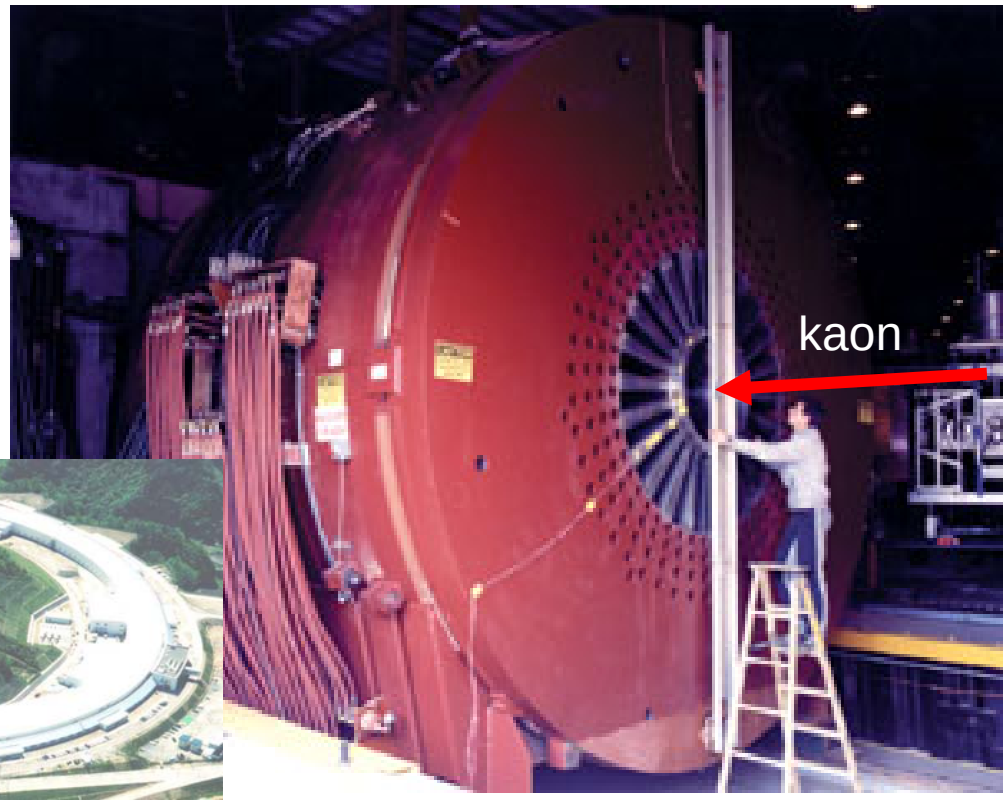
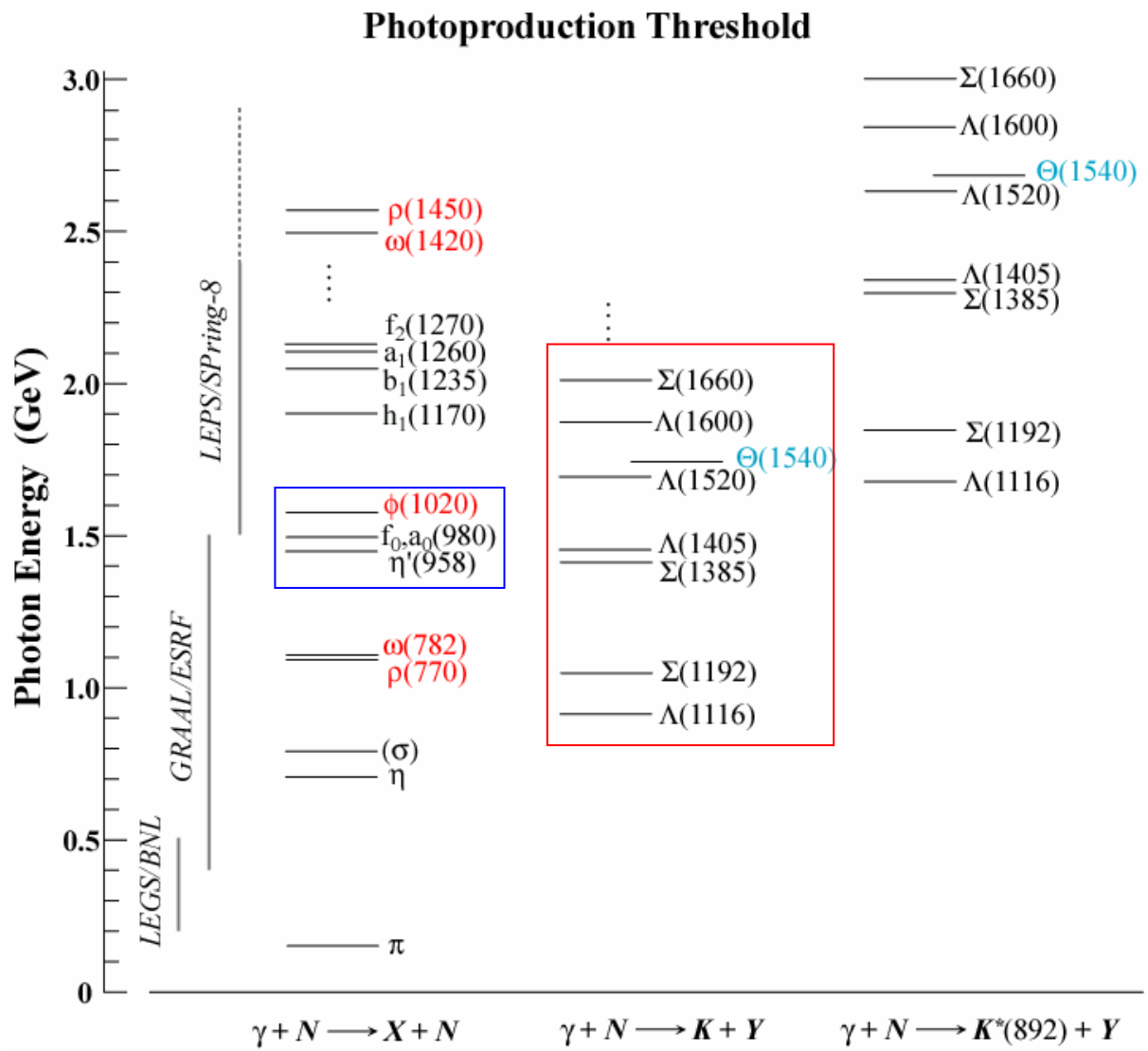
Design for LEPS2 Detector

Yoshikazu Maeda
RCNP
For LEPS collaboration



- Introduction
  - Why LEPS2
- Detector
  - Tracking system
- Simulation study
- Summary



- High flux
- Polarization
- Strangeness

Reaction

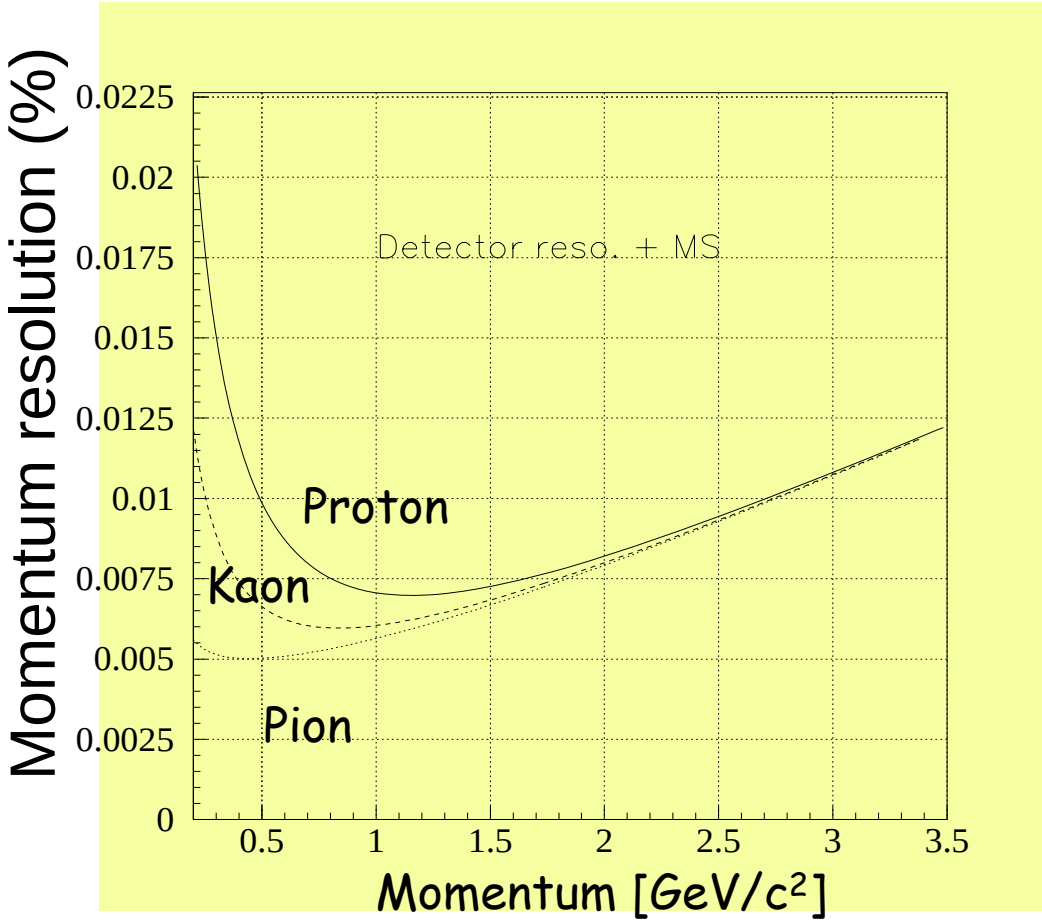
Decay

→

Confinement?

Structure of hadron?

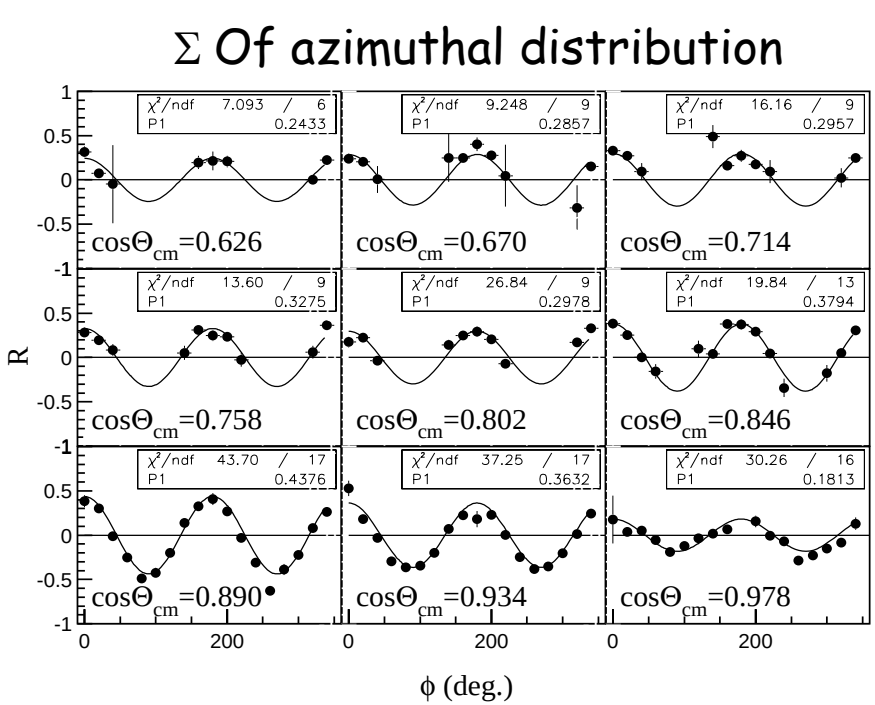
LEPS detector



- Forward spectrometer for charged particle
  - Θ_H= +-23 deg
  - Θ_V= +-12 deg
- PID(momentum and TOF)
  - ΔTOF=150ps
  - $\rightarrow \Delta m$=30 MeV/c^2 (4m)
  - K/π separation 10σ
- Momentum resolution
  - $\Delta P/P$ < 1.0 % upto 2.5 GeV

Hyperon production with linear polarized beam

M. Sumihama et. al., PRC 73 (2006), 035214



Good PID and $\Delta P/P$
ΔMM = 10 MeV at 1 GeV.

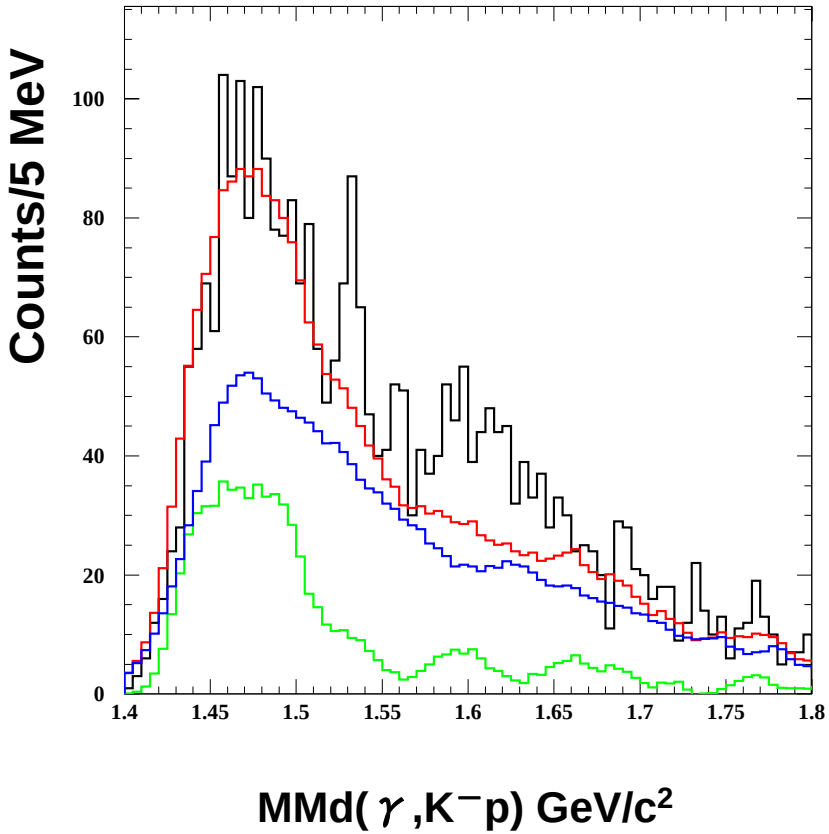
$\gamma p \rightarrow K^+ \Lambda, \quad \Sigma$
$\rightarrow p\ \pi^- \quad \rightarrow \Lambda\gamma$

$\gamma p \rightarrow K^+ \Lambda(1405), \quad \Sigma(1385)$
$\rightarrow \Sigma^0\pi^0 \rightarrow \Lambda\pi(12\%),$
$\rightarrow \Lambda 3\gamma \quad \Sigma\pi(12\%)$

Large acceptance
and
symmetrical shape azimuthally

Penta-quark Θ^+

- $\gamma\, n \rightarrow K^-\, \Theta^+$
  LEPS MM(γ,K^-)
  $\rightarrow$IM(pK^0)
- $\gamma p \rightarrow K^0\, \Theta^+$
  SAPHIR 300nb
  CLAS <2 nb
- $\gamma\, d \rightarrow \Theta^+\ K^- p(\Lambda^*)$
  CLAS < 450pb
  LEPS (forward region)
  IM(pK^0)

