

Feynman Diagrams & the Higgs Boson

IB PHYSICS | ATOMIC PHYSICS




















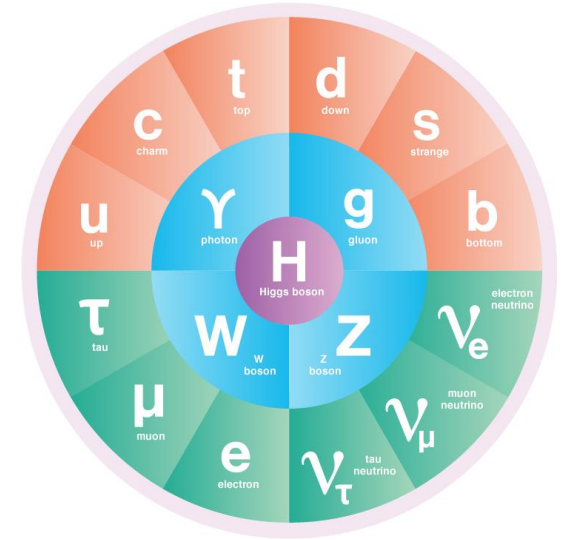
IB Physics Data Booklet

Sub-topic 7.1 – Discrete energy and radioactivity		Sub-topic 7.2 – Nuclear reactions																												
$E = hf$ $\lambda = \frac{hc}{E}$		$\Delta E = \Delta m c^2$																												
Sub-topic 7.3 – The structure of matter																														
<table border="1"> <thead> <tr> <th>Charge</th> <th colspan="3">Quarks</th> <th>Baryon number</th> </tr> </thead> <tbody> <tr> <td>$\frac{2}{3}e$</td> <td>u</td> <td>c</td> <td>t</td> <td>$\frac{1}{3}$</td> </tr> <tr> <td>$\frac{1}{3}e$</td> <td>d</td> <td>s</td> <td>b</td> <td>$\frac{1}{3}$</td> </tr> </tbody> </table> <p>All quarks have a strangeness number of 0 except the strange quark that has a strangeness number of -1</p>		Charge	Quarks			Baryon number	$\frac{2}{3}e$	u	c	t	$\frac{1}{3}$	$\frac{1}{3}e$	d	s	b	$\frac{1}{3}$	<table border="1"> <thead> <tr> <th>Charge</th> <th colspan="3">Leptons</th> </tr> </thead> <tbody> <tr> <td>-1</td> <td>e</td> <td>μ</td> <td>τ</td> </tr> <tr> <td>0</td> <td>ν_e</td> <td>ν_μ</td> <td>ν_τ</td> </tr> </tbody> </table> <p>All leptons have a lepton number of 1 and antileptons have a lepton number of -1</p>		Charge	Leptons			-1	e	μ	τ	0	ν_e	ν_μ	ν_τ
Charge	Quarks			Baryon number																										
$\frac{2}{3}e$	u	c	t	$\frac{1}{3}$																										
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-1	e	μ	τ																											
0	ν_e	ν_μ	ν_τ																											
	Gravitational	Weak	Electromagnetic	Strong																										
Particles experiencing	All	Quarks, leptons	Charged	Quarks, gluons																										
Particles mediating	Graviton	W^+, W^-, Z^0	γ	Gluons																										

