Preparation for QM2019: Status of the Hyperon Flow Analysis

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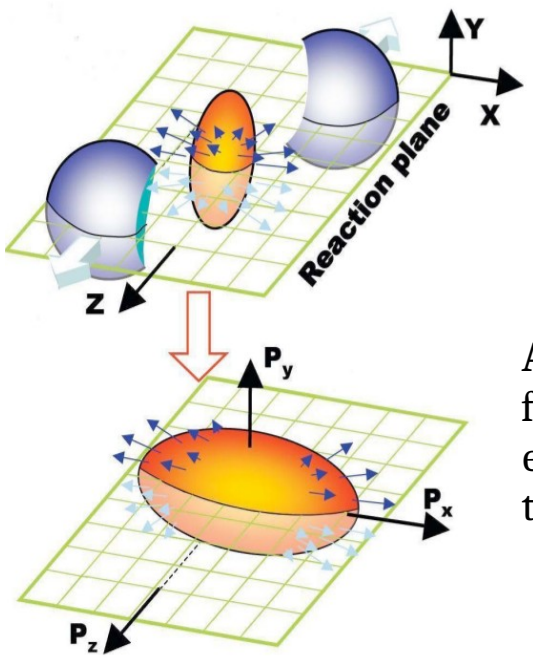
MPD PWG2 13.09.19

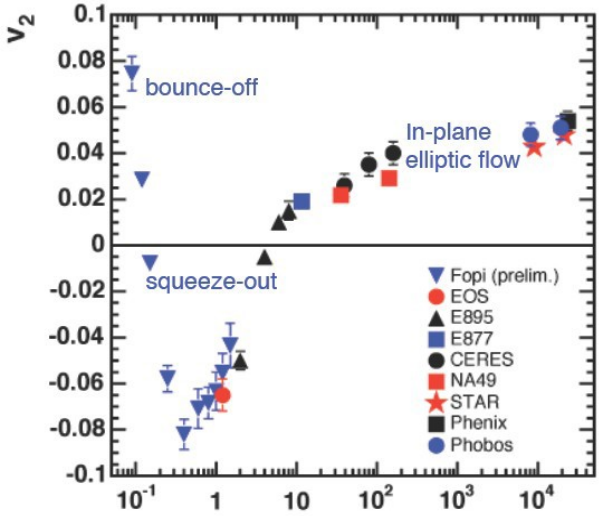
Anisotropic Flow @ NICA/MPD



In HIC a non-zero b leads to:
* Spatial anisotropy
* Pressure gradient
* Momentum anisotropy
* Fourier expansion→Flow v_n

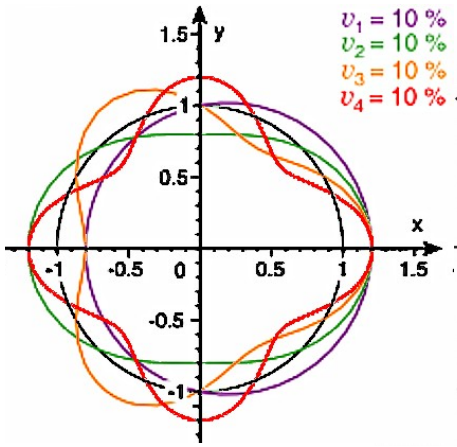
At Nuclotron-NICA energy range elliptic flow as a function of energy changes sign. Both directed and elliptic flow can signal a first order phase transition.

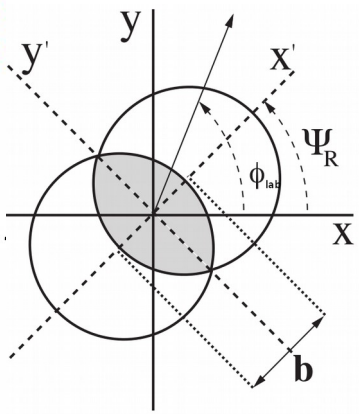
At RHIC a difference between v2 of particles and their corresponding antiparticles was observed. NICA is expected to measure this.

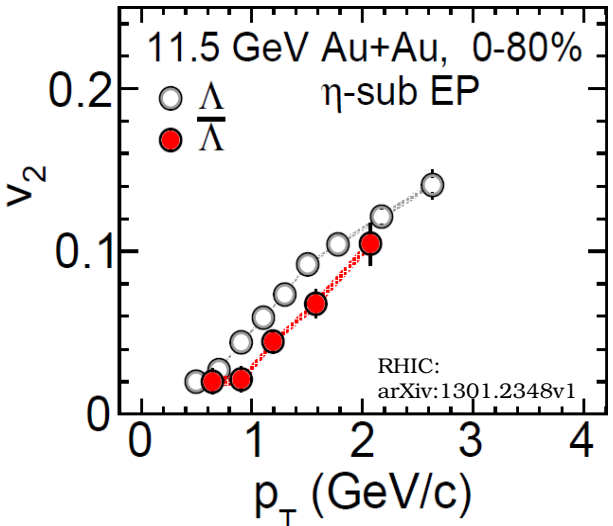


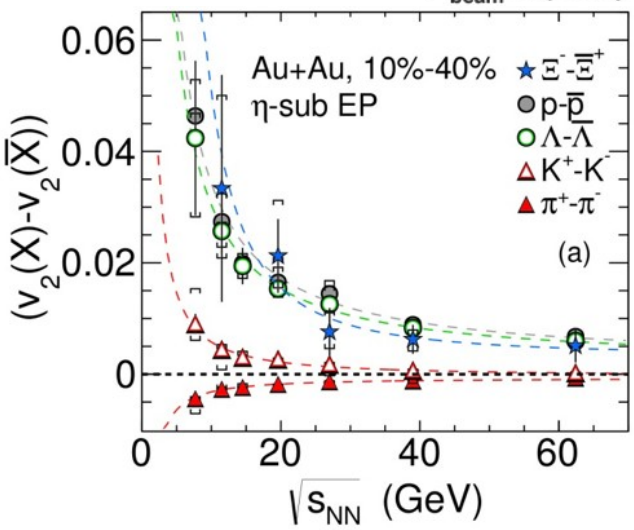
$$E\frac{d^3N}{d^3\boldsymbol{p}} = \frac{dN}{2\pi\, p_T dp_T dy}\left(1 + 2\sum_{n=1}^{\infty} v_n(p_T, y)\cos(n(\phi - \Psi_n))\right)$$

