Synchrotron Radiation at TPOL?

Some thoughts and a bit of MC about…

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Synchrotron Radiation - What if we had some?

- Synchrotron radiation in the line of sight of our calorimeter is genererated by the two weak bends (ρ = 3215m) and the quadrupole in the TPOL straight section
  - → Critical energy of bends is only 14.5 keV at E_e = 27.6 GeV
- Radiation is attenuated by amount of material in front of the first scintillator of the calorimeter
  - → Exit windows (Al, 3x0.5 mm)
  - → Calorimeter front plate (Al, 10 mm)
  - → First tungsten absorber (Densimet, 6.2 mm)
  - → Preradiator (Pb, 5.6 mm) (NEW since HERA II !)
- Relevant photon energy range is about 100-400keV
  - → Photons of that energy are not measured like high-energy photons
    - ➢ They do not shower
    - ➢ They are absorbed directly, primarily by the photoelectric effect
    - ➢ Hence, they deposit all their energy in the first scintillator and not only a fraction corresponding to the sampling fraction (2.5% here)
  - → A synchrotron radiation photon generates a signal corresponding to that of a high-energy photon with an energy 40 times higher

Synchrotron Radiation - What if we had some?

- A significant amount of synchrotron radiation would appear like a shift in energy scale

$$E \longrightarrow E + \delta$$

- Because of the small energy of a single photon, a significant amount must be the result of multiple interactions
  - → Small variations over time, almost constant shift as long as beam conditions do not change – Whole fills? Days? Weeks?
  - → Remember: we have long-term ratio problems, where the LPOL/TPOL ratio is bad over days/weeks and might then suddenly jump to a good or another bad value…
- Synchrotron radiation has been studied last early HERA I (1990-1993)
  - → A bit lower beam energy (E_e = 26.7 GeV)
  - → Calorimeter front plate was thicker (15mm)
  - → No preradiator
  - → Chose a first tungsten absorber thick enough, so that measured shifts are <0.15GeV
  - → Concluded, that synchrotron radiation would not be a problem anymore

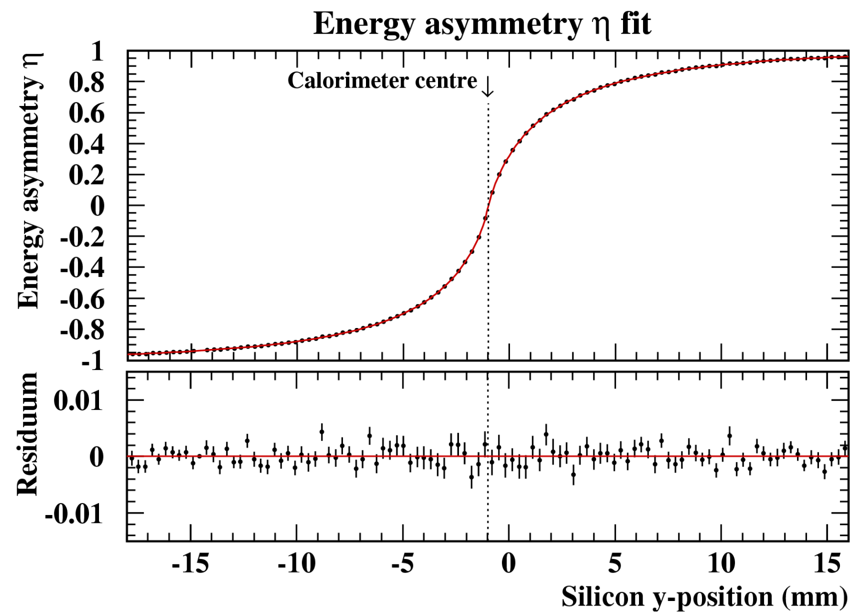
→ Are we sure?

