Atlas software preparation for LHC switch-on

IOP HEPP 2009

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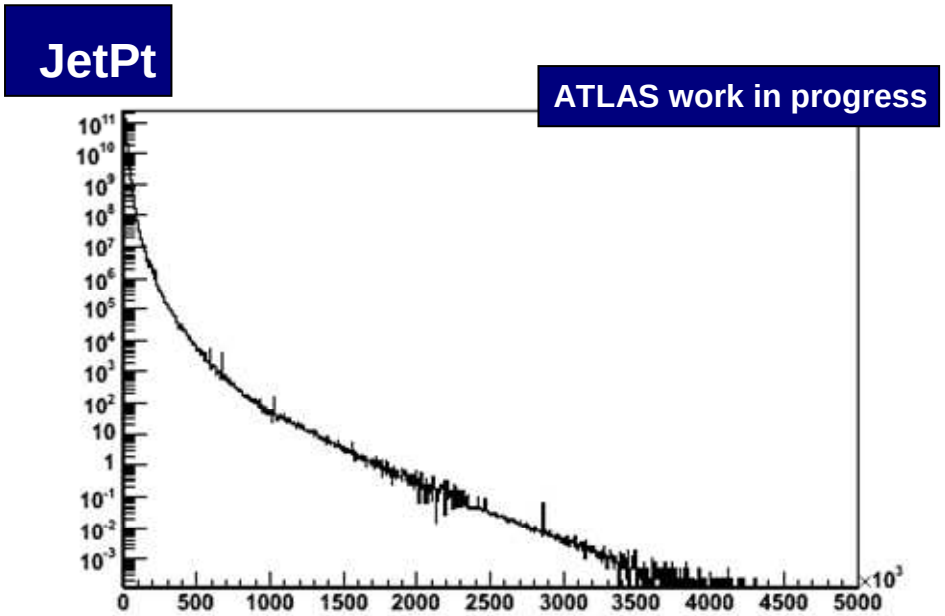
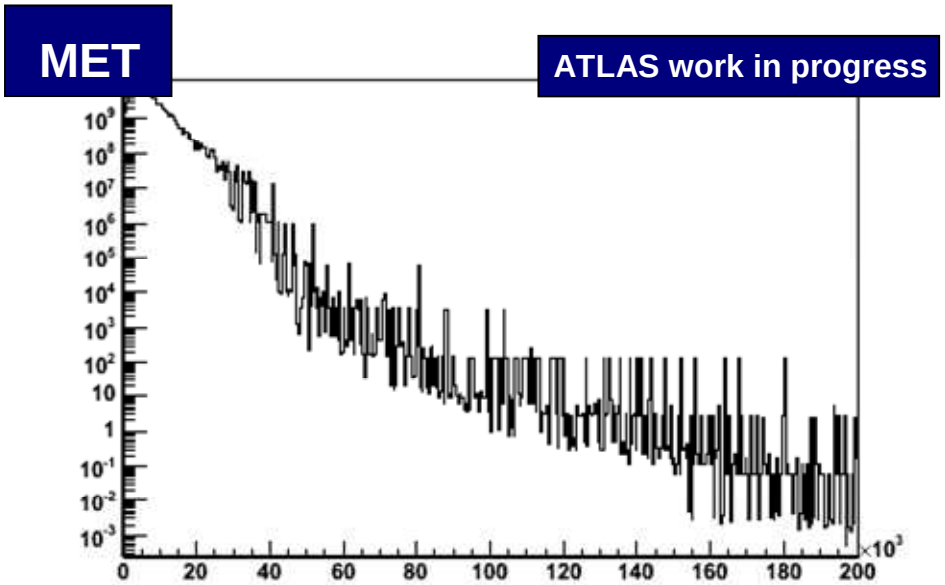
Early data plots

- **Likely to look at simple kinematic variables**
- **Jet kinematics sensitive to jet definition (more later)**

