Kaon Decay workshop for Young Phycisists

Study of separation of neutron from γ-ray up to 12 GeV with SLSD.

Feb. 14, 2001

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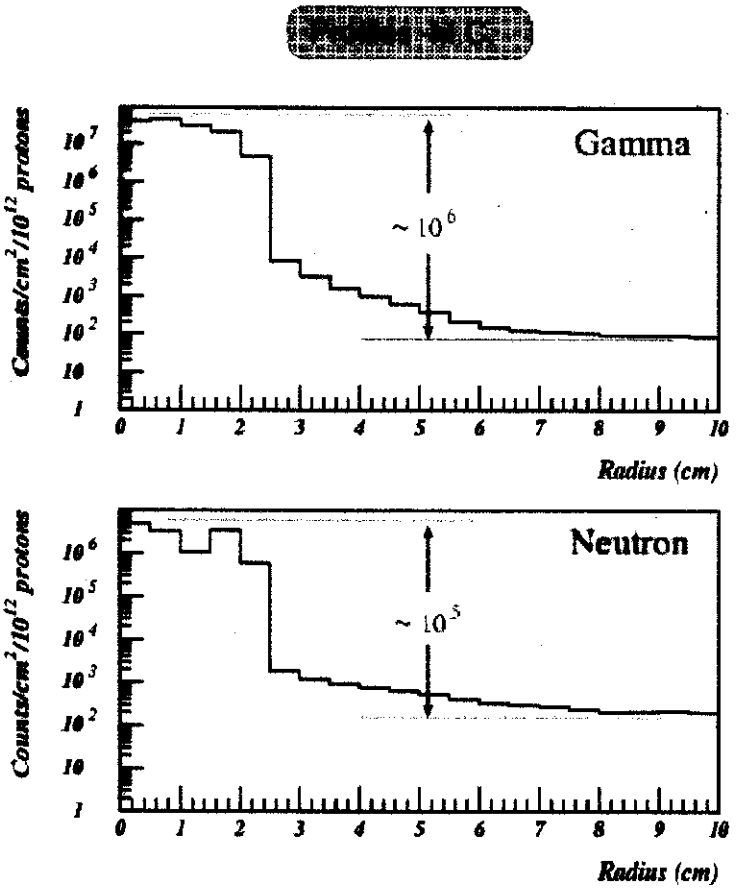
Tsukamoto Lab., Saga Uviversity
(E391a collaboration)

E391a experiment, $K_L^0 \to \pi^0 \nu\overline{\nu}$

→ Neutron flux, energy spectrum, profile(G.Y. Lim talked).

KEK-PS E391a (Search for $K_L^0 \to \pi^0 \nu\overline{\nu}$ Decay)



JPS Meeting 2000, Niigata Univ.

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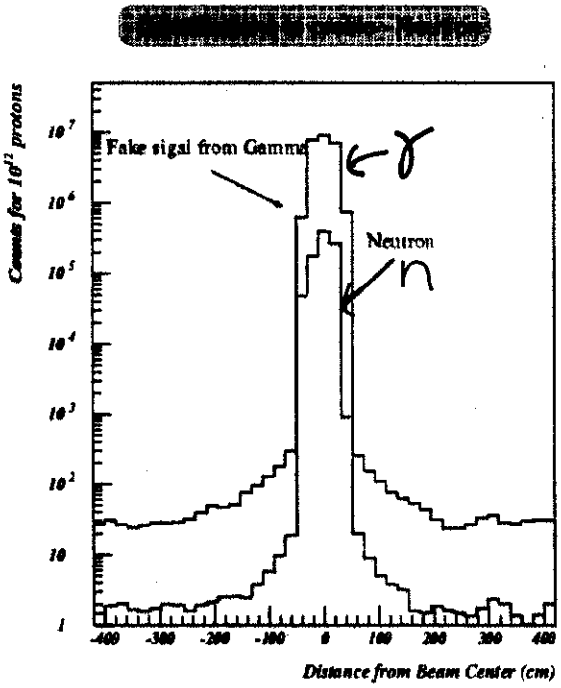
requirement : S/N ratio > 100

conventinal neutron detector

- **Single block of plastic scintillator.**
  → S/N ∼ 1
- **Hydrogen enrich scintillator, NE228(H/C ratio=2.11)**
  → S/N ∼ 2
- **Pulse Shape Discrimination of scintillators or CsI**
  → good performance up to 30 MeV.

KEK-PS E391a (Search for $K^0_L \to \pi^0\nu\bar{\nu}$ Decay)



6cm Scinti. Block

JPS Meeting 2000, Niigata Univ.

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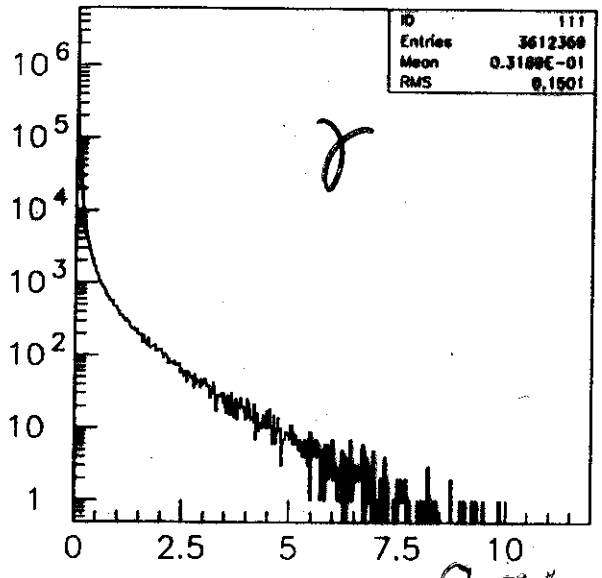
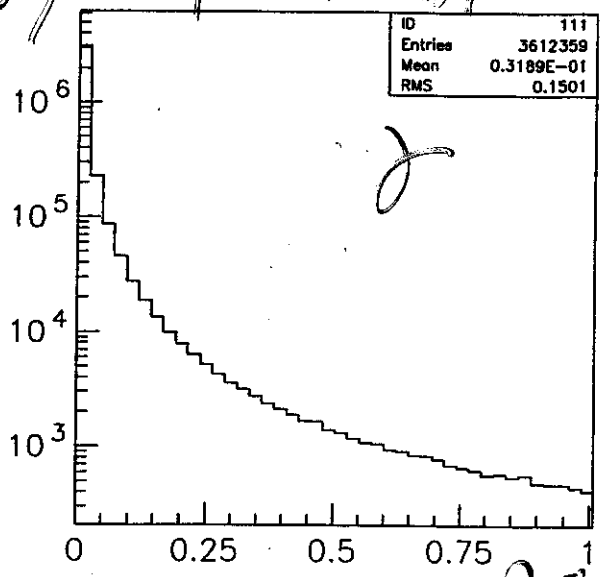
Scintillator-Lucite Sandwich Detector(SLSD).

M.C. Simulation

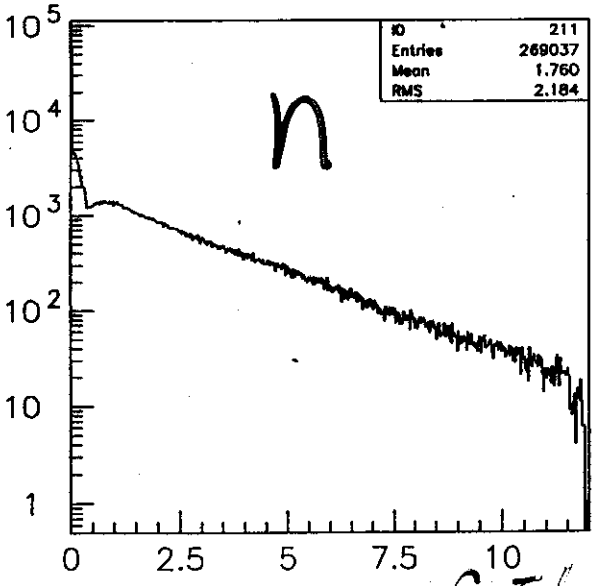
Energy spectrum



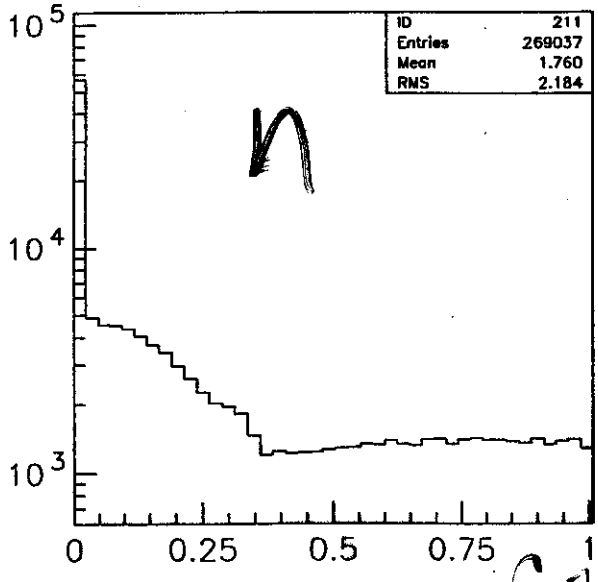
Target+6cm ganmma energy 0–r1



Target+6cm ganmma energy 0–r1



Target+6cm neutron energy 0–r1

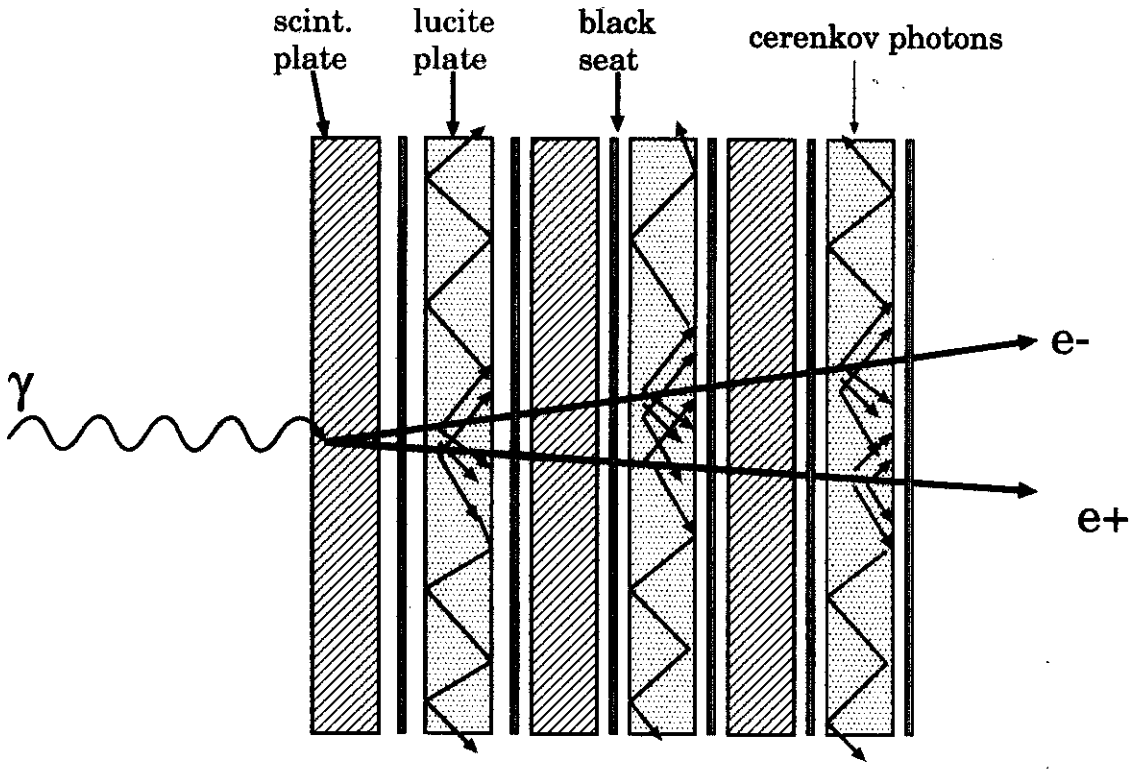


Target+6cm neutron energy 0–r1

Lucite optical property :

