Physics at LHC (with ATLAS)

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Georgian Teachers' Programme

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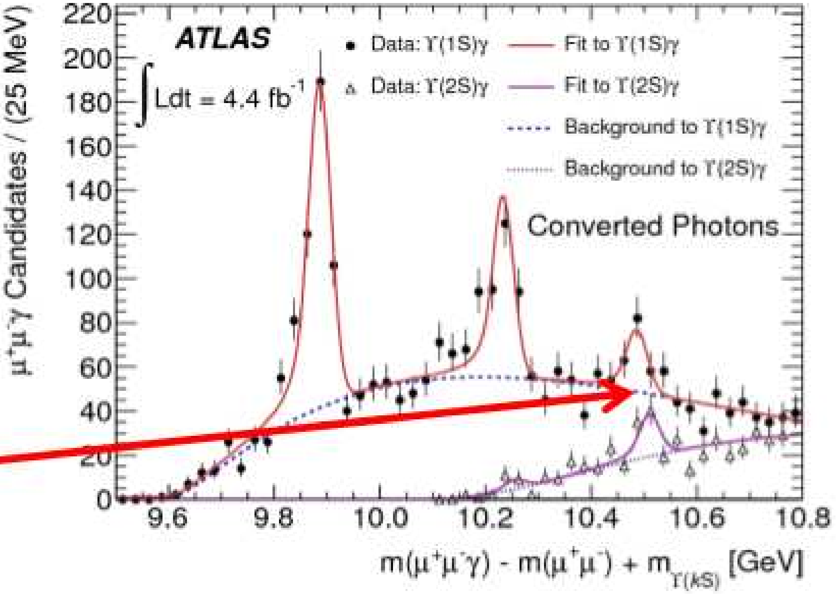
Vakhtang (Vato) Kartvelishvili

- Graduated from Ivane Javakhishvili Tbilisi State University in 1976
- PhD at IHEP (Protvino) in 1979, worked for HEPI TSU for many years
- Since 2001: permanent position (Readership) at Lancaster University, UK
- Created and lead Quarkonium physics subgroup in ATLAS since 2006
- Lead a number of published measurements on J/ψ, Upsilon production in ATLAS

One of them resulted in the DISCOVERY OF THE FIRST NEW PARTICLE AT LHC:

Phys. Rev. Lett. 108 (2012) 152001

χb(3P)

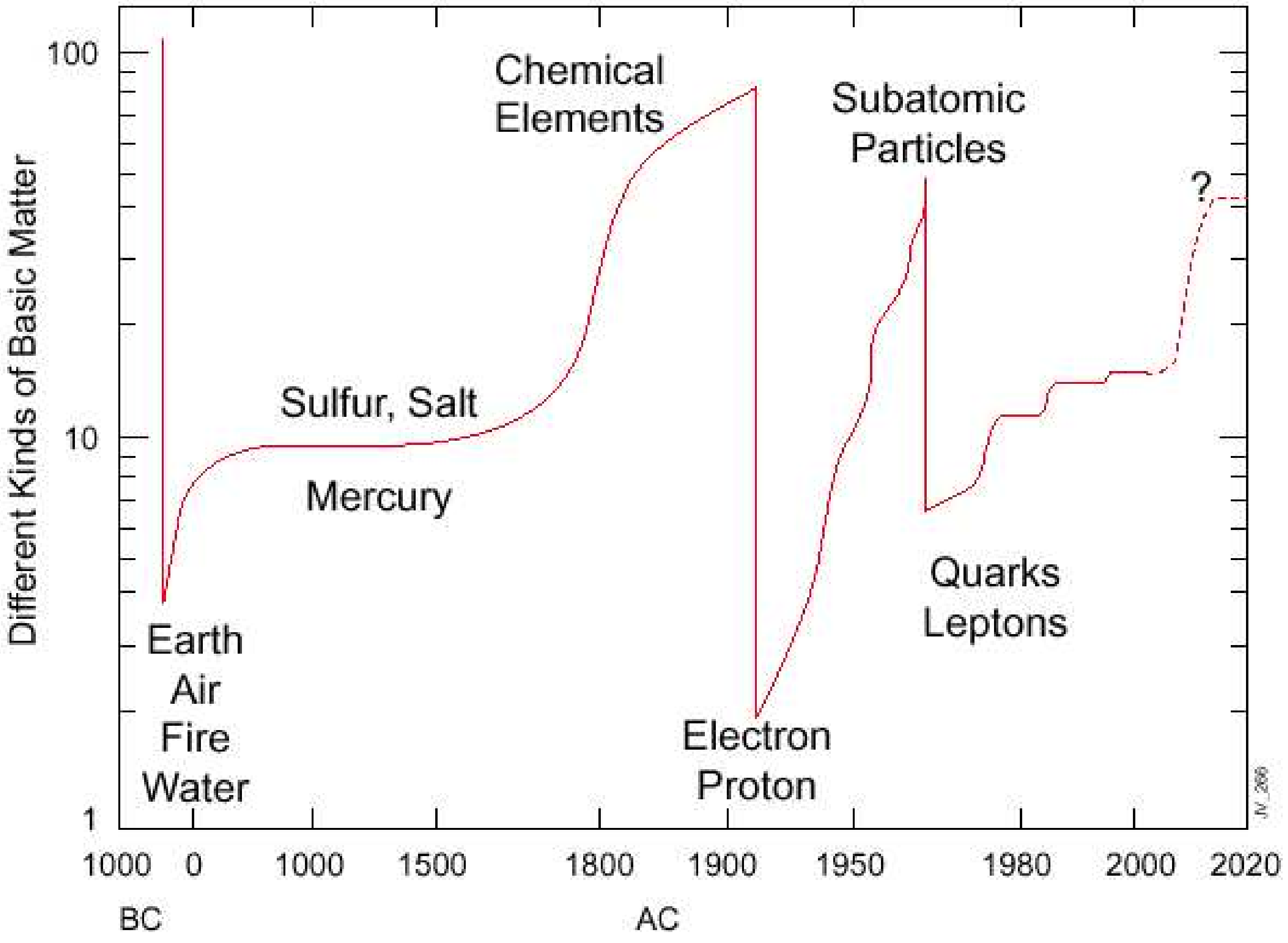


- Now finalizing several measurements with Run I data, preparing for Run II

Outline

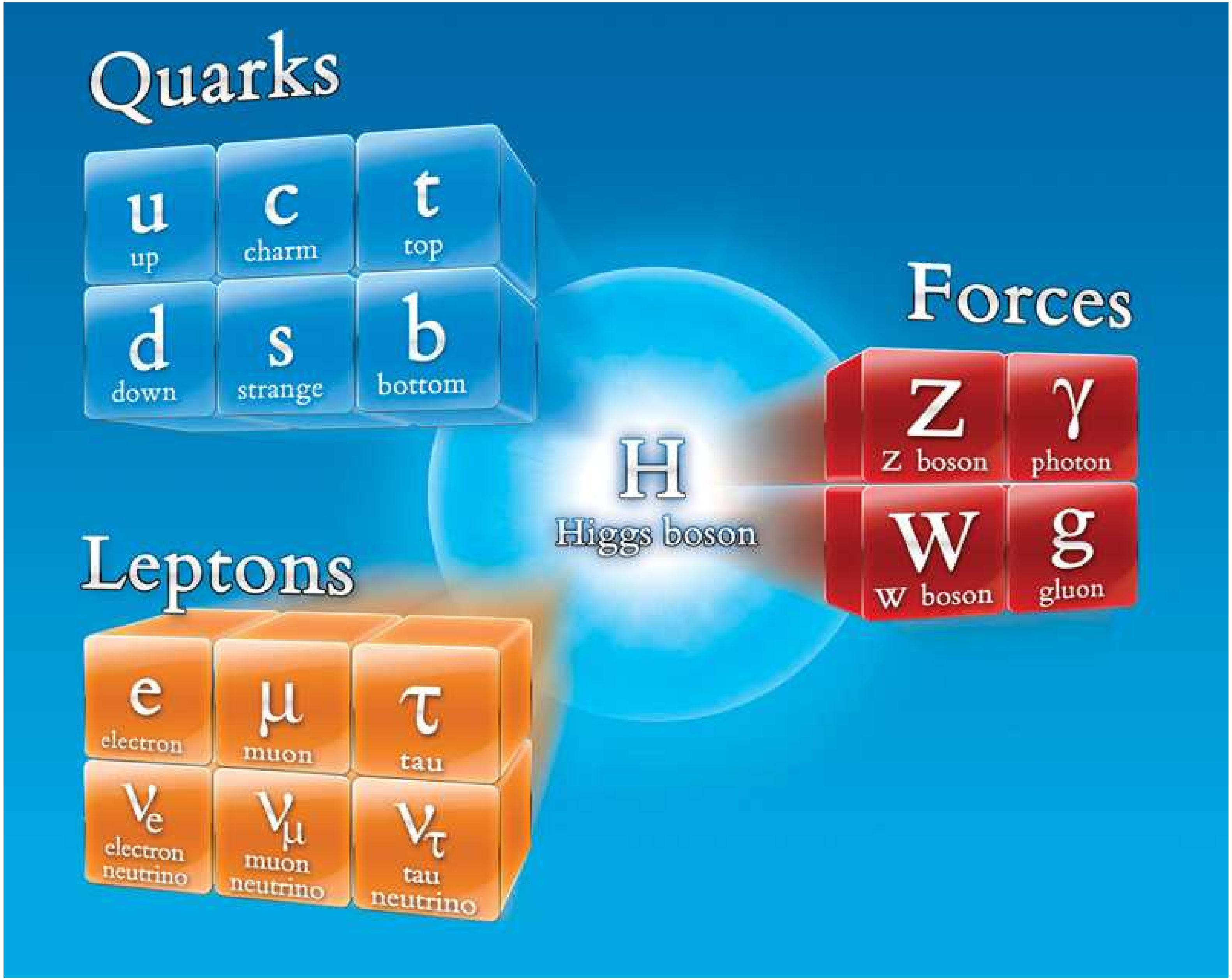
- The Standard Model (SM)
- Proton-proton collisions in terms of quarks and gluons
- Luminosity and Triggers
- Lepton pair production: $J/\psi, \Upsilon, Z, \ldots$
- Some measurements: J/ψ – prompt, non-prompt
- The first new particle discovered at LHC: $\chi_b(3P)$
- Other SM measurements: $t\bar{t}$, $W^\pm$, Z, . . .
- Observation of the Higgs Boson
- Searches for Supersymmetry, Exotics
- Summary and outlook

Constituents of Matter



From http://teachers.web.cern.ch/teachers/archiv/HST2002/webgroup/mcclean/Introduction to Particle Physics.ppt

Fundamental constituents of the Standard Model



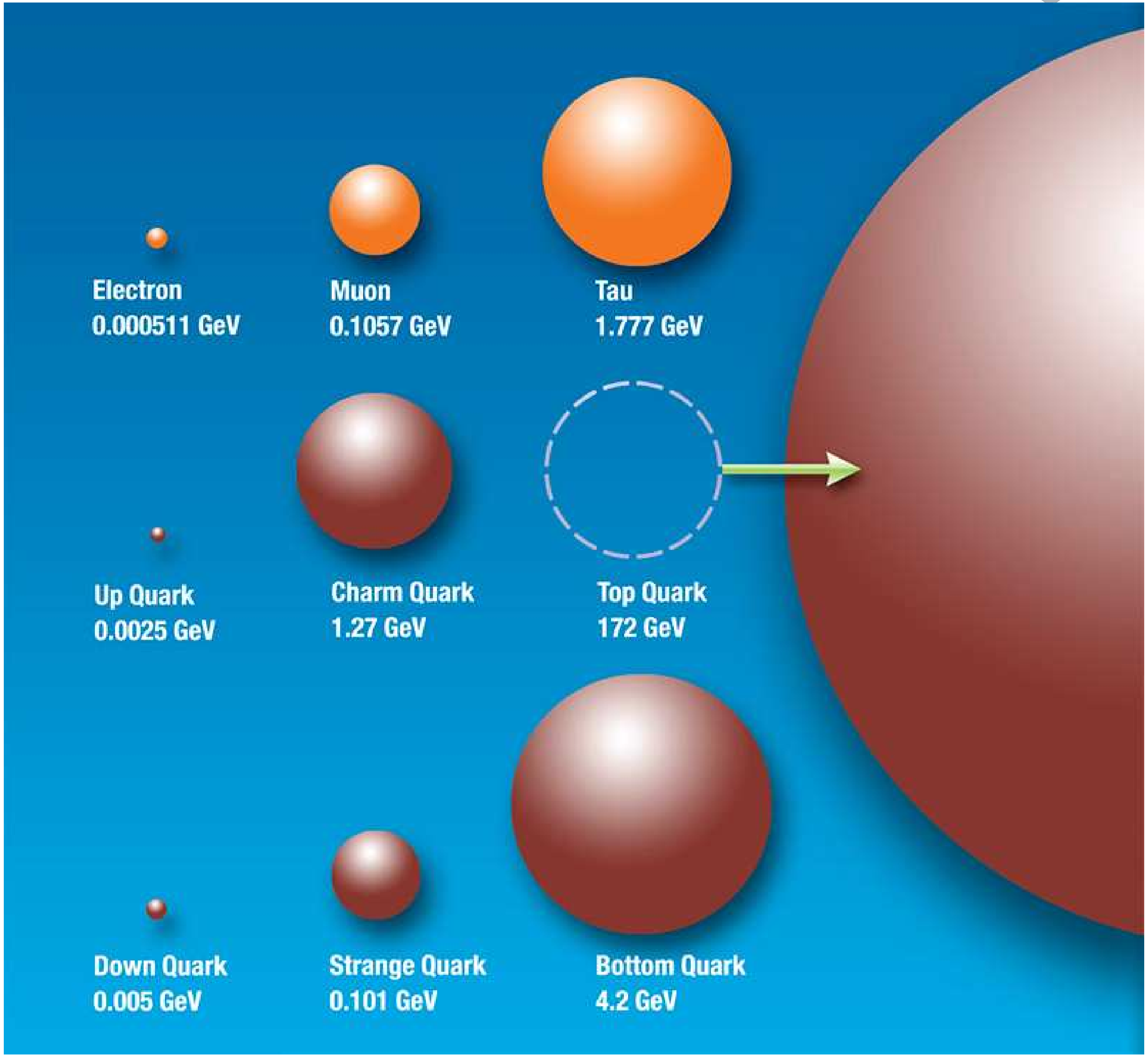
Generations and masses

Three “generations”

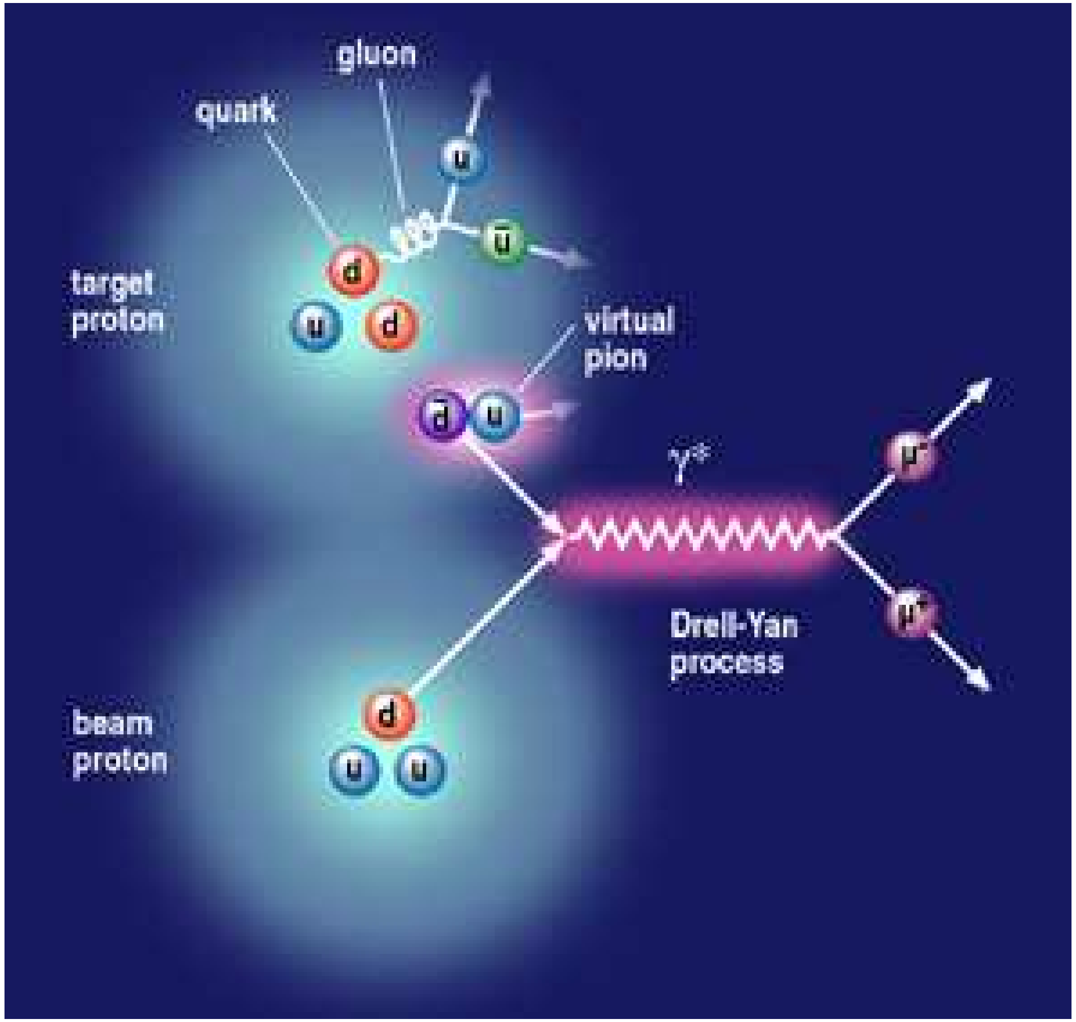
Getting heavier and heavier

Top quark especially heavy

No clue why. . .



Is LHC really a proton - proton collider?



High energy of constituents is needed to produce something new and interesting

A proton is a bunch of quarks and gluons, each carrying a fraction of energy

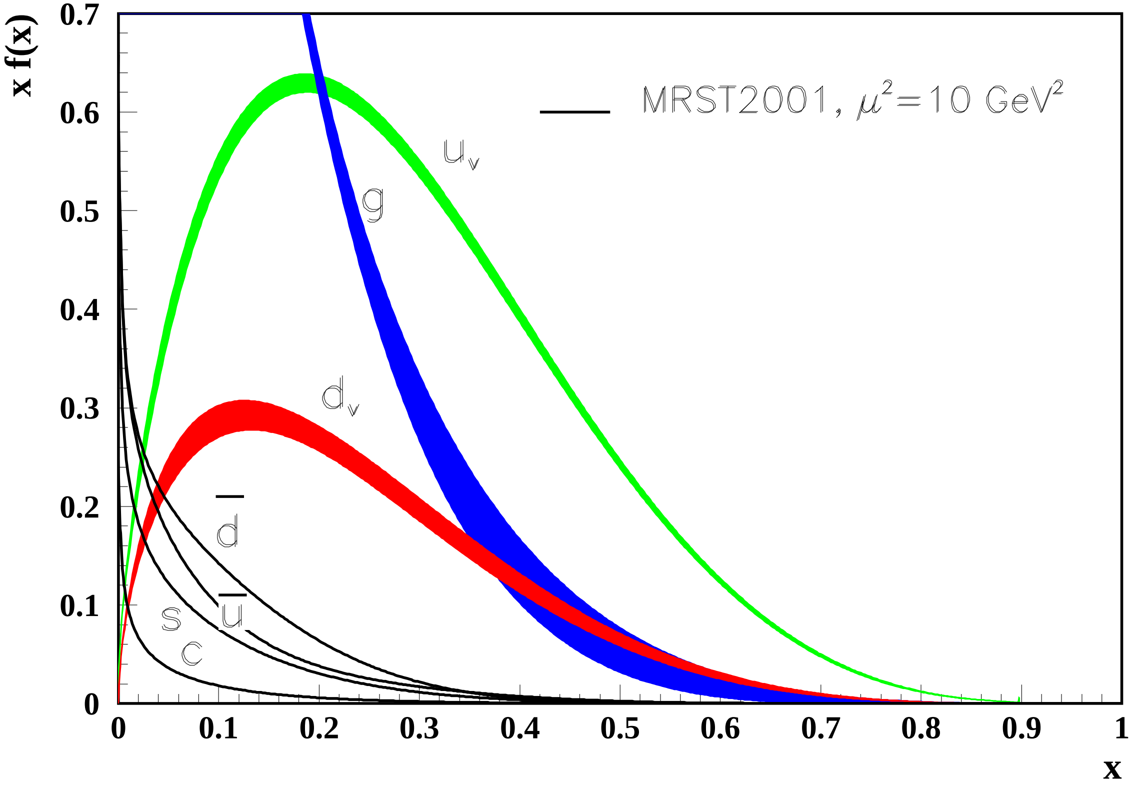
8 TeV of pp collision energy barely enough to produce a 1 TeV object. . .