$$v_n(p_T, y) = \langle \cos[n(\phi - \Psi_n)] \rangle$$





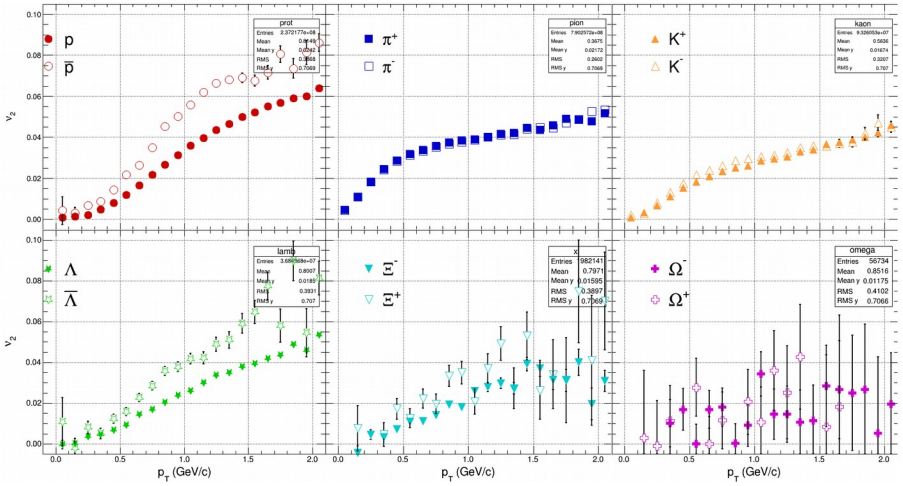


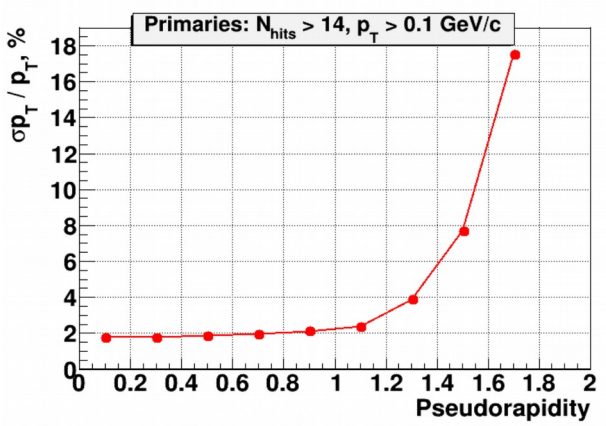


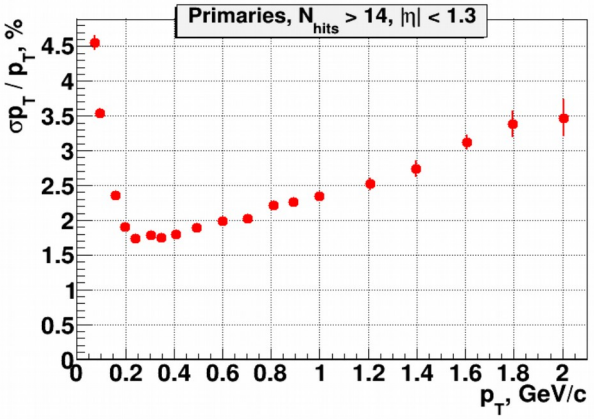
Requirements for Hyperon Flow Studies @ NICA/MPD

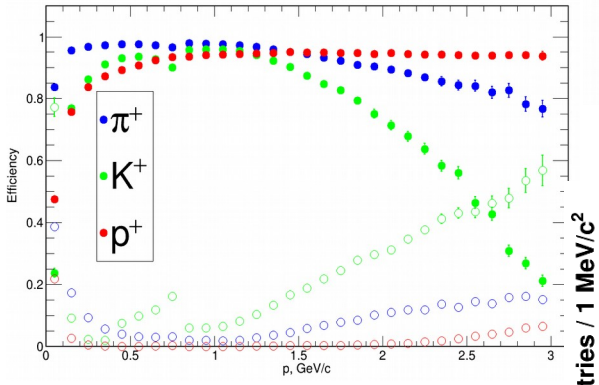
Precise tracking at both low and high p_T
Good particle identification
Precise primary and secondary vertexing with good efficiency
Event-plane determination and correction
Hyperon flow requires much larger statistics

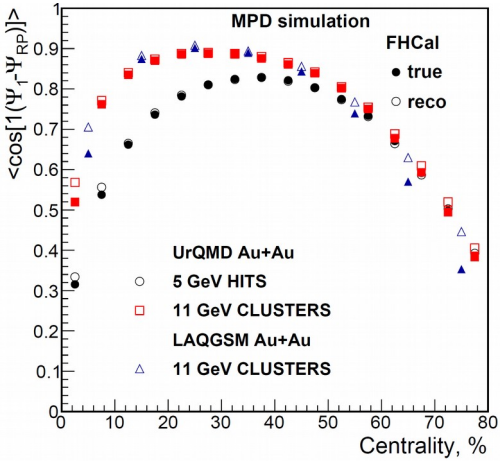
10 million, UrQMD(non-hydro), AuAu, 11 GeV, 0..16 fm

