CALICE ScECAL beam test @ DESY

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for the CALICE ScECAL group

Calorimeter for ILC

KOBE UNIVERSITY

strip scintillator calorimeter

sampling calorimeter

- active material: scintillator
- absorber: W/Fe/Pb

designed for PFA: fine segmentation

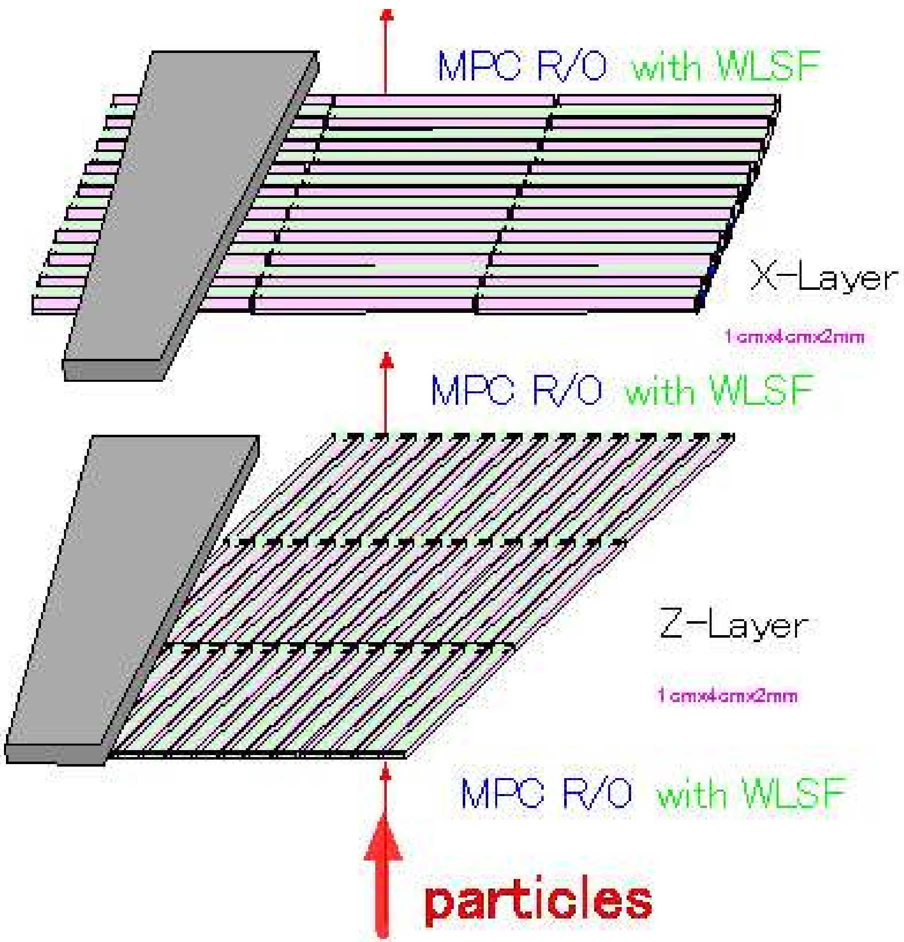
- scintillator strips ~1x4 cm^2
- orthogonal layers

each strip read out by MPPC

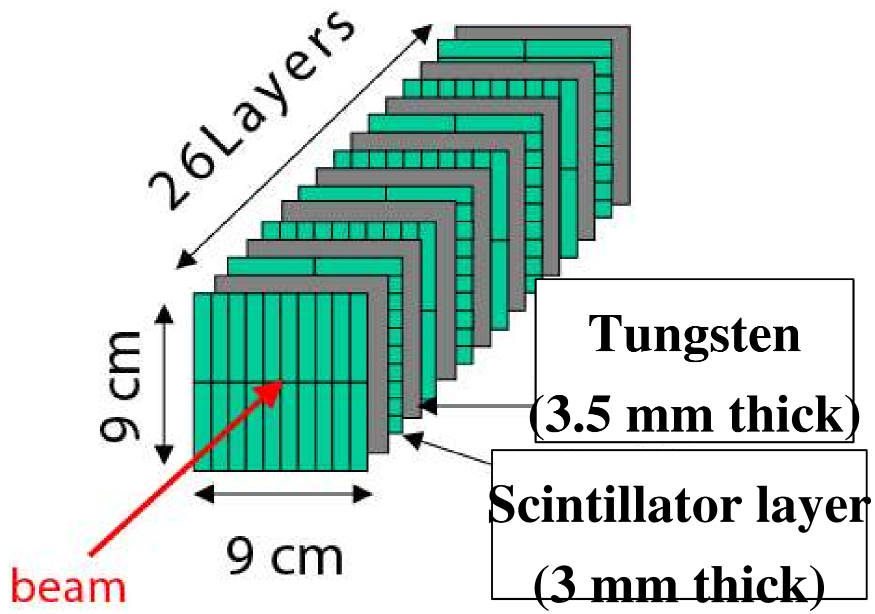
- photon counting device

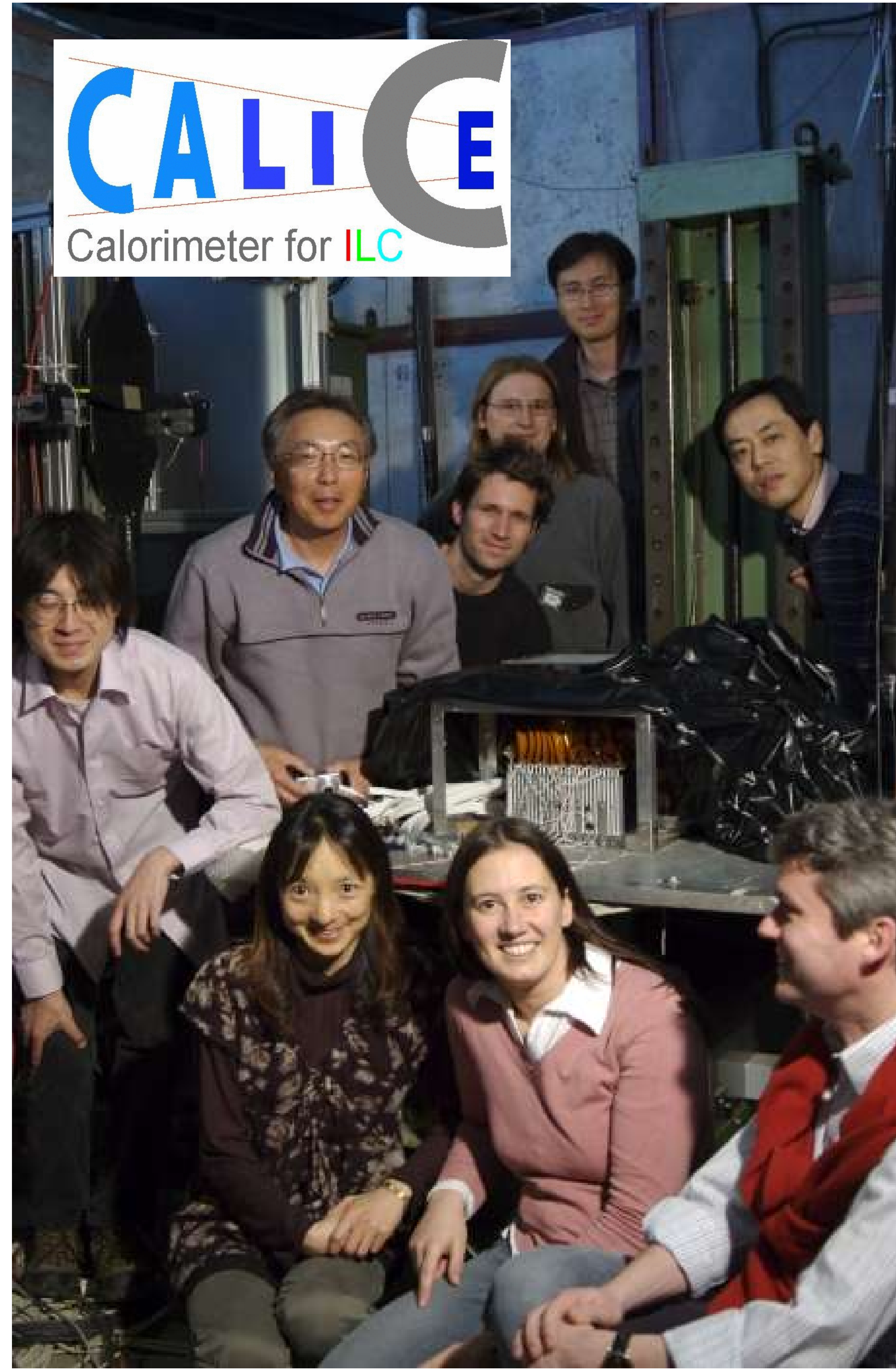
built and tested small prototype

- first test for scintillator + MPPC calorimeter
- check suitability for ILC ECAL



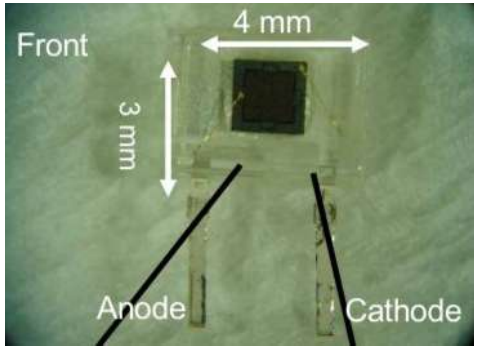
exposed to 1-6 GeV e+ beam at DESY 03/07

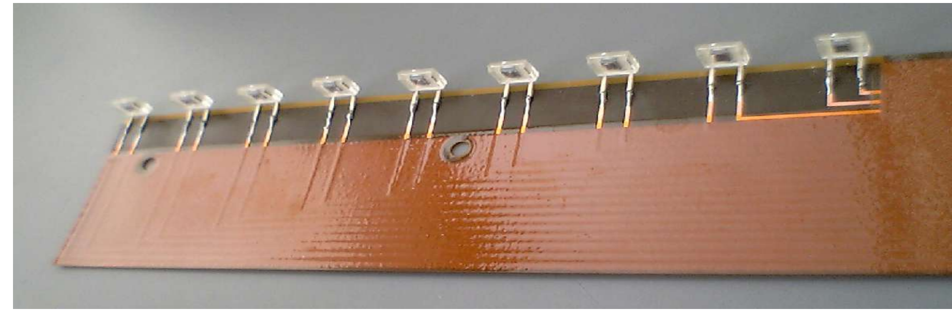


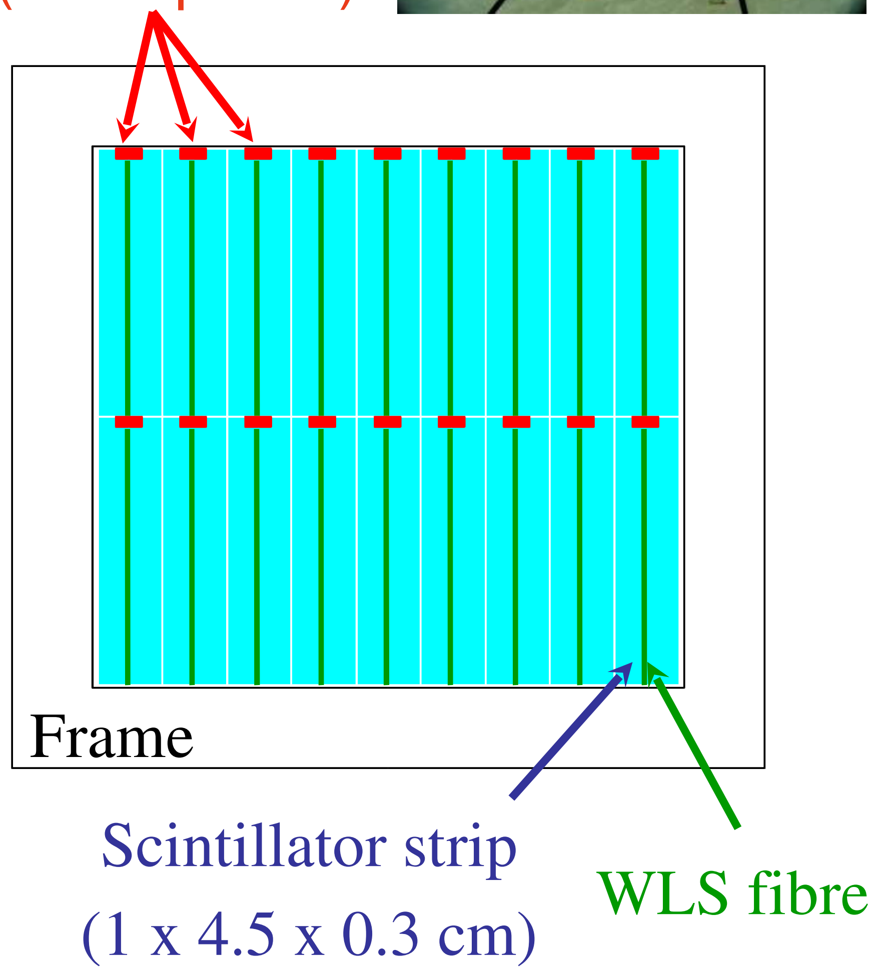


Detector setup, scintillator types

MPPCs
(1600 pixels)







3 types of scintillator strips:

Kuraray (Megastrip)
- WLSF readout
- direct readout (simpler)