Quark and gluon distributions in a proton

Only 30% of proton energy is carried by the three constituent uud quarks

Most of proton energy is carried by gluons

The "sea" of quark-antiquark pairs is also important



$$M^2 = x_1 \times x_2 \times (8\ TeV)^2$$

$$d\sigma \sim f_1(x_1) \times f_2(x_2) \times \hat{\sigma}(M^2)$$

Cross sections and units

- The intensity of various collisions is measured in terms of the cross section for particular reactions
- Cross section is the effective area which needs to be crossed by a test particle to get scattered
- Since early days of nuclear physics, measured in barns

$$1 \text{ barn} = 10^{-28} \text{ m}^2 = 100 \text{ fm}^2$$

  is about the size of lead or uranium nucleus

- Total cross section of proton-proton collisions is about 100 millibarn at 7 TeV
- Interesting processes like Higgs production have much smaller probabilities, and hence much smaller cross sections, measured in picobarns (10^{-12} barn) or femtobarns (10^{-15} barn) or even attobarns (10^{-18} barn)
- The smaller the cross section of a process, the fewer events you get
- Integrated luminosity of 100 pb^{-1} means that if the cross section is 1 pb, you will see 100 events

Luminosity

In early days of LHC:

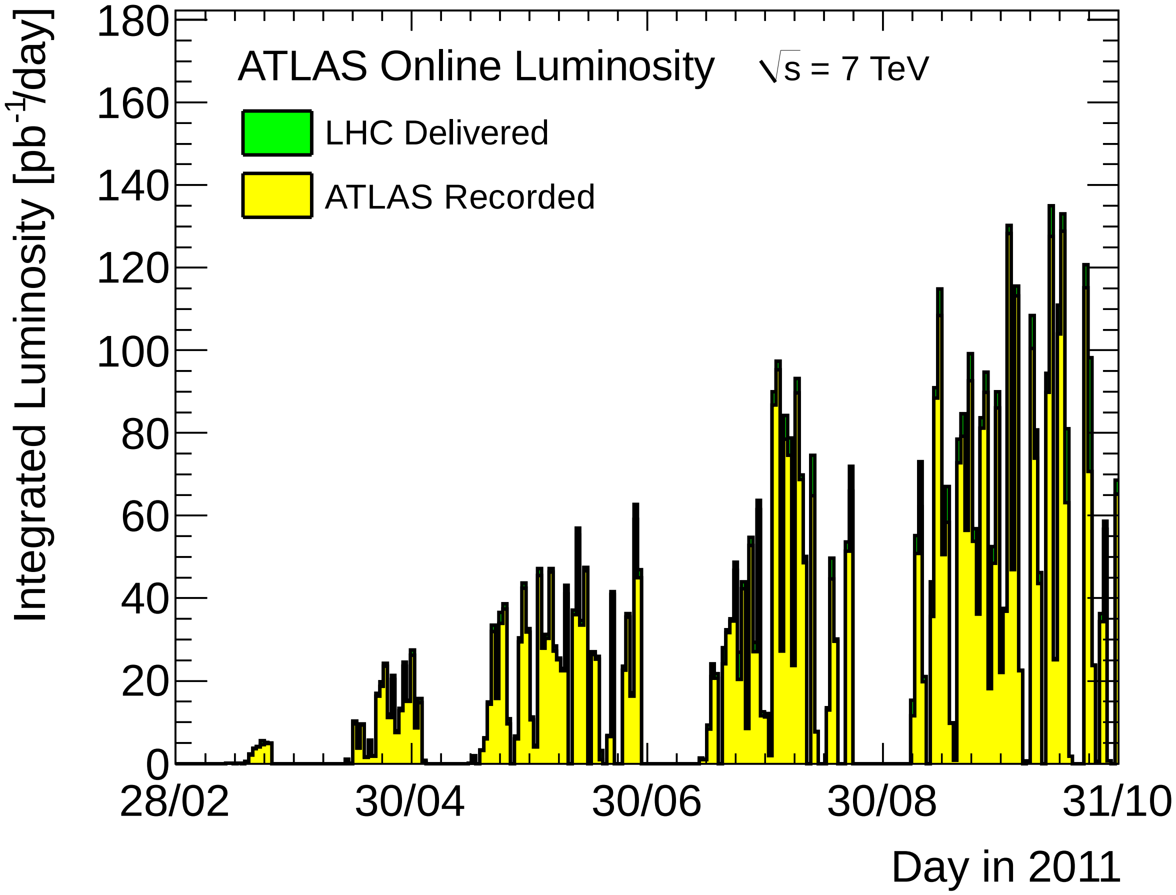
100's of collisions / sec

Now:

many millions / sec

No time for viewing

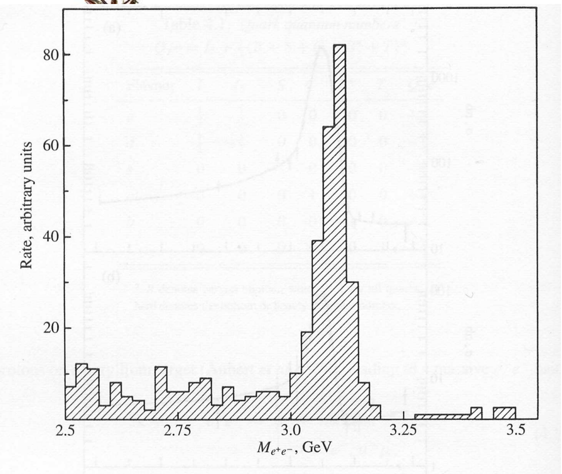
events one-by one. . .



Full computing power of CERN only allows to reconstruct "just" a few hundred events per second

Very careful selection ("triggering") of potentially interesting events is required!

1974: discovery of J/ψ



⇐ **Discovery 1:** Ting's group

$$pN \to e^+e^-X$$

at $P_{\text{lab}} = 30$ GeV/c

[Aubert et al., PRL, 6/11/1974]

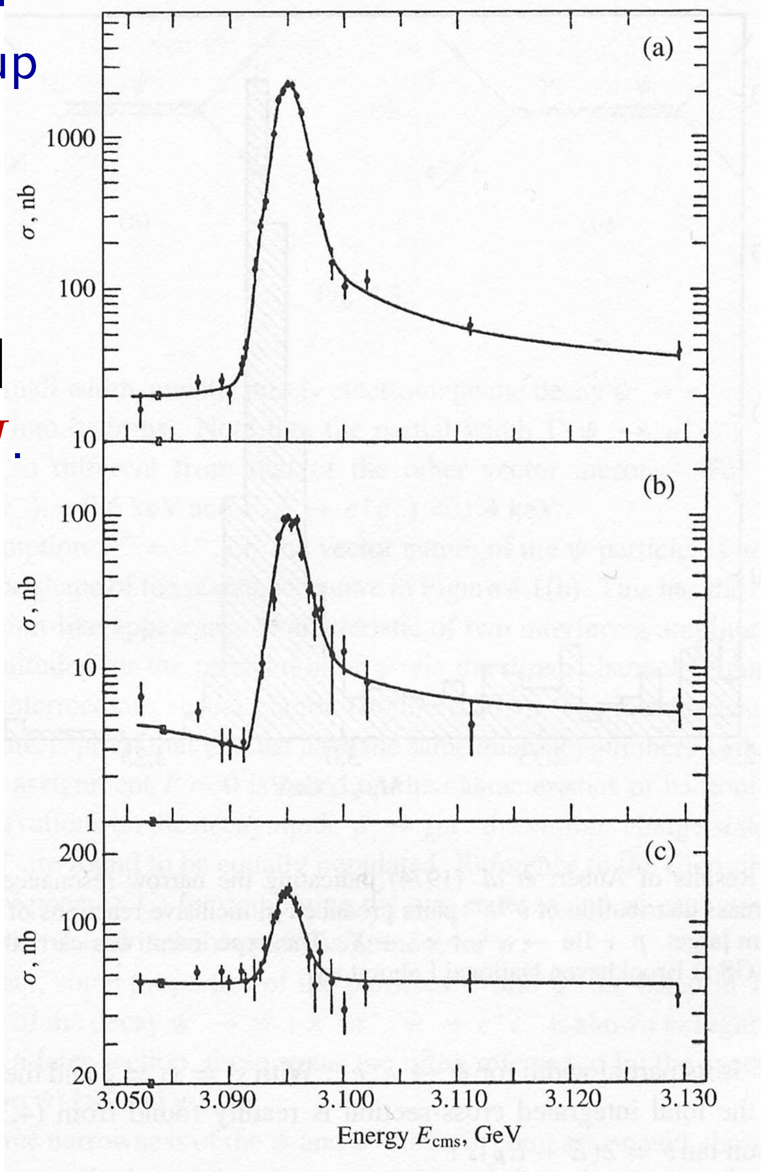
Found a peak in e^+e^- inv.mass at 3.1 GeV, called it J.

Discovery 2: Richter's group ⇒

$$\begin{array}{llll} (a) & e^+e^- & \to & \text{hadrons} \\ (b) & e^+e^- & \to & \mu^+\mu^- \\ (c) & e^+e^- & \to & e^+e^- \end{array}$$

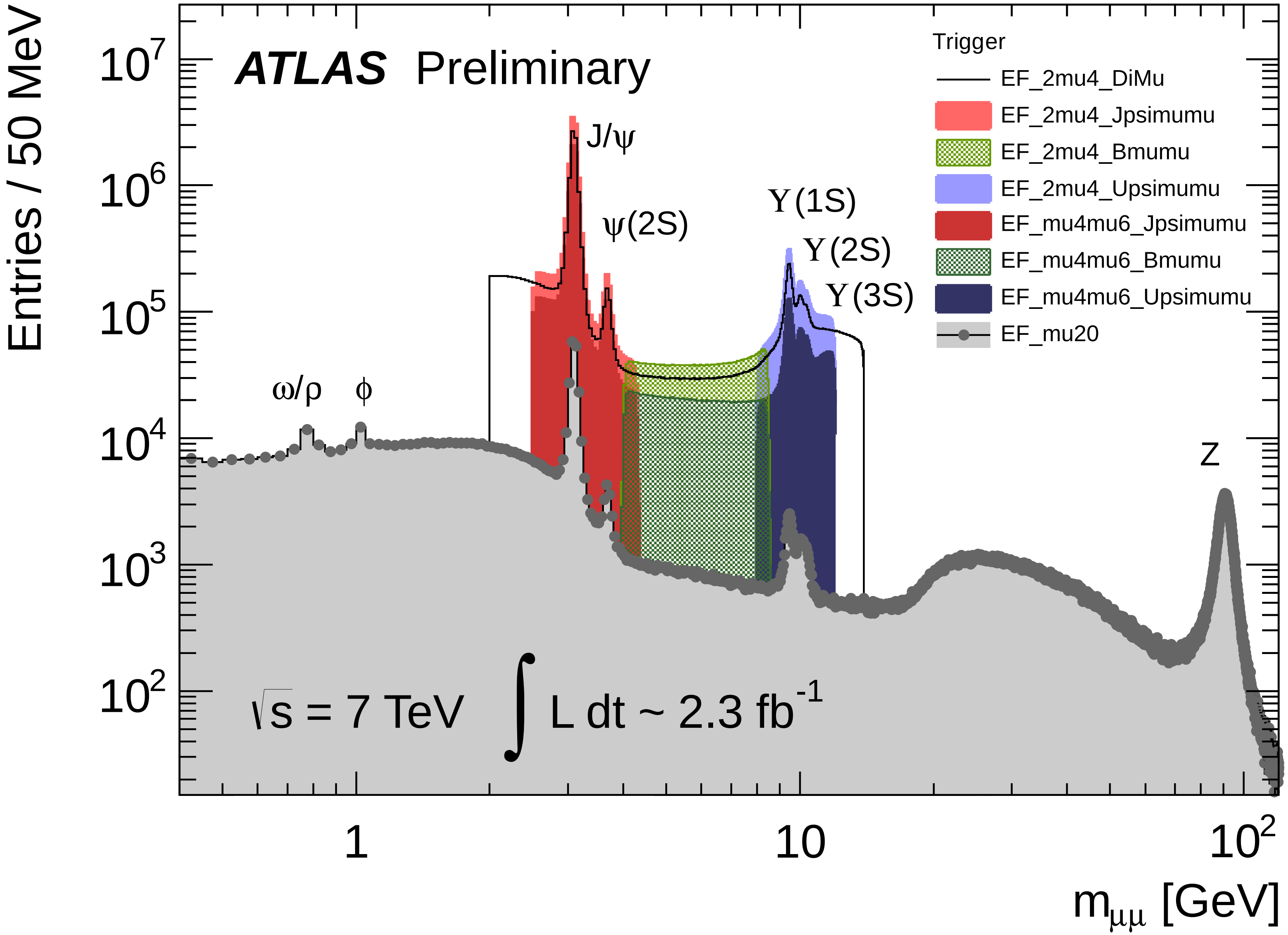
[Augustin et al., PRL, 7/11/1974]

Found a peak in all these three cross-sections, at the c.m.s. energy 3.1 GeV; called it ψ.

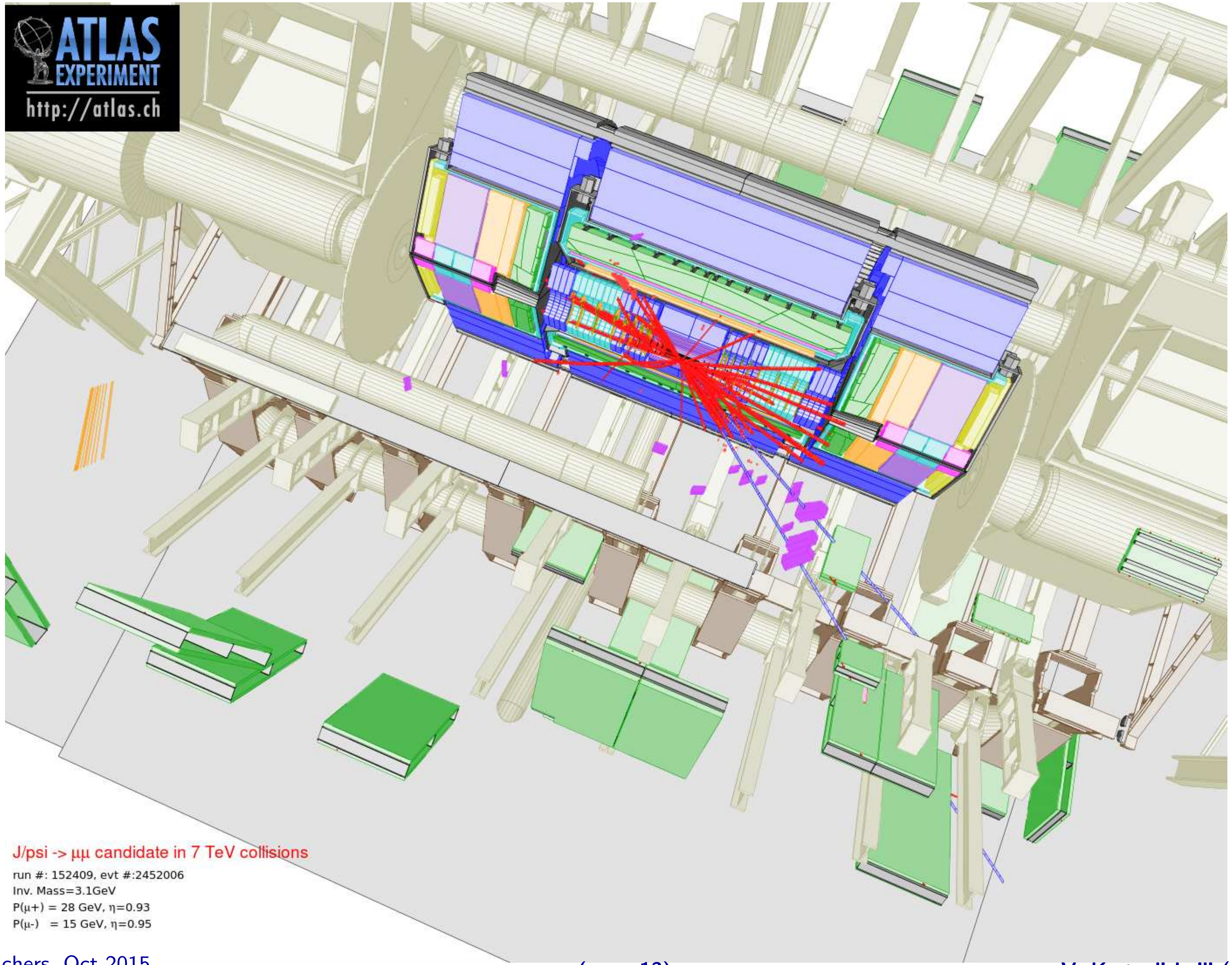


Now we know: J/ψ is a bound state of charm-anticharm, $c\bar{c}$.

History of 20th century Particle Physics in one plot



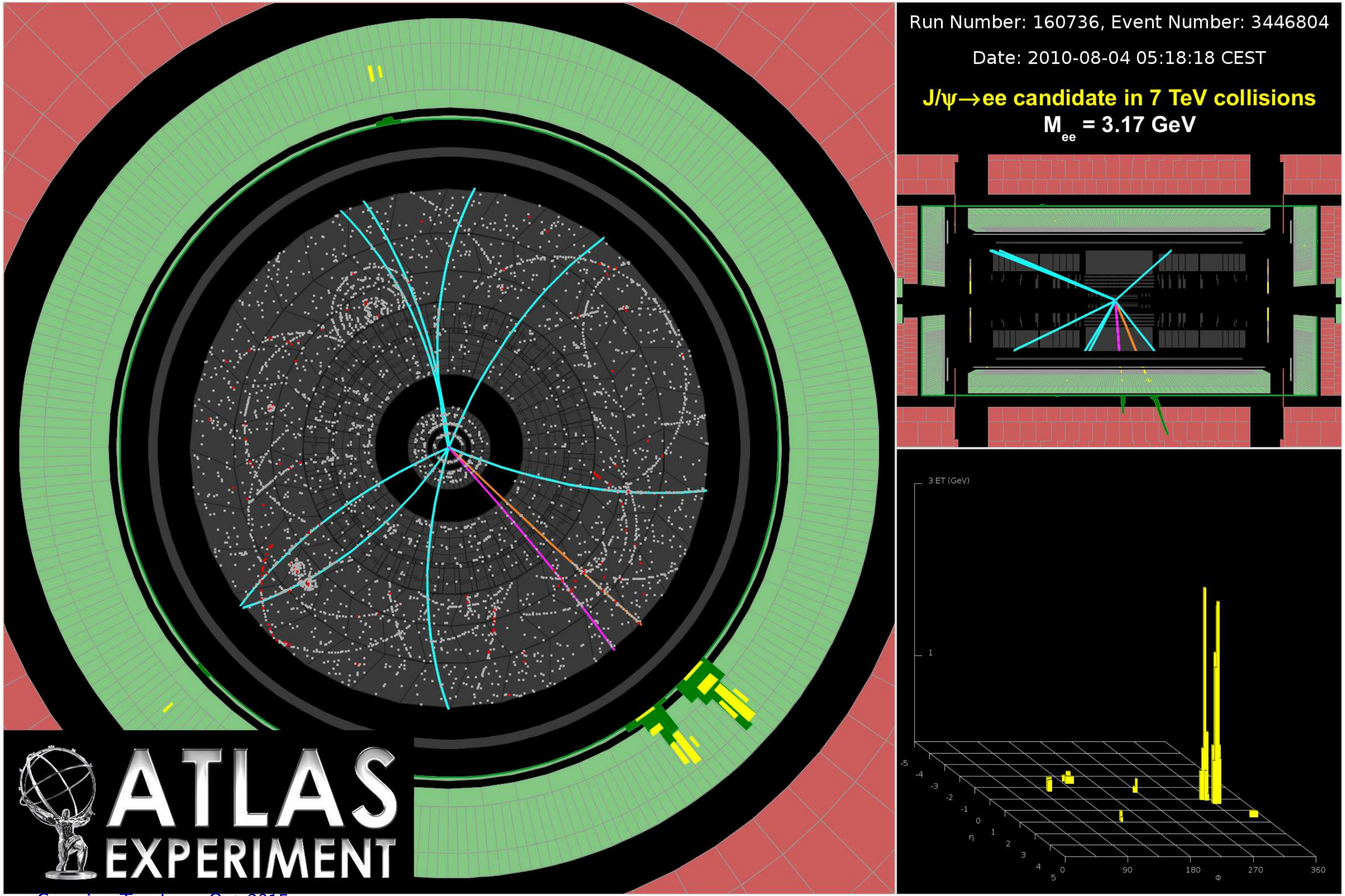
$pp \to J/\psi(\to \mu^+\mu^-) + X$



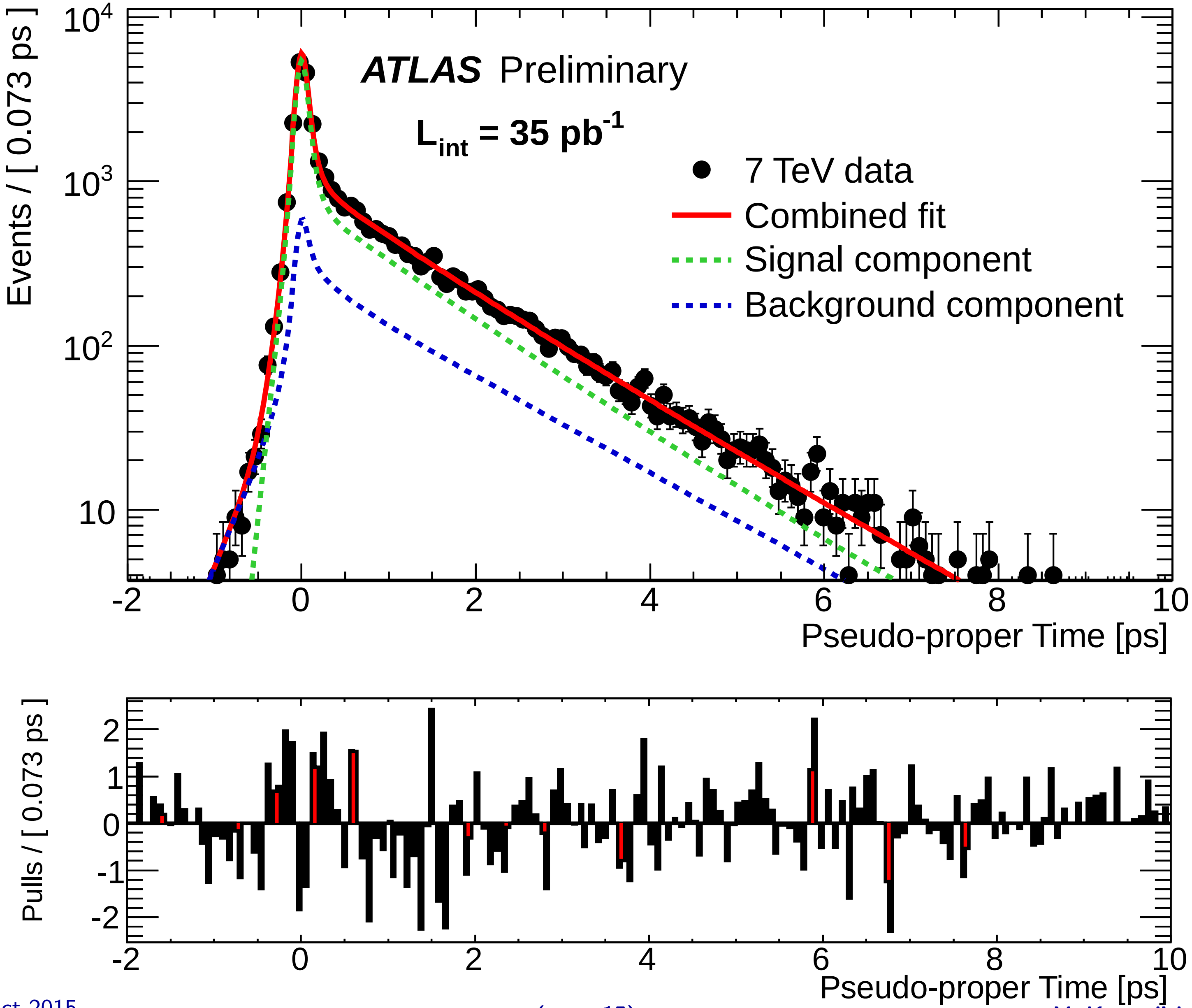
J/psi -> μμ candidate in 7 TeV collisions

run #: 152409, evt #:2452006
Inv. Mass=3.1GeV
P(μ+) = 28 GeV, η=0.93
P(μ-) = 15 GeV, η=0.95