$$\vec{E}_T = \frac{E}{|p|}\vec{p}_T$$

- **MissingEt (MET) = -1*vector sum Et**



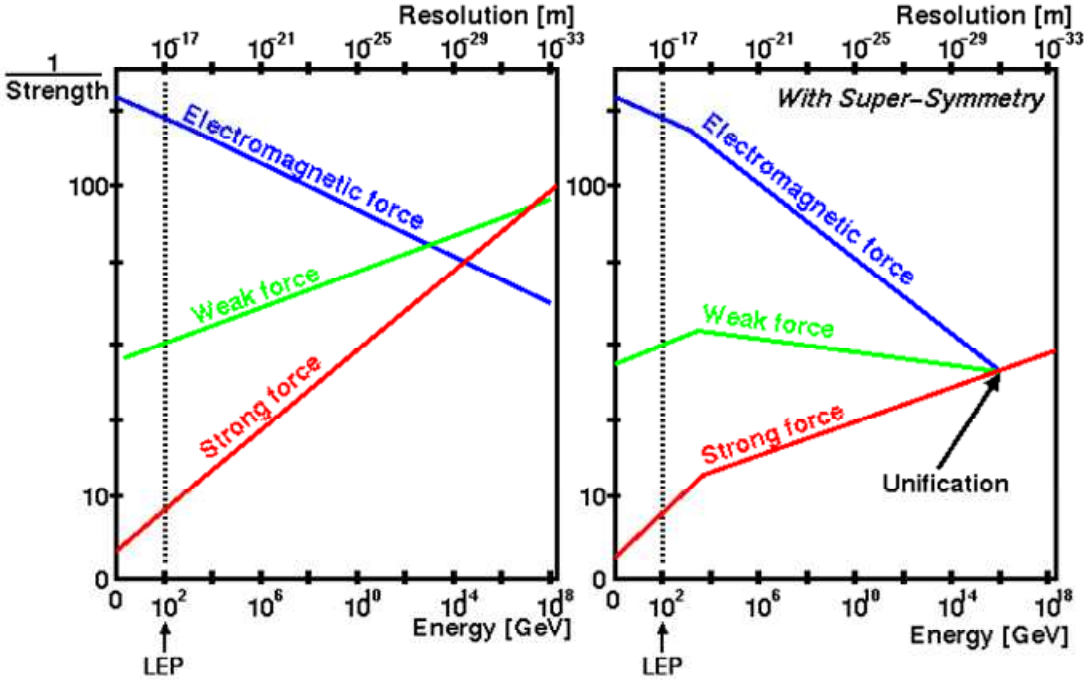


SUSY

Fermion ⟷ **Boson**

R-Parity

$$P_R = (-1)^{3(B-L)+2S}$$

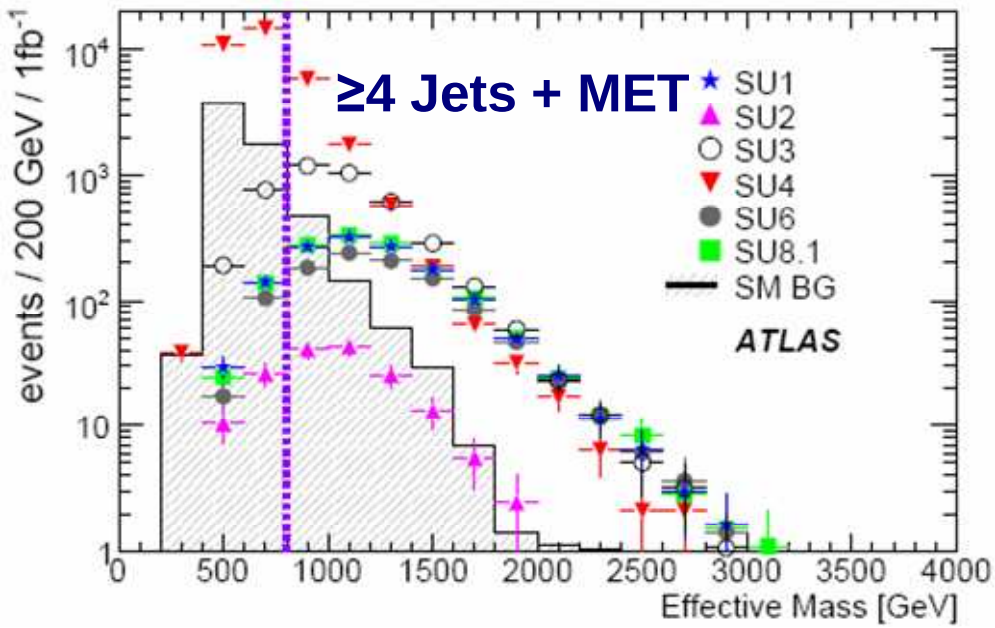


- R-Parity conserving SUSY
  - Higgs mass stability
  - Unification of gauge coupling constants
  - Stable WIMP – good dark matter candidate

SUSY search with jets + MET

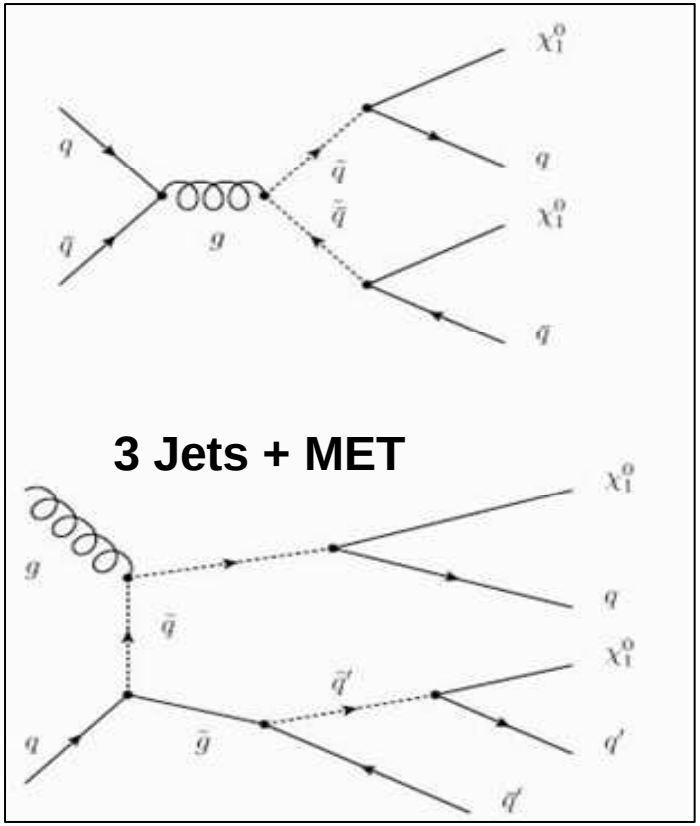
- With leptons
  - Generally smaller cross section
  - Less SM background
  - Rely on multiple cascade decays
  - Model dependent
- Hadronic only
  - Higher cross sections
  - More SM background
  - Most efforts concentrated on large jet multiplicities (>3) to help reduce the QCD background.
  - Reliance on hadronic cascade increases with jet multiplicity

Expected Performance of the ATLAS Experiment
Detector, Trigger and Physics, The Atlas Collaboration (G. Aad et al.) arxiv: 0901.0512



