Scintillator-Tungsten ECAL testbeam

"first impressions"

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for the GLD-CAL group & the CALICE collaboration

- Scintillator strip – Tungsten ECAL prototype
- test beam @ DESY positron beam Feb-Mar 2007
- very preliminary results

KOBE UNIVERSITY

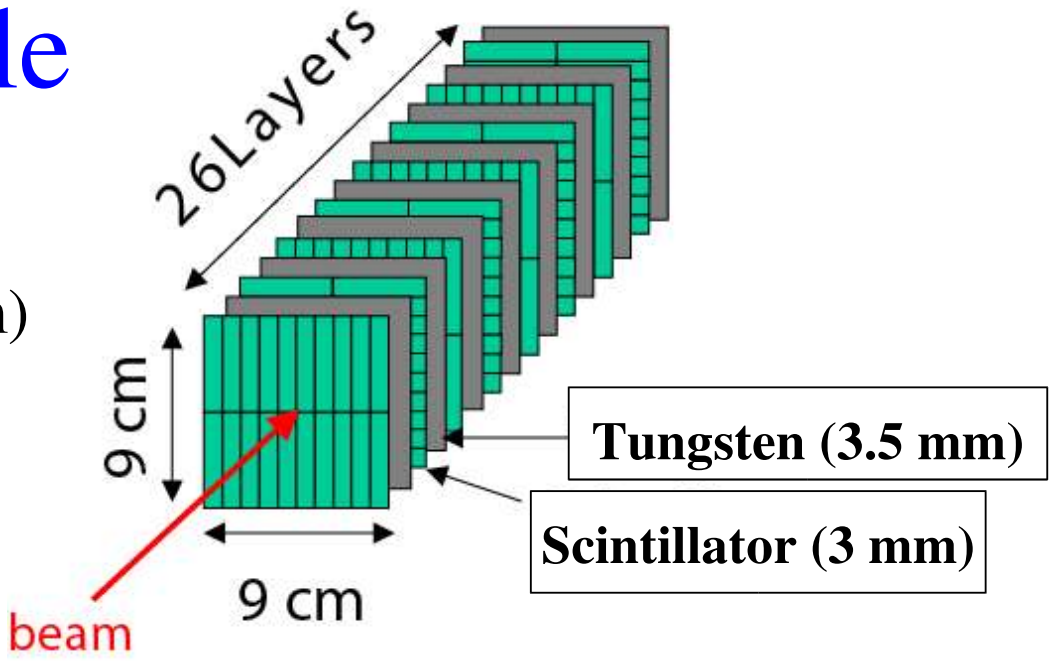
CALICE
Calorimeter for ILC

SCECAL test module

scintillator layers: 9 x 2 strips
(4.5cm x 1cm x 3mm)

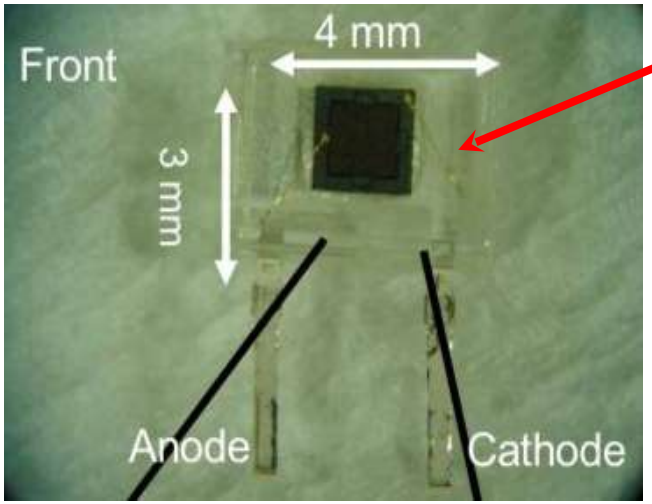
absorber: 3.5mm
tungsten/cobalt(12%)/carbon(0.5%)

