Simulation of gamma quanta scattering in organic strip scintillator

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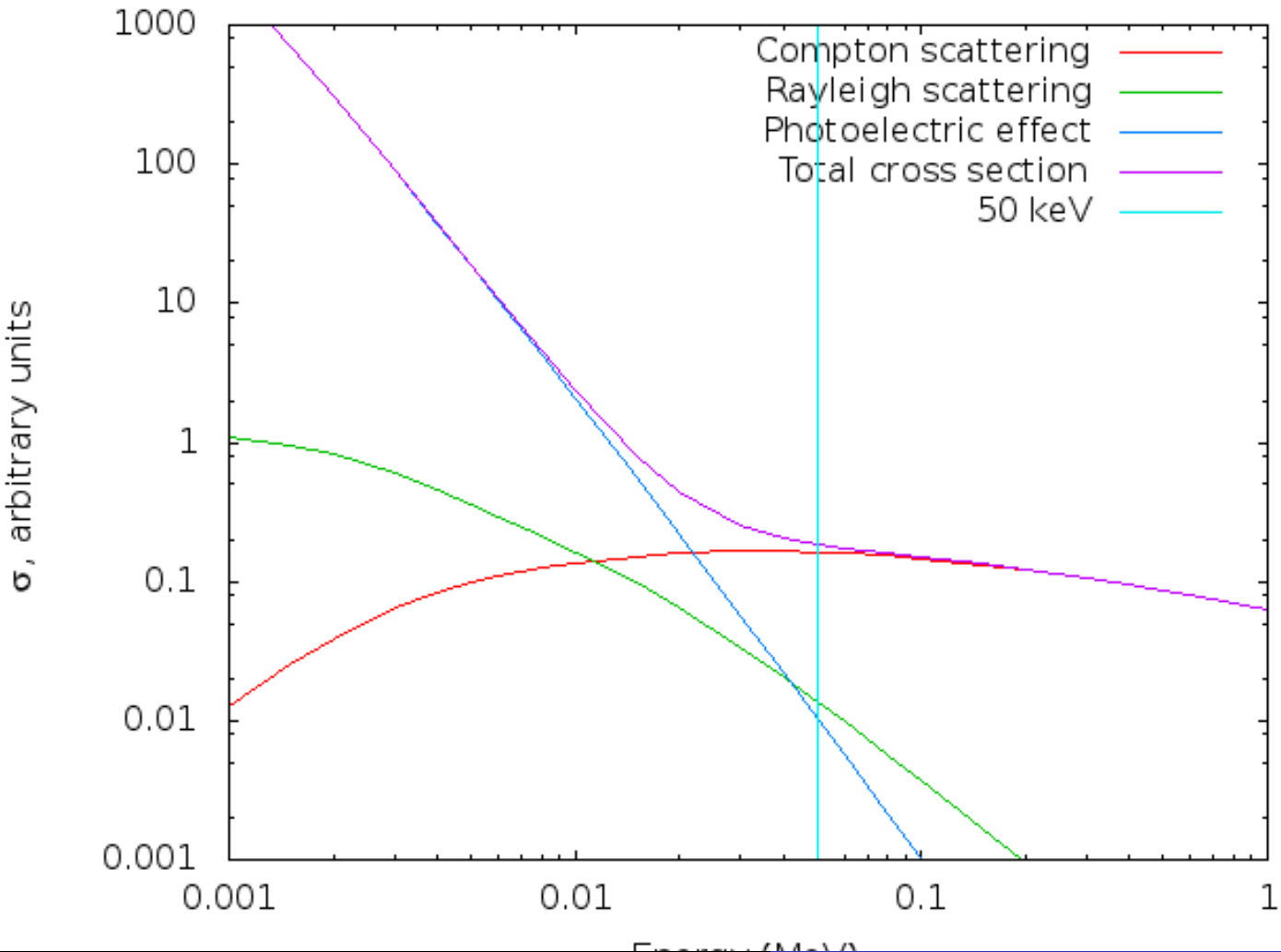
Input data

- Scintillator description: dimensions of cuboid, attenuation constant for gamma quanta of energy $m_e c^2 \approx 511$ keV
- Gamma quanta beam description: initial position, energy, momentum direction
- Number of events, maximum number of interactions (to ensure algorithm stops)

Assumptions

- Rayleigh scattering is neglegible — much lower cross section in interesting energy range
- Photoelectric effect is neglegible — it has infulence when energy is $\leq$50 keV. 50 keV energy could be achieved at least after fifth interaction (initial energy = 511 keV)
- Gamma quanta speed = c
- Scintillator has convex shape

Cross sections of interactions of gamma quanta with carbon



Algorithm outline I

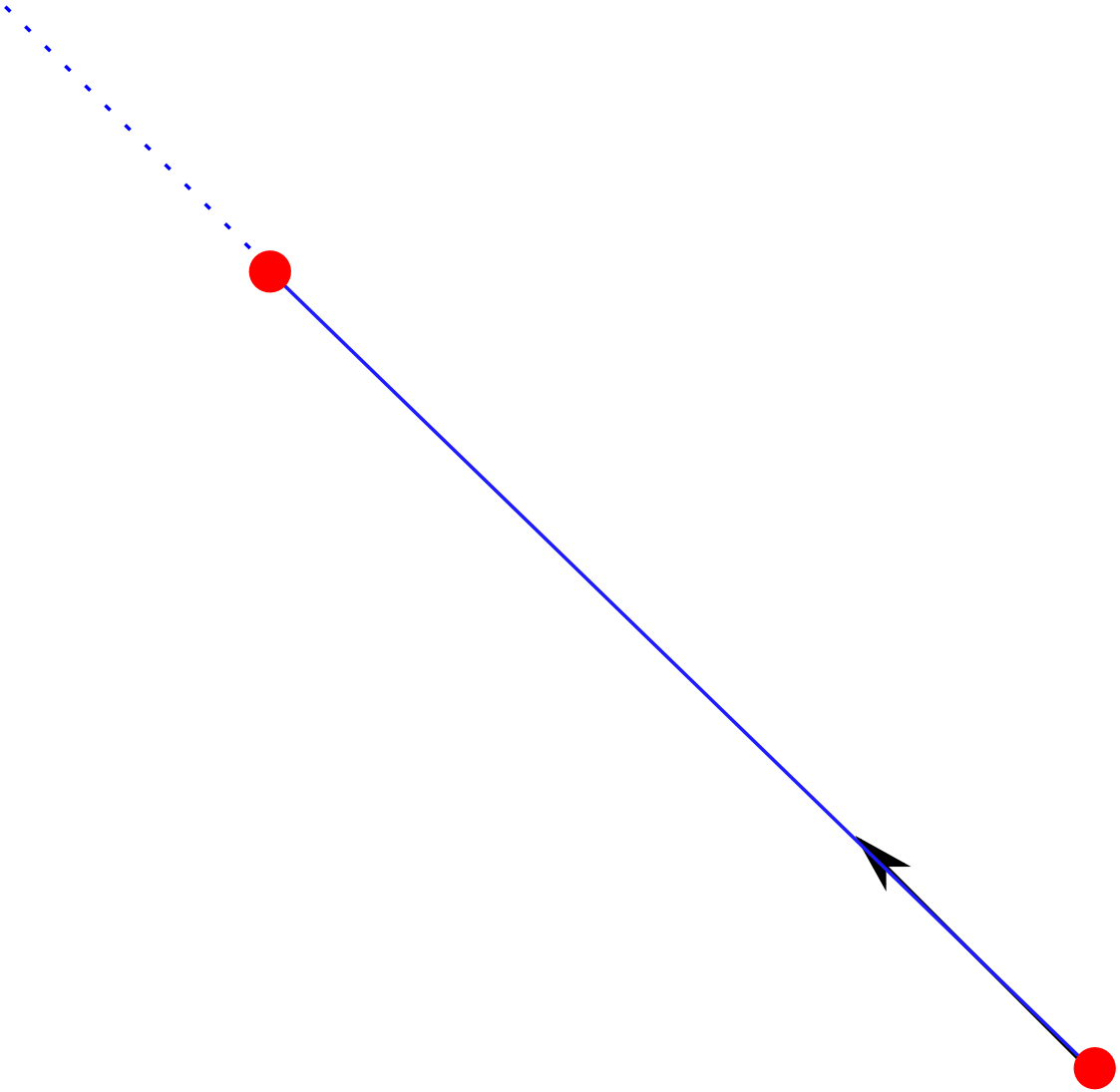
N — number of events
k — maximum number of interactions within one event

while current number of events $\leq$ N **do**
  position $\leftarrow$ initial position
  direction $\leftarrow$ initial direction
  energy $\leftarrow$ initial energy
  while current number of interactions $\leq$ k **do**
    $\lambda \leftarrow n_e \cdot$ total cross section
    length $\leftarrow$ random value of exponential distribution
    $\rho(x > 0) = \lambda \exp(-x\lambda)$
    position $\leftarrow$ position + direction $\cdot$ length
    if position not in scintillator **then**
      end event

