BSM mid-term report

SUSY Projects

- **Light stop model**

Choudury, Galanti, Godbole, Guchait, Lari, Polesello, Schumacher, Zhukov

- **tau polarization**

Choudury, Godbole, Guchait, Heldmann, Mangeol

- **Focus-point studies and model discrimination**

Galanti, Lari, Zhukov

- **CPV Higgs**

Choudury, Godbole, Schumacher

People not on the list (did I forgot someone?) are encorauged to join. This also applies on people attending the second session and those not attending the workshp. Contact T. Lari (tommaso.lari@cern.ch) and see the BSM web page for details.

Light stop: parameter space scan

- MSSM (non-mSUGRA) model, discussed in

C. Balazs, M. Carena and C.E.M. Wagner, Phys. Rev. D70 015007

- Searched for a phenomenology
  - Motivated by baryogenesis
  - With relic density equal to Dark Matter abundance
  - Consistent with LEP and Tevatron limits
  - With heavy squark and sleptons, light stop, intermediate mass gluino
- Parameter space scanned. A few days to get everything right.
  - Running stop mass scale in ISAJET is sqrt[$m(t_R)m(t_L)$]. Set to m(Z) to use zero t_R mass.
  - Different codes use different levels of precision (radiative corrections): the same soft SUSY parameters give different results. Used LO whenever possible, still few GeV differences between ISAJET (masses and decays, interface to HERWIG), MICROMEGAS+ISAJET (relic density), Guchait private code (4-body decay BRs).

Light stop: Selected Point

Scalar u d c s t_2	1200 GeV
sleptons	1000 GeV
gluino	800 GeV
Heavy Higgs	350 GeV
Charginos	174 and 300 GeV
Neutralinos	117 to 304 GeV
Light stop	142 GeV
Light Higgs	114 GeV

Decays in $t\,\tilde{t}$

Decays in $\chi^0_1 c$ (30%) and $\chi^0_1 bW^*$ (70%)

- Low Stop-LSP mass difference: difficult for Tevatron
- Stop pair production O(100 pb):

$\tilde{t}\,\tilde{t} \rightarrow cc\chi\chi$ (impossible?) or $\tilde{t}\,\tilde{t} \rightarrow bbW^*W^*\,\chi\chi$ (easy?)

- Gluino pair production O(1 pb)

$gg \rightarrow \tilde{t}\,\tilde{t}\,tt \rightarrow bbWWcc\chi\chi$ or $bbbb\ WW\ W^*W^*\chi\chi$ or $bbbcWWW^*\chi\chi$

- Squark pair (rare): mostly gluino pair plus two jets
- Charginos and neutralinos not in any decay chain – only direct production possible (difficult).

Light stop: status and plans

- Generated 5000 events with HERWIG and ATLAS fast simulation.

Observation of SUSY production and reconstruction of mass edges to be studied.

- CMS fast simulation production to be started. A number of people from CMS interested to study this point.

- Parameter scan: select other points? Dependence on parameters?
- Observation of 4-body decay at Tevatron?
- Volunteers willing to study the ATLAS or CMS ntuples?
- …

tau polarization

The energy distribution of the π produced in the decays $\tau \rightarrow \nu\, \pi$ as well as those in $\tau \rightarrow \rho\, \nu$, $\tau \rightarrow a_1\, \nu$ depends on the handedness of the τ and can be used to determine τ polarisation. **General tool for physics at LHC.**

SUSY application: net helicity of τ produced in decay $\tilde{\tau} \rightarrow \chi^0\, \tau$ depends on mixing of $\tilde{\tau}_L$ and $\tilde{\tau}_R$ and on gaugino content of χ^0.

mSUGRA: $\chi^0_1 \sim$ B

- Small $\tan\beta$, $\cos\theta_\tau$ small $\rightarrow P_\tau \approx +1$
- Large $\tan\beta$, $\cos\theta_\tau$ large $\rightarrow$ but still $P_\tau > 0.9$.

AMSB: $\chi^0_1 \sim$ Wino $\rightarrow P_\tau \sim -1$

GMSB: if $\tilde{\tau}$ is NLSP, $\tilde{\tau} \rightarrow \tau$ G and $P_\tau = \sin^2\theta_\tau - \cos^2\theta_\tau$

- M. Guchait, D.P. Roy and R. Godbole, [arXiv:hep-ph/0411306].
- M. Guchait and D. P. Roy, Phys. Lett. B535(2002)243; B541(2002)356.
- S. Raychaudhuri and D. P. Roy, Phys. Rev. D52(1995)1556; D53(1996)4902; D. P. Roy, Phys. Lett. B459(1999)607.
- S. Kraml, T. Gadosijk, R.G., JHEP 0409, 051 (2004)

τ polarization: how to measure

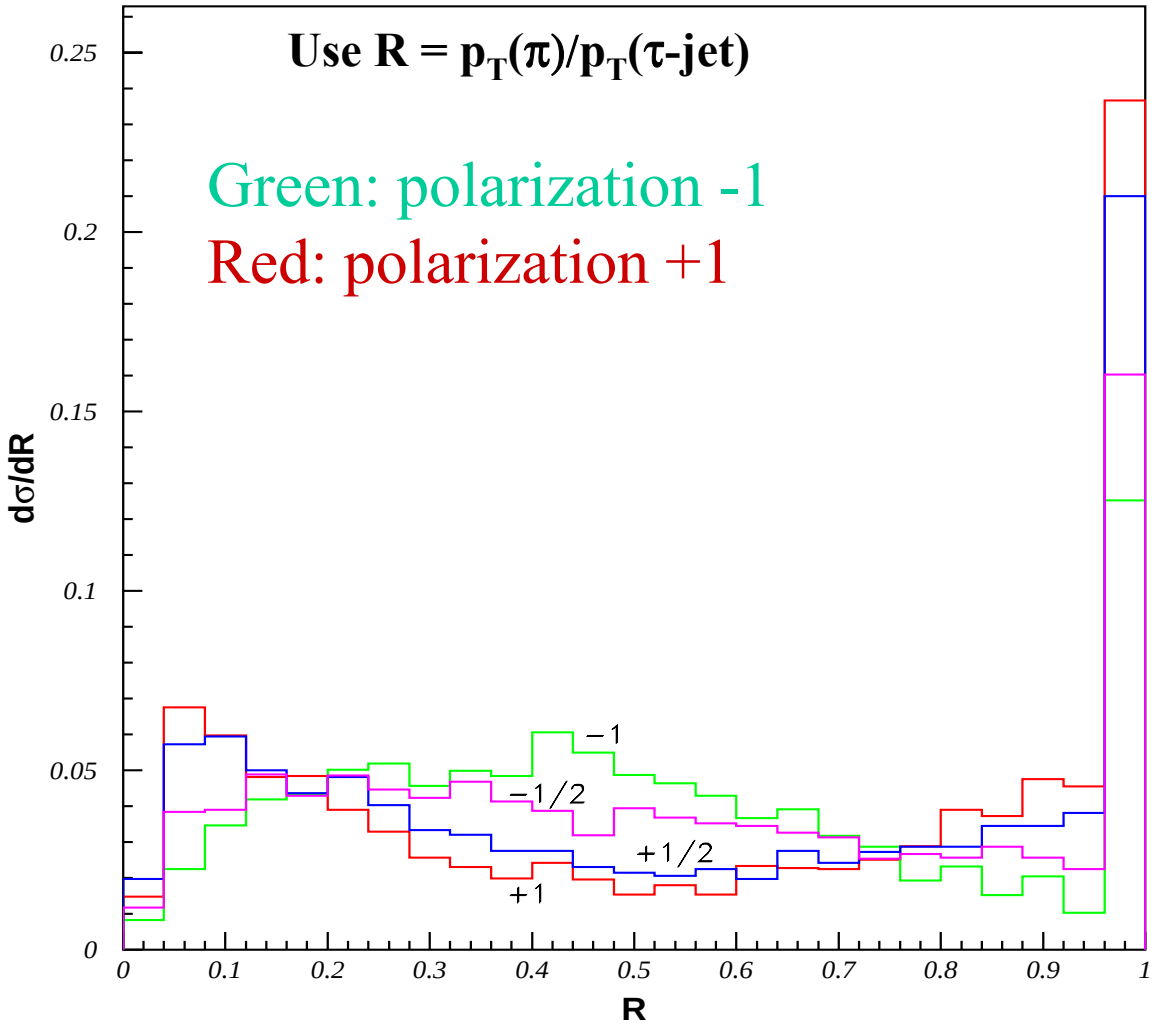
LHC CMS study 1:

