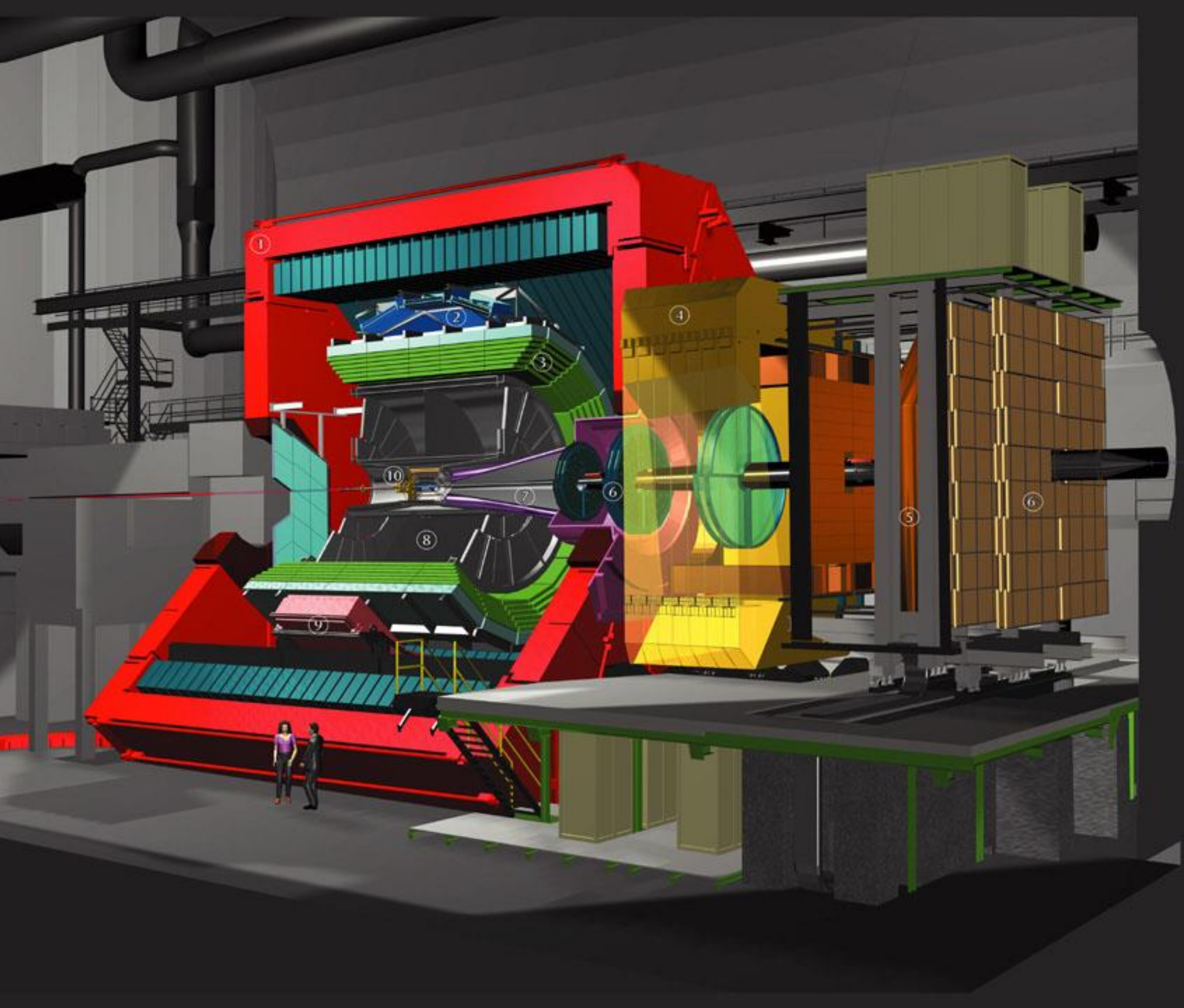
Electron-hadron separation by Neural-network

Yonsei university


1 2 3 4 5 6 6' 7 8 9 10
1• L3 MAGNET
2• HMPID
3• TOF
4• DIPOLE MAGNE
5• MUON FILTER
6• TRACKING CHA
6'• TRIGGER CHAM
7• ABSORBER
8• TPC
9• PHOS
10• ITS

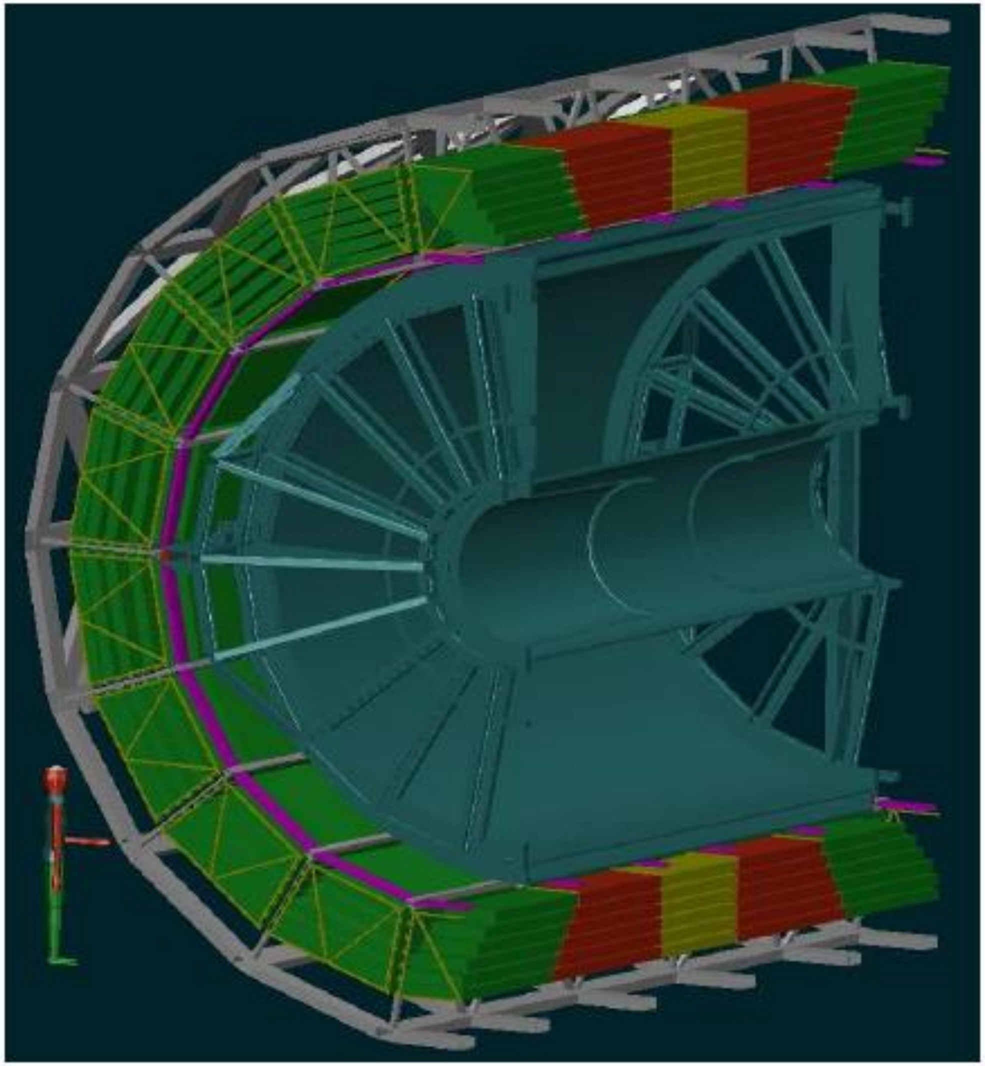
TRD(Transition Radiation Detector)

- $|\eta|<0.9$, $45°<\theta<135°$
- 18 supermodules in Φ sector
- 6 Radial layers
- 5 z-longitudinal stack

