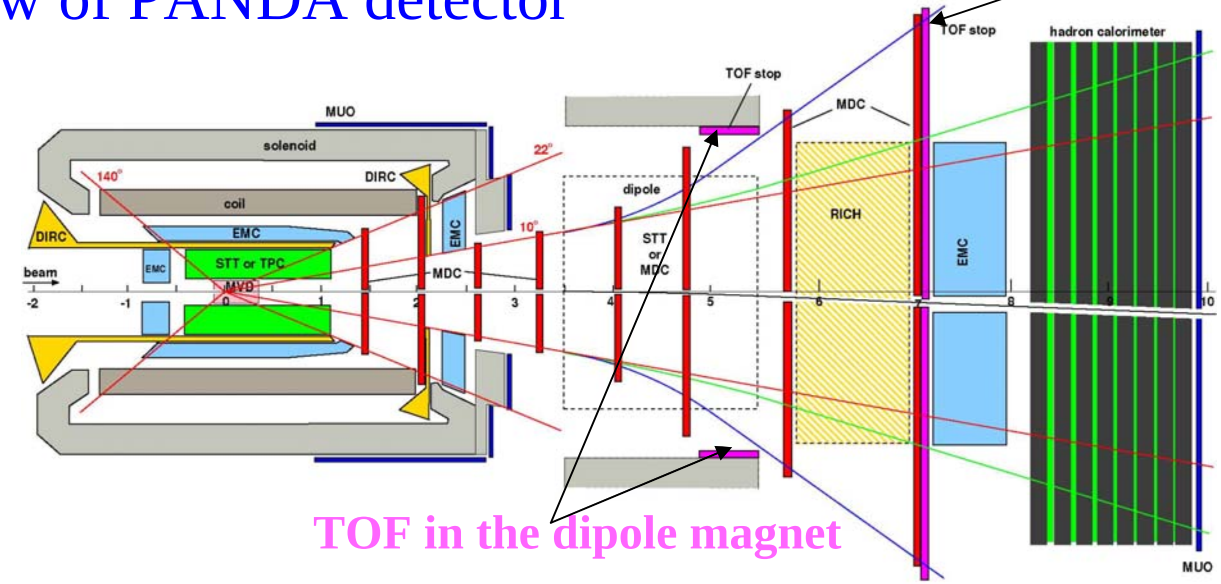
TOF-based PID for PANDA Forward Spectrometer

