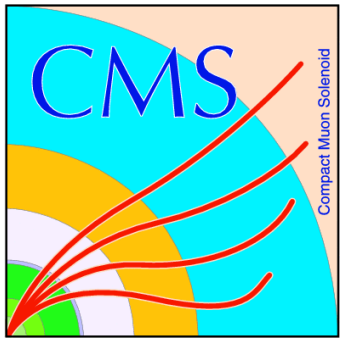


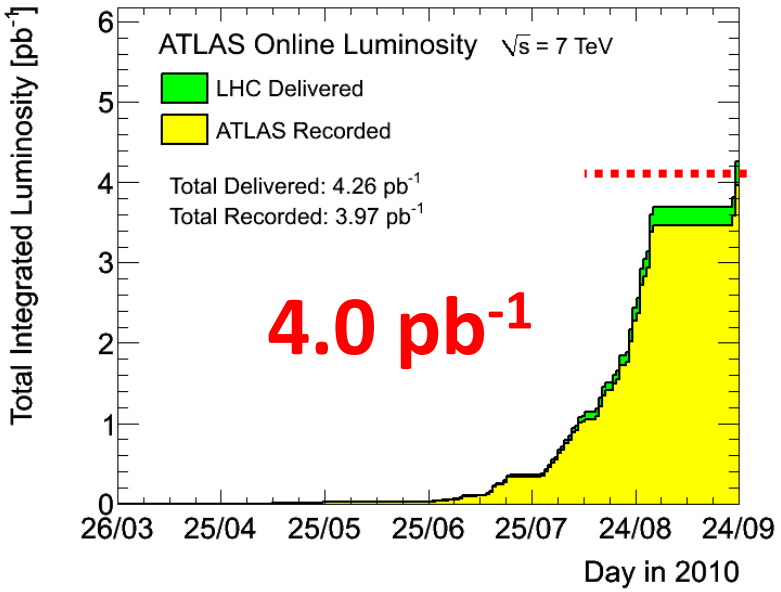
Higgs searches at the LHC

Koji Nakamura(Univ. of Tokyo)

On behalf of CMS and ATLAS collaborations

Introduction

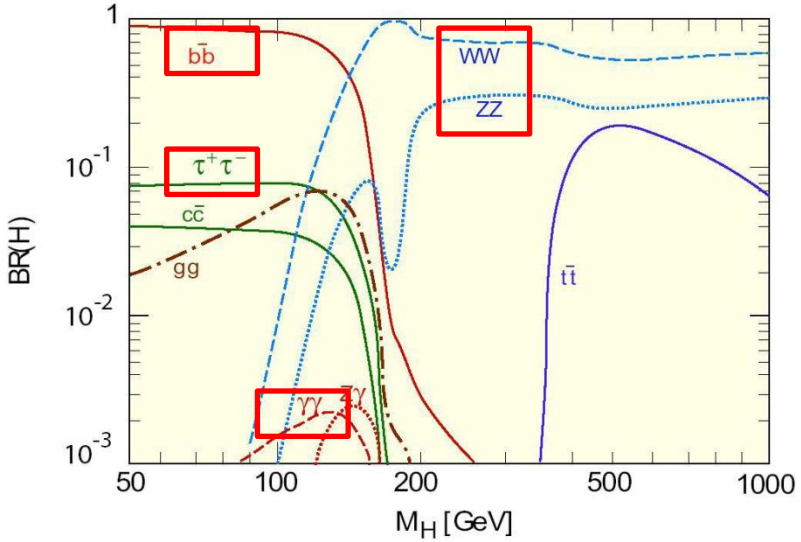
LHC operation
Recorded 4.0 pb^{-1} data in 7TeV
Expected o(100pb^{-1}) in 2010
1 fb^{-1} by the end of 2011

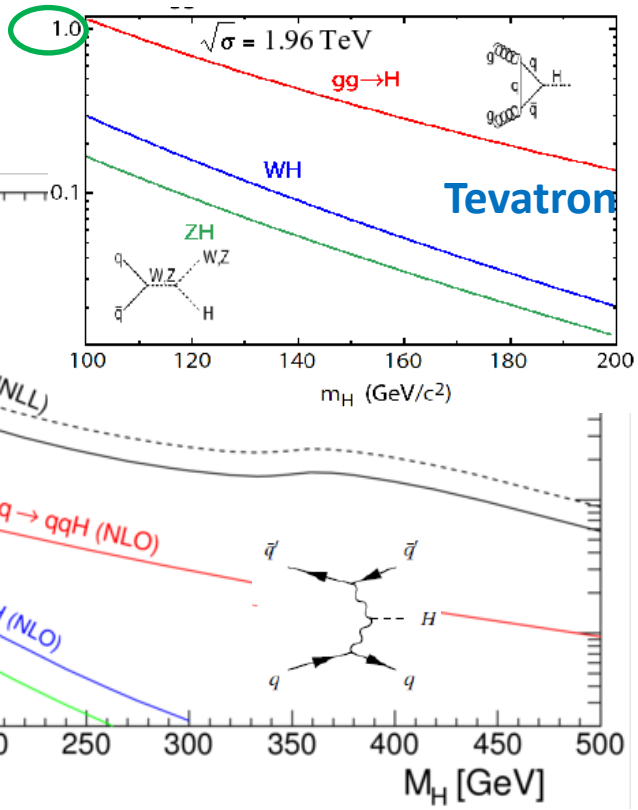


- **1 fb^{-1} Sensitivity prospect**
  - Evaluated by cross section scaling from 10/14 TeV study with full simulation. Not optimized to 7 TeV.
- **Background study with real data**
  - Performance of final state particles and data driven background estimations are performed using current luminosity of data. Especially for the fake background.

Standard Model Higgs Boson

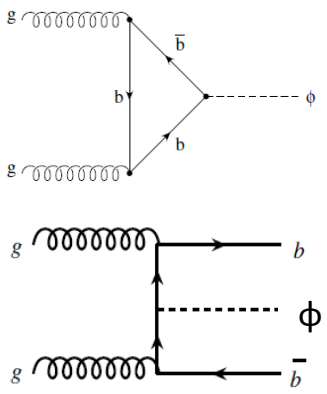
- gg→H production dominates for all Higgs masses.
  - 10 times larger cross section than Tevatron
  - Need clean final state i.e. photons/leptons(γγ,WW,ZZ,ττ)
- VBF qq→qqH production is promising for the low mass region.
  - High pT forward jets can be tagged (γγ,ττ)
- Small WH/ZH cross section against background.
- Branching ratio:

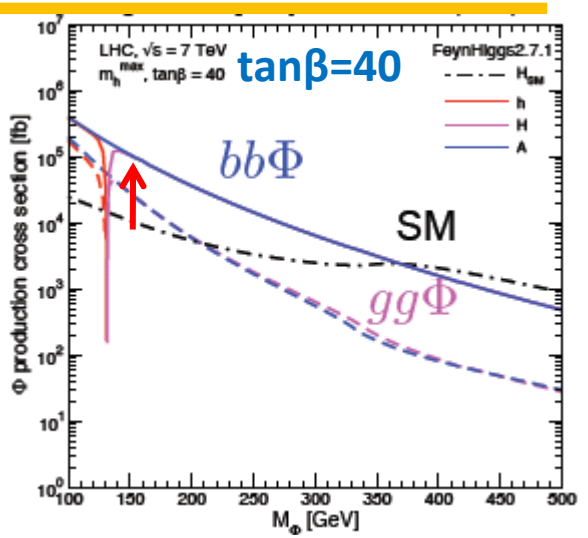


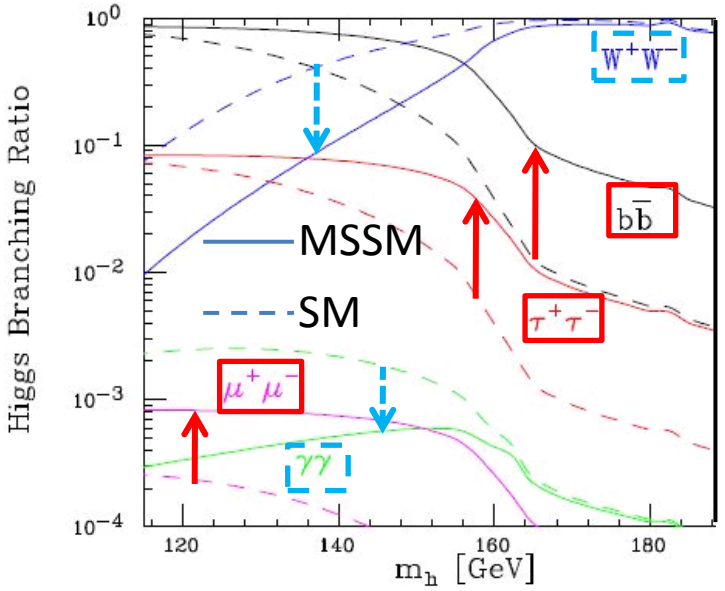


MSSM scenario

- Super symmetric models extend Higgs sector
  - ϕ=(H,A,h), and H±
  - Two parameters at tree level (tanβ,M_A)
- Signature at LHC
  - production:
    - gg→ϕ, bb→bbϕ dominant
    - 10 times larger cross section than SM (tanβ~40)
  - Branching ratio :
    - 90% bb, 10% ττ -- enhanced
    - WW and γγ are suppressed
    - μμ is also promising by clean signature and good mass resolution
  - need clean final state: i.e. ττ







What can we see at a first fb^{-1}?

What can we see at a first fb^{-1}?

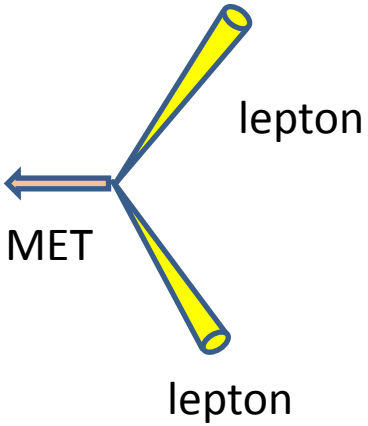
H→WW→lνlν

- Dilepton with large MET
- Main background is SM WW

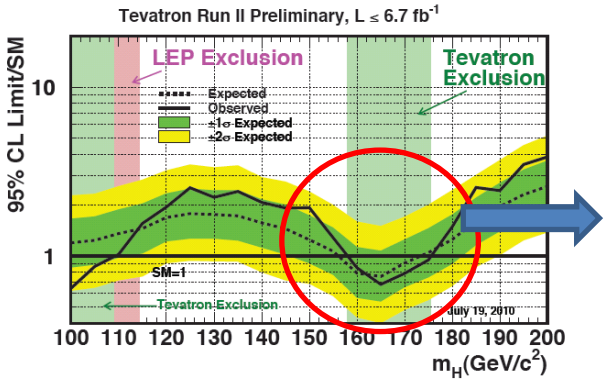
Estimated number of events at 1fb^{-1}

M_H (GeV)	160
SM WW	55.2
top	14.0
W+jets	5.6
Total background	74.8
Signal	39.5

Only 1,2 jet



- One fake lepton background is not negligible
  - need data-driven background estimation

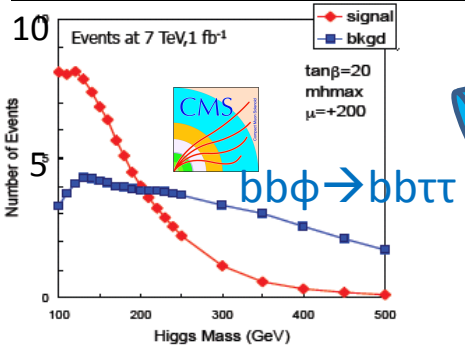


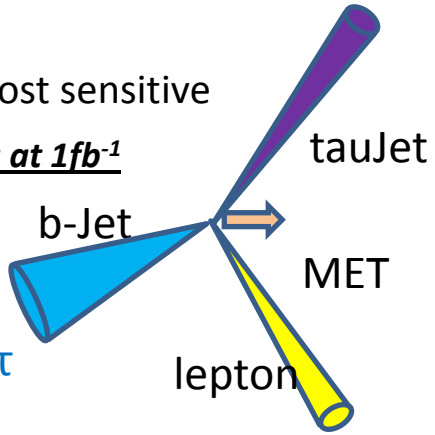
LHC 1fb-1 ?

MSSM H→ττ

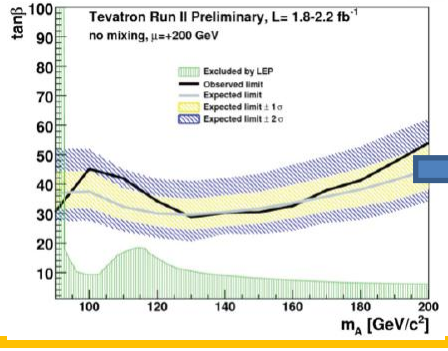
- Lepton + Tau + MET
- ττ→lepton hadron is most sensitive

Estimated number of events at 1fb^{-1}





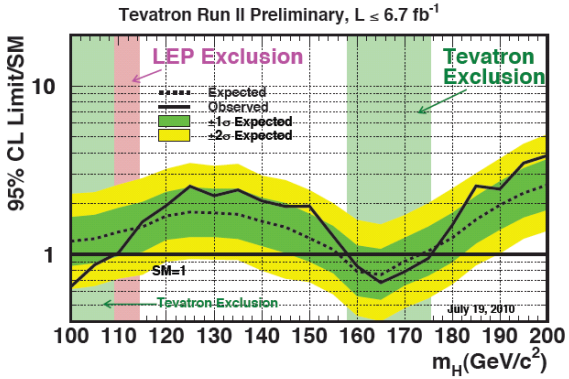
- With B-tagging analysis: background is tt and Z+HF
- W/o B-tagging : Z+jets and fake(W+jets,QCD)
  - need data-driven background estimation

