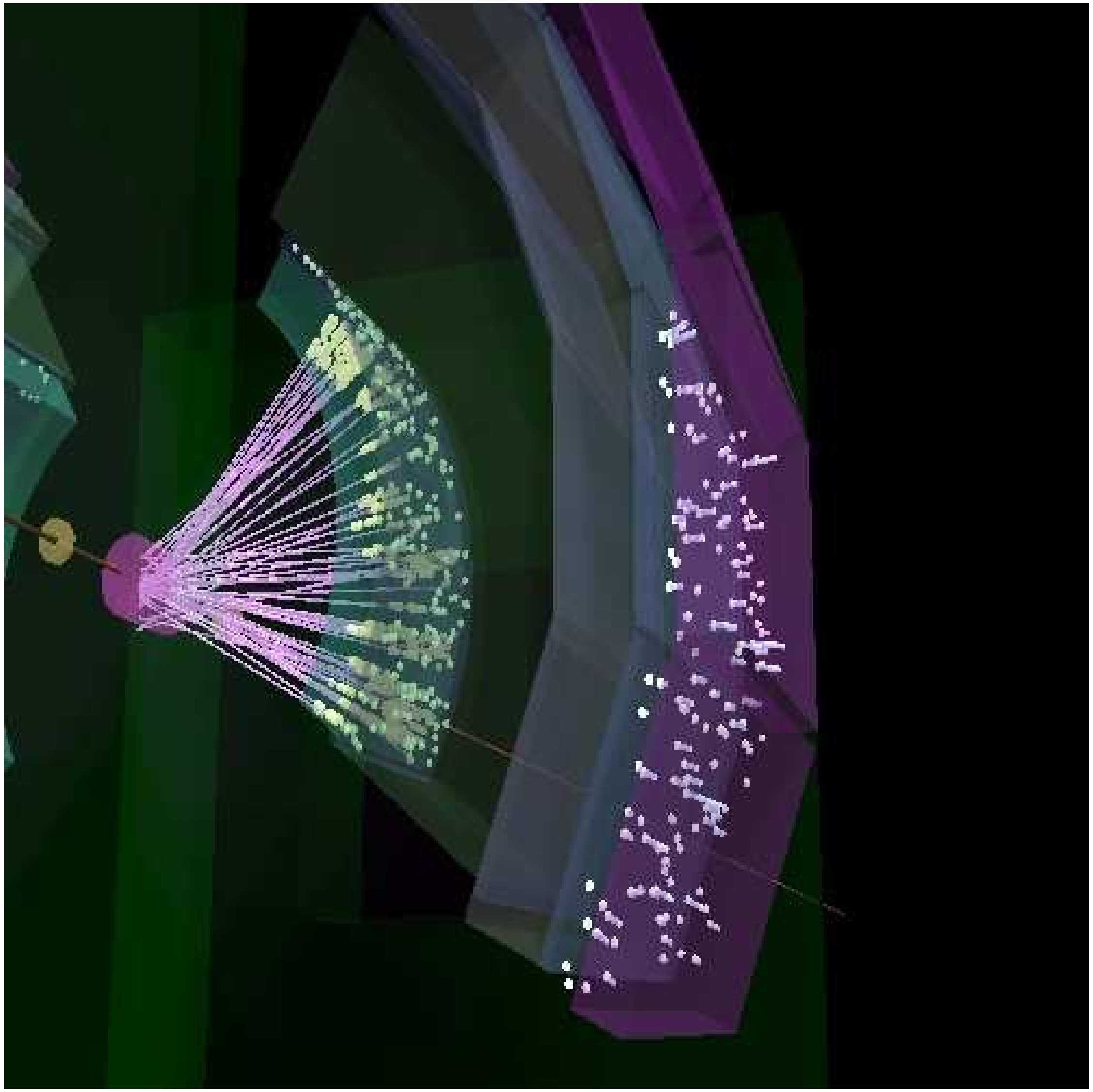
Event-by-event fluctuations in Mean p_t and Mean e_t in PHENIX



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for the PHENIX Collaboration

RHIC/INT Winter Workshop

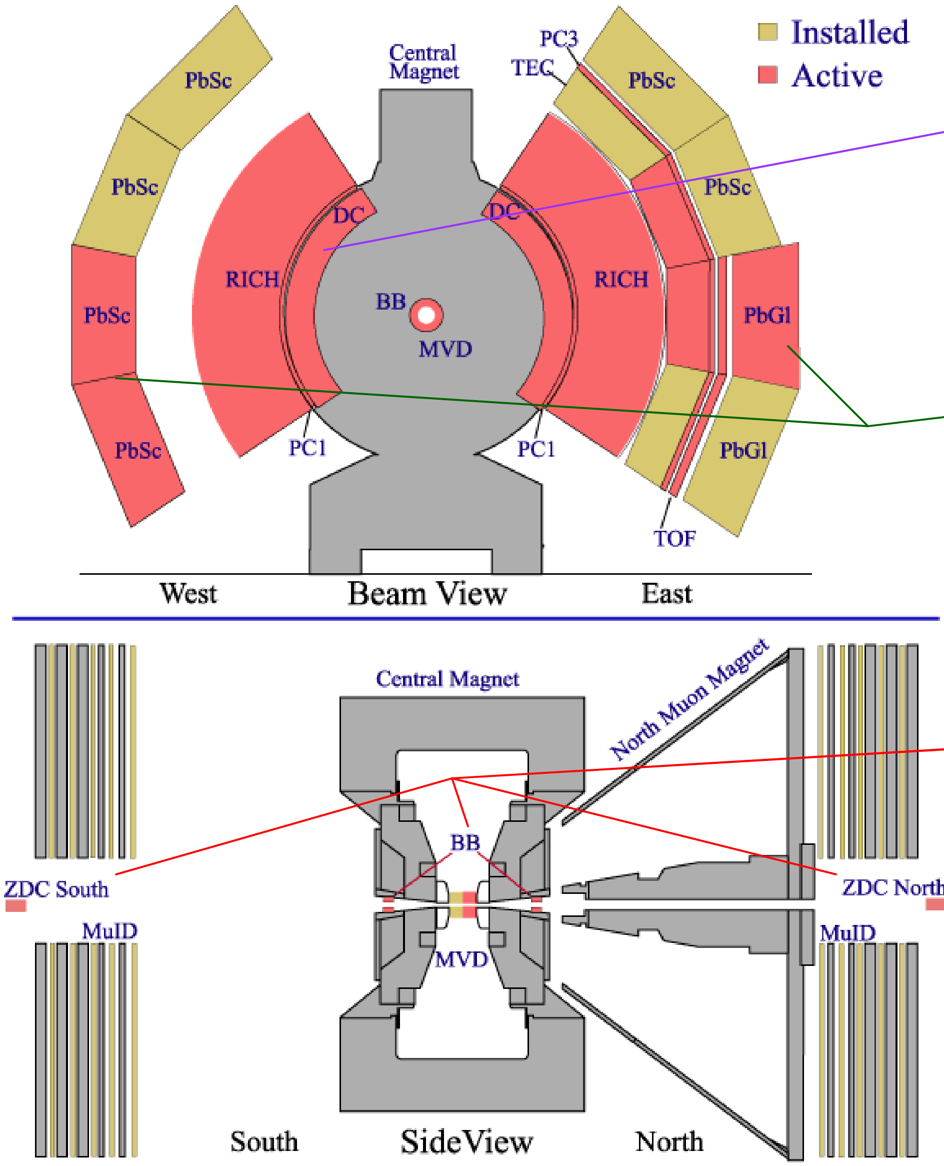
Seattle, WA

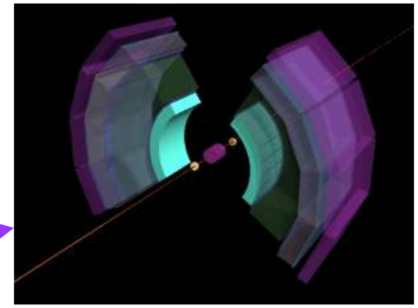
1/5/02

Outline

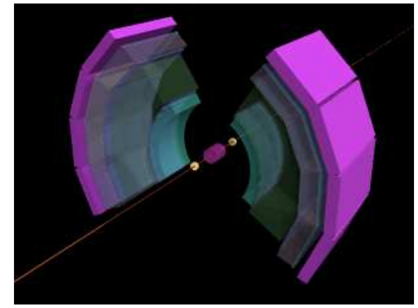
- **Analysis**
- **Results**
- **Sensitivity**
- **Conclusions**
- **Outlook**