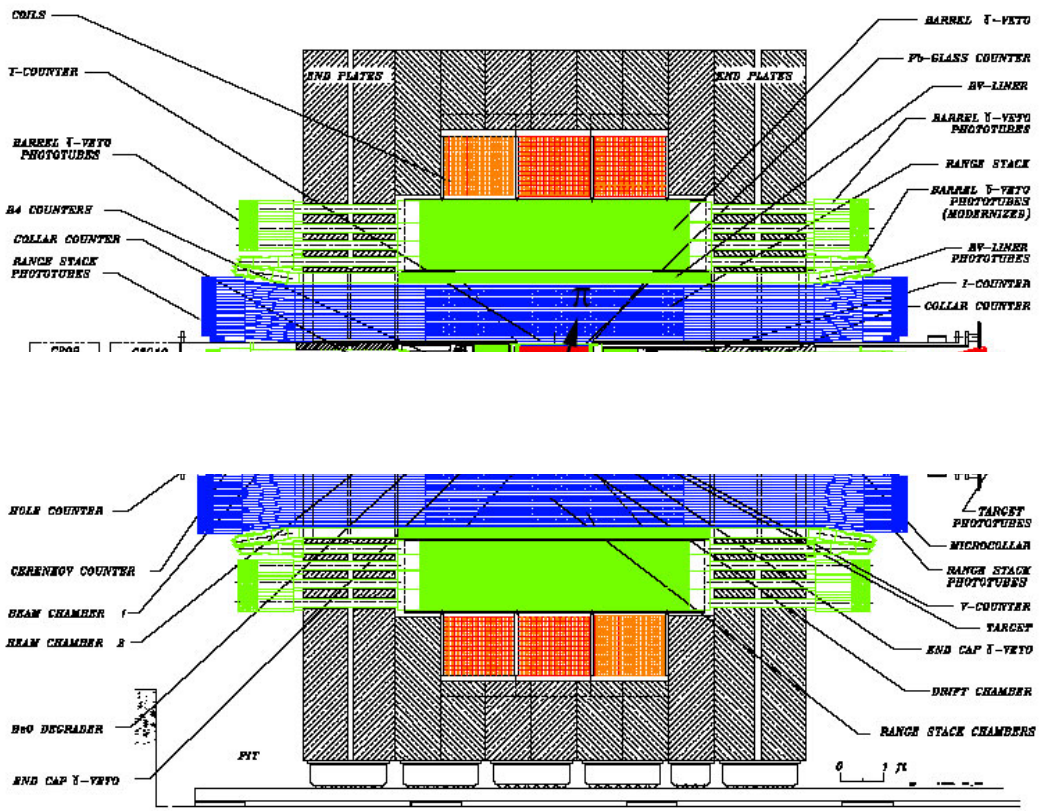


Keywords

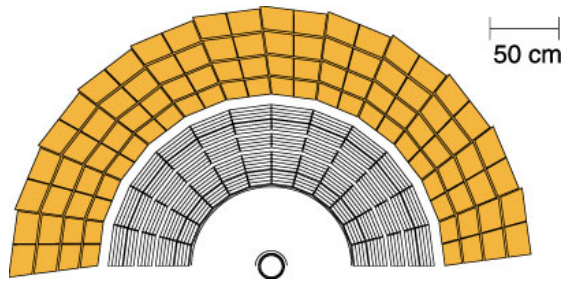
- Momentum resolution at forward angle $\Delta p/p \sim 1\%$.
- Good π/K separation.
- Large and smooth acceptance azimuthally → Decay and polarization.
- Detection of decay product down to lower momentum 100 MeV/c
- Detection of neutral particle (Photon)

BNL-E949 detector

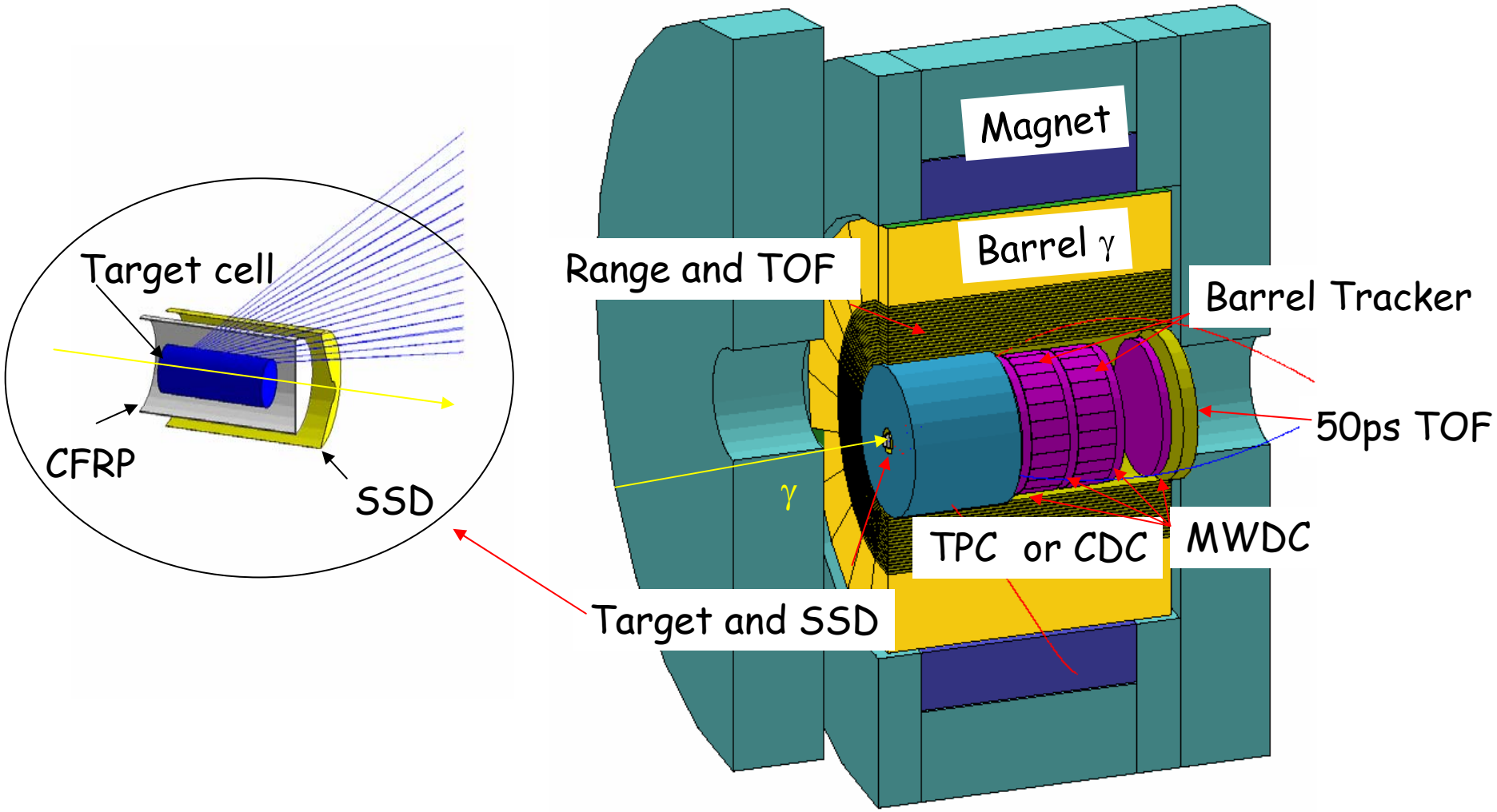
Designed for $K^+ \rightarrow \pi^+ \nu\nu$



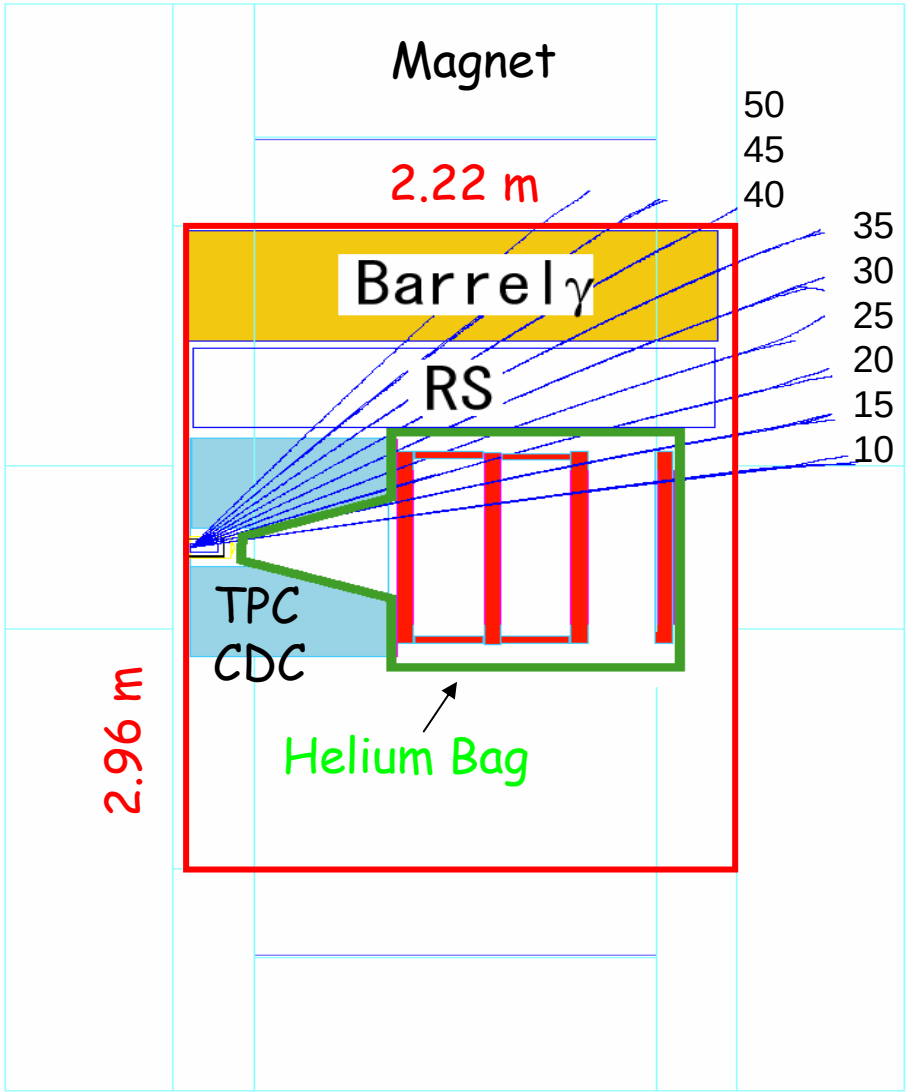
- Solenoid
  1 T
- Inner volume
  2.22x2.96 m
- Barrel Photon detector
  Plastic & lead sandwich detector
  $14.3X_0$
  Energy and position
- Range counter
  Plastic scintillators 19 layers
  Enegy and Range



Setup


Target cell
CFRP
SSD
Magnet
Barrel γ
Range and TOF
Barrel Tracker
50ps TOF
γ
TPC or CDC
MWDC
Target and SSD

Tracking system



- SSD (Cylindrical+ Corn)
  Double side,
  σ=35um,
  100um thick,

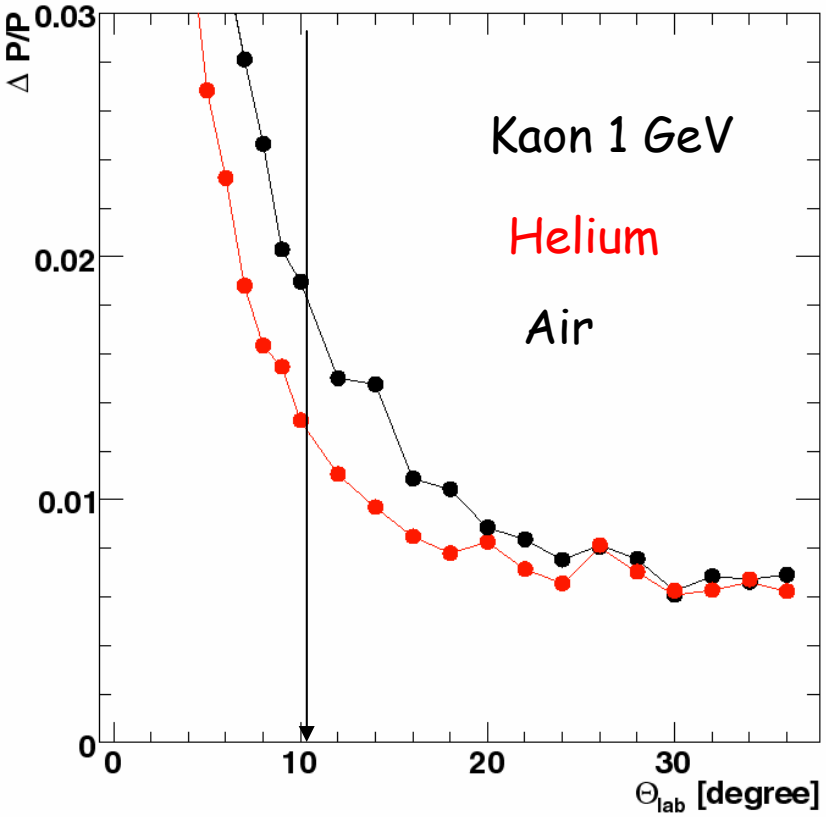
- Forward MWDC chamber
  He4+Ethane,
  R = 450 mm,
  6 wire plane,
  σ_{xy} =150um,
  $X/X_0 = 1.1\times10^{-3}$,

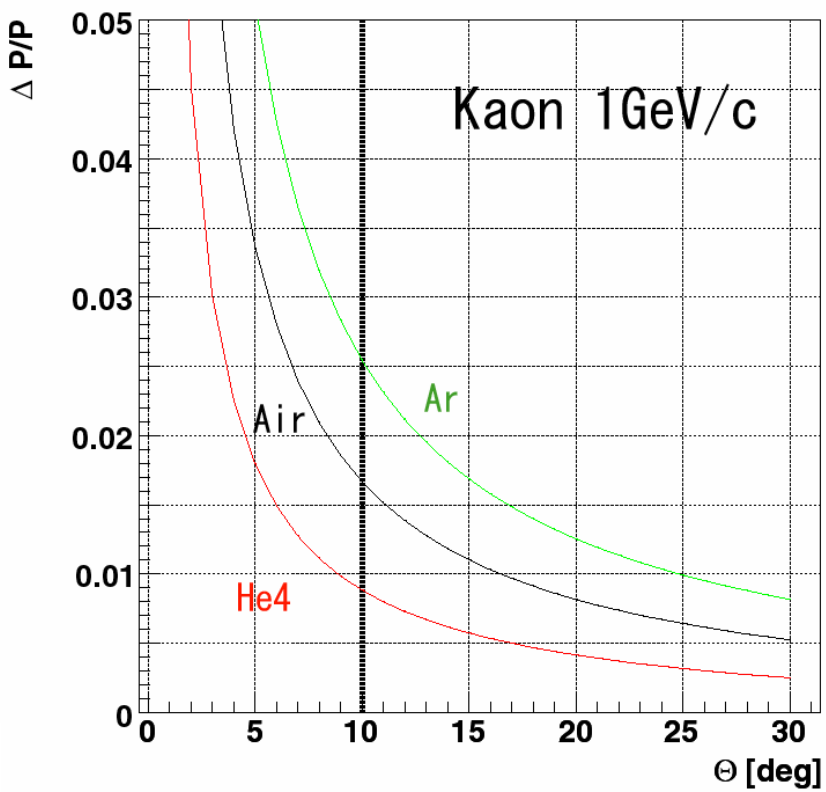
- Barrel tracker
  Cathode strip + Anode wire
  $\sigma_{r\phi}$ = 250um, σ_z = 2-3 mm

