CP violation in B decays: prospects for LHCb

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CP Violation

Aim: Understand sources of CP Violation

Theory:

- **Standard Model:** $\not{CP}$ implemented by complex phase in CKM matrix

  Natural: no reason for CKM matrix to be real

- **Beyond Standard Model:** many extensions predict new interactions which produce $\not{CP}$

  Natural: Standard Model is not complete

Combination ???

Measurement:

- Precise measurement of many complementary channels with reliable Standard Model prediction:
  - No (small) QCD corrections due to final state interaction
  - $\not{CP}$ in oscillations and decays (and interferences)
  - Different combinations of CKM elements
- Channels with large and small (no) $\not{CP}$ within Standard Model

"Measure all angles of CKM matrix"

Detector Requirements

Efficient trigger and reconstruction of many different channels, both hadronic and leptonic final states

Robust and flexible trigger

- high p_T leptons and hadrons
- secondary verteces

Good proper time resoution

- CP asymmetries in fast oscillating B_s
- reduce background

Good mass resolution

- reduce background

Particle Identification

- tagging (muons, electrons and kaons)
- reduce background (π/K separation in RICH)

Detector Acceptance

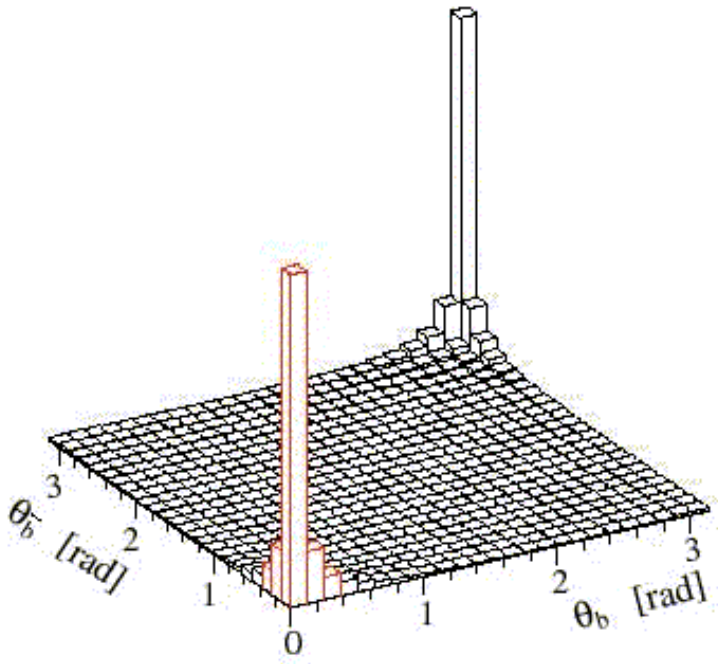
A single-arm spectrometer covering

θ_{min} = ~15 mrad (beam pipe and radiation)

to

θ_{max} = ~300 mrad (cost)

