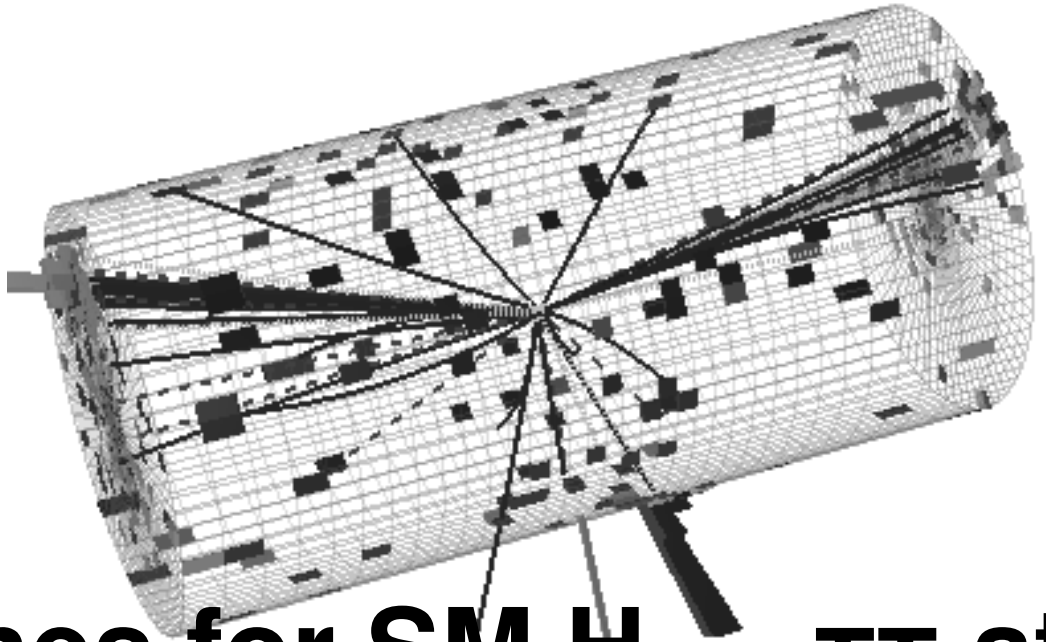

Searches for SM H → ττ at the LHC

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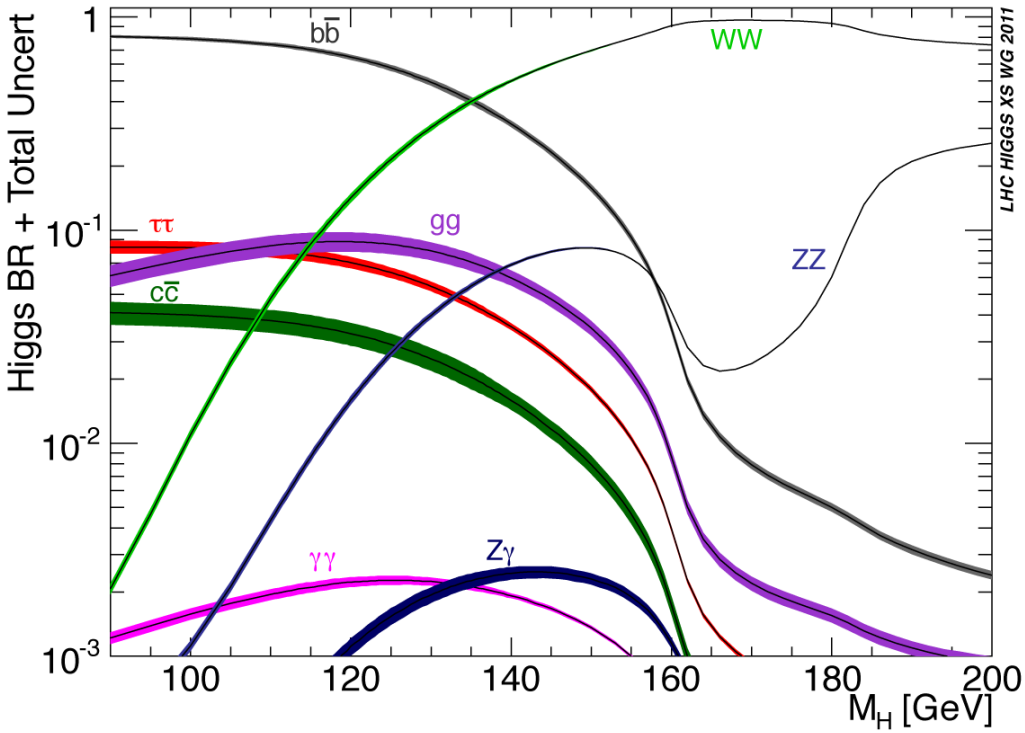
University of Wisconsin-Madison

On behalf of the ATLAS and CMS Collaborations

arXiv:1202.4083, ATLAS-CONF-2012-014
CMS PAS HIG-12-006, HIG-12-007

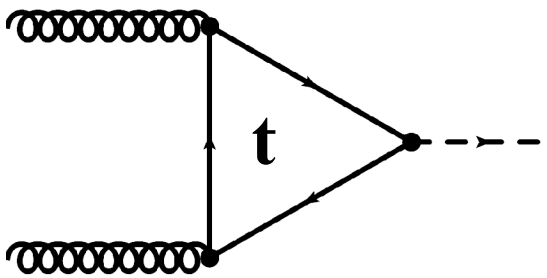
Introduction

- Tau is the heaviest lepton (1.7 GeV)
  - Large coupling to the Higgs
- BR(H → ττ) ~ 10% at low Higgs mass
- Experimentally challenging
  - Hadronic Tau Identification
  - Overwhelming Z →ττ background
  - Neutrinos in the final state smear the mass



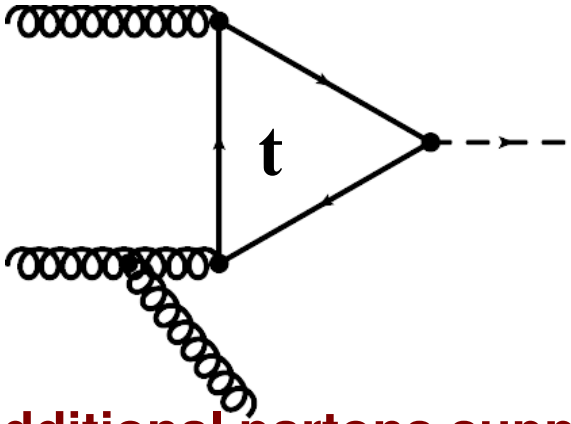
Relevant production mechanisms

Gluon Fusion



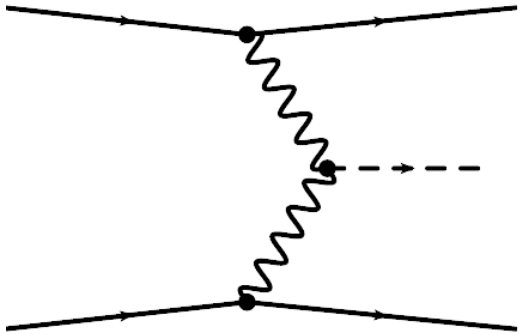
Highest cross section
Irreducible Z → ττ

Gluon Fusion+ parton



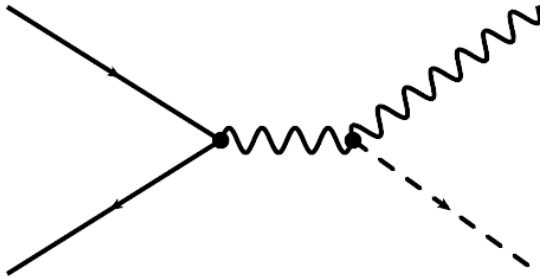
Additional partons suppress Z production+ improve mass reconstruction

