THE UNIVERSITY of WISCONSIN MADISON

SUSY AND BSM HIGGS FROM CMS

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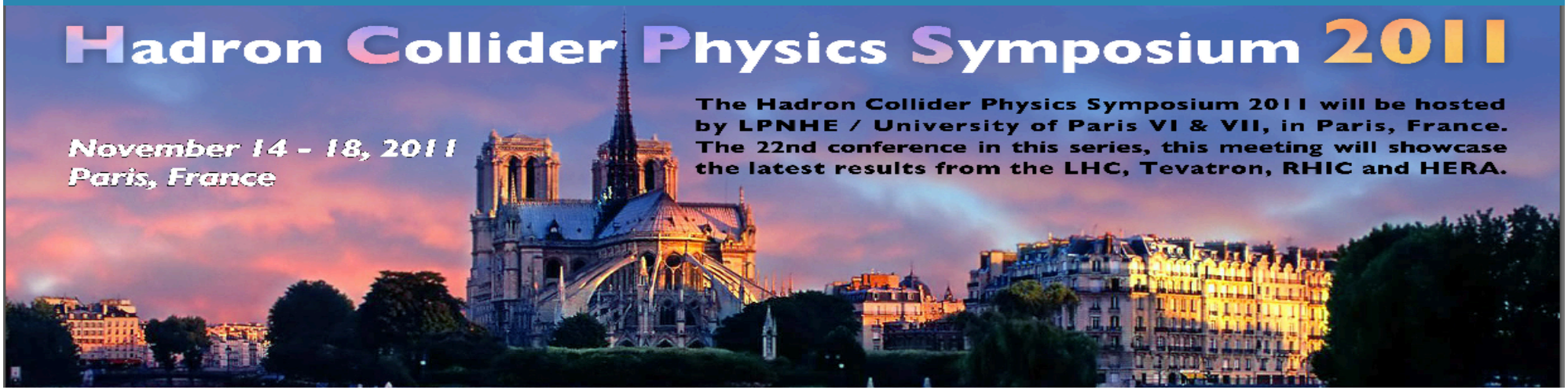
University of Wisconsin-Madison

on behalf of the CMS collaboration



Overview

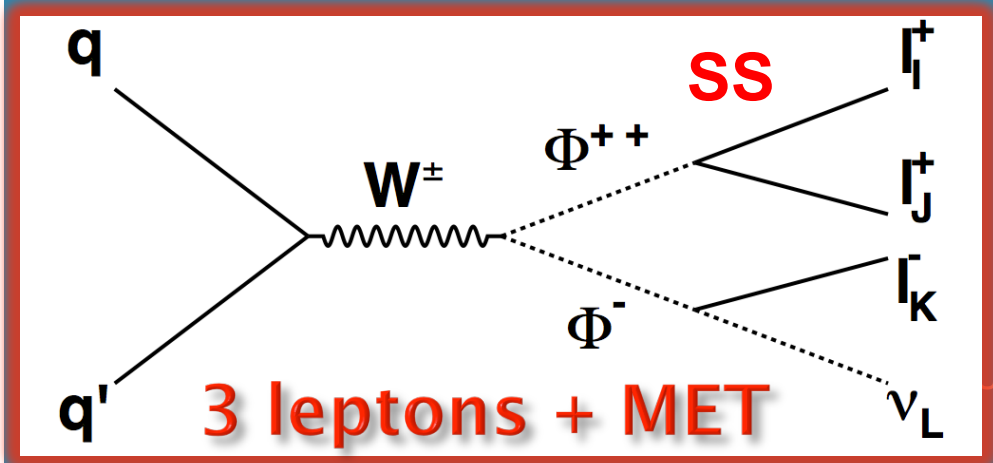
Results af three analyses are presented:

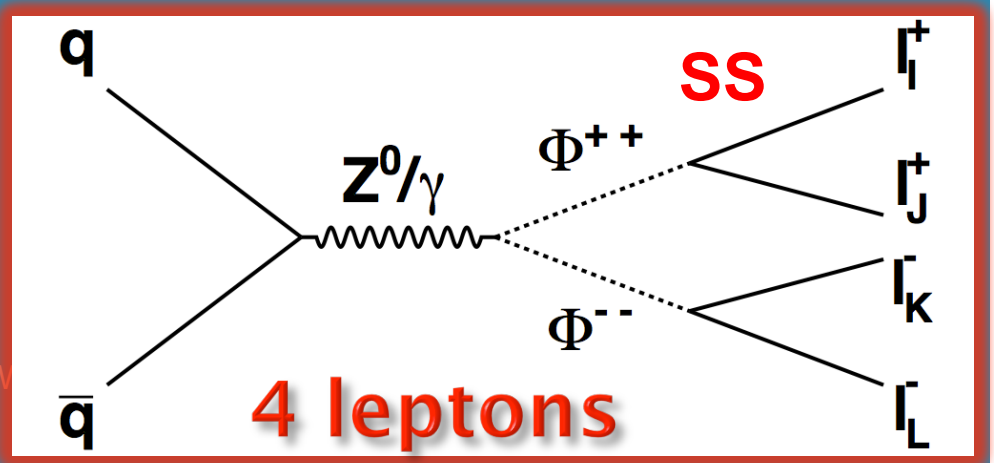
- Doubly charged Higgs search
- Minimal Supersymmetric Standard Model (MSSM) Higgs
  - $H \rightarrow \tau\ \tau$ search
  - Charged Higgs $t \rightarrow H+b$, $H^{+} \rightarrow \tau\ \nu$
- Interpretation of results

Analyses were performed with up to 1.6 fb^{-1} of 2011 data

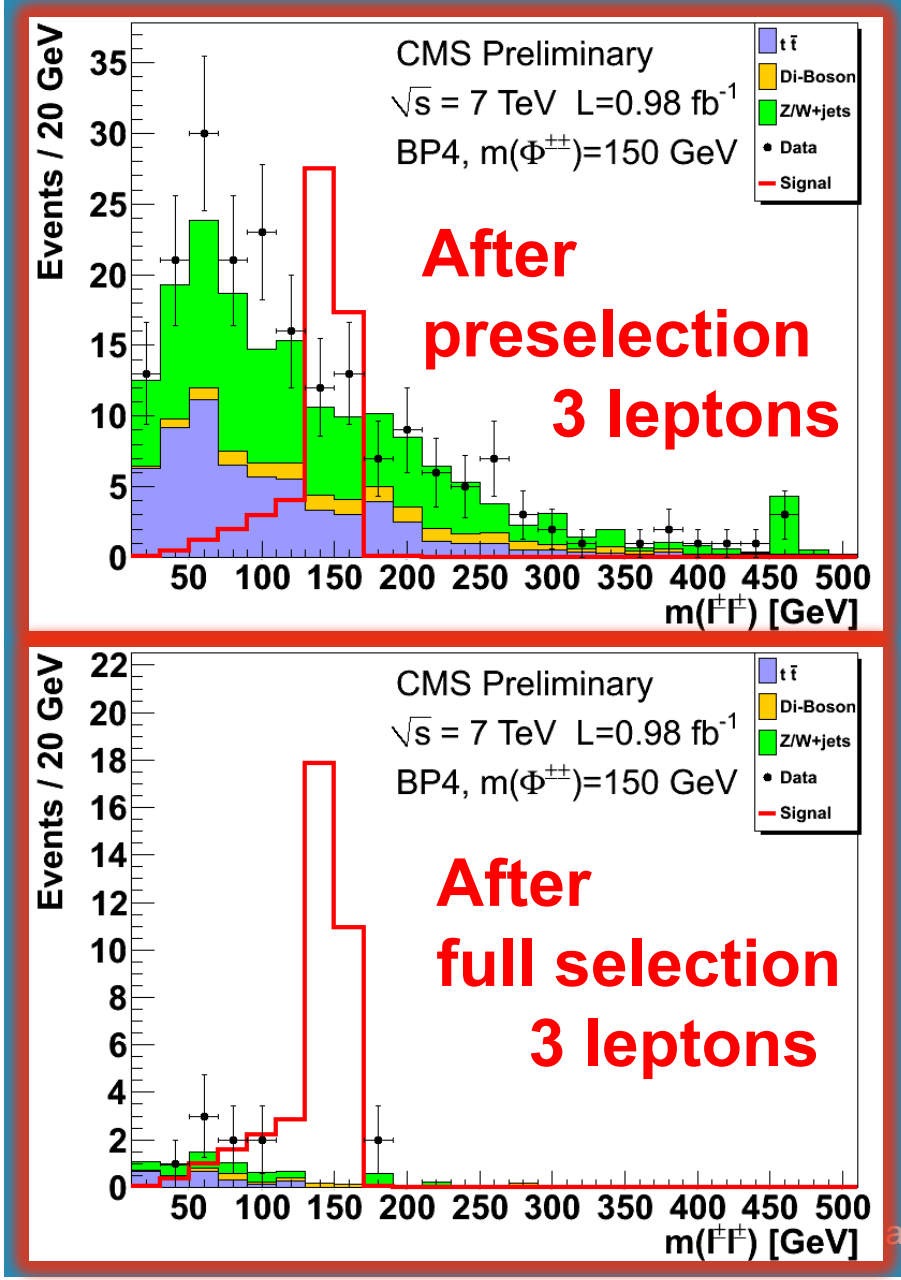
Double Charged Higgs
CMS-PAS-HIG-11-007

- Minimal seesaw model (type II), explains light neutrino mass
  - Includes scalar triplet: $\Phi^{++}\Phi^{+}\Phi^{0}$
- Φ^{++} Yukawa coupling matrix ~ to neutrino mass matrix
- Test neutrino mass mechanism via Φ^{++} branching fractions





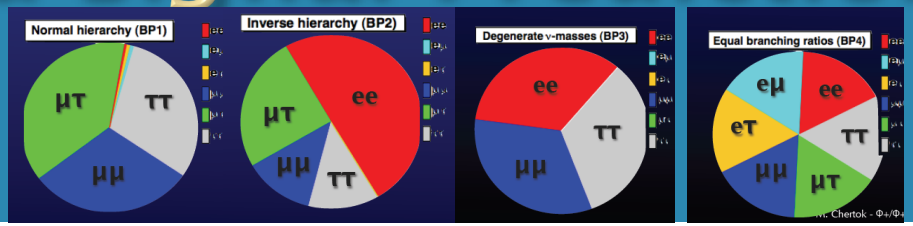
Event Selections and Background



- 3-4 lepton final states
  - Muons: P_T >5 GeV
  - Electrons: P_T>15 GeV
  - Taus: P_T>15 GeV
  - At least two leptons with 35 and 10 GeV
  - Dilepton trigger 17/8
- Backgrounds
  - Z/W + jets
  - top antitop
  - ZZ, WW