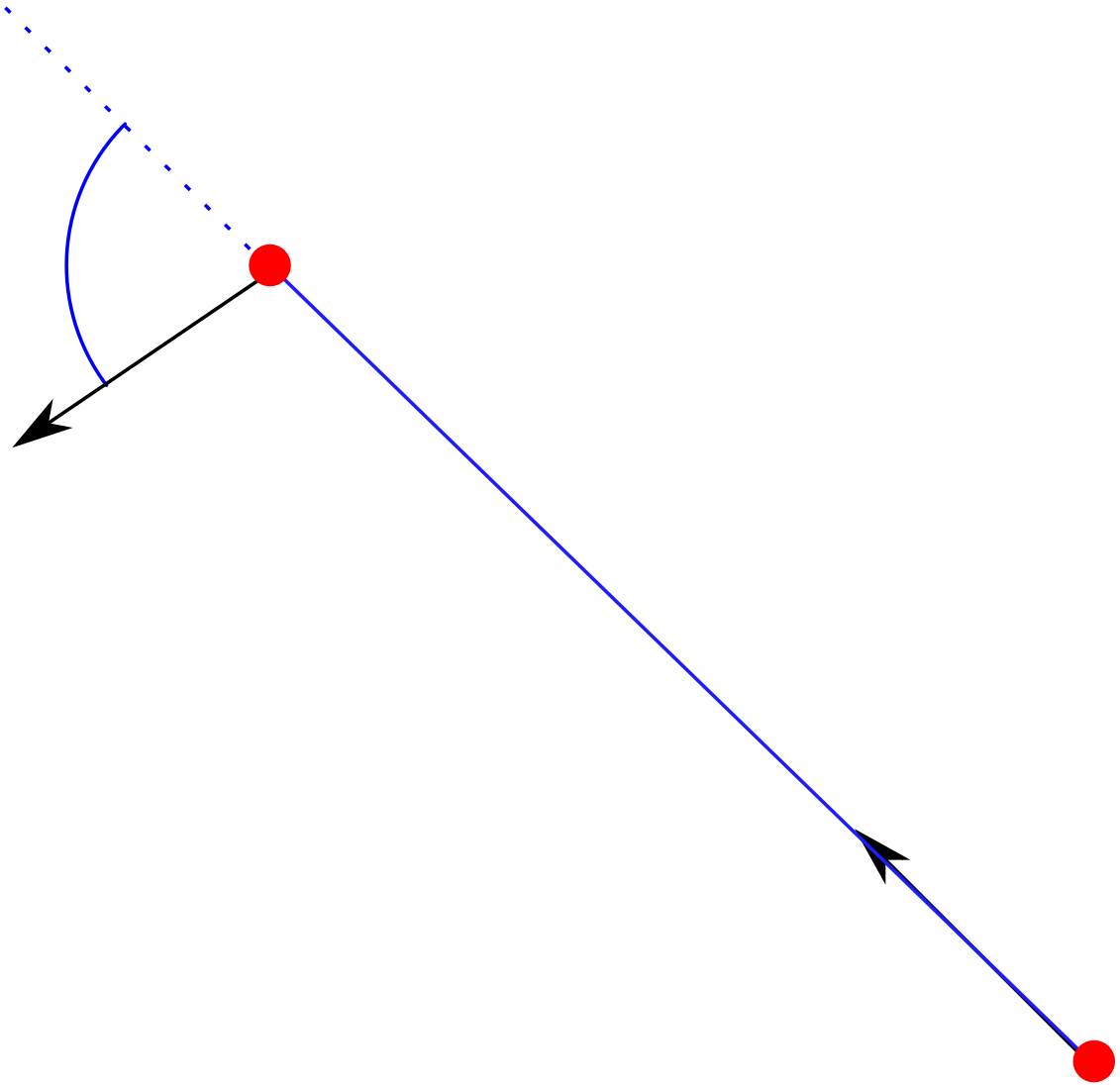
Algorithm outline II

end if
angle $\leftarrow$ random angle of Klein-Nishina distribution
rotate direction in calculated angle
write down position, deposited energy, time
end while
end while