Vector Boson Fusion



Golden channel.
VBF tagging crucial

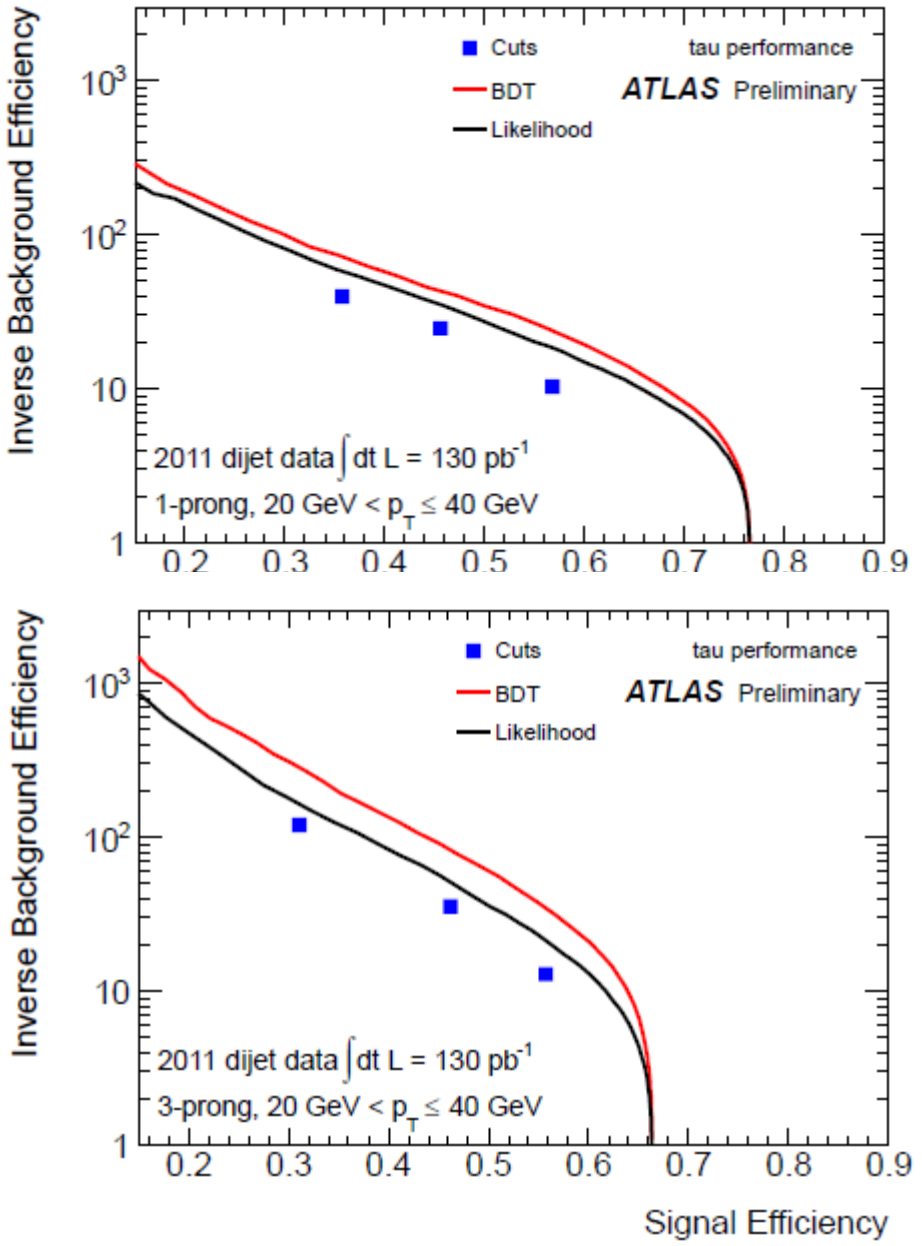
Associated Production



Very low signal yield
Low background

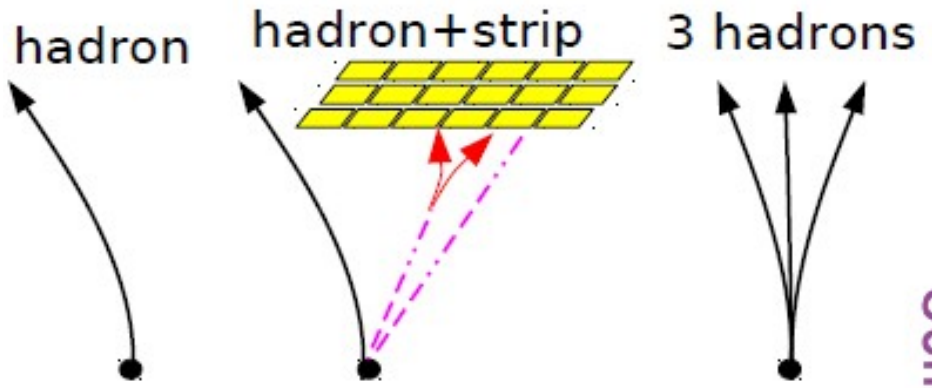
Tau Identification (ATLAS)

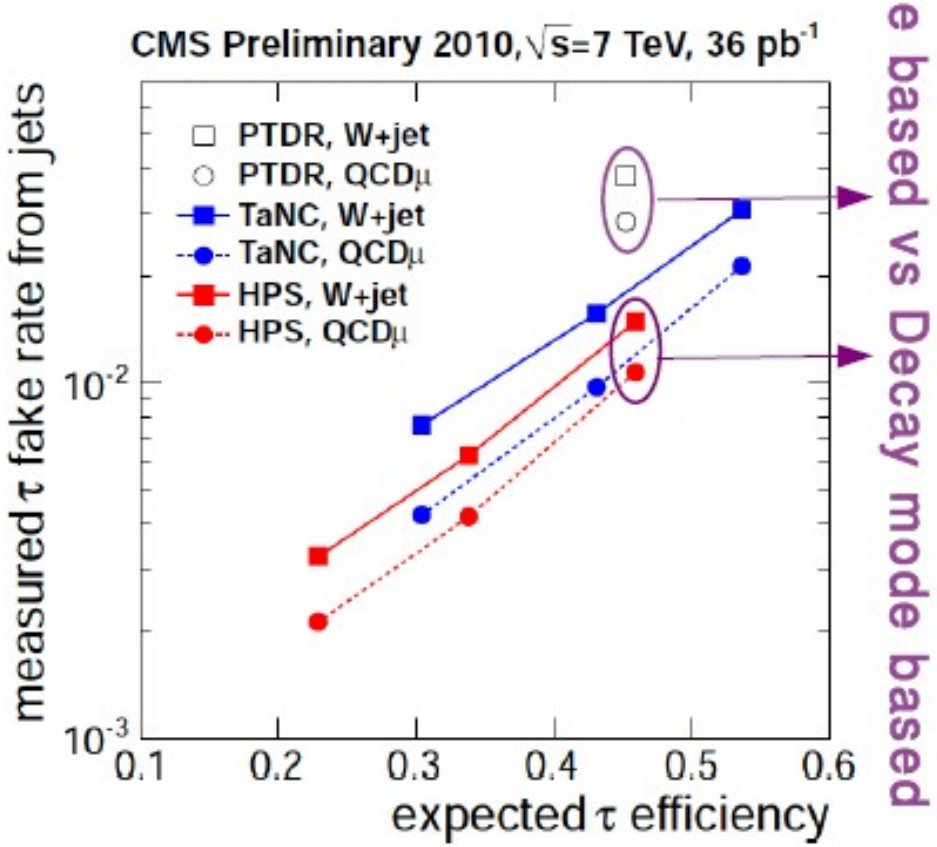
- **Seeded by jets**
  - **Tracks are associated with the jets**
  - **Discrimination variables are formed**
    - **Combined in a boosted decision tree**
- **Tau energy measured with the calorimeter**
  - **Tau specific energy corrections applied**



Tau Identification (CMS)

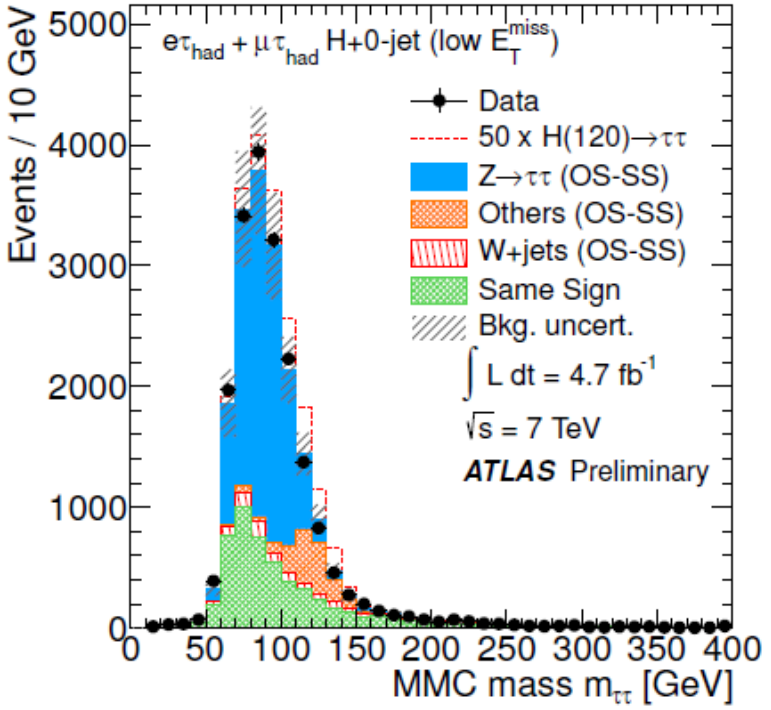
- Uses reconstructed particles from Particle Flow Algorithm
- Reconstructs individual decay modes
  - In the case of π^0s
    - Material effects taken into account by using strips of photons
- Cut based selection
  - Mass of the vector mesons, Isolation, Opening Angle
- Energy of the tau measured using only associated decay mode PF constituents
  - Dominated by Tracker+ECAL

