Tau Leptons in Supersymmetric Events in ATLAS

Jörg Mechnich
Nikhef Amsterdam

“General” SUSY Phenomenology

- R-Parity conservation
  →SUSY particles are created in pairs, decay to exactly one SUSY particle (+ SM particles)
  →lightest particle (which should be uncharged) exits detector
  →large MET
- Chains mostly start with heavy strong-interacting SUSY particles (sgluons,squarks) which produce quarks
  →hard jets
- Additional leptons from sleptons and gauginos

Searches in ATLAS

- Inclusive searches use cuts similar to the following (mainly for QCD suppression)
  - MET>100 GeV
  - 4 jets with more then (100,50,50,50) GeV
  - add 0-1 leptons, b-jets, taus
  - for multi-lepton searches, MET and jet constraints can/should/have to be loosened
  - Trigger follows similar patterns
  - In exclusive searches one could come up with better ideas

SUSY in ATLAS

- At ATLAS, the majority of analyses concentrated on mSUGRA
- Few benchmark points have been chosen in order to handle enormous parameter space
- More recently, large "grid scans" of the parameter space are possible with MC samples available
- Other breaking mechanisms like GMSB are gaining more attention

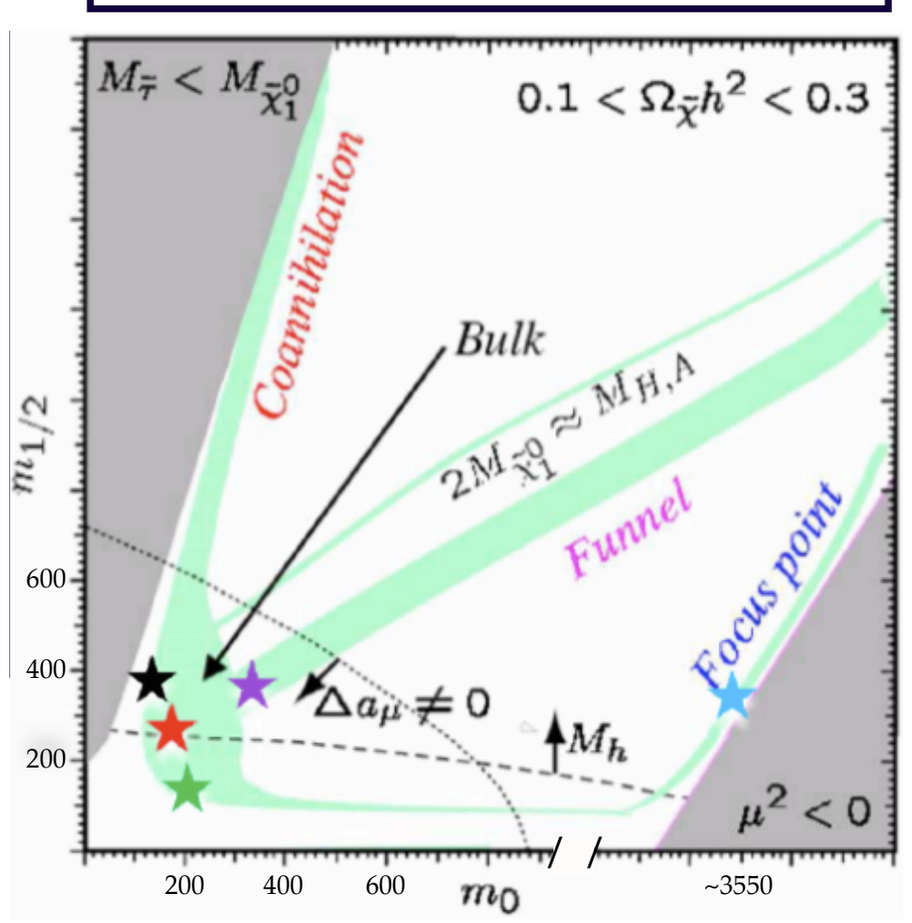
★ **SU1:** ($m_{\tilde{g}}$, $m_{\tilde{q}}$)~(830, 760) GeV; tanβ=10
coannihilation region (LSP~slepton)

★ **SU2:** ($m_{\tilde{g}}$, $m_{\tilde{q}}$)~(860, 3560) GeV; tanβ=10
Focus point (LSP~$\tilde{H}$: $\chi^0_1\chi^0_1$ -> WW)

★ **SU3:** ($m_{\tilde{g}}$, $m_{\tilde{q}}$)~(720, 620) GeV; tanβ=6
Bulk region (exchange light sleptons)

