Study of TOF-PET performance

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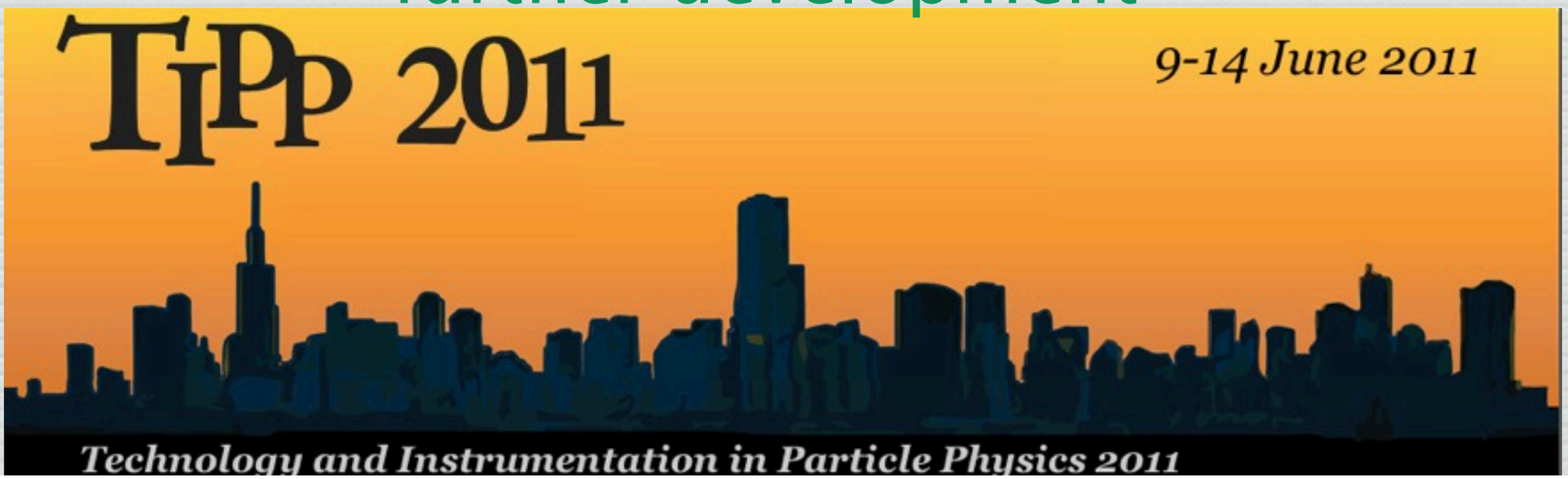
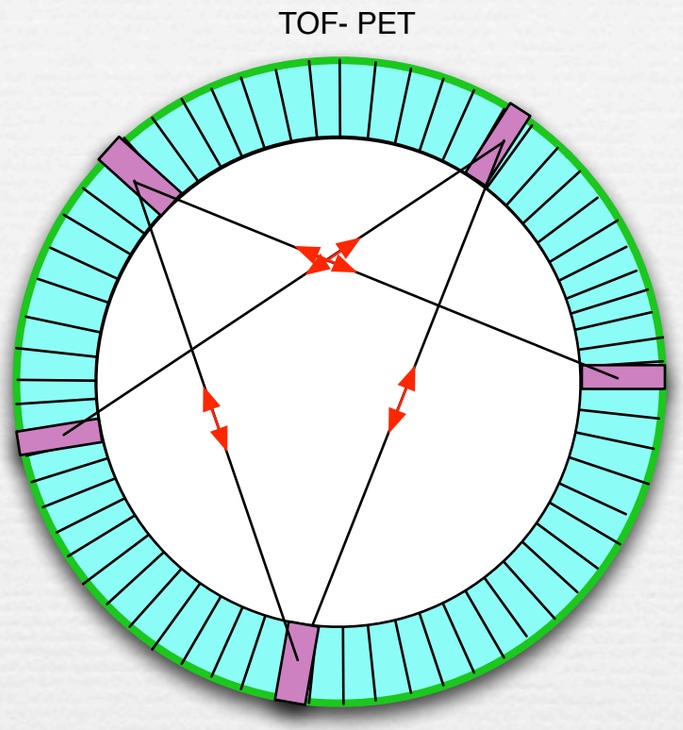
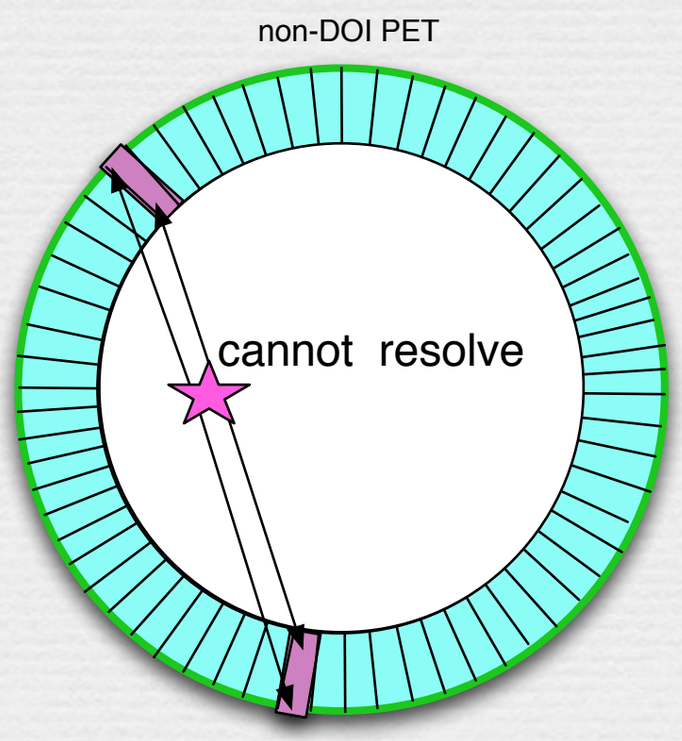
next generation PET
TOF performance
further development

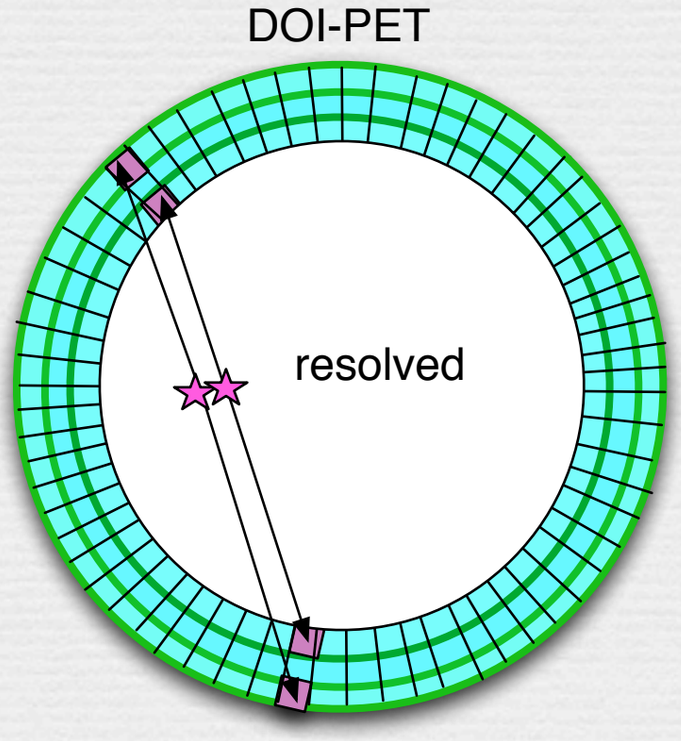


next generation PET

- cleaner view : TOF ＜0.1ns
- homogeneous picture at non-center
- DOI : Depth Of Interaction proposed
- multi layer structure







