HIGGS AT CMS

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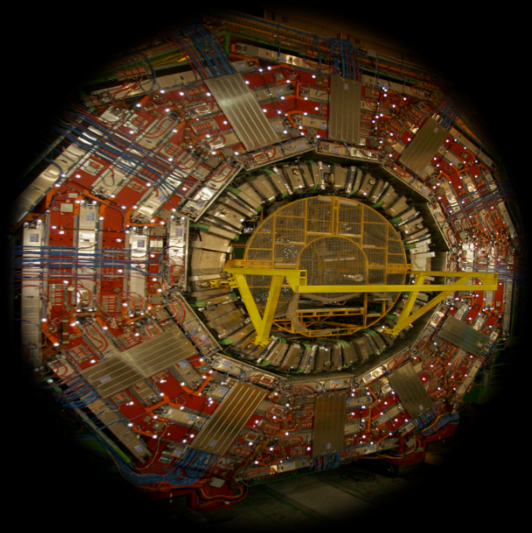
for the CMS Collaboration

Aspen 2011, 13-18 February

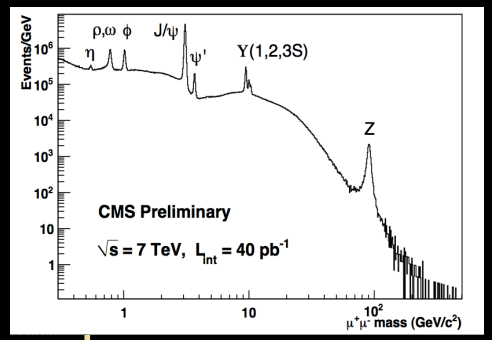
OUTLINE



- 2010: CMS recorded 43pb^{-1} of data

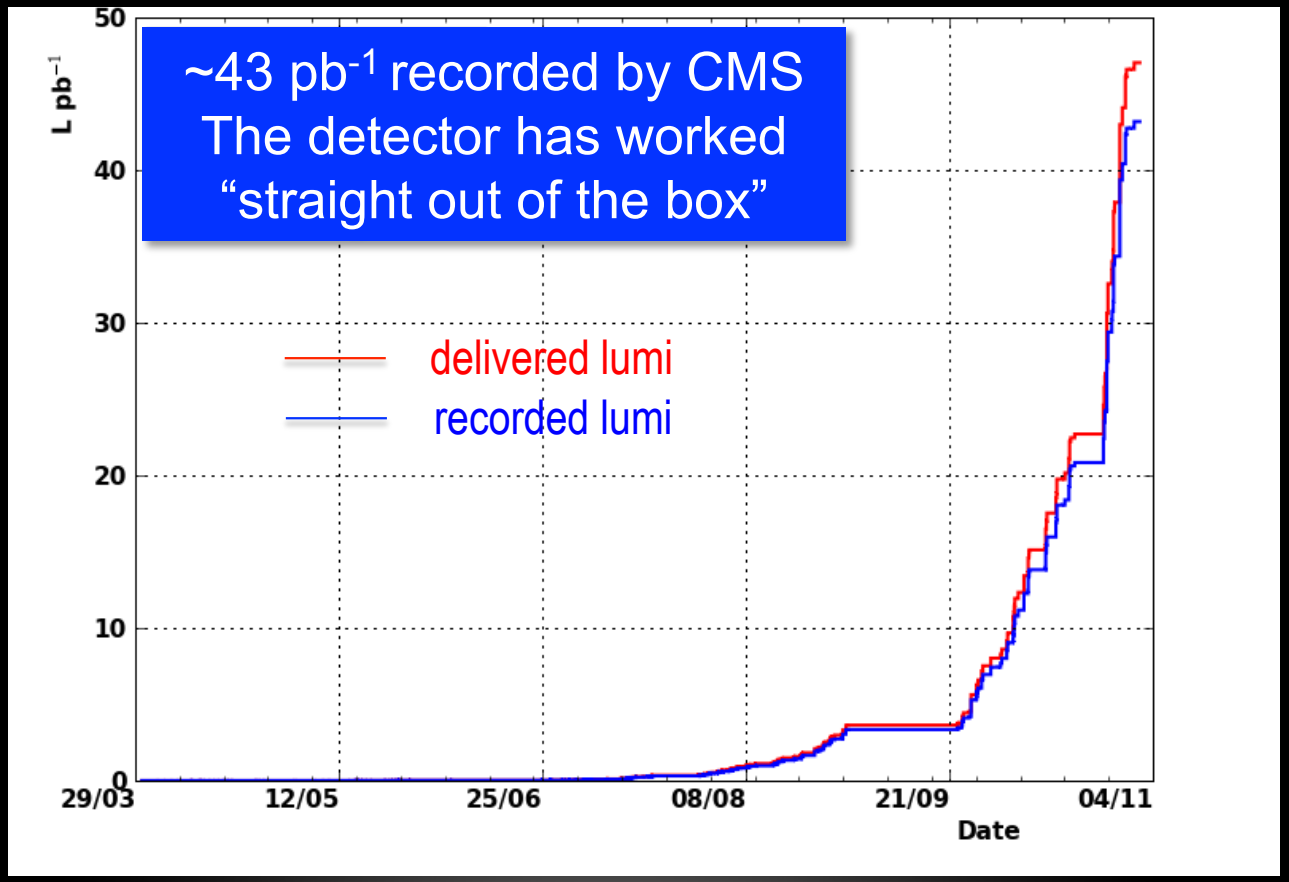
  → Performance of CMS is excellent!

  Rediscovery of the SM

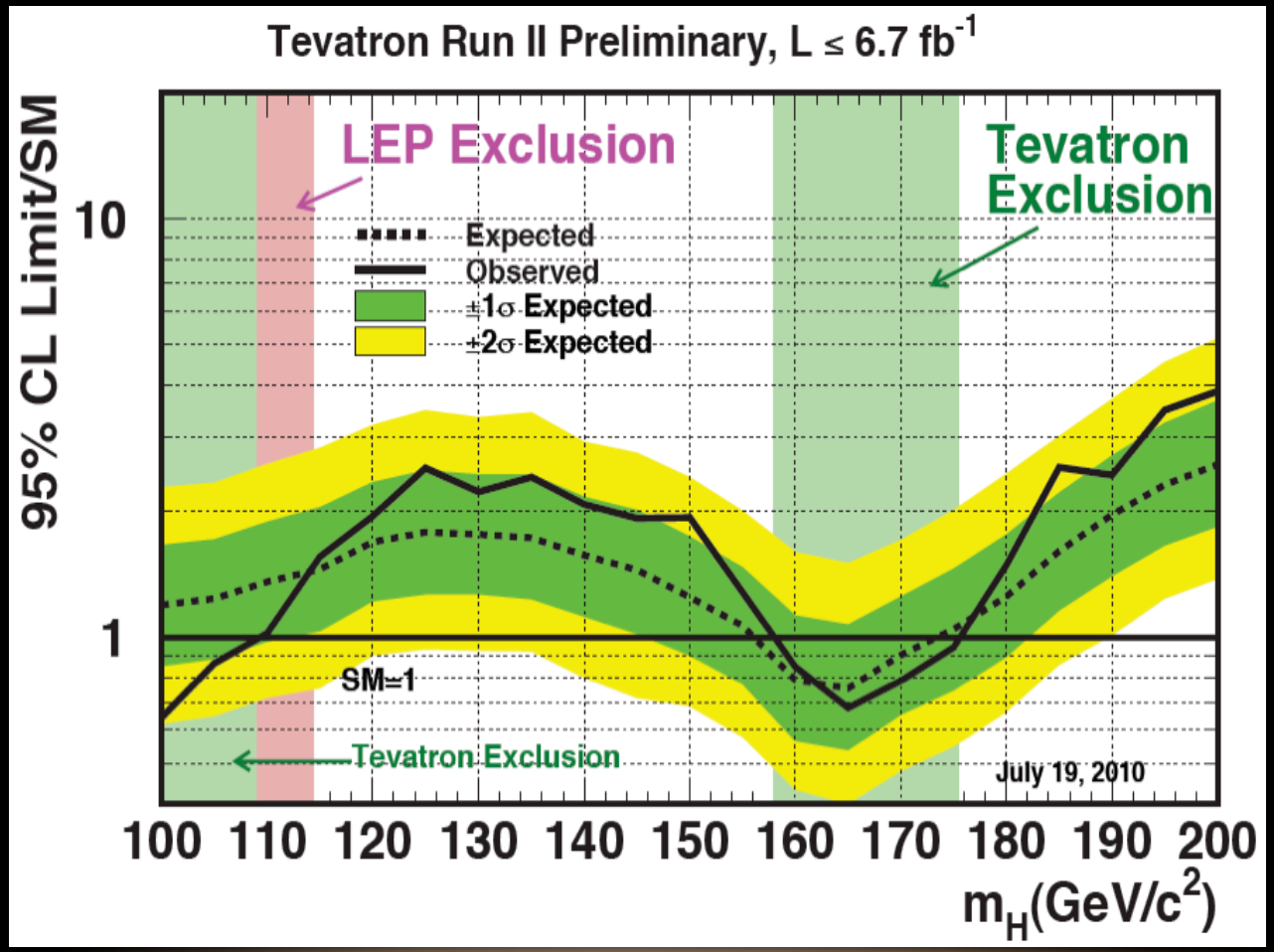


- 2011: LHC is expected to deliver ≥1 fb^{-1} @ 7TeV
- Standard Model Higgs searches
  - Prospects for individual channels
  - Potential of the combination
- MSSM Higgs searches

2010: FABULOUS PERFORMANCE



WHY SHOULD WE CARE ABOUT 43pb^{-1} ?