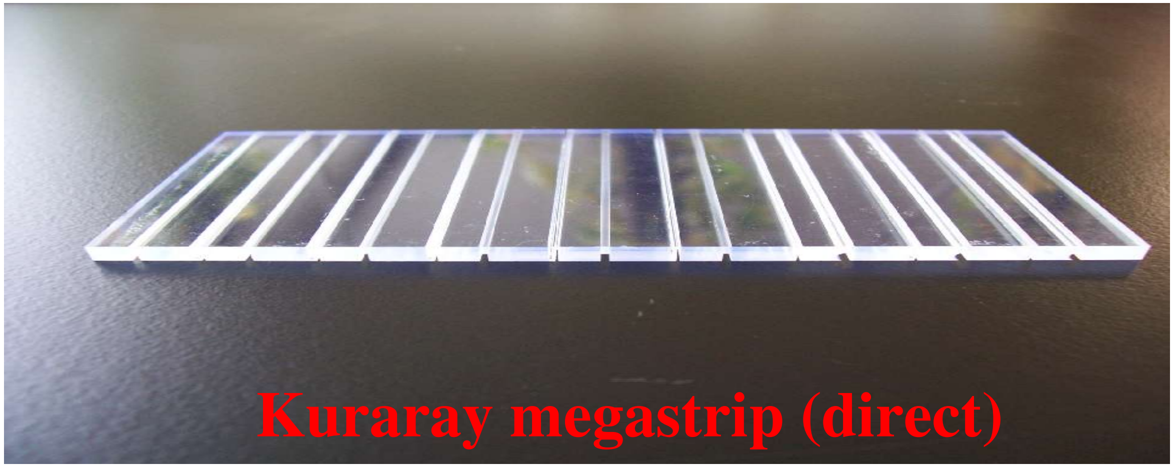
KNU/Korea (separate strips)
- extruded scintillator (inexpensive)
- WLSF readout

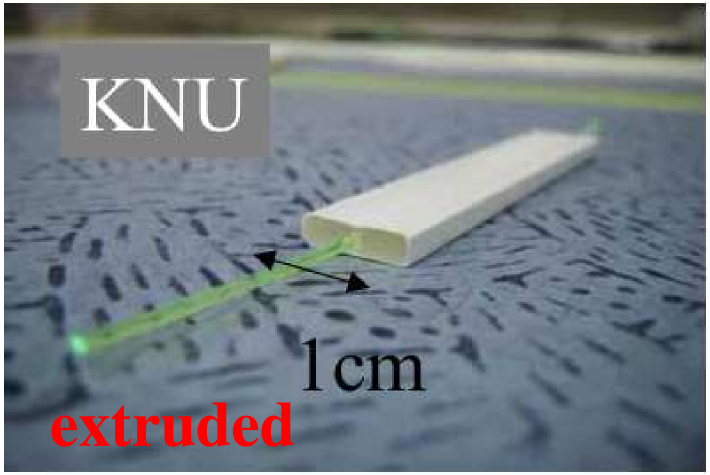
CALICE readout electronics (LAL-Orsay) borrowed from DESY CALICE A-HCAL group

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

tested 3 configurations

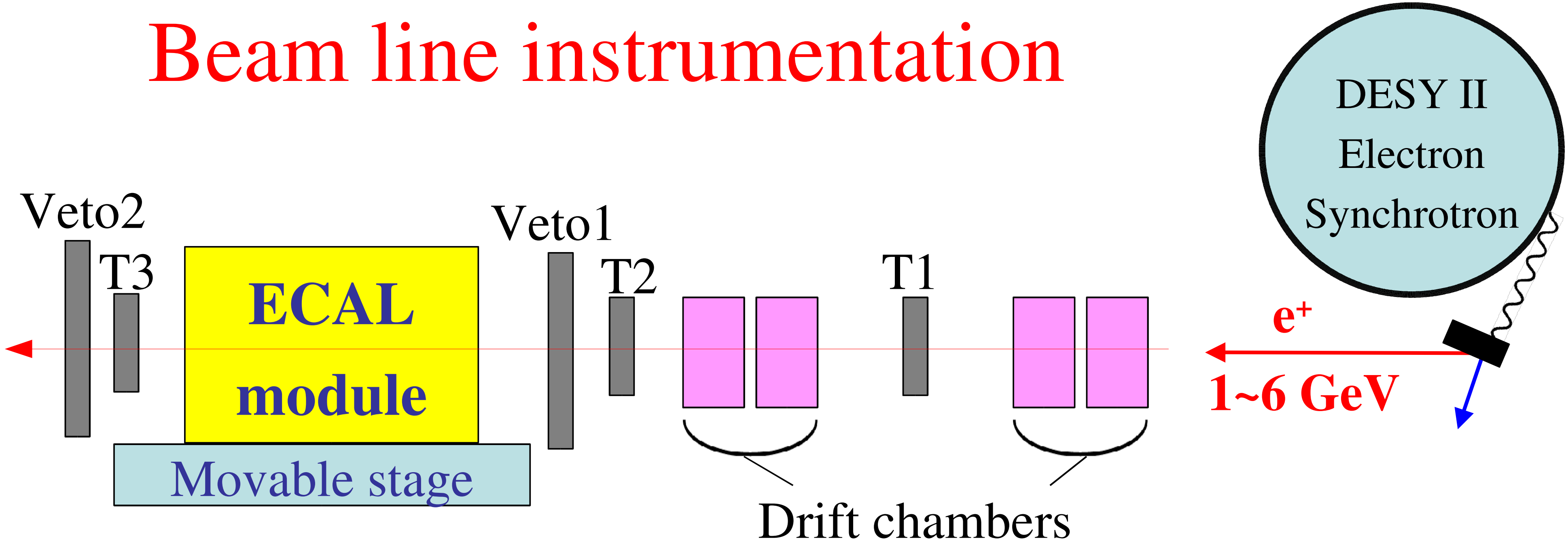
- Kuraray (fibre) + Kuraray (direct)
- Kuraray (direct) + Kuraray (fibre)
- Extruded (fibre) + Kuraray (fibre)