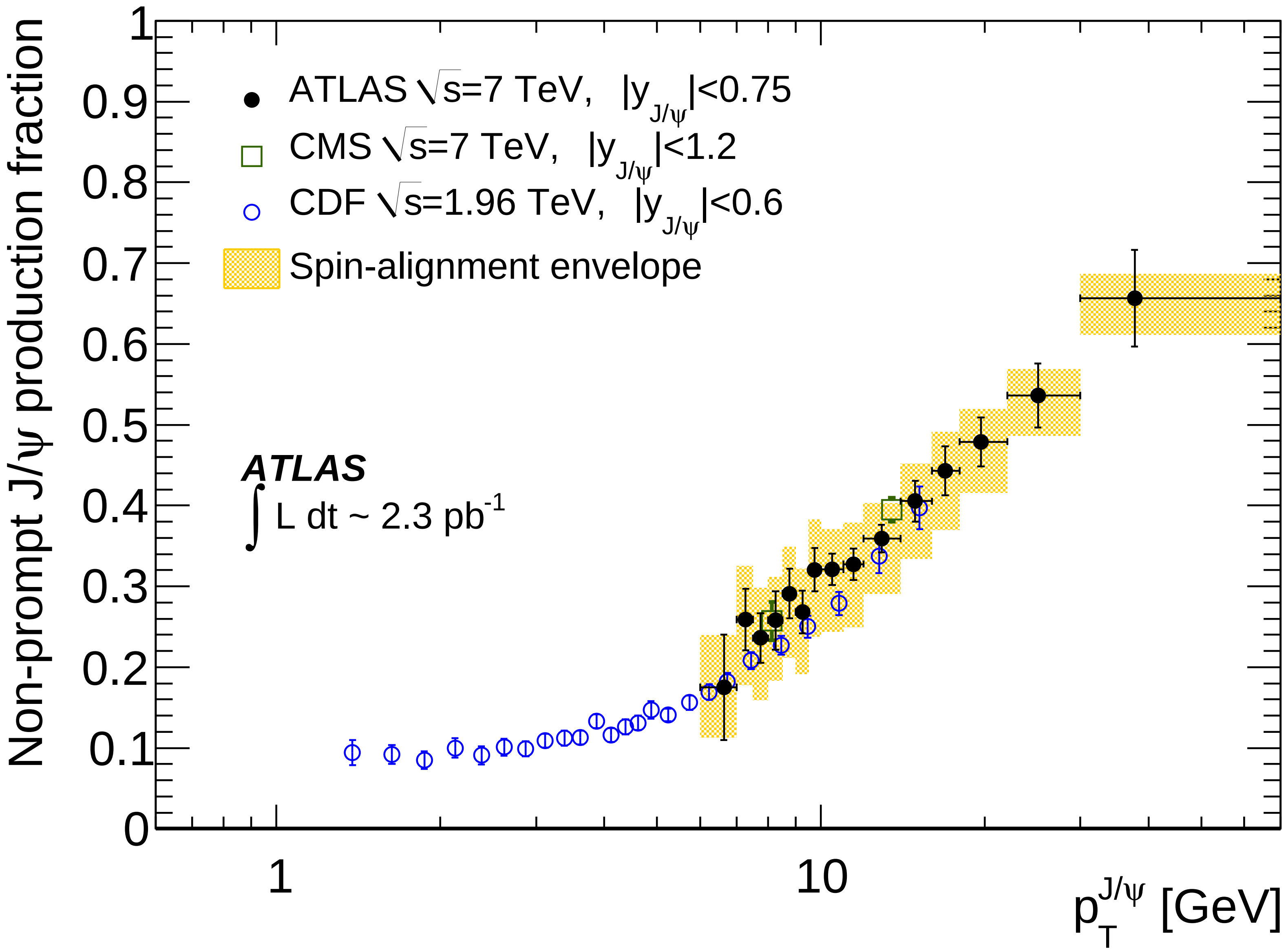
$pp \to J/\psi(\to e^+e^-) + X$



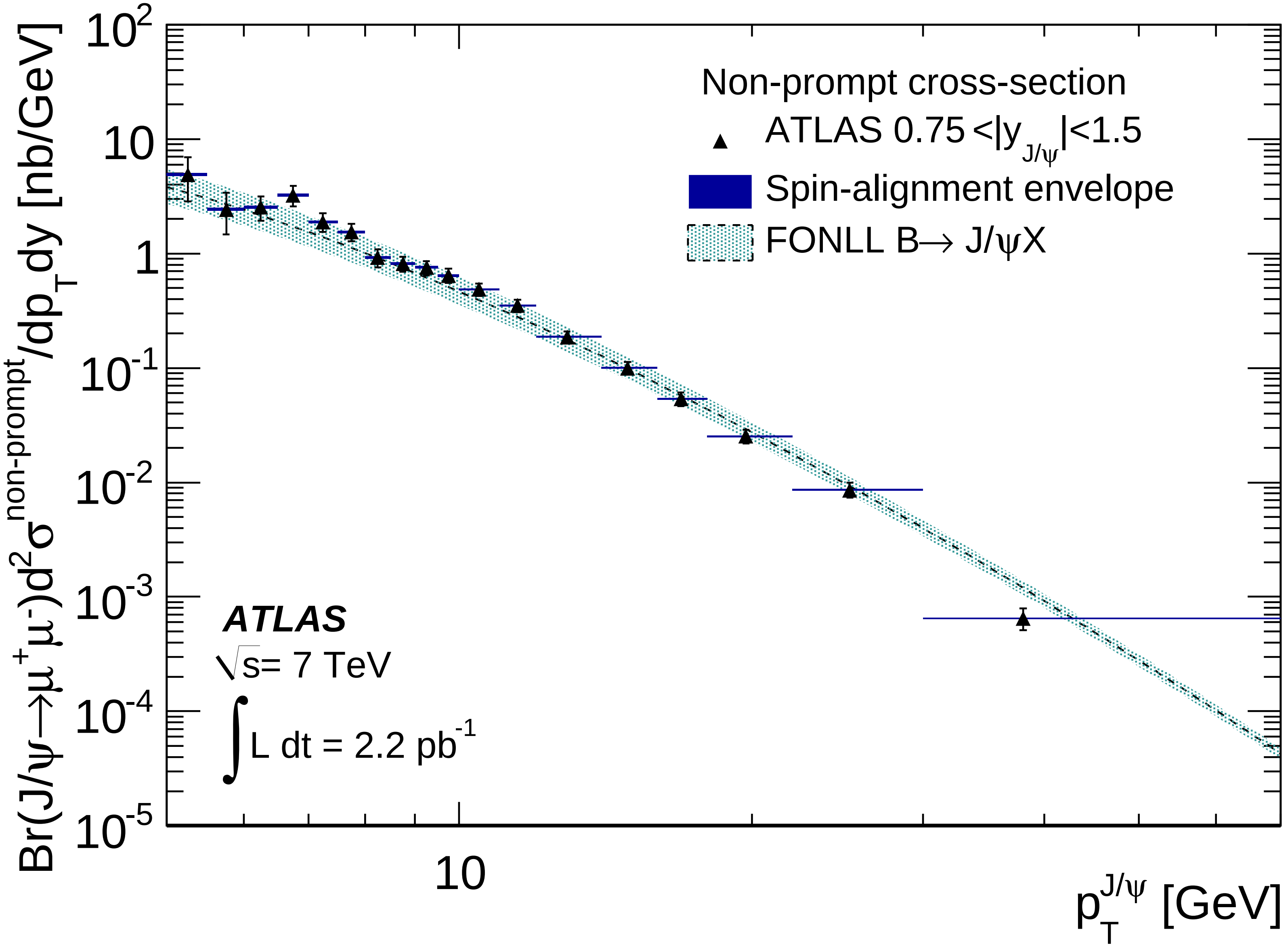
Proper Decay Time of the J/ψ vertex



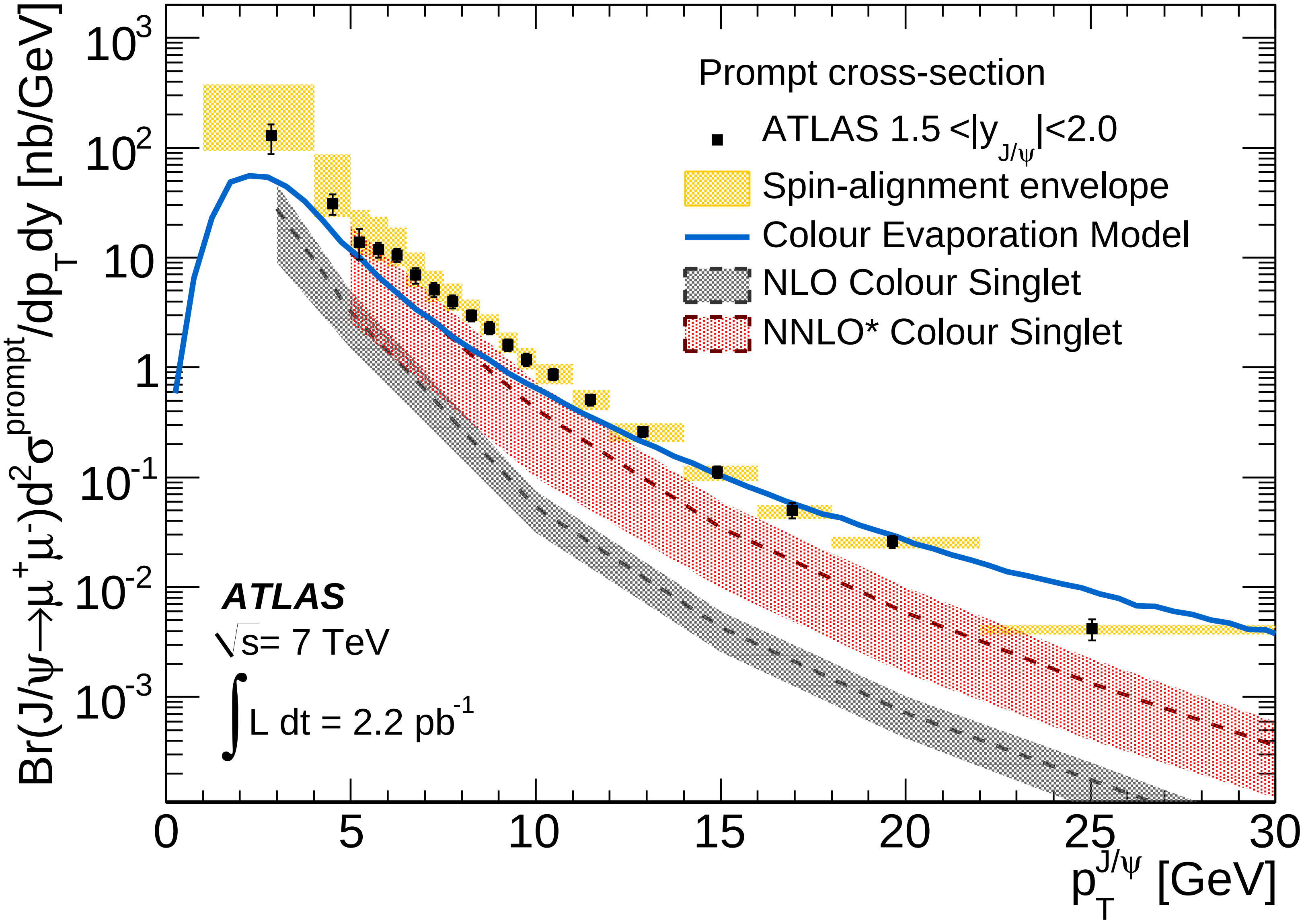
Fraction of non-promptly produced J/ψ



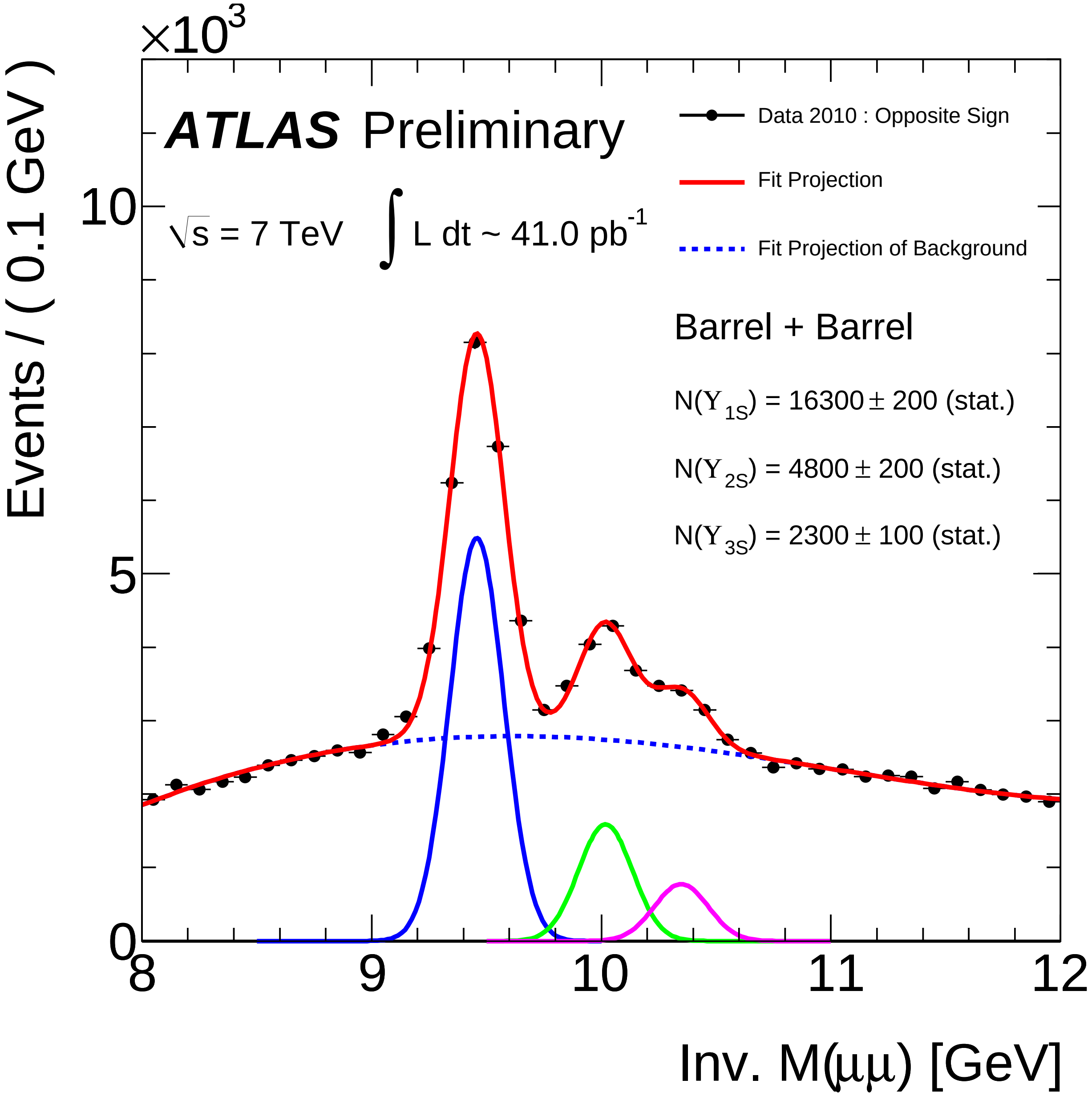
p_T dependence of non-prompt J/ψ



p_T dependence of prompt J/ψ



$b\bar{b}$ bound states: Υ system



Spectroscopy of $b\bar{b}$ mesons

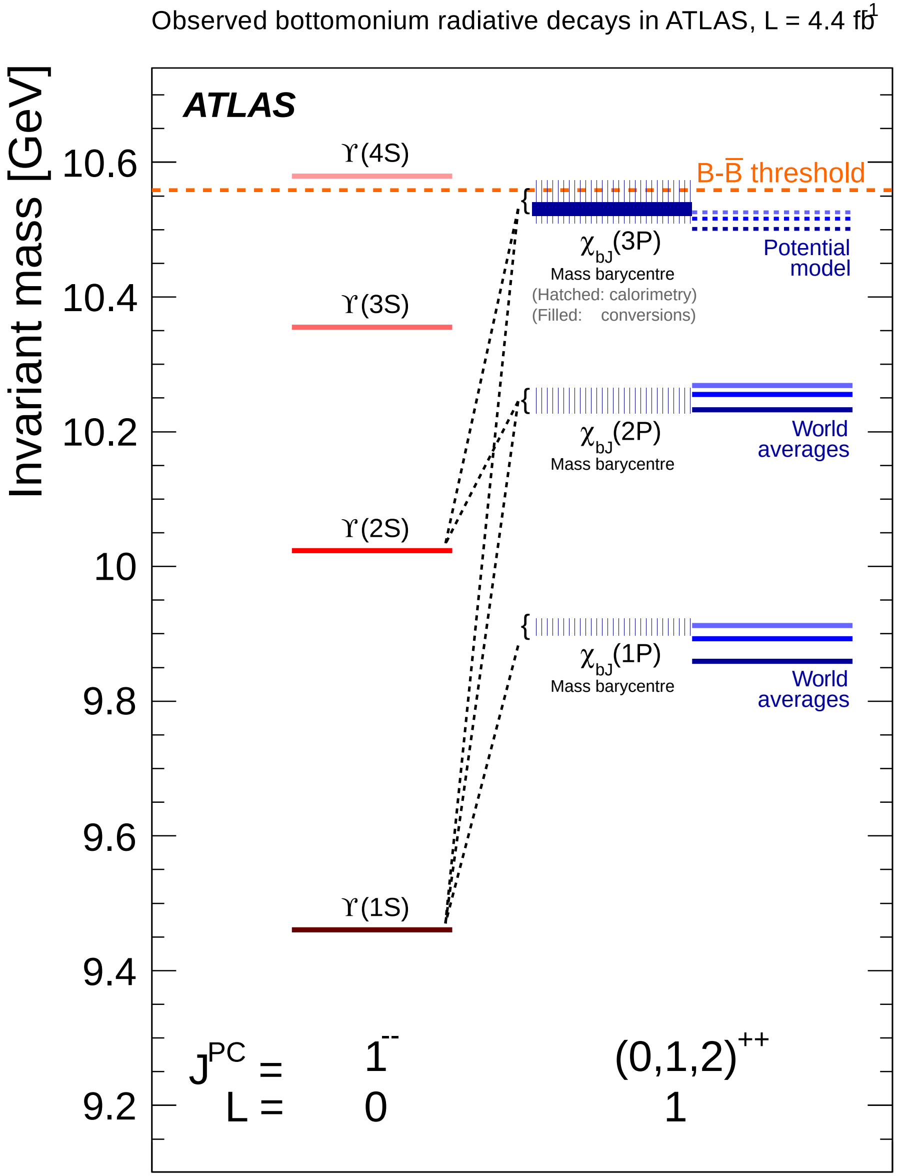
Spectroscopy similar to hydrogen atom

$\Upsilon(1S)$: ground state

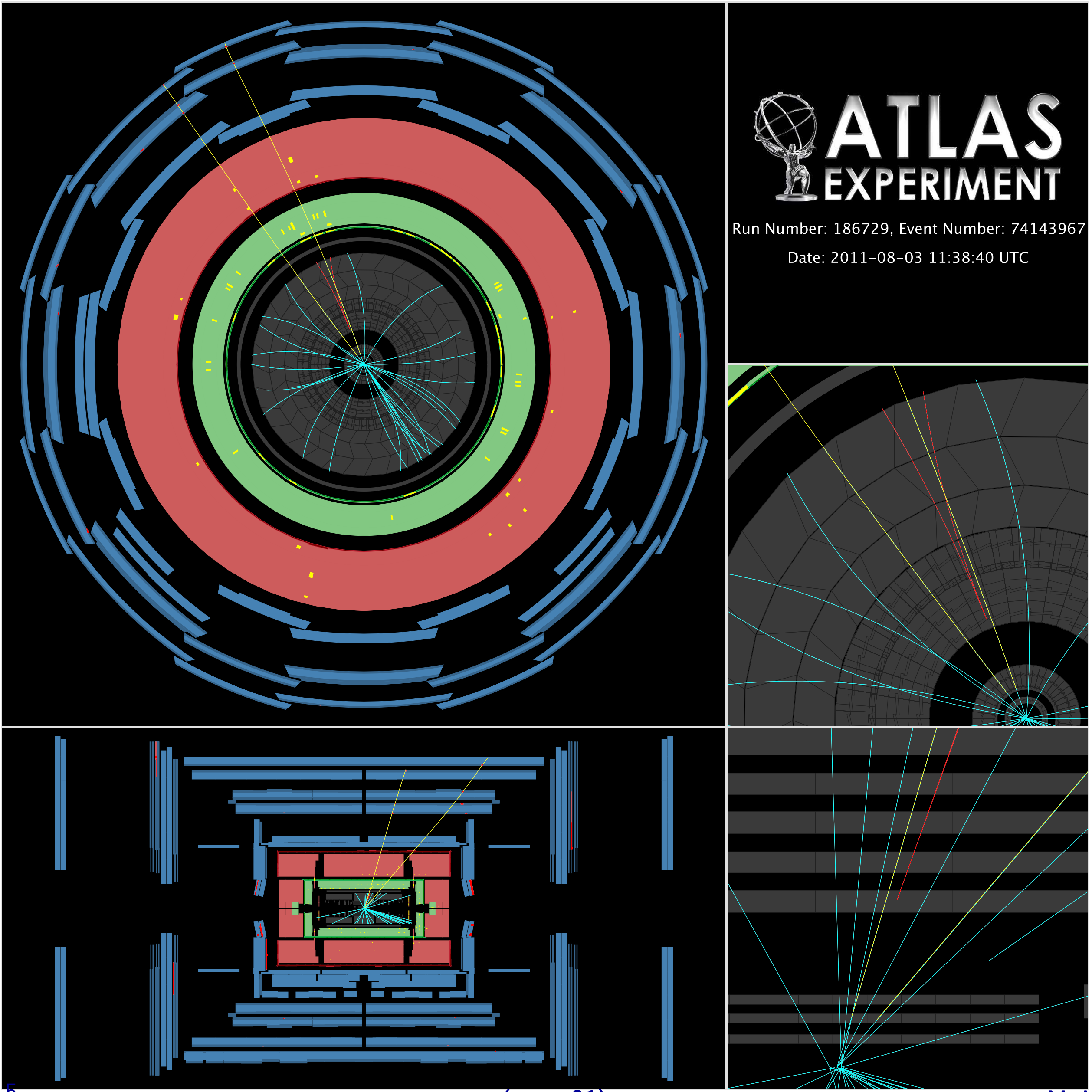
$\Upsilon(2S, 3S)$: radial excitations

Three families of χ_b:
orbital excitations, $L = 1$

Until 22 December 2011, only
$\chi_b(1P)$ and $\chi_b(2P)$ were observed



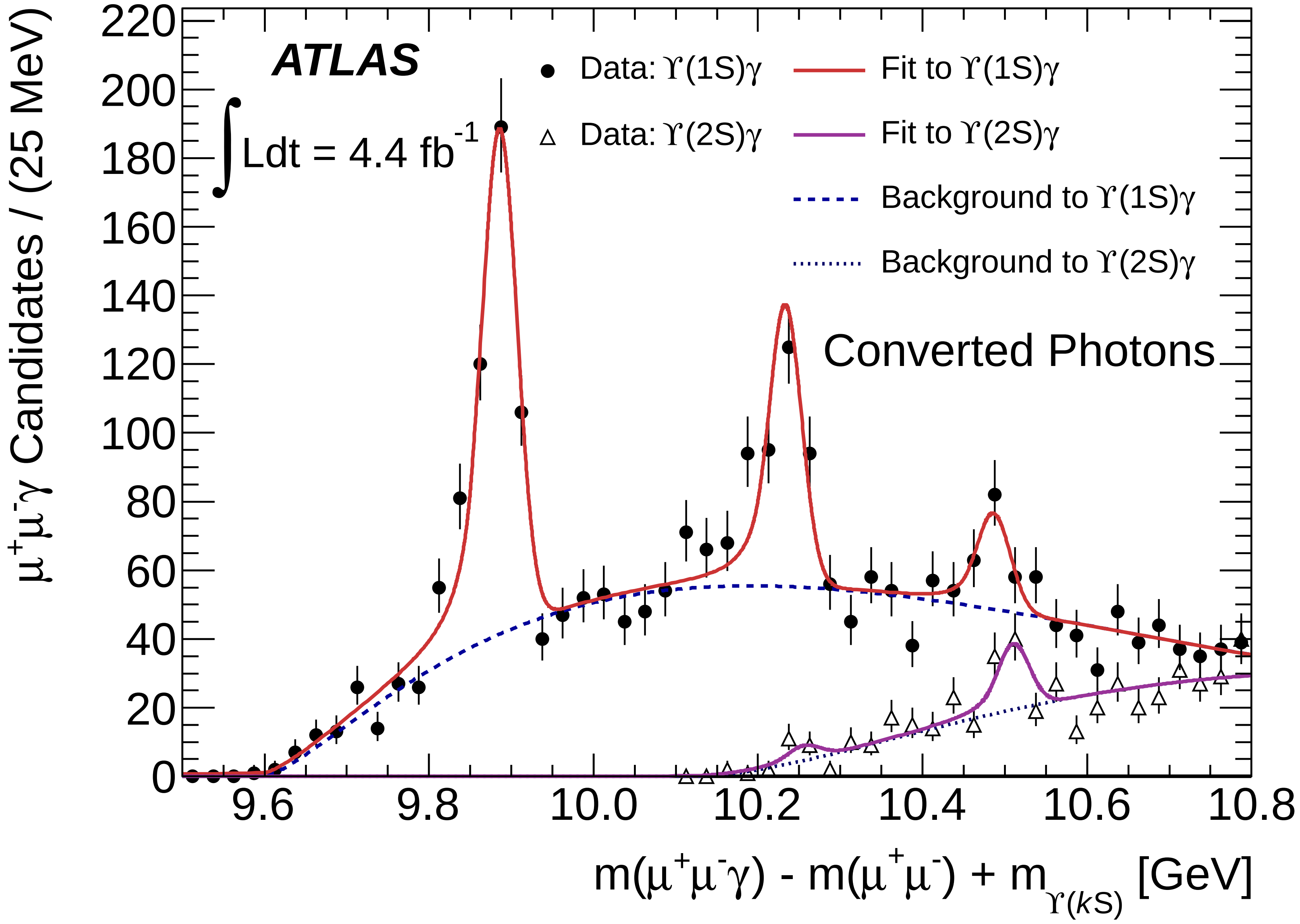