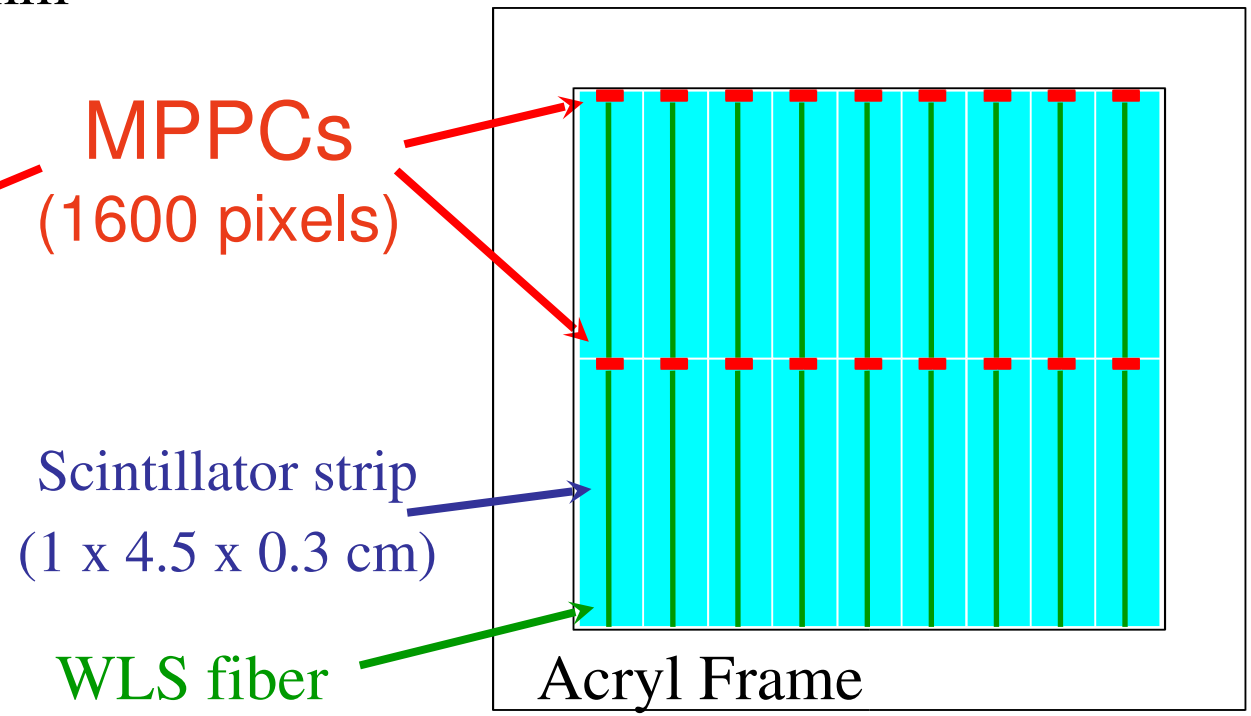
1mm gap for readout cables



effective Moliere radius ~ 21 mm

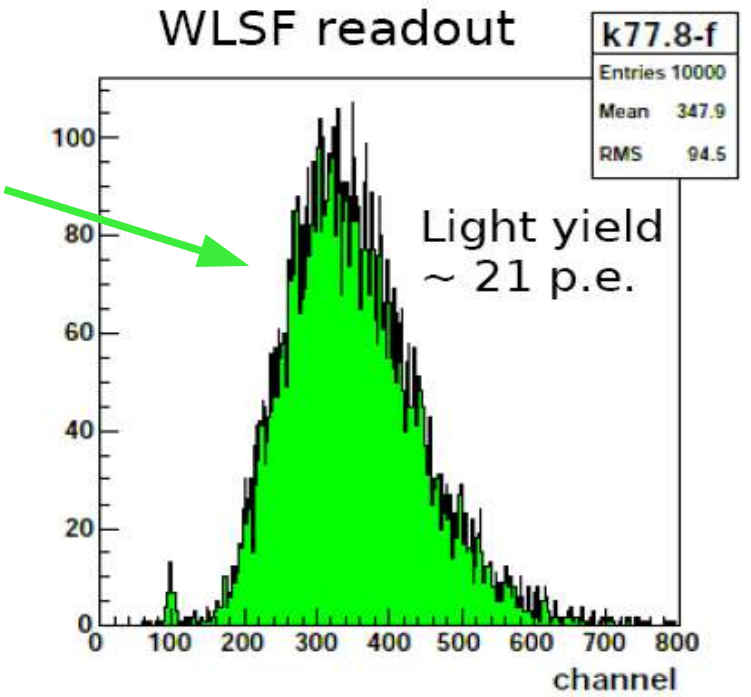
X_0 = 8 mm





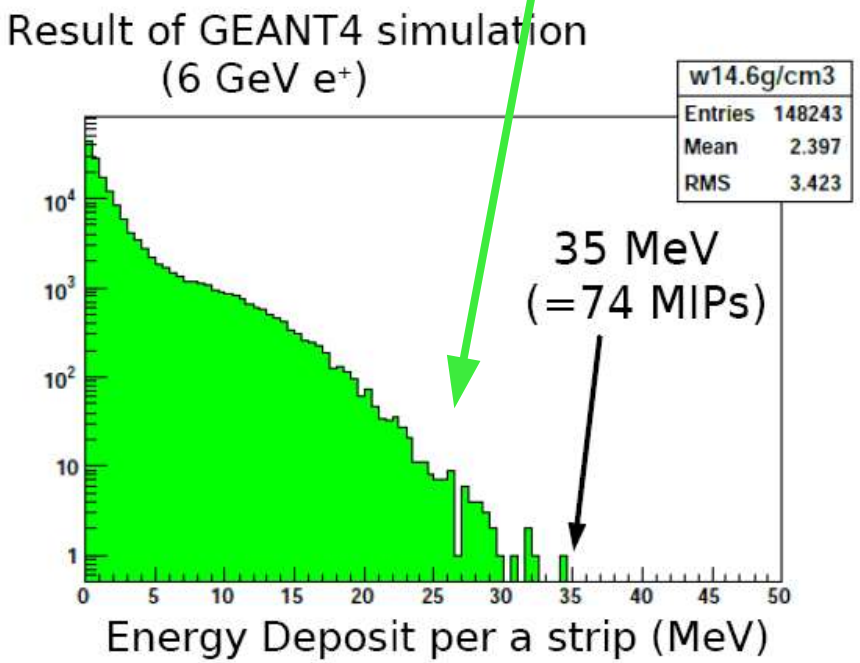
test-bench results

from test-bench measurements,
expect MPPC to detect ~ 21 photons/MIP



from GEANT4 simulation,

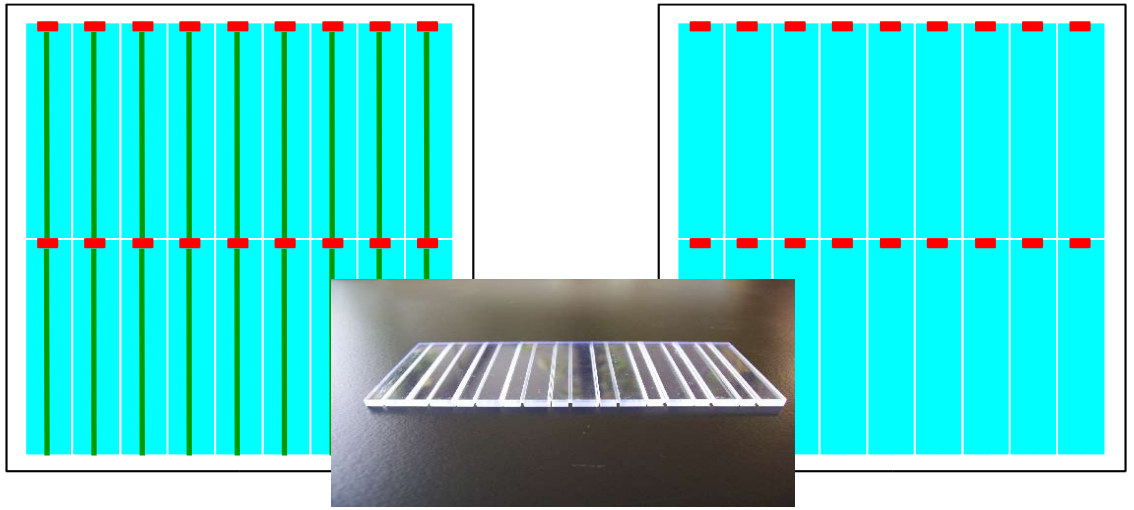
expect maximum ~74 MIPs/strip in
6 GeV e^+ shower

