# SUSY in DC2
# Plans for the Physics Workshop

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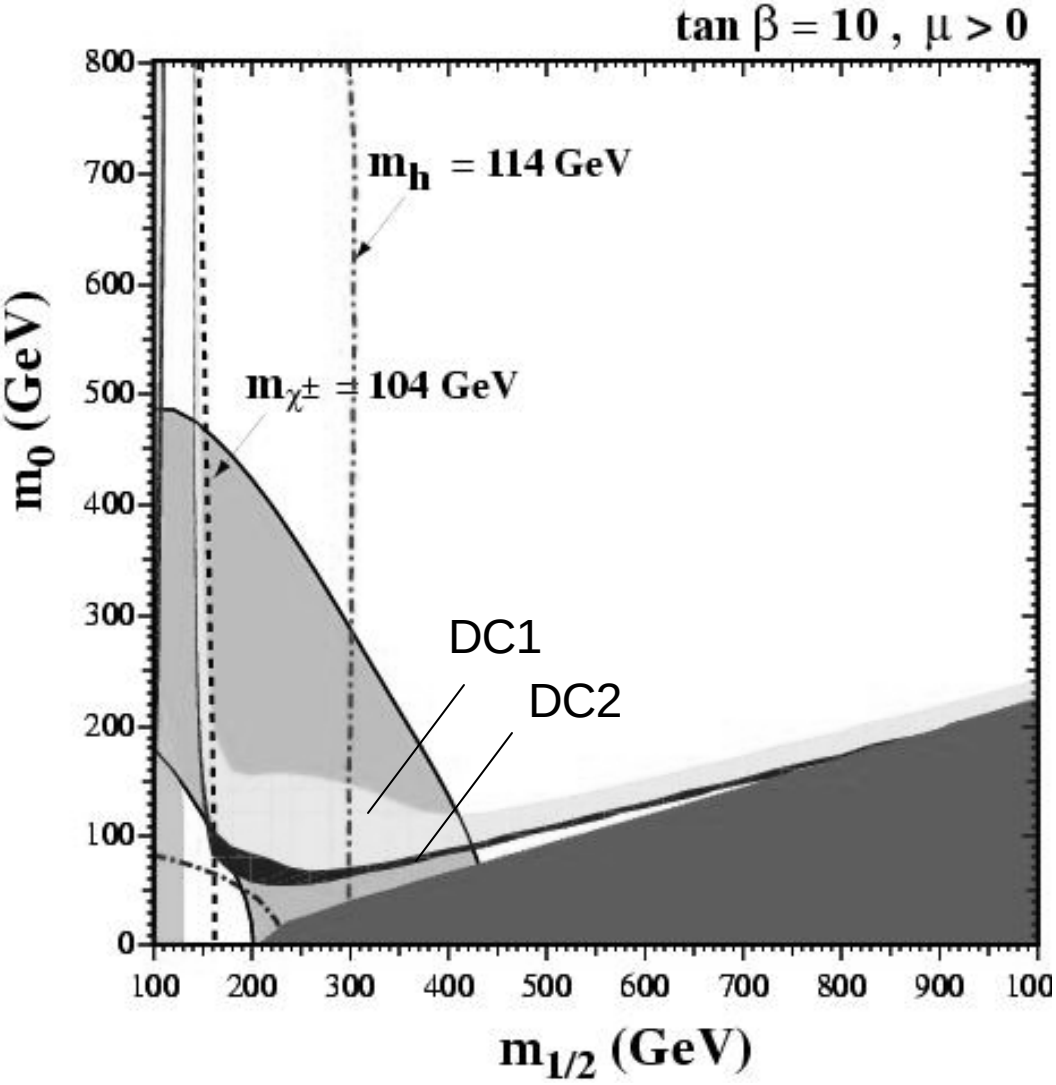
# Introduction

- New SUSY point for DC2 (and beyond)
  - Find a case to be studied (see later)
  - First round with DC2, Summer ’04
  - Physics Week in November ‘04
  - Time scale is the Physics Workshop, Rome, May/June ‘05
  - Add SM background to the plots
- Very good stress-test for the ATLAS offline software. SUSY events have:
  - Lots of Jets and Missing $E_t$
  - B-jets
  - Soft Charged leptons (e, $\mu$)
  - Tau Leptons

# SUSY Case for DC2

Use SUGRA model

DC1 Point shown by Frank last week



# SUSY Case for DC2

Proposed case

$m_0 = 70,\ m_1/2 = 350,\ A = 0,\ \tan\beta = 10,\ \mu = +$

$m_{\tilde{g}} = 832$ GeV, $m_{\tilde{q}} \sim 750$ GeV

Cross section similar to Point 5

$m_{\widetilde{\chi_2^0}} = 261,\ m_{\widetilde{e_L}} = 255,\ m_{\widetilde{e_R}} = 154,\ m_{\widetilde{\chi_1^0}} = 137,\ m_{\widetilde{\tau_2}} = 257,\ m_{\widetilde{\tau_1}} = 146,\ m_h = 116$

It has $\Omega h^2 = 0.09$ favored by WMAP

Also OK with $b \to s\gamma$ if use either $R$ or $\tau$ decay.

