CAT-SUSY progress report

- Technical issues
  - SUSYView, Datasets…
- Simple inclusive analysis
- Electron ID study
- Event variable study
- Di-Lepton analysis
- Conclusions

For the CAT SUSY group:
Amir Farbin, Stefan Ask, Christophe Clement, **Jamie Boyd**, Andreas Hoecker, Wouter Hulsbergen, Nicolas Berger, + students Siva Darbha, Benjamin Sanders + some non CERN effort (Martina Hurwitz, Till Eifert, Olya Igonkina, Richard Teuscher, Johannes Haller)

Amir, Jamie

SUSYView

- Athena code based on EventView
- Runs on AOD and produces an Athena Aware Ntuple
- Calculates various useful SUSY variables and dumps 4-vectors of 'inserted' particles, does truth , reco matching etc..
- Quite a lot of interest from outside CERN (~5 groups using this)
- Wiki:

https://twiki.cern.ch/twiki/bin/view/Atlas/SusyView

- Updated to use the new configurables
- Being ported to 12 series now
- We are providing the ntuples (via castor) to the SUSY WG as a service

Datasets

Have run over csc data (reco'd with 11.0.42 or greater)

Sample	Nevts	X-sec (pb)	Lumi
J1	148950	1.38e9	0.11 nb-1
J2	150000	9.33e7	1.61 nb-1
J3	140700	5.88e6	23.9 nb-1
J4	130000	3.08e5	422 nb-1
J5	119000	1.25e4	9.52 pb-1
J6	86750	3.60e2	241 pb-1
J7	86100	5.71e0	15.1 fb-1
J8	91750	2.40e-1	382 fb-1
Wenu	31700	1.12e4	2.83 pb-1
Zee	48350	1.32e3	36.6 pb-1
T1	143800	4.61e2	249 pb-1
SU2	56550	4.90e0	11.5 fb-1
SU3	125000	19.3	6.5 fb-1
SU8	39000	?	?

Want to run on T2 but cant find any csc data for this??

Amir, Jamie,Benjamin

Technical Stuff – getting data

- Subscribed to many datasets using dq2
  - Means the data is automatically copied to cern castor as it is produced
  - Nice book-keeping table from Benjamin Sanders keeps track of what is available there

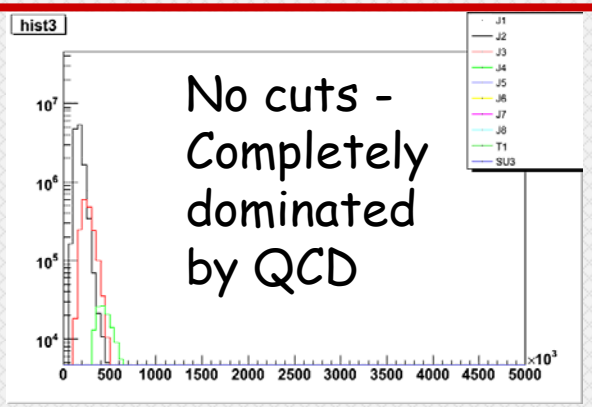
  https://twiki.cern.ch/twiki/bin/viewfile/Main/AtlasSusyCernLocal?rev=7;filename=AOD_tracker.pdf

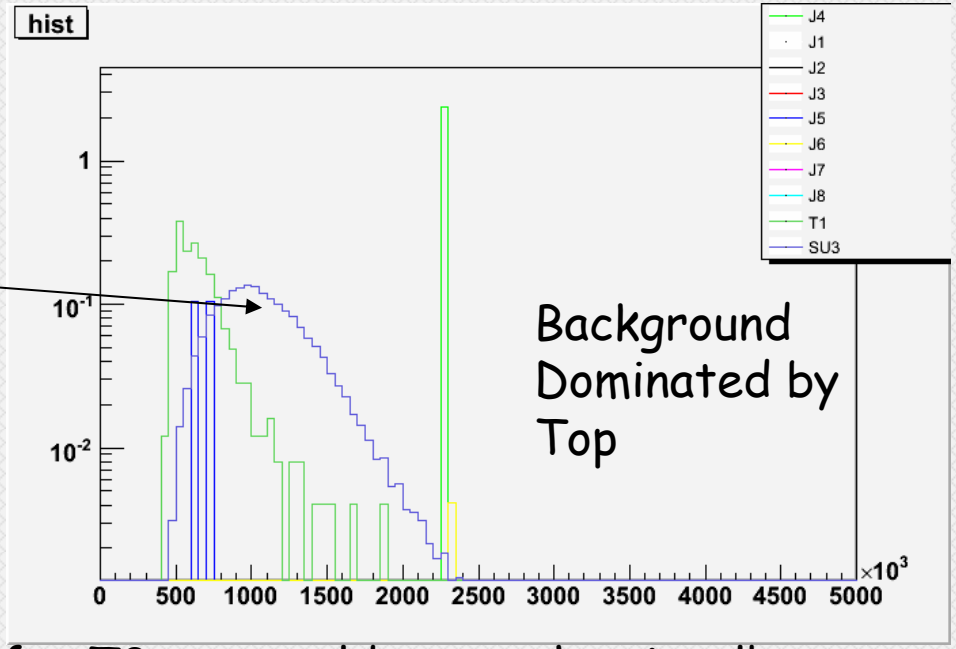
  could be useful for others too
- Running SUSYView on the cat queues (atlascatlong)
- Written some scripts to aid production
  - Copy AOD files from castor to batch worker
  - Write root file to batch worker
  - Copy root files to castor (disk pool) when job ends
- Allows large(ish) ntuple production in easy way (~5% jobs die – mostly due to castor problems)
- Problem using castor disk pool for analysis (we copy the ntuples to local disk for use with root)
- Others are welcome to use our scripts if they are useful

Siva, Benjamin

Simple inclusive analysis

- Plot of Meff = MissingEt+ scalar sum of Pt of hardest 4 jets
- 'Classic' Cuts
  - Met>100GeV,
  - Pt1,2>100GeV,
  - Pt3,4>50GeV,
  - Sph>0.8,
  - Met>0.2xMeff
- SU3 signal clear above QCD and top background
- Need to look at W+njets, Z+njets, top+njets





Last talk had the wrong normalisation for T2 – so couldnt see the signal!