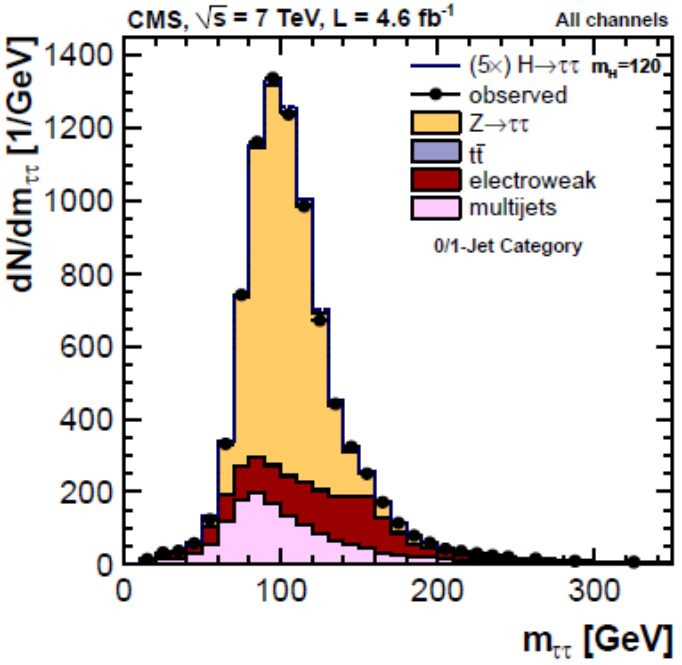




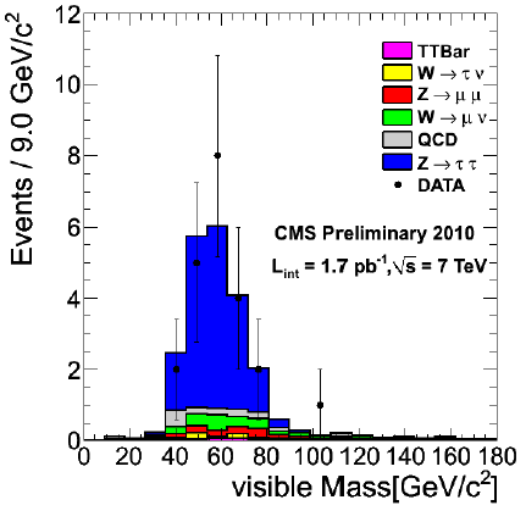
Reconstruction of the τ-pair mass

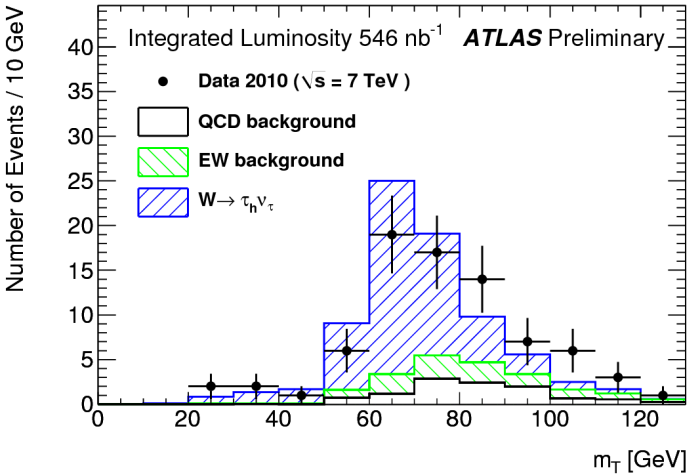
- Crucial to separate H from Z
- ATLAS
  - Collinear approximation in the (μμ,ee,eμ) final states
  - Missing mass calculator(MMC) for the μτ,eτ
- CMS
  - Svfit mass reconstruction for all final states
- Collinear approximation
  - Some events have no solution so they are discarded
- MMC and SVfit very similar
  - Based on likelihood minimization

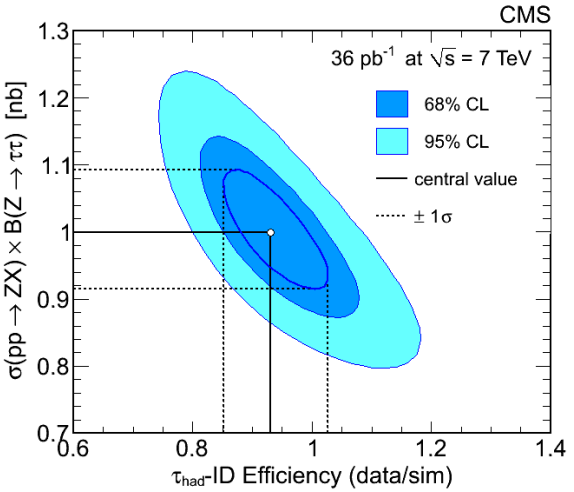


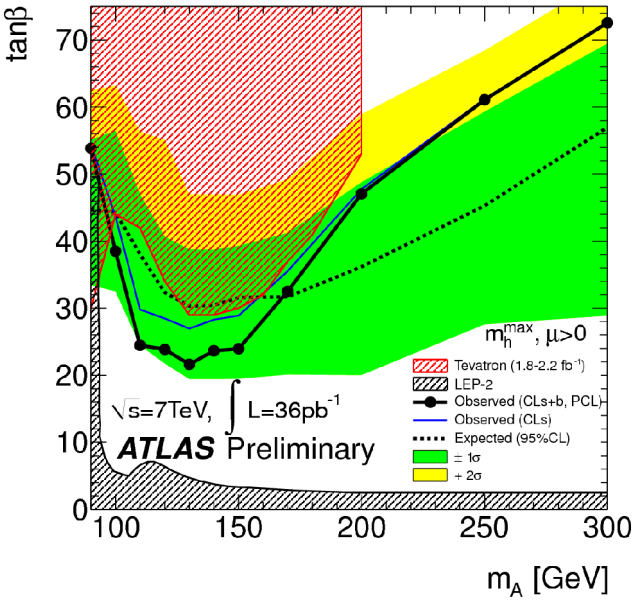


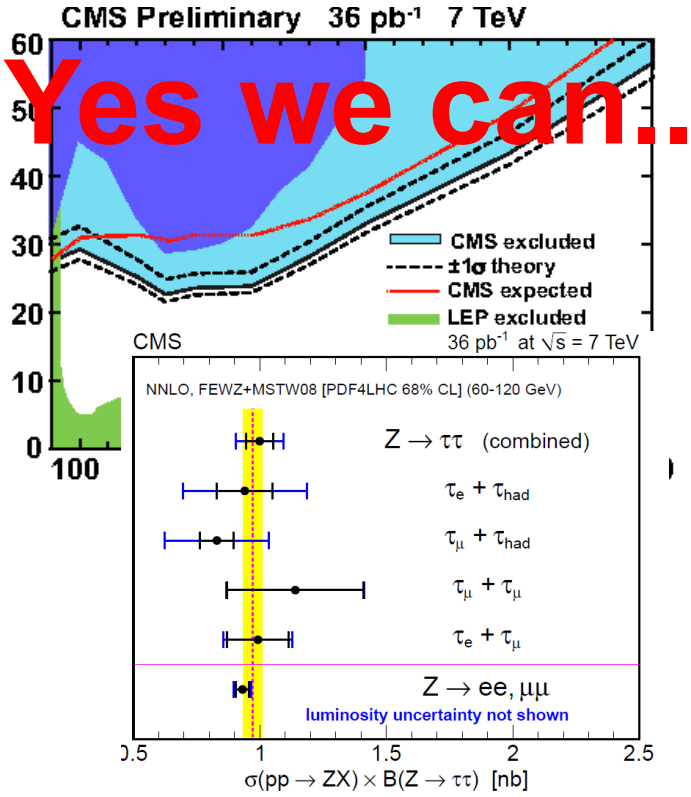
Can we do taus at the LHC?



