PEP−N simulation and multihadron detection

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e^+e^- physics at intermediate energies workshop
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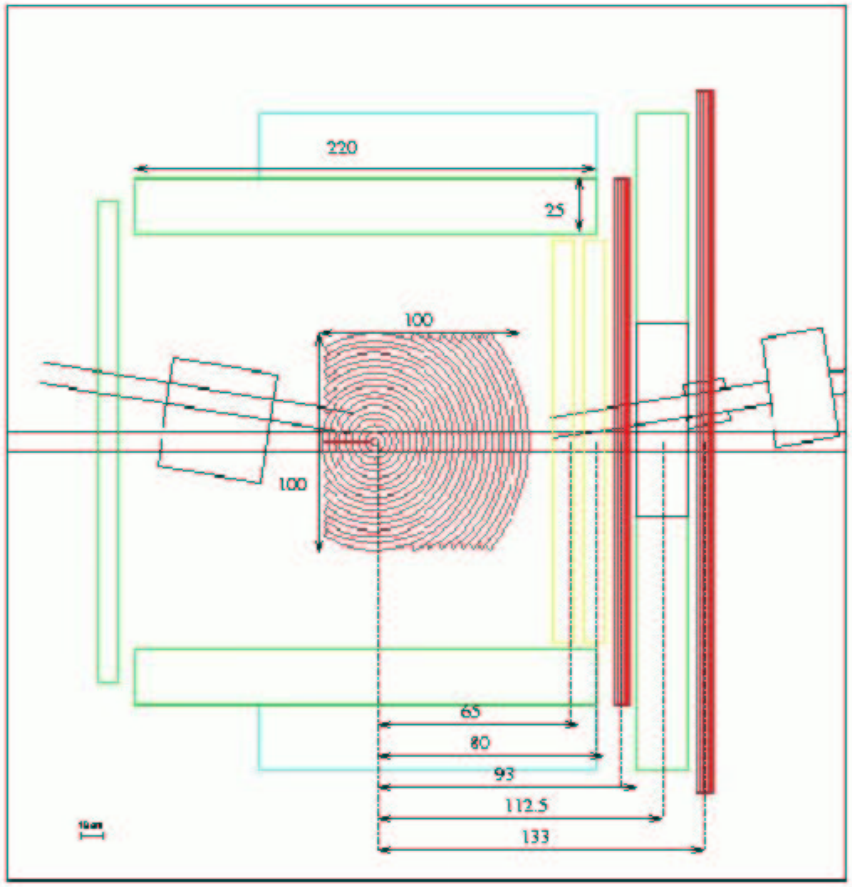
Outline

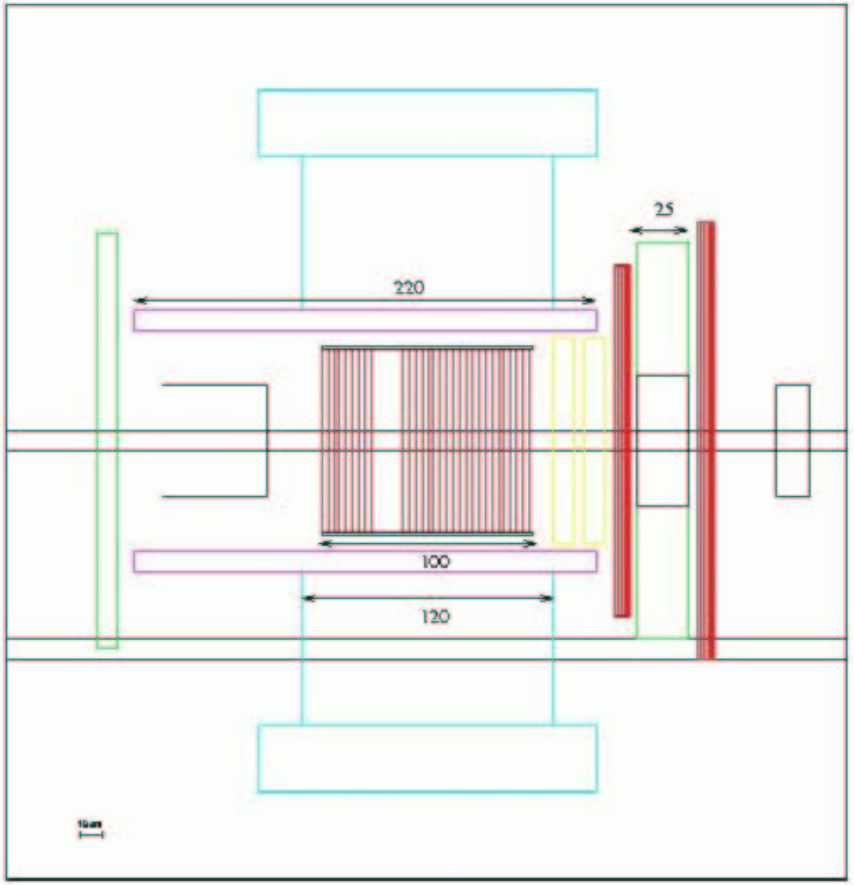
- Detector review
- Features of multihadron channels
- Detector acceptance for multihadrons
- Efficiency for R measurement