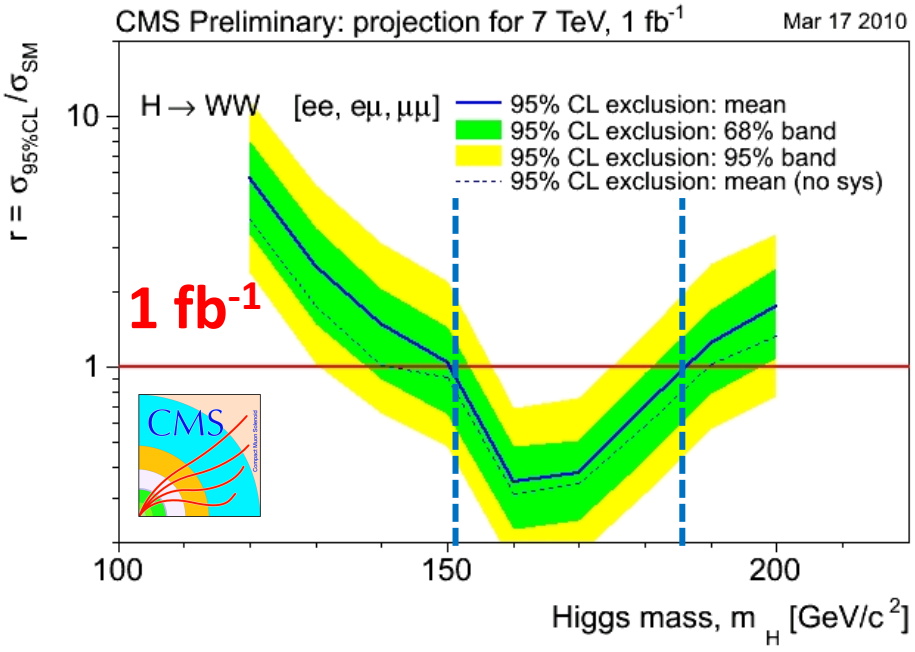


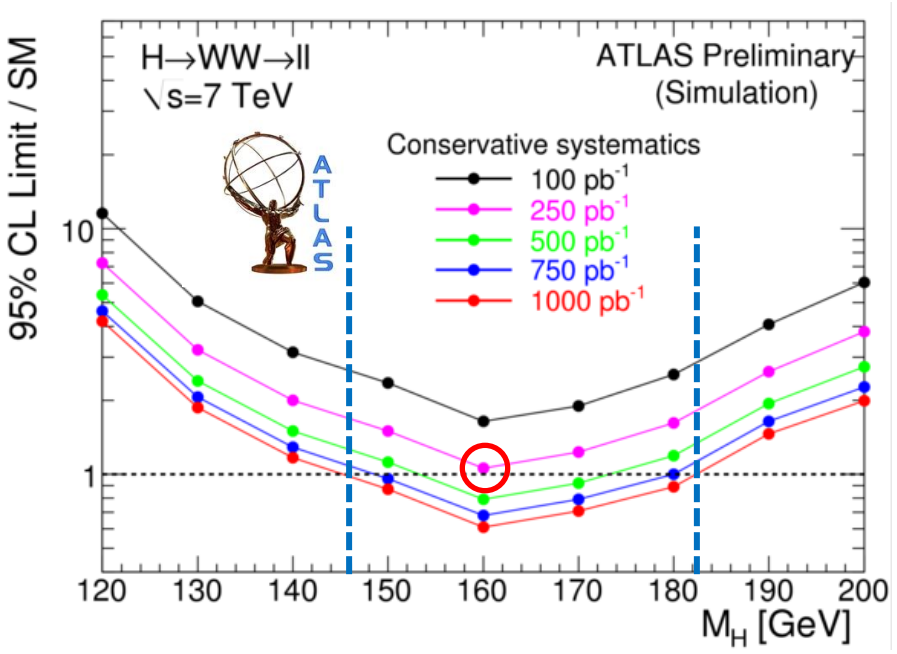
LHC 1fb-1 ?

H→WW→lvlv(Simulation)

- Di-lepton final state with large missing energy
- CMS result
  - using Neural Network for the event selection.
  - Counting experiment on the high output region
- ATLAS result
  - Cut based counting experiment.
  - estimated limit by 250pb^{-1} Luminosity steps







Performance Study for H→WW

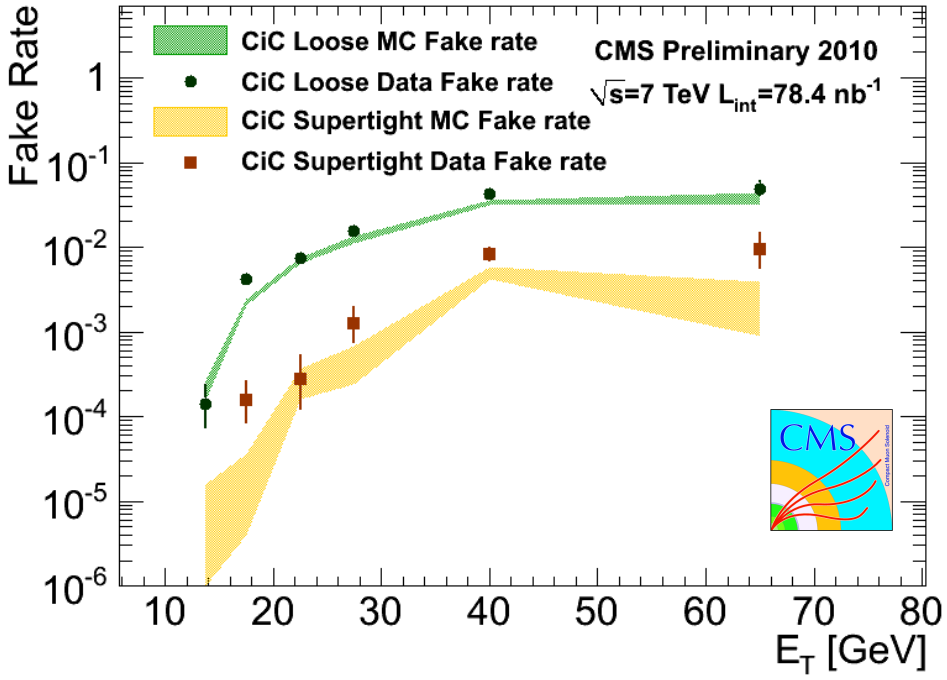
Performance of W + fake lepton will be estimated by data driven way.

e.g. # of Fake bkg = [W + fake candidate] x [Fake rate]

Fake rate should be calculated "IDed lepton" divided by "fake candidate" by jet data.

