MPD plenary meeting
25 April 2017

Participation of SINP MSU group in data analysis for MPD

Ludmila Malinina (SINP MSU JINR),
Konstantin Mikhaylov (ITEP & JINR),
Gulnara Eyyubova (SINP MSU),
Stanislav Shushkevich (SINP MSU)

Present activities of SINP MSU group

within the agreement between JINR and SINP MSU : 01.06.16-30.04.17

- **Femtoscopy study for NICA .**
  - MC study of femto observables
  - Development of MPD Femto software
  - PID & tracking studies

(Malinina Ludmila, Konstantin Mikhailov, Gulnara Eyyubova)
together with JINR group of Oleg Rogachevsky - Pavel Batyuk

- **Development of tracking algorithm for ITS MPD**
  (Stanislav Shushkevich)

Status of FEMTOSCOPY study

Konstantin Mikhaylov (ITEP & JINR),
Ludmila Malinina (SINP MSU JINR),

ArXiv 1703.09628

Correlation femtoscopy study at NICA and STAR energies within the vHLLE+UrQMD model

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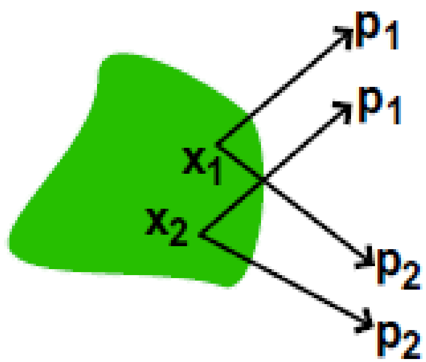
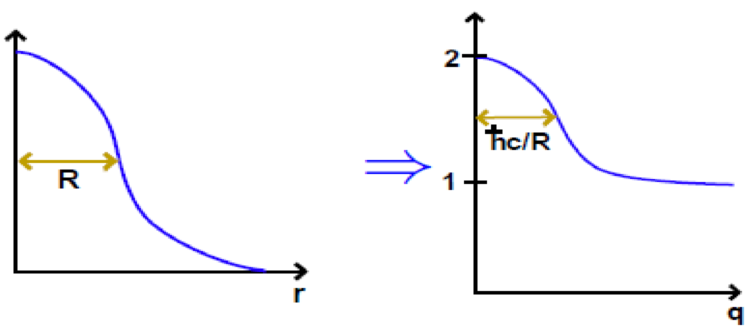
Correlation femtoscopy allows one to measure the space-time characteristics of particle production in relativistic heavy-ion collisions due to the effects of quantum statistics (QS) and final state interactions (FSI). The main features of the femtoscopy measurements at top RHIC and LHC energies are considered as a manifestation of strong collective flow and are well interpreted within hydrodynamic models employing equation of state (EoS) with a crossover type transition between Quark-Gluon Plasma (QGP) and hadron gas phases. The femtoscopy at lower energies was intensively studied at AGS and SPS accelerators and is being studied now in the Beam Energy Scan program (BES) at the BNL Relativistic Heavy Ion Collider in the context of exploration of the QCD phase diagram. In this article we present femtoscopic observables calculated for Au-Au collisions at $\sqrt{s_{NN}} = 7.7 - 62.4$ GeV in a viscous hydro + cascade model `vHLLE+UrQMD` and their dependence on the EoS of thermalized matter.

PACS numbers: 25.75.-q, 25.75.Gz
Keywords: relativistic heavy-ion collisions, hydrodynamics, collective phenomena, Monte Carlo simulations, vHLLE, UrQMD

Introduction

Correlation femtoscopy : measurement of space-time characteristics R, cτ ~fm of particle production using particle correlations due to the effects of quantum statistics (QS) and final state interactions (FSI)





- Two particle Correlation Function (CF):

Theory: $$C(q)=\frac{N_2(p_1,p_2)}{N_1(p_1)\cdot N_2(p_1)}, C(\infty)=1$$

Experiment: $$C(q)=\frac{S(q)}{B(q)}, q=p_1-p_2$$

S(q) – pairs from same event
B(q) – pairs from different event

- Parametrization:

1D: $C(q_{inv})=1+\lambda\exp(-R^2 q_{inv}^2)$ ***R*** Gaussian radius in Pair Rest Frame (**PRF**), ***λ*** correlation strength parameter

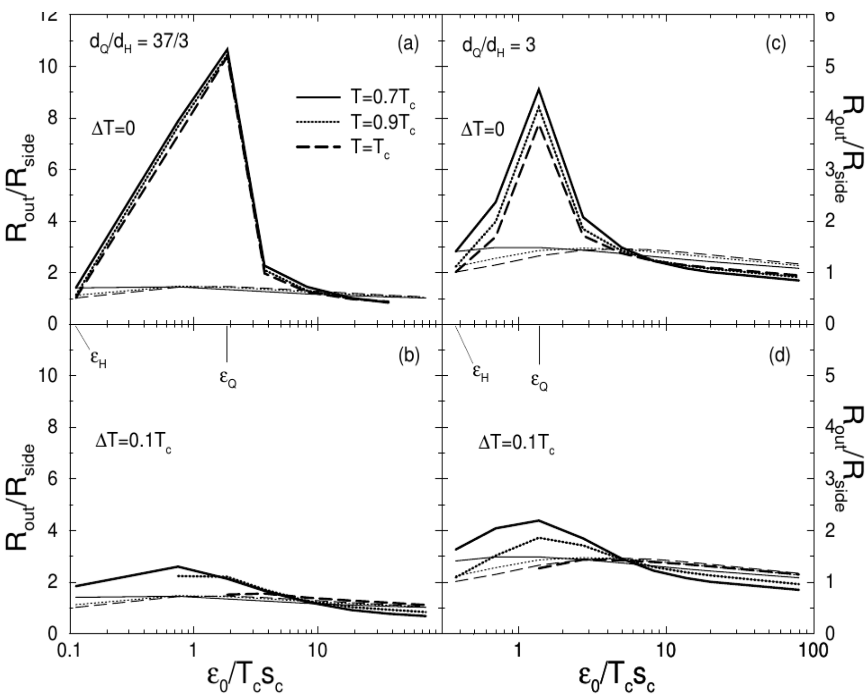
3D: $$C(q_{out},q_{side},q_{long})=1+\lambda\exp(-R_{out}^2 q_{out}^2-R_{side}^2 q_{side}^2-R_{long}^2 q_{long}^2)$$

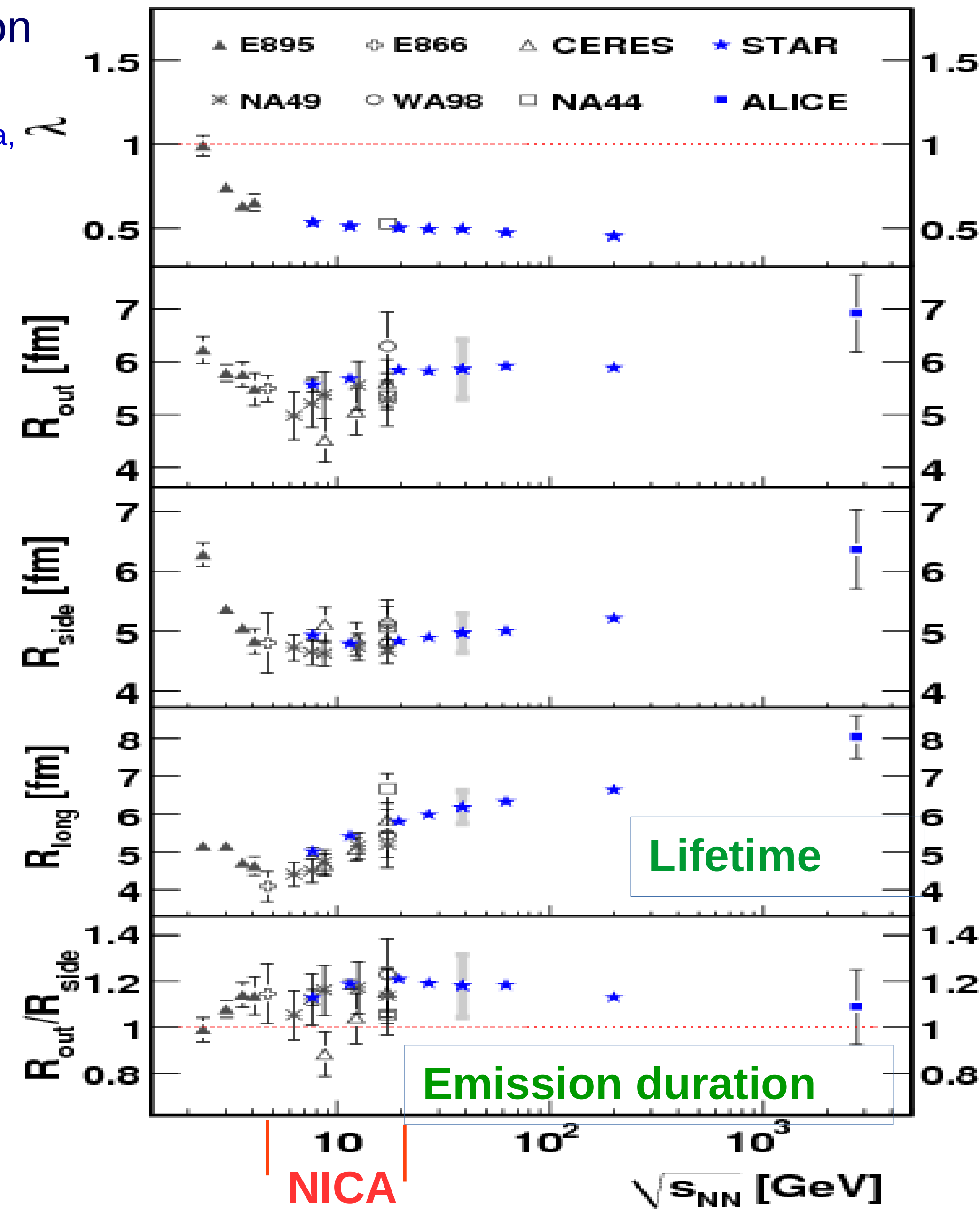
where both ***R*** and ***q*** are in Longitudinally Co-Moving Frame (**LCMS**)
long || beam; out || transverse pair velocity $\boldsymbol{v}_T$; side normal to out,long

Expected features of 1st order PT

- It was predicted that for 1st order phase transition $R_{out}/R_{side} > 1$ & large R_{long} due to emission stalling during phase transition
(S. Pratt, Phys. Rev. D 33 (1986) 1314.G. Bertsch, M. Gong, M. Tohyama, Phys. Rev. C 37 (1988) 1896)
D. H. Rischke and M. Gyulassy, Nucl. Phys. A608, 479 (1996)

STAR, Phys.Rev. C92 (2015) 1, 014904



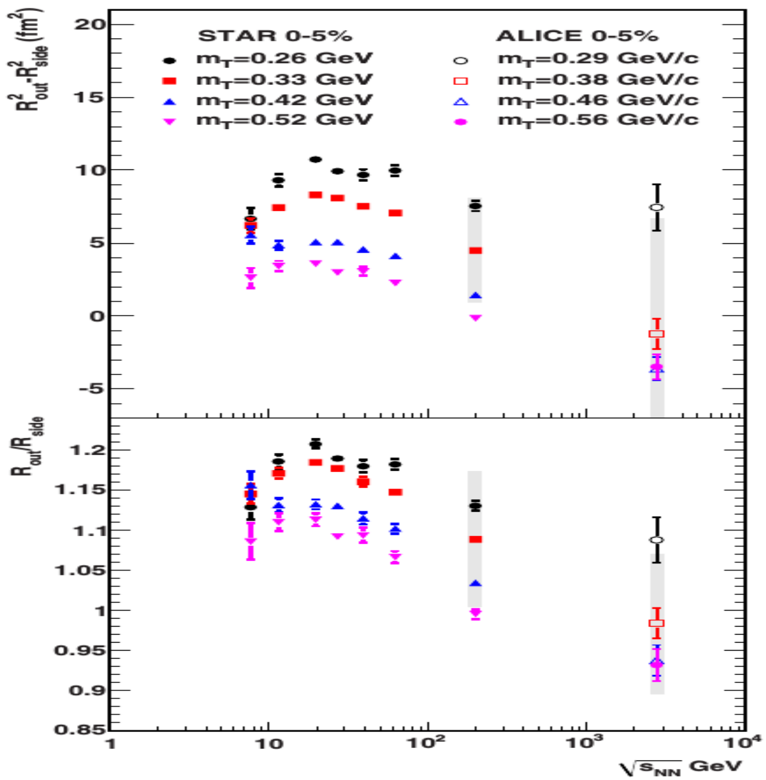


- But r-t correlations in expanding source reduce the observed R_{out} -> R_{out}/R_{side}

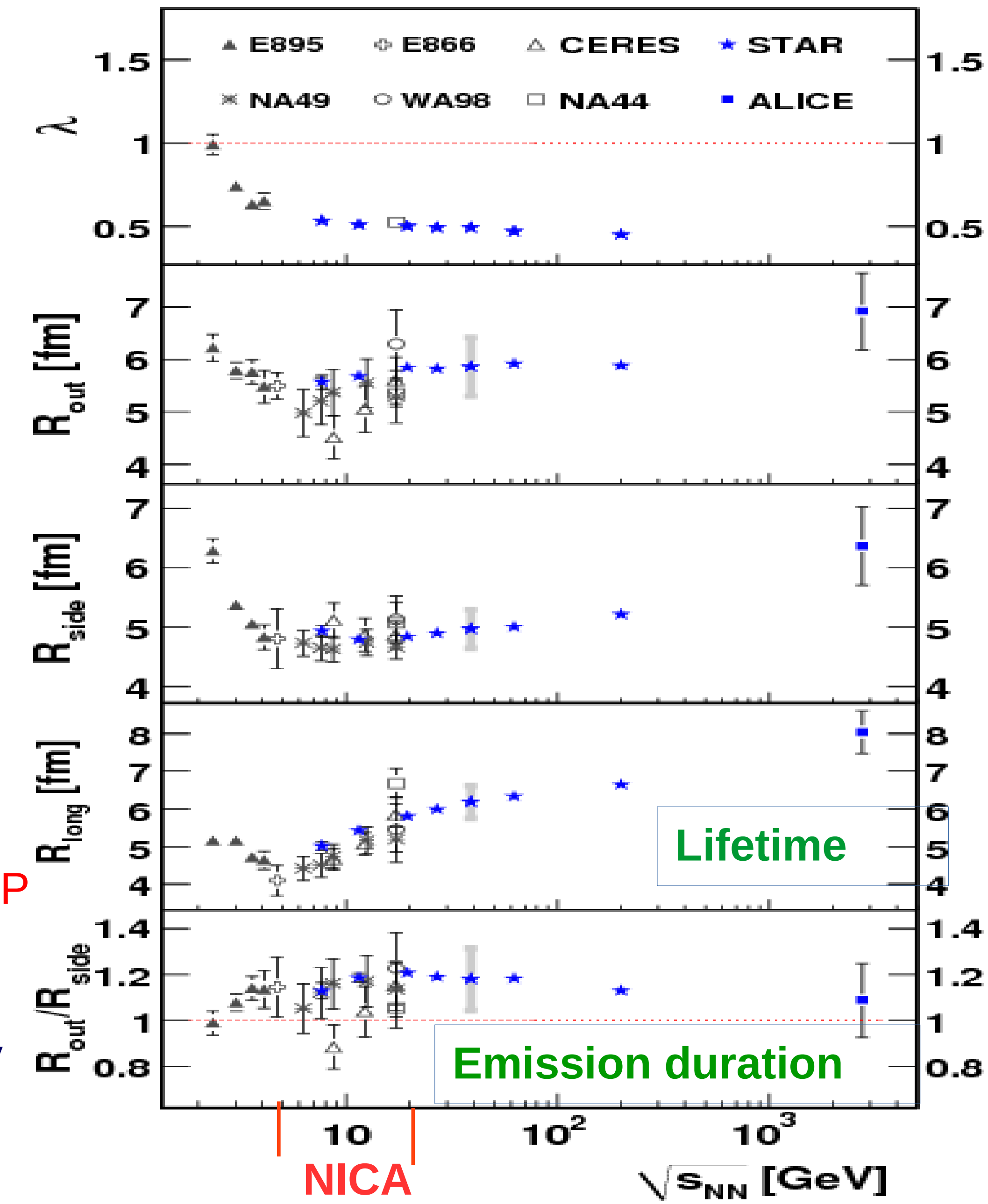
- What do the modern hydrodynamic (hybrid) models expect ?

Expected features of 1st order PT

- **Critical point ?**



STAR, Phys.Rev. C92 (2015) 1, 014904



- A peak in R_{out}/R_{side} may not be related with CEP
- What do the modern hydrodynamic (hybrid) models expect ?
- VHLLE+UrQMD model was used for tis study

vHLLE+UrQMD model

Pre-thermal phase → hydrodynamic phase → hadronic cascade

UrQMD | vHLLE (3+1)-D viscous hydrodynamics | UrQMD

Iu. Karpenko, P. Huovinen, H.Petersen, M. Bleicher, Phys.Rev. C 91, 064901 (2015), arXiv:1502.01978,1509.3751 , talk QM2015

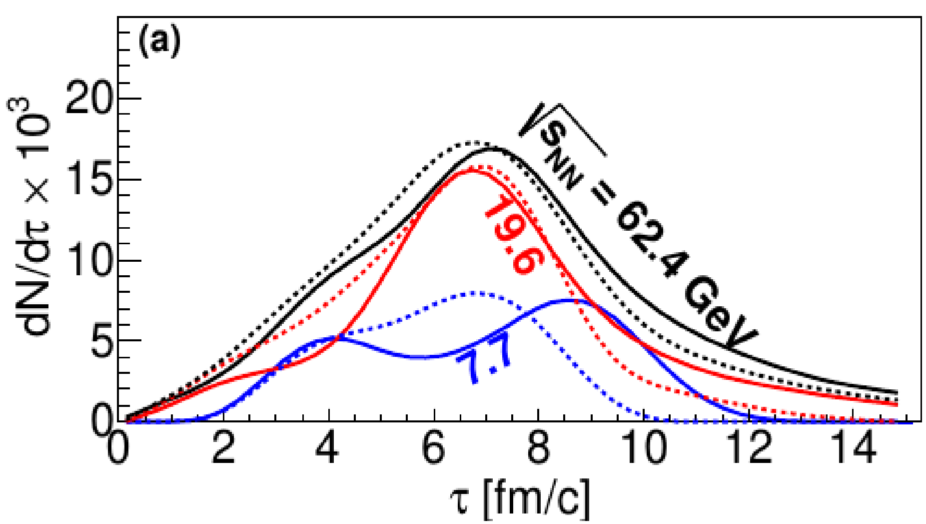
vHLLE code: free and open source, https://github.com/yukarpenko/vhlle, Comput. Phys. Commun. 185 (2014), 3016

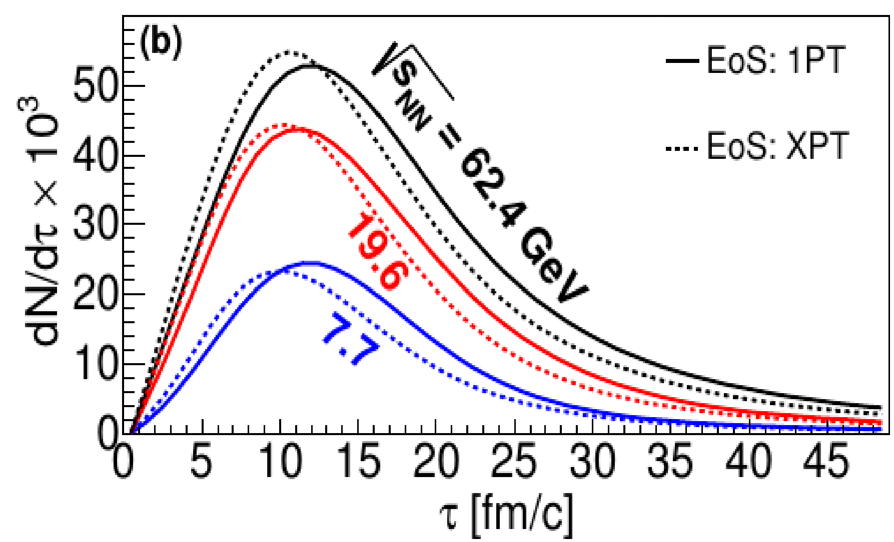
Model tuned by matching with the experimental data of SPS and BES RHIC.