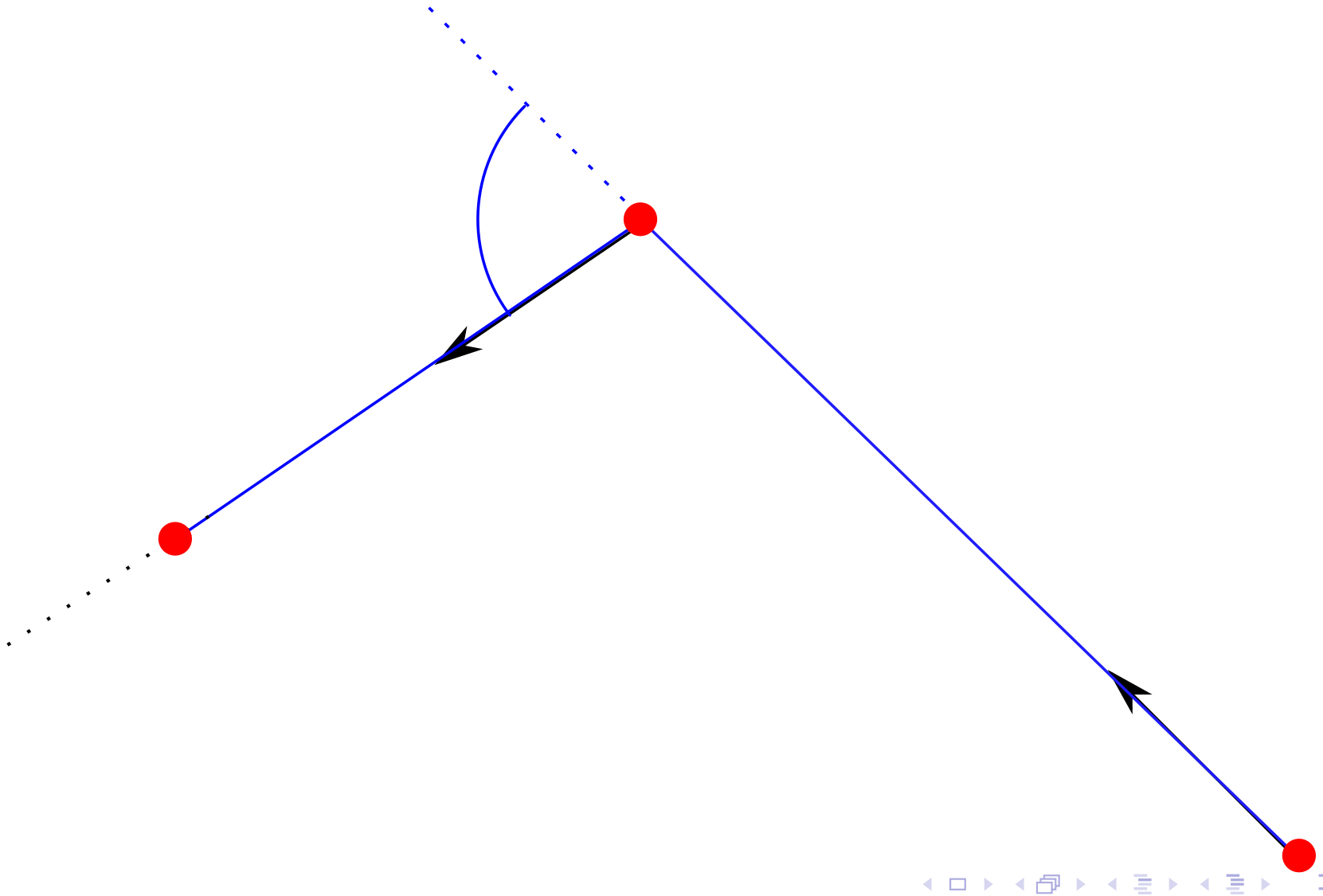
Depiction of algorithm



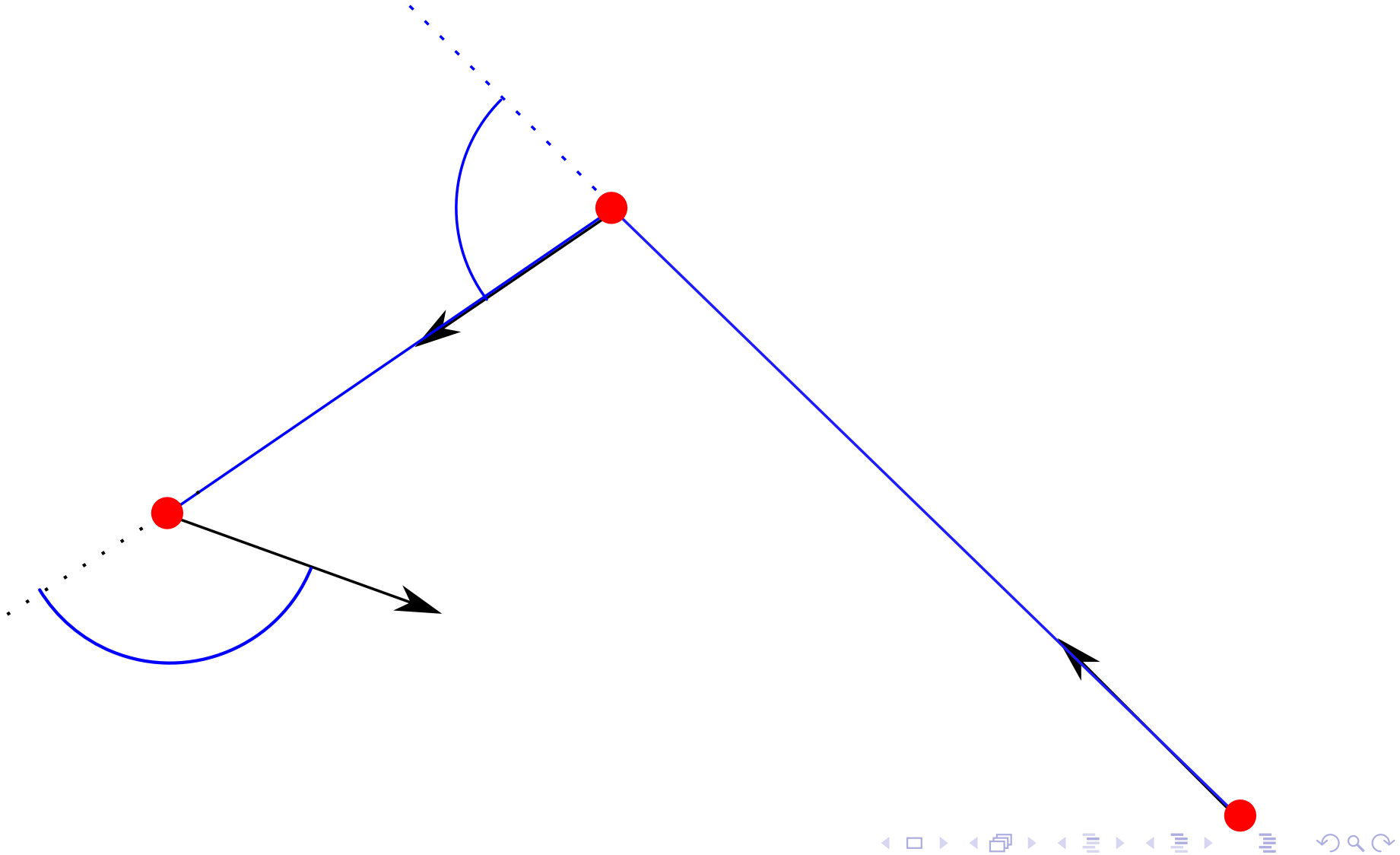
Depiction of algorithm



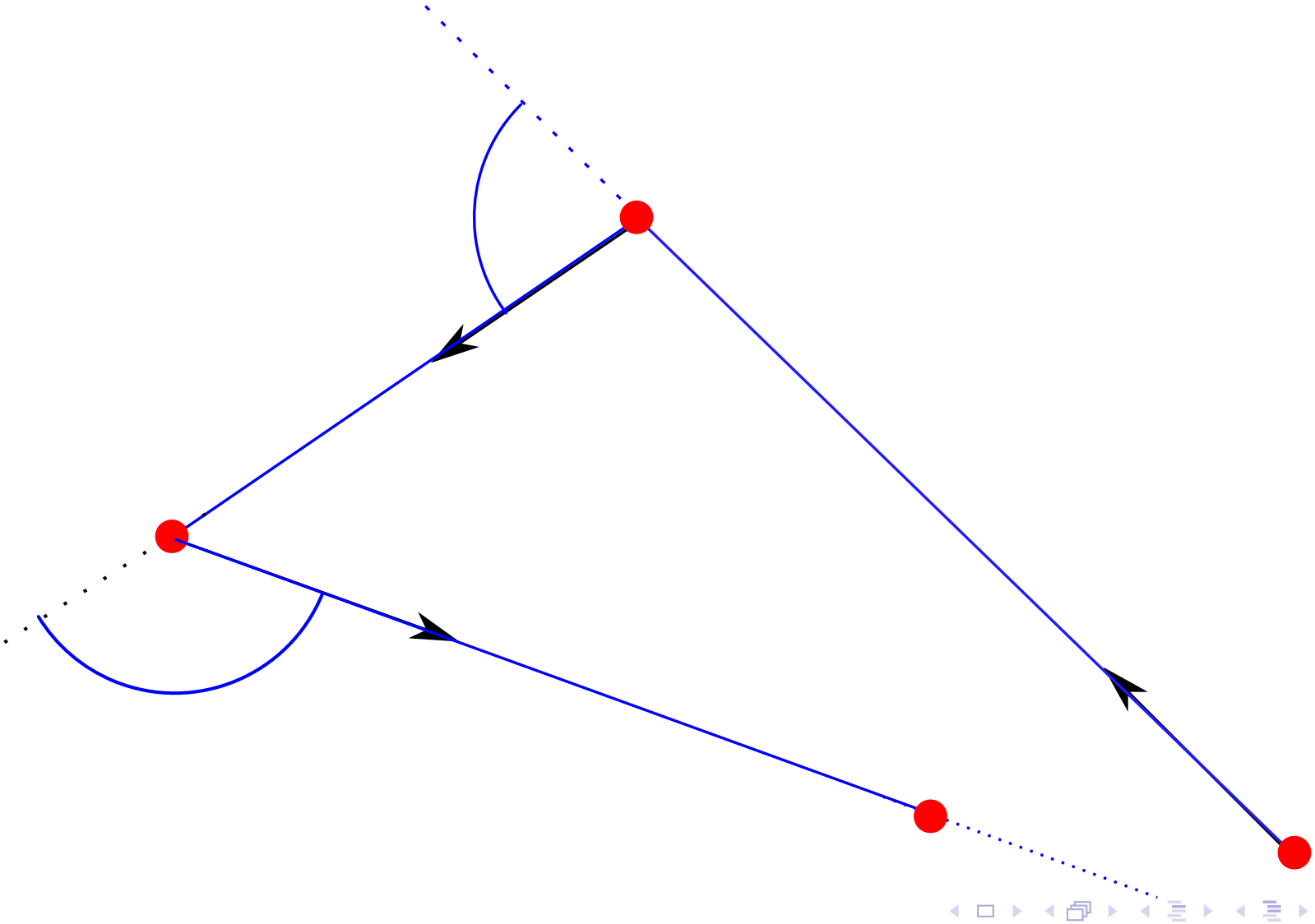
Depiction of algorithm



Depiction of algorithm