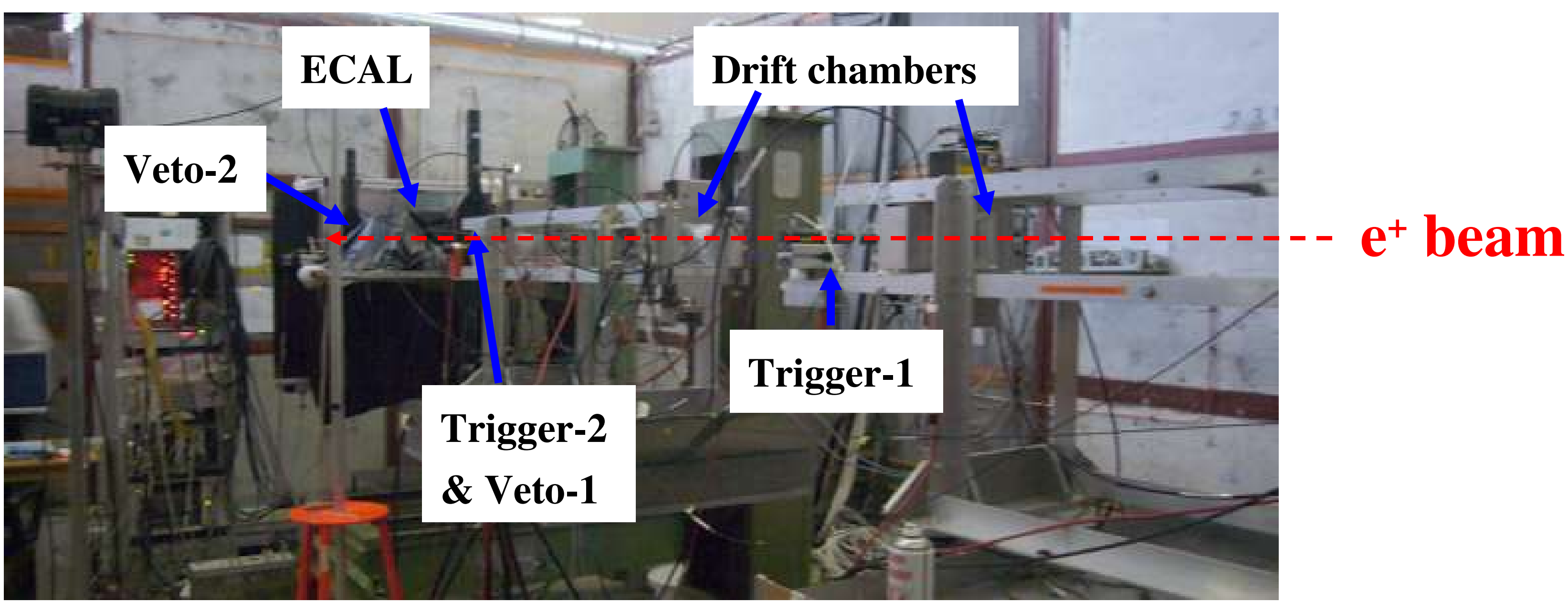




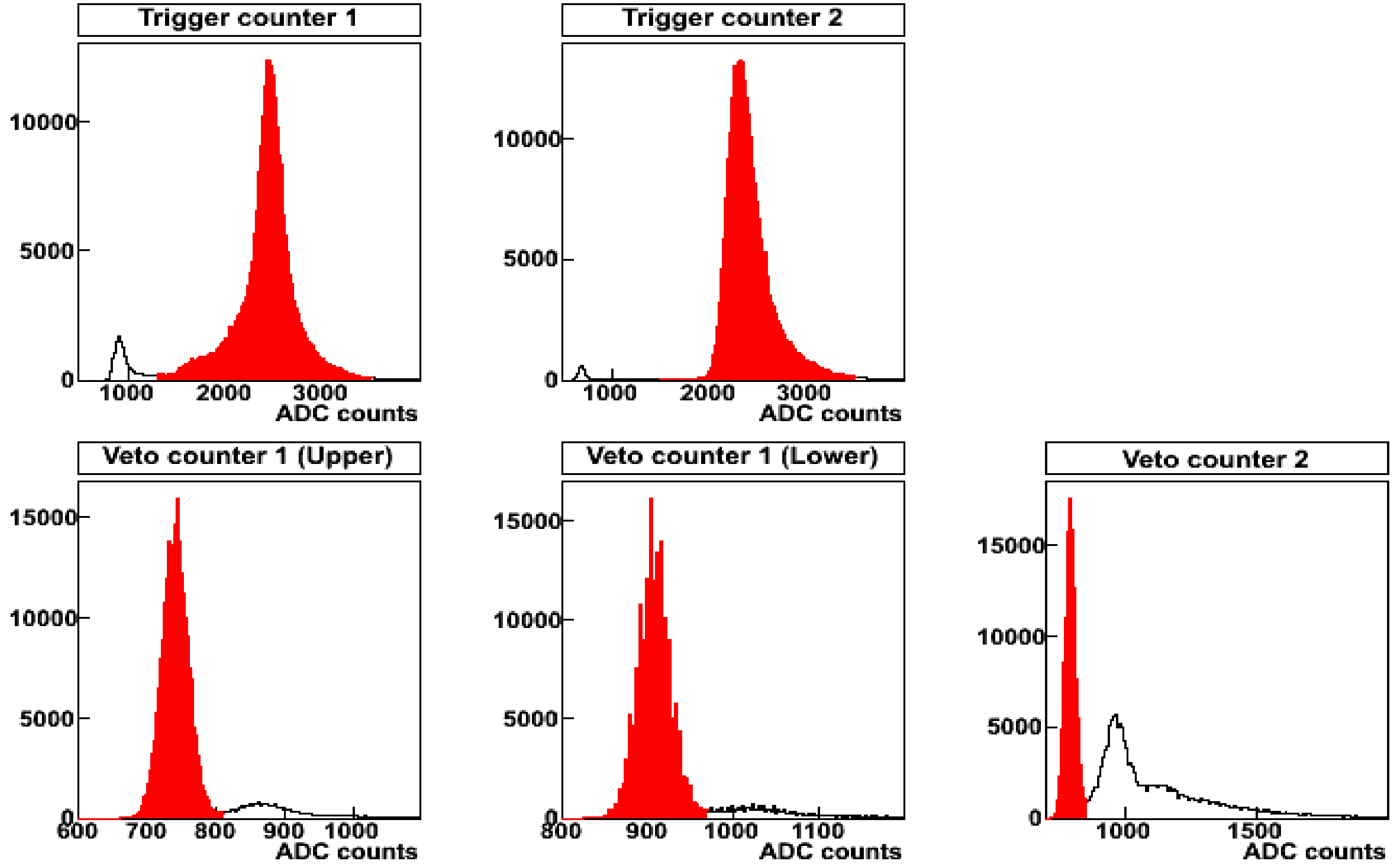
compare performance of configurations

Beam line instrumentation



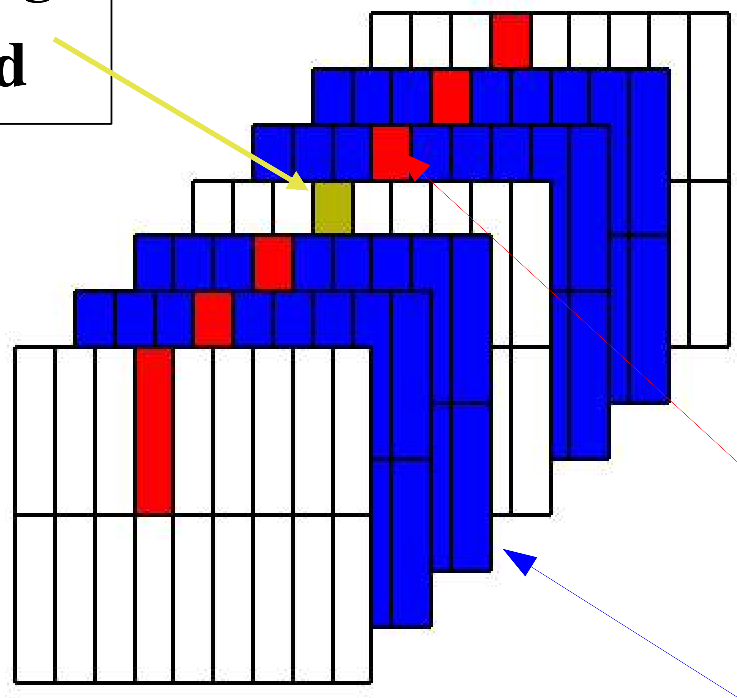


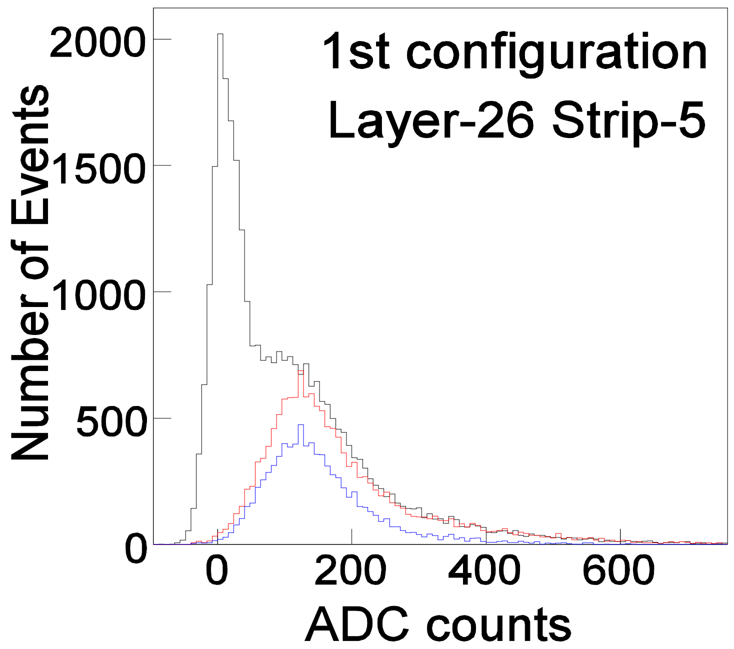
Trigger & Veto counter event selection



MIP calibration

Strip being calibrated

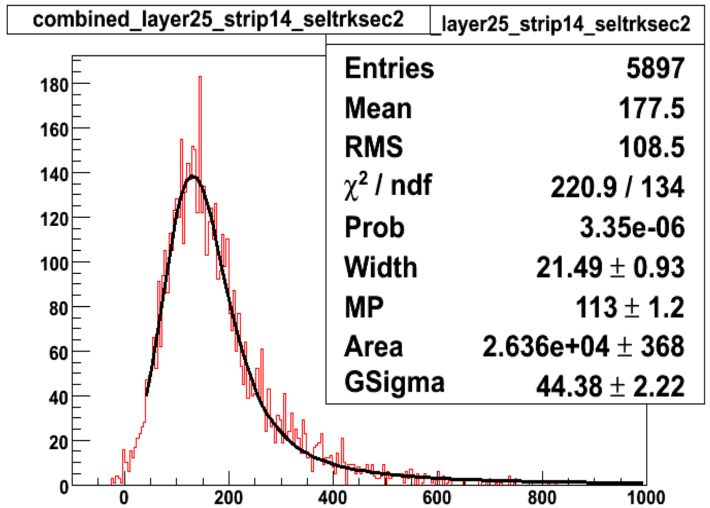




Trigger only

Red strips have non-pedestal signal

Blue strips have only pedestal signal

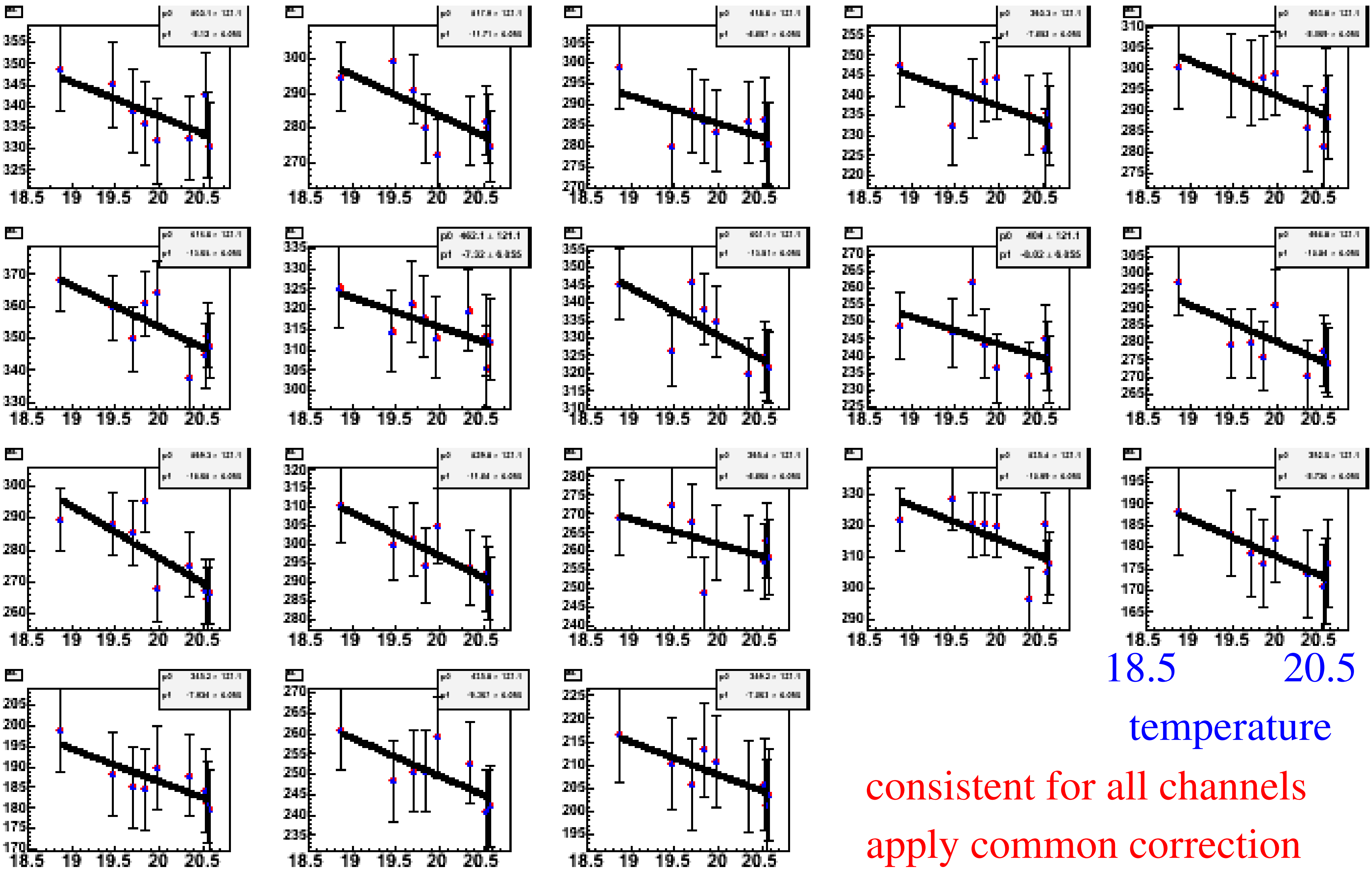


fit to Gaussian-convoluted Landau

MIP response temperature dependence

MPPC properties change with temperature

example: 18 strips in one layer



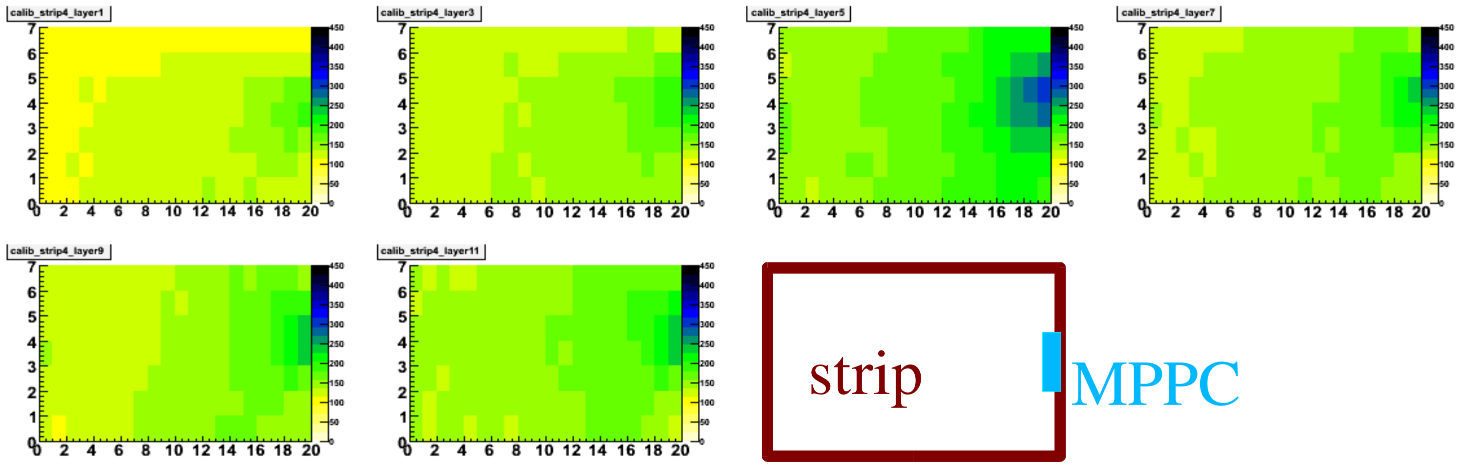
18.5 20.5

temperature

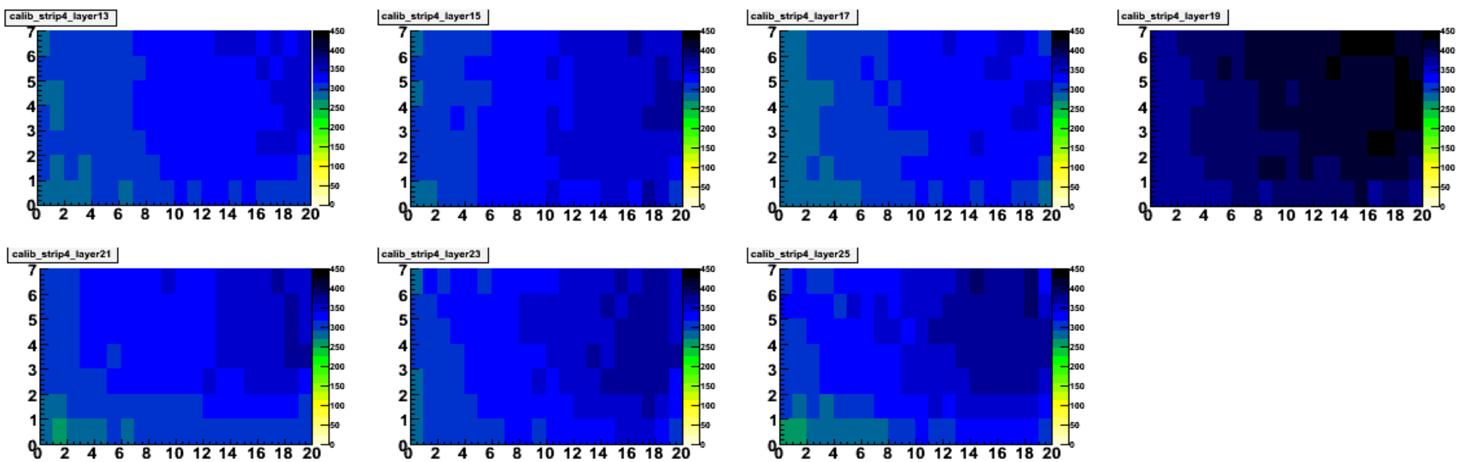
consistent for all channels

apply common correction

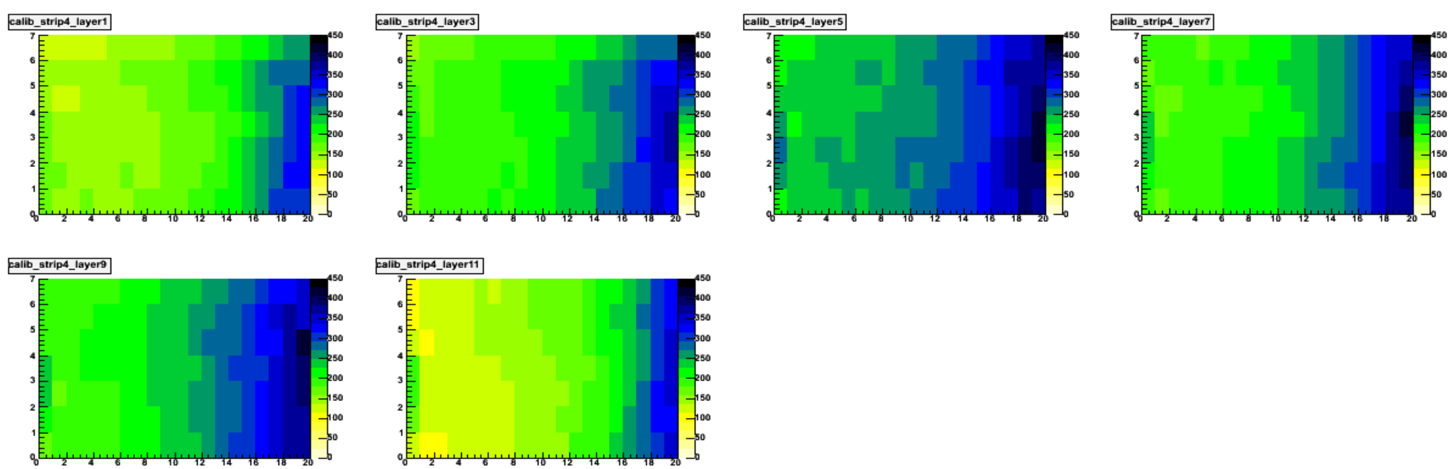
MIP response uniformity: detailed scan across single strip



