Review for Honors 135

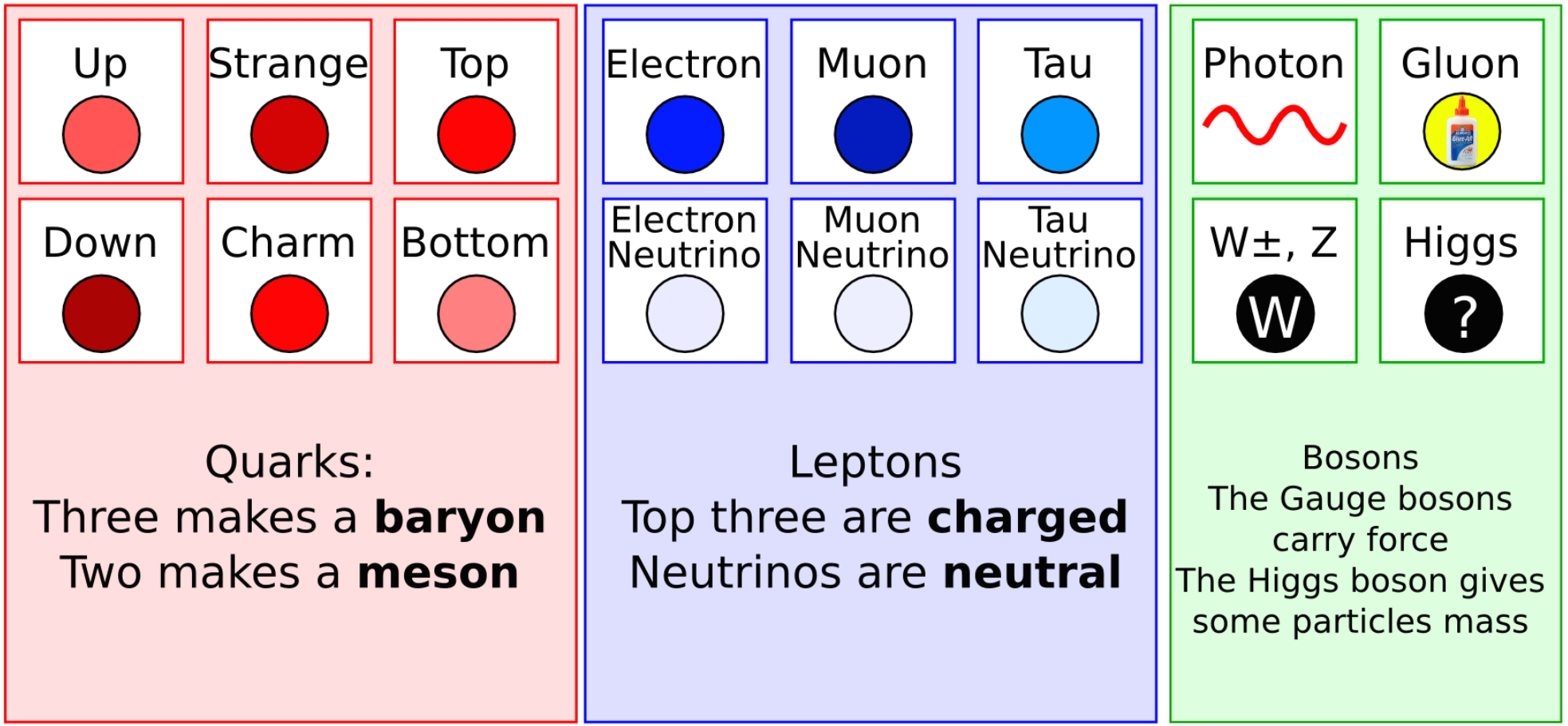
Aaron White

Today

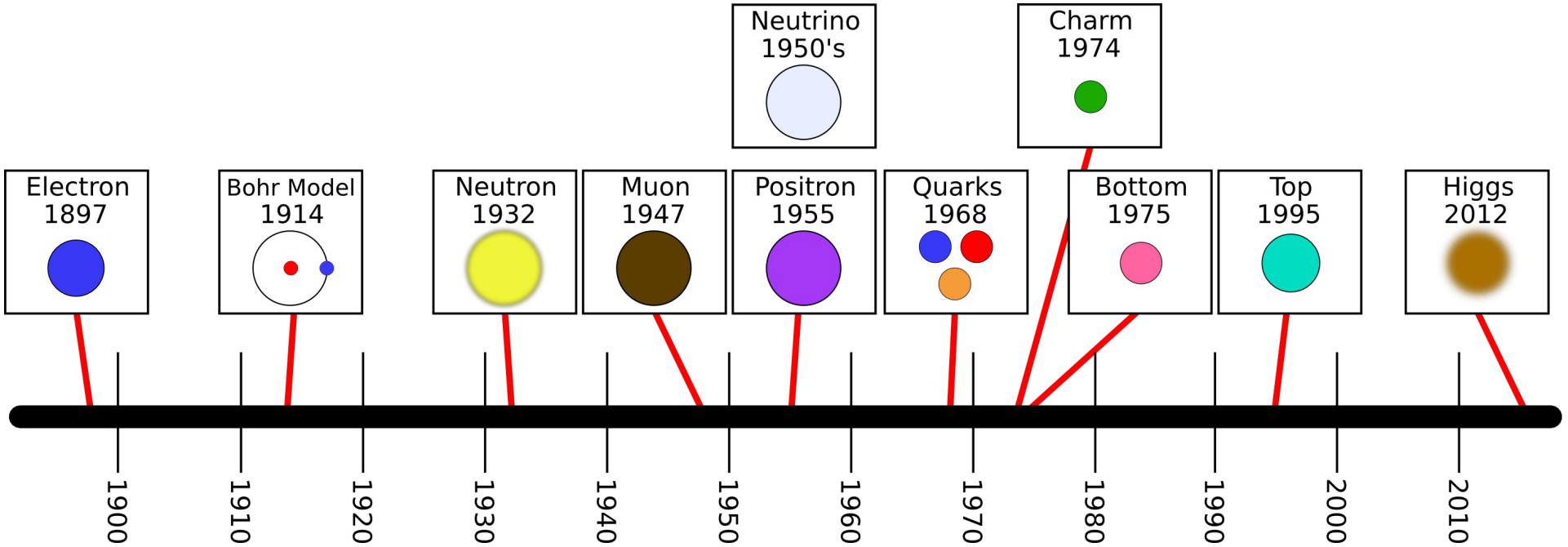
- Review topics for course
- Review Lagrangian
- Homopolar Motor Demo
- Survey
- Particle fever

