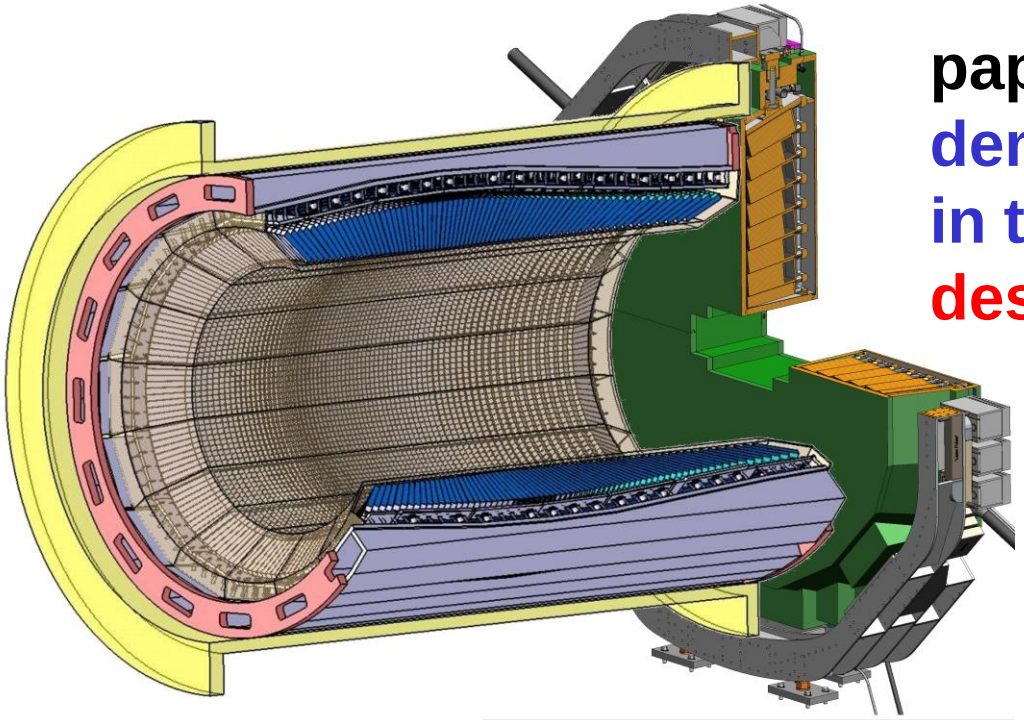
Performance of PWO endcap calorimeter



paper draft, aim:
demonstrate the quality of the EMC in the present (final) mechanical design with gaps and dead layers; clustering, edge effects, position resolution

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and …

Updated authorlist …to be completed

Design

~~Performance~~ of the PWO End-cap Calorimeter for $\overline{\mathrm{P}}$ANDA

and performance studies

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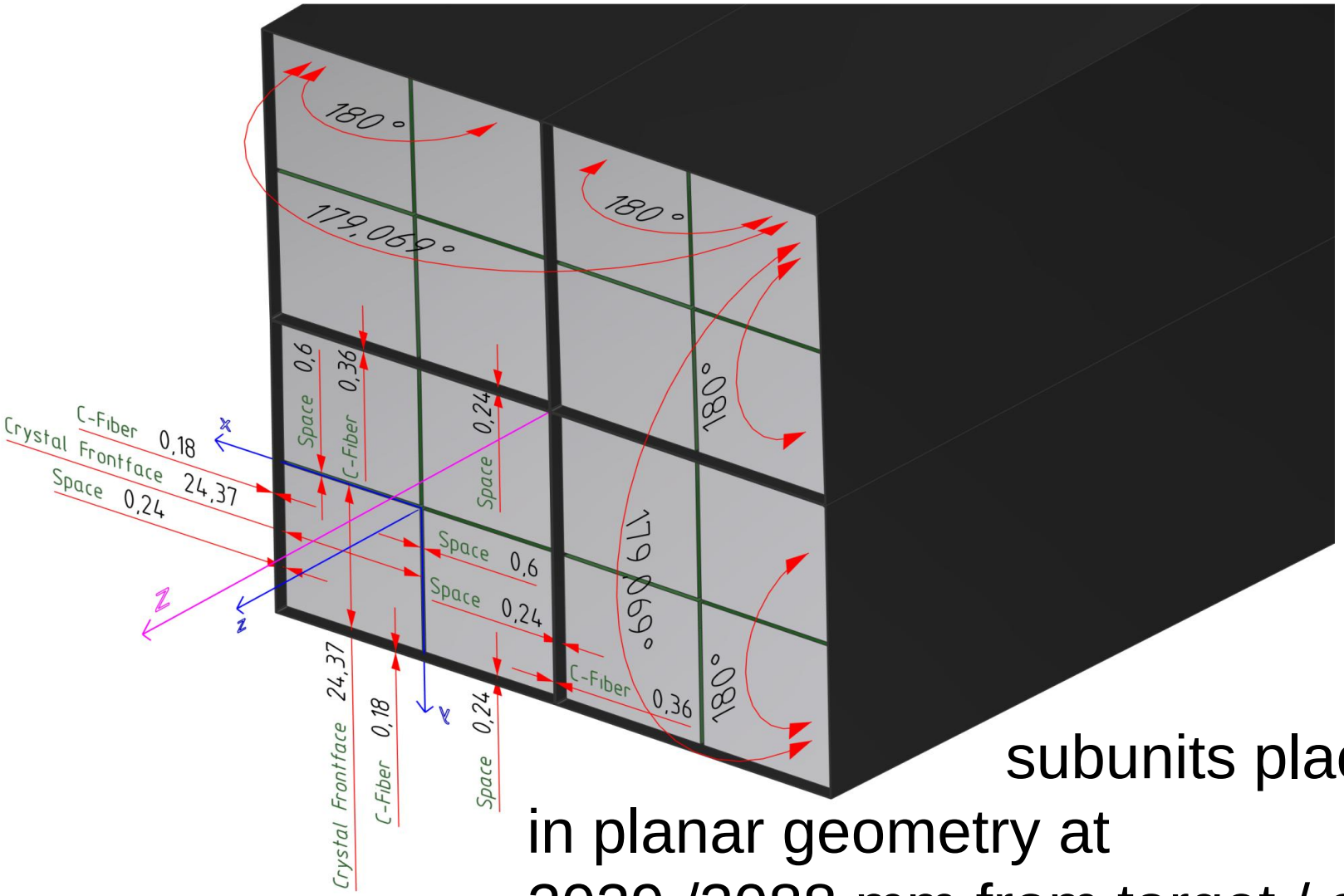
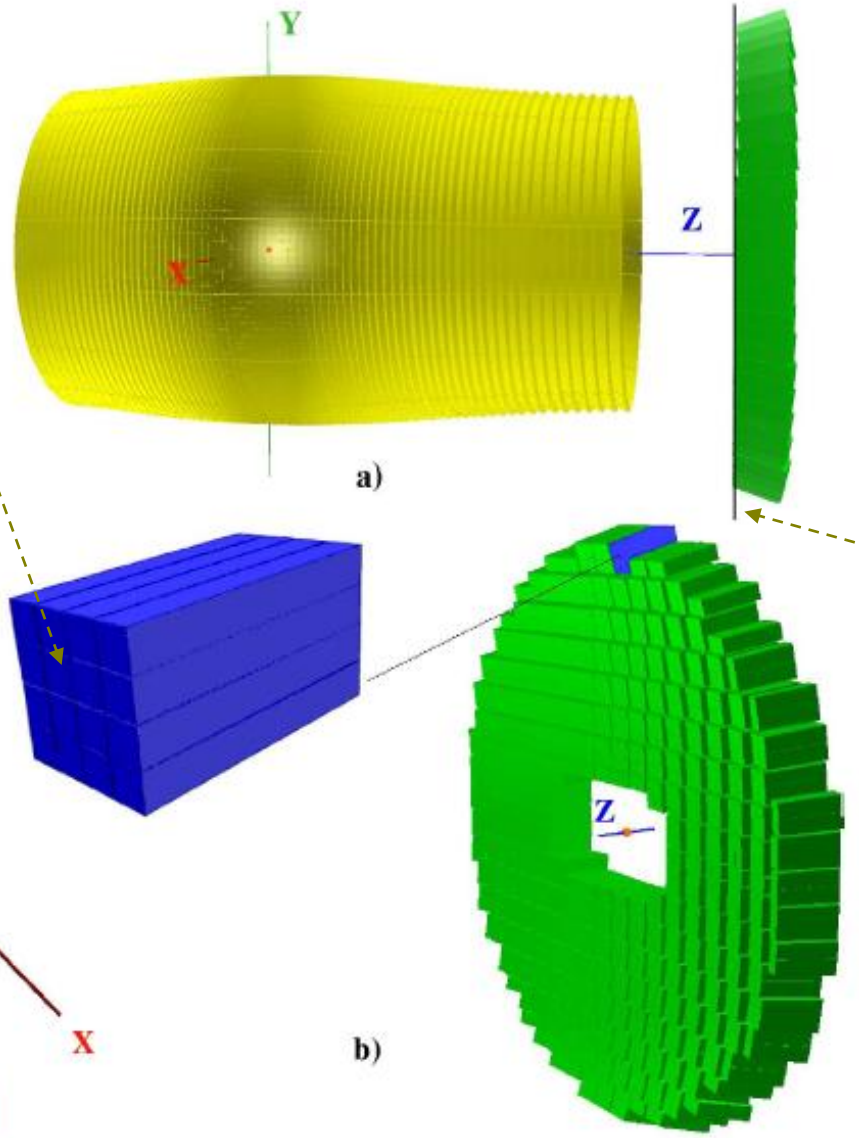
subunit geometry



