$$\frac{dN_r}{dt} = \sigma \mathcal{L} \implies N_r = \sigma \cdot \int \mathcal{L} \cdot dt$$

$$\underbrace{\qquad}_{\substack{L_{int} \quad lum \cdot (b^{-1}) \\ integrate.}}$$

CMS Integrated Luminosity Delivered, pp

Data included from 2010-03-30 11:22 to 2018-10-26 08:23 UTC

Legend:
- 2010, 7 TeV, 45.0 pb^{-1}
- 2011, 7 TeV, 6.1 fb^{-1}
- 2012, 8 TeV, 23.3 fb^{-1}
- 2015, 13 TeV, 4.2 fb^{-1}
- 2016, 13 TeV, 41.0 fb^{-1}
- 2017, 13 TeV, 49.8 fb^{-1}
- 2018, 13 TeV, 67.9 fb^{-1}

Total Integrated Luminosity (fb^{-1}) vs Date (UTC)

$\times 50$

$$P \qquad P$$
$$\longrightarrow \qquad \longleftarrow$$
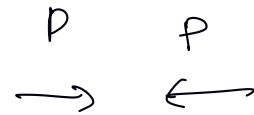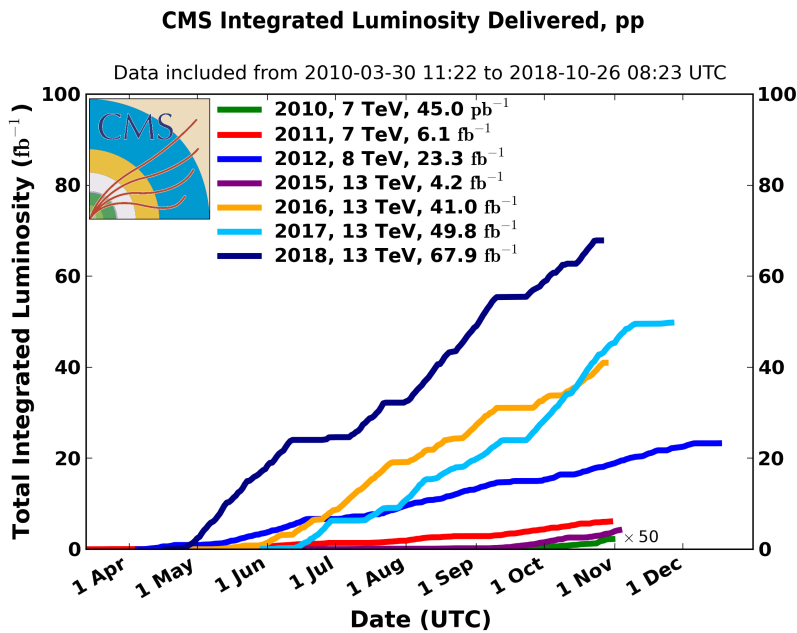
$$\underline{P_1} = (P, P, 0, 0)$$

