Photon-related studies @ ATLAS

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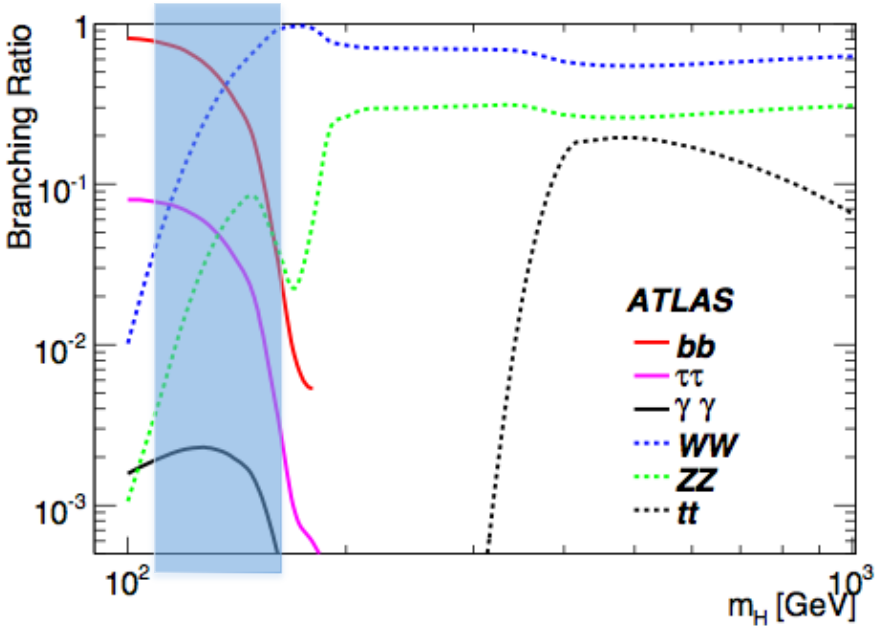
Outline

- Photon-related physics study
  - $H \to \gamma\gamma$ analysis
  - Prompt photon production
- Photon-related performance study
  - Photon trigger efficiency measurement
  - Results from 900GeV data
- Conclusion

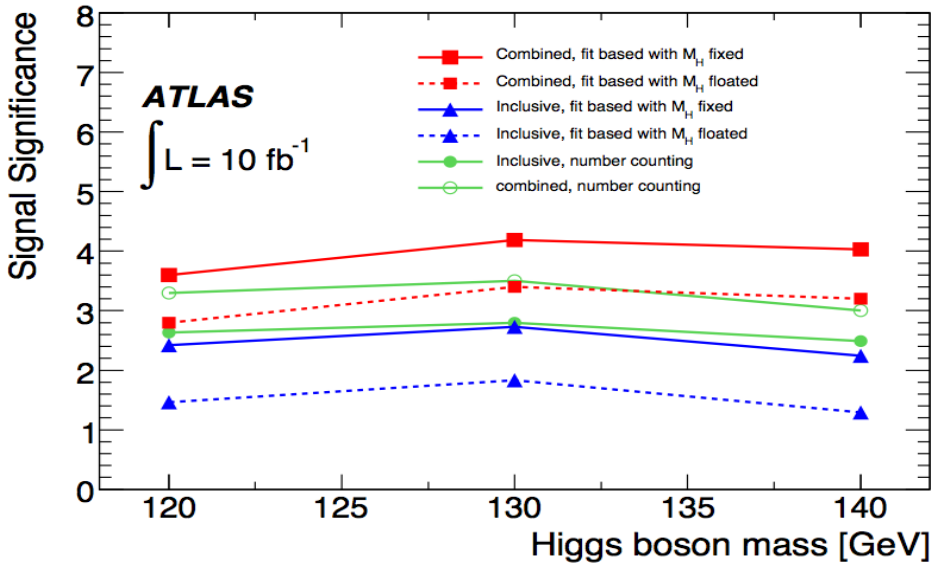
H→γγ analysis



- This is one of the most promising discovery channels for a SM Higgs search in low mass region.
- Simple signature.
- Very good mass resolution(~1.5GeV)

