ATLAS latest physics results for EPS 2011

Soshi Tsuno (KEK/IPNS)

-- series of KEK seminar for ATLAS results --

Introduction

ALL ATLAS public results are available in

https://twiki.cern.ch/twiki/bin/view/AtlasPublic

https://twiki.cern.ch/twiki/bin/view/Atlas/EventDisplayPublicResults

This talk is based on the latest results for EPS 2011.

July.21-27, Grenoble, FRANCE

http://eps-hep2011.eu/

ATLAS made (will make) **29 papers and >15 conference notes** for this summer.

(101 papers in pipeline.)

Contents

Highlights:

SM and top physics:

-- W/Z boson p_T measurements,

-- Top (**asymmetry**, cross section)

Skip: W+n-jets, QCD jet studeis (See last seminar: Nagano-san's talk)

Skip: top mass and cross section measurement (See Nagano-san's talk)

SUSY/Exotics searches:

-- MET+multi-jet channel (0-lepton mode)

-- eμ-channel and 0-lepton w/ b-jets channel, tt resonance

Skip: SUSY 1-lepton channel (165pb^{-1}), since no major update.

Skip: high mass bump searches (di-lepton, di-jet resonance)

Higgs searches:

-- **H->WW** , H->$\gamma\gamma$ etc.

-- Combined sensitivity at 1fb^{-1}

LHC accelerator

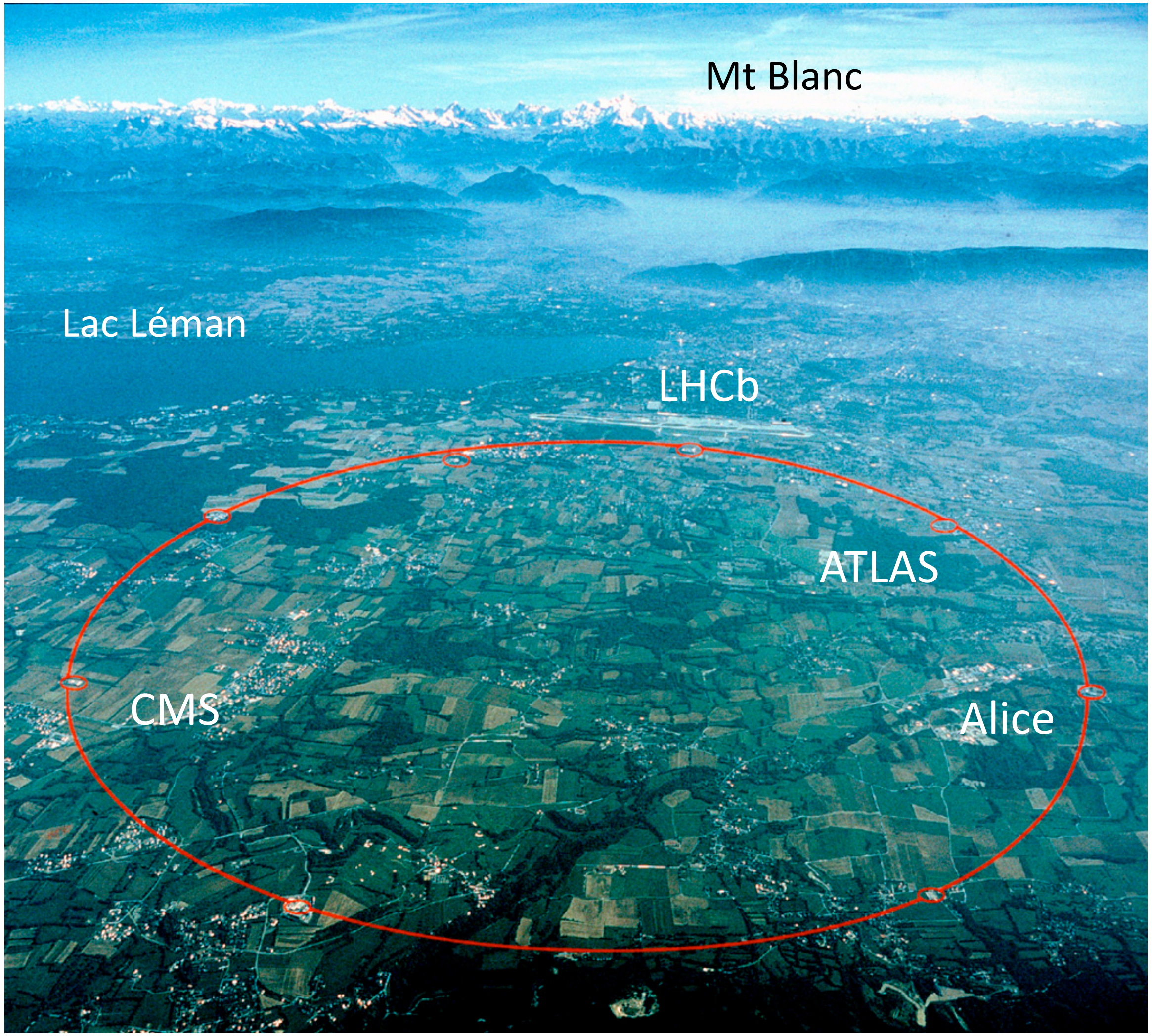
Proton-proton collider located underground 100m below with 27 km long.

CM energy : 7 TeV w/ 50ns

(designed 14 TeV w/ 25ns)

8 IP points: 4 experiments

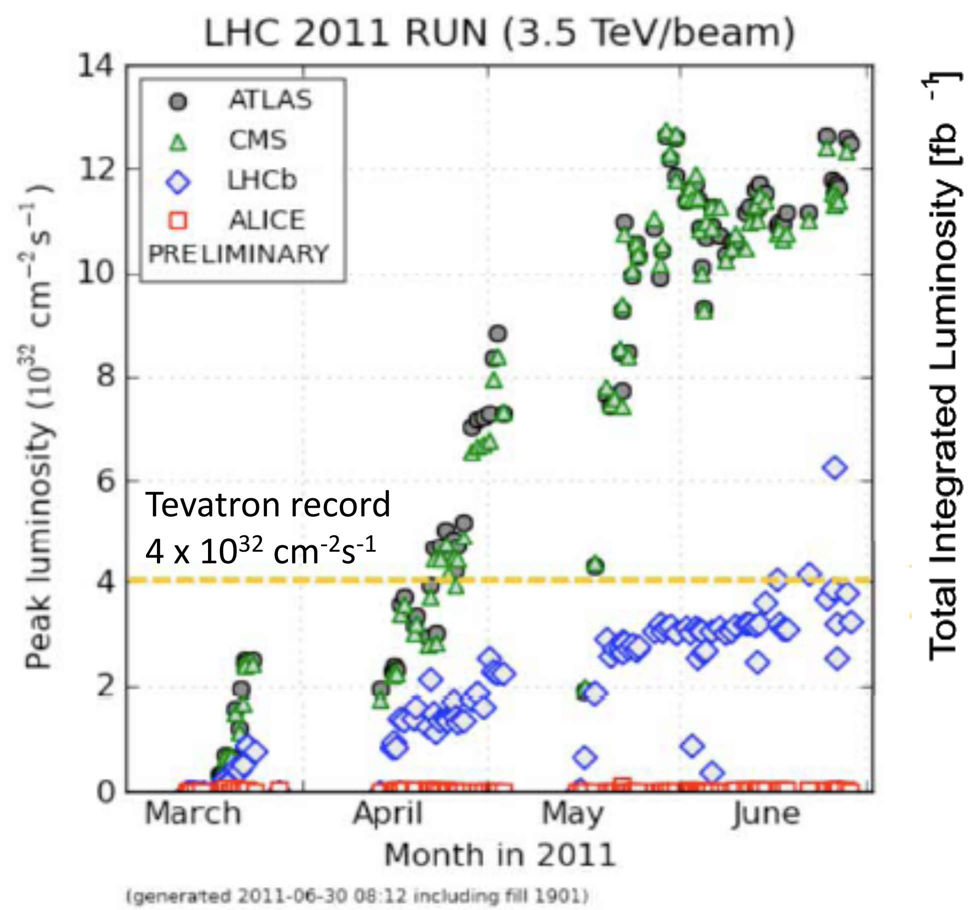
- **ATLAS**
- CMS
- Alice
- LHCb



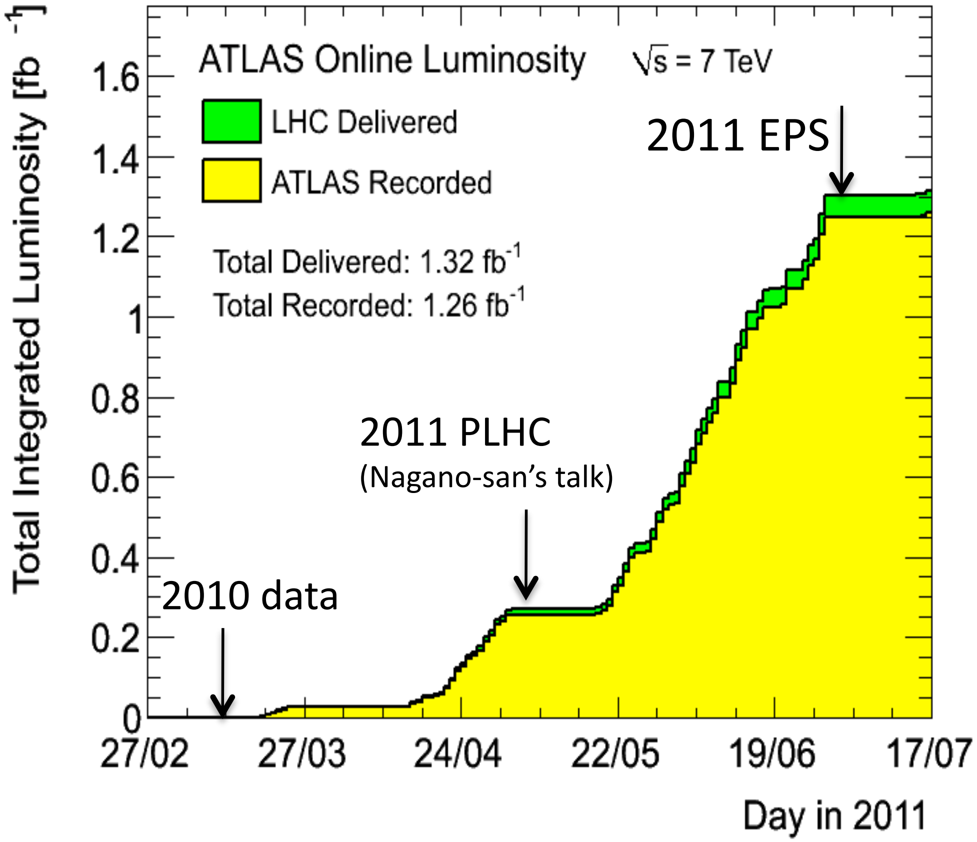
LHC 2010 - 2011

New record in inst.luminosity ~1.75 x 10^{33} $cm^{-2}s^{-1}$

Integrated luminosity 1.32 fb^{-1}. (ATLAS Data taking efficiency ~95.7%)



Tevatron record
4 x 10^{32} $cm^{-2}s^{-1}$



2011 EPS

2011 PLHC
(Nagano-san's talk)

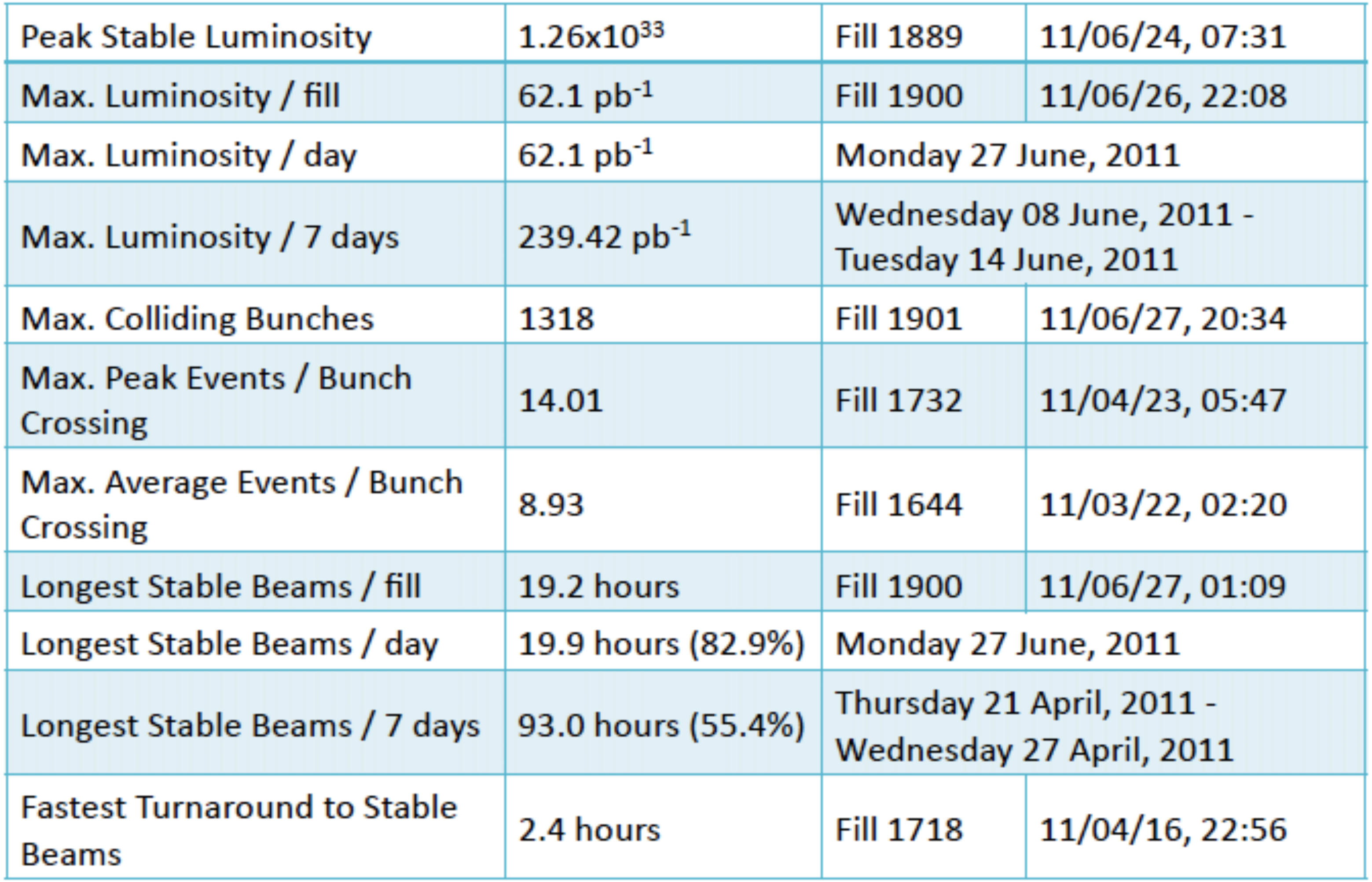
2010 data

World record (LHC)

Accelerator seminar July 1st by Frank Zimermann

http://www.kek.jp/acc/seminar/file/LHC_Performance_Zimmermann.pdf

courtesy ATLAS



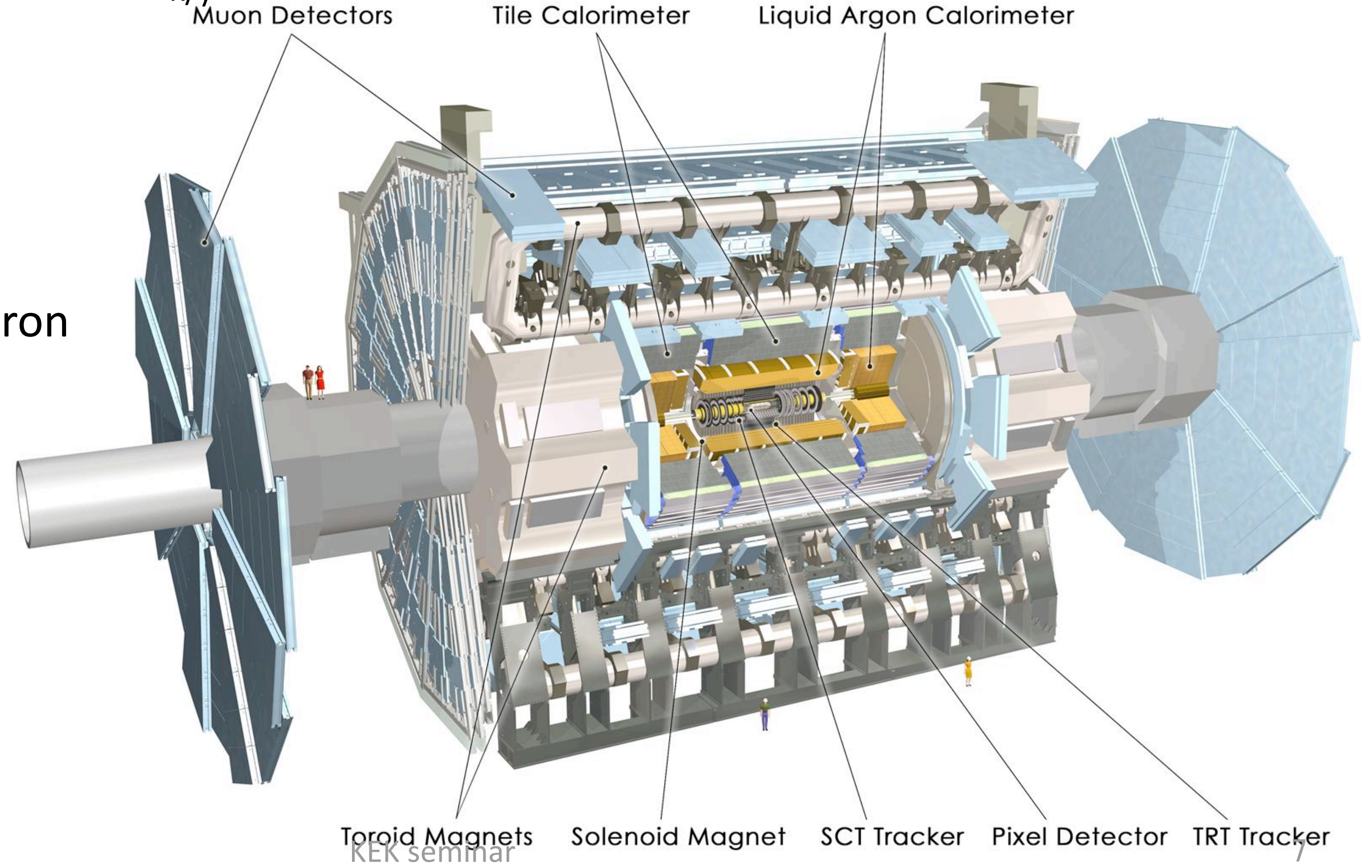
Peak Stable Luminosity	1.26x10^{33}	Fill 1889	11/06/24, 07:31
Max. Luminosity / fill	62.1 pb^{-1}	Fill 1900	11/06/26, 22:08
Max. Luminosity / day	62.1 pb^{-1}	Monday 27 June, 2011	
Max. Luminosity / 7 days	239.42 pb^{-1}	Wednesday 08 June, 2011 - Tuesday 14 June, 2011	
Max. Colliding Bunches	1318	Fill 1901	11/06/27, 20:34
Max. Peak Events / Bunch Crossing	14.01	Fill 1732	11/04/23, 05:47
Max. Average Events / Bunch Crossing	8.93	Fill 1644	11/03/22, 02:20
Longest Stable Beams / fill	19.2 hours	Fill 1900	11/06/27, 01:09
Longest Stable Beams / day	19.9 hours (82.9%)	Monday 27 June, 2011	
Longest Stable Beams / 7 days	93.0 hours (55.4%)	Thursday 21 April, 2011 - Wednesday 27 April, 2011	
Fastest Turnaround to Stable Beams	2.4 hours	Fill 1718	11/04/16, 22:56

The ATLAS detector

Some remarkable parameters:

- Tracking : $-2.8 < \eta < 2.8$ with pT>100MeV ($\sigma/p_T \sim 3.8\text{x}10^{-4} p_T$ (GeV) $\oplus$ 0.015),
- Calorimeter : $-4.9 < \eta < 4.9$ ($\sigma/E \sim 10\%/\sqrt{E}$ (EM), $50\%/\sqrt{E} \oplus 0.03$ (Had))
- muon : $-2.7 < \eta < 2.7$ by air-core toroid,
- 3-level triggers allow to save data by 300Hz,
- Beam spot: $\sigma_Z \sim 10\text{mm}$, $\sigma_{x/y} \sim 2\text{mm}$.
- 2T solenoid.

About 4 times larger acceptance than Tevatron detectors.



Data quality

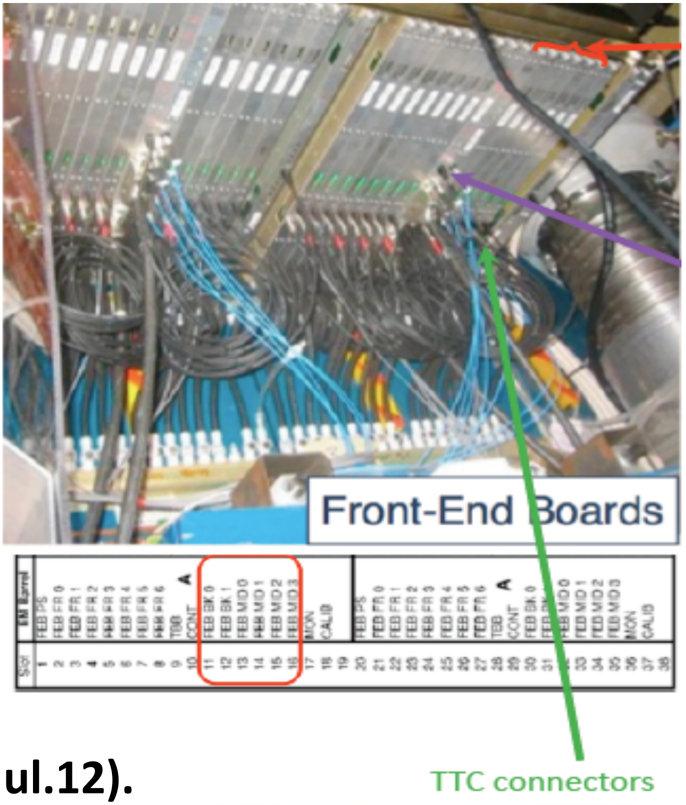
~99% detectors are operational.

Typically, 300-400Hz of data to tape.

We lost a connection from 6 FEBs in April.30.
Occupancy ~1.6% is affected.

⇨ Affect in jet and MET reconstruction.

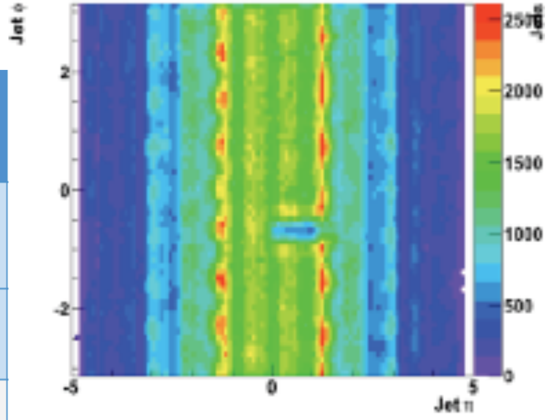
Veto events if a jet falls in this hole.



They are recently recovered after Technical shutdown (Jul.12).

Inner Tracking Detectors			Calorimeters				Muon Detectors				Magnets	
Pixel	SCT	TRT	LAr EM	LAr HAD	LAr FWD	Tile	MDT	RPC	CSC	TGC	Solenoid	Toroid
99.9	99.8	100	89.0	92.4	94.2	99.7	99.8	99.7	99.8	99.7	99.3	99.0

Luminosity weighted relative detector uptime and good quality data delivery during 2011 stable beams in pp collisions at $\sqrt{s}$=7 TeV between March 13th and June 29th (in %). The inefficiencies in the LAr calorimeter will partially be recovered in the future. The magnets were not operational for a 3-day period at the start of the data taking.

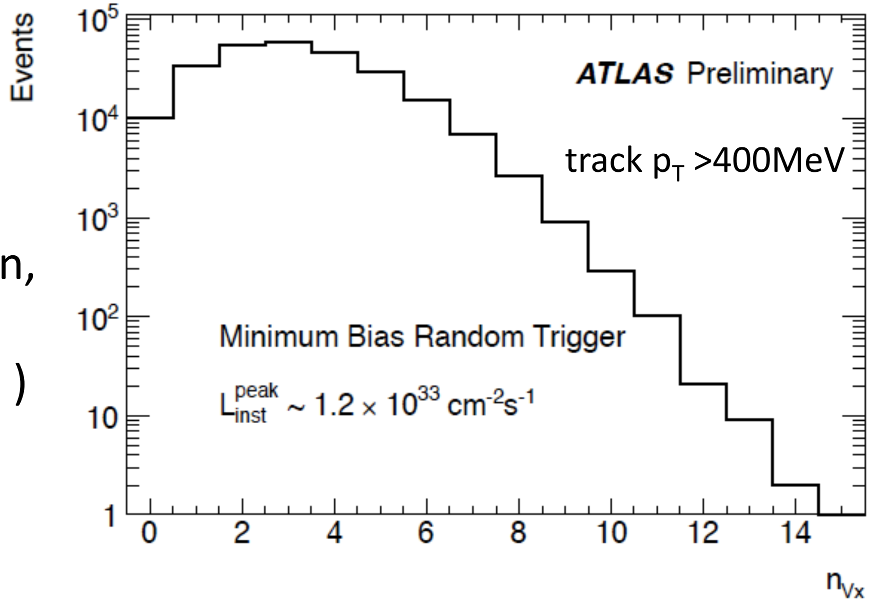


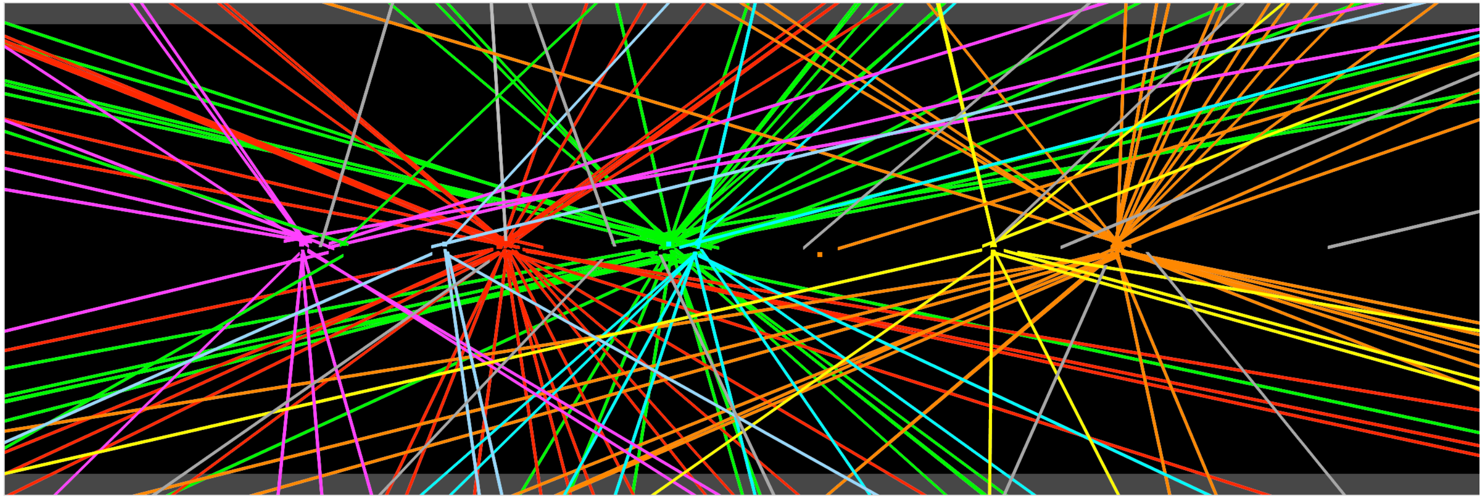
Pileup

Number of interactions per bunch.