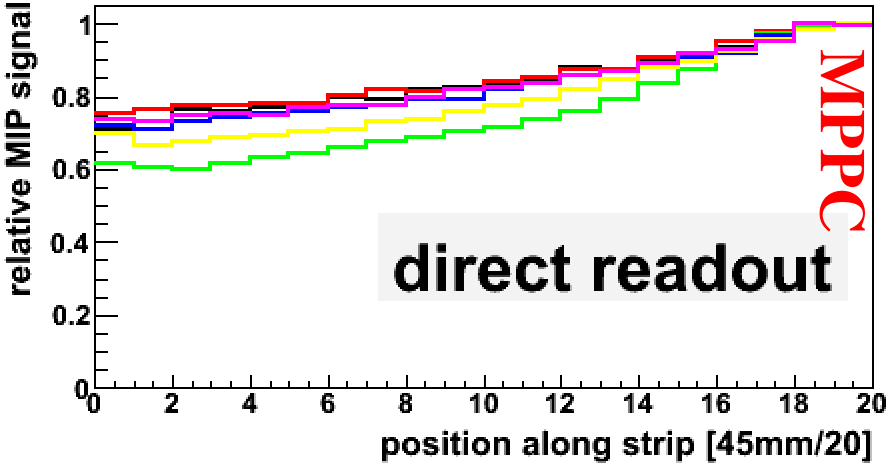
Kuraray
direct readout

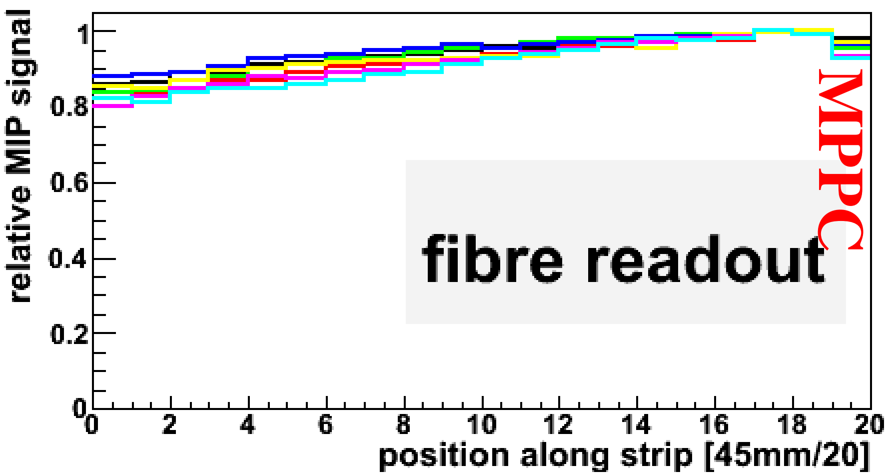


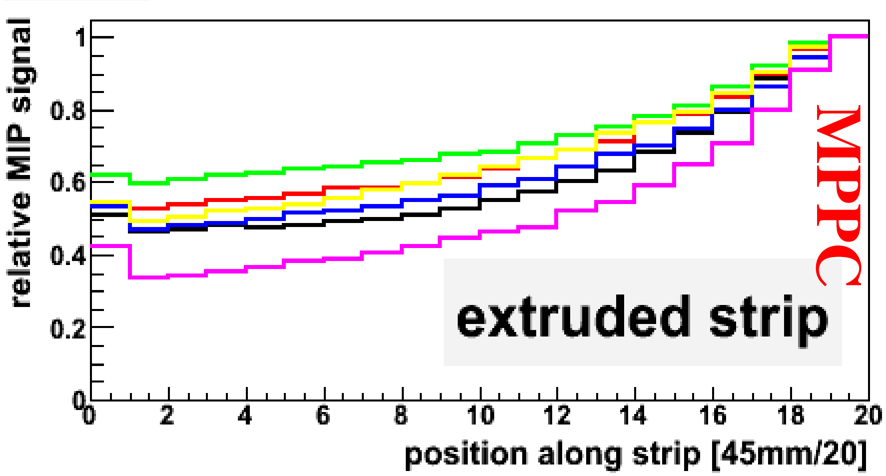
Kuraray
fibre readout



KNU extruded
fibre readout





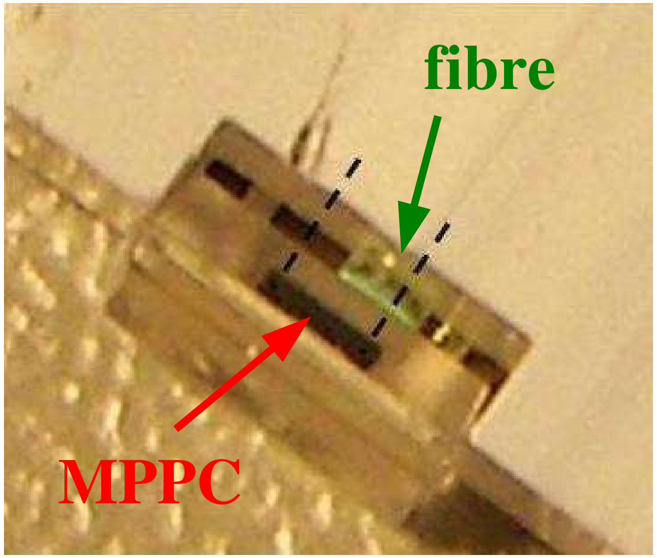


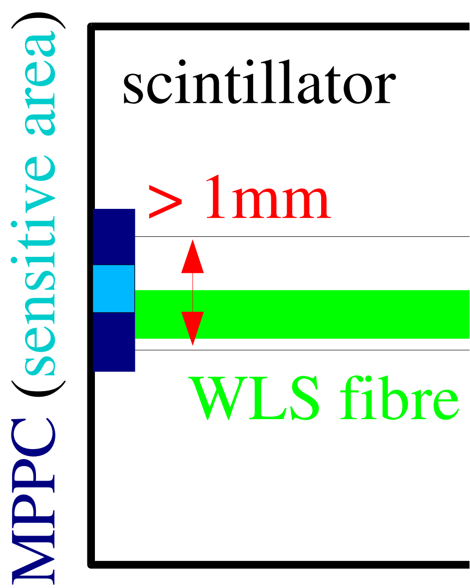
Projected along strip length

extruded strips show significant non-uniformity

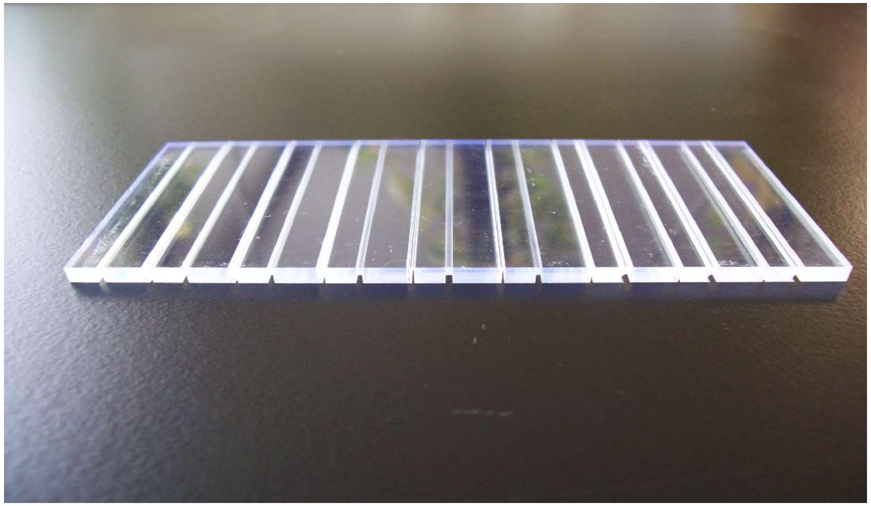
fibre-MPPC matching found to be bad in extruded strips

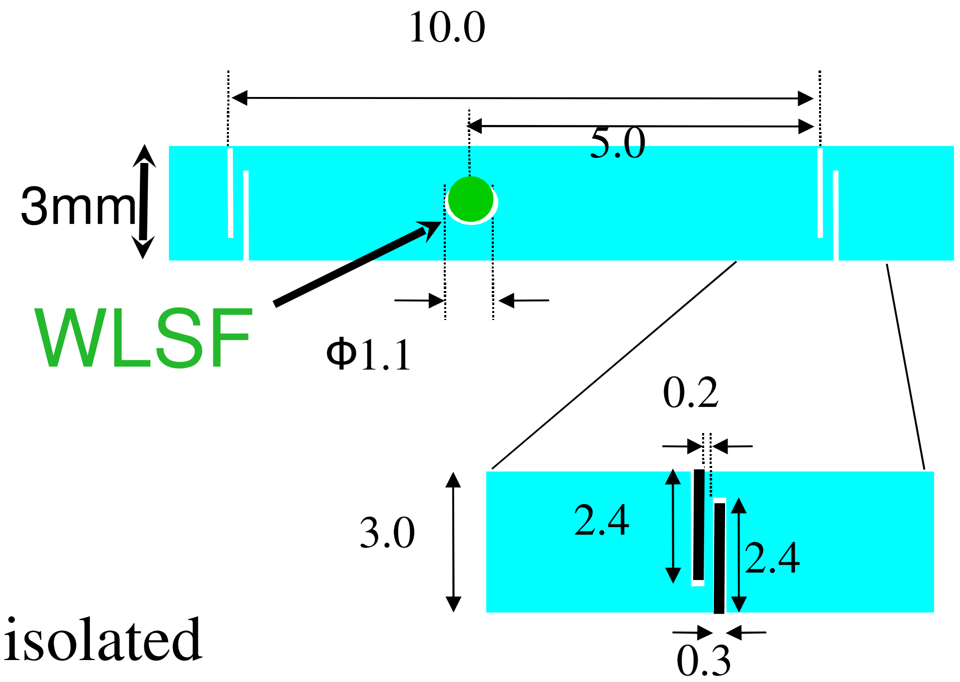
checked in dedicated beamtest: more details in Nishiyama-san's talk



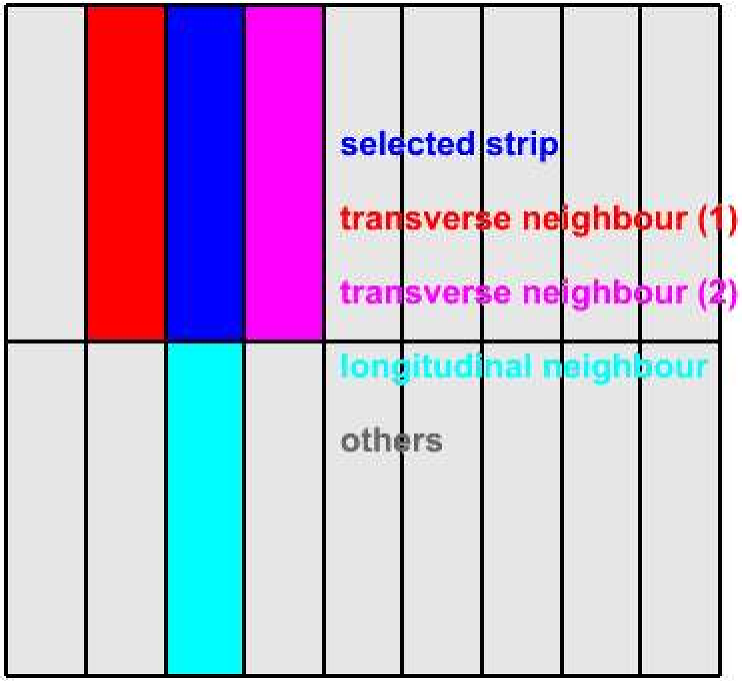


light cross-talk between adjacent strips

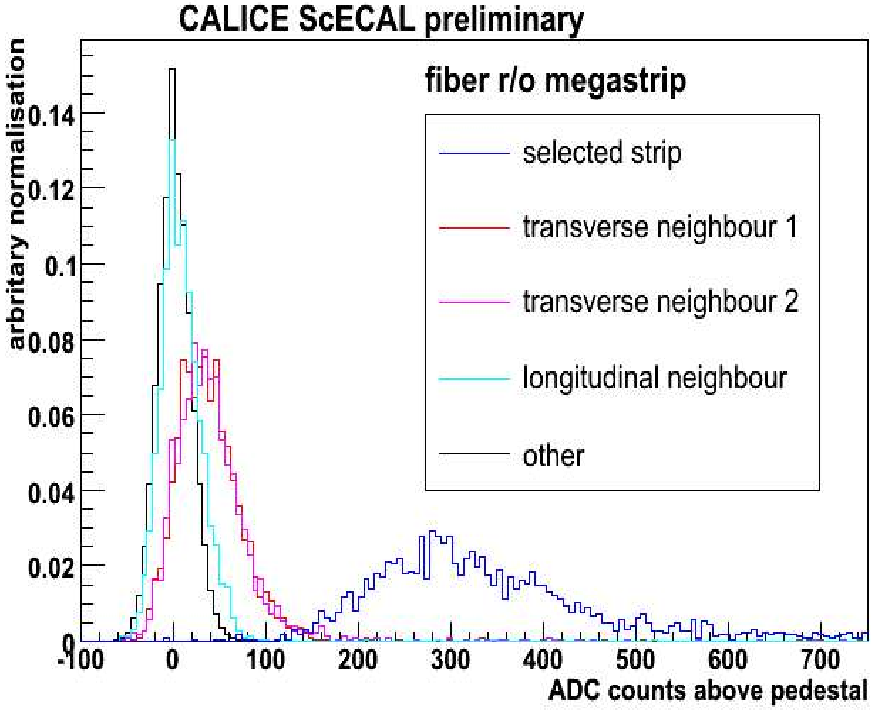




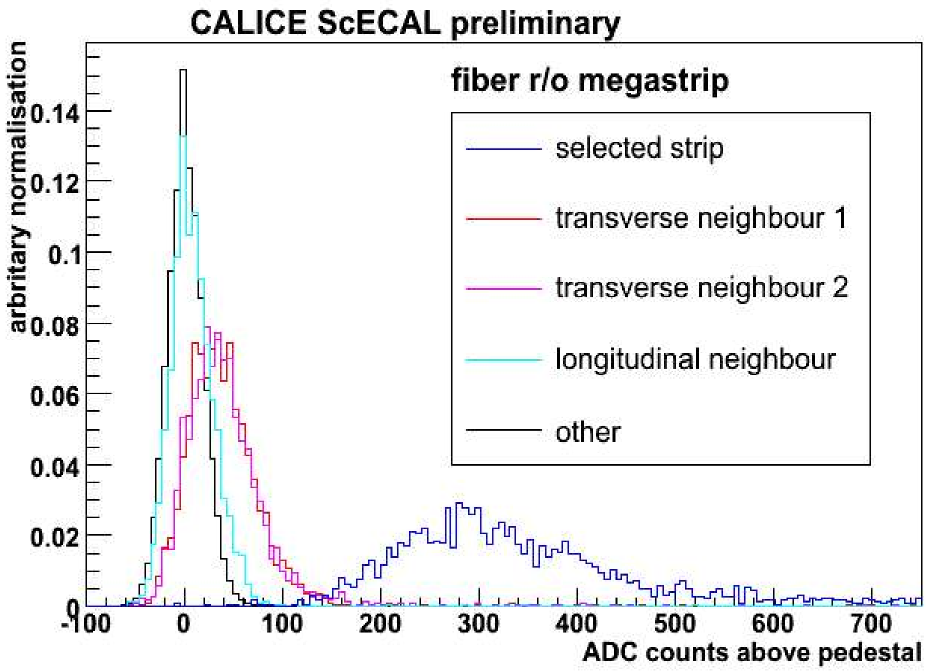
Mega-strip structure: strips not perfectly isolated