10 three-lepton events and 1 four-lepton event found

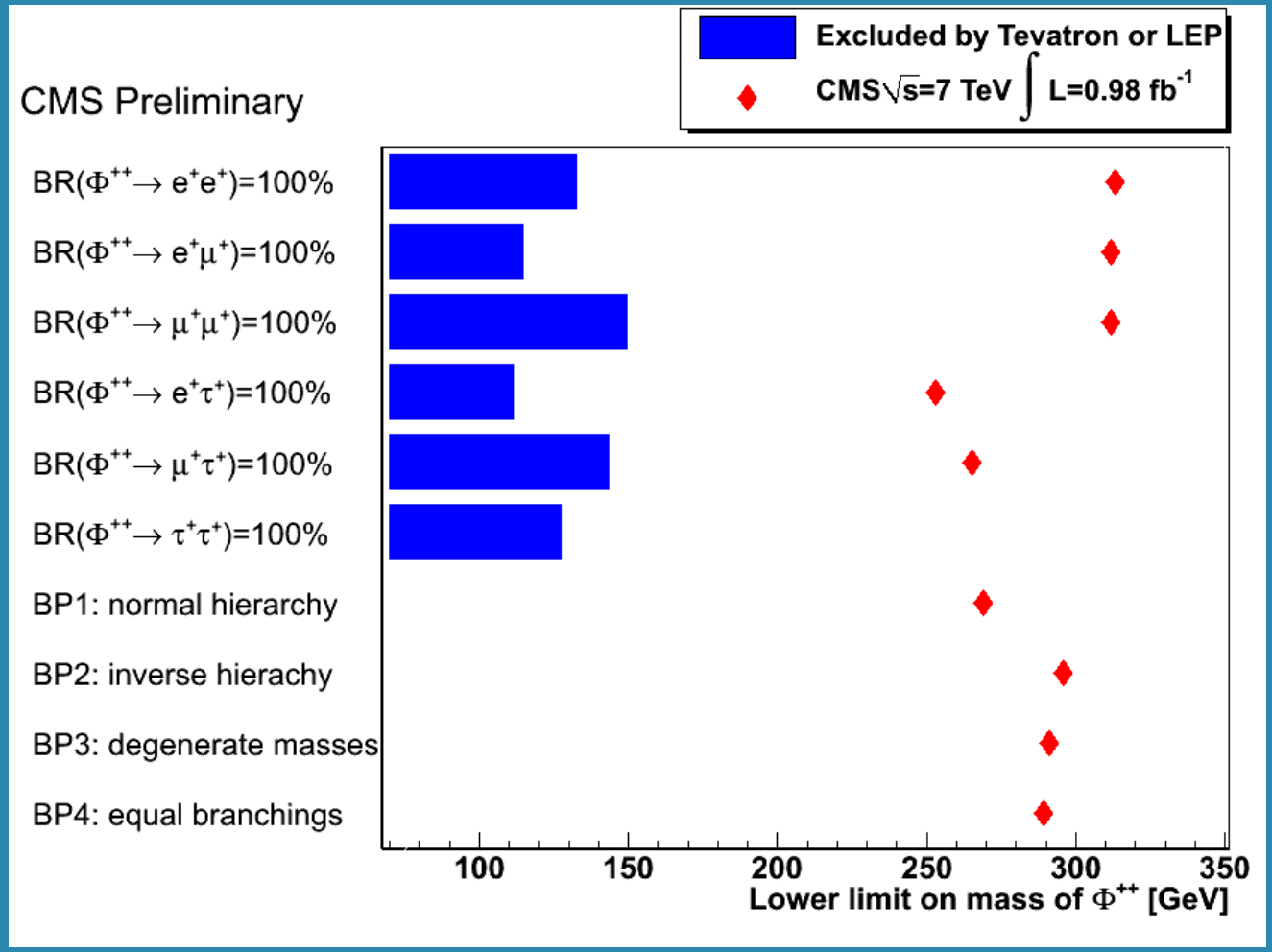
SM estimate and Signal Predictions



4l final states

Mass	Background	Data	BP1	BP2	BP3	BP4
90	1.33 ± 0.29	0	127.51	211.65	227.64	182.70
110	0.75 ± 0.28	0	69.91	116.33	122.58	100.60
130	0.63 ± 0.28	1	40.83	69.31	70.31	59.07
150	0.48 ± 0.28	0	24.49	41.80	42.14	35.72
170	0.38 ± 0.26	0	15.09	26.43	26.09	22.29
190	0.28 ± 0.26	0	9.70	16.78	16.71	14.33
210	0.19 ± 0.26	0	6.34	10.97	10.85	9.39
230	0.13 ± 0.26	0	4.21	7.38	7.15	6.27
250	0.09 ± 0.26	0	2.79	4.97	4.72	4.19
270	0.08 ± 0.26	0	1.97	3.54	3.33	2.95
290	0.09 ± 0.26	0	1.39	2.52	2.35	2.08
310	0.07 ± 0.15	0	0.99	1.81	1.68	1.49
330	0.07 ± 0.15	0	0.70	1.31	1.22	1.08
350	0.03 ± 0.15	0	0.50	0.95	0.88	0.78

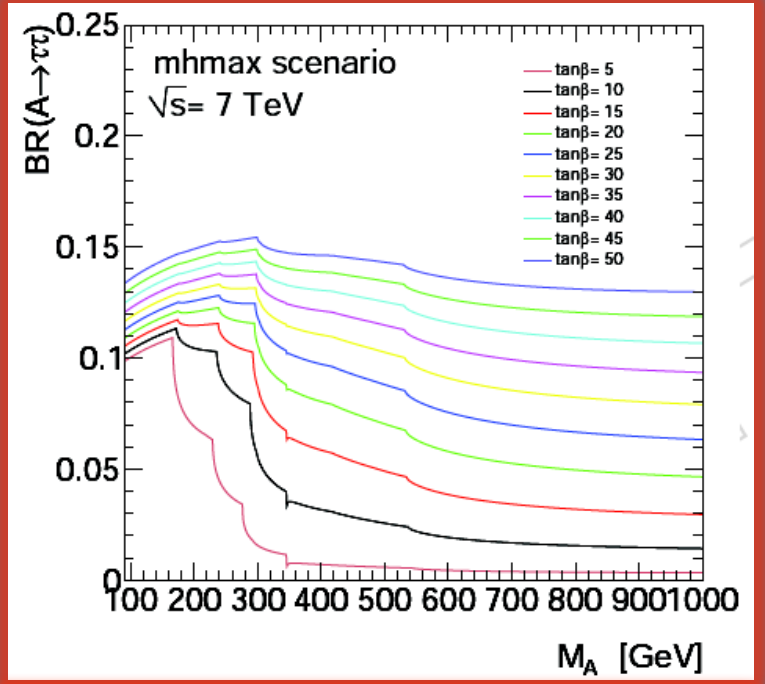
Double Charged Higgs: Results

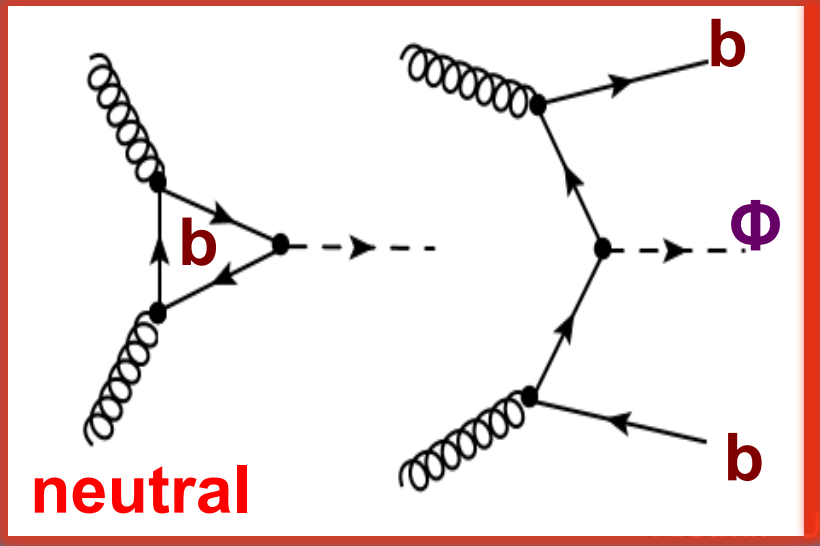


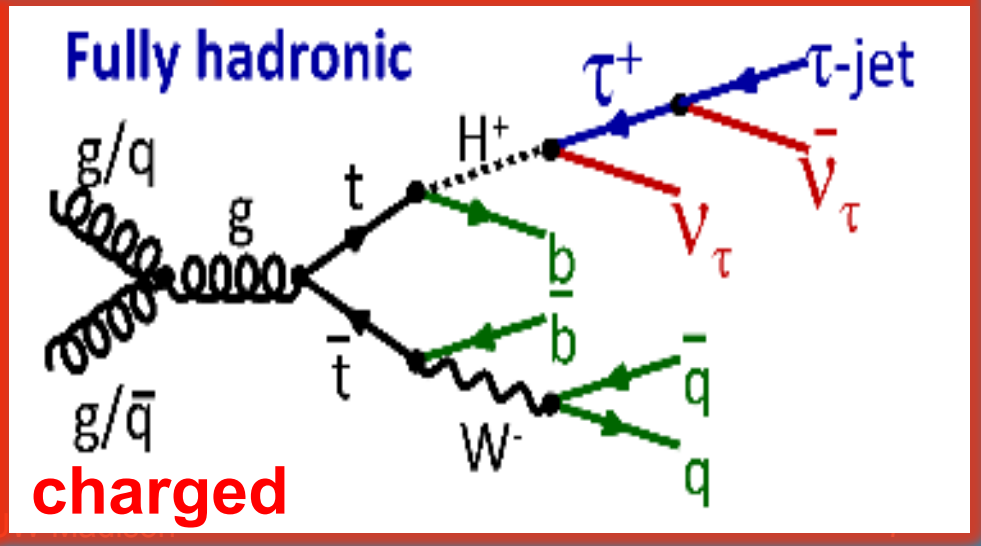
World's new limits

MSSM Higgs

- Minimal Supersymmetric Standard Model
  - Branching fraction to $\tau\ \tau$ 10-15% at low M_A
  - Enhanced at high tan β
  - Charged Higgs possible