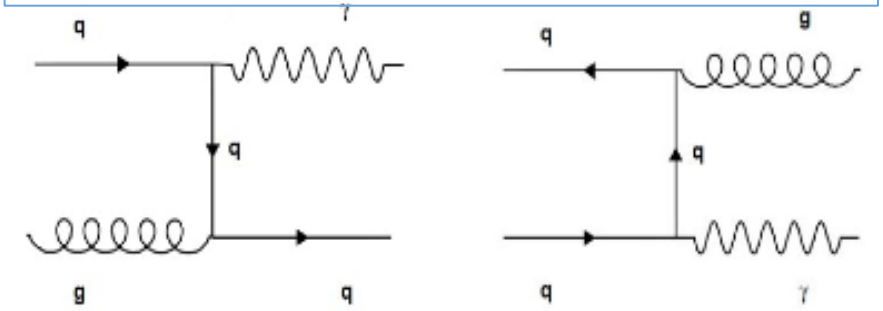
H→γγ inclusive analysis @10TeV has been performed. Result was extrapolated to 7TeV. (not public) I was involved in this inclusive analysis, and mainly contribute to the study of signal efficiency and final fit.

CSC result @ 14TeV

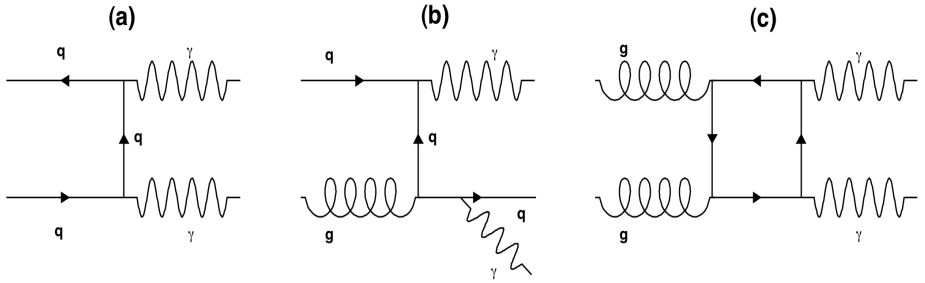


Prompt photon production

- Single prompt photon production:



- Double prompt photon production:



Importance:

- Main background for H $\rightarrow \gamma\gamma$
- Prediction tests of perturbative QCD.
- Contributes significantly to the measurement of gluon distribution in hadrons.
- Use to calibrate Jet/MET objects

In order to get a precise measurement of photon production. It is important to know various photon efficiencies. Here I mainly talk about photon trigger efficiency measurement.

$$\sigma_\gamma = (N_{obs} - N_{bkg}) / (\alpha_\gamma \cdot \varepsilon_\gamma \cdot L)$$

$$\varepsilon_\gamma = \varepsilon^{ID} \cdot \varepsilon^{iso} \cdot \varepsilon^{trig}$$

α_γ : detector acceptance

L : integrated luminosity of data sample

Proposed First Physics Trigger Menu 10^{31} for photon

e/gamma Primary trigger

Trigger	EF Rate*	Prescaled	Motivation
2e5_medium	1.5 ± 0.5 Hz	no	J/ψ, Y, Drell-Yan
e10_medium	15 ± 2 Hz	no	b/c, DY, Z→ττ
e20_loose	4 ± 1 Hz	no	W, Z, top
em105_passHLT	<1 Hz	no	exotics
g20_loose	4 ± 1 Hz	no	direct photon

- Primary : g20_loose
- Supporting:
  - g10_loose
  - g20i_loose
  - 2g20_loose
- Commissioning: 2g10_loose
- Back-up: g25_loose

Photon trigger efficiency measurement

- Definition: $\varepsilon = \frac{tight\ selected\ reco\ \gamma\ matching\ with\ g20\_loose\ trigger}{tight\ selected\ reco\ \gamma}$

  marginal trigger efficiency with respect to the offline photon selection.

- Difficulty:

  For the long term with high statistics, Z→γee, Z→γμμ events could be used. But with low luminosity, no good way to select high purity photon sample.