- TPC or CDC
  R = 500 mm (24-26 layer),
  $\sigma_{r\phi}$ =150um, σ_z =2mm,

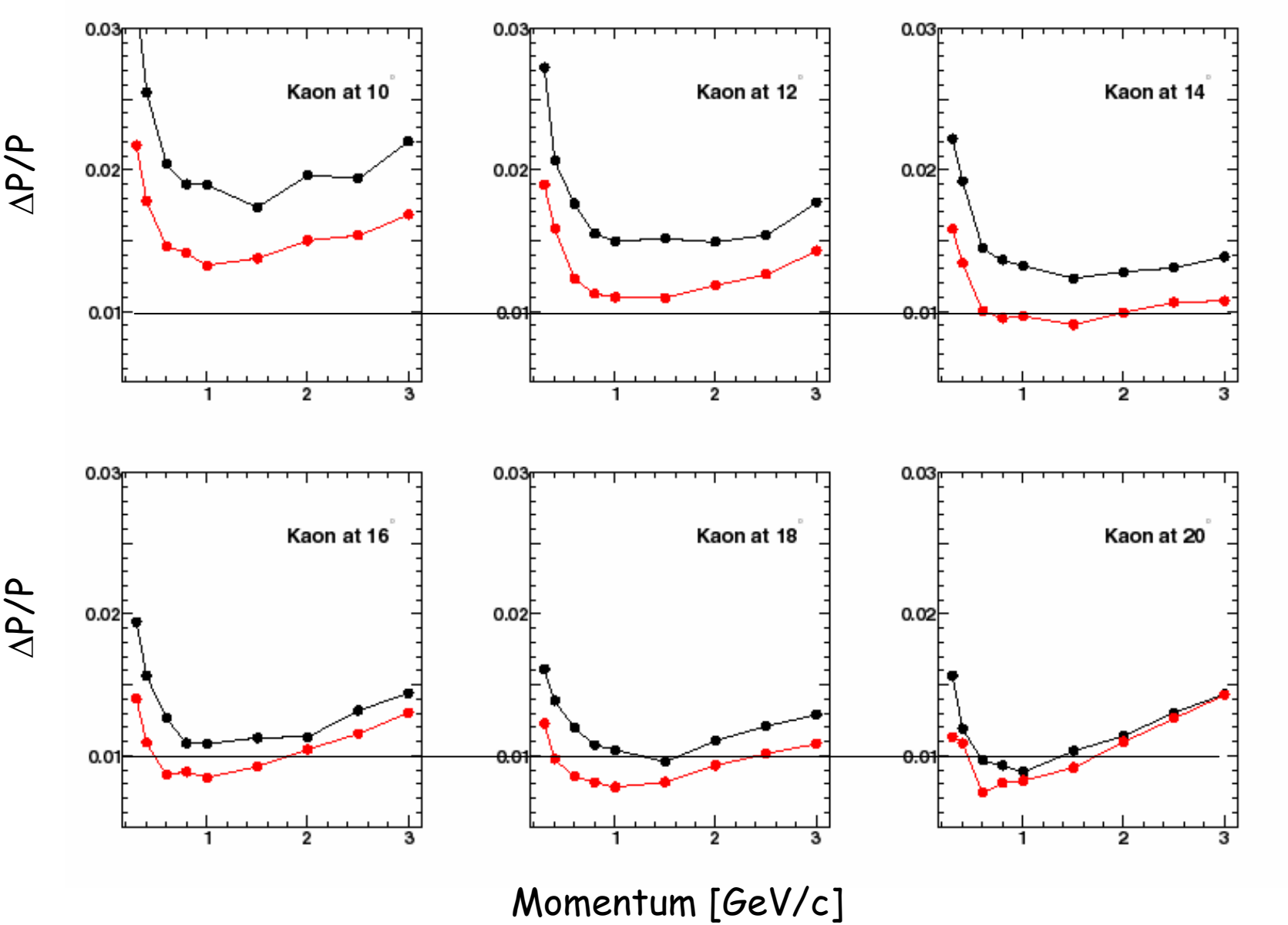
ΔP/P at forward region

$$\frac{\sigma_{P_t}}{P_t} = \frac{0.016}{0.3B\,\beta\sin\theta\sqrt{L\,X_0}}$$



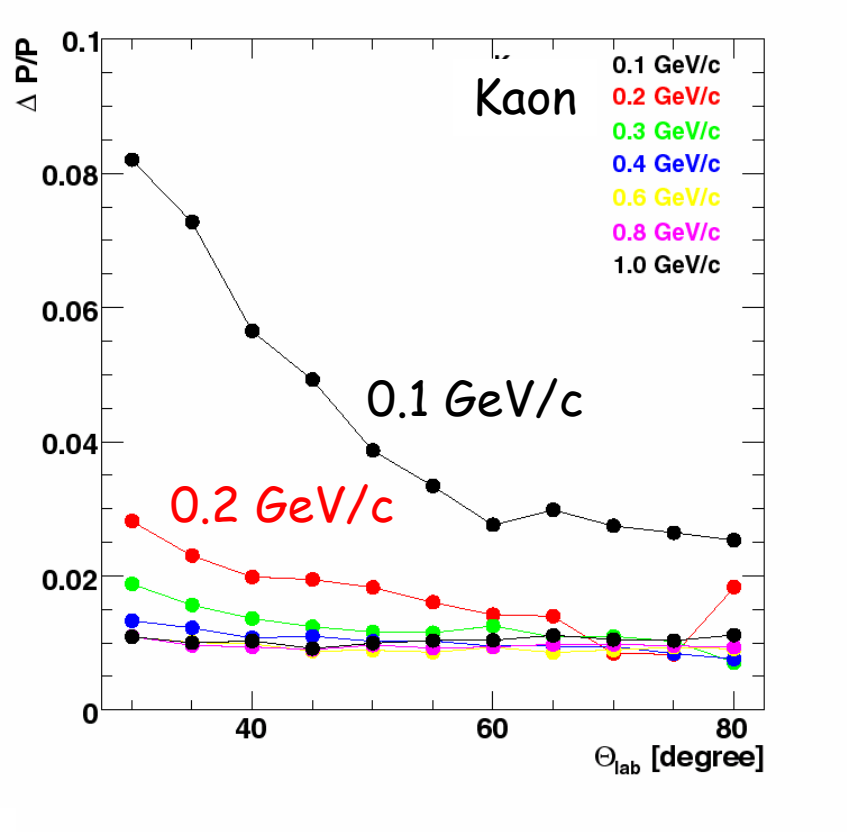


Momentum dependence of ΔP/P

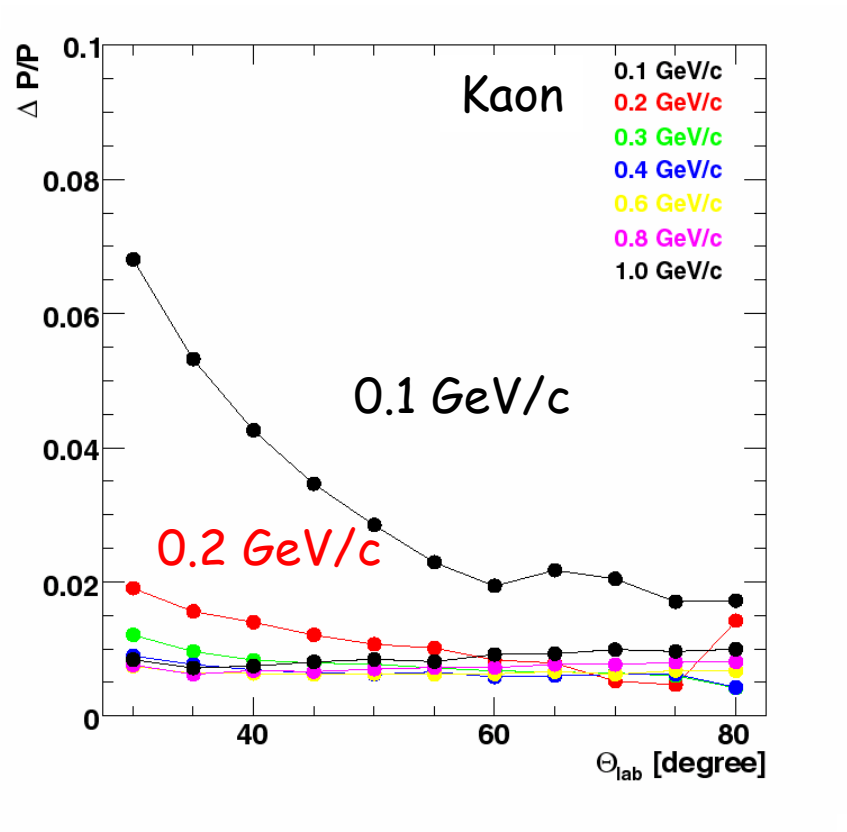


ΔP/P of TPC

Ar(90%)+Methan(10%) (P10)



Ne(90%)+Methan(10%)

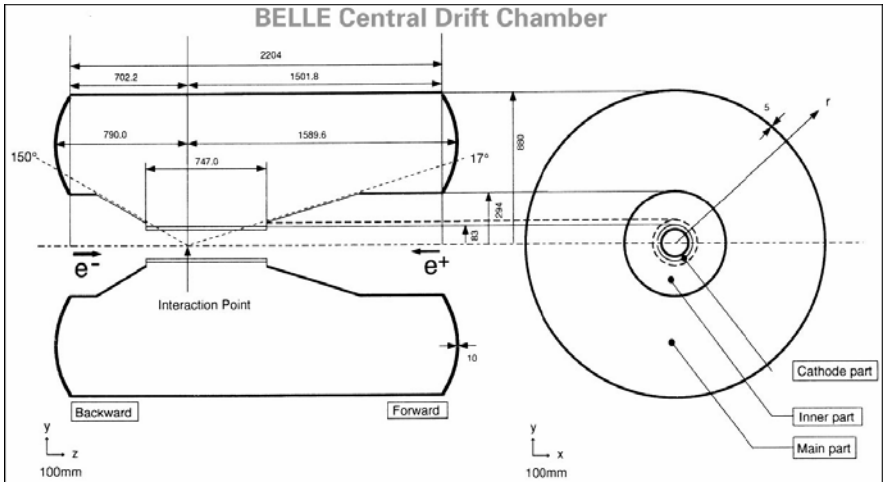


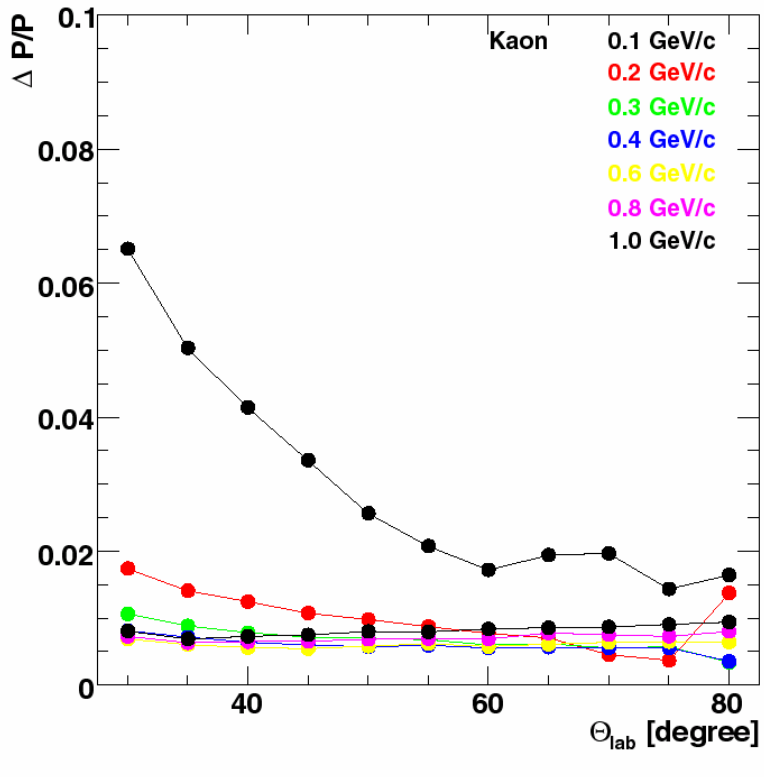
ΔP/P of CDC

He(50%)+Ethane(50%)

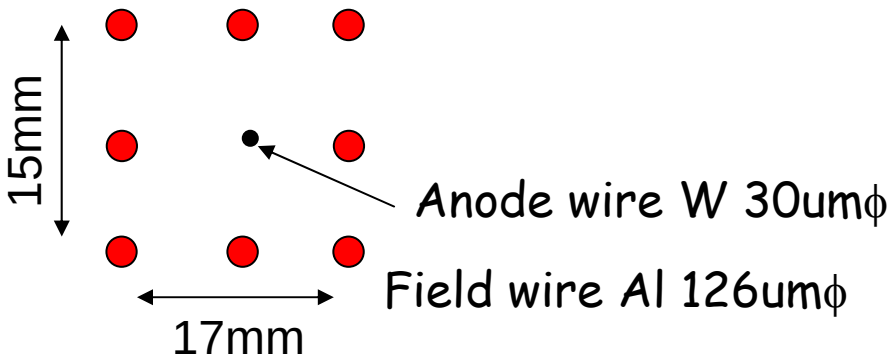
BELLE CDC

H. Hirano et al. Nucl. Instr. and Meth. A455 (2000) 294-304



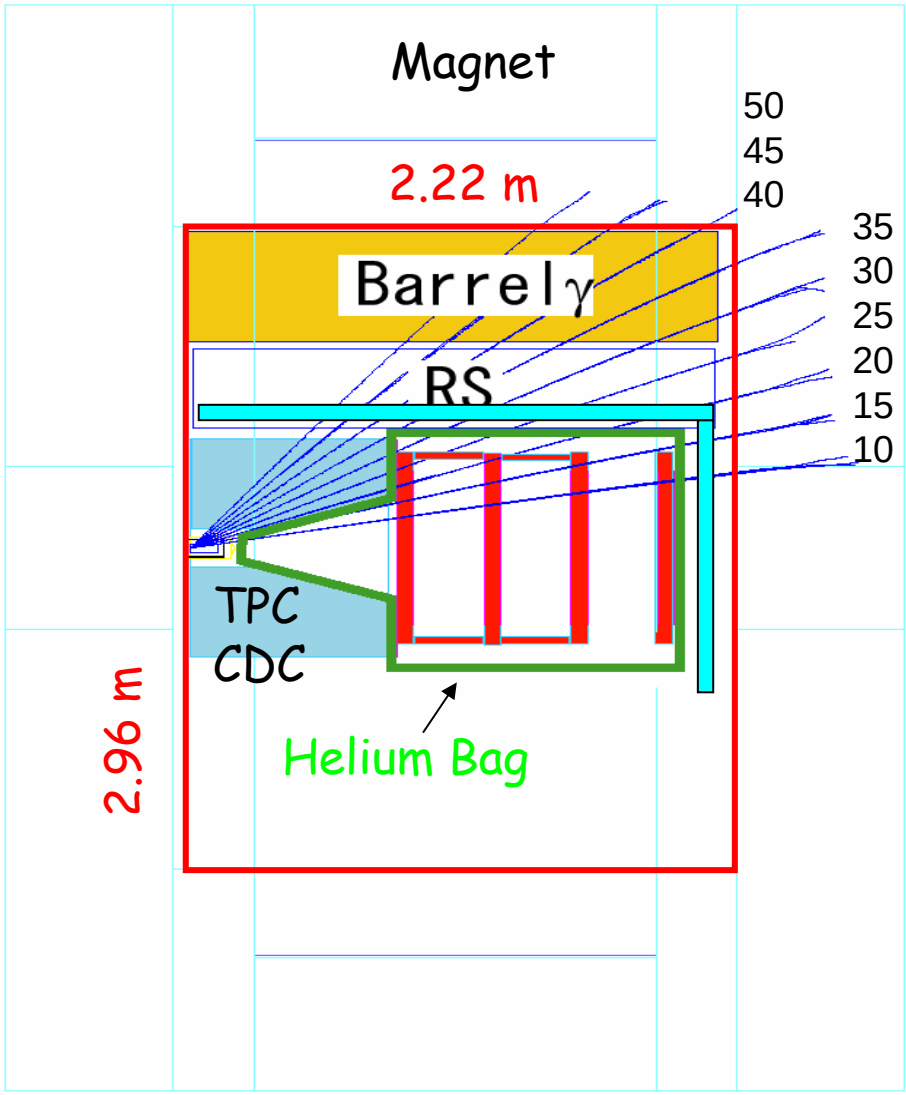


Cell structure

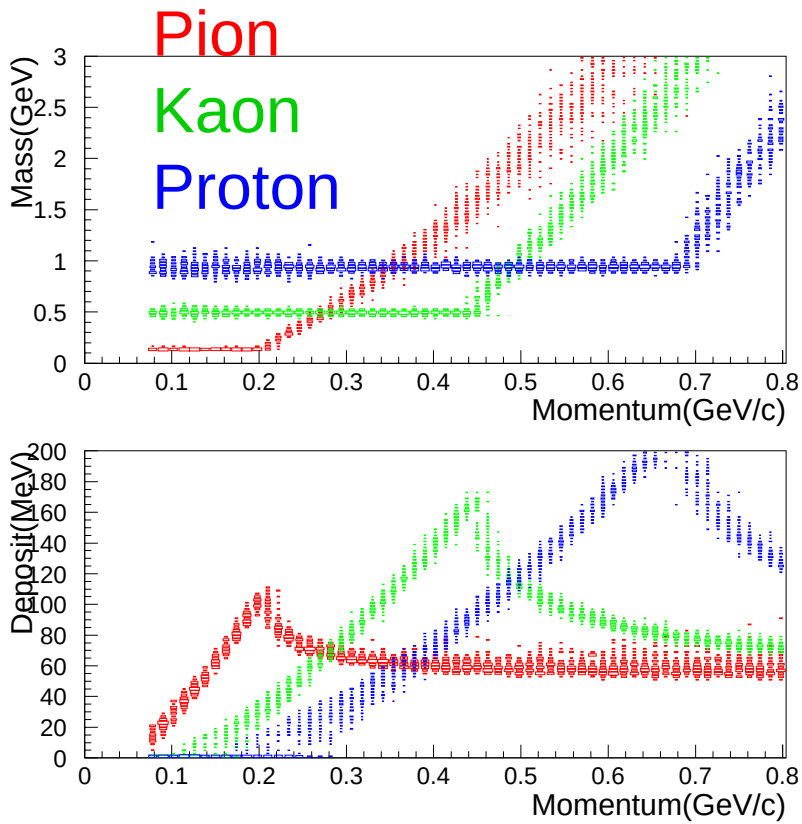


Same resolution as the one of TPC(Ne)

