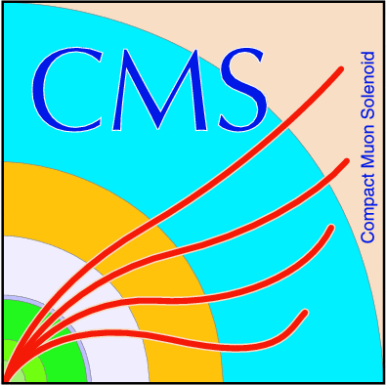


Higgs Overview in CMS

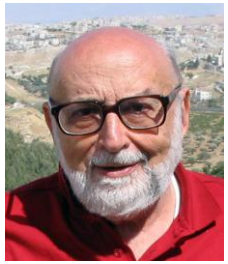
Michele Selvaggi

(On behalf of CMS)

GDR Terascale

Brussels , November 5 2010

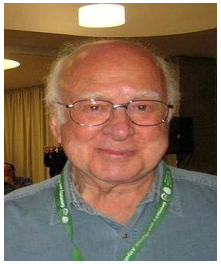
Higgs (BEHHGK) mechanism



Englert

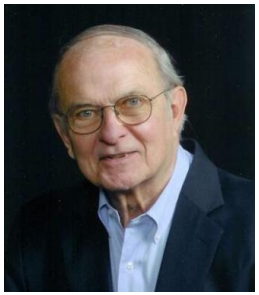
Brout

PRL 13, 321-323 (1964)
"Broken Symmetry and the Mass of Gauge Vector Mesons"



Higgs

PRL 13, 508-509 (1964)
"Broken Symmetries and the Masses of Gauge Bosons"



Hagen

Guralnik

Kibble

PRL 13, 585-587 (1964)
"Global Conservation Laws and Massless Particles"

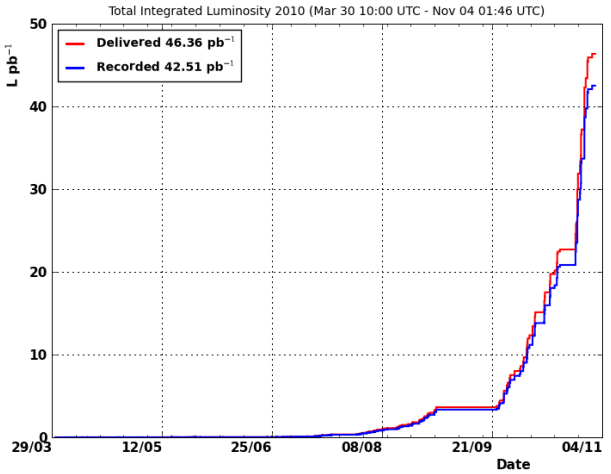
LHC Operations

LHC operation

Recorded 42 pb-1

Expected 100 pb-1 by end 2010

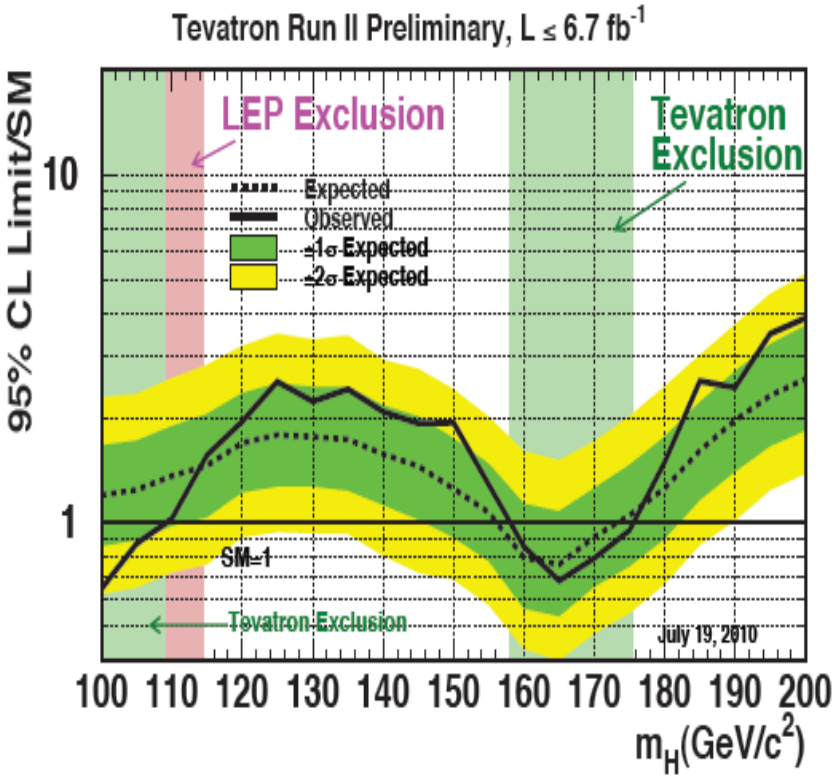
Expected 1 fb-1 by end 2011

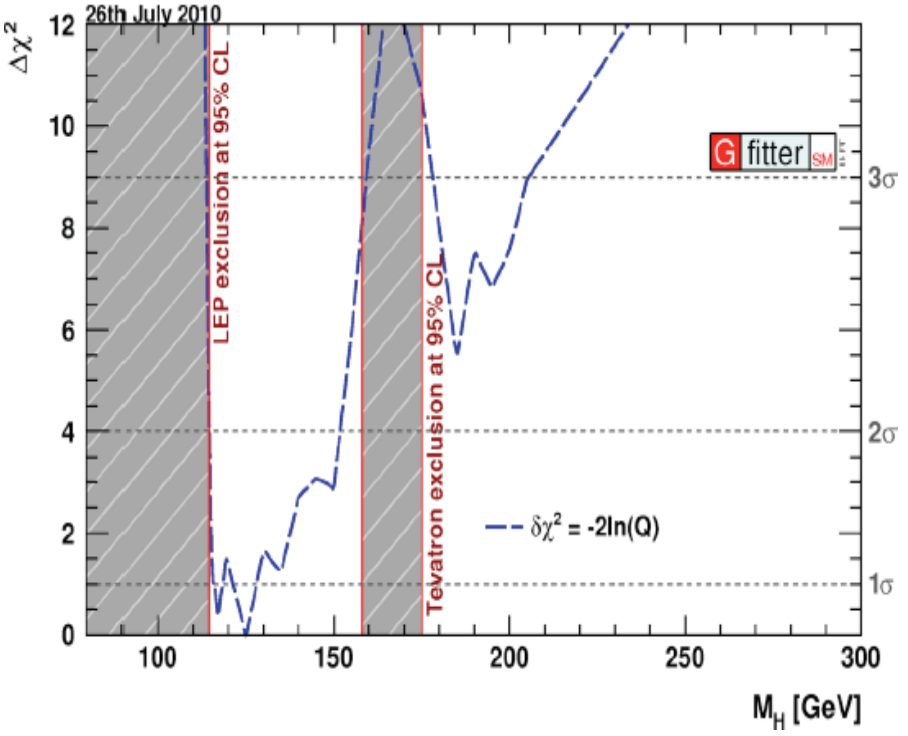


Sensitivity projections at 7 TeV for 1 fb-1 lumi presented here

→ obtained by rescaling previous studies at 10 and 14 TeV down to 7TeV. Assumes same event topology

What we know already ..