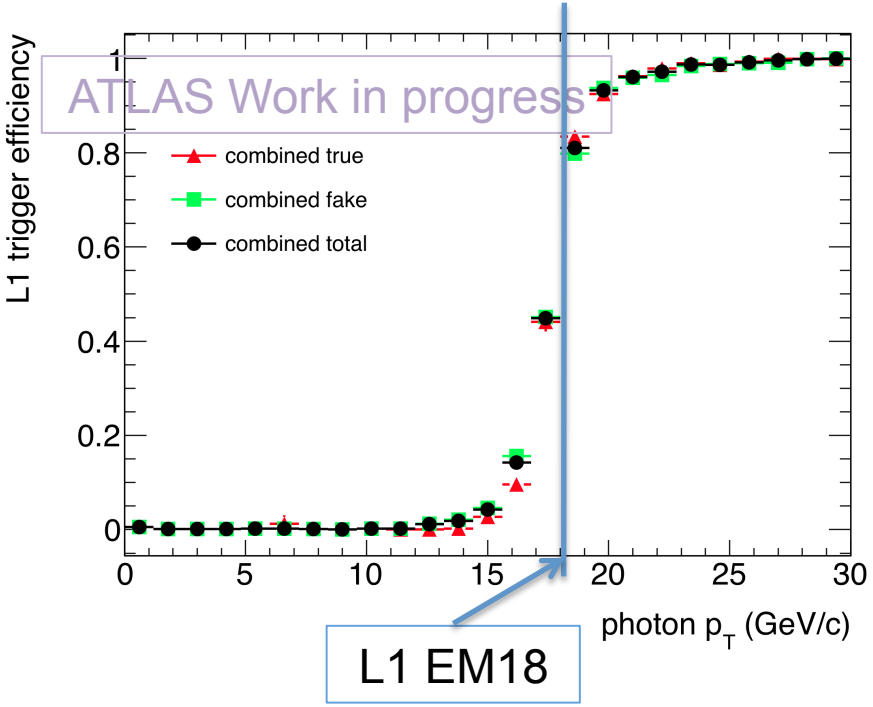
- Possible Methods :
  - Electron to photon extrapolation
    - Select pure electron sample from Zee
  - "tag & probe" method
    - Select events with at least two offline photons passing single photon trigger
    - One photon considered as "tag" photon and the other to be "probe"
  - Bootstrap
    - select events with leading photon passing lower threshold trigger
    - Measure the photon trigger efficiency with this photon

Assumption:

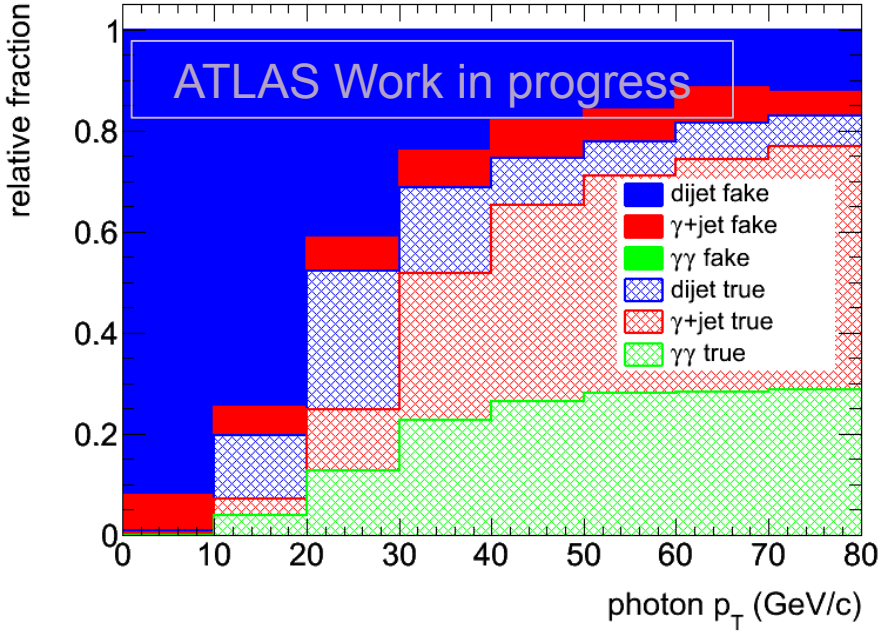
low purity photon samples, $\varepsilon = w_s\varepsilon_s + w_b\varepsilon_b$ if fake/true behave the same after tight offline selection $\varepsilon_s \doteq \varepsilon_b$, $\varepsilon = \varepsilon_s = \varepsilon_b$.

example of “tag&probe” method

True/fake efficiencies are close.



