Detection of Sbottom Squark Events with Small Visible Energy

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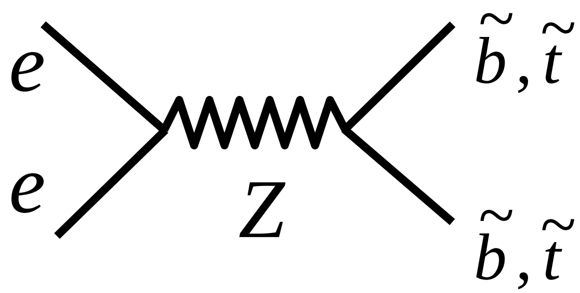
MOTIVATION

Sbottom and Dark Matter

- SUSY LSP particle neutralino is a potential dark matter candidate.
- In order not to have too many neutralinos left in the Universe, they must annihilate effectively.
  - This means that their mass difference to the next SUSY particle (sbottom in our scenario) should be small.
- Sbottoms can be eventually produced at ILC

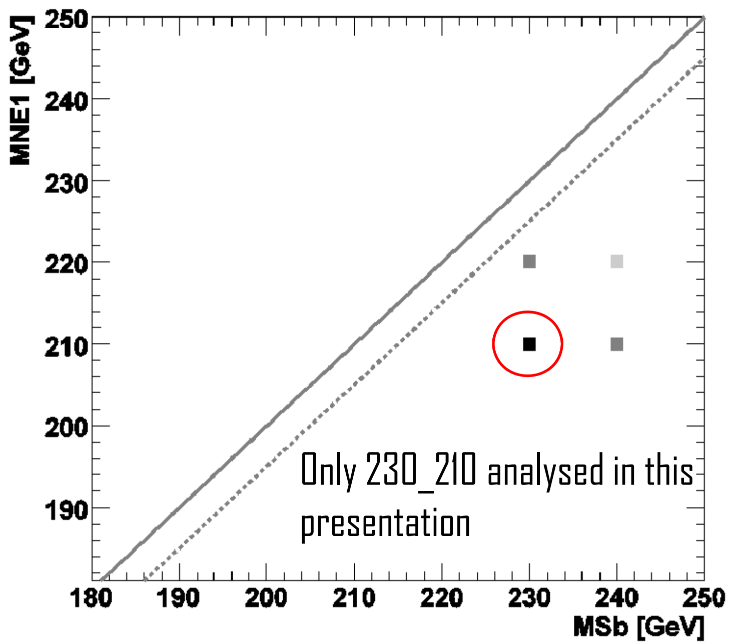


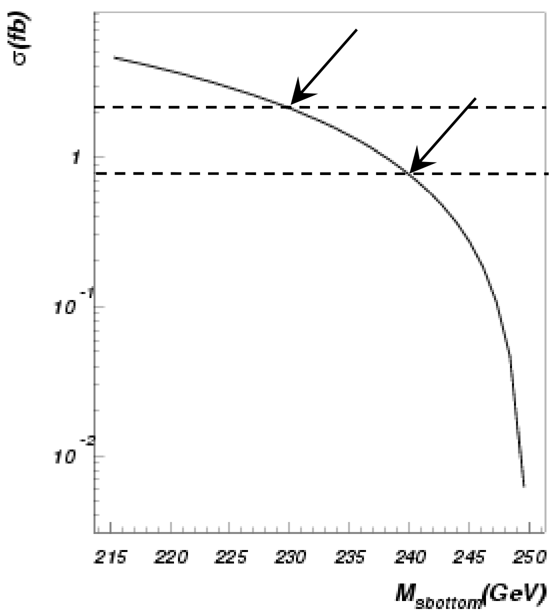
This measurement is challenging due to softness of sbottom events and very large (not only) two photon background.

  - Followed by decay to neutralino a b-quark.