Modelling Synchrotron - In parametrized Monte Carlo

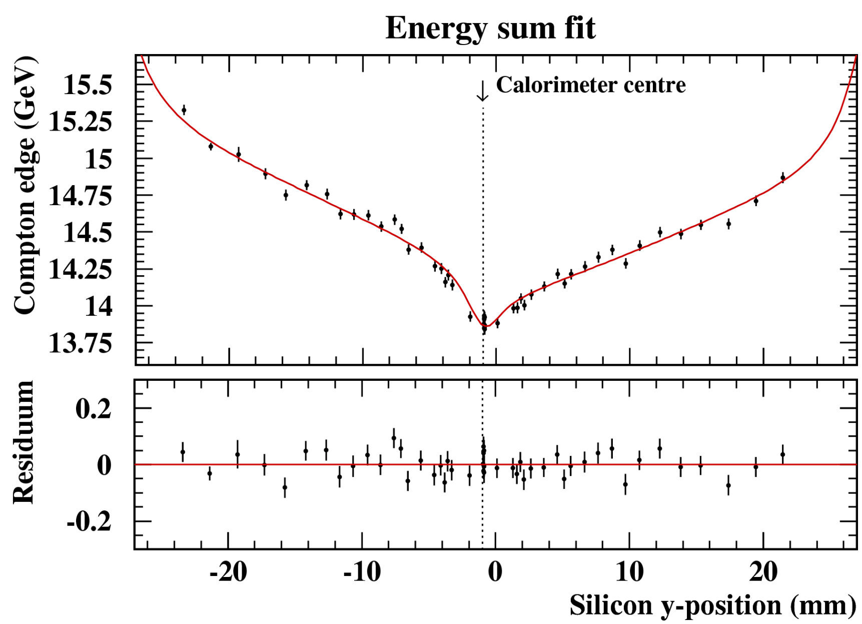
- Parametrized Monte Carlo uses a detailed calorimeter response model

$$(y, E_\gamma) \to (\eta_{\text{ideal}}, E_{\text{ideal}}) \to (\eta, E)$$

Ideal energy response, i.e. η(y)-transformation and E(y)



- Physical shower model with 2 components plus shower related and hardware effects
  - Broadening of 2nd component
  - Gap with 100% energy loss
  - Linear attenuation
  - Photomultiplier gain difference
  - Lead frames
  - End of scintillators
  - Offset of tungsten absorber



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Energy resolution model

- Correlation of Up and Down energies by

$$C = \begin{pmatrix} a^2 E_{\text{U}} + b^2 E_{\text{U}}^2 & b^2 E_{\text{U}} E_{\text{D}} \\ b^2 E_{\text{U}} E_{\text{D}} & a^2 E_{\text{D}} + b^2 E_{\text{D}}^2 \end{pmatrix}$$

$\rightarrow$ Resolution of e.g. energy sum

$$\frac{\sigma^2}{E^2} = \frac{a^2}{E} + b^2$$

- Physical shower model with 2 components plus shower related and hardware effects
  - Broadening of 2nd component
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Modelling Synchrotron - In parametrized Monte Carlo

- Parametrized Monte Carlo extended by a simple energy shift model

$$(y, E_\gamma) \rightarrow (\eta_{\text{ideal}}, E_{\text{ideal}}) \rightarrow (E_{\text{U}}, E_{\text{D}}) \rightarrow (E_{\text{U}}+\delta_{\text{U}}, E_{\text{D}}+\delta_{\text{D}}) \rightarrow (\eta', E+\delta)$$

Ideal energy response, i.e.
η(y)-transformation and E(y)

Choosen here:
$\delta_{\text{U}} = \delta_{\text{D}} = \delta/2$

η is distorted, E is shifted

$$E_{\text{U,D}} = \frac{1 \pm \eta_{\text{ideal}}}{2} E_{\text{ideal}}$$

- Compton edge is first shifted and then squeezed by calibration

$$E_{\text{C}} \rightarrow E_{\text{C}}+\delta \rightarrow E'_{\text{C}} = g\cdot(E_{\text{C}}+\delta) \Rightarrow (\eta', E+\delta) \rightarrow (\eta', g\cdot(E+\delta))$$

Add shift

Calibration: $g = \dfrac{E_{\text{C}}}{E_{\text{C}} + \delta}$

Both η and E are distorted:

$$(\eta', E') = \left(\frac{E_{\text{U}} - E_{\text{D}}}{E + \delta}, \frac{E_{\text{C}}}{E_{\text{C}} + \delta}(E + \delta) \right)$$

Modelling Synchrotron - In parametrized Monte Carlo

- Parametrized Monte Carlo extended by a simple energy shift model

$$(y, E_\gamma) \to (\eta_{\text{ideal}}, E_{\text{ideal}}) \to (E_U, E_D) \to (E_U{+}\delta_U, E_D{+}\delta_D) \to (\eta', E{+}\delta)$$

Ideal energy response, i.e.
η(y)-transformation and E(y)

Choosen here:
$\delta_U = \delta_D = \delta/2$

η is distorted, E is shifted

$E_{U,D} = \frac{1 \pm \eta_{\text{ideal}}}{\ldots} E_{\text{ideal}}$

Situation becomes even more complicated, if assumption of equal shifts in both channels is dropped.