see guchait.ps

LHC CMS study 2:

see next slides

LHC ATLAS study has started

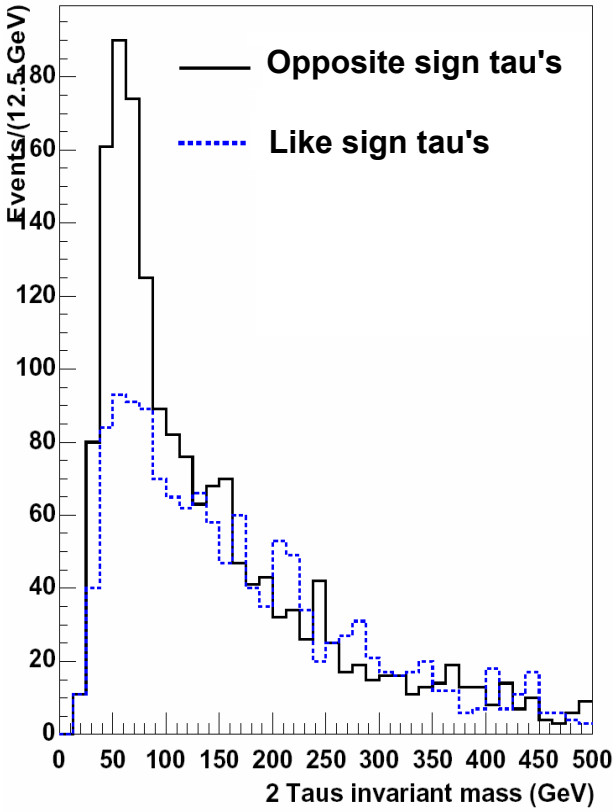


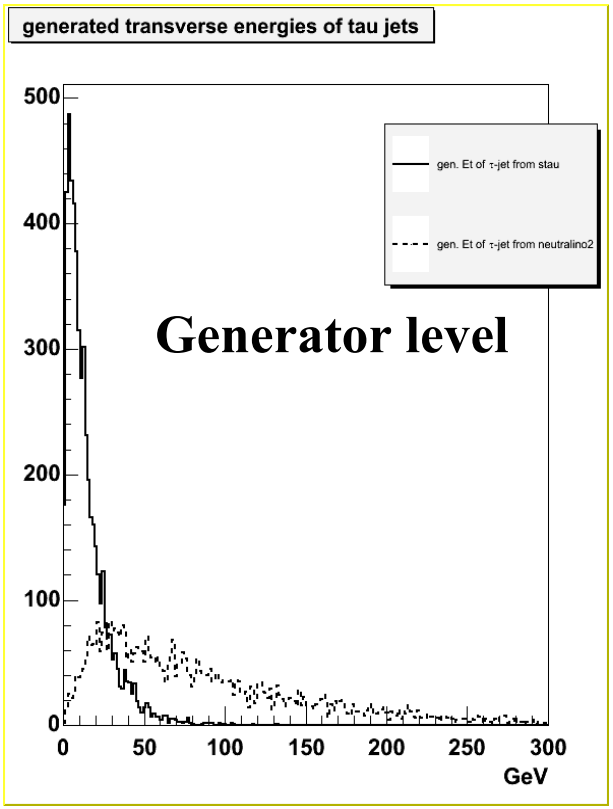
τ polarization at LHC

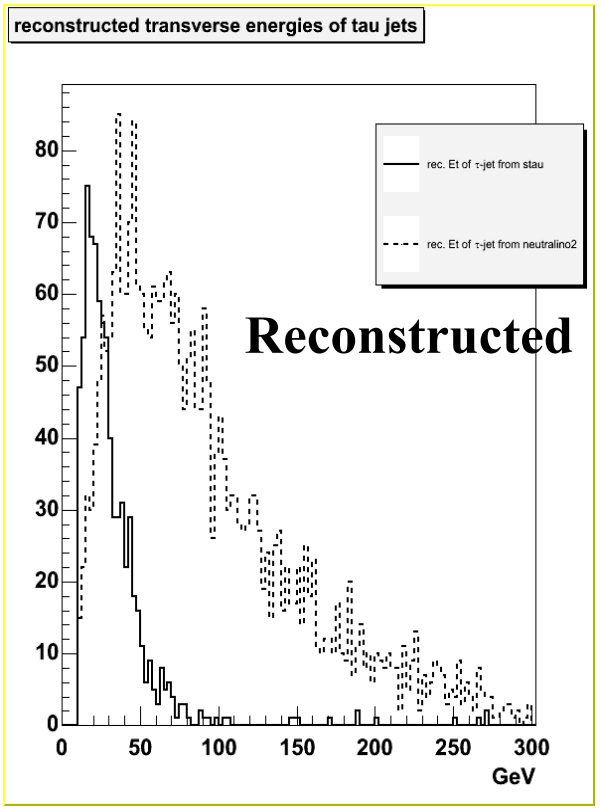
- **OS-SS distribution can be used to subtract background (2-tau invariant mass).**

$$\chi^0_2 \rightarrow \tilde{\tau}\,\tau \rightarrow \chi^0_1\,\tau\tau$$

- **The τ from the two decays istribution can be discriminated with their transverse momentum if the two mass differences are very different.**







