探求的教材のコーディネート3

物理分野

高嶋　隆一

概要

- アトラス検出器とシリコン検出器
- 地上実験棟で宇宙線テスト
- 2010年のテストランの結果
- 2011年ヒッグスの可能性(ファビオラ)
- 2012年ヒッグスの発見か？(ファビオラ)
- 測定器技術と電子回路

Higgsの発見が話題に

- 基礎物理学研究室が2002年から取り組む
  - 2003年：シリコンストリップ検出器のジオメトリーの研究（修士学生は河内君）
  - 2004年：アセナフレームワークの研究
  - 2005年：アラインメントの研究
  - 2006年：バレル部完成、宇宙線試験（山下修論）
  - 2007年：ピット宇宙線試験（エレキは部分実装）
  - 2008年：9月試運転、直後にトラブル
  - 2009年：年末に再開、450GeVx450GeV(武田、ヒッグス対生成で修論）

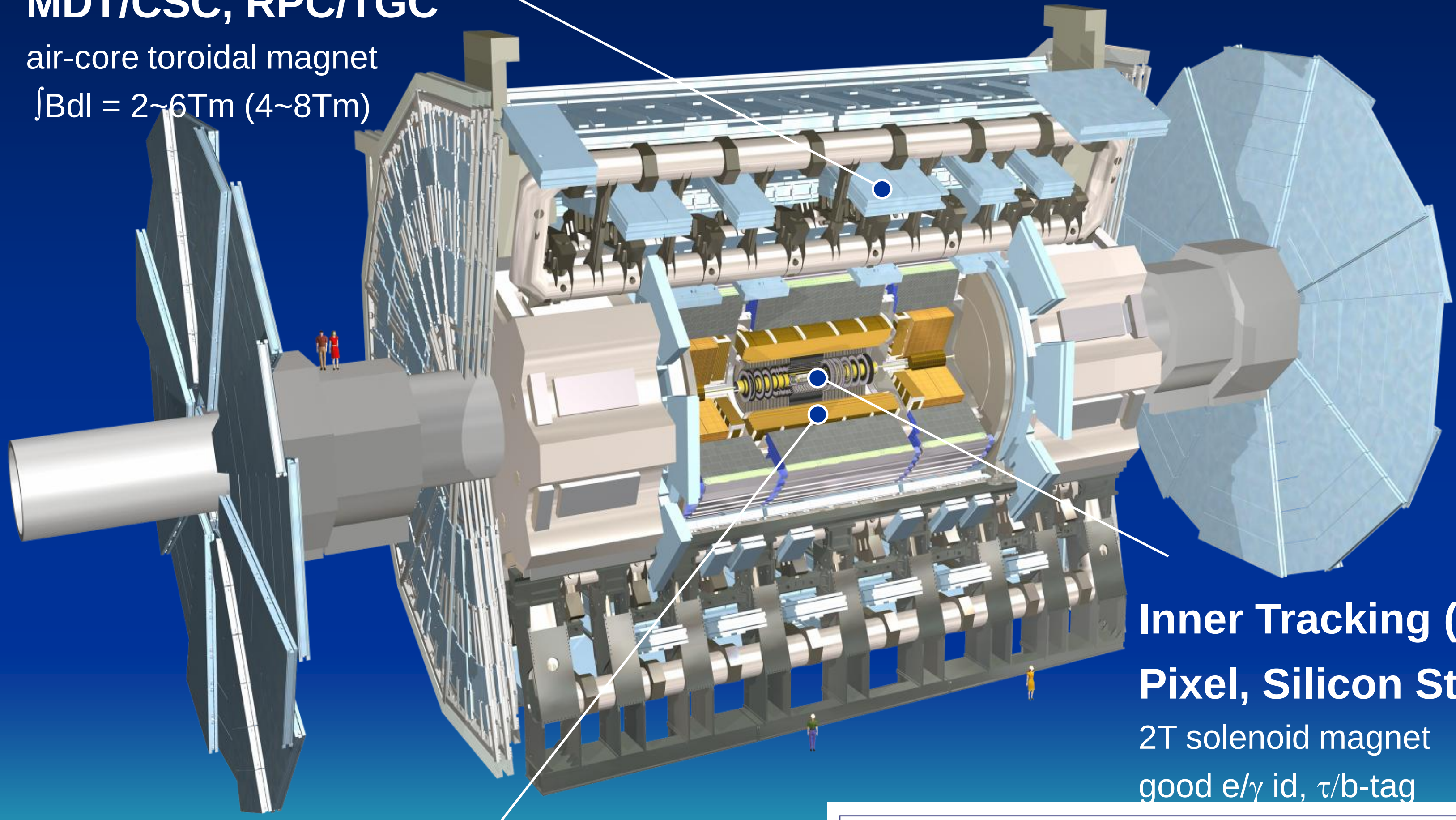
A Toroidal LHC ApparatuS (ATLAS)

Muon Spectrometer(η<2.7)

MDT/CSC, RPC/TGC

air-core toroidal magnet

$\int Bdl$ = 2~6Tm (4~8Tm)



Inner Tracking (η<2.5)

Pixel, Silicon Strip, TRT

2T solenoid magnet

good e/γ id, τ/b-tag

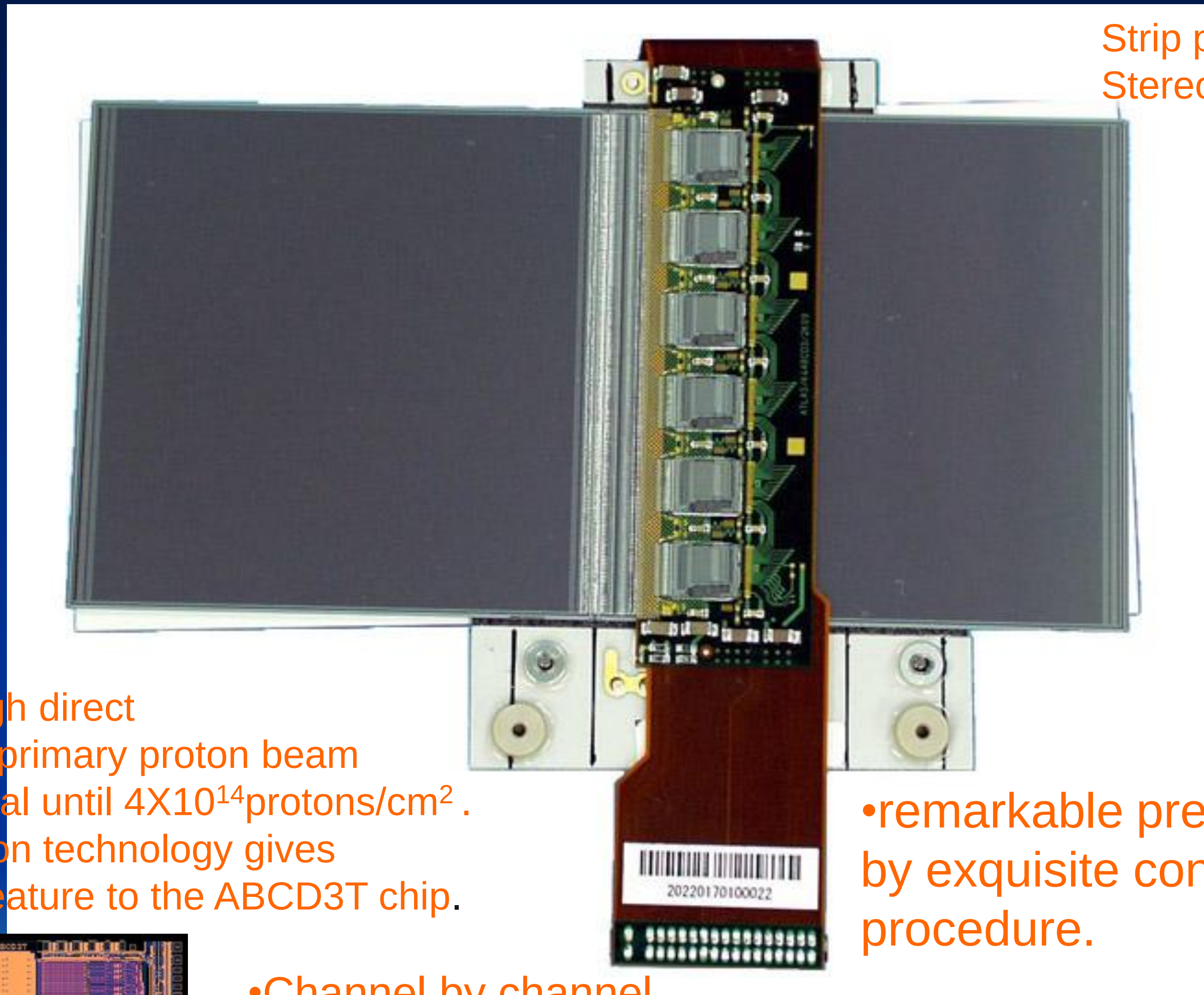
Diameter	*25 m*
Barrel toroid length	*26 m*
End-cap end-wall chamber span	*46 m*
Overall weight	*7000 Tons*

Calorimeter (η<4.9)

Liq.Ar EM/HAD/FCAL, Tile HAD

good e/γ id, energy, E_T^{miss}

アンプリファイアーはバイポーラートランジスター

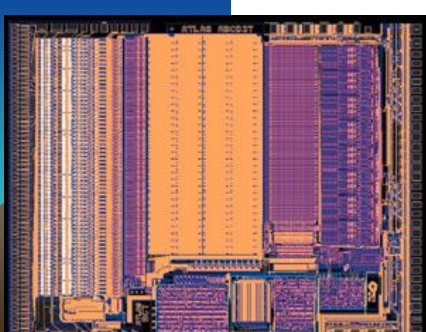


Strip pitch:80μm
Stereo Angle:40mrad

•Survive through direct irradiation by primary proton beam
Operational until $4X10^{14}$protons/cm^2 .

•deep submicron technology gives the radhard feature to the ABCD3T chip.

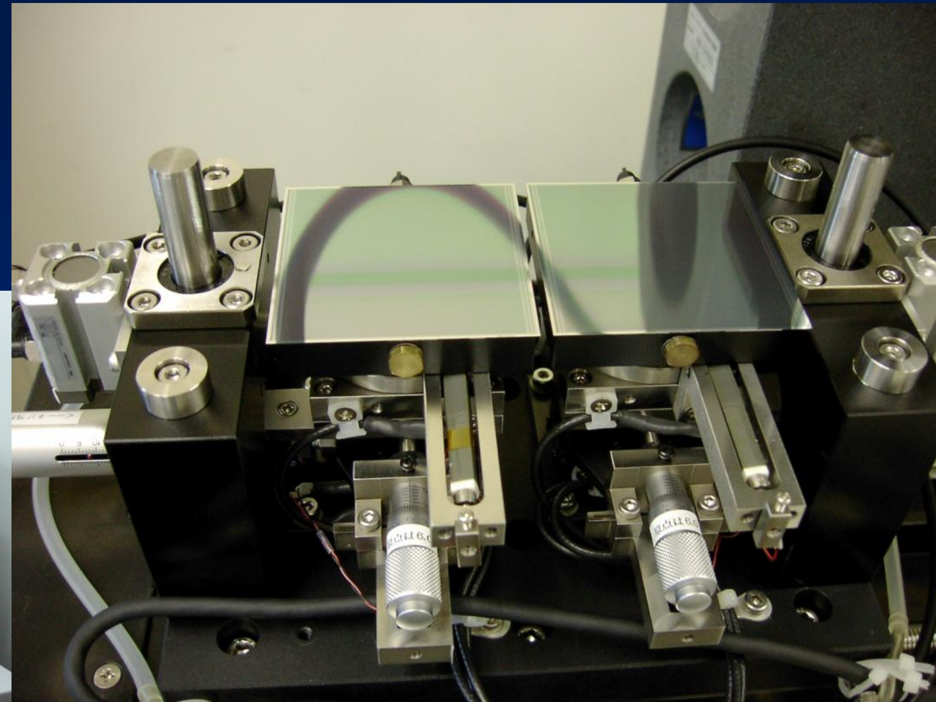
•remarkable precision < 5 μm by exquisite construction procedure.

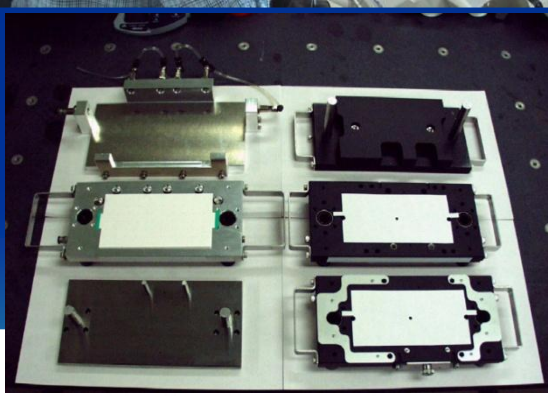


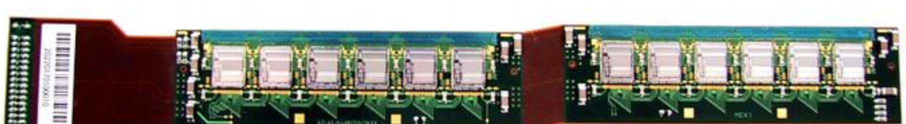
•Channel by channel adjustment of threshold to give uniform response to signal.

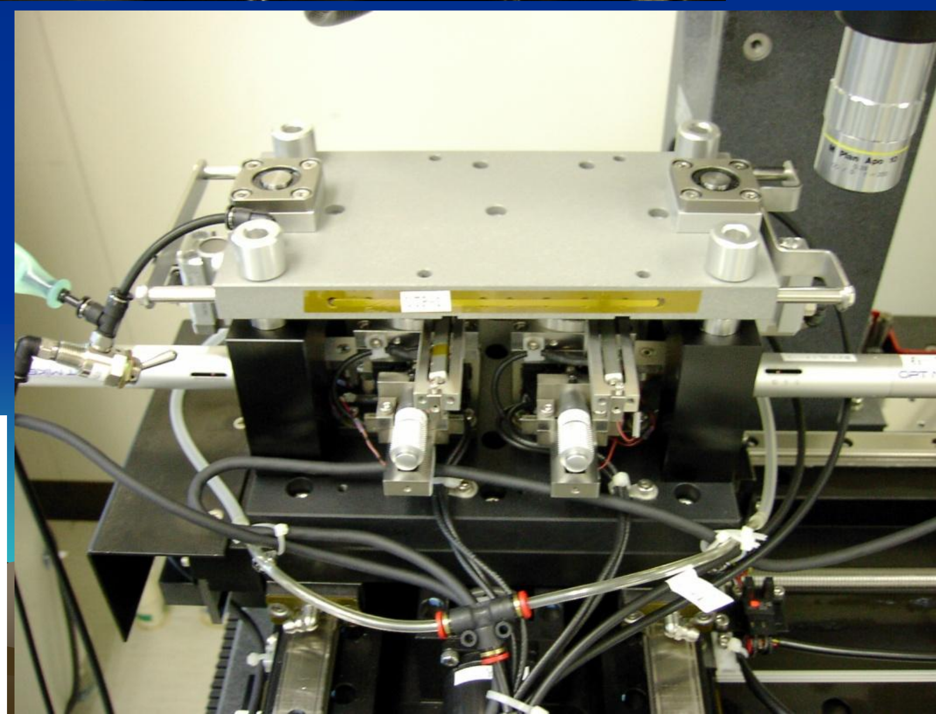
•The readout link can bypass through a dead chip.

- Chips generates ~6W.
- Eaborate thermal property design needed.

