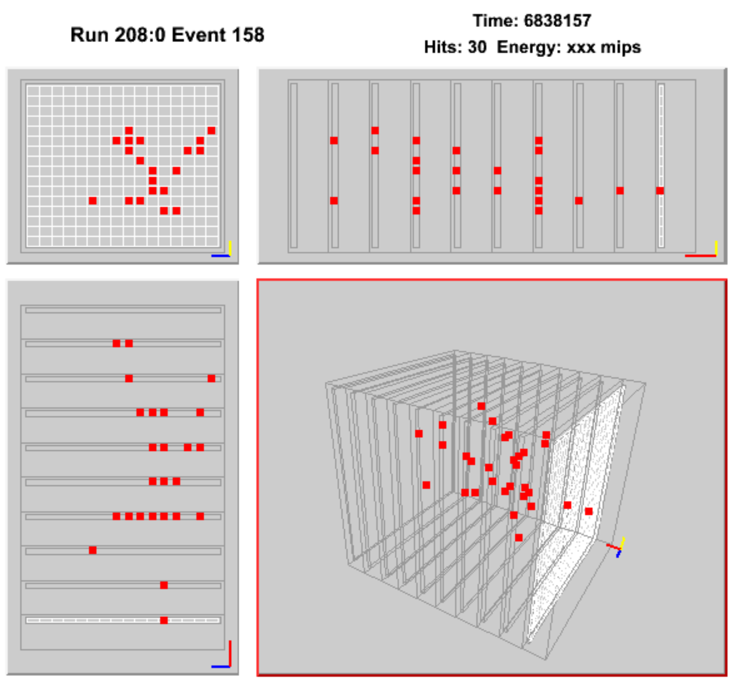
Status of RPC based DHCAL

H. Weerts, Argonne Nat. Lab.

for

DHCAL RPC group



CALICE
Calorimeter for ILC

TILC09, Tsukuba, Japan, April 2009

Outline

Vertical Slice Test-- Intro

RPC characteristics

Performance

- Rate capability
- Positron showers
- Pion data
- Environmental dependence

Future

Conclusions

Vertical Slice Test

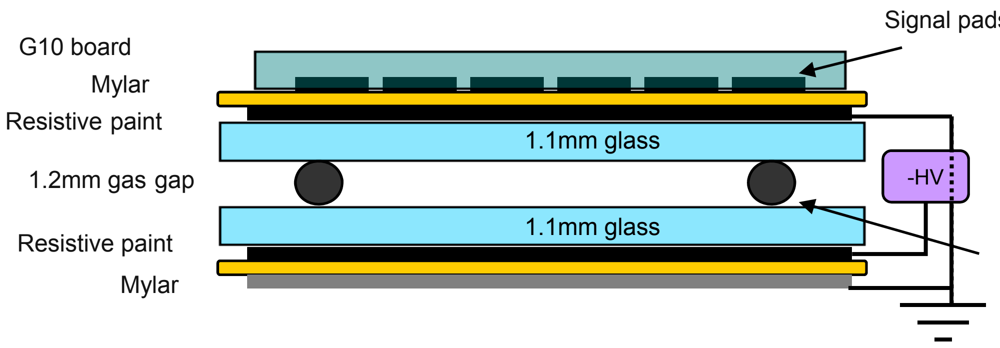
Test of whole system with

- Up to 10 RPCs, each 20 x 20 cm^2
- (Up to 2560 channels)

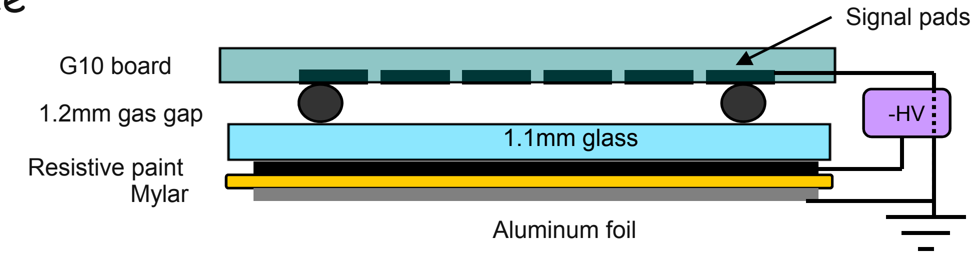
RPCs

- Up to 9 two-glass designs
- 1 one-glass design
- Only use RPC0 – RPC5 in analysis of e^+, π^+
- Only use RPC0 – RPC3 for rate dependence

Two-glass design



One-glass ('exotic') design



Vertical Slice Test

Test of whole system with

Up to 10 RPCs, each 20 x 20 cm^2
(Up to 2560 channels)

RPCs

Up to 9 two-glass designs
1 one-glass design
Only use RPC0 – RPC5 in analysis of e^+, π^+
Only use RPC0 – RPC3 for rate dependence

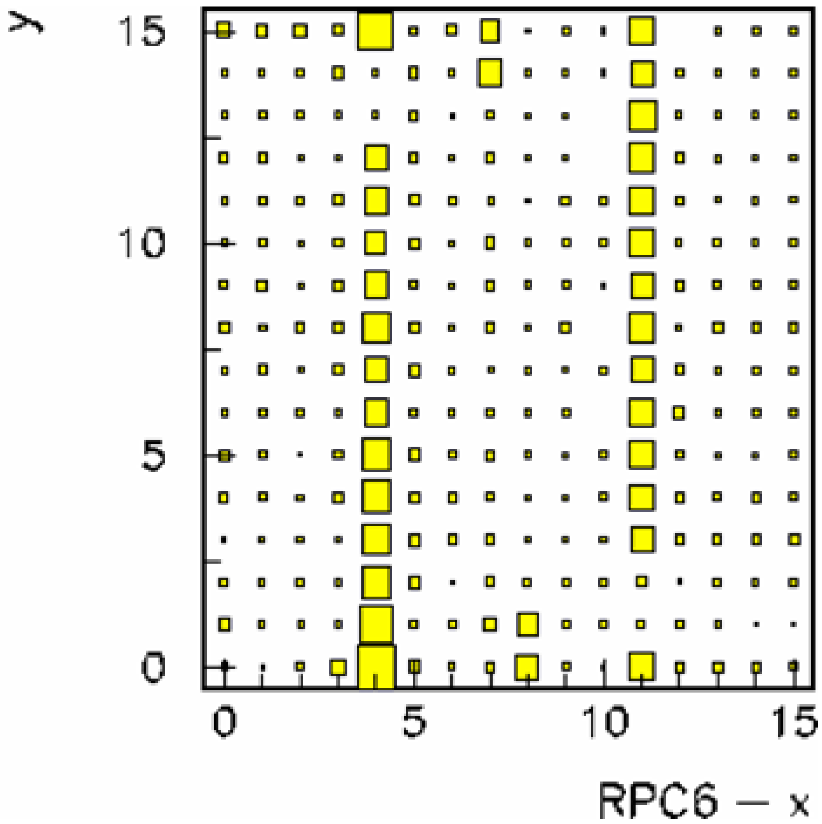
Slice of a "complete" system

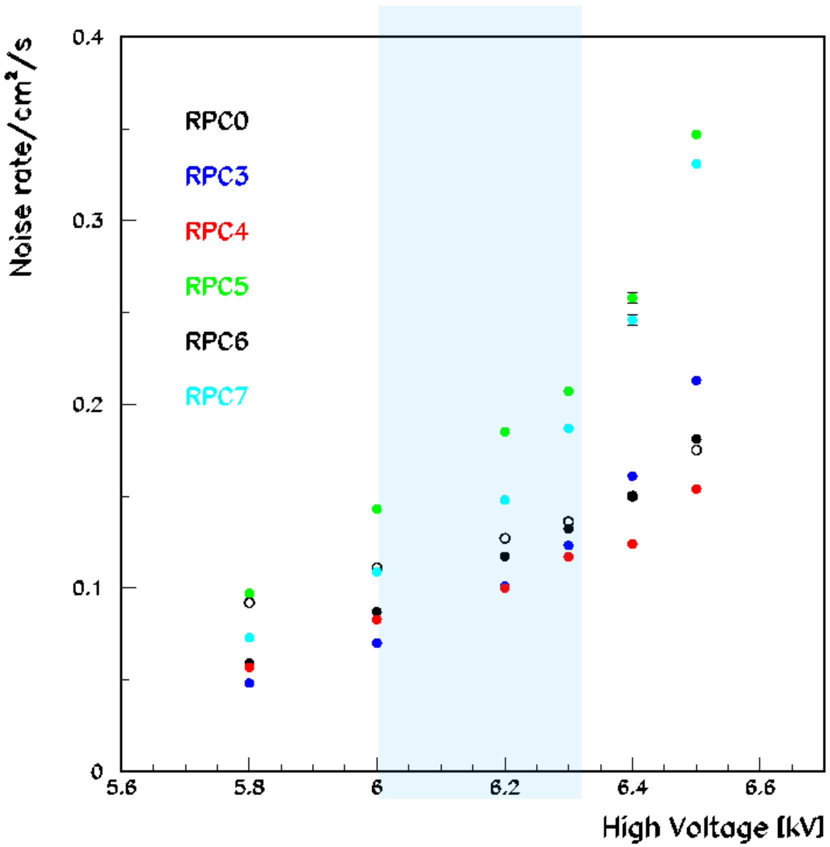
Absorber
For cosmic rays, muon, pions, electrons: Steel (16 mm) + Copper (4 mm)
Rate capability measurement (120 GeV protons): 16 mm PVC with whole cut out in center

