DHCAL RPC Digitization

Manqi Ruan

Outline

- Motivation & Introduction
- Method & Toy MC
- Digitization with Muon and Pion
- Summary

Introduction: Avalanche in RPC

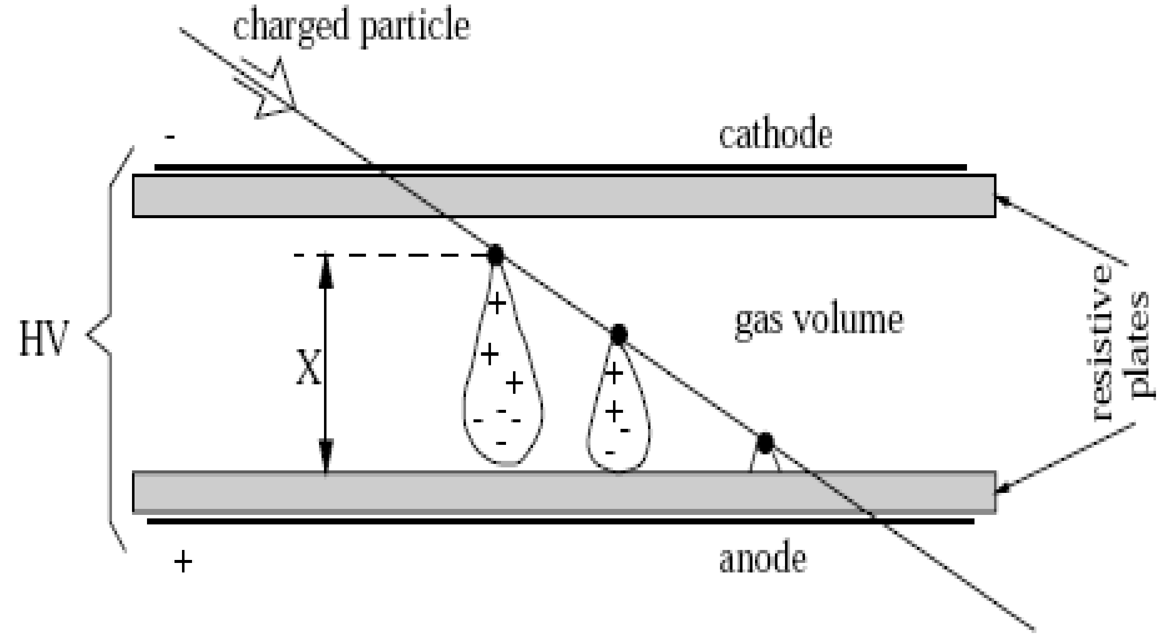


Fig. 1. Sketch of RPC gap.

- Motivation: estimate the total induced charge!

Important parameters:

λ: primary cluster density, based on gas type, pressure, ...

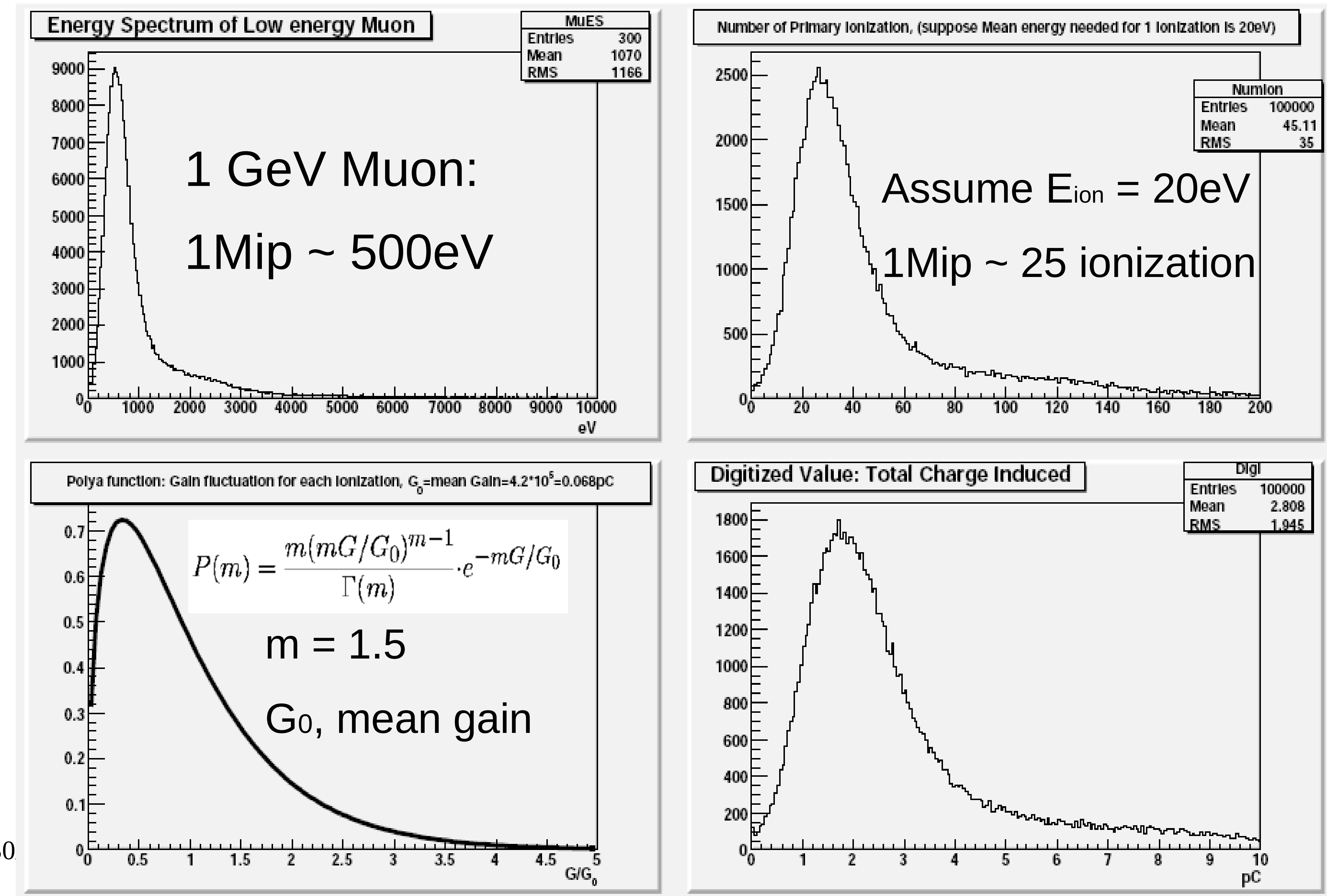
η: Efficient townsend coefficient (*Inverse of the distance needed to get charge increase by a factor of e, Q~exp(xη)*)