Depiction of algorithm



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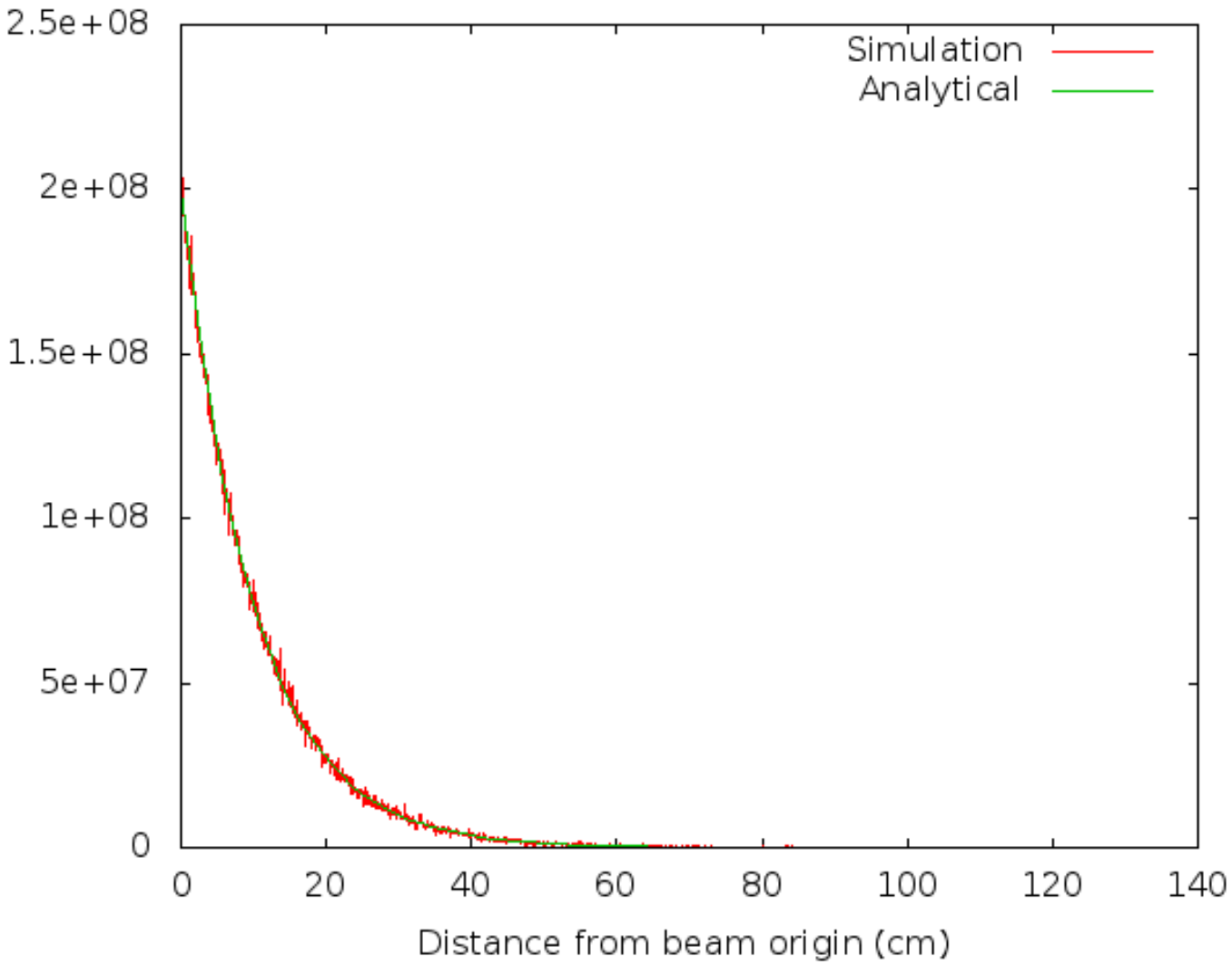
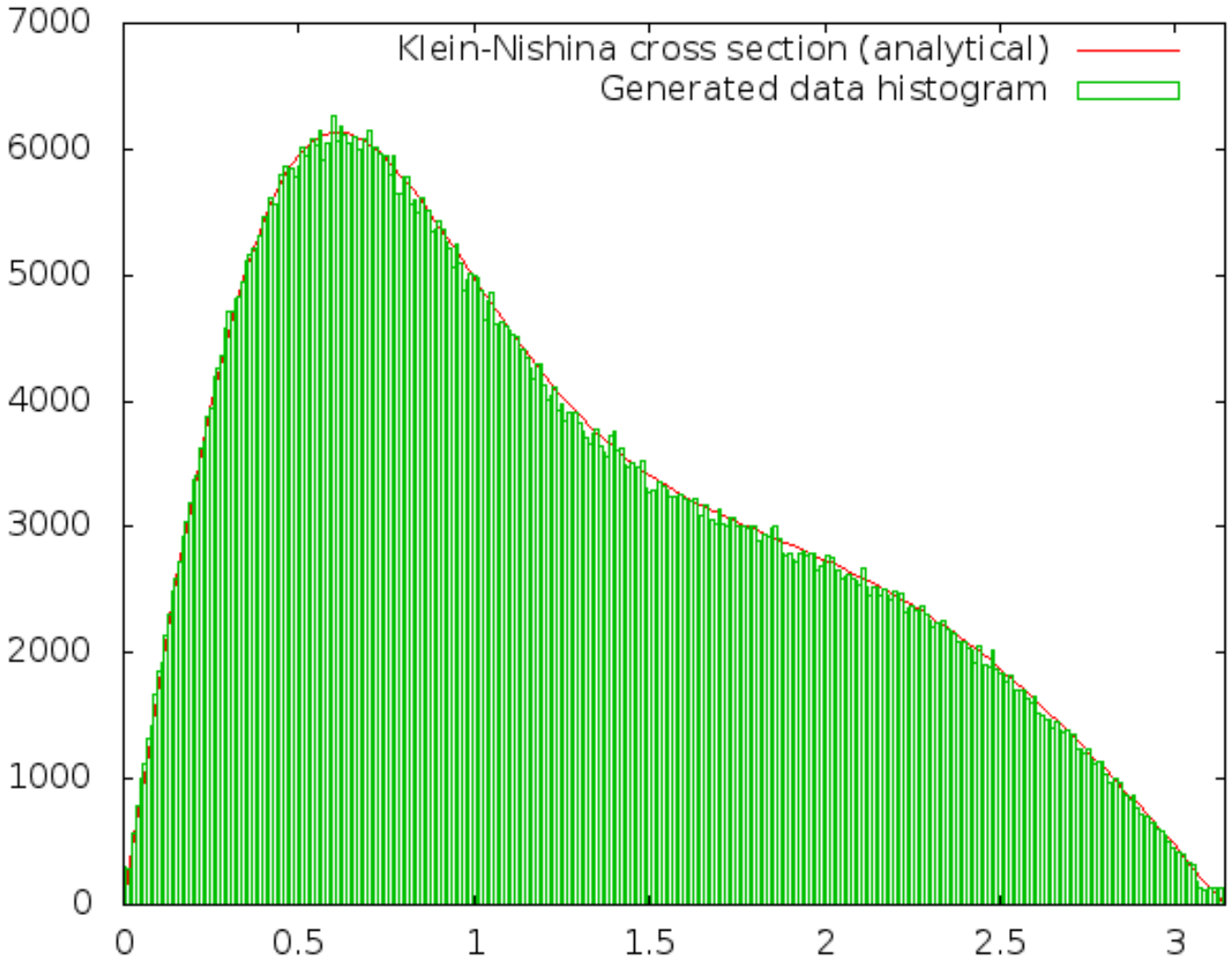
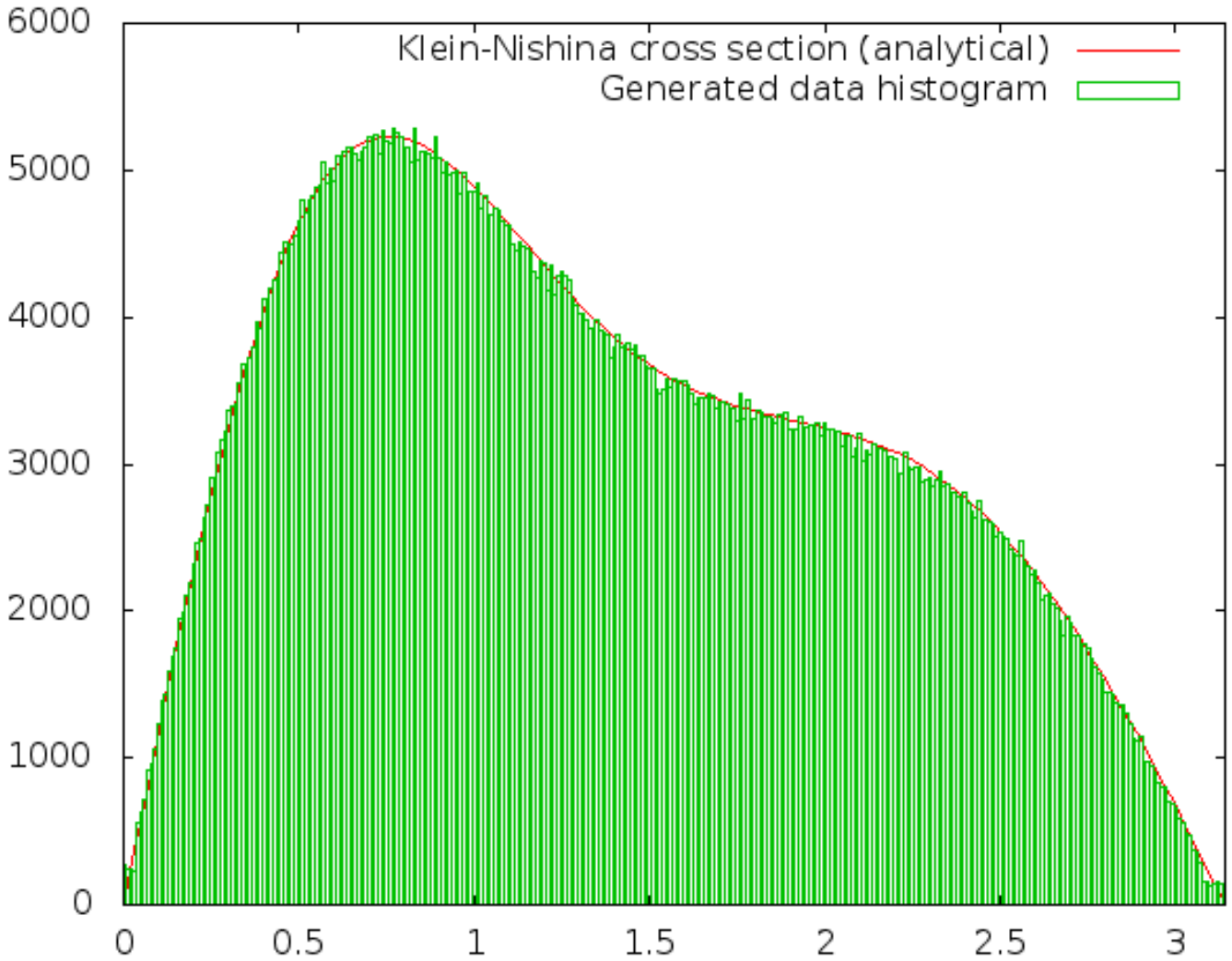
Total cross section test for energy $1 m_e$