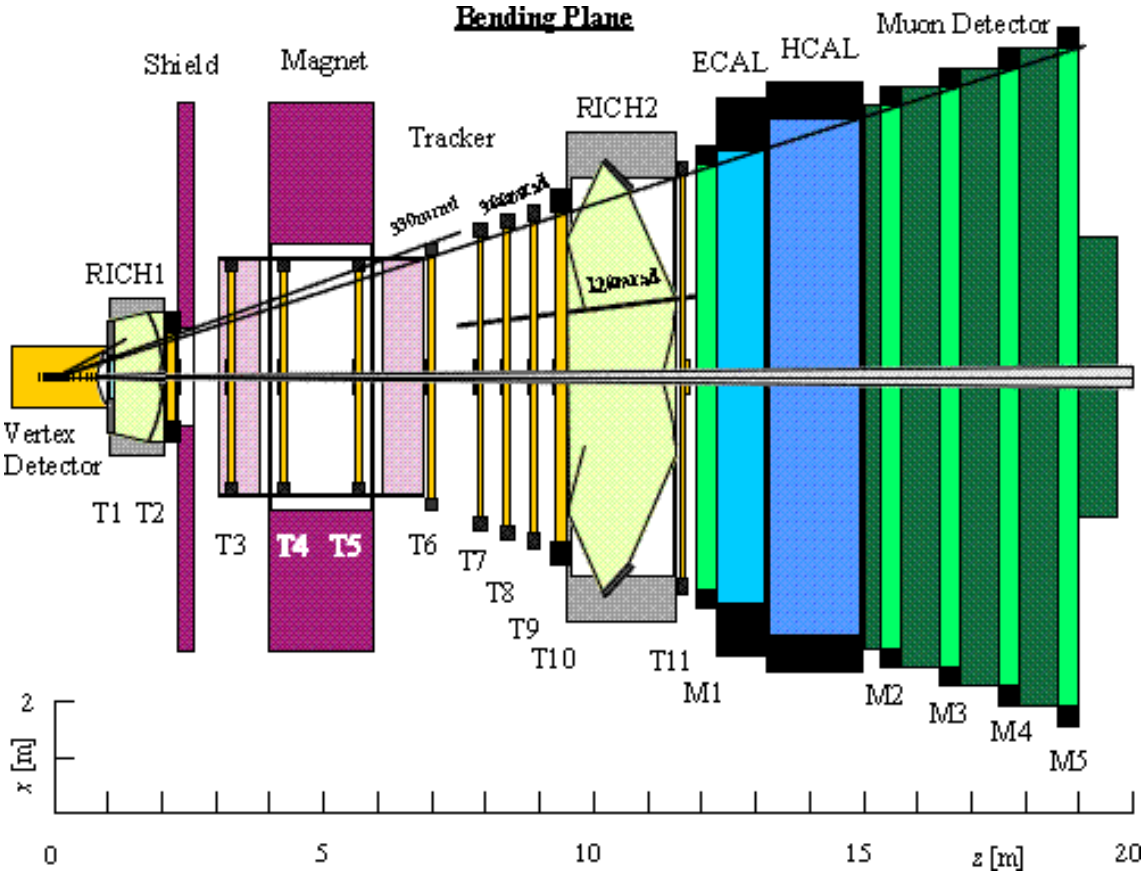
i.e. η = ~1.88 to ~4.89
has an equal $b\bar{b}$ acceptance
as a large central detector.



Single arm forward spectrometer:

Easy access to all detector components for maintenance and fexible for upgrades

LHCb Detector



Tracking System:

Vertex Detector: Silicon Microstrip

Main: MSGC or MCSC (inner) + Honeycombs (outer)

Muon: Cathode Pads and Multigap Resistive Pads

RICH system (3 radiators):

π - K separation at $>3\sigma$ for momenta between

1 GeV/c (K tag) and 150 GeV/c ($B_d \rightarrow \pi^+\pi^-$)

Calorimeters:

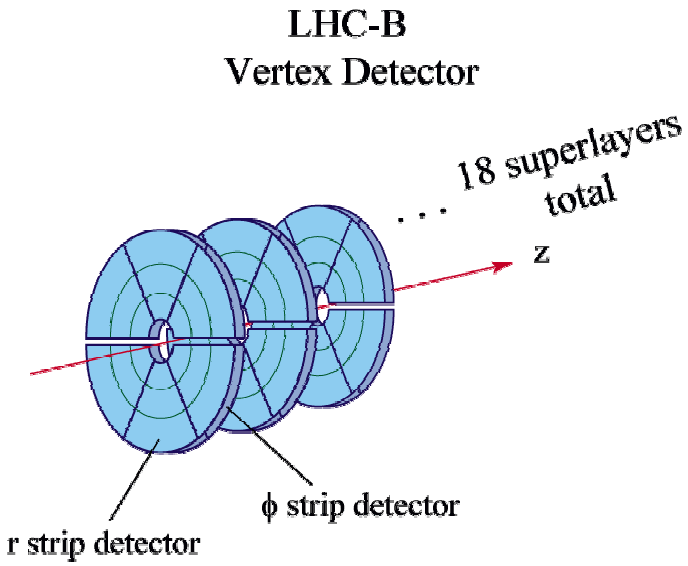
Preshower + ECAL (Shashlik) + HCAL(Scintillating-tile)