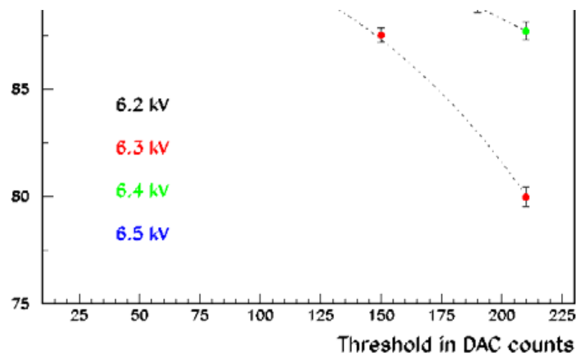
Test beam
Collected data in Fermilab's MT6 beam line

Cosmic Rays
Collected data for ~18 months

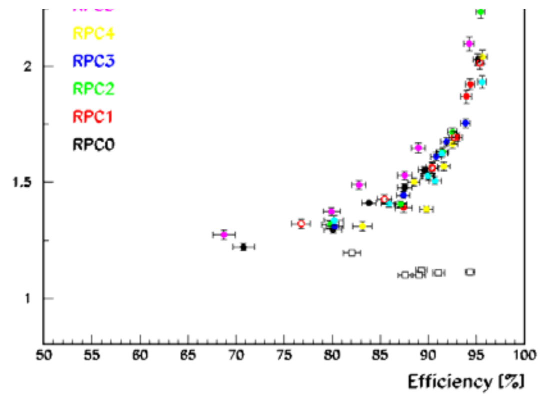
RPC performance



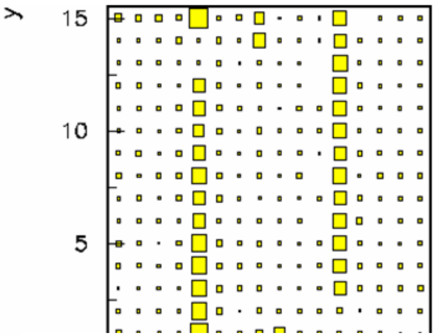




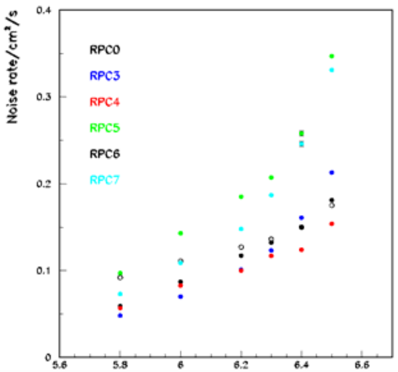
Operation:
HV: 6.0-6.3KV
Threshold: 110
Effic. ~90%

