Simulations for the Dynamic Range of the EMC

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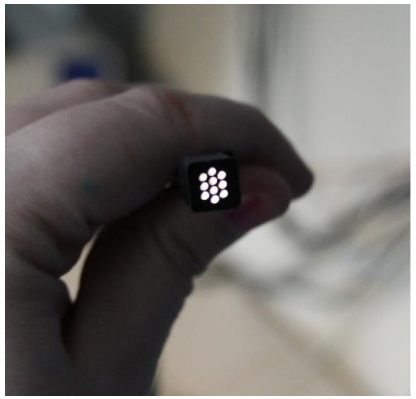
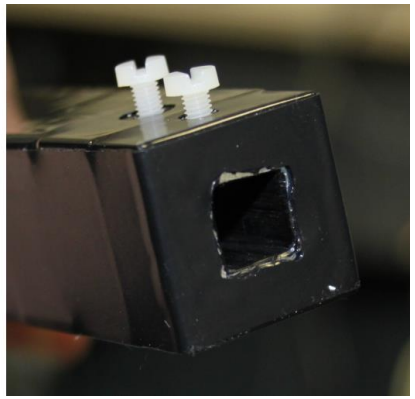
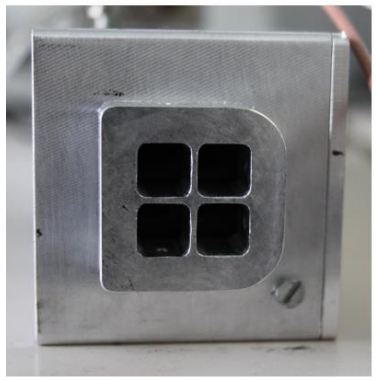
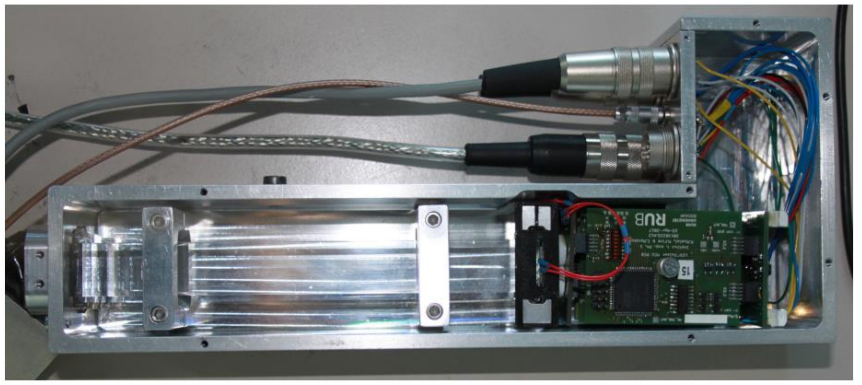
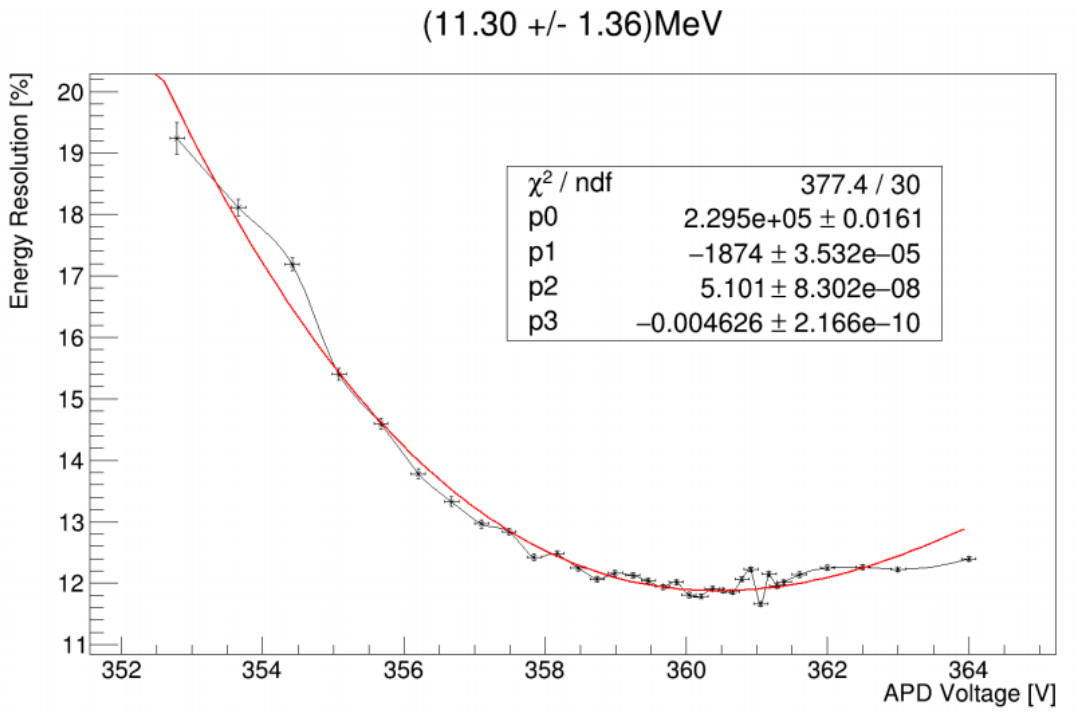
- EMC : high energy resolution is needed, especially in MeV range
- 2019: Measurements with prototype LED lightpulser from Bochum
- One single LAAPD glued with optical grease to type-6 crystal + APFEL-ASIC + SADC (ver. 2.0) inside a climate chamber (-25°C)
- Trying to determine optimal bias voltage/gain for optimal energy resolution[1]

