Search for MSSM Higgs by Tau-Tau decay at the CMS Experiment

IoP 2010 @ UCL

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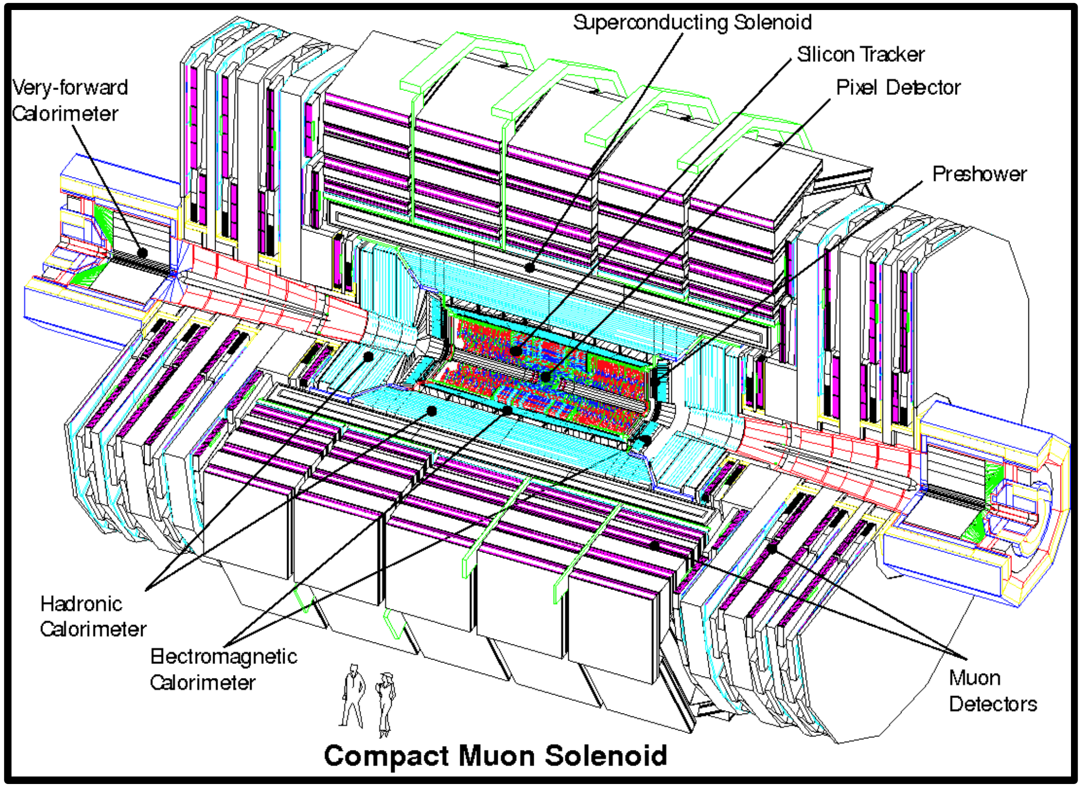

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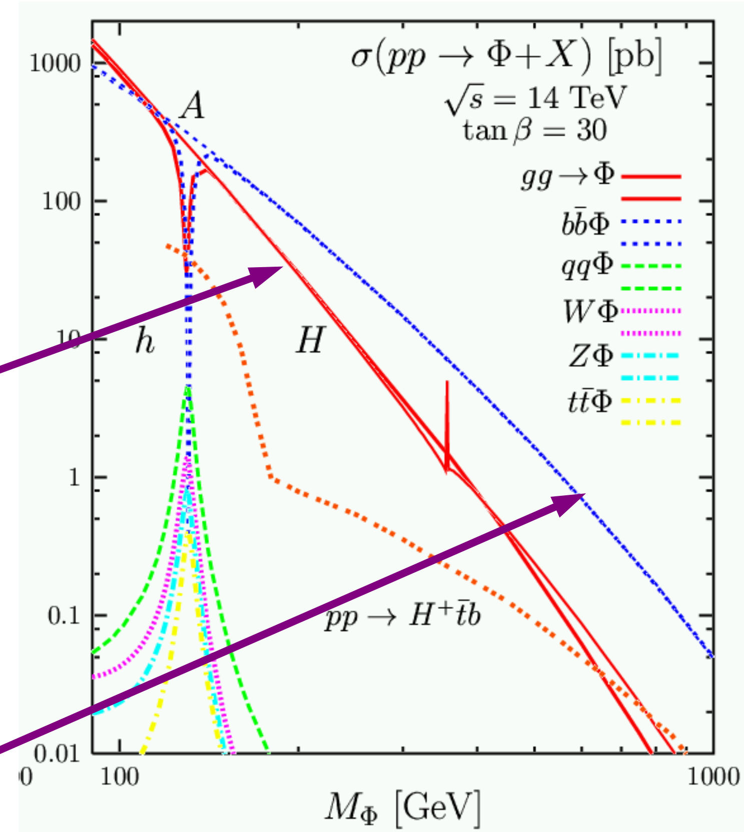
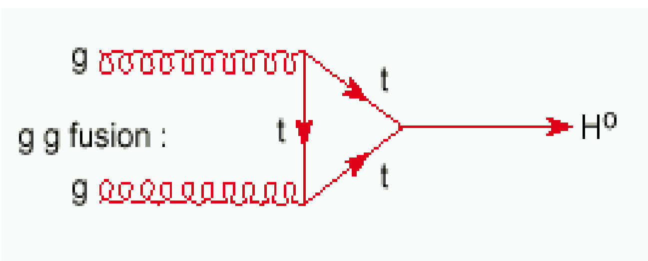
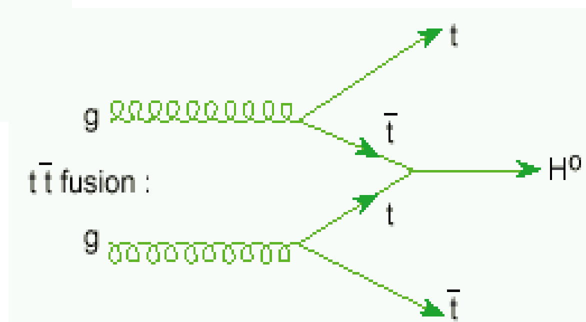
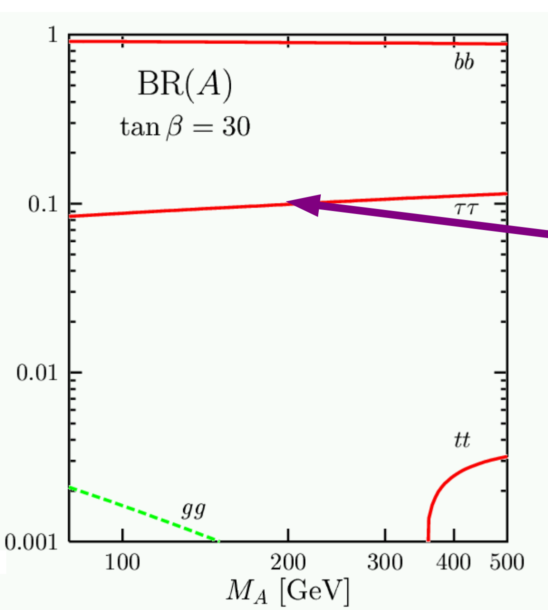
MSSM Higgs