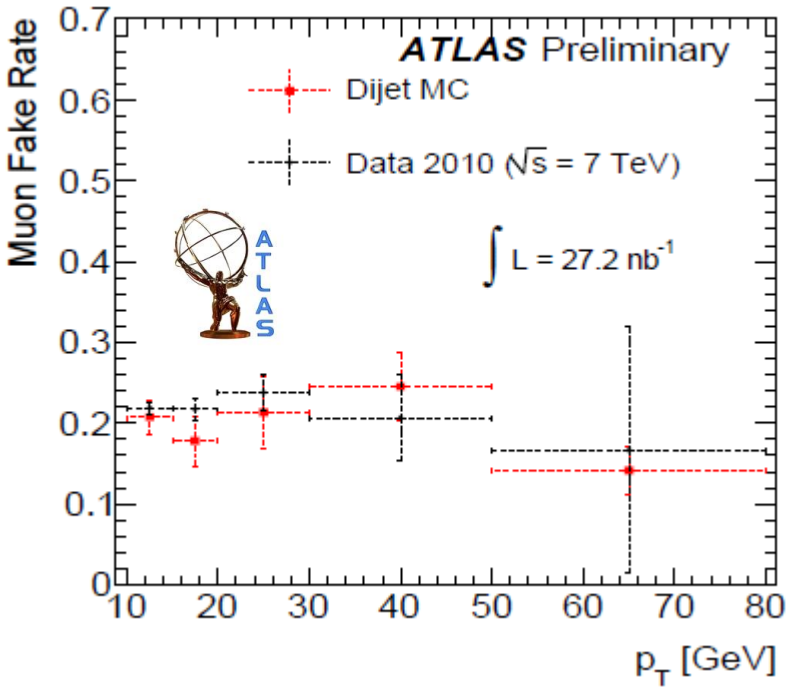
Electron Fake rate

$$\text{Fake Rate} = \frac{\text{Identified electron candidate}}{\text{Reconstructed electron candidate}}$$



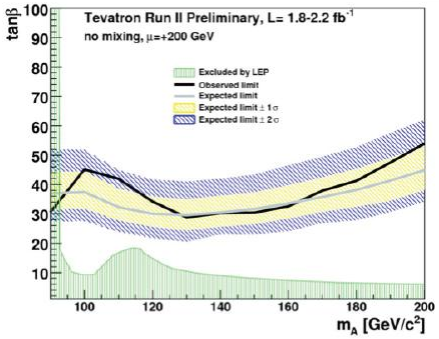
Muon Fake rate

$$\text{Fake Rate} = \frac{\text{Identified muon candidate}}{\text{Non-isolated muon candidate}}$$

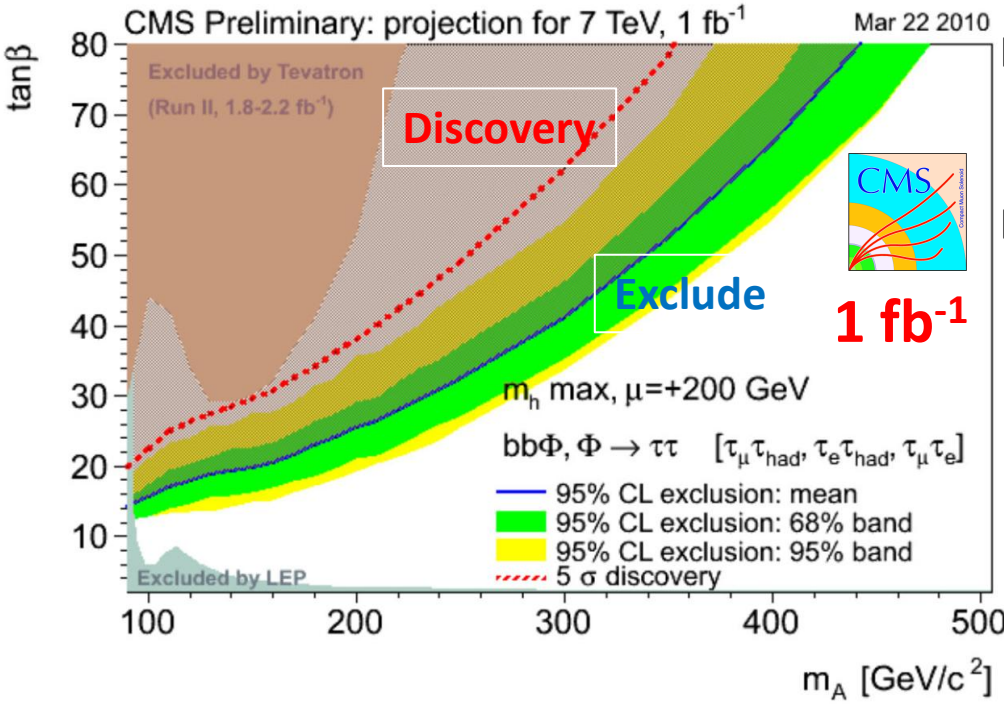


MSSM A/h/H→ττ

- Isolated pairs of ($\tau_{had}\tau_{\mu}$), ($\tau_{had}\tau_{e}$), ($\tau_{\mu}\tau_{e}$)
- With MET, 1 tagged bjet, veto extra jets
- Build ττ-mass using collinear approx*
- Dominant background : tt, Z+bb & Z+cc



*direction of the τ approximated by direction of visible decay product



Discovery :

We have chance to discover MSSM Higgs, at the region not excluded by Tevatron!!

Exclude :

Can be excluded

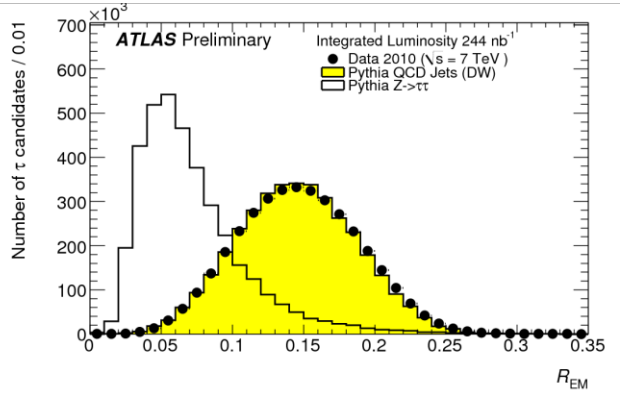
$\tan\beta>18$ @ $M_A=120$ GeV

$\tan\beta>40$ @ $M_A=300$ GeV

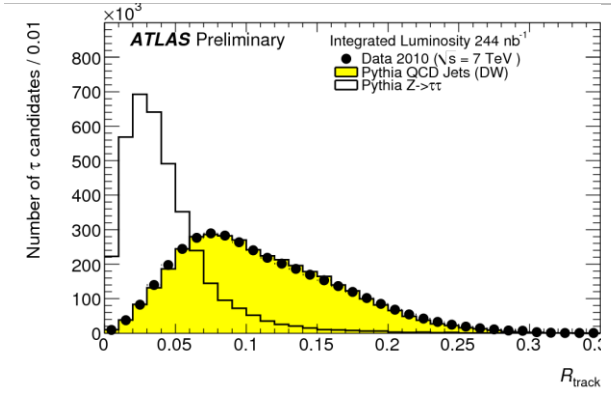
Optimized analysis for 7TeV is on-going by ATLAS and CMS with real data.

