Di-tau background estimation in Higgs To Tau Searches with CMS

LHC Physics Discussion
Feb 6, 2012

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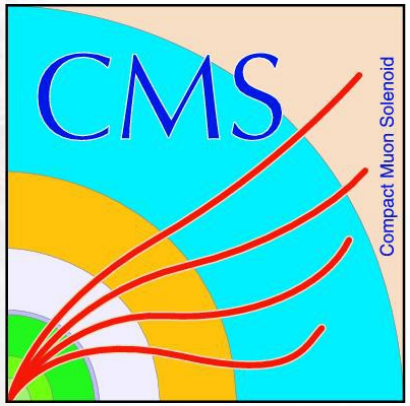


Higgs Searches in CMS

- CMS (SM) Higgs searches with 4.6 – 4.7 fb^{-1}:

Low Higgs masses:

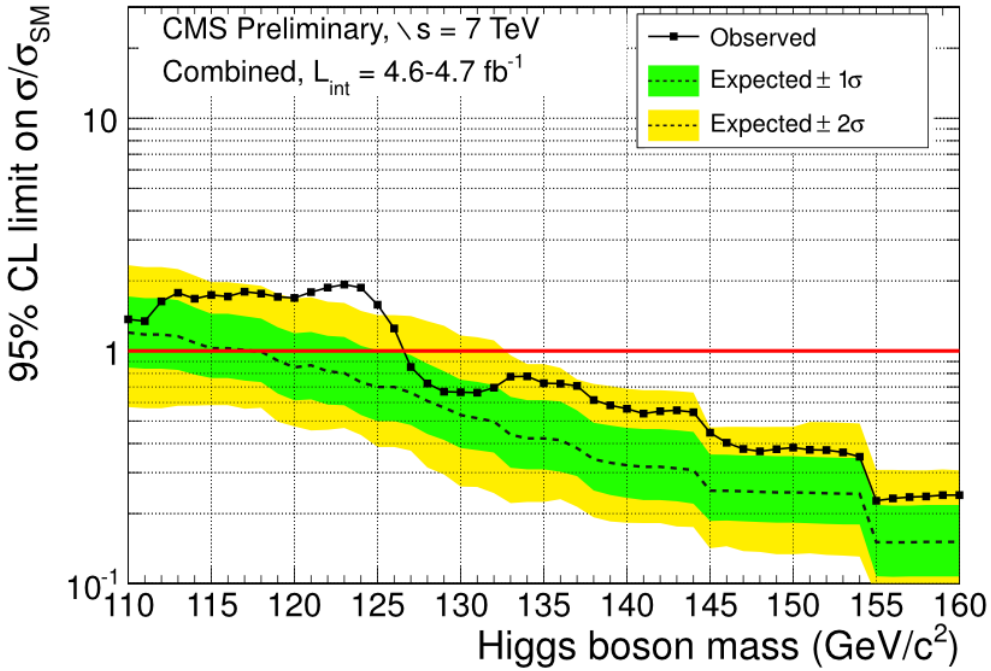
- $H \rightarrow \gamma\gamma$ CMS-PAS-HIG-11-030
- $H \rightarrow \tau\tau \rightarrow \mu\tau_h 3\nu$, $e\tau_h 3\nu$, $e\mu 4\nu$ CMS-PAS-HIG-11-029
- $VH \rightarrow Vbb \rightarrow l\nu 2b$, $2l2b$, $2\nu 2b$ CMS-PAS-HIG-11-031

Mid to High Higgs masses:

- $H \rightarrow WW \rightarrow 2l2\nu$ CMS-PAS-HIG-11-024
- $H \rightarrow ZZ \rightarrow 4l$, $2l2\nu$, $2l2q$, $2l2\tau_h$ CMS-PAS-HIG-11-025, CMS-PAS-HIG-11-026, CMS-PAS-HIG-11-027, CMS-PAS-HIG-11-028

Results from Dec 13

All channels combined



- Higgs Masses from 127 – 600 GeV excluded at 95% C.L.
- No conclusive signal yet!

