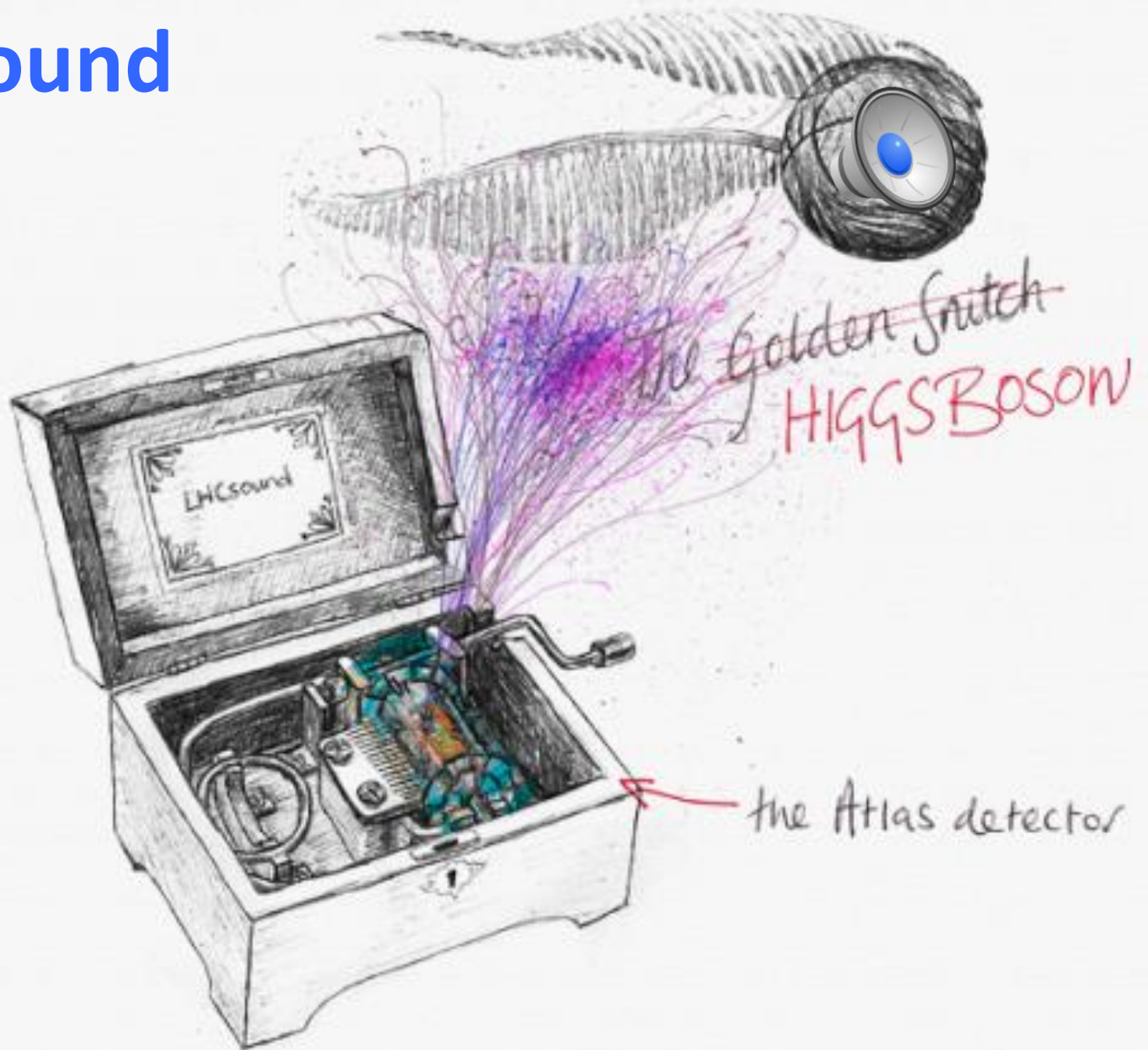


LHCsound



mu·sic

/ˈmyʊˌzɪk/ 

Noun

1. The art or science of combining vocal or instrumental sounds (or both) to produce beauty of form, harmony, and expression of emotion.

mu·sic

/ˈmyʊˌzɪk/ 

Noun

1. The art or science of combining vocal or instrumental sounds (or both) to produce ~~beauty of form, harmony, and expression of emotion.~~

~~mu sic~~ **sonification**

/ˈmyʊˌɒzɪk/ 

Noun

1. The art or science of combining vocal or instrumental sounds (or both) to ~~produce~~
~~beauty of form, harmony, and expression of emotion.~~

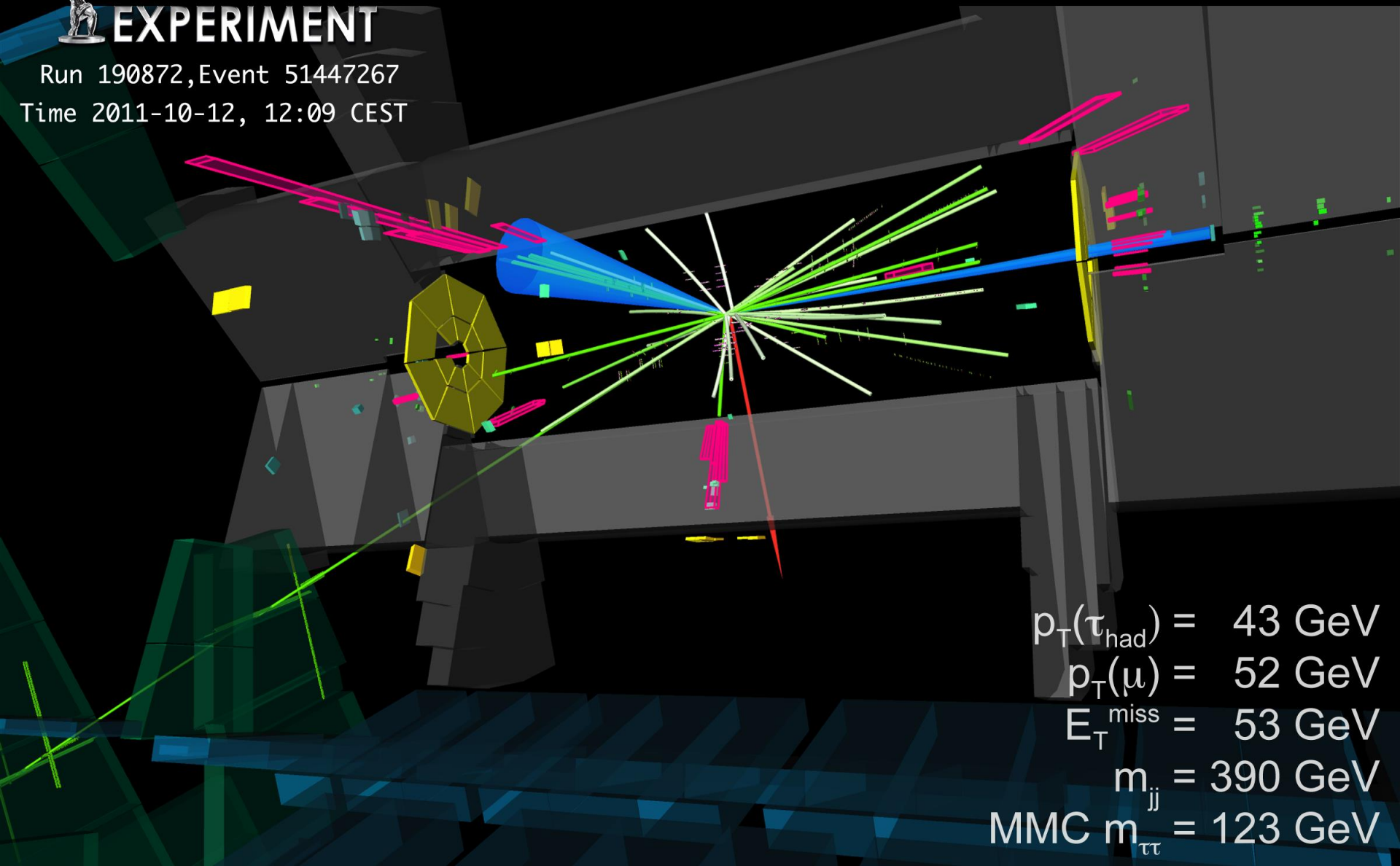
convey information!