Need to consider fake bkg by relaxed event selection.

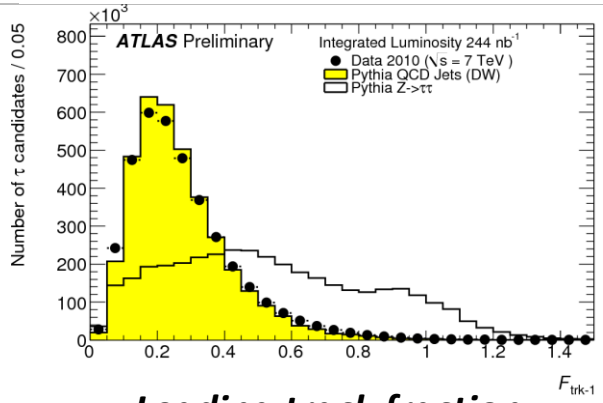
Performance Study for H→ττ



Electromagnetic radius : E_T weighted shower width in EM calo

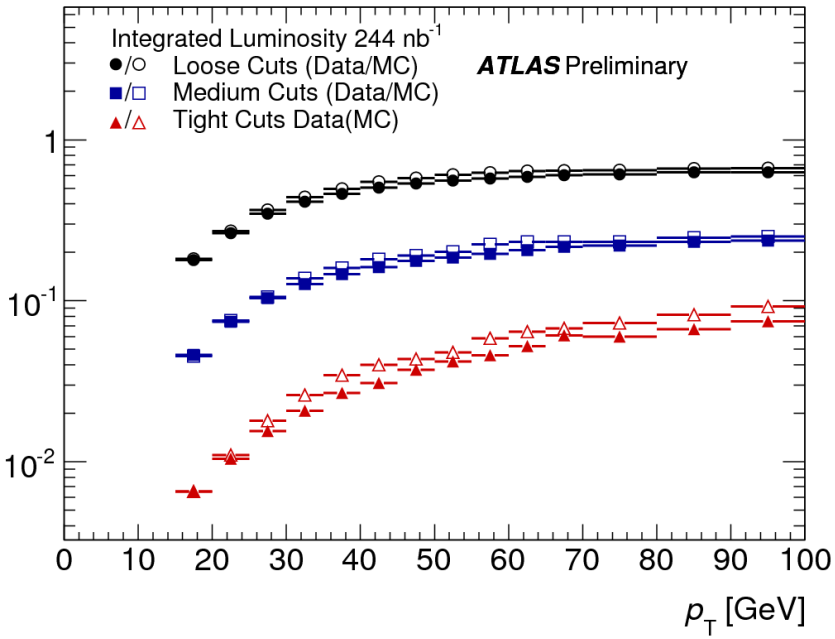


Track radius : p_T weighted track width



Leading track fraction: Momentum fraction of leading track

- Cut based tau id uses three variables.
- Three selections according to signal efficiency.
  Tight :30%, Medium: 50%, Loose: 60%
- Different cuts are applied for tau candidates with Ntrk=1 and Ntrk≥1.



Background Efficiency (fake rate) is estimated by data.

Other significant contributions and combination

γγ and ZZ results from CMS

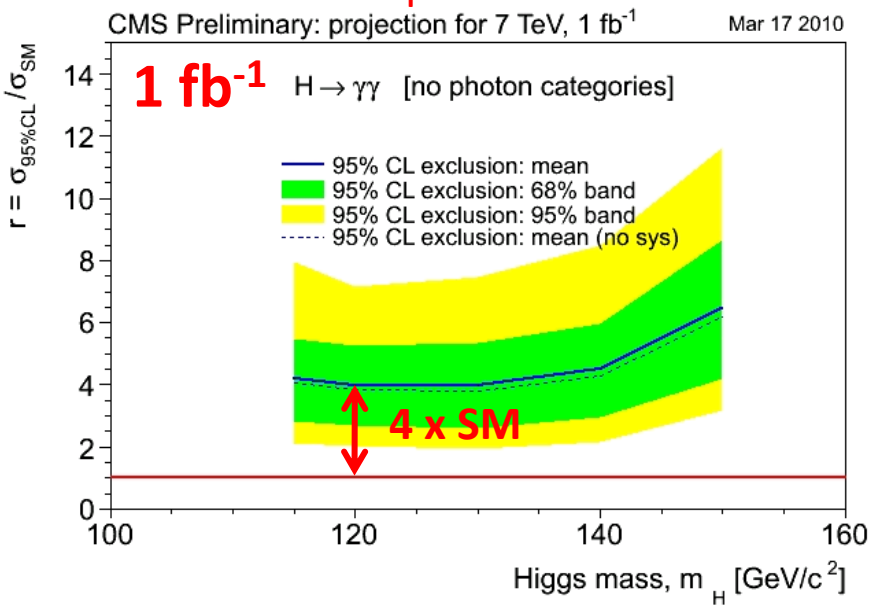
H→γγ

Conservative option:

No reconstructed photon categories

Simple counting events in mass window

⇒ Will be improved with photon category or MVA techniques.