The Tau Lepton

m_τ = 1.78 GeV, $c\tau$ = 87 μm

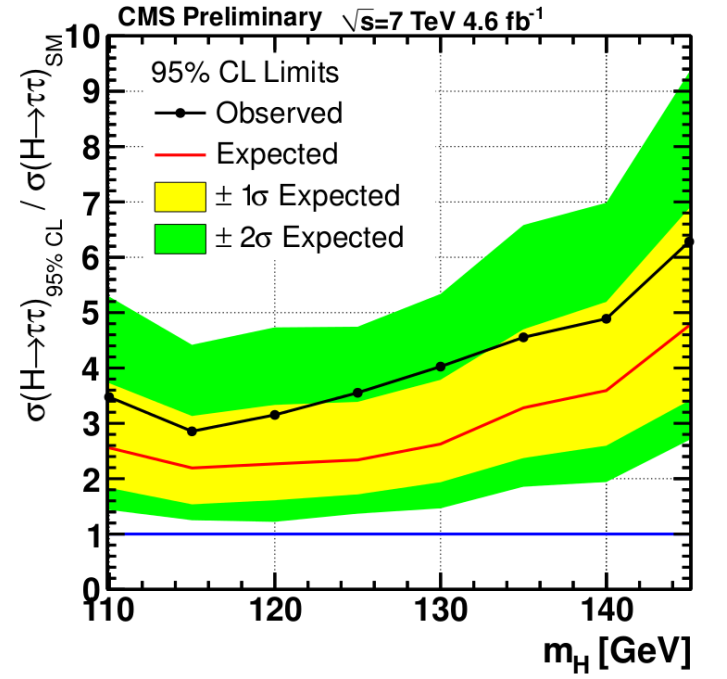
Decay mode	Resonance	Branching ratio
$\tau^- \rightarrow e^- \nu\nu$	-	17.8%
$\tau^- \rightarrow \mu^- \nu\nu$	-	17.4%
$\tau^- \rightarrow h^- \nu$	-	11.6%
$\tau^- \rightarrow h^- \pi^0 \nu$	ρ(770)	26.0%
$\tau^- \rightarrow h^- \pi^0 \pi^0 \nu$	$a_1(1260)$	10.8%
$\tau^- \rightarrow h^- h^+ h^- \nu$	$a_1(1260)$	9.8%

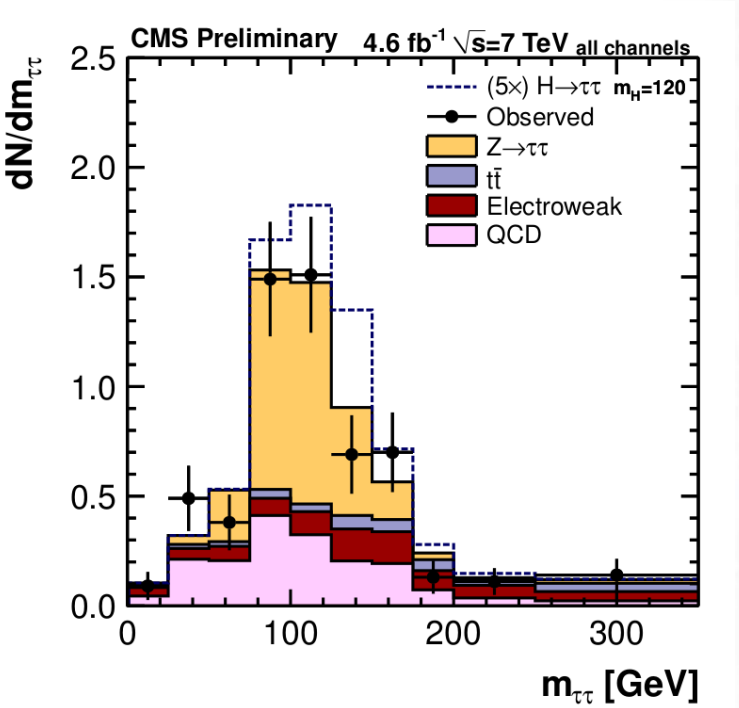
($h^- = \pi^-, K^-$)

- Missing Energy
- Isolation
- Photons compatible to π^0
- Displaced tracks
- 1 or 3 charged tracks
- Compatible to heavy resonance

Higgs To Taus in CMS

- $\mu\tau_h$, $e\tau_h$, $e\mu$ channels considered
- "SVfit" mass reconstruction
- VBF category most sensitive