ATLAS EXPERIMENT

Run 190872, Event 51447267

Time 2011-10-12, 12:09 CEST



$$p_T(\tau_{\text{had}}) = 43 \text{ GeV}$$

$$p_T(\mu) = 52 \text{ GeV}$$

$$E_T^{\text{miss}} = 53 \text{ GeV}$$

$$m_{jj} = 390 \text{ GeV}$$

$$\text{MMC } m_{\tau\tau} = 123 \text{ GeV}$$

Sonic properties

Physical properties

Speed
Mass
Energy
Direction
Angle
Particle type
...

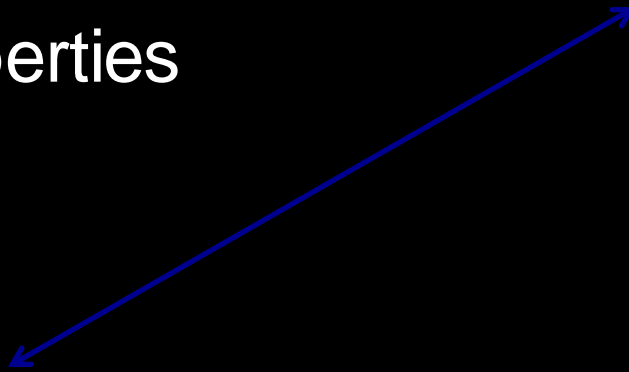
Pitch
Amplitude
Timbre
Duration
Tempo
...

Sonic properties

Physical properties

Speed
Mass
Energy
Direction
Angle
Particle type
...

Pitch
Amplitude
Timbre
Duration
Tempo
...



Sonic properties

Physical properties

Speed

Mass

Energy

Direction

Angle

Particle type

...

Pitch

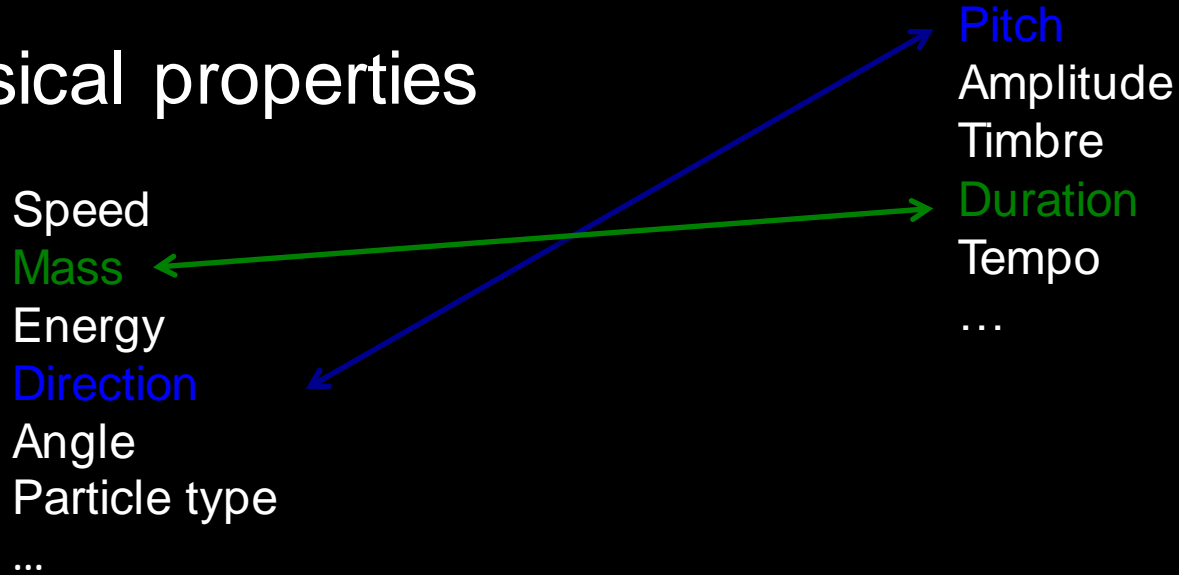
Amplitude

Timbre

Duration

Tempo

...



Sonic properties

Physical properties

Speed

Mass

Energy

Direction

Angle

Particle type

...