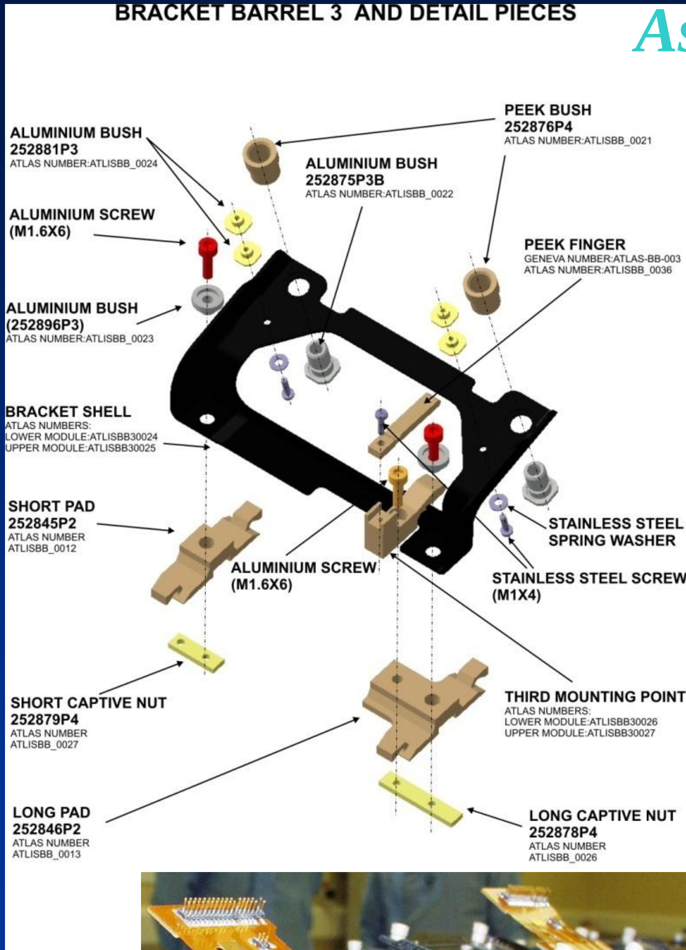


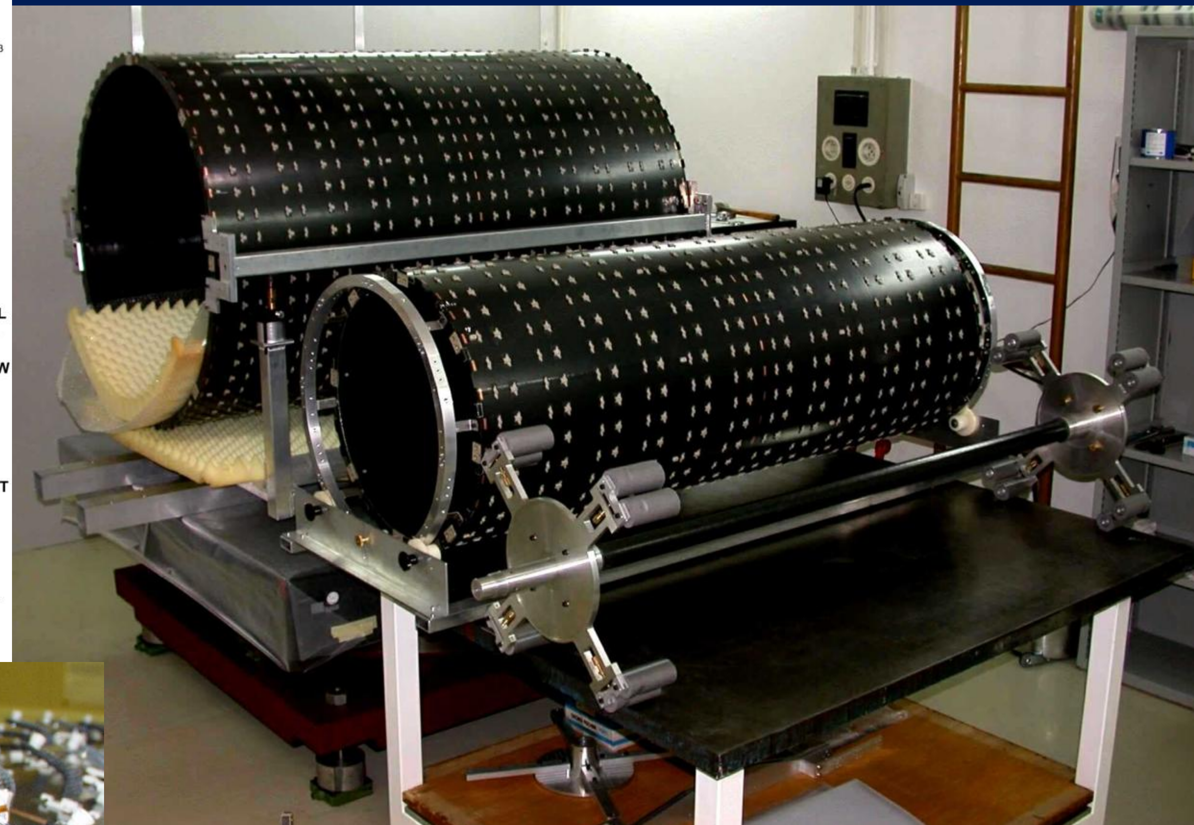


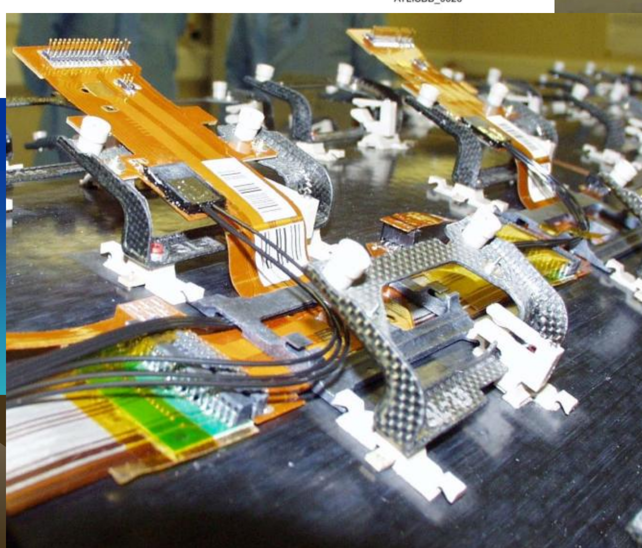




Assembly.1 Support structure Geneva

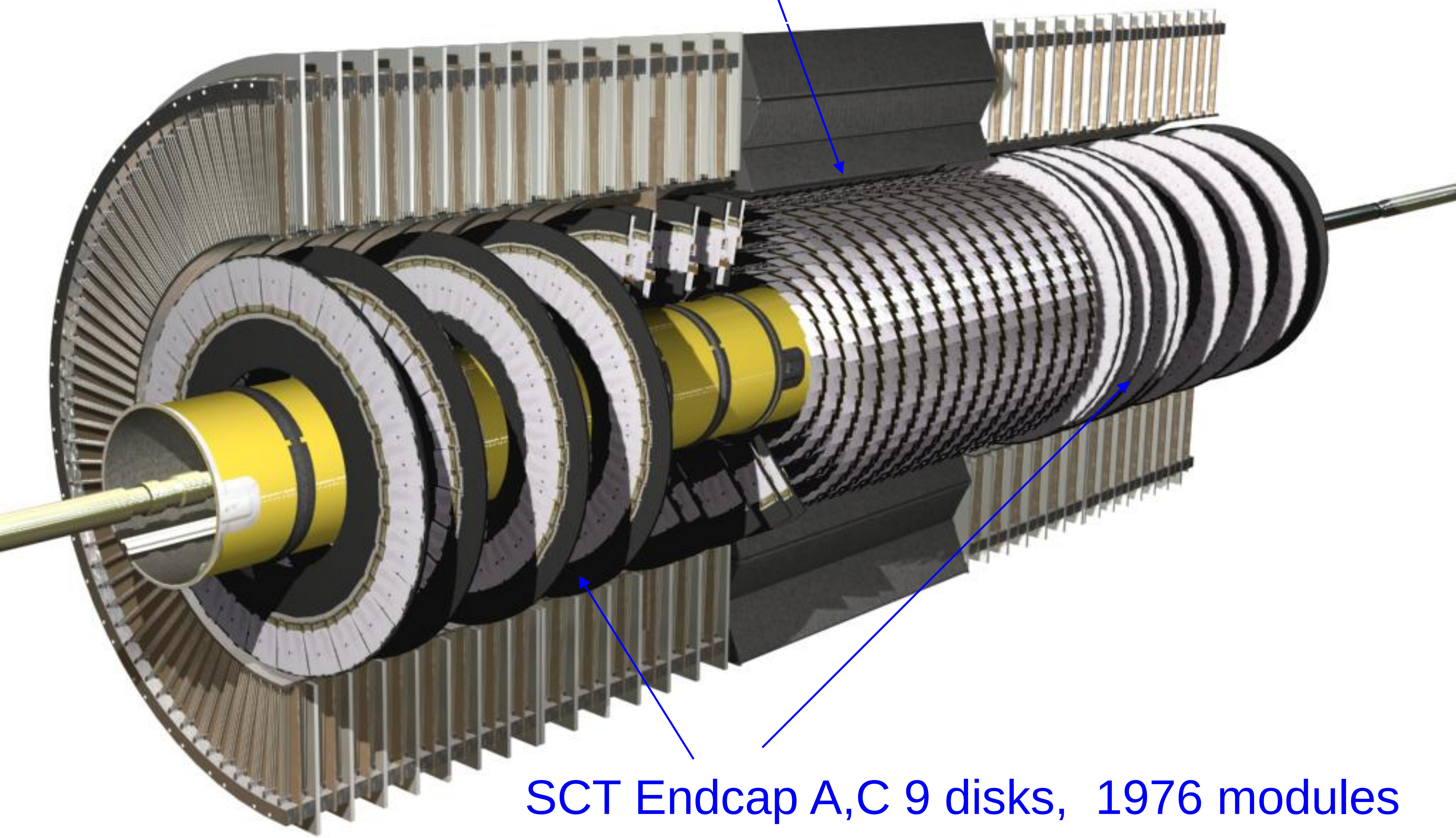




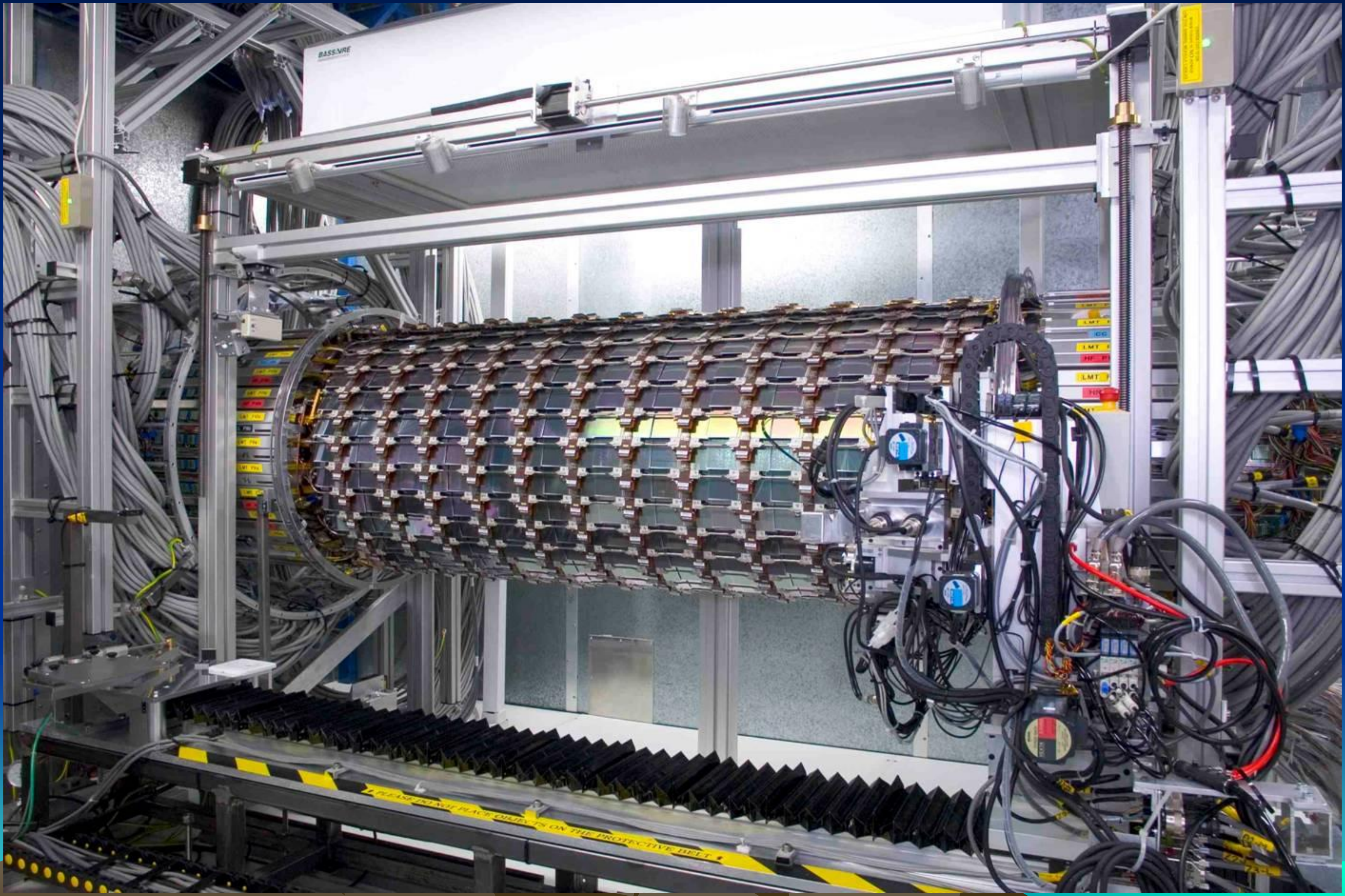


SCT Barrel 4 layers, 2112 modules

Binary read out via opt fiber, work independently



assembly at Oxford



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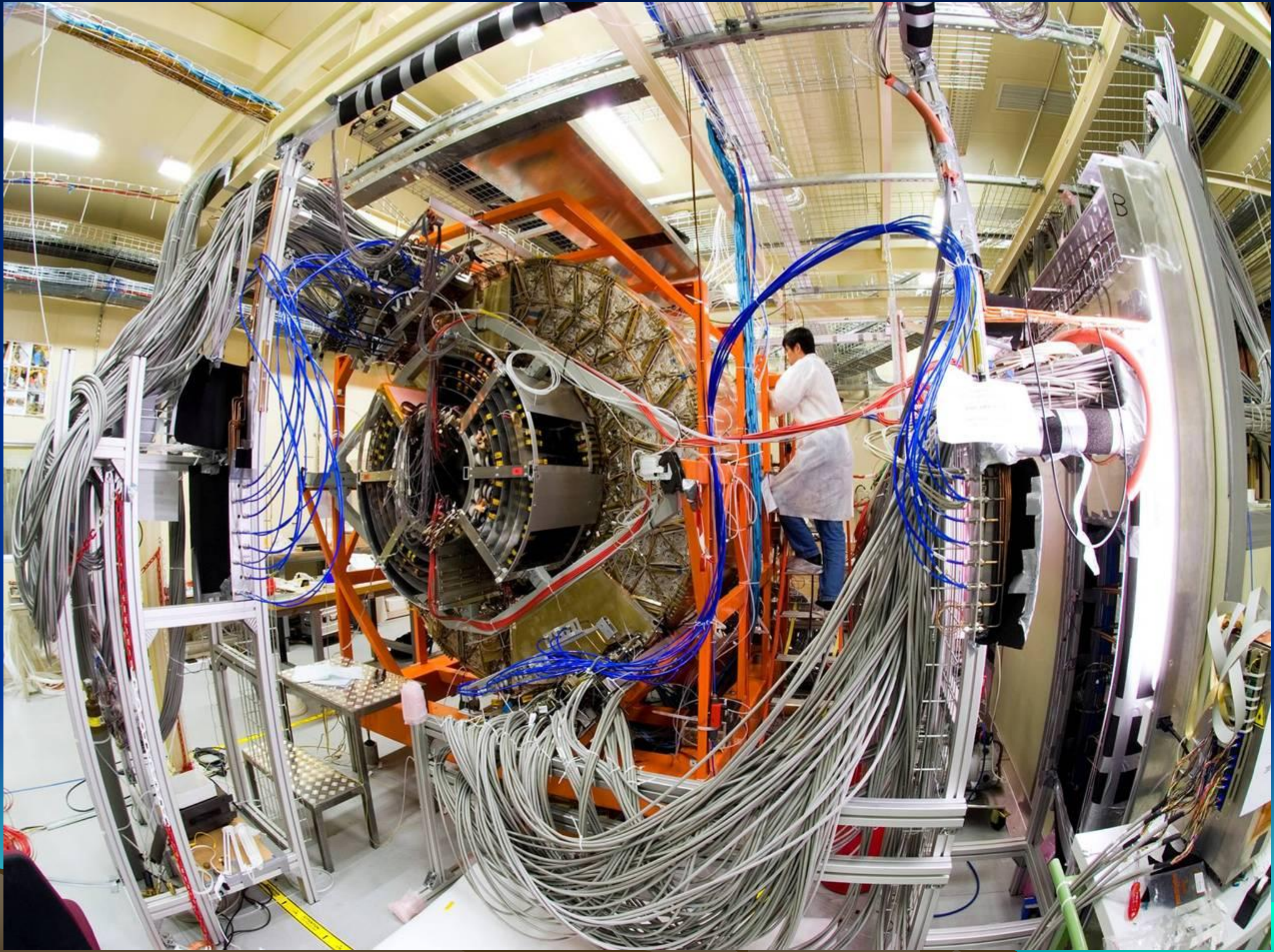
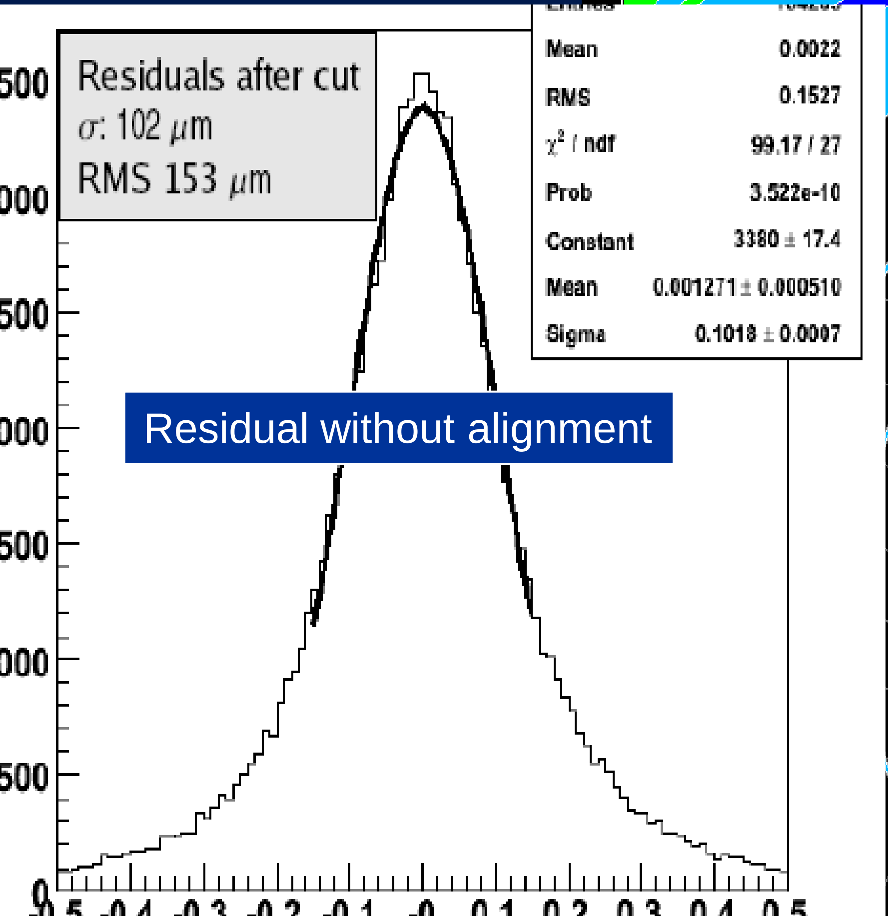
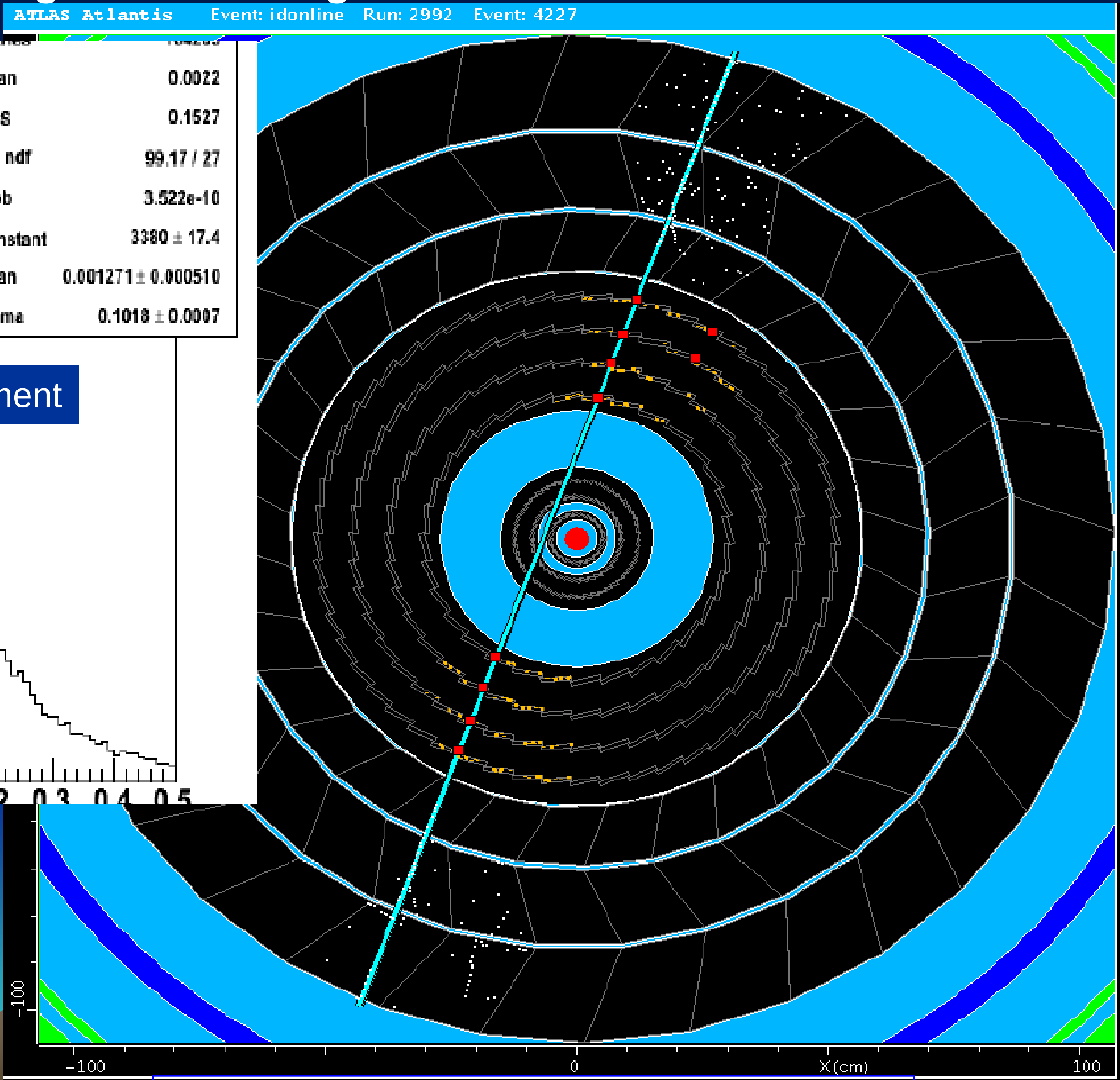
Cables of SCT and TRT



SCT module works independently. Cabling shows that.

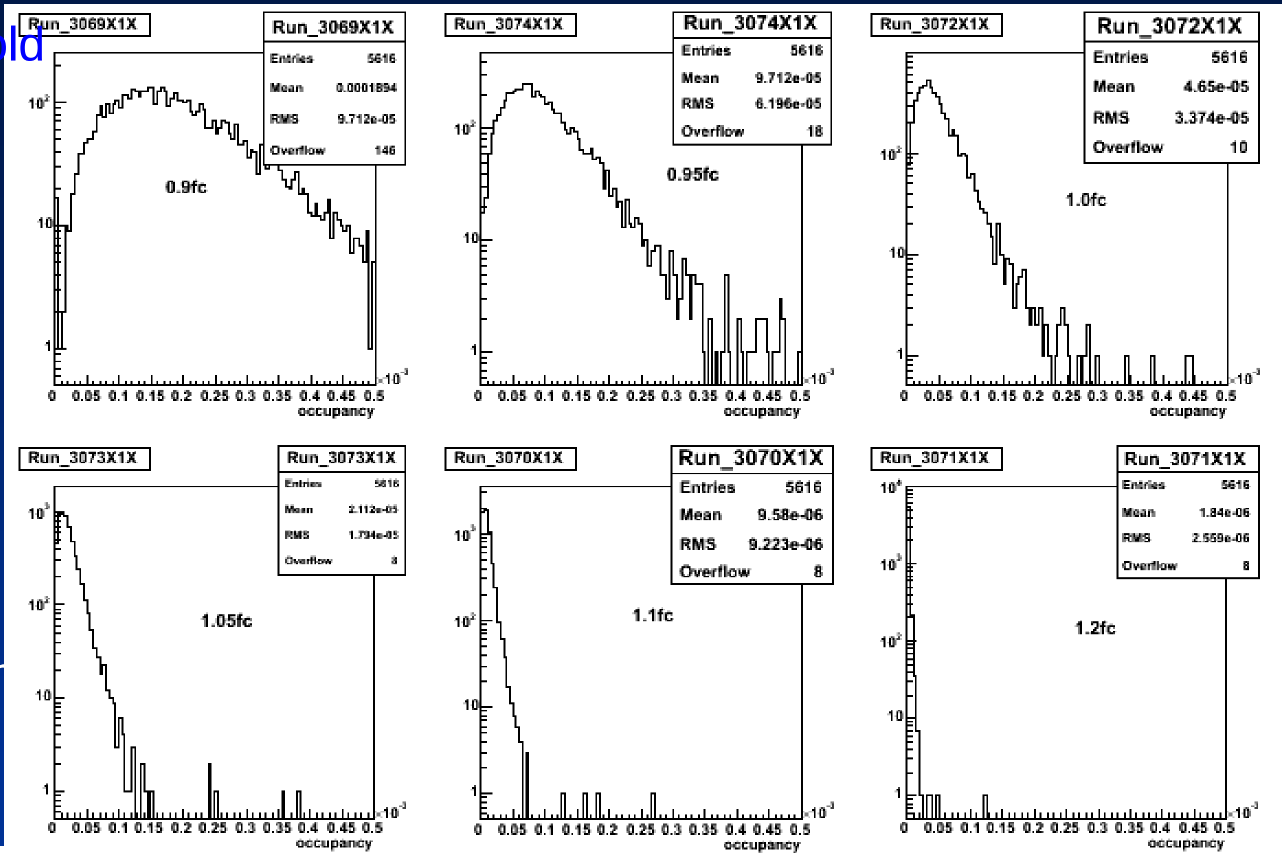
Alignment using Cosmic tracks



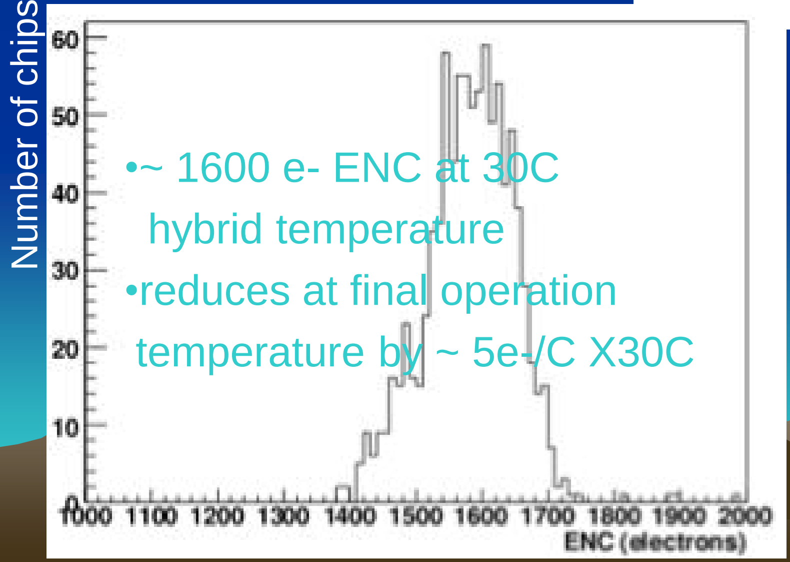


red dots: space poits, orange dots: cluster hits

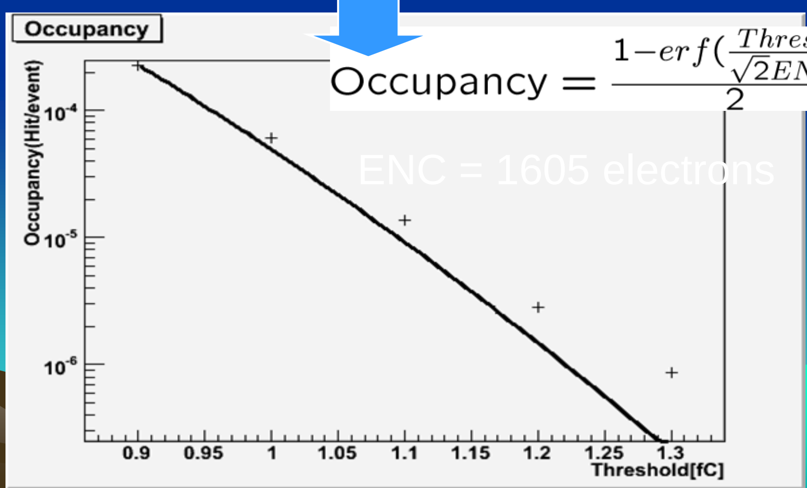
- Noise runs changing threshold
  - Equivalent Noise Charge is very sensitive to the threshold setting.



- ENC can be derived fitting a plot of occupancy vs threshold using error function
- Offline value matched with production.



- ~ 1600 e- ENC at 30C hybrid temperature
- reduces at final operation temperature by ~ 5e-/C X30C



$$\text{Occupancy} = \frac{1 - erf\left(\frac{Thresh}{\sqrt{2}ENC}\right)}{2}$$

ENC = 1605 electrons

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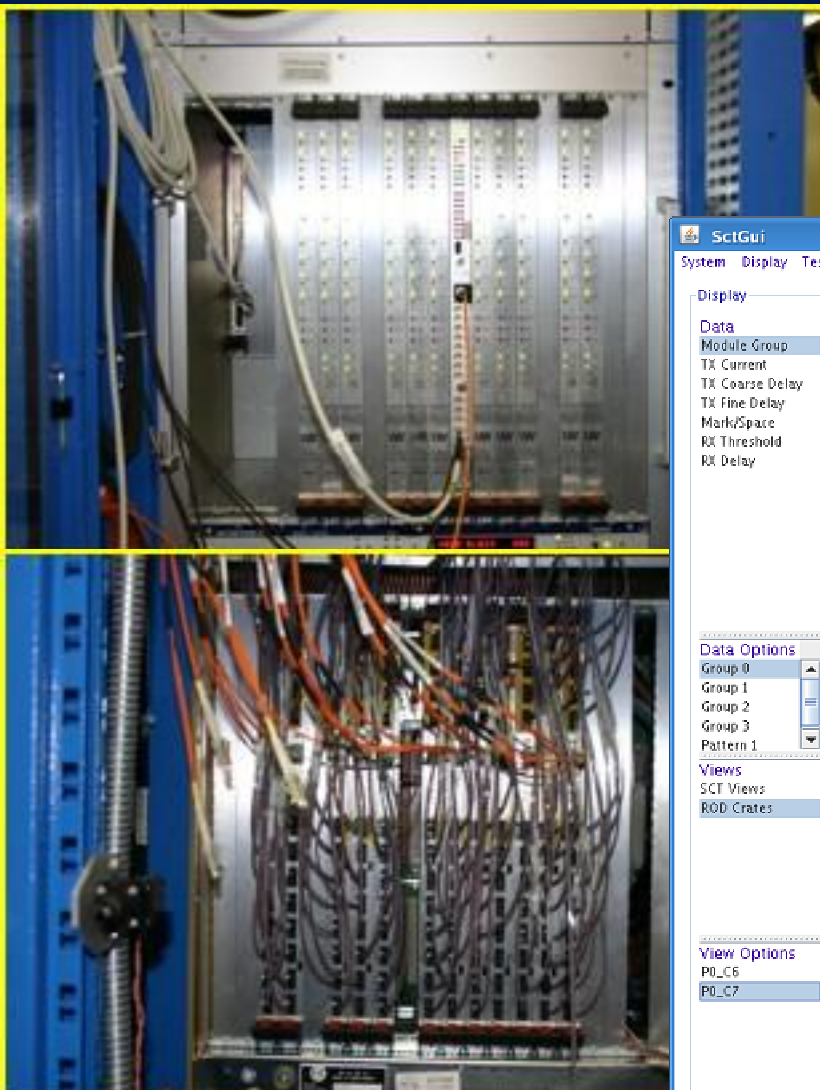
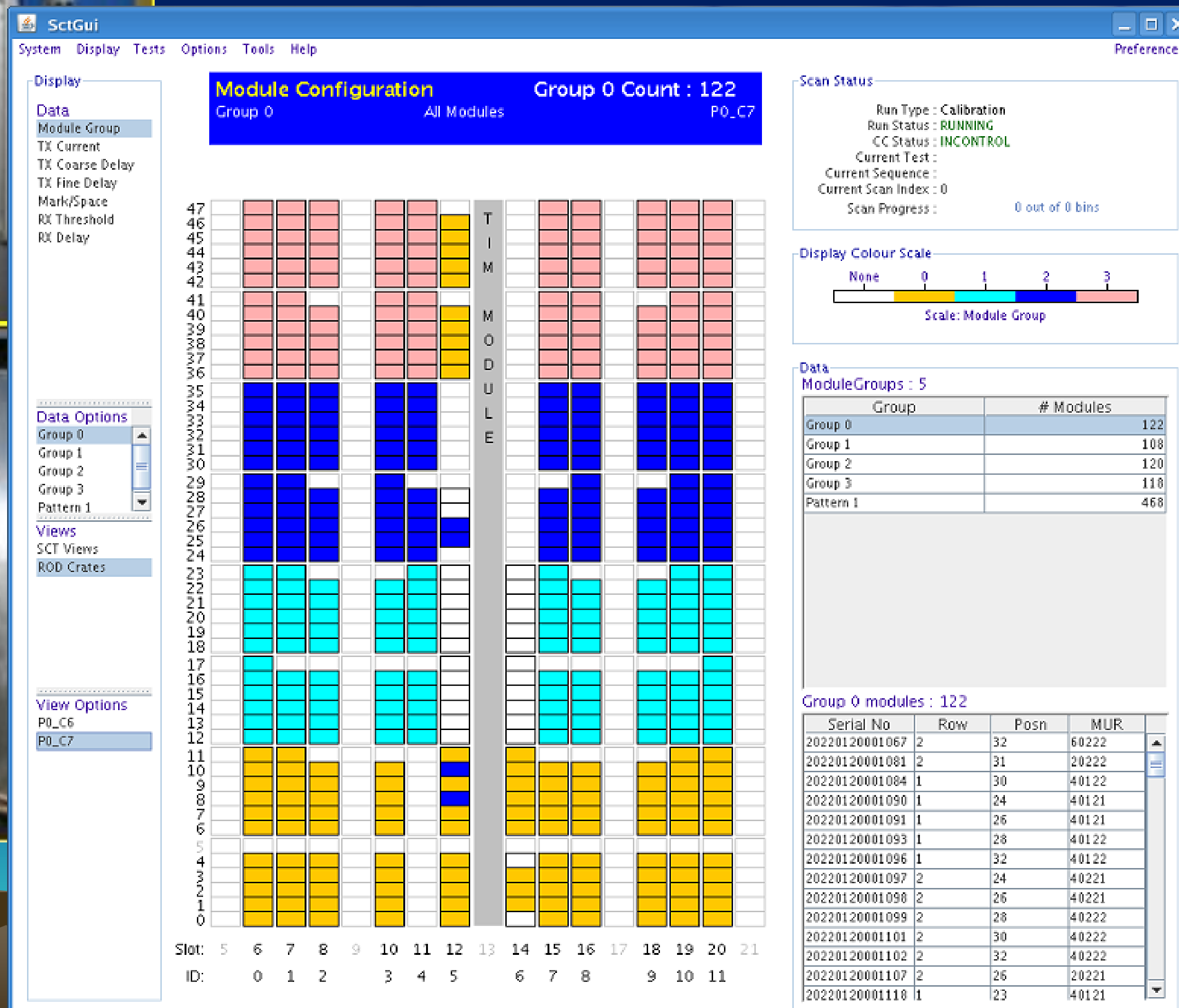
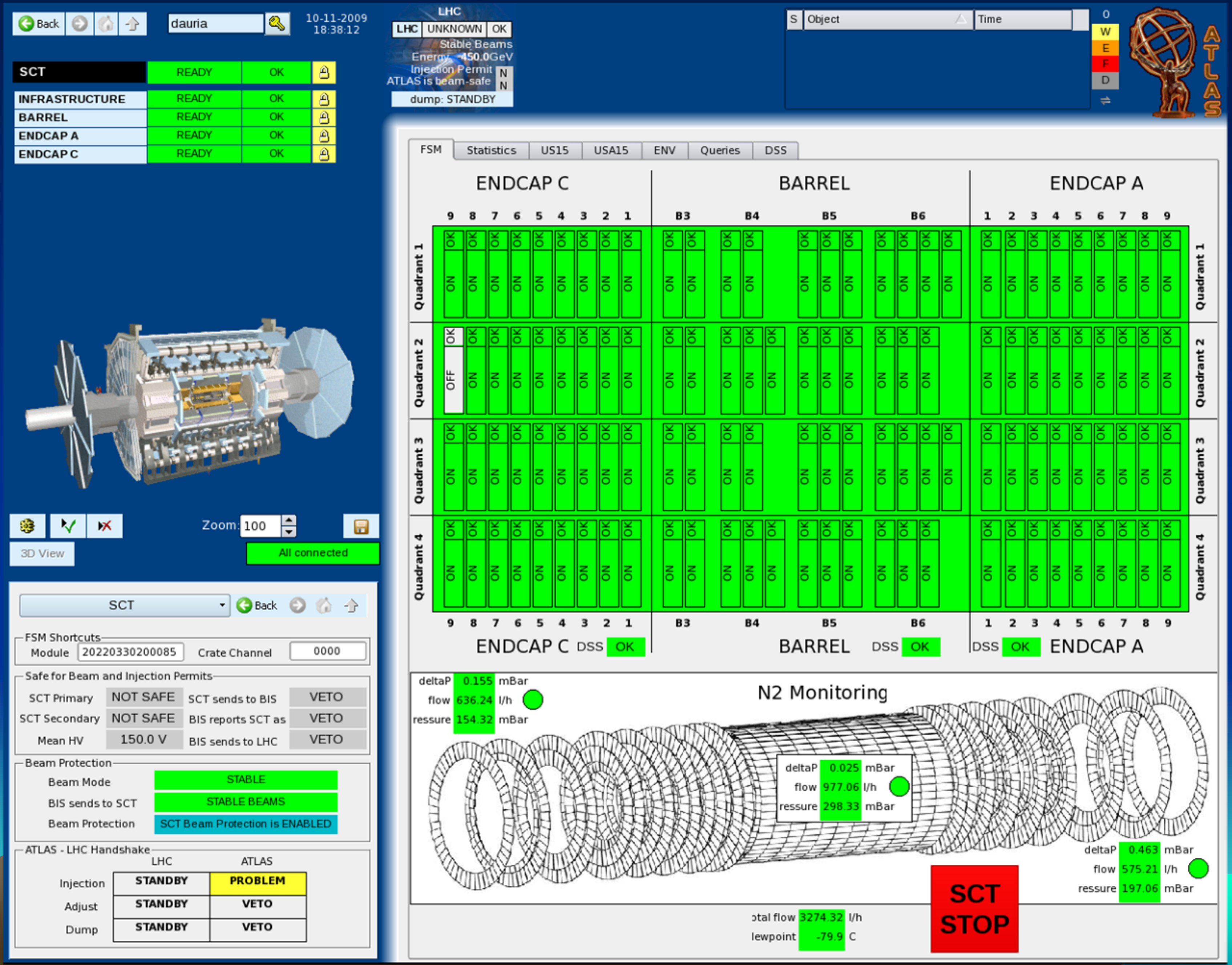
SCTのキャリブレーションとDAQ

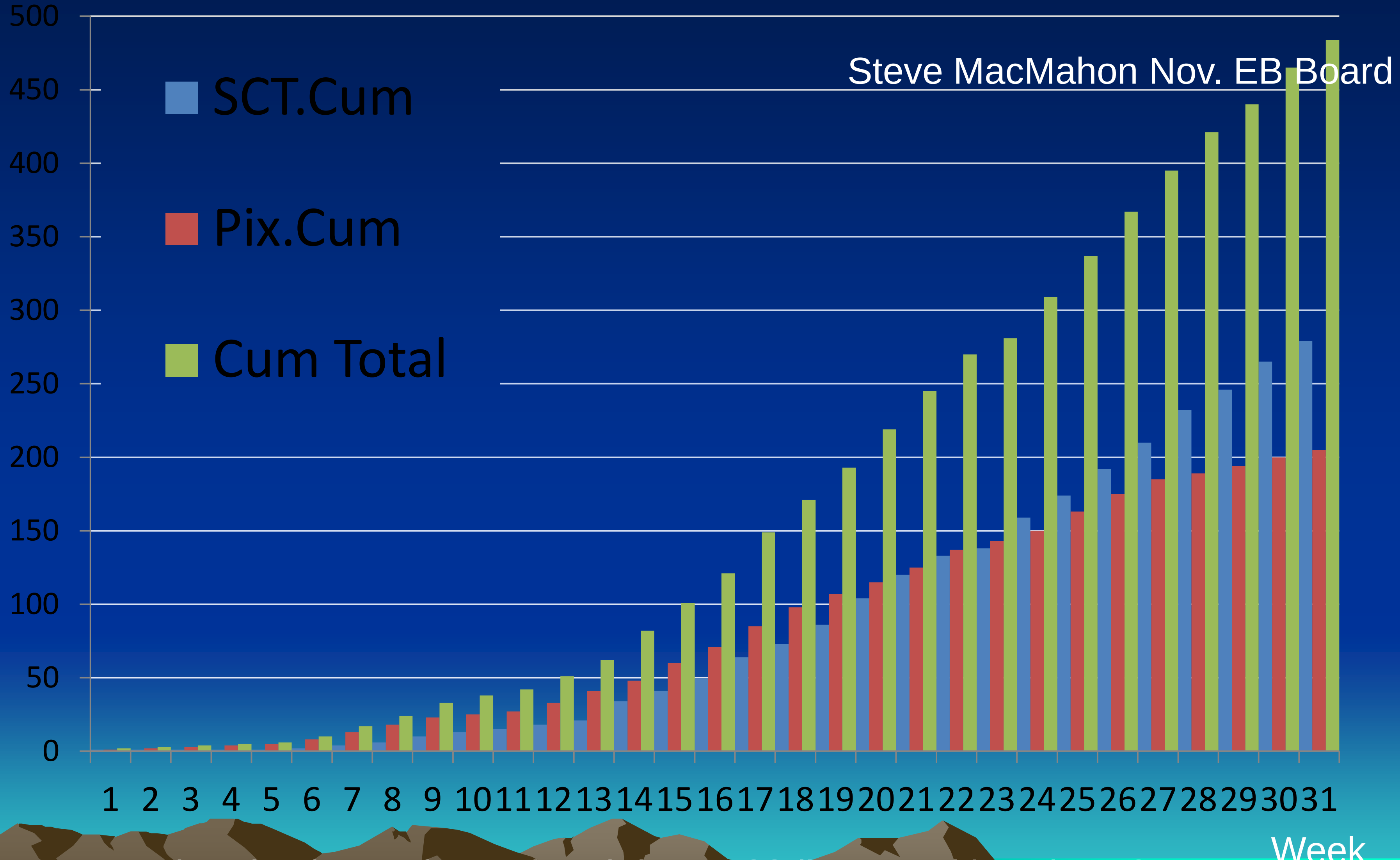




測定器コントロールパネル



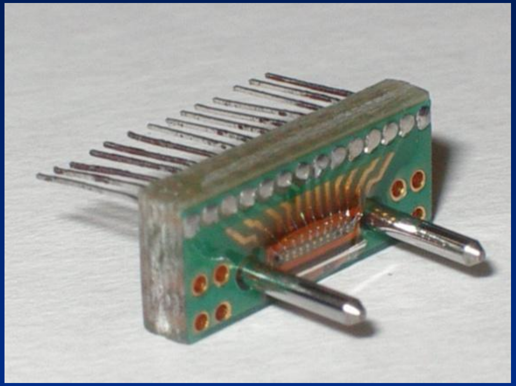
Number of failed VCSELs since 7th March 2010



TX tracker database gives a breakdown of failures and location of spares.
https://atlasop.cern.ch/local-server/pc-sct-db-02/bookkeepingdb/txhistory.php

What does a TX look like ?

