

L'esperimento ATLAS a LHC e $H \rightarrow b\bar{b}$

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Presentazioni

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2001-2007 | Laurea triennale e magistrale | Genova

2007-2010 | PhD | Genova, CERN

2010-2011 | Post-Doc | Genova

2012-2015 | Post-Doc | Università di Washington, CERN

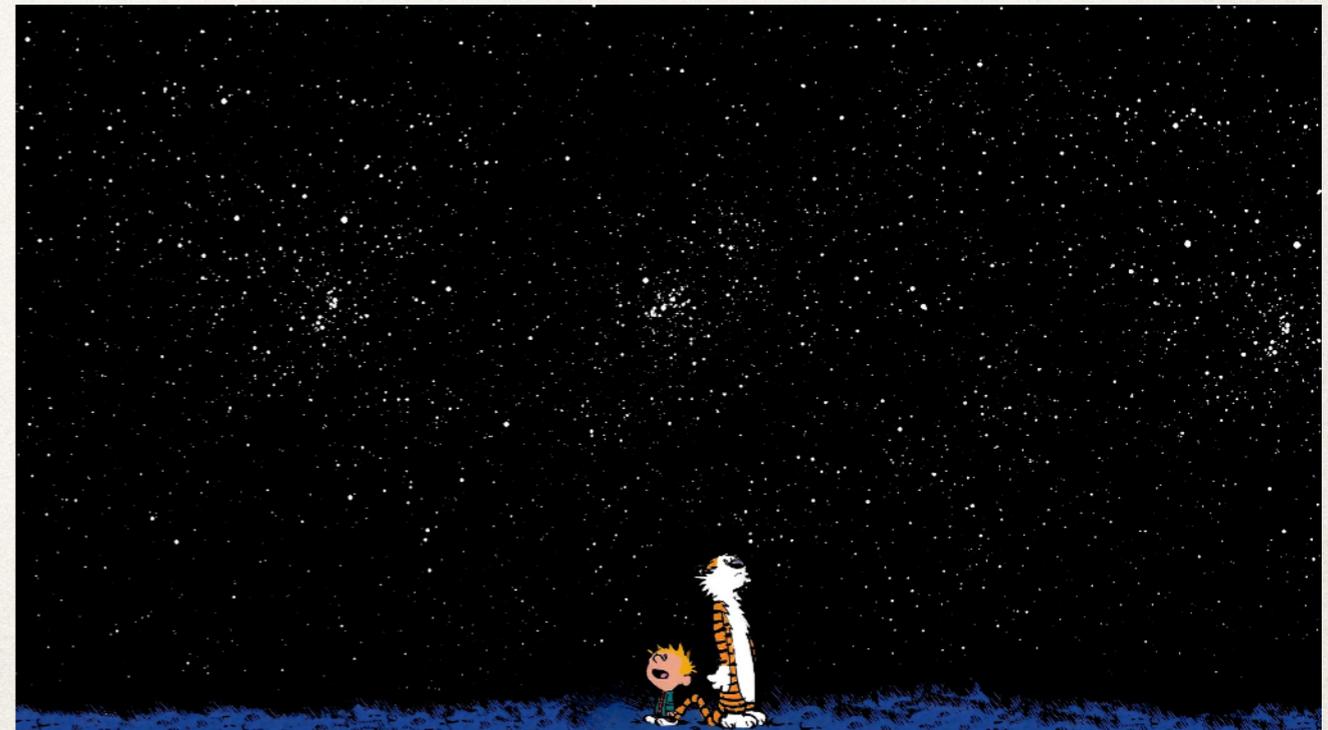
2015-2017 | Post-Doc | Università di Ginevra, CERN

2017 - | Ricercatore INFN | Genova



Perché?

- Per lo stimolo ricevuto in alcuni corsi chiave qua a Genova
- Per l'esperienza summer student al CERN
- Perché l'appetito vien mangiando
- Perché no?



Di cosa parliamo?

1. Fisica della particelle

2. Modello Standard

3. Large Hadron Collider

4. ATLAS

5. Bosone di Higgs

6. Analisi dati

Di cosa parliamo?

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» MARCO DELMASTRO

Il 4 luglio del 2012, il Cern di Ginevra, annunciava una notizia che i fisici aspettavano da quasi cinquant'anni. Il bosone di Higgs, teoricamente predetto nel 1964 nel tentativo di spiegare la ragione per cui le particelle elementari hanno una massa, era finalmente stato scoperto. Con una modalità sino a quel momento insolita, la conferenza di presentazione dei risultati

LINGUAGGI La fisica al Festival della Comunicazione di Sarzana

Bosone di Higgs: più facile da scoprire che da spiegare

La danza della scienza

Il metodo scientifico è la modalità con la quale la scienza avanza nella comprensione della realtà

1 | Osservazione di un fenomeno tramite esperimento

2 | Formulazione di una teoria per spiegare il fenomeno

3 | Potere predittivo della teoria per un nuovo fenomeno

4 | Messa alla prova della teoria con nuovo esperimento

Nell'ultimo secolo, esperimento e teoria sono progrediti mano nella mano verso una comprensione profonda delle interazioni fondamentali

Materia

e (1887),
 μ (1937),
 ν_e (1956),
c (1974),
...
 ν_τ (2000)

Mecc. Quant. (1901)

Relatività (1905)
Simmetrie ('60)

Forze

γ (1905),
gluone (1978)
 W^\pm/Z^0 (1984),

Standard Model of Elementary Particles

		three generations of matter (fermions)				
		I	II	III		
mass		$\approx 2.4 \text{ MeV}/c^2$	$\approx 1.275 \text{ GeV}/c^2$	$\approx 172.44 \text{ GeV}/c^2$	0	$\approx 125.09 \text{ GeV}/c^2$
charge		$2/3$	$2/3$	$2/3$	0	0
spin		$1/2$	$1/2$	$1/2$	1	0
		u up	c charm	t top	g gluon	H Higgs
		$\approx 4.8 \text{ MeV}/c^2$	$\approx 95 \text{ MeV}/c^2$	$\approx 4.18 \text{ GeV}/c^2$	0	
		$-1/3$	$-1/3$	$-1/3$	0	
		$1/2$	$1/2$	$1/2$	1	
		d down	s strange	b bottom	γ photon	
		$\approx 0.511 \text{ MeV}/c^2$	$\approx 105.67 \text{ MeV}/c^2$	$\approx 1.7768 \text{ GeV}/c^2$	$\approx 91.19 \text{ GeV}/c^2$	
		-1	-1	-1	0	
		$1/2$	$1/2$	$1/2$	1	
		e electron	μ muon	τ tau	Z Z boson	
		$< 2.2 \text{ eV}/c^2$	$< 1.7 \text{ MeV}/c^2$	$< 15.5 \text{ MeV}/c^2$	$\approx 80.39 \text{ GeV}/c^2$	
		0	0	0	± 1	
		$1/2$	$1/2$	$1/2$	1	
		ν_e electron neutrino	ν_μ muon neutrino	ν_τ tau neutrino	W W boson	

QUARKS

LEPTONS

GAUGE BOSONS

SCALAR BOSONS

quark & leptoni | particelle di materie

bosone di gauge | mediatori delle forze fondamentali

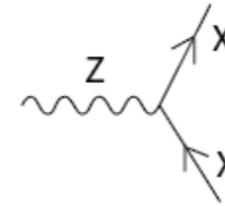
bosone di Higgs | responsabile della rottura spontanea di simmetria

Ma che cosa è il Modello Standard?

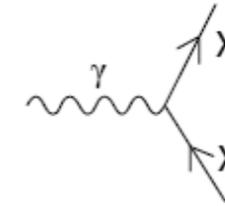
Ma che cosa è il Modello Standard?

$$\begin{aligned}
 \mathcal{L}_{SM} = & -\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 - \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_\mu A_\nu \partial_\mu A_\nu - igc_w (\partial_\nu Z_\mu^0 (W_\mu^+ W_\nu^- - \\
 & W_\nu^+ W_\mu^-) - Z_\nu^0 (W_\mu^+ \partial_\nu W_\mu^- - W_\mu^- \partial_\nu W_\mu^+) + Z_\mu^0 (W_\nu^+ \partial_\nu W_\mu^- - W_\nu^- \partial_\nu 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_\mu^- \partial_\nu W_\mu^+) + A_\mu (W_\nu^+ \partial_\nu W_\mu^- - \\
 & W_\nu^- \partial_\nu 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_\mu^+ Z_\nu^0 W_\nu^- - \\
 & Z_\mu^0 Z_\nu^0 W_\mu^+ W_\nu^-) + g^2 s_w^2 (A_\mu W_\mu^+ A_\nu W_\nu^- - 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^-) - \frac{1}{2}\partial_\mu H \partial_\mu H - 2M^2 \alpha_h H^2 - \partial_\mu \phi^+ \partial_\mu \phi^- - \frac{1}{2}\partial_\mu \phi^0 \partial_\mu \phi^0 - \\
 & \beta_h \left(\frac{2M^2}{g^2} + \frac{2M}{g} H + \frac{1}{2}(H^2 + \phi^0 \phi^0 + 2\phi^+ \phi^-) \right) + \frac{2M^4}{g^2} \alpha_h - \\
 & g\alpha_h M (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} (Z_\mu^0 (H \partial_\mu \phi^0 - \phi^0 \partial_\mu H) + \\
 & M (\frac{1}{c_w} Z_\mu^0 \partial_\mu \phi^0 + W_\mu^+ \partial_\mu \phi^- + W_\mu^- \partial_\mu \phi^+)) - ig \frac{s_w^2}{c_w} 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}{4}g^2 W_\mu^+ W_\mu^- (H^2 + (\phi^0)^2 + 2\phi^+ \phi^-) - \frac{1}{8}g^2 \frac{1}{c_w} 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{s_w^2}{c_w} Z_\mu^0 \phi^0 (W_\mu^+ \phi^- + W_\mu^- \phi^+) - \frac{1}{2}ig^2 \frac{s_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{s_w}{c_w} (2c_w^2 - 1) Z_\mu^0 A_\mu \phi^+ \phi^- - \\
 & g^2 s_w^2 A_\mu A_\mu \phi^+ \phi^- + \frac{1}{2}ig s_w \lambda_{ij}^a (\bar{q}_i^\sigma \gamma^\mu q_j^\sigma) g_\mu^a - \bar{e}^\lambda (\gamma^\mu + m_e^\lambda) e^\lambda - \bar{\nu}^\lambda (\gamma^\mu + m_\nu^\lambda) \nu^\lambda - \bar{u}_j^\lambda (\gamma^\mu + \\
 & m_u^\lambda) u_j^\lambda - \bar{d}_j^\lambda (\gamma^\mu + m_d^\lambda) d_j^\lambda + ig s_w A_\mu (-\bar{e}^\lambda \gamma^\mu e^\lambda) + \frac{2}{3}(\bar{u}_j^\lambda \gamma^\mu u_j^\lambda) - \frac{1}{3}(\bar{d}_j^\lambda \gamma^\mu d_j^\lambda) + \\
 & \frac{ig}{4c_w} Z_\mu^0 \{ (\bar{\nu}^\lambda \gamma^\mu (1 + \gamma^5) \nu^\lambda) + (\bar{e}^\lambda \gamma^\mu (4s_w^2 - 1 - \gamma^5) e^\lambda) + (\bar{d}_j^\lambda \gamma^\mu (\frac{4}{3}s_w^2 - 1 - \gamma^5) d_j^\lambda) + \\
 & (\bar{u}_j^\lambda \gamma^\mu (1 - \frac{8}{3}s_w^2 + \gamma^5) u_j^\lambda) \} + \frac{ig}{2\sqrt{2}} W_\mu^+ ((\bar{\nu}^\lambda \gamma^\mu (1 + \gamma^5) U^{lep}{}_{\lambda\kappa} e^\kappa) + (\bar{u}_j^\lambda \gamma^\mu (1 + \gamma^5) C_{\lambda\kappa} d_j^\kappa)) + \\
 & \frac{ig}{2\sqrt{2}} W_\mu^- ((\bar{e}^\kappa U^{lep}{}_{\kappa\lambda} \gamma^\mu (1 + \gamma^5) \nu^\lambda) + (\bar{d}_j^\kappa C_{\kappa\lambda}^\dagger \gamma^\mu (1 + \gamma^5) u_j^\lambda)) + \\
 & \frac{ig}{2M\sqrt{2}} \phi^+ (-m_e^\kappa (\bar{\nu}^\lambda U^{lep}{}_{\lambda\kappa} (1 - \gamma^5) e^\kappa) + m_\nu^\lambda (\bar{\nu}^\lambda U^{lep}{}_{\lambda\kappa} (1 + \gamma^5) e^\kappa) + \\
 & \frac{ig}{2M\sqrt{2}} \phi^- (m_e^\lambda (\bar{e}^\lambda U^{lep}{}_{\lambda\kappa} (1 + \gamma^5) \nu^\kappa) - m_\nu^\kappa (\bar{e}^\lambda U^{lep}{}_{\lambda\kappa} (1 - \gamma^5) \nu^\kappa) - \frac{g}{2} \frac{m_\nu^\lambda}{M} H (\bar{\nu}^\lambda \nu^\lambda) - \\
 & \frac{g}{2} \frac{m_e^\lambda}{M} H (\bar{e}^\lambda e^\lambda) + \frac{ig}{2} \frac{m_\nu^\lambda}{M} \phi^0 (\bar{\nu}^\lambda \gamma^5 \nu^\lambda) - \frac{ig}{2} \frac{m_e^\lambda}{M} \phi^0 (\bar{e}^\lambda \gamma^5 e^\lambda) - \frac{1}{4} \bar{\nu}_\lambda M_{\lambda\kappa}^R (1 - \gamma_5) \hat{\nu}_\kappa - \\
 & \frac{1}{4} \bar{\nu}_\lambda M_{\lambda\kappa}^R (1 - \gamma_5) \hat{\nu}_\kappa + \frac{ig}{2M\sqrt{2}} \phi^+ (-m_d^\kappa (\bar{u}_j^\lambda C_{\lambda\kappa} (1 - \gamma^5) d_j^\kappa) + m_u^\lambda (\bar{u}_j^\lambda C_{\lambda\kappa} (1 + \gamma^5) d_j^\kappa) + \\
 & \frac{ig}{2M\sqrt{2}} \phi^- (m_d^\lambda (\bar{d}_j^\lambda C_{\lambda\kappa}^\dagger (1 + \gamma^5) u_j^\kappa) - m_u^\kappa (\bar{d}_j^\lambda C_{\lambda\kappa}^\dagger (1 - \gamma^5) u_j^\kappa) - \frac{g}{2} \frac{m_u^\lambda}{M} H (\bar{u}_j^\lambda u_j^\lambda) - \\
 & \frac{g}{2} \frac{m_d^\lambda}{M} H (\bar{d}_j^\lambda d_j^\lambda) + \frac{ig}{2} \frac{m_u^\lambda}{M} \phi^0 (\bar{u}_j^\lambda \gamma^5 u_j^\lambda) - \frac{ig}{2} \frac{m_d^\lambda}{M} \phi^0 (\bar{d}_j^\lambda \gamma^5 d_j^\lambda) + \bar{G}^a \partial^2 G^a + g_s f^{abc} \partial_\mu \bar{G}^a G^b g_\mu^c + \\
 & \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 + igc_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) + igc_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^+) + igc_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^2} \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}$$

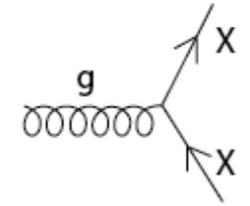
Standard Model Interactions (Forces Mediated by Gauge Bosons)



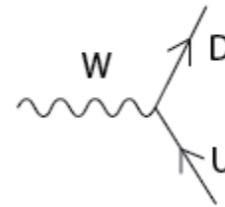
X is any fermion in the Standard Model.



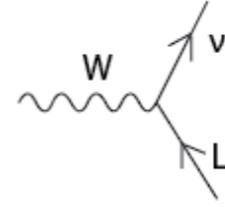
X is electrically charged.



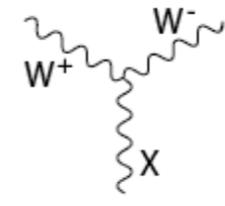
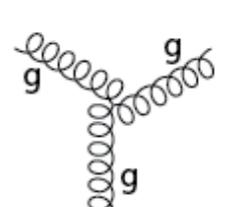
X is any quark.



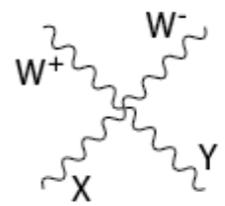
U is a up-type quark; D is a down-type quark.



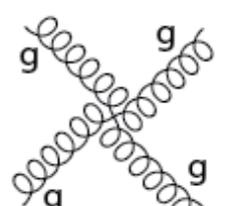
L is a lepton and ν is the corresponding neutrino.



X is a photon or Z-boson.



X and Y are any two electroweak bosons such that charge is conserved.



Ma che cosa è il Modello Standard?

- una teoria di gauge non abeliana basata sulla Teoria Quantistica dei Campi
- la teoria che descrive le interazioni forte, elettromagnetica e debole con tutte le particelle elementari
- ha predetto l'esistenza dei bosoni W e Z, del gluone, dei quark charm e top e del bosone di Higgs prima della loro scoperta

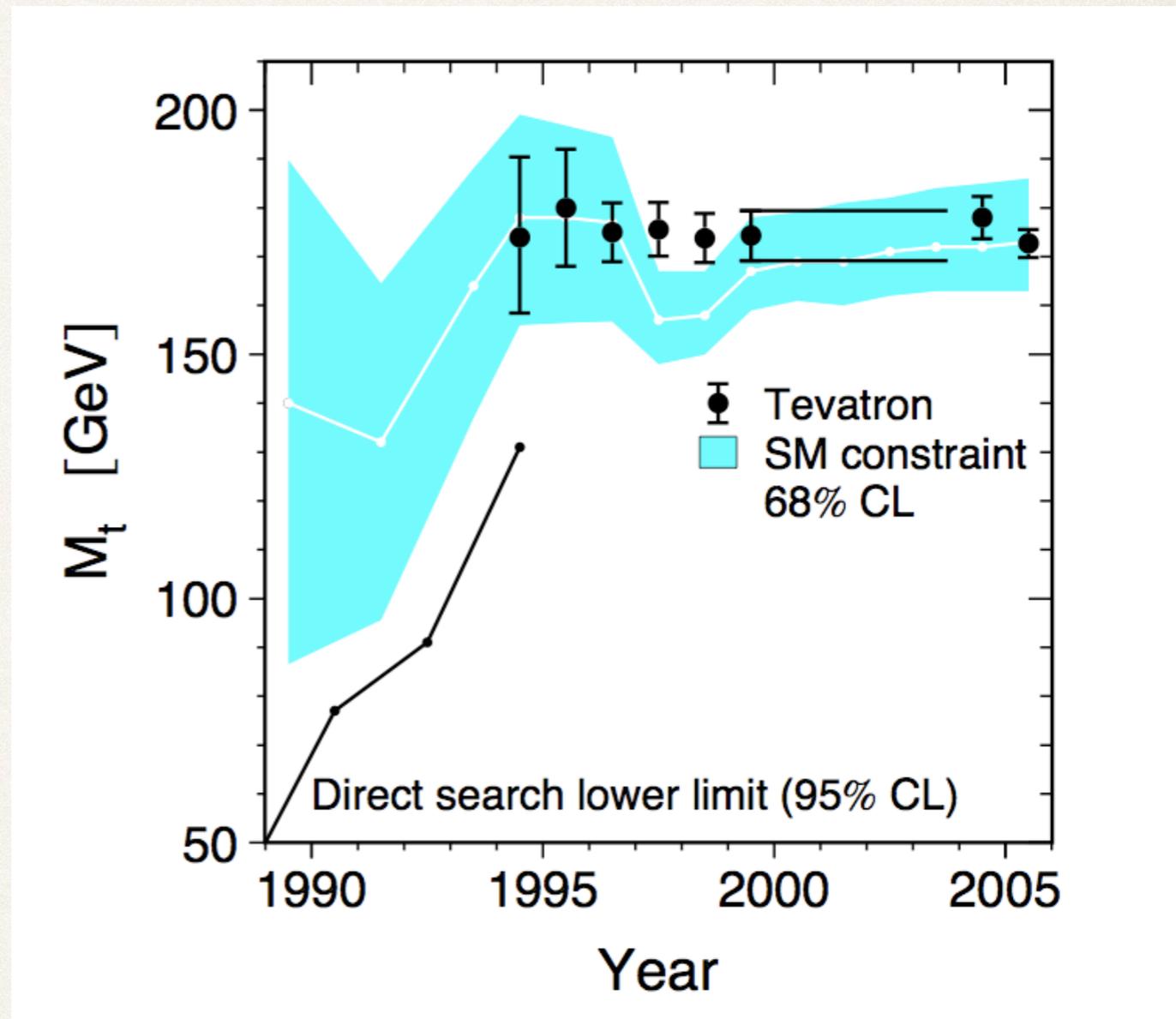
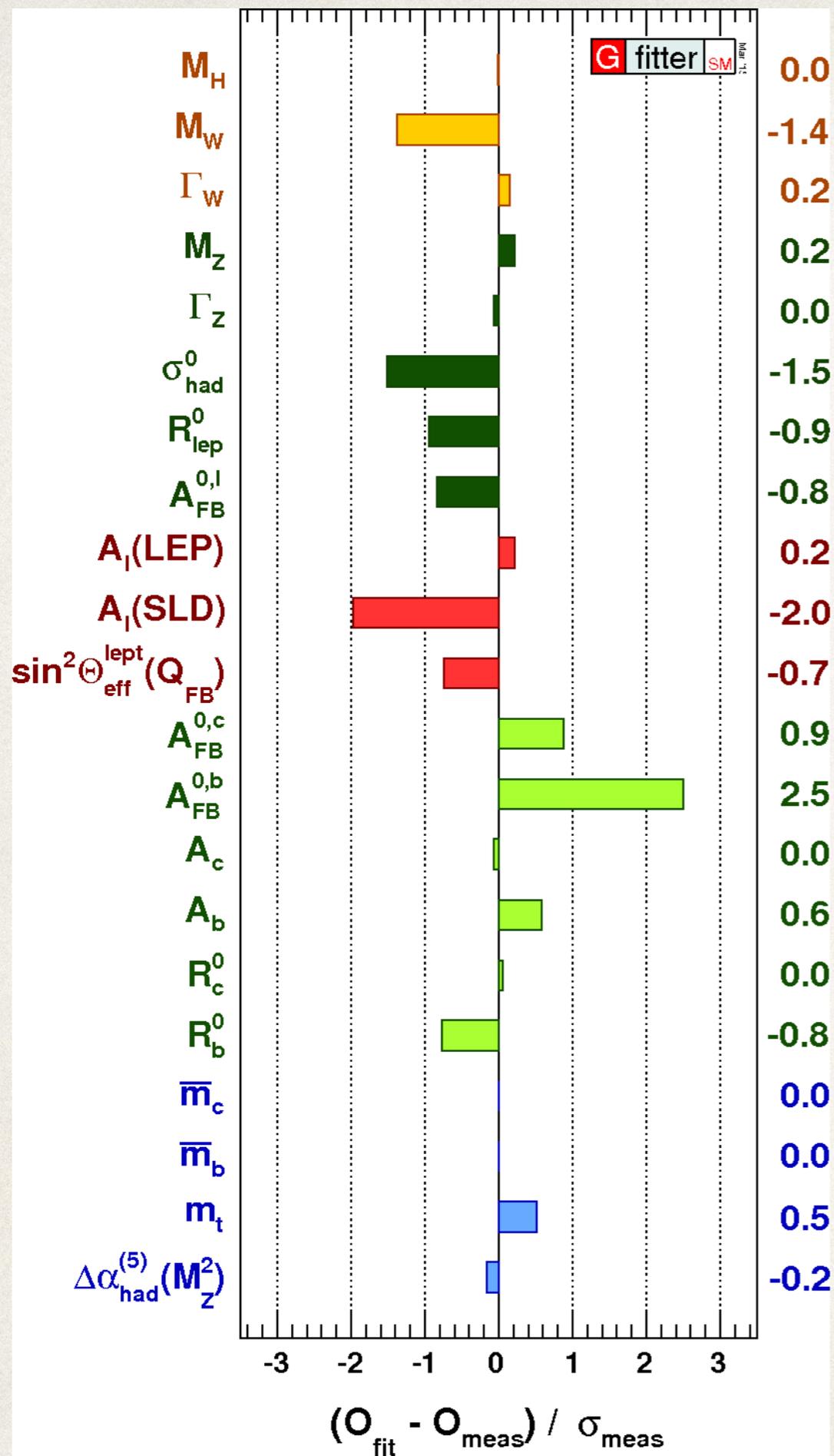
$$\mathcal{L}_{SM} = -\frac{1}{2}\partial_\nu g_\mu^a \partial^\nu g^{\mu a} - \frac{1}{2}M^2 W_\mu^+ W_\mu^- - \frac{1}{2}W_\nu^+ W_\nu^- - 2ig s_w (\partial_\nu A_\mu (W_\mu^+ W_\nu^- - W_\nu^+ W_\mu^-) - \frac{1}{2}W_\nu^- \partial_\nu W_\mu^+) - \frac{1}{2}Z_\mu^0 Z_\mu^0 (W_\nu^+ W_\nu^-) + W_\nu^+ W_\nu^- - 2A_\mu Z_\mu \beta_h \left(\frac{1}{8}g^2 \alpha_h (H^4 + \frac{1}{2}ig (W_\mu^+ (H\partial_\mu \phi^- - M(\frac{1}{c_w}Z_\mu^0 \partial_\mu \phi^0 + W_\mu^+ W_\mu^- \phi^+) - ig^2 W_\mu^+ W_\mu^- (H^2 + \frac{1}{2}g^2 \frac{s_w^2}{c_w} Z_\mu^0 \phi^0 (W_\mu^+ W_\mu^- \phi^+) + \frac{1}{2}g^2 s_w^2 A_\mu A_\mu \phi^+ \phi^- + m_u^\lambda u_j^\lambda - d_j^\lambda (\gamma^\mu (\bar{u}_j^\lambda \gamma^\mu (1 - \frac{8}{3}s_w^2 + \gamma^5) \frac{ig}{2\sqrt{2}} W_\mu^+ \phi^+ + \frac{ig}{2M\sqrt{2}} \phi^+ - \frac{ig}{2M\sqrt{2}} \phi^- (m_e^\lambda (\bar{e}^\lambda e^\lambda) - \frac{g}{2} \frac{m_\lambda^2}{M} H(\bar{e}^\lambda e^\lambda) + \frac{1}{4} \bar{\nu}_\lambda M_{\lambda\kappa}^R (1 - \gamma_5) \nu_\kappa + \frac{1}{2M\sqrt{2}} \phi^- (-m_d (a_j C_{\lambda\kappa} (1 - \gamma^5) a_j) + m_u (a_j C_{\lambda\kappa} (1 + \gamma^5) a_j) + \frac{ig}{2M\sqrt{2}} \phi^- (m_d^\lambda (\bar{d}_j^\lambda C_{\lambda\kappa}^\dagger (1 + \gamma^5) u_j^\kappa) - m_u^\kappa (\bar{d}_j^\lambda C_{\lambda\kappa}^\dagger (1 - \gamma^5) u_j^\kappa) - \frac{g}{2} \frac{m_\lambda^2}{M} H(\bar{u}_j^\lambda u_j^\lambda) - \frac{g}{2} \frac{m_\lambda^2}{M} H(\bar{d}_j^\lambda d_j^\lambda) + \frac{ig}{2} \frac{m_\lambda^2}{M} \phi^0 (\bar{u}_j^\lambda \gamma^5 u_j^\lambda) - \frac{ig}{2} \frac{m_\lambda^2}{M} \phi^0 (\bar{d}_j^\lambda \gamma^5 d_j^\lambda) + \bar{G}^a \partial^2 G^a + g_s f^{abc} \partial_\mu \bar{G}^a G^b g_\mu^c + \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) .$$



X is any quark.