Chiral EoS → crossover PT (XPT)
J. Steinheimer, et al, J. Phys. G 38, 035001 (2011)

HadronGas + Bag Model → 1st order PT (1PT)
P.F. Kolb, et al, Phys.Rev. C 62, 054909 (2000)

Pion emission times at the particlization surface and at the last interaction points



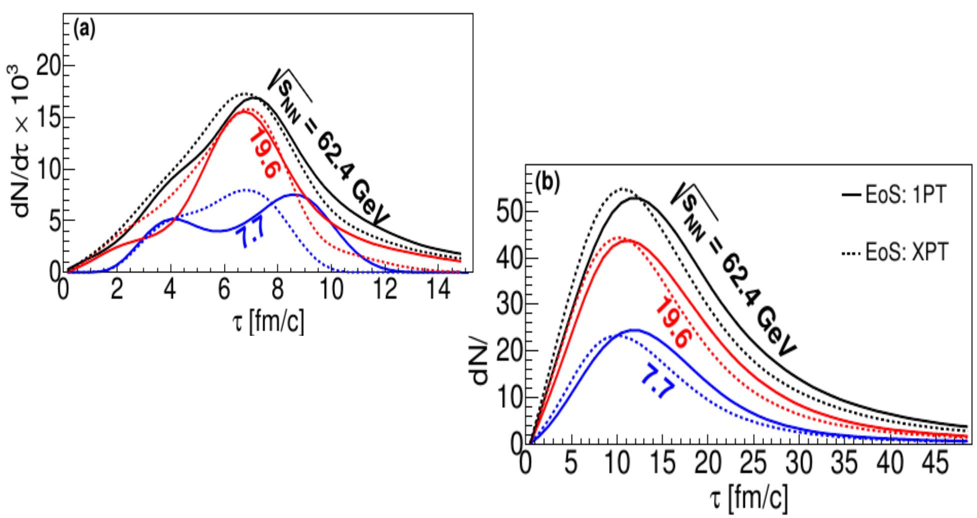


vHLLE+UrQMD model

Mean CMS times of pion emission at particlization and last interaction

$\sqrt{s_{NN}}$ [GeV]	EoS	particlization surface		last interactions	
		$\bar{t}$ [fm/c]	RMS [fm/c]	$\bar{t}$ [fm/c]	RMS [fm/c]
7.7	1PT	7.24	2.84	13.15	6.56
	XPT	6.16	2.01	11.61	6.26
11.5	1PT	7.33	2.31	13.09	6.92
	XPT	6.36	1.91	11.57	6.41
19.6	1PT	6.88	2.16	13.18	7.56
	XPT	6.41	2.15	11.93	6.93
27	1PT	6.85	2.37	13.38	8.07
	XPT	6.40	2.39	12.62	7.57
39	1PT	7.17	2.75	13.98	8.30
	XPT	6.64	2.58	13.05	7.85
62.4	1PT	7.00	2.82	14.11	8.50
	XPT	6.60	2.63	12.72	7.81

CMS times of pion emission at last interaction



Emission times for 1st order phase transition are larger than for crossover.

- Weak dependence of the average pion creation time on the collision energy. Maximal difference : ~1.5 fm. Interplay of longer pre- thermal and shorter hydrodynamic stage at lower collision energies

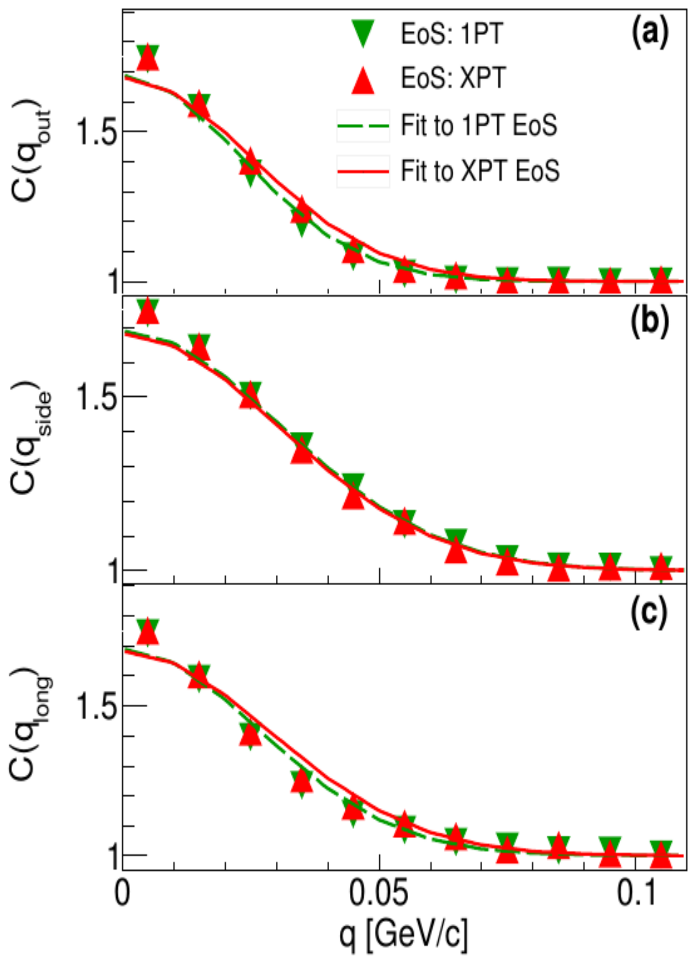
- On the other hand, the duration of hydro stage gets shorter as collision energy decreases because of lower initial energy density at the hydro starting time.

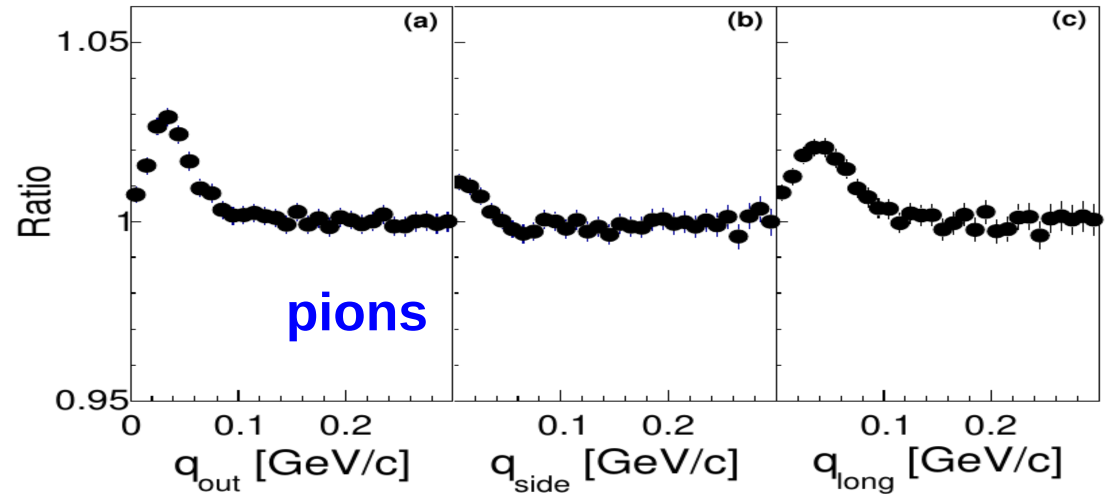
- The cascade smears the relative difference between the 1PT and XPT scenarios

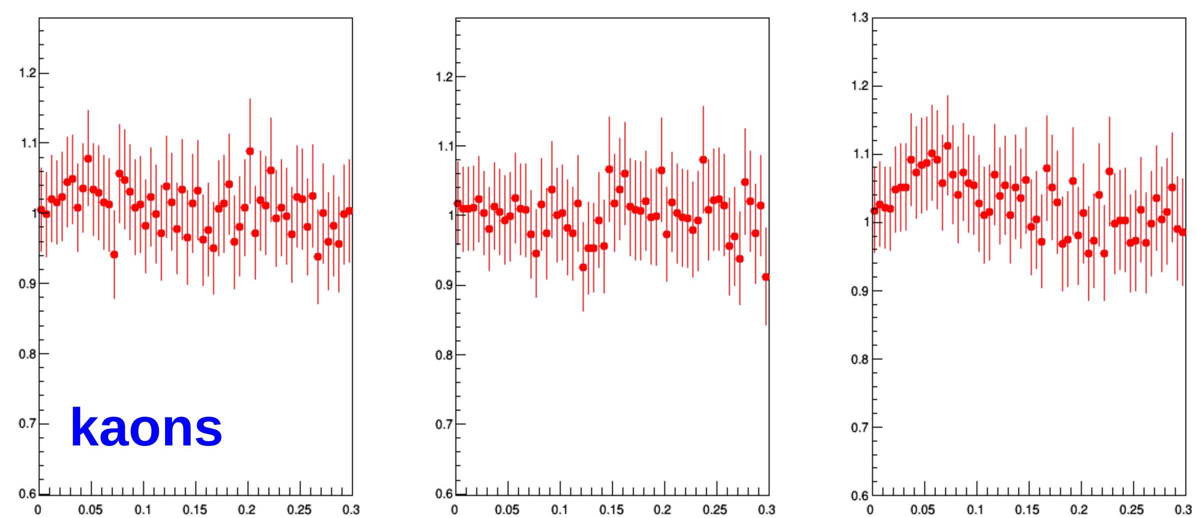
We are studying the possibilities to extract this difference experimentally at NICA/MPD using femtoscopy technique.

Correlation functions with vHLLE+UrQMD

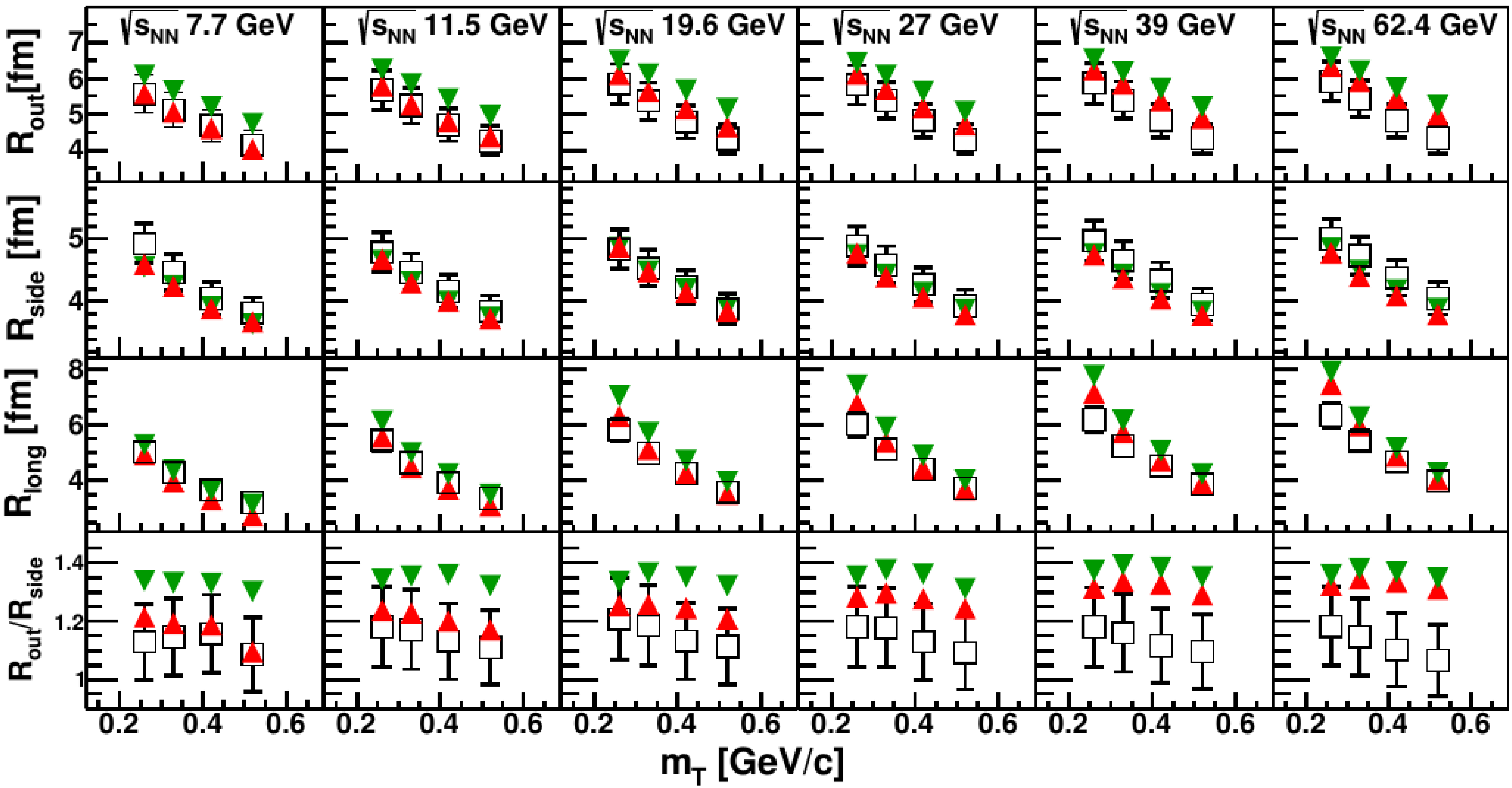
- The difference between pion CF for 1st order PT and crossover < 5%
- For kaons it is expected to be larger ~ 10%
- It is necessary to study different particle types. Importance of PID







3D Pion radii versus m_T with vHLLE+UrQMD model

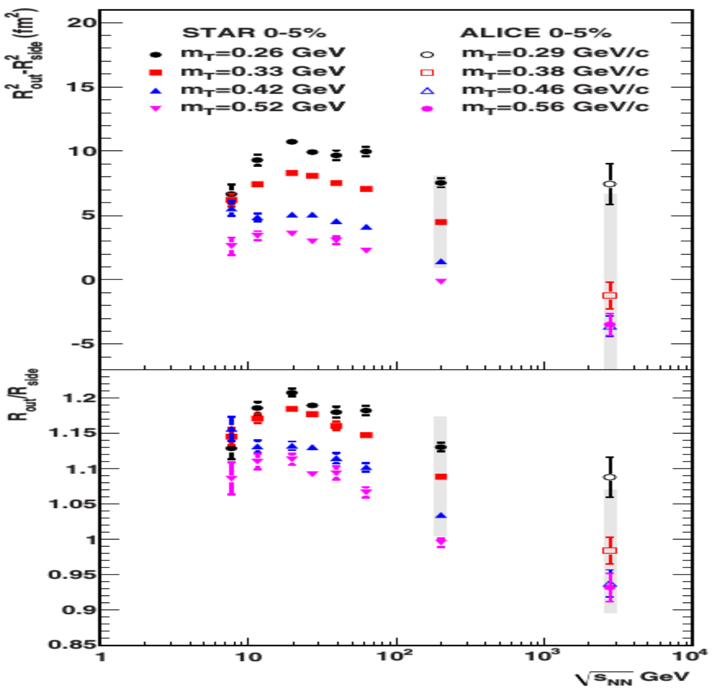


Green triangles - 1PT EoS, **Red triangles** - XPT EoS, **Open black squares** STAR data BES

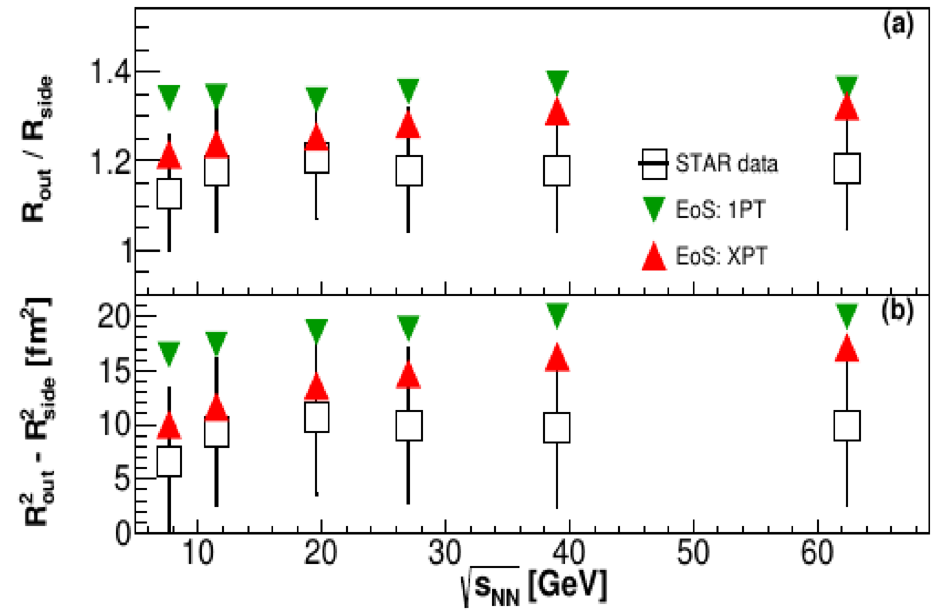
- R_{out}(XPT) at high energies and R_{out}(1PT) at all energies are slightly overestimated -> an indication of the need to reduce the emission time in the model
- R(1PT) > R(XPT) by ~ 1 fm for “out” and “long” radii

R_{out}/R_{side} with vHLLE + UrQMD model

- R_{out}/R_{side} and $R_{out} - R_{side}$ as a function of s_{NN} were studied at fixed m_T by the STAR Collaboration. A wide maximum near s_{NN} ~ 20 GeV/c in both excitation functions was observed.

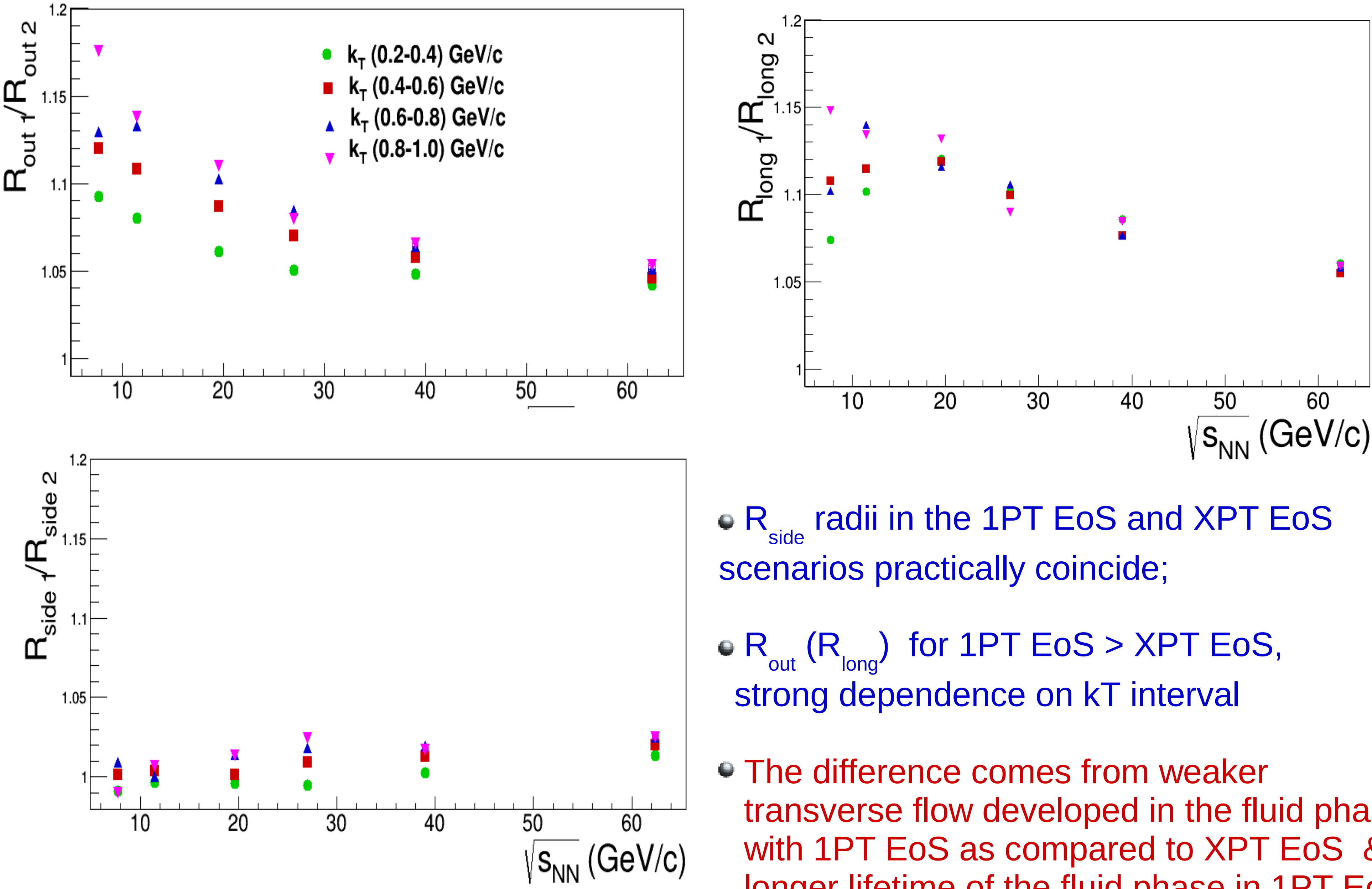


- R_{out}/R_{side}(XPT) agrees with almost all STAR data points within rather large systematic errors, while R_{out}/R_{side}(1PT) overshoots the data.