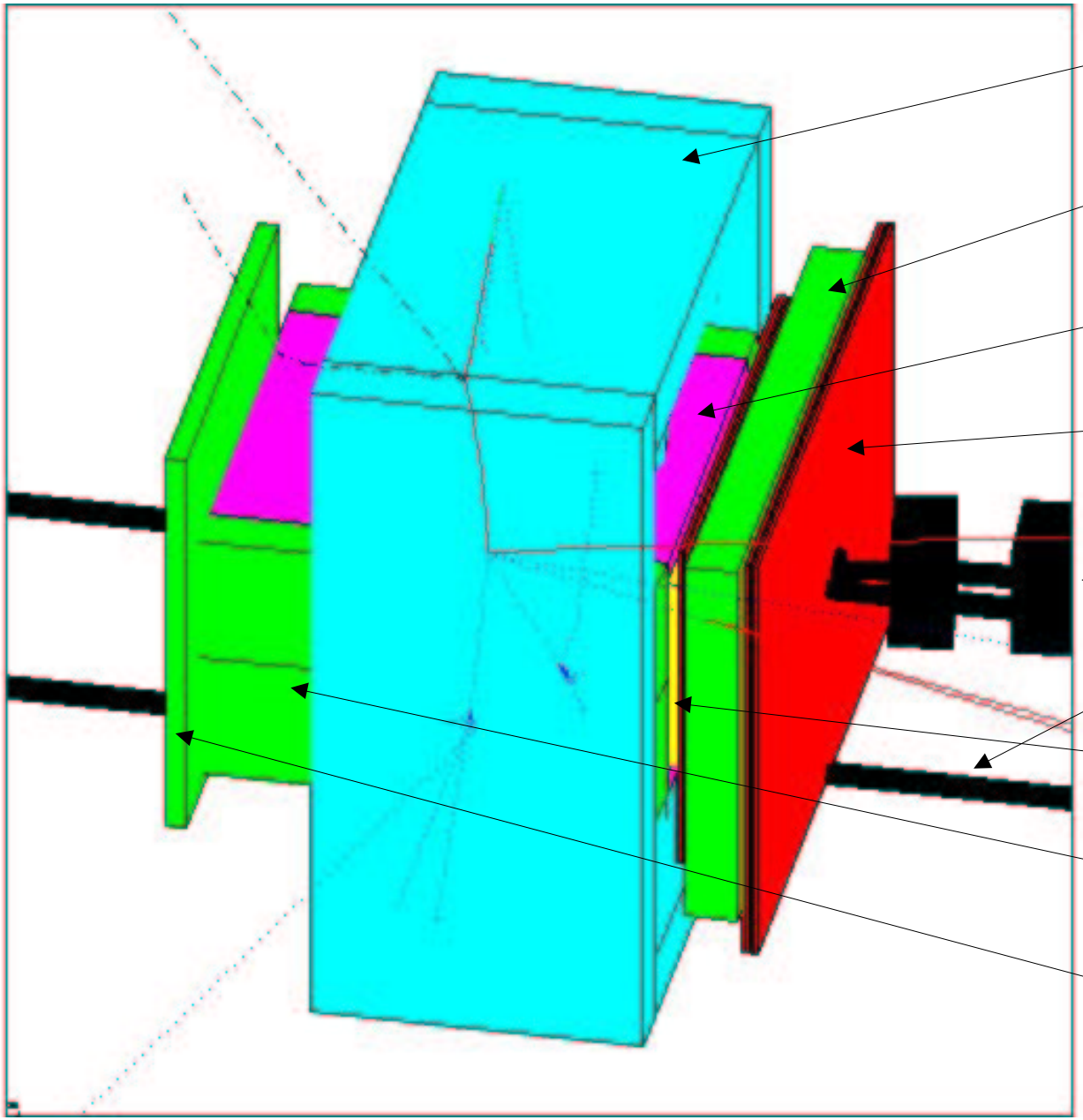
PEP-N Detector

Top view



Side view




Magnet
Forward calorimeter
Pole calorimeter
Forward tracking chambers
Peam pipes and magnets
Aerogel
"Barrel" calorimeter
Rear calorimeter

Magnet

- Poles diameter = 120 cm
- Distance between poles = 120 cm
- Space between yokes = 240 cm
- B field = 0.3 T (vertical direction)

Calorimeters

1 mm Pb layer + 1 mm scintillating fibers modules

- FORWARD + BARREL:
  - Thickness = 25 cm (~15 rad. len.)
  - Efficiency ~99% (E>20 MeV)
  - Energy resolution = 5%/sqrt(E)
- POLES + REAR:
  - Thickness = 10 cm (~6 rad. Len.)
  - Efficiency >95% (E>20 MeV), ~98% (E>40 MeV)
  - Energy resolution = 23%

TPC

Dimensions: 100cm x 100cm x 90cm

TPC centered between the magnet poles to have uniform B field.

Interaction point located 25cm upstream with respect to the center of the magnet.

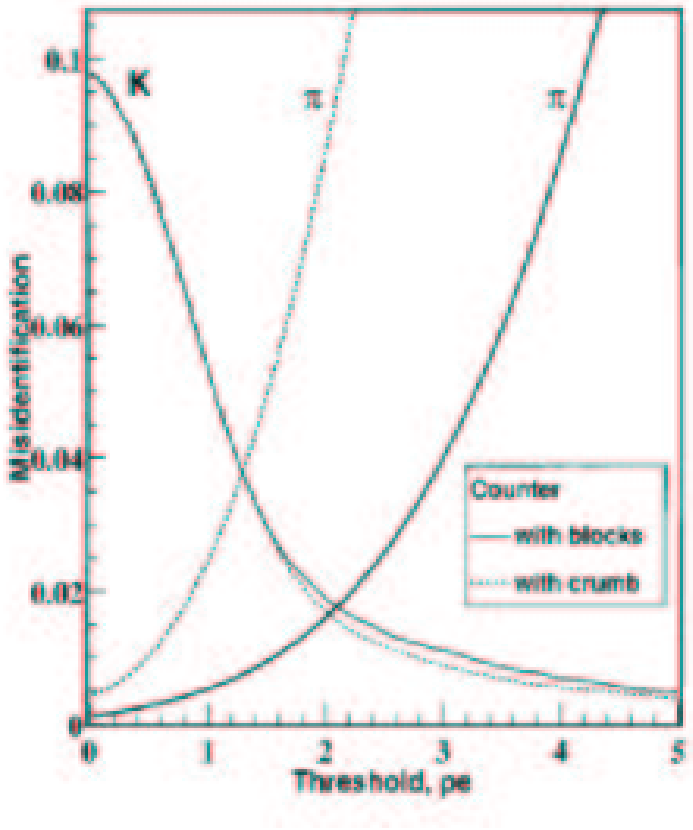
Table of $\Delta p/p$ for different number of hit layers (spatial resolution= 200μm) :