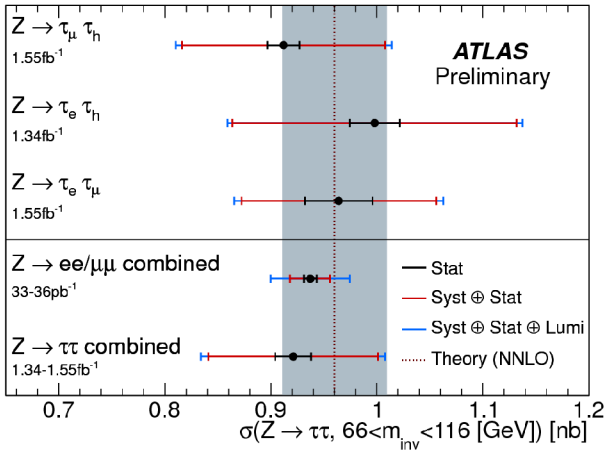








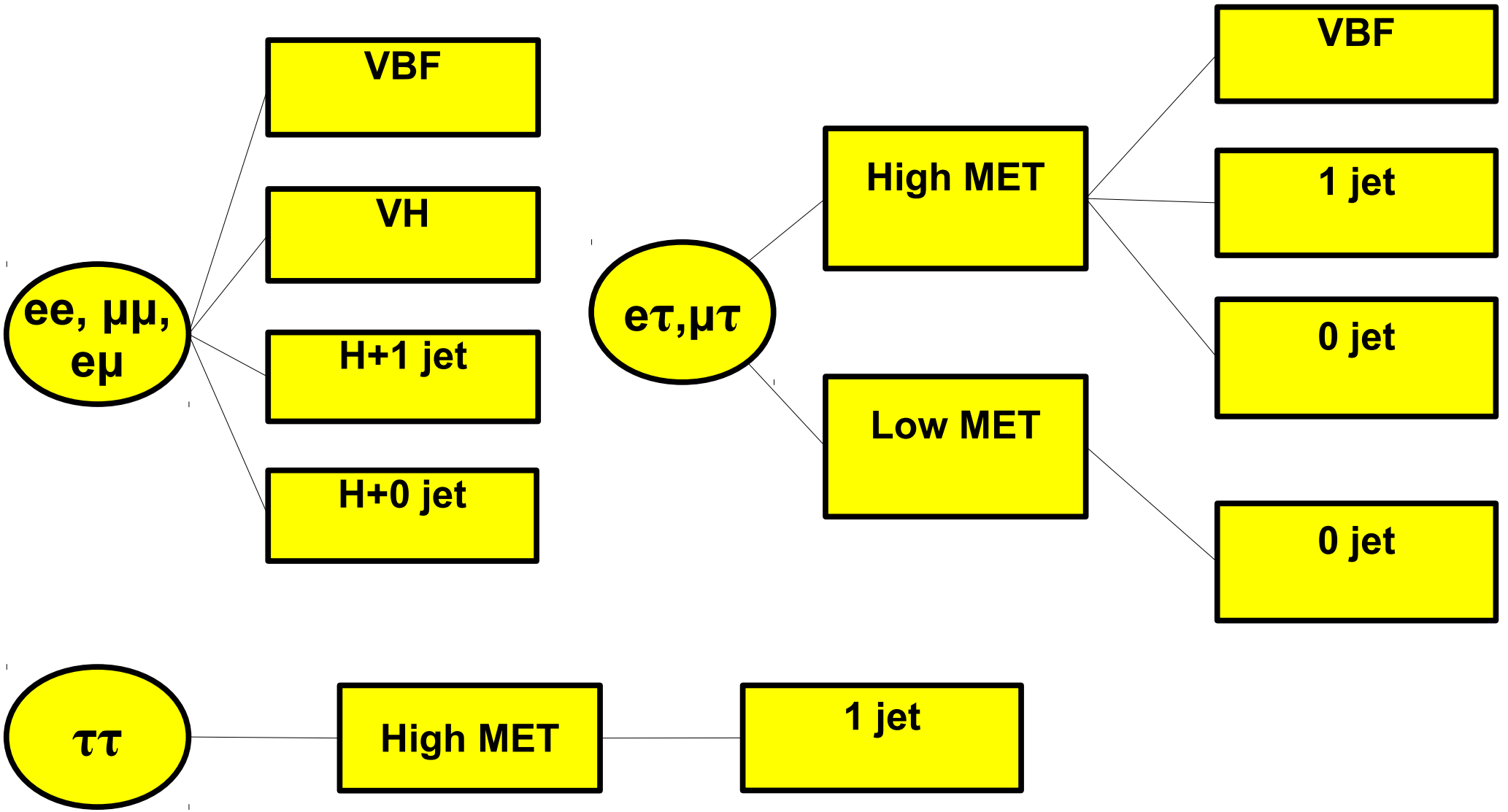
Yes we can...



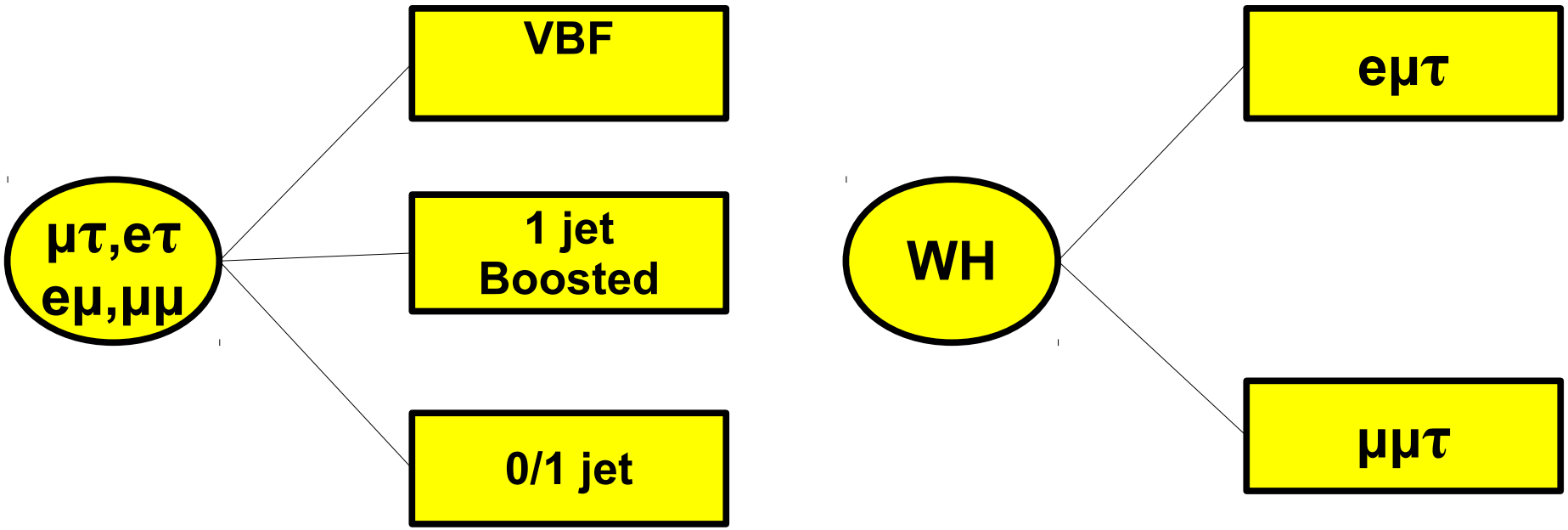
SM Higgs Search strategy

- Common strategy by the two experiments
- Exploit the maximum of the data sample
  - Separate the sample into categories that enhance the sensitivity (e.g VBF, VH)
  - Add additional categories for the failing events
- Perform combined fit
  - Combine the several categories by taking into account the correlations
    - i.e combining e+μ and l+τ constrains the tau ID efficiency in the fit

ATLAS categorization



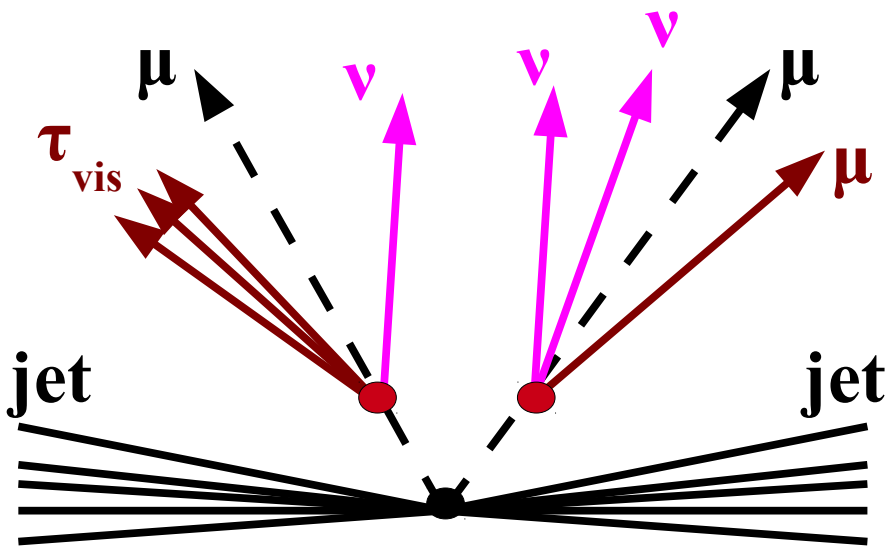
CMS Categorization



Background estimation techniques

- **Well established and similar techniques in both experiments**

Embedding Technique



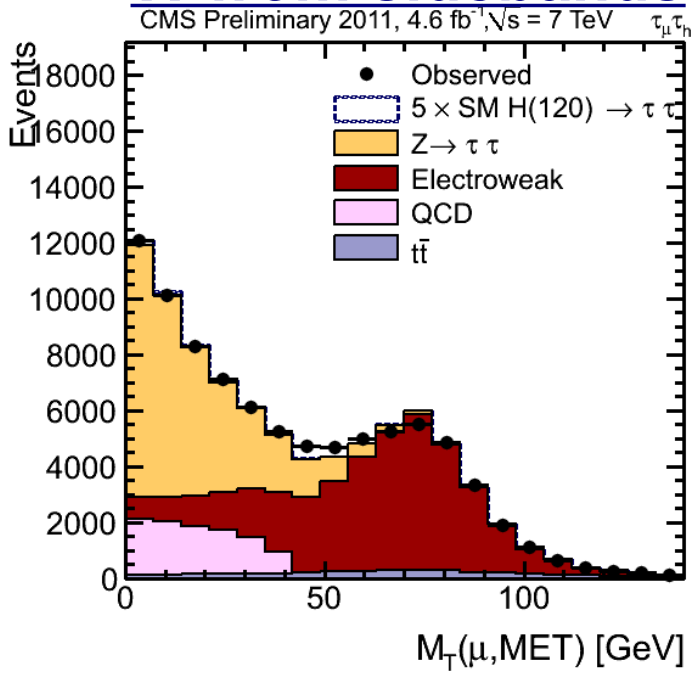
- **Reconstruct Z → μμ events in data**
- **Replace μ with decay the event**
- **Mix the simulated tau pair event with the initial events without the muon**
- **PU/UE and jets from data!**