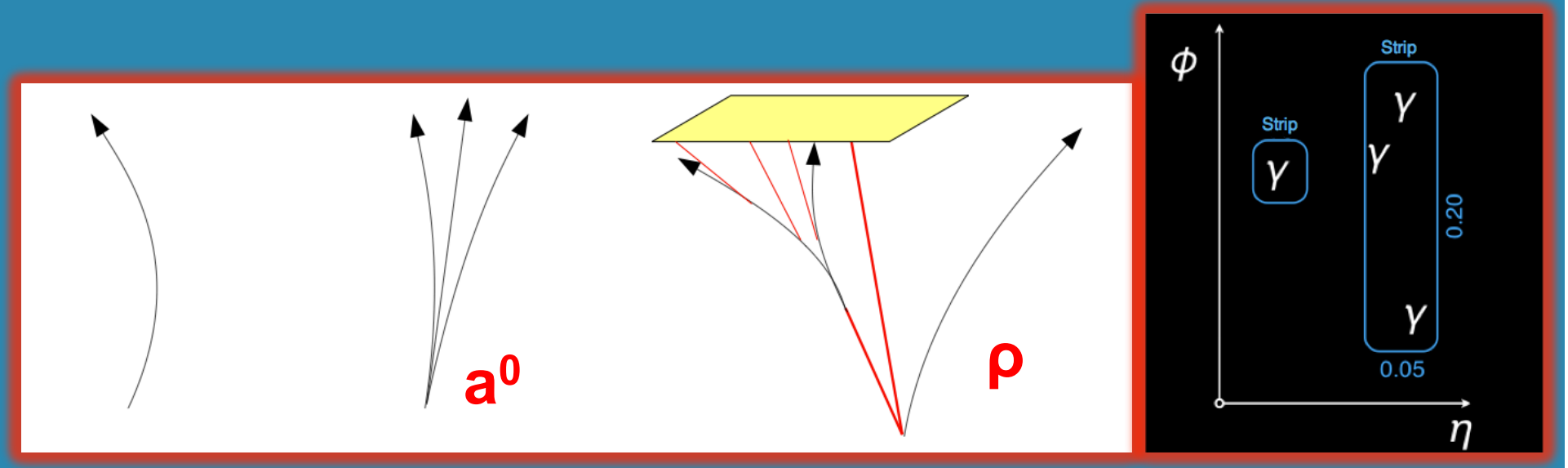




Tau reconstruction

CMS-PAS-TAU-11-001

- Charged hadrons are combined electromagnetic objects, arranged in strips or single photons



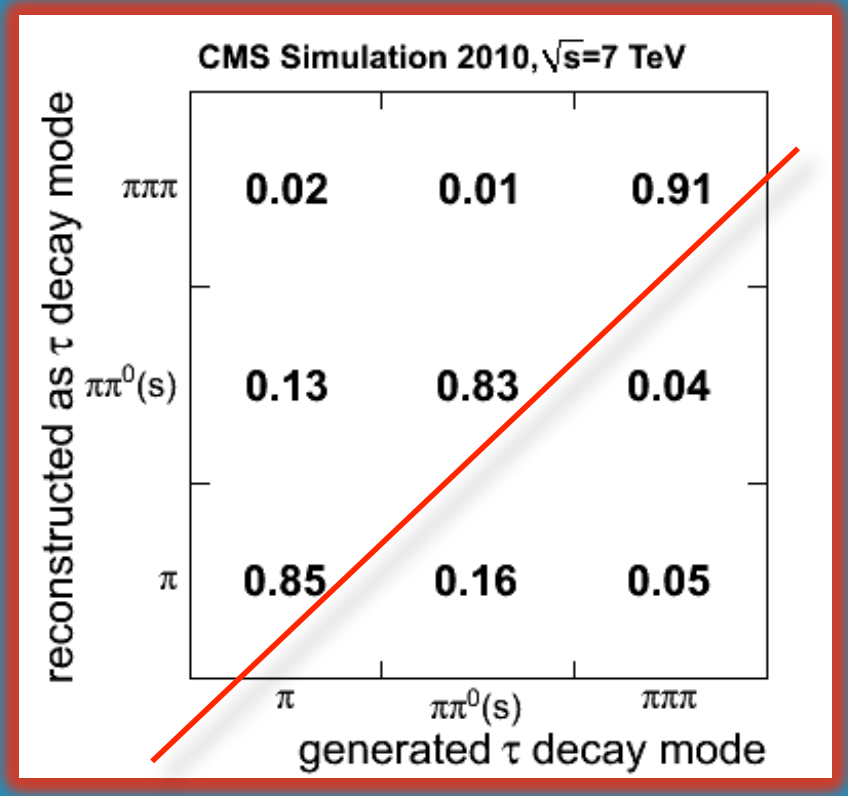
Single Prong Three Prongs Single Prong + Strip

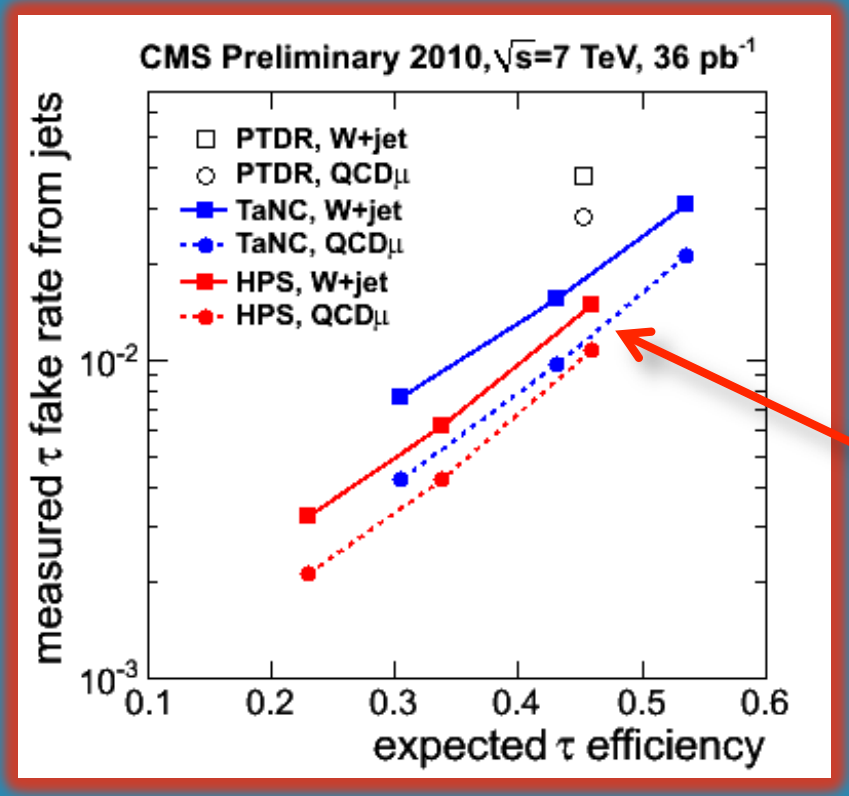
- Taus are isolated using a dR cone around the leading charged candidate.
- τ leptons decay to one or more hadrons 64% of the time.

Tau reconstruction

Correct decay mode reconstruction is required

High efficiency of ~50% at ~1% fake rate from jets





- TauID uncertainty 6% measured with T&P
- Energy scale uncertainty 3%

H→ττ Analysis Strategy

CMS-PAS-HIG-11-020

Analysis Channels

$\mu + \tau_h$	High statistics, clean
$e + \tau_h$	High statistics, larger background
$e + \mu$	Low statistics, very clean

Two categories: with and without b-jet
Fit visible mass of all channels and categories simulteneously

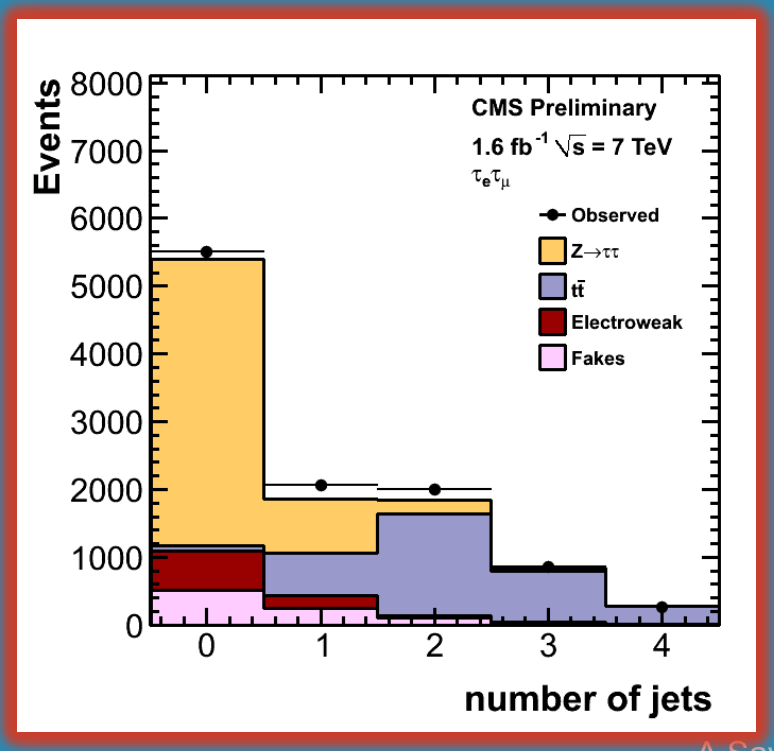
Event Selection

Channel		Trigger	Offline
μ + τ	μ	$P_T > 15$ GeV	$P_T > 15$ GeV, $\eta < 2.1$
	τ	$P_T > 15,20$ GeV	$P_T > 20$ GeV, $\eta < 2.3$
e + τ	e	$P_T > 18$ GeV	$P_T > 20$ GeV, $\eta < 2.1$
	τ	$P_T > 20$ GeV	$P_T > 20$ GeV, $\eta < 2.3$
e + μ	e	$P_T > 8/17$ GeV	$P_T > 20/10$ GeV, $\eta < 2.1$
	μ	$P_T > 17/8$ GeV	$P_T > 10/20$ GeV, $\eta < 2.5$

Event Categorization

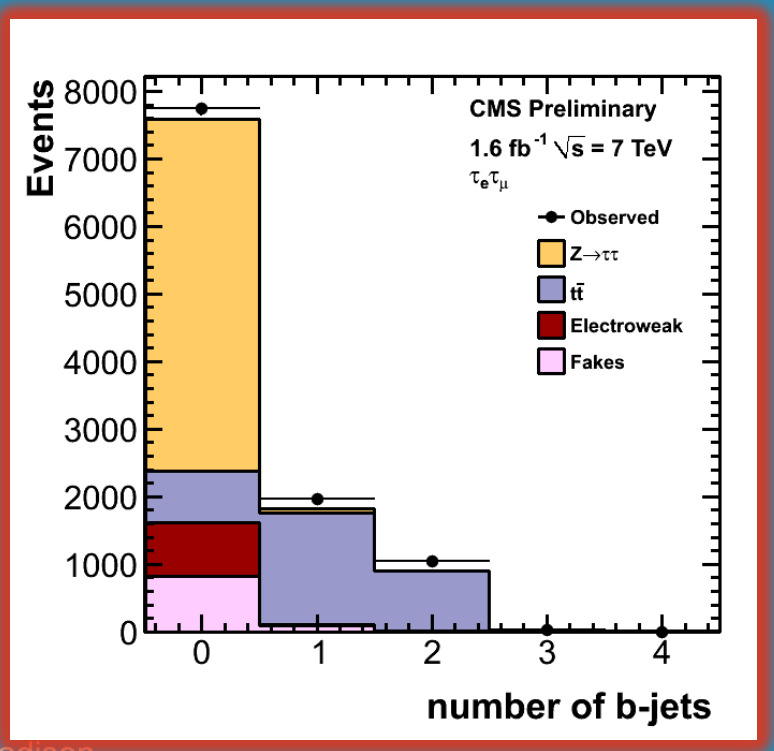
MSSM(No b-tag)