Low jet multiplicity SUSY search

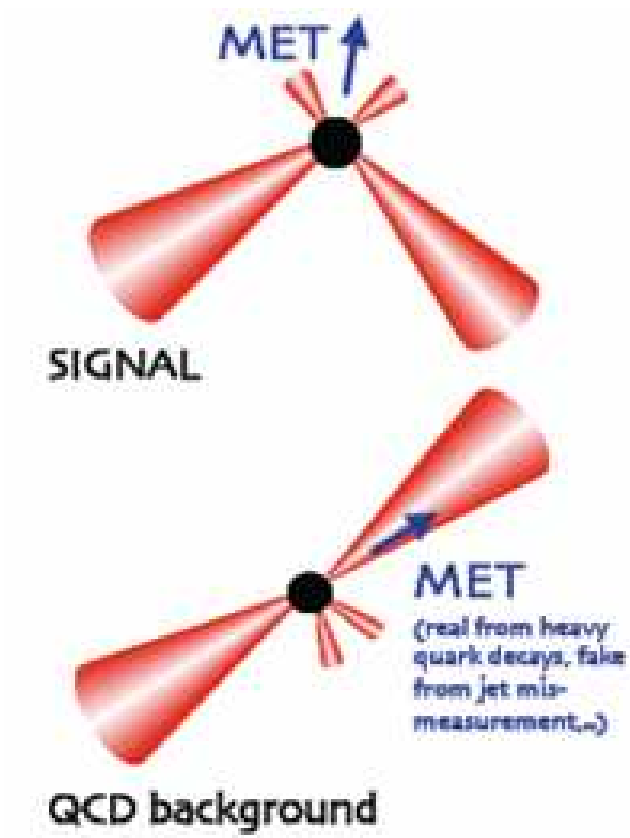
2 Jets + MET



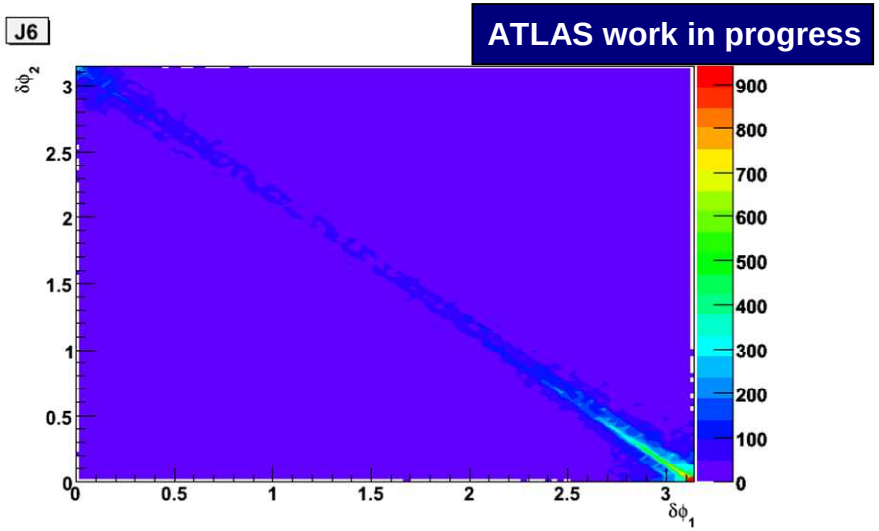
- **Large signal cross section**
- **Relatively well known SM backgrounds**
- **Relatively model independent**
  - **Do not rely on leptonic cascades**
  - **Do not rely on hadronic cascades like higher no. jets**

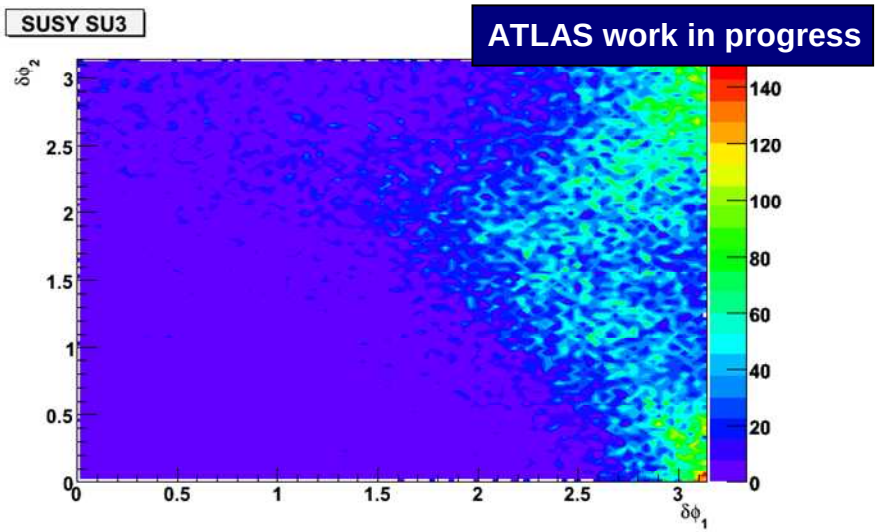
Use Kinematics, rather than "busyness of event" to pick out SUSY

Suppressing QCD background



(C.Gwenlan, Oxford)





Results

$$M_{eff} = MET + \sum_n p_T^{\,n}$$

Cuts	2-Jet	3-Jet
Cut1	$pT^{jet1,2}$>150,100 GeV |η|<2.5	$pT^{jet1,3}$>150,100 GeV |η|<2.5
Cut2	MET>max(100, 0.3Meff)GeV	MET>max(100, 0.25Meff)GeV
Cut3	$\delta\phi^{1,2,3}$>0.2	$\delta\phi^{1,2}$>0.2
Cut4	$R_{1,2}$>0.5	$R_{1,2}$>0.5
Cut5	No isolated leptons	No isolated leptons

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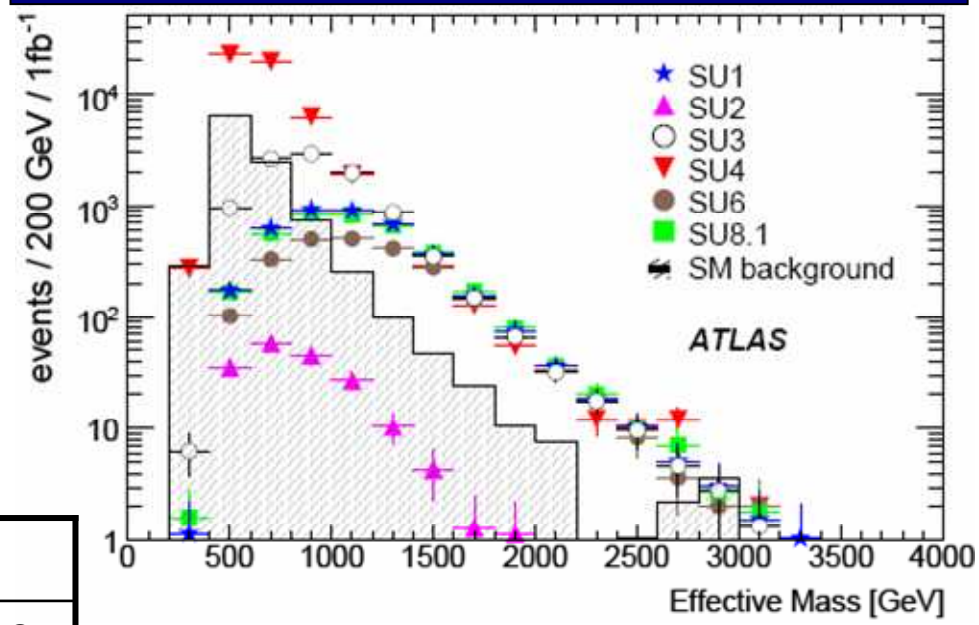
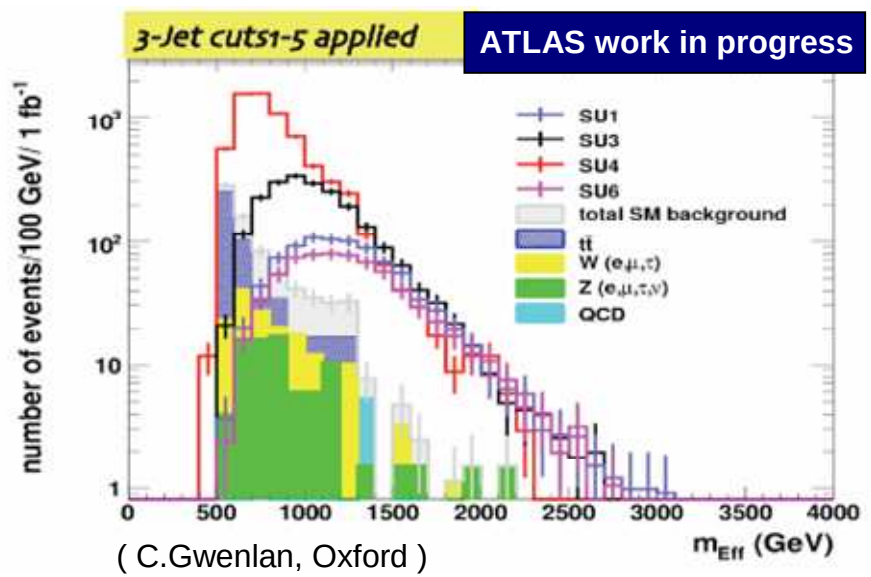




(C.Gwenlan, Oxford)

How do we know its signal?