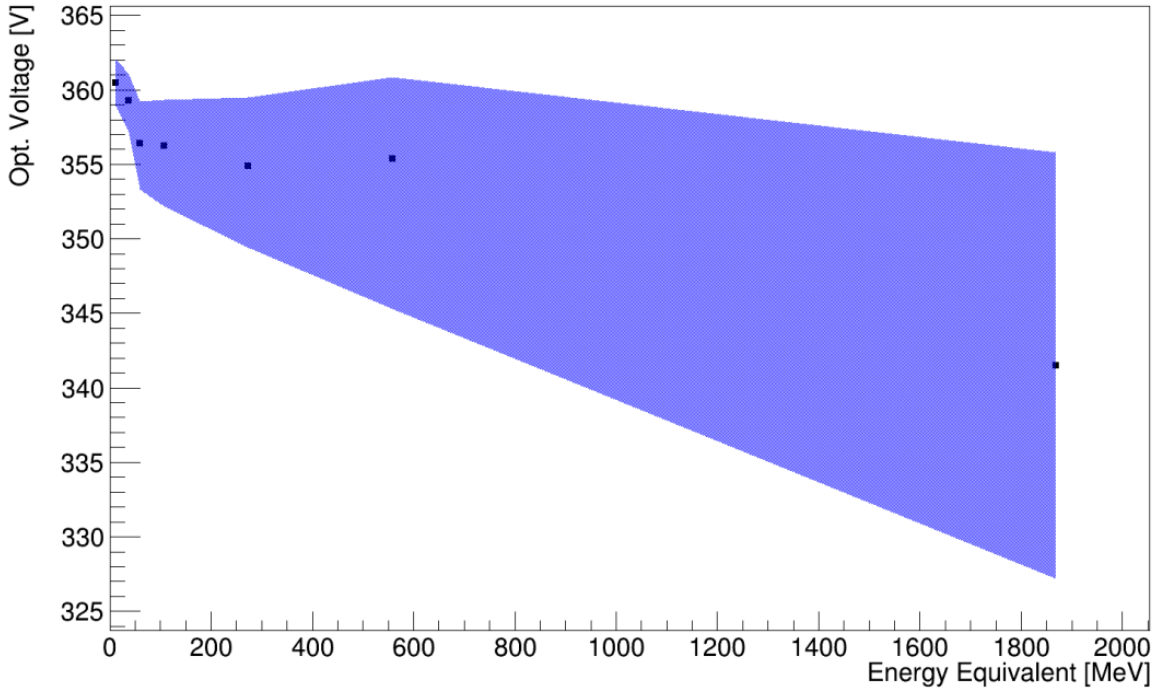


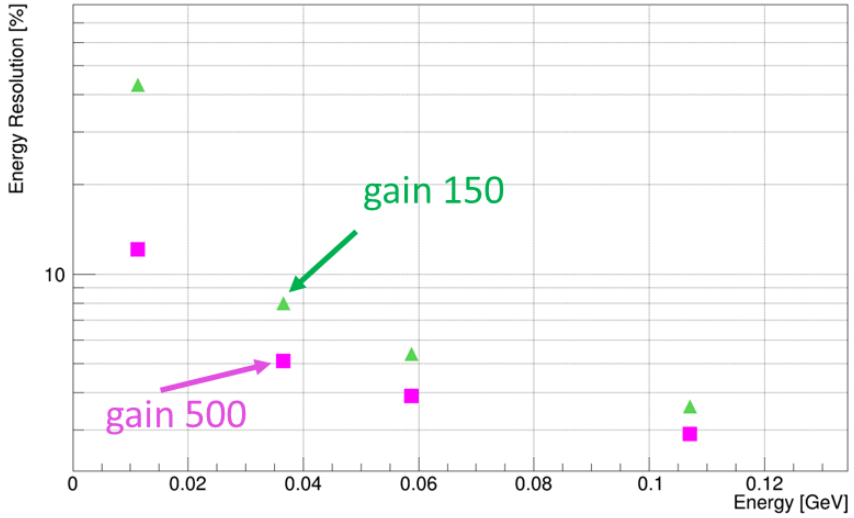








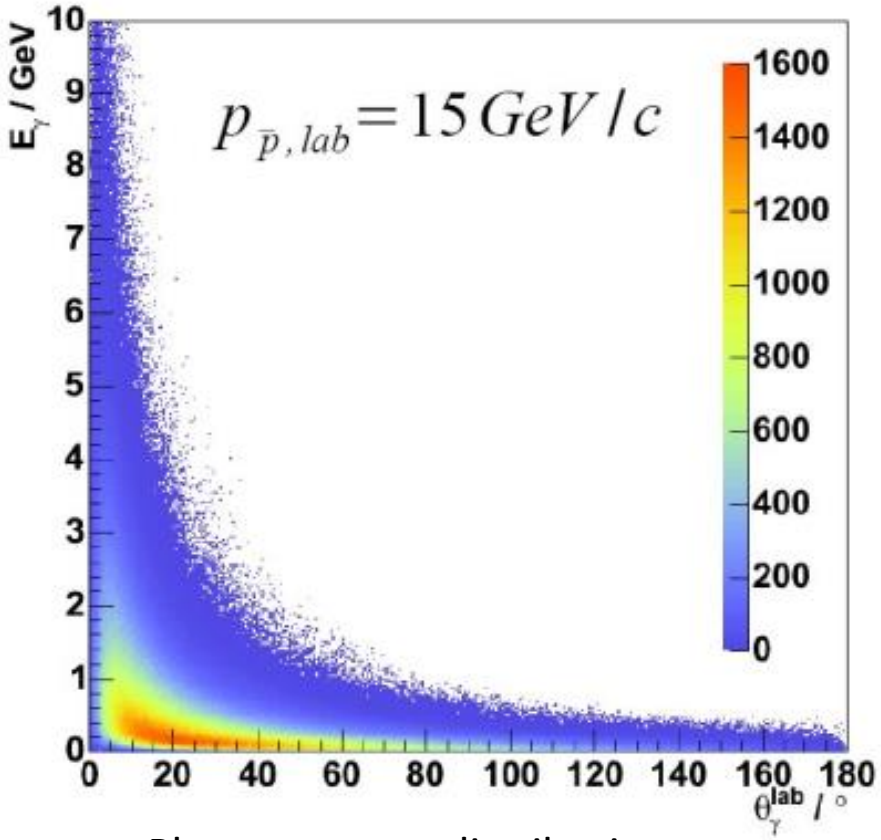