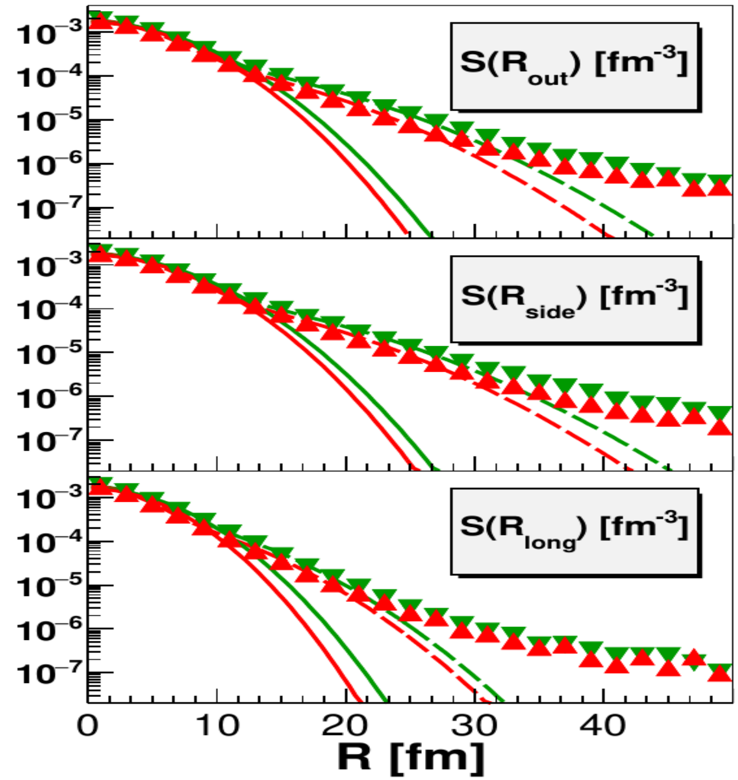
There is an indication in our study that optimal description of the femtoscopic radii requires about 1 fm shorter duration of pion emission with the present setup of the model, at all collision energies. It is an open question whether a new set of parameters can be found which accommodates the the femtoscopic radii.

Ratio R_{osl} 1PT/ R_{osl} XPT versus sqrt(s_{NN})



- R_{side} radii in the 1PT EoS and XPT EoS scenarios practically coincide;
- R_{out} (R_{long}) for 1PT EoS > XPT EoS, strong dependence on kT interval
- The difference comes from weaker transverse flow developed in the fluid phase with 1PT EoS as compared to XPT EoS & longer lifetime of the fluid phase in 1PT EoS

Source functions



The new Source Function technique was used.

SF for 1st order is wider than the one for crossover.

Main advantage of this technique is the possibility to use the Source Functions itself without any hypothesis about its shape.

$$C(\mathbf{k}^*,\mathbf{P}) = \int \mathrm{d}^3\mathbf{r}^* S^{\alpha}(\mathbf{r}^*,\mathbf{P}) \overline{\left|\psi^{S,\alpha'\alpha}_{-\mathbf{k}^*}(\mathbf{r}^*)\right|^2},$$

Different functions were tested to describe the shape of SF projections: single Gaussian

$$S(\vec{r^*}) \sim exp\left(-\frac{r^{*2}_{out}}{4R^{*2}_{out}} - \frac{r^{*2}_{side}}{4R^{*2}_{side}} - \frac{r^{*2}_{long}}{4R^{*2}_{long}}\right),$$

Gaussian + Gaussian;
Gaussian +Lorencian
Gaussian +Exp

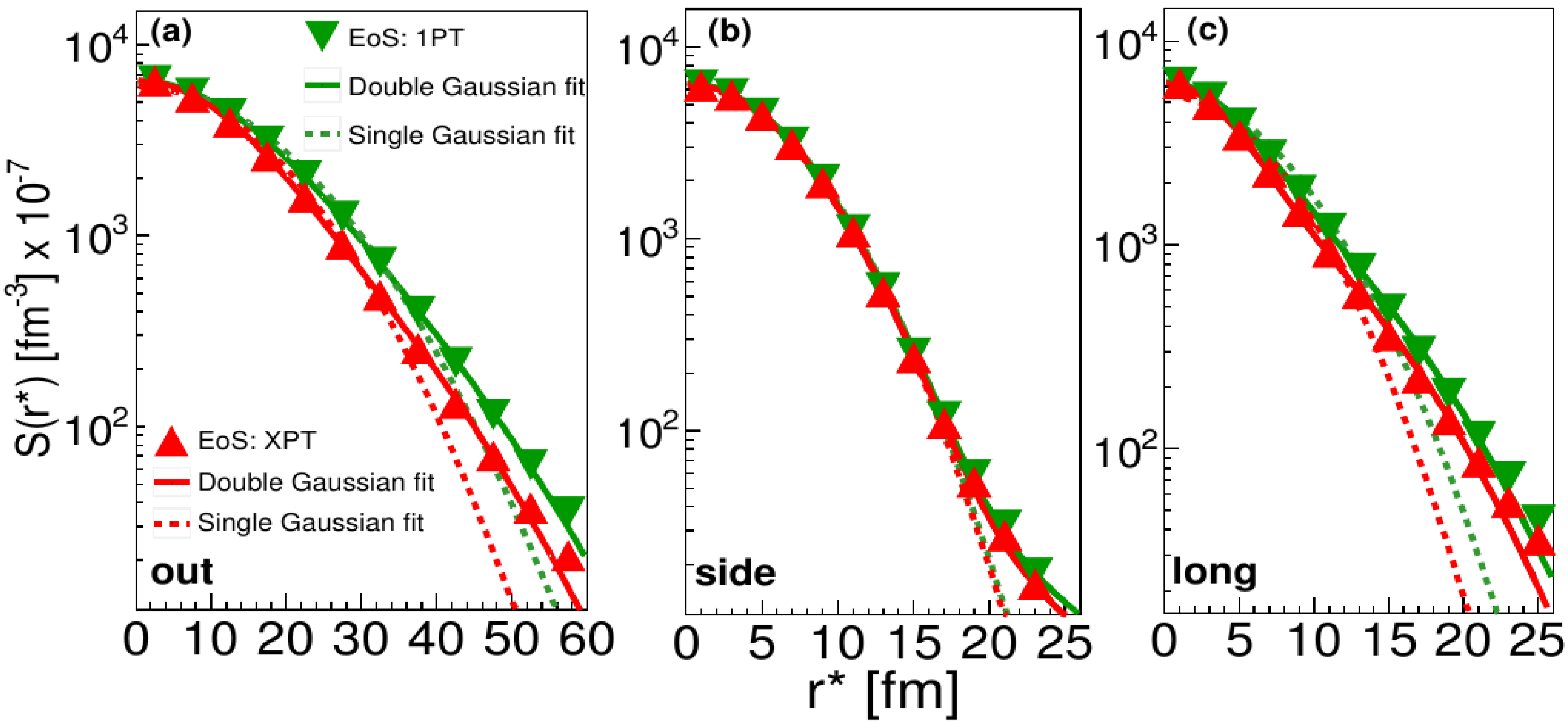
$$\mathrm{S^H(r_x,r_y,r_z)} = \lambda \exp[-\mathrm{f_s}(\frac{\mathrm{x}^2}{4\mathrm{r}^2_{xs}} + \frac{\mathrm{y}^2}{4\mathrm{r}^2_{ys}} + \frac{\mathrm{z}^2}{4\mathrm{r}^2_{zs}}) - \mathrm{f_l}(\frac{\mathrm{x}^2}{4\mathrm{r}^2_{xl}} + \frac{\mathrm{y}^2}{4\mathrm{r}^2_{yl}} + \frac{\mathrm{z}^2}{4\mathrm{r}^2_{zl}})],$$

$$f_s = 1/[1 + (r/r_0)^2], \quad f_l = 1 - f_s.$$

Hump-function

- The best description was obtained with Gaussian+Gaussian and Hump-function.
- Gaussian+Gaussian - simple interpretation (core-resonances) & more stable fitting procedure

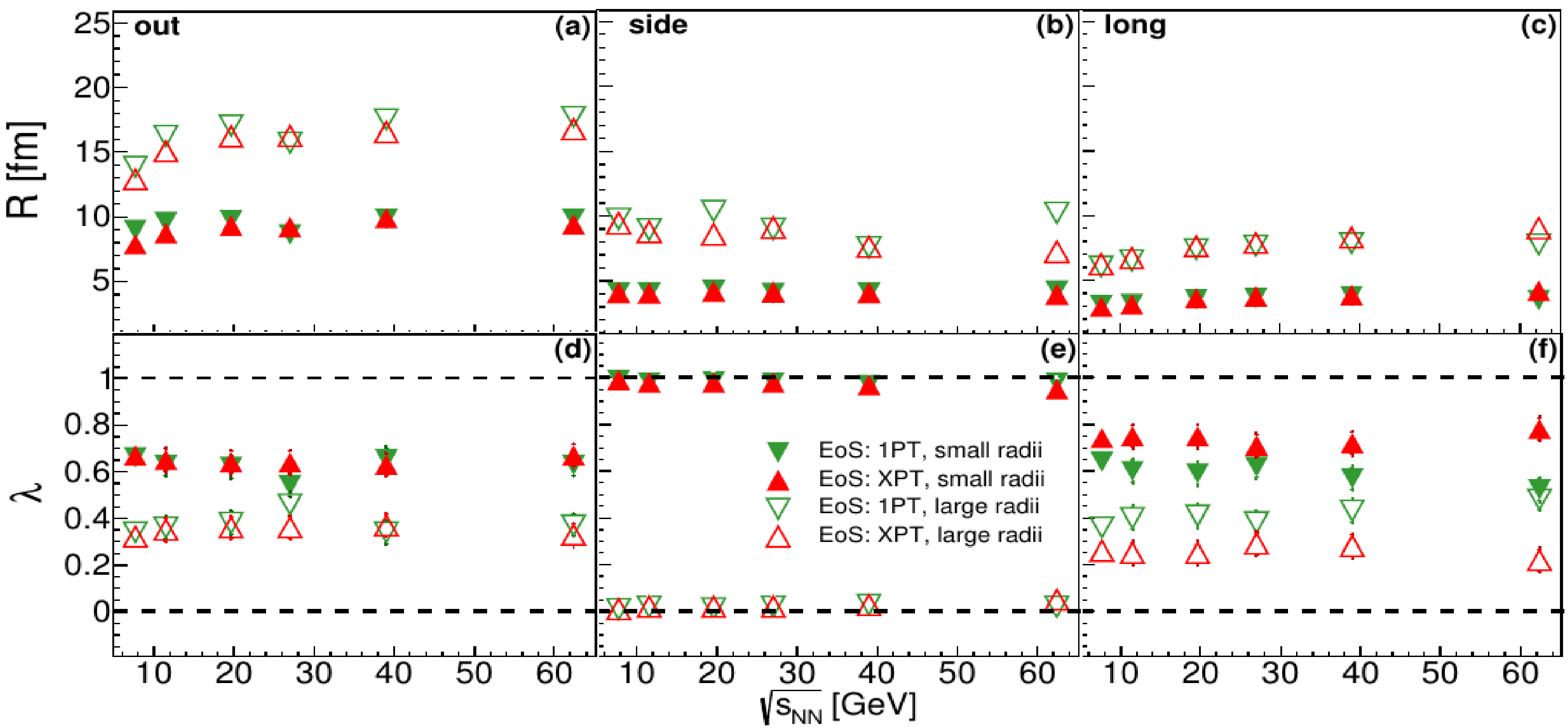
Source Function with vHLLE + UrQMD model



- Two-Gaussian fit describes reasonably SF till ~60 fm «out» and ~25 fm «side» and «long» directions.

- One-Gaussian fit gives large χ^2 / NdF, but the values of radii are equal to the ones of two Gaussian radii averaged according with relative contributions of small and large radii; That is why it reflects reasonably the main features of 2-Gaussian fit at small r*.

Pion Source Function with vHLLE + UrQMD



- "out" : $R_{out1,2}$ (1PT) > $R_{out1,2}$ (XPT); for the calculations with the first order phase transition and for the one with crossover phase transition decreases with increasing $\sqrt{s_{NN}}$;

  The relative contributions of small and large radii
  λ1 ~ 0.65 and λ2 ~ 0.35 do not depend on $\sqrt{s_{NN}}$ and on the type of EoS.
- The radii $R_{side1,2}$ and corresponding λ1,2 do not depend on $\sqrt{s_{NN}}$.
- "long": radii almost coincide for both types of EoS, The relative contribution of the large radii, λ2 increases with $\sqrt{s_{NN}}$, while λ1 decreases. λ2 (1PT) > λ2 (XPT)

Conclusions

- Possibility to distinguish between hybrid model source functions with 1st order phase transition and crossover was studied using vHLLE+UrQMD model
- Hydro phase lasts longer with 1st order PT.
- Hadronic cascade diminishes the difference between 1PT and XPT source functions,

  though there is still a possibility to distinguish them using the femtoscopy technique.
- vHLLE+UrQMD model with XPT describes RHIC femtoscopy radii at sqrt(s_{NN}) = 7.7-62.4 GeV
- There is an indication that optimal description of the femtoscopic radii requires about 1 fm

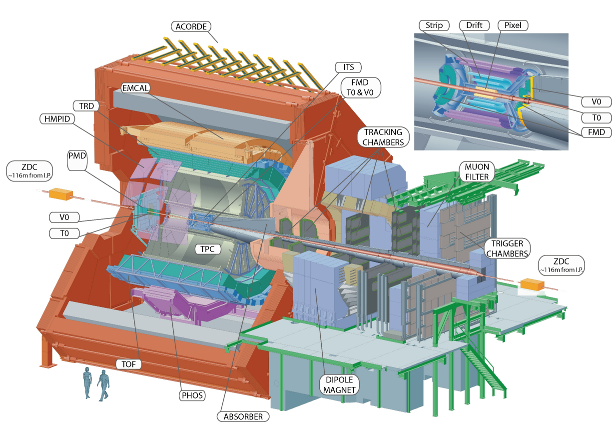
  shorter pion emission time with the present setup of the model, at all collision energies. - new tune of vHLLE+UrQMD model is needed.

  It'll be very interesting to try to use 3 phase hydro model (THESEUS) at low energies
- R_{out}(1PT) > R_{out}(XPT) & R_{long}(1PT) > R_{long}(XPT)
- --
- Source functions technique allows to get an additional information about differences between 1PT / XPT; Best parametrizations of SF : Gauss+Gauss and Hump
- The standard one-Gaussian parametrization of the 3D CF reflects correctly the behaviour of the SF at small r* and is sufficiently sensitive to EoS.
- It is very promising to make 3D CF analysis using heavier particles: K,p becuuse of more Gaussian shape of SF and less influence of resonances

MPD detector has the same advantages as ALICE to study femtoscopy:

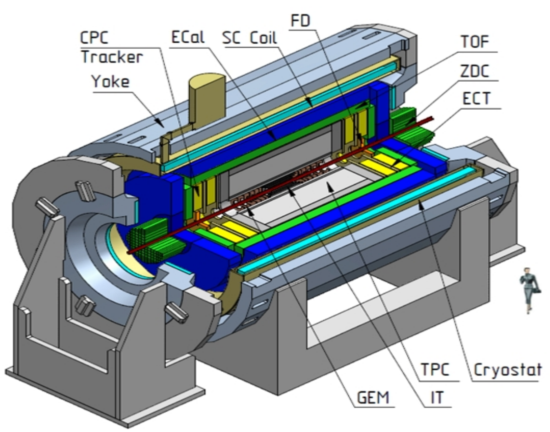
- It can be promising to make 3D CF analysis using heavier particles: K,p because of more Gaussian shape of SF and less influence of resonances
- Different particle pairs: πK, K+K-, πp, π Λ, ΛΛ .. can be studied -- different influence of cascade phase, emission assymetries..
- Az-sensitive femtoscopy is particularly sensitive to the evolution time (in addition to R_{long}) and to the expansion velocity.

ALICE	MPD
• Low momenum cut-off (p_T>100 MeV/c)	V
• Small material budget	V
• Excellent particle identification (PID) by: specific energy loss (dE/dx) & TOF	V
• Good primary and secondary vertex resolution	V



Package for femtoscopy study: FEMTOMPD is under developement

PID study is very important



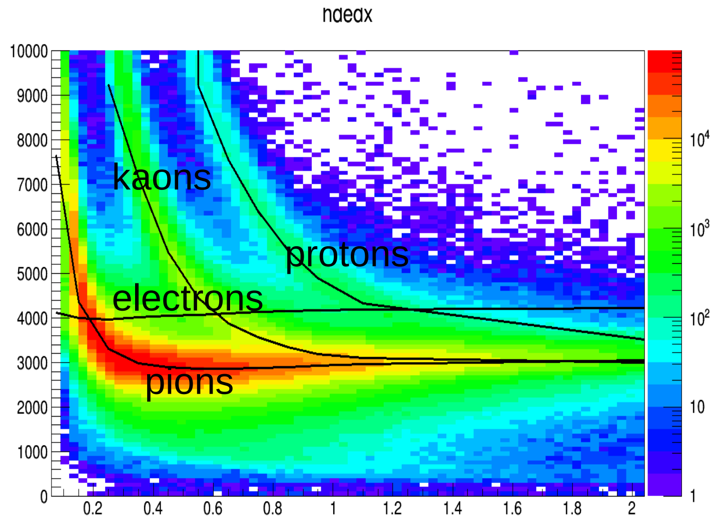
MPD plenary meeting
25 April 2017

Status of PID MPD study

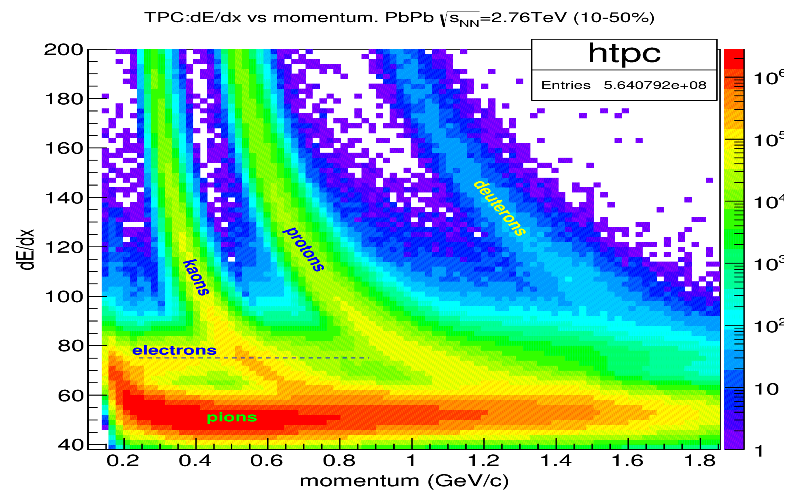
Konstantin Mikhaylov (ITEP & JINR),
Ludmila Malinina (SINP MSU JINR),
Gulnara Eyyubova (SINP MSU)

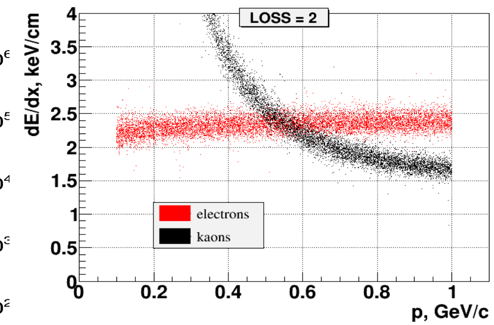
Particle Identification by TPC energy loss

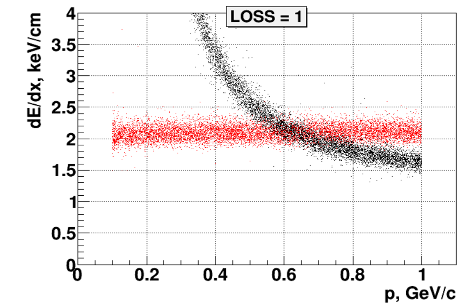
MPD



ALICE







It was found that the intersection of e and K curves for ALICE & STAR and Bethe-Bloch calculations are at about 0.45 GeV/c but in MPD vHLLE+UrQMD simulations at ~0.6 GeV/c

The LOSS parameter in GEANT-3.21 simulations Should be choosen LOSS=2

The new simulation is started with vHLLE+UrQMD model with LOSS=2 (Daniel Wielanek)

It was found out (A. Zinchenko): GEANT parameter LOSS essentially affects the electron dE/dx.

