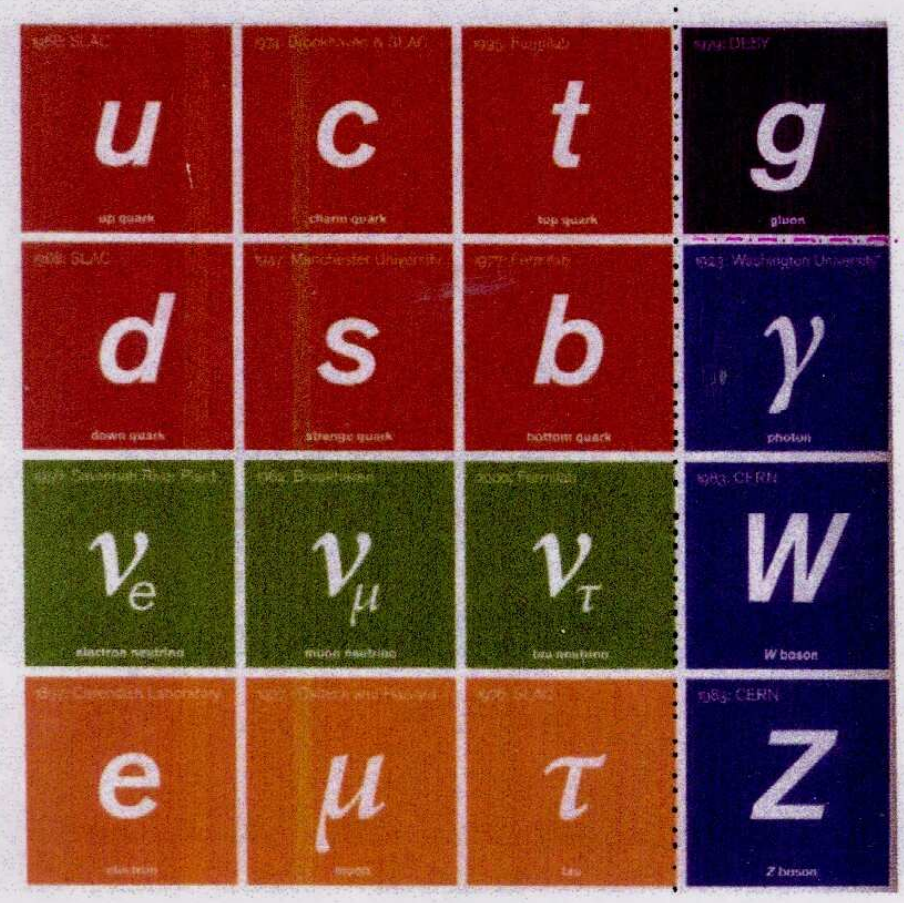
(4. $E^2 = p^2c^2 + m^2c^4$)