Transv. P (GeV/c)	***22 points (forward track)***	***22 points * 1 point at 120 cm***	***14 points***	***6 points (backward track)***
0.1			1.0%	9%
0.2	0.7%	0.3%	2.0%	17%
0.4	1.4%	0.7%	4.1%	
0.6	2.0%	1.0%	6.1%	
0.8	2.7%	1.4%	8.1%	
1.0	3.3%	1.7%		
1.2	4.0%	2.1%		
1.4	4.6%	2.4%		
1.6	5.3%	2.8%		

Aerogel

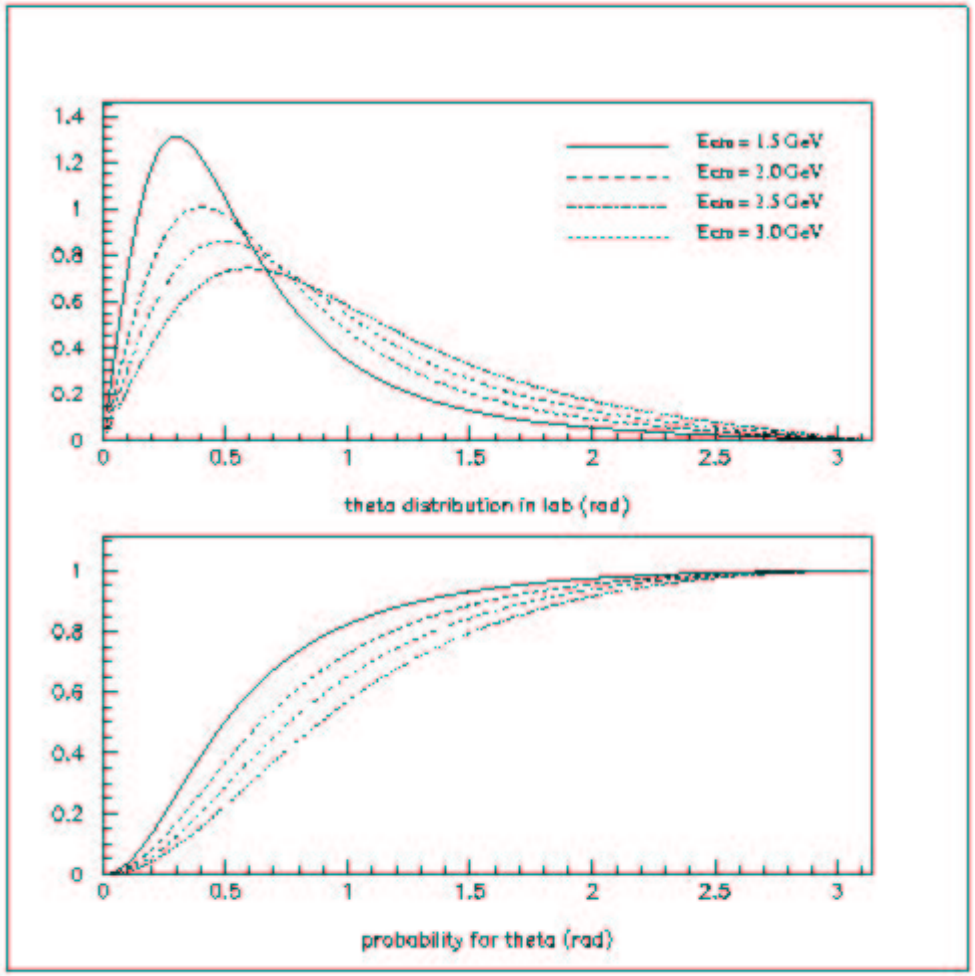
Separation between K and π in momentum range from 0.6 to 1.5 GeV/c

- Probability for misidentification of K: ~5%
- Probability for misidentification of π: ~0.05%



M.Yu.Barnyakov et al.,
Nucl.Instrum.Meth.A453:326−330,2000

Geometrical acceptance for isotropic distribution



Geometrical acceptance ~98% for θ>100mrad

(beam pipe at the end of the TPC)

Angular distribution in laboratory frame.