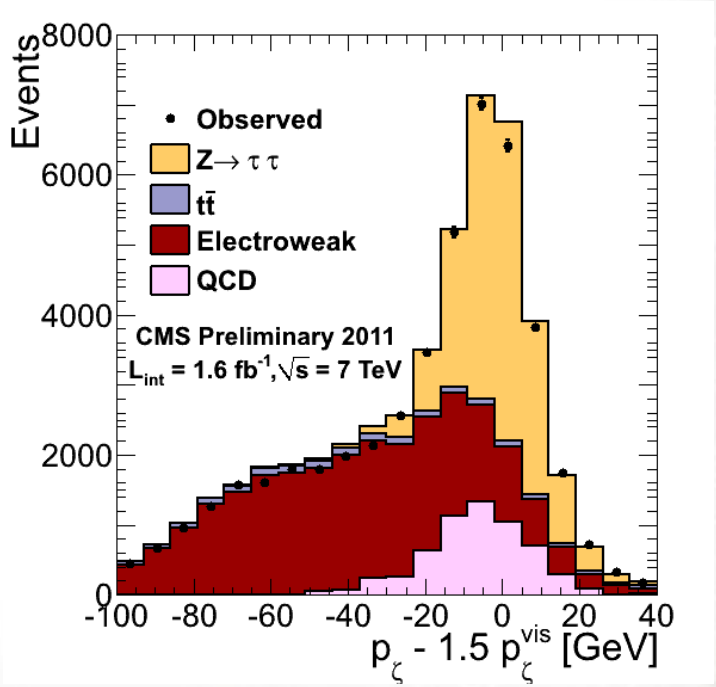




Background in Higgs to Taus

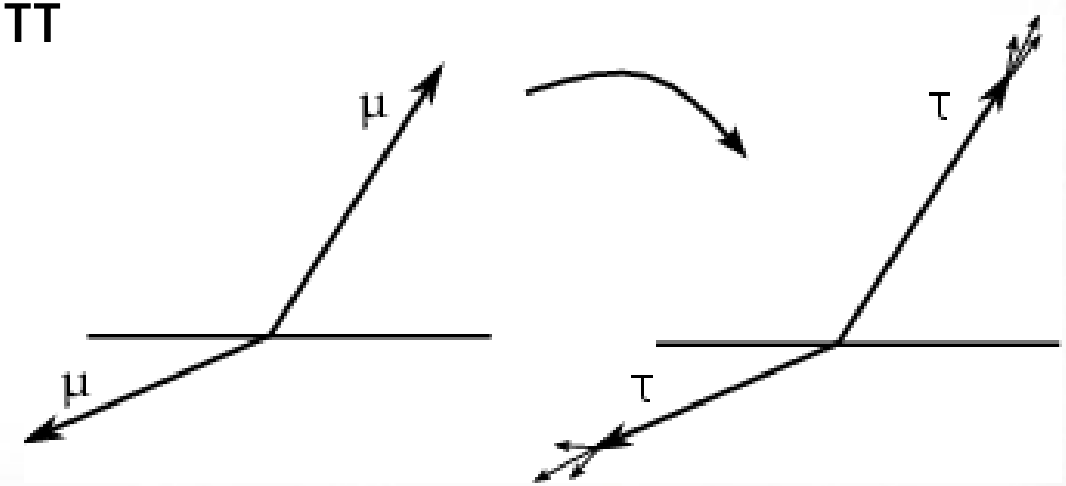
Mass Shapes and/or Normalization for
Most background can be obtained from data

- **Diboson (WW, WZ, ZZ):** Small
- **$t\bar{t}$:** MET Sideband
- **QCD:** Same Sign Sample
- **W + Jets:** M_T/P_ζ Sideband
- **$Z \rightarrow \tau\tau$:** Irreducible!!