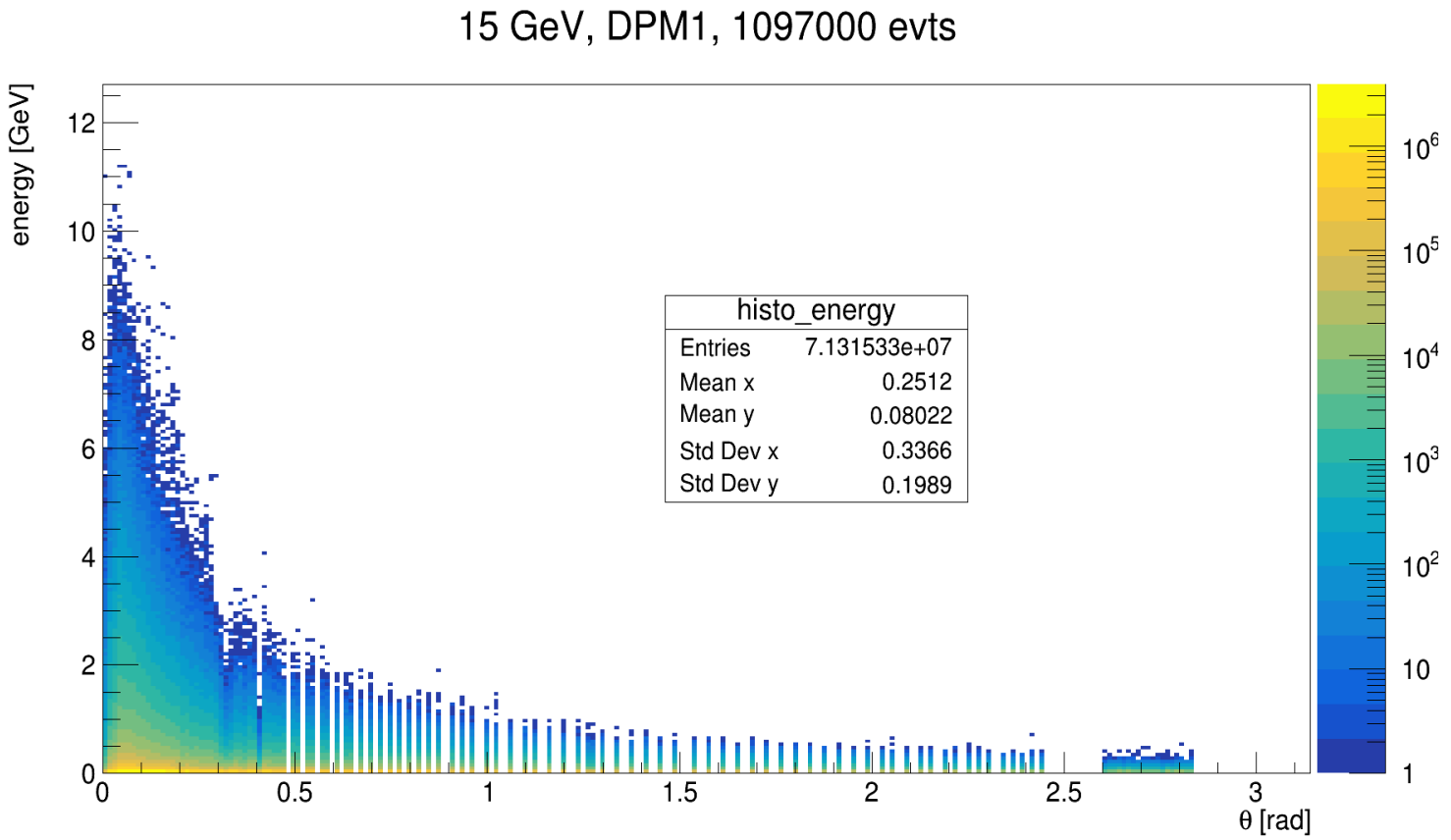
- Results supported by a study done by Aniko [2] with a matrix of BEC like crystals
- However: limited by dynamic range of APFEL-ASIC