Case is much more complicated than previous ones

$BR(\widetilde{\chi_2^0} \to \widetilde{e_R} e) = 2\%$

$BR(\widetilde{\chi_2^0} \to \widetilde{e_L} e) = 29\%$

$BR(\widetilde{\chi_2^0} \to \widetilde{\tau_1} \tau) = 18\%$

$BR(\widetilde{\chi_2^0} \to \widetilde{\tau_2} \tau) = 2\%$

$BR(\widetilde{\chi_2^0} \to \widetilde{\chi_1^0} h) = 48\%$

# Cross Section



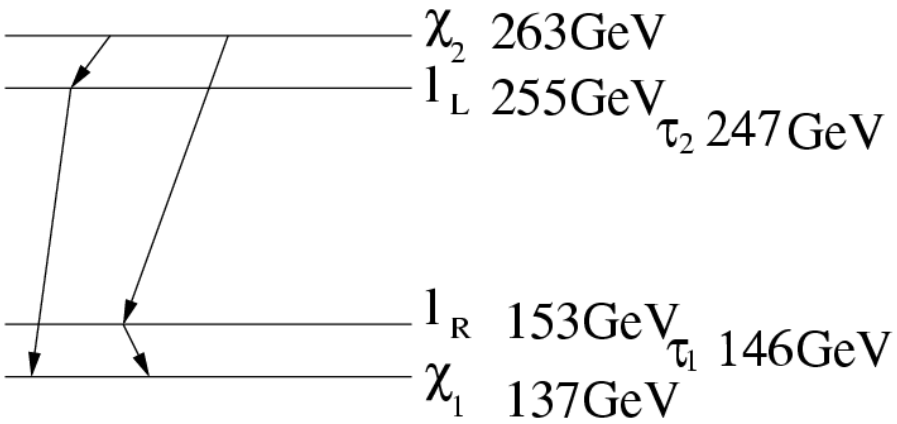
| *Process* | *fb* |
|---|---|
| $pp \rightarrow \tilde{g}\,\tilde{g}$ | 554 |
| $pp \rightarrow \tilde{q}_L\,\tilde{q}_L$ | 665 |
| $pp \rightarrow \tilde{q}_R\,\tilde{q}_R$ | 779 |
| $pp \rightarrow \tilde{q}_L\,\tilde{q}_R$ | 885 |
| $pp \rightarrow \tilde{q}_R\,\tilde{g}$ | 1757 |
| $pp \rightarrow \tilde{q}_L\,\tilde{g}$ | 1620 |
| $pp \rightarrow \tilde{c}_1^{\pm}\,\tilde{q}_L$ | 154 |
| $pp \rightarrow \tilde{l}\,\tilde{l}\ (\ l = e, m\ )$ | 15 |
| $pp \rightarrow \tilde{c}_1^{\pm}\,\tilde{c}_1^{\pm}$ | 140 |
| $pp \rightarrow \tilde{c}_1^{\pm}\,\tilde{c}_2^{0}$ | 258 |
| $pp \rightarrow \tilde{b}_1\,\tilde{b}_1$ | 160 |
| $pp \rightarrow \tilde{b}_2\,\tilde{b}_2$ | 32 |
| $pp \rightarrow \tilde{t}_1\,\tilde{t}_1$ | 49 |
| $pp \rightarrow \tilde{t}_2\,\tilde{t}_2$ | 38 |

Total X-sec = 7.8 pb

- ***All numbers from Herwig output***

# Full Simulation Needed






$\chi_2 \rightarrow l_L\, l \rightarrow l\, l\, \chi_1$

$\chi_2 \rightarrow l_R\, l \rightarrow l\, l\, \chi_1$

Slow Leptons expected in this case (includes tau's)

Fast simulation to give a first preliminary indication

Full Simulation needed.