PID

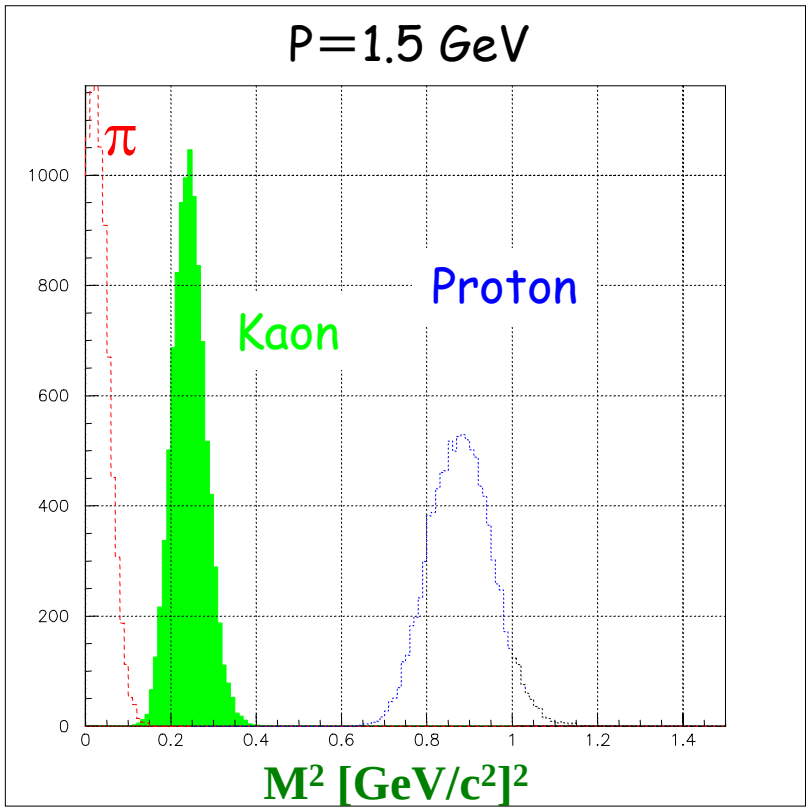


- Energy loss in Range counter+(TPC)
  Large angle and p<0.7 GeV/c



Nuclear reaction ?

PID at forward angle



$N(\pi)/N(K) = 10^3$
3 % in 2σ cut
$\rightarrow 6\sigma$ at 1.5 GeV/c

- Forward TOF
  ΔT=50 psec,
  Scintilating fiber type

Hyperon production at Eγ=2.4 GeV

Strangeness tagging

$\gamma + p \rightarrow K^+ + \Lambda(1116)$

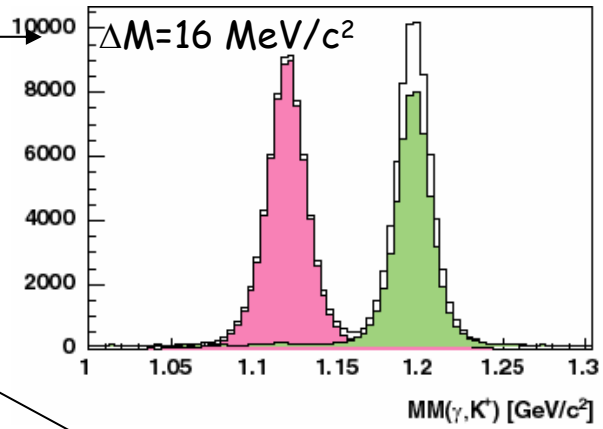
$\rightarrow p \ \pi^-$

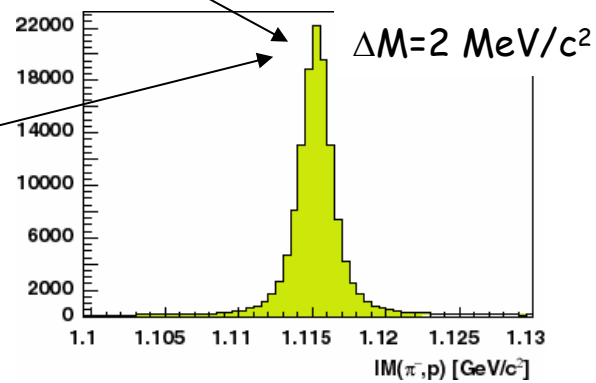
$\gamma + p \rightarrow K^+ + \Sigma(1192)$

$\rightarrow \Lambda \ \gamma$

$\rightarrow p \ \pi^-$

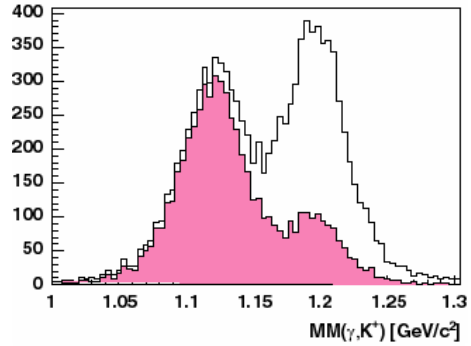
$\Theta_K > 15$ degree

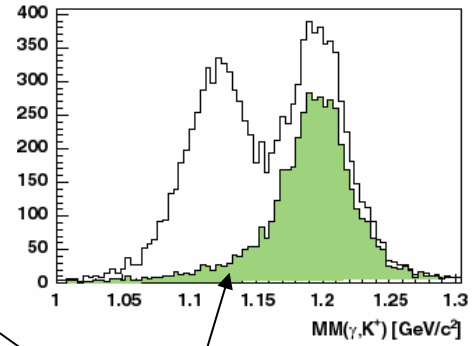




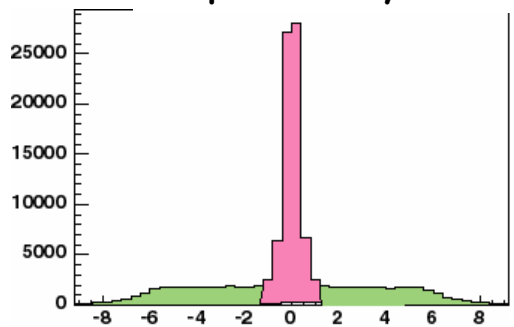
$\Theta_K < 15$ degree

ΔM=40 MeV/c²





Coplanerity Cut



Penta-quark Θ^+

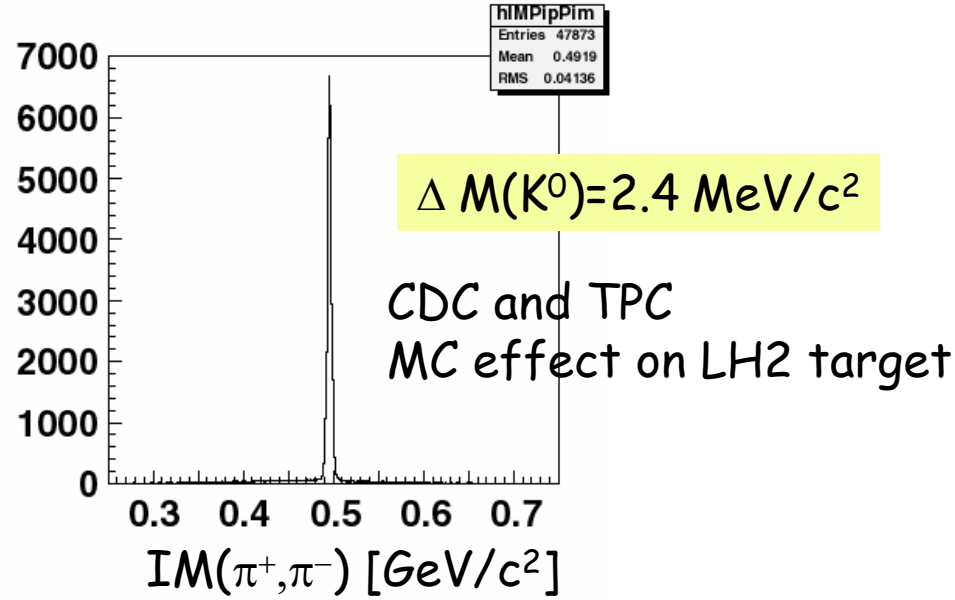
Strangeness tagging

$$\gamma + n \rightarrow K^- + \Theta^+$$

$$\rightarrow p \; K^0$$

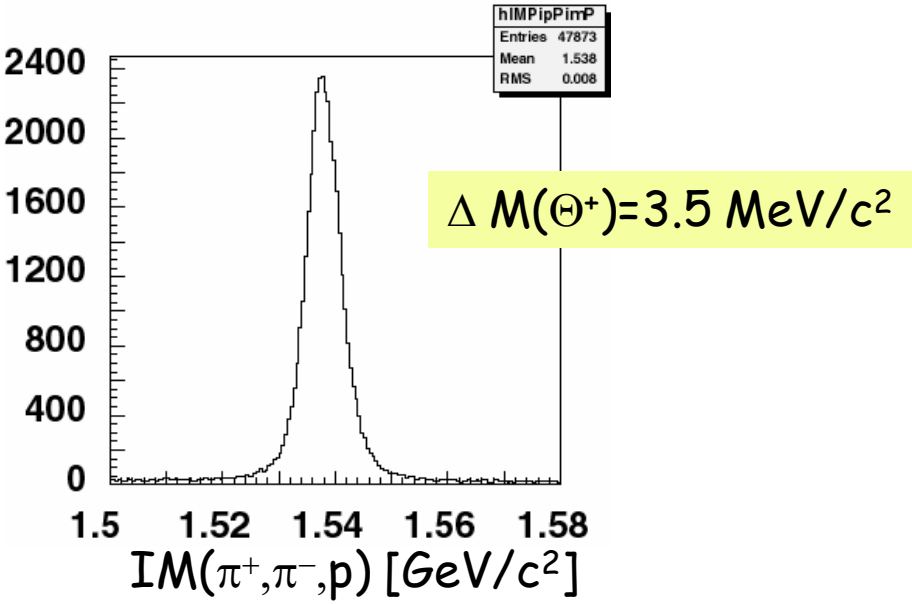
$$\rightarrow \pi^+ \pi^-$$

Invariant Mass measureme



Δ M(K^0)=2.4 MeV/c^2

CDC and TPC
MC effect on LH2 target



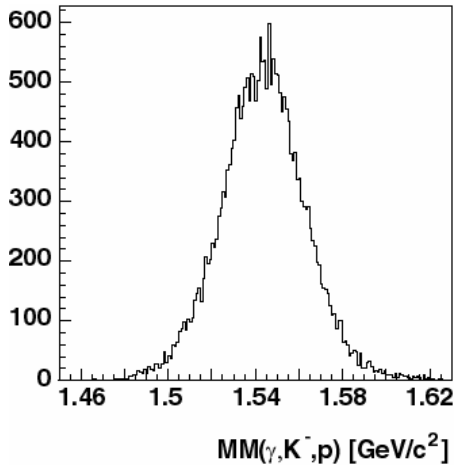
Δ M(Θ^+)=3.5 MeV/c^2

$\gamma d \rightarrow \Lambda(1520)\Theta^+$

$\gamma d \rightarrow \Lambda(1520)\ \Theta^+$ → $K^-\ p$

Missing Mass

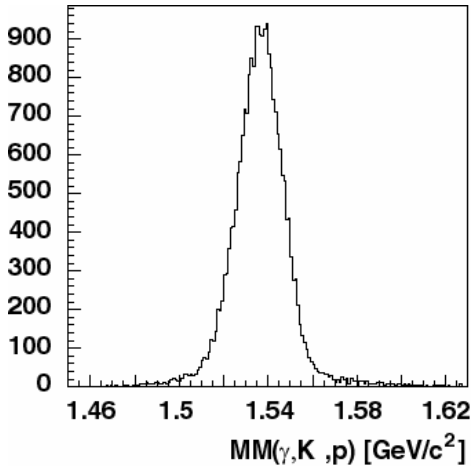
$\Delta M(\Theta^+)$=17 MeV/c^2



$\gamma d \rightarrow \Lambda(1520)\ \Theta^+$ → $K^-\ p$ → $K^+\ n$

+ Kinematical fit

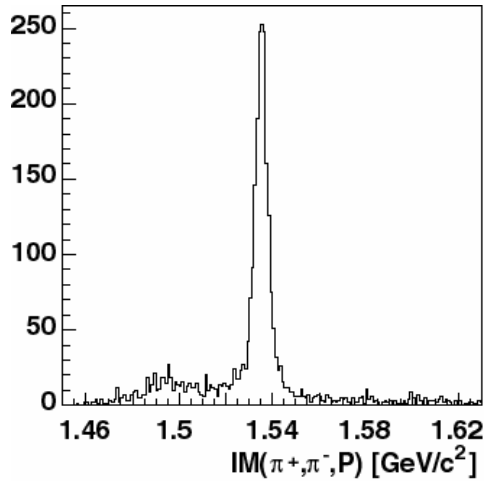
$\Delta M(\Theta^+)$=10 MeV/c^2



$\gamma d \rightarrow \Lambda(1520)\ \Theta^+$ → $K^-\ p$ → $K_s\ p$

Invariant Mass

$\Delta M(\Theta^+)$=3 MeV/c^2



Summary

- BNL-E949 is now considered to be used as the large acceptance detector at Spring8.
- SSD and Planer DC for forward ,and TPC or CDCfor large angle are considered for tracking system inside solenoid.
- Helium gas is effective to reduced MS effect at forward region < 20 degree.

  $\Delta P/P$ = 1.4% at 10 degree
- CDC (He4 base) gives better resolution for very low momentum.

