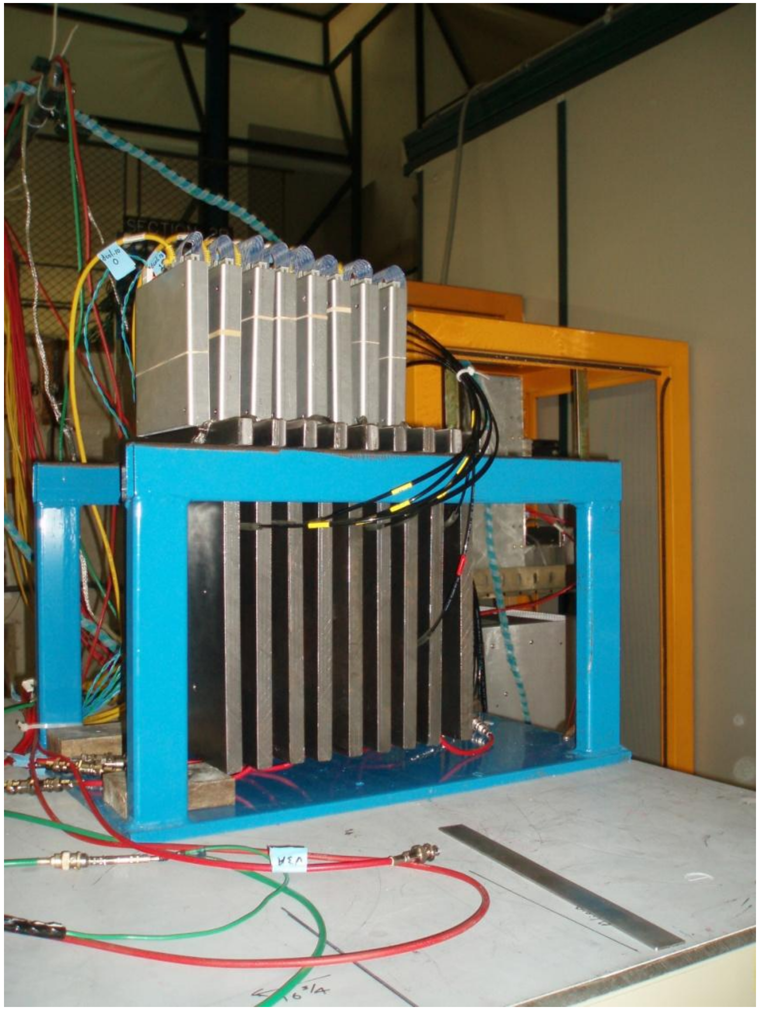
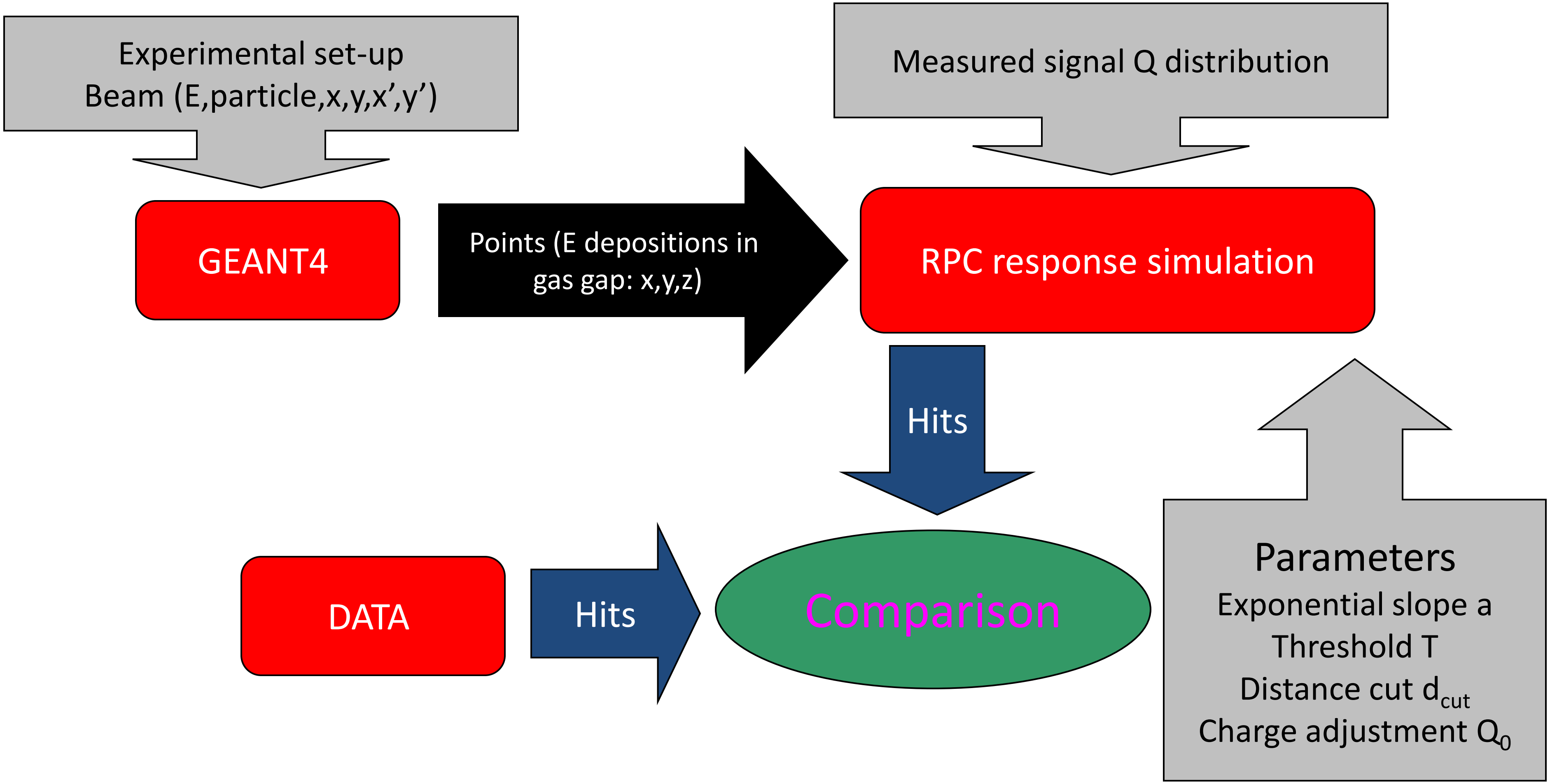
Simulation of the RPC Response



José Repond
Argonne National Laboratory

CALICE Collaboration Meeting
University Hassan II
Casablanca, Morocco
September 22 – 24, 2010