$$P_2 = (P, -P, 0, 0)$$

$$P = 3.5 \ TeV$$

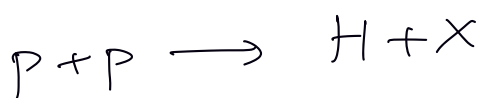$$m_p = 1 \ GeV$$

$$\frac{P}{m} = \frac{3.5 \times 10^3}{1}$$

$$E \bowtie P$$

$$\sqrt{S} = \sqrt{|\underline{P_1} + P_2|^2} = 2P = 7 \ TeV$$

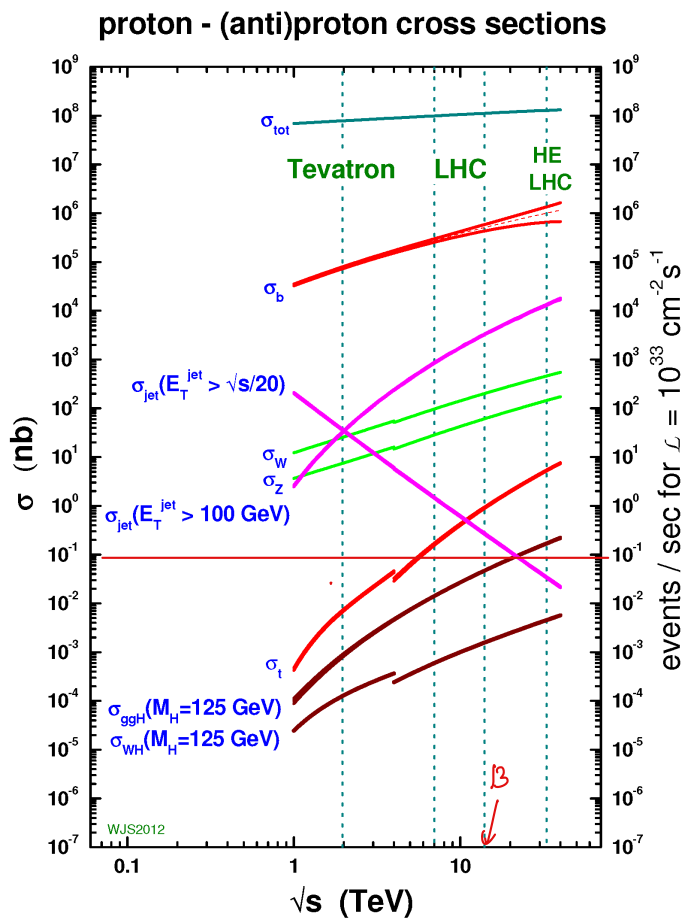$$(fb)^{-1} = 10^{15} \ b^{-1}$$

$$\mathcal{L} \propto \frac{N_1 \cdot N_2}{S} f$$

$$N_H = \sigma_H \cdot L_{int}$$

$$P + P \longrightarrow H + X$$

2016-2018: $L_{int} = 163 \ fb^{-1}$

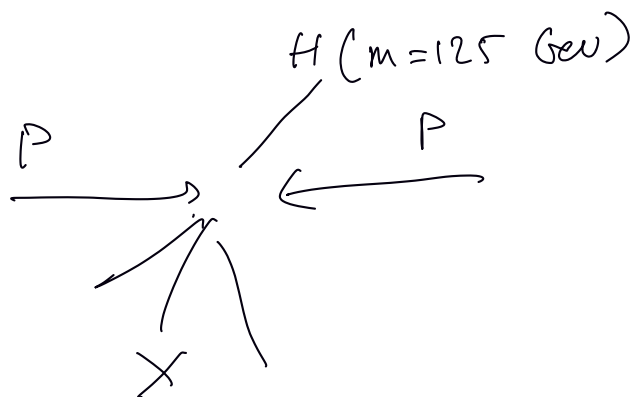## proton - (anti)proton cross sections

$$N_H = 160 \text{ fb}^{-1} \times 0.1 \text{ nb}$$
$$= 2 \times 10^{2} \times 10^{-1} \times 10^{-9} \times 10^{15}$$
$$= 2 \times 10^{7}$$

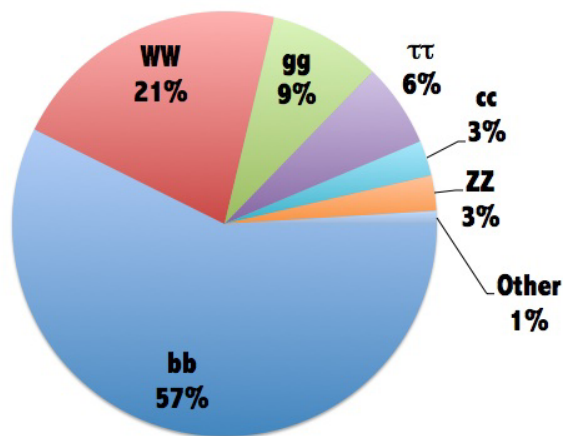$$0.1 \text{ nb} = \sigma_H$$

$H \ (m = 125 \text{ GeV})$

$$\sqrt{S} = 13 \times 10^{3} \text{ GeV}$$

$$3\% \qquad$$
$$H \longrightarrow Z^{0} \ Z^{0}$$
$$\longrightarrow \mu^{+}\mu^{-}$$
$$\longrightarrow \mu^{+}\mu^{-}$$