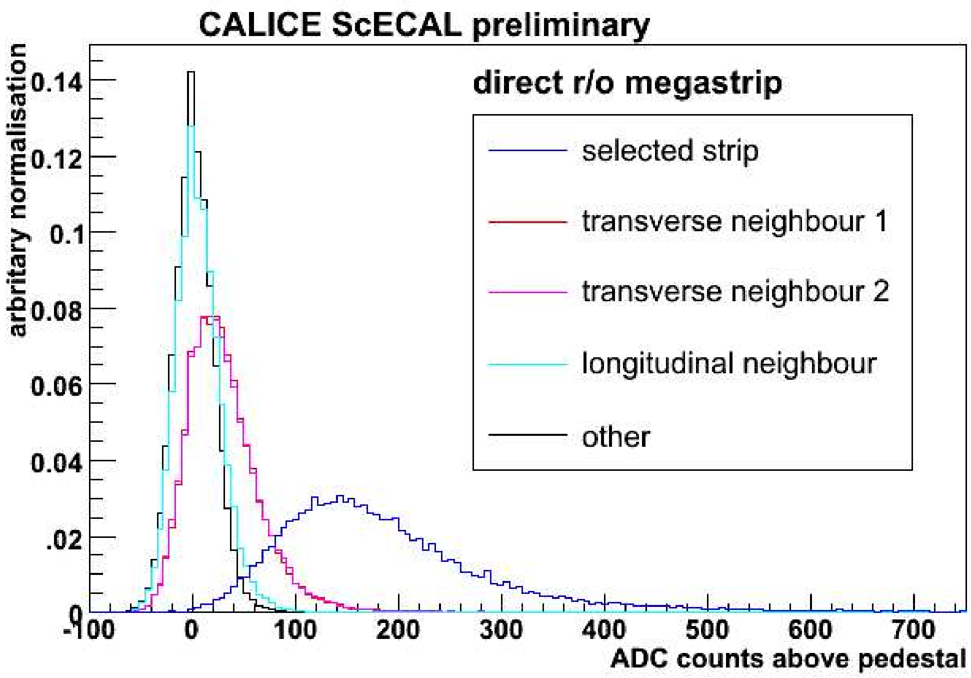


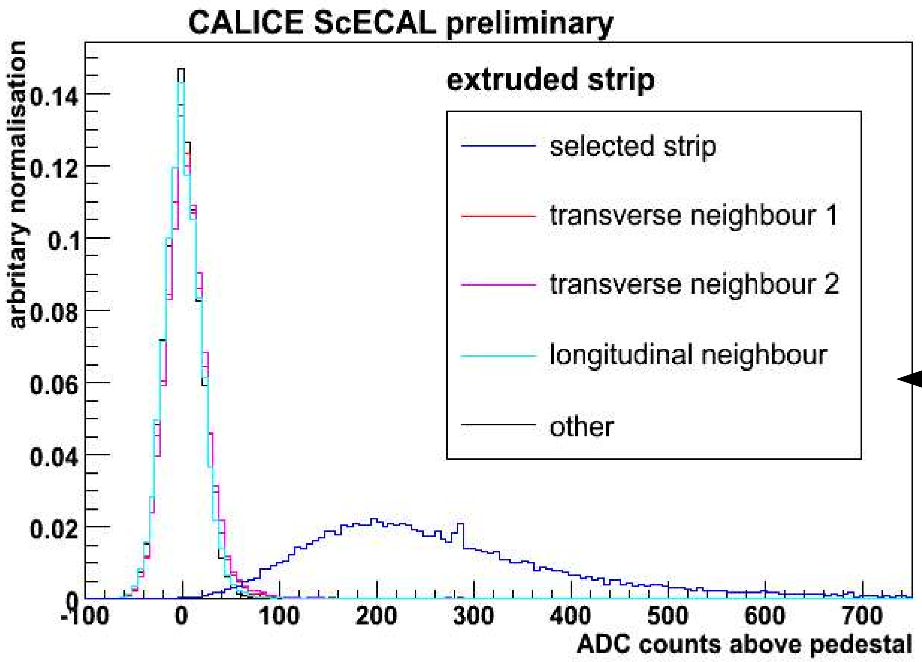
look at signal when MIP hits adjacent strips



light xtalk: different configurations







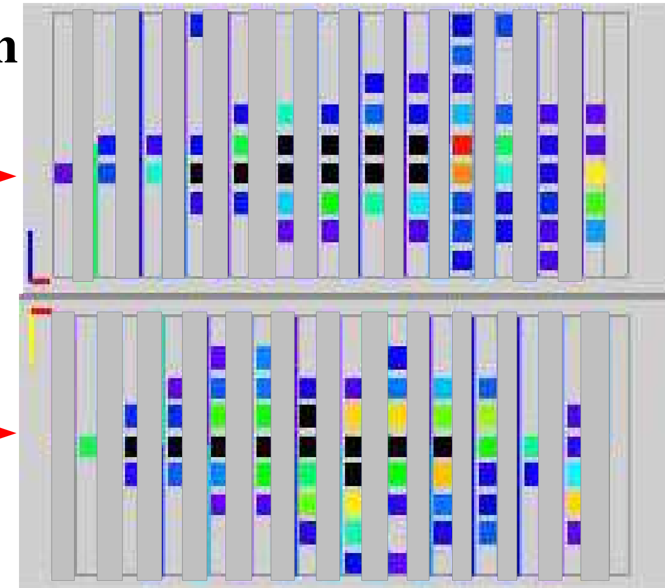
much less light cross-talk
in extruded strips

runs with tungsten plates

6 GeV e^+, center injection

x projection

y projection



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

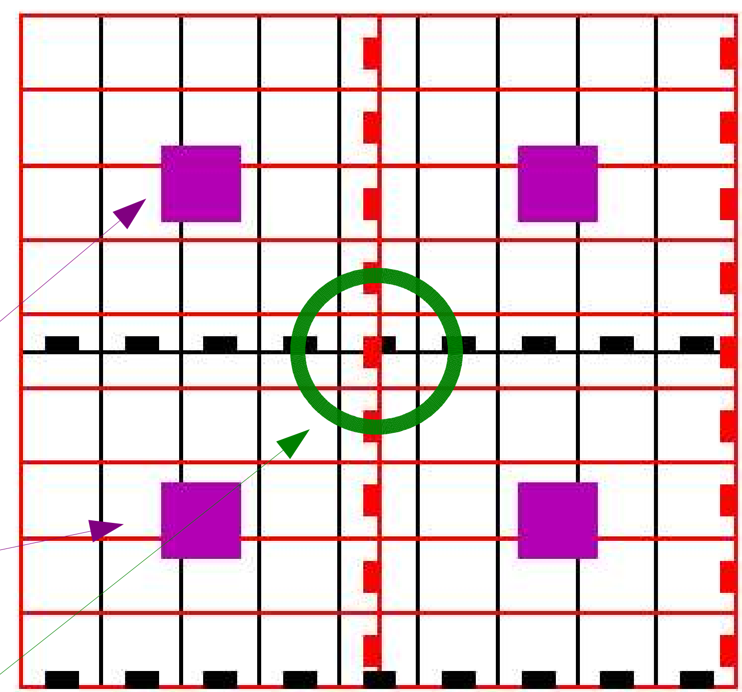
scanned front face of detector

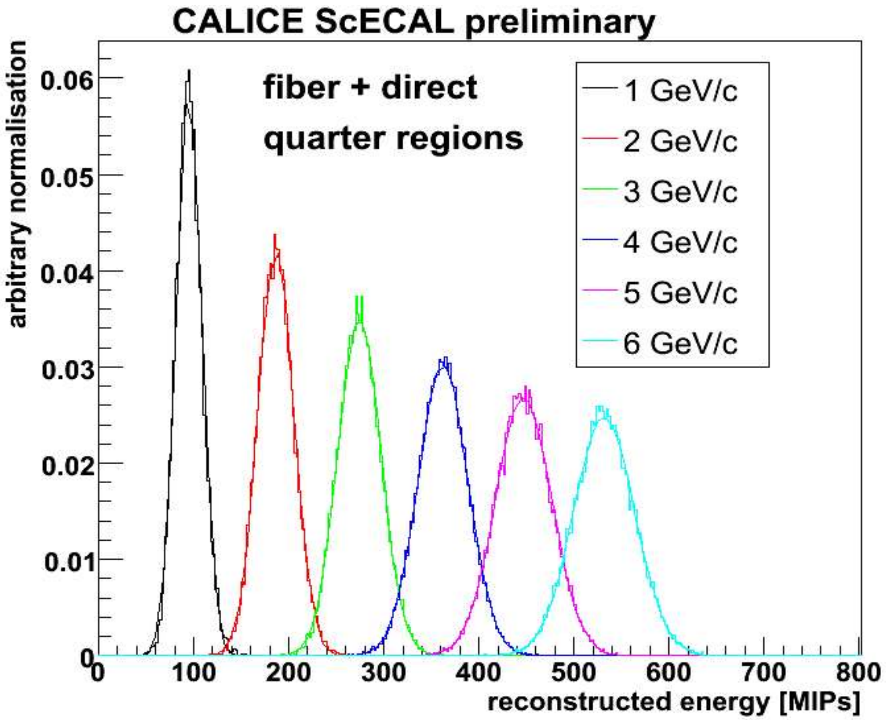
apply calibration constants

- temperature correction
- cross-talk correction

look at different detector regions

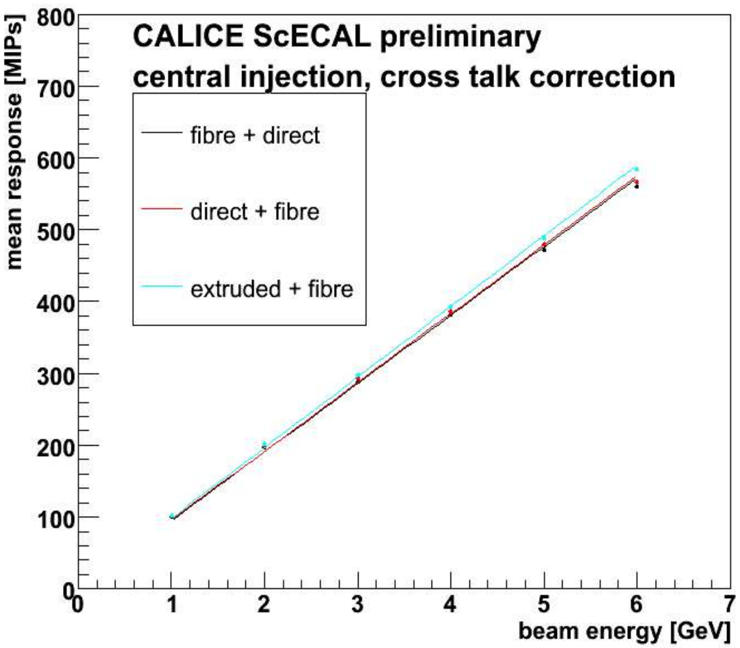
- quarter regions – most uniform
- central region – least uniform, least leakage