- The MSSM light Higgs presents an attractive early data target
- We will look at both gluon-fusion and quark-associated production mechanisms









The decay to a pair of tau leptons offers a cleaner and more distinguishable channel than b decay.

I am focussing on the further decay to electron and tau jet. The overall branching ratio for this process is ~2.4%.

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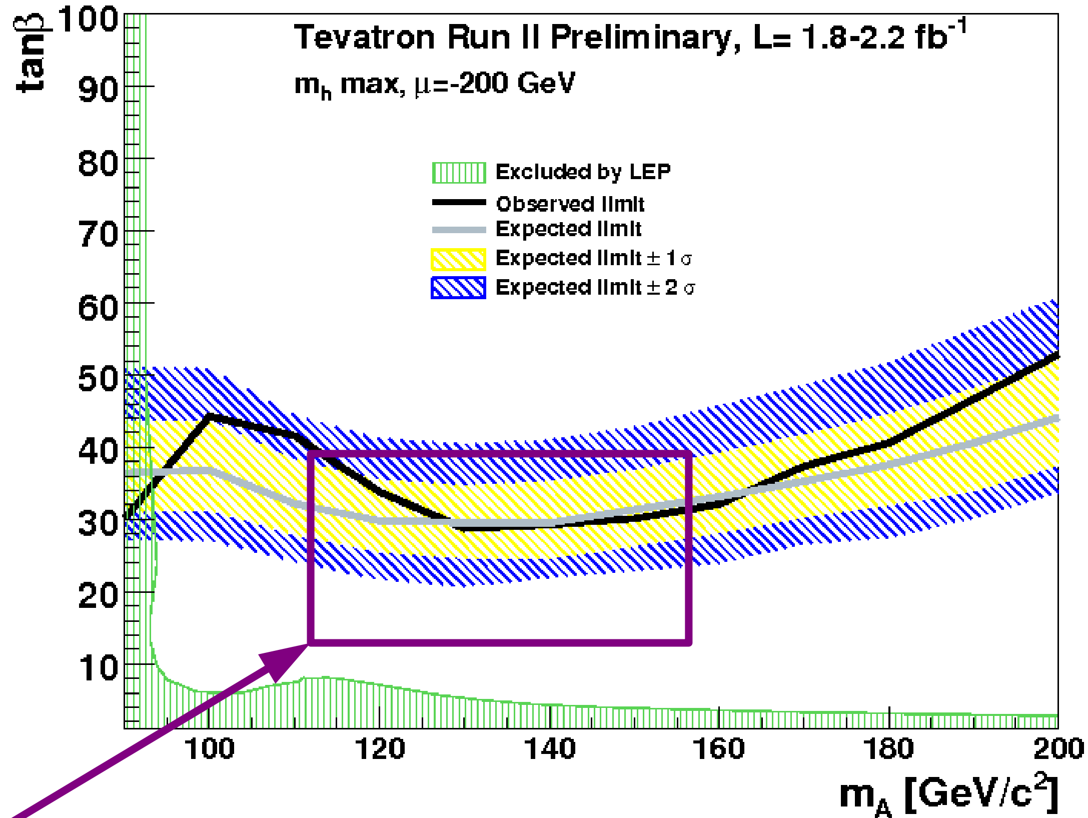
Current Results

- Recent results from Tevatron have started to push exclusior limits down to tan β = 30
- With sufficient data, this analysis (combined with other tau-tau channels) should be able to close the gap between Tevatron and LEP data
- Results presented are for the maximal mixing model
- We consider
  - Mass points 115, 160 GeV
  - tan β = 15, 20, 30, 40