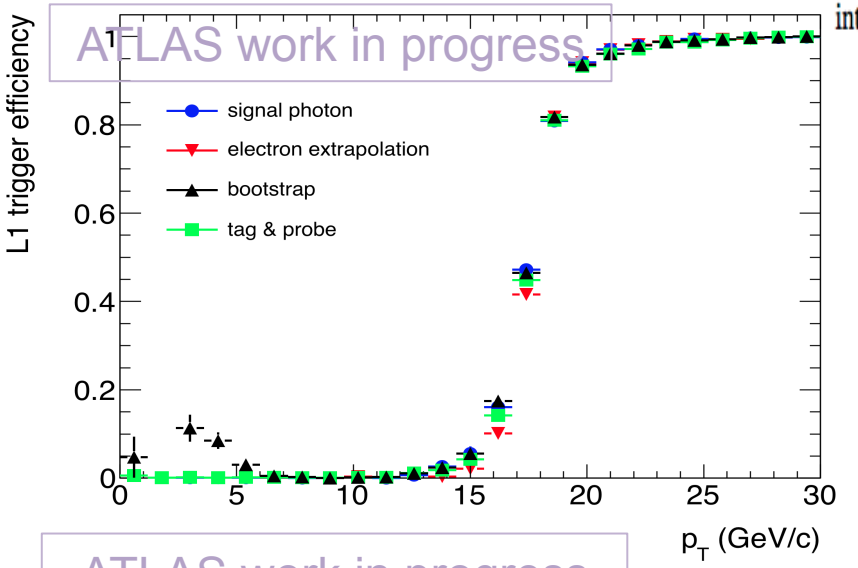
Purity at the turn-on region is 20%~40%.



Efficiency for photons above 25GeV is almost 100%.

Similar agreement with MC truth also obtained at High Level triggers.