- **index n=1.49 → $\beta_{\check{C}}$ >0.67**
- **total reflection angle n=42° → $\beta_{\check{C}}$ >0.9**

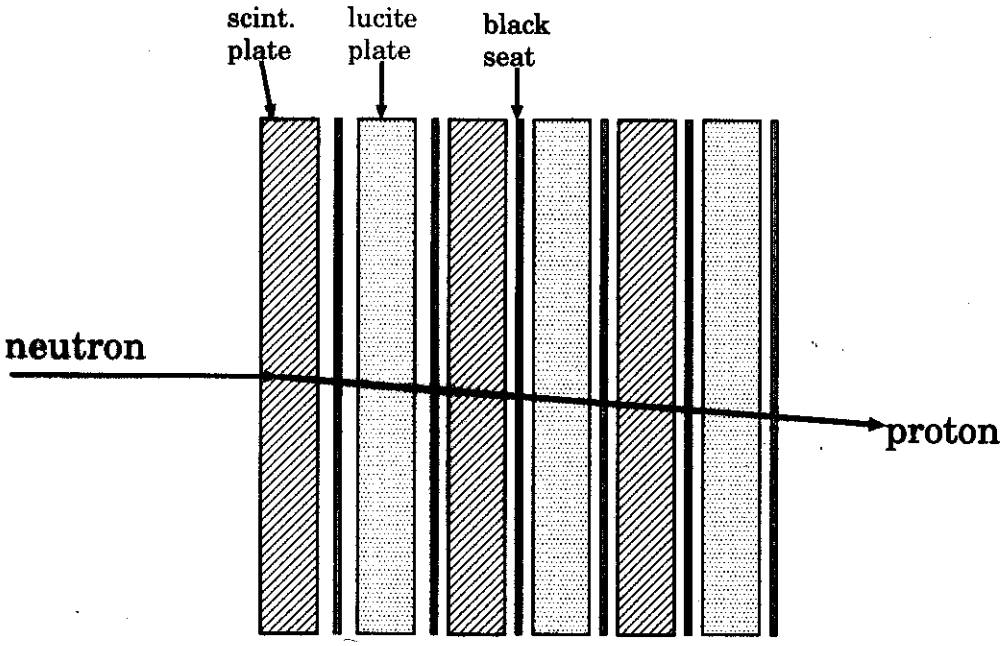
Response for γ



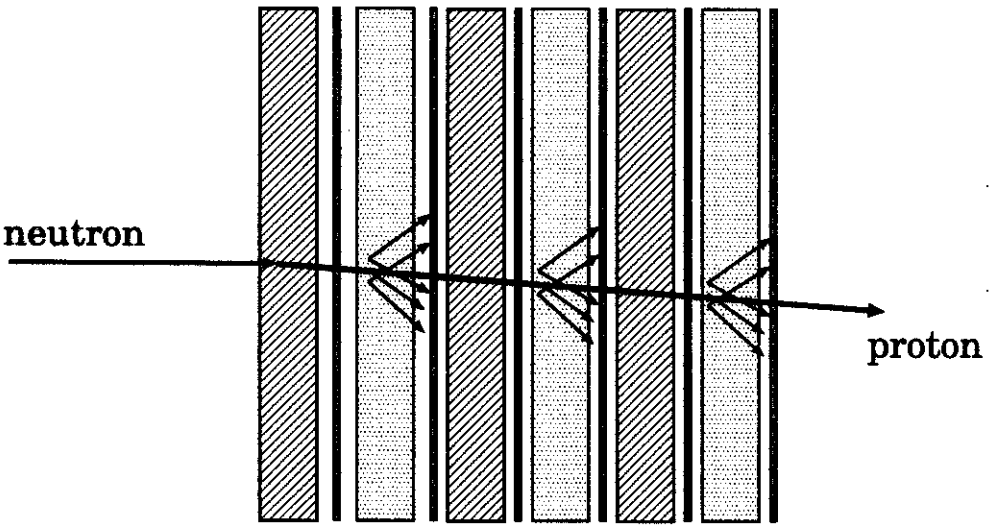
γ = Scinti. & Cerenkov

Response for neutron

n+N-->p+X



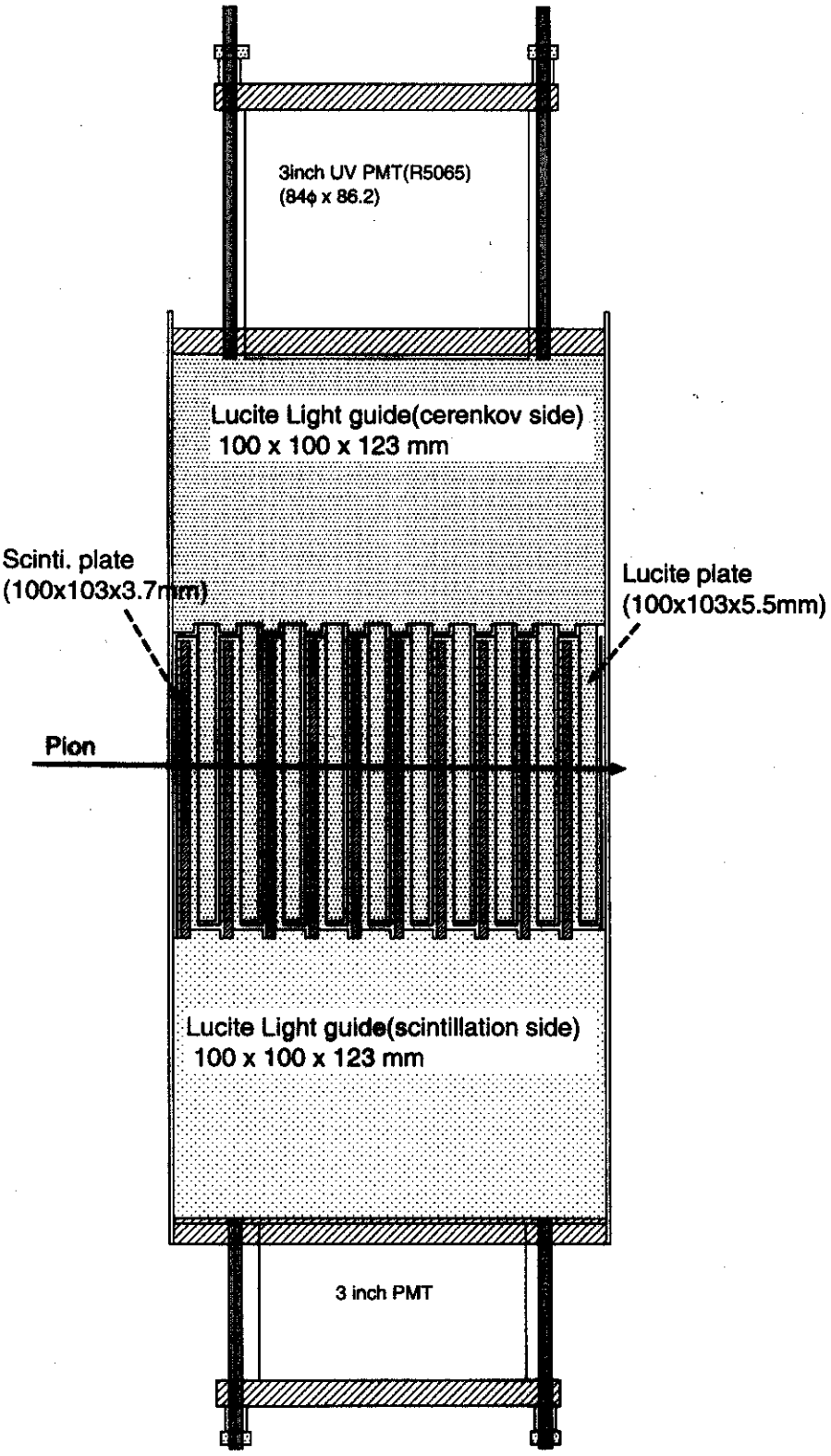
proton < 850 MeV/c --> no cerenkov photon

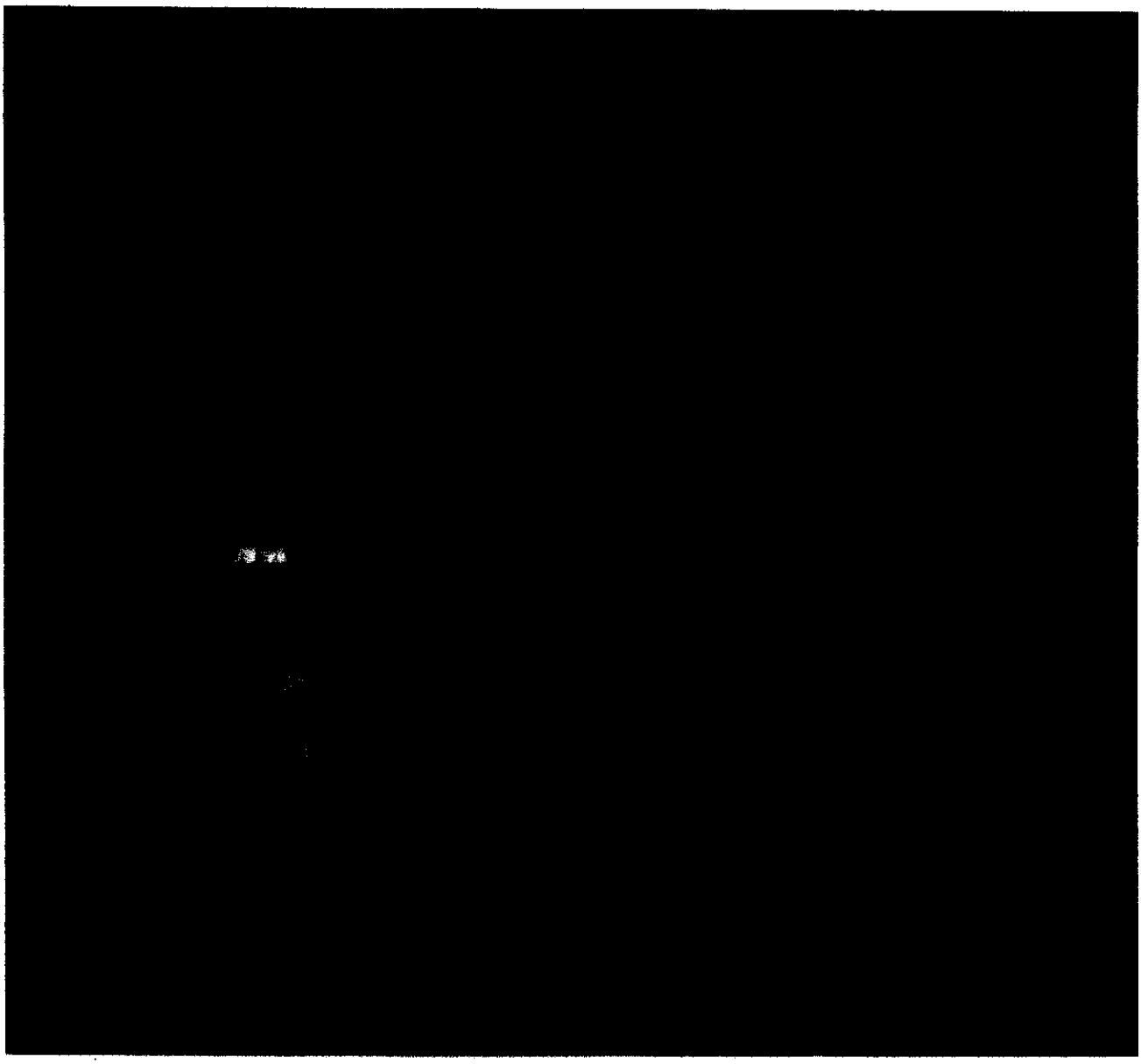


proton < 2 GeV/c ->cerenkov emitted, but below total reflection angle
--> suppress detectable cerenkov photon

