RICH Expected Performances and Integration in CLAS12

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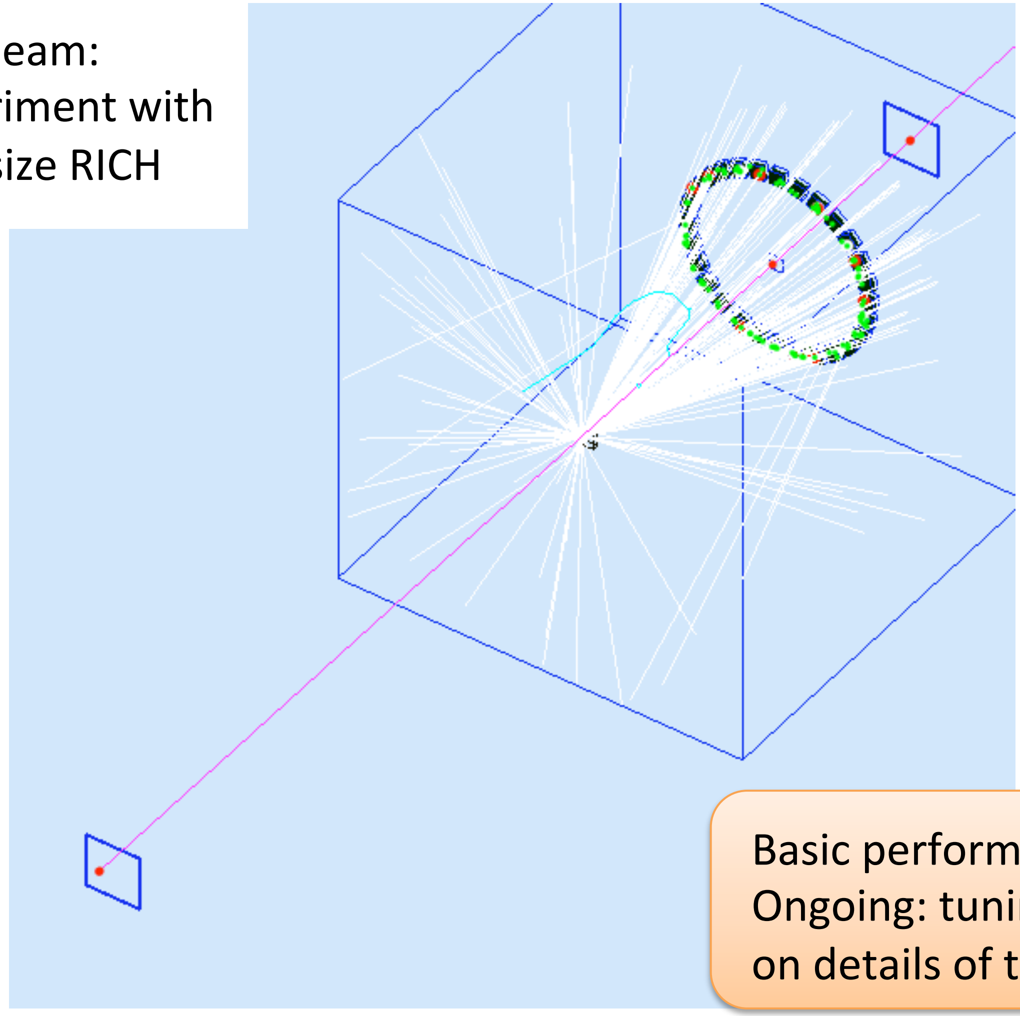
Rich Technical Review, 27 June 2013

Prototype Simulation

Validation and Tune of Simulations on Prototype Data

Protoype test-beam:
complete experiment with
tracking + real size RICH



Basic performances reproduced
Ongoing: tuning simulation models
on details of the measurements