Bethe Bloch Parameterization

Bethe Bloch Function (BBF): mean energy loss per unit path length

$$\left\langle \frac{dE}{dx} \right\rangle = K z^2 \frac{Z}{A\beta^2} \left[\frac{1}{2} \ln \frac{2 m_e c^2 \beta^2 \gamma^2 T_{max}}{I^2} - \beta^2 - \frac{\delta(\beta\gamma)}{2} \right]$$

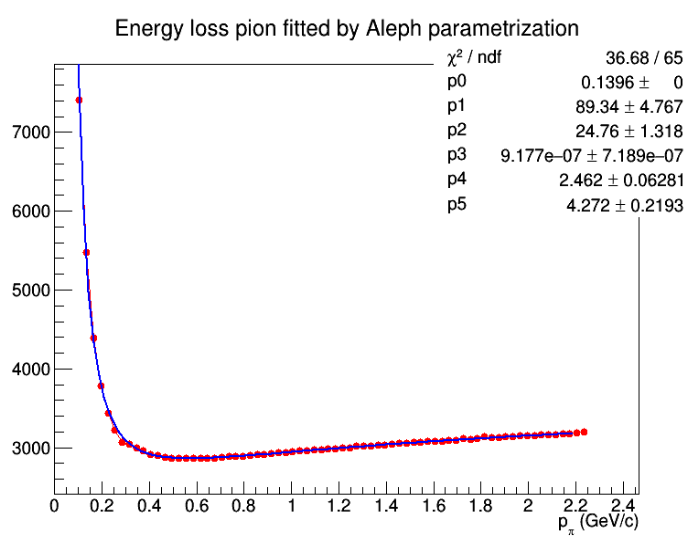
Parametrization (Aleph Parametrization)

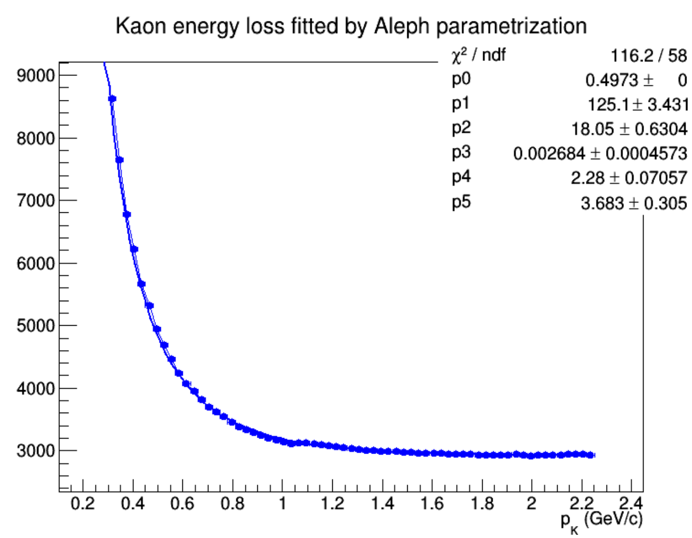
$$\beta\gamma = \frac{\text{momentum}}{\text{mass}}$$

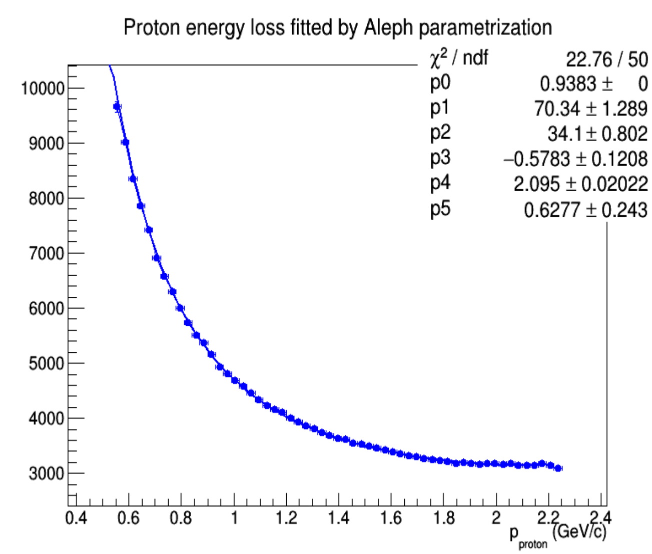
$$\beta = \frac{\beta\gamma}{\sqrt{1 + (\beta\gamma)^2}}$$

$$\left\langle \frac{dE}{dx} \right\rangle = \frac{p_0}{\beta^{p_3}} \left[p_1 - \beta^{p_3} - \ln\left(p_2 + \frac{1}{(\beta\gamma)^{p_4}} \right) \right]$$

- The parametres of dEdx BB Aleph parameterization for pi, K, p, e were found and stored in the MPD ROOT class: MpdTPCPid.



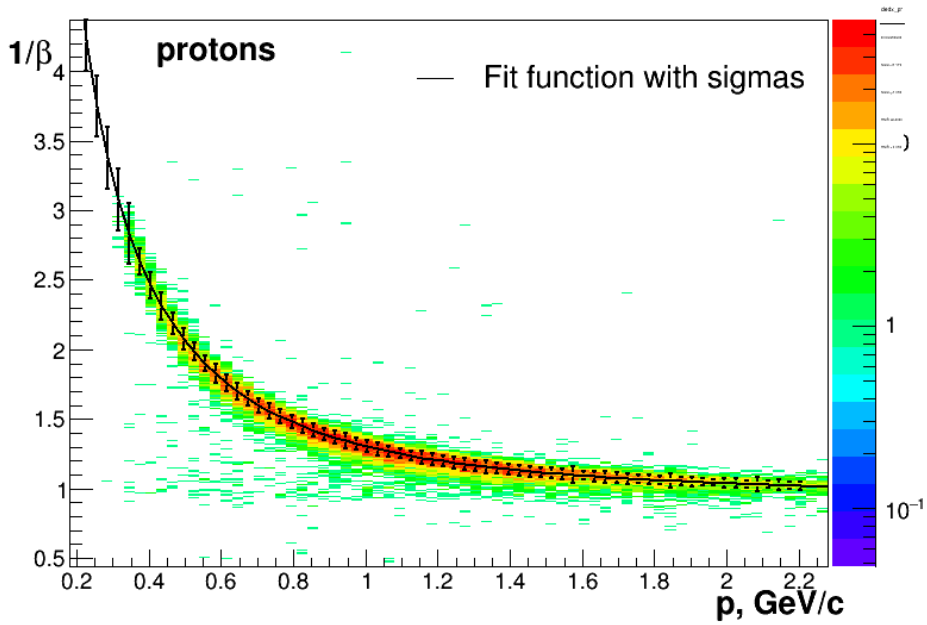




TOF 1/beta parametrisation

Fit with hyperbolic function with a parameter:

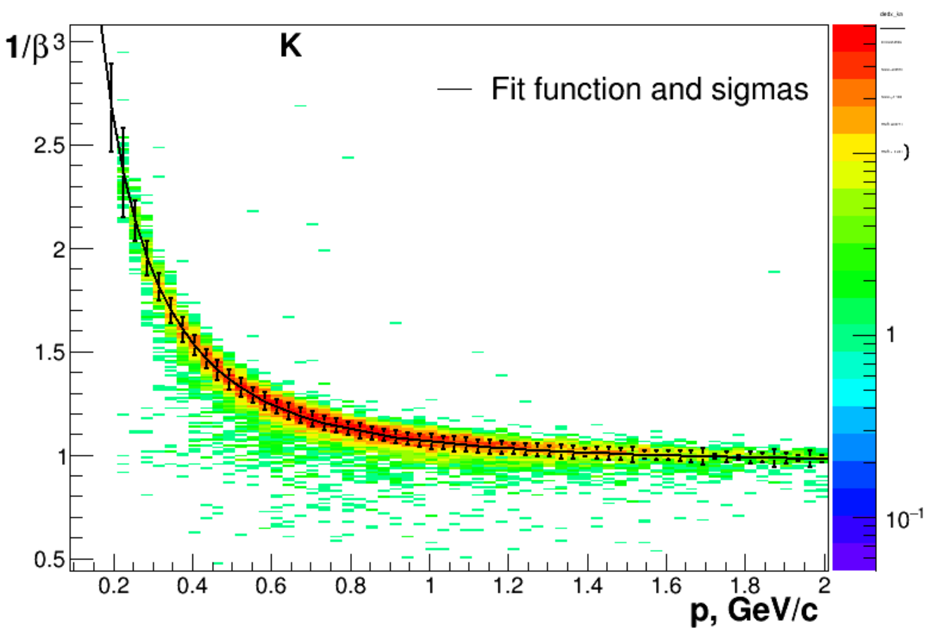
$$1/\beta=\sqrt{1+(m/p)^2}+P1$$

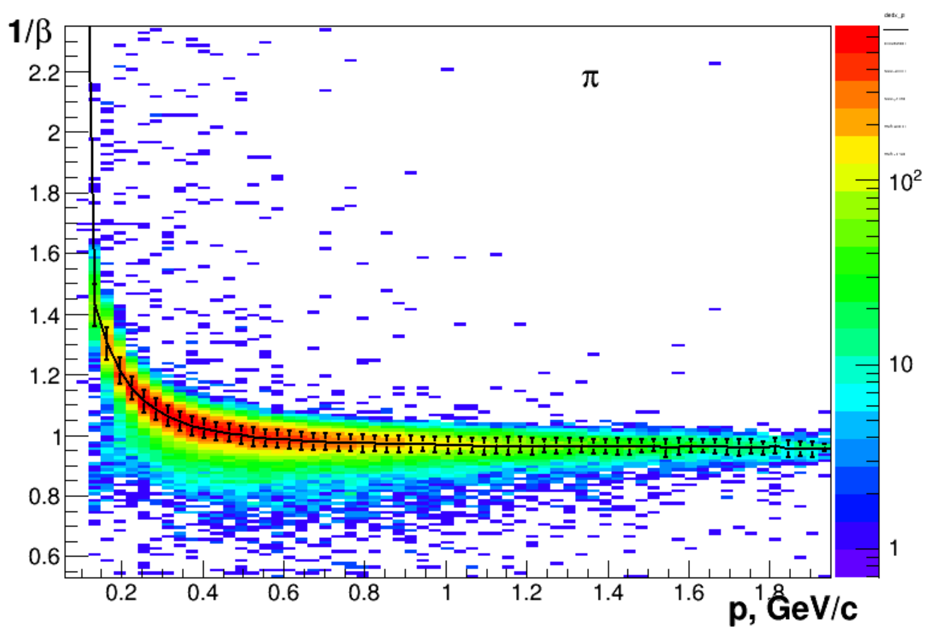


- Primaries only (cut via MC)
- N clusters>20;
- |η|<1, pt>0.1 GeV/c
- TofHitIndex>0
- TOF-TPC matching

Underlayer exist still in 1/β TOF distribution.

- The parametres of TOF 1/beta parameterization for pi, K, p, e were found and stored in the MPD ROOT class: MpdTOFPid





Bayesian method:

Probability for the particle to be of a type *i*:

$$P(i) = \frac{1}{\sqrt{2\pi}\sigma_{dE/dx}} \exp\left(- \frac{(dE/dx)_{meas} - (dE/dx)_{BB,i})^2}{2\sigma^2_{dE/dx}} \right)$$

$$w(i) = \frac{C(i)P(i)}{\sum_k P(k)w(k)}, \ C(i) = a'priori\ probabilities.$$

For now: C(i) =1.

n-sigma method:

True/false decision for the particle to be of a type *i*:

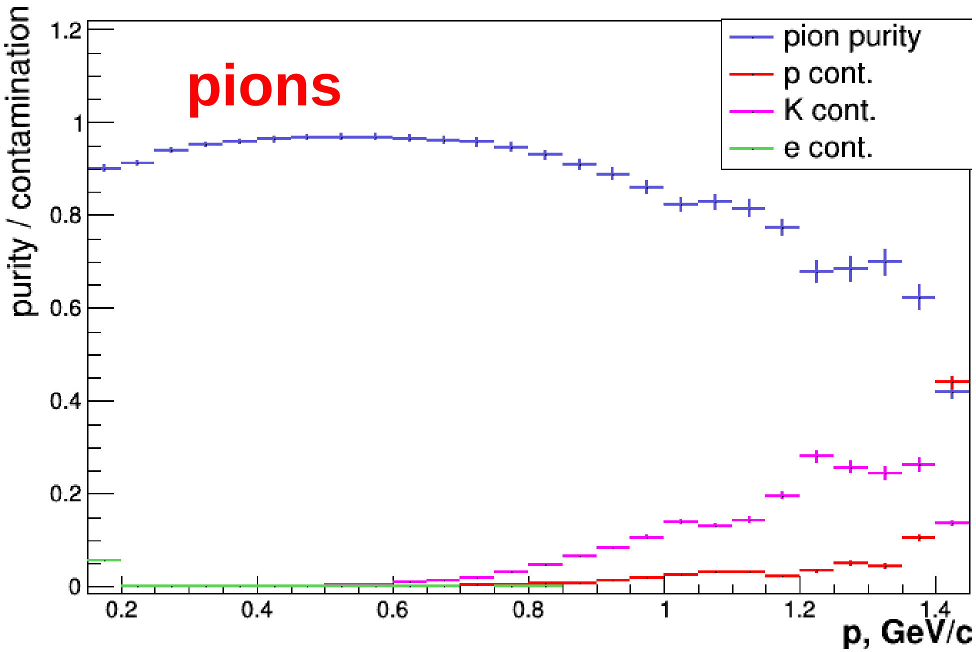
$$|(dE/dx)_{meas} - (dE/dx)_{BB,i}| < n^* \sigma_{dE/dx,i} \quad \rightarrow \quad w(i) = 1$$
$$|(dE/dx)_{meas} - (dE/dx)_{BB,i}| > n^* \sigma_{dE/dx,i} \quad \rightarrow \quad w(i) = 0$$

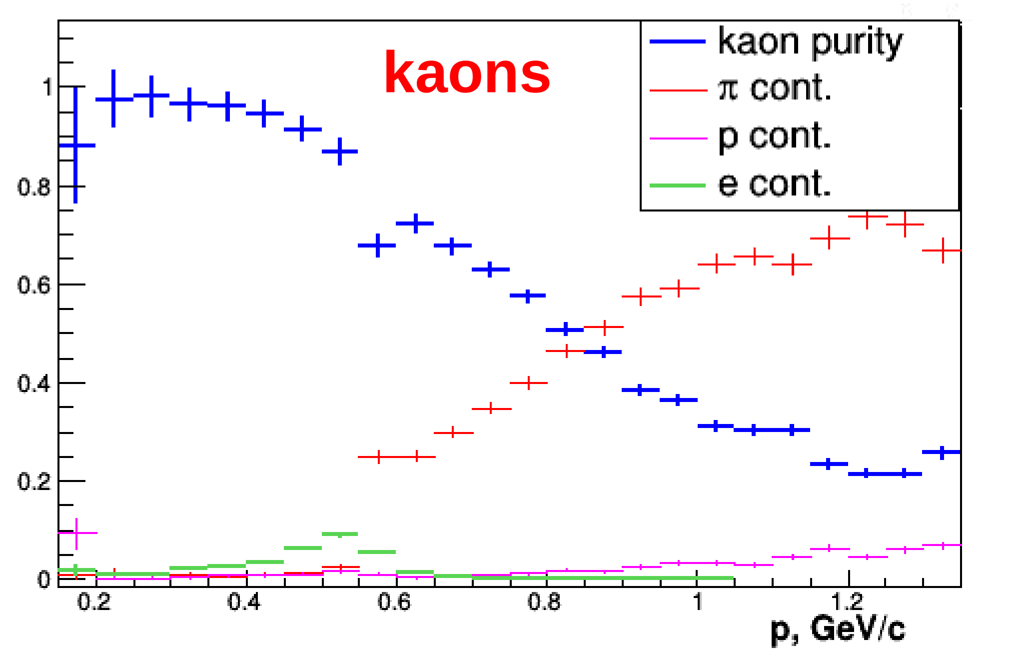
* the n-sigma method because it is more robust and easy to control.