TOF performance

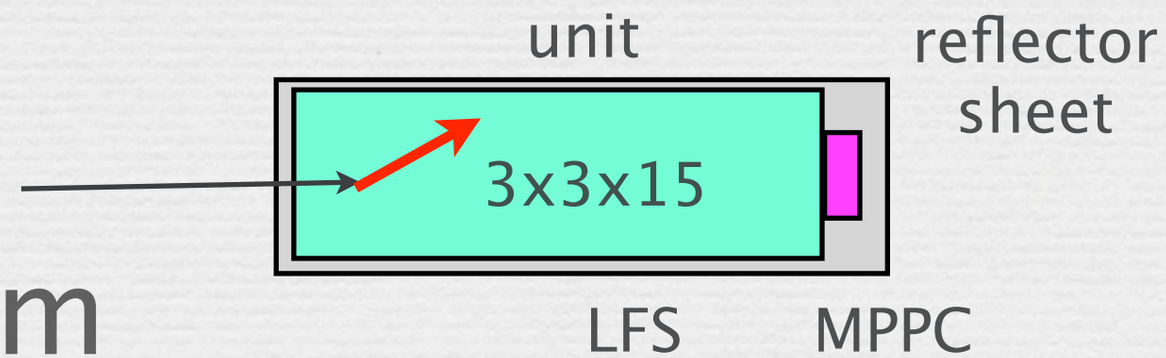
- measurement by a pair of unit
- unit : a scintillator & a photosensor

Zecotek

- scintillator : LFS 3x3x15mm^3 ~ LYSO
  - emission peak~ 420nm, short signal ~ 30ns

Hamamatsu

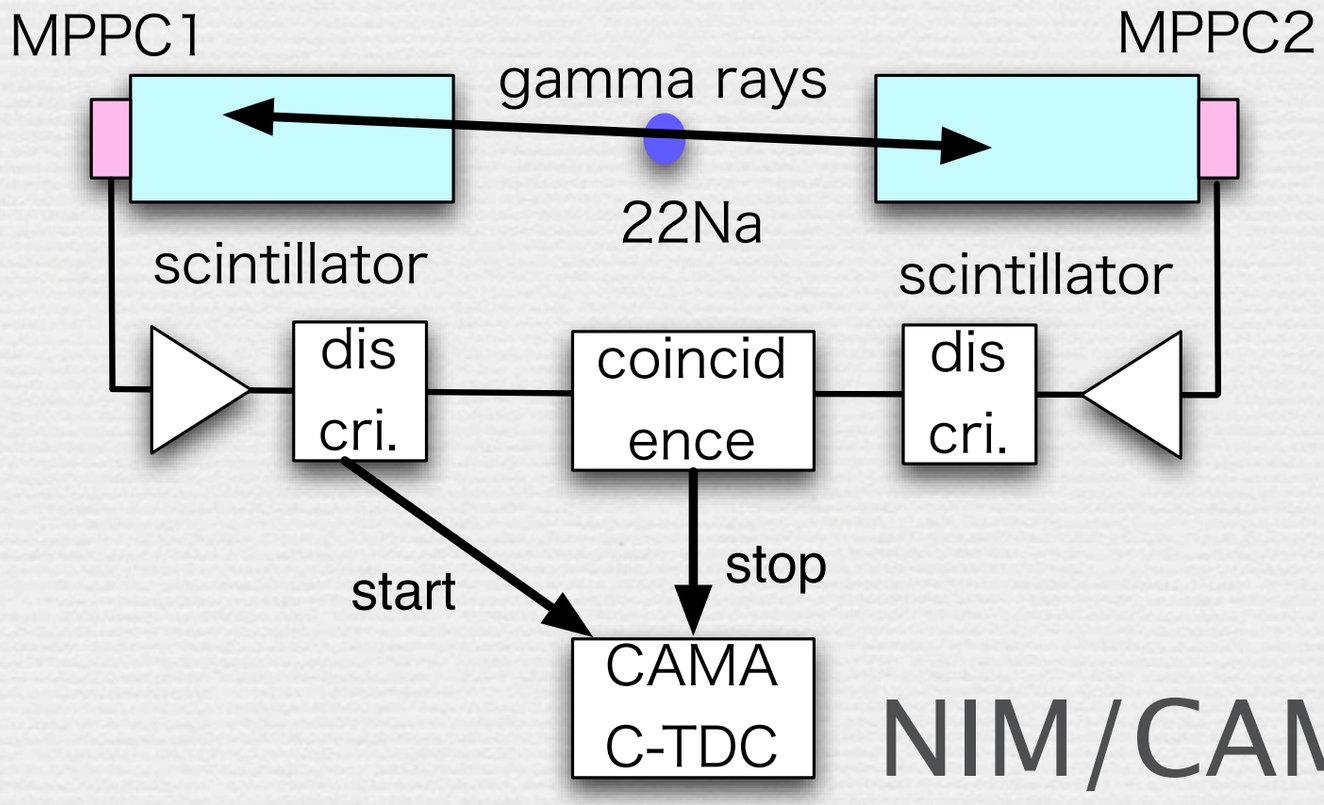
- photosensor : MPPC, 1600 pixel for 1mm^2 25 μm pitch
  - PDE peak at 420nm

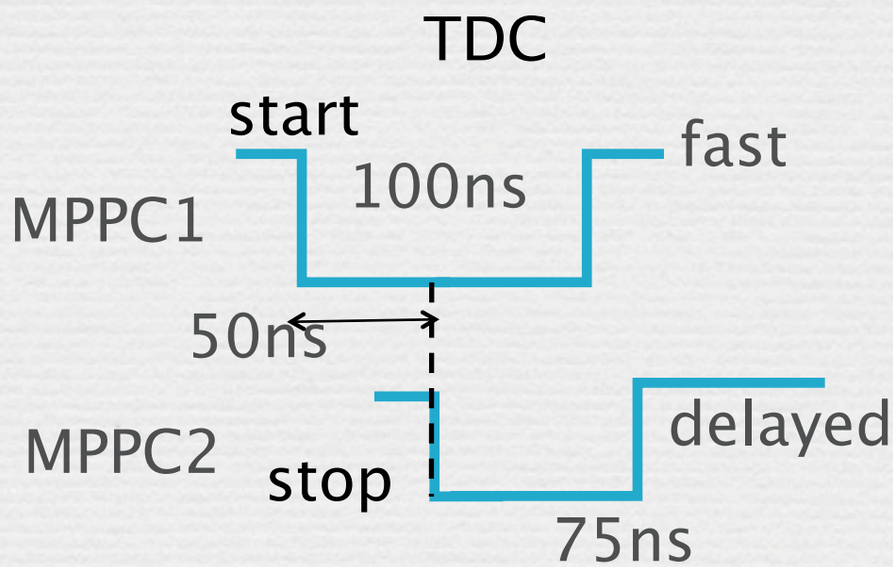


TOF test set up

- measure rise time difference in two units
- TOF: one MPPC1 and the coincidence signal from 22Na