- So far used: Simulated photon energy distribution from the EMC TDR [3] from 2008

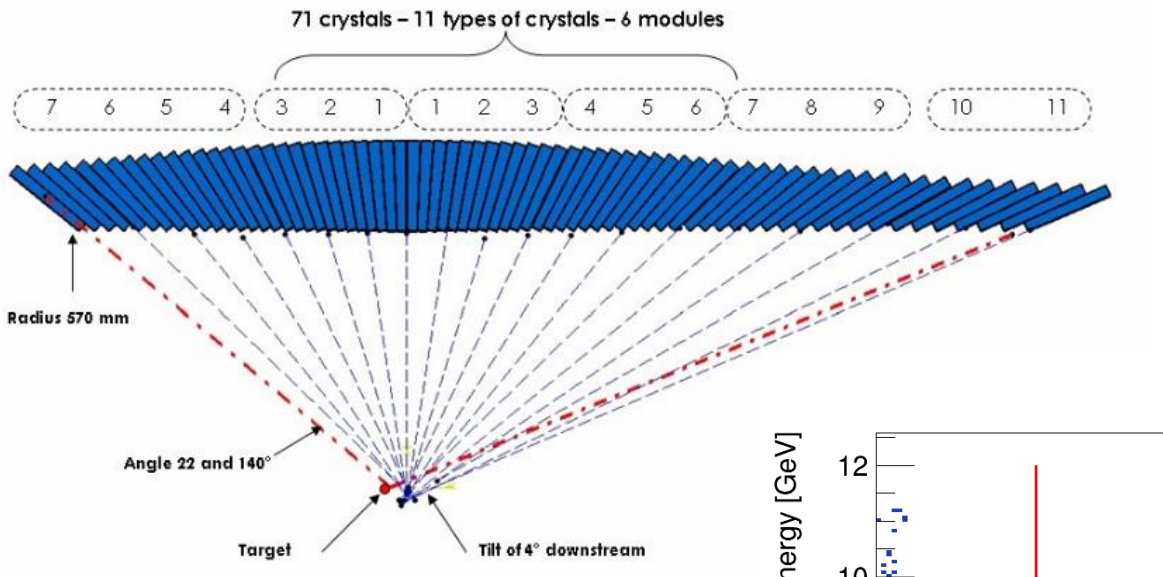
- However: Since then changes have been made to the simulation framework -> new simulations with the DPM1 background & one of the latest pandaroot versions (jun19):