Combined D0, CDF limits. From 18th March, arXiv:1003.3363v1

For 10TeV, M_H=115GeV, tan β =30

Event rate (e+τ) ~ **20 / pb^{-1}**

Where not specified, plots correspond to M=115GeV and tan β = 30

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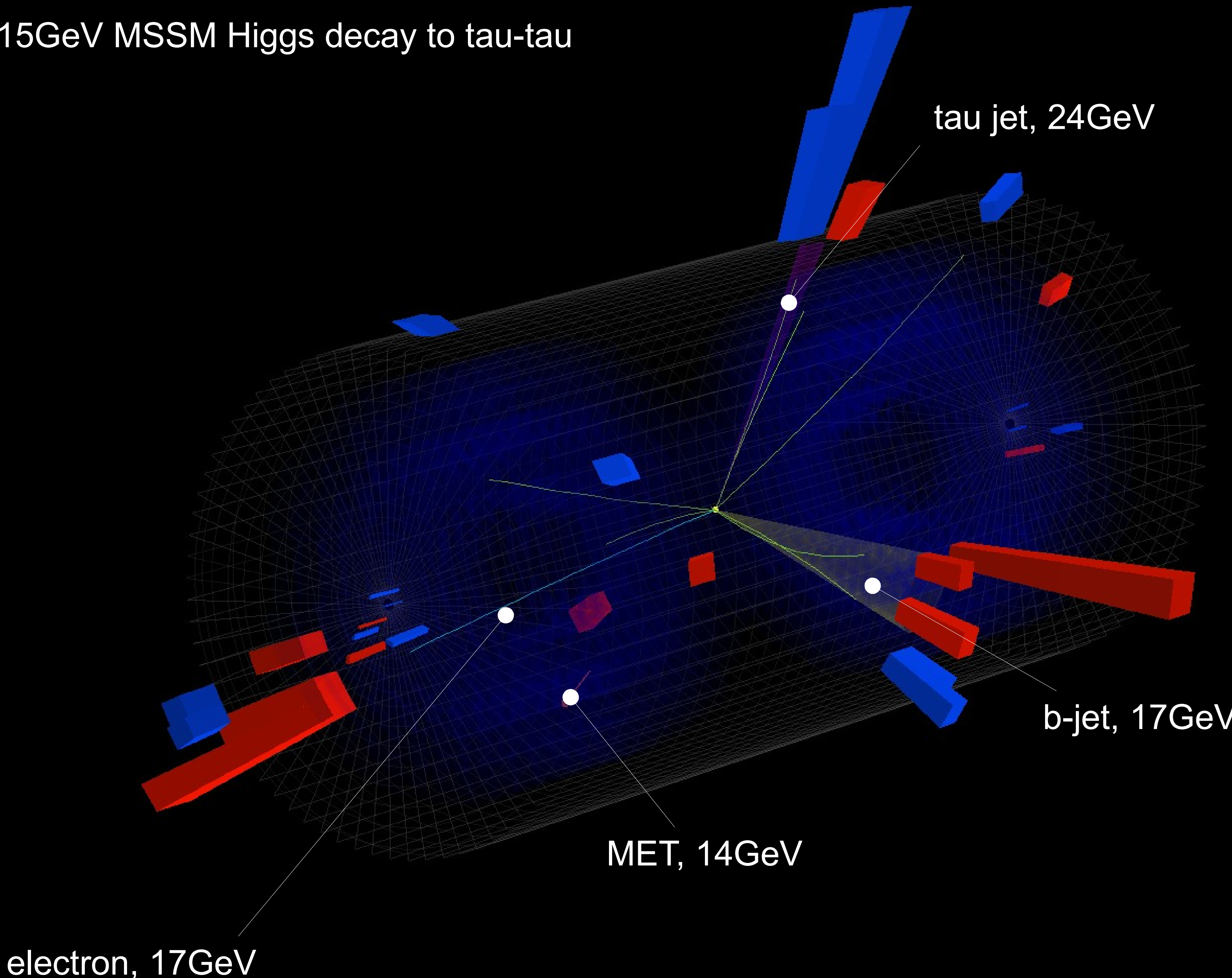
115GeV MSSM Higgs decay to tau-tau



CMS Fireworks Event Display

Analysis Summary

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- Selections optimised
  - individually, by distribution
  - all together, using Python/ROOT/MINUIT
- This data is for **10TeV**, re-running this analysis for **7TeV** is not yet complete

Signal Samples		Events	Intlumi /pb
Higgs (bb) *	(115GeV)	200k	3800
	(160GeV)	200k	11400
Higgs (gluon-gluon)*	(115GeV)	200k	7800
	(160GeV)	200k	36800

^(tan β = 30)

Backgrounds Samples	Events	Intlumi /pb
QCD (with >0 electrons) *	65M	6+
Photon+Jet ~	500k	4+
W+jet(s) ^	10M	240
TTbar +jet(s) ^	1M	2600
Z+jet(s) ^	1M	330
Zbb ^	150k	3500
Zcc ^	250k	3500