★ **SU4:** ($m_{\tilde{g}}$, $m_{\tilde{q}}$)~(420, 420) GeV; tanβ=10
Bulk region close to Tevatron limits

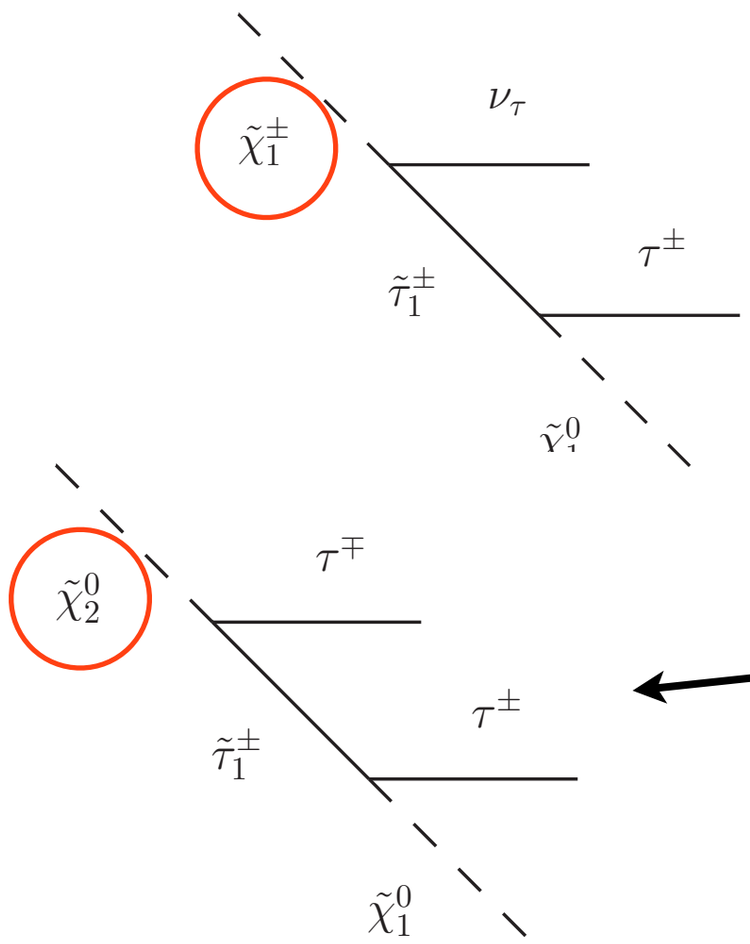
★ **SU6:** ($m_{\tilde{g}}$, $m_{\tilde{q}}$)~(890, 870) GeV; tanβ=50
Funnel region ($2m_{LSP}$~m_A)