Could it be a generator parameter?

Could it be a detector effect?

Need to **rapidly** interactively tune or (quick and dirty) investigate size of uncertainties.
(e.g. for conference plots, first papers, etc...)

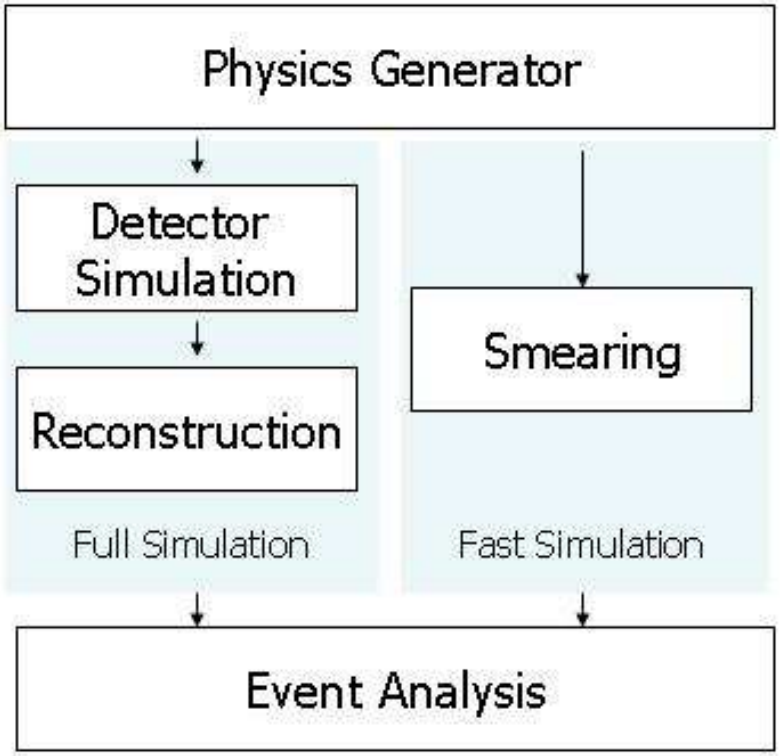
For this Atlfast is ideal !

Fast Simulation (Atlfast)

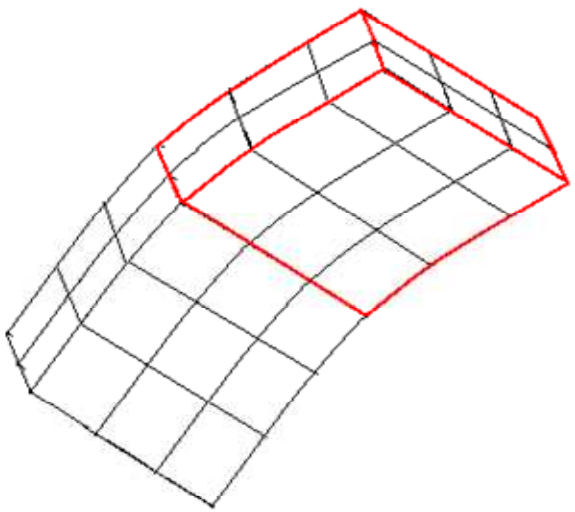
- **Smearing functions replace full chain**
- **orders of magnitude faster than full simulation**

Full Simulation	Fast Simulation
1990s per ttbar event	0.097s per ttbar event

ATLAS work in progress



Atlfast Calorimeter/Cells



Atlfast Cal Granularity ($\Delta\eta x \Delta\phi$):

- Barrel ($|\eta|<3.2$) = 0.1x0.1
- Forward ($3.2<|\eta|<5$) = 0.2x0.2

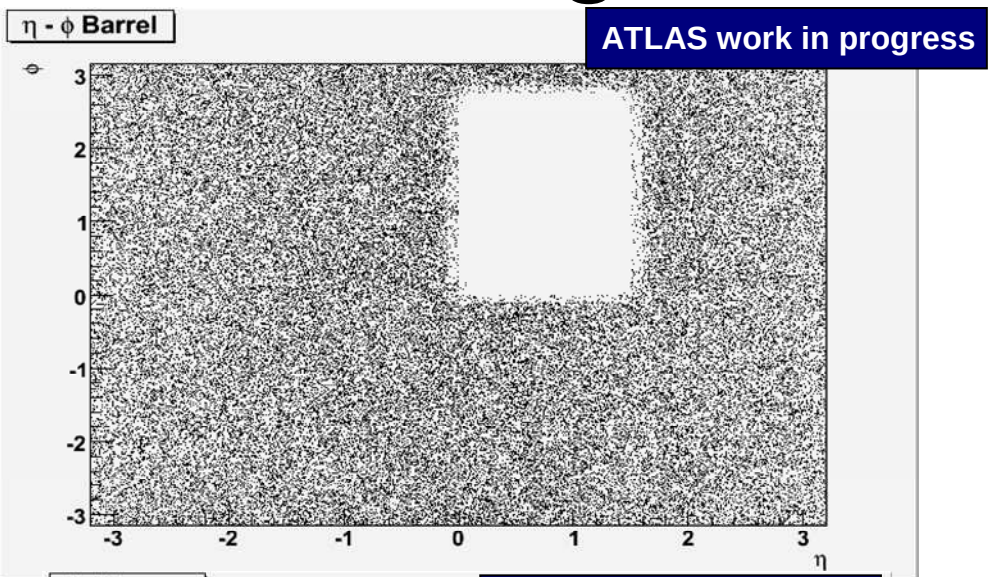
Real Calorimeter Granularity ($\Delta\eta x \Delta\phi$):

