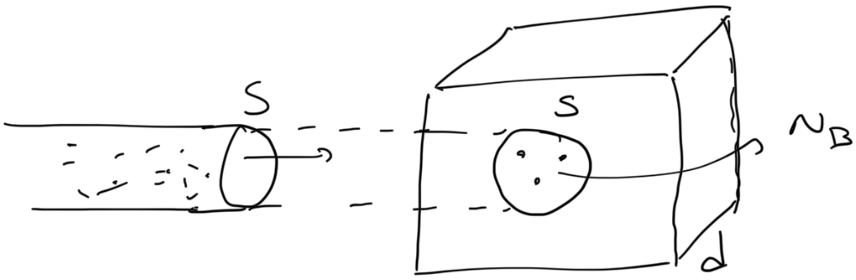
Videolezione-2020-03-20

sezione d'urto $\quad \sigma = \dfrac{1}{n_b \cdot d} \dfrac{(N_r/T)}{(N_p/T)}$

$N_r/T \qquad \dfrac{dN_r}{dt} = \dfrac{N_r}{T}$

$$\sigma = \frac{1}{n_b \cdot d} \frac{N_r}{N_p}$$



$$N_B = n_b \cdot S \cdot d \Rightarrow n_b \cdot d = \frac{N_B}{S}$$

$$\sigma = \frac{1}{\frac{N_B}{S}} \frac{(dN_r/dt)}{(dN_p/dt)} = \frac{1}{N_B}\left(\frac{dN_r}{dt}\right)\frac{1}{\left(\frac{1}{S}\frac{dN_p}{dt}\right)}$$

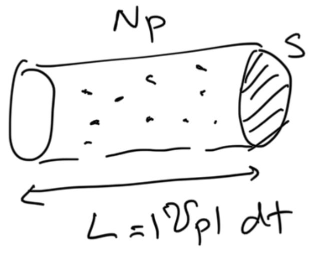
prob di interazione di un proiettile su un bersaglio

$$\sigma = \frac{1}{N_B}\left(\frac{dN_r}{dt}\right)\frac{1}{\Phi_p}$$

$$= \frac{1}{N_B}\left(\frac{dN_r}{dt}\right)\frac{1}{\Phi_p} \qquad \Phi_p = \frac{dN_p}{dt}\frac{1}{S}$$

flusso proiettili

$$N_p = n_p \, L \cdot S =$$
$$= n_p \cdot |v_p| \, dt \cdot S$$



$$\frac{N_p}{dt \cdot S} \equiv \phi = n_p \cdot |\vec{v}_p|$$

$$\sigma = \frac{1}{N_B} \, \frac{1}{n_p \cdot v_p} \, \frac{dN_r}{dt}$$

$$\frac{dN_r}{dt} = \sigma \, \frac{dN_p}{dt} \, n_b \cdot d$$

$$\hookrightarrow [\sigma] = [L]^2$$

m^2

unità di misura per σ

$$1 \text{ barn} = 1b = 10^{-28} \, m^2$$

$\hookrightarrow$ stalla

$$1 \, fb = 10^{-15} \, b = 10^{-43} \, m^2$$

$p + p \rightarrow X$ $\quad \sigma \simeq 10 \, mb$

$= 10^{-2} \, b = 10^{-30} \, m$

$\nu_e + p \rightarrow X$ $\quad \sigma \sim 10 \, fb$

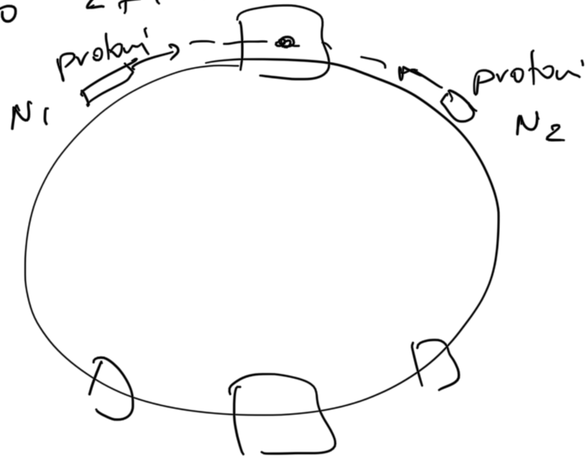
$= 10^{-14} \, b$

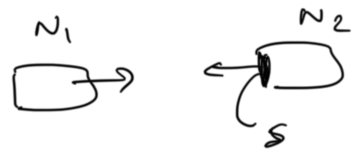
$\chi + p \rightarrow X$ $\quad \sigma \sim 0.01 \, fb$