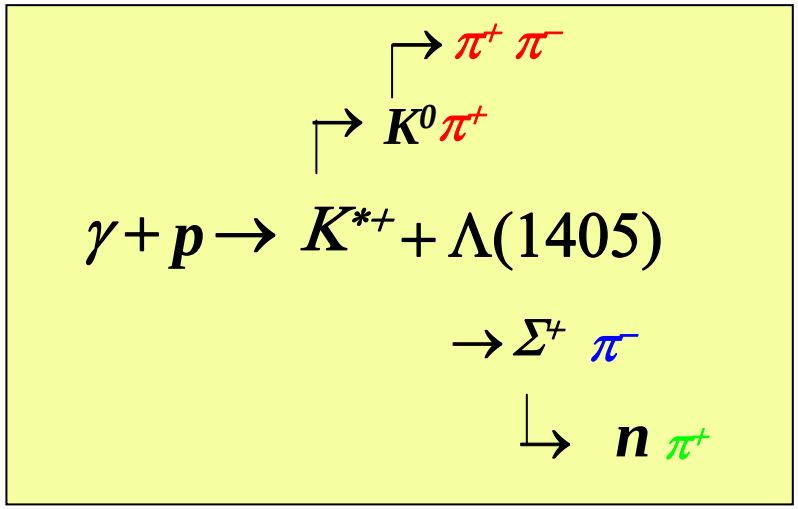
  However MS effect on L target dominates the resolution.
- For PID,

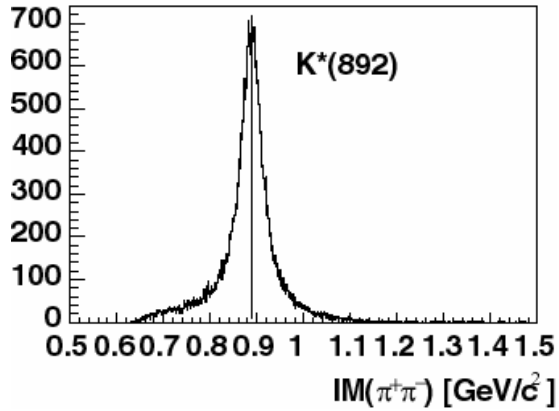
  Energy loss information on the range counter for lower momentum

  ΔT=50 ps -> π/K separation at 1.5 GeV/c

Back up

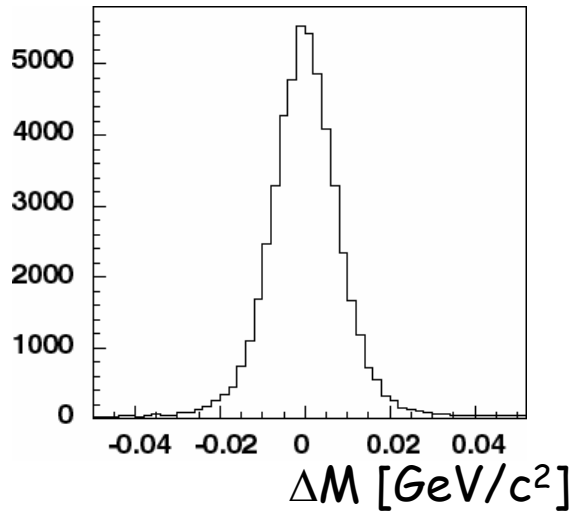
γp→K*Λ(1405)



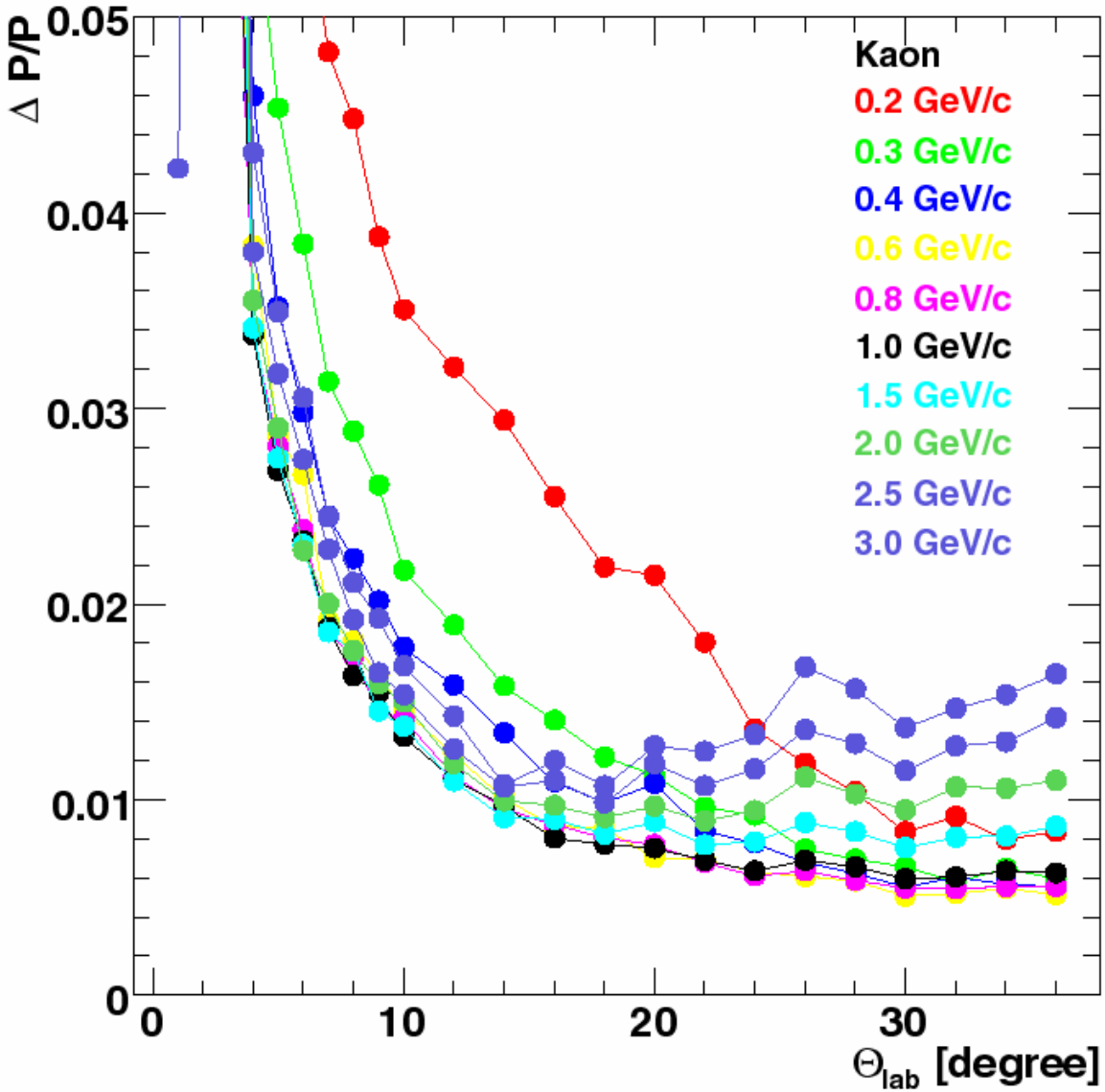


Missing mass resolution for Λ(1405)

8 MeV/c^2

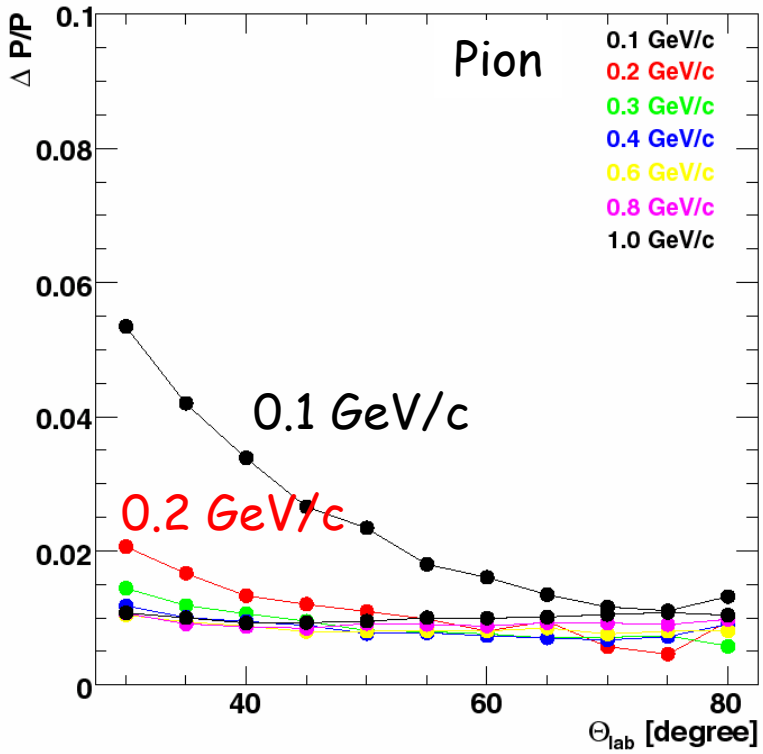


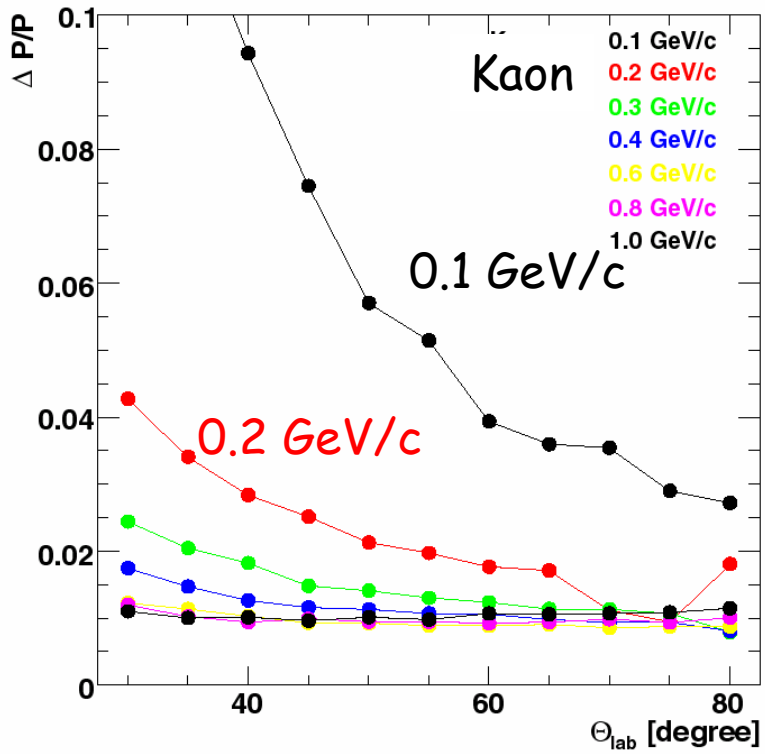
R=500 mm in Helium



ΔP/P of TPC(With target)

Ar(90%)+Methan(10%) (P10)

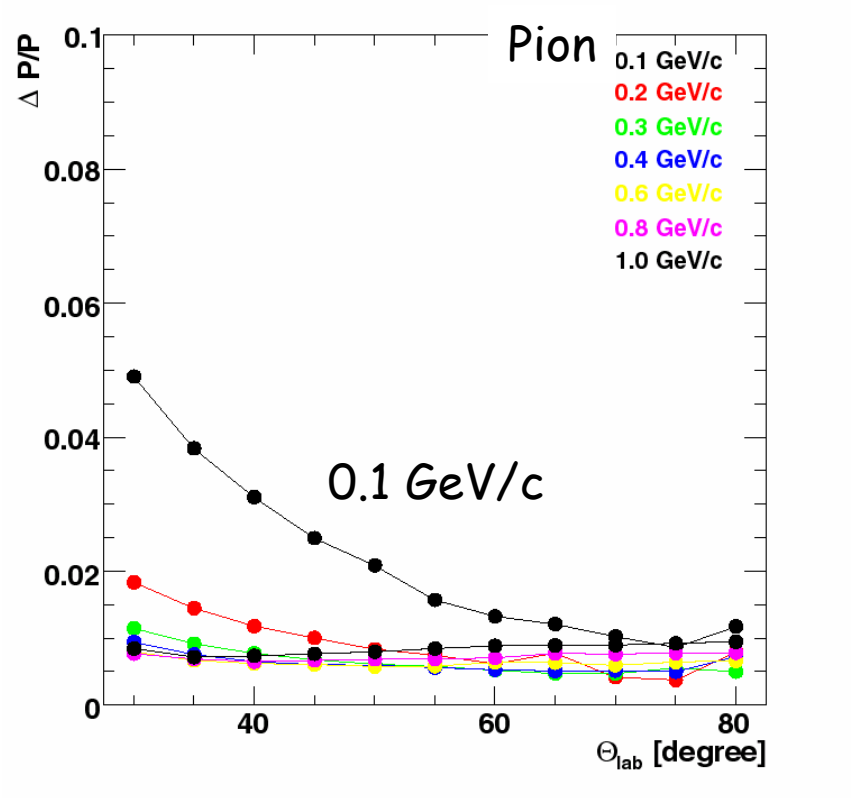


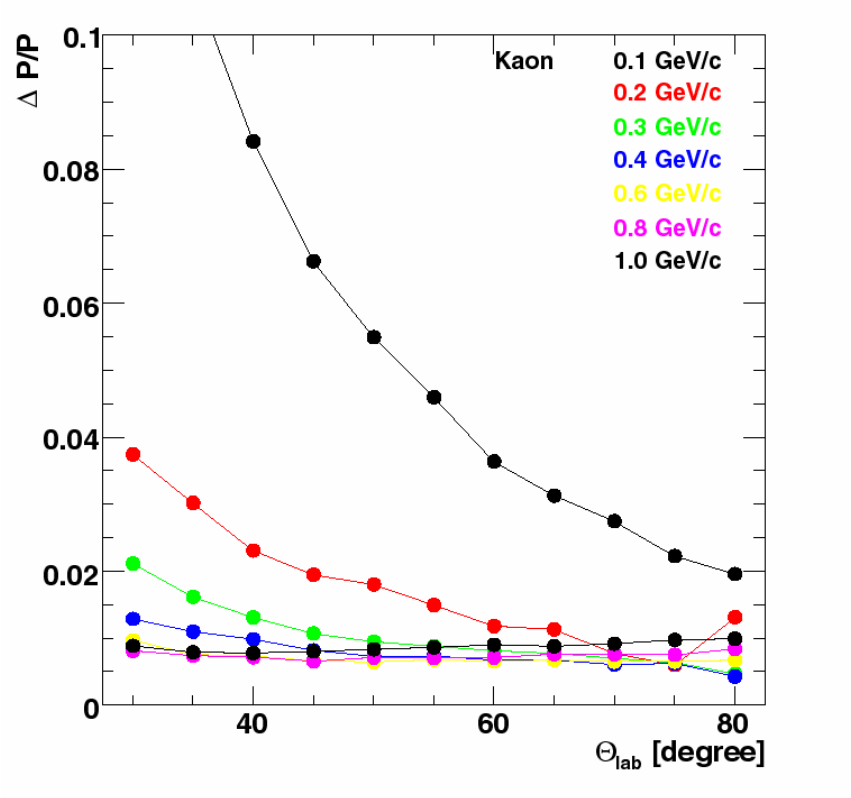


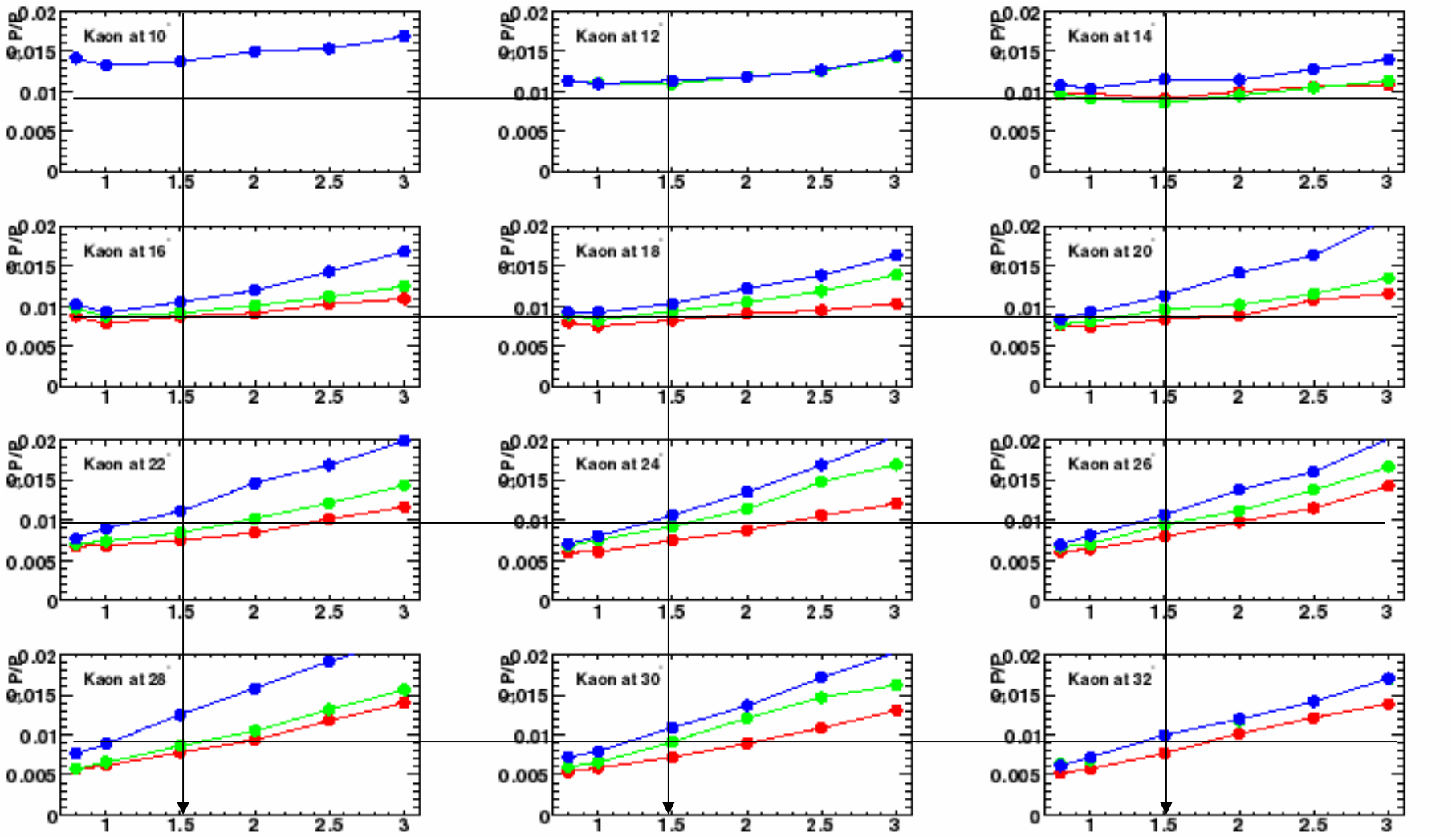
MC effect is large for low momentum <0.3 GeV

