Flow of Λ-hyperons in 158 AGeV Pb+Pb collisions

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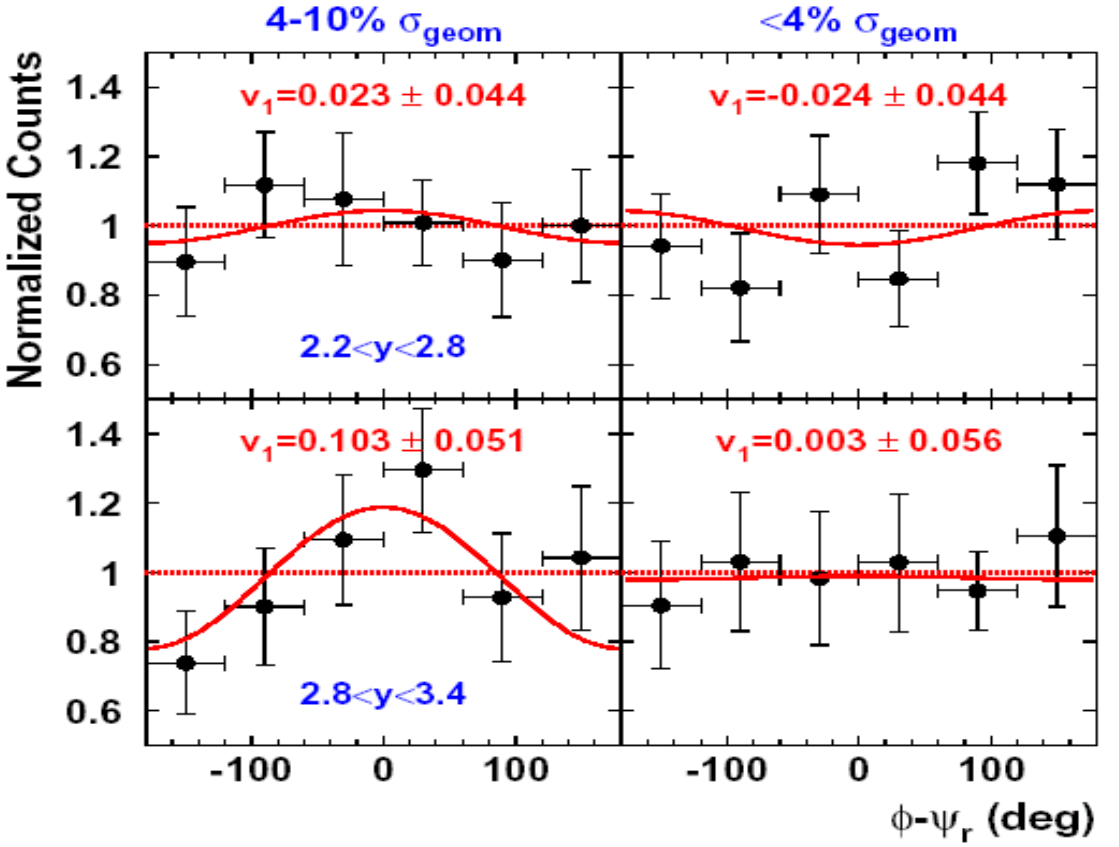
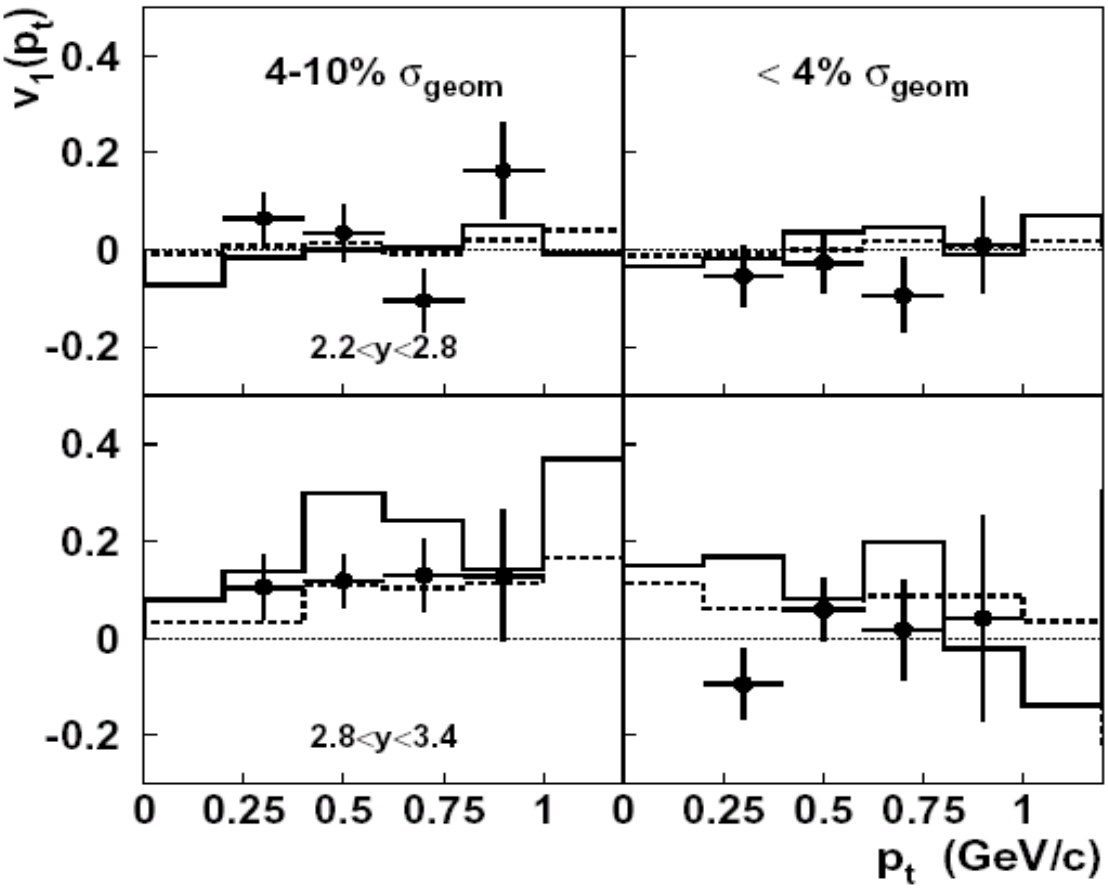
Outline

- **Λ-flow at SIS, AGS and RHIC energy**
- **data sample and centrality selection**
- **applied cuts**
- **event plane**
- **reaction plane resolution**
- **directed and elliptic flow for π mesons and protons**
- **Λ-hyperons and daughter tracks identification**
- **accepted Λ's**
- **directed and elliptic flow of Λ-hyperons**

Flow at AGS energy

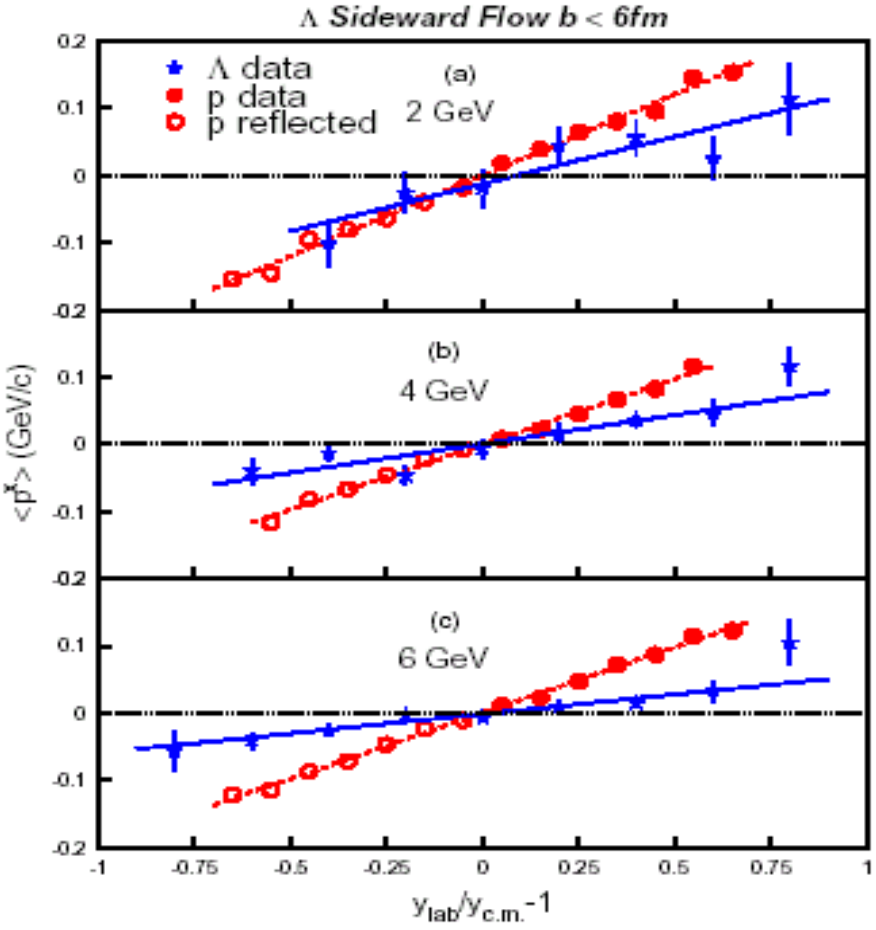
E877 experiment - Phys. Rev. C63, 014902 (2001)

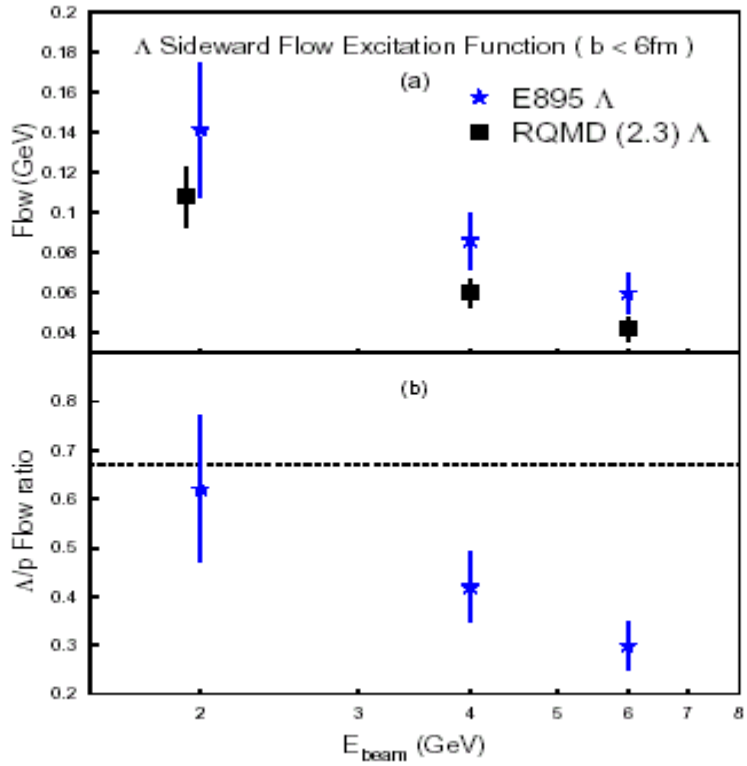




Flow at AGS energy

E895 experiment - Phys. Rev. Letters 86 (2001) 2533.





Flow at AGS energy

Conclusions:

- **the E877 experiment which covers rapidity 2.2<y<3.4 and transverse momentum p_t = 0.15 - 1.5 GeV/c has measured a strong positive directed flow at forward rapidity for semicentral collisions**

- **the measured p_t dependence of directed flow is consistent with RQMD predictions although interpretation is limited due to low statistics**

- **the E895 experiment has measured the directed flow of Λ-hyperons at 2, 4, 6 AGeV for b <5-6 fm**

- **the measurements indicated that Λ-hyperons flow consistently in the same direction and with smaller magnitudes than those of protons**

- **the measurements agree with calculations which include the influence of the Λ-nucleon potential**

- **the experimental flow ratio Λ/p is in qualitative agreement with expectations (~2/3) from the quark counting rule at 2 AGeV but is found to decrease with increase beam energy**

Flow at RHIC energy

STAR experiment - nucl-ex/0306007

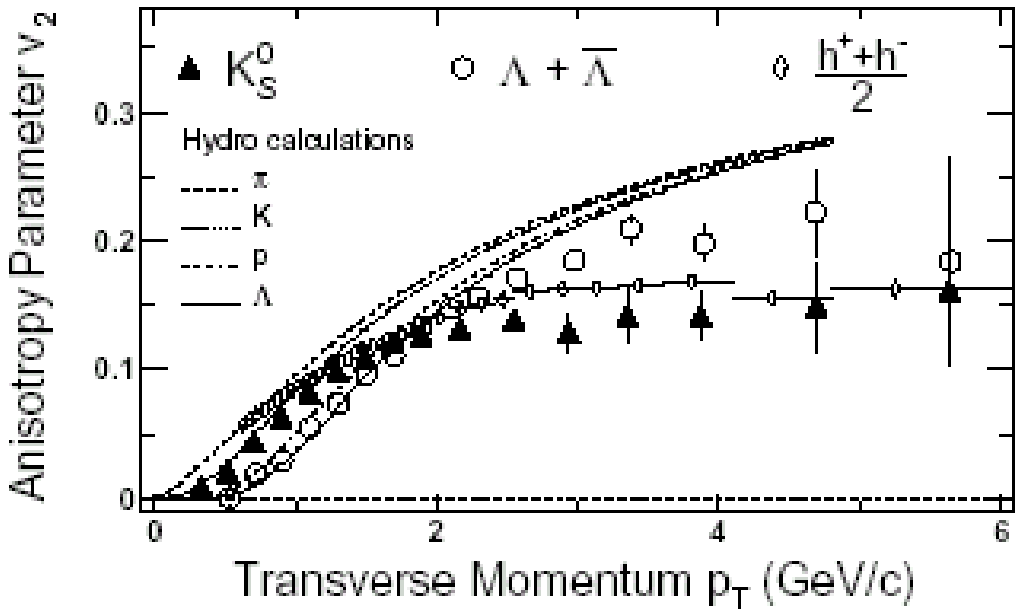


FIG. 1: The minimum-bias (0–80% of the collision cross section) $v_2(p_T)$ for K^0_S, $\Lambda + \overline{\Lambda}$ and $h^{\pm}$. The error bars shown are statistical only. Hydrodynamical calculations of v_2 for pions, kaons, protons and lambdas are also plotted [10].