* PYTHIA 6
~ PYTHIA 8
^ MadGraph
\+ Multiple Bins

CMS *Summer08* Production

python™

CMSSW 2.2.13, ROOT 5.22, Python 2.6.4

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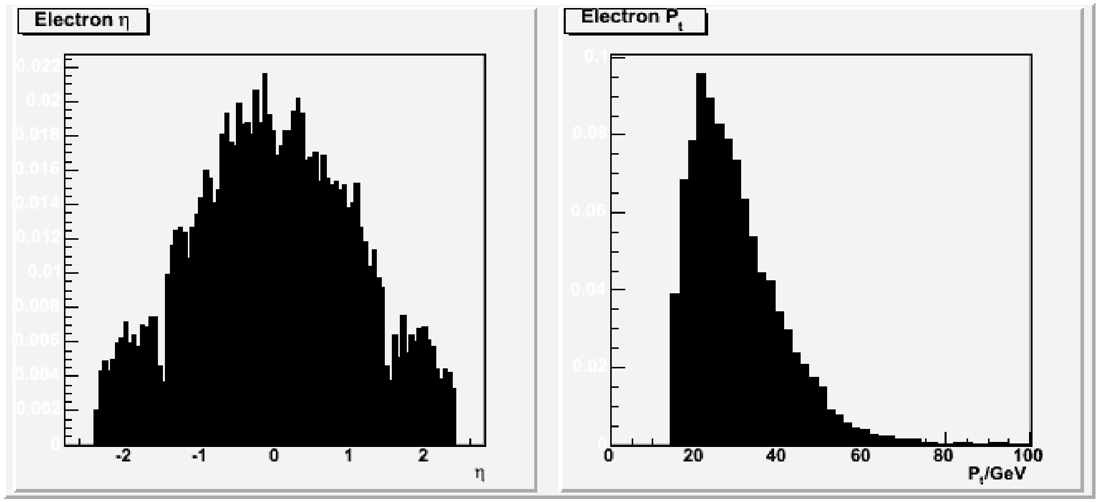
Electrons

- Events triggered with a single, isolated electron trigger
  - HLT_IsoEle15
- Use good, offline electrons
- Built from both a GSF* track and a ECAL cluster
- Select electrons within the tracker acceptance ($\eta<2.4$) and $P_t > 15$GeV
- Electron Identification cut
- Isolated in both tracker and ECAL
  - Cone size 0.4 in η,φ



*Gaussian Sum Filter, a track reconstruction method designed to handle bremstrahlung events

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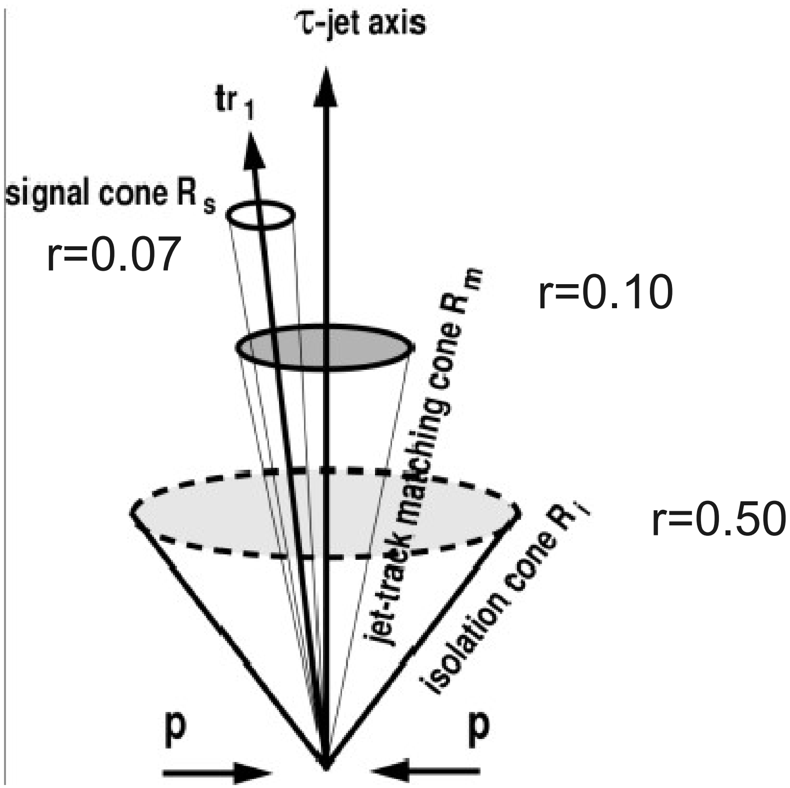
Multivariate Electron ID (“robust”) from CMS eγ working group. Variables such as HCAL/ECAL, deposit shape, E/p and track extrapolated position

Tau Jets

- Use "Particle Flow"* Taus
- Select taus within the tracker acceptance ($\eta<2.4$) with $P_t >$ 20GeV
- Must be non-colinear with the selected electron(s)
- Leading track at least 5GeV
- Isolated in both tracker and ECAL
  - Cone size 0.5 in η,φ
- Passes electron-rejection cuts^



*This is an algorithm intended to reconstruct the entire detector in one pass, classifying each track and deposit only once.