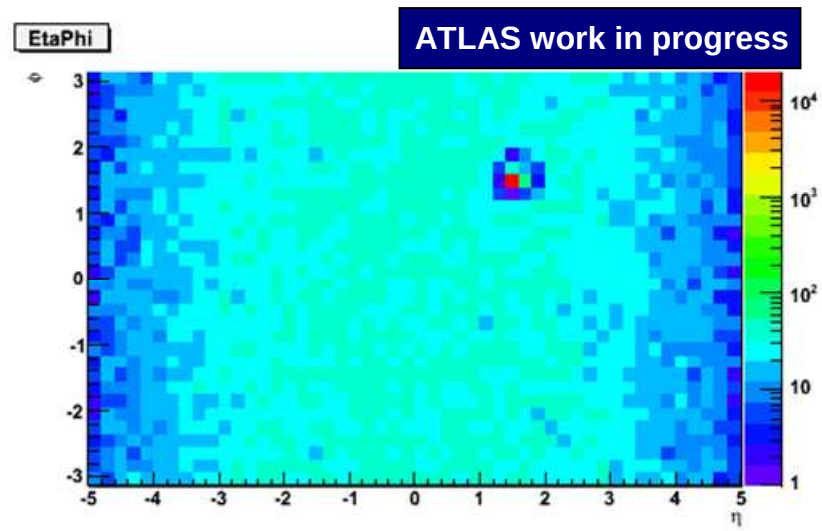
- Barrel+End-cap ($|\eta|<3.2$) = finer in general than Atlfast
- Forward ($3.1<|\eta|<4.9$) = same as Atlfast but 3 samplings

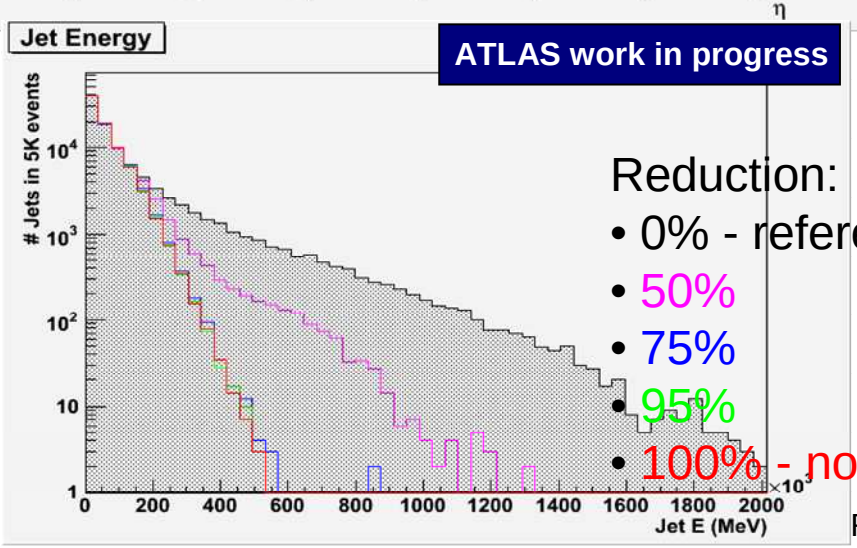
We can :

- Simulate loss of entire Atlfast cell
- Simulate loss of partial Atlfast cell by scaling the energy it collects
- Simulate hot Atlfast cell with a given energy in all events

Simulating dead/hot regions

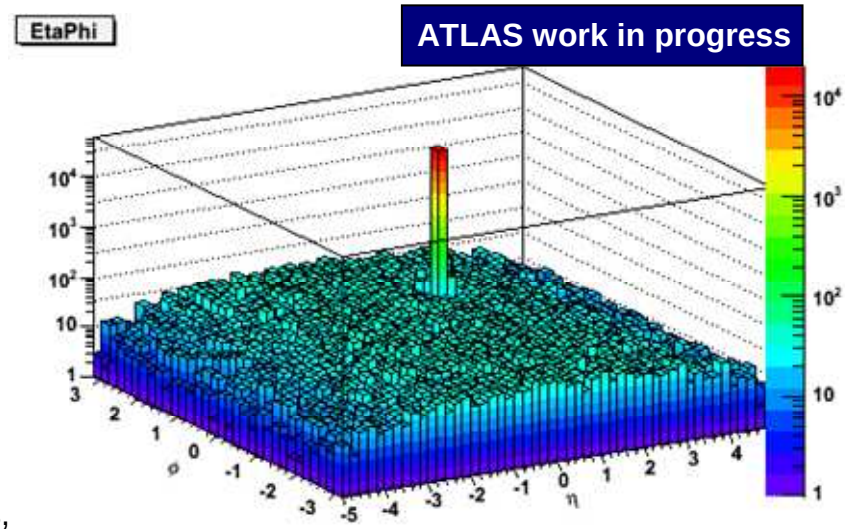






Reduction:

- 0% - reference
- 50%
- 75%
- 95%
- 100% - no FCal



Richards,

Jet ‘Finding‘ Algorithms

- Define rather than ‘find’ jets.
- Cone
  - Atlas Cone – not infrared or collinear safe
  - SISCone
- Sequential recombination
  - Kt (p=1)
  - Cambridge/Aachen (p=0)
  - AntiKt (p=-1)

$$d_{ij} = \min(k_{ti}^{2p}, k_{tj}^{2p}) \frac{\Delta R_{ij}^{2}}{R}$$

$$d_{iB} = k_{ti}^{2p}$$

Atlfast jet algorithm update

Pre release 14

- Cone
- Kt
- Shared

Post release 14

- LegacyCone
- Kt (FastKt)
- Cam/Aach Kt
- AntiKt
- Cone (SISCone)

•Standardise jet algorithm between Atlfast and full simulation

Summary

- Analysis groups eagerly awaiting data
- Atlfast jet finding algorithms match full simulation
- Very fast simulation of physics output which users can rerun easily
- Detector problems/configurations framework makes it relatively easy to simulate new detector problems

Backup slides

What is Atlfast ?

- ATLAS fast simulation package
- It includes most crucial detector aspects: jets reconstruction in the calorimeter, momentum/energy smearing for leptons and photons, magnetic fields effects and missing transverse energy
- It provides, starting from the list of particles in the event, the list of reconstructed jets, isolated leptons and photons and expected missing transverse energy.
- Optionally package provides a list of reconstructed charge tracks

How does it perform?