Review Course Topics

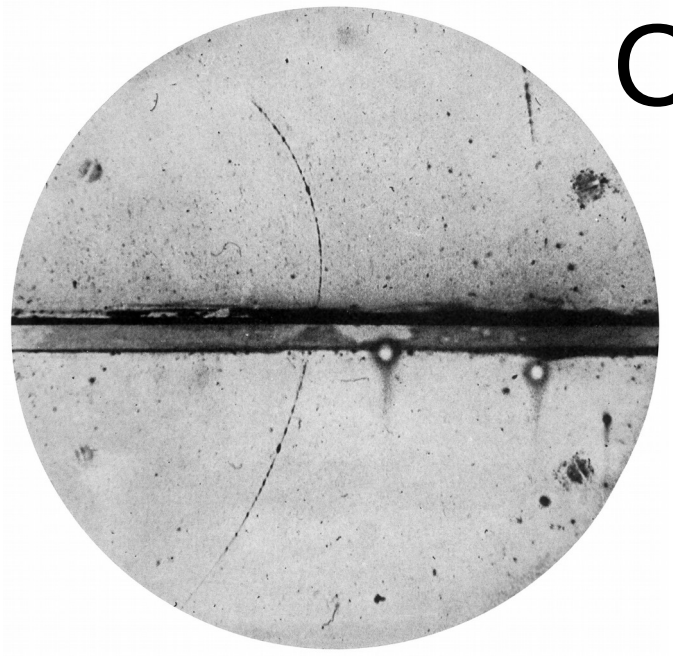
Particles of the Standard Model



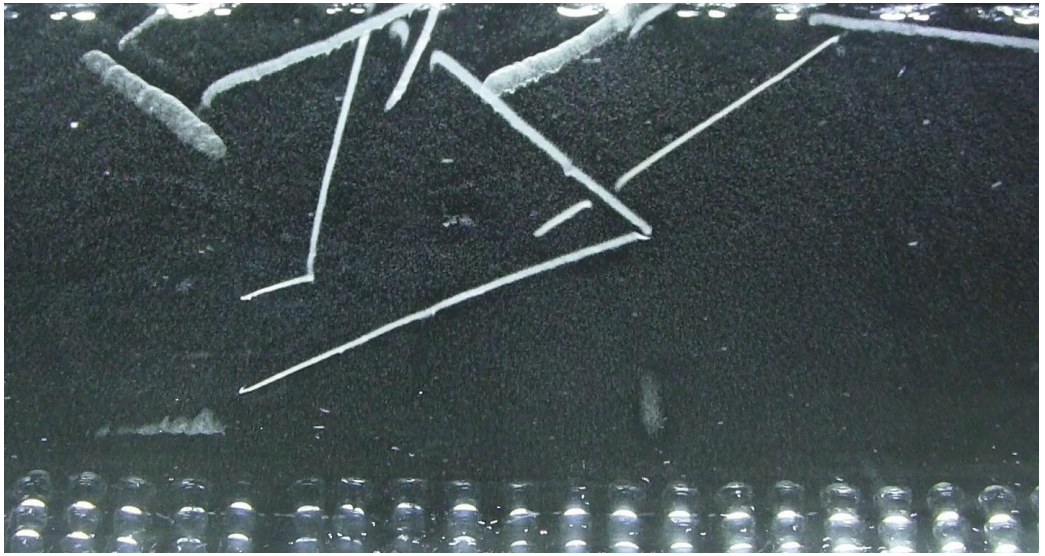
Timeline


Electron
1897
Bohr Model
1914
Neutron
1932
Muon
1947
Neutrino
1950's
Positron
1955
Quarks
1968
Charm
1974
Bottom
1975
Top
1995
Higgs
2012
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010