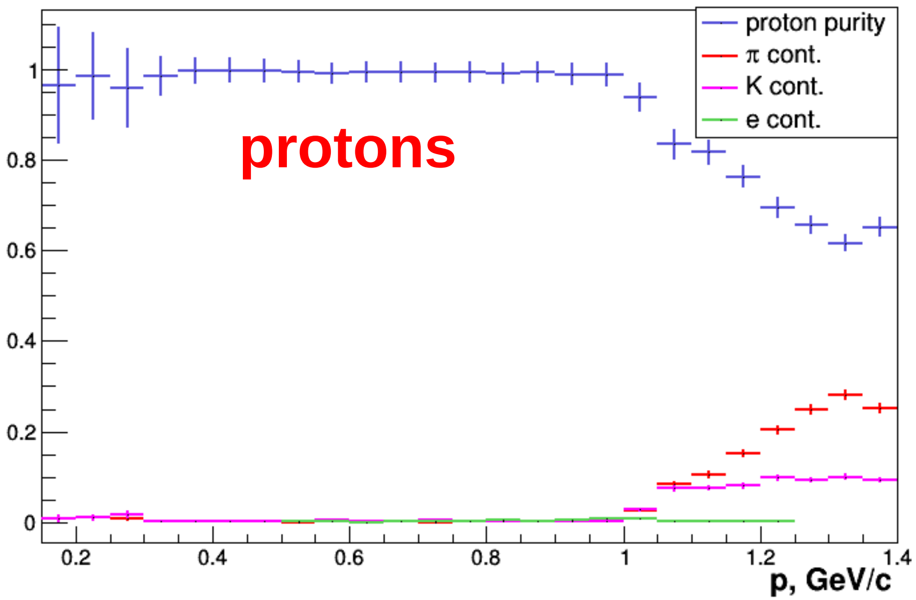
The same for TOF detector: dE/dx (in TPC) → 1/β (in TOF)

MpdParticleIdentification::SetNSigmaDedx(n) method is added to the class
MpdParticleIdentification::SetNSigmaBeta(n) method is added to the class

Purity / contamination, TPC







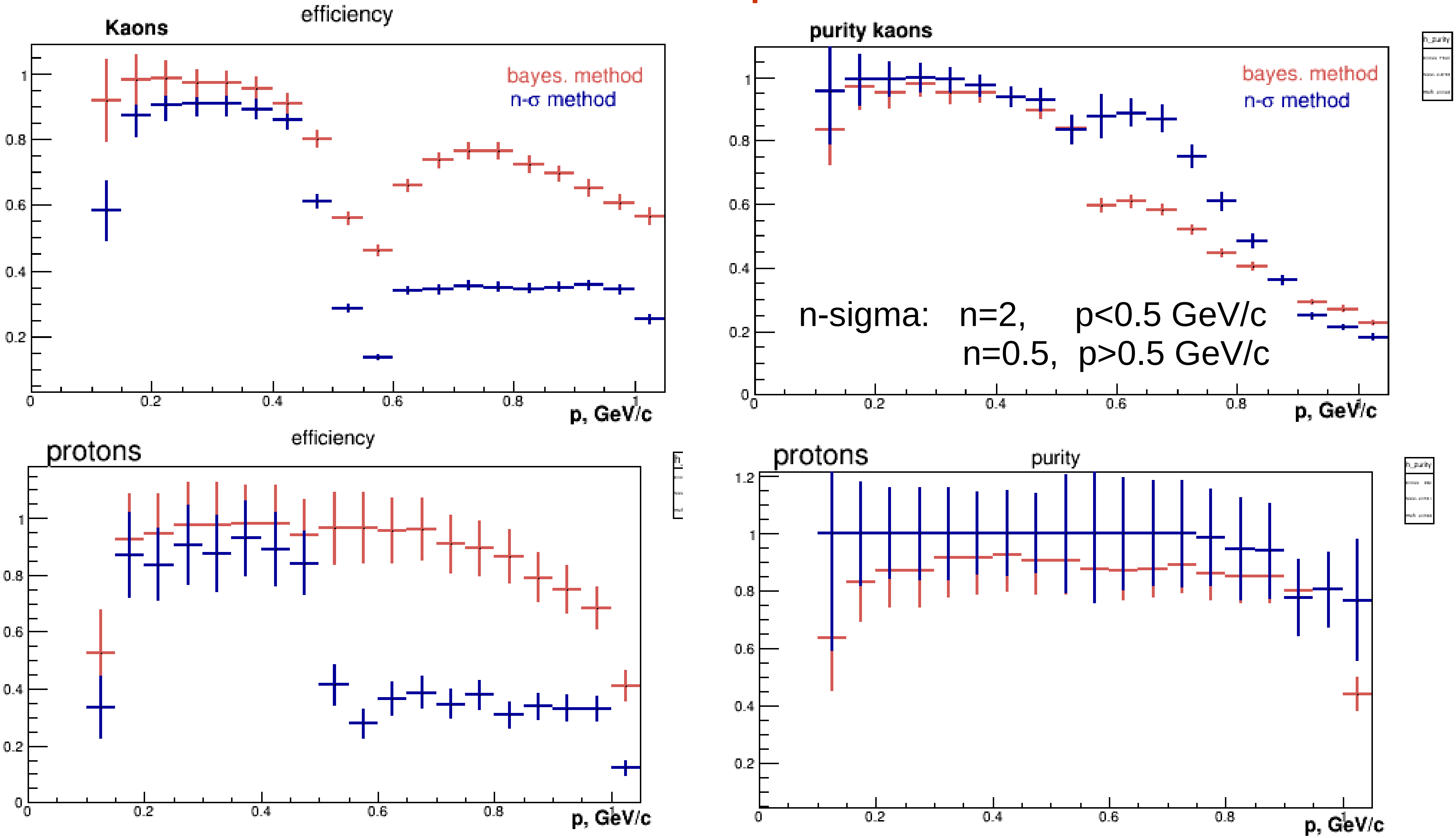
N^{meas}_{i} : all particles identified as specie I

N^{true}_{ii} : particles identified as specie i, and are actually i (within N^{meas}_{i})

Purity = $N_{true,i}$ / $N_{mes,i}$

Cont = $N_{false\ mesured\ as\ i}$ / $N_{mes,i}$

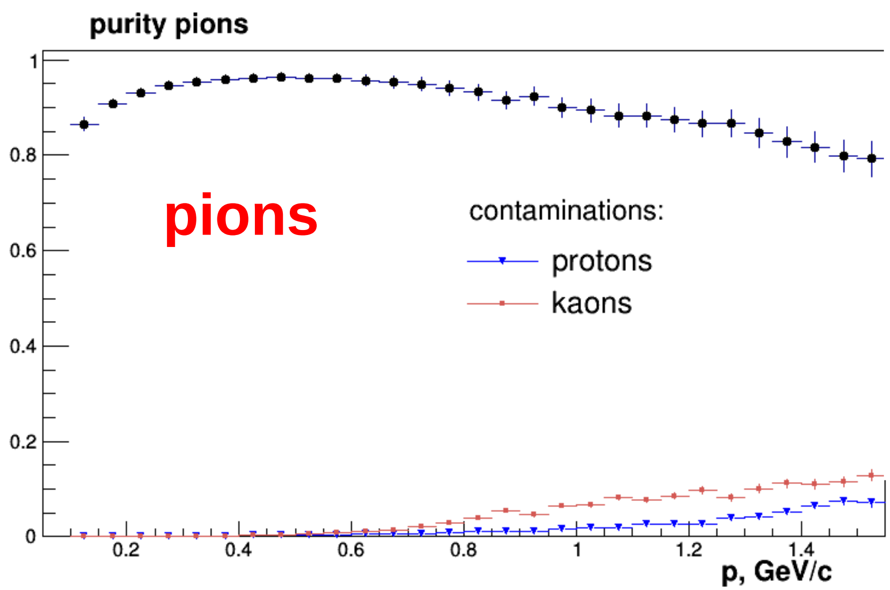
PID method comparison for TPC

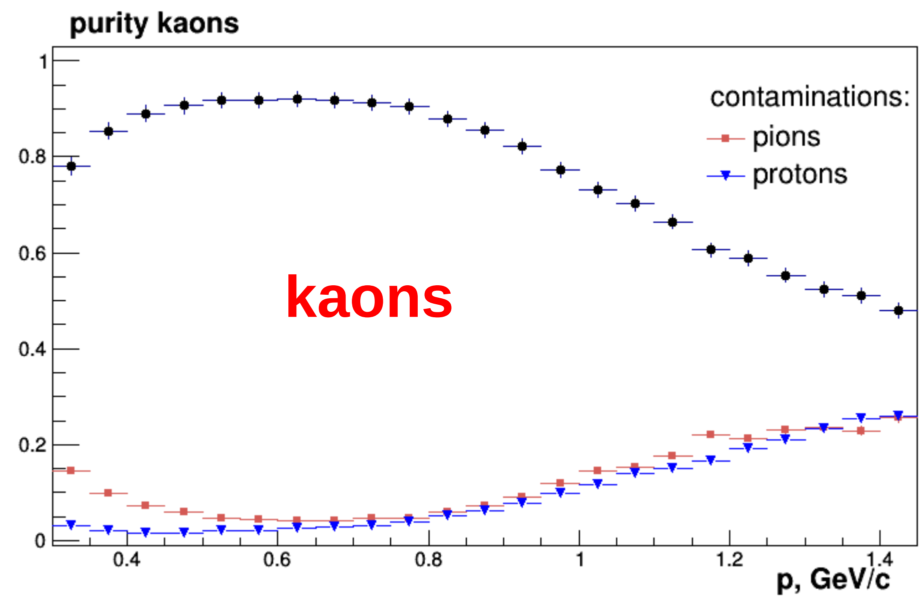


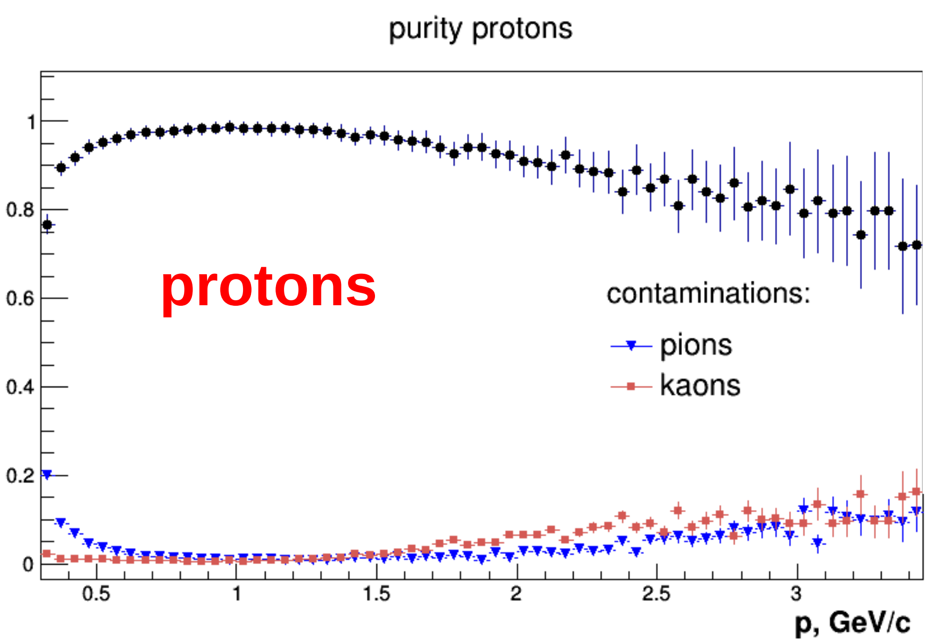
n-sigma method allows to get more pure sample of particle, but the yield of identified particles can decrease.

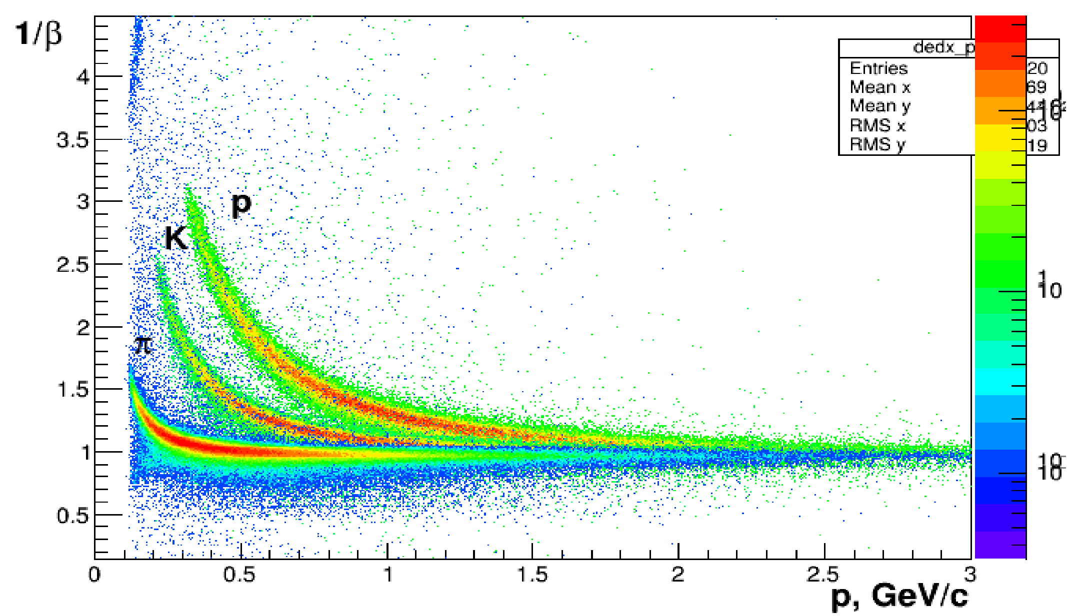
The user can play with SetNSigmaDedx(n)(p) to increase efficiency/purity.

Purity / contamination, TOF







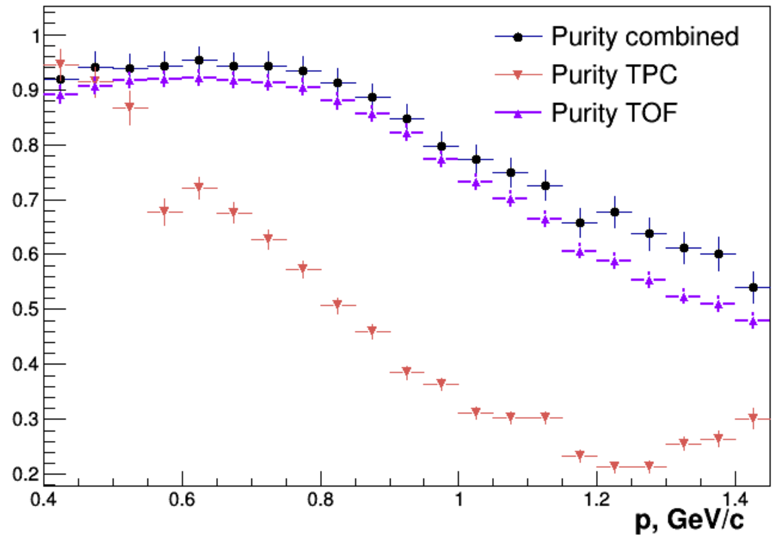


Purity / contamination, TPC +TOF

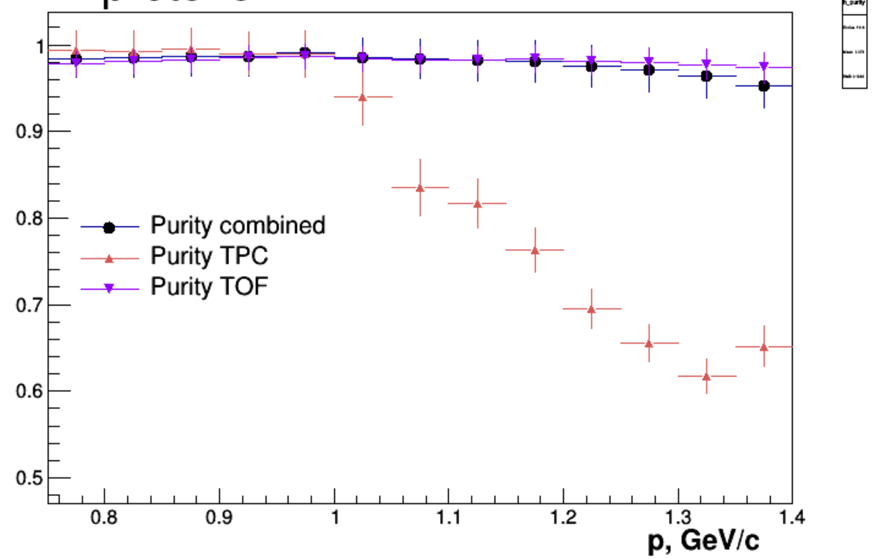
Combined prob. *:*

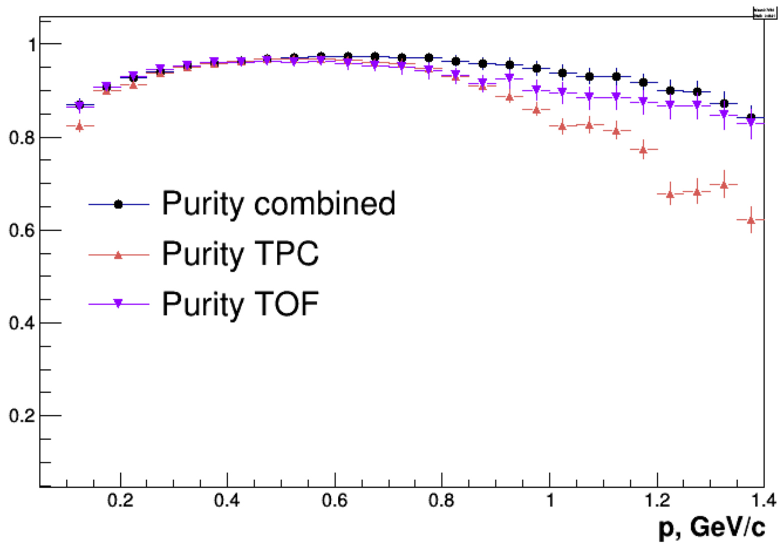
$$P^i_{comb} = P^i_{tof} * P^i_{tpc} \;/\; \sum P^i_{tof} * P^i_{tpc}$$
$$P^i_{comb} = P^i_{tof} \text{ if } P^i_{tpc} = 0 \text{ (and otherwise)}$$

Kaons



protons





	TPC	TOF	TPC+TOF
π	0.1<p<1.3	0.1<p<1.8	0.1<1.4
K	0.15<p<0.7	0.3<p<1.4	0.4<p<1.5
p	0.1<p<1.3	0.4<p<3	0.8<p<1.4

- Due to acceptance, different *p* range is used for PID.
- In a given *p* range comb. purity is better than a single one.

Summary &

- It was found that in previous simulations with vHLLE+UrQMD model were incorrect energy loss dE/dx in TPC for electrons. The new simulations started with LOSS=2 in GEANT3.

- It was found that dE/dx doesn't correspond to Bethe-Bloch at low momenta → track momenta have to be corrected for energy loss.

- The parameters of dE/dx in TPC BB Aleph parameterization for pi, K, p, e were found and stored in the MPD ROOT class.

- The parameters of TOF 1/beta parameterization for pi, K, p, e were found and stored in the MPD ROOT class.

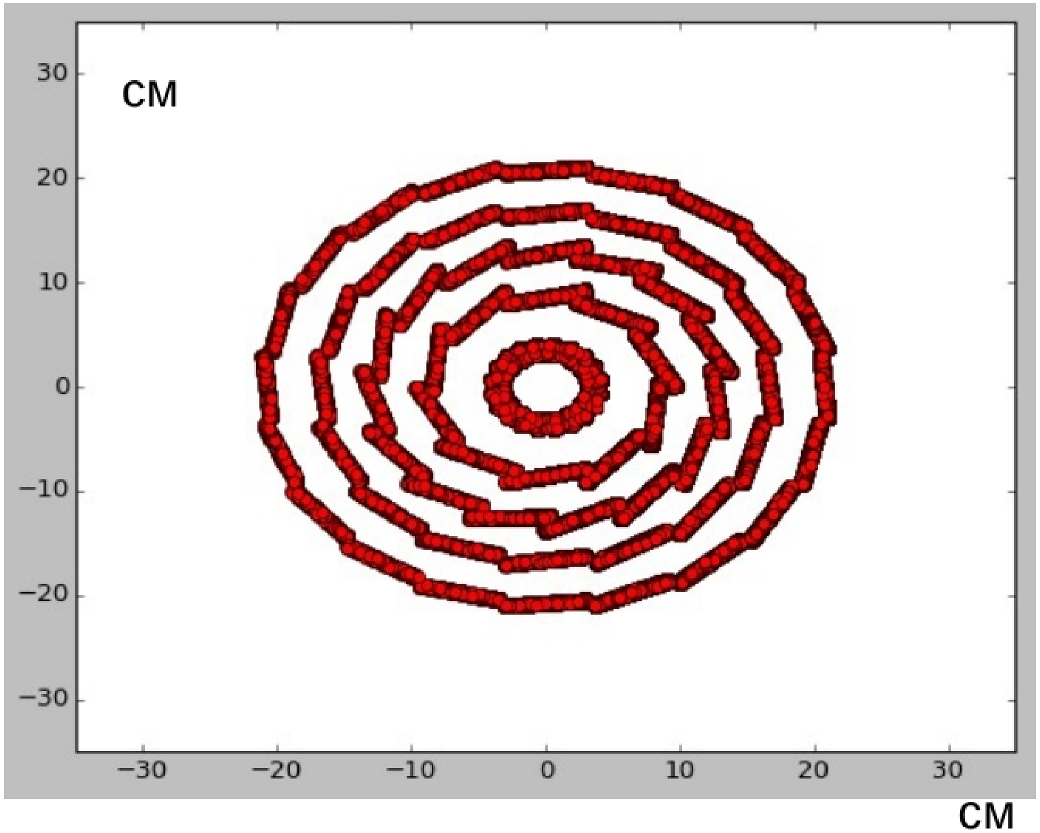
- The alternative method of PID : n-sigma method was implemented in MPD ROOT