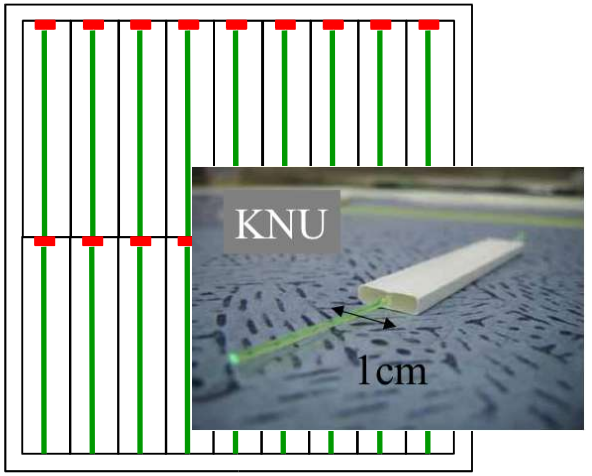


21 p.e. * 74 MIPs = 1554

expect dynamic range of
1600 pixel MPPC to be OK

different scintillator configurations





Kuraray scintillator megastrip with WLS fibre

without

KNU extruded with WLS

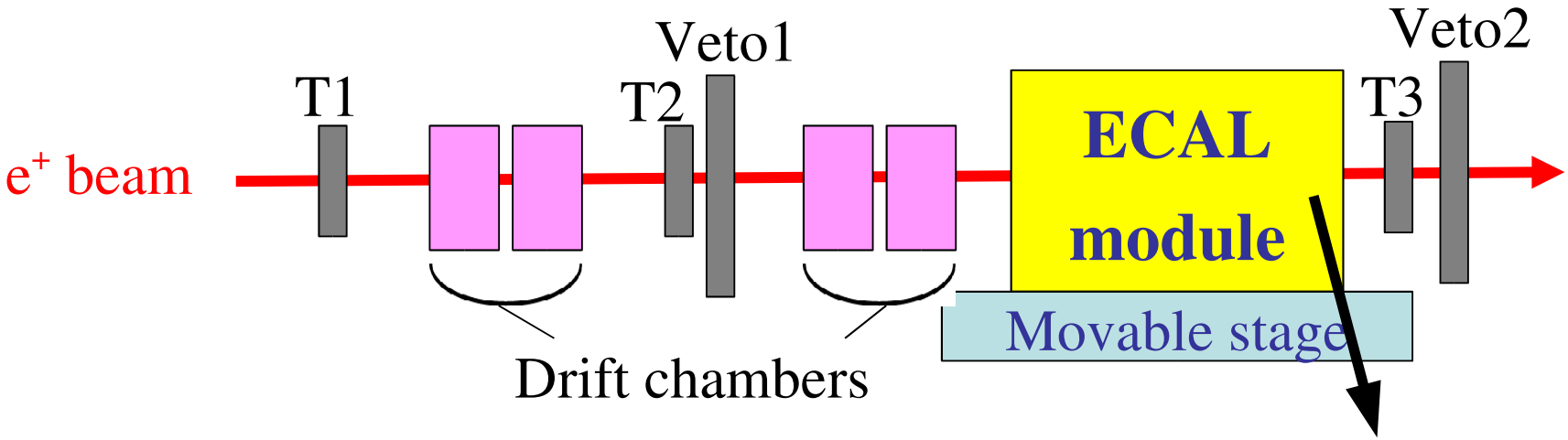
13 layers of each scintillator type, assembled into ½ modules

tested various combinations

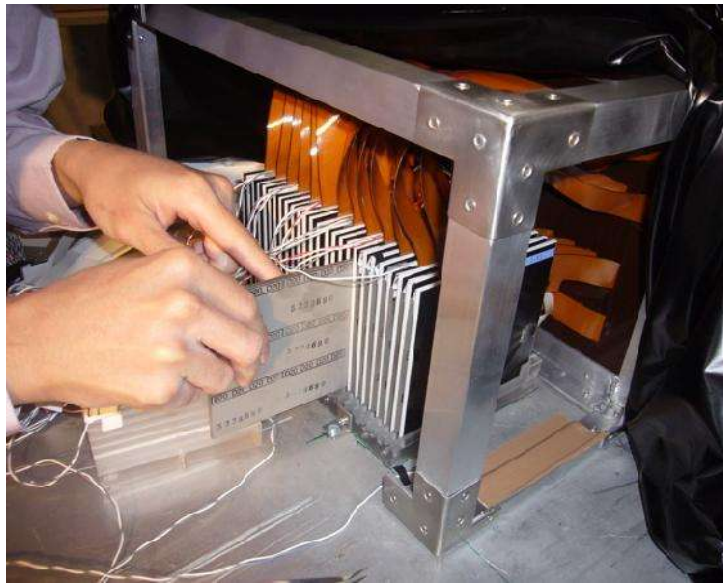
results shown here are with Kuraray scintillator:

first ½ module with WLS, second ½ module without fibre

test beam setup @ DESY



- 3 trigger & 2 veto counters:
  scintillator + PMT
- 4 drift chambers: measure beam position
- movable stage: ~0.1mm precision
- readout electronics same as CALICE AHCAL
- collected ~ 10^8 events in ~ 4 weeks



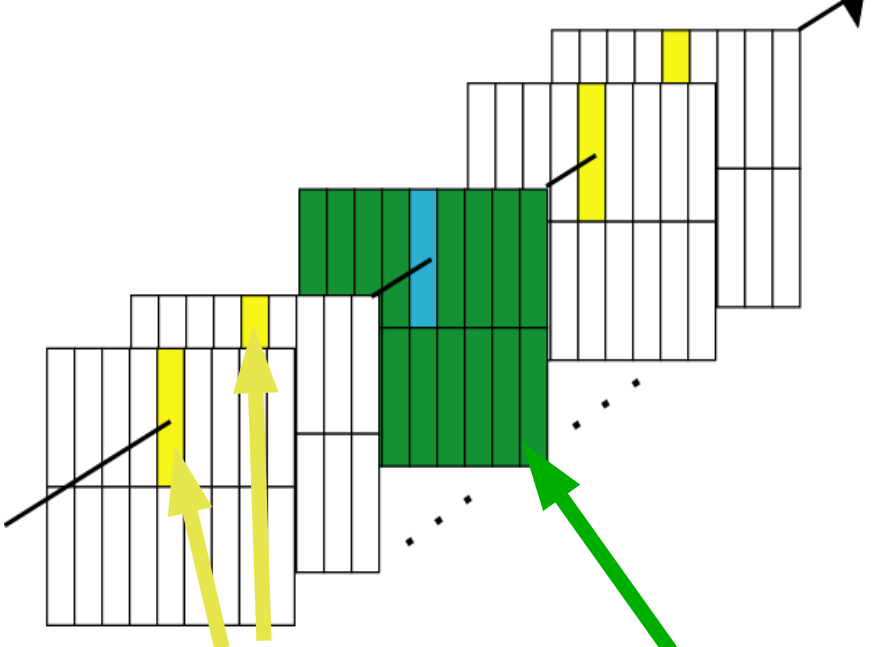
9 people from Japan & Korea went to DESY; invaluable assistance from CALICE members from DESY & UK & others.