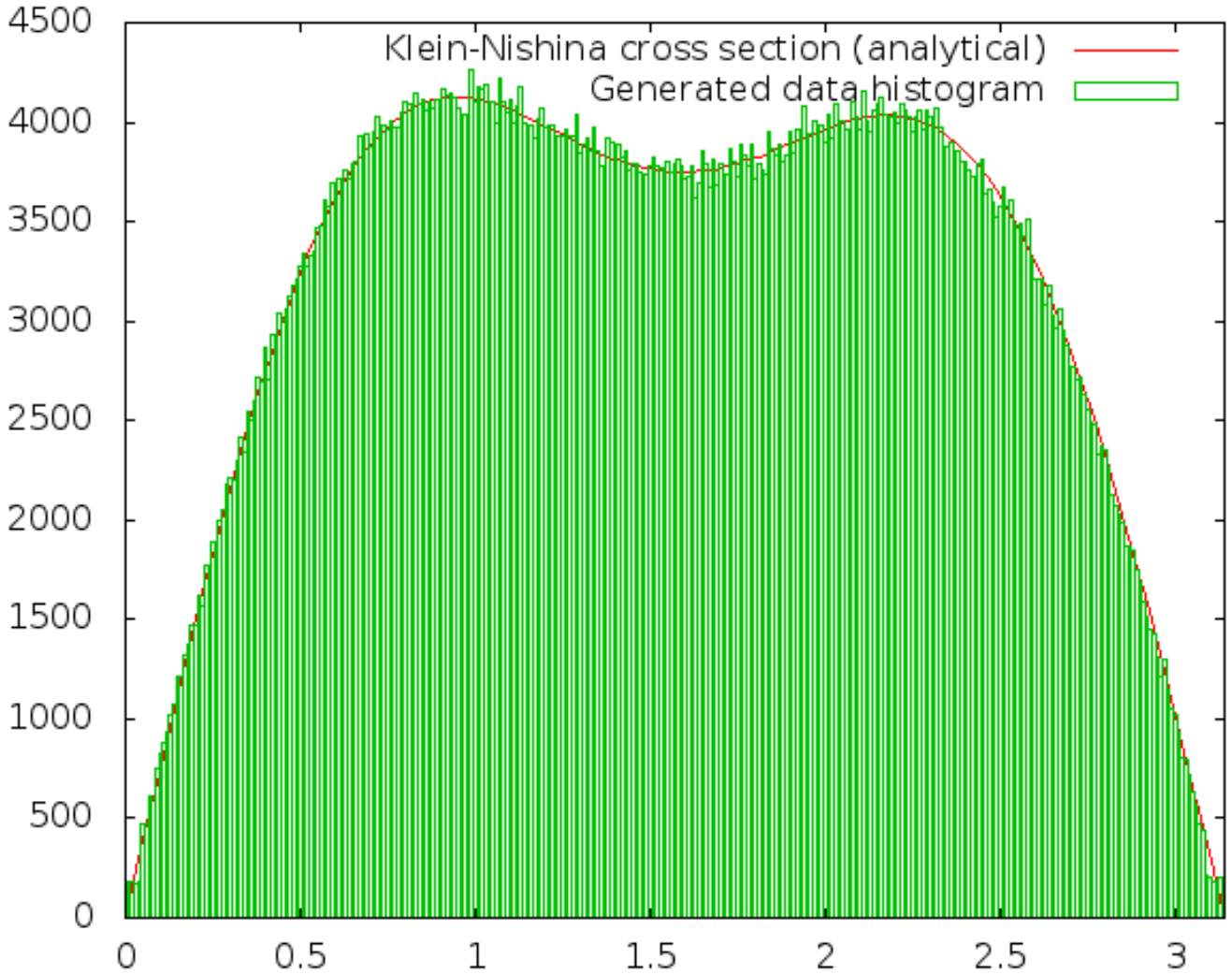
Angular distribution check for energy $1 m_e$