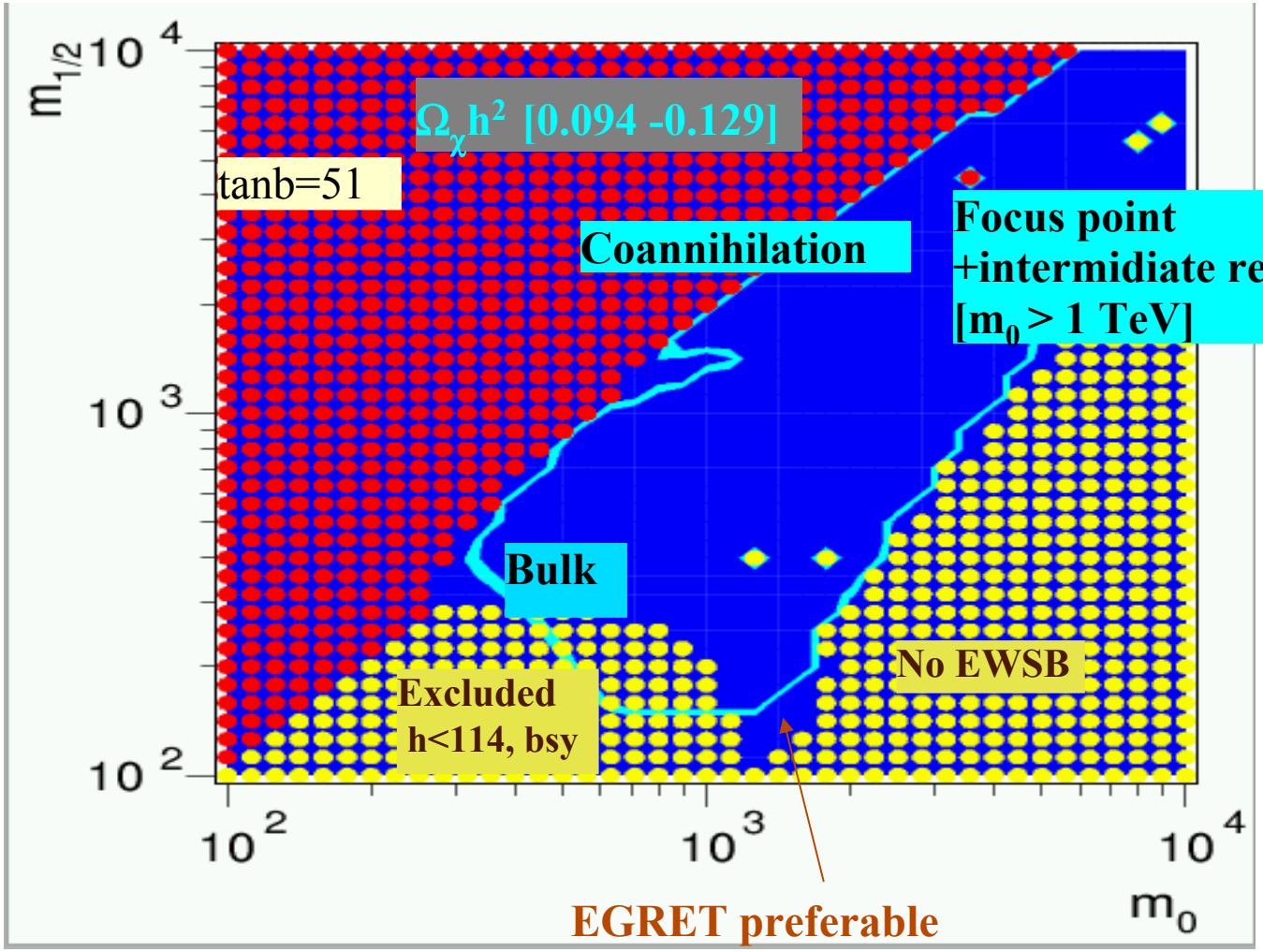
τ polarization: status and plans

- First studies on the measurement of the polarization of τ with the CMS detector have started. First results promising, more work is needed to assess how well can we measure the polarization in SUSY events and constrain the underlying model.
- This study has started also on the ATLAS side.

- Other (SM and BSM) physics which can be studied with τ polarization?

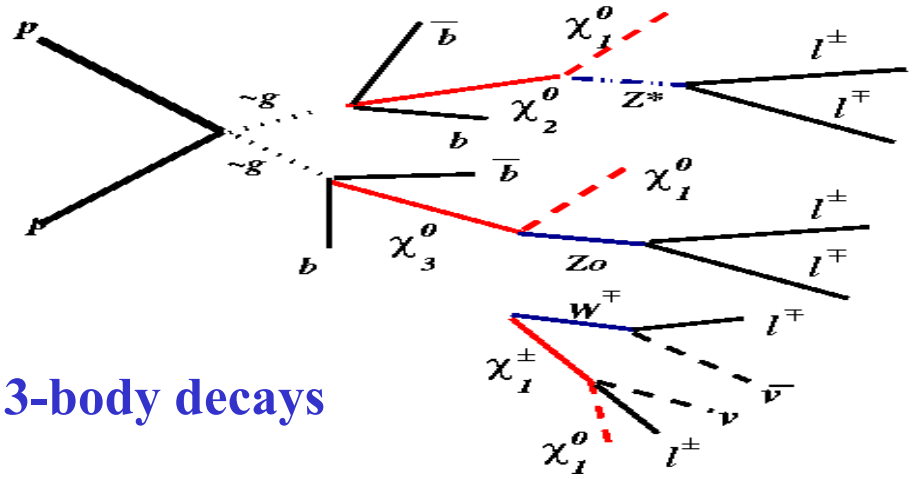
FP Studies: Motivation

-Relic density WMAP constraints in mSUGRA
-light neutralino are preferable for indirect and large m0 by direct DM search (complimentarity)