A. Kiselev, Yu. Naryshkin

PNPI, St. Petersburg

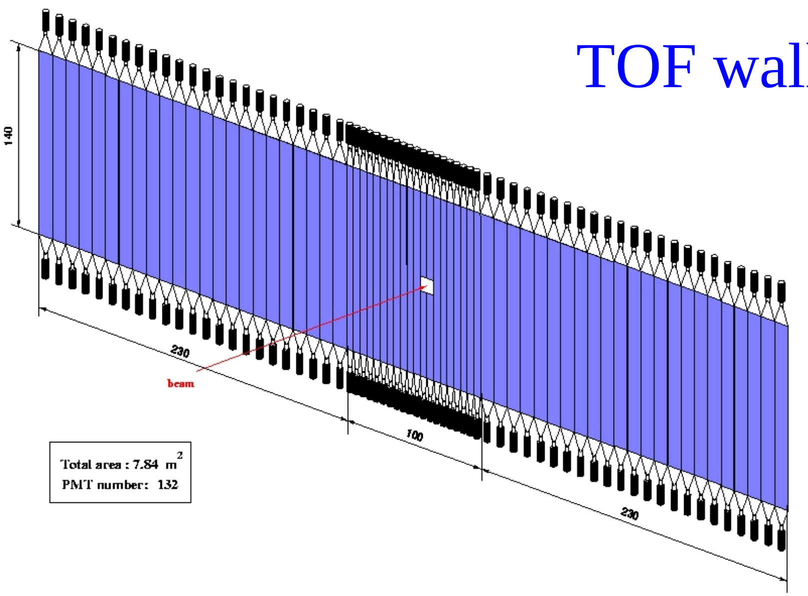
Top view of PANDA detector

TOF wall



TOF in the dipole magnet

TOF wall



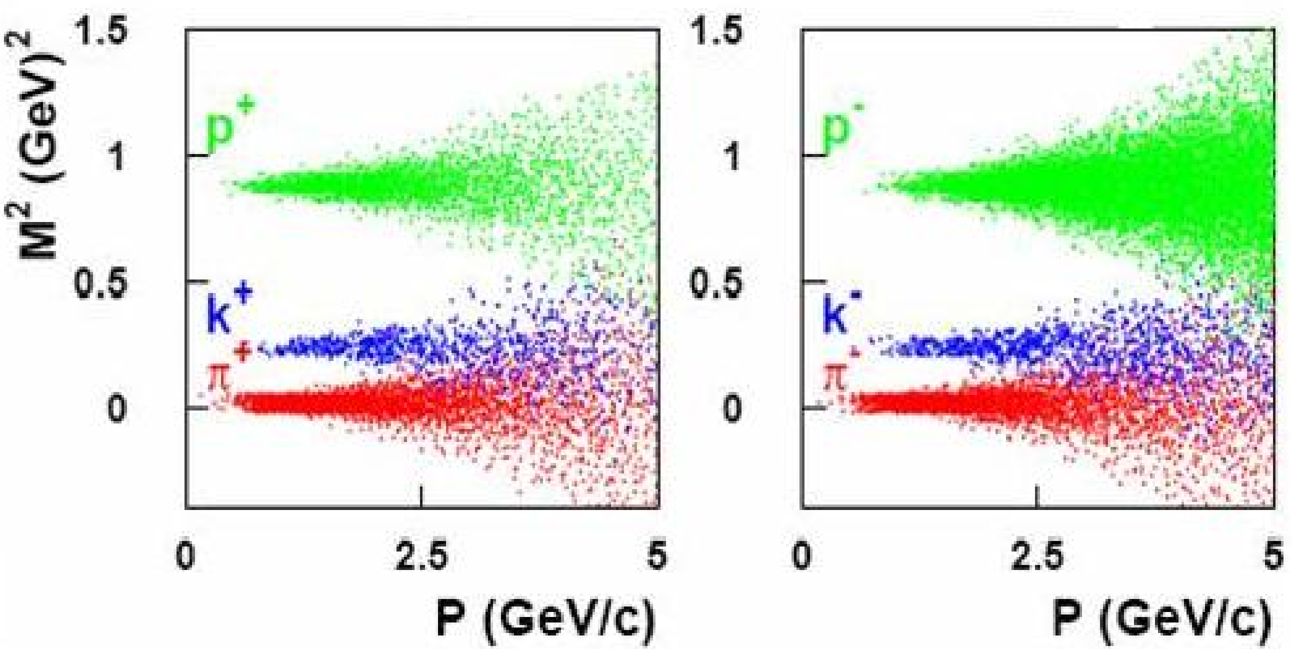
- forward scintillation wall
  140x5x2.5 cm^3, 20 strips,
  140x10x2.5 cm^3, 46 strips
- two side walls, inside the dipole magnet
  100x10x2.5 cm^3, 5 strips each

made of plastic scintillator BC408
time resolution of TOF ≤100 ps

Mass reconstruction with T_0 (start) measurement

- ***Each track considered individually (track-level PID)***
- ***Monte-Carlo T_0(start) was used without smearing***

TOF resolution 100 ps



$$m = p\sqrt{\frac{t^2c^2}{L^2} - 1}$$

Effective π/K separation up to 3 GeV/c, K/p separation up to 4 GeV/c

ToF-based event-level PID formalism for PANDA

→No T_0(start) measurement is required!

- ***Quantify as much as possible pion/kaon/proton separation***
- ***Work the same way for barrel/side/forward ToF detectors***
- ***Account properly for ToF and tracking uncertainties***

ToF-based event-level PID formalism for PANDA

→No T_0(start) measurement is required!