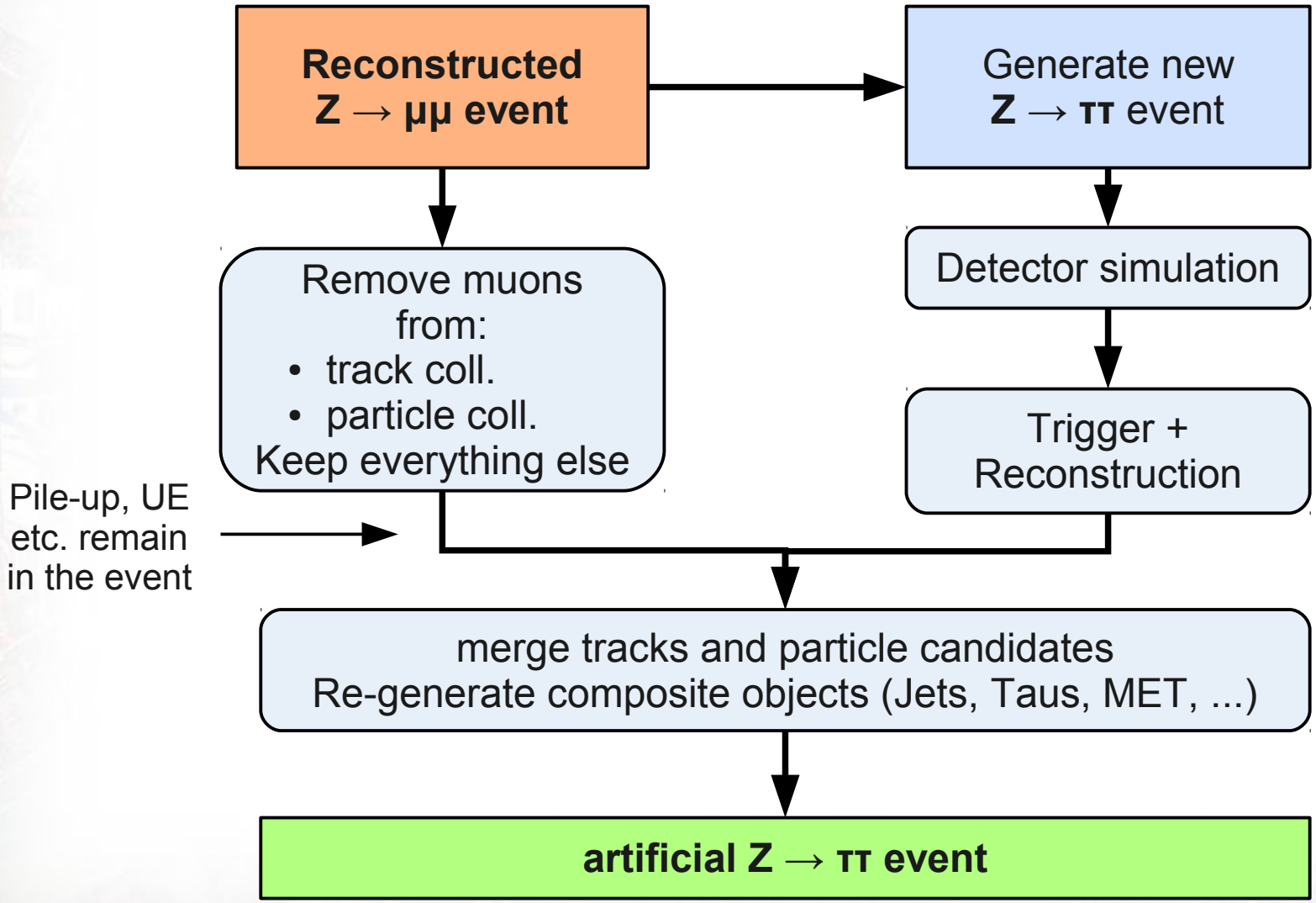


The Embedding Technique

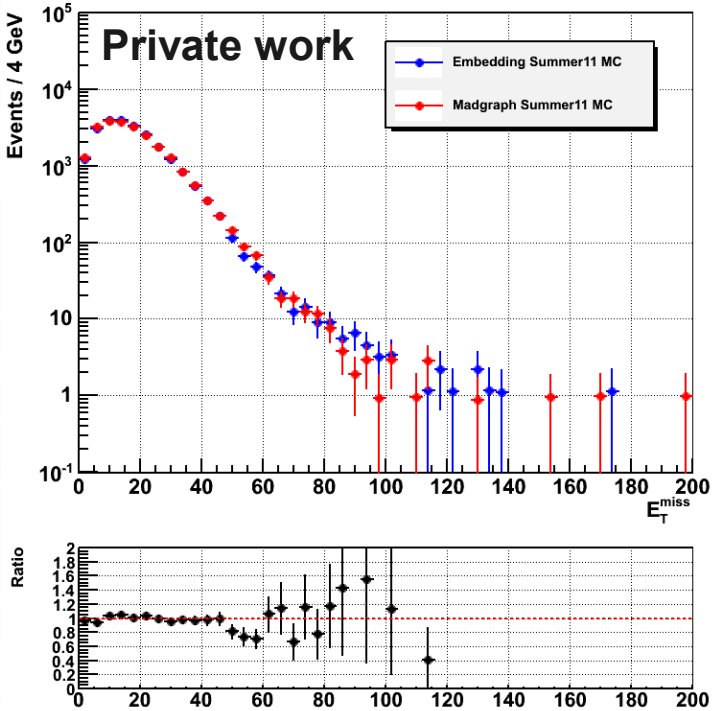
- Select di-muon events from Z decays in data
- Replace measured muons by simulated generator level tau leptons
- Other event content (UE, PU) taken from data
- $Z \rightarrow \mu\mu$ and $Z \rightarrow \tau\tau$ kinematically equivalent