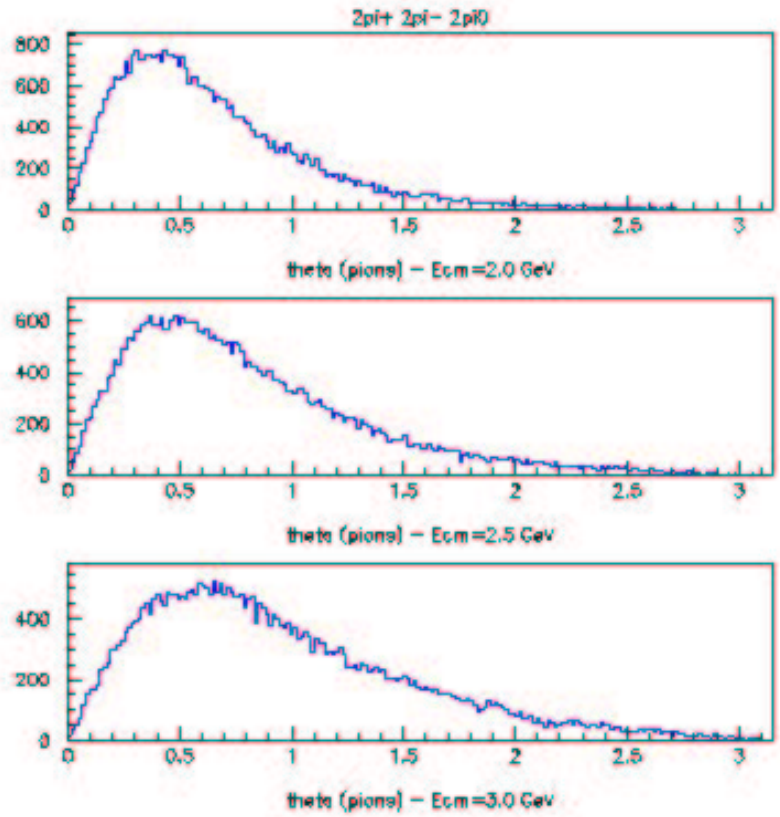
Multihadron reaction contribution

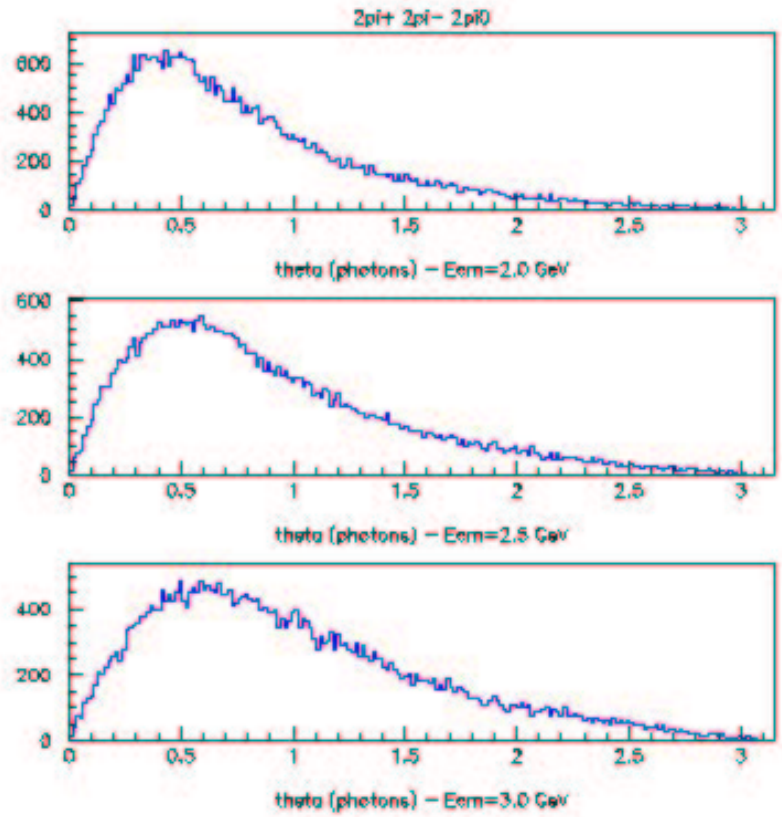
Final state	*1.5 GeV*	*2.0 GeV*	*lreac*
π+ π−	3%		1
π+ π+ π0	4%	1.5%	2
π+ π− 2π0	40%	21.5%	3
2π+ 2π−	36%	16%	4
2π+ 2π− π0	2%	1%	5
π+ π− 3π0	1%	0.5%	6
2π+ 2π− 2π0	6%	24%	7
3π+ 3π−	1%	5%	8
π+ π− 4π0	2%	8%	9
K+ K−	4%	1.5%	10
K+ K− π0	1%	3%	11
K+ K− π+ π−		8%	12
K+ K− π0 π0		4%	13
Ks Kl		0.5%	14
Ks Kl π+ π−		4%	15
Ks Kl π0 π0		1.5%	16

lreac = reaction code in the simulation

$2\pi^+ 2\pi^- 2\pi^0$ simulation

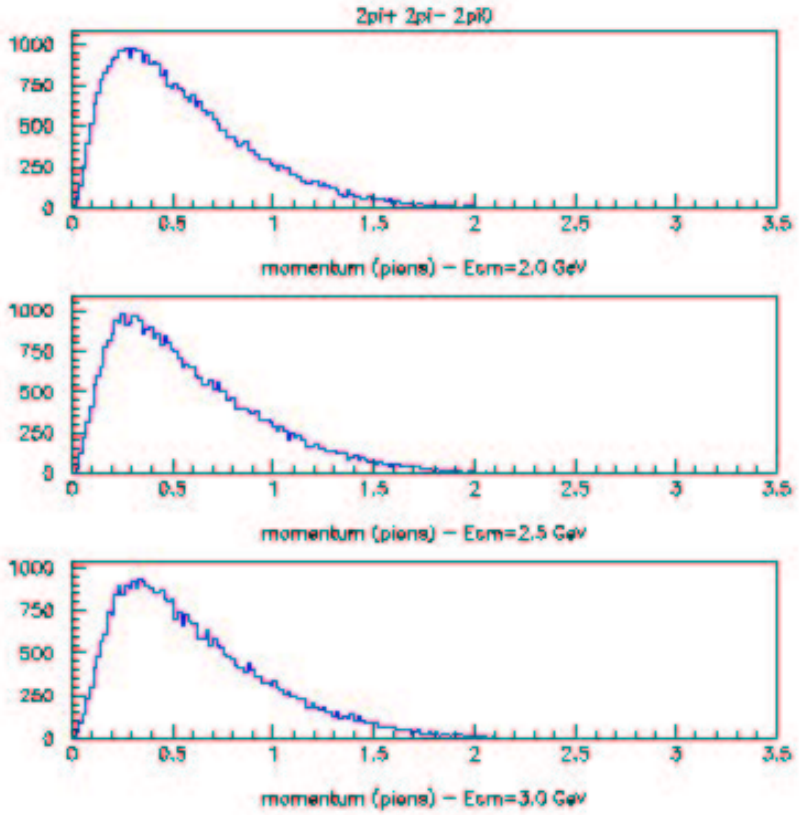
Polar angle distribution for charged π and γ for CM energy of 2.0 GeV, 2.5 GeV and 3.0 GeV.