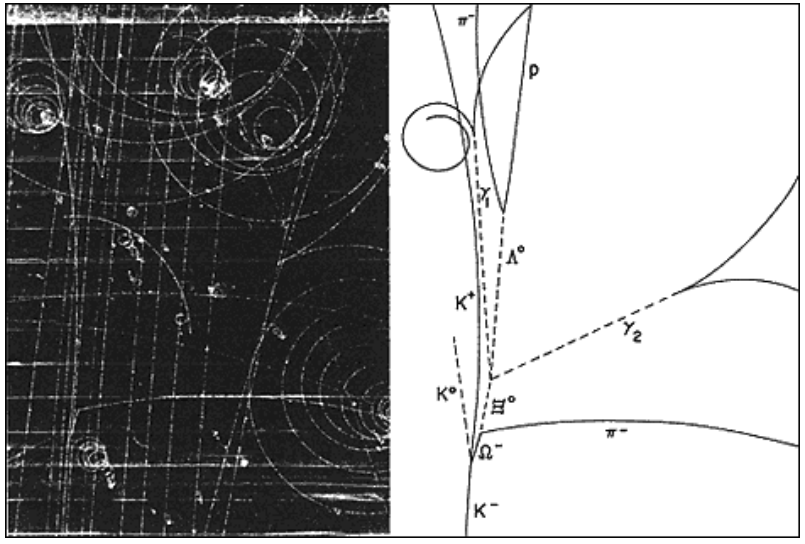
Cloud Chamber



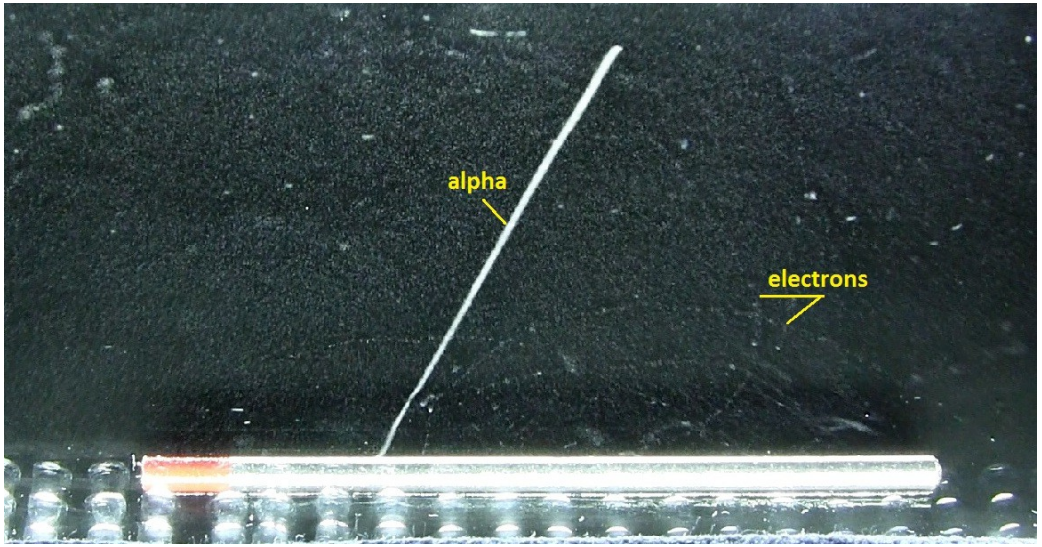
http://upload.wikimedia.org/wikipedia/commons/6/69/PositronDiscovery.jpg



http://upload.wikimedia.org/wikipedia/commons/2/2a/Radon220_decay_in_a_cloud_chamber.jpg



http://www.pd.infn.it/~dorigo/omega-dia-w.gif

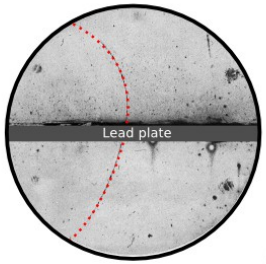


http://upload.wikimedia.org/wikipedia/commons/a/ac/Alpha_particle_and_electrons_from_a_thorium_rod_in_a_cloud_chamber.jpg

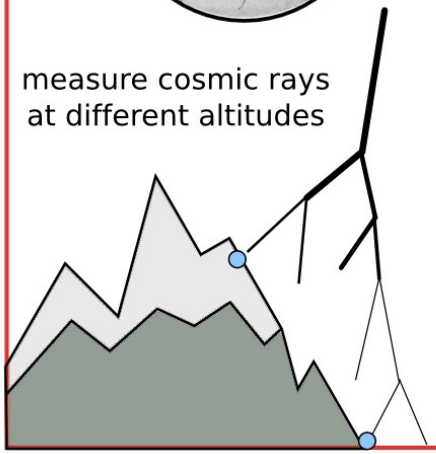
Methods of Particle Detection

Cloud Chamber

Particles leave tracks of ionization, clouds form

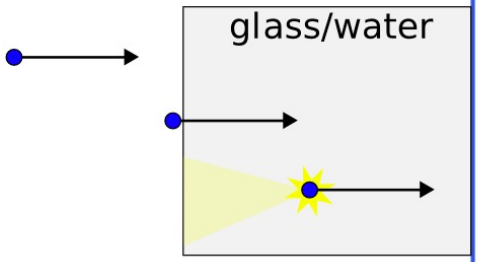


measure cosmic rays at different altitudes



Cherenkov

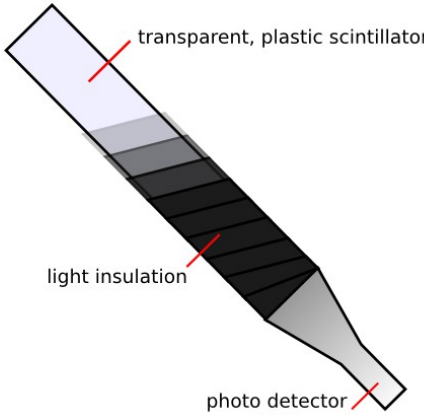
Particles moving faster than speed of light in medium, polarize medium