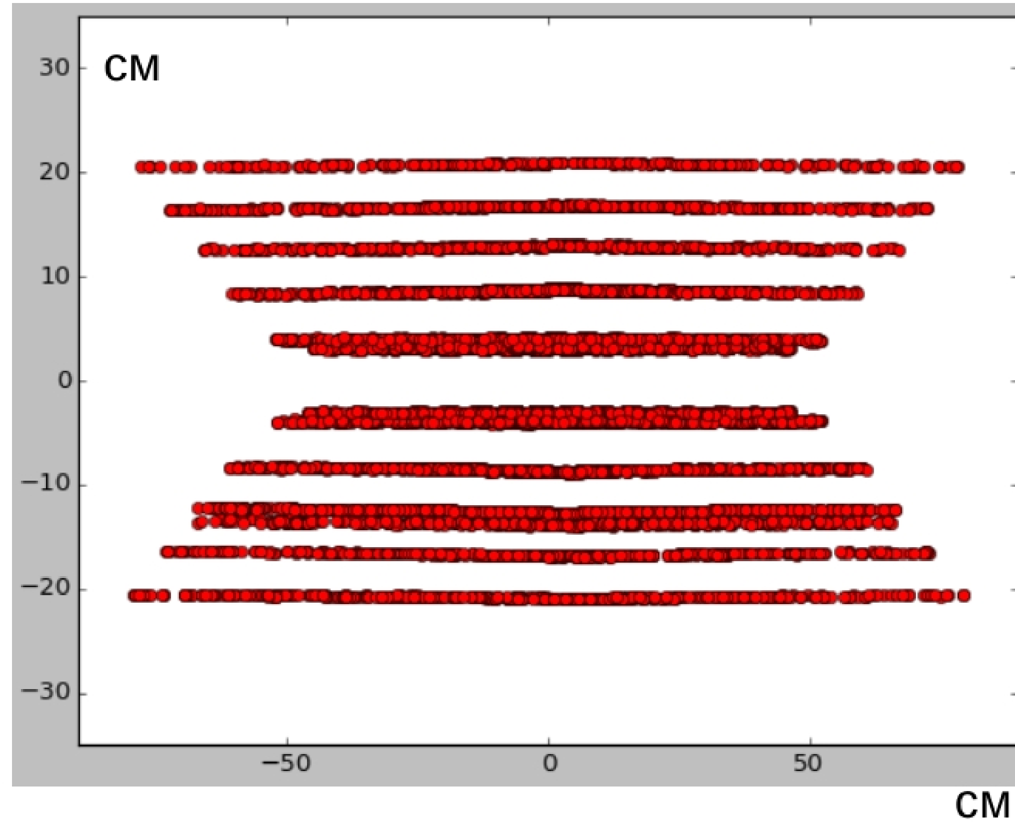
- Purity and contaminations were estimated for Bayesian method for TPC, TOF, TPC+TOF

Status of developement of tracking algorithm for ITS MPD

Stanislav Shushkevich (SINP MSU)

Геометрия кремниевого детектора



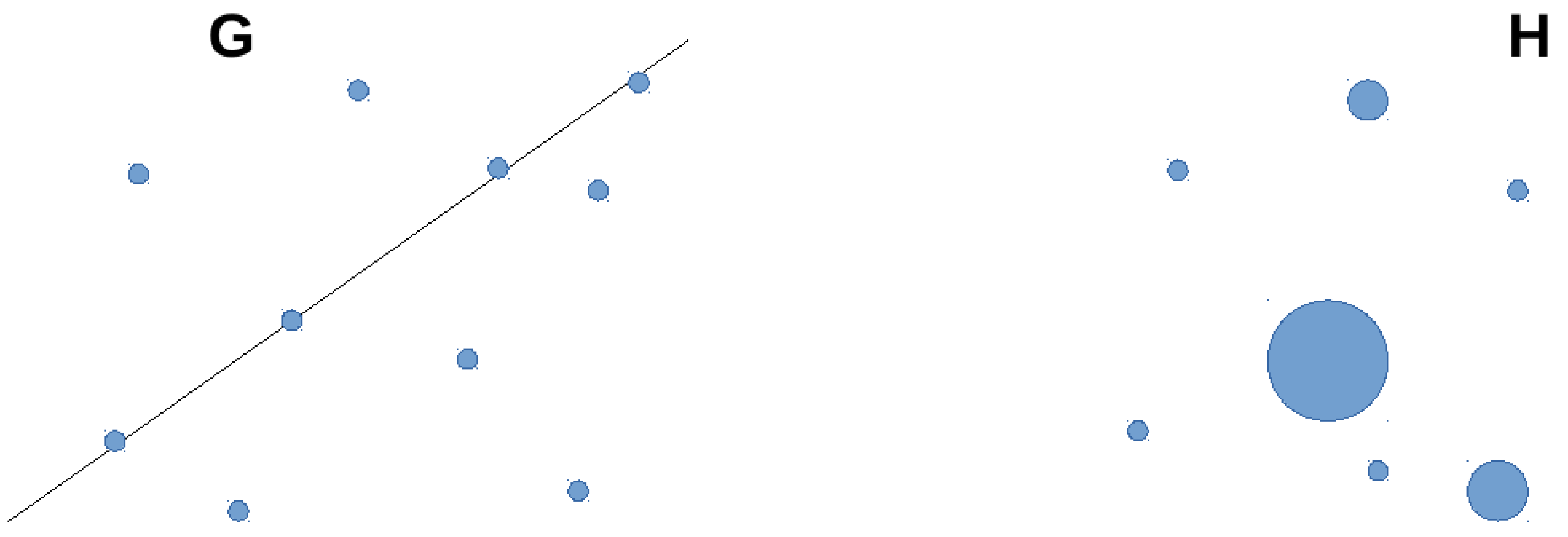


Геометрия детектора от В. Кондратьева.

6 слоёв кремния: 2 пиксельных слоя, 4 стриповых слоя.

Принцип алгоритма Хоха (Hough transform)

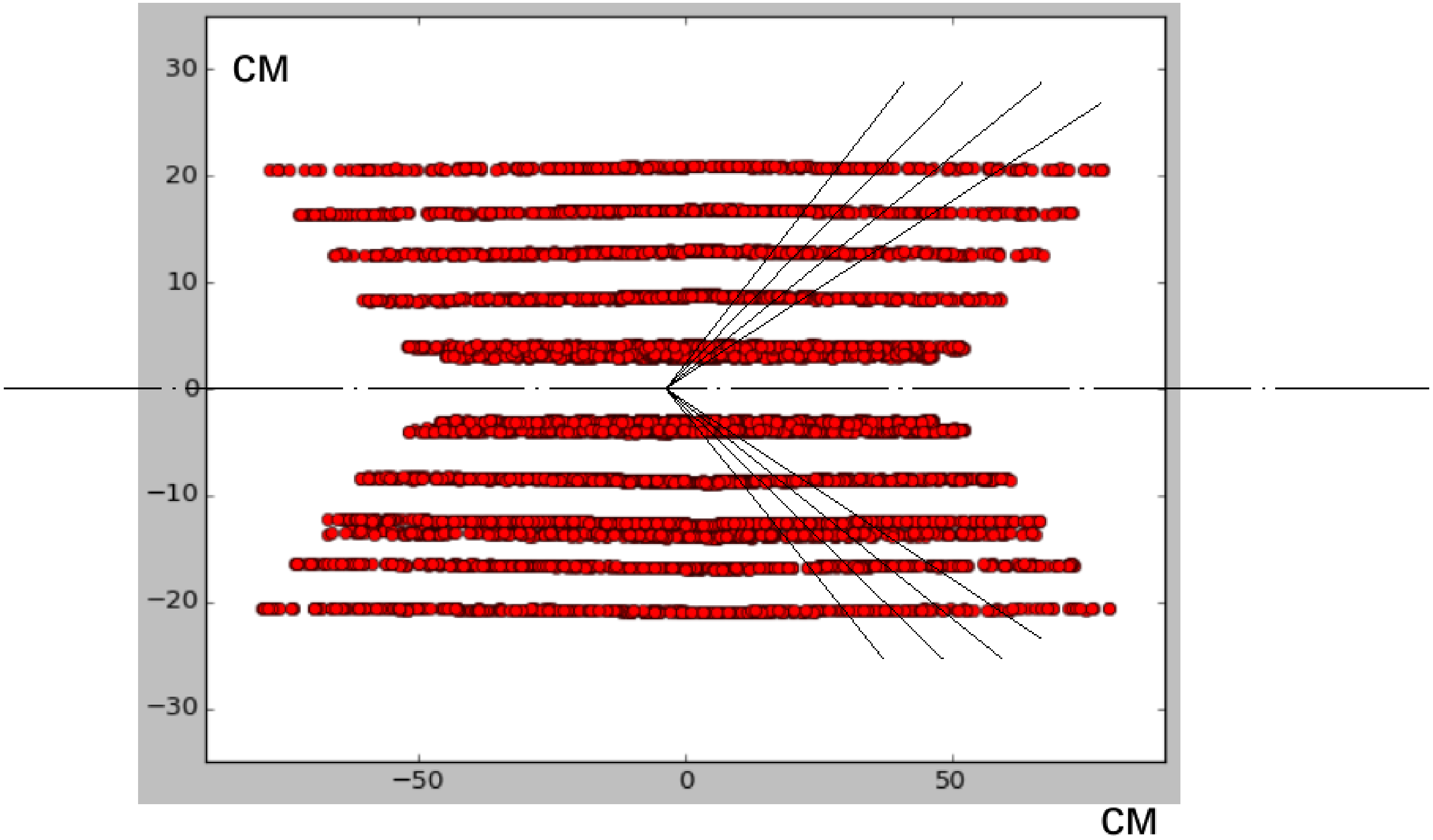
Идея: переход от геометрического пространста, в котором ищутся треки, к пространству параметров этих треков.



трек y = ax + b с шумом   пространство Хоха с координатами a, b

Для каждой пары точек в G вычислим коэффициенты прямой, через них проходящей, и отметим точку с такими координатами в H. Точки, лежащие на одной прямой, образуют в H кластер размера $O(n^2)$ (здесь 4*3/2 = 6 точек). Ищем затем кластера в H, которые соответствуют возможным трекам.

Применение алгоритма Хоха

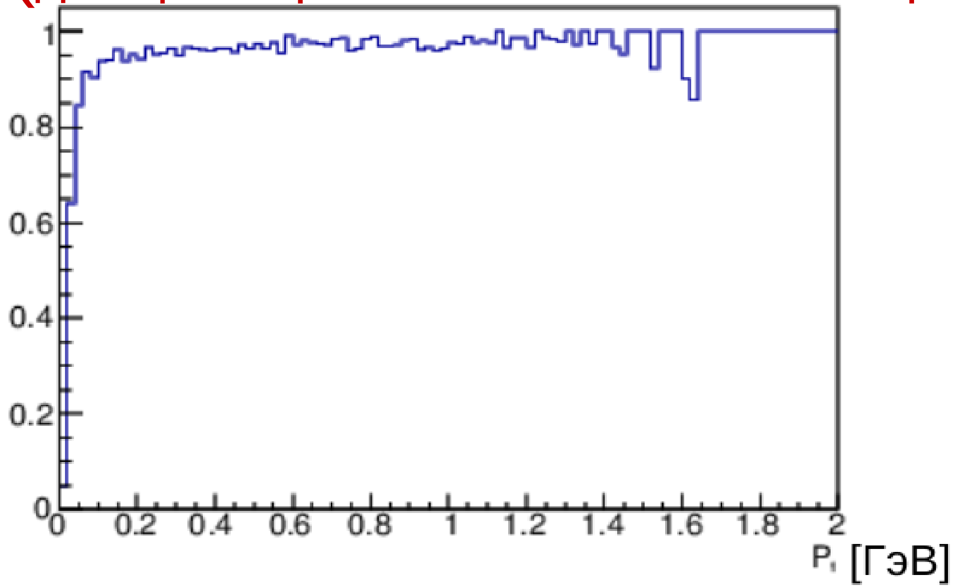


Применение конформного преобразования к x-y координатам хитов переводит первичные треки (окружности с центром в начале координат) в прямые.

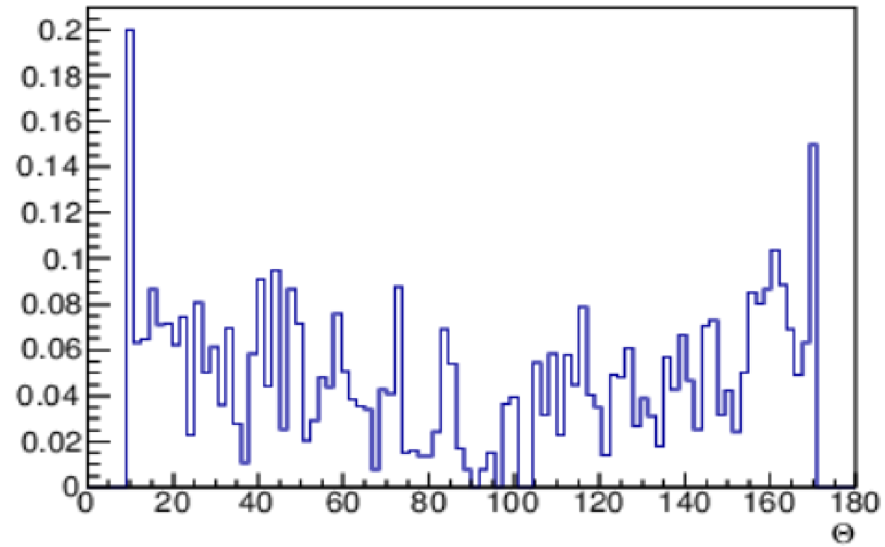
Разбиение на сегменты по Θ разделяет все хиты события на слайсы, в каждом из которых алгоритм Хоха может быть применён независимо.
Сейчас использовано 2*180*5 перекрывающихся слайсов.

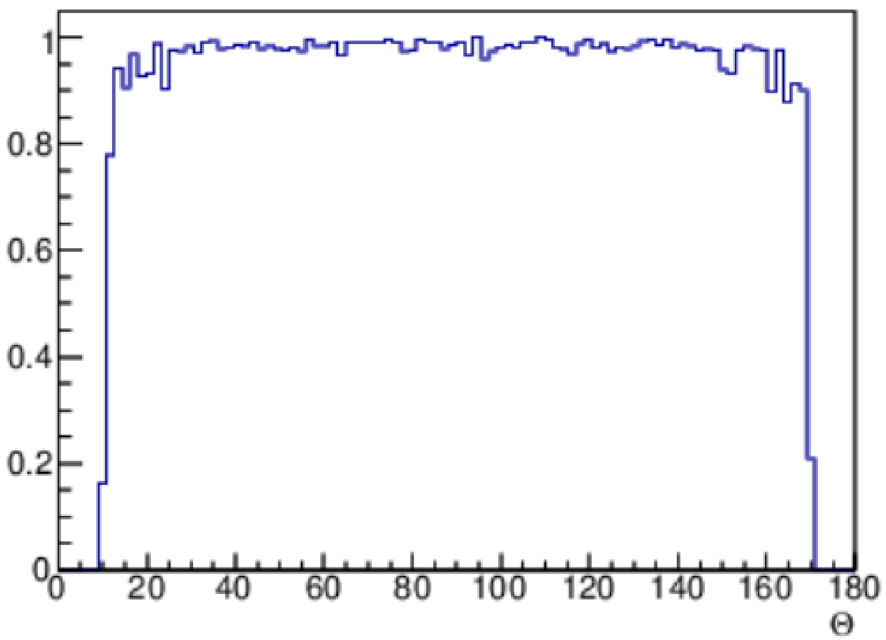
Эффективность восстановления

(для фиксированного положения вершины (0,0,0))



Примесь ложно-восстановленных треков около 6%, распределение примерно равномерно по Θ и pT ?



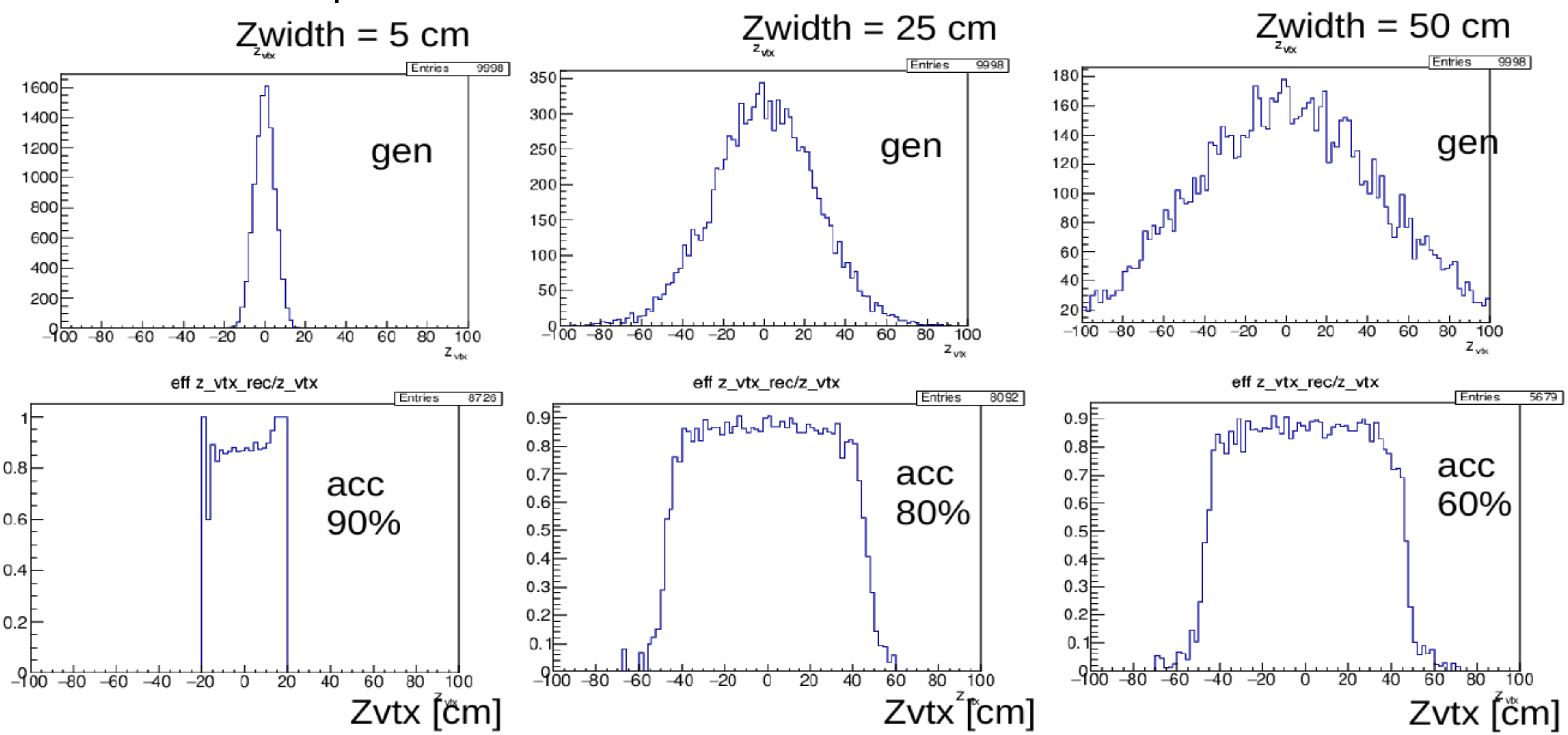


4hit = 4 хита в разных плоскостях + хиты в 1 и 2 плоскостях

>95% первичных центральных треков с Pt > 200 МэВ имеют подходящее число и расположение хитов

Доля треков попадающих в аксептанс установки и пригодных для реконструкци и в ITS
(с размытой точкой первичного взаимодействия)

Трек считается пригодным к реконструкции, если он оставил хиты в 0 и 1 слоях и имеет хиты более, чем в трёх слоях



Для вершин вдали от краёв (|Zvtx| < 40 см) 90% треков попадают в детектор и оставляют подходящее количество хитов; распределение доли попавших треков примерно плоское по z-координате вершины.
При ширине пятна в 25 см 80% всех треков могут быть реконструированы. При ширине пятна в 50 см это доля падает до 60%.

4

Заключение и планы

- Написан отдельный алгоритм реконструкции исключительно по хитам в кремниевом детекторе.
- Алгоритм может быть использован для независимого измерения эффективности других алгоритмов реконструкции (например, поиска треков в TPC)
- Требуется:
- Встроить код в общий фреймворк MPD.
- Перейти от генерированных хитов к реконструированным.
- Получить информацию из TPC (например, для отбрасывания ложных треков; также для "чернового" определения первичной вершины).
- Оптимизировать алгоритм с учётом всей имеющейся информации.
- Расширить насколько возможно фазовое пространство текущего алгоритма реконструкции треков.