Average Luminosity: 2×10^{-32} cm^{-2}s^{-1}

Vertex Detector

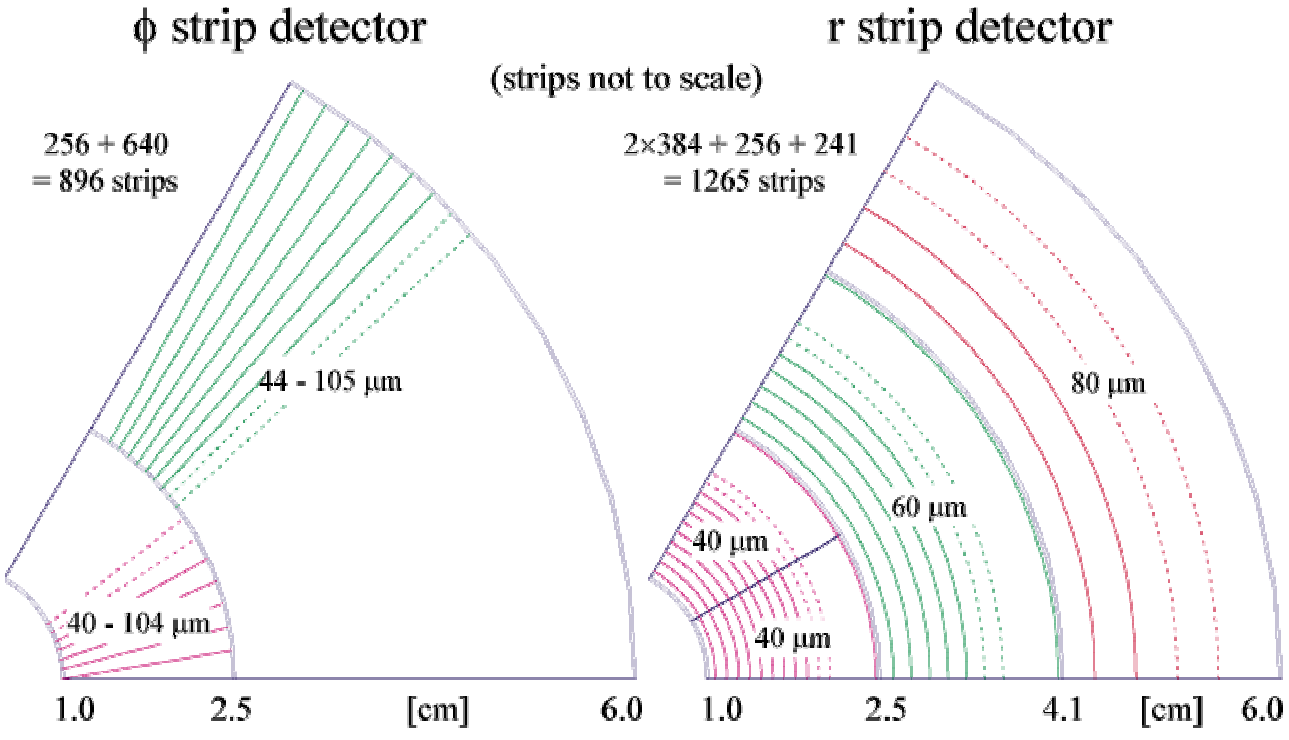
Precise Vertex Determination:

- Precise Detector: Silicon Microstrip Counters
- First point of measurement close to decay point
- No material between measurement and decay vertex