Tracking for Direct Light Case

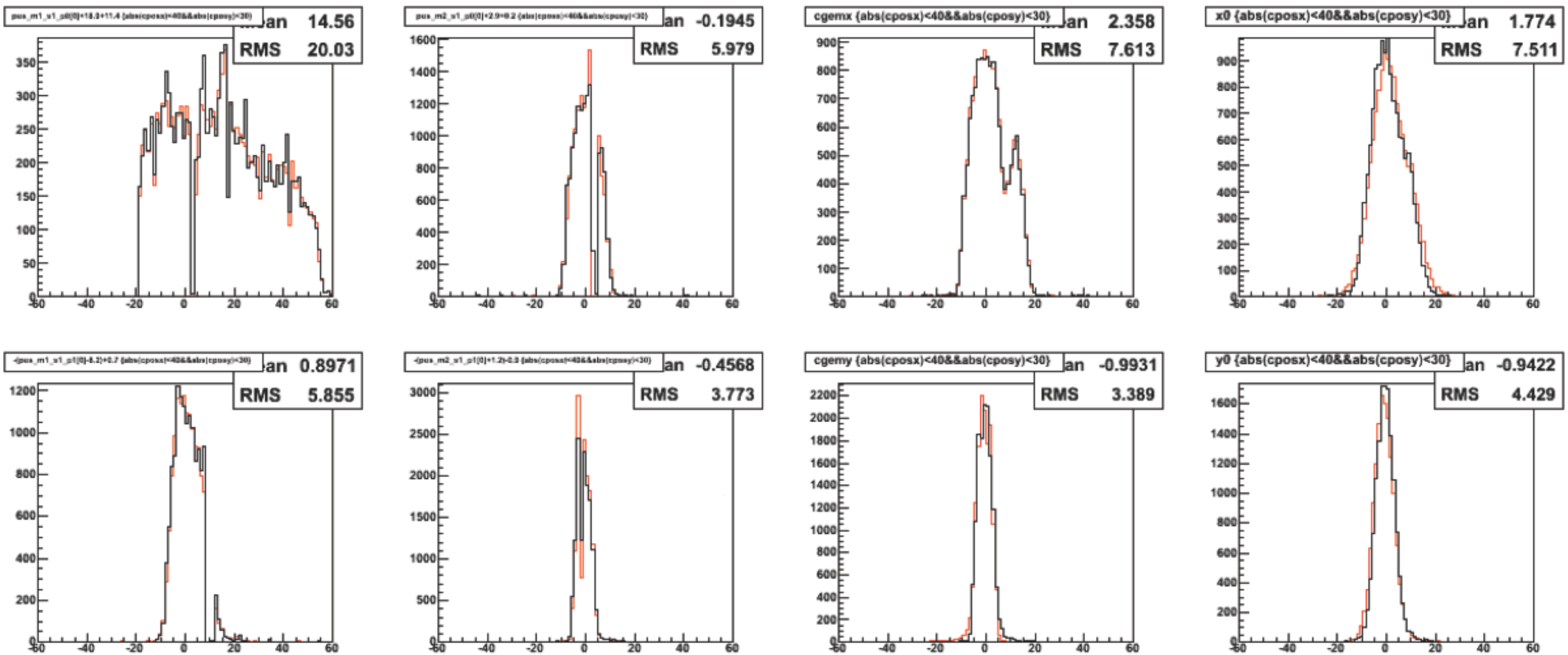
MC vs DATA Comparison

Input: Upstream GEM 0

Downstream GEM

GEM extrapolation at PMT plane

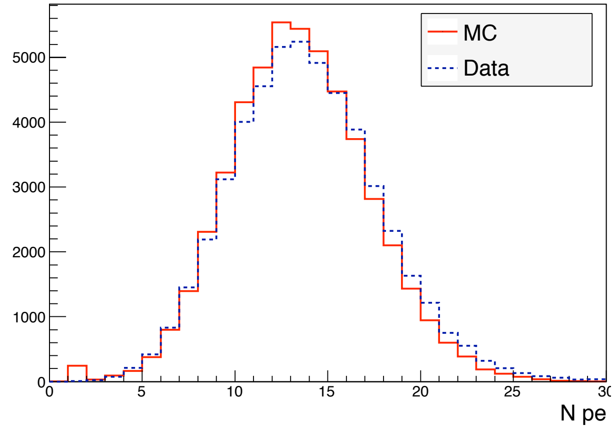
Fitted center of PMT signals

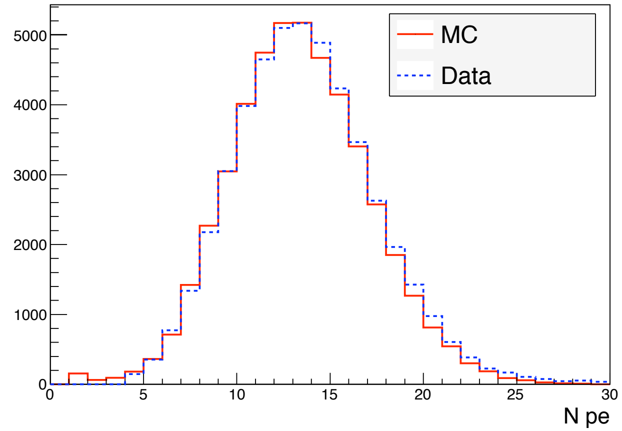


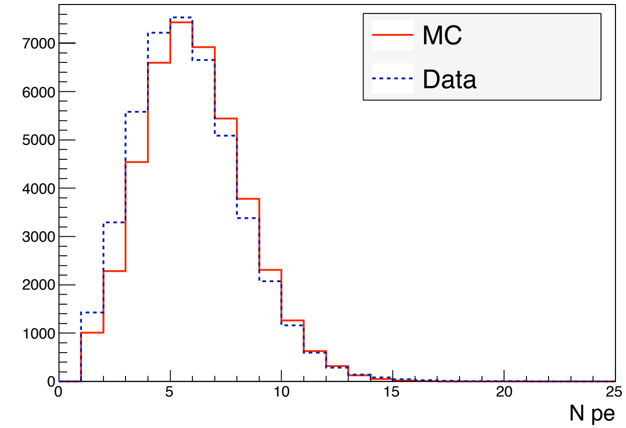
x (cm) x (cm) x (cm) x (cm)

Prototype Simulation

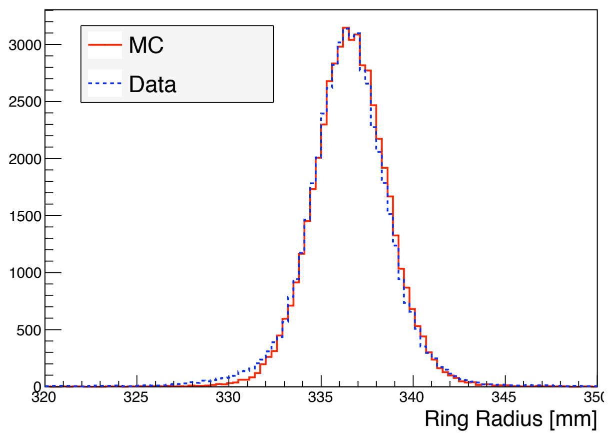
Number of photo-electrons

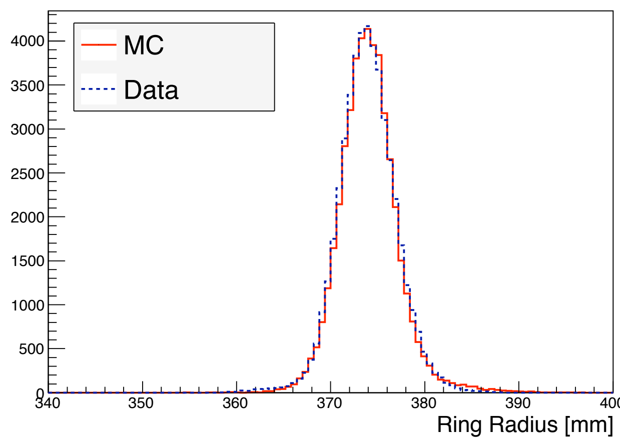


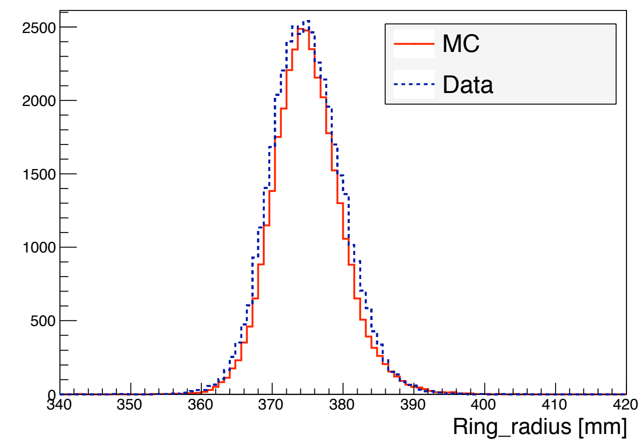




Radius Resolution







Direct Light Case

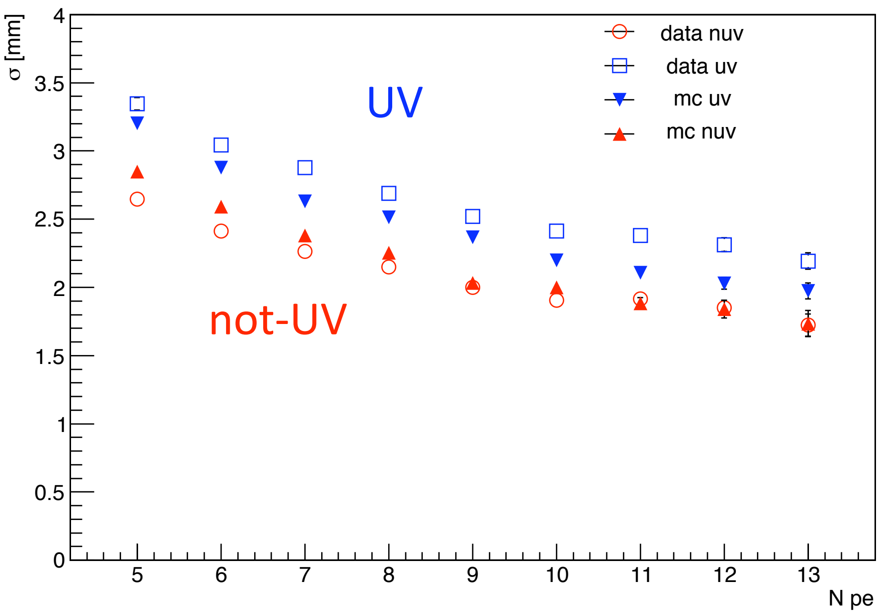
Reflected w/o Abs.