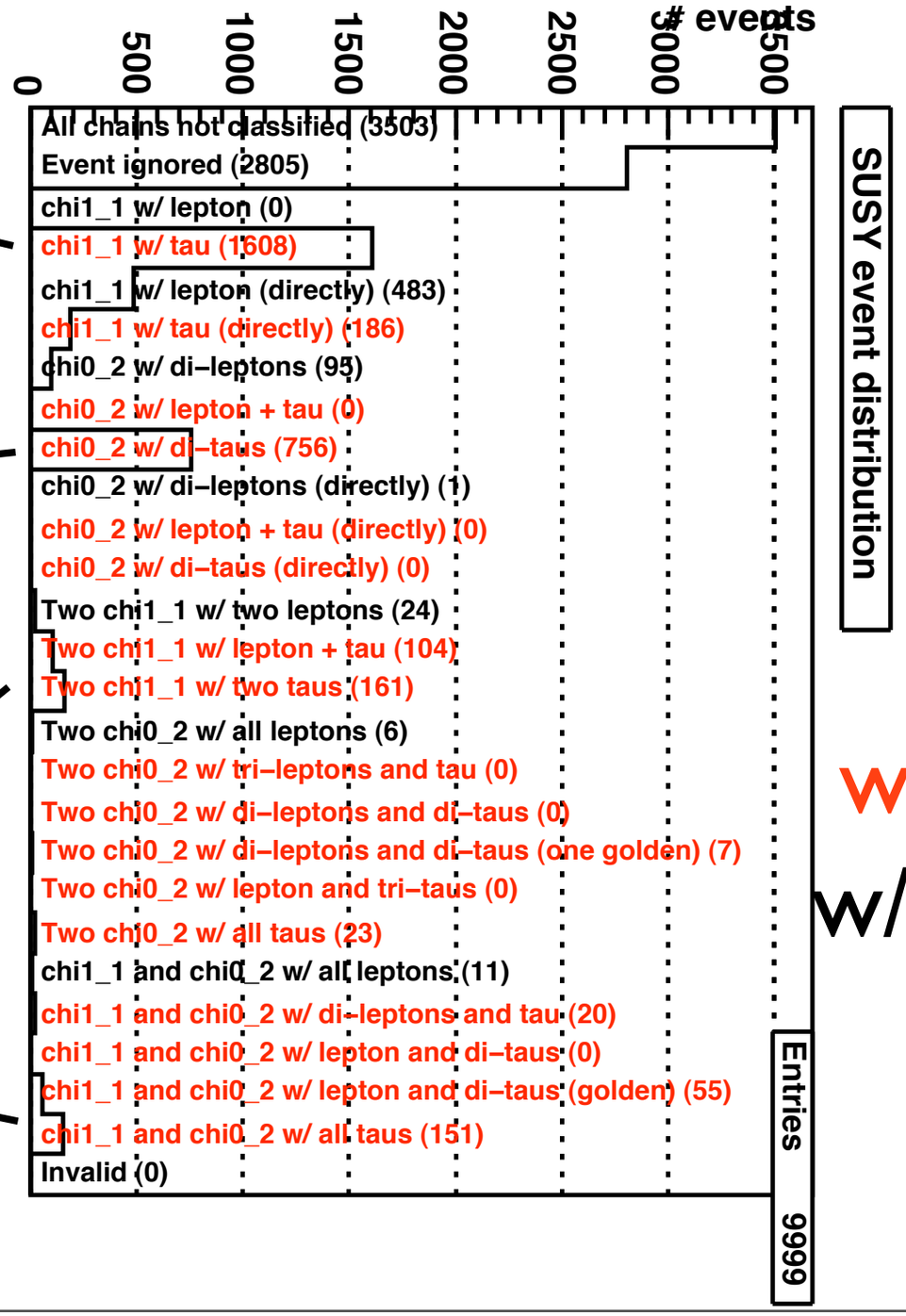


Taus and SUSY

- Taus can play a big role in SUSY (seems to prefer 3rd generation)
- Usual SUSY event selection cuts/trigger based on jets and MET
- Does not necessarily hold for all regions of SUSY space
- Try to be as general as possible by using constraints on event introduced by taus
- Look at trigger combinations containing hadronic tau/ lepton triggers with looser MET/jet triggers