Distortion of η is then much more difficult.

It would affect table centering and relative calibration! (Horror!)

...d by calibration

$$\ldots\delta) \to (\eta', g\cdot(E{+}\delta))$$

Add shift

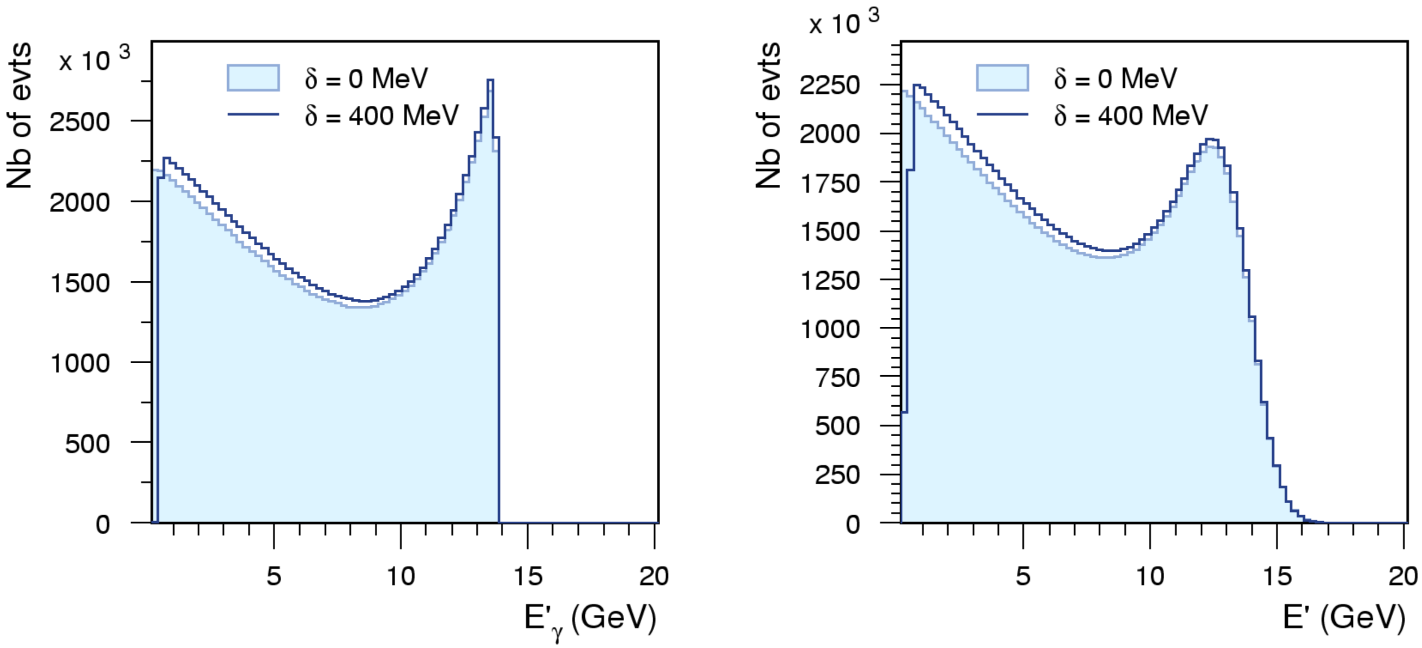
Calibration: $g = \frac{E_C}{E_C + \delta}$

Both η and E are distorted:

$$(\eta', E') = \left(\frac{E_U - E_D}{E + \delta}, \frac{E_C}{E_C + \delta}(E + \delta) \right)$$