subunits placed
in planar geometry at
2039 /3088 mm from target / off-point

PandaROOT implementation



crystal plane

front plane

full and half subunits implemented

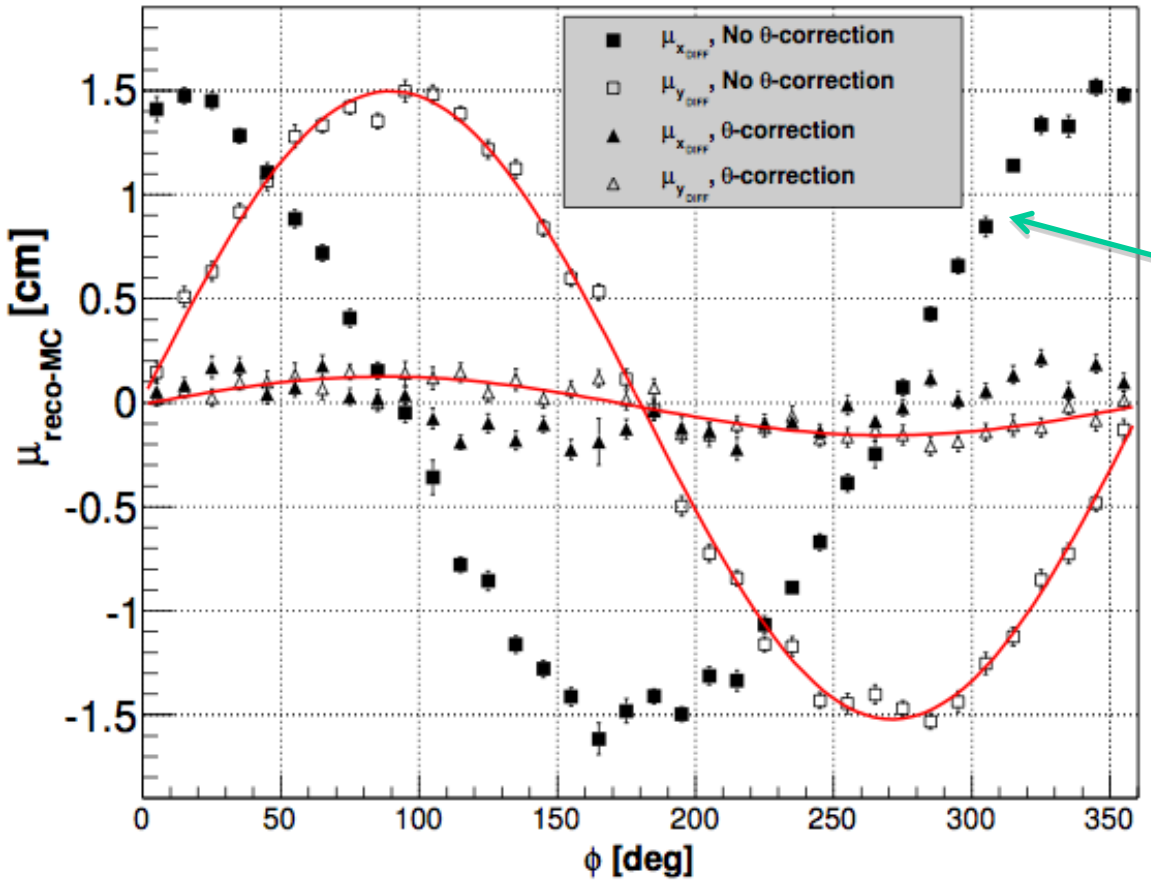
Position reconstruction

"digi" = signal after digitization passing detection threshold (2-3 MeV)