X is a photon or Z-boson. X and Y are any two electroweak bosons such that charge is conserved.

	massa predetta	massa misurata
bosone W	80.385 +/- 0.015 GeV	80.387 +/- 0.019 GeV
bosone Z	91.1874 +/- 0.0020 GeV	91.1876 +/- 0.0021 GeV



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- Anche se...**
- contiene 19 parametri liberi
 - non spiega l'asimmetria tra materia e antimateria
 - non spiega il valore 'non naturale' della massa di Higgs
 - non comprende l'interazione gravitazionale né sorgenti di materia oscura
 - non provvede a dare una massa ai neutrini

$$\mathcal{L}_{SM} = -\frac{1}{2}\partial_\nu g_\mu^\alpha M^2 W_\mu^+ W_\mu^- - \frac{1}{2} W_\nu^+ W_\nu^- - 2igs_w(\partial_\nu A_\mu(W_\mu^+ W_\mu^- - W_\nu^- \partial_\nu W_\mu^+)) - \frac{1}{2} Z_\mu^0 Z_\mu^0 W_\nu^+ W_\nu^- + W_\nu^+ W_\nu^- - 2A_\mu Z_\mu \beta_h \left(\frac{1}{8}g^2\alpha_h(H^4 + \frac{1}{2}ig(W_\mu^+(H\partial_\mu\phi^- - M(\frac{1}{c_w}Z_\mu^0\partial_\mu\phi^0 + W_\mu^+ W_\mu^-\phi^+)) - ig^2\frac{1}{4}g^2W_\mu^+W_\mu^-(H^2 + \frac{1}{2}g^2\frac{s_w^2}{c_w}Z_\mu^0\phi^0(W_\mu^+\phi^- W_\mu^-\phi^+)) + \frac{1}{2}g^2s_w^2A_\mu A_\mu\phi^+\phi^- + m_u^\lambda u_j^\lambda - d_j^\lambda(\gamma_5(\bar{u}_j^\lambda\gamma^\mu(1 - \frac{8}{3}s_w^2 + \gamma_5^{\frac{ig}{2\sqrt{2}}W_\mu^+} \frac{ig}{2M\sqrt{2}}\phi^+ \frac{ig}{2M\sqrt{2}}\phi^- (m_e^\lambda(\bar{e}^\lambda e^\lambda) \frac{g}{2}M^\lambda H(\bar{e}^\lambda e^\lambda) \frac{1}{4}\bar{\nu}_\lambda M_{\lambda\kappa}^R(1 - \gamma_5) \frac{ig}{2M\sqrt{2}}\phi^- (m_d^\lambda(\bar{d}_j^\lambda d_j^\lambda) + \frac{ig}{2} \bar{X}^+(\partial^2 - M^2)X^+ + \partial_\mu \bar{X}^+ X \partial_\mu \bar{X}^0 X \partial_\mu X^- X^-) - \frac{1}{2}gM(\frac{1}{2c_w}igM($$



Come testare il Modello Standard?

Relatività speciale e relazione di Einstein $E = c^2 \sqrt{m^2 + p^2/c^2}$

Dualismo onda-corpusco e relazione di De Broglie $\lambda = \frac{h}{p} = \frac{hc}{E}$

La luce visibile non è abbastanza !

$$400 \text{ nm} < \lambda < 700 \text{ nm}$$

$$\Delta d_{min} = 4 \cdot 10^{-7} \text{ m} \Rightarrow E \sim \mathcal{O}(eV); 1 \text{ eV} = 1.6 \cdot 10^{-19} \text{ J}$$

eV

keV

MeV

GeV

TeV

PeV

**Fisica
atomica**

**Fisica
nucleare**

**Fisica
particellare**

**Raggi cosmici di
maggiore energia**

Ada | 1960 | Laboratori INFN di Frascati



**Primo collider di elettroni e positroni con
energia nel centro di massa di 250 MeV**



SUISSE
FRANCE

CMS

LHCb

CERN Prévessin

ATLAS

CERN Meyrin

SPS 7 km

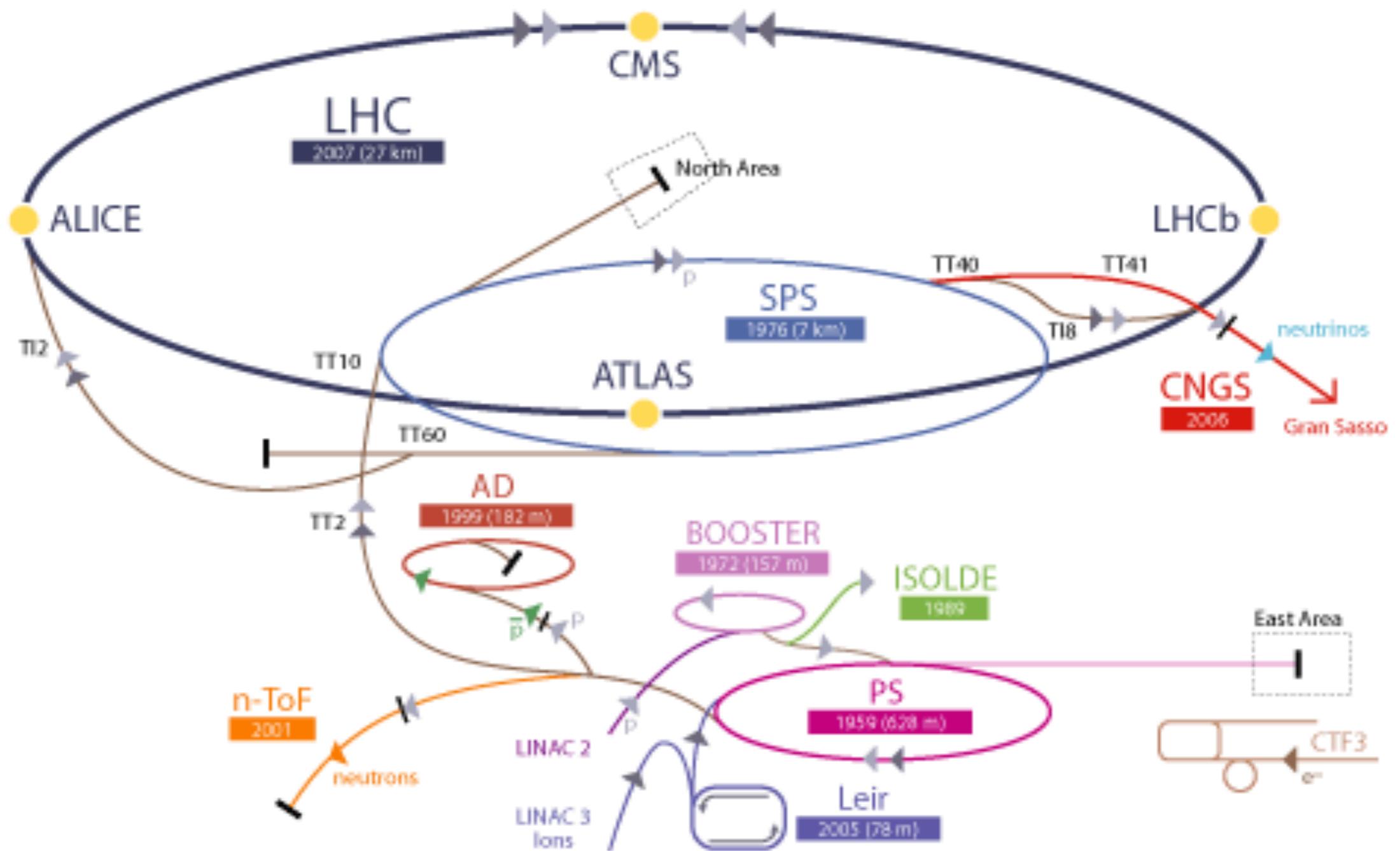
ALICE

LHC 27 km

“...abbiamo rivolto la nostra attenzione alla creazione di questo nuovo ente internazionale, un laboratorio o un istituto dove sia possibile effettuare ricerca scientifica al di là del quadro nazionale dei vari stati membri ... un ente dotato di risorse maggiori di quelle disponibili ai laboratori nazionali che possa quindi farsi carico di compiti le cui dimensioni e la cui natura siano tali che i singoli Stati non possano svolgerli da soli.”

Louis De Broglie - 1949

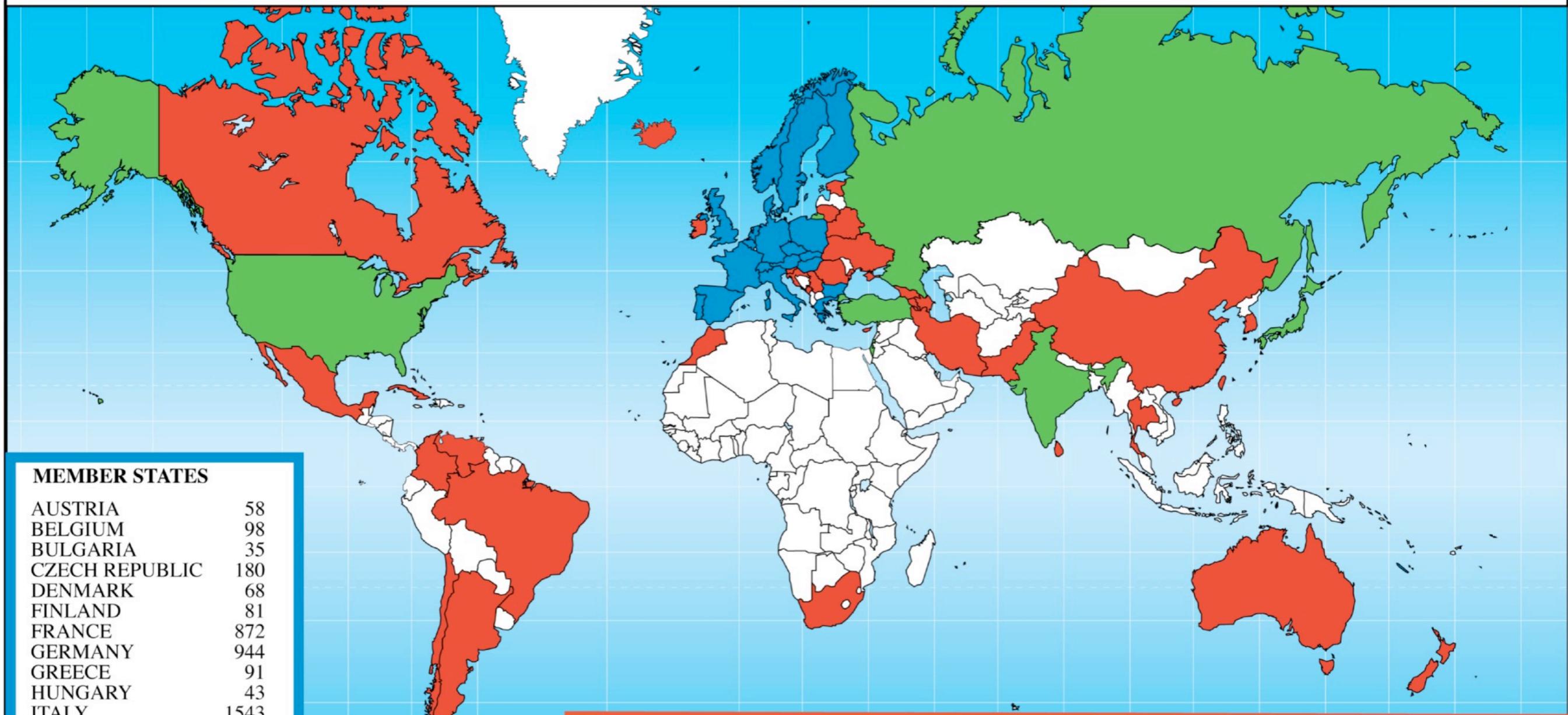
CERN Accelerator Complex



▶ p (proton) ▶ ion ▶ neutrons ▶ \bar{p} (antiproton) ▶ neutrinos ▶ electron
 ⇄⇄⇄ proton/antiproton conversion

LHC Large Hadron Collider SPS Super Proton Synchrotron PS Proton Synchrotron
 AD Antiproton Decelerator CTF3 Clic Test Facility
 CNGS Cern Neutrinos to Gran Sasso ISOLDE Isotope Separator OnLine DEvice
 LEIR Low Energy Ion Ring LINAC LINEar ACcelerator n-ToF Neutrons Time Of Flight

Distribution of All CERN Users by Nation of Institute on 5 February 2008



MEMBER STATES

AUSTRIA	58
BELGIUM	98
BULGARIA	35
CZECH REPUBLIC	180
DENMARK	68
FINLAND	81
FRANCE	872
GERMANY	944
GREECE	91
HUNGARY	43
ITALY	1543
NETHERLANDS	163
NORWAY	70
POLAND	175
PORTUGAL	109
SLOVAKIA	46
SPAIN	270
SWEDEN	74
SWITZERLAND	344
UNITED KINGDOM	645

OBSERVER STATES

INDIA	93
ISRAEL	64
JAPAN	182
RUSSIA	940
TURKEY	35
USA	1278

OTHER STATES

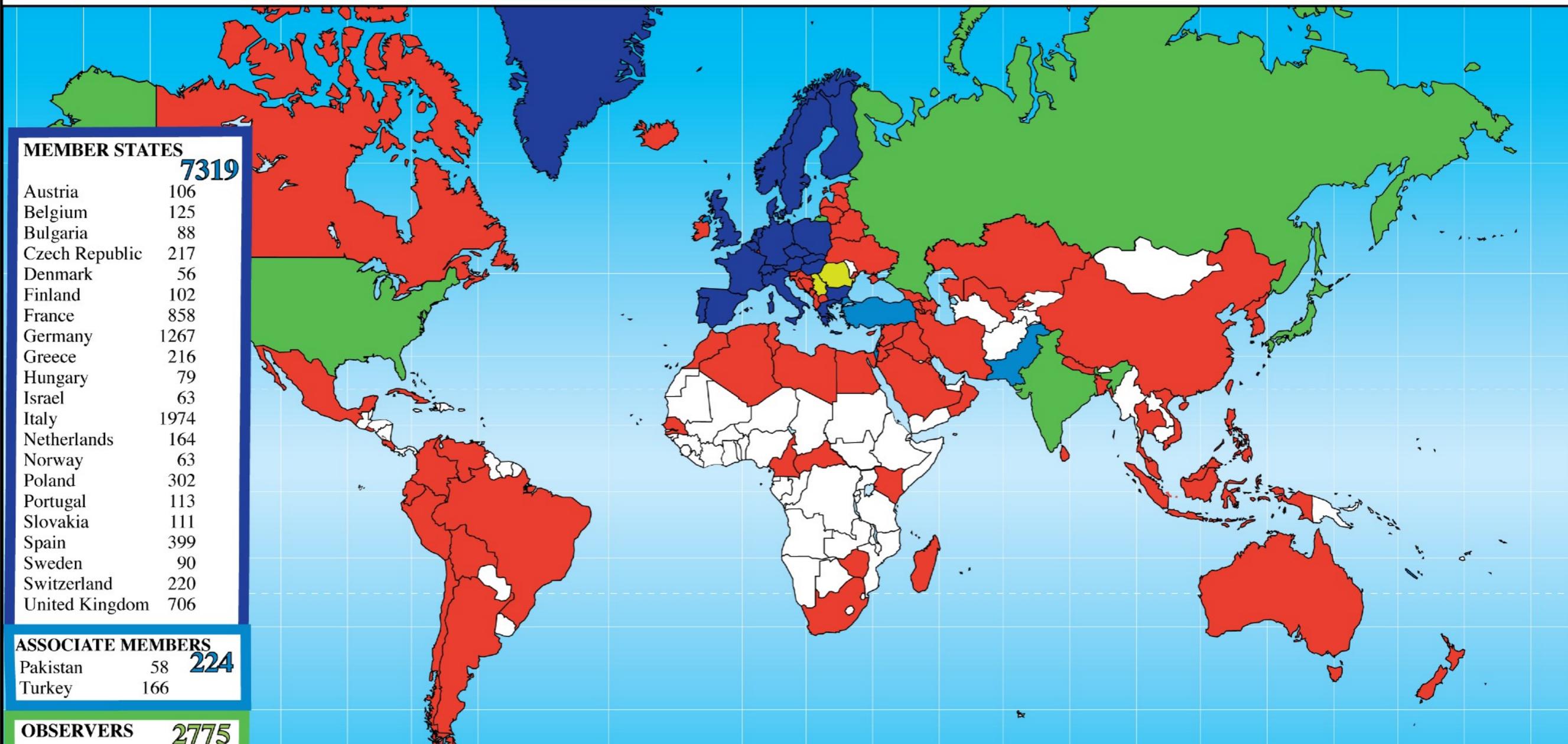
ARGENTINA	8	CROATIA	17	MEXICO	23	TAIWAN	40
ARMENIA	17	CUBA	3	MONTENEGRO	1	THAILAND	1
AUSTRALIA	13	CYPRUS	6	MOROCCO	6	UKRAINE	17
AZERBAIJAN	1	ESTONIA	10	NEW ZEALAND	7		
BELARUS	23	GEORGIA	9	PAKISTAN	23		
BRAZIL	68	ICELAND	1	ROMANIA	46		
CANADA	119	IRAN	6	SERBIA	16		
CHILE	4	IRELAND	14	SLOVENIA	16		
CHINA	60	KOREA	44	SOUTH AFRICA	2		
COLOMBIA	5	LITHUANIA	5	SRI LANKA	1		

5909

2592

632

Distribution of All CERN Users by Nationality on 12 January 2016



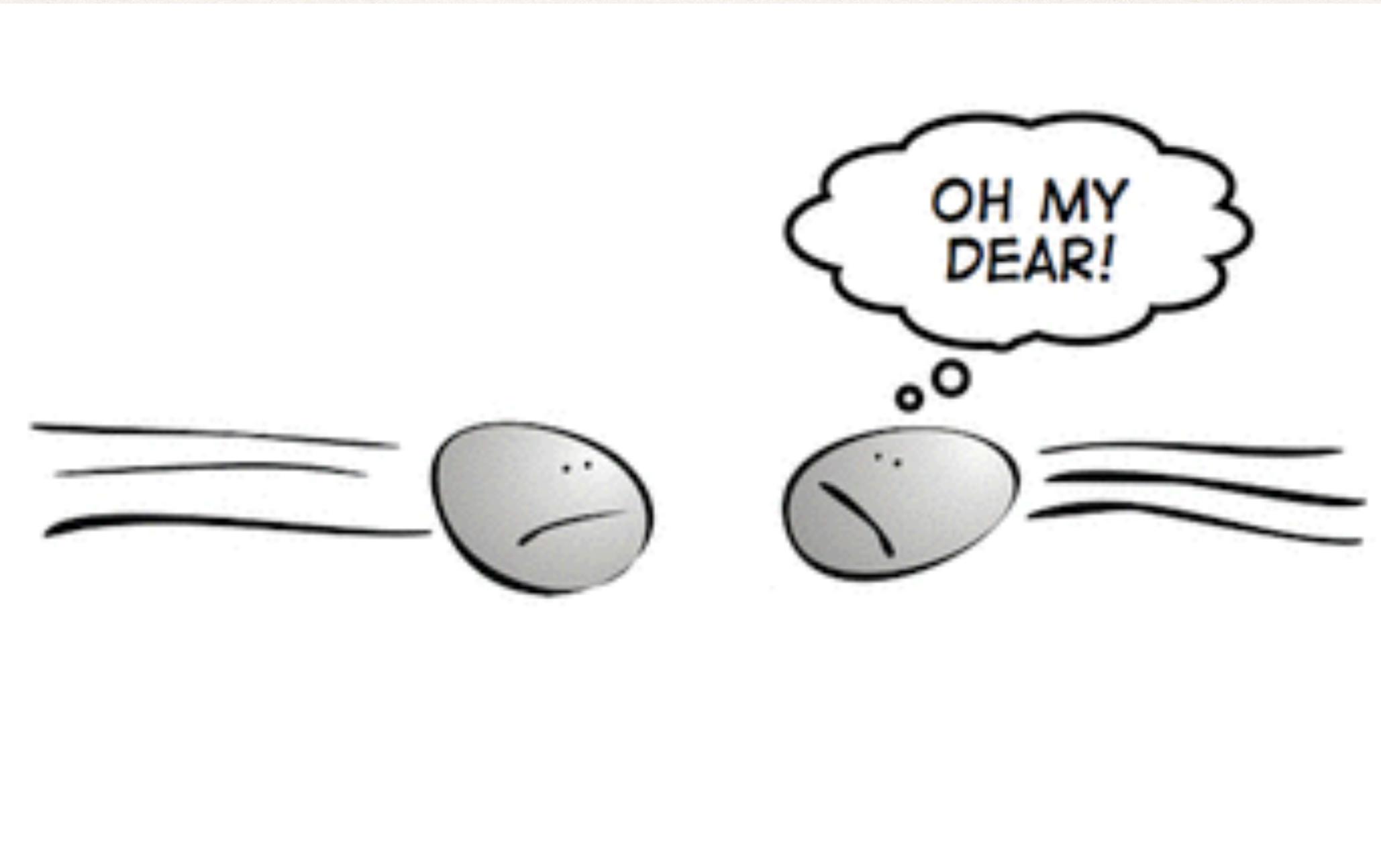
MEMBER STATES		7319
Austria	106	
Belgium	125	
Bulgaria	88	
Czech Republic	217	
Denmark	56	
Finland	102	
France	858	
Germany	1267	
Greece	216	
Hungary	79	
Israel	63	
Italy	1974	
Netherlands	164	
Norway	63	
Poland	302	
Portugal	113	
Slovakia	111	
Spain	399	
Sweden	90	
Switzerland	220	
United Kingdom	706	

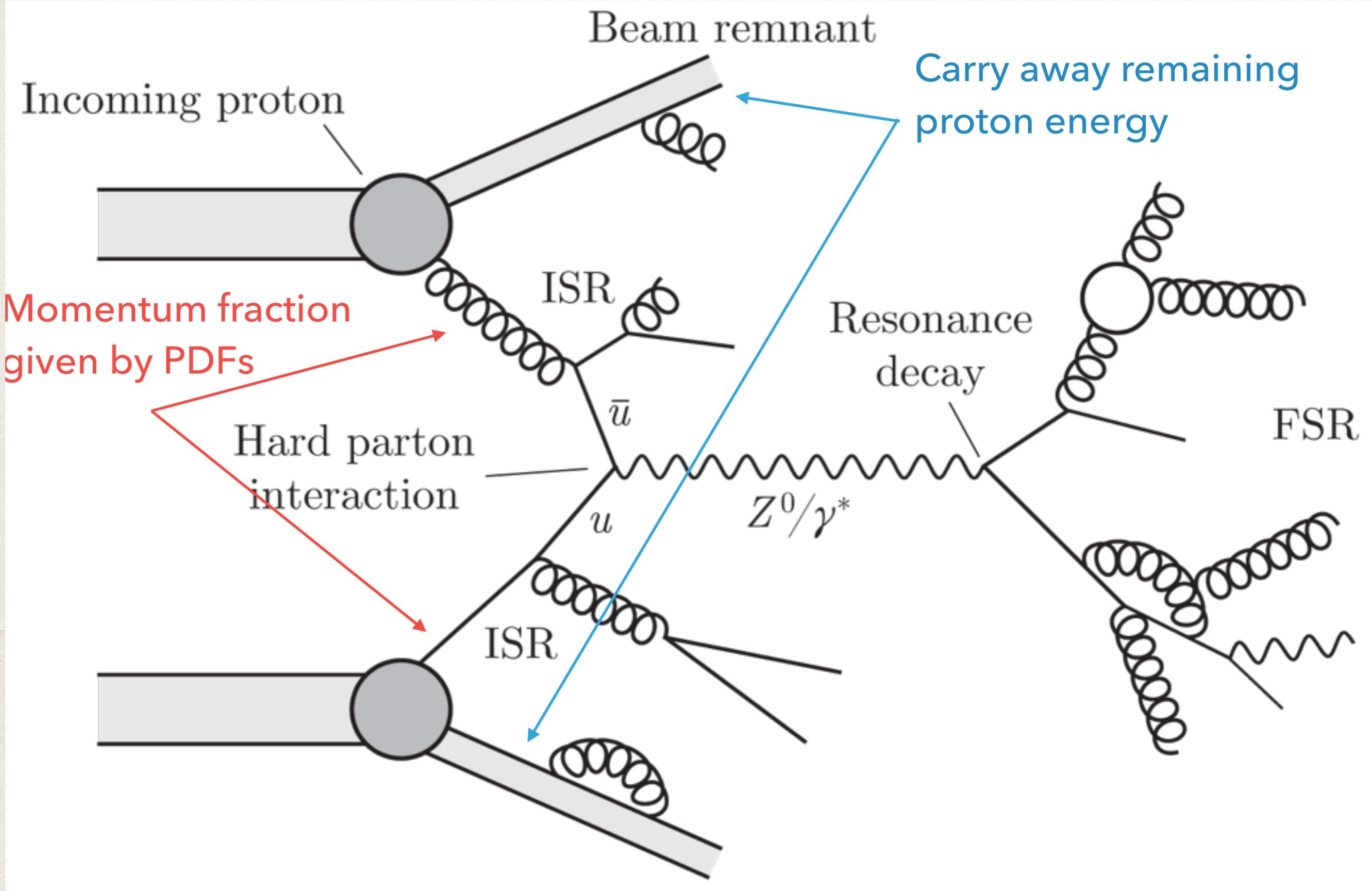
ASSOCIATE MEMBERS		224
Pakistan	58	
Turkey	166	