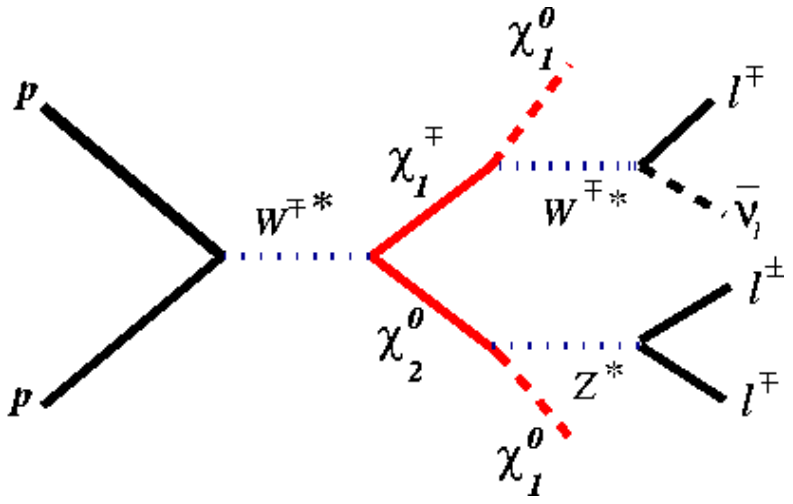


FP studies: bulk vs focus-point

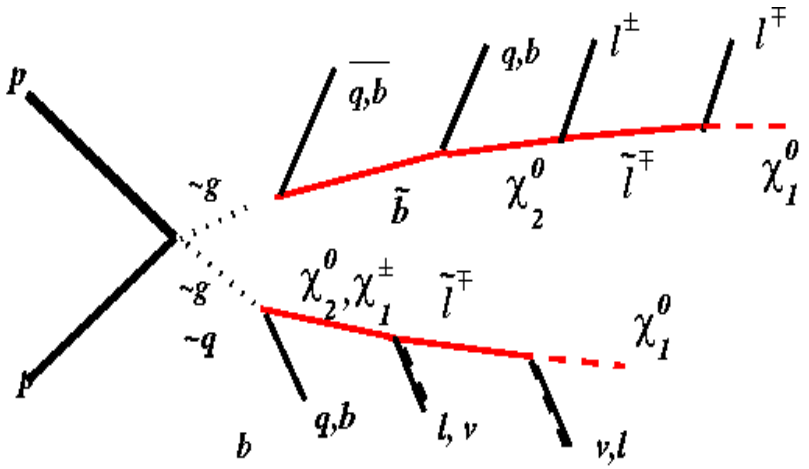
Focus point (gg production)



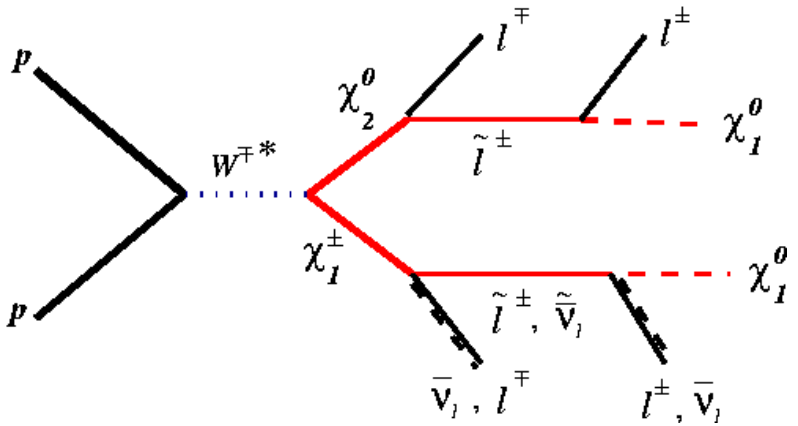
Focus point (χχ production)



Bulk region (qq or gg production)



Bulk region (χχ production)



FP studies: general idea

FP regions:

scalars are heavy

$\chi_1^{\pm}\chi_2^{o}\chi_1^{o}$ are light

only gluino and gaugino production)

3-body decays

Bulk and coannihilation regions

scalars are light (abundant squark production and sleptons in decays)

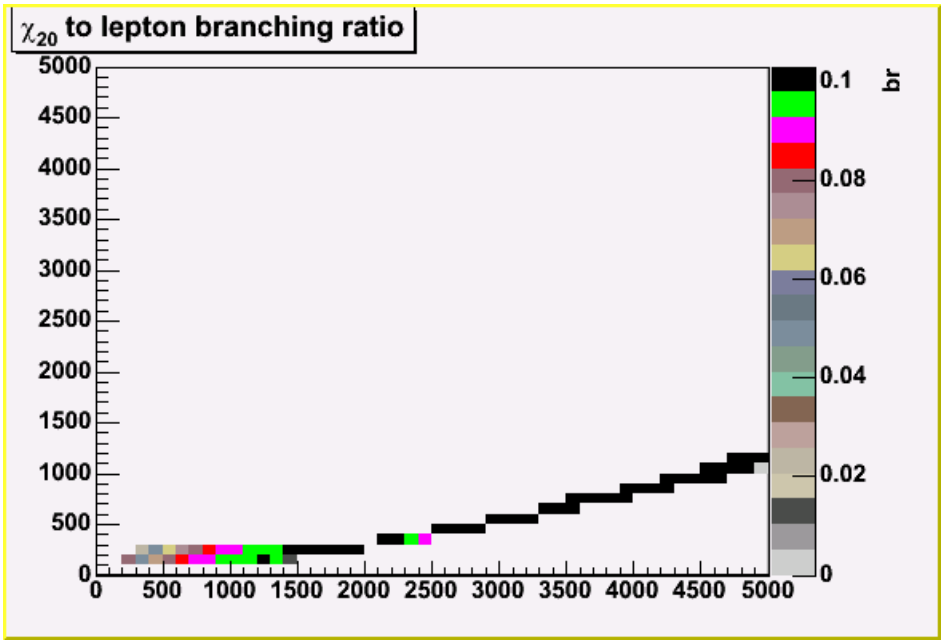
2-body decays

Goal

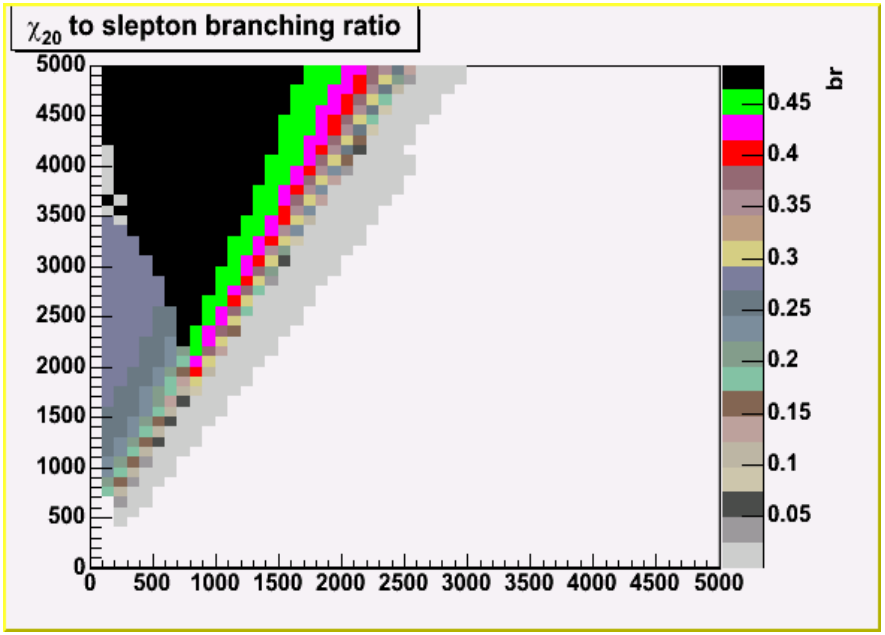
Identify focus/bulk regions by topology - without assumptions on the mass spectrum of a specific point)