QCD from Same Sign Events

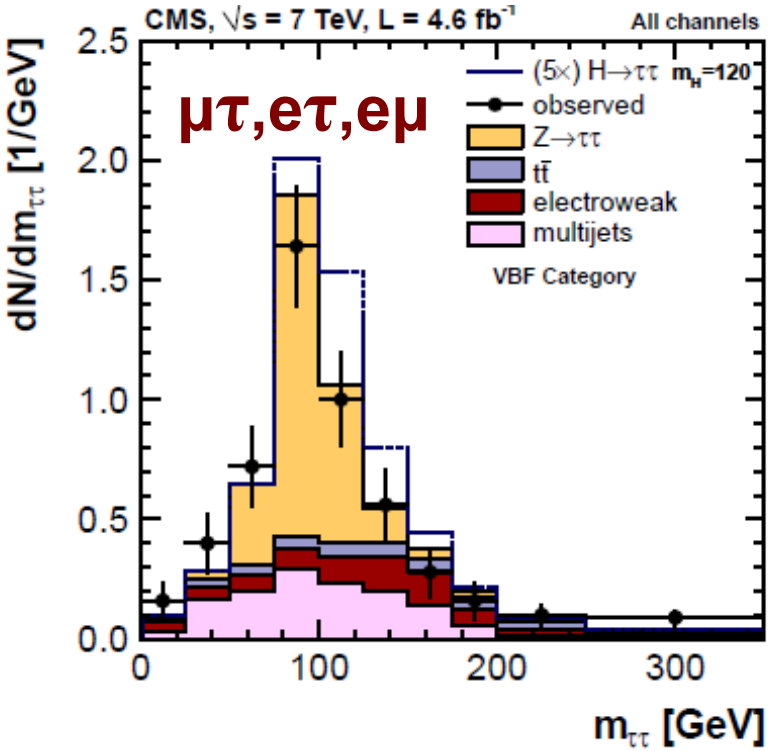
ATLAS : QCD(OS/SS)=1.10 ± 0.09

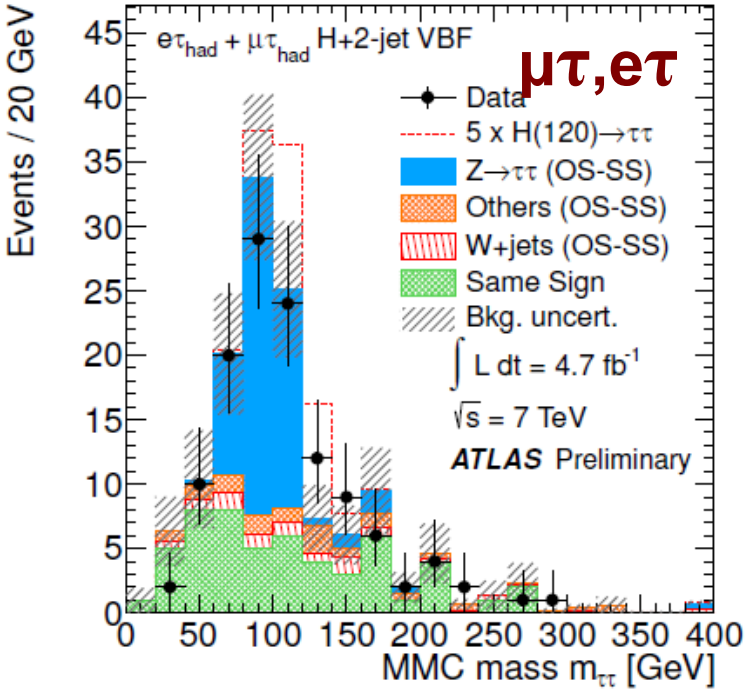
CMS : QCD(OS/SS)=1.11 ± 0.03

W from sidebands



Vector Boson Fusion

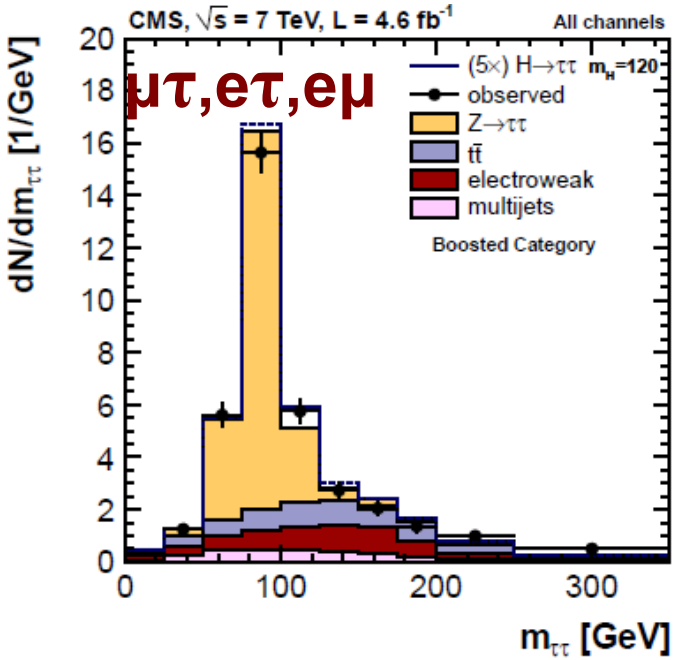


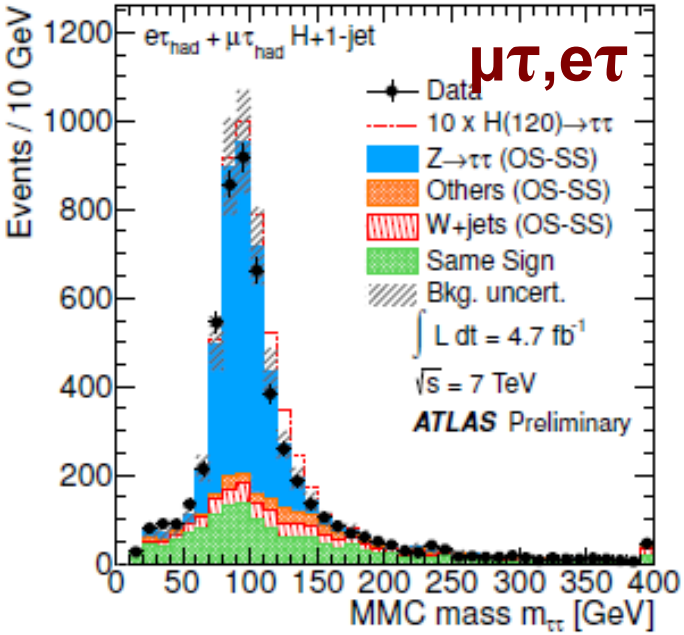


- **ATLAS**
  - **Two jets (25 GeV) , Δη > 3 , M_{jj}>300 GeV**
- **CMS**
  - **Two jets (30 GeV) , Δη >4 ,M_{jj}>400 GeV**
- **Jet veto in the Δη gap**

Most sensitive category! No excess in the data in either experiment

H+1 Jet

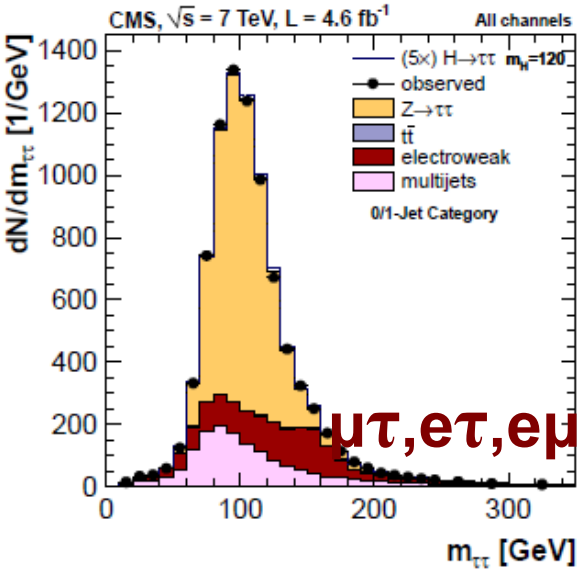


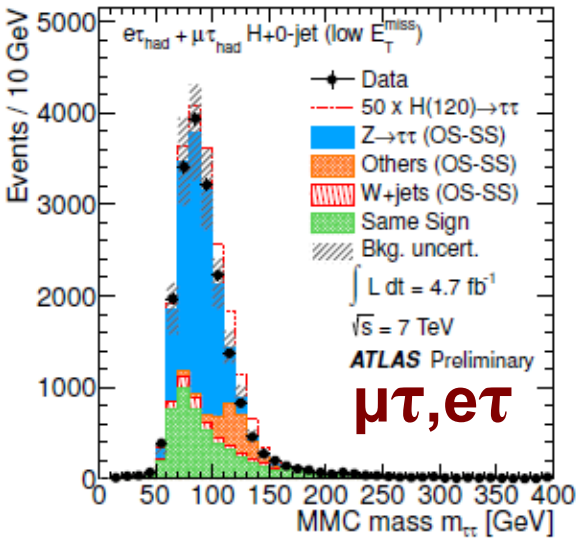


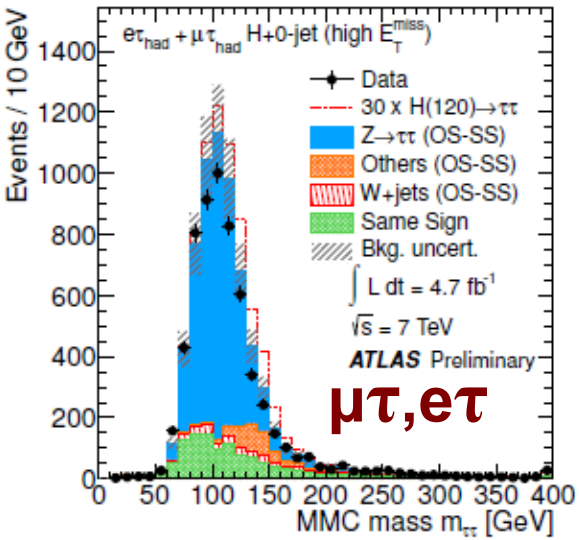
- **ATLAS**
  - **MET>20 GeV , Jet Pt>25 GeV**
- **CMS**
  - **Jet pt >150 GeV**
  - **Large effect from Higgs Pt spectrum**
    - **POWHEG re-weighted with FeHiPro**