Steve MacMahon Nov. EB Board



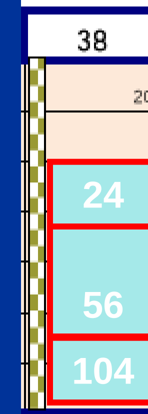
BPM-12

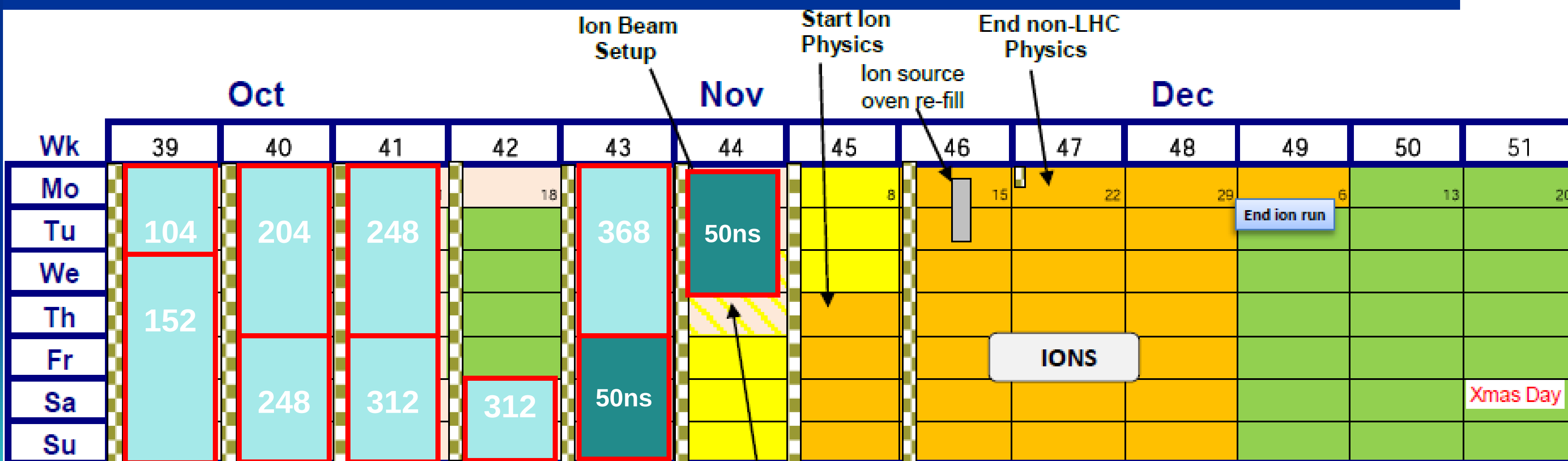
VCSEL array

- The TX consists of two major components
  - An array of 12 VCSELS (Current Vendor = Truelight)
  - BPM12 driver chip (we exhausted the supply for the 2009 production)

150ns bunch train running , 22/09 to 29/10

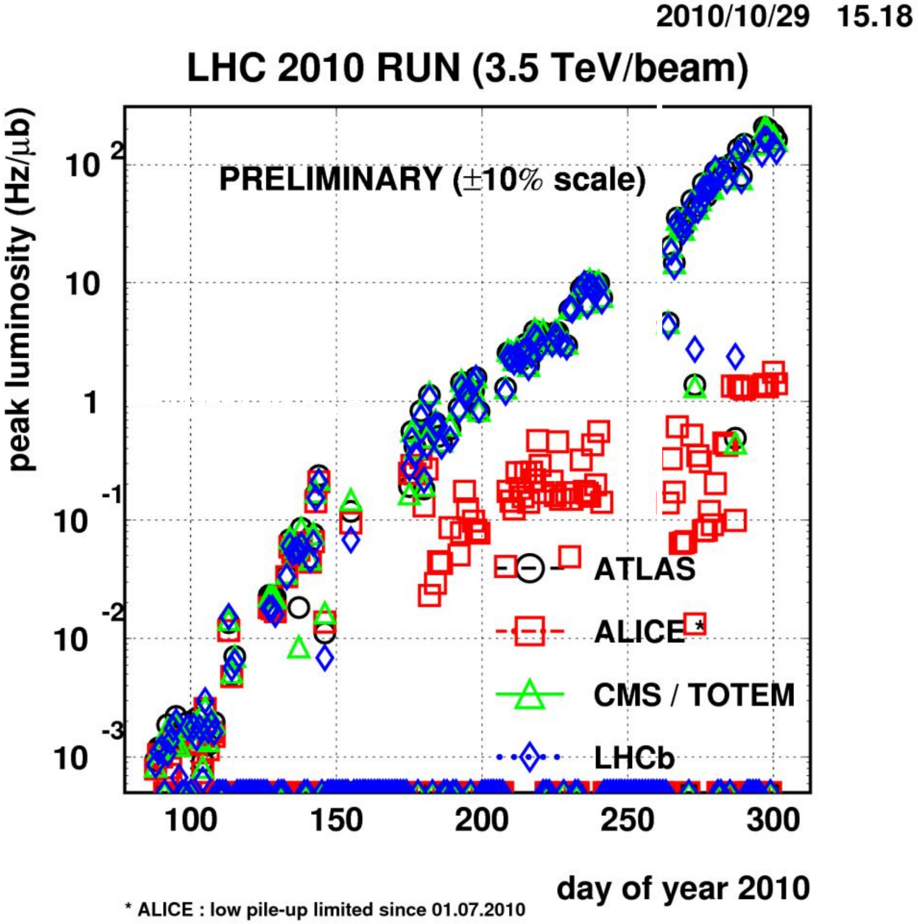
- Strategy (all with ~nominal bunch intensities)
  - Started with 24 on 24 (September 22)
  - Moved to 56 on 56 after 1 fill (September 23)
  - Incremental increase thereafter
    - After 3 fills and 20 hours, add ~ 50 bunches per beam
- Technical stop of week 44 advanced to week 42 (injection IR2)



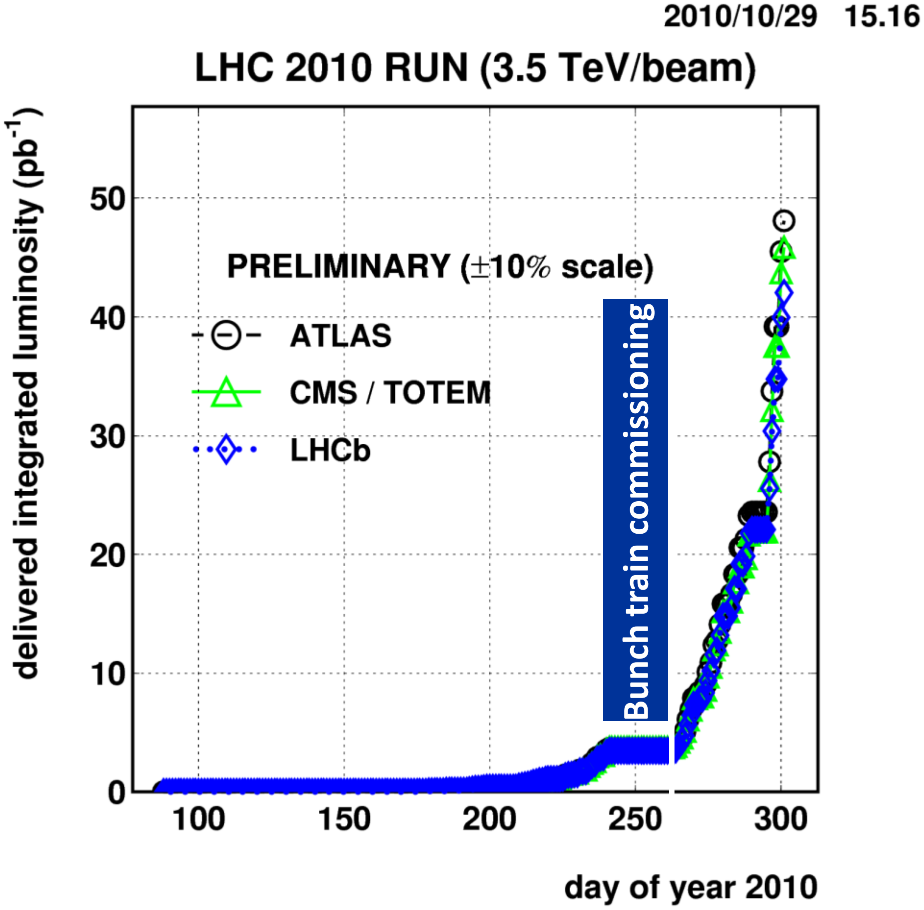


Luminosity evolution 2010

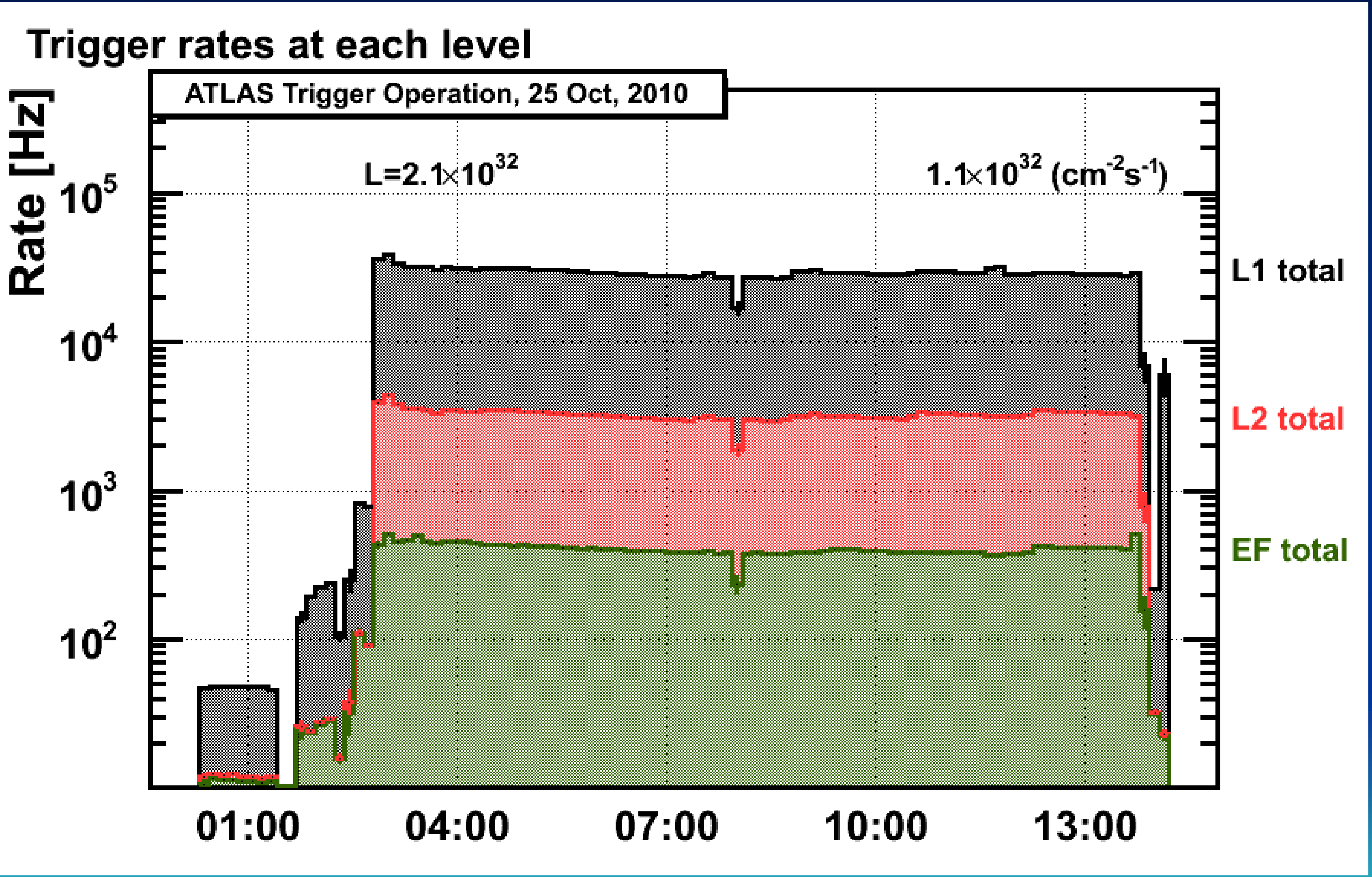
5 orders of magnitude in ~200 days



~50 pb^{-1} delivered, half of it in the last week !

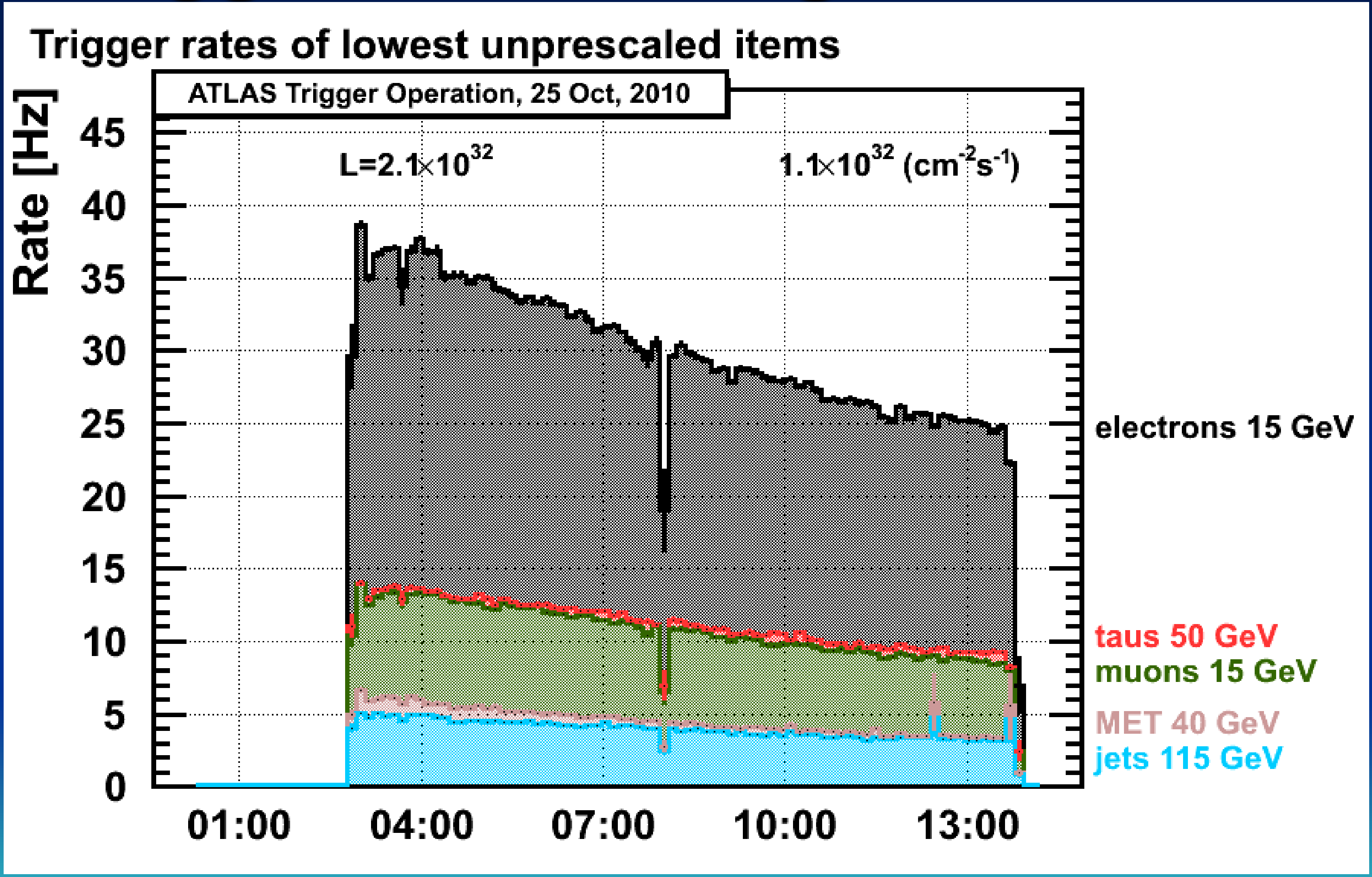


Trigger rates in the highest lumi



- Adjust prescales to maintain ~400 Hz EF output

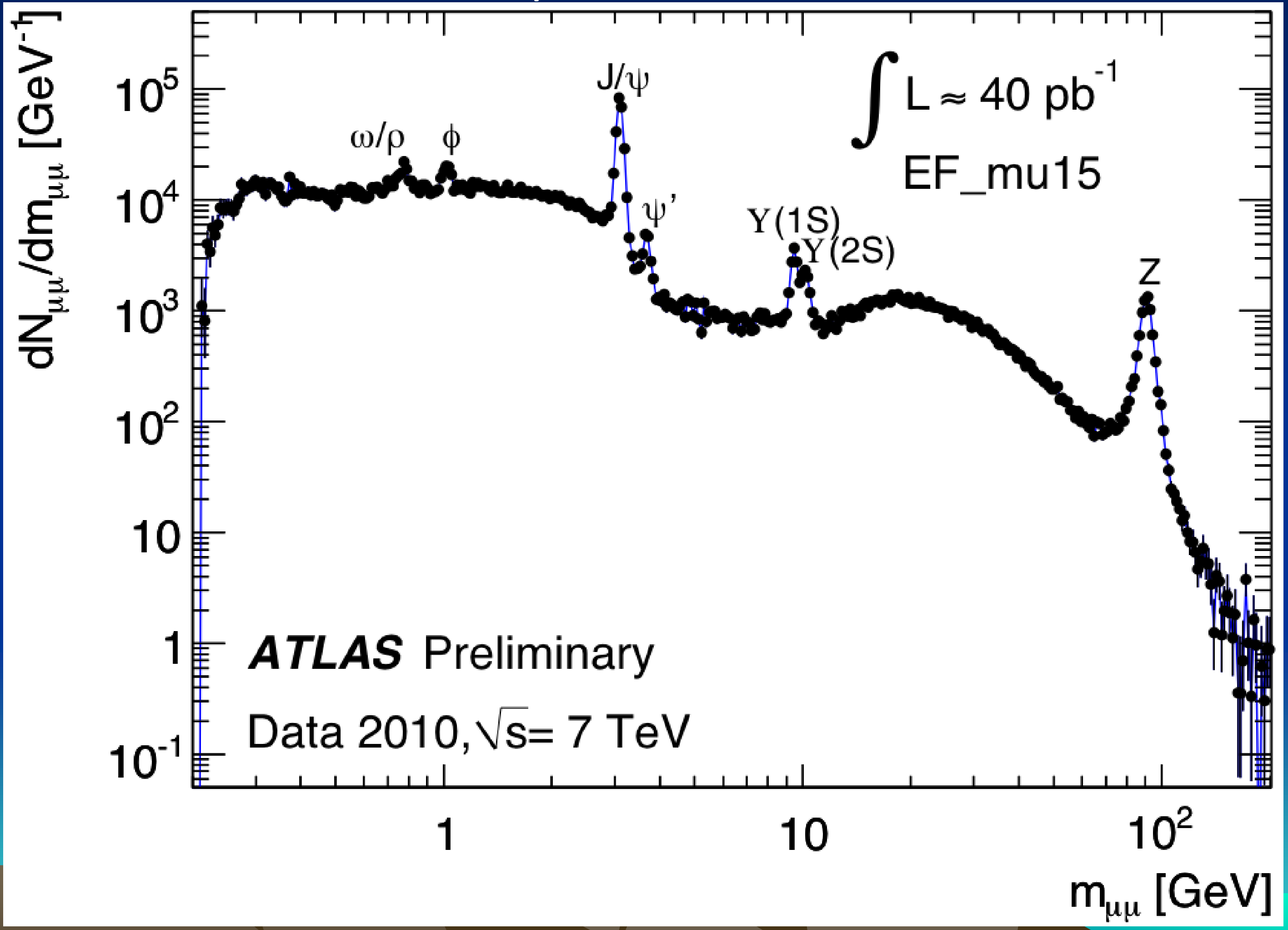
Trigger rates in highest lumi fill



- Rates fall with luminosity

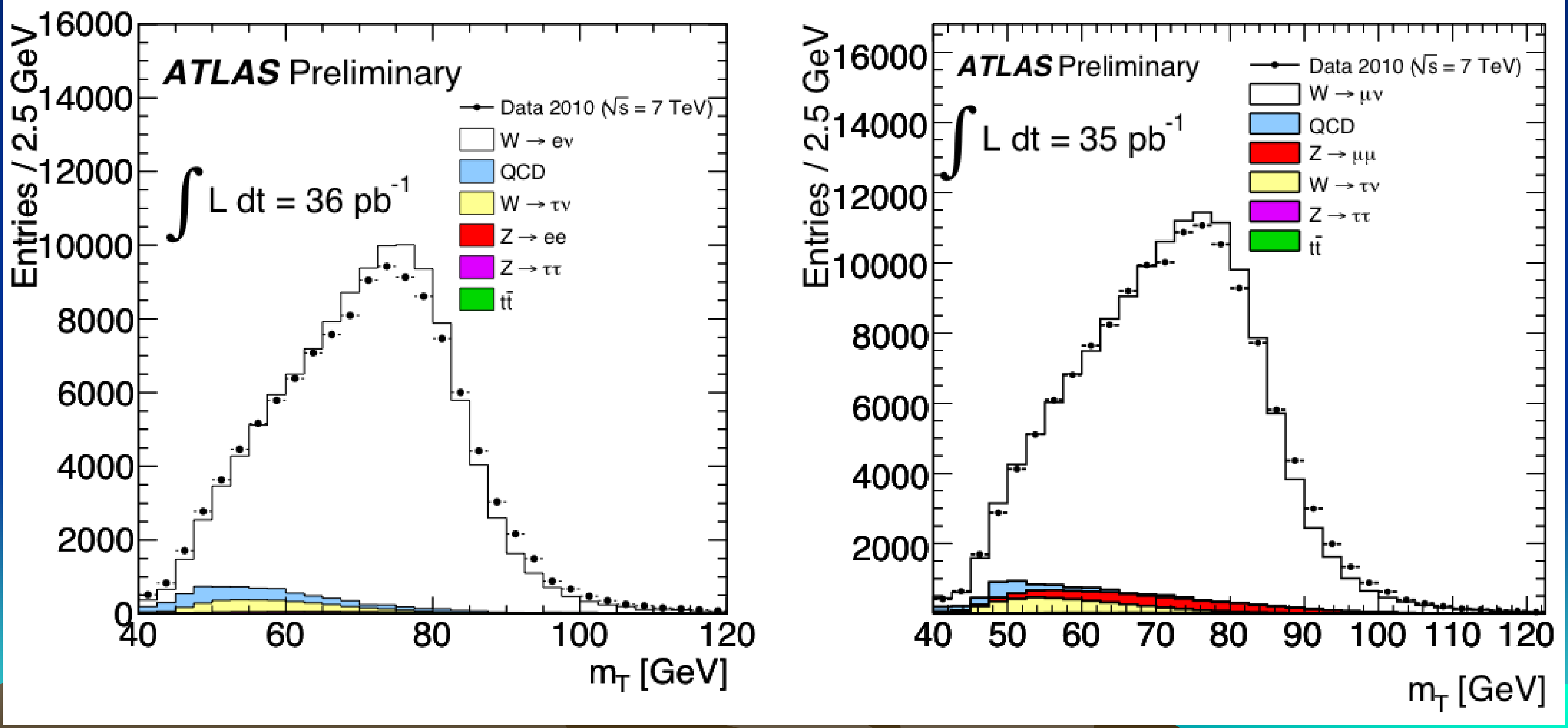
Di-muon invariant mass

- Leading muon, p_T>15 GeV, second muon,

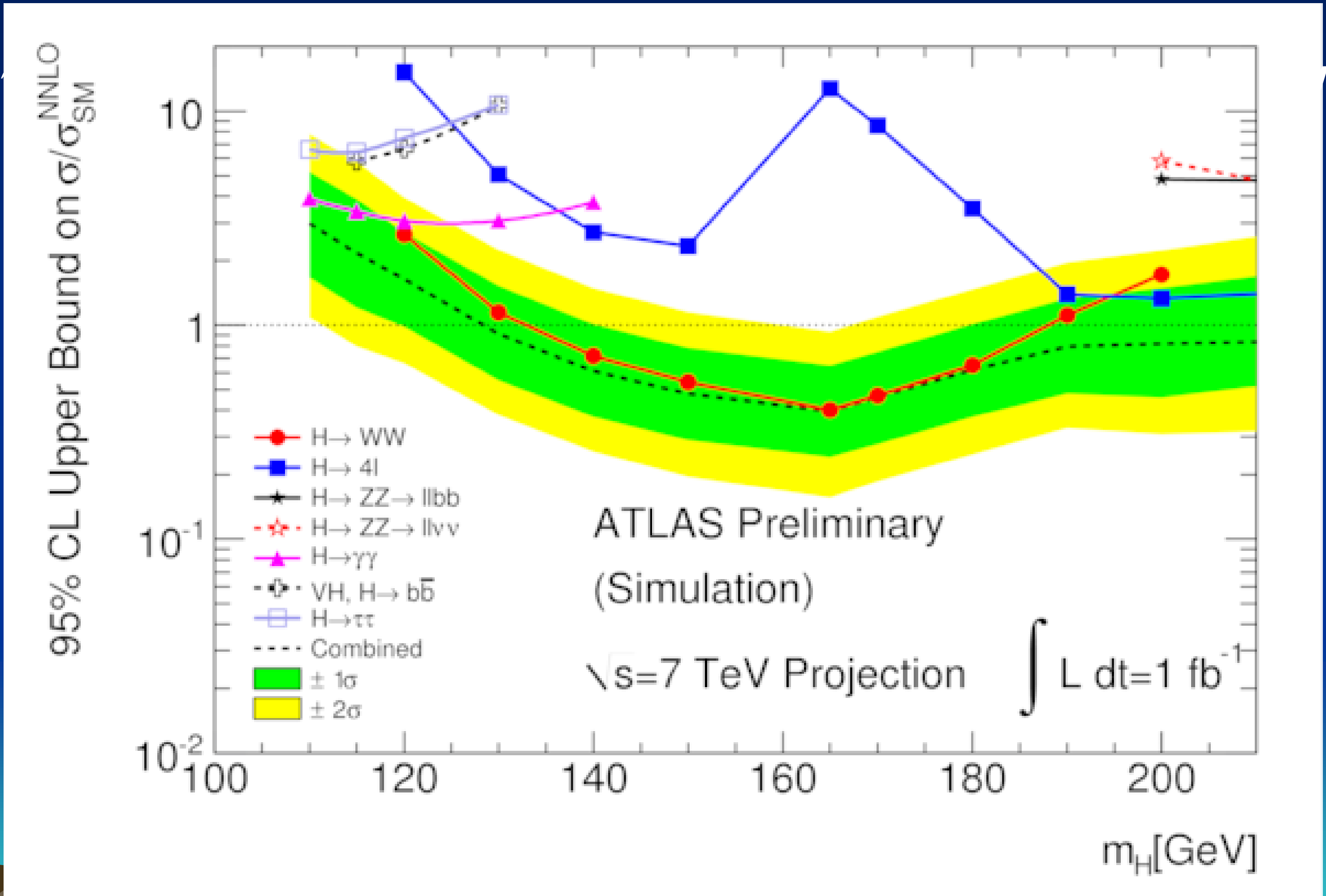


W transverse mass

- e or μ with p_T>20 GeV, E_T^{miss}>25GeV
- MC normalised to data
- 119k electron and 135k muon candidates