Photon energy distribution



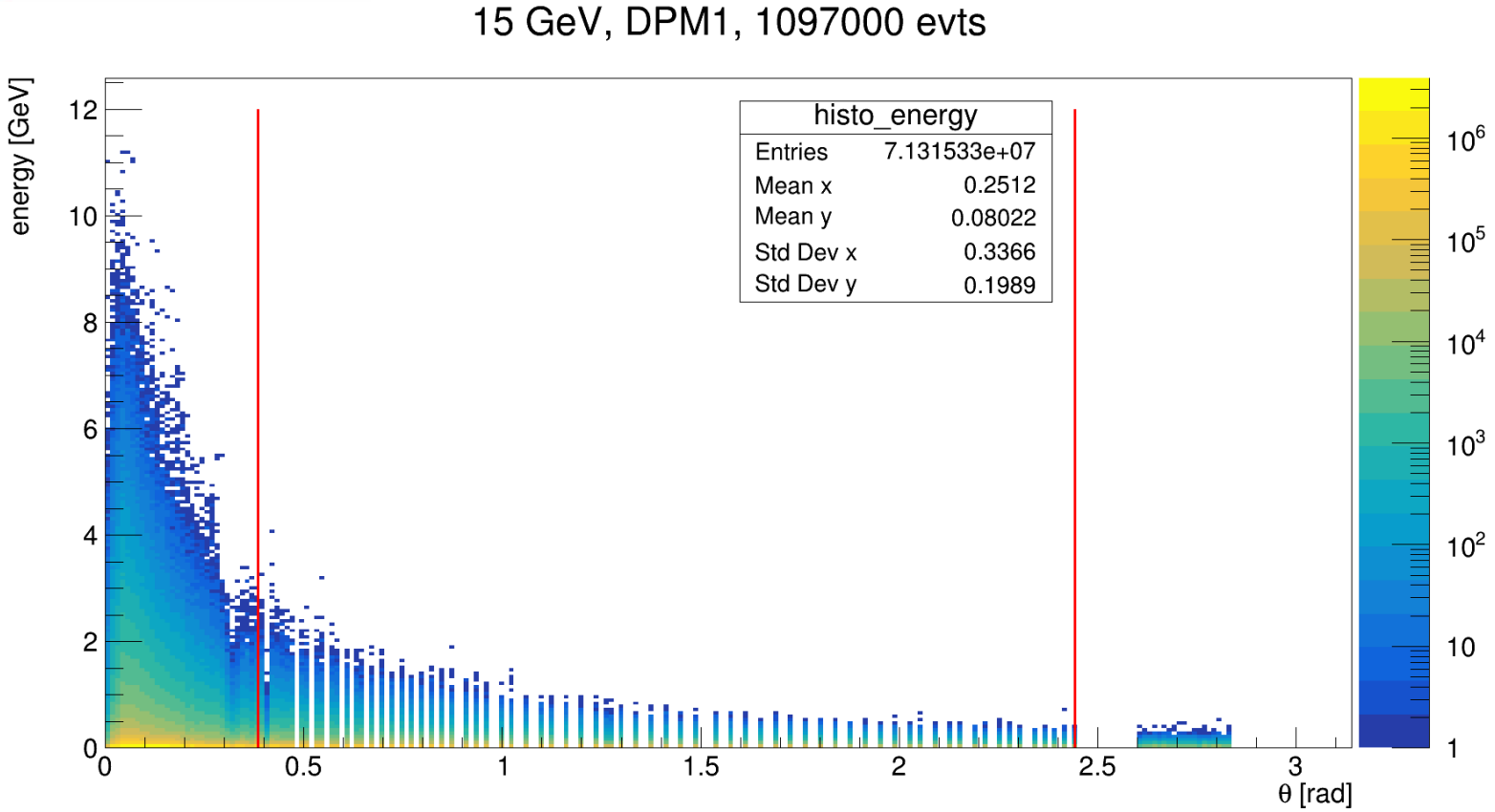
Deposited energy in crystal



- The EMC covers angles between 22° and 140° with 71 different crystal rows

- On average this leaves a gap of ~ 1.7° (0.03 rads)

- This can be seen with the simulation



Discussion

Reminder[4]

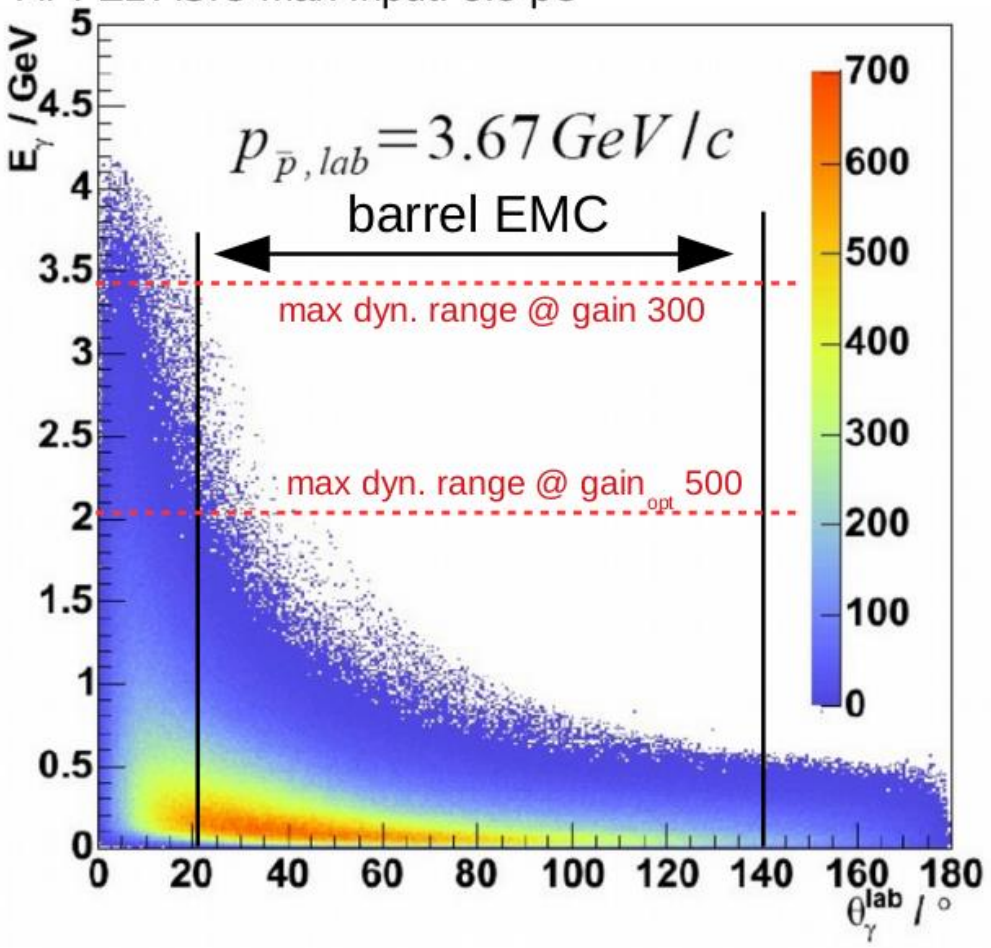
PWO-II LY @ -25°C: 100 PMT-phe/MeV (LY@18°C X4)