Example for Taus in SUSY: SU3





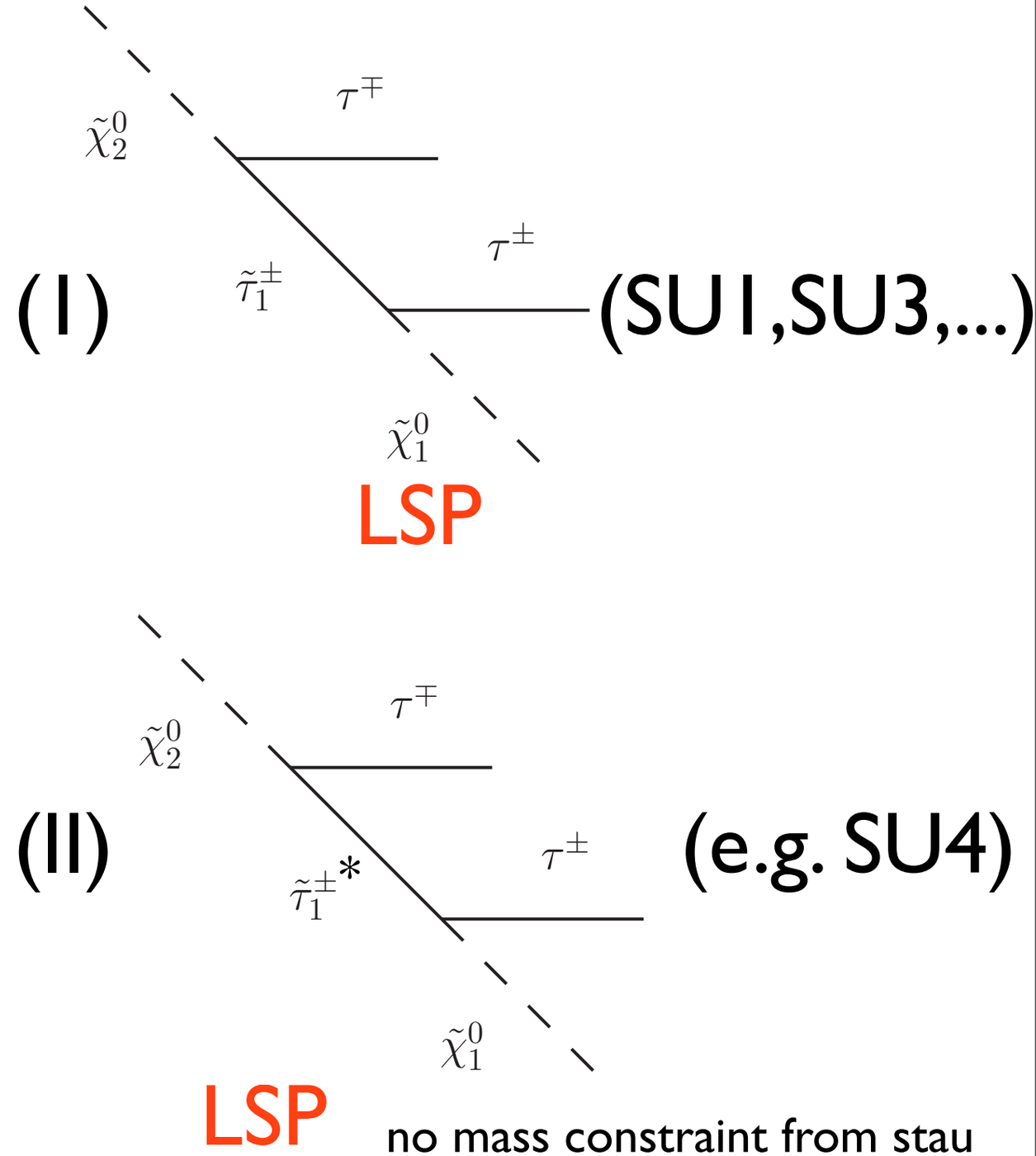
Combinations of upper diagrams

w/ taus

w/o taus

Di-Lepton Mass Edges

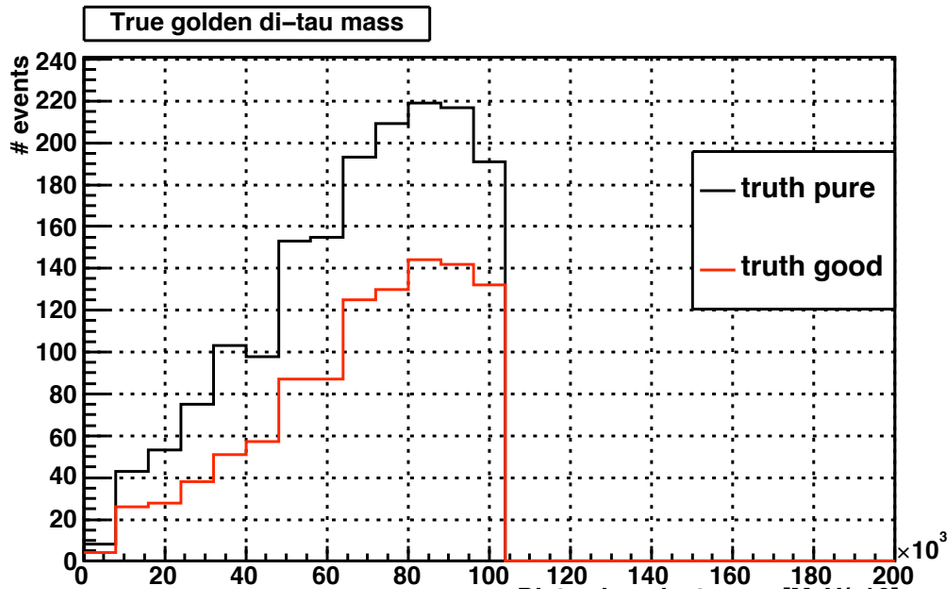
- Distinctive signature in neutralino decays (OSSF)
- Relevant for slepton mass measurement (see next slide)
- If 2nd neutralino is very light (lighter than the sleptons), 3-body decay to 2 leptons + LSP opens
- Leptons from this kind of decay will be called "golden" in the following