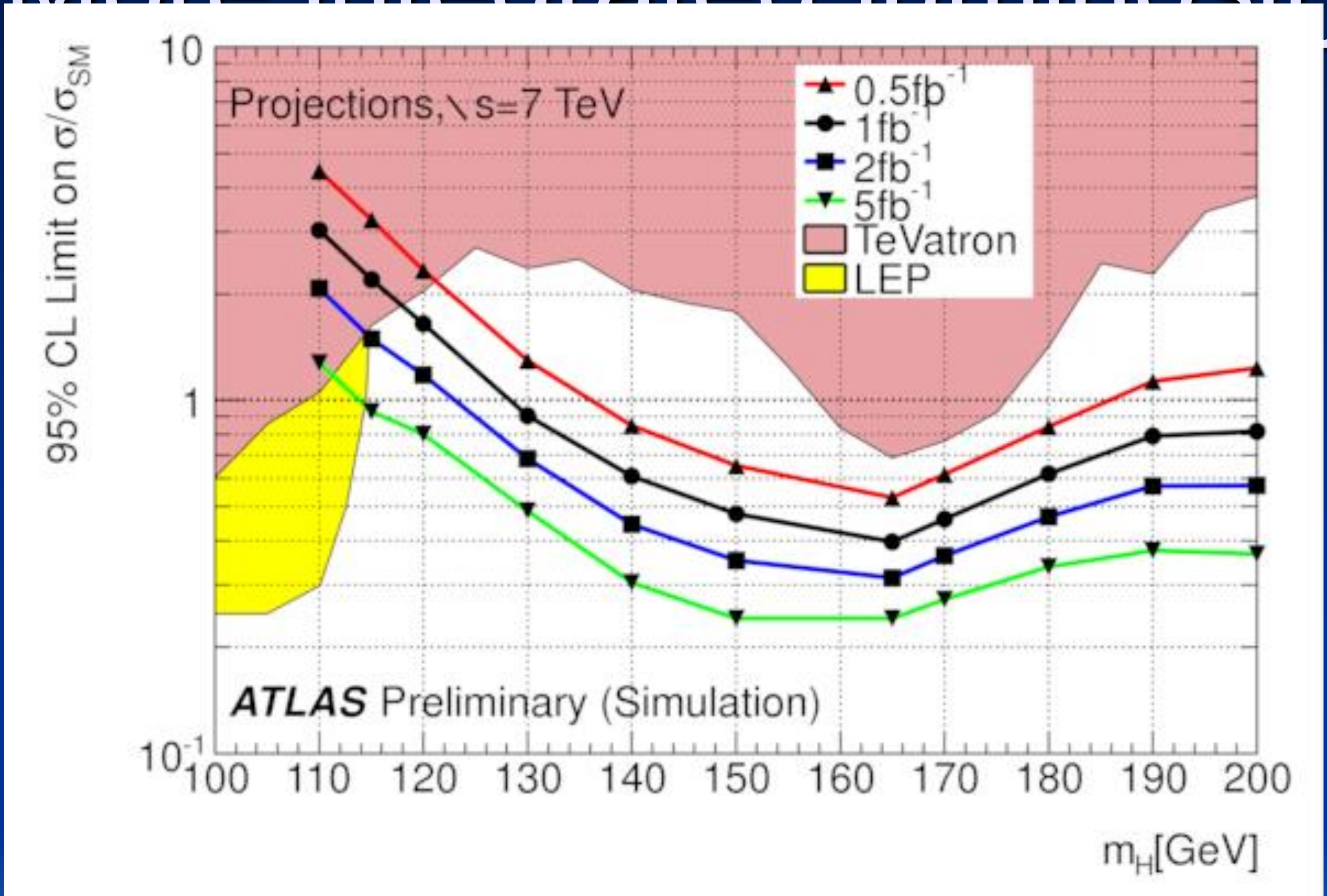


7 TeV, 1 fb^{-1}



95% CL Upper Bound on σ/σ_SM^NNLO
10
1
10^-1
10^-2
100
120
140
160
180
200
m_H[GeV]
H→ WW
H→ 4l
H→ ZZ→ llbb
H→ ZZ→ llνν
H→γγ
VH, H→ bb̄
H→ττ
Combined
± 1σ
± 2σ
ATLAS Preliminary
(Simulation)
√s=7 TeV Projection
∫ L dt=1 fb^-1

More integrated luminosity



- $5fb^{-1}$ enough to close gap with LEP at 7 TeV
- Expected 3σ observation from 123 to 550 GeV

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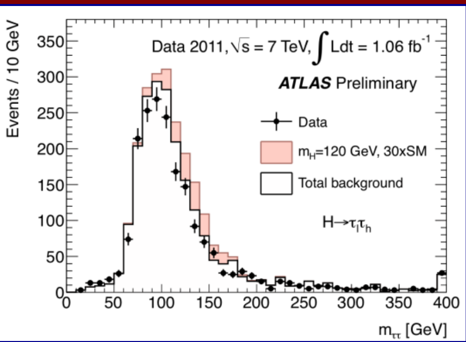
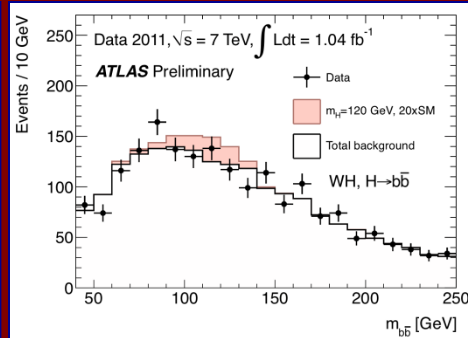
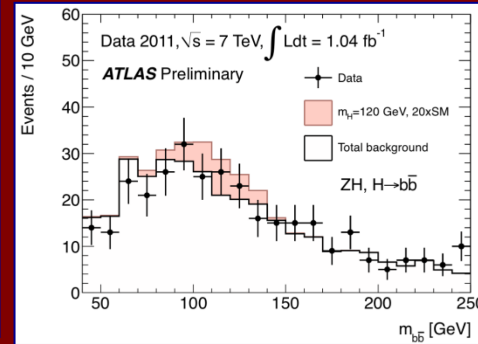
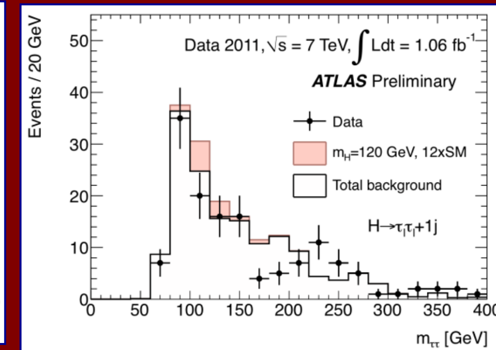


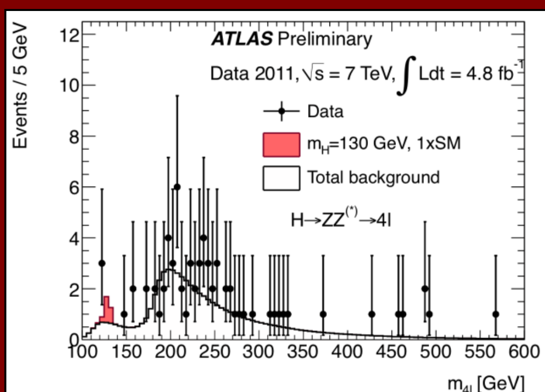


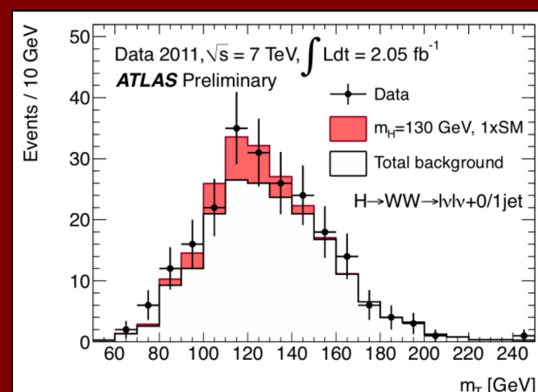


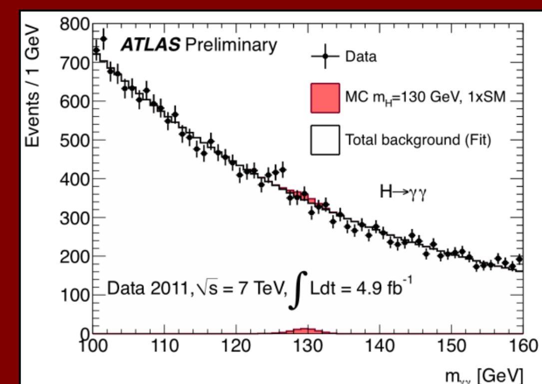


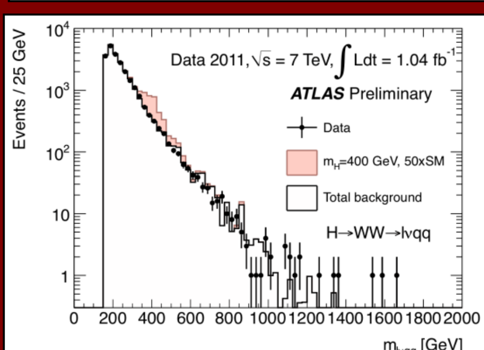
Update of Standard Model Higgs searches in ATLAS

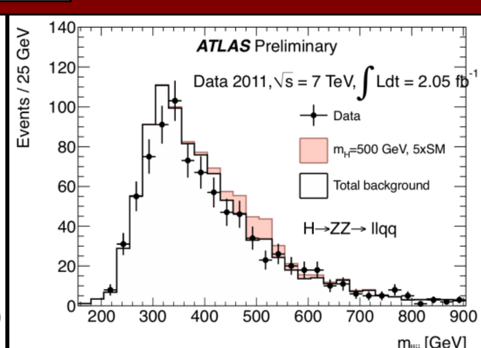
Fabiola Gianotti,
representing the
ATLAS Collaboration

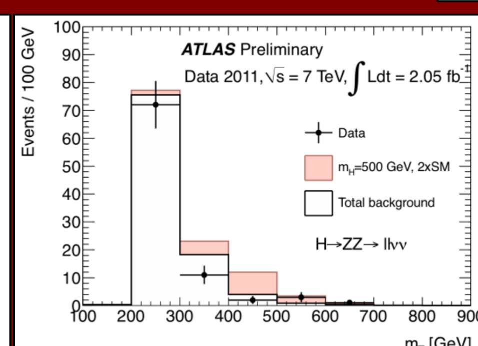


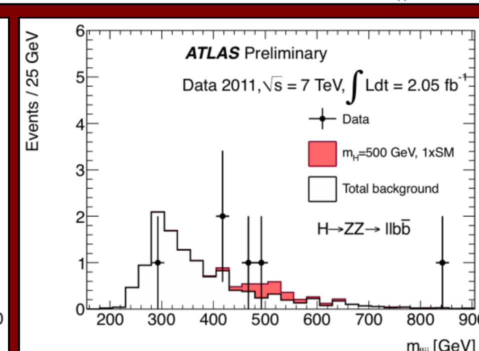


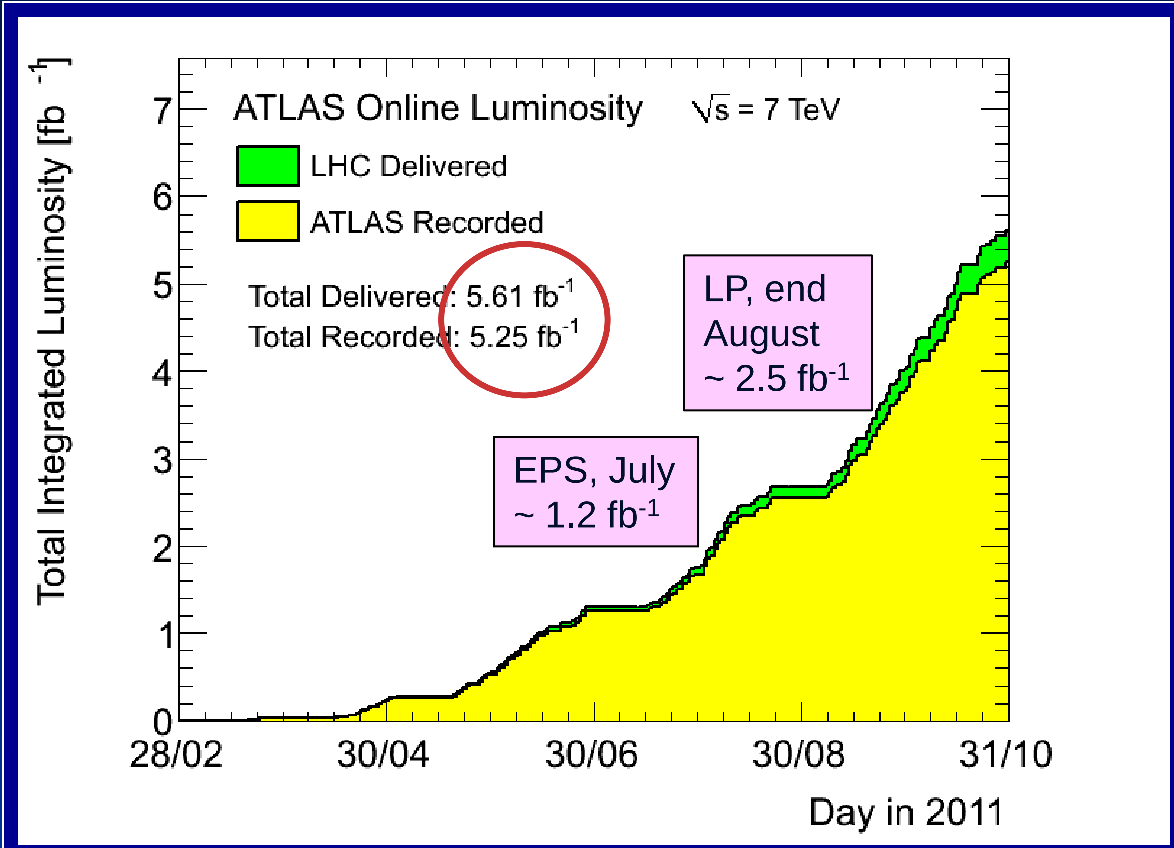






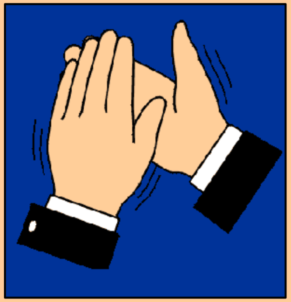






Peak luminosity seen by ATLAS: ~ 3.6×10^{33} cm^{-2} s^{-1}

Many thanks to the LHC team for such a superb performance !



Fraction of non-operational detector channels: (depends on the sub-detector)	few permil to 3.5%
Data-taking efficiency = (recorded lumi)/(delivered lumi):	~ 93.5%
Good-quality data fraction, used for analysis : (depends on the analysis)	90-96%

Price to pay for the high luminosity: larger-than-expected pile-up

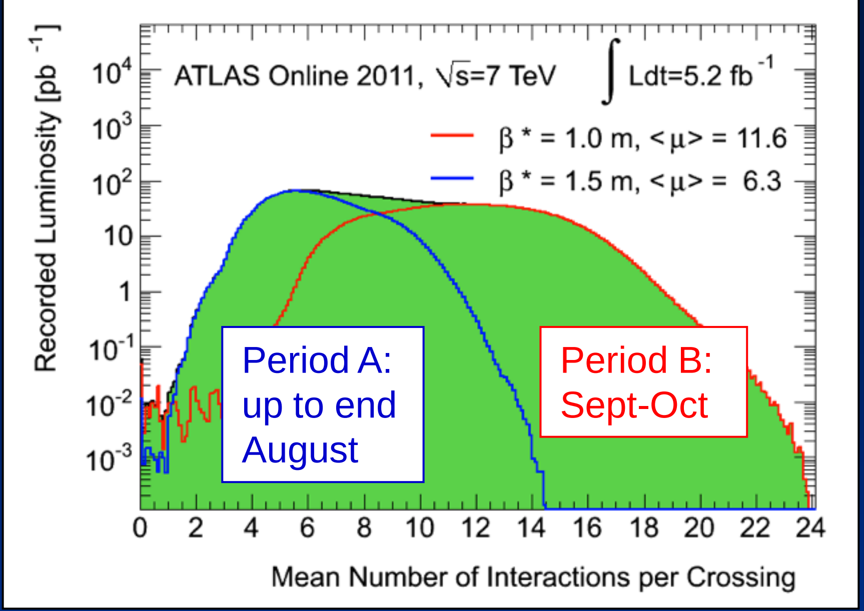
Pile-up = number of interactions per crossing

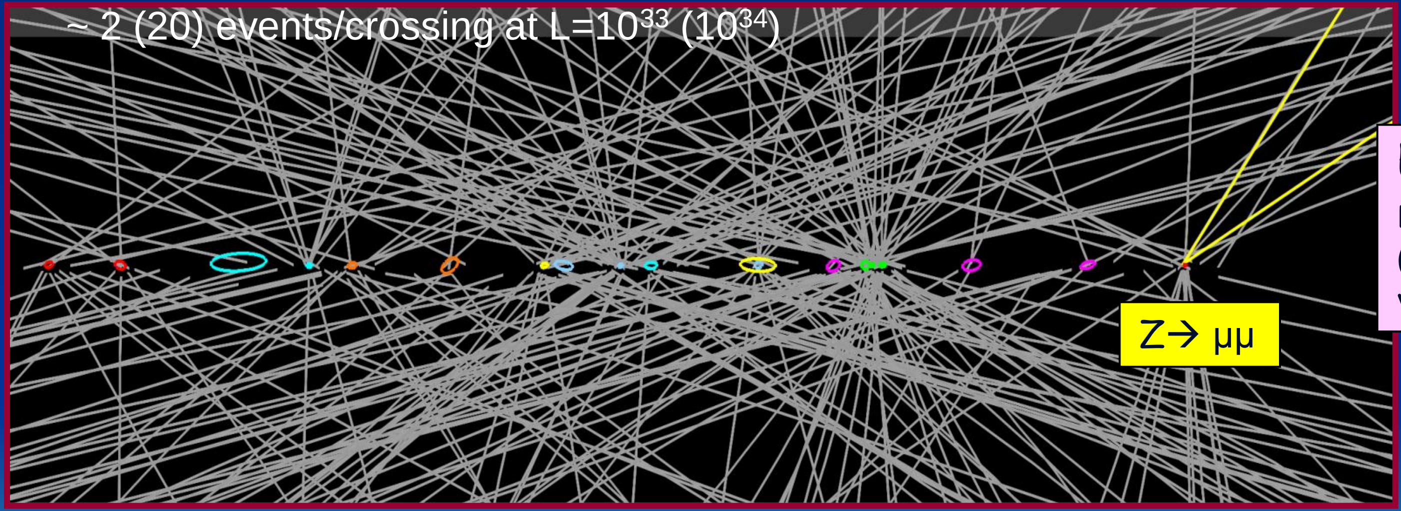
Tails up to ~20 → comparable to design luminosity

(50 ns operation; several machine parameters pushed beyond design)

LHC figures used over the last 20 years:

~ 2 (20) events/crossing at $L=10^{33}$ (10^{34})





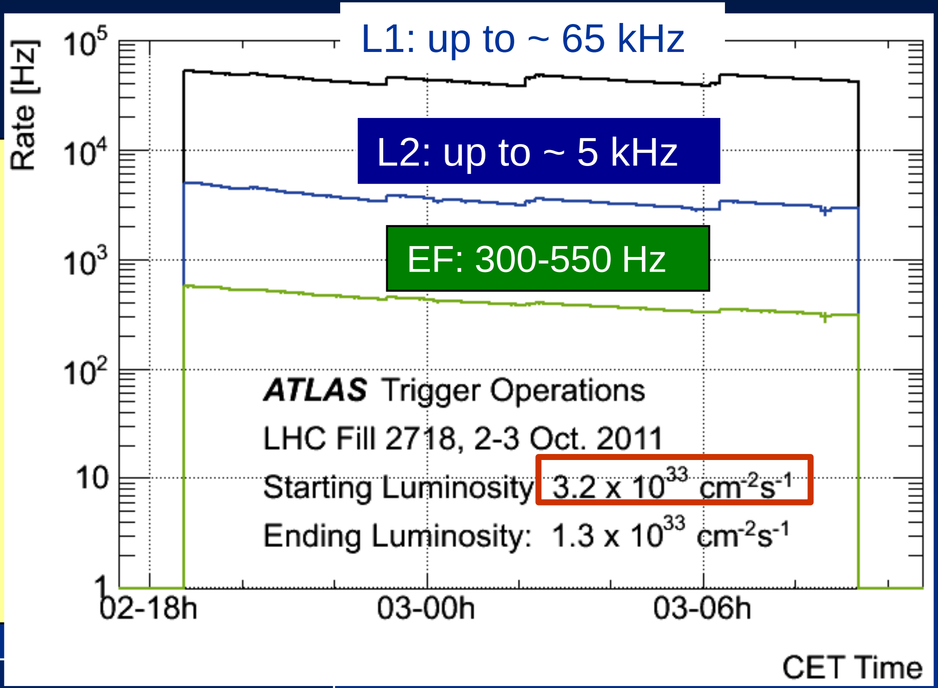
Event with 20 reconstructed vertices (ellipses have 20 σ size for visibility reasons)

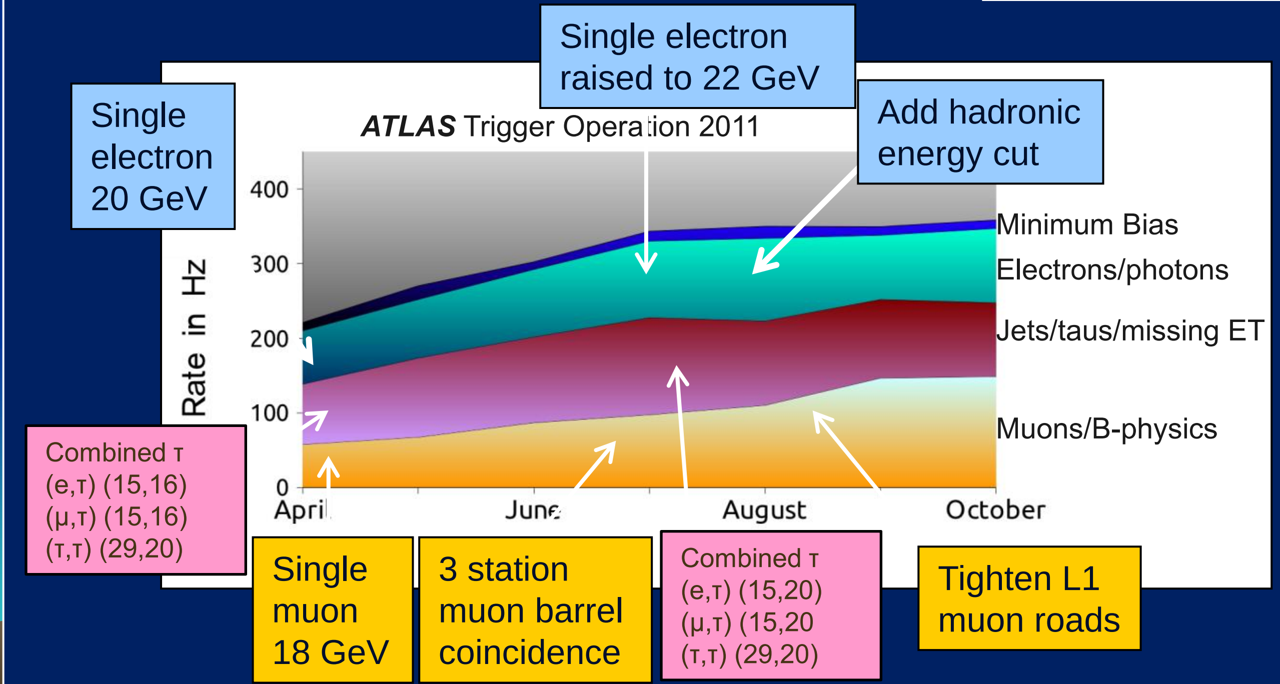
Challenging for trigger, computing resources, reconstruction of physics objects (in particular E_T^{miss}, soft jets, ..)