PHENIX for Fluctuations, RHIC Run of the Summer 2000

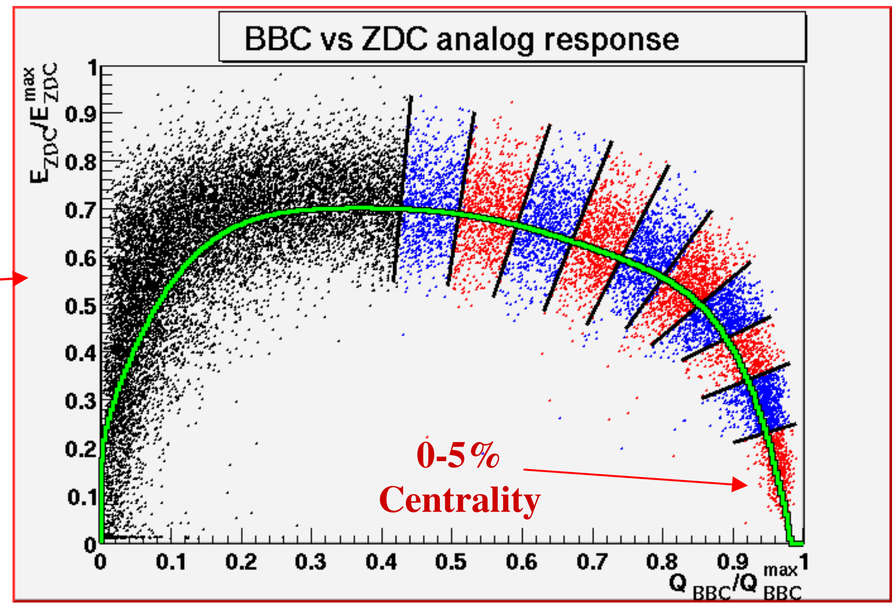




Drift Chamber: Mean p_t



Calorimeters: Mean e_t



Centrality Selection

Analysis Details...

Data:

• The mean p_t and e_t are determined on an event-by-event basis:

$$Mp_t = \Sigma\, p_{t,\,i}/N_{pt} \quad Me_t = \Sigma\, e_{t,\,i}/N_{et}$$

200 MeV/c < p_t < 1.5 GeV/c, 225 MeV < e_t < 2.0 GeV

• *An event must have at least 10 tracks/clusters per event to be included in the mean distribution.*

Mixed Events:

• Mixed event distributions are built from reconstructed tracks/clusters in real events from the same centrality/multiplicity class.

• *No 2 tracks/clusters from the same real event are allowed in the same mixed event.*

• *The number of tracks/clusters distribution, N_{pt} or N_{et}, in mixed events are sampled from the data N distribution.*

Dataset Statistics

Small apertures in the PHENIX central arm spectrometers, but particles are plentiful in RHIC Collisions…

Acceptance: $\eta<|0.35|$, $\Delta\phi \sim 45^0$

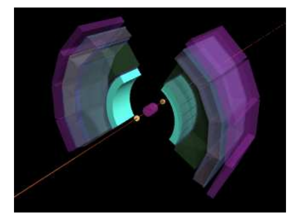
NOTE: Distributions are left uncorrected for static acceptance/efficiency

Statistics for the 0-5% centrality class:

Mean p_t analysis:

$N_{events} = 72692$, $\langle N_{tracks}\rangle = 59.6$, $\sigma_{Ntracks} = 10.8$

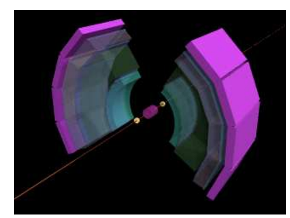
$\langle M_{pt}\rangle = 523$ MeV/c, $\sigma_{Mpt} = 38.6$ MeV/c, $\sigma_{pt} = 290$ MeV/c



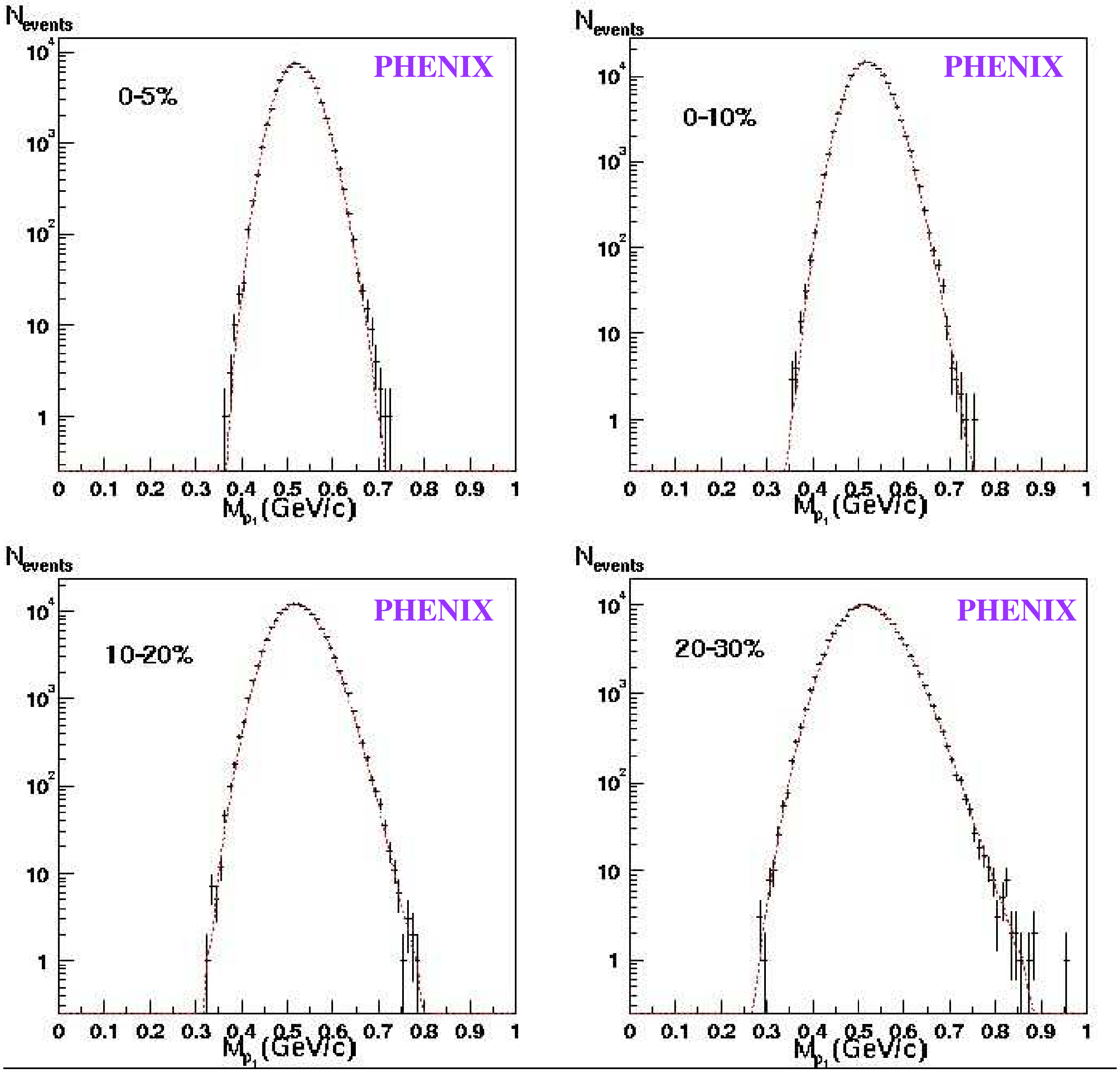
Mean e_t analysis:

$N_{events} = 69224$, $\langle N_{clusters}\rangle = 68.6$, $\sigma_{Nclusters} = 11.6$

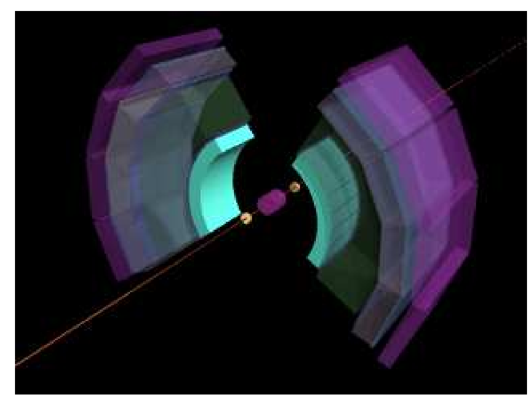
$\langle M_{et}\rangle = 466$ MeV, $\sigma_{Met} = 34.1$ MeV, $\sigma_{pt} = 267$ MeV



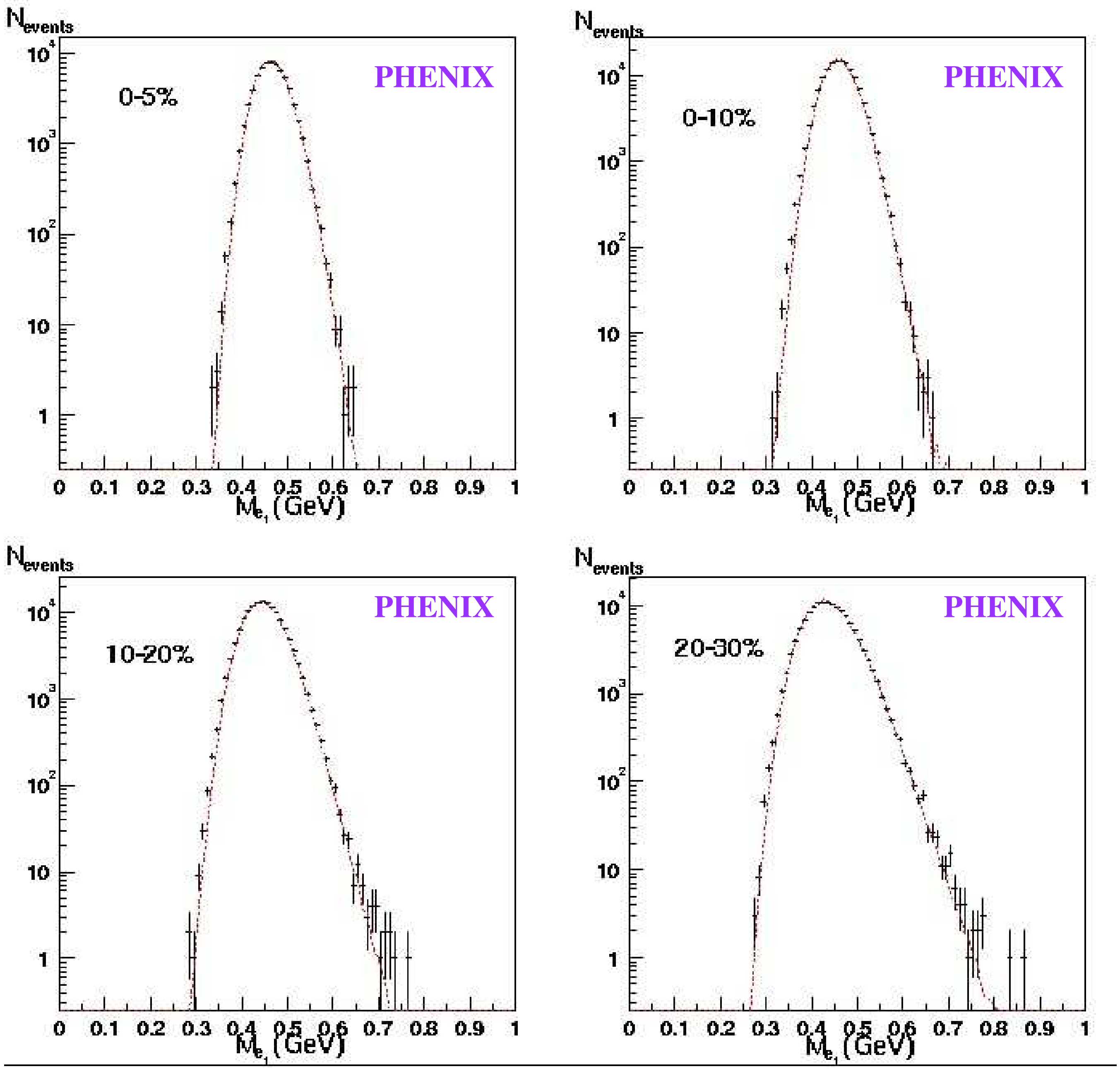
Mean p_t Distributions



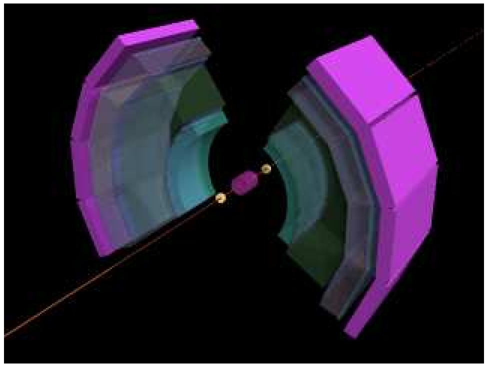
Mixed Event Distribution



Mean e_t Distributions



Mixed Event Distribution



Quantifying the Fluctuations

Define the magnitude of a fluctuation, ω_t:

$$\omega_t = \frac{\sqrt{<X^2> - <X>^2}}{<X>} \times 100\% = \frac{\sigma_{M_X}}{\mu_{M_X}} \times 100\%$$

Define the fractional fluctuation difference from random, F_t:

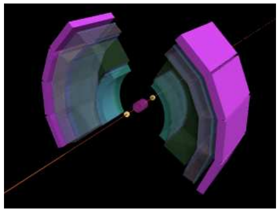
$$F_t = \frac{(\omega_{data} - \omega_{random})}{\omega_{random}}$$

F is related to the fluctuation variable ϕ via:

$$\phi = \sqrt{n}\left(\sigma_{data} - \sigma_{random}\right) = F_t \times \sigma_{inclusive}$$

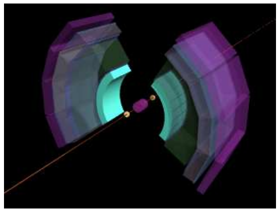
PHENIX Fluctuation Results

Centrality class	$\omega_{(t,\ data)}$ (%)	F_t (%)	ϕ_{p_t} (MeV/c)
0 - 5 %	7.37 ± 0.10	1.9 ± 2.1	5.65 ± 6.02
0 - 10 %	7.85 ± 0.13	2.0 ± 2.5	6.03 ± 7.28
10 - 20 %	9.52 ± 0.14	2.1 ± 2.2	6.11 ± 6.63
20 - 30 %	11.7 ± 0.21	1.8 ± 3.0	5.47 ± 9.16



Mean P_t

Centrality class	$\omega_{(t,\ data)}$ (%)	F_t (%)	ϕ_{e_t} (MeV)
0 - 5 %	7.32 ± 0.07	4.3 ± 1.3	11.5 ± 3.59
0 - 10 %	7.84 ± 0.08	5.0 ± 1.6	13.6 ± 4.23
10 - 20 %	9.58 ± 0.17	4.2 ± 2.2	11.1 ± 5.75
20 - 30 %	11.8 ± 0.26	3.5 ± 2.8	9.28 ± 7.34



Mean E_t

PHENIX Sensitivity: Modelling a fluctuation

Goal: Produce a fluctuation that does not change the mean or variance of the final inclusive distribution.

- The final inclusive distribution (fixed by observation) can be expressed as:

$$\frac{dN}{dp_t} = \Gamma(p_t, p, b)$$

where T = 1/b is the *inverse slope parameter* of the distribution.