detector calibration

remove absorber plates

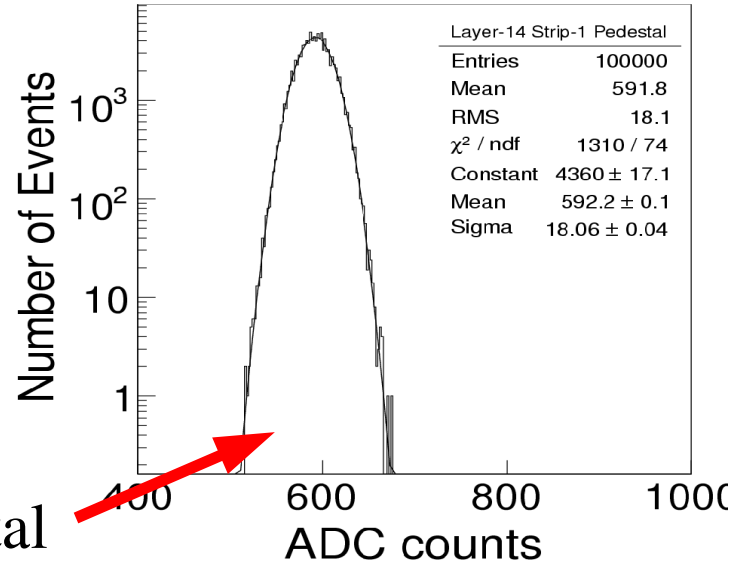
scan entire detector in position beam:

aim beam at centre of each strip



non-pedestal signal in all yellow strips

pedestal signal in all green strips

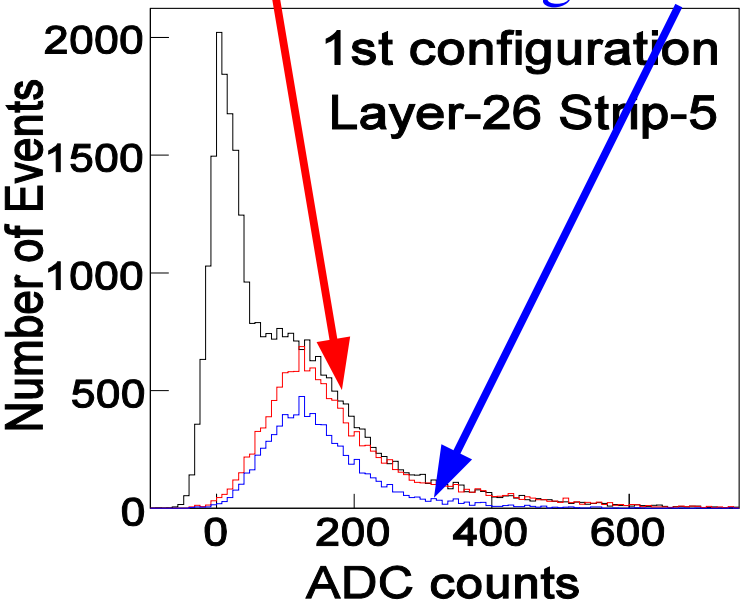


for each strip:

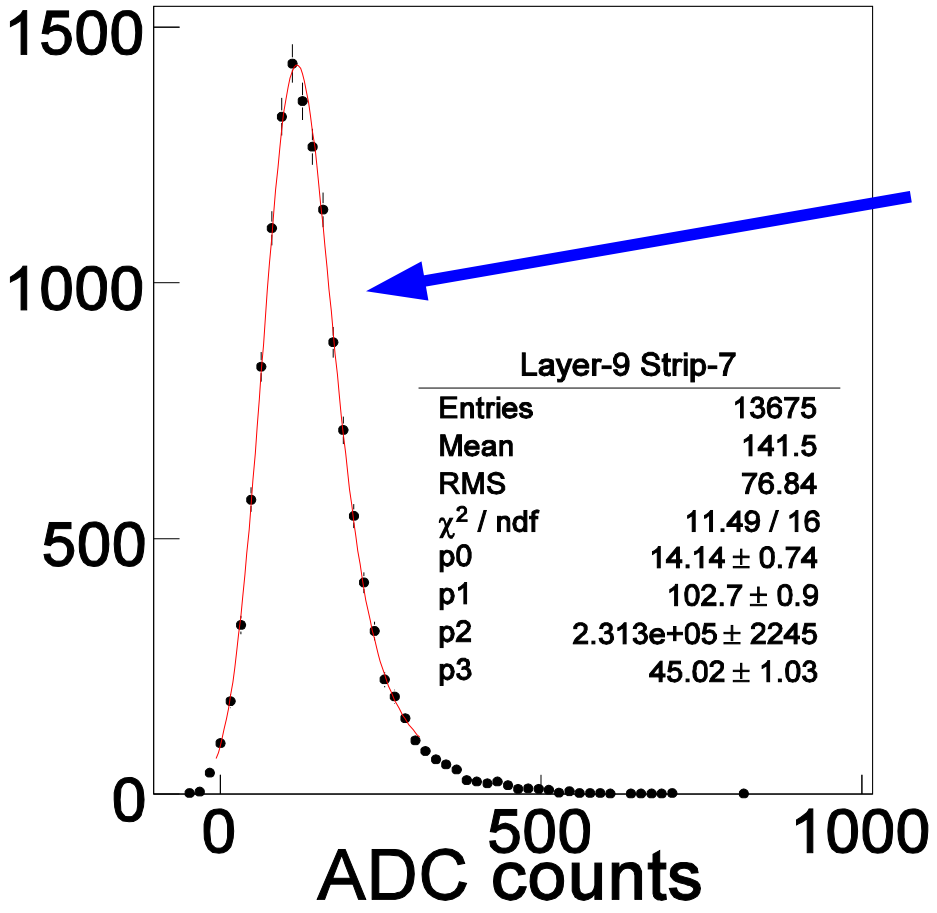
subtract pedestal

select events where single e+ passed through strip:

1. trigger & veto counters
2. requirements on other strips



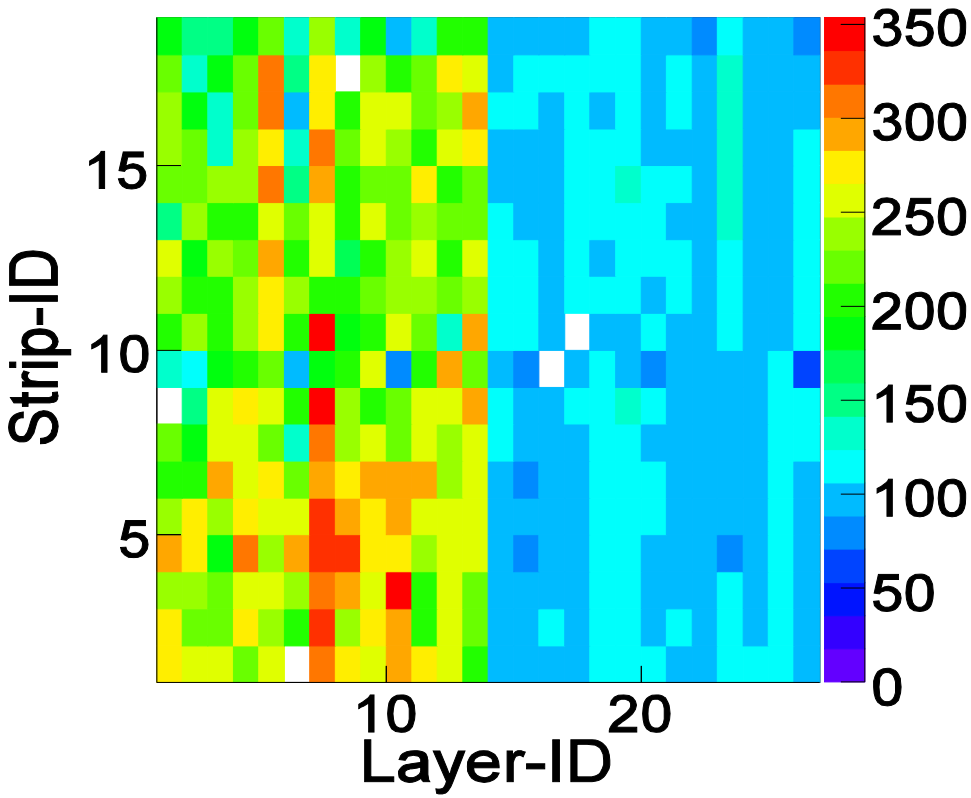
calibration



fit selected ADC distribution to Gaussian-convoluted Landau distr.

calibration constant in each strip →

fibre R/O direct R/O



direct r/o collect less photons,
as expected

energy scan

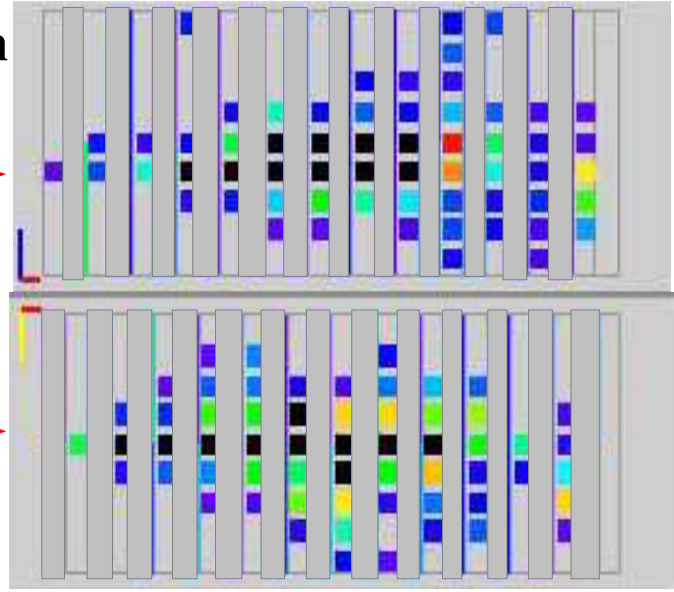
- insert absorber plates
- expose to e+ beam, 1-6 GeV
- select events using trigger & veto counters
- convert signal in each strip to "MIP-equivalents"
- sum "MIP-equivalents" over strips