Christophe, Jamie, Andreas

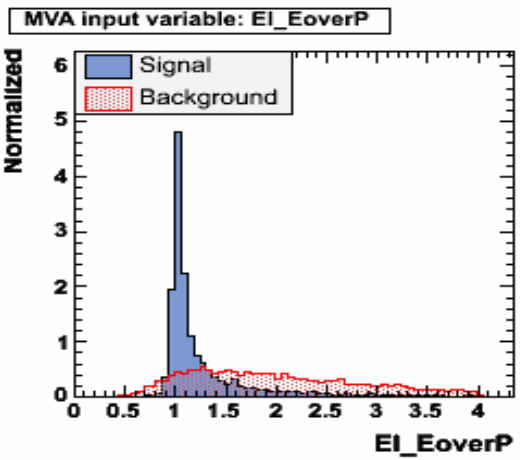
Electron Id study

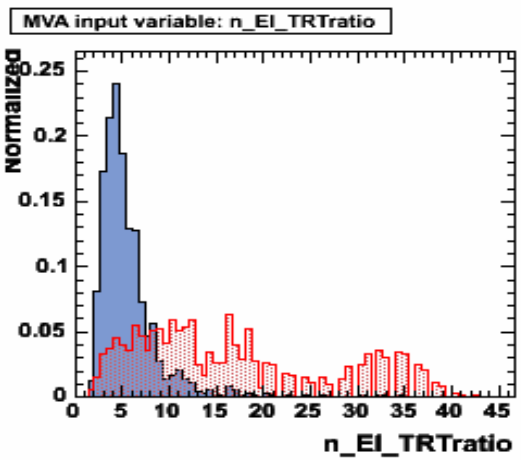
- Trying to develop an Electron selection with excellent jet rejection for use in inclusive jets + 1 lepton, and 2 lepton SUSY analyses
- Configured SUSYView to produce specific ntuple for this study – dump all possible useful El ID variables that are in the AOD (including associated tracks and clusters)
  - For signal start from truth El's in SU2,3,8 samples and if there is a matching (in DeltaR) reconstructed El, dump El ID variables
  - For background run on J1-J8 samples dump El ID variables of any reconstructed Electrons found in these samples (as there should be no true isolated electrons in these samples)
- Look at the variables in TMVA to choose which are the best and to come up with a discriminant
- This study also useful as
  - Check e-gamma (isEM) selection makes sense
  - Check that useful quantities are in the AOD
  - Validate the new CSC data (eg. Many Muon quantities bad)

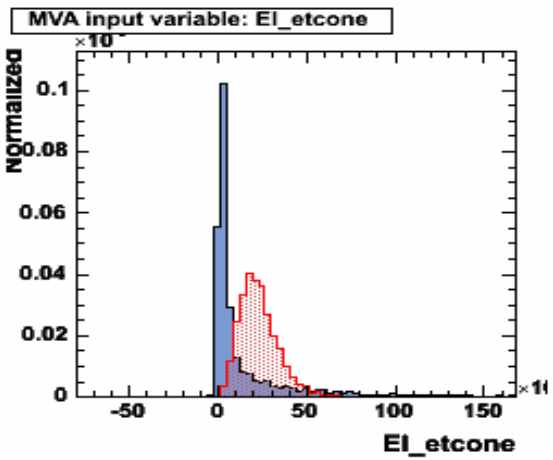
Electron ID study

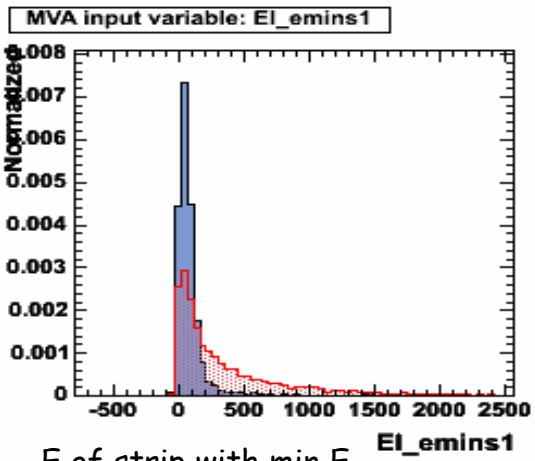
NTRTHit/NTRTHiThreshHit

Et in a DR=0.45 cone around shower (shower energy not included)

