CALICE Scintillator ECAL beam test @ DESY

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for the CALICE collaboration

Introduction

Scintillator ECAL module

Beam test @ DESY

Detector calibration

Detector response to EM showers

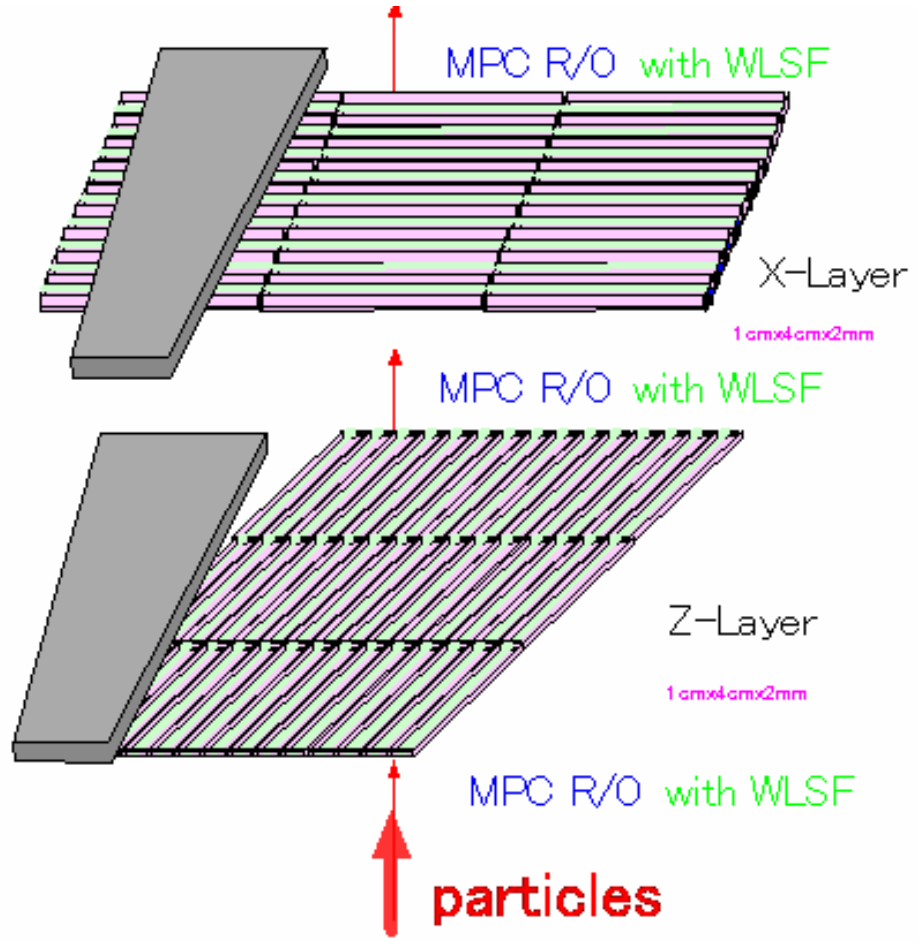
Future plans

strip scintillator calorimeter for an ILC detector

sampling calorimeter
- active material: scintillator
- absorber: Tungsten

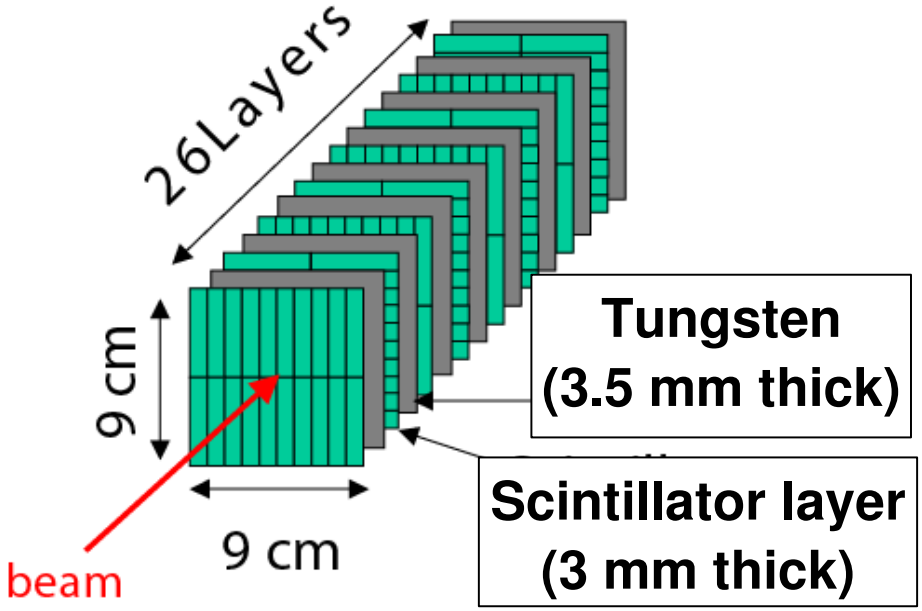
designed for PFA: fine segmentation
- scintillator strips ~1x4 cm^2
- orthogonal layers

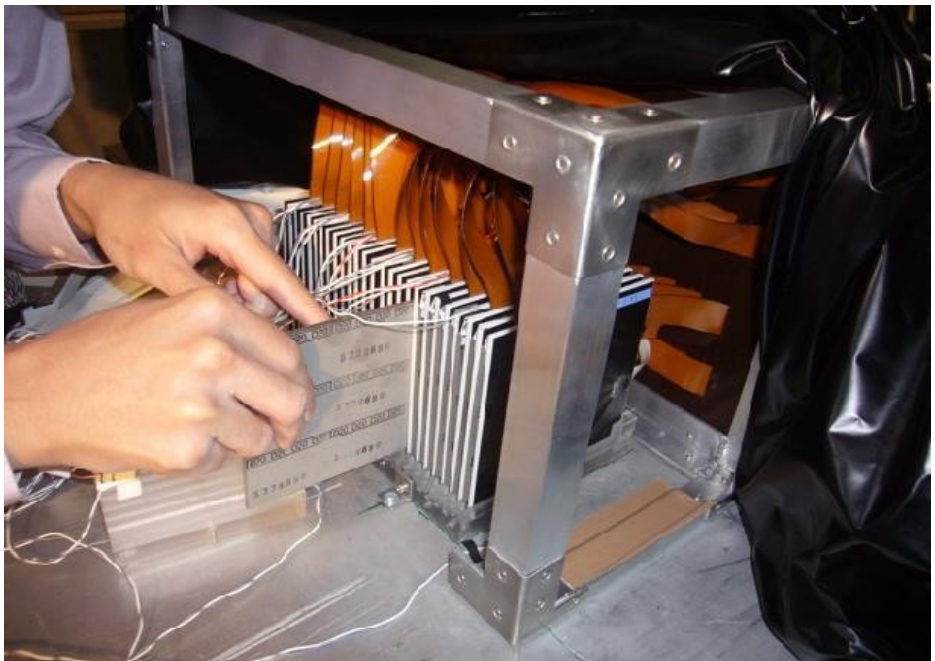
each strip read out by MPPC
- photon counting device from Hamamatsu Photonics

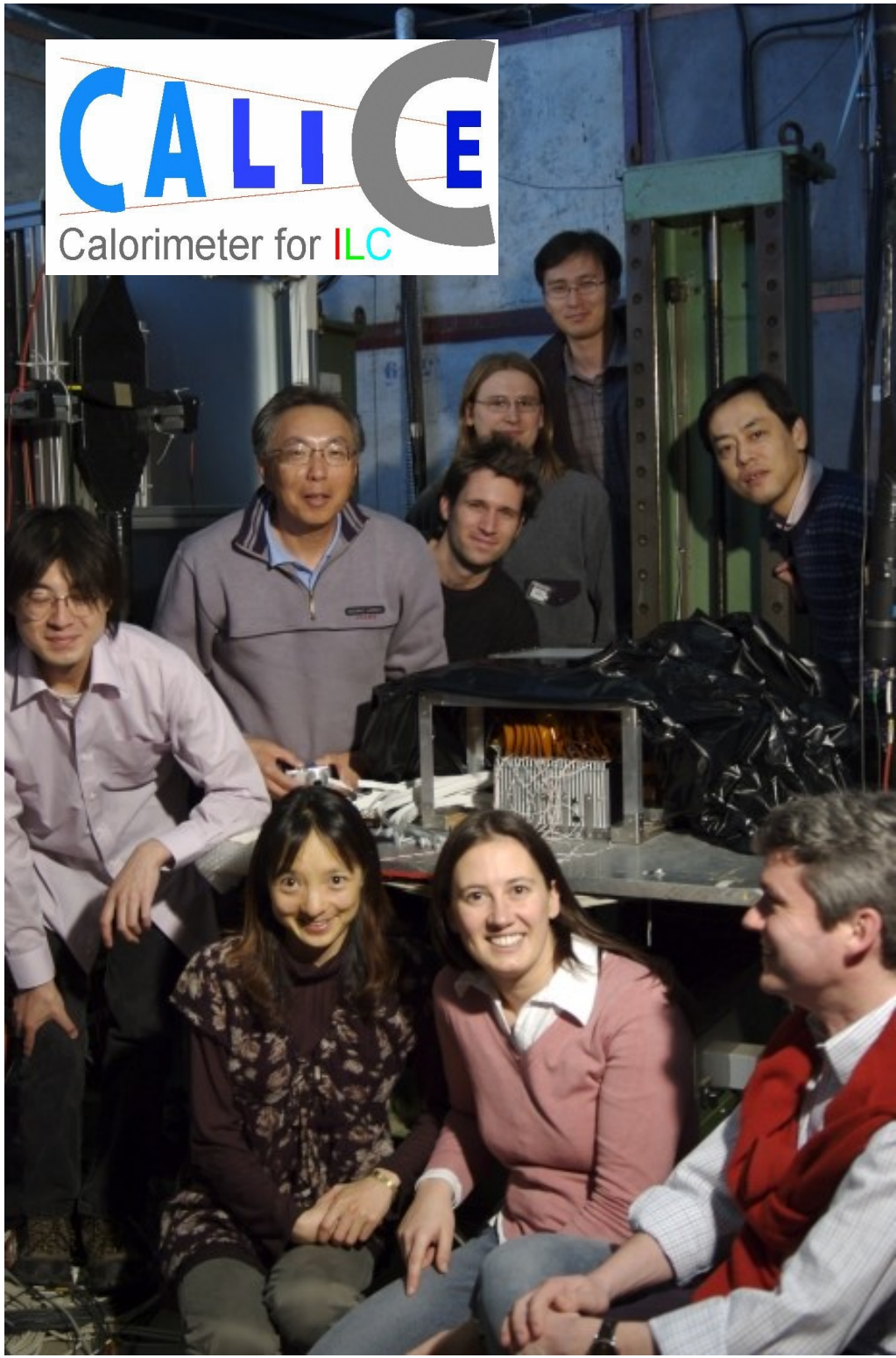


built and tested small prototype
- first test of scintillator + MPPC calorimeter
- check suitability for ILC ECAL

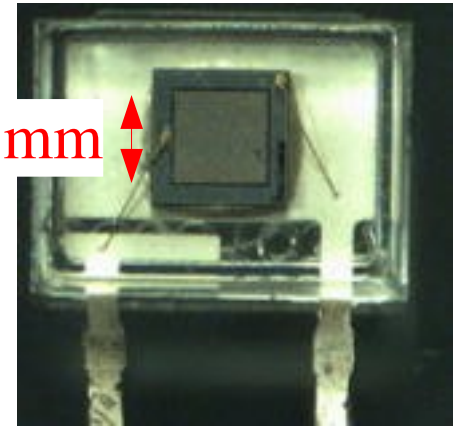
exposed to 1-6 GeV e+ beam at DESY 03/07

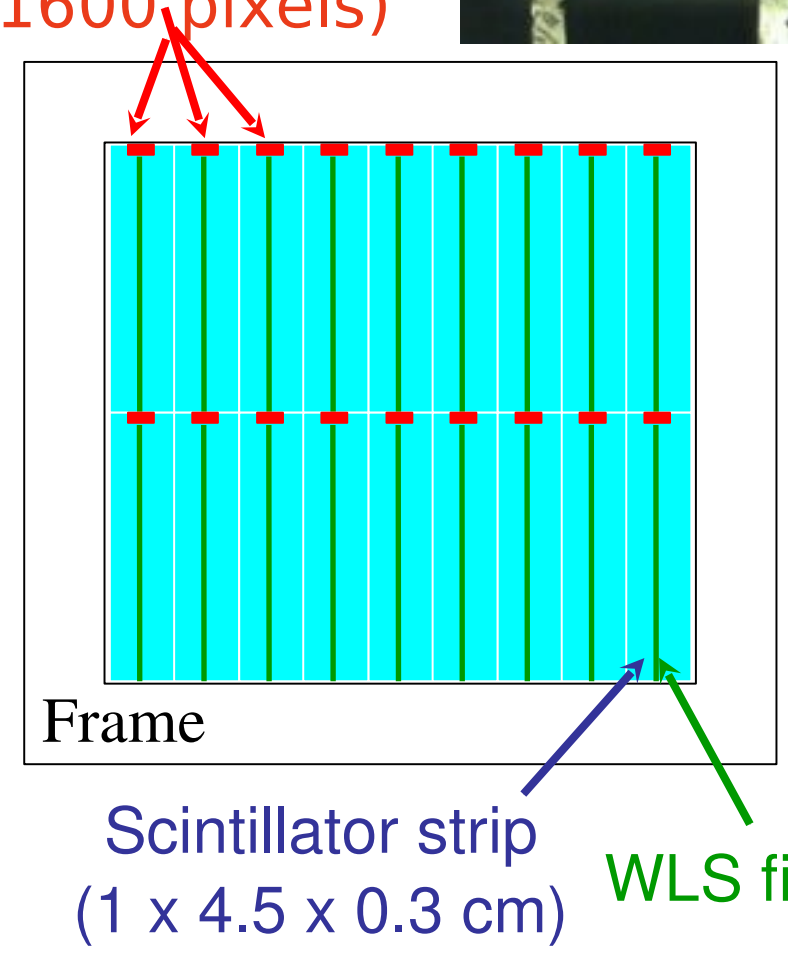






Detector setup, scintillator types





MPPC: good photon detection, compact size, reasonable price

3 types of scintillator strips:

Kuraray (Megastrip)

- WLSF readout
- direct readout (simpler)

KNU/Korea (separate strips)

- extruded scintillator (inexpensive)
- co-extruded TiO_2 covering
- WLSF readout

~12 p.e. per MIP

CALICE readout electronics and DAQ
(from LAL-Orsay, DESY, UK groups)
same as used by CALICE Analogue-HCAL group

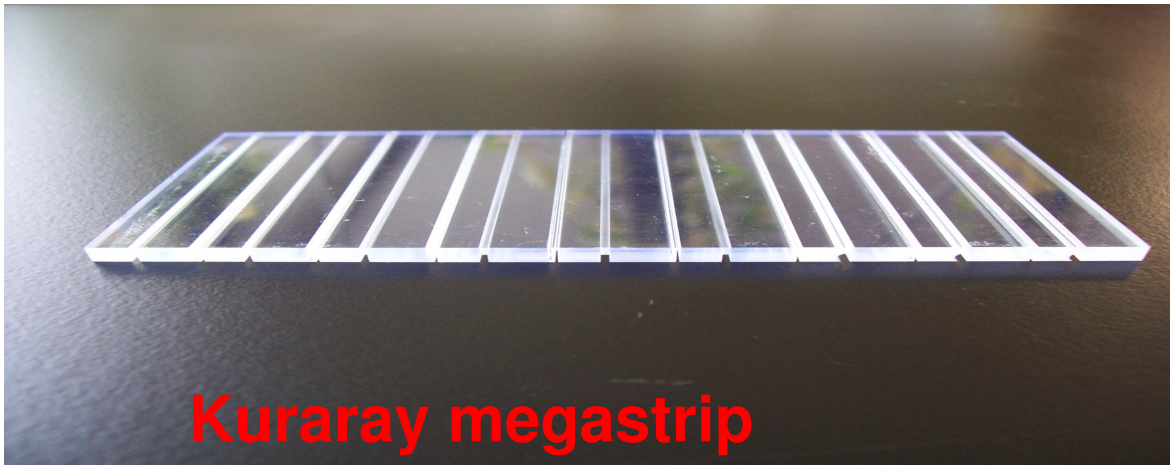
produced 3 half-modules (13 layers each)
with different scintillator types

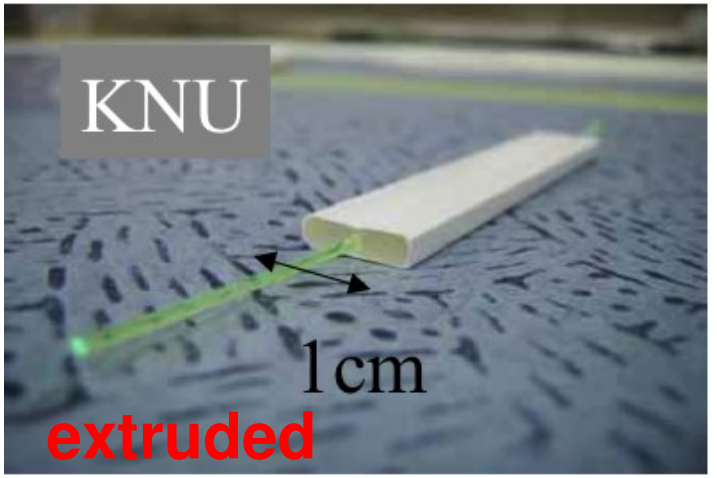
tested 3 configurations

Kuraray (fibre) + Kuraray (direct)

Kuraray (direct) + Kuraray (fibre)

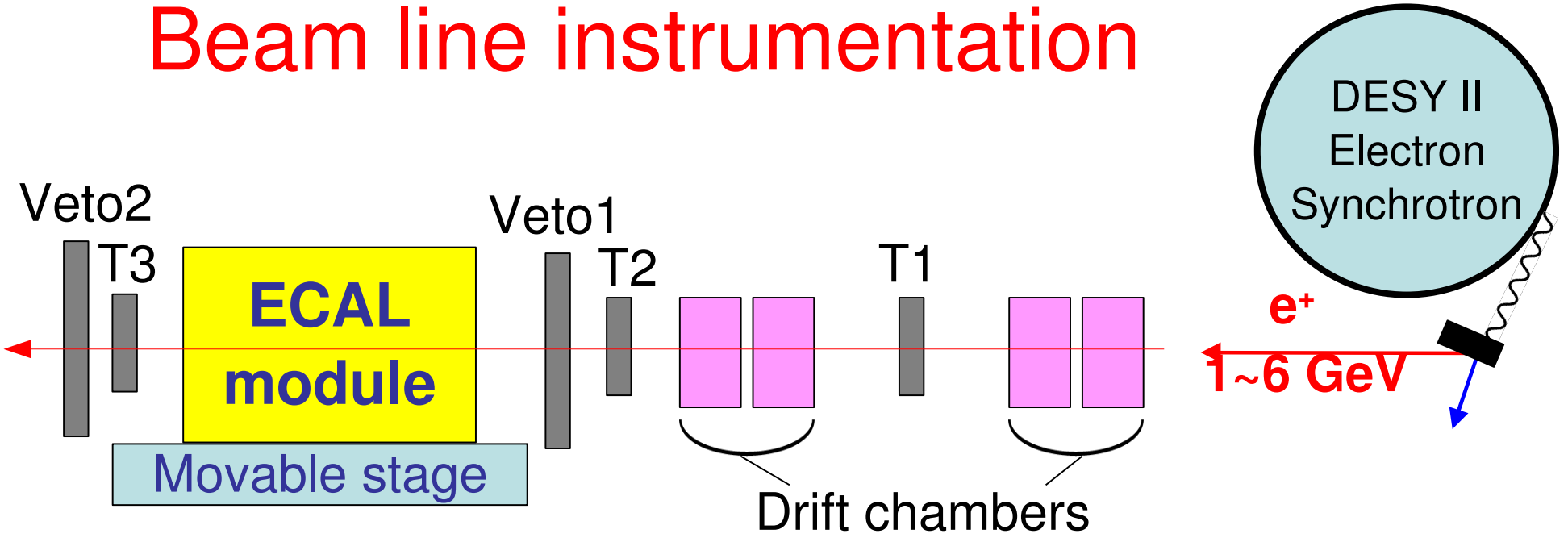
Extruded (fibre) + Kuraray (fibre)