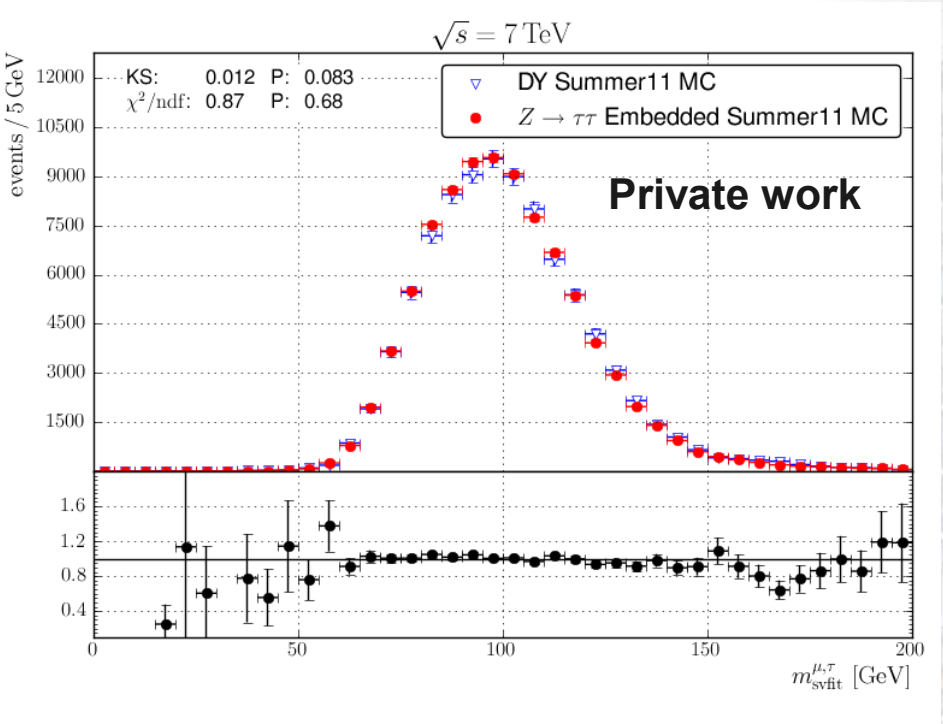
Overview of the Method



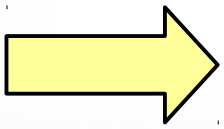
Closure Test with Monte Carlo



Missing energy in ττ → μμ

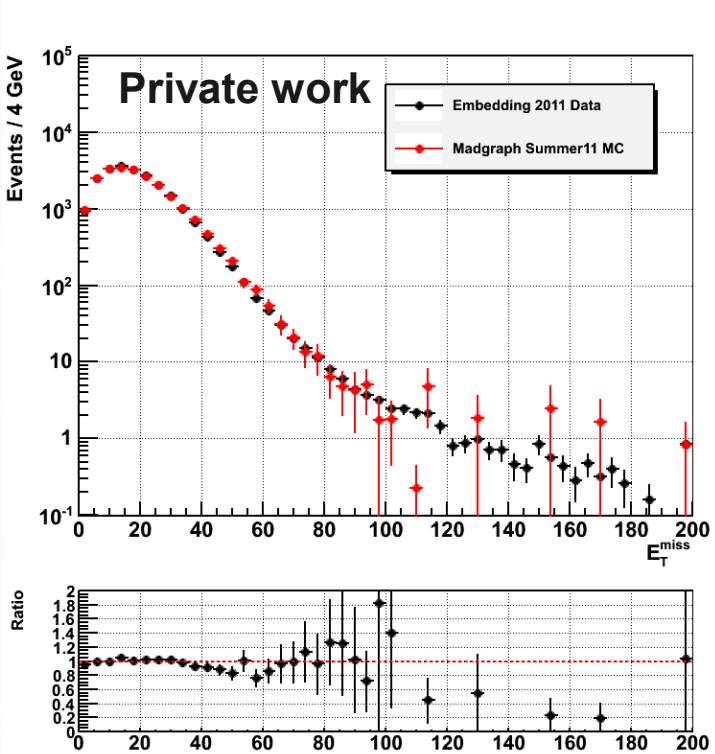


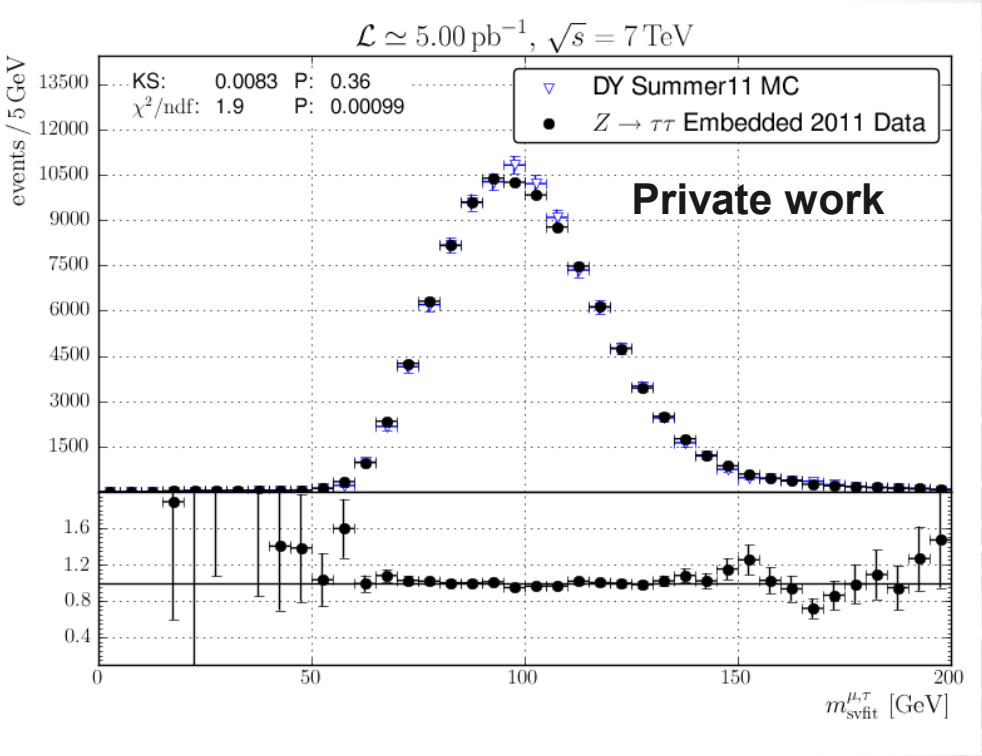
SVfit mass in ττ → μτ_h



Embedding describes full event well

Kinematic Distributions

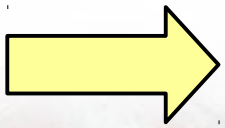




Missing energy in ττ → μμ