OBSERVERS		2775
India	284	
Japan	316	
Russia	1071	
USA	1104	

STATES IN ACCESSION TO MEMBERSHIP		195
Cyprus	19	
Romania	131	
Serbia	45	

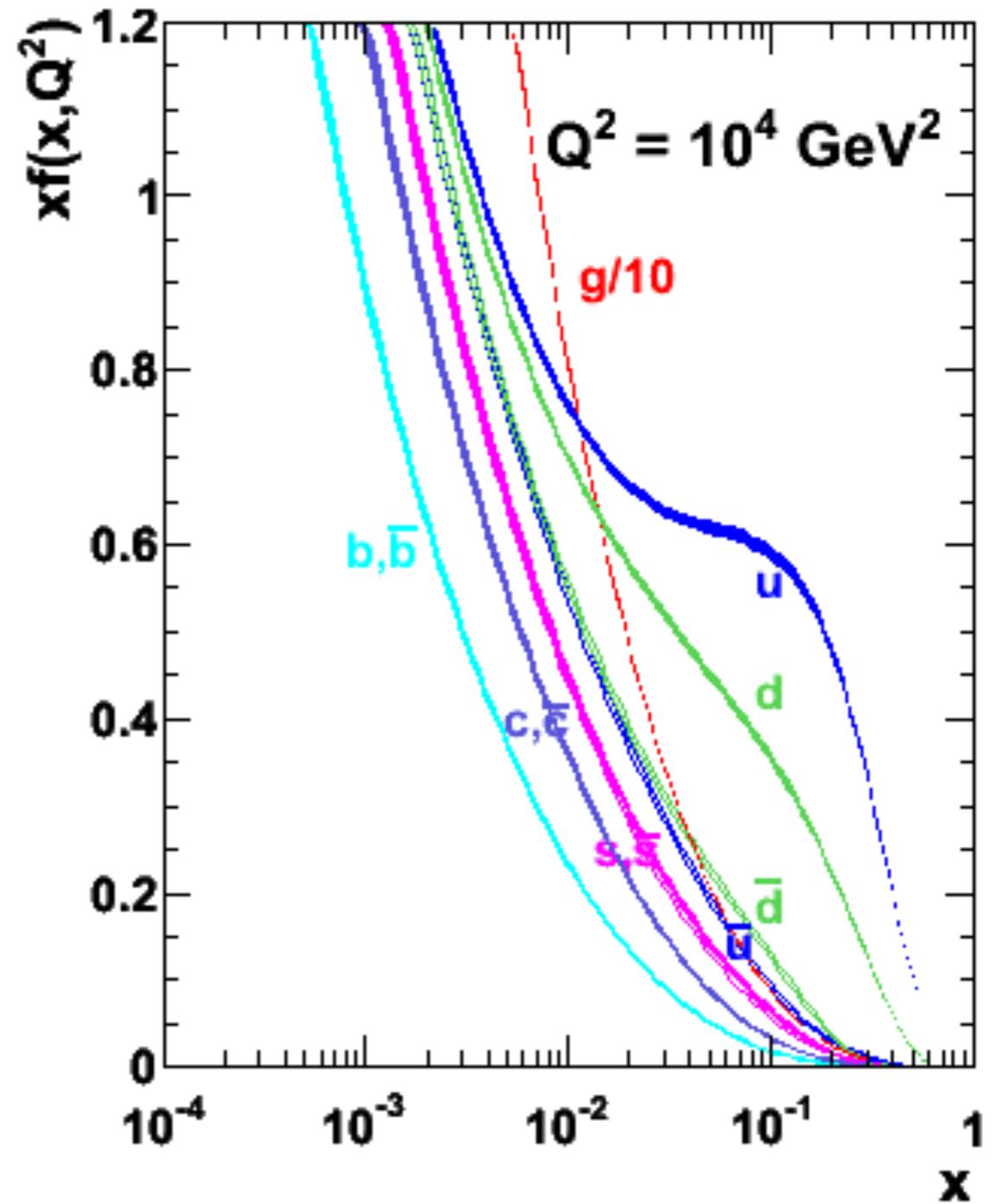
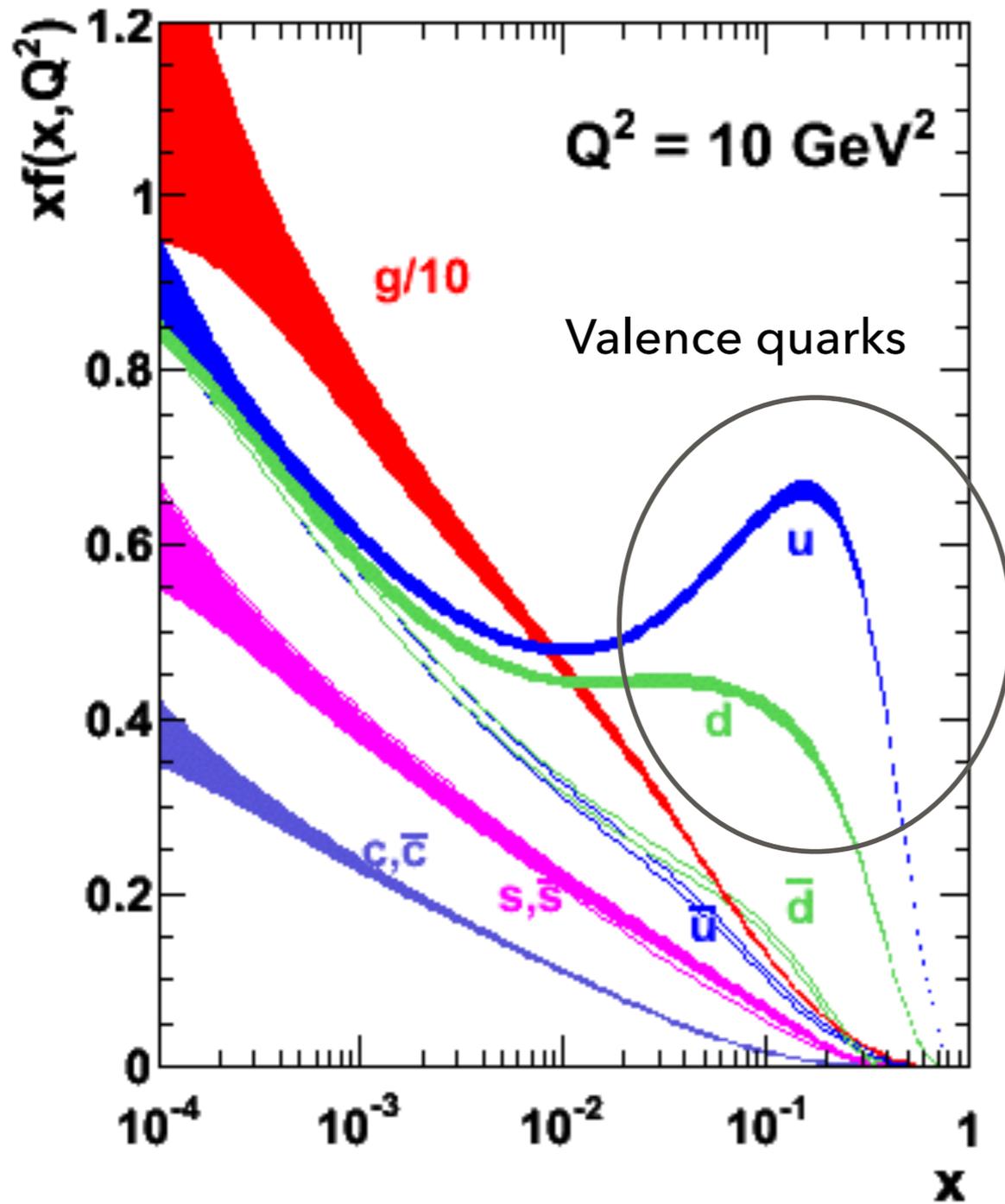
OTHERS										1803			
Albania	4	Bosnia & Herzegovina	1	Ecuador	4	Kazakhstan	1	Malta	5	Qatar	1	Thailand	20
Algeria	8	Brazil	135	Egypt	24	Kenya	2	Mauritius	1	San Marino	1	T.F.Y.R.O.M.	2
Argentina	24	Cameroon	2	El Salvador	1	Korea, D.P.R.	4	Mexico	84	Saudi Arabia	1	Tunisia	3
Armenia	27	Canada	154	Estonia	15	Korea Rep.	151	Montenegro	2	Senegal	1	Ukraine	88
Australia	31	Central African Rep.	1	Georgia	44	Latvia	1	Morocco	13	Singapore	3	Uzbekistan	5
Azerbaijan	11	Chile	20	Iceland	4	Lebanon	12	Nepal	7	Sint Maarten	1	Venezuela	11
Bangladesh	7	China	421	Indonesia	10	Libya	1	New Zealand	6	Slovenia	27	Viet Nam	8
Belarus	50	Colombia	38	Iran	54	Lithuania	30	Oman	1	South Africa	31	Zimbabwe	5
Bolivia	2	Costa Rica	1	Iraq	1	Luxembourg	2	Palestine (O.T.)	7	Sri Lanka	3		
		Croatia	38	Ireland	20	Madagascar	4	Peru	6	Syria	1		
		Cuba	13	Jordan	8	Malaysia	18	Philippines	4	Taiwan	56		





Funzioni di distribuzione dell'impulso tra i costituenti del protone

MSTW 2008 NLO PDFs (68% C.L.)



Dammi tre parole...

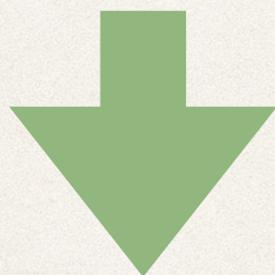
Il risultato di ogni singola collisione non è deterministico

1) Sezione d'urto | Misura della probabilità di occorrenza di un processo fisico



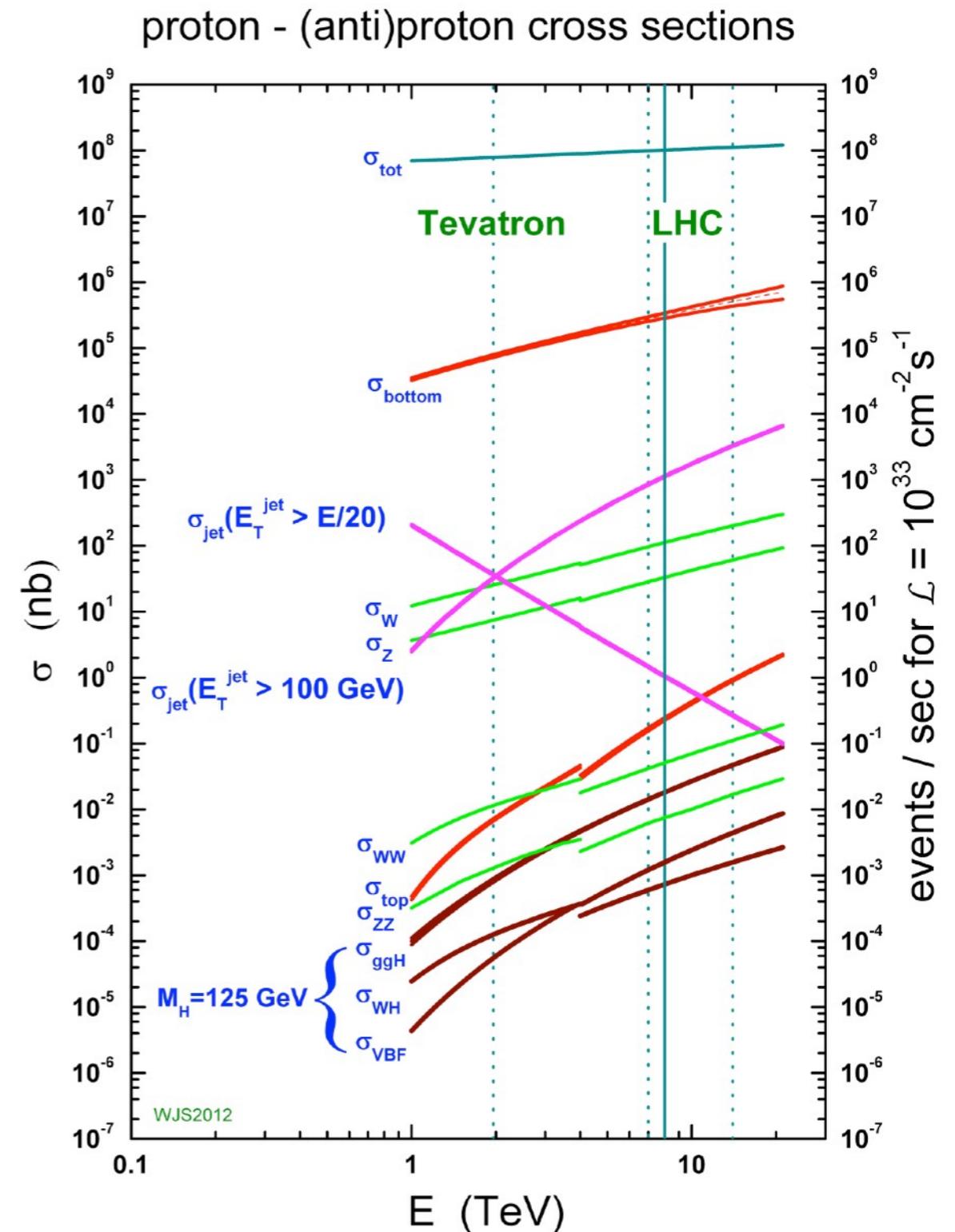
Collisioni interessanti sono rare

2) Luminosità | Rapporto tra il numero di collisioni in un arco temporale e la sezione d'urto

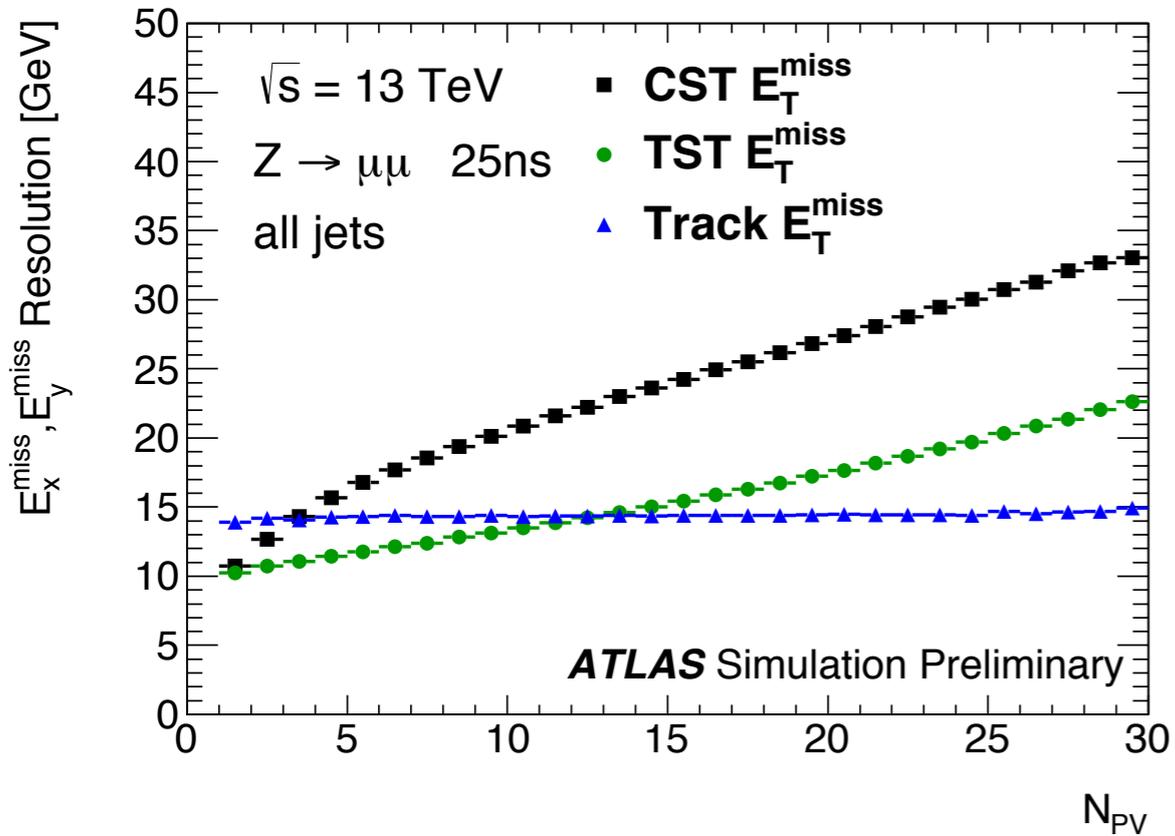
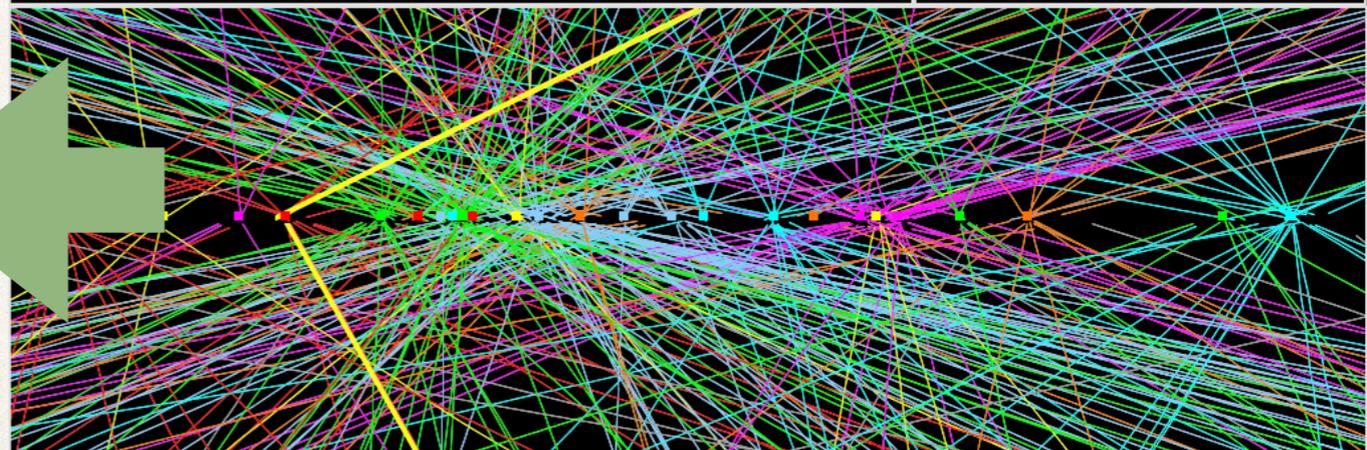
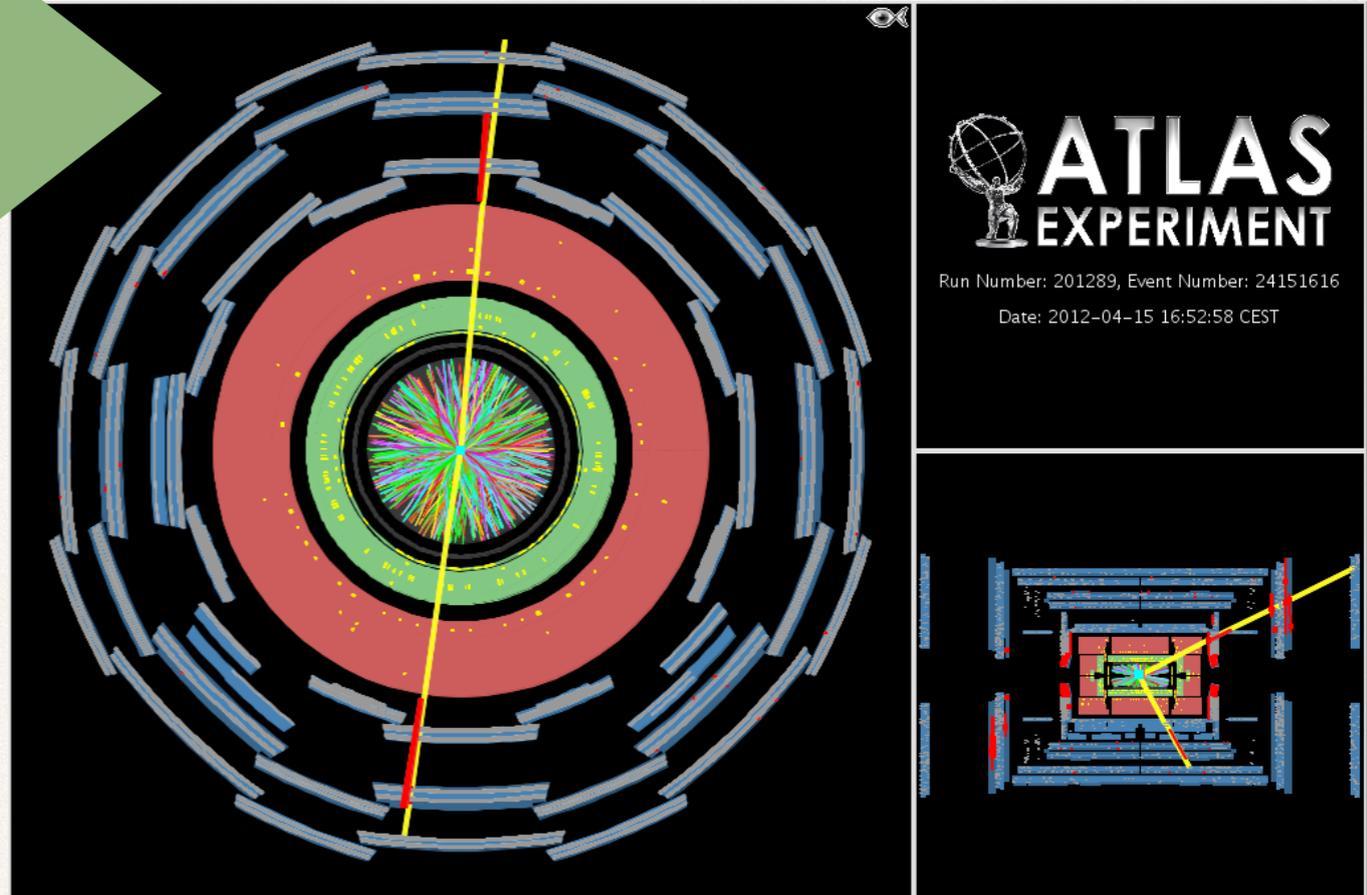
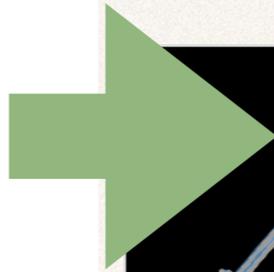
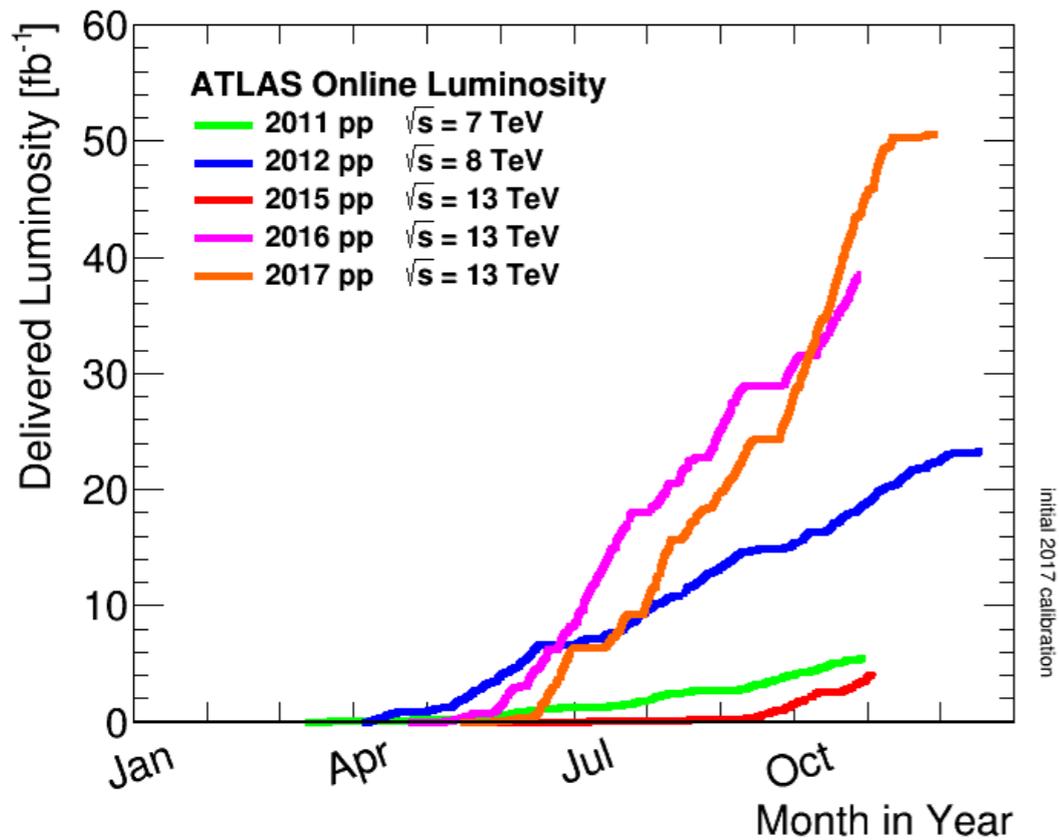


C'è un prezzo da pagare...

3) Pile-up | Sovrapposizione di più collisioni allo stesso incrocio di fasci



Pile-up



Misura della sezione d'urto ...

Number of observed events: counted

Background:
Measured from data /
calculated from theory

$$\sigma = \frac{N_{\text{obs}} - N_{\text{BG}}}{\int L dt \cdot \epsilon}$$

Cross section σ

Efficiency:
optimized by
experimentalist

Luminosity:
Determined by accelerator,
trigger prescale, ...