- Consider an event sample with two classes of events.

Define $q = N_{\text{events, class 1}} / N_{\text{events, total}}$

- The distribution for the two component fluctuating sample can be taken as:

$$f(p_t) = q \times \Gamma(p_t, b1, p1) + (q-1) \times \Gamma(p_t, b2, p2)$$

Modelling a fluctuation

Goal: Produce a fluctuation that does not change the mean or variance of the final inclusive distribution.

- We consider two models of this type:
  - Fluctuation Model A: *The inclusive distributions of the two event classes have the same mean, but different variance.*
  - Fluctuation Model B: *The inclusive distributions of the two event classes have the same variance, but different means.*
- After applying the constraints for each model, two event classes are defined with differing inverse slope parameters.

$$\text{Define } \Delta T = T_{\text{class 1}} - T_{\text{class 2}} > 0$$

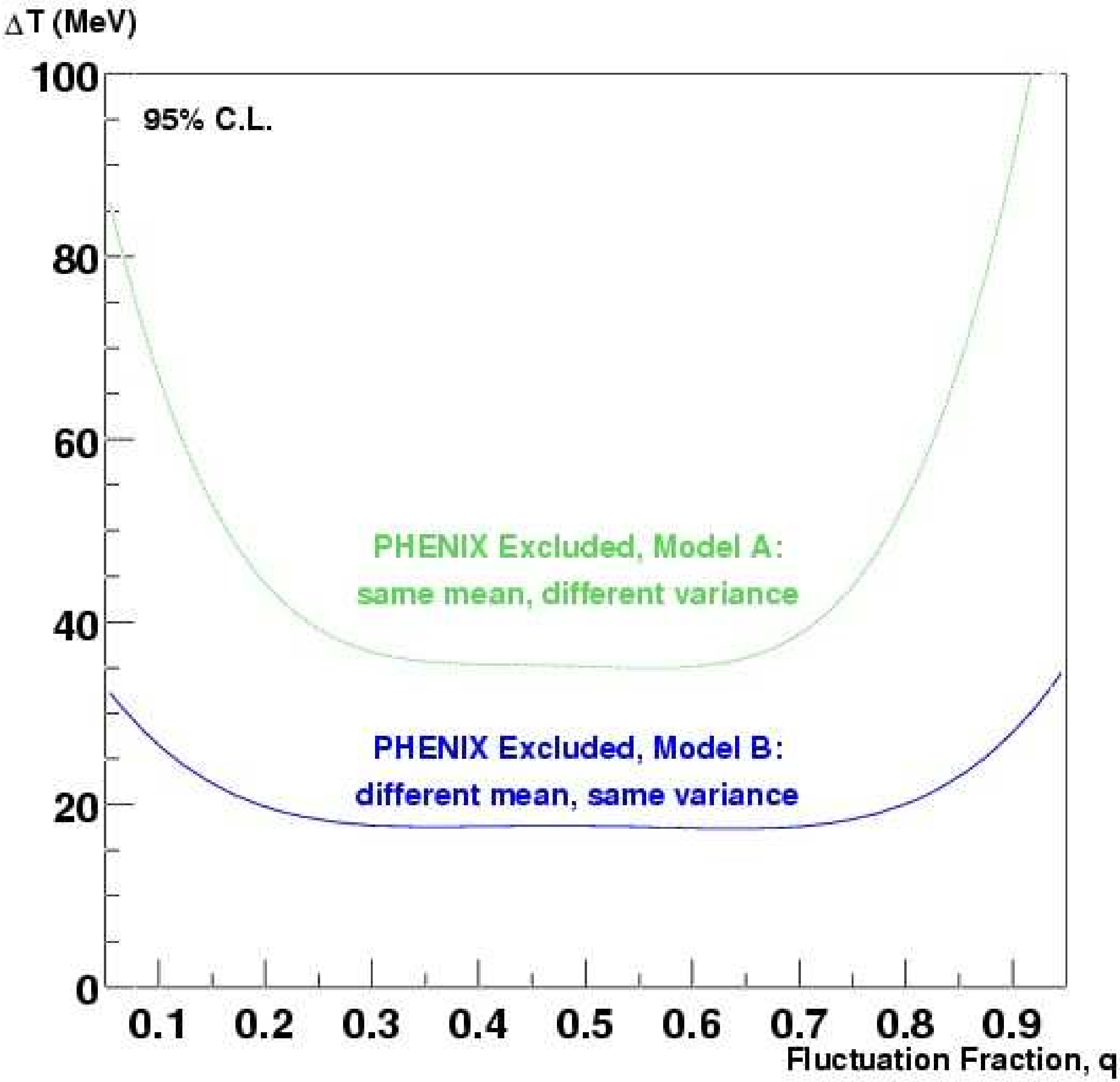
Determining the Fluctuation Sensitivity

Simulation for Statistically Independent Emission:

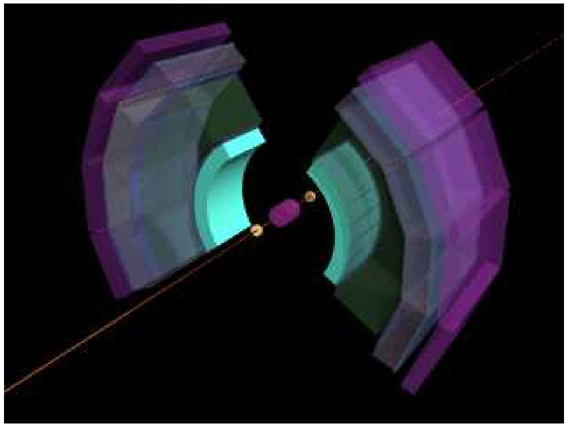
MEAN MAX

- Determine the number of events by sampling a Gaussian distribution fit to the mixed event data.
- Generate inclusive spectra by sampling the appropriate Gamma distribution. Non-fluctuating baseline generated from a fit to mixed event data.
- Calculate the mean p_t over a given number of events, accounting for cuts on data such as p_t range.
- For sensitivity, scan over q and ΔT. A chi-square test is performed against the mixed event data to determine a 95% Confidence Level.

PHENIX Mean p_t fluctuation Sensitivity



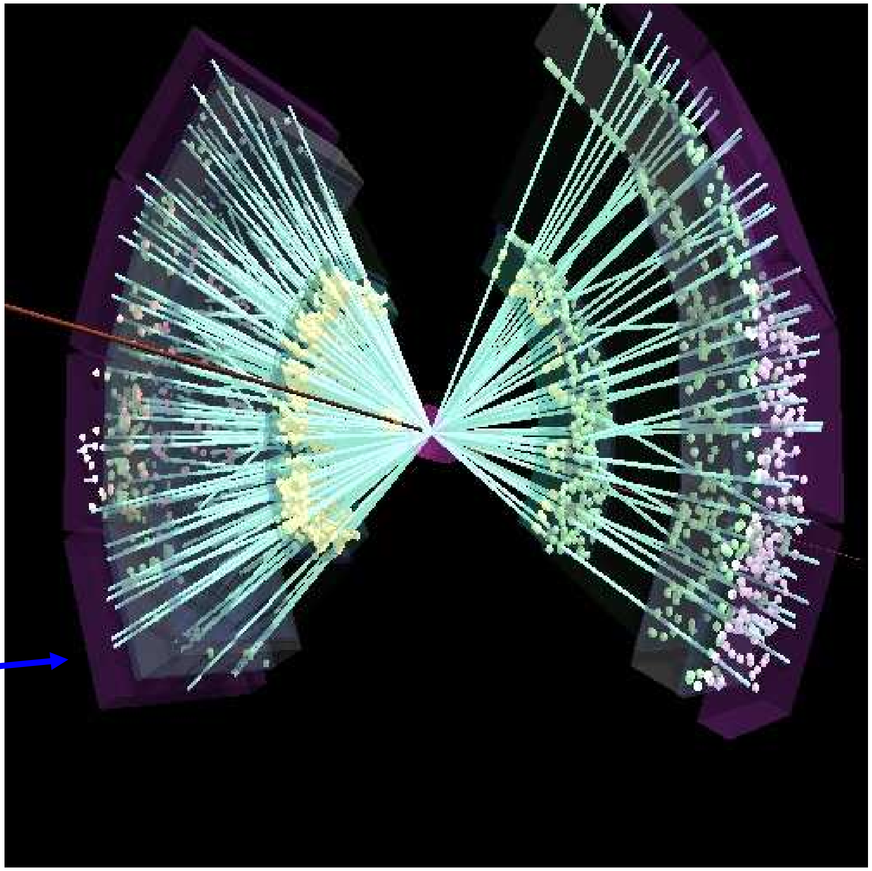
PHENIX



Conclusions and Outlook

Conclusions:

- There are no *significant* non-random fluctuations in Mean p_t or Mean e_t over the most 30% central $\gamma = 130$ Au+Au collisions within the PHENIX acceptance.
- All event-by-event spectra are well described by the semi-inclusive spectra accounting for known detector effects.
- Given simple dual event class fluctuation models, limits have been set on the level of fluctuations based upon these measurements.