Event with $\chi_b(3P)$ candidate



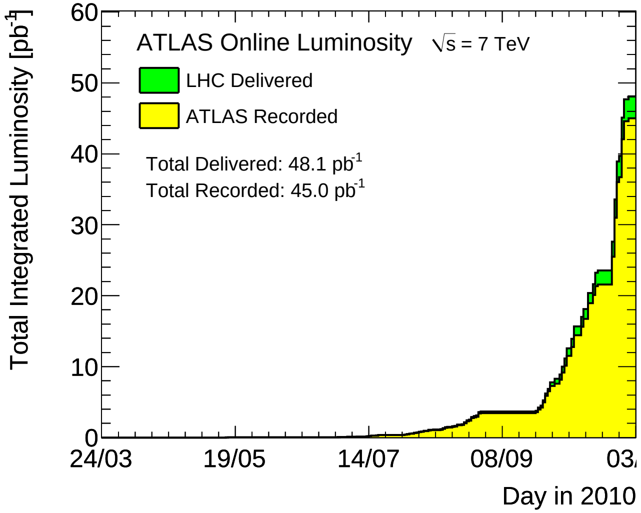
Run Number: 186729, Event Number: 74143967

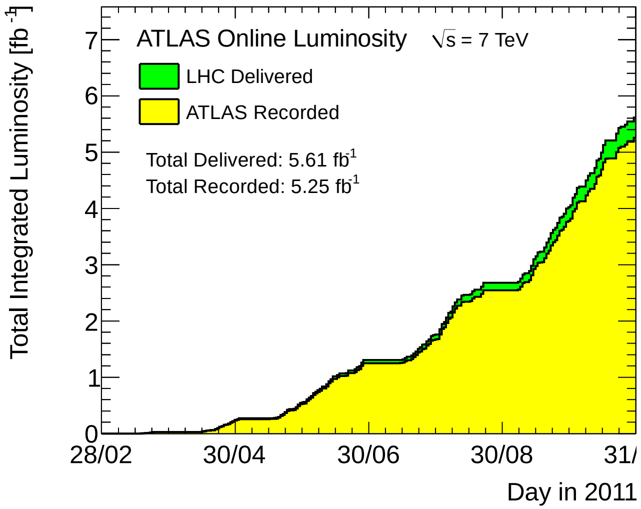
Date: 2011-08-03 11:38:40 UTC

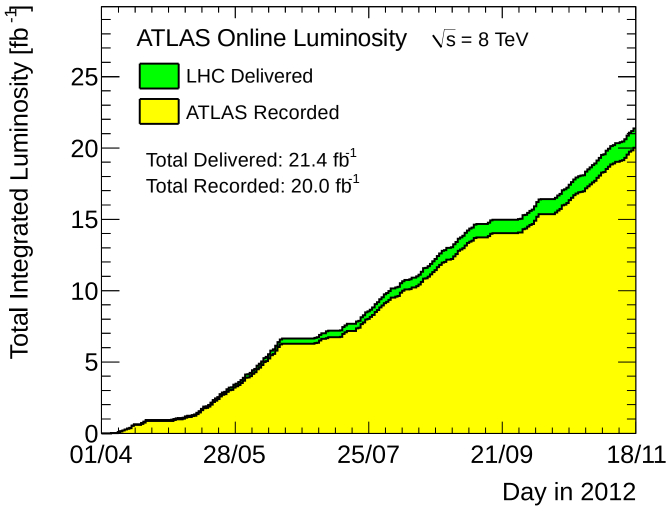
All three χ_b peaks as seen by ATLAS



Integrated luminosity in 2010, 2011, 2012





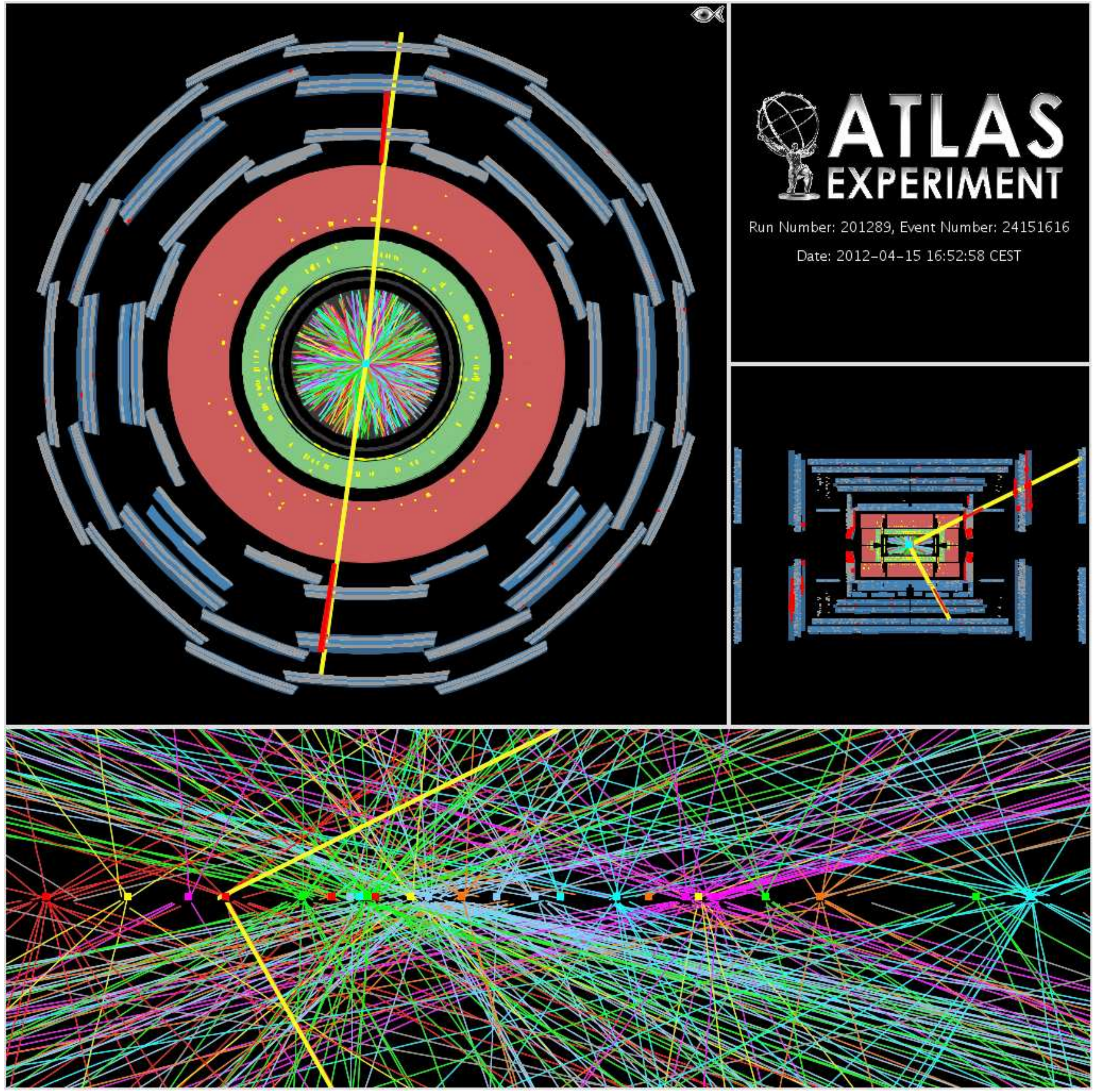


Look at the scales on y-axes: 1 fb$^{-1} = 1000$ pb^{-1}

Dramatic progress in luminosity over the years, meaning that one can now access less and less frequent processes...

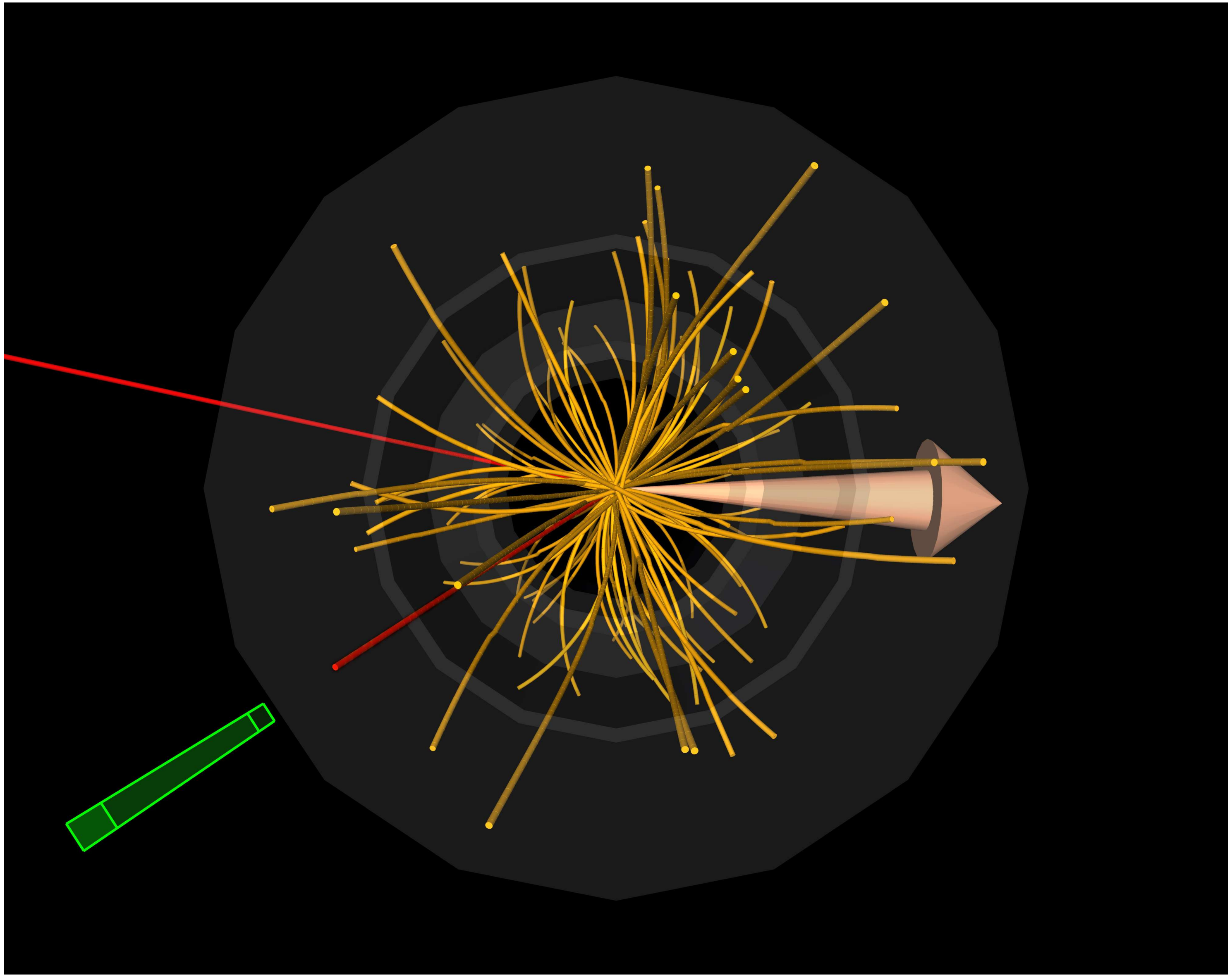
...but need tighter and tighter trigger selections!

$Z \to \mu^+\mu^-$ candidate at high luminosity



There are 20+ collisions
in one bunch crossing,
with a $Z \to \mu^+\mu^-$ candidate
produced in one of them.