Neutron = Scinti. & $\overline{\text{Cerenkov}}$

Design and Production



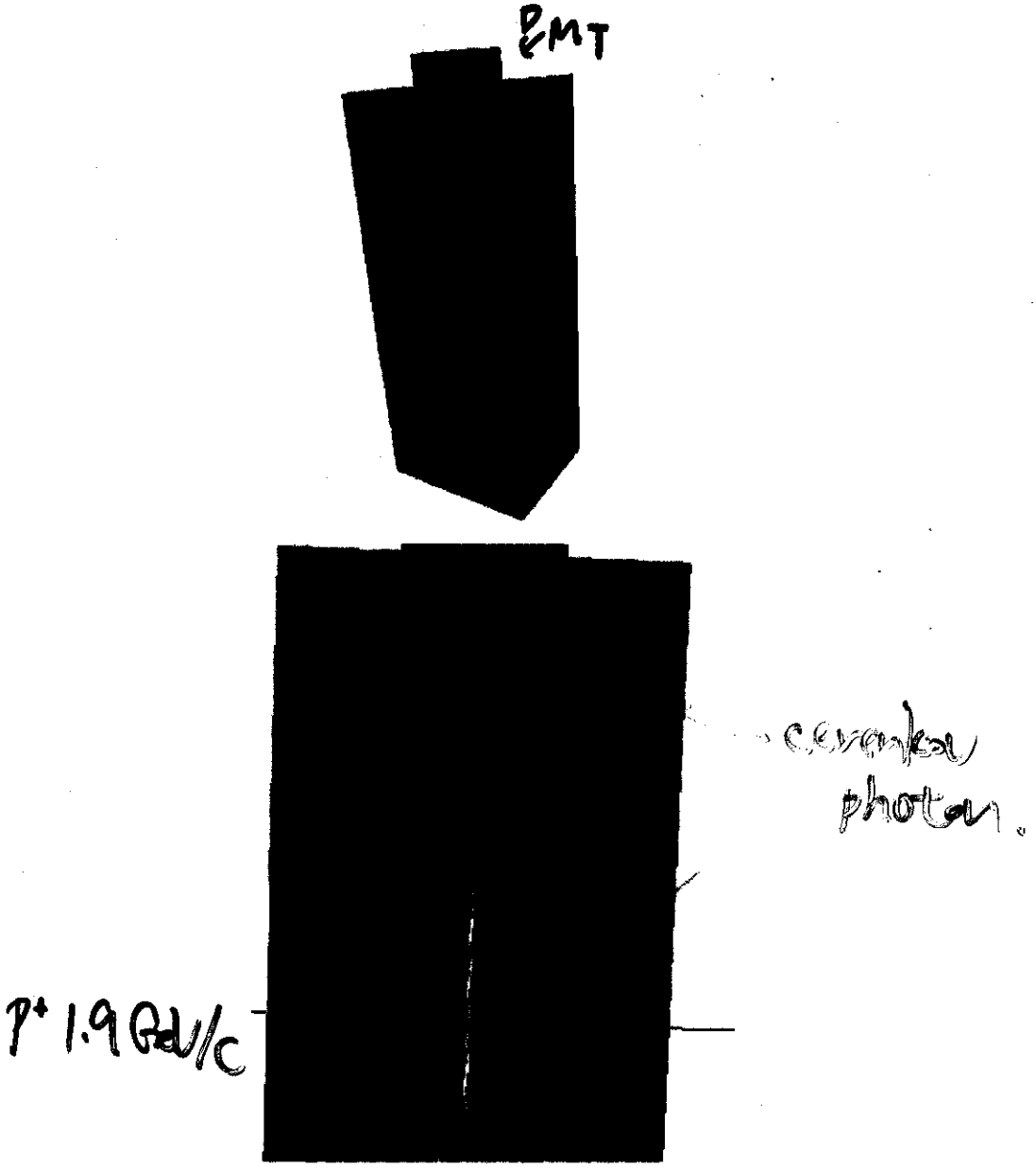


Monte carlo simulation.

Cerenkov generator and optics → GEANT4.

- detectable wavelength of cerenkov photon: 400 to 550 nm.
- PMT quantum efficiency is 15% and flat responce for wavelength.
- absorption of silicon rubber : 14%
- Unknown factor : absorption length of lucite.

Geometry



Strategy

n/γ separation → Cerenkov yield !!

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Monochromatic neutron and γ up to GeV/c → difficult!

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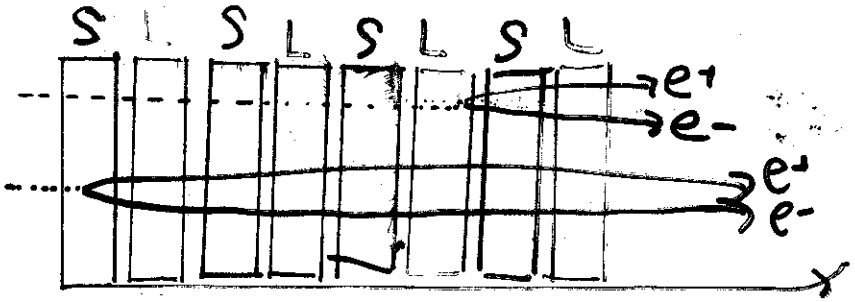
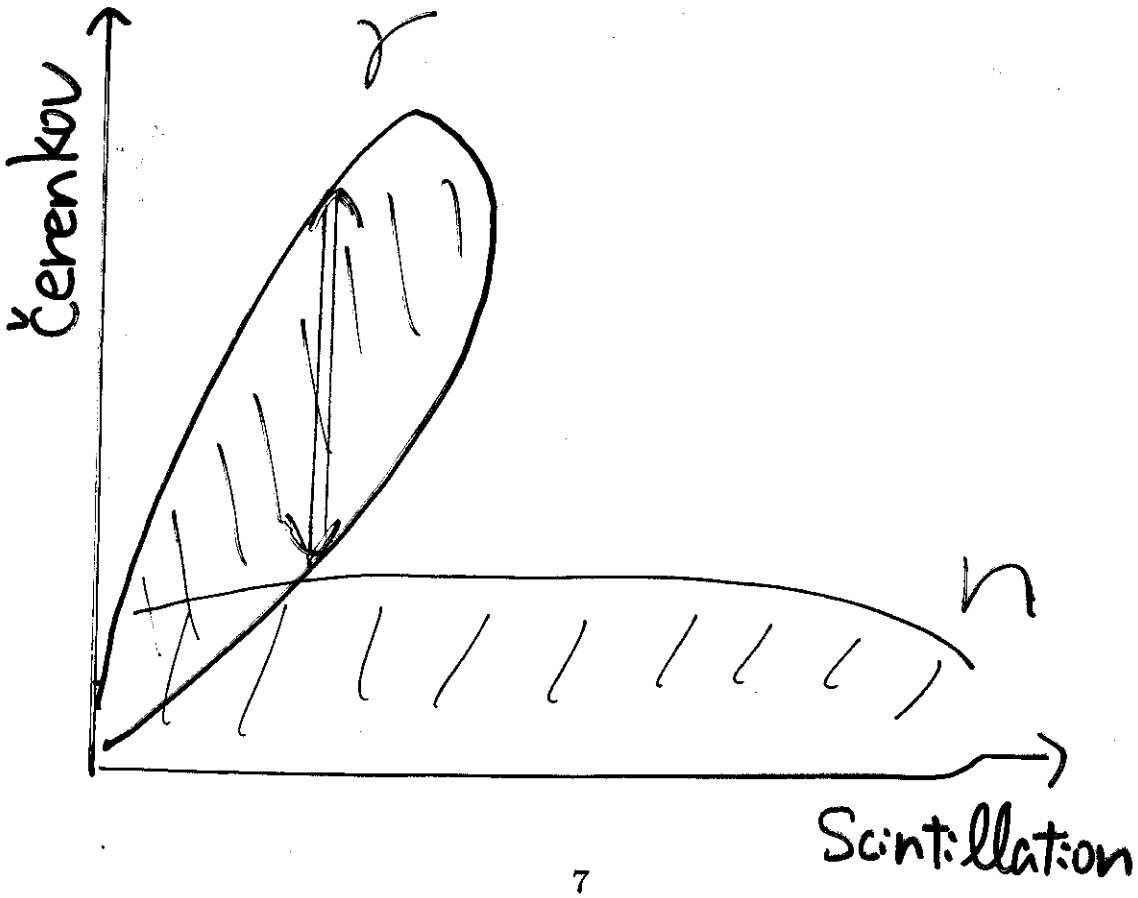
Proton, π, electron → Cerenkov yield