SVfit mass in ττ → μτ_h

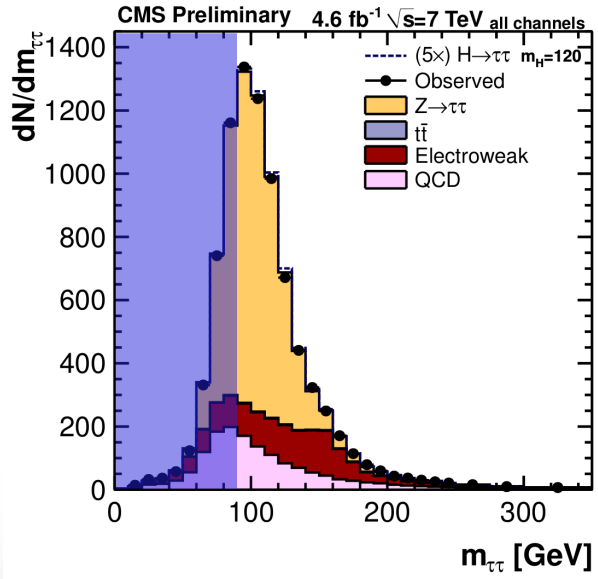
Embedding agrees well with MC!



Verification for MC corrections

Normalization

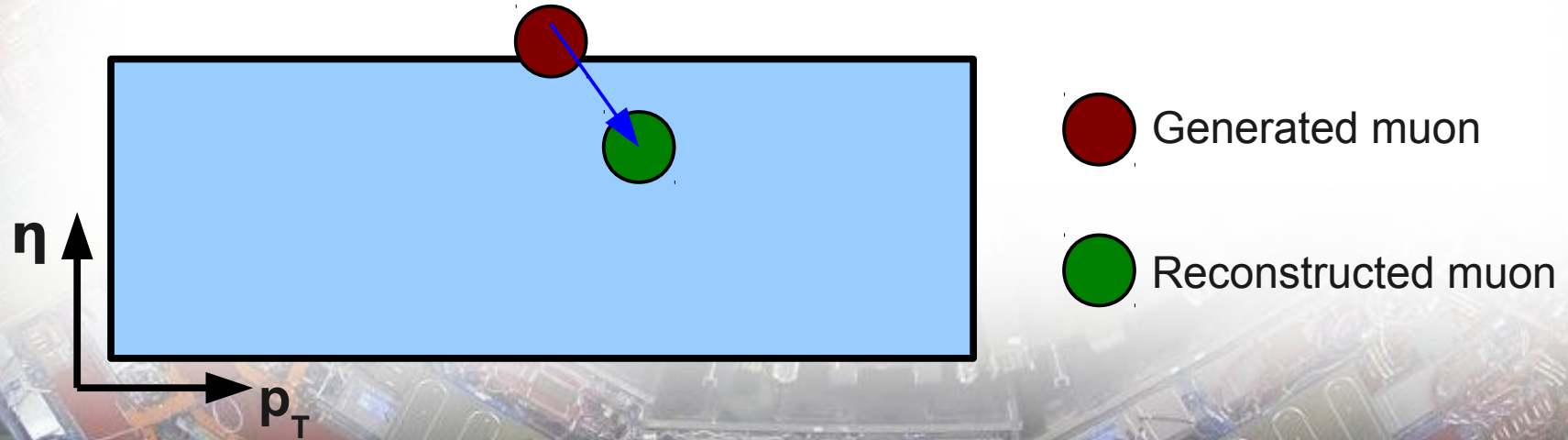
- By cross section and integrated luminosity
  - Luminosity uncertainty stays
- Fit to data
  - Need a signal-free region with high statistics
    - $M_{TT} < 90$ GeV
- Absolute normalization
  - BR(Z → μμ) = BR(Z → ττ)