W^+W^- pair production



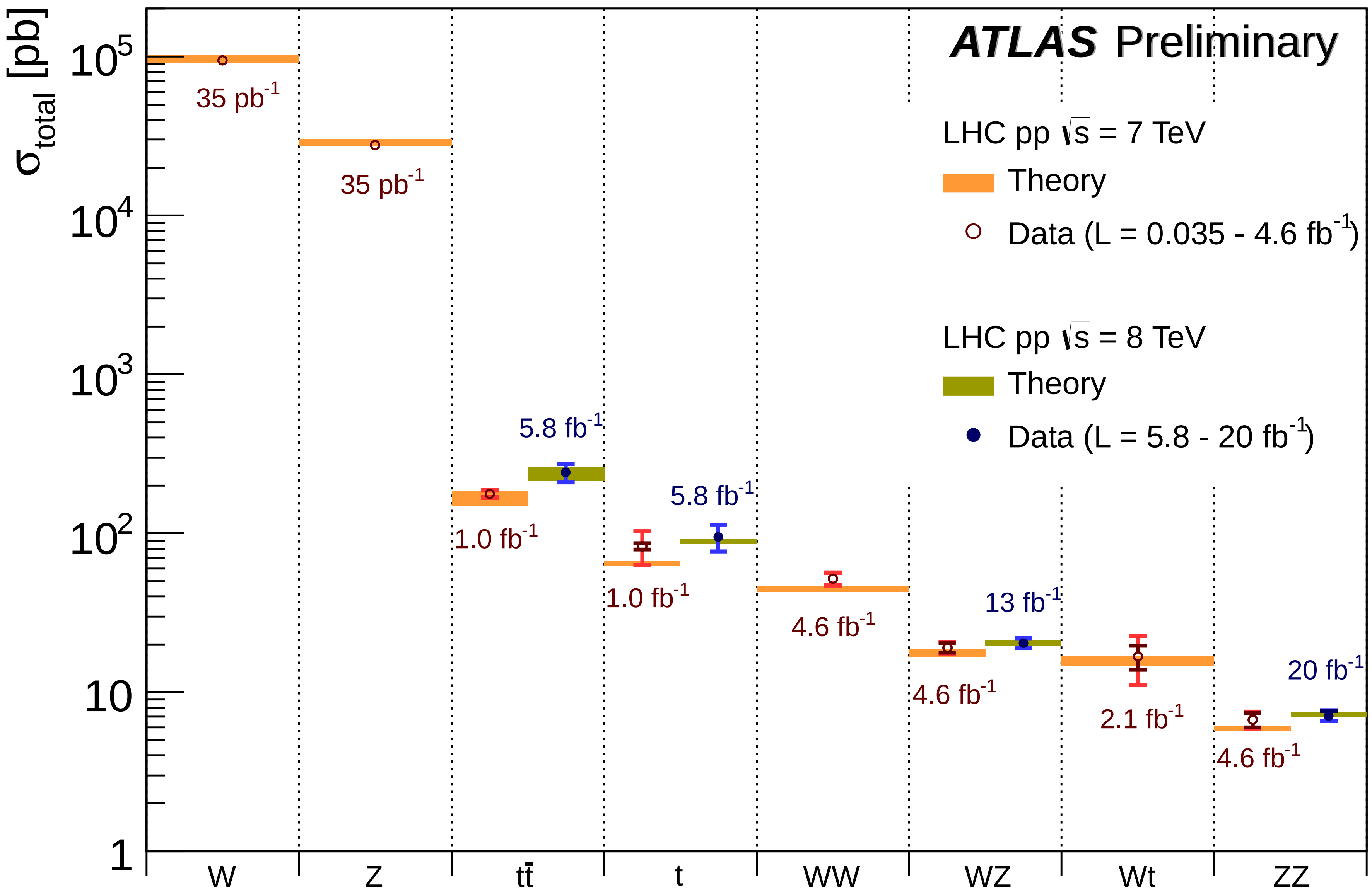
$W^+ \to \mu^+\nu_\mu$

$W^- \to e^-\bar{\nu}_e$

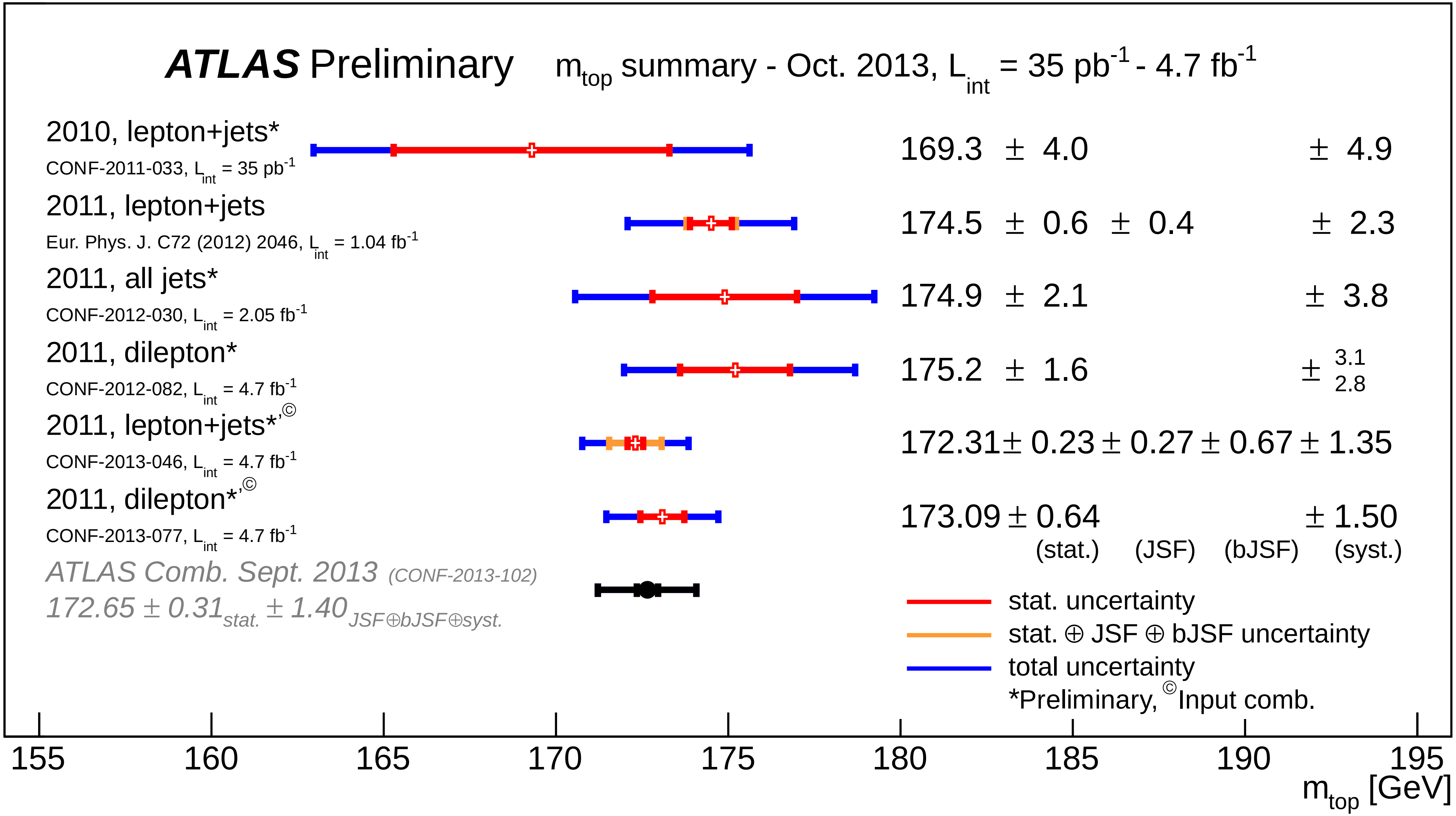
Neutrinos escape detection

$\Rightarrow$ missing P_T

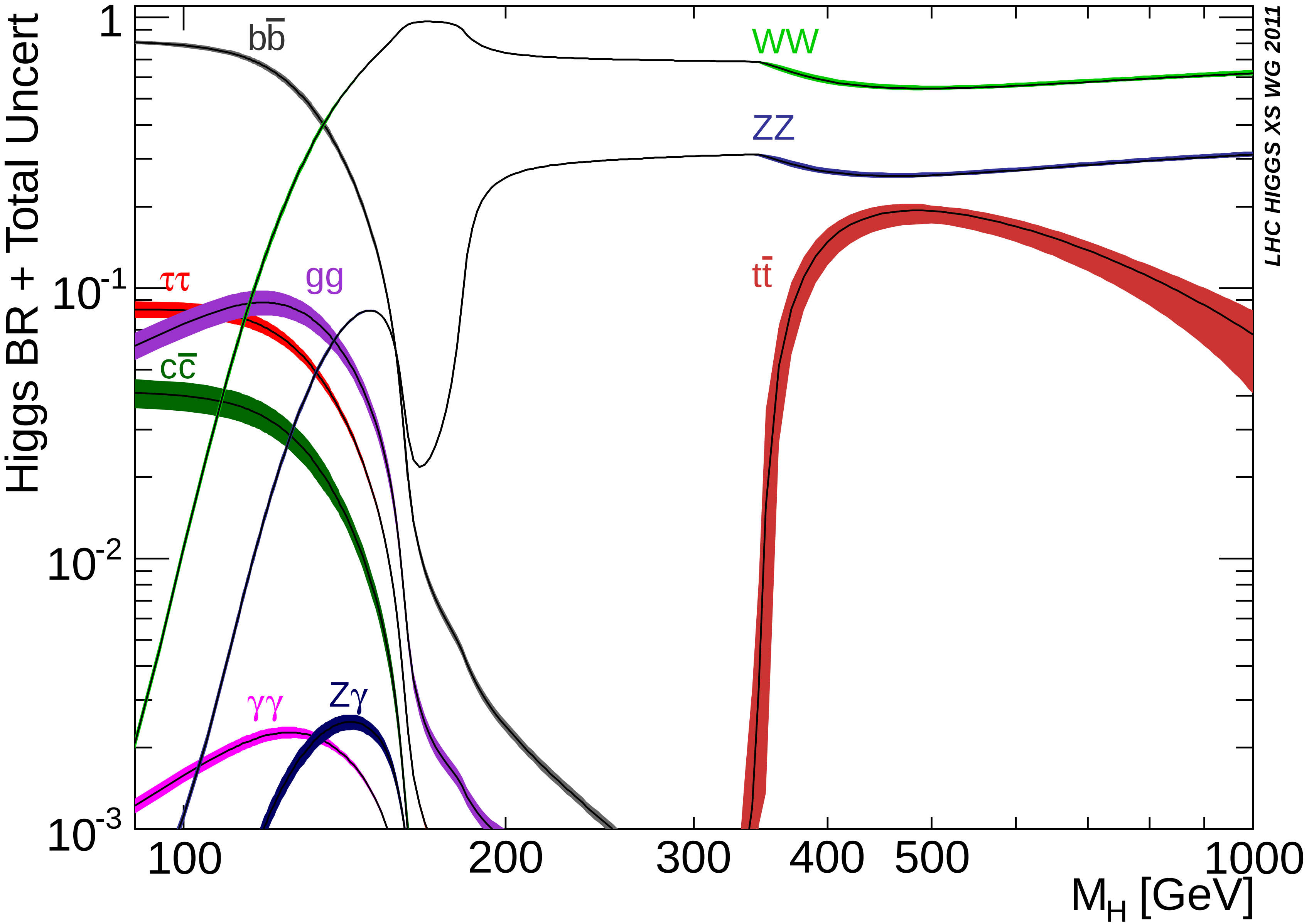
Standard Model cross sections vs theory



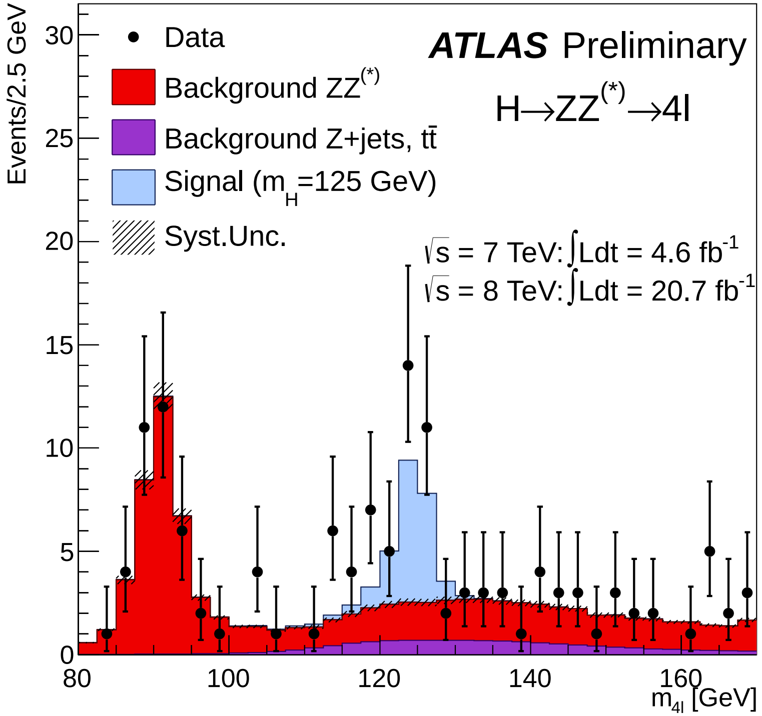
Top quark mass measurement

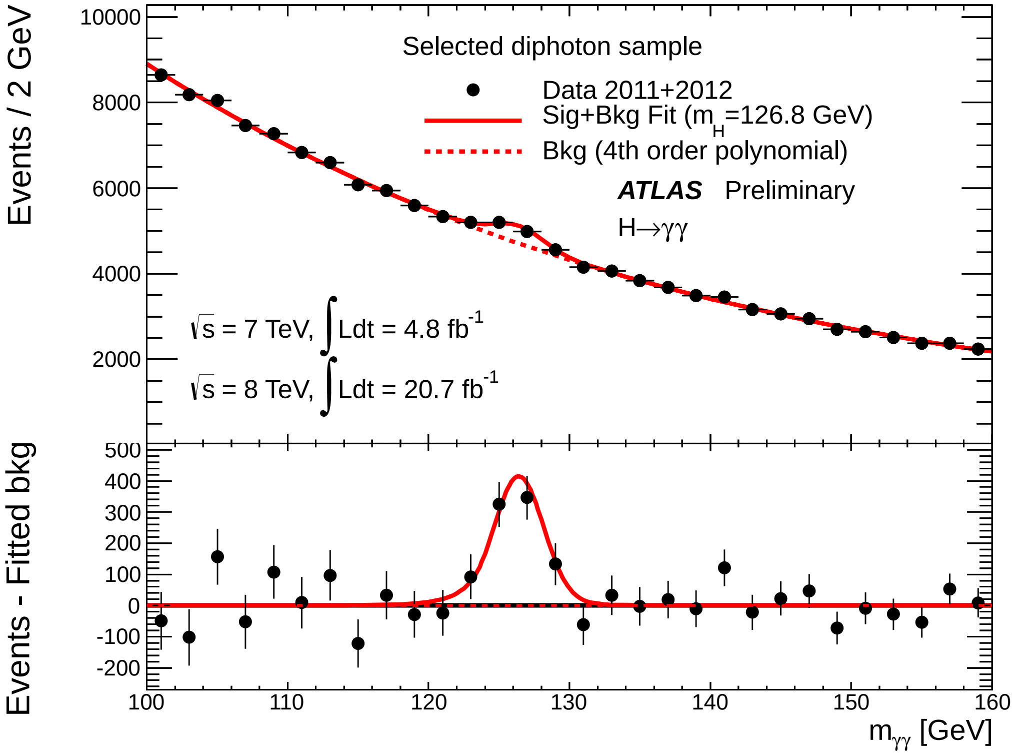


Decay modes of the Standard Model Higgs Boson

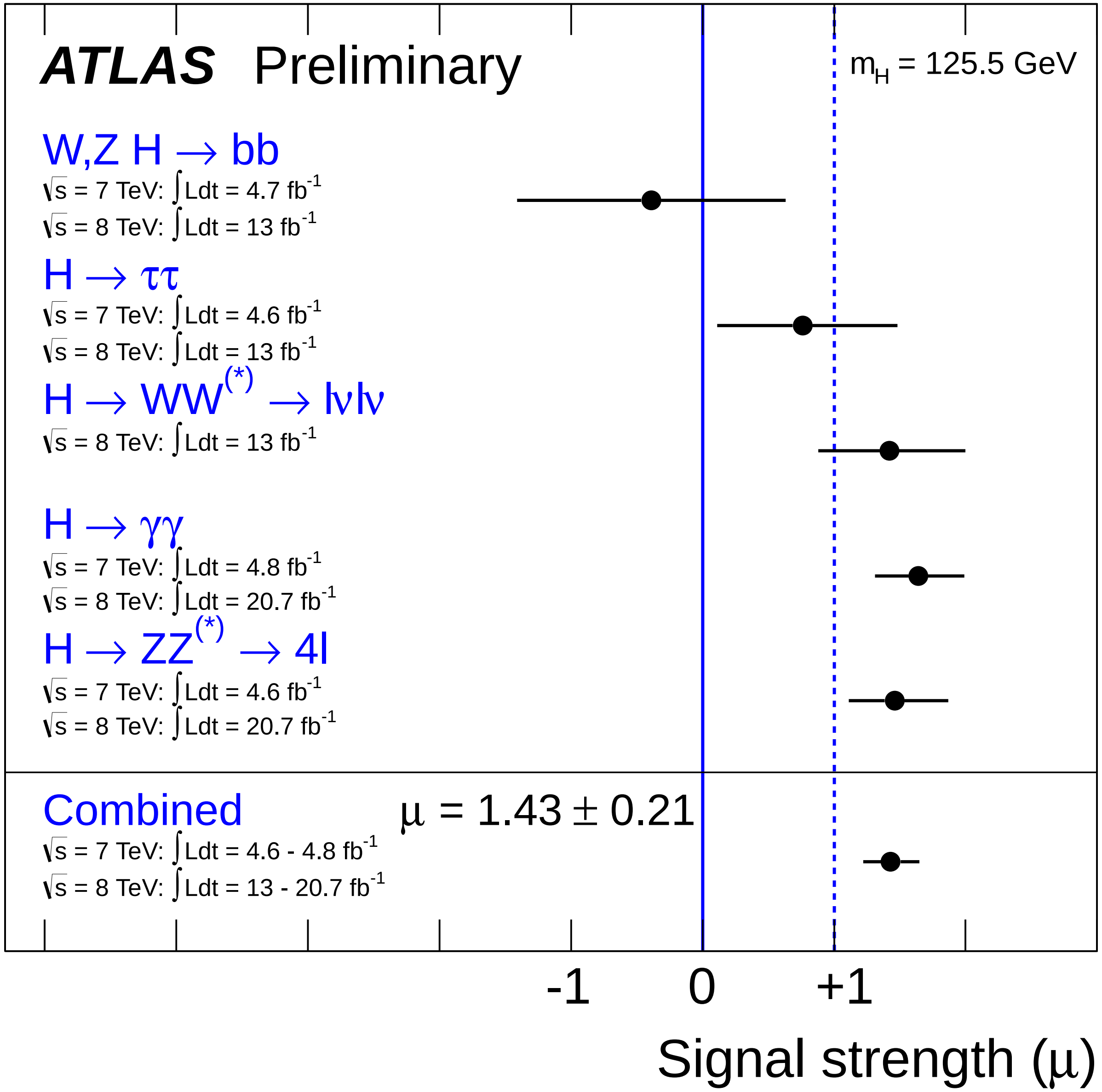


Higgs(-like object) observation

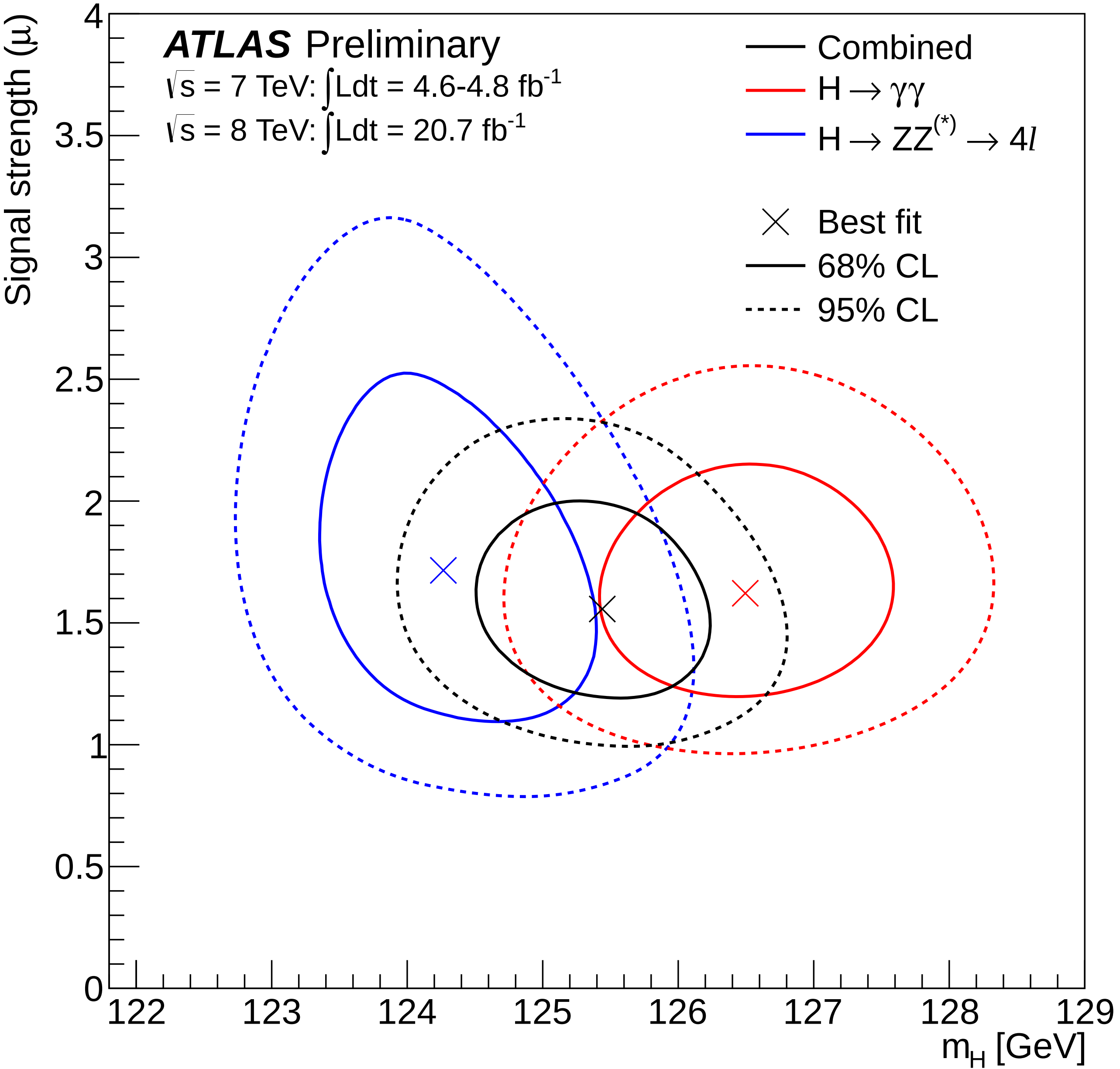




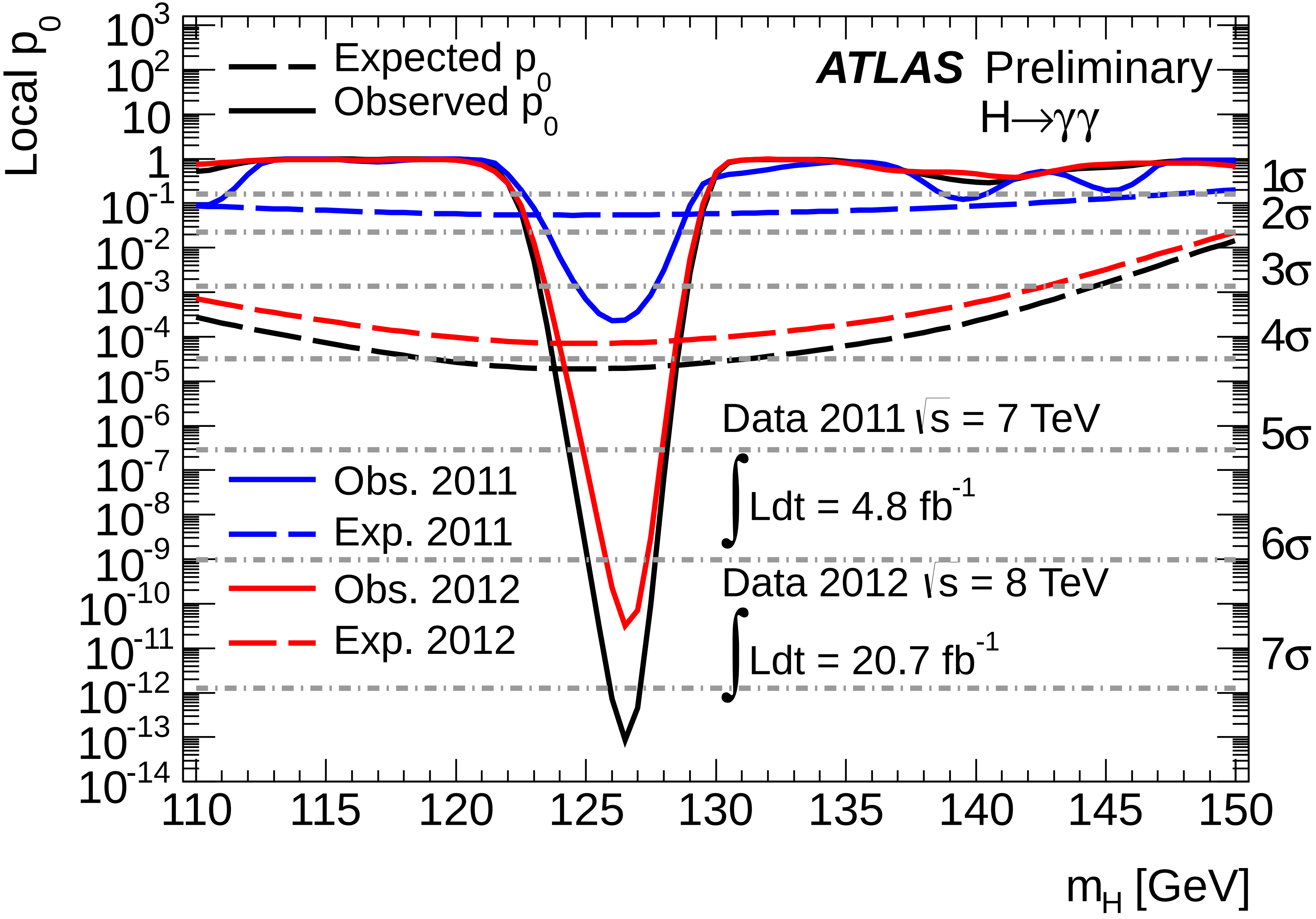
Higgs(-like object): signal strength



Higgs(-like object): mass contours



SM Higgs(-like) object: summary



Questions to the Standard Model

The (gauge) symmetry group of the Standard Model is $SU(2) \times U(1) \times SU(3)$

Hence three types of interactions, and the variety of gauge bosons, the interaction carriers: $\gamma, W^{\pm}, Z^{0}, g$

- Why are these three types so different – and the fourth, gravity, even more so?
- Why three generations?
- Why fractional electric charges of quarks?
- Why are the fermion masses so different?
- What determines the mixing of various generations?

These and many more questions cannot be answered within SM.

We need a bigger theory. . .