Di-Lepton Mass Edges II

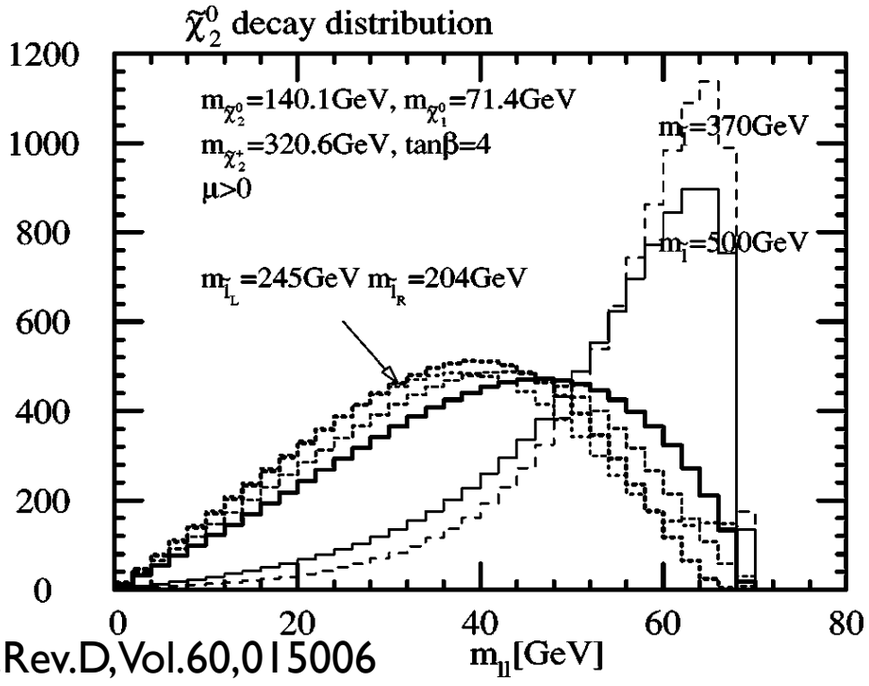
- Decay type (I) yields triangular shape of di-lepton invariant mass for all sleptons lighter than the 2nd neutralino

(I)



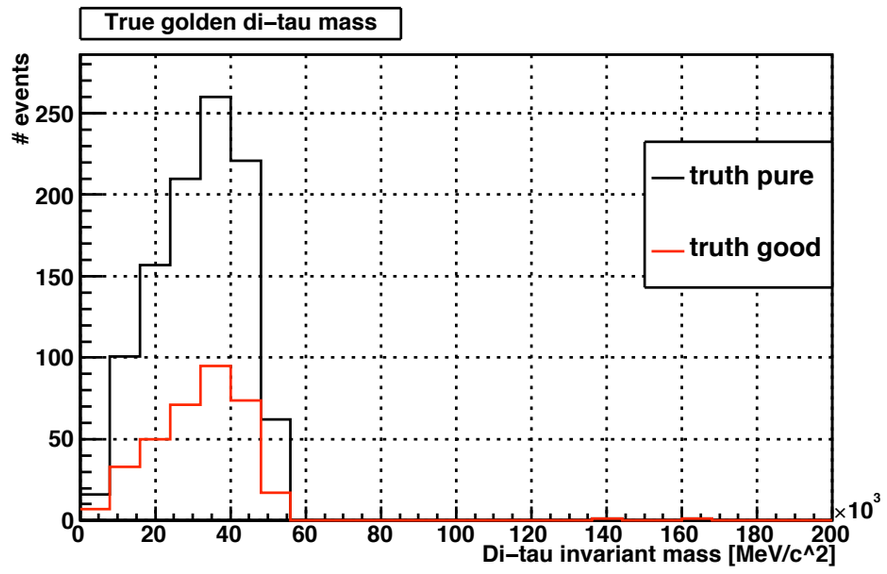
$$m_{\tau\tau}^{max} = \sqrt{\frac{(m(\tilde{\chi}_2^0)^2 - m(\tilde{\tau}_1)^2)(m(\tilde{\tau}_1)^2 - m(\tilde{\chi}_1^0)^2)}{(m(\tilde{\tau}_1)^2)}}$$

- Non-triangular shape for decay type (II)



Phys.Rev.D,Vol.60,015006

(II)