Weights $W_{digi} = W_0 + \ln (E_{digi} / E_{cl})$

$W_0 = A - B \exp (-C E_{cl})$

$$\vec{r}_{cl} = \frac{\sum_{digi} W_{digi} \cdot \vec{r}_{digi}}{\sum_{digi} W_{digi}}.$$



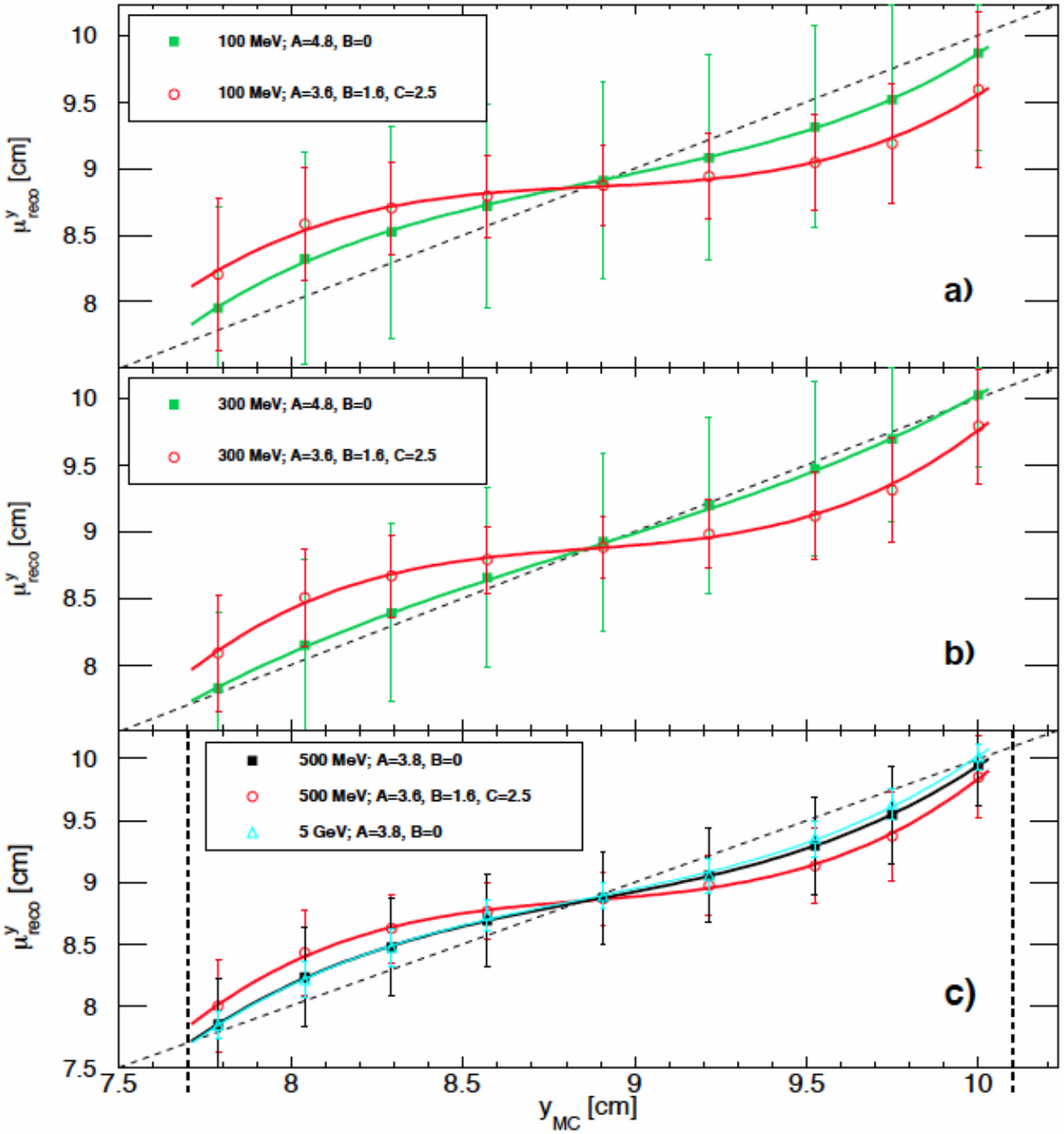
sinusoidal deviations reco-MC (caused by off-point design)