THIS IS WHY!

For $M_X > 140$:

gg σ at 7 TeV > 15x that at Tevatron

Higher rate for Higgs production

Irreducible backgrounds (WW, ZZ) originate from qqbar which rises relatively slowly

$\Rightarrow$ S/N rises, LHC competitive with $1fb^{-1}$

For $M_X < 140$: slow rise in qq σ

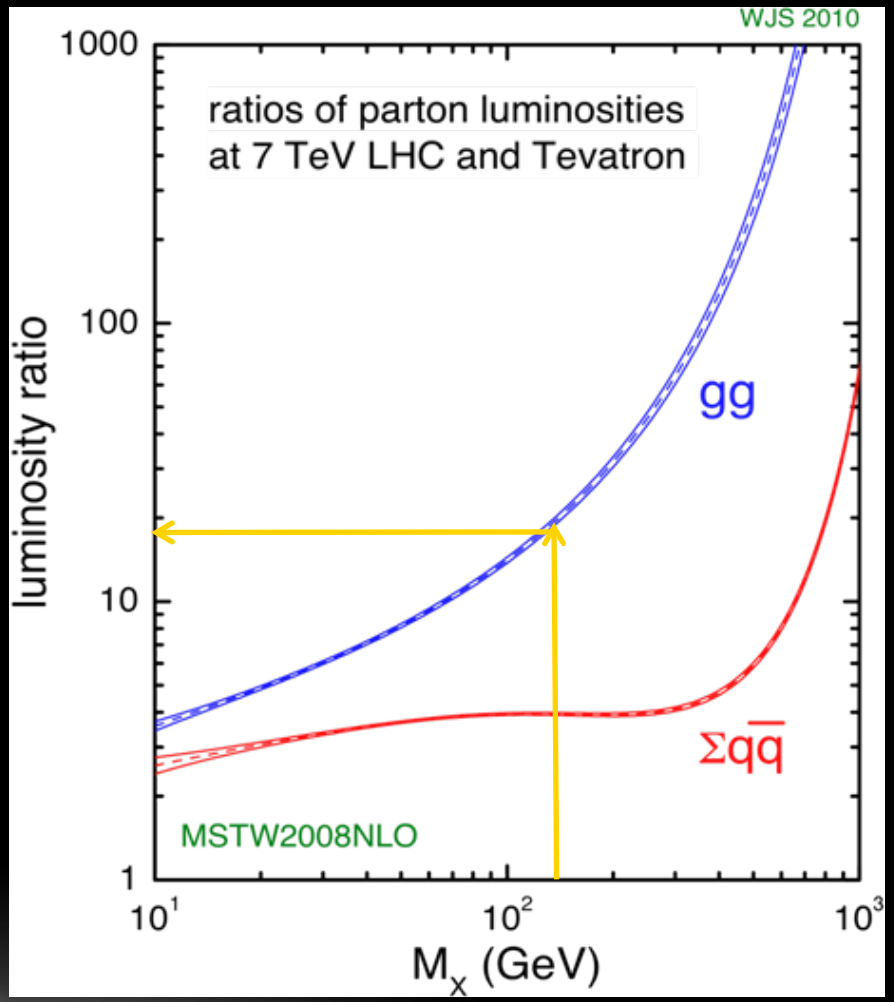
Compared to Tevatron, Higgs-strahlung (pp $\rightarrow$ VH) rate @ 7 TeV not much larger

Major backgrounds (W/Z+bb, ttbar) rise sharply due to rapid rise in gg σ
$\Rightarrow$ small signal rate & poor S/N

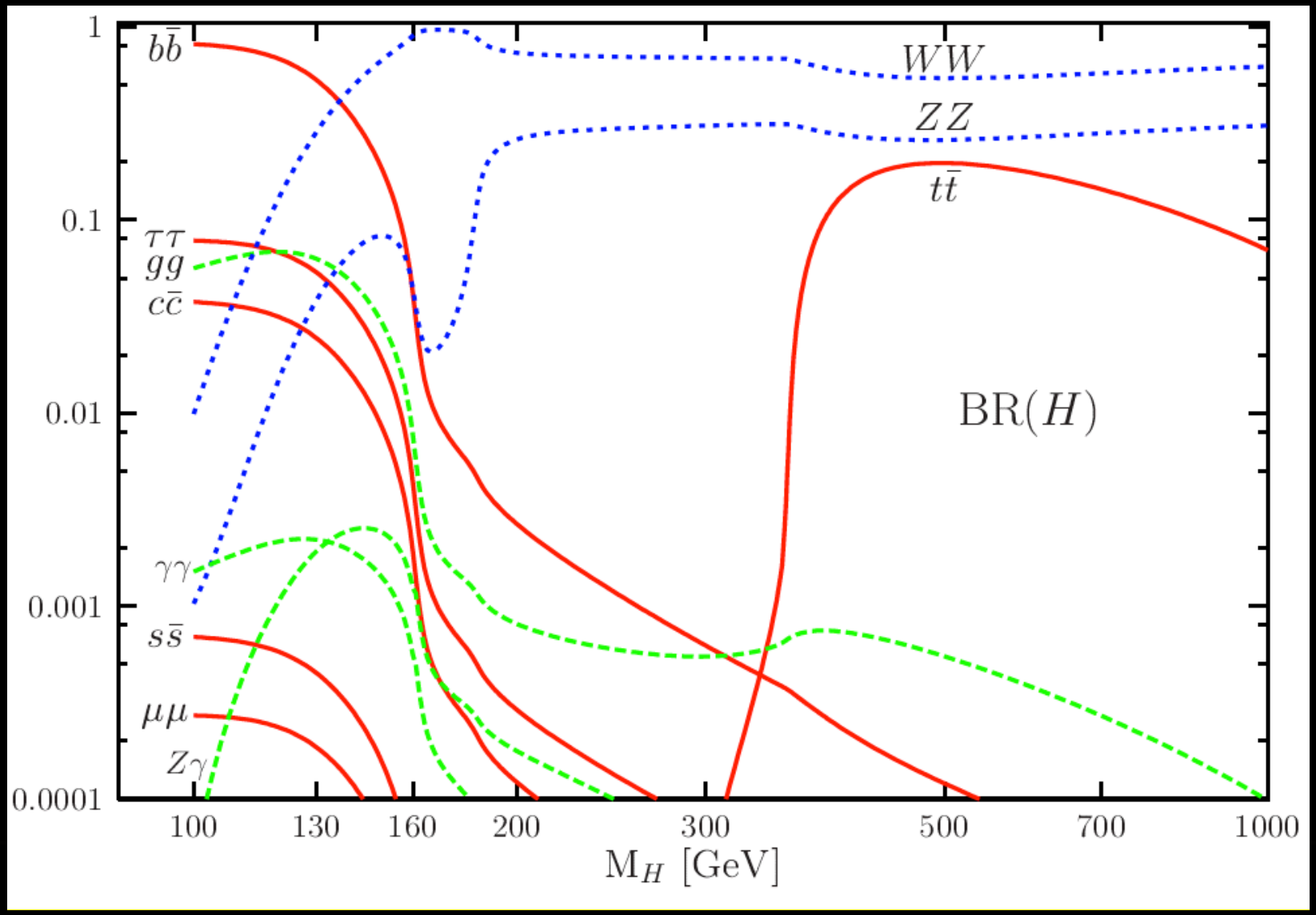
gg $\rightarrow$ H $\rightarrow\gamma\gamma$ favored in production, but Br $\cong$ 0.2% and large QCD $\gamma\gamma$ background