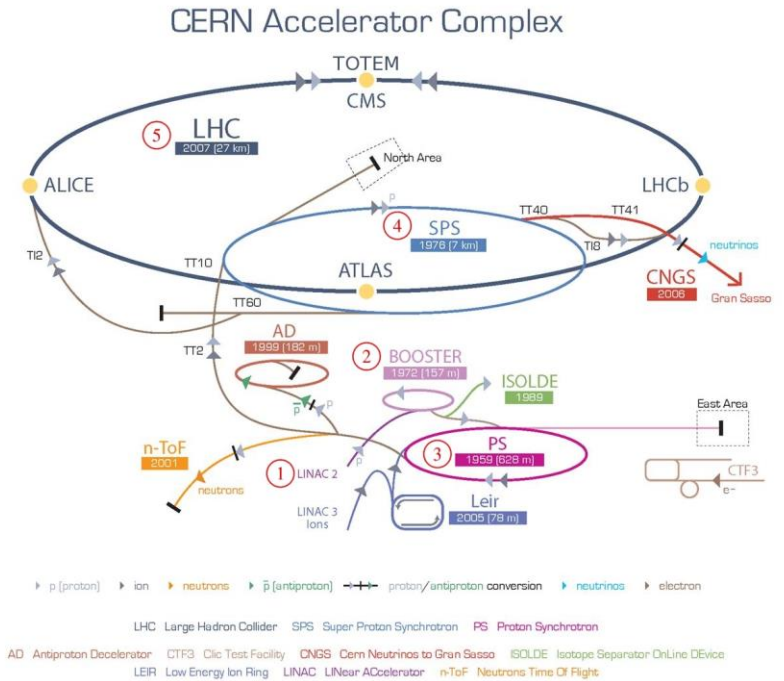
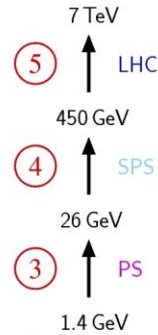
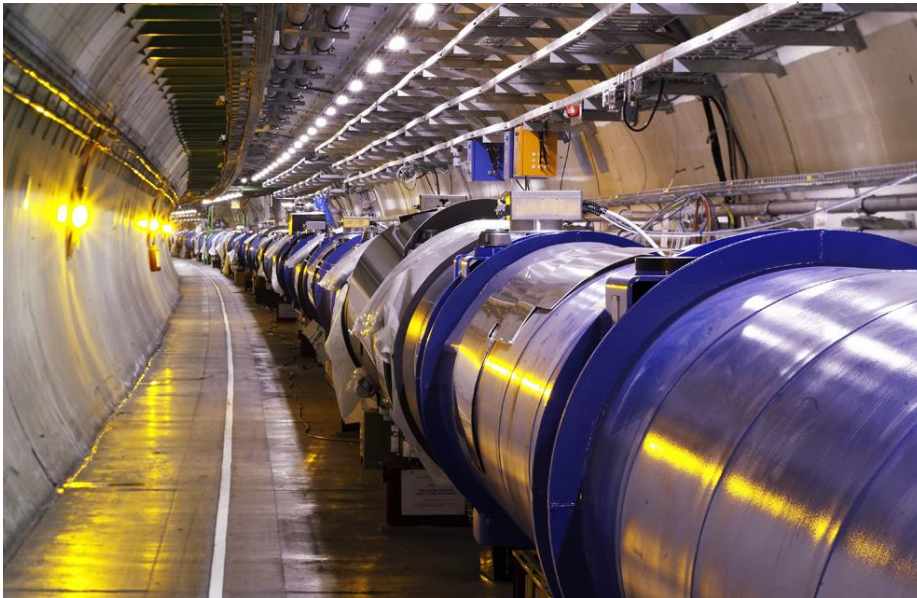
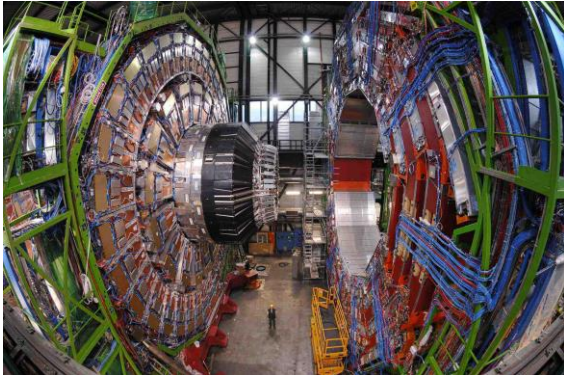
The Standard Model