Reflected with Abs

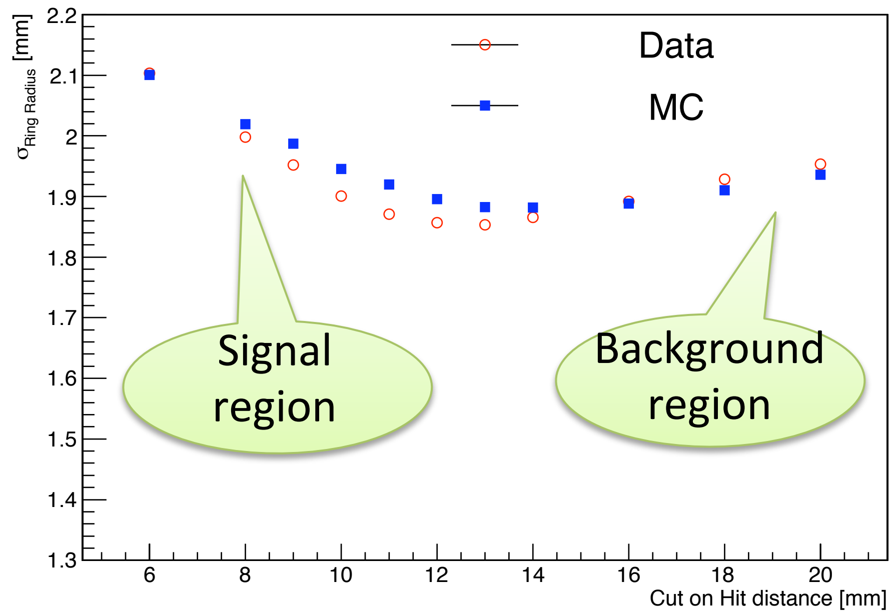
Prototype Simulation

Direct Light Case

Radius Resolution vs maximum hit residual



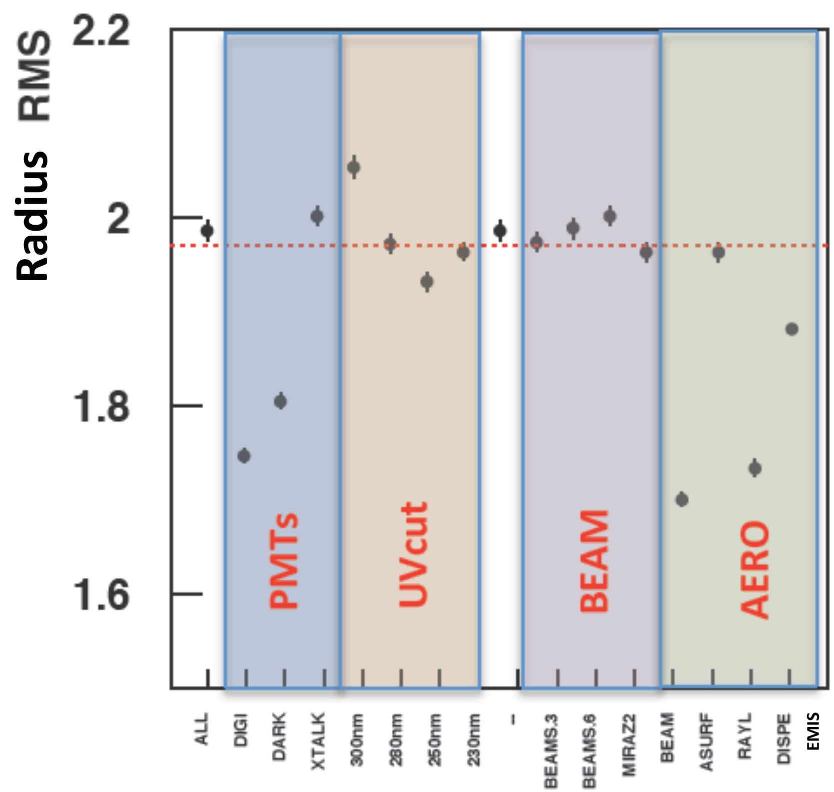
Radius Resolution vs maximum hit residual