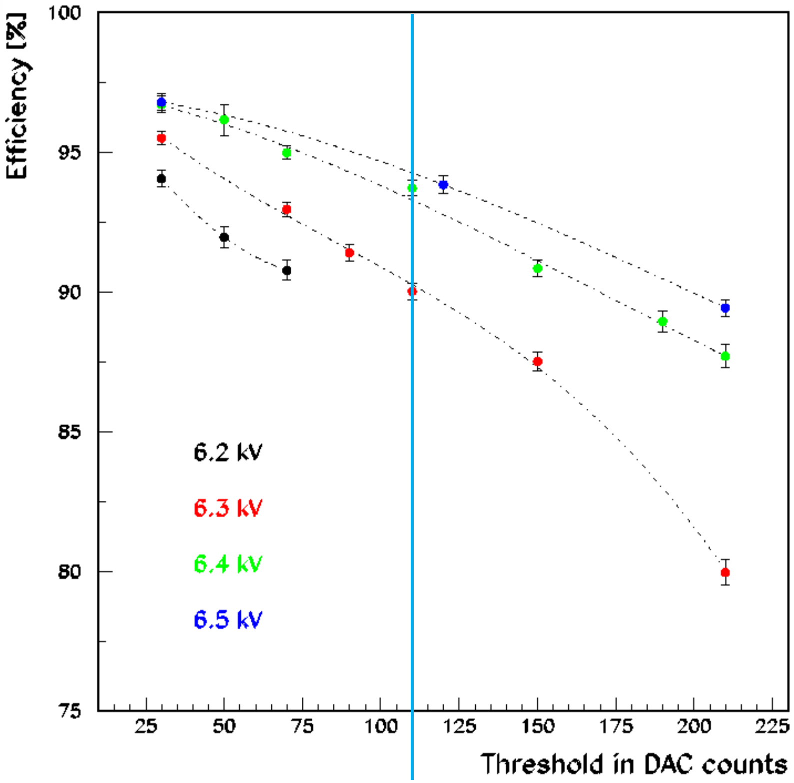


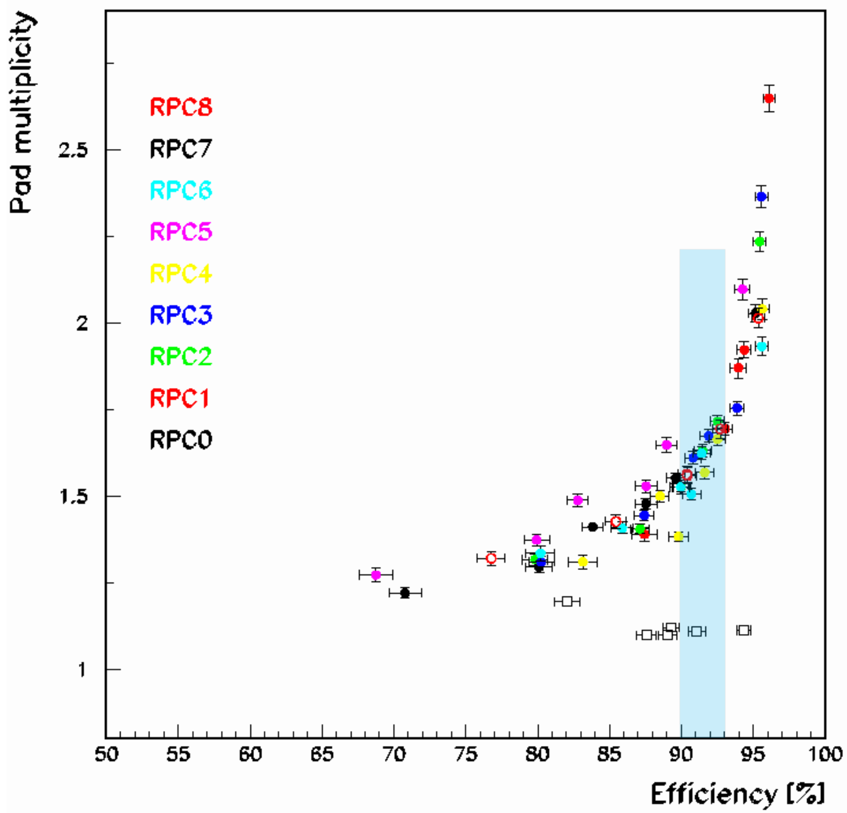
RPC performance



Operation:
HV: 6.0-6.3KV
Threshold: 110
Effic: 90-95%



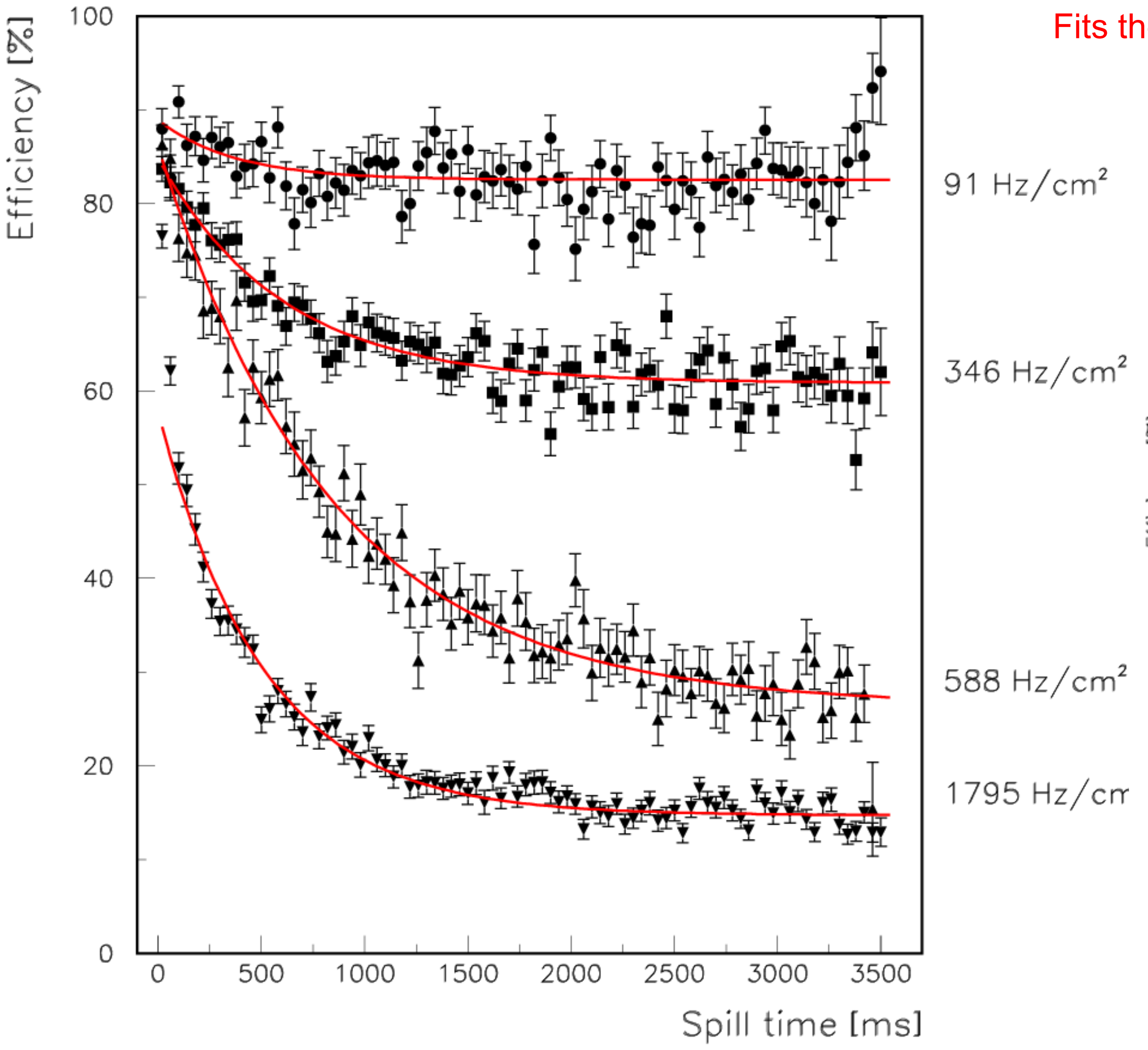


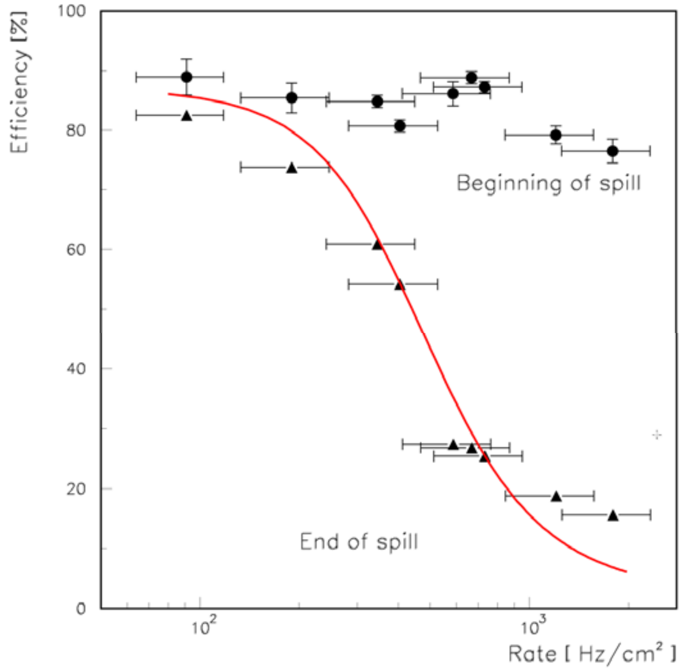


Rate Capability

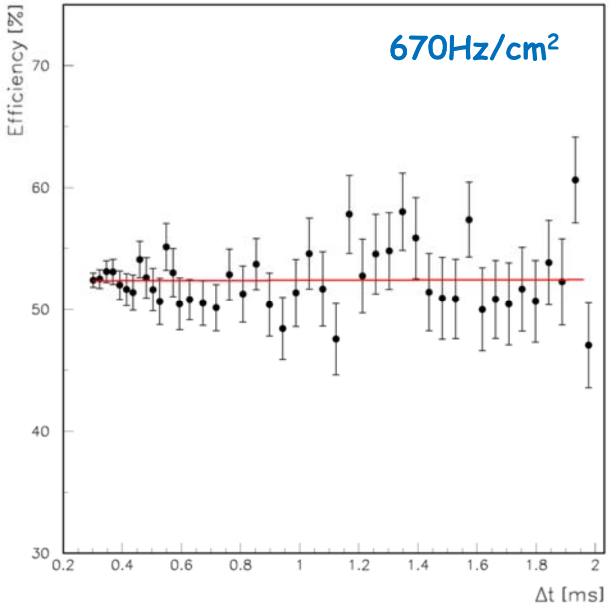
Use time and intensity within test-beam spill

