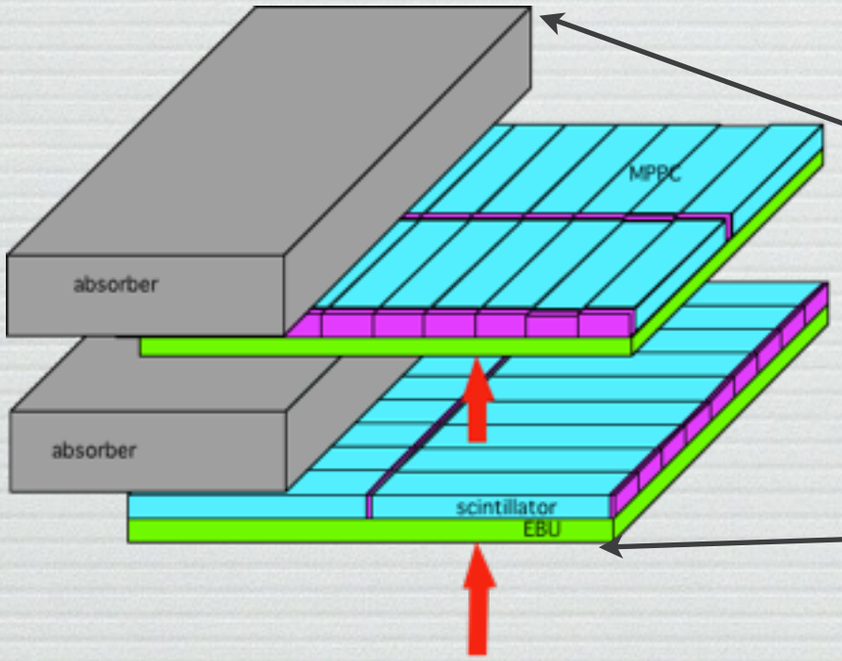
scintillator CAL

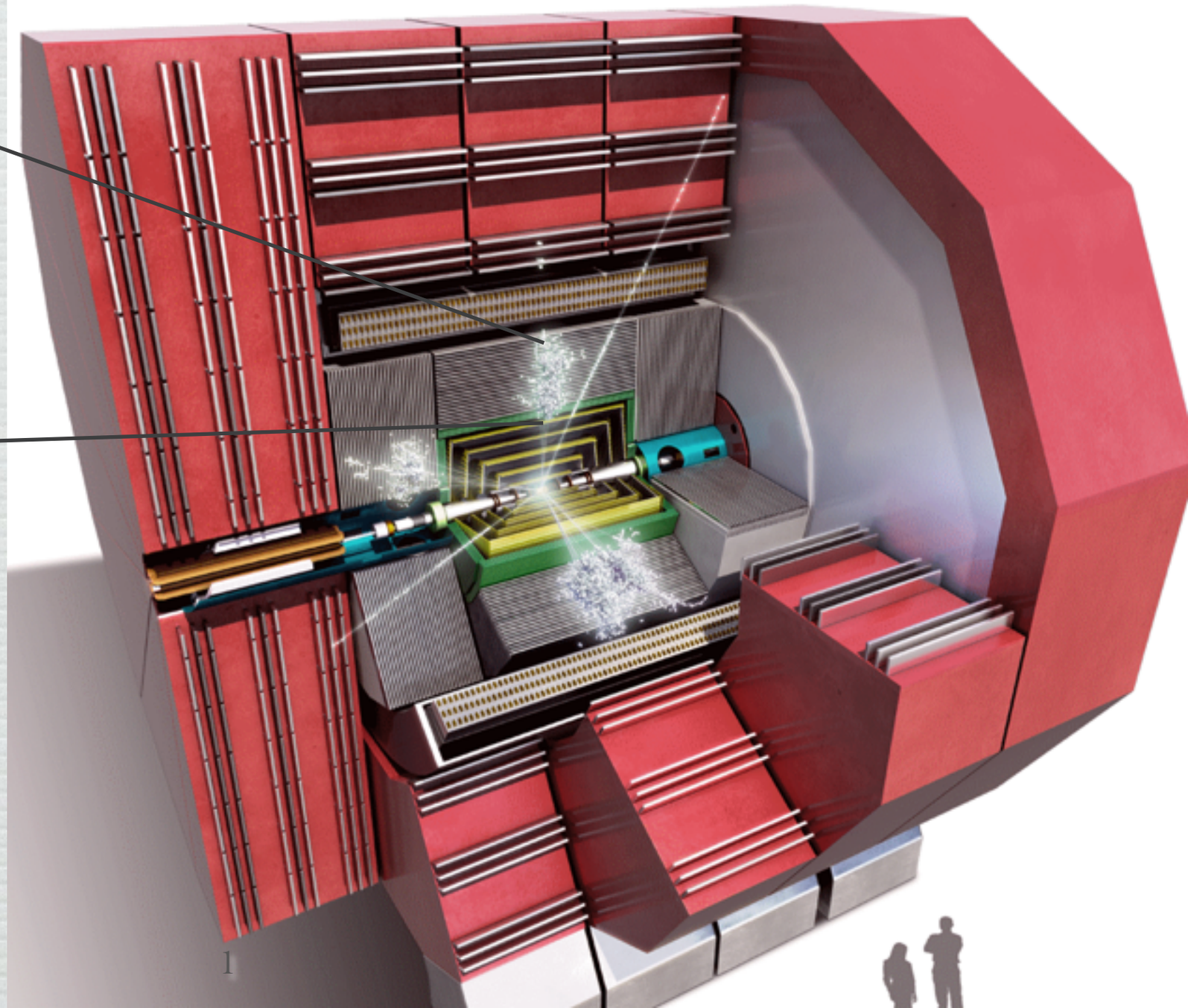
hadron energy measurement

Shinshu University



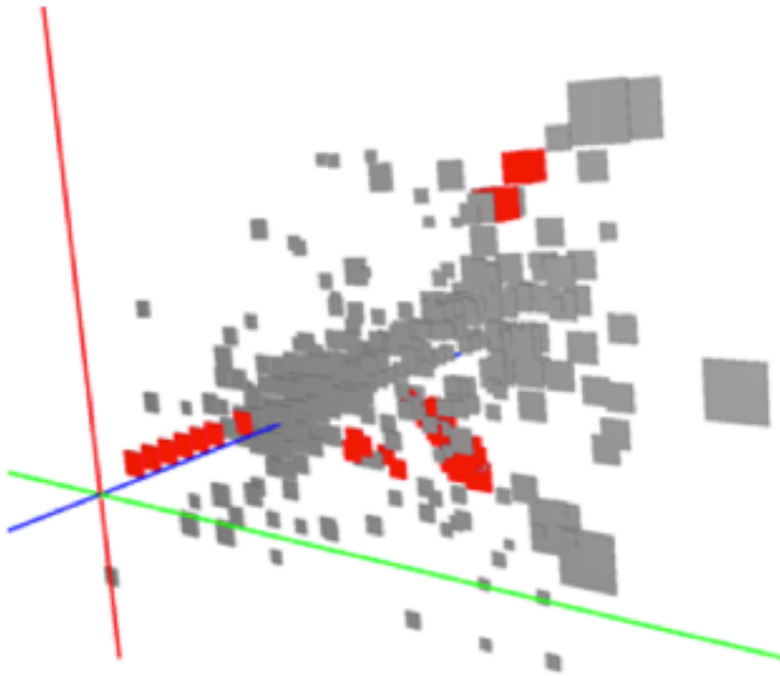
Tohru Takeshita
(Shinshu)
for CALICE-ASIA

strip technology



HCALs

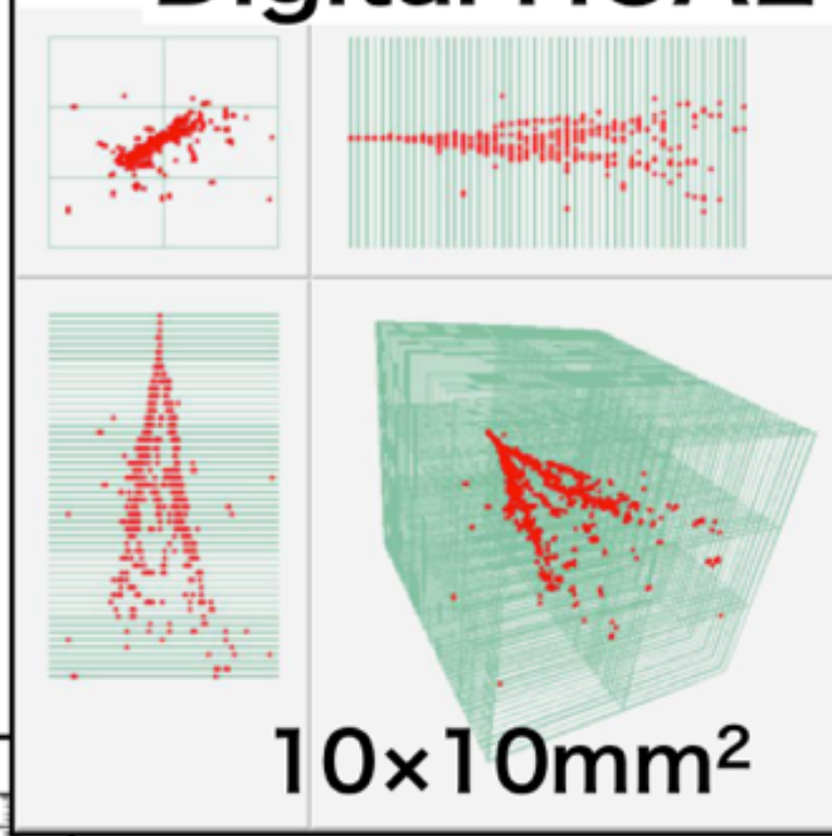
Analog HCAL



scintillator tile

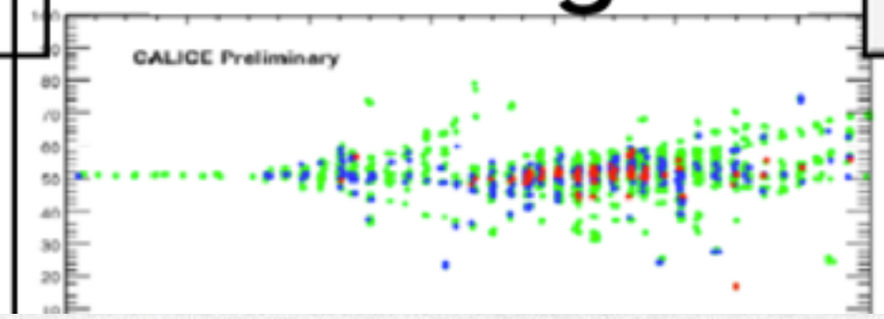
CALICE Calorimeter for ILC

Digital HCAL



RPC pad

Semi Digital

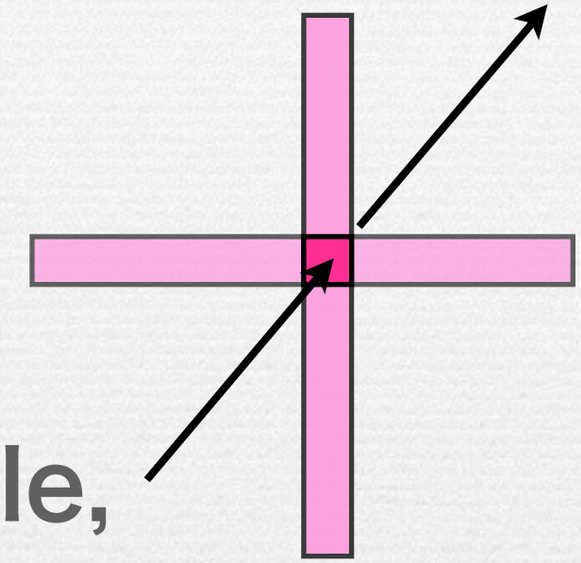


(S)D-HCAL :

- tracking: 1cm x1cm
- energy

scintillator strip

- scintillator is robust, reliable and stable for calorimeter sensor
- to meet PFA, requirement is fine granularity
- perpendicular strips make it possible,

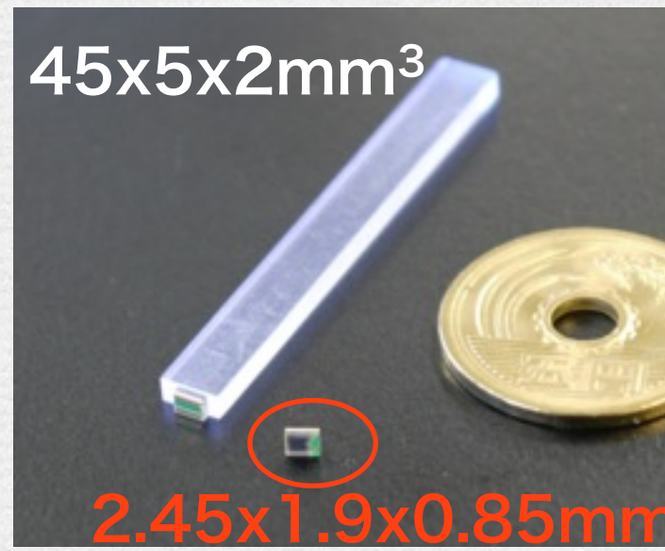


- while keeping the number of readout channel reduced (than pad/pixel type)
- with novel silicon-photo-detector
- issues: calorimeter

ECAL <<

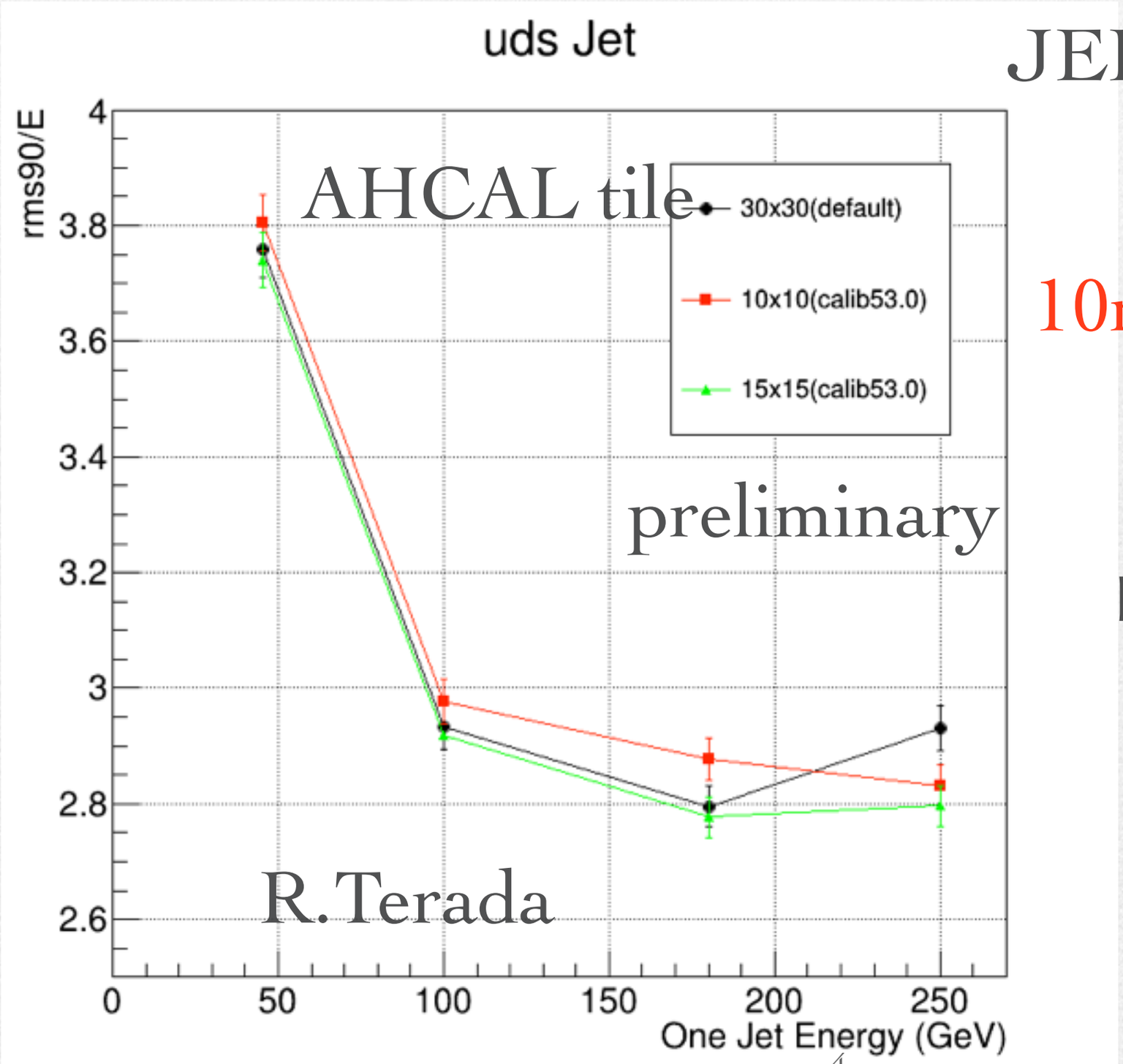
45mm <<

ECAL strip



HCAL JER

- Pandora is optimized for 3cmx3cm AHCAL



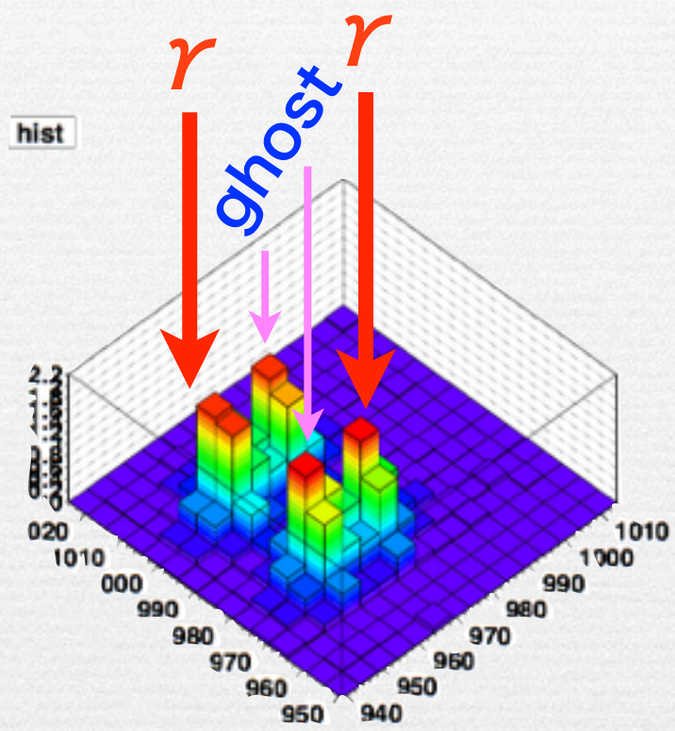
JERs are

10mmx10mm

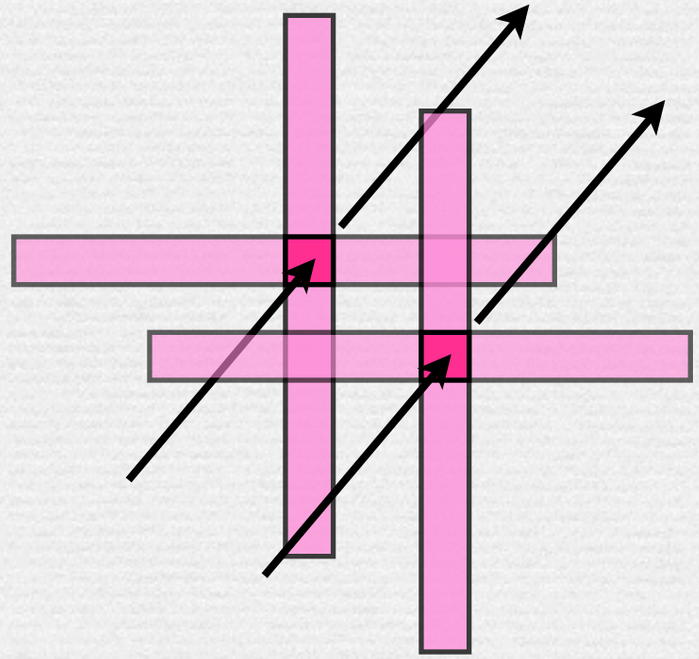
need software optimization & strip installation

ghost problem

- strip system may suffer from ghost
- ghost appears when multi-particle passing near by



- can be avoided by introducing tile layer
- size of a tile must be smaller than three times of strip width



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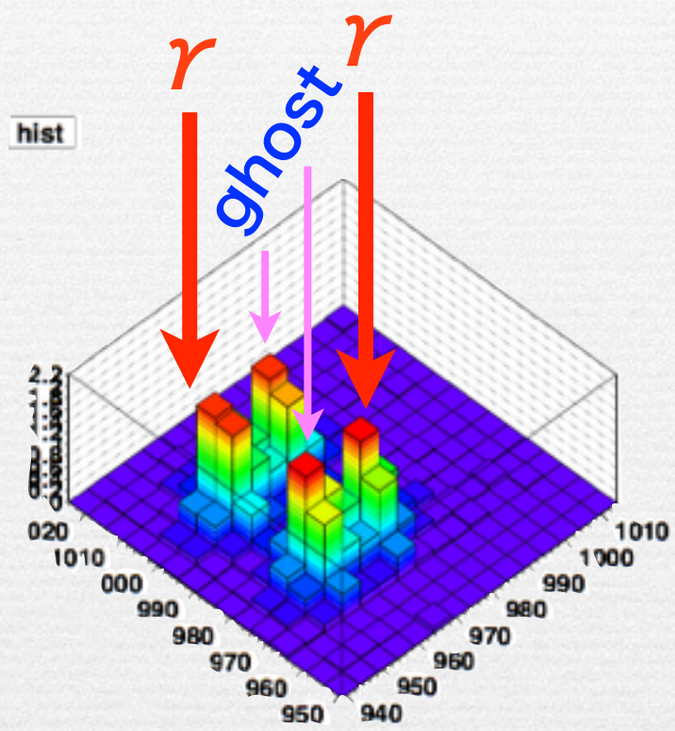