-- Tracking performances are critical

-- Hadronic tau's not properly reconstructed with Atlfast

Repeat an exercise similar to DC1, more events, background simulation

# Atlfast Studies for the SUSY-DC2 point

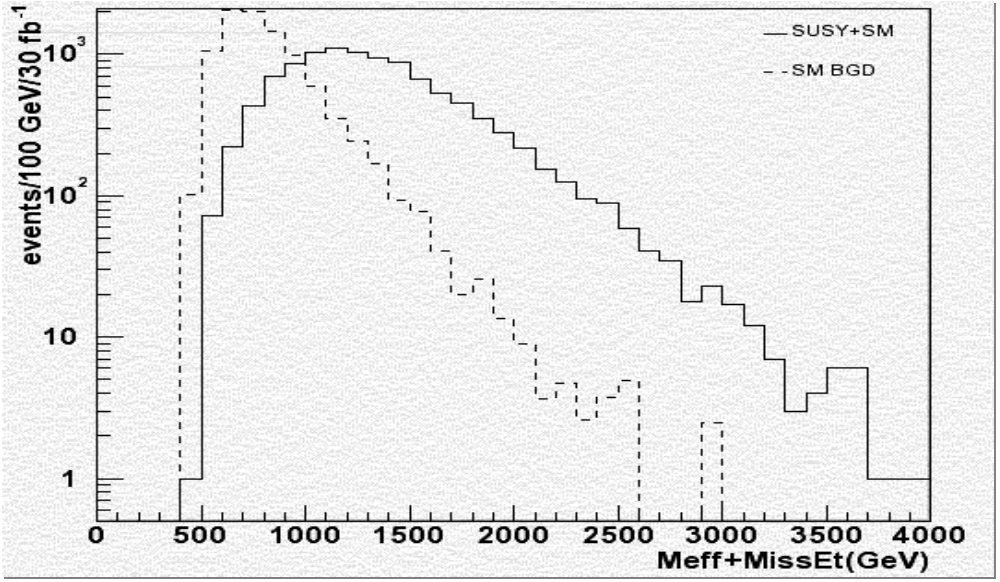


- First iteration with the fast simulation, to better understand the Physics involved
  - I will show some fast simulation results for this case (G. Comune, Bern)
  - Atlfast is good starting point for people willing to start with ATLAS Physics.
  - Now possible to use also on a "non-CERN" environment, Install Kit
- Some more Generators studies needed before we embark into Full Simulation
  - Tau polarization to be checked. We use tauola.
  - Underlying Event tuning. Herwig UE is softer than Pythia
  - Time scale for this is a few weeks
- More Physics signature are present in this channel:
  - Look for $\chi_4$ decays to Higgs

# Effective Mass

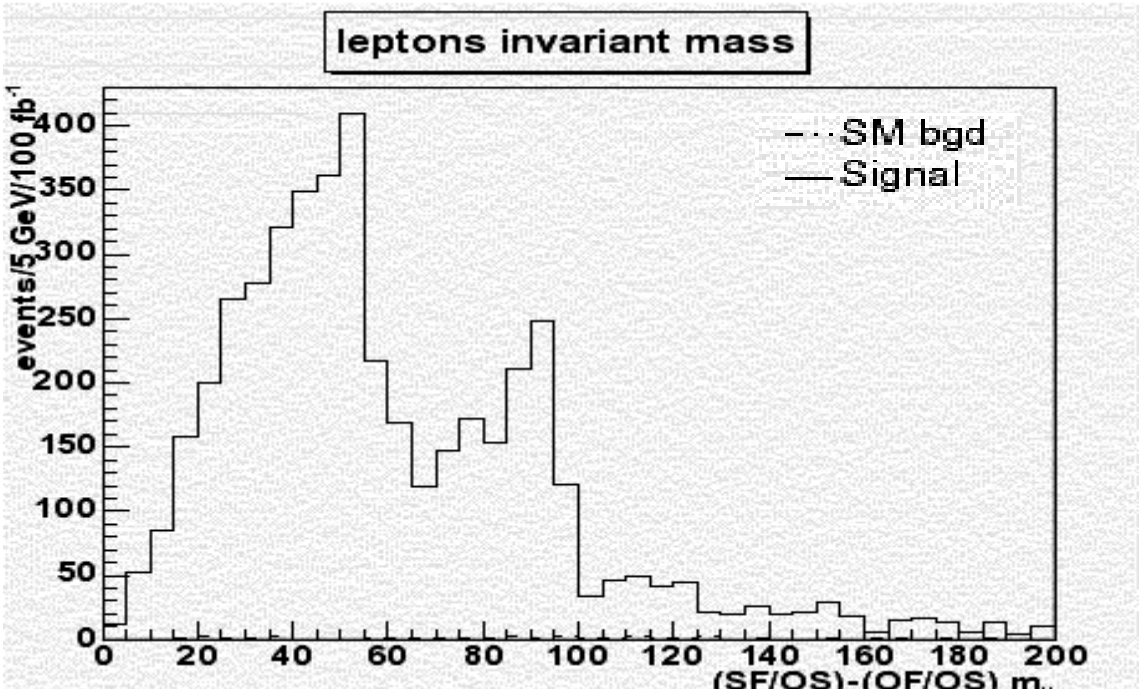
$M_{eff} = P_{t,1} + P_{t,2} + P_{t,3} + P_{t,4} + \not{E}_T$