↓

Monte Carlo

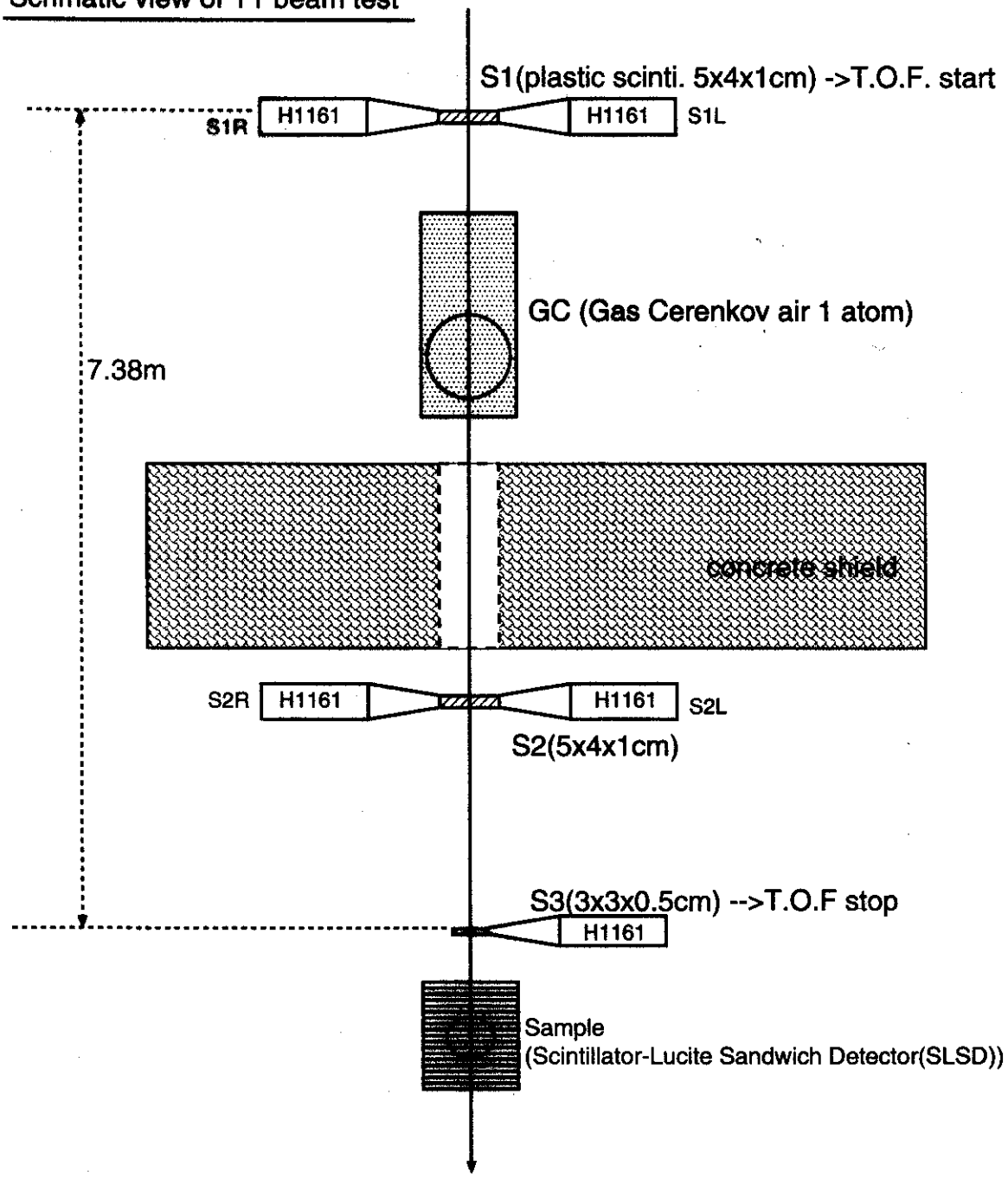




Beam test of SLSD
using proton, pion, electron
in the T1 beam line.

- **p^+/π^+ : 0.5, 0.8, 1.0, 1.2, 1.5, 2.0 GeV/c (10 kevent)**
- **Electron : -0.8 GeV/c (3000 event)**
- **Particle ID: Time Of Flight, Gas Cerenkov, dE/dx**

Schmatic view of T1 beam test

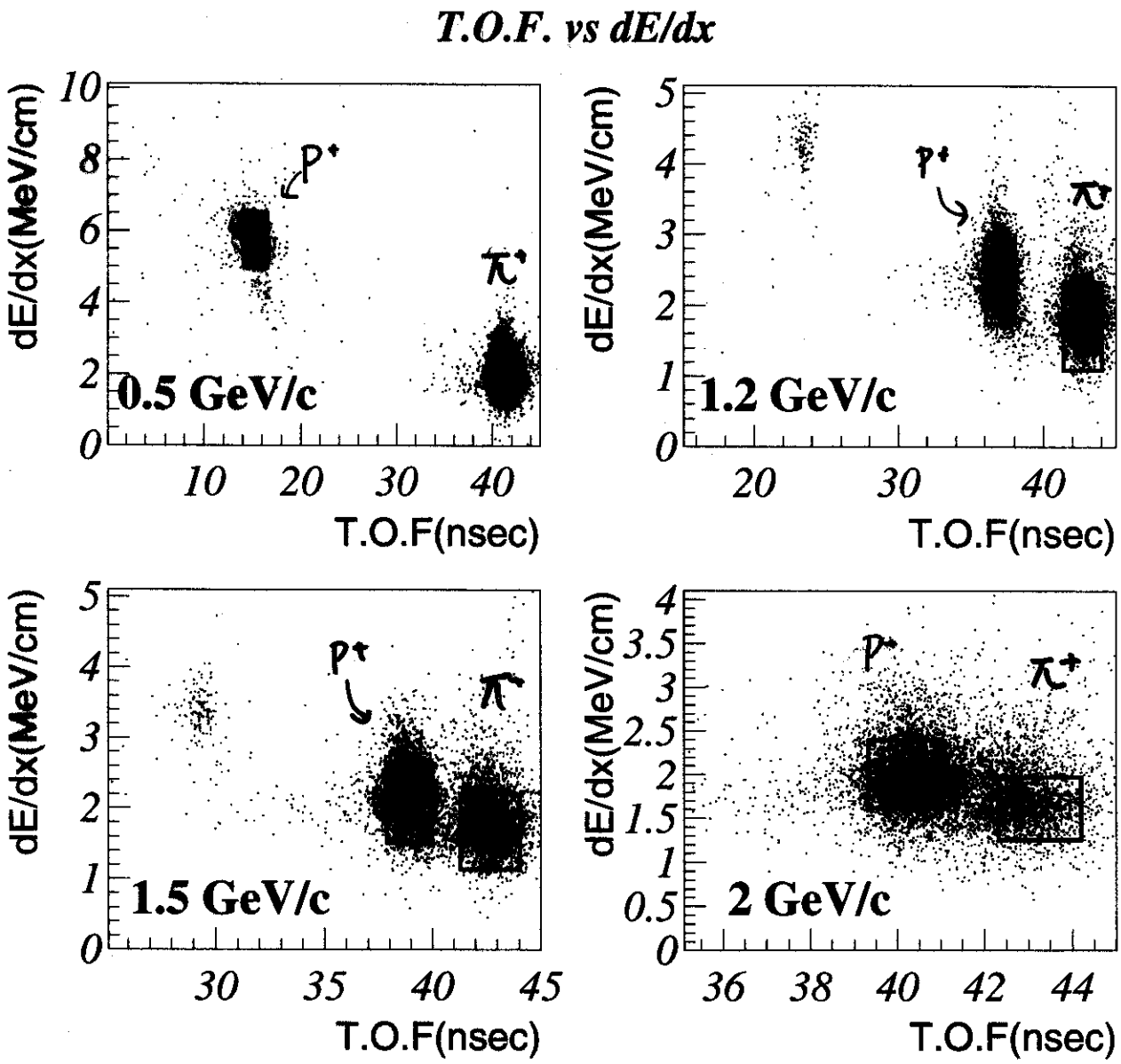


Trigger conditions

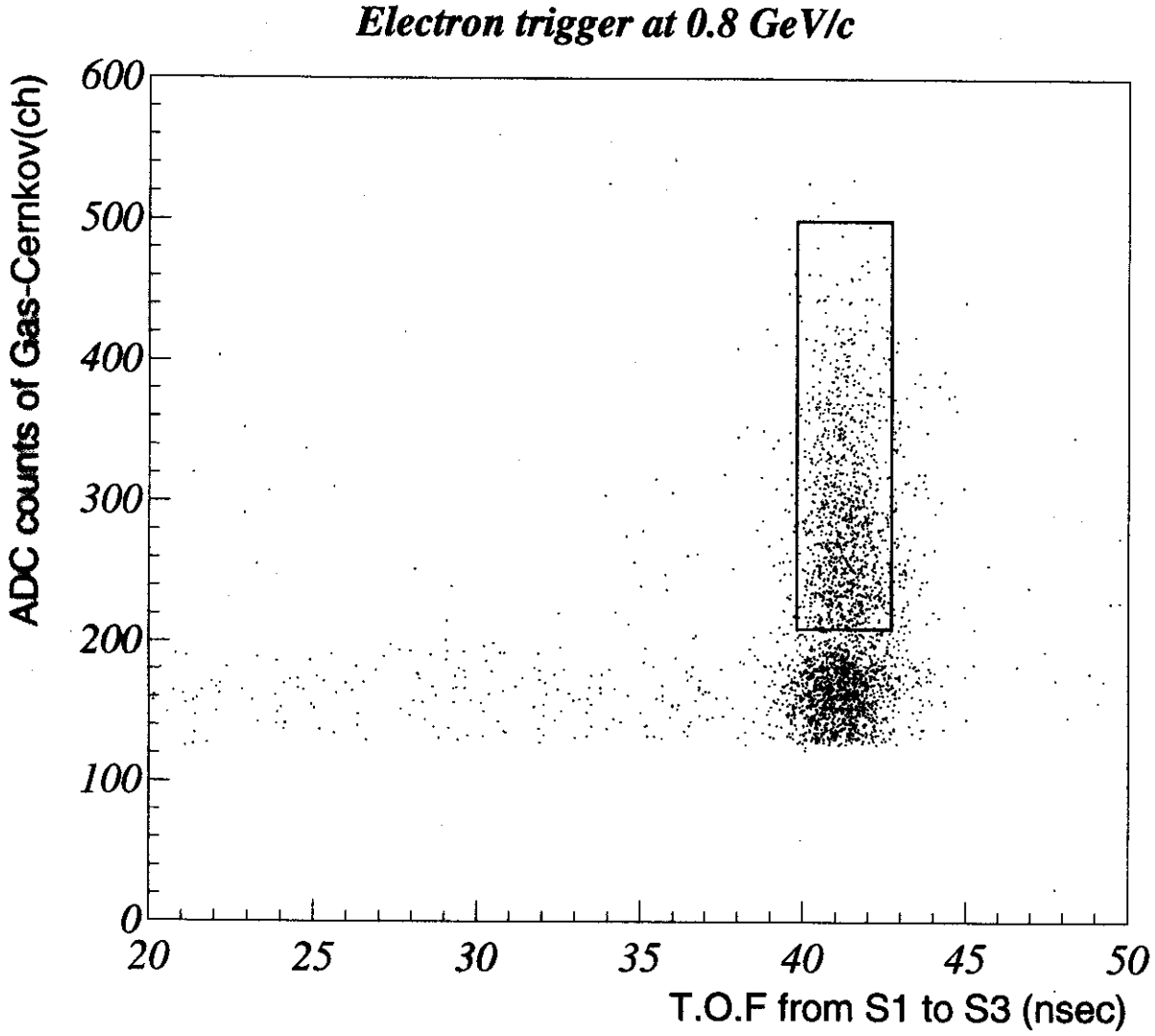
Hadron trigger : (S1L & S1R) &(S2L & S2L) & S3 -> ~100 event/spill

Electron trigger : (S1L & S1R) &(S2L & S2L) & S3 &(GS) -> ~ 1 event/spill

π/p separation using T.O.F and dE/dx(S1+S2+S3)