Precise modeling of both in-time and out-of-time pile-up in simulation is essential

Trigger

- Coping very well with rapidly-increasing luminosity (factor ~10 over 2011) and pile-up by adapting prescales, thresholds, menu.
- Strive to maximise physics (e.g. keeping low thresholds for inclusive leptons)
- Main menu complemented by set of calibration/support triggers: e.g. special J/ψ → ee stream (few Hz) for unbiased low-p_T electron studies



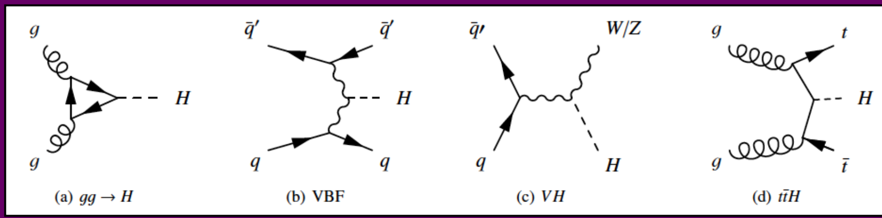


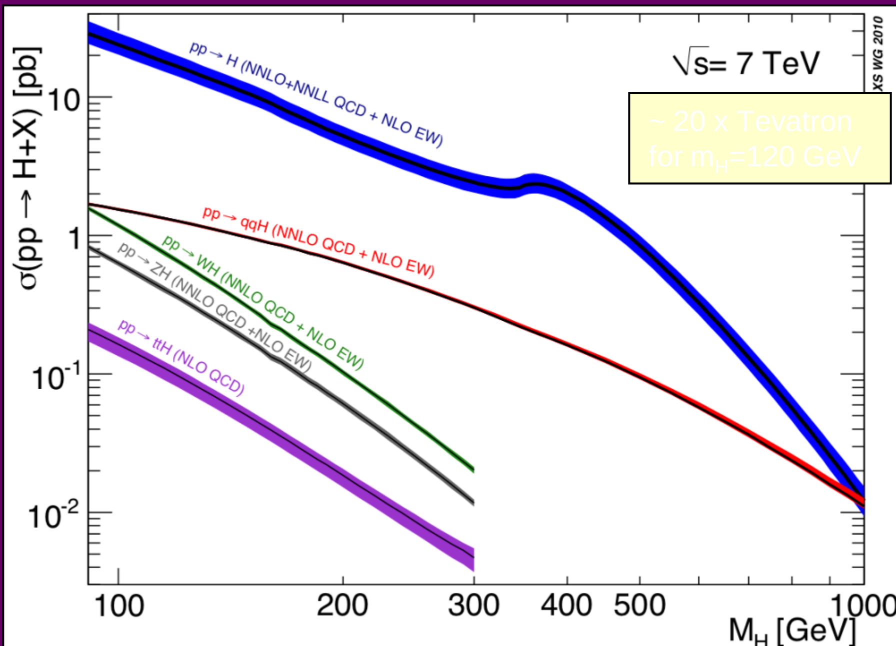
Typical recorded rates for main streams:

e/γ	~ 100 Hz
Jets/τ/E_T^{miss}	~ 100 Hz
Muons	~ 150 Hz

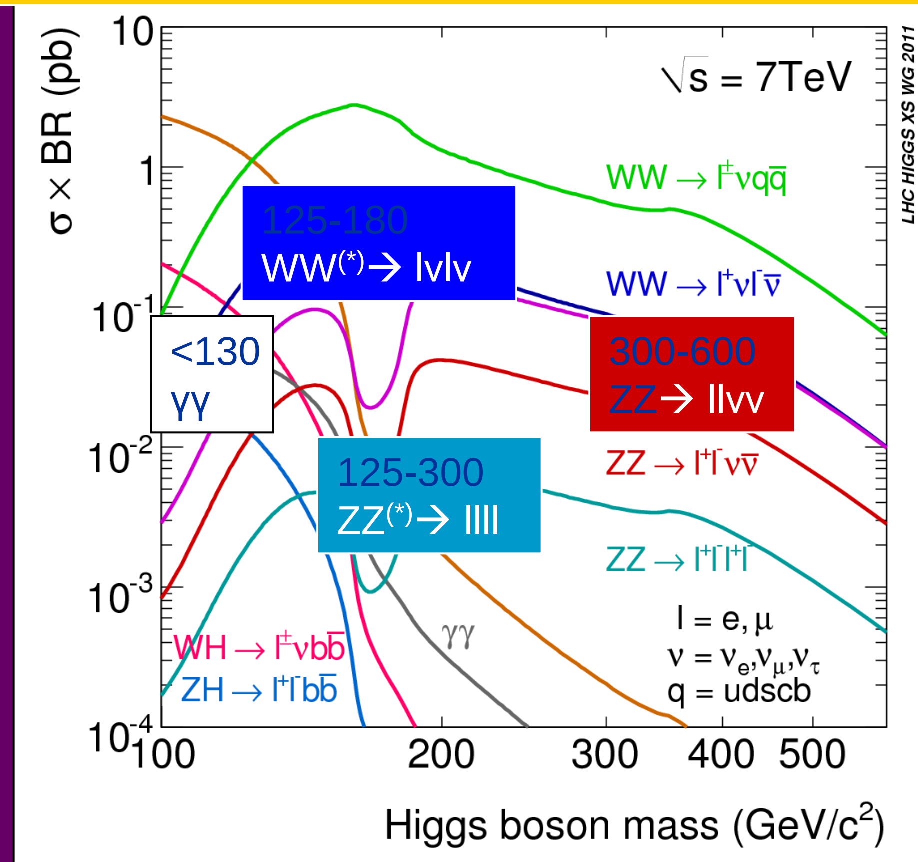
Managed to keep inclusive lepton thresholds ~ stable during 2011

SM Higgs production cross-section and decay modes





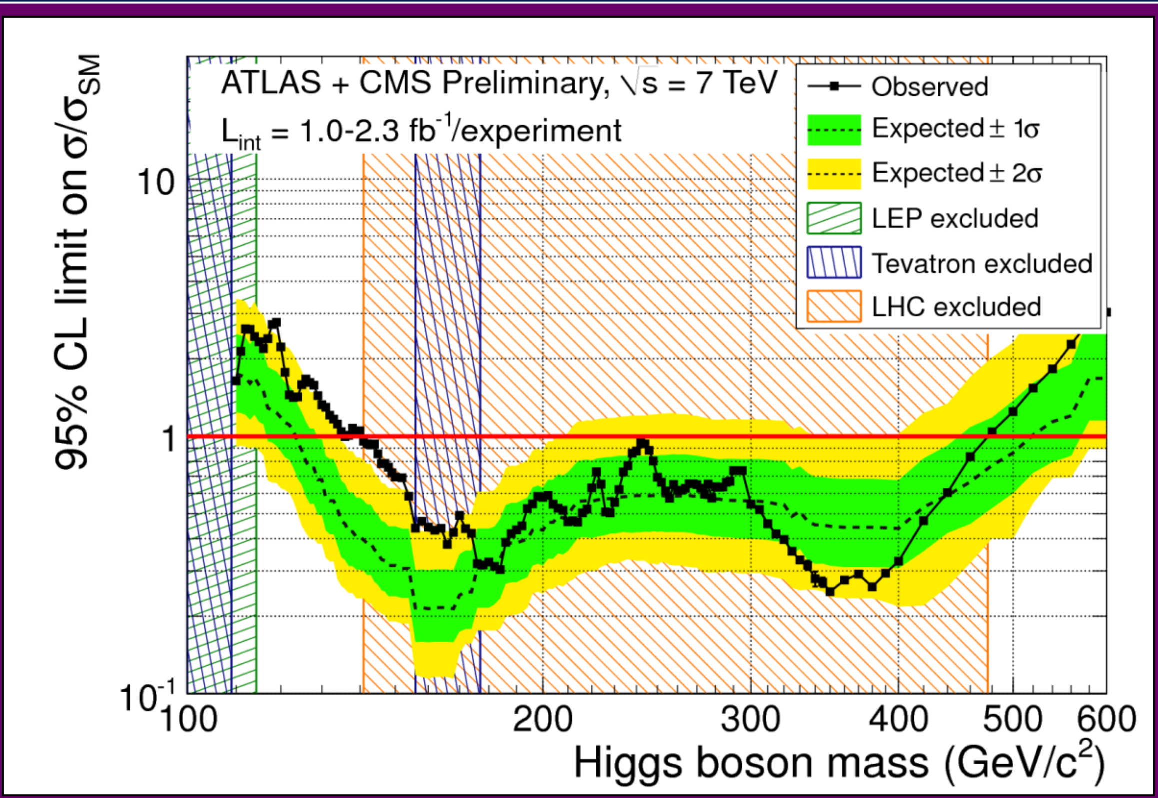
Experimentally most sensitive channels vs m_H



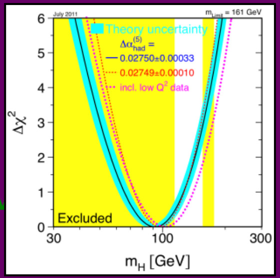
- ❑ Cross-sections computed to NNLO in most cases → theory uncertainties reduced to <
- ❑ Huge progress also in the theoretical predictions of numerous and complex backgroun

→ Excellent achievements of the theory community; very fruitful discussions with the experiments (e.g. through LHC Higgs Cross Section WG, LPCC, etc.)

Present status (as of this morning …)



November 2011
CMS PAS HIG-11-023,
ATLAS-CONF-201-157



LEP (95%CL)
m_H > 114.4 GeV

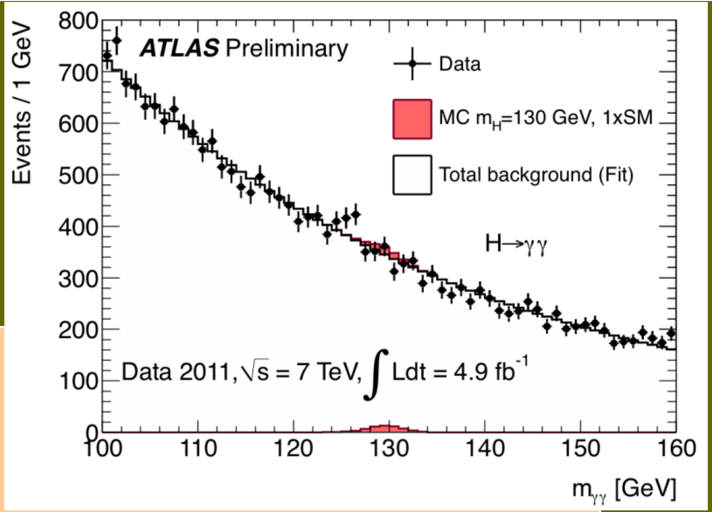
Tevatron exclusion (95%CL):
100 < m_H < 109 GeV
156 < m_H < 177 GeV

First ATLAS+CMS combination: based on data recorded until end August 2011: up to ~2.3 fb^{-1} per experiment

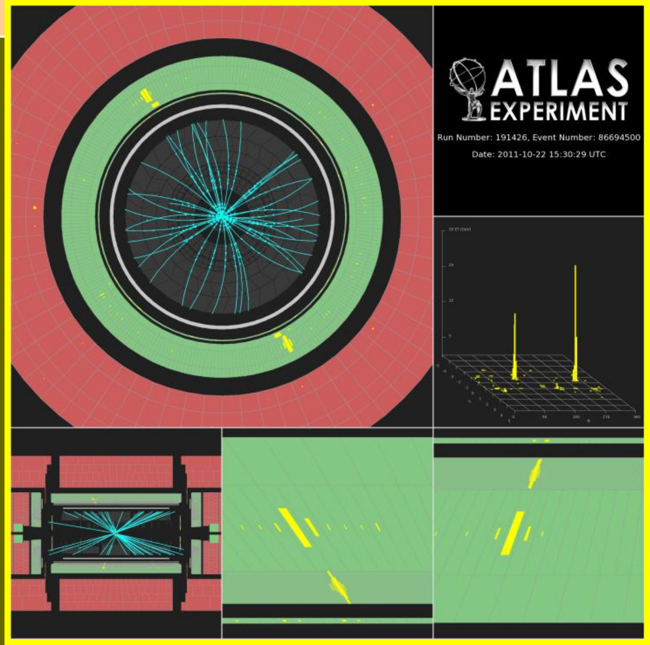
Excluded 95% CL : 141-476 GeV
Excluded 99% CL : 146-443 GeV (except ~222, 238-248, ~295 GeV)
Expected 95% CL : 124-520 GeV → max deviation from background-only: ~ 3σ (m_H~144 GeV)

$H \rightarrow \gamma\gamma$

$110 \leq m_H \leq 150$ GeV



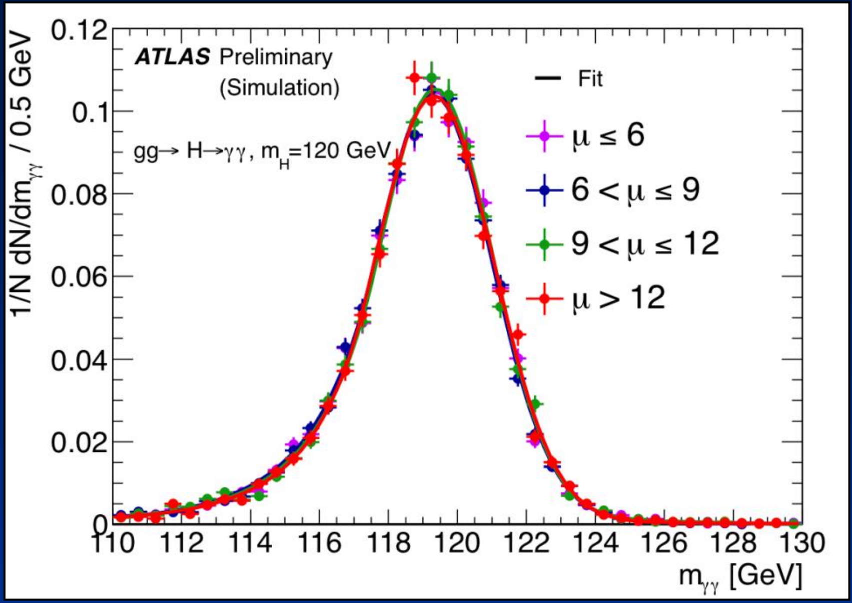
- ❑ Small cross-section: $\sigma \sim 40$ fb
- ❑ Simple final state: two high-p_T isolated photons
  $E_T(\gamma_1, \gamma_2) > 40, 25$ GeV
- ❑ Main background: γγ continuum (irreducible, smooth, ..)
- ❑ Events divided into 9 categories based on η-photon (e.g. central, rest, …), converted/unconverted, $p_T^{\gamma\gamma}$ perpendicular to γγ thrust axis
- ❑ ~70 signal events expected in 4.9 fb^{-1} after all selections for m_H=125 GeV
  ~ 3000 background events in signal mass window → S/B ~ 0.02

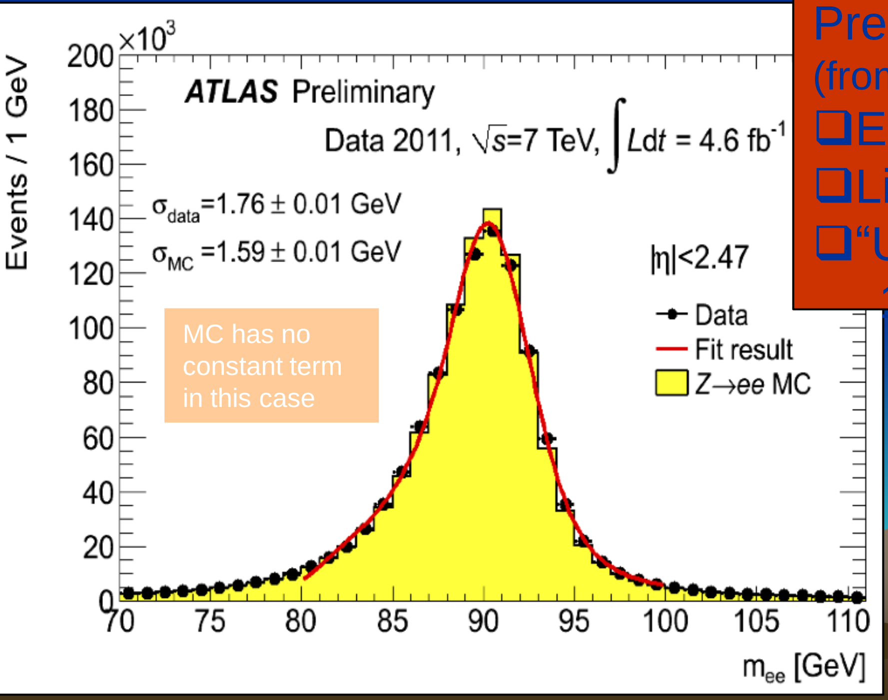


Crucial experimental aspects:
- ❑excellent γγ mass resolution to observe narrow
  signal peak above irreducible background
- ❑powerful γ/jet separation to suppress γj and jj
  background with jet → π^0 faking single γ

$m^2_{\gamma\gamma} = 2 E_1 E_2 (1-\cos\alpha)$

m_H=120 GeV	$\sigma(m_{\gamma\gamma})$ GeV	Event fraction in $\pm 1.4\,\sigma(m_{\gamma\gamma})$
All	1.7	80 %
Best category (unconverted central)	1.4	84%
Worst category (~10%) (≥ 1 γ converted, ≥ 1 γ near barrel/end-cap transition)	2.3	70%

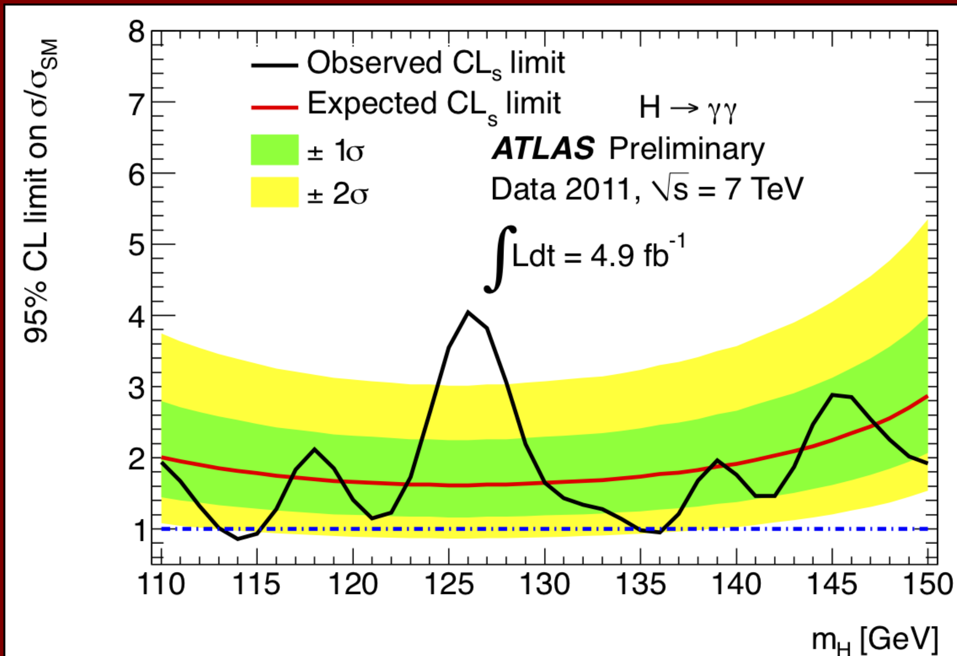




Present understanding of calorimeter E response (from Z, J/ψ → ee, W→ eν data and MC):

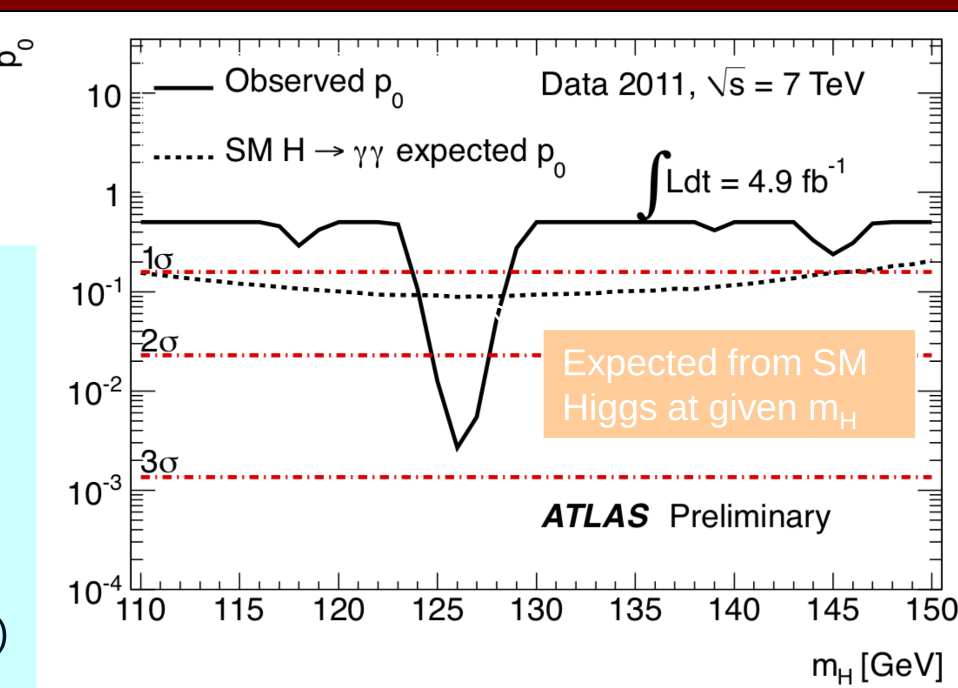
- Energy scale at m_Z known to ~ 0.5%
- Linearity better than 1% (over few GeV-few 100 GeV)
- "Uniformity" (constant term of resolution): 1% (barrel) -1.7 % (end-cap)

Electron scale and resolution transported to photons using MC
(systematics few from material effects)



Excluded (95% CL):
$114 \le m_H \le 115$ GeV, $135 \le m_H \le 136$ GeV

Consistency of the data with the background-only expectation



Maximum deviation from background-only expectation observed for m_H~126 GeV:

- local p_0-value: 0.27% or 2.8σ
- *expected from SM Higgs*: ~ 1.4σ local
- global p_0-value: includes probability for such an excess to appear anywhere in the investigated mass range (110-150 GeV) ("Look-Elsewhere-Effect"): ~7% (1.5σ)

$H \rightarrow ZZ^{(*)} \rightarrow 4l$ (4e, 4μ, 2e2μ)

$110 < m_H < 600$ GeV

- σ ~ 2-5 fb
- However:
  - -- mass can be fully reconstructed → events would cluster in a (narrow) peak
  - -- pure: S/B ~ 1
- 4 leptons: $p_T^{1,2,3,4} > 20,20,7,7$ GeV; $m_{12} = m_Z \pm 15$ GeV; $m_{34} > 15\text{-}60$ GeV (depending on m_H)
- Main backgrounds:
  - -- $ZZ^{(*)}$ (irreducible)
  - -- $m_H < 2m_Z$: Zbb, Z+jets, tt with two leptons from b/q-jets → l

→ Suppressed with isolation and impact parameter cuts on two softest leptons

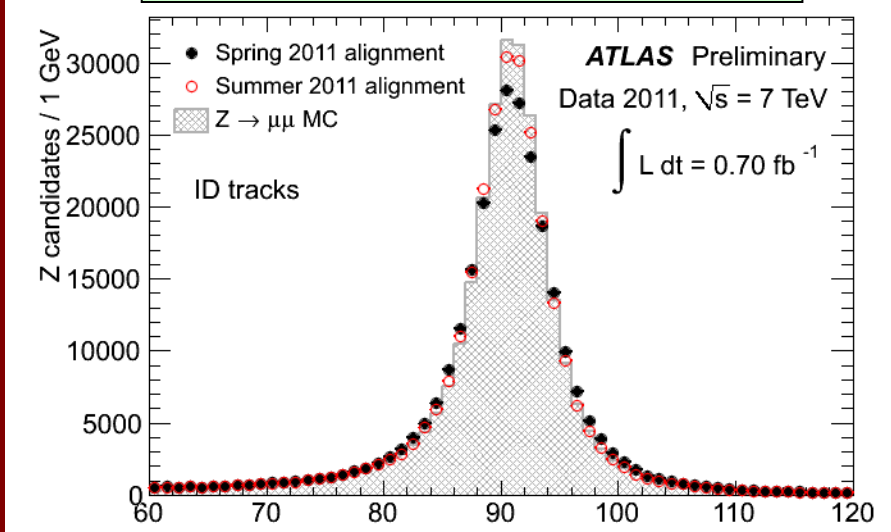
- Signal acceptance x efficiency: ~ 15 % for m_H~ 125 GeV

Crucial experimental aspects:

- High lepton reconstruction and identification efficiency down to lowest p_T
- Good lepton energy/momentum resolution
- Good control of reducible backgrounds (Zbb, Z+jets, tt) in low-mass region:
  - → cannot rely on MC alone (theoretical uncertainties, b/q-jet → l modeling, ..)
  - → need to compare MC to data in background-enriched control regions (but: low statistics ..)

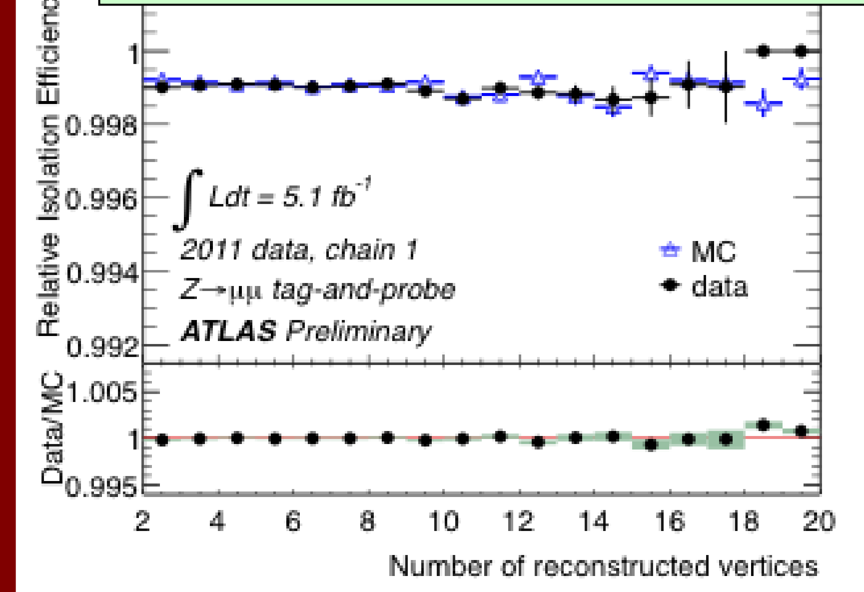
→ Conservative/stringent p_T and m(ll) cuts used at this stage

Improving Z→μμ mass resolution



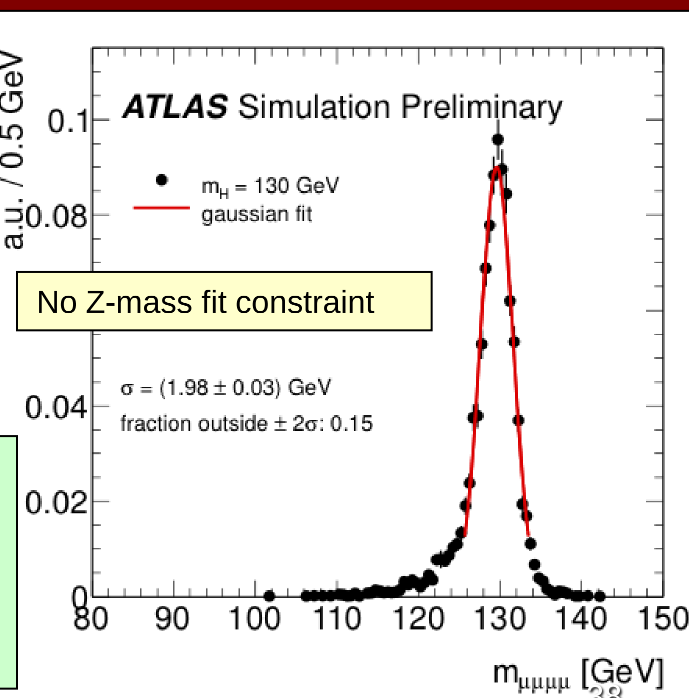
MC (perfect): 2.31±.01 GeV
Data Spring 2011 : 2.89±.01 GeV
Data Summer 2011: 2.45±.01 GeV

Muon (calorimetric) isolation efficiency from Z→μμ events in data and MC



Muon performance

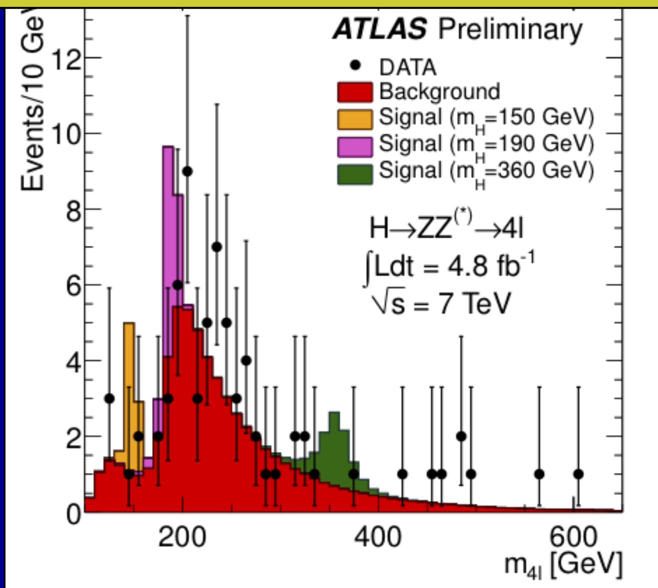
Muon reconstruction efficiency > 95% over 4 < p < 100 GeV



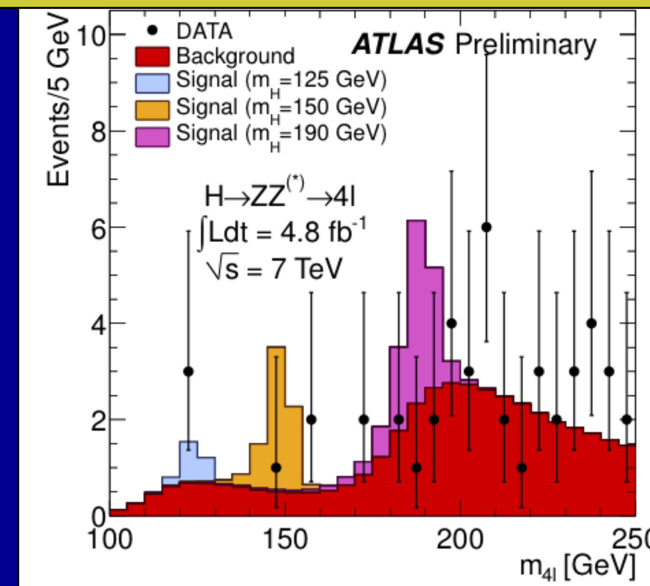
H→ 4μ mass resolution: ~2 GeV
Event fraction in ±2σ: ~ 85%

After all selections: kinematic cuts, isolation, impact

Full mass range
Observed: 71 events: 24 4μ + 30 2e2μ + 17 4e
Expected from background: 62±9



m(4l) < 180 GeV
Observed: 8 events: 3 4μ + 3 2e2μ + 2 4e
Expected from background: 9.3±1.5



In the region m_H < 141 GeV (not already excluded at 95% C.L.) 3 events are observed: two 2e2μ events (m=123.6 GeV, m=124.3 GeV) and one 4μ event (m=124.6 GeV)

In the region 117< m_{4l} <128 GeV
(containing ~90% of a m_H=125 GeV signal):