- Quantify as much as possible pion/kaon/proton separation
- Work the same way for barrel/side/forward ToF detectors
- Account properly for ToF and tracking uncertainties

This talk → a simplified (introductory) version:

- pion/proton separation
- Monte-Carlo with forward ToF detector only
- tracking uncertainties accounted in a simple (yet correct!) way

Proton-pion separation with Forward ToF Wall

Consider N-track event → 2^N particle mass configurations $\{m_1,\ldots,m_N\}$, for each of them start timing offset (t_S^0) can be easily calculated:

$$\Psi(t_S) = \sum_{i=1}^{N} \frac{(t_i^{REC} - t_i^{TOF} - t_S)^2}{(\sigma_i^{TOF})^2 + (\sigma_i^{REC})^2}, \frac{d\Psi}{dt_S} = 0 \rightarrow t_S^{\,0}, \chi^2{}_0 \equiv \Psi(t_S^{\,0})$$

$$t_i^{REC} = \sqrt{p_i^{\,2} + m_i^{\,2}} \,/\, (p_i c), (\sigma_i^{REC})^2 = (\frac{\partial t^{REC}}{\partial L}\sigma_L)^2 + (\frac{\partial t^{REC}}{\partial p}\sigma_p)^2$$

This gives a "weight" for each of $\{m_1,\ldots,m_N\}$ configurations: $\omega_{\{m_1,\ldots,m_N\}} = PROB(\chi^2{}_0, N-1)$

Then probability for j-th track to be a pion (proton) can be defined as

$$\varepsilon_\pi^{\,j} = \sum_{\{j\}=\pi} \omega_i \,/\, \sum_{i=1}^{2^N} \omega_i \qquad \varepsilon_p^{\,j} = \sum_{\{j\}=p} \omega_i \,/\, \sum_{i=1}^{2^N} \omega_i$$

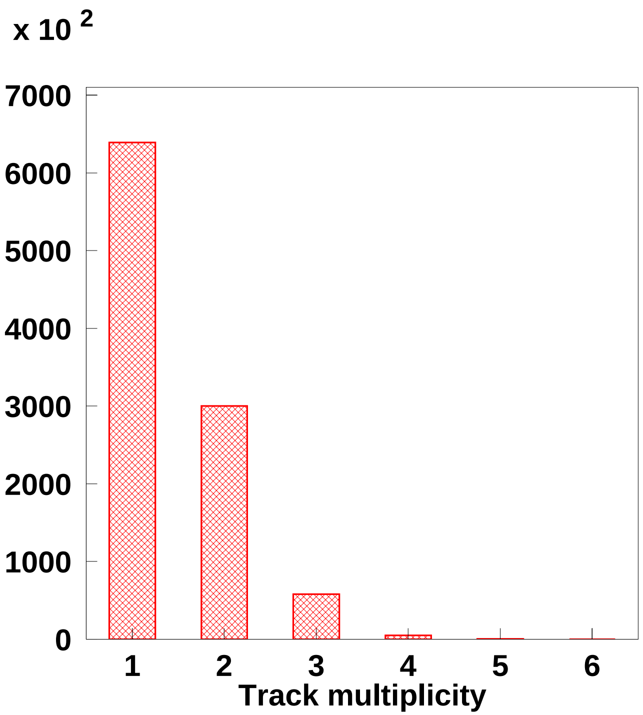
- ***Path length uncertainty, few mm*** → ***small effect***
- ***Momentum resolution on the level 0.2% (TDR)*** → ***small effect***