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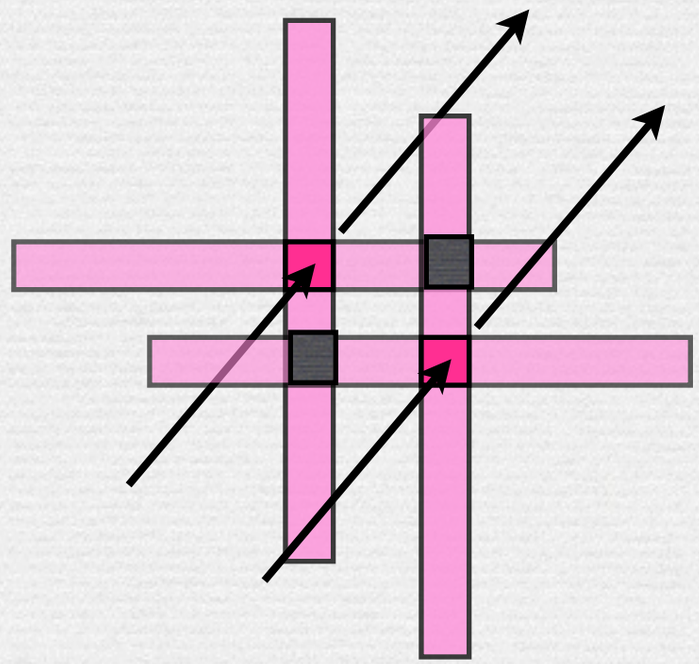

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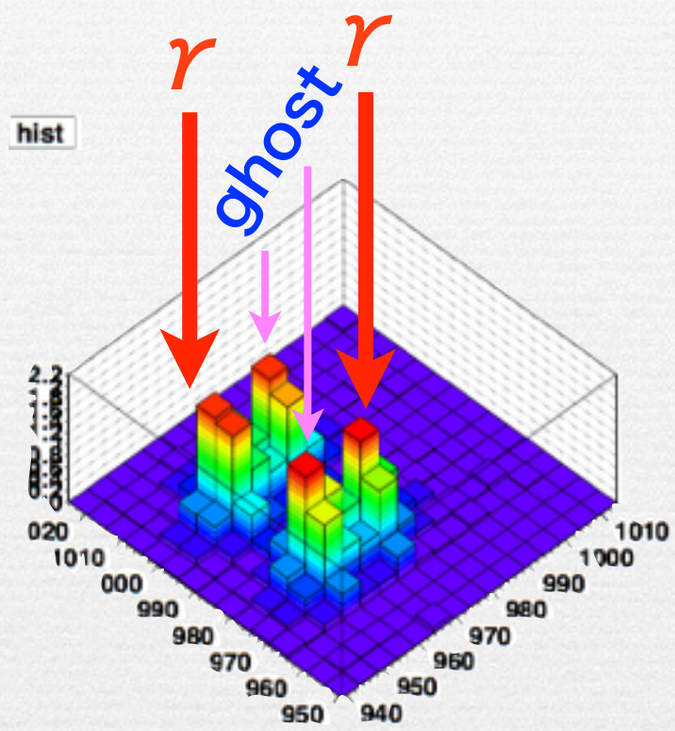

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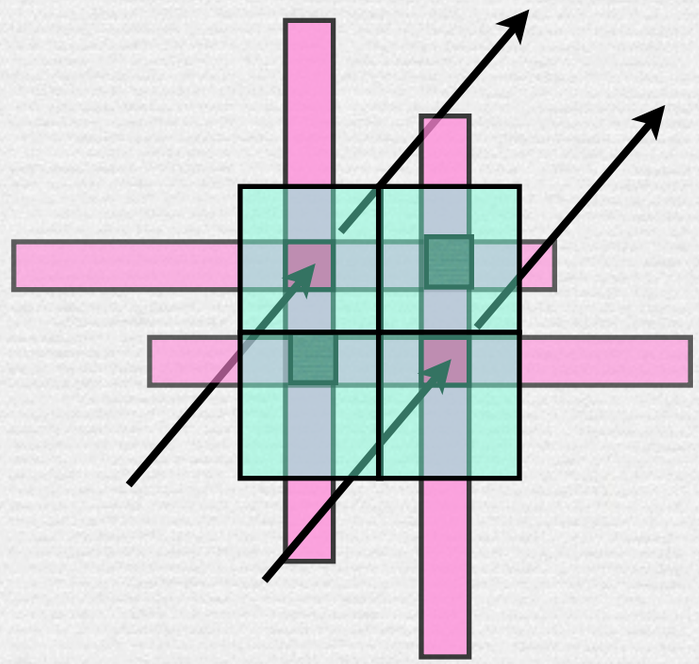

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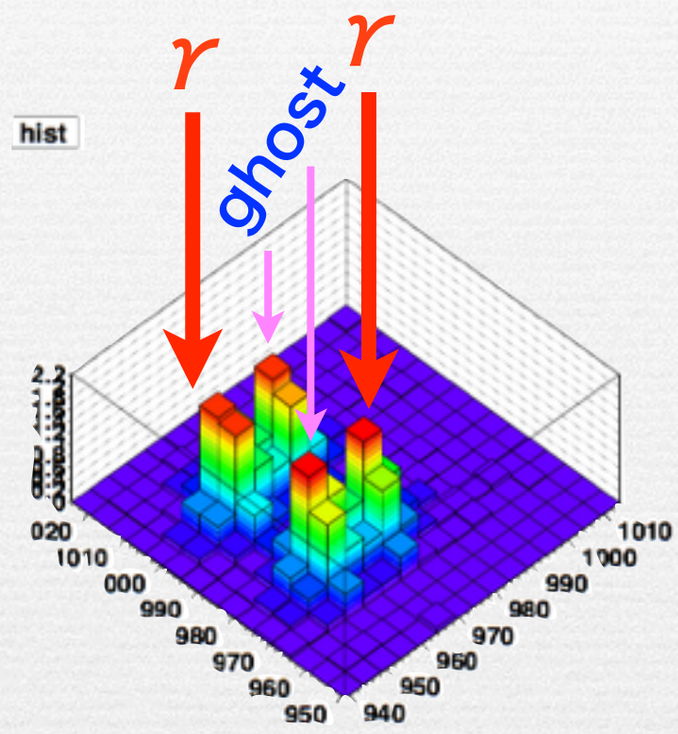

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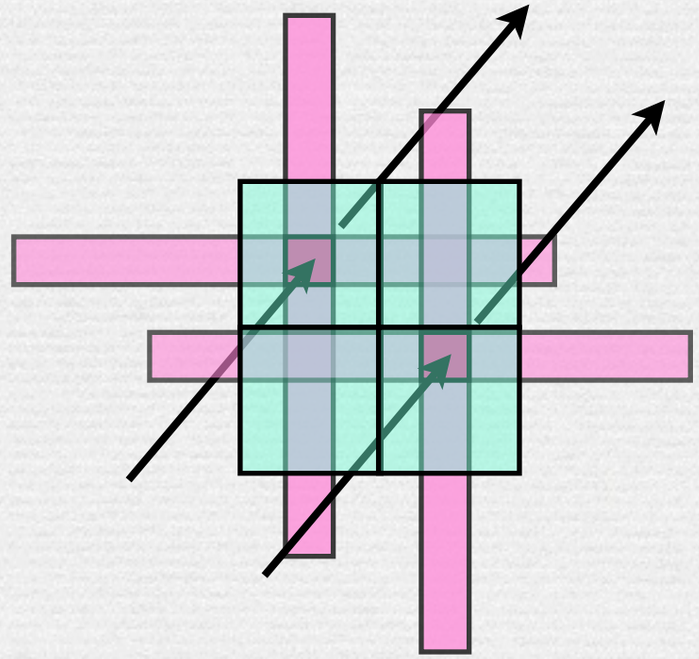
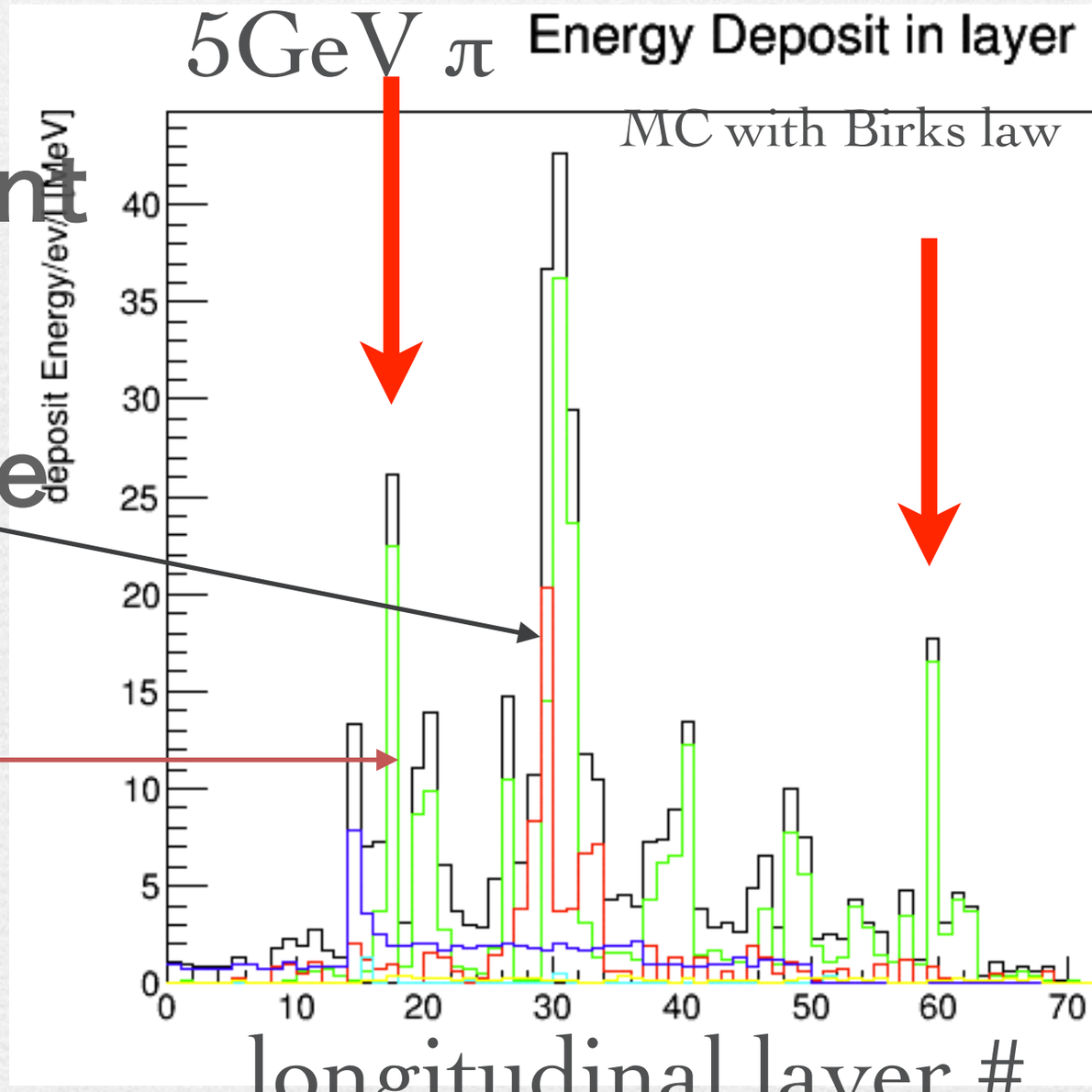


Hadron Shower

- PFA requires segmentation, as well as lateral direction
- analog scintillator information has large fluctuation event by event basis
  - EM shower successive layers
  - single layer (strip)
  - due to low energy protons

black: total
green : proton
cyan : heavy ion
red : electrons
blue : pi+-



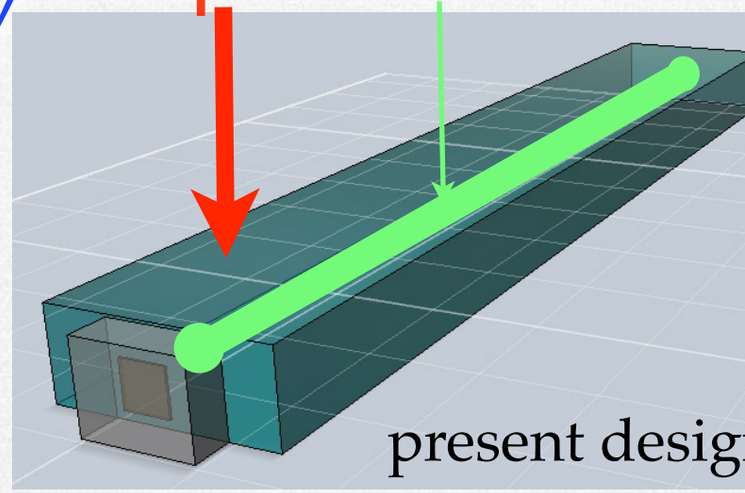
long strip uniformity

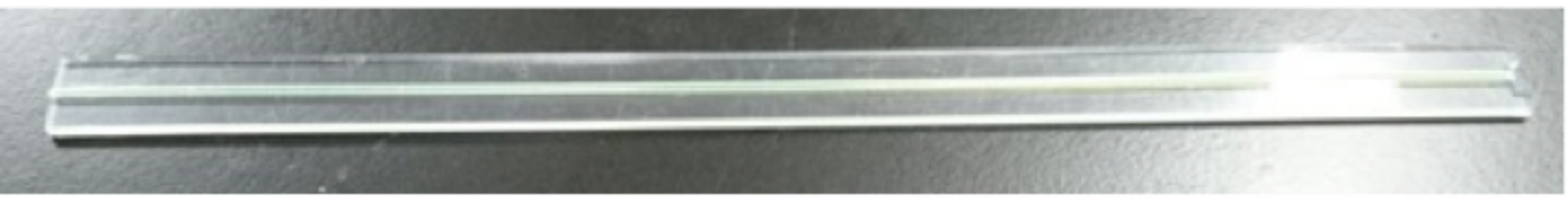
- 90 & 180 mm with WLSF

HCAL

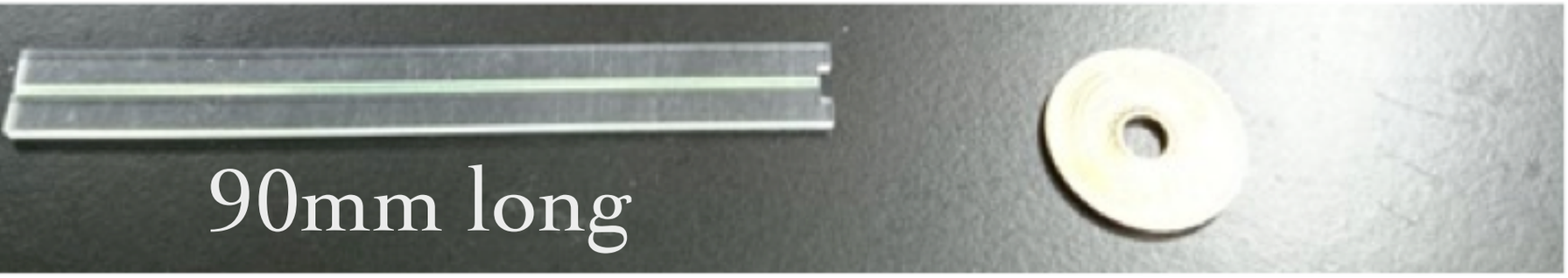
- measured in lab. by beta rays

light yield with reflector

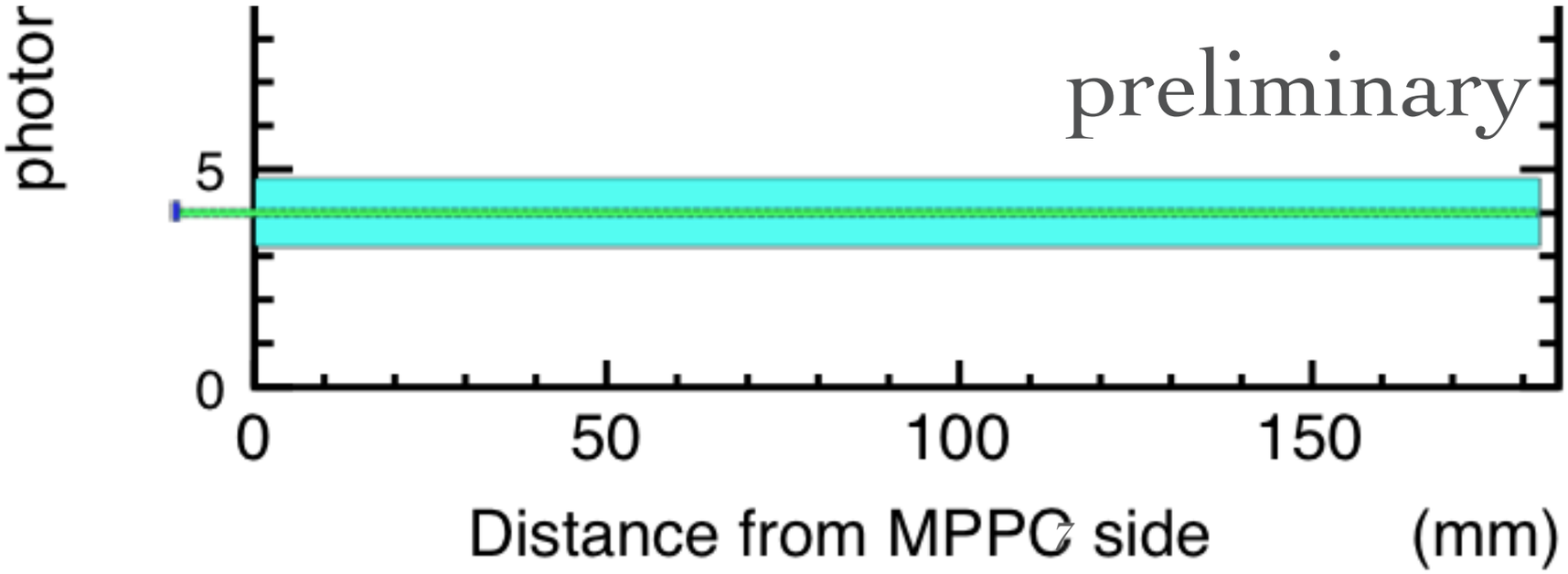




180 x 10 x 2 mm^3



90 x 10 x 2 mm^3



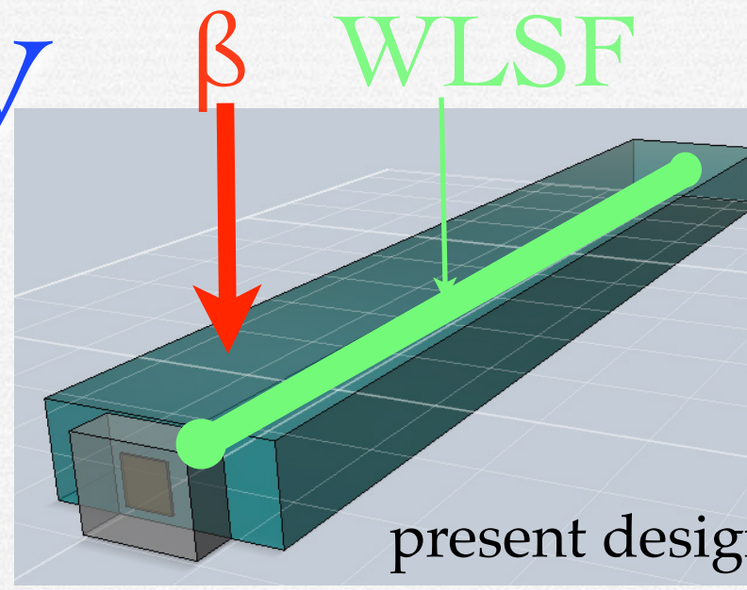
preliminary

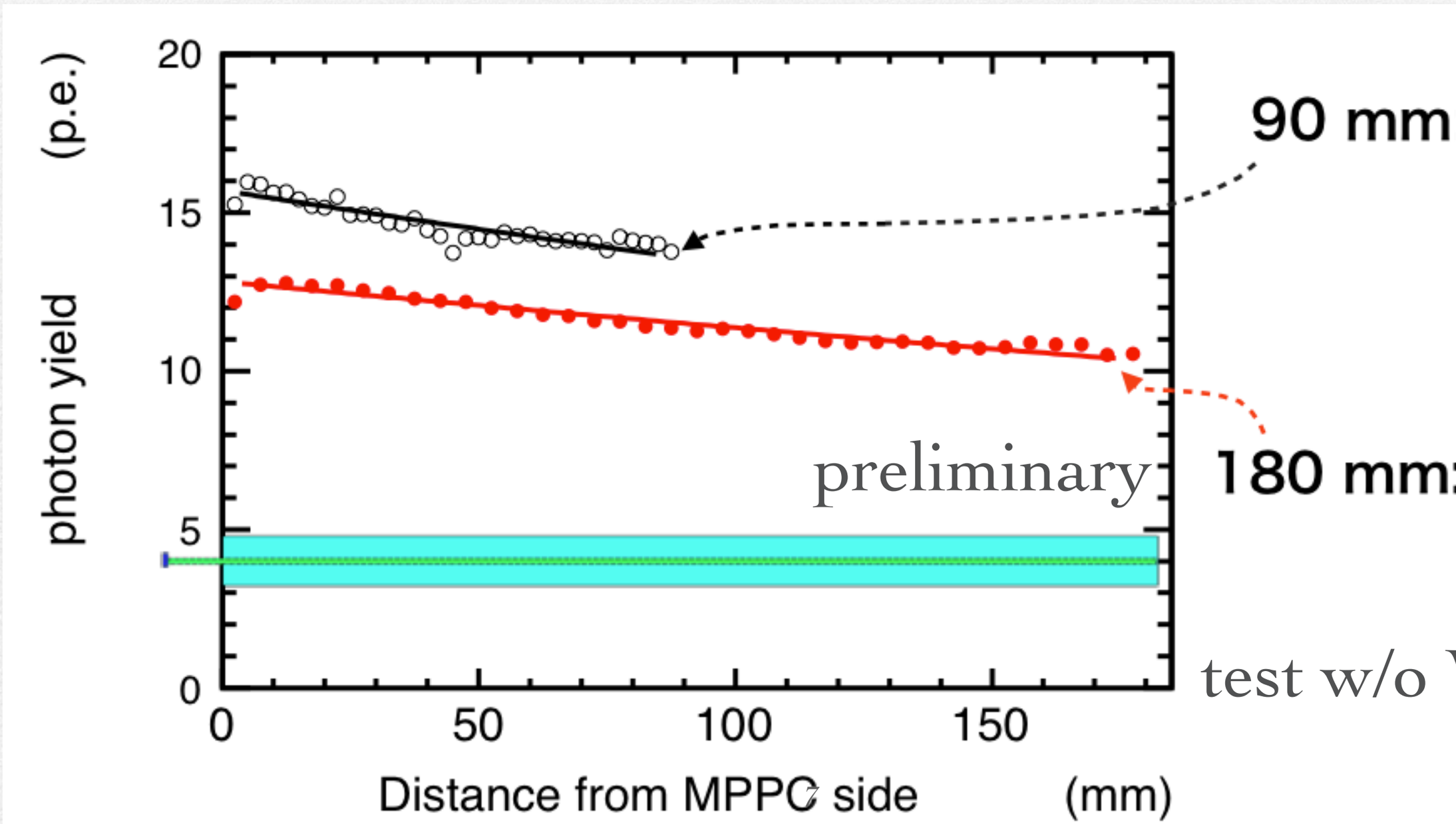
180 mm

test w/o WLSF

long strip uniformity

- 90 & 180 mm with WLSF
  HCAL
- measured in lab. by beta rays
  light yield with reflector