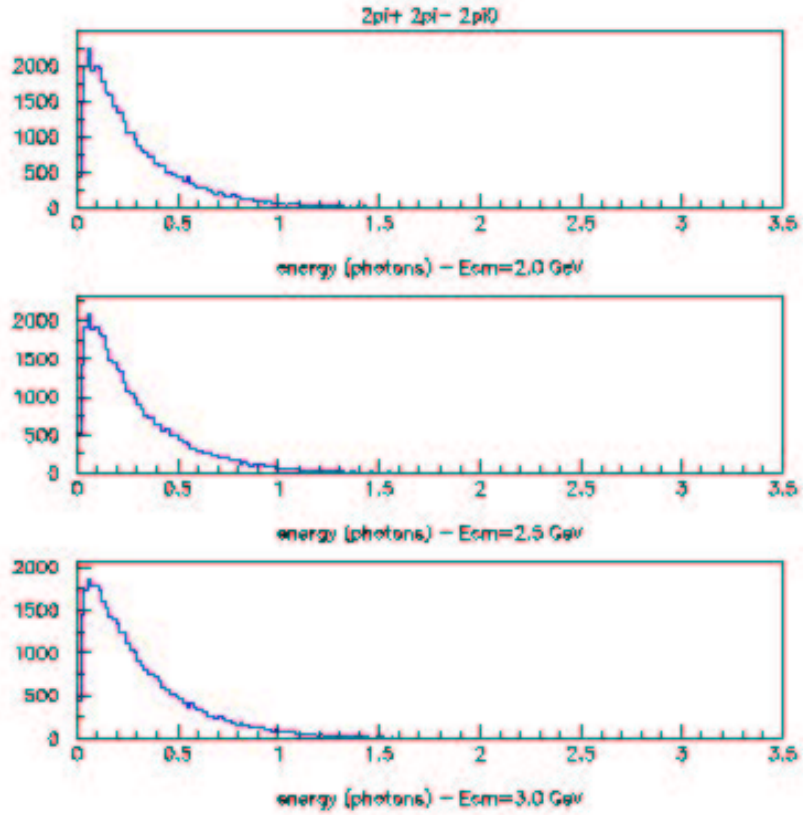




$2\pi^+ 2\pi^- 2\pi^0$ simulation

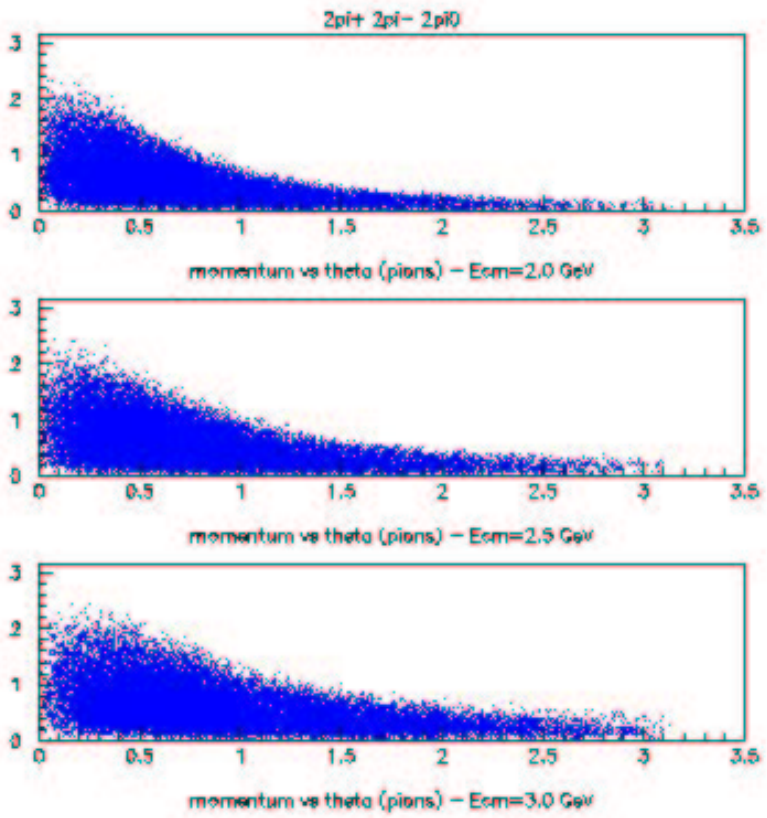
Momentum (π) and energy (γ) distribution.
CM energy = 2.0 GeV, 2.5 GeV, 3.0 GeV