Pitch

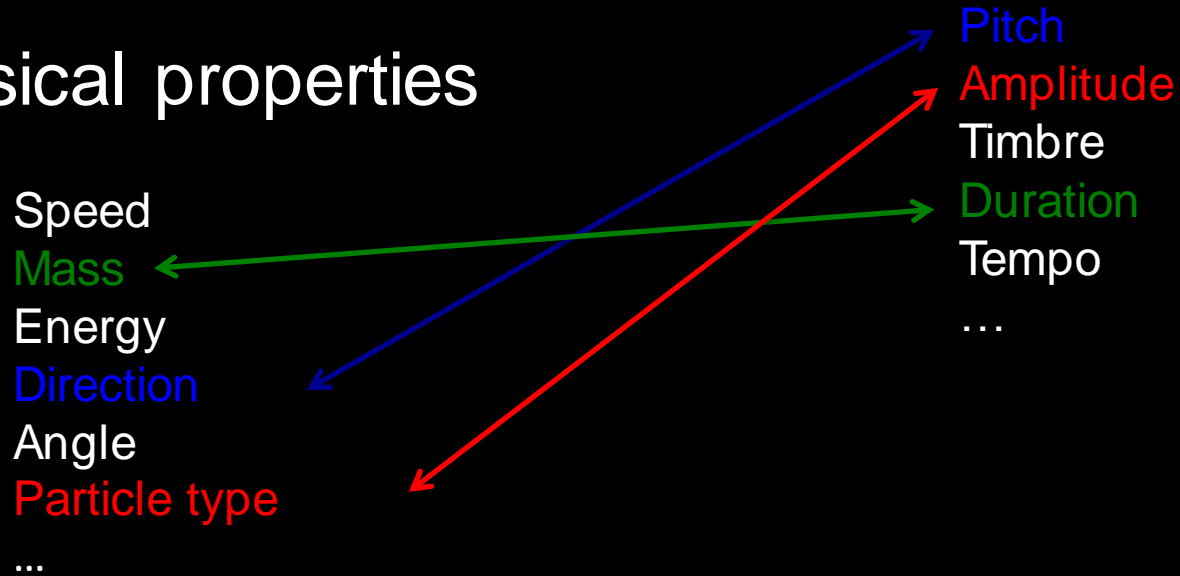
Amplitude

Timbre

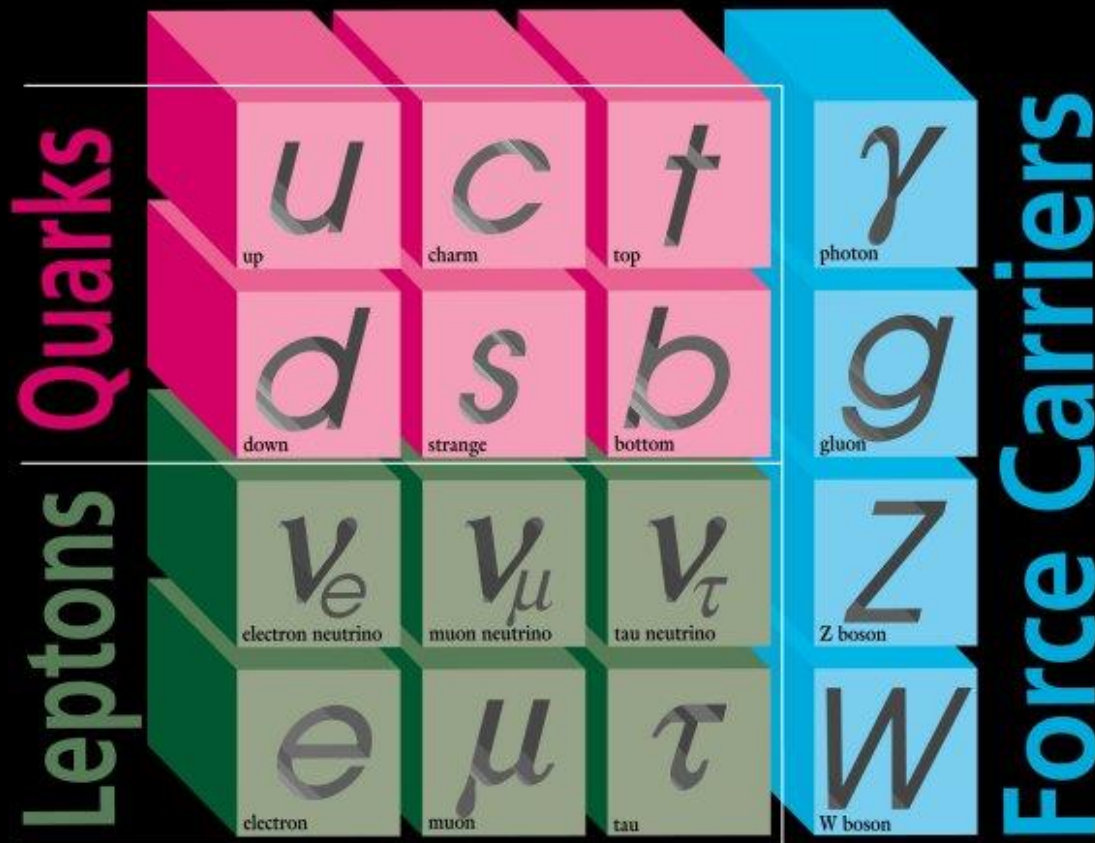
Duration

Tempo

...