Detailed MC vs DATA comparison useful to tune the simulation models

Cherenkov Angle Resolution

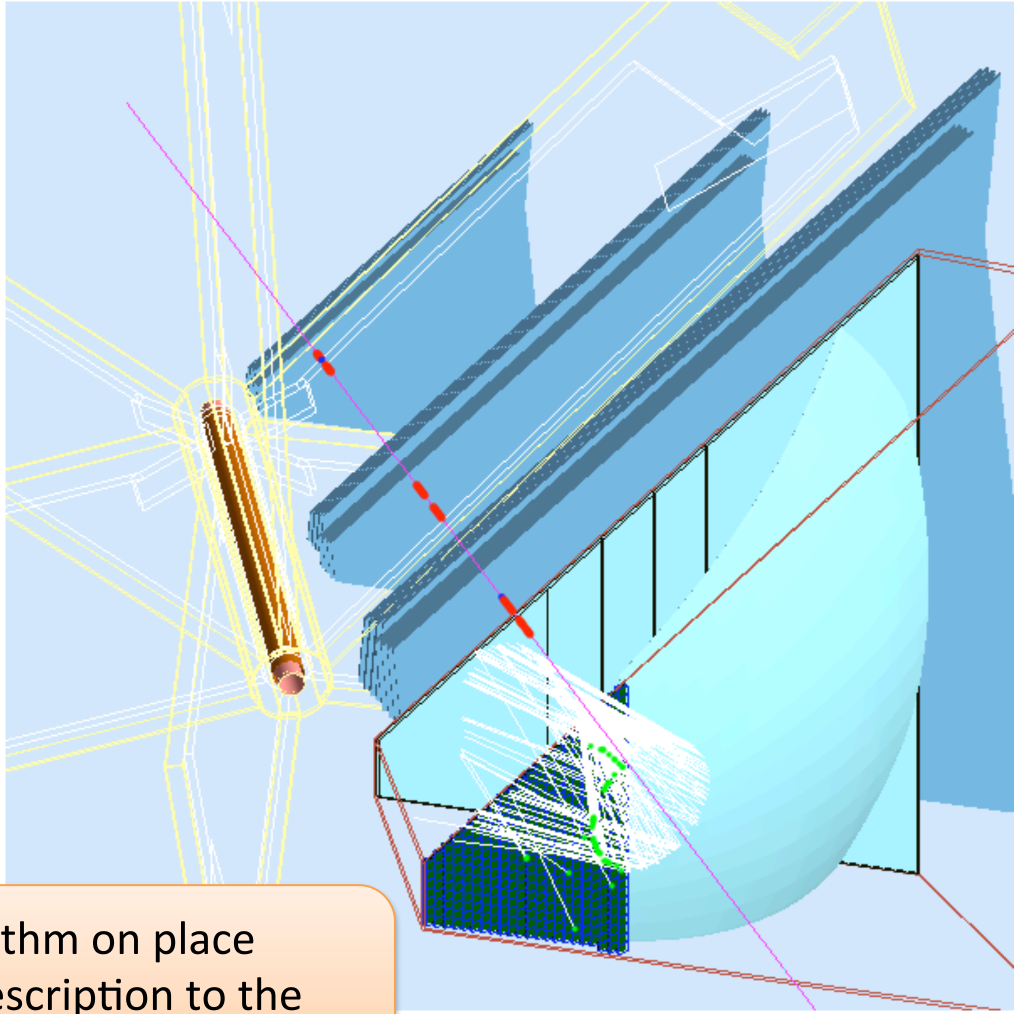
Direct Light Case



Prototype data important to study the main contributions to the resolution

Events in CLAS12

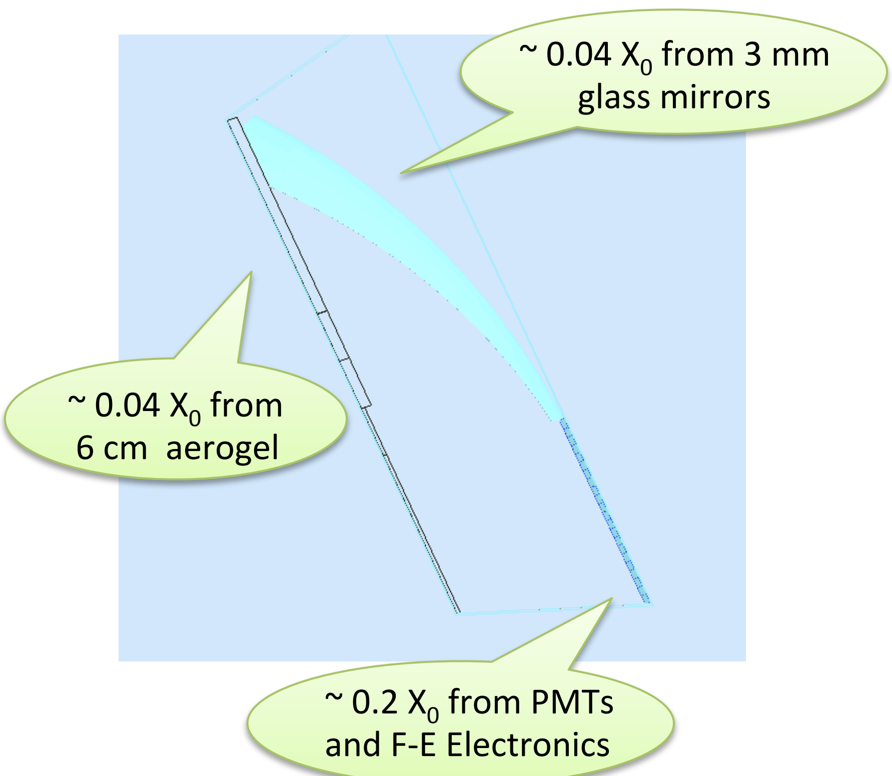
Verify and optimize the performances

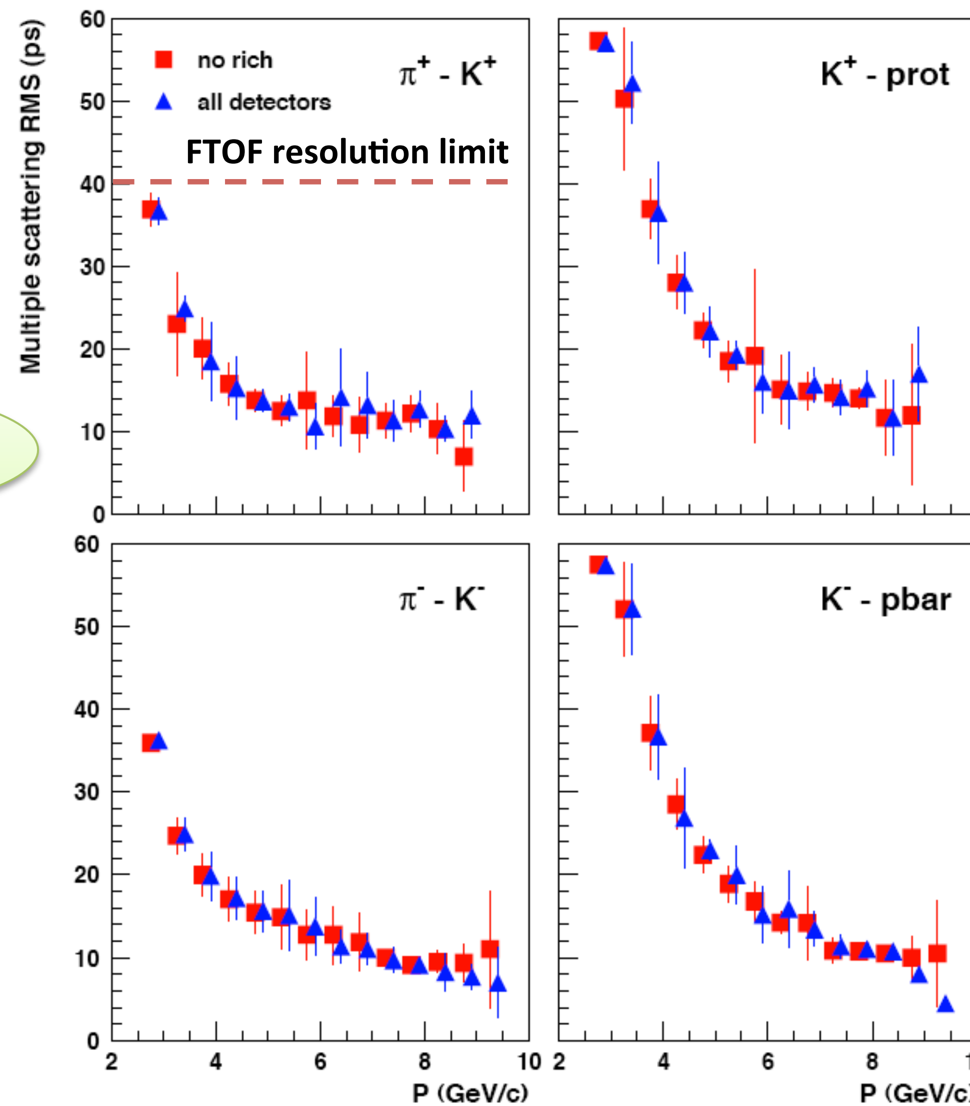


Reconstruction algorithm on place
Ongoing: updating description to the prototype level and optimization

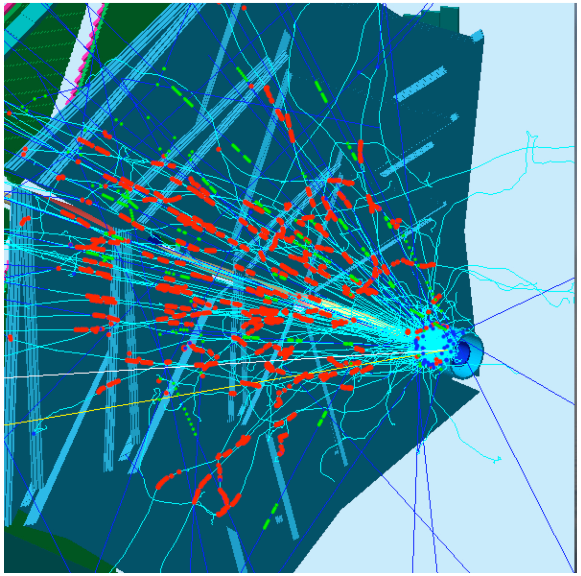
Interference with Other Detectors

RICH material budget has no visible effect on the FTOF time resolution and is much less than preshower ~5 X_0