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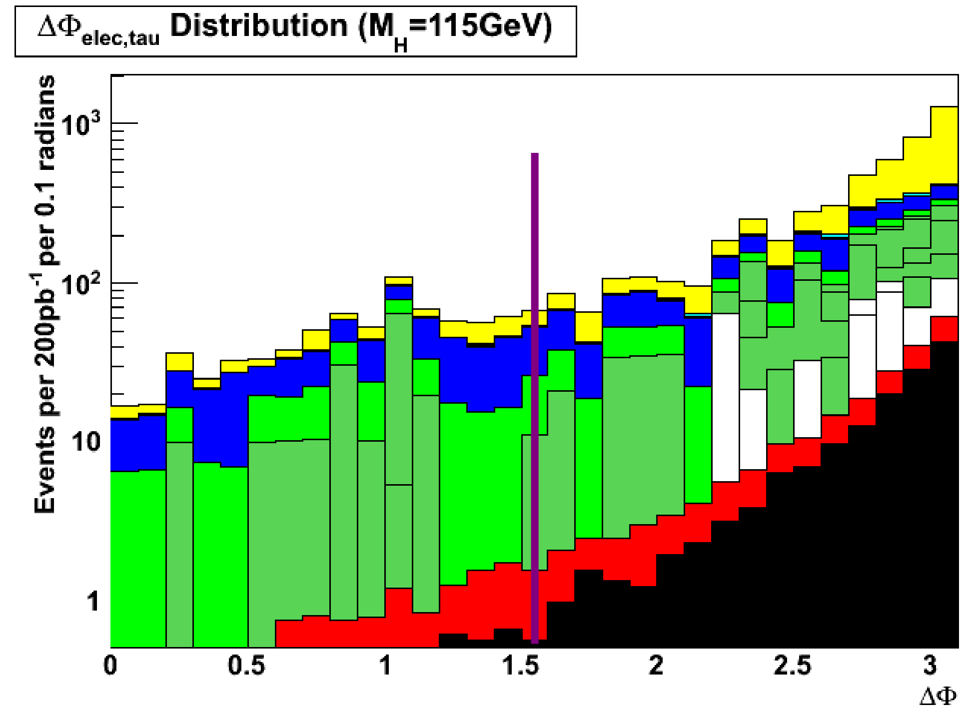
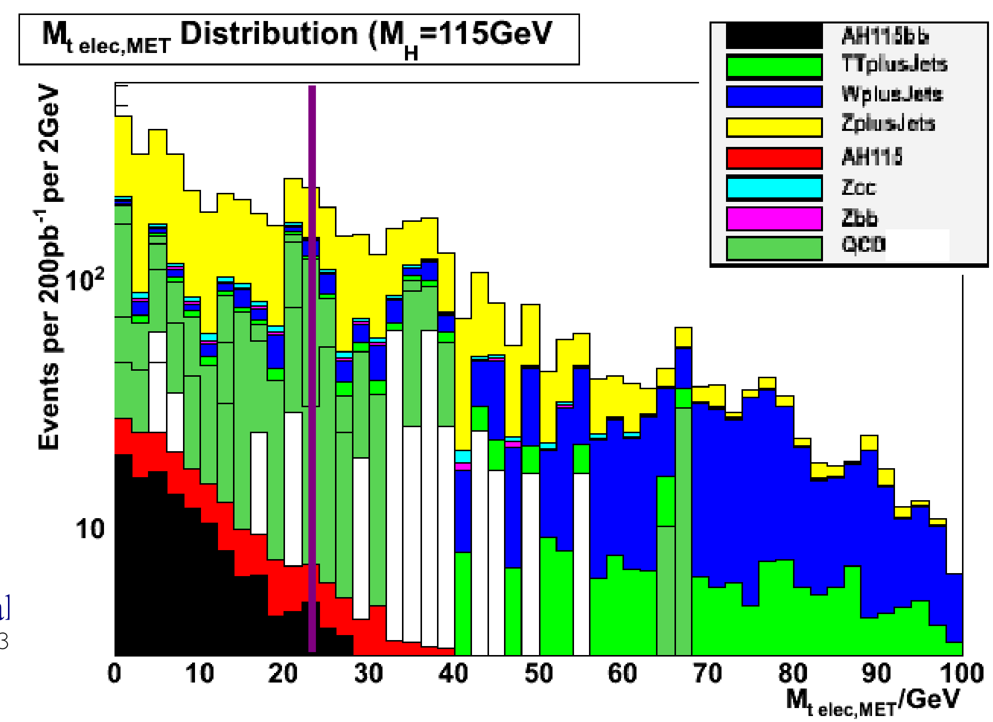
^This is another MVA intended to identify electrons faking taus. This is based on the Particle Flow electron pre-ID decision and HCAL/track pt.

Electron-Tau Pairs

- Build all possible electron-tau pairs
  - where ΔR > 0.7
- Require opposite charge $q_{elec} \times q_{tau} < 0$
  - reduces losses due to badly counted tracks
- Require $\Delta\Phi_{elec,tau} > 1.5$
  - this eliminates a lot of QCD and W background
- Require $M_{t\,elec,MET} < 25$ GeV
  - this is sensitive to higher higgs masses but useful in this region to remove W and TTbar background





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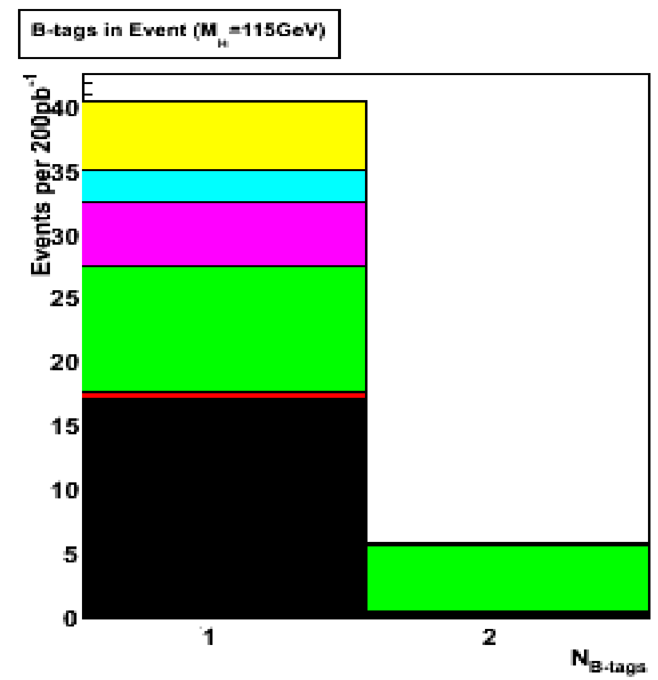
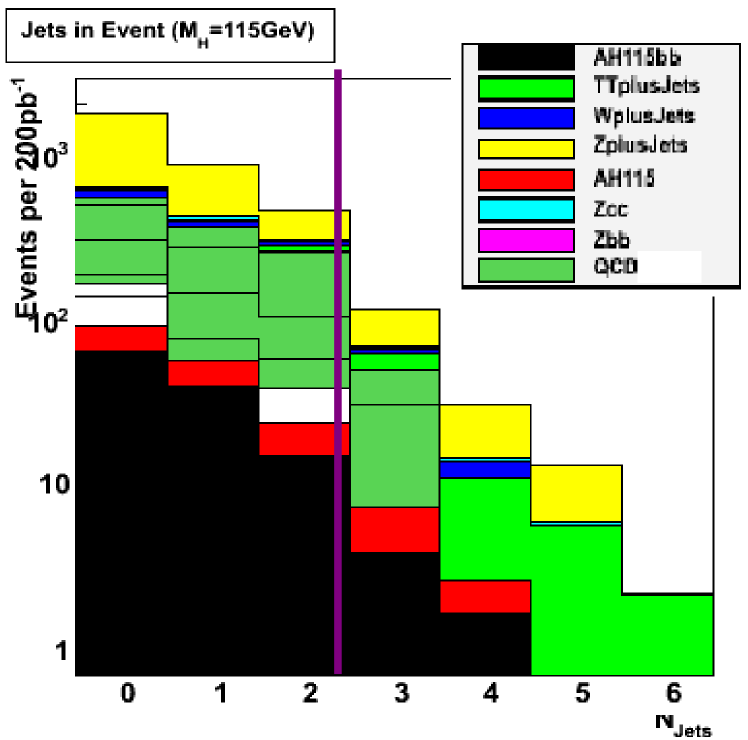
Jets and B-Tagging