timing of MPPC2





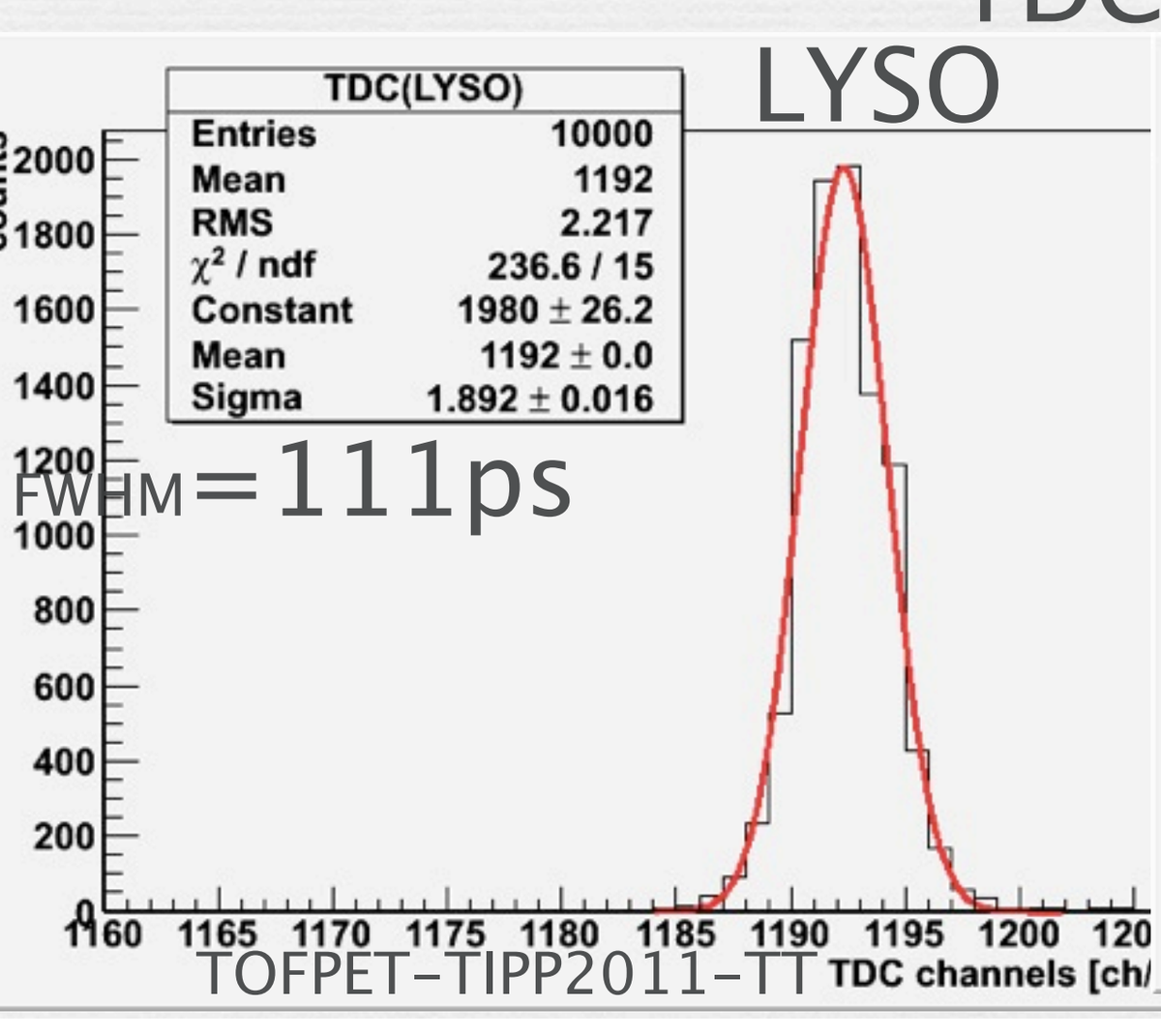
- LFS and LYSO with the same MPPCs

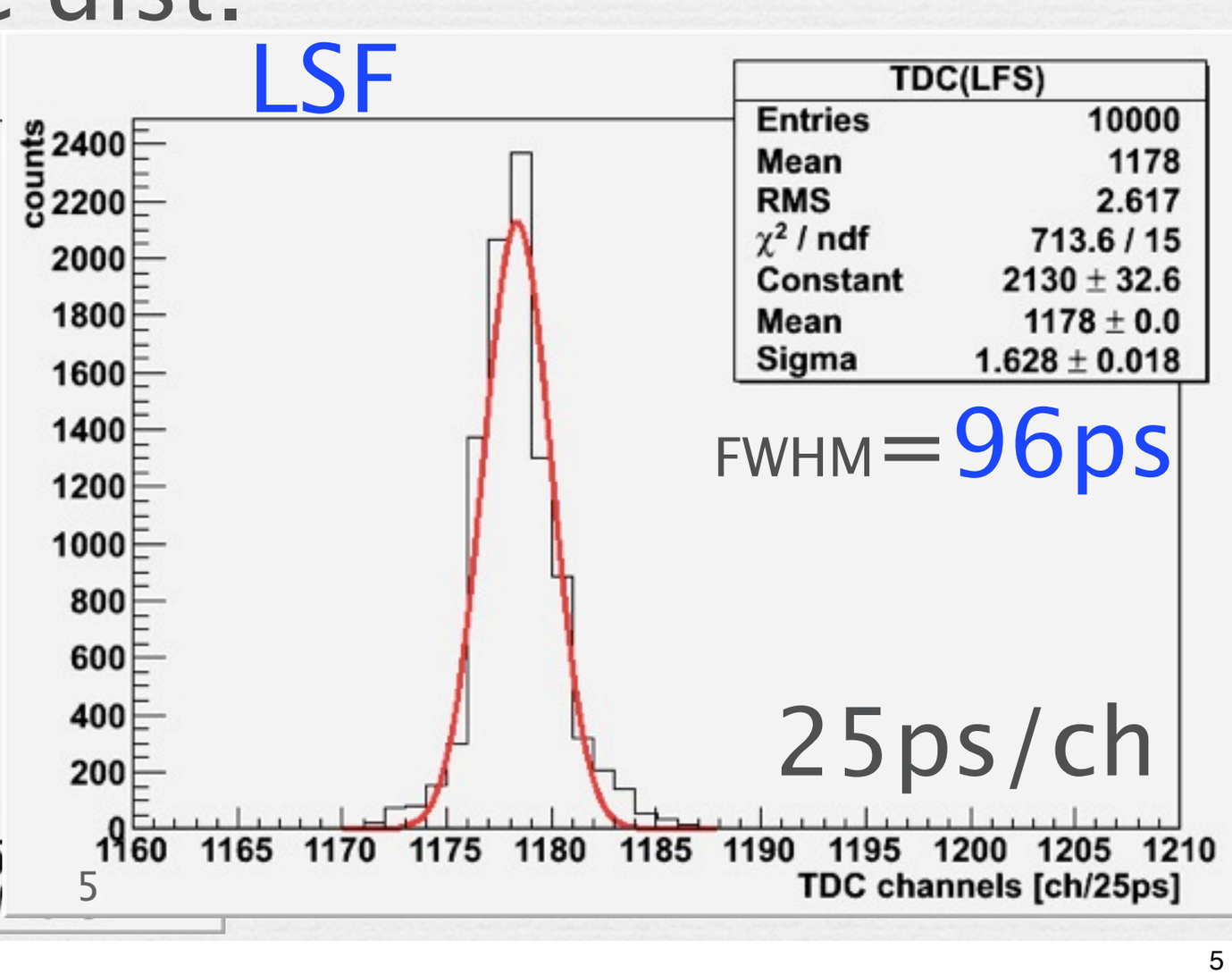
NIM/CAMAC

TOF results

- TDC distribution : time difference measurement between two units
- FWHM **96**+-1ps for LFS & 111+-1 ps for LYSO

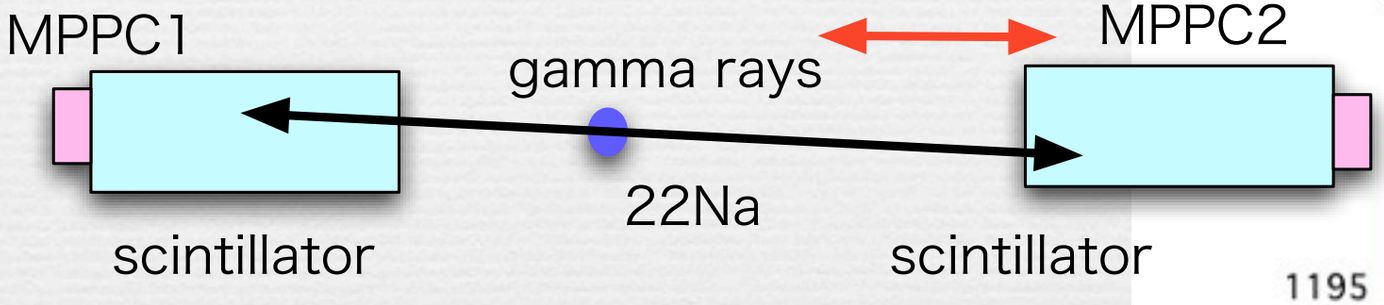
TDC dist.