corrected by lookup table: residual (σ) deviations

0.1 0.13 0.2 mm for

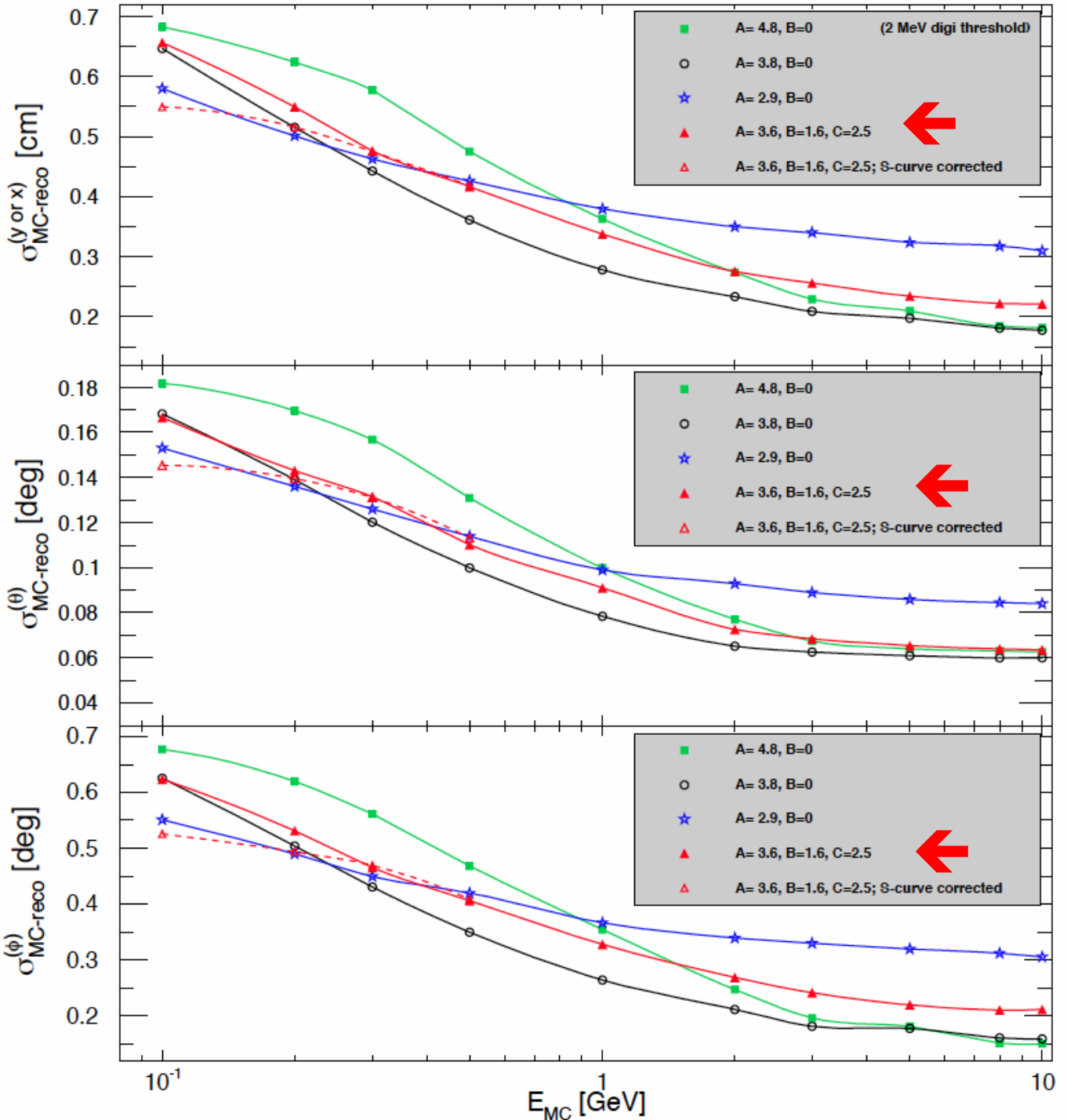
0.1 1 5 GeV

Reconstructed vs. MC positions

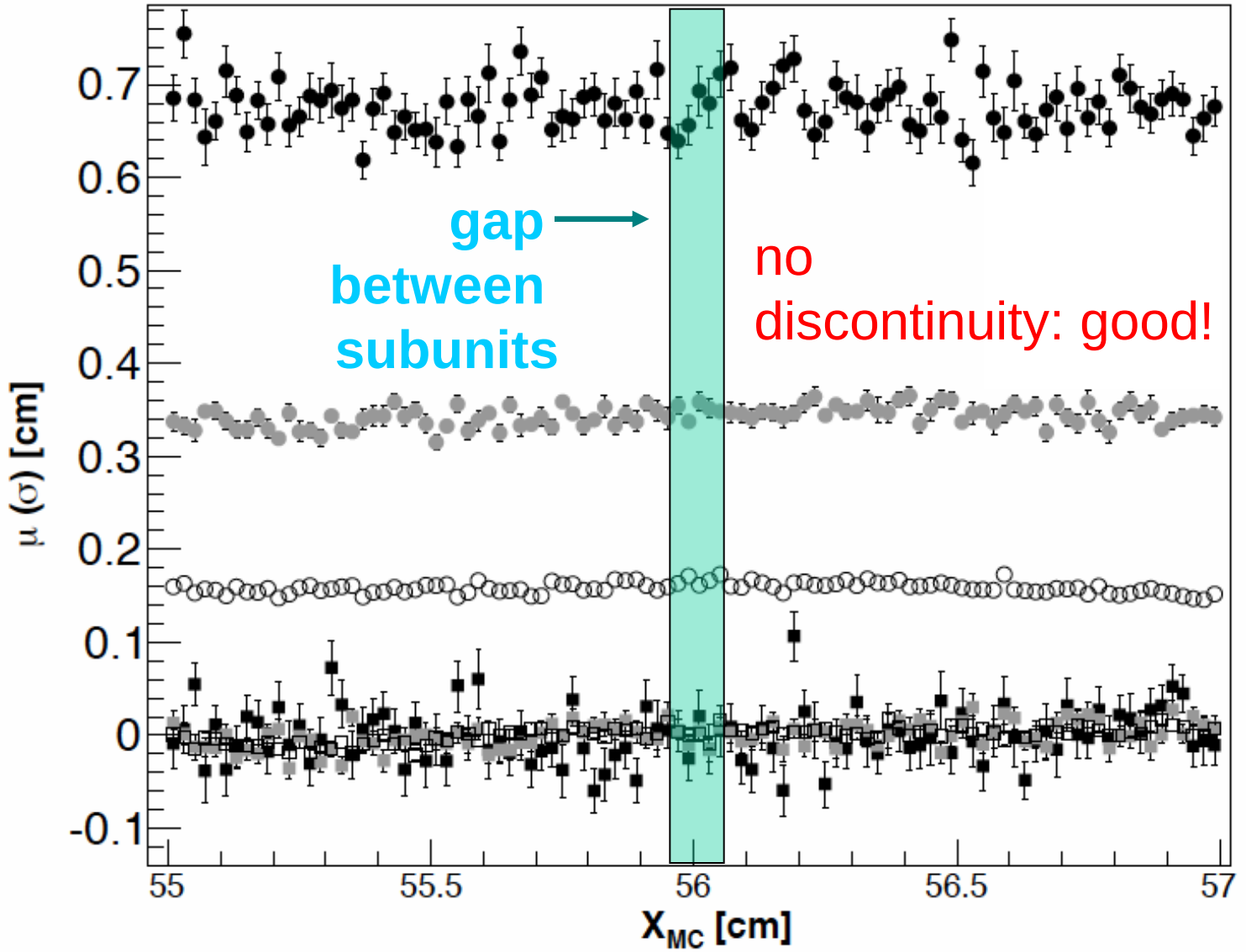


Deviations (σ)