Angular distribution check for energy $0.3456 m_e$



Angular distribution check for energy $0.01 m_e$



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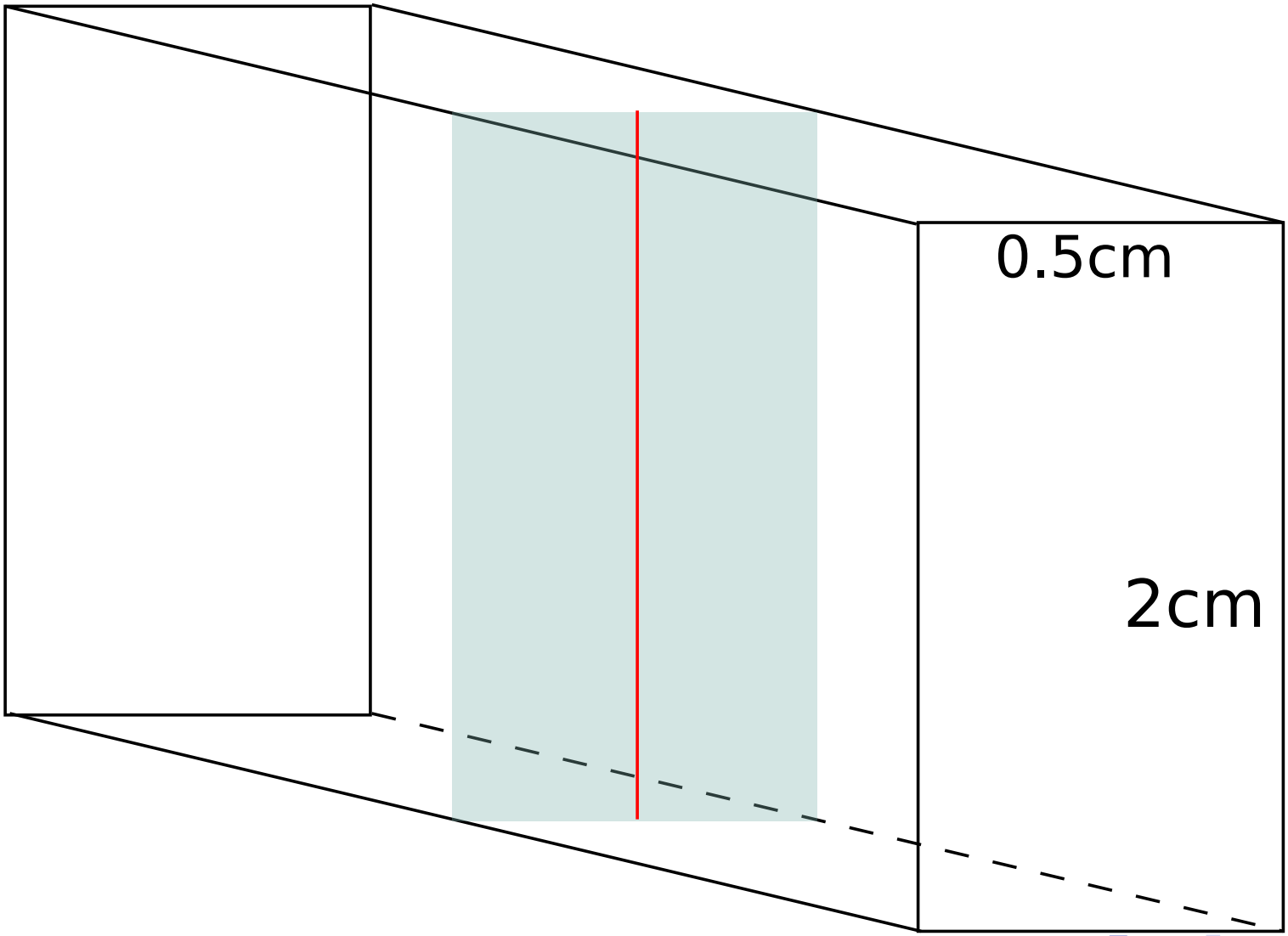
Conditions

- Scintillator's dimensions: 2000cm $\times$ 0.5 cm $\times$ 2 cm
- Initial point on center of top surface, direction — z–axis
- Initial energy — $m_e c^2$
- Maximum number of interactions — 1000
- Number of events — 10^6
- Attenuation constant for gamma quantum of energy $m_e c^2$ — $(10\,\mathrm{cm})^{-1}$