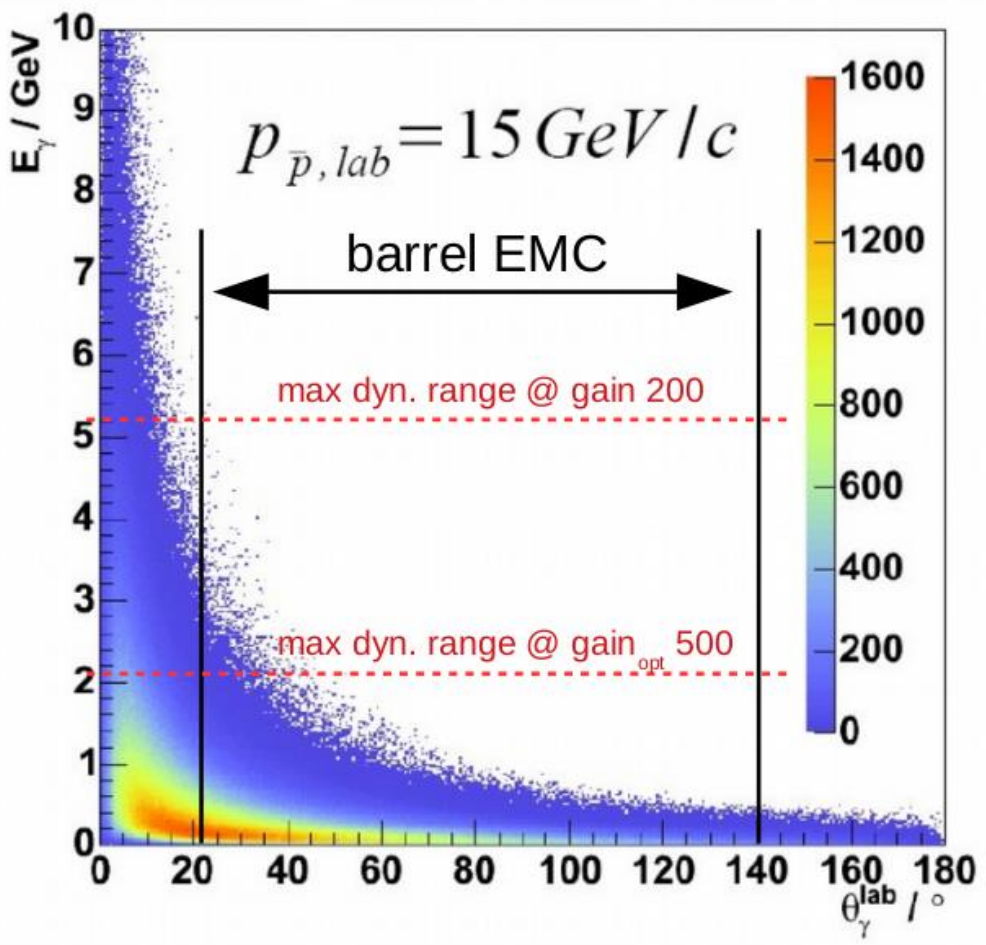
APD covers ~13% crystal endface

PMT QE = 20%, LAAP QE= 80% → 52 APD-phe/MeV

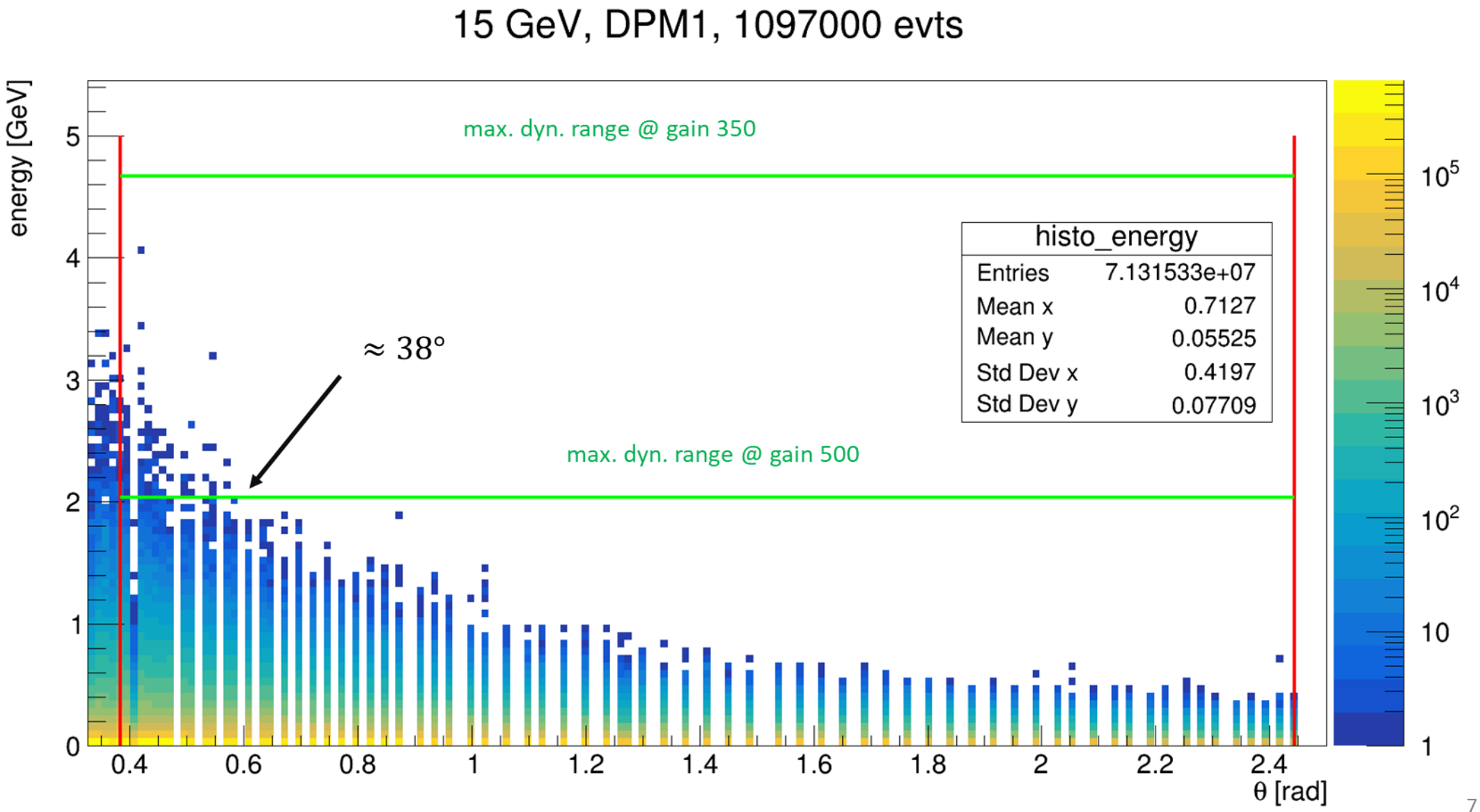
APFEL ASIC max Input: 8.5 pC

$$E_{max}(gain_{opt}500) = \frac{8.5\,10^{-12}C}{52 \cdot 1.6 \cdot 10^{-19}\,C/MeV \cdot 500} = 2043.3\,MeV$$