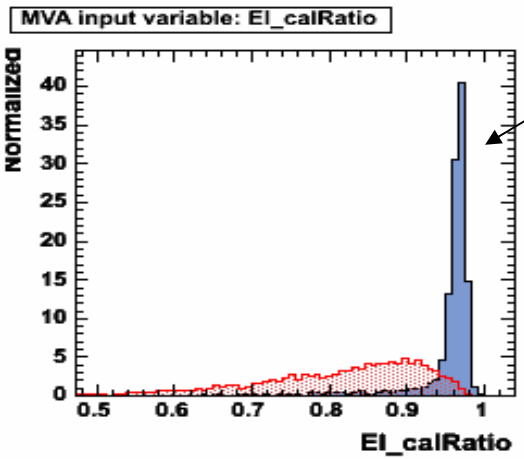








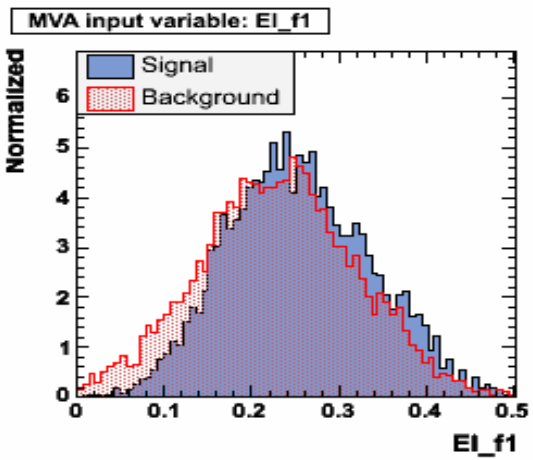
E of strip with min E



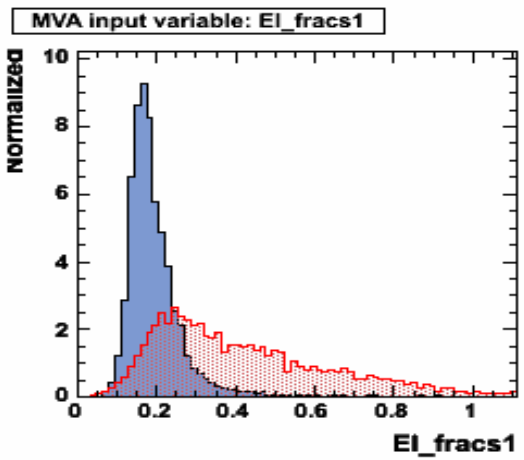
E in 2nd sampling in 3x7 region / in 7x7 region