Conditions depiction

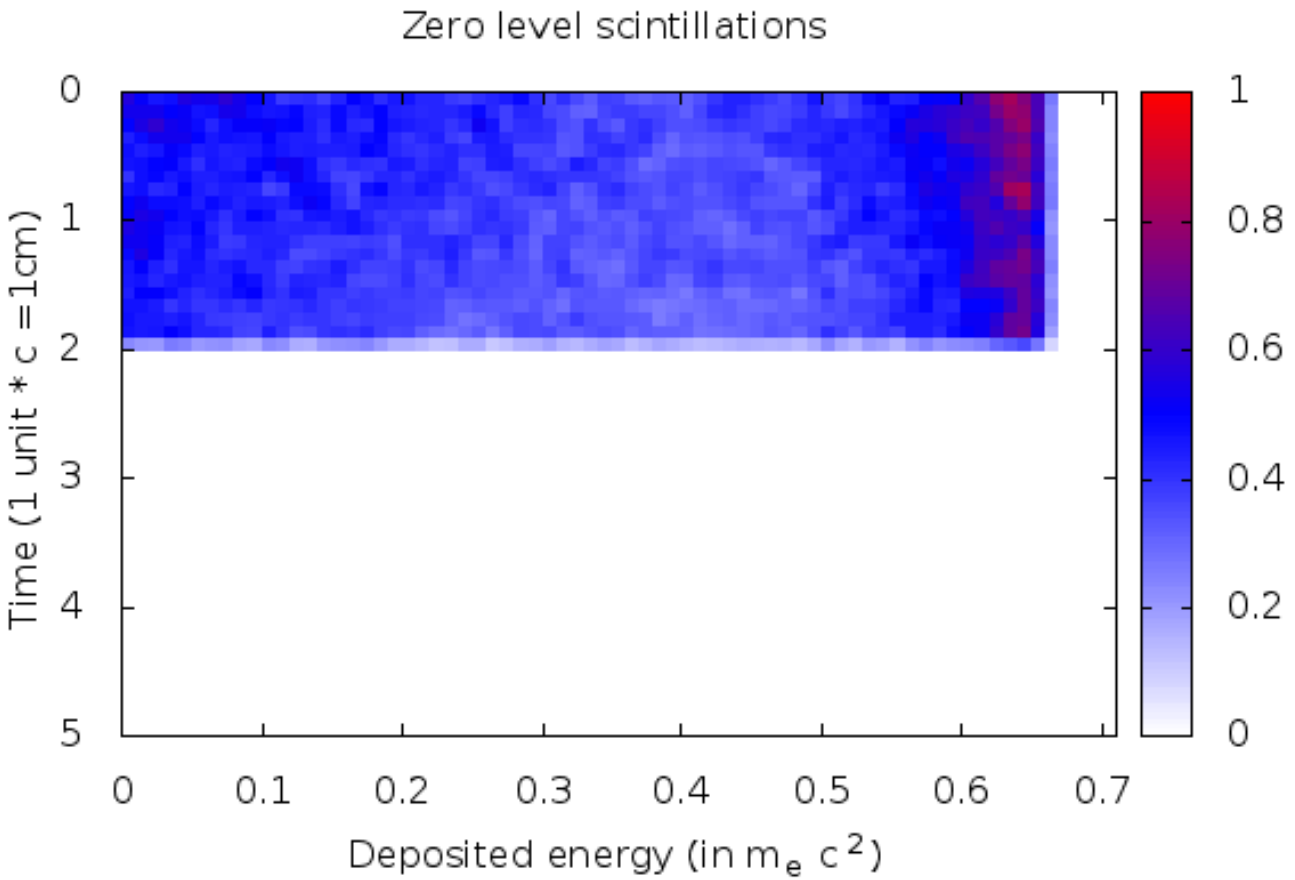


Higher order interactions frequency

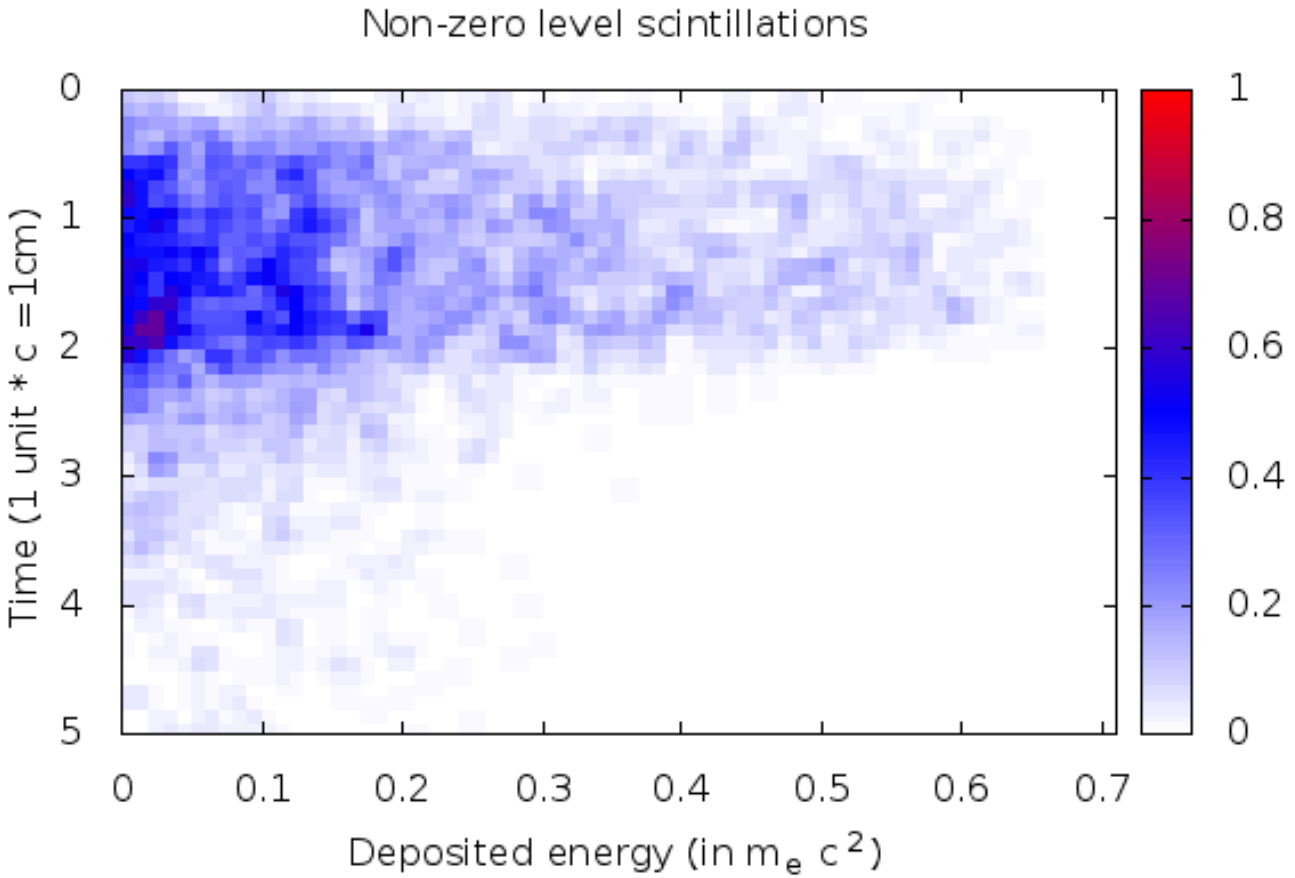
Order	Frequency	Number of events
1	100 %	1000000
2	7.60 %	76013
3	0.589 %	5899
4	0.0508 %	508
5	0.00460 %	46
6	0.0002 %	2

It is acceptable to neglects Rayleigh scattering and photoelectric effect.

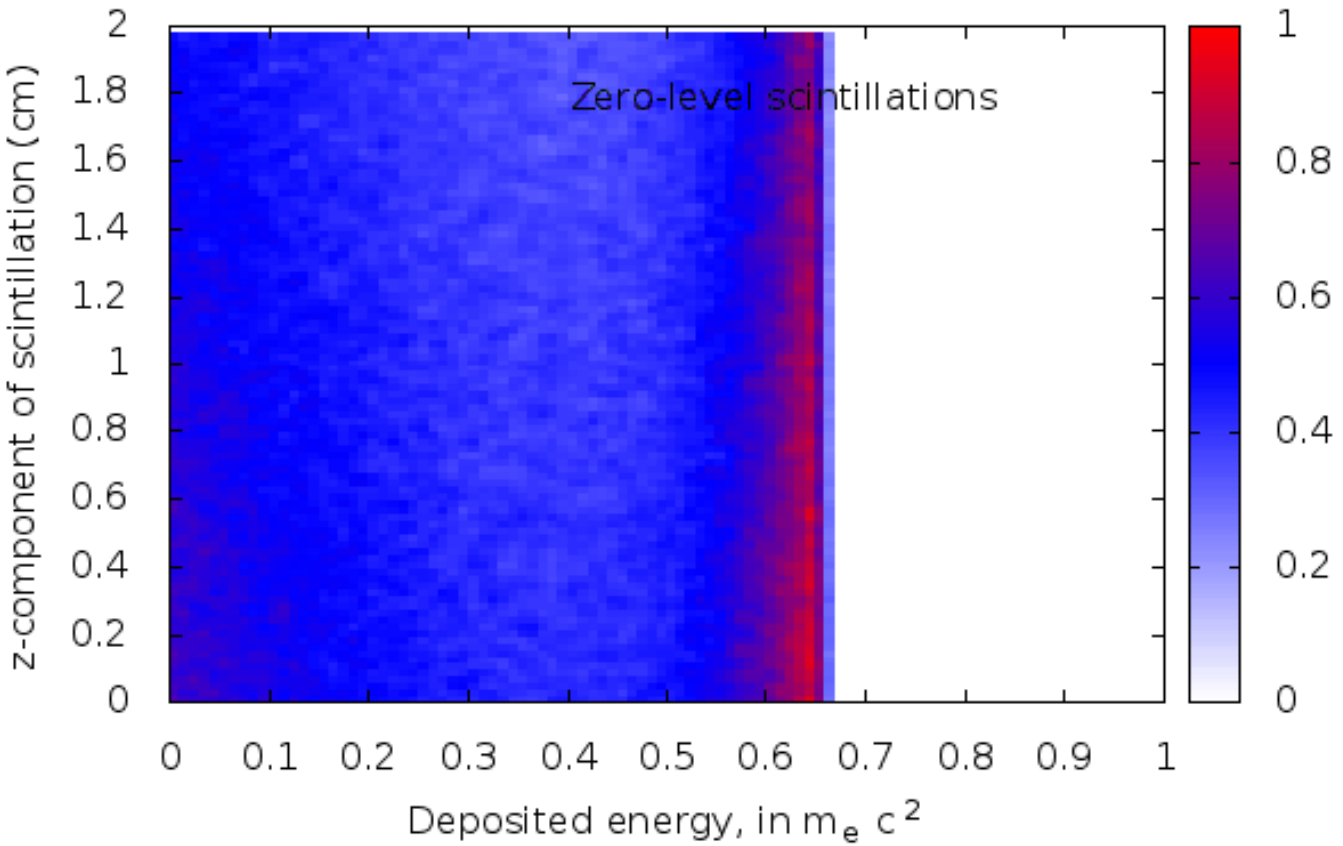
E–t histogram — first order interactions