Back Up

vHLLE+UrQMD model

Pre-thermal phase	→	hydrodynamic phase	→	hadronic cascade
UrQMD		vHLLE (3+1)-D viscous hydrodynamics		UrQMD

Iu. Karpenko, P. Huovinen, H.Petersen, M. Bleicher, Phys.Rev. C 91, 064901 (2015), arXiv:1502.01978,1509.3751 , talk QM2015

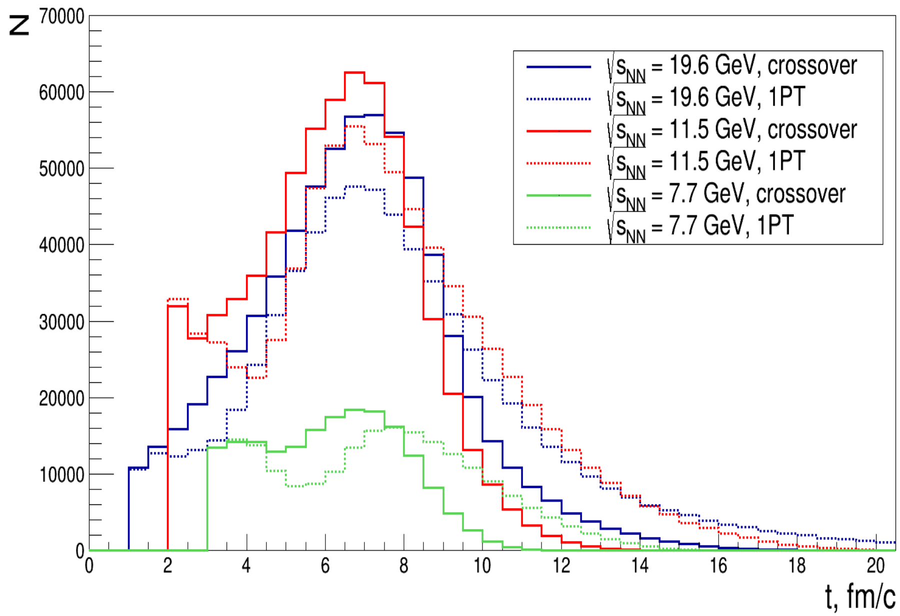
vHLLE code: free and open source, https://github.com/yukarpenko/vhlle, Comput. Phys. Commun. 185 (2014), 3016

Model tuned by matching with the experimental data of SPS and BES RHIC.

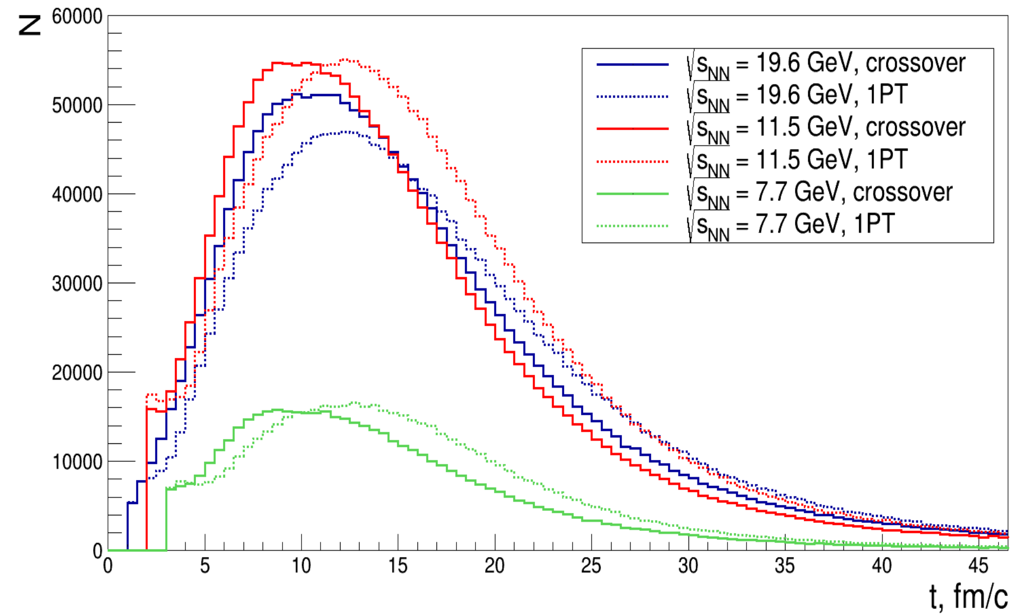
Chiral EoS -crossover phase transition
J. Steinheimer, et al, J. Phys. G 38, 035001 (2011)

HadronGas + Bag Model – 1st order PT
P.F. Kolb, et al, Phys.Rev. C 62, 054909 (2000)

vHLLE



vHLLE+UrQMD



macro for Konstantin's calculations of energy loss

BetheBlochFormula.C - emacs@asusf23

File Edit Options Buffers Tools C++ Help

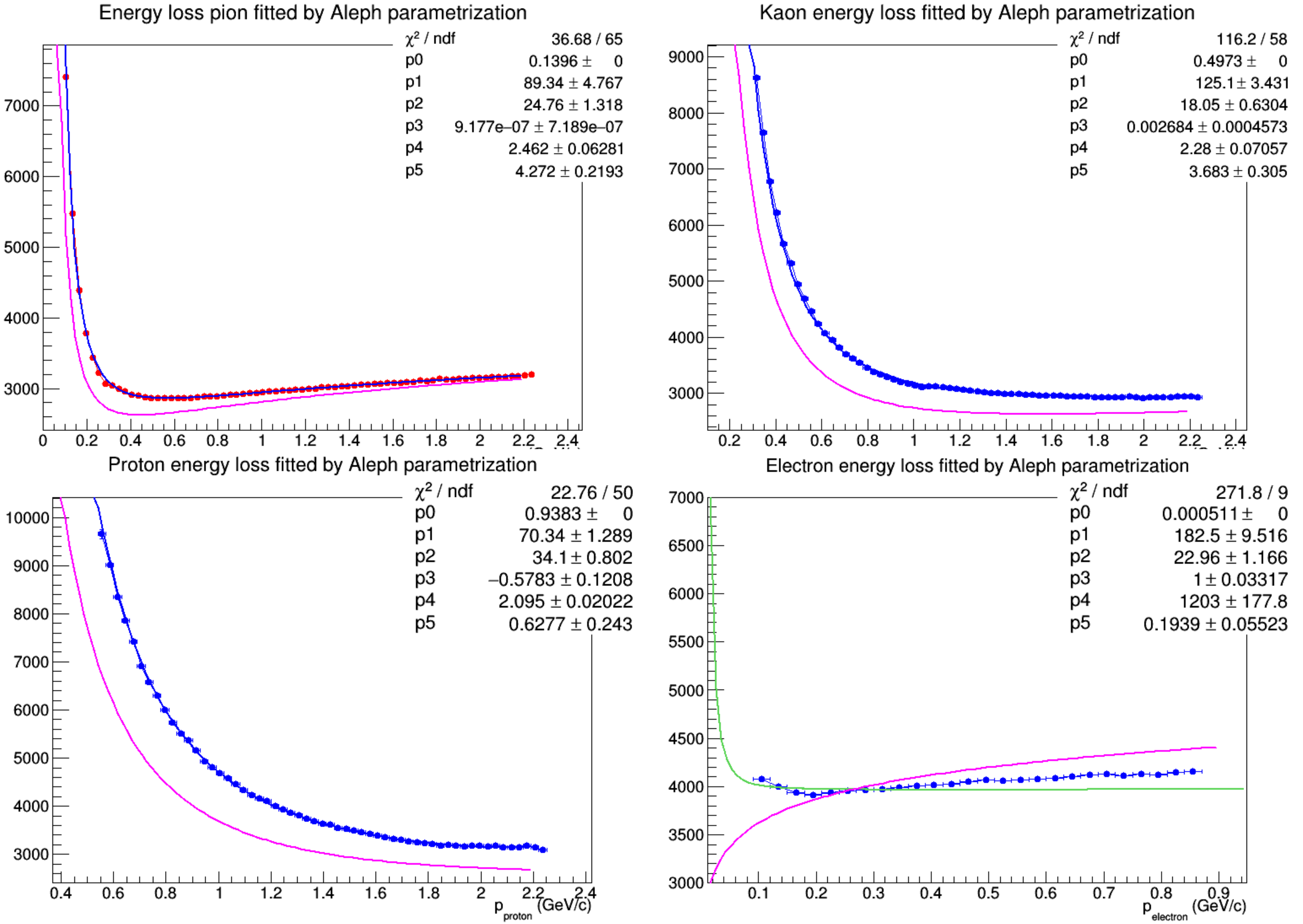
Save Undo

```
//Konstantin.Mikhaylov@cern.ch (October 2016)
Double_t My_BetheBloch(Double_t *x, Double_t *par) {
  Double_t p=x[0];//momentum in GeV/c
  Double_t mass=par[0];//Mass GeV
  Double_t beta=p/TMath::Sqrt(p*p+mass*mass);
  Double_t beta2=beta*beta;
  Double_t gamma=1/TMath::Sqrt(1-beta*beta);
  Double_t bg=beta*gamma;
  Double_t bg2=bg*bg;
  Double_t me=0.5109989461e-3;//mass of e
  Double_t K=0.30707;
  Double_t z2=1*1;
  //TPC STAR: 90% Ar + 10% CH_4
  Double_t Z=18.;//18Ar40
  Double_t A=40.;//Ar
  Double_t dedx=K*z2*Z/A/beta2;
  Double_t Wmax=2*me*bg2/(1+2*gamma*me/mass+(me/mass)*(me/mass));//minimum energy transfer
  Double_t I=10*Z*1e-9;//mean excitation energy ??? for elements heavier oxygen I=(10+/-1)*Z eV
  Double_t I2=I*I;
  Double_t logarg=2*me*bg*bg*Wmax/I2;
  dedx=dedx*(0.5*TMath::Log(logarg)-beta2);
  return dedx;
}
```

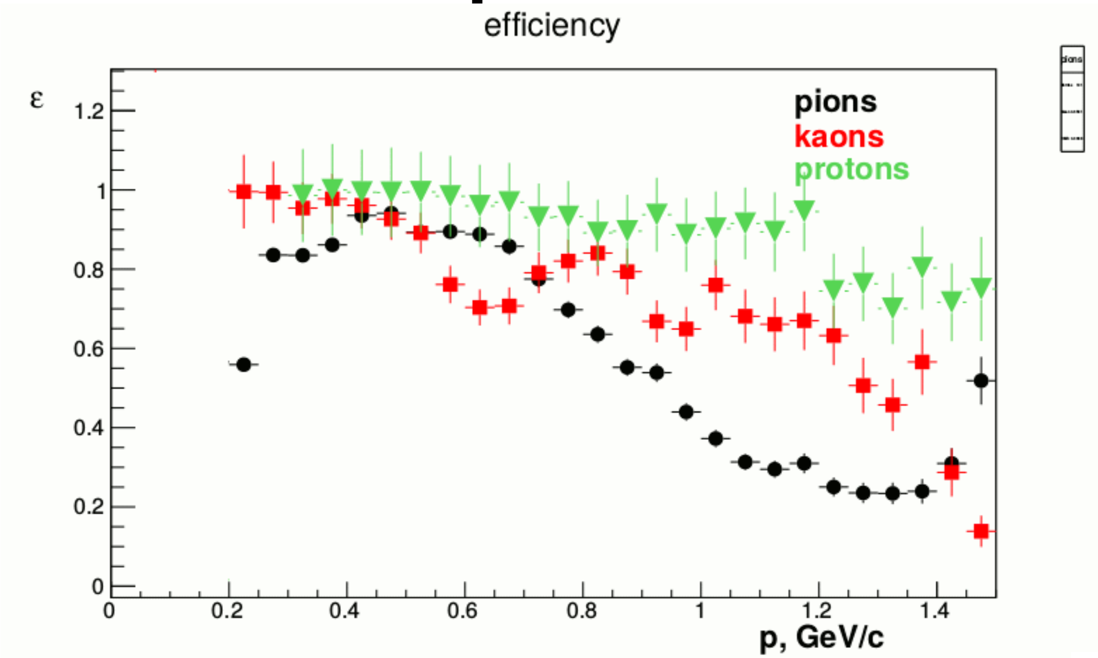
U:--- **BetheBlochFormula.C** Top L2 (C++/l Abbrev)

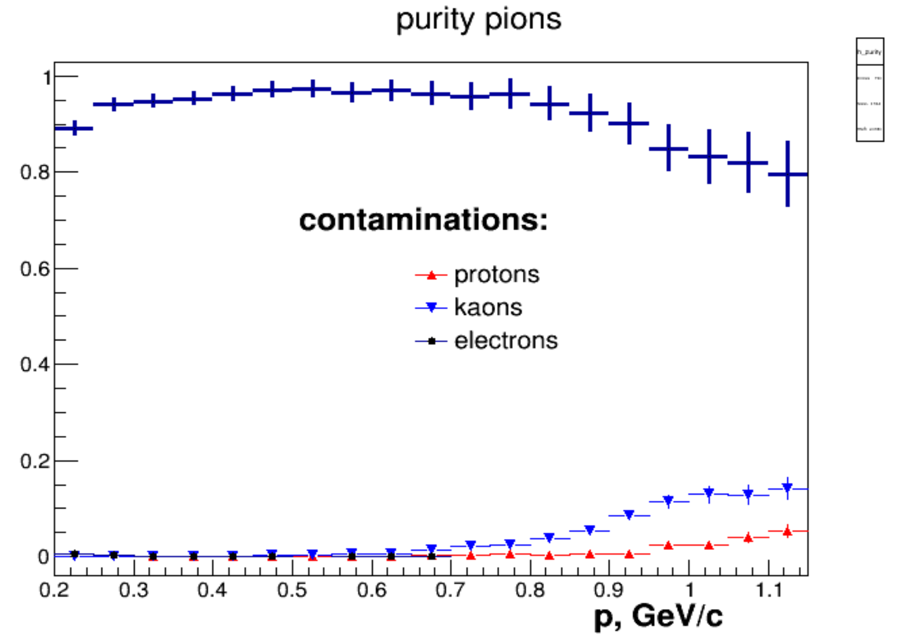
Wrote /cern/users3b/kmikhail/NICA/dEdx/BetheBlochFormula.C

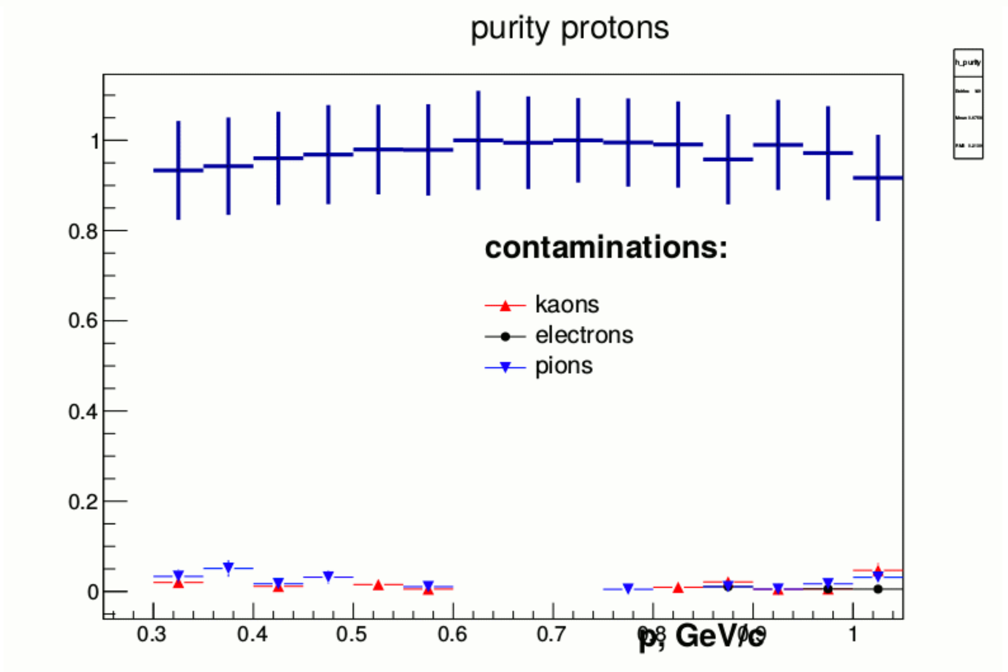
Fit of <dE/dx> by BBF ALEPH parametrization