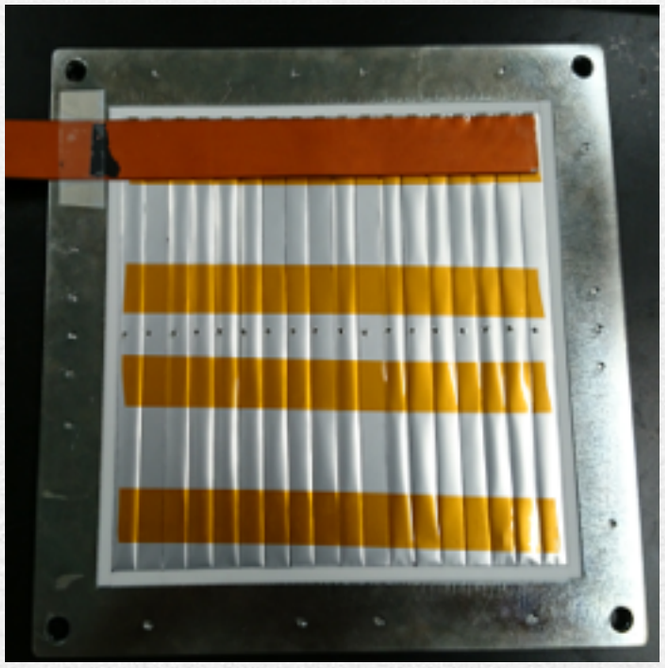




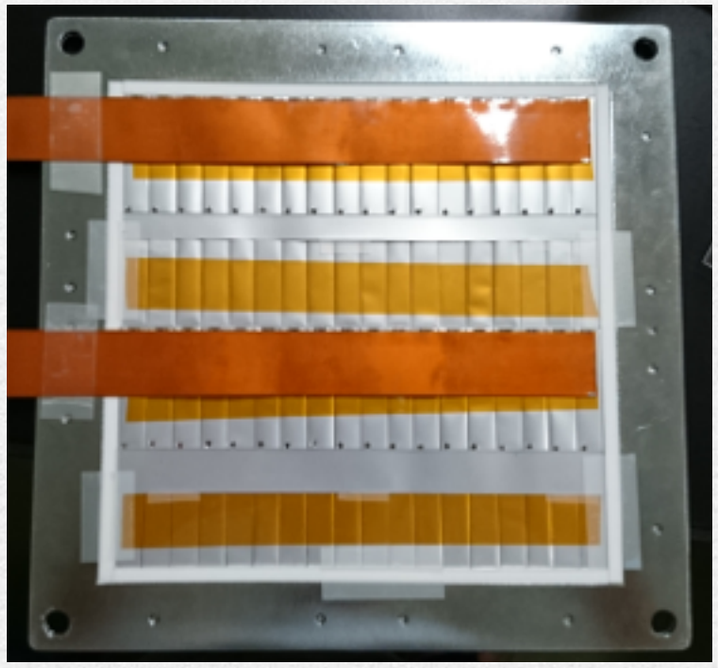
strip HCAL prototype

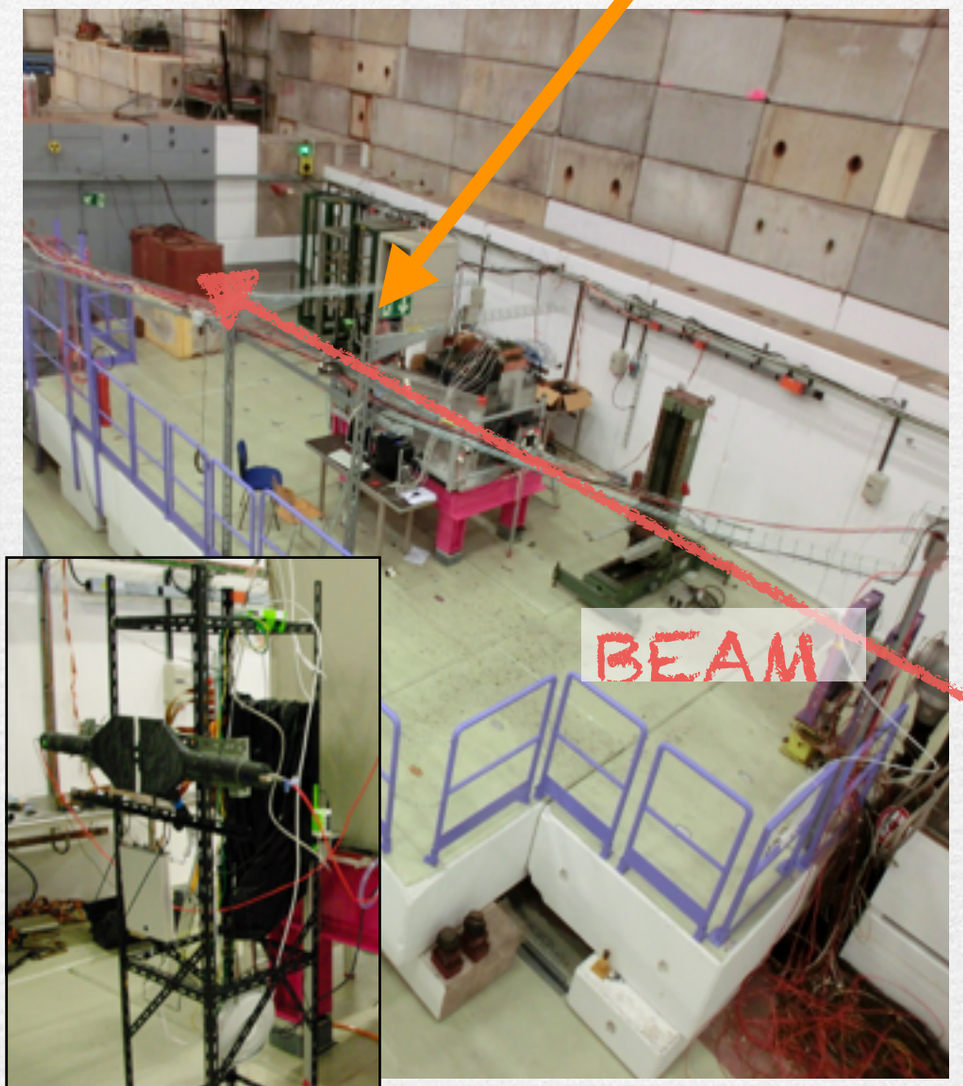
- two strip layers 9cm & 18cm with WLSF r/o