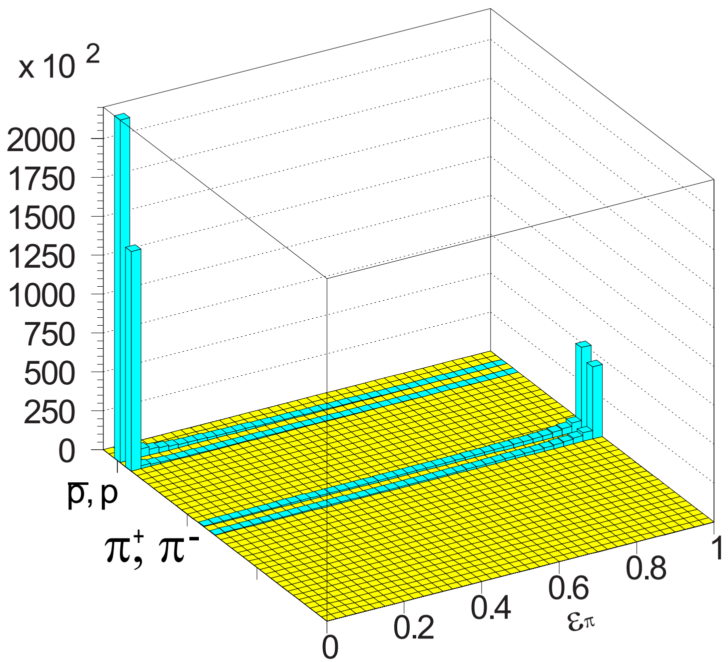
MC simulation

$$\varepsilon_\pi^{\ j} = \sum_{\{j\}=\pi} \omega_i \Big/ \sum_{i=1}^{2^N} \omega_i$$

PYTHIA6 → GEANT3 → PID program

P_{beam}=10 GeV





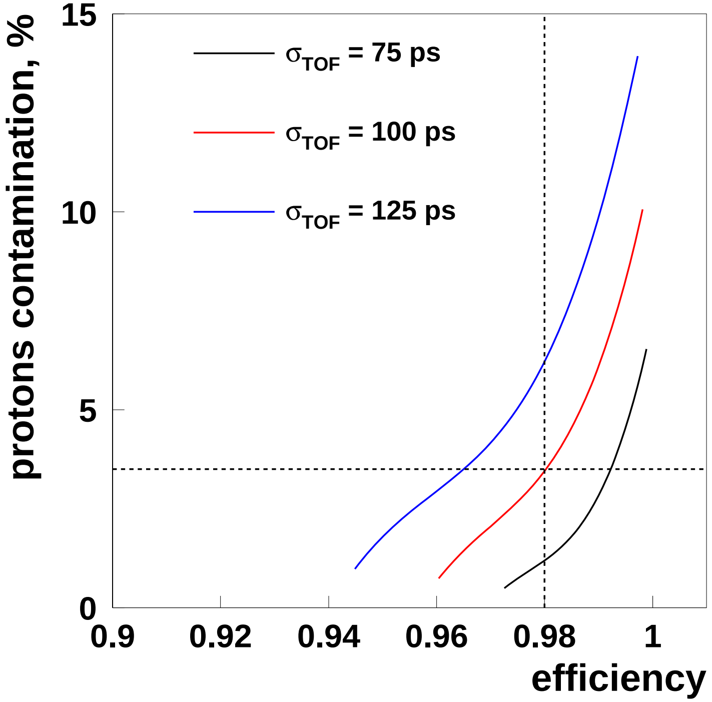
$$\text{pion efficiency} = \frac{N_{\pi,\,\text{after}\,\varepsilon\,\text{cut}}}{N_{\pi,\,\text{total}}}$$

$$\text{proton contamination} = \frac{N_{p,\,\text{after}\,\varepsilon\,\text{cut}}}{N_{p,\,\text{total}}}$$