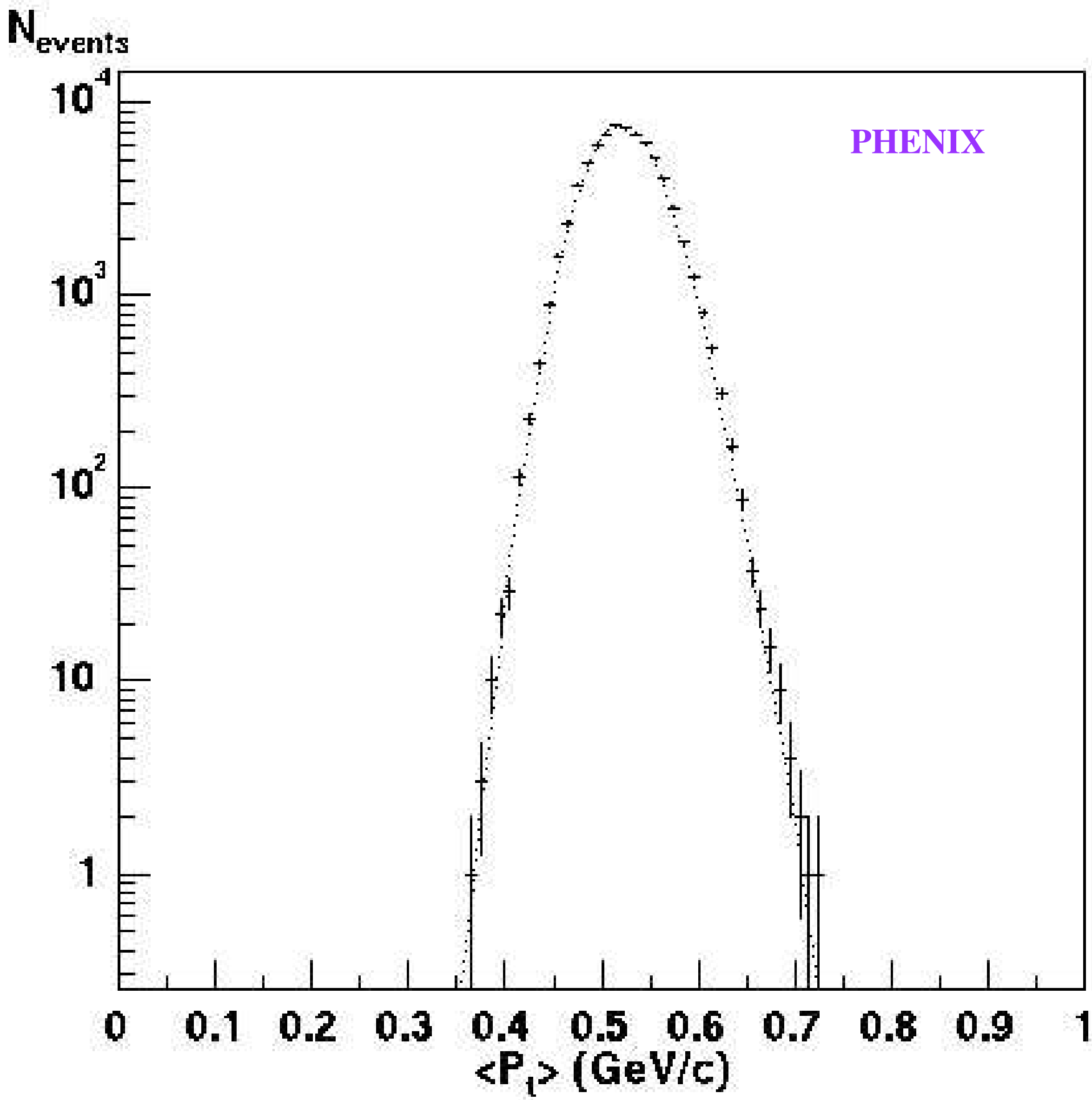


Outlook:

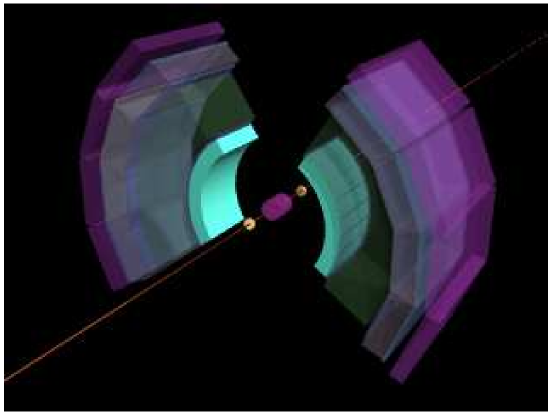
- Extension of this analysis to cover more peripheral collisions will be possible in the 2001 PHENIX run due to a factor of ~4 increase in azimuthal acceptance in the central arm spectrometers.