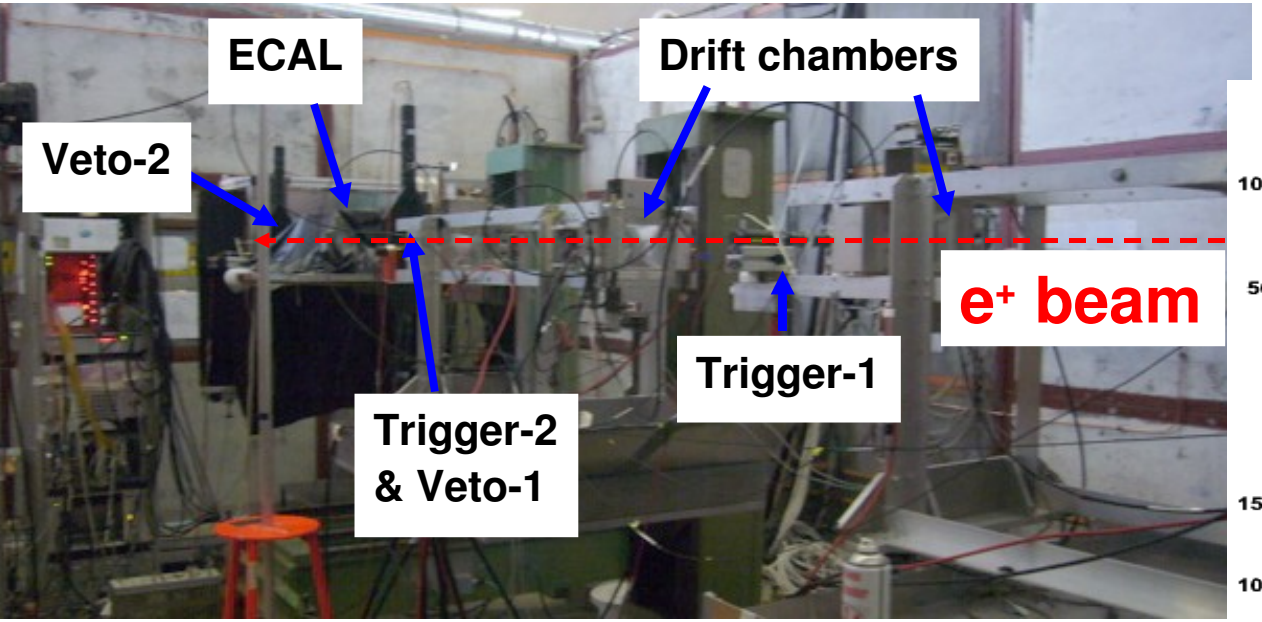




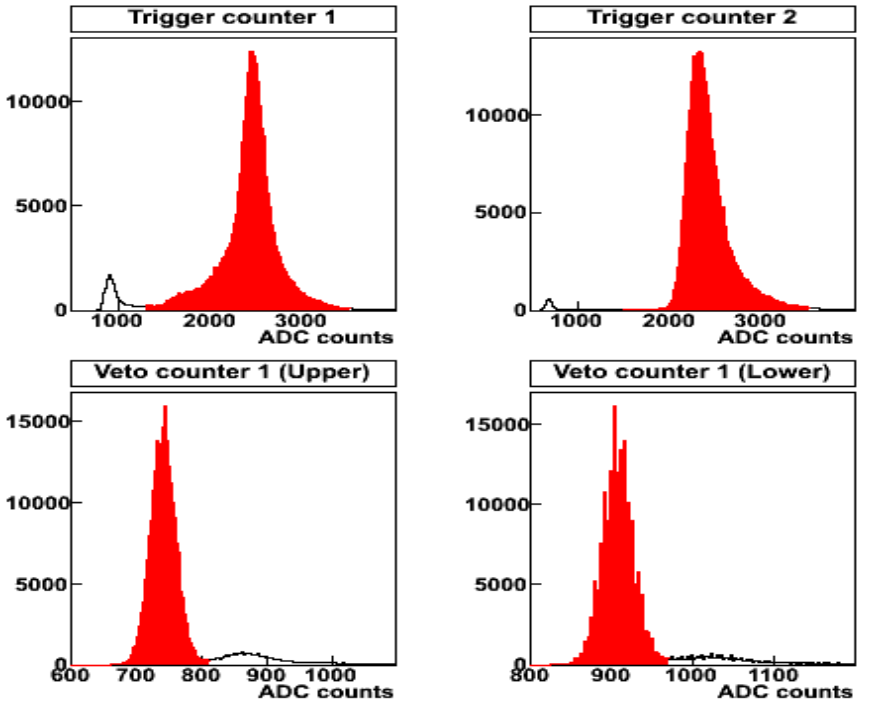
compare performance of configurations

Beam line instrumentation





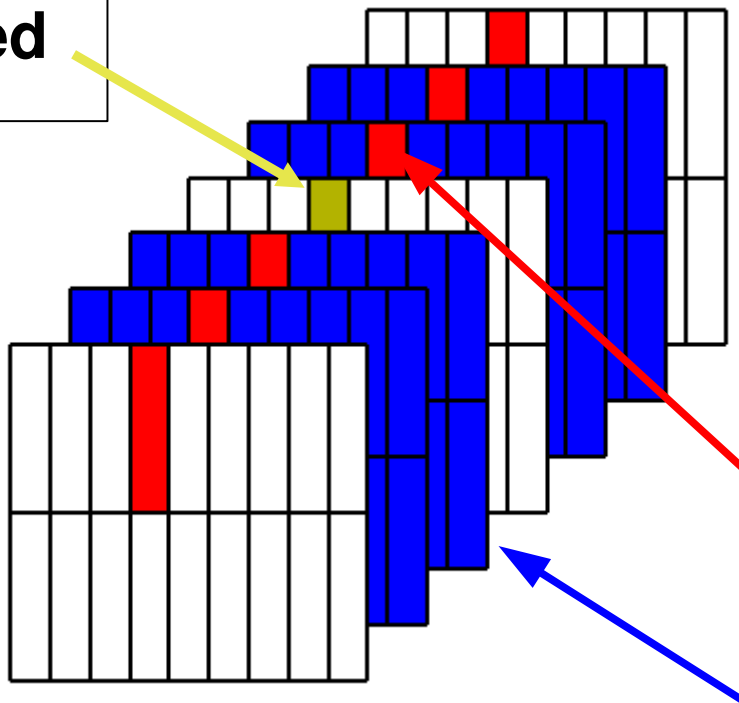
Trigger & veto

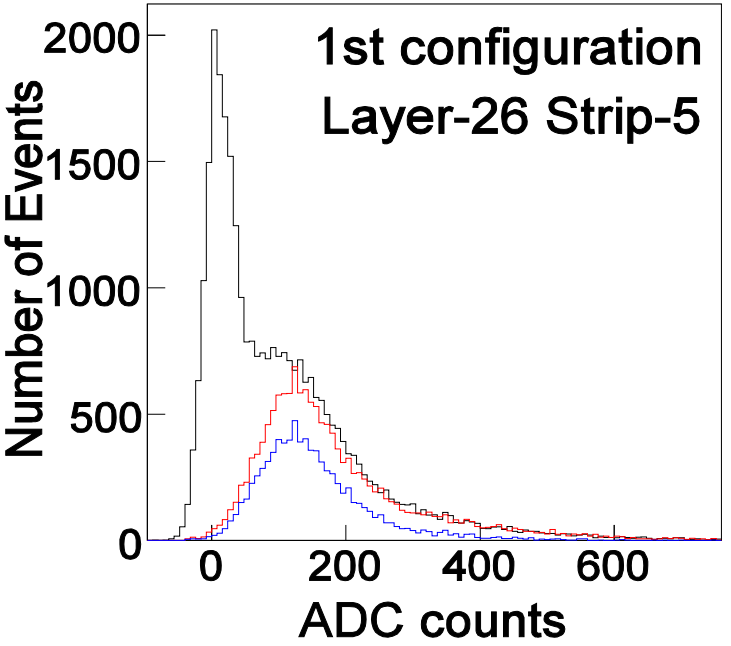


detector calibration

e+ beam, no W plates

Strip being calibrated

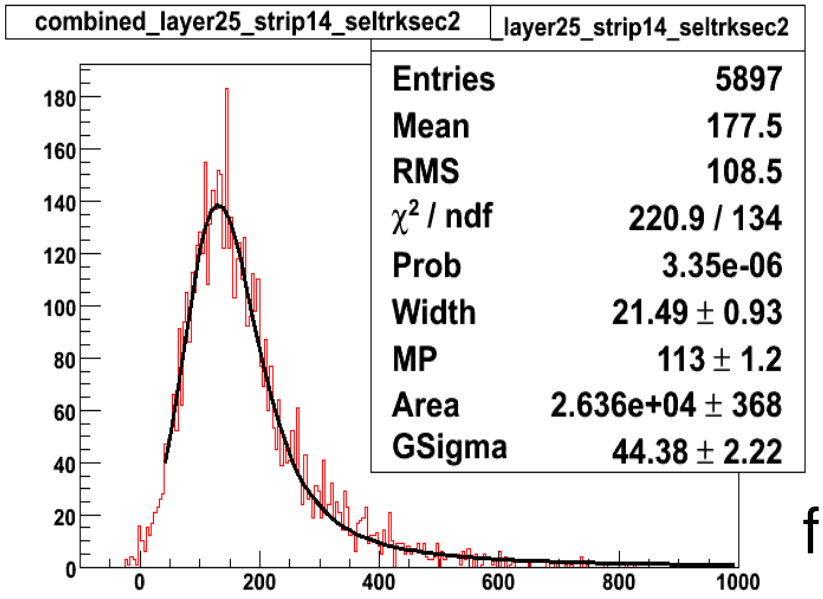




Trigger only

Red strips have non-pedestal signal

Blue strips have only pedestal signal

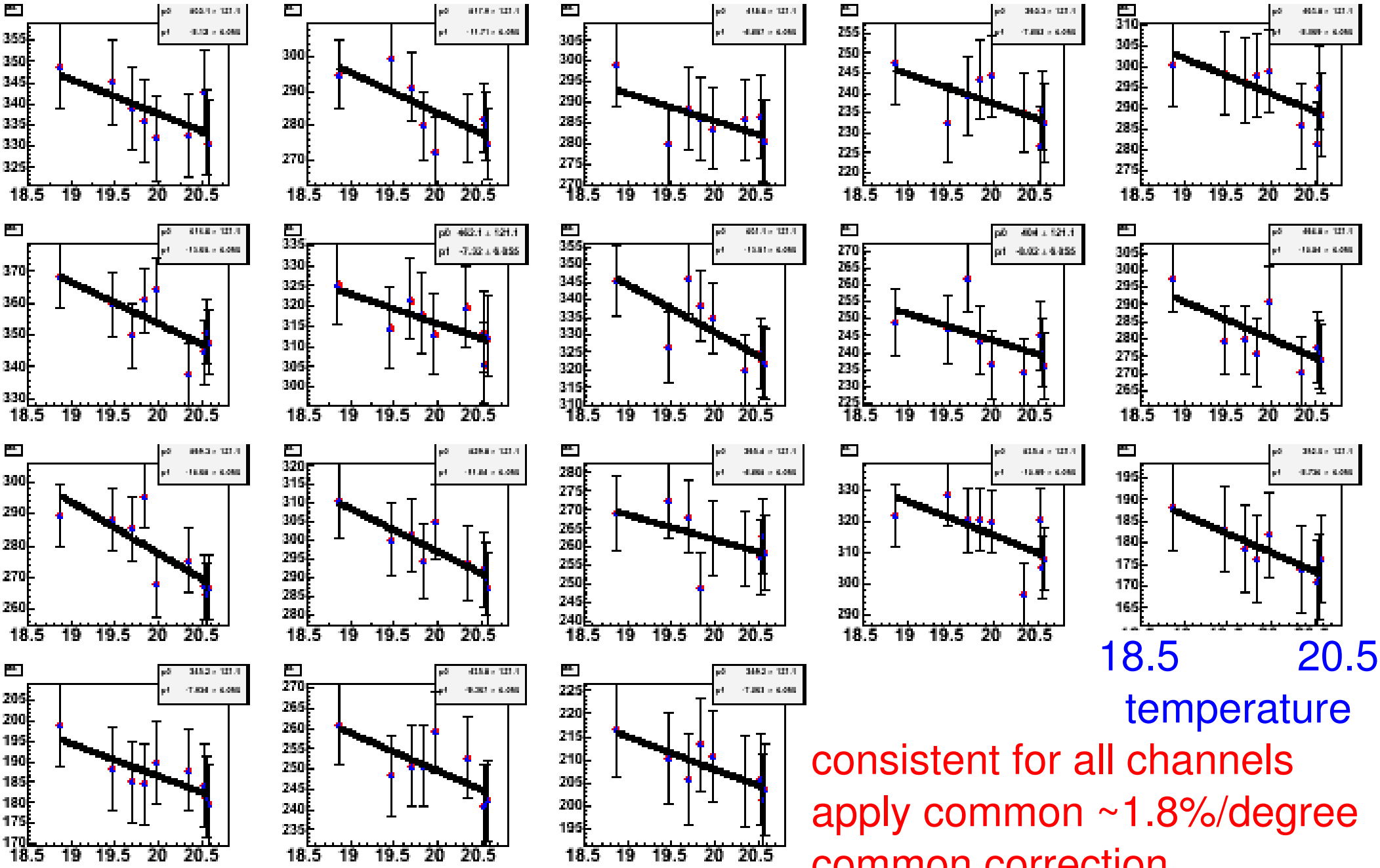


fit to Gaussian-convoluted Landau

MIP response temperature dependence

MPPC properties change with temperature

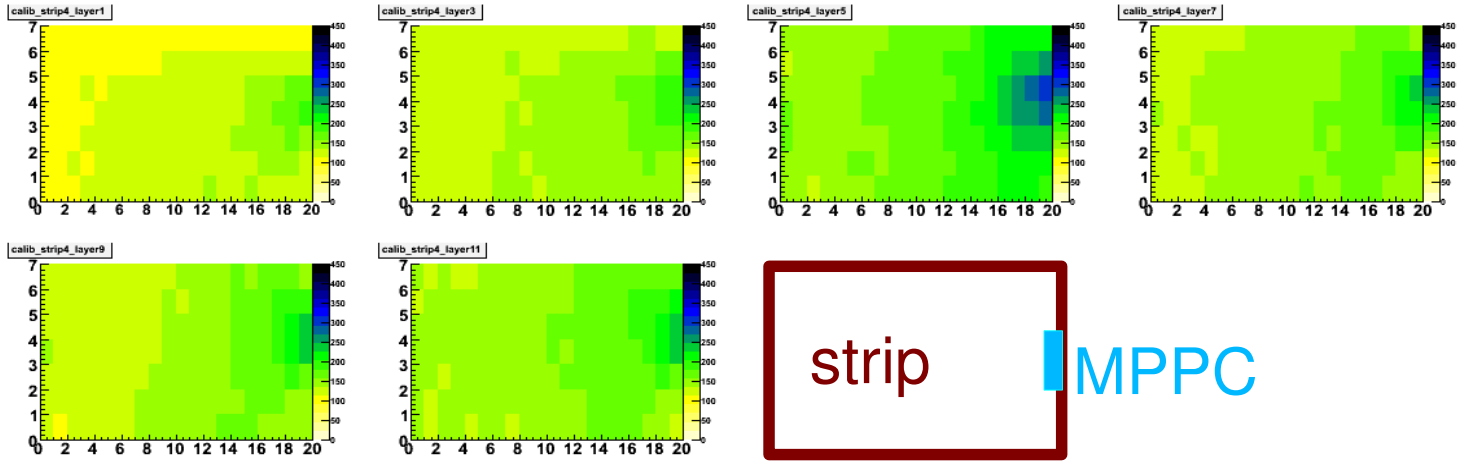
example: 18 strips in one layer

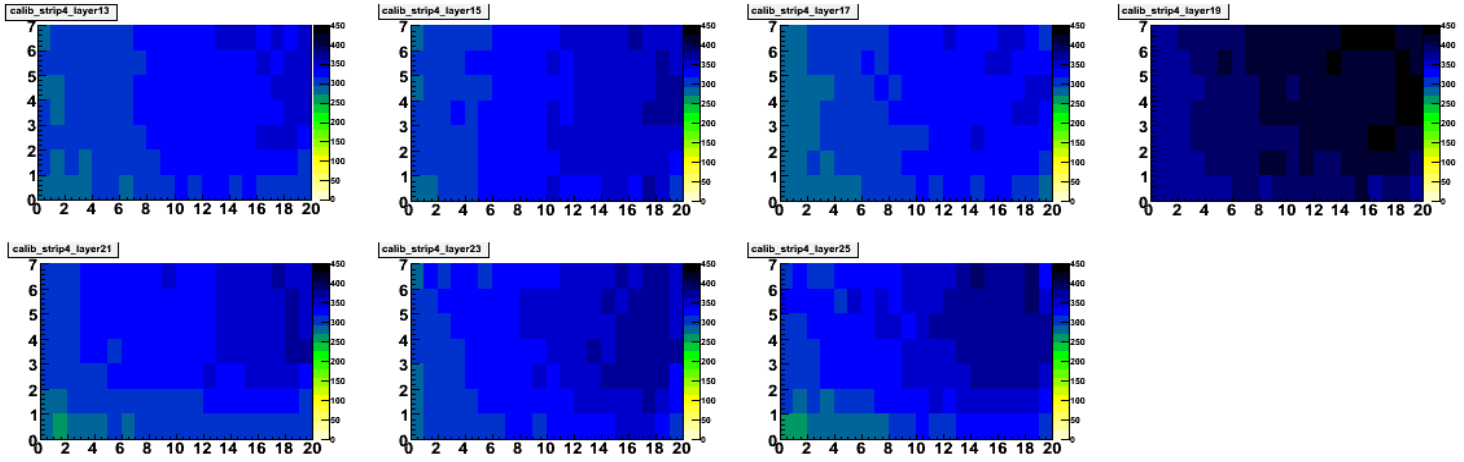


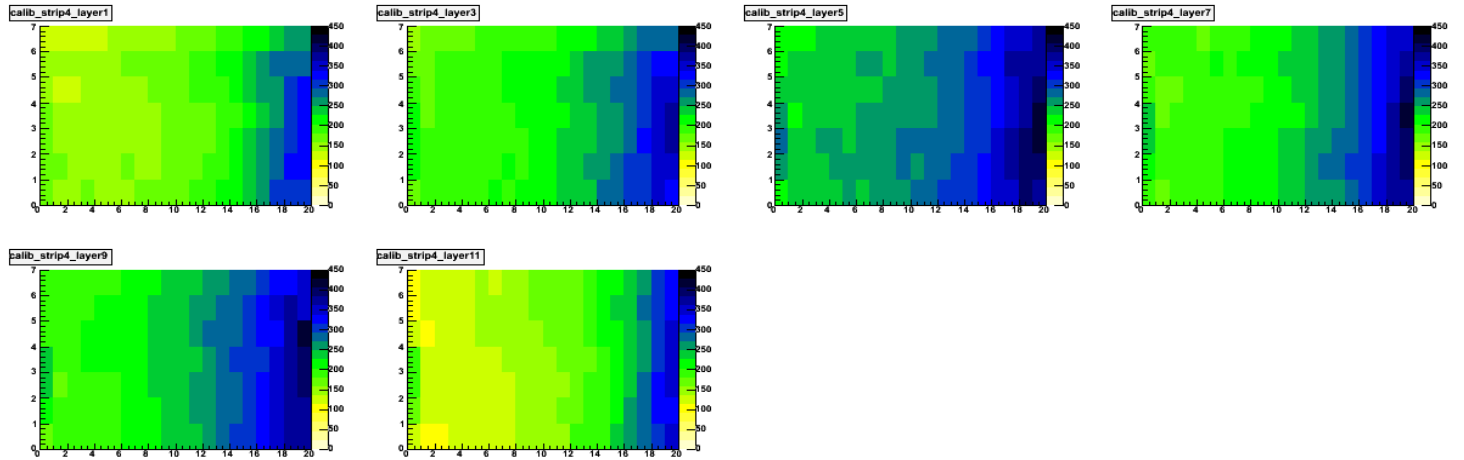
consistent for all channels

apply common ~1.8%/degree common correction

MIP response uniformity: detailed scan across single strip