Used to give a "first evidence" of SUSY




- Missing $E_T$>100 GeV
- 4 jets $P_T$>100
- No isolated electron/Muon

# Dilepton invariant mass



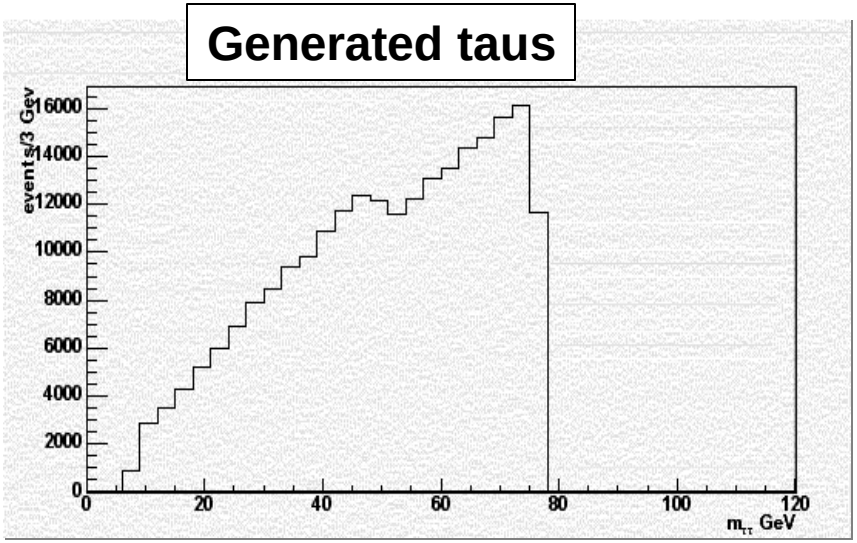

Cascade decay $\tilde{\chi}_2^0 \to \tilde{\ell}^{\pm}\ell^{\mp} \to \tilde{\chi}_1^0 \ell^+ \ell^-$ gives endpoint at

$$M_{\ell\ell}^{\max} = \frac{1}{M_{\tilde{\ell}}} \sqrt{(M_{\tilde{\chi}_2^0}^2 - M_{\tilde{\ell}}^2)(M_{\tilde{\ell}}^2 - M_{\tilde{\chi}_1^0}^2)}$$

# Tau tau invariant mass

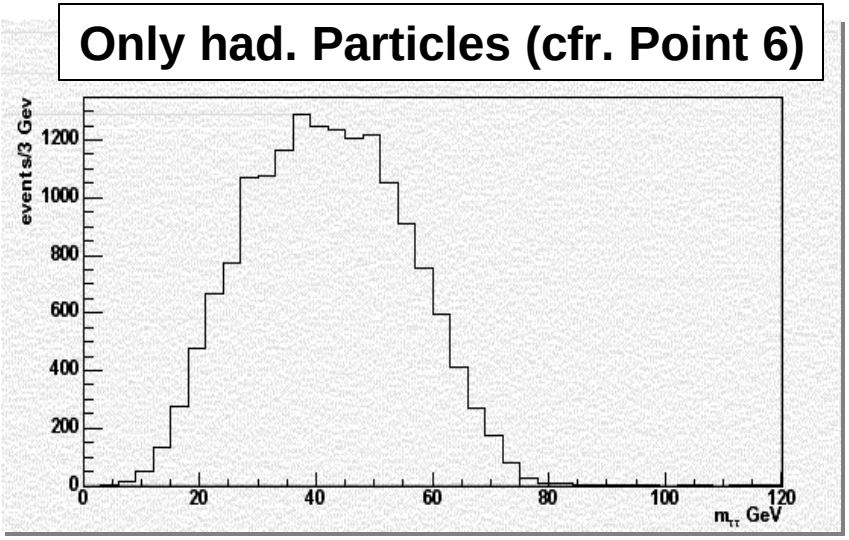
$$q_L \rightarrow c_2^0 + q; c_2^0 \rightarrow t_{1,2}^{\pm} + t^{\mu}; t_{1,2}^{\pm} \rightarrow t^{\pm} + c_1^0 \qquad m_{\tilde{t}_1} - m_{c_1^0} \approx 10 GeV$$