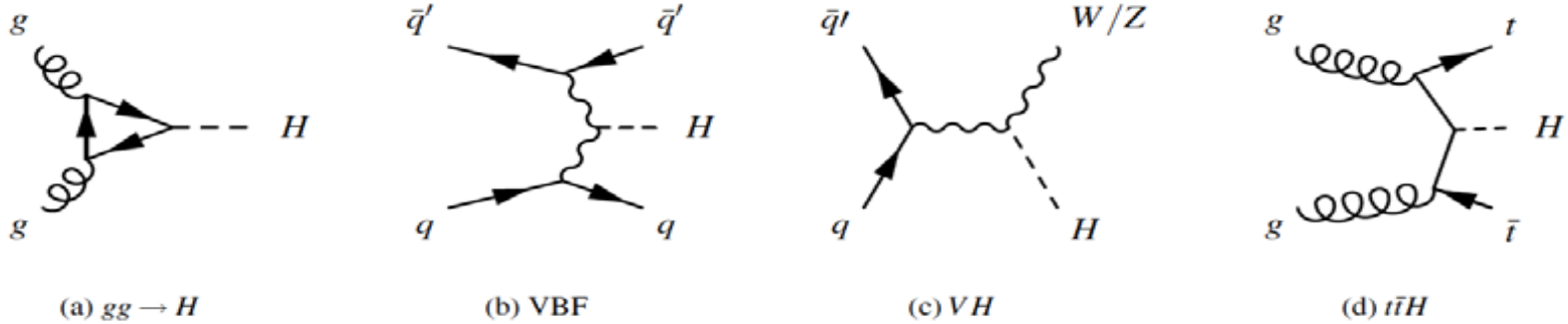


Medium mass 95% CL exclusion :

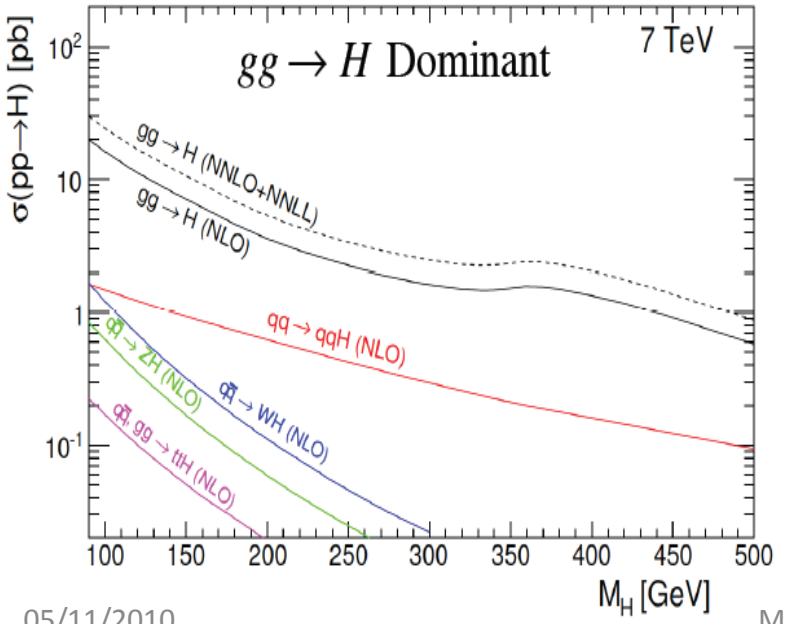
158 < m_H < 175 GeV

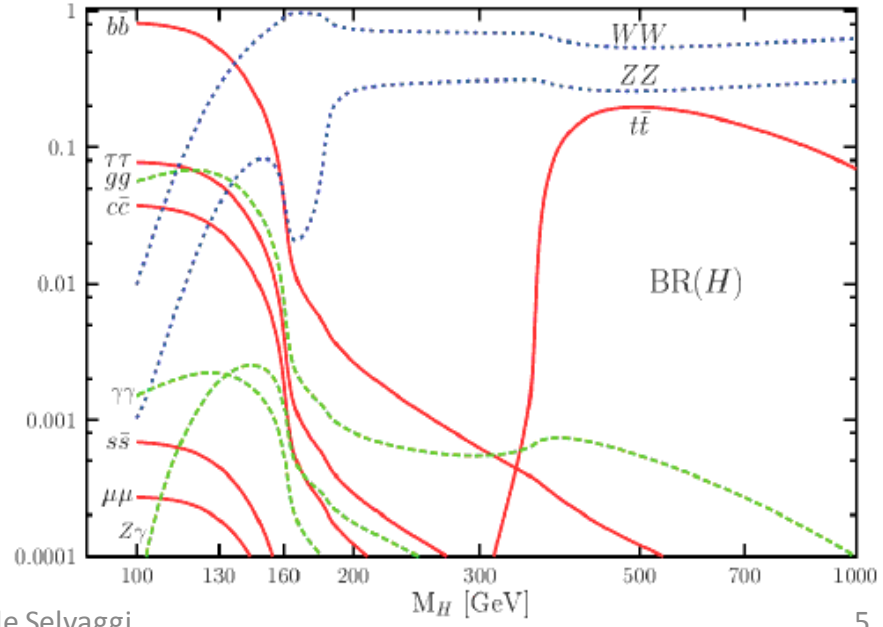
Data prefers low mass Higgs ~ 120 GeV

Standard Model Higgs



(a) $gg \to H$ (b) VBF (c) VH (d) $t\bar{t}H$





Main SM seaches in CMS

- **Low mass** (120 GeV)

  mainly H → γγ

  also qqH → qq (ττ) and VH → V (bb) ,

  some H → WW (low sensitivity !!)

- **Medium mass** (160 GeV)

  mainly H → WW → 2l2ν

  also qqH → qqWW → (2l2νqq) and (lνqqq'q')

- **High mass** (> 200 GeV)

  mainly H → ZZ → 4l and 2l2j

  also H → WW → 2l2ν

H → γγ (low mass)

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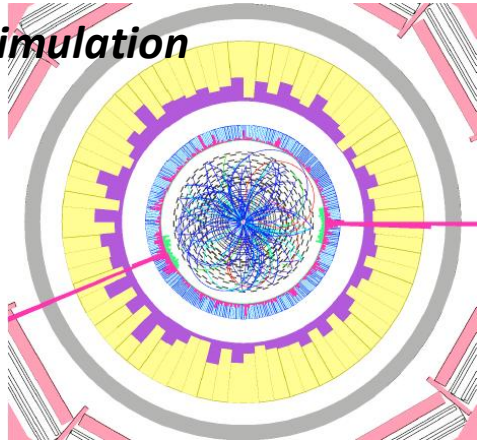
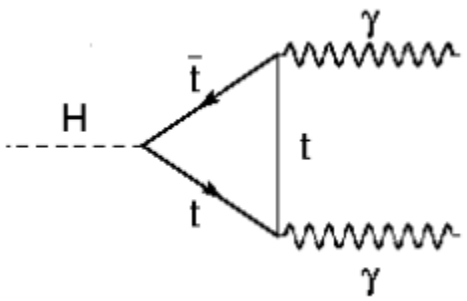
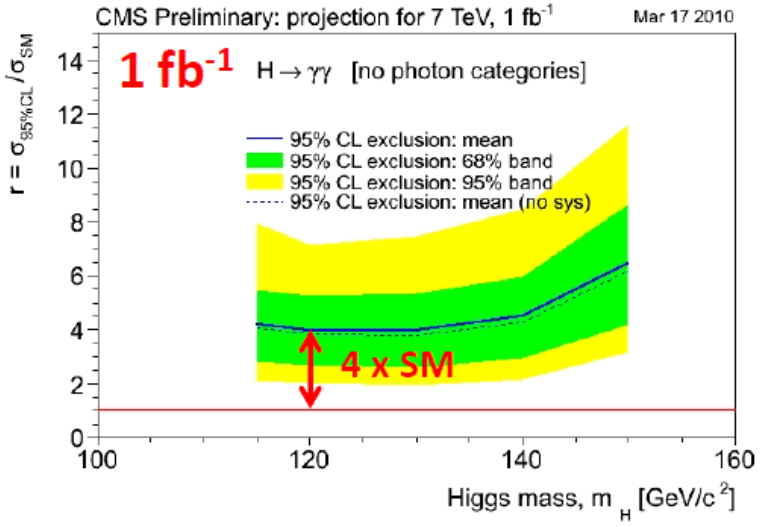