Standard Model of Elementary Particles

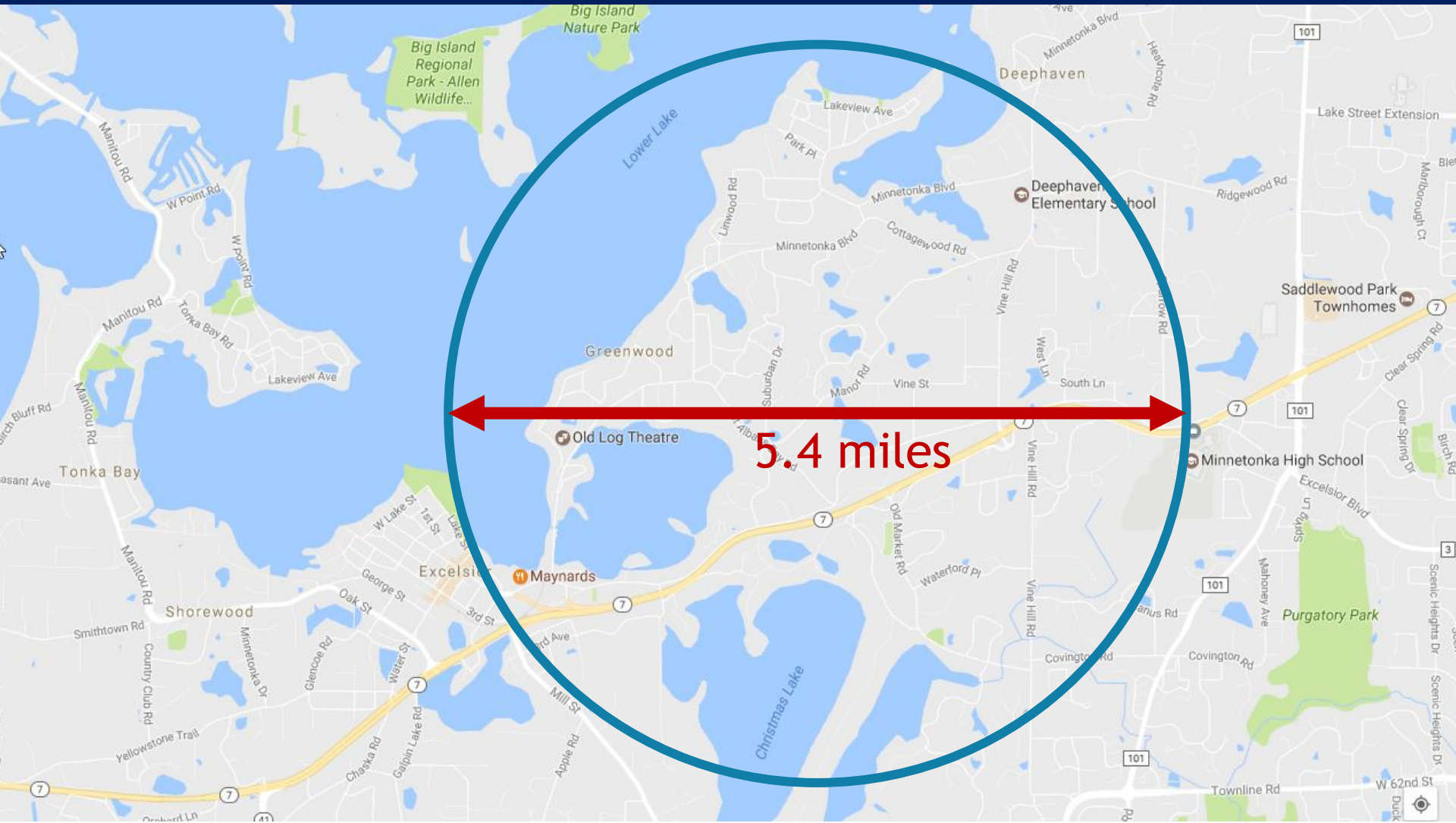
	three generations of matter (fermions)			interactions / force carriers (bosons)	
	I	II	III		
mass	$\approx 2.2 \text{ MeV}/c^2$	$\approx 1.28 \text{ GeV}/c^2$	$\approx 173.1 \text{ GeV}/c^2$	0	$\approx 124.97 \text{ GeV}/c^2$
charge	$\frac{2}{3}$	$\frac{2}{3}$	$\frac{2}{3}$	0	0
spin	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	1	0
QUARKS	$\frac{2}{3}$ $\frac{1}{2}$  u up	$\frac{2}{3}$ $\frac{1}{2}$  c charm	$\frac{2}{3}$ $\frac{1}{2}$  t top	 g gluon	 H higgs
	$-\frac{1}{3}$ $\frac{1}{2}$  d down	$-\frac{1}{3}$ $\frac{1}{2}$  s strange	$-\frac{1}{3}$ $\frac{1}{2}$  b bottom	 γ photon	
	-1 $\frac{1}{2}$  e electron	-1 $\frac{1}{2}$  μ muon	-1 $\frac{1}{2}$  τ tau	 Z Z boson	
LEPTONS	$< 1.0 \text{ eV}/c^2$ 0 $\frac{1}{2}$  ν_e electron neutrino	$< 0.17 \text{ MeV}/c^2$ 0 $\frac{1}{2}$  ν_μ muon neutrino	$< 18.2 \text{ MeV}/c^2$ 0 $\frac{1}{2}$  ν_τ tau neutrino	 W W boson	GAUGE BOSONS VECTOR BOSONS
					SCALAR BOSONS