We select the events with n_{tracks} =2, 3, 4

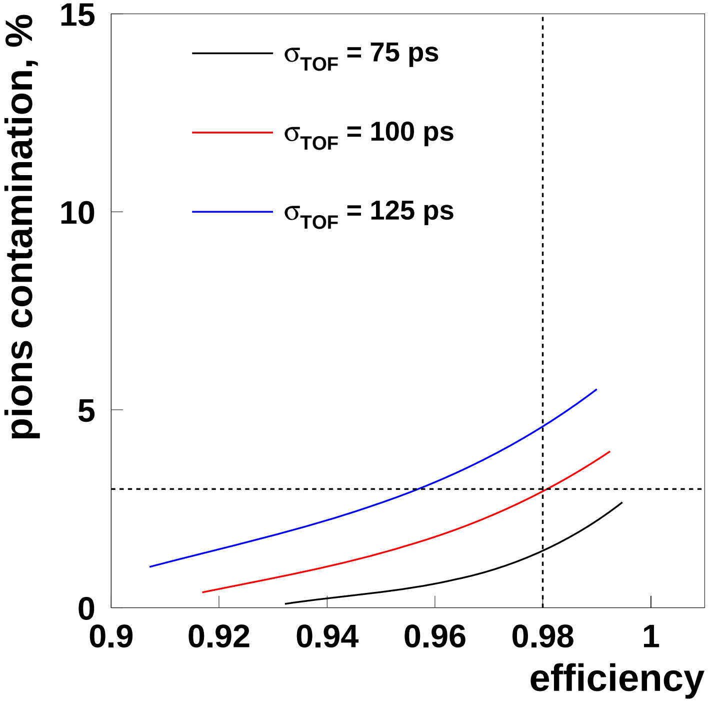
Proton-pion separation vs TOF resolution