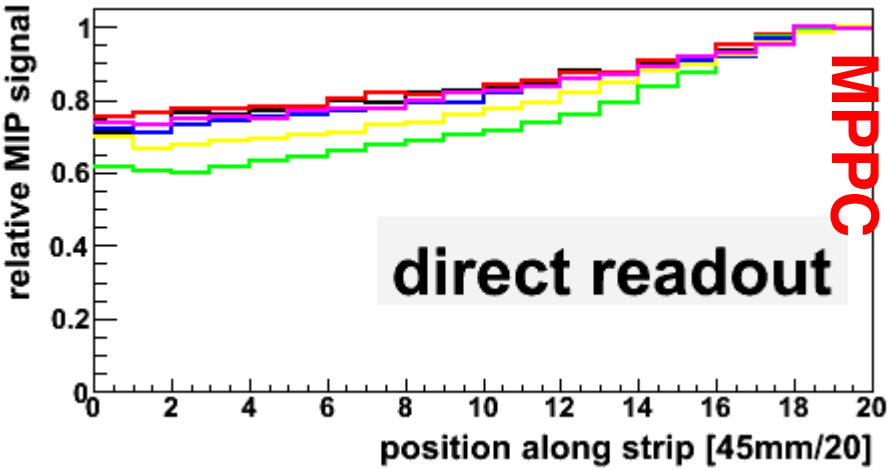


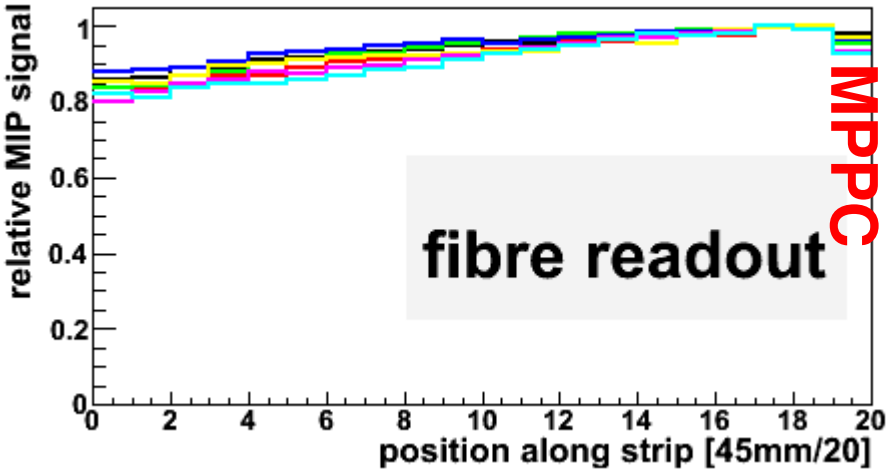


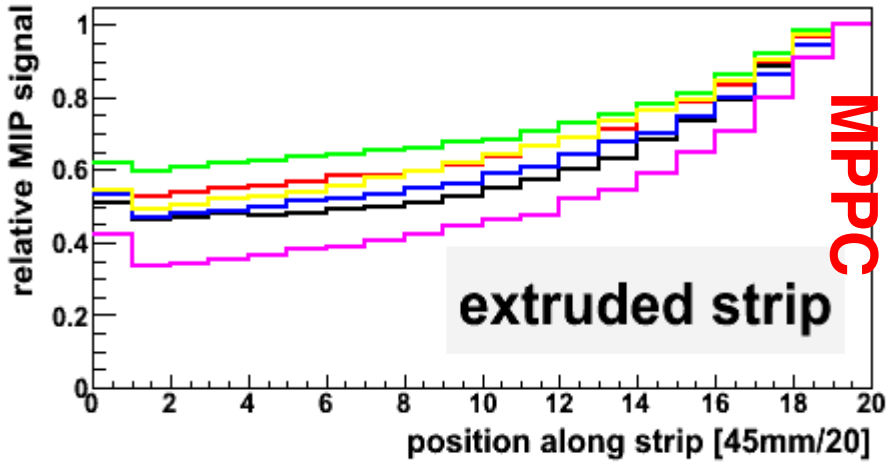
Kuraray
direct readout

Kuraray
fibre readout

KNU extruded
fibre readout





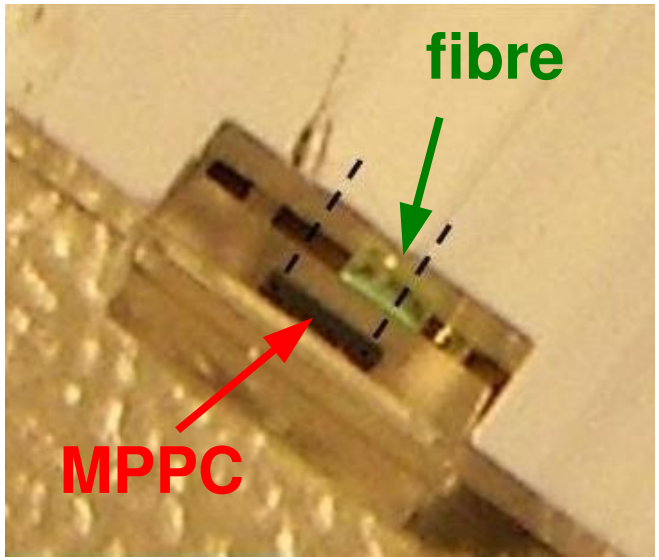


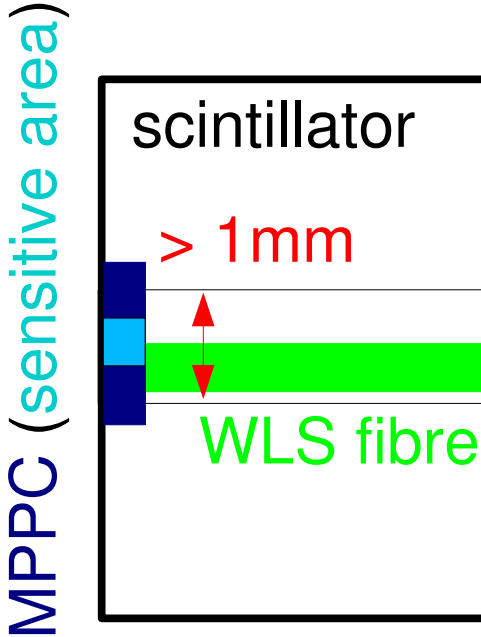
Projected along strip length

extruded strips show significant non-uniformity

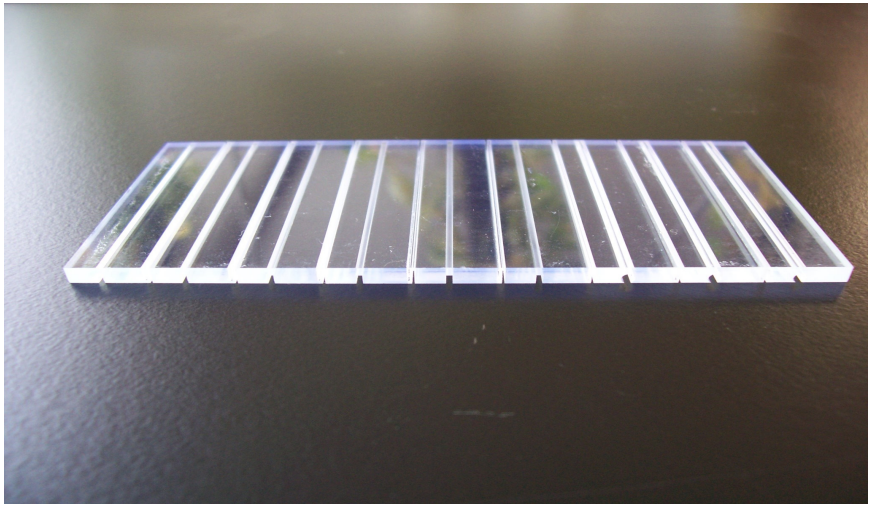
fibre-MPPC matching found to be bad in some extruded strips
mixture of fibre & direct light

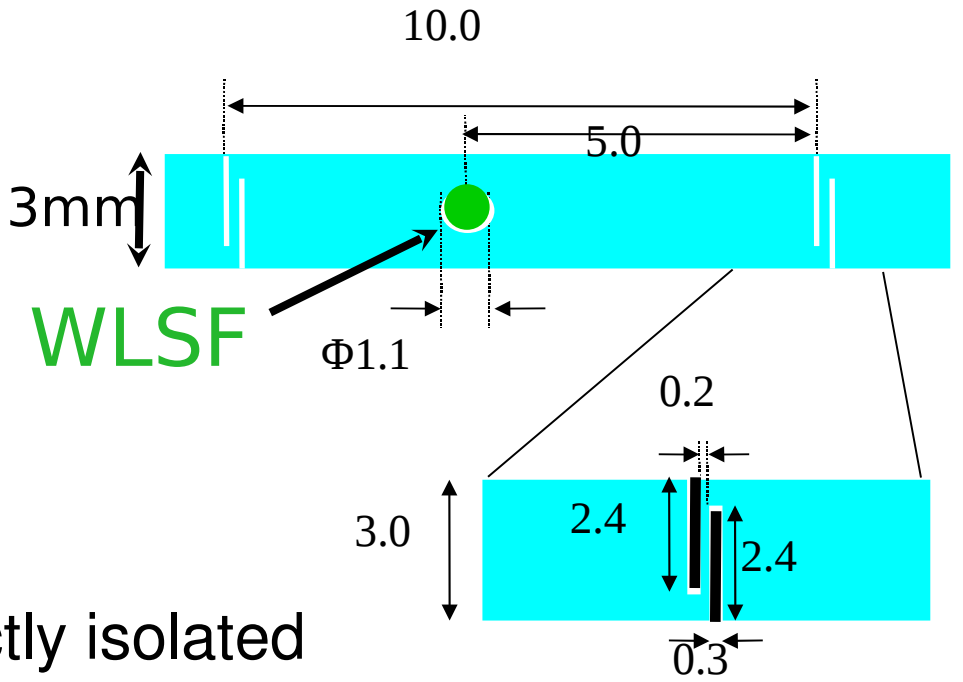
checked in dedicated beamtest @ KEK
improved extruded scintillator now in production



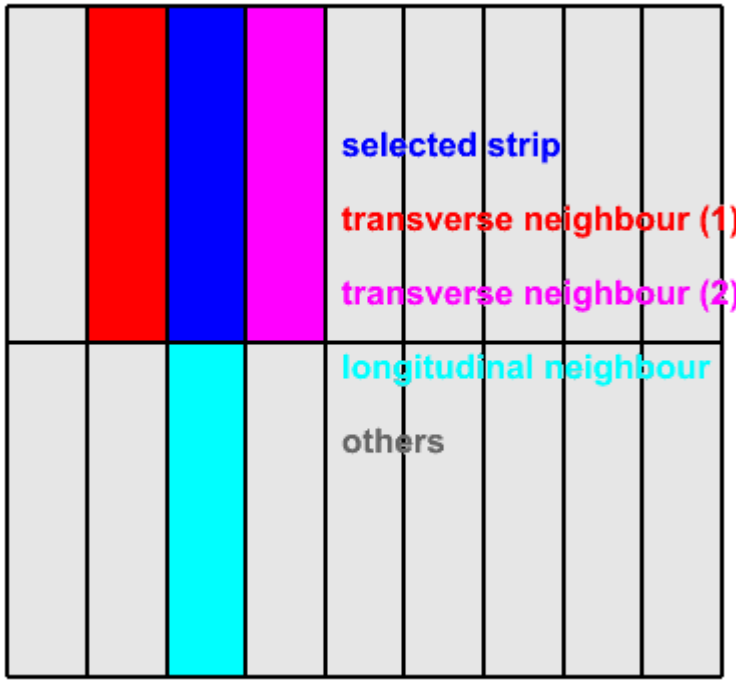


light cross-talk between adjacent strips

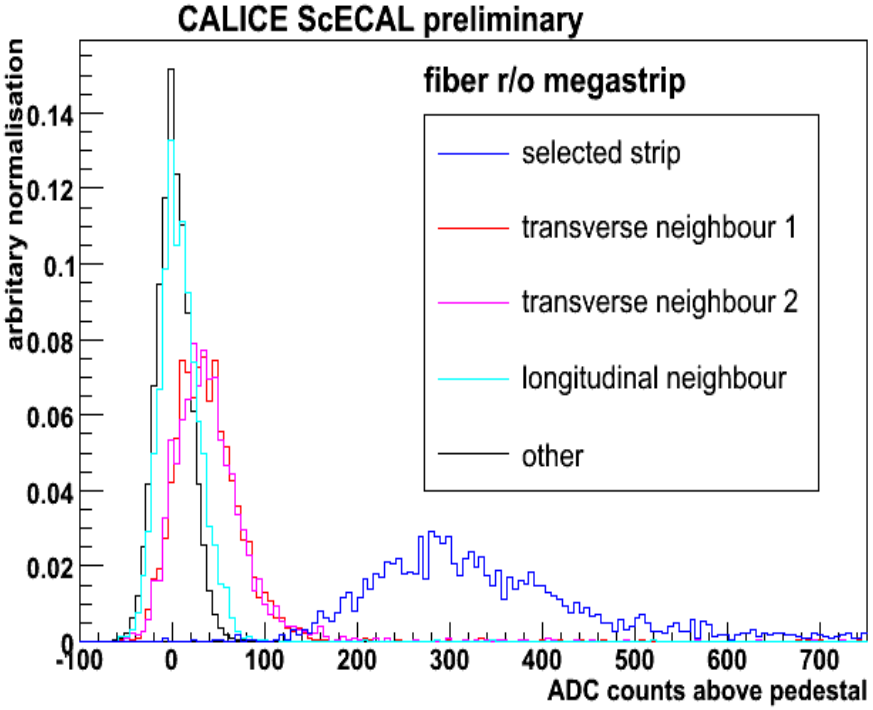




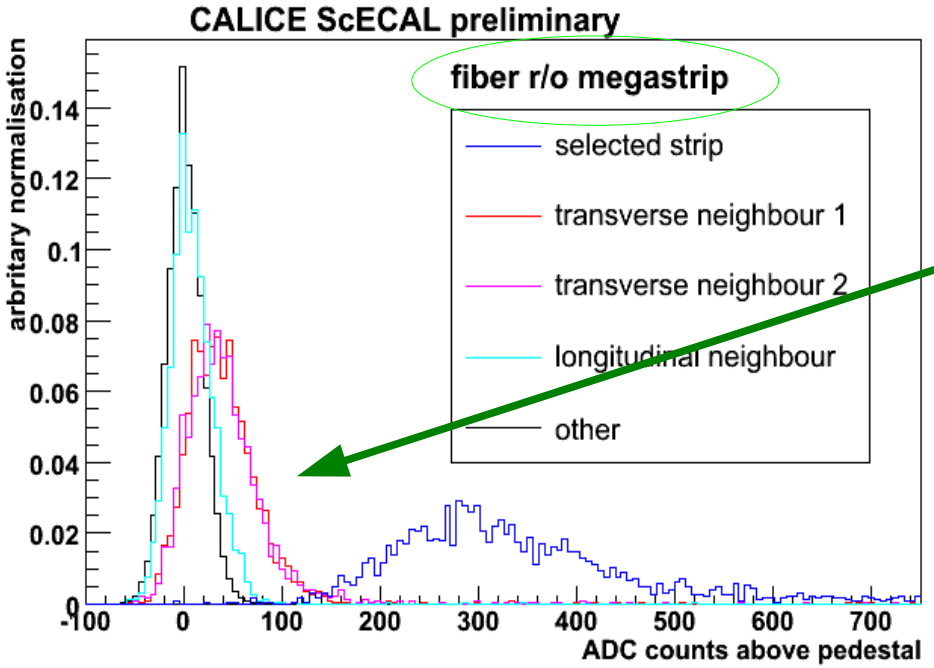
Mega-strip structure: strips not perfectly isolated