  → total 540 chambers

  → 750m² active area

  → 28m³ of gas
- In total 1.18 million read-out channels



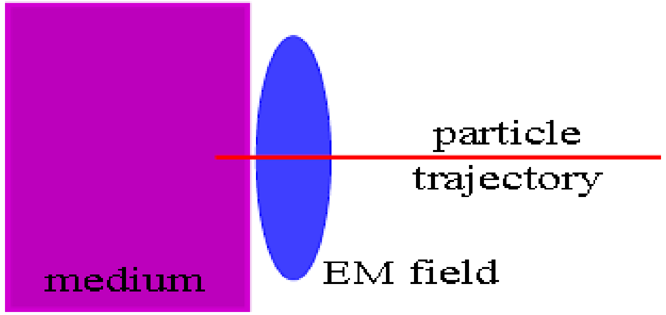
FROM C. Adler -- Hadron Collider Physics, Les Diablerets, 4-9 July 2005

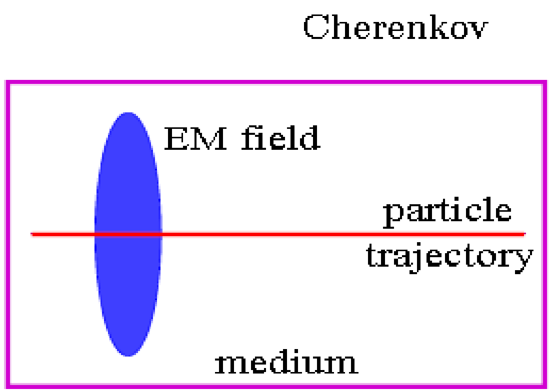
TRD(Transition Radiation Detector)
(What is transition radiation?)

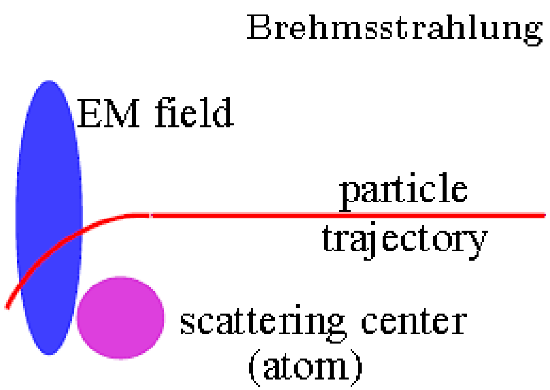
"Transition radiation is emitted whenever a charged particle crosses an interface between two media with different dielectric functions."

- L.Durand, Phys. Rev. D 11, 89(1975)

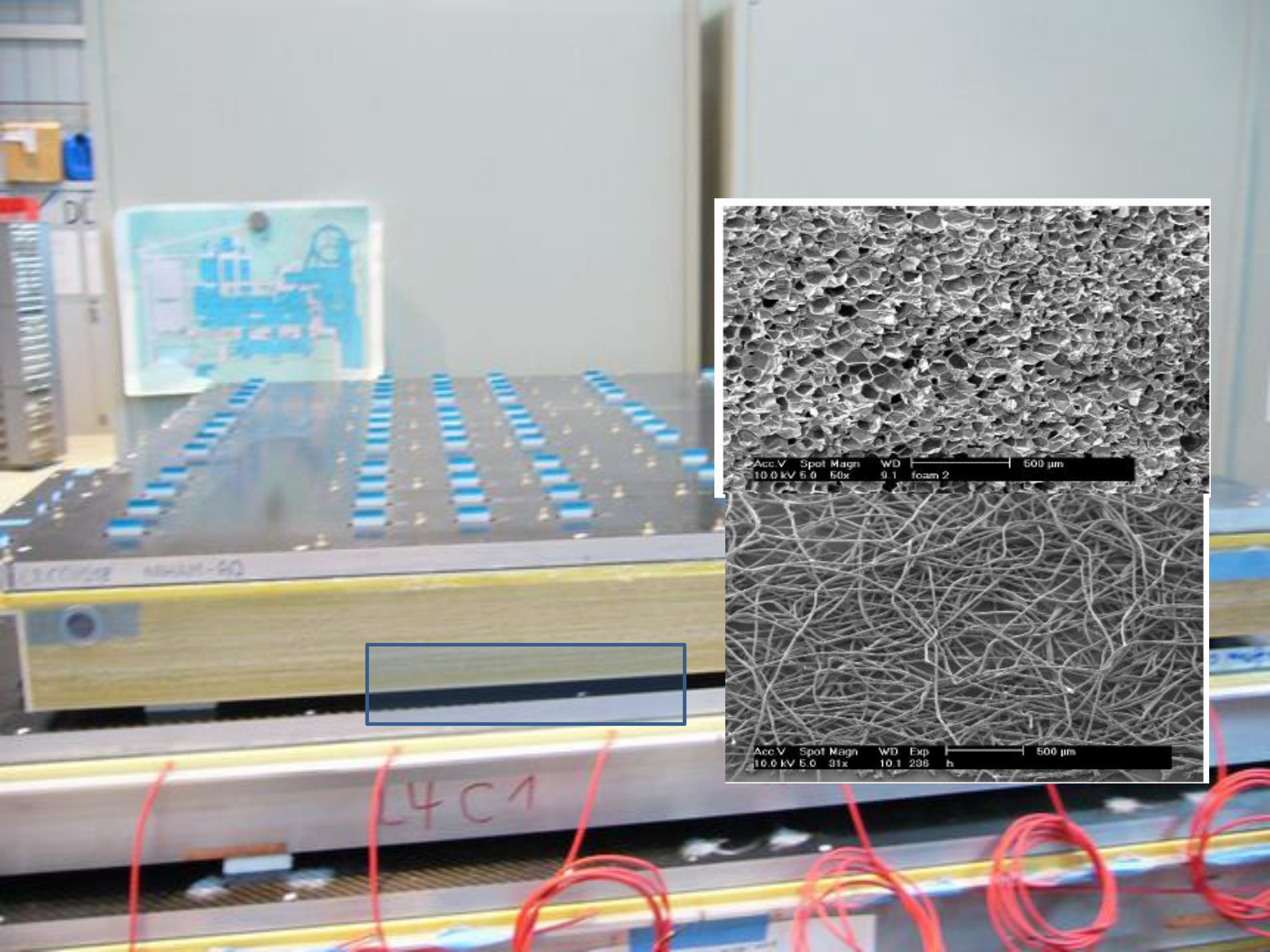
- Predicted : Ginzburg & Frank, 1946
- Observed : Goldsmith & Jelly, 1959(optical)
- It's sizeable(X-rays) for relativistic particles.