- Use simple calorimeter jets, since energy resolution is not important
- For the associated production channel, we can look for b-jets to eliminate backgrounds
- Tag b-jets by looking at the impact parameter significance of the 2nd best track in the jet
- Although the signal should usually contain 2 b-jets, most of the time we do not find a second
- Requiring exactly one b-tag significantly reduces tt-bar background
- Requiring no more than two jets, in tracker and E_t>15GeV further reduces this background
  - But this is sensitive to pileup





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Results

At **10TeV** with **200pb[-1]** of data

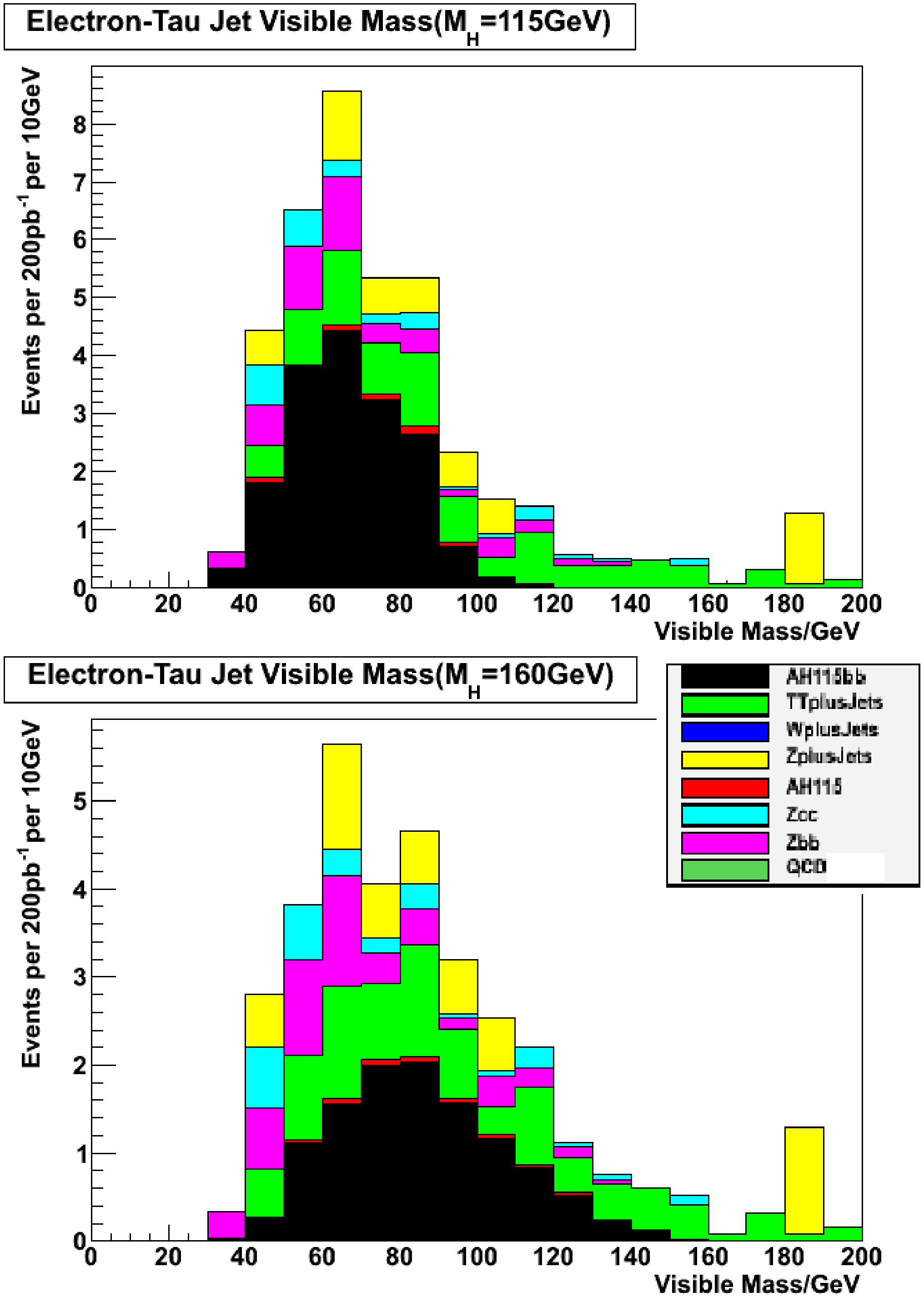
Signal (115 GeV)	17.8 ± 1.0 evts
Signal (160 GeV)	11.9 ± 0.5 evts
Background	22.8 ± 2.2 evts