**Generated taus**




(Only signal initial MC)

**Only had. Particles (cfr. Point 6)**

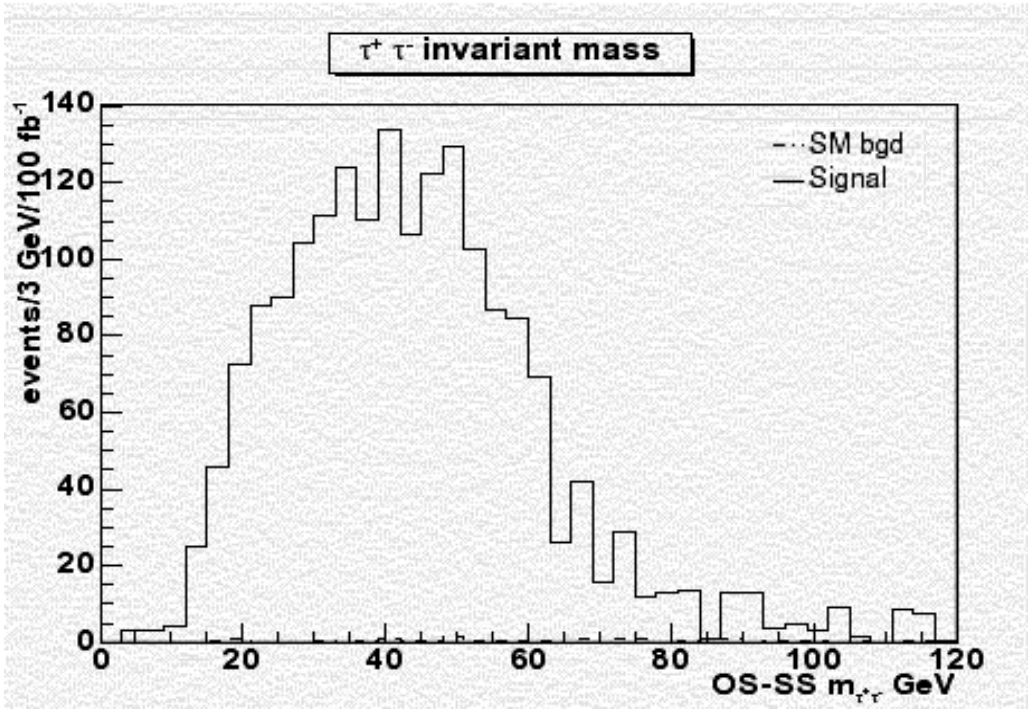



(Only signal reconstructed)

$$BR(c_2^0 \rightarrow t_1^{\pm} + t^{\mu}) \sim 19\%$$

$$BR(c_2^0 \rightarrow t_2^{\pm} + t^{\mu}) \sim 2\%$$

# Tau tau invariant mass (Atlfast)




$$m_{t^+t^-}^{\max} \cong 79 \ GeV$$

Model of hadronic tau in ATLFAST is not reliable (needs work)

# SUSY Full Simulation Work



- Getting ready to do Physics in a more "realistic" way (w.r.t. fast simulation)
  - Big (disk space) data sets
  - Long processing time
  - Several collaborators, over different time zones
- Learned from DC1:
  - Information and analysis code sharing
  - C++ analysis instead of fortran
  - More ATLAS-wide analysis tools needed
  - Use of the SM background will make life more difficult
- The "old" DC1 point and the "new" point are in the list of DC2 productions
  - Need to look at the events as we did during DC1
  - Possibly get ready for another round of processing next fall

# More Work to do on SUSY

**http://paige.home.cern.ch/paige/susy/susytopics.html**

| Point | Comments |
|---|---|
| 1a | Similar to ATLAS Point 5, somewhat softer. |
| 1b | $chi_2^0$ and $chi_1^+$ decay maintly to tau. Need good experimental control of hadronic tau decays. Not many signatures. |
| 2 | Focus point region. |
| 3 | Coannihilation region with very light sleptons. $chi_2^0$ decays to a mixture of leptons, taus, and higgs. Soft single leptons. Nice signatures, comparatively easy. |
| 4 | High tan(beta), so $chi_2^0$ -> $chi_1^0$ Z dominant. Lots of t,b from gluino decays. Could start with gluino -> $b_1$ -> $chi_2^0$ -> $chi_1^0$ decay chain. Clear signatures. |
| 5 | Very light stop, produced both directly and through gluino -> stop top. Somewhat hard but instructive. |
| 6 | Non-unified $m_1$, $m_2$, $m_3$. Chosen to be difficult due to degeneracy of $chi_1^0$ with $chi_2^0$ and $chi_1^+$. |