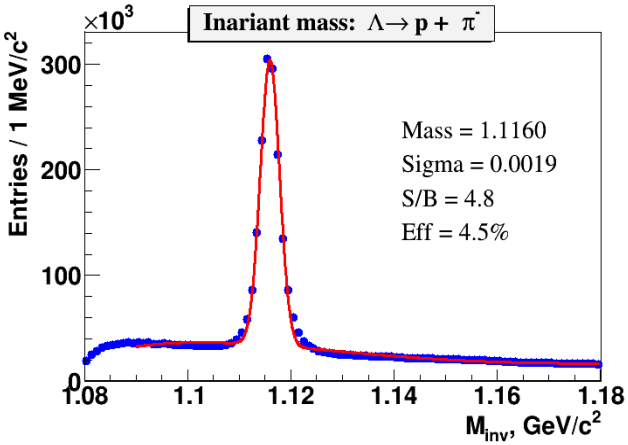










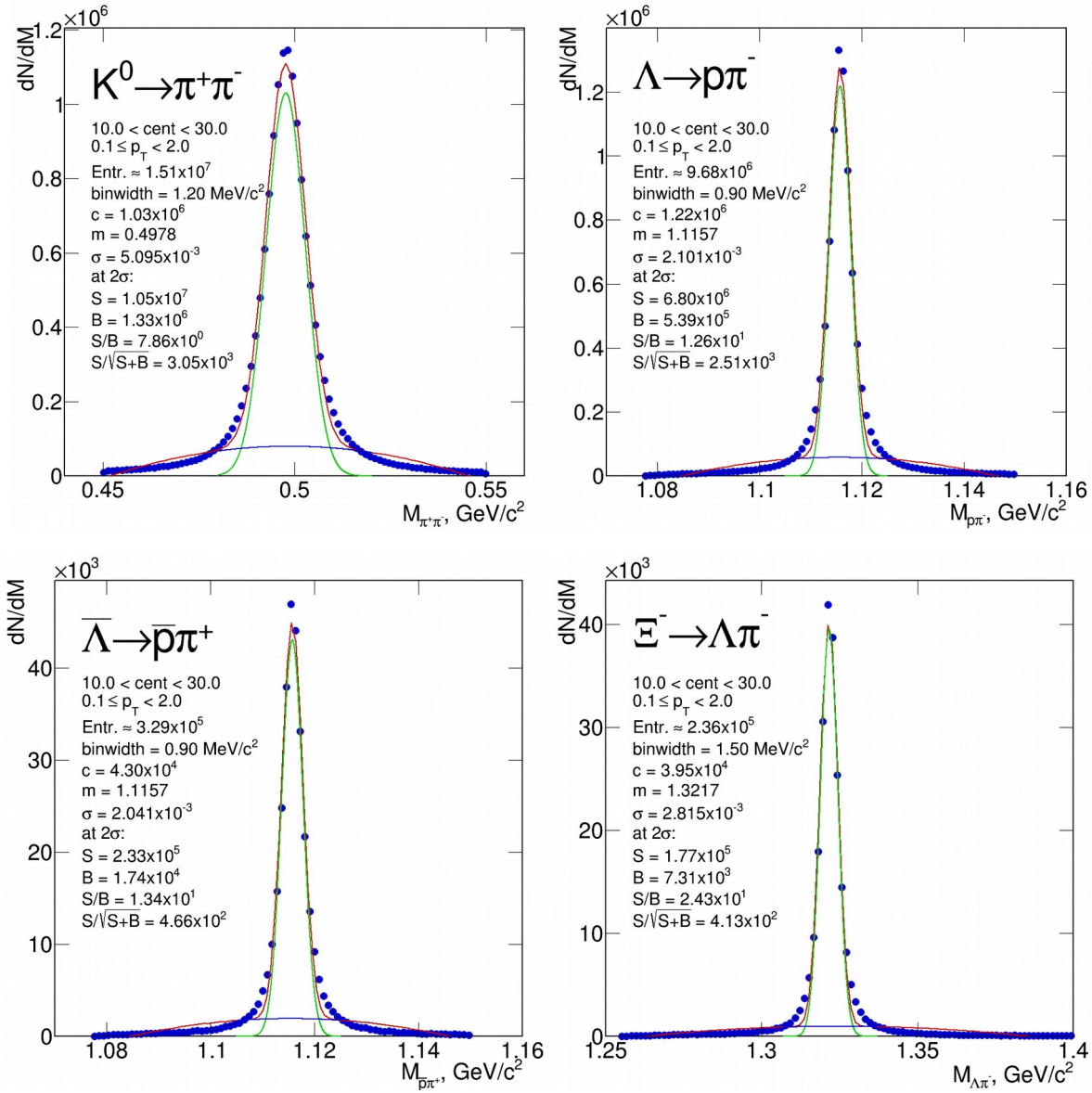


Previous Results I: Reconstructed Decays

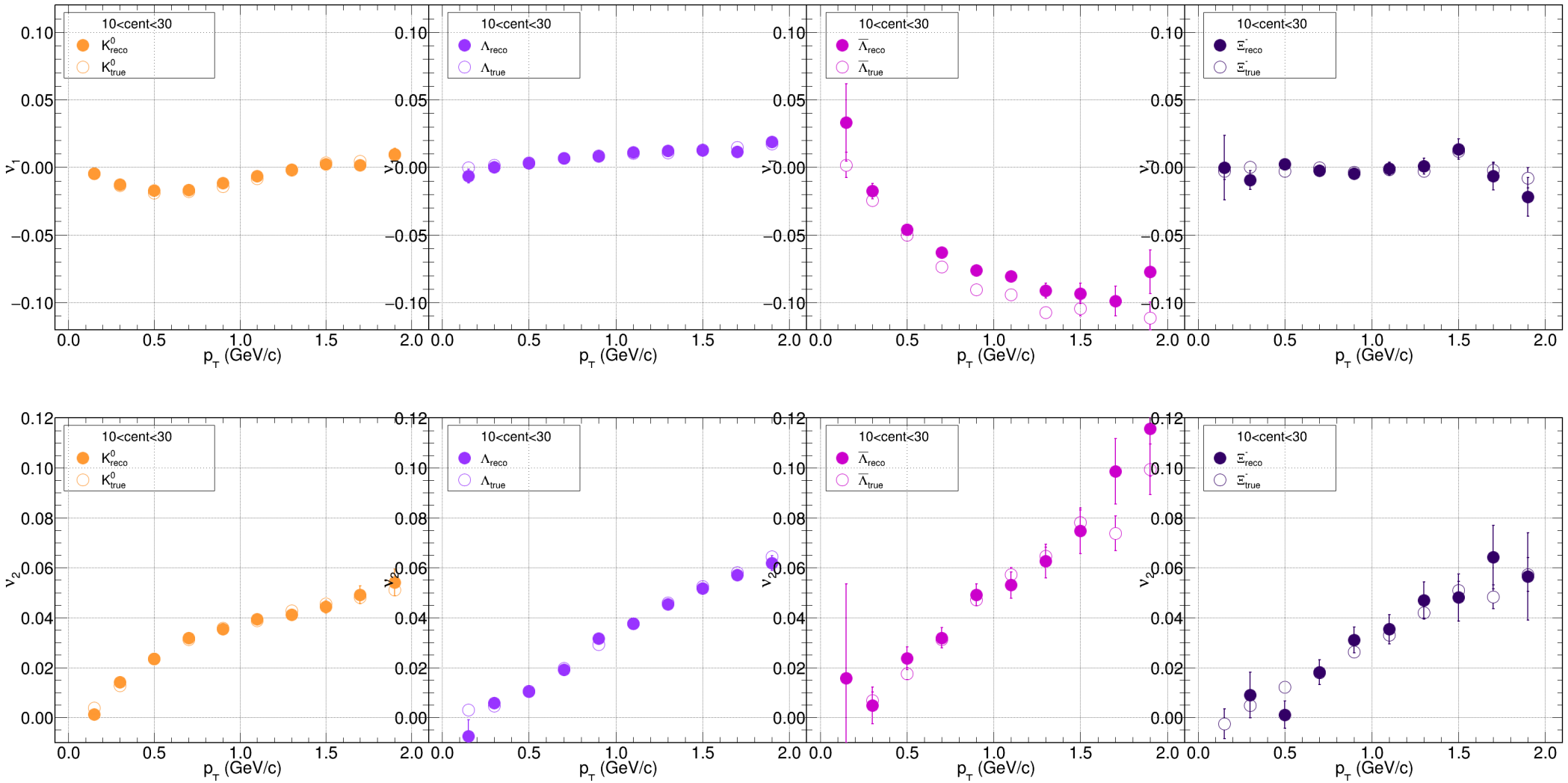
Previous Results
15.04.19 MPD PWG Round Table

Fully reconstructed particles,
but true MC ID and MC PID used.
(please disregard S, B, etc.)