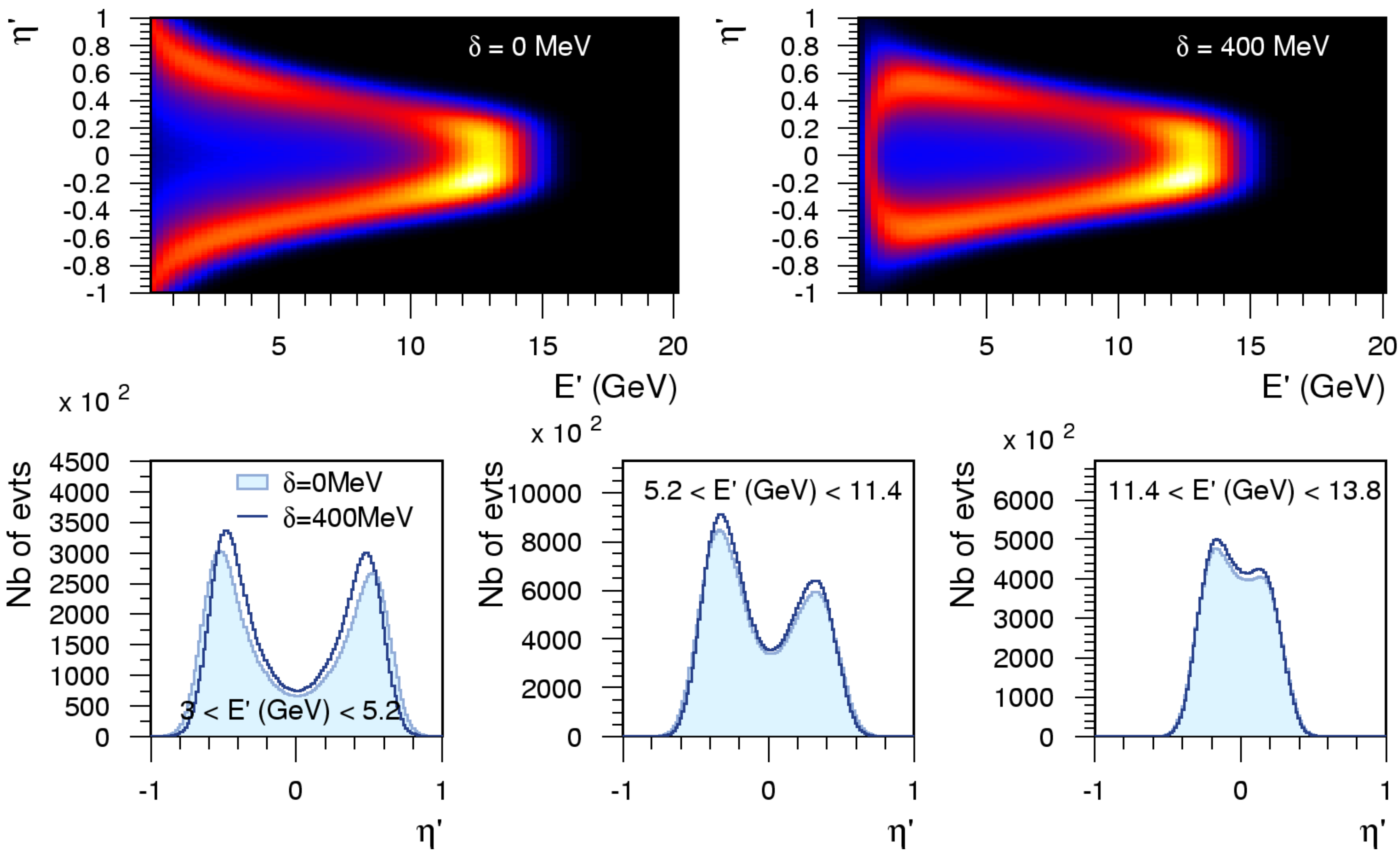
Energy Scale Shifts - What if we had some?

- How would it look like in energy distribution?