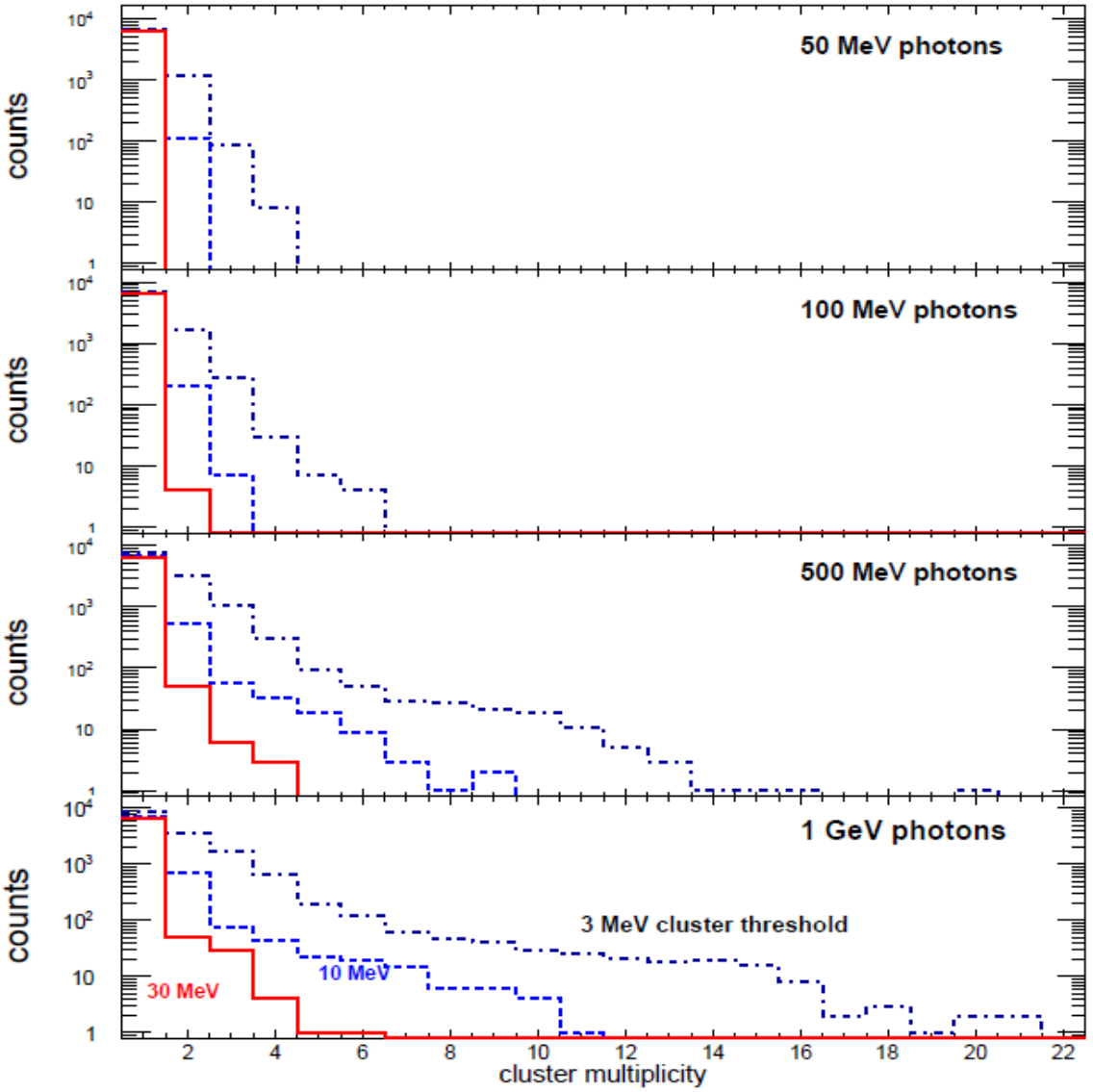
MC - reconstructed



gap sensitivity: μ (σ) of y_{cl}-y_{MC} vs. x_{MC}



cluster multiplicity in FwEndcap

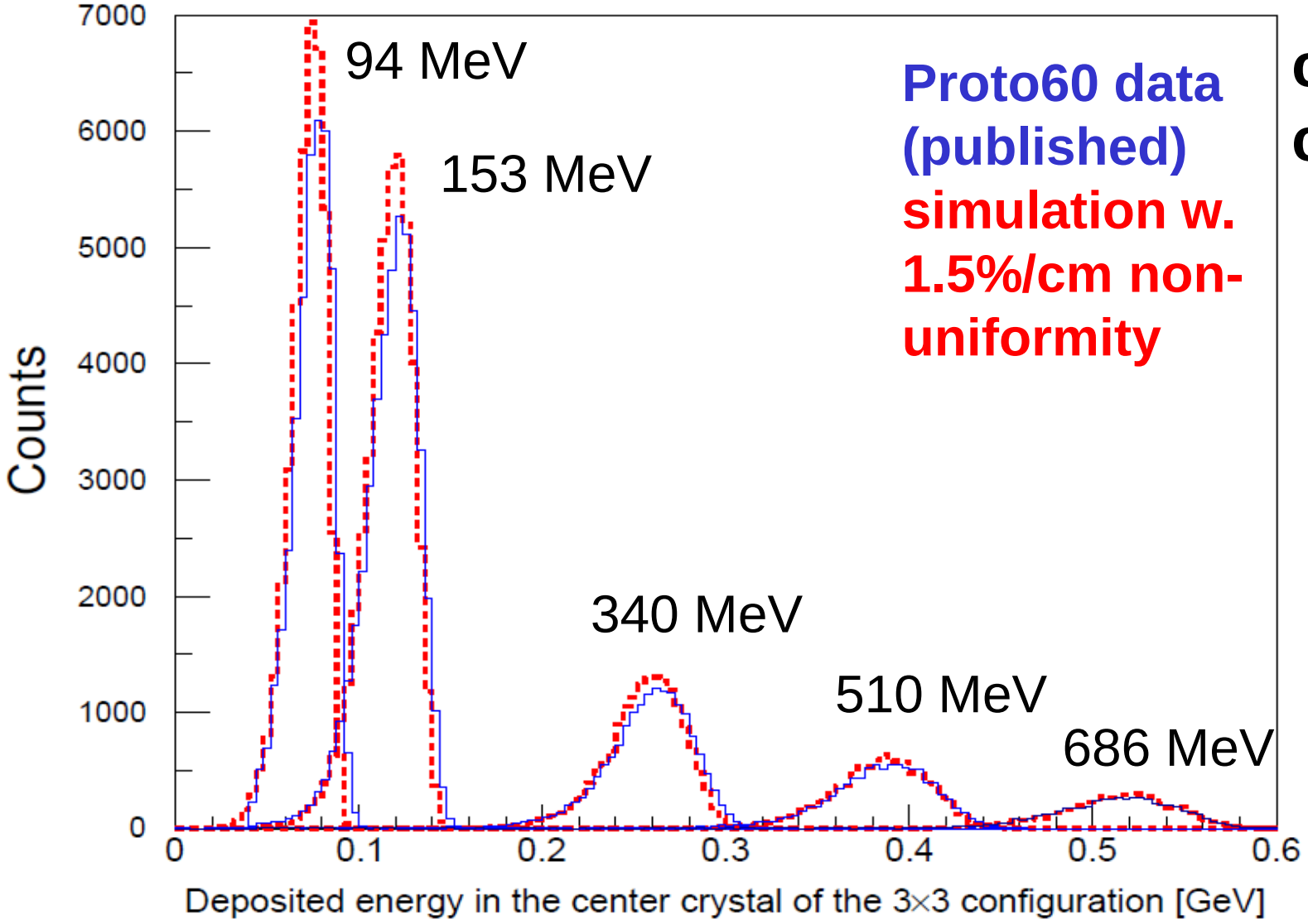


in presence of barrel

multiplicity > 1
due to
split-offs and
barrel “splash”