$0.1<p_T<2.0$

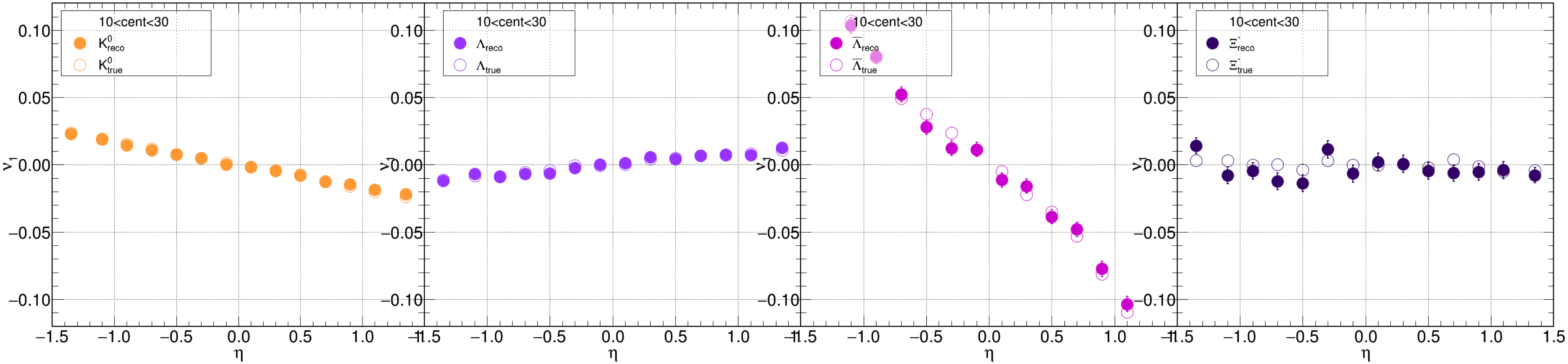
Q: Why only TRUE?
A: Establishing a baseline,
no systematics due to cuts,
highest possible efficiency/statistics

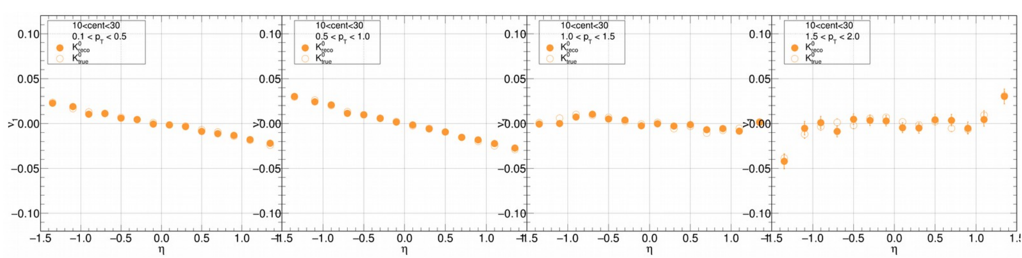


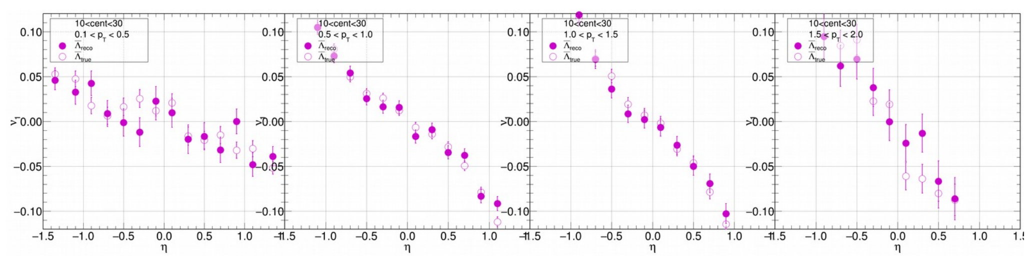
Previous Results II: Flow Results $v_{1,2}$ vs p_T