Selection efficiency is 0.5% (of e+τ events)

Data required for 3σ exclusion

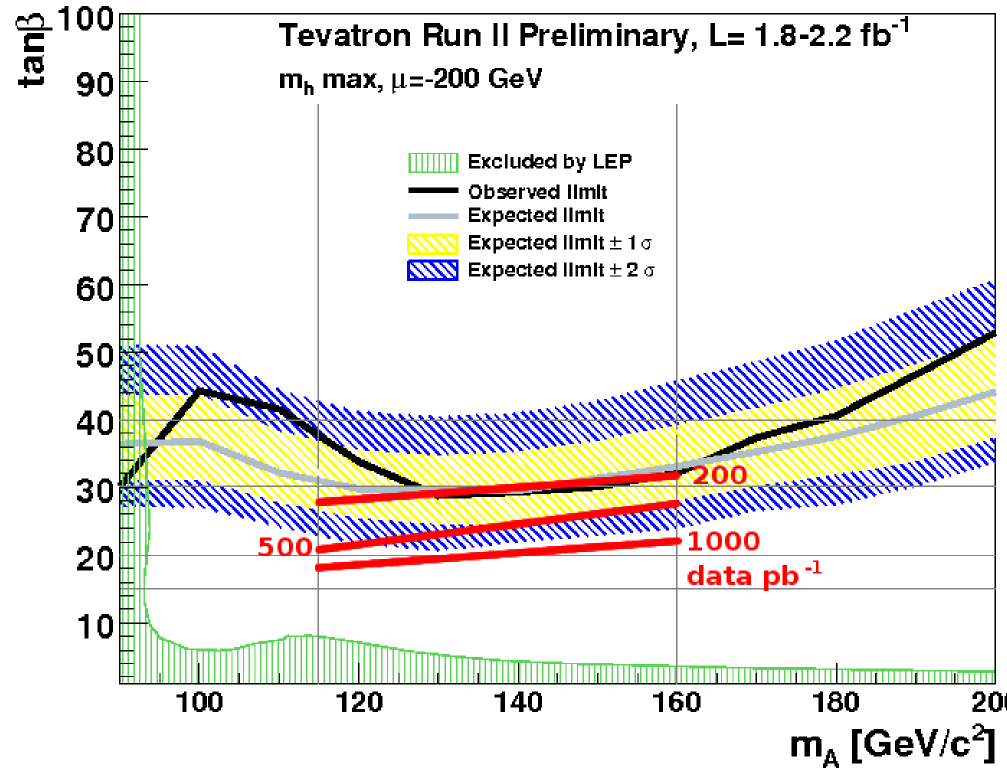
115 GeV	**129** ± 16 pb^{-1}
160 GeV	**291** ± 31 pb^{-1}

(Systematic errors not included)



Conclusions

- With a 1 fb^{-1} of data, we can significantly advance the current exclusion limits with this channel alone
- This analysis will be combined with other tau-tau channels to improve reach
- The limits will however worsen when recalculated with 7TeV Monte-Carlo data
- Many of the ideas for this analysis will be commissioned by looking at $Z\rightarrow\tau\tau$ events in early data



Expected exclusion limits for electron+tau channel only, without systematic uncertainities and with 10TeV data.