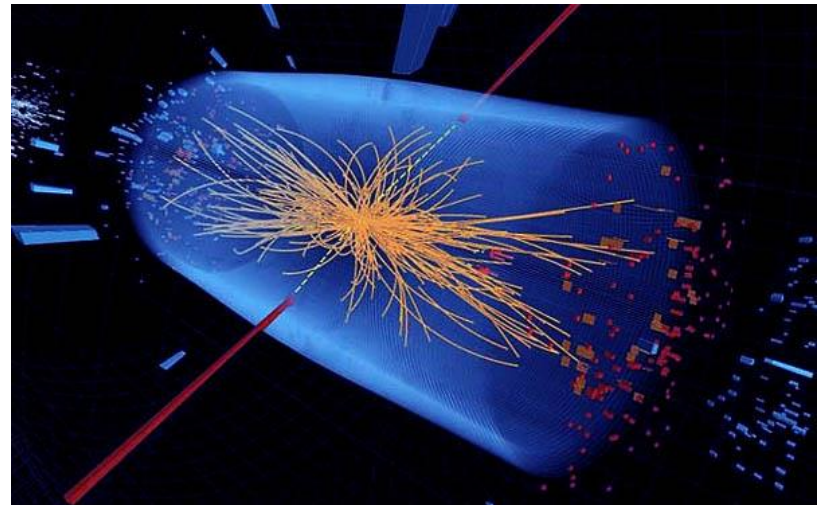
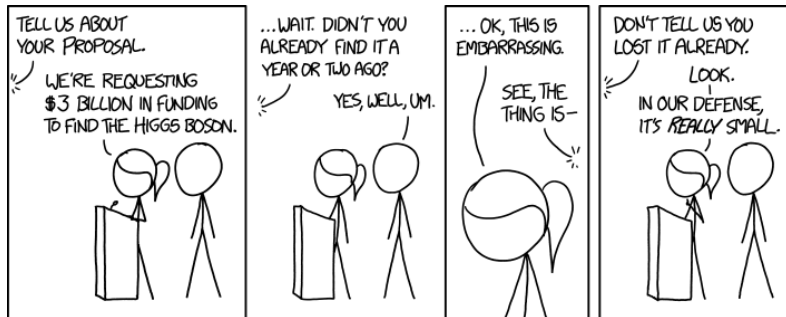
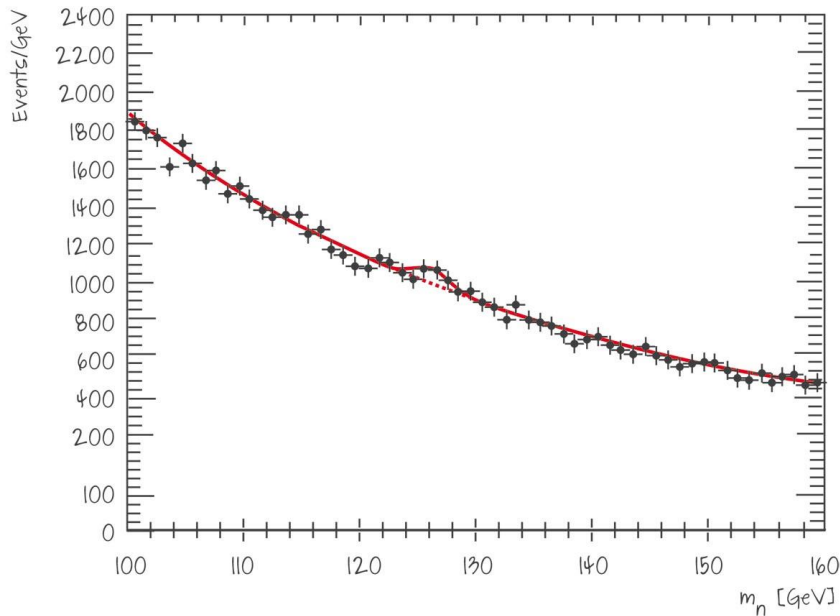
The Large Hadron Collider