... e del suo errore

Number of observed events: counted

Background:
Measured from data /
calculated from theory

$$\sigma = \frac{N_{\text{obs}} - N_{\text{BG}}}{\int \mathcal{L} dt \cdot \epsilon}$$

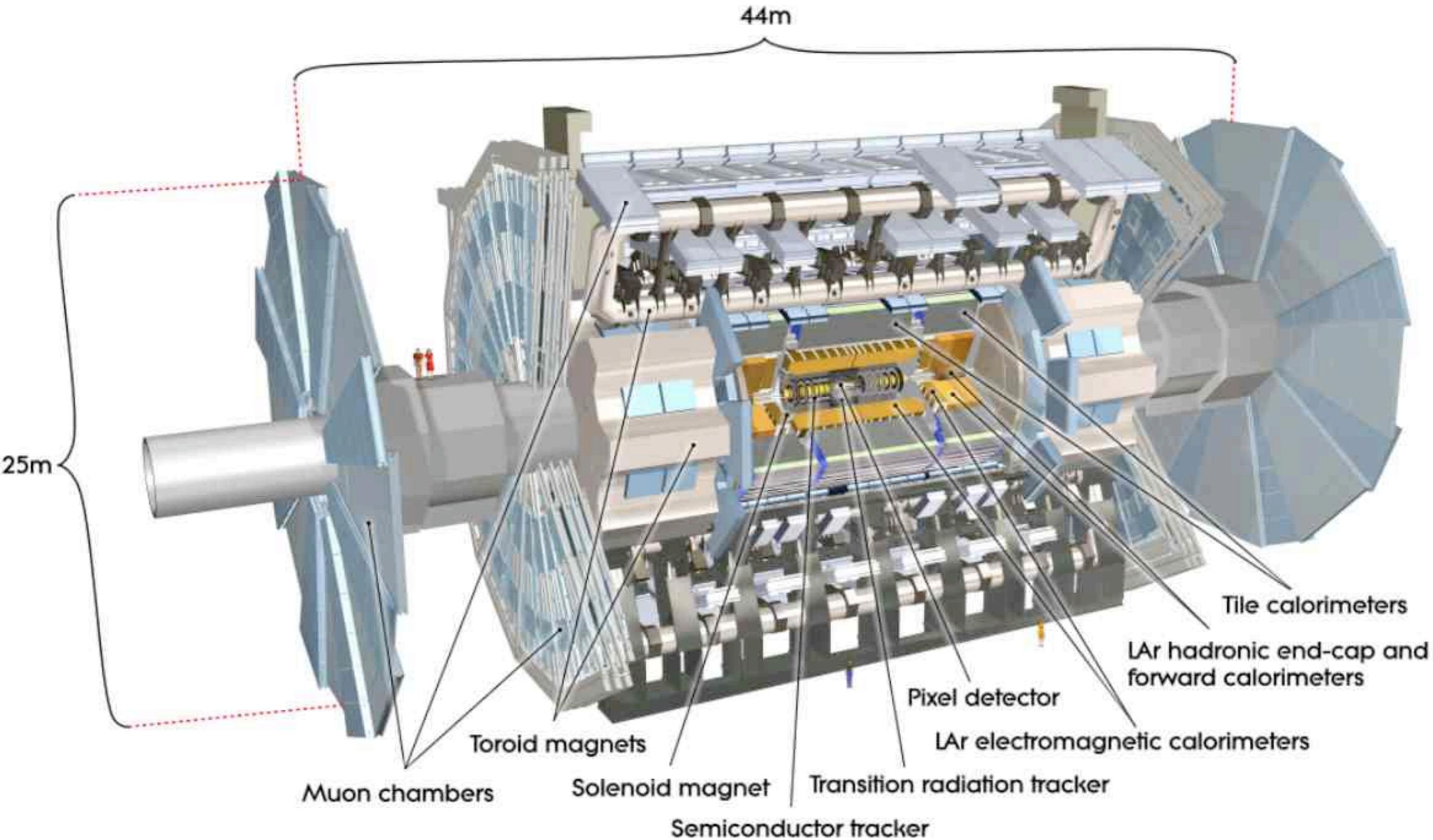
Cross section σ

Efficiency:
optimized by
experimentalist

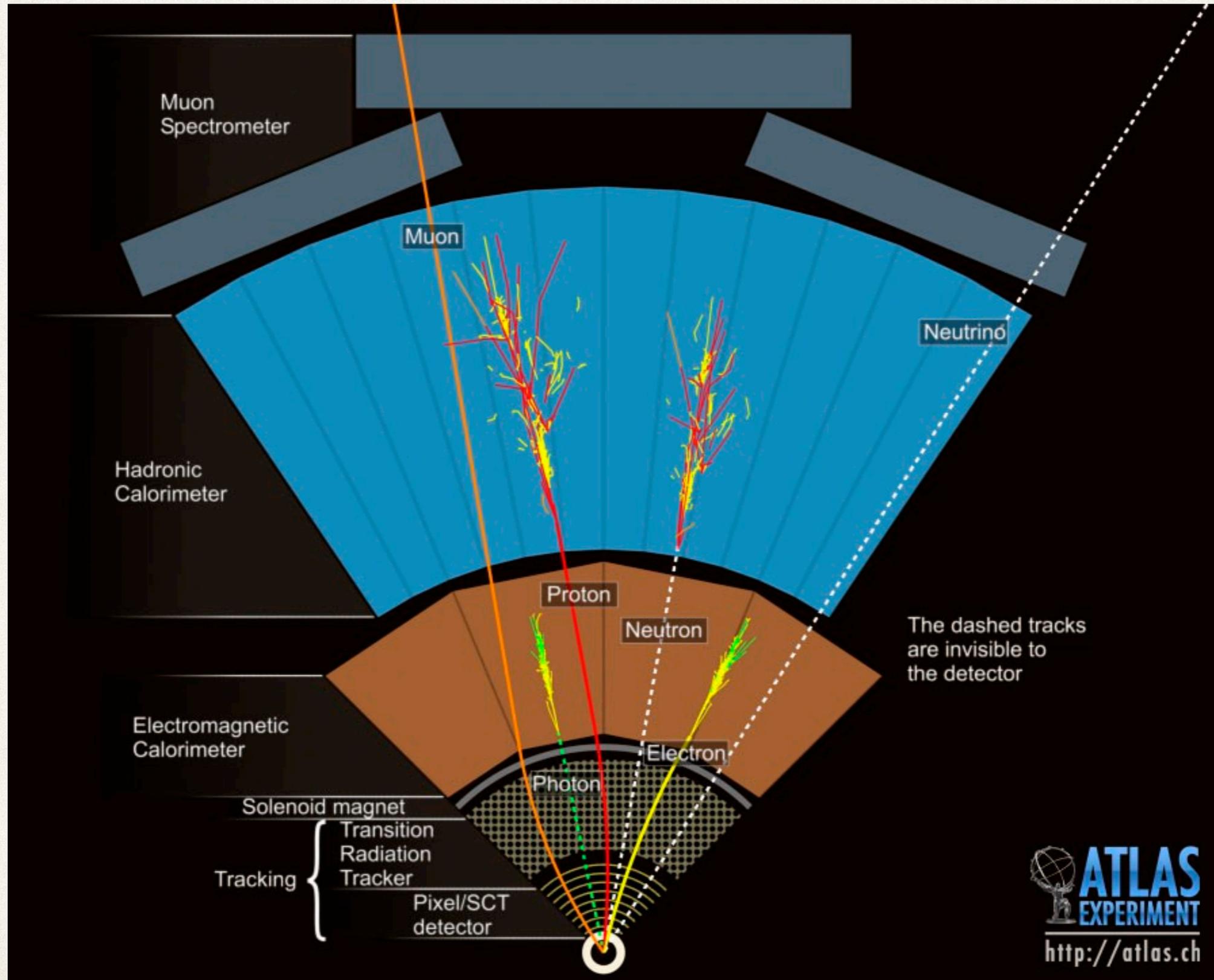
Luminosity:
Determined by accelerator,
trigger prescale, ...

$$\frac{\delta\sigma}{\sigma} = \sqrt{\frac{\delta N_{\text{obs}}^2 + \delta N_{\text{bg}}^2}{N_{\text{obs}} - N_{\text{bg}}} + \left(\frac{\delta\mathcal{L}}{\mathcal{L}}\right)^2 + \left(\frac{\delta\epsilon}{\epsilon}\right)^2}$$

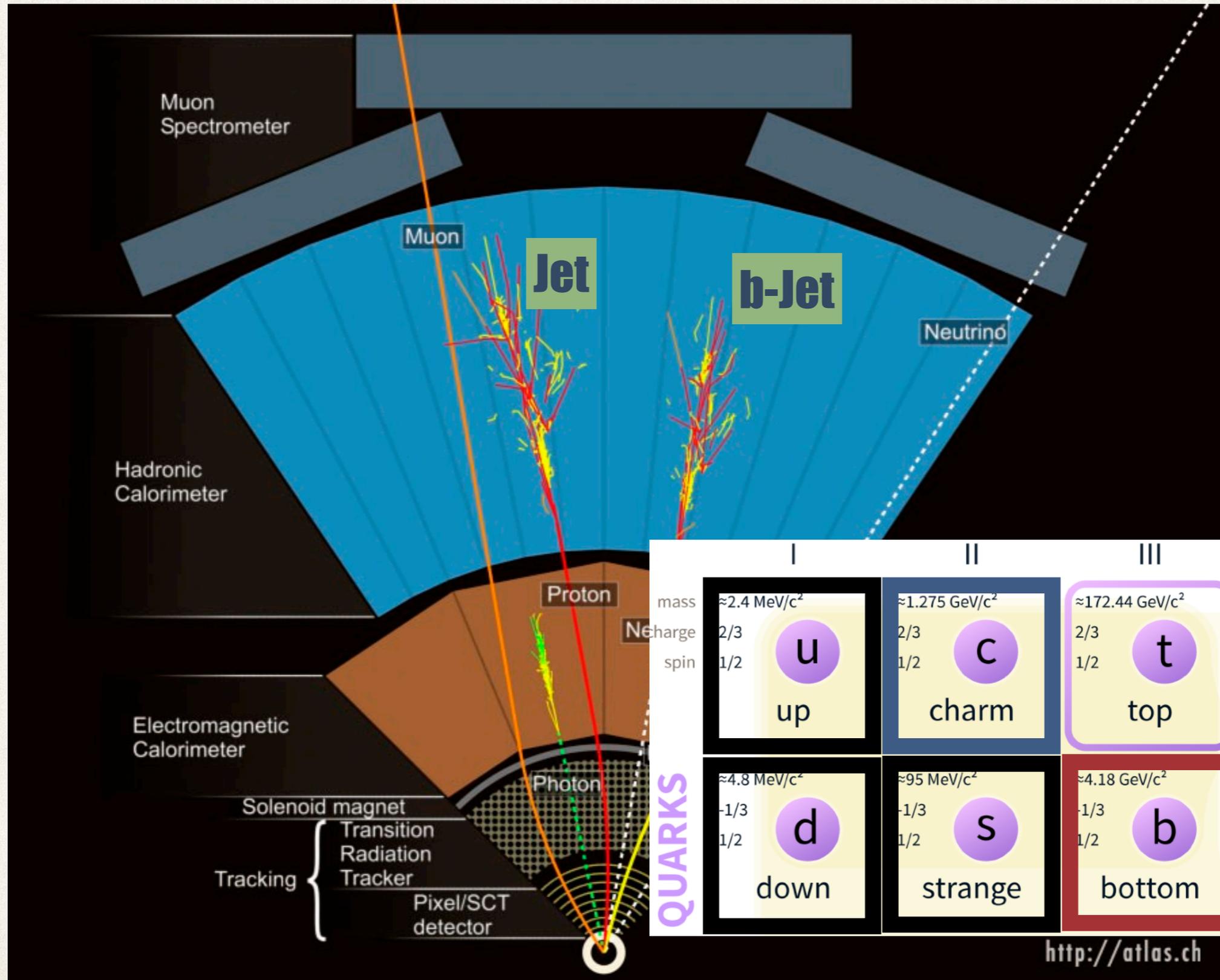
ATLAS



La firma di (poche) particelle



La firma di (poche) particelle



l-jets

c-jets

b-jets

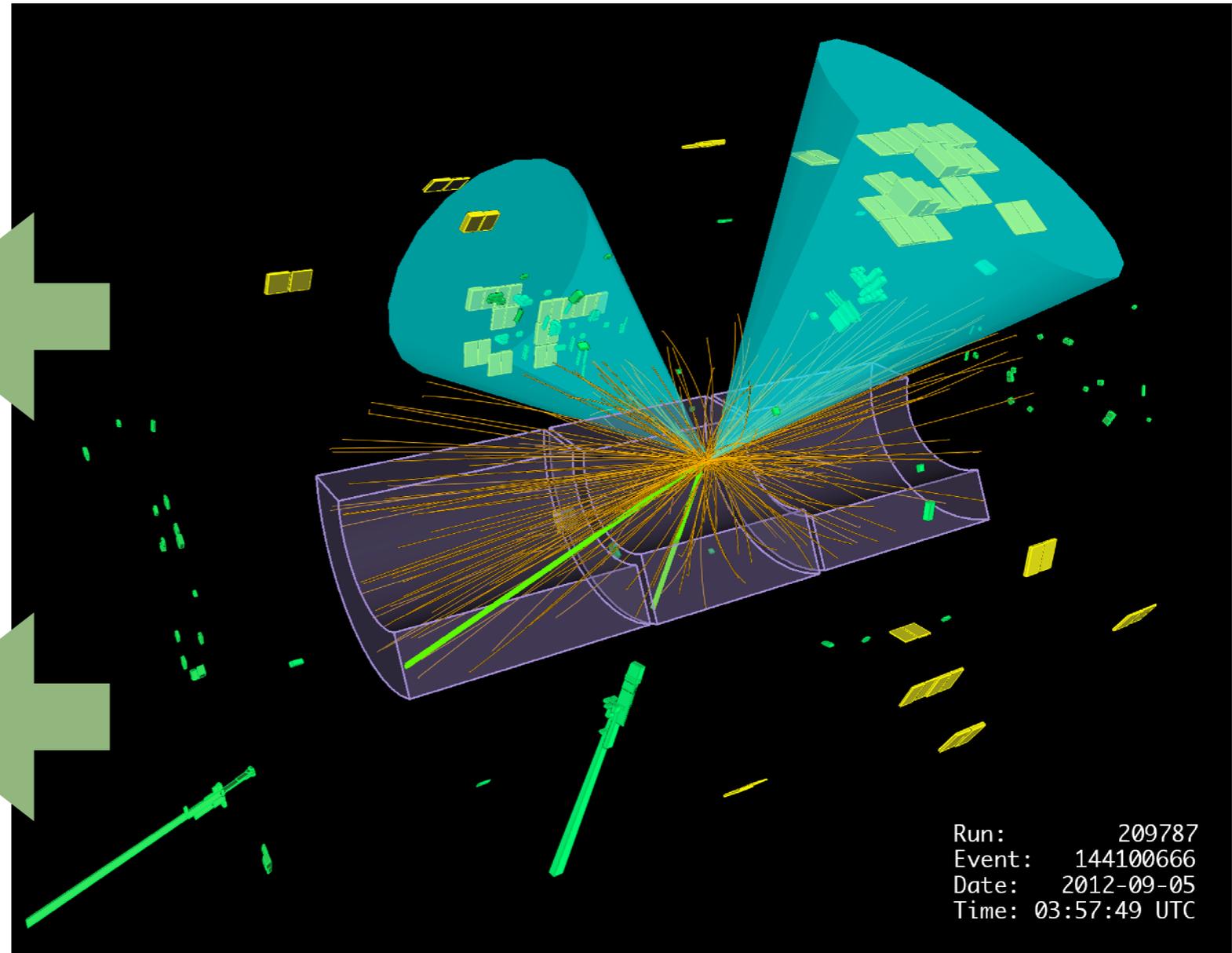
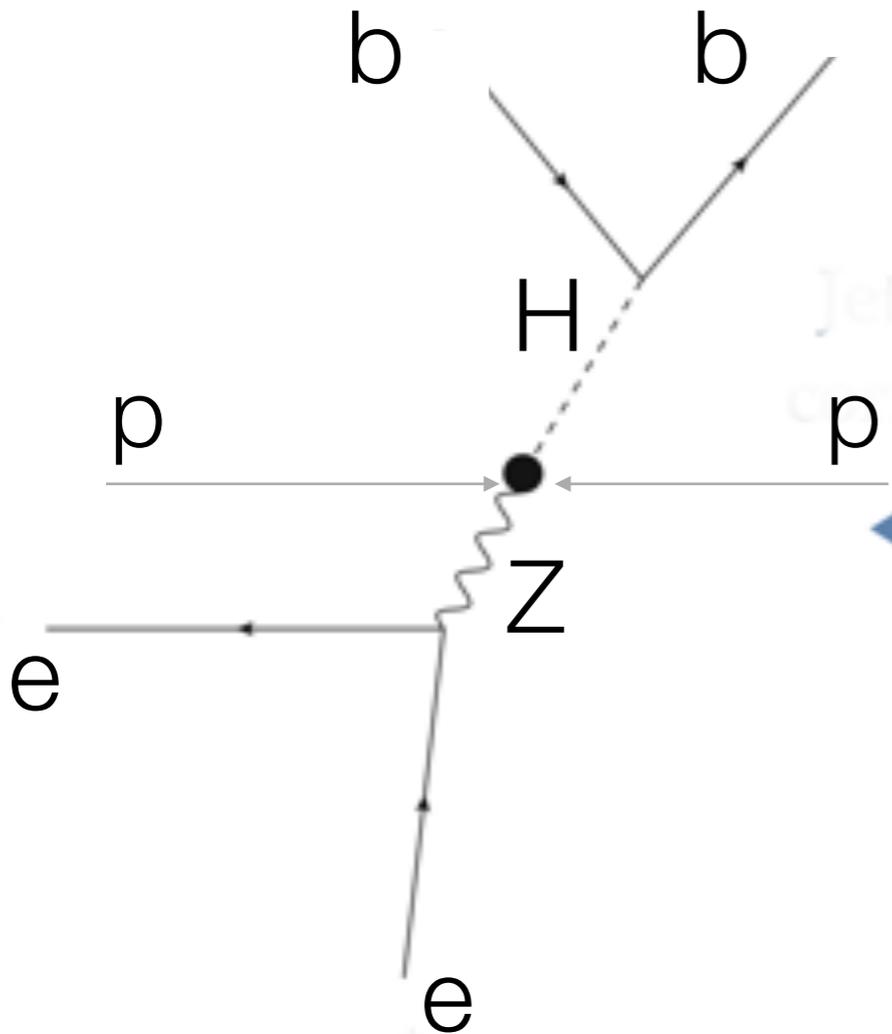
	I	II	III
mass	$\approx 2.4 \text{ MeV}/c^2$	$\approx 1.275 \text{ GeV}/c^2$	$\approx 172.44 \text{ GeV}/c^2$
charge	$2/3$	$2/3$	$2/3$
spin	$1/2$	$1/2$	$1/2$
	u up	c charm	t top
	d down	s strange	b bottom

g
gluon

<http://atlas.ch>

Cosa si vede più nel dettaglio

$pp \rightarrow ZH \rightarrow eebb$

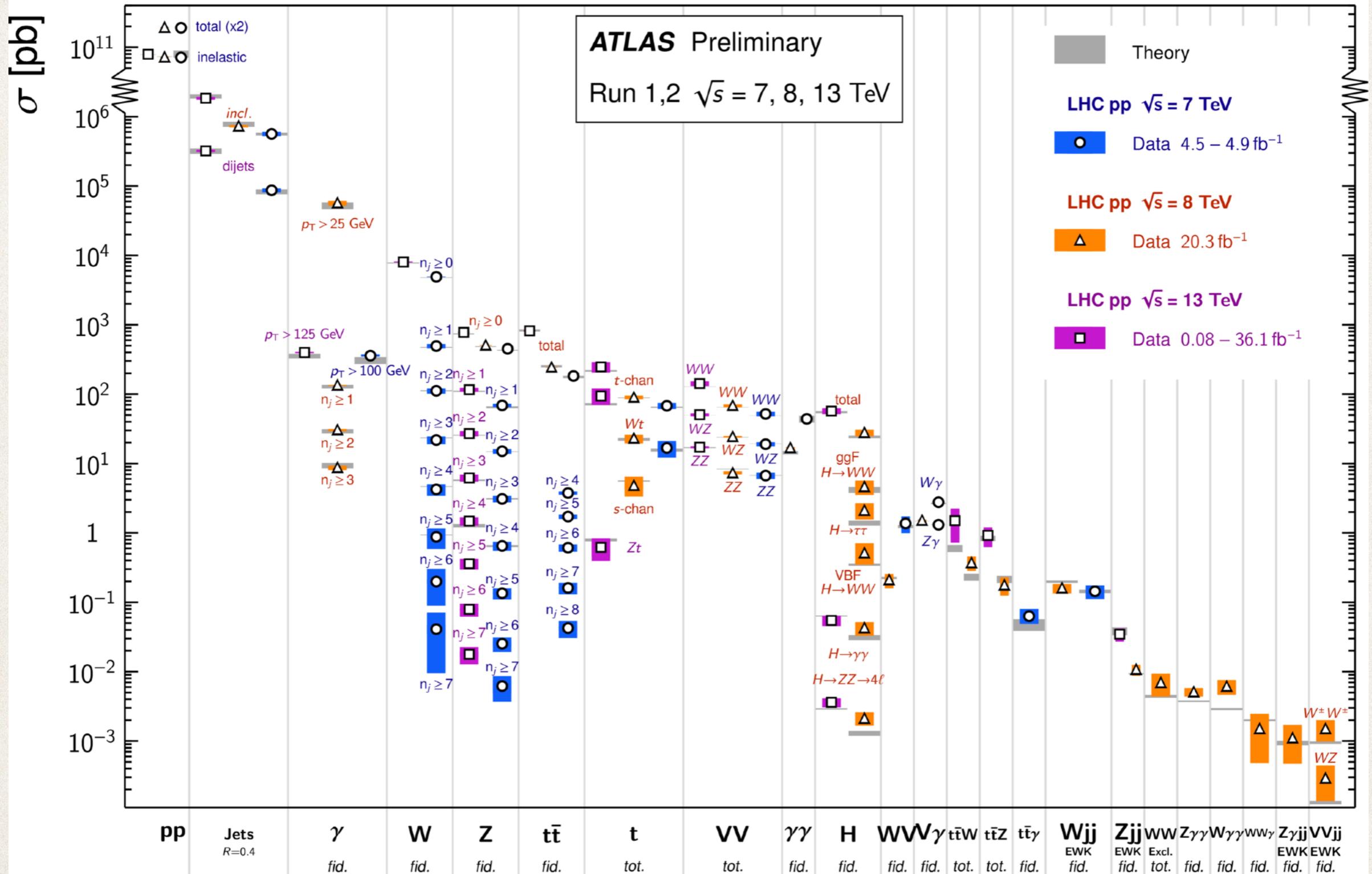


L'analisi dati consiste nel 'mappare' un insieme di eventi con un certo processo teorico con lo scopo di effettuare una misura o una ricerca di un fenomeno non ancora osservato

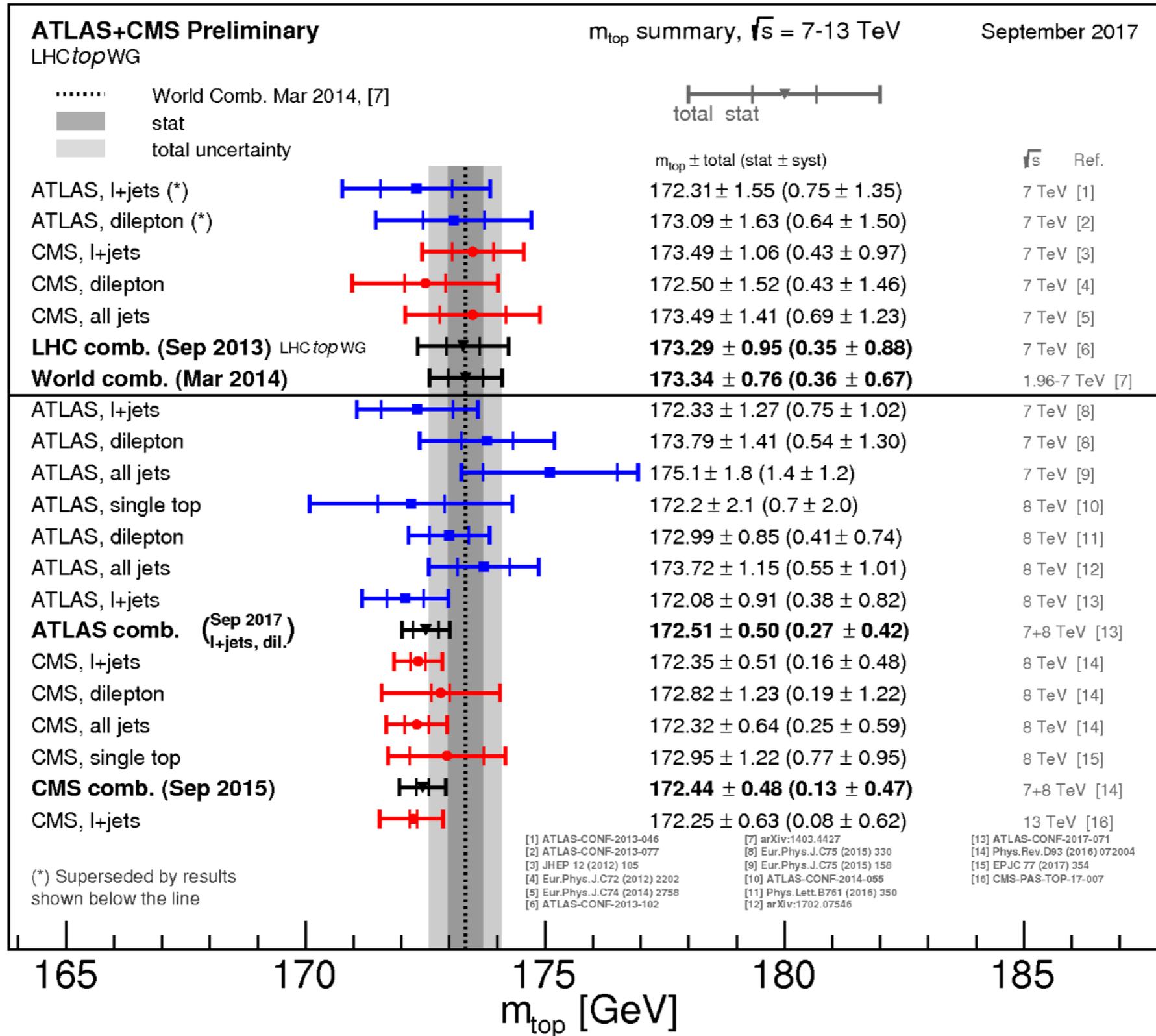
Cosa misura ATLAS?

Standard Model Production Cross Section Measurements

Status: July 2017



Cosa misura ATLAS?



Cosa cerca ATLAS?