Three methods comparison
electron extrapolation, “tag&probe”, bootstrap



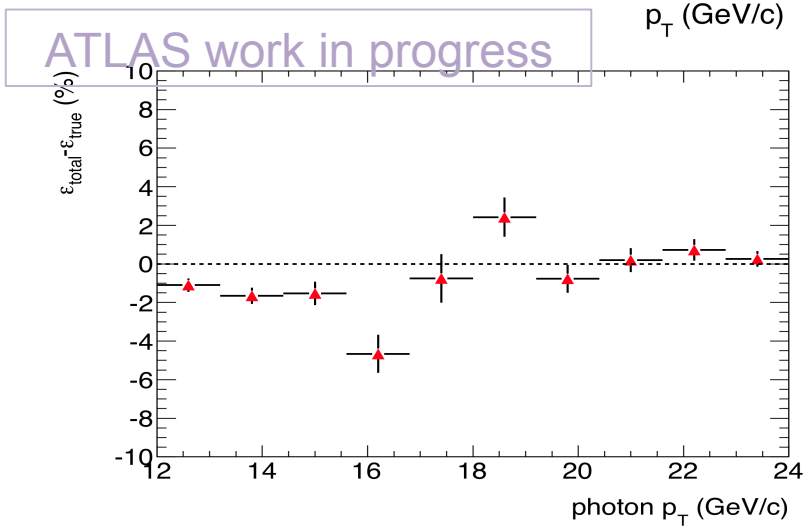


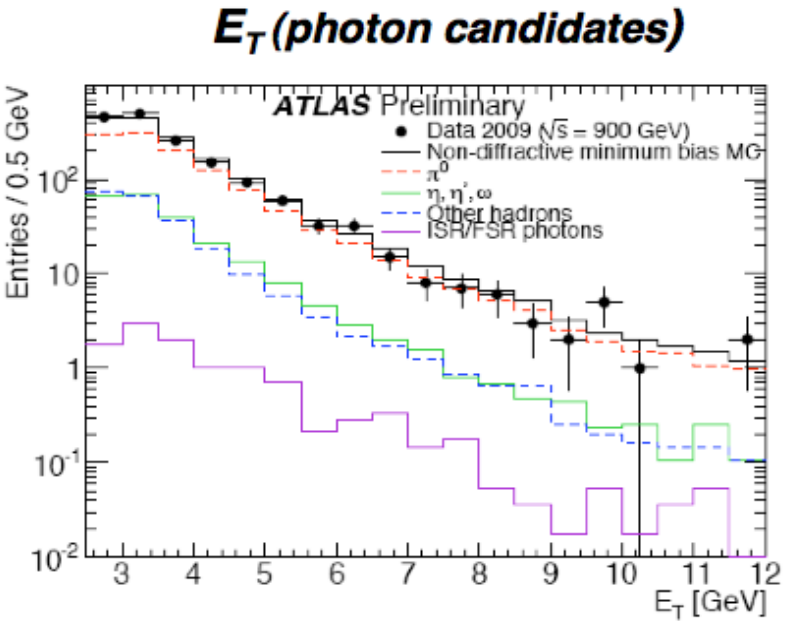
Table 31: Estimated number of photon candidates expected for each method as a function of p_T with an integrated luminosity of 20 pb^{-1}.

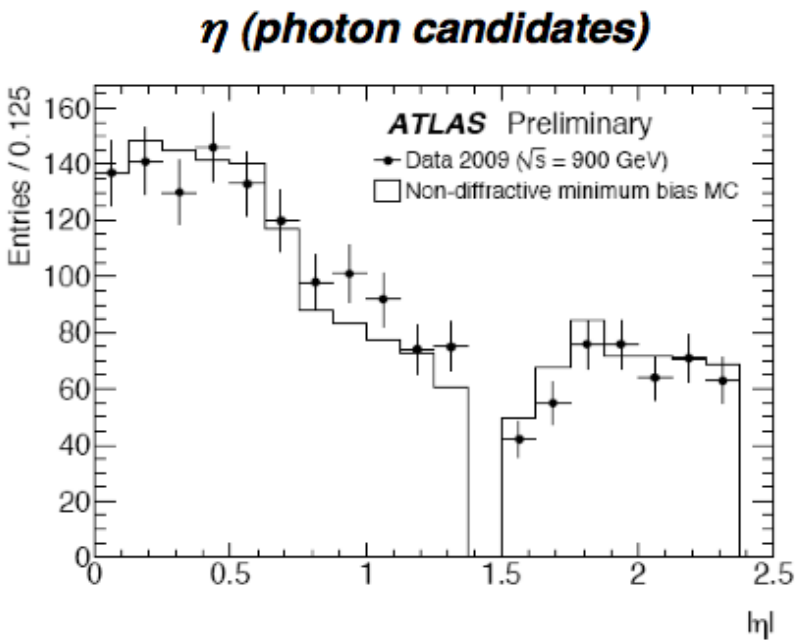
Method	Photon p_T [GeV/c]		
	< 14	$14-20$	> 20
tag&probe	24372 ± 387	5556 ± 129	5489 ± 223
bootstrap	$(44.0 \pm 0.3)10^5$	$(37.2 \pm 0.5)10^5$	$(33.4 \pm 1.0)10^5$
extrapolation	32 ± 7	136 ± 21	6302 ± 93

The efficiencies from the three data-driven methods agree well with MC truth.
Bootstrap method select a sample with low purity, but can offer a high statistics. First to be tried on the data.
Extrapolation method can not offer a good check at the low luminosity.

The systematic uncertainty for the three methods at the turn-on region is at the level 2%~4% on average.
All results summarised in the internal note [ATL-COM-PHYS-2010-113]

Results from 900GeV (1)





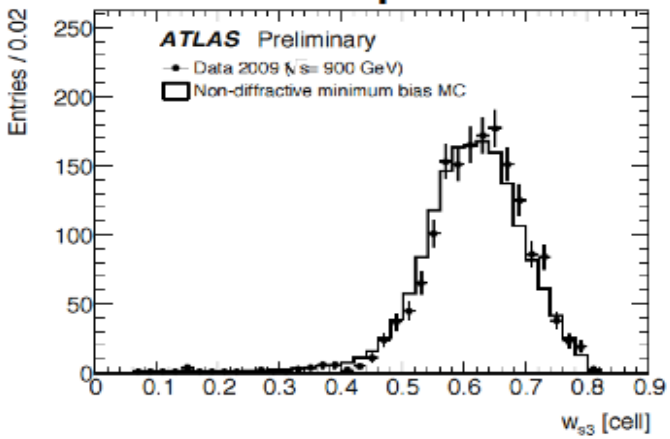
The Monte Carlo sample is sub-divided in this case into four components:

* Approximately 71% of the candidates correspond to photon from π^0 decay.
* An ~14% are from η, η', ω.
* An ~14% are from hadrons with complex decay process and particles interaction in the tracker material.
* Only a very small fraction of ~0.7% of all photon candidates are expected to be "prompt" at these energies .