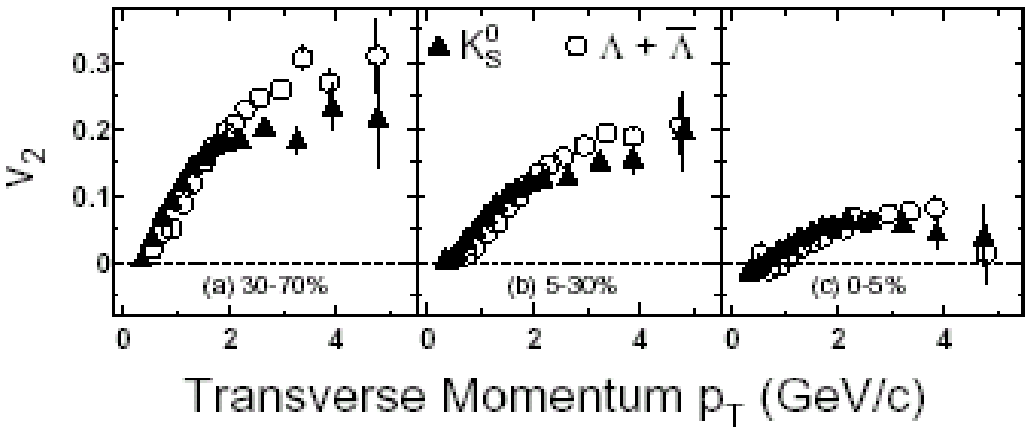


FIG. 2: The v_2 of K^0_S and $\Lambda + \overline{\Lambda}$ as a function of p_T for 30–70% (most central), 5–30% and 0–5% of the collision cross section. The error bars represent statistical errors only. The non-flow systematic errors for the 30–70%, 5–30% and 0–5% centralities are -25%, -20% and -80% respectively.

Flow at RHIC energy

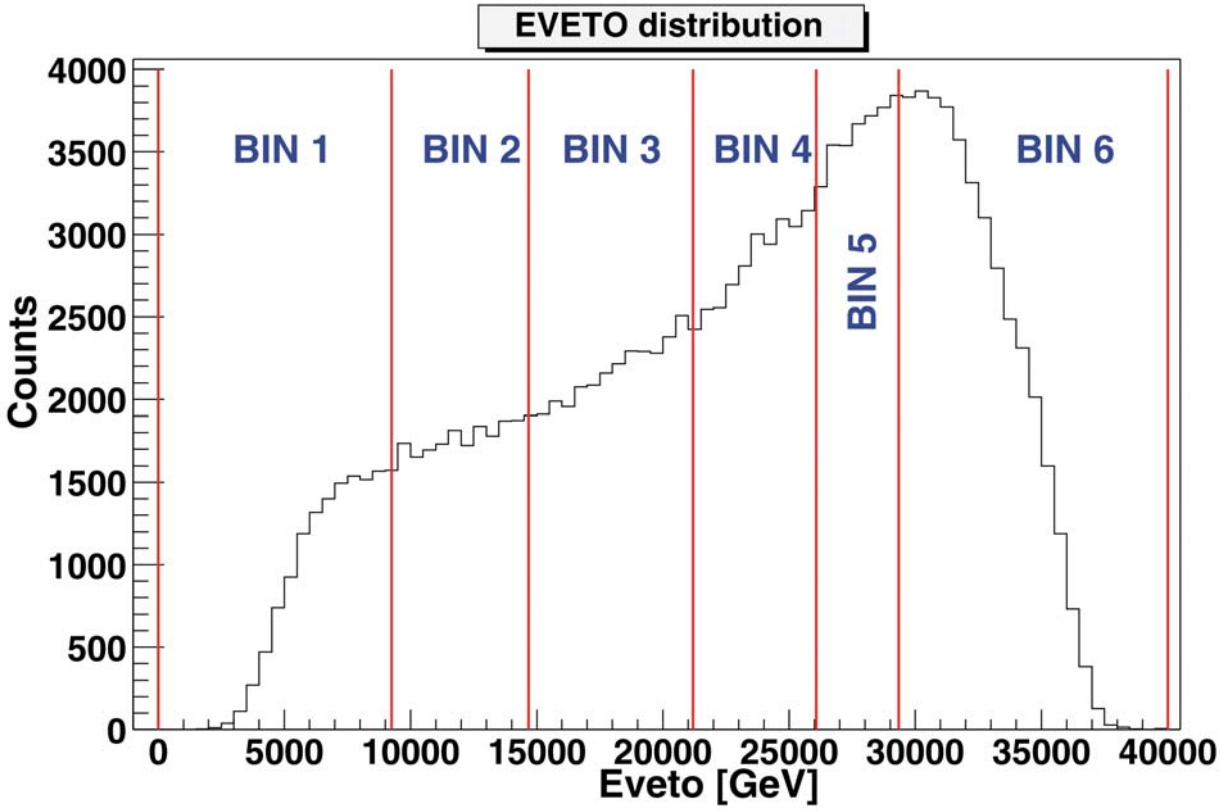
Conclusions:

- **large elliptic flow for Λ-hyperons have been measured both at 130 and 200 GeV Au+Au energy (midrapidity $|y| < 1$)**
- **at low p_T , V2 for Λ-hyperons is consistent with hydrodynamical calculation and is smaller then for lighter particles**
- **the p_T , dependence of the V2 saturates at intermediate $p_T \cong 2.5$ GeV/c**
- **at $p_T > 2.5$ GeV/c the elliptic flow deviate from the hydrodynamic type behaviour observed in the low - p_T region**
- **the values of V2 at saturation show a particle-type (increase with a mass) and centrality dependence**

Centrality selection

Data set - 00M (minimum-bias 256.000 events)

Bins in Eveto distribution:



Cuts

Event cuts:

- **Iflag = 0**
- **VertexX = (-0.5,0.5)**
- **VertexY = (-0.5,0.5)**
- **VertexZ = (-579.5,-578.3)**
- **Mult > 10**

Track cuts:

- **Iflag =0**
- **Bx = (-3,3)**
- **By = (-0.5, 0.5)**
- **Pchi2 = (0.0, 10.0)**
- **Pt = (0.0, 2.0)**
- **MaxPtsV1 = (20,200)**
- **MaxPtsV2 = (20,200)**
- **MaxPtsM = (30,200)**
  (at least 20 points in VTPC1 or at least 20 points in VTPC2 or at least 30 points in MTPC)
- **FitOverMax = (0.55, 1.1)**

Event Plane

$$X_n = Q_n \cos(n\Phi_n) = \sum_i w_i \left(\cos(n\varphi_i) - \langle \cos(n\varphi) \rangle \right)$$
$$Y_n = Q_n \sin(n\Phi_n) = \sum_i w_i \left(\sin(n\varphi_i) - \langle \sin(n\varphi) \rangle \right)$$

$$\Phi_n = (\tan^{-1} Y_n / X_n) / n$$

Event plane determination:

- identified pions and protons

- acceptance correction by shifting method
  (<cos(nϕ)>, <sin(nϕ)> stored in a matrix
  pt = 0.0-1.0 GeV/c - 20 bins
  y = 1- 6 - 50 bins)

- y-pt bins with $|\langle \cos(n\phi) \rangle| < 0.2$,
  $|\langle \sin(n\phi) \rangle| < 0.2$ used for shifting

Selection of tracks used for event plane determination:

- first harmonic , ($w_i = y_i$)
  y = 4.0 - 6.0
  pt = 0.0 - 0.3 GeV/c (centrality bin 1)
  pt = 0.0 - 0.6 GeV/c (centrality bin 2)
  pt = 0.0 - 1.0 GeV/c (centrality bins 3-6)

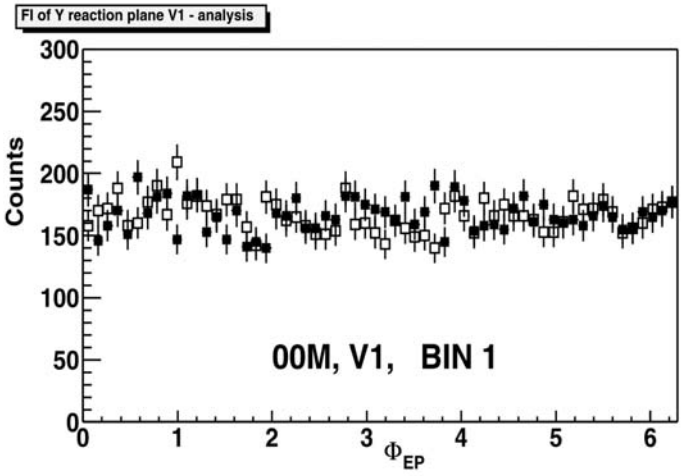
- second harmonic, ($w_i = pt_i$)
  y = 2.4 - 5.0
  pt = 0.0 - 1.0 GeV/c (centrality bins 1-6)

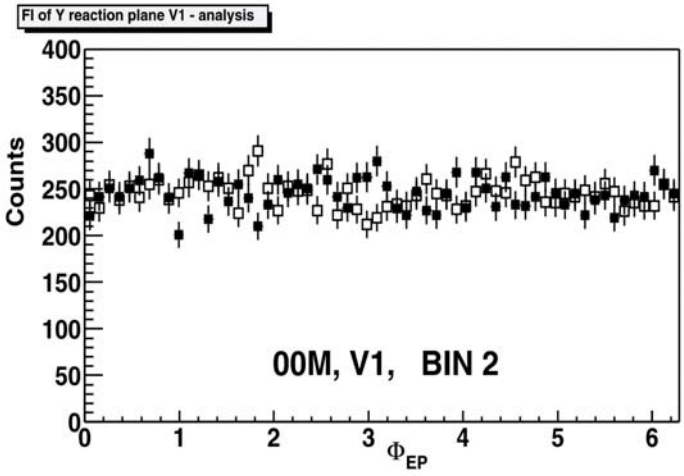
Mixed events

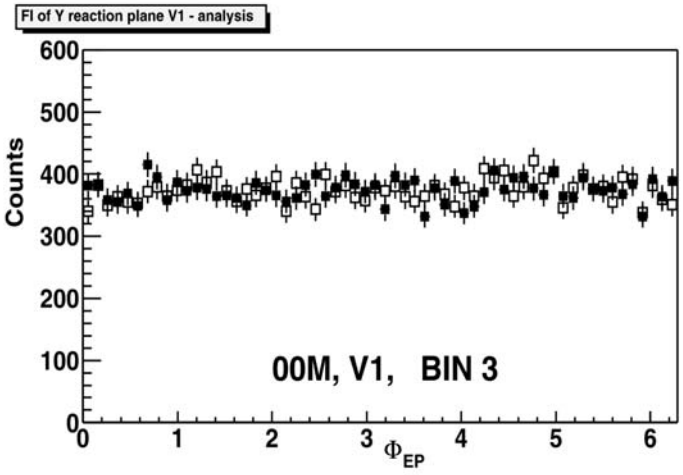
- **particles in a mixed event come from various experimental events**
- **particles are mixed inside a single centrality bin, measured by eveto**
- **one mixed event per one experimental event**

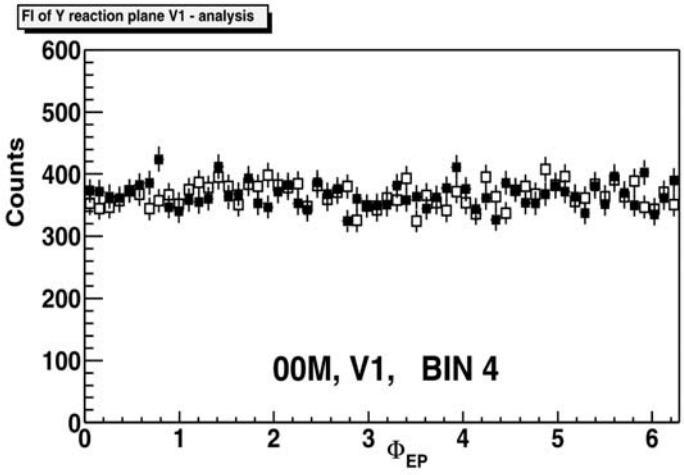
Event Plane - V1

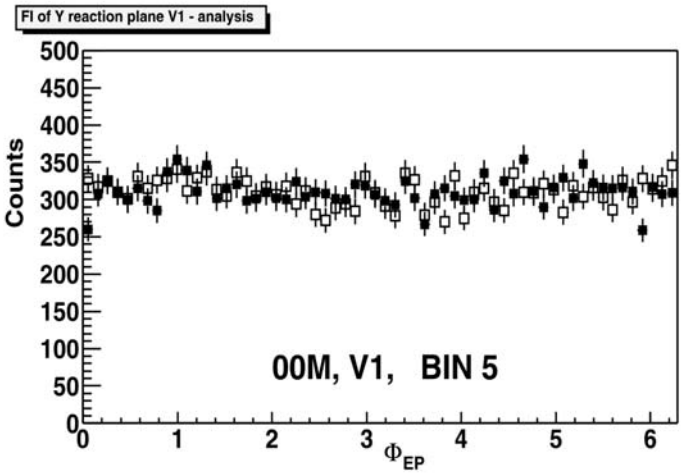
Azimuthal distribution:

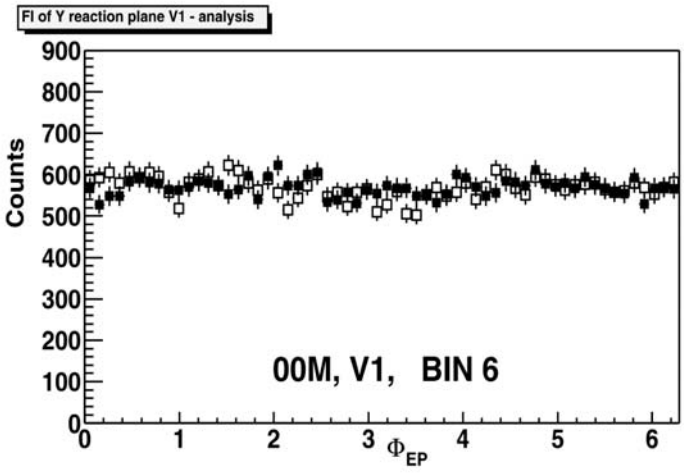






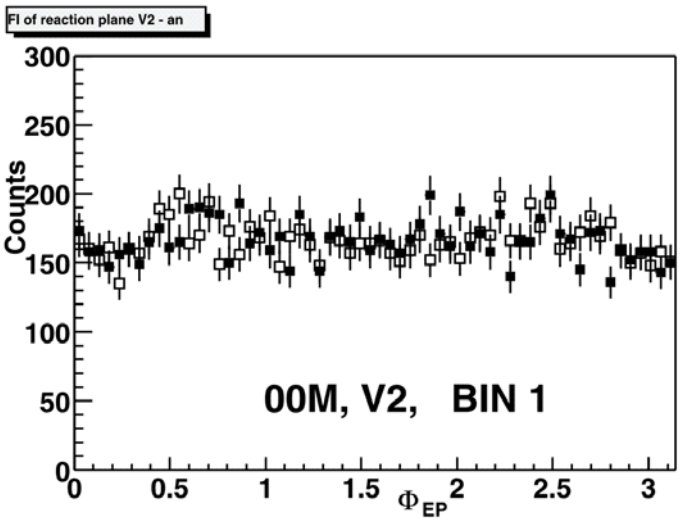


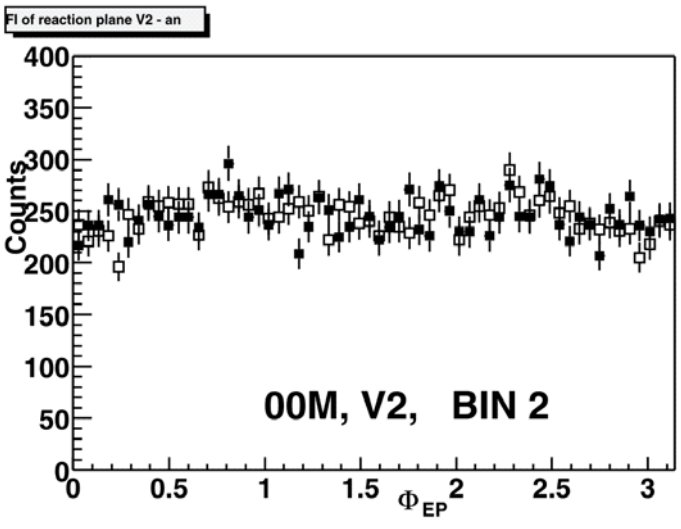


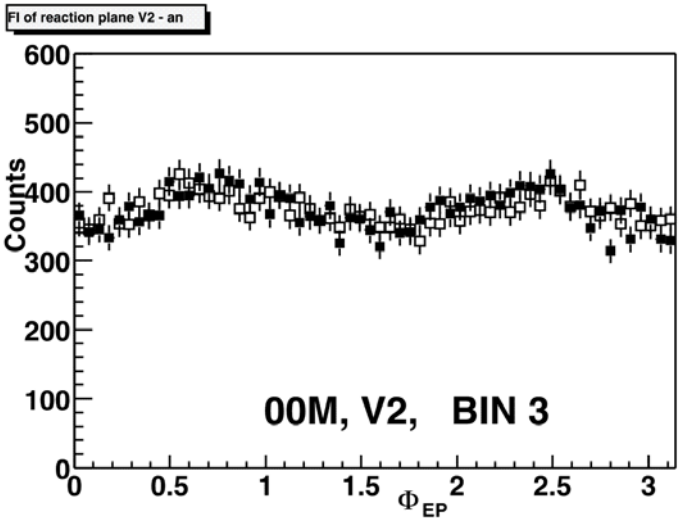


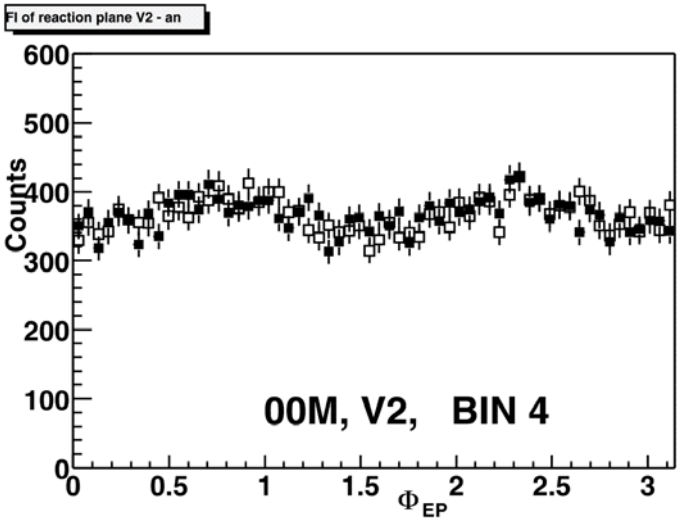
Event Plane - V2

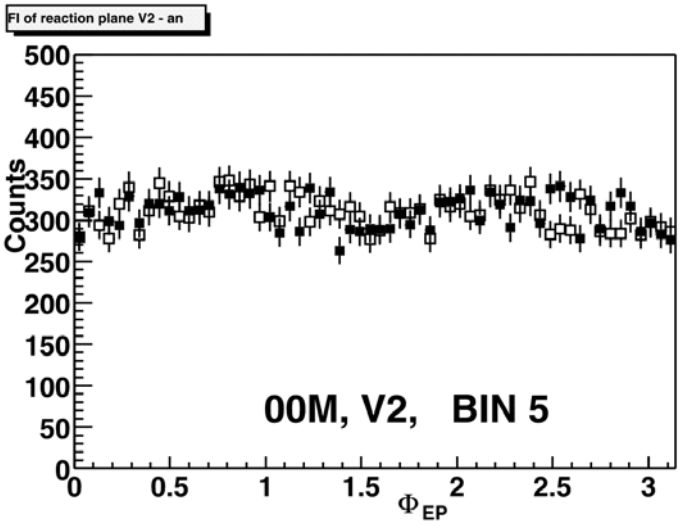
Azimuthal distribution:

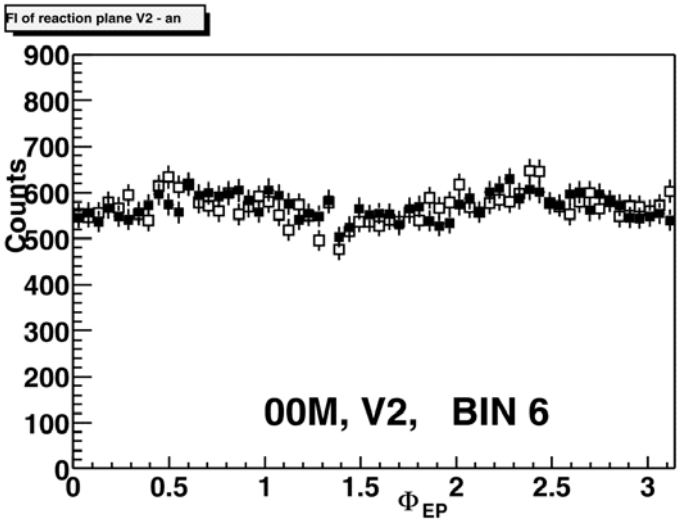






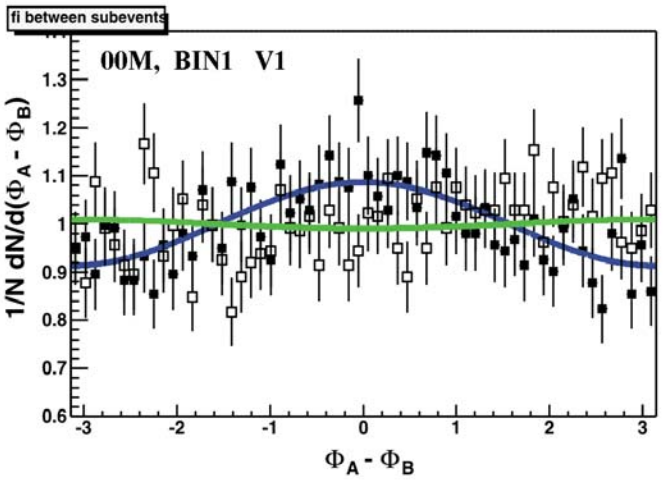


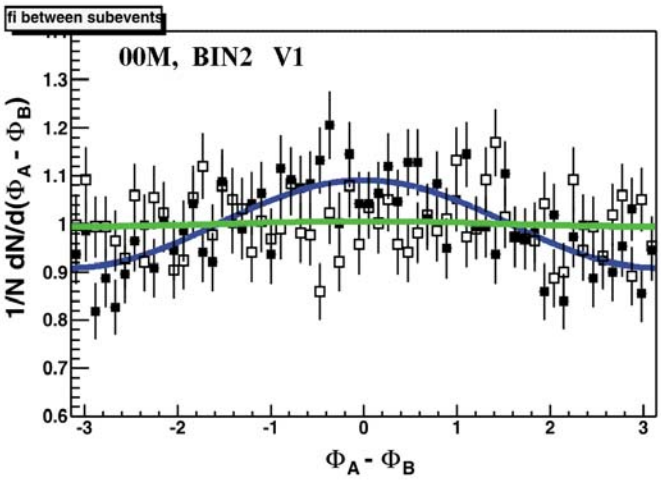


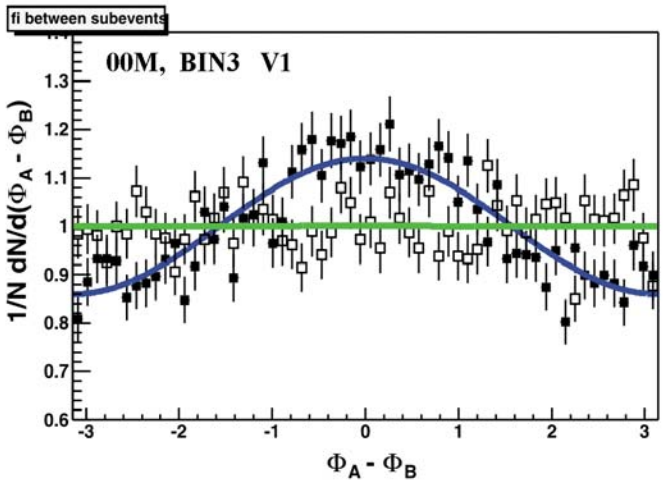


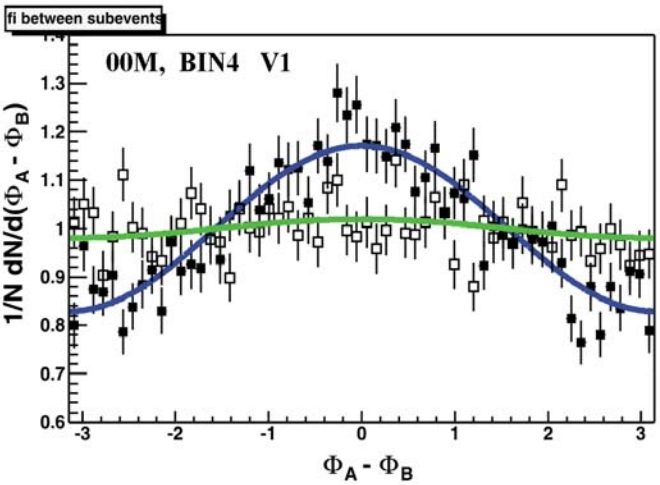
Reaction Plane Resolution - V1

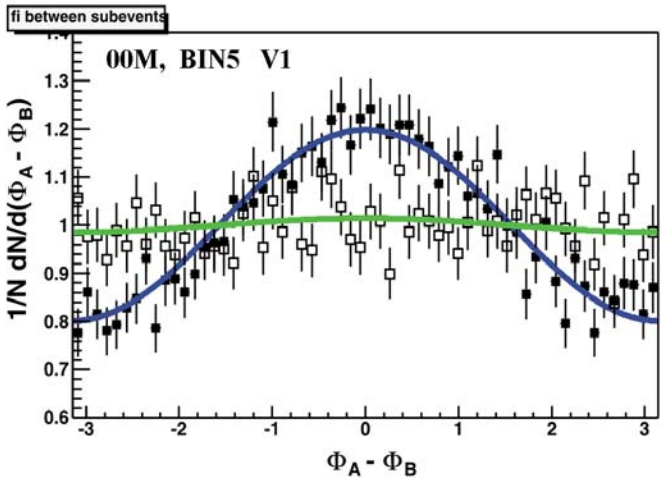
Correlation of subevents $\rightarrow$ < cos (Φ_A - Φ_B) >