only endcap:
$N(M_{cl}=2) = 0.2\%$
barrel+endcap:
N(Mcl=2) = 0.8%

light-yield non-uniformity: 1.5%/cm

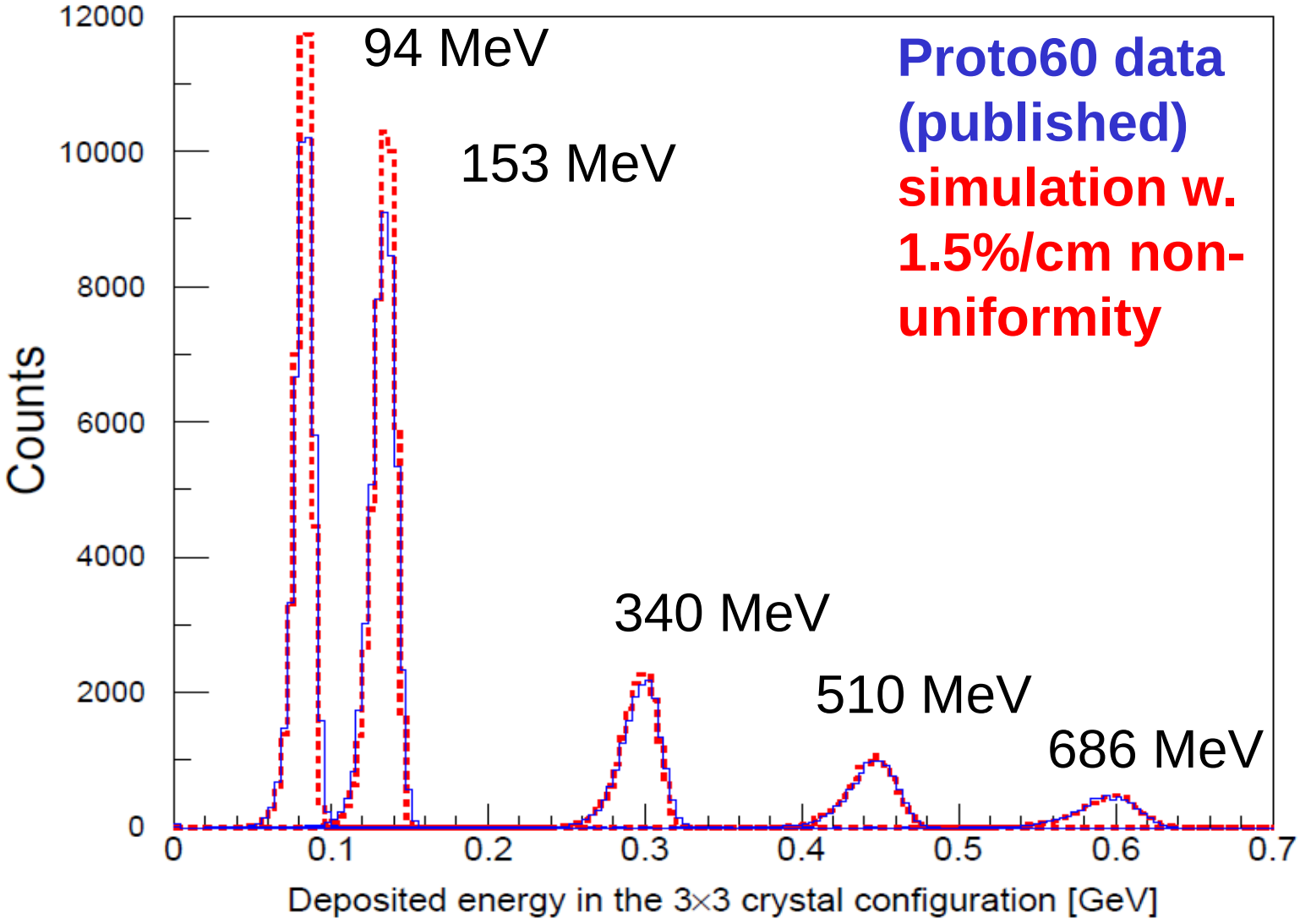


Proto60 data (published)