Induced charge proportional to both λ and η

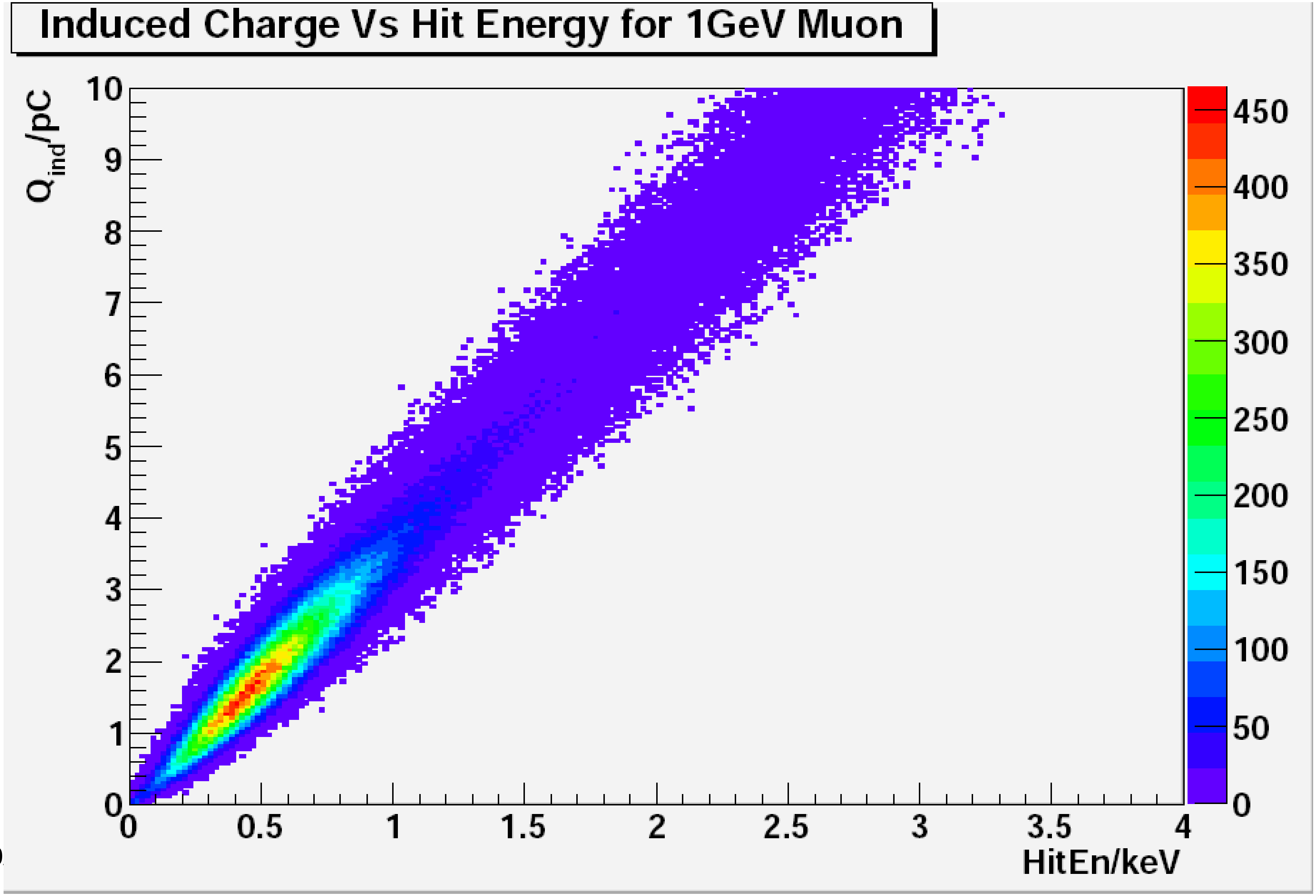
Method

- Get the true energy deposition in gas gap from MC (eg, Mokka)
- Express the true energy deposition in unit of primary ionization (E_{truth}/E_{ion}): calculate the number of ionization
- For each ionization, we use Polya function ($P(m) = \frac{m(mG/G_0)^{m-1}}{\Gamma(m)} \cdot e^{-mG/G_0}$) to estimate the corresponding charge inducing
- Sum induced charge over every ionization ~ total induced Charge