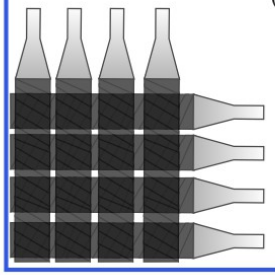


PHENIX RICH

Scintillation

Particles excite electrons in media, media emits light

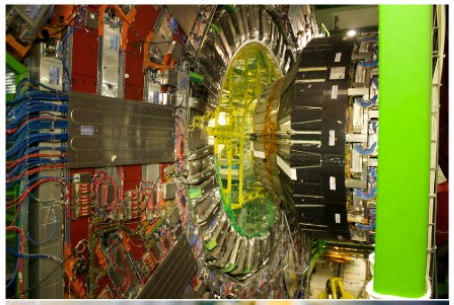


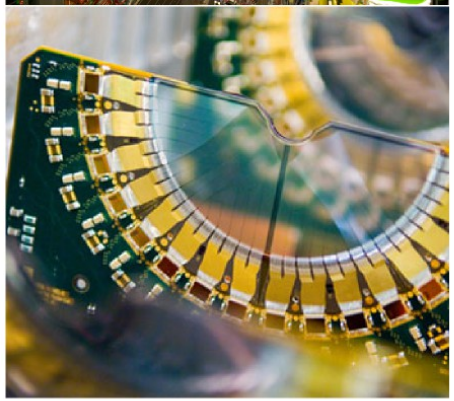


Build into array

Silicon

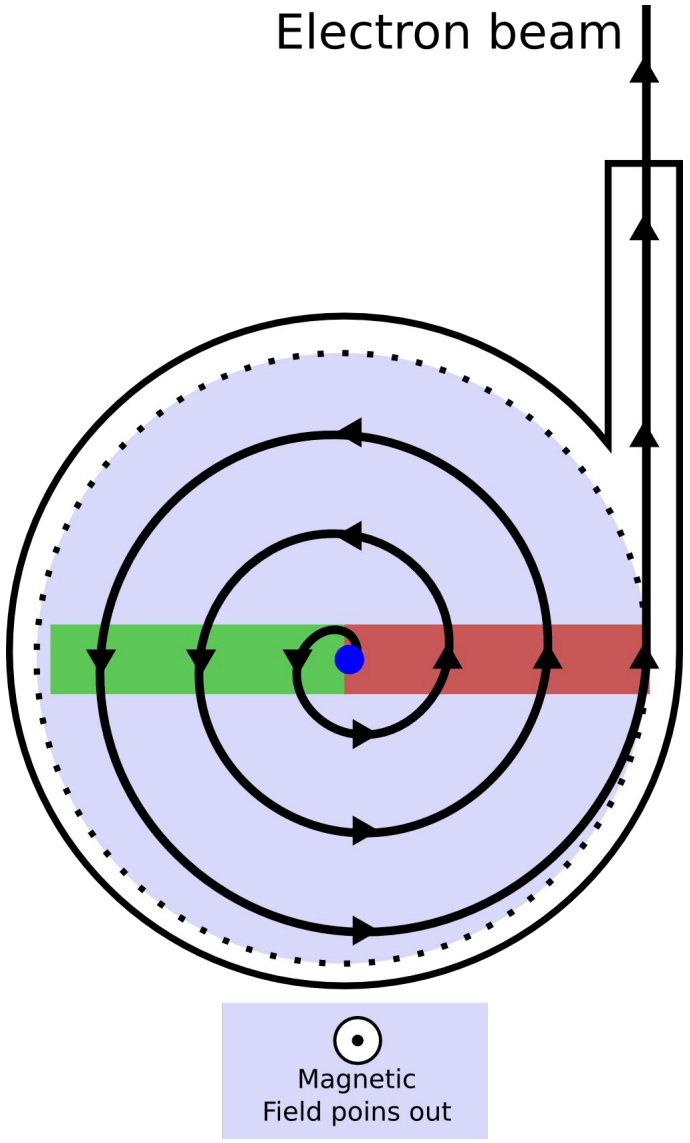
Silicon detectors used for precision tracking