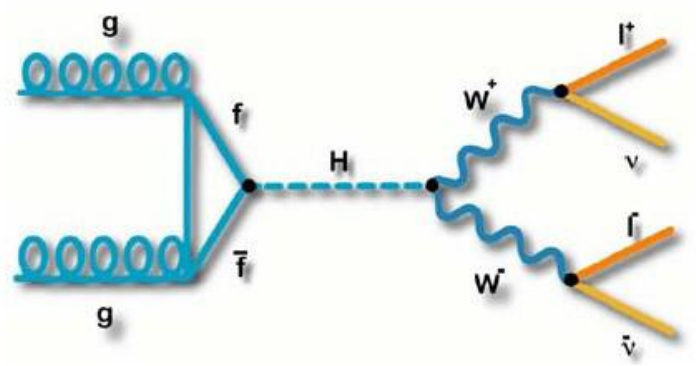


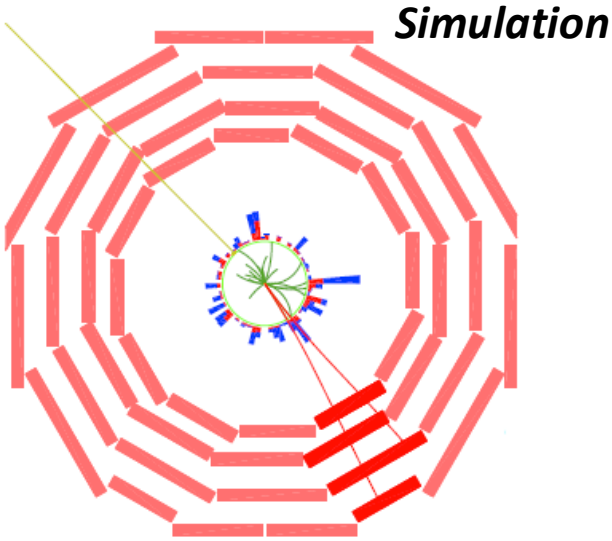


- Strategy:
  - → look for 2 high energetic photons and reconstruct invariant mass
  - → discriminate S from B using mass, photon id, angular distributions
  - → cut-based or MVA
- Pros
  - →a peak in invariant mass distribution or MVA output
  - → a clean photon Id leads to 0.7 % unc. on mass resolution
- Cons
  - → big background rate
  - → very low signal rate

Effective from 10 fb-1 on

H → WW → 2l2v (med. mass) (I)





- General Strategy:

  → counting experiment
  → divide in 4 subchannels: ee,μμ, μe,eμ
  → cut-based or MVA (Boosted Decision Trees and Neural Networks)

- Main backgrounds

→WW (irreducible), W+jets, tt, Single Top,Drell-Yan

H → WW → 2l2ν (med. mass) (II)

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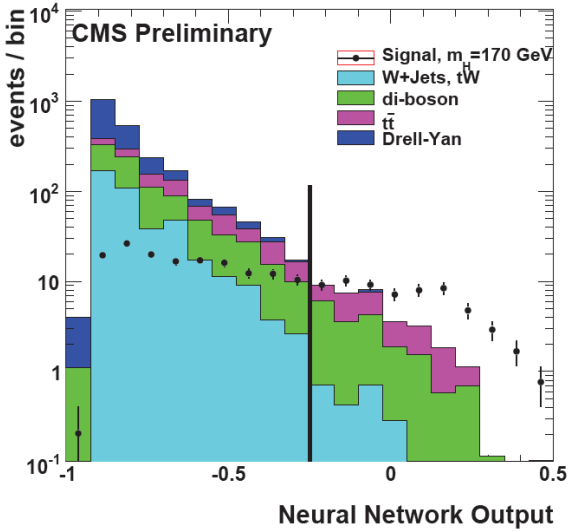
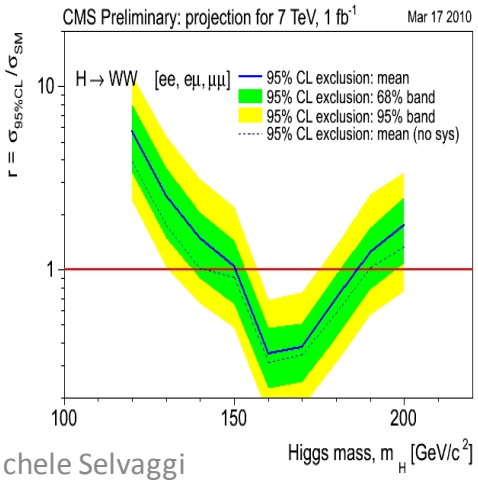
•Background Rejection (key variables):

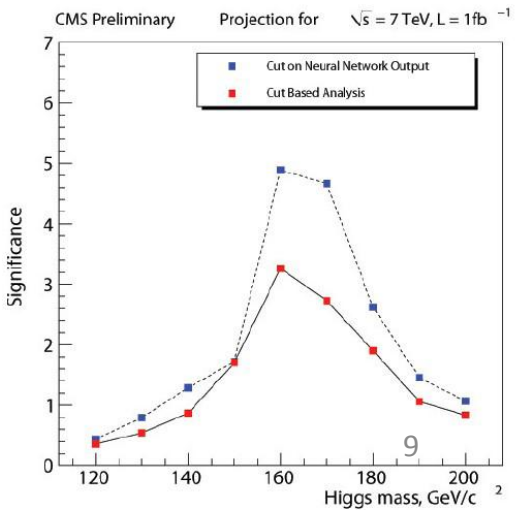
→ WW : angle between leptons
→ W+jets : electron Identification
→ top pair : central jet veto
→ Drell-Yann: Missing Tranverse Energy



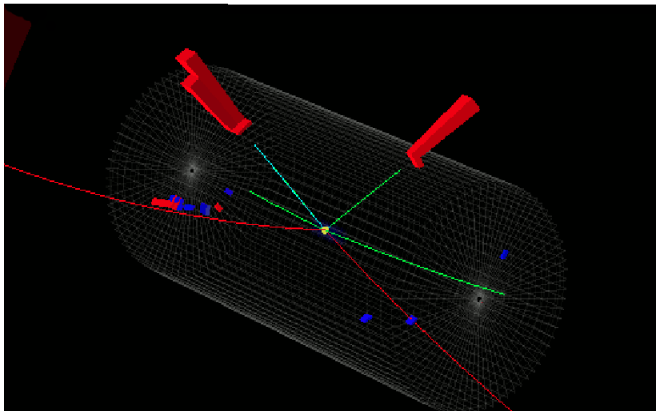
Require two well isolated leptons with large missing transverse energy and no central jets.