$= 10^{-45} \, \cancel{b} \, m^2$

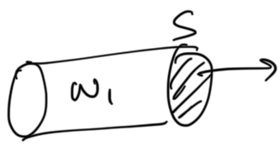
Sezione d'urto con fasci incrociati

LHC: anello 27 km



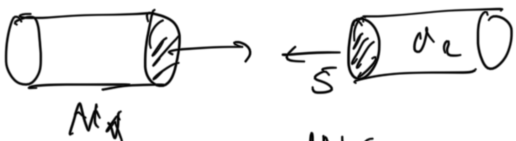


$$\frac{dN_r}{dt} = \sigma \cdot \frac{dN_p}{dt} n_b \cdot d$$

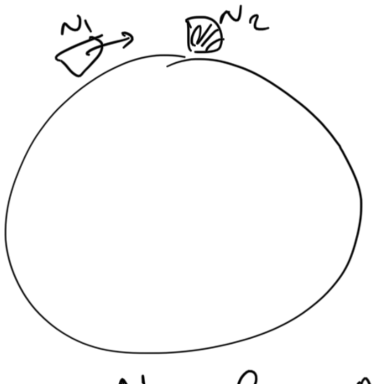


$$= \sigma \cdot \frac{dN_p}{dt \cdot S} \cdot \underbrace{S \cdot d \cdot n_b}_{N_B = N_2}$$

$$\phi_1 = \frac{N_1}{dt \cdot S}$$



$$\frac{dN_r}{dt} = \sigma \, \phi_1 \, N_2$$

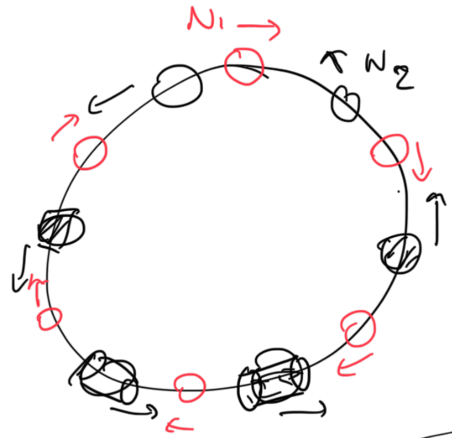


$$\phi_1 = \frac{N_1}{S} f_{int}$$

freq. di interazione

$$\frac{dN_r}{dt} = \sigma \frac{N_1}{S} f_{int} N_2 = \sigma \frac{N_1 N_2}{S} f_{in}$$

prop fisica dell'inter.



$N_1 = m_1 \cdot N_p$

numero di pacchetti

$$[T]^{-1} \longrightarrow \frac{dN_r}{dt} = \sigma \frac{N_1 N_2}{S} f \longrightarrow [L]^{-2}[T]^{-1}$$