Standard Model Particles



Matter particles

Force carrying particles



gluon
STRONG FORCE

photon
ELECTROMAGNETIC FORCE

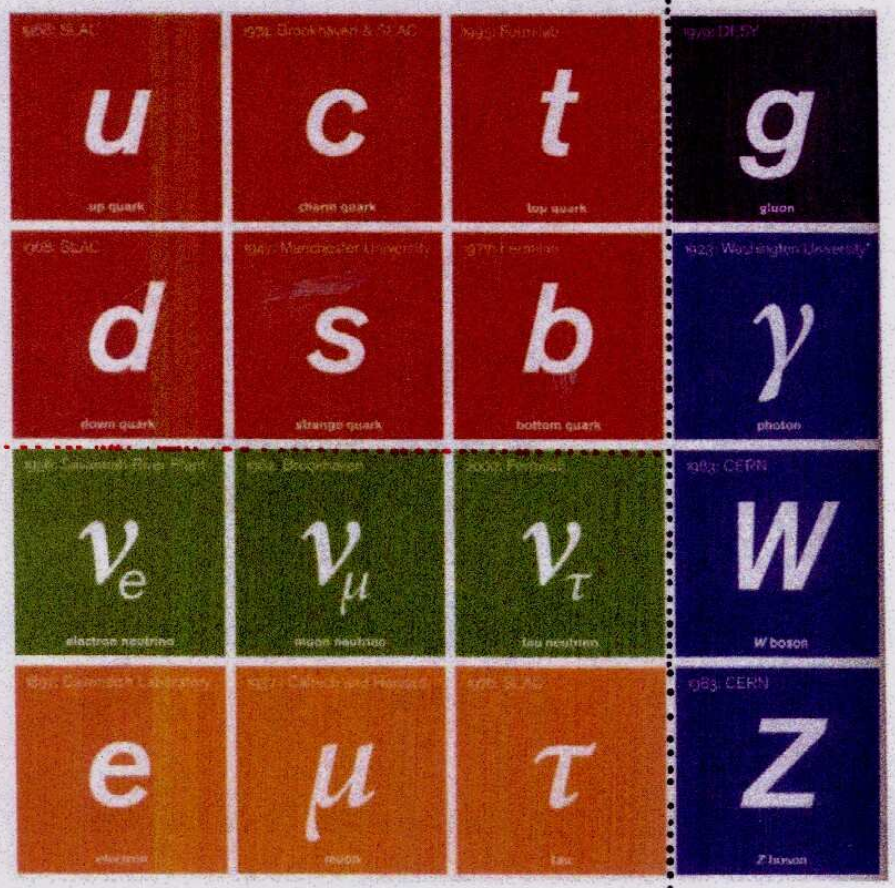
$W^{\pm}$-boson

Z^0-boson

WEAK FORCE

Matter particles

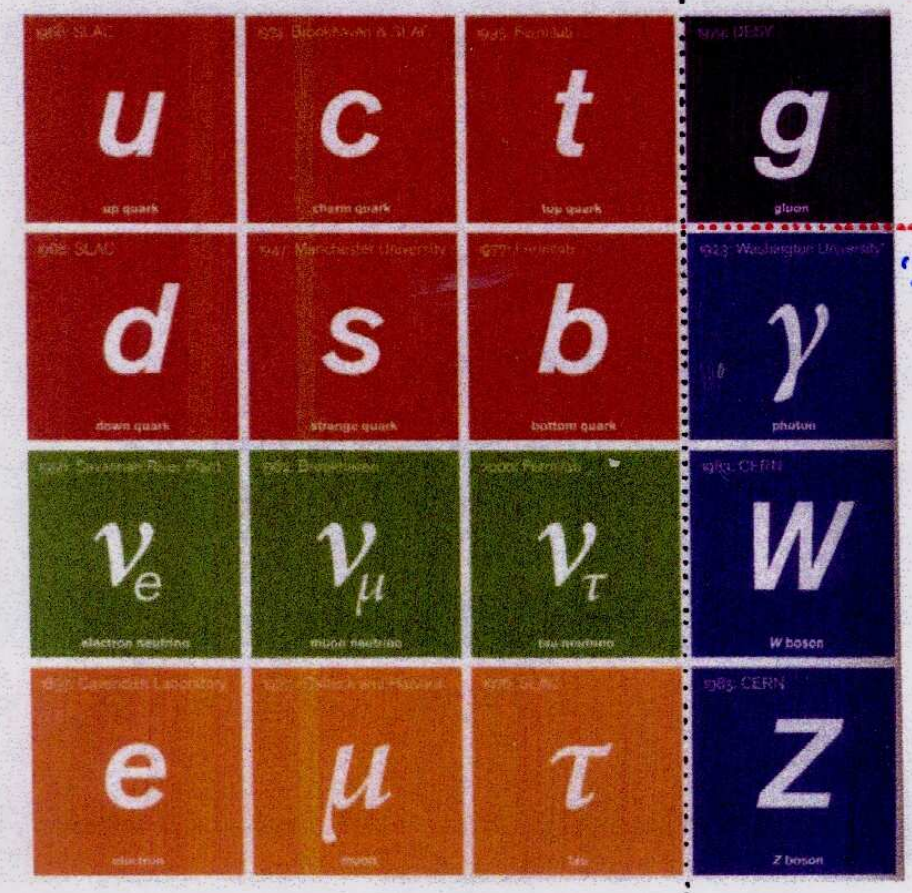
Quarks – cannot be detected directly; always bound, in HADRONS.