Phase Space Coverage

- We have selected our edge of sensitivity corner with the main sample being (M_{sb},M_{ne})=(230,210) plus two more demanding samples (230,220), (240,210) and one challenging (240,220).
  - We might be missing (220,210) if things will not go well for (230,220) though…





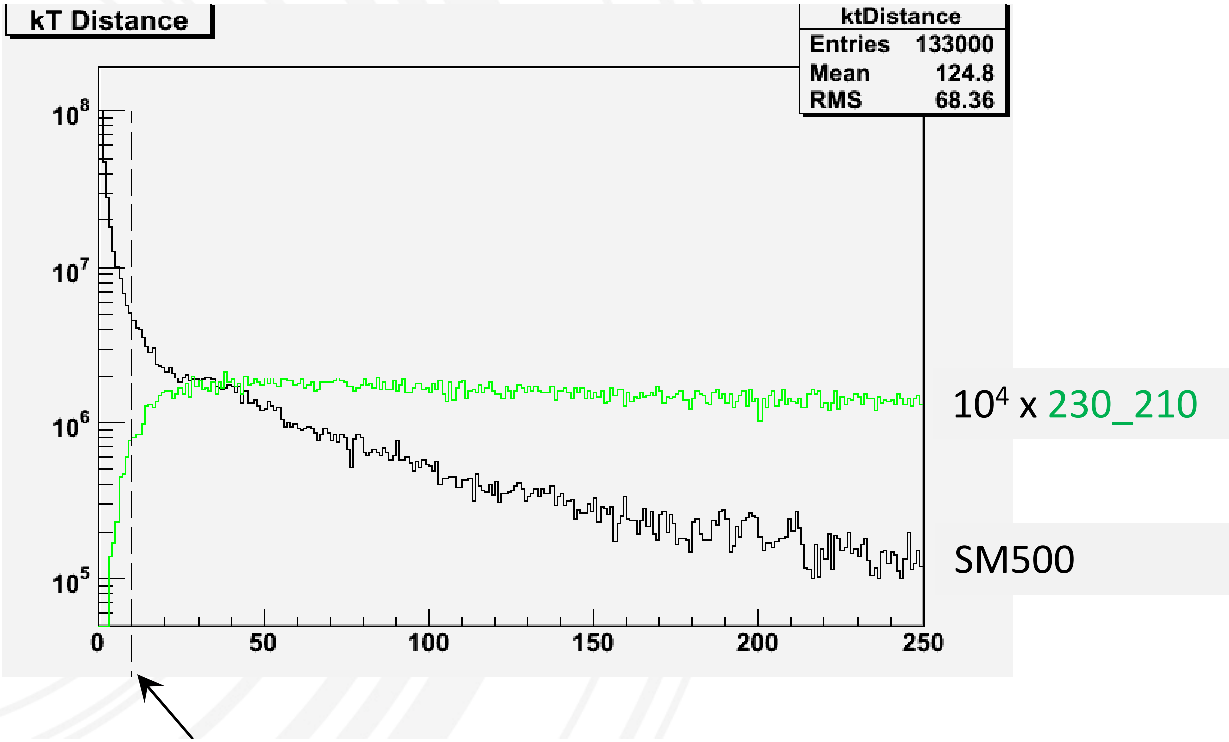
Sample Features

- The samples are normalised to 1000 fb^{-1} instead of standard 500fb^{-1}
  – This corresponds to about 1300 events for M_{sb} = 230 GeV
- The sbottom samples are unpolarised
  – Obtained with CalcHep and "ported" to stdhep file format via Les Houches format and CalcHep's own format…
  – Hence SM background sample is reweighted accordingly.
  – Constituent quark mass for b-quark in CalcHep and Pythia is 5.5GeV instead of 5 GeV or less
    - we are at the production threshold and low mass would lead to problems with fragmentation.
  – Otherwise beamstrahlung, ISR, FSR all is ON and treated by CalcHEP and Pythia 6.

EVENT SELECTION

Jet Reconstruction

- Events are passed through complete chain, including lepton ID, LCFI package.
- Jets are reconstructed using Durham k_T algorithm with k_{Tmin} = 10GeV and not more than 2 jets reconstructed – as in our previous study.
  - So I basically take 2-jet event collection and look at k_T
  - Furthermore, 1-particle jets are discarded



Basic Selection Cuts

- Neural Network should be able to internally perform simple “box cuts”
  - But its life is easier when some obvious cuts are done beforehand