Most of the gain comes from the better mass resolution In the boosted topology

H+0/1 jet

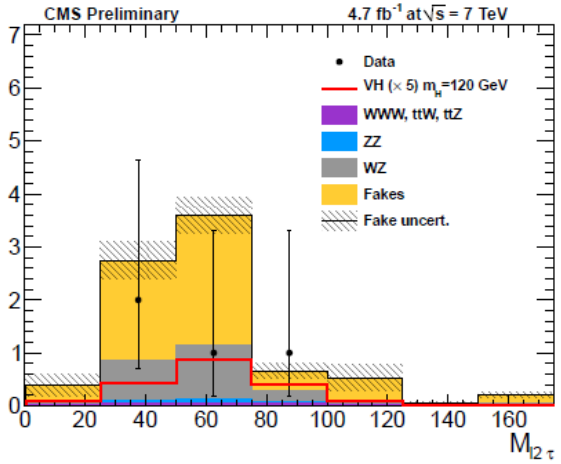


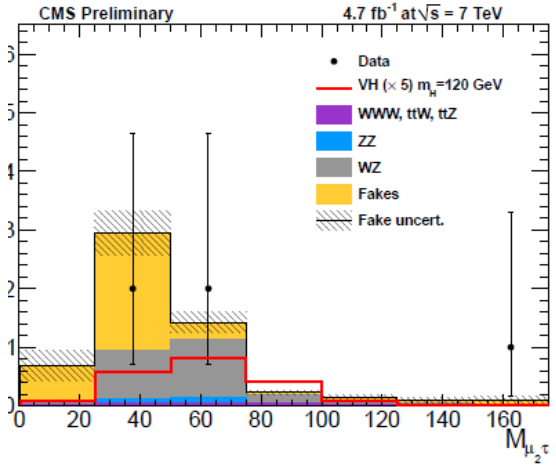




- **ATLAS**
  - **0 jets , separating MET>20 and MET<20 GeV**
- **CMS**
  - **0 or 1 jet<150 GeV**
- **Background dominated categories**
- **Contribute to the fit via correlations with high sensitivity categories**

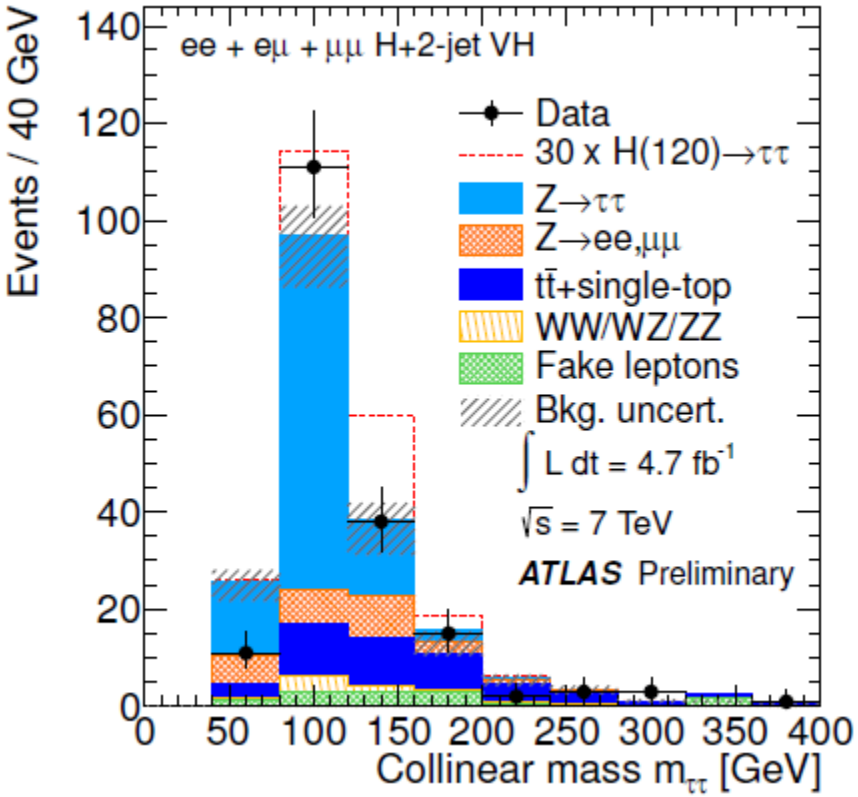
Associated production(VH)





CMS

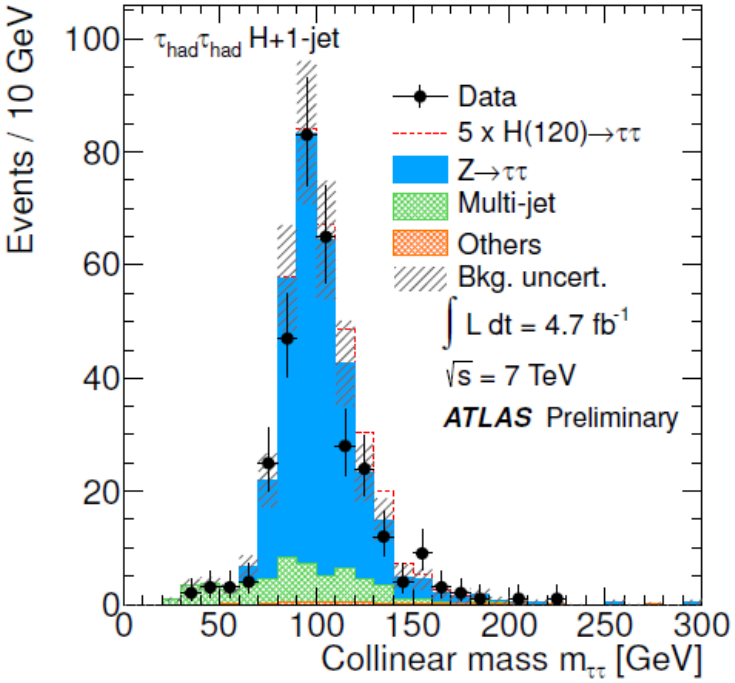
- WH →lν ττ → μμτ (eμτ)
- μμτ overwhelmed by Z → μμ+jets
  - Require SS muons!
- eμτ overwhelmed by Z → ττ → eμ+jets
  - Require SS e/μ!