$\Rightarrow$ Poor S/N

Stirling et al



HIGGS DECAY DOMINATED BY DIBOSONS

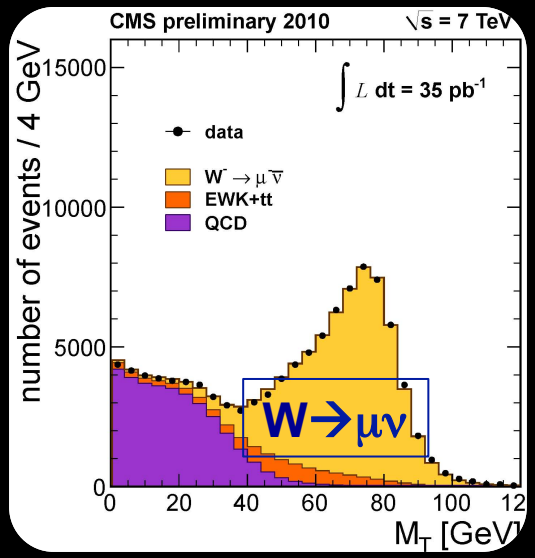


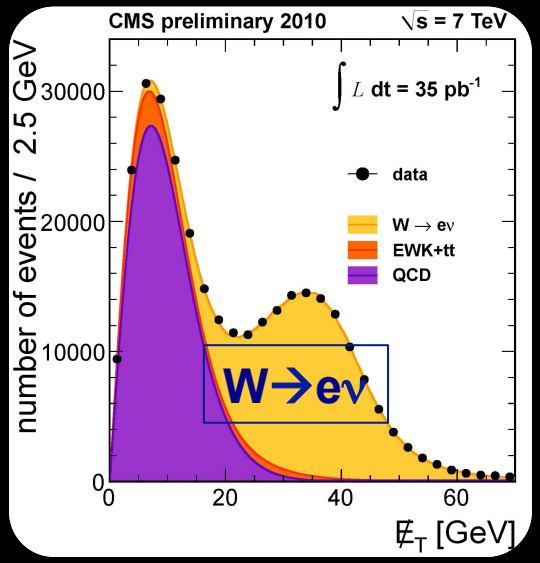
"MANY DROPS FILL THE BUCKET"

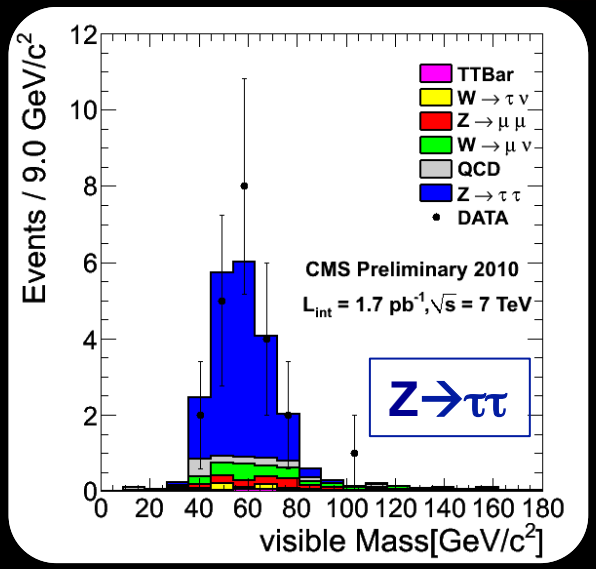
- Develop cut-and-count as well as MVT analyses
- Rely mostly on data driven methods for background estimation

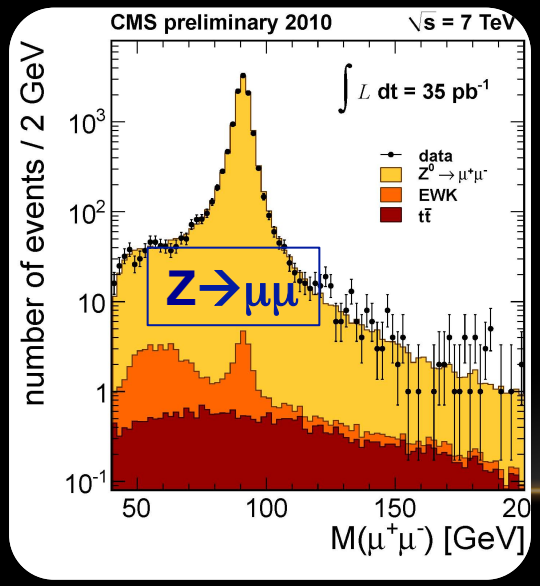
Channel	Physics Objects	Higgs mass range used in analysis (GeV)
$H \rightarrow \gamma\gamma$	photons	115-150
qqH, $H \rightarrow \tau\tau$	taus, MET	115-145
VH, $H \rightarrow bb$ (highly boosted)	b-tagging	115-125
VH, $H \rightarrow WW \rightarrow l\nu jj$	jets, MET, W's	130-200
$H \rightarrow WW \rightarrow 2l2\nu$ + 0/1 jets	μ, e, MET, W's	120-600
qqH, $H \rightarrow WW \rightarrow 2l2\nu$	μ, e, MET, jets, W's	130-500
$H \rightarrow ZZ \rightarrow 4l$	μ, e, Z's	120-600
$H \rightarrow ZZ \rightarrow 2l2\nu$	μ, e, MET, Z's	200-600
$H \rightarrow ZZ \rightarrow 2l2b$	μ, e, b-tagging	300-600