Mean p_t Distributions,

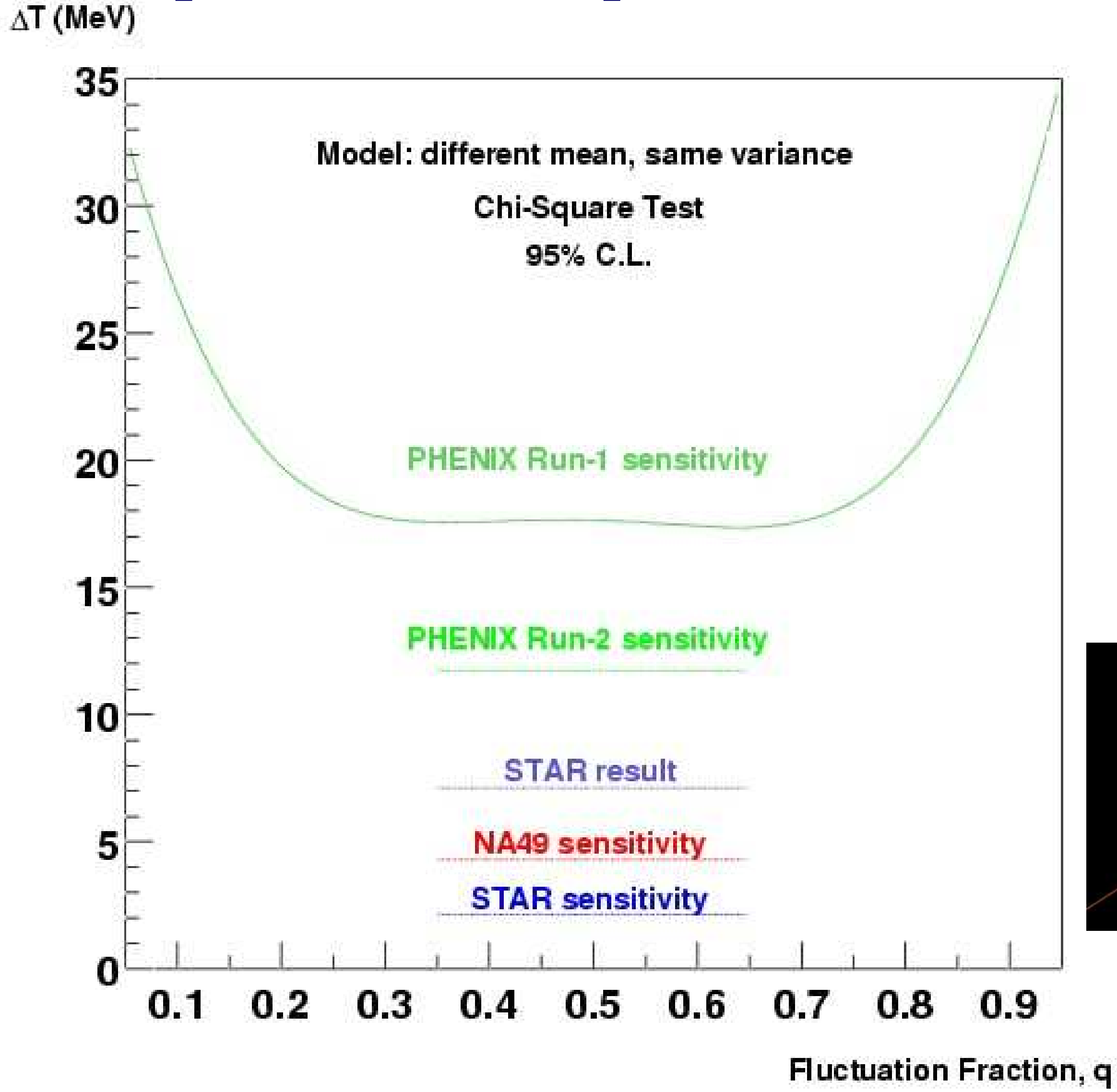
0-5% centrality

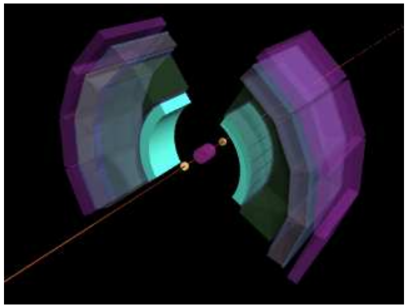


.... **Gamma Distribution <u>calculation</u> based upon semi-inclusive spectra**

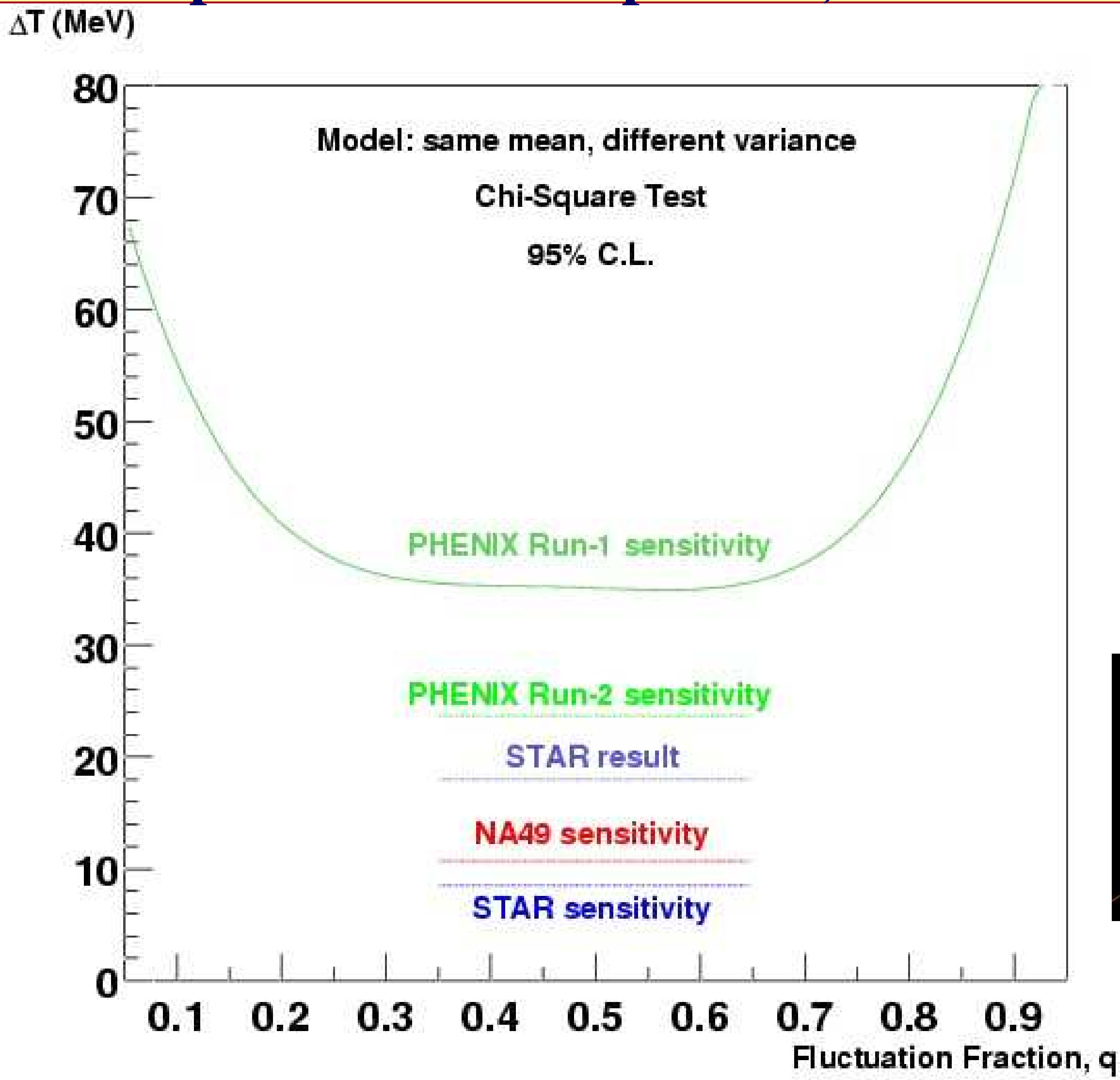


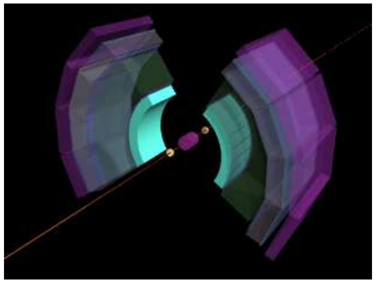
Mean p_t fluctuation Sensitivity: Experimental Comparison, Model B