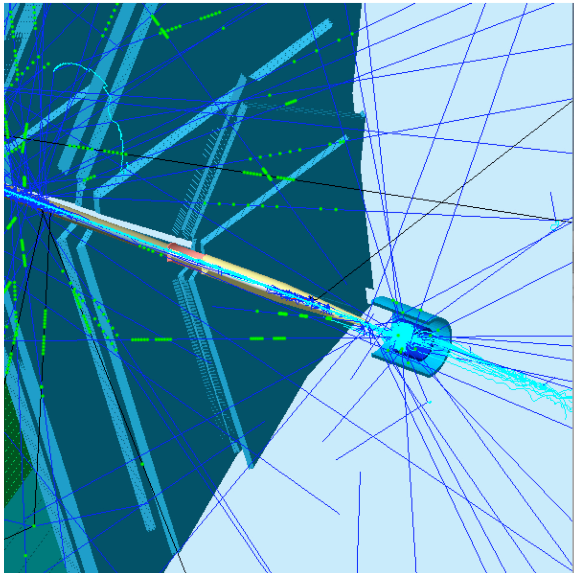




Drift Chamber Occupancy



No target field



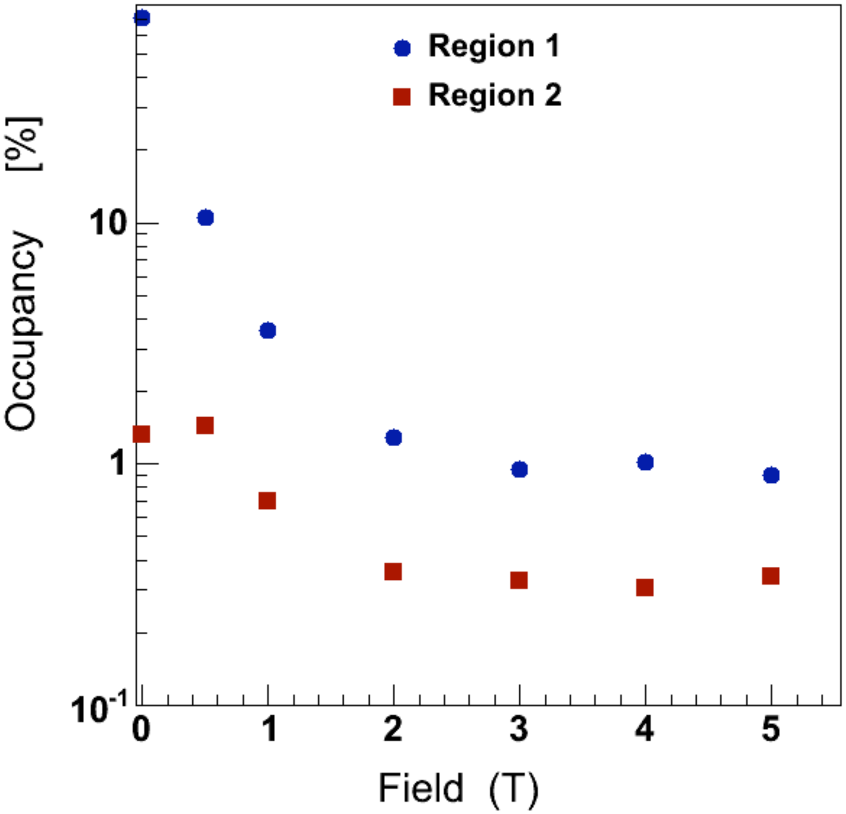
With target field

L = 10^{35} cm^{-2} s^{-1}

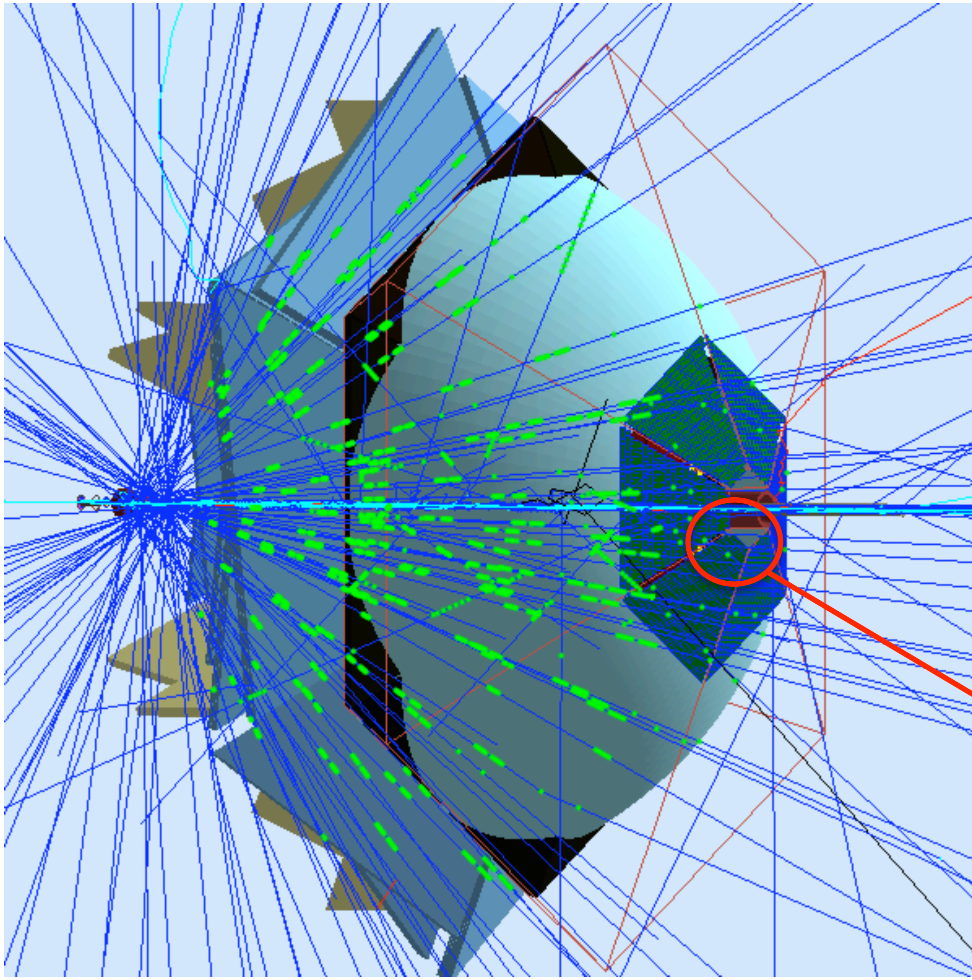
DIS rate: 1-10 kHz

Severe Moeller background

- *10-100 k within 250 ns*
- contained by central solenoid
- showering into long-range photons

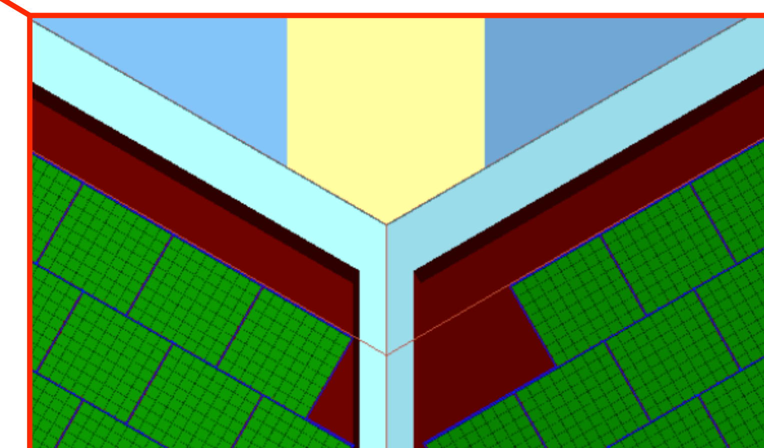


The RICH Background



Major source of backgrounds

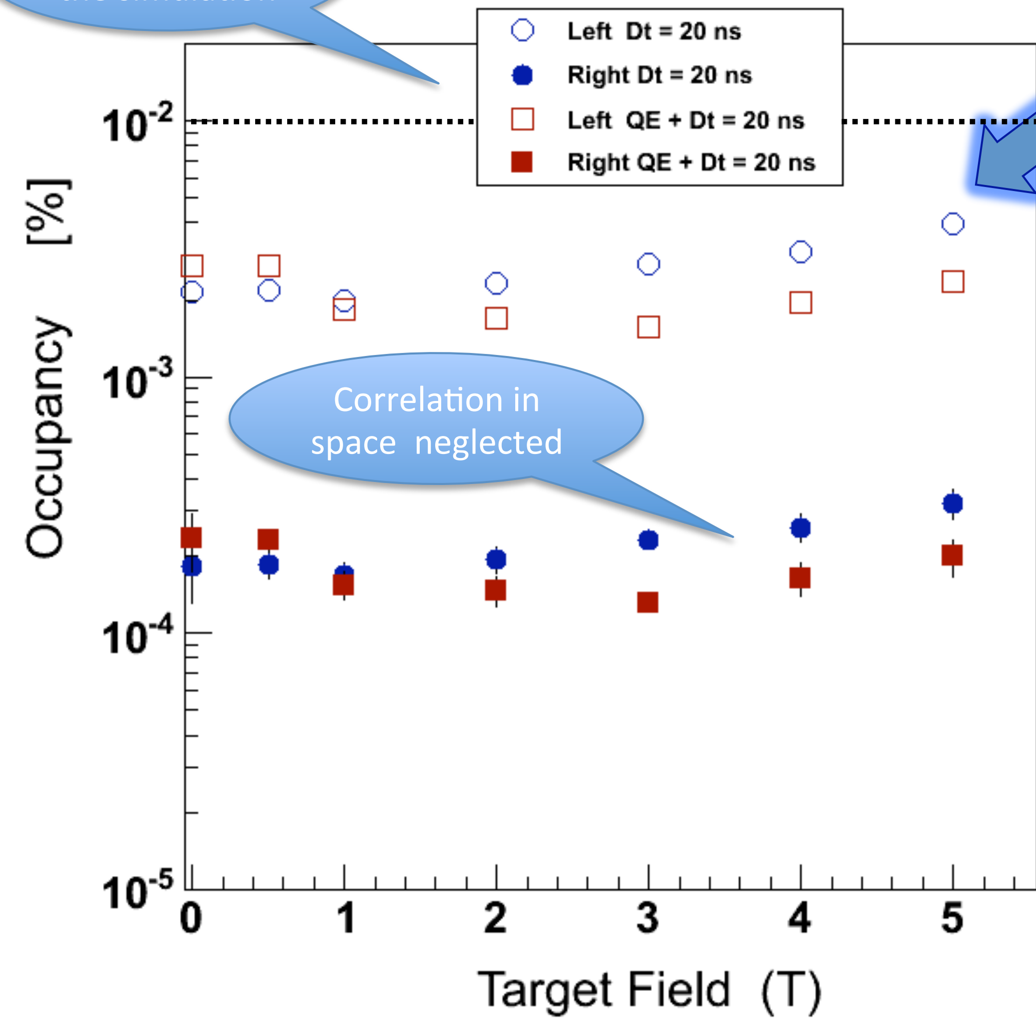
Photons conversions into the aerogel or in the PMT glass window producing Cerenkov light



The RICH Occupancy @ $L=10^{34}$

Studies done for the physics run with transverse target indicates the Moeller background is under control up to the maximum luminosity thanks to RICH position, segmentation and fast readout

Value used in the simulation



Correlation in space neglected

20 ns in-time window

Target transverse magnet torque

20 ns in-time window + H8500 Q.E.

The Likelihood Method

For a given track t and particle hypothesis h $(=\pi, K, p)$ use **direct ray tracing** for a large number of generated photons to determine the **hit probability for each PMT**

The **measured hit pattern** is compared to the hit **probability densities** for the different hypotheses through a likelihood function:

$$L^{(h,t)} = \Sigma_i log[P_{PMT}^{(h,t)}(i) C_{PMT}(i) + \overline{P}_{PMT}^{(h,t)}(i)(1 - C_{PMT}(i))]$$

(the hypothesis that maximizes $\mathbf{L^{(h,t)}}$ is assumed to be true)

$C_{PMT}(i)$ is the hit pattern from data
- = 1 if the ith PMT is hit
- = 0 if the ith PMT is not hit

$P_{PMT}^{(h,t)}(i)$ is the probability of a hit given the kinematics of track t and hypothesis h