18cm long



9cm long



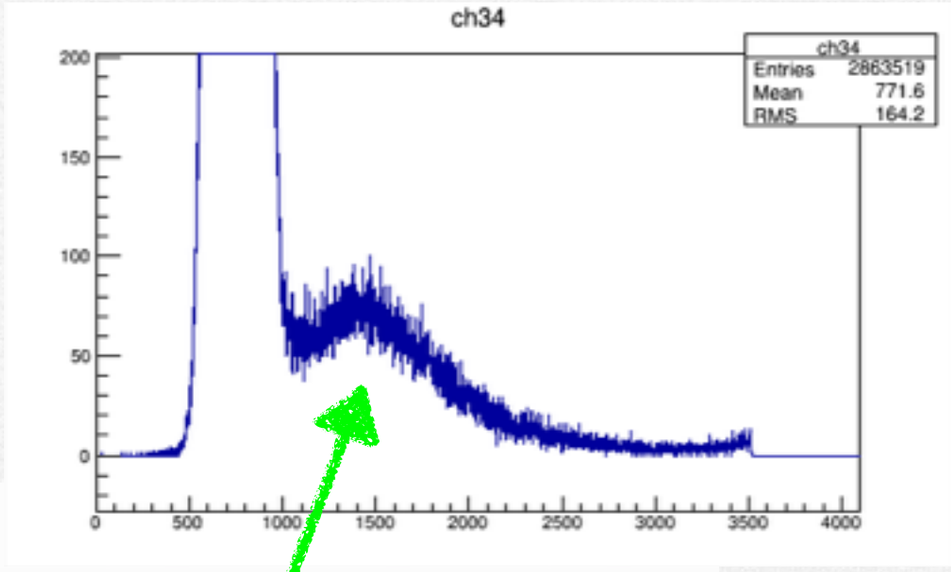


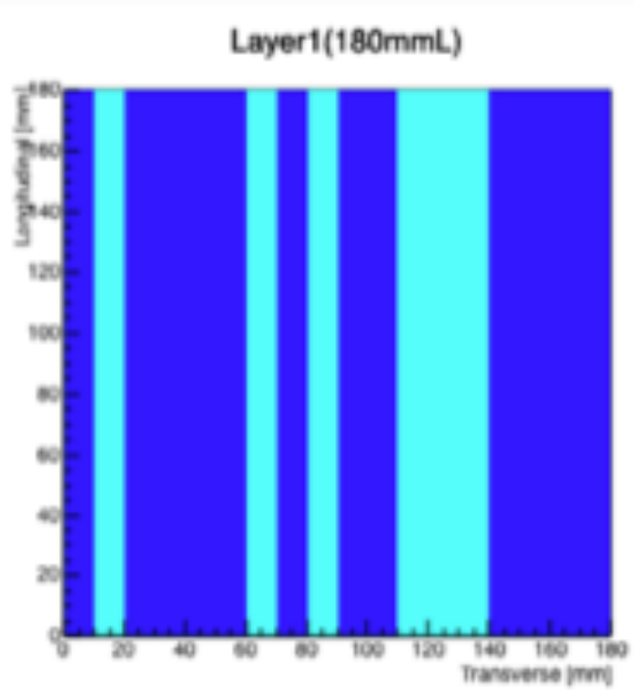
SET UP

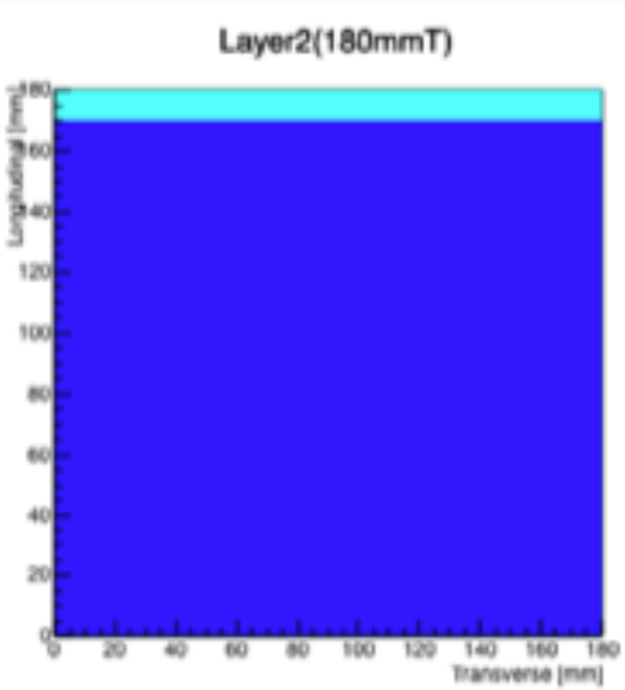
tested at T9/CERN-PS
Oct/2014

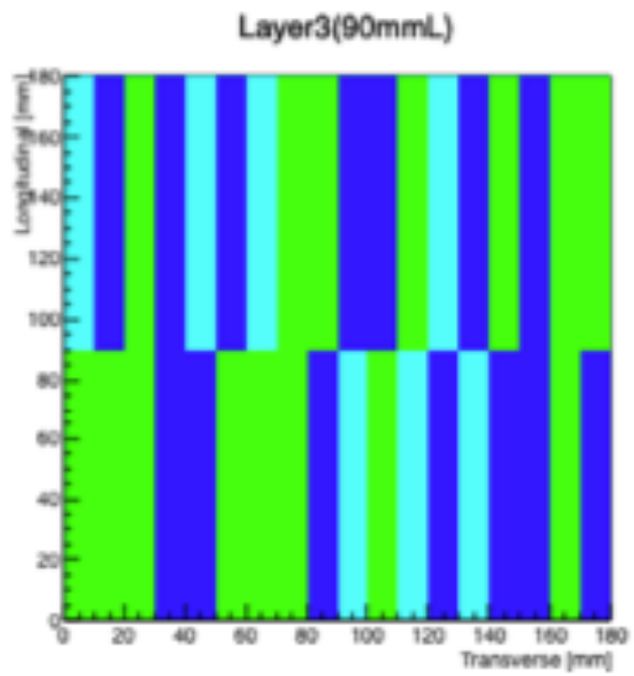
strip HCAL BT

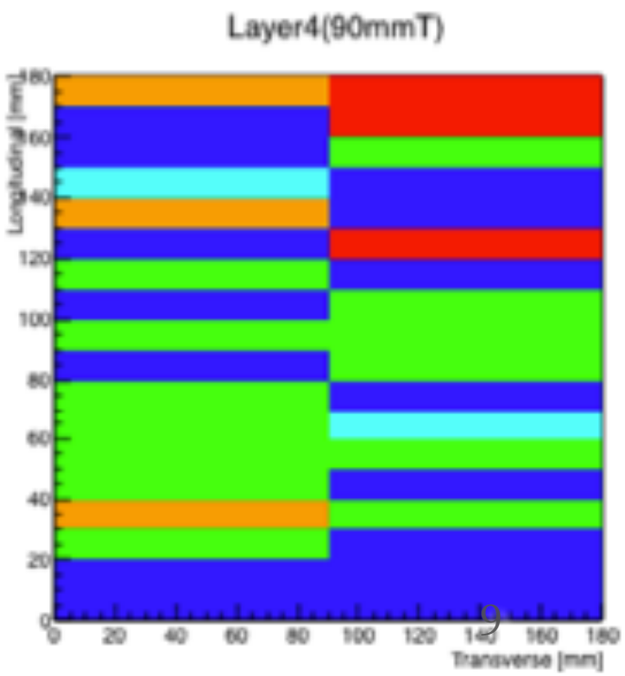
- needed fine tuning at BT











can see MIP peak

see MIP shoulder

No peak

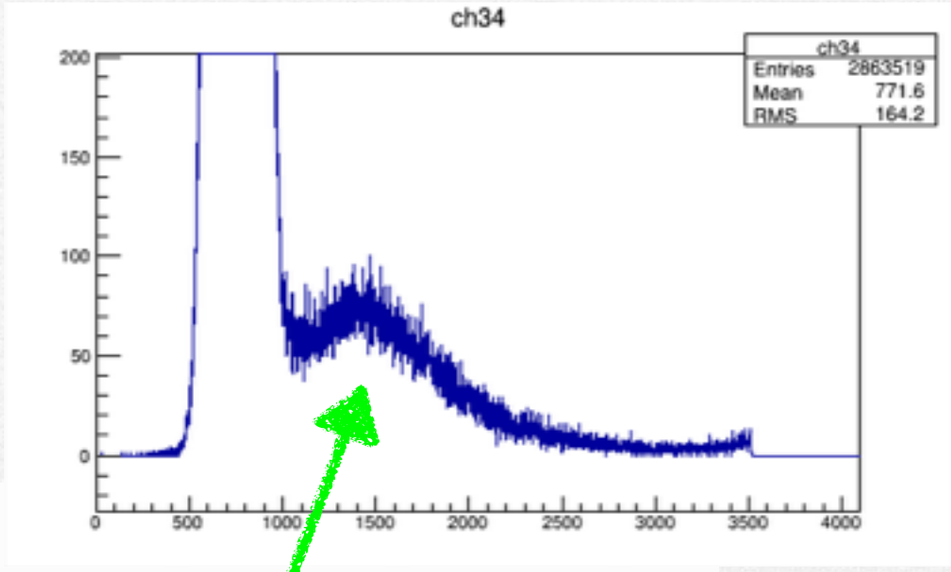
ADC don’t work

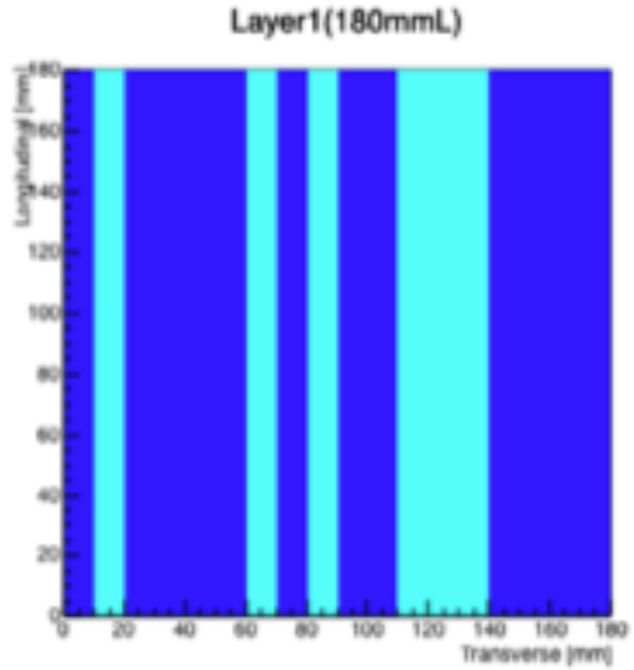
dead

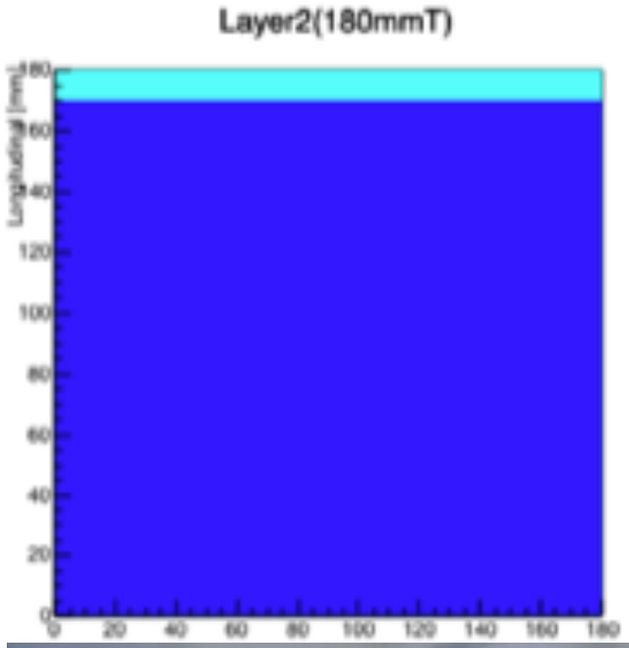
ADC count

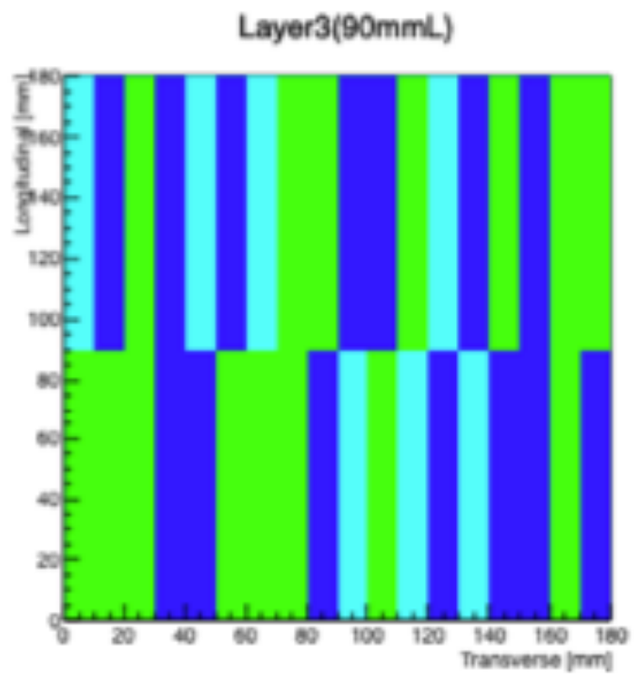
strip HCAL BT

- needed fine tuning at BT



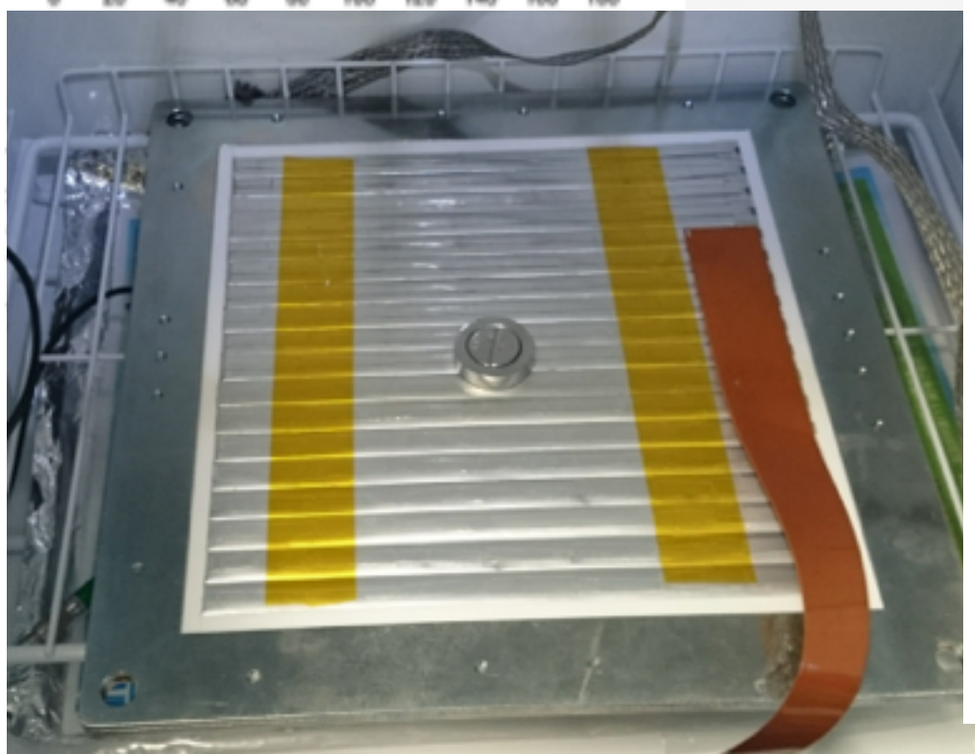


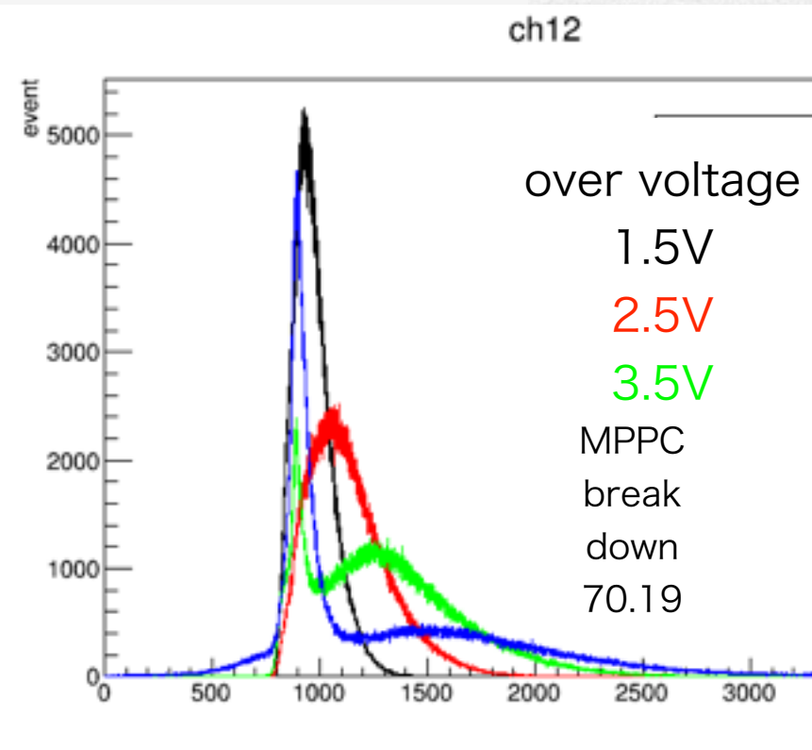




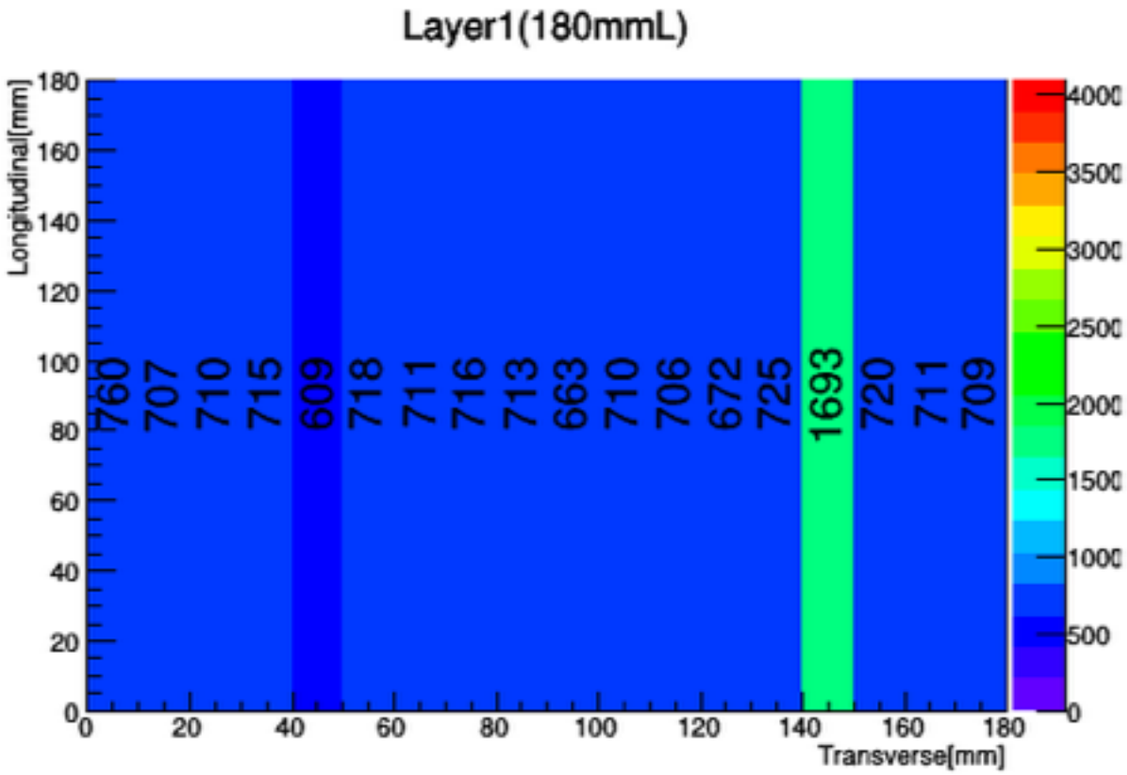
can see MIP peak

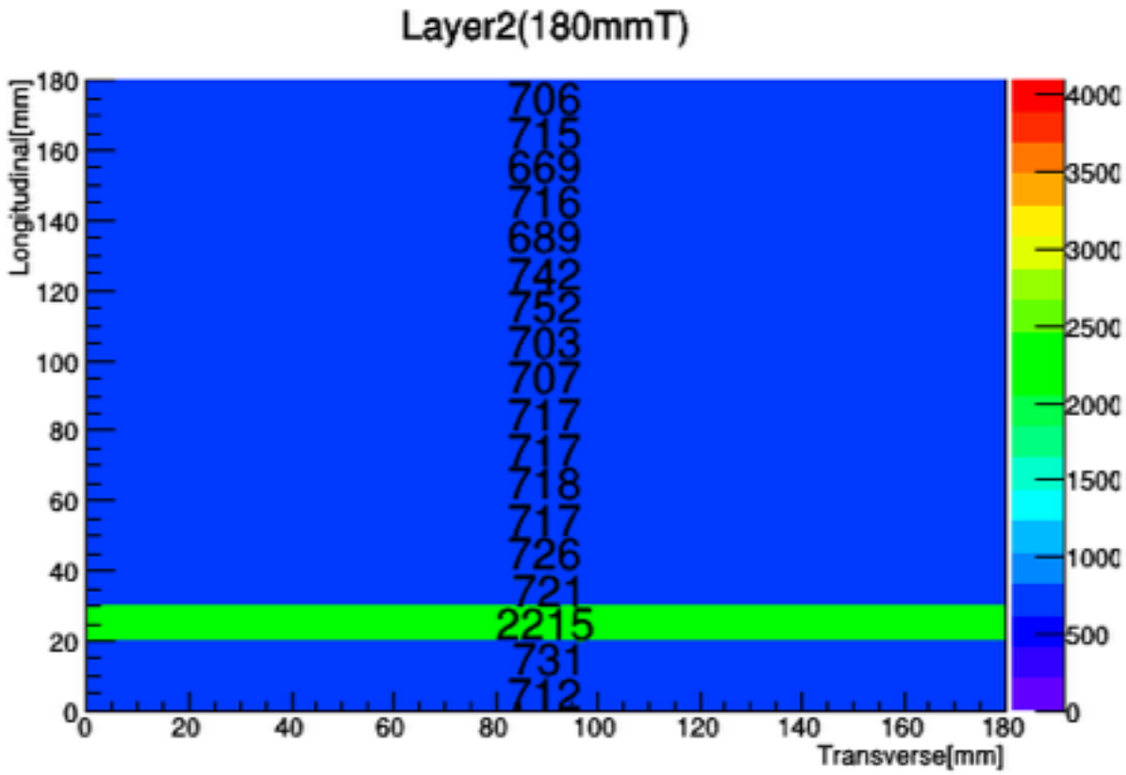
see MIP shoulder

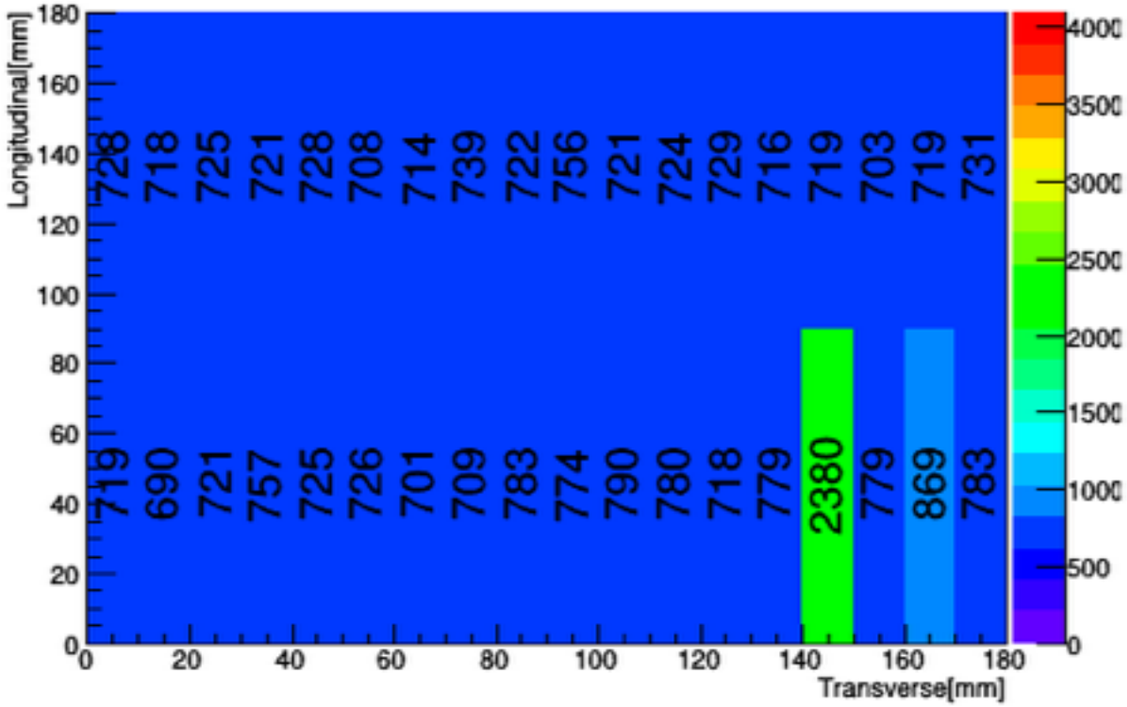


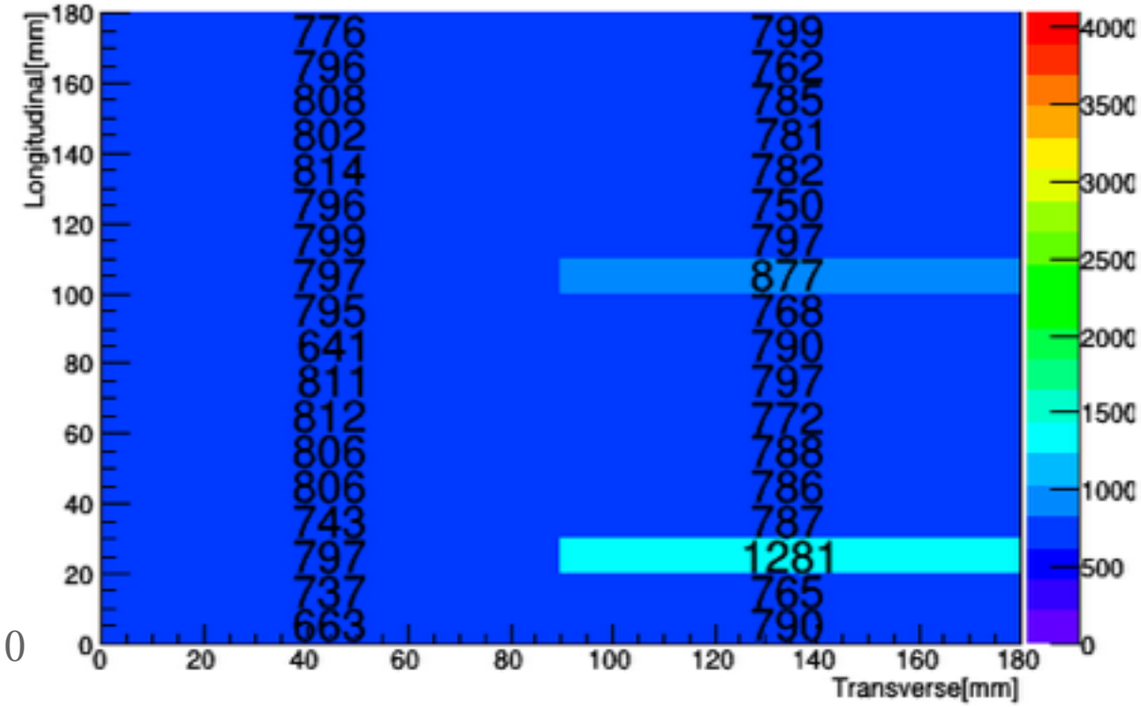


a muon event

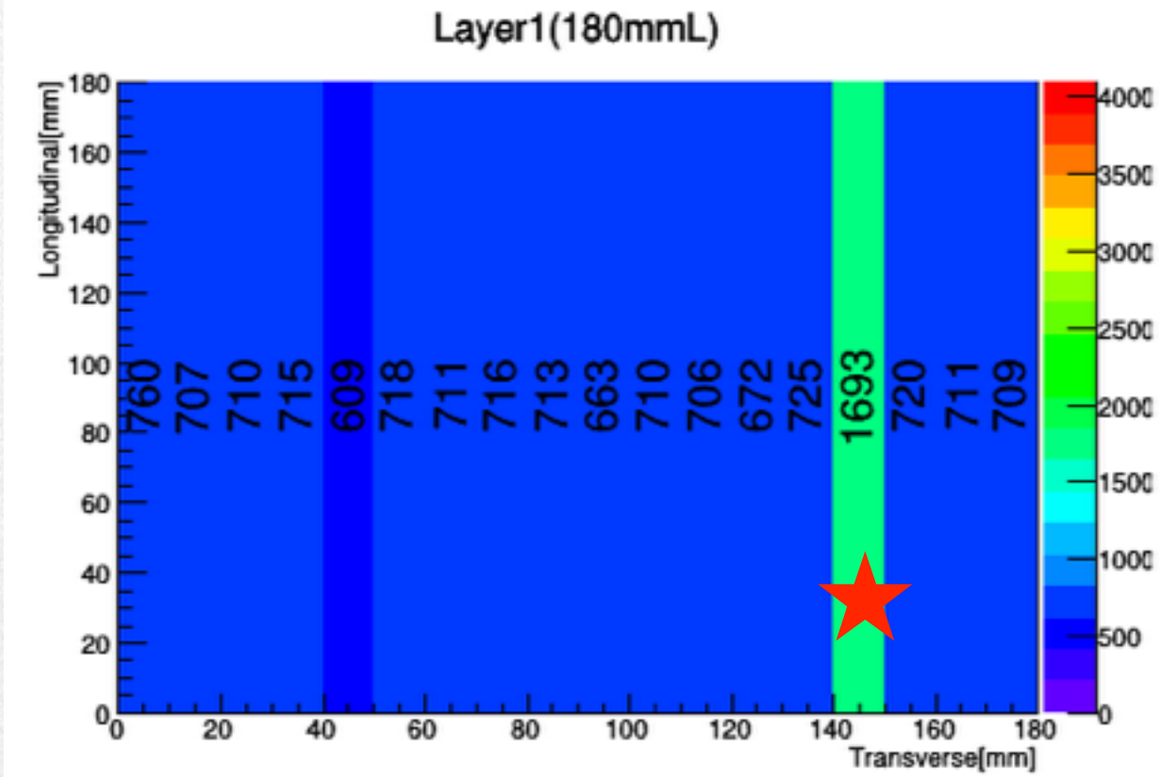

Layer1(180mmL)
Longitudinal[mm]
Transverse[mm]
760 707 710 715 609 718 711 716 713 663 710 706 672 725 1693 720 711 709

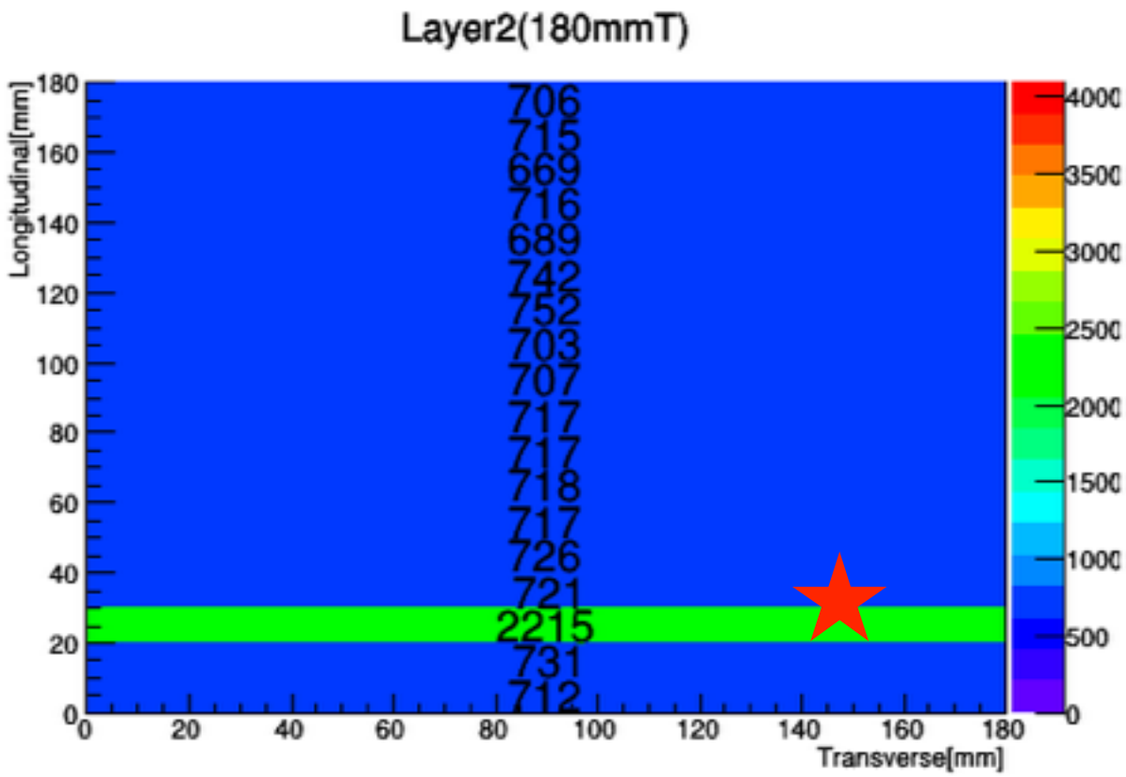

Layer2(180mmT)
Longitudinal[mm]
Transverse[mm]
706 715 669 716 689 742 752 703 707 717 717 718 717 726 721 2215 731 712

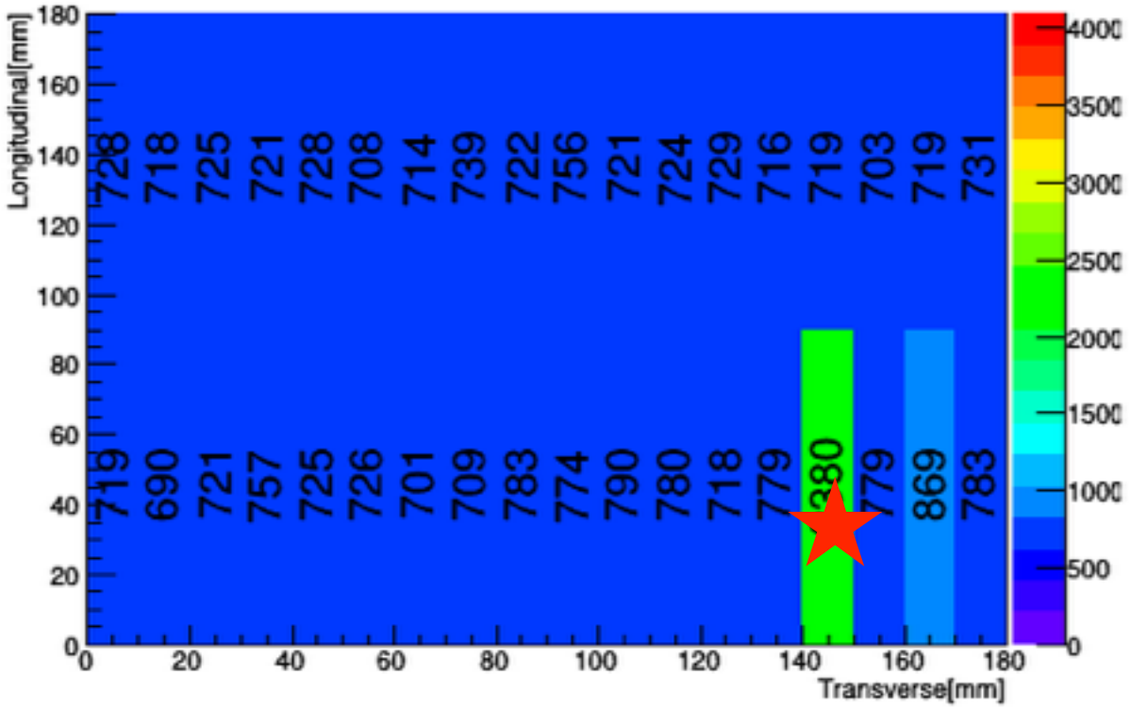

Layer3(180mmL)
Longitudinal[mm]
Transverse[mm]
728 718 725 721 728 708 714 739 722 756 721 724 729 716 719 703 719 731
719 690 721 757 725 726 701 709 783 774 790 780 718 779 2380 779 869 783