Leptons – can travel individually and be detected

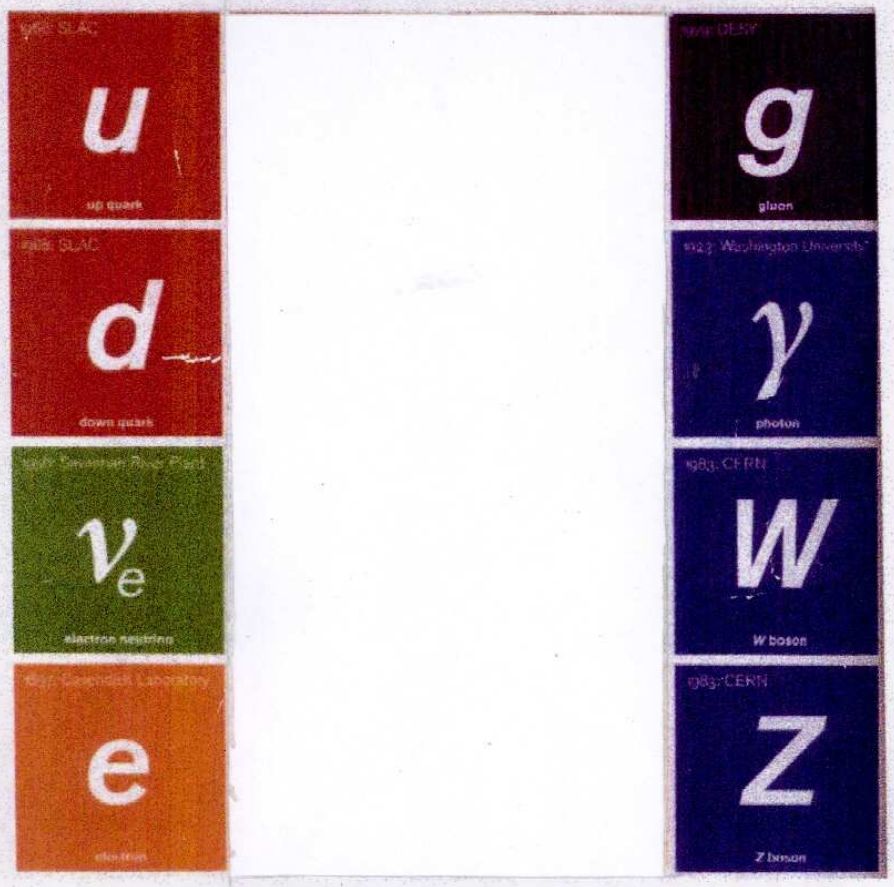
Force carrying particles

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



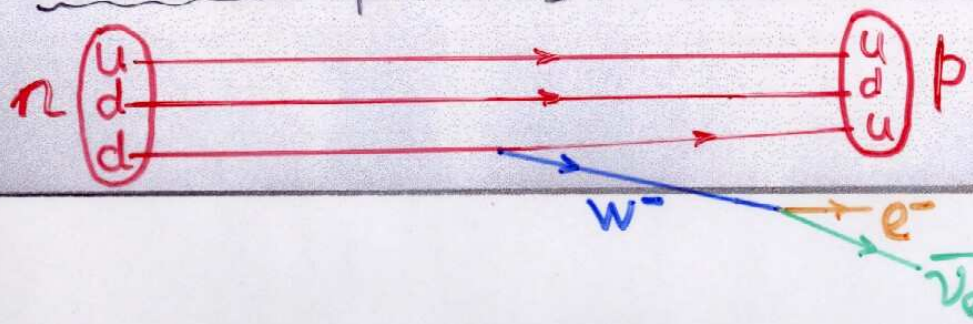
"Vector bosons" (γ, $W^{\pm}$, Z^{0}) can travel freely and be detected

3 generations of quarks and leptons



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

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



We can detect:

- **HADRONS**

			MeV/c^2	
e.g.	π^+	$u\bar{d}$	139.6	mesons
	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	baryons
	n	udd	939.6	
	$\bar{n}$	$\bar{u}\bar{d}\bar{d}$	939.6	
	Λ^0	uds	1115.7	

- **LEPTONS** e^- μ^- τ^- ν_e ν_μ ν_τ

  e^+ μ^+ τ^+ $\bar{\nu}_e$ $\bar{\nu}_\mu$ $\bar{\nu}_\tau$

- **VECTOR BOSONS** γ ; $W^\pm$, Z^0

  $W^\pm \to 80.4$ GeV/c^2, $Z^0 \to 91.9$

- Working group