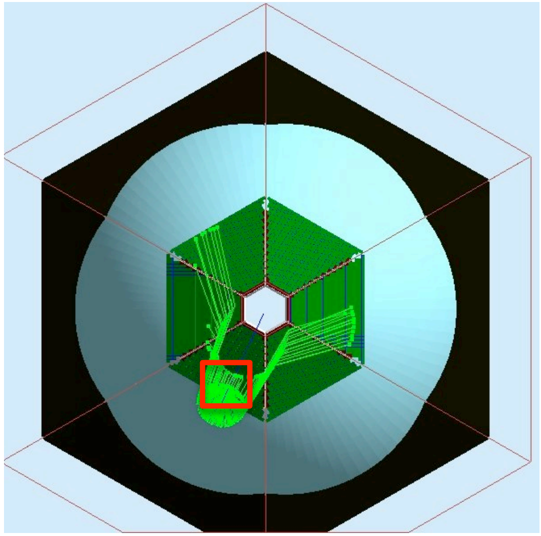
$$P_{PMT}^{(h,t)}(i) = 1 - exp(-\frac{N^{(h,t)}(i)}{\Sigma_i N^{(h,t)}(i)} n^{(h,t)} - B(i))$$

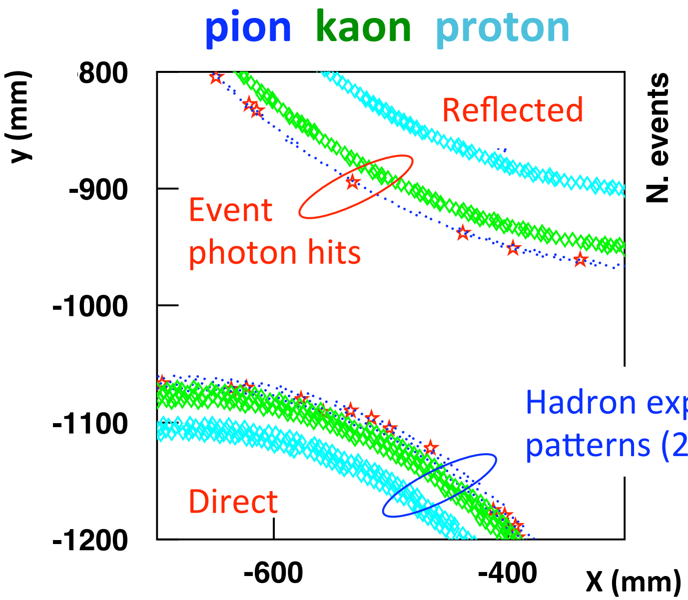
$\overline{P}_{PMT}^{(h,t)}(i) = 1 - P_{(PMT)}^{(h,t)}$ is the probability of no hit

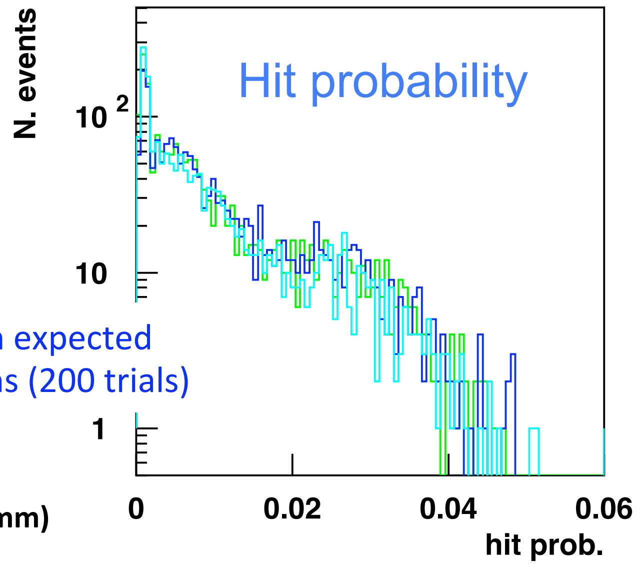
$n^{(h,t)}$ is the total number of expected PMT hits

$B(i)$ is a background term (assumed to be 10^{-4}, fine with Moeller prelim. studies)

The RICH Reconstruction Algorithm







Standard techniques available but important to optimize:
Geometry together with Likelihood parameters
(background, time coincidence window, p.d.f precision)