ΔP/P of TPC (with target)

Ne(90%)+Methan(10%)





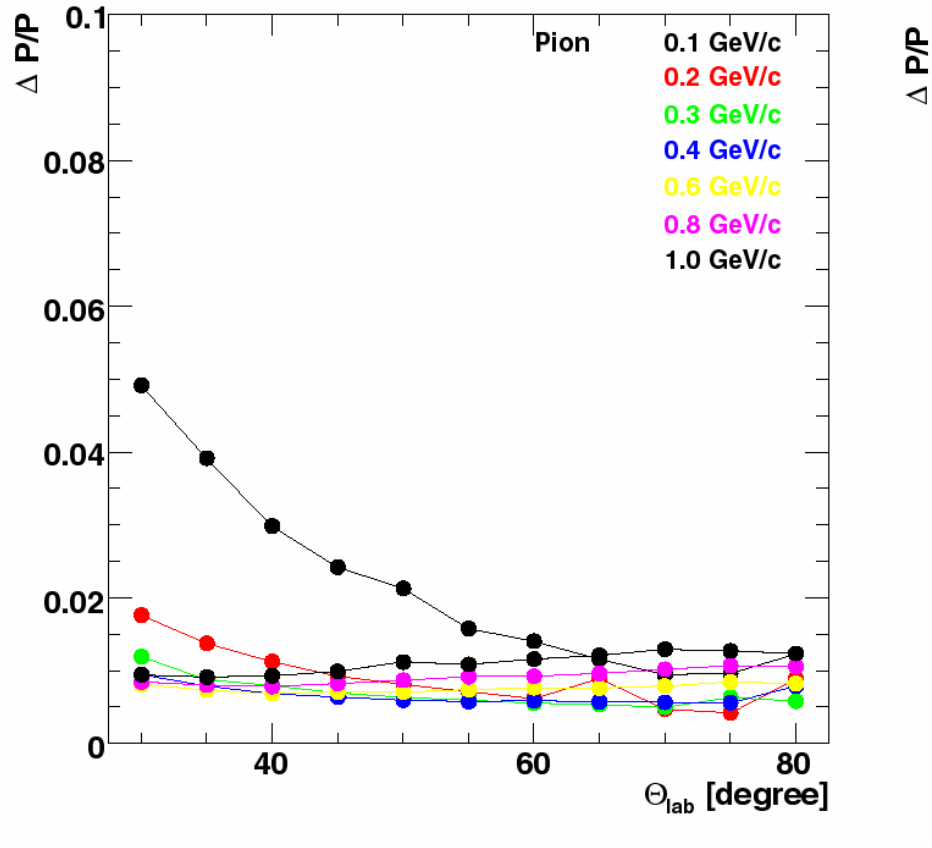


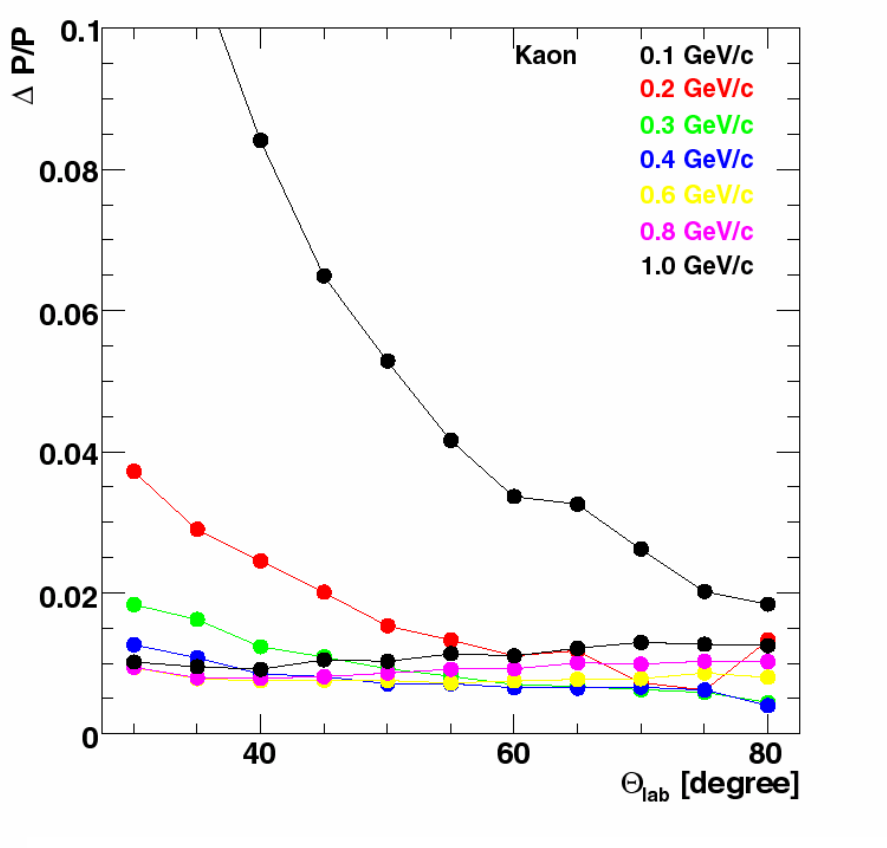
R=400 mm
450 mm
500 mm

At P<1.5 GeV Down to R=400 mm is possible!

ΔP/P of CDC (with target)

He(50%)+Ethane(50%)





Same resolution as the one of TPC

Basic concept for tracking system

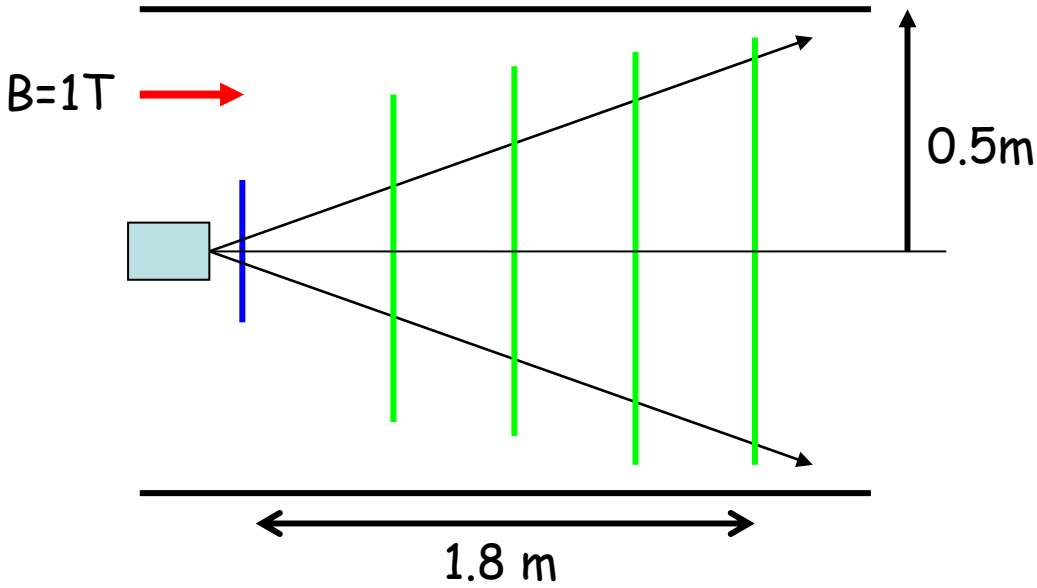
$$\frac{\sigma_{P_T}}{P_T} = \frac{\sigma_{r\varphi} P_T}{0.3 \cdot BL^2} \sqrt{\frac{720}{N+4}}$$

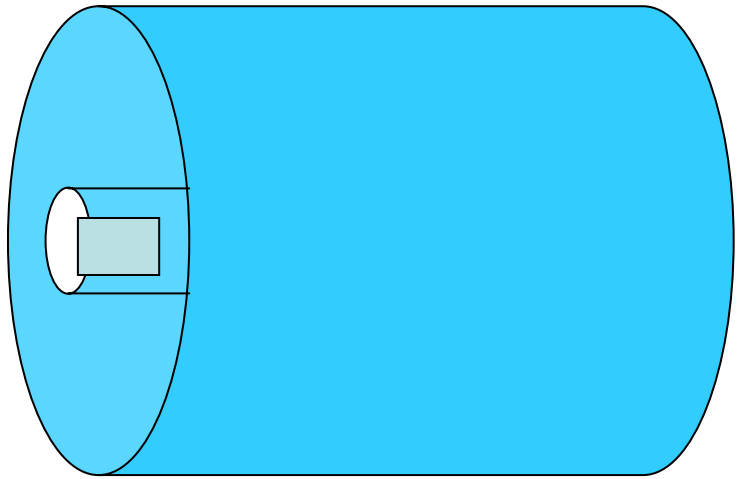
Forward part Θ< 20 deg

Side part 20 < Θ < 90 deg

SSD and Planer DC chamber

TPC or CDC

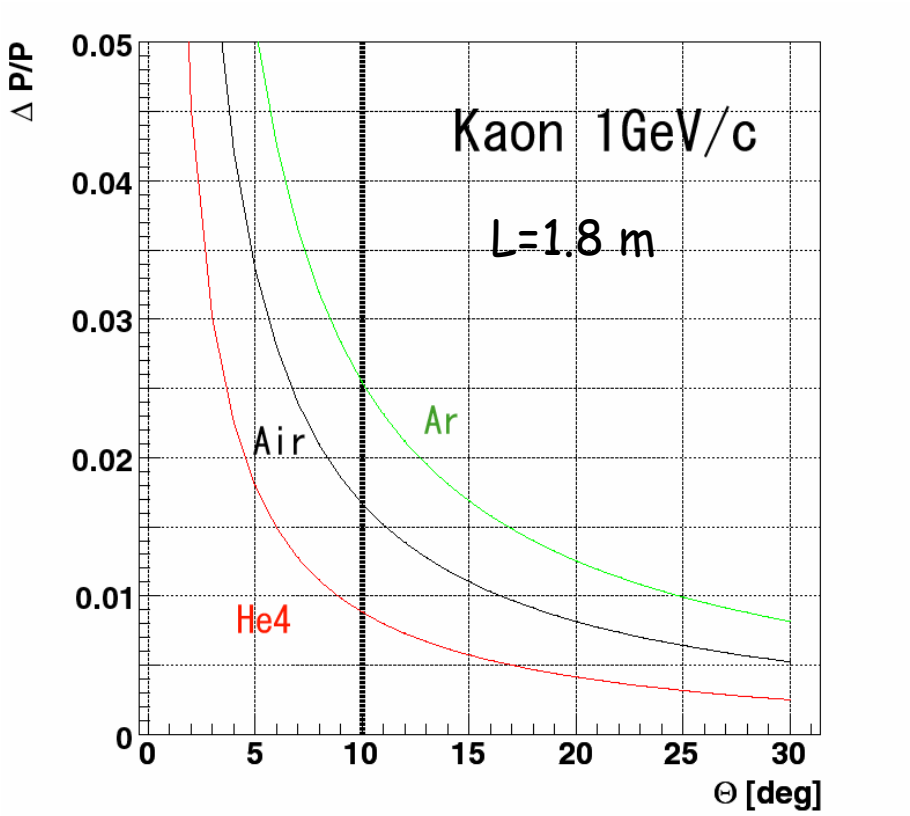




σ_{xy} =150um, N=13, P=1 GeV/c
→ ΔP/P = 0.5 % at Θ=10(deg)

N=26, P=0.5 GeV/c
→ ΔP/P = 0.5 % at Θ=90(deg)

Multiple scattering effect for forward charged particle



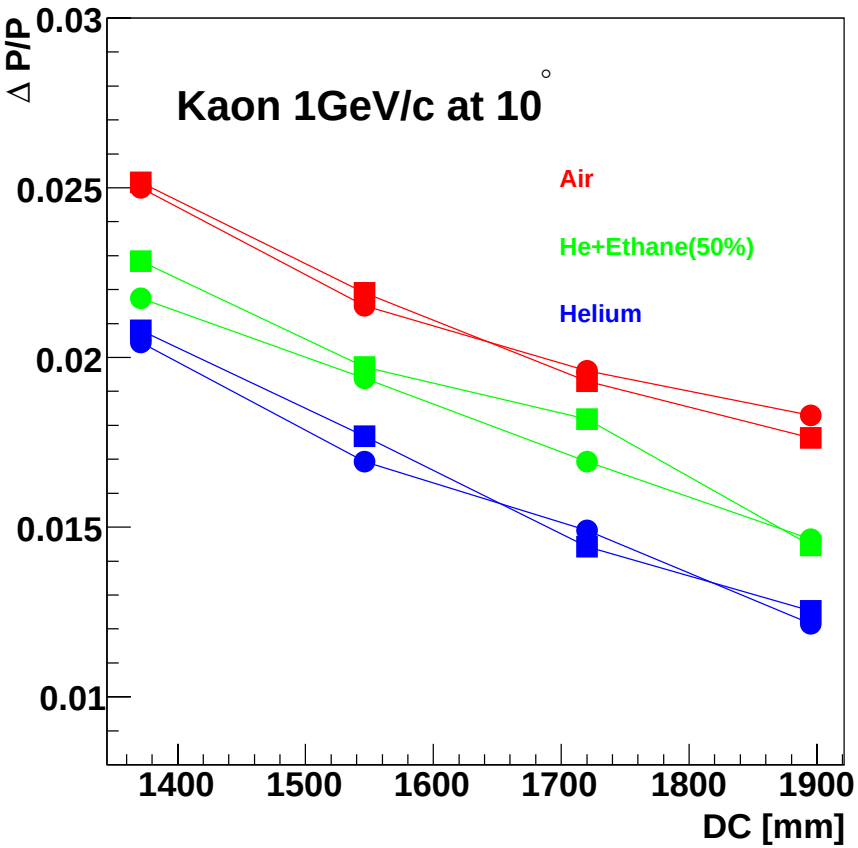
$$\frac{\sigma_{P_t}}{P_t} = \frac{0.016}{0.3B\,\beta\sin\theta\sqrt{L\,X_0}}$$