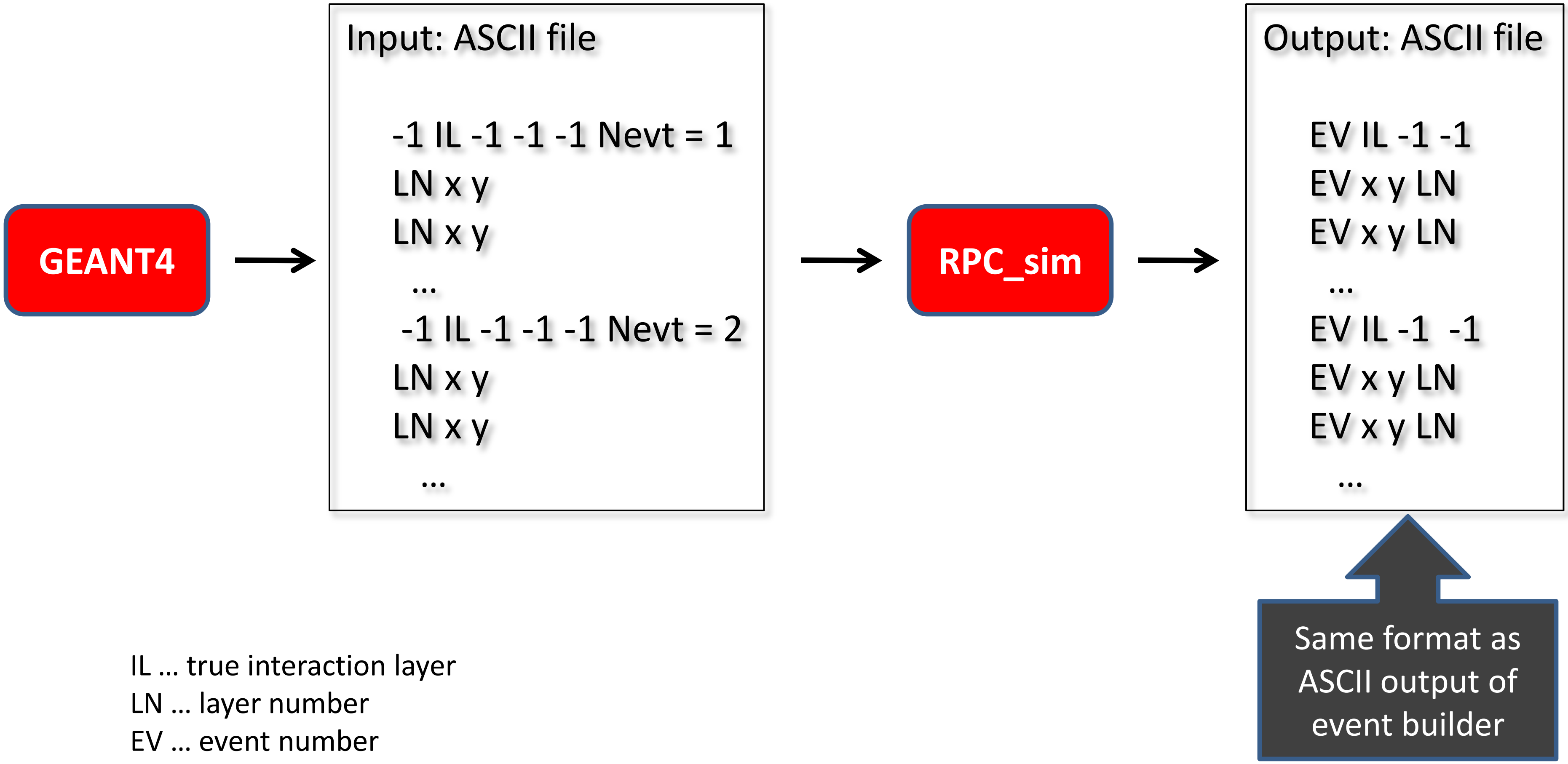
Simulation Strategy



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

RPC_sim

Language: Fortran 77
276 lines of code
(I think it is well documented)



RPC_sim: Step I

Discard close-by points

RPCs do not generate multiple avalanches very close by

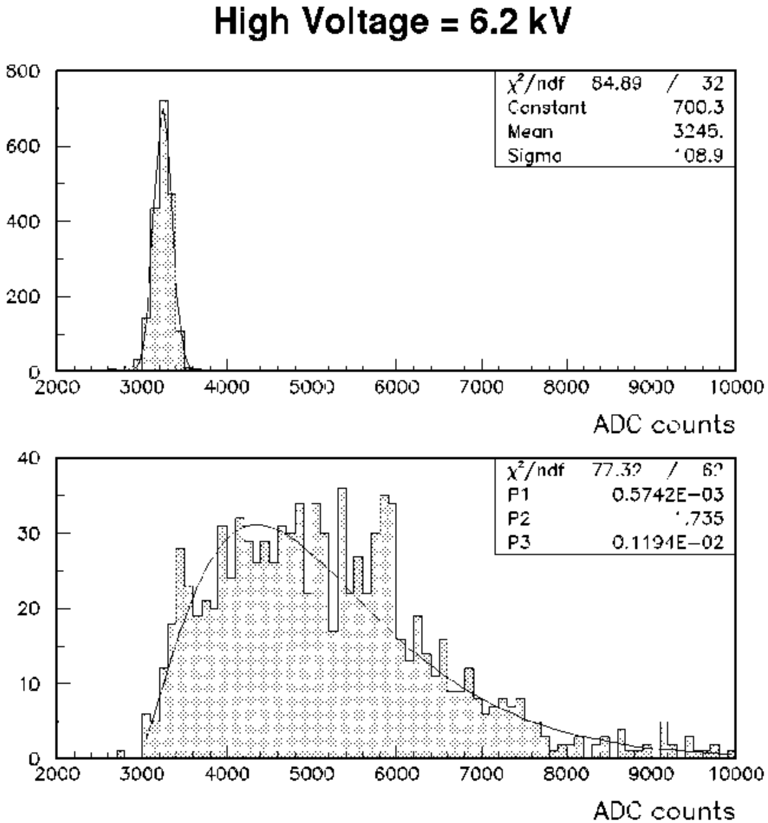
Check distance d between all pairs of points