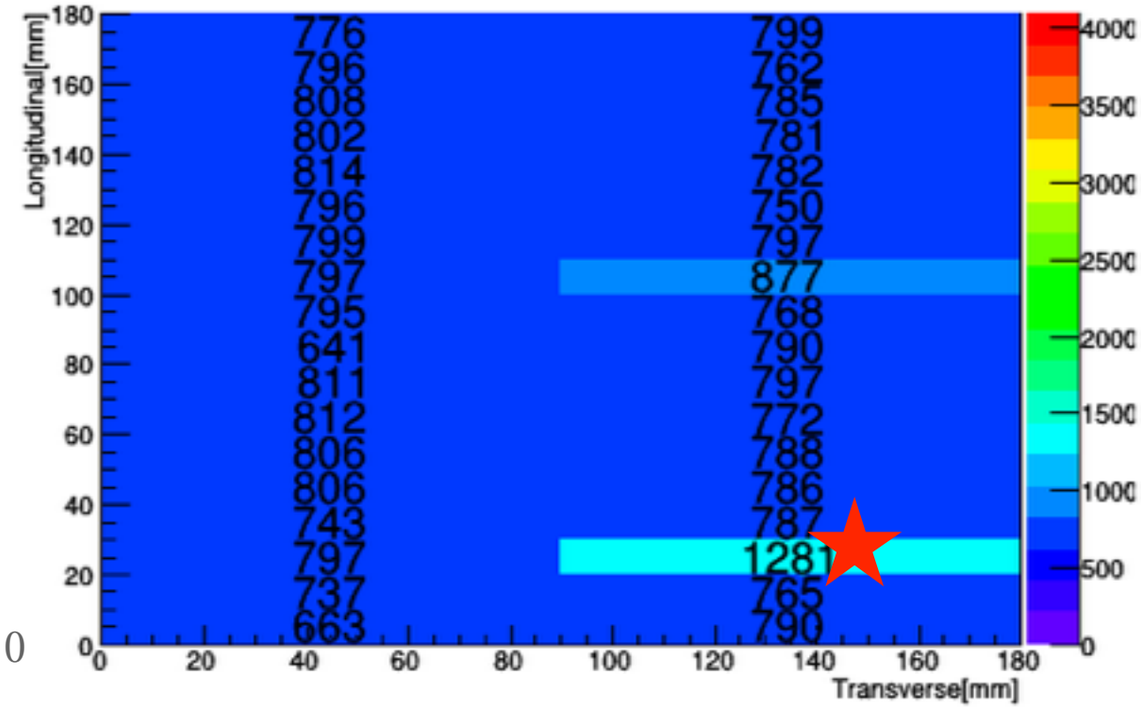

Layer4(180mmT)
Longitudinal[mm]
Transverse[mm]
776 796 808 802 814 796 799 797 795 641 811 812 806 806 743 797 737 663
799 762 785 781 782 750 797 877 768 790 797 772 788 786 787 1281 765 790

a muon event


Layer1(180mmL)
Longitudinal[mm]
Transverse[mm]
760 707 710 715 609 718 711 716 713 663 710 706 672 725 1693 720 711 709

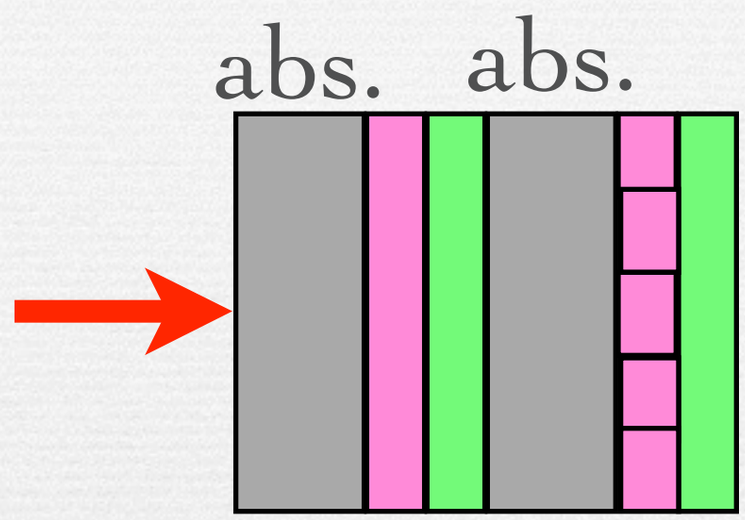

Layer2(180mmT)
Longitudinal[mm]
Transverse[mm]
706 715 669 716 689 742 752 703 707 717 717 718 717 726 721 2215 731 712


Layer3(180mmL)
Longitudinal[mm]
Transverse[mm]
728 718 725 721 728 708 714 739 722 756 721 724 729 716 719 703 719 731
719 690 721 757 725 726 701 709 783 774 790 780 718 779 880 779 869 783


Layer4(180mmT)
Longitudinal[mm]
Transverse[mm]
776 796 808 802 814 796 799 797 795 641 811 812 806 806 743 797 737 663
799 762 785 781 782 750 797 877 768 790 797 772 788 786 787 1281 765 790

integrated read

- longitudinal segmentation demands read out integration in layers
- read out layer contains
- photo-sensor (PPD)



- ASIC (amp/discriminator/ADC/ memory)
  - pedestal suppression
  - digital output where hit exists

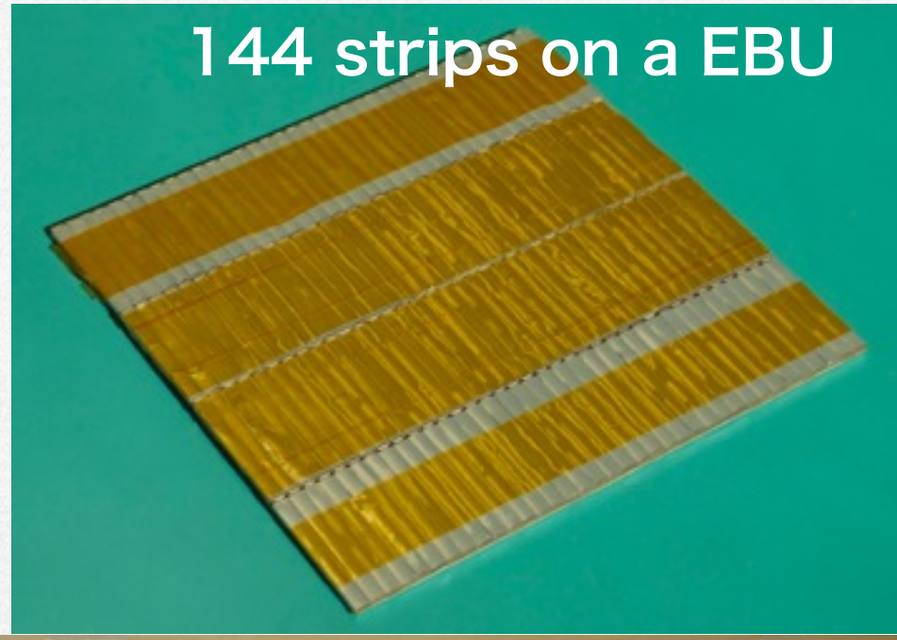
scinti R/O

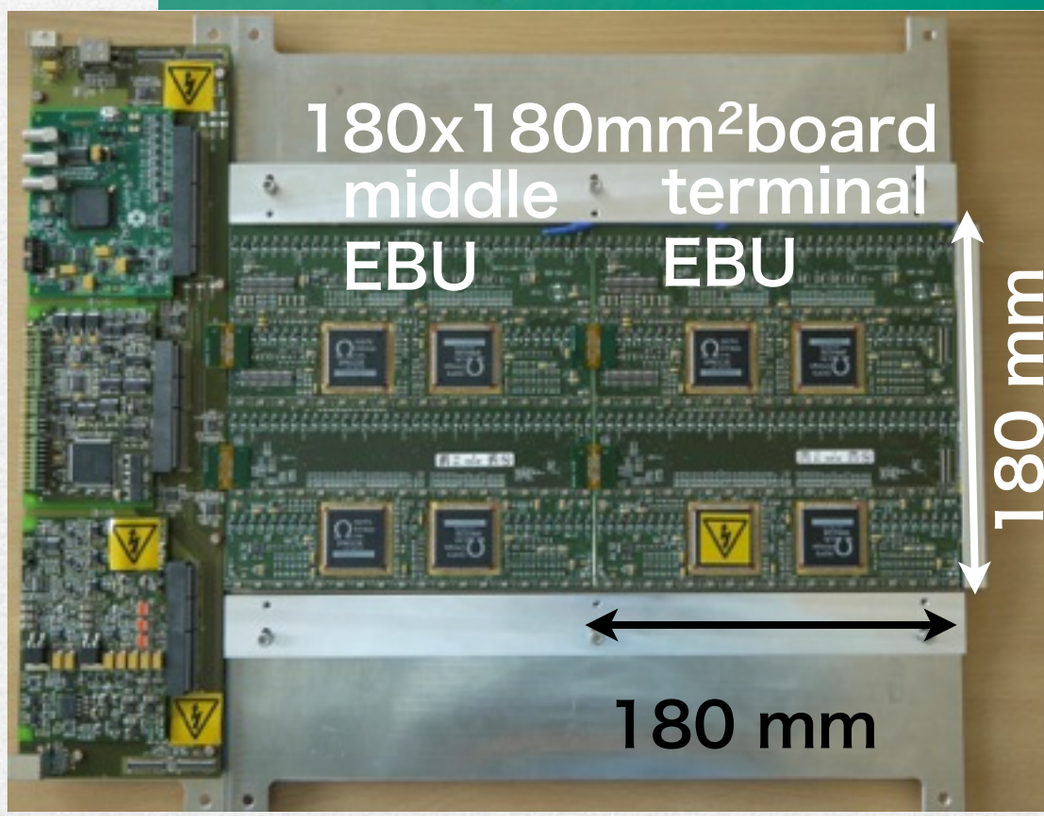
reduce readout channels

- calibration scheme integrated

ECAL layer

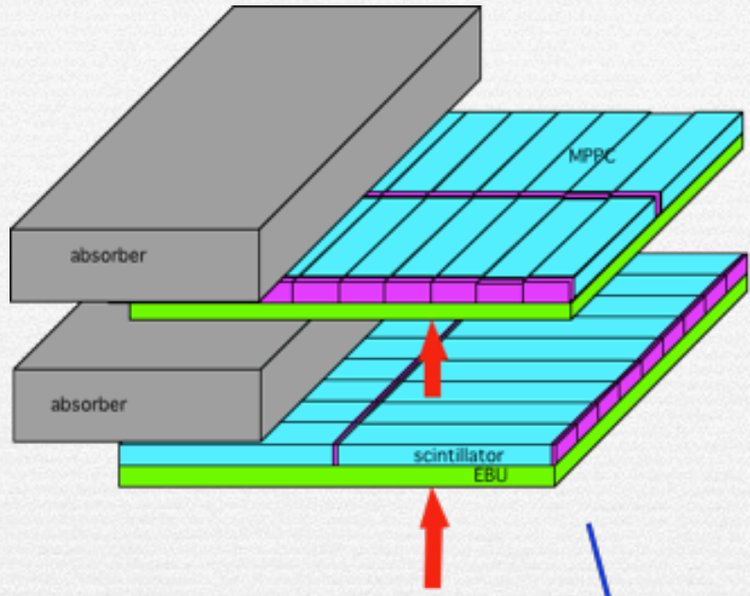
- sensor & elec. combined
- strip: 5mm x 45mm x 2mm thick
- 144 ch./layer of 18cm x18cm
- front end electronics embedded
- 4 SPIROCs (4x36ch)
- EBU (Ecal Base Unit)

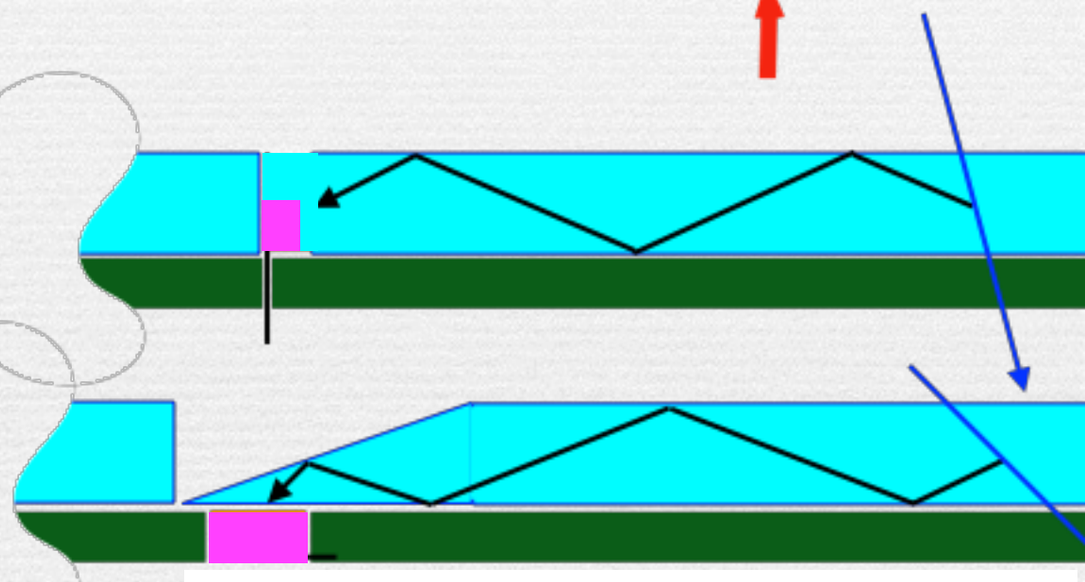




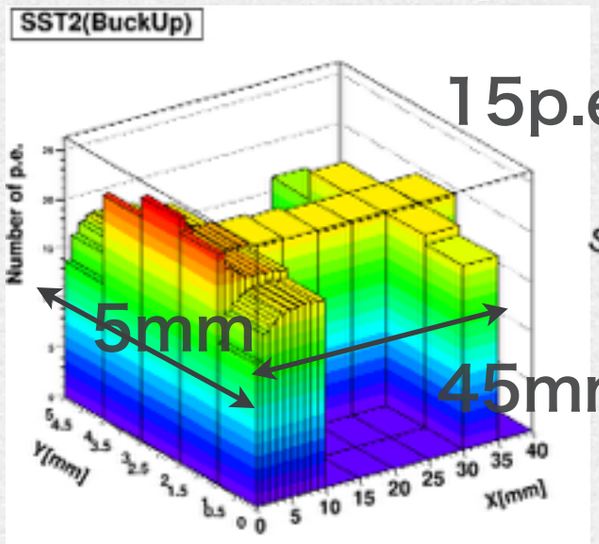
design of a

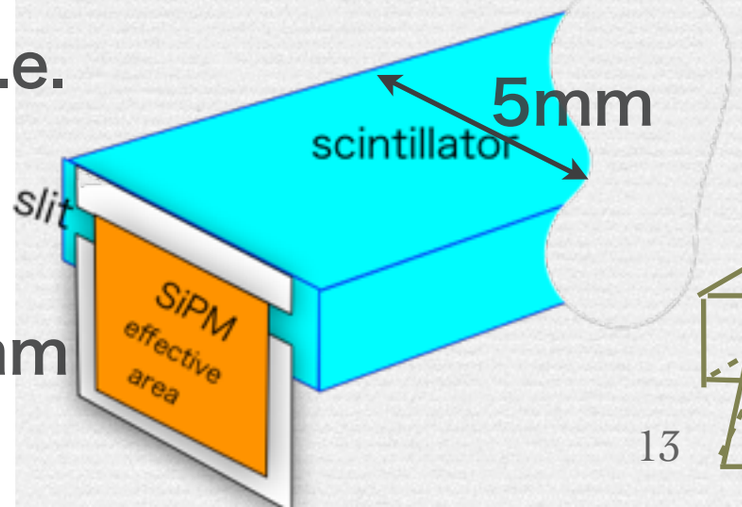
- PPD
  scintillator area
- to avoid it, surface mounted
  PPD
- to reduce scintillator
  thickness in front of PPD
- simulated Np.e. for a type

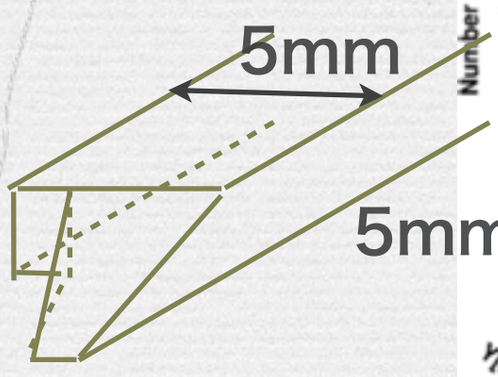


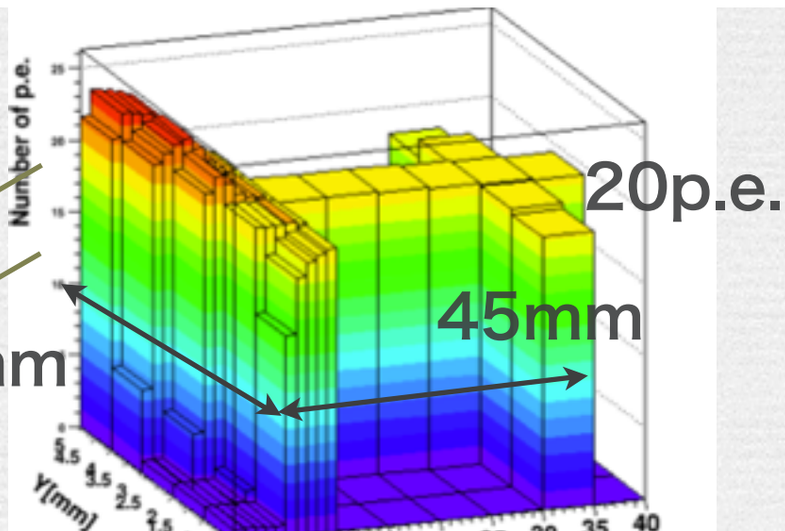


single side tapered2(simulation)



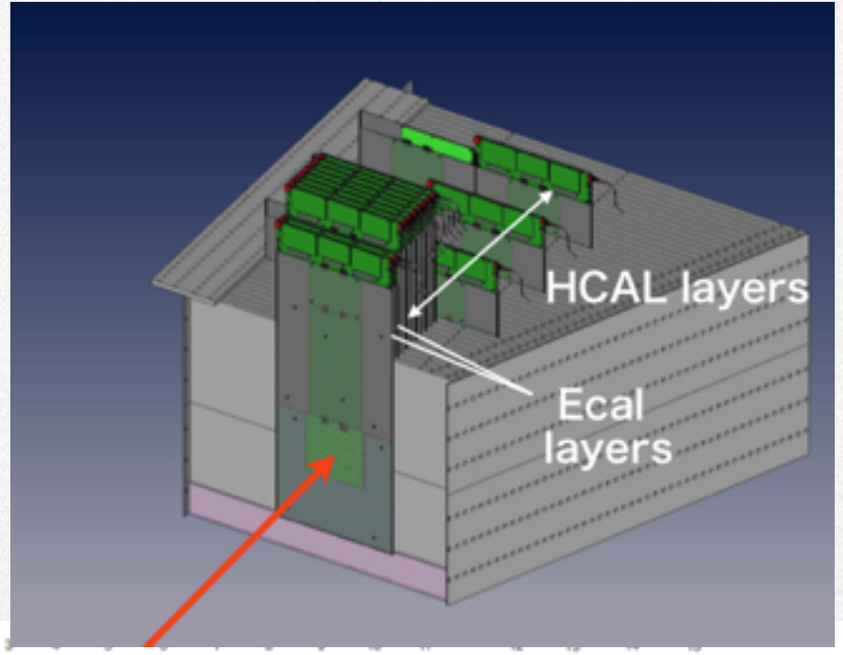


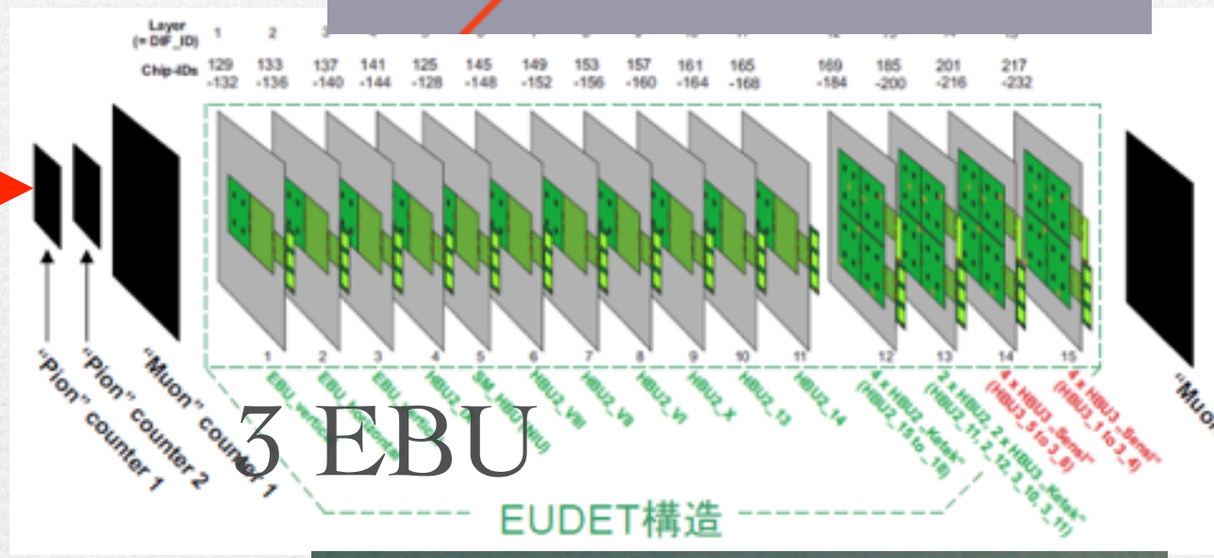




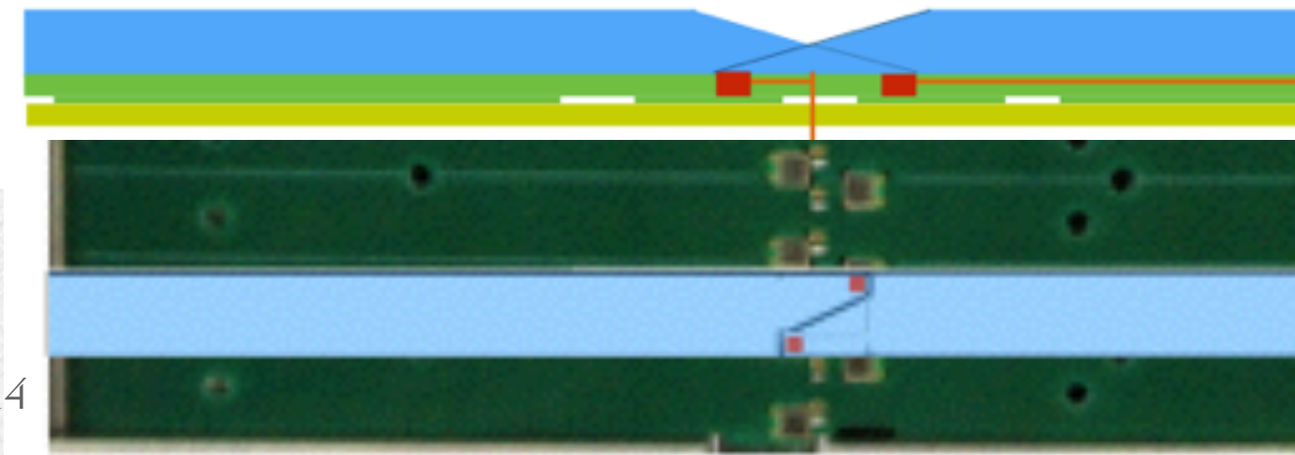
CERN beam test

- at T9 Oct&Dec/2014
- three EBU types: M & T
- 10kpix MPPC
- baseline + wedge stirp
- synchronized DAQ with
  - AHCAL (SPIROC)