ELEMENTARY PARTICLES



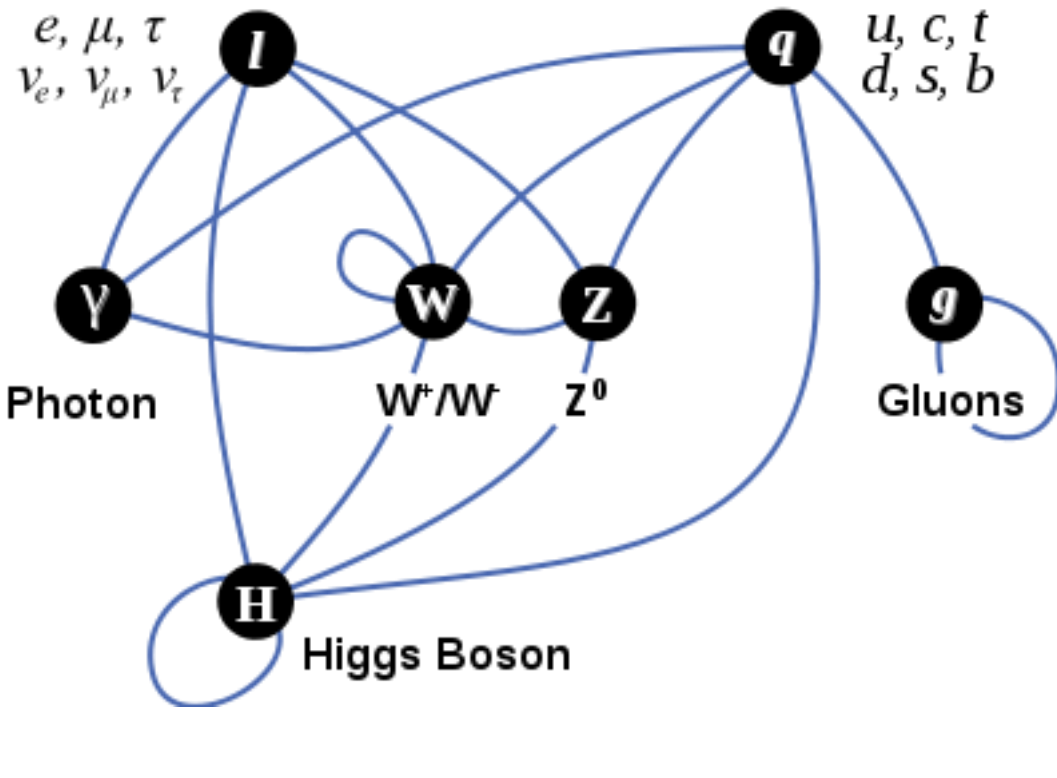
I II III
Three Generations of Matter

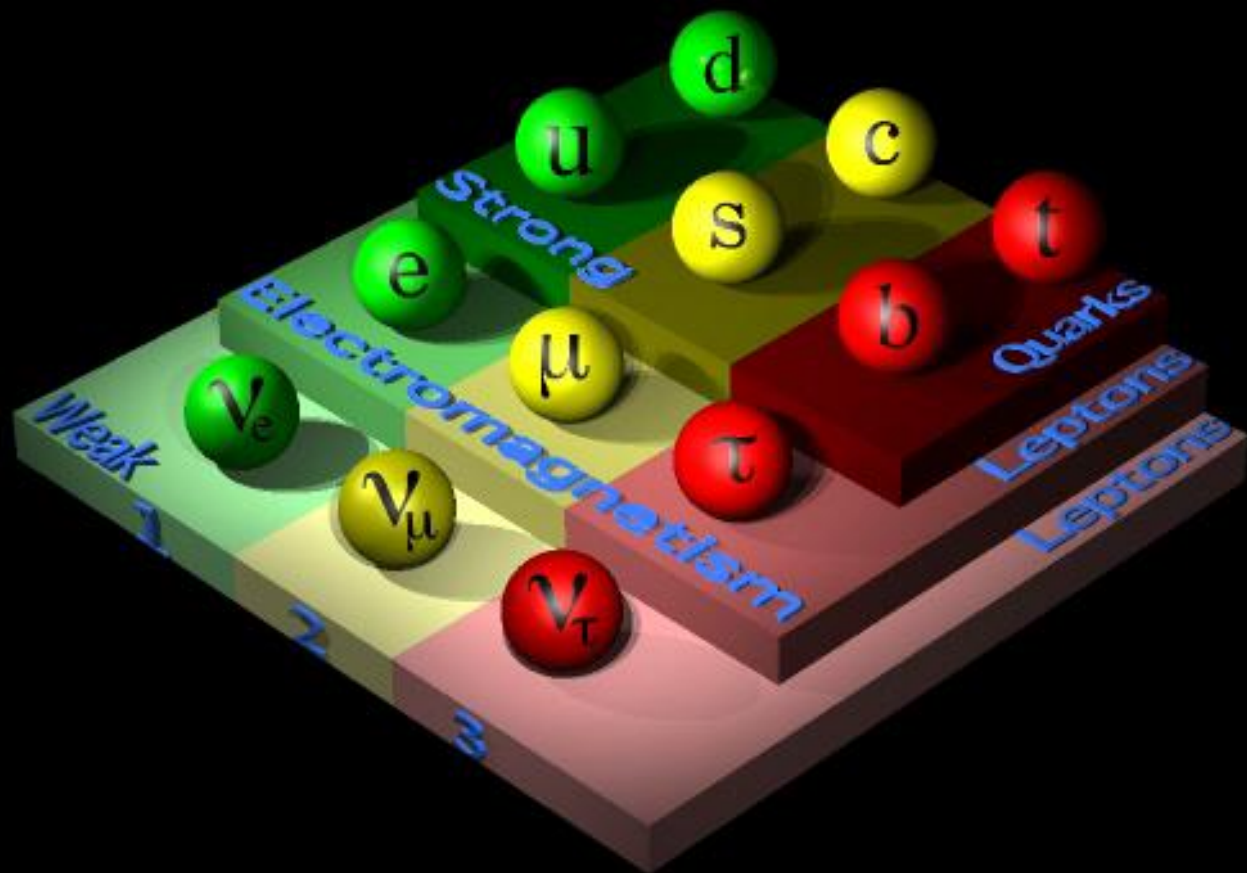
Leptons

e, μ, τ
 ν_e, ν_μ, ν_τ

Quarks

u, c, t
 d, s, b





$$\begin{aligned}
& -\frac{1}{2}\partial_\nu g_\mu^a \partial_\nu g_\mu^a - g_s f^{abc} \partial_\mu g_\nu^a g_\mu^b g_\nu^c - \frac{1}{4}g_s^2 f^{abc} f^{ade} g_\mu^b g_\nu^c g_\mu^d g_\nu^e + \\
& \frac{1}{2}ig_s^2 (\bar{q}_i^\mu \gamma^\mu q_j^\nu) g_\mu^a + G^a \partial^2 G^a + g_s f^{abc} \partial_\mu G^a G^b g_\mu^c - \partial_\nu W_\mu^+ \partial_\nu W_\mu^- - \\
M^2 W_\mu^+ W_\mu^- - \frac{1}{2}\partial_\nu Z_\mu^0 \partial_\nu Z_\mu^0 - \frac{1}{2c_w^2} M^2 Z_\mu^0 Z_\mu^0 - \frac{1}{2}\partial_\nu A_\mu \partial_\nu A_\mu - \frac{1}{2}\partial_\nu H \partial_\nu H - \\
\frac{1}{2}m_h^2 H^2 - \partial_\mu \phi^+ \partial_\mu \phi^- - M^2 \phi^+ \phi^- - \frac{1}{2}\partial_\mu \phi^0 \partial_\mu \phi^0 - \frac{1}{2c_w^2} M \phi^0 \phi^0 - \beta_h [\frac{2M^2}{g^2} + \\
\frac{2M}{g} H + \frac{1}{2}(H^2 + \phi^0 \phi^0 + 2\phi^+ \phi^-)] + \frac{2M^4}{g^2} \alpha_h - ig_{c_w} [\partial_\nu Z_\mu^0 (W_\mu^+ W_\nu^- - \\
W_\nu^+ W_\mu^-) - Z_\mu^0 (W_\mu^+ \partial_\nu W_\nu^- - W_\nu^- \partial_\mu W_\mu^+) + Z_\mu^0 (W_\nu^+ \partial_\mu W_\nu^- - \\
W_\nu^- \partial_\mu W_\mu^+)] - ig_{s_w} [\partial_\nu A_\mu (W_\mu^+ W_\nu^- - W_\nu^+ W_\mu^-) - A_\nu (W_\mu^+ \partial_\nu W_\mu^- - \\
W_\nu^- \partial_\mu W_\mu^+) + A_\mu (W_\nu^+ \partial_\nu W_\mu^- - W_\nu^- \partial_\mu W_\mu^+)] - \frac{1}{2}g^2 W_\mu^+ W_\mu^- W_\nu^+ W_\nu^- + \\
\frac{1}{2}g^2 W_\mu^+ W_\nu^- W_\mu^+ W_\nu^- + g^2 c_w^2 (Z_\mu^0 W_\nu^+ Z_\mu^0 W_\nu^- - Z_\mu^0 Z_\nu^0 W_\mu^+ W_\nu^-) + \\
g^2 s_w^2 (A_\mu W_\nu^+ A_\nu W_\mu^- - A_\mu A_\nu W_\mu^+ W_\nu^-) + g^2 s_w c_w [A_\mu Z_\nu^0 (W_\mu^+ W_\nu^- - \\
W_\nu^+ W_\mu^-) - 2A_\mu Z_\mu^0 W_\nu^+ W_\nu^-] - g\alpha [H^3 + H\phi^0 \phi^0 + 2H\phi^+ \phi^-] - \\
\frac{1}{8}g^2 \alpha_h [H^4 + (\phi^0)^4 + 4(\phi^+ \phi^-)^2 + 4(\phi^0)^2 \phi^+ \phi^- + 4H^2 \phi^+ \phi^- + 2(\phi^0)^2 H^2] - \\
gM W_\mu^+ W_\mu^- H - \frac{1}{2}g \frac{M}{c_w^2} Z_\mu^0 Z_\mu^0 H - \frac{1}{2}ig [W_\mu^+ (\phi^0 \partial_\mu \phi^- - \phi^- \partial_\mu \phi^0) - \\
W_\mu^- (\phi^0 \partial_\mu \phi^+ - \phi^+ \partial_\mu \phi^0)] + \frac{1}{2}g [W_\mu^+ (H \partial_\mu \phi^- - \phi^- \partial_\mu H) - W_\mu^- (H \partial_\mu \phi^+ - \\
\phi^+ \partial_\mu H)] + \frac{1}{2}g \frac{1}{c_w^2} [Z_\mu^0 (H \partial_\mu \phi^0 - \phi^0 \partial_\mu H) - ig \frac{M}{c_w^2} M Z_\mu^0 (W_\mu^+ \phi^- - W_\mu^- \phi^+) + \\
ig_{s_w} M A_\mu (W_\mu^+ \phi^- - W_\mu^- \phi^+) - ig \frac{1-2c_w^2}{2c_w} Z_\mu^0 (\phi^+ \partial_\mu \phi^- - \phi^- \partial_\mu \phi^+) + \\
ig_{s_w} A_\mu (\phi^+ \partial_\mu \phi^- - \phi^- \partial_\mu \phi^+) - \frac{1}{2}g^2 W_\mu^+ W_\mu^- [H^2 + (\phi^0)^2 + 2\phi^+ \phi^-] - \\
\frac{1}{2}g^2 \frac{1}{c_w^2} Z_\mu^0 Z_\mu^0 [H^2 + (\phi^0)^2 + 2(2s_w^2 - 1)^2 \phi^+ \phi^-] - \frac{1}{2}g^2 \frac{2c_w^2}{c_w} Z_\mu^0 \phi^0 (W_\mu^+ \phi^- + \\