Electron ID study

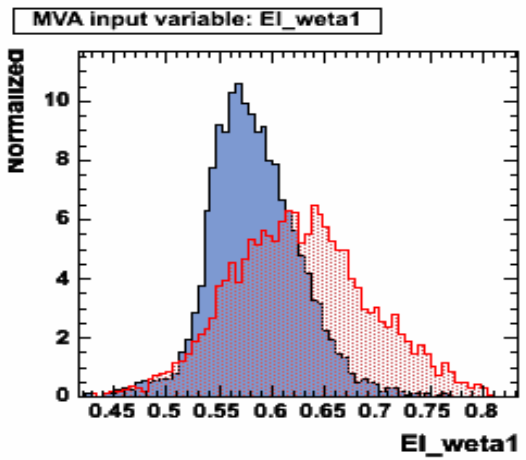
fraction of energy in the 1st sampling

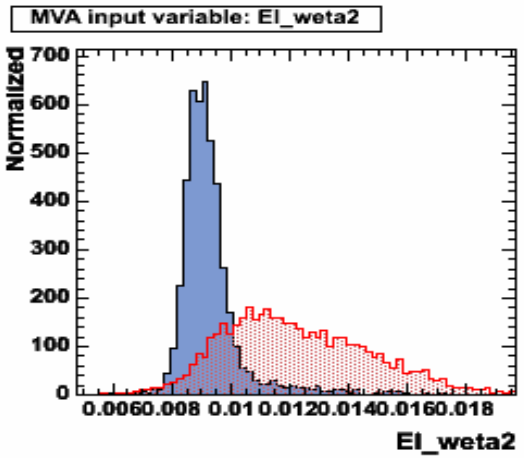


fraction of energy outside core in S1

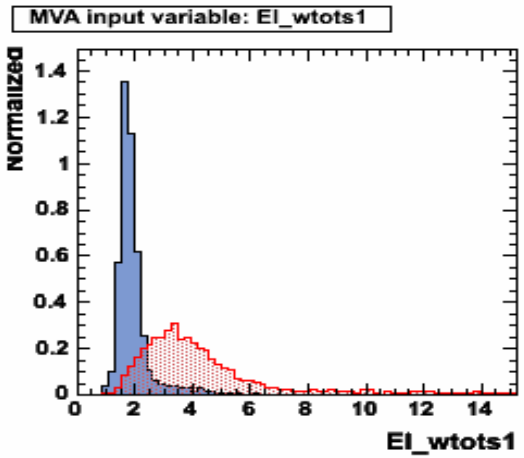


corrected lateral width with 3 strips

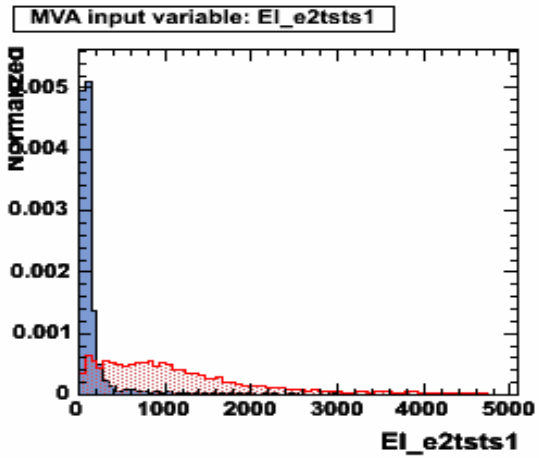




corrected lateral width in sample 2

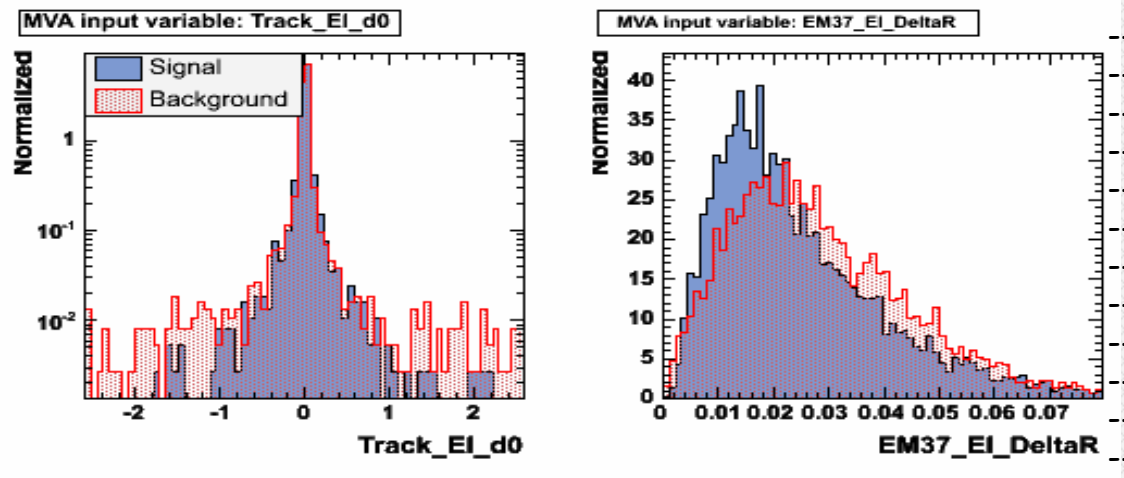


Total width in 20 strips



energy in group of 3 adjacent strips
(3 strip cluster must be the 2nd most energetic one

Electron ID Study




```
------------------------------------------------------------
--- Rank : Variable       : Sum of weights-squared
------------------------------------------------------------
----   1 : El_calRatio    : 2.812e+01
---    2 : El_weta2       : 9.113e+00
---    3 : El_weta1       : 8.956e+00
---    4 : Track_El_d0    : 4.193e+00
---    5 : El_EoverP      : 3.586e+00
---    6 : El_f1          : 3.425e+00
---    7 : El_fracs1      : 1.218e+00
---    8 : n_El_TRTratio  : 1.121e+00
---    9 : EM37_El_DeltaR : 1.094e+00
---   10 : El_etcone      : 1.951e-01
---   11 : El_emins1      : 1.176e-01
---   12 : El_wtots1      : 1.029e-01
---   13 : El_e2tsts1     : 3.750e-02
---   14 : El_PtOverEhad1 : 2.463e-04
------------------------------------------------------------
```

Some quantities that we were interested in that are not in the AOD:

- Track / Cluster match (DeltaPhi, DeltaEta, match chi^2)

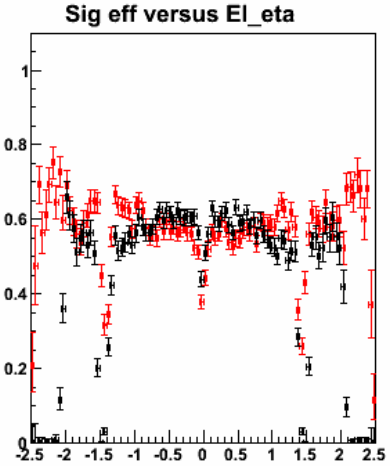
Want to add track isolation.

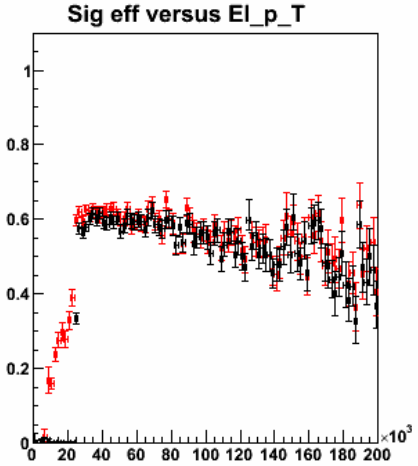
Only looking at e-gamma electrons for now (Author==1) pre cuts Et>25GeV, eta<2.4

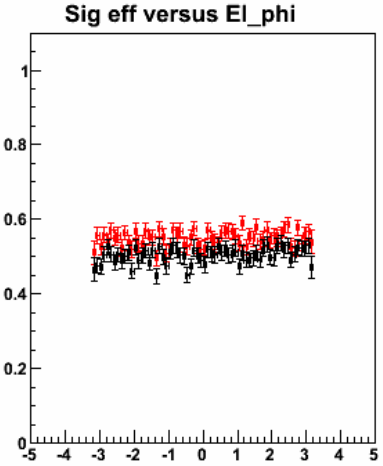
Electron ID Study

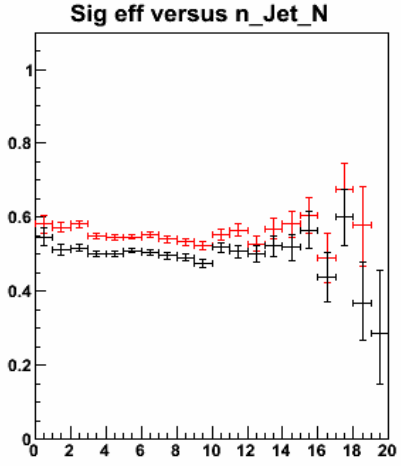
- Create a LH discriminants using these variables
  - Discriminants in 2 eta bins (>,<1.0) (would like to have more bins but MC stats don't allow training)
  - E-gamma isEM cuts have 14 bins in eta!
- Look at El eff and Jet rejection compare to standard isEM selection
- Look at dependencies on event variables
  - If we measure the efficiency in wenu, zee – can we trust it on SUSY events?
- Some variables used in isEM not available in AOD