$$m_{\tau\tau}^{max} = m(\tilde{\chi}_2^0)^2 - m(\tilde{\chi}_1^0)^2$$

Di-Tau Mass Edge

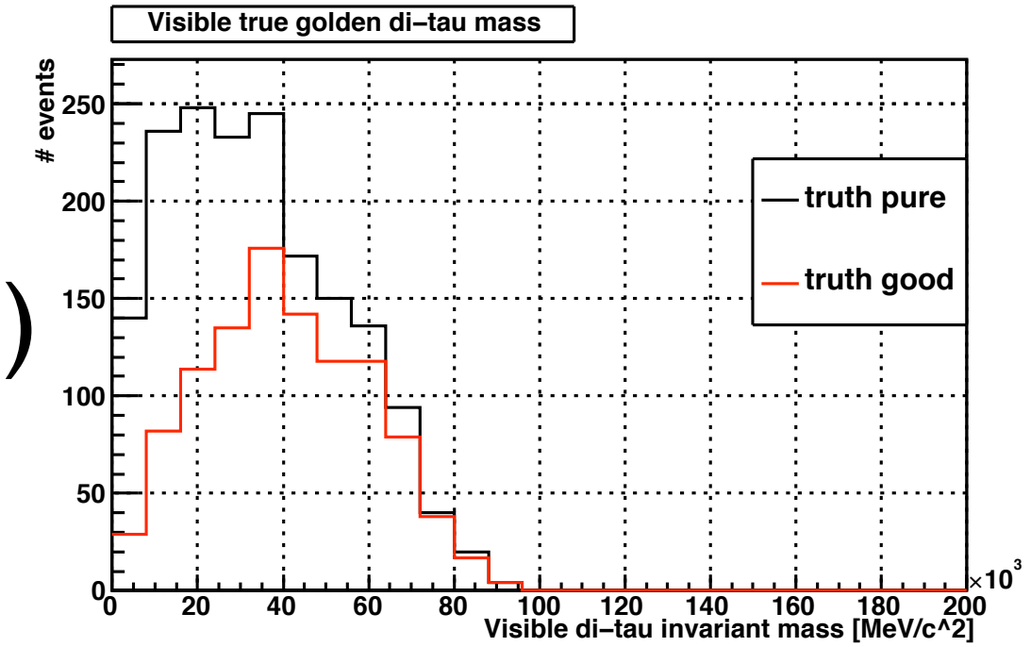
- For taus the edge is smeared due to its decay with neutrino(s)

- Plots on the right show all tau decays (FH,SL,FL)

- Existing analysis concentrates on fully hadronic golden tau decays

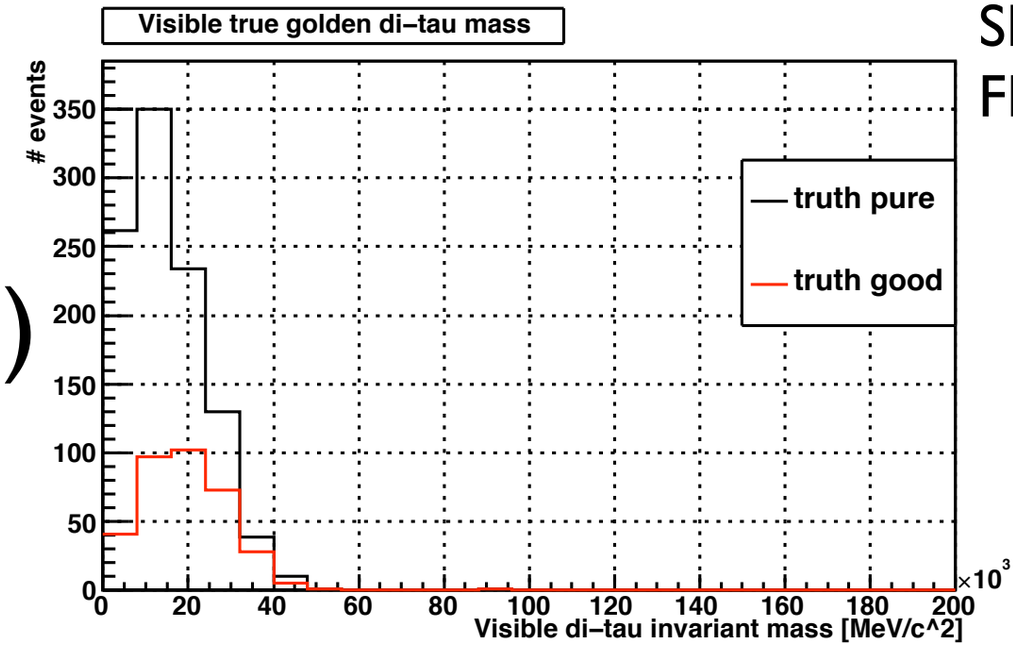
- Should also try using events where taus are going to leptons

(I)



FH: 42.25%
SL: 45.50%
FL: 12.25%

(II)



A Closer Look Reveals...