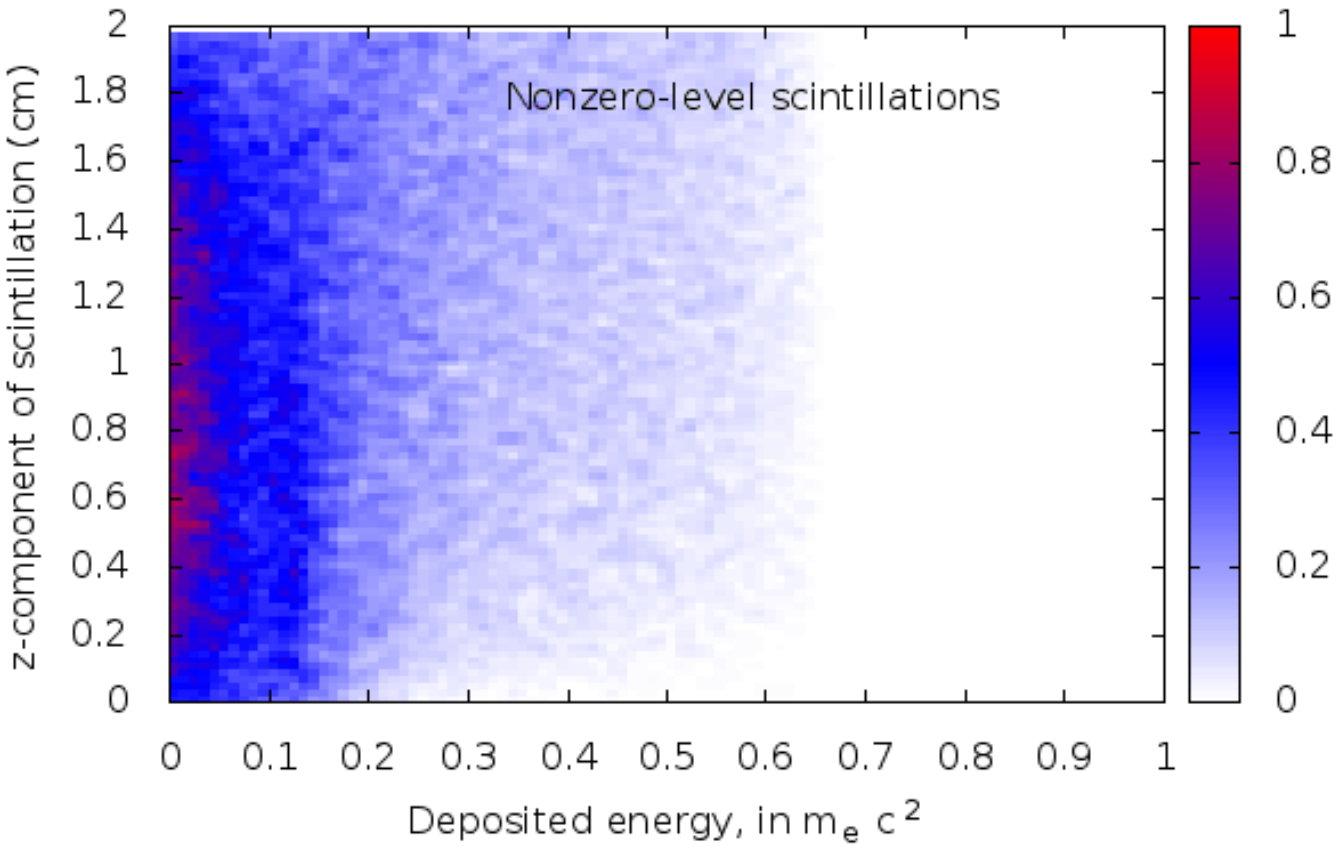
E–t histogram — higher order interactions



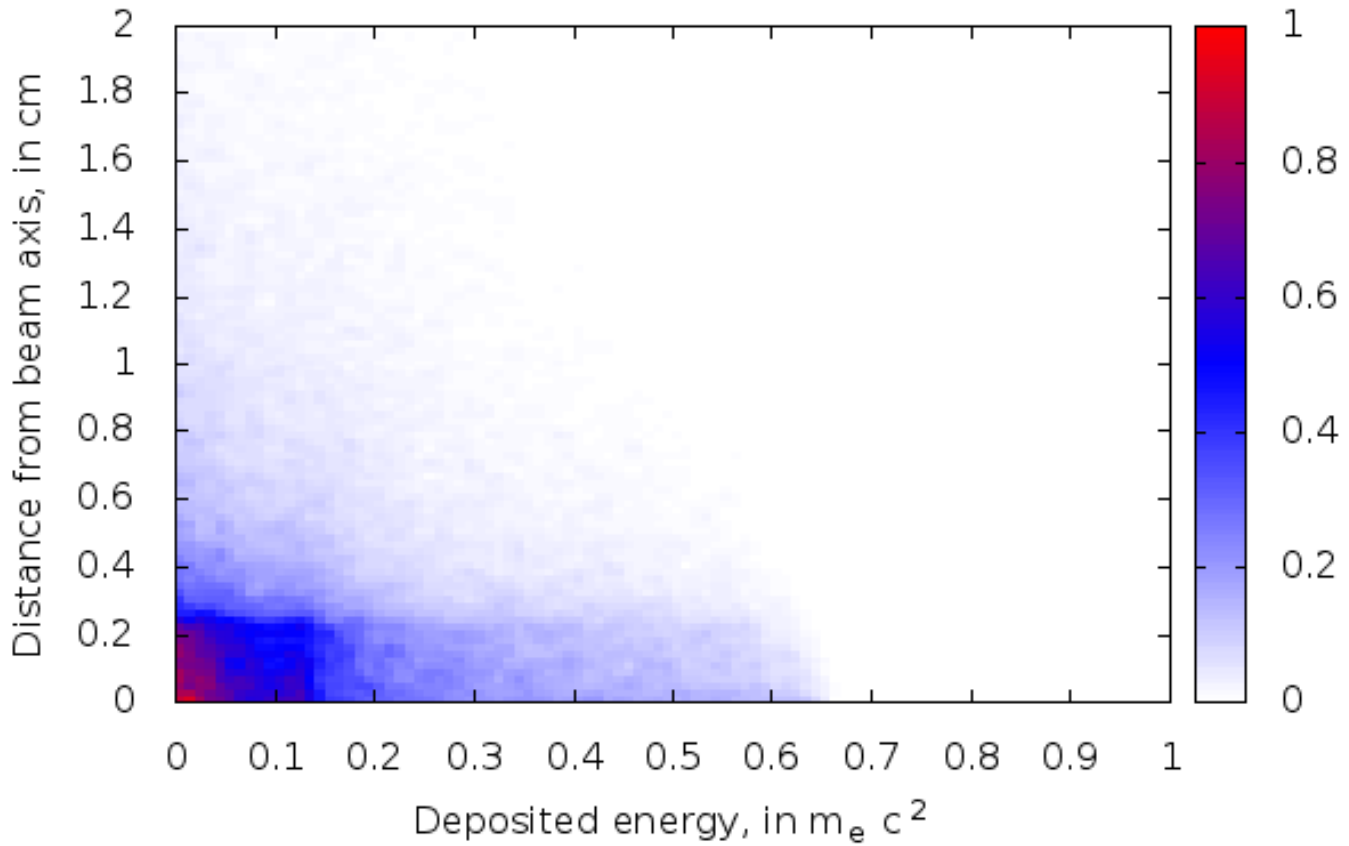
E–z histogram — first order interactions



E–z histogram — higher order interactions



E-r histogram



Summary

- Only first