If $d <$ **dist_cut**, discard one of the points

RPC_sim: Step II

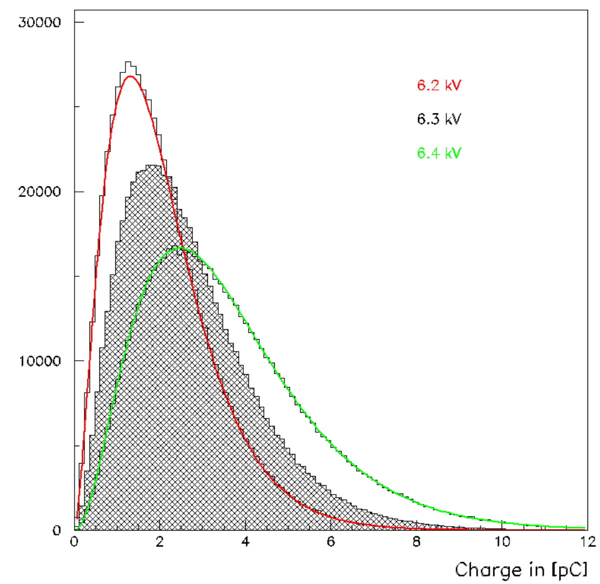
Generate overall charge

Measured charge distribution
for HV = 6.2 kV



→

Generated charge distributions
for different HV settings



Fit to $y = \alpha\,(x-2900)^{\beta}\,e^{-\gamma(x-2900)}$

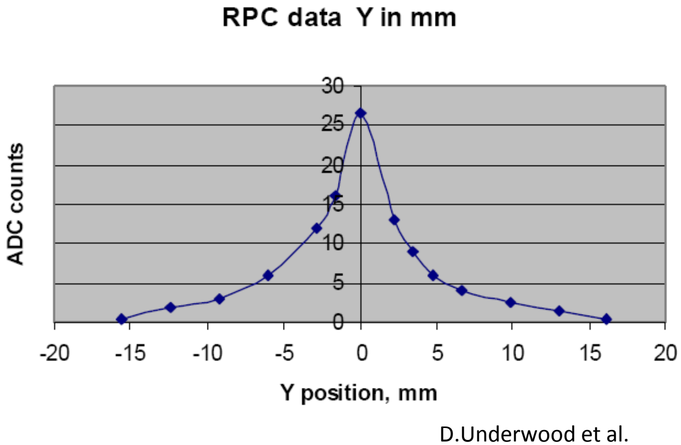
Allow for shift of Q spectrum by $\mathbf{Q_0}$

RPC_sim: Step III

Distribute charge over pads

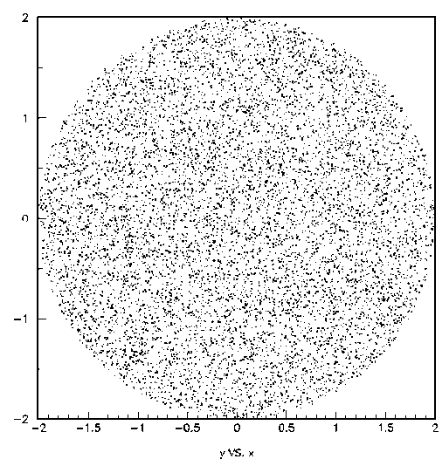
Assume exponential dependence on distance from avalanche

Measured charge distribution as function of y in the pick-up plane

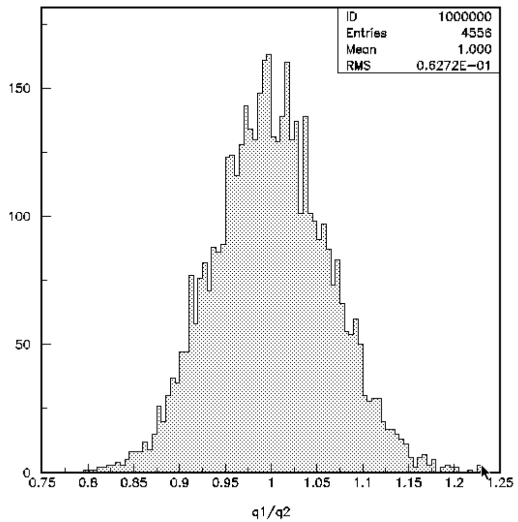


Exponential with slope a

Throw 10,000 points in x,y plane within radius R_0 of avalanche
Calculate charge Q(r)
Sum up charge on 1 x 1 cm^2 pads



Cross check:
sum of charges on pads



RPC_sim: Step IV

Identify hits

Pad identified as hit if Q_{pad} > **T**

Note:

This procedure reproduces the average efficiency and pad multiplicity of RPCs for single tracks (muons)

It deals properly with the overlap of avalanches within a shower or from different particles

It does not deal with the effect of particles crossing the chambers at an angle (we know that the efficiency (pad multiplicity) is slightly (somewhat) dependent on the angle of incidence).

RPC_sim: Tuning I

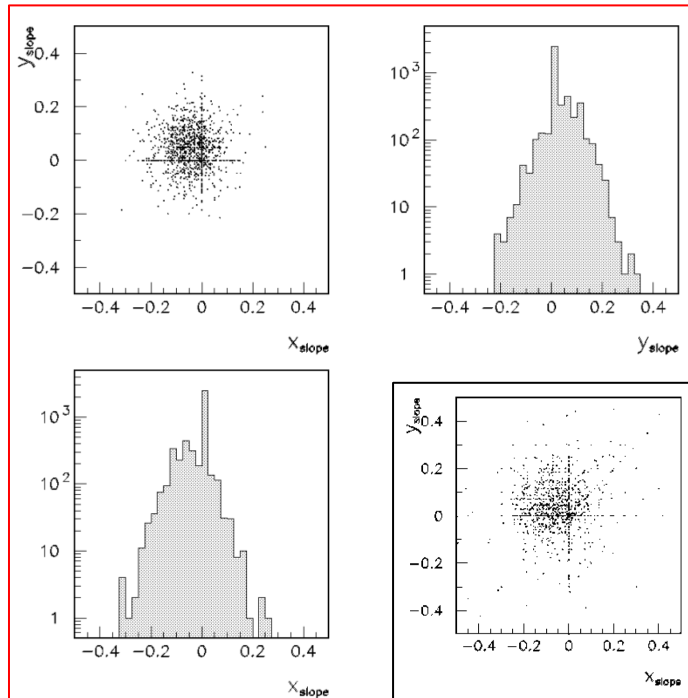
Location and angle of particles

Procedure

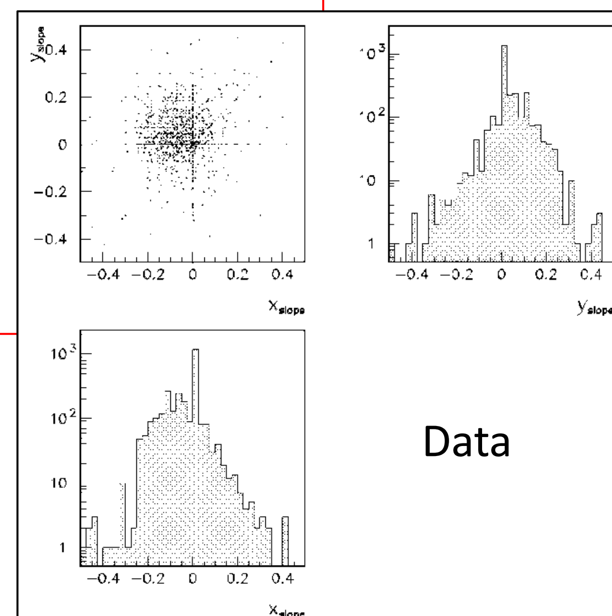
Cluster hits in each layer
Fit straight line to clusters
Compare MC and data:

Clusters in first layer
Slopes of straight lines

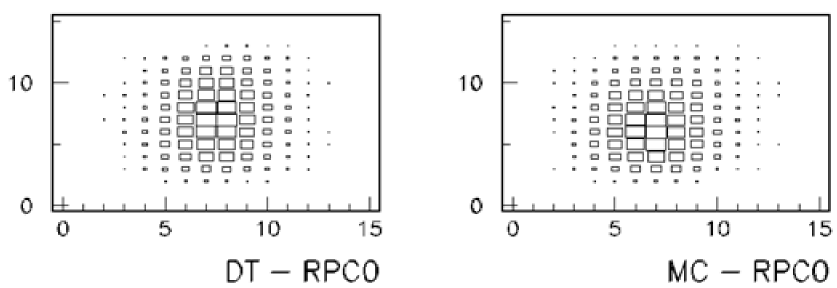
Adjust MC to reproduce data



Simulation



x - y map of hits



RPC_sim: Tuning II

Tune parameters Q_0, a, and T

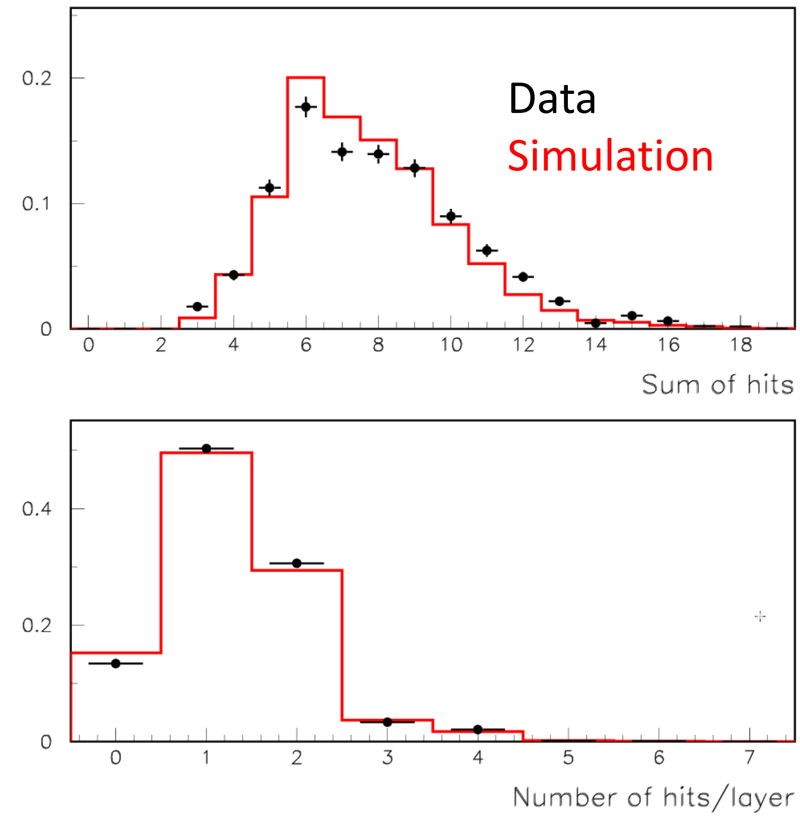
Broadband muons

from FNAL test beam (with 3 m Fe blocker)

Tune

slope **a**
threshold T
charge adjustment Q_0
(Muon data not sensitive to **dist_cut**)

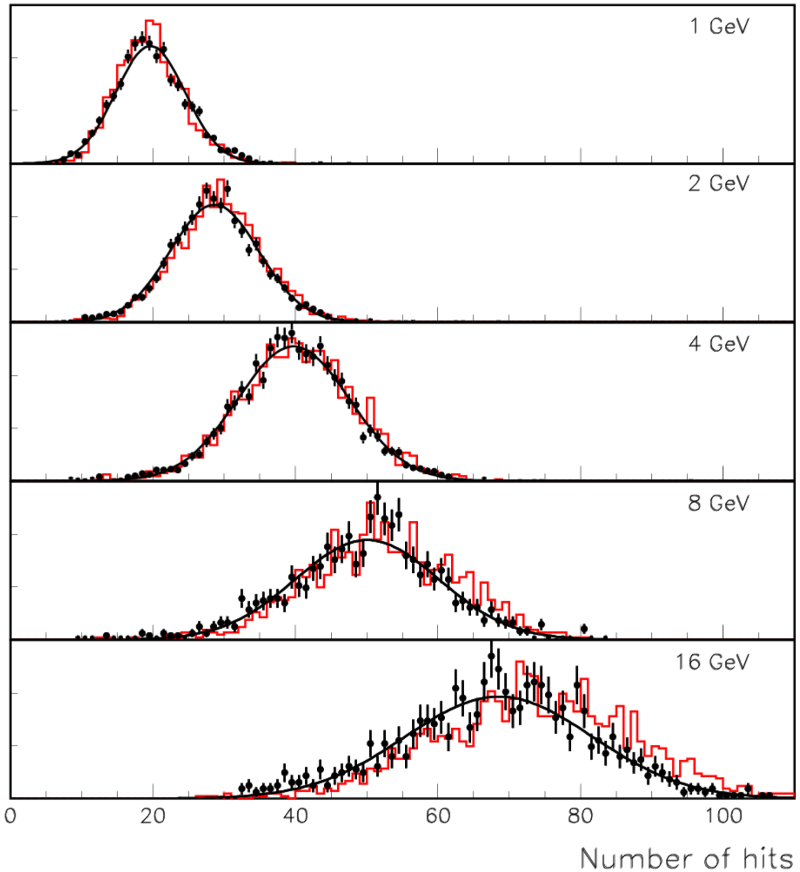
→ reproduce the distributions of the sum of hits and hits/layer



