Digitization Studies with muon and positron data

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Overview

Simulation of optical crosstalk Hits in GeV from Mokka are converted to MIP scale.
10 % of hit energy is distributed to neighboring cells.

Simulation of SiPM behaviour For every energy of every hit the number of pixels is calculated which would have fired.
The number of pixel is smeared with a Binomial function .
Saturation effect included.

Merging of hits and noise Hits of noise collection (extracted from test beam run) are added to the simulated hits.

So far:

Comparison between test beam positron runs of CERN-07 and simulation:

- Nov 2008:
  Linearity better than 0.5 % only fullfilled up to 30 GeV in data and simulation.
  For higher energies deviations in test beam data.
  2 % difference in stochastic term of energy resolution (22.5 % in test beam data; 20.2 % in simulation)
- Changes from November 2008 till November 2009
  New Mokka and geant4 version.
  Updated detector geometry in Mokka (thicker absorber plates).
  Birks law and TimeCut (150 ns) implemented to Mokka.
- Studies so far could not reproduce the same EnergySum of a 10GeV run in data and simulations.
  GeVtoMip factor 861 keV

Definition:

GeVtoMip factor: Factor that converts the energy output of Mokka in GeV to the MIP scale (first step in digitization).
Extracted from the MPV of simulated 80 GeV μ^- run.

rangeCut: Steerable parameter (mm) in Mokka.
Default value: 0.005 mm
GEANT4: Secondaries with a range below a specified cut are not tracked. The rangeCut can be translated into a minimum production energy threshold in a given material.

Birks law: Birks law describes the attenuated scintillator response ΔL:
$\Delta L = \frac{\Delta E}{1+k_B \cdot \frac{dE}{dx}}$

MPV - GeVtoMip

Different simulations for 80 GeV μ runs:

Test-Nr.	Mokka Version mokka-	Geant4 tag geant4-	Detector model	Birks law	Time cut	rangeCut	GeVtoMIP
1	06-06-p03	09-00-patch-01	old	-	0 ns	0.05 mm	861 keV
2	06-08-p01-calice	09-00-patch-01	old	-	0 ns	0.05 mm	861 keV
3	06-08-p01-calice	09-02	old	-	0 ns	0.05 mm	828 keV
4	06-08-p01-calice	09-02	old	on	150 ns	0.05 mm	816 keV
5	06-08-p01-calice	09-02	new	-	0 ns	0.005 mm	828 keV
6	06-08-p01-calice	09-02	new	on	0 ns	0.005 mm	798 keV
7	06-08-p01-calice	09-02	new	on	150 ns	0.005 mm	798 keV
8	06-08-p01-calice	09-02	new	on	150 ns	0.05 mm	816 keV

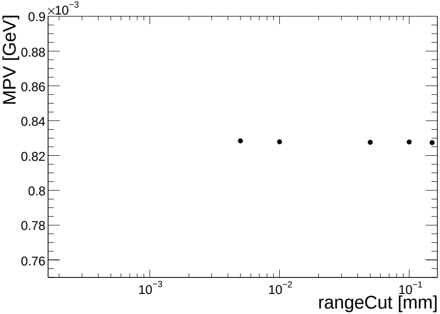
Detector model old: $TBCern07\_01$

Detector model new: $TBCern0807\_p0709$

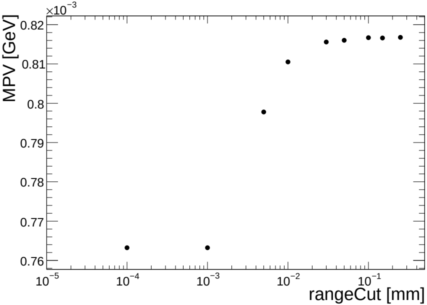
rangeCut scans

Big effects on MPV value due to Birks law ⇒ rangeCut scans

mokka-06-08-p01-calice,
$TBCern0807\_p0709$,
TimeCut = 150 ns,
Birks law OFF



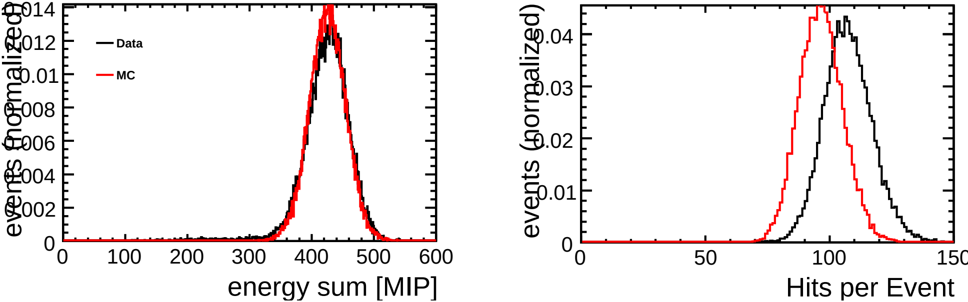
mokka-06-08-p01-calice,
$TBCern0807\_p0709$,
TimeCut = 150 ns,
Birks ON