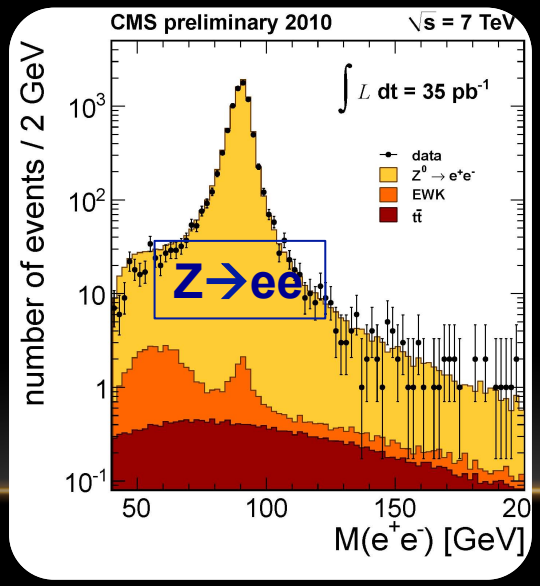
2010: COMMISSIONING OF PHYSICS OBJECTS

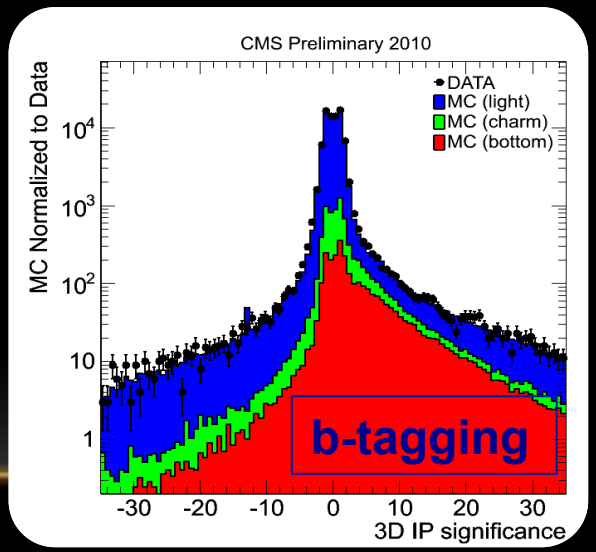






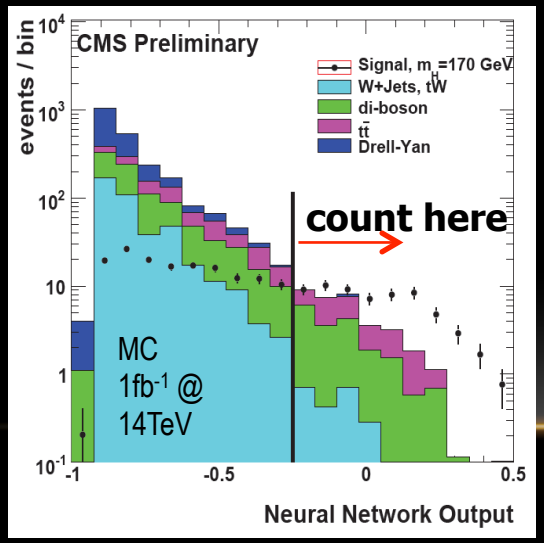


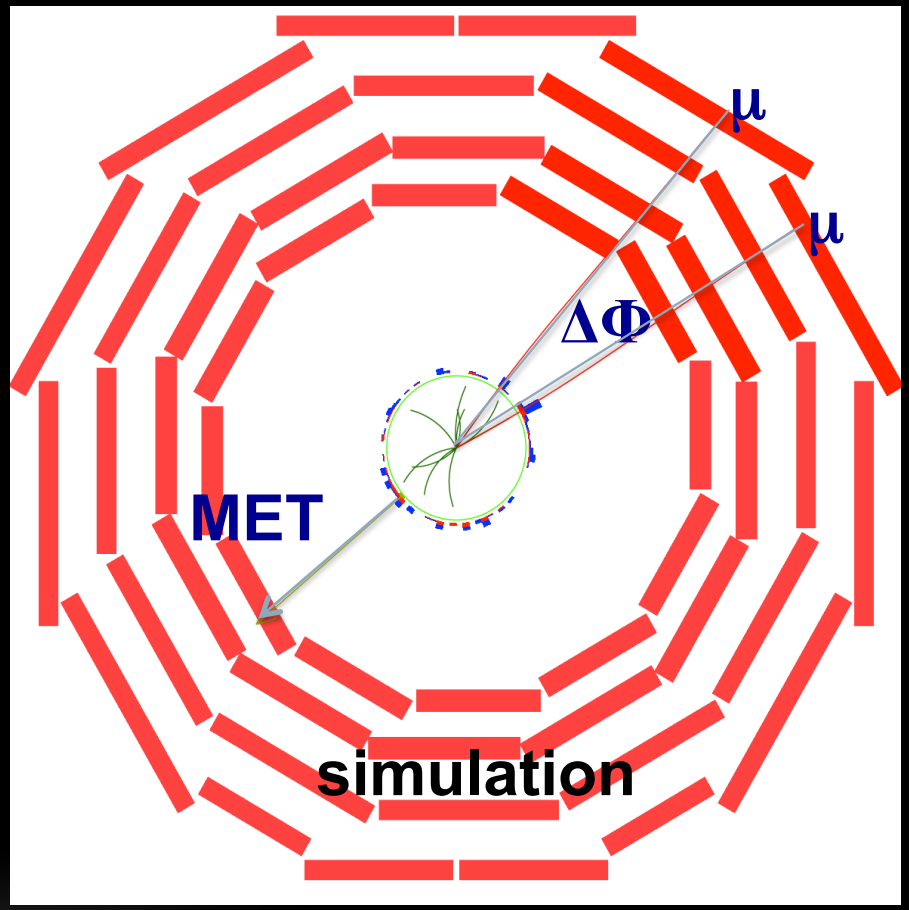




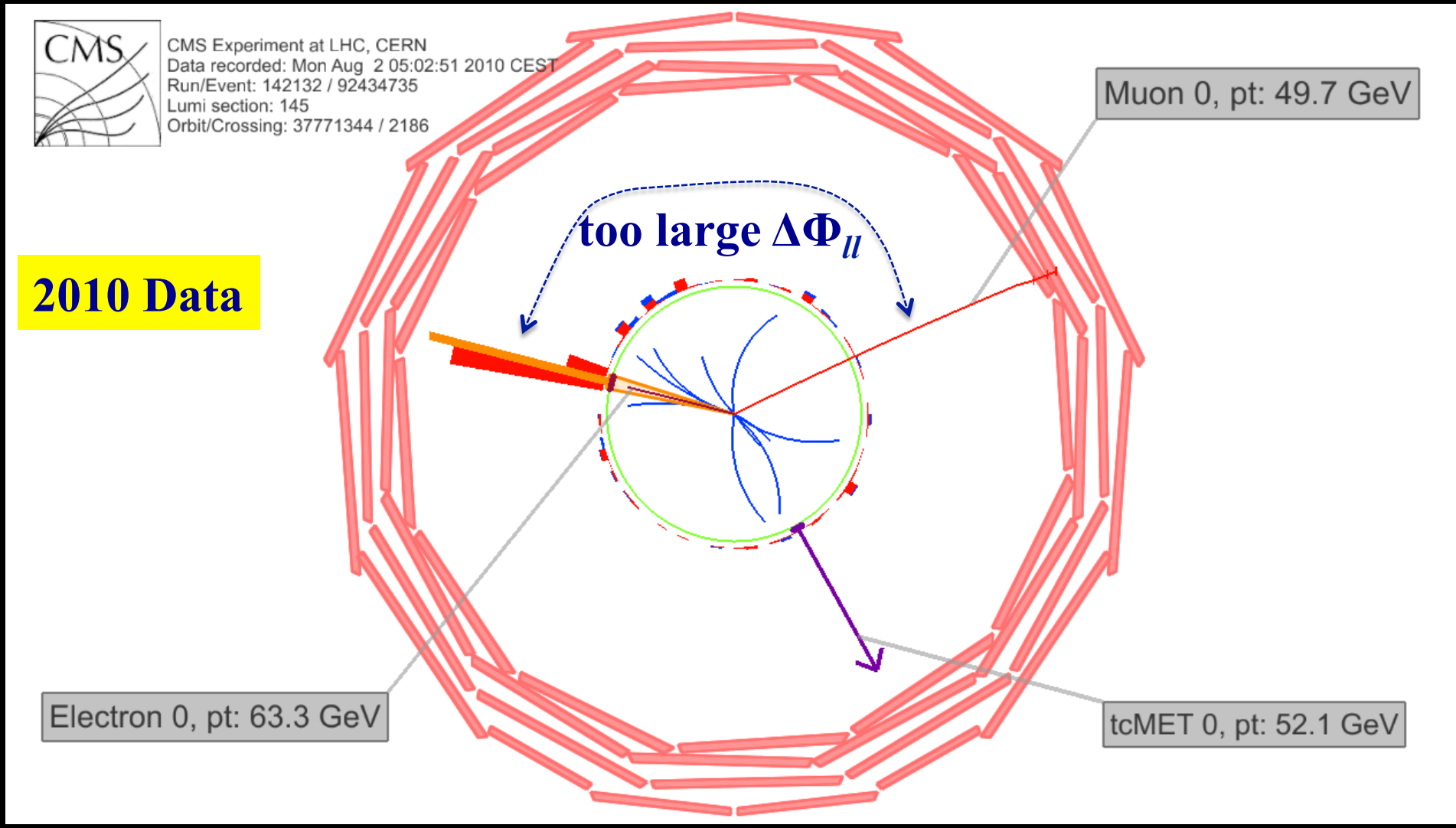
H→WW→2l2ν: THE GOLDEN CHANNEL

- **Signal: 2 isolated leptons with small Δφ + MET + no central jets (jet veto)**
- Background reduction:
  - **WW: Δφ & m_{ll}**
  - ttbar: cental jet veto, Δφ & m_{ll}
  - W+jets: tight lepton id
  - DY alleviated by MET requirement & m_{ll}
  - WZ/ZZ: 2 leptons in final state, MET, m_{ll}
- look for excess above a cut on NN output