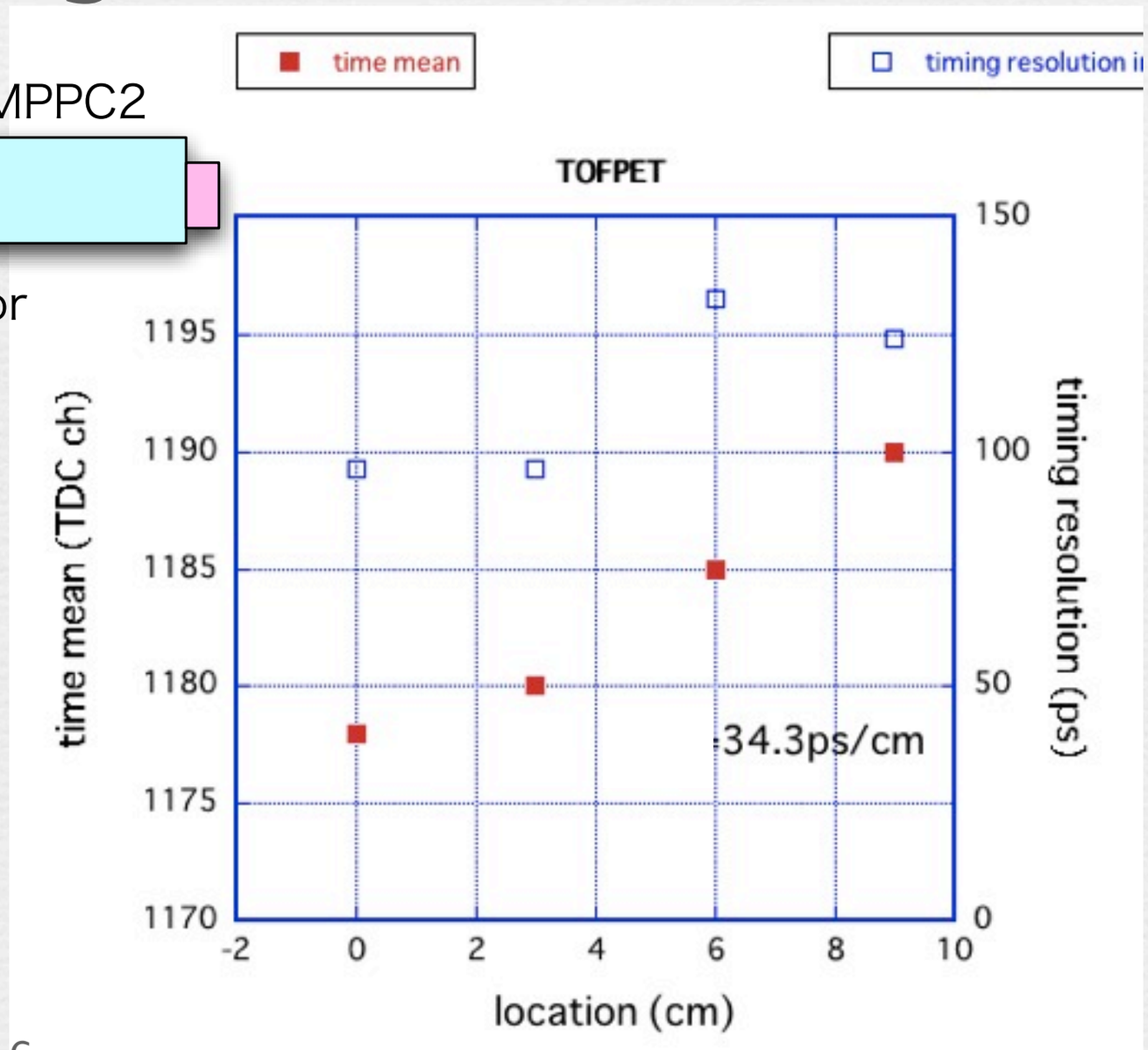


confirmation – I

- location of a unit shifted from the source
- timing of the stop signals were moved



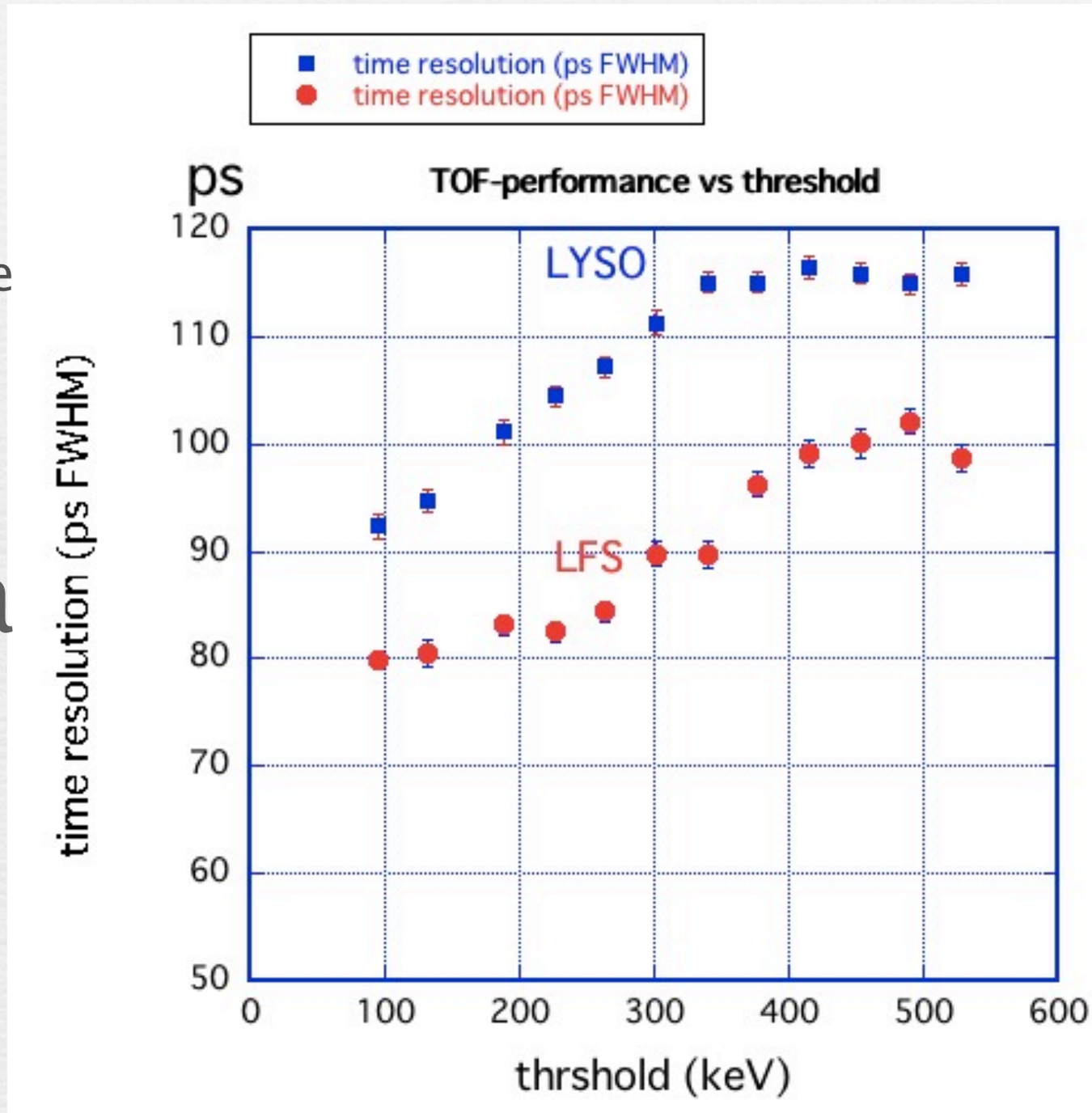
by moving the detector2 resulted 34 ps/cm ~ 1/c