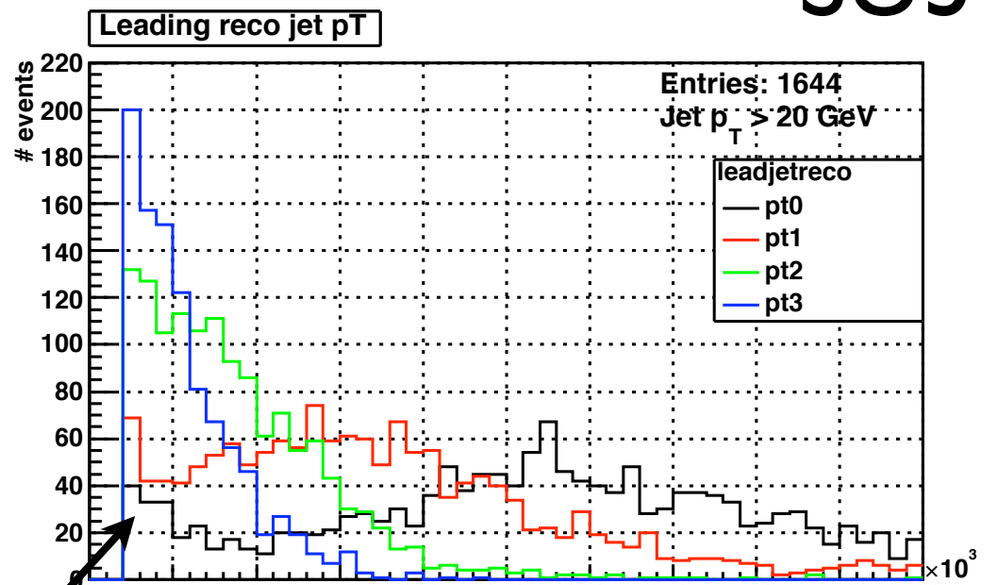
SU3

- Distributions of hardest jets in "golden" events show peak at low p_T

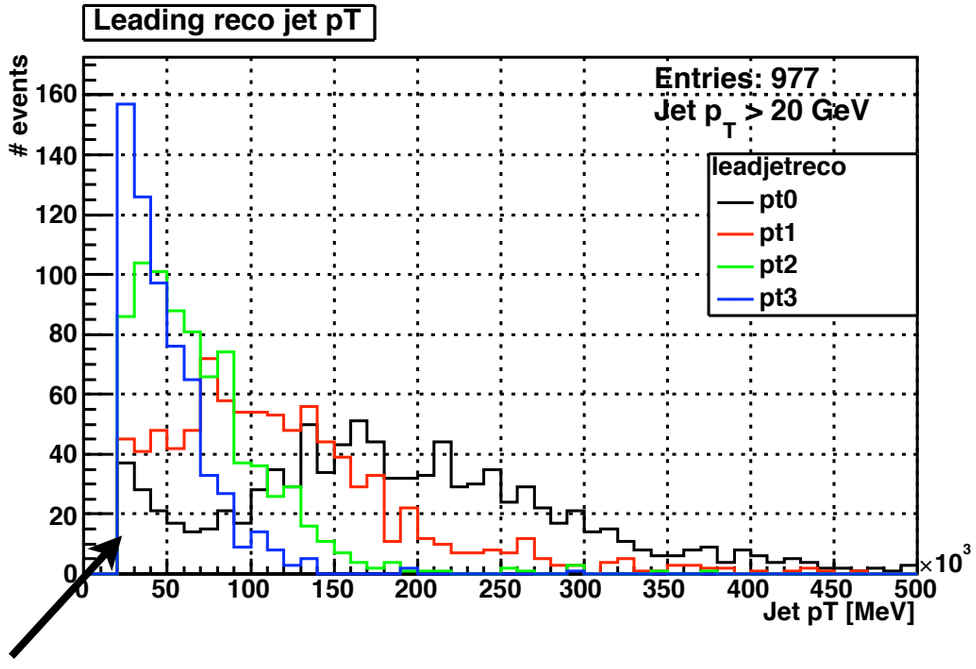
- Using cuts (or trigger) from earlier slide we lose those events

- Possible recovery ?

(I)



(II)