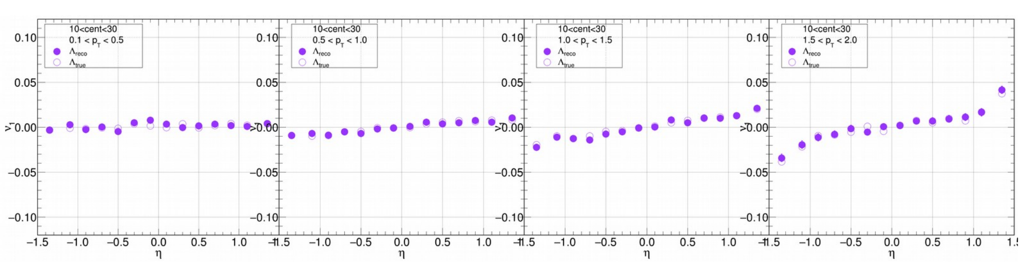


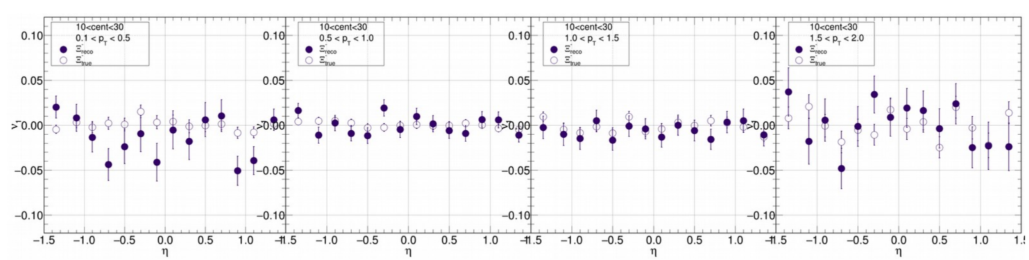
Previous Results III: Flow Results v_1 vs η (p_T bins)











Recent Developments

Converted to ROOT6

Added 2 more particles to MpdParticleRecoTask for a total of 7:
K_s^0, Λ, $\overline{\Lambda}$, Ξ^-, $\overline{\Xi}^+$, Ω^-, $\overline{\Omega}^+$

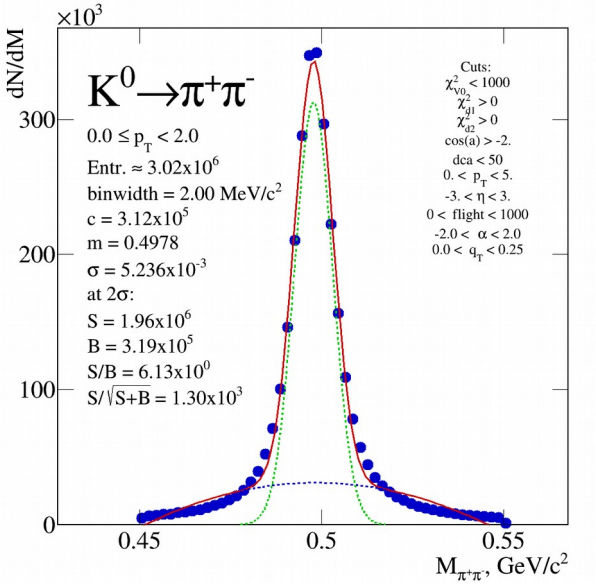
Added convenient interface for setting cuts for decays.
Works ok for True Particles without cuts.
Currently investigating some issues with cut application.

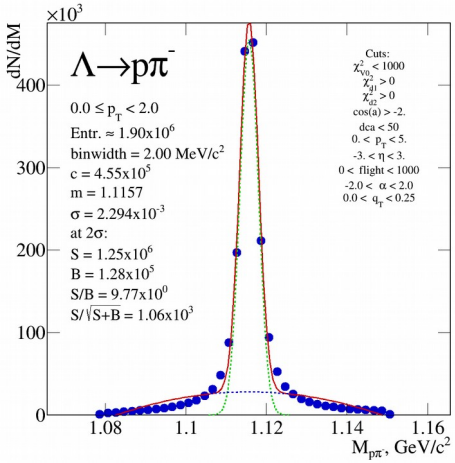
Added flow code to mpdroot, simplified decay particles part

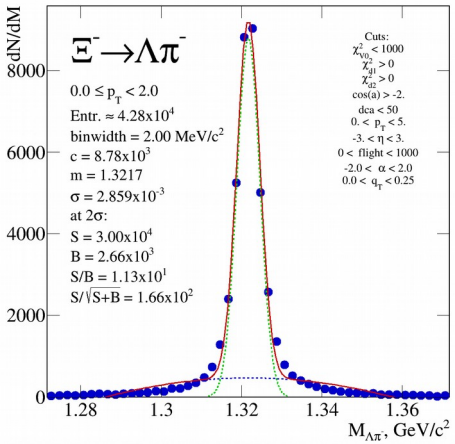
Extended flow with 2d centrality flow analysis bins:
It is now possible to have overlapping centrality bins
10-25%, 15-30%, 10-30%, 15-25%, etc.
all in the same (e.g. 20%) event / run!