- in-time pileup … comes from same collision,
- out-of-time pileup … from different bunches.
  (bunch intensity ~10^{11})

# of vertices represents the "in-time" pileup.
"out-of-time pileup" can be calculated by inelastic cross section.



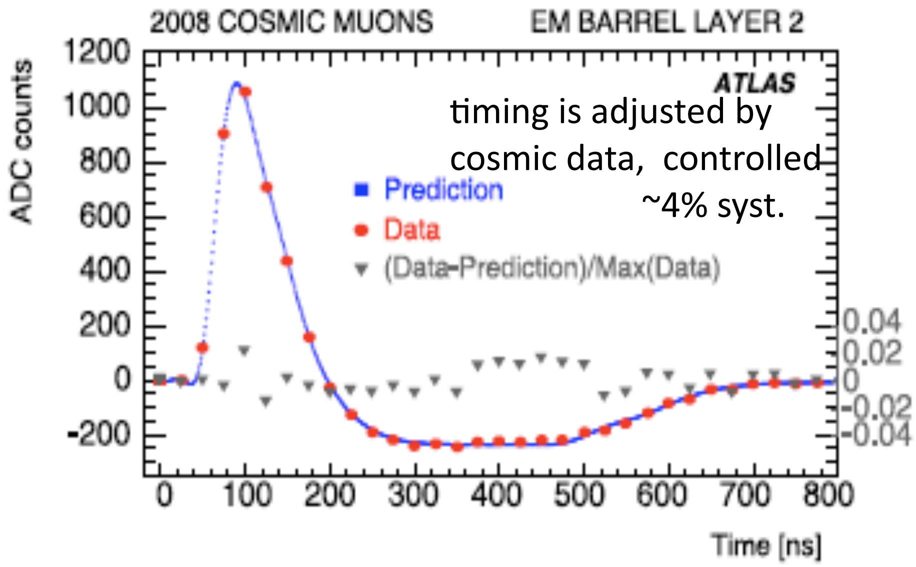


Pileup in calorimeter

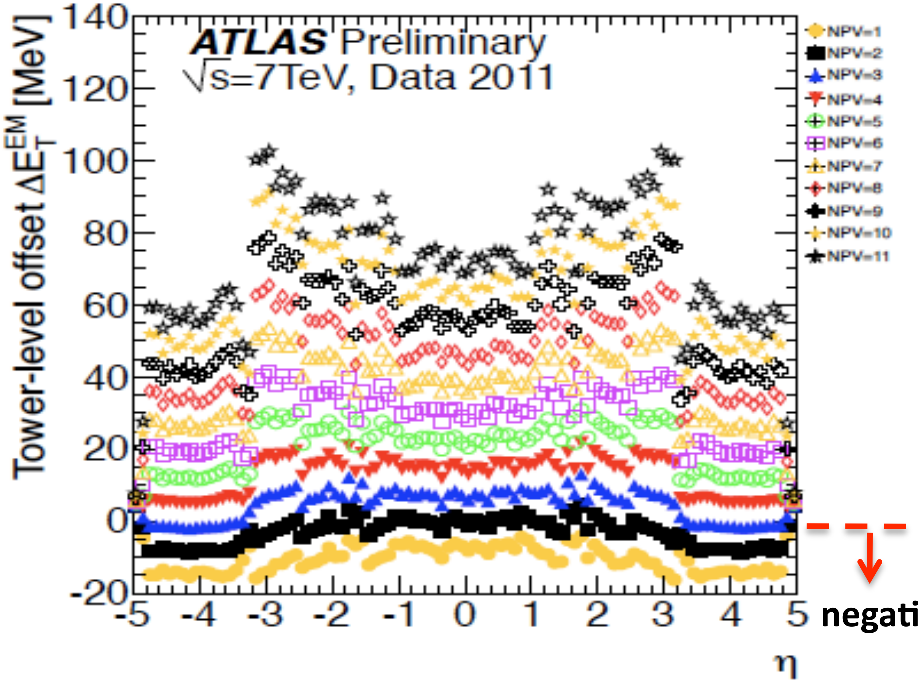
“Out-of-time” pileup creates negative energy.

Time-constant in bipolar shaping amp
is tuned according the “expected # of pileup.”

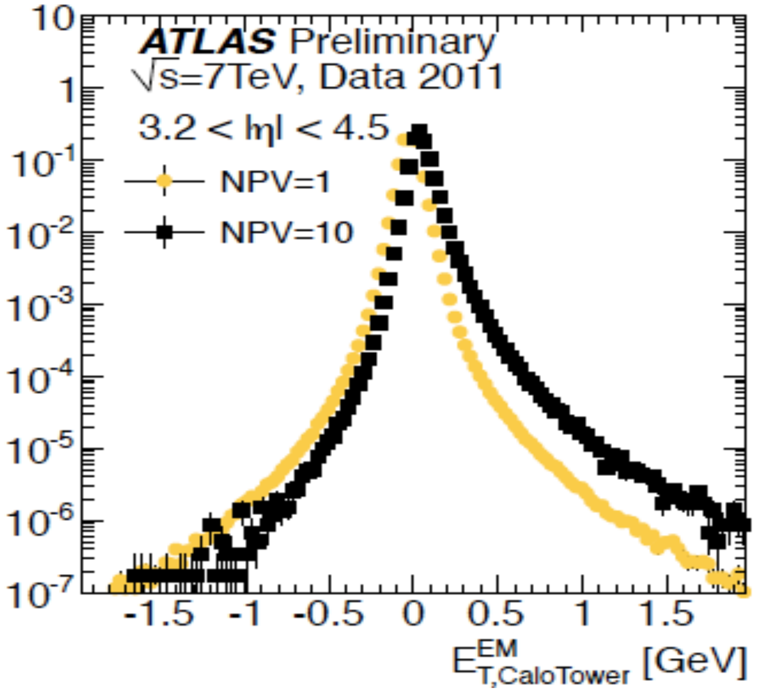
Noise modeling (+coherent noise) < 5% syst.



timing is adjusted by cosmic data, controlled ~4% syst.



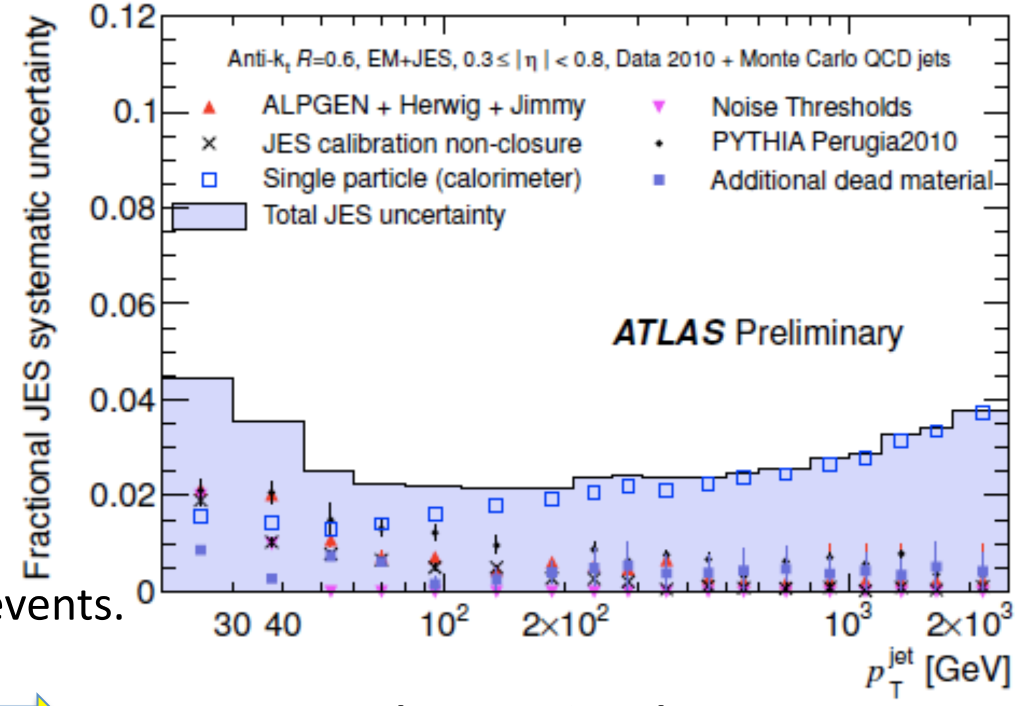
negative



Jet energy scale

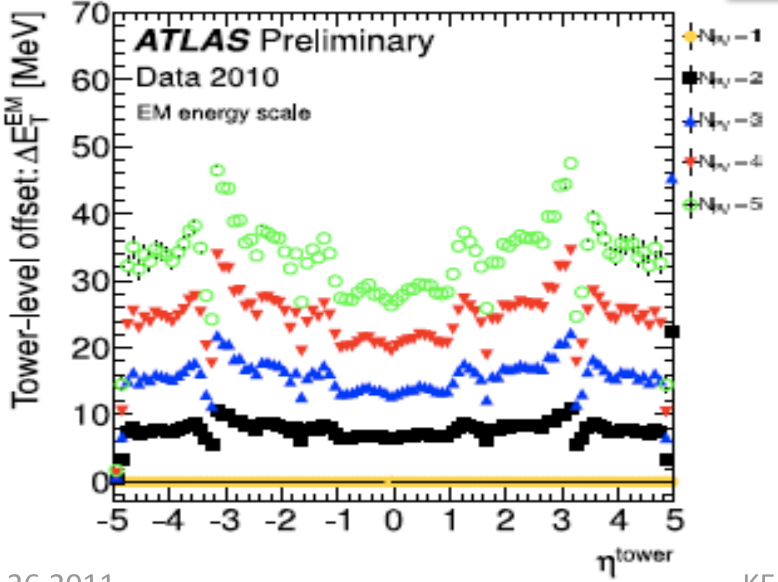
- E/p single hadron response (test beam)
- MC modeling (G4 shower model, etc.)
- p_T-balance in di-jet events
- pileup offset correction

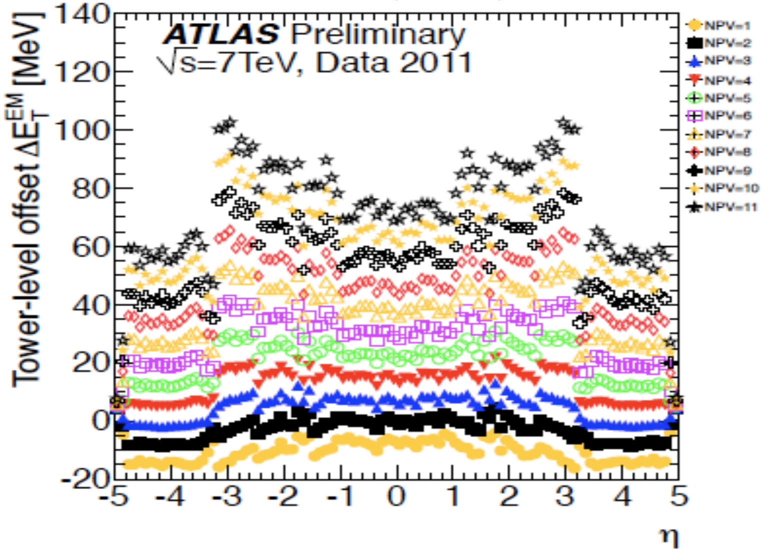
→ 5% in central, 7% in forward



This is verified by γ+jet , Z+jet / multi-jet events.

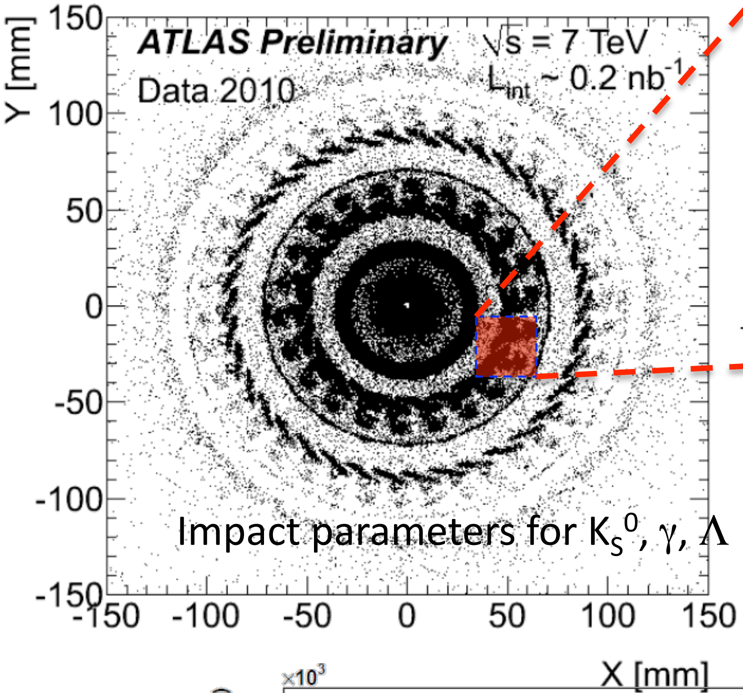
2010 Data (less pileup) → **2011 Data (more pileup)**





Excellent Performance

Good alignment:

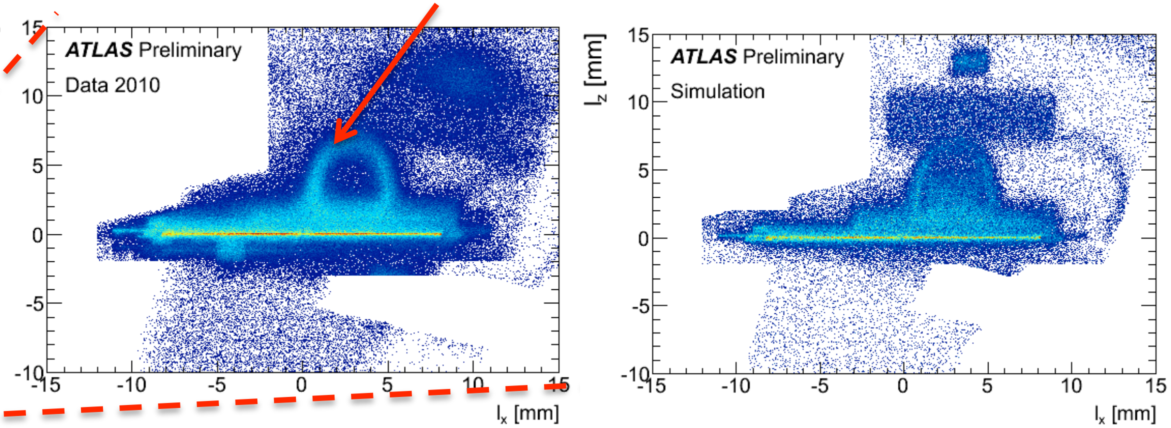


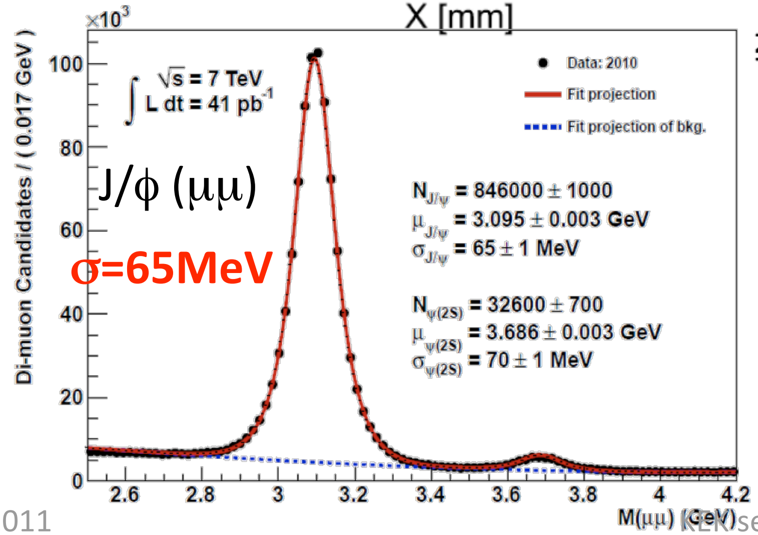
Impact parameters for K_S^0, γ, Λ

DATA

cooling pipe

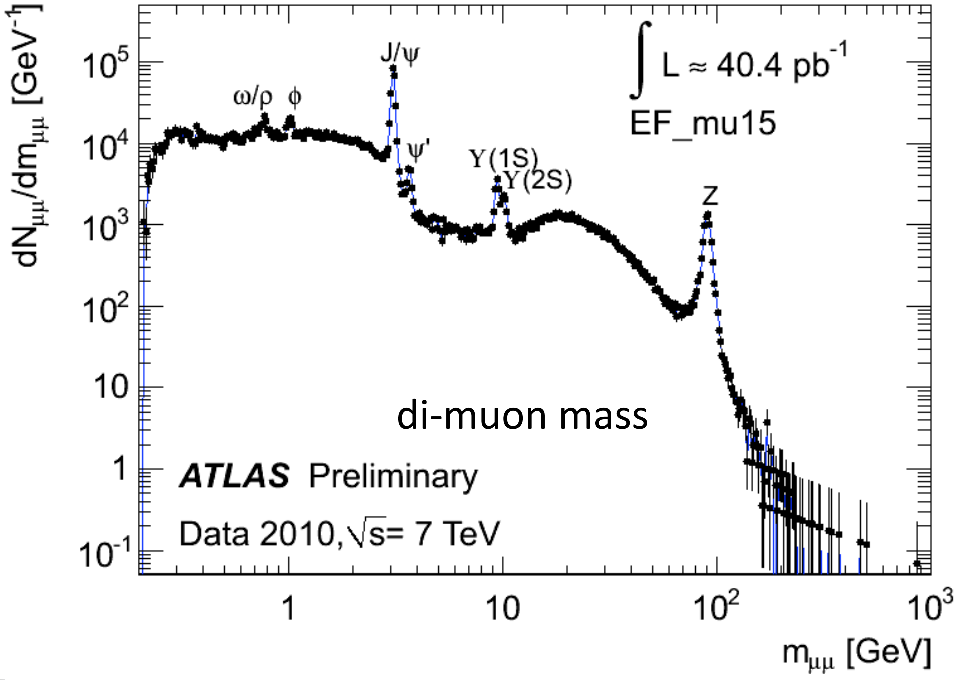
MC





J/ϕ (μμ)

σ=65MeV



di-muon mass

SM and Top physics

First validation of Z and W spectrum

Z-analysis:

two muons (electron) w/ p_T>20(25) GeV
opposite charge
66 GeV < m_{ll} < 116 GeV

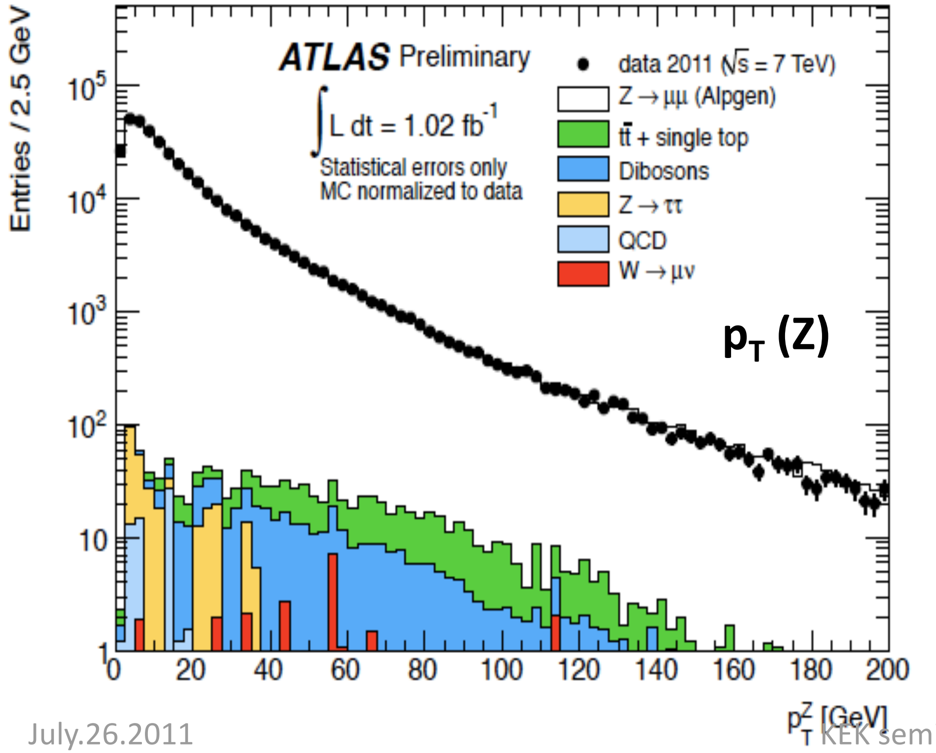
AlpGen is used for comparison.

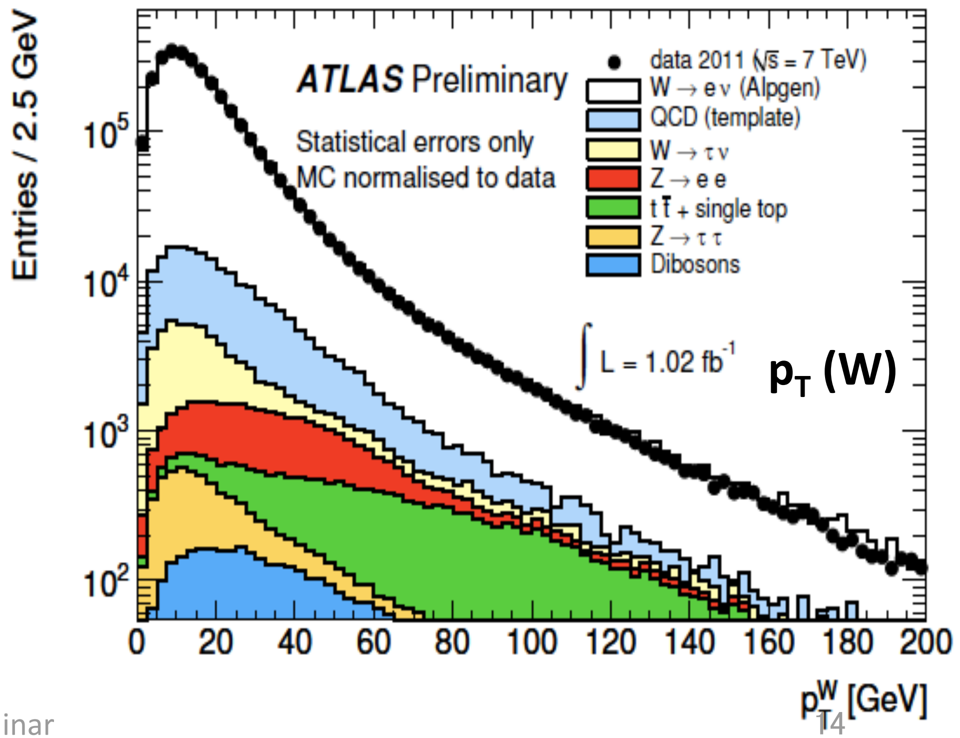
W-analysis:

one muon (electron) w/ p_T >20(25) GeV
MET > 25 GeV, m_T > 40 GeV

All kinematical distribution looks very good.

Details evaluation come out soon.





Differential distributions

Z p_T distribution: hep-ex/11072381

Test of higher order effect

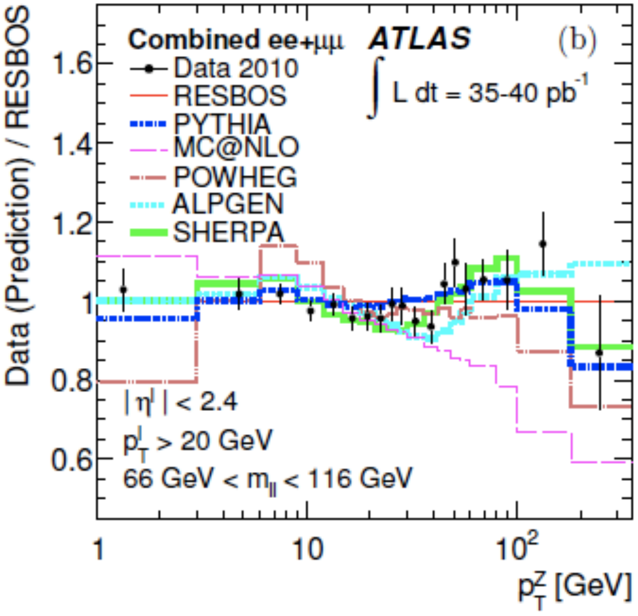
Acceptance is corrected by NLO generators.
Compared various prediction with data.

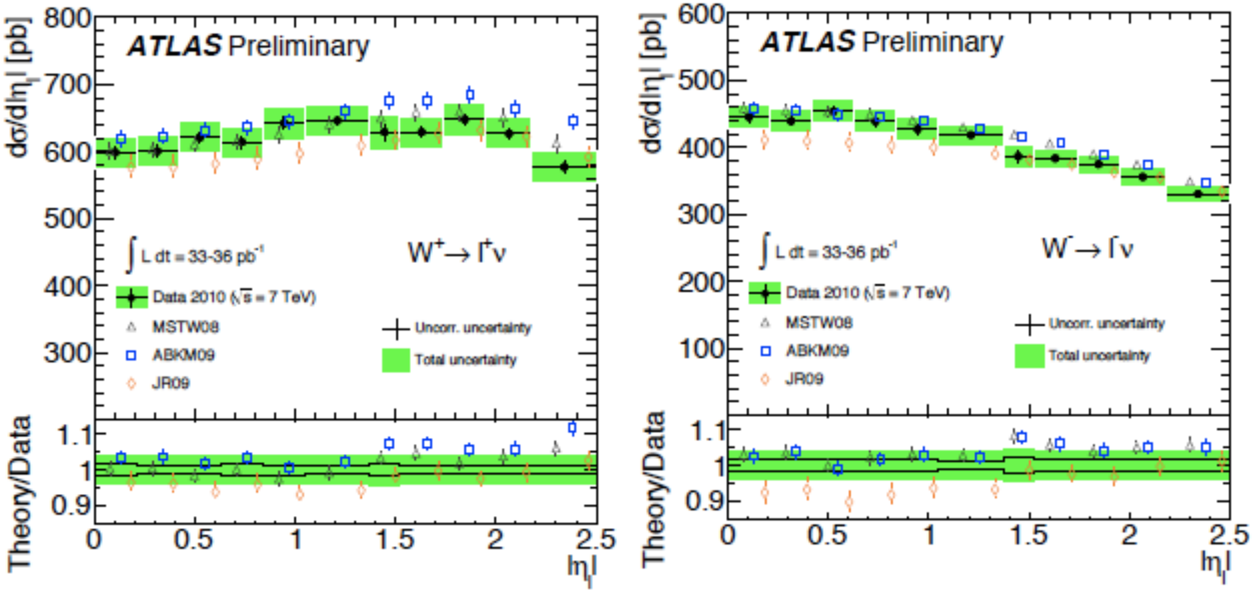
Interesting to see all full NLO generators shows discrepancy in high p_T region.