ATLAS SUSY Searches* - 95% CL Lower Limits May 2017

ATLAS Preliminary
 $\sqrt{s} = 7, 8, 13$ TeV

Model		e, μ, τ, γ	Jets	E_T^{miss}	$\int \mathcal{L} dt [\text{fb}^{-1}]$	Mass limit	$\sqrt{s} = 7, 8$ TeV	$\sqrt{s} = 13$ TeV	Reference
Inclusive Searches	MSUGRA/CMSSM	0-3 $e, \mu/1-2 \tau$	2-10 jets/3 b	Yes	20.3	\tilde{q}, \tilde{g}	1.85 TeV	$m(\tilde{q})=m(\tilde{g})$	1507.05525
	$\tilde{q}\tilde{q}, \tilde{q} \rightarrow q\tilde{\chi}_1^0$	0	2-6 jets	Yes	36.1	\tilde{q}	1.57 TeV	$m(\tilde{\chi}_1^0) < 200$ GeV, $m(1^{\text{st}} \text{ gen. } \tilde{q})=m(2^{\text{nd}} \text{ gen. } \tilde{q})$	ATLAS-CONF-2017-022
	$\tilde{q}\tilde{q}, \tilde{q} \rightarrow q\tilde{\chi}_1^0$ (compressed)	mono-jet	1-3 jets	Yes	3.2	\tilde{q}	608 GeV	$m(\tilde{q})-m(\tilde{\chi}_1^0) < 5$ GeV	1604.07773
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow q\tilde{q}\tilde{\chi}_1^0$	0	2-6 jets	Yes	36.1	\tilde{g}	2.02 TeV	$m(\tilde{\chi}_1^0) < 200$ GeV	ATLAS-CONF-2017-022
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow q\tilde{q}\tilde{\chi}_1^0 \rightarrow qgW^\pm\tilde{\chi}_1^0$	0	2-6 jets	Yes	36.1	\tilde{g}	2.01 TeV	$m(\tilde{\chi}_1^0) < 200$ GeV, $m(\tilde{\chi}_2^\pm)=0.5(m(\tilde{\chi}_1^0)+m(\tilde{g}))$	ATLAS-CONF-2017-022
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow q\tilde{q}(\ell\ell/\nu\nu)\tilde{\chi}_1^0$	3 e, μ	4 jets	-	36.1	\tilde{g}	1.825 TeV	$m(\tilde{\chi}_1^0) < 400$ GeV	ATLAS-CONF-2017-030
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow q\tilde{q}WZ\tilde{\chi}_1^0$	0	7-11 jets	Yes	36.1	\tilde{g}	1.8 TeV	$m(\tilde{\chi}_1^0) < 400$ GeV	ATLAS-CONF-2017-033
	GMSB ($\tilde{\ell}$ NLSP)	1-2 $\tau + 0-1 \ell$	0-2 jets	Yes	3.2	\tilde{g}	2.0 TeV	$c\tau(\text{NLSP}) < 0.1$ mm	1607.05979
	GGM (bino NLSP)	2 γ	-	Yes	3.2	\tilde{g}	1.65 TeV	$m(\tilde{\chi}_1^0) < 950$ GeV, $c\tau(\text{NLSP}) < 0.1$ mm, $\mu < 0$	1606.09150
	GGM (higgsino-bino NLSP)	γ	1 b	Yes	20.3	\tilde{g}	1.37 TeV	$m(\tilde{\chi}_1^0) > 680$ GeV, $c\tau(\text{NLSP}) < 0.1$ mm, $\mu > 0$	1507.05493
	GGM (higgsino-bino NLSP)	γ	2 jets	Yes	13.3	\tilde{g}	1.8 TeV	$m(\text{NLSP}) > 430$ GeV	ATLAS-CONF-2016-066
	GGM (higgsino NLSP)	2 e, μ (Z)	2 jets	Yes	20.3	\tilde{g}	900 GeV	$m(\tilde{G}) > 1.8 \times 10^{-4}$ eV, $m(\tilde{g})=m(\tilde{q})=1.5$ TeV	1503.03290
Gravitino LSP	0	mono-jet	Yes	20.3	$P^{1/2}$ scale	865 GeV		1502.01518	
3 rd gen. \tilde{g} med.	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow b\tilde{b}\tilde{\chi}_1^0$	0	3 b	Yes	36.1	\tilde{g}	1.92 TeV	$m(\tilde{\chi}_1^0) < 600$ GeV	ATLAS-CONF-2017-021
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow t\tilde{t}\tilde{\chi}_1^0$	0-1 e, μ	3 b	Yes	36.1	\tilde{g}	1.97 TeV	$m(\tilde{\chi}_1^0) < 200$ GeV	ATLAS-CONF-2017-021
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow b\tilde{t}\tilde{\chi}_1^0$	0-1 e, μ	3 b	Yes	20.1	\tilde{g}	1.37 TeV	$m(\tilde{\chi}_1^0) < 300$ GeV	1407.0600
3 rd gen. squarks direct production	$\tilde{b}_1\tilde{b}_1, \tilde{b}_1 \rightarrow b\tilde{\chi}_1^0$	0	2 b	Yes	36.1	\tilde{b}_1	950 GeV	$m(\tilde{\chi}_1^0) < 420$ GeV	ATLAS-CONF-2017-038
	$\tilde{b}_1\tilde{b}_1, \tilde{b}_1 \rightarrow t\tilde{\chi}_1^\pm$	2 e, μ (SS)	1 b	Yes	36.1	\tilde{b}_1	275-700 GeV	$m(\tilde{\chi}_1^0) < 200$ GeV, $m(\tilde{\chi}_1^\pm) = m(\tilde{\chi}_1^0) + 100$ GeV	ATLAS-CONF-2017-030
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1 \rightarrow b\tilde{\chi}_1^\pm$	0-2 e, μ	1-2 b	Yes	4.7/13.3	\tilde{t}_1	117-170 GeV	$m(\tilde{\chi}_1^\pm) = 2m(\tilde{\chi}_1^0), m(\tilde{\chi}_1^\pm)=55$ GeV	1209.2102, ATLAS-CONF-2016-077
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1 \rightarrow Wb\tilde{\chi}_1^0$ or $t\tilde{\chi}_1^0$	0-2 e, μ	0-2 jets/1-2 b	Yes	20.3/36.1	\tilde{t}_1	90-198 GeV	$m(\tilde{\chi}_1^0) = 1$ GeV	1506.08616, ATLAS-CONF-2017-020
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1 \rightarrow c\tilde{\chi}_1^0$	0	mono-jet	Yes	3.2	\tilde{t}_1	90-323 GeV	$m(\tilde{t}_1)-m(\tilde{\chi}_1^0)=5$ GeV	1604.07773
	$\tilde{t}_1\tilde{t}_1$ (natural GMSB)	2 e, μ (Z)	1 b	Yes	20.3	\tilde{t}_1	150-600 GeV	$m(\tilde{\chi}_1^0) > 150$ GeV	1403.5222
	$\tilde{t}_2\tilde{t}_2, \tilde{t}_2 \rightarrow \tilde{t}_1 + Z$	3 e, μ (Z)	1 b	Yes	36.1	\tilde{t}_2	290-790 GeV	$m(\tilde{\chi}_1^0) = 0$ GeV	ATLAS-CONF-2017-019
	$\tilde{t}_2\tilde{t}_2, \tilde{t}_2 \rightarrow \tilde{t}_1 + h$	1-2 e, μ	4 b	Yes	36.1	\tilde{t}_2	320-880 GeV	$m(\tilde{\chi}_1^0) = 0$ GeV	ATLAS-CONF-2017-019
	EW direct	$\tilde{\chi}_{1,2}^0\tilde{\chi}_{1,2}^0, \tilde{\chi}_1^0 \rightarrow \tilde{\chi}_1^0\tilde{\chi}_1^0$	2 e, μ	0	Yes	36.1	$\tilde{\chi}_1^0$	90-440 GeV	$m(\tilde{\chi}_1^0) = 0$
$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^0 \rightarrow \tilde{\chi}_1^0\tilde{\chi}_1^0$		2 e, μ	0	Yes	36.1	$\tilde{\chi}_1^\pm$	710 GeV	$m(\tilde{\chi}_1^0) = 0, m(\tilde{\chi}_1^\pm) = 0.5(m(\tilde{\chi}_1^0) + m(\tilde{\chi}_1^\pm))$	ATLAS-CONF-2017-039
$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^0 \rightarrow \tilde{\chi}_1^0\tilde{\chi}_1^0$		2 τ	-	Yes	36.1	$\tilde{\chi}_1^\pm$	760 GeV	$m(\tilde{\chi}_1^0) = 0, m(\tilde{\chi}_1^\pm) = 0.5(m(\tilde{\chi}_1^0) + m(\tilde{\chi}_1^\pm))$	ATLAS-CONF-2017-035
$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^0 \rightarrow \tilde{\chi}_1^0\tilde{\chi}_1^0$		3 e, μ	0	Yes	36.1	$\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$	1.16 TeV	$m(\tilde{\chi}_1^\pm) = m(\tilde{\chi}_2^0), m(\tilde{\chi}_1^0) = 0, m(\tilde{\chi}_1^\pm) = 0.5(m(\tilde{\chi}_1^0) + m(\tilde{\chi}_1^\pm))$	ATLAS-CONF-2017-039
$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^0 \rightarrow W\tilde{\chi}_1^0 Z\tilde{\chi}_1^0$		2-3 e, μ	0-2 jets	Yes	36.1	$\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$	580 GeV	$m(\tilde{\chi}_1^\pm) = m(\tilde{\chi}_2^0), m(\tilde{\chi}_1^0) = 0, \tilde{\ell}$ decoupled	ATLAS-CONF-2017-039
$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^0 \rightarrow W\tilde{\chi}_1^0 h\tilde{\chi}_1^0, h \rightarrow b\tilde{b}/WW/\tau\tau/\gamma\gamma$		e, μ, γ	0-2 b	Yes	20.3	$\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$	270 GeV	$m(\tilde{\chi}_1^\pm) = m(\tilde{\chi}_2^0), m(\tilde{\chi}_1^0) = 0, \tilde{\ell}$ decoupled	1501.07110
$\tilde{\chi}_2^0\tilde{\chi}_2^0, \tilde{\chi}_2^0 \rightarrow \tilde{\chi}_1^0\tilde{\chi}_1^0$		4 e, μ	0	Yes	20.3	$\tilde{\chi}_2^0$	635 GeV	$m(\tilde{\chi}_2^0) = m(\tilde{\chi}_1^0), m(\tilde{\chi}_1^0) = 0, m(\tilde{\chi}_1^\pm) = 0.5(m(\tilde{\chi}_2^0) + m(\tilde{\chi}_1^0))$	1405.5086
GGM (wino NLSP) weak prod., $\tilde{\chi}_1^0 \rightarrow \gamma\tilde{G}$		1 $e, \mu + \gamma$	-	Yes	20.3	\tilde{W}	115-370 GeV	$c\tau < 1$ mm	1507.05493
GGM (bino NLSP) weak prod., $\tilde{\chi}_1^0 \rightarrow \gamma\tilde{G}$		2 γ	-	Yes	20.3	\tilde{W}	590 GeV	$c\tau < 1$ mm	1507.05493
Long-lived particles	Direct $\tilde{\chi}_1^+\tilde{\chi}_1^-$ prod., long-lived $\tilde{\chi}_1^\pm$	Disapp. trk	1 jet	Yes	36.1	$\tilde{\chi}_1^\pm$	430 GeV	$m(\tilde{\chi}_1^\pm) - m(\tilde{\chi}_1^0) \sim 160$ MeV, $\tau(\tilde{\chi}_1^\pm) = 0.2$ ns	ATLAS-CONF-2017-017
	Direct $\tilde{\chi}_1^+\tilde{\chi}_1^-$ prod., long-lived $\tilde{\chi}_1^\pm$	dE/dx trk	-	Yes	18.4	$\tilde{\chi}_1^\pm$	495 GeV	$m(\tilde{\chi}_1^\pm) - m(\tilde{\chi}_1^0) \sim 160$ MeV, $\tau(\tilde{\chi}_1^\pm) < 15$ ns	1506.05332
	Stable, stopped \tilde{g} R-hadron	0	1-5 jets	Yes	27.9	\tilde{g}	850 GeV	$m(\tilde{\chi}_1^0) = 100$ GeV, $10 \mu\text{s} < \tau(\tilde{g}) < 1000$ s	1310.6584
	Stable \tilde{g} R-hadron	trk	-	-	3.2	\tilde{g}	1.58 TeV		1606.05129
	Metastable \tilde{g} R-hadron	dE/dx trk	-	-	3.2	\tilde{g}	1.57 TeV		1604.04520
	GMSB, stable $\tilde{\tau}, \tilde{\chi}_1^0 \rightarrow \tilde{\tau}(\tilde{e}, \tilde{\mu}) + \tau(e, \mu)$	1-2 μ	-	-	19.1	$\tilde{\chi}_1^0$	537 GeV	$m(\tilde{\chi}_1^0) = 100$ GeV, $\tau > 10$ ns	1411.6795
	GMSB, $\tilde{\chi}_1^0 \rightarrow \gamma\tilde{G}$, long-lived $\tilde{\chi}_1^0$	2 γ	-	Yes	20.3	$\tilde{\chi}_1^0$	440 GeV	$1 < \tau(\tilde{\chi}_1^0) < 3$ ns, SPS8 model	1409.5542
	$\tilde{g}\tilde{g}, \tilde{\chi}_1^0 \rightarrow e\tilde{\nu}/e\tilde{\nu}/\mu\tilde{\nu}$	displ. $e\tilde{\nu}/e\tilde{\nu}/\mu\tilde{\nu}$	-	-	20.3	$\tilde{\chi}_1^0$	1.0 TeV	$7 < c\tau(\tilde{\chi}_1^0) < 740$ mm, $m(\tilde{g}) = 1.3$ TeV	1504.05162
	GGM $\tilde{g}\tilde{g}, \tilde{\chi}_1^0 \rightarrow Z\tilde{G}$	displ. vtx + jets	-	-	20.3	$\tilde{\chi}_1^0$	1.0 TeV	$6 < c\tau(\tilde{\chi}_1^0) < 480$ mm, $m(\tilde{g}) = 1.1$ TeV	1504.05162
RPV	LFV $pp \rightarrow \tilde{\nu}_\tau + X, \tilde{\nu}_\tau \rightarrow e\mu/\tau\mu$	$e\mu, e\tau, \mu\tau$	-	-	3.2	$\tilde{\nu}_\tau$	1.9 TeV	$\lambda'_{311} = 0.11, \lambda'_{132/133/233} = 0.07$	1607.08079
	Bilinear RPV CMSSM	2 e, μ (SS)	0-3 b	Yes	20.3	\tilde{q}, \tilde{g}	1.45 TeV	$m(\tilde{q})=m(\tilde{g}), c\tau_{LSP} < 1$ mm	1404.2500
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^0 \rightarrow W\tilde{\chi}_1^0, \tilde{\chi}_1^0 \rightarrow e\tilde{\nu}, e\tilde{\nu}, \mu\tilde{\nu}$	4 e, μ	-	Yes	13.3	$\tilde{\chi}_1^\pm$	1.14 TeV	$m(\tilde{\chi}_1^0) > 400$ GeV, $\lambda_{12k} \neq 0$ ($k = 1, 2$)	ATLAS-CONF-2016-075
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^0 \rightarrow W\tilde{\chi}_1^0, \tilde{\chi}_1^0 \rightarrow \tau\tilde{\nu}_e, e\tau, \nu_\tau$	3 $e, \mu + \tau$	-	Yes	20.3	$\tilde{\chi}_1^\pm$	450 GeV	$m(\tilde{\chi}_1^0) > 0.2 \times m(\tilde{\chi}_1^\pm), \lambda_{133} \neq 0$	1405.5086
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow qq\tilde{\chi}_1^0$	0	4-5 large-R jets	-	14.8	\tilde{g}	1.08 TeV	$\text{BR}(h) = \text{BR}(b) = \text{BR}(c) = 0\%$	ATLAS-CONF-2016-057
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow qq\tilde{\chi}_1^0, \tilde{\chi}_1^0 \rightarrow qq\tilde{\chi}_1^0$	0	4-5 large-R jets	-	14.8	\tilde{g}	1.55 TeV	$m(\tilde{\chi}_1^0) = 800$ GeV	ATLAS-CONF-2016-057
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow t\tilde{t}\tilde{\chi}_1^0, \tilde{\chi}_1^0 \rightarrow qq\tilde{\chi}_1^0$	1 e, μ	8-10 jets/0-4 b	-	36.1	\tilde{g}	2.1 TeV	$m(\tilde{\chi}_1^0) = 1$ TeV, $\lambda_{112} \neq 0$	ATLAS-CONF-2017-013
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow \tilde{t}_1\tilde{t}_1, \tilde{t}_1 \rightarrow bs$	1 e, μ	8-10 jets/0-4 b	-	36.1	\tilde{g}	1.65 TeV	$m(\tilde{t}_1) = 1$ TeV, $\lambda_{323} \neq 0$	ATLAS-CONF-2017-013
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1 \rightarrow bs$	0	2 jets + 2 b	-	15.4	\tilde{t}_1	410 GeV		ATLAS-CONF-2016-022, ATLAS-CONF-2016-084
$\tilde{t}_1\tilde{t}_1, \tilde{t}_1 \rightarrow b\tilde{\ell}$	2 e, μ	2 b	-	36.1	\tilde{t}_1	0.4-1.45 TeV	$\text{BR}(\tilde{t}_1 \rightarrow b\tilde{\ell}/\mu) > 20\%$	ATLAS-CONF-2017-036	
Other	Scalar charm, $\tilde{c} \rightarrow c\tilde{\chi}_1^0$	0	2 c	Yes	20.3	\tilde{c}	510 GeV	$m(\tilde{\chi}_1^0) < 200$ GeV	1501.01325

*Only a selection of the available mass limits on new states or phenomena is shown. Many of the limits are based on simplified models, c.f. refs. for the assumptions made.

Cosa cerca ATLAS?

ATLAS Exotics Searches* - 95% CL Upper Exclusion Limits

Status: July 2017

ATLAS Preliminary

$$\int \mathcal{L} dt = (3.2 - 37.0) \text{ fb}^{-1}$$

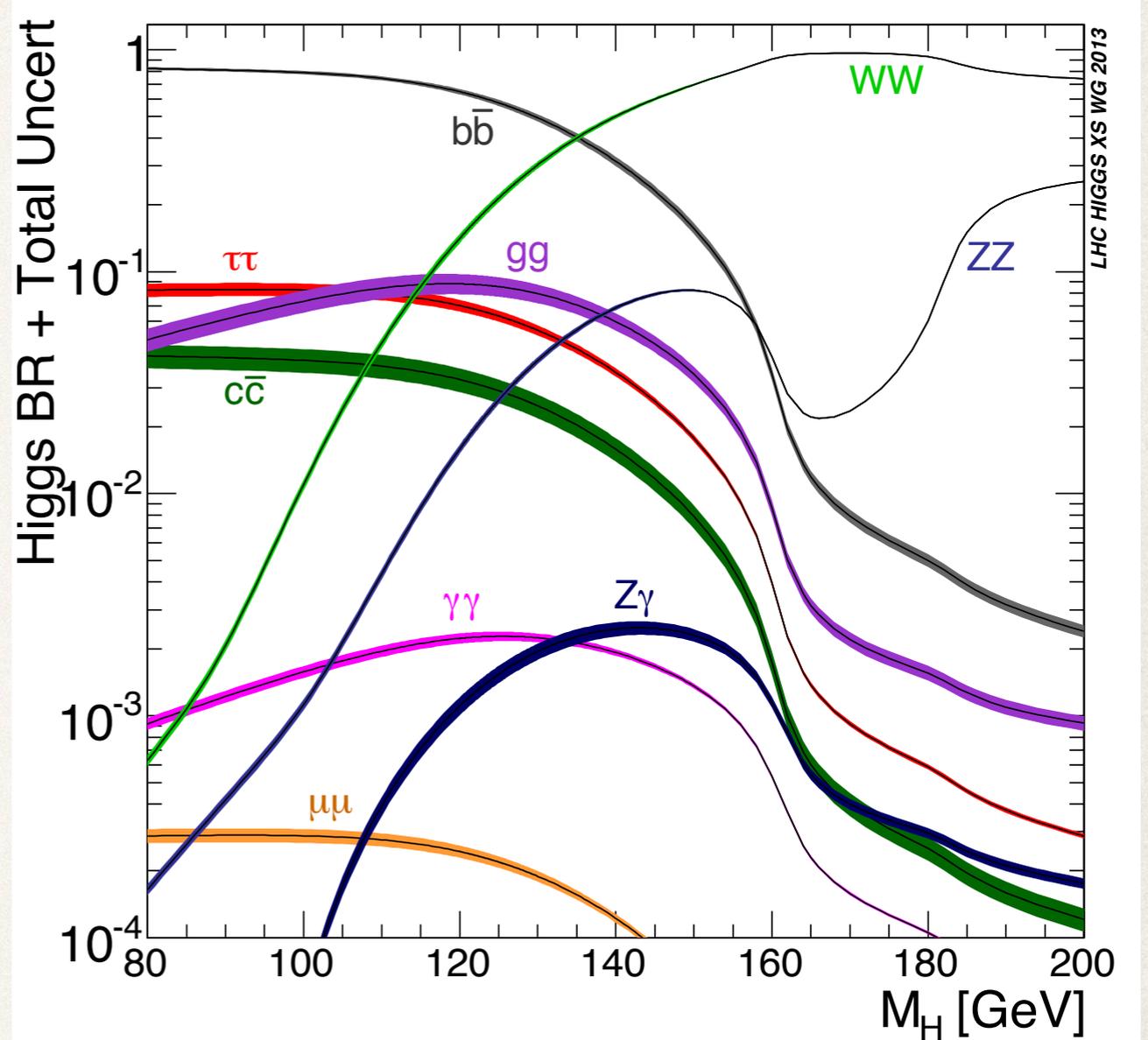
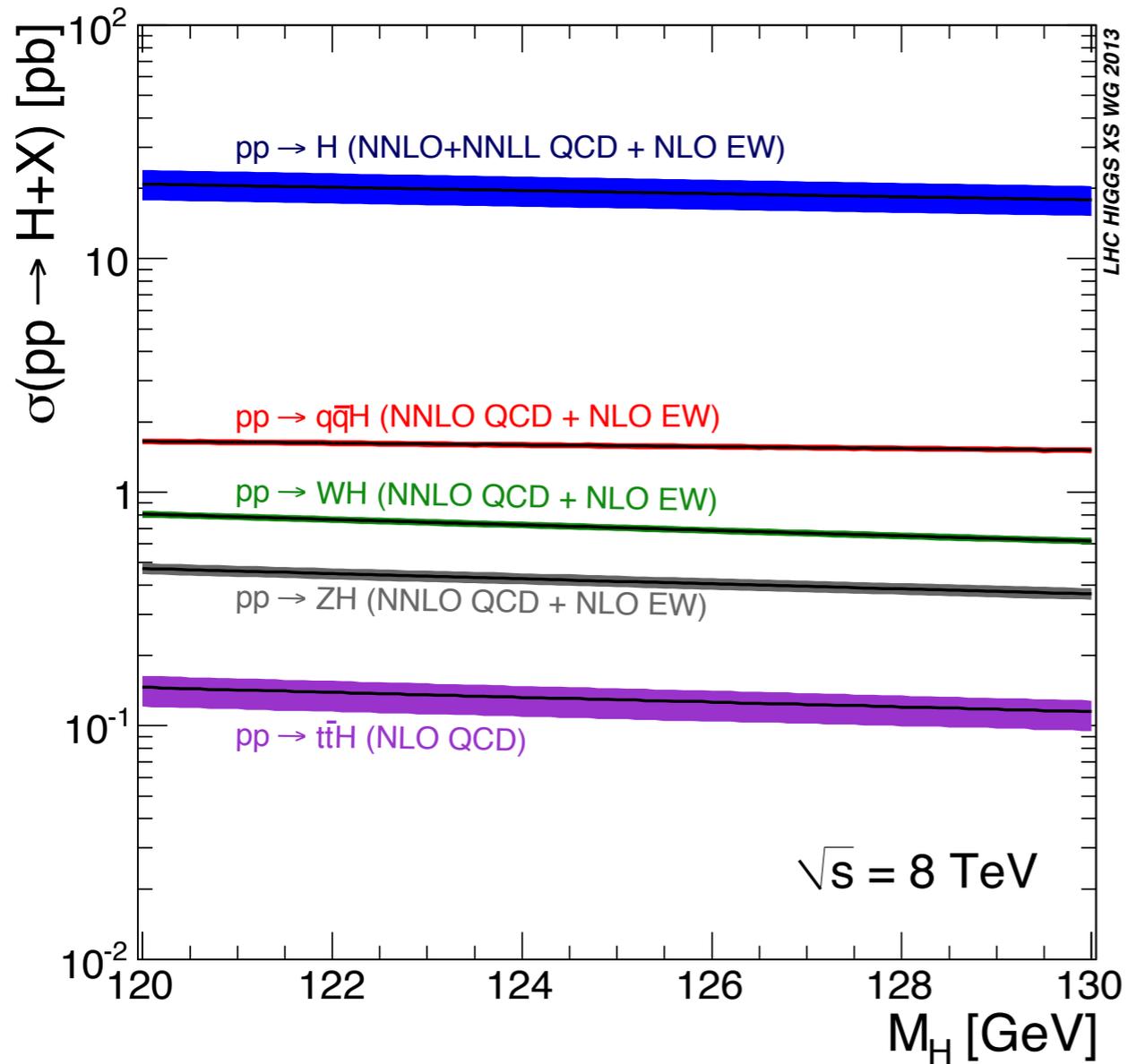
$$\sqrt{s} = 8, 13 \text{ TeV}$$