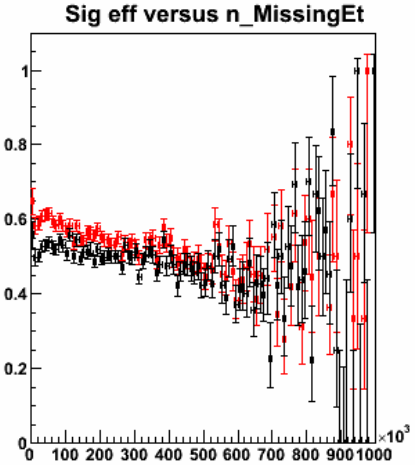
Electron ID Study - efficiency

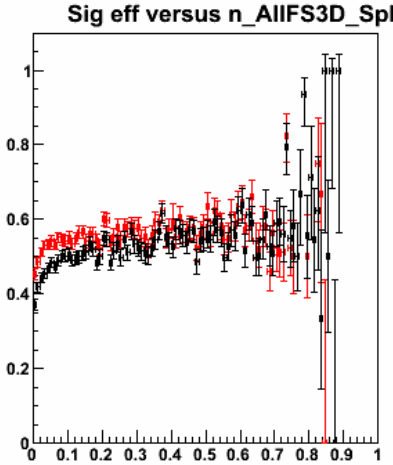


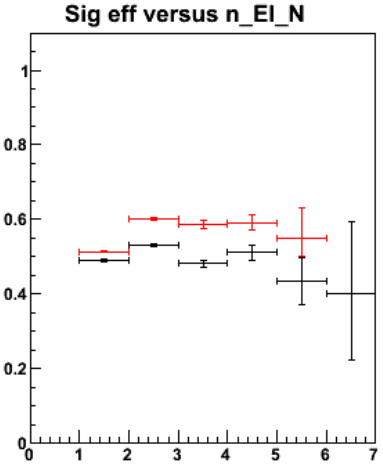






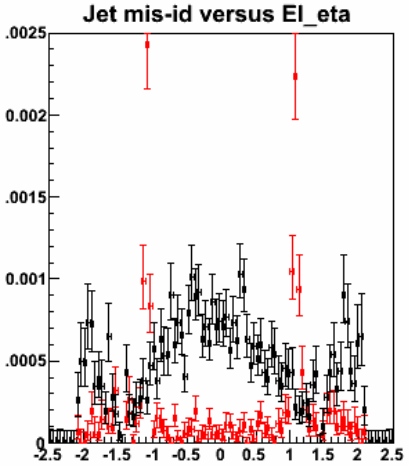


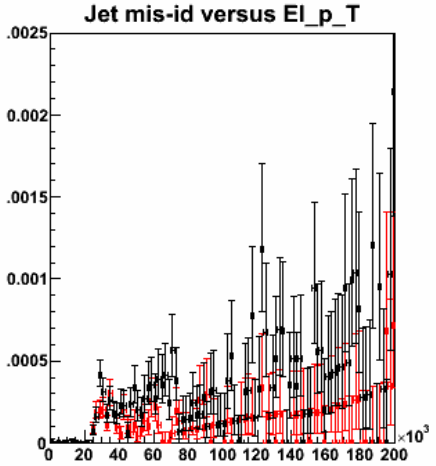


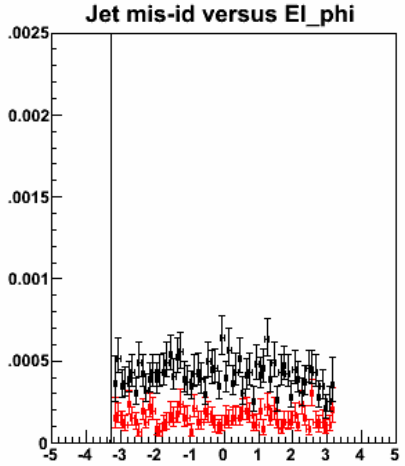


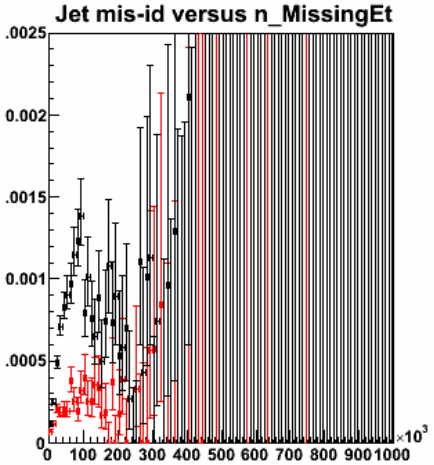
Signal eff (from true El in SUSY)
Red = isEM
Black = LH selection