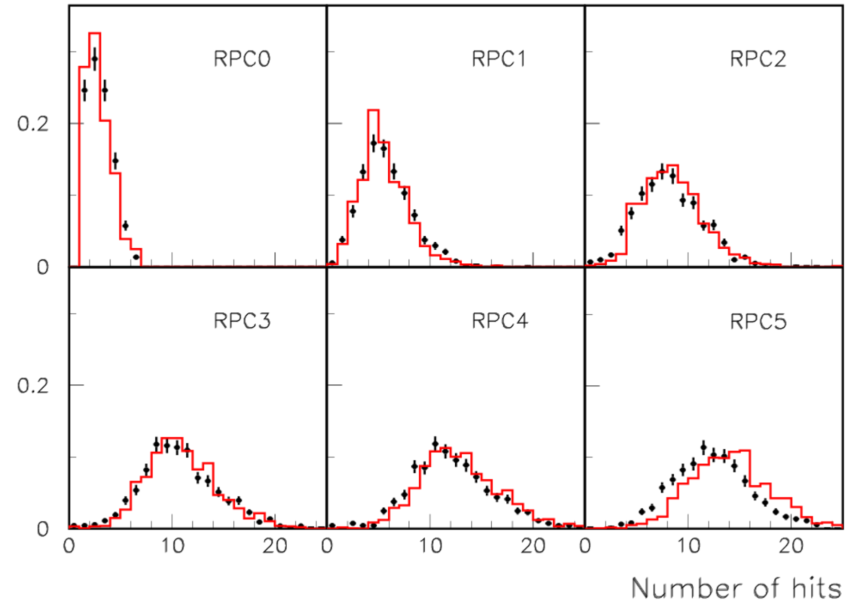
RPC_sim: Tuning III

Tune parameter dist_cut

Adjust **dist_cut** to reproduce Σ_{hits} for 4 GeV positrons

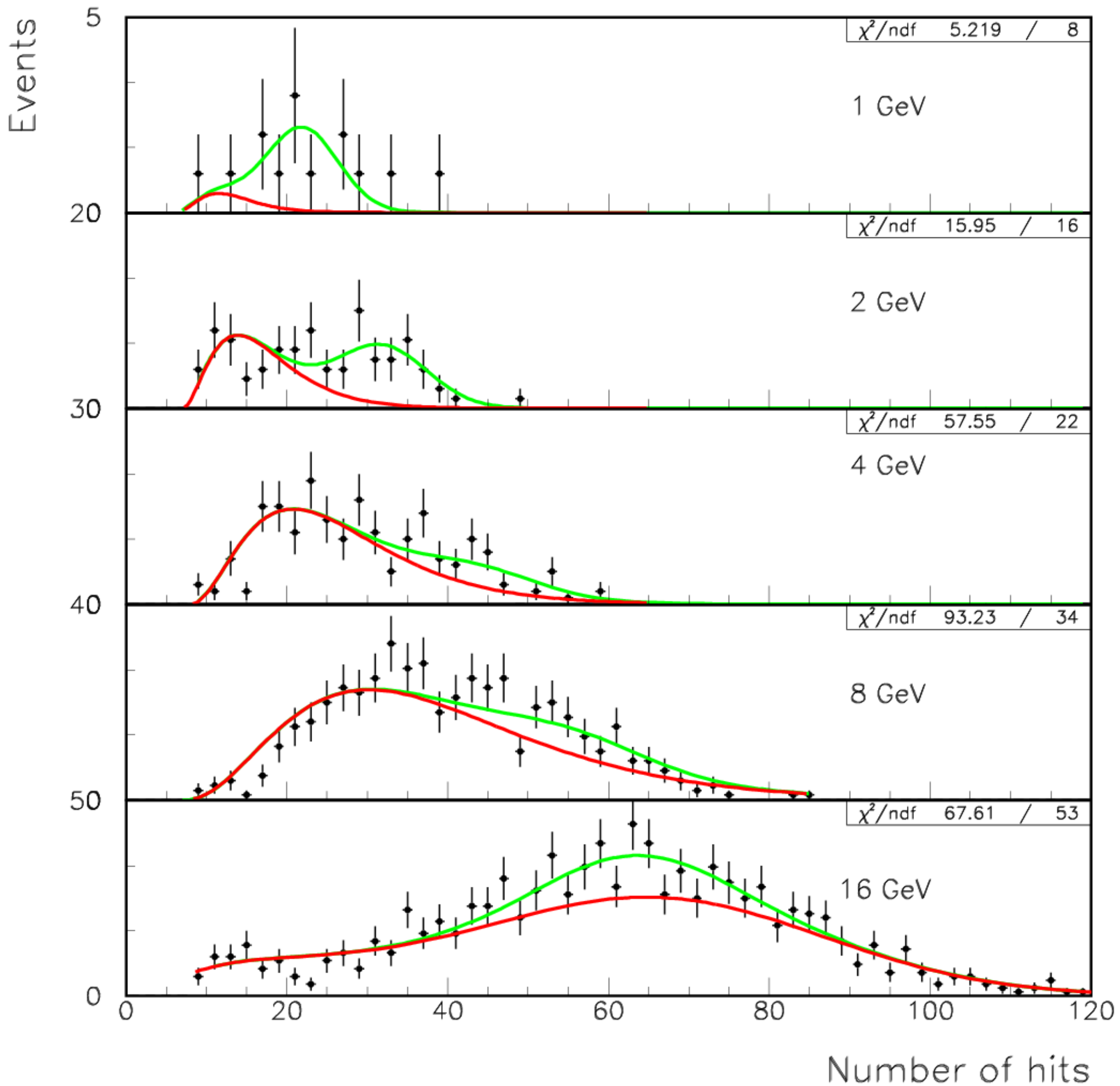


8 GeV Positrons



RPC_sim: Tuning IV

Cross – check with pions



Fit to 2 components

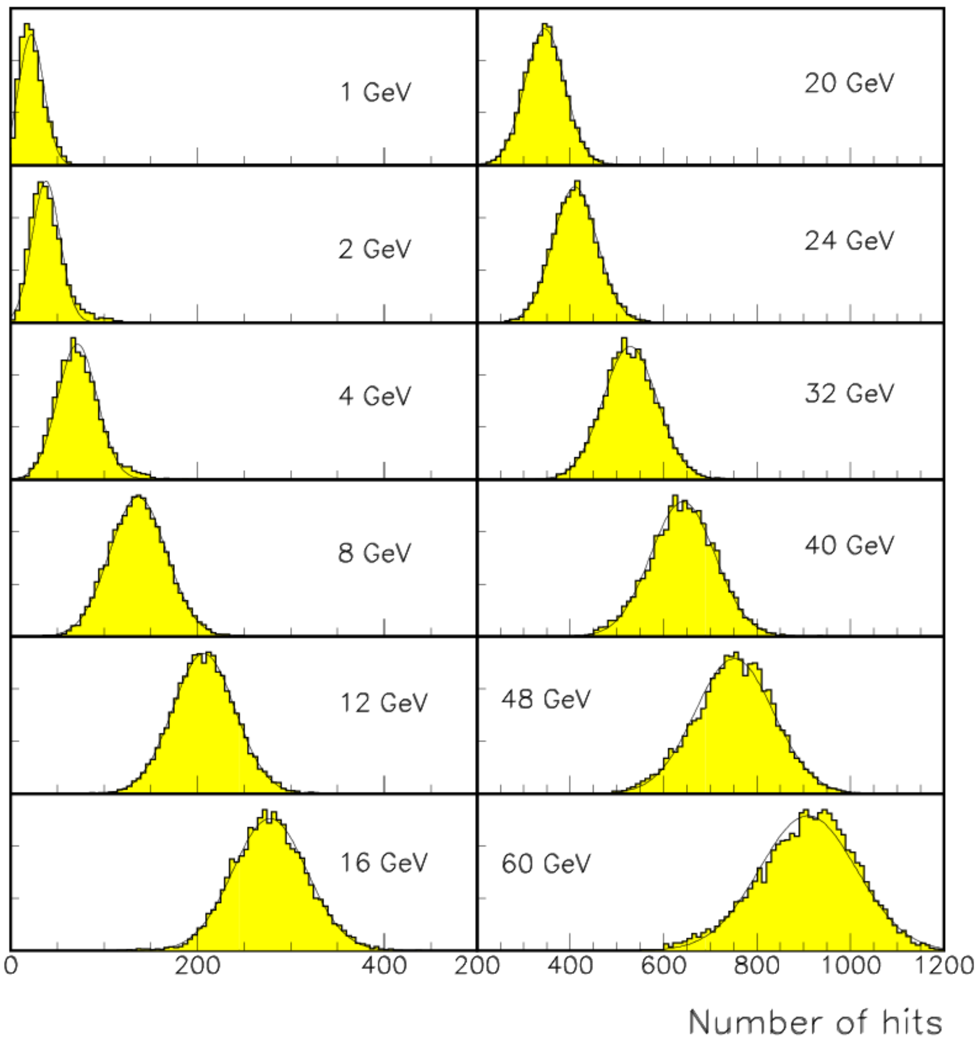
- Pions (from MC)
- Positrons (from MC)