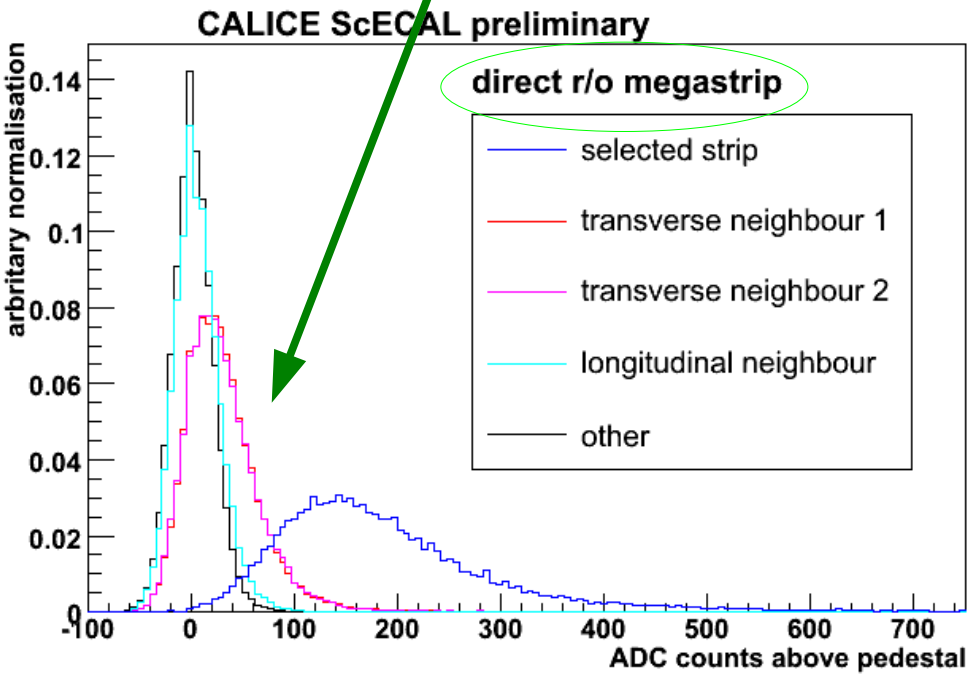
look at signal when MIP hits adjacent strips

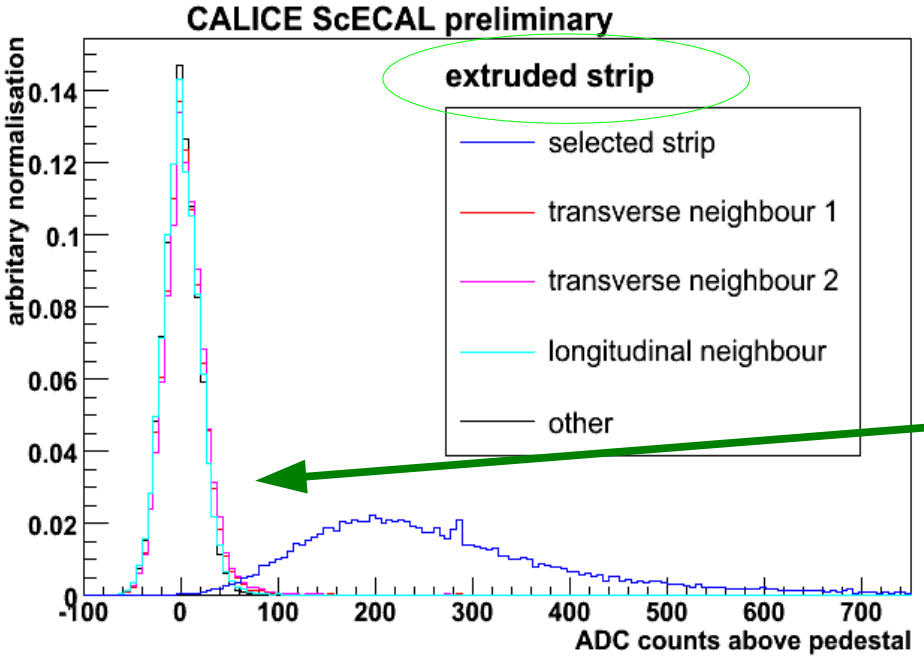


light xtalk in different scintillators



significant xtalk in megastrip tiles





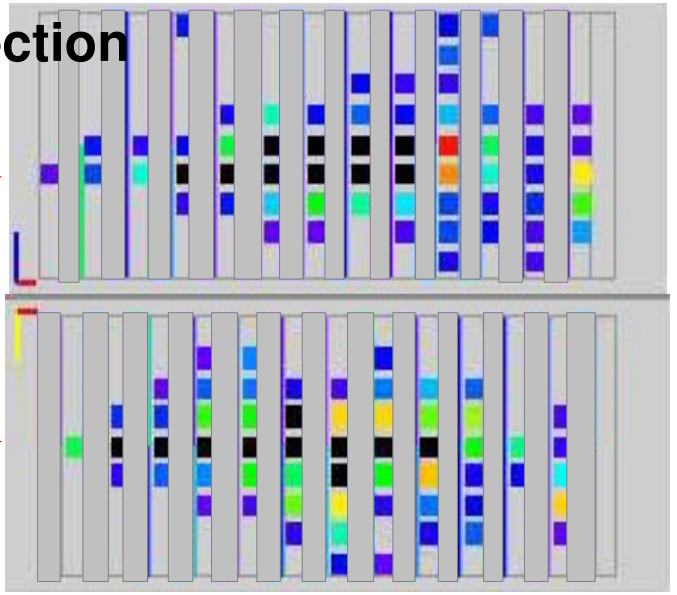
much less light cross-talk
in extruded strips

runs with tungsten plates

6 GeV e^+, center injection

x projection →

y projection →

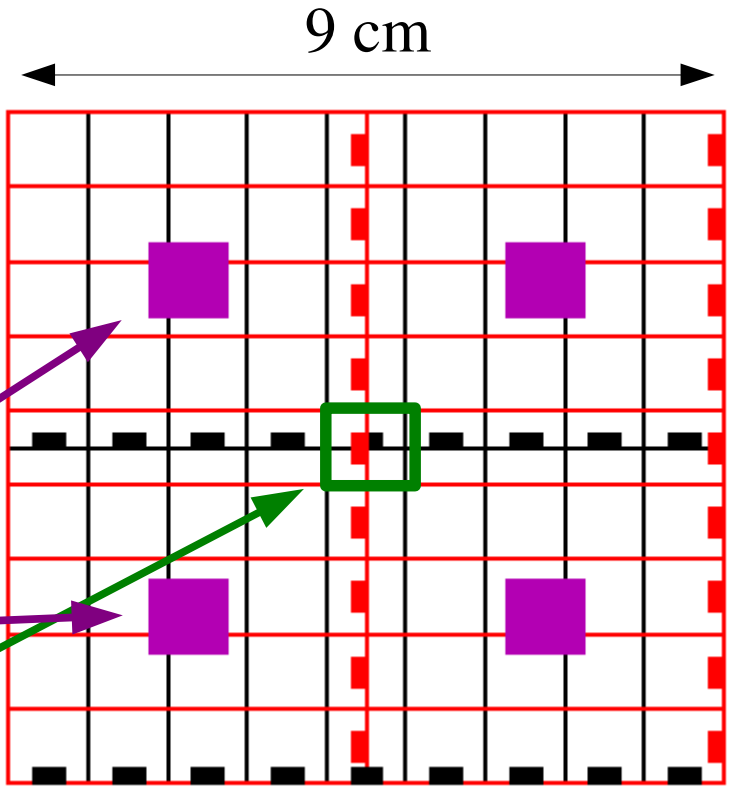


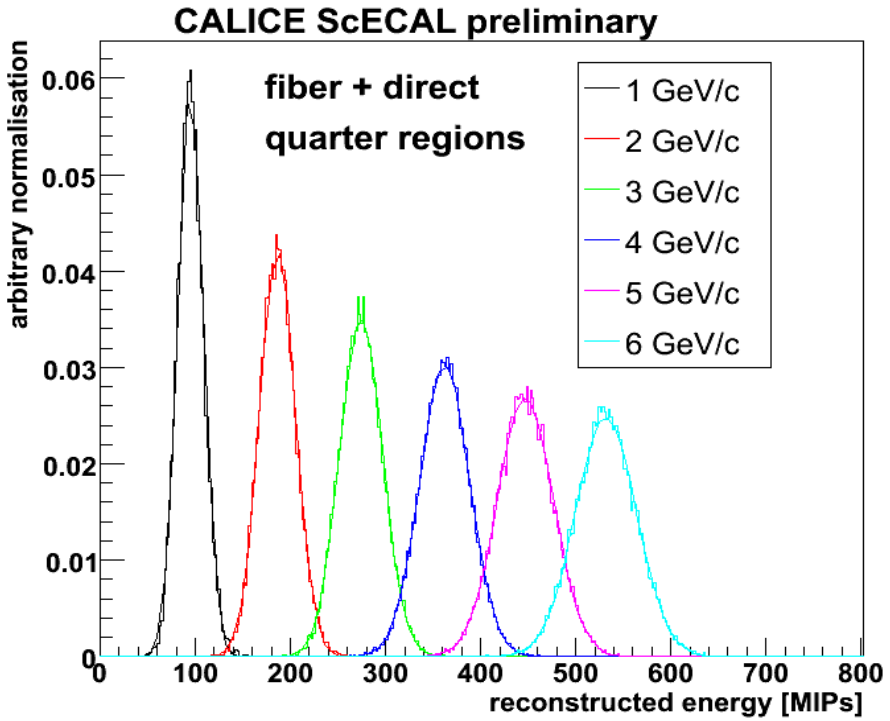
range of e+ beam momentum: 1->6 GeV/c

scanned front face of detector

apply calibration constants
- temperature correction
- cross-talk correction

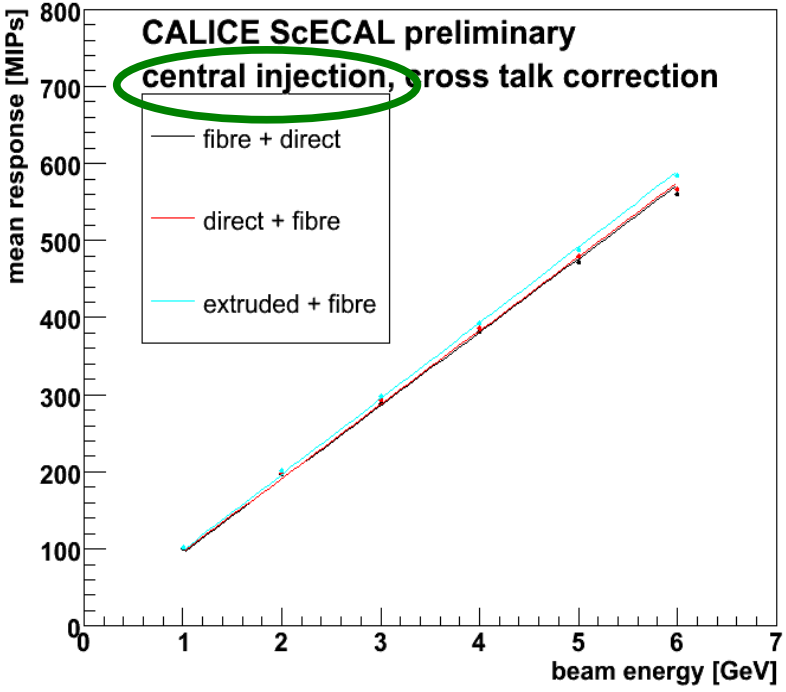
look at different detector regions
- quarter regions – most uniform
- central region – least uniform, least leakage