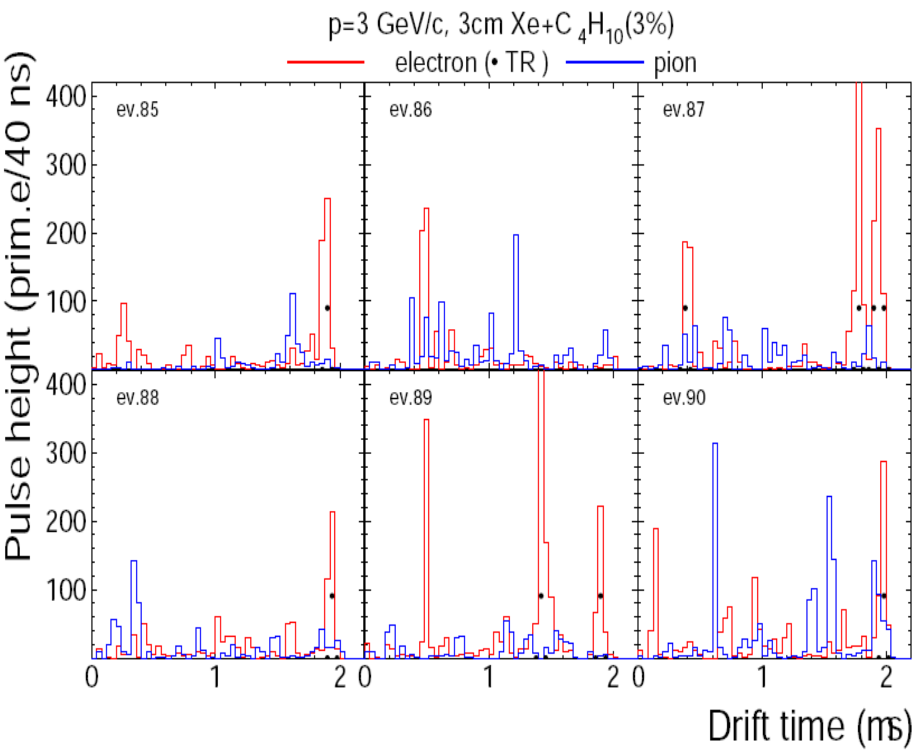


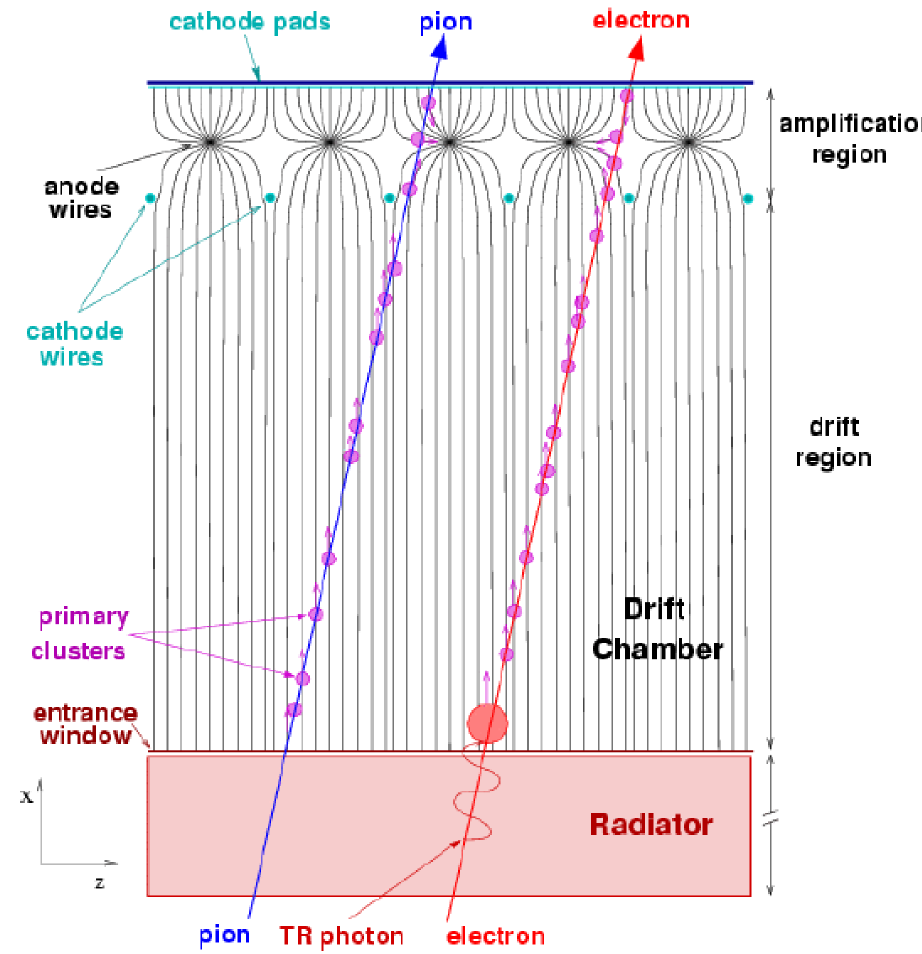


FROM A. Andronic -- an overview for students, GSI, Feb. 6th, 2007


Acc.V Spot Magn WD 500 µm
10.0 kV 5.0 50x 9.1 foam 2
Acc.V Spot Magn WD Exp 500 µm
10.0 kV 5.0 31x 10.1 236 h
L4C1