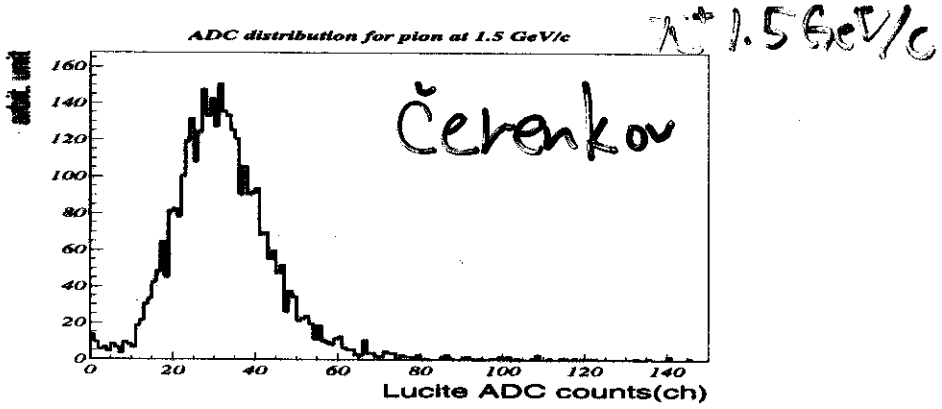
Gas Cerenkov for e/π separation

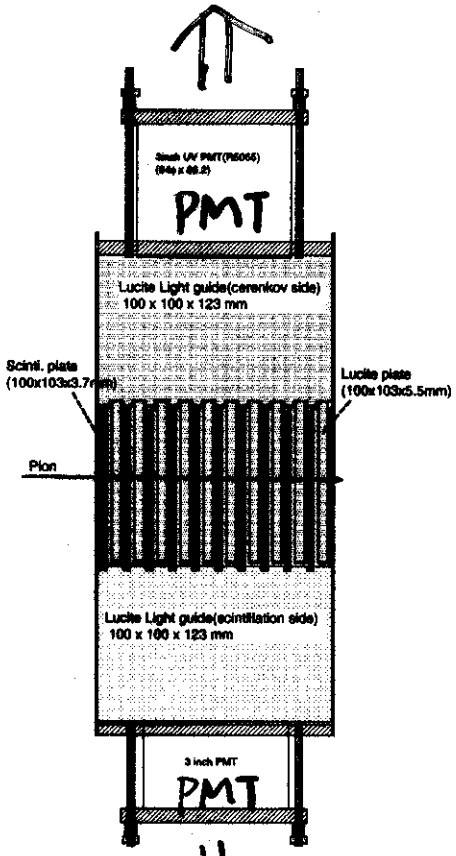


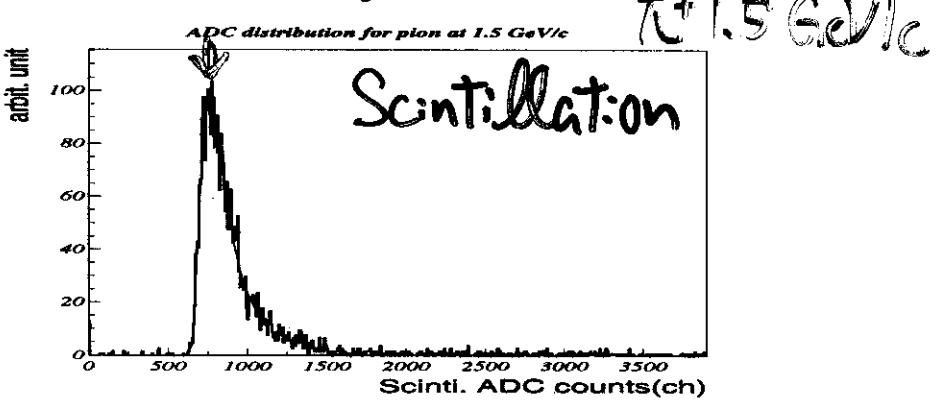
$\downarrow$

high purity $\pi^+/p^+/e^-$

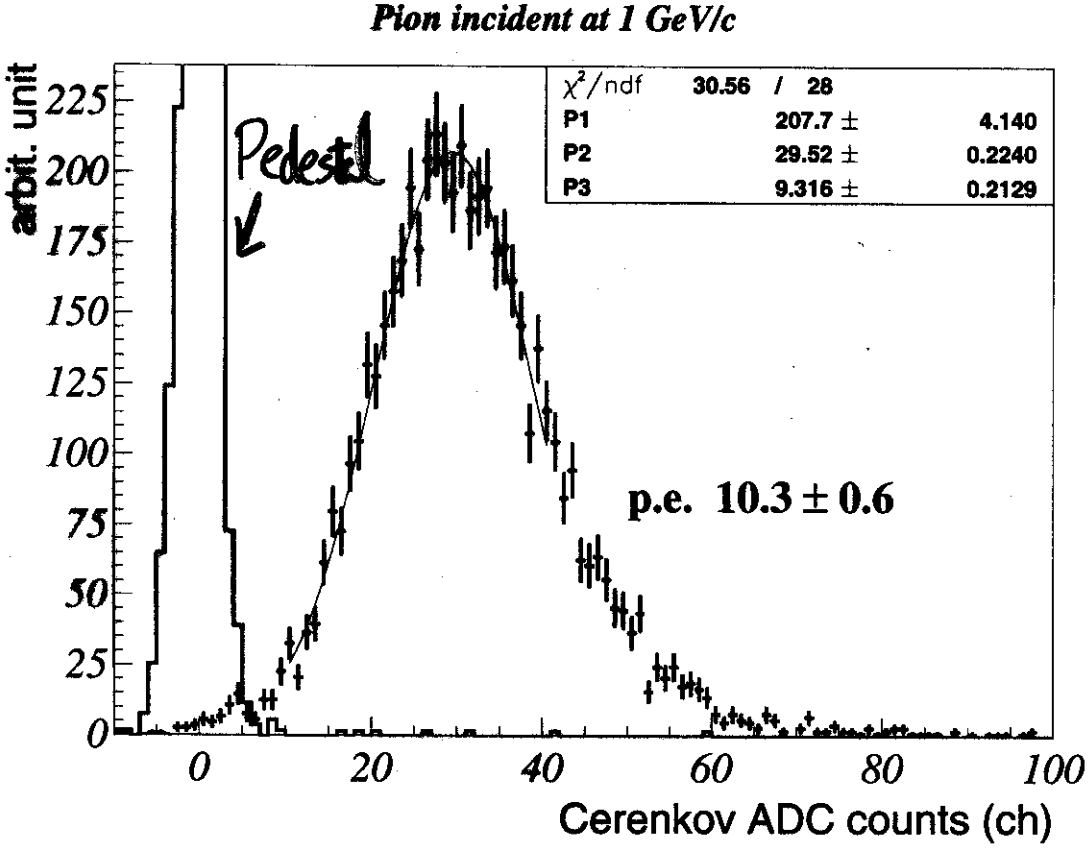
Sample(SLSD) analysis.


ADC distribution for pion at 1.5 GeV/c
arbit. unit
Čerenkov
Lucite ADC counts(ch)


PMT
Lucite Light guide(cerenkov side)
100 x 100 x 123 mm
Scinti. plate
Lucite plate
(100x103x5.5mm)
Pion
Lucite Light guide(scintillation side)
100 x 100 x 123 mm
3 inch PMT
PMT


ADC distribution for pion at 1.5 GeV/c
arbit. unit
Scintillation
Scinti. ADC counts(ch)

Calibration of Cerenkov



$N_{p.e.}$ ⇒ MIP (π^+) 0.8 ~ 1.5 GeV/c

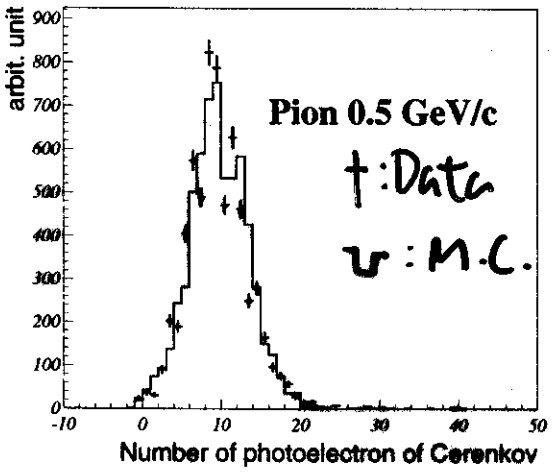
~ 11 p.e.

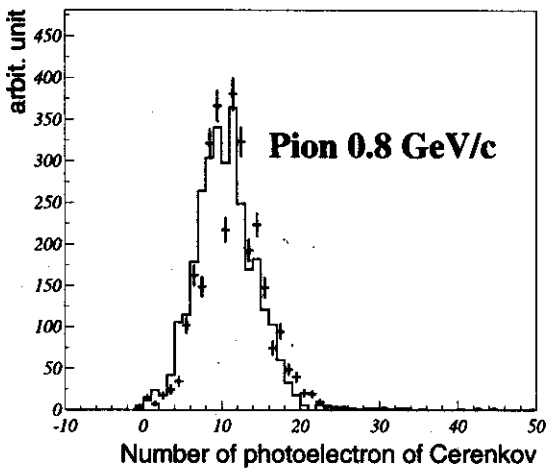
⇒ ~ 1 p.e. / layer.

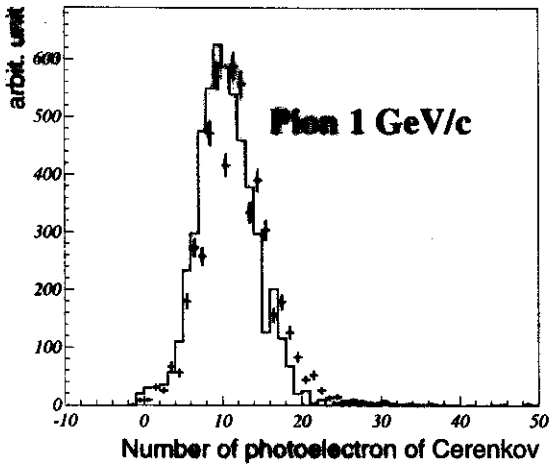
⇓

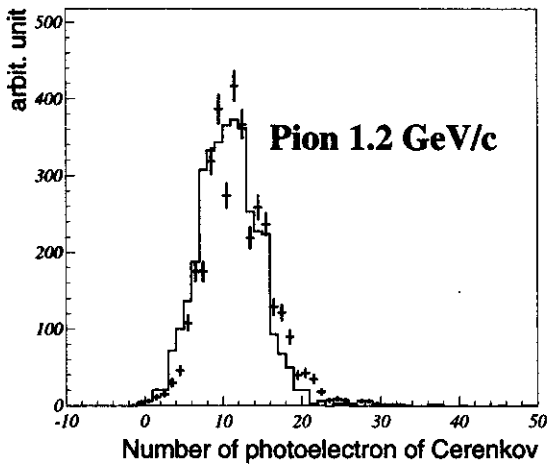
Input to M.C. simulation.