also performed position scan: not yet analysed

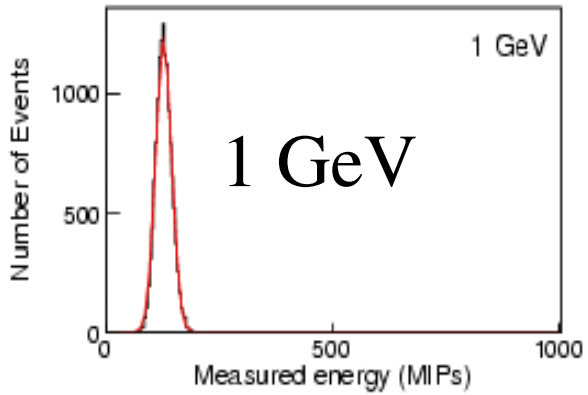
6 GeV e^+, center injection

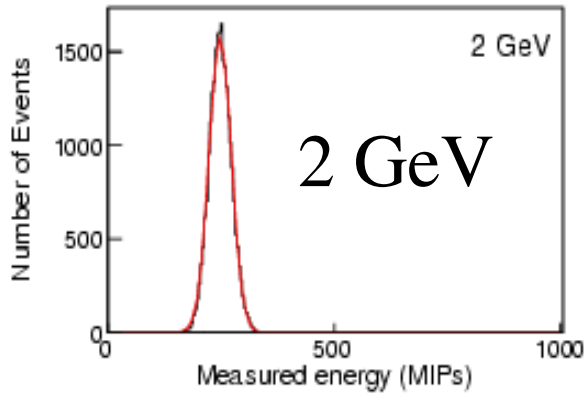
x projection →

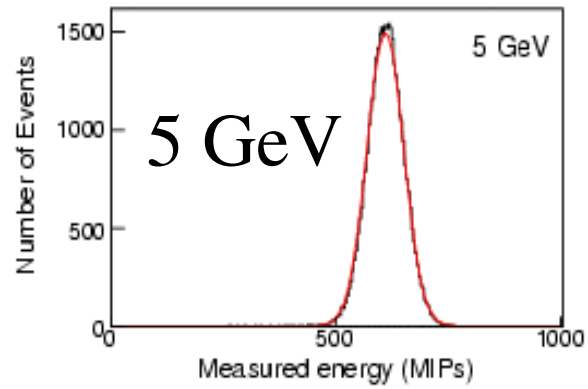
y projection →

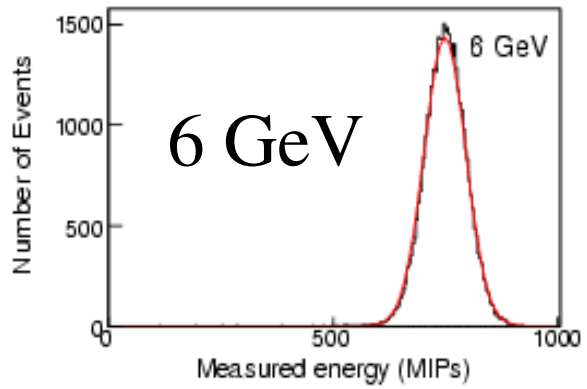


beam aimed at detector centre

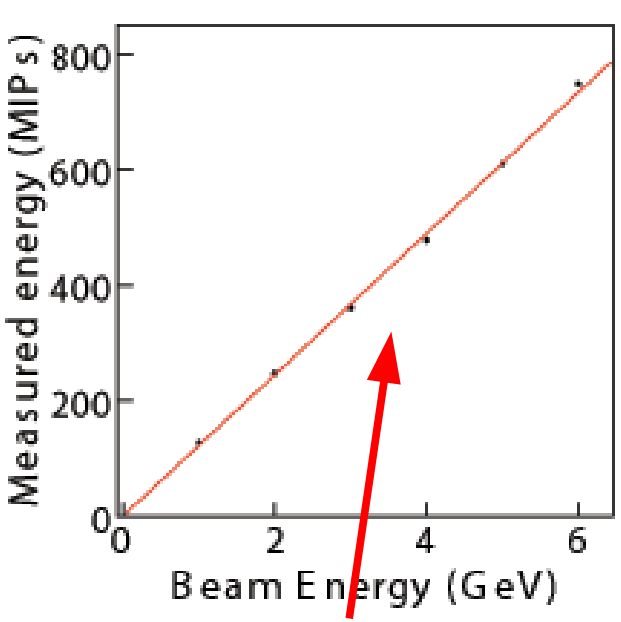


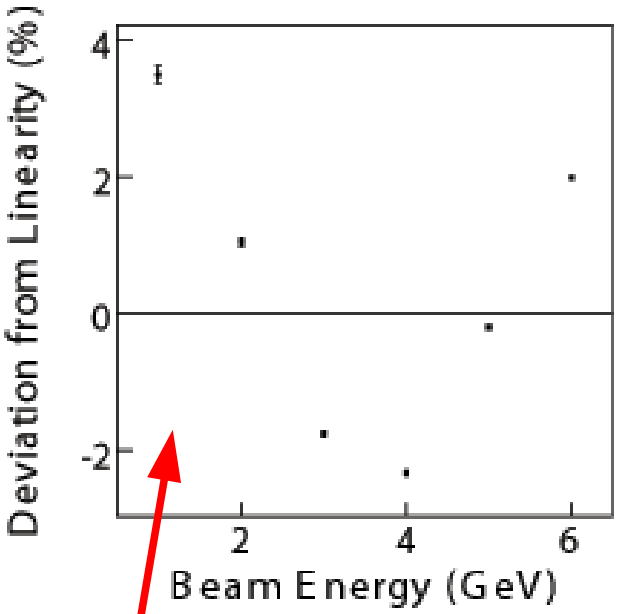






Energy linearity & resolution

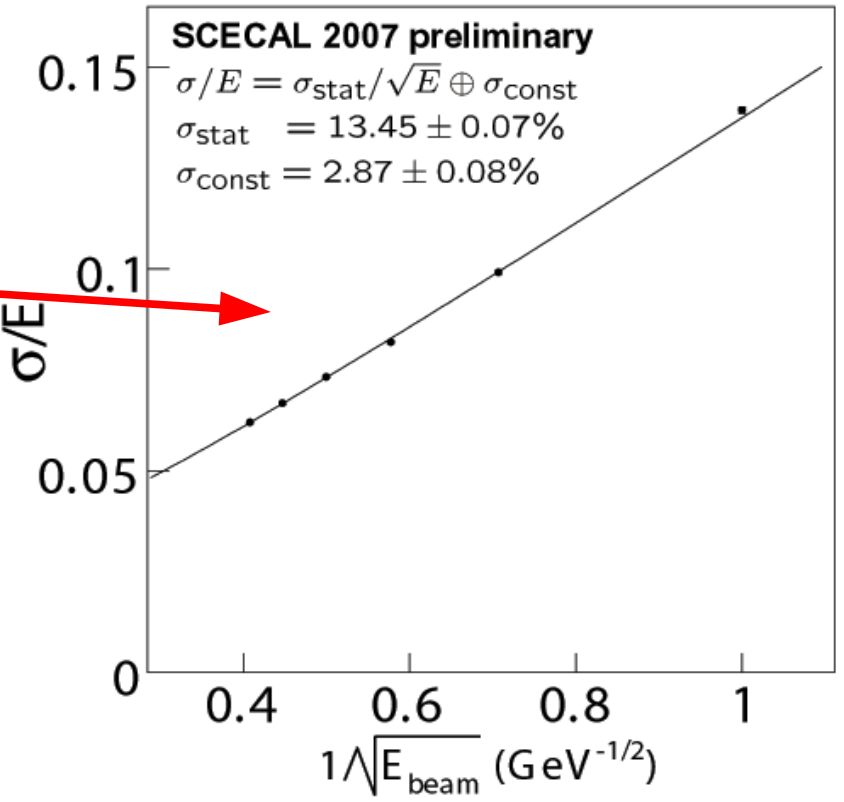




response fairly linear

non-linearity of order 4%

resolution ~ 13.45%/√E⊕2.87%



(simple) simulation suggested slightly smaller statistical term, and ~0 constant term

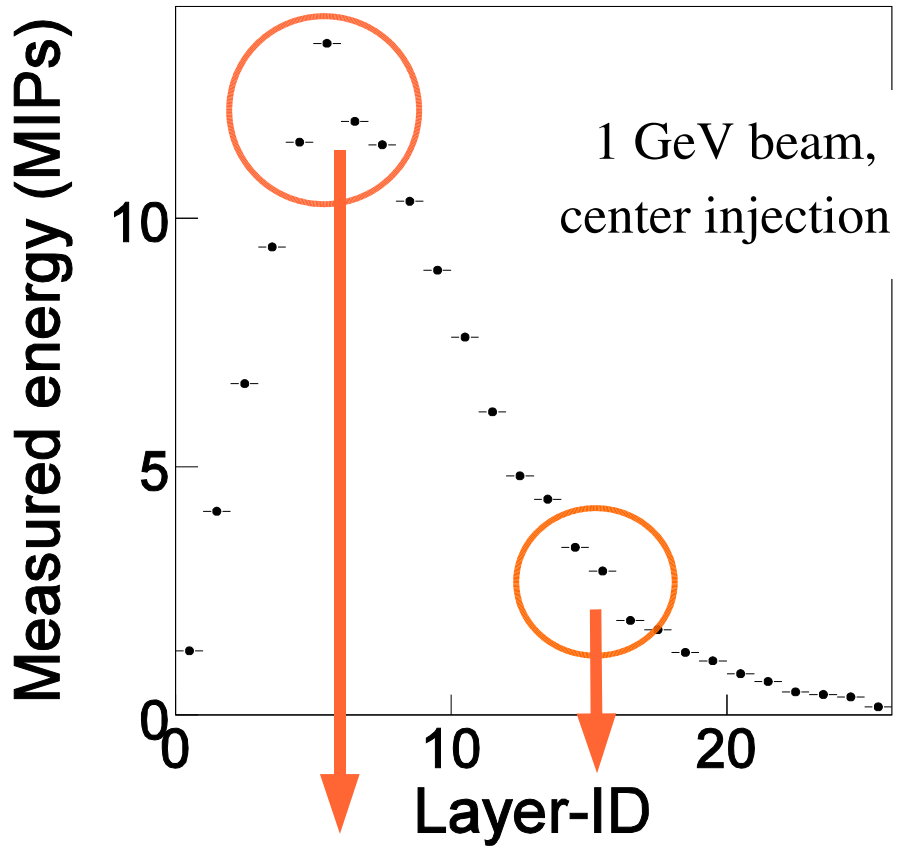
reasons for discrepancy under investigation