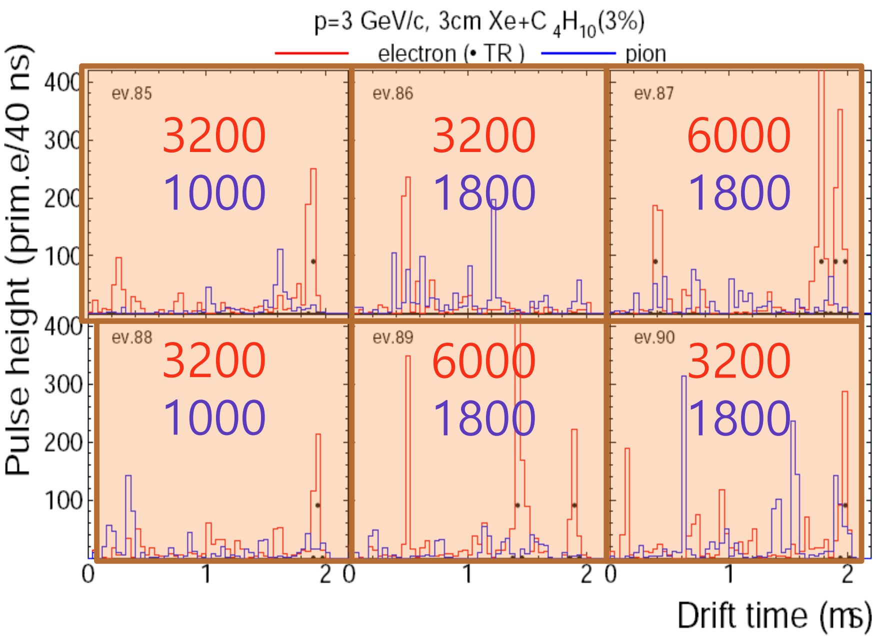
1 Event signals of Electron and Pion

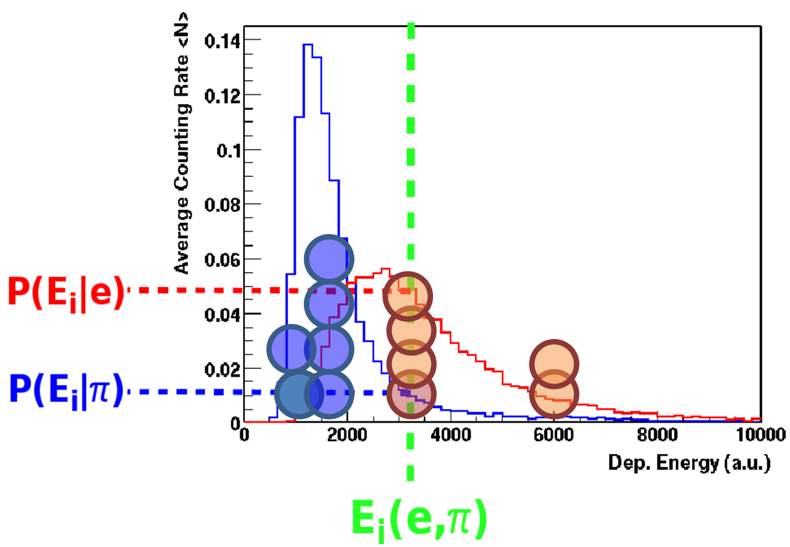




FROM P. Shukla -- [ICPA-QGP'05](), Kolkata, 8-12 February 2005

e/π-Separation





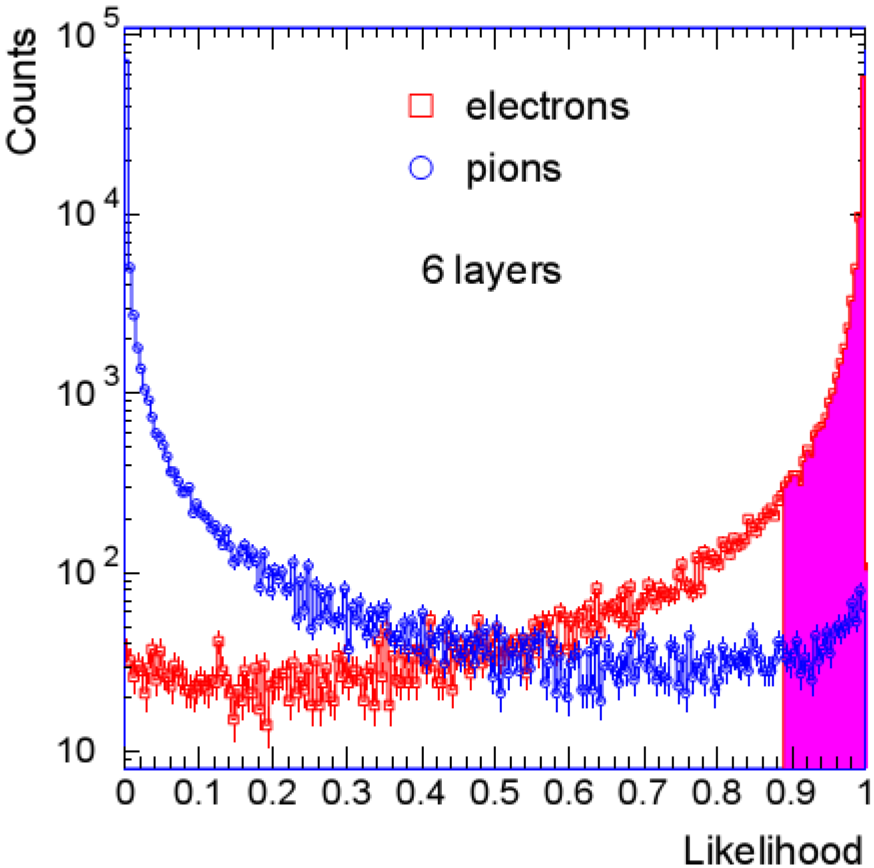
Likelihood to be electrons

$$L = \frac{P_e}{P_e + P_\pi}$$

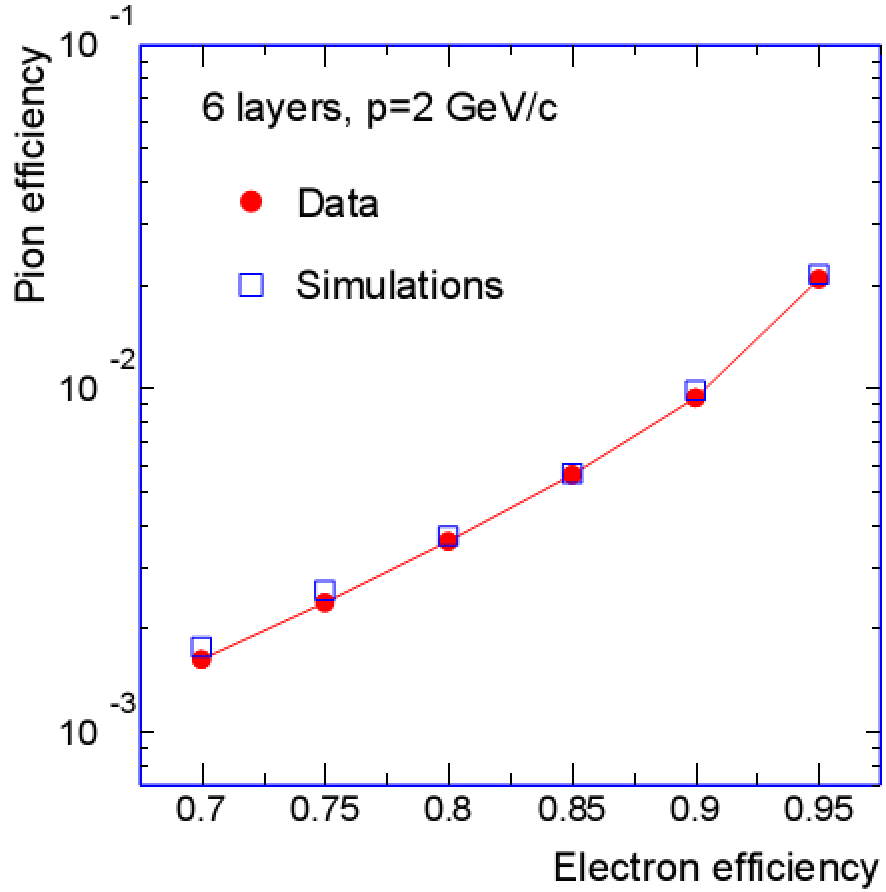
$$P_e = \prod_{i=1}^{N} P(X_i | e)$$

$$P_\pi = \prod_{i=1}^{N} P(X_i | \pi),$$

e/π-Separation-Classical Methods

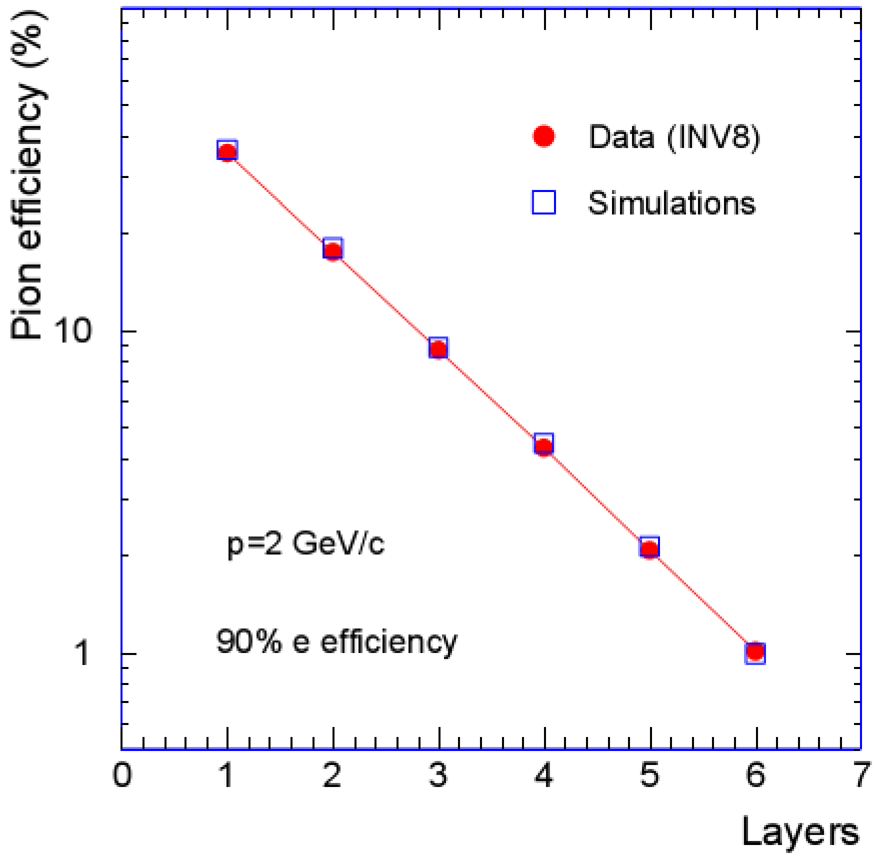


Distributions of the likelihood for electrons and pions of 2GeV/c, obtained from the total energy deposit.