- Require less than two jets with P_T>30 GeV
- Require no b-tagged jets with P_T> 20 GeV



MSSM(b-tag)

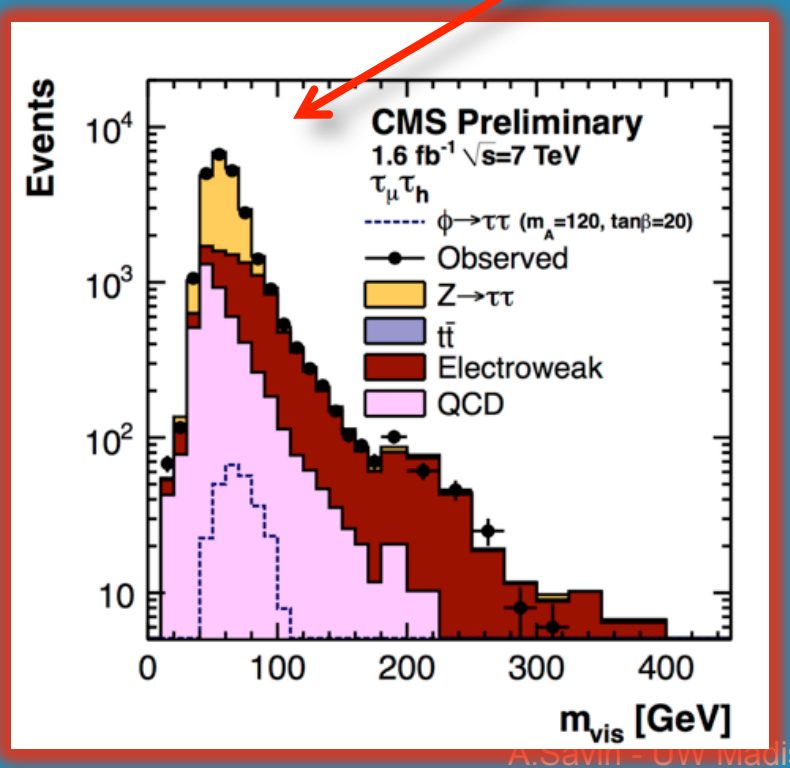
- Require less than 2 jets with P_T>30 GeV
- Require at least one b-tagged jet with P_T>20 GeV