•Pros
→ High Signal yield
• Cons
→ No mass peak , due to neutrinos

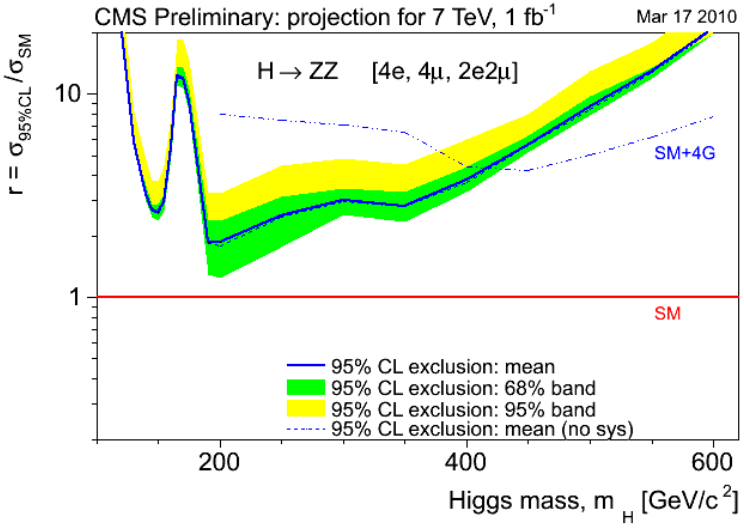




H → ZZ → 4l (high mass)



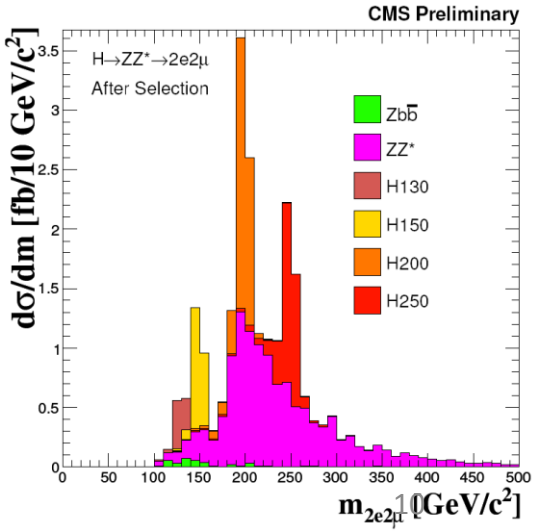
Simulation



- General Strategy:
  - → require 4 isolated leptons
  - → look for a mass peak in the 4-leptons mass distribution
- Backgrounds
  - → ZZ irreducible, just different mass shape
  - → tt & Zbb: lepton isolation and b-tagging, to reject b → lX decays
- Pros
  - →a mass peak

Cons
  - → very low signal yield

Need more than 1 fb-1 !!

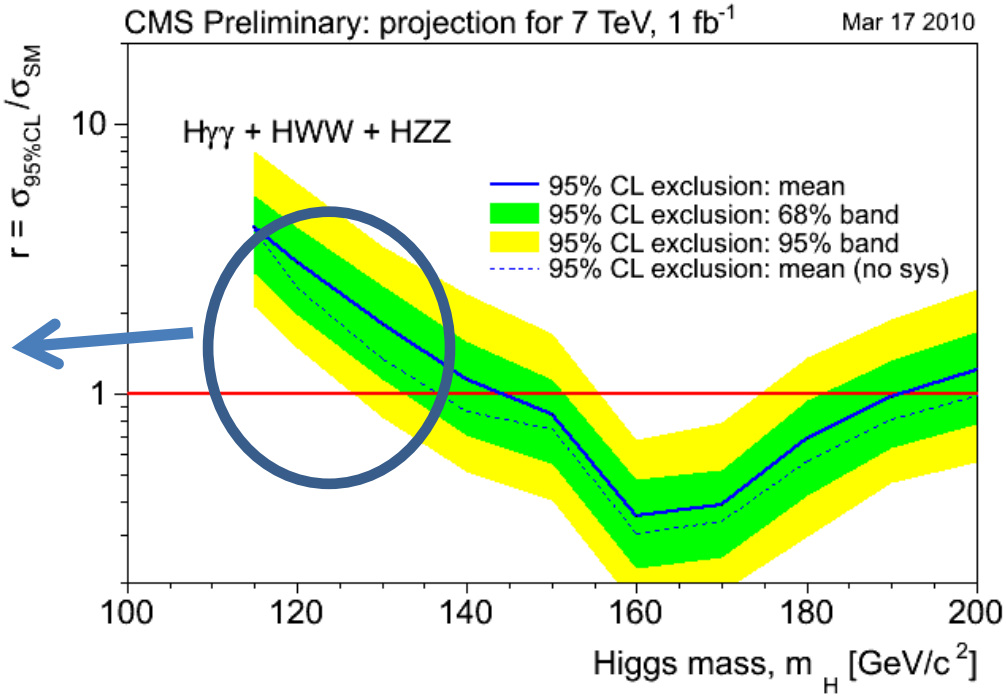


Combination projections (WW+ZZ+γγ)

Can be improved by using

H → bb

H → ττ



SM Higgs expected 95% CL exclusion range at 1 fb-1: 145-190 GeV

Projections are "indicative" and conservative.

MSSM Higgs searches in CMS (I)

MSSM Higgs requires 2 doublets → 5 scalars:

ϕ (= h, H, A) and H±

At tree-level, MSSM Higgs fully specified by two free parameters: m_A , $\tan\beta$ = <Hu>/<Hd>

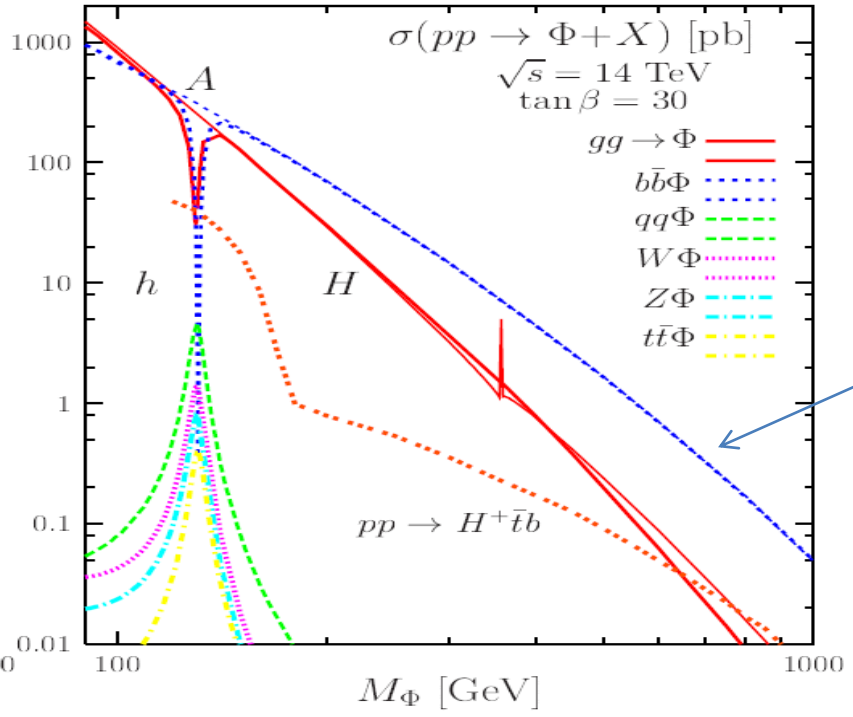
In the large m_A limit:

- Heavy scalar decouples from Vector Bosons
- Light scalar has same couplings as in SM

Cross Section:

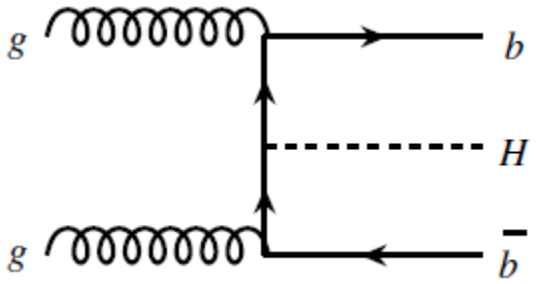
- (ϕdd) enhanced by factor $\tan\beta$ for $\phi\tau\tau$ and ϕbb
- (ϕuu) suppressed by factor $\tan\beta$ for ϕtt

MSSM Higgs searches in CMS (II)

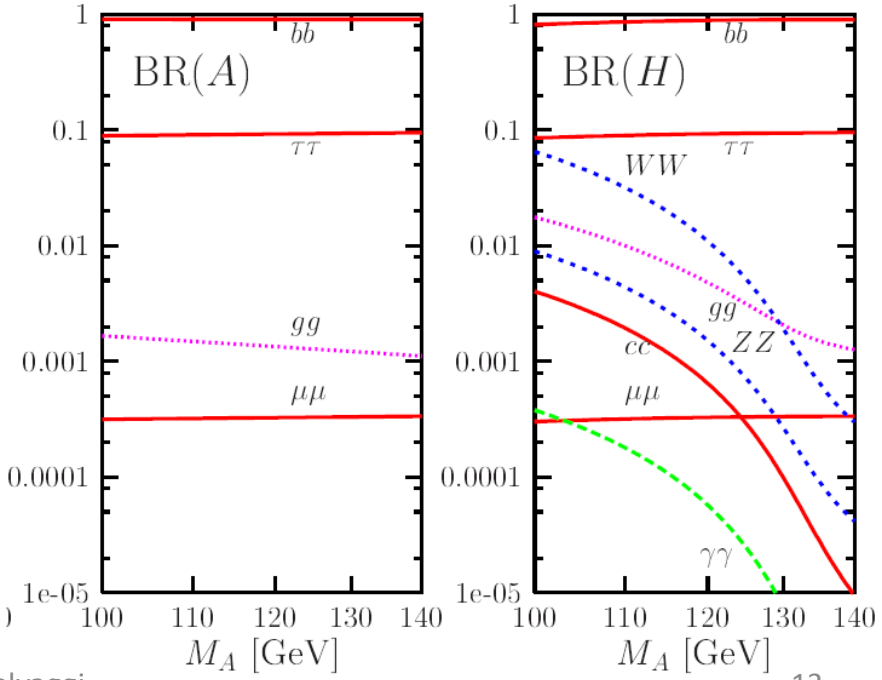


Dominant production mode

bbϕ, ggϕ



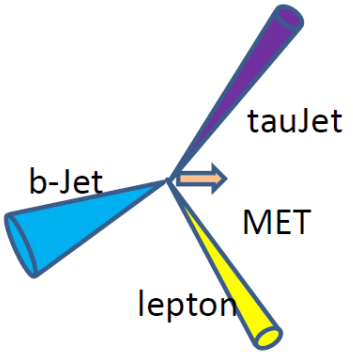
ϕ decays mainly to bb (90%)
and to ττ (10%)
but **bbϕ, Φ→ττ** EASIER!

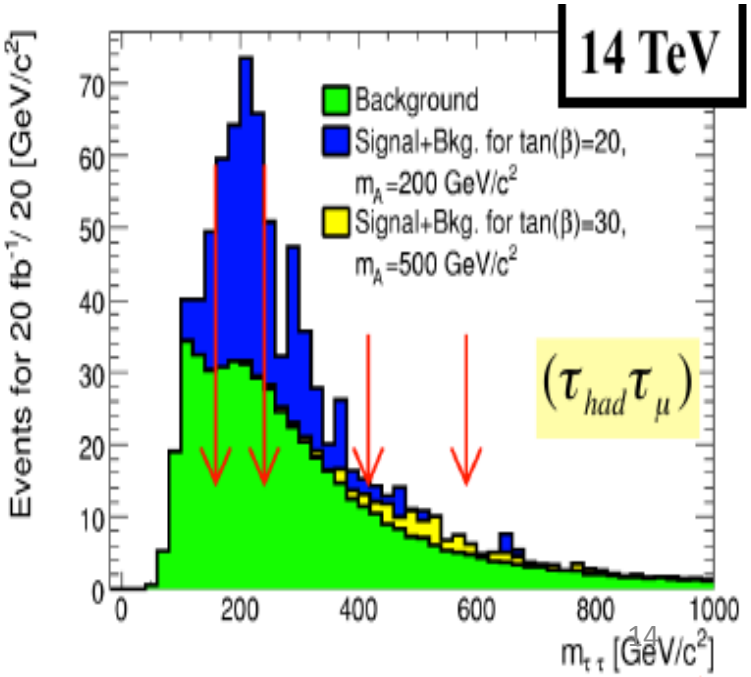


gg→bbϕ, ϕ → ττ (I)

- General Strategy:

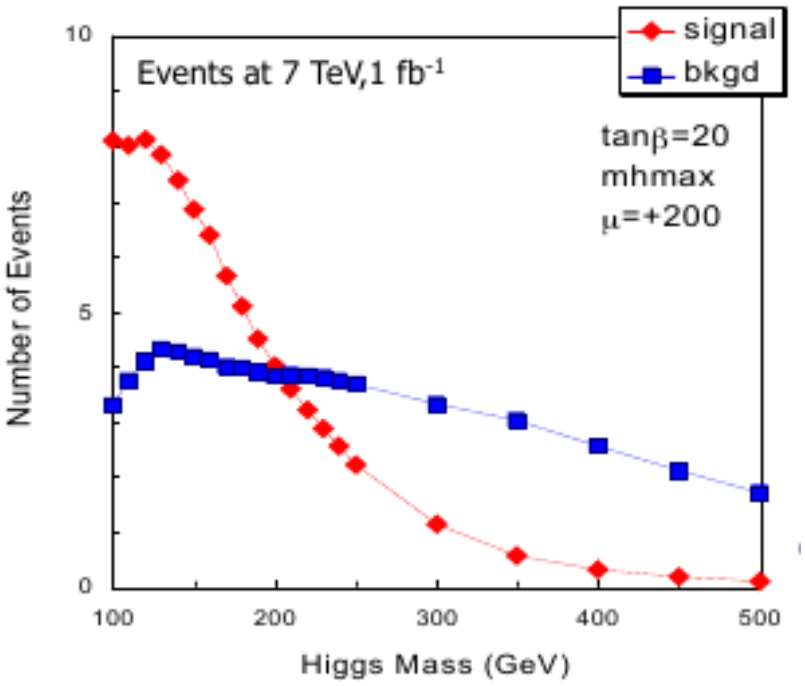
→ Isolated pairs of (τhad τhad) ,(τhad τμ), (τhad τe), (τμ τe)
→with Missing transverse Energy, 1 tagged bjet, veto extra jets
→ build ττ—mass using collinear approximation
→ count events in sliding ττ-mass window