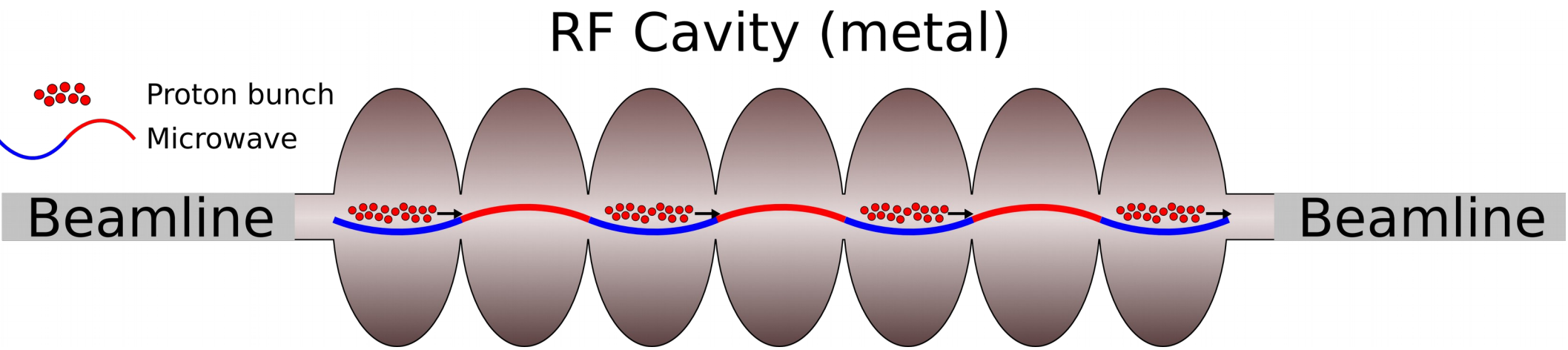


Cyclotron

- Lawrence in 1929, 500MeV
- Electron starts in center
- Magnetic field bends around in circle
- Passes through **voltage gradient** multiple times
- *Frequency~charge*field/mass* does not depend on radius. Useful property of cyclotron