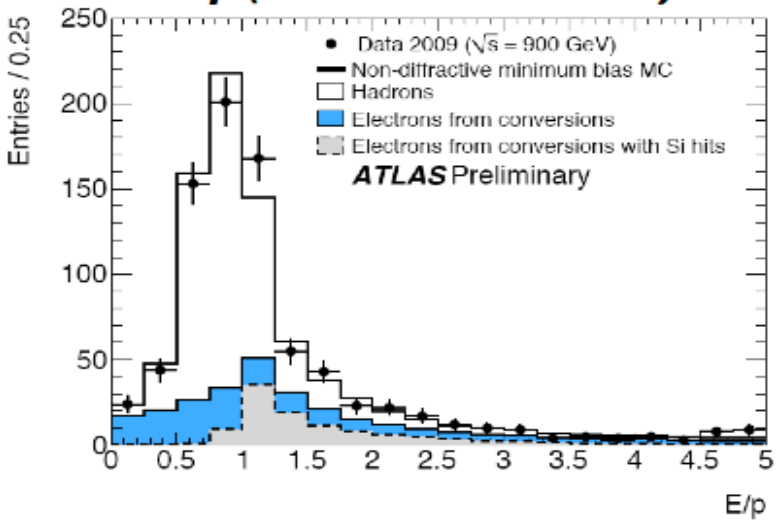
From Rencontres de Moriond EW 2010.

Results from 900GeV (2)

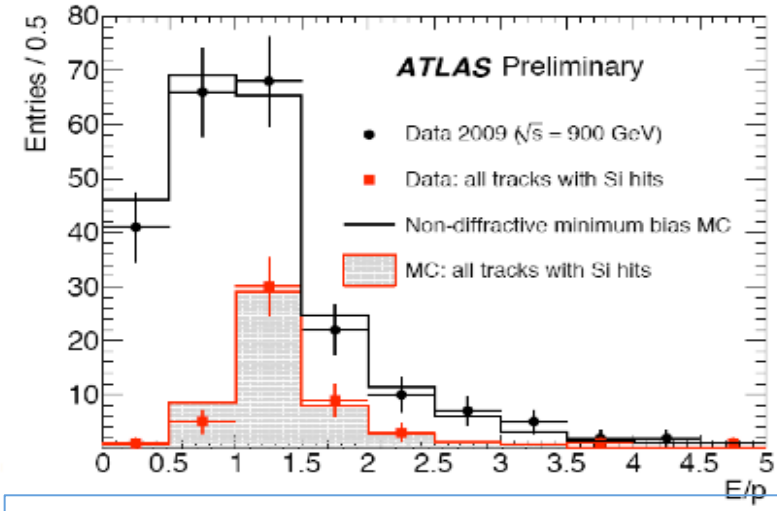
Shower width for three strips around maximum strip



E/p (electron candidates)



E/p (converted photon candidates)



From Rencontres de Moriond EW 2010.

Results from 900GeV (3)

Special calibration based in Longitudinal Weight , reconstruction seeding cluster