Fits theoretically motivated





Rate Capability

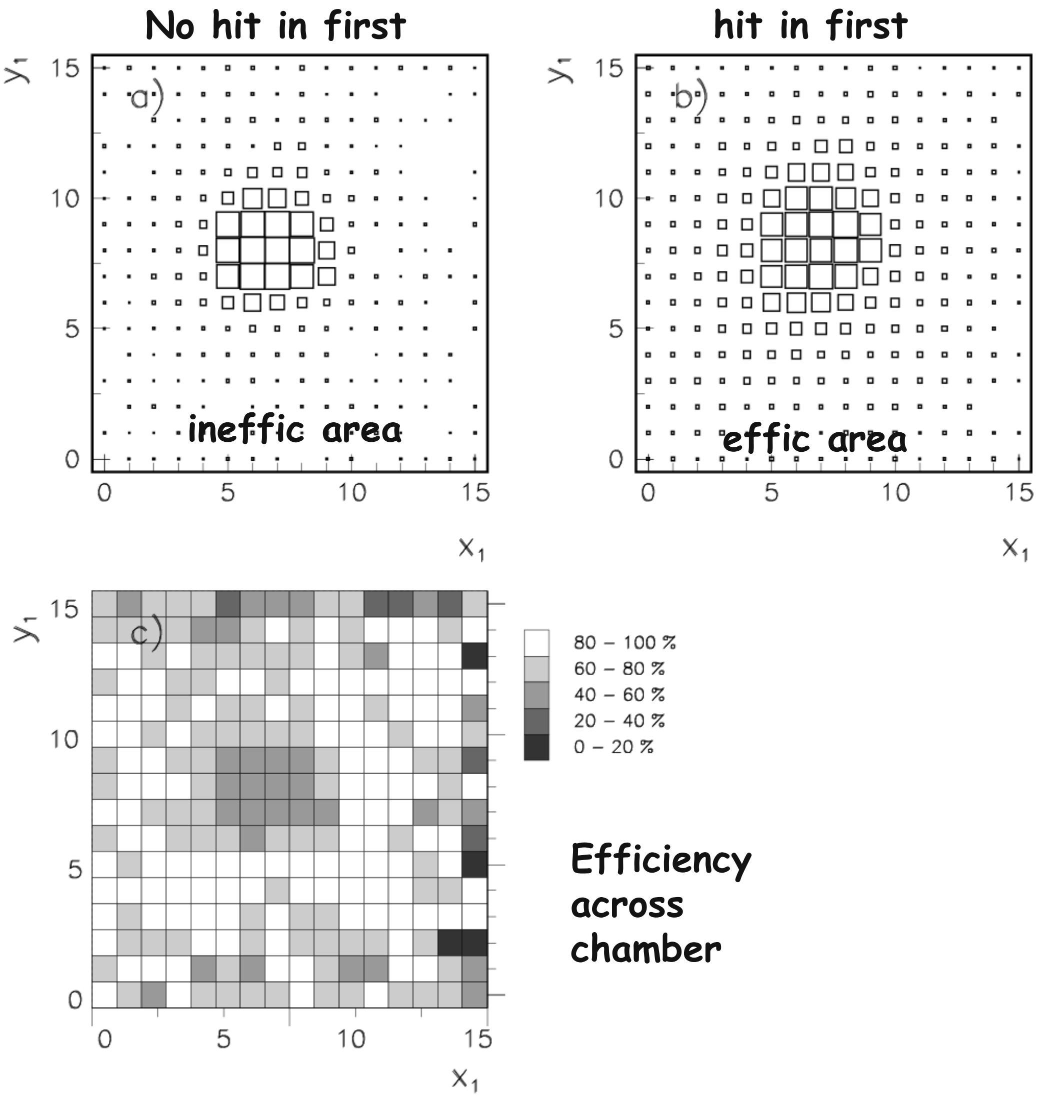


Δt between two protons

Time between consecutive events

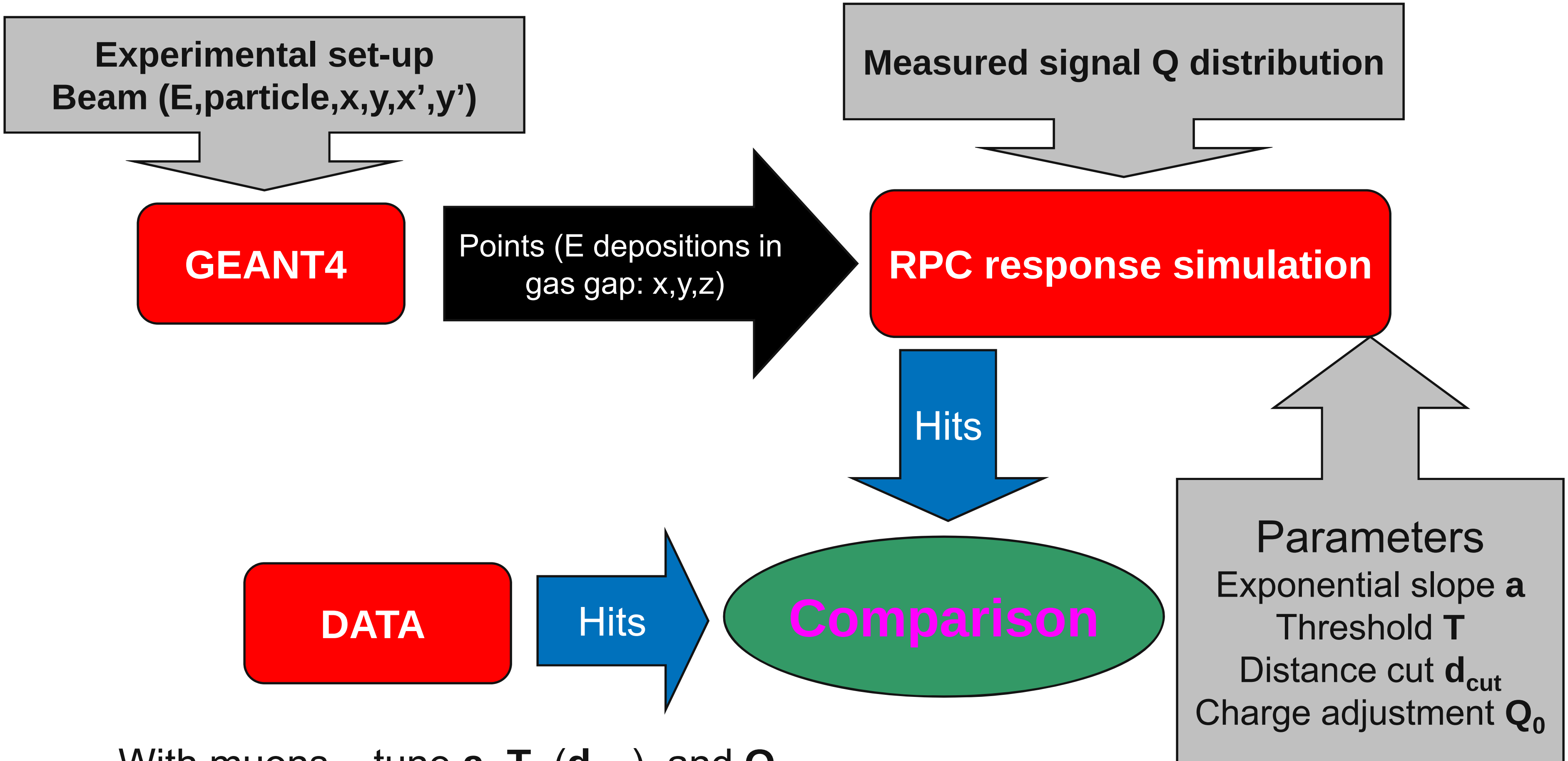
Two chambers: position of hit in 2nd chamber

1800Hz/cm²



Efficiency across chamber

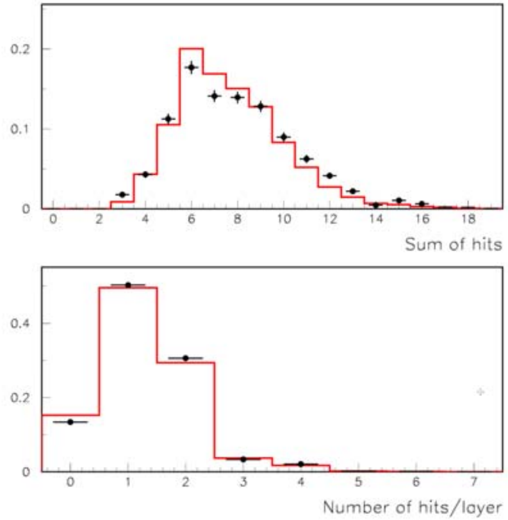
Simulation Strategy and comparison to test beam data



With muons – tune **a**, **T**, ($\mathbf{d_{cut}}$), and $\mathbf{Q_0}$
With positrons – tune $\mathbf{d_{cut}}$
Pions – no additional tuning