The Large Hadron Collider

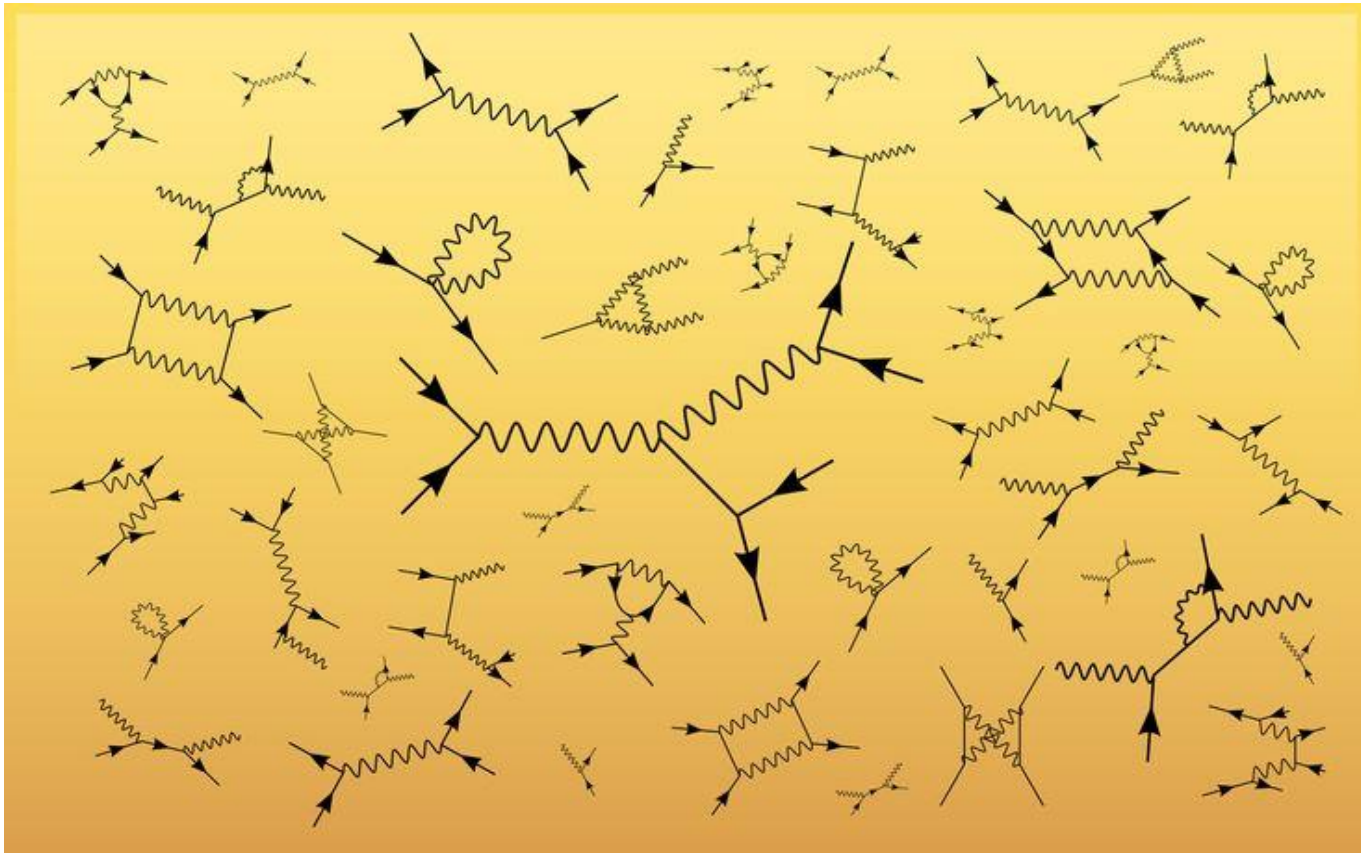


The Higgs Boson