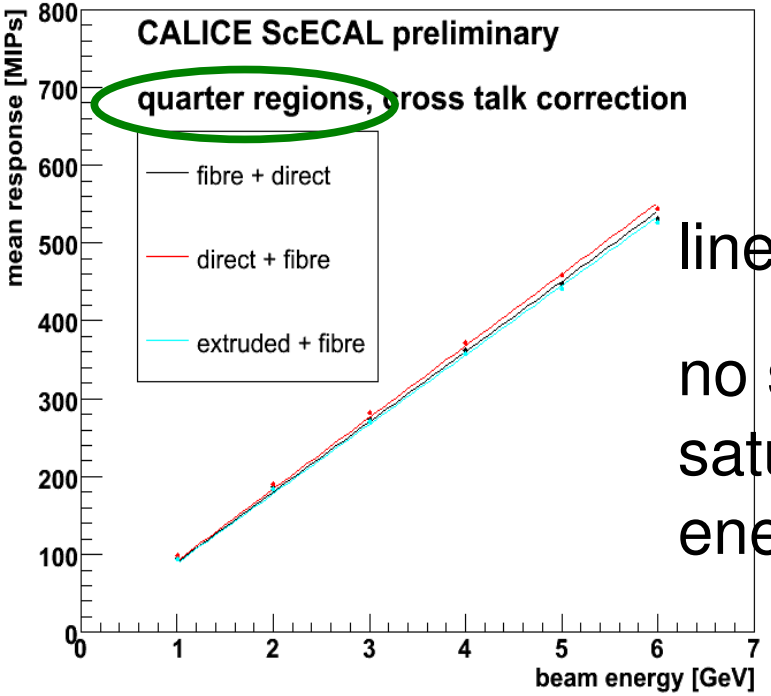




energy response

reconstruct total energy deposited in calorimeter



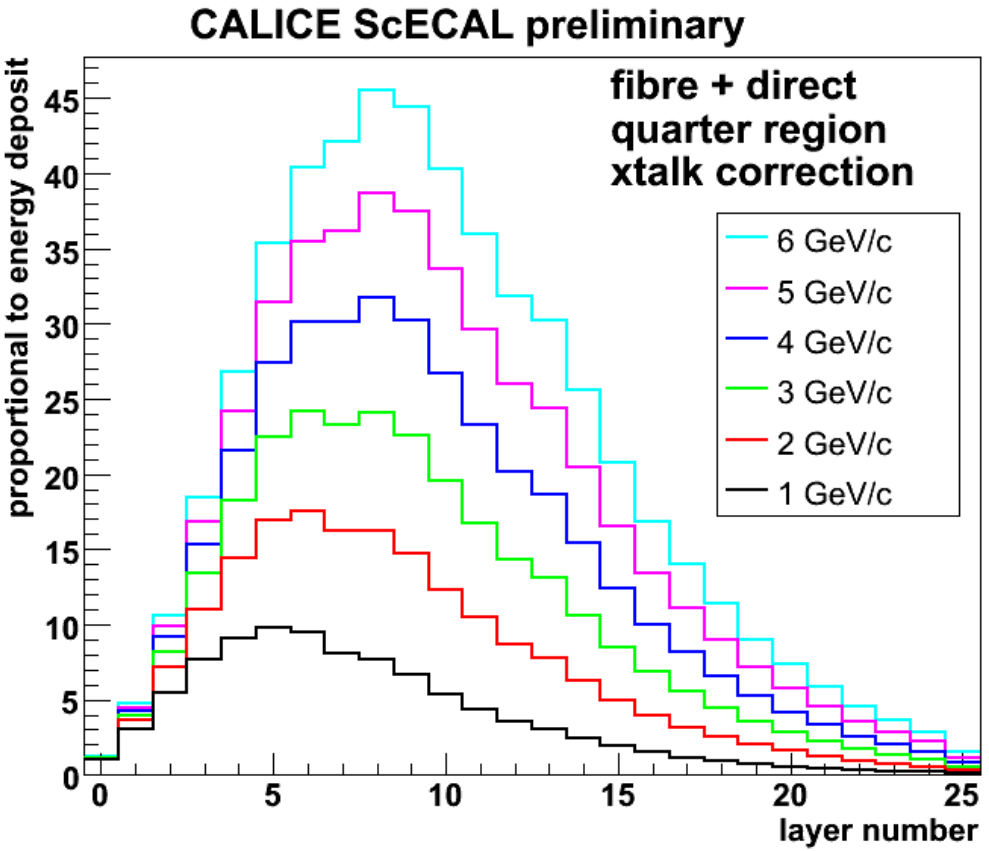


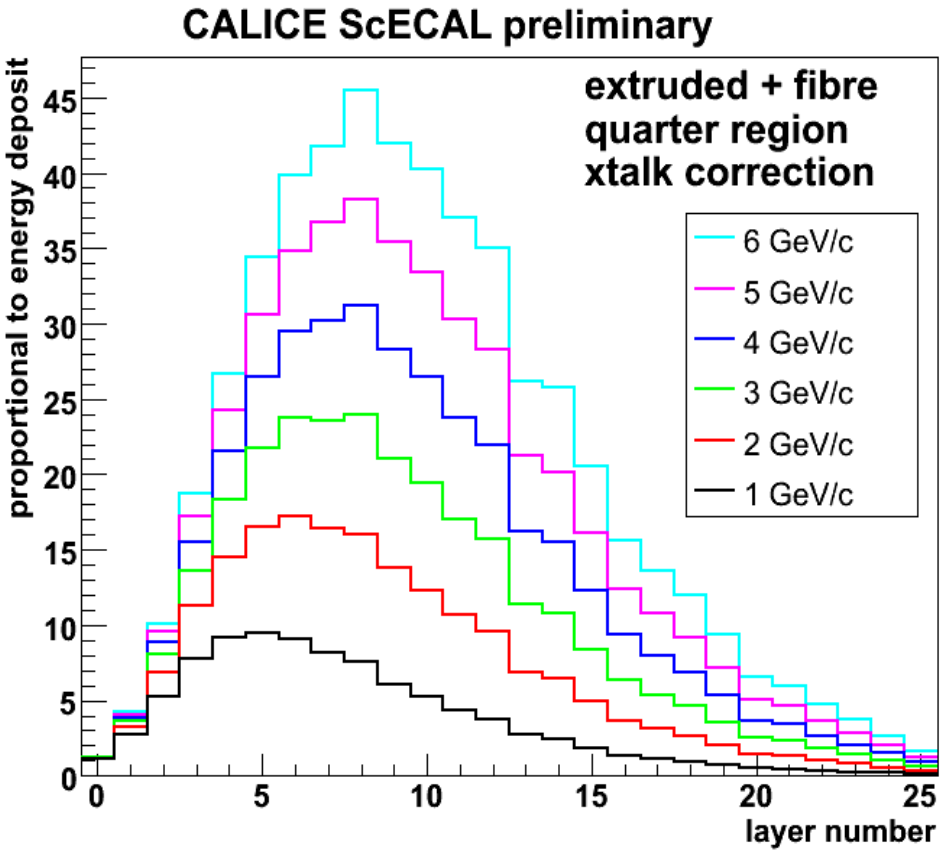
linear response

no sign of MPPC saturation @ higher energies

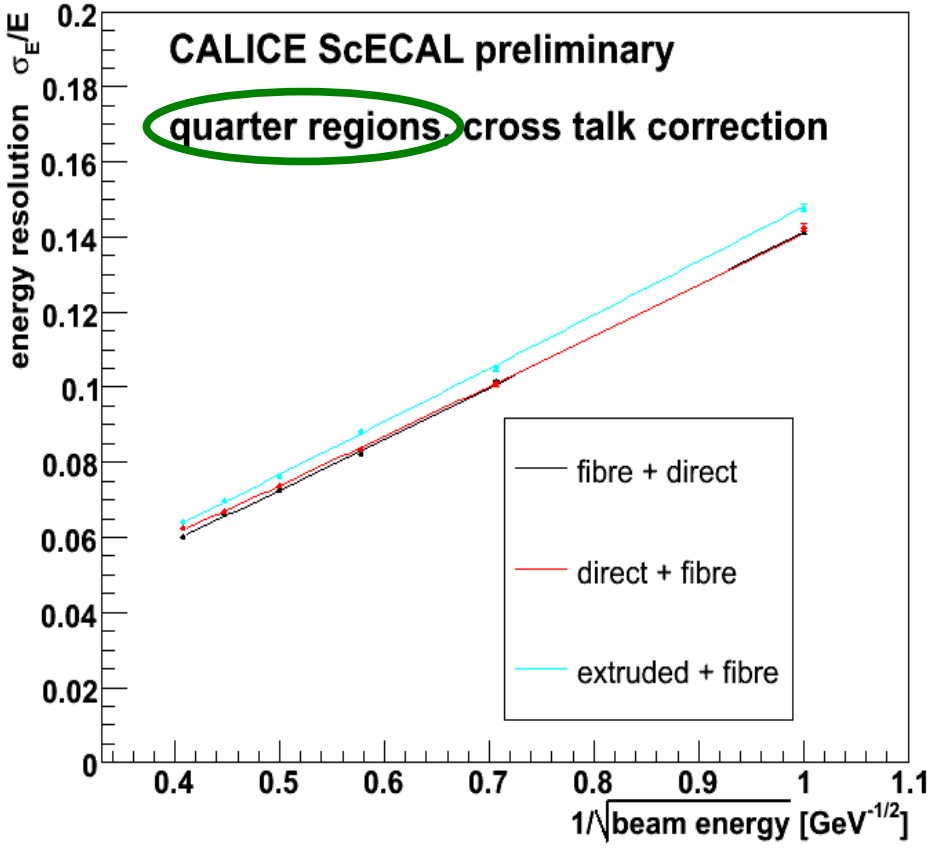
longitudinal shower profiles

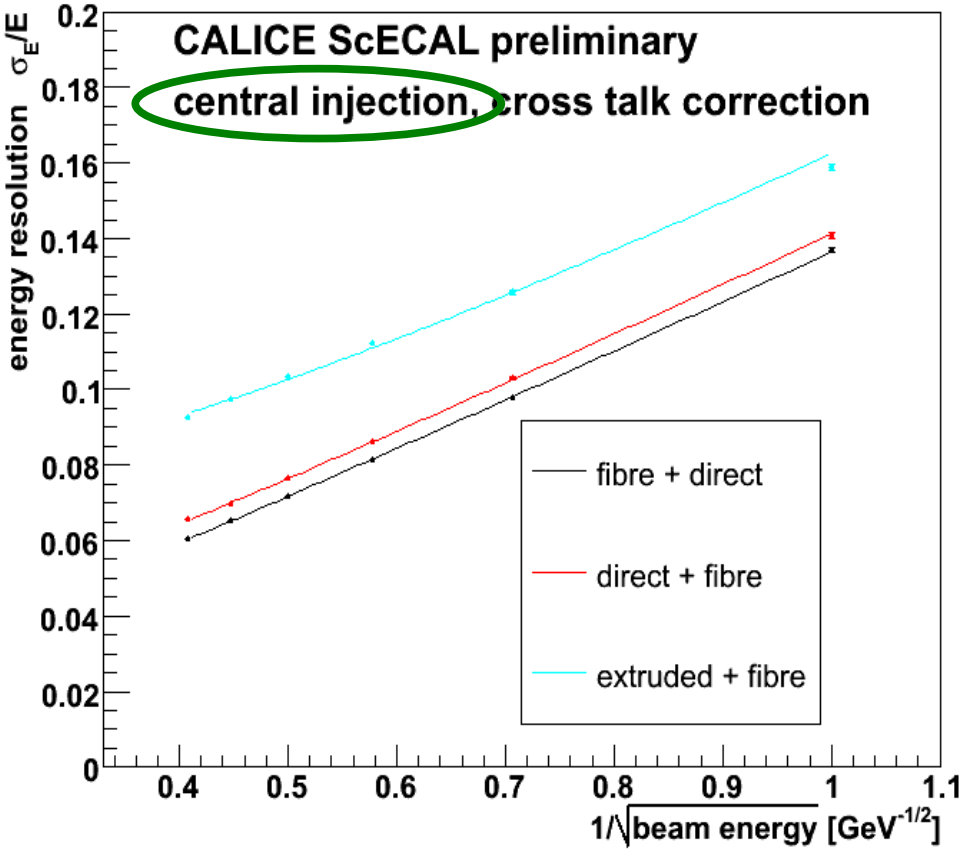
quite smooth, a couple of smallish discontinuities
reason still under investigation





Energy resolution of 3 configurations





resolution of configurations similar in quarter regions

at centre of detector, extruded+fibre much worse:
effects of strip uniformity enhanced in this region

Measured energy resolution

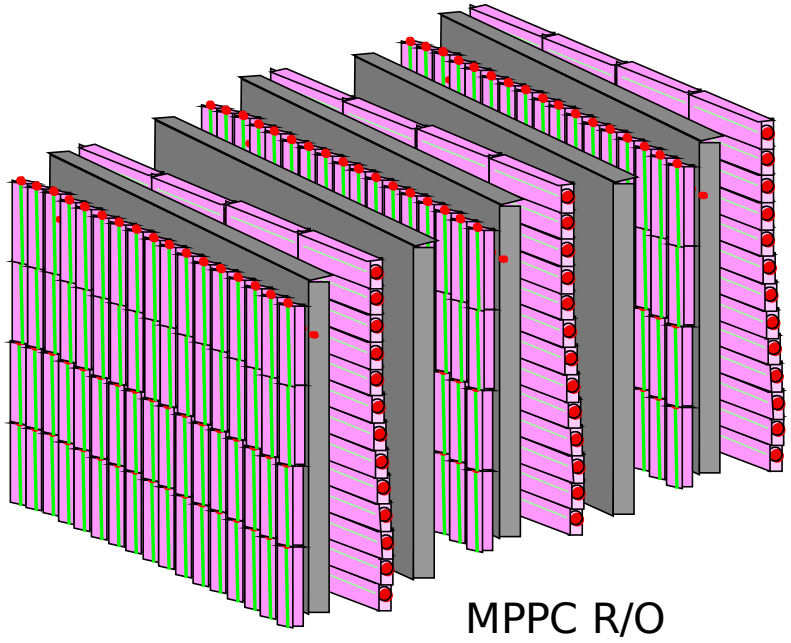
	quarter regions		central region	
	stoch. term(%)	const term(%)	stoch. term(%)	const term(%)
fibre+direct:	13.98 ± 0.07	1.96 ± 0.12	13.39 ± 0.05	2.57 ± 0.07
direct+fibre:	13.83 ± 0.07	2.58 ± 0.09	13.70 ± 0.06	3.39 ± 0.05
extruded+fibre:	14.61 ± 0.08	2.35 ± 0.12	14.52 ± 0.09	7.26 ± 0.05

Shower leakage gives significant contribution to constant term

Non-uniformity gives large constant term in central region

future plans

now constructing ~4x larger
detector with improved
extruded scintillator strips
30 layers, 18x18 cm^2
-> less energy leakage



CALICE beamtest at FNAL – September '08
run together with Scintillator+SiPM HCAL

test with different particle, wider energy range
hadrons, muons, $\pi^0 \rightarrow \gamma\gamma$

Conclusions

Analysis of DESY testbeam data in good shape

In uniform regions, detector works well

sufficient energy resolution for ILC ECAL

(σ/E ~ 14%/$\sqrt{E}$ $\oplus$ 2%)

Non-uniformity of extruded strips significantly degrades performance

improved samples have since been tested

In progress...