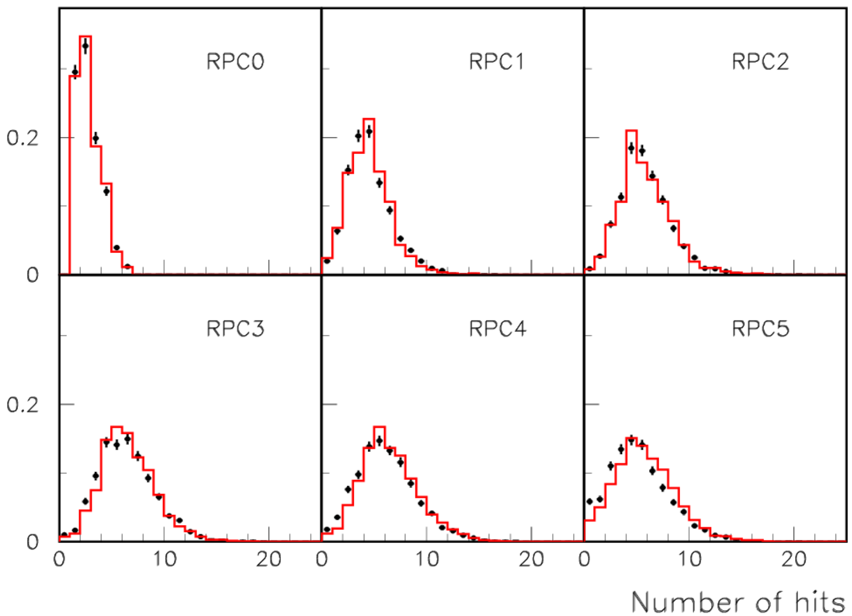
Monte Carlo simulations

Broadband μ

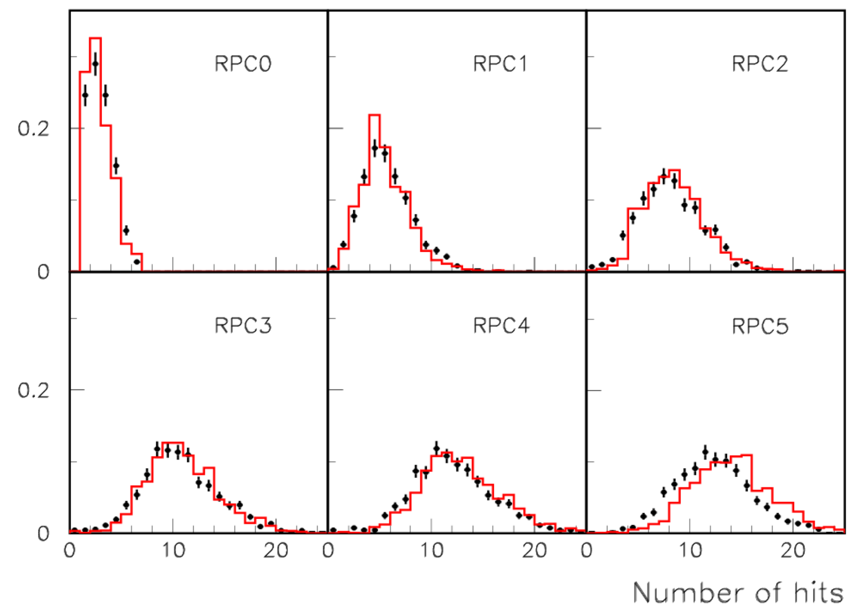


Positron Showers

2GeV e^+

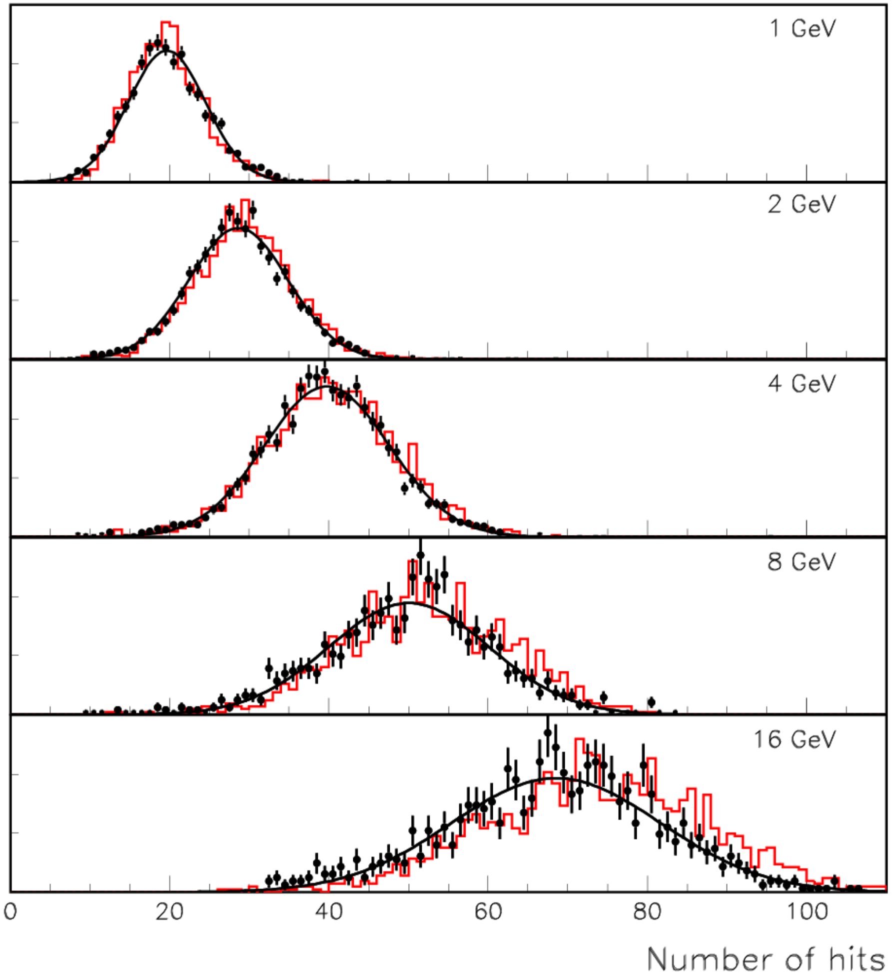


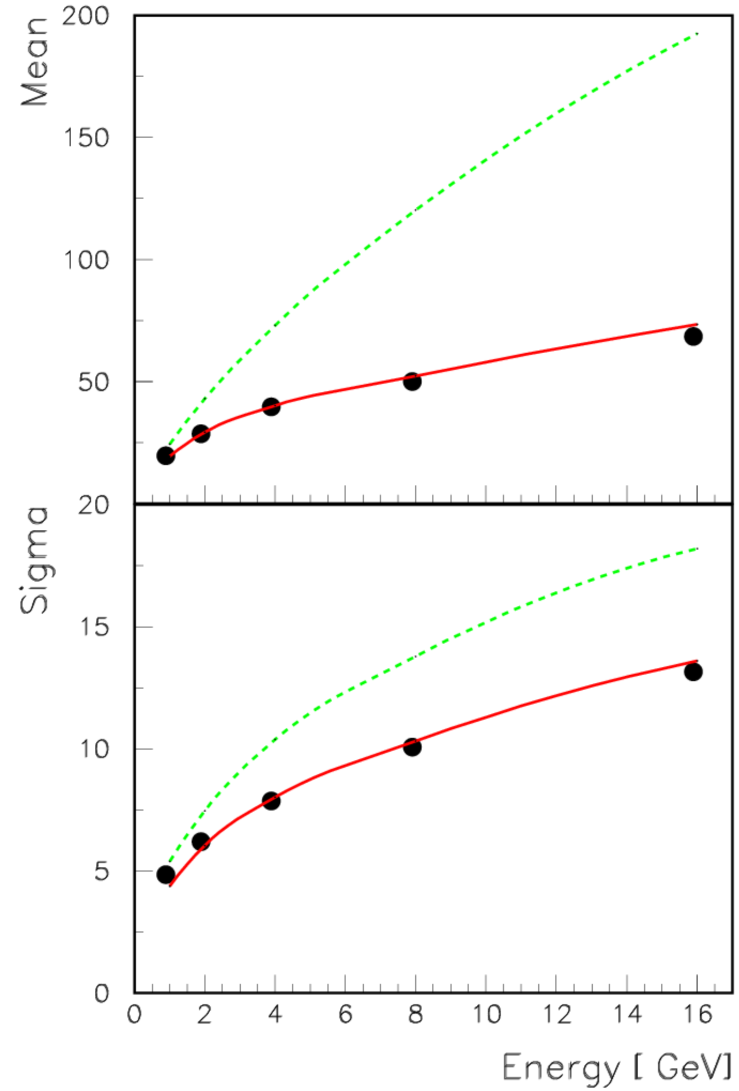
8 GeV e^+



Positron Showers

Monte Carlo simulations – 6 layers
Monte Carlo simulations – Infinite stack





Response to Pions

Simulation needs to be redone with tuned parameters…

Data at

1, 2, 4, 8, 16 GeV (electrons rejected by Čerenkov)

6 layer stack corresponding to 0.7 λ_I

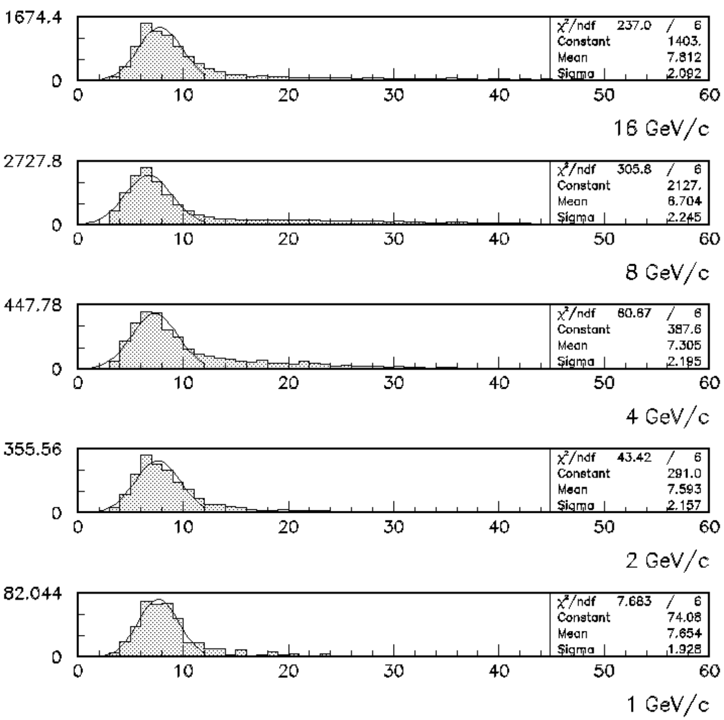
Analysis separates

- Non-interacting pions/muons
- Pions interacting in first layers
- Pions interacting later (rejected)