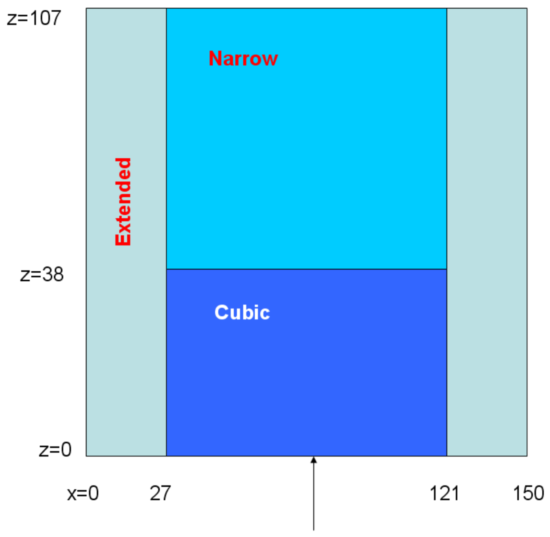
Note

MC curves = absolute predictions, apart from general scaling due to efficiency problems (rate) at 16 GeV (-9%)

RPC_sim: Predictions I

Response curves



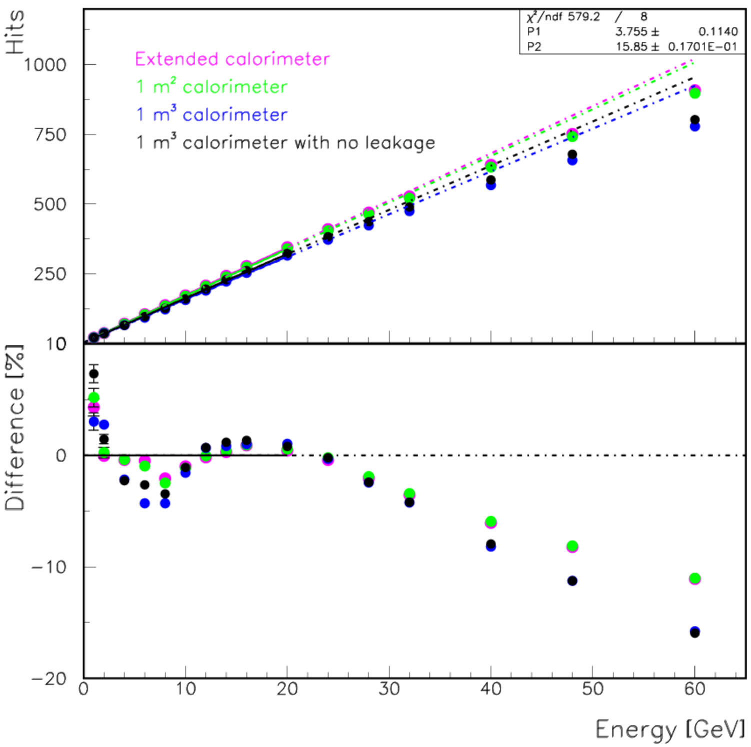


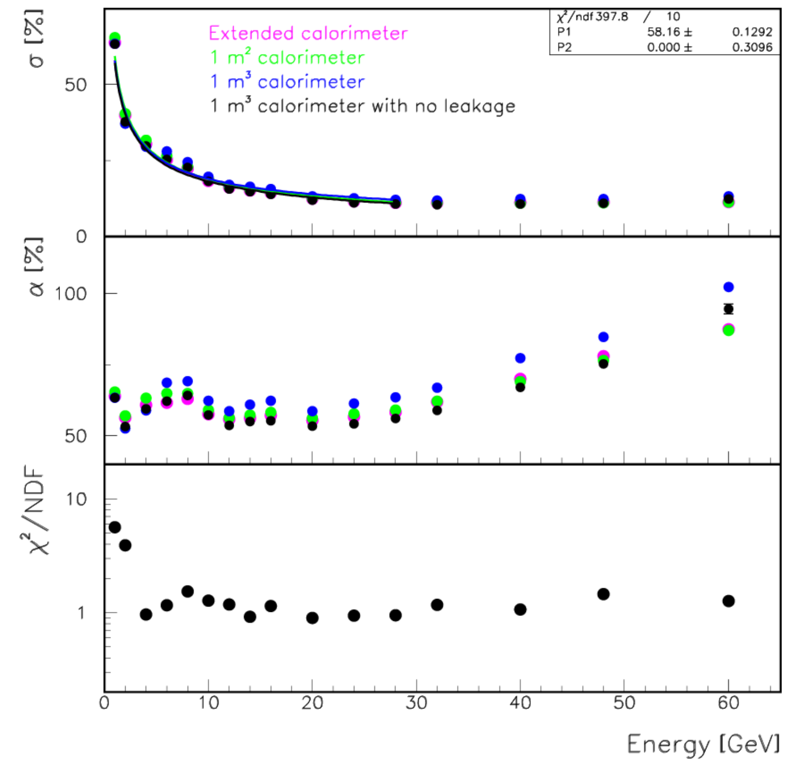
107 layers (minimal leakage)
Each 1.5 x 1.5 m^2

Reasonable Gaussian fits for E > 2 GeV

RPC_sim: Predictions II

Linearity and resolution





Reasonable Gaussian fits for E > 2 GeV

Discontinuity at E ~ 8 GeV (surprising, changes with physics list)