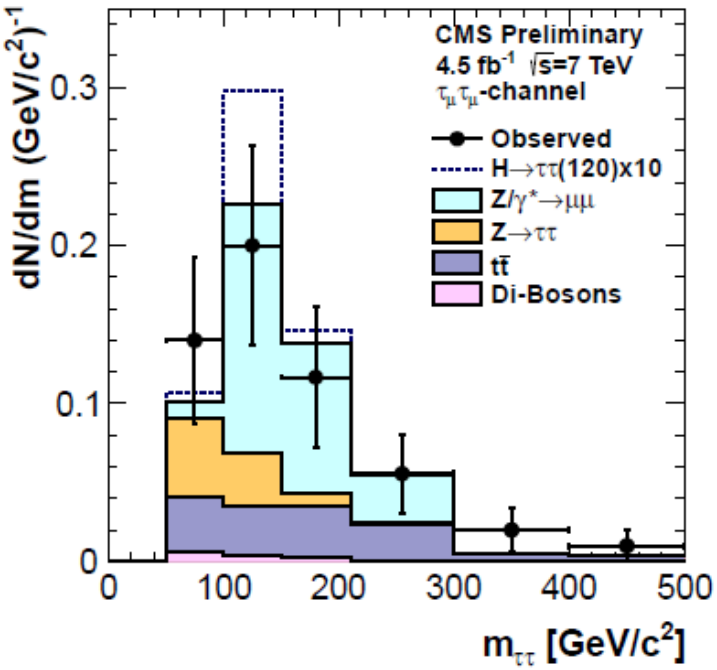


ATLAS

- WH → qq ττ → qq ll 4ν
- Require two jets in the W/Z window

Other final states





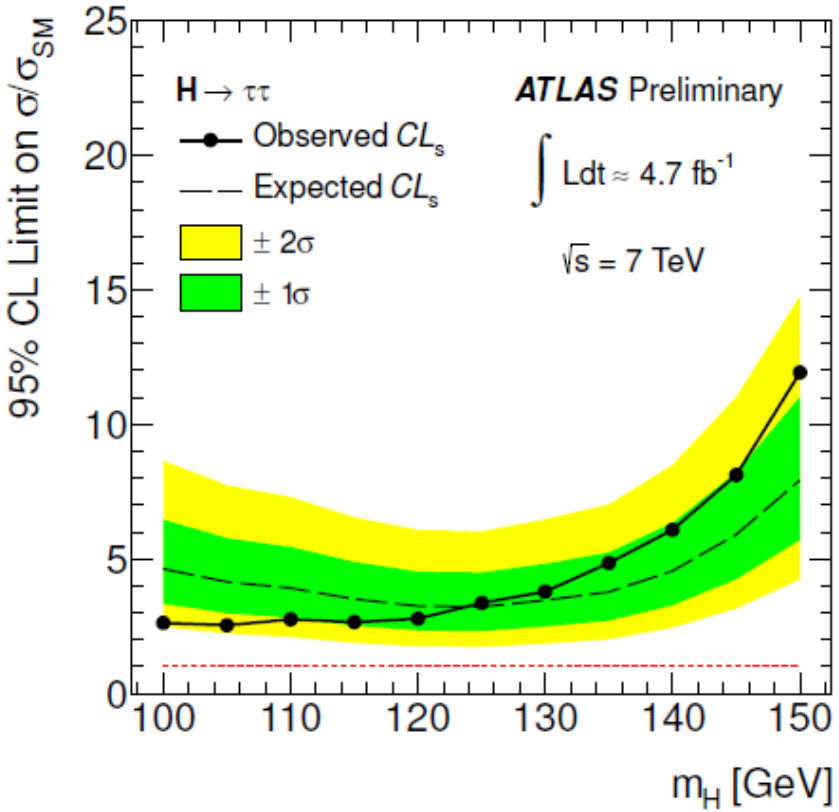
- **ATLAS**
  - **Full hadronic ττ with 1 jet category**
- **CMS**
  - **μμ final state**
  - **All three categories**

Systematic Uncertainties

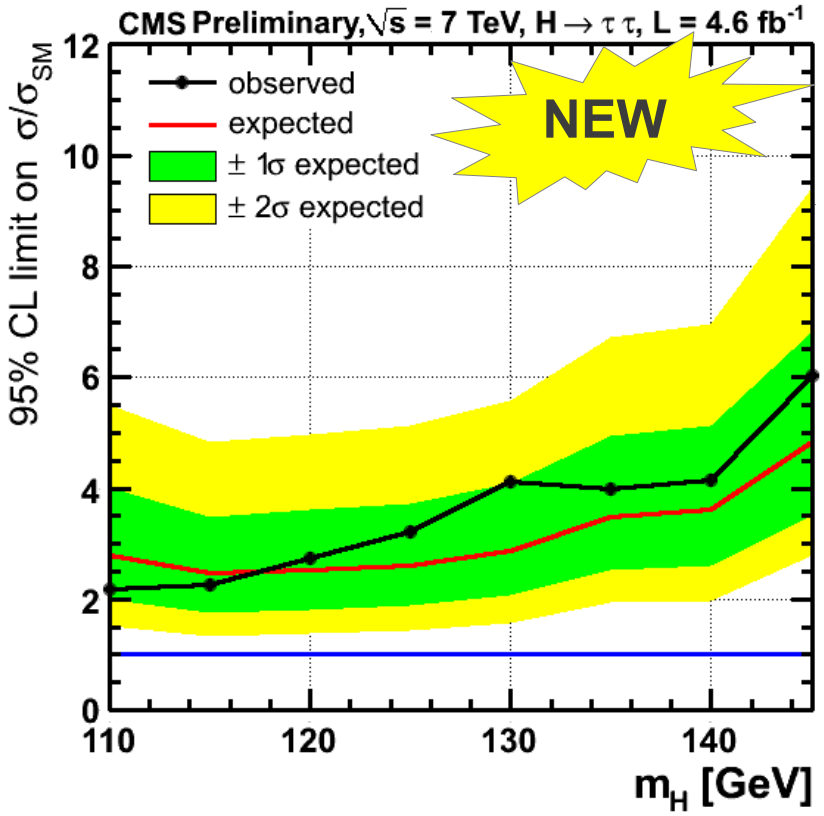
Source	ATLAS	CMS
Luminosity	3.9%	4.5%
Tau ID efficiency	4%	6%
Jet Energy Scale	<12%	<5%
Tau Energy Scale	2-5%	3%
Electron /Muon Efficiency	1-2%	1-2%
QCD scale (ggH)	8-25%	12-30%
QCD scale (VBF)	1%	4-12%
PDFs	4-8%	8%

95% CL upper limits

ATLAS



CMS

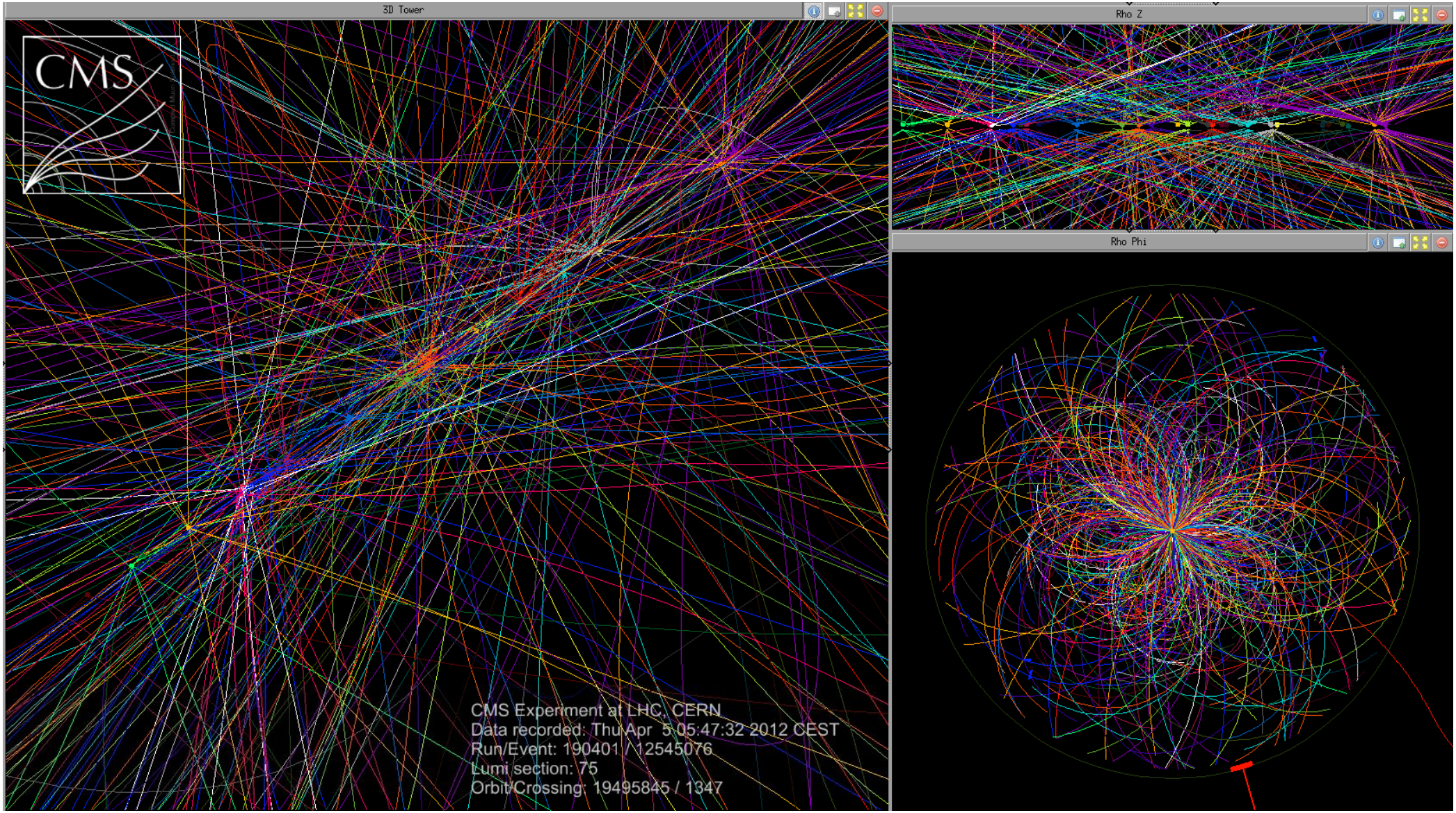


- **Maximum sensitivity at ~ 2.5- 3.0 x SM between 115-125 GeV per experiment**
- **Observed Limits compatible with expectation**