$\sigma \rightarrow [L]^2$

$\mathcal{L}$: luminosità istantanea dell'acceleratore

$$\frac{Hz}{barn} = barn^{-1} s^{-1} = cm^{-2} s^{-1}$$

LHC : $\mathcal{L} \sim 10^{34} \ cm^{-2} s^{-1}$

$$\frac{dN_r}{dt} = \sigma \cdot \mathcal{L} = \frac{\#\ eventi}{sec}$$

$N_r = ?$ misure/ collisioni in tempo T

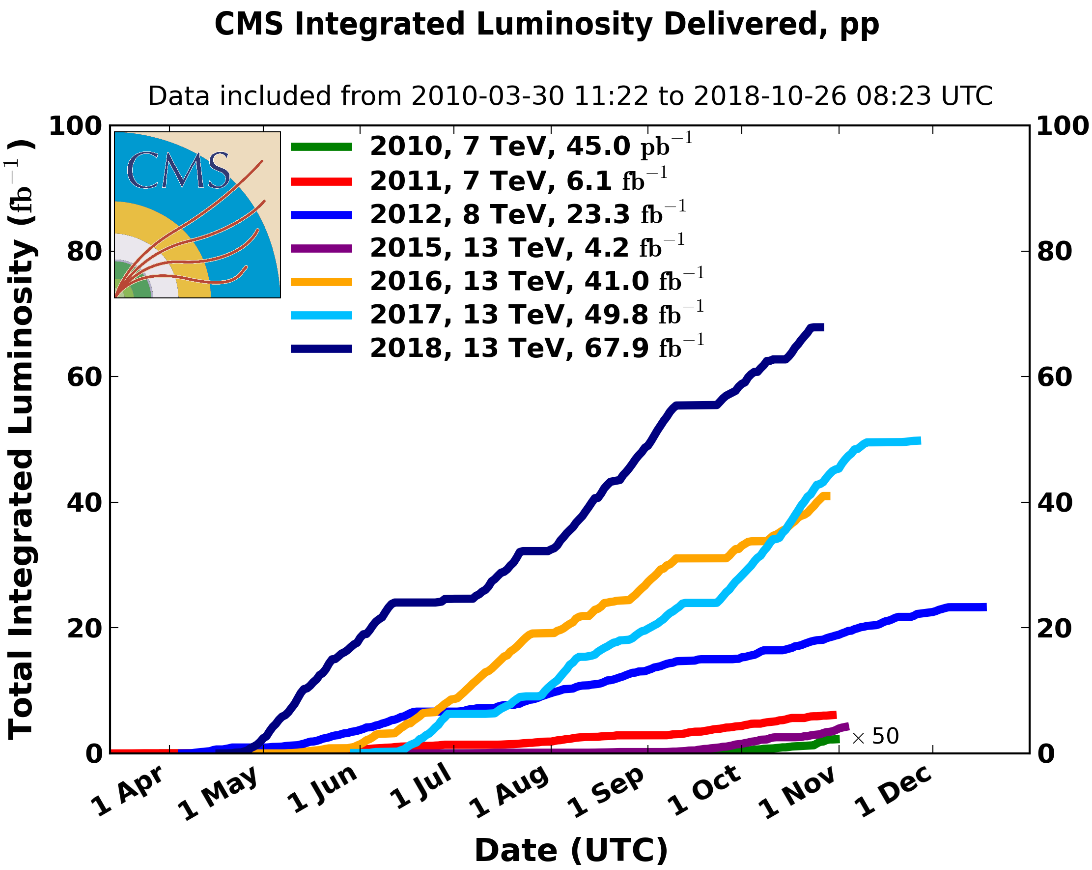
$$N_r = \frac{dN_r}{dt} \cdot T = \sigma \cdot \mathcal{L} \cdot T$$