Absolute Normalization

$BR(Z \rightarrow \mu\mu) = BR(Z \rightarrow \tau\tau)$, but...

- Di-muon selection is not 100% efficient
  - Trigger, Quality, Isolation
- Di-muon events from other sources
- Different efficiency of tau isolation
- Reconstructed objects used as gen-level taus



Conclusions

Absolute Normalization in ττ → μμ:

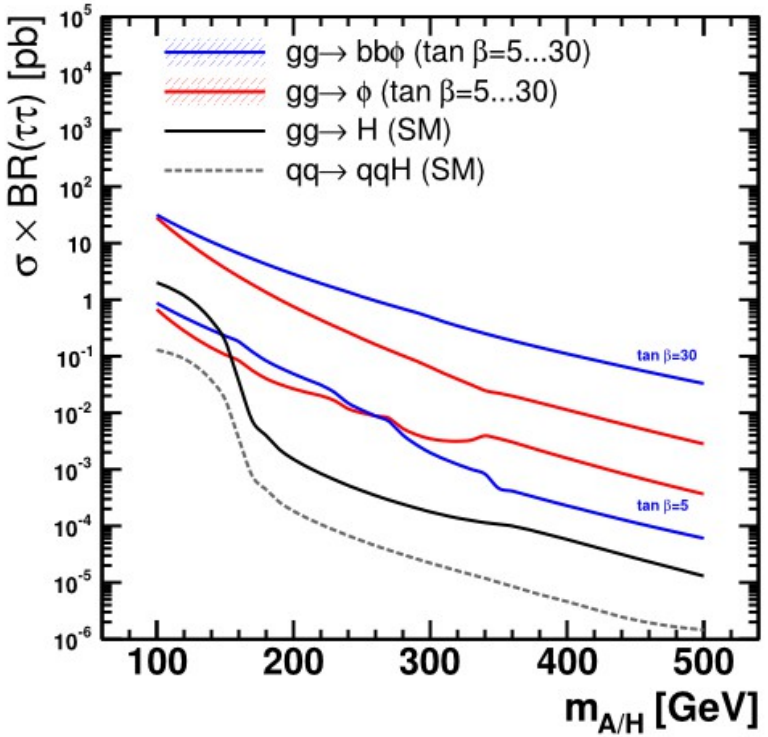
Monte Carlo	2505 ± 39
Embedding	2469 ± 6

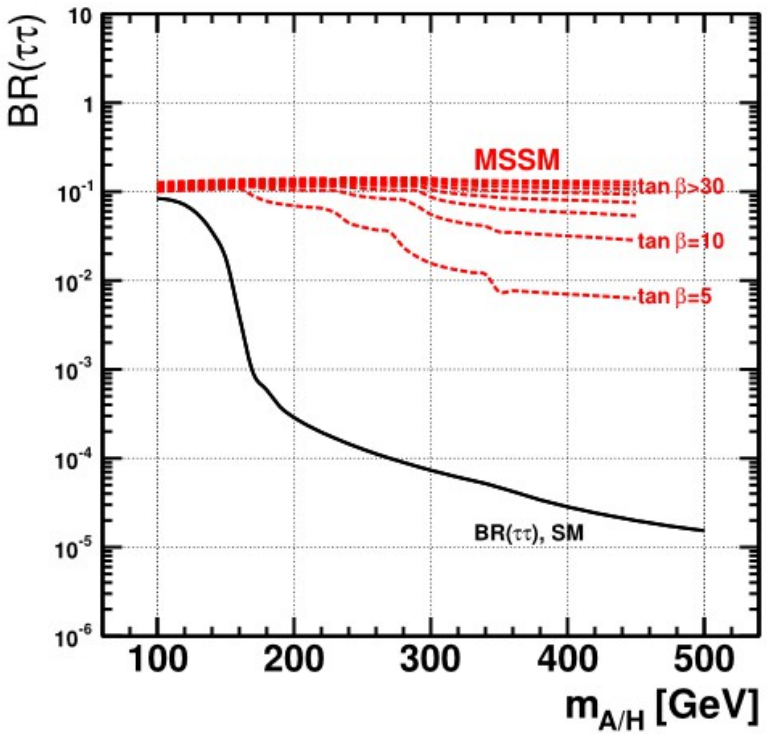
(stat. error only)