confirmation – II

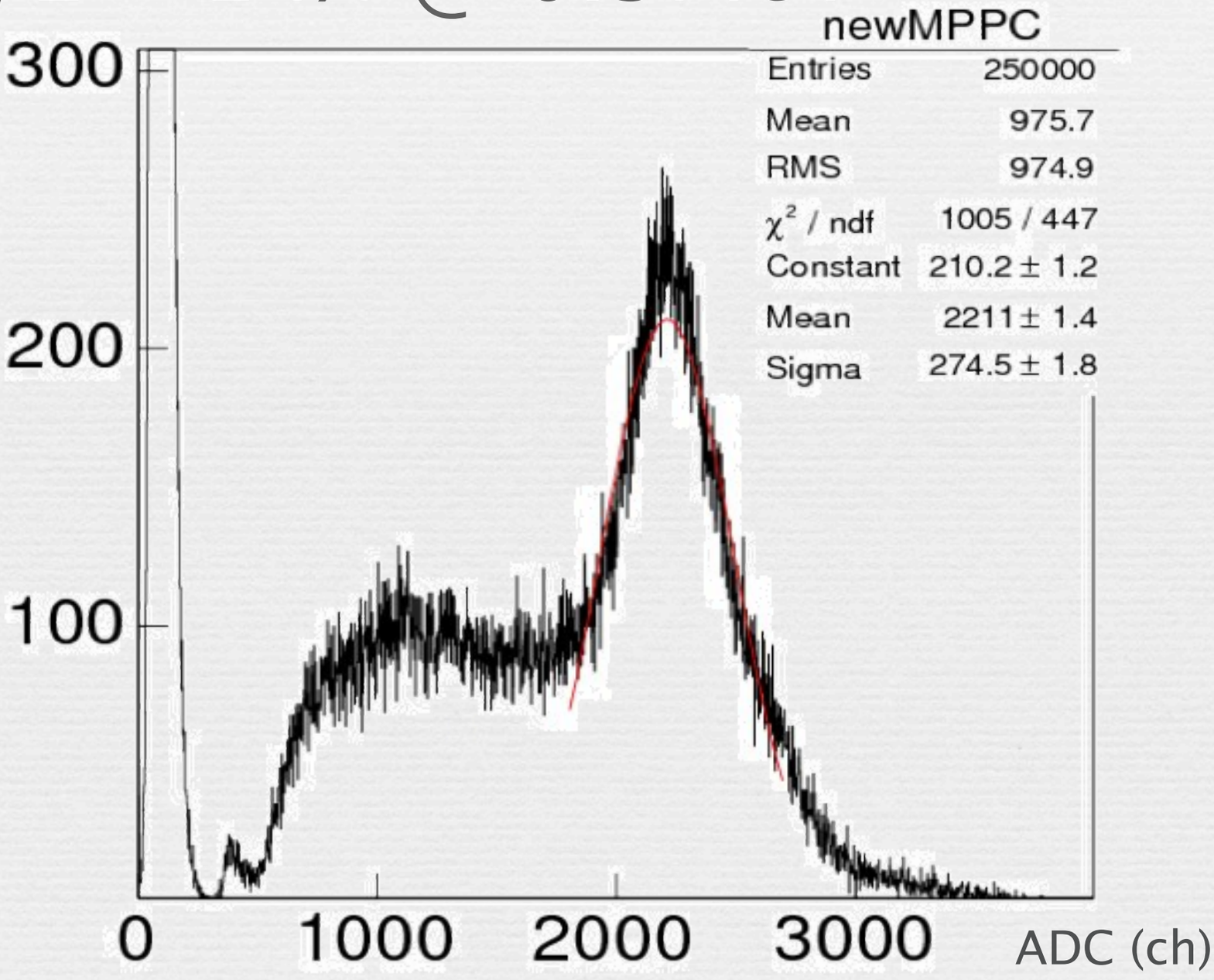
- timing resolution by a 22Na source
- threshold dependence

  simultaneous change
- LFS is better than LYSO
- at 0.5MeV gamma TOF resolution stays const.
- at lower energies, better TOF resolution