Further data analysis: MPPC saturation correction, shower shapes

Detailed simulation

Preparations for next beam test

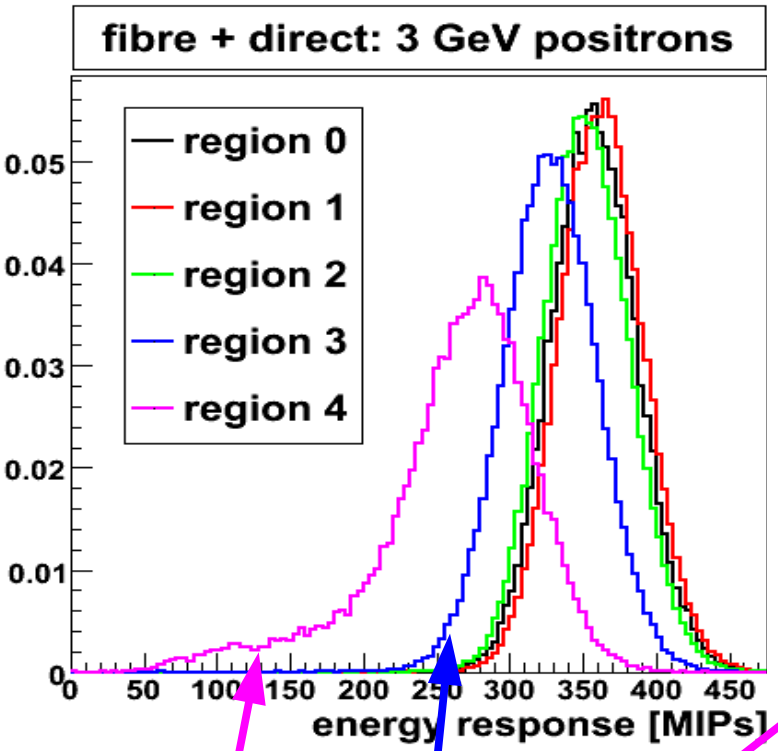
CALICE Calorimeter for ILC

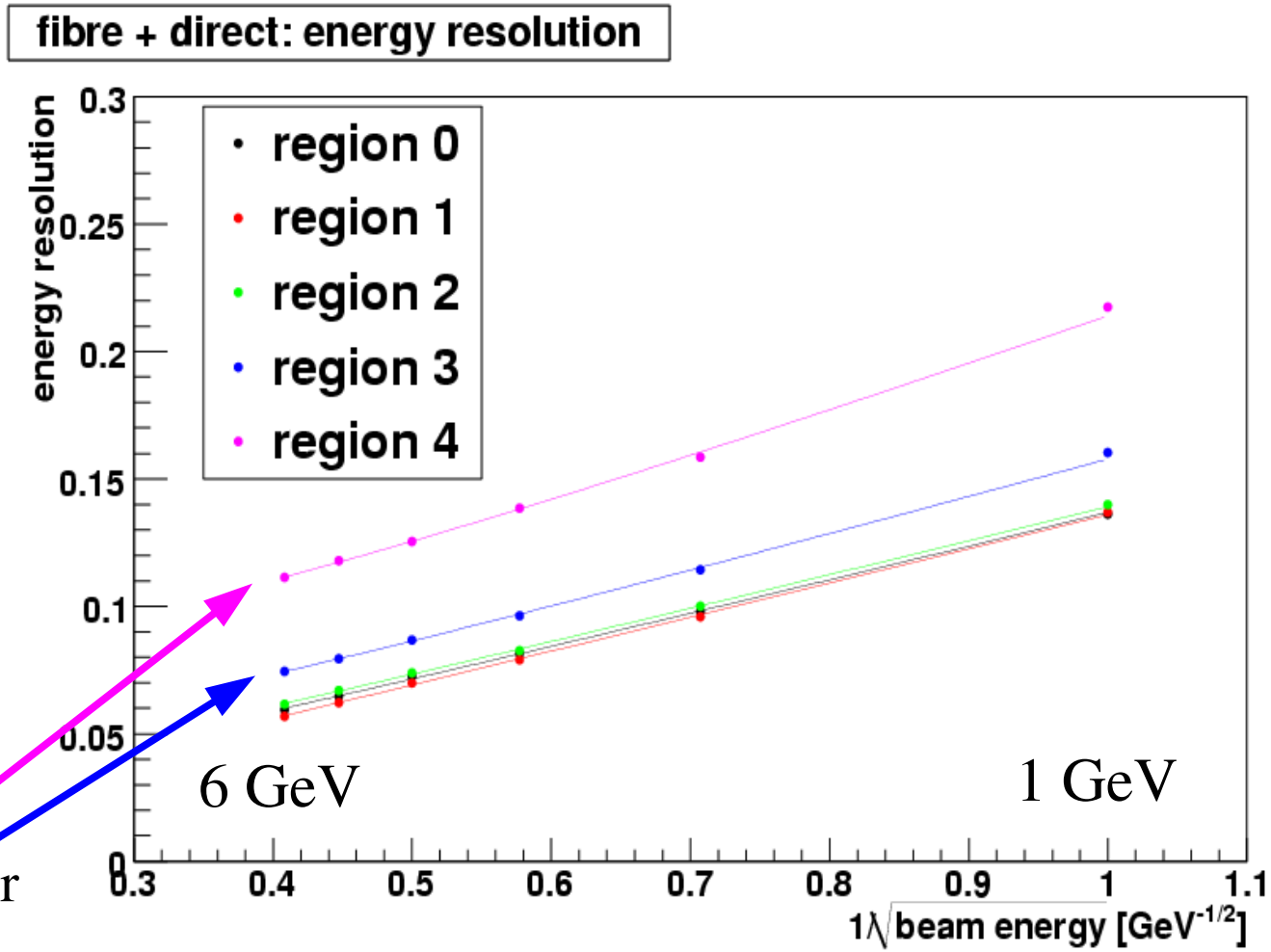
KOBE UNIVERSITY

Backups

Energy resolution in different detector regions

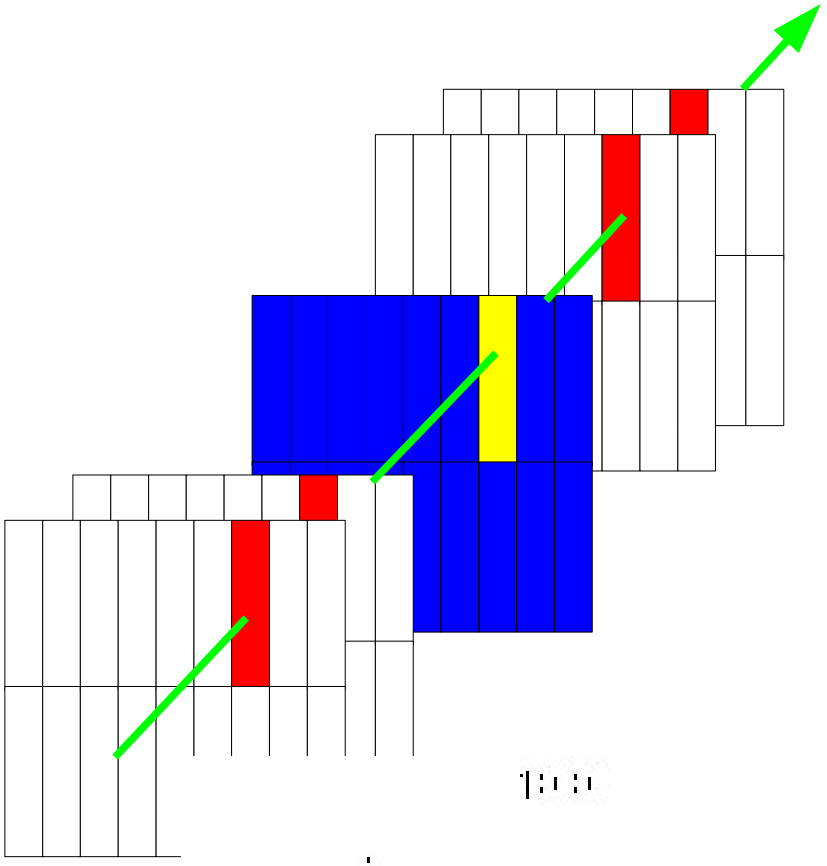
(fibre+direct, with absorber)

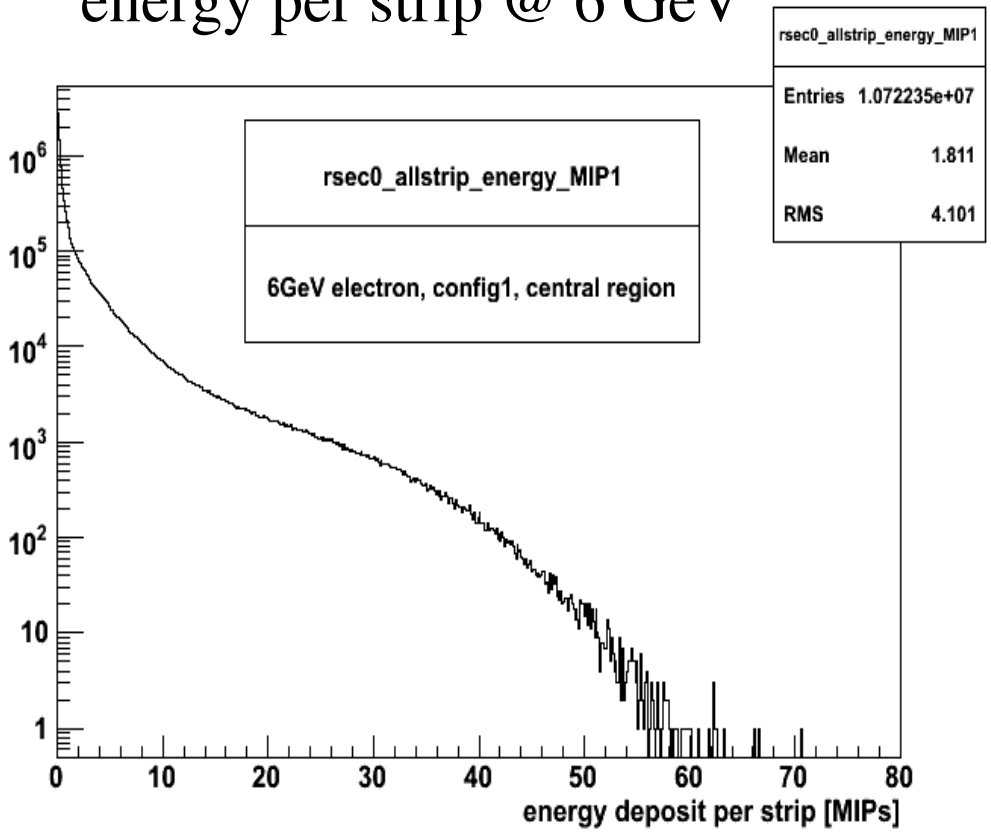


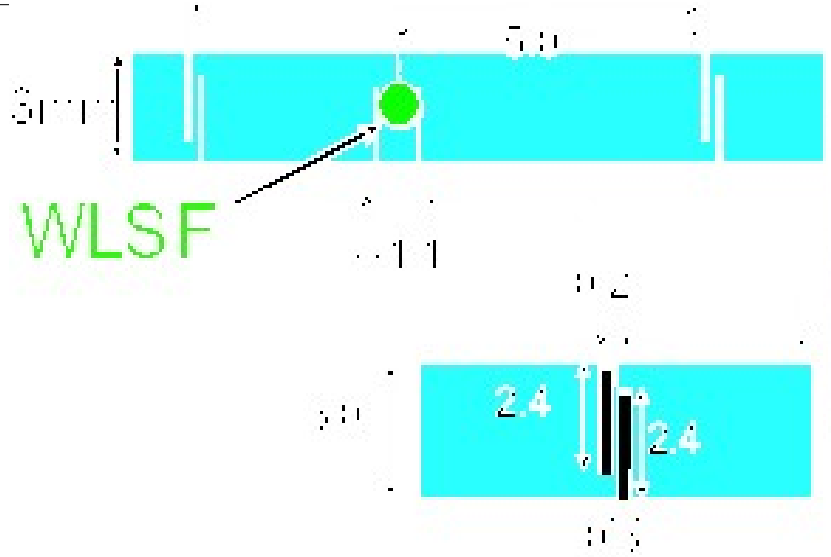


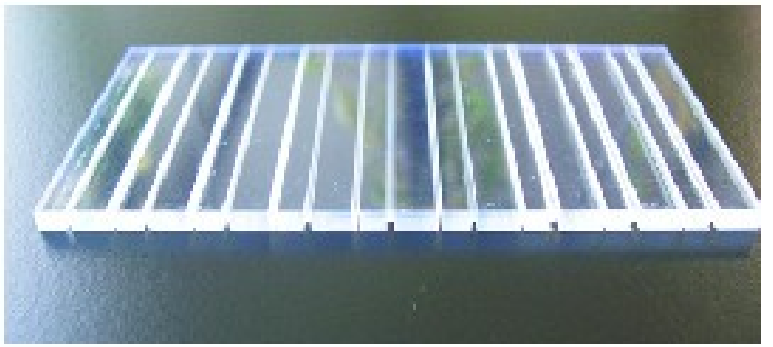
clear evidence of lateral shower leakage in outer two regions