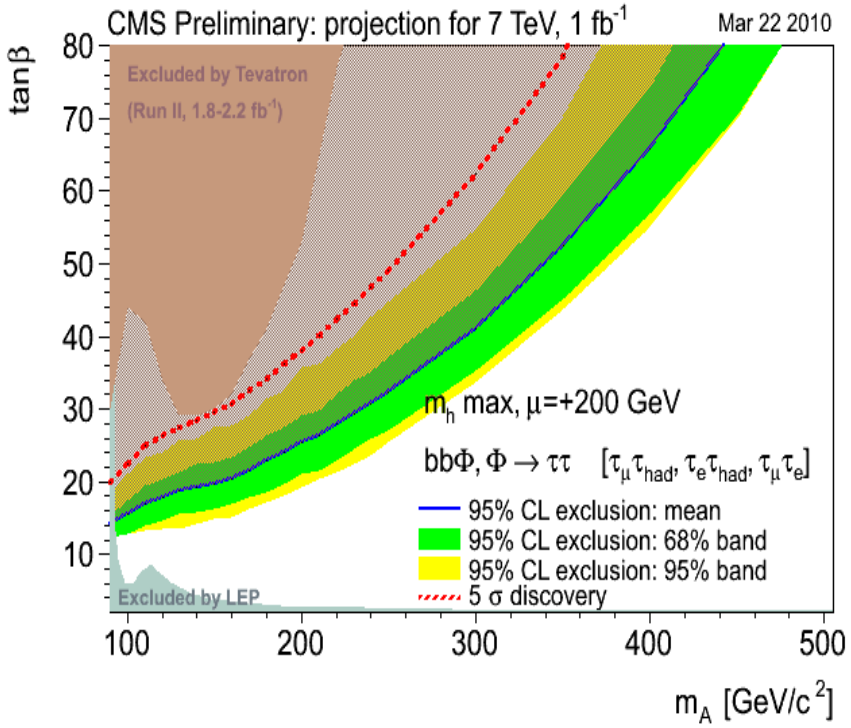




Dominant backgrounds:
→ tt, Zbb Zcc rejected by jet veto
→ Drell-Yann, Wjets

gg→bbϕ, ϕ → ττ (II)





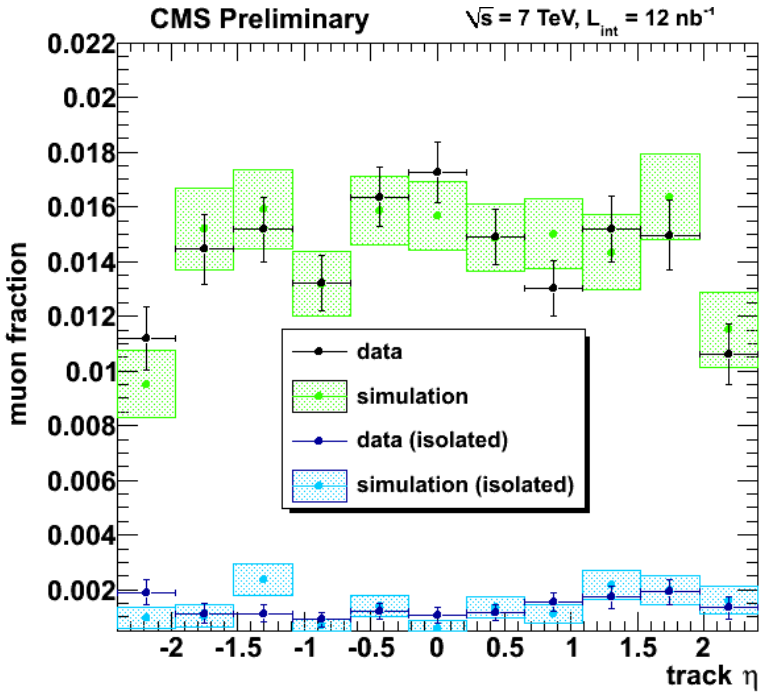
Can definitely improve Tevatron sensivity with 1 fb-1 !!
(this is a conservative projection from 14 to 7 TeV)

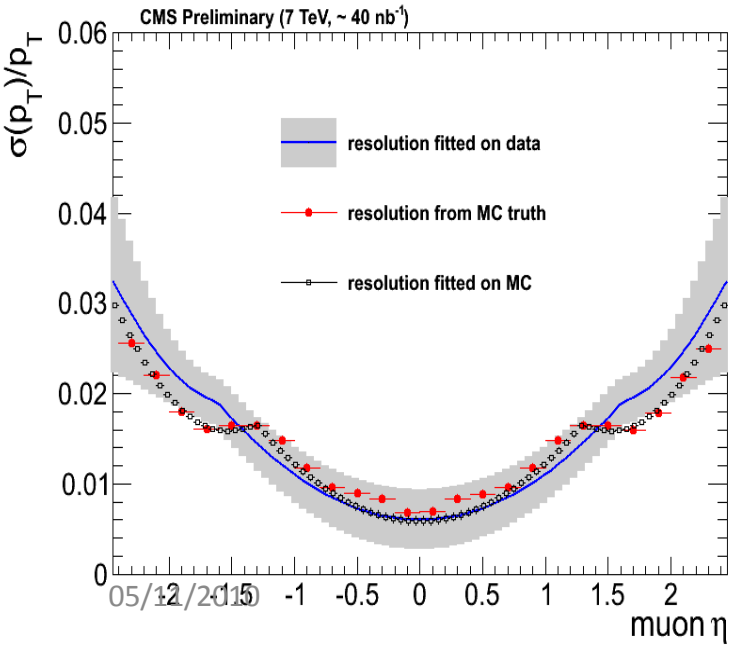
Muons Commissioning

CRUCIAL FOR WW, ZZ ANALYSES !!

- Isolation

→ Fraction of QCD tracks misidentified as muons is reduced by > 90% after isolation





- Resolution

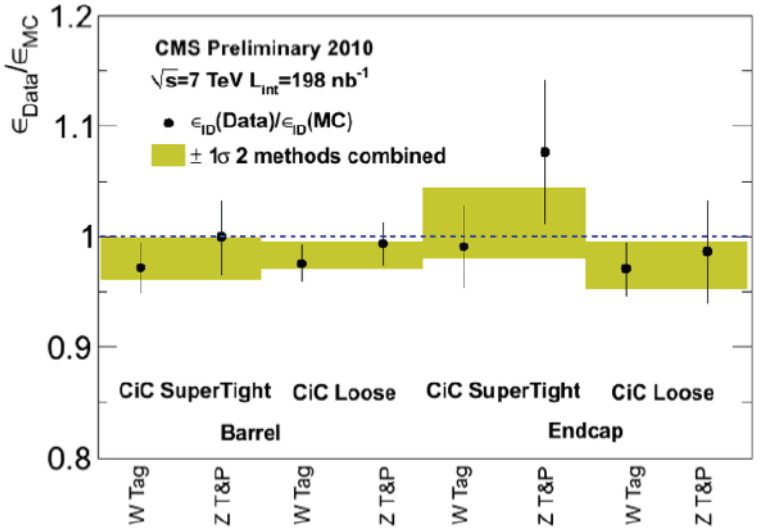
→ Of the order of 1% in the barrel and 3% in the endcaps, in good agreement wih MC predictions

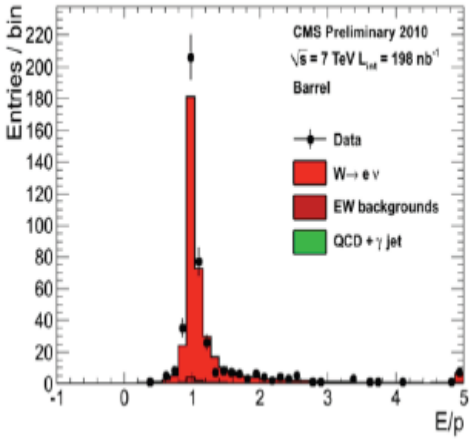
Electrons Commissioning

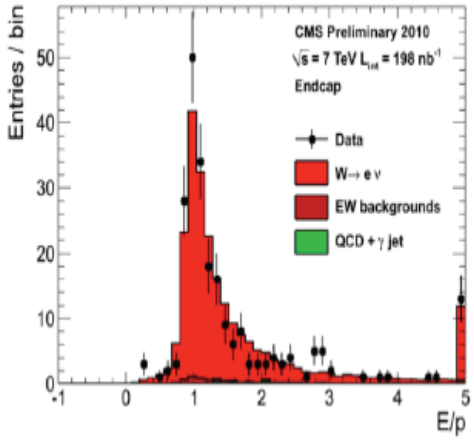
CRUCIAL FOR WW, ZZ ANALYSES !!