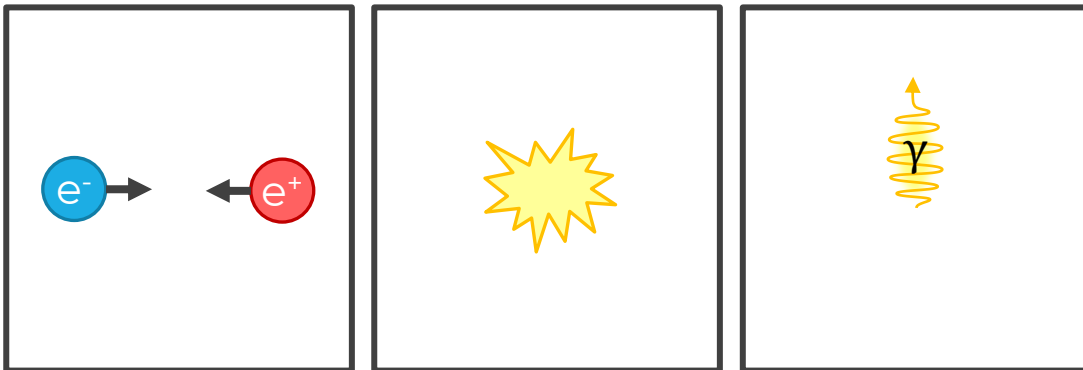
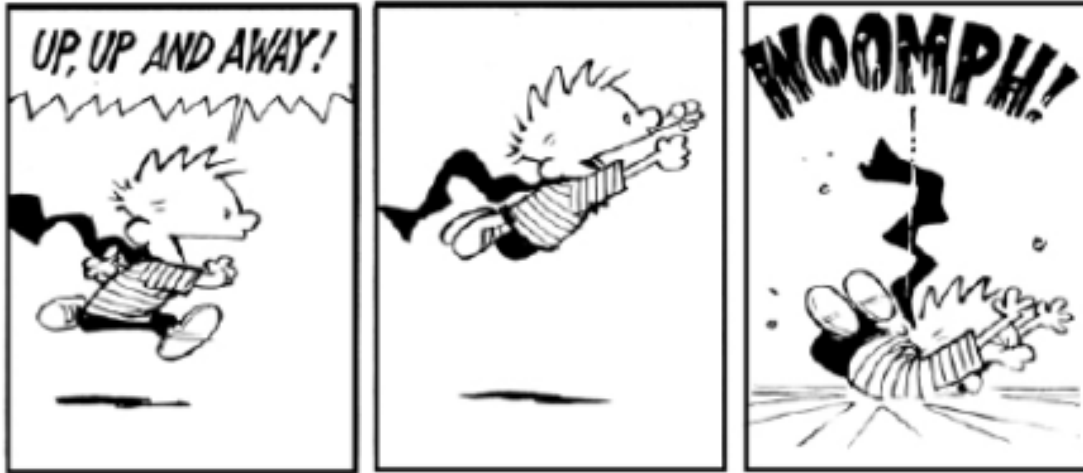