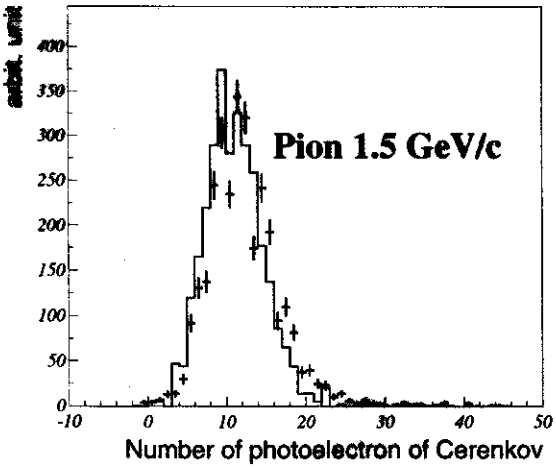
Data vs M.C. for Pion

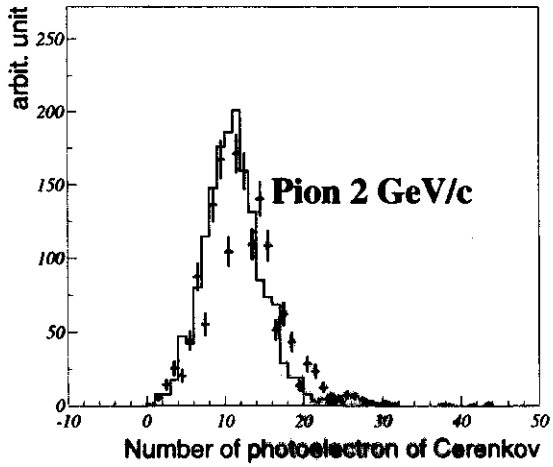




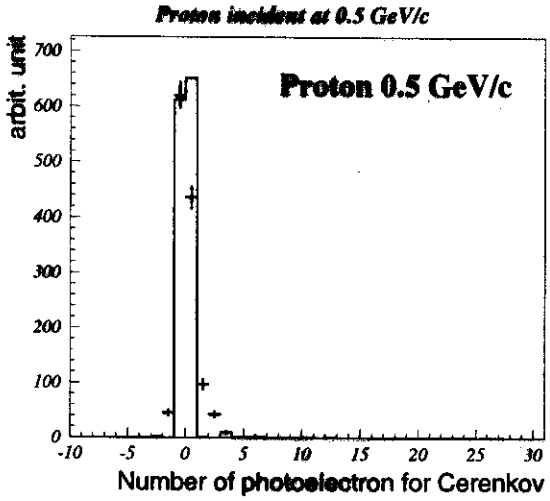


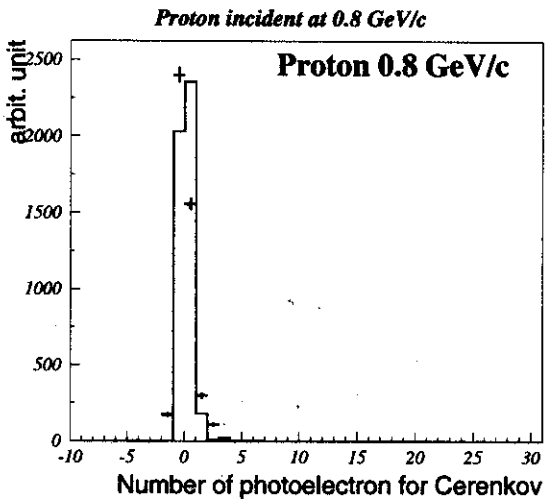


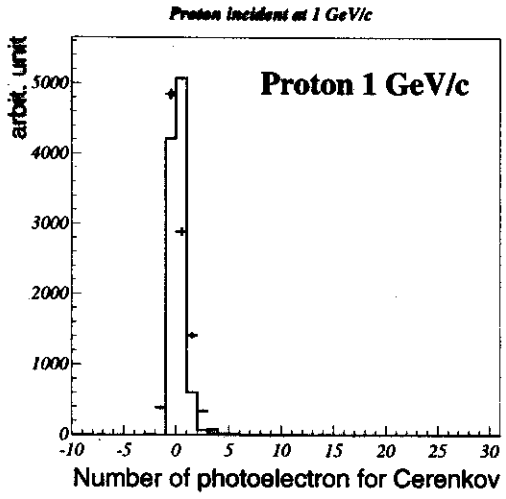


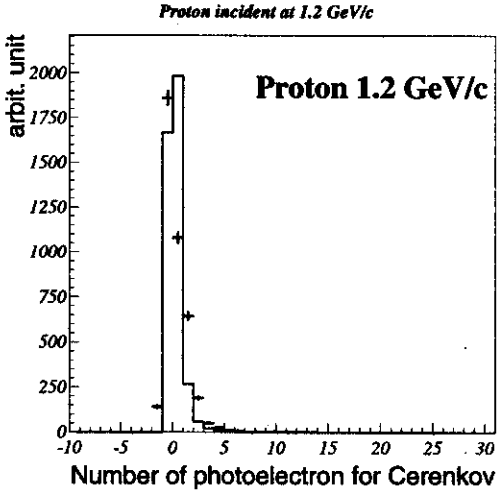


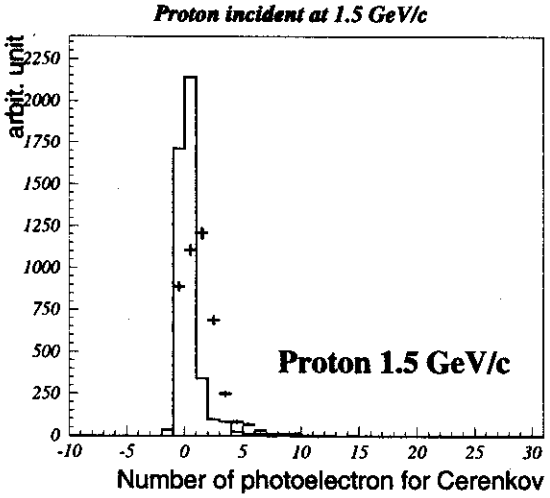
Data vs M.C. for Proton

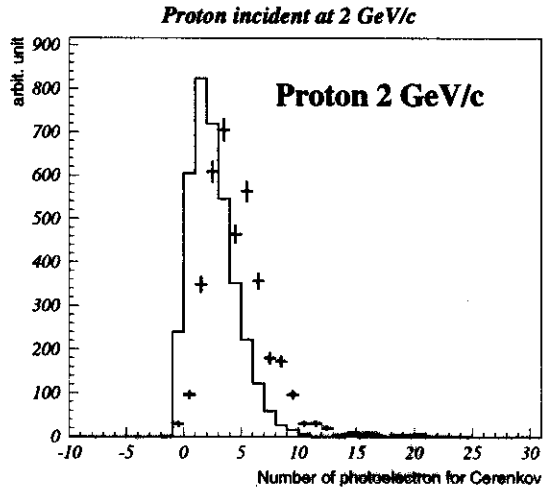








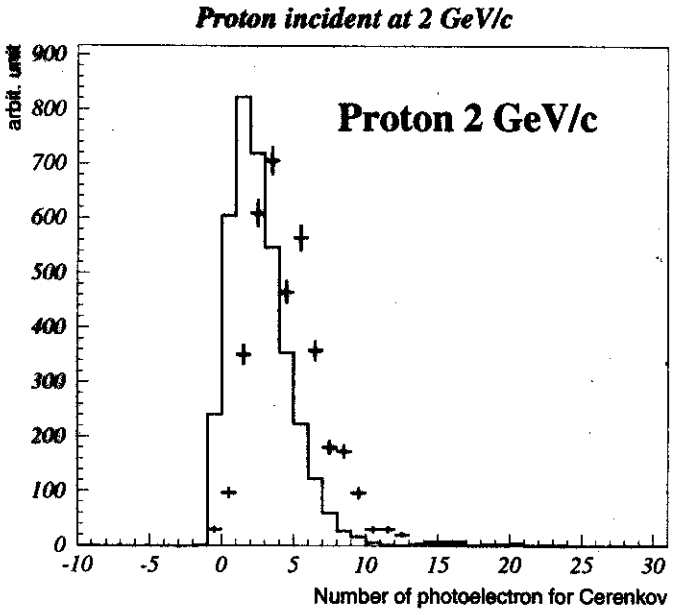


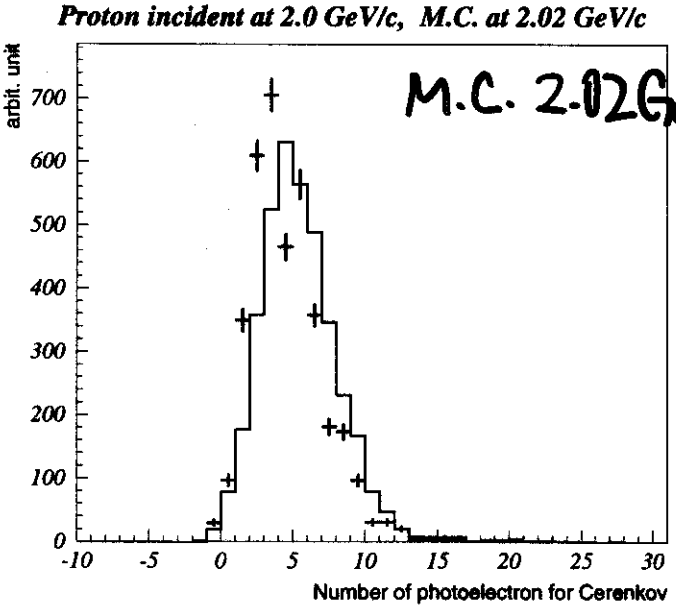


total reflecton angle

P > 2.008 GeV/c

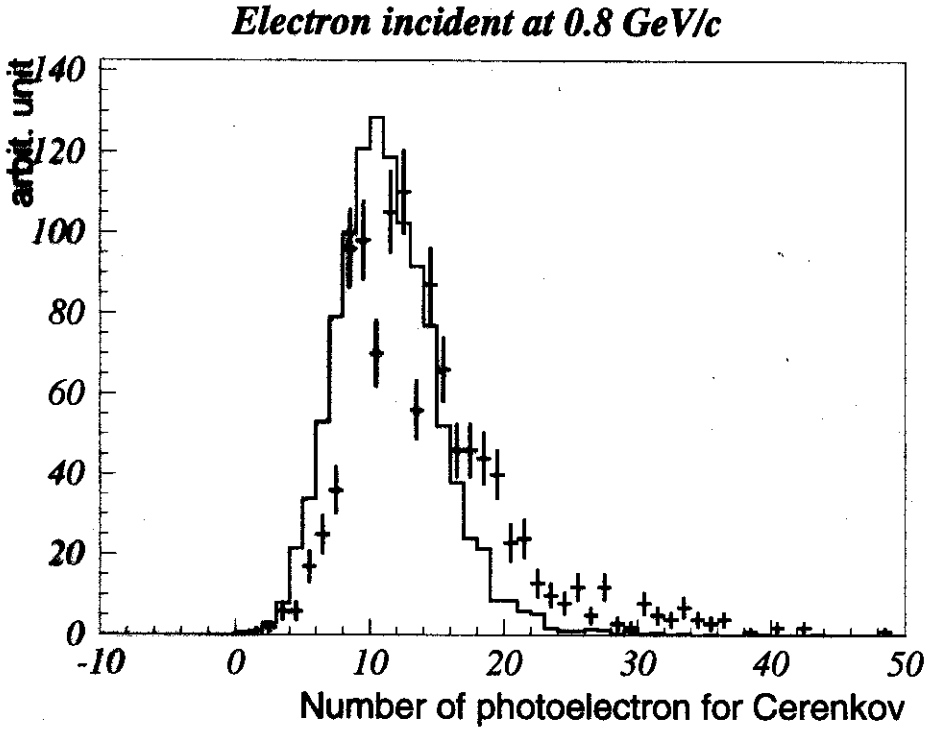
Data vs M.C. for Proton at 2 GeV/c and 2.02 GeV/c