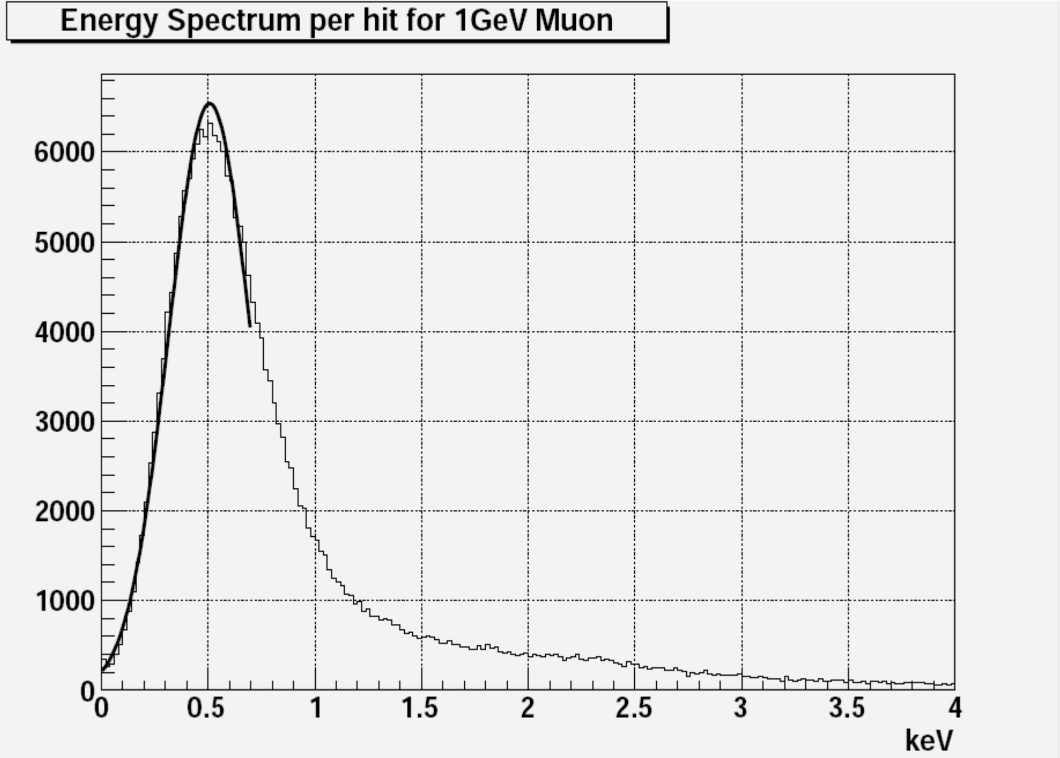
Result of toy MC

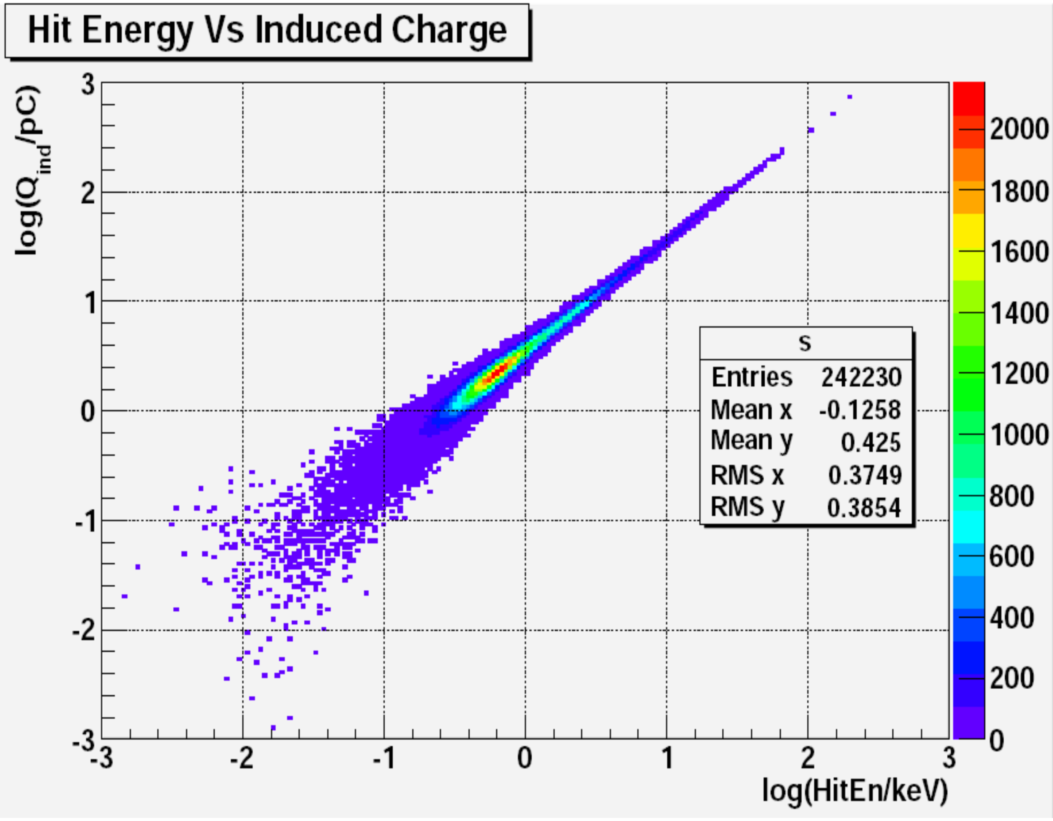