Conclusions

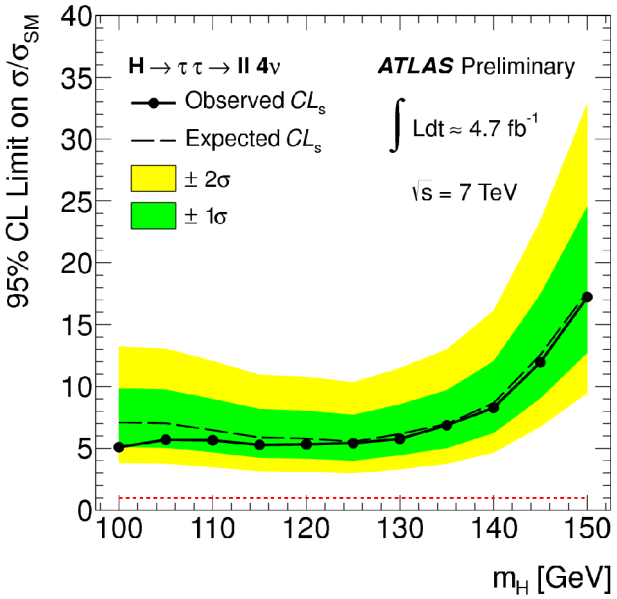
- **Both ATLAS and CMS produced $H \rightarrow \tau\tau$ results with the full 2011 dataset**
- **Analysis in both experiments is sensitive to exclude a cross section of 2.5-3.0 times the Standard Model Higgs cross section**
  - **No signal like excess is observed in any of ATLAS or CMS data**
  - **$H \rightarrow \tau\tau$ will be one of the major players in 2012**
  - **There is still significant space for improvements**

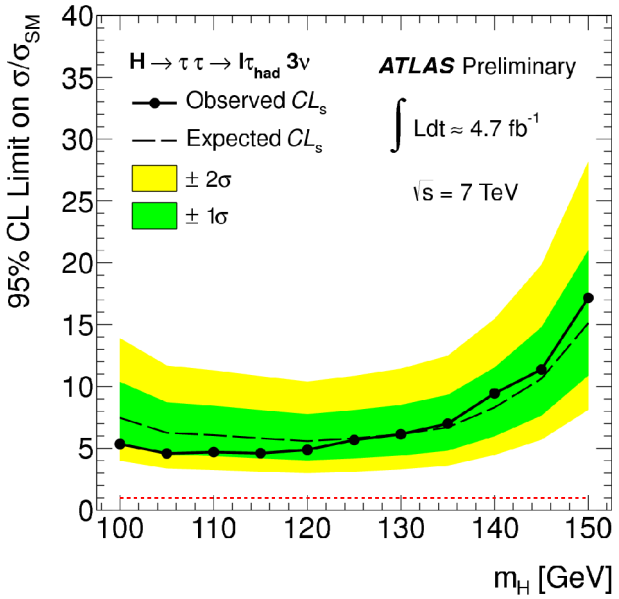
8 TeV data taking started

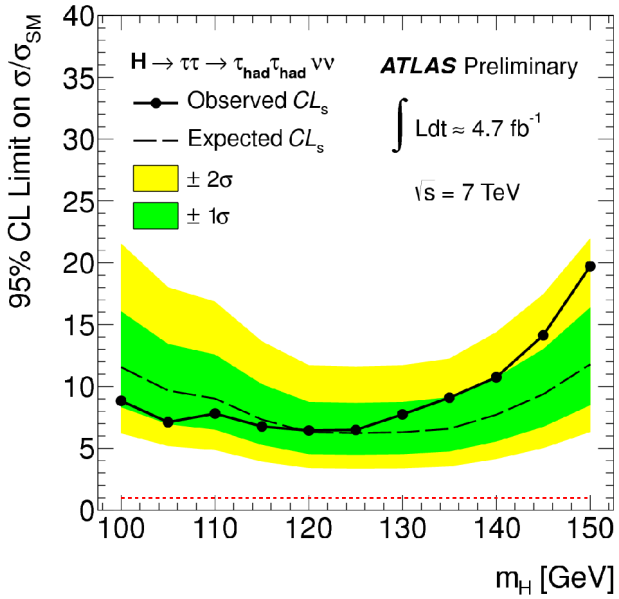


Backup

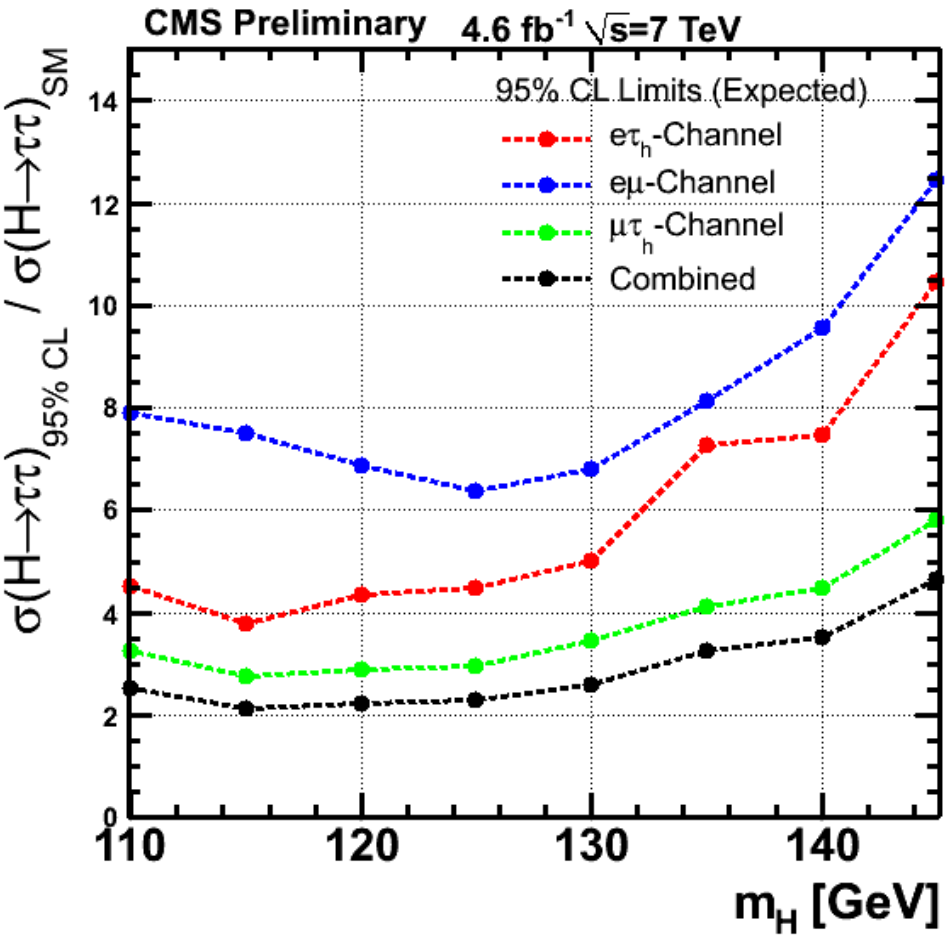
Limits per channel (ATLAS)

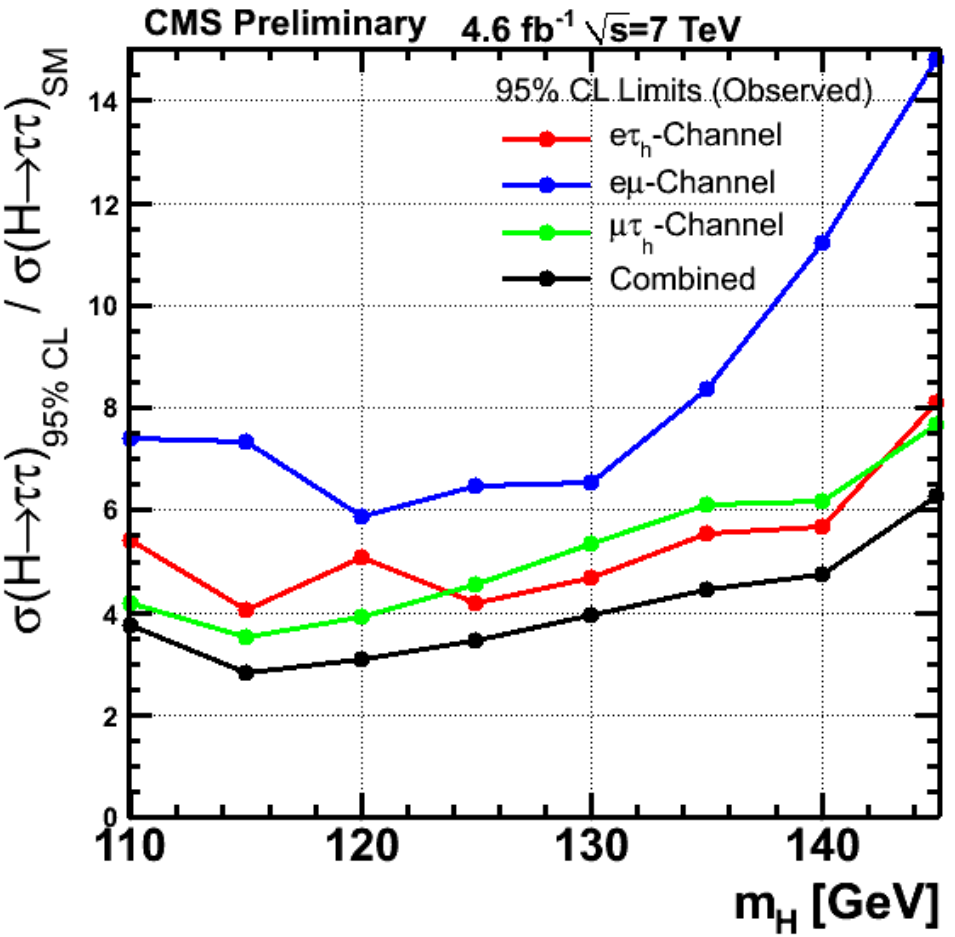






Limits per channel (CMS)





Tau energy scale studies(CMS)