W_\mu^- \phi^+) - \frac{1}{2}ig^2 \frac{2c_w^2}{c_w} Z_\mu^0 H (W_\mu^+ \phi^- - W_\mu^- \phi^+) + \frac{1}{2}g^2 s_w A_\mu \phi^0 (W_\mu^+ \phi^- + \\
W_\mu^- \phi^+) + \frac{1}{2}ig^2 s_w A_\mu H (W_\mu^+ \phi^- - W_\mu^- \phi^+) - g^2 \frac{2c_w^2}{c_w} (2c_w^2 - 1) Z_\mu^0 A_\mu \phi^+ \phi^- - \\
g^1 s_w^2 A_\mu A_\mu \phi^+ \phi^- - e^\lambda (\gamma \partial + m_\lambda^1) e^\lambda - \nu^\lambda \gamma \partial \nu^\lambda - \bar{u}_j^1 (\gamma \partial + m_\lambda^1) u_j^1 - \\
d_j^1 (\gamma \partial + m_\lambda^1) d_j^1 + ig_{s_w} A_\mu [-(e^\lambda \gamma^\mu e^\lambda) + \frac{2}{3}(\bar{u}_j^1 \gamma^\mu u_j^1) - \frac{1}{3}(\bar{d}_j^1 \gamma^\mu d_j^1)] + \\
\frac{ig}{4c_w} Z_\mu^0 [(\nu^\lambda \gamma^\mu (1 + \gamma^5) \nu^\lambda) + (e^\lambda \gamma^\mu (4s_w^2 - 1 - \gamma^5) e^\lambda) + (\bar{u}_j^1 \gamma^\mu (\frac{2}{3}s_w^2 - \\
1 - \gamma^5) u_j^1) + (\bar{d}_j^1 \gamma^\mu (1 - \frac{2}{3}s_w^2 - \gamma^5) d_j^1)] + \frac{ig}{2\sqrt{2}} W_\mu^+ [(\nu^\lambda \gamma^\mu (1 + \gamma^5) \nu^\lambda) + \\
(\bar{u}_j^1 \gamma^\mu (1 + \gamma^5) C_{\lambda\alpha} d_j^1)] + \frac{ig}{2\sqrt{2}} W_\mu^- [(\nu^\lambda \gamma^\mu (1 + \gamma^5) \nu^\lambda) + (\bar{d}_j^1 C_{\lambda\alpha}^1 \gamma^\mu (1 + \\
\gamma^5) u_j^1)] + \frac{ig}{2\sqrt{2}} \frac{m_\lambda^2}{M} [-\phi^+ (\nu^\lambda (1 - \gamma^5) e^\lambda) + \phi^- (e^\lambda (1 + \gamma^5) \nu^\lambda)] - \\
\frac{g}{2} \frac{m_\lambda^2}{M} [H (e^\lambda e^\lambda) + i\phi^0 (e^\lambda \gamma^5 e^\lambda)] + \frac{ig}{2M\sqrt{2}} \phi^+ [-m_\lambda^2 (\bar{u}_j^1 C_{\lambda\alpha} (1 - \gamma^5) d_j^1) + \\
m_\lambda^1 (\bar{u}_j^1 C_{\lambda\alpha} (1 + \gamma^5) d_j^1) + \frac{ig}{2M\sqrt{2}} \phi^- [m_\lambda^2 (\bar{d}_j^1 C_{\lambda\alpha}^1 (1 + \gamma^5) u_j^1) - m_\lambda^1 (\bar{d}_j^1 C_{\lambda\alpha}^1 (1 - \\
\gamma^5) u_j^1) - \frac{g}{2} \frac{m_\lambda^2}{M} H (\bar{u}_j^1 u_j^1) - \frac{g}{2} \frac{m_\lambda^2}{M} H (\bar{d}_j^1 d_j^1) + \frac{ig}{2} \frac{m_\lambda^2}{M} \phi^0 (\bar{u}_j^1 \gamma^5 u_j^1) - \\
\frac{ig}{2} \frac{m_\lambda^2}{M} \phi^0 (\bar{d}_j^1 \gamma^5 d_j^1) + \bar{X}^+ (\partial^2 - M^2) X^+ + \bar{X}^- (\partial^2 - M^2) X^- + \bar{X}^0 (\partial^2 - \\
\frac{M^2}{c_w^2}) X^0 + \bar{Y} \partial^2 Y + ig_{c_w} W_\mu^+ (\partial_\mu \bar{X}^0 X^- - \partial_\mu \bar{X}^+ X^0) + ig_{s_w} W_\mu^+ (\partial_\mu \bar{Y} X^- - \\
\partial_\mu \bar{X}^+ Y) + ig_{c_w} W_\mu^- (\partial_\mu \bar{X}^- X^0 - \partial_\mu \bar{X}^0 X^+) + ig_{s_w} W_\mu^- (\partial_\mu \bar{X}^- Y - \\
\partial_\mu \bar{Y} X^+) + ig_{c_w} Z_\mu^0 (\partial_\mu \bar{X}^+ X^+ - \partial_\mu \bar{X}^- X^-) + ig_{s_w} A_\mu (\partial_\mu \bar{X}^+ X^+ - \\
\partial_\mu \bar{X}^- X^-) - \frac{1}{2}gM [\bar{X}^+ X^+ H + \bar{X}^- X^- H + \frac{1}{c_w} \bar{X}^0 X^0 H] + \\
\frac{1-2c_w^2}{2c_w} igM [\bar{X}^+ X^0 \phi^+ - \bar{X}^- X^0 \phi^-] + \frac{1}{2c_w} igM [\bar{X}^0 X^- \phi^- - \bar{X}^0 X^+ \phi^+] + \\
igM s_w [\bar{X}^0 X^- \phi^+ - \bar{X}^0 X^+ \phi^-] + \frac{1}{2}igM [\bar{X}^+ X^+ \phi^0 - \bar{X}^- X^- \phi^0]
\end{aligned}$$