Model	ℓ, γ	Jets [†]	E_T^{miss}	$\int \mathcal{L} dt [\text{fb}^{-1}]$	Limit	Reference		
Extra dimensions	ADD $G_{KK} + g/q$	$0 e, \mu$	$1-4 j$	Yes	36.1	M_D 7.75 TeV	$n = 2$	ATLAS-CONF-2017-060
	ADD non-resonant $\gamma\gamma$	2γ	-	-	36.7	M_S 8.6 TeV	$n = 3$ HLZ NLO	CERN-EP-2017-132
	ADD QBH	-	$2 j$	-	37.0	M_{th} 8.9 TeV	$n = 6$	1703.09217
	ADD BH high $\sum p_T$	$\geq 1 e, \mu$	$\geq 2 j$	-	3.2	M_{th} 8.2 TeV	$n = 6, M_D = 3 \text{ TeV}$, rot BH	1606.02265
	ADD BH multijet	-	$\geq 3 j$	-	3.6	M_{th} 9.55 TeV	$n = 6, M_D = 3 \text{ TeV}$, rot BH	1512.02586
	RS1 $G_{KK} \rightarrow \gamma\gamma$	2γ	-	-	36.7	G_{KK} mass 4.1 TeV	$k/\bar{M}_{pl} = 0.1$	CERN-EP-2017-132
	Bulk RS $G_{KK} \rightarrow WW \rightarrow qq\ell\nu$	$1 e, \mu$	$1 J$	Yes	36.1	G_{KK} mass 1.75 TeV	$k/\bar{M}_{pl} = 1.0$	ATLAS-CONF-2017-051
2UED / RPP	$1 e, \mu$	$\geq 2 b, \geq 3 j$	Yes	13.2	KK mass 1.6 TeV	Tier (1,1), $\mathcal{B}(A^{(1,1)} \rightarrow tt) = 1$	ATLAS-CONF-2016-104	
Gauge bosons	SSM $Z' \rightarrow \ell\ell$	$2 e, \mu$	-	-	36.1	Z' mass 4.5 TeV		ATLAS-CONF-2017-027
	SSM $Z' \rightarrow \tau\tau$	2τ	-	-	36.1	Z' mass 2.4 TeV		ATLAS-CONF-2017-050
	Leptophobic $Z' \rightarrow bb$	-	$2 b$	-	3.2	Z' mass 1.5 TeV		1603.08791
	Leptophobic $Z' \rightarrow tt$	$1 e, \mu$	$\geq 1 b, \geq 1J/2j$	Yes	3.2	Z' mass 2.0 TeV	$\Gamma/m = 3\%$	ATLAS-CONF-2016-014
	SSM $W' \rightarrow \ell\nu$	$1 e, \mu$	-	Yes	36.1	W' mass 5.1 TeV		1706.04786
	HVT $V' \rightarrow WV \rightarrow qq\ell\ell$ model B	$0 e, \mu$	$2 J$	-	36.7	V' mass 3.5 TeV	$g_V = 3$	CERN-EP-2017-147
	HVT $V' \rightarrow WH/ZH$ model B	multi-channel	-	-	36.1	V' mass 2.93 TeV	$g_V = 3$	ATLAS-CONF-2017-055
	LRSM $W'_R \rightarrow tb$	$1 e, \mu$	$2 b, 0-1 j$	Yes	20.3	W' mass 1.92 TeV		1410.4103
LRSM $W'_R \rightarrow tb$	$0 e, \mu$	$\geq 1 b, 1 J$	-	20.3	W' mass 1.76 TeV		1408.0886	
CI	CI $qqqq$	-	$2 j$	-	37.0	Λ 21.8 TeV η_{LL}		1703.09217
	CI $\ell\ell qq$	$2 e, \mu$	-	-	36.1	Λ 40.1 TeV η_{LL}		ATLAS-CONF-2017-027
	CI $uutt$	$2(SS)/\geq 3 e, \mu \geq 1 b, \geq 1 j$	Yes	20.3	Λ 4.9 TeV	$ C_{RR} = 1$		1504.04605
DM	Axial-vector mediator (Dirac DM)	$0 e, \mu$	$1-4 j$	Yes	36.1	m_{med} 1.5 TeV	$g_q=0.25, g_\nu=1.0, m(\chi) < 400 \text{ GeV}$	ATLAS-CONF-2017-060
	Vector mediator (Dirac DM)	$0 e, \mu, 1 \gamma$	$\leq 1 j$	Yes	36.1	m_{med} 1.2 TeV	$g_q=0.25, g_\nu=1.0, m(\chi) < 480 \text{ GeV}$	1704.03848
	VV $\chi\chi$ EFT (Dirac DM)	$0 e, \mu$	$1 J, \leq 1 j$	Yes	3.2	M_* 700 GeV	$m(\chi) < 150 \text{ GeV}$	1608.02372
LQ	Scalar LQ 1 st gen	$2 e$	$\geq 2 j$	-	3.2	LQ mass 1.1 TeV	$\beta = 1$	1605.06035
	Scalar LQ 2 nd gen	2μ	$\geq 2 j$	-	3.2	LQ mass 1.05 TeV	$\beta = 1$	1605.06035
	Scalar LQ 3 rd gen	$1 e, \mu$	$\geq 1 b, \geq 3 j$	Yes	20.3	LQ mass 640 GeV	$\beta = 0$	1508.04735
Heavy quarks	VLQ $TT \rightarrow Ht + X$	0 or $1 e, \mu$	$\geq 2 b, \geq 3 j$	Yes	13.2	T mass 1.2 TeV	$\mathcal{B}(T \rightarrow Ht) = 1$	ATLAS-CONF-2016-104
	VLQ $TT \rightarrow Zt + X$	$1 e, \mu$	$\geq 1 b, \geq 3 j$	Yes	36.1	T mass 1.16 TeV	$\mathcal{B}(T \rightarrow Zt) = 1$	1705.10751
	VLQ $TT \rightarrow Wb + X$	$1 e, \mu$	$\geq 1 b, \geq 1J/2j$	Yes	36.1	T mass 1.35 TeV	$\mathcal{B}(T \rightarrow Wb) = 1$	CERN-EP-2017-094
	VLQ $BB \rightarrow Hb + X$	$1 e, \mu$	$\geq 2 b, \geq 3 j$	Yes	20.3	B mass 700 GeV	$\mathcal{B}(B \rightarrow Hb) = 1$	1505.04306
	VLQ $BB \rightarrow Zb + X$	$2/\geq 3 e, \mu$	$\geq 2/\geq 1 b$	-	20.3	B mass 790 GeV	$\mathcal{B}(B \rightarrow Zb) = 1$	1409.5500
	VLQ $BB \rightarrow Wt + X$	$1 e, \mu$	$\geq 1 b, \geq 1J/2j$	Yes	36.1	B mass 1.25 TeV	$\mathcal{B}(B \rightarrow Wt) = 1$	CERN-EP-2017-094
	VLQ $QQ \rightarrow WqWq$	$1 e, \mu$	$\geq 4 j$	Yes	20.3	Q mass 690 GeV		1509.04261
Excited fermions	Excited quark $q^* \rightarrow qg$	-	$2 j$	-	37.0	q^* mass 6.0 TeV	only u^* and d^* , $\Lambda = m(q^*)$	1703.09127
	Excited quark $q^* \rightarrow q\gamma$	1γ	$1 j$	-	36.7	q^* mass 5.3 TeV	only u^* and d^* , $\Lambda = m(q^*)$	CERN-EP-2017-148
	Excited quark $b^* \rightarrow bg$	-	$1 b, 1 j$	-	13.3	b^* mass 2.3 TeV		ATLAS-CONF-2016-060
	Excited quark $b^* \rightarrow Wt$	1 or $2 e, \mu$	$1 b, 2-0 j$	Yes	20.3	b^* mass 1.5 TeV	$f_L = f_R = 1$	1510.02664
	Excited lepton ℓ^*	$3 e, \mu$	-	-	20.3	ℓ^* mass 3.0 TeV	$\Lambda = 3.0 \text{ TeV}$	1411.2921
	Excited lepton ν^*	$3 e, \mu, \tau$	-	-	20.3	ν^* mass 1.6 TeV	$\Lambda = 1.6 \text{ TeV}$	1411.2921
Other	LRSM Majorana ν	$2 e, \mu$	$2 j$	-	20.3	N^0 mass 2.0 TeV	$m(W_R) = 2.4 \text{ TeV}$, no mixing	1506.06020
	Higgs triplet $H^{\pm\pm} \rightarrow \ell\ell$	$2,3,4 e, \mu$ (SS)	-	-	36.1	$H^{\pm\pm}$ mass 870 GeV	DY production	ATLAS-CONF-2017-053
	Higgs triplet $H^{\pm\pm} \rightarrow \ell\tau$	$3 e, \mu, \tau$	-	-	20.3	$H^{\pm\pm}$ mass 400 GeV	DY production, $\mathcal{B}(H_L^{\pm\pm} \rightarrow \ell\tau) = 1$	1411.2921
	Monotop (non-res prod)	$1 e, \mu$	$1 b$	Yes	20.3	spin-1 invisible particle mass 657 GeV	$a_{\text{non-res}} = 0.2$	1410.5404
	Multi-charged particles	-	-	-	20.3	multi-charged particle mass 785 GeV	DY production, $ q = 5e$	1504.04188
	Magnetic monopoles	-	-	-	7.0	monopole mass 1.34 TeV	DY production, $ g = 1g_D$, spin 1/2	1509.08059

*Only a selection of the available mass limits on new states or phenomena is shown.

†Small-radius (large-radius) jets are denoted by the letter j (J).

Fenomenologia del bosone di Higgs



ATLAS+CMS Run-I	125.09 ± 0.24 GeV
ATLAS Run-II	124.98 ± 0.28 GeV
CMS Run-II	125.26 ± 0.21 GeV

Accoppiamenti fermionici del bosone di Higgs

Standard Model of Elementary Particles

		three generations of matter (fermions)				
		I	II	III		
QUARKS	mass	≈2.4 MeV/c ²	≈1.275 GeV/c ²	≈172.44 GeV/c ²	0	≈125.09 GeV/c ²
	charge	2/3	2/3	2/3	0	0
	spin	1/2	1/2	1/2	1	0
		u up	c charm	t top	g gluon	H Higgs
		d down	s strange	b bottom	γ photon	
		e electron	μ muon	τ tau	Z Z boson	
LEPTONS		<2.2 eV/c ²	<1.7 MeV/c ²	<15.5 MeV/c ²	±1	
		0	0	0	1	
		1/2	1/2	1/2	1	
	ν_e electron neutrino	ν_μ muon neutrino	ν_τ tau neutrino	W W boson		

2012 | Scoperta solo tramite bosoni!

$$H \rightarrow \gamma\gamma$$

$$H \rightarrow ZZ^* \rightarrow 4\ell$$

$$H \rightarrow WW^* \rightarrow e\nu\mu\nu$$

2012 | Osservazione indiretta

$$gg \rightarrow H$$

2013 | Premio nobel a Higgs e Englert

2015 | Osservazione diretta

$$H \rightarrow \tau\tau$$

2017 | Evidenza (3 < sigma < 5)

$$H \rightarrow b\bar{b}$$

$$gg \rightarrow t\bar{t}H$$

Accoppiamenti fermionici del bosone di Higgs

Standard Model of Elementary Particles

		three generations of matter (fermions)				
		I	II	III		
QUARKS	mass	≈2.4 MeV/c ²	≈1.275 GeV/c ²	≈172.44 GeV/c ²	0	≈125.09 GeV/c ²
	charge	2/3	2/3	2/3	0	0
	spin	1/2	1/2	1/2	1	0
		u up	c charm	t top	g gluon	H Higgs
		d down	s strange	b bottom		
LEPTONS	mass	≈0.511 MeV/c ²	≈105.67 MeV/c ²	≈1.7768 GeV/c ²	≈91.19 GeV/c ²	
	charge	-1	-1	-1	0	
	spin	1/2	1/2	1/2	1	
		e electron	μ muon	τ tau	Z Z boson	
		ν _e electron neutrino	ν _μ muon neutrino	ν _τ tau neutrino	W W boson	

It's a long way to the top if you wanna rock 'n' roll

Scoperta | 2012

$$H \rightarrow \gamma\gamma$$

$$H \rightarrow ZZ^* \rightarrow 4\ell$$

$$H \rightarrow WW^* \rightarrow e\nu\mu\nu$$

Osservazione indiretta | 2012

$$gg \rightarrow H$$

Osservazione diretta | 2015

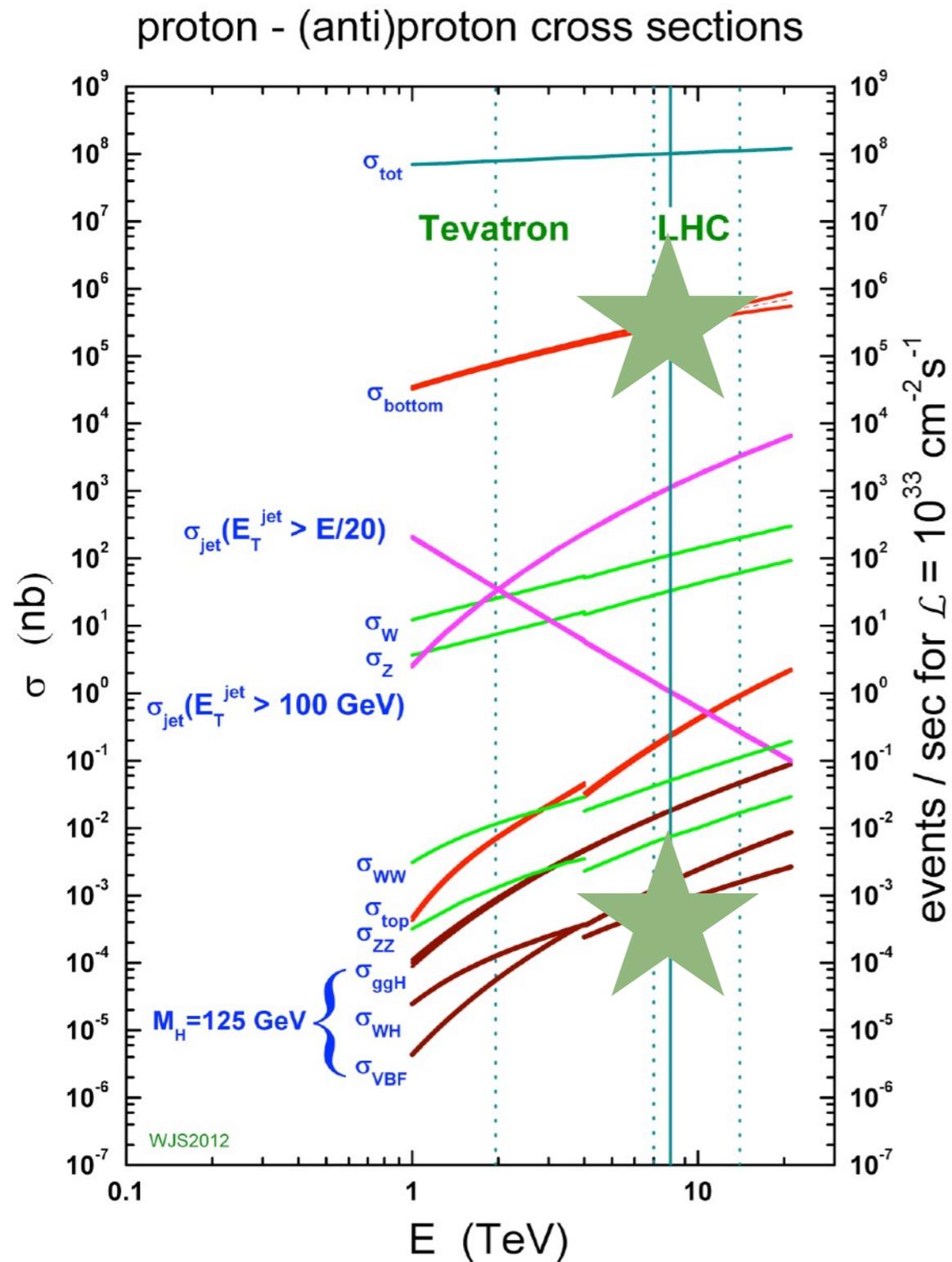
$$H \rightarrow \tau\tau$$

Evidenza (3 < sigma < 5) | 2017

$$H \rightarrow b\bar{b}$$

$$gg \rightarrow t\bar{t}H$$

Decadimento in quark beauty



Enorme fondo da produzione diretta di quark beauty

Discriminazione tra jet da quark beauty e jet da quark leggeri

Produzione associata per ridurre il fondo e utilizzare trigger di leptone

b-tagging

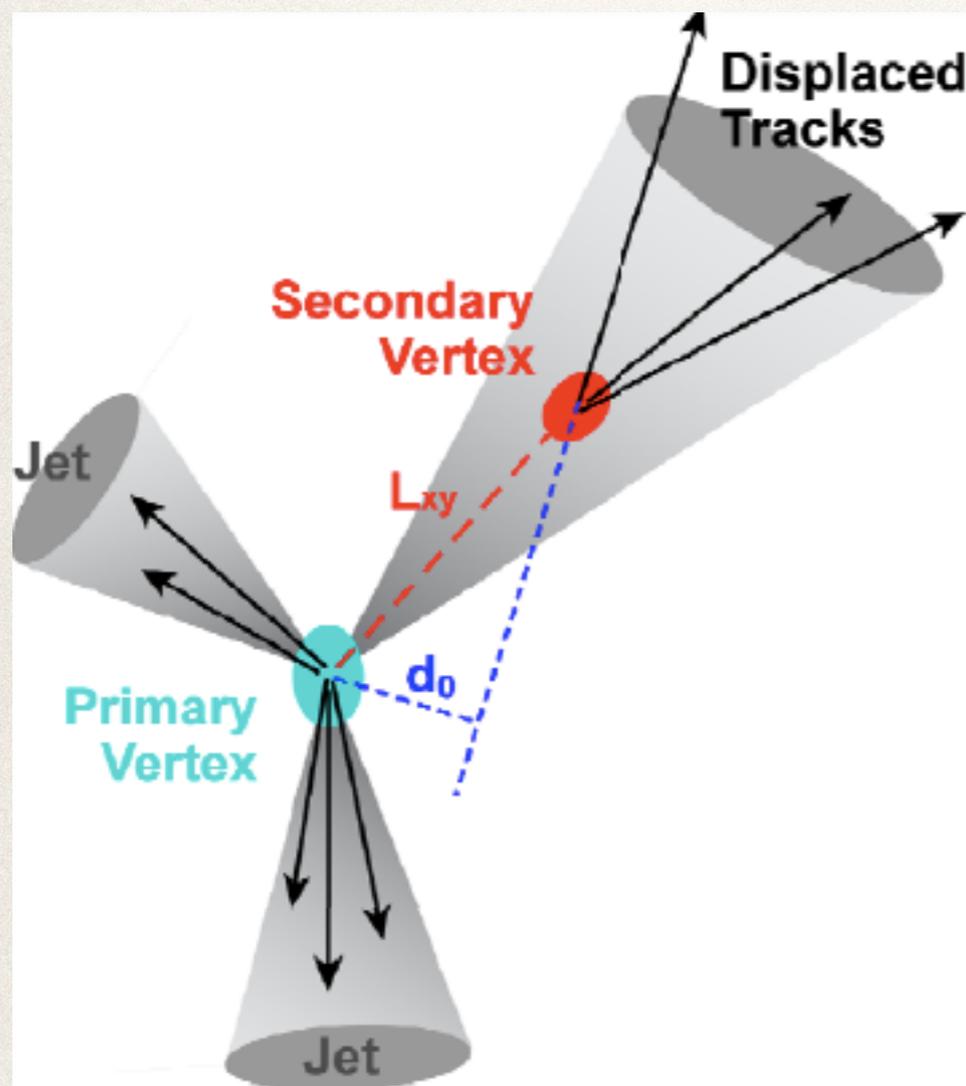
Un jet da quark beauty ha interessanti proprietà fisiche

1 | La maggior parte dell'energia iniziale è trasferita al b-adrone (~80%)

2 | La massa del b-adrone è elevata (~5 GeV)

3 | Il b-adrone ha una vita media misurabile (~1.5 ps)

4 | Il b-adrone decade in un alto numero di particelle cariche (~5)

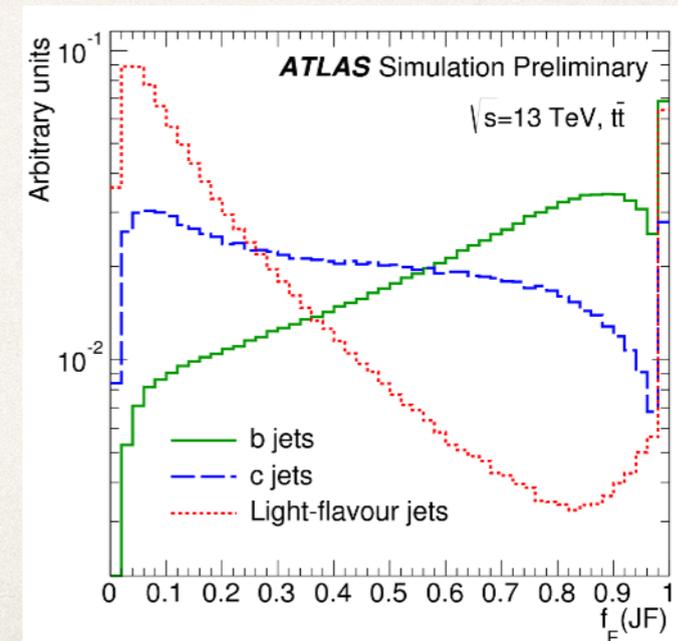
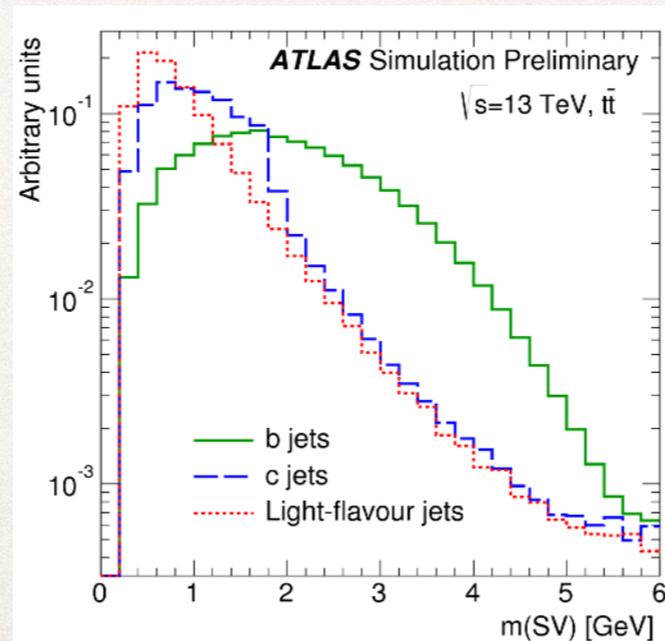
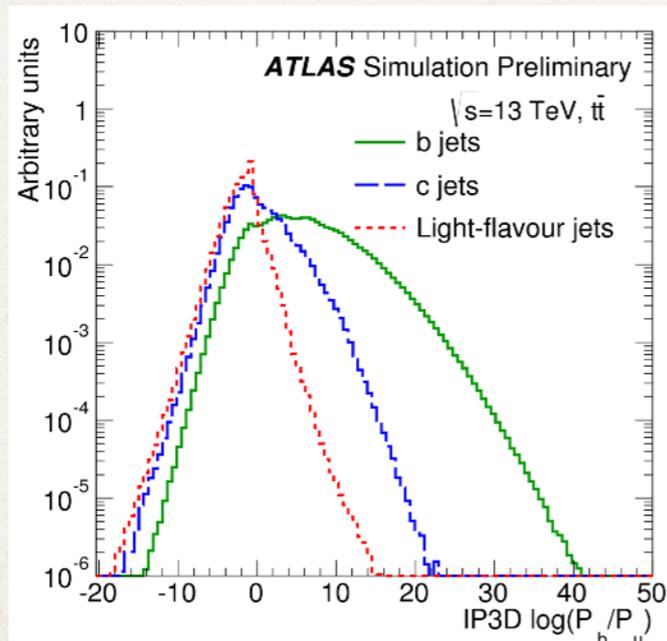


$$L = \beta\gamma c\tau = \frac{p}{m} c\tau$$

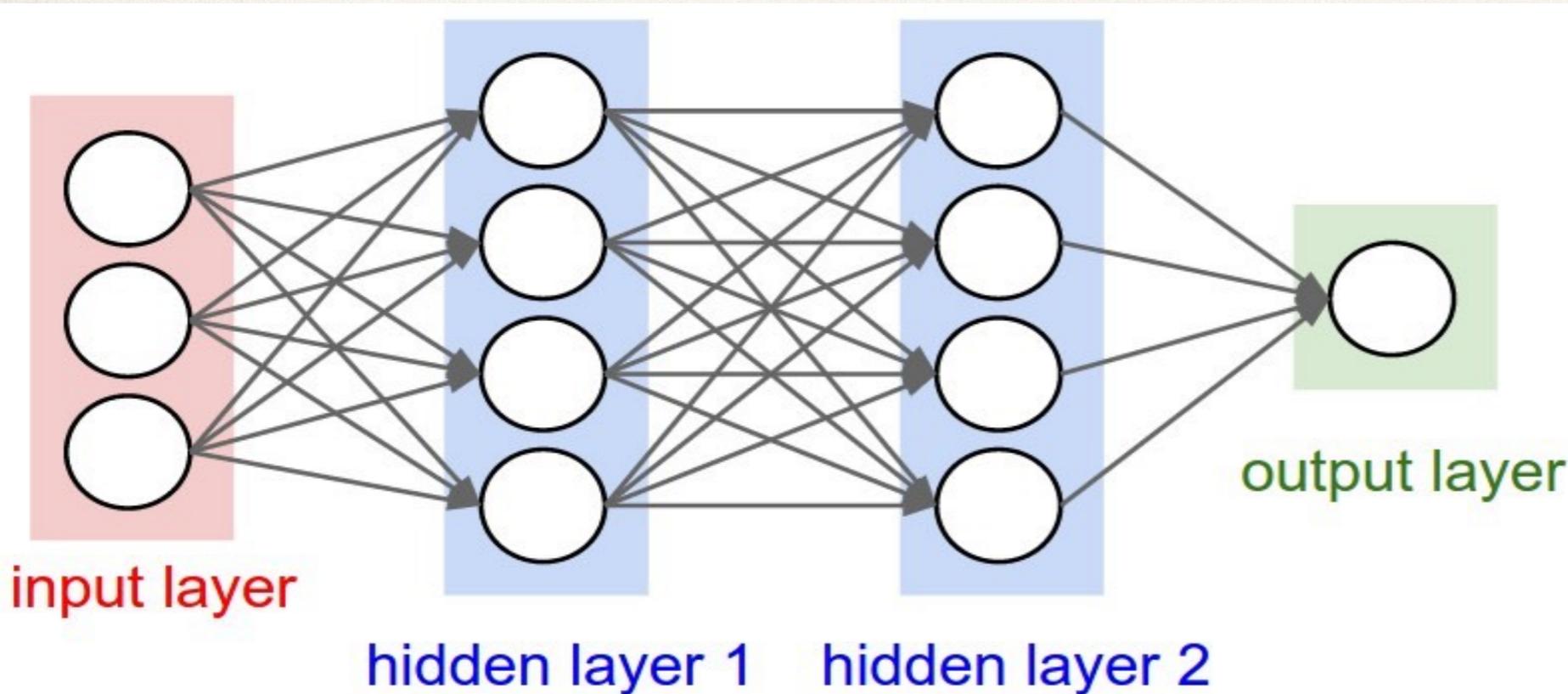
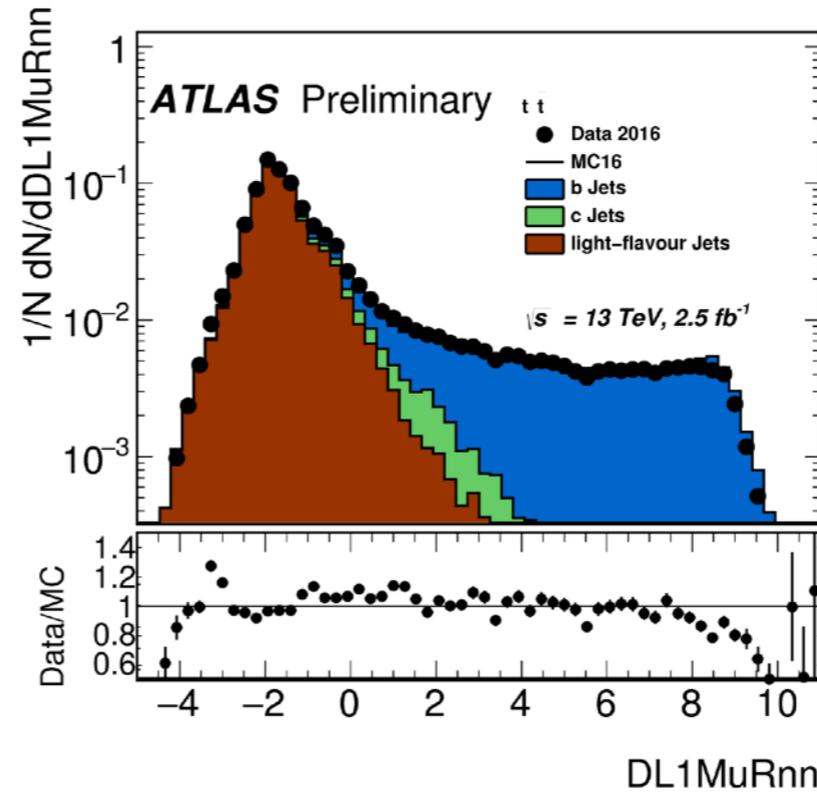
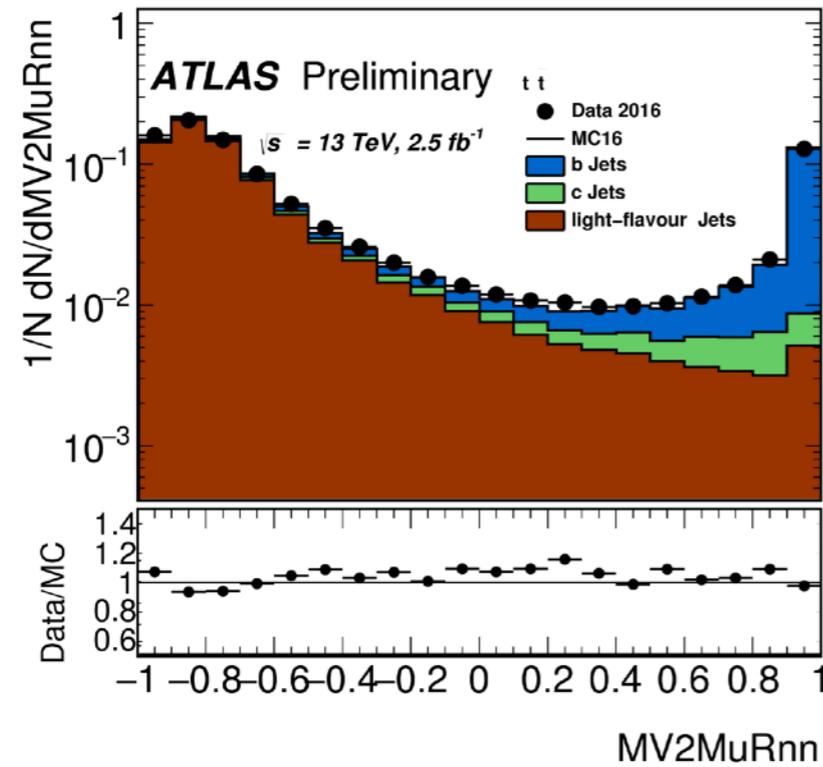
impulso	lunghezza decadimento
60 GeV	~ 4.3 mm
200 GeV	~ 14 mm
2 TeV	~ 14 cm