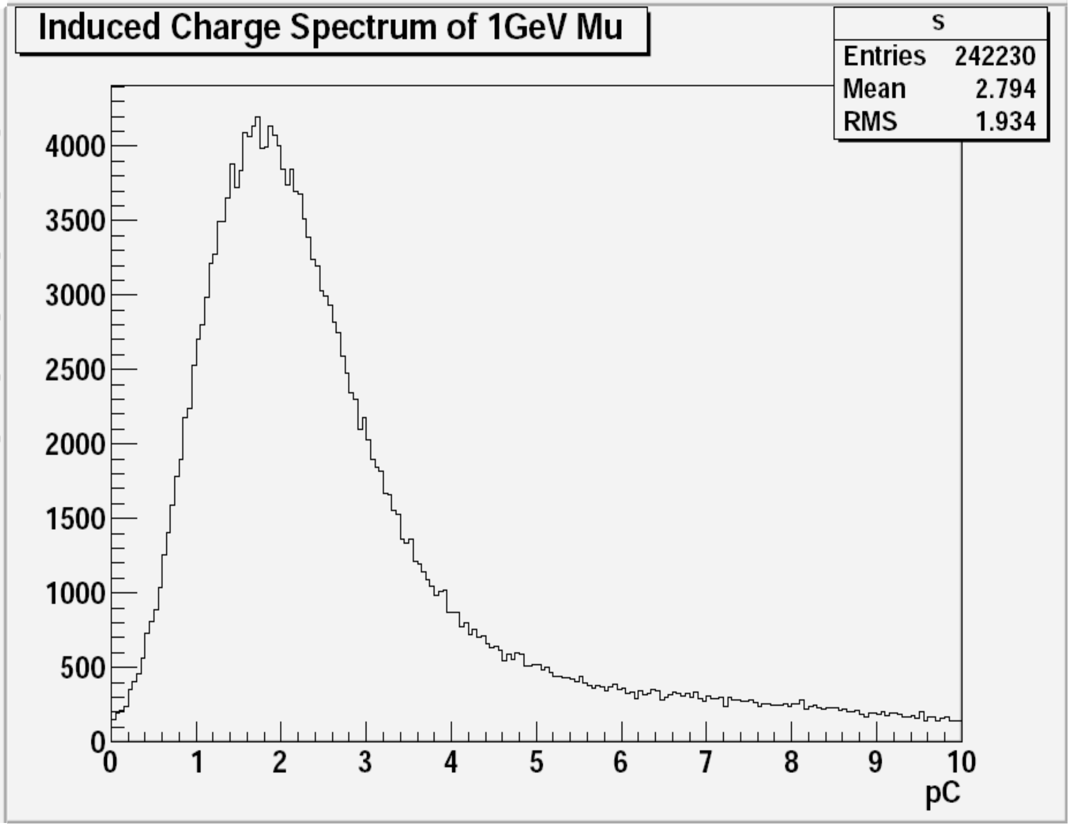
Digitization with 1 GeV Muon
(Barrel region, no magnet field)