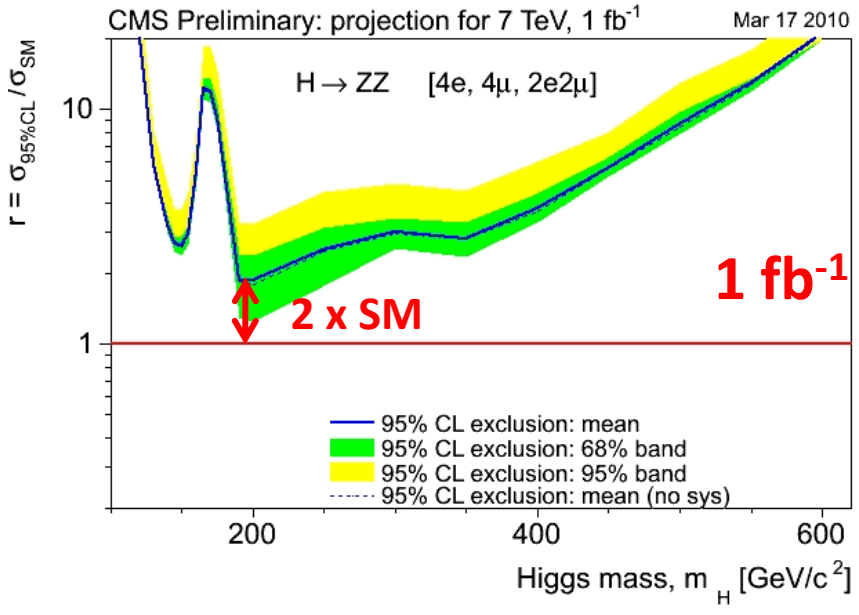


H→ZZ→llll

Signal x-sec: NNLO

4lepton signature (4e,4μ,2e2μ)

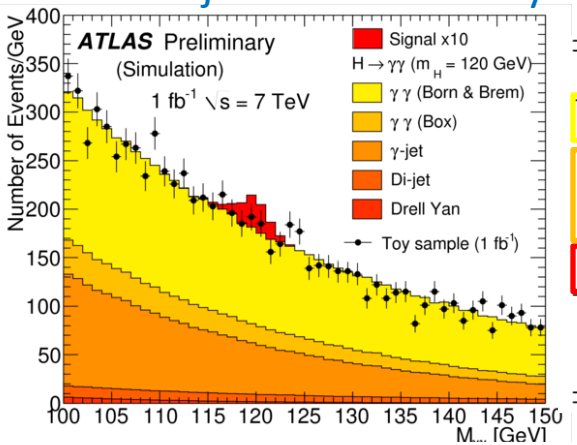
H→WW and H→ZZ searches have similar sensitivities for mH~200 GeV.



γγ and ZZ results from ATLAS

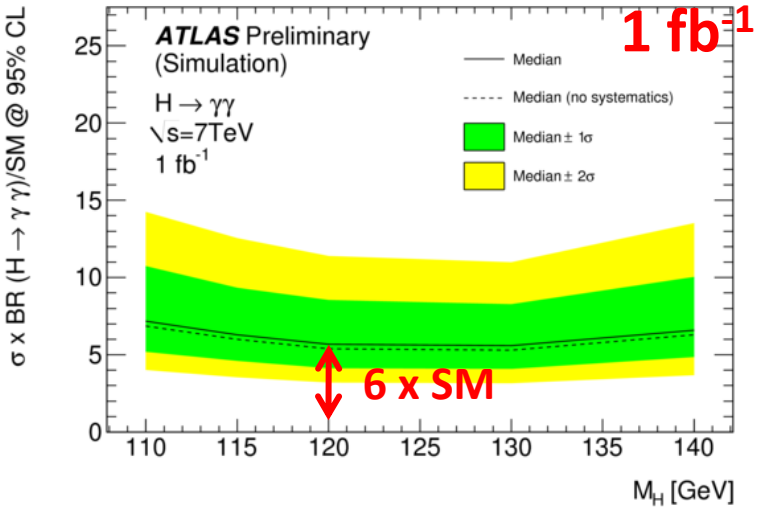
H→γγ

Perform jet inclusive analysis for early data



M_H (GeV)	120
$\gamma\gamma$	5540
γj	2500
jj	360
Drell Yan	90
Total background	8490
Signal	13.0

reducible

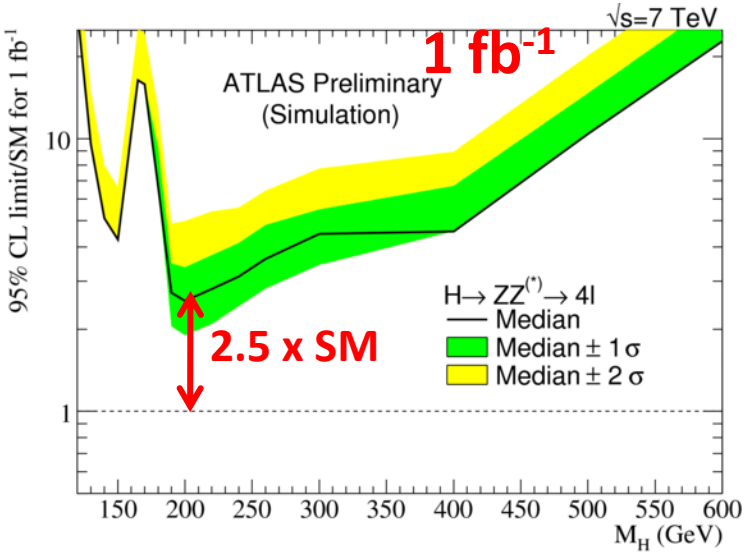


H→ZZ→llll

Signal x-sec: NLO=0.7xNNLO

4lepton signature (4e,4μ,2e2μ)

M_H(GeV)	190
SM ZZ	0.981
top & Z+jets	0.003
Total background	0.984
Signal	1.49



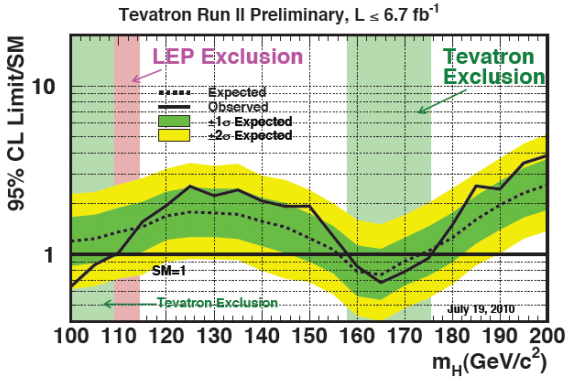
Combination (γγ, WW, ZZ)

H→WW→lνlν, ZZ→4l, γγ channels are combined

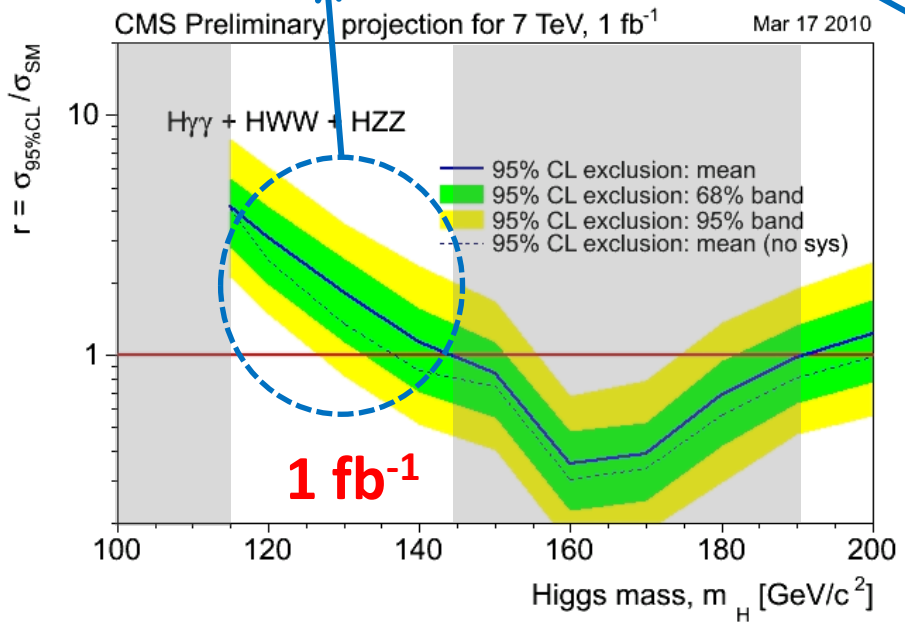
Expected 95% C.L. exclusion of SM Higgs is:

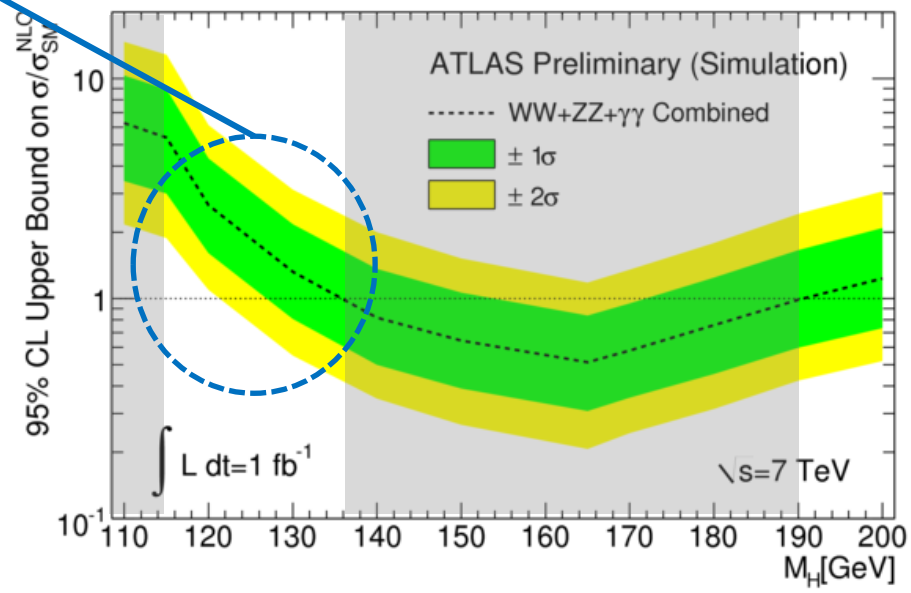
ATLAS 135-188 GeV @ 1fb^{-1}

CMS 145-190 GeV @ 1fb^{-1}



H→ττ and bb help to improve sensitivity in low mass region!!



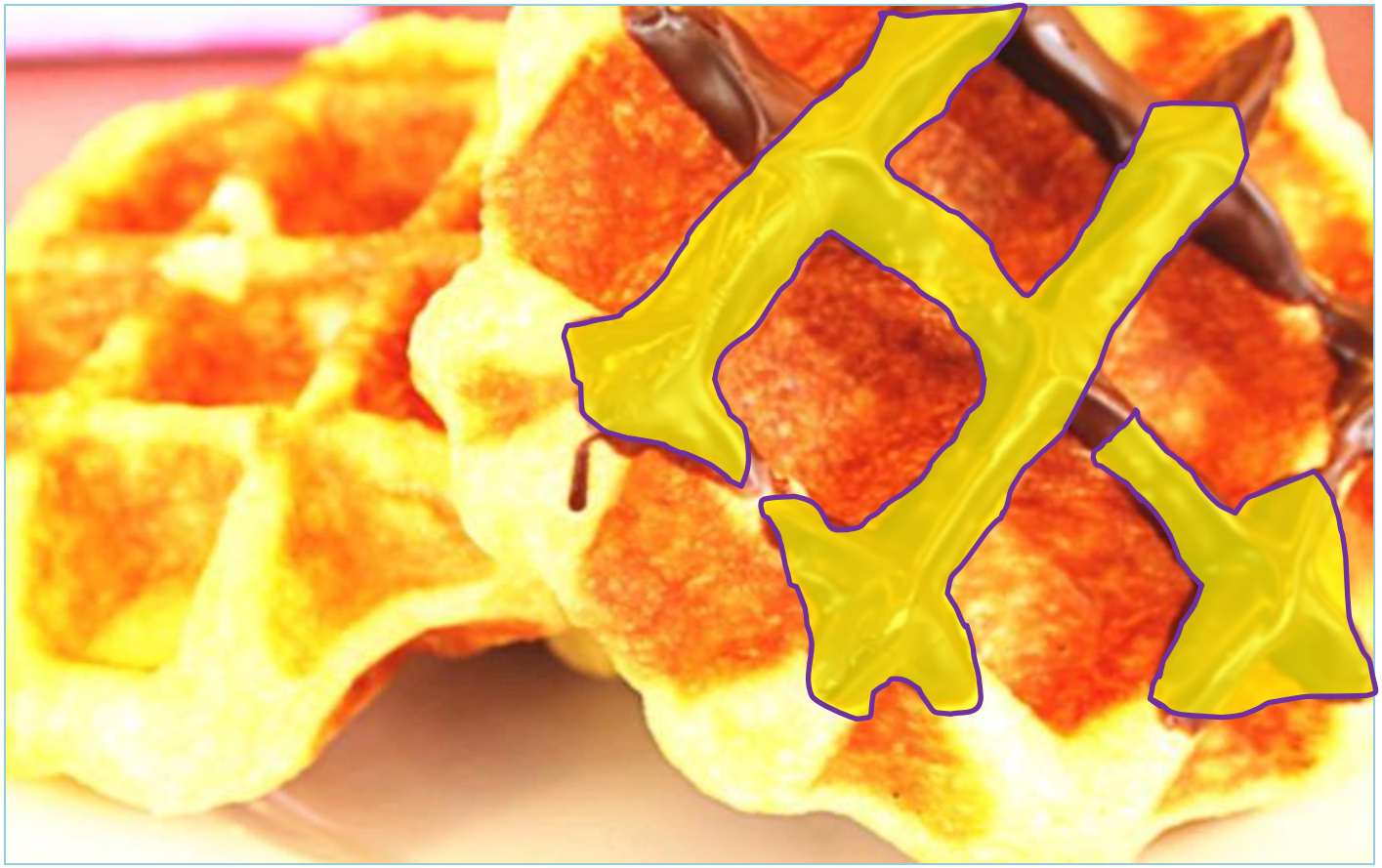


Again, all results are scaled from 10/14 TeV study!!