Feynman Diagrams

Useful to represent, analyze, and predict particle interactions



Feynman Diagrams are like Comics

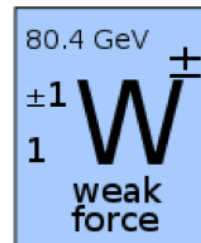
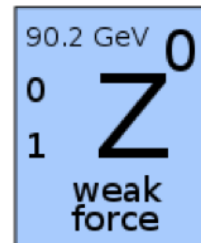
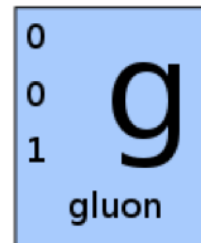
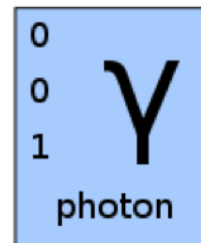


An electron and positron (antielectron) annihilate into a photon

“The Characters”

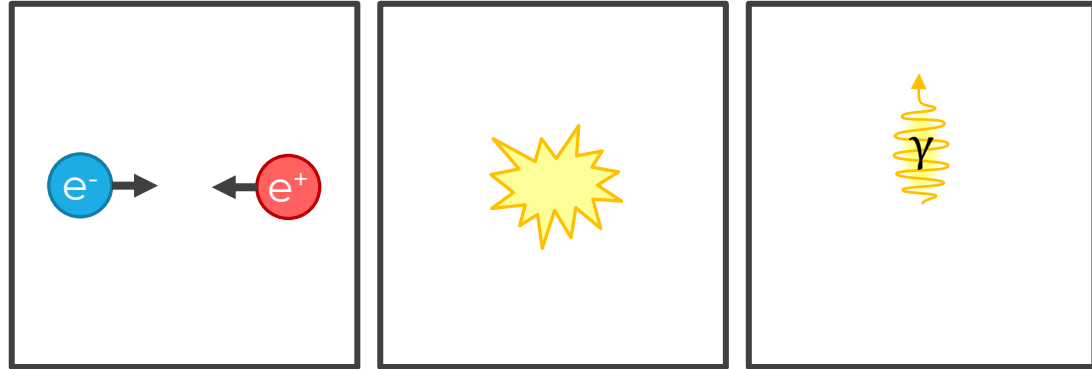
Matter Particle

Antimatter Particle

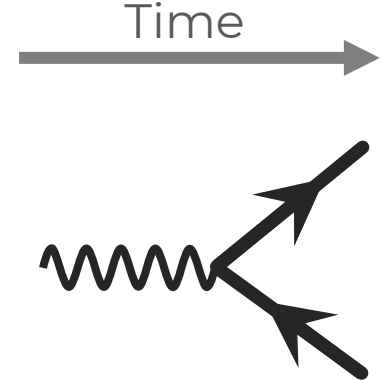
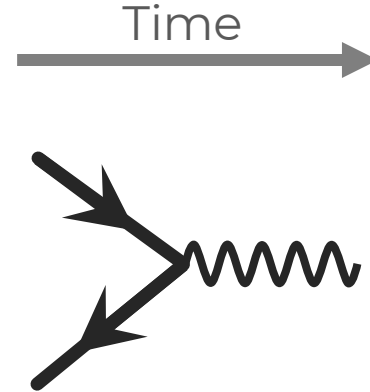
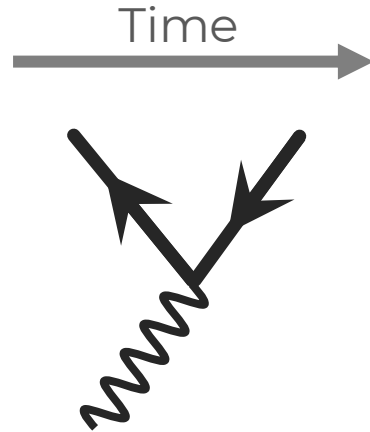
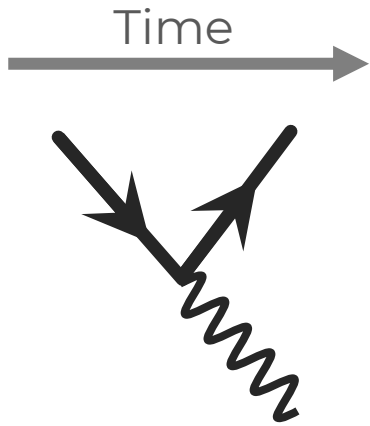