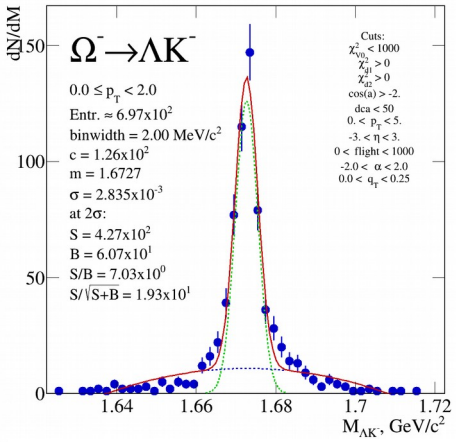
Developments – 7 particle decays

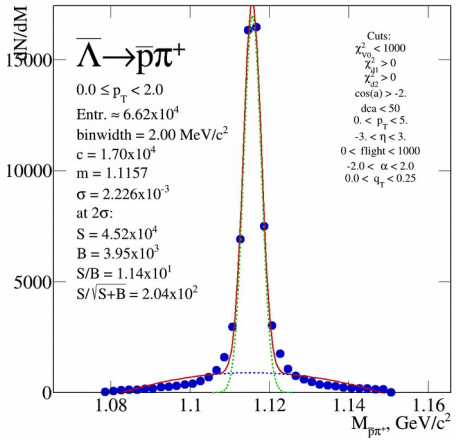
UrQMD3.4, AuAu,
11 GeV, 0-16fm
1 million events,
TPC, TOF, FHCal
ClusterFinder
MC PID
TrueParticle

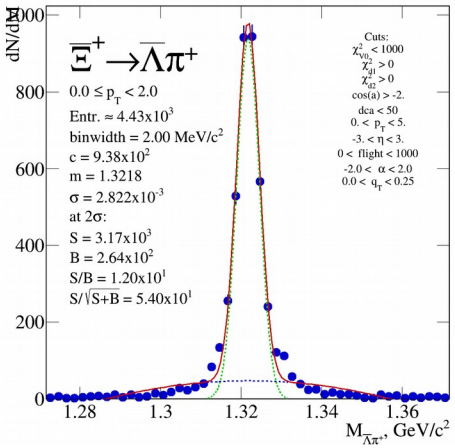


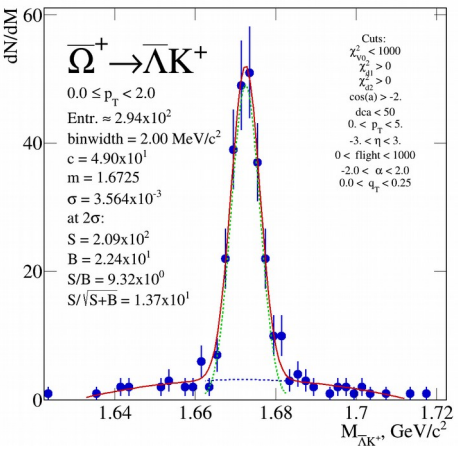












Developments – 2d centrality flow analysis bins

Multiple bin selections are now possible.
Loop in the event on the number of bins in which the event centrality falls within.
Maybe not realistic or useful to do too many centrality bins.
However, useful for diagnostics and preliminary studies
e.g. {10,20}, {10,30} simultaneously.
Also ROOT can have some problems with writing too many histograms.

{10.,20.,30.,40.,50.,60.,70.,80.,90,100.},
{15.,25.,35.,45.,55.,65.,75.,85.,95,100.},
{10.,25.,40.,55.,70.,85.,100.,-1,-1,-1},
{15.,30.,45.,60.,75.,90.,100.,-1,-1,-1},
{20.,35.,50.,65.,80.,95.,100.,-1,-1,-1},
{10.,30.,50.,70.,90, -1, -1, -1, -1, -1},
{15.,35.,55.,75.,95., -1, -1, -1, -1, -1},
{20.,40.,60.,80.,100., -1, -1, -1, -1, -1},

TODO: Currently most binning settings are hard coded in utility.h and require recompilation. It will be better to make them more dynamic and set them in a macro. This will require a lot of changes in flow code.

Computing Status

Registered to HybriLIT, installed MPDROOT without issues,
more tests required, not sure how to run on GOVORUN, knl?

Issues on nc-cluster are resolved:
- slow run on disk mpd4 – set sge -o and -e to /dev/null
- Eqw-status of tasks is resolved by administrator

Currently running 200 tasks at a time.
Additional space 30 TB was allowed on /eos by administrator

25 million events, UrQMD 3.4, 11 GeV, 0-16 fm,
RECO: TPC ClusterMLEM, TOF, FHCal

ParticleTrue + RECO → Flow Reduced Files → Flow Analysis
Can be ready by next week meeting.

ParticleCuts + RECO → Flow Reduced Files → Flow Analysis
Currently investigating a technical issue with applying cuts.

Proper Flow Signal Extraction

The total (s+b) flow signal can be expressed as a sum of the decay particle signal flow and background flow multiplied by the respective relative yields in m_{inv} .

The background flow contribution can be extrapolated with a linear function fitted to the sidebands

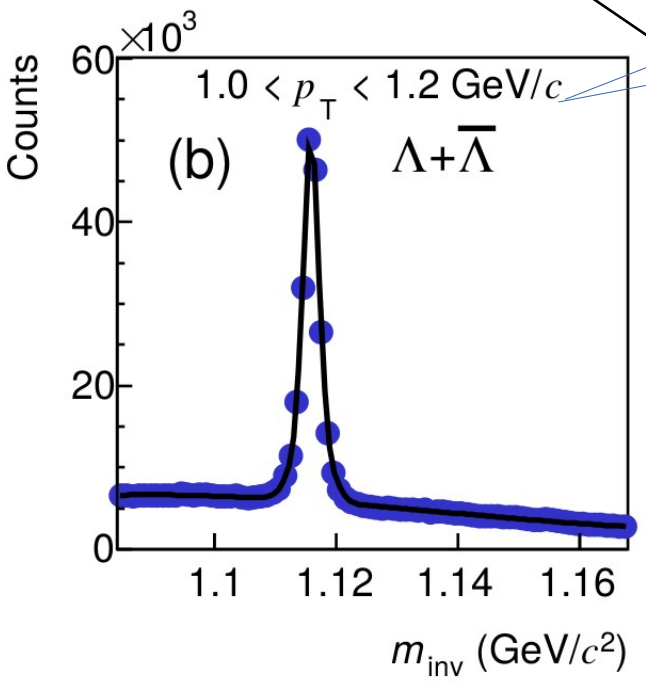
The total flow signal vs m_{inv} is fitted by the combined function and the signal contribution is extracted from the fit.