Conclusion

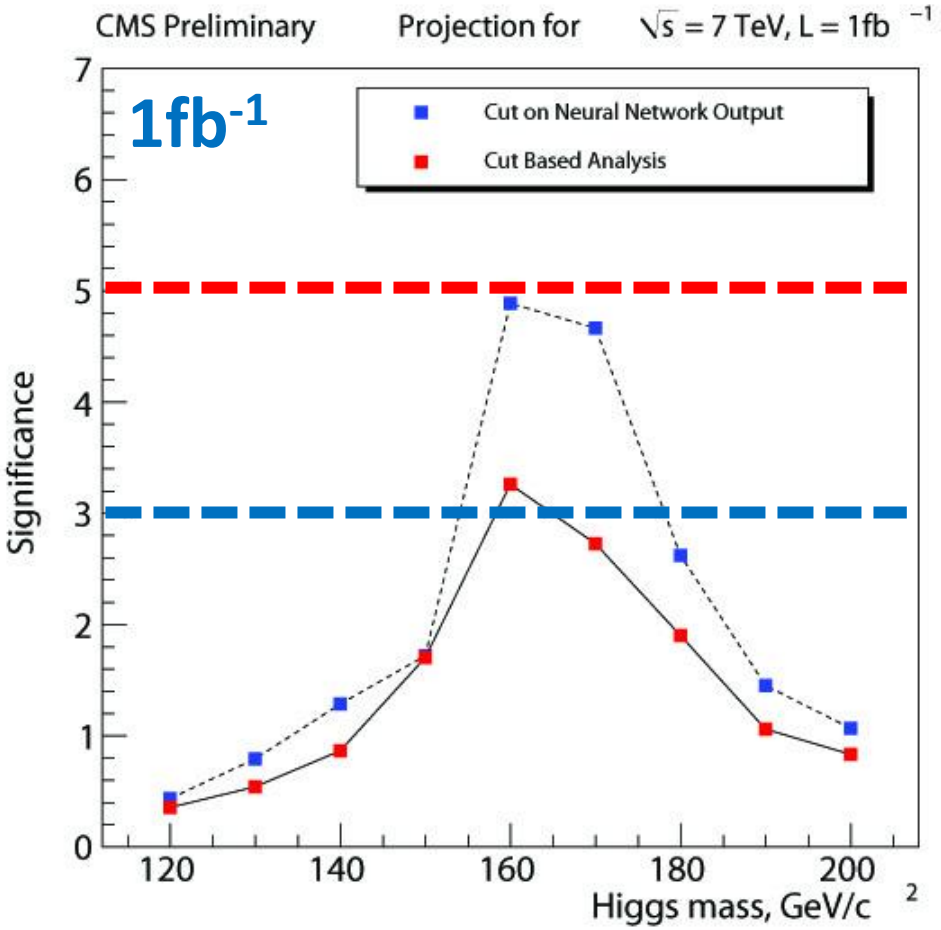
- LHC accumulated 4.0 pb^{-1} of data already.
  - Certain performance and data driven background estimation studies are on-going.
- Sensitivity expectation scaled from 10/14 TeV results at 1 fb^{-1} was shown by CMS and ATLAS.
- 7TeV optimized analysis and low mass results improvement are on-going with real data.
- First physics impact from LHC Higgs search will be $H \rightarrow WW$ and MSSM $H \rightarrow \tau\tau$ (World best @<1fb^{-1})

Thank you!

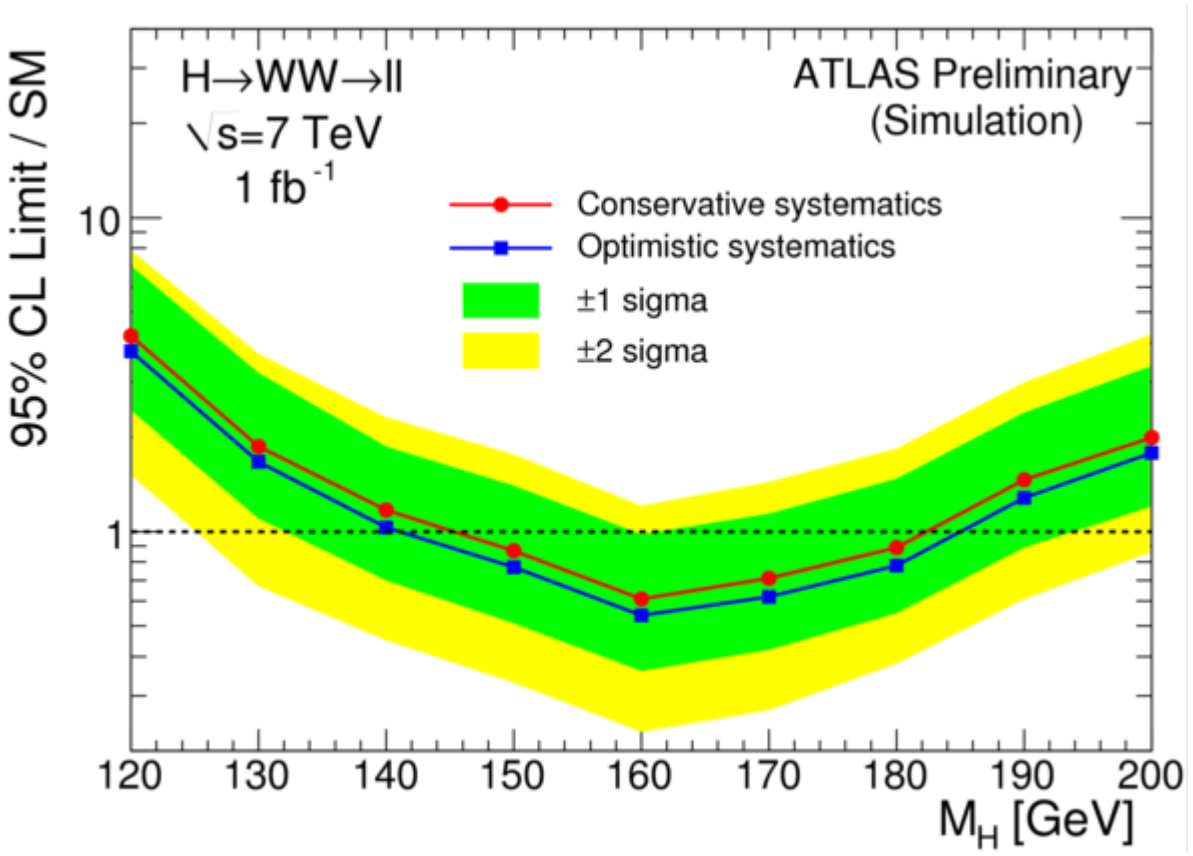


backup

Sensitivity of H→WW→lvlv



Systematic effect



Difference between "Conservative" and "Optimistic" systematic uncertainties comes from background estimation uncertainty.