Representing Time

An electron and positron
(antielectron) annihilate
into a photon



Match these!



a photon spontaneously
“pair produces” an
electron and positron

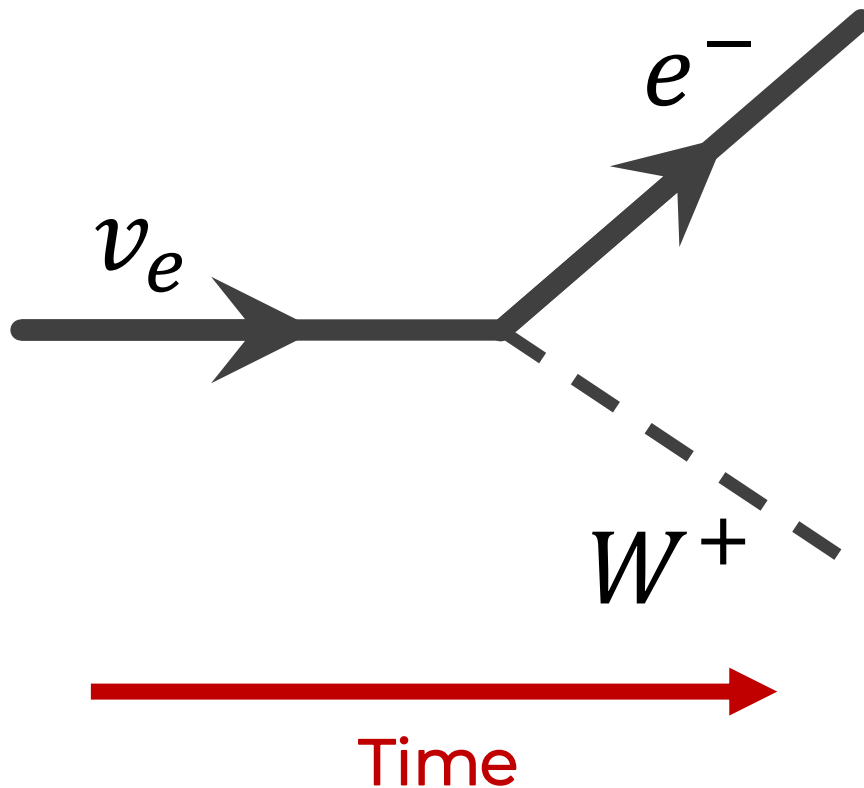
a positron absorbs a
photon and keeps going

an electron emits a
photon and keeps going

an electron and
positron annihilate
into a photon

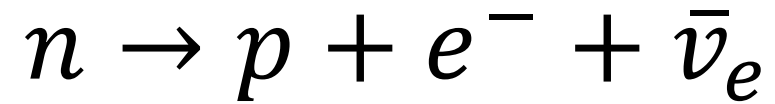
Junction Conservation

Every junction will have two lines with arrows (one pointing in, one pointing out) meeting a single exchange particle and all properties are conserved before/after



	ν_e	e^-	W^+
Baryon #			
Lepton #			
Charge			

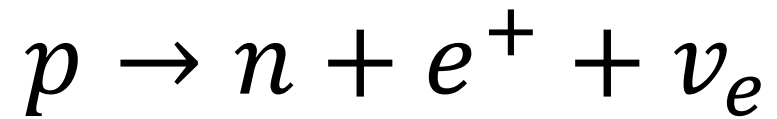
Beta-Negative Decay



Time



Beta-Positive Decay



Time