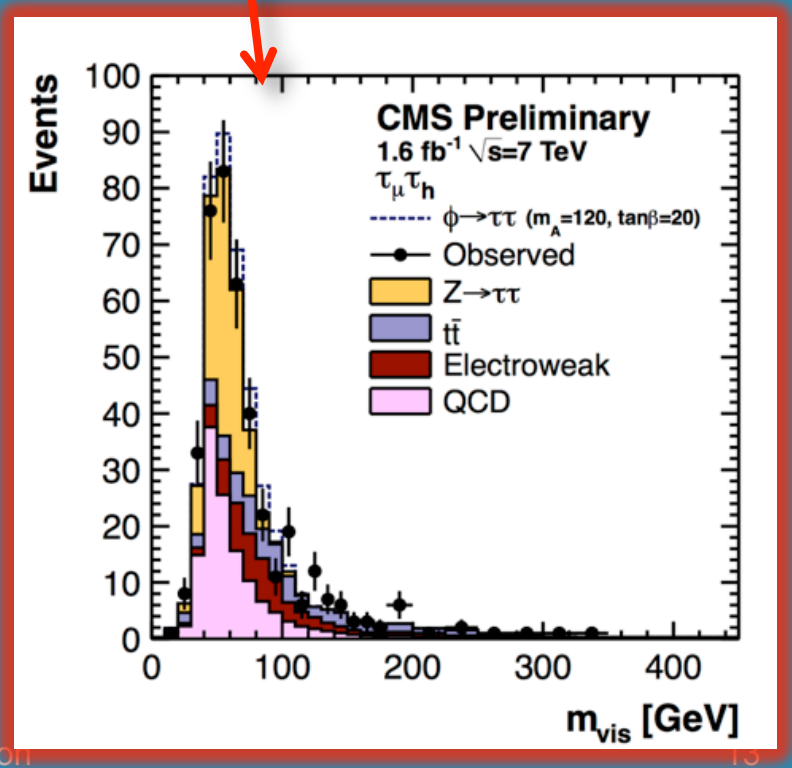


Visible mass

	no b-tag	b-tag
background	25376±1132	387±31
data	25314	408

μ + τ

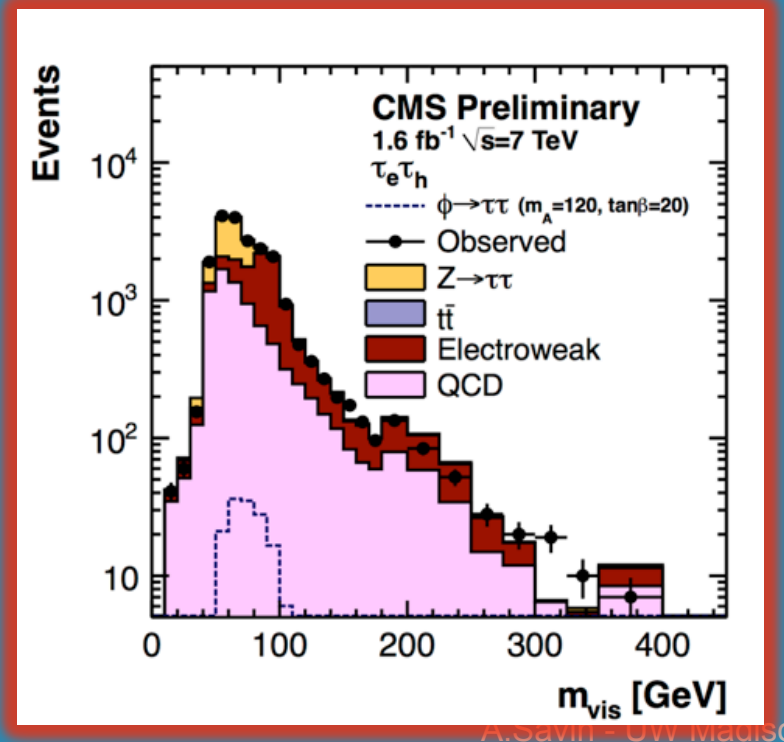


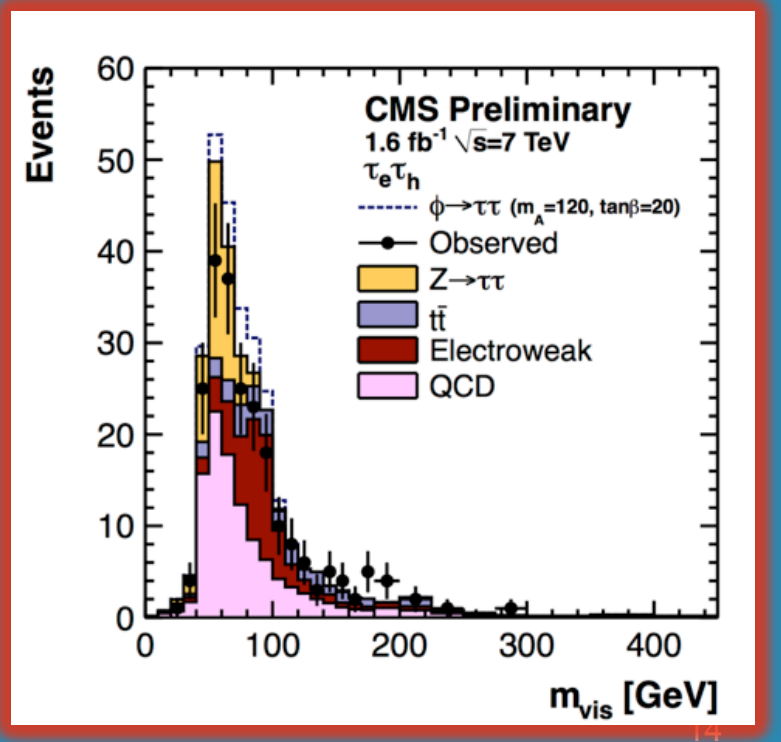


Visible mass

	no b-tag	b-tag
background	19646±640	244±18
data	20384	223

e + τ

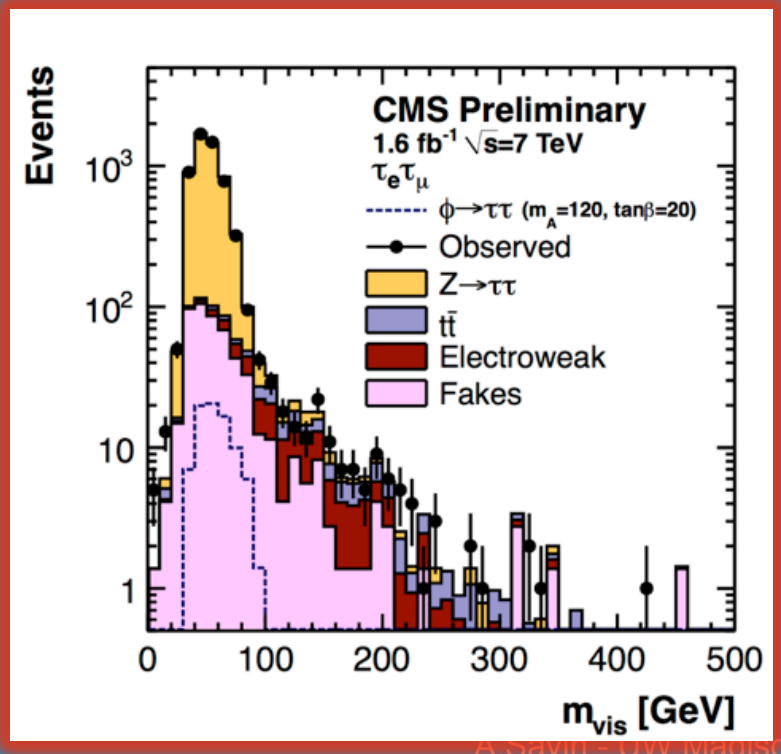


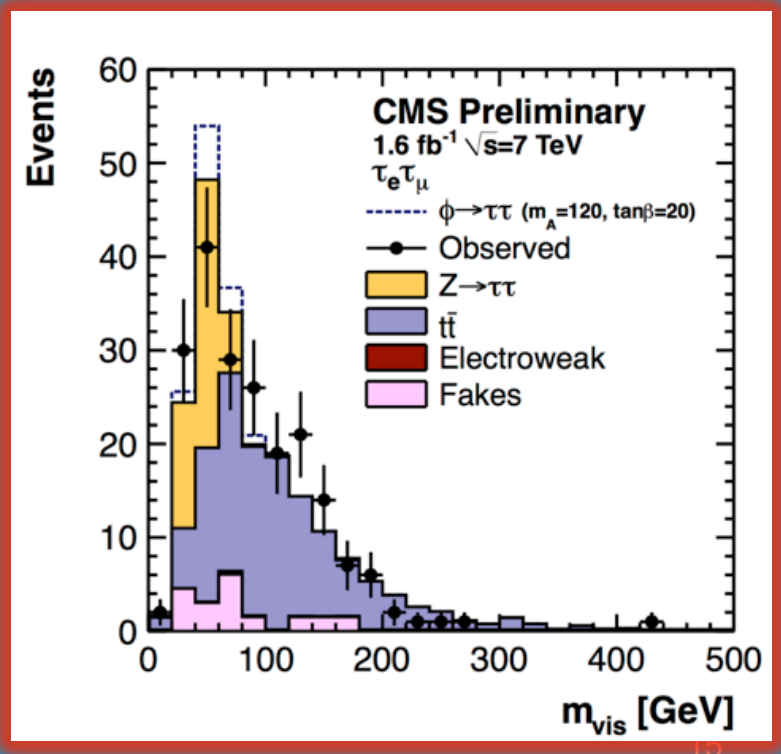


Visible mass

	no b-tag	b-tag
background	5496±201	181±14
data	5528	201

e + μ





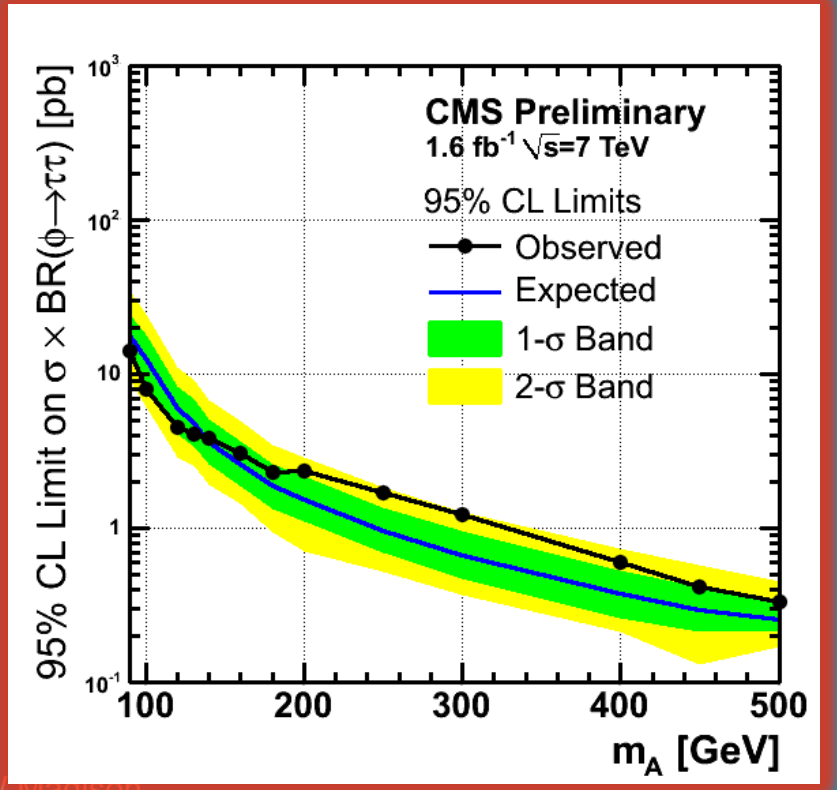
Systematic Uncertainties

- $Z \rightarrow \tau\ \tau$ and TTbar : irreducible estimated from CMS σ(Z) / σ (ttbar)
- Data driven estimation for QCD and W+jets (OS/SS+W sideband for l+ τ ; fake rate for e+ μ)
- Fit: background and systematic uncertainties as nuisance parameter
- Fit: shapes from data(QCD) or MC, checked in sideband regions
- Fit: MC shapes allowed to vary

Source	Uncertainty
Lepton ID /trigger	1%
Tau ID efficiency	6%
Tau energy scale	3%
σ(Z → μμ/ee)	3%
σ(ttbar)	12%
B-Tag Efficiency	10%
B-Tag Mistag rate	14%
Jet energy scale	2-5%
PDFs	3%
UE/Parton Shower	4%
QCD Scale	4-12%
Luminosity	4.5%

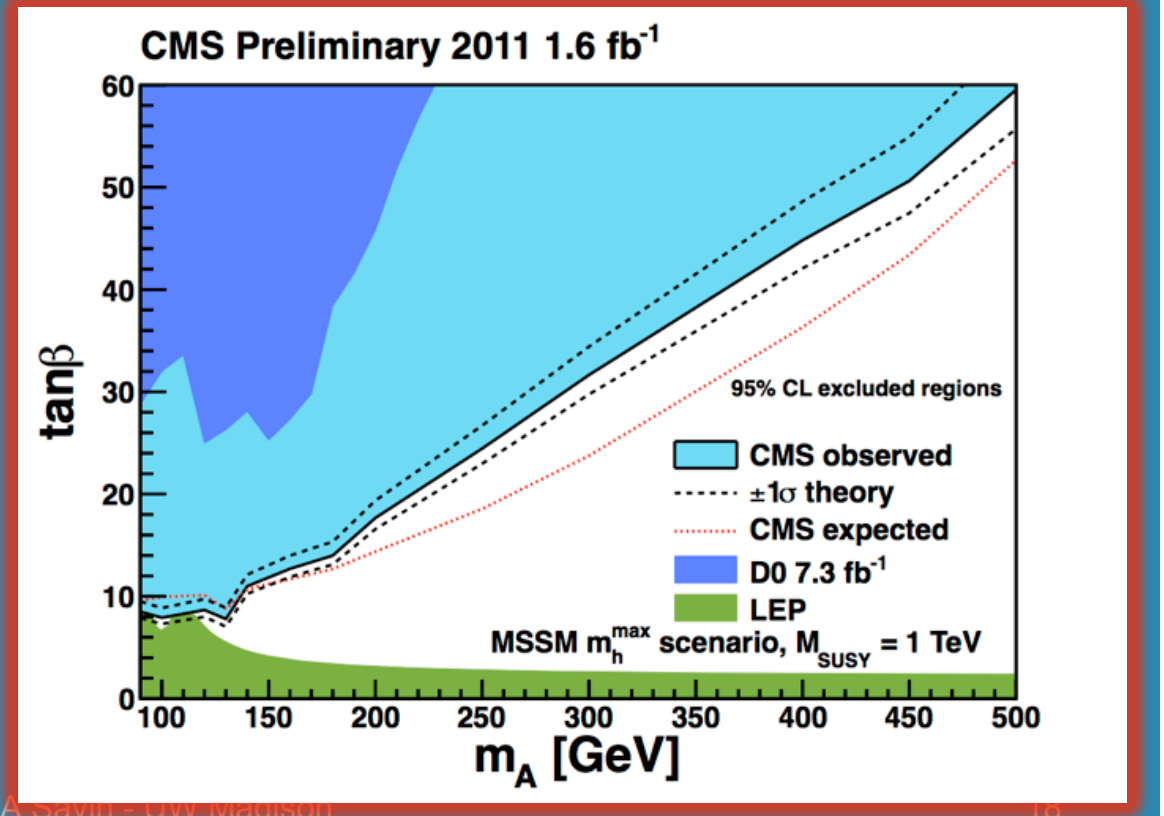
CL_S Limit

- No significant excess , CL_S limits set on σ x BR($\Phi \rightarrow \tau\ \tau$)
- The limit is not model independent, MSSM specific:
- bbH/ggH cross section ratio constrained to the ratio in MSSM
  - $\tan\beta$ =30
  - Changes with M_A



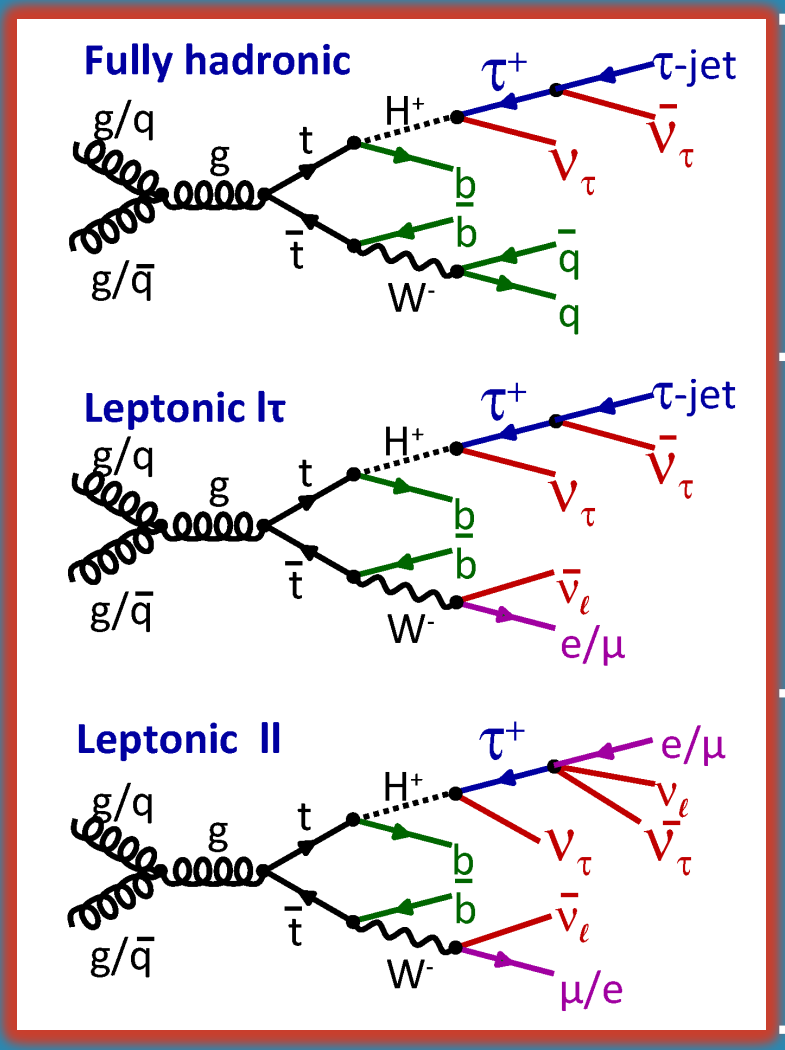
Interpretation in MSSM

- MSSM mostly excluded at $M_A < 120$ (CMS-LEP)
- Opening new regime at high M_A
- Huge improvement wrt 2010 result: b-tagging/tau ID efficiency
- More data coming!