Non-linearity above E ~ 20 GeV (saturation)

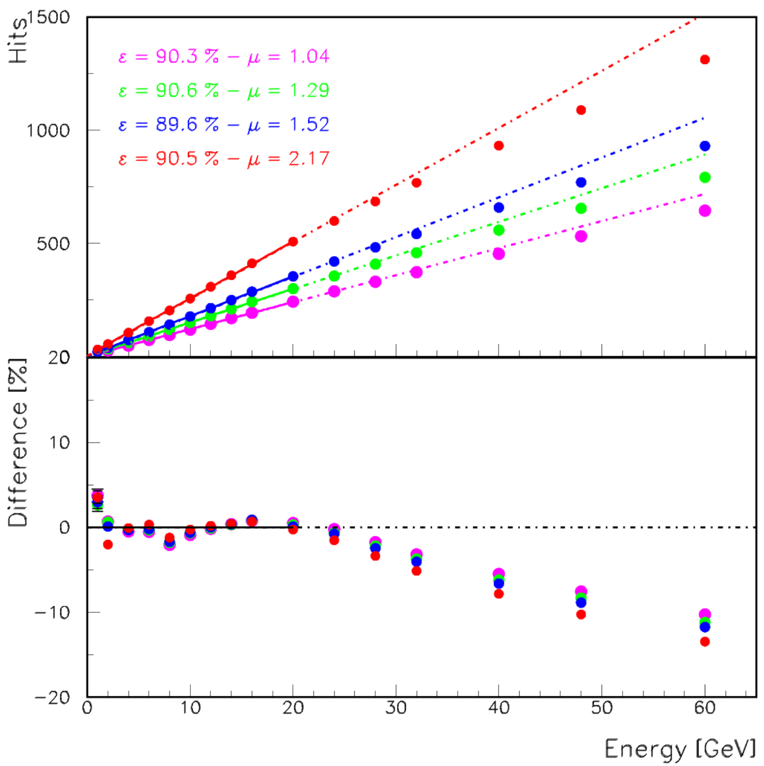
Resolution ~ 58%/√E(GeV) (for E < 28 GeV)

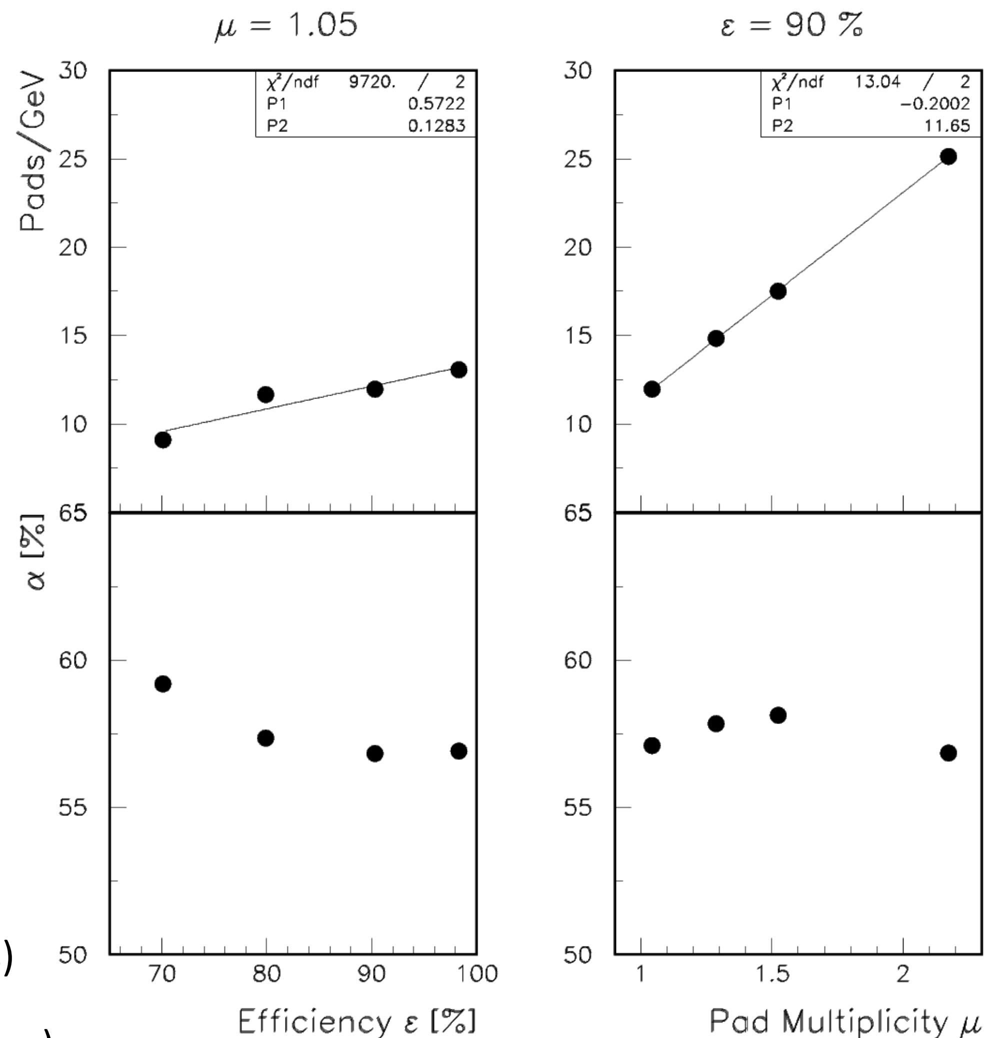
Resolution degrades above 28 GeV (saturation)

Resolution of 1m^3 with containment cut somewhat better than for extended calorimeter