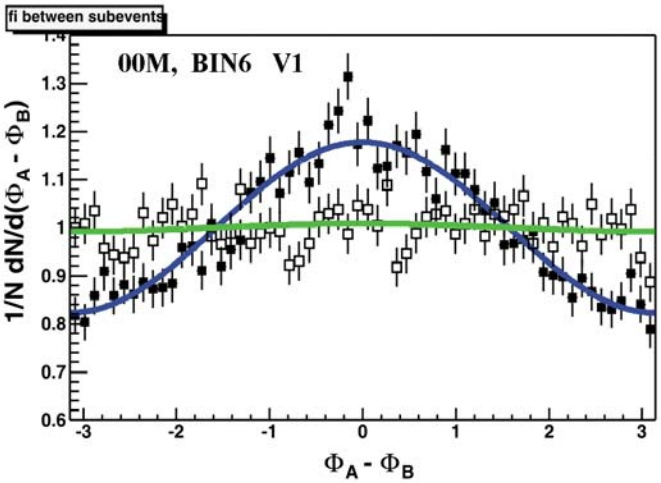






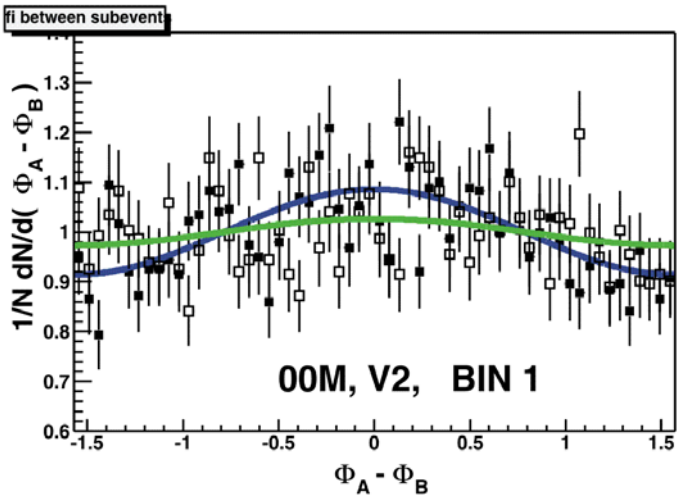


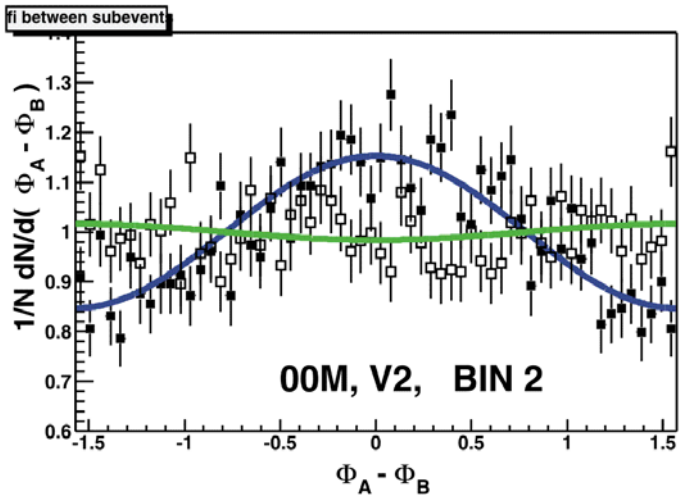


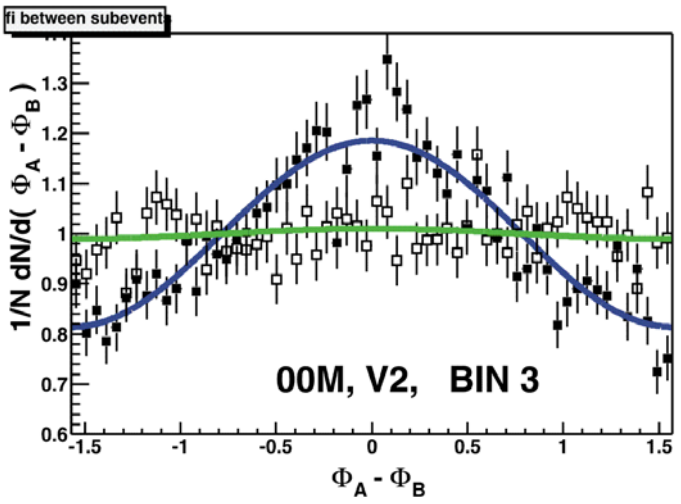


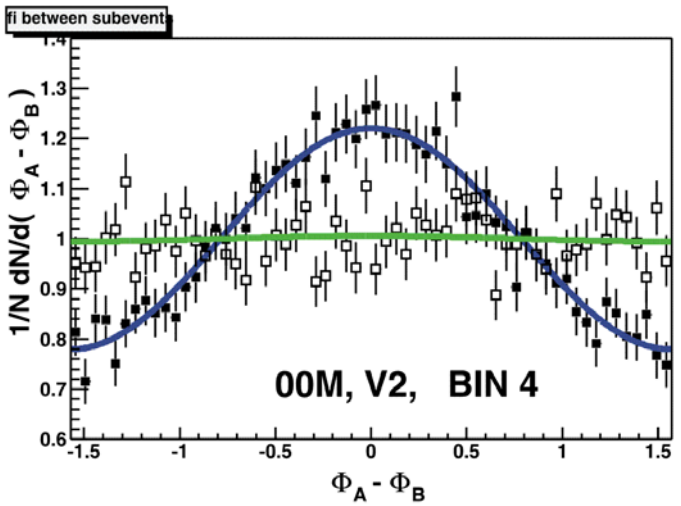
Reaction Plane Resolution - V2

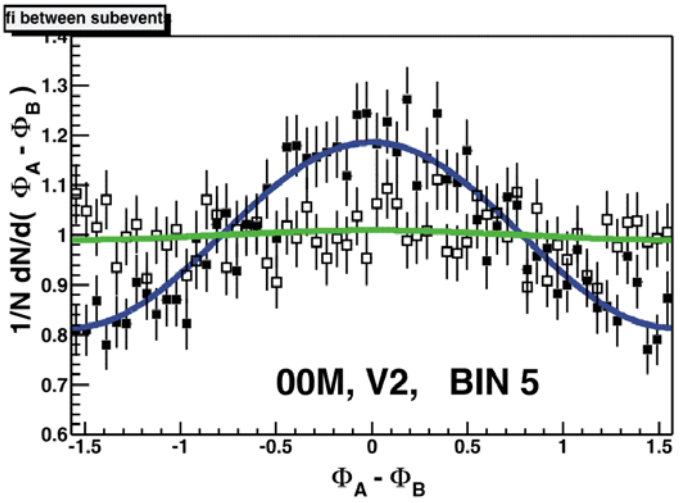
Correlation of subevents $\rightarrow$ < cos (Φ_A - Φ_B) >

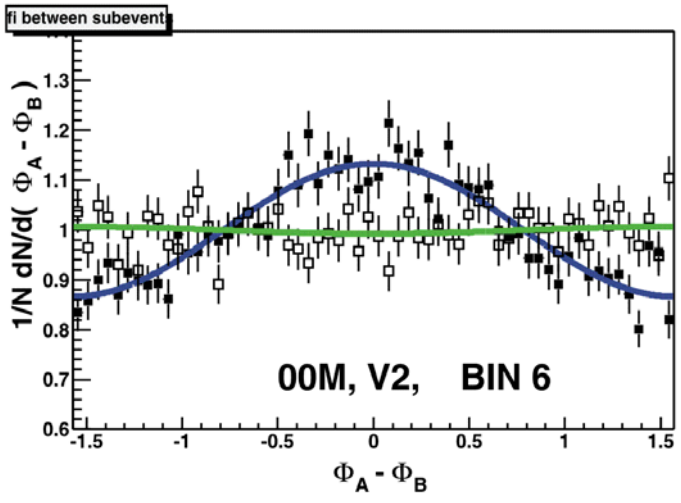








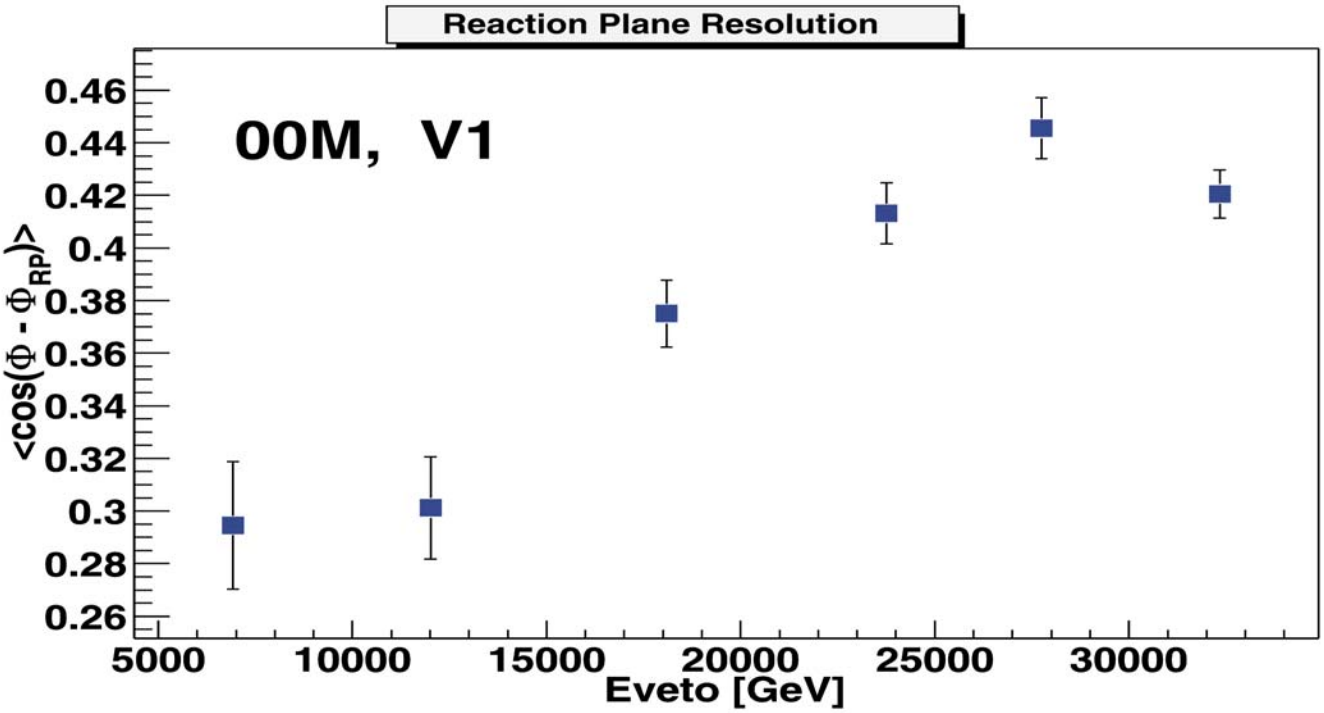


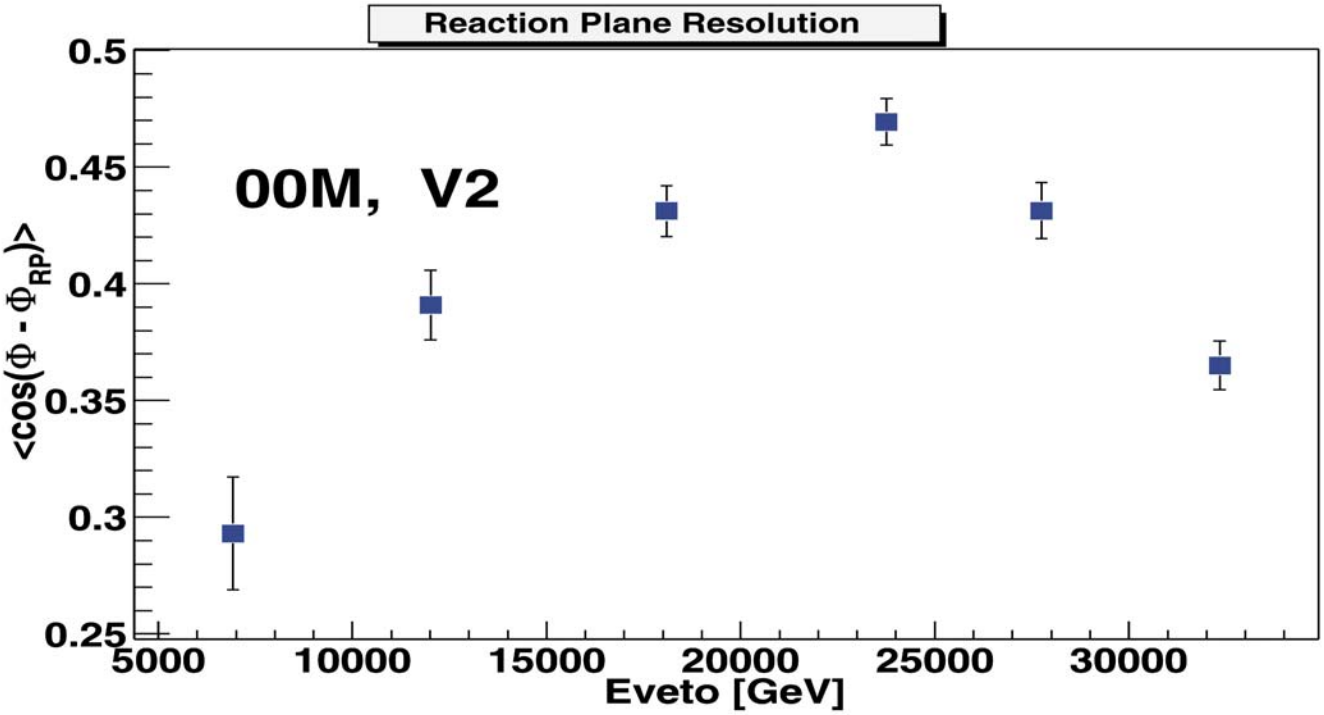


Reaction Plane Resolution

$\sigma_n = < \cos(\Phi_{EP} - \Phi_{RP})>$

$= (2 * < \cos (\Phi^n_A - \Phi^n_B) >)^{1/2}$





Fit functions

- **first harmonic**

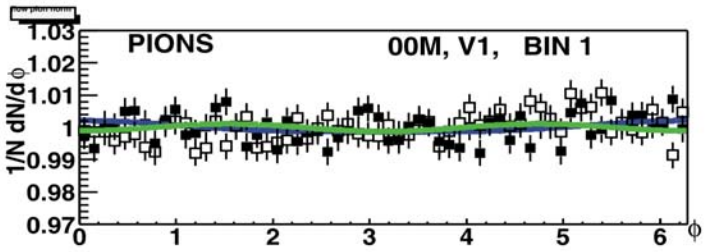
$$1/N\ dN/d\varphi = 1 + 2 \cdot V1_{EP1} \cos(\varphi) + 2 \cdot V2_{EP1} \cos(2\varphi)$$

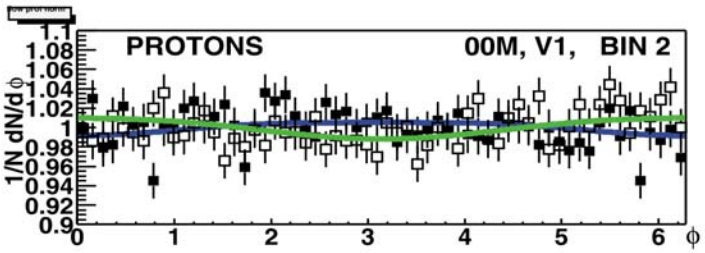
- **second harmonic**

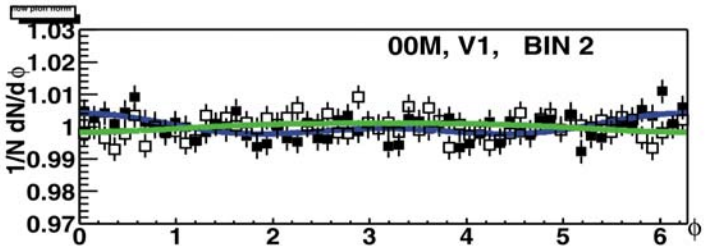
$$1/N\ dN/d\varphi = 1 + 2 \cdot V2_{EP2} \cos(2\varphi)$$