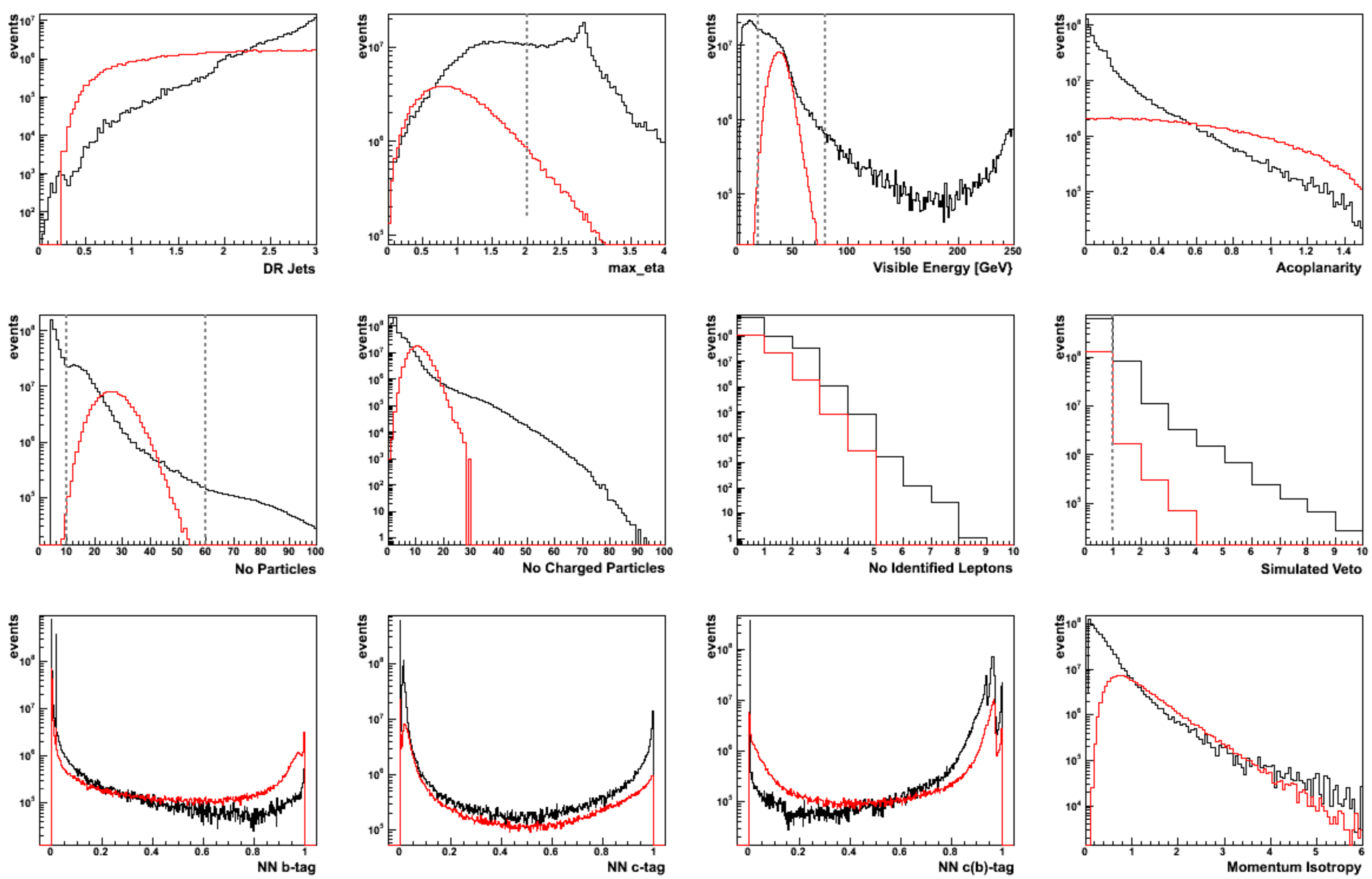
- These are:

$E_{visible}$	< 80 GeV
DR_{jets}	< 3
E_{jet1}, E_{jet2}	> 5 GeV
N_{veto}	< 1
$\max(\lvert\eta_1\rvert, \lvert\eta_2\rvert)$	< 2
$N_{particles}$	< 60
$N_{particles}$	> 10

- N_{veto} – a number of electrons/photons with E>300MeV in “electromagnetic veto” = at very low angles (above 30mm at z=3000mm)
  - Estimated from MCParticles, not simulated.