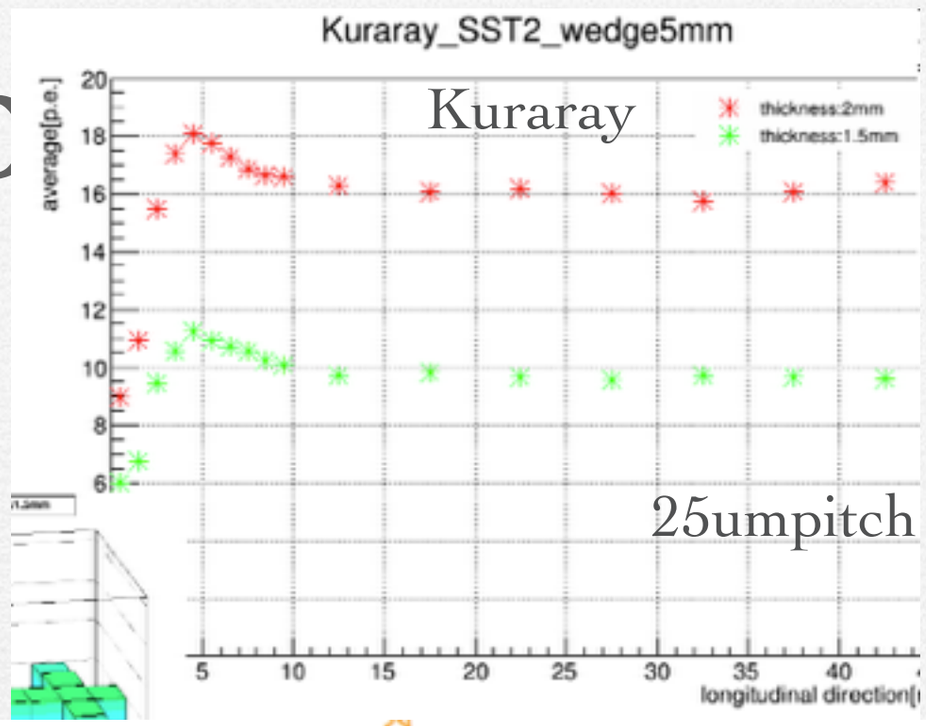


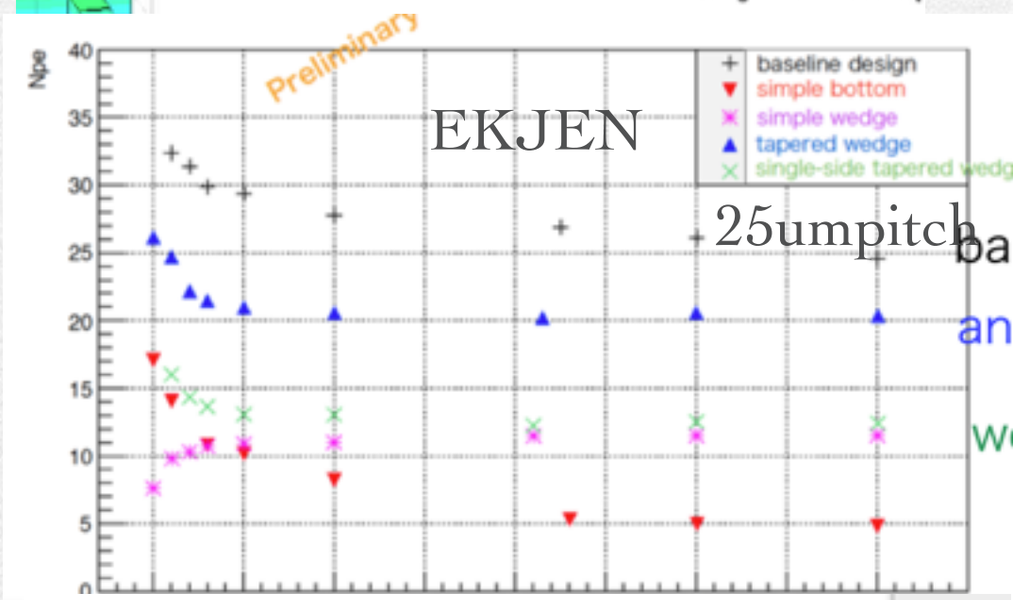
Bottom side readout design (side view)

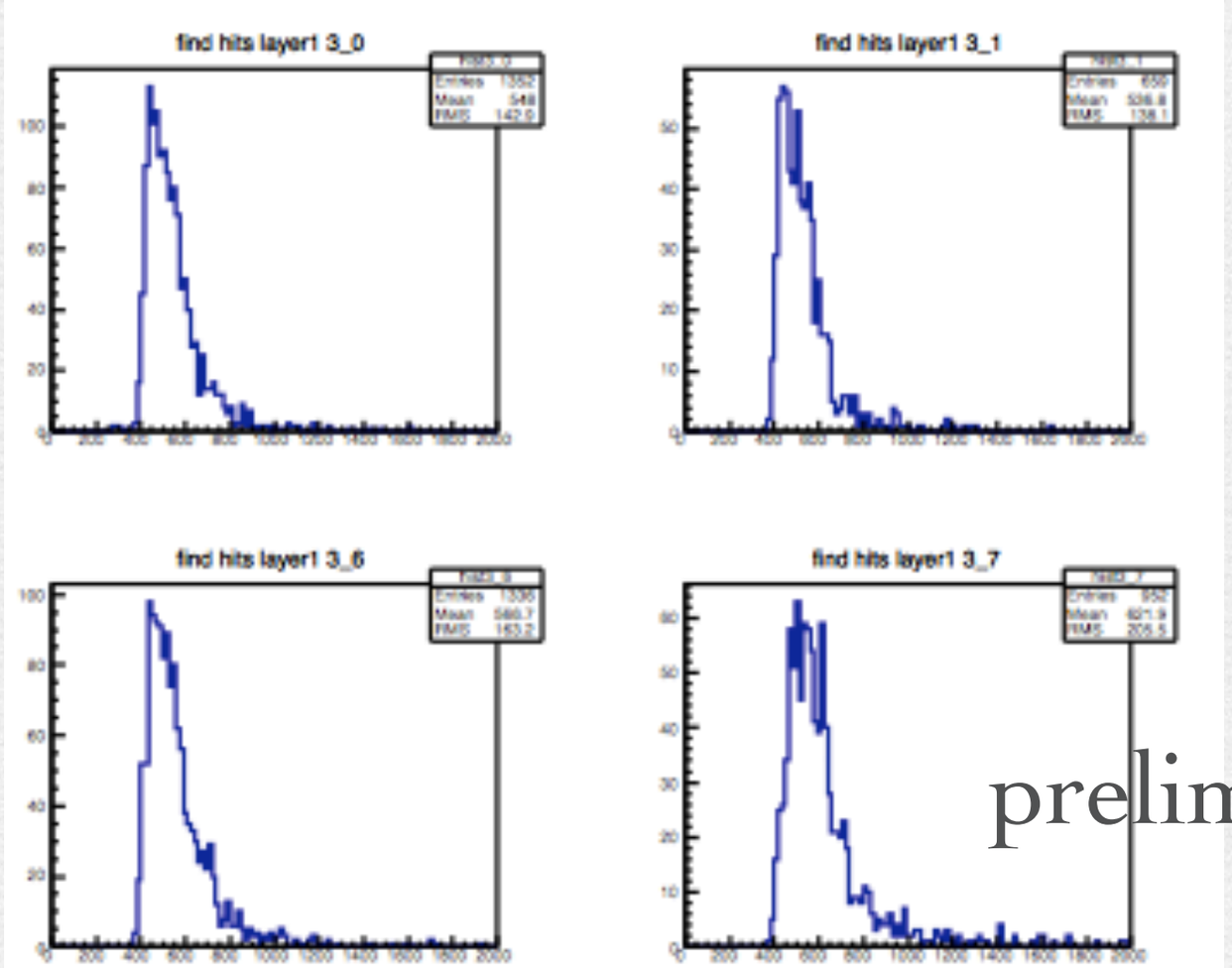


wedge shape strip

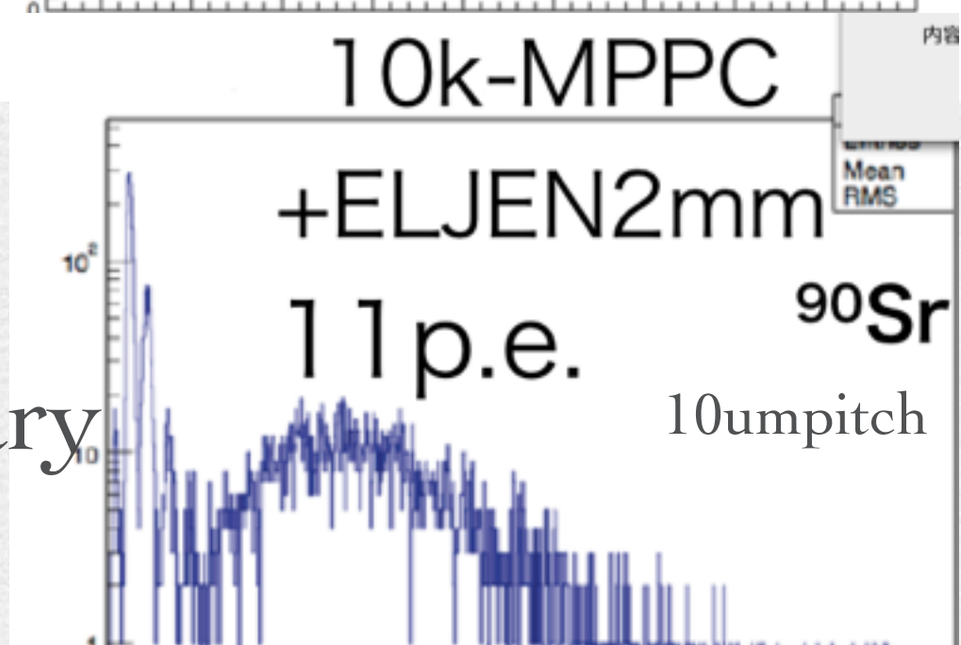
- bench test
- MIP~11p.e. by 10um pitch MPPC
- at beam
- we had to set very high threshold





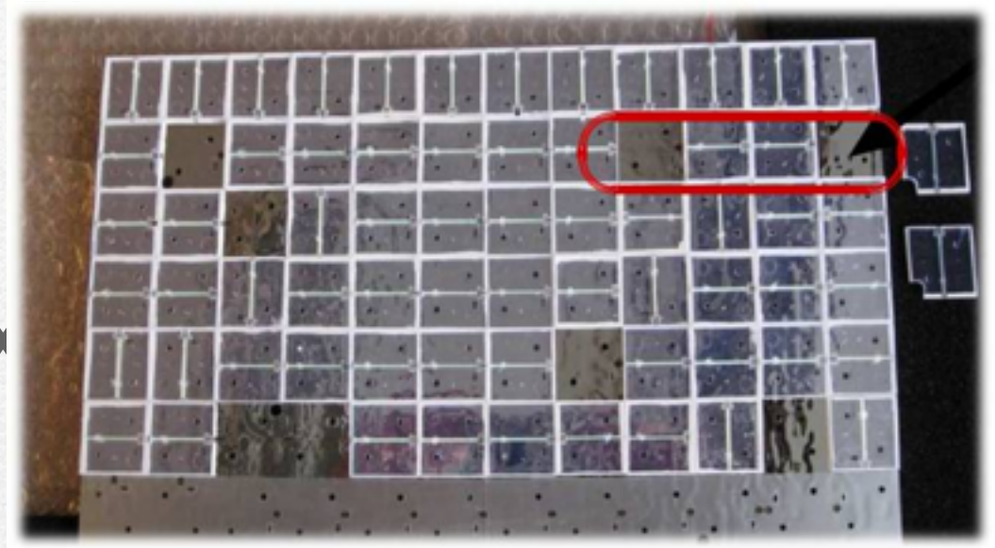


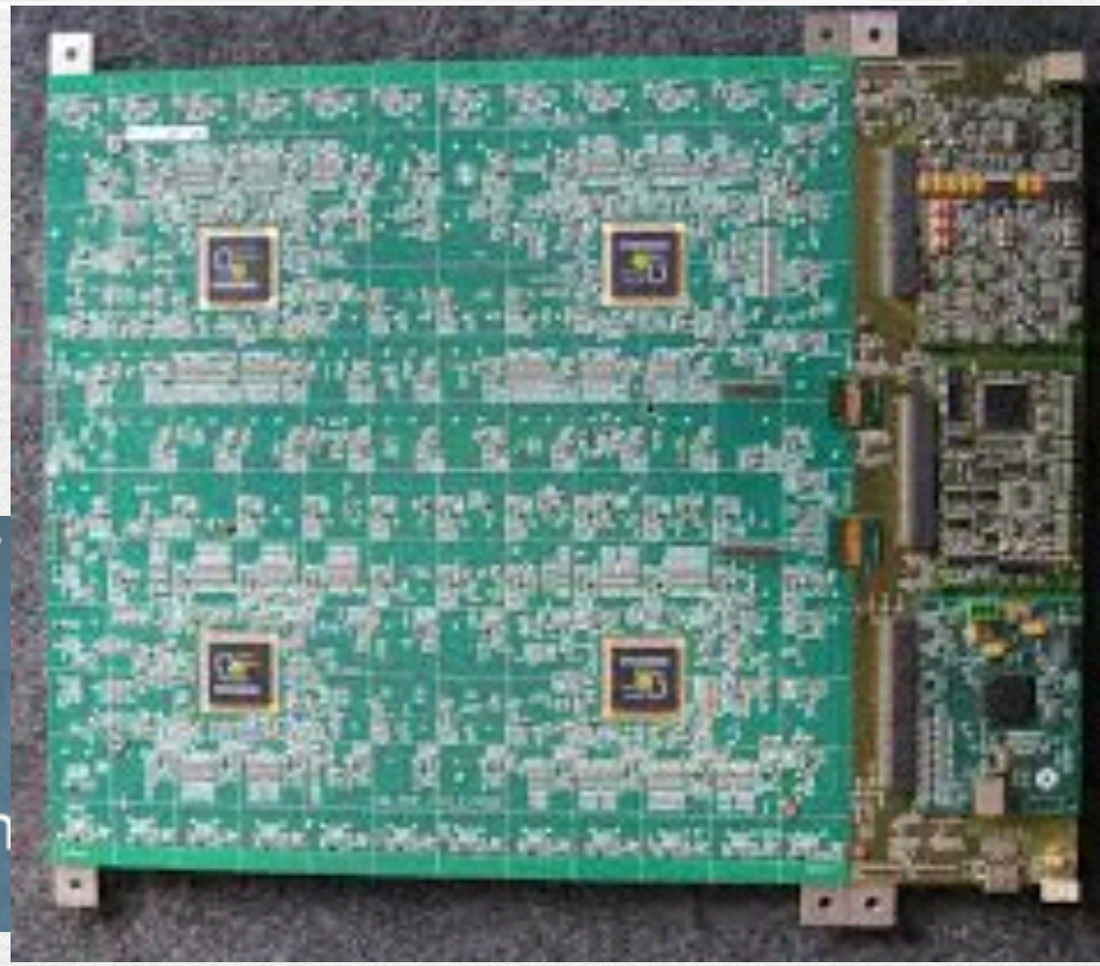
preliminary

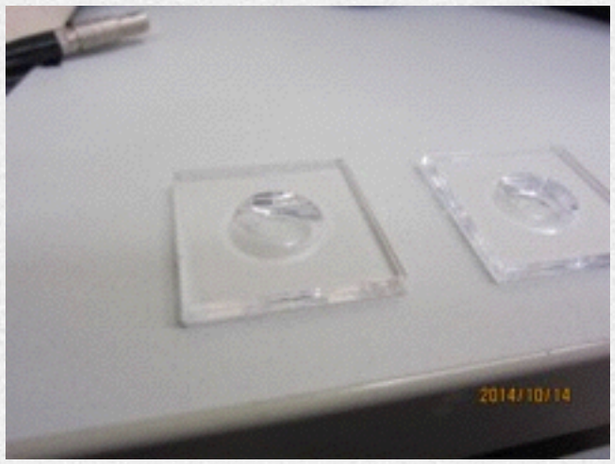


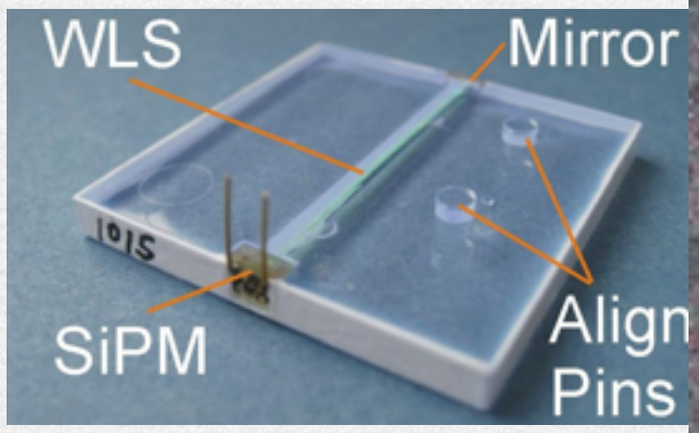
HCAL layers

- 3cm x 3cm x 3mm tiles
- HBU 36cmx36 or 72cmx
  12x12=144ch 12x12x4=576ch
- side read out
- dimple read out