Pion efficiency as a function of electron efficiency for a 6 layer likelihood on total energy, for momentum of 2GeV/c. The values corresponding to measured data are compared simulations.

e/π-Separation-Classical Methods



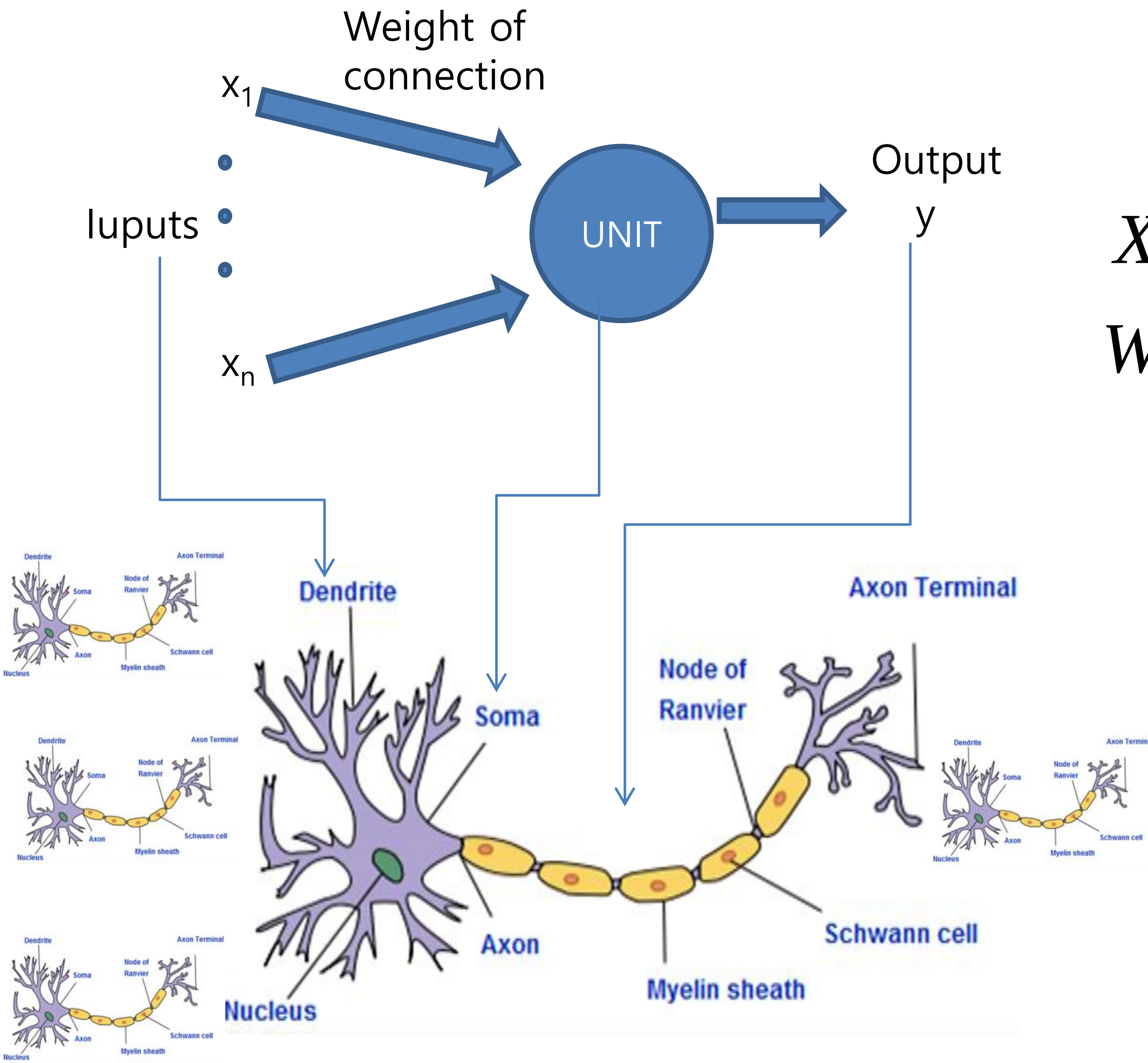
Pion efficiency as a function of number of layers
for a momentum of 2GeV/c

Other method?

Neural-network

- A simple Modeling of the biological neuron system
- Being used in various fields for data analysis and classification
- Examples : Image analysis
  Financial movement's prediction
  Sales forecast
  In particle physics

Modeling of neuron



$$X = [x_1, x_2, x_3 \quad \dots \quad , x_n]$$

$$W = [w_1, w_2, w_3 \quad \dots , w_n]$$

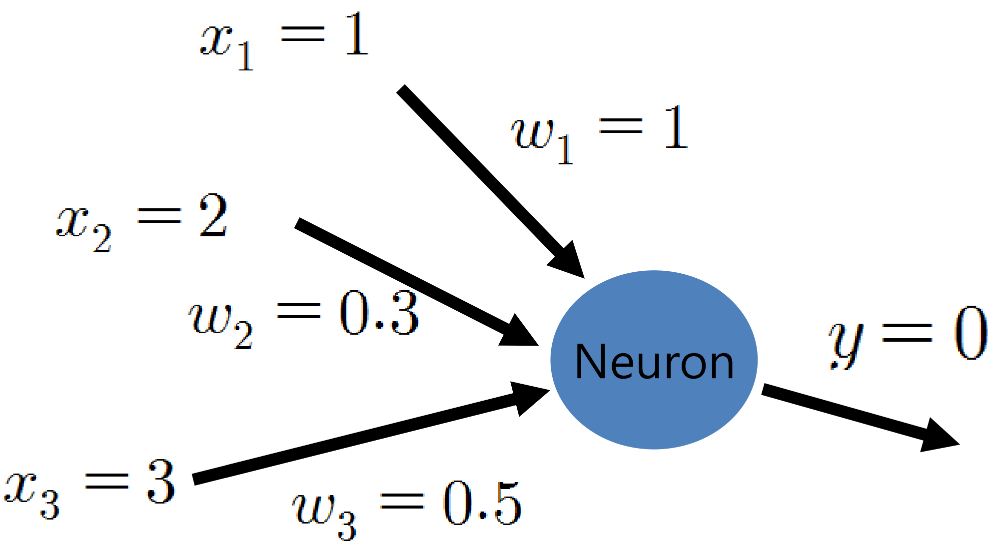
$$NET = XW^T$$

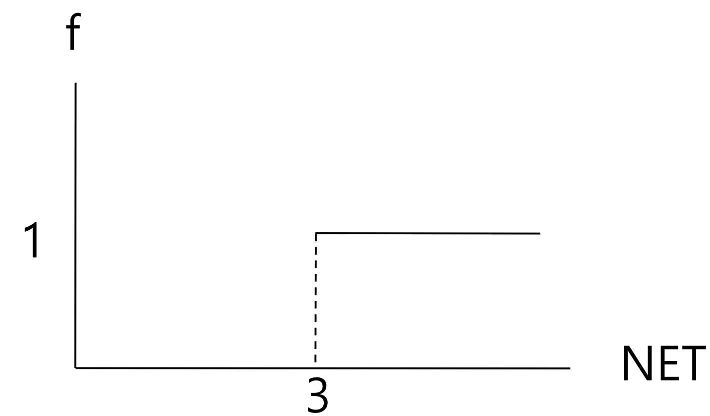
$$y = f(NET)$$

NN-Example

Training sample
(x_1=1, x_2=2, x_3=3, y=1)

$$X = [x_1, x_2, x_3 \quad \ldots \quad , x_n]$$
$$W = [w_1, w_2, w_3 \quad \ldots, w_n]$$