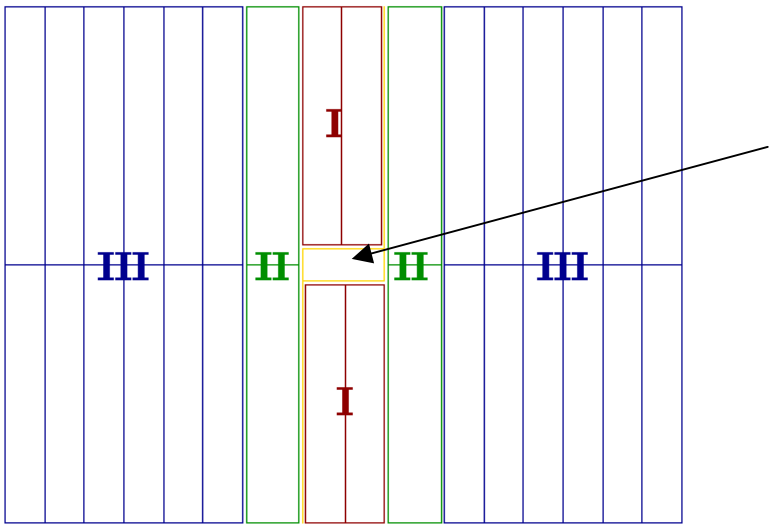
Install silicon counters in LHC vacuum, as close as possible to the beams (10 mm), limited by radiation damage.
For injection of beam move silicon out by 3 cm.

In LHCb Vertex information is used in Level 1 Trigger: r-φ geometry, which also makes occupancy per strip more homogenous.



Main Tracking Station

Modular Design to keep all cell occupancies < 10%
Multilayer with y u v y orientations (5° stereo)



Inner Tracker:

Size 40 x 60 cm^2

High granularity

MSGC or MCSC

Outer Tracker:
Strawtube-like drift chambers (Honeycombs)
Cell radius: 5mm (Module type I and II) and 8 mm (type III)
Resolution: < 200 μm

Perfomance:

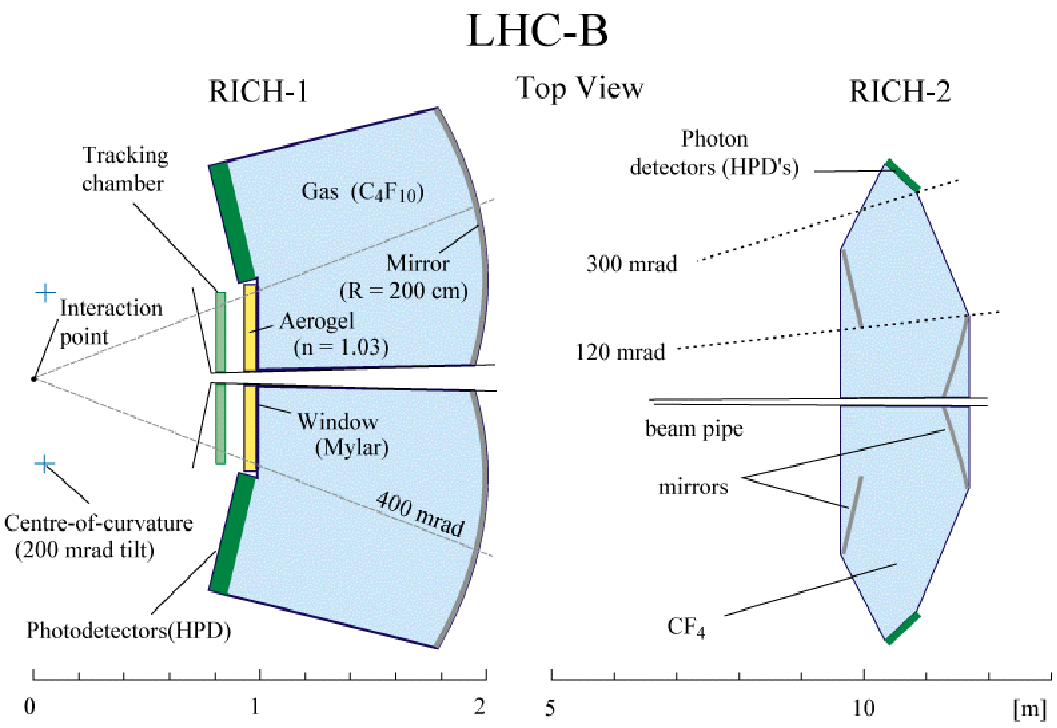
$\delta p/p = 0.3$ %, constant between 5 GeV/c and 200 GeV/c