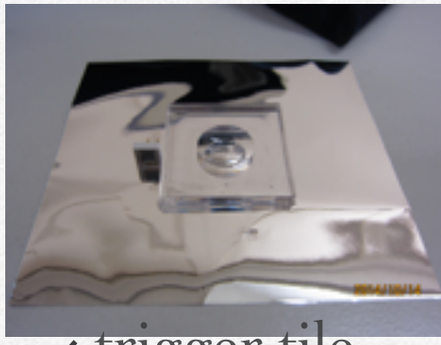


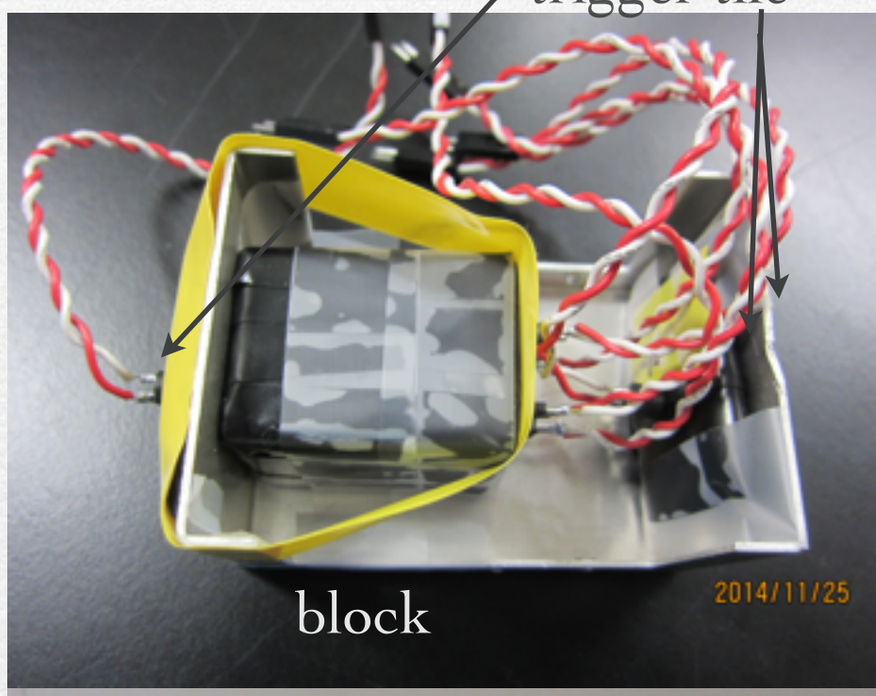


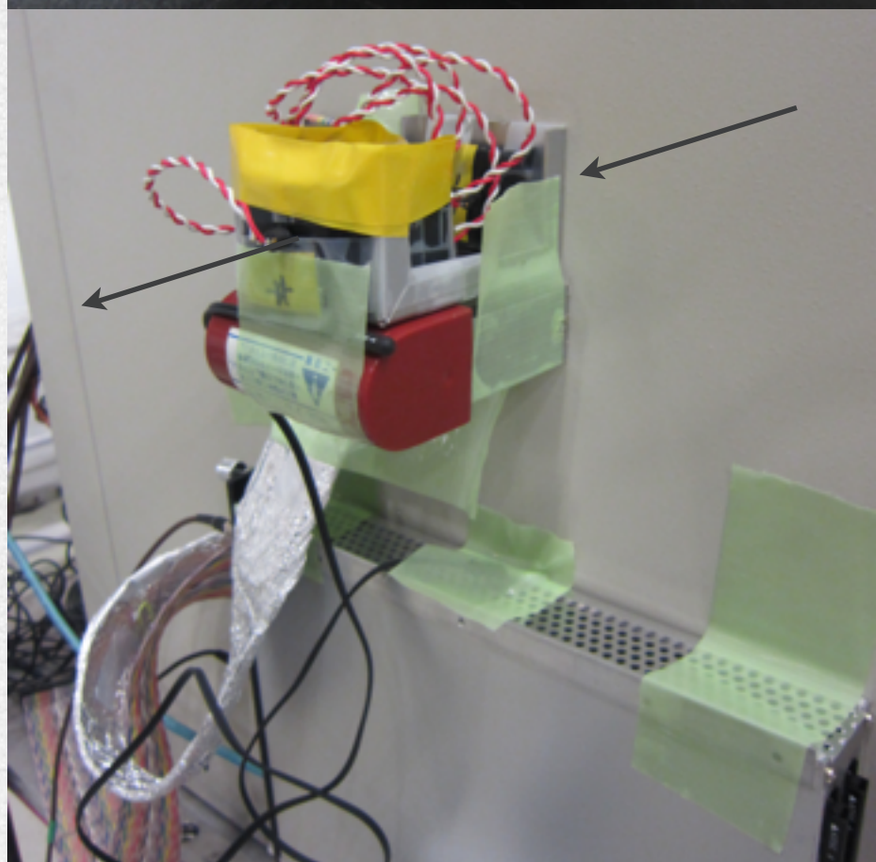


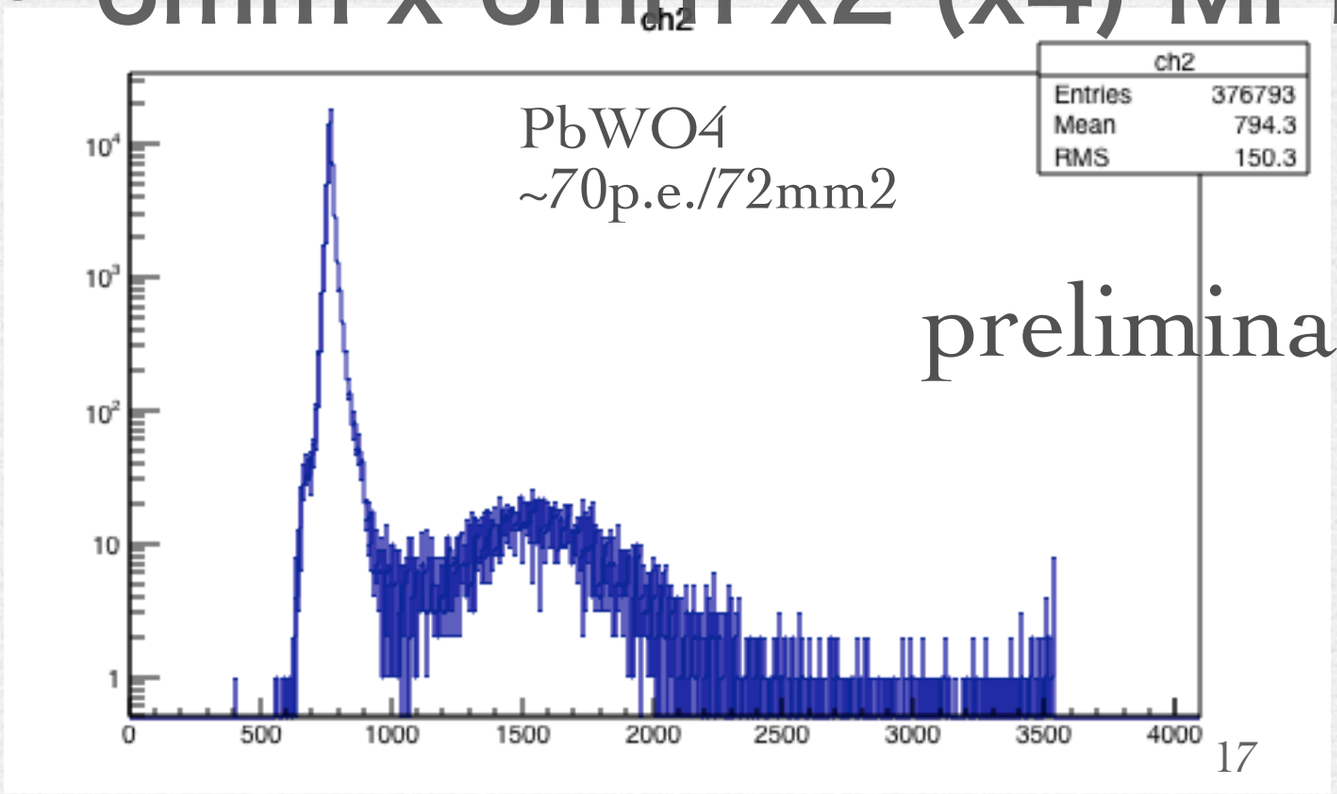
CERN beam test

- lead glass
- PbWO4
- of 40mm long has beed tested by
- 6mm x 6mm x2 (x4) MPPCs









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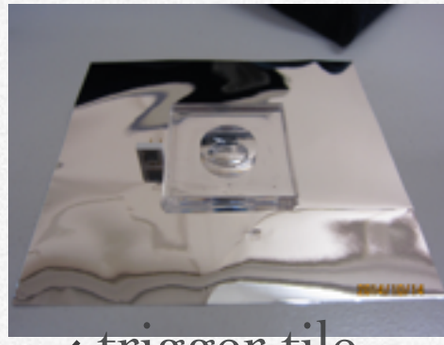
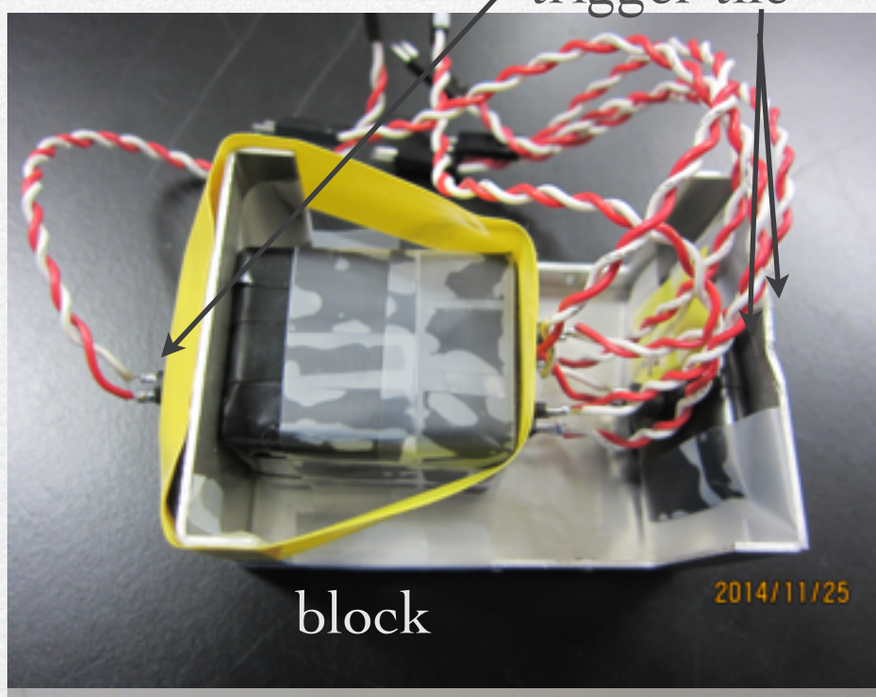
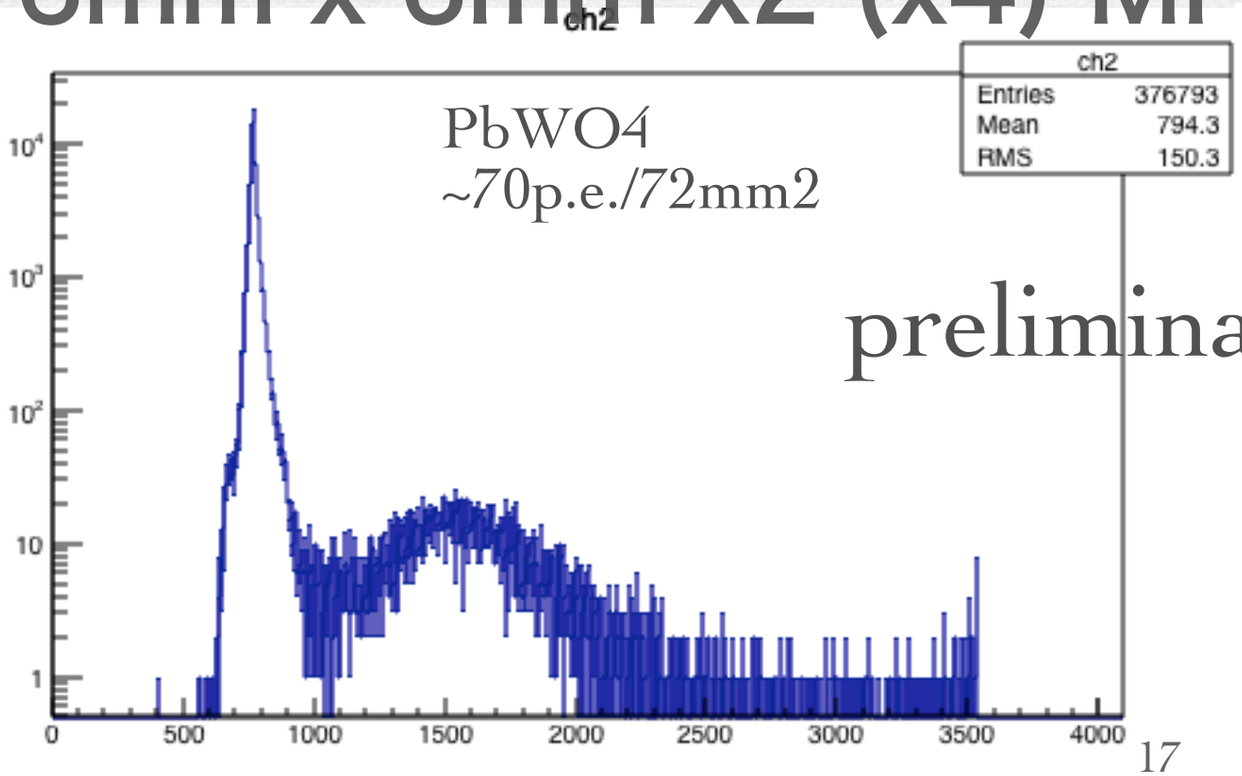
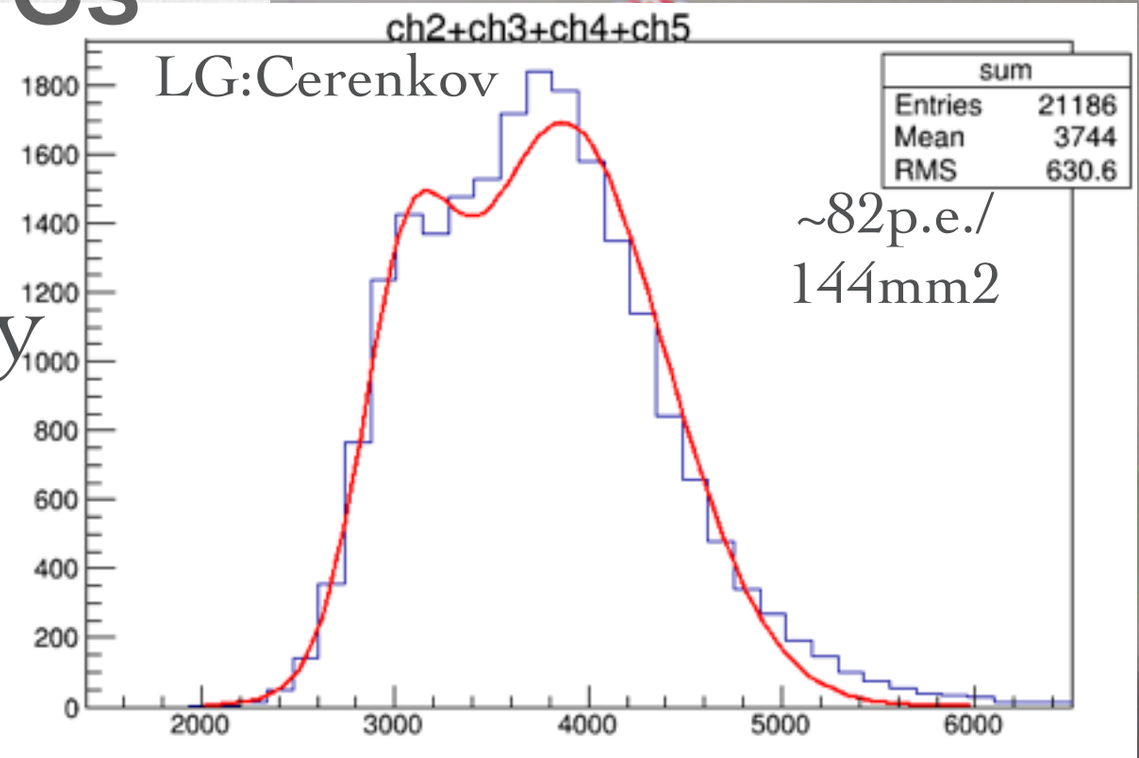






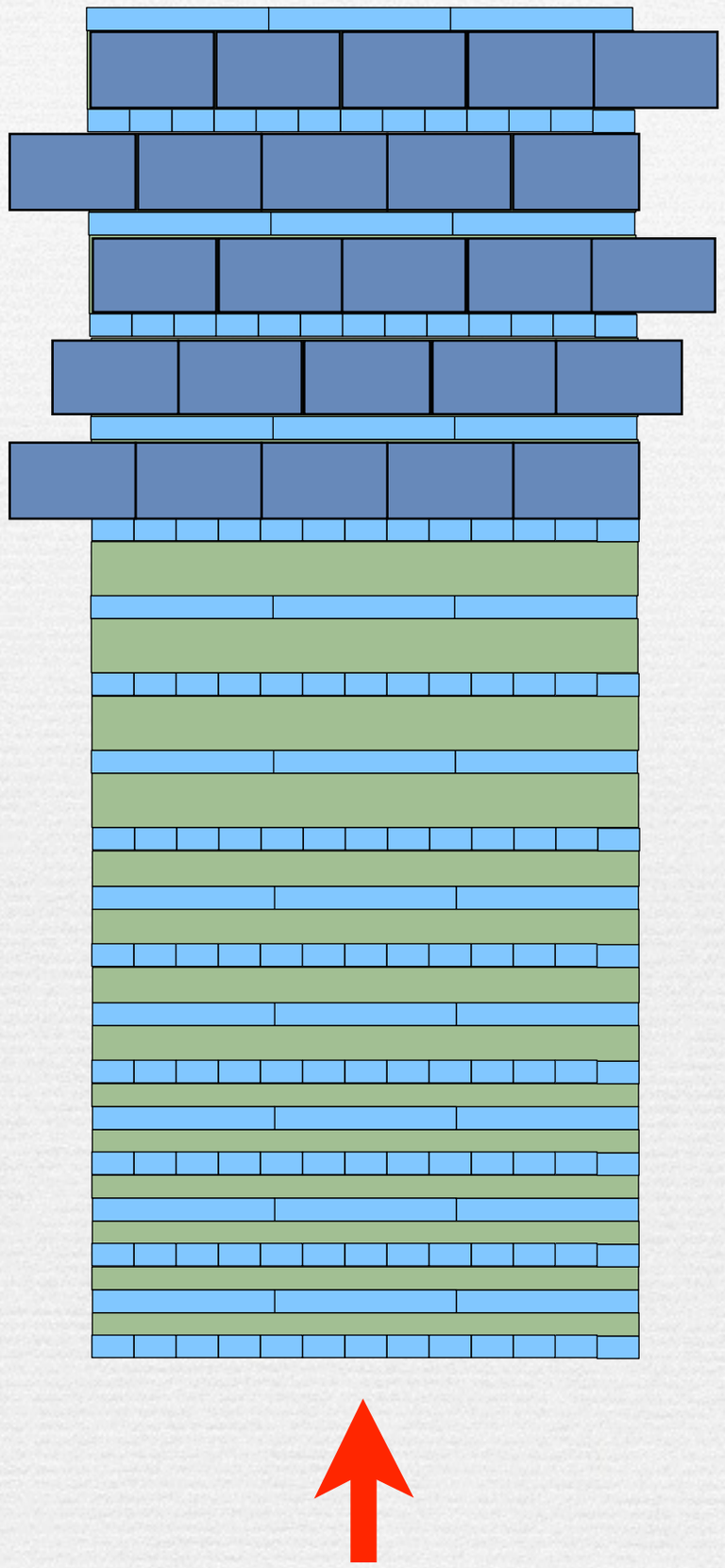


summary & outlook

- fine segmented scintillator strip CAL. is under developing with good timing capability
- strip has become homogeneous enough, without dead space by PPD
- embedded FEE is developed with LED & source calibration capability in lab. by auto-trigger mode
- combined DAQ with ECAL/AHCAL has been done

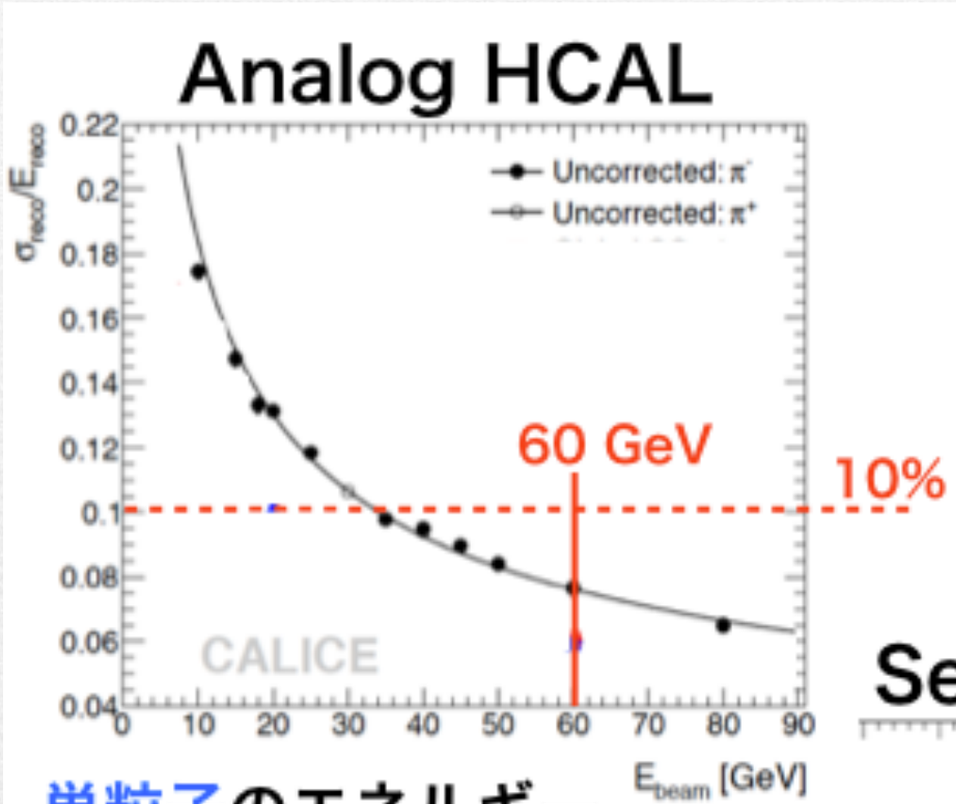
yet another Dream

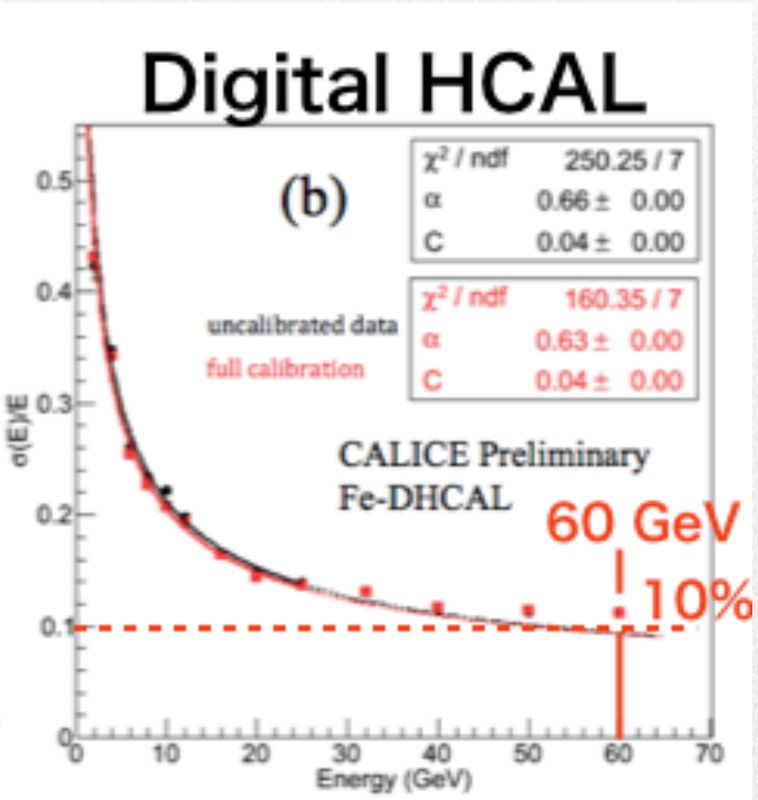
- a calorimeter with layered structure
- tungsten & active absorbers gradually thicker gradually and same thickness scintillator sensors