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Other Work

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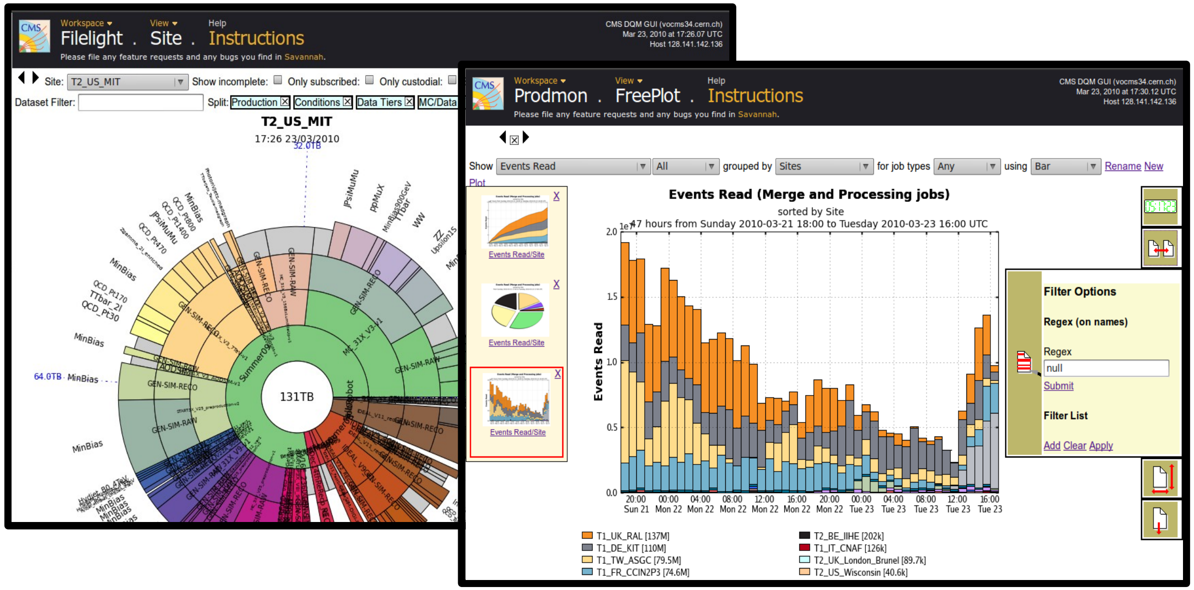
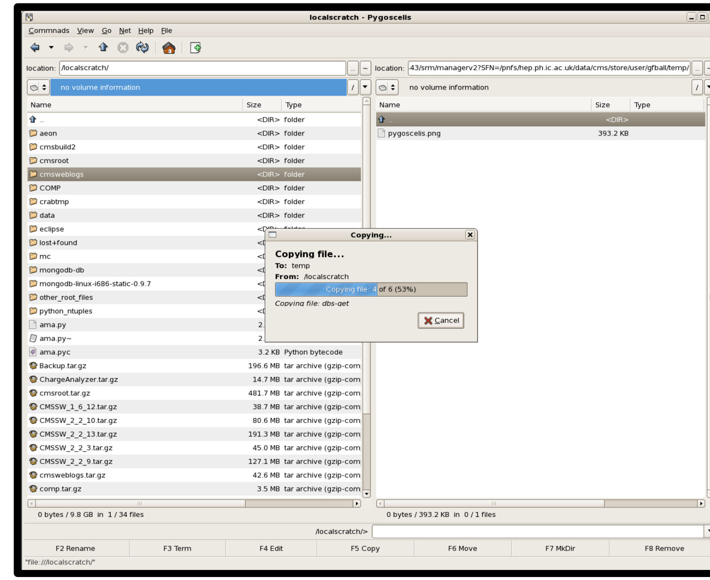
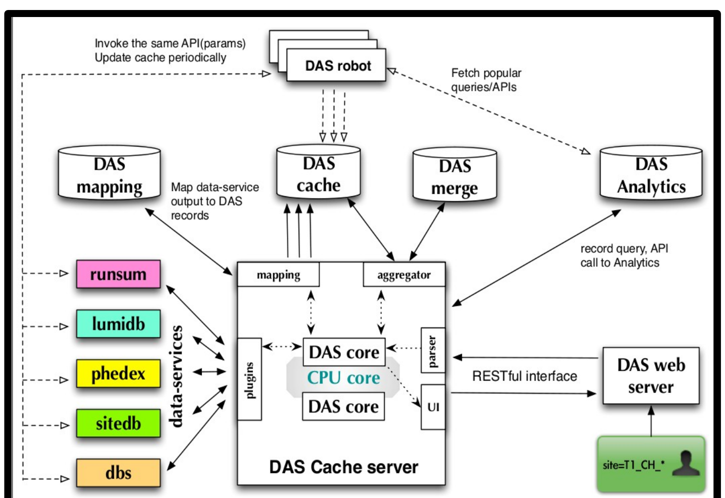
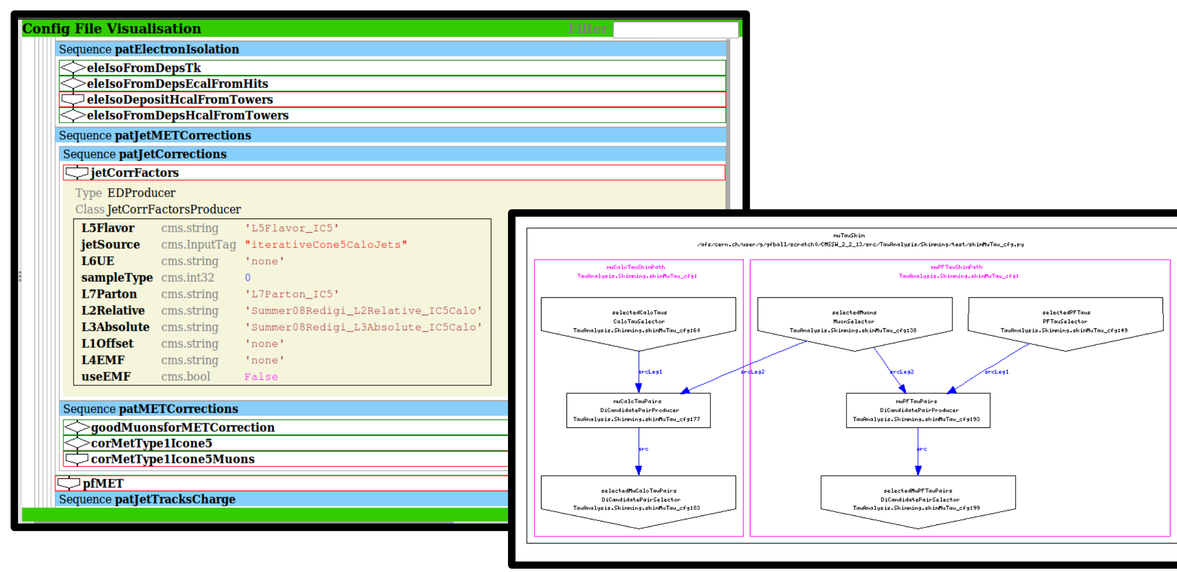


Overview Web Tools –
Production and Site Monitoring



Pygoscelis – a grid copying GUI





DAS – CMS Data Aggregation Service

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CMSSW Config Visualisations –
HTML and Graph