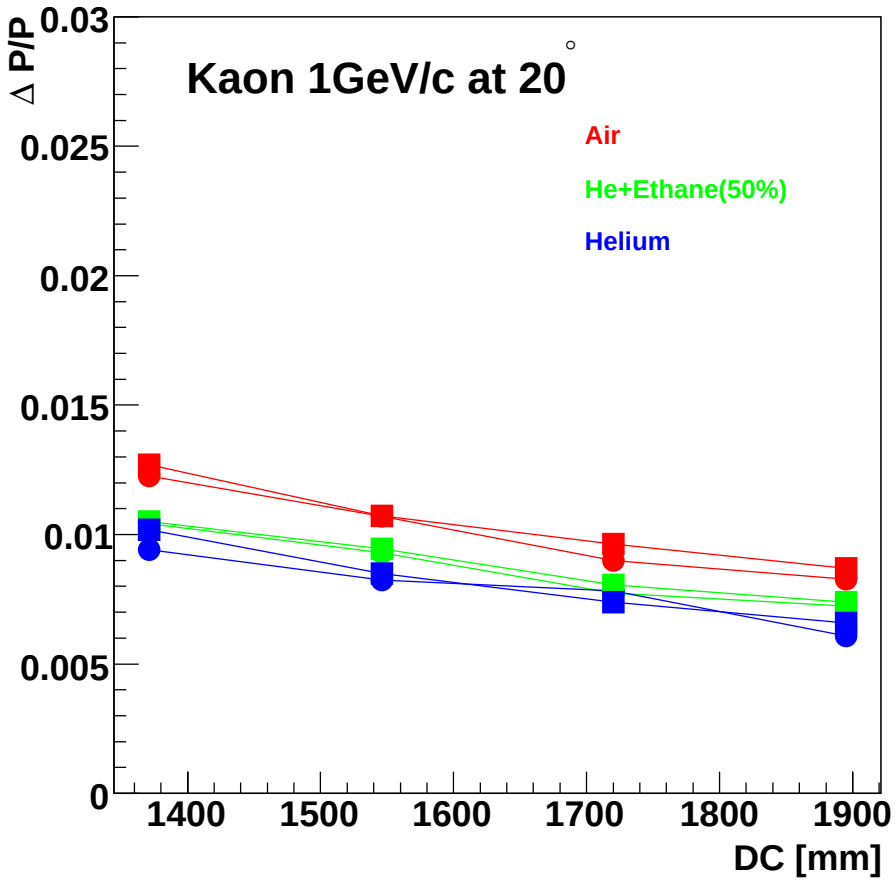
	X/X_0 10^{-3}
Air	6.0
Ar	9.1
He4	0.3

Setup

SSD + TPC(Ar) + planer DC(He4)

SSD + CDC(He4)



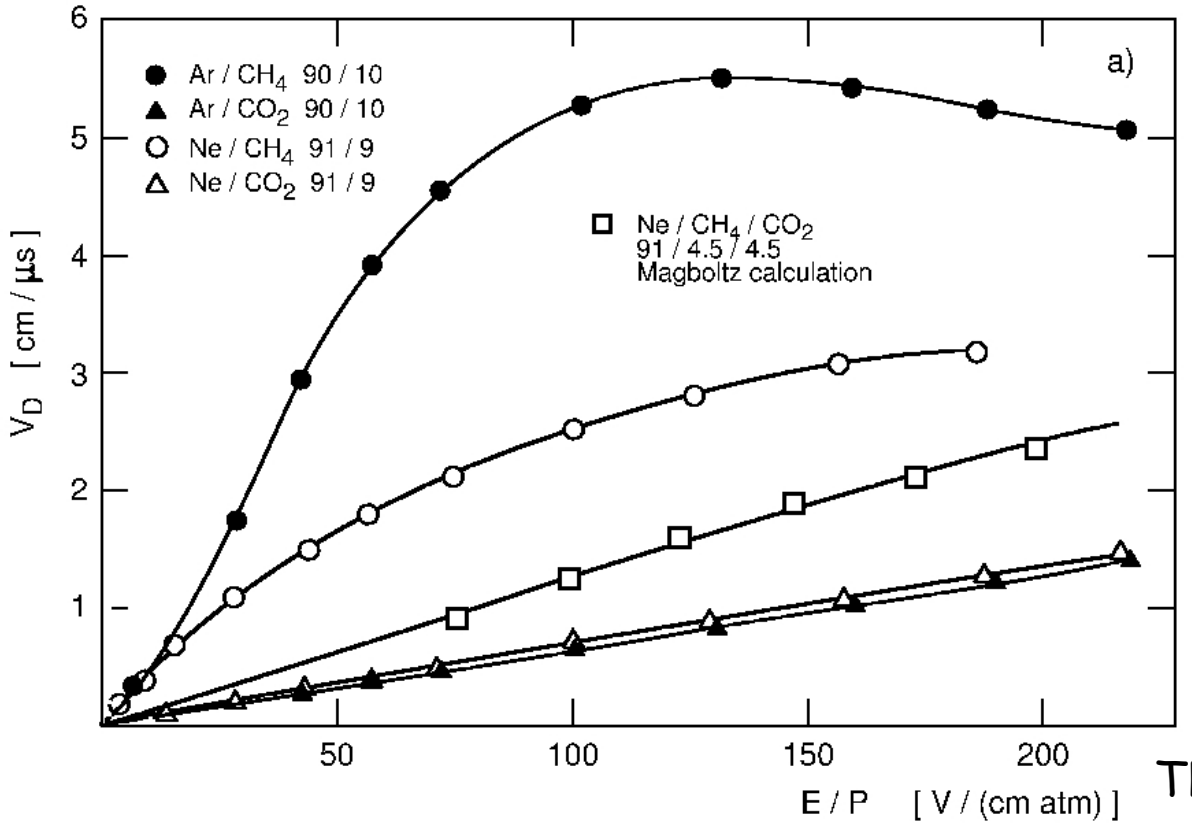


50 cm space for TOF and other component? -> 33%-16% worse at 10 degree

GAS mixture for TPC

Experiment	Gas mixture	Proportion
ALEPH	Ar/CH4	91/9
NA49 VTPC	Ne/CO2	90/10
NA49 MTPC	Ar/CO2/CH4	90/5/5
STAR	Ar/CH4 (P10)	90/10
ALICE	Ne/CO2	90/10
TESLA	Ar/CO2/CH4	93/2/5

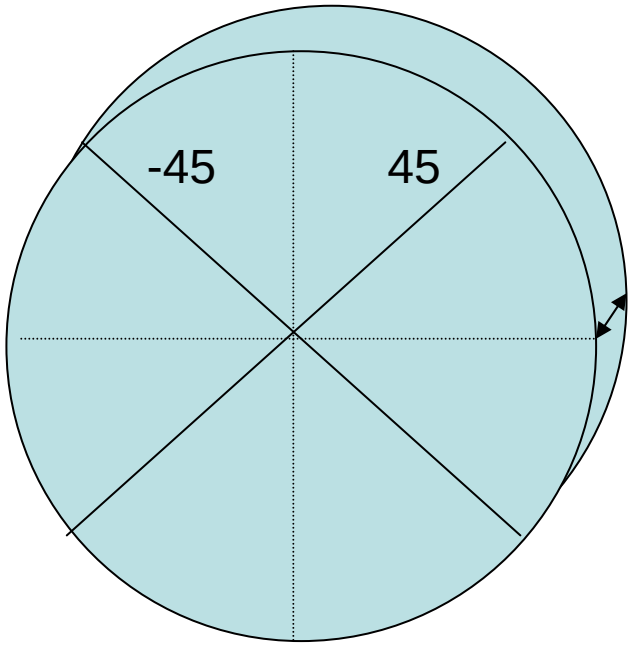
Gas	ρ [g/ l]	X0 [g/cm2]	X0 [m]	n_{mp} [1/cm]
He	0.1785	94.32	5280	2.7
Ne	0.89990	28.94	322	16
Ar	1.784	19.55	110	38
CH4	0.717	46.22	645	30
CO2	1.977	36.2	183	50
C2H6	1.356	45.47	335	59

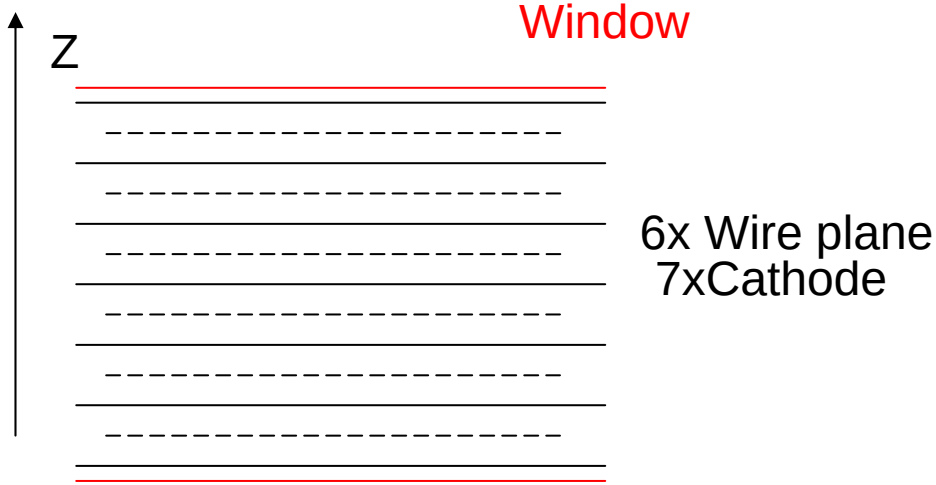


TDR of PANDA

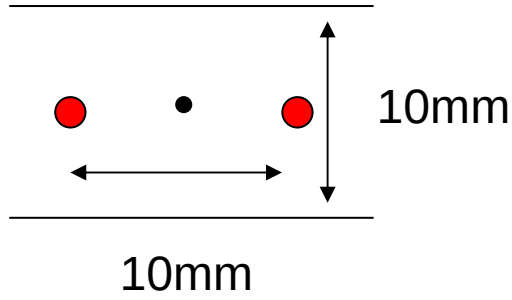
MWDC

6 wire plane x,x', u(45) u'(-45), y y'





Cell structure



Material for MWDC

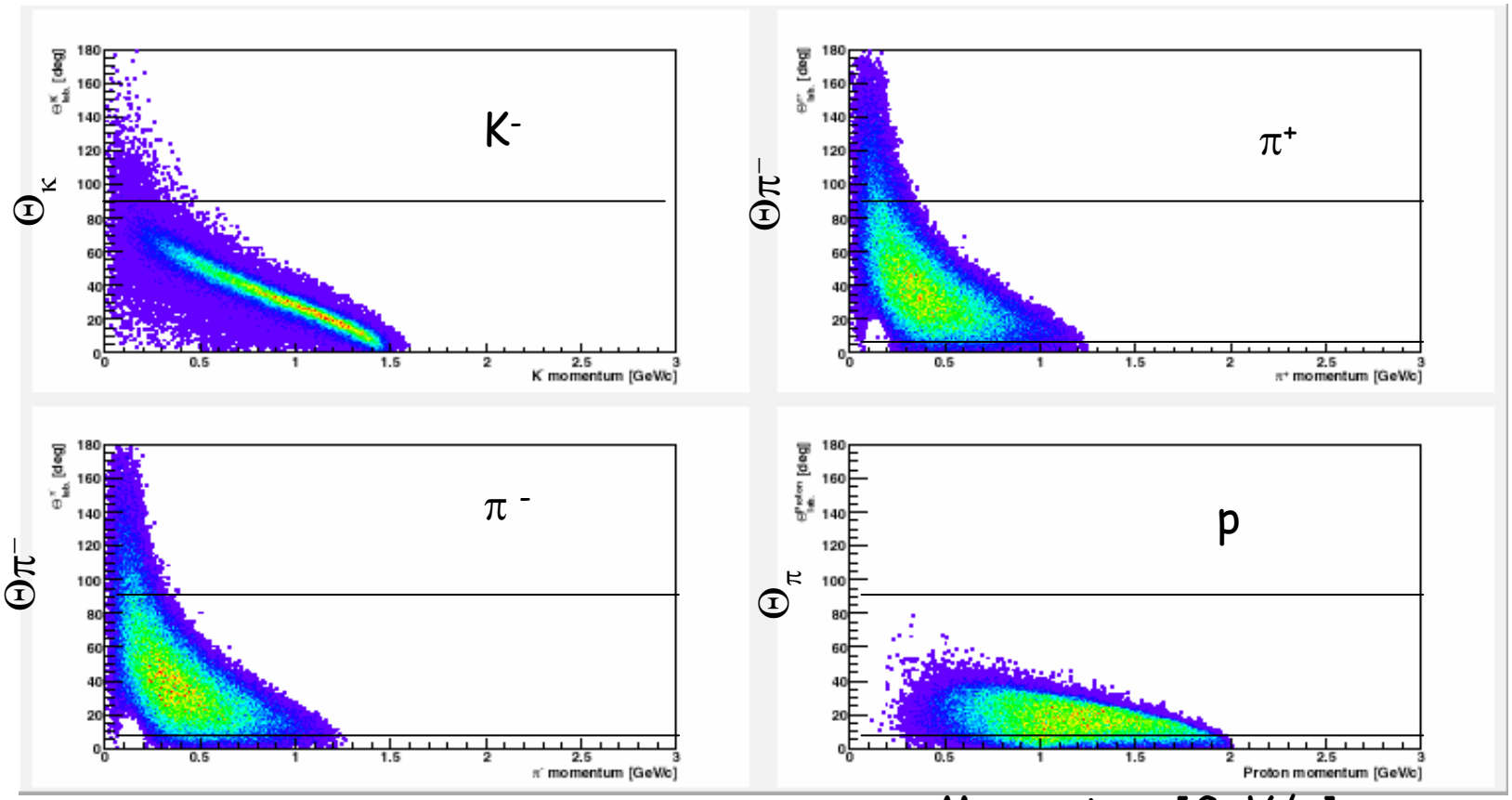
GAS	X0 [m]	X[mm]		X/X0x10^{-4}
He+Ethane(50%)	640	60		0.94
Ar +IsoB(30%)	127	60		4.72
Window	[cm]	[um]		
Mylar	28.7	2x50		3.48
Cathode plane	[cm]	[um]		
Mylar	28.7	7x10		2.44
Al	8.9	7x3		2.36
Cathode wire	[cm]	[um]		
CuBe(ϕ50um)	2.11	6.87		3.26
Al(125um)	8.9	43		4.83
Anode wire				
W(30um)	0.35	0.50		1.41
Field wire				
CuBe(ϕ50um)	2.11	1.37		0.65
Al(125um)	8.9	8.5		0.96

- Cathode plane
- CuBe for FW

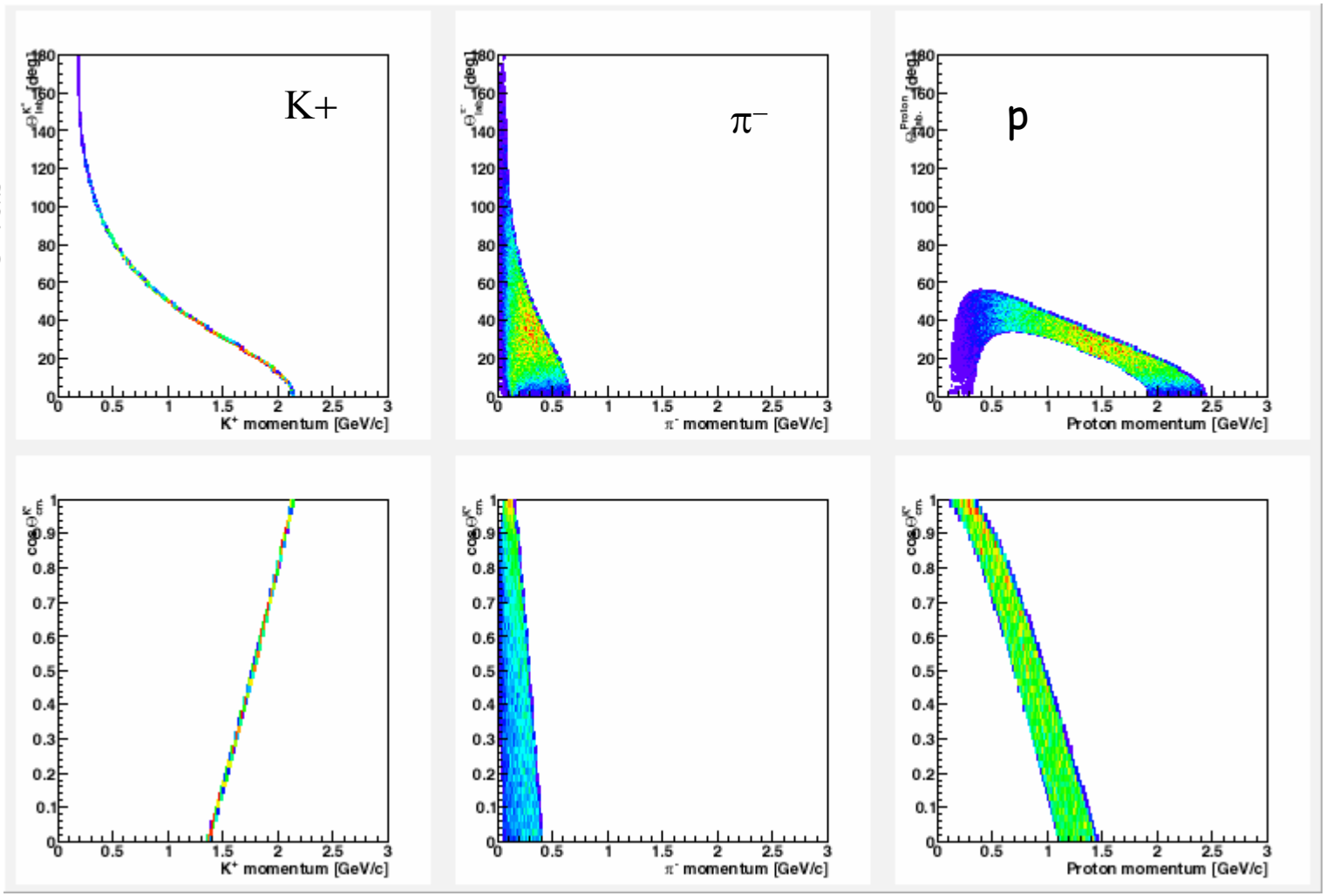
ΣX/X0= 1.1x10^{-3} (He)
1.5x10^{-3} (Ar)