10 GeV e^+ run - Sums

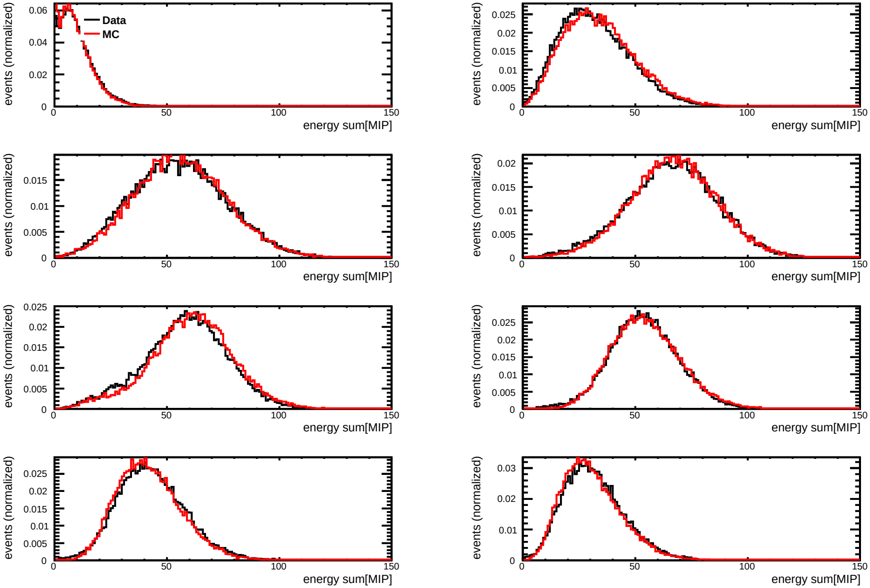
rangeCut: 0.05 mm

GeVtoMIP factor: 816 keV

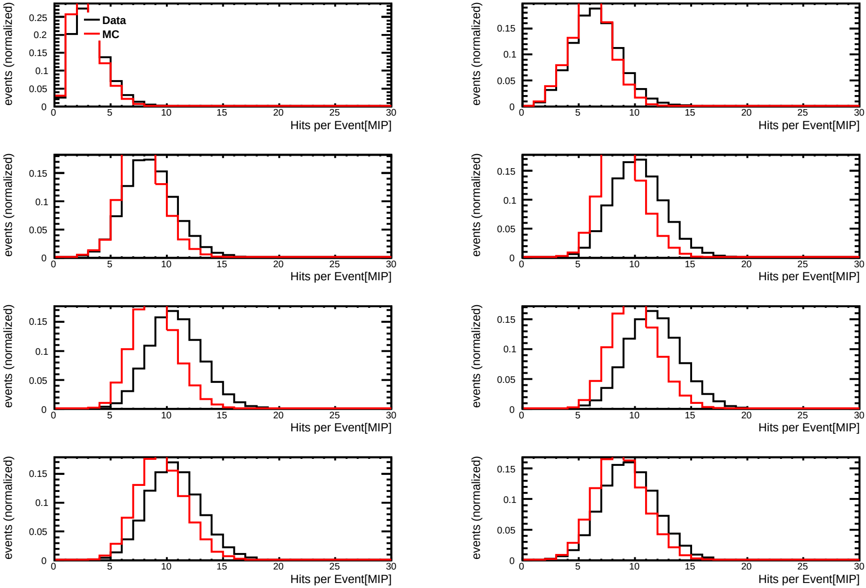


$\Rightarrow$ Agreement in Energy Sum but not in the number of Hits

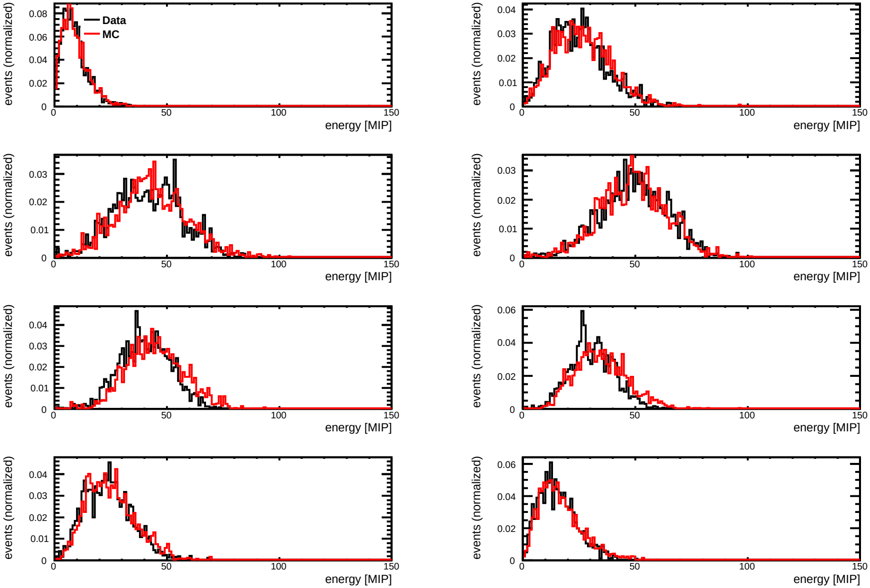
10 GeV e^+ run - energy in layers



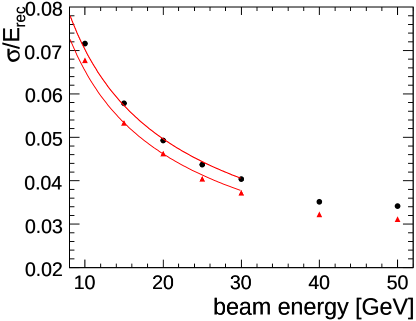
10 GeV e^+ run - hits in layers

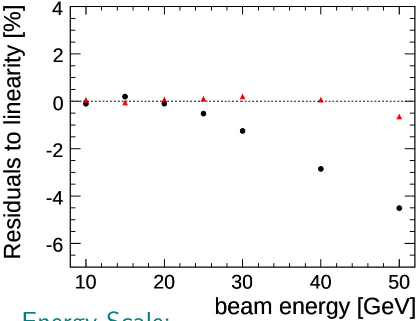


10 GeV e^+ run - centered tile



Linearity and Energy resolution





Energy Resolution:

Data:

$$\frac{\sigma}{E} = 22.20 \pm 0.02\% \cdot \frac{1}{\sqrt{E}} \oplus 0.0 \pm 0.4\%$$

MC:

$$\frac{\sigma}{E} = 20.66 \pm 0.02\% \cdot \frac{1}{\sqrt{E}} \oplus 0.0 \pm 0.1\%$$

Energy Scale:

Data:

$$E[GeV] = 42.88 \pm 0.05 \cdot E[MIP] + -1.3 \pm 0.7$$

MC:

$$E[GeV] = 42.93 \pm 0.03 \cdot E[MIP] + -4.7 \pm 0.4$$

Number of Hits differences

Do we miss something in Mokka? Do we loose hits in the digitization?

Test-Nr.	Collection / Setting	#Hits	Energy
1	AfterGanging	60	0.31 GeV
2	Fully digitized; no Noise, no x-Talk	60	376 MIP
3	Fully digitized; no Noise, 10 % x-Talk	75	411 MIP
4	Fully digitized; Noise, 10 % x-Talk	95	424 MIP

Data: #Hits: 105, Energy: 424 MIP

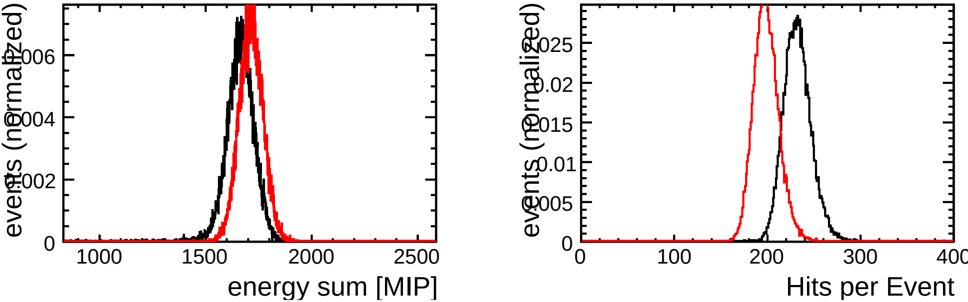
- Expected Sampling fraction: $\approx \frac{1}{30}$
- Digitization does the right thing
- Additional noise source: electronic noise which is related to neighboring amplitude?
- Study on electronic noise