hypercharge

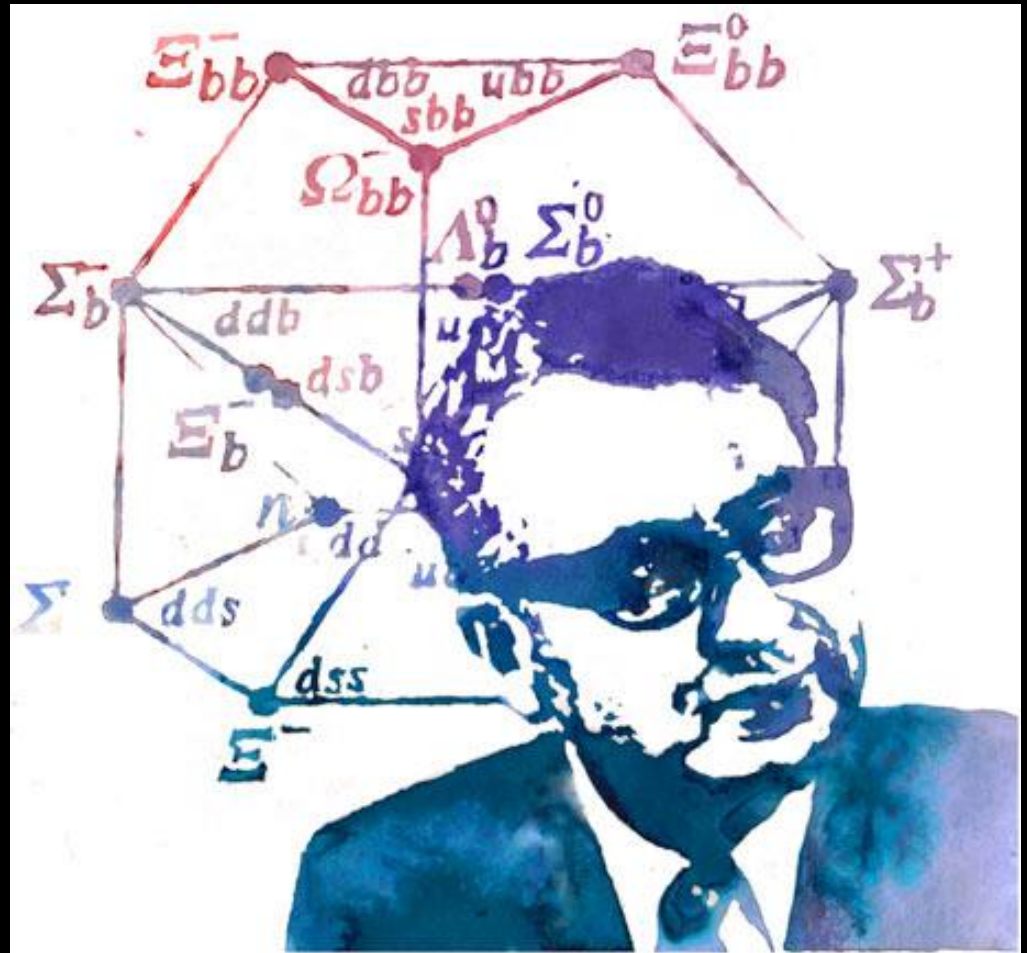
color

beauty

flavor

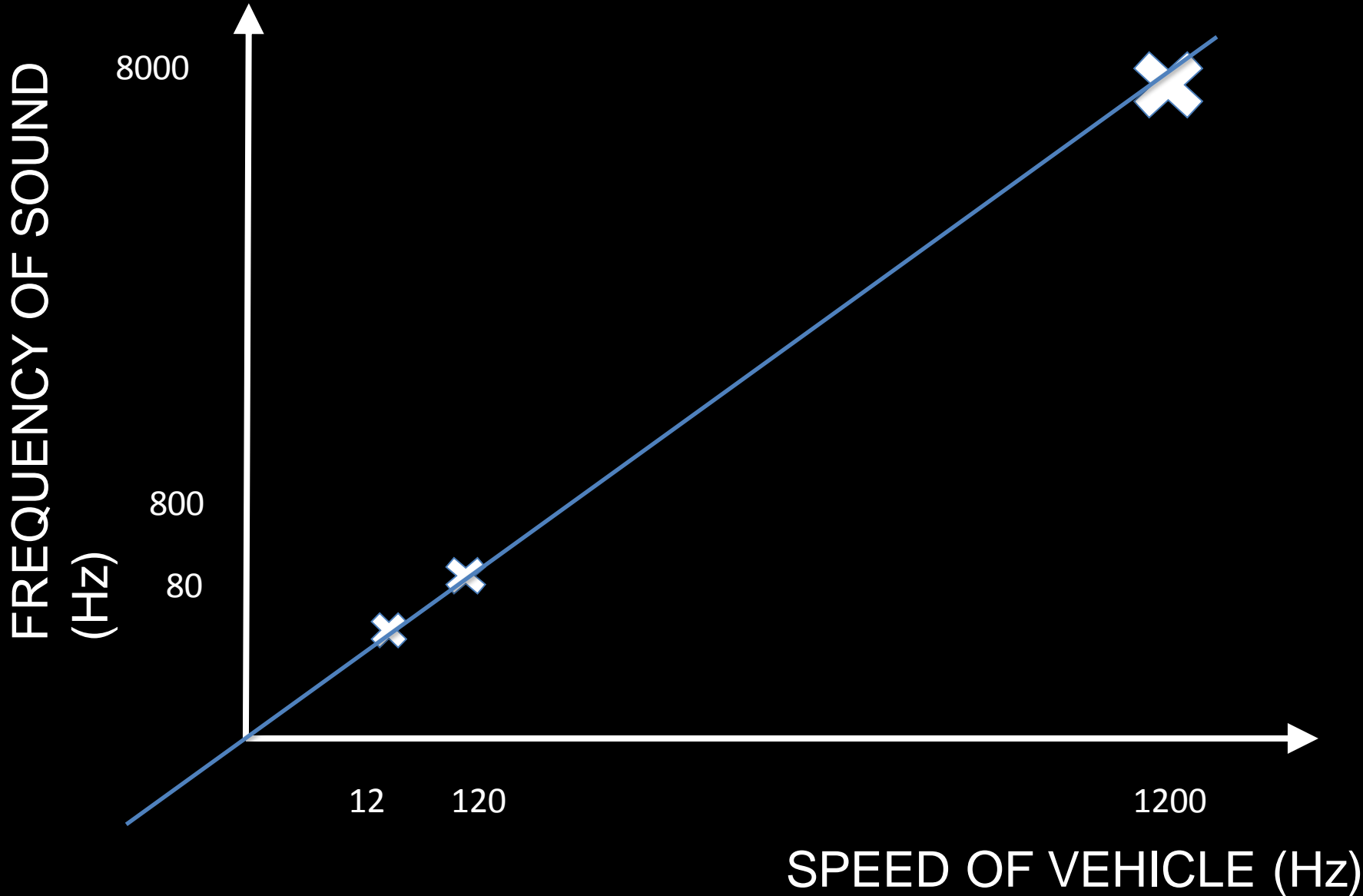
strangeness

spin

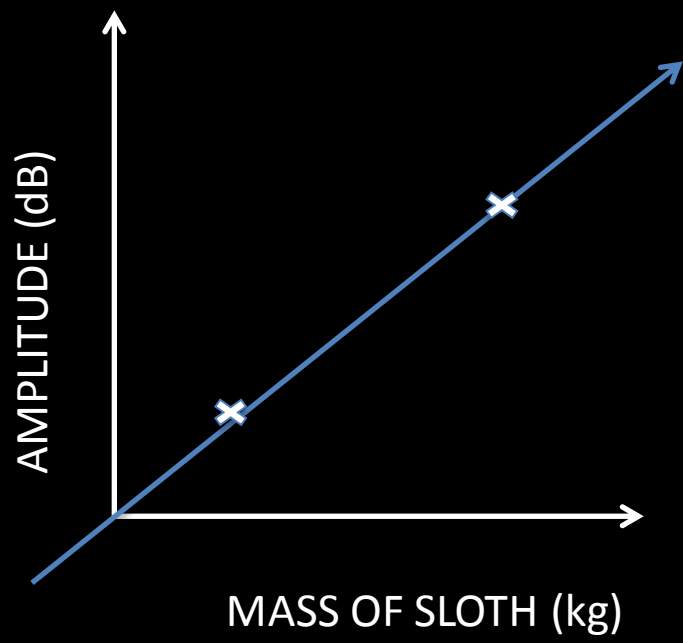


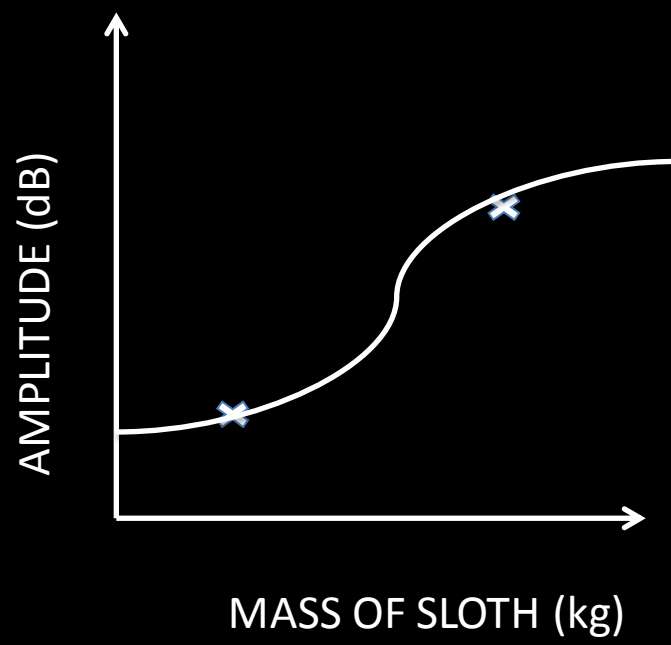


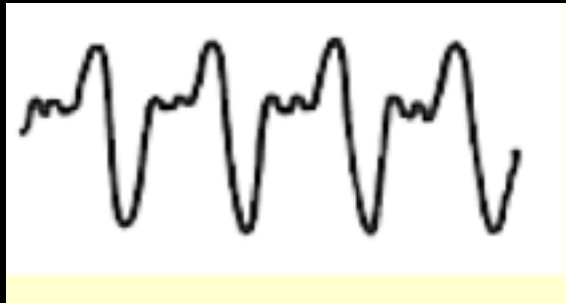
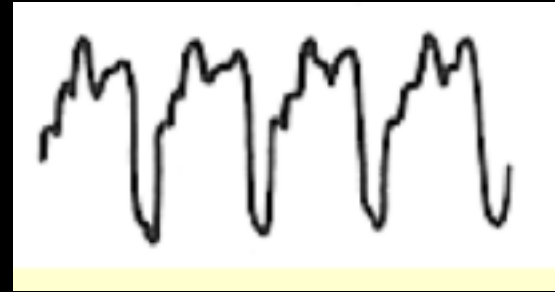