W rapidity distribution: Test of PDF

MSTW08, ABKM09, JR09(GRV) are used .

HERAPDF will be added soon. (which gives unbias test from hadron-collider data.)





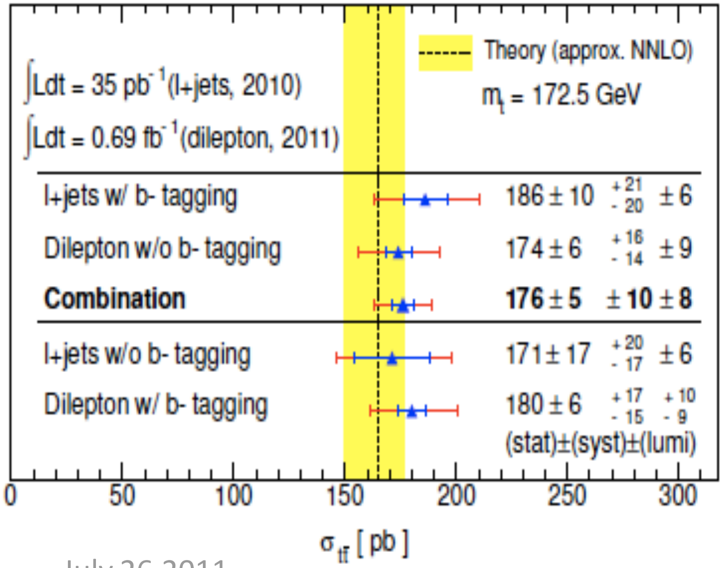
Top cross section

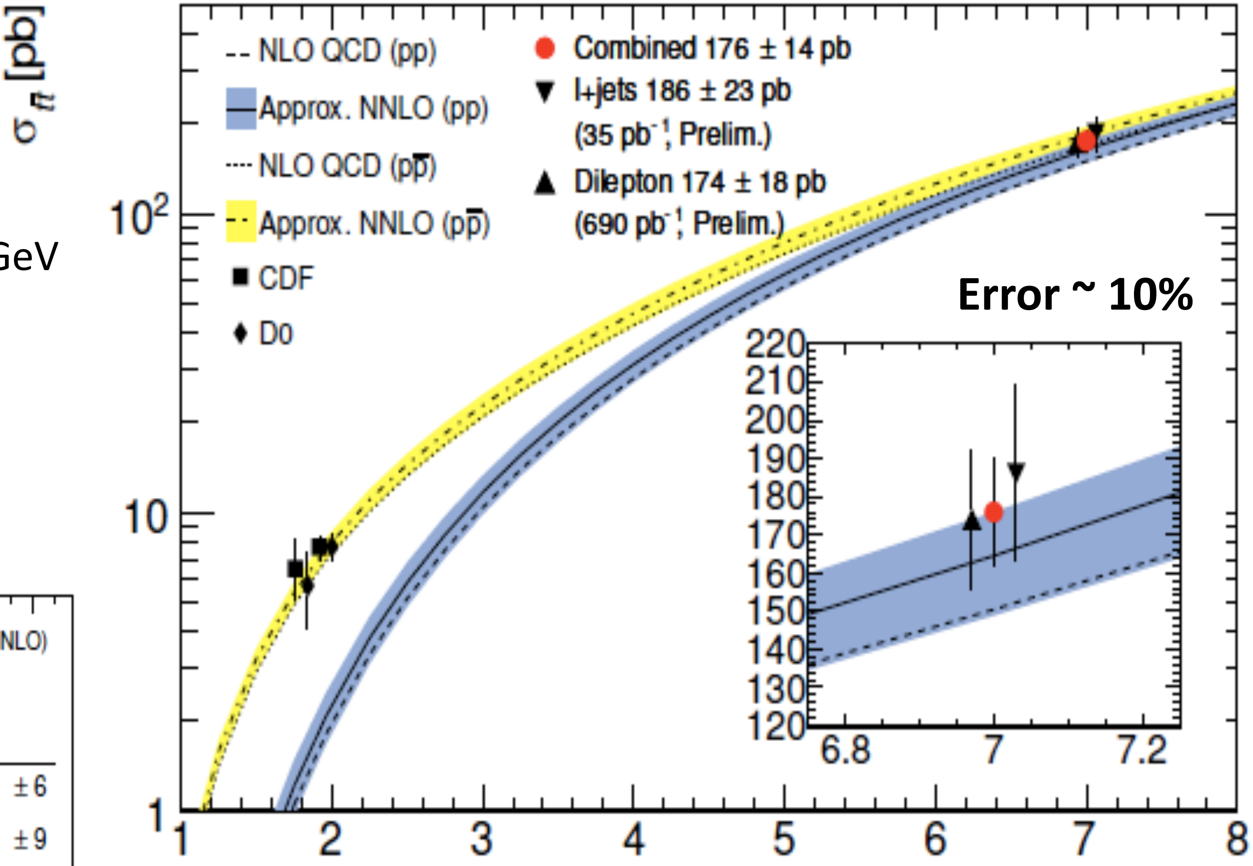
Standard top selection:

- $p_T > 25(20)$ GeV for e (μ),
- MET > 35 GeV, $m_T(W)>25$GeV for e-channel,
- MET > 20 GeV, $m_T(W)$+MET>60GeV for μ-channel,
- at least one b-jet with >= 4 jets (p_T>25 GeV).

Five channel combination:

(standard analysis)





Error ~ 10%

Single lepton + jets:

- e / μ + jets

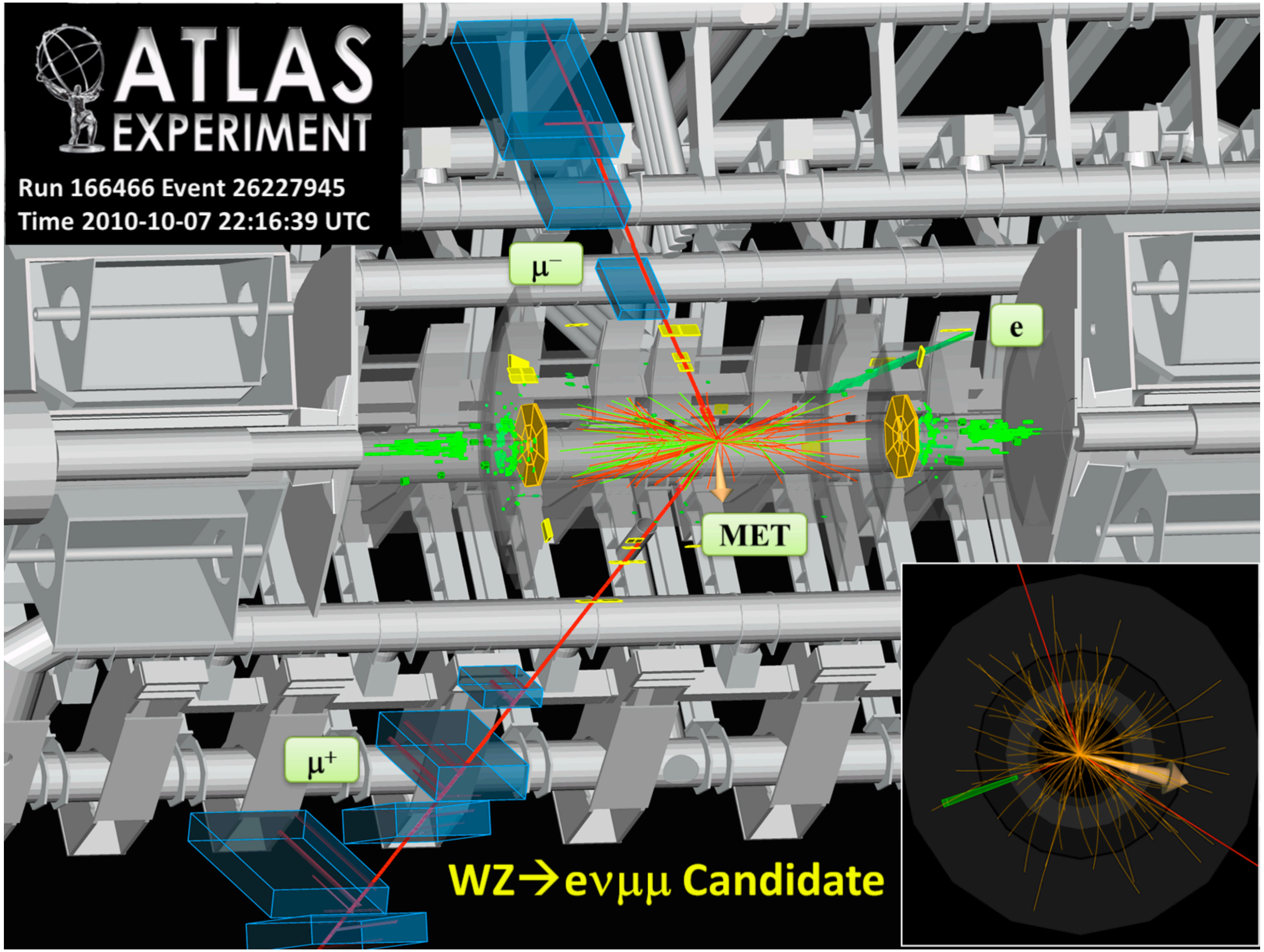
Dilepton channel:

- ee / $\mu\mu$ / eμ

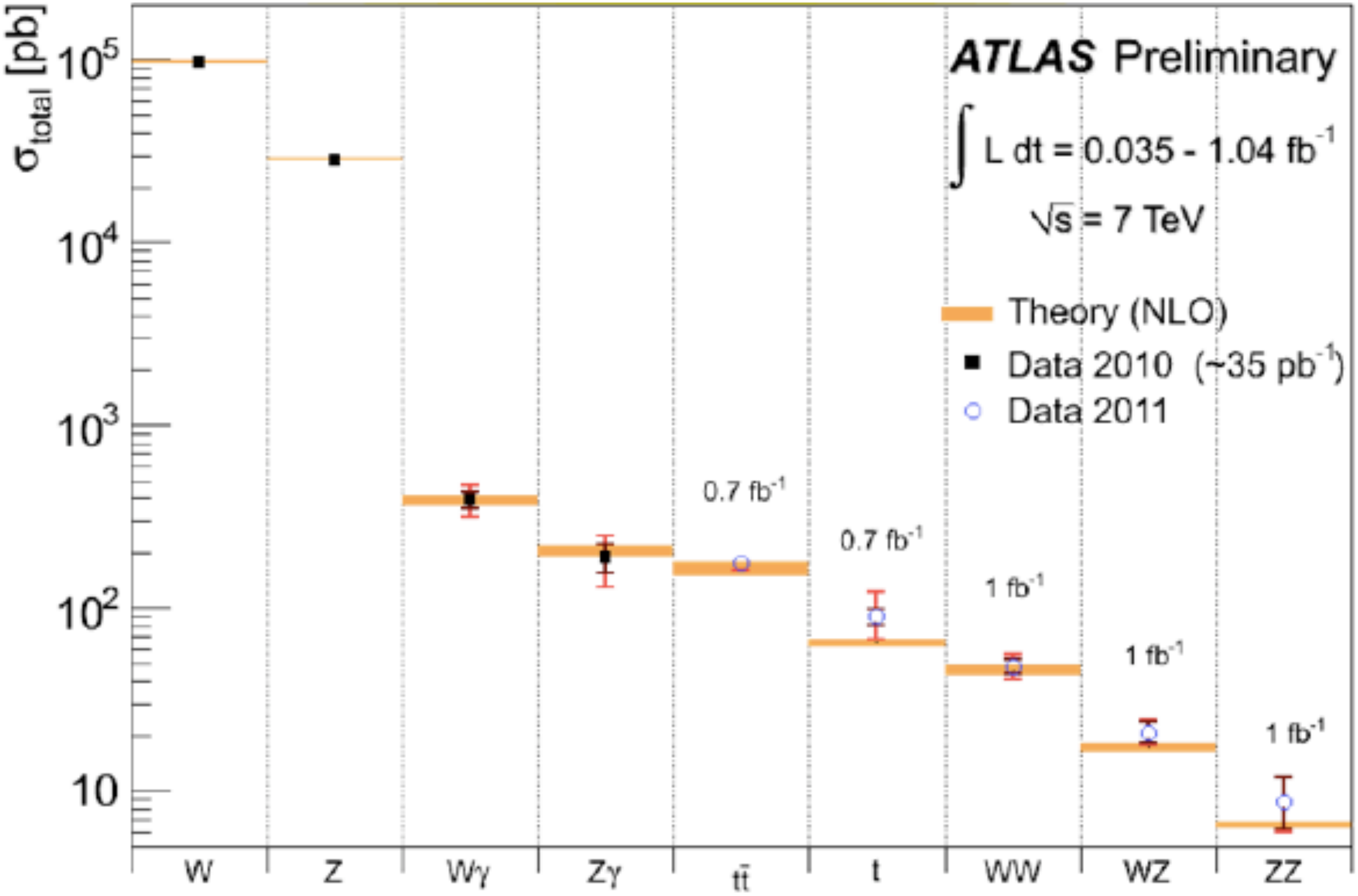
WZ candidate

$p_T(\mu^+)$ = 65 GeV
$p_T(\mu^-)$ = 40 GeV
$p_T(e)$ = 64 GeV
MET = 21 GeV

$m_{\mu\mu}$ = 96 GeV
m_T = 57 GeV



Cross section summary



Top asymmetry

3.4 σ excess is reported at CDF. (hep-ex/1101003)

NOW, D0 also find an excess. (3σ excess).

Asymmetry is more enhanced at high mass region.

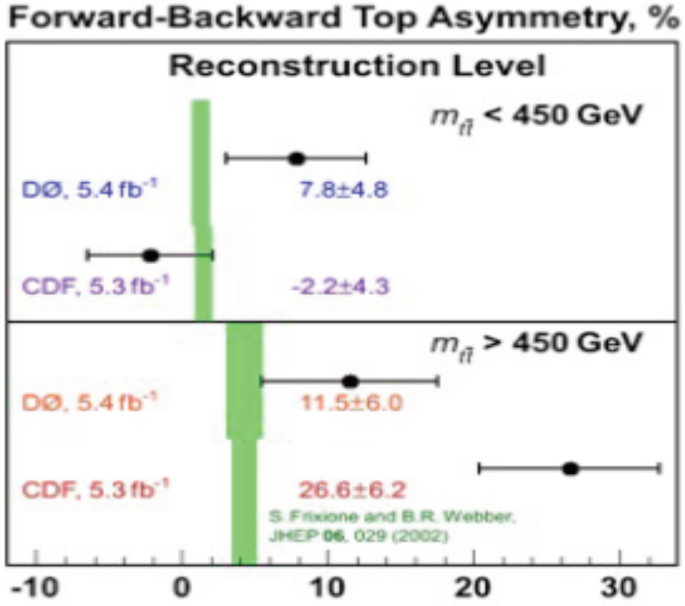
Forward-backward asymmetry:

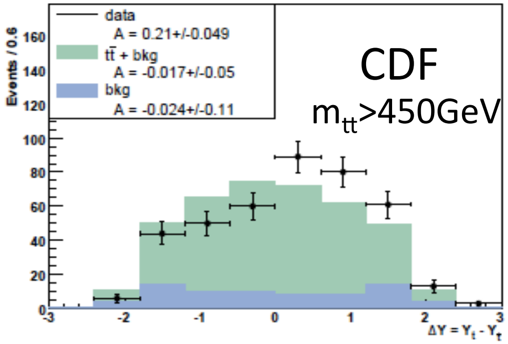
CDF : $A_{fb}(m_{tt}>450\text{GeV}) = 0.48 \text{ +- } 0.11$ at 5.3 fb^{-1}

Theory ($m_{tt}>450\text{GeV}$) = **0.088** (3.4σ deviation)

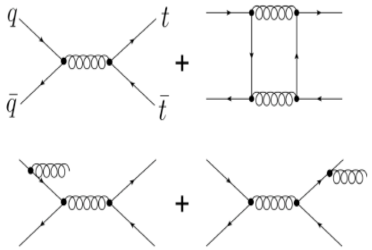
D0 : $A_{fb} = 0.08 \text{ +- } 0.04(\text{stat}) \text{ +- } 0.01(\text{syst})$ at 4.6 fb^{-1}

CMS : $A_{fb} = 0.06 \text{ +- } 0.13(\text{stat}) \text{ +- } 0.03(\text{syst})$ (theory 0.013)





In general, it is hard to test SM asymmetry in LHC because of gluon-gluon collider.
Nevertheless, finding asymmetry indicates a new physics.



Top charge asymmetry measurement

Background estimation:

- W+jets background:

OS-SS subtraction method:

$$N_{W+} + N_{W-} = \left(\frac{r_{MC}+1}{r_{MC}-1}\right)\left(D^{+} - D^{-}\right)$$

where, D⁺ (D⁻) is total number of events with positive (negative) charge, and $r_{MC} = \frac{\sigma(pp \to W^{+})}{\sigma(pp \to W^{-})}$ is estimated from MC.

- QCD multi-jet background: so-call “Matrix Method”

$$\begin{pmatrix} N^{loose} \\ \boxed{N^{tight}} \end{pmatrix} = \begin{pmatrix} 1 & 1 \\ \boxed{\varepsilon_{real} \quad \varepsilon_{fake}} \end{pmatrix} \boxed{\begin{pmatrix} N^{loose}_{real} \\ N^{loose}_{fake} \end{pmatrix}}$$

QCD jets dominant
W+jets bkg is subtracted.

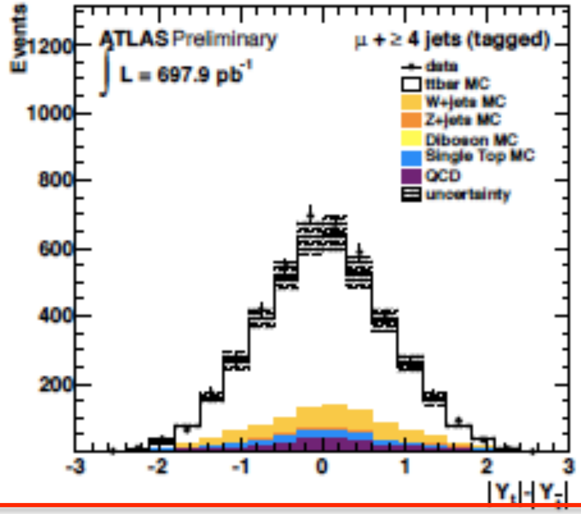
QCD bkg.

obtained from CR region
(low m_T region)

Asymmetry is given as

$$A_C = \frac{N(\Delta|Y|>0) - N(\Delta|Y|<0)}{N(\Delta|Y|>0) + N(\Delta|Y|<0)}$$

where, $\Delta|Y| = |Y_t| - |Y_{tbar}|$



No indication was found:

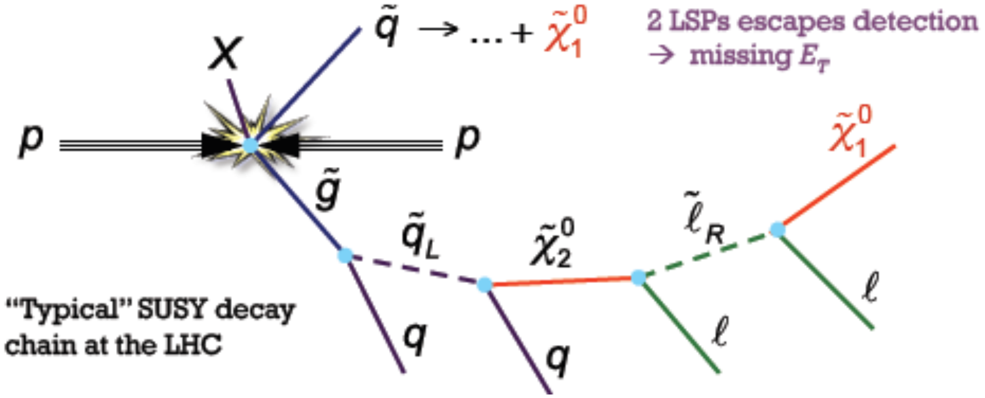
A_C=-0.009+-0.022(stat)+-0.073(syst) (theory 0.005)

So far, no division in high/low mass.

SUSY and beyond SM

SUSY production and analysis strategy

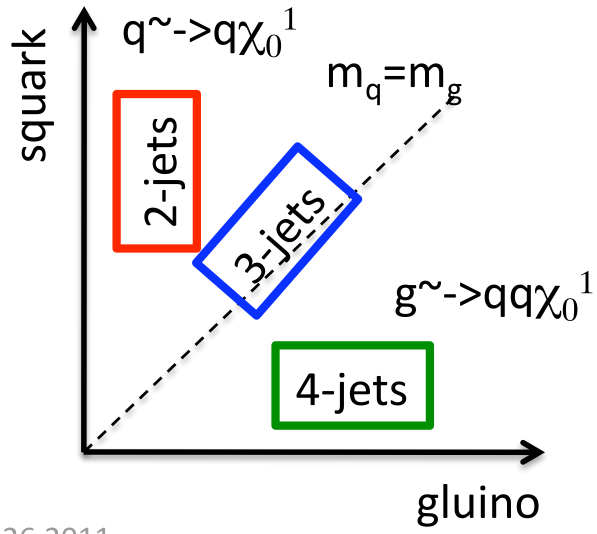
Dominant production is direct production of gluino and squark pair.

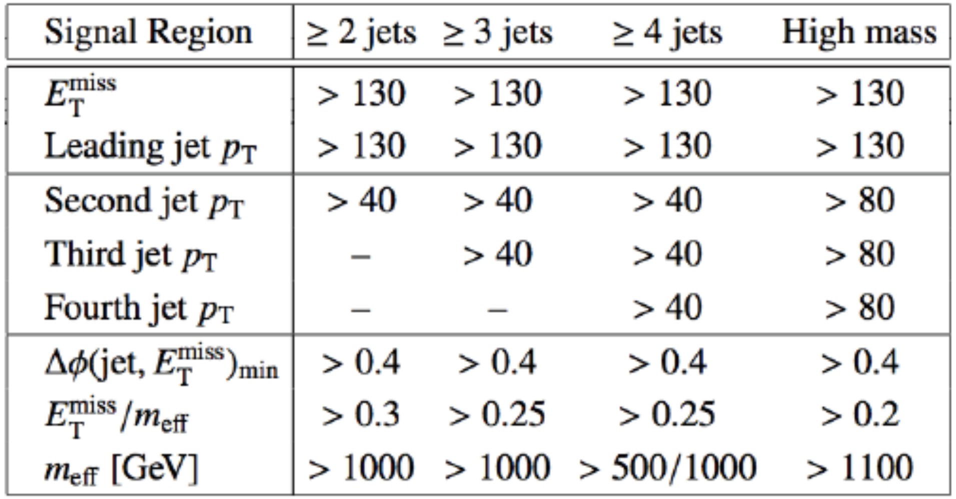


Category :

- 0-lepton + MET
- 1-lepton + MET
- 2-leptons + MET
- >=2 leptons

"Cascade chain of SUSY decay" produces many jets in the final state.

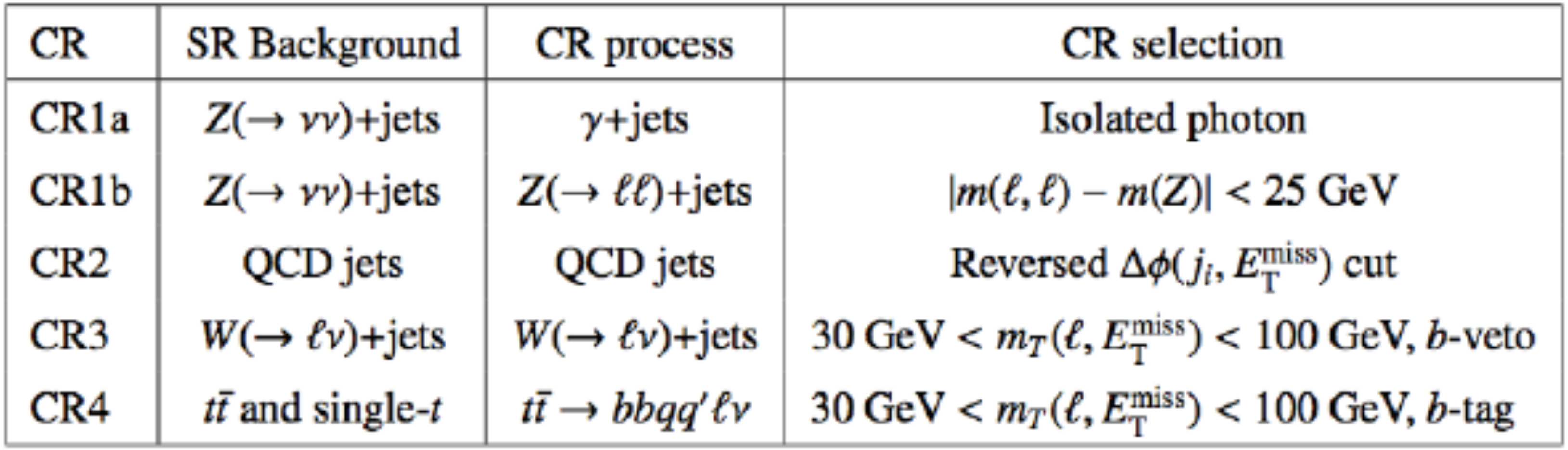




Signal Region	≥ 2 jets	≥ 3 jets	≥ 4 jets	High mass
E_T^{miss}	> 130	> 130	> 130	> 130
Leading jet p_T	> 130	> 130	> 130	> 130
Second jet p_T	> 40	> 40	> 40	> 80
Third jet p_T	–	> 40	> 40	> 80
Fourth jet p_T	–	–	> 40	> 80
$\Delta\phi(\text{jet}, E_T^{miss})_{min}$	> 0.4	> 0.4	> 0.4	> 0.4
E_T^{miss}/m_{eff}	> 0.3	> 0.25	> 0.25	> 0.2
m_{eff} [GeV]	> 1000	> 1000	> 500/1000	> 1100

Control region and background estimation

- Extract each of kinematic property in background process from Control Region.