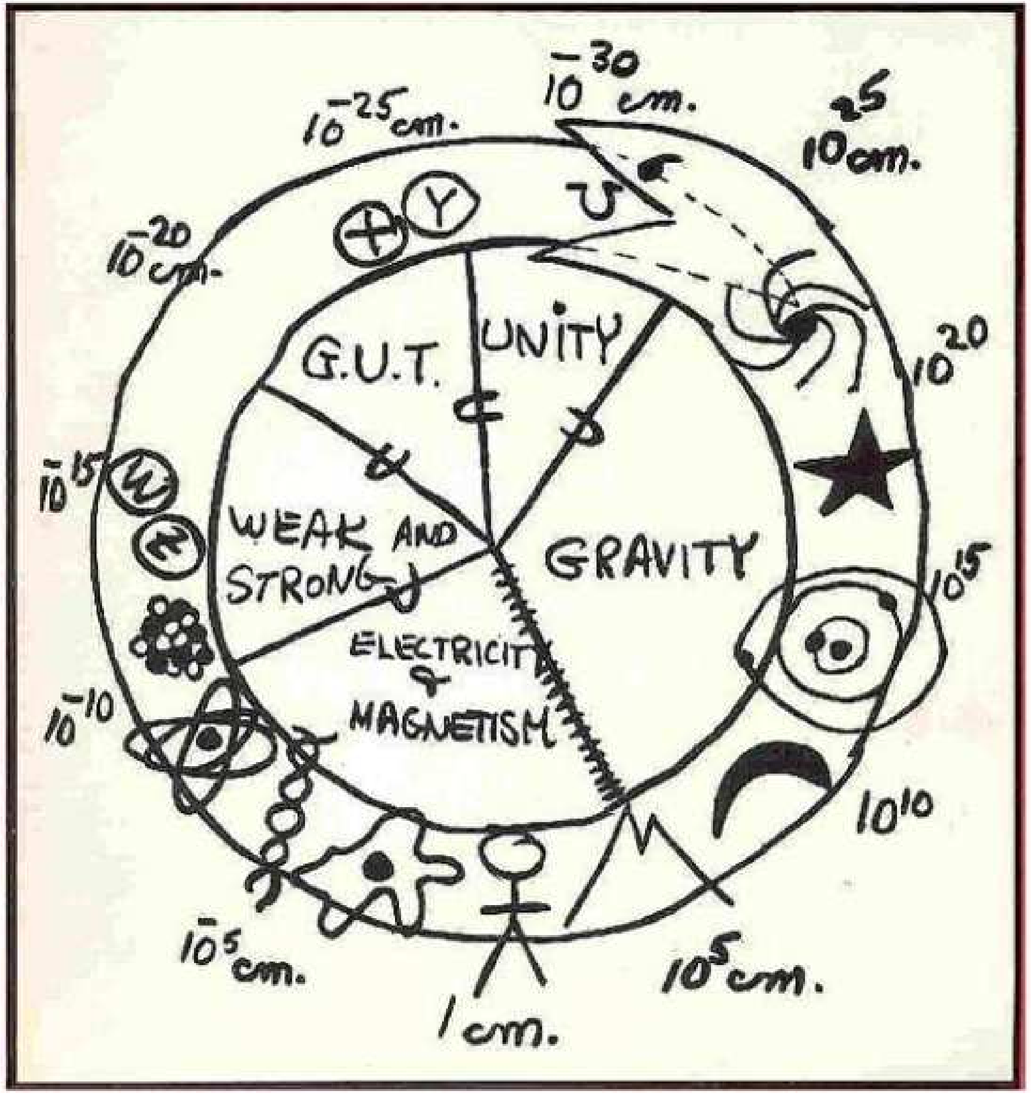
Cosmology: source of inspiration

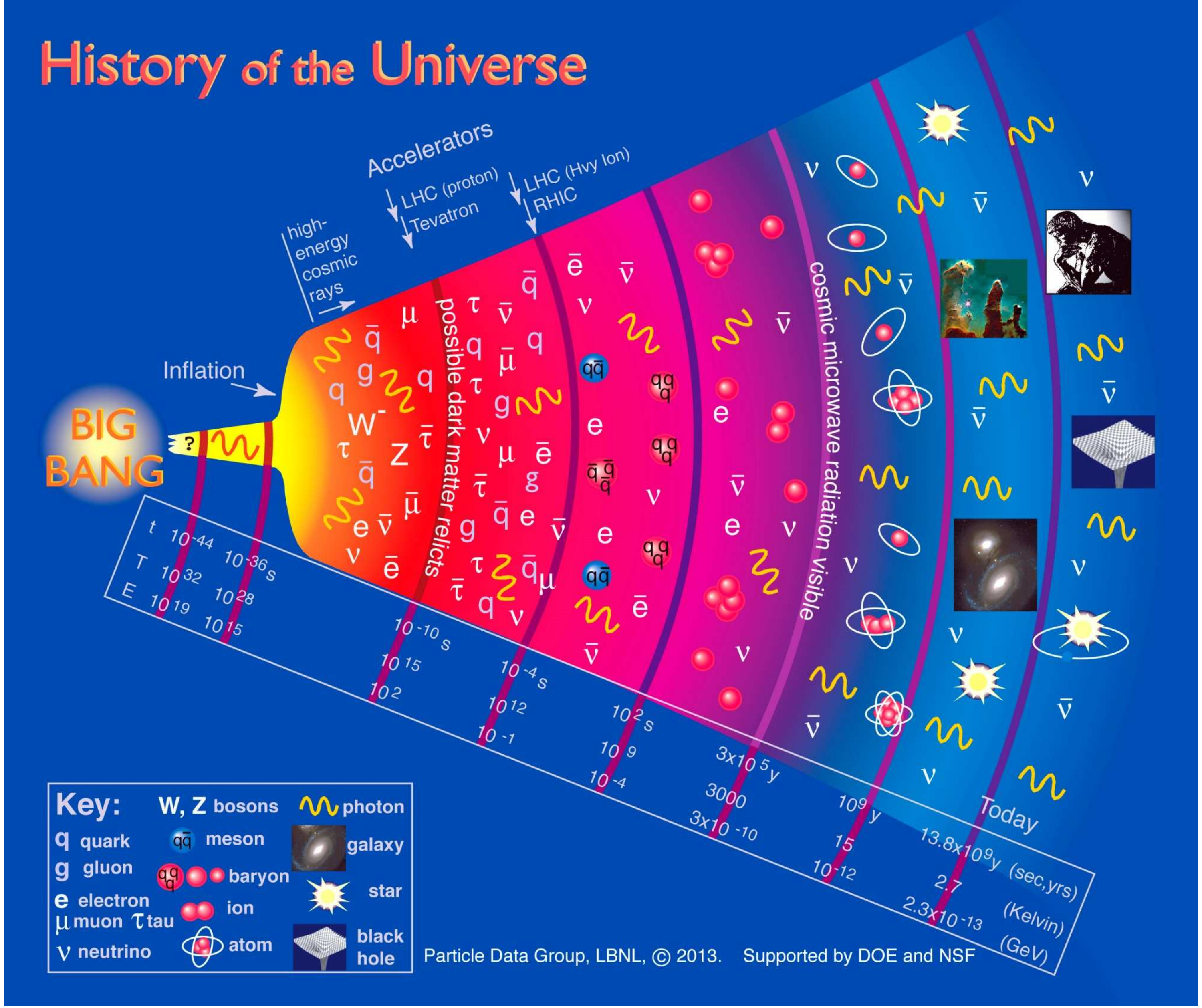
- Universe is made up of $\sim 10^{11}$ galaxies; each galaxy contains $10^{10} - 10^{12}$ stars
- Cosmology: science about the history of the Universe
- Assumption: laws of physics have not changed along the way
- Method 1: observe the Universe evolution NOW and try to extrapolate backward
- Method 2: assume some starting point (the Big Bang) and extrapolate forward
- The overall established picture in modern cosmology is arguably as stable and solid as the Standard Model in Particle Physics, but it also has its unanswered questions
- The hope (from both camps) is that the answers may be shared!

Glashow's serpent

As usual, "natural" system of units:

- ✦ $\hbar = 1,\ c = 1,\ k_B = 1$
- ✦ distance $\sim$ time
- ✦ Energy $\sim 1/$distance
- ✦ Temperature $\sim$ Energy
- ✦ Hence, Planck's mass $M_p = \sqrt{\frac{\hbar c}{G_N}} = 10^{19}$ GeV





Particle Data Group, LBNL, © 2013. Supported by DOE and NSF

Expanding Universe

Experimental fact: Universe is expanding

Light from distant galaxies is red-shifted (Doppler effect)

The larger the distance, the more the shift (can be measured precisely)

The light wave expands with space, hence the shift towards lower frequency

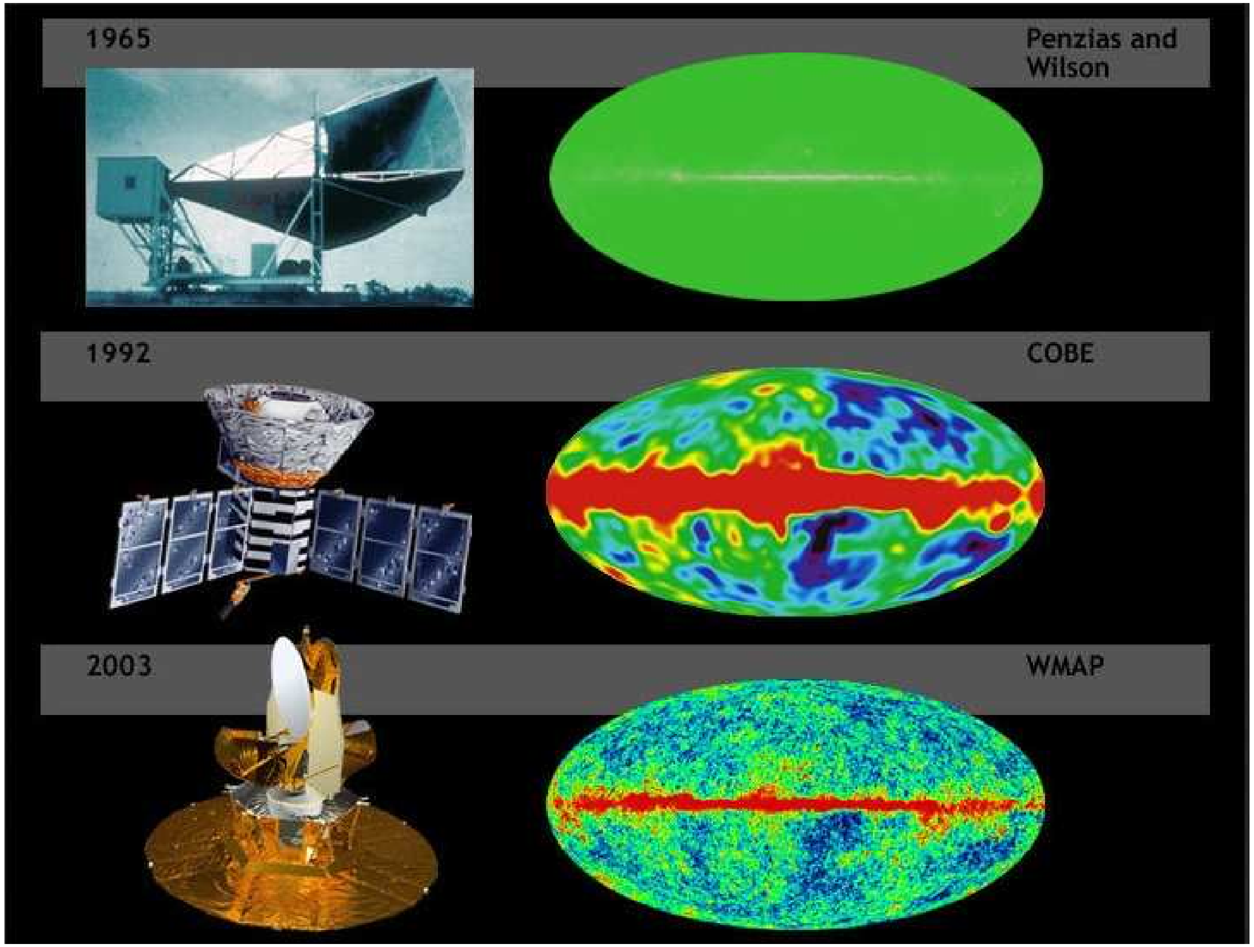
Hubble constant: 70 km/s per Megaparsec

Once, the Universe was 3000 times smaller – and 3000 times hotter than today

Cosmic Microwave Background 2.7 K today: photons wandering in space since then

Almost isotropic (same in all directions) – but NOT EXACTLY!

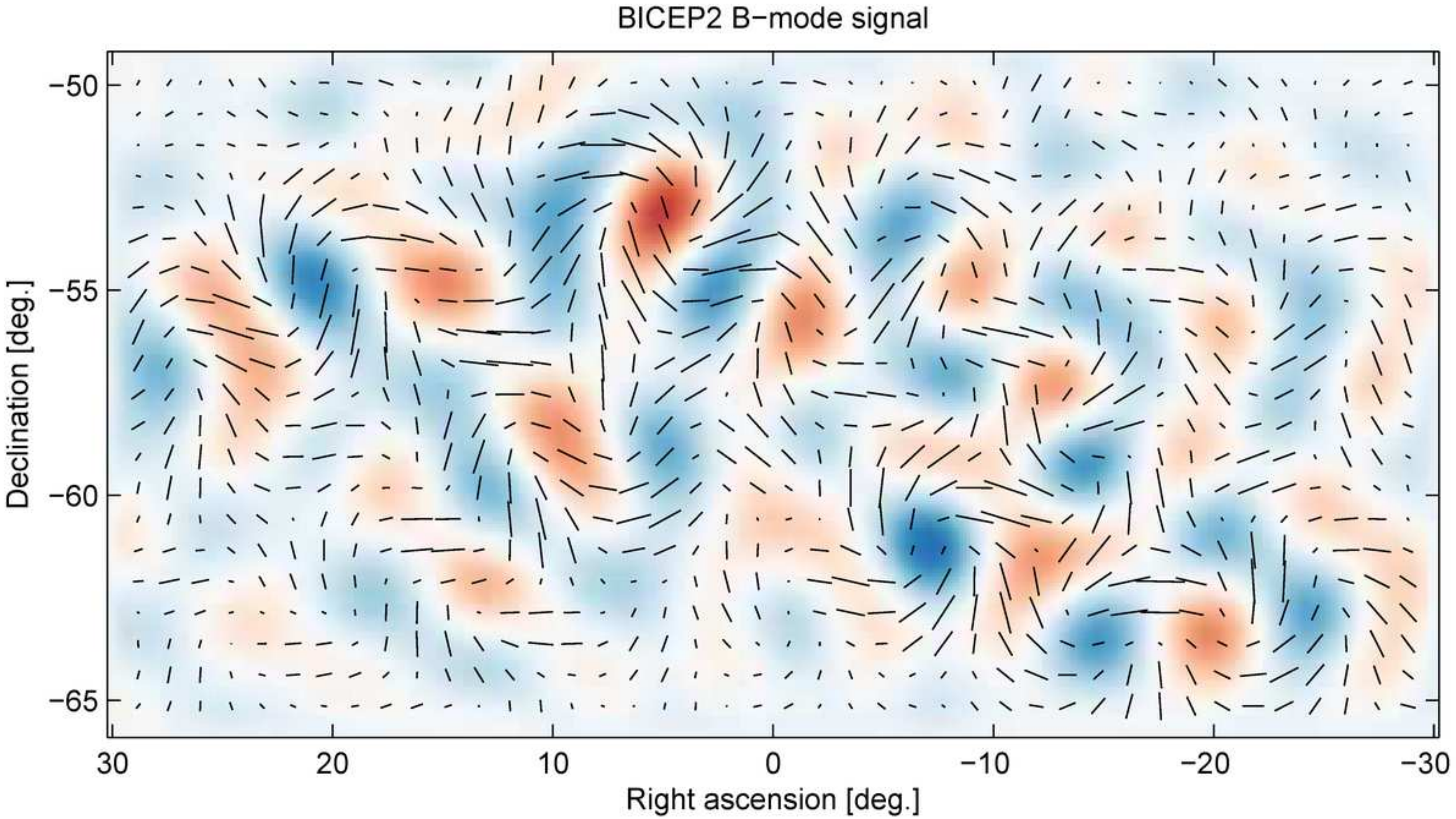
CMB anisotropy



Ripples from times 300 000 years ago, at the level of 10^{-3}

These small non-uniformities may be signals from the seeds of galaxy formation

Polarisation fluctuations



Possible signs of gravitational waves from the Big Bang?

Bariogenesis

Once the Universe was a billion times smaller and hotter than today

Light chemical elements were formed: $He^4,\ D,\ He^3,\ Li,\ \ldots$

Relative abundance of these elements can be predicted by theory

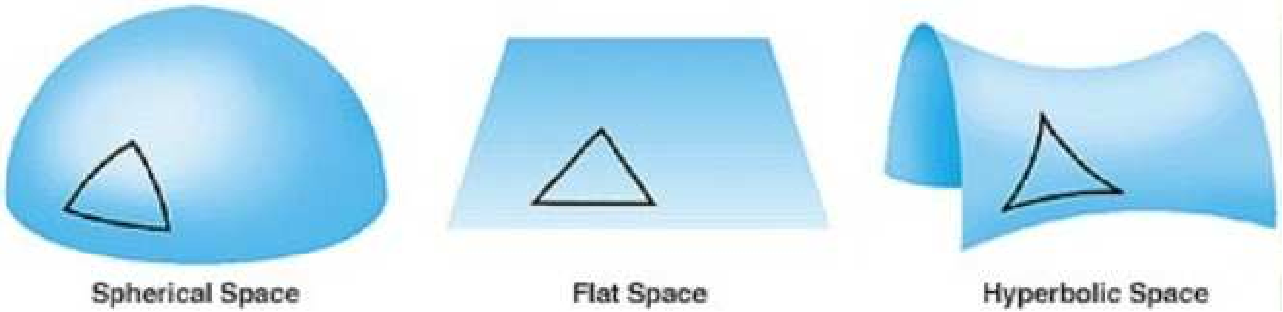
Depends on density of matter and number of types of particles

Does not seem to be enough to stop expansion, or even to form the galaxies like ours:

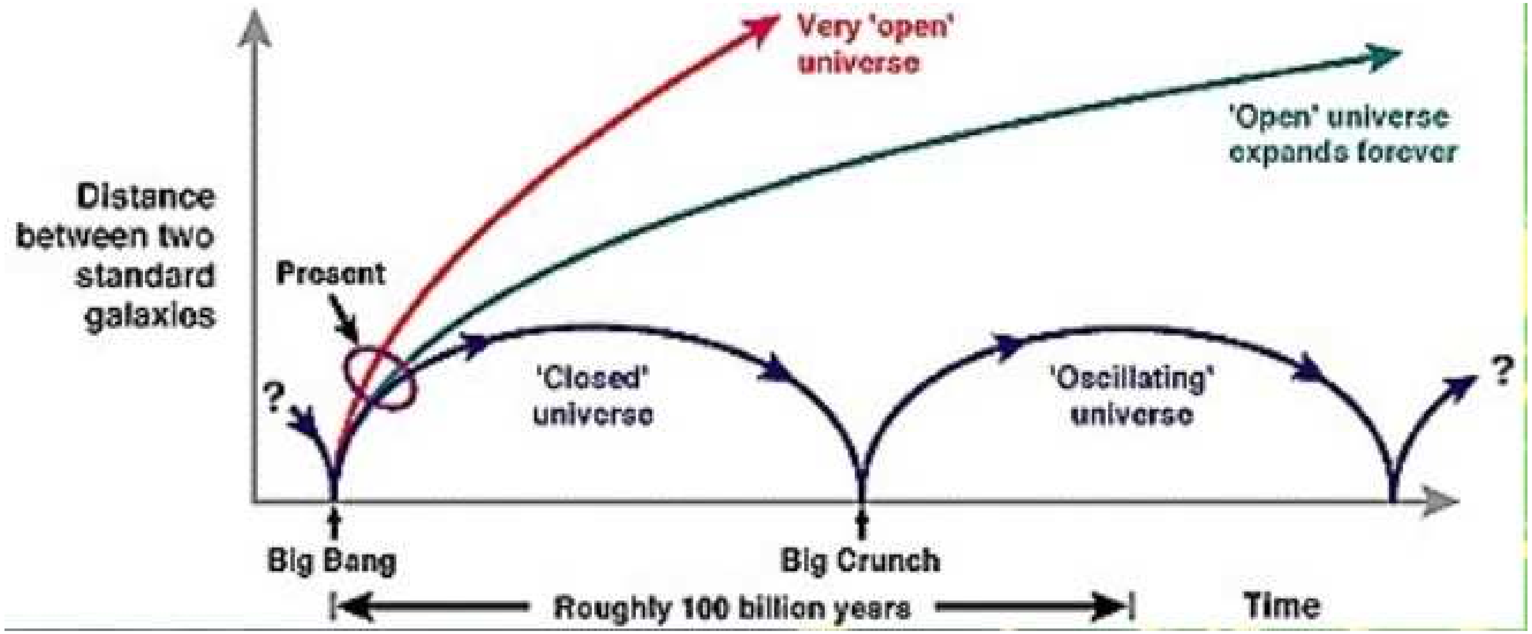
Cosmological inflation

Basic idea: very early, about maybe 10^{-35} s after the Big Bang, the expansion was exponentially fast

Can explain why the universe looks almost flat now



Fate of the Universe depends on this:

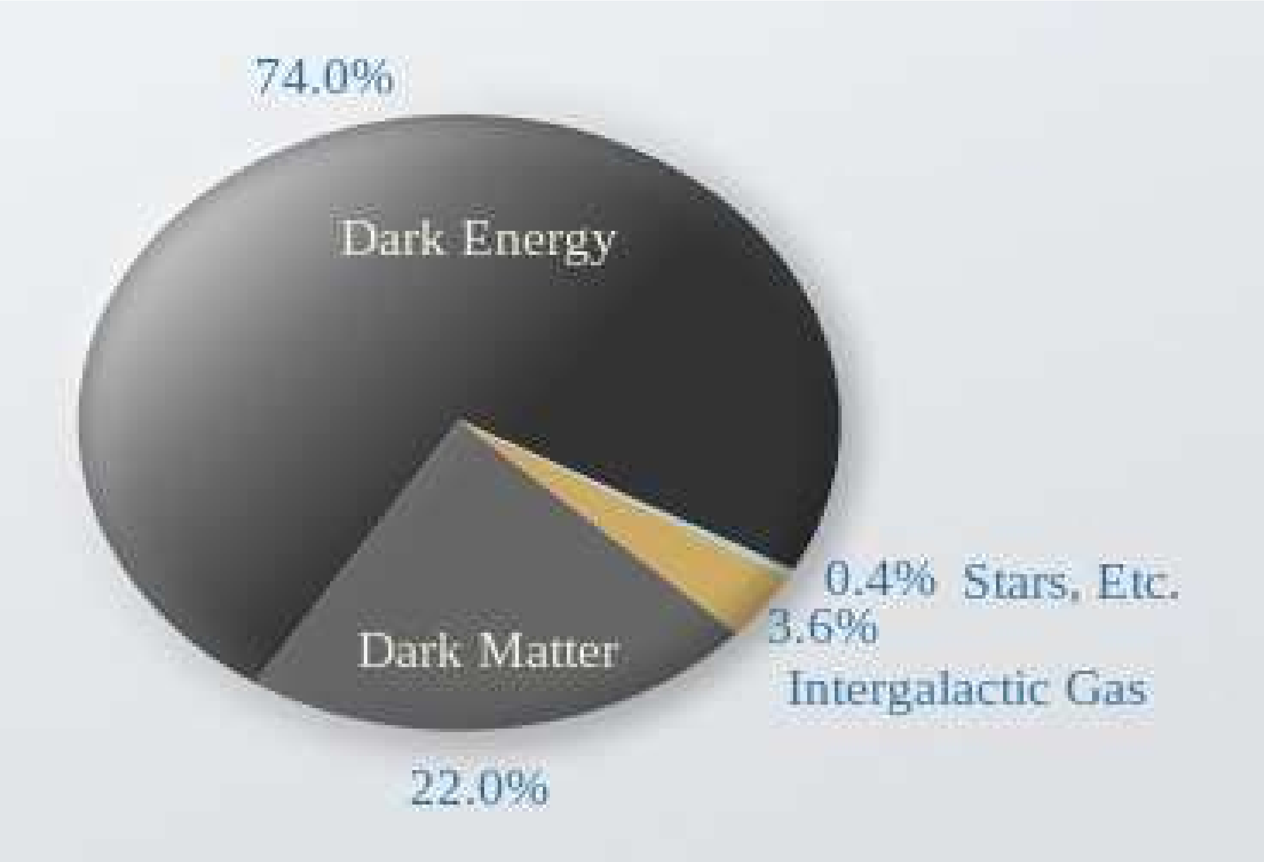


Energy density budget of the Universe

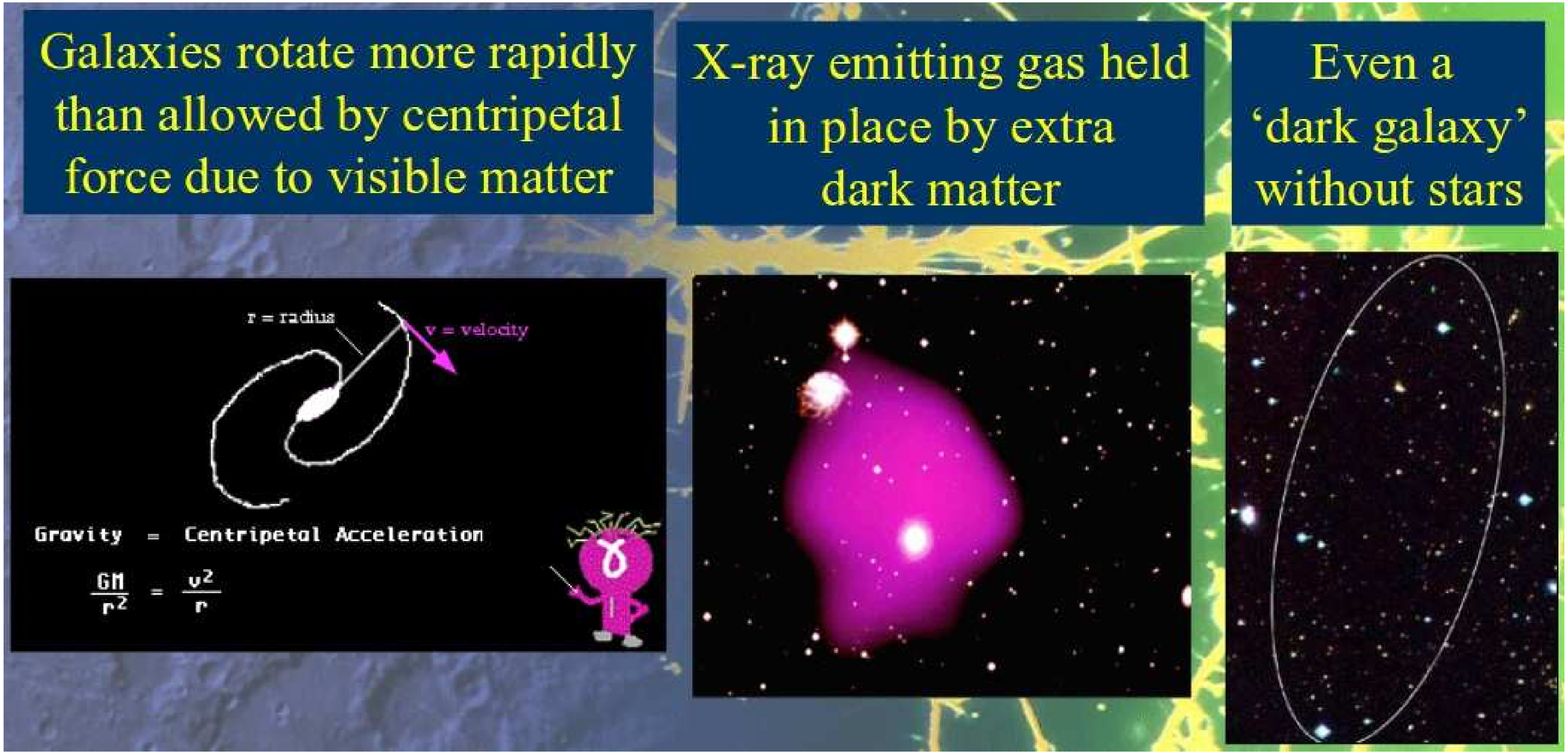
There is some critical value of the energy density which keeps the balance between expansion and contraction of the universe.