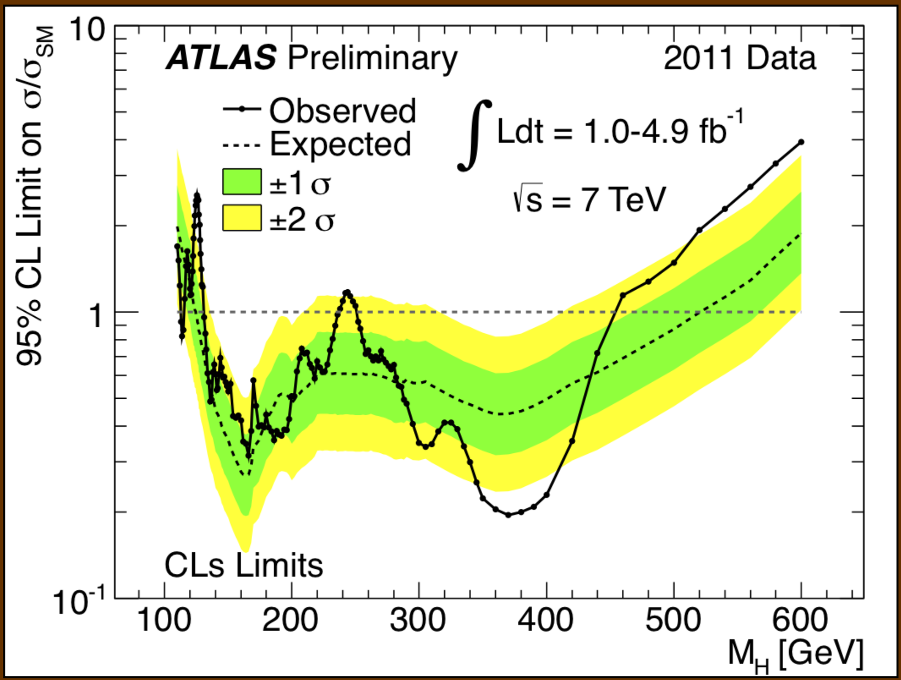
- similar contributions expected from signal and background: ~ 1.5 events each
- S/B ~ 2 (4μ), ~ 1 (2e2μ), ~ 0.3 (4e)
- Background dominated by ZZ* (4μ and 2e2μ), ZZ* and Z+jets (4e)

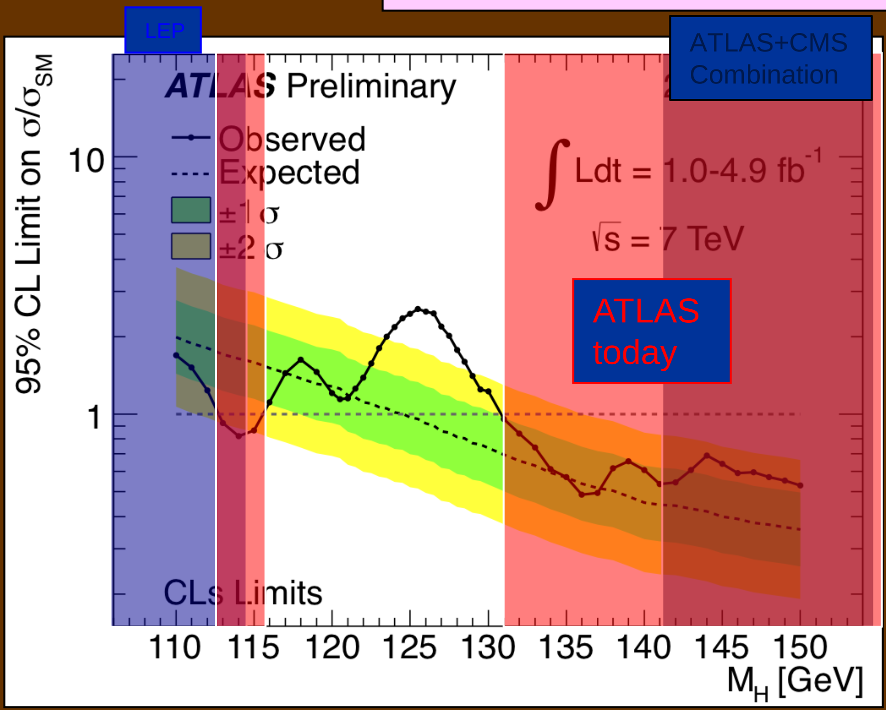
Main systematic uncertainties

Higgs cross-section	: ~ 15%
Electron efficiency	: ~ 2-8%
ZZ* background	: ~ 15%
Zbb, +jets backgrounds	: ~ 40%

Putting all channels together → combined constraints

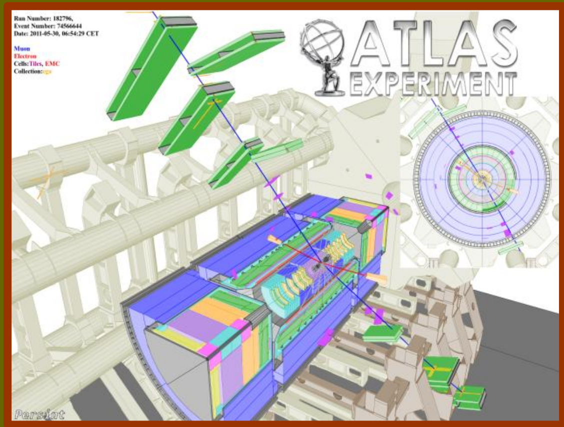
$H\to\gamma\gamma$, $H\to\tau\tau$
$H\to WW^{(*)}\to l\nu l\nu$
$H\to ZZ^{(*)}\to 4l$, $H\to ZZ\to ll\nu\nu$
$H\to ZZ\to llqq$, $H\to WW\to l\nu qq$
$W/ZH\to lbb+X$ not included

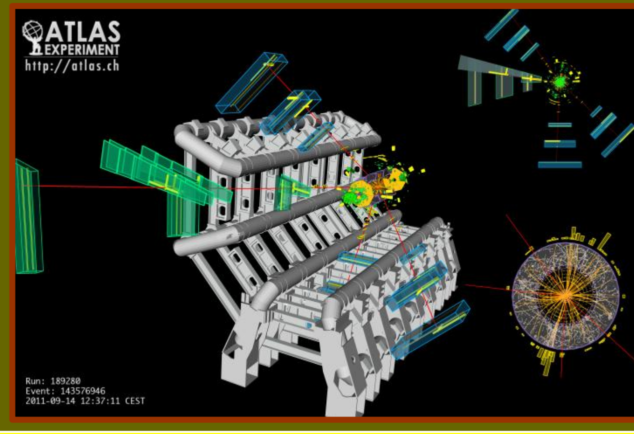


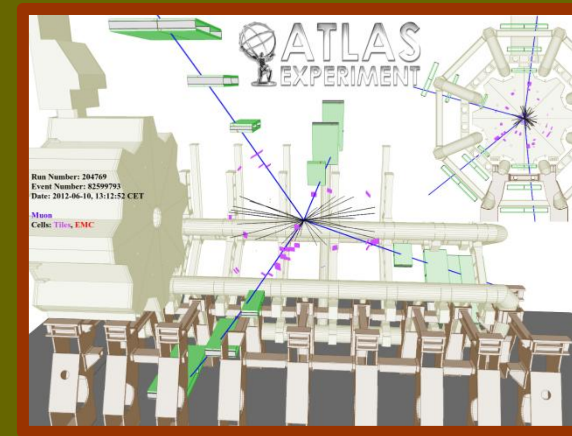


Excluded at 95% CL	$112.7 < m_H < 115.5$ GeV $131 < m_H < 453$ GeV, except 237-251 GeV
Expected if no signal	124.6-520 GeV
Excluded at 99% CL	$133 < m_H < 230$ GeV, $260 < m_H < 437$ GeV

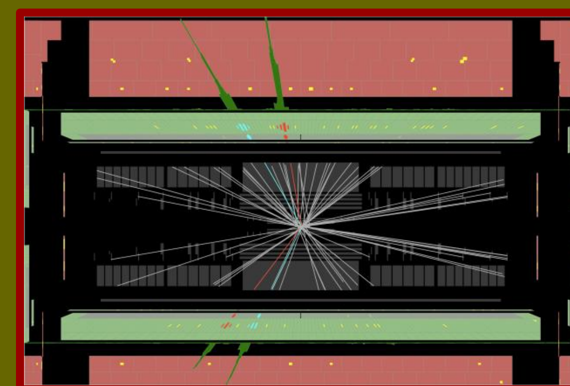
- アトラス検出器とシリコン検出器
- 地上実験棟で宇宙線テスト
- ２０１０年のテストランの結果
- ２０１１年ヒッグスの可能性（ファビオラ）
- ２０１２年ヒッグスの発見か？（ファビオラ）
- 測定器技術と電子回路





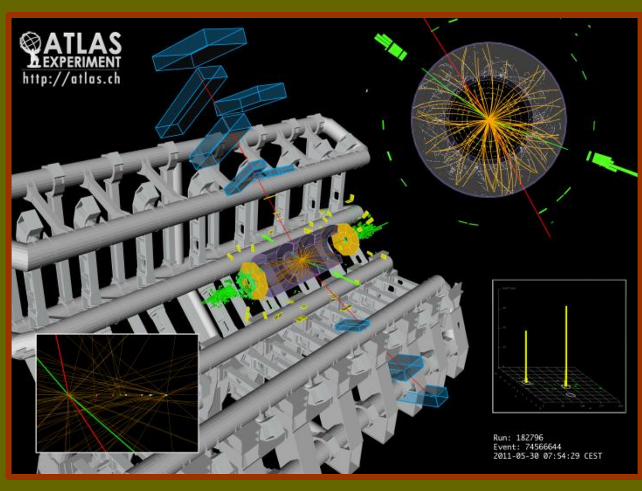


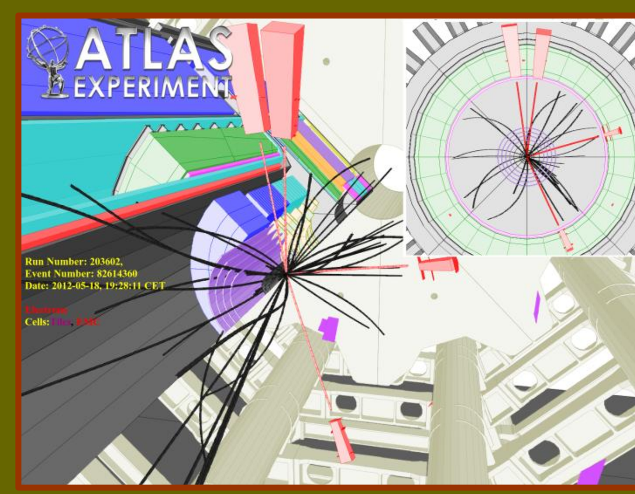
Status of Standard Model Higgs searches in ATLAS



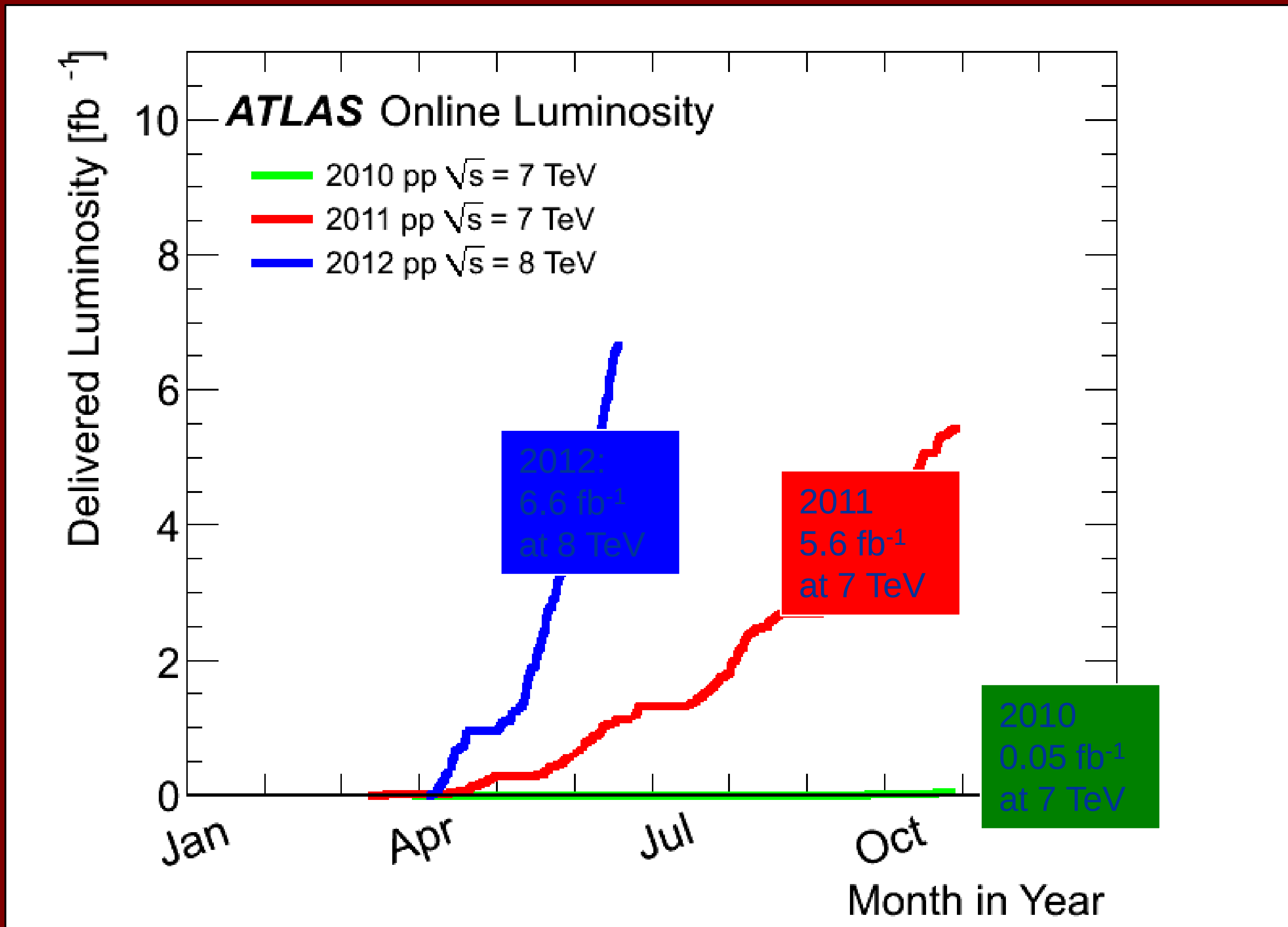
Using the full datasets recorded in 2011 at √s= 7 TeV and 2012 at √s=8 TeV: up to 10.7 fb^{-1}

Fabiola Gianotti (CERN), representing the ATLAS Collaboration

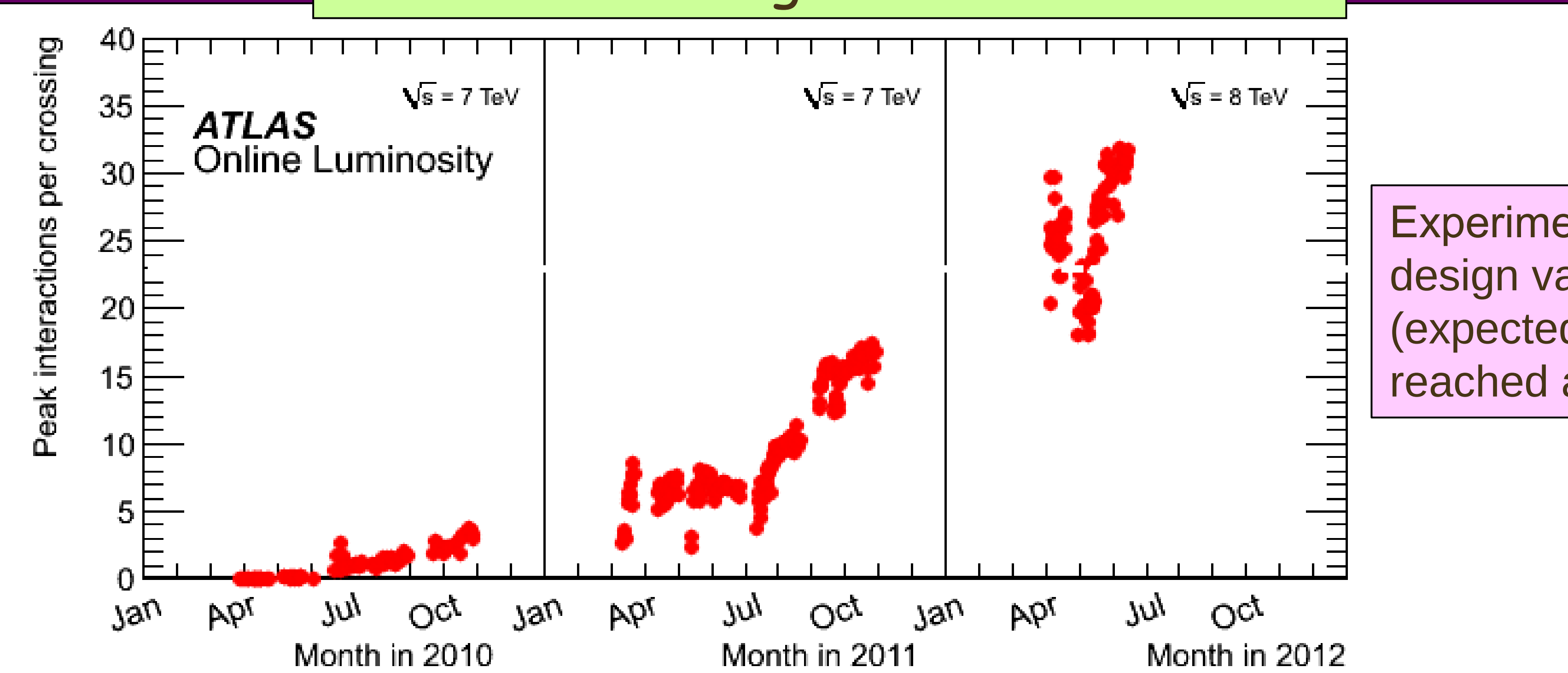




Luminosity delivered to ATLAS since the beginning



The BIG challenge in 2012: PILE-UP

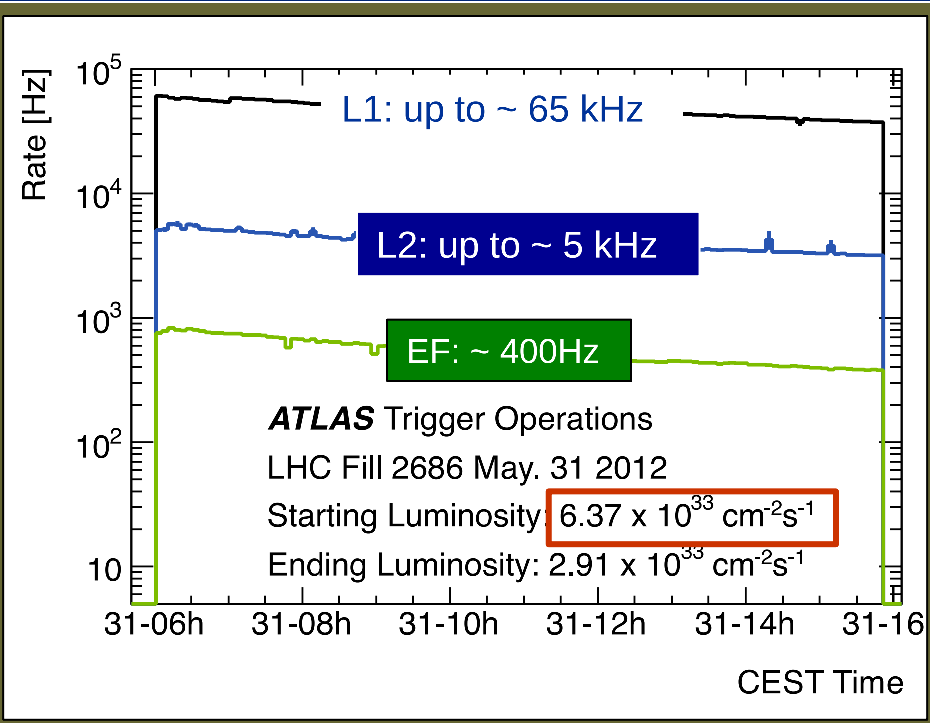


Experiment's design value (expected to be reached at $L=10^{34}$!)

Trigger in 2012

- Optimization of selections (e.g. object isolation) to maintain low un-prescaled thresholds (e.g. for inclusive leptons) in spite of projected x2 higher L and pile-up than in 2011
- Pile-up robust algorithms developed (~flat performance vs pile-up, minimize CPU usage, …)

→ Results from 2012 operation show trigger is coping very well (in terms of rates, efficiencies, robustness, ..) with harsh conditions while meeting physics requirements



Lowest un-prescaled thresholds (examples)

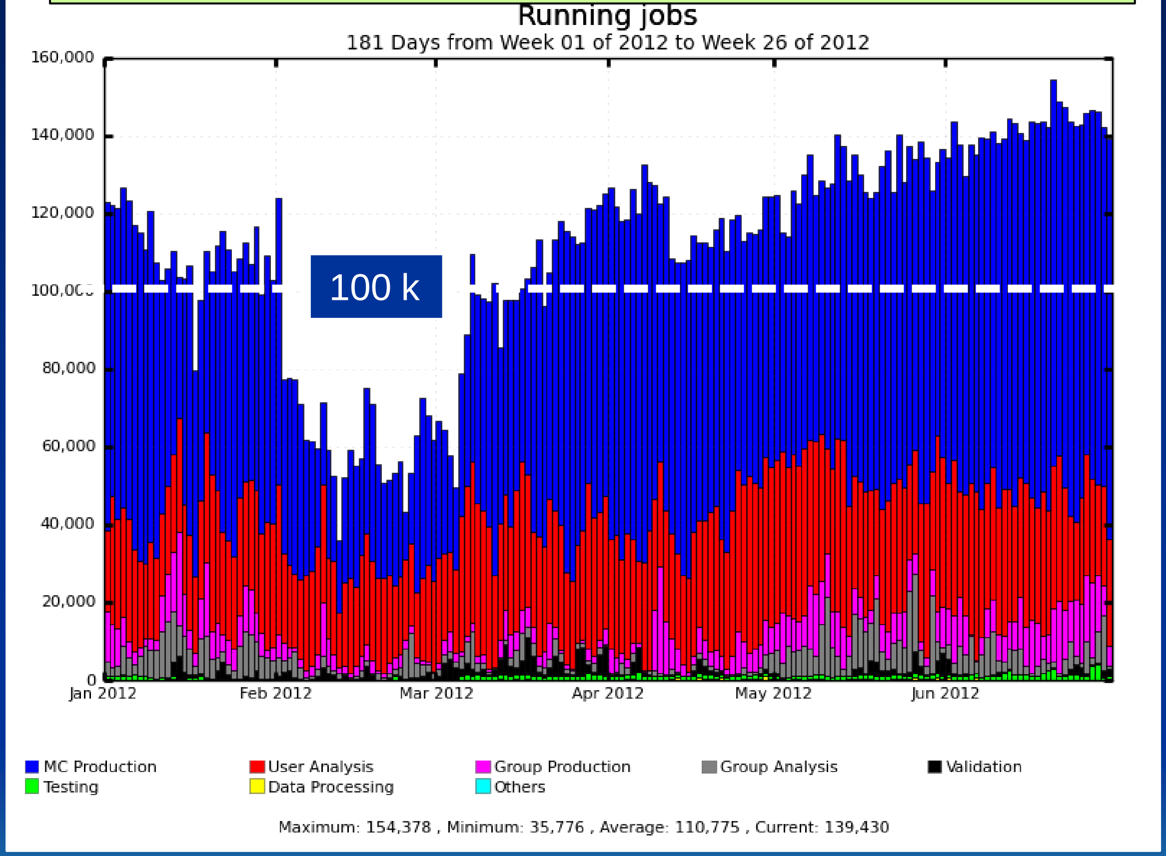
Item	p_T threshold (GeV)	Rate (Hz) 5×10^{33}
Incl. e	24	70
Incl. μ	24	45
ee	12	8
μμ	13	5
ττ	29,20	12
γγ	35,25	10
E_T^{miss}	80	17
5j	55	8

Note: ~ 500 items in trigger menu !

Managed to keep inclusive un-prescaled lept[…] thresholds within ~ 5 GeV over last two year[…] in spite factor ~ 70 peak lumi increase

It would have been impossible to release physics results so quickly without the outstanding performance of the Grid (including the CERN Tier-0)

Number of concurrent ATLAS jobs Jan-July 2012



Includes MC production, user and group analysis at CERN, 10 Tier1-s, ~ 70 Tier-2 federations → > 80 sites

> 1500 distinct ATLAS users do analysis on the GRID

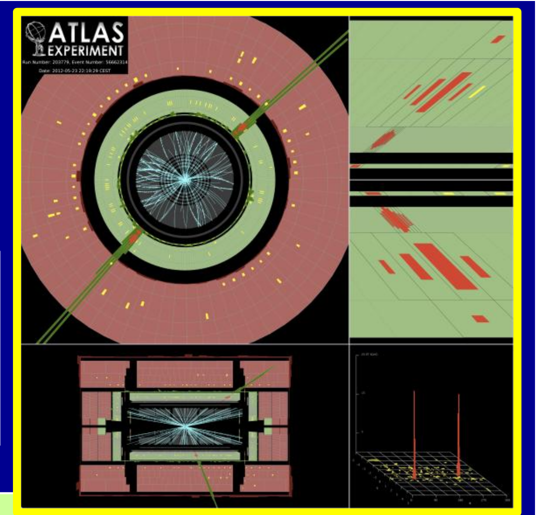
- ❑ Available resources fully used/stressed (beyond pledges in some cases)
- ❑ Massive production of 8 TeV Monte Carlo samples
- ❑ Very effective and flexible Computing Model and Operation team → accommodate hig trigger rates and pile-up, intense MC simulation, analysis demands from worldwide users (through e.g. dynamic data placement)

$H \to \gamma\gamma$

$110 \leq m_H \leq 150$ GeV

σ x BR ~ 50 fb m_H ~ 126 GeV

- ❑ Simple topology: two high-p_T isolated photons
  E_T (γ_1, γ_2) > 40, 30 GeV
- ❑ Main background: $\gamma\gamma$ continuum (irreducible, smooth, ..)