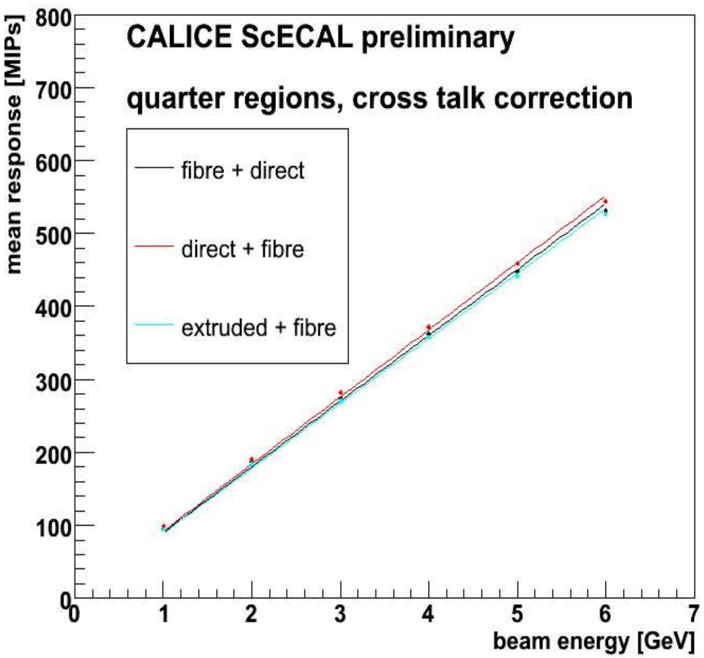




energy response

reconstruct total energy deposited in calorimeter





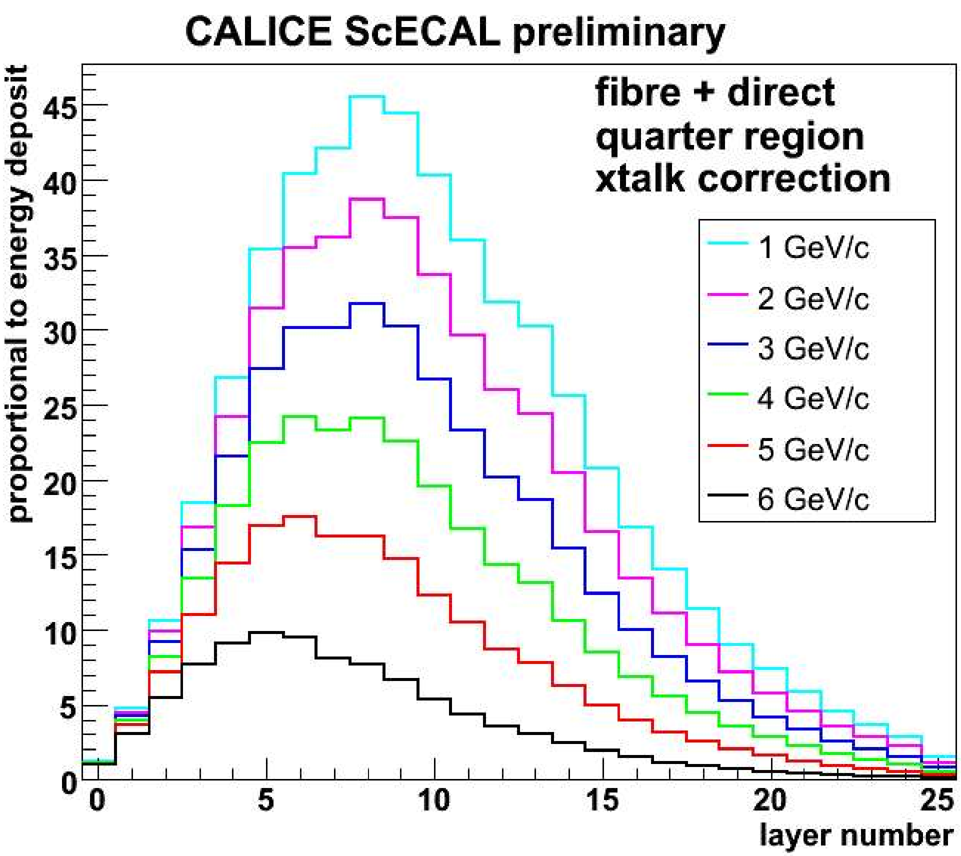
linear response

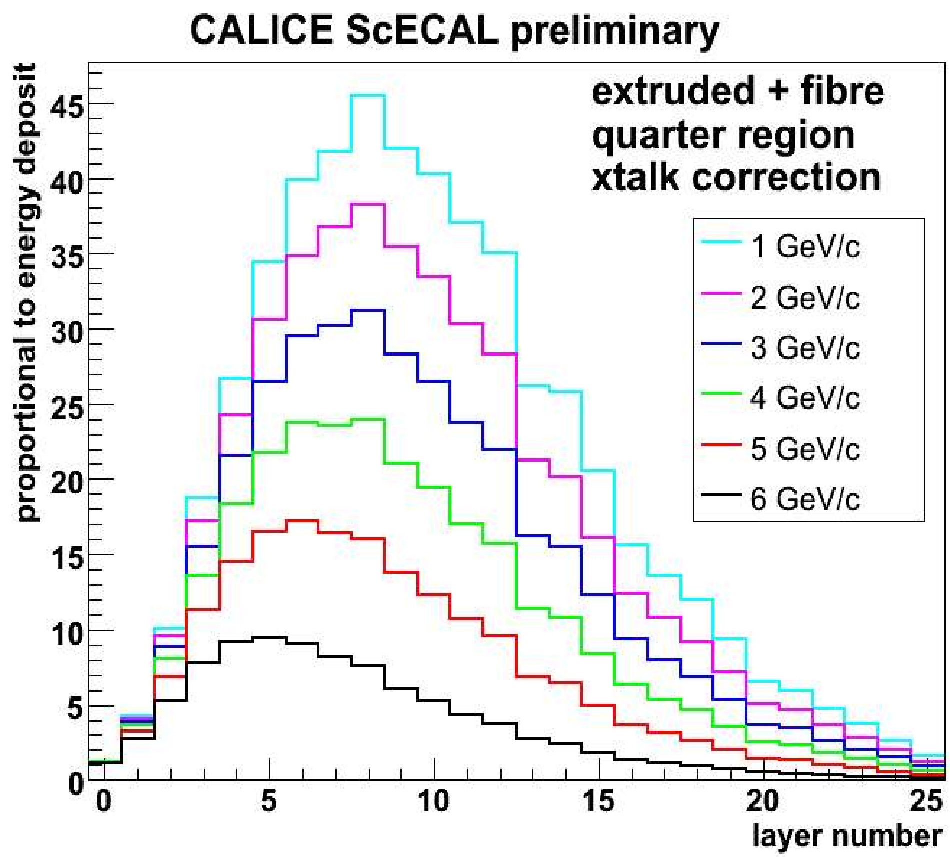
no sign of MPPC saturation @ higher energies

longitudinal shower profiles

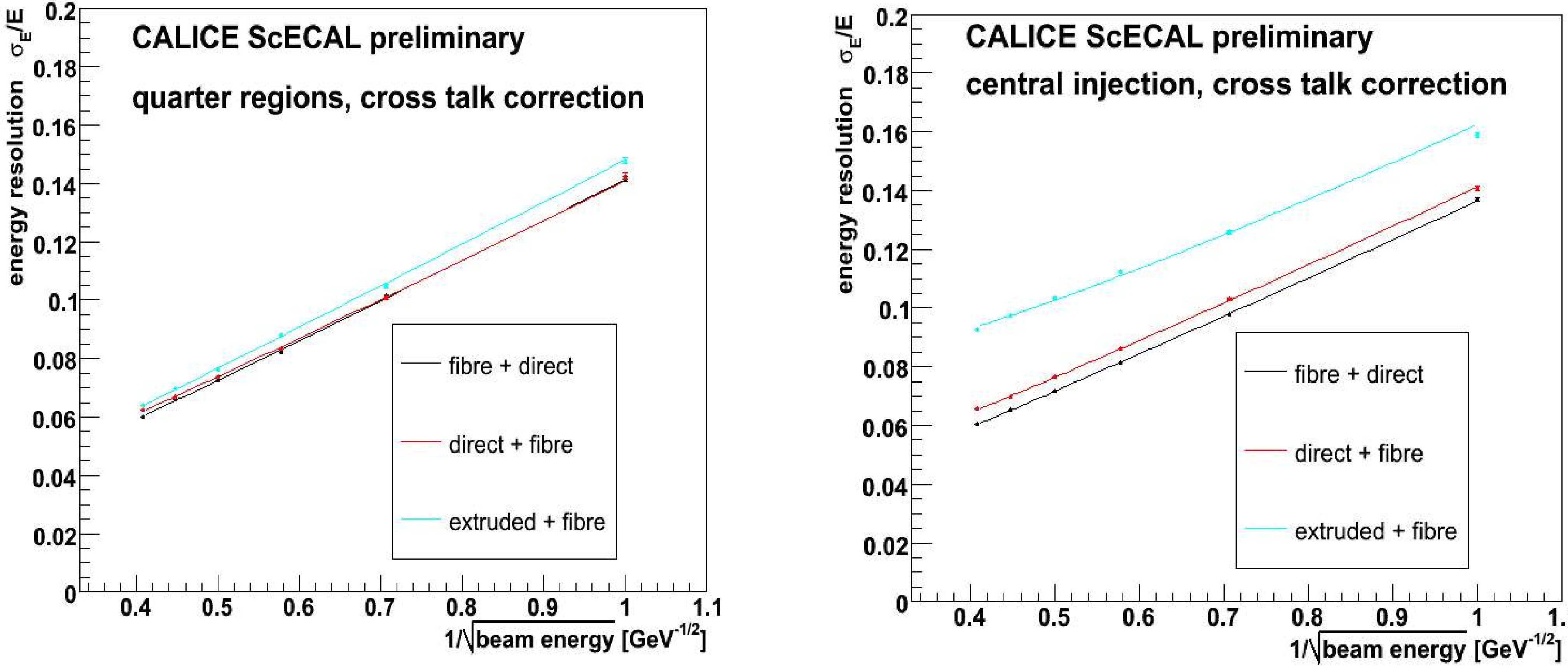
quite smooth, a couple of smallish discontinuities

reason still under investigation





Energy resolution of 3 configurations



resolution of configurations similar in quarter regions

at centre of detector, extruded+fibre much worse:

strip uniformity improtant in this region

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

non-uniformity

significant contribution
from shower leakage

future plans

CALICE beamtest at FNAL – September '08

with Scintillator+SiPM HCAL (Felix's talk)

construct ~4x larger detector

improved extruded scintillator strips

test in higher energy beams, different beam particles

see effects of MPPC dynamic range

Conclusions

Analysis of DESY testbeam data in good shape

In uniform regions, detector works well

sufficient energy resolution for ILC ECAL ($\sigma/E \sim 14\%/\sqrt{E} \oplus 2\%$)

Non-uniformity of extruded strips significantly degrades performance

improved samples have since been tested (Nishiyama-san's talk)

In progress...

Some further data analysis (MPPC saturation correction...)