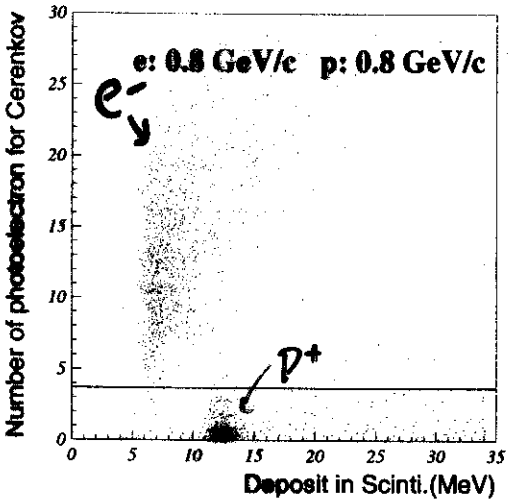
→ **Difference between data and M.C. at 2 GeV/c proton can be explaned within resolution of beam momentum.**

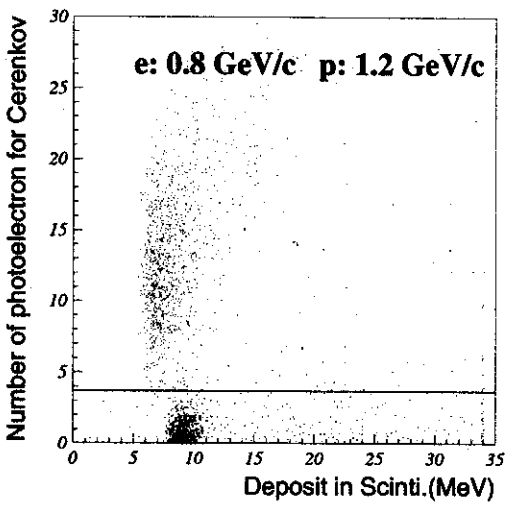
Data vs M.C. for electron

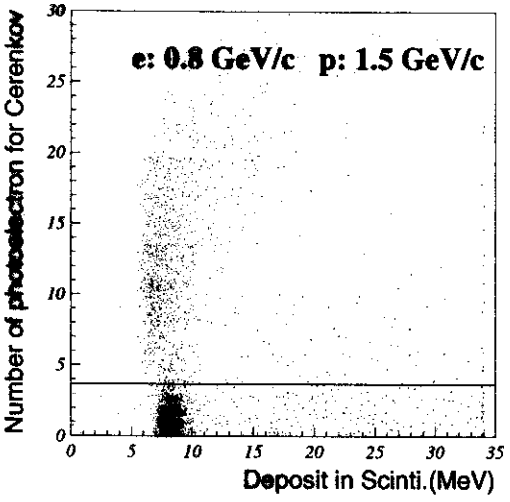


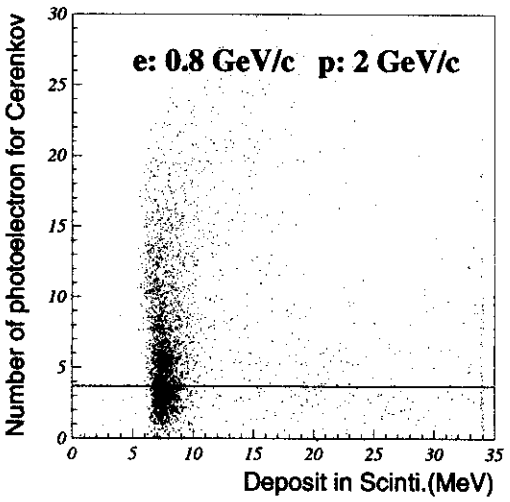
→ **difference between data and M.C. :** $+2.5 \pm 1.7$ **p.e..**

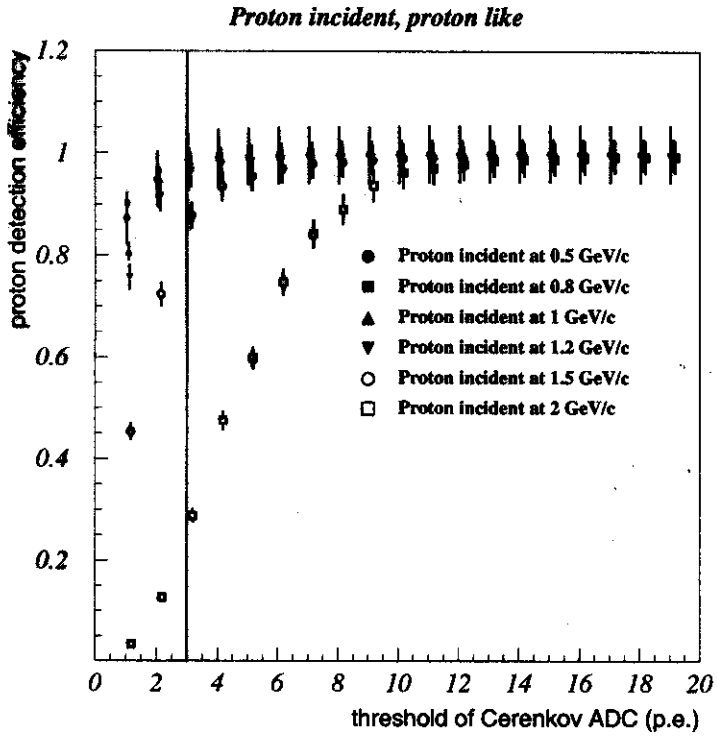
Threshold study for e/p separation.

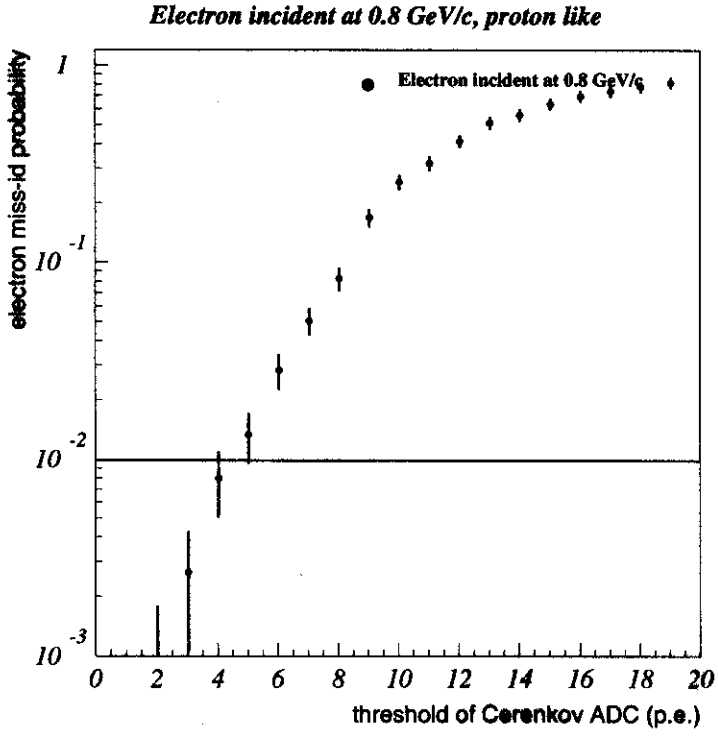




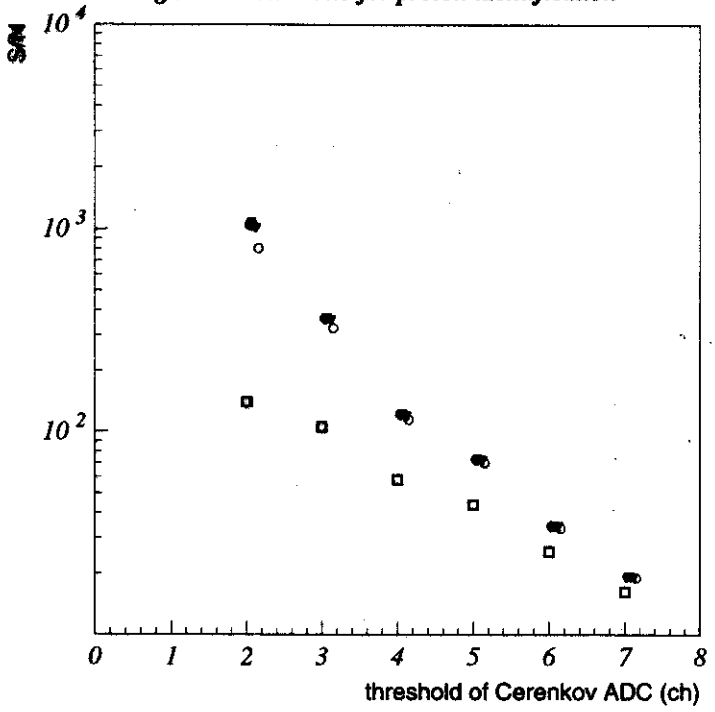




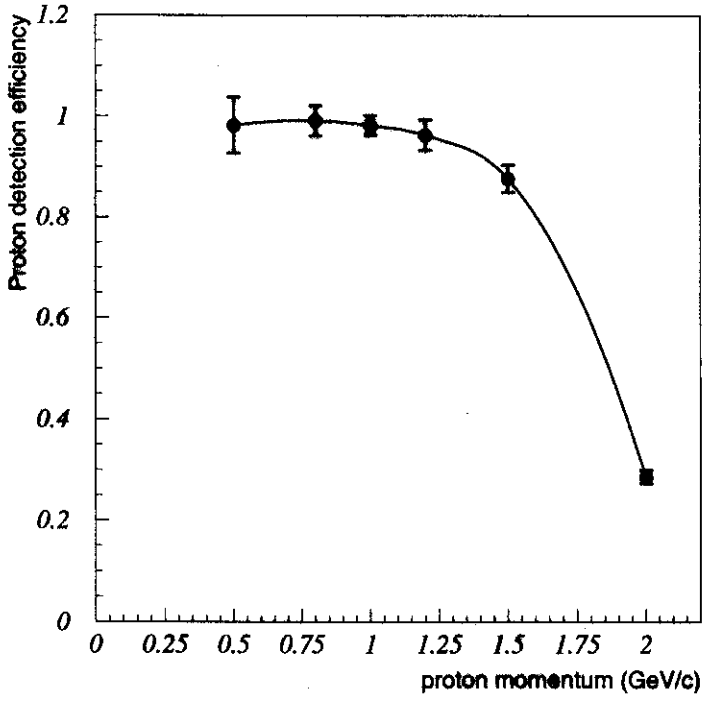

Proton incident, proton like
proton detection efficiency
1.2
1
0.8
0.6
0.4
0.2
0
2
4
6
8
10
12
14
16
18
20
threshold of Cerenkov ADC (p.e.)
Proton incident at 0.5 GeV/c
Proton incident at 0.8 GeV/c
Proton incident at 1 GeV/c
Proton incident at 1.2 GeV/c
Proton incident at 1.5 GeV/c
Proton incident at 2 GeV/c


Electron incident at 0.8 GeV/c, proton like
electron miss-id probability
1
10 -1
10 -2
10 -3
0
2
4
6
8
10
12
14
16
18
20
threshold of Cerenkov ADC (p.e.)
Electron incident at 0.8 GeV/c