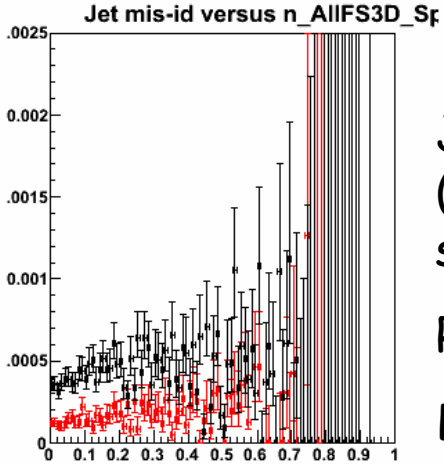
Electron ID Study – mis-ID











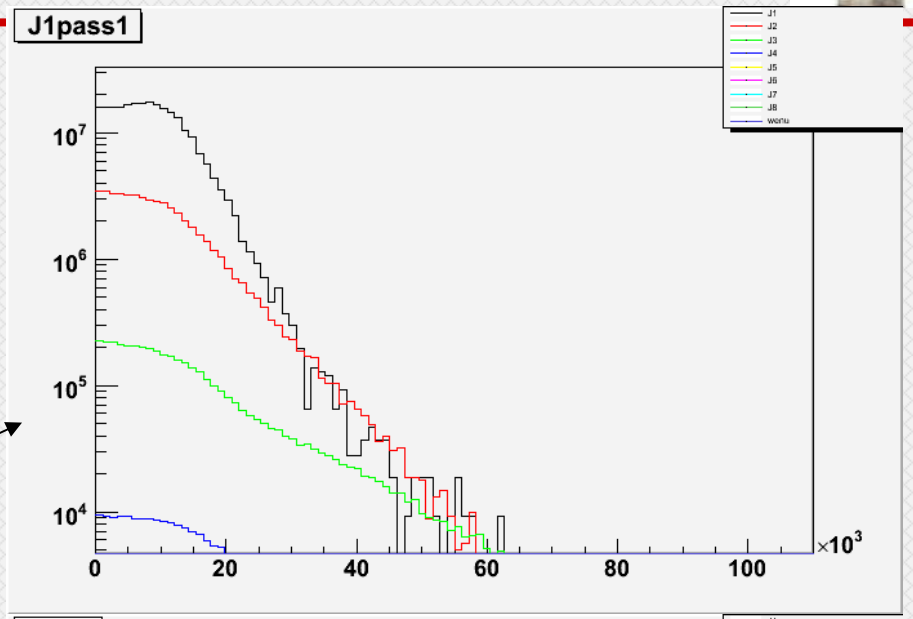
Jet mis-id rate (from all J1-8 samples)

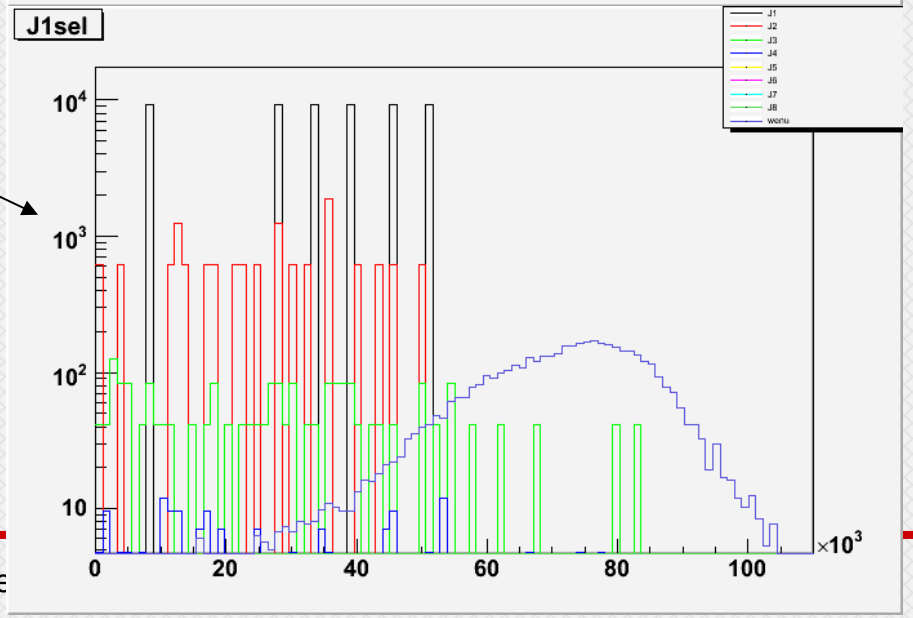
Red = isEM selection

Black = LH selection

Looking at the efficency in wenu

- Transverse mass for Wenu events and scaled QCD background
  - With no El ID
  - With the LH selection





Electron ID Study

- LH selection not as good as isEM but we have hope that adding more variables and training in better bins will be as good if not better
- Want to also try NN
- Plan to add in the tracks in a cone around the electron candidate
  - Improve isolation criteria (no track isolation at the moment)
  - Reject photon conversions (tracks in very tight cone)
- Probably want to come up with 3 selections
  - Calorimeter based, Everything based, something in between (no TRT?)
- Study how to measure the efficiency and mis-id from the data (wenu transverse mass, zee mass spectrum)
- Presenting this at the next SUSY WG meeting (13th Sept)