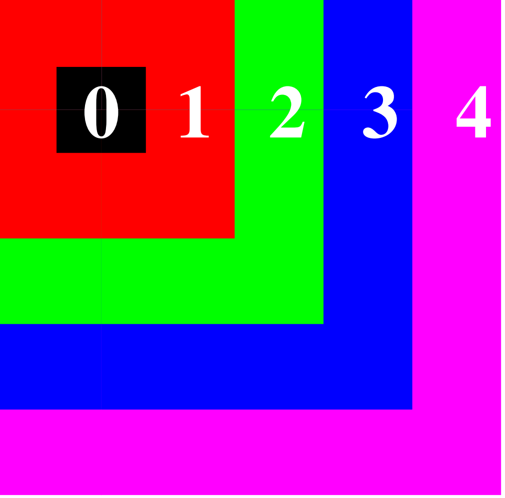
Detailed simulation

Preparations for next beam test

Calorimeter for ILC

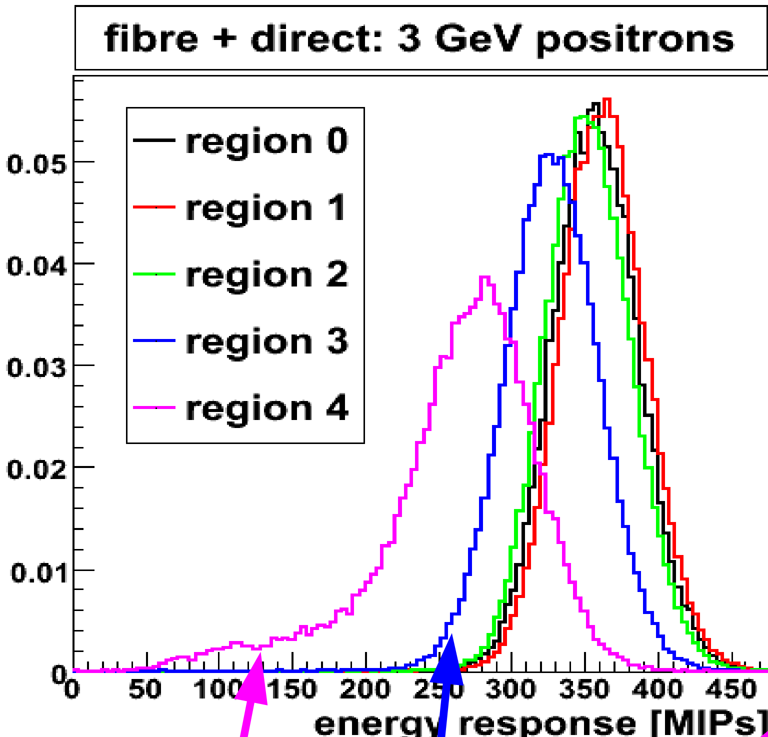
KOBE UNIVERSITY

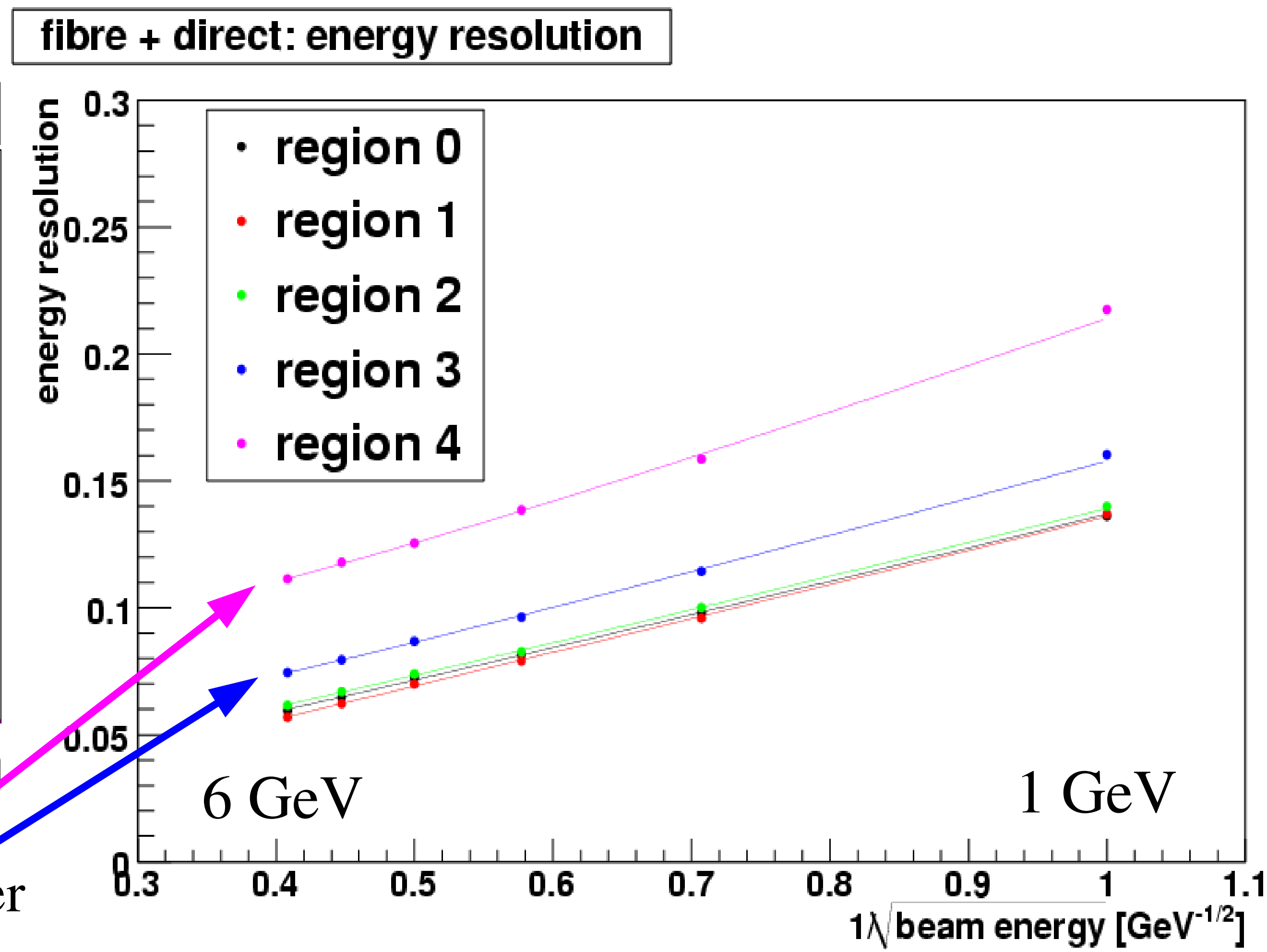
Backups



Energy resolution in different detector regions

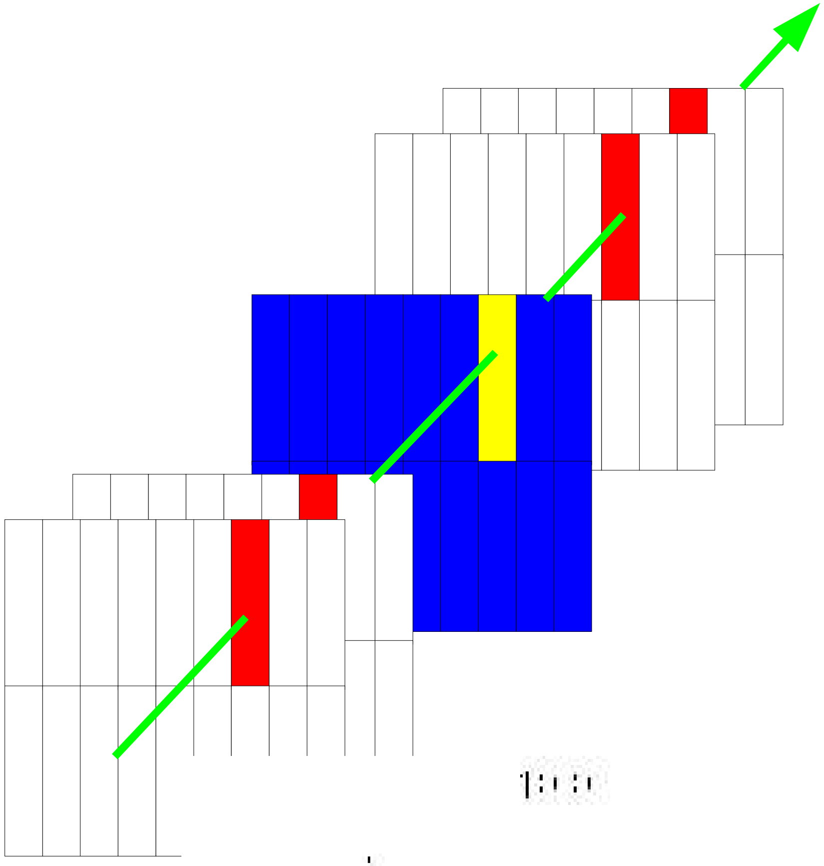
(fibre+direct, with absorber)

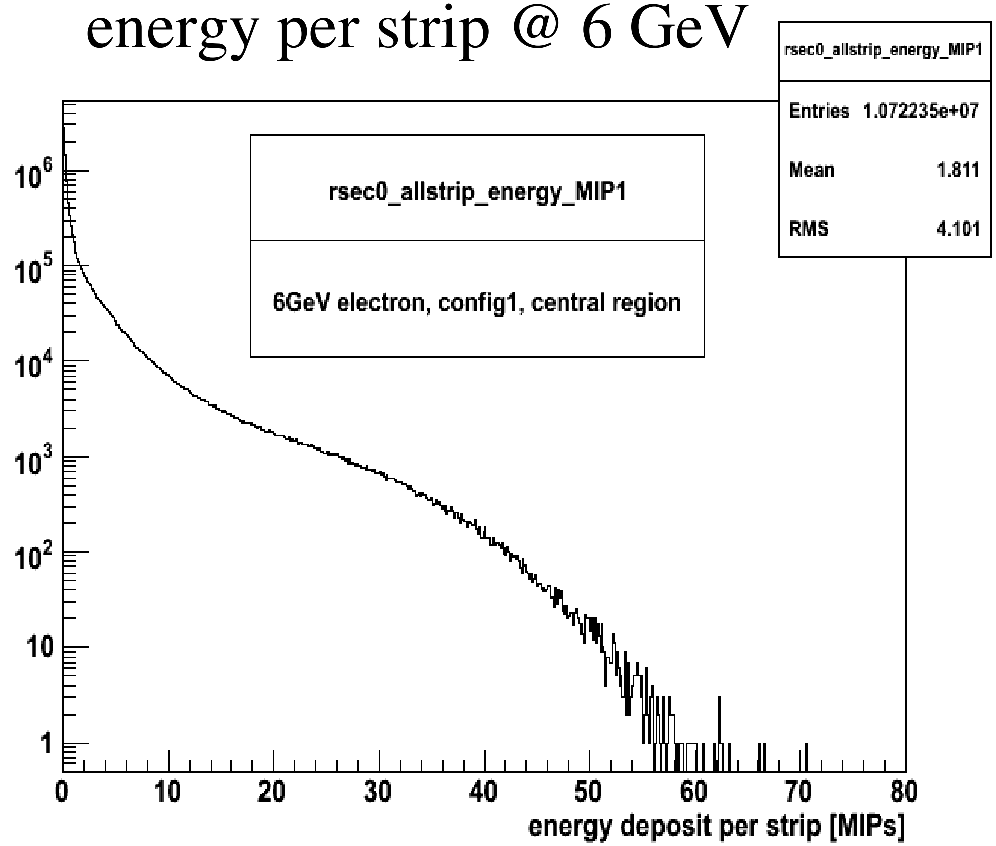


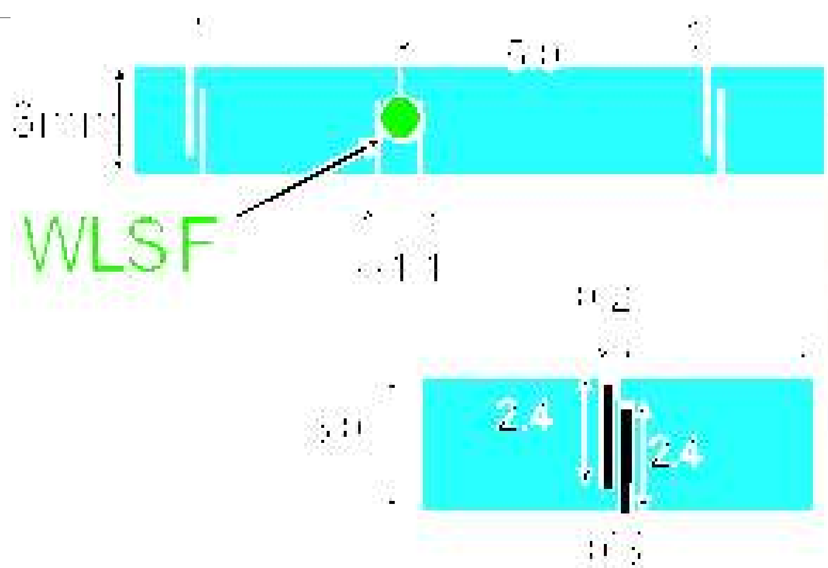


clear evidence of lateral shower leakage in outer two regions

energy per strip @ 6 GeV







Tracking detector alignment

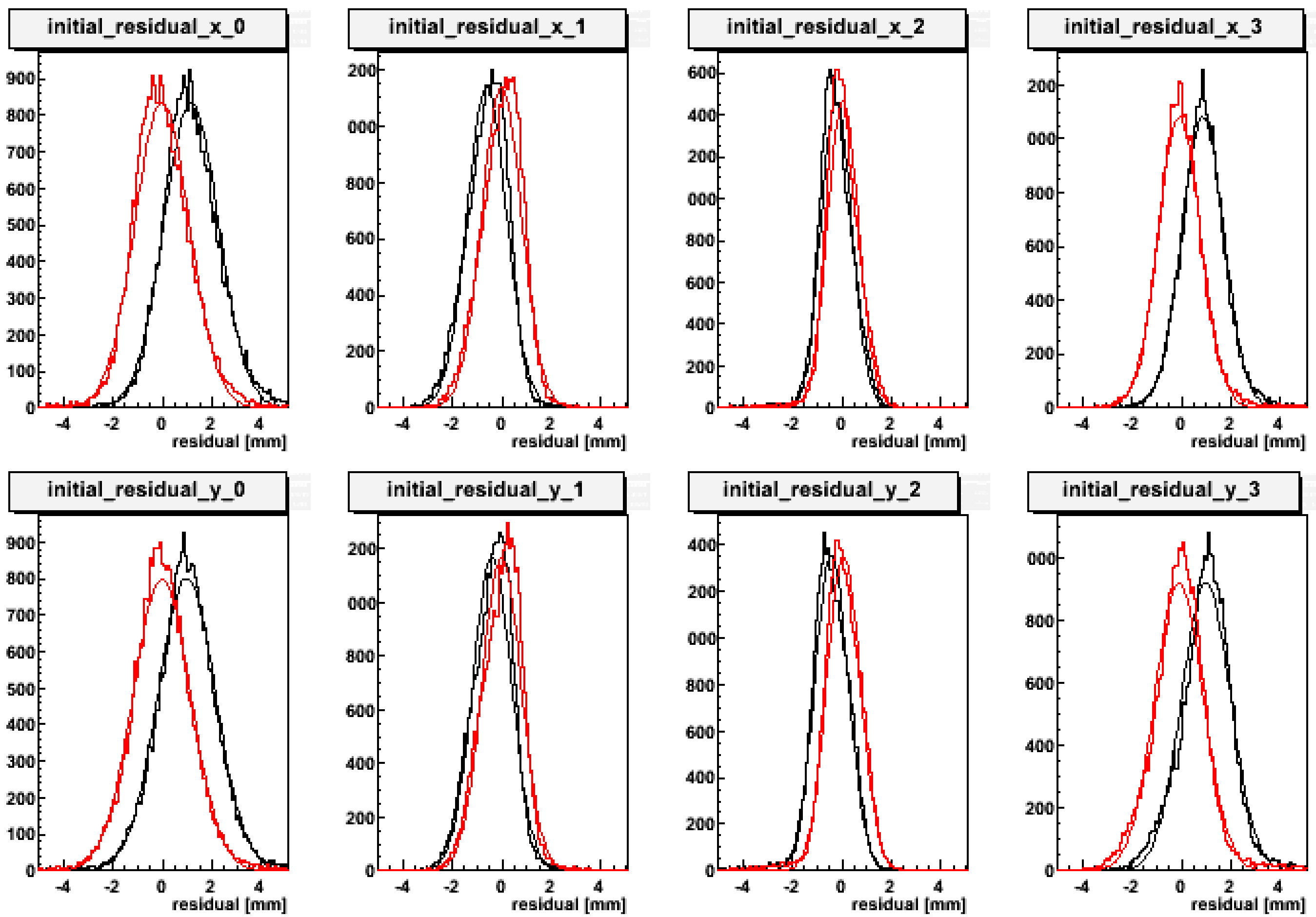
determine drift velocity and relative positions of 4 drift chambers