Exactly one cluster in first layer
Distance R< 5
Number of hits in **first** layer <5

MIP selection

Number of hits in **second** layer < 5



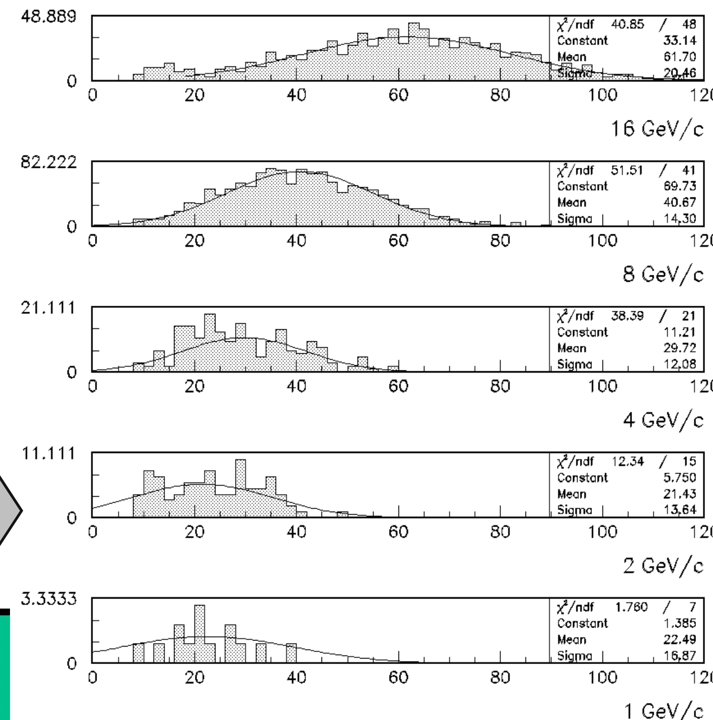
Plot total #hits

Nice MIP peaks

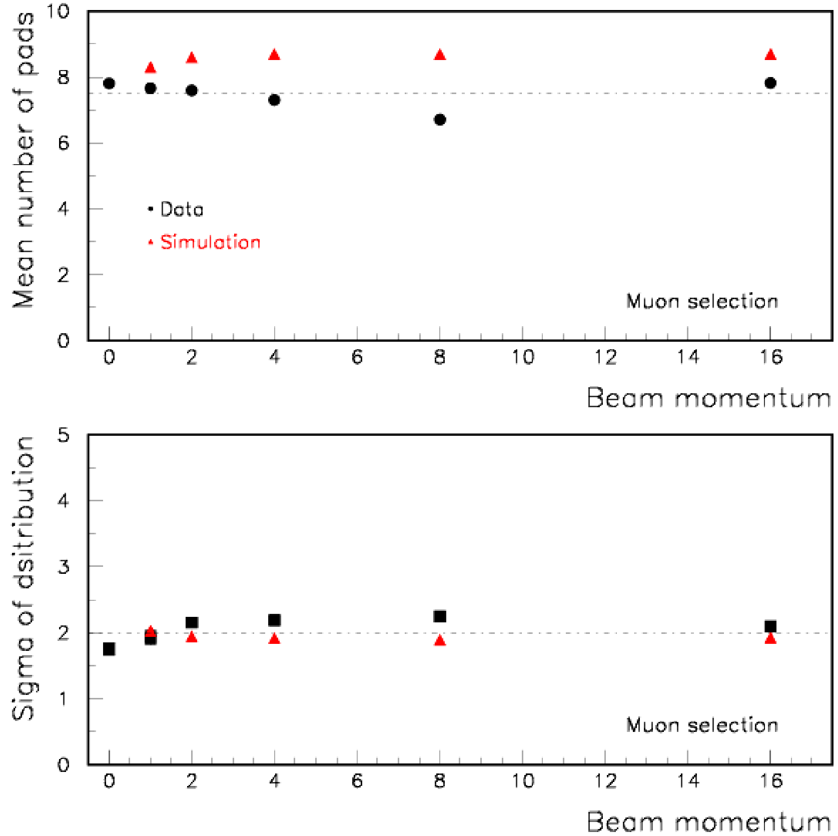
Gaussian distributions

Pion selection

Number of hits in **second** layer ≥ 5

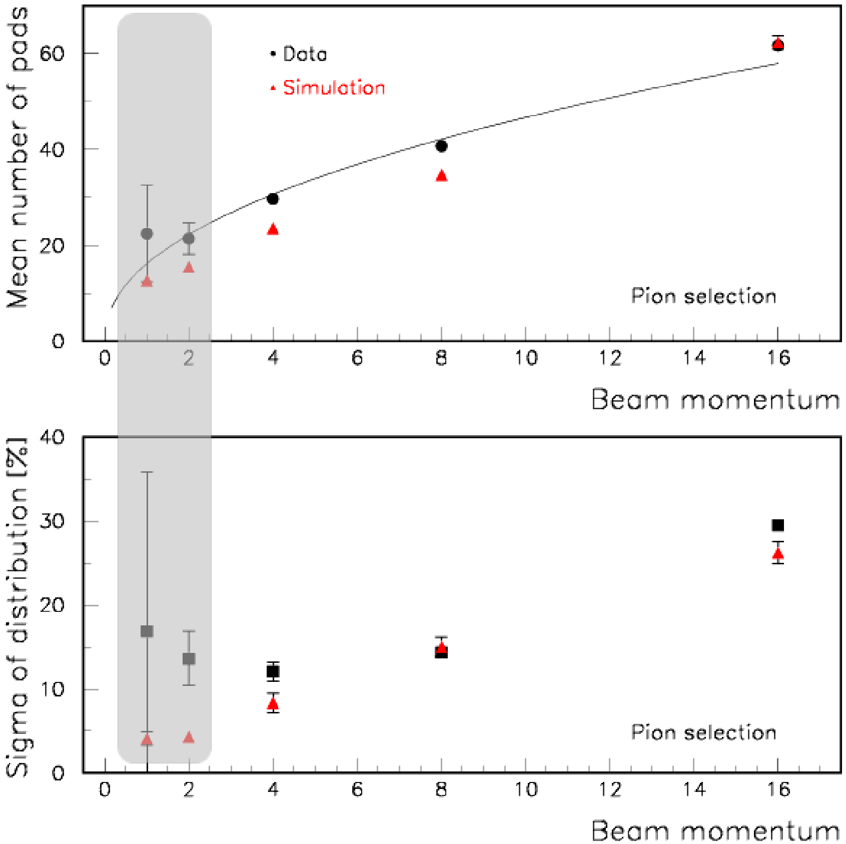


Response to Pions



MIP selection

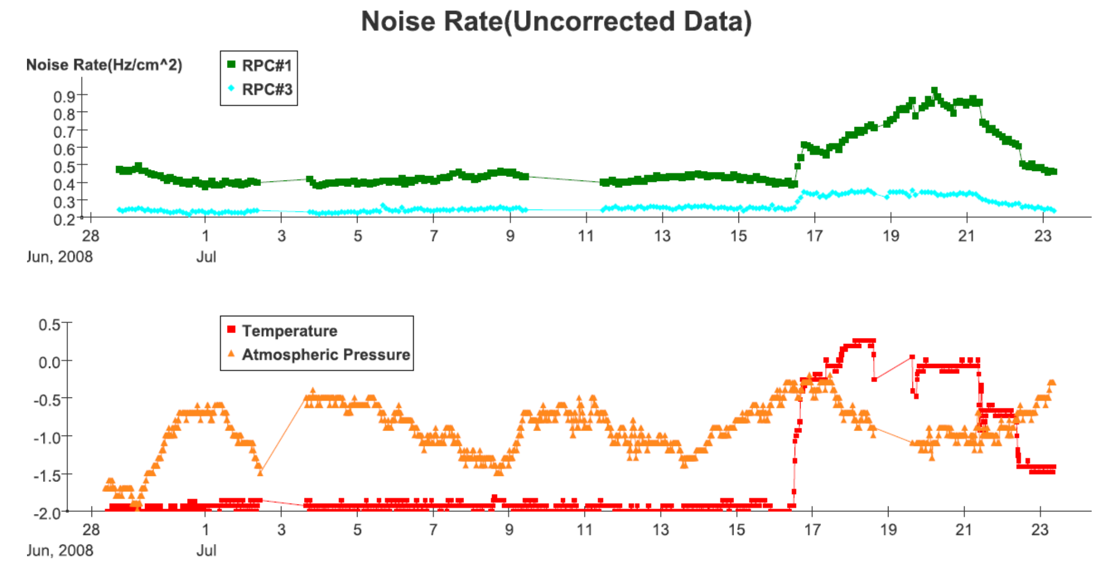
Mean and sigma ~independent of beam momentum
Mean not very well reproduced by simulation
→ Beam contains muons, simulation does not
(data are cleaner !!!)
Width of distributions adequately reproduced