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Some work is still needed for the point studied in DC1:

A few problems observed in the invariant mass distributions (see Frank's talk)

The same case re-simulated with DC2, for validation purposes

# DC2: Scenario & Time scale



**September 03: Release7**

**Put in place, understand & validate**:

- **Geant4; POOL; LCG applications**
- **Event Data Model**
- **Digitization; pile-up; byte-stream**
- **Conversion of DC1 data to POOL; large scale persistency tests and reconstruction**

**Testing and validation**

- **Run test-production**

**March 17th: Release 8 (production)**

**Start final validation**

**May 3rd 04:**

**Start simulation; Pile-up & digitization**
**Event mixing**
**Transfer data to CERN**

**July 1st 04: "DC2"**

**Intensive Reconstruction on "Tier0"**
**Distribution of ESD & AOD**
**Calibration; alignment**

**August 1st:**

**Start Physics analysis**
**Reprocessing**

# The next year

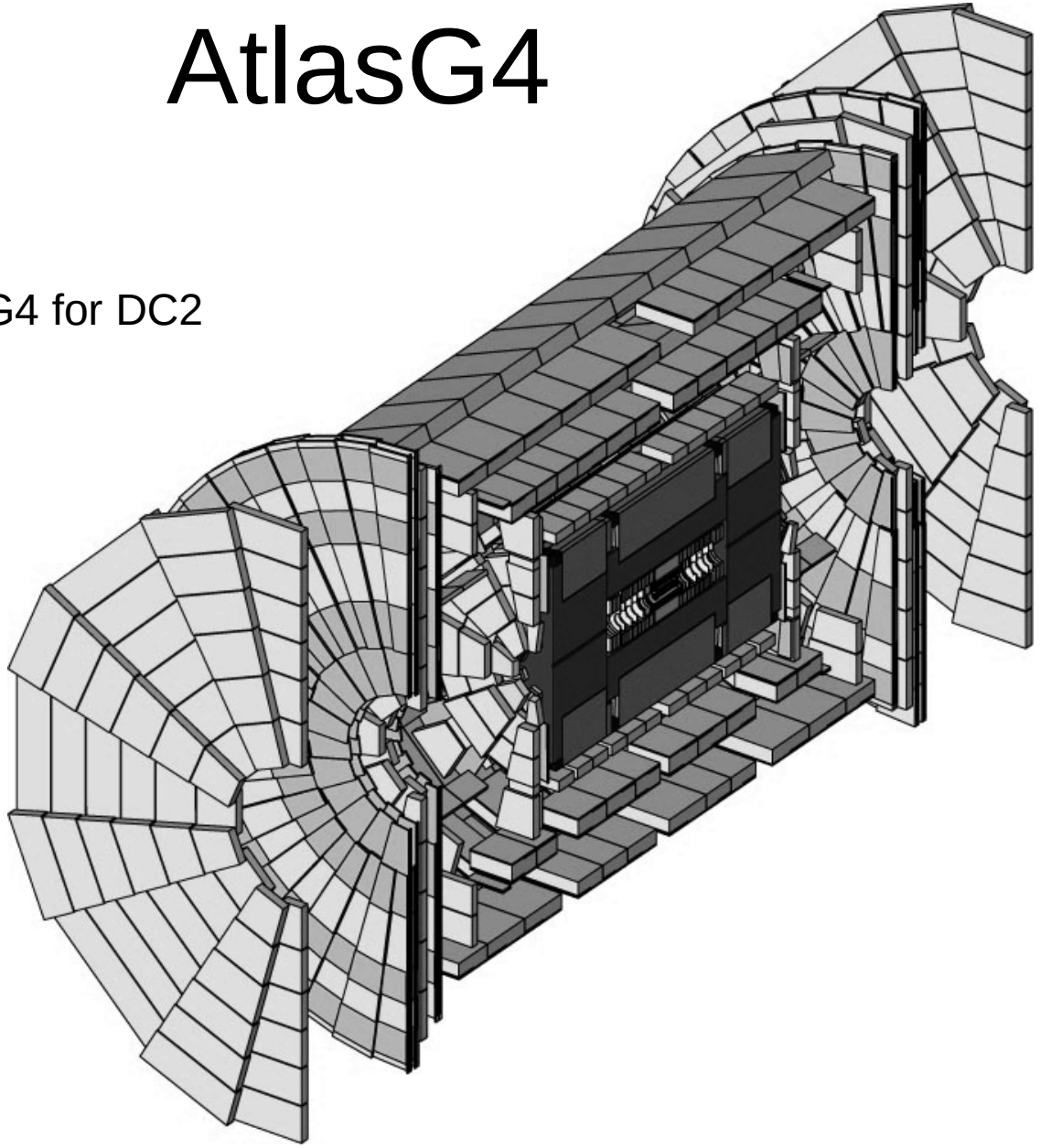
- Data Challenge 2 to start on May 3rd
  - Goal to simulate and reconstruct $10^7$ events in ~ 2 months
  - Computing Model TDR
  - Extensive use of Grid tools
  - A new set of production tools (db, event replica, …)