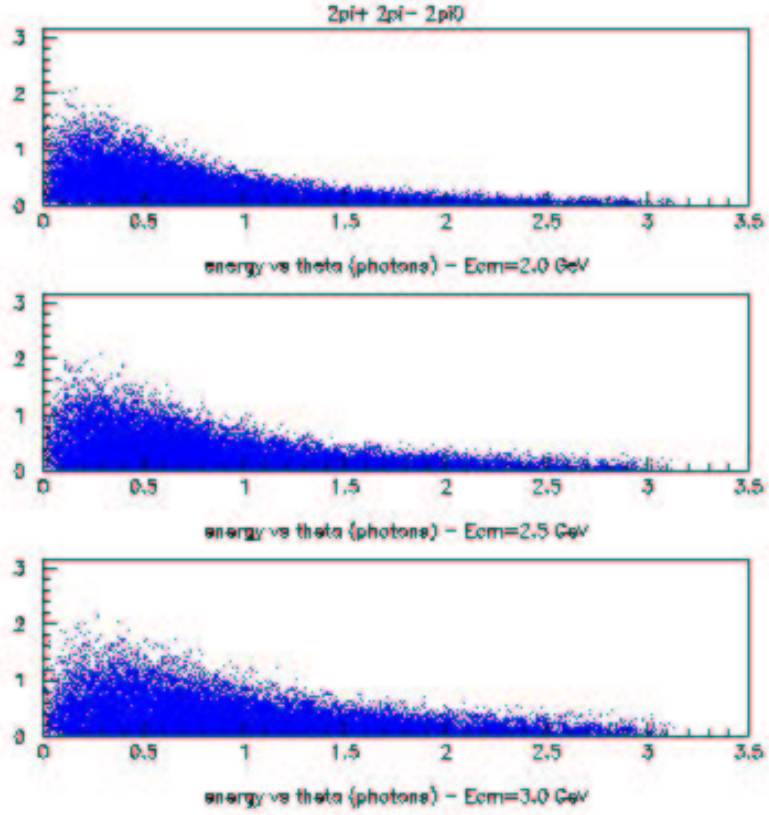




$2\pi^+ 2\pi^- 2\pi^0$ simulation

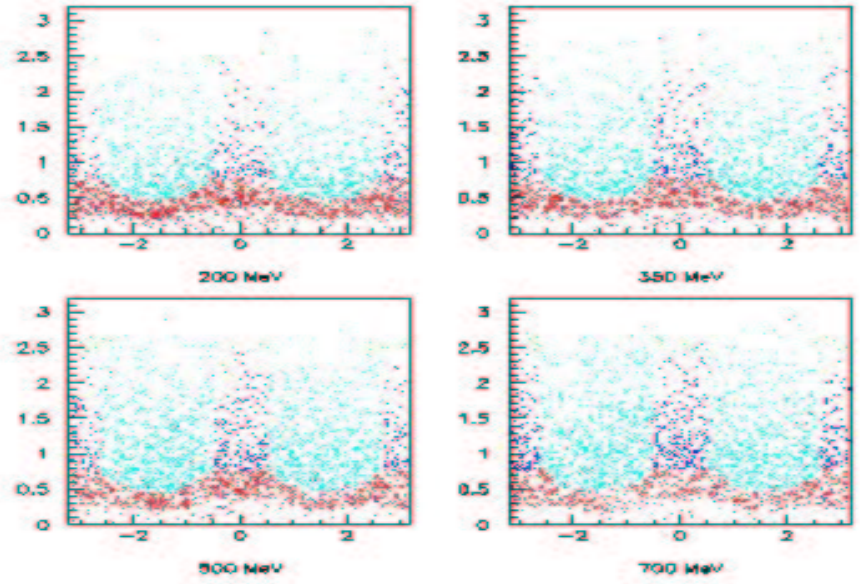
Scatter plot of momentum (π) and energy (γ) distribution vs θ.
CM energy = 2.0 GeV, 2.5 GeV, 3.0 GeV





$2\pi^+ 2\pi^- 2\pi^0$ simulation

Angular distribution (θ vs φ) of γ into the calorimeters for different values of CM energy.



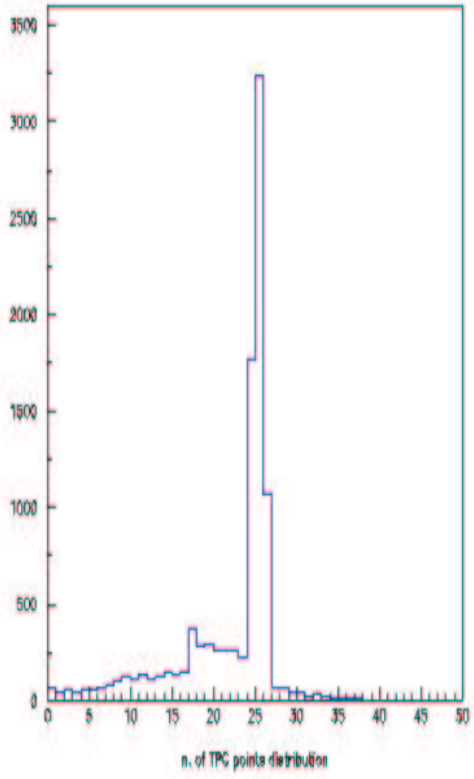
Forward CAL
Barrel CAL
Pole CAL

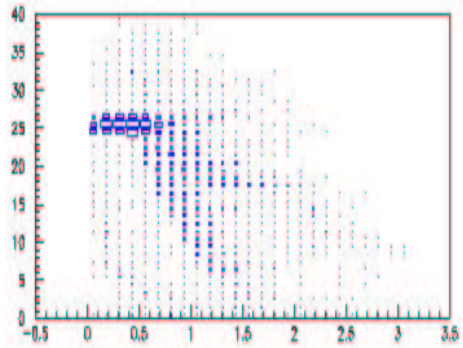
CM energy	*Not detected*	*FCAL*	*BCAL*	*PCAL*	*RCAL*
1.5 GeV	17.5%	42.2%	9.3%	30.5%	0.5%
2.0 GeV	12.6%	35.4%	13.6%	37.9%	0.5%
2.5 GeV	9.4%	31.2%	14.1%	44.5%	0.8%
3.0 GeV	7.8%	25.8%	17.8%	47.4%	1.2%

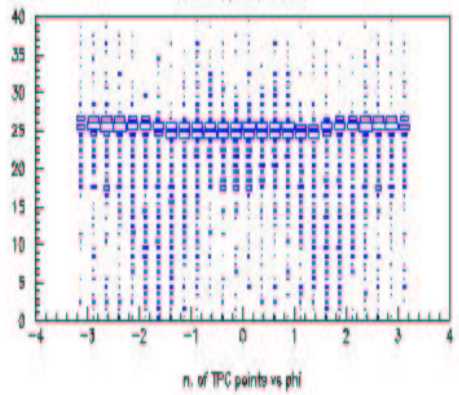
TPC resolution

~70% of the tracks have a number of points in the TPC between 20 and 30.

Typical momentum resolution for those tracks between 1% and 5%.