Variabili discriminanti

Input	Variable	Description
Kinematics	$p_T(jet)$	Jet transverse momentum
	$\eta(jet)$	Jet pseudo-rapidity
IP2D, IP3D	$\log(P_b/P_{light})$	Likelihood ratio between the b - and light jet hypotheses
	$\log(P_b/P_c)$	Likelihood ratio between the b - and c -jet hypotheses
	$\log(P_c/P_{light})$	Likelihood ratio between the c - and light jet hypotheses
SV	$m(SV)$	Invariant mass of tracks at the secondary vertex assuming pion masses
	$f_E(SV)$	Fraction of the charged jet energy in the secondary vertex
	$N_{TrkAtVtx}(SV)$	Number of tracks used in the secondary vertex
	$N_{2TrkVtx}(SV)$	Number of two track vertex candidates
	$L_{xy}(SV)$	Transverse distance between the primary and secondary vertices
	$L_{xyz}(SV)$	Distance between the primary and secondary vertices
	$S_{xyz}(SV)$	Distance between the primary and secondary vertices divided by its uncertainty
	$\Delta R(jet, SV)$	ΔR between the jet axis and the direction of the secondary vertex relative to the primary vertex
Jet Fitter	$N_{2TrkVtx}(JF)$	Number of 2-track vertex candidates (prior to decay chain fit)
	$m(JF)$	Invariant mass of tracks from displaced vertices assuming pion masses
	$S_{xyz}(JF)$	Significance of the average distance between the primary and displaced vertices
	$f_E(JF)$	Fraction of the charged jet energy in the secondary vertices
	$N_{1-trk\ vertices}(JF)$	Number of displaced vertices with one track
	$N_{\geq 2-trk\ vertices}(JF)$	Number of displaced vertices with more than one track
	$N_{TrkAtVtx}(JF)$	Number of tracks from displaced vertices with at least two tracks
	$\Delta R(\vec{p}_{jet}, \vec{p}_{vtx})$	ΔR between the jet axis and the vectorial sum of the momenta of all tracks attached to displaced vertices

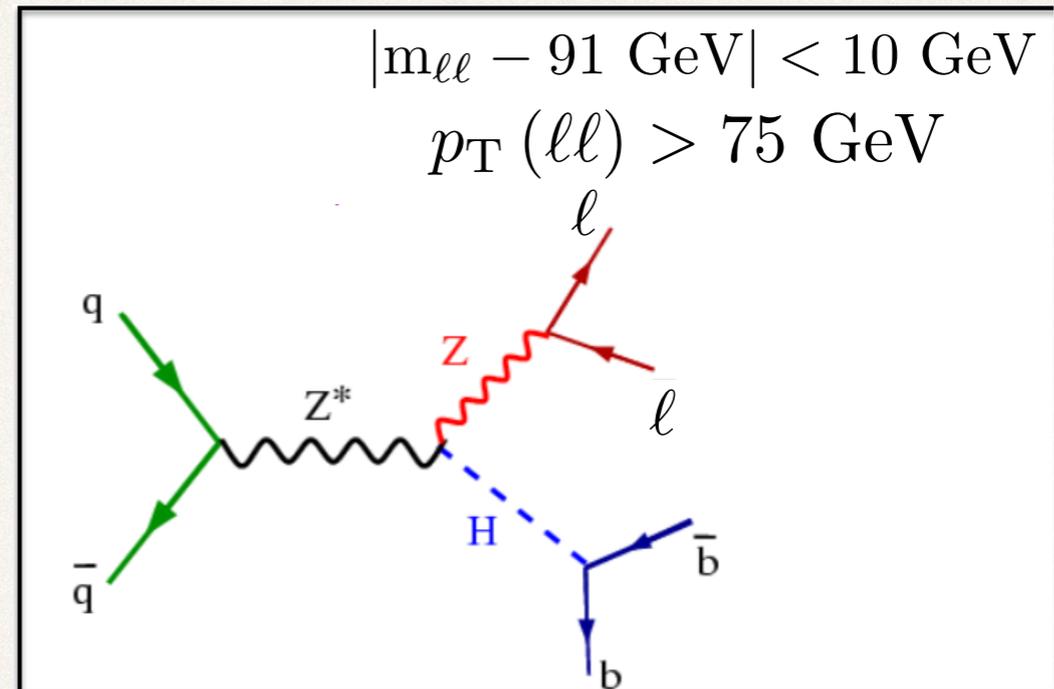


Analisi dati con Machine Learning



Selezione dei dati per Higgs in quark beauty

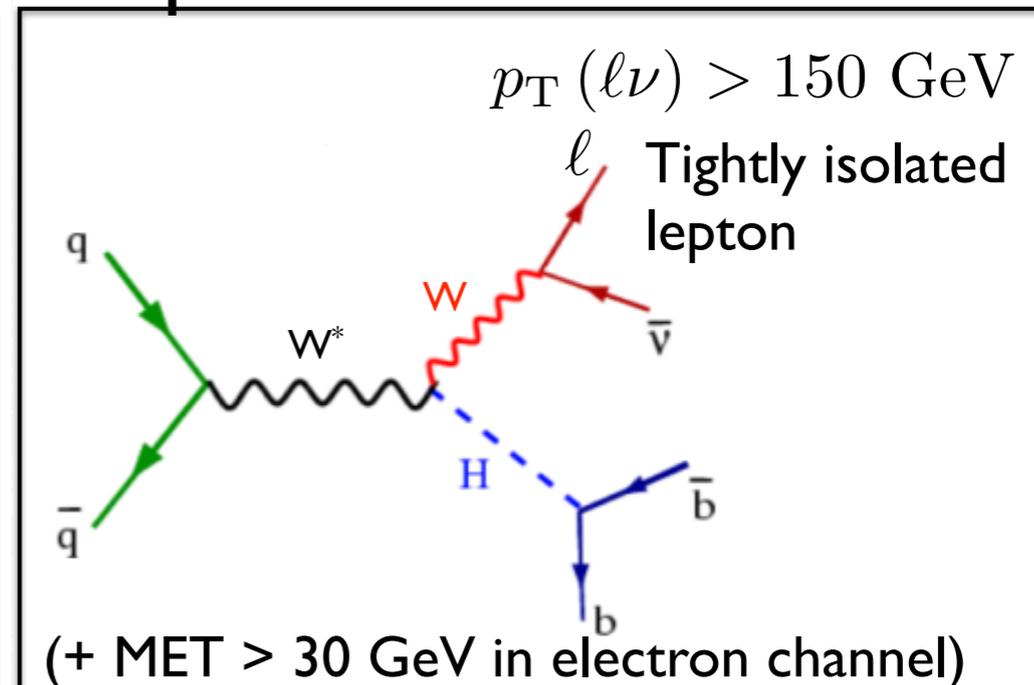
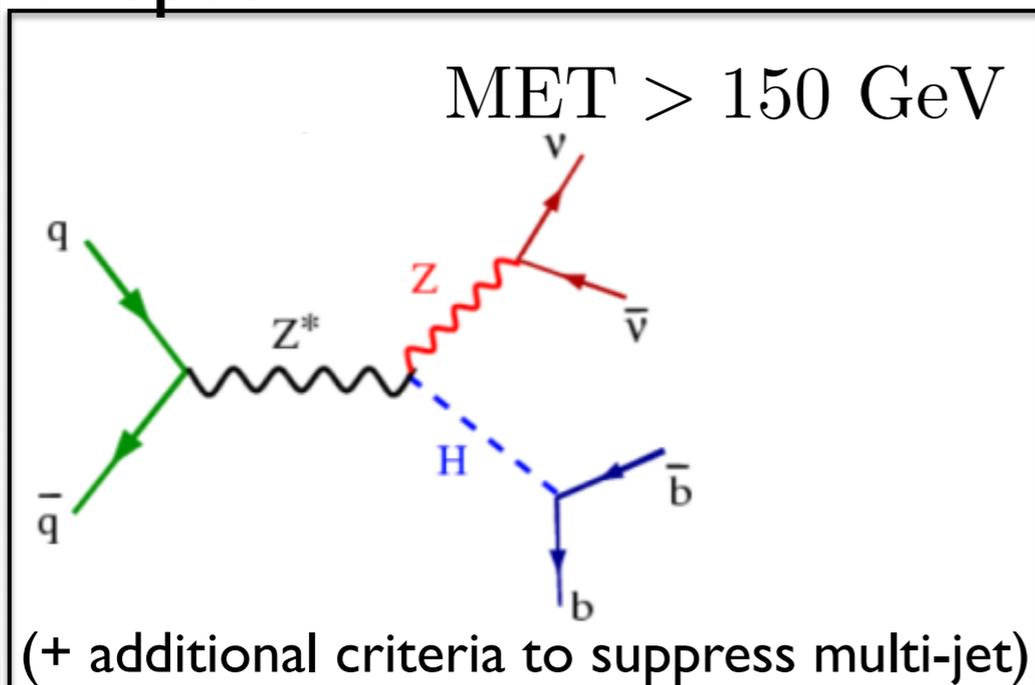
- tre canali a seconda del numero di leptoni
- ricostruzione dei prodotti di decadimento e loro calibrazione
- stima dei fondi con simulazione e regioni di controllo
- analisi multi-variata per discriminare il segnale dal fondo



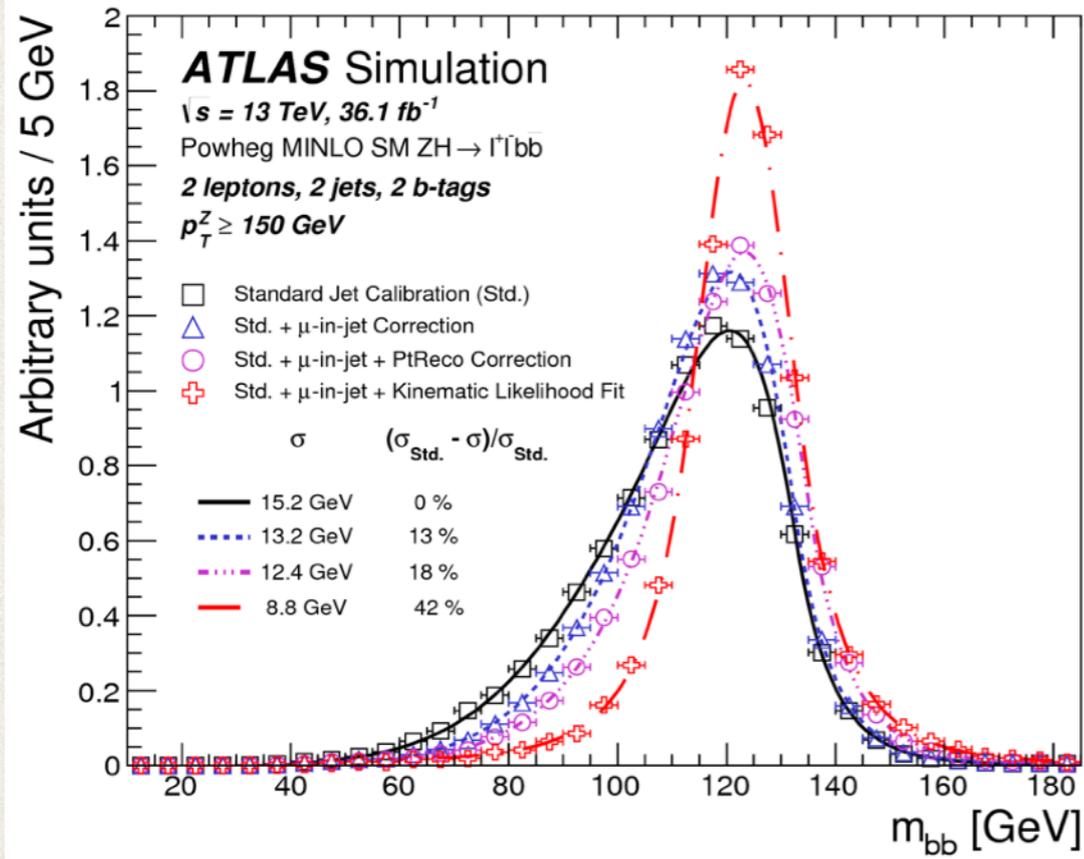
2-lepton

1-lepton

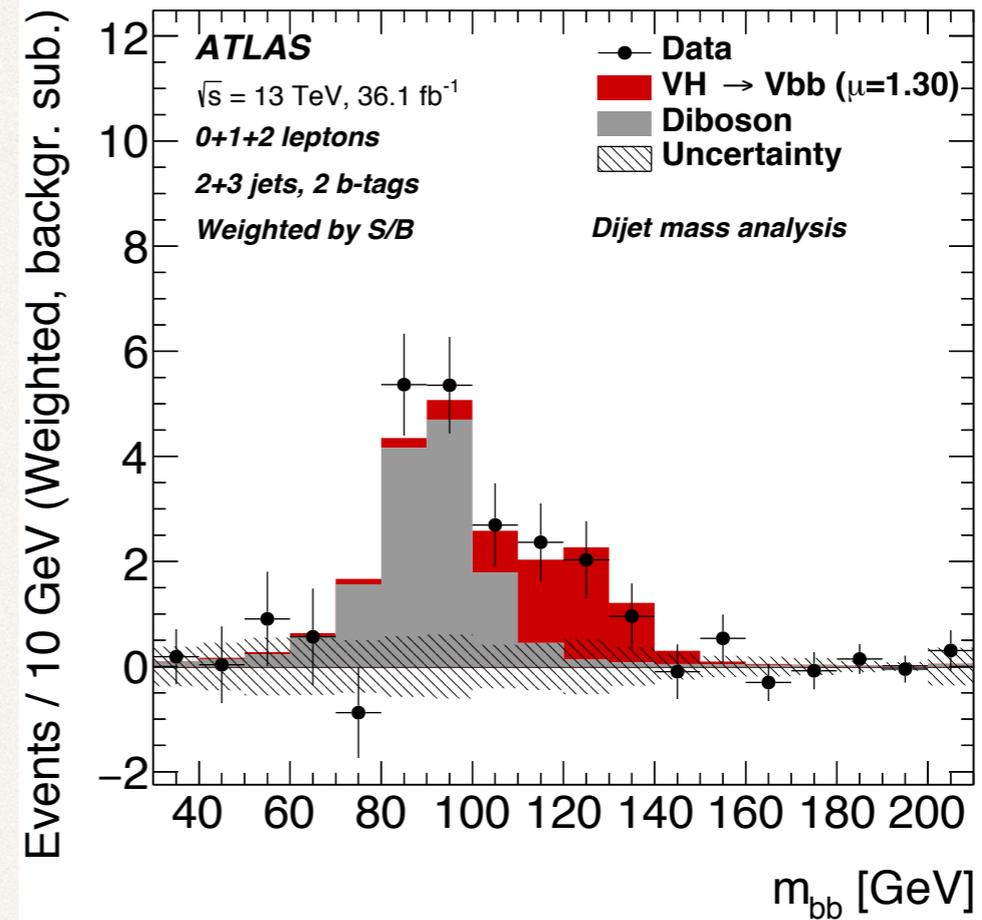
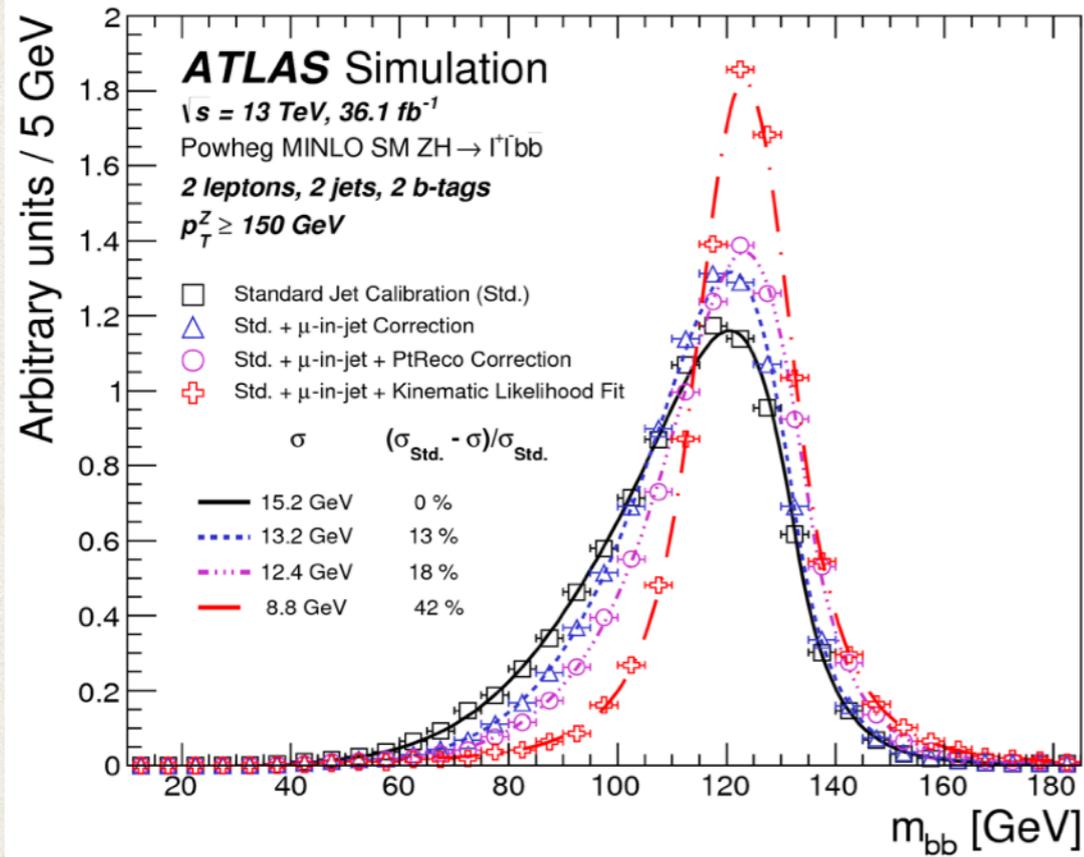
0-lepton



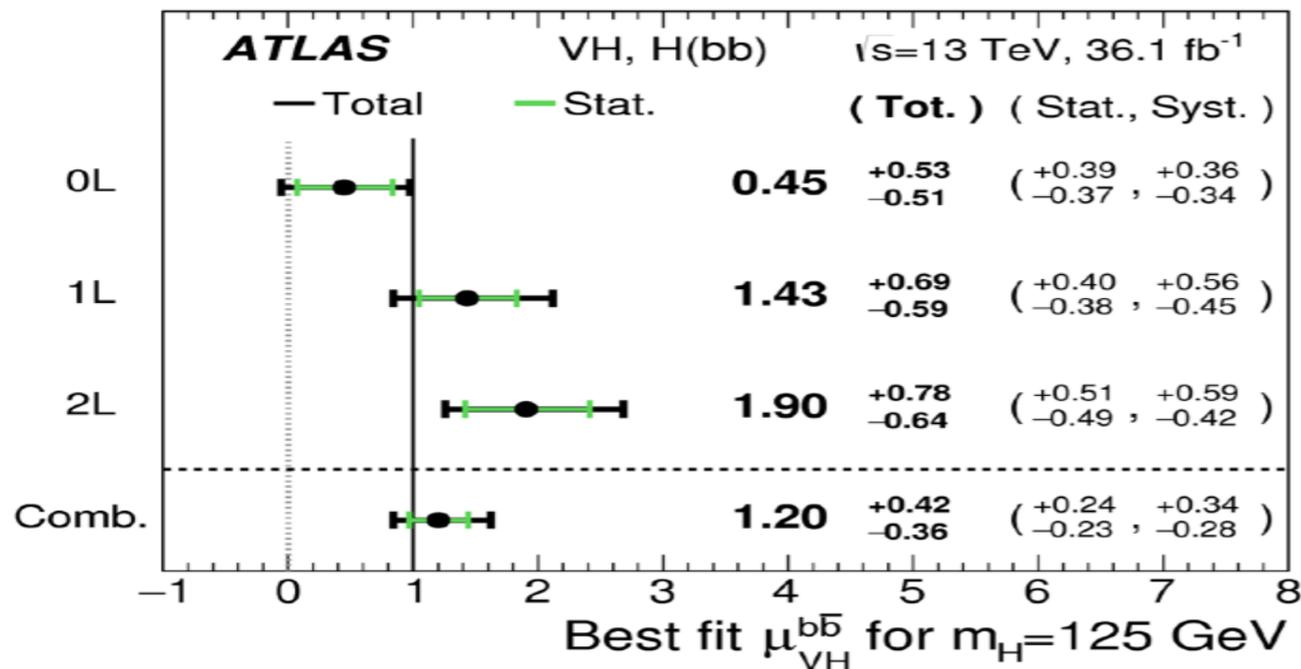
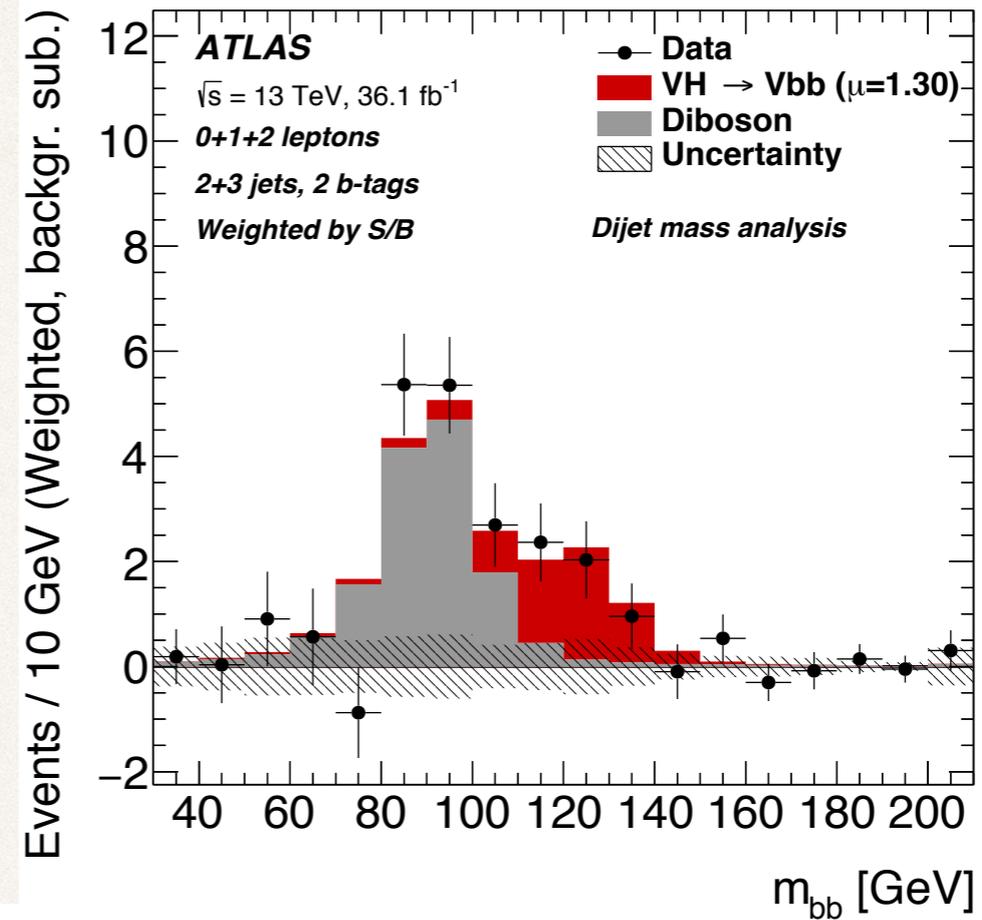
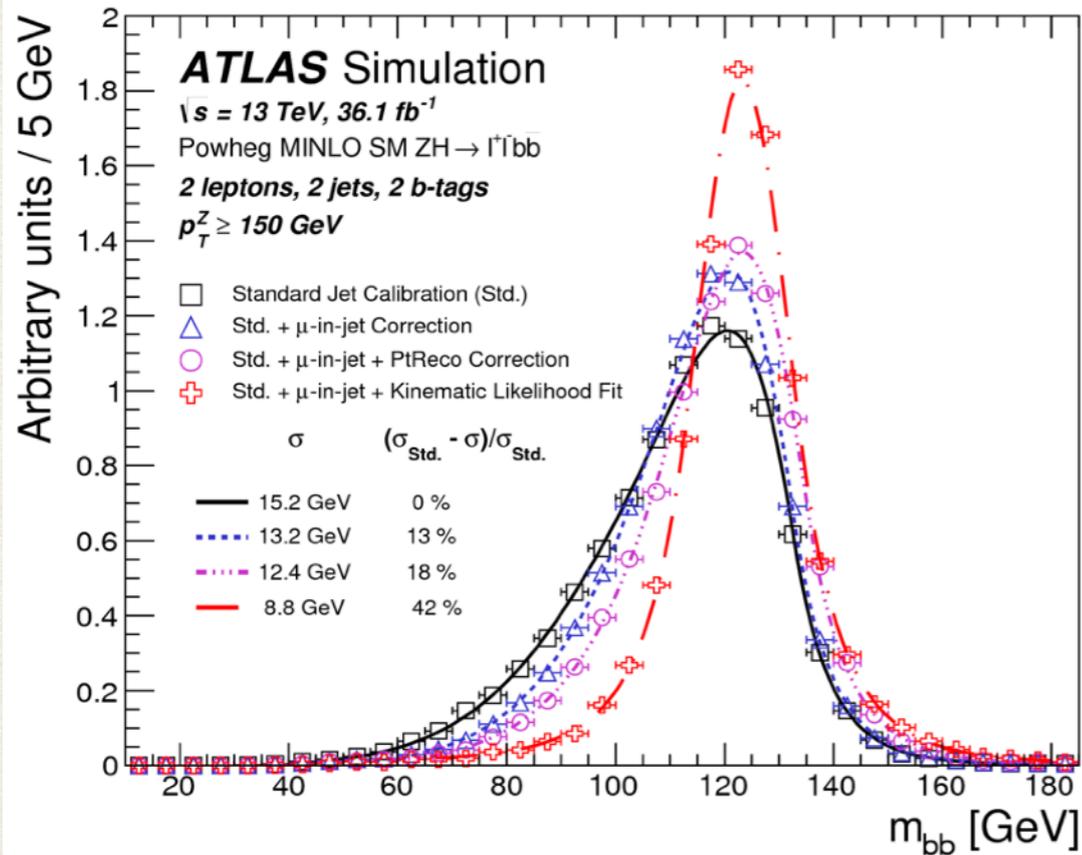
Evidenza dell'accoppiamento con i quark beauty