CR	SR Background	CR process	CR selection
CR1a	$Z(\rightarrow \nu\nu)$+jets	γ+jets	Isolated photon
CR1b	$Z(\rightarrow \nu\nu)$+jets	$Z(\rightarrow \ell\ell)$+jets	$\lvert m(\ell,\ell) - m(Z)\rvert < 25$ GeV
CR2	QCD jets	QCD jets	Reversed $\Delta\phi(j_i, E_{\mathrm{T}}^{\mathrm{miss}})$ cut
CR3	$W(\rightarrow \ell\nu)$+jets	$W(\rightarrow \ell\nu)$+jets	30 GeV $< m_T(\ell, E_{\mathrm{T}}^{\mathrm{miss}}) <$ 100 GeV, b-veto
CR4	$t\bar{t}$ and single-t	$t\bar{t} \rightarrow bbqq'\ell\nu$	30 GeV $< m_T(\ell, E_{\mathrm{T}}^{\mathrm{miss}}) <$ 100 GeV, b-tag

- Estimate the Transfer Factor from Control Region to Signal Region.

$$\mathrm{N(SR, est, proc) = N(CR, obs, proc)} * \left[\frac{\mathrm{N(SR, raw, proc)}}{\mathrm{N(CR, raw, proc)}}\right].$$

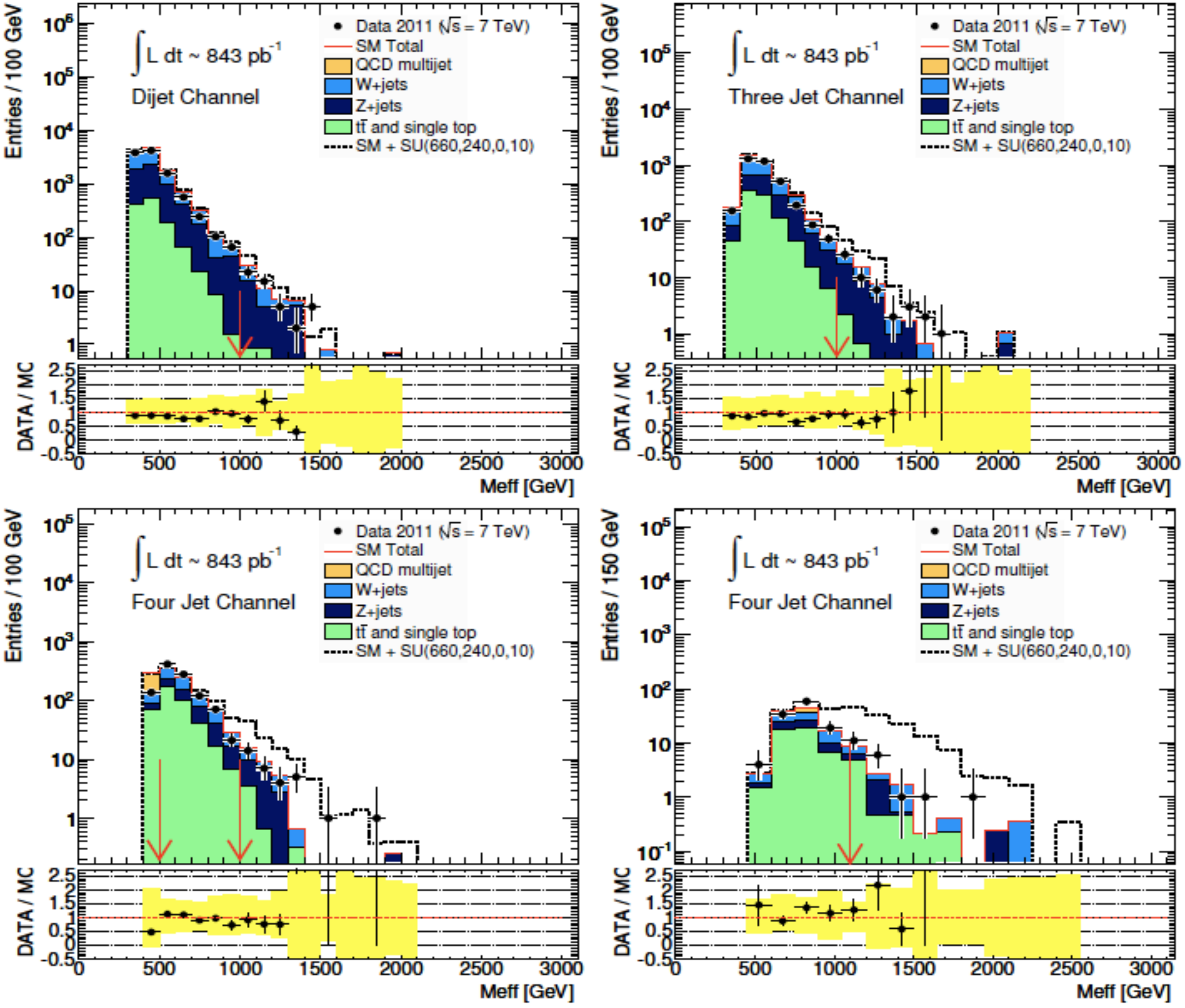
- Background contamination in each CR has to be estimated independently.

Effective mass distribution

0-lepton+MET channel:

$$m_{eff} = MET + \sum p_T(jet)$$

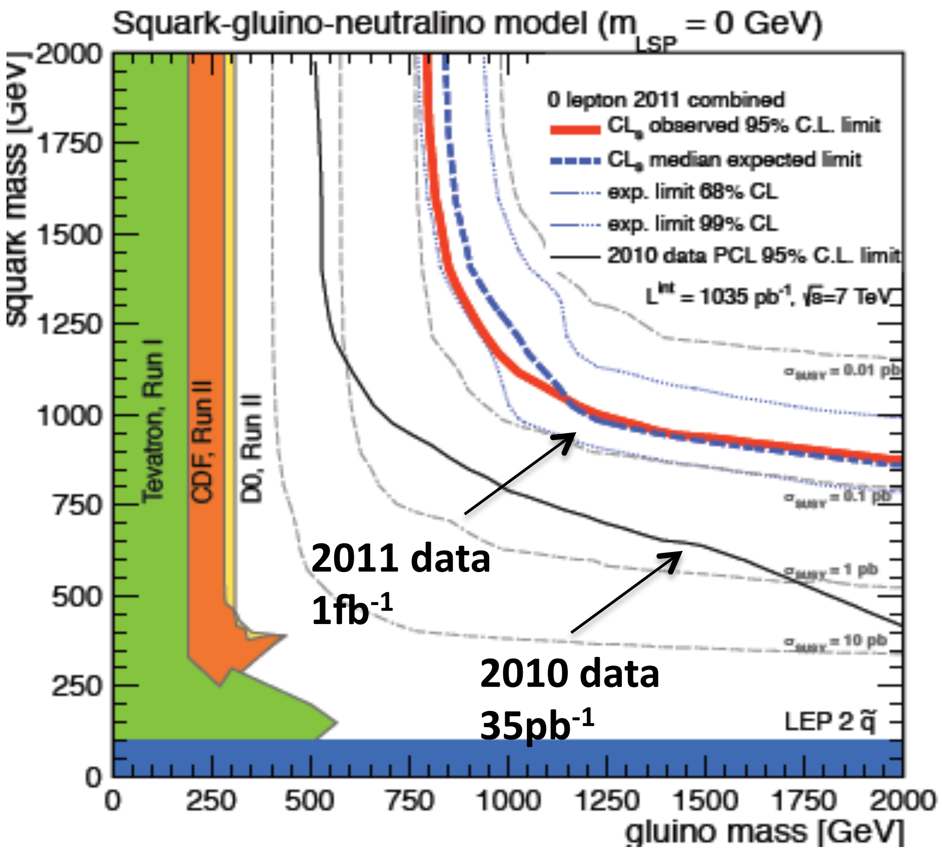
The red arrow indicates actual cut point.

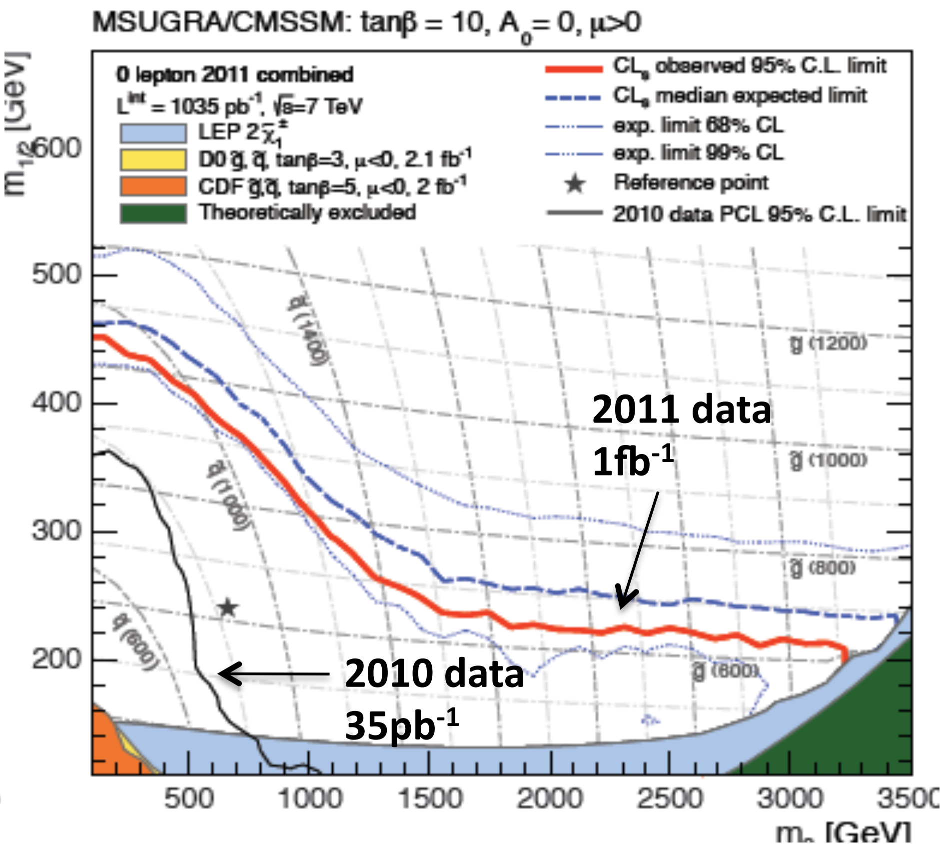


Exclusion of 0-lepton channel at $1fb^{-1}$

Simplified model: (gives conservative results)

Limit : gluino ~ 775GeV, squark ~ 675 GeV

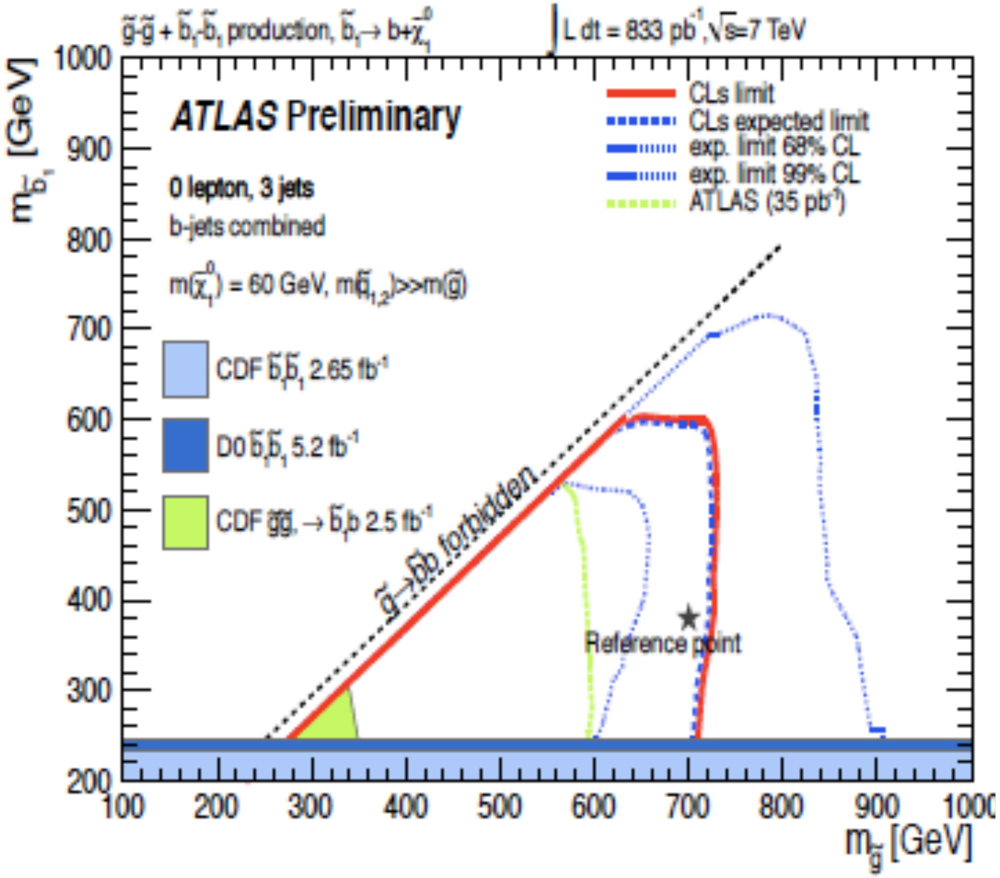




Heavy particle decays

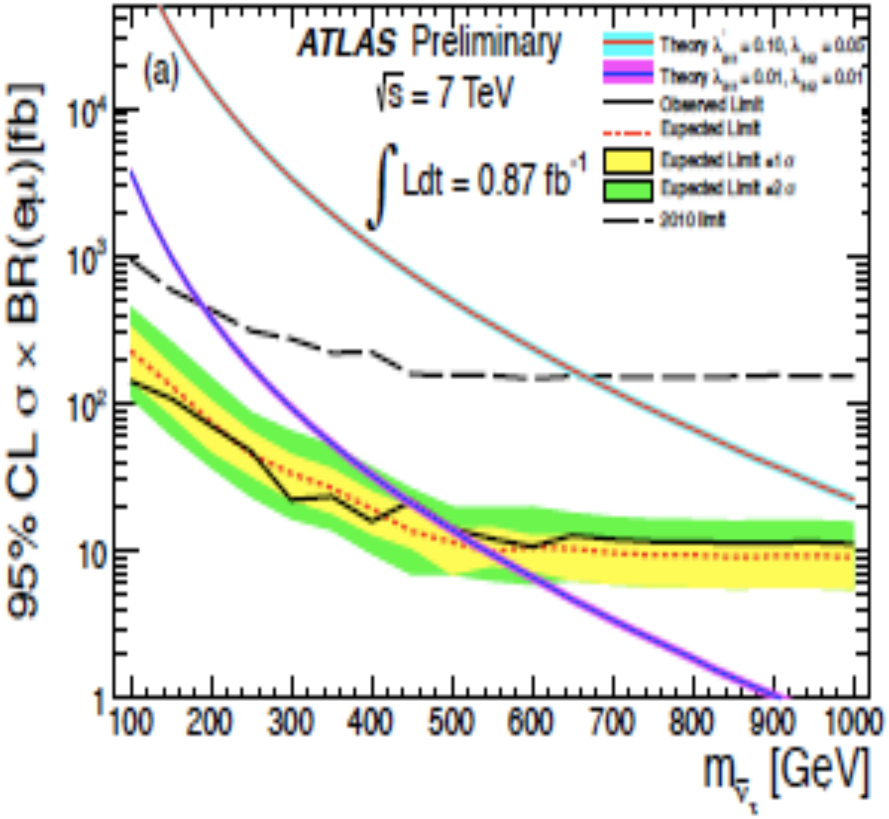
R-parity conserving scenario : sbottom

0-lepton + b-jet channel



R-parity violating scenario : sneutrino

eμ-channel

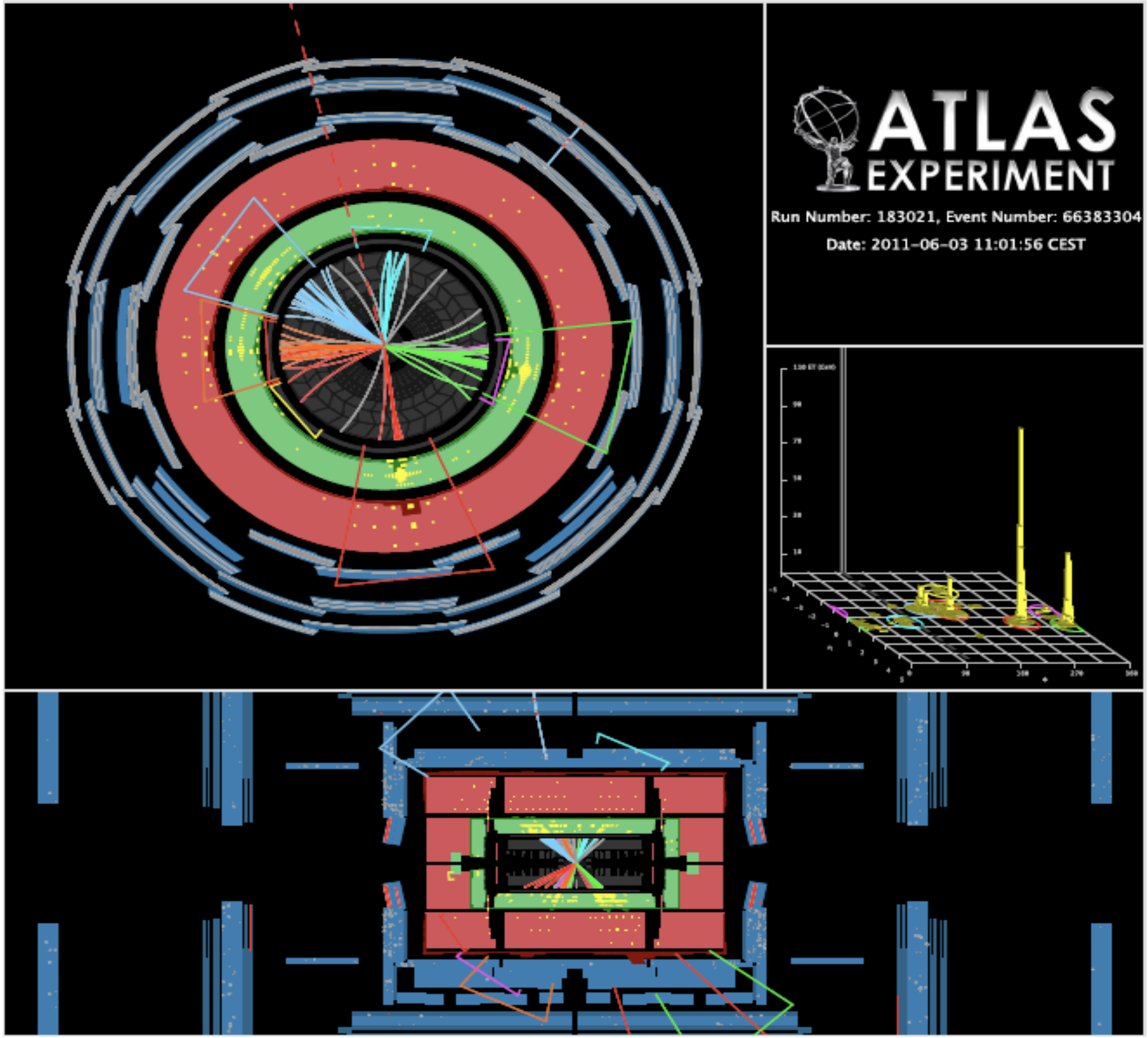


Highest effective mass

MET = 460 GeV

Jet 1 p_T = 528 GeV
Jet 2 p_T = 418 GeV
Jet 3 p_T = 233 GeV
Jet 4 p_T = 171 GeV
Jet 5 p_T = 42 GeV

m_{eff} = 1810 GeV

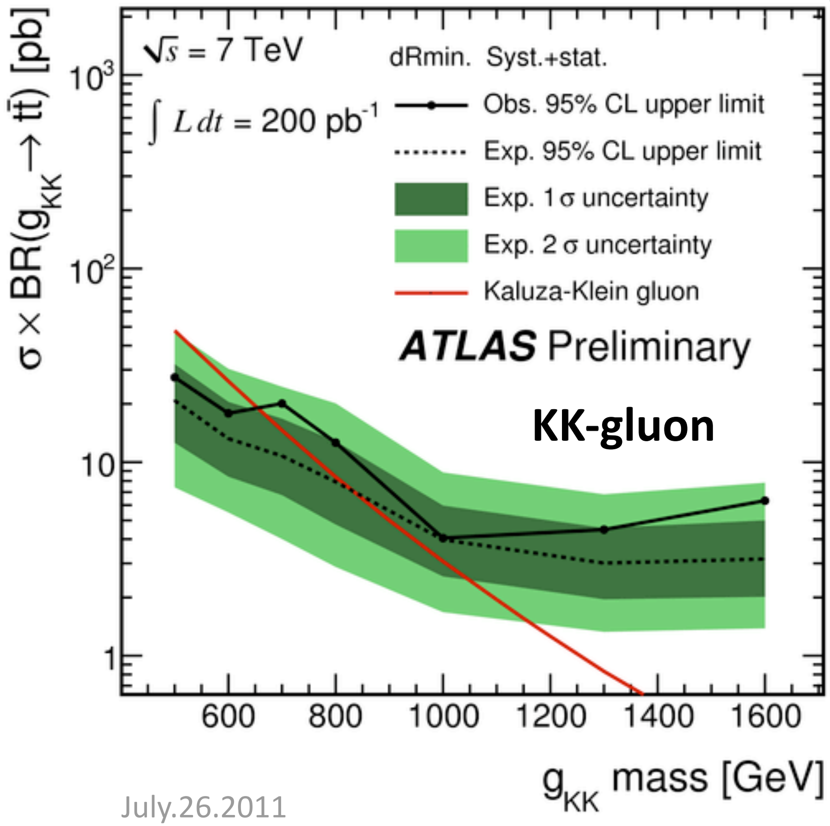


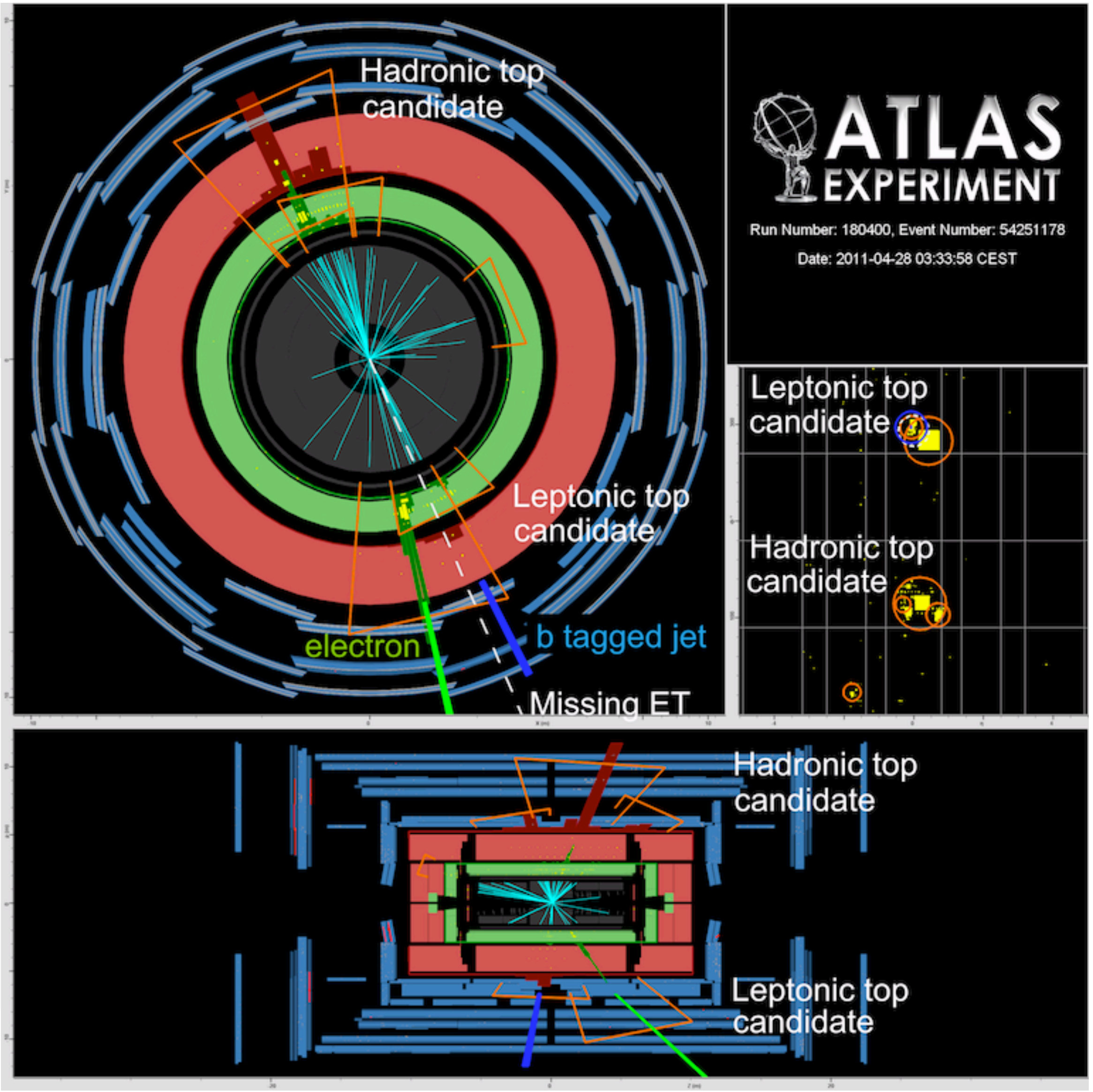
Top pair resonance search

dRmin algorithm:

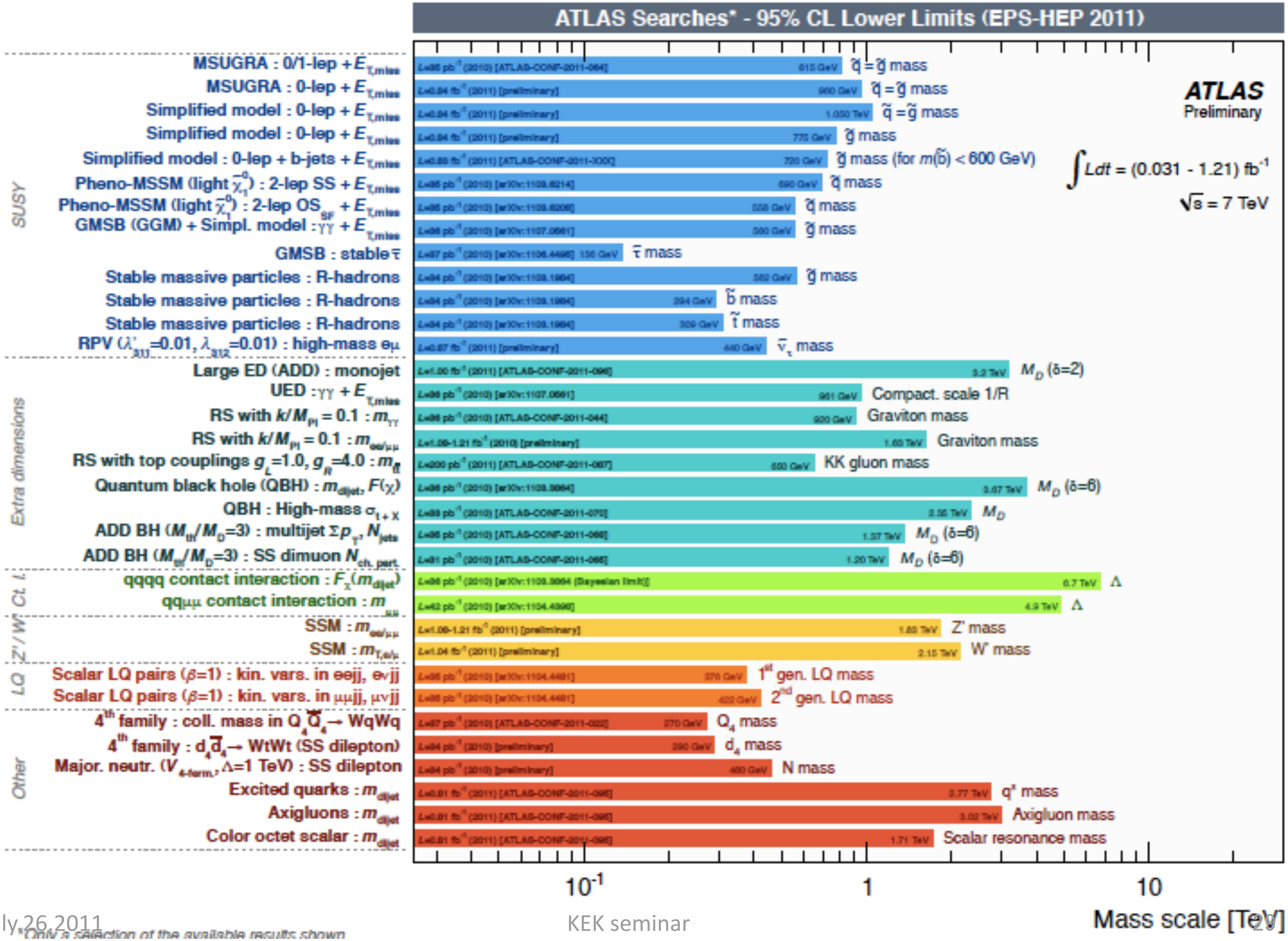
Take three narrow jets.