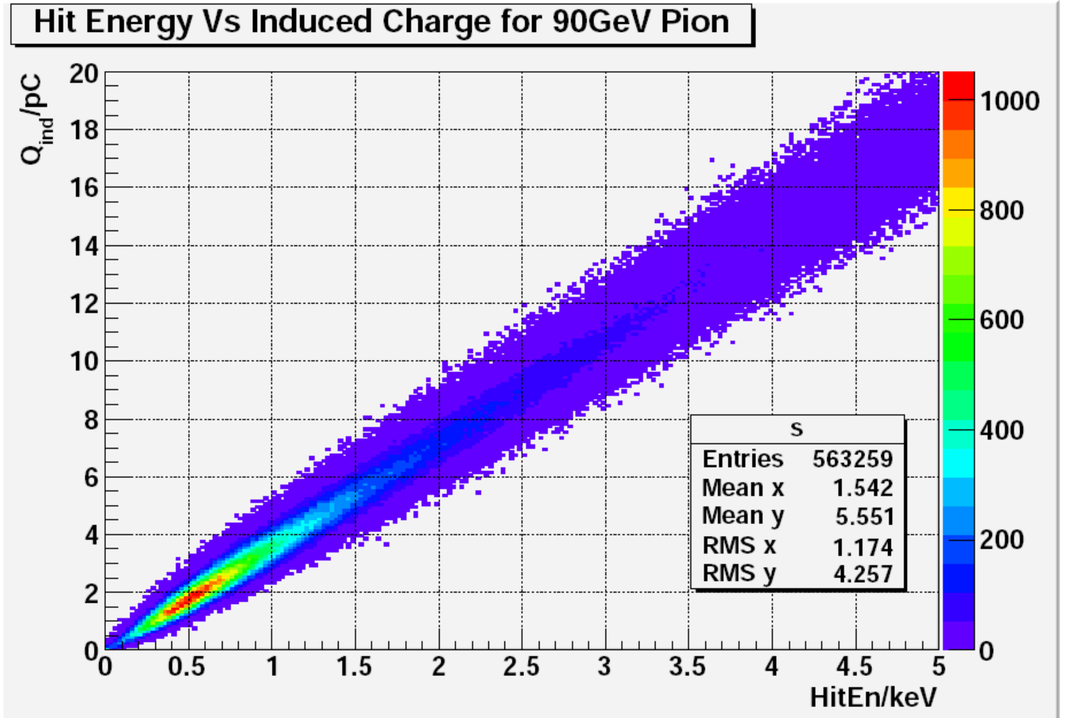
Digitization with 1 GeV Muon

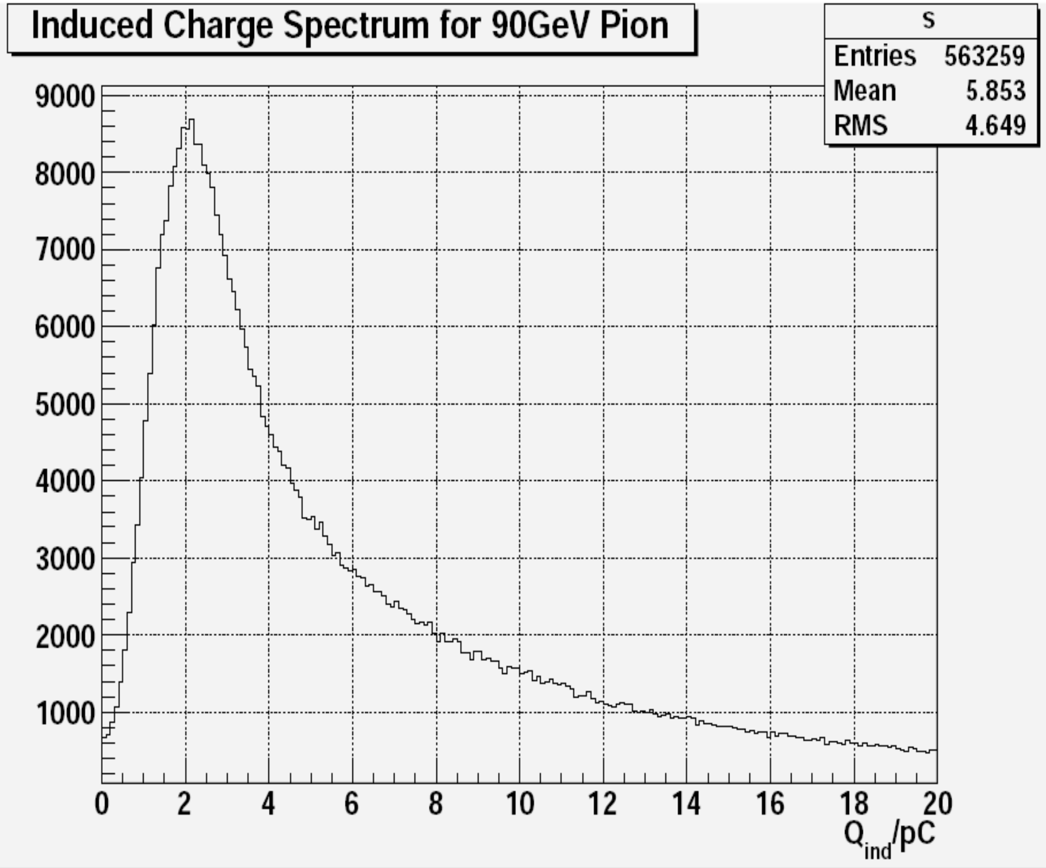


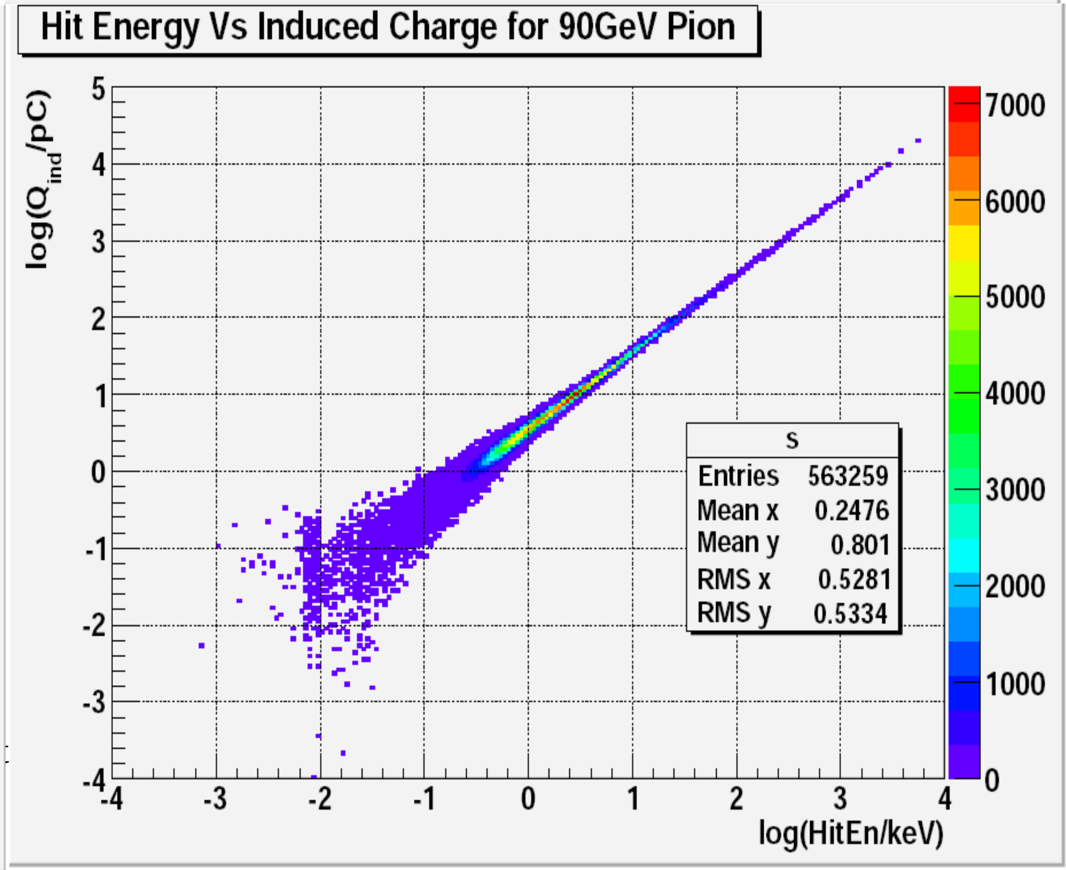




Digitization with 90 GeV Pion







Summary

- RPC DHCAL Digitization tools developed & played with 1GeV Muon sample (10k statistic, no magnet field) and 90GeV pion sample (1k statistic)

- Digitization has relatively large smearing at low energy, and shows nice linear correlation with true energy deposition at high energy

- To do list:
  - Parameters fine-tuning for DHCAL TB experiment (m for P(m), E_{ion}, G_0)
  - Taken into account the Saturation effect
  - Threshold optimization study (**Important!**)
  - Polish the software package & release as a MarlinReco module

Back Up Slides

- Technical details
- Saturation effect
- Parameter estimation

Technical details

- In estimation of number of ionization: if (E_{truth}/E_{ion}) is not an integral, then the number of ionization is chosen to be either [E_{truth}/E_{ion}] (with chance [E_{truth}/E_{ion}]+1-(E_{truth}/E_{ion})) or [E_{truth}/E_{ion}]+1 (with chance (E_{truth}/E_{ion})-[E_{truth}/E_{ion}]),
  - For example, if (E_{truth}/E_{ion})=2.3, we have 30% the chance to identify this event with 3 ionization & 70% the chance to say there is 2 ionization

- Polya function: Ideal PDF which statisfy:
  - integral(0-inf)dx P(x) = 1, ($\Gamma(m)/\Gamma(m)=1$);
  - integral(0-inf)dx xP(x) = 1, ($\Gamma(m+1)/\Gamma(m)=m$);

  Take m = 1.5 according to http://www4.rcf.bnl.gov/~lebedev/tec/polya.html and G.D. Alkhazov, *Nucl. Instr. and Meth.* **89** (1970) 155

Saturation effect

- Saturation effect is at least two-fold:
  - 1st, for large true energy deposition in gas gap, which is corresponding to the δ-photon in the high energy tail in landau distribution. Photon interact weakly with the gas gap, and carried most of its energy into the non-sensitive region.
  - 2nd, if the large true energy deposition is caused by large multiplicity of charged particles, then these corresponding avalanche will happen in a very concentrate spacial area – which will cause the charge induce to exceed its available range.