Energy measurement

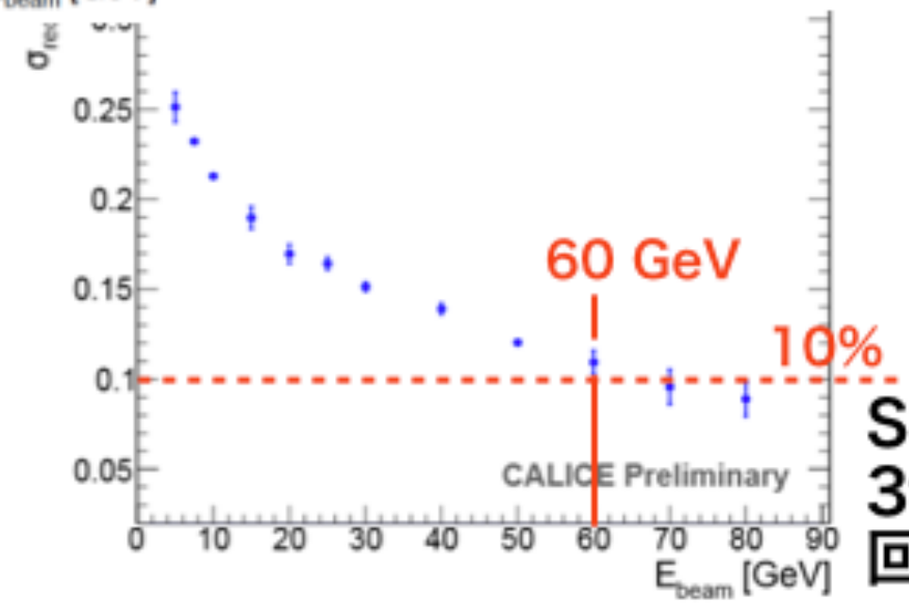
- AHCAL vs DHCAL





Semi Digital

単粒子のエネルギー分解能は AHCAL がよい

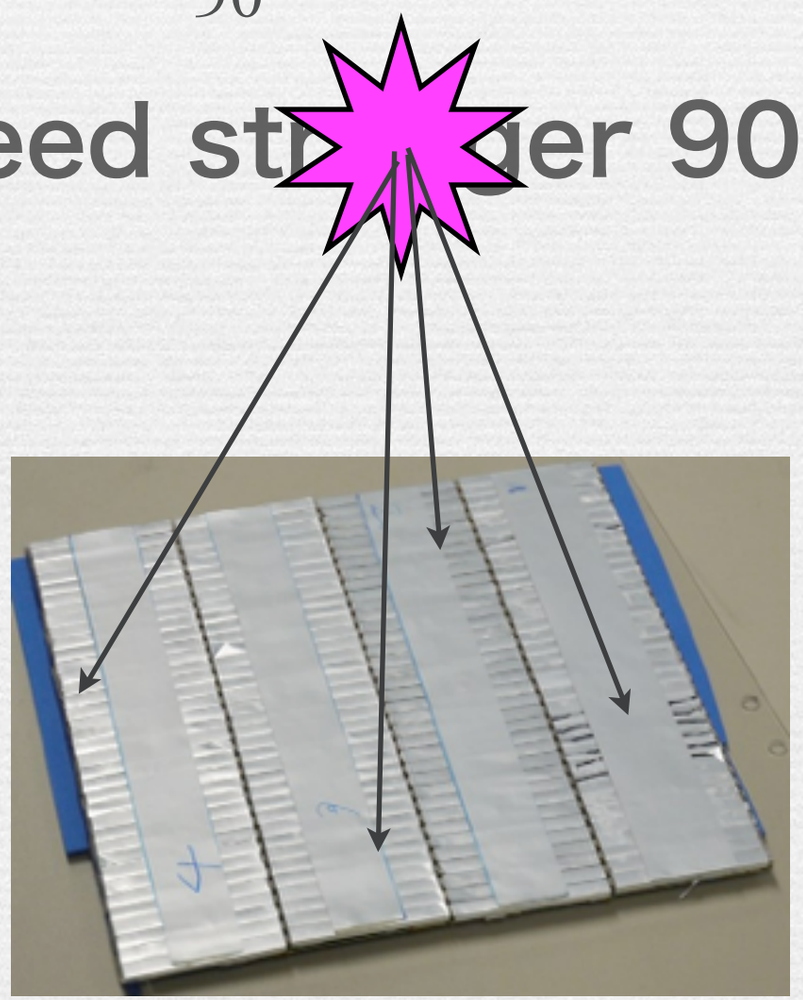


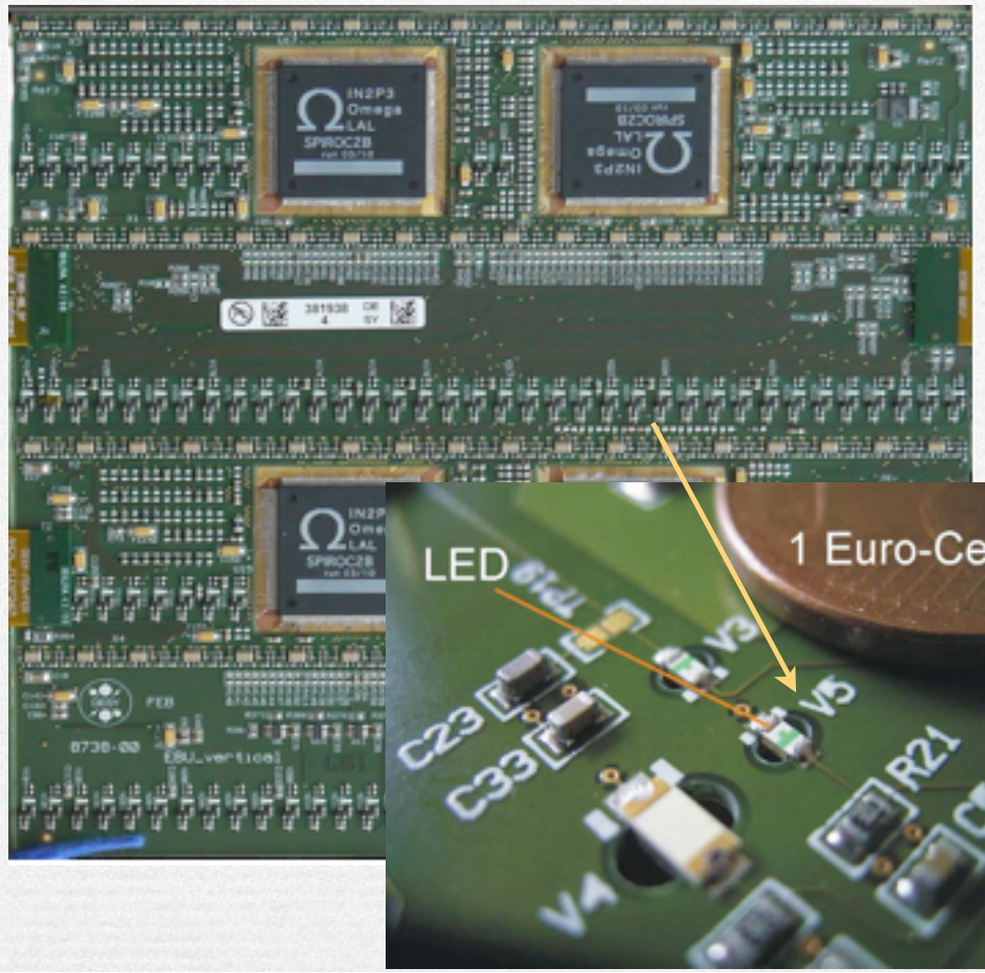
Semi D-HCAL は 3threshold で少し回復

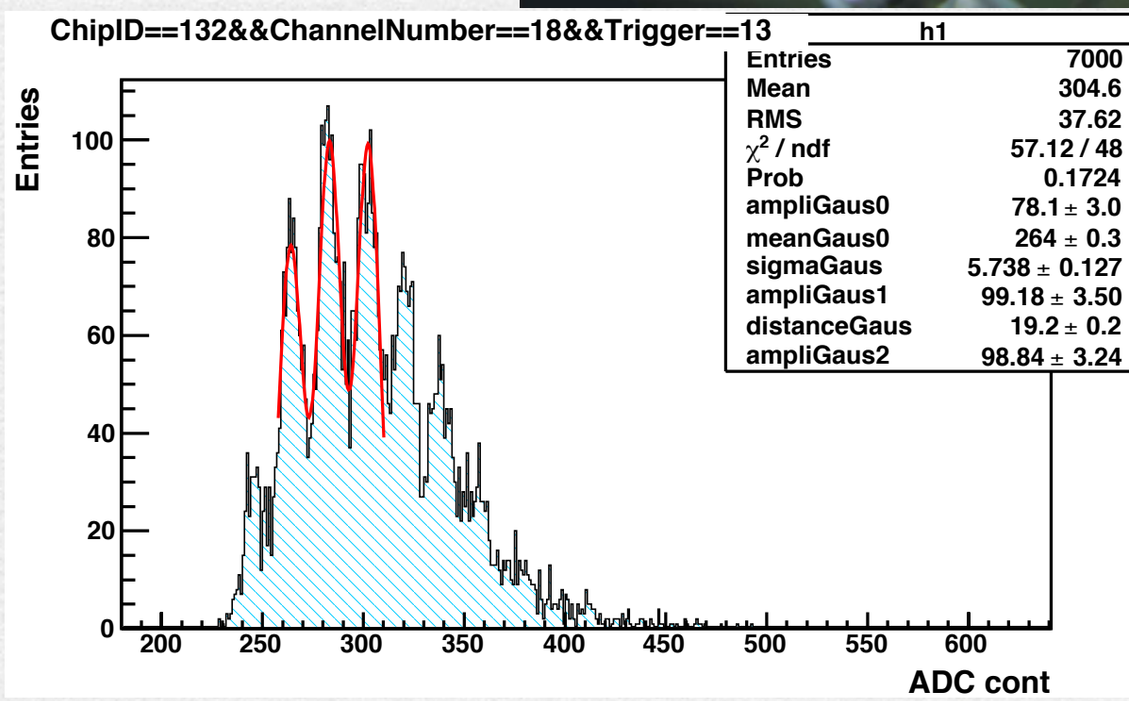
6

calibration

- LED lights go through a hole for each strip
- source test with auto-trig
- need st[illegible]ger 90Sr





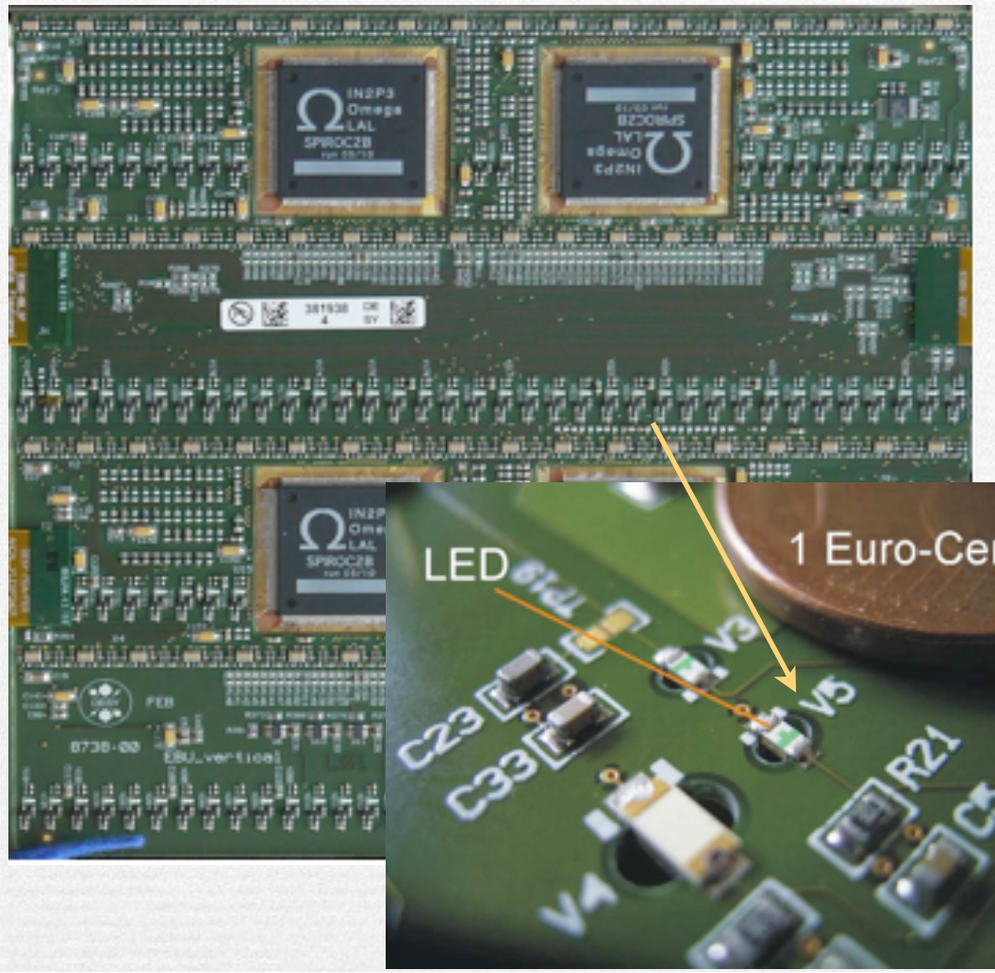


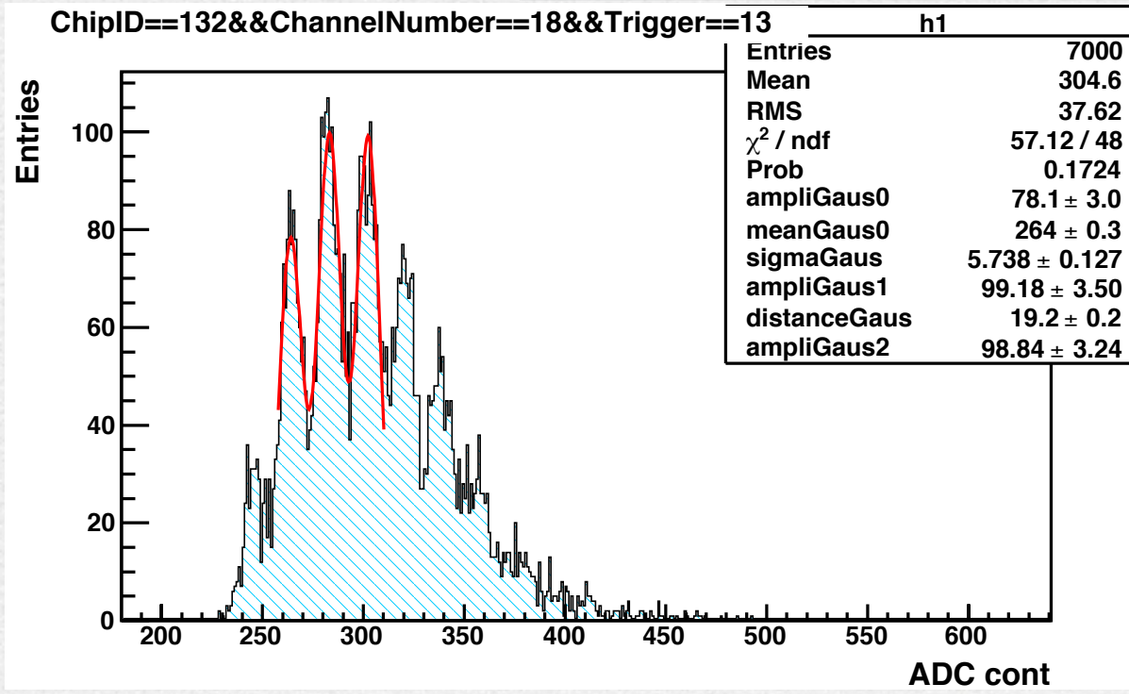
good for mass test

can be carried out at lab.

calibration

- LED lights go through a hole for each strip
- source test with auto-trig
- need stronger 90Sr

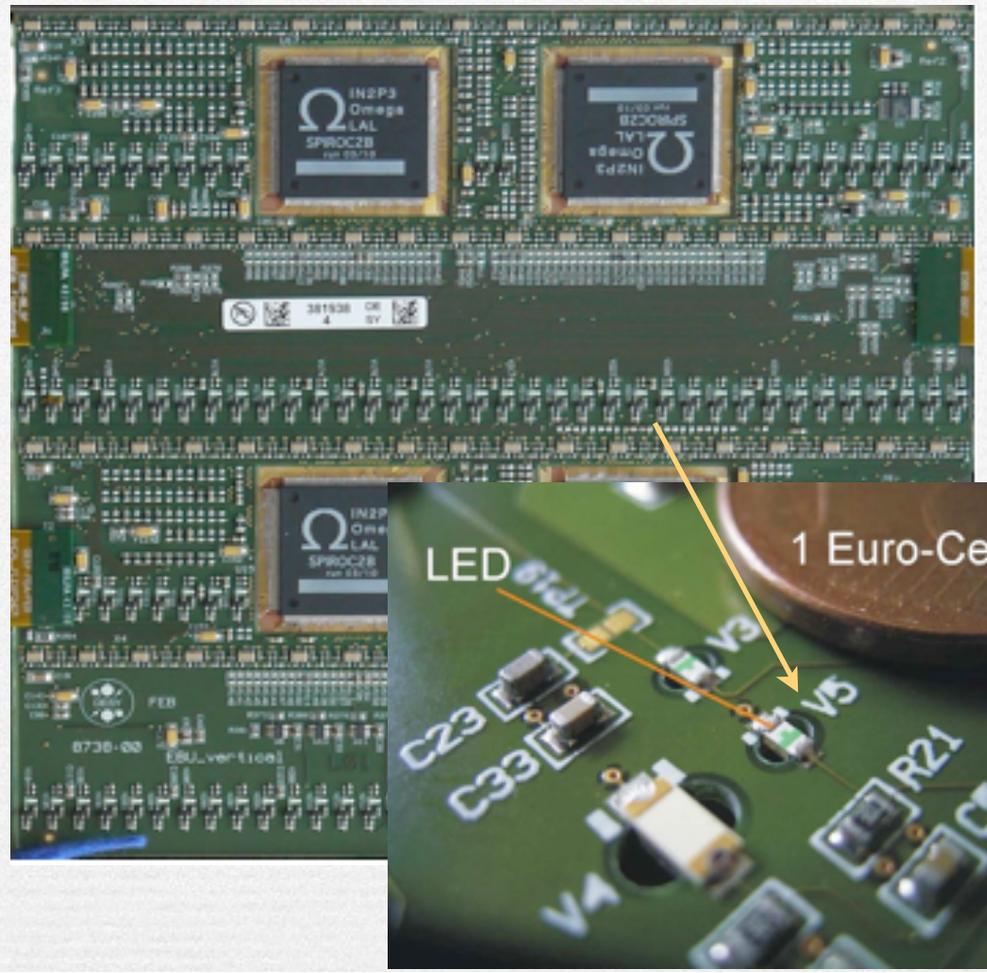


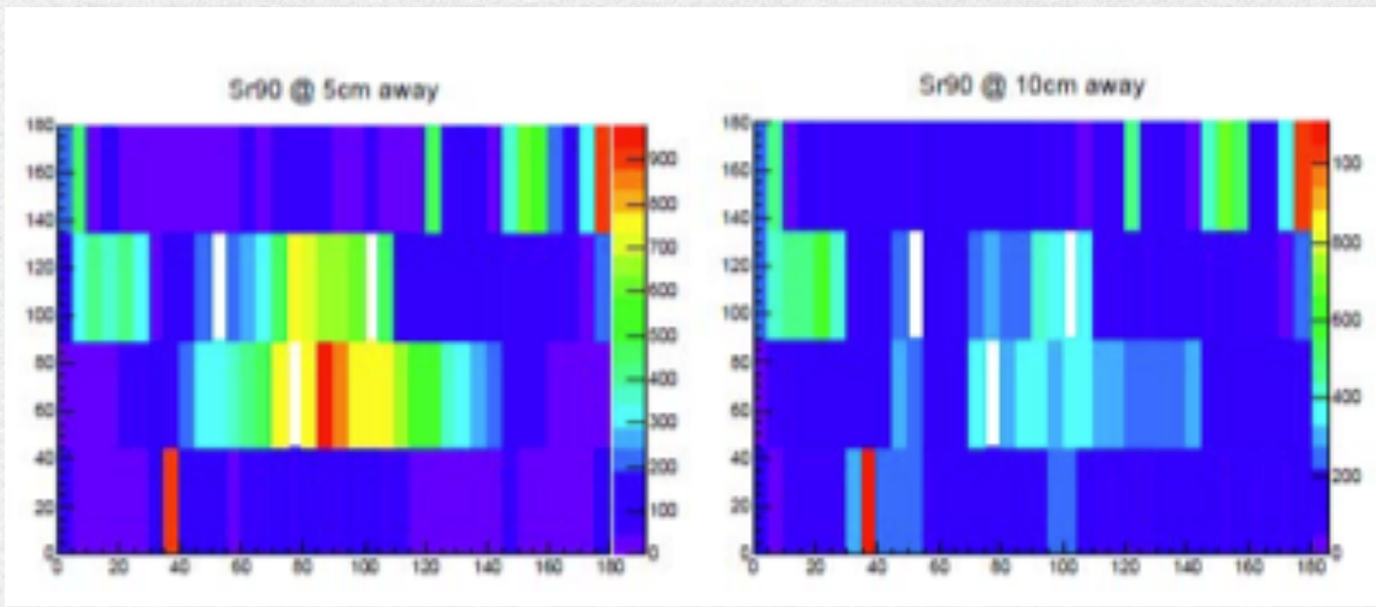


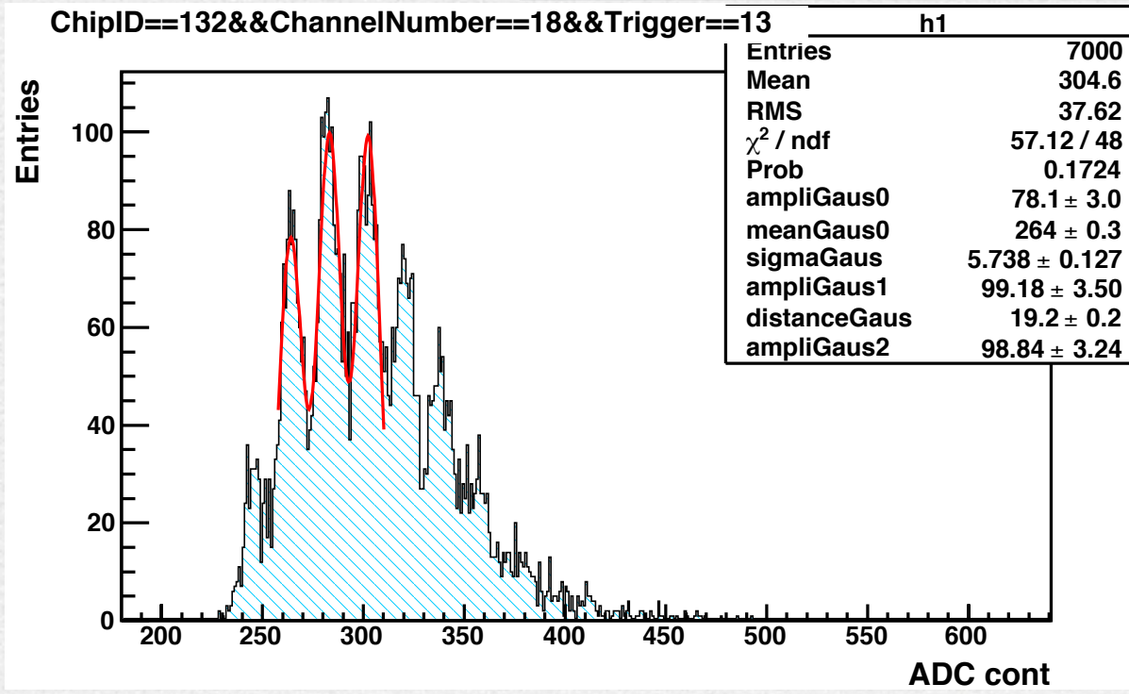
can be carried out at lab.

calibration

- LED lights go through a hole for each strip
- source test with auto-trig
- need stronger 90Sr







5cm 10cm can be carried out at lab.