RPC_sim: Predictions III

Dependence on ε and μ





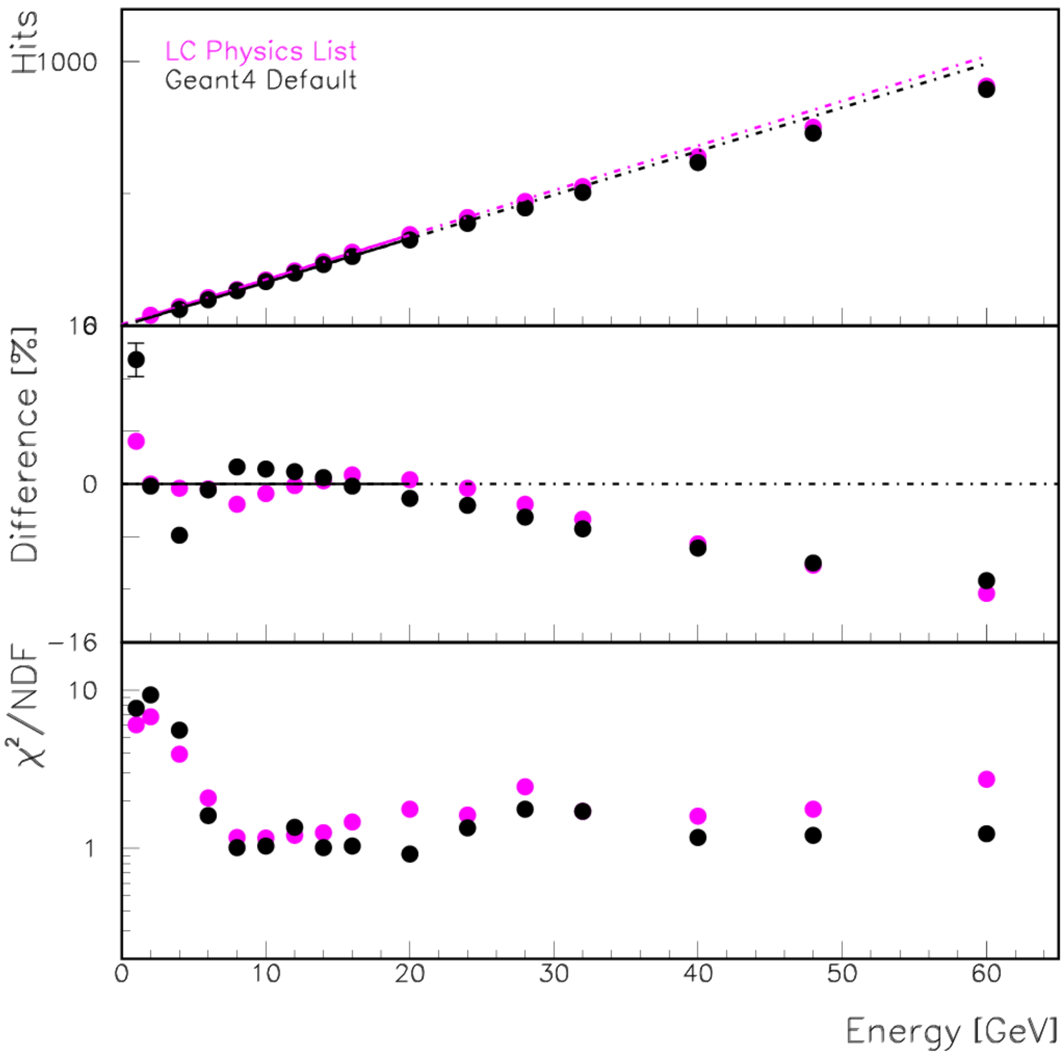
Efficiency and pad multiplicity have only minor effect on resolution
(Large ε/small μ might be desirable for PFAs)

However values need to be known (calibration)

Note: Linear calibration corrections for ε,μ will work (P_1 ~ 0)

RPC_sim: Predictions IV

Different physics lists



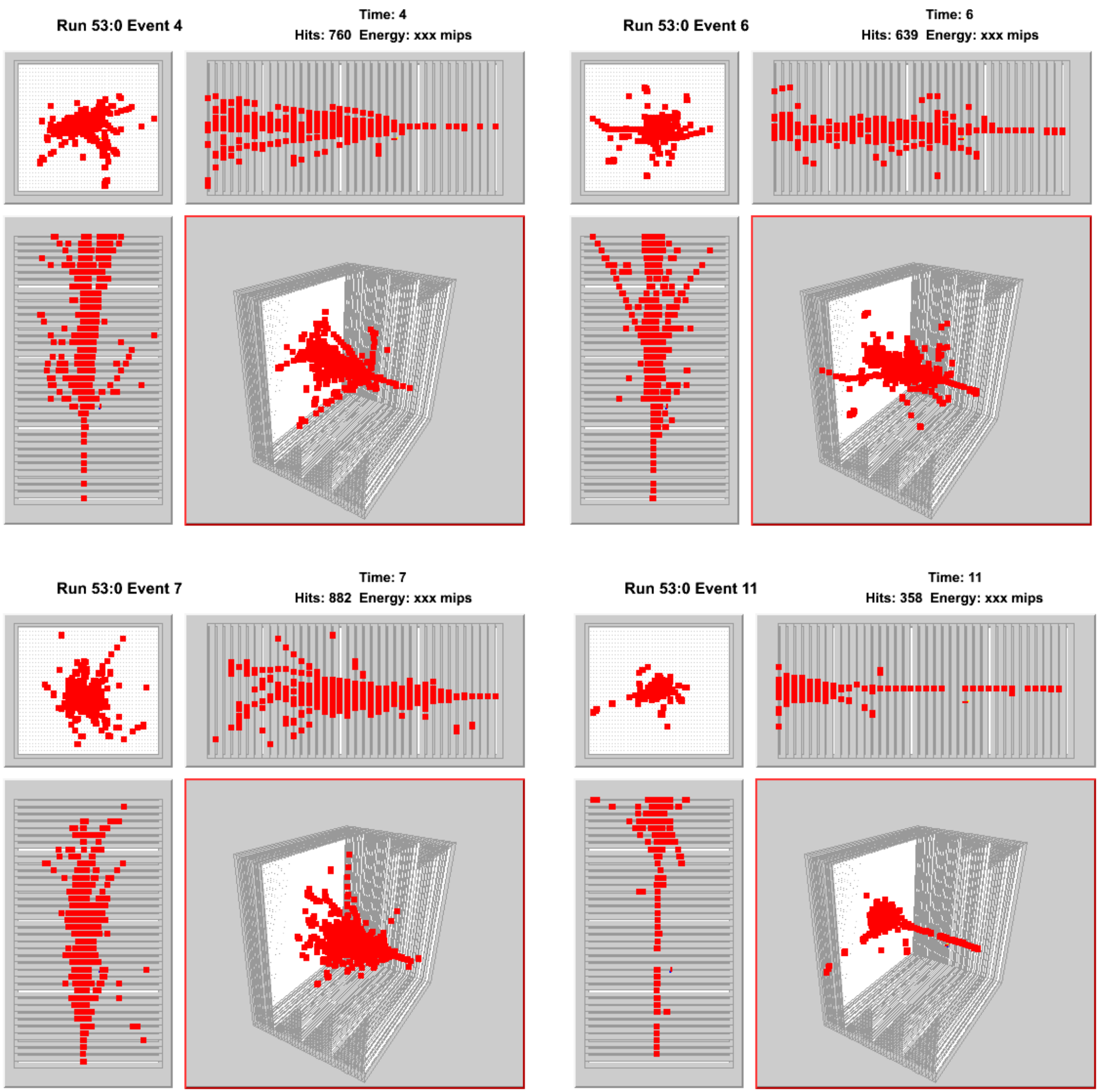
Discontinuity seems to move from 8 to 4 GeV

Discontinuity due to transition in hadron showering models

These physics lists obsolete by now

RPC_sim: Predictions V

Event displays



60 GeV Pions

GEANT4 simulation +
RPC response simulation