Evidenza dell'accoppiamento con i quark beauty



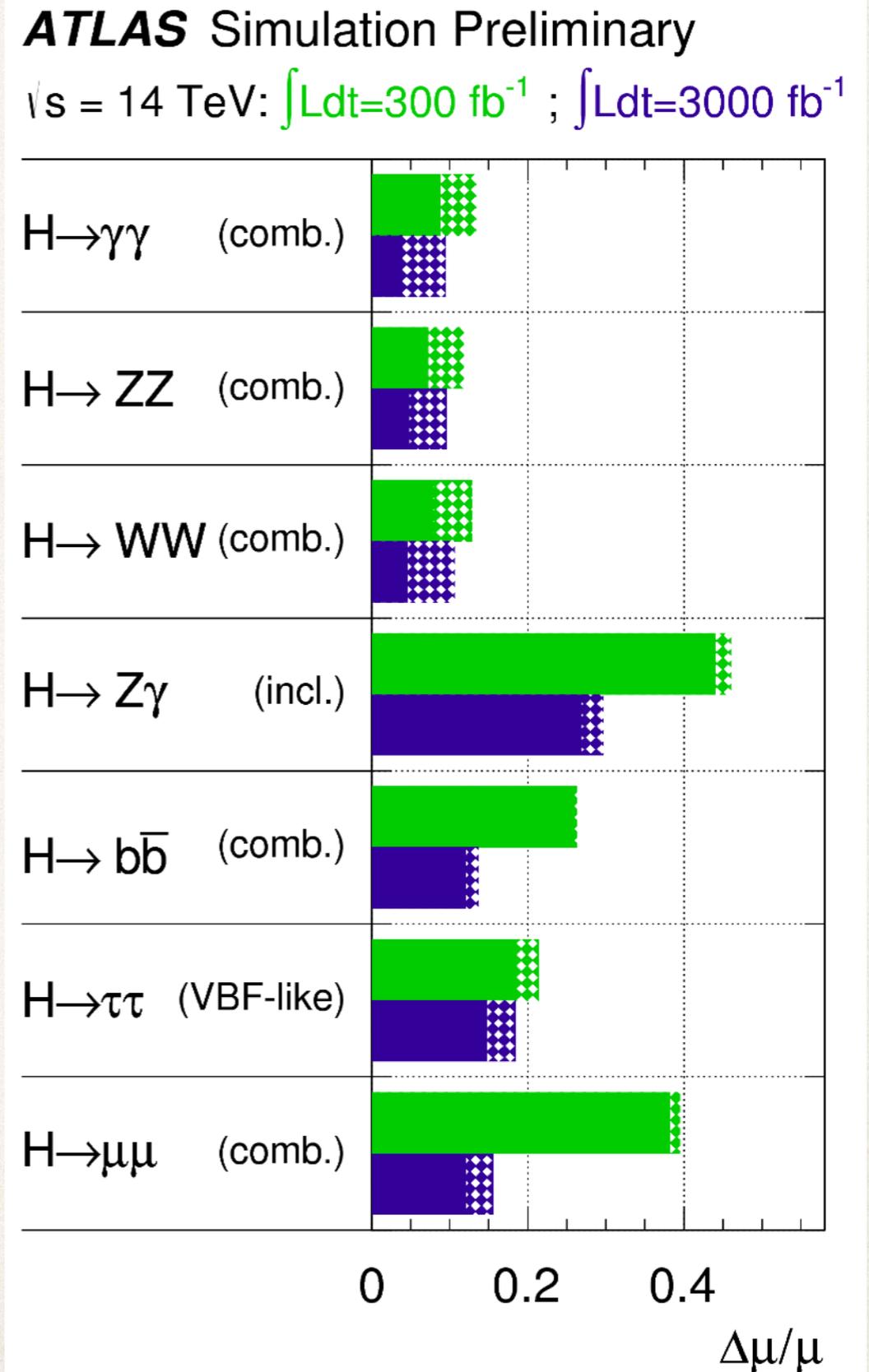
Evidenza dell'accoppiamento con i quark beauty



Significanza dell'eccesso di eventi rispetto all'ipotesi di assenza di segnale 3.5σ

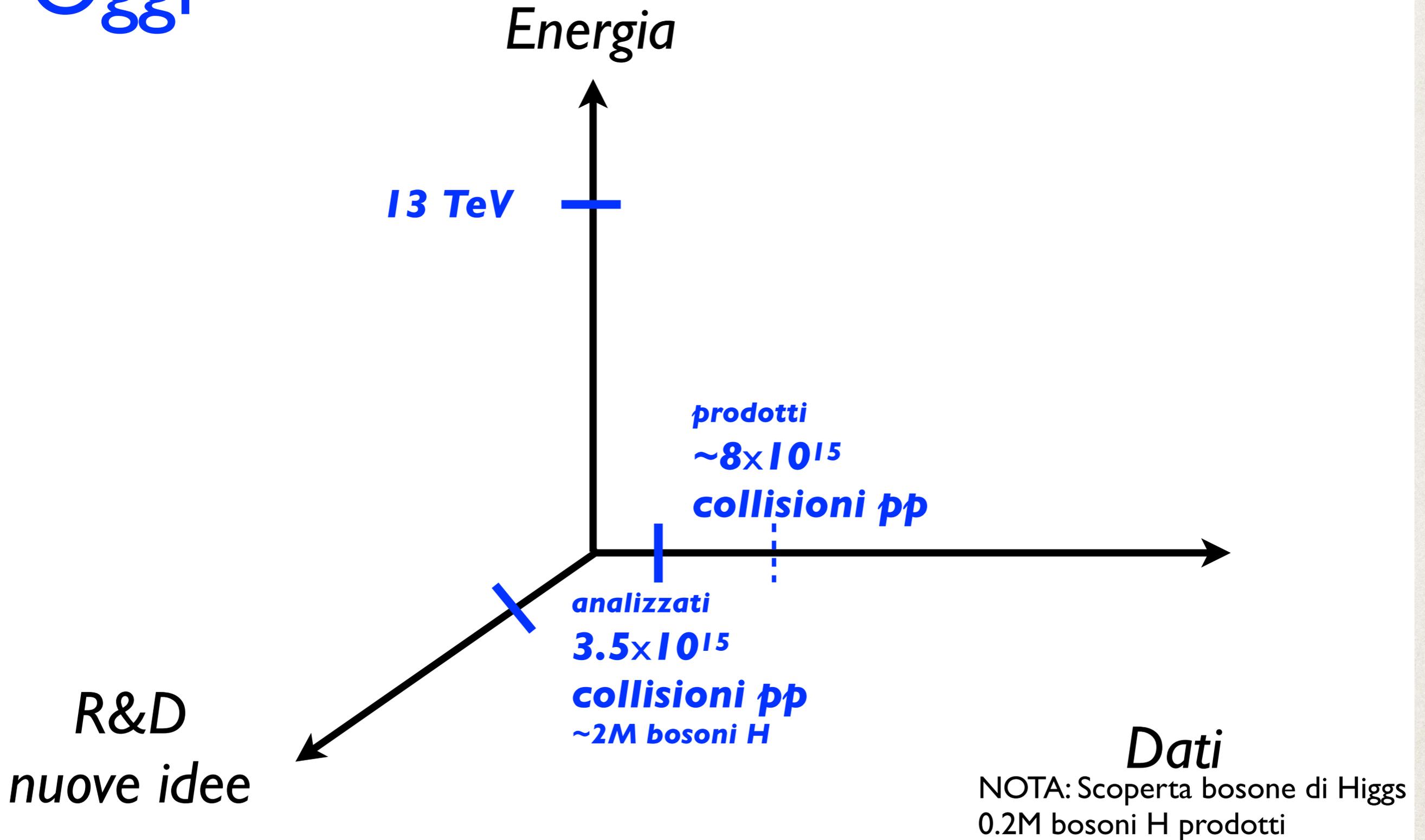
Bosone di Higgs, what next?

- osservazione di processi rari di produzione e decadimento
- ricerca di decadimenti 'esotici' del bosone di Higgs
- misura con tecniche sperimentali 'boost'
- misure di proprietà di spin/CP e distribuzioni differenziali
- auto-accoppiamento
- ricerca di altri bosoni di Higgs a masse più elevate
- test di compatibilità del Modello Standard
- etc.



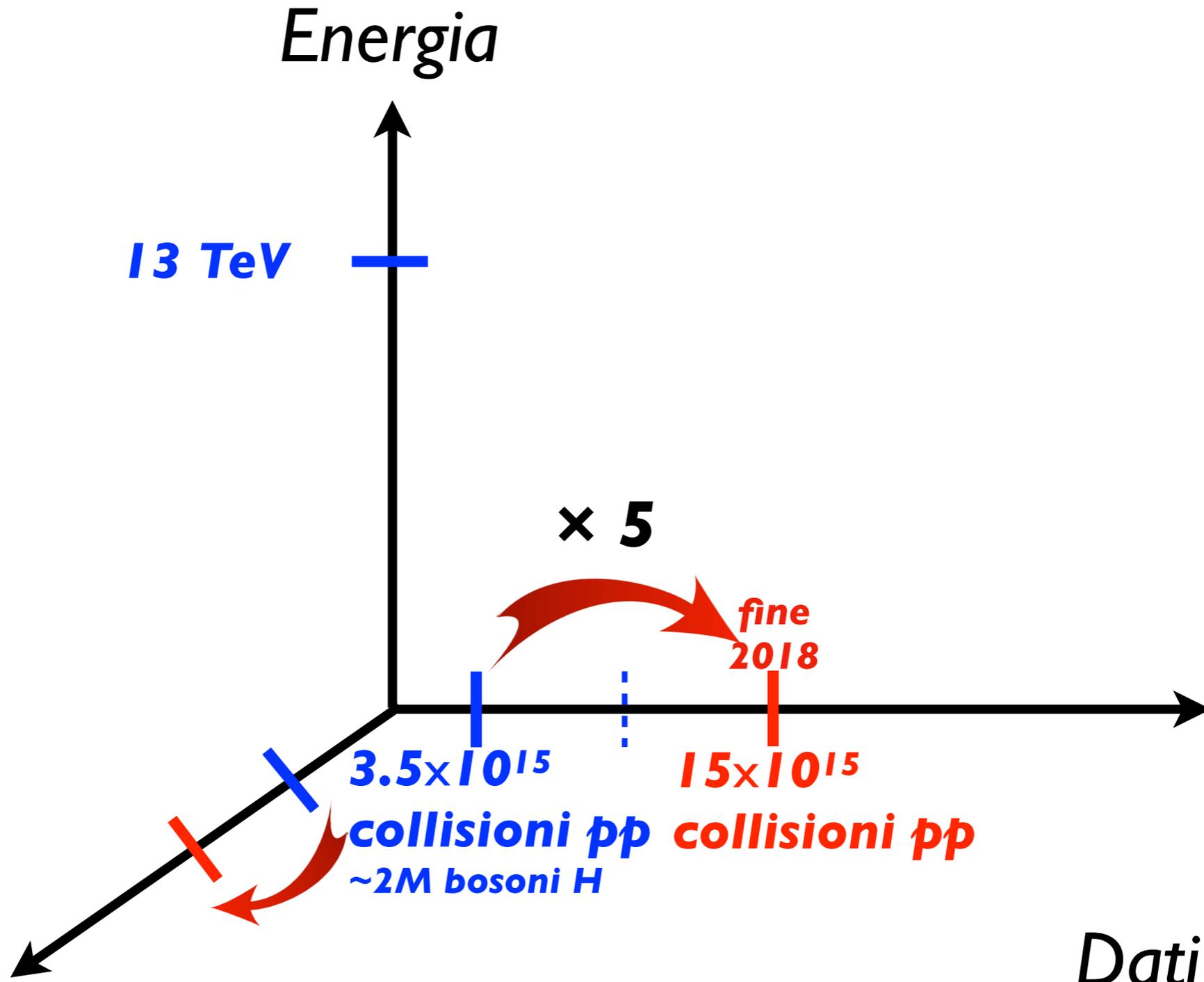
What next?

Oggi



What next?

Oggi
Master

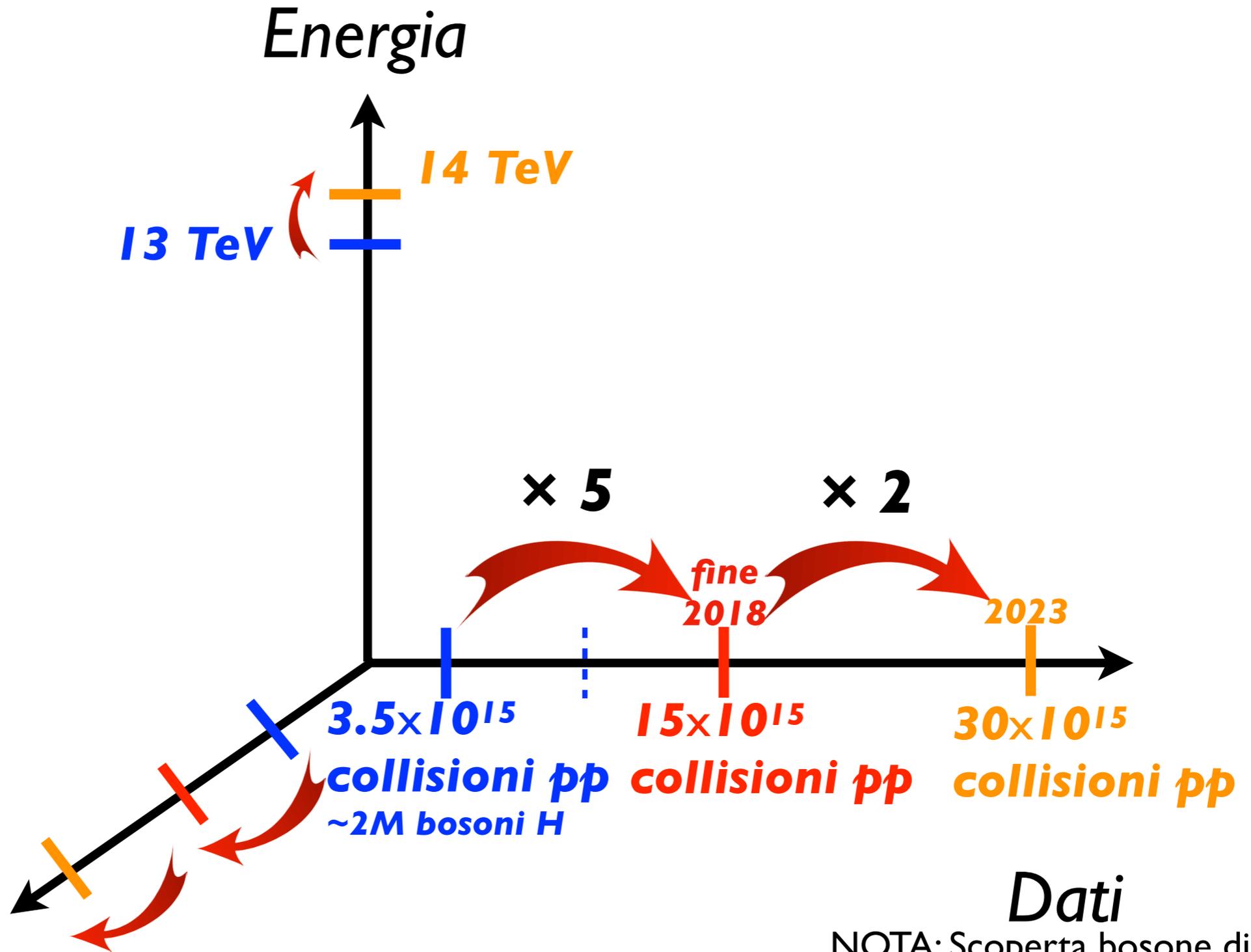


R&D nuove idee

Dati
NOTA: Scoperta bosone di Higgs
0.2M bosoni H prodotti

What next?

Oggi
Master
PhD

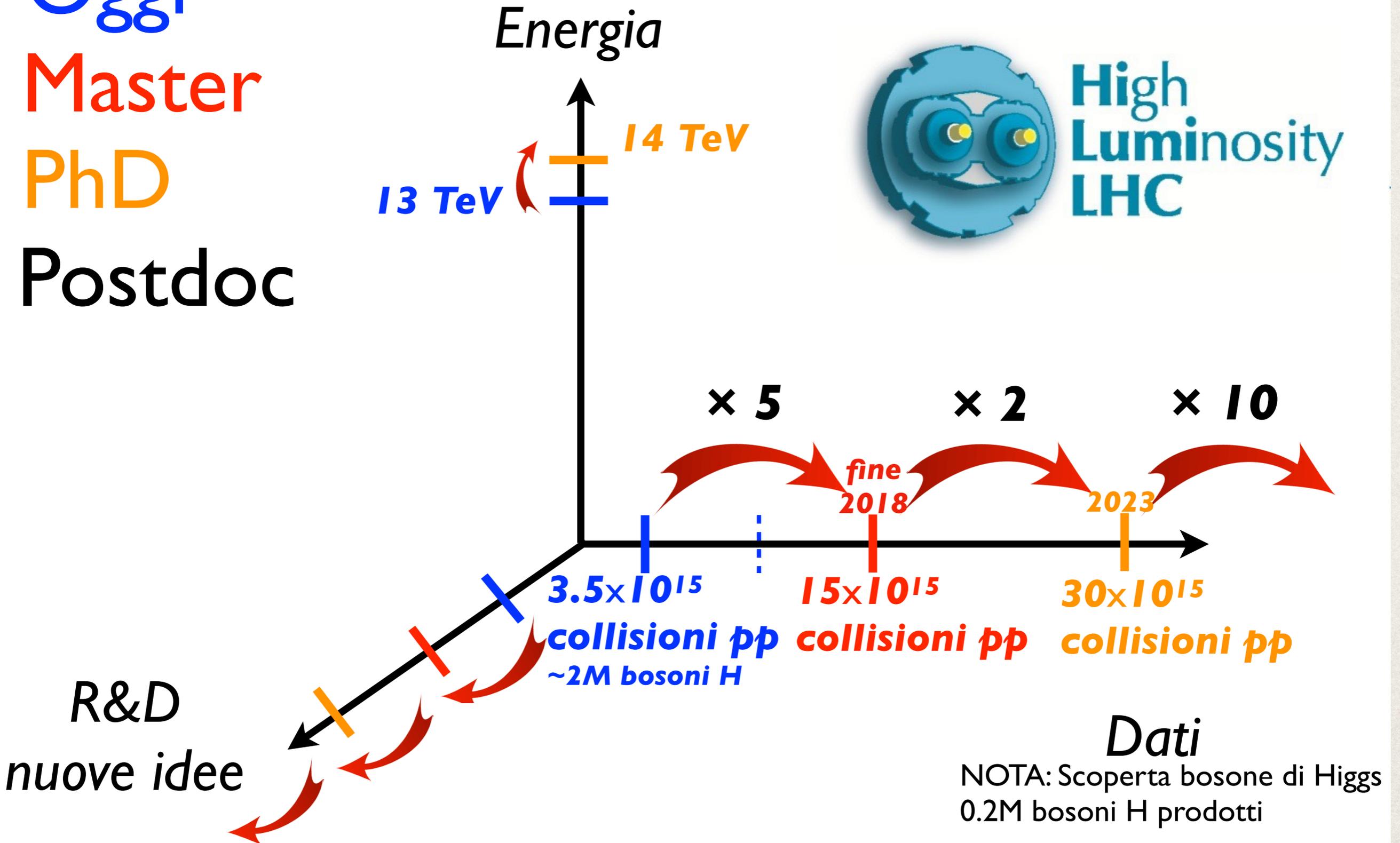


R&D
nuove idee

Dati
NOTA: Scoperta bosone di Higgs
0.2M bosoni H prodotti

What next?

Oggi
Master
PhD
Postdoc



Il gruppo ATLAS a Genova

PROPOSTE DI TESI NELL'ESPERIMENTO



ATLAS A LHC



CHI SIAMO

ATLAS è un esperimento di fisica delle particelle elementari che studia le collisioni prodotte dal **Large Hadron Collider** del **CERN** di Ginevra.

Il risultato più eclatante ottenuto finora è stata la **scoperta del bosone di Higgs** e la **prima misura delle sue proprietà**.

Attualmente è in corso un **periodo di presa dati** ad una energia di **13 TeV** e una intensità di collisioni senza precedenti, ma allo stesso tempo ci si prepara ad una **futura presa dati ad intensità ancora maggiore** (HL-LHC, High Luminosity LHC).

Il gruppo **ATLAS Genova**, associato al **CERN** e all'**INFN**, è composto da una ventina di persone, inclusi postdoc e dottorandi.

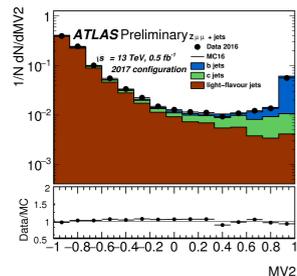
DOVE LAVORIAMO

Le attività del gruppo si svolgono sia nel **Dipartimento di Fisica di Genova**, sia presso i **laboratori del CERN**.

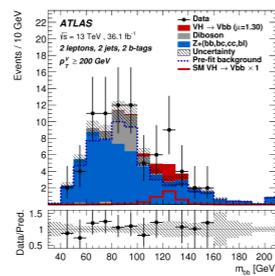
Il candidato parteciperà di persona o in videoconferenza a **riunioni della collaborazione internazionale ATLAS** presentando i risultati della propria attività.

TEMI DI RICERCA ARGOMENTO DI TESI DI LAUREA E DOTTORATO

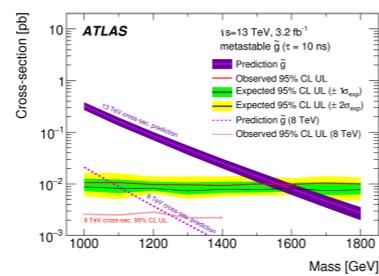
IDENTIFICAZIONE DI B-JET



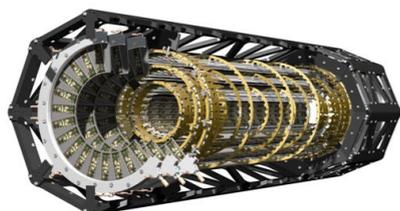
FISICA DELL'HIGGS



RICERCA DI NUOVE PARTICELLE



SVILUPPO DI RIVELATORI A PIXEL



CONTATTI PRINCIPALI, SITO E ULTERIORI DETTAGLI

Persone

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C. Schiavi (carlo.schiavi@ge.infn.it, S823)

Sito Web

<http://atlas-ge.weebly.com/tesi.html>



PROPOSTE DI TESI NELL'ESPERIMENTO



ATLAS A LHC



RICERCA DI PARTICELLE SUPERSIMMETRICHE O ESOTICHE CON IONIZZAZIONE ANOMALA
SEARCH FOR ANOMALOUSLY IONIZING SUPERSYMMETRIC OR EXOTIC PARTICLES

Tag: Supersymmetry, Dark Matter, Data Analysis

MISURA DELLA IONIZZAZIONE SPECIFICA NEL RIVELATORE A PIXEL DI ATLAS
SPECIFIC IONISATION MEASUREMENT IN THE ATLAS PIXEL DETECTOR

Tag: Pixel Detector, Data Analysis

MISURA DELLA SEZIONE D'URTO DI PRODUZIONE ASSOCIATA DI W+CHARM
MEASUREMENT OF ASSOCIATED W+CHARM PRODUCTION CROSS SECTION

Tag: Standard Model Physics, Data Analysis

STUDIO DEL DECADIMENTO DEL BOSONE DI HIGGS IN COPPIE DI QUARK BEAUTY IN DIVERSI PROCESSI DI PRODUZIONE
STUDY OF THE HIGGS BOSON DECAY TO BEAUTY QUARK PAIRS EXPLOITING DIFFERENT PRODUCTION MECHANISMS

Tag: Standard Model Physics, Higgs Physics, Data Analysis, Deep Learning

SVILUPPO DI NUOVI ALGORITMI PER L'IDENTIFICAZIONE DI JET BEAUTY O CHARM CON TECNICHE DI DEEP LEARNING
DEVELOPMENT OF NEW BEAUTY- AND CHARM-TAGGING ALGORITHMS USING DEEP LEARNING TECHNIQUES

Tag: Data Analysis, Flavour Tagging, Deep Learning

CONSTRUZIONE DEL PRIMO PROTOTIPO PER IL RIVELATORE A PIXEL DI ATLAS IN HL-LHC
CONSTRUCTION OF A FULL PROTOTYPE OF THE ATLAS PIXEL DETECTOR AT THE HL-LHC

Tag: Pixel Sensors, Future Pixel Detectors, High-Luminosity LHC

SVILUPPO DELL'ELETTRONICA DI LETTURA PER IL RIVELATORE A PIXEL DI ATLAS IN HL-LHC
DEVELOPMENT OF A READOUT SYSTEM FOR THE ATLAS PIXEL DETECTOR AT THE HL-LHC

Tag: Readout, Future Pixel Detectors, High-Luminosity LHC

CONTATTI

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La lista aggiornata dei titoli e una loro descrizione dettagliata sono disponibili alla pagina:
<http://atlas-ge.weebly.com/tesi.html>



Grazie per l'attenzione!

Fjällräven Polar 2018

**Support Andrea Coccaro's application for a 300 km
polar expedition by Fjällräven**

Application open until Dec 14th, 2017

<http://polar.fjallraven.com/contestant/?id=3662>