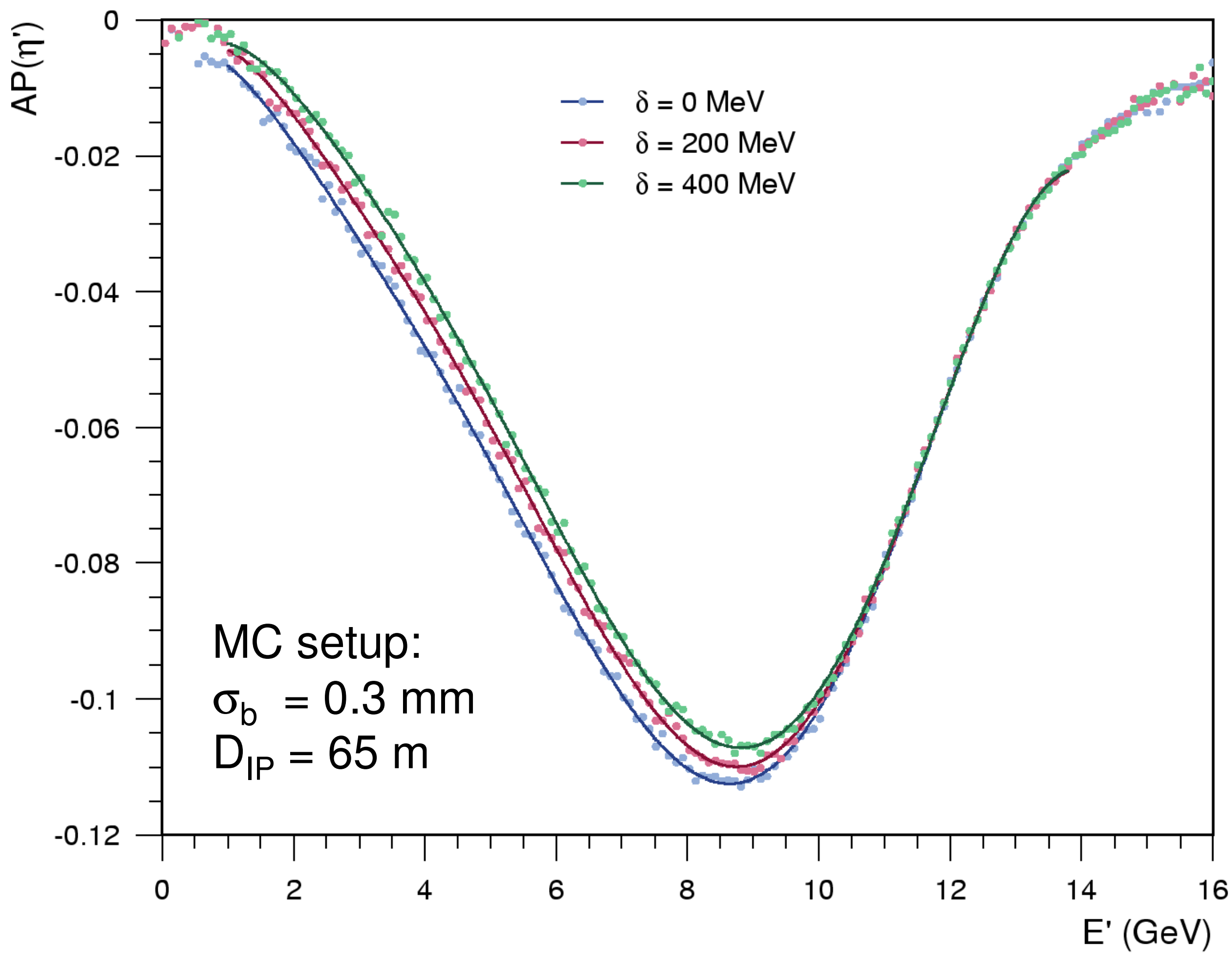
Energy Scale Shifts - What if we had some?

- How would it look like in energy asymmetry?



Energy Scale Shifts - What if we had some?

- How would it feel like? (I.e. what happens with the analysing power?)