Radio Frequency Cavity

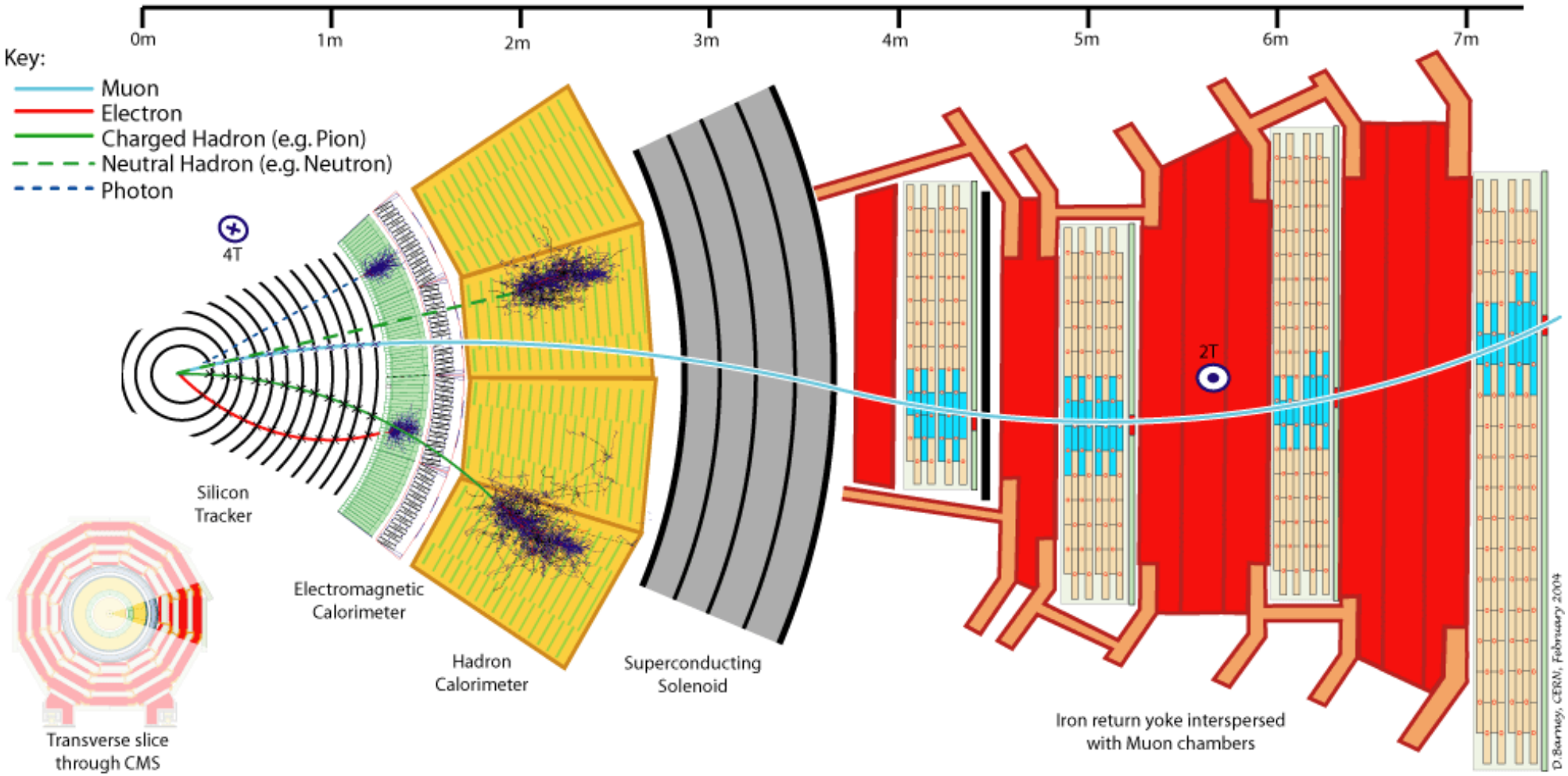


Metal amplifies the microwave
Very high wattage, driven by klystron machine

http://www.phys.vt.edu/~kimballton/gem-star/workshop/images/sc_cavity.jpg

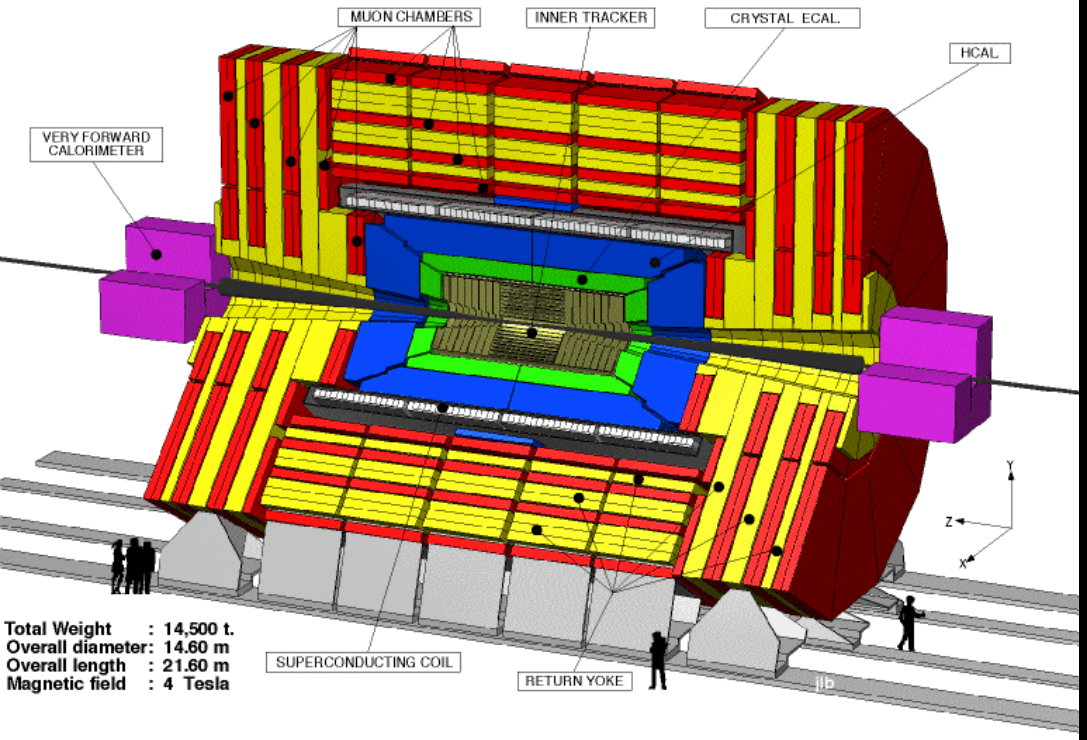
http://at-dep-acr-op.web.cern.ch/at-dep-acr-op/images/module_LHC.jpg