↳ lumi costante nel tempo

$$= \sigma \cdot \int_T \mathcal{L} \cdot dt$$

luminosità integrata $[barn]^{-1}$

$$= \sigma \cdot L$$



$$L = \int \mathcal{L} \cdot dt \qquad \mathcal{L} = \frac{dL}{dt}$$

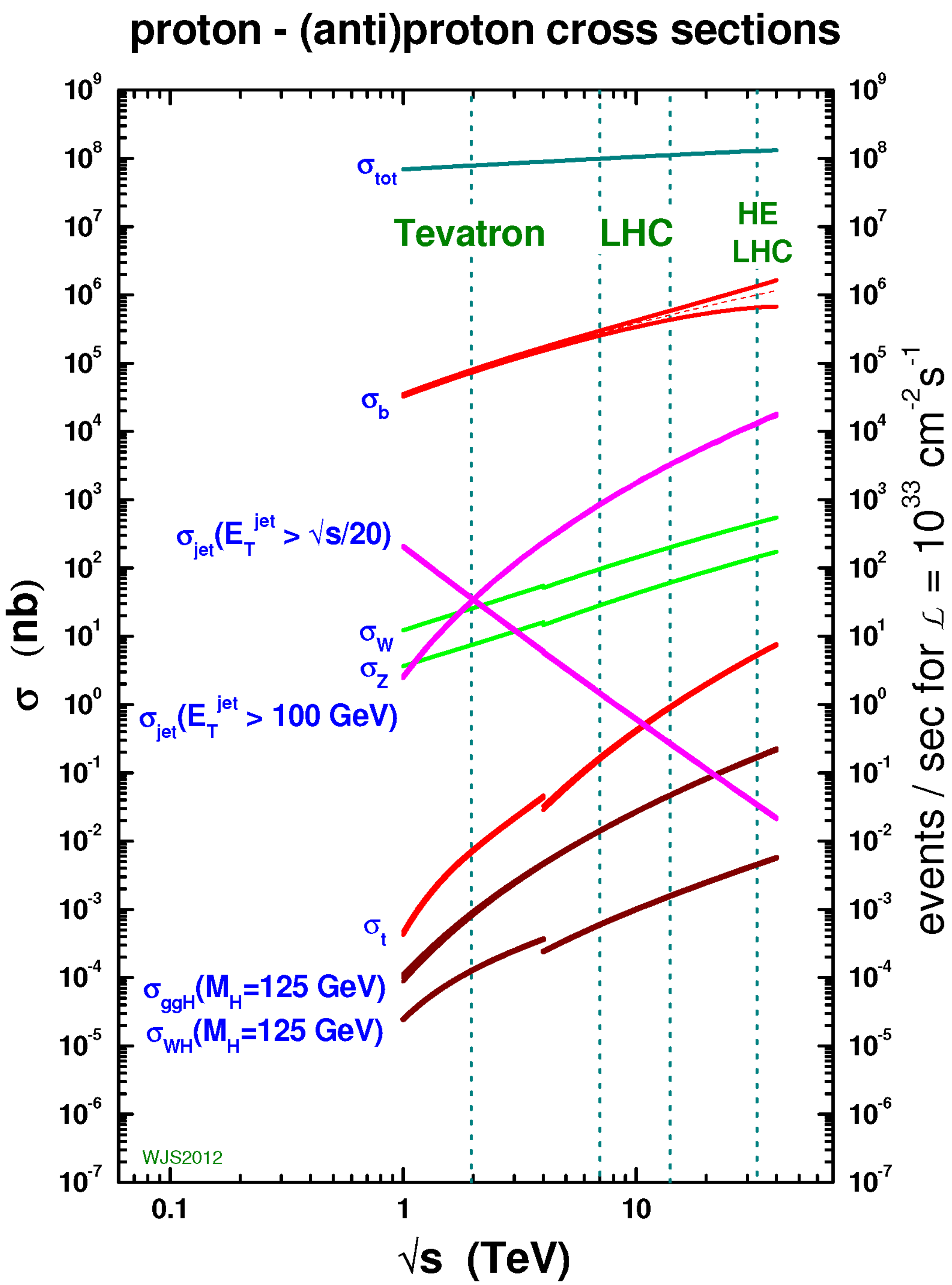
$$\mathcal{L}_{2018} \gg \mathcal{L}_{2012} \gg \mathcal{L}_{201}$$

$L = 163\ fb^{-1}$ $2015 \to 2018$

Run 2 LHC

$p + p \to H + X$ sezione d'urto inclusiva

$$N_H = L \cdot \sigma_{H+X}$$


proton - (anti)proton cross sections
σ (nb)
events / sec for ℒ = 10^33 cm^-2 s^-1
√s (TeV)
σtot
Tevatron
LHC
HE LHC
σb
σjet(ET jet > √s/20)
σW
σZ
σjet(ET jet > 100 GeV)
σt
σggH(MH=125 GeV)
σWH(MH=125 GeV)
WJS2012
0.1
1
10

$\sigma \simeq 0.1\ \mu b = 10^{-10} b.$

$\sqrt{s} = 13\, TeV$

$$N_{Higgs} = L \cdot \sigma = 163\ fb^{-1} \times 10^{-10} b$$
$$= 163 \times 10^{+15} \cancel{b^{-1}} \times 10^{-10} \cancel{b}$$
$$= 163 \times 10^{5}$$
$$\simeq 16 \times 10^{6}$$