$H^+ \to \tau^+ \nu$ Analysis Strategy

CMS-PAS-HIG-11-008



τ + jets

μ + τ

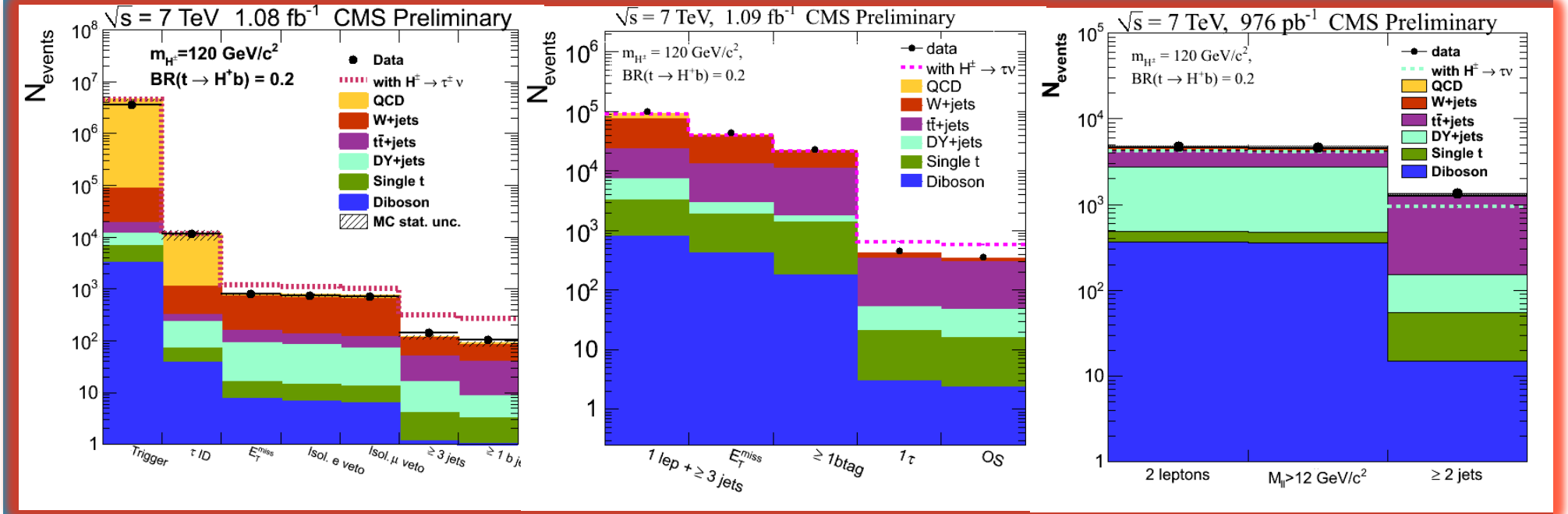
e + μ

Three channels analyzed

Charged Higgs Event Selection

Channel		Trigger	Offline/leptons	Offline/ jets,MET
τ + jets	τ	P_T > 35 GeV MET> 60	P_T > 40 GeV, η < 2.1	At least 3 jets , 1 b-tag, MET>70 GeV
μ + τ	μ	P_T >17 GeV	P_T > 20 GeV, η < 2.1	At least 2 jets, 1 b-jet, MET>40 GeV
	τ		P_T > 20 GeV, η < 2.4	…
e + μ	e	P_T > 8/17 GeV	P_T > 20 GeV, η < 2.4	At least 2 jets, 1 b-jet,
	μ	P_T > 17/8 GeV	P_T > 20 GeV, η < 2.4	…

Event Selection and Background

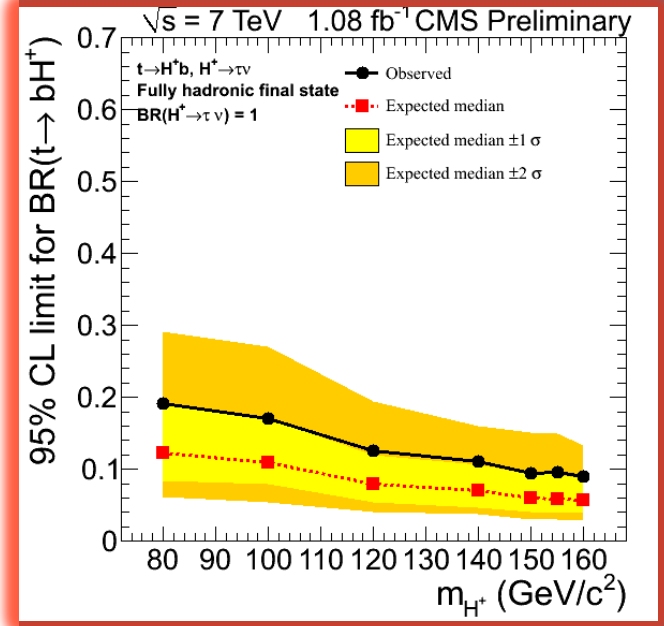


Background estimate

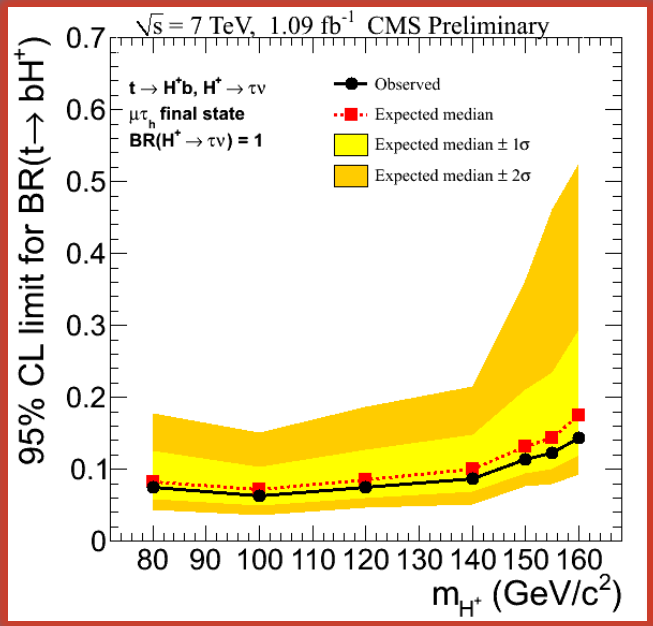
- **Fully hadronic**
  - QCD multijet from data
  - EWK/tt with real taus estimated with embedding on muon events
  - EWK/tt fake taus from MC
- $\mu + \tau$
  - QCD estimated by tau fake rate method
  - Other backgrounds from simulation
- e+ μ
  - Ttbar background dominant
  - Estimated from simulation

Charged Higgs Results

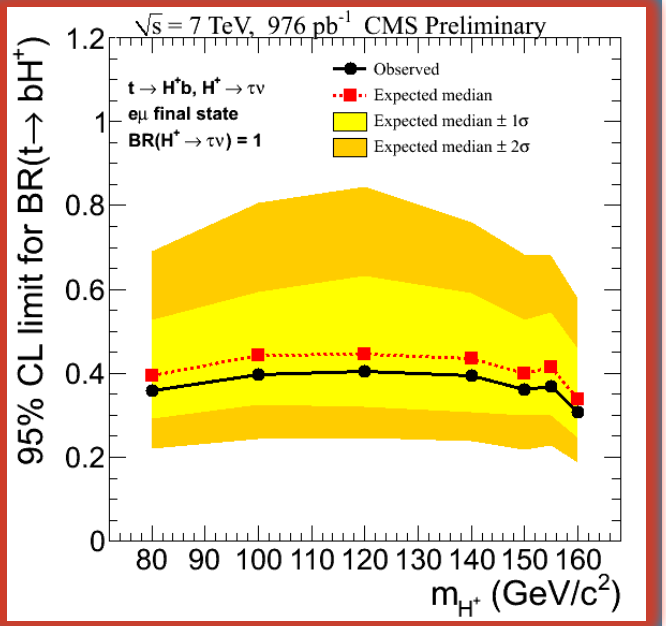
Fully hadronic



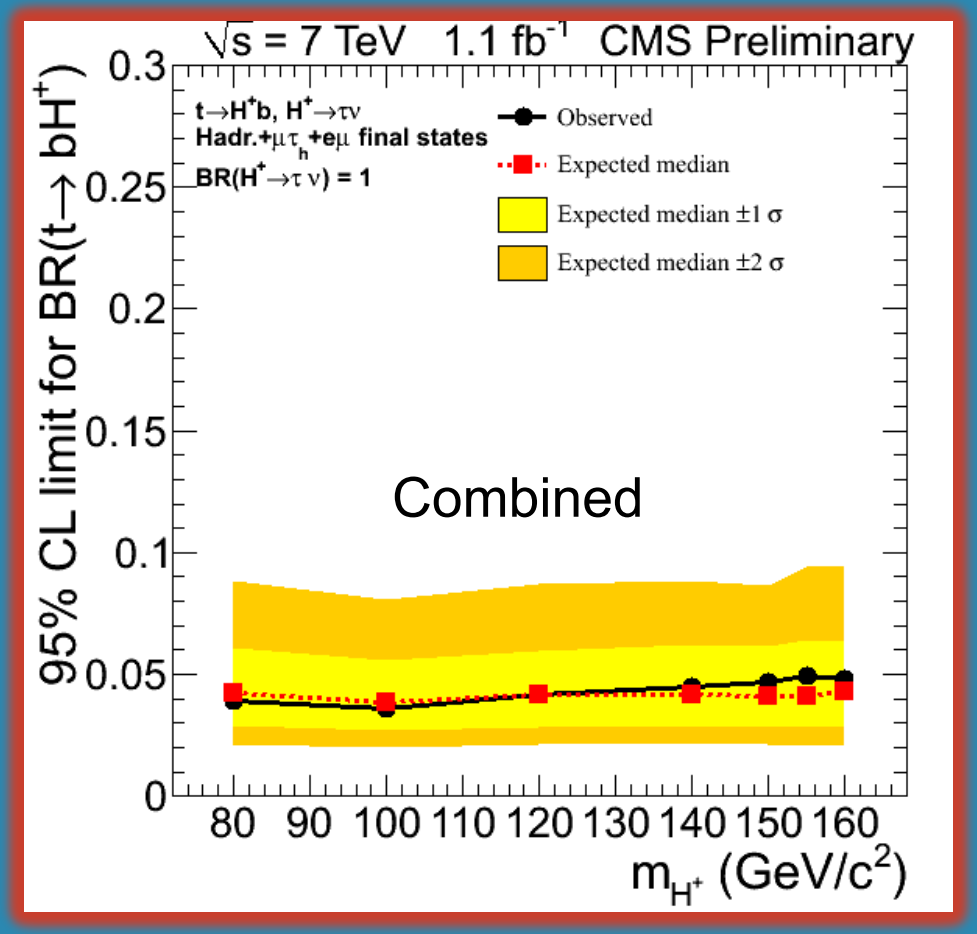
μ+τ



μ+e



Charged Higgs Results



Excluding
BR(t → bH) ~5%
80 < mH+ < 160 GeV/c2
Assuming Br(H+ → τ ν)=1

Conclusions

- An inclusive search for Φ^{++} has been performed, no excess is observed, new limits are set
- Results have been presented on MSSM Higgs searches with taus using 1.6 fb^{-1} of CMS data
- Results set new stringent limits in MSSM parameter space