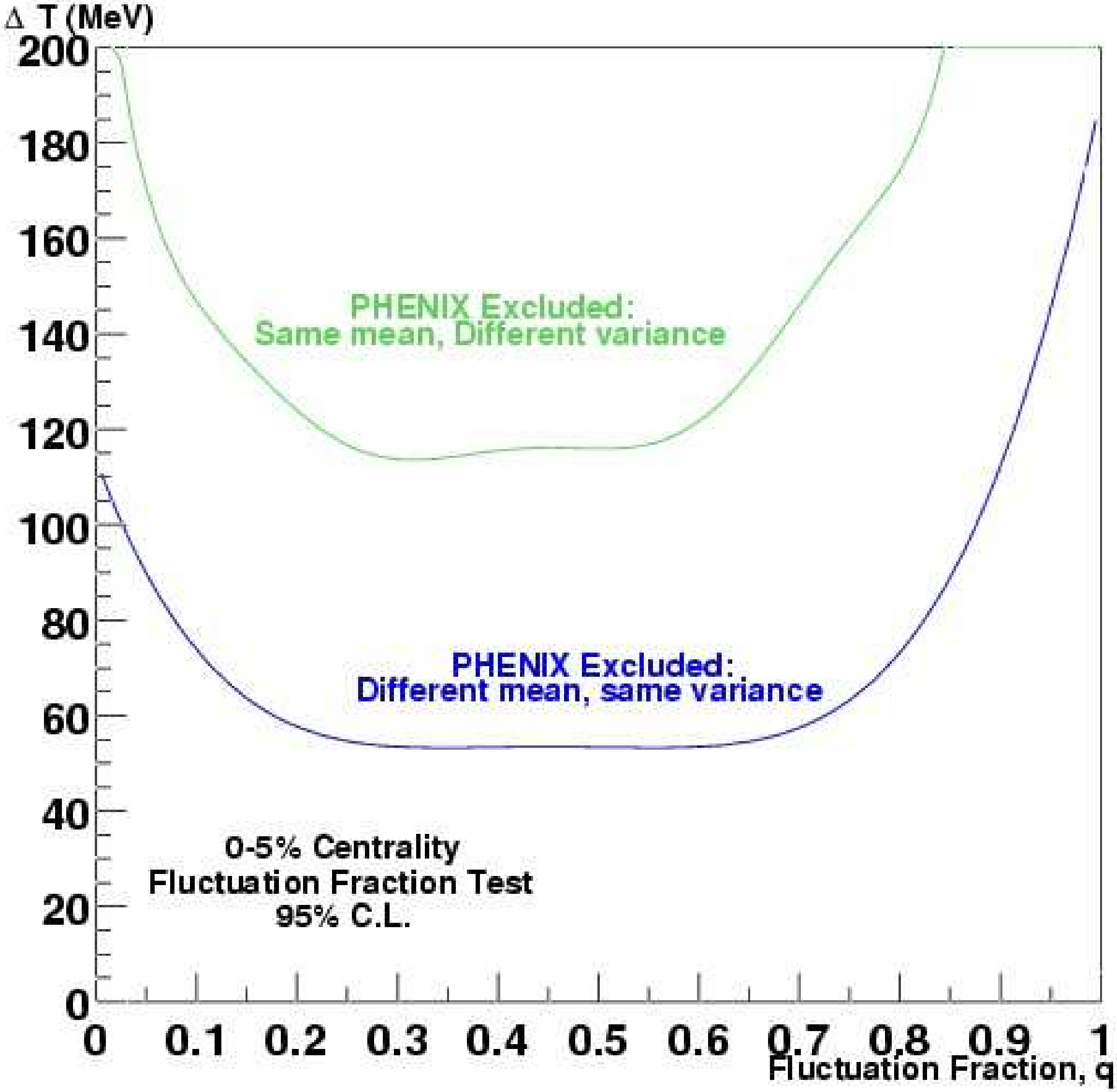


Mean p_t fluctuation Sensitivity: Experimental Comparison, Model A

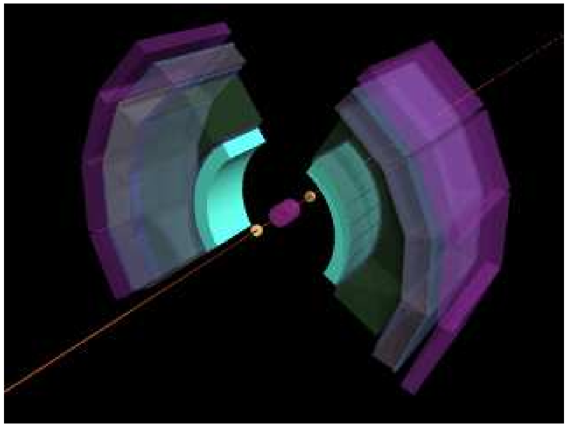




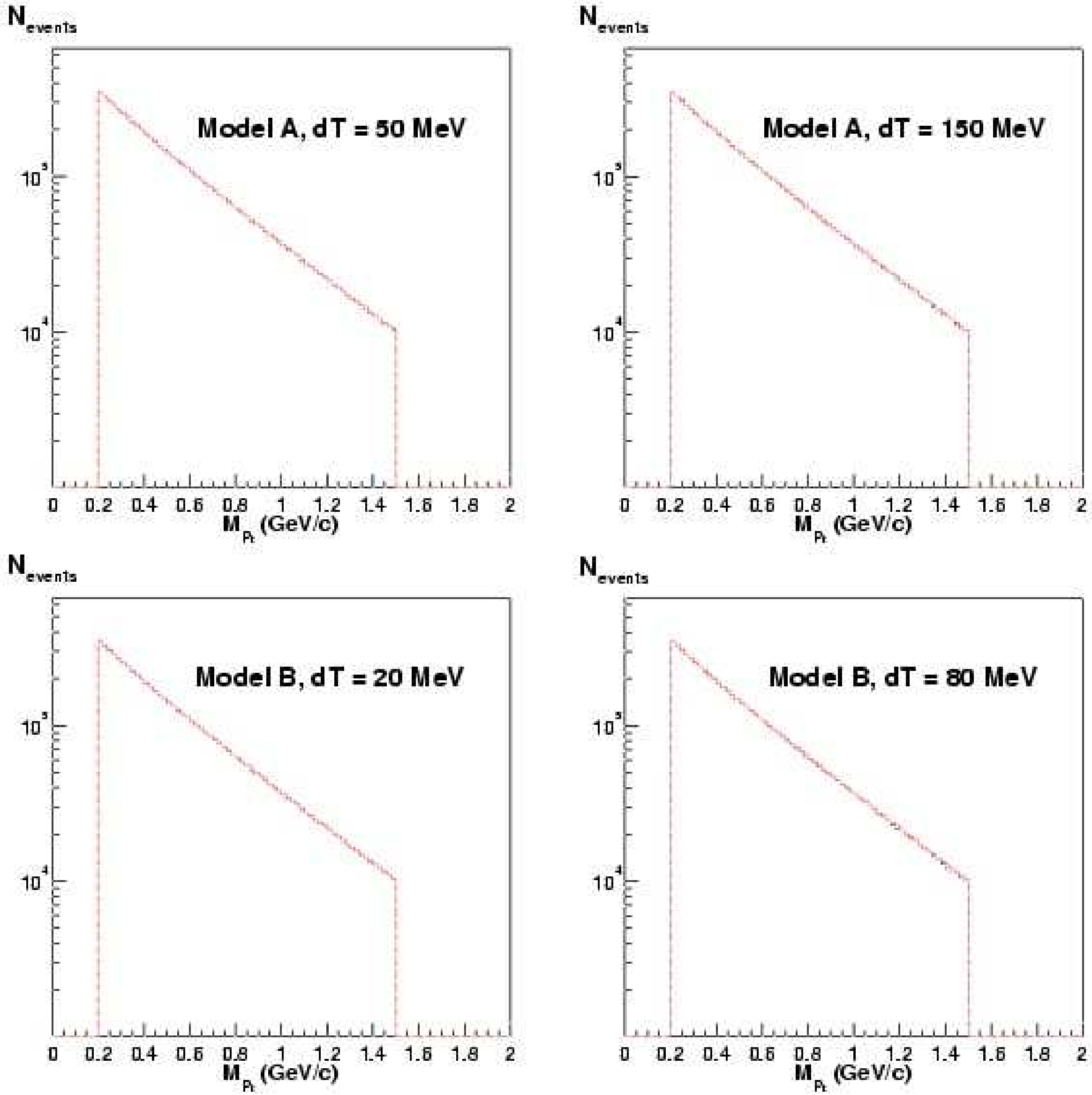
Mean p_t fluctuation Sensitivity: F_t-based test