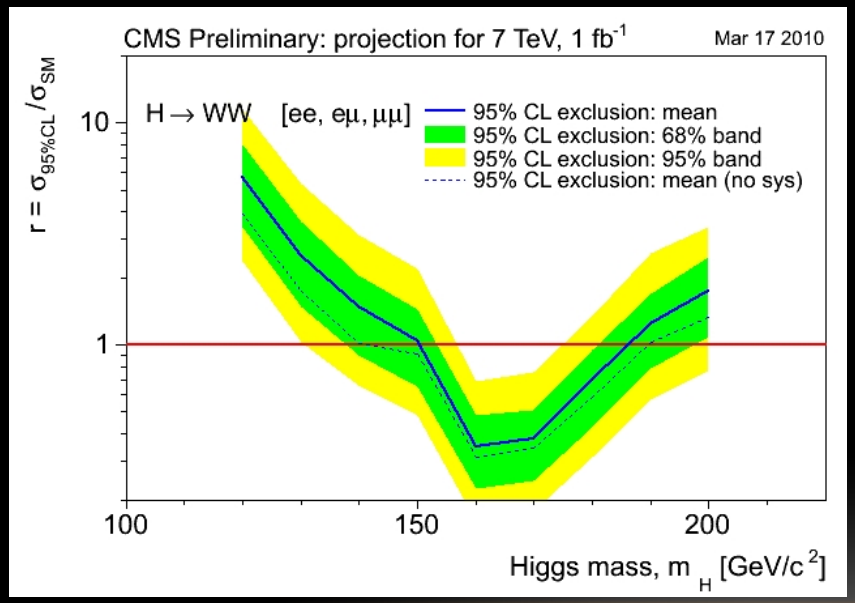
VS. IRREDUCIBLE WW BACKGROUND

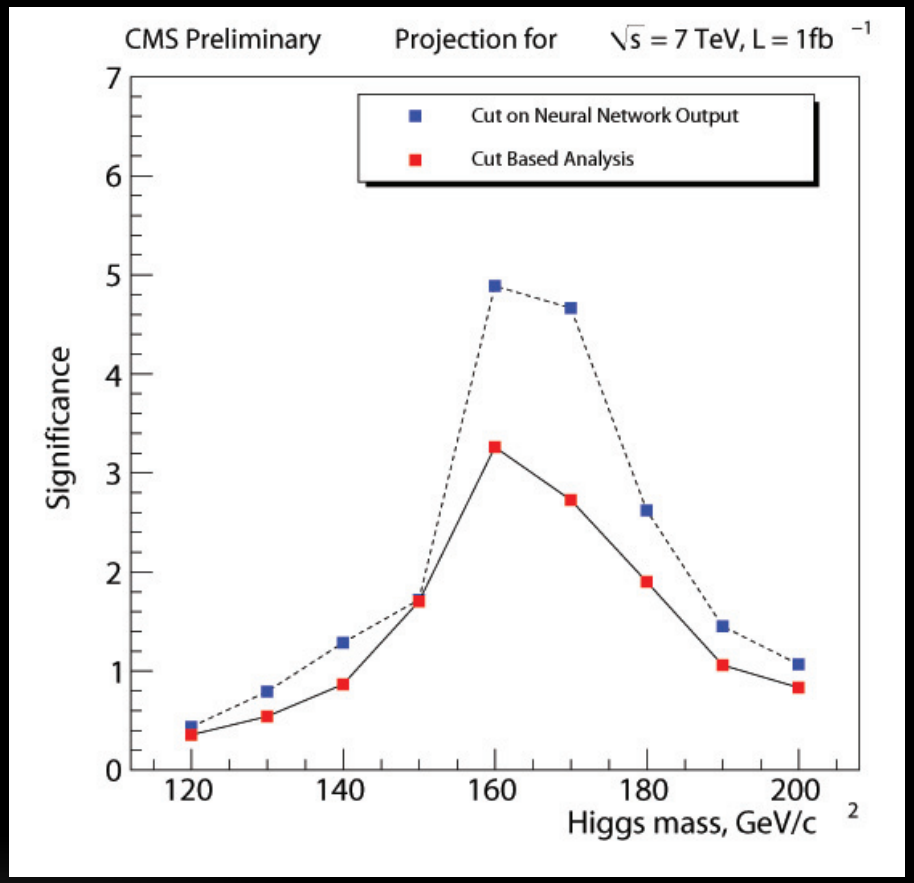


H→WW→2l2ν EXPECTATIONS

With 1fb^{-1} @ 7TeV:

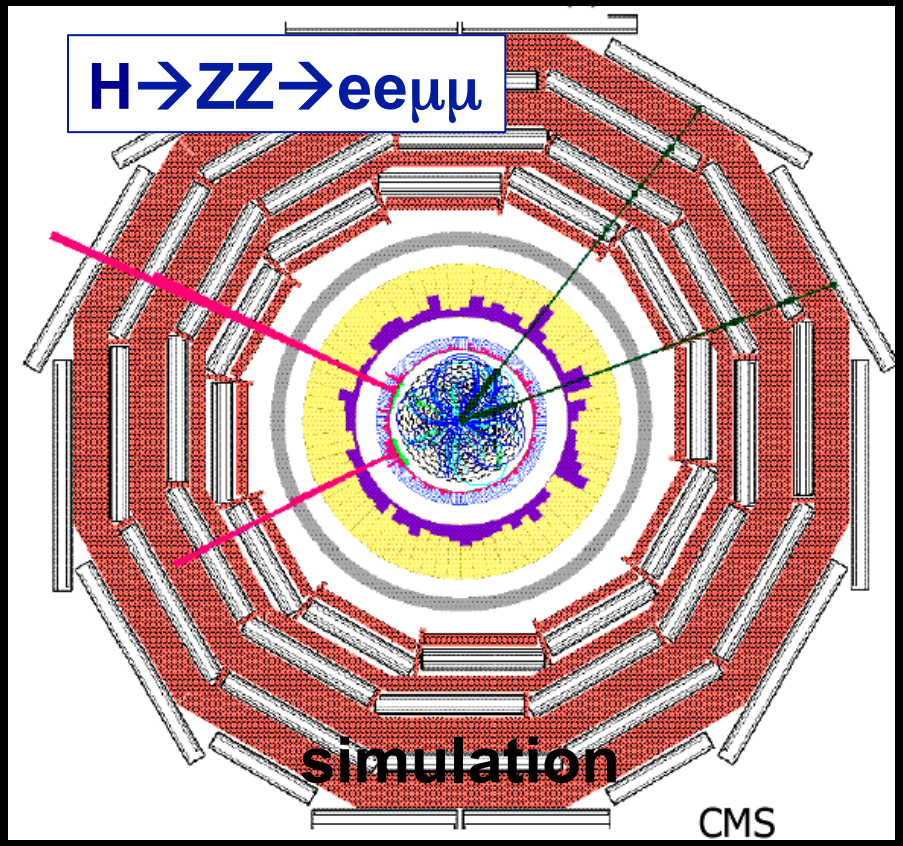
- Expected exclusion reach: ***150<m_H<185 GeV/c²***
- Close to discovery limit: ***160<m_H<170 GeV/c²***