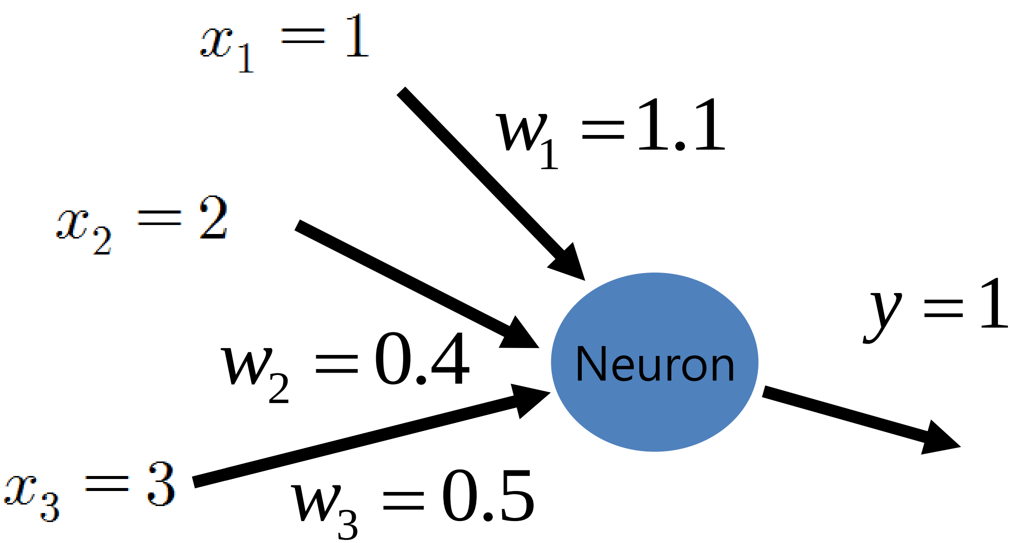


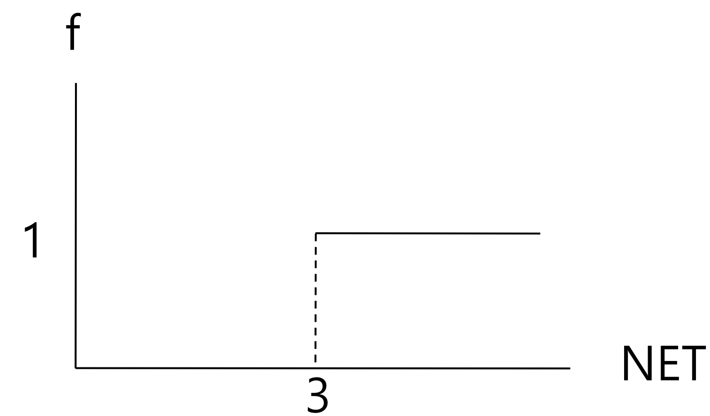
$$NET = XW^T = 2.6$$
$$y = f(NET) = 0$$

NN-Example

Training sample
($x_1=1$, $x_2=2$, $x_3=3$, $y=1$)