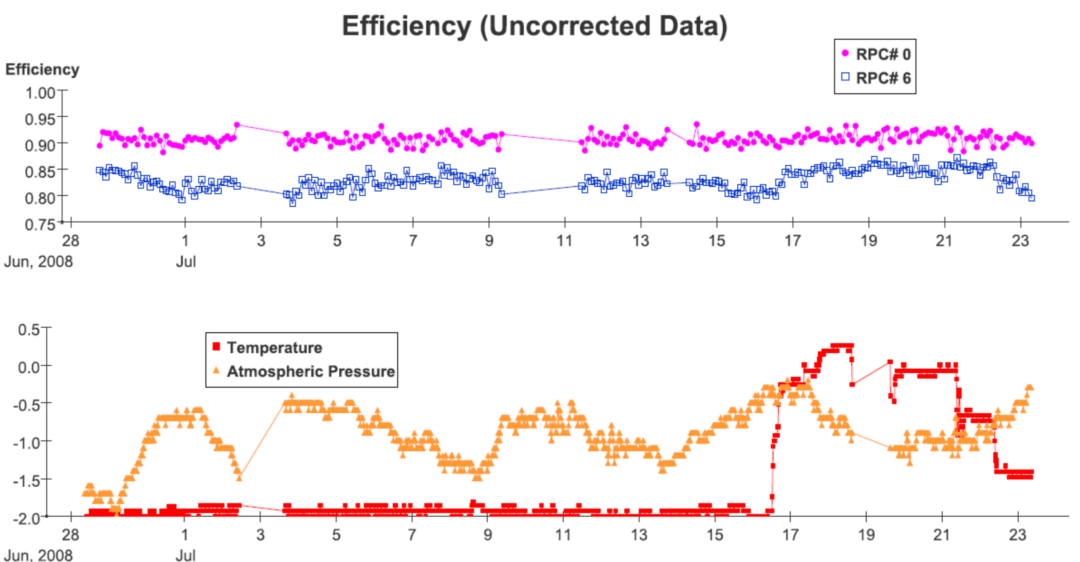


Pion selection

Measurements at 16, 8 and 4GeV/c
Not sufficient statistics at 2, 1 GeV/c
Non-linearity due to leakage
Adequate agreement with simulation

Environmental





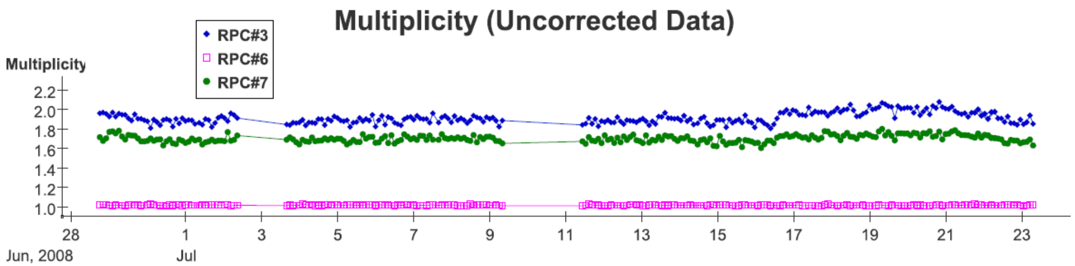
Data collected over period of 18 months

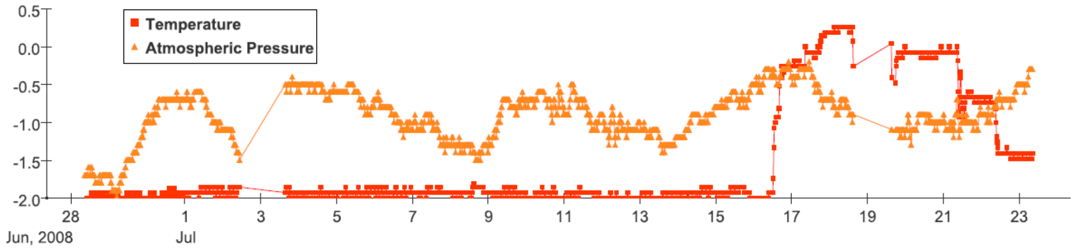
Weather station added about 9 months ago

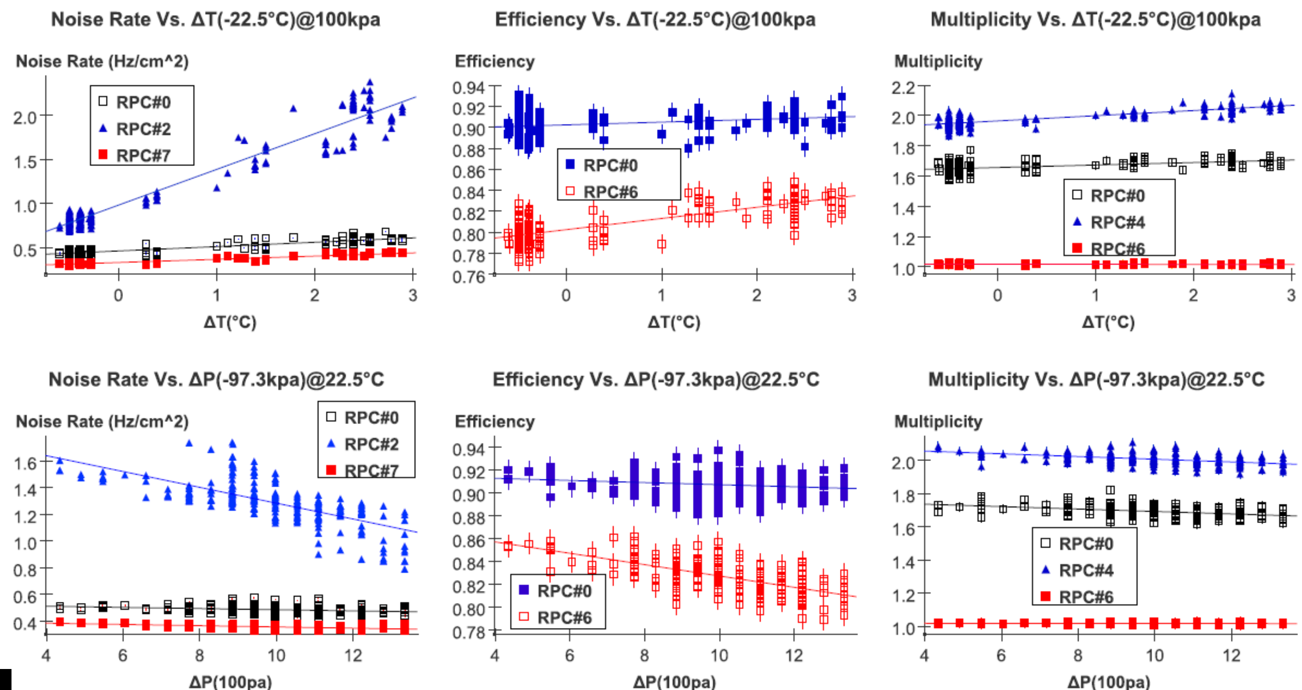
Barometric pressure
Ambient temperature
Air humidity