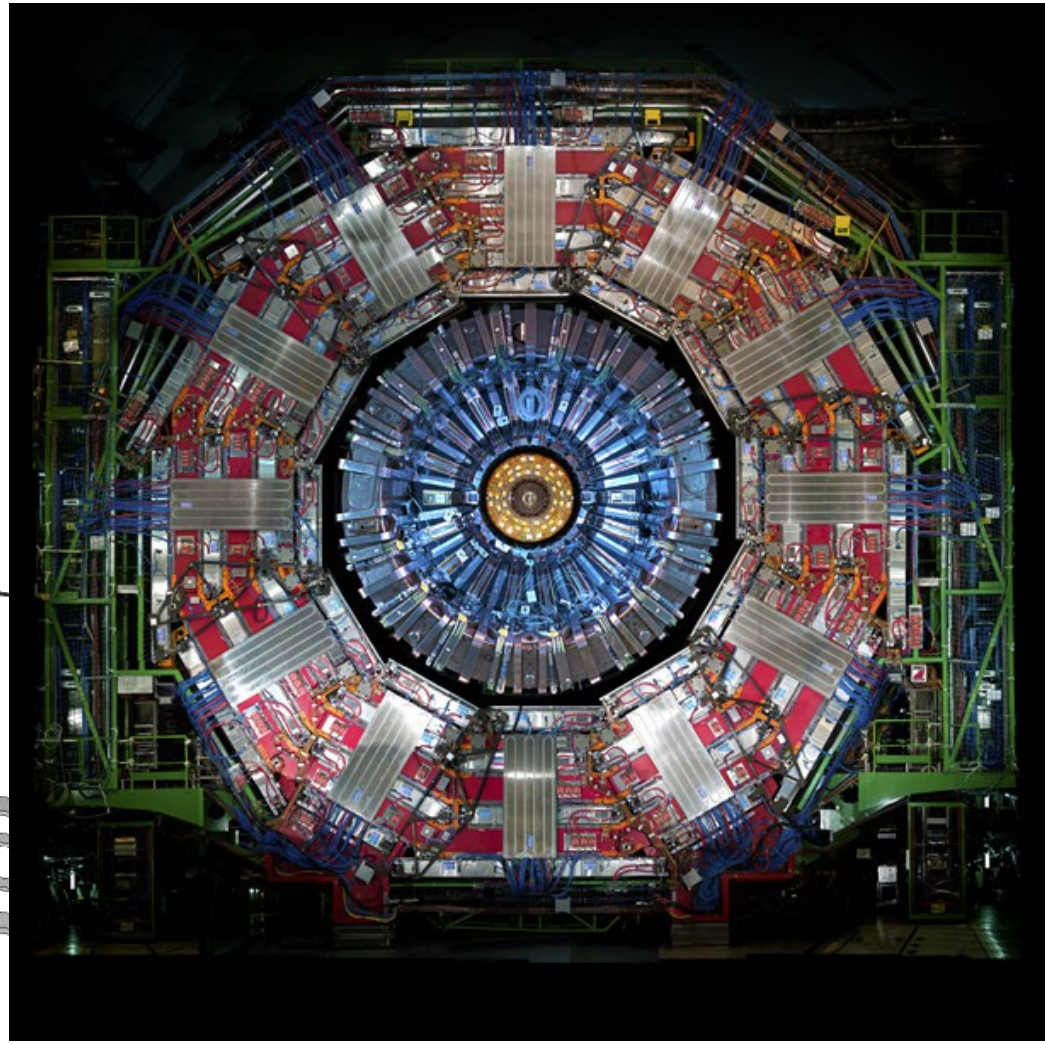
Detector Composition



http://www.lhc-closer.es/img/subidas/CMS_Slice.gif

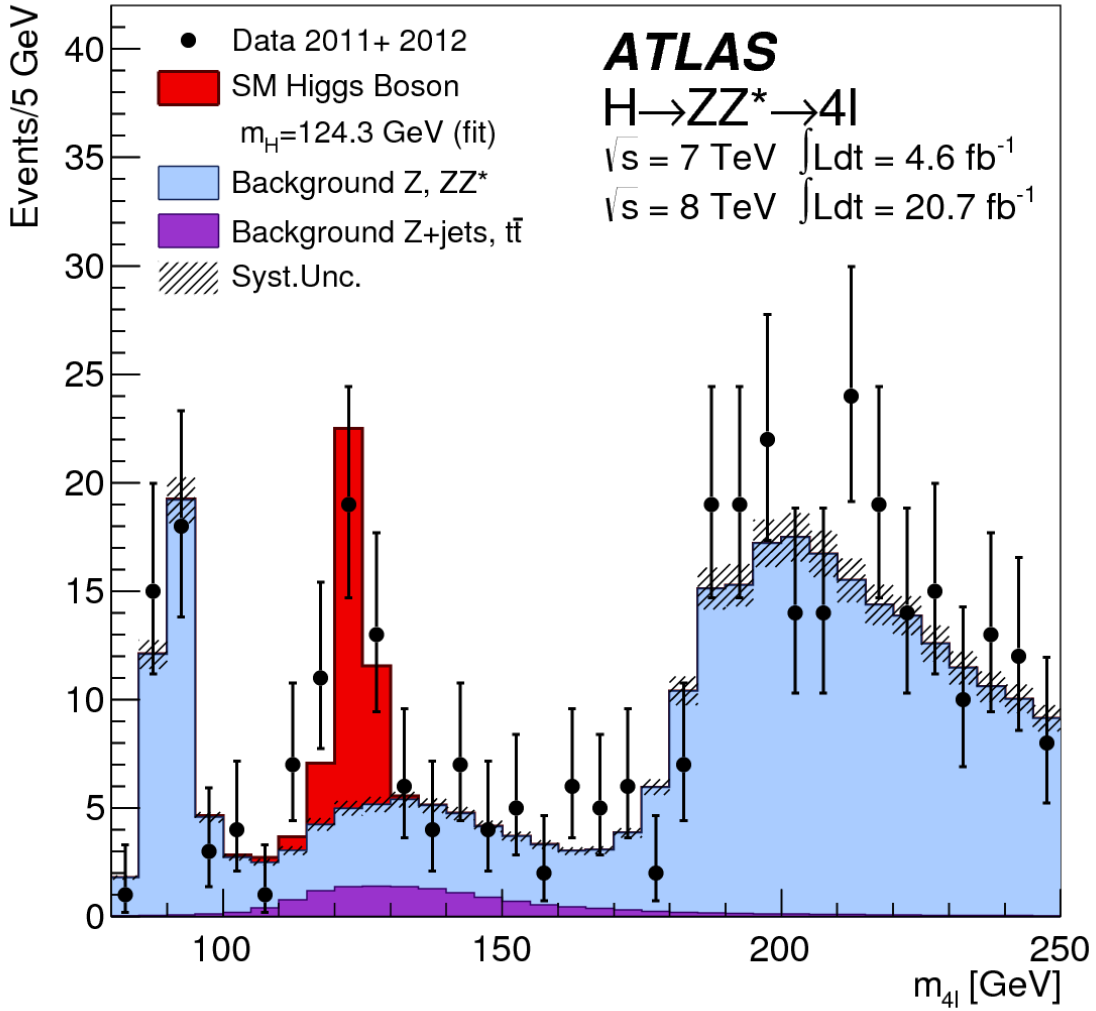
Energy frontier: CMS

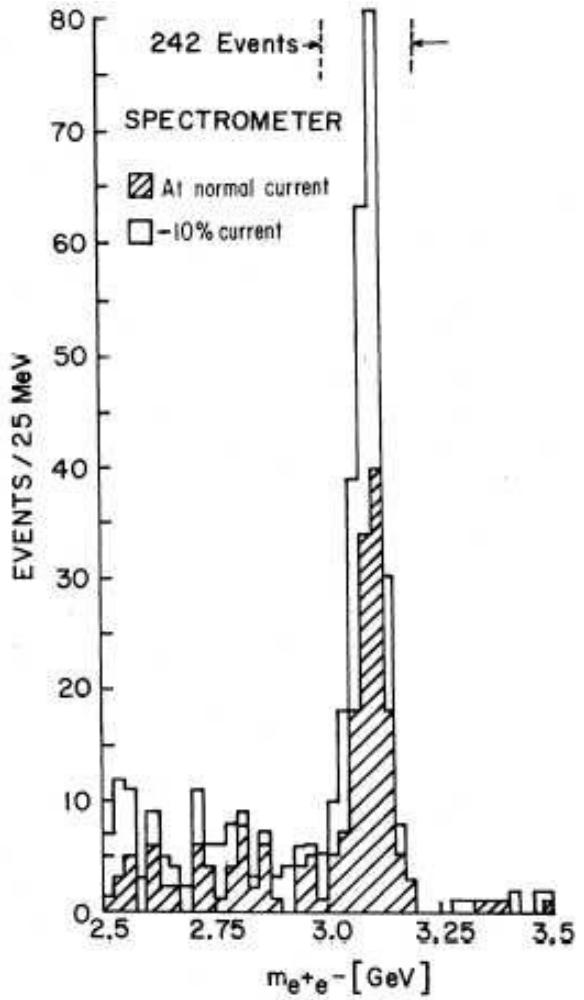




http://msnbcmedia.msn.com/i/MSNBC/Components/Photo/_new/110831-coslog-cms-230p.jpg , https://c1.staticflickr.com/9/8174/8040228597_19bb374b03_z.jpg , http://www.ncp.edu.pk/images/rpc/cms-3d-detector.gif

Higgs and J/psi Discovery



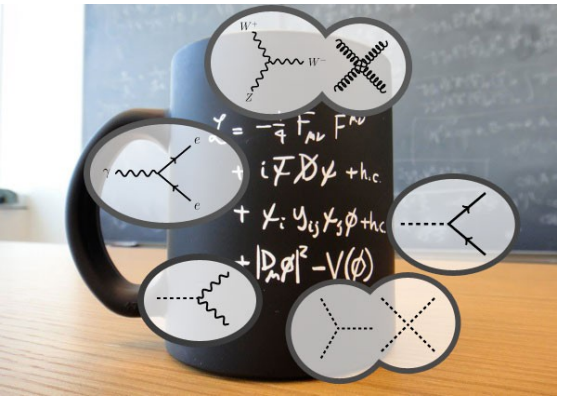


http://dorigo.wordpress.com/2007/11/15/top-quark-a-short-history-part-i/

Review of Lagrangian Method

Lagrangian

- L=T-U
  - T=Kinetic energy
  - U=Potential energy
  - Example: L=(mv^2)/2 – mgx
- Equation:
  - dL/dx = d/dt (dL/dv)
  - -mg=d/dt (mv)
  - **a=-g**, which we know is the right answer



Standard Model Interaction Lagrangian

$$\mathcal{L}_{int} = \sum_{f=e,u,d} e\, Q_f\, \underbrace{\Psi_f \gamma^\mu \Psi_f A_\mu}_{\text{QED}} \quad \text{(photon)} +$$

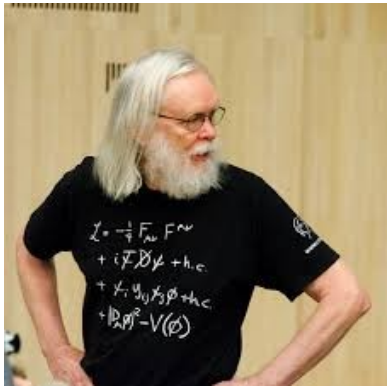