FP studies: 2 and 3-body decays

Neutralino decays



Branching χ_2->2l+χ_1

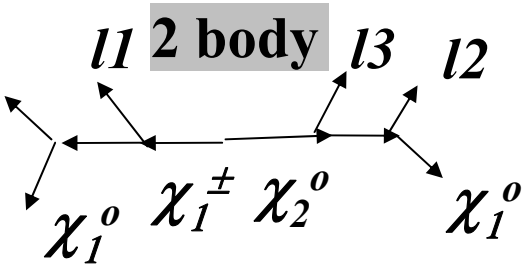


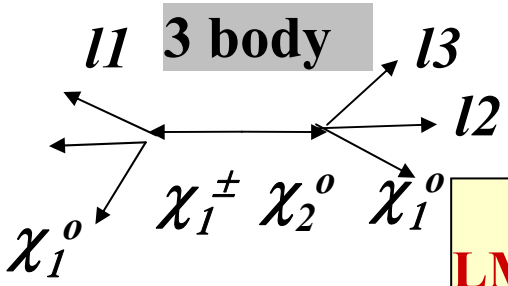
Branching χ_2 ->$\tilde{l}$ l->2l+χ_1

Parton level study of pure leptonic mode

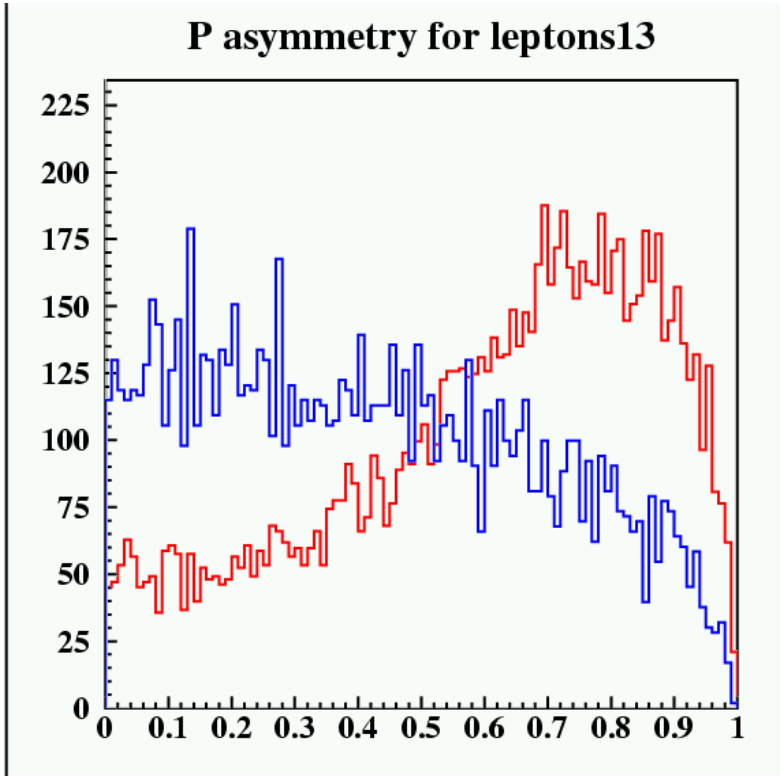
Assymetry of the pt in the tagged dilepton pairs