Draft exists, plots being finalized

Environmental





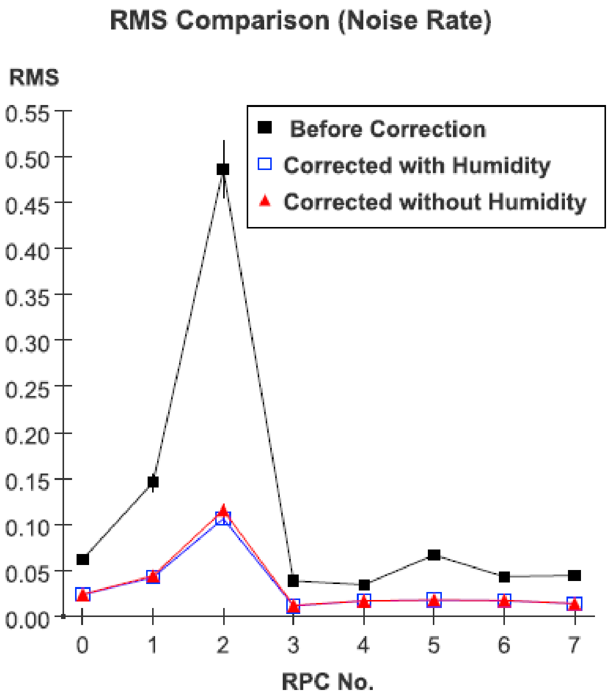


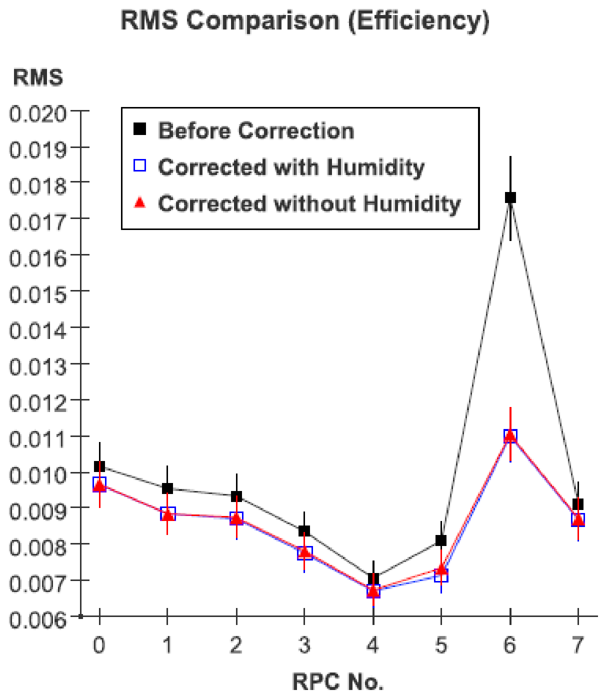
Draft exists, plots being finalized

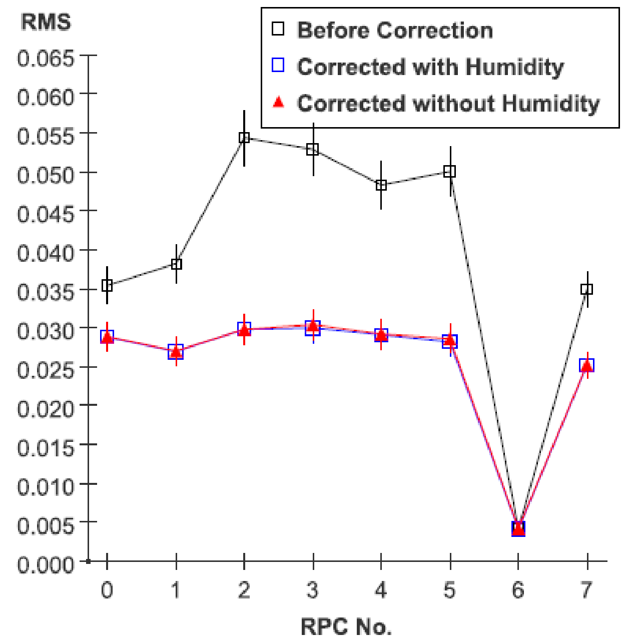
Assume linear dependence on p,T,H

$F_i(p,T,H) = F_{i,0} + b_{i,1}\,\Delta p + b_{i,2}\,\Delta T + b_{i,3}\,\Delta H$ with i = N,E,M

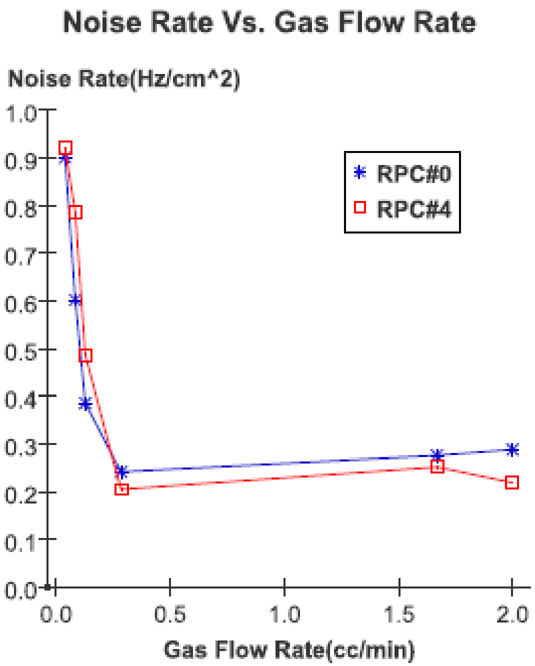
Apply correction → check RMS of distributions

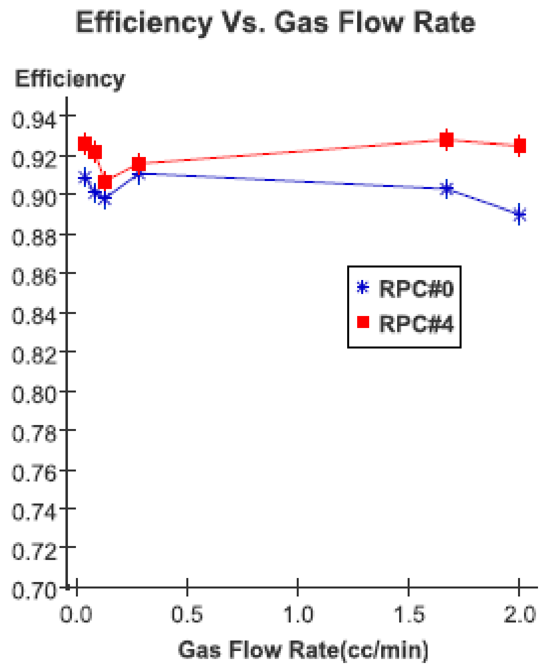


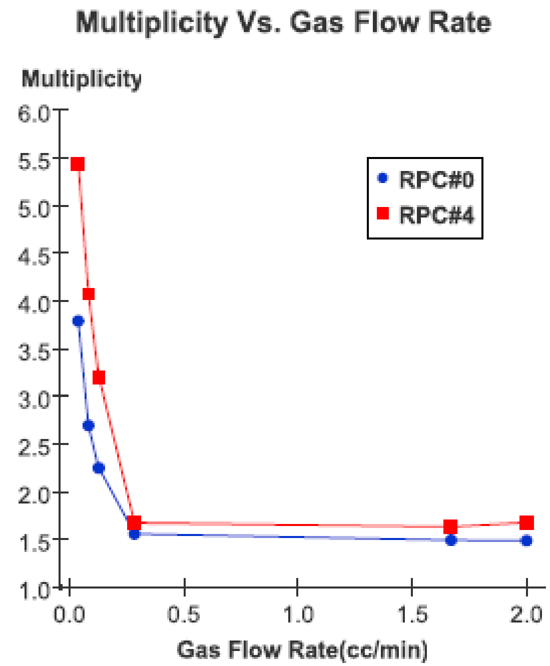




Bonus: performance versus gas flow rate







Future

1 m^3 – Physics Prototype

Description

40 layers each ~ 1 x 1 m^2
Each layer with 3 RPCs, each 32 x 96 cm^2
Readout of 1 x 1 cm^2 pads with one threshold (1-bit)
~400,000 readout channels
Layers to be inserted into the existing AHCAL CALICE structure

Purpose

Validate DHCAL concept
Gain experience running large RPC system
Measure contained hadronic showers in great detail
Validate hadronic shower models

Status

Started construction in fall 2008

Front-end Electronics

DCAL III chip

Produced in 2008
Received 11 wafers with 966 chips each → 10626 chips

→ Packaged chips by early March--done

Testing to be done

'by hand' at Argonne for first chips (in progress)
by robot at FNAL (being programmed)

Pad- and Front-end board

On critical path

32 x 48 cm^2 → 4 x 6 chips
Being designed (first prototype in hand)

Data concentrator

Design and firmware completed
To be implemented onto front-end board

Future

DHCAL Construction Overview

Item	Status	Outstanding problems/tasks	Critical path
RPC construction	Several prototypes exist	Test of thin-glass 2-glass chambers Test of full-scale 1-glass chambers (requires final front-end board) Develop production procedure	No
DCAL chips	In hand	Robot testing	Until ~May
Front-end boards	Being prototyped	Final design/prototype (ASIC in hand) Testing procedure being developed	~May - October
Back-end	Being produced	Small modifications to existing design	No
Gas system	Being assembled	None	No
HV system	Completed	None	No
DAQ software	Being modified	None	No
OFFLINE software	Being developed	None	No

Conclusions

Learned a lot from vertical slice test and extended operation of chamber stack

Excellent foundation for next step

Building planes/electronics/DAQ for $1m^3$ test calorimeter to go into CALICE stack