Control with Goodness Estimator

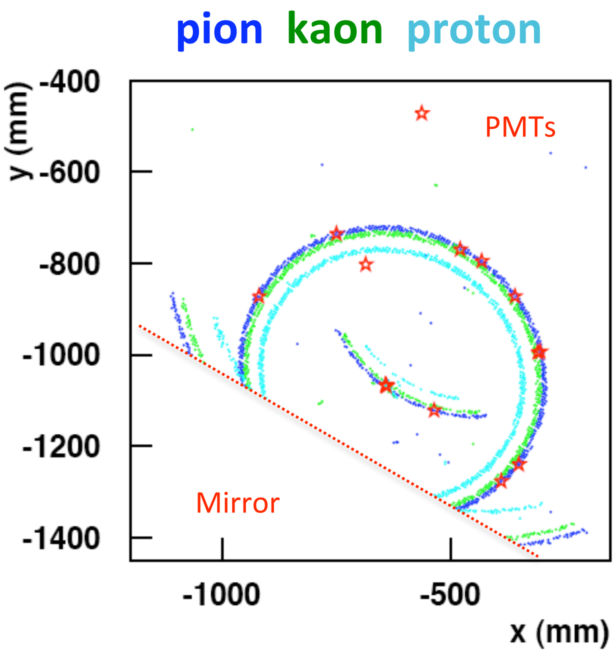
Poor | ID confidence | Good

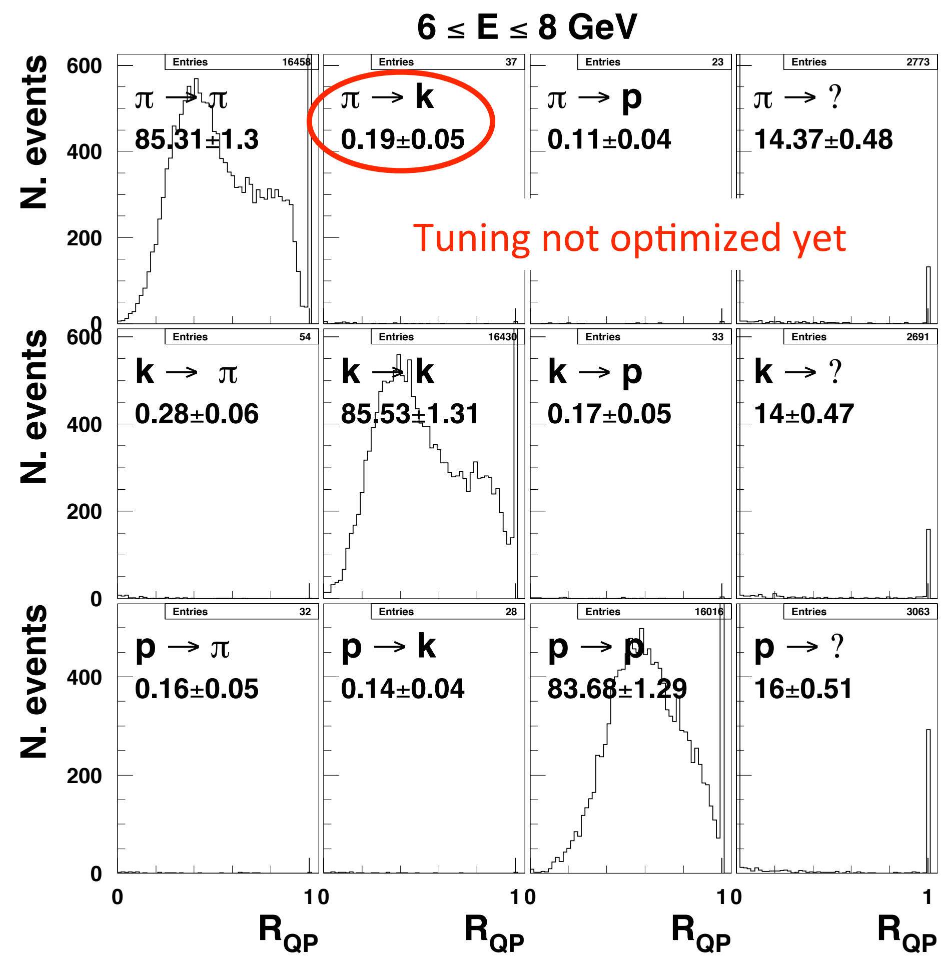
0 → 1

$$R_{QP} = 1 - \frac{LH^{2st}}{LH^{1st}}$$

Events in CLAS12

$P = 6.3$ GeV/c $\theta = 6$ degrees $R_{QP} = 0.59$

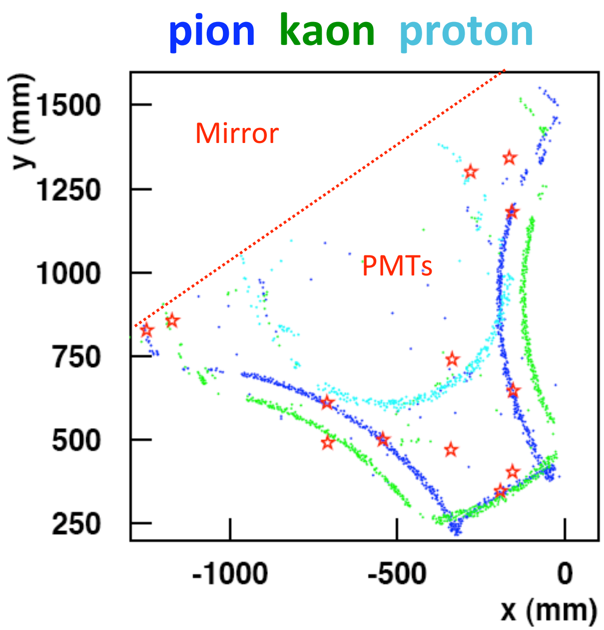


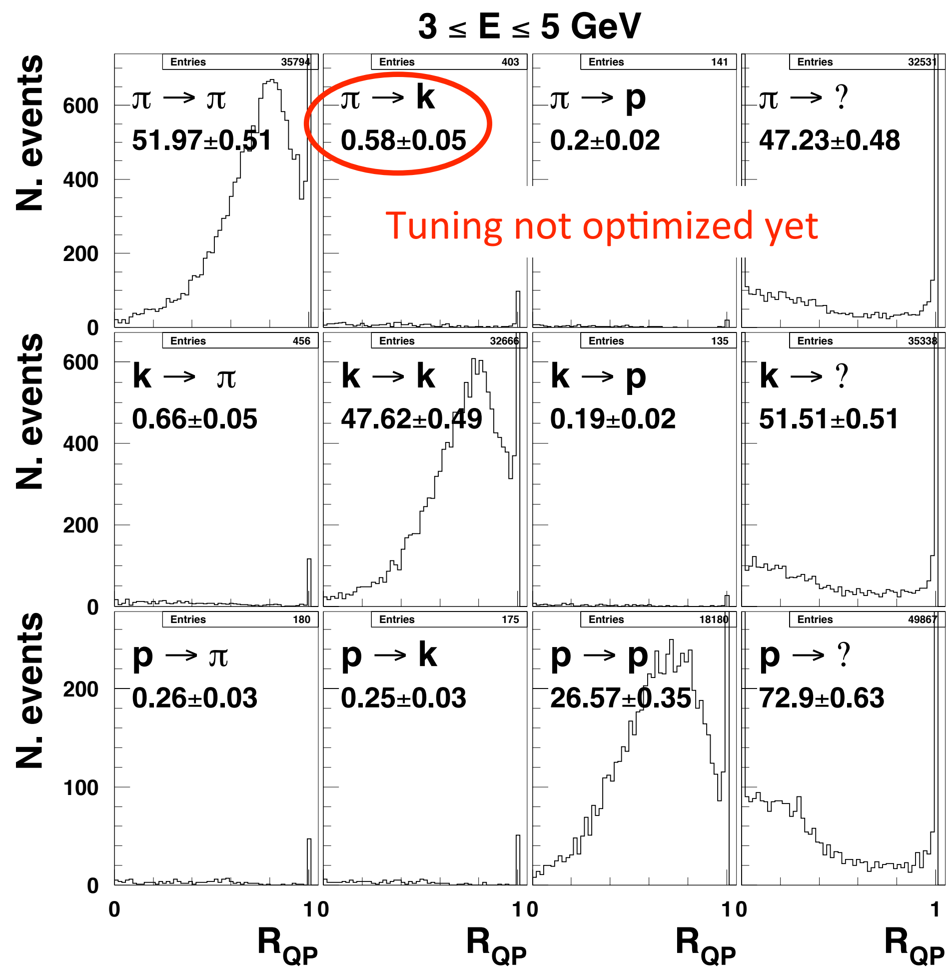


Good ID thanks to high photon yield
R_{QP} reflects close Cherenkov rings

Events in CLAS12

P = 3.7 GeV/c θ = 22 degrees R_{QP} = 0.98





Good ID thanks to separate patterns
Un-identifications reflect photon yield

CLAS12 Combined PID

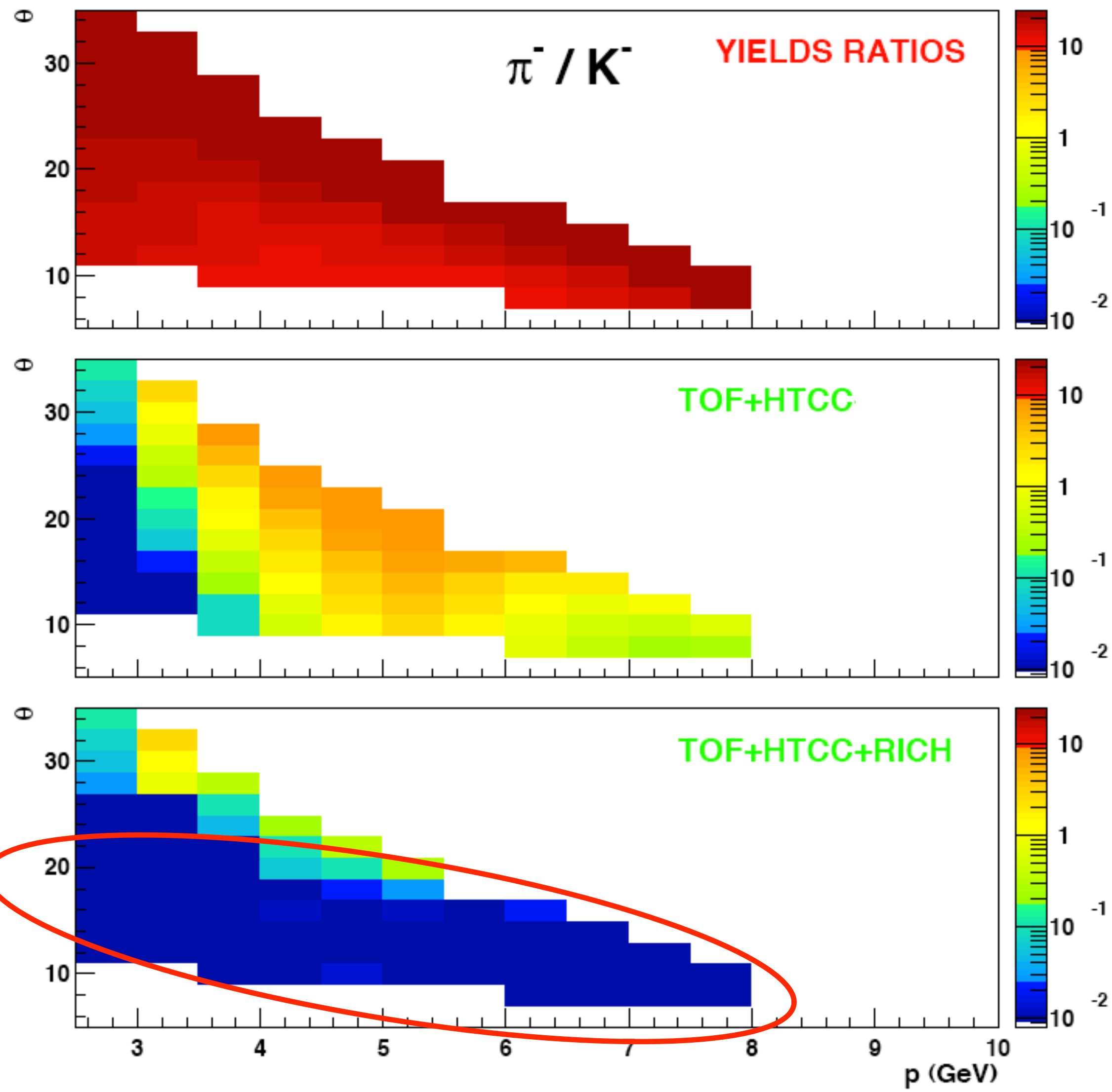
Pion contamination in the kaon sample for In-bending Particles