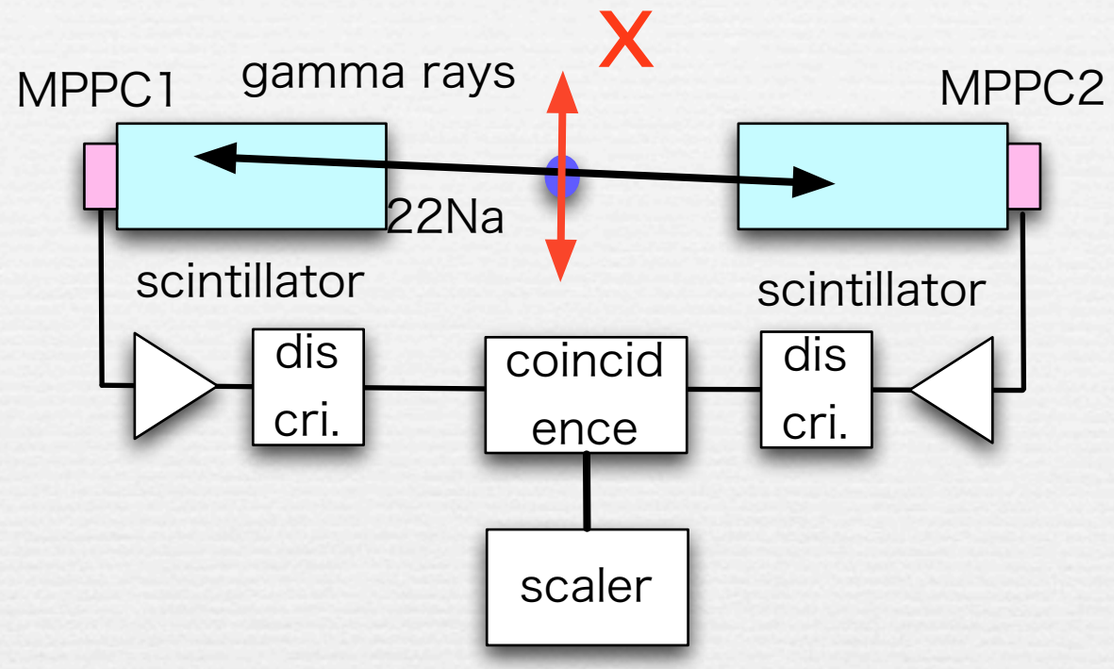
confirmation – III

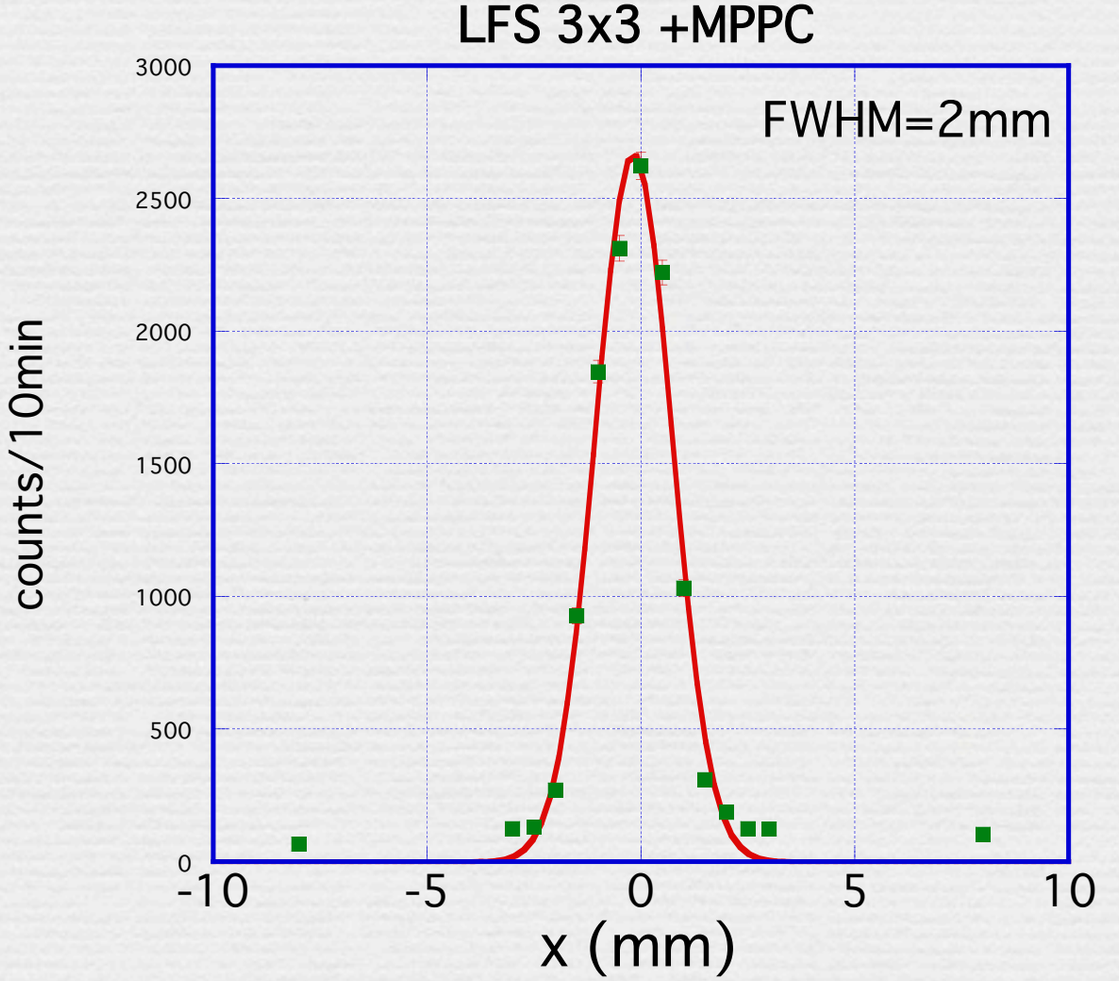
- energy distribution: LFS+MPPC
- $\sigma/E \sim 14\%$ @ 0.5MeV 3x3 vs 1x1 mm^2



special resolution

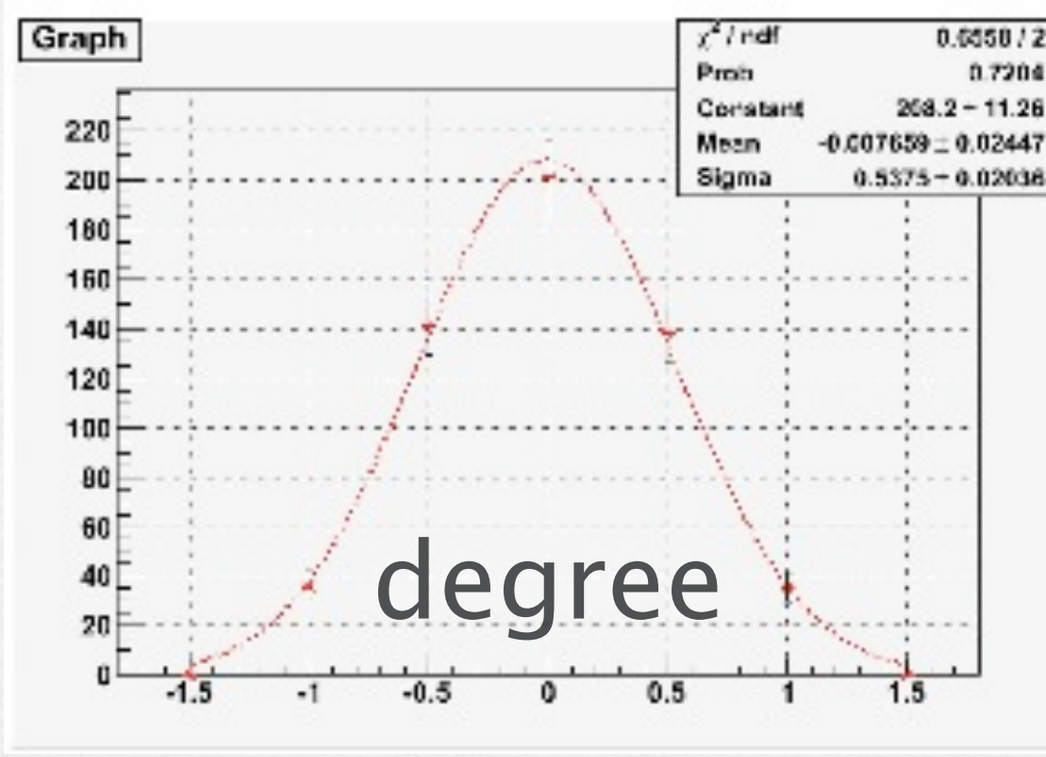
- using 2 units of LFS & MPPC
- by moving the source position
- 2mm resolution for LSF/LYSO
- size 3mm of scintillator
- consistent with simulation