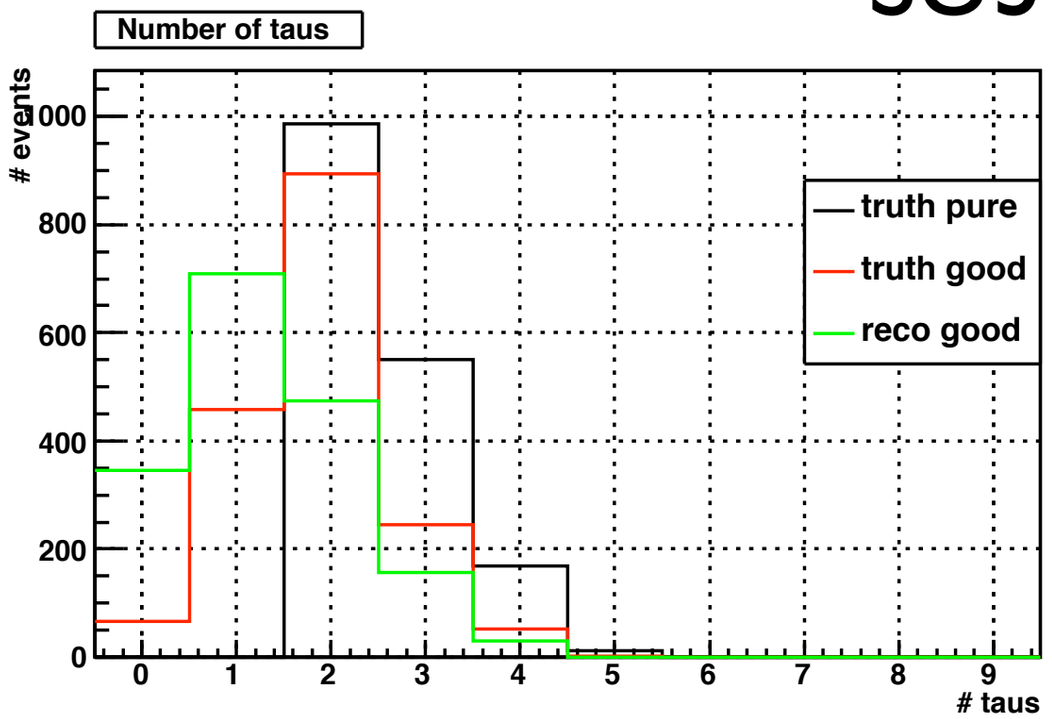


...and even more

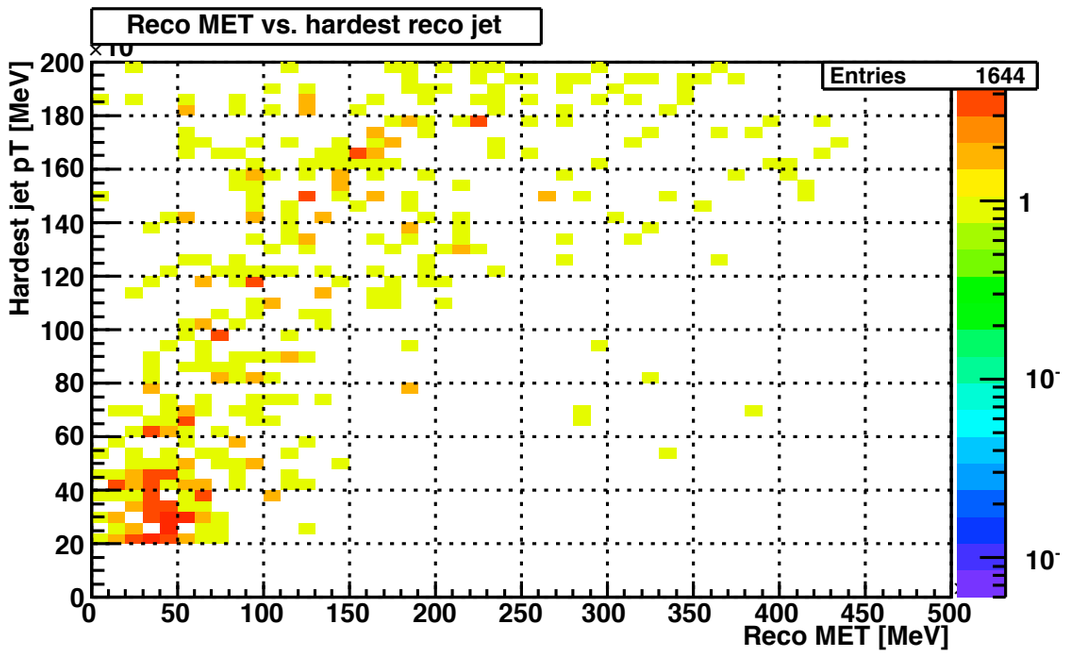
SU3

- Number of taus is often greater than 2 in "golden" events

- Green histogram is hadronically decaying taus only



- Plotting MET vs. hardest jet shows maximum at low transverse momenta



Summary and Outlook

- Try to get away from cuts/triggers to strongly on assumptions of how SUSY "exactly" looks like
- Use special signature of taus to suppress backgrounds
- Specifically also examine various combinations with e/μ-based triggers/cuts
- Could use tag-and-probe method for di-tau signatures to increase efficiencies (especially with kinematic constraints)