SIDIS particle flux
within acceptance
pion >> kaon everywhere

TOF +HTCC pion rejection
for 90% kaon efficiency
pion >> kaon in a broad region

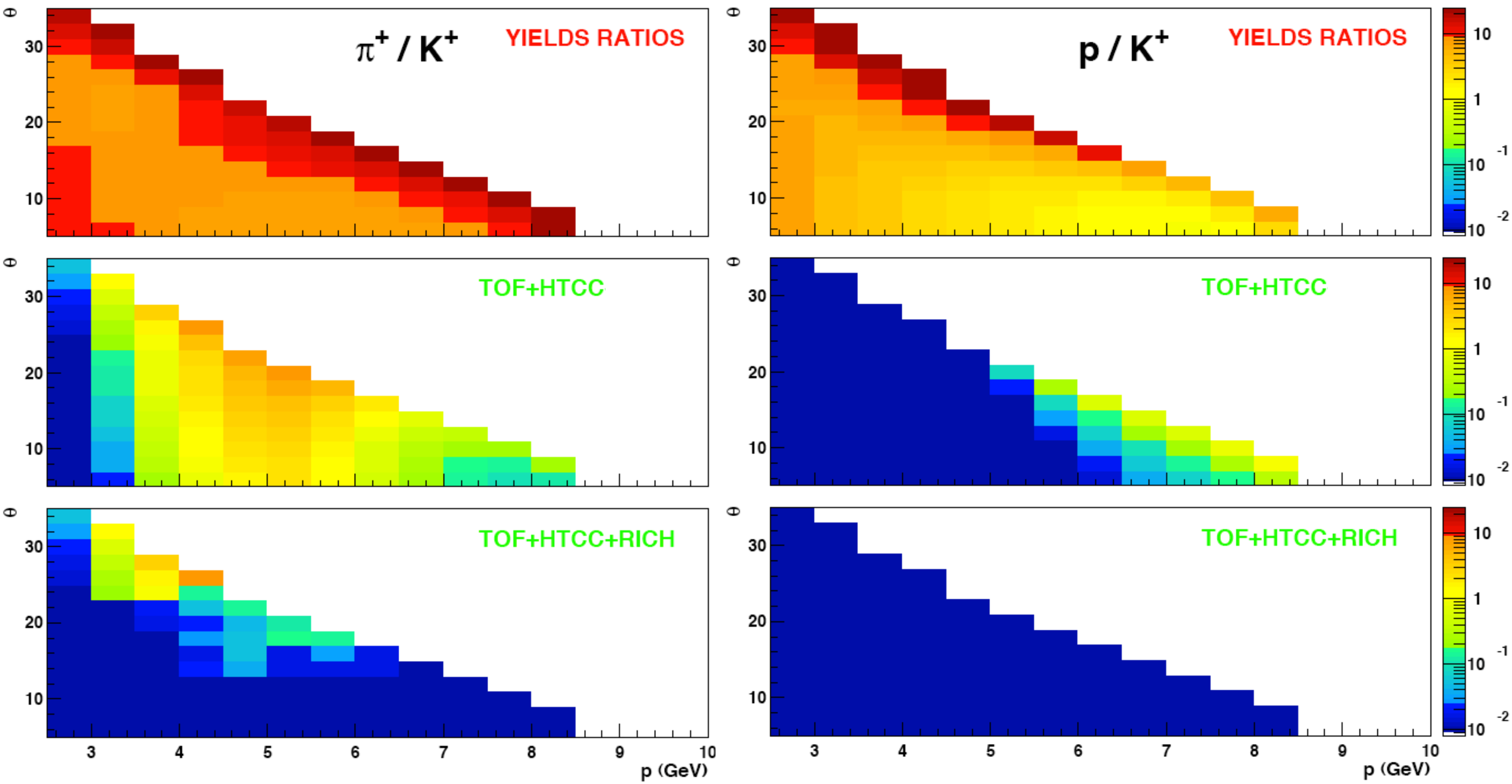
TOF+HTCC+RICH
pion rejection

Even with a tuning not yet optimized the pion contamination is well below 1% level



CLAS12 Combined PID

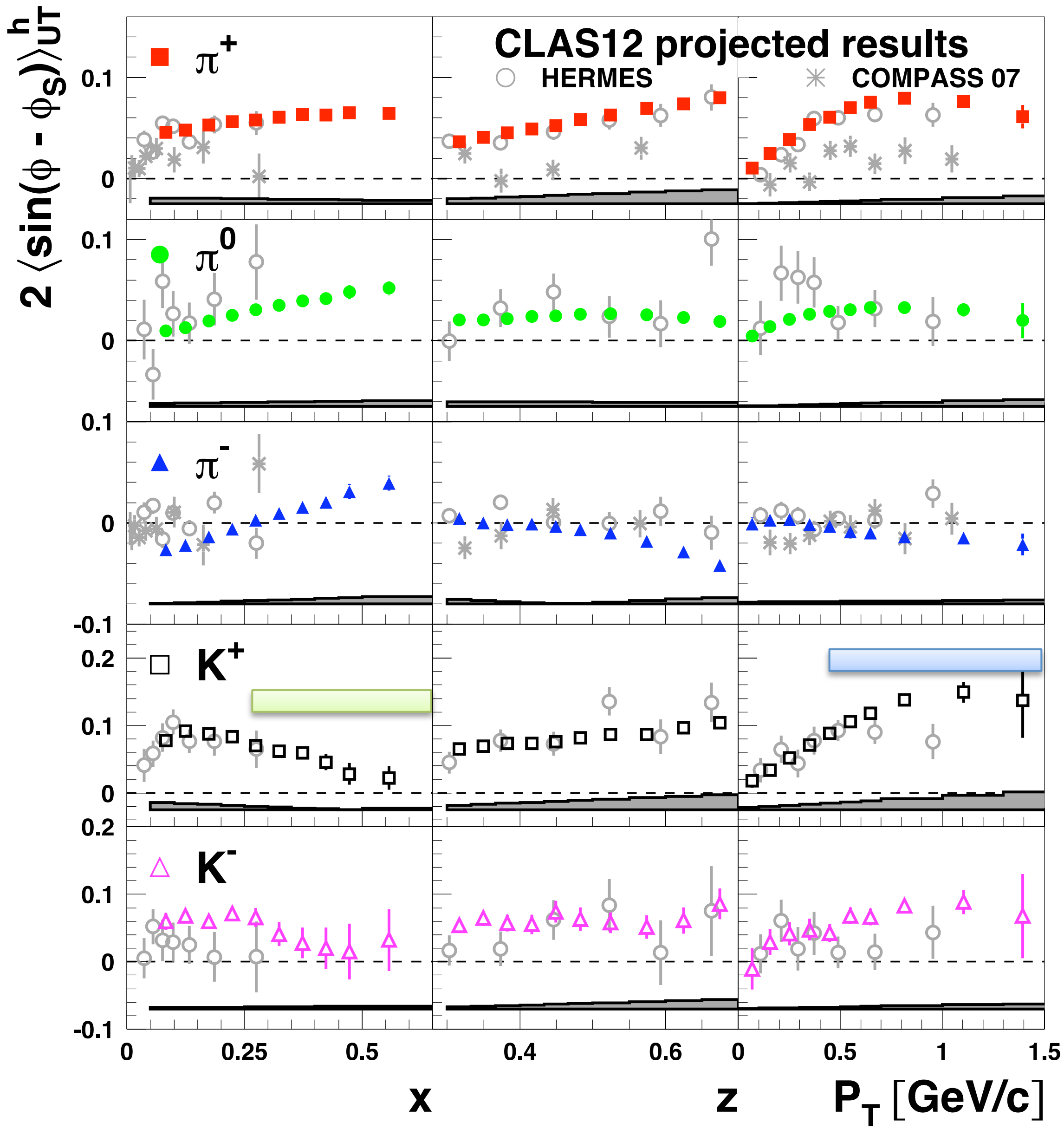
Pion contamination in the kaon sample for Out-bending Particles



C12-11-111:
Transverse spin effects in SIDIS at 11 GeV with a Transversely polarized target using the CLAS12 Detector

Covering so far unexplored quark valence region

Achieve unprecedent precision in a broad range of p_T



Conclusions

Prototype :

Simulations able to reproduce measured quantities
Lot of data to further improve simulations model (i.e. aerogel forward scattering)

CLAS12:

RICH meets the requirements
space for improvement in the high-angle low-momentum corner

Work ongoing to update the simulations and optimize the response

The RICH detector allows hadron ID in the full CLAS12 kinematics
ensuring the approved physics program to be accomplished