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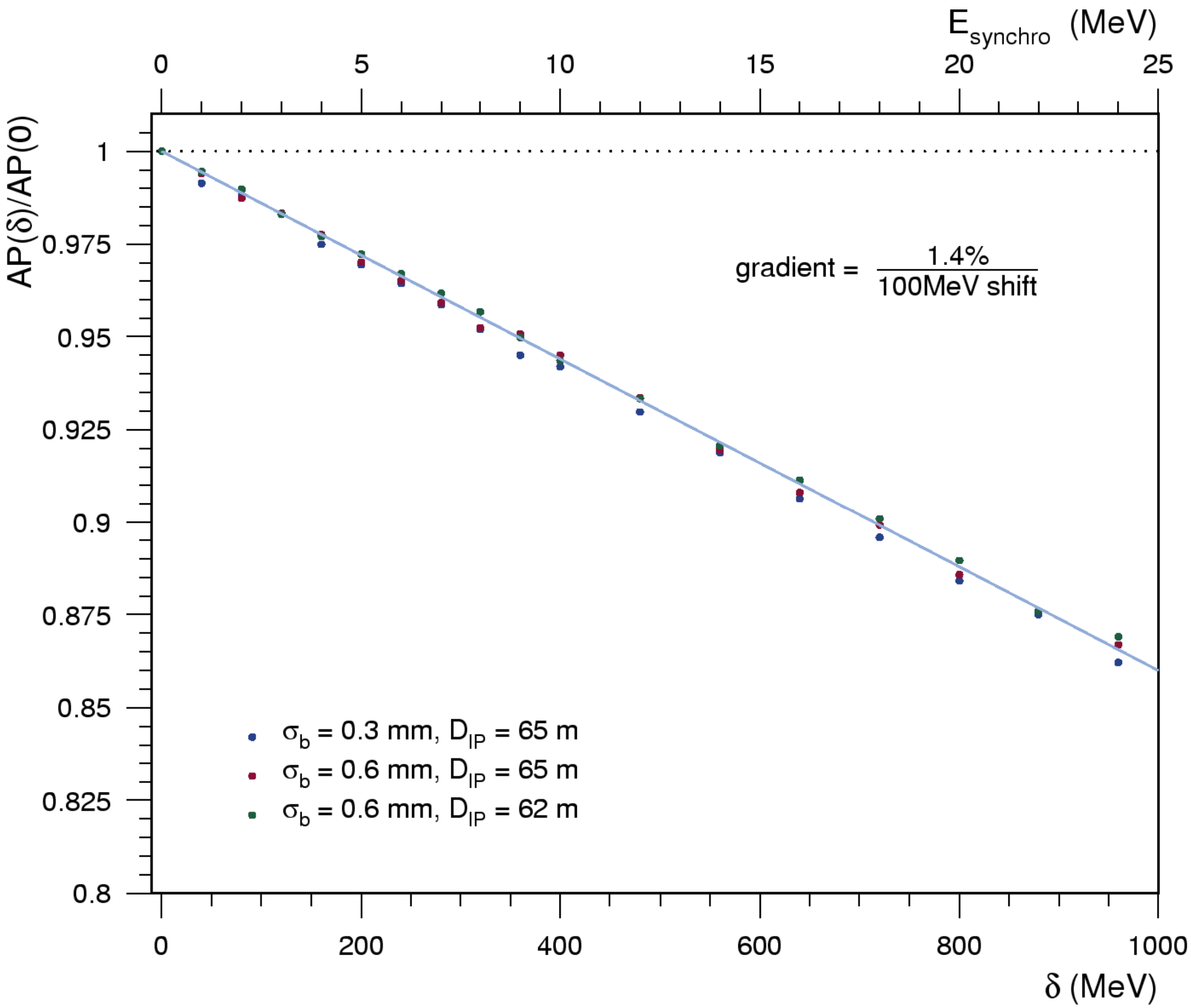

- Relative change of analysing power is

  → mostly independent of MC setup (good for universal correction)
  → linear up to large shifts

  → significant, analysing power degrades by 1.4% per 100MeV shift

Energy scale shifts - Could we possibly observe them in data?

- Absolute calibration of the up and down channel takes currently only one edge into account

  $\rightarrow$ the Compton edge

- And applies a calibration with one multiplicative parameter

  $\rightarrow$ the gain

- But we have an extra marker in our energy spectrum

  $\rightarrow$ the Bremsstrahlung's edge

- Using both possibly allows to extend the absolute calibration to a two-parameter calibration with gain and shift

- Currently unknown here:

  $\rightarrow$ If the edge would be statistically precise enough

  $\rightarrow$ If determination of the edge would be unbiased

  $\rightarrow$ If we will find hints for energy shifts with that at all…

  $\rightarrow$ But the expected influence of already small shifts is too large to ignore them