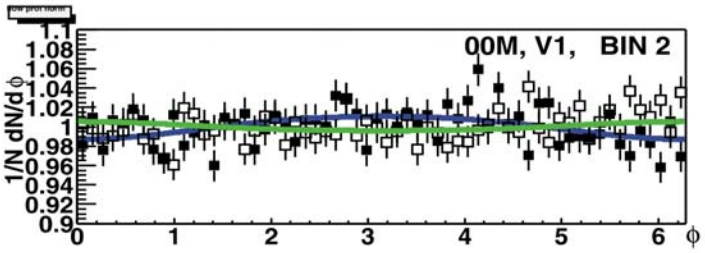
Directed Flow - V1

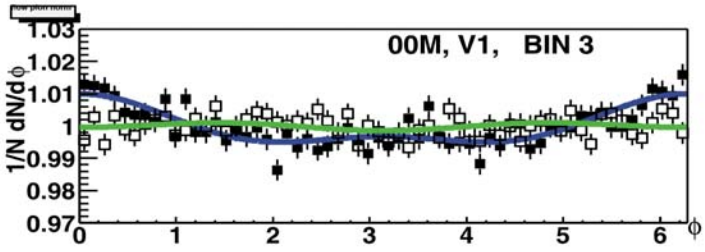
Azimuthal distribution around event plane Φ_{EP} :

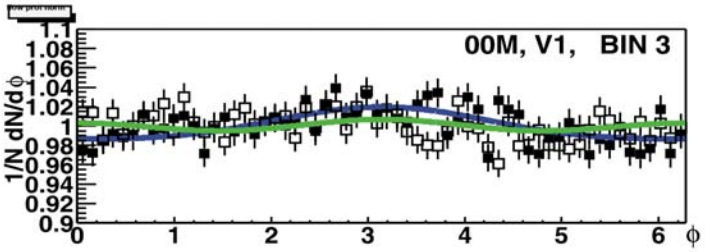


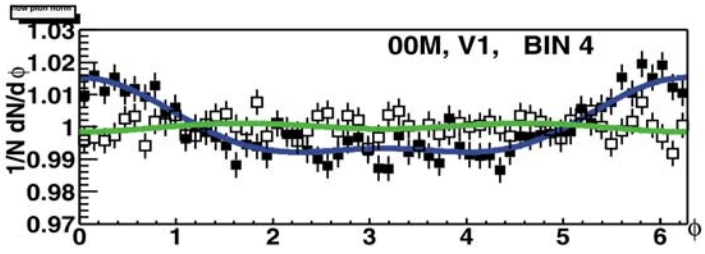


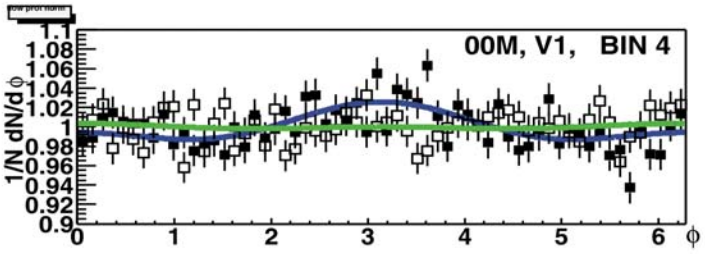


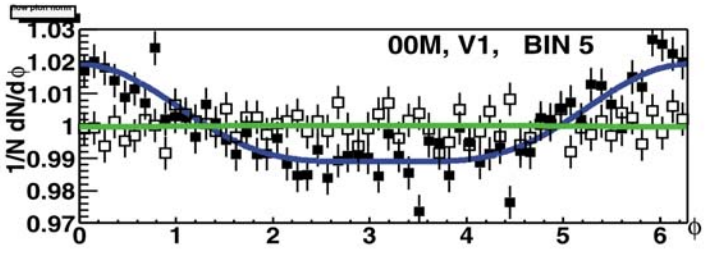


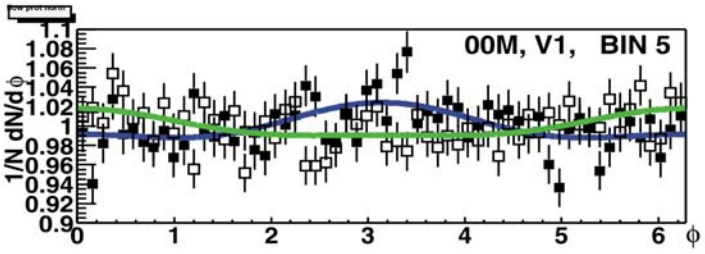


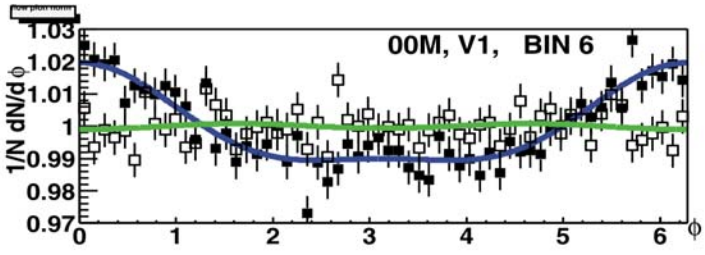


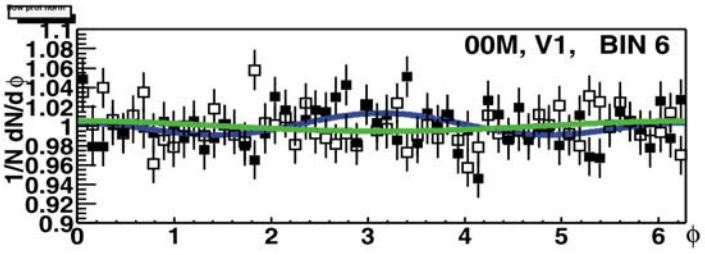






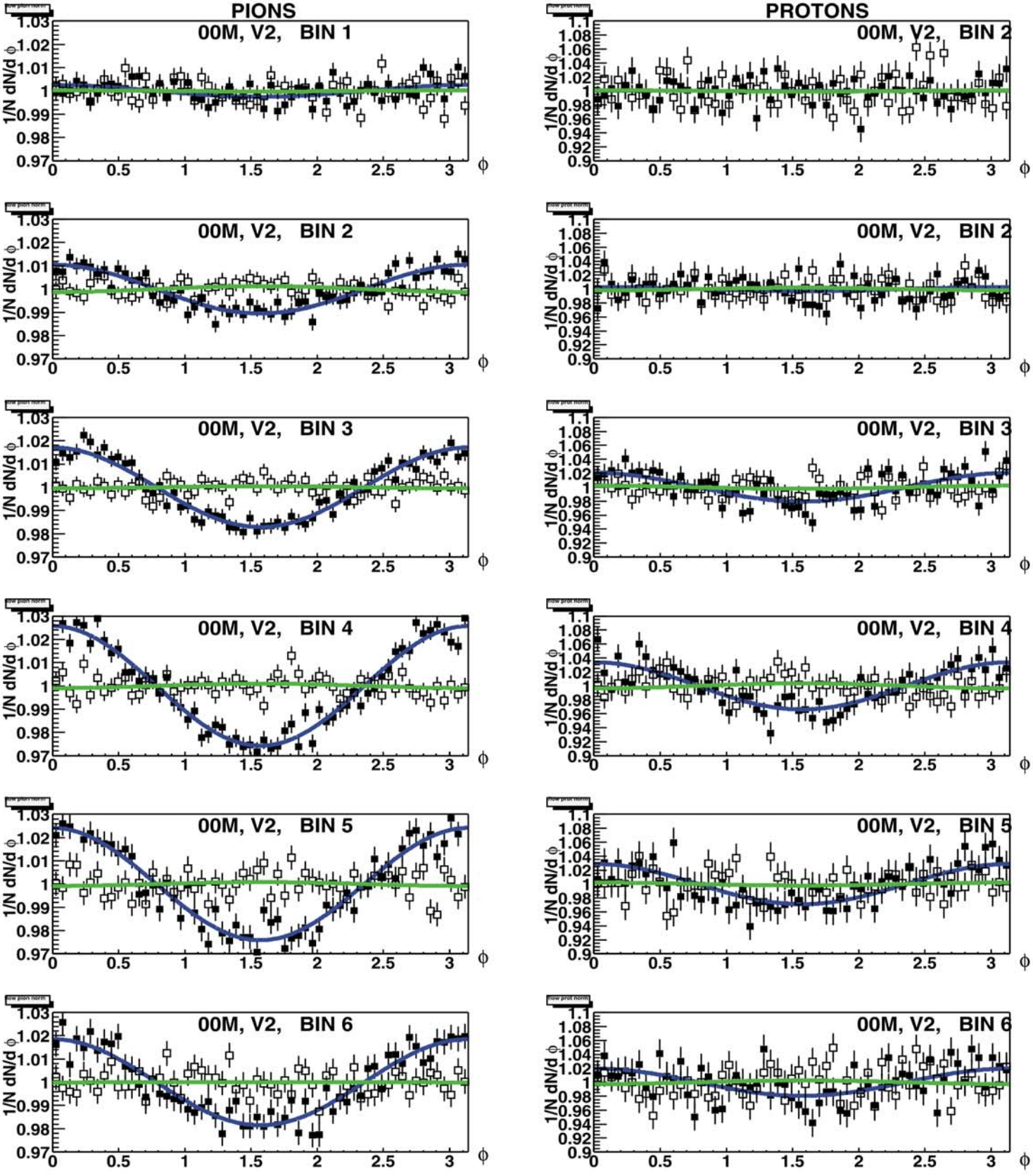






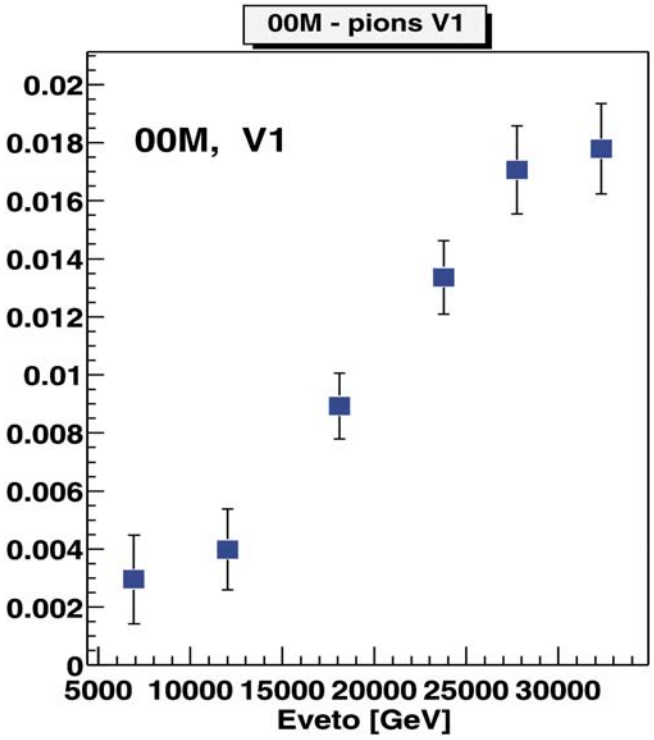
Elliptic Flow - V2

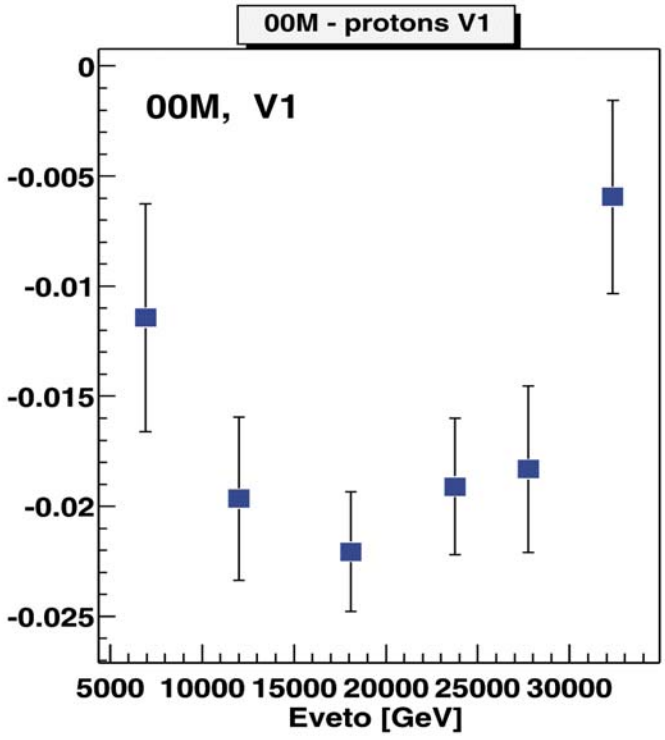
Azimuthal distribution around event plane Φ_{EP} :