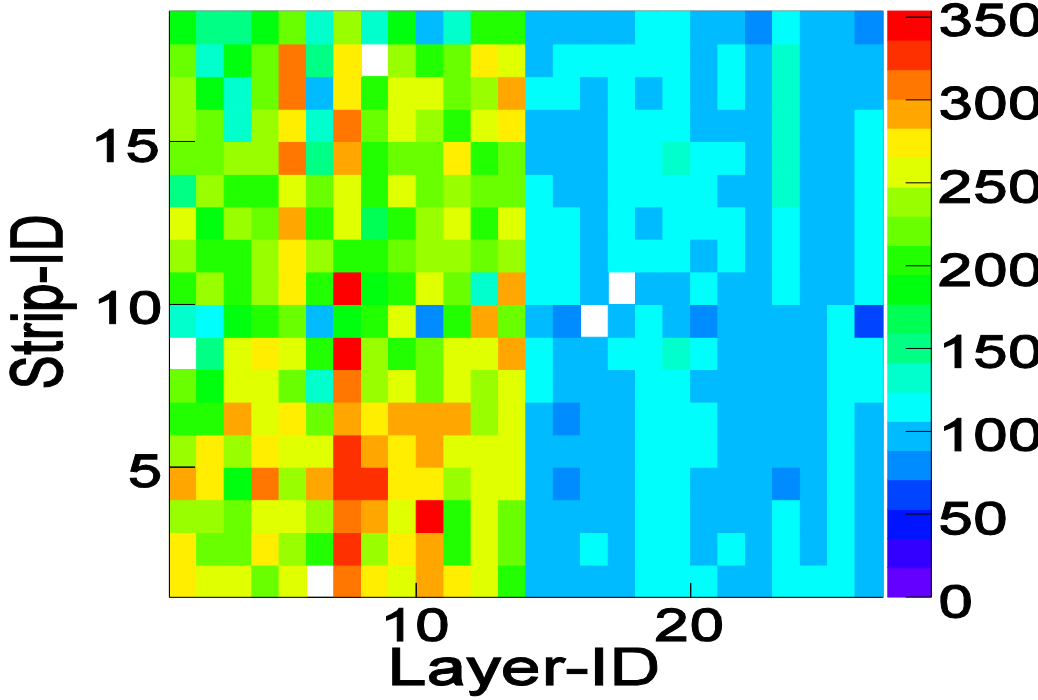
longitudinal shower profile

some non-continuities

not yet understood

probably calibration issue





future refinements

in the coming months we will improve the analysis:

- correct for MPPC non-linearity
- correct for temperature variations (small ~ few degrees)
- look for variations along the length of a strip (use tracking)
- measure performance of the other scintillator configurations
- others...