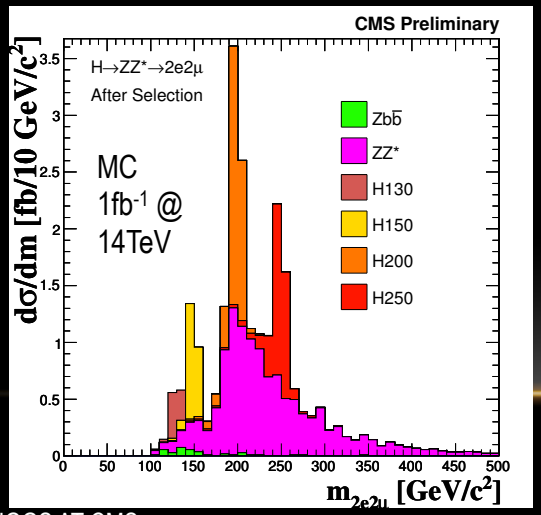




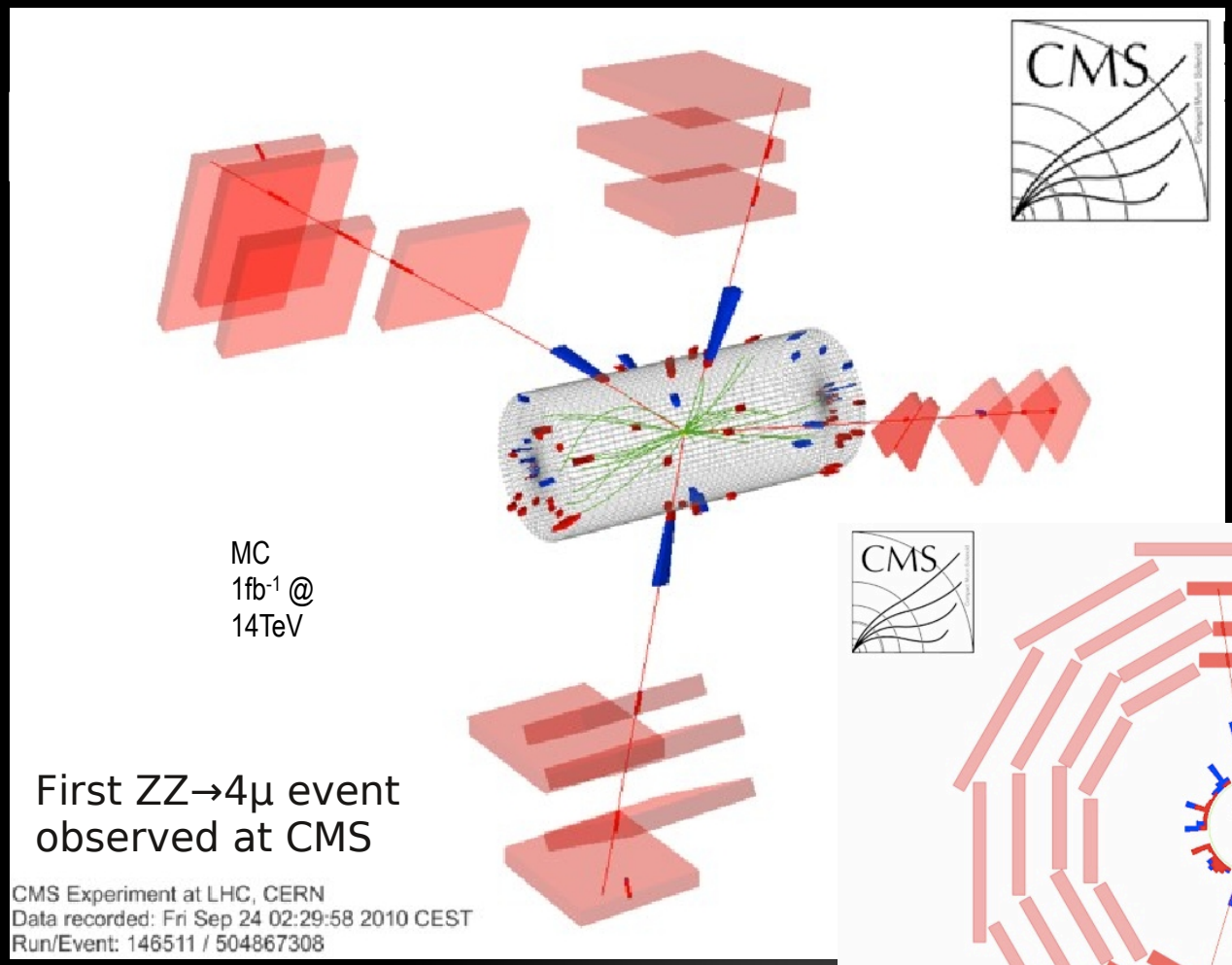
H→ZZ→4l

- Signal: four isolated leptons, fully reconstructed →Higgs mass peak
- Backgrounds:
  - ZZ : irreducible
  - ttbar & Z+bb removed by lepton isolation & impact parameter cut
- low background, but low yield





GOLDEN pp→ZZ→$\mu^+\mu^-\mu^+\mu^-$ EVENT



$P_t^{\mu 1} = 48.1$ GeV

$P_t^{\mu 2} = 43.4$ GeV

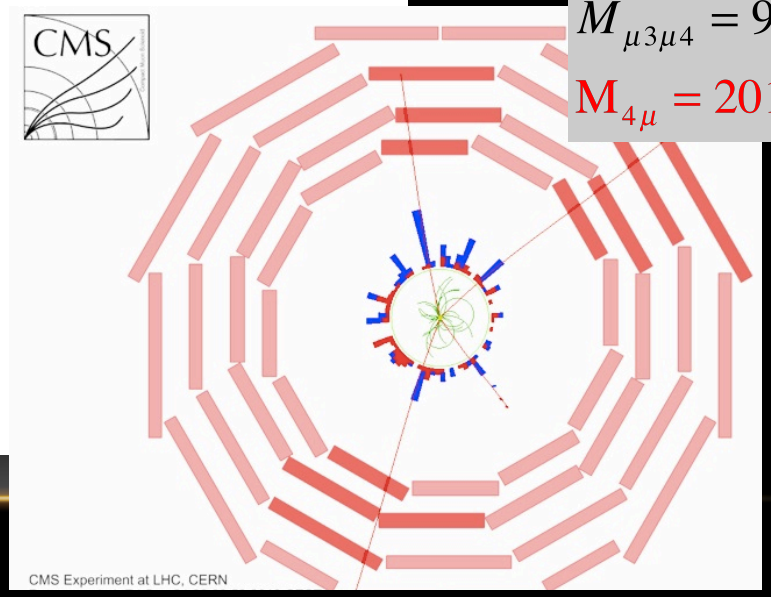
$P_t^{\mu 3} = 25.9$ GeV

$P_t^{\mu 4} = 19.6$ GeV

$M_{\mu 1 \mu 2} = 92.15$ GeV

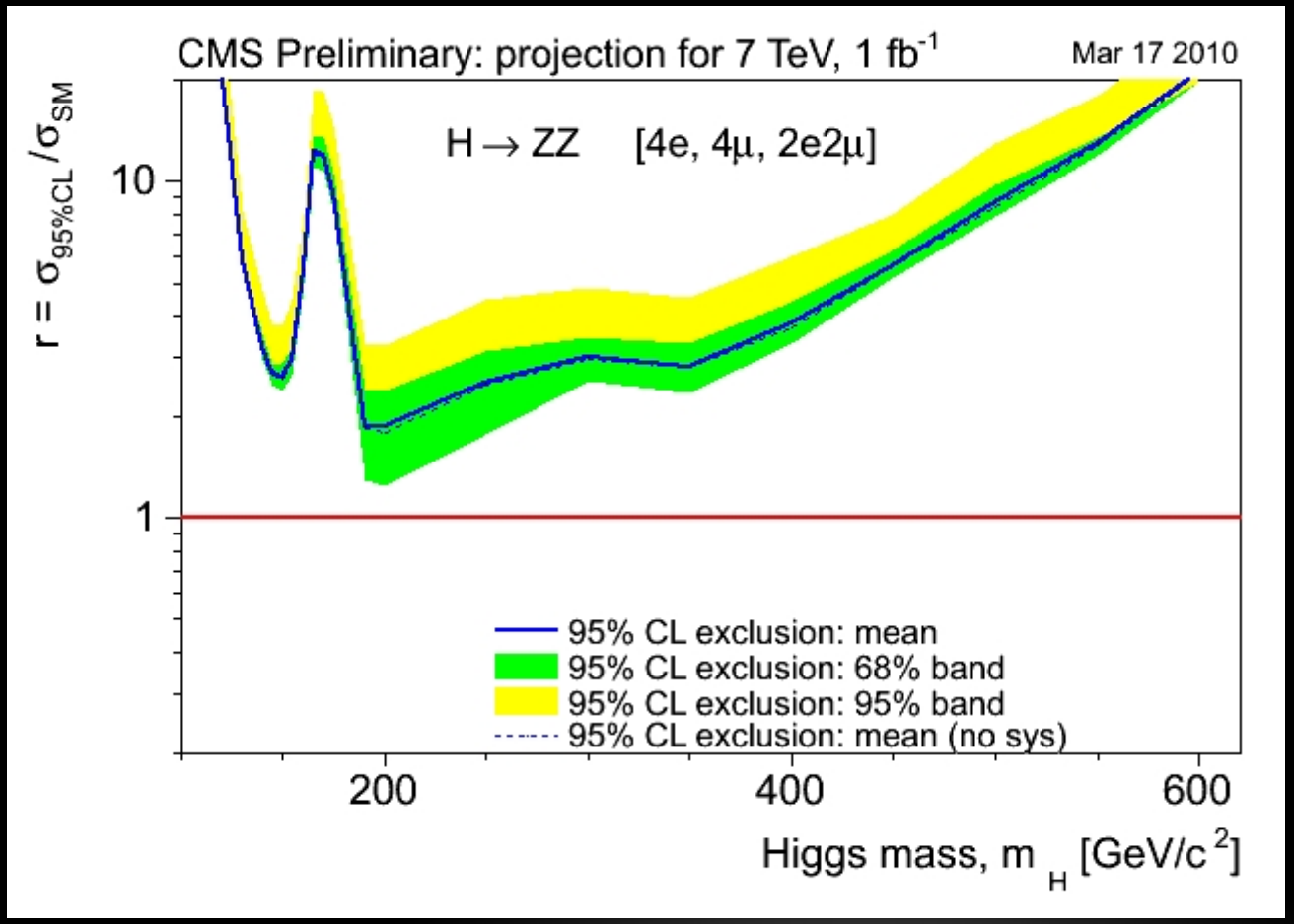
$M_{\mu 3 \mu 4} = 92.24$ GeV

$M_{4\mu} = 201$ GeV



Probability of observing a ZZ → $\mu^+\mu^-\mu^+\mu^-$ event in ~ 40 pb^{-1} is ~ 20%