Event Distributions Before Cuts

- Signal$_{(230,210)}$ x10^5 (red) and SM 500 background (black)



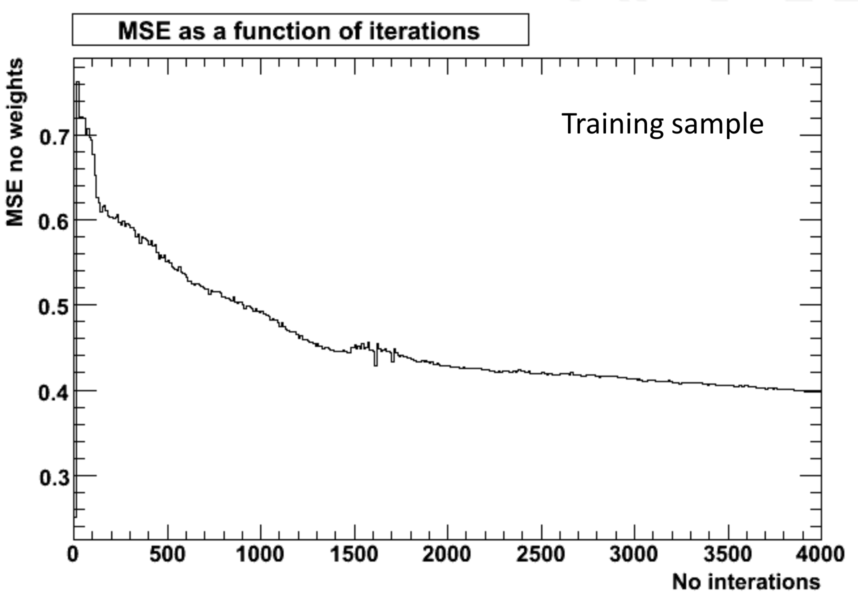
Background Events Composition

- The events are saved in text files for faster processing
  - And for NN training.
- Background is classified according to its IDRUP number.
- Total number of expected sbottom events based on σ is 1295.
- Jet Rec
  - jet reconstructed and saved
- After cuts
  - passing basic selection cuts (see next slide)

Classification	Jet Rec.	After cuts	
SIGNAL	**1,282**	**976**	
light_pair	3,847,890	1,478	
cC	1,317,400	554	
bB	1,269,330	293	
AA_to_anything	441,740,000	9,297,390	
eA_to_anything	46,005,300	1,256,310	most difficult one
eE_lightpair	368,870	33,415	
eE_AA(AAA)	3,909,250	0	
eEcC	4,506	4	
eEbB	314,625	32,437	
nN_lightpair	118,992	986	
nNcC	35,849	753	
nNbB	41,597	590	
eEeE	509,052	2,911	
eE	193,705,000	33	
eEneNe	160,705	233	
eEeEneNe	460	0	
eEeEeE	55	0	
qqen	1,934,040	2,437	
nNA	20,742	41	
nNAA	15,838	0	
nNAAA	4,781	0	
nNnNeE	73	0	
nNnN_lightpair	264	47	
eEeEcC	20	2	
NNNqqe	2,245	58	
eENNbB	17,282	2	
other	2,469,730	1	

Neural Network Analysis

- Modified FANN (Fast Artificial Neural Network) package is used:
  - Accounts for weights
  - Calculates NN input importance
- Topology 15+30+1 (inputs, hidden, output)
- No iterations: 4000



Vyrobit plots	Cut	Input
kT	>10	
dR	<3.0	
acoplanarity		
max(|eta1|,|eta2|)	<2.0	
NNb1, NNb2		
NNc1, NNc2		
NNcb1, NNcb2		
Ncharged		
Nparticles	10<N<60	
Nelectron		
Nveto	== 0	
Evis	< 80 GeV	
Ejet1, Ejet2	> 5 GeV	
Npjet1, Npjet2	> 1	
mom_isotropy		