PHENIX

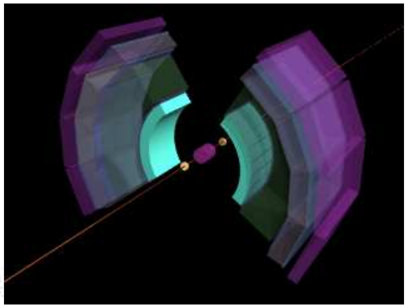


Model Demonstration: Inclusive Distributions

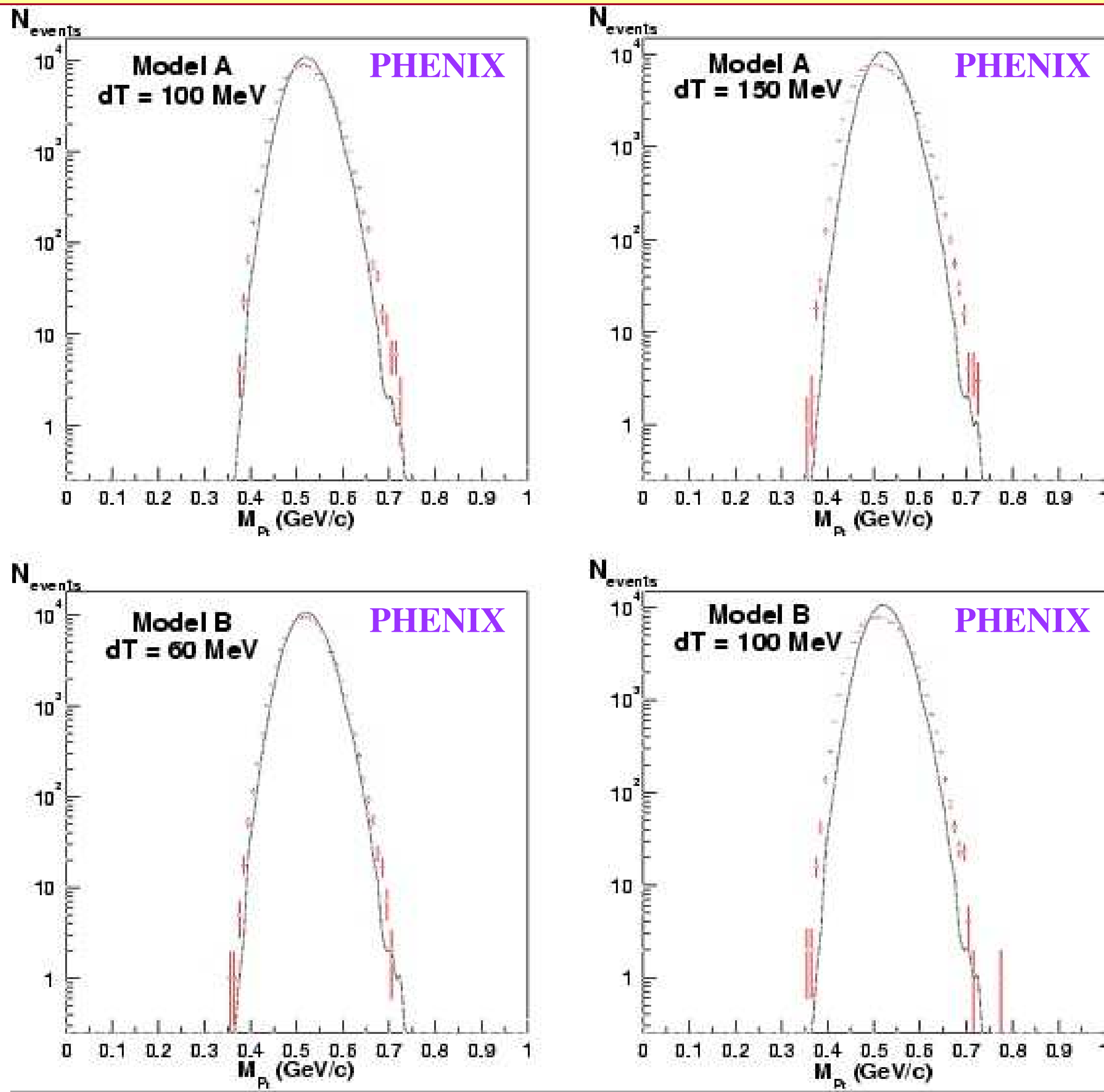


Black = mixed event data

red = generated distributions



Model Demonstration: Mean P_t Distributions



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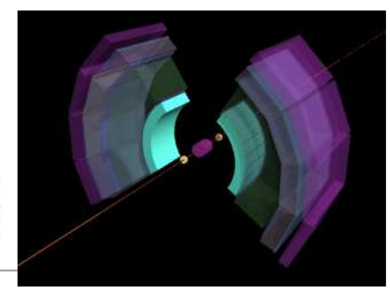
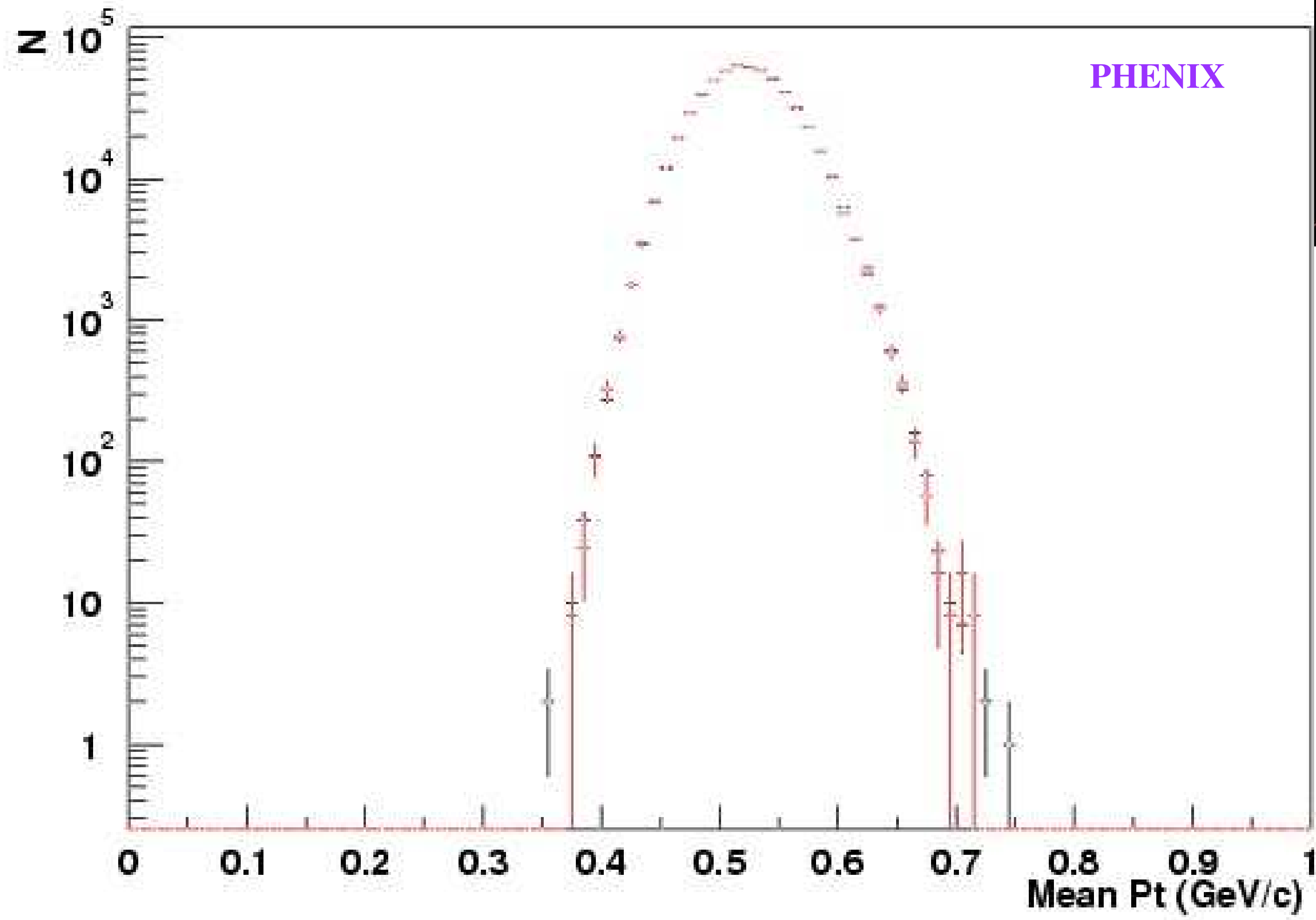
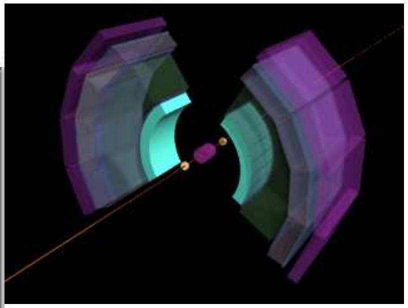


Simulation Consistency with Data





Black = generated non-fluctuating distribution

red = mixed event data distribution

Comparison of data and mixed N_{track} distributions