H→ZZ→4l REACH

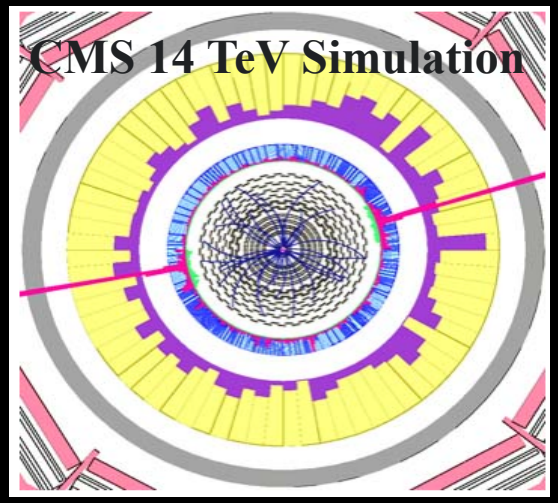


No exclusion in this channel alone with $1fb^{-1}$ @ 7 TeV

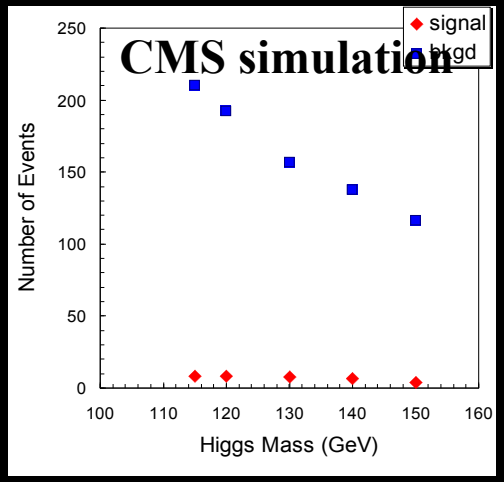
But getting close…

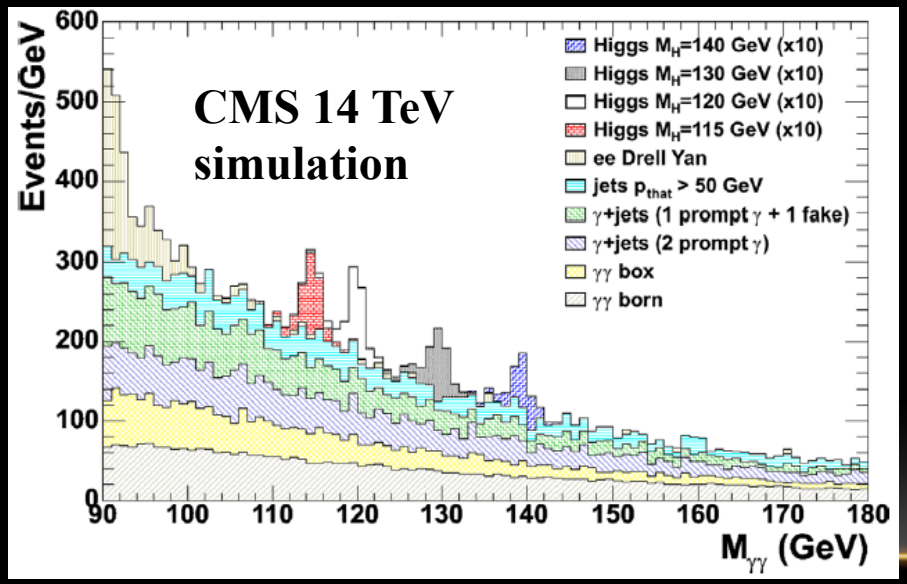
- Add other ZZ decay modes:
  2l2n, 2l2b, 2l2j …
- Possible thanks to well commissioned MET and b-tagging

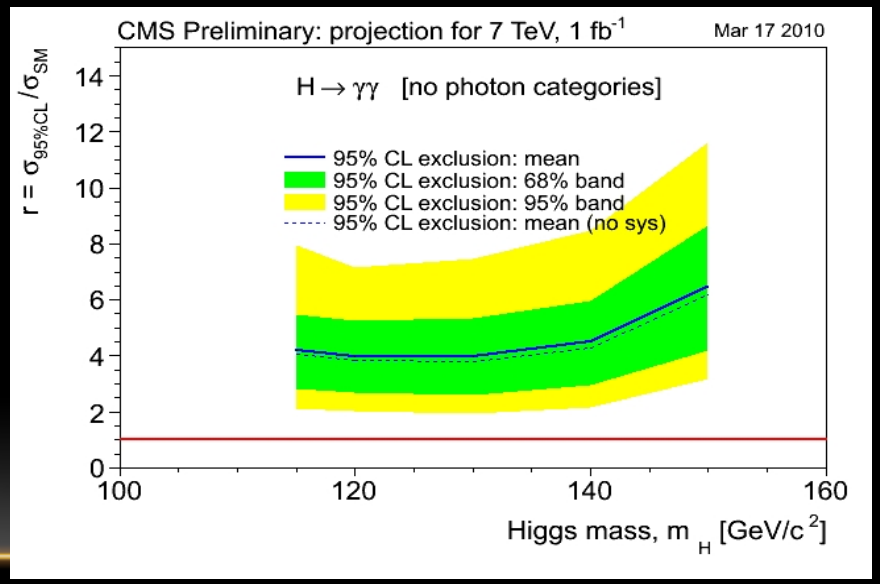
H→γγ



- two isolated photons → narrow mass peak
- QCD bkgd is large and partly irreducible (sidebands)
- Discriminating variables: $E_t\gamma/m\gamma\gamma$, $|\eta_1-\eta_2|$