Higgs boson

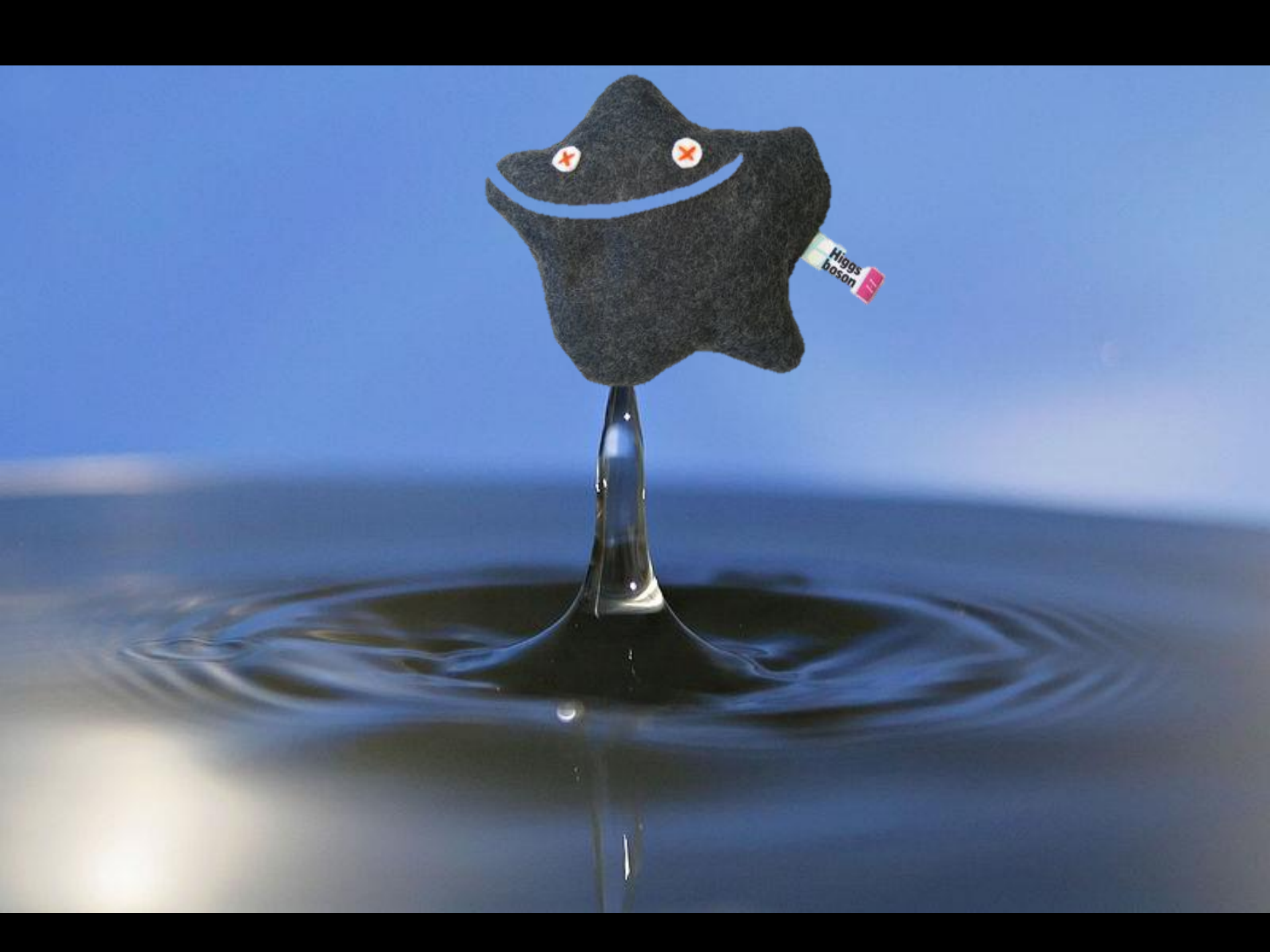
Higgs boson

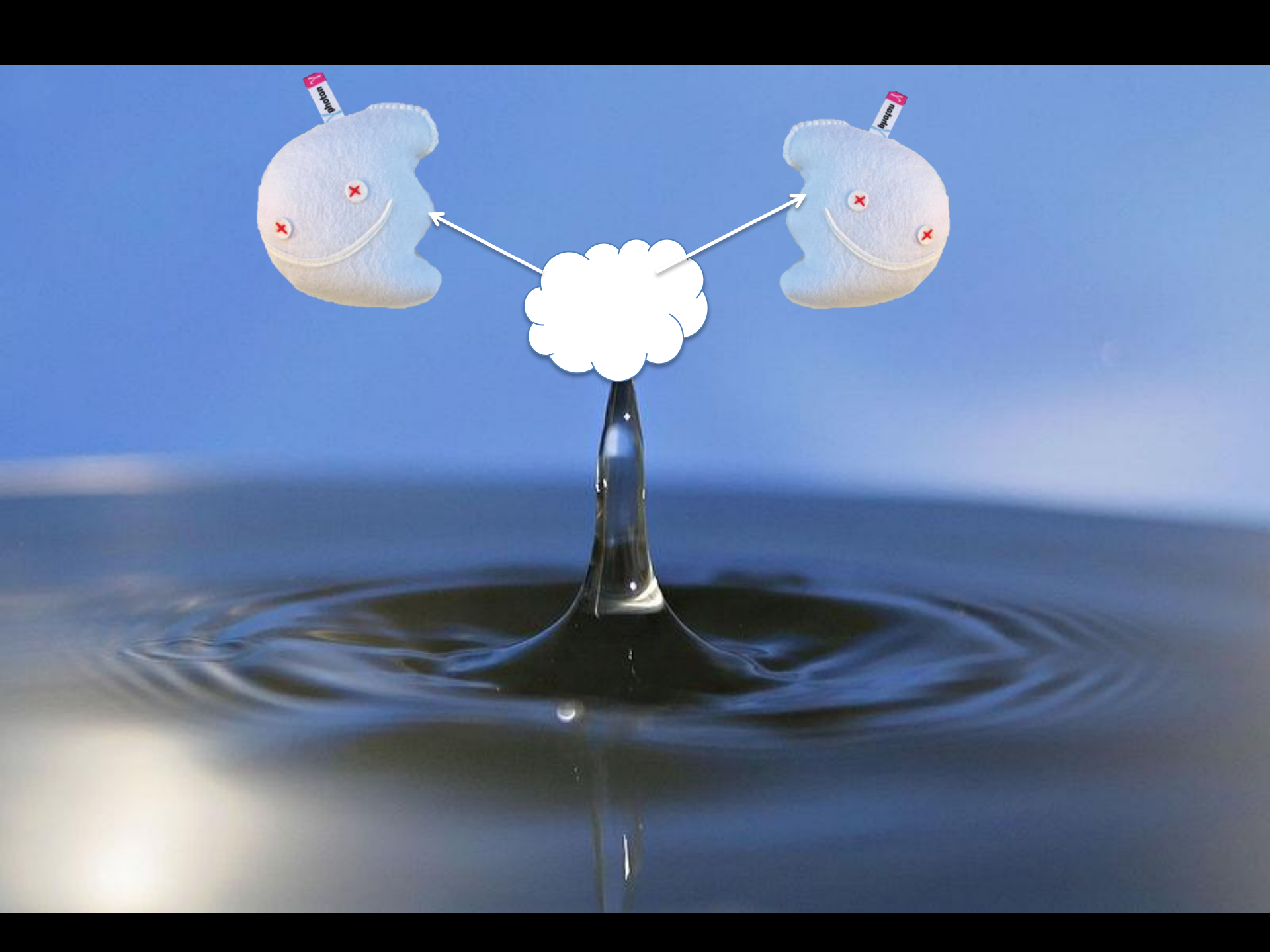


Higgs Bos(e)on







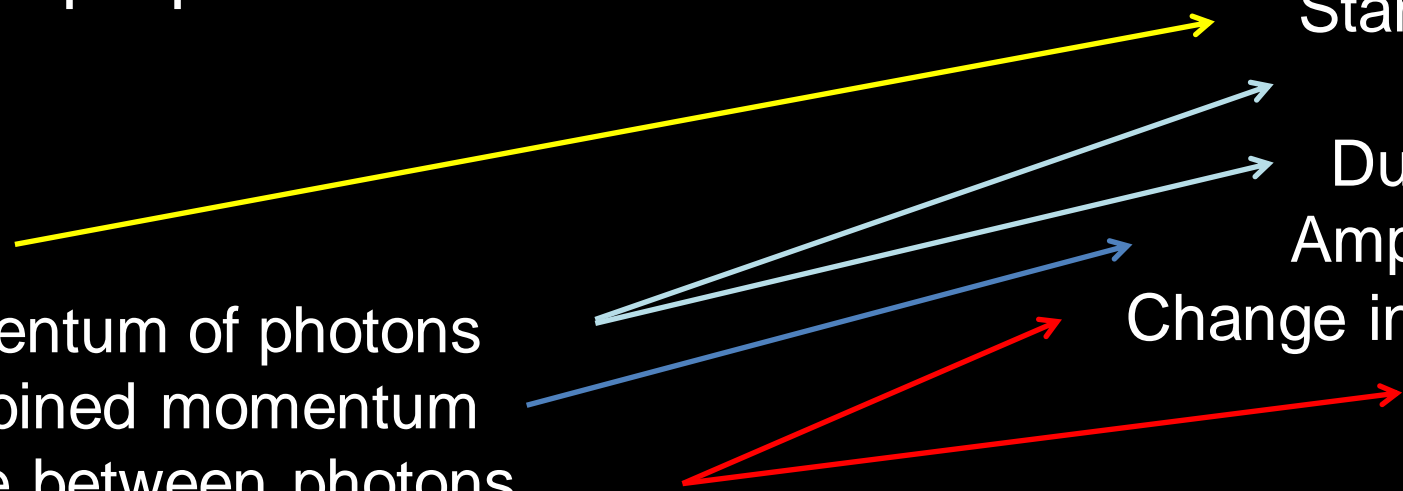


Sonic properties

Physical properties

Mass
Momentum of photons
Combined momentum
Angle between photons

Start time
Pitch
Duration
Amplitude
Change in pitch
Pan



<https://soundcloud.com/paca-rana/gev120-130-ptt-40-222>

Shorten duration:

<https://soundcloud.com/paca-rana/gev120-130-ptt-0-222>

Slice it up according to the total momentum:

<https://soundcloud.com/paca-rana/gev120-130-ptt-0-40-32durscale>

<https://soundcloud.com/paca-rana/gev120-130-ptt-40-222-1>

Play all events, but extend the duration of the second set