- No public news since Dec 13
- Many improvements in the pipeline for Moriond
- H → ττ channel sensitive to low mass Higgs
  - Large irreducible Z → tautau background
  - Can be estimated with the Embedding method

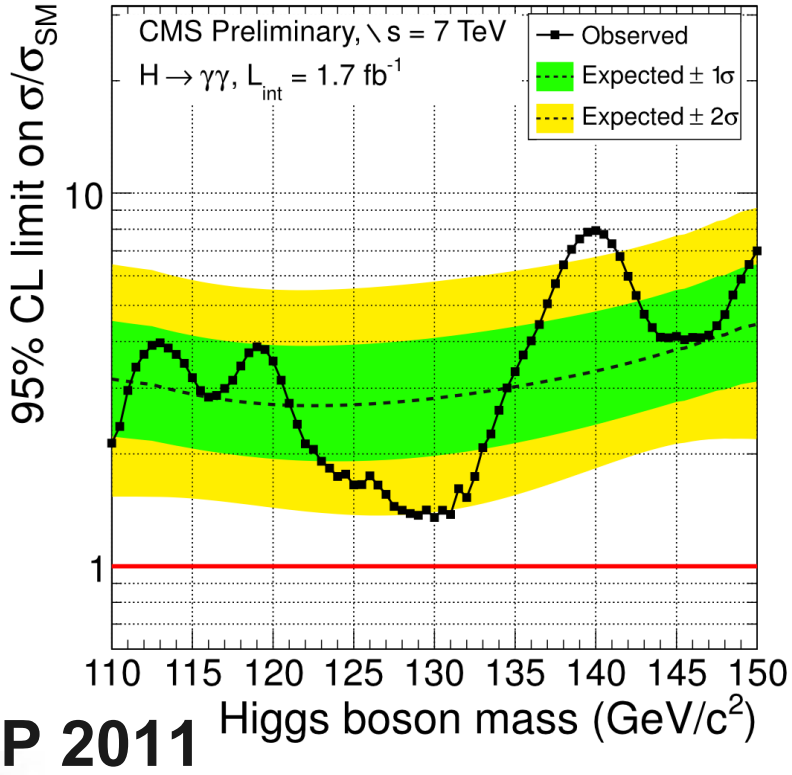
Backup

Branching Ratio in Higgs To Tau

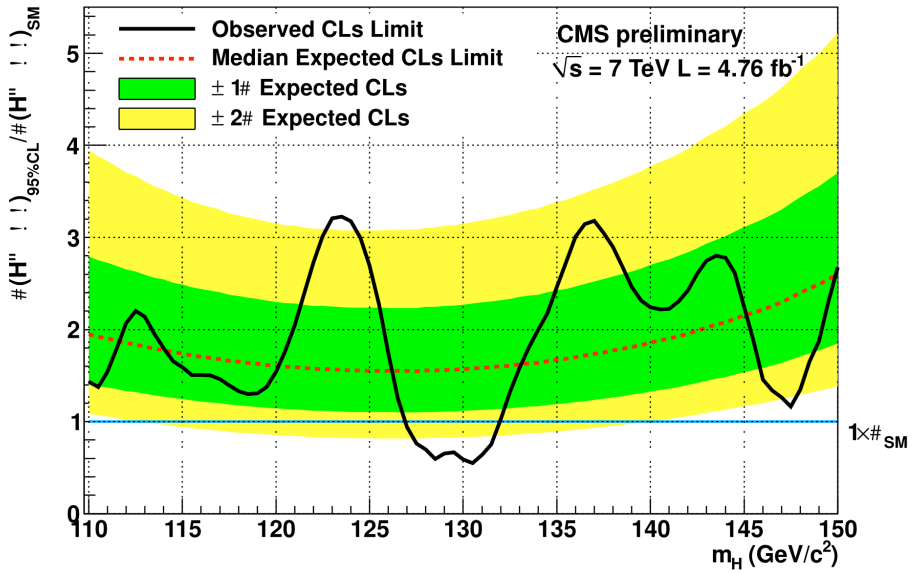




H → γγ at LP2011 and now



LP 2011



Dec 13

Is it different this time?

- **We are much more sensitive now – we expect the signal to reveal itself**
- **ATLAS sees something as well**
  - **Though not quite at the same mass!**