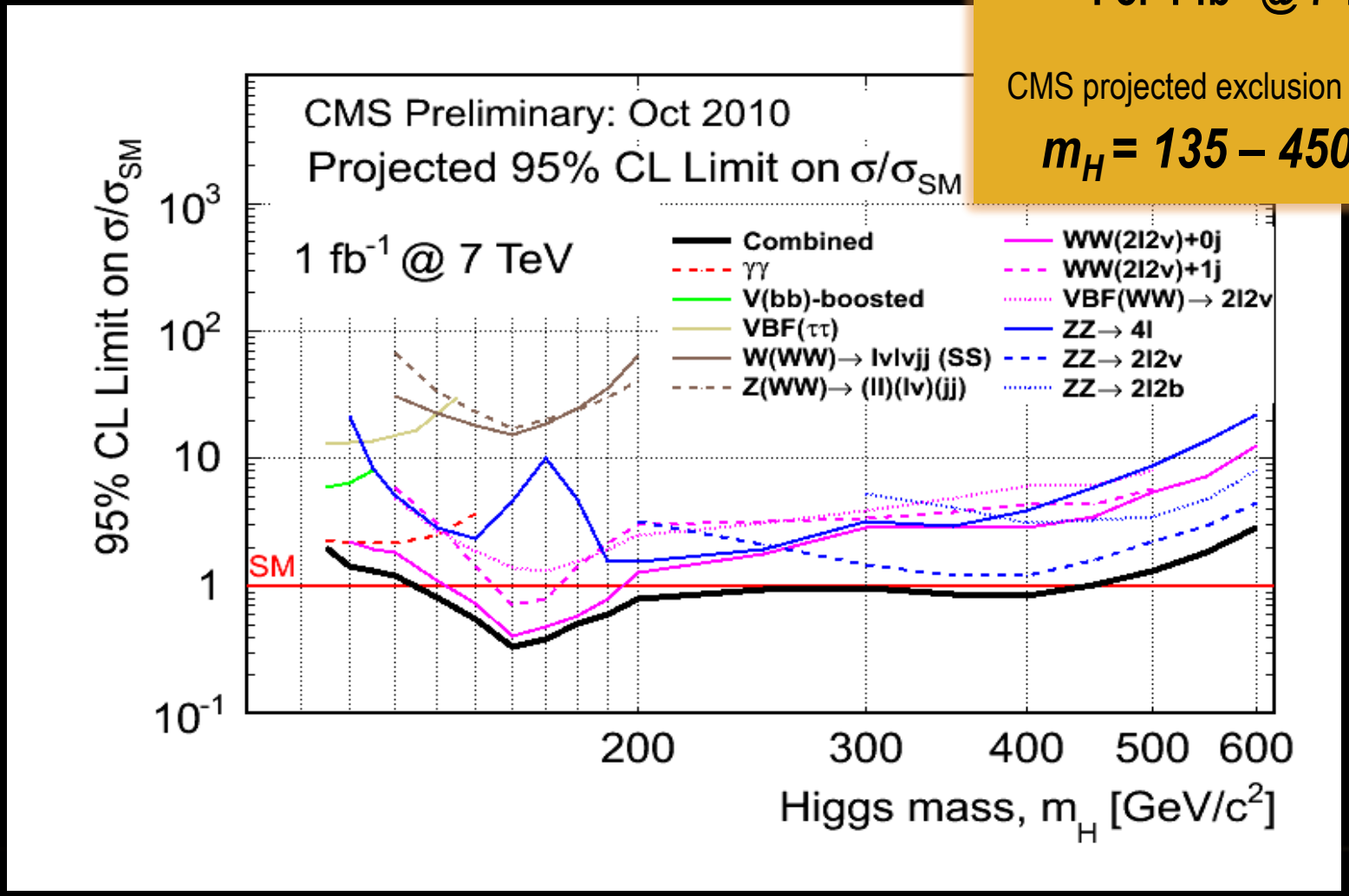


EXCLUSION SENSITIVITY

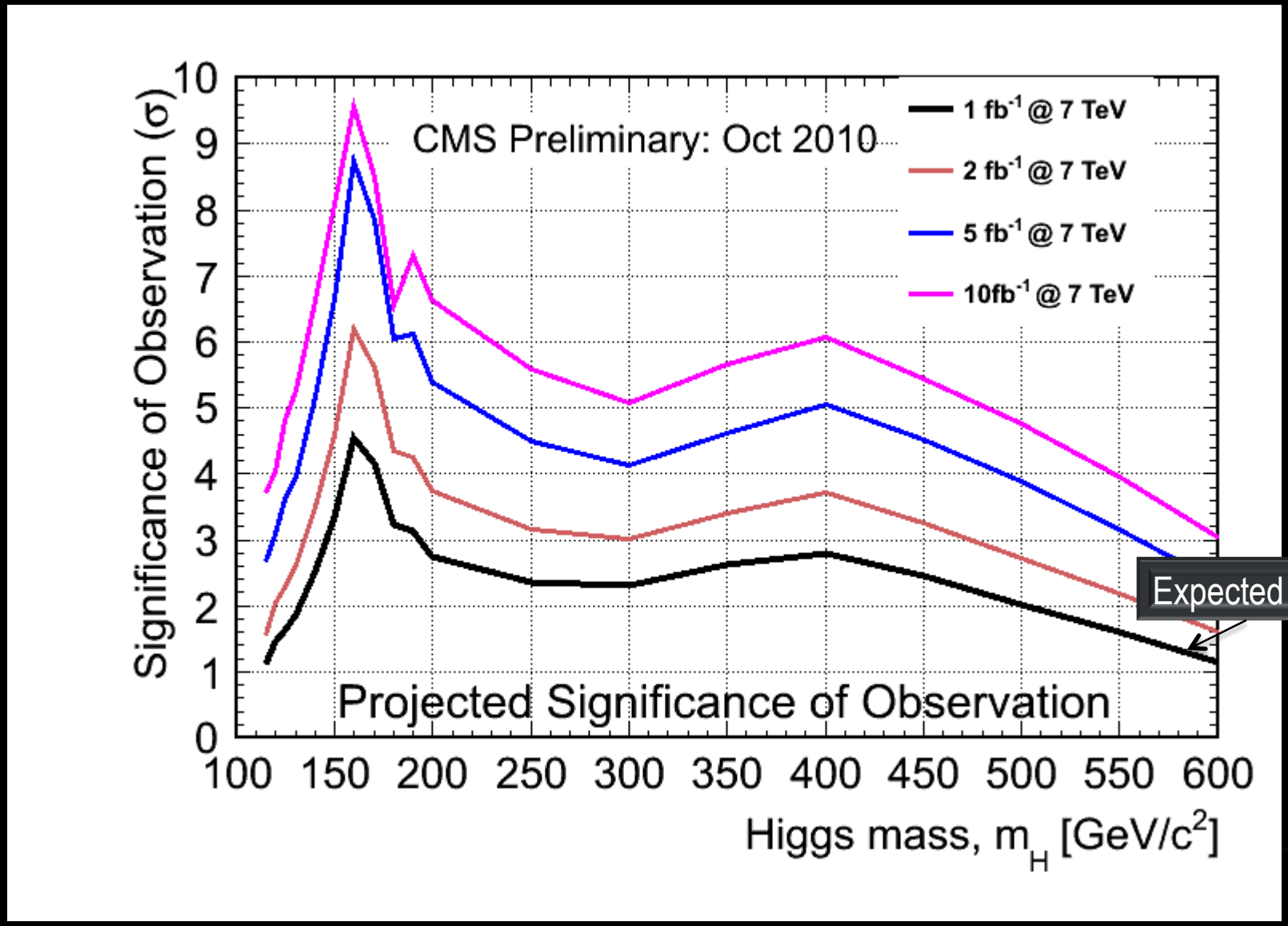
For 1 fb^{-1} @ 7 TeV

CMS projected exclusion sensitivity:

m_H = 135 – 450 GeV

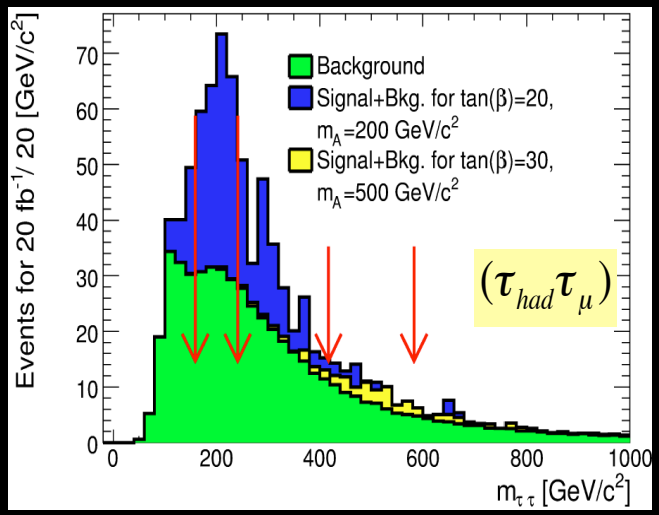


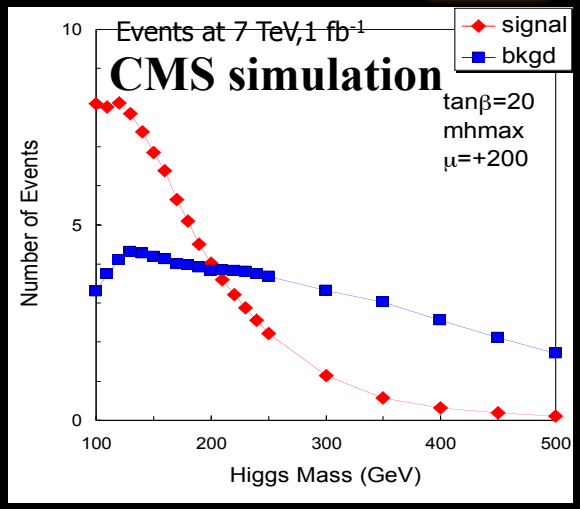
OBSERVATION SENSITIVITY

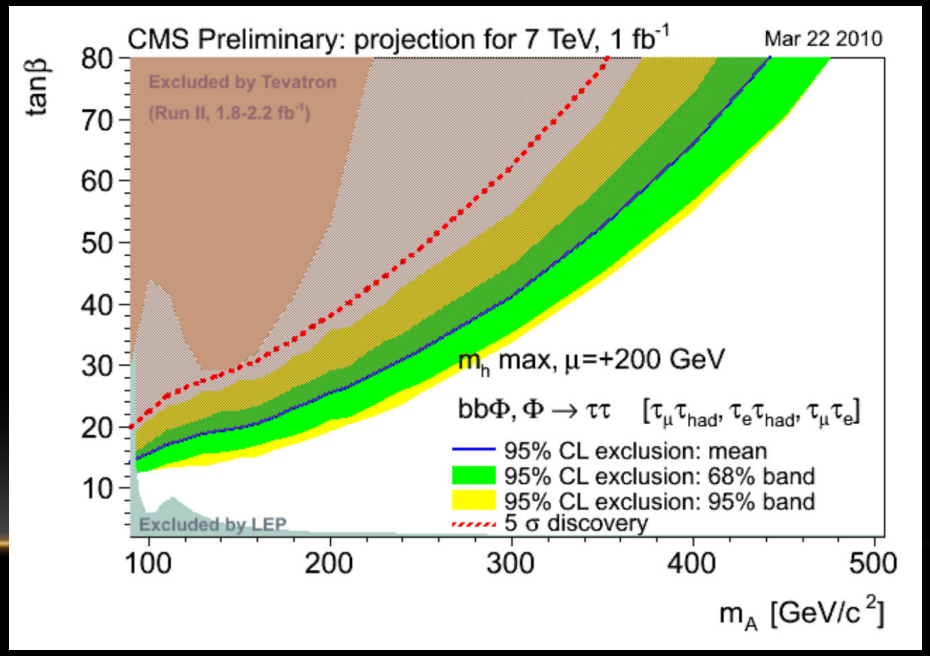


MSSM bbΦ, $\Phi \rightarrow \tau^+\tau^-$

- Isolated pairs of $(\tau_{had}\tau_\mu),(\tau_{had}\tau_e),(\tau_\mu\tau_e)$ & some MET
- Build ττ-visible mass
- Count events in sliding ττ-mass window
- Assess dominant backgrounds ($Z\rightarrow\tau\tau$, ttbar) from data
- Other channels are being explored as well, such as: $H^+\rightarrow\tau\nu$, or $H^{++}\rightarrow 2l$







CONCLUSIONS

- CMS has excellent understanding of detector and physics objects
- Many different Higgs channels are being explored
- With the data from 2011/12 CMS will be able to either exclude or discover the Higgs boson over a large range of Higgs masses
- We are ready!