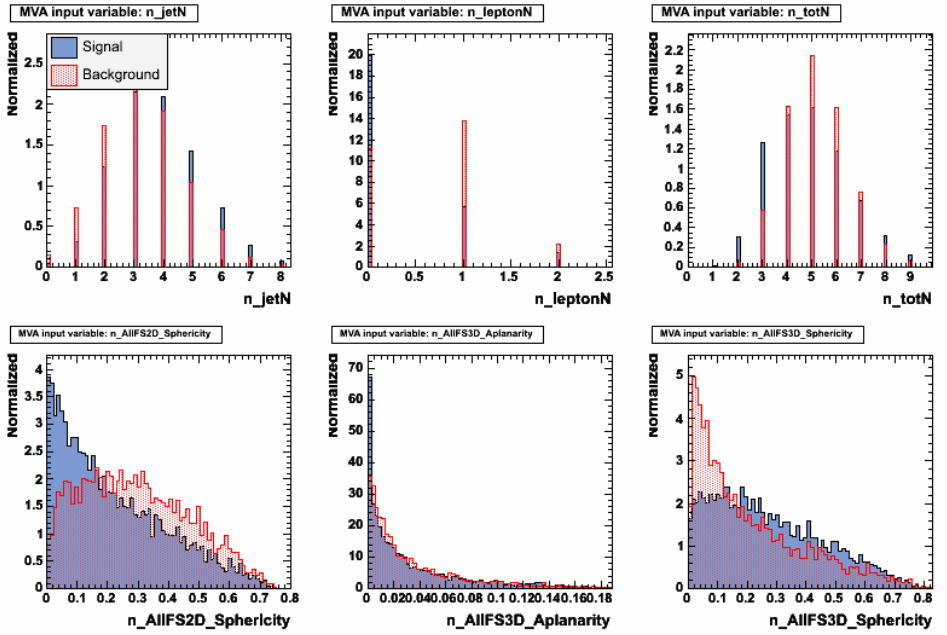
Andreas

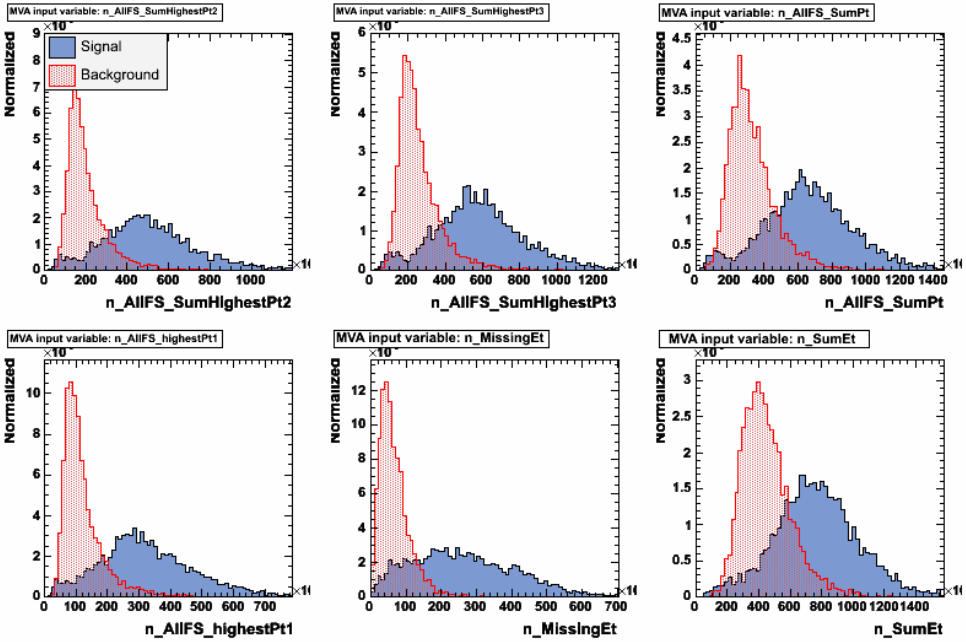
Event Variables

- SUSYView ntuples contain many event variables: Sphericity, Aplanarity, ESum, highest P, …
- Use TMVA to rank these in order of discrimination power for different SUSY points versus background
- Very preliminary look at discriminating SU3 from top (T1):

```
------------------------------------------------------------
--- Rank : Variable : Discr. power
------------------------------------------------------------
--- 1 : n_all_Meff : 5.017e-01
--- 2 : n_MissingEt : 4.517e-01
--- 3 : n_AllFS_highestPt1 : 4.253e-01
--- 4 : n_AllFS_SumHighestPt2 : 4.218e-01
--- 5 : n_AllFS_SumHighestPt3 : 4.172e-01
--- 6 : n_AllFS_SumPt : 3.837e-01
--- 7 : n_totSum_E_T : 3.825e-01
--- 8 : n_SumEt : 3.433e-01
--- 9 : n_leptonN : 6.710e-02
--- 10 : n_AllFS2D_Sphericity : 4.169e-02
--- 11 : n_jetN : 3.021e-02
--- 12 : n_AllFS3D_Sphericity : 2.453e-02
--- 13 : n_totN : 8.877e-03
--- 14 : n_AllFS3D_Aplanarity : 5.317e-04
```

Event variables





Stefan, Johannes

Di-Lepton Study

Initial Approach:

- Produce ROOT tree files using SUSYView
  - "Standard" EventView particle ID used for now (to be refined by results from lepton ID study)
  - To minimize file size, tree tailored for di-lepton study

- Produced test sample,

  To debug our analysis frame work and for first iteration of tree content

  All based on CSC11 samples, but only fraction of available statistics

  - SU2, SU3 (sample 5402-5403, v11000505)
  - Zee (sample 5144, v11004201)
  - T1 (sample 5200, v11004204)

Many samples missing!
QCD jets, T2 jets
W/Z+jets …

- "Home-made" high-level ROOT analysis framework: **SFrame**

  → Builds on SUSYView ntuples

  → Provides proper event weighting, monitoring and reduces original ntuple information by calling iterative processing cycles

Some First Checks / Results

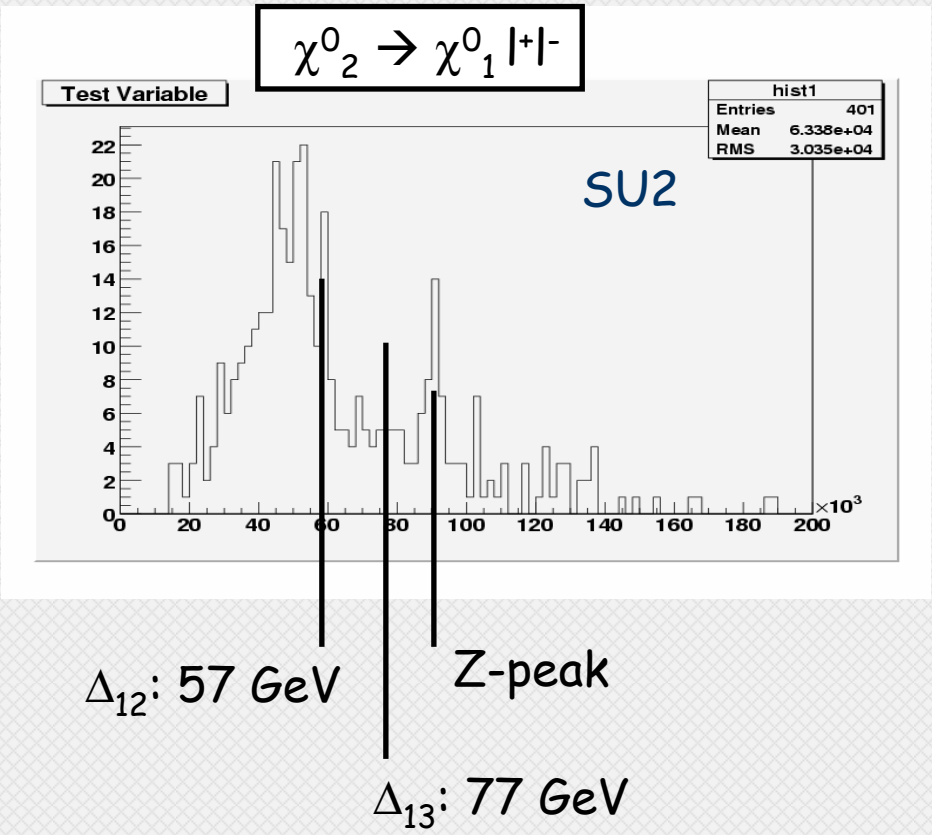
Check that invariant mass structure is present (not normalized…)