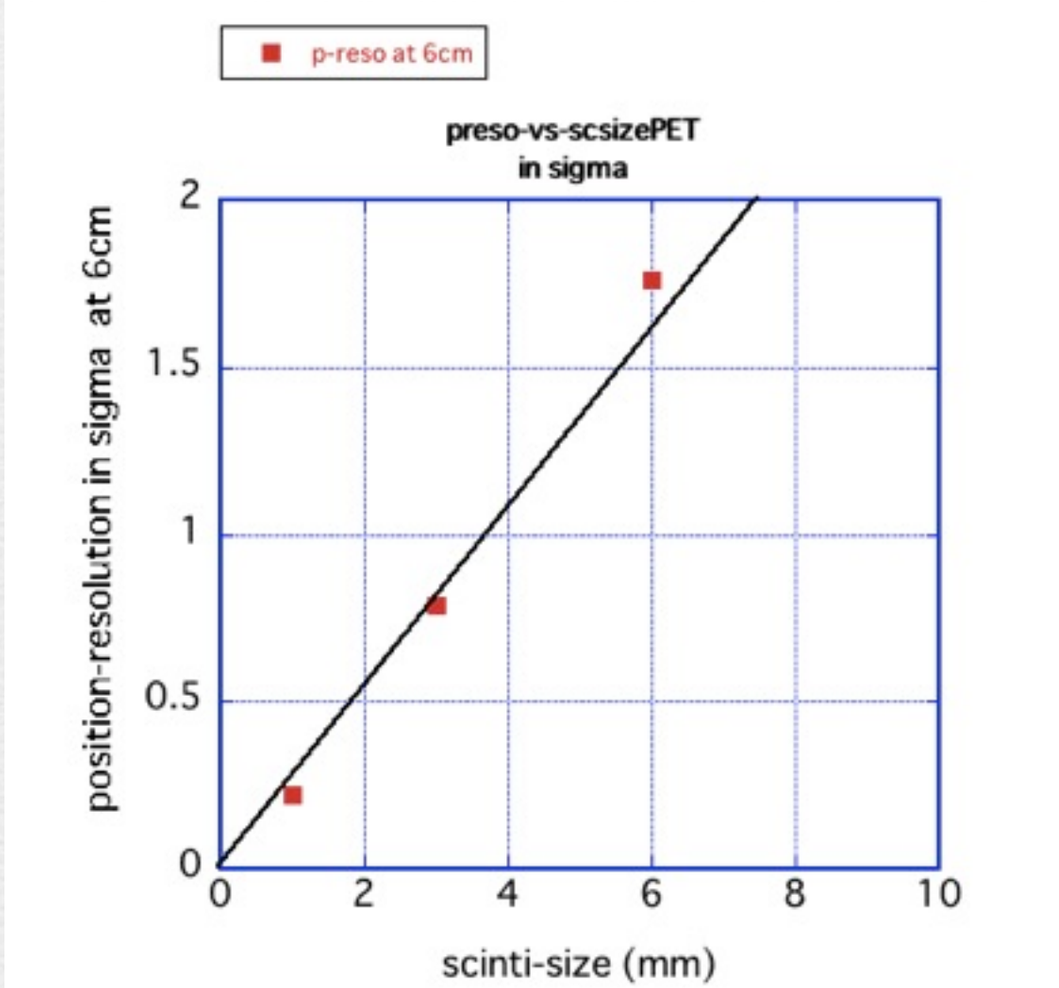




PET simulation

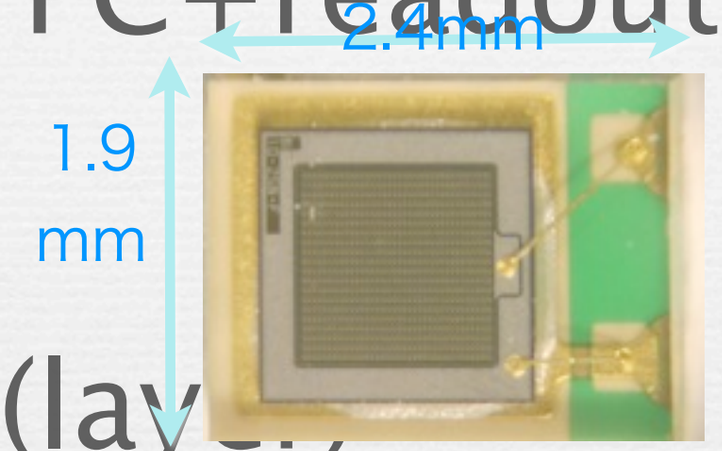
- GEANT4
- angle resolution at 6cm with 3x3mm^2
  - 0.6 deg. in sigma
    - consistent with exp.
- special resolution ~1mm
- achievable with 3mm cell

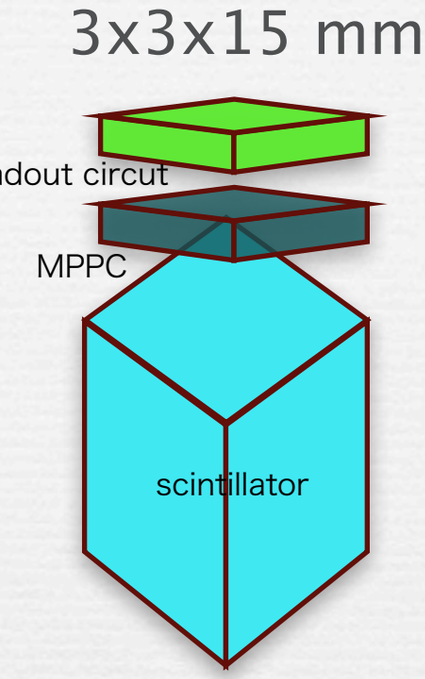


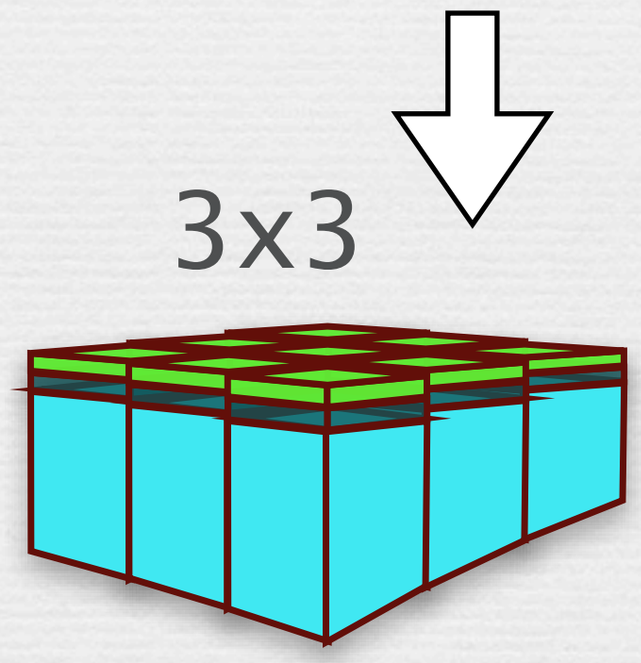


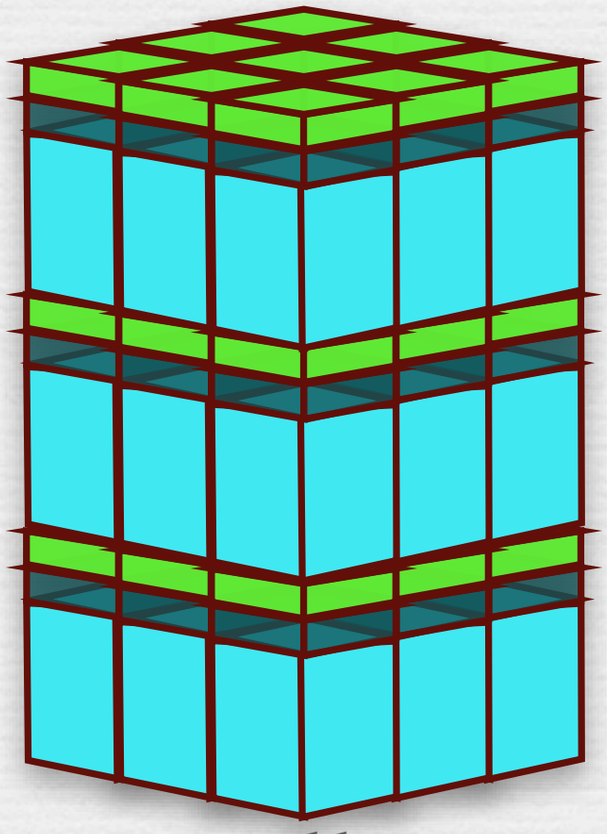
DOI capability

- units block : LFS+MPPC+readout
- matrix of 3x3
- 3D matrix of 3x3x3 (layer)
  - precise timing