Potential ionization (minimal energy need for ionization) of Freons: Unit in eV

Freon 11 (CFCl3)			11,77			
Freon 12 (CF2Cl2)			12,31			
Freon 13 (CF3Cl)			12,91			
Freon 13 B-1 CBrF3			12,08			
Freon 14 (neat) CF_4			16,25			
Freon 21 CHCl2F			12,00			
Freon 22 (CHClF2)			12,45			
Freon 113 (CF3CCl3)			11,78			
Freon 114 $C_2Cl_2F_4$			12,00			

Our gas mixture: TFE 134($C_2H_2F_4$)/ISB/SF_6 = 93/5/2

→ the Potential ionization for our gas is ~ 12eV

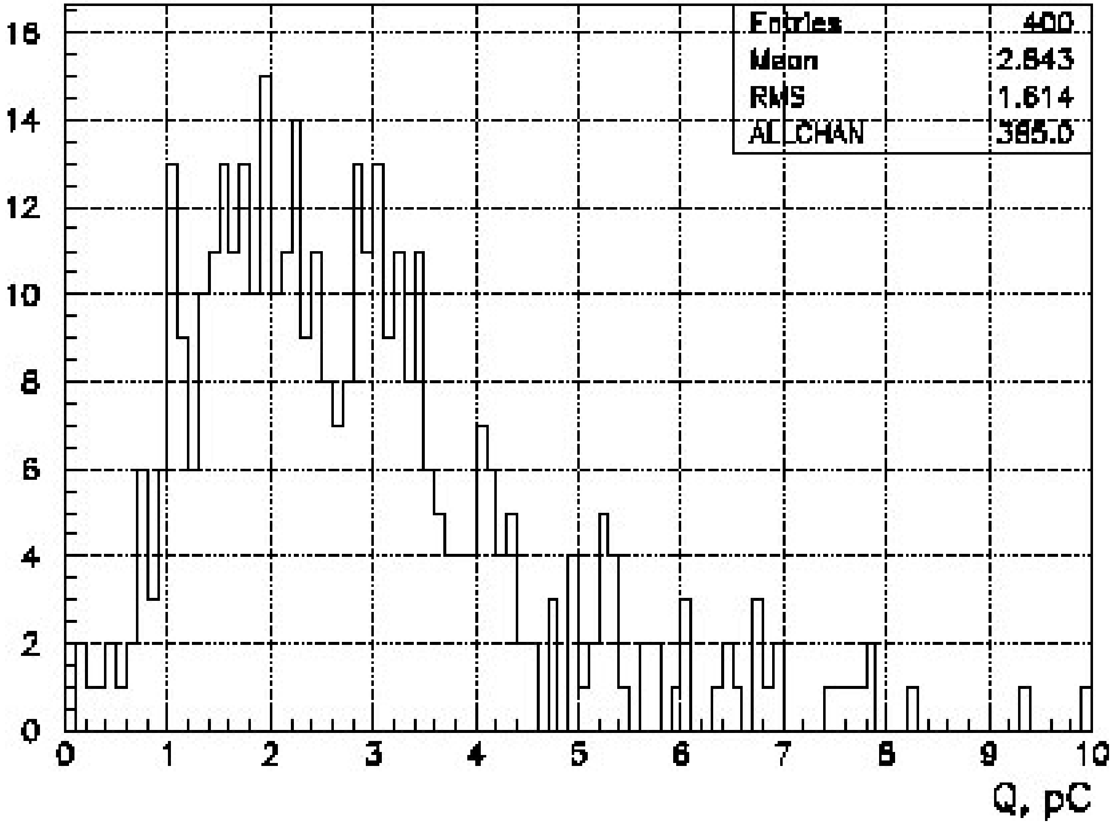
We assume the mean ionization energy E_{ion} ~ 20eV

E_{ion} > Potential ionization also because of the molecule excitation will release photon not strongly interact with gas

G_0 estimation from Ammosov's presentation

(Oct 2003 at RPC meeting at Clermont):

V.Ammosov:
RPC in avalanche mode
(TFE/Iso/SF6 = 93/5/2)
1.2 mm,
8.4 kV - working point,
2.2 mV thr