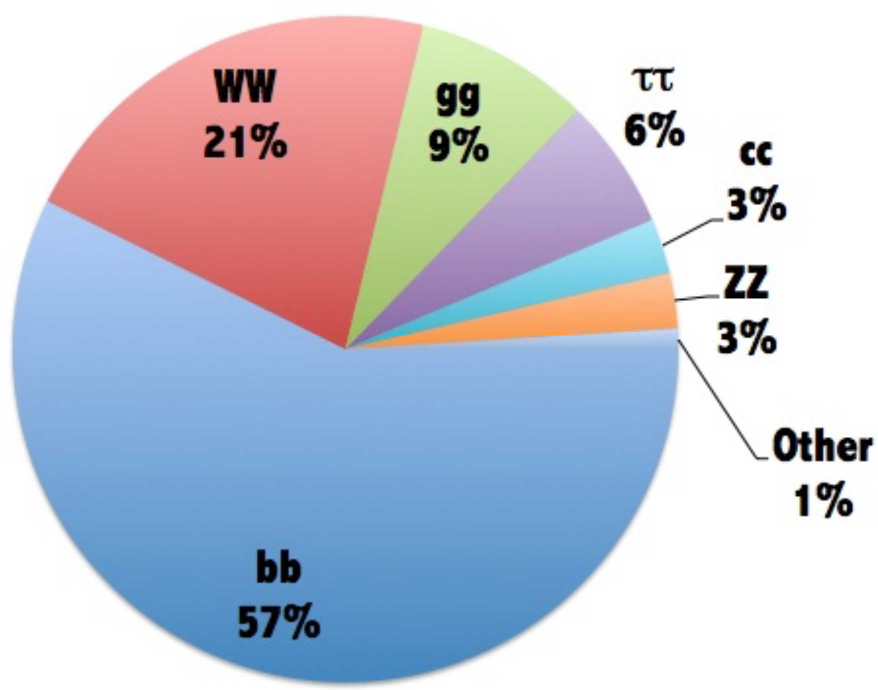
16 millioni di Higgs del 2015 → 2018

$H \to b b$ BF$_i$
$\gamma\gamma$
$Z Z$
$W W$

Quanti $H \to \gamma\gamma$?

$$N_{H\to\gamma\gamma} = N_H \cdot BF(H \to \gamma\gamma)$$

Higgs decays at m_H=125GeV



$$BF(H \to ZZ) = 3\%$$

$$N(H \to ZZ) = 16 \times 10^6 \times 3 \times 10^{-2}$$

$$= 48 \times 10^4 = 480\,K$$

$$Z \to e^+e^-$$
$$\mu^+\mu^-$$
$$\tau^+\tau^-$$

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	$(u\overline{u}+c\overline{c})/2$		(11.6 ± 0.6) %	
Γ_8	$(d\overline{d}+s\overline{s}+b\overline{b})/3$		(15.6 ± 0.4) %	
Γ_9	$c\overline{c}$		(12.03 ± 0.21) %	
Γ_{10}	$b\overline{b}$		(15.12 ± 0.05) %	
Γ_{11}	$b\overline{b}b\overline{b}$		$(3.6 \pm 1.3) \times 10^{-4}$	
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%

$N(p+p \to H + X)$

$\hookrightarrow Z + Z$

$Z \hookrightarrow e^+e^-$

$Z \hookrightarrow e^+e^-$

$= \sigma_H \cdot L \cdot BF(H \to ZZ) \cdot \underbrace{BF(Z \to ee)} \underbrace{BF(Z \to ee)}$

$= 16 \times 10^6 \times 3 \times 10^{-2} \times 3 \times 10^{-2} \times 3 \times 10^{-2}$

$= 432$ $p+p \to H+X \to e^+e^-e^+e^-$

in 4 anni di presa dati

se non conosco σH:

Come si misura?

$$N_H = \sigma \cdot L \cdot \underbrace{BF(H \to ZZ)}_{\text{calcolo theorico}} \big(\underbrace{BF(Z \to ee)}_{\text{misurato a LEP}}\big)^2$$

N_H → conteggio

L → si misura sperim.