Backup

Backup

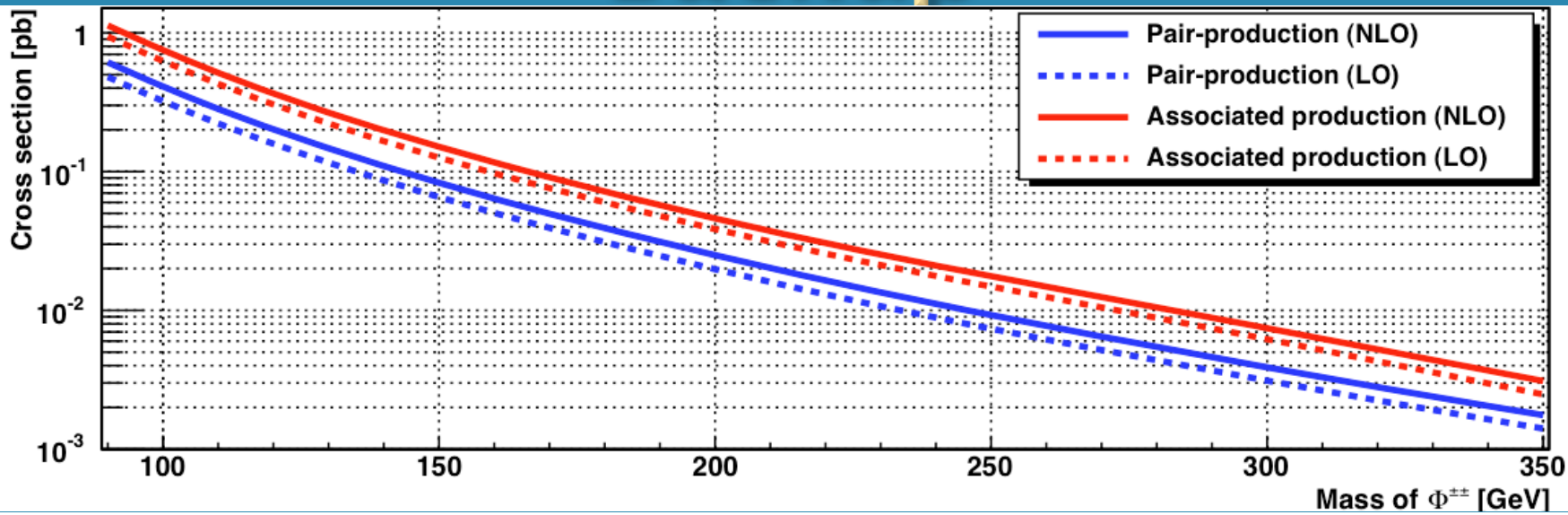
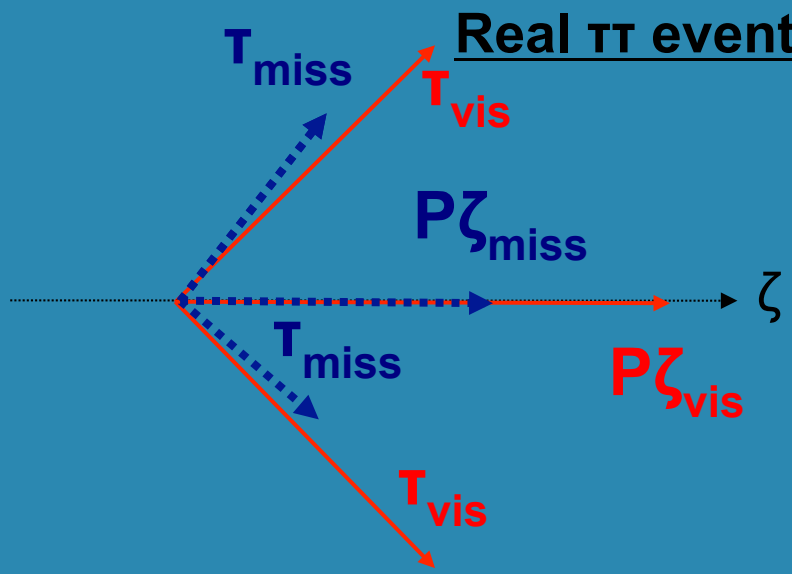
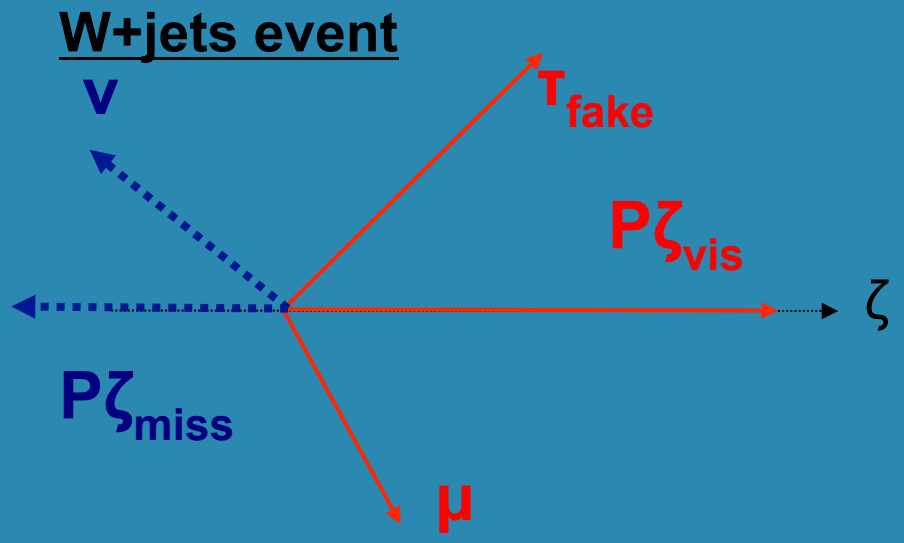


Table 4: Source of systematic uncertainties and impact on the full selection efficiency

Lepton (e or μ) ID and isolation	2%
τ-jet ID and isolation	8%
Trigger and primary vertex finding	1.5%
Signal cross section	10%
Luminosity (for signal only)	6%
Ratio used in background estimation	5%
Statistical uncertainty of observed data events in sideband	10-100%
Statistical uncertainty of signal samples	1-7%

Topological requirements





- Neutrinos from taus tend to be collinear to the visible part
  - Not the case for W+jets and TTBar
- Define P_{ζ} variables(introduced in CDF)
  - Project visible di-tau transverse momentum vector and MET in the bisector axis of the visible products
  - Request collinearity between visible and missing E_T part

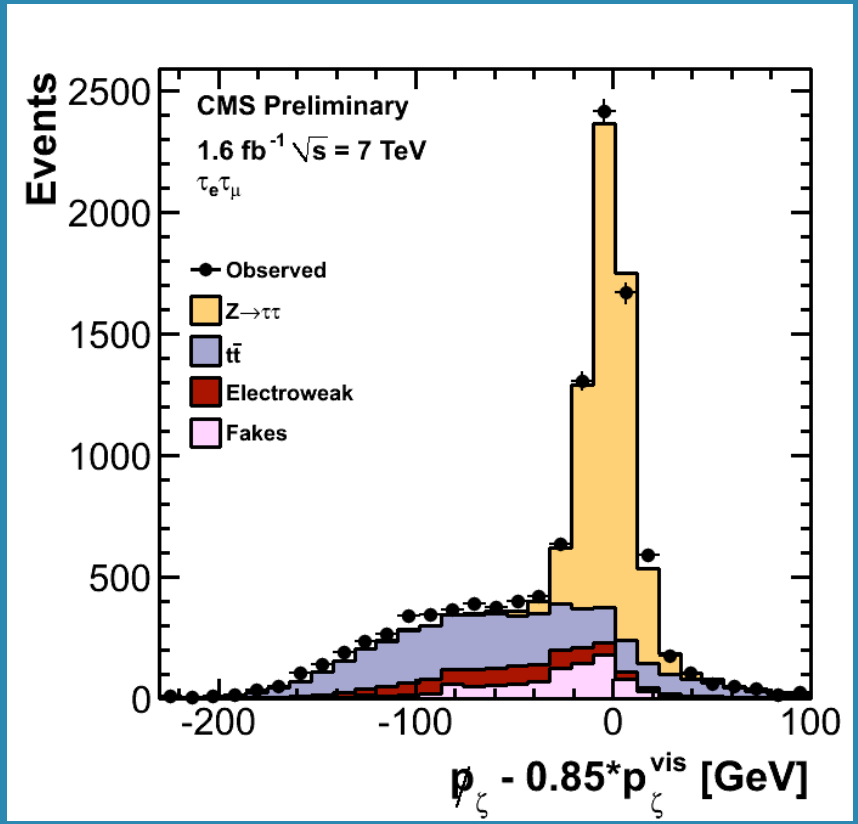
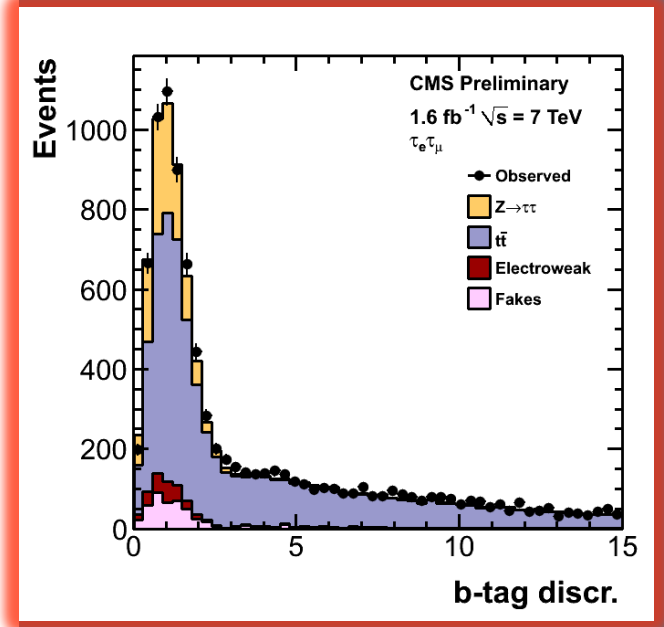
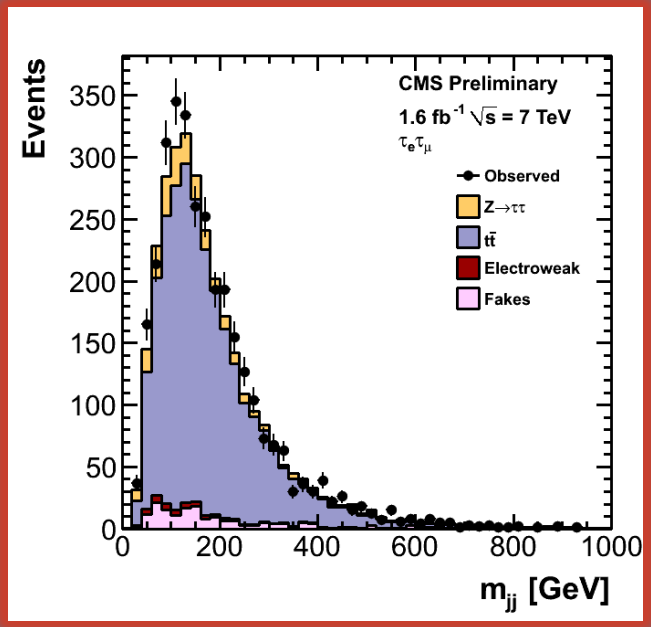