TPC resolution parametrization: $\frac{dp}{p} = \frac{66.2\, p_T}{N_{point}^{2.46}}$

Detection of exclusive channels

Particle selection:

- charged π,K detected if seen in 5 or more TPC pad layers
- K identified in aerogel or with dE/dx
- γ detected with cut at 20MeV and calorimeter efficiency

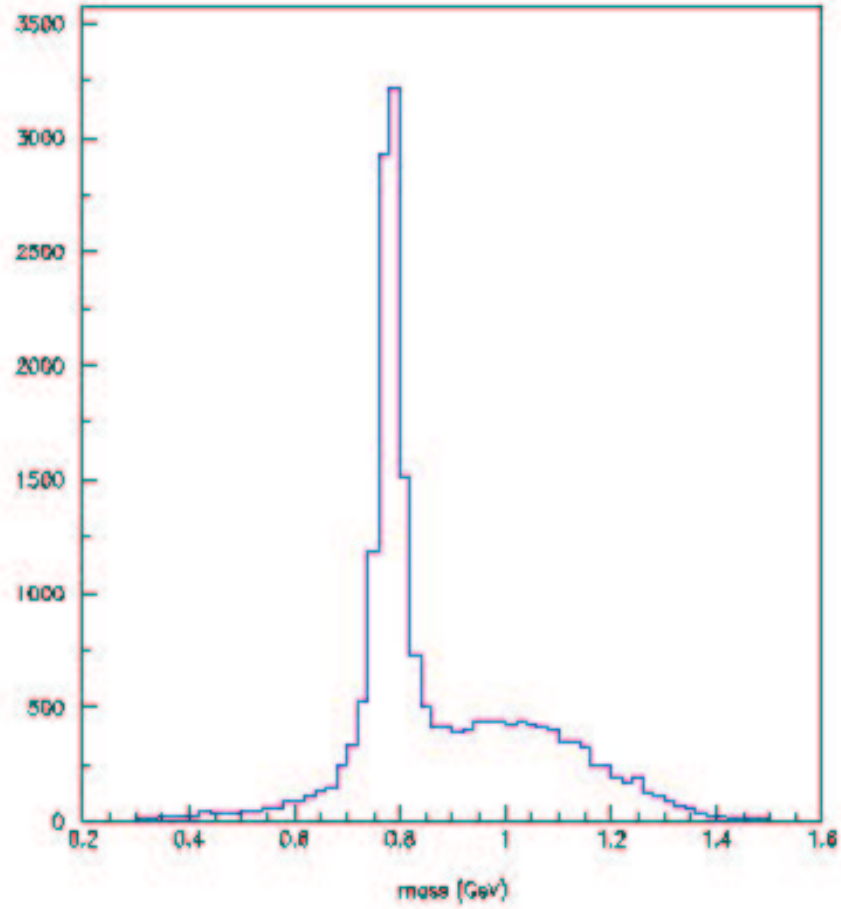
Acceptances for detection of the most important exclusive final states:

Channel	1.5 GeV	2.0 GeV	2.5 GeV	3.0 GeV
$\pi^+ \pi^- 2\pi^0$ (all detected)	42.7%	56.3%	64.2%	
$\pi^+ \pi^- 2\pi^0$ (1 part. lost)	90.4%	94.1%	95.1%	
$2\pi^+ 2\pi^- 2\pi^0$ (all detected)		52.0%	56.6%	55.3%
$2\pi^+ 2\pi^- 2\pi^0$ (1 part. lost)		82.8%	80.6%	79.9%
$\pi^+ \pi^- K^+ K^-$ (all detected)		82.0%	73.0%	63.4%
$\pi^+ \pi^- K^+ K^-$ (1 part. lost)		90.9%	82.3%	72.0%

Resonance detection

Example of reconstruction of ω invariant mass from $\omega\pi^0$ events on $\pi^+ \pi^- 2\pi^0$ background.

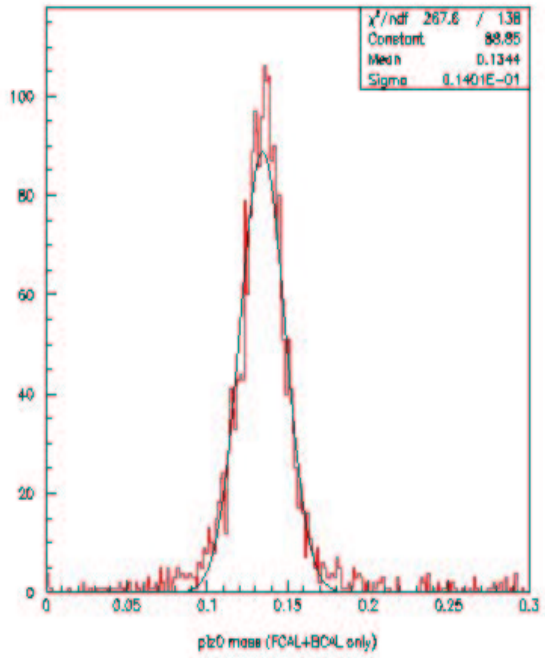
Cut on invariant mass between 0.70 GeV and 0.87 GeV
90.0% efficient with ~20% background.



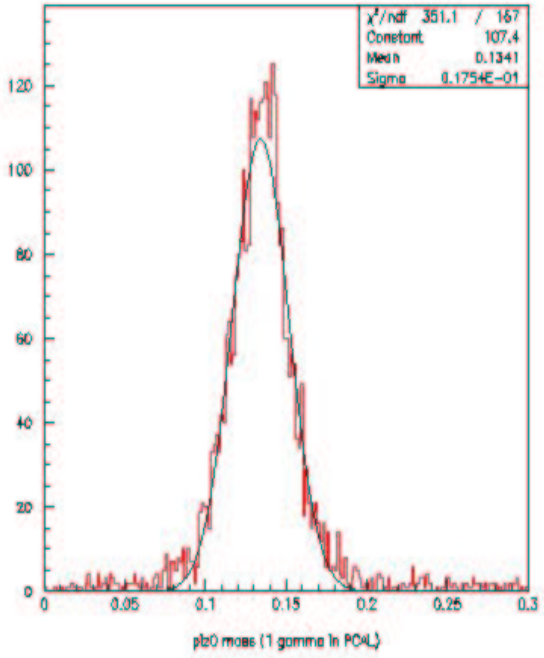
π^0 reconstruction

Example of π^0 reconstruction in calorimeter:

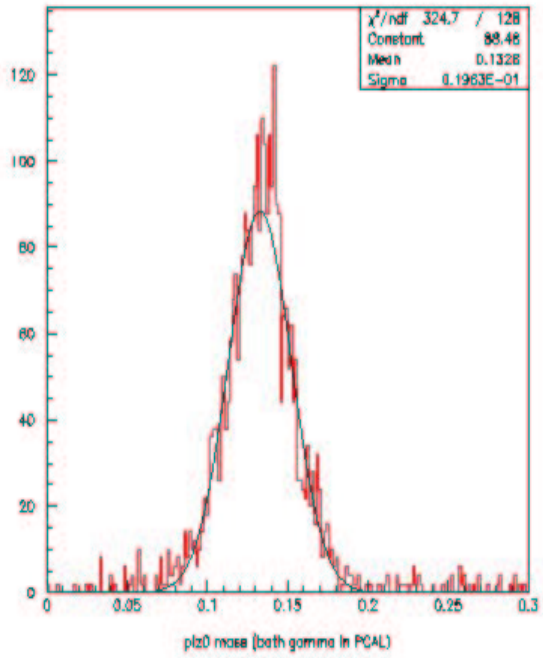
Both γ in FCAL or BCAL



One γ in FCAL or BCAL



Both γ in PCAL



Detection efficiency on K

Multihadron sample built according with the proportions given on the previous table.

Cuts:

- $n_{\pi} \geq 3$ (π detected if hits 5 or more TPC layers)

or

- $n_{\pi} \geq 2$ and $n_{\gamma} \geq 1$ (γ detected with cut at 20 MeV)

or

- $n_{\pi} \geq 1$ and $n_{\pi_0} \geq 1$

or

- $n_{K} \geq 1$ (K detected in aerogel or if hits 5 or more TPC layers)

or

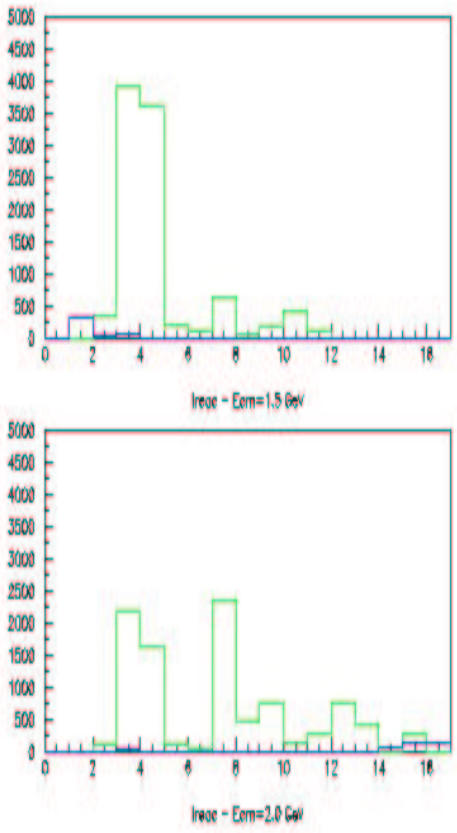
- $n_{\pi} \geq 1$ and $n_{Ks} \geq 1$ (energy deposition in calorimeters from Ks)

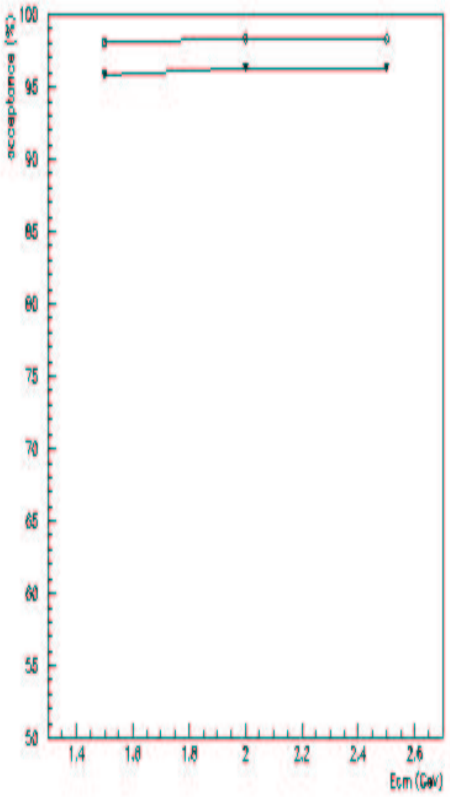
Detection efficiency on K

Ecm (GeV)	*Efficiency*
1.5	95.6%
2.0	96.3%
2.5	96.3%

lerac: green detected
blue not detected

Efficiency vs CM energy





Very high efficiency even with the basic cuts applied.

Losses, mostly due to channels:

- $\pi^+ \pi^-$
- $K_s K_l X$

can be recovered with hadron calorimeter and special trigger to reach efficiency >98% (not simulated).

Exclusive detection efficiency

Final state	*Fraction at 2.0 GeV*	*All particles detected*	*One particle not detected*
π+ π–	––	––	––
π+ π+ π0	1.5%	76.5%	98.8%
π+ π– 2π0	21.5%	56.3%	94.1%
2π+ 2π–	16%	89.4%	99.8%
2π+ 2π– π0	1%	68.5%	97.9%
π+ π– 3π0	0.5%	44.3%	86.9%
2π+ 2π– 2π0	24%	52.0%	82.8%
3π+ 3π–	5%	82.5%	99.1%
π+ π– 4π0	8%	30.2%	72.0%
K+ K−	1.5%	29.6%	29.7%
K+ K− π0	3%	54.1%	72.3%
K+ K− π+ π–	8%	82.0%	90.9%
K+ K− π0 π0	4%	54.1%	85.9%
Ks Kl	0.5%	––	––
Ks Kl π+ π–	4%	––	––
Ks Kl π0 π0	1.5%	––	––

NOTE: For channel with charged K, at least one K is required to be identified in aerogel or with dE/dx