!! But we want the output to be 1
Change the W vector by some rules

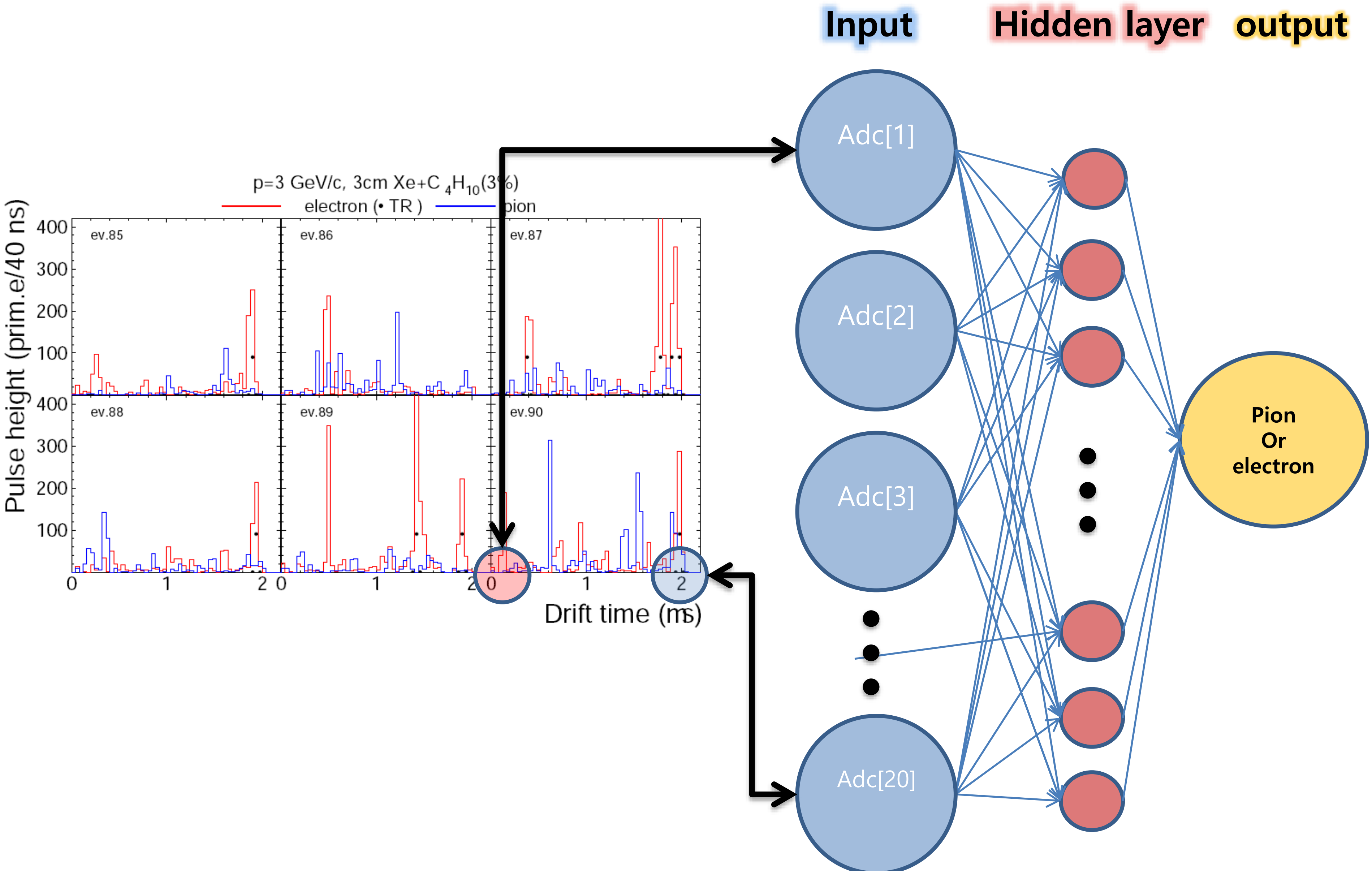




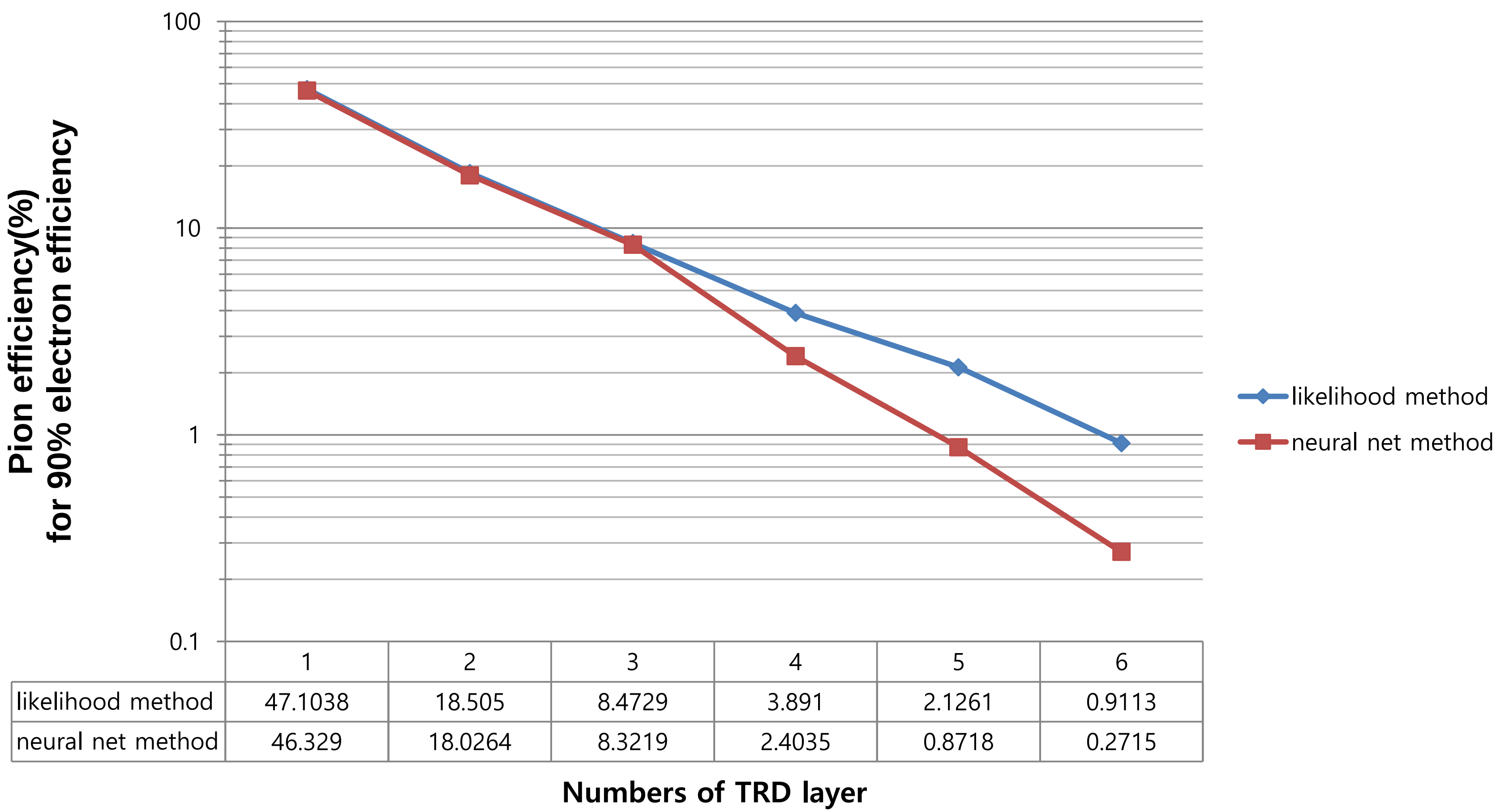
$$NET = XW^T = 3.4$$

$$y = f(NET) = 1$$

e/π-Separation-Neural network



Comparison of methods



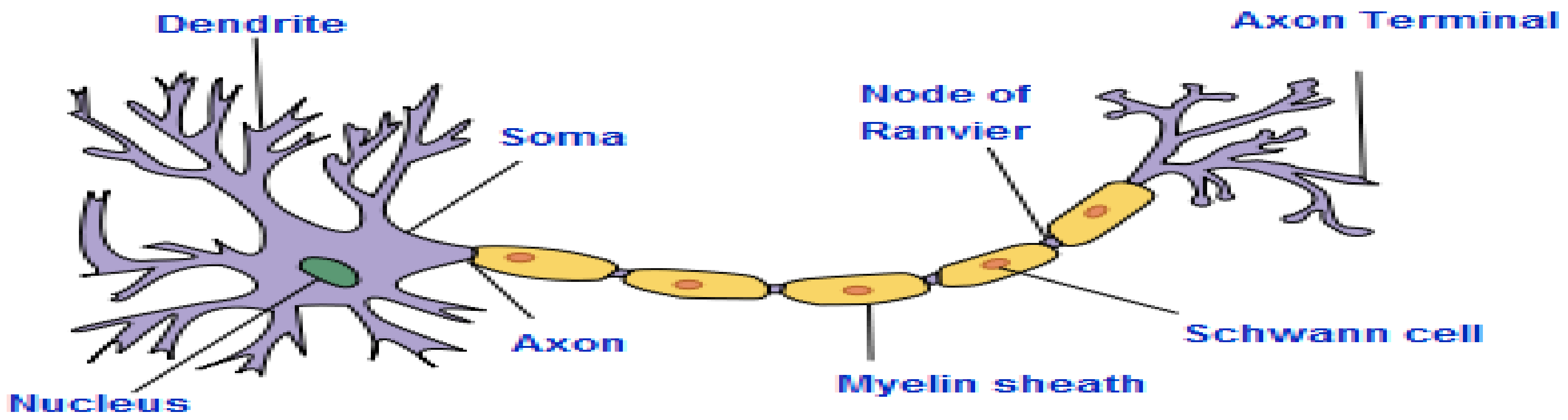
	1	2	3	4	5	6
likelihood method	47.1038	18.505	8.4729	3.891	2.1261	0.9113
neural net method	46.329	18.0264	8.3219	2.4035	0.8718	0.2715

Summary

- The suppression factor was improved by about a factor of 3 by Neural net when compared with classical method.

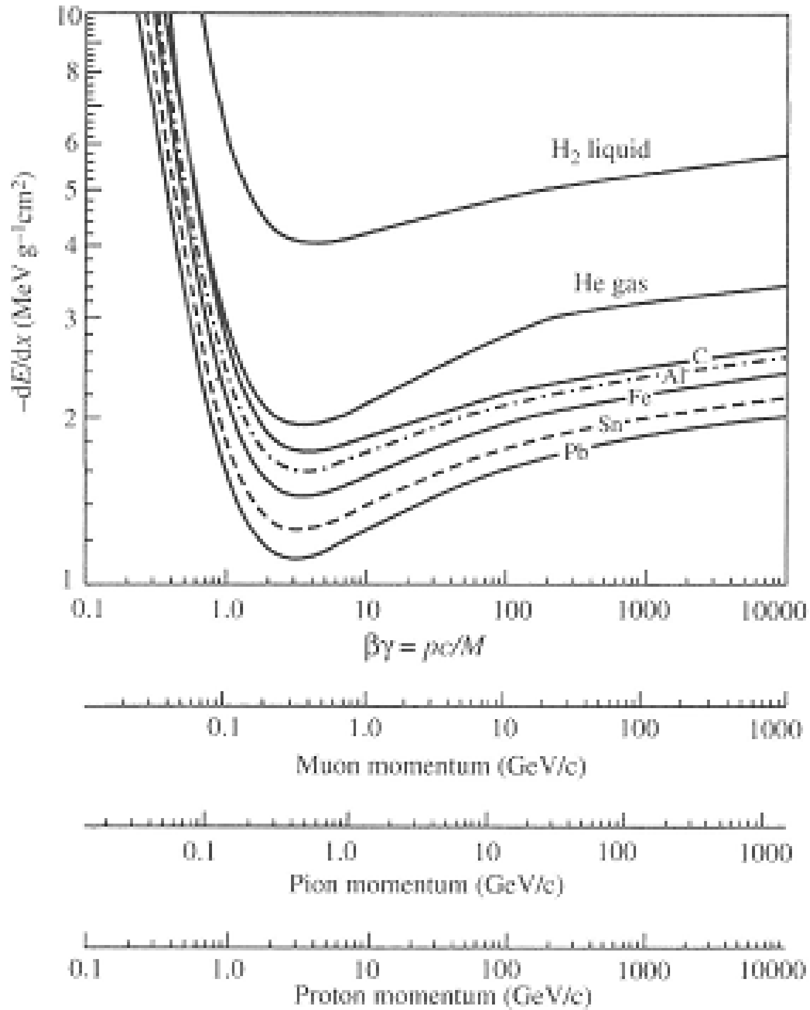
- Need to be done
  - Application to the full simulation sample
  - Refined Neural Network
    Other NN structures must be considered

Modeling of Neuron



Dendrites	Soma		Soma	Axon
x →	[Σ]	→ NET	[f(NET)]	→ y
Input	Combination function		Activation function	Output