- New things in DC2:
  - Simulation using Geant4 (C++) instead of Geant3(F77)
  - New Digitization package
  - Improved and more modular Reconstruction
  - Pool persistency mechanism (to replace Zebra in DC1)
  - Major validation needed. Validation group.

- After DC2, before the Physics workshop (Summer 05):
  - Better understanding of the ATLAS simulation and Reconstruction
  - Test-beam running this summer
  - Events simulation will continue (~50M events after DC2)
  - Physics full simulation studies to start after the summer

# AtlasG4

ATLAS moving to G4 for DC2



**Class A:**

1M top (weight=2.92) Joboptions file 100K processed via atlfast Ntuple Right mouse click on link then "Save Link Target as"... sample will be made with MC@NLO/Herwig. Note that this is an unbiased top sample.

3M Z (to e mu and tau), no pt cut. (weight=1). JobOptions file Note that Tauola is on 300K processed via atlfast Ntuple3

1M W (to leptons) MC@NLO used as this will give good representation of W+2 jets.

0.5M Z+jet sample (cuts not yet defined)

0.25M dijets (pt>600) (weight=1.36) JobOptions file 50K processed via atlfast Ntuple

0.25M W(to leptons) +4 jets with Alpgen. Approximate cuts are p_T>15 GeV for jets and

0.5M QCD events filtered to provide a sample with at least 1 b-jet with pt>15 and eta<2.5

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**Class B:**

1 M jets (pt>180) (Weight= 0.001) JobOptions File 200K processed via atlfast Ntuple1

0.2 M gamma+jet (p_t>20) (Weight=0.00125) JobOptionsfile 50K processed via atlfast Ntuple

0.25M bb->B->Jpsi(mu6mu3)K0*(K+pi-)

1M jets with (p_T>17), prefiltering to provide sample of e/gamma fakes. Weight depends on Filter.

50K gamma_jet prefiltering to provide sample of gamma- gamma fakes. Weight depends on Filter.

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Physics samples (These are almost Class A)

20K susy coanihilation point
20K DC1 susy
100K Higgs to tau tau
200K Other Higgs

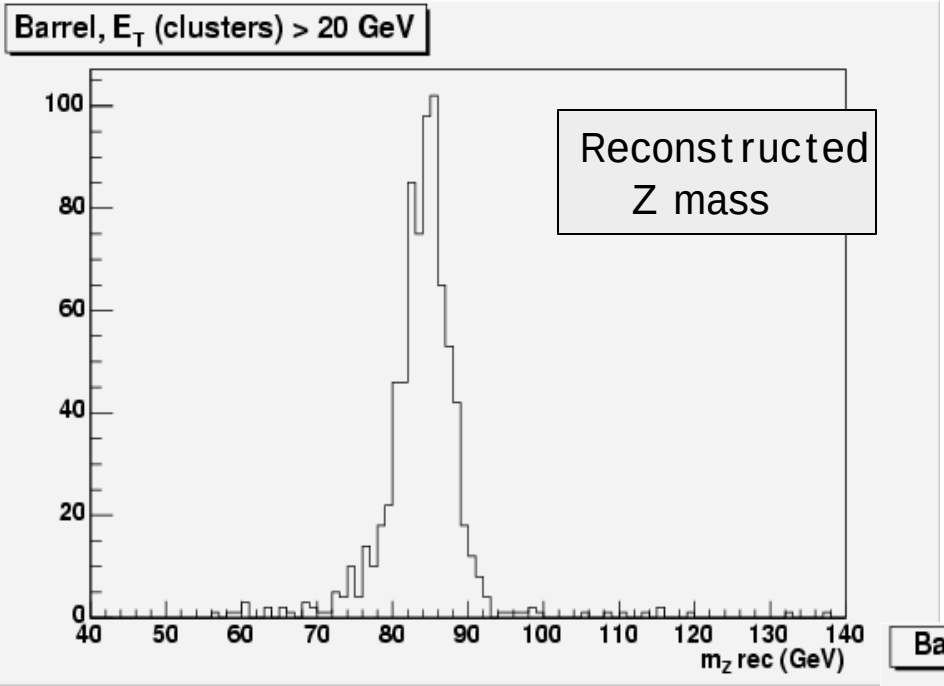
# The Physics Validation Group

- The DC1 experience proved this useful. Exchange information between the Physics groups and between the Physics and the Software communities
  - Meets every 2 weeks. Next meeting on 4/28, contact DCostanzo@lbl.gov