Invariant mass of two highest p_T electrons

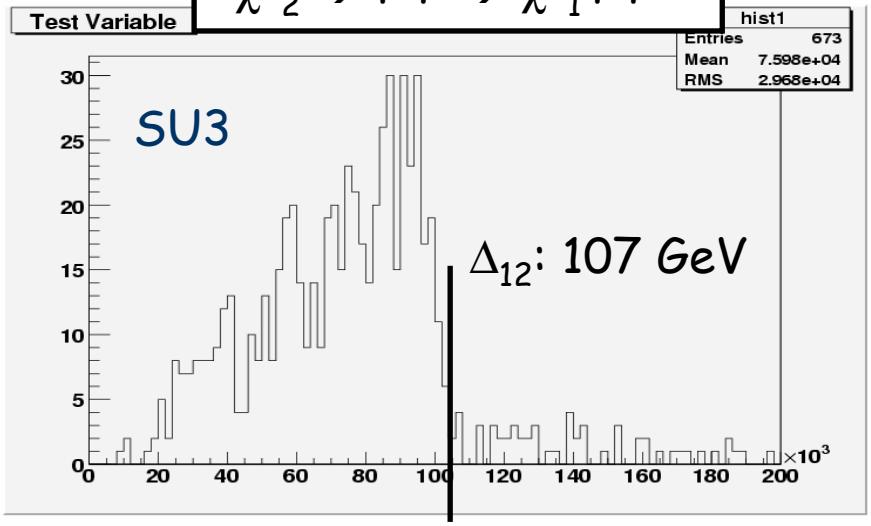
	SU2	SU3
$m(\chi^0_1)$	103	116 GeV
$m(\chi^0_2)$	160	223 GeV
$m(\chi^0_3)$	180	460 GeV
$m(e_R)$	3550	157 GeV

$\Delta_{xy} = m(\chi^0_x) - m(\chi^0_y)$

$\chi^0_2 \rightarrow \chi^0_1 l^+l^-$

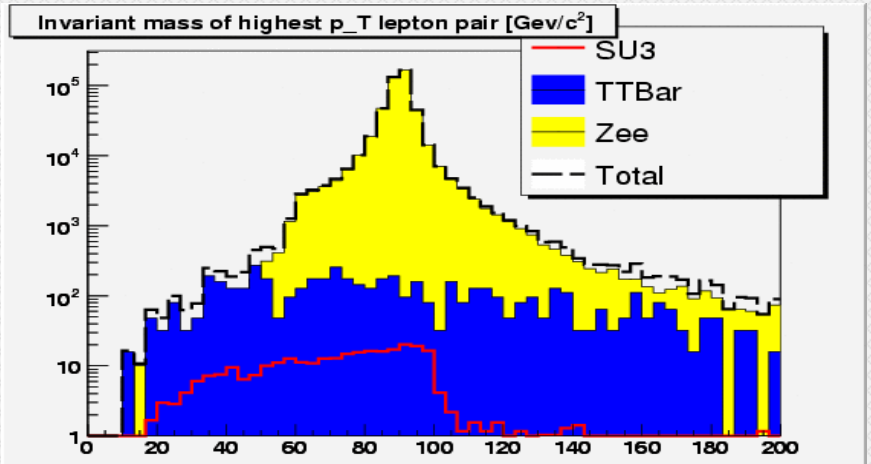


$\chi^0_2 \rightarrow \tilde{l}^- l^+ \rightarrow \chi^0_1 l^- l^+$



Results and Plans

$e^+ e^-$,
p_T > 10 GeV, |eta|<2.5



Infrastructure in place

(Merging files, Control Histograming Proper weighting, Event Selection, …)

Next Plans

SUSYView tree-files:

(next iteration → refined content)

- Process all available CSC11 statistics
- Complementary high stat. ATLFAST

Analysis plans:

- Reproduce lepton efficiency and fake rates (based on truth info and more "data aware" methods)
- Integrate TMVA in analysis framework
  - Discriminating variables
  - Bkg suppression
- End-point study
  - Does m_{ll} exploit all kinematic info.
  - Fit shape, unfolding… ??

Conclusions

- SUSYView Production becoming more automated and easy to run
- Detailed electron ID study being undertaken
- Starting to Look at what are the best event variables for distinguishing SUSY from background
- Starting di-lepton endpoint analysis
- CAT SUSY group will be contributing to the CSC notes
  - QCD background fighting & estimation from data (SUSY3)
  - Inclusive studies for SUSY events (SUSY5)
  - DiLepton edges (SUSY6,7)