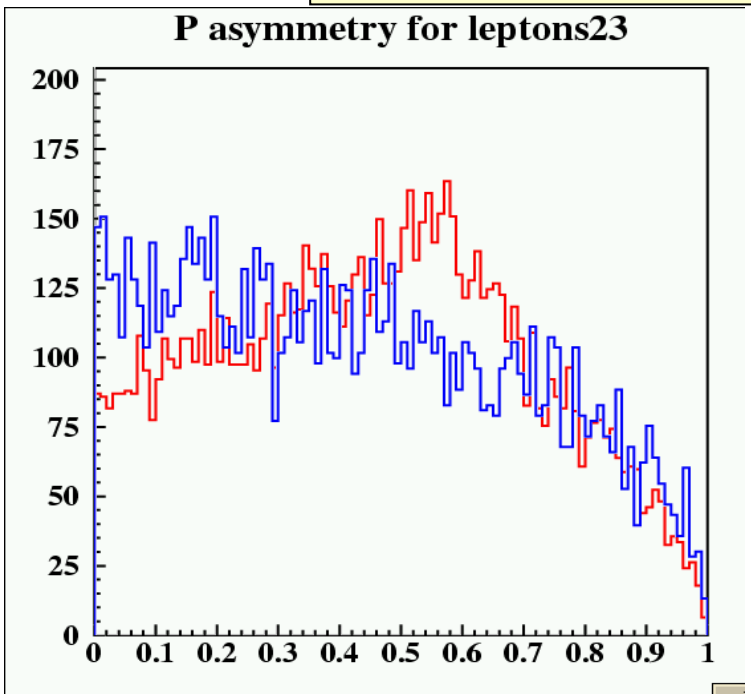
$$\frac{pt1-pt2}{pt1+pt2}$$





	m1/2	mo	tanβ
LM1	60	250	10
LM7	230	3000	10



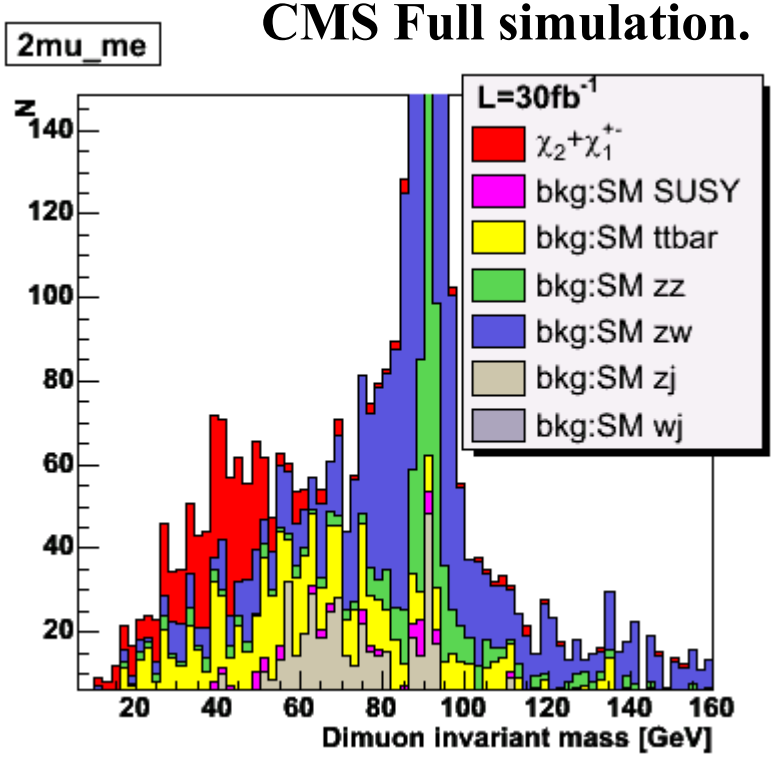


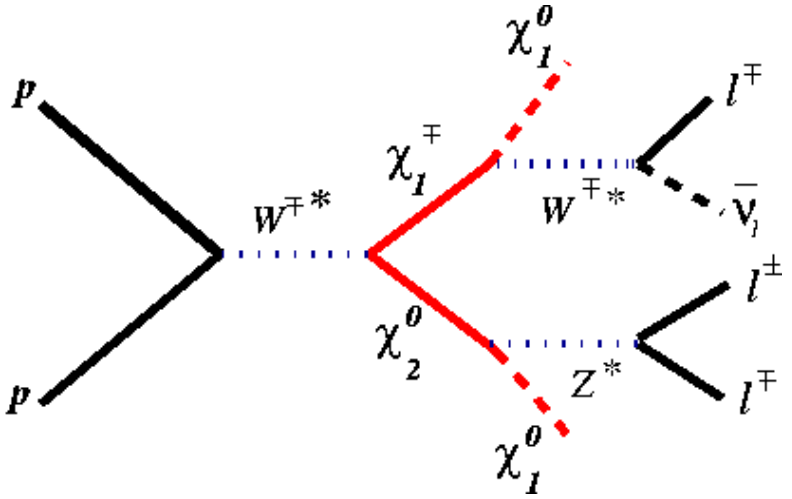
Focus Point: trileptons selections

- L1 Trigger
- 3 isolated leptons with 2 OSSF
  - *no tracks ΣPt < 1.5 GeV/c R<0.3*
  - *Ecal+Hcal < 5 GeV R<0.3*
  - μ: Pt > 10 GeV/c η<2.4
  - e : Pt > 15 Gev/c η<2.4
- No Jets ET>20GeV η<2.5

	m1/2	mo	tanβ	σ_{tot}^{LO},pb	$\sigma_{\chi 1^{\pm}\chi_2 -> 3l}$ fb
LM9	175	1450	50	25	95

CMS Full simulation.





Direct production of gaugino pairs observable if mass not too high

FP: status and plans

Large m_0 region (msugra m_o>1000, $m_{1/2}$<500) compatible with the WMAP relic density constraints will be accessible at LHC via neutralino and gluino production.

The χ^o_n , $\chi^{\pm}_n$ have 3 body decays only in this region and can be selected by assymetry and MET (sumET) cuts.

Gluino also has 3 body decays only in this region.

Plans

Optimize model-independent topologycal selections to discriminate different regions of parameter space (and SUSY from SM).

Reconstruction of mass spectra in the FP .

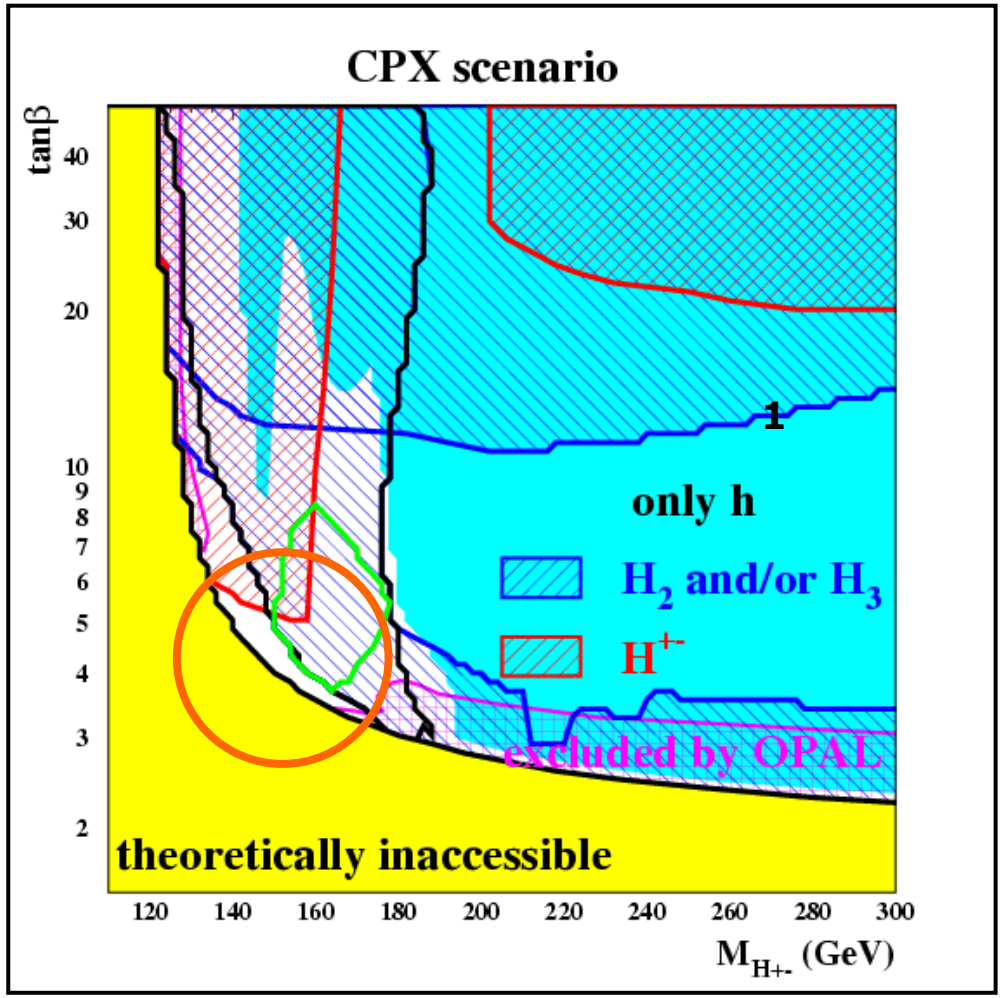
Understand NLO SUSY cross sections.

Volunteers?

CPX-Scenario: Overall Discovery Potential with 300 fb^{-1}

ATLAS preliminary at

SUSY04 hep-ph/0410112



small uncovered area

M_{H1}: < 70 GeV
M_{H2}: 105 to 120 GeV
M_{H3}: 140 to 180 GeV

small masses below 70 GeV not yet studied in ATLAS

channels at the border:

ttH_2, $H_2 \rightarrow bb$

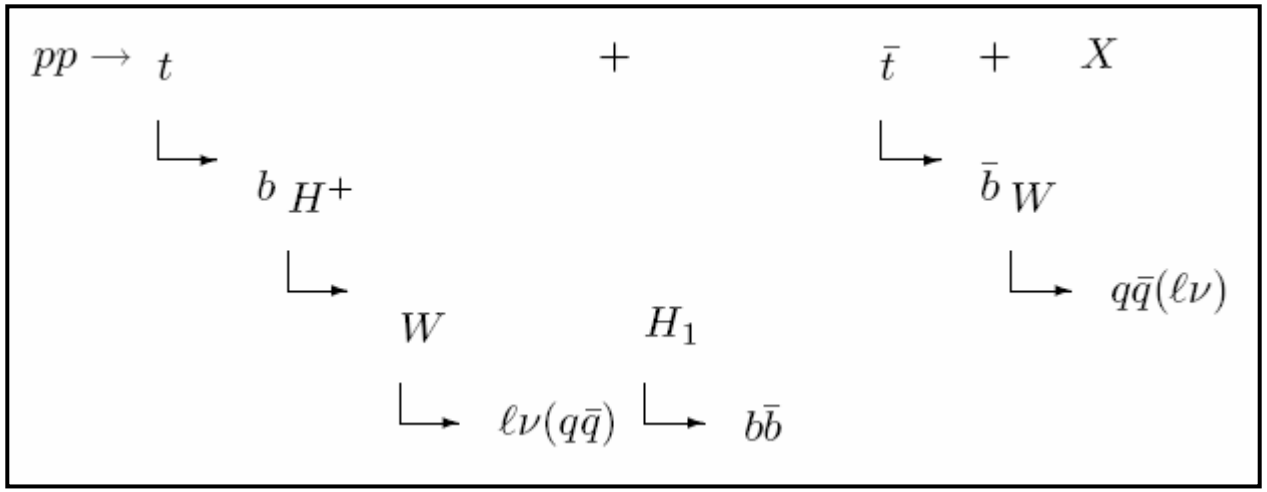
VBF, $H_2 \rightarrow \tau\tau$

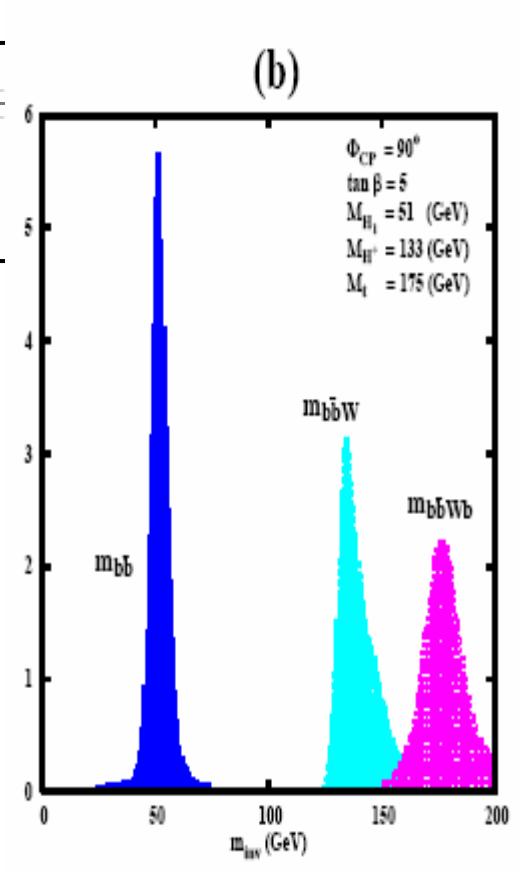
$tt \rightarrow Wb\ H^{+-}b$, $H^{+-} \rightarrow \tau\nu$

Maybe close hole via: $tt \rightarrow bW\, bH^{+-}$, $H^{+-} \rightarrow H_1 W$, $H_1 \rightarrow bb$

Probing the CP-violating light neutral Higgs in the charged H decay at the LHC

Dilip Kumar Ghosh[a], R.M. Godbole[b] and D.P. Roy[c,d]





First very preliminary look with ATLFAST

W decays considered: 1st W→qq + 2nd W→μν

Background considered: ttbb (generated with ACERMC)

σ = 3.9 pb for Q_{QCD}=shat

(σ = 8.1 pb for Q_{QCD}=(M_{top}+60GeV))

Signal:

	M_{H+-} (GeV)	M_{H1} (GeV)	$tan\beta$	Xsec (fb)
(1)	140	50	3.9	1302
(2)	160	40	2.8	525
(3)	130	30	4.3	1787

Signal Xsec includes all branching ratios

Signal generated with PYTHIA

Primitive Selection

- >= 1 muon with pt > 20 GeV

  >= 4 b-tagged jets with pt>20 GeV (ideal b-tagging used)

  >= 2 non-b-tagged jets with pt>20GeV

- reconstruct neutrinos P_Z from M_W constraint (>0 solutions)
- make list of light jet pairs with $|M_{JJ}-M_W|<25$ GeV

- reconstruction of top quarks:

  find combination for t1 = b lν + t2 = b bb qq

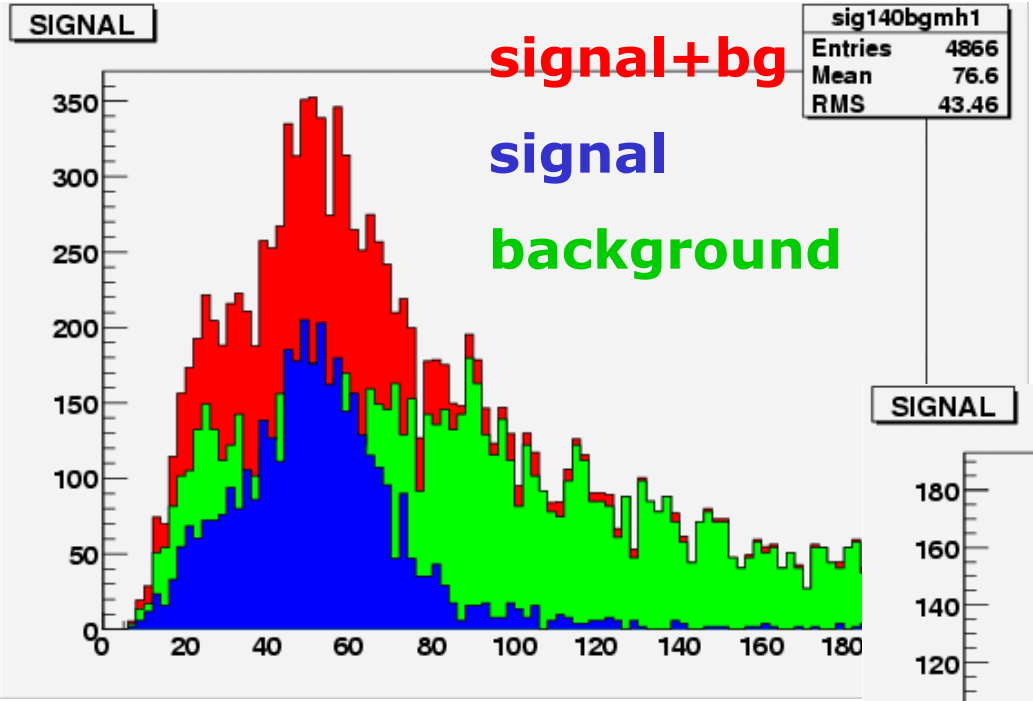
  or t1 = b qq + t2 = b bb lν

  which minimises $\Delta=(m_t-m_{t1})^2 + (m_t-m_{t2})^2$

- require: $(m_t-m_{t1}) < 25$ GeV and $(m_t-m_{t2}) <25$GeV

Reconstructed H1 Mass: 3 entries per evt.