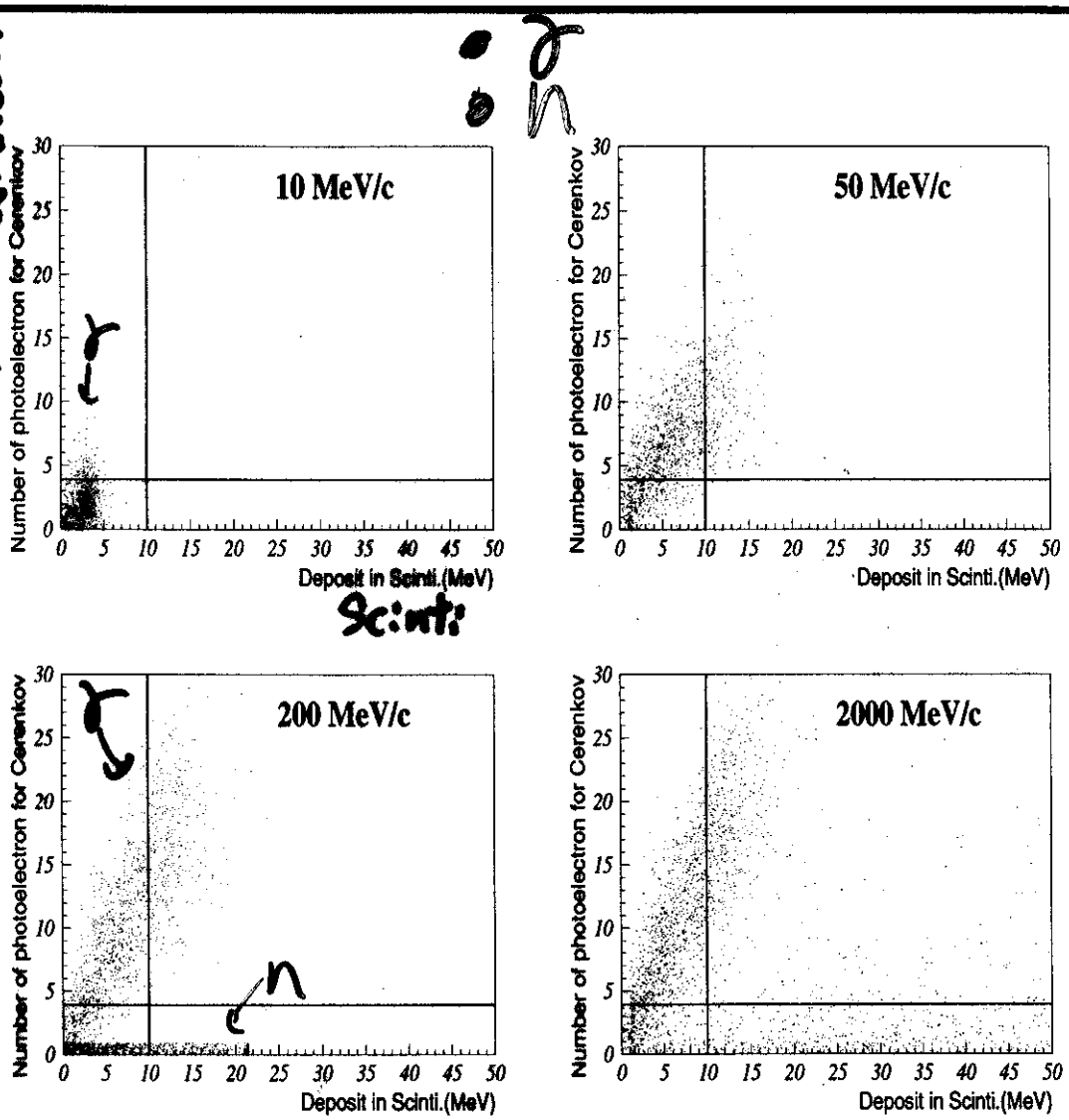
Signal to Noise ratio for proton identification



Energy dependence of neutron detection efficiency

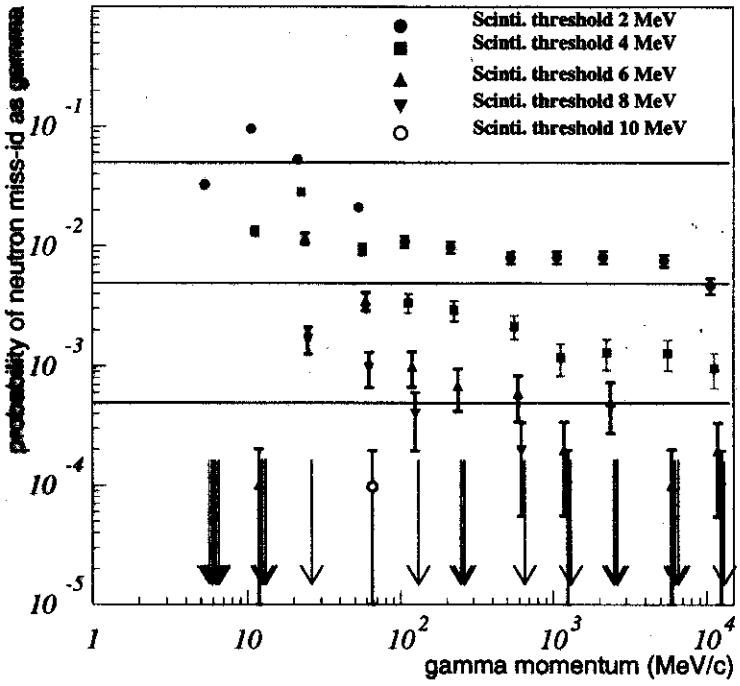


Monte Carlo Study of neutron and gamma separation with GEANT4.


10 MeV/c
50 MeV/c
200 MeV/c
2000 MeV/c
Number of photoelectron for Cerenkov
Deposit in Scinti.(MeV)

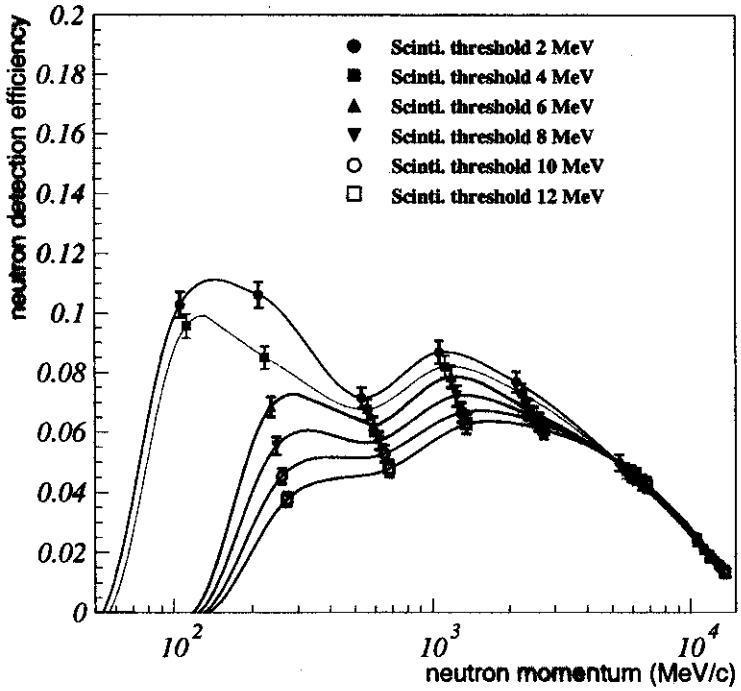
Study of scinti. threshold for neutron detection.

Gamma incident, neutron like



γ incident
n like

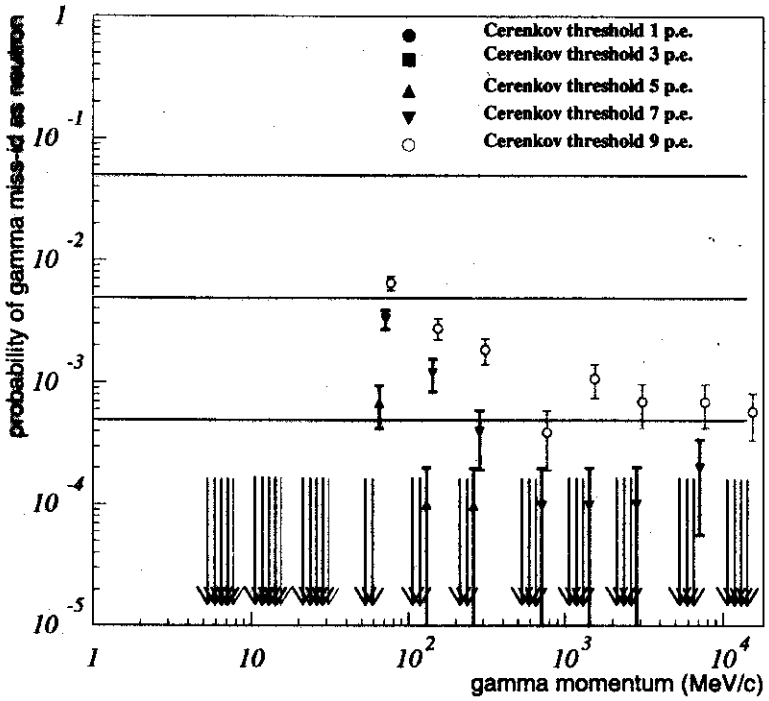
Neturon incident, neutron like



n incident
n like.

study of cerenkov threshold for neutron detection

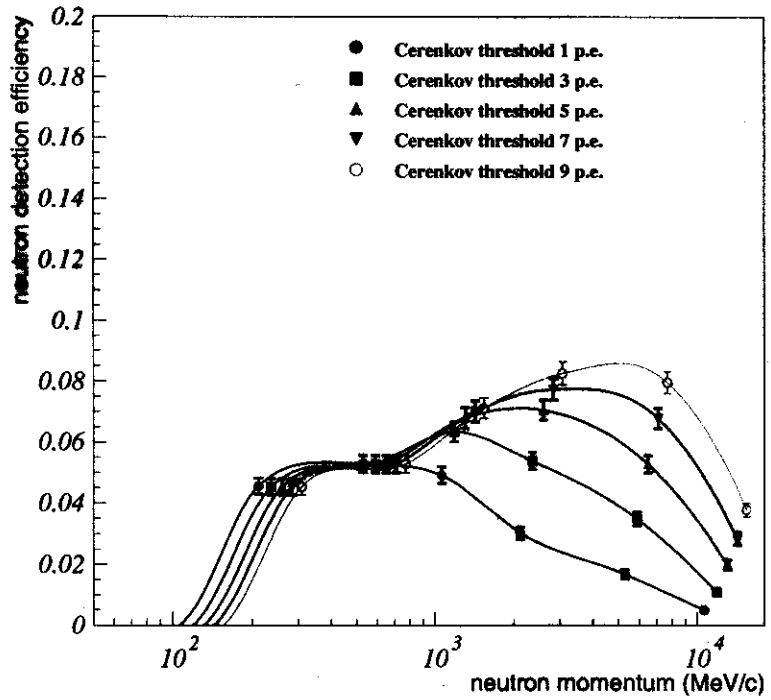
Gamma incident, neutron like



γ incident

n-like

Neturon incident, neutron like



n incident

n like