Ionization energy loss



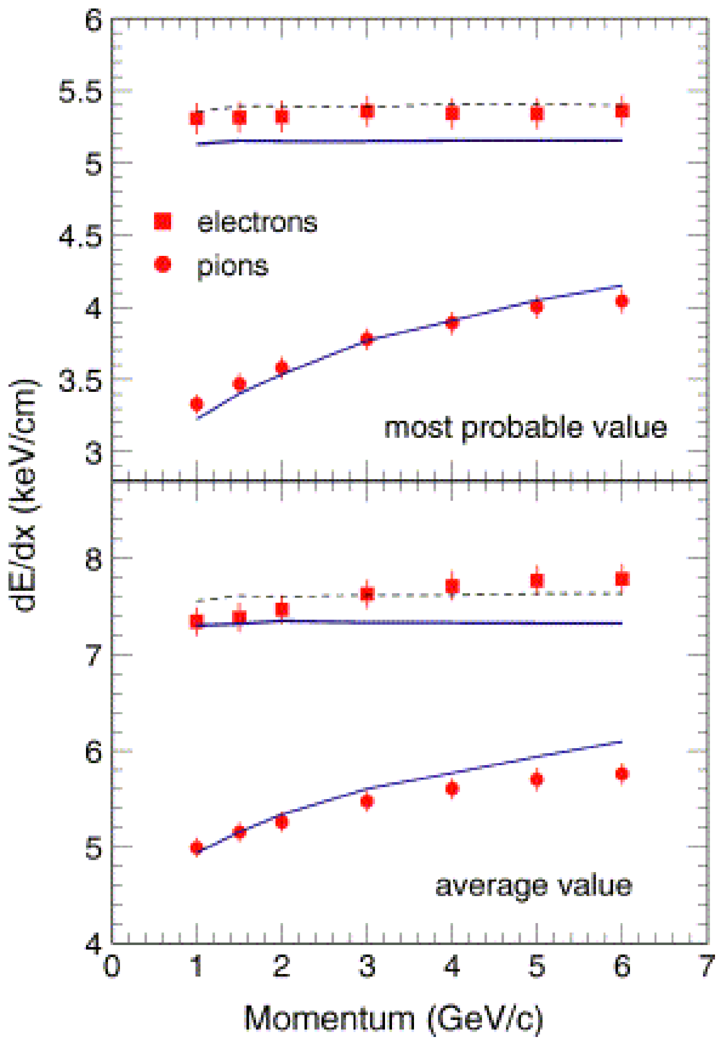
Ionization energy loss for muons and pions and protons on a variety of materials.

Bethe-Bloch formula

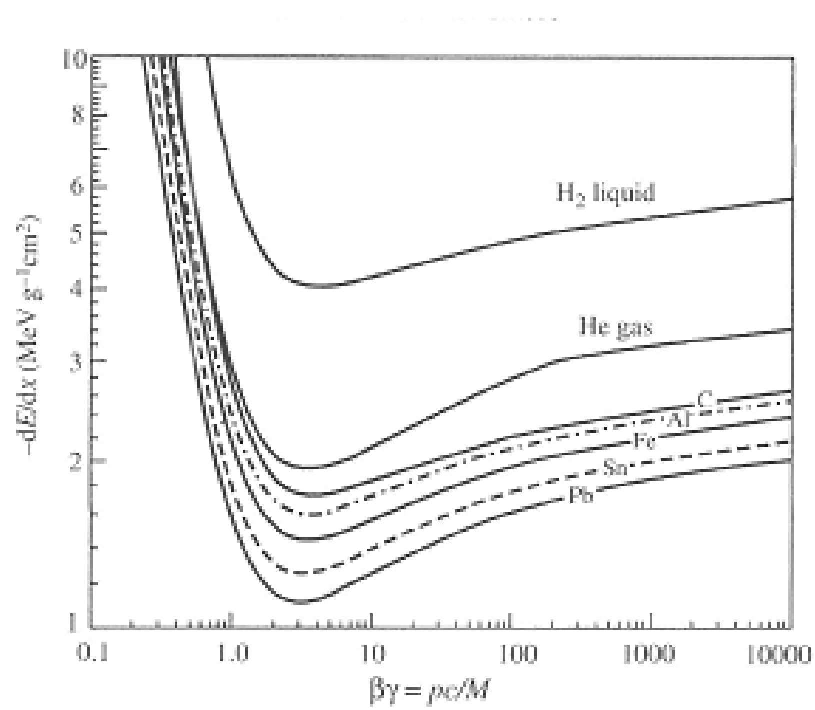
$$-\frac{dE}{dx} = \frac{Dq^2 n_e}{\beta^2}[\ln(\frac{2m_e c^2\beta^2\gamma^2}{I}) - \beta^2]$$

$$D = 5.1\times 10^{-25} MeVcm^2$$

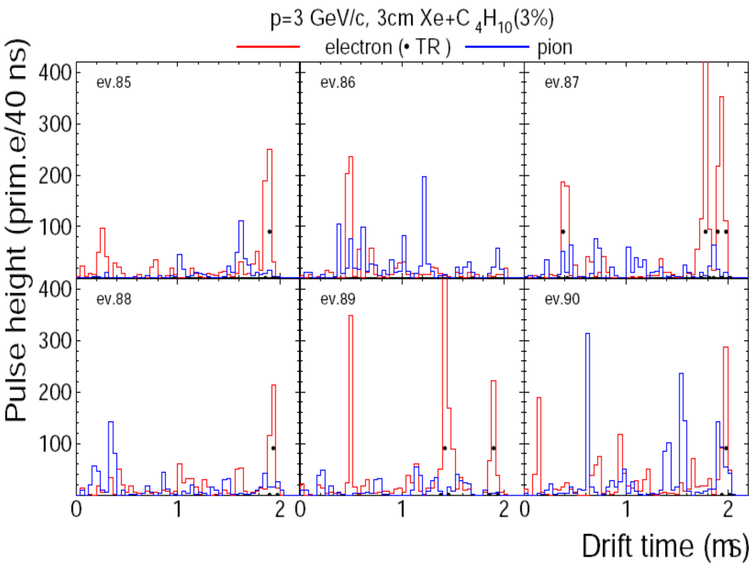
Ionization energy loss



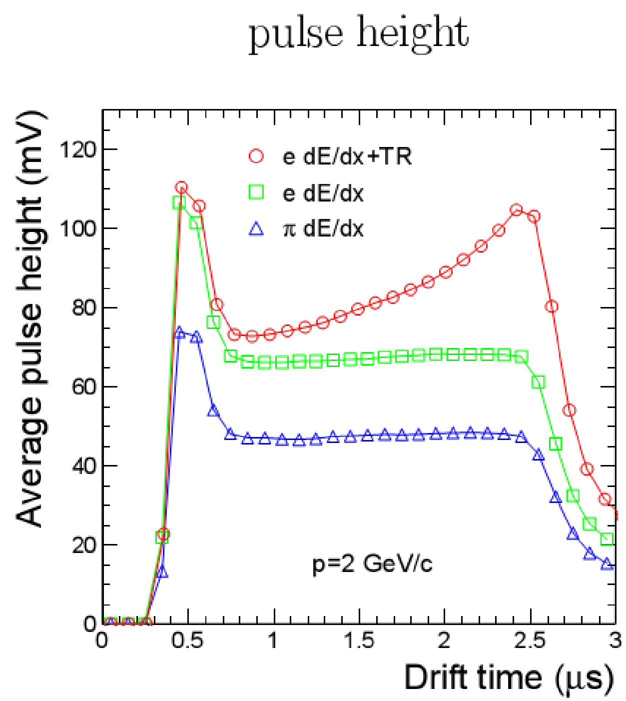
Momentum dependence of the most probable and the average values of the energy loss for pions and electrons. The symbols are measurements, the lines are calculations



Signals of Electron and Pion



Many Events Averaged!!



Mean signal of Electron and Pion