$\Omega = 1$ corresponds to a flat universe – close to what we see today

Latest measurements show that there are different components to this density:



Evidence for Dark Matter – I



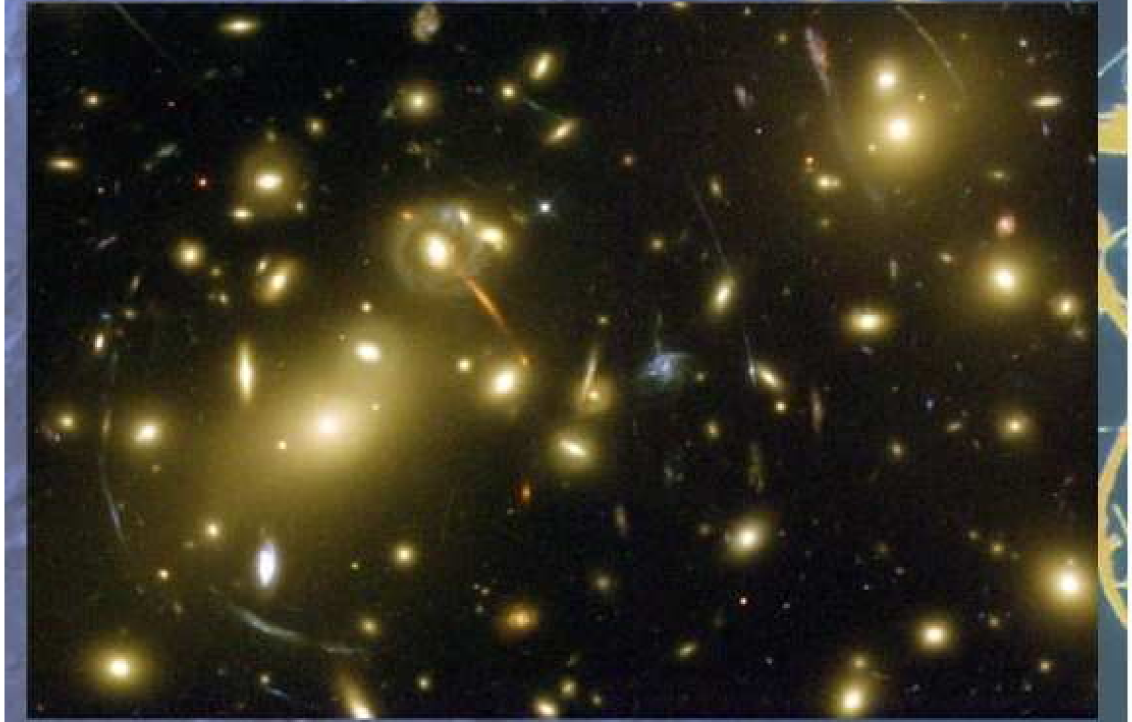
Galaxies rotate more rapidly than allowed by centripetal force due to visible matter

X-ray emitting gas held in place by extra dark matter

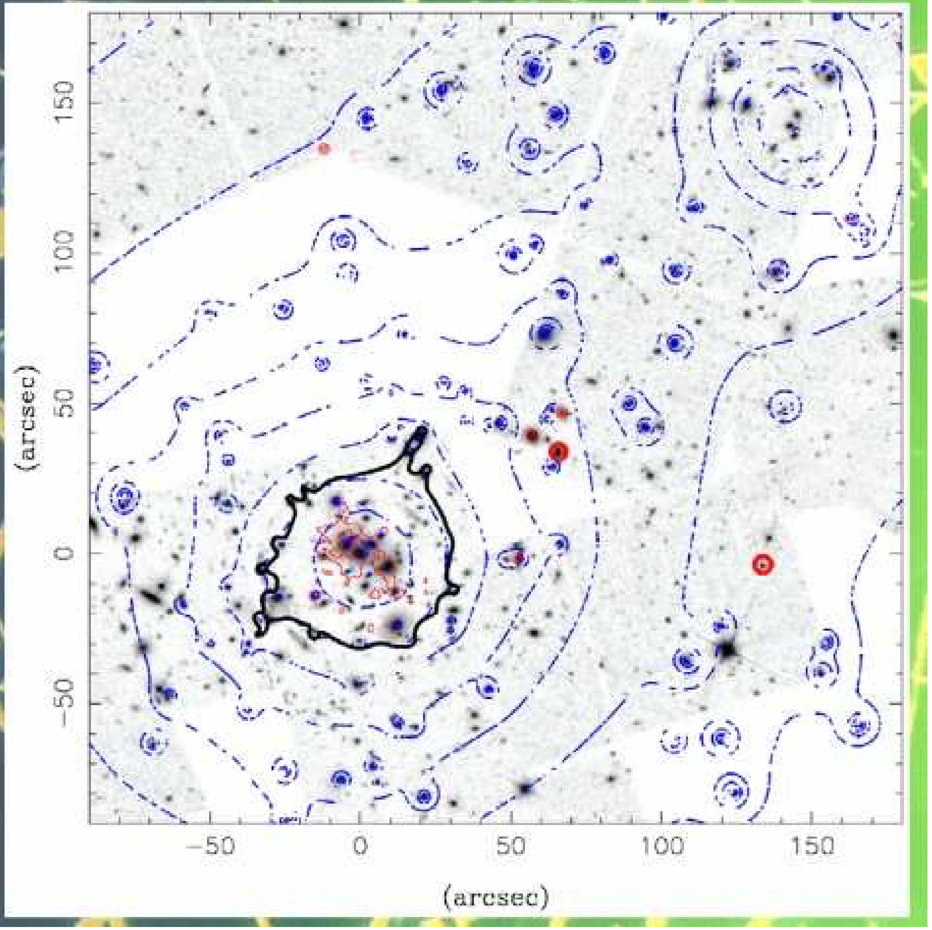
Even a ‘dark galaxy’ without stars

Evidence for Dark Matter – II

Light bent by gravitational field of dark matter

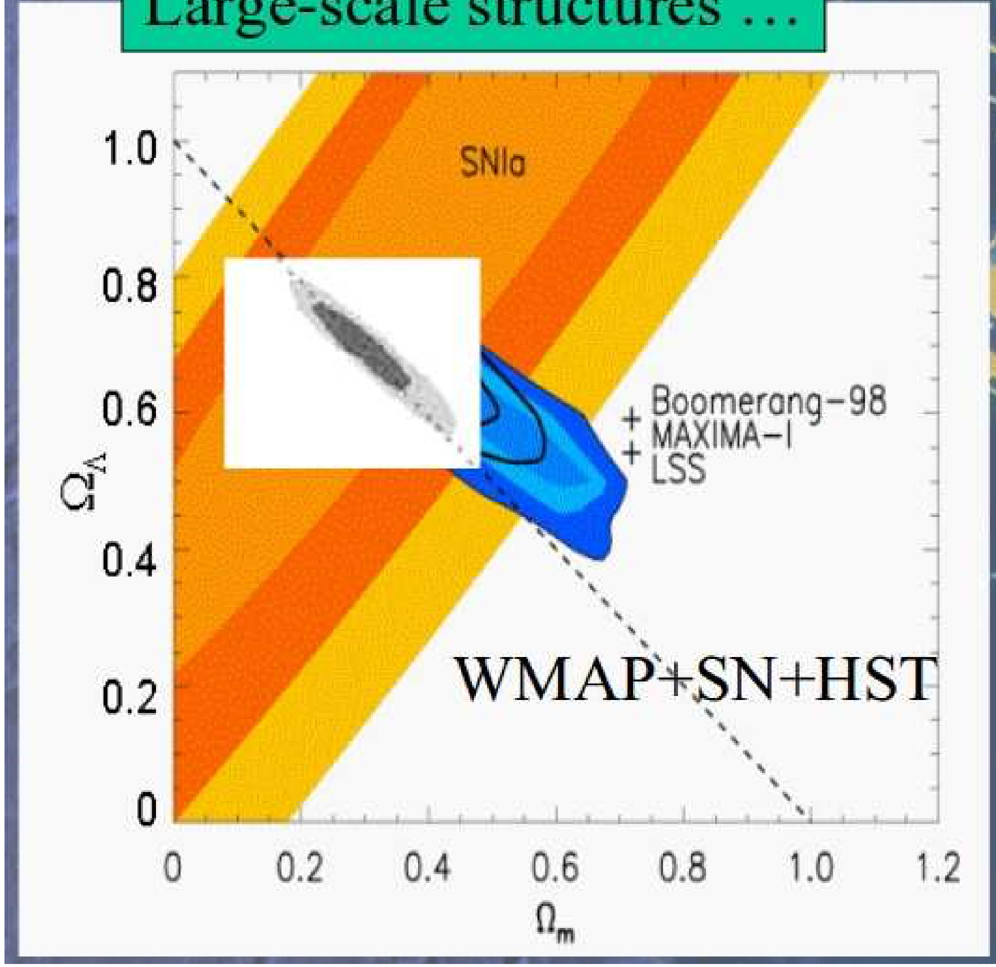


Contours of mass density

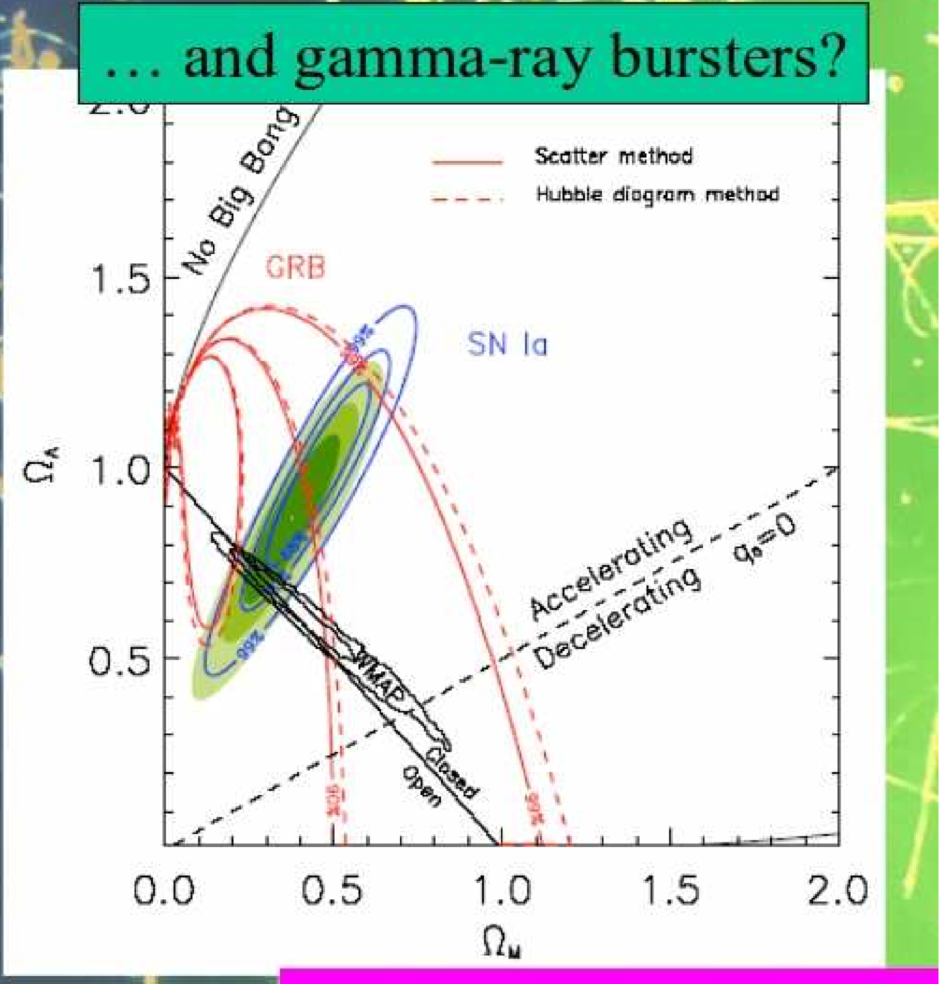


Experimental data on components of Ω

WMAP, Supernovae, Large-scale structures …

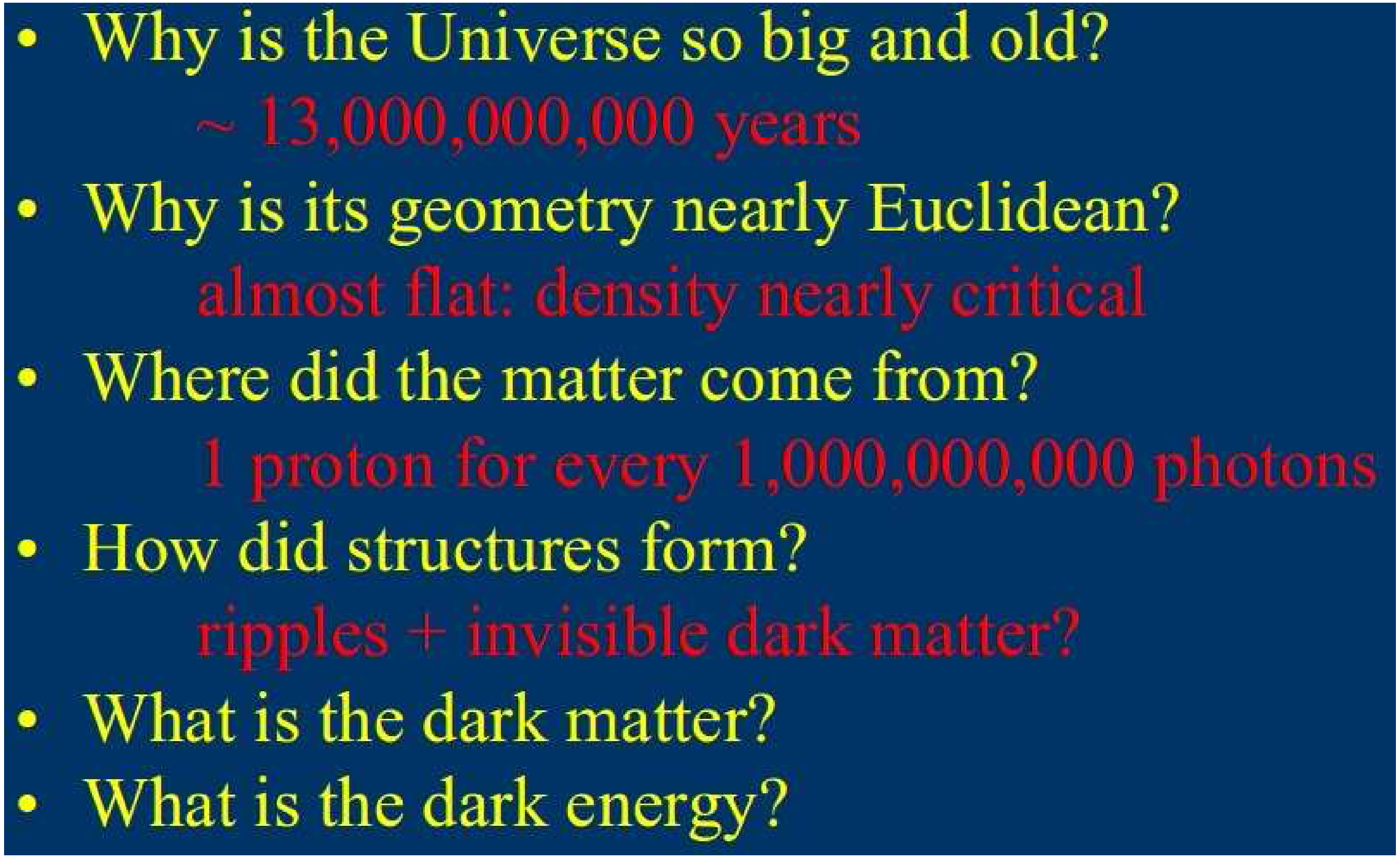


… and gamma-ray bursters?



Barbiellini //, Ghirlanda et al

Unresolved questions in Cosmology



- Why is the Universe so big and old?
  - $\sim$ 13,000,000,000 years
- Why is its geometry nearly Euclidean?
  - almost flat: density nearly critical
- Where did the matter come from?
  - 1 proton for every 1,000,000,000 photons
- How did structures form?
  - ripples + invisible dark matter?
- What is the dark matter?
- What is the dark energy?

The hope is that Particle Physics can help answer at least some of these!

Beyond the Standard Model

- Is there a bigger symmetry group, which will become visible at higher energies?
  ⇒ Grand Unification

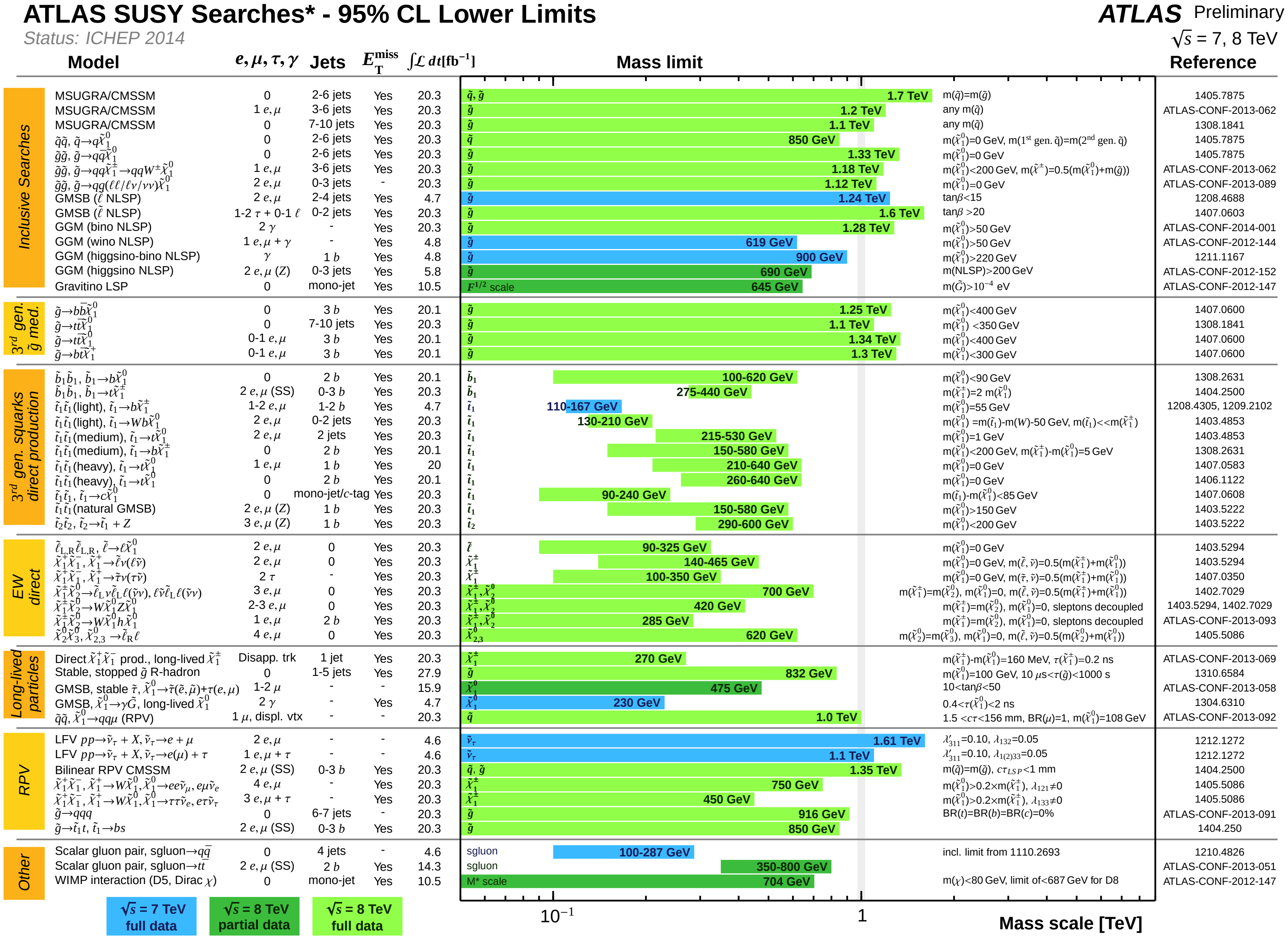
- Or maybe the Poincaré-Lorentz invariance group can be extended to include anticummutation relations?
  ⇒ Supersymmetry

- Or maybe our space-time has more than 3+1 dimensions, some of which are "compactified" ?
  ⇒ Large extra dimensions

These, and many other, theories exist — and predict some observable effects.