- Identification

→ correction factors from MC to data close to 1. Good understanding of data and MC





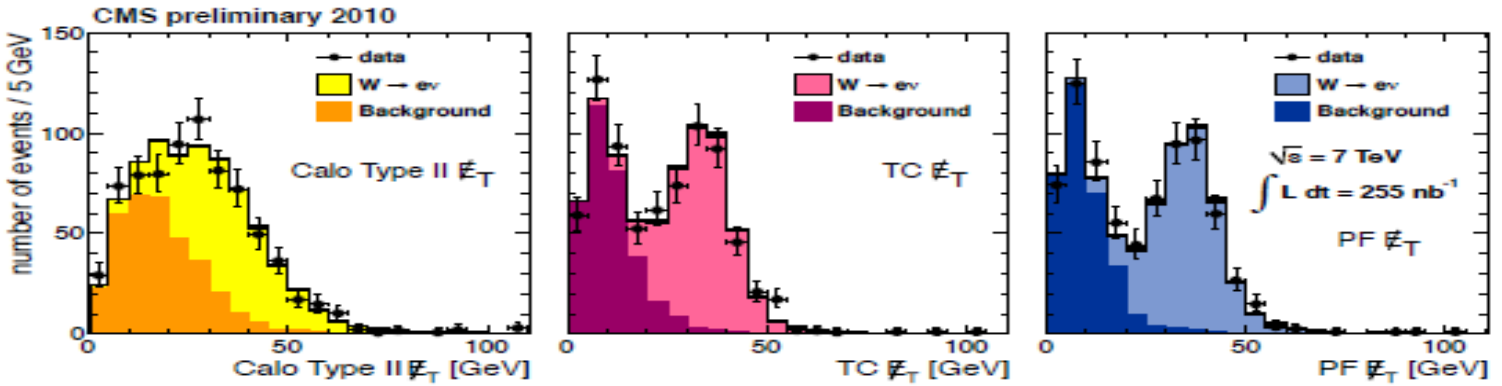


→ Identification works as expected

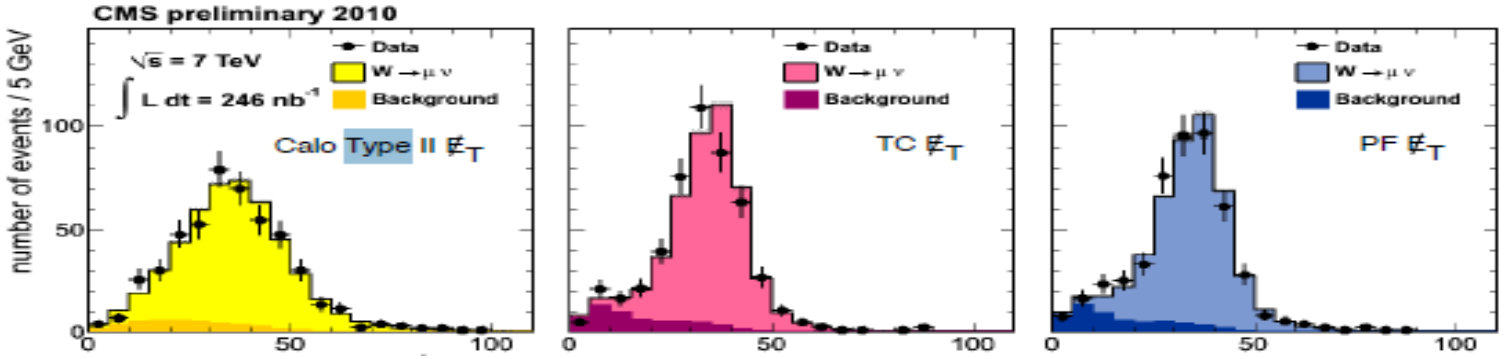
Missing E_T

CRUCIAL FOR WW, ττ ANALYSES !!

W→eν



W→μν



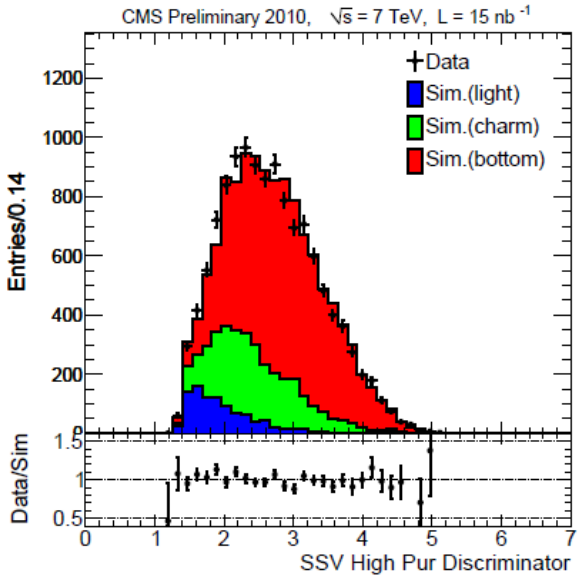
→ Use three different collections of MET; Particle Flow MET is the one that performs best

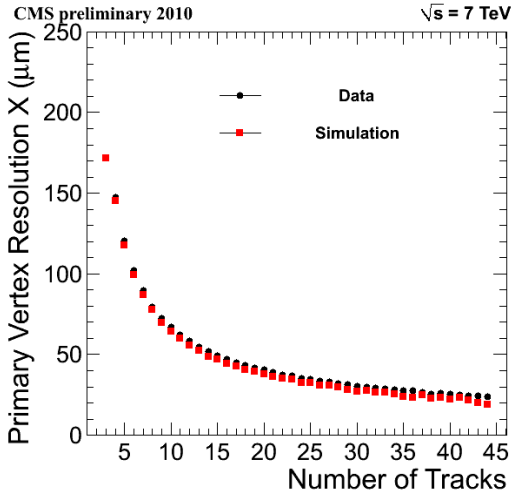
Tracking performance

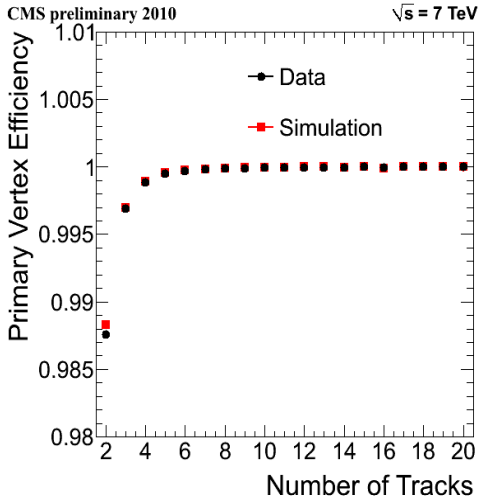
CRUCIAL FOR EVERY ANALYSIS!!