RESULTS

Interpretation of Results

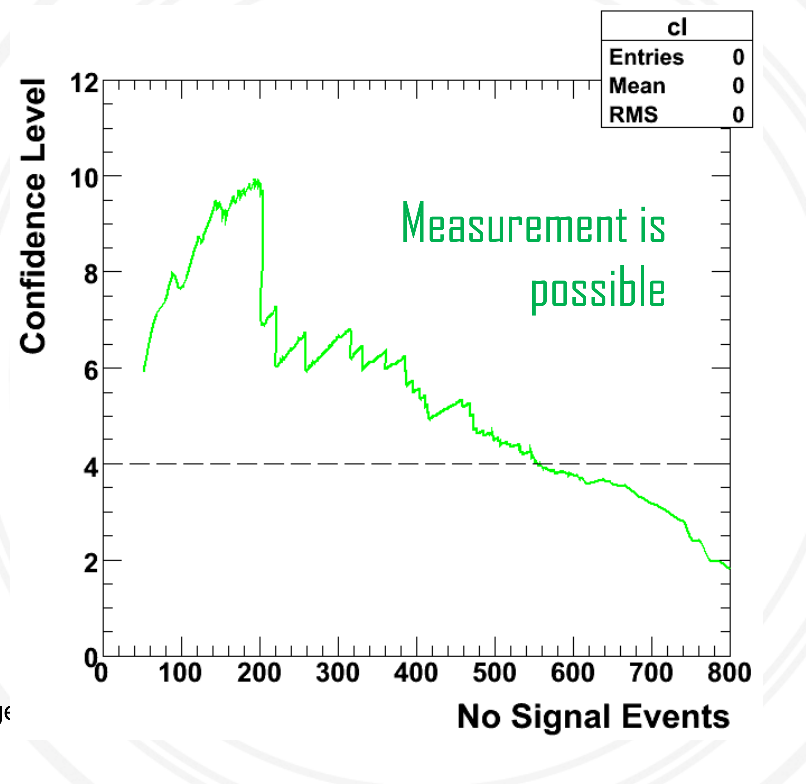
- Results are interpreted in terms of confidence level defined as

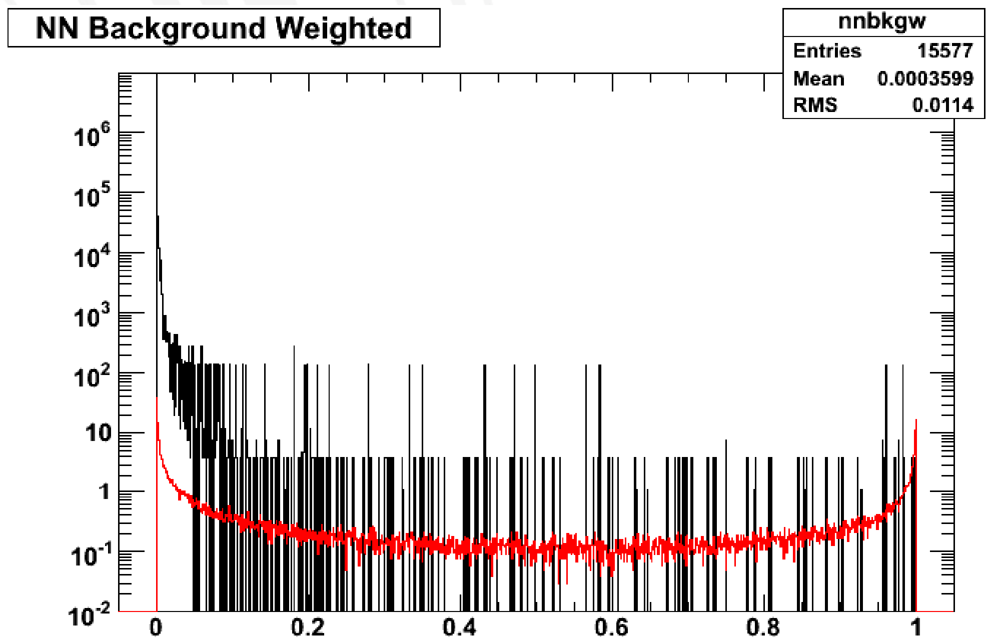
$$CL = \frac{S}{\sqrt{S+B}}$$

- Rather than cutting on NN_{output} or plotting $CL(NN_{output})$ we show CL as a function of a number of potentially selected signal events S.

Neural Net Output

- Confidence level looks very good even when considering large error due to background statistics - which can even be guessed from the plot.
- Good sign: signal peaks at 1
  - note it is with weights and overwhelmed by massive background)