- Full simulation + reconstruction takes ~½ hr per event.
- Atlfast test jobs in 12.0.3

Sample	$Z \rightarrow ee$ (10k, Pythia)	$ttH(H \rightarrow bb)$ (10k, Pythia)
Atlfast execute per event	8.15 ms	21.8 ms
Pythia execute per event	12.6 ms	200 ms
Total (includes initialisation)	307 s	2376 s

- 10^4-10^5 x faster than full chain

Motivation

- Full sim too slow to conduct **rapid** investigations of anomalous effects as they show up in data
- Atlfast I very fast could on scale of hours/days do what would take months for full sim.
- Therefore quick to re-run with different inputs – uncertainty estimation

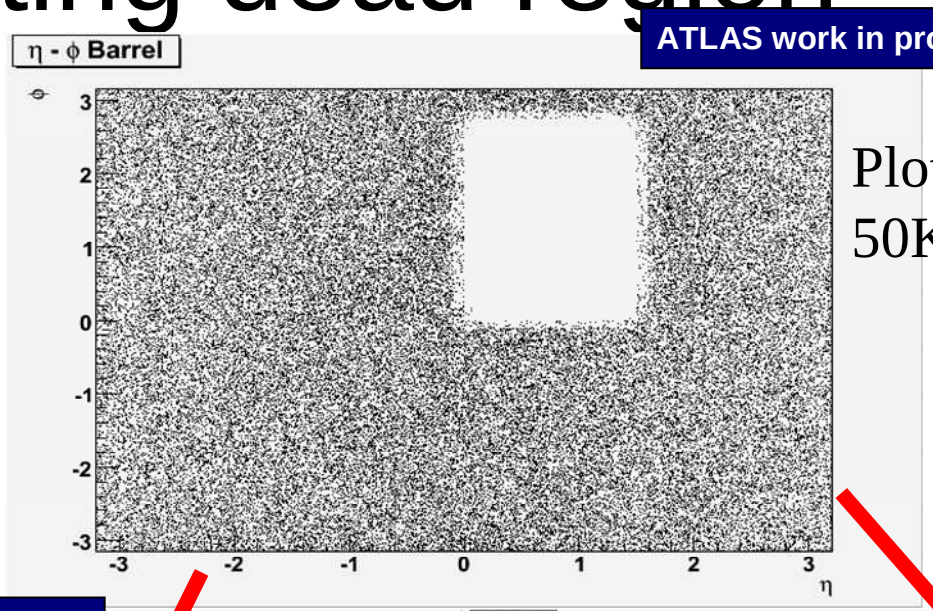
<u>Generator parameter example:</u>

- Could use Atlfast I to guide Atlfast II/full simulation

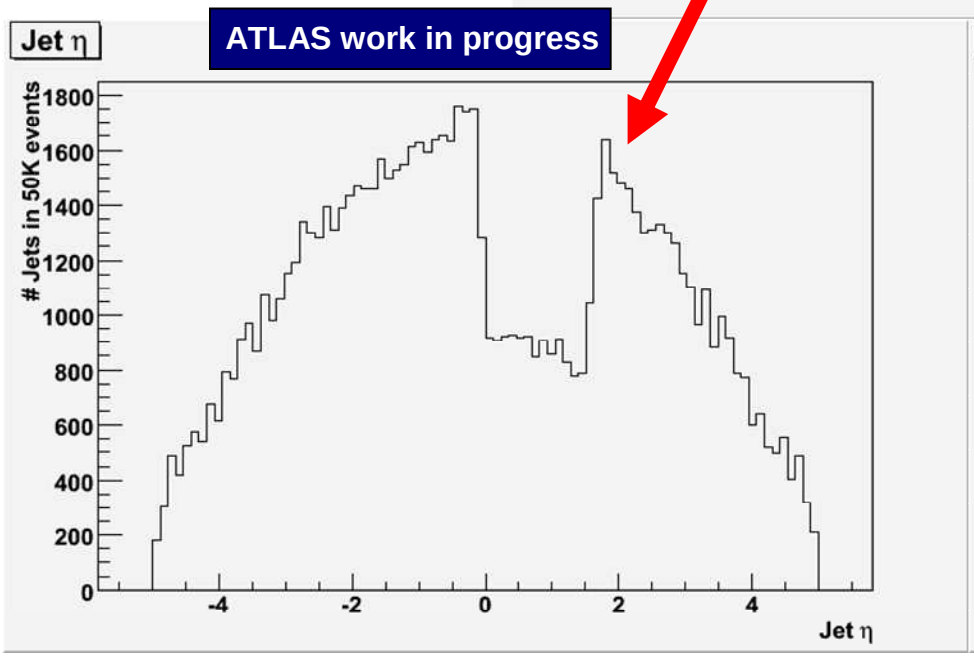
Many 1000's events per hour

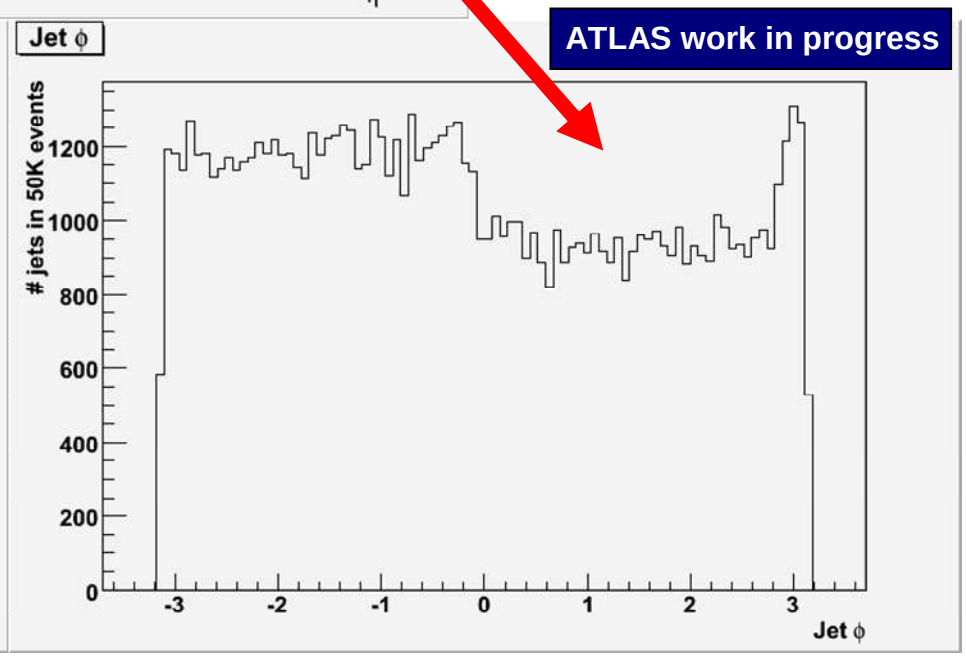
Simulating dead region

Completely knocked out asymmetric region in η and ϕ.



Plot shows jets in 50K dijet events.