Branching Fraction H

Higgs decays at m_H=125GeV

Z DECAY MODES

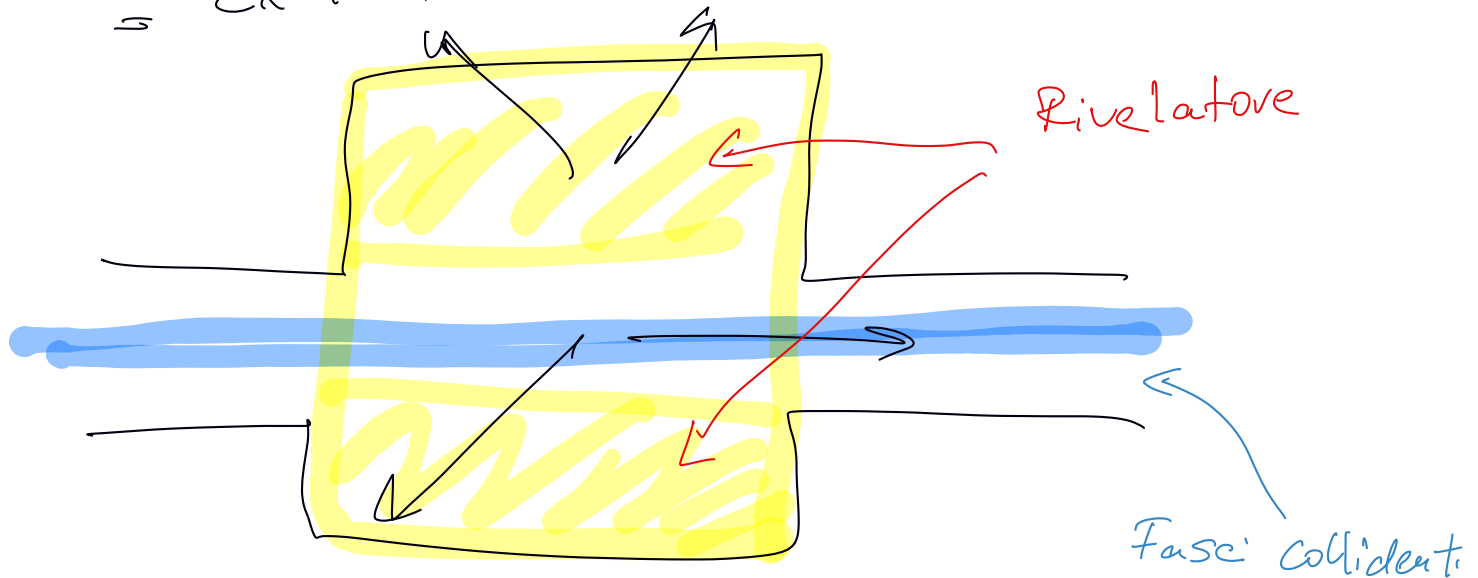|	Mode		Fraction (Γ_i/Γ)	Scale factor/ Confidence level
Γ_1	e^+e^-		(3.363 ±0.004) %	
Γ_2	$\mu^+\mu^-$		(3.366 ±0.007) %	
Γ_3	$\tau^+\tau^-$		(3.370 ±0.008) %	
Γ_4	$\ell^+\ell^-$	[a]	(3.3658±0.0023) %	
Γ_5	invisible		(20.00 ±0.06) %	
Γ_6	hadrons		(69.91 ±0.06) %	
Γ_7	$(u\bar{u}+c\bar{c})/2$		(11.6 ±0.6) %	
Γ_8	$(d\bar{d}+s\bar{s}+b\bar{b})/3$		(15.6 ±0.4) %	
Γ_9	$c\bar{c}$		(12.03 ±0.21) %	
Γ_{10}	$b\bar{b}$		(15.12 ±0.05) %	
Γ_{11}	$b\bar{b}b\bar{b}$		(3.6 ±1.3) $\times 10^{-4}$	
Γ_{12}	ggg		< 1.1 %	CL=95%
Γ_{13}	$\pi^0\gamma$		< 5.2 $\times 10^{-5}$	CL=95%
Γ_{14}	$\eta\gamma$		< 5.1 $\times 10^{-5}$	CL=95%
Γ_{15}	$\omega\gamma$		< 6.5 $\times 10^{-4}$	CL=95%
Γ_{16}	$\eta'(958)\gamma$		< 4.2 $\times 10^{-5}$	CL=95%
Γ_{17}	$\gamma\gamma$		< 5.2 $\times 10^{-5}$	CL=95%
Γ_{18}	$\gamma\gamma\gamma$		< 1.0 $\times 10^{-5}$	CL=95%
Γ_{19}	$\pi^\pm W^\mp$	[b]	< 7 $\times 10^{-5}$	CL=95%