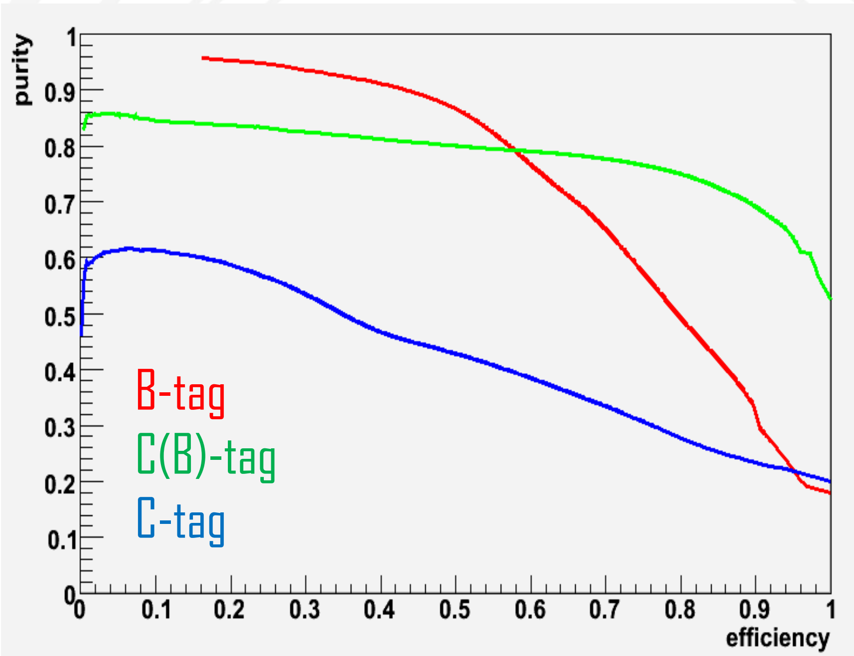


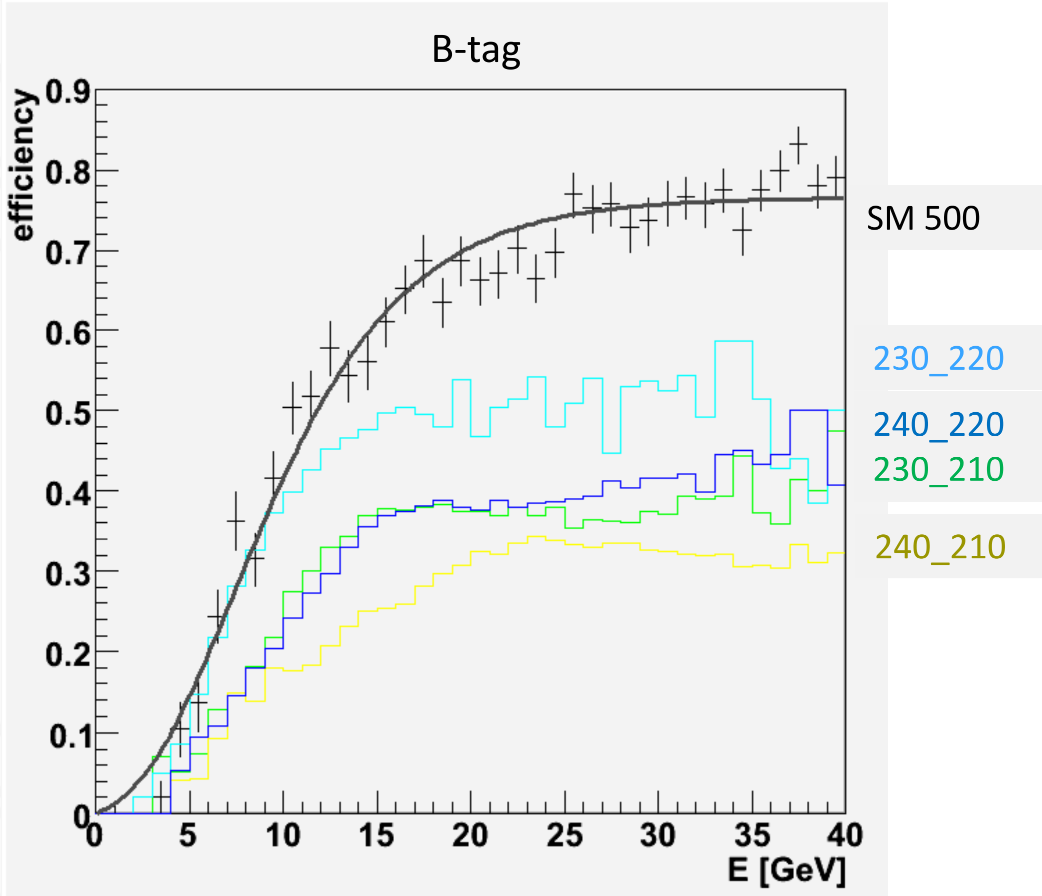
What is remaining?

- Analyse other samples: (230,220) , (240,210) and (240,220).

By-products for LoI

- Other useful plots for LoI done in this analysis might be
  - Jet tagging purity vs efficiency plots.
  - Tagging efficiency as a function of the jet energy.
  - ...





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