->DP/P ~ 1 %

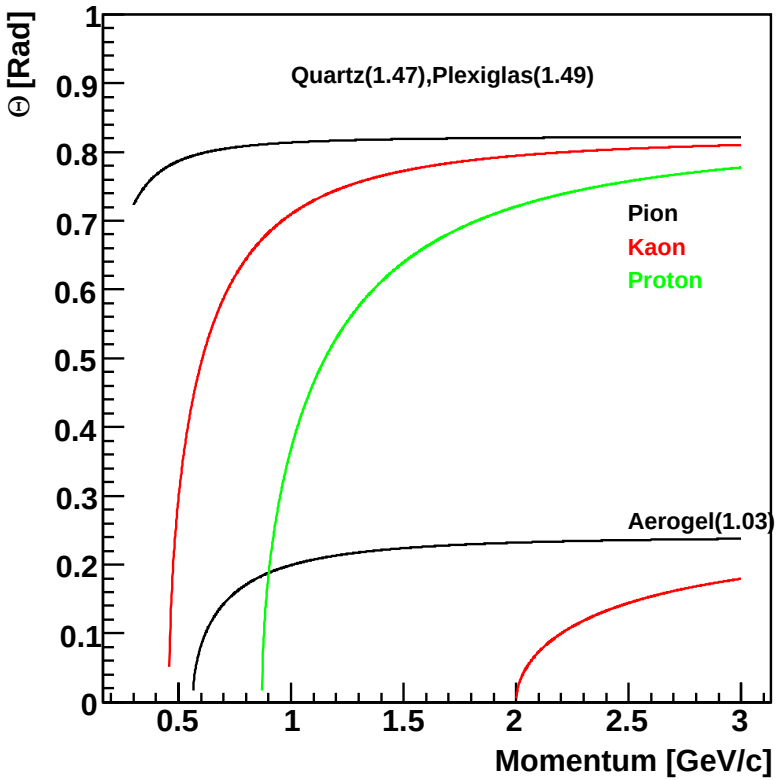
$\gamma n \rightarrow \Theta^+ K^- \rightarrow (K^0 p)\ K^-$



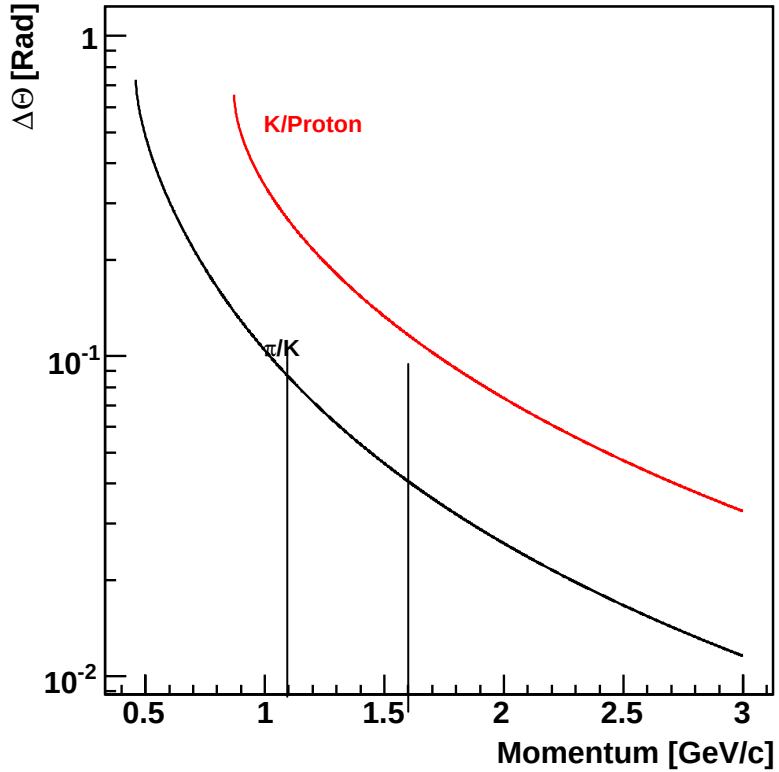
$\gamma p \rightarrow K^+\Lambda$



PID (Chrenkov)



Chrenkov Angle

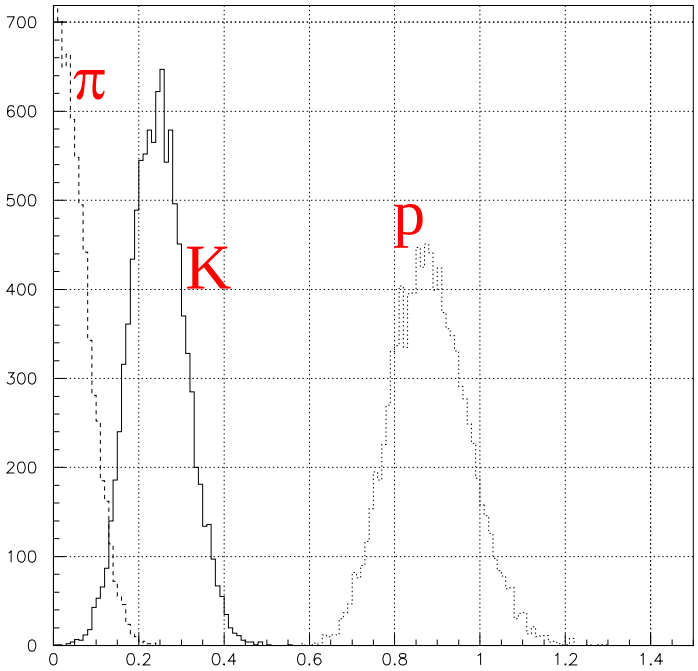


30mrad (p K separation) at 2 GeV

PID(TOF)

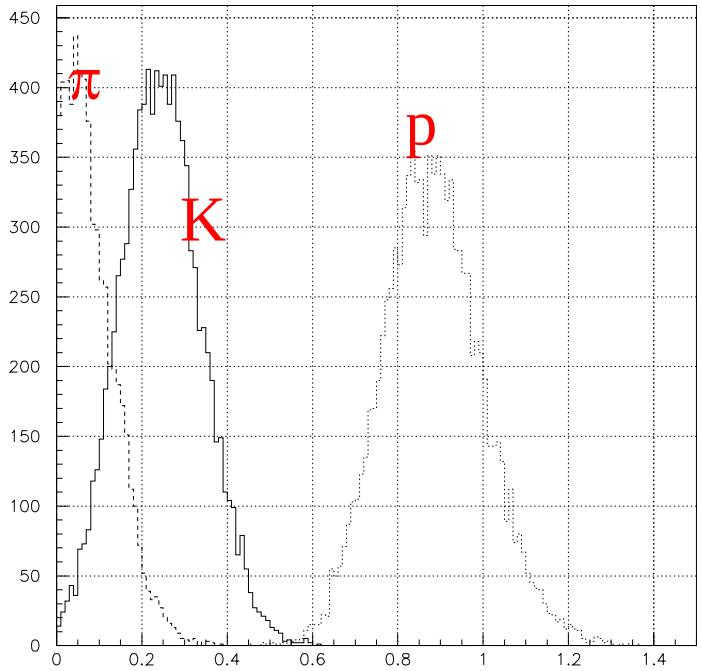
$\Delta T = 50$ ps

P=2.0 GeV



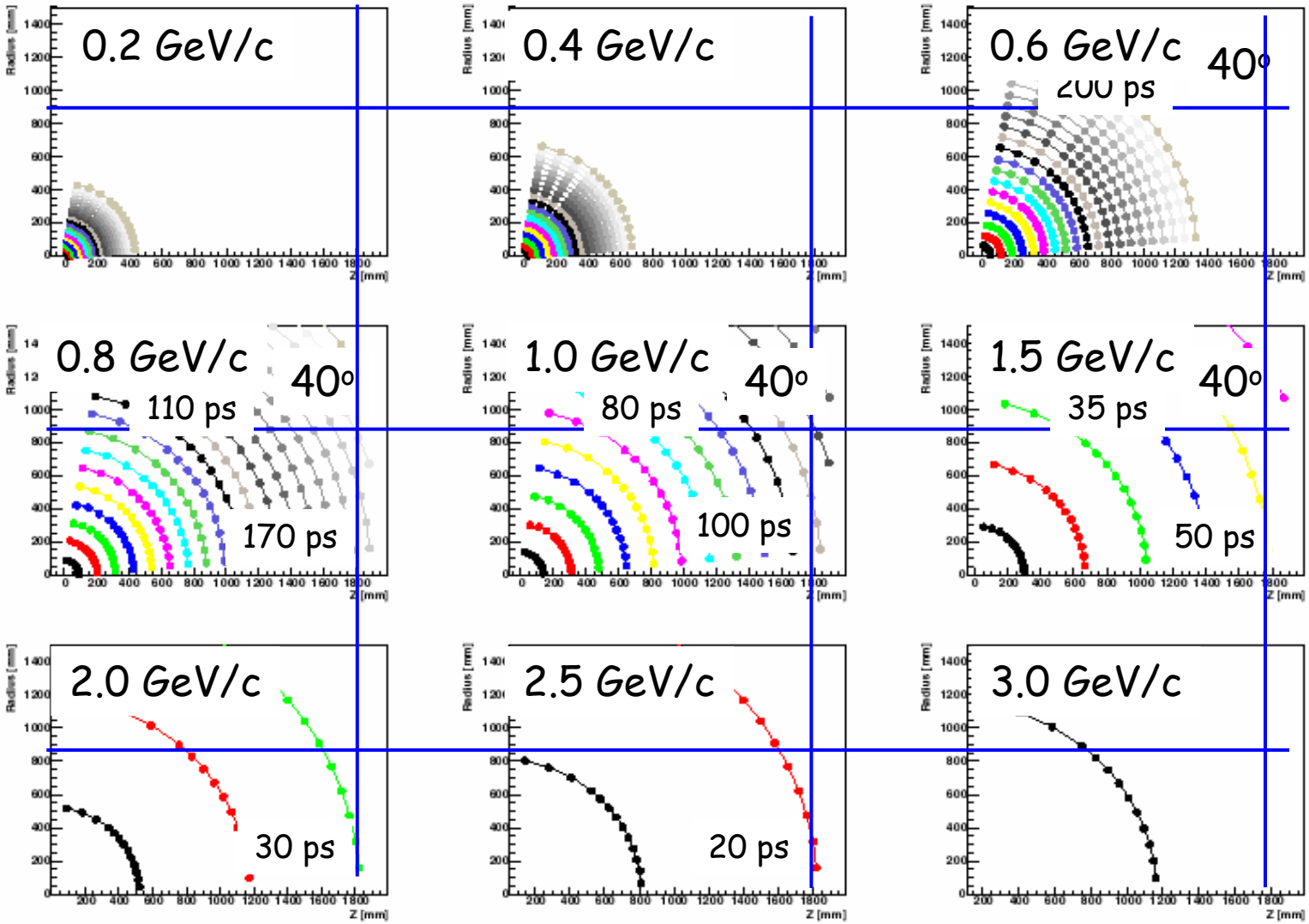
M^2 [GeV/c^2]^2

P=2.5 GeV



M^2 [GeV/c^2]^2

π/K separation 6 σ (Resolution contuor)



SAPHIR/LEPS
CLAS/LEPS
SAPHIR/CLAS/LEPS

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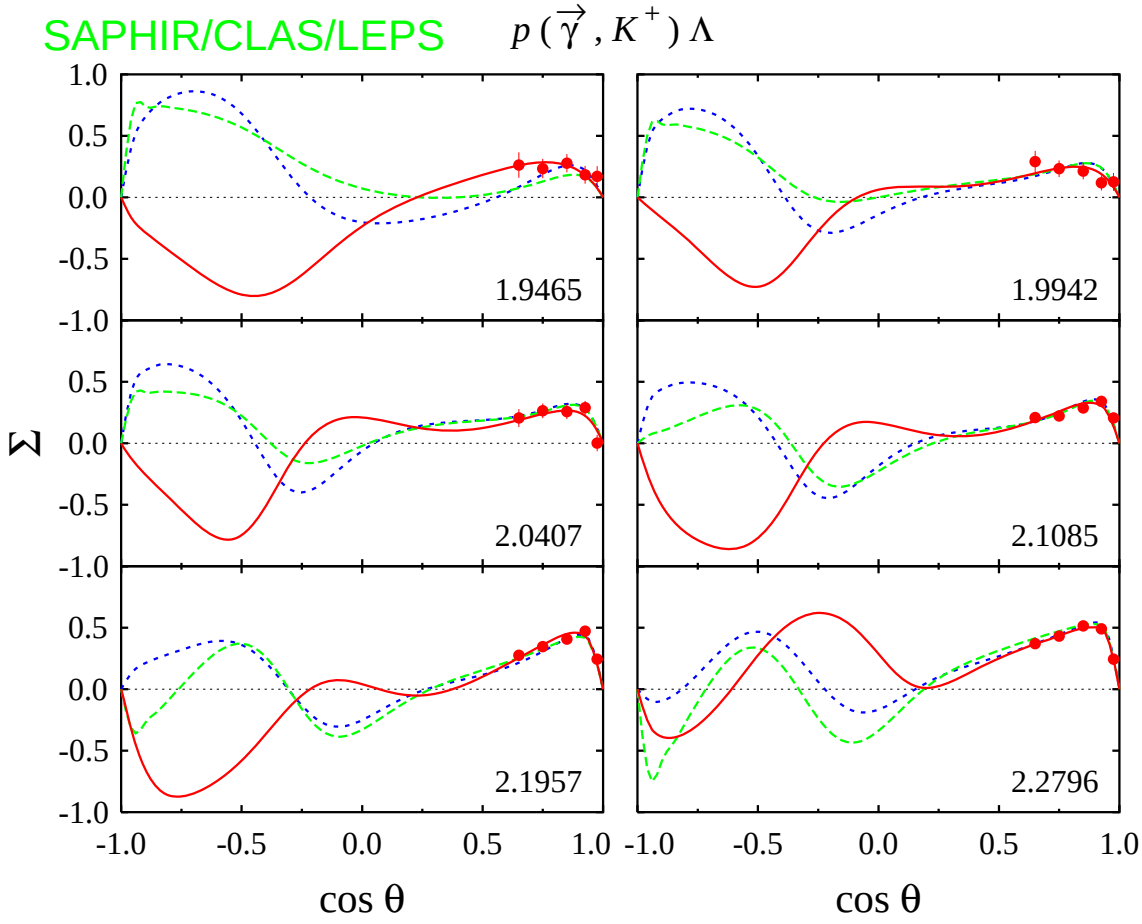

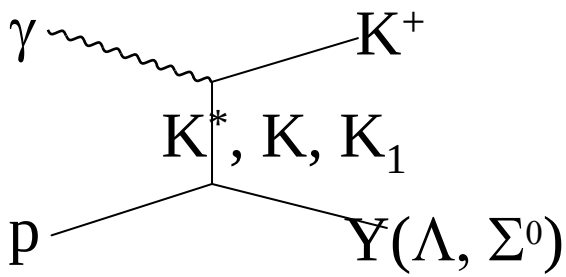

K* → Σ = + 1
K, K1 → Σ = −1
at forward angle