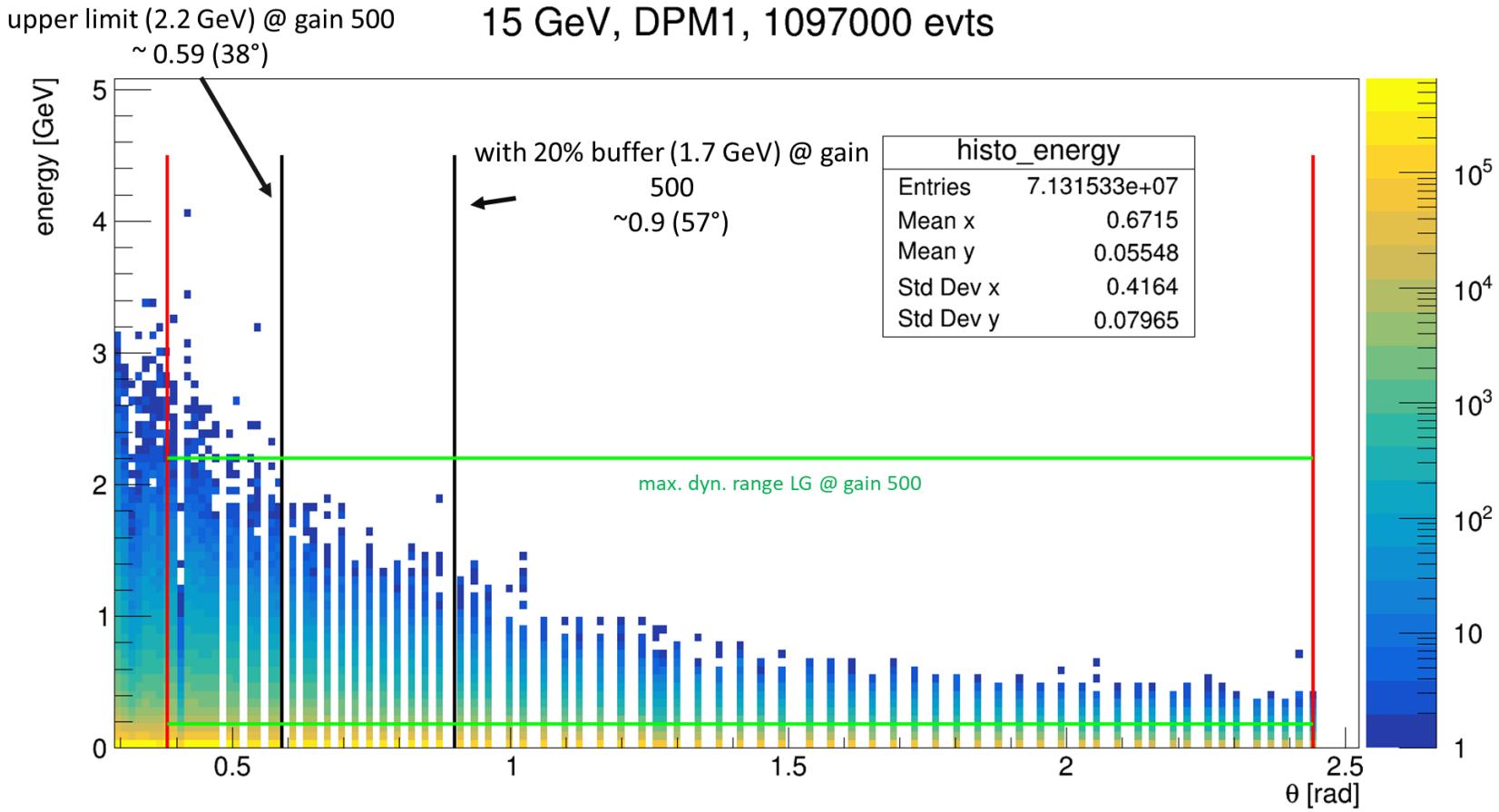


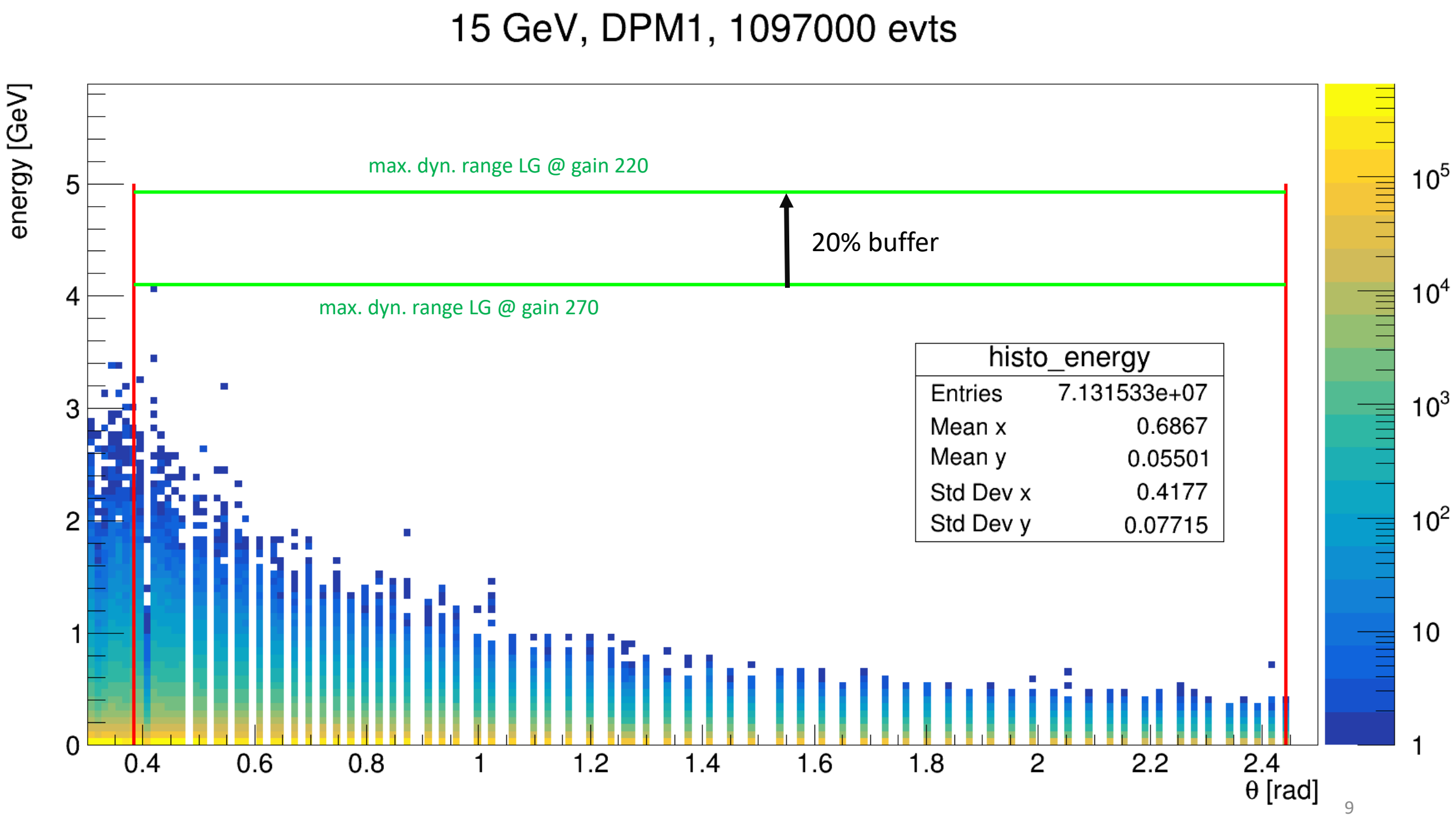
Same calculation with gain 350 yields E_{max} of 4670 MeV



- New measurement during beamtime 2019 with crystal matrix by Aniko[2]
  - Mostly backward endcap like crystals, calibrated with muons (MVP = 28.1MeV)

- Dynamic range is limited: rough estimation yields $\approx 2.2\ GeV$ LG limit & $\approx 184\ MeV$ HG limit at gain 500




15 GeV, DPM1, 1097000 evts
energy [GeV]
θ [rad]
max. dyn. range LG @ gain 220
max. dyn. range LG @ gain 270
20% buffer
histo_energy
Entries 7.131533e+07
Mean x 0.6867
Mean y 0.05501
Std Dev x 0.4177
Std Dev y 0.07715

Summary

- Higher gain improves energy resolution, especially for lower energies
- Gain 500 can be used (even with generous margin) down to $\Theta \approx 57°$
- Gain 220 could be used for lower angles (even with 20% margin) without any information loss

Outlook

- More statistics for 15 GeV beam momentum
- Simulations for lower energies

Thank you for your attention

Sources

- [1] : Large Area Avalanche Photodiode Gain Optimization for the APFEL ASIC Preamplifiers of the PANDA Calorimeter, Bachelorthesis, Kim Tabea Giebenhain, 2019
  - https://www.uni-giessen.de/fbz/fb07/fachgebiete/physik/institute/iipi/arbeitsgruppen/ag-brinkmann/forschung/theses
- [2] : Revision of the PANDA Calorimeter Front-End operating parameters by means of high energetic photons, Masterthesis, Aniko Tim Falk, 2020
  - https://www.uni-giessen.de/fbz/fb07/fachgebiete/physik/institute/iipi/arbeitsgruppen/ag-brinkmann/forschung/theses
- [3]: Technical Design Report for: PANDA Electromagnetic Calorimeter, Rainer Novotny et al, 8th August 2008
  - https://panda.gsi.de/publication/re-tdr-2008-001
- [4]: Talk by Dr. Markus Moritz, 6th November 2019