develop more realistic simulation & compare to data

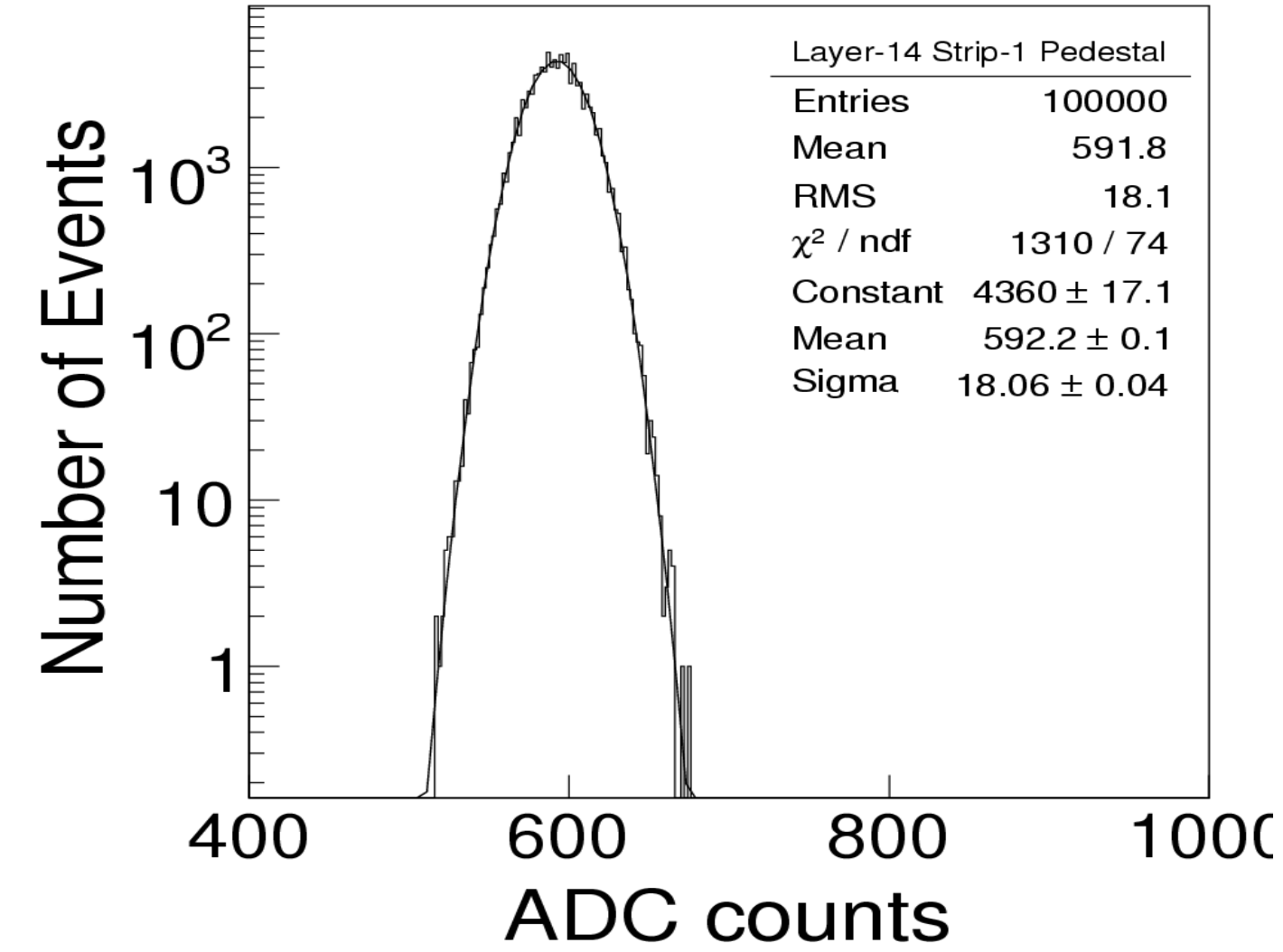
Summary

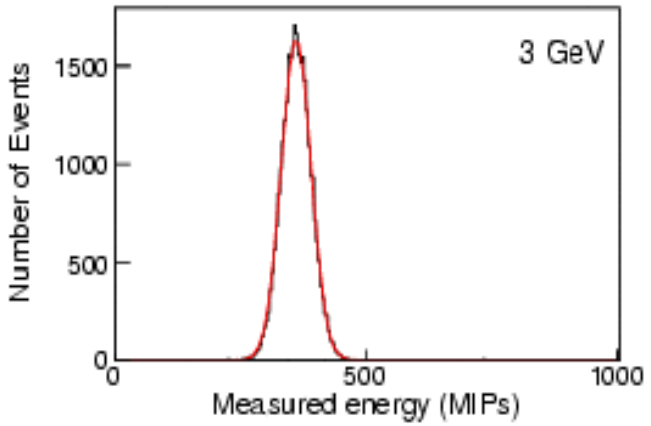
Successful SCECAL beam test at DESY

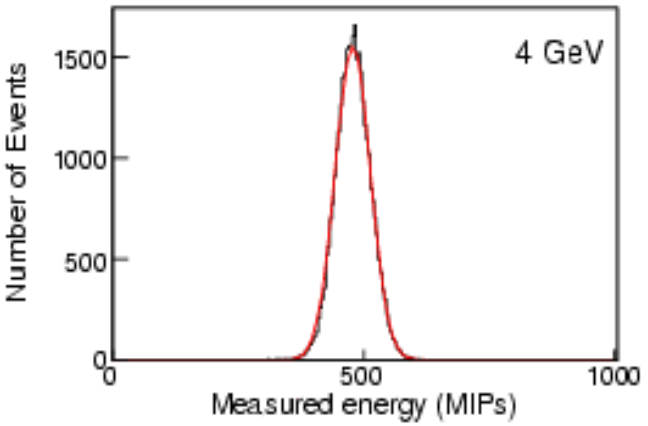
Started analysing the data:

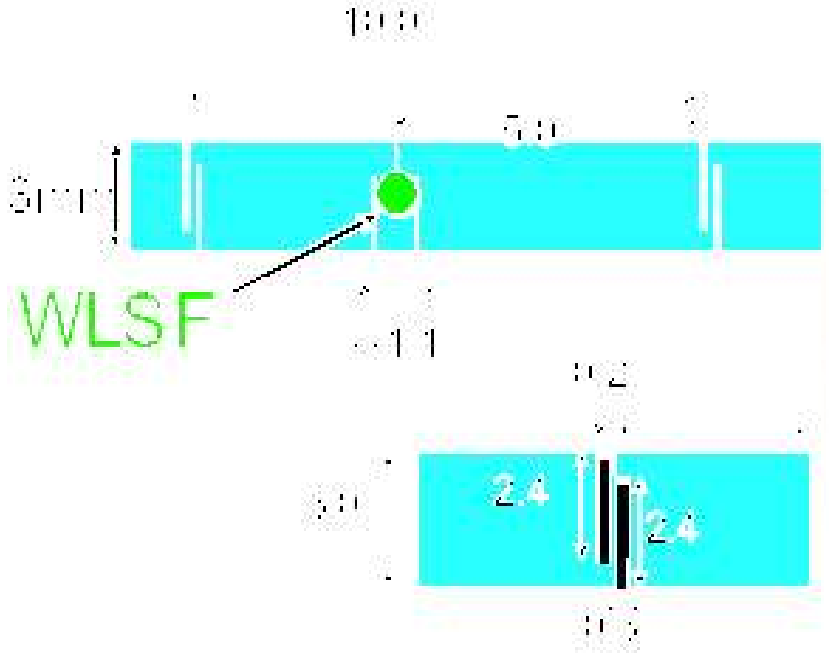
- at 0^{th} order results look fine
- at 1^{st} order there are several features not yet understood:
  - resolution slightly worse than expected (particularly constant term)
  - non-linearity ~ 4%
  - non-smooth longitudinal profile
- we have a plan to improve the analysis & understand issues

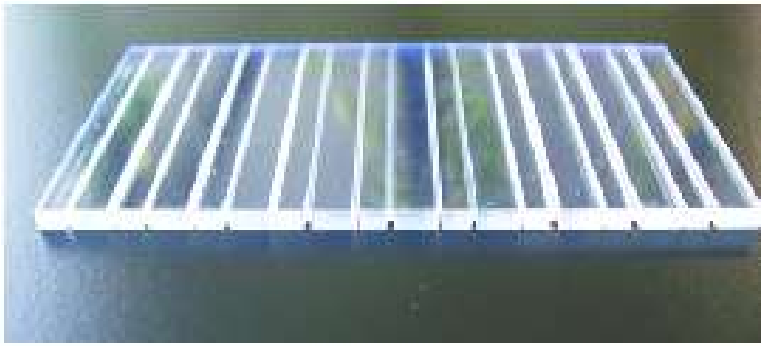
We look forward to next (hadron) beam test, 2008 @ FNAL

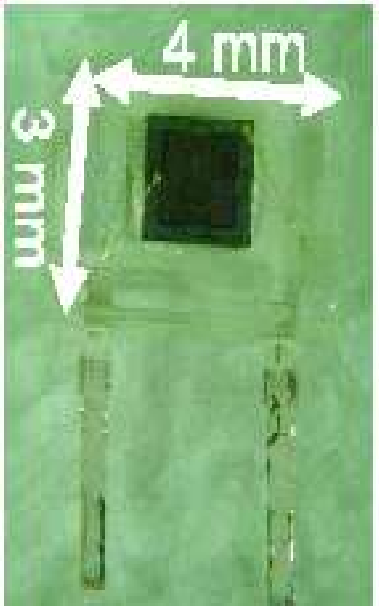

Layer-14 Strip-1 Pedestal
Entries 100000
Mean 591.8
RMS 18.1
χ² / ndf 1310 / 74
Constant 4360 ± 17.1
Mean 592.2 ± 0.1
Sigma 18.06 ± 0.04
Number of Events
10³
10²
10
1
400
600
800
1000
ADC counts


3 GeV
Number of Events
1500
1000
500
0
0
500
1000
Measured energy (MIPs)


4 GeV
Number of Events
1500
1000
500
0
0
500
1000
Measured energy (MIPs)


WLSF
2.4
2.4




4 mm
3 mm