simulation w. 1.5%/cm non-uniformity

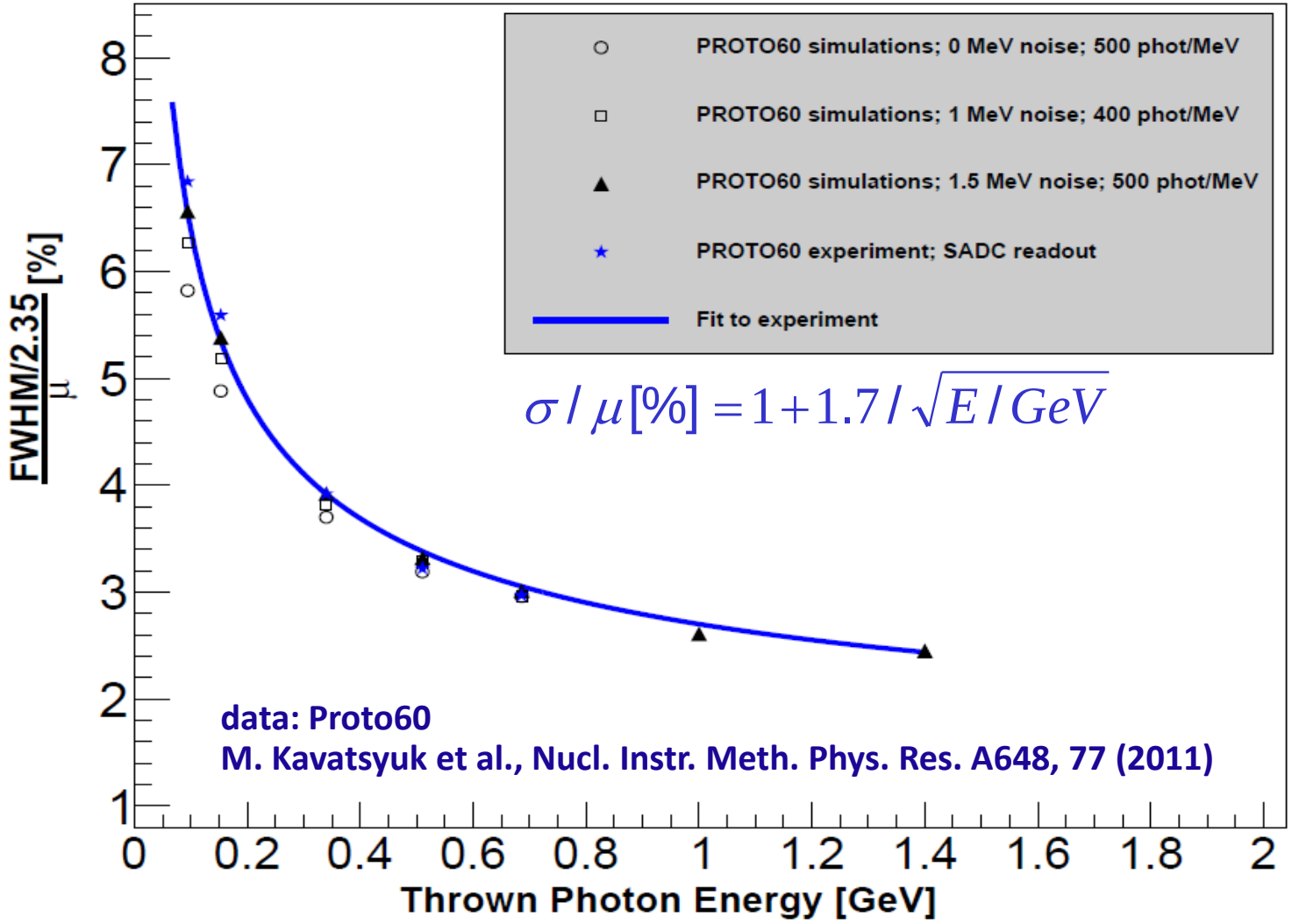
central crystal

light-yield non-uniformity: 1.5%/cm



Energy resolution

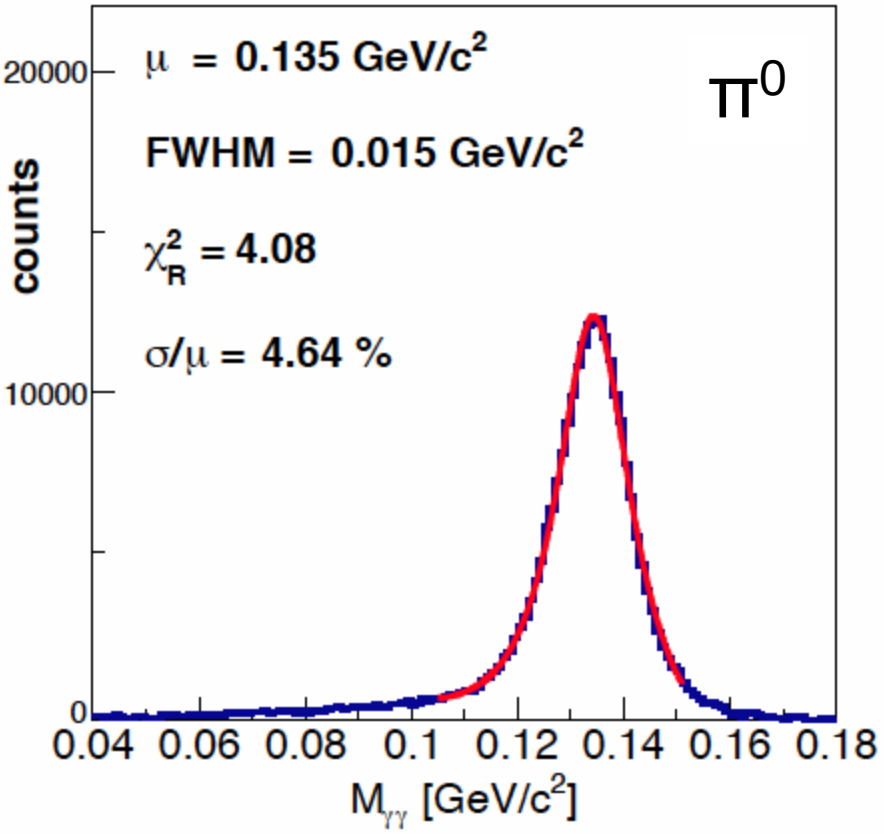
3x3 crystals, 2 MeV threshold, 1.5%/cm non-uniformity

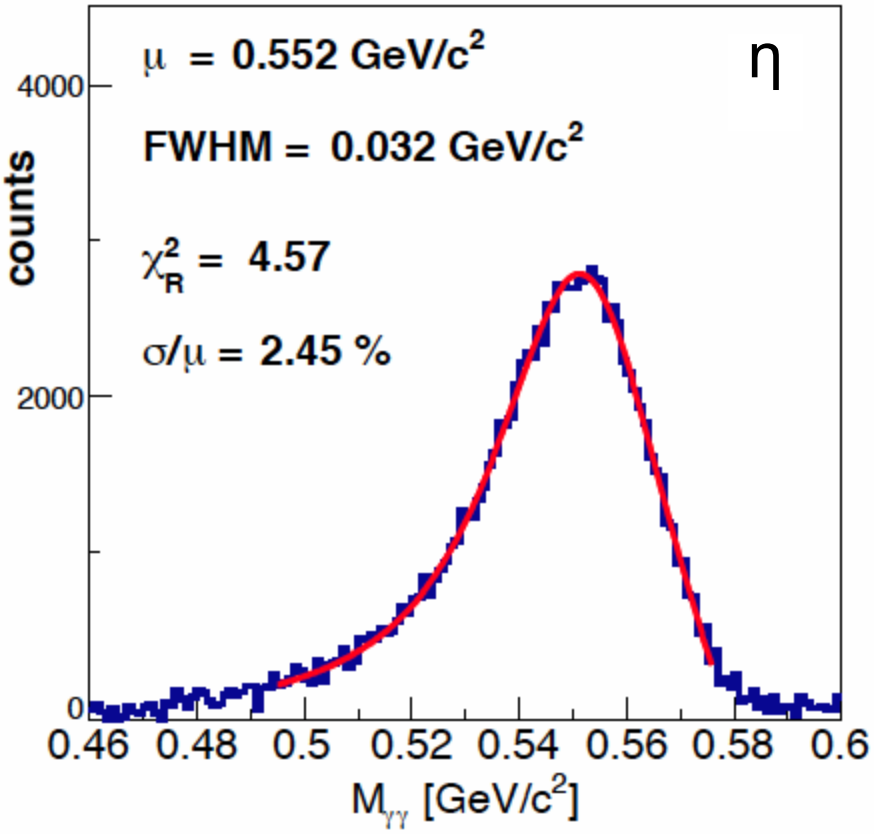


worst-case scenario for full EMC

Invariant-mass resolution (full EMC)