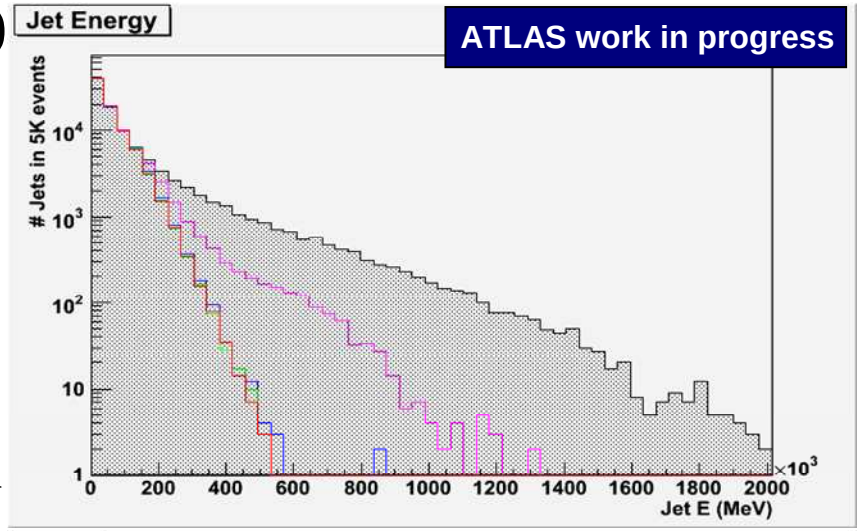


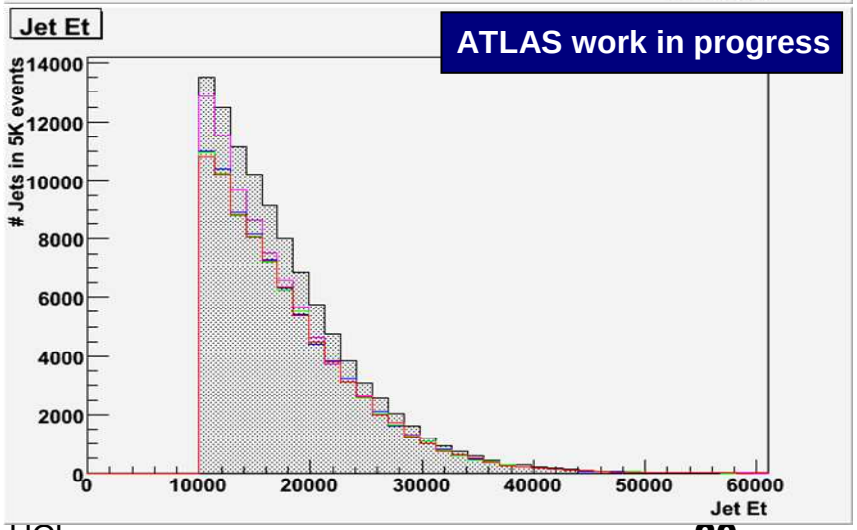
Defective FCal

- Sample: 50K J1 dijet events (17-35 GeV)
- JO: CSC.005010.J1_pythia_jetjet.py
- Generated on the fly in Atlfast in release 14.2.20
- Atlfast – 10 GeV jet Et cut

Simulated effect of partially/fully off FCal energy collected reduced by:

- 0% - reference
- 50%
- 75%
- 95%
- 100% - no FCal





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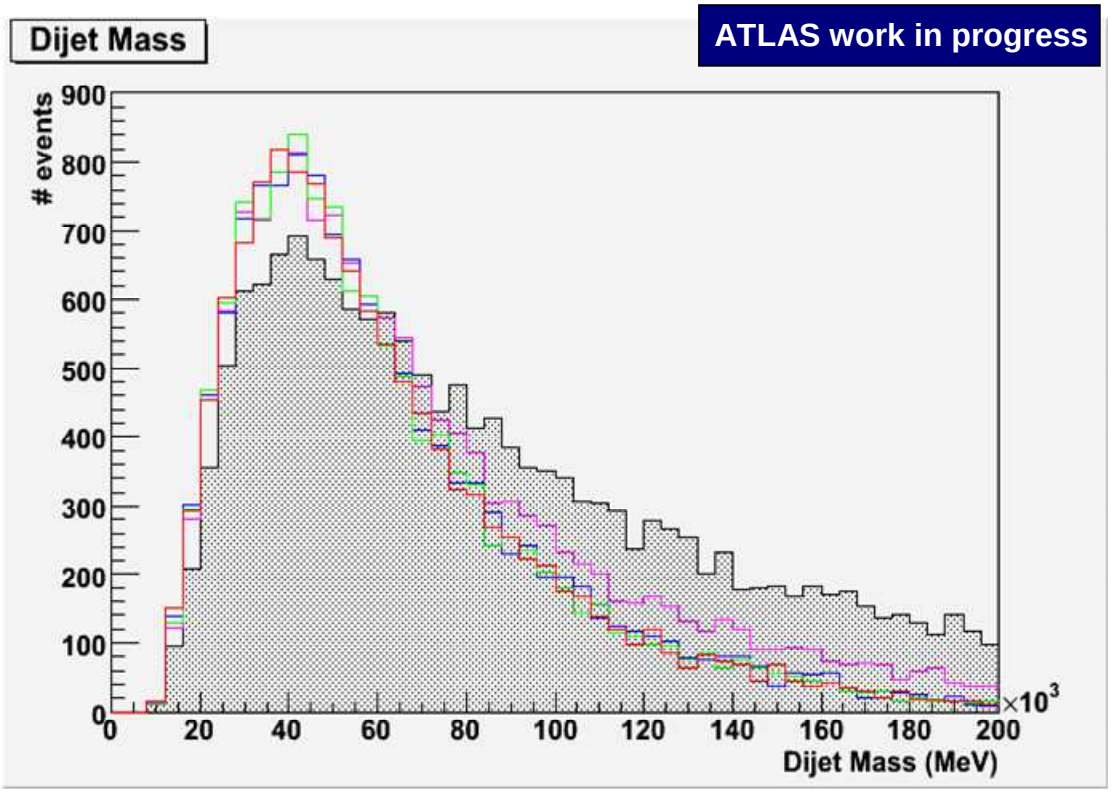
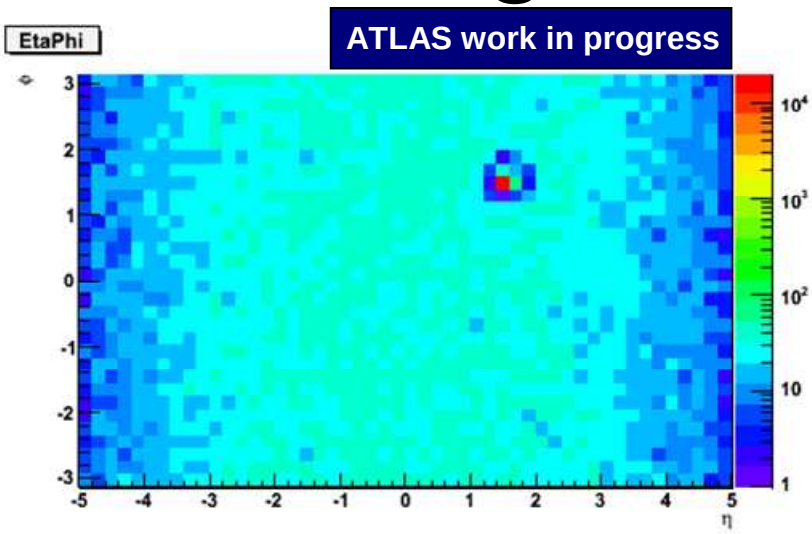
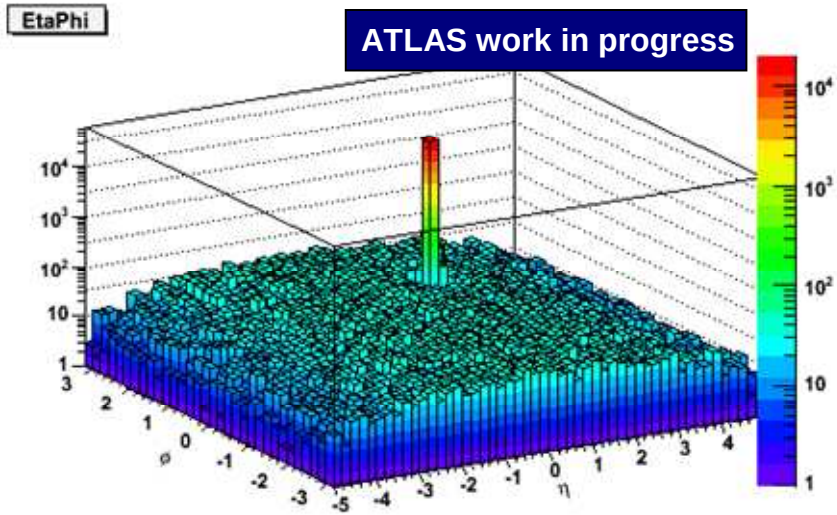