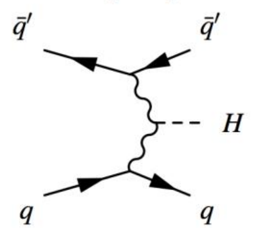
To increase sensitivity, events divided in 10 categories based on γ rapidity, converted/unconverted γ; p_{Tt} ($p_T^{\gamma\gamma}$ perpendicular to $\gamma\gamma$ thrust axis); 2jets

Main improvements in new analysis:
- ❑ 2jet category introduced → targeting VBF process
- ❑ γ identification (NN used for 2011 data) and isolation

→ Expected gain in sensitivity: + 15%

Background fit procedure also improved

σ_{SM} (VBF) ~7%



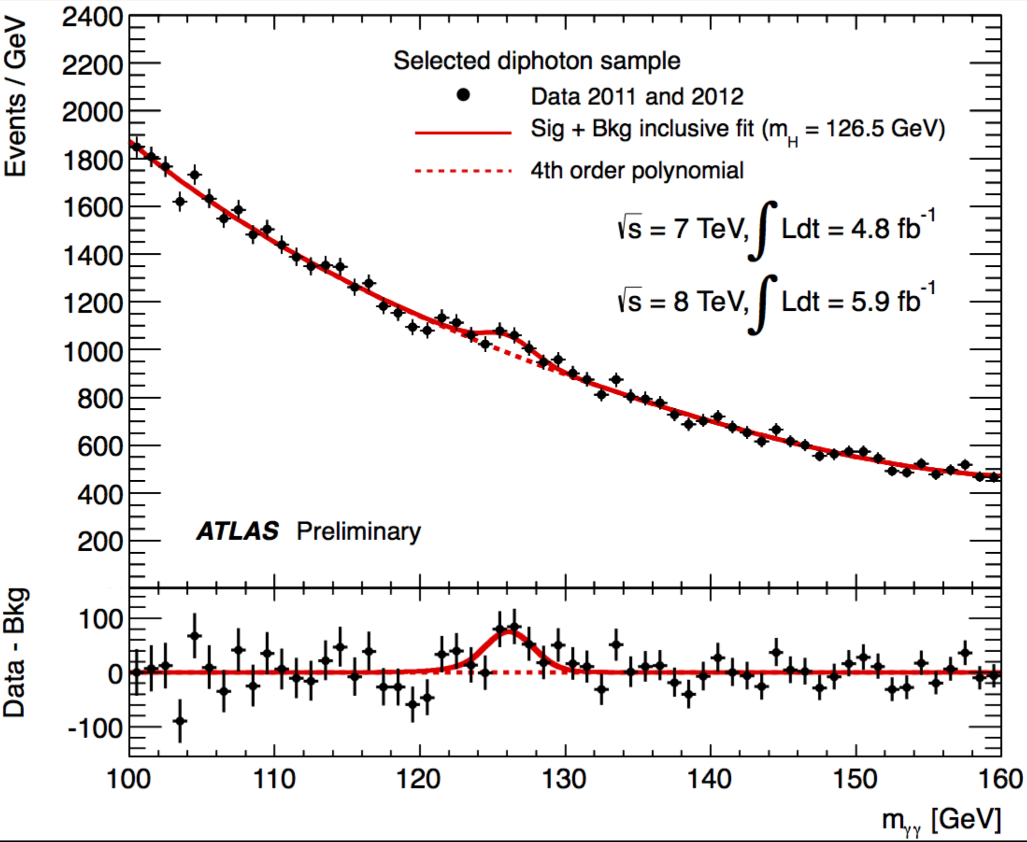
2 jets with
p_T > 25-30 GeV
$|\eta|$<4.5
$|\Delta\eta|_{jj}$ > 2.8
M_{jj} > 400 GeV
$|\Delta\varphi|$ ($\gamma\gamma$-jj) > 2.6

Expected gain in sensitivity: 3%

After all selections, expect (10.7 fb^{-1}, m_H~ 126 GeV)
- ~ 170 signal events (total signal efficiency ~ 40%)
- ~ 6340 background events in mass window

→ S/B ~ 3% inclusive (~ 20% 2jet category)

Crucial experimental aspects:
- ❑ excellent $\gamma\gamma$ mass resolution to observe narrow signal above irreducible background
- ❑ powerful γ identification to suppress γj and jj background with jet → π^0 → fake γ
  (cross sections are 10^4-10^7 larger than $\gamma\gamma$ background)



Total after selections: 59059 events

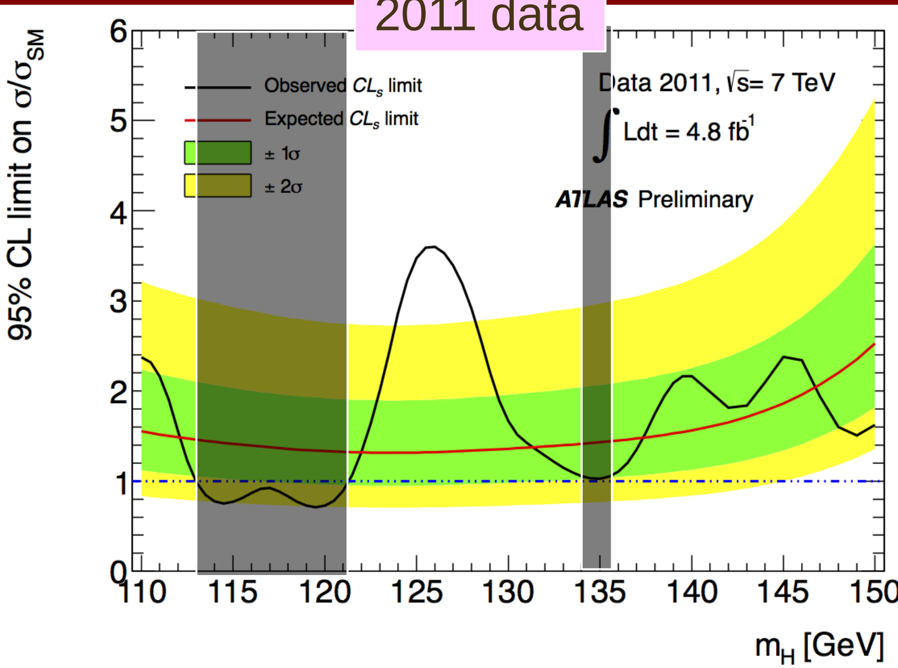
$m_{\gamma\gamma}$ spectrum fit, for each category, with Crystal Ball + Gaussian for signal plus background model optimised (with MC) to minimize biases

Max deviation of background model from expected background distribution taken as systematic uncertainty

Main systematic uncertainties

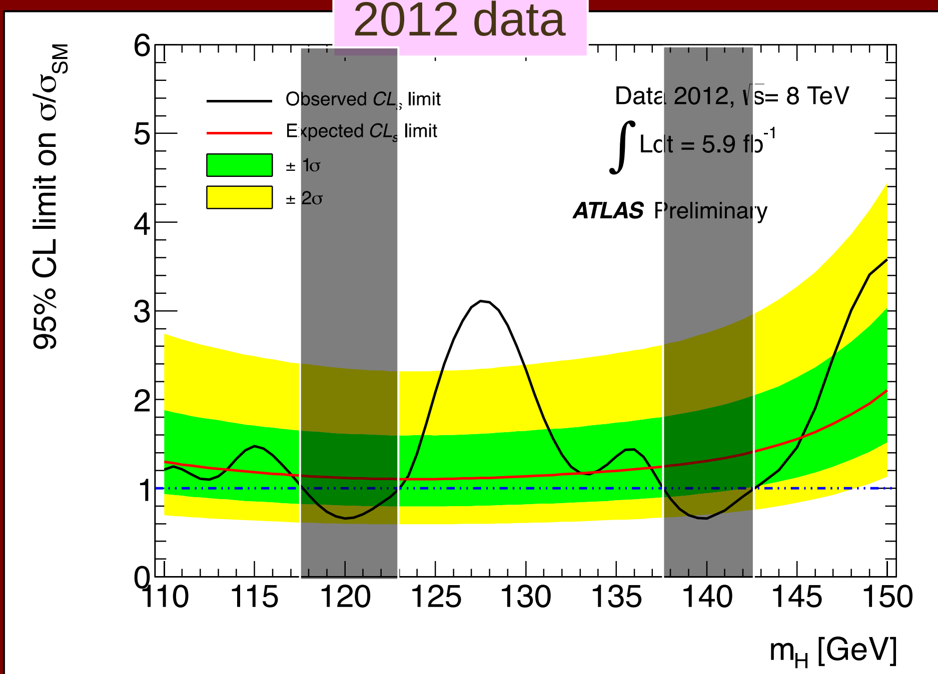
Signal yield	
Theory	~ 20%
Photon efficiency	~ 10%
Background model	~ 10%
Categories migration	
Higgs p_T modeling	up to ~ 10%
Conv/unconv γ	up to ~ 6%
Jet E-scale	up to 20% (2j/VBF)
Underlying event	up to 30% (2j/VBF)
H→ $\gamma\gamma$ mass resolution	~ 14%
Photon E-scale	~ 0.6%

2011 data

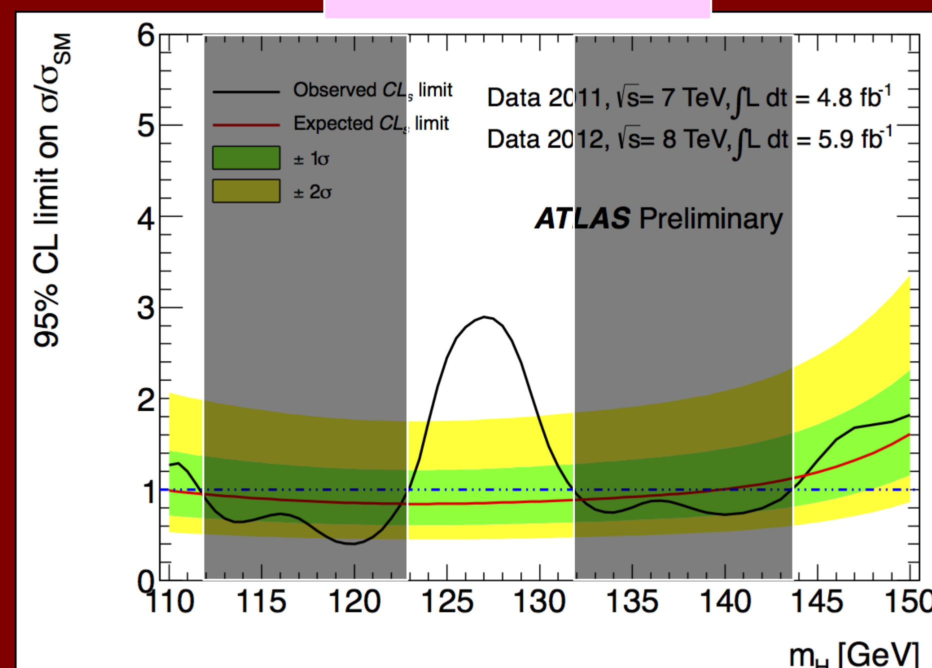


Excluded (95% CL):
112-122.5 GeV, 132-143 GeV
Expected: 110-139.5 GeV

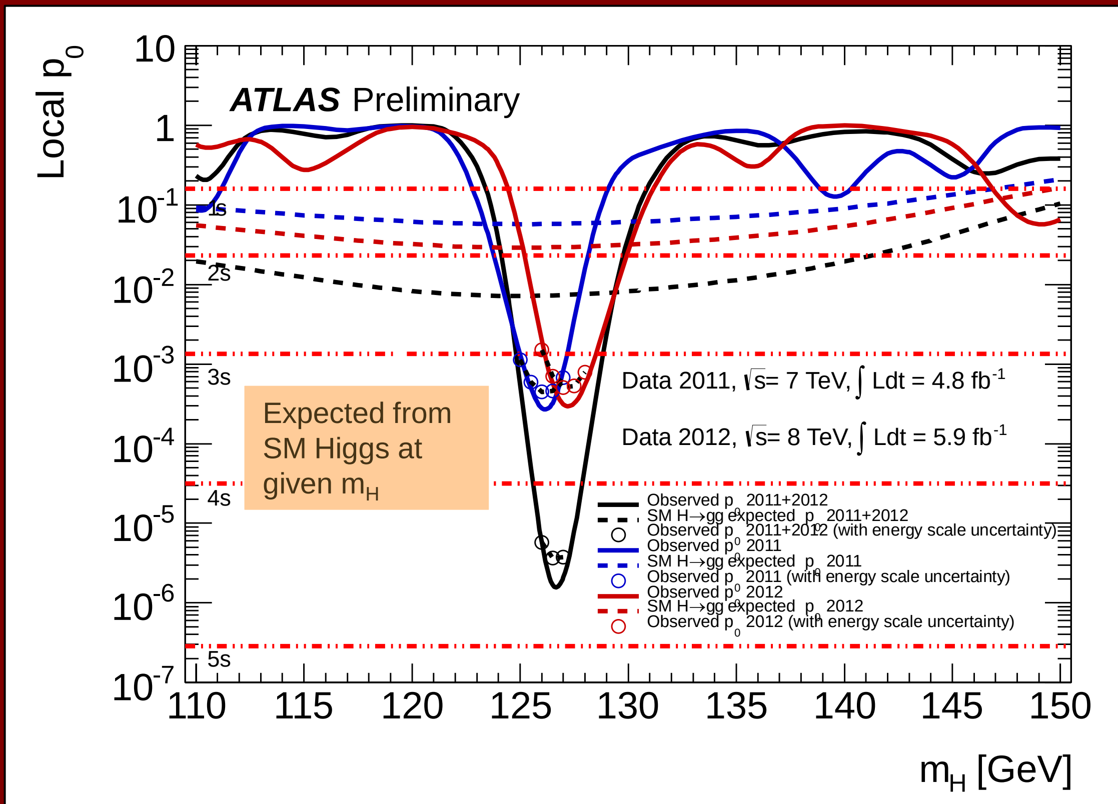
2012 data



2011+2012 data



Consistency of data with background-only expectation



Points indicate impact of 0.6% uncertainty on photon energy scale: ~ 0.1 sigma

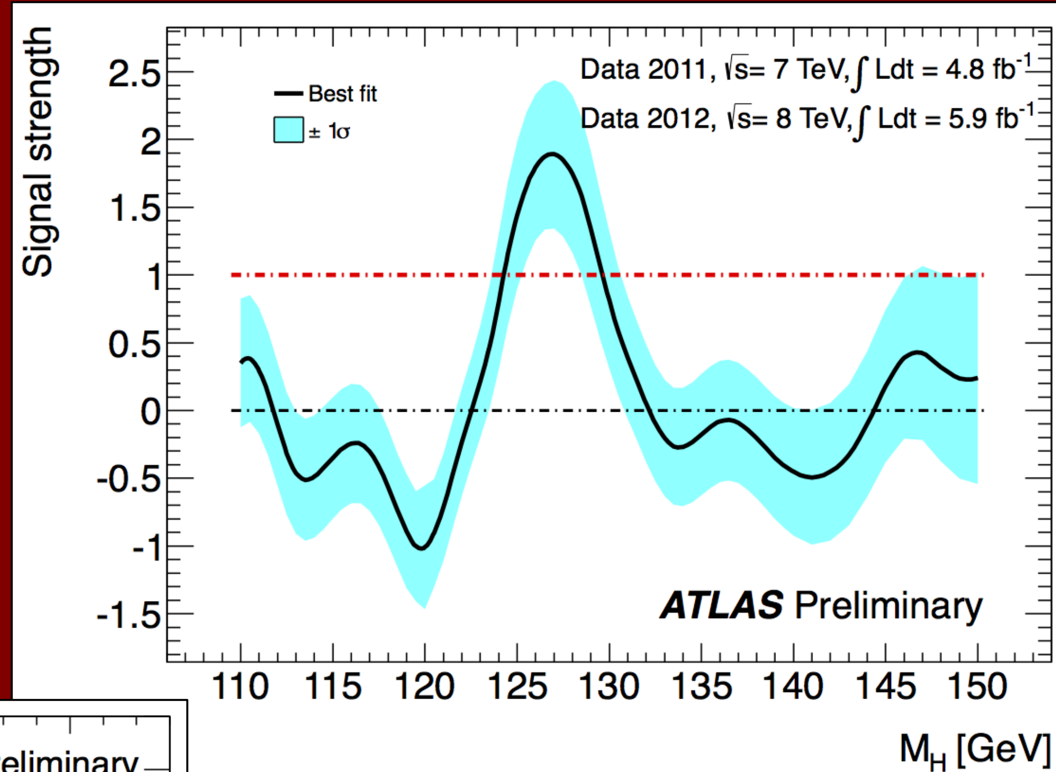
Data sample	m_H of max deviation	local p-value	local significance	expected from SM Higgs
2011	126 GeV	3×10^{-4}	3.5 σ	1.6 σ
2012	127 GeV	3×10^{-4}	3.4 σ	1.9 σ
2011+2012	126.5 GeV	2×10^{-6}	4.5 σ	2.4 σ

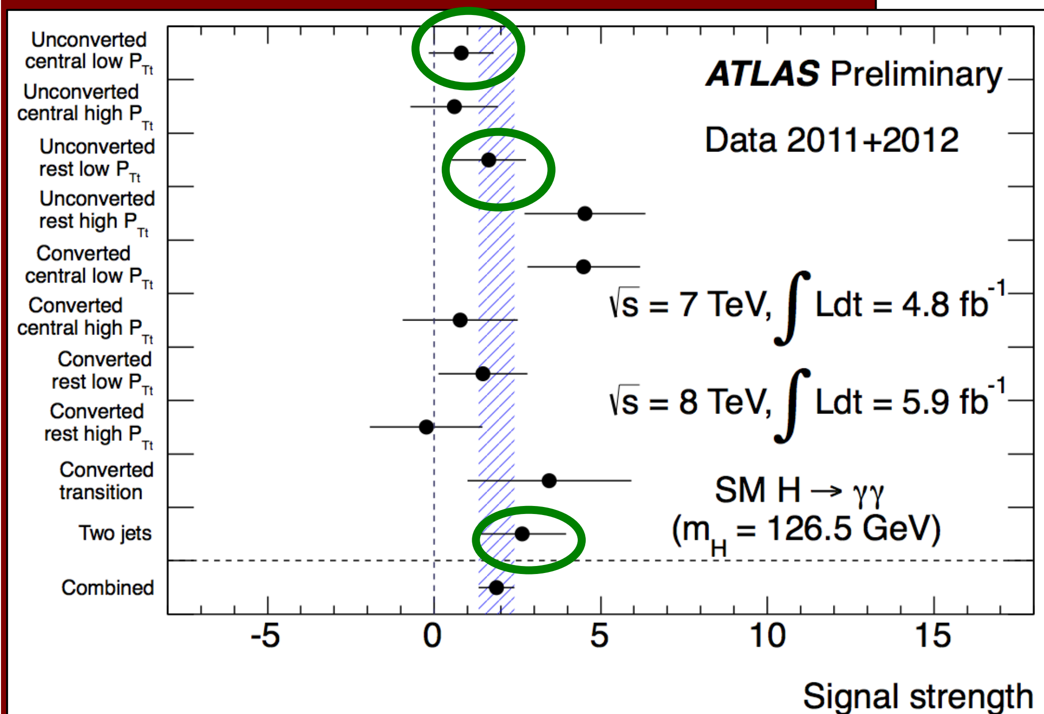
Global 2011+2012 (including LEE over 110-150 GeV range): 3.6 σ

Fitted signal strength

Normalized to SM Higgs expectation at given m_H (μ)

Best-fit value at 126.5 GeV:
μ=1.9 ± 0.5





Consistent results from various categories within uncertainties (most sensitive ones indicated)

$H \rightarrow ZZ^{(*)} \rightarrow 4l$ (4e, 4μ, 2e2μ)

$110 < m_H < 600$ GeV

σ x BR ~ 2.5 fb $m_H \sim 126$ GeV

- Tiny rate, BUT:
  - -- mass can be fully reconstructed → events should cluster in a (narrow) peak
  - -- pure: S/B ~ 1
- 4 leptons: $p_T^{1,2,3,4} > 20,15,10,7\text{-}6$ (e-μ) GeV; $50 < m_{12} < 106$ GeV; $m_{34} > 17.5\text{-}50$ GeV (vs m_H)
- Main backgrounds:
  - -- $ZZ^{(*)}$: irreducible
  - -- low-mass region $m_H < 2m_Z$: Zbb, Z+jets, tt with two leptons from b-jets or q-jets →

Crucial experimental aspects:

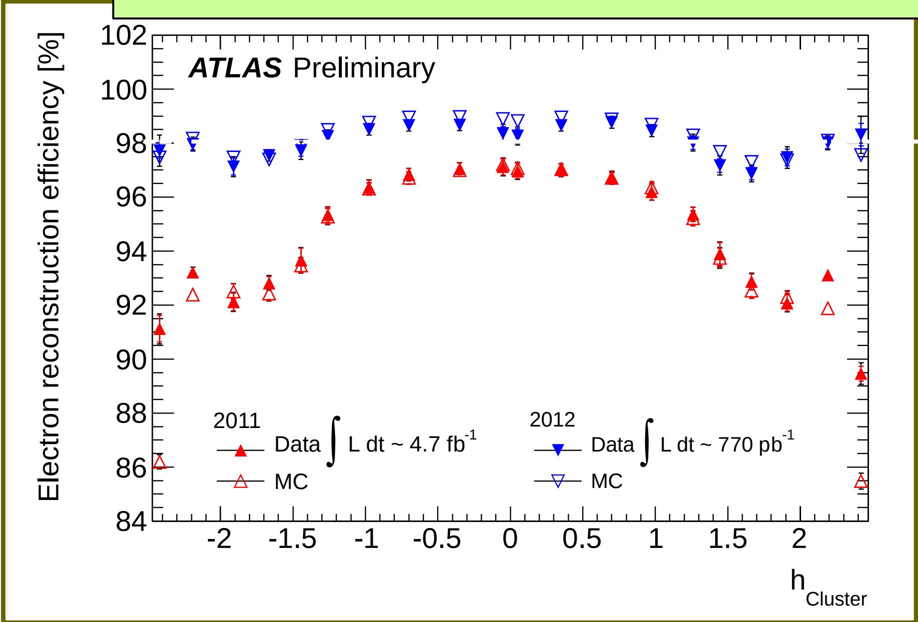
- High lepton acceptance, reconstruction & identification efficiency down to lowest p_T
- Good lepton energy/momentum resolution
- Good control of reducible backgrounds (Zbb, Z+jets, tt) in low-mass region:
  - → cannot rely on MC alone (theoretical uncertainties, b/q-jet → l modeling, ..)
  - → need to validate MC with data in background-enriched control regions

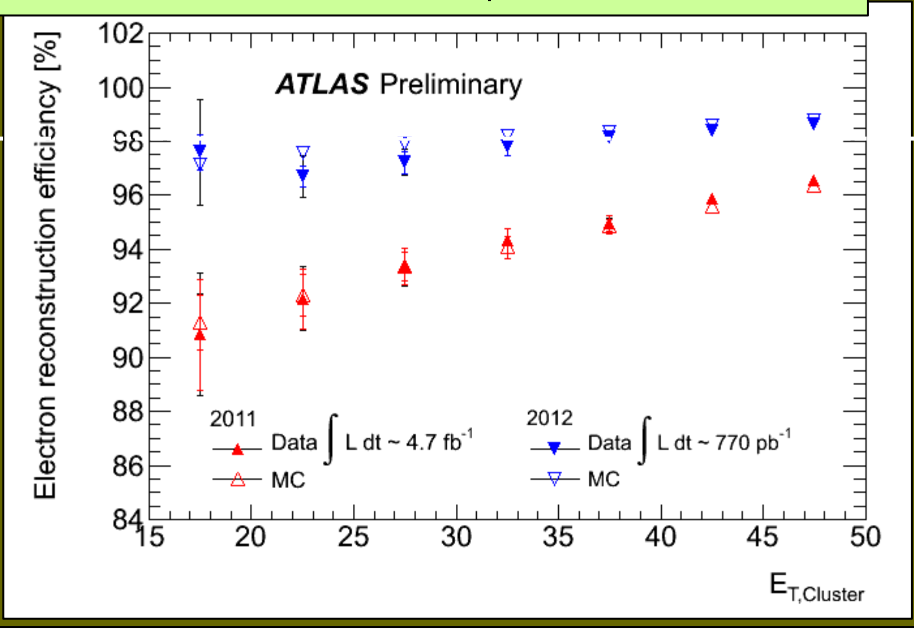
Main improvements in new analysis:

- kinematic cuts (e.g. on m_{12}) optimized/relaxed to increase signal sensitivity at low mass
- increased $e^{\pm}$ reconstruction and identification efficiency at low p_T , increased pile-up robustness, with negligible increase in the reducible backgrounds

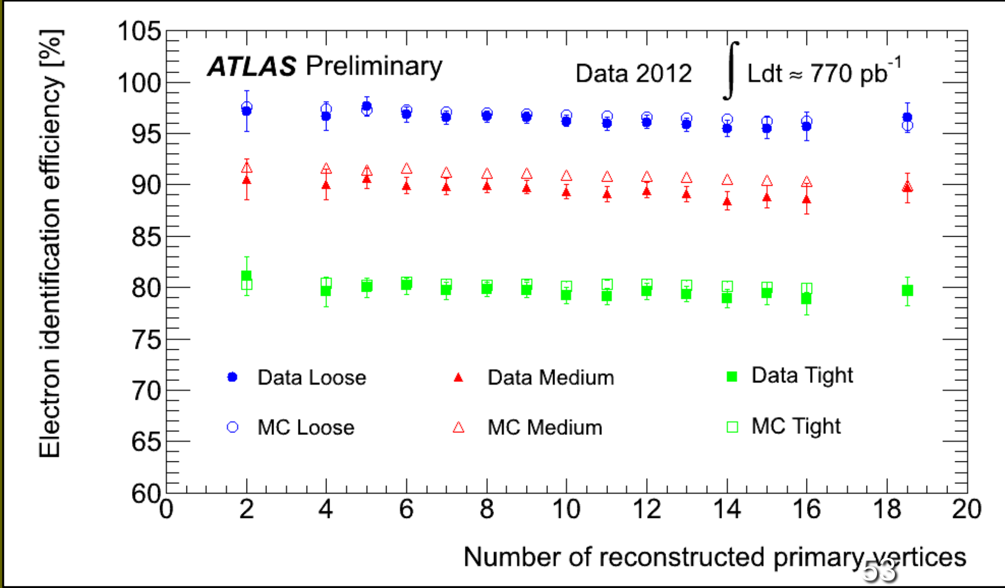
High efficiency for low-p_T electrons (affected by material) crucial for H→ 4e, 2μ2e

Improved track reconstruction and fitting to recover $e^{\pm}$ undergoing hard Brem
→ achieved ~ 98% reconstruction efficiency, flatter vs η and E_T





Re-optimized $e^{\pm}$ identification using pile-up robust variables (e.g. Transition Radiation, calorimeter strips) → achieved ~ 95% identification efficiency, ~ flat vs pile-up; higher rejections of fakes

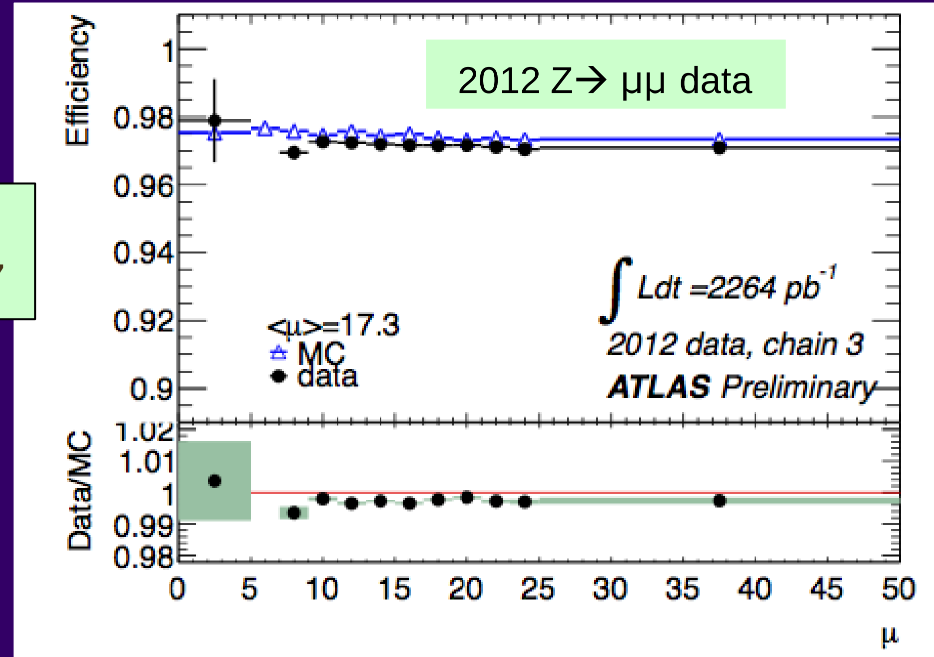


Results are from Z→ ee data and MC tag-and-probe

Muons reconstructed down to p_T = 6 GeV over |η|<2.7

Reconstruction efficiency ~ 97%,
~ flat down to p_T ~ 6 GeV and over |η|~2.7

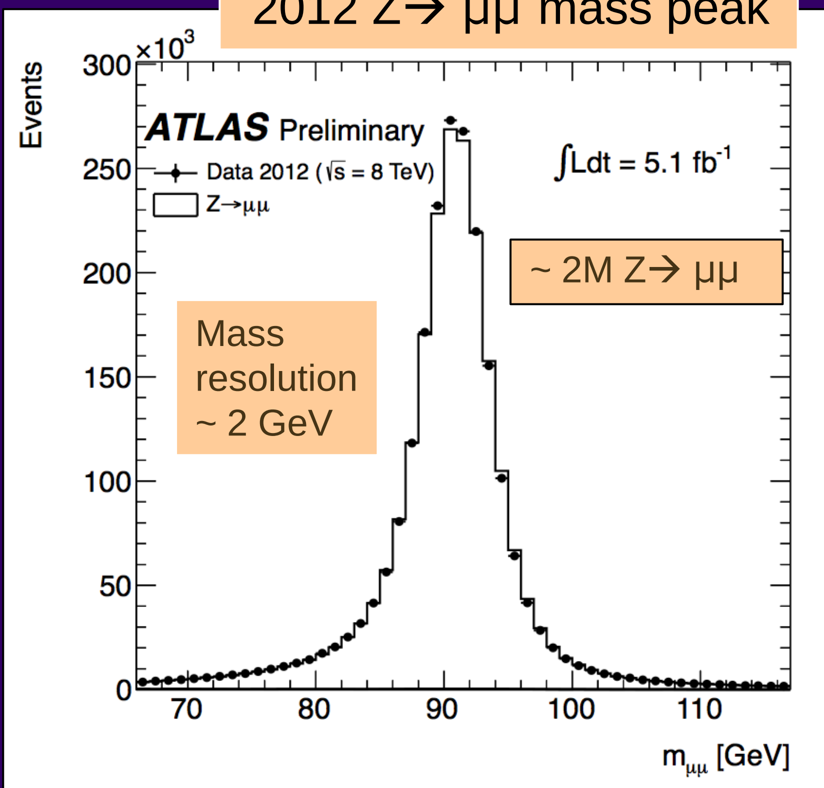
Total acceptance x efficiency for H→ 4μ: ~ 40% (+45% gain)