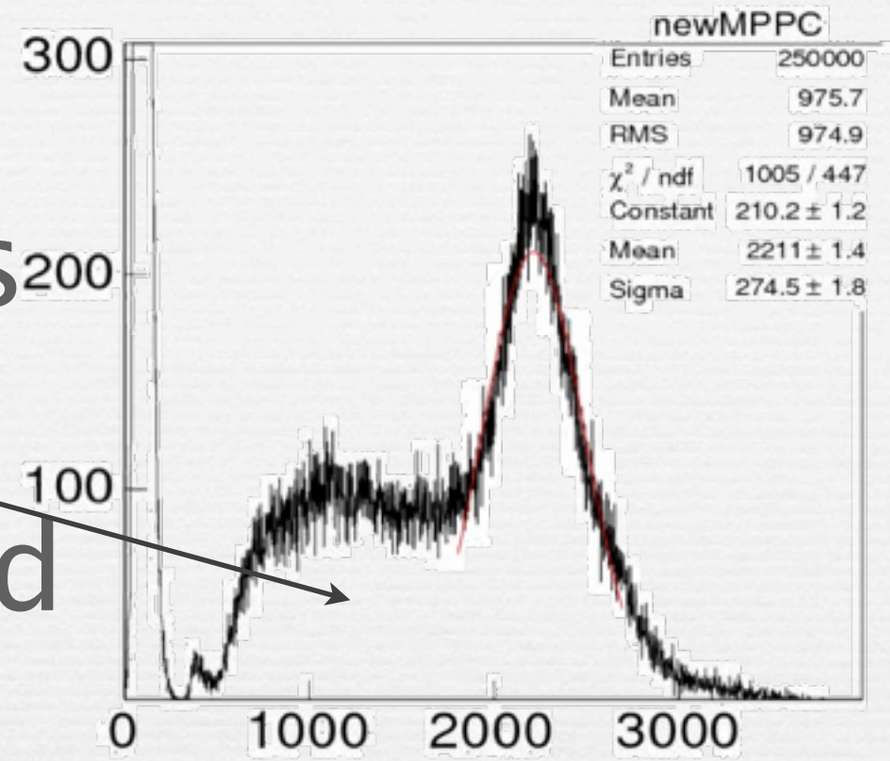




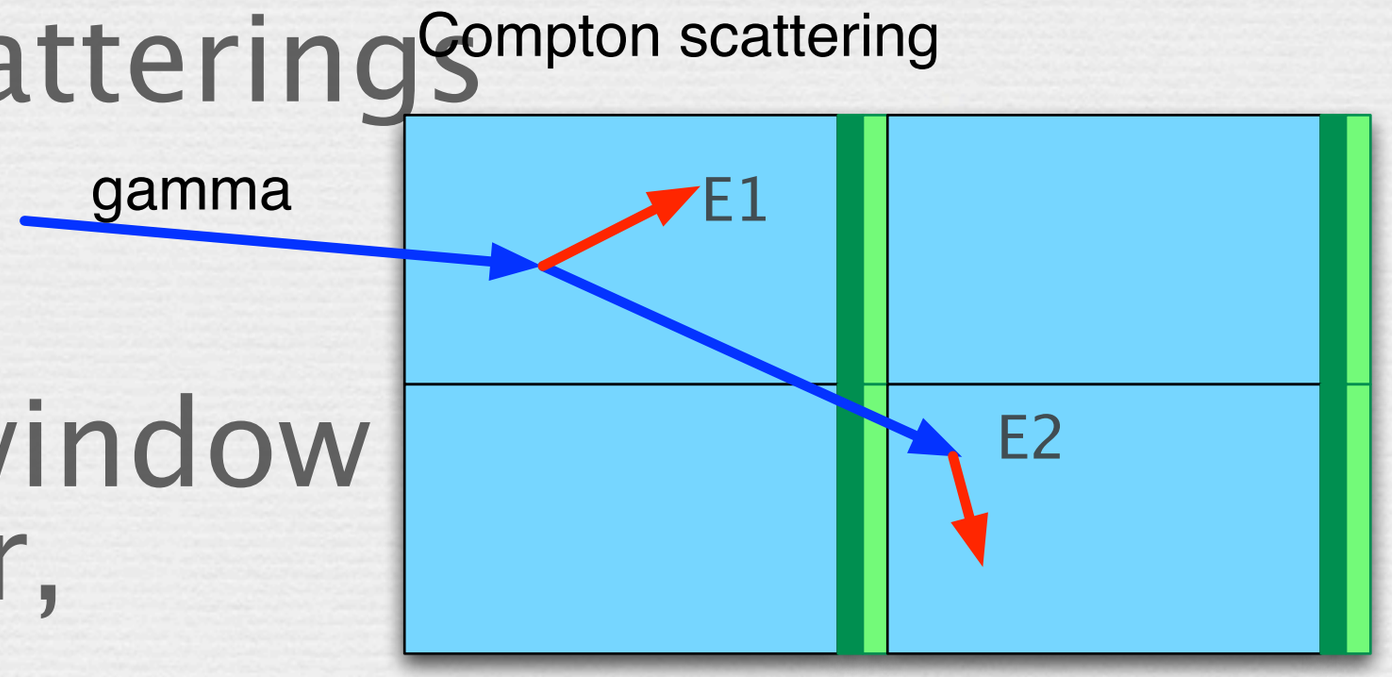


Compton PET

- ~ half of interactions does Compton scattering
- applying 0.4MeV threshold
- $(0.5)^2$ of positron annihilation used ~25%



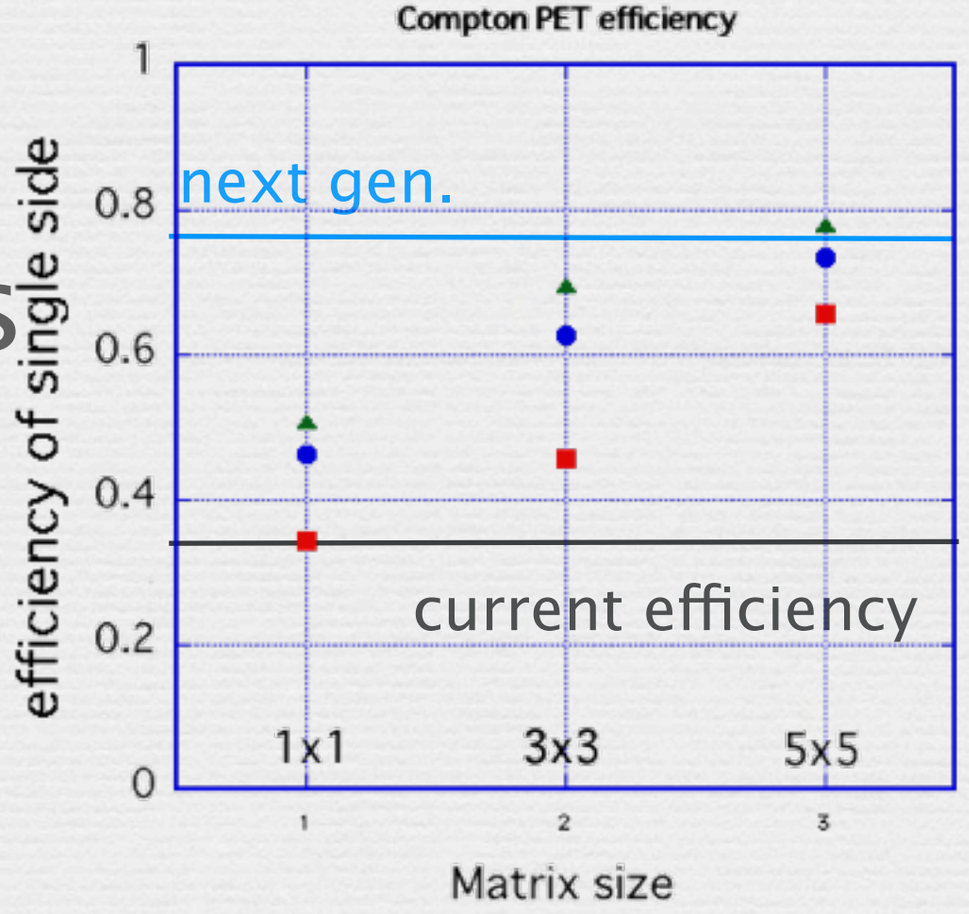
- lower the thresholds : take into Compton scatterings
- ~80% events
- with short time window to fast scintillator, E1+E2~0.5MeV



Compton PET II

simulation cont.

- 15mm long scintillators make layers into 1,2 &3
- 5x5 matrix can detect 80% efficiency simulation
- efficiency ~ 35% : 1x1x1
- coincidence in both sides
- makes 3 times better eff.



summary and outlook

- for the next generation PET
- TOF capability < 100ps ~ 3cm=cΔt
  - achievable with MPPC & LFS
- spacial resolution ~ 1mm possible with 3mm cell
- DOI test kit 3x3x3 under construction
- Compton PET reduces dose by 3 times higher eff.