- Primary Vertex

→ Good PV Reconstruction





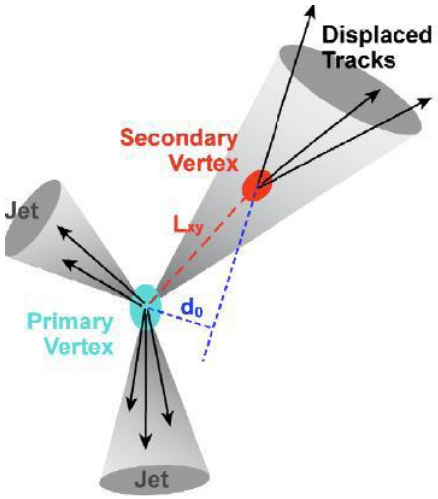


- B-tagging

→ Excellent agreement between data and MC

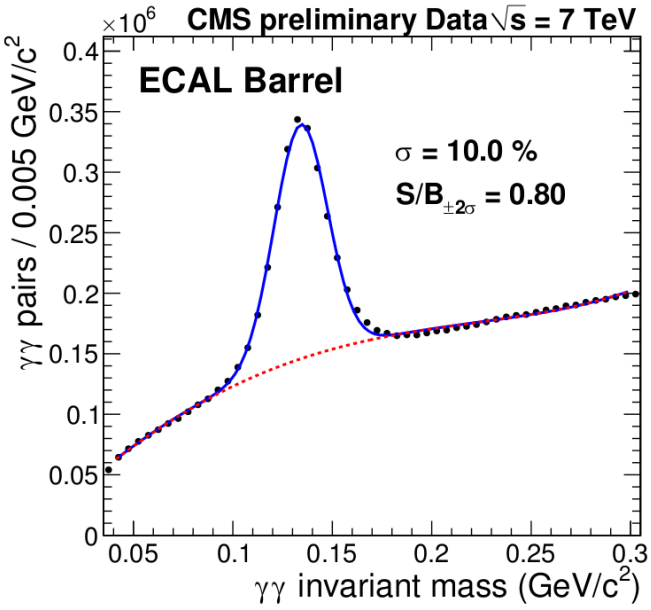
→ Good discriminating power for SV identification

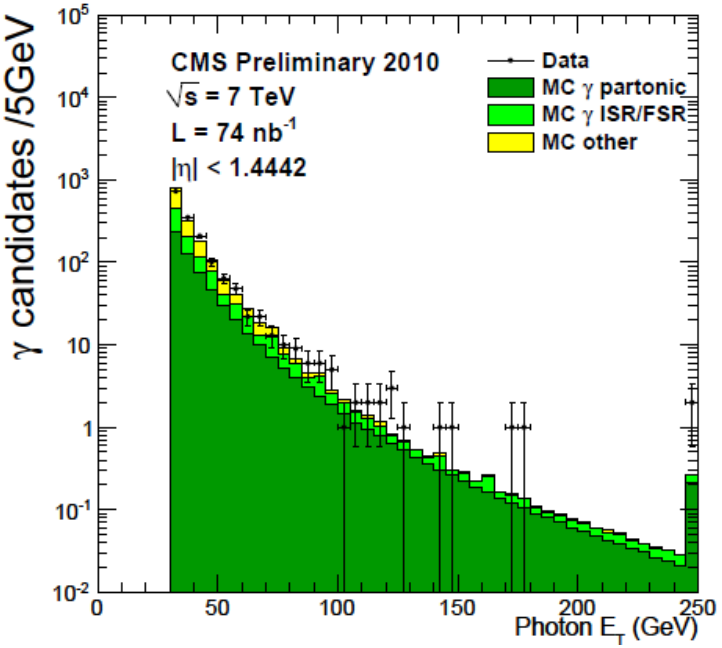
→ Needed for background rejection such as tt, Zbb …



Photons

CRUCIAL FOR H→ γγ





Goal is to reach 0.5 % in energy resolution. We are at 1% now …

Conclusions

•LHC has accumulated **42 pb-1** of data already.
Certain performance and data driven background estimation studies are on-going.

• Sensitivity expectation scaled from 10/14 TeV to 7 TeV results 1 fb^{-1} was shown.

• Expected exclusion for **$145 < m_H < 190$ GeV** in SM

• Need more than 1 fb^{-1} to say something at low mass

• Pushing exclusion to **$\tan\beta = 15,20$** for MSSM for 1fb-1

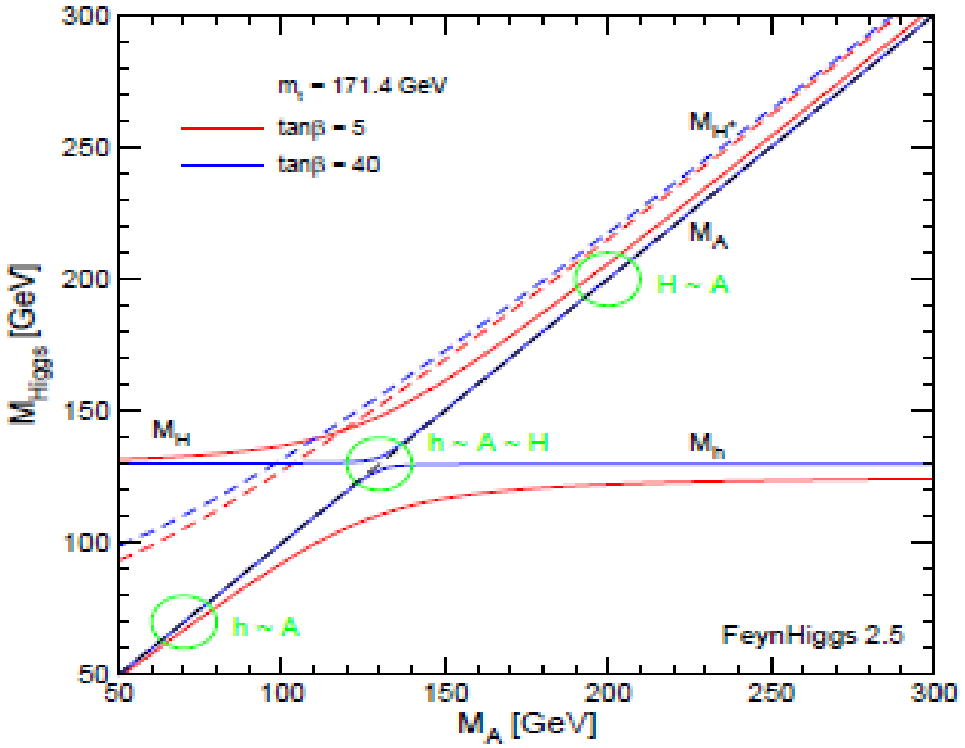
• Apologyze for leaving out so many interesting studies: charged higgs, $qqH \rightarrow qq\tau\tau$, $H \rightarrow ZZ \rightarrow 2j2l$ …

• Waiting more luminosity !!

Backup

Possible realizations of the MSSM Higgs sector:

[FeynHiggs 2.5]



At lower $\tan\beta$:
Higgs masses
and couplings
somewhat separated

At higher $\tan\beta$:
low M_A: $h \approx A$
med. M_A: $h \approx A \approx H$
higher M_A: $H \approx A$

Upper limit on M_h:
$M_h \lesssim 130$ GeV

τ – Identification

CRUCIAL FOR H→ ττ