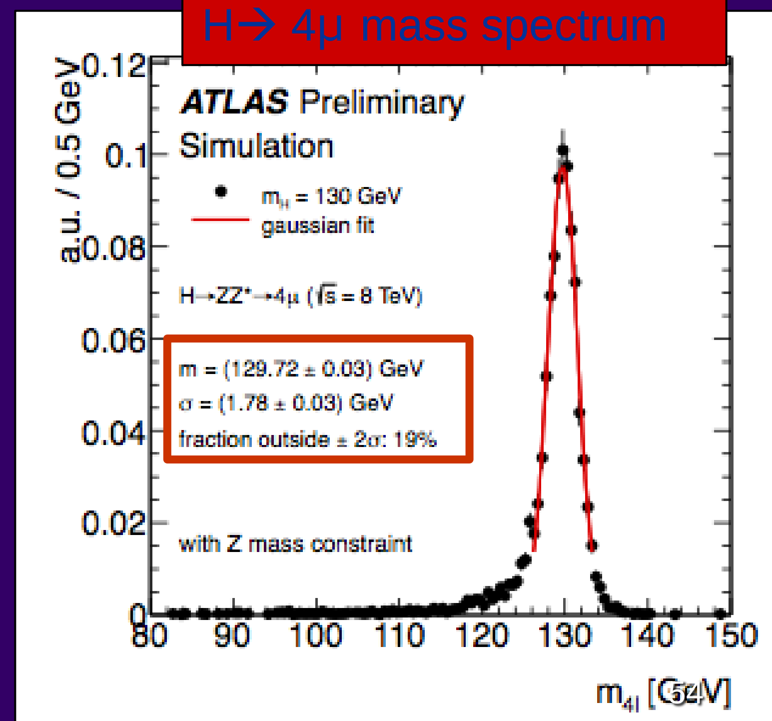
2012 Z→ μμ mass peak

~ 2M Z→ μμ

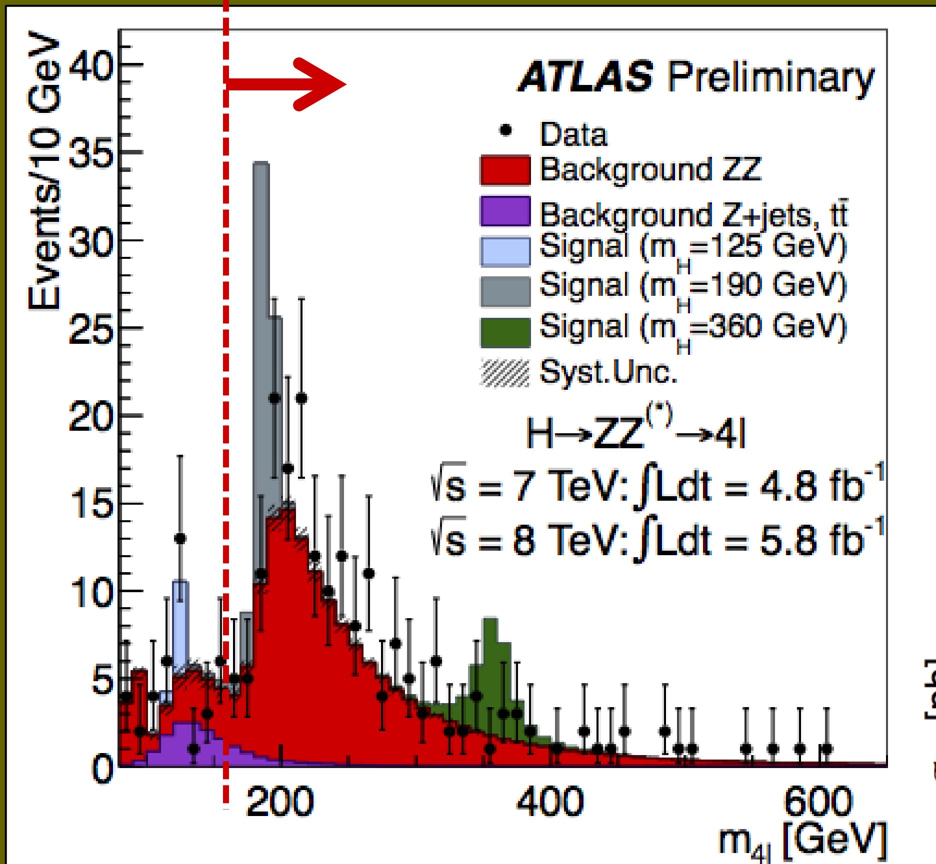
Mass resolution ~ 2 GeV



H→ 4μ mass spectrum



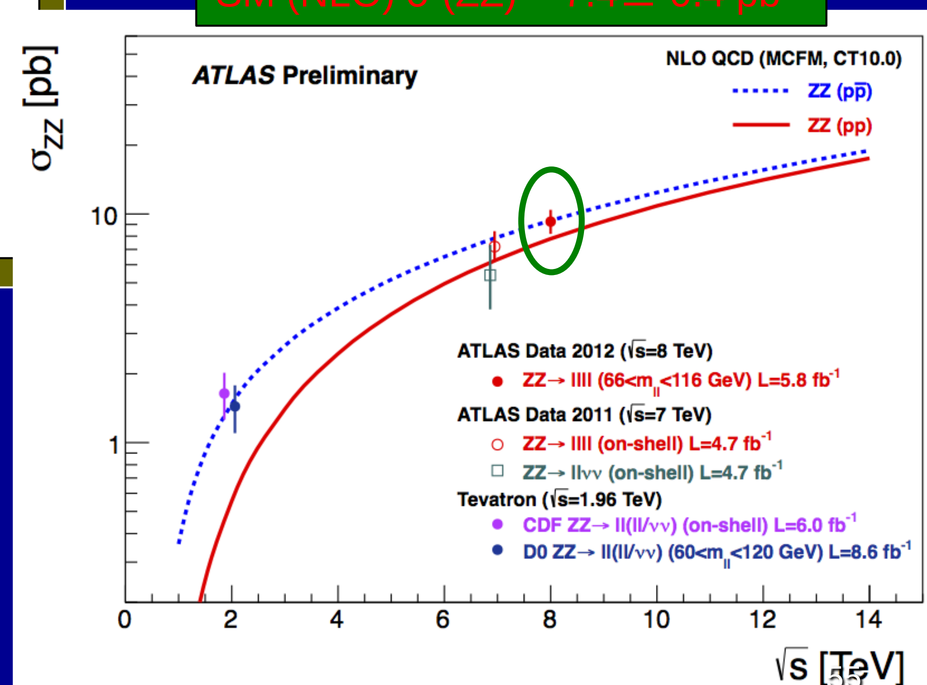
H→ 4l mass spectrum after all selections: 2011+2012 data



m(4l) > 160 GeV
(dominated by ZZ background):
147 ± 11 events expected
191 observed

~ 1.3 times more ZZ events in data than SM prediction →in agreement with measured ZZ cross-section in 4l final states at √s = 8 TeV

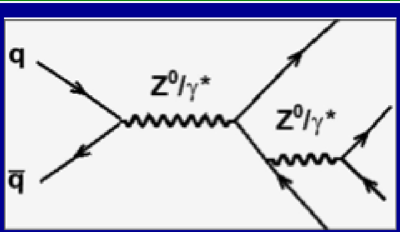
Measured σ (ZZ) = 9.3 ± 1.2 pb
SM (NLO) σ (ZZ) = 7.4± 0.4 pb



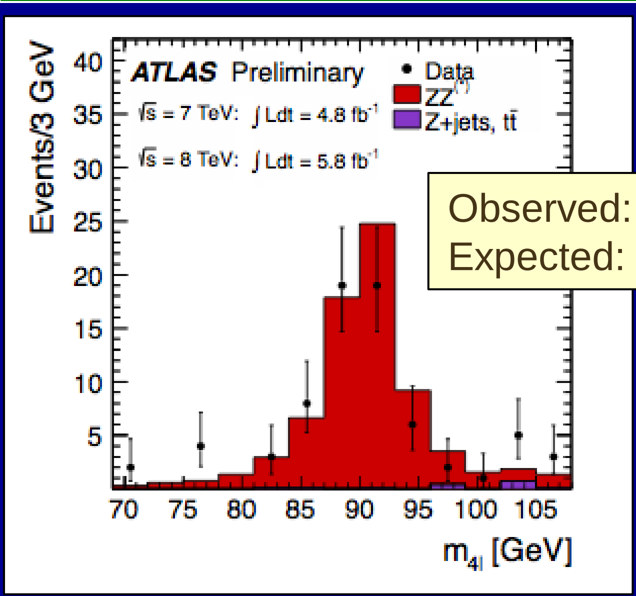
Discrepancy has negligible impact on the low-mass region < 160 GeV
(no change in results if in the fit ZZ is constrained
to its uncertainty or left free)

H→ 4l mass spectrum after all selections: 2011+2012 data

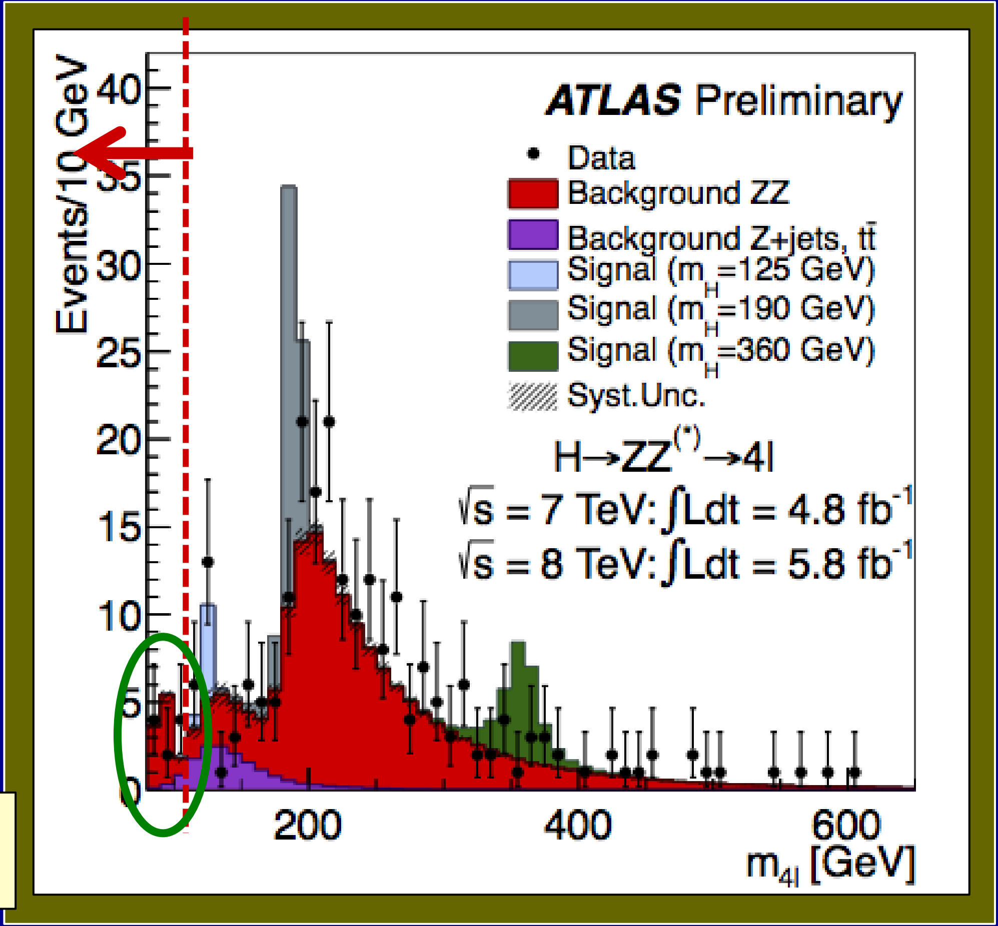
Peak at m(4l) ~ 90 GeV from single-resonant Z→ 4l production

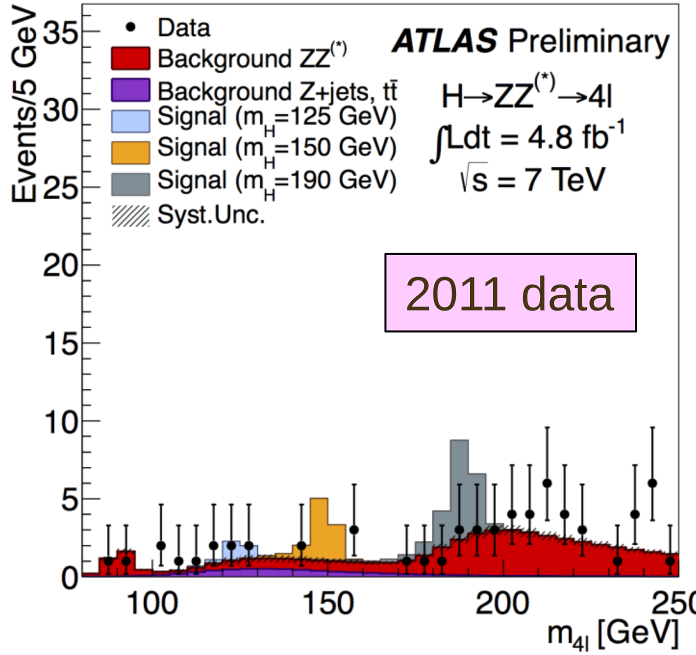


Enhanced by relaxing cuts on m_{12}, m_{34} and $p_T(\mu_4)$



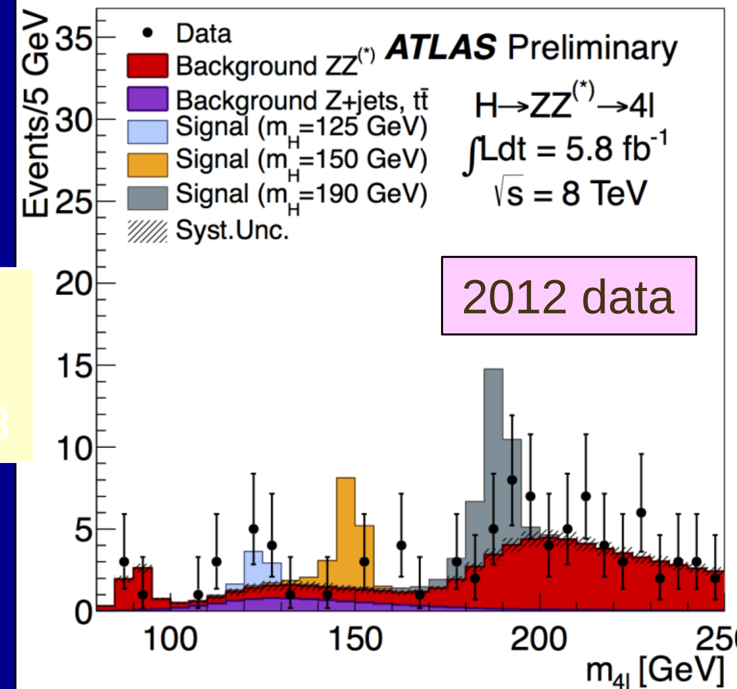
Observed: 57 events
Expected: 65 ± 5



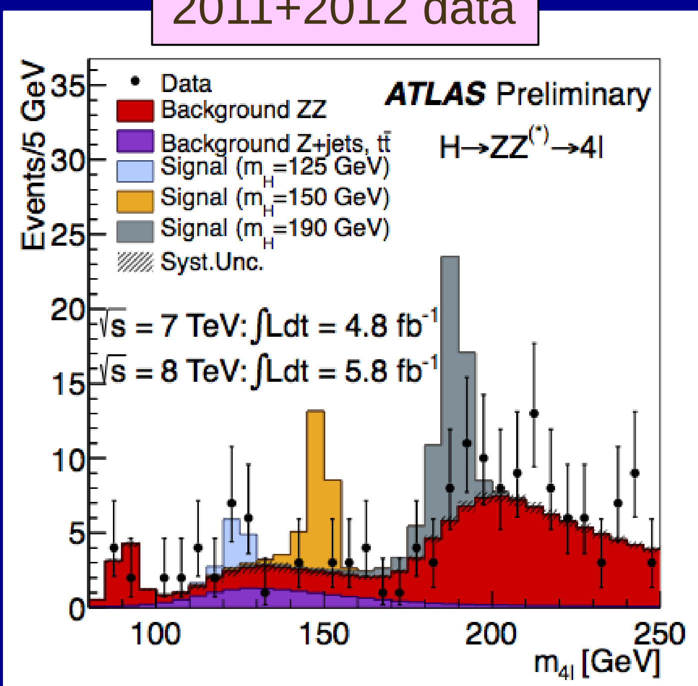


The low-mass region

m4l <160 GeV:
Observed: 39
Expected: 34 ± 3



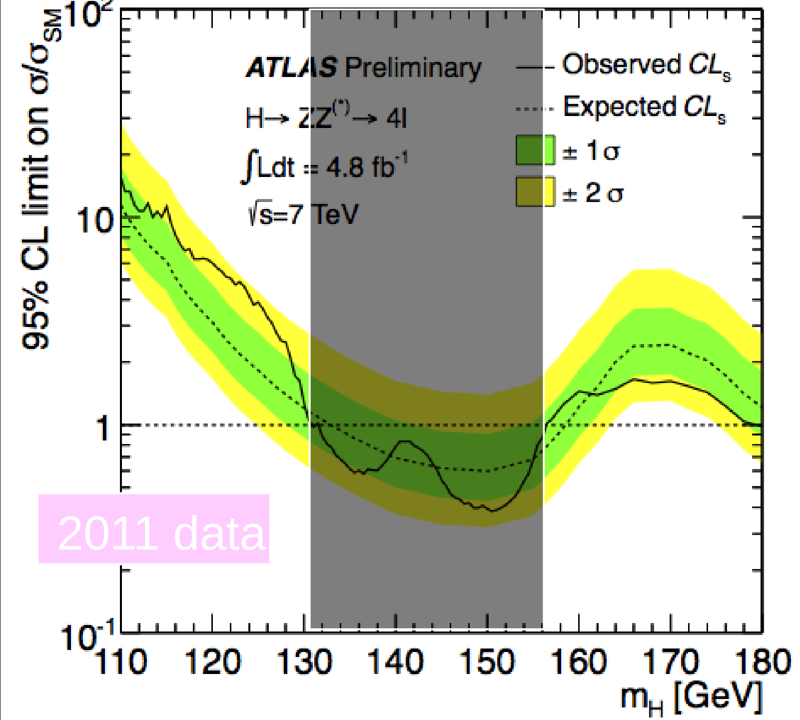
2011+2012 data



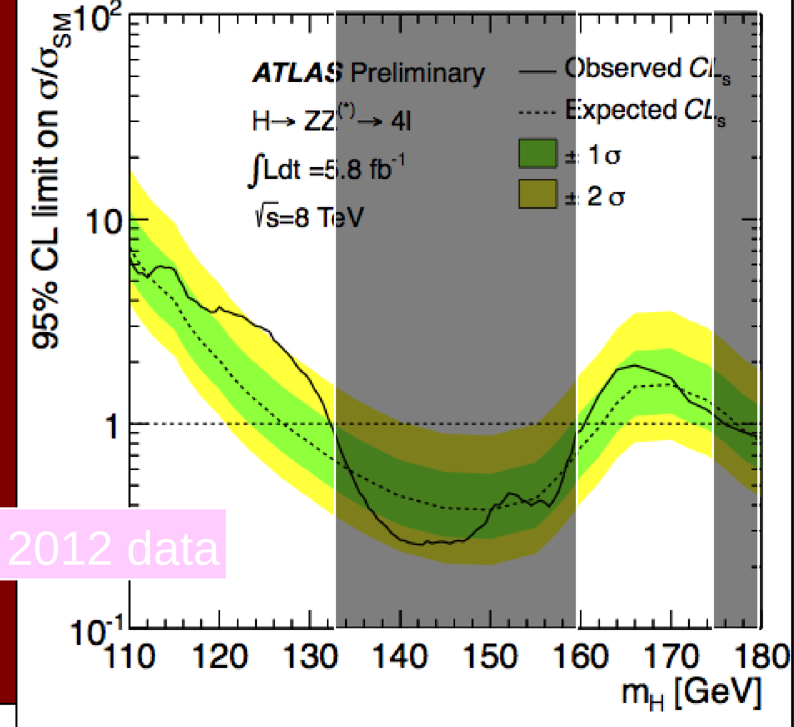
In the region 125 ± 5 GeV

Dataset	2011	2012	2011+2012
Expected B only	2±0.3	3±0.4	5.1±0.8
Expected S m_H=125 GeV	2±0.3	3±0.5	5.3±0.8
Observed in the data	4	9	13

2011+ 2012	4μ	2e2μ	4e
Data	6	5	2
Expected S/B	1.6	1	0.5
Reducible/total background	5%	45%	55%

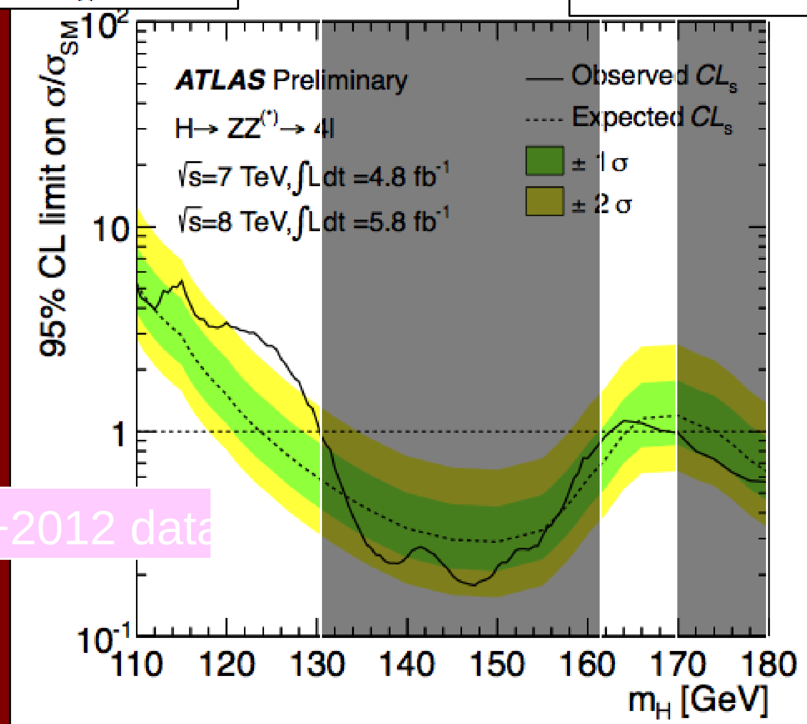


2011 data



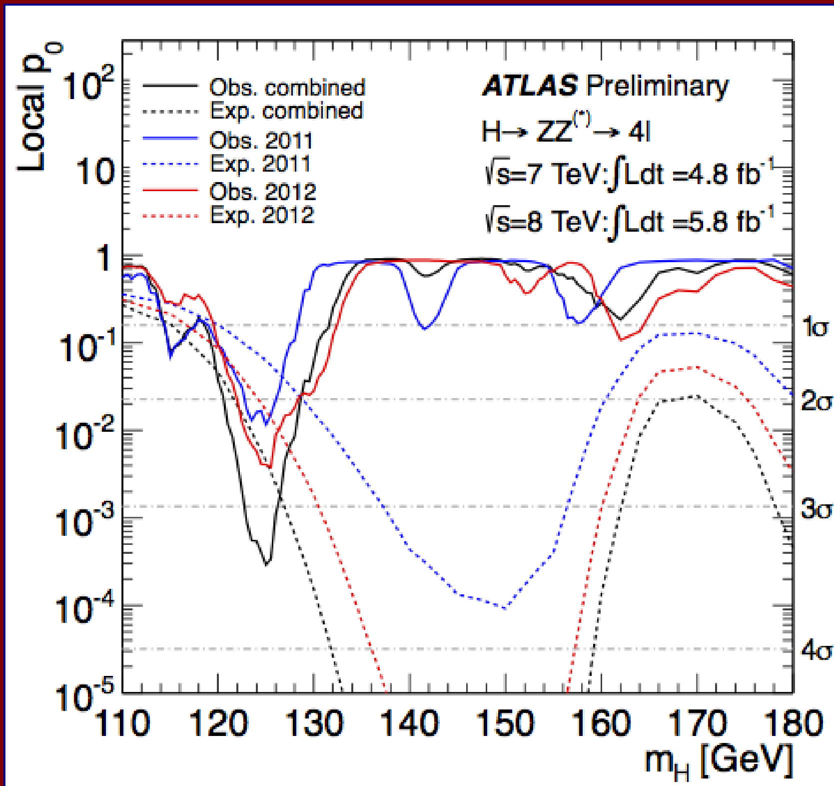
2012 data

Excluded (95% CL):
131-162, 170-460 GeV
Expected:
124-164, 176-500 GeV



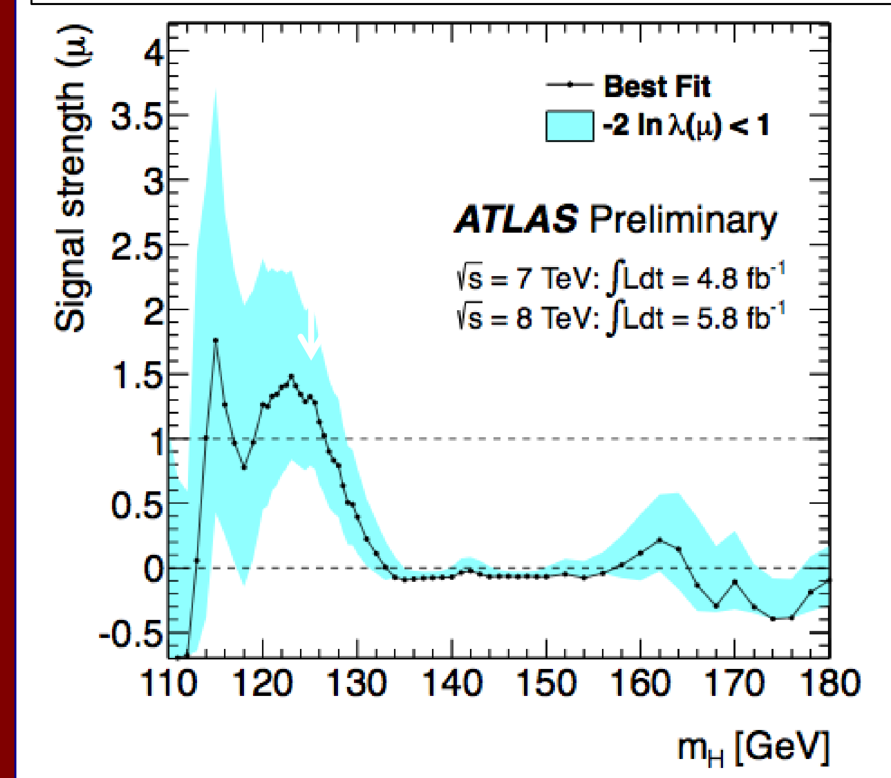
2011+2012 data

Consistency of the data with the background-only expectation



Fitted signal strength

Best-fit value at 125 GeV: μ=1.3 ± 0.6



Data sample	m_H of max deviation	local p-value	local significance	expected from SM Higgs
2011	125 GeV	1.1%	2.3 σ	1.5 σ
2012	125.5 GeV	0.4%	2.7 σ	2.1 σ
2011+2012	125 GeV	0.03%	3.4 σ	2.6 σ

Global 2011+2012 (including LEE over full 110-141 GeV range): 2.5σ

- アトラス検出器とシリコン検出器
- 地上実験棟で宇宙線テスト
- ２０１０年のテストランの結果
- ２０１１年ヒッグスの可能性（ファビオラ）
- ２０１２年ヒッグスの発見か？（ファビオラ）
- 測定器技術と電子回路

Field Programmable Gate Array

- Flip-flop回路と組み合わせ回路で構成
  - 組み合わせ回路はゲート素子からなる。
    - AND,OR,INVで記述可能
- Flip-flop回路はState　Machineの状態記憶
  - 炊飯器なら、加熱中、炊飯終了、保温中などを示すFlip-flop回路を用意する。（レジスターと呼ばれる）
- 今回の実習では内田智久氏が作成した、シリアル通信State Machine：Ex2を使ってみる。

User Constraint File

- 配布されている例にはucfファイルがありません。
- PACEを使ってUCFファイルを記述していきます。PACEはFPGAが使う信号線を読み取り、設定を促します。スターターキットのマニュアルから読み取っていきますがとりあえずは次のファイルを使ってください。

信号名	LOC	IOSTAND.	DRIVE	TERMINA.	SLEW
LED[0]	F12	LVTTL	8		SLOW
LED[1]	E12	LVTTL	8		SLOW
LED[2]	E11	LVTTL	8		SLOW
LED[3]	F11	LVTTL	8		SLOW
LED[4]	C11	LVTTL	8		SLOW
LED[5]	D11	LVTTL	8		SLOW
LED[6]	E9	LVTTL	8		SLOW
LED[7]	F9	LVTTL	8		SLOW
OSC	C9	LVCMS33			
PUSH_SW	K17	LVTTL		PULLDOWN	
RS232RD	R7	LVTTL			
RS232TD	M14	LVTTL	8		SLOW
SLIDE[0]	L13	LVTTL		PULLUP	
SLIDE[1]	L14	LVTTL		PULLUP	
SLIDE[2]	H18	LVTTL		PULLUP	
SLIDE[3]	N17	LVTTL		PULLUP	

テストはJTAGで

- Generate Programming Fileのところのpropertyで Startup OptionsでJTAG clockを選択します。
- スターターキットのクロック設定は真ん中だけ接続です。(RS232のコネクターのすぐそば)
- BITファイルを作成します。
- Configure　Devieceでimpactを起動します。spartan3Eに書き込んで、ほかはbypassとします。Deviceの上で右クリックしてプログラムをロードします。

パソコンから信号を送る

- COMポート番号をデバイスマネージャーで見ておきます。
- Hyper Terminalを立ち上げ、以下の設定をします。
  - ボーレート：19200、パリティ無、フロー制御無、ストップビット：1
- スタート：S、停止：P、クリアCの3状態をLEDの点灯で確認します。LEDは変化していき、停止：Pで乱雑な点灯状態となり、クリアですべて消えます