pions PID



$\langle p_\pi \rangle = 2.15$ GeV

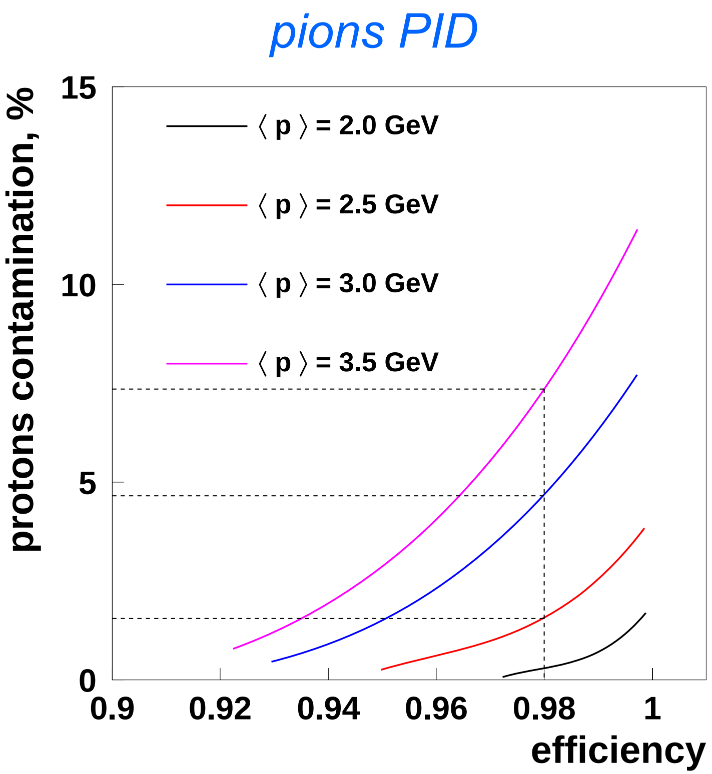
protons PID

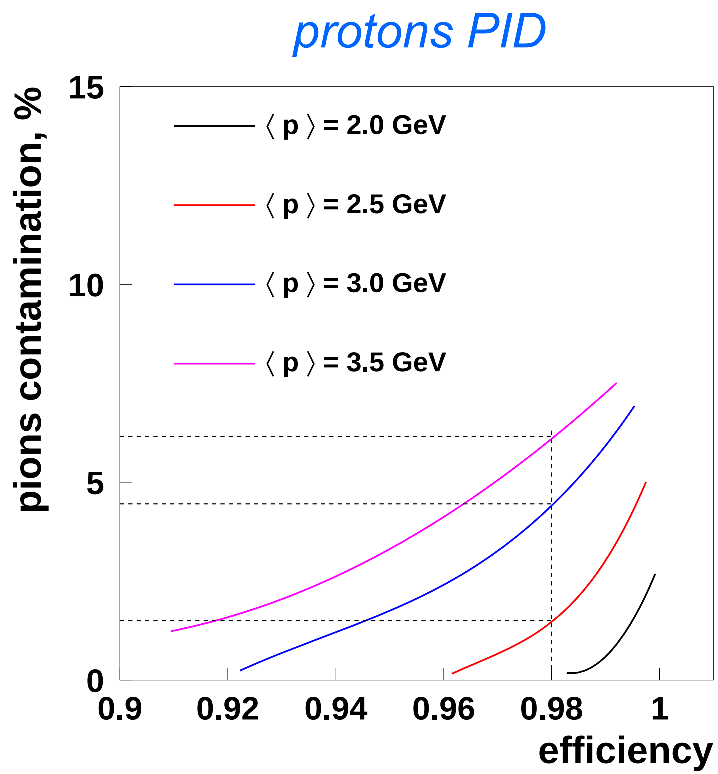


$\langle p_p \rangle = 3.26$ GeV

No fluxes are taken into count

Proton-pion separation in momentum bins





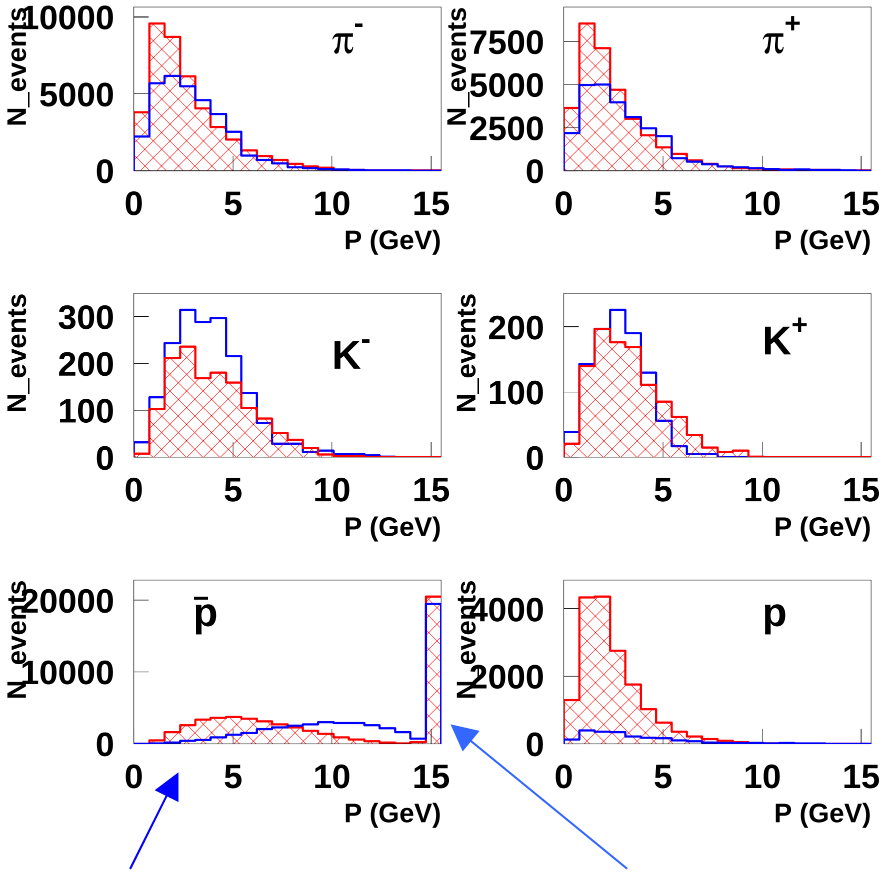
σ_{TOF} = *100 ps*

No fluxes are taken into count

Outlook

- *Check algorithm for kaon separation*
- *Justify the algorithm within PANDAROOT framework, including track reconstruction*
- *Include side TOF walls and barrel TOF*
- *Prepare PANDA internal note*

Monte-Carlo p_{beam}=15 Гэв/с



PYTHIA

DPM

$\bar{p}p \to \bar{p}X$

elastic scattering $\bar{p}$