CMS Preliminary
1.6 fb^{-1} $\sqrt{s}$ = 7 TeV
$\tau_e\tau_\mu$
Observed
$Z\rightarrow\tau\tau$
$t\bar{t}$
Electroweak
Fakes
Events
2500
2000
1500
1000
500
0
-200
-100
0
100
$\not{p}_\zeta$ - 0.85*p_ζ^{vis} [GeV]

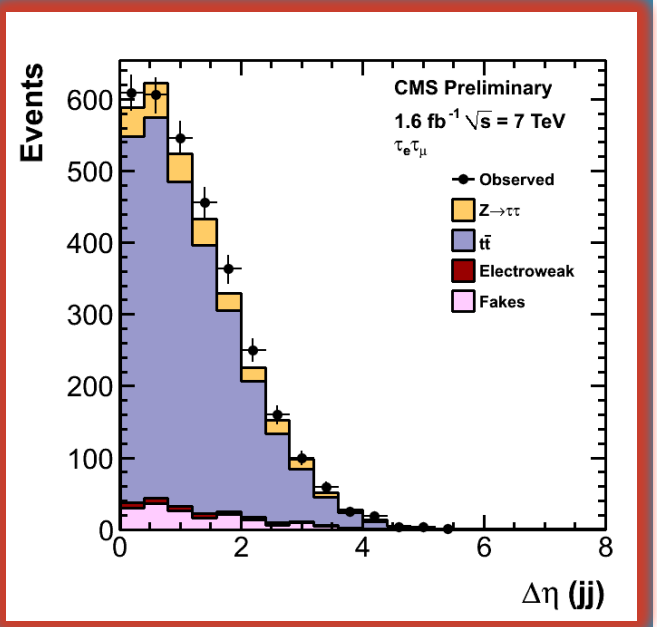
Table 1: The systematic uncertainties (in %) for the backgrounds and the signal from $t\bar{t} \to H^{\pm}bH^{\mp}\bar{b}$ (HH) and $t\bar{t} \to W^{\pm}bH^{\mp}\bar{b}$ (WH) processes at $m_{H^{\pm}}$=80-160 GeV/c^2.

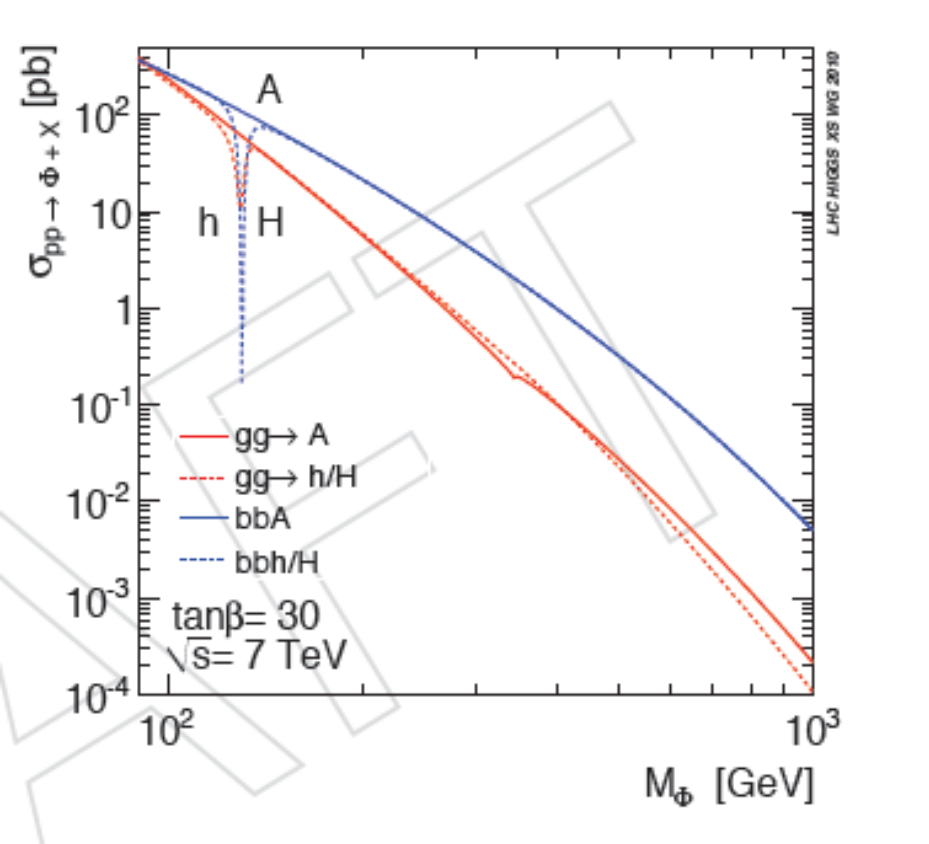
	HH	WH	QCD	EWK+$t\bar{t}$	EWK+$t\bar{t}$ τ fakes				
				τ	$t\bar{t}$	tW	W+jets	Z+jets	VV
$\tau - p_T^{miss}$ trigger	24–26	24–25		9.6	22	22	22	24	23
τ-jet id	7.0	7.0		7.0					
jet, $\ell \to \tau$ mis-id					15	15	15	15	15
JES+JER+MET	13–17	14–19		18	17	25	14	19	22
lepton veto	0.2–0.3	0.3–0.4			1.5	0.6	0.6	0.6	0.7
b-jet tagging	12–15	14-16			16	17			
jet→b mis-id							13	10	11
QCD stat.+syst.			7.1						
EWK+$t\bar{t}$ τ stat.				6.8					
$f_{W\to\tau\to\mu}$				0.7					
muon selections				0.6					
MC stat	4.1–7.0	4.8–7.2			16.3	56	100	100	90
cross-section	20	20			20	8	5	4	4
luminosity	6.0				6.0				

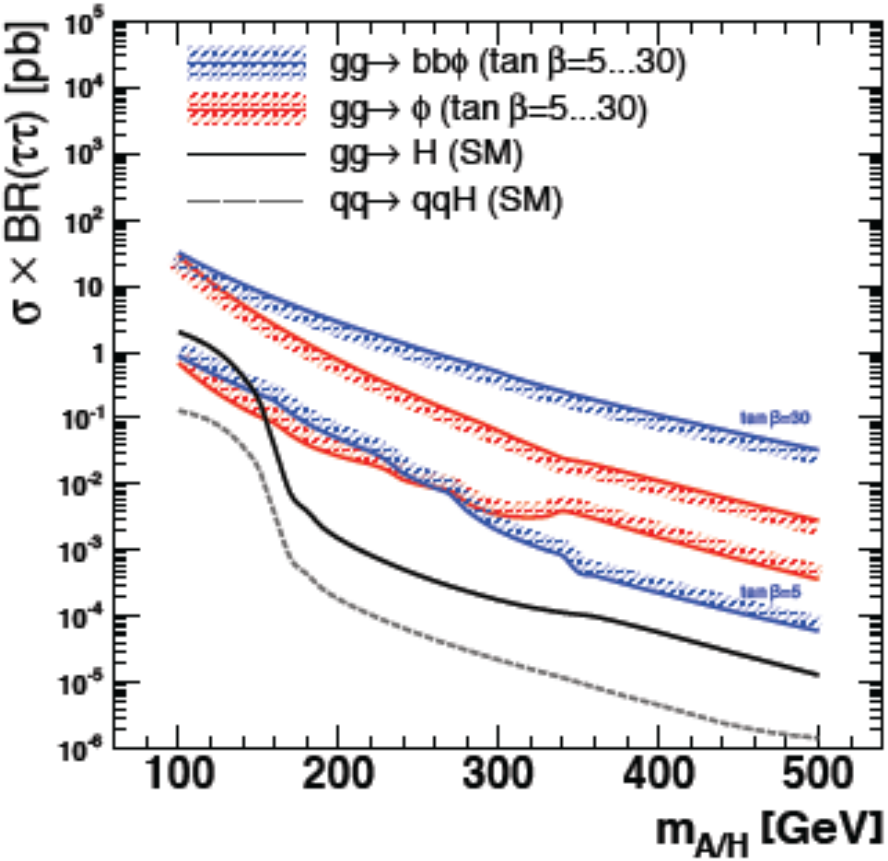
Event categorization








$\sigma_{pp\to\Phi+X}$ [pb]
A
h
H
gg→ A
gg→ h/H
bbA
bbh/H
tanβ= 30
√s= 7 TeV
M_Φ [GeV]
LHC HIGGS XS WG 2010


σ × BR(ττ) [pb]
gg→ bbϕ (tan β=5...30)
gg→ ϕ (tan β=5...30)
gg→ H (SM)
qq→ qqH (SM)
tan β=30
tan β=5
$m_{A/H}$ [GeV]