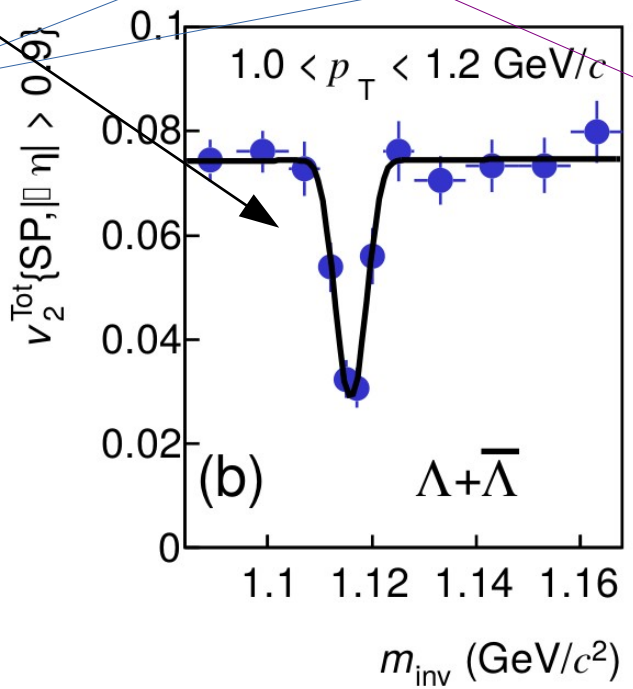
arXiv:nucl-th/0407041v2 N. Borghini, J.-Y. Ollitrault
arXiv:0801.3466 [nucl-ex] STAR Collaboration: B.I.Abelev
arXiv:1405.4632 [nucl-ex] ALICE Collaboration

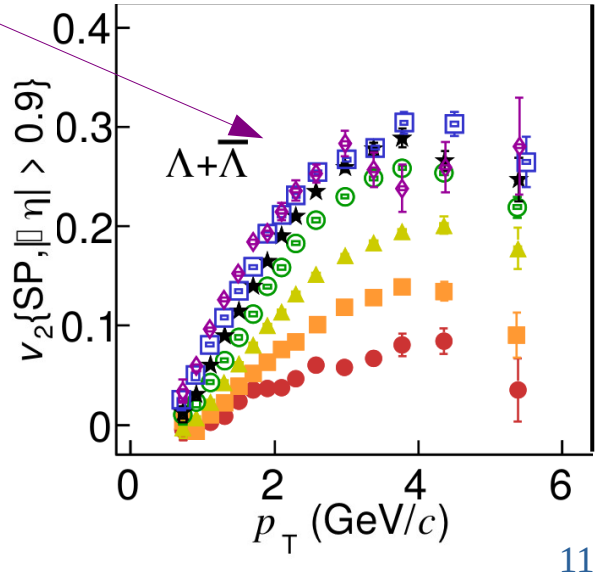
Extrapolate in signal region

$$\nu_2^{Bg}(m_{inv}, p_T) = p_0 + p_1 m_{inv}$$

$$v_2^{\mathrm{Tot}}(m_{\mathrm{inv}}, p_{\mathrm{T}}) = v_2^{\mathrm{Sgn}}(p_{\mathrm{T}}) \frac{N^{\mathrm{Sgn}}(m_{\mathrm{inv}}, p_{\mathrm{T}})}{N^{\mathrm{Tot}}(m_{\mathrm{inv}}, p_{\mathrm{T}})} + v_2^{\mathrm{Bg}}(m_{\mathrm{inv}}, p_{\mathrm{T}}) \frac{N^{\mathrm{Bg}}(m_{\mathrm{inv}}, p_{\mathrm{T}})}{N^{\mathrm{Tot}}(m_{\mathrm{inv}}, p_{\mathrm{T}})}$$







Status Proper Flow Signal Extraction

TProfile2D used – 3d object containing flow in bins of both pt and mass.

In bins of pt project TProfile flow vs mass. Fit mass

The invariant mass fit provides relative yields

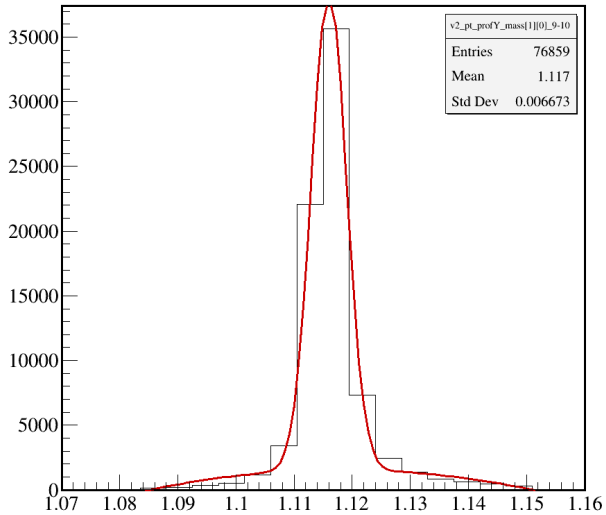
TODO: Fit background flow (requires ParticleCuts file)