Summary

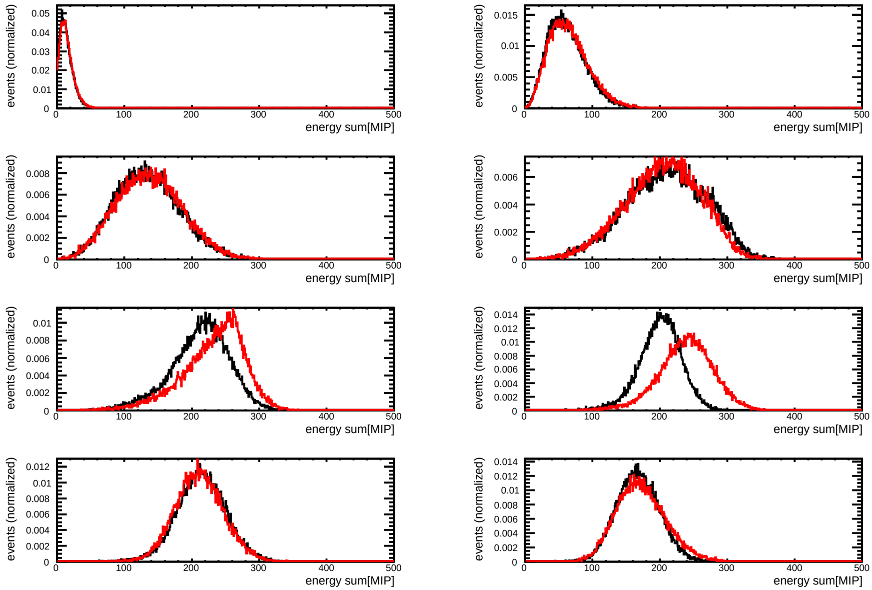
- Always use values for rangeCut in Mokka and MipPerGeV in Marlin digitization that belong together!!!
- MC at low energies look good exept for number of hits
- Electronic noise should be discussed
- New saturation treatment could change the high energy spectra significantly
- Many recent changes includes $\Rightarrow$ energy scale and energy resolution like November 2008 now ☺ ☹

Comparison 40 GeV

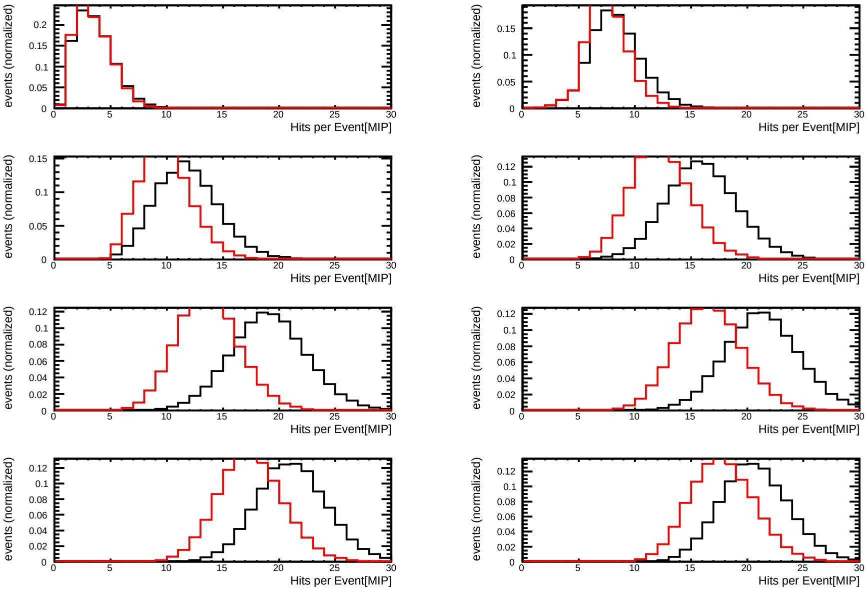
rangeCut: 0.05 mm
GeVtoMIP factor: 816 keV



40 GeV e^+ run - energy in layers



0 GeV e^+ run - hits in layers



40 GeV e^+ run - centered tile