$$g_2/\cos\theta_w \sum_{f=\nu,e,u,d} [\underbrace{\Psi_{Lf}\gamma^\mu\Psi_{Lf}(T^3{}_{fL} - Q_f \sin^2\theta_w) Z_\mu}_{\text{Left handed neutral weak int.}} + \underbrace{\Psi_{Rf}\gamma^\mu\Psi_{Rf}(-Q_f \sin^2\theta_w) Z_\mu}_{\text{Right handed neutral weak int.}}]$$

$$+ g_2/\sqrt{2} \Big[\underbrace{(u_L \gamma^\mu d_L + \nu_e \gamma^\mu e_L) W^+{}_\mu}_{\text{flavor changing weak interactions}} + \underbrace{(d_L \gamma^\mu u_L + e_L \gamma^\mu \nu_e) W^-{}_\mu}_{\text{flavor changing weak interactions}} \Big]$$

$$+ g_3/2 \sum_{q=u,d} \underbrace{\sum_a}_{\text{Sum over gluons}} (q_{red}, q_{green}, q_{blue}) \gamma^\mu \underbrace{\lambda^a}_{\text{SU(3) generators}} \begin{pmatrix} q_{red} \\ q_{green} \\ q_{blue} \end{pmatrix} \overbrace{G^a{}_\mu}^{\text{Gluons - carry color/anti-color}}$$

Shows only first generation interactions.

B. Hale 11-17-10



http://web.mst.edu/~hale/courses/Physics_357_457/Standard.Model.Lagrangian.fall.2010.jpg

Homopolar Magnet Demo

Evaluation Survey

Particle Fever, Left over Questions?