energy per strip @ 6 GeV







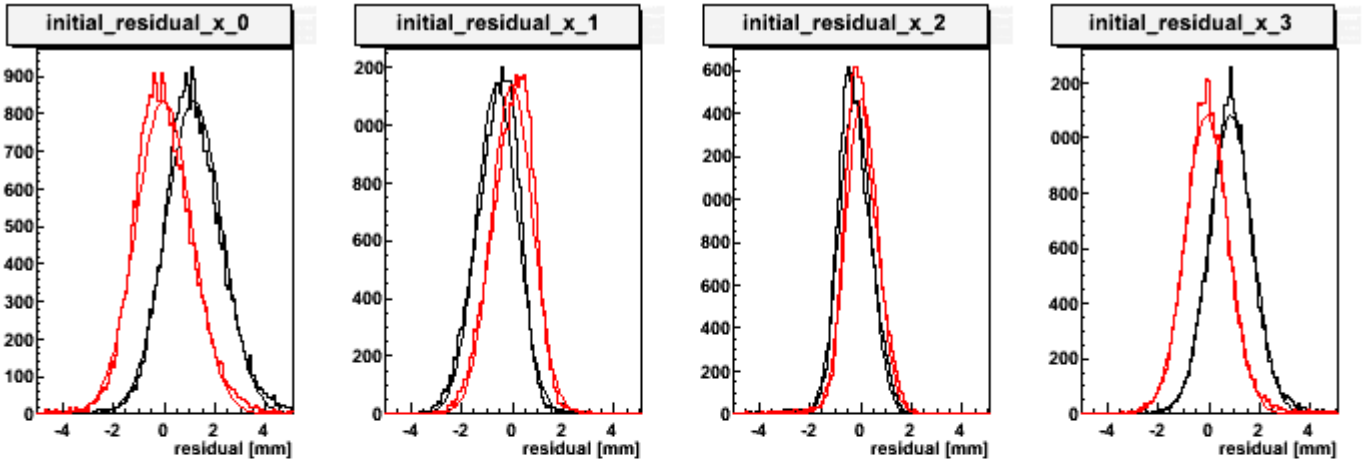


Tracking detector alignment

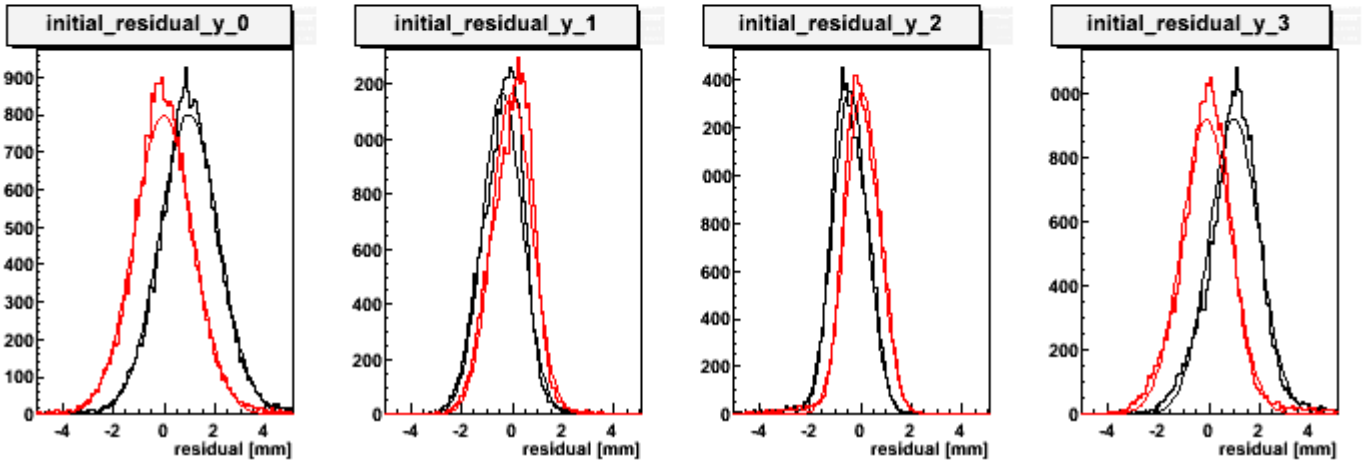
determine drift velocity and relative positions of 4 drift chambers
each chamber measures x,y position

chamber 0 1 2 3

x



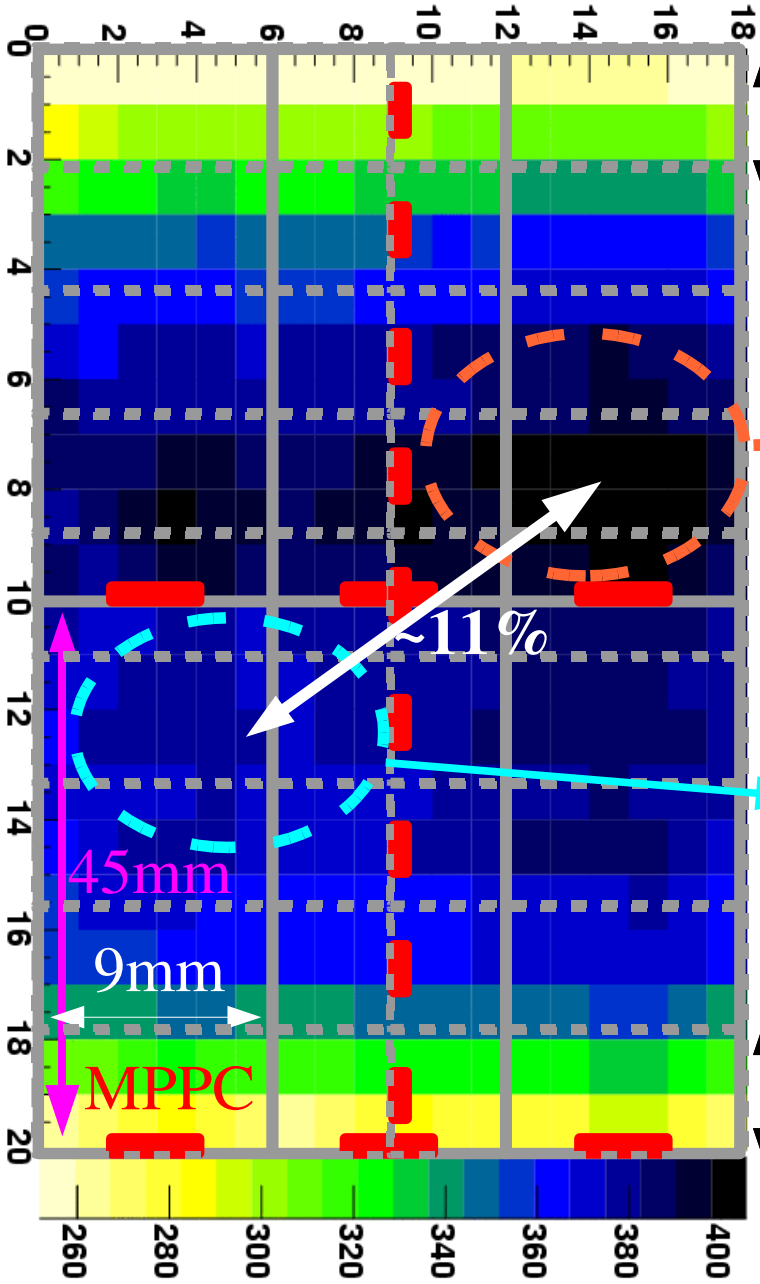
y

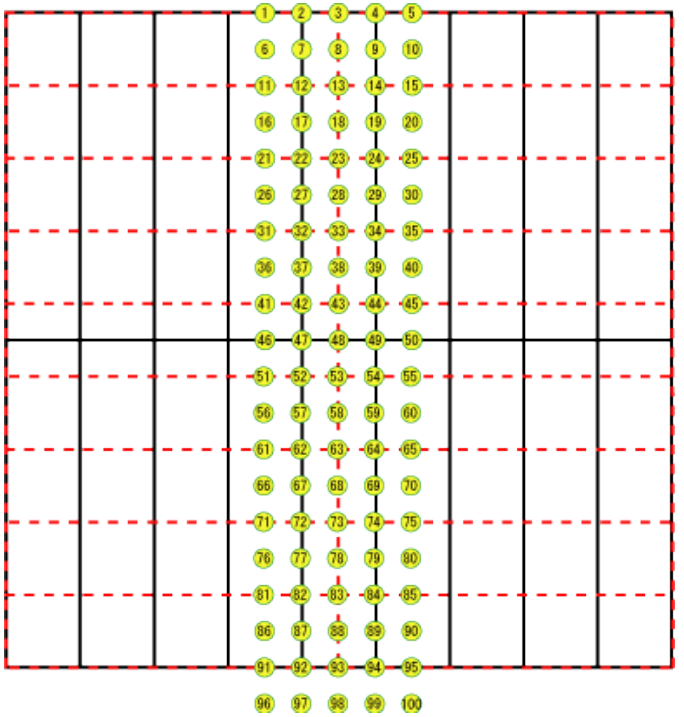


before
(after)
alignment

hit residual/mm

Energy response uniformity, direct+fibre, 3 GeV

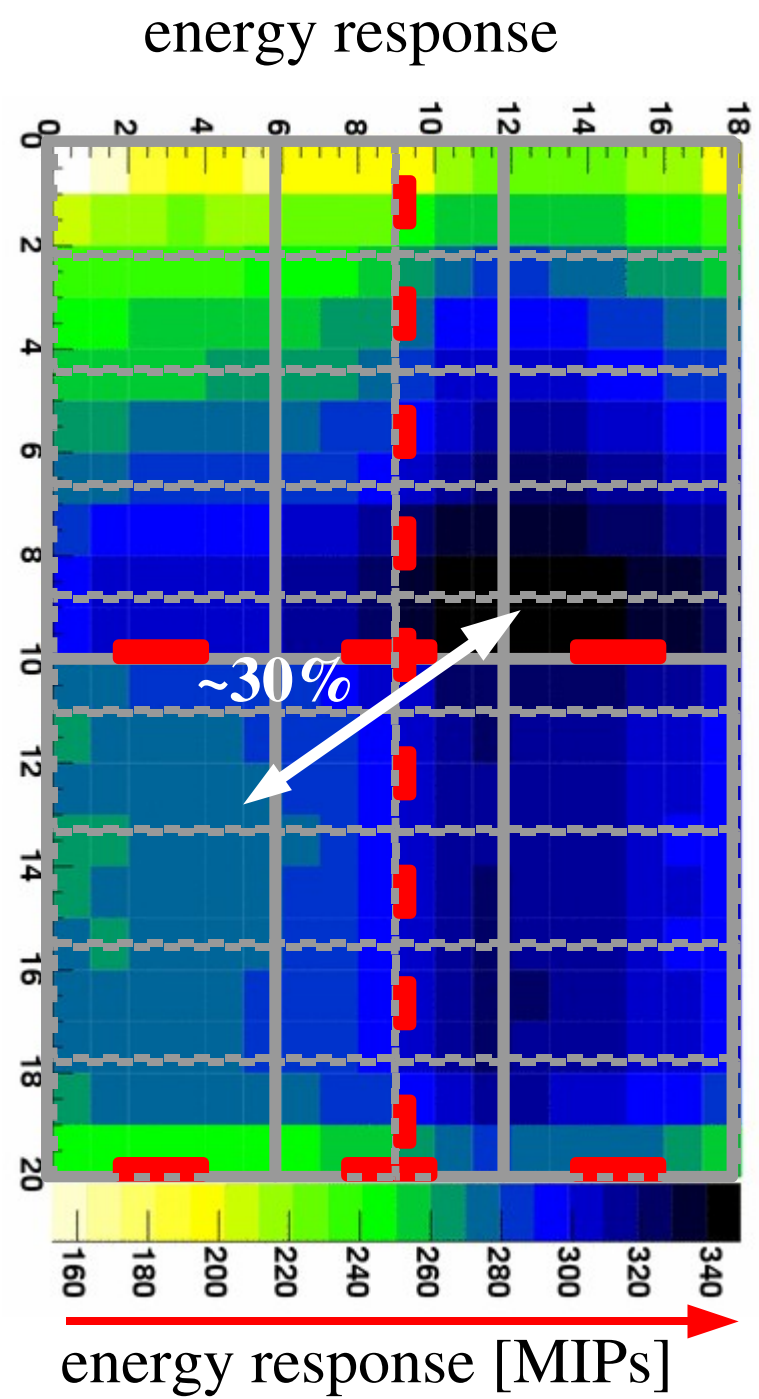




scanned 1/3 detector

can alternate orientation to minimise this effect

extruded+fibre @ 3 GeV: energy response vs. position



2-3 times more variation that direct+fibre configuration

extruded strips are less uniform