$$H \to Z^0 Z^0 \quad 3\%$$

$$Z^0 \to \mu^+\mu^- \quad 3\%$$

$$P+P \longrightarrow H+X \longrightarrow Z^0 Z^0 \longrightarrow \mu^+\mu^- \ \mu^+\mu^-$$

$$N_{eventi} = \underline{L_{int} \cdot \sigma} \times BF(H \to ZZ) \times BF(Z^0 \to \mu\mu) \times BF(Z \to \mu)$$

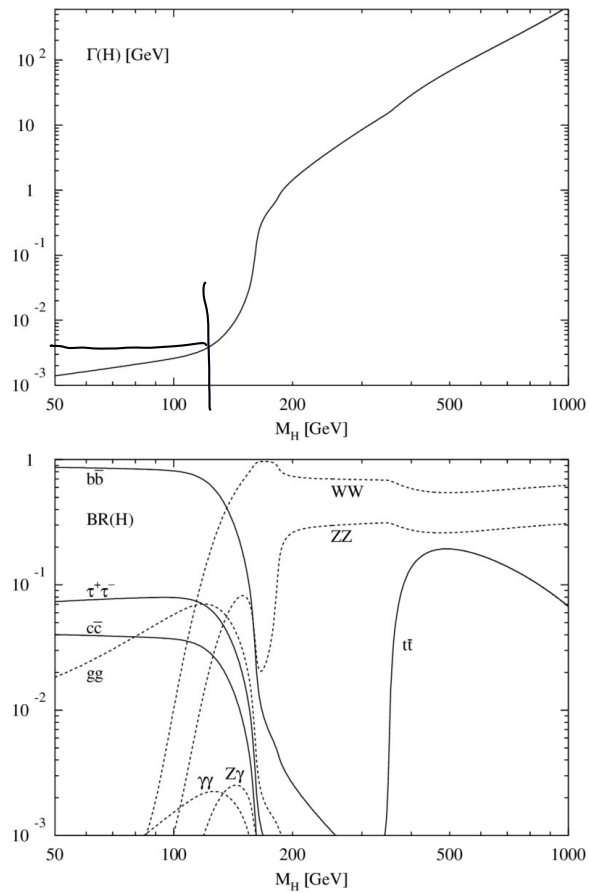$$= 2\times 10^7 \times 3\times 10^{-2} \times 3\times 10^{-2} \times 3\times 10^{-2}$$

$$= 2\times 10^7 \times 27 \times 10^{-6} = 54 \times 10 = 540$$

Rivelatore

Fasci collidenti

$$M_{inv}^2 = |P_{\mu 1} + P_{\mu 2} + P_{\mu 3} + P_{\mu 4}|^2$$

CMS   137 fb^{-1} (13 TeV)

Data
H(125)
$q\bar{q} \to ZZ, Z\gamma^*$
$gg \to ZZ, Z\gamma^*$
EW
Z+X

$= \sqrt{|P_{\mu 1} + P_{\mu 2} + P_{\mu 3} + P_{\mu 4}|^2}$

$M_H = 125$ GeV

$\Gamma_H < 1$ GeV

$\dfrac{\Gamma}{m}$

G (risolutione)

risol.
spen.