Mass resolution:

$\Delta m_B = 15.2$ MeV/c^2 in $B_d \rightarrow \pi^+\pi^-$

$\Delta m_D = 4.2$ MeV/c^2 in $D_S \rightarrow K^+K^-\pi^-$ from B_S decays

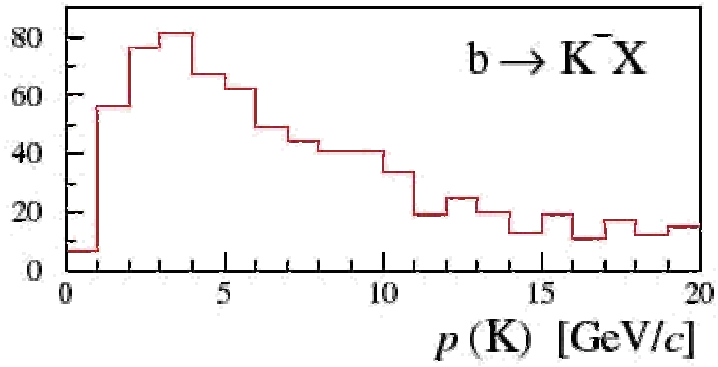
RICH Detectors



Cover full kinematic range: three radiators

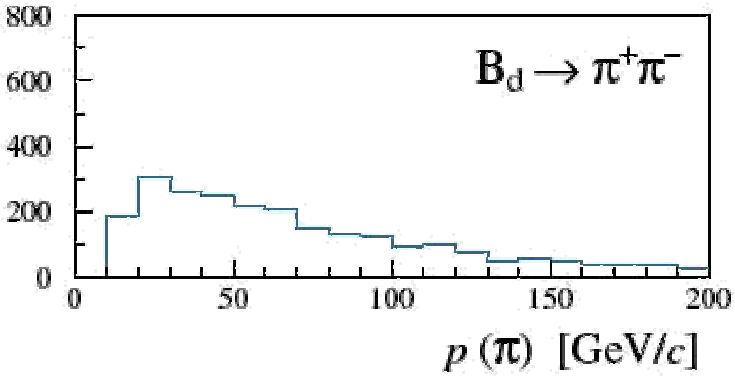
	Aerogel	C_4F_{10}	CF_4
$P_{thres}(\pi)$ [GeV/c]	0.6	2.6	4.4
$P_{thres}(K)$ [GeV/c]	2.0	9.3	15.6