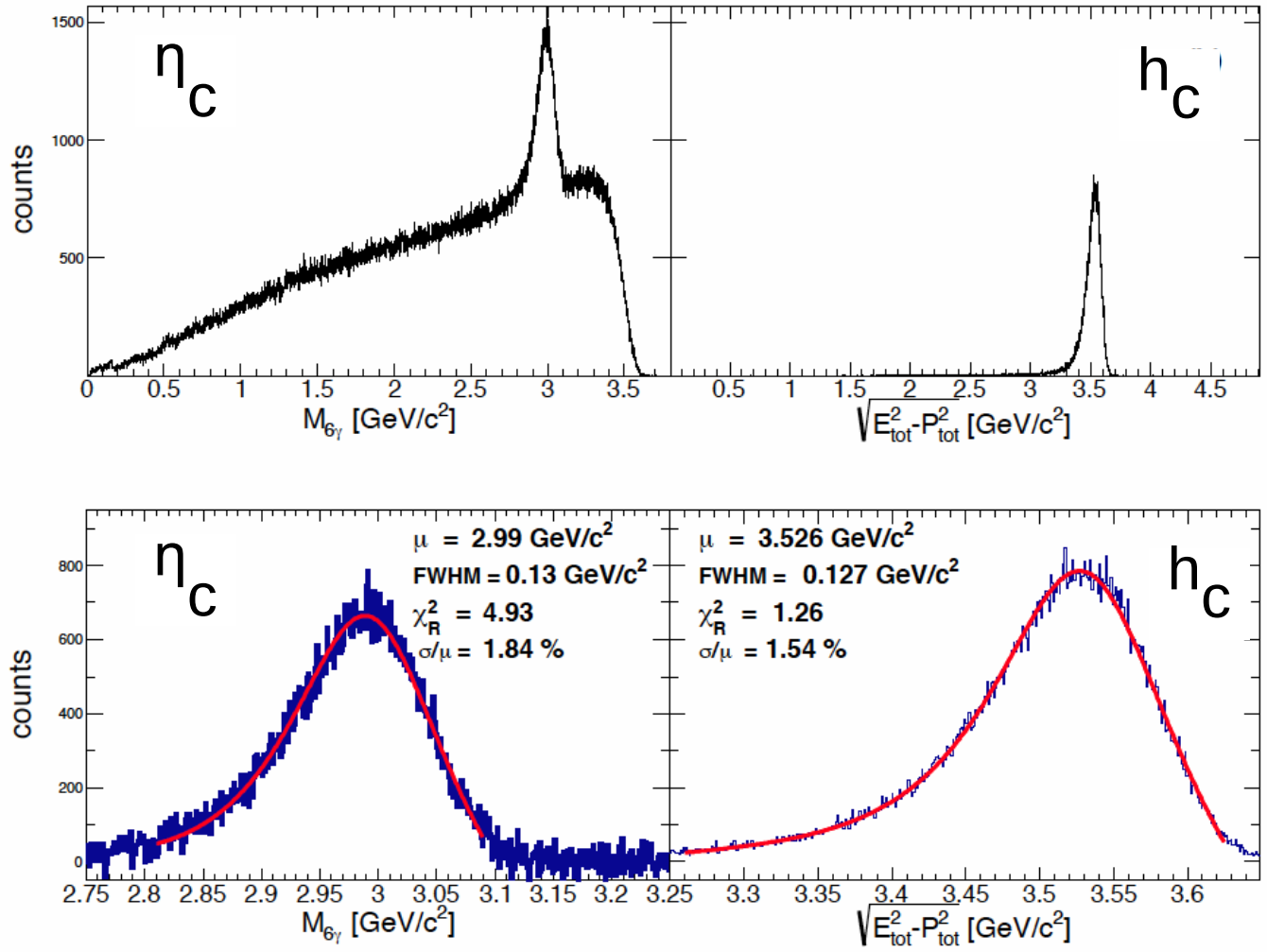
$$h_c \to \eta_c \gamma \to \pi^0 \pi^0 \eta\gamma \to 7\gamma$$





Invariant-mass resolution (full EMC)

$$h_c \to \eta_c\gamma \to \pi^0\pi^0\eta\gamma \to 7\gamma$$



Resolution parameters for EMC, FwEndCap, full Panda

decayed particle	μ [MeV]	FWHM/2.35 [MeV]	χ^2_R	resolution [%]
Full EMC				
π^0	134.76 ± 0.02	6.25 ± 0.04	4.08	4.64 ± 0.06
	(134.67 ± 0.02)	(6.15 ± 0.04)	(5.98)	(4.57 ± 0.07)
η	551.83 ± 0.05	13.52 ± 0.15	4.57	2.45 ± 0.06
	(551.92 ± 0.10)	(13.42 ± 0.23)	(5.4)	(2.43 ± 0.09)
η_c	2989.9 ± 0.25	55.11 ± 0.85	4.93	1.84 ± 0.07
	(2995.7 ± 0.25)	(54.72 ± 0.88)	(4.68)	(1.83 ± 0.06)
h_c	3526.38 ± 0.37	54.24 ± 0.85	1.26	$1.54^{+0.02}_{-0.03}$
	(3533.98 ± 0.39)	(53.87 ± 0.86)	(1.09)	$(1.52^{+0.03}_{-0.02})$
h_c total energy	6652.29 ± 0.88	104.30 ± 1.73	1.06	$1.57^{+0.02}_{-0.03}$
	(6667.85 ± 1.02)	(102.47 ± 1.84)	(1.11)	$(1.54^{+0.02}_{-0.03})$
FwEndCap				
π^0	139.87 ± 0.06	6.02 ± 0.18	2.63	4.30 ± 0.21
	(139.67 ± 0.07)	(5.80 ± 0.15)	(3.64)	(4.15 ± 0.21)
η	555.05 ± 0.53	12.52 ± 1.12	3.91	2.25 ± 0.39
	(555.21 ± 0.69)	(12.91 ± 1.85)	(2.48)	(2.32 ± 0.53)
Full $\overline{\text{P}}$ANDA Detector				
π^0	134.31 ± 0.02	6.54 ± 0.05	6.9	4.87 ± 0.1
η	551.25 ± 0.06	14.15 ± 0.17	3.11	2.57 ± 0.05
η_c	2979.15 ± 0.24	59.36 ± 0.80	4.88	1.99 ± 0.07
h_c	3514.54 ± 0.34	55.17 ± 0.83	1.44	1.57 ± 0.02

Comparison performance parameters

Parameter	$\overline{\text{P}}$ANDA	BESIII	CLEO-c	BaBar	Belle
X_0	22	15	16	$16 - 17.5$	16.2
σ_E at 1 GeV [MeV]	25.4	≈ 25	≈ 20	≈ 28	≈ 17
σ_E at 100 MeV [MeV]	6.6	3.3	4	4.5	4
Position resolution (σ) at 1 GeV [mm]	2.7	6	4	4	6

Summary

- We describe the FWEndcap design
- investigated gaps, barrel-splash, clustering, non-uniformity
- validated energy resolution in agreement with Proto60

- demonstrated quality of position resolution:
  quasi-planar off-point geometry corrected by lookup table

- demonstration quality of charmonium reconstruction:
  charmonium h_c –decay analysis: invariant-masses, widths

draft was developed in small circle at KVI,
communicated at meeting June 2012,
communicated to system- and subsystem managers december 2012.
Next step: technical coordinator and whole collaboration.