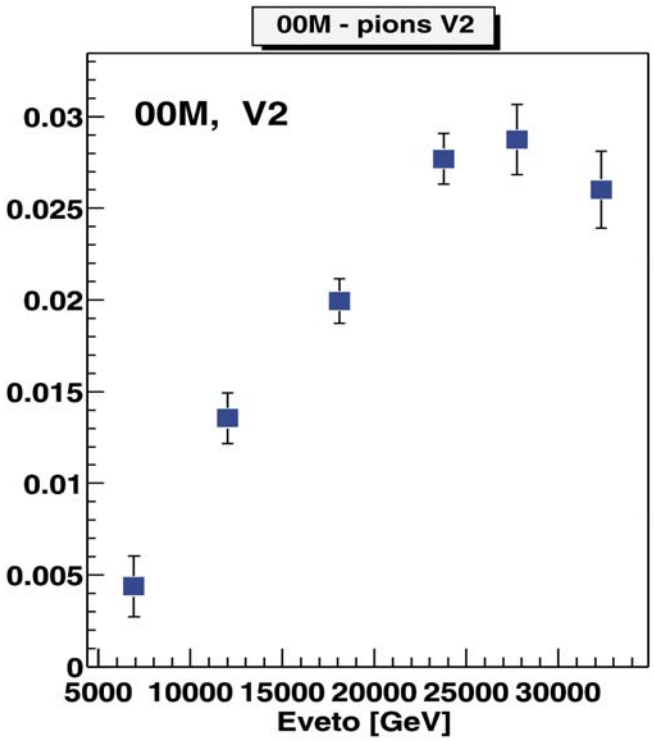


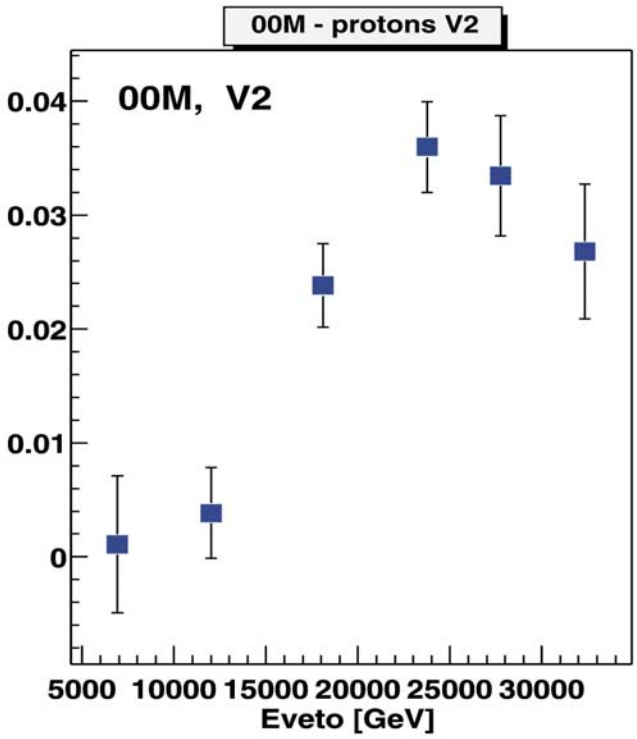
Directed and Elliptic Flow

Directed flow - $V1_{RP} = V1_{EP} / \sigma_1$
Elliptic flow - $V2_{RP} = V2_{EP} / \sigma_2$









V0 cuts

Standard Birmingham Cuts:

- **Iflag =0**
- **ZV0 > -555.0**
- **Xtarg < 1.5**
- **Ytarg < 1.0**
- **X1minX2 > 2.5**
- **SameSide**
- **MV0Pts = (20,200)**
  (both tracks with at least 20 points in VTPC1
  or at least 20 points in VTPC2)

Λ identification

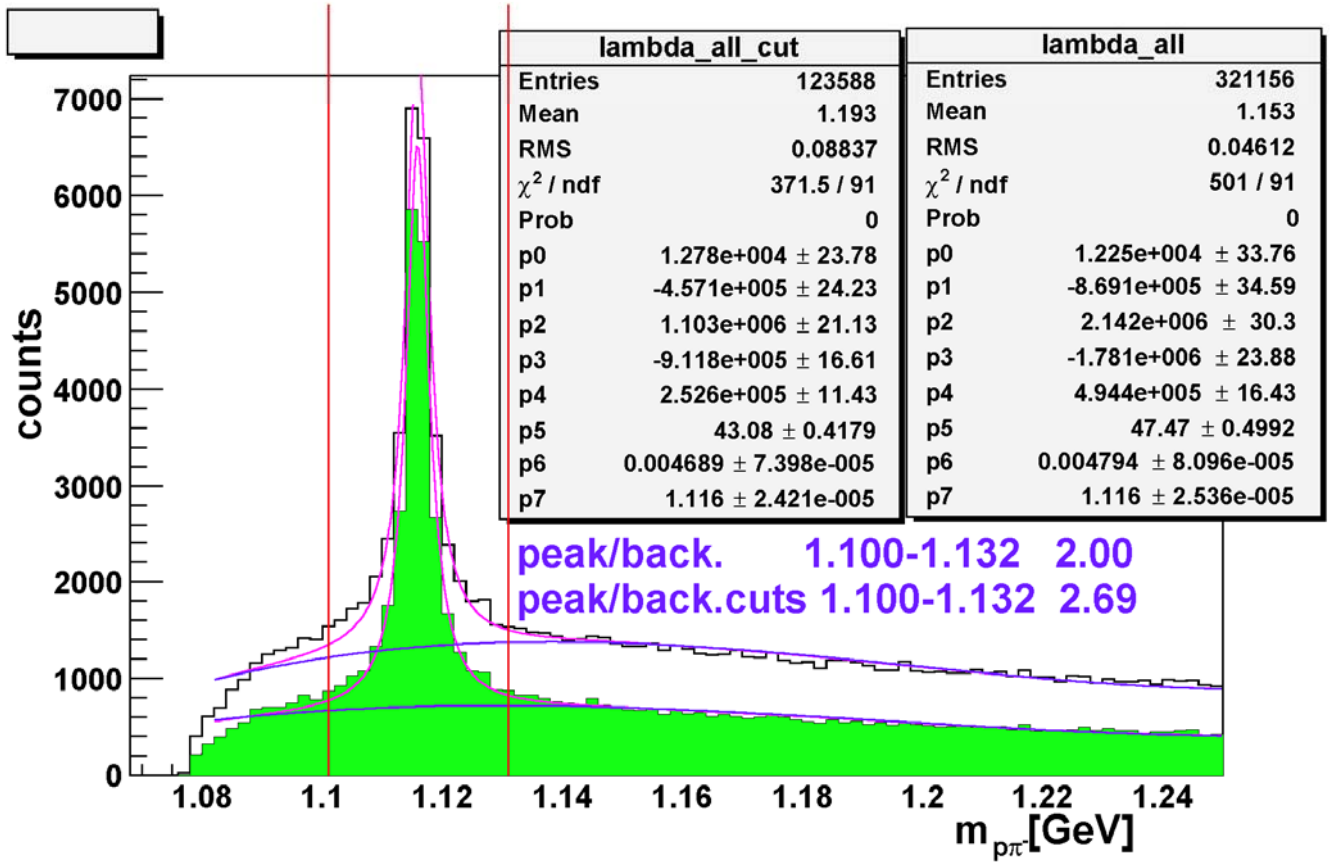
Invariant mass:

PDG : $M_\Lambda = 1115.683 \pm 0.006$ MeV

Cut : $1.100 \text{ GeV} < M_\Lambda < 1.132 \text{ GeV}$

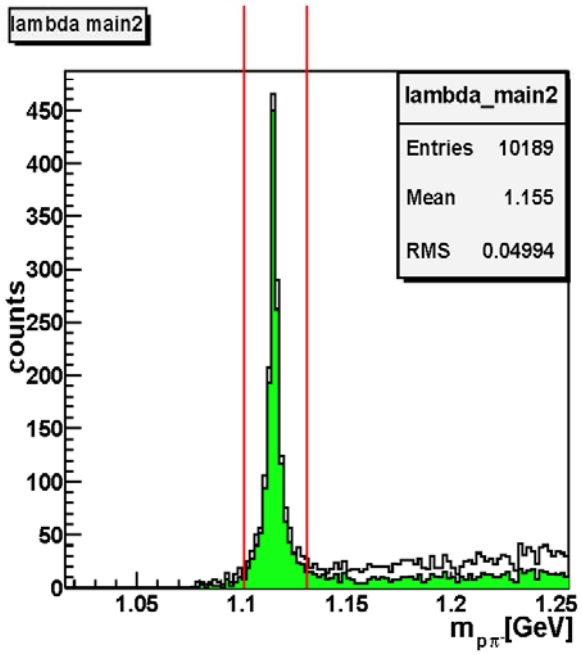
Identification of daughter tracks:

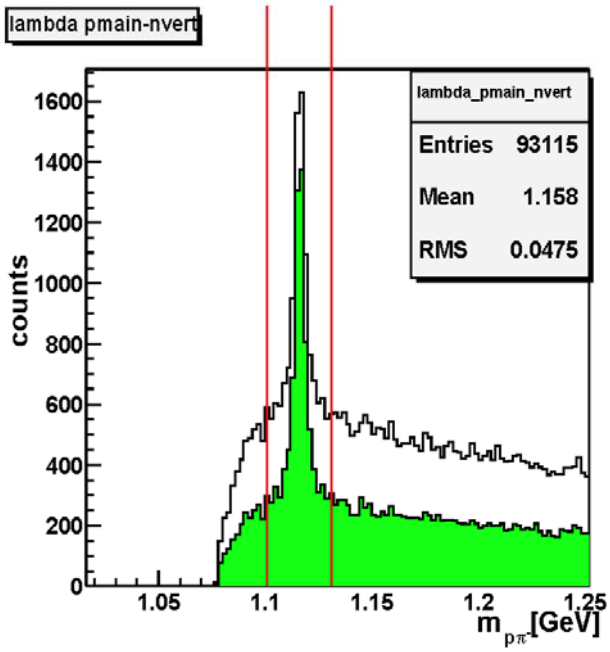
$\Lambda \rightarrow p + \pi^-$ **(BR - 69.3%)**

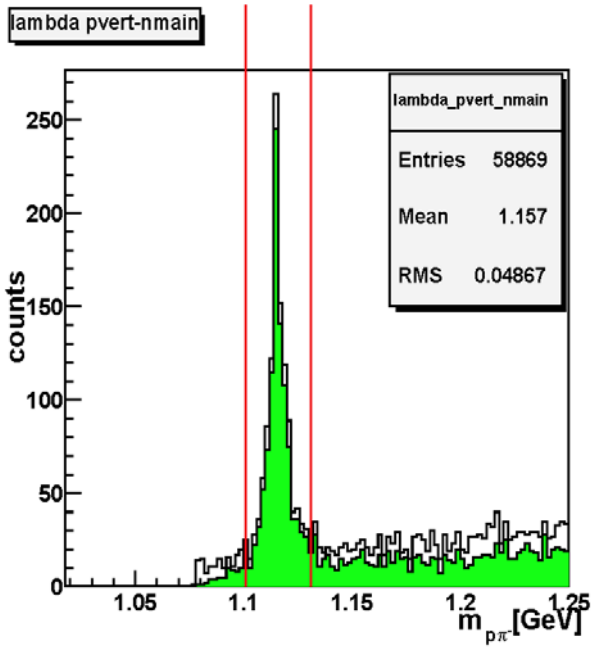


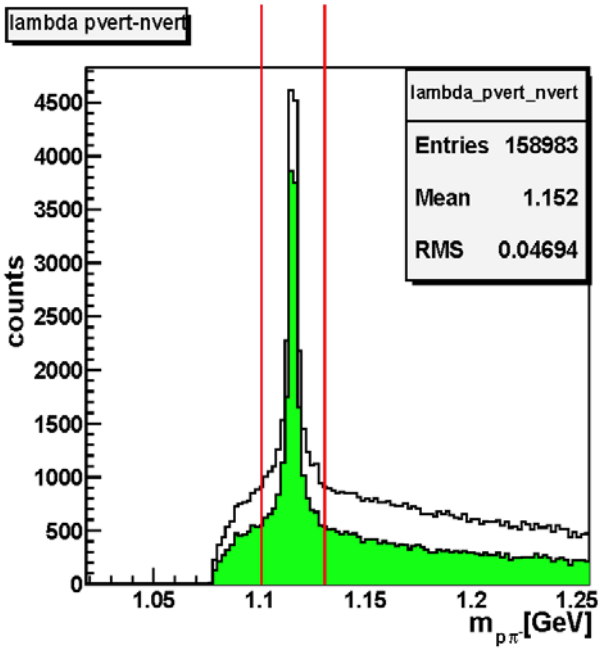
Λ identification

Invariant mass for MTPC and VTPC tracks:







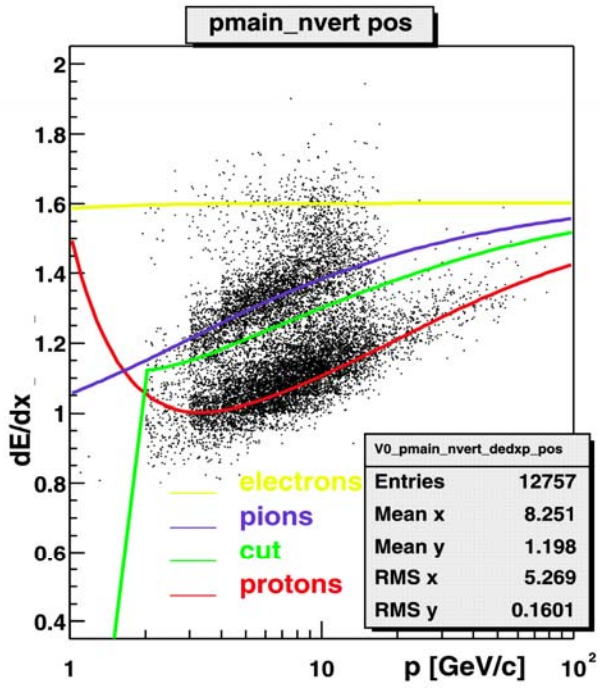


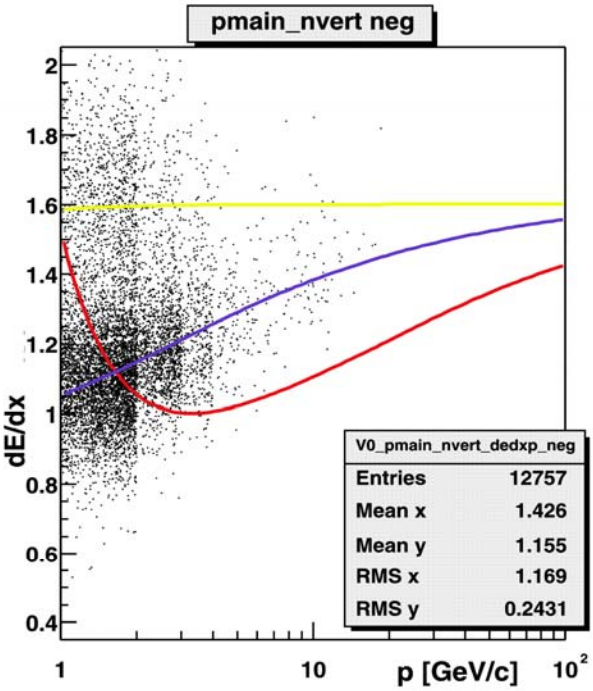
Daughter tracks identification

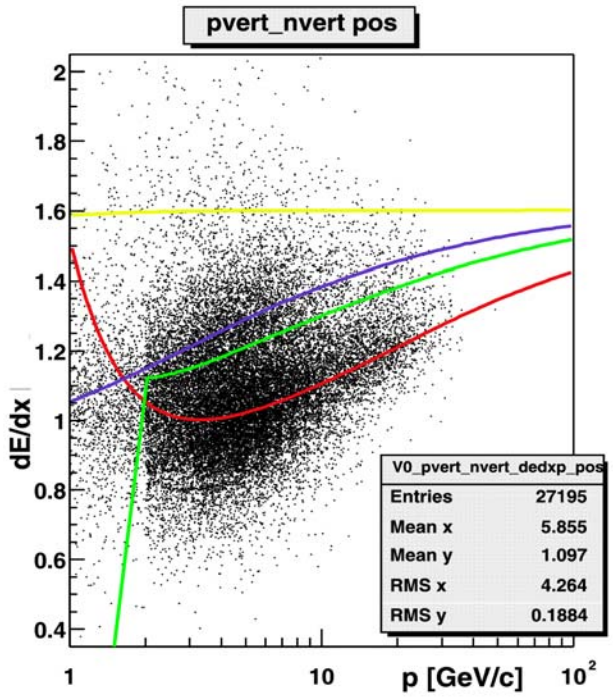
Dedx(P) for daughter MTPC and VTPC tracks:

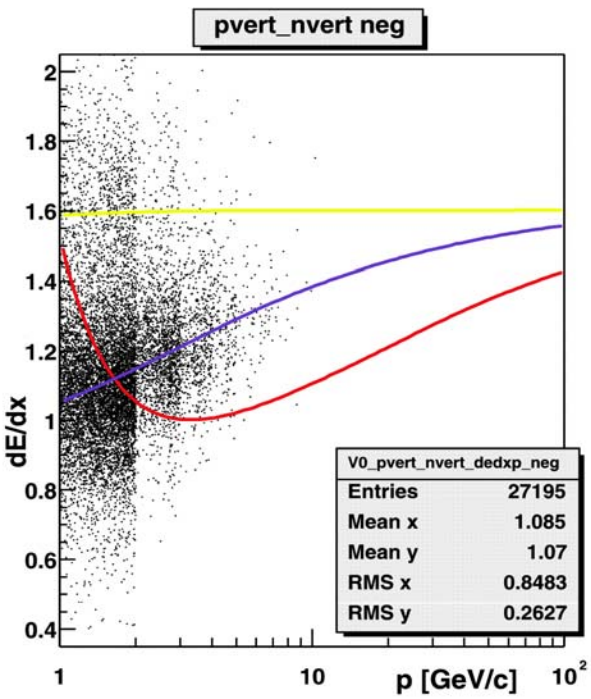
Cuts for class with negative VTPC track:

positive Dedx < $Dedx_p + 0.7 * \Delta Dedx_{\pi p}$

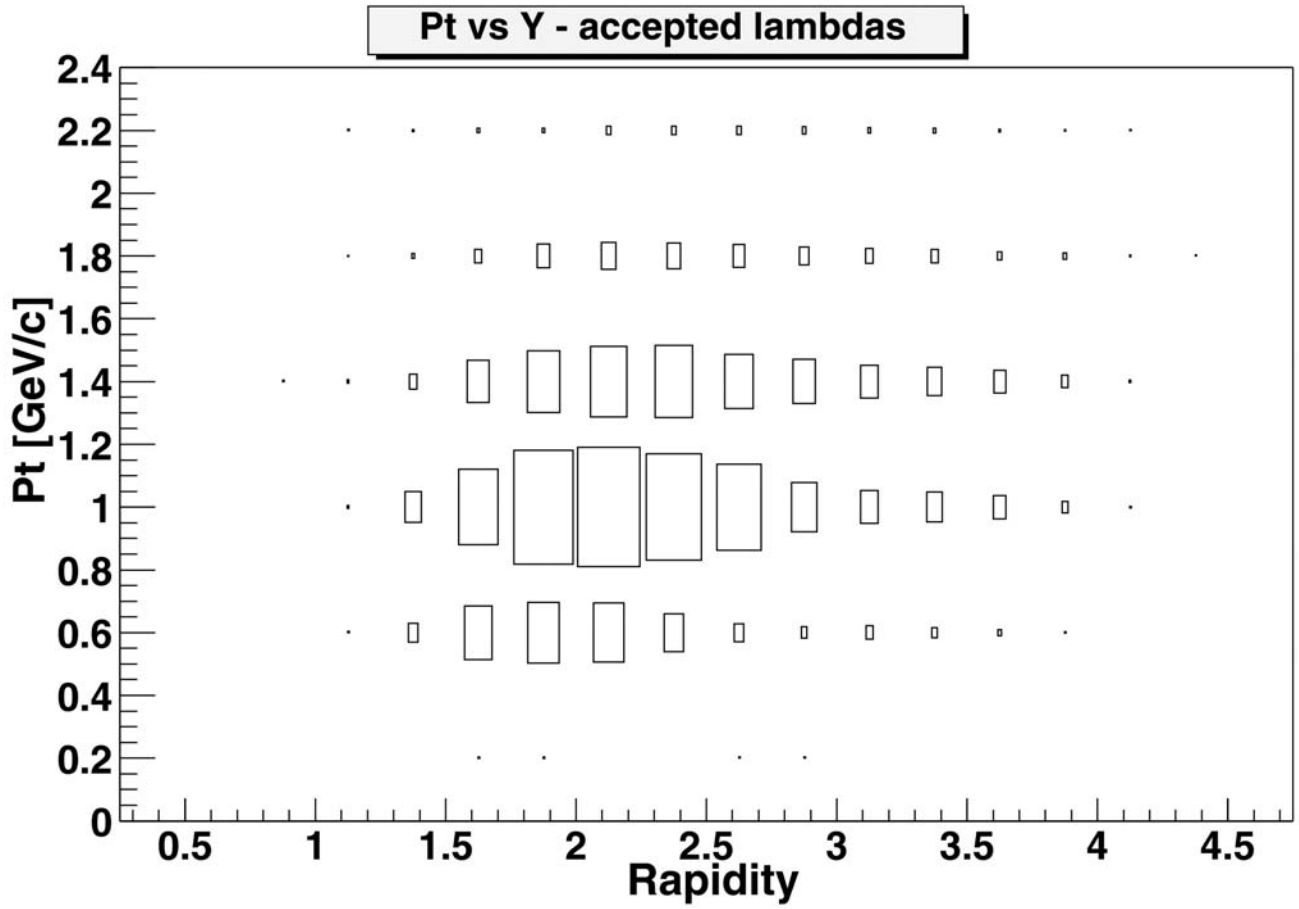


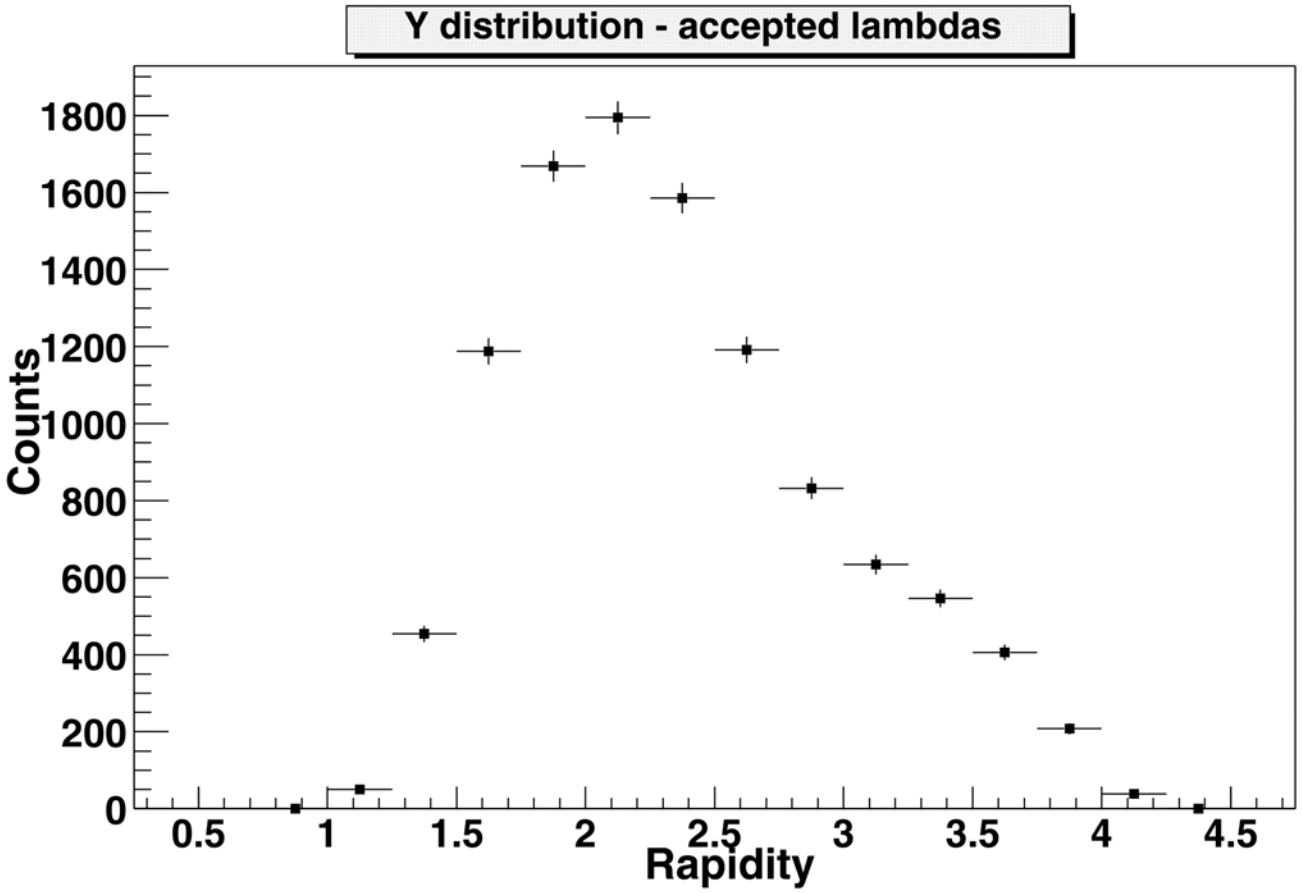






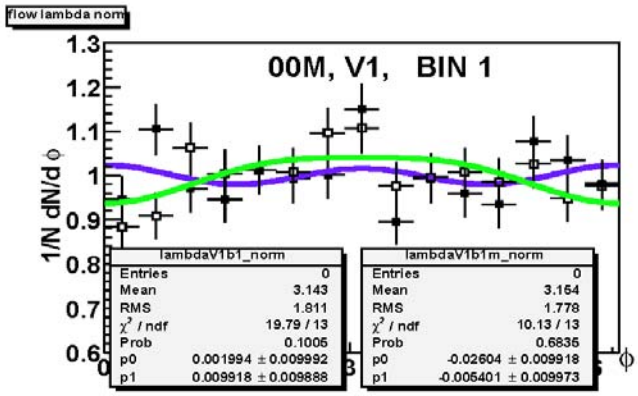
Accepted Λ-hyperons

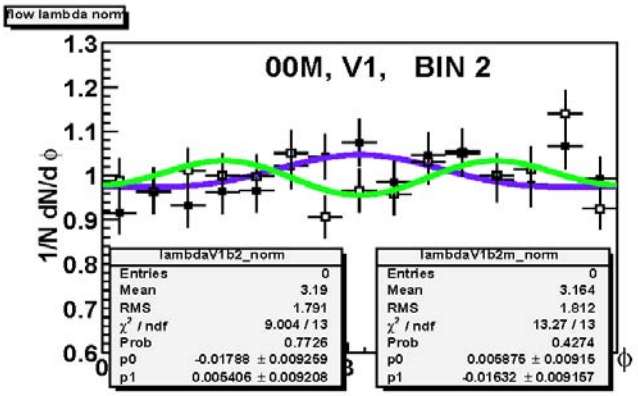


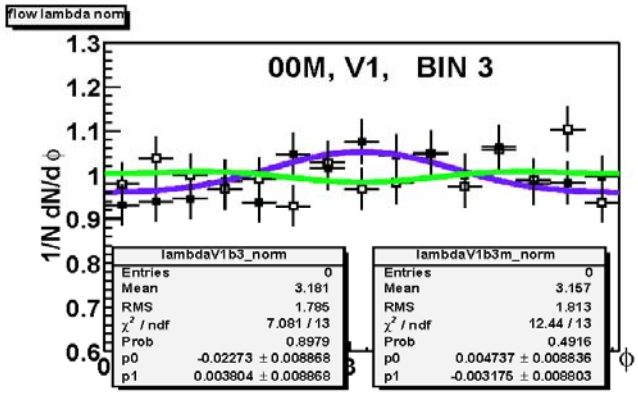


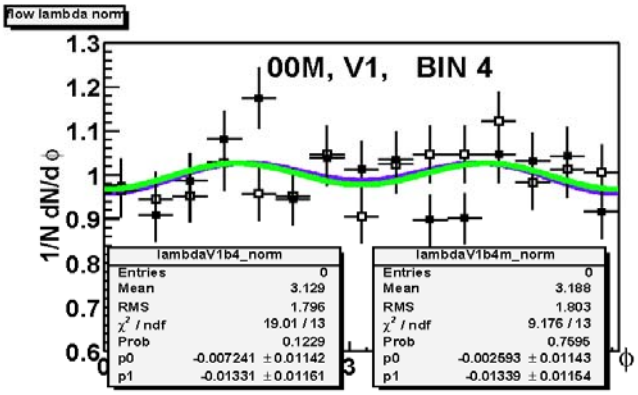
Λ directed flow - V1

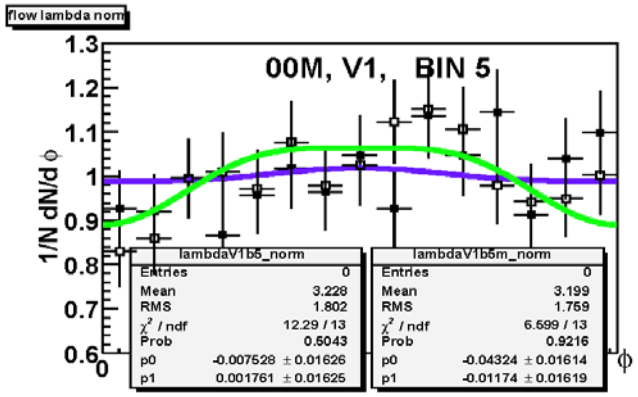
Azimuthal distribution around event plane Φ_{EP}:

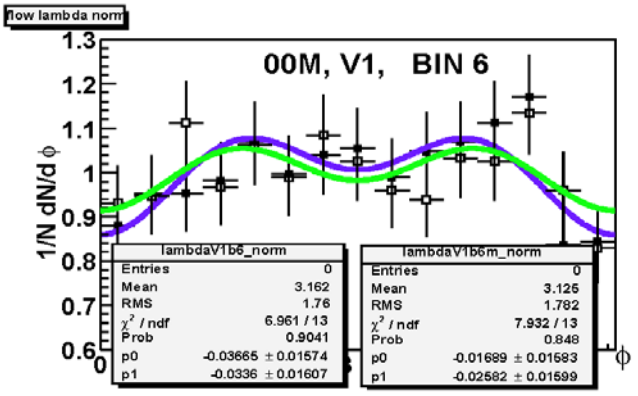






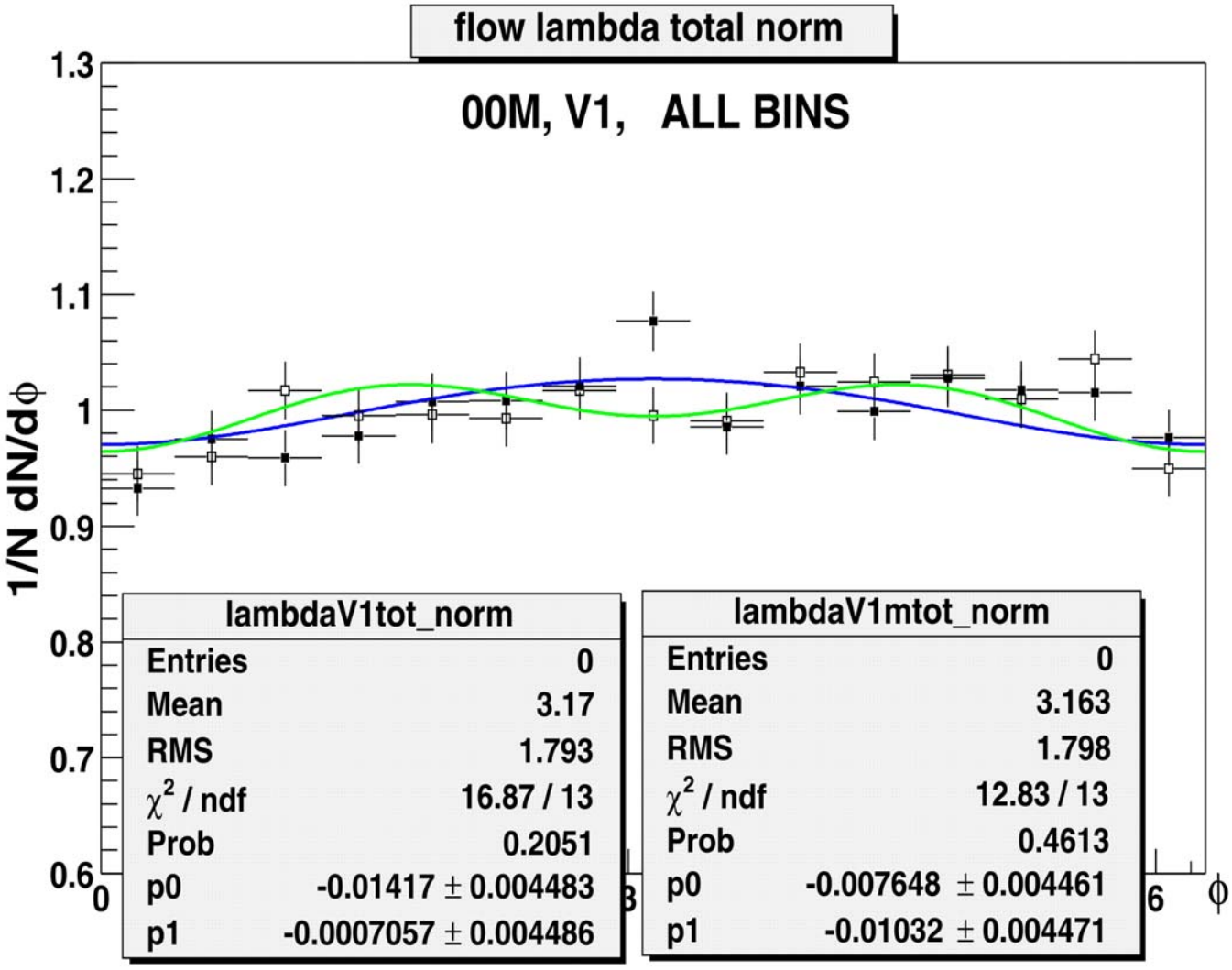






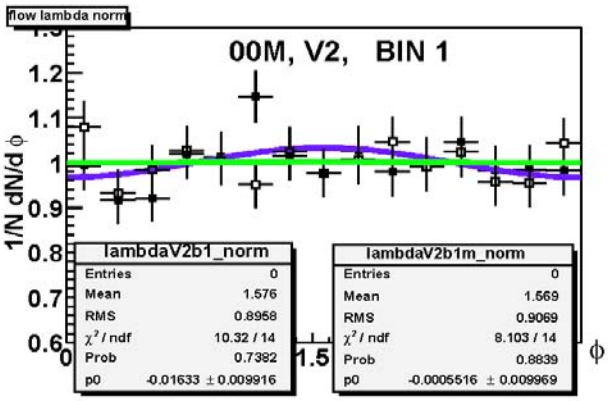
Λ directed flow - V1

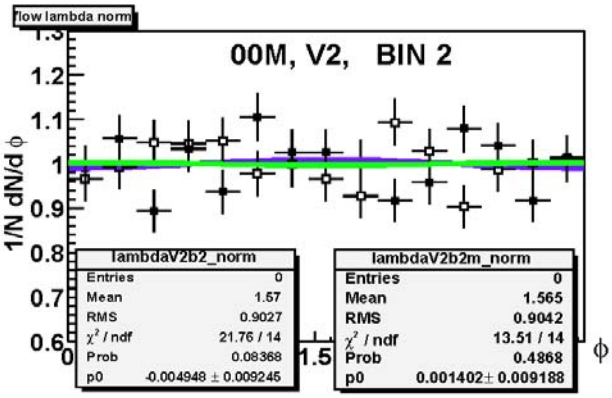
Azimuthal distribution around event plane Φ_{EP}:

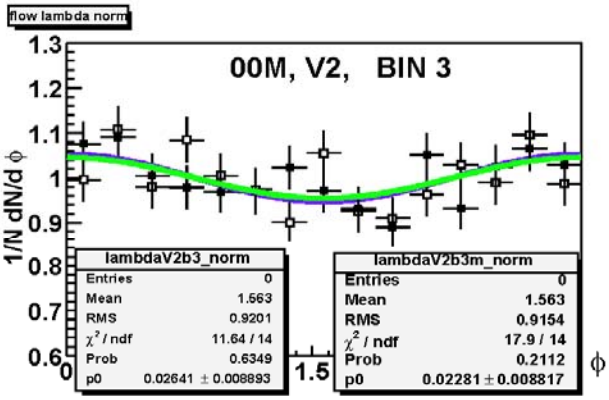


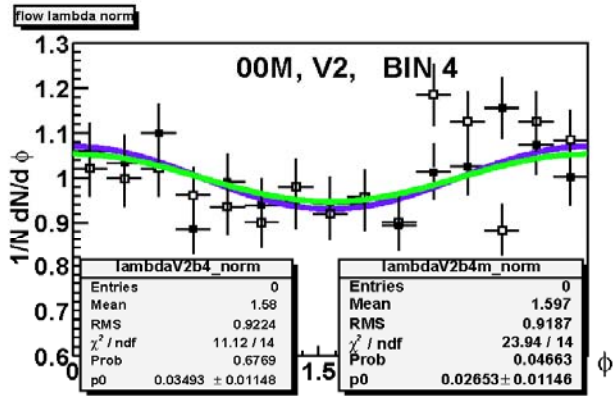
Λ elliptic flow – V2

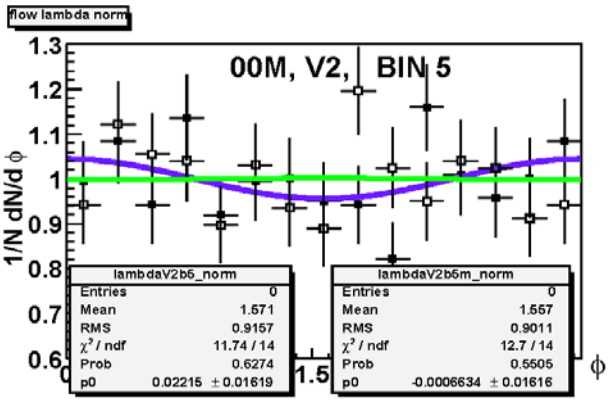
Azimuthal distribution around event plane Φ_{EP}:

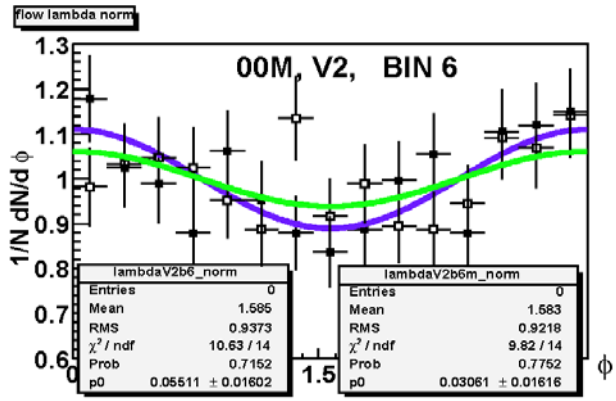






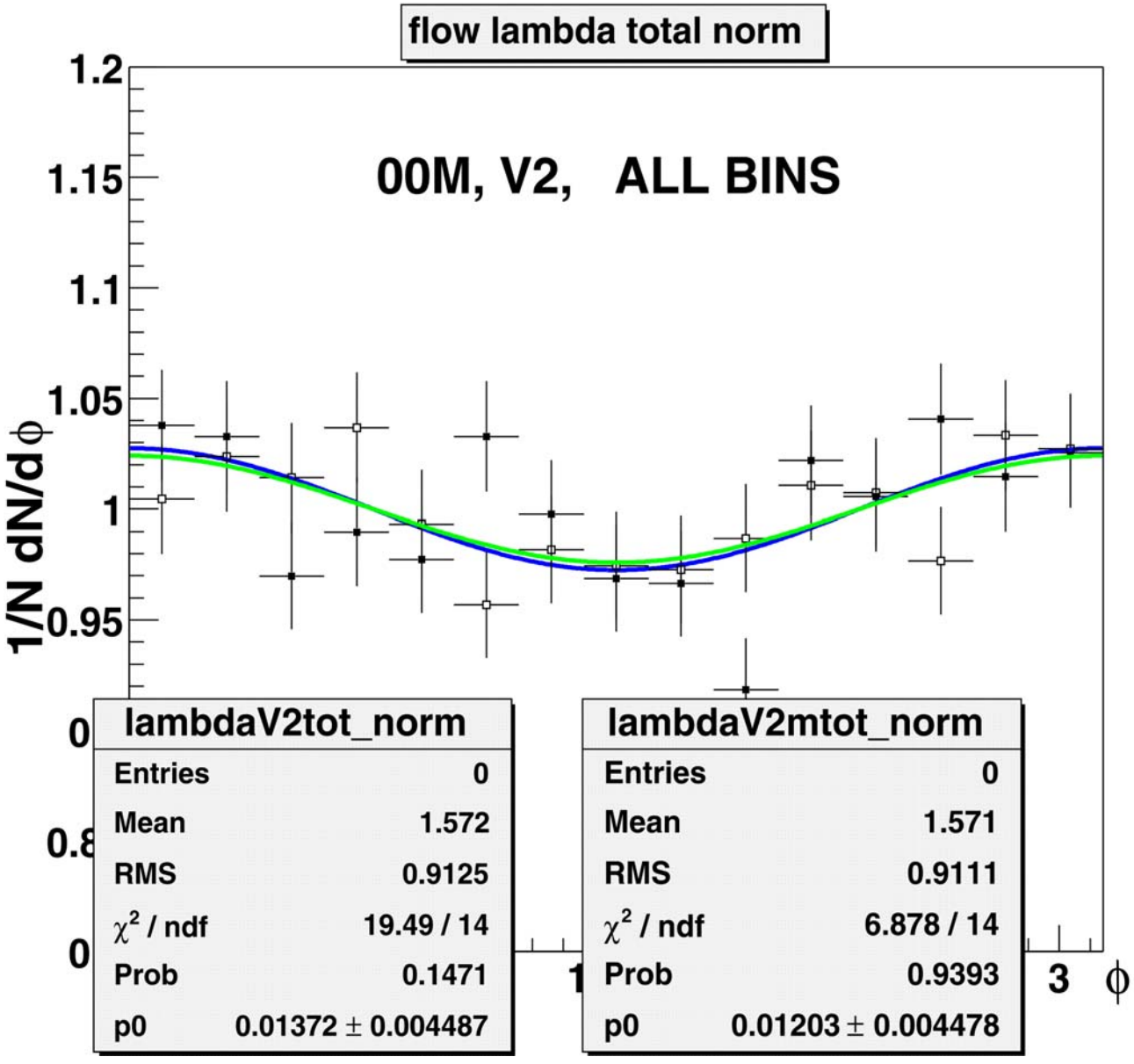






Λ elliptic flow – V2

Azimuthal distribution around event plane Φ_{EP}:



Summary:

Done:

- **the method of event plane determination has been prepared and checked**
- **significant directed and elliptic flow of pions and protons are measured**
- **Λ-hyperons are identified**
- **no qualitative results of Λ-flow analysis are obtained**

The method of Λ-flow analysis needs further investigation and checking.

To Do:

- **event plane shifting procedure**
- **review mixed events production**
- **increase statistics (central events - 00B, 00I productions)**