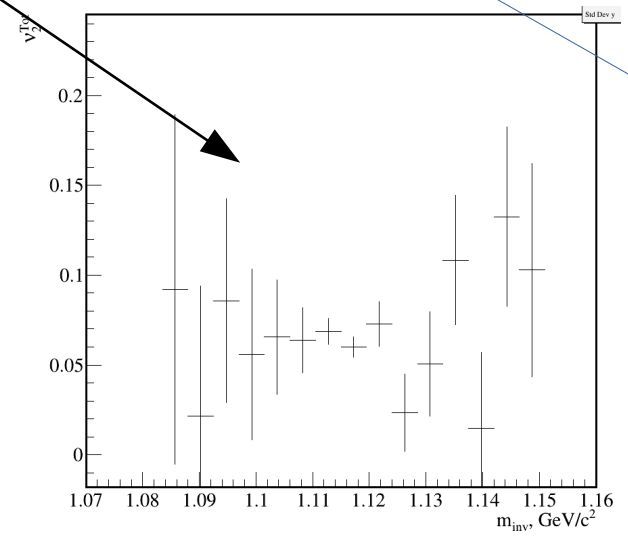
TODO: Fit total flow and extract signal

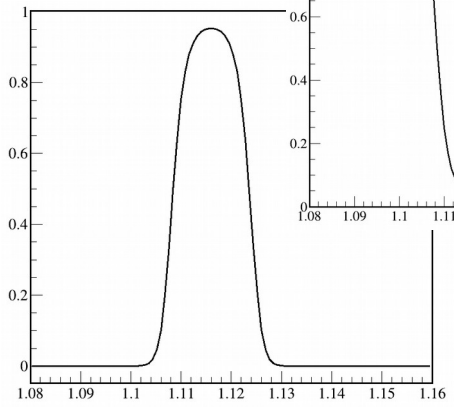
Extrapolate in signal region

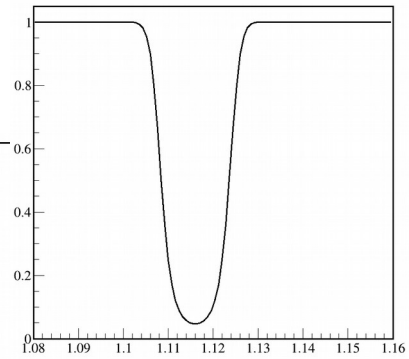
$$\nu_2^{Bg}(m_{inv}, p_T) = p_0 + p_1 m_{inv}$$

$$v_2^{\mathrm{Tot}}(m_{\mathrm{inv}}, p_{\mathrm{T}}) = v_2^{\mathrm{Sgn}}(p_{\mathrm{T}}) \frac{N^{\mathrm{Sgn}}(m_{\mathrm{inv}}, p_{\mathrm{T}})}{N^{\mathrm{Tot}}(m_{\mathrm{inv}}, p_{\mathrm{T}})} + v_2^{\mathrm{Bg}}(m_{\mathrm{inv}}, p_{\mathrm{T}}) \frac{N^{\mathrm{Bg}}(m_{\mathrm{inv}}, p_{\mathrm{T}})}{N^{\mathrm{Tot}}(m_{\mathrm{inv}}, p_{\mathrm{T}})}$$









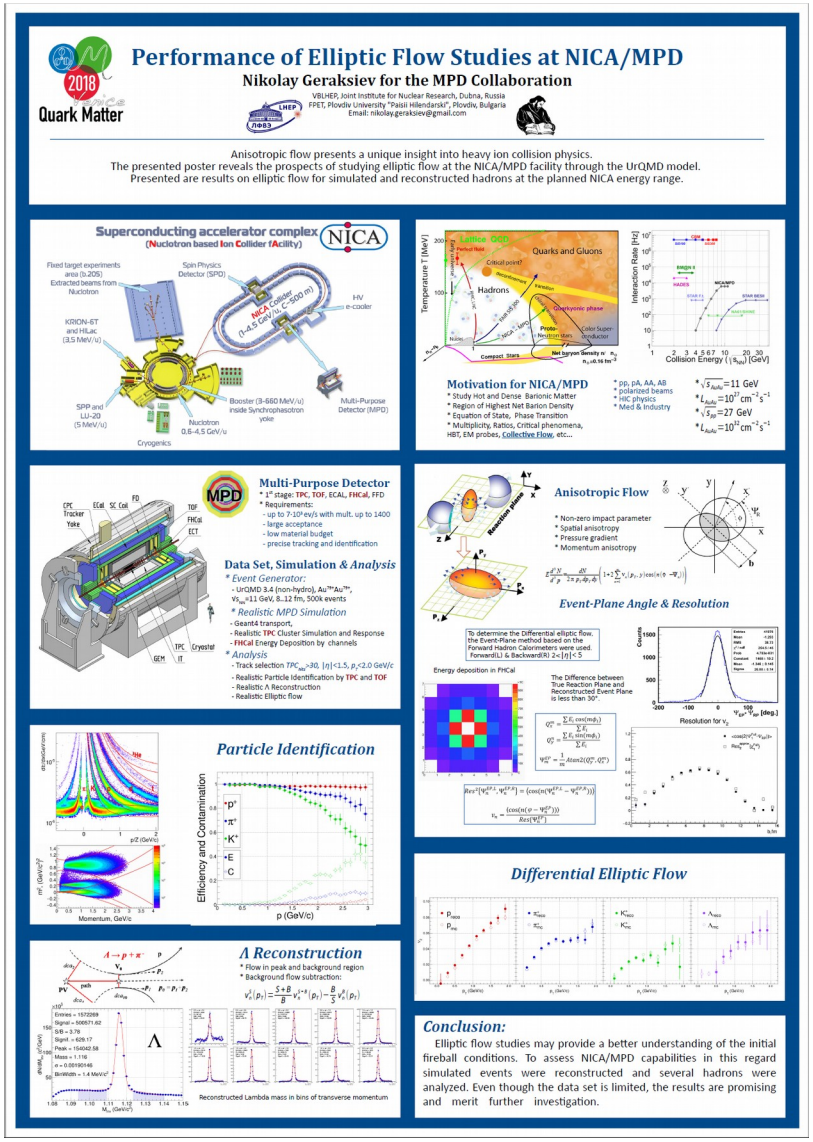
Some Considerations and Previous Poster for QM 2018

Previous poster was formatted A3 it was slightly small for the amount of plots shown.

If more data is to be shown it should be A4

In general it is good to follow a similar style of plots

Contents in my opinion:
* title, abstract, conclusion ofc.
* accelerator facility, beam config, experiments
* general place in HIC physics and goals
* detector, mpdroot and simulation
* tracking, vertexing, pid
* reconstruction of hyperons / cuts
* results of analysis on hyperons
* flow, FHCal event-plane method, resolution
* results of flow analysis on hyperons



Conclusion

In principle analysis of 7 particle (true) decays should be ready by next week's PWG2 meeting.

Depending on statistics for "true" $\overline{\Xi}^{+}$, Ω^{-}, $\overline{\Omega}^{+}$ they may be included/excluded.

Depending on readiness of particle cuts and signal flow extraction procedure those can be added, as well. Probably only for K_s^0, Λ, $\overline{\Lambda}$

Thank you!