Rivelatore perfetto

$$\sigma(p+p \to H+x) = \sigma_H = \frac{N_H}{L \cdot BF(H \to ZZ) \cdot (BF(Z \to ee))^2}$$

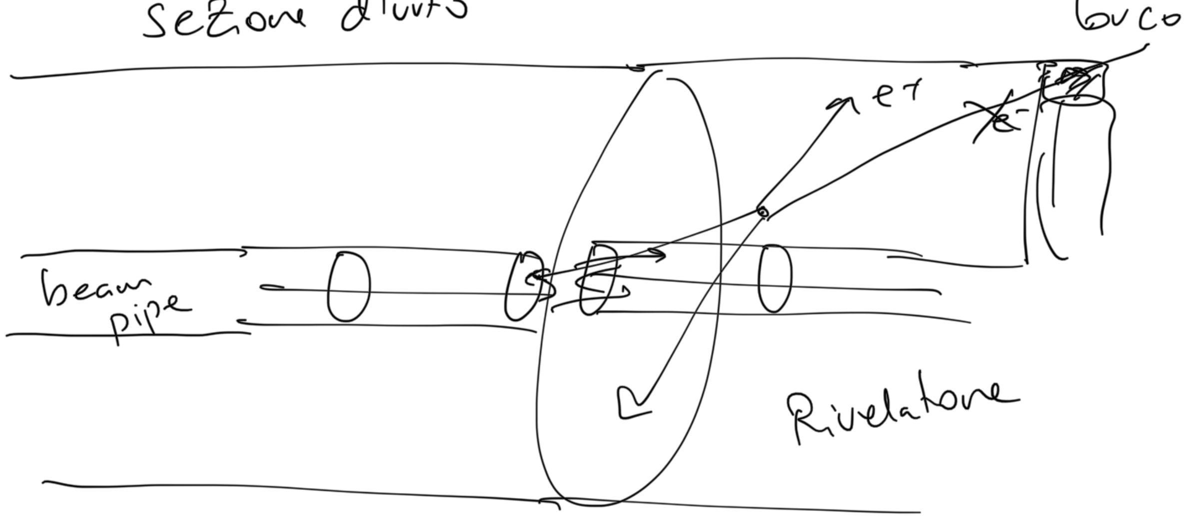
$\mathcal{E}$: efficienze : selezione + ricostruzione + rivelatore

$$\sigma_H = \frac{N_H}{L \cdot BF(H)(BF(Z))^2 \cdot \mathcal{E}}$$

N_H → conteggio

L → lum integ.

misura sezione d'urto



Sezione d'urto inclusiva ed esclusiva

tipo di reazione

$$p + p \longrightarrow \begin{array}{ll} H + X & \sigma_1 \\ p + p & \vdots \\ Z + X & \\ q_1 + q_2 & \\ W^+ W^- + X & \sigma_N \\ \vdots & \end{array}$$

$\sigma(pp) \simeq 10$ mb totale

come sapere $H + X$ $\quad$ $e^+e^-e^+e^-$ XXXXX

$p + p$ XXXX

$\sigma_{tot} = \sum_i \sigma_i$

$\sigma_i \hookrightarrow$ sez. d'urto esclusiva per singola reazione $p+p \longrightarrow$ stato $|i\rangle$

$\sigma_{tot} \swarrow$ $p+p \longrightarrow X$

$p+p \longrightarrow H+X$ $\quad$ e^+e^- e^+e^-

$H \to Z Z$

1

$\hookrightarrow e^+e^-$

$\hookrightarrow e^+e^-$

(2)