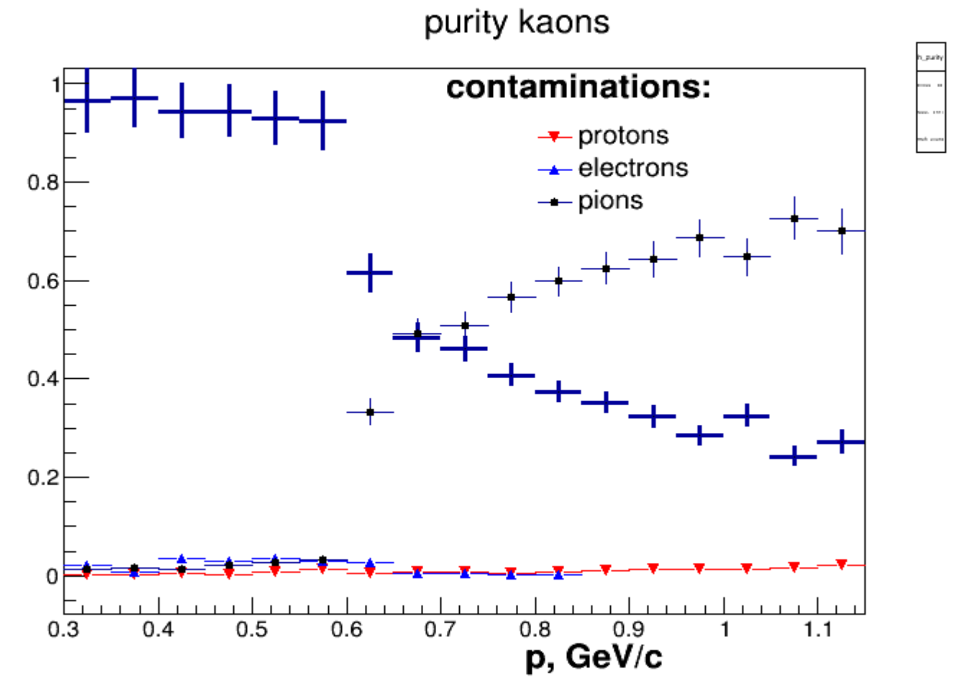


PID performance, Bayesian pid





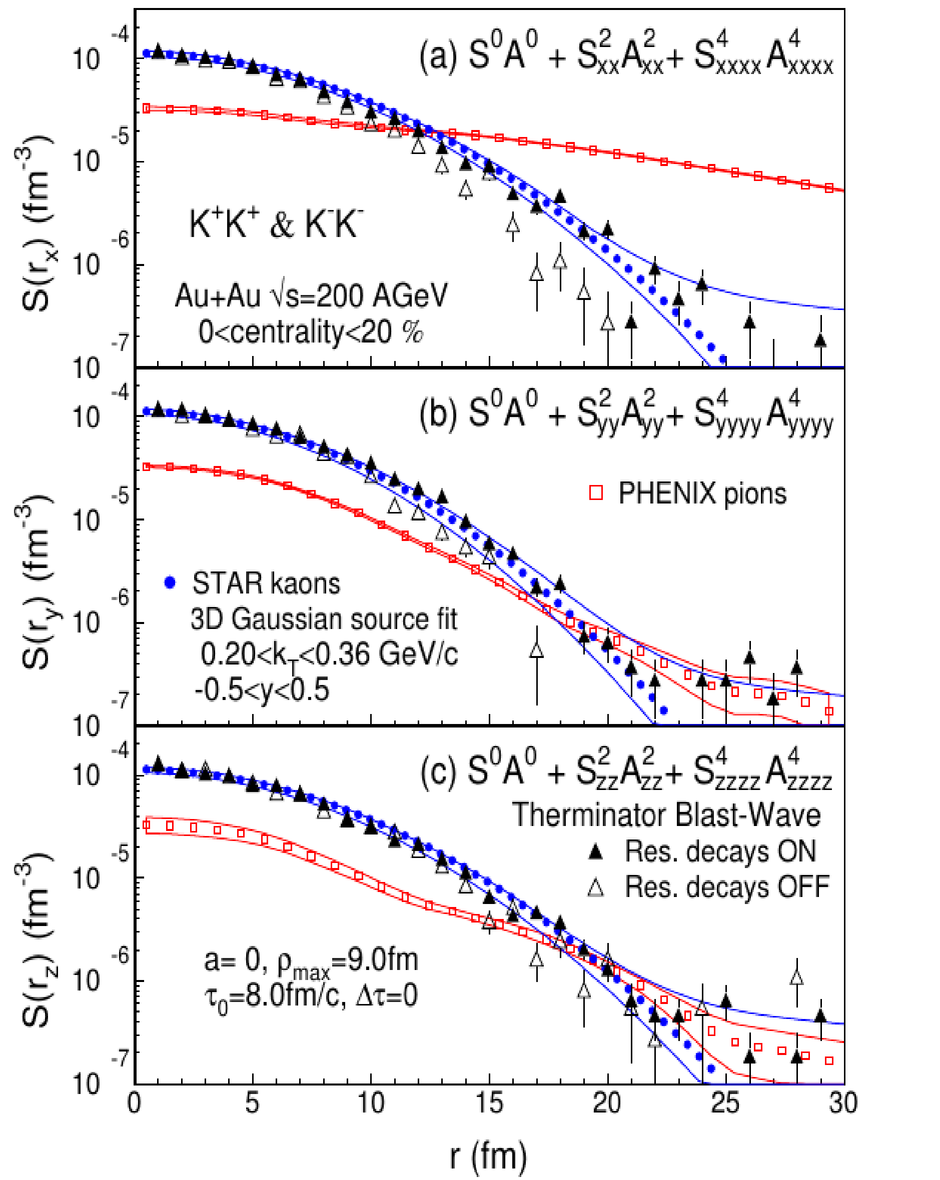




The contamination for kaons at low momenta is under study

Imaging

STAR, Phys.Rev. C88 (2013) 3, 034906



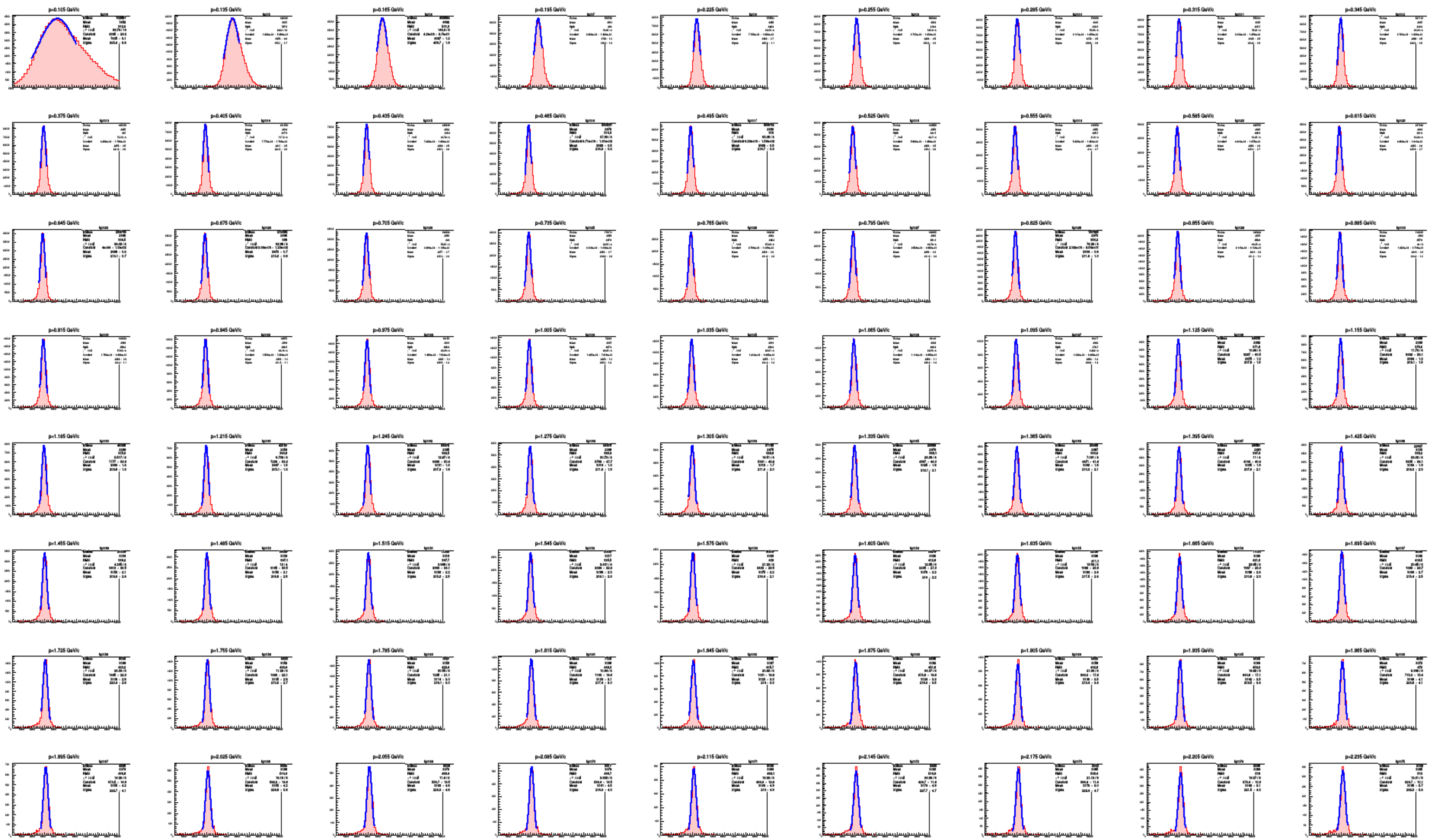
- PHENIX and STAR collaborations apply a new "imaging technique" to extract the S(r*)-source function, which represents time-integrated distribution of particle emission points separation r* in the pair rest frame (PRF).

$$C(\mathbf{q}) - 1 \equiv R(\mathbf{q}) = \int \left(|\phi(\mathbf{q},\mathbf{r})|^2 - 1\right) S(\mathbf{r}) d\mathbf{r}.$$

- The method is suitable for extracting the S(r) directly from the data without any hypothesis about source shape; it seems to be very useful for comparison of the experimental data with the models with 1PT or Crossover EoS

- The good knowledge of all factors influencing the shape of correlation function is needed

dE/dx distributions for pions



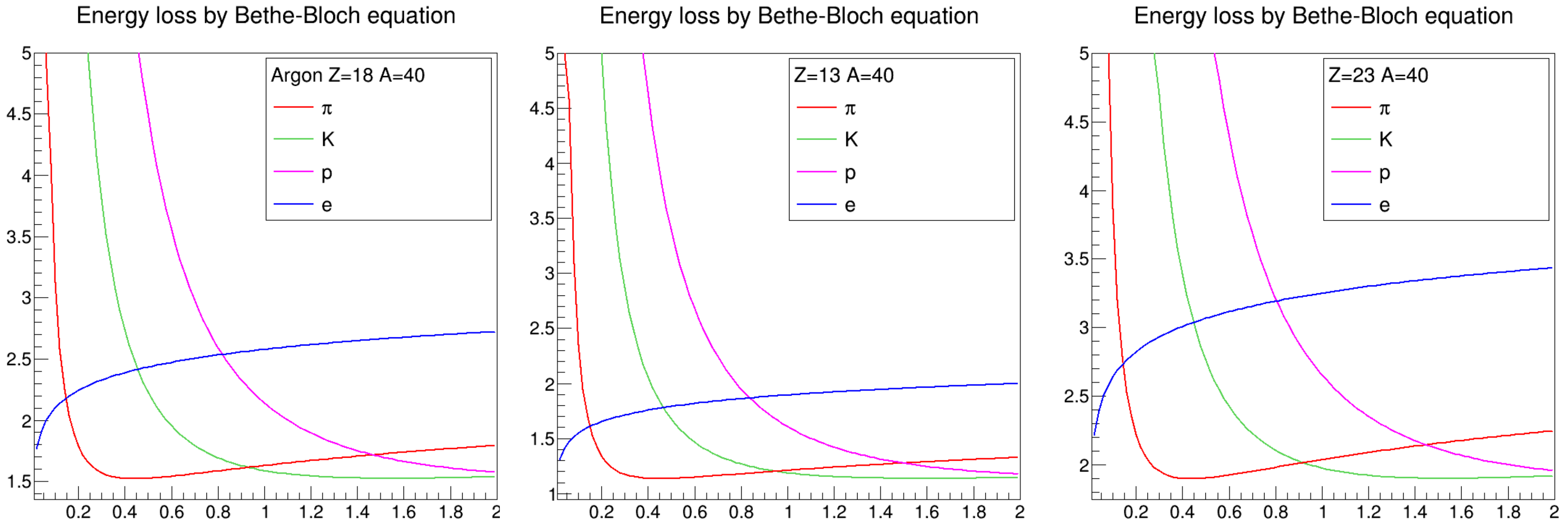
p (0.09, 2.25) GeV/c, 72 slices ; Blue color – Gaussian fit region : Maximum +/- RMS

Energy loss by Bethe-Bloch equation

$$\left\langle -\frac{dE}{dx} \right\rangle = K z^2 \frac{Z}{A} \frac{1}{\beta^2} \left[\frac{1}{2} \ln \frac{2 m_e c^2 \beta^2 \gamma^2 W_{\max}}{I^2} - \beta^2 - \frac{\delta(\beta\gamma)}{2} \right]$$

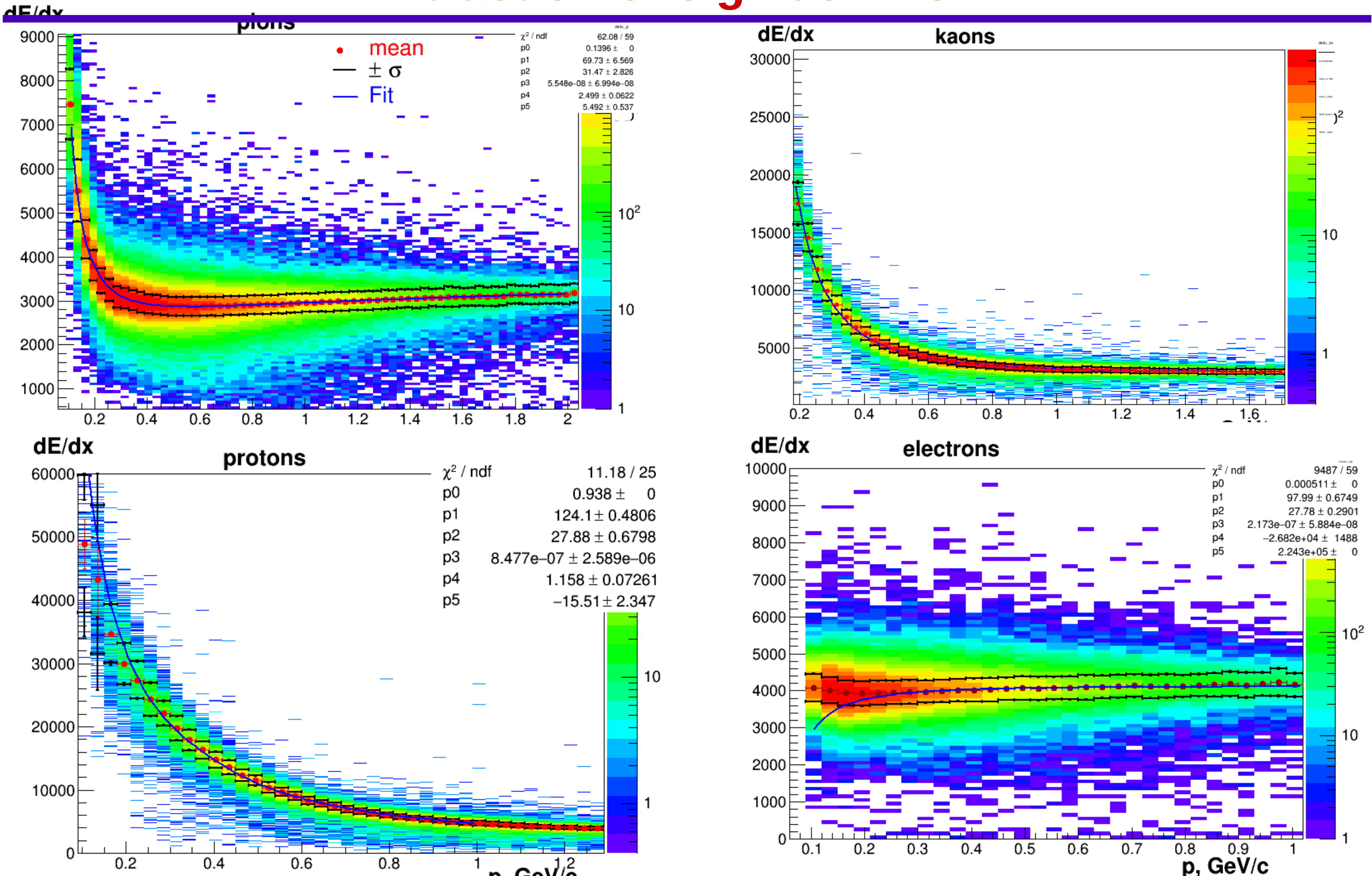
To estimate <dE/dx> by BB equation Ar was used (STAR: 90%Ar+10%CH_4)

The intersection curves weakly dependent on the gas mixture (vary Z ± 5)



The intersection of K and electrons is about momentum 450 MeV/c

Extraction of sigmas TPC



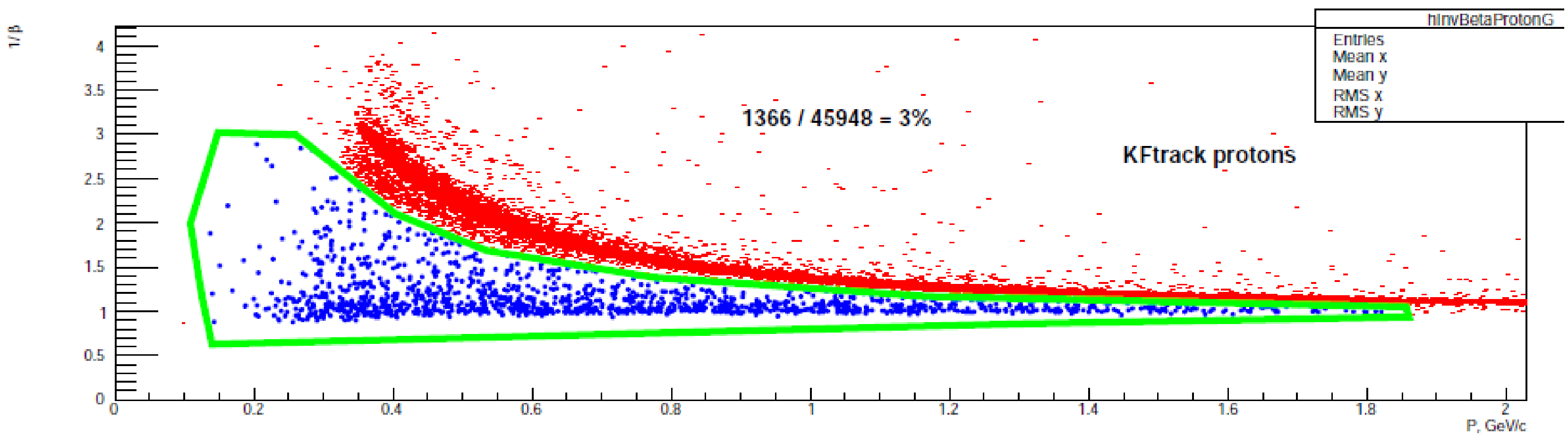
Electrons are not described by the fit!

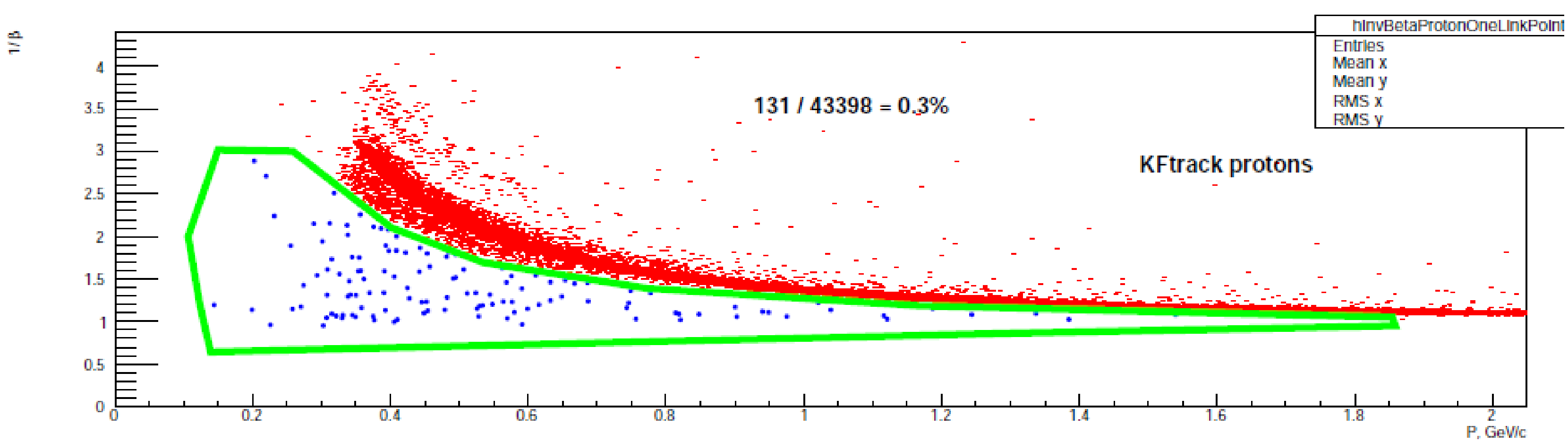
Note: not realistic contamination of e at p<0.25 GeV/c for a moment.

Study of 1/β distribution for protons
by S. Lobastov

Upper plot: the underlayer corresponds to pions and electrons. Contribution is 3%.

Lower plot: additional cuts are applied: 1) remove events with >1 tracks in a pad
2) remove electrons and pions by TPC pid
The remaining contribution is 0.3%





QGSM generator, MpdTofMatchingData

Алгоритм восстановления (1)

Для проверки предположения о том, что треки можно восстанавливать по хитам кремниевого детектора (**здесь хит = положение + погрешность**), и оценки эффективности такой реконструкции, был написан алгоритм восстановления треков "первом" приближении:

-- Фиксируем положение первичной вершины.
-- (Сначала бралась точка (0., 0., 0.), в следующем приближении первичная вершина с погрешностью должна приходить из TPC;
-- Из всевозможных комбинаций хитов первого и второго внутренних слоёв строим массив "ростков" треков.
-- Пытаемся дополнить каждый росток хитами с внешних слоёв таким образом, чтобы через все хиты и первичную вершину проходил трек с разумной ошибкой (какой ?).
(Трек проводится оптимизацией промахов по значению 3-импульса в первичной вершине.) -- не поняла
-- Поглощаем и сшиваем треки с общими хитами. Убираем двоящиеся треки.
Все решения "средние" - баланс между точностью и сложностью кода.

Очевидные пути улучшения алгоритма:
искать треки, не оставившие следов в 1 или 2 внутреннем слое
аккуратно разбирать все случаи пересечения треков
улучшать алгоритм сшивки треков
уменьшать (комбинаторную) сложность алгоритма
точно измерить неопределённости в положении хитов
заменить глобальную оптимизацию на фильтрацию
включить в рассмотрение вторичные вершины
делать несколько проходов, меняя требования на реконструкцию
Что надо сделать для улучшения:
определиться с восстановлением первичной вершины
произвести реалистичные реконструированные хиты