% Reduction	Mean (GeV)
0	82.75
50	69.01
75	62.19
95	61.66
100	61.51

Reduction in dijet mass as more energy lost in FCal.

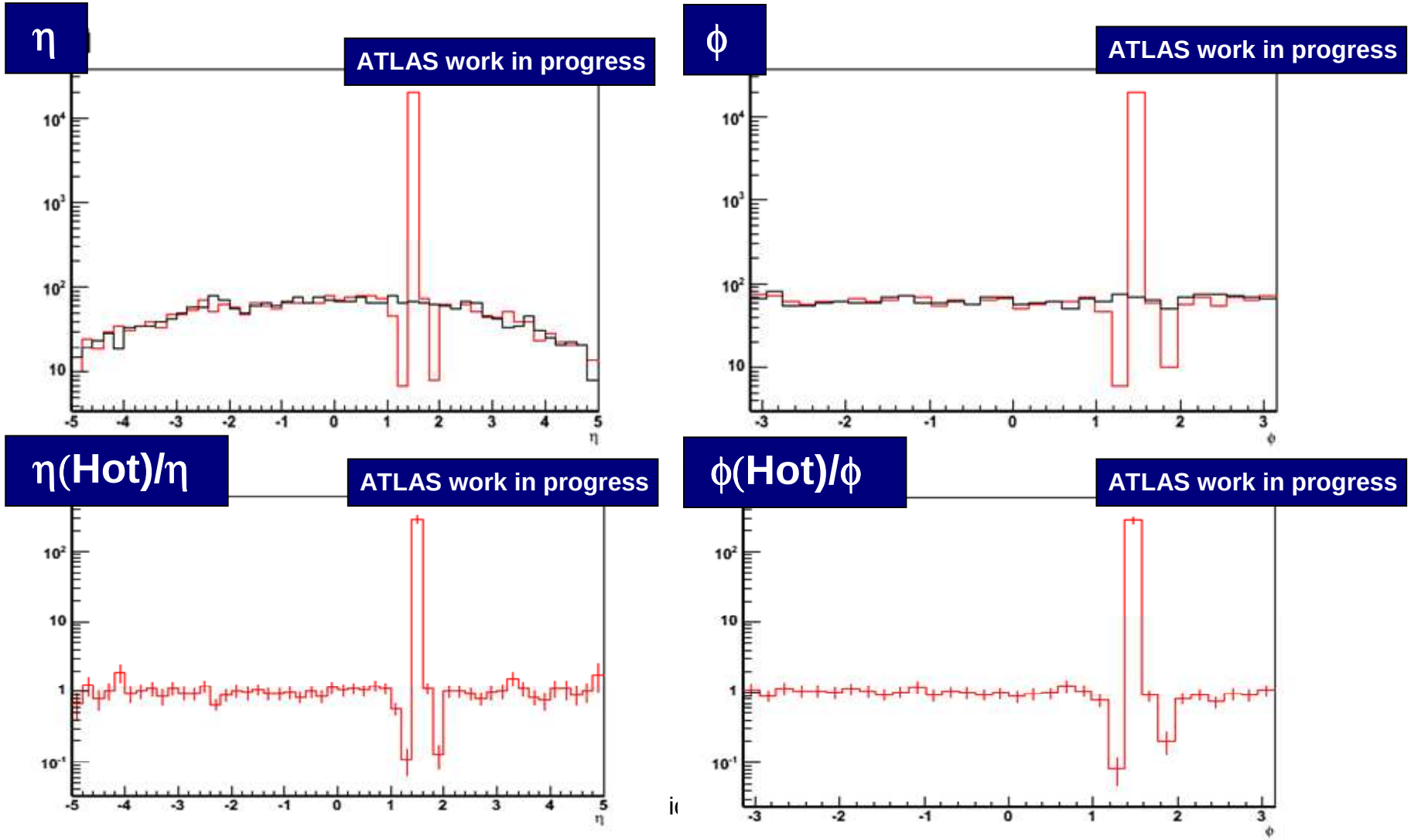
Simulating a hot cell.





- 20K J1 (17-35 GeV) QCD jet events.
- Cell in region $\eta=\phi=1.5$-1.6 set to 50GeV

Eta and phi cross sections



Future plans

- Perform ‘mock-analysis’
- Fake early data with one generator + Atlfast data problems
- Tune to it with a second generator
- Improve atlas modelling very rapidly