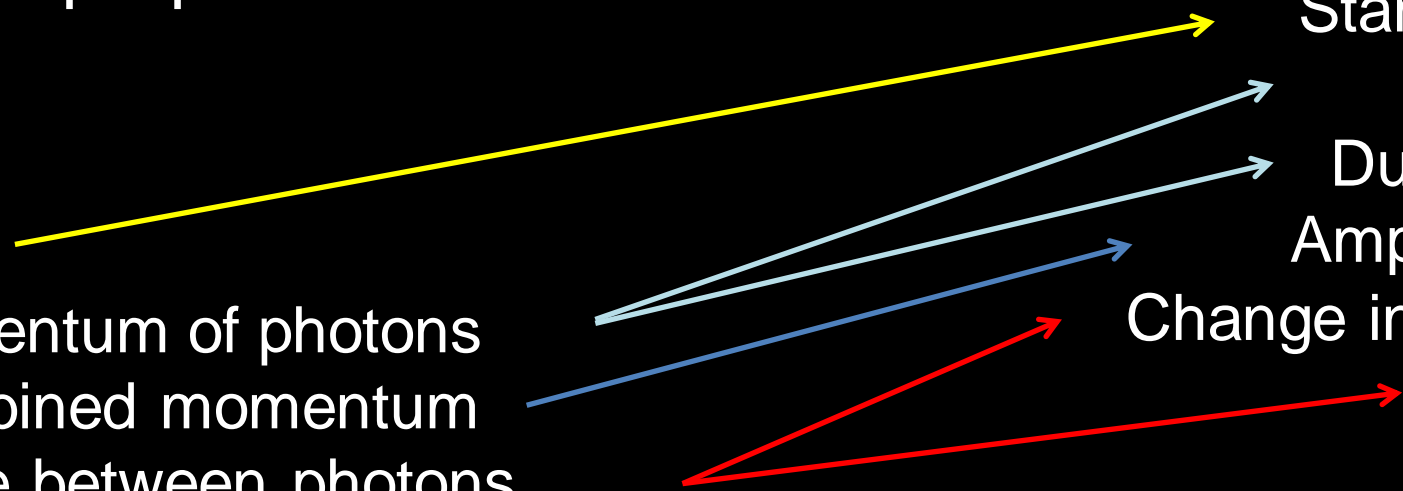
<https://soundcloud.com/paca-rana/gev120-130-gammasum166-222-ptt>

Sonic properties

Physical properties

Mass
Momentum of photons
Combined momentum
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Start time
Pitch
Duration
Amplitude
Change in pitch
Pan

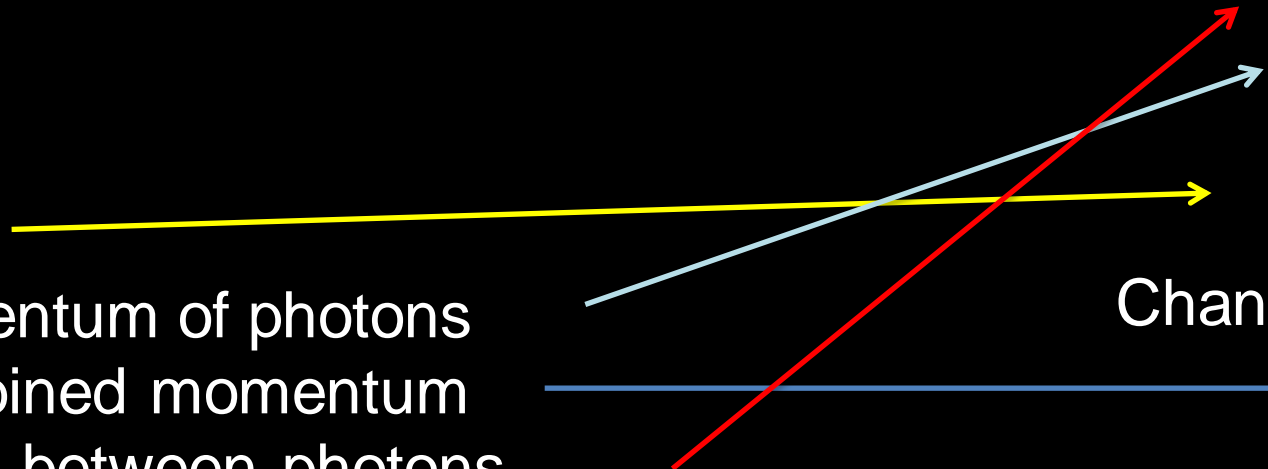


Sonic properties

Physical properties

Mass
Momentum of photons
Combined momentum
Angle between photons

Start time
Pitch
Duration
Amplitude
Change in pitch
Pan



Angle as time:

<https://soundcloud.com/paca-rana/delr-g1pt-gev-ptt>

Combined momentum as time:

<https://soundcloud.com/paca-rana/ptt-g1pt-gev-delr>

Limitations