before cut on mtop

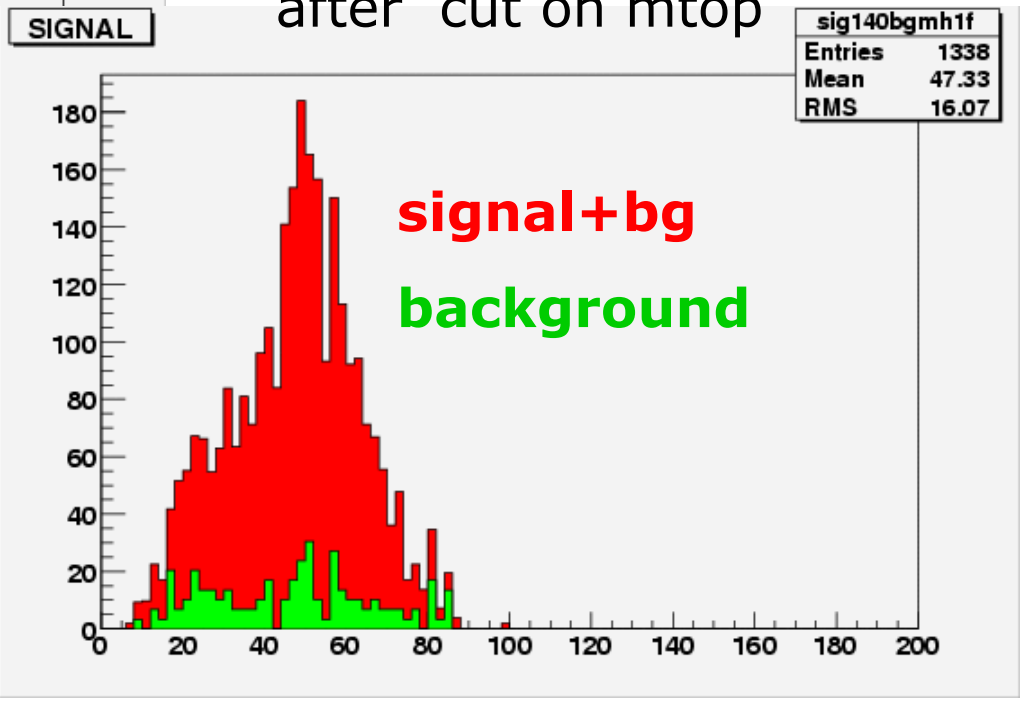


MH1 = 50 GeV

MH+- = 140 GeV

L = 30 fb^{-1}

after cut on mtop

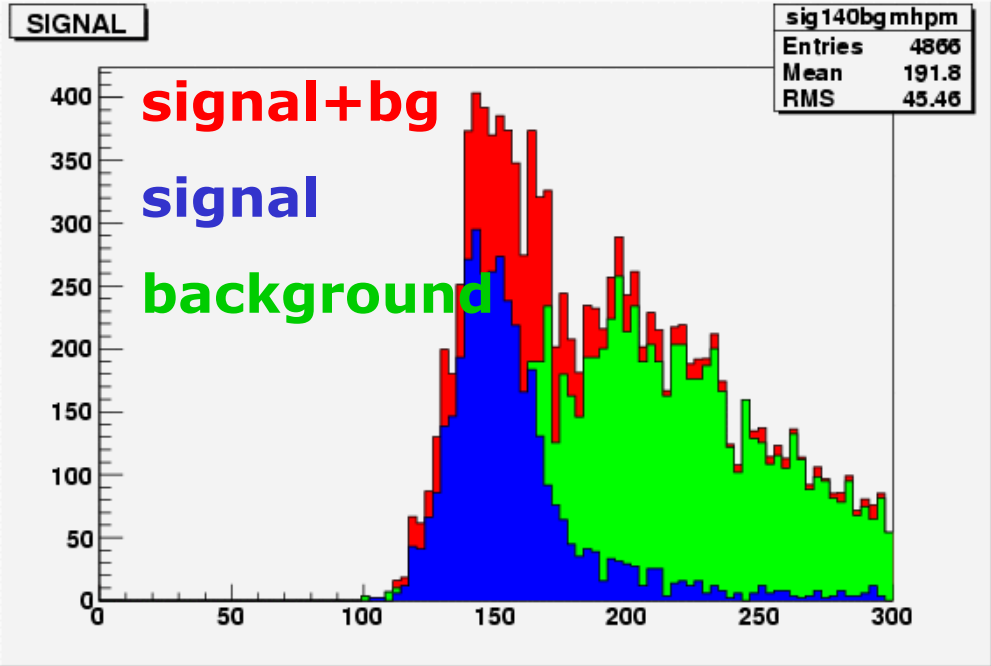


Eff(signal) = 2.0%

Eff(ttbb BG) = 0.2%

Reconstructed H+- Mass: 3 entries per evt.

Before cut on mtop



MH1 = 50 GeV

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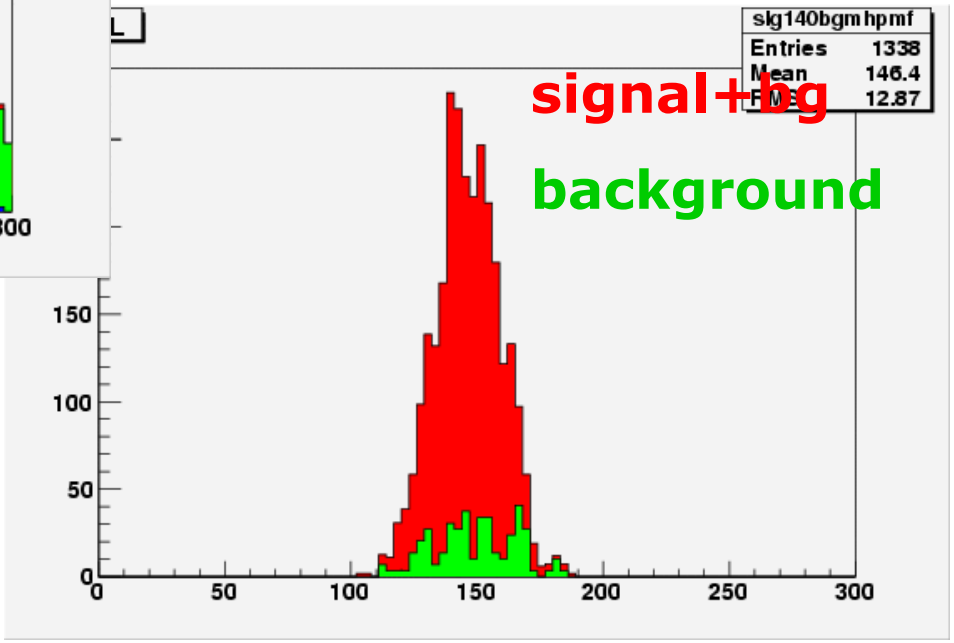
after cut on mtop



CPX Higgs: status and plans

- Analysis appears promising.

- Realistic b-tagging, add electrons, optimize cuts, other backgrounds…
- Can we cover the whole hole in discovery reach?