$p+p \longrightarrow Z + Z$

$\hookrightarrow e^+e^-$

$\hookrightarrow e^+e^-$

$|i\rangle = |pp\rangle$

$|f\rangle = |e^+e^-e^+e^-\rangle$

$$\underbrace{e_1^+ e_1^-}_{Z_1} \; \underbrace{e_2^+ e_2^-}_{Z_2}$$

$$\underline{P}_{Z_1} = \underline{P}_{e_1^+} + \underline{P}_{e_1^-}$$

$$\underline{P}_{Z_2} = \underline{P}_{e_2^+} + \underline{P}_{e_2^-}$$

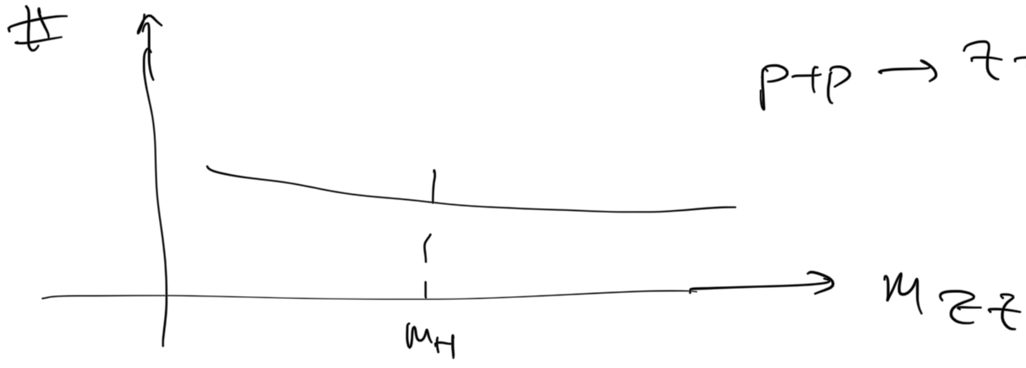
$$m_{ZZ} = \sqrt{|\underline{P}_{Z_1} + \underline{P}_{Z_2}|^2}$$

$p+p \longrightarrow H + X$

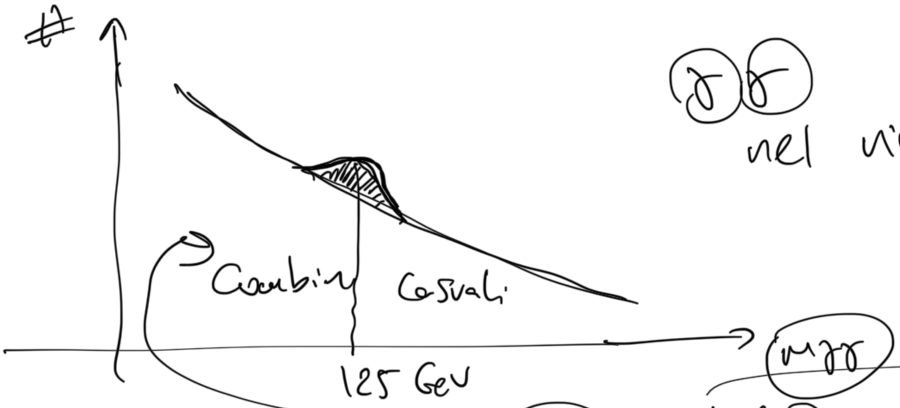
$\hookrightarrow Z\ Z$

$\hookrightarrow e^+e^-$

$\hookrightarrow e^+e^-$



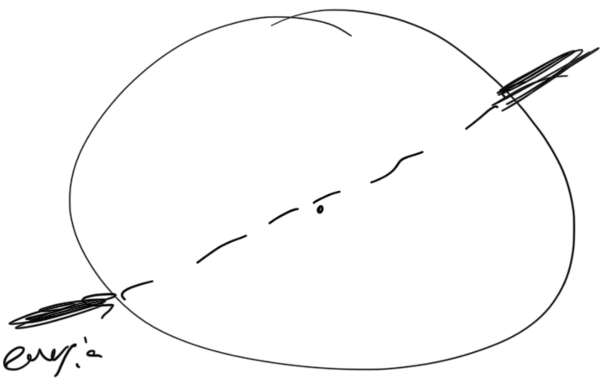
$p+p \longrightarrow Z + Z$



$\gamma\gamma$ nel rivelatore

$$p+p \to C_1 + (H + X)$$
$$\hookrightarrow \gamma\gamma$$

processo raro



$$\sqrt{|\underline{P}_{\gamma_1} + \underline{P}_{\gamma_2}|^2} = m_{\gamma\gamma}$$