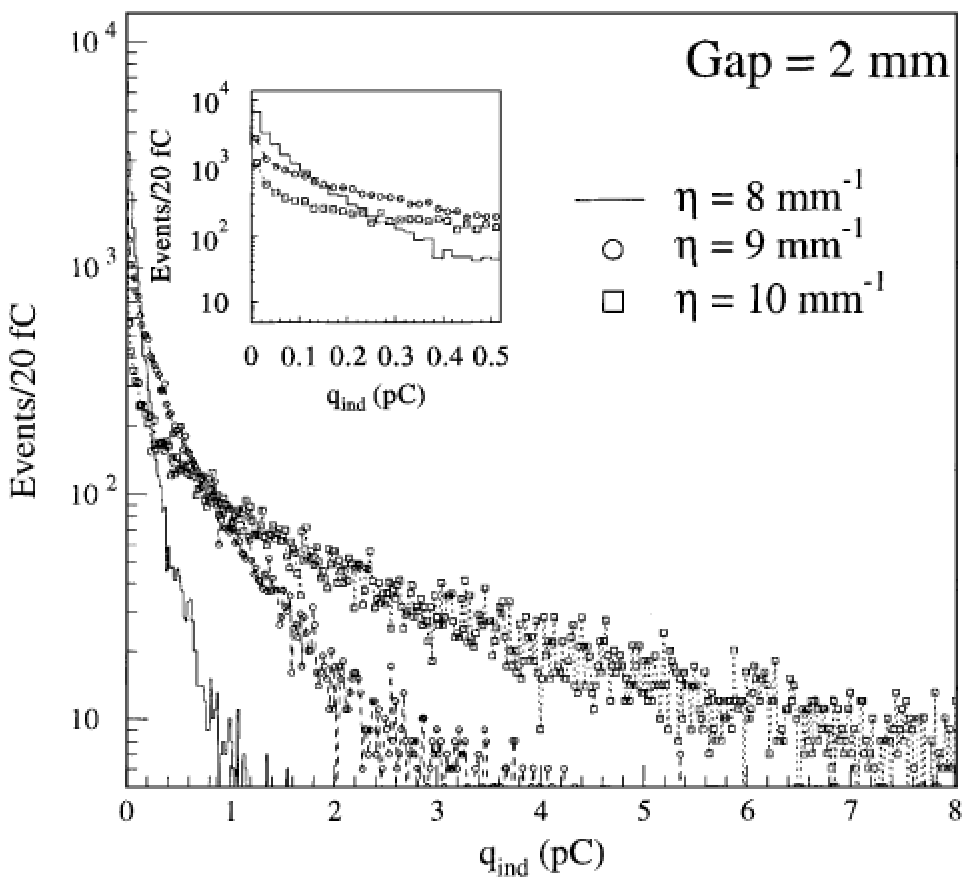


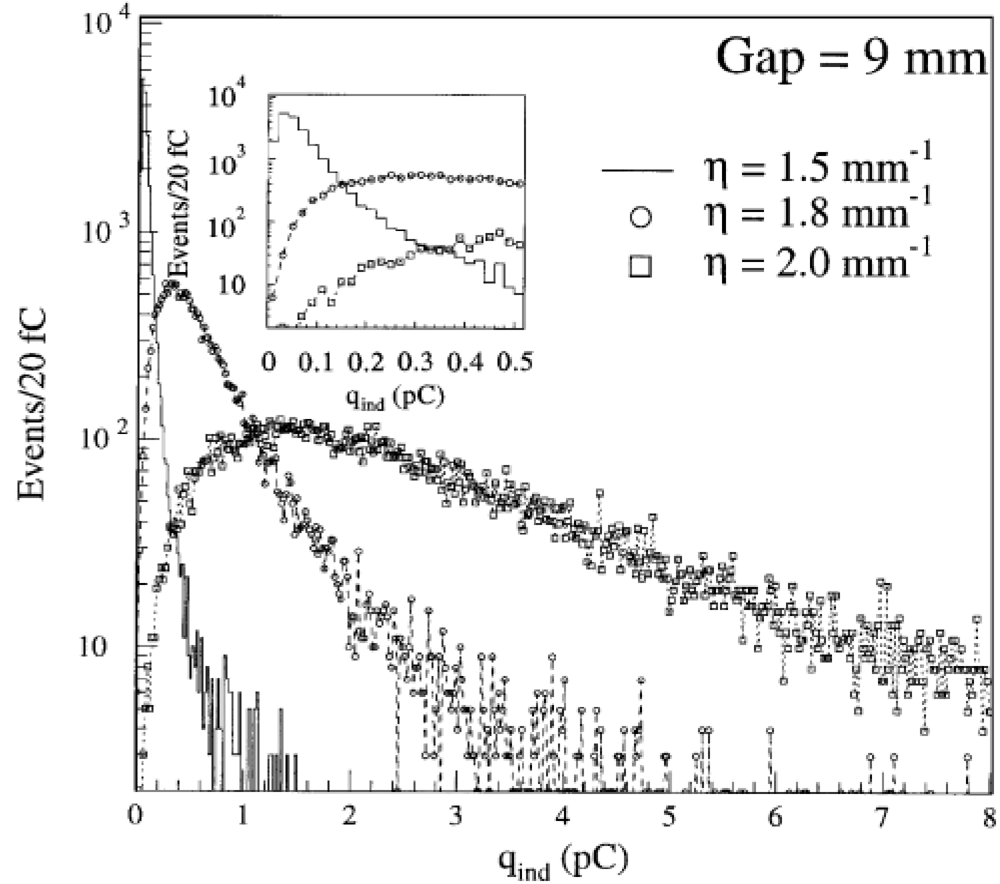
Tune G_0 and E_{ion} to make the mean Charge induced at ~ 2.8pC

What are our parameters & Scale?

How shall we measure them?

BK plots from M.Abbrescia





The simulation of resistive plate chambers in avalanche mode:
charge spectra and efficiency
Nuclear Instruments and Methods in Physics Research A 431 (1999) 413}427