m

$$p + p \longrightarrow Z^0 + Z^0 + X$$
$$\hookrightarrow \mu^+ \mu^-$$
$$\longrightarrow \mu^+ \mu^-$$

$$\overline{x} = \beta \gamma c \tau \qquad\qquad \tau = 2.2 \ \mu s.$$

$$u_\mu = 906 \ \text{MeV} = 0.1 \ \text{GeV}$$

$$\beta \gamma = \frac{p}{m} \qquad\qquad m_Z = 91 \ \text{GeV}$$
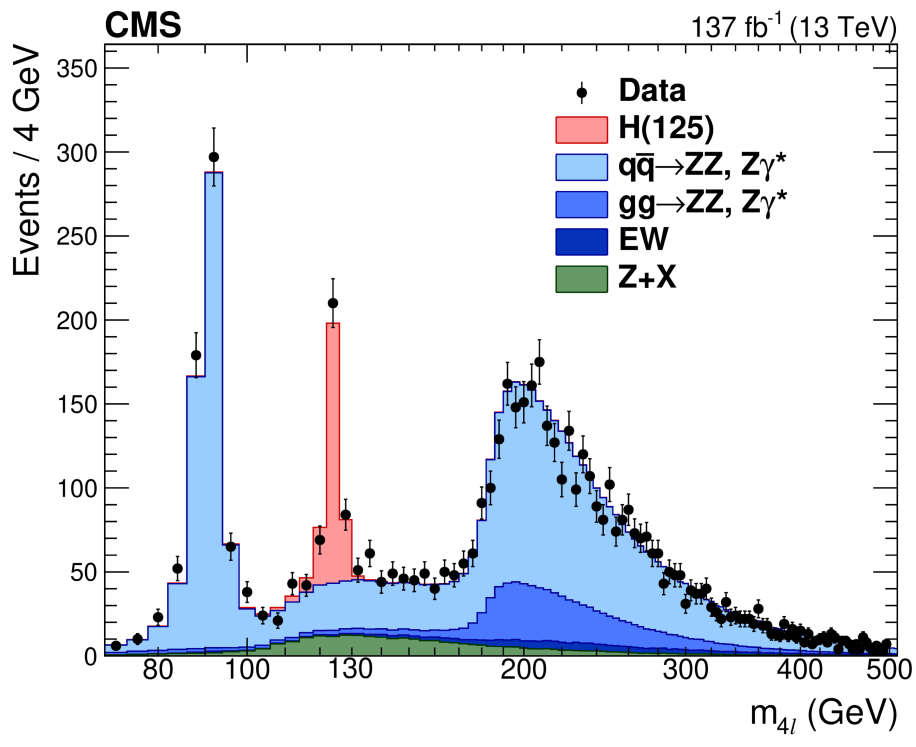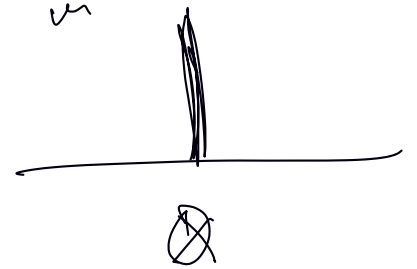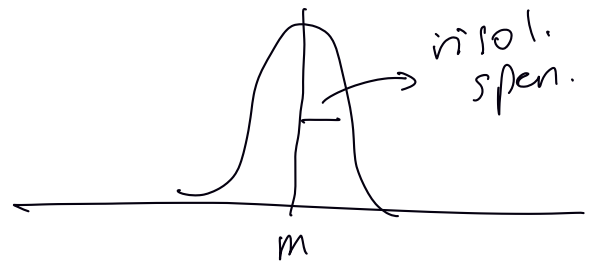
$$Z^0 \to \mu \mu \qquad \Rightarrow \qquad p_\mu \simeq 45 \ \text{GeV}.$$

$$\frac{p}{m} = \frac{45}{0.1} \qquad \leq 450.$$

$$\beta \gamma c \tau = 4.5 \times 10^2 \times 3 \times 10^8 \times 2.2 \times 10^{-6}. \ m$$