RICH Detectors



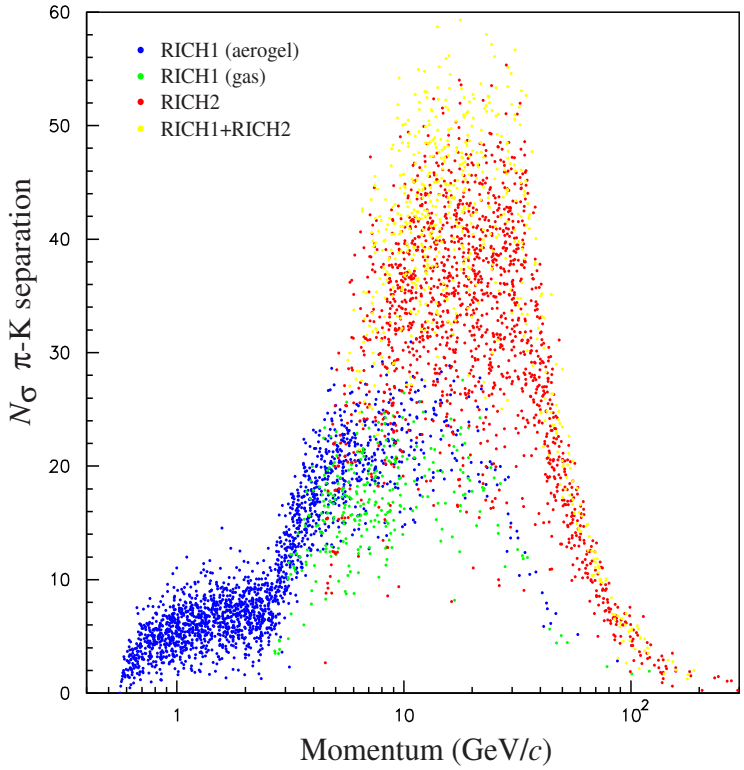
p_{min} ~ 1 GeV/c

K tag



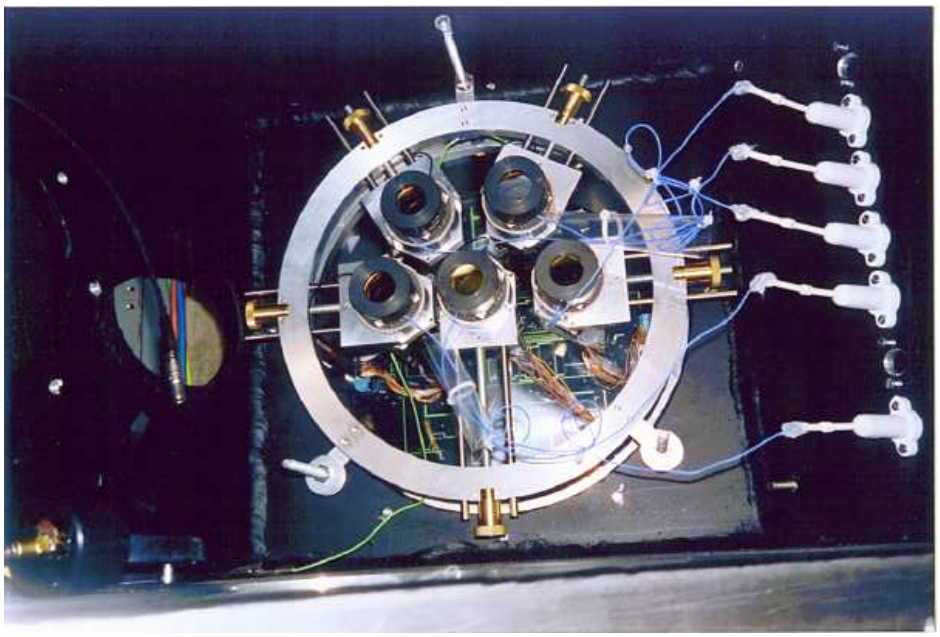
p_{max}~ 150 GeV/c

two-body B decays

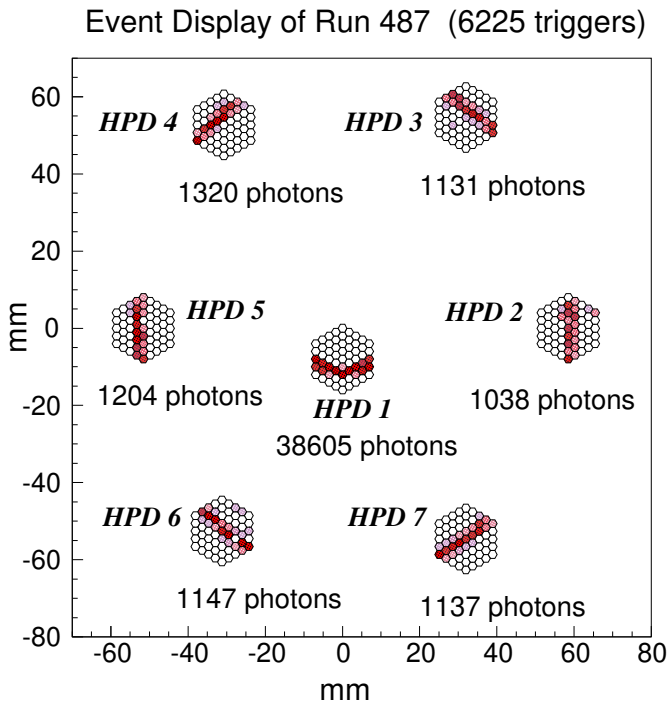


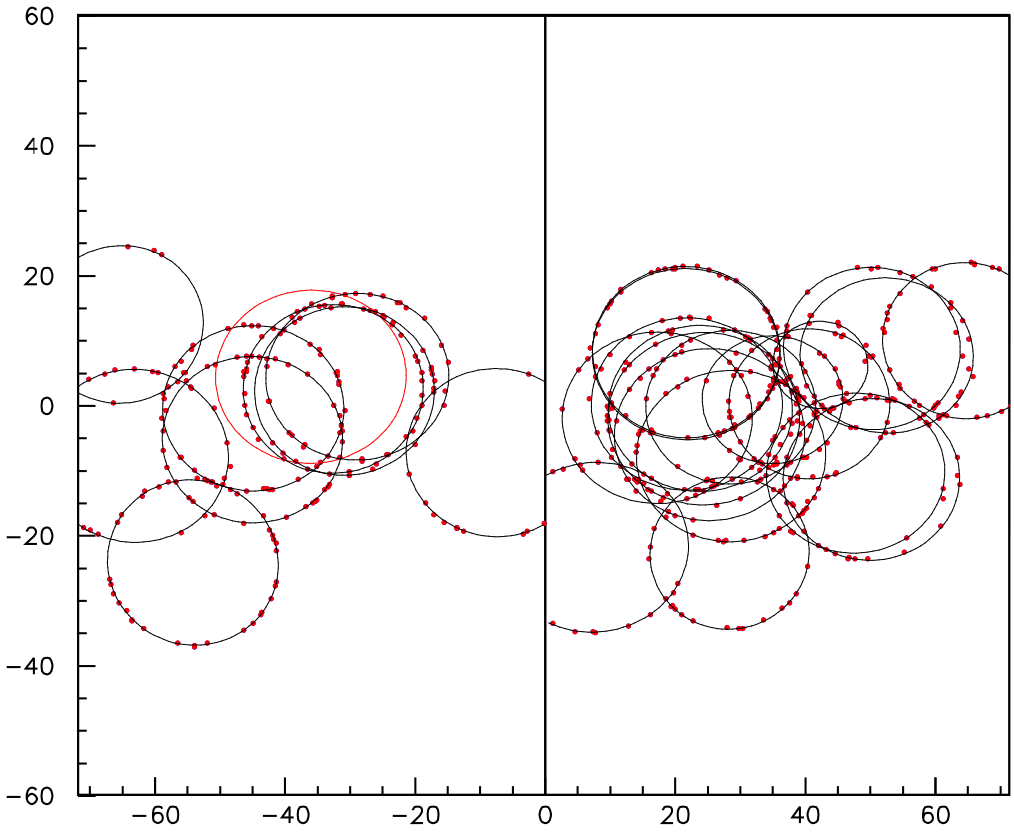
π-K separation (in σ) vs. Momentum (full pattern recognition)

RICH Beam Test



- **Beam Test RICH 1 prototype (1/4 scale)**
- **Resolution and Nb. Photon as expected**

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