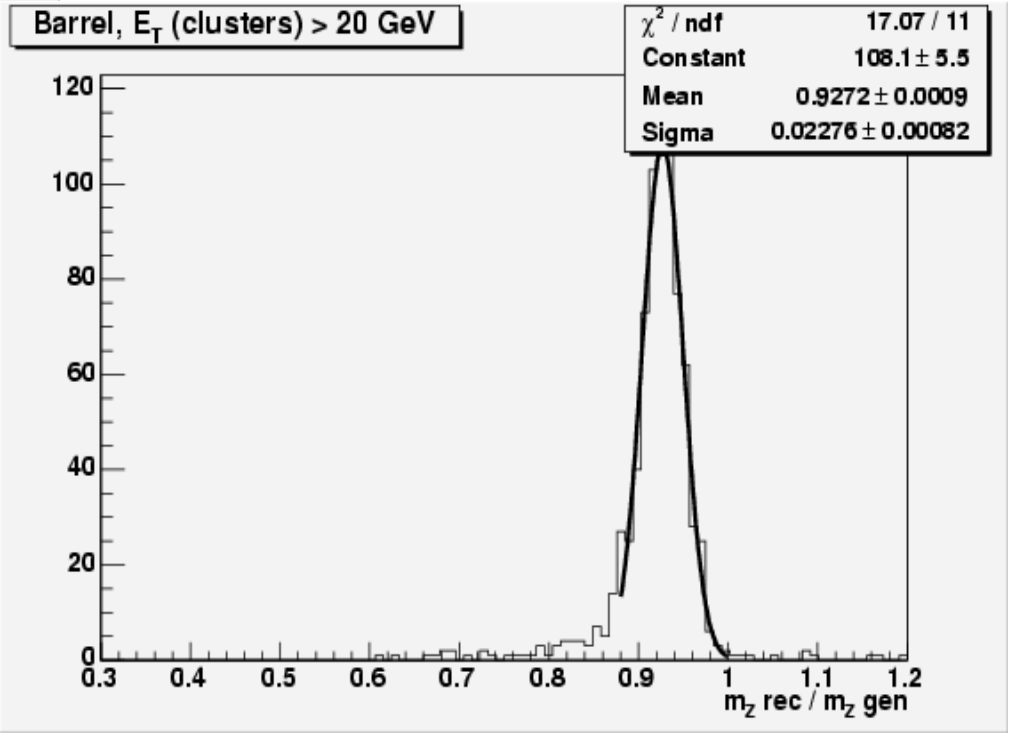
- Three main activities:
  - Reconstruction of DC1 events using the "old" Zebra Events
  - Validation of Generators, readiness for the Events generation part of DC2.
  - Reconstruction of Geant4 events in preparation for DC2

- Validation plan for the next year or so
  - The DC1 experience proved this useful. Exchange information between the Physics groups and between the Physics and the Software communities
  - Now, ~100s of events: Spot obvious problems
  - From now to the summer, $10^6$ of events: Real Validation of the detector performances
  - After the summer, $10^7$ of events: Getting ready for the Physics workshop

# Now Showing at the Validation Meetings




Reconstructed / generated Z mass




First G4 simulations of complete ATLAS events seem to work very well (although many details need to be checked ..)

# How to get started…



Remarks and feedback from a low-level-user: (Fabiola 4/14)

- Documentation is not perfect … but several helpful tools:
  -- ATLAS Software Developer's Guide
  (it's what you need to start with CMT and ATHENA …)
  -- ATHENA Developer Guide :
  a little old (2001 …) but very useful to understand things
  in detail (if you know already something …)
  -- some very good / useful WEB pages
  (e.g. RecExample, LXR source code browser, …)
  -- standard jobOptions of the various packages

Learning how to run ATLAS Software is easy.

-- Learning how to configure ATLAS Software is quite painful
(you need to invest at least one month-FTE of your time) … but not impossible.
Note: needs continuity in the effort, at least at the beginning

# Conclusion

- Full Simulation studies are useful (but require a lot of effort)
- We identified the next exercise to be studied. Interesting Physics and Detector performance issues
- There is much more to do and to say, about SUSY and about ATLAS Physics in general. Follow-up discussion
- Link between Physics studies and Software validation