Efficiently choose correct jet combination in high (boosted) mass $t\bar{t}$ system.





Summary of new particle searches



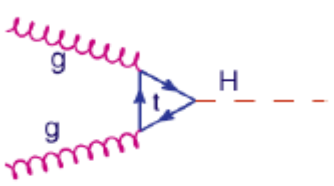
*Only a selection of the available results shown

Higgs searches

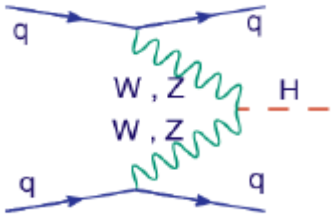
Higgs production at LHC

hep-ph/1101.0593

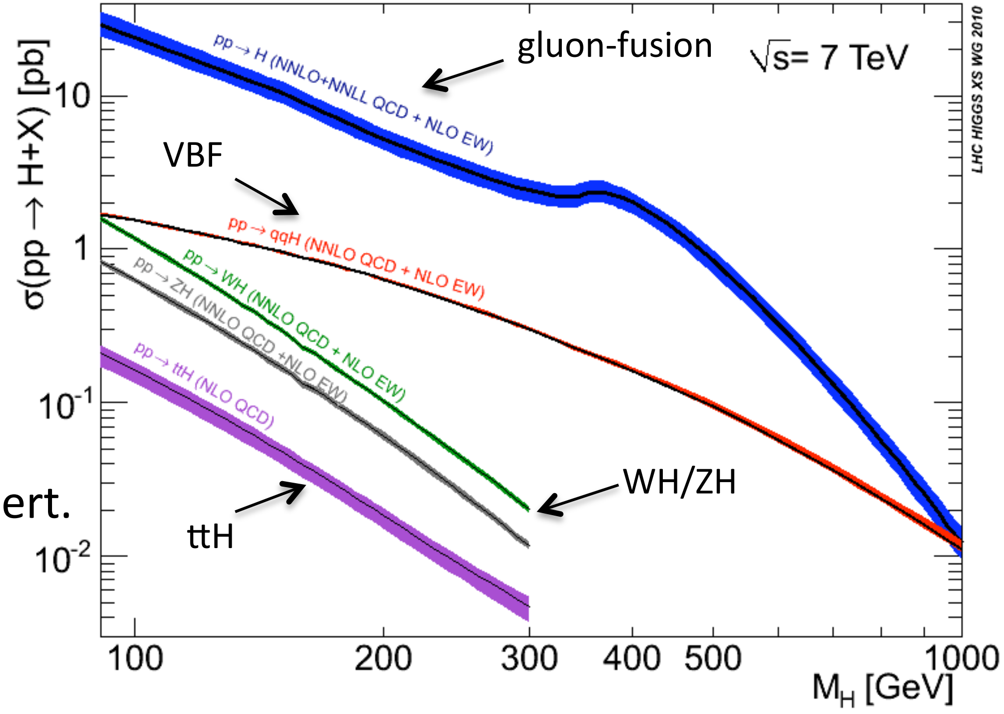
LHC Higgs XS working group :



Gluon Fusion (GF)



Vector Boson Fusion (VB



At m_H=120GeV, the cross section is

gluon-fusion : ~16 pb ~15-20% uncert.

VBF : ~1.3 pb ~3-9%

WH/ZH : ~1.0 pb ~ 5%

ttH : ~0.1 pb

We expect ~650 signal events from 2010 DATA (~35pb^{-1}).

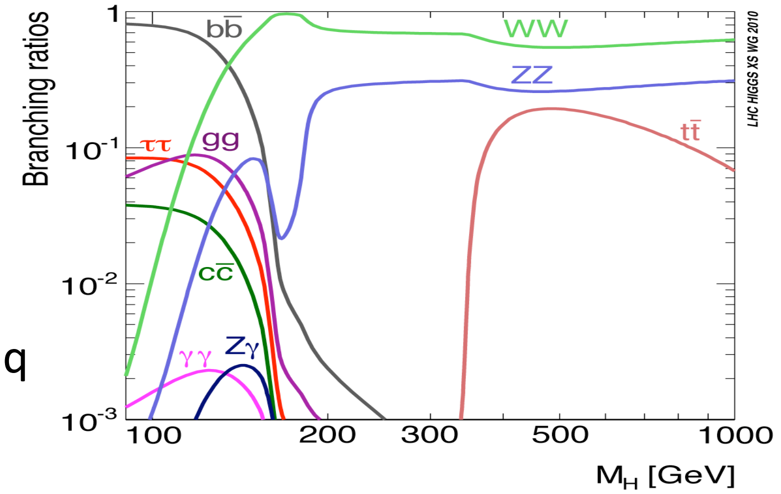
~20,000 signal events from 2011 DATA SUMMER (~1fb^{-1})

Higgs hunting strategy

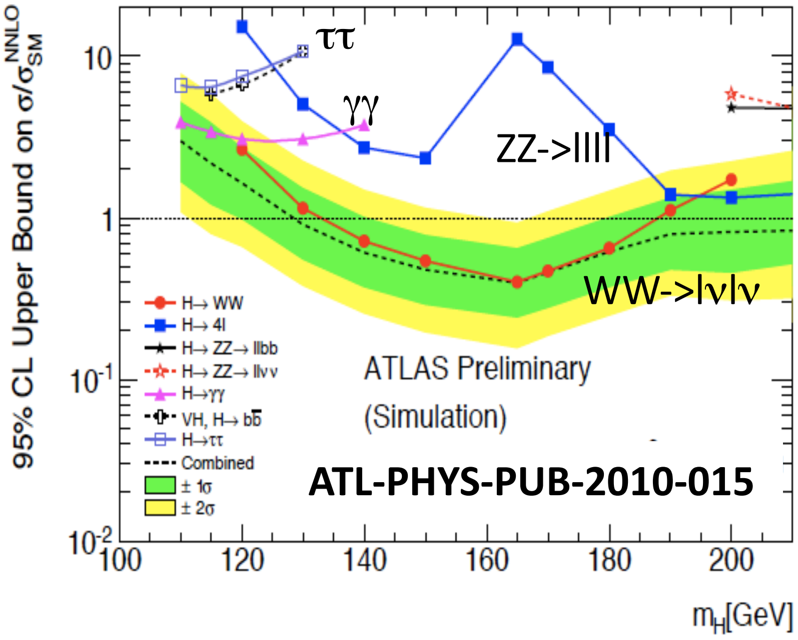
Experimentally, "practical" analysis channels are

- Low mass Higgs : H -> γγ , H -> ττ, H->WW->lνlν , H->ZZ->llll
- High mass Higgs : H->WW->lνqq, H->ZZ->llνν, llqq

(H->bb is more challenging)

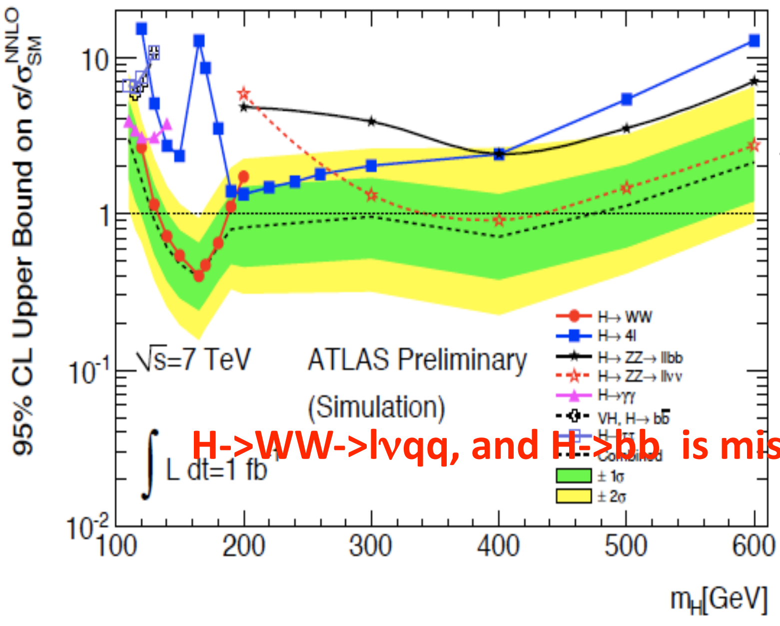


Low mass sensitivity (Monte Carlo)



ATL-PHYS-PUB-2010-015

High mass sensitivity (Monte Carlo)



ZZ->llll

ZZ->llqq

ZZ->llνν

H->WW->lνqq, and H->bb is missing.

H -> γγ (2011, 209pb^{-1})

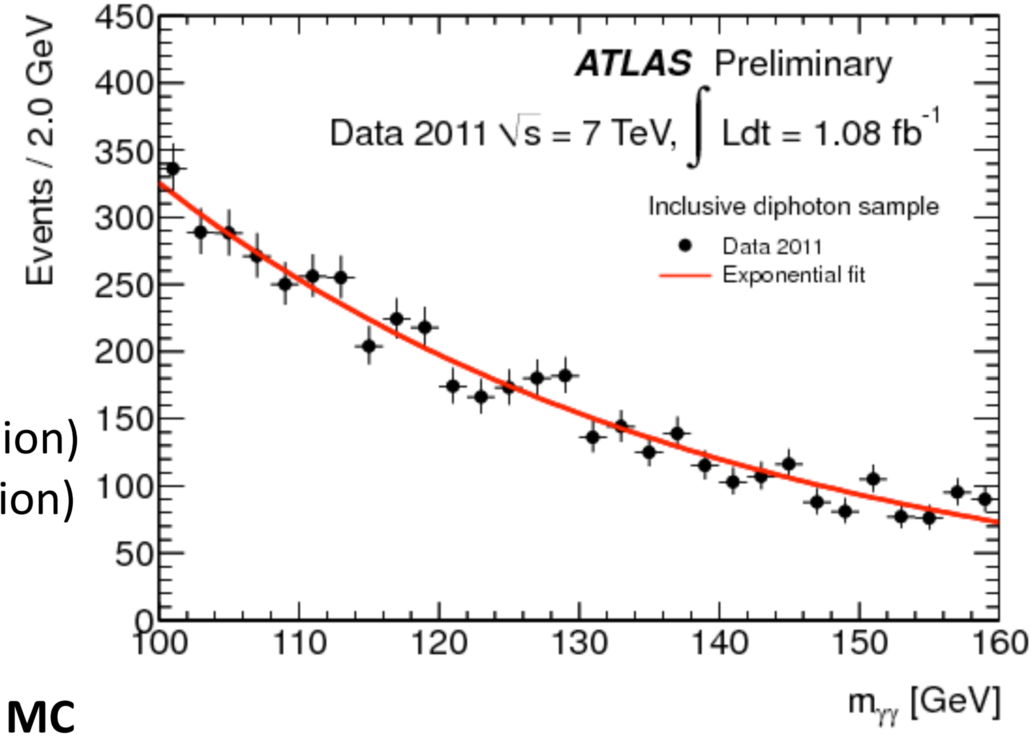
Event selection:

two isolated photons w/ 40, 25GeV,
isolation energy (ΔR<0.4) < 5GeV

Obtained 5063 events at 1.08 fb^{-1}.

Mass resolution σ ~1.4 GeV (no-conversion)
~1.6 GeV (w/ conversion)
(CMS: ~1.2GeV)

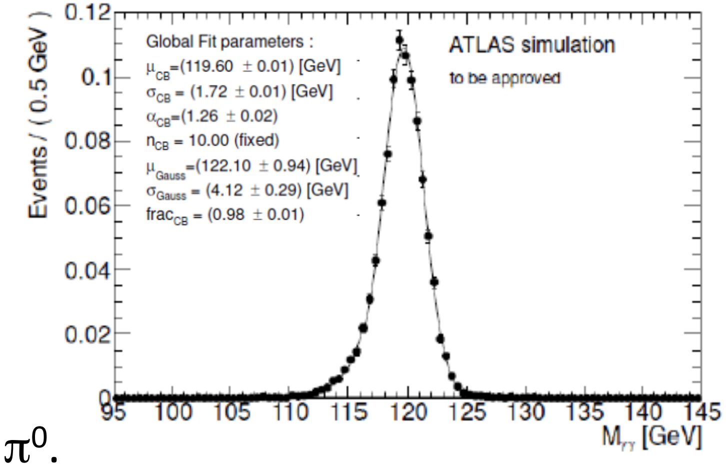
Side-band exponential fit



Background composition is checked by MC

70%	γγ (direct prod.)	… ResBos (NLO+NNLL)
	fragmentation	… DiPhox (NLO)
25%	γj (gamma+jets)	… JetPhox (NLO)
1%	jj (QCD)	… NLOjet++ (NLO)
2%	DY Z/γ*	… Pythia

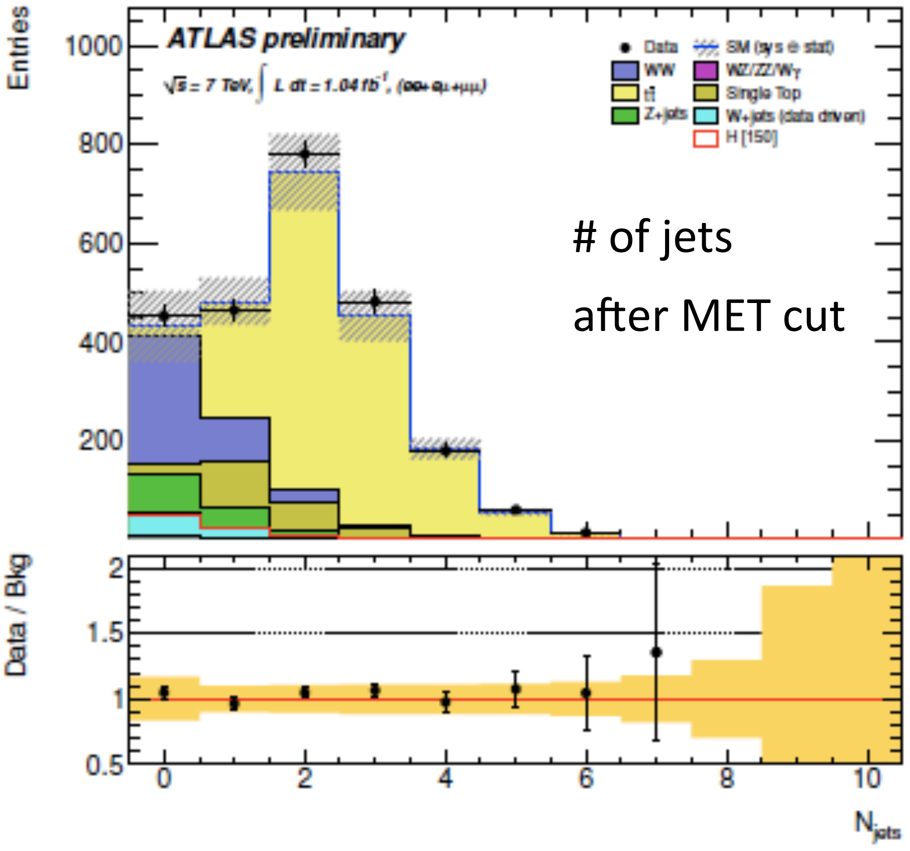
Large uncertainty comes from jet fragmentation to leading π^0.



Low mass H -> WW -> lνlν

Event selection:

- leading lepton $p_T > 25$ GeV,
- sub-leading lepton $p_T > 20(15)$ GeV
  for e (μ) w/ opposite sign,
- METrel > 40 (25) GeV for ee / μμ,
- $30 < m_{ll} < 50$ GeV, $\Delta\phi_{ll} < 1.3$,
- no jet w/ $p_T > 25$ GeV, ← **H+0jet**
- one jet w/ $p_T > 25$ GeV, ← **H+1jet**
  b-jet veto, p_T(tot) < 30 GeV, Z->ττ veto.



# of jets

after MET cut

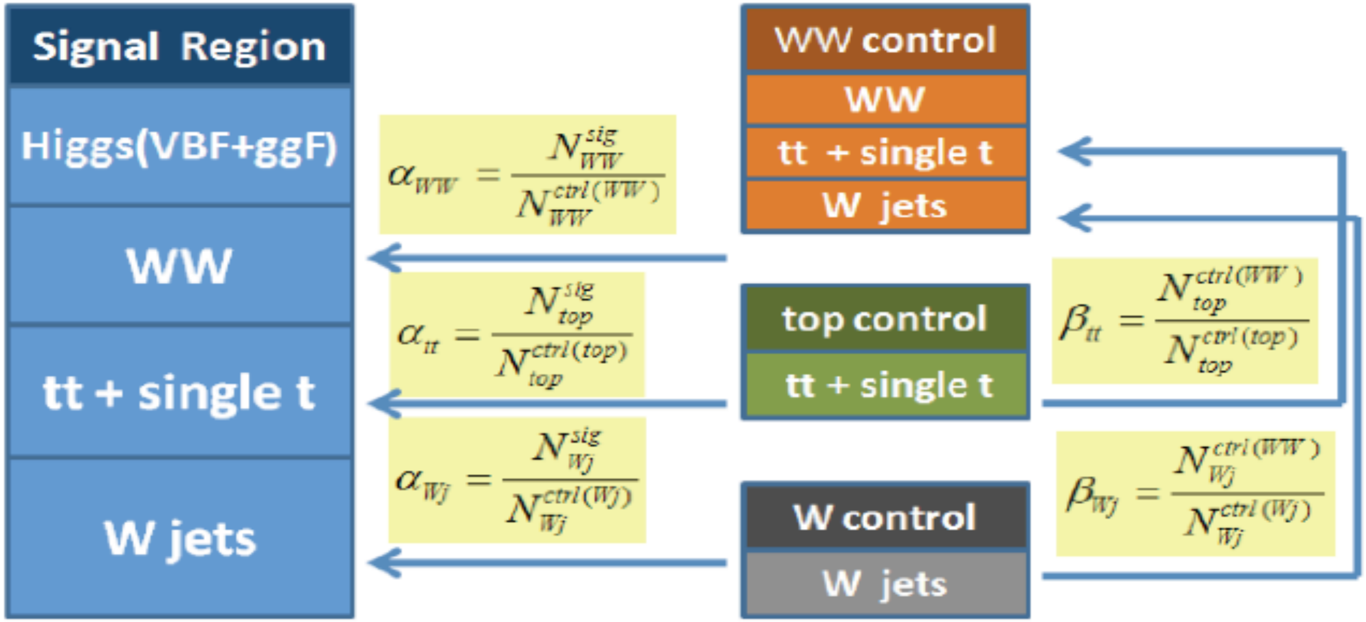
Backgrounds:

di-bosons (WW/ZZ/WZ) … dominant for H+0j analysis (**rely on MC prediction**)
tt and single top … comparable with WW in H+1j analysis.
W+jets / Z+jets … data-driven estimation method.

rely on theory

Understanding of the particle ID performance and event kinematics are crucial.

Background estimation



Signal Region

Higgs(VBF+ggF)

WW

tt + single t

W jets

$$\alpha_{WW} = \frac{N_{WW}^{sig}}{N_{WW}^{ctrl(WW)}}$$

$$\alpha_{tt} = \frac{N_{top}^{sig}}{N_{top}^{ctrl(top)}}$$

$$\alpha_{Wj} = \frac{N_{Wj}^{sig}}{N_{Wj}^{ctrl(Wj)}}$$

WW control

WW

tt + single t

W jets

top control

tt + single t

W control

W jets

$$\beta_{tt} = \frac{N_{top}^{ctrl(WW)}}{N_{top}^{ctrl(top)}}$$

$$\beta_{Wj} = \frac{N_{Wj}^{ctrl(WW)}}{N_{Wj}^{ctrl(Wj)}}$$

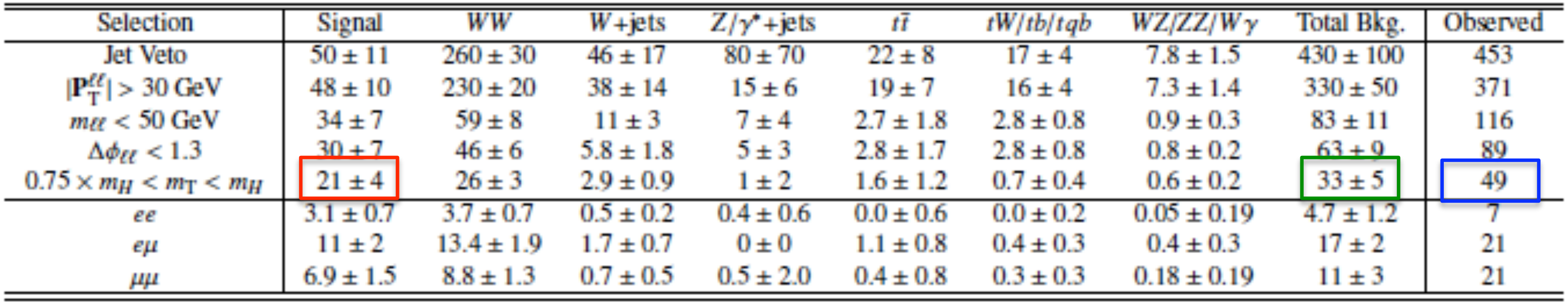
W+jets: CR: m_T > 30 GeV, The “fake factor” is evaluate using di-jet data.
Apply “fake factor” to CR. Method is verified by looking at the same-sing events.

Top : CR: reverse “b-jet veto”. Estimate the jet survival probability in CR.
Apply it to SR.

WW: CR: m_{ll} > 80 GeV. The yield is obtained by MC@NLO. Apply this ratio to CR.

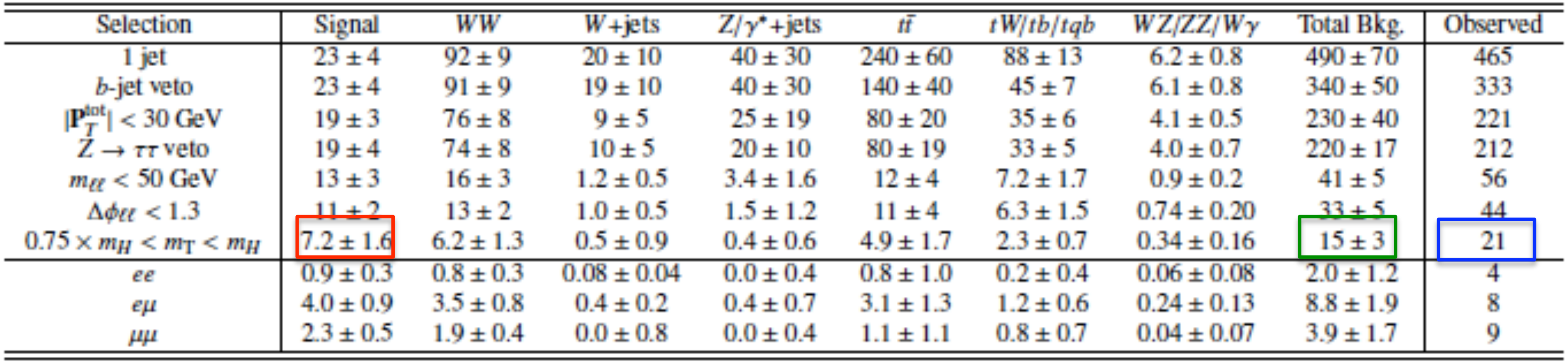
Acceptance at 1fb^{-1}

H + 0 jet channel : (m_H = 150 GeV)



Selection	Signal	WW	W+jets	Z/γ^*+jets	$t\bar{t}$	$tW/tb/tqb$	$WZ/ZZ/W\gamma$	Total Bkg.	Observed
Jet Veto	50 ± 11	260 ± 30	46 ± 17	80 ± 70	22 ± 8	17 ± 4	7.8 ± 1.5	430 ± 100	453
$\|\mathbf{P}_T^{\ell\ell}\| > 30$ GeV	48 ± 10	230 ± 20	38 ± 14	15 ± 6	19 ± 7	16 ± 4	7.3 ± 1.4	330 ± 50	371
$m_{\ell\ell} < 50$ GeV	34 ± 7	59 ± 8	11 ± 3	7 ± 4	2.7 ± 1.8	2.8 ± 0.8	0.9 ± 0.3	83 ± 11	116
$\Delta\phi_{\ell\ell} < 1.3$	30 ± 7	46 ± 6	5.8 ± 1.8	5 ± 3	2.8 ± 1.7	2.8 ± 0.8	0.8 ± 0.2	63 ± 9	89
$0.75 \times m_H < m_T < m_H$	21 ± 4	26 ± 3	2.9 ± 0.9	1 ± 2	1.6 ± 1.2	0.7 ± 0.4	0.6 ± 0.2	33 ± 5	49
ee	3.1 ± 0.7	3.7 ± 0.7	0.5 ± 0.2	0.4 ± 0.6	0.0 ± 0.6	0.0 ± 0.2	0.05 ± 0.19	4.7 ± 1.2	7
$e\mu$	11 ± 2	13.4 ± 1.9	1.7 ± 0.7	0 ± 0	1.1 ± 0.8	0.4 ± 0.3	0.4 ± 0.3	17 ± 2	21
$\mu\mu$	6.9 ± 1.5	8.8 ± 1.3	0.7 ± 0.5	0.5 ± 2.0	0.4 ± 0.8	0.3 ± 0.3	0.18 ± 0.19	11 ± 3	21

H + 1 jet channel : (m_H = 150 GeV)

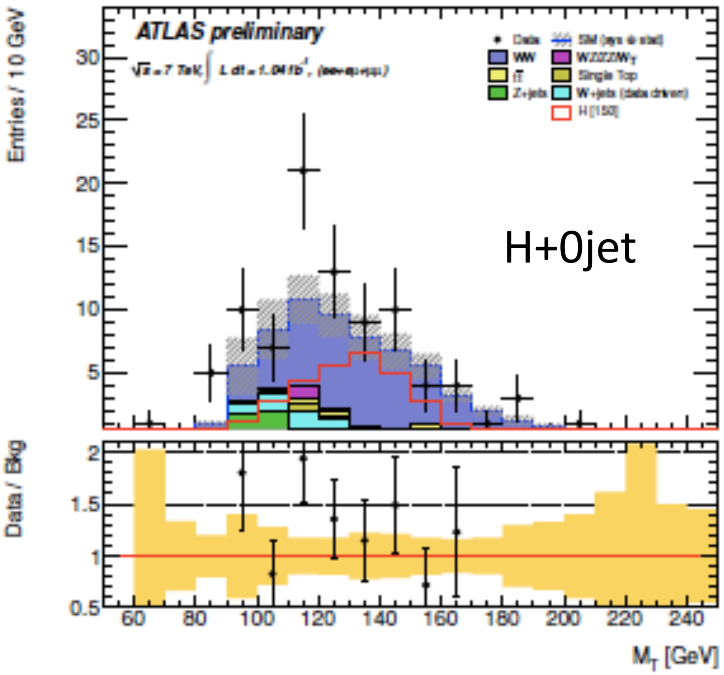


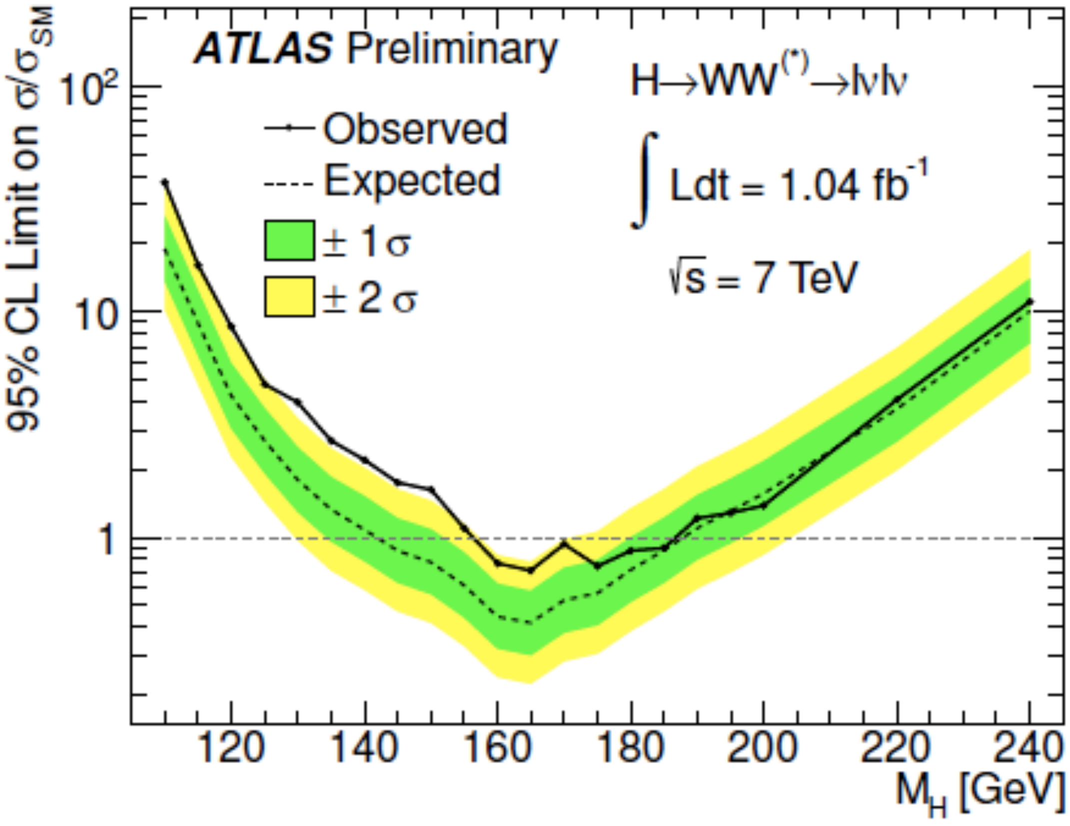
Selection	Signal	WW	W+jets	Z/γ^*+jets	$t\bar{t}$	$tW/tb/tqb$	$WZ/ZZ/W\gamma$	Total Bkg.	Observed
1 jet	23 ± 4	92 ± 9	20 ± 10	40 ± 30	240 ± 60	88 ± 13	6.2 ± 0.8	490 ± 70	465
b-jet veto	23 ± 4	91 ± 9	19 ± 10	40 ± 30	140 ± 40	45 ± 7	6.1 ± 0.8	340 ± 50	333
$\|\mathbf{P}_T^{\text{tot}}\| < 30$ GeV	19 ± 3	76 ± 8	9 ± 5	25 ± 19	80 ± 20	35 ± 6	4.1 ± 0.5	230 ± 40	221
$Z \rightarrow \tau\tau$ veto	19 ± 4	74 ± 8	10 ± 5	20 ± 10	80 ± 19	33 ± 5	4.0 ± 0.7	220 ± 17	212
$m_{\ell\ell} < 50$ GeV	13 ± 3	16 ± 3	1.2 ± 0.5	3.4 ± 1.6	12 ± 4	7.2 ± 1.7	0.9 ± 0.2	41 ± 5	56
$\Delta\phi_{\ell\ell} < 1.3$	11 ± 2	13 ± 2	1.0 ± 0.5	1.5 ± 1.2	11 ± 4	6.3 ± 1.5	0.74 ± 0.20	33 ± 5	44
$0.75 \times m_H < m_T < m_H$	7.2 ± 1.6	6.2 ± 1.3	0.5 ± 0.9	0.4 ± 0.6	4.9 ± 1.7	2.3 ± 0.7	0.34 ± 0.16	15 ± 3	21
ee	0.9 ± 0.3	0.8 ± 0.3	0.08 ± 0.04	0.0 ± 0.4	0.8 ± 1.0	0.2 ± 0.4	0.06 ± 0.08	2.0 ± 1.2	4
$e\mu$	4.0 ± 0.9	3.5 ± 0.8	0.4 ± 0.2	0.4 ± 0.7	3.1 ± 1.3	1.2 ± 0.6	0.24 ± 0.13	8.8 ± 1.9	8
$\mu\mu$	2.3 ± 0.5	1.9 ± 0.4	0.0 ± 0.8	0.0 ± 0.4	1.1 ± 1.1	0.8 ± 0.7	0.04 ± 0.07	3.9 ± 1.7	9

Sensitivity of H->WW

Transverse mass reconstruction:

$$m_T = \sqrt{(E_T^{ll} + E_T^{miss})^2 - (P_T^{ll} + P_T^{miss})^2}$$





Exclude : 142 < m_H < 186 GeV

Maximum 2.7σ deviation from background-only hypothesis in 126 ~ 158 GeV.

H -> ZZ -> llll

Golden discovery channel

Event selection:

two pair of same flavor and
opposite sign leptons,
muon pT>7GeV, electron pT>15GeV,
at least , leading two lepton pT>20GeV.
at least one 76 < m_{ll} < 106 GeV.
ΔR_{ll}>0.1, isolation

One of Z is not always necessary
to be the Z mass resonance.

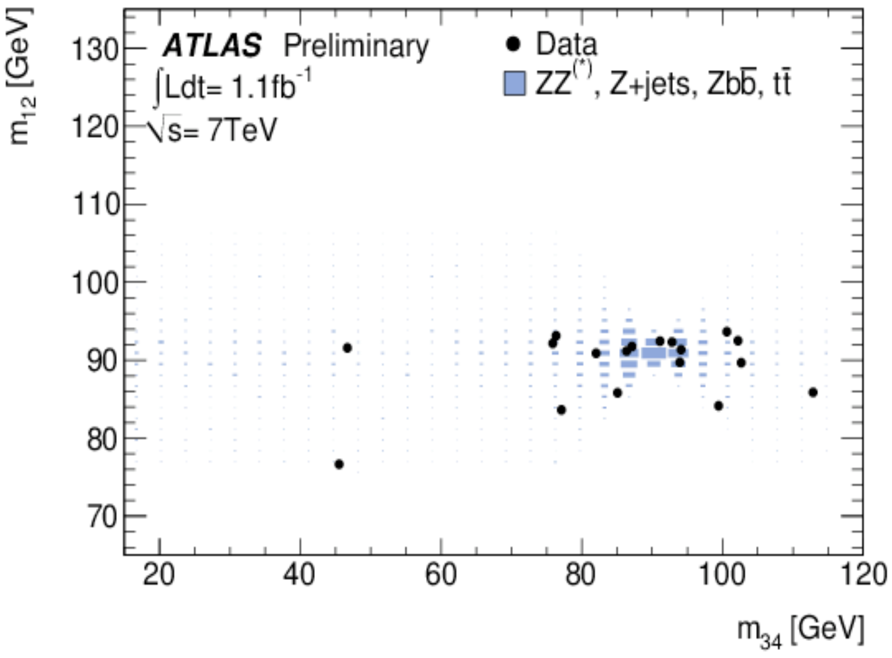
Background normalization:

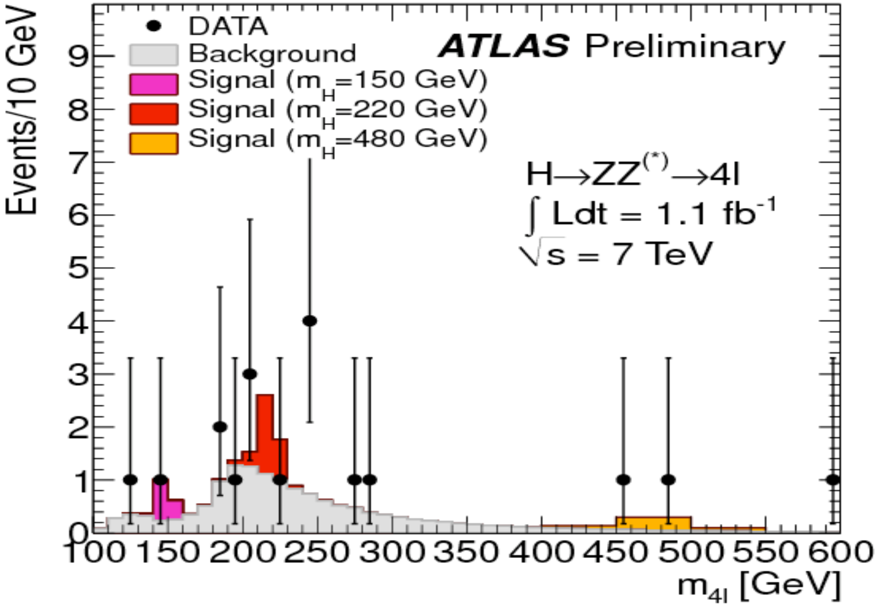
$$N_{ZZ} = \sigma_{ZZ}\varepsilon_{ZZ}^{exp}L \times \boxed{\left[\frac{N_Z^{Data}}{\sigma_Z\varepsilon_Z^{exp}L}\right]} = N_{ZZ}^{MC} \times \boxed{R}$$

Phys.Rev.D80(2009)054023

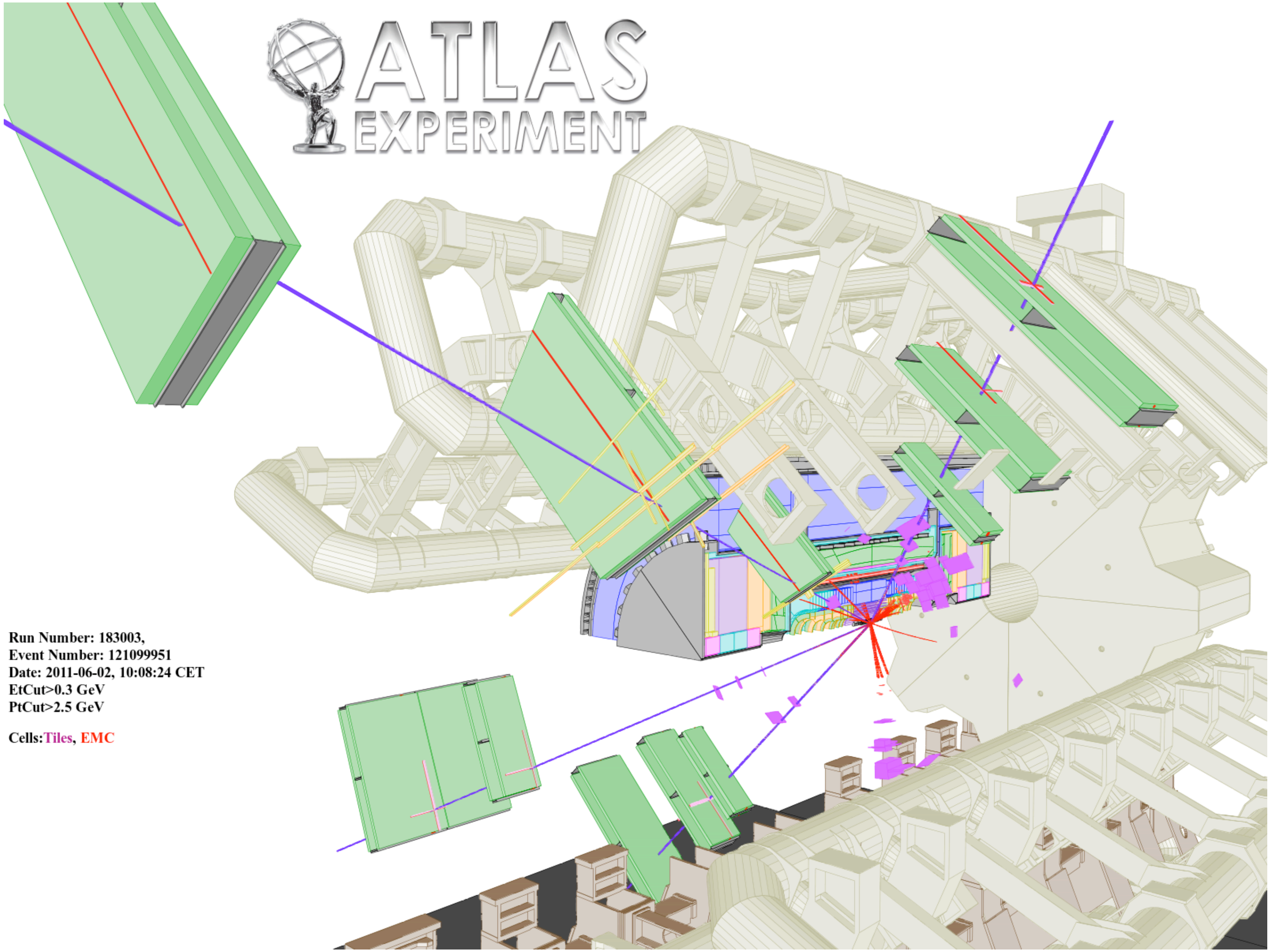
Higher-order effect is partially involved.

R~0.97





4-lepton (muon) candidate



Run Number: 183003,
Event Number: 121099951
Date: 2011-06-02, 10:08:24 CET
EtCut>0.3 GeV
PtCut>2.5 GeV

Cells:Tiles, EMC

High mass Higgs

H->ZZ->llνν and llqq :

Event selection:

- di-lepton 76 < m_{ll} < 106 GeV,
- MET > 66 (82) GeV, $\Delta\phi_{ll}$ <2.64 (2.25)
- MET < 50 GeV, n-jets>=2, 70 < m_{jj} < 105GeV

Background:

- di-bosons (WW/ZZ/WZ), Z+jets … dominant
- W+jets, tt and single top

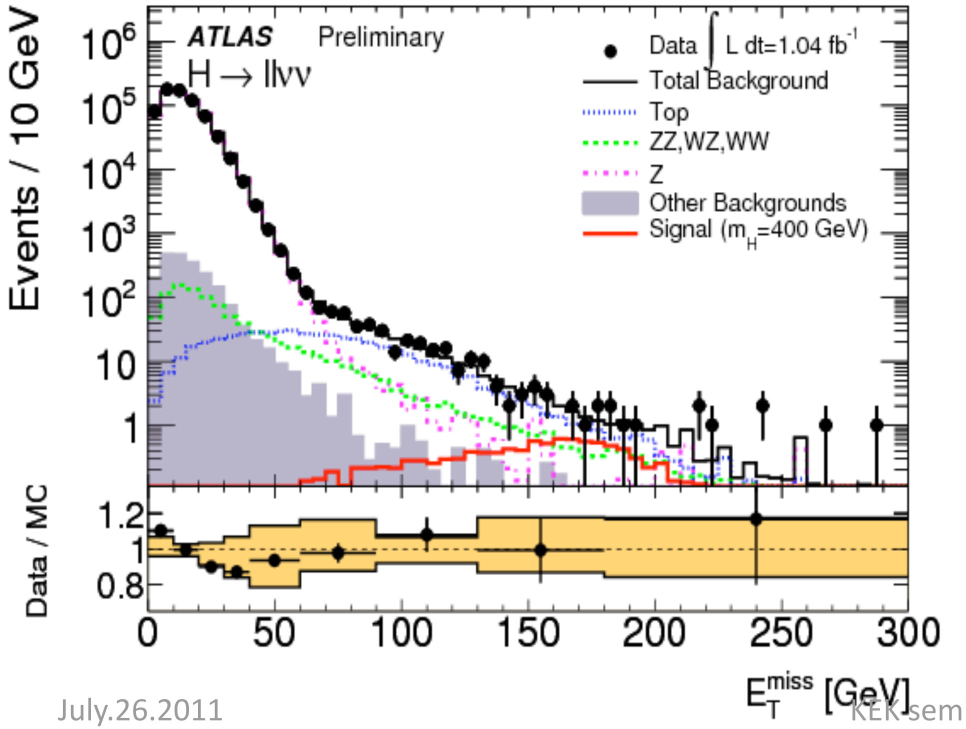
H->WW->lνqq :

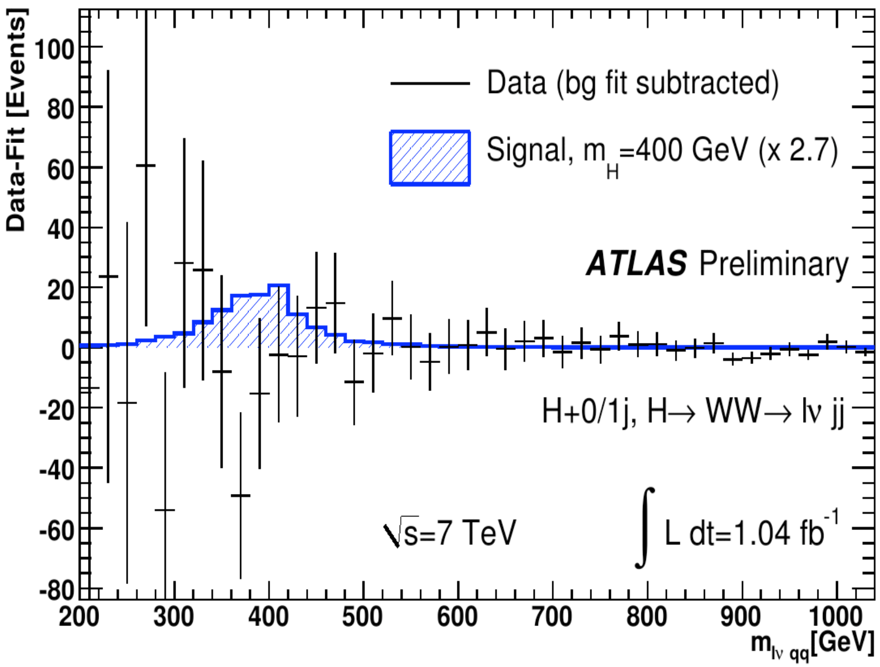
Event selection:

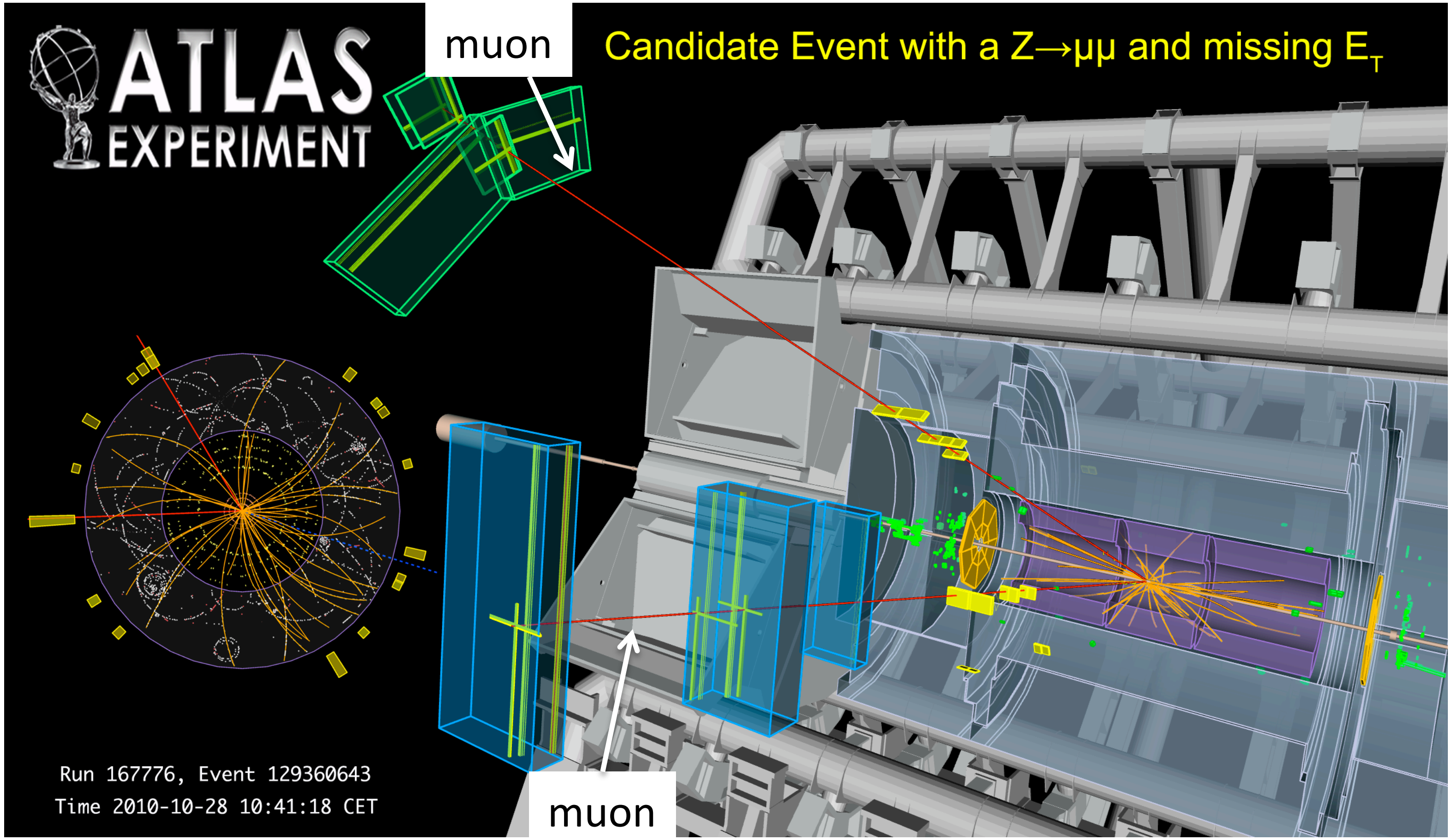
- one lepton w/ p_T > 30 GeV, MET>30GeV,
- n-jet >= 2, 71 < m_{jj} < 91 GeV

Background:

- W+jets / Z+jets … dominant background
- di-bosons (WW/ZZ/WZ) , tt and single top







Candidate Event with a Z→μμ and missing E_T

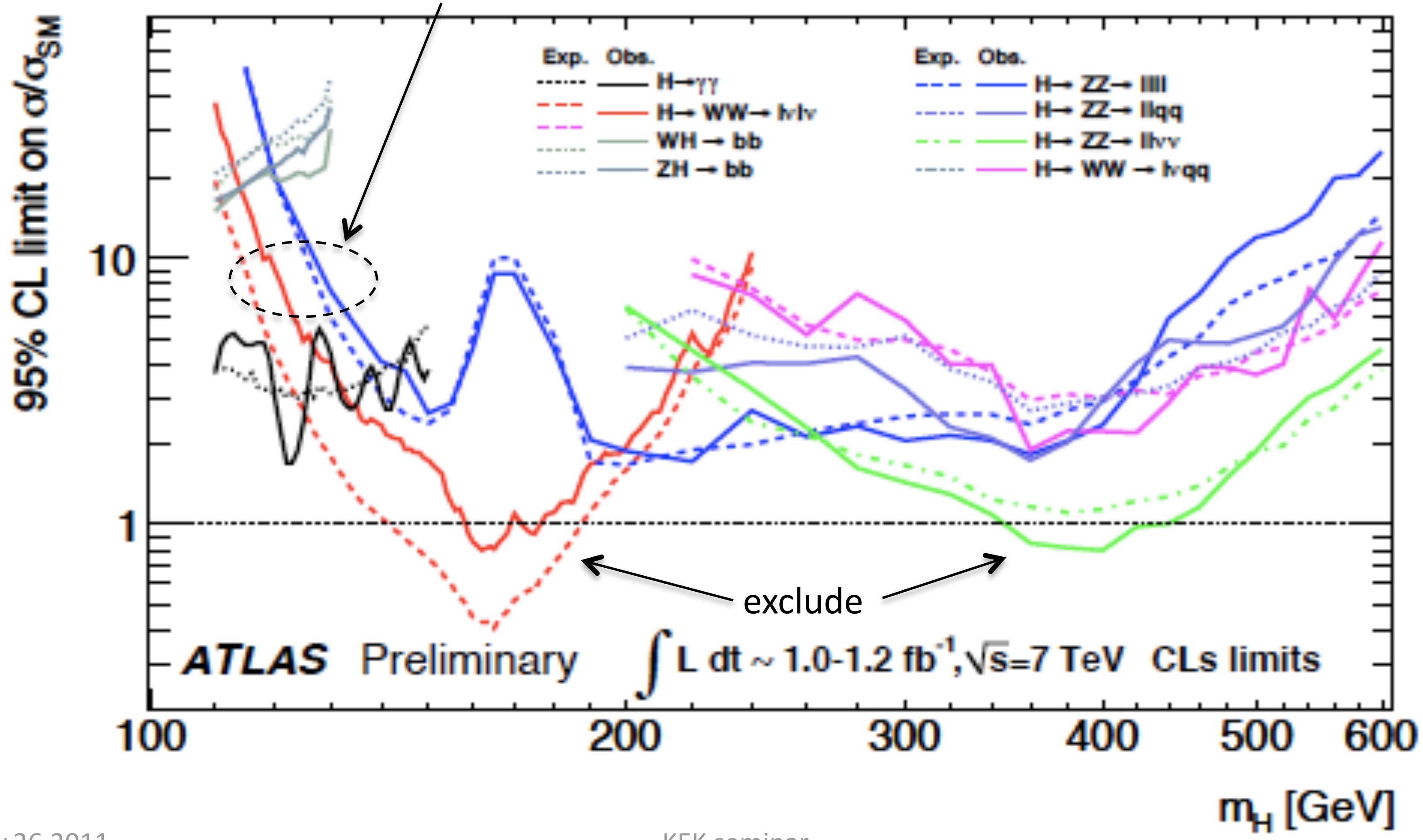
Run 167776, Event 129360643
Time 2010-10-28 10:41:18 CET

SM Higgs sensitivity

σ_{SM} is based on NNLO calculation.   Luminosity uncert. 3.7%

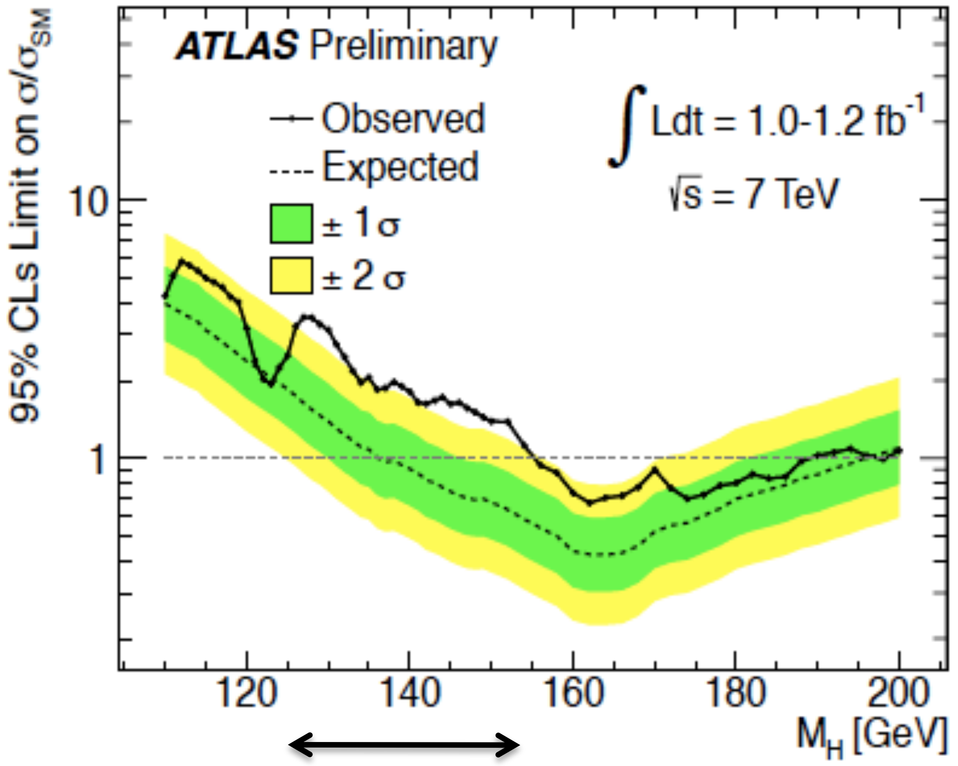
The WW channel alone excludes Higgs in range 140~190, 340~450 GeV.

The WW and ZZ channels shows similar tendency in low mass region.

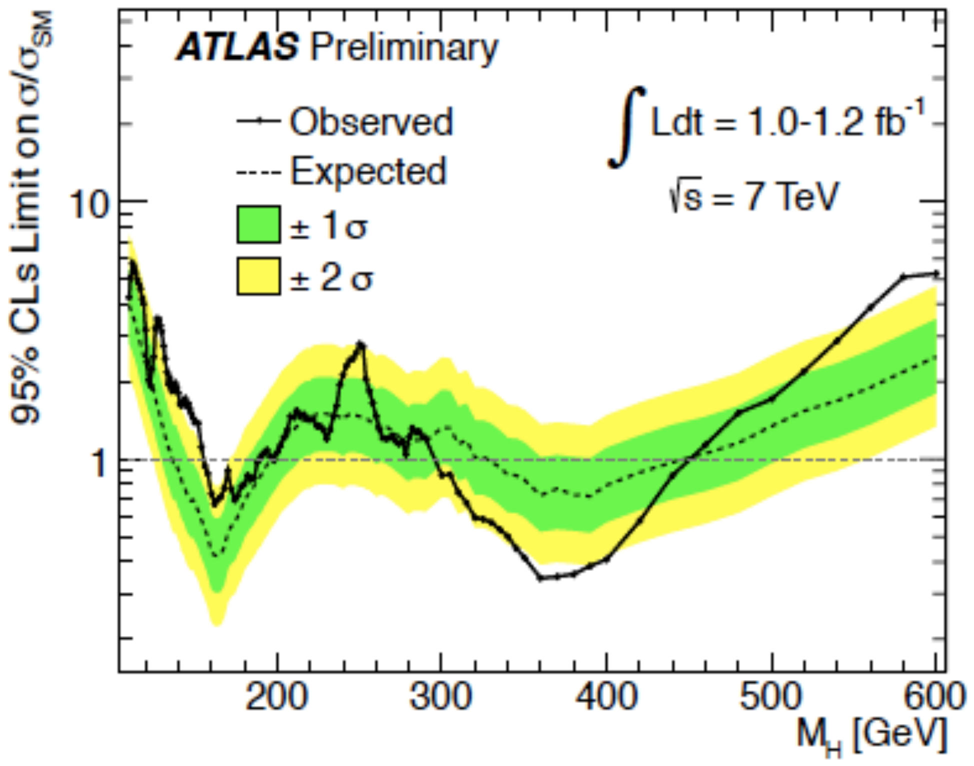


Combined sensitivity

low mass



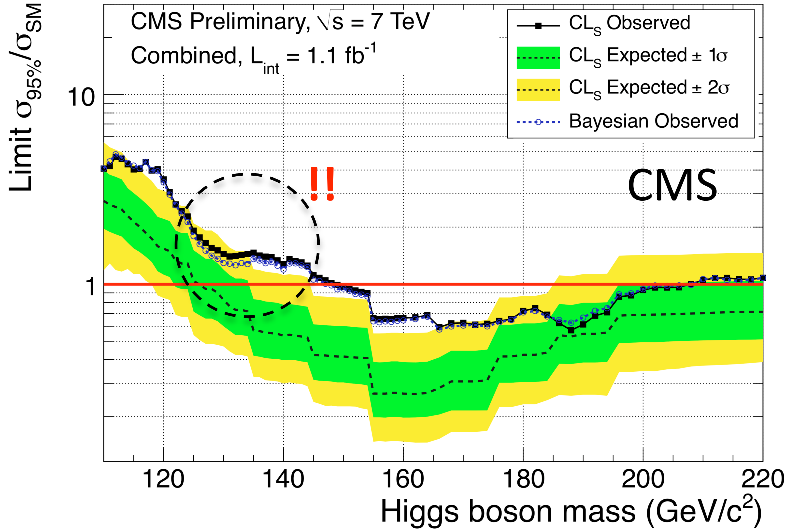
High mass

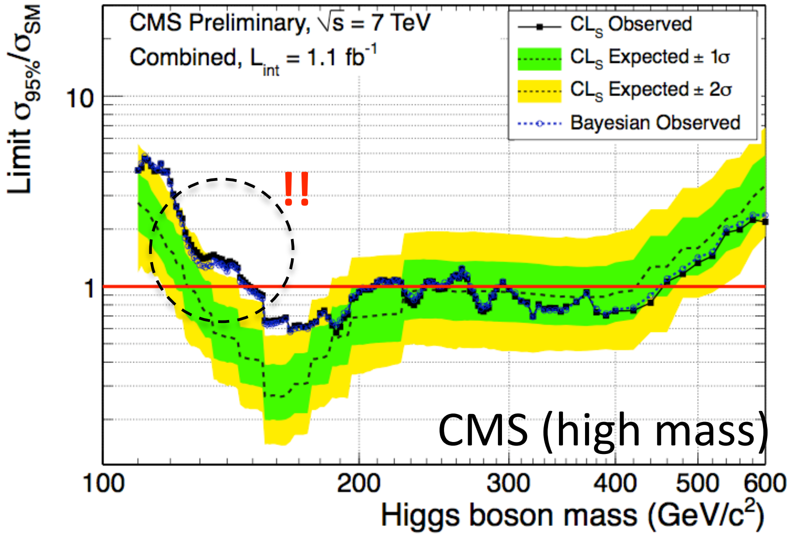


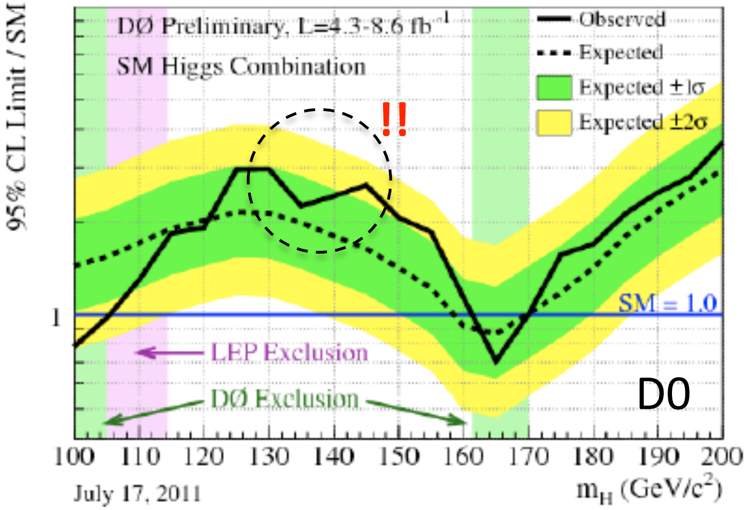
Broad excess >2σ

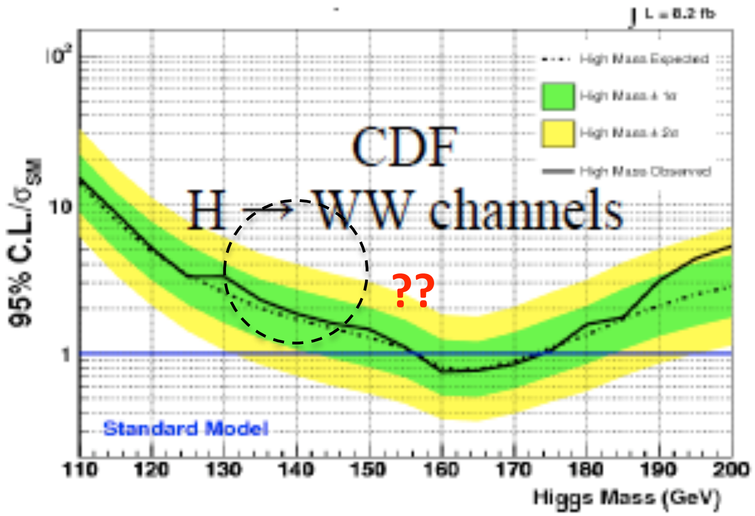
Tevatron/CMS results

Now, 4-experiments see similar tendency.









Significance

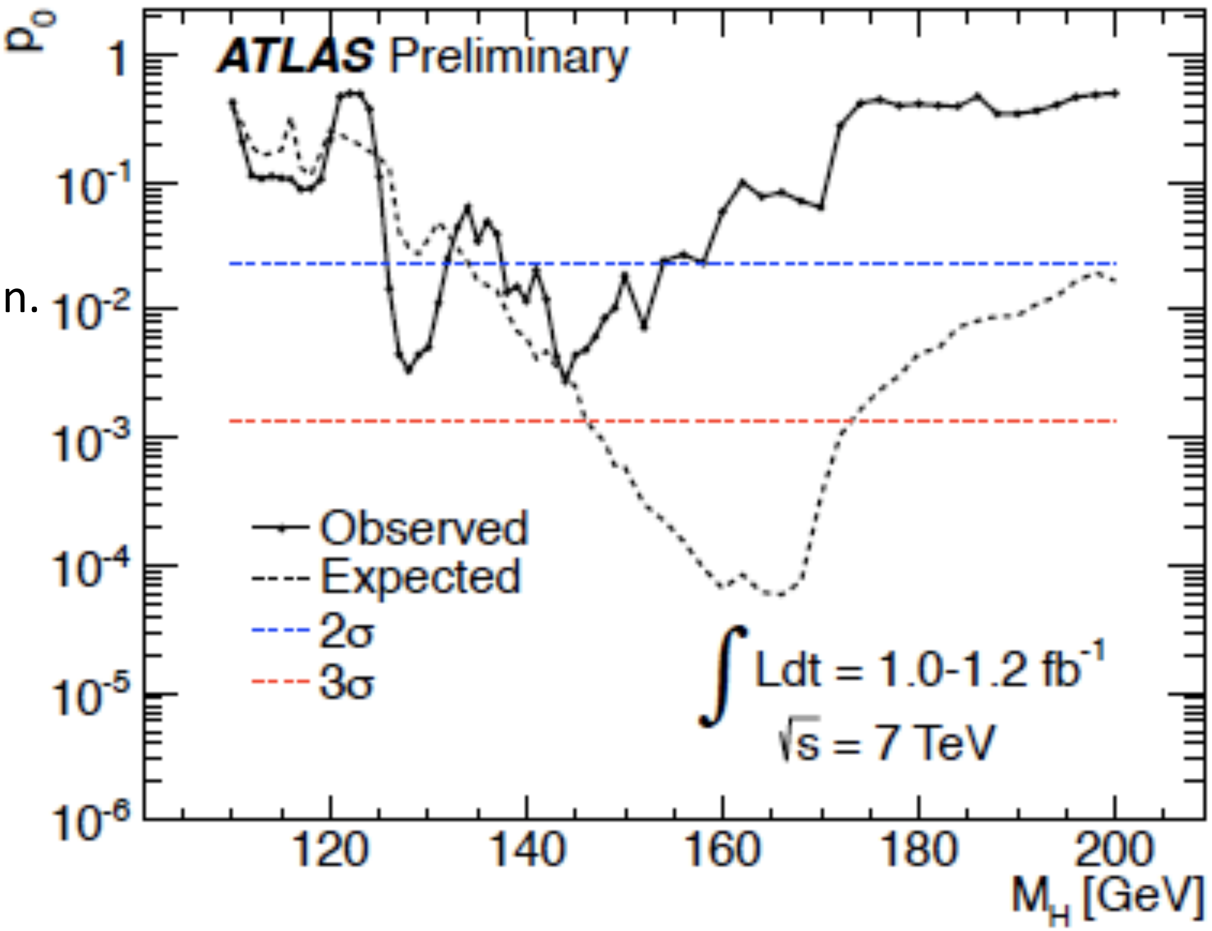
No “look-elsewhere effect” involved.

130-140 Higgs :
consistent with expectation.

➡ up to 2.7σ

125-130 Higgs:
pretty lucky.

H->γγ is contributing.



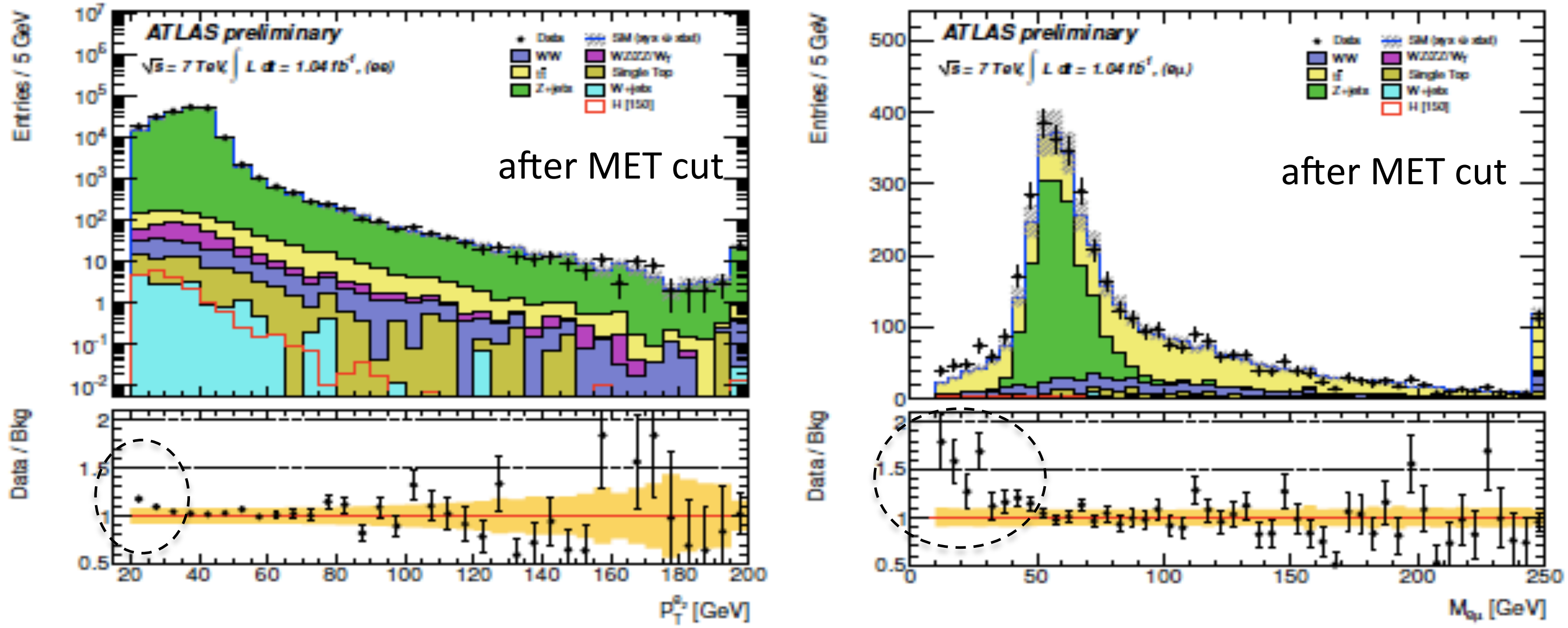
Prospect

There are number of things to improve/establish our results.

Observe discrepancy in low p_T electron.

Checked number of things… low mass DY, isolation quantity, noisy run,
tau-decay polarization, single top, ZZ etcetc…

So far, none of them explain them.



after MET cut

after MET cut

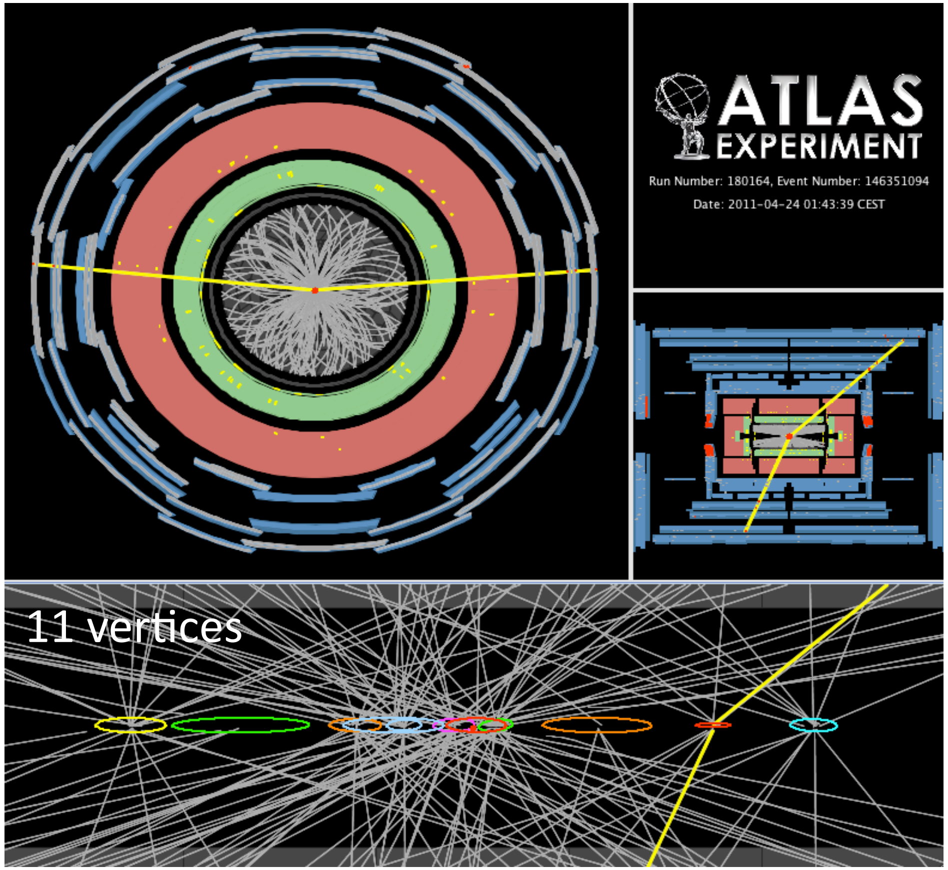
Experimental side:

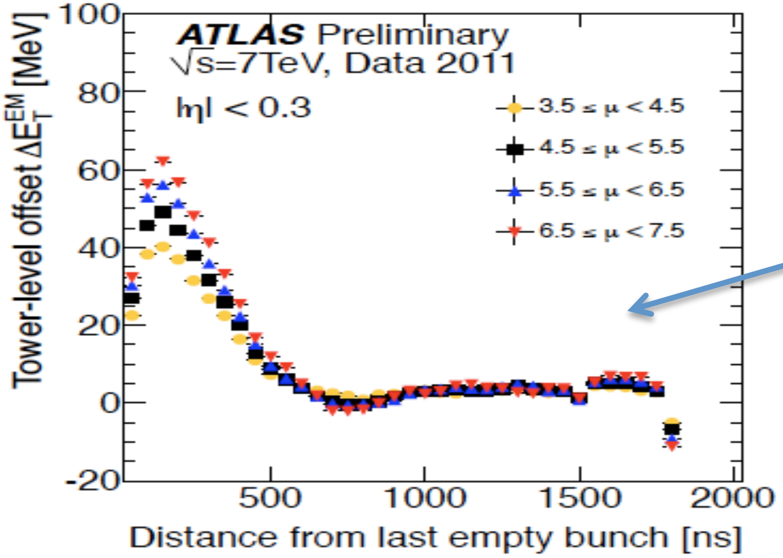
NEED more understanding of pileup.

- Definition of "Primary Vertex". →

Historically, the "primary vertex"
is defined as "**largest Σp_T^2 of tracks**".

But an example reveals not a case….
It potentially bias the b-tagging/tau ID
as well as isolation quality.





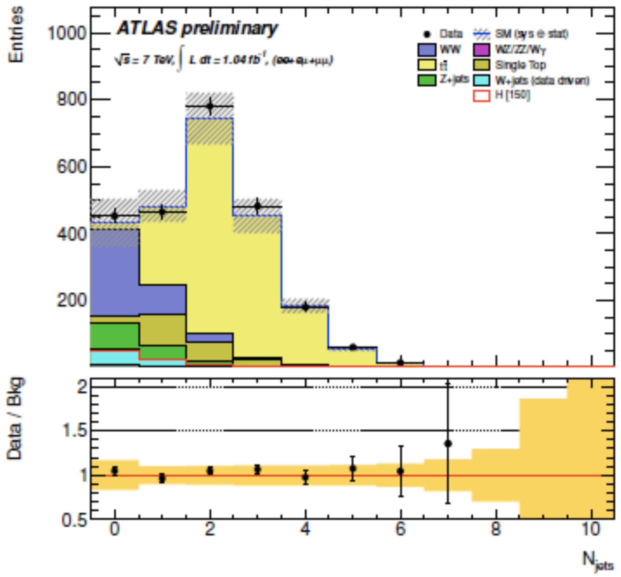
- "Out-of-time" pileup structure.

Sensitive to "bunch train structure".

The energy offset correction can change
beam bunch-by-bunch.

Impact in MET resolution is not so negligible.

Theory side:



- a bit poor eta description in MC,

  ⇒ need better PDF.
  We already know LO PDF is not sufficient.

- prediction of $\Delta\phi_{ll}$ and low m_{ll} distribution are critical,

  ⇒ "Jet-multiplicity" is largely depending on kinematical cuts. Changing "lepton p_T" also change the multiplicity.

  In most case, our NLO generators are fine for inclusive measurement, but how do we trust it in very local phase space?

  ⇒ single top production has large ambiguity.
  5-fermion v.s. 4-ferion scheme ???

Yukawa coupling:

decay mode	gluon fusion (top-loop)	VBF
H->$\gamma\gamma$	indirect Yt	gauge
H->$\tau\tau$	Yt * Yb	direct Yb
H->bb	Yt * Yb	direct Yb
H->WW	indirect Yt	gauge
H->ZZ	indirect Yt	gauge

So far, inclusive searches are mainly performed.

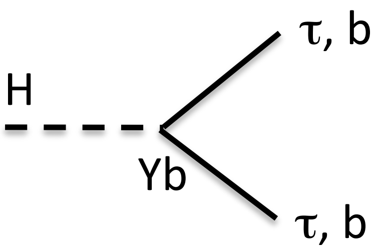
Further check/confirmation, the other search channel is very important.

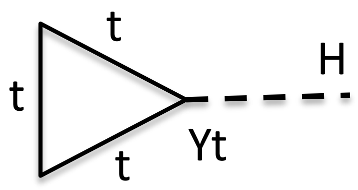
The VBF production searches will be a key to know the production mechanism.

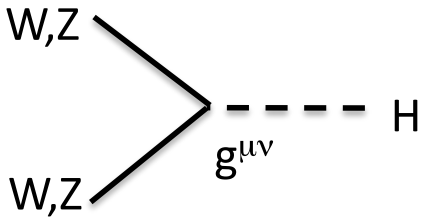
The H->$\tau\tau$ / bb search allows us to be able to see Yukawa coupling directly.

Also High precision measurement of Higgs p_T is able to see the ratio of Yt and Yb.

In the high mass region, separate analysis of gluon-fusion and VBF searches are important. (multi-jet categorization)







Summary

- Explore wide range of SUSY parameter space.
- Combination Higgs sensitivity with ATLAS and CMS will be at Lepton-Photon.
- We expect 3~4 fb^{-1} data this year.
- LHC plan for next year is still floating. (possible option: 8 TeV w/ 25ns collision)

before dawn of adventure…

LHC actual versus design parameters

	design	mid June 2011	comment
Beam energy	7 TeV	**3.5 TeV**	½ design
transv. norm. emittance	3.75 μm	**2.9 μm**	¾ design!
beta*	0.55 m	1.5 m	3x design
IP beam size	16.7 μm	34 μm	2x design
bunch intensity	1.15×10^{11}	**1.25×10^{11}**	higher than design
luminosity / bunch	3.6×10^{30} cm^{-2}s^{-1}	1.1×10^{30} cm^{-2}s^{-1}	only factor 3 away (x4 from energy!)
# bunches	2808	1092	approaching ½ design
bunch spacing	25 ns	**50 ns**	
beam current	0.582 A	0.236 A	close to ½ design
rms bunch length	7.55 cm	≥8.7 cm	
crossing angle	285 μrad	240 μrad	
"Piwinski angle"	0.64	≥0.31	
luminosity	10^{34} cm^{-2}s^{-1}	1.2×10^{33} cm^{-2}s^{-1}	>10% design

luminosity potential of present LHC

how to go further? $L = \frac{f_{rev} n_b N_b^2}{4\pi\beta^* \varepsilon} \frac{1}{\sqrt{1+\phi_{piw}^2}}$ $\phi_{piw} \equiv \frac{\sigma_z \theta_c}{2\sigma_{x,y}^*}$

50 ns spacing:
n_b: 1092 → 1380, N_b: $1.2\text{x}10^{11} \rightarrow 1.7\text{x}10^{11}$ (double batch inj.)
β^*: 1.5 → 1.0 m
total gain ~ factor 4 → **$5\text{x}10^{33}$ cm^{-2}s^{-1} at 3.5 TeV**

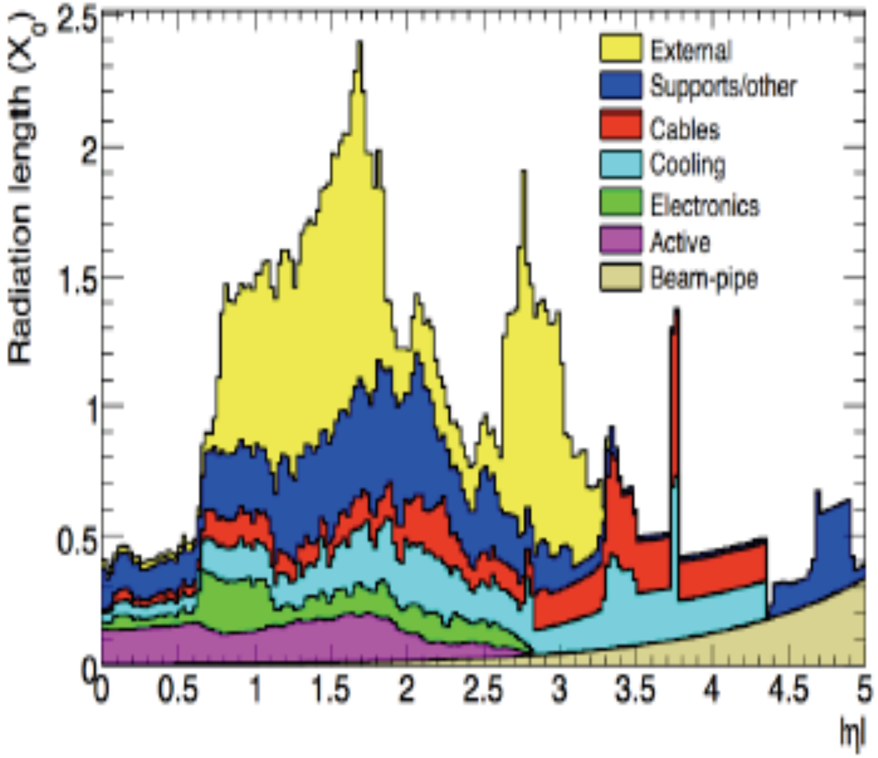
25 ns spacing (e- cloud in SPS & LHC!?):
n_b: 1092 → 2808, N_b: $1.2\text{x}10^{11}$
β^*: 1.5 → 1.0 m, $\gamma\varepsilon$: 3 μm → 4 μm
total gain ~ factor 3 → **$4\text{x}10^{33}$ cm^{-2}s^{-1} at 3.5 TeV**

another factor 4 from going to ~7 TeV (&β^*~0.5 m)
$2\text{x}10^{34}$ cm^{-2}s^{-1} at ~7 TeV does not appear impossible

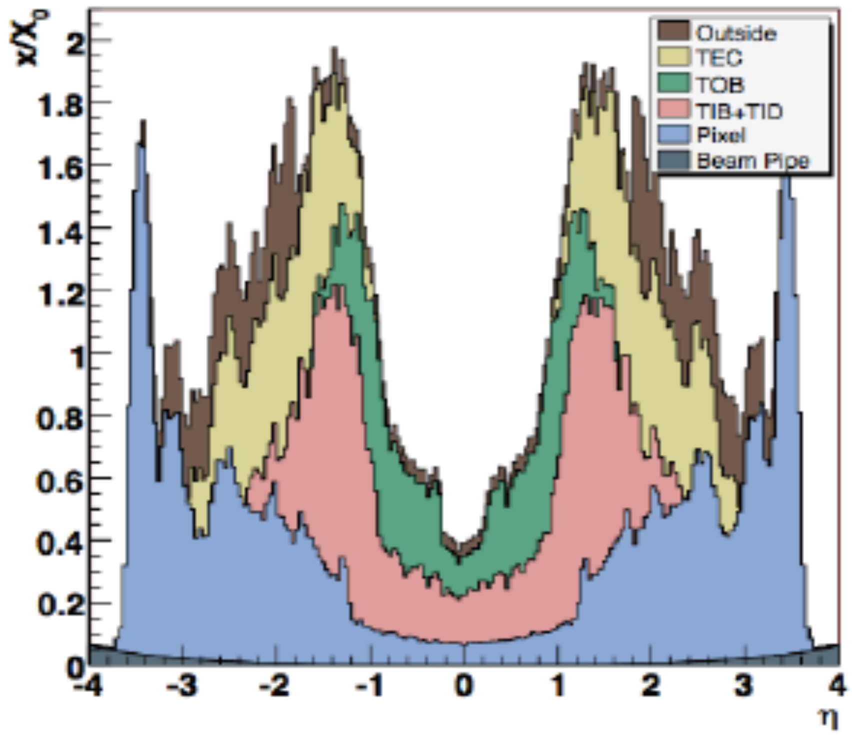
Material profile

Radiation length:

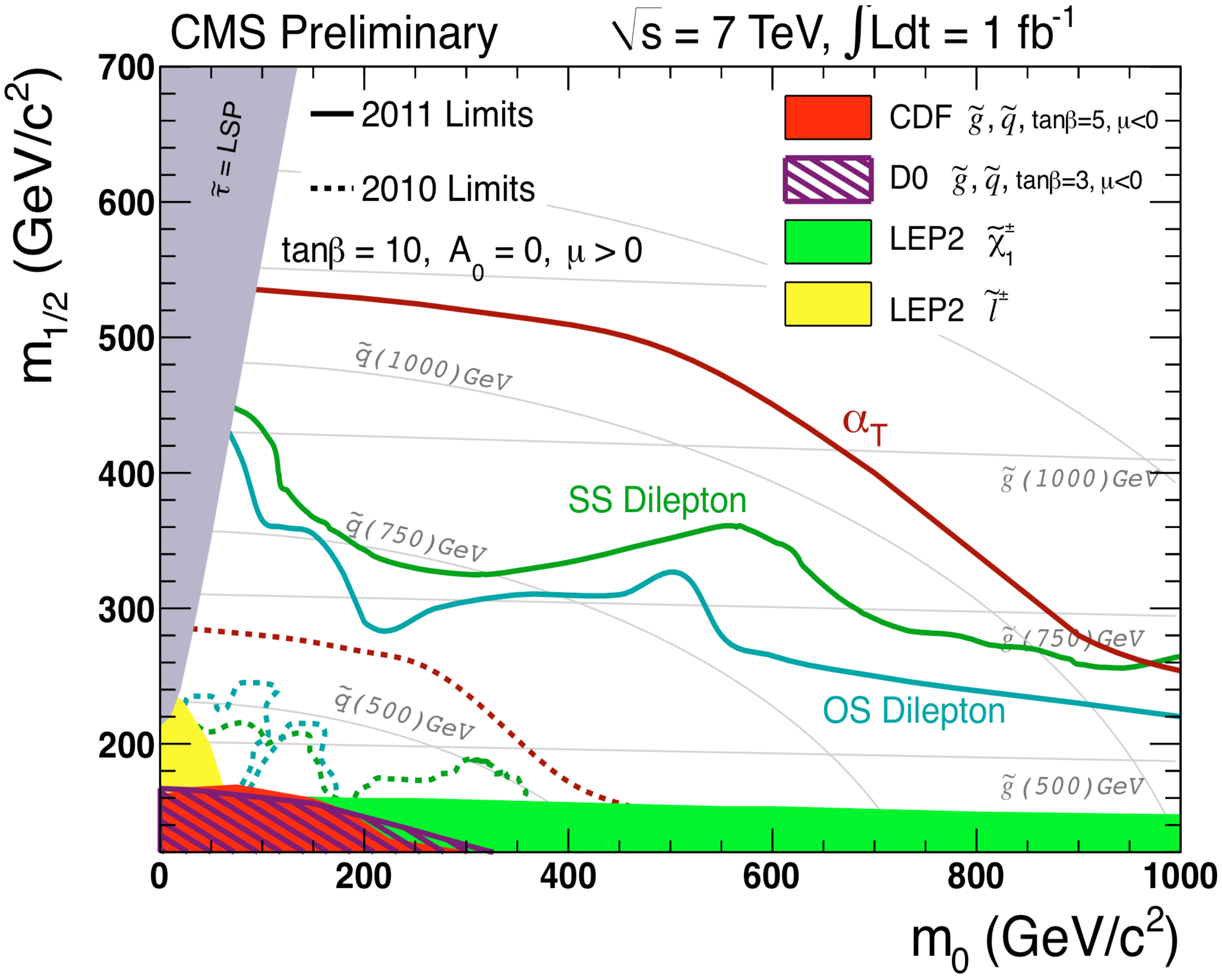
ATLAS

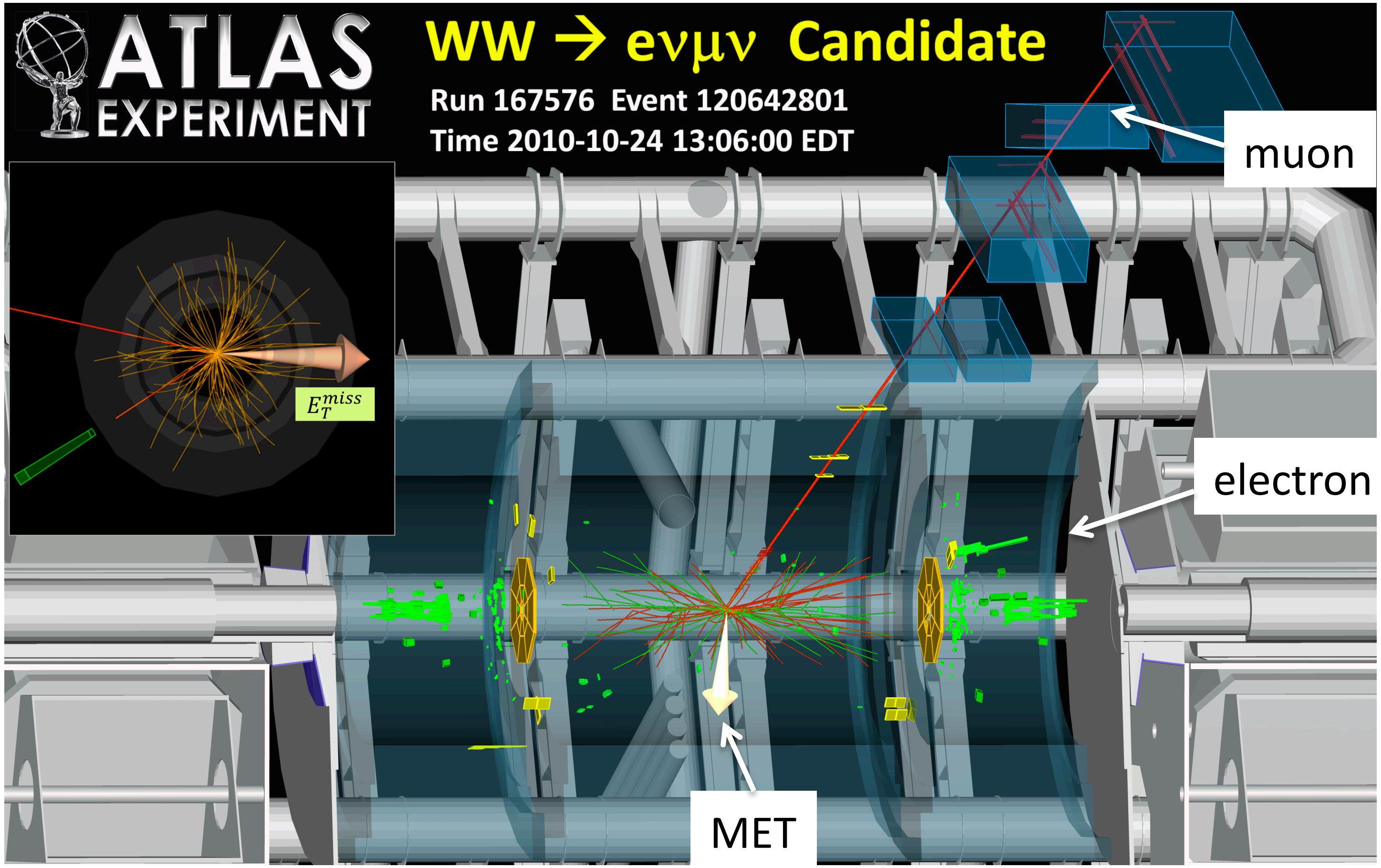


CMS



CMS SUSY result





WW → eνμν Candidate

Run 167576 Event 120642801

Time 2010-10-24 13:06:00 EDT

muon

electron

MET

High mass H -> WW -> lνqq

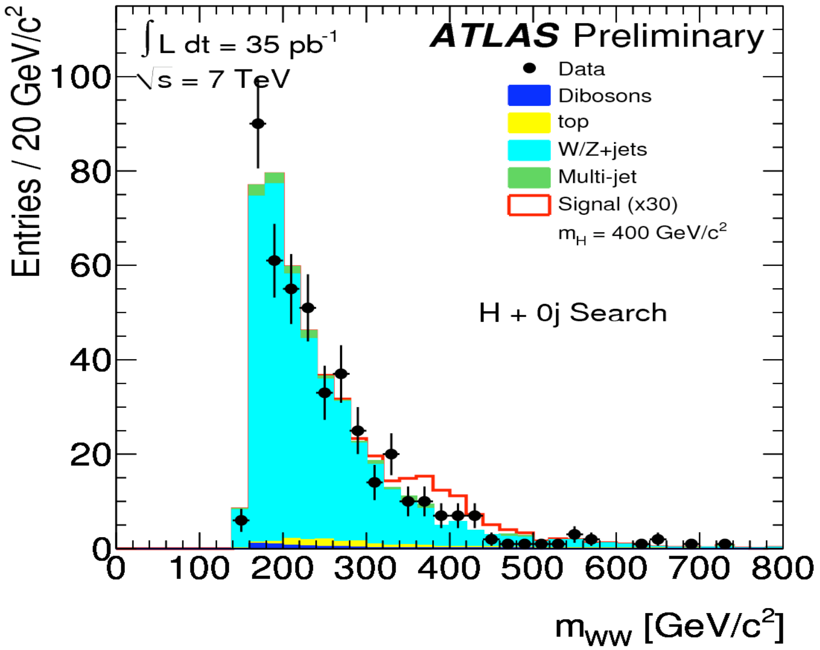
Note this channel was not in the previous Higgs sensitivity.

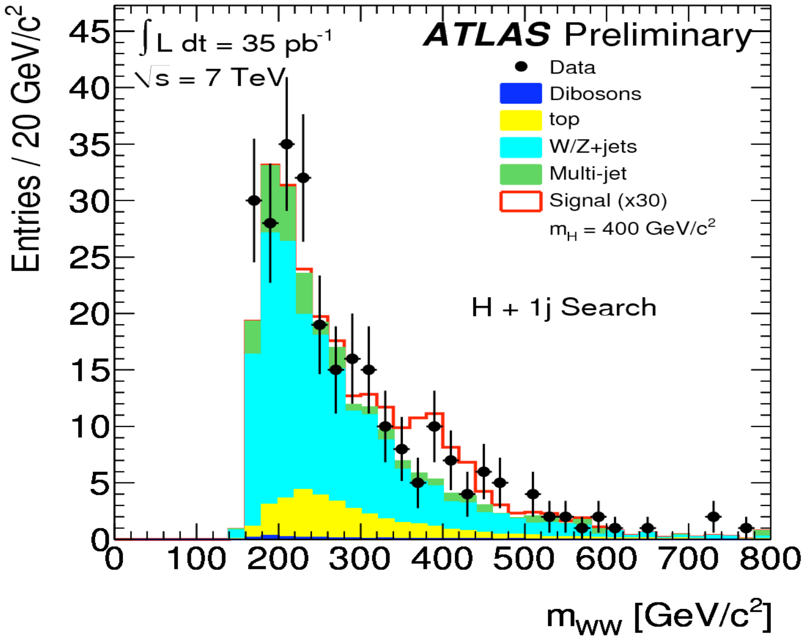
Event selection:

one lepton w/ pT>30GeV.
MET>30GeV,
n-jet >= 2, 71<m_{jj}<91GeV

Backgrounds:

W+jets / Z+jets … dominant background
di-bosons (WW/ZZ/WZ)
tt and single top





Limit is obtained by the background shape fitting (double exponential).

High mass H -> ZZ -> ll$\nu\nu$

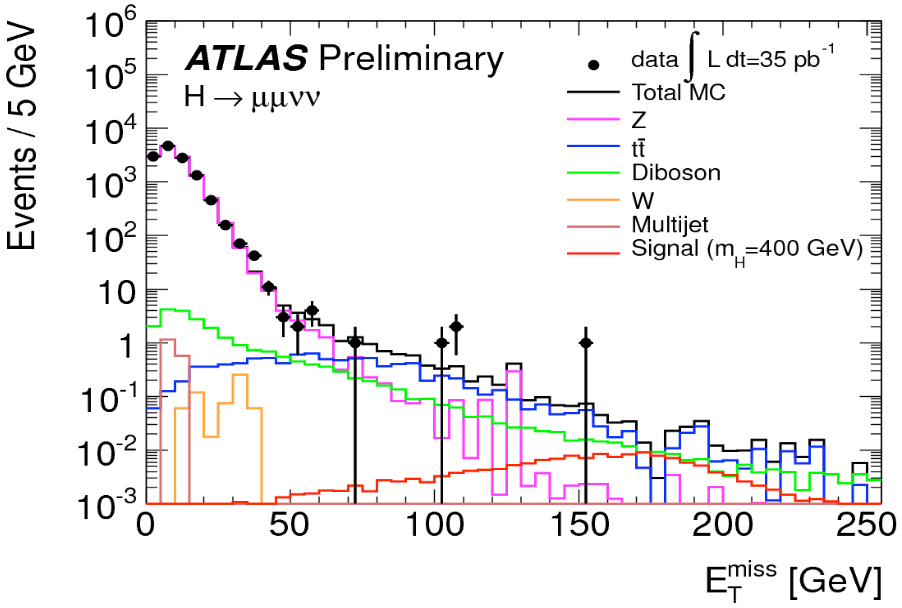
Require large MET :

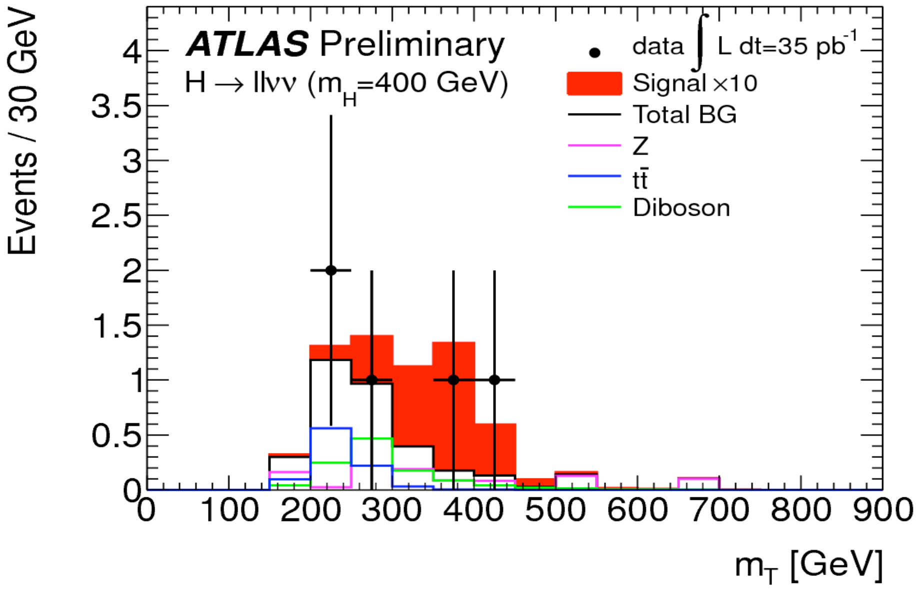
one pair of same flavor and opposite sign leptons w/ 76 < m_{ll} < 106 GeV.
MET > 66 (82) GeV, $\Delta\phi_{ll}$ <2.64 (2.25)

Backgrounds:

di-bosons (WW/ZZ/WZ) … dominant
W+jets / Z+jets
tt and single top

Significant contribution from H->WW->lνlν : 76% at m_H=200GeV, 9% at 300GeV.





5 events was observed with 3.5+-0.4+-0.8 expectation.

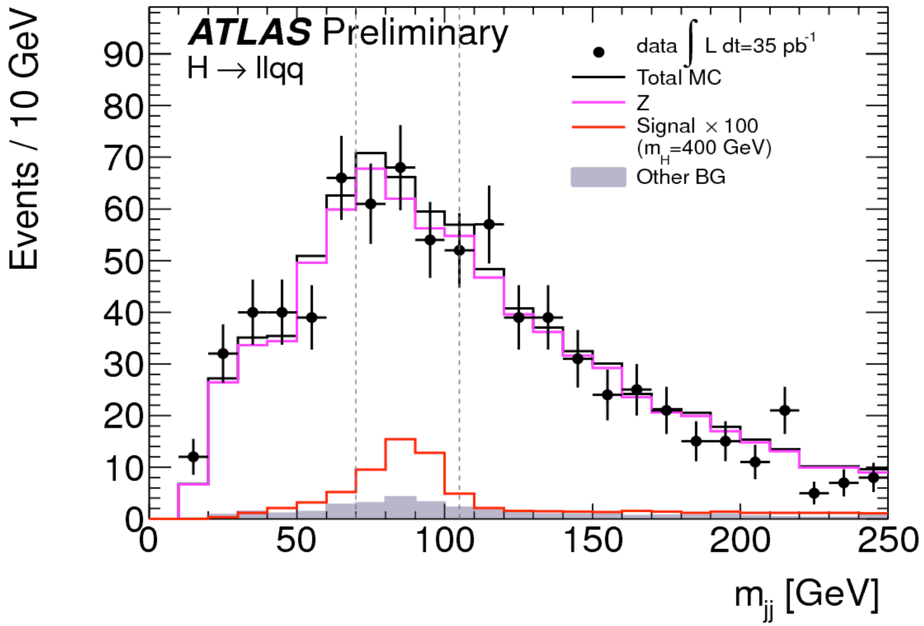
High mass H -> ZZ -> llqq

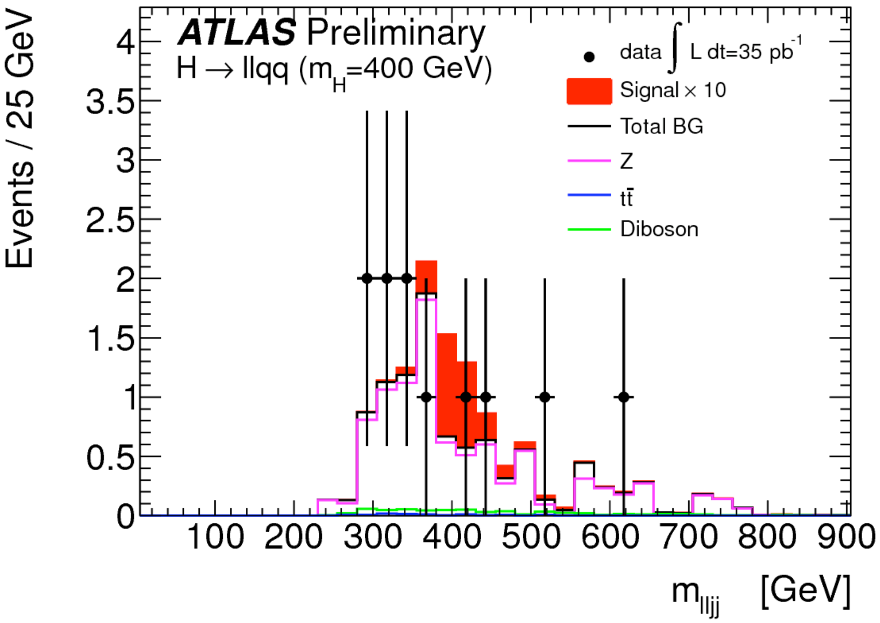
Event selection:

one pair of same flavor and opposite sign leptons w/ 76 < m_{ll} < 106 GeV.
MET < 50 GeV,
n-jets>=2, 70 < m_{jj} < 105GeV

Backgrounds:

Z+jets .... main background
di-bosons (WW/ZZ/WZ)
W+jets, tt and single top





11 events observed for 9.9+-0.9+-1.5 expectation.

MSSM H -> $\tau\tau$

Cross section: $\sigma_{MSSM} \sim (\tan\beta)^2 \times \sigma_{SM}$

Event selection:

electron pT>20GeV or muon pT>15GeV,
hadronic tau pT>20GeV,
MET>20GeV, m_T < 30GeV

Backgrounds:

$Z\to\tau\tau$ …. main background
W+jets
Z->ee/$\mu\mu$
di-boson/top