each chamber measures x,y position

chamber 0 1 2 3

x

y



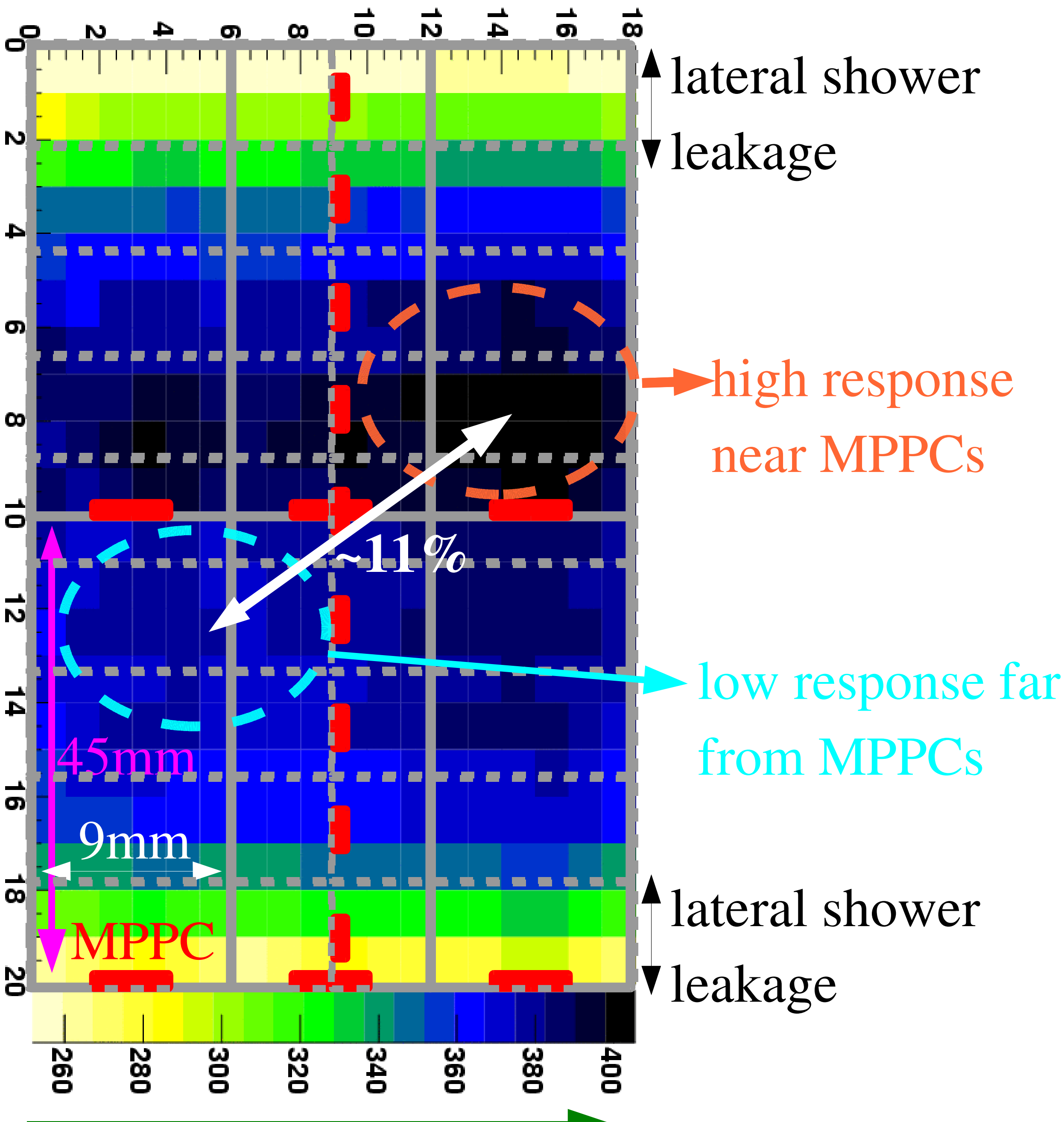
before

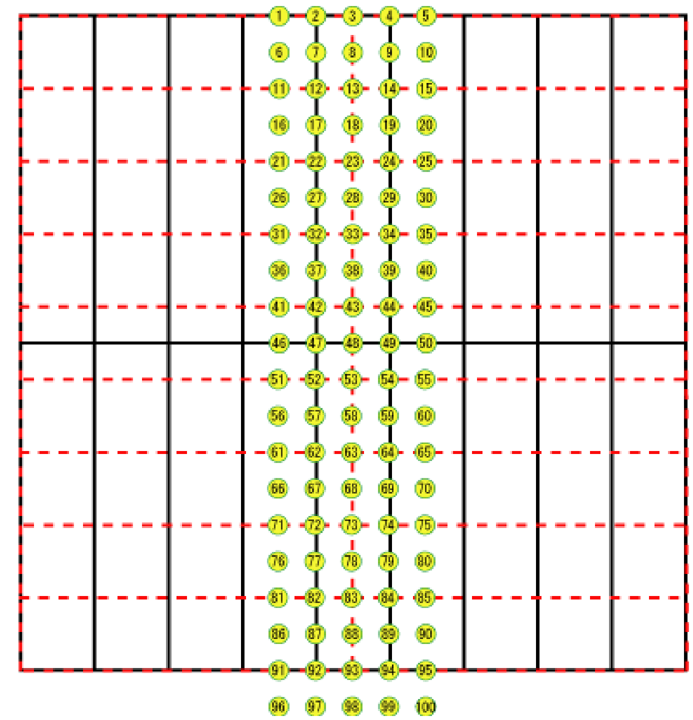
(after)

alignment

hit residual/mm

Energy response uniformity, direct+fibre, 3 GeV



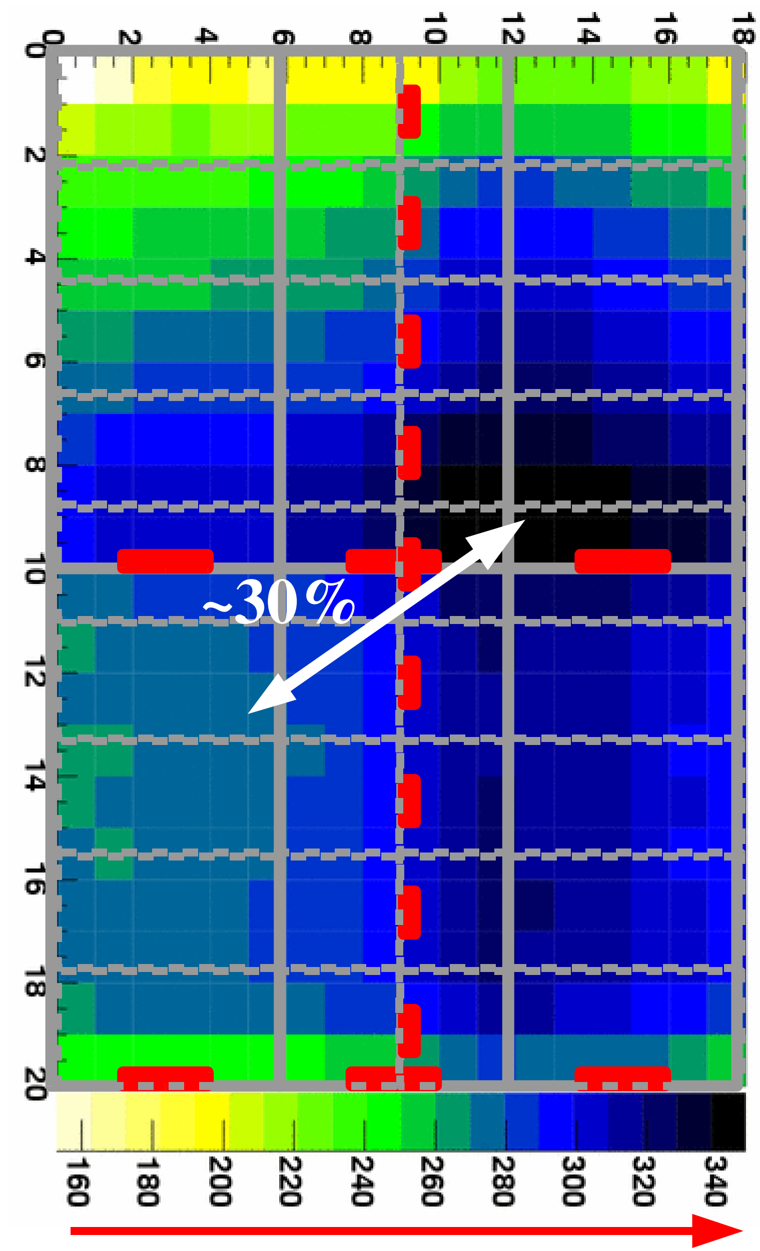


scanned 1/3 detector

can alternate orientation to minimise this effect

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

energy response



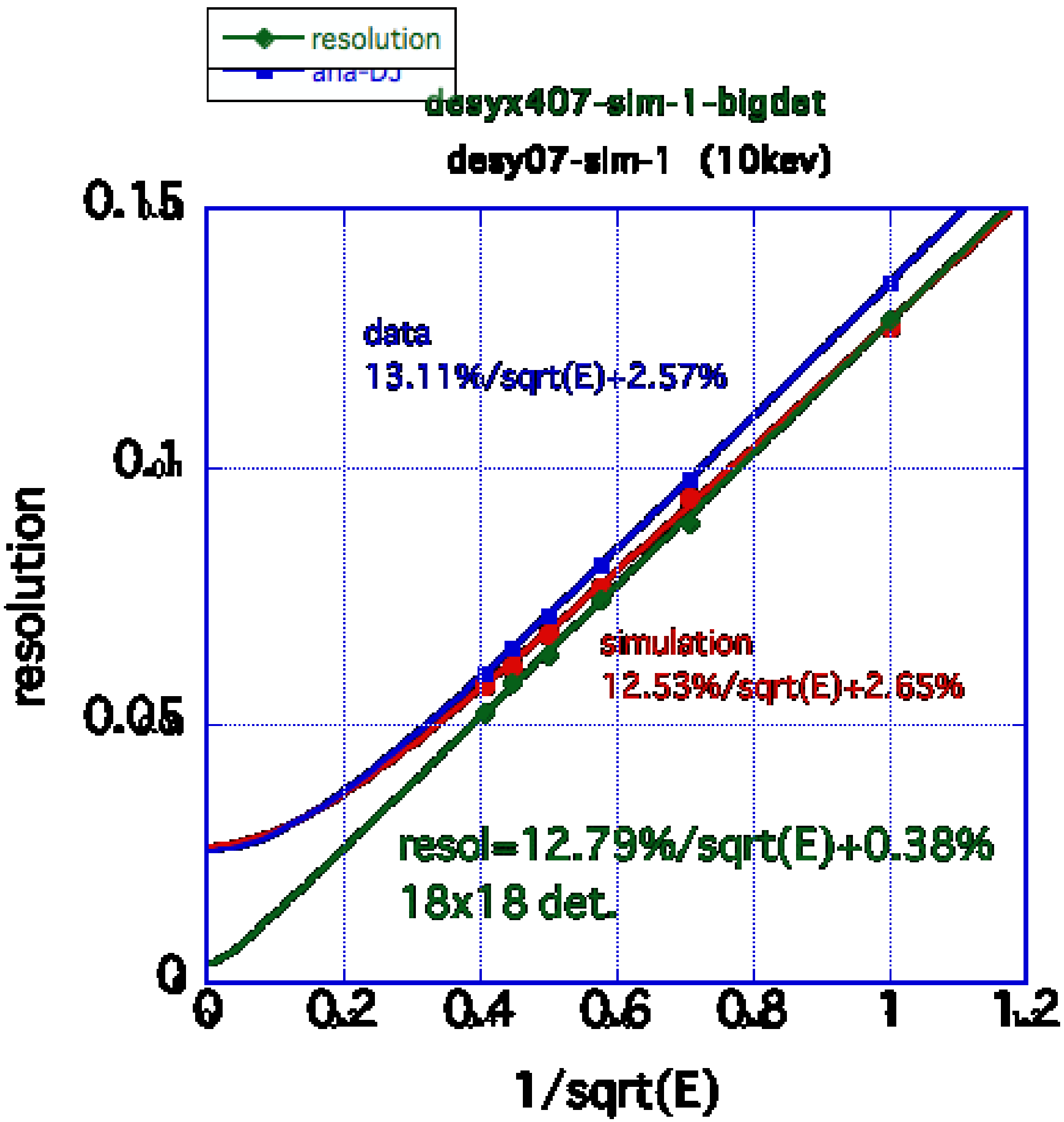
energy response [MIPs]

2-3 times more variation that direct+fibre configuration

extruded strips are less uniform

Simulation studies

simulation shows 4% lateral energy leakage, 1% longitudinal leakage (central beam injection)



simulate a larger detector

(2x larger in each direction)

resolution of 1st configuration

(real data)

simulation of our detector

26 layers x 9x9cm^2

simulation of larger detector

52 layers x 18x18 cm^2:

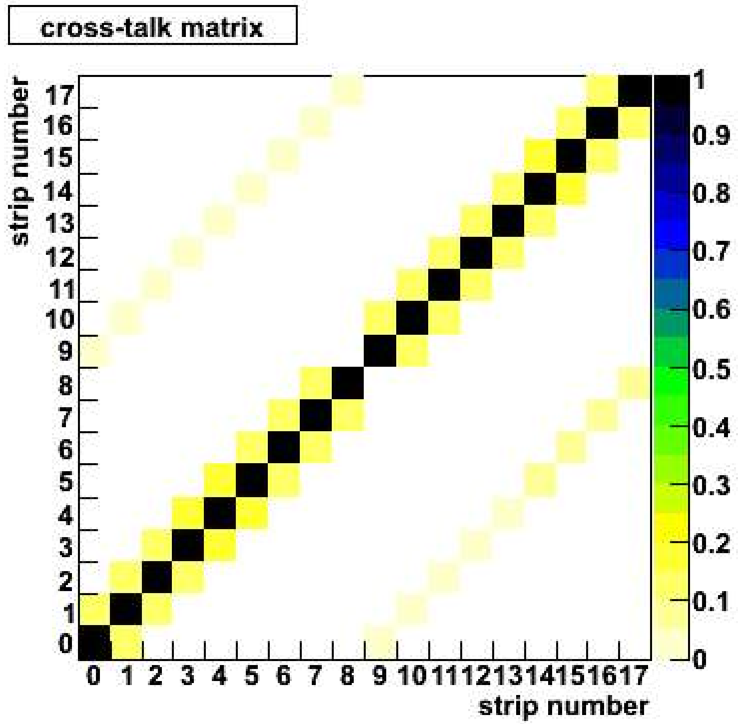
no constant term!

shower leakage causes constant term of around 2.6%

measure xtalk across each strip boundary

correction of cross-talk

in each layer, define matrix with measured xtalk probabilities (~10%)



use this matrix to unfold the cross-talk