$E_T^{cluster}$>300MeV

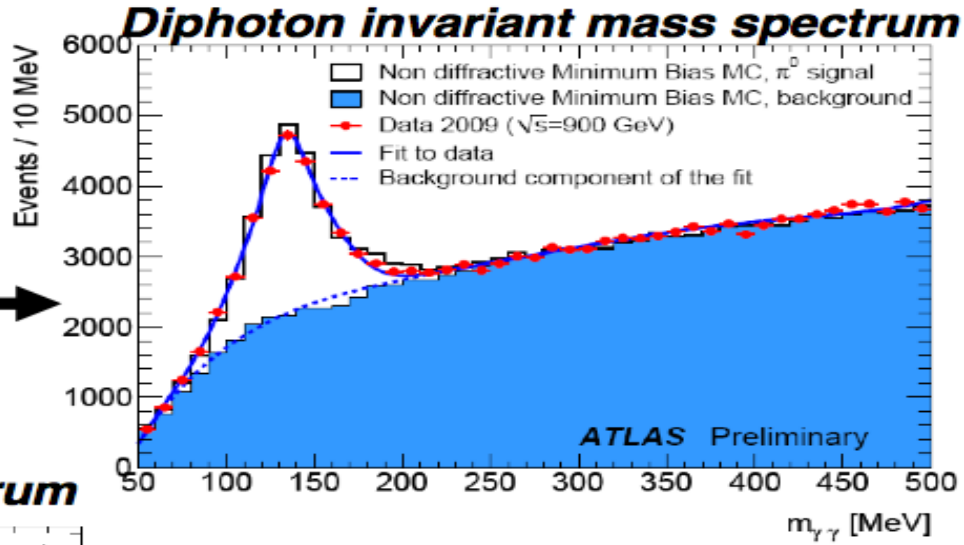
selection cuts:

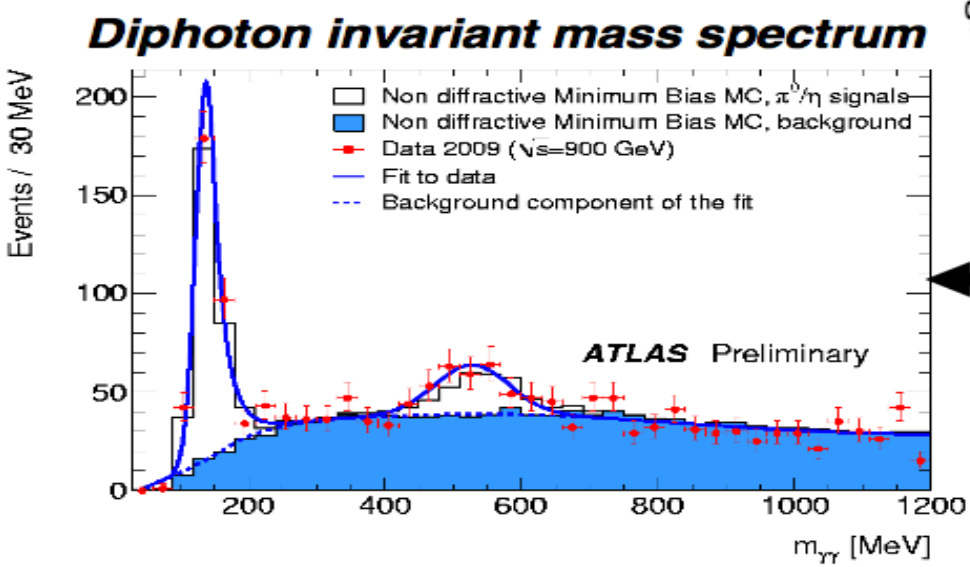
$E_T^{cluster}$>400MeV, p_T^{pair}>900MeV

$$m_{\pi^0}^{Data} = 134.0 \pm 0.8_{(stat)}\ MeV$$

$$m_{\pi^0}^{MC} = 132.9 \pm 0.2_{(stat)}\ MeV$$

$$m_{\pi^0}^{PDG} = 134.9766 \pm 0.0006\ MeV$$





Selection cuts (tighter):

$E_T^{cluster}$>800MeV, p_T^{pair}>2200MeV, track veto applied.

$$m_{\eta}^{Data} = 527.0 \pm 11.0_{(stat)}\ MeV$$

$$m_{\eta}^{MC} = 544.0 \pm 3.0_{(stat)}\ MeV$$

$$m_{\eta}^{PDG} = 547.853 \pm 0.024\ MeV$$

d EW 2010 13

From Rencontres de Moriond EW 2010.

Conclusion

- Three methods have been developed for the photon trigger efficiency measurement.
  Waiting for data to test those methods.
- Results from 900GeV data has shown a nice agreement between Data/MC.
- With the 7TeV data increasing, more and more exciting results will be produced.