Physicists are searching for them, in a hope to answer some of the questions...

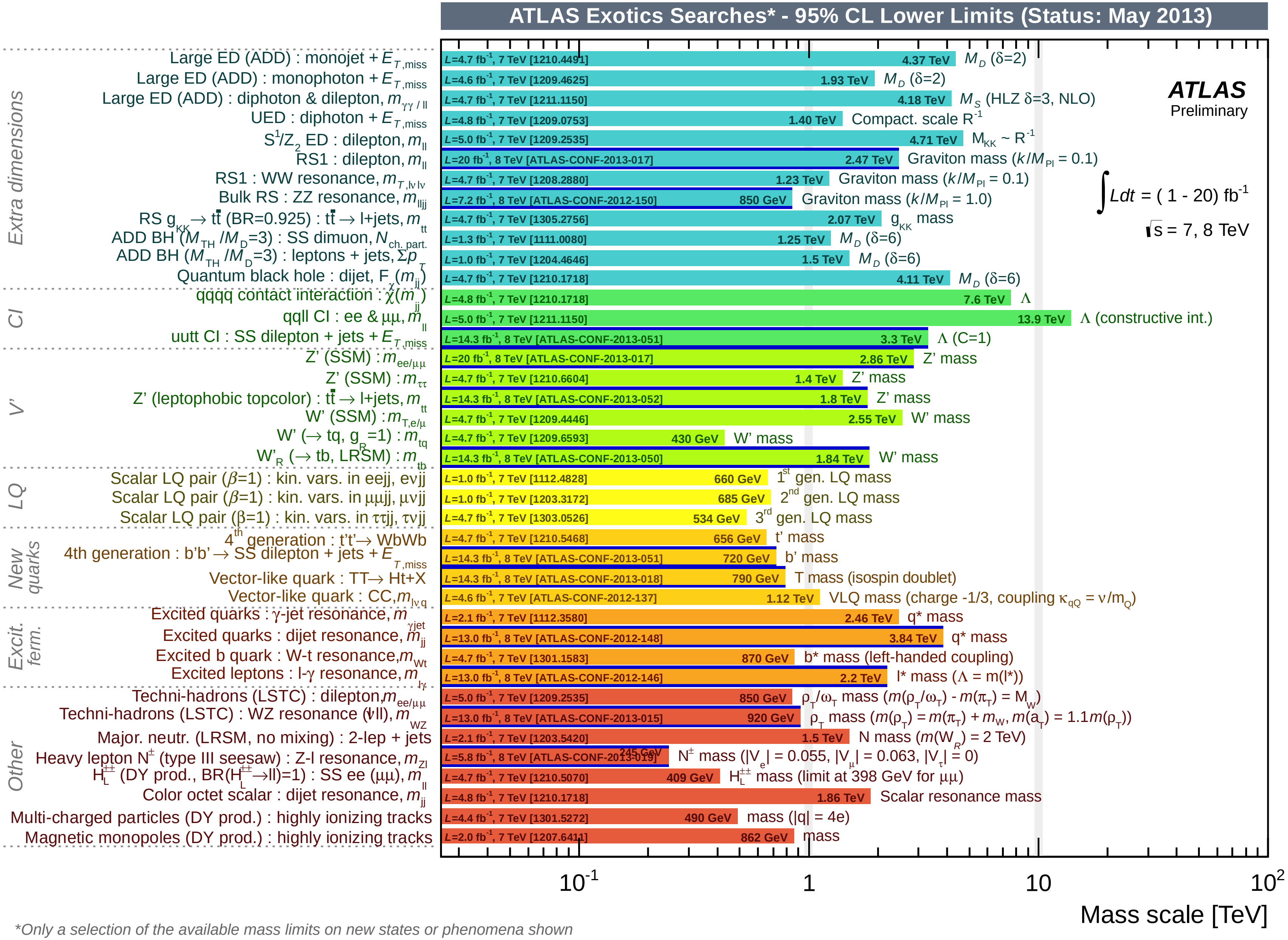
Supersymmetry searches: lower limits



	Model	e,μ,τ,γ	Jets	E_T^{miss}	$\int\mathcal{L}\,dt[\mathrm{fb}^{-1}]$	Mass limit			Reference
Inclusive Searches	MSUGRA/CMSSM	0	2-6 jets	Yes	20.3	$\tilde{q},\tilde{g}$	1.7 TeV	m($\tilde{q}$)=m($\tilde{g}$)	1405.7875
	MSUGRA/CMSSM	1 e,μ	3-6 jets	Yes	20.3	$\tilde{g}$	1.2 TeV	any m($\tilde{q}$)	ATLAS-CONF-2013-062
	MSUGRA/CMSSM	0	7-10 jets	Yes	20.3	$\tilde{g}$	1.1 TeV	any m($\tilde{q}$)	1308.1841
	$\tilde{q}\tilde{q}$, $\tilde{q}\to q\tilde{\chi}^0_1$	0	2-6 jets	Yes	20.3	$\tilde{q}$	850 GeV	m($\tilde{\chi}^0_1$)=0 GeV, m(1st gen. $\tilde{q}$)=m(2nd gen. $\tilde{q}$)	1405.7875
	$\tilde{g}\tilde{g}$, $\tilde{g}\to q\bar{q}\tilde{\chi}^0_1$	0	2-6 jets	Yes	20.3	$\tilde{g}$	1.33 TeV	m($\tilde{\chi}^0_1$)=0 GeV	1405.7875
	$\tilde{g}\tilde{g}$, $\tilde{g}\to qq\tilde{\chi}^\pm_1\to qqW^\pm\tilde{\chi}^0_1$	1 e,μ	3-6 jets	Yes	20.3	$\tilde{g}$	1.18 TeV	m($\tilde{\chi}^0_1$)<200 GeV, m($\tilde{\chi}^\pm$)=0.5(m($\tilde{\chi}^0_1$)+m($\tilde{g}$))	ATLAS-CONF-2013-062
	$\tilde{g}\tilde{g}$, $\tilde{g}\to qq(\ell\ell/\ell\nu/\nu\nu)\tilde{\chi}^0_1$	2 e,μ	0-3 jets	-	20.3	$\tilde{g}$	1.12 TeV	m($\tilde{\chi}^0_1$)=0 GeV	ATLAS-CONF-2013-089
	GMSB ($\tilde{\ell}$ NLSP)	2 e,μ	2-4 jets	Yes	4.7	$\tilde{g}$	1.24 TeV	tanβ<15	1208.4688
	GMSB ($\tilde{\ell}$ NLSP)	1-2 τ + 0-1 ℓ	0-2 jets	Yes	20.3	$\tilde{g}$	1.6 TeV	tanβ >20	1407.0603
	GGM (bino NLSP)	2 γ	-	Yes	20.3	$\tilde{g}$	1.28 TeV	m($\tilde{\chi}^0_1$)>50 GeV	ATLAS-CONF-2014-001
	GGM (wino NLSP)	1 e,μ + γ	-	Yes	4.8	$\tilde{g}$	619 GeV	m($\tilde{\chi}^0_1$)>50 GeV	ATLAS-CONF-2012-144
	GGM (higgsino-bino NLSP)	γ	1 b	Yes	4.8	$\tilde{g}$	900 GeV	m($\tilde{\chi}^0_1$)>220 GeV	1211.1167
	GGM (higgsino NLSP)	2 e,μ (Z)	0-3 jets	Yes	5.8	$\tilde{g}$	690 GeV	m(NLSP)>200 GeV	ATLAS-CONF-2012-152
	Gravitino LSP	0	mono-jet	Yes	10.5	$F^{1/2}$ scale	645 GeV	m($\tilde{G}$)>10^{-4} eV	ATLAS-CONF-2012-147
3rd gen. $\tilde{g}$ med.	$\tilde{g}\to b\bar{b}\tilde{\chi}^0_1$	0	3 b	Yes	20.1	$\tilde{g}$	1.25 TeV	m($\tilde{\chi}^0_1$)<400 GeV	1407.0600
	$\tilde{g}\to t\bar{t}\tilde{\chi}^0_1$	0	7-10 jets	Yes	20.3	$\tilde{g}$	1.1 TeV	m($\tilde{\chi}^0_1$) <350 GeV	1308.1841
	$\tilde{g}\to t\bar{t}\tilde{\chi}^0_1$	0-1 e,μ	3 b	Yes	20.1	$\tilde{g}$	1.34 TeV	m($\tilde{\chi}^0_1$)<400 GeV	1407.0600
	$\tilde{g}\to b\bar{t}\tilde{\chi}^+_1$	0-1 e,μ	3 b	Yes	20.1	$\tilde{g}$	1.3 TeV	m($\tilde{\chi}^0_1$)<300 GeV	1407.0600
3rd gen. squarks direct production	$\tilde{b}_1\tilde{b}_1$, $\tilde{b}_1\to b\tilde{\chi}^0_1$	0	2 b	Yes	20.1	$\tilde{b}_1$	100-620 GeV	m($\tilde{\chi}^0_1$)<90 GeV	1308.2631
	$\tilde{b}_1\tilde{b}_1$, $\tilde{b}_1\to t\tilde{\chi}^\pm_1$	2 e,μ (SS)	0-3 b	Yes	20.3	$\tilde{b}_1$	275-440 GeV	m($\tilde{\chi}^\pm_1$)=2 m($\tilde{\chi}^0_1$)	1404.2500
	$\tilde{t}_1\tilde{t}_1$(light), $\tilde{t}_1\to b\tilde{\chi}^\pm_1$	1-2 e,μ	1-2 b	Yes	4.7	$\tilde{t}_1$	110-167 GeV	m($\tilde{\chi}^0_1$)=55 GeV	1208.4305, 1209.2102
	$\tilde{t}_1\tilde{t}_1$(light), $\tilde{t}_1\to Wb\tilde{\chi}^0_1$	2 e,μ	0-2 jets	Yes	20.3	$\tilde{t}_1$	130-210 GeV	m($\tilde{\chi}^0_1$) =m($\tilde{t}_1$)-m(W)-50 GeV, m($\tilde{t}_1$)<<m($\tilde{\chi}^\pm_1$)	1403.4853
	$\tilde{t}_1\tilde{t}_1$(medium), $\tilde{t}_1\to t\tilde{\chi}^0_1$	2 e,μ	2 jets	Yes	20.3	$\tilde{t}_1$	215-530 GeV	m($\tilde{\chi}^0_1$)=1 GeV	1403.4853
	$\tilde{t}_1\tilde{t}_1$(medium), $\tilde{t}_1\to b\tilde{\chi}^\pm_1$	0	2 b	Yes	20.1	$\tilde{t}_1$	150-580 GeV	m($\tilde{\chi}^0_1$)<200 GeV, m($\tilde{\chi}^\pm_1$)-m($\tilde{\chi}^0_1$)=5 GeV	1308.2631
	$\tilde{t}_1\tilde{t}_1$(heavy), $\tilde{t}_1\to t\tilde{\chi}^0_1$	1 e,μ	1 b	Yes	20	$\tilde{t}_1$	210-640 GeV	m($\tilde{\chi}^0_1$)=0 GeV	1407.0583
	$\tilde{t}_1\tilde{t}_1$(heavy), $\tilde{t}_1\to t\tilde{\chi}^0_1$	0	2 b	Yes	20.1	$\tilde{t}_1$	260-640 GeV	m($\tilde{\chi}^0_1$)=0 GeV	1406.1122
	$\tilde{t}_1\tilde{t}_1$, $\tilde{t}_1\to c\tilde{\chi}^0_1$	0	mono-jet/c-tag	Yes	20.3	$\tilde{t}_1$	90-240 GeV	m($\tilde{t}_1$)-m($\tilde{\chi}^0_1$)<85 GeV	1407.0608
	$\tilde{t}_1\tilde{t}_1$(natural GMSB)	2 e,μ (Z)	1 b	Yes	20.3	$\tilde{t}_1$	150-580 GeV	m($\tilde{\chi}^0_1$)>150 GeV	1403.5222
	$\tilde{t}_2\tilde{t}_2$, $\tilde{t}_2\to\tilde{t}_1 + Z$	3 e,μ (Z)	1 b	Yes	20.3	$\tilde{t}_2$	290-600 GeV	m($\tilde{\chi}^0_1$)<200 GeV	1403.5222
EW direct	$\tilde{\ell}_{L,R}\tilde{\ell}_{L,R}$, $\tilde{\ell}\to\ell\tilde{\chi}^0_1$	2 e,μ	0	Yes	20.3	$\tilde{\ell}$	90-325 GeV	m($\tilde{\chi}^0_1$)=0 GeV	1403.5294
	$\tilde{\chi}^+_1\tilde{\chi}^-_1$, $\tilde{\chi}^+_1\to\tilde{\ell}\nu(\ell\tilde{\nu})$	2 e,μ	0	Yes	20.3	$\tilde{\chi}^\pm_1$	140-465 GeV	m($\tilde{\chi}^0_1$)=0 GeV, m($\tilde{\ell},\tilde{\nu}$)=0.5(m($\tilde{\chi}^\pm_1$)+m($\tilde{\chi}^0_1$))	1403.5294
	$\tilde{\chi}^+_1\tilde{\chi}^-_1$, $\tilde{\chi}^+_1\to\tilde{\tau}\nu(\tau\tilde{\nu})$	2 τ	-	Yes	20.3	$\tilde{\chi}^\pm_1$	100-350 GeV	m($\tilde{\chi}^0_1$)=0 GeV, m($\tilde{\tau},\tilde{\nu}$)=0.5(m($\tilde{\chi}^\pm_1$)+m($\tilde{\chi}^0_1$))	1407.0350
	$\tilde{\chi}^\pm_1\tilde{\chi}^0_2\to\tilde{\ell}_L\nu\tilde{\ell}_L\ell(\tilde{\nu}\nu)$, $\ell\tilde{\nu}\tilde{\ell}_L\ell(\tilde{\nu}\nu)$	3 e,μ	0	Yes	20.3	$\tilde{\chi}^\pm_1,\tilde{\chi}^0_2$	700 GeV	m($\tilde{\chi}^\pm_1$)=m($\tilde{\chi}^0_2$), m($\tilde{\chi}^0_1$)=0, m($\tilde{\ell},\tilde{\nu}$)=0.5(m($\tilde{\chi}^\pm_1$)+m($\tilde{\chi}^0_1$))	1402.7029
	$\tilde{\chi}^\pm_1\tilde{\chi}^0_2\to W\tilde{\chi}^0_1 Z\tilde{\chi}^0_1$	2-3 e,μ	0	Yes	20.3	$\tilde{\chi}^\pm_1,\tilde{\chi}^0_2$	420 GeV	m($\tilde{\chi}^\pm_1$)=m($\tilde{\chi}^0_2$), m($\tilde{\chi}^0_1$)=0, sleptons decoupled	1403.5294, 1402.7029
	$\tilde{\chi}^\pm_1\tilde{\chi}^0_2\to W\tilde{\chi}^0_1 h\tilde{\chi}^0_1$	1 e,μ	2 b	Yes	20.3	$\tilde{\chi}^\pm_1,\tilde{\chi}^0_2$	285 GeV	m($\tilde{\chi}^\pm_1$)=m($\tilde{\chi}^0_2$), m($\tilde{\chi}^0_1$)=0, sleptons decoupled	ATLAS-CONF-2013-093
	$\tilde{\chi}^0_2\tilde{\chi}^0_3$, $\tilde{\chi}^0_{2,3}\to\tilde{\ell}_R\ell$	4 e,μ	0	Yes	20.3	$\tilde{\chi}^0_{2,3}$	620 GeV	m($\tilde{\chi}^0_2$)=m($\tilde{\chi}^0_3$), m($\tilde{\chi}^0_1$)=0, m($\tilde{\ell},\tilde{\nu}$)=0.5(m($\tilde{\chi}^0_2$)+m($\tilde{\chi}^0_1$))	1405.5086
Long-lived particles	Direct $\tilde{\chi}^+_1\tilde{\chi}^-_1$ prod., long-lived $\tilde{\chi}^\pm_1$	Disapp. trk	1 jet	Yes	20.3	$\tilde{\chi}^\pm_1$	270 GeV	m($\tilde{\chi}^\pm_1$)-m($\tilde{\chi}^0_1$)=160 MeV, τ($\tilde{\chi}^\pm_1$)=0.2 ns	ATLAS-CONF-2013-069
	Stable, stopped $\tilde{g}$ R-hadron	0	1-5 jets	Yes	27.9	$\tilde{g}$	832 GeV	m($\tilde{\chi}^0_1$)=100 GeV, 10 μs<τ($\tilde{g}$)<1000 s	1310.6584
	GMSB, stable $\tilde{\tau}$, $\tilde{\chi}^0_1\to\tilde{\tau}(\tilde{e},\tilde{\mu})+\tau(e,\mu)$	1-2 μ	-	-	15.9	$\tilde{\chi}^0_1$	475 GeV	10<tanβ<50	ATLAS-CONF-2013-058
	GMSB, $\tilde{\chi}^0_1\to\gamma\tilde{G}$, long-lived $\tilde{\chi}^0_1$	2 γ	-	Yes	4.7	$\tilde{\chi}^0_1$	230 GeV	0.4<τ($\tilde{\chi}^0_1$)<2 ns	1304.6310
	$\tilde{q}\tilde{q}$, $\tilde{\chi}^0_1\to qq\mu$ (RPV)	1 μ, displ. vtx	-	-	20.3	$\tilde{q}$	1.0 TeV	1.5 <$c\tau$<156 mm, BR(μ)=1, m($\tilde{\chi}^0_1$)=108 GeV	ATLAS-CONF-2013-092
RPV	LFV $pp\to\tilde{\nu}_\tau + X$, $\tilde{\nu}_\tau\to e + \mu$	2 e,μ	-	-	4.6	$\tilde{\nu}_\tau$	1.61 TeV	λ'_{311}=0.10, λ_{132}=0.05	1212.1272
	LFV $pp\to\tilde{\nu}_\tau + X$, $\tilde{\nu}_\tau\to e(\mu) + \tau$	1 e,μ + τ	-	-	4.6	$\tilde{\nu}_\tau$	1.1 TeV	λ'_{311}=0.10, $\lambda_{1(2)33}$=0.05	1212.1272
	Bilinear RPV CMSSM	2 e,μ (SS)	0-3 b	Yes	20.3	$\tilde{q}$, $\tilde{g}$	1.35 TeV	m($\tilde{q}$)=m($\tilde{g}$), $c\tau_{LSP}$<1 mm	1404.2500
	$\tilde{\chi}^+_1\tilde{\chi}^-_1$, $\tilde{\chi}^+_1\to W\tilde{\chi}^0_1$, $\tilde{\chi}^0_1\to ee\tilde{\nu}_\mu, e\mu\tilde{\nu}_e$	4 e,μ	-	Yes	20.3	$\tilde{\chi}^\pm_1$	750 GeV	m($\tilde{\chi}^0_1$)>0.2×m($\tilde{\chi}^\pm_1$), $\lambda_{121}\neq0$	1405.5086
	$\tilde{\chi}^+_1\tilde{\chi}^-_1$, $\tilde{\chi}^+_1\to W\tilde{\chi}^0_1$, $\tilde{\chi}^0_1\to\tau\tau\tilde{\nu}_e, e\tau\tilde{\nu}_\tau$	3 e,μ + τ	-	Yes	20.3	$\tilde{\chi}^\pm_1$	450 GeV	m($\tilde{\chi}^0_1$)>0.2×m($\tilde{\chi}^\pm_1$), $\lambda_{133}\neq0$	1405.5086
	$\tilde{g}\to qqq$	0	6-7 jets	-	20.3	$\tilde{g}$	916 GeV	BR(t)=BR(b)=BR(c)=0%	ATLAS-CONF-2013-091
	$\tilde{g}\to\tilde{t}_1 t$, $\tilde{t}_1\to bs$	2 e,μ (SS)	0-3 b	Yes	20.3	$\tilde{g}$	850 GeV		1404.250
Other	Scalar gluon pair, sgluon$\to q\bar{q}$	0	4 jets	-	4.6	sgluon	100-287 GeV	incl. limit from 1110.2693	1210.4826
	Scalar gluon pair, sgluon$\to t\bar{t}$	2 e,μ (SS)	2 b	Yes	14.3	sgluon	350-800 GeV		ATLAS-CONF-2013-051
	WIMP interaction (D5, Dirac χ)	0	mono-jet	Yes	10.5	M* scale	704 GeV	m(χ)<80 GeV, limit of<687 GeV for D8	ATLAS-CONF-2012-147

*Only a selection of the available mass limits on new states or phenomena is shown. All limits quoted are observed minus 1σ theoretical signal cross section uncertainty.

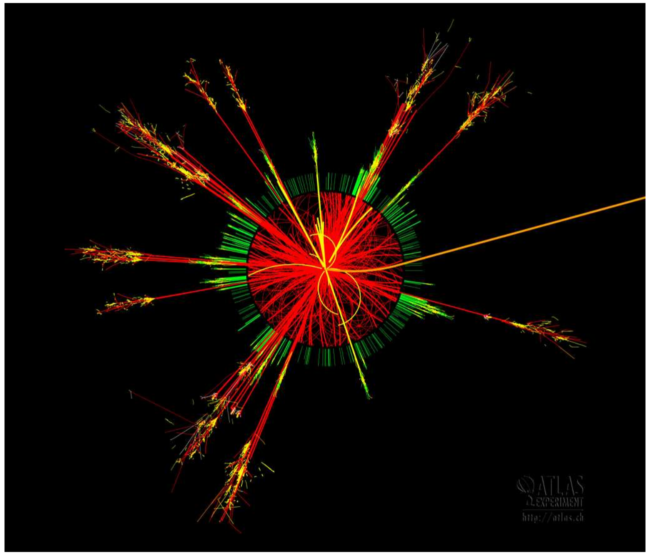
Exotics searches: lower limits



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

Summary and outlook

- Huge amount of work has been done by LHC experiments
- An object was observed which looks very much like a Higgs boson!
- Future studies will determine if this is indeed the Standard Model Higgs
- The Standard Model is standing strong – no SUSY, no sign of any exotics either. . .
- Some data still to be analysed, and much more data is still to come
- Hoping for many fascinating discoveries in the near future!



Info on Higgs-like object observation in ATLAS

Web-page with the official Press release:

`http://www.atlas.ch/news/2012/latest-results-from-higgs-search.html`

Official press release in Georgian:

`http://www.atlas.ch/news/2012/HiggsStatementATLAS-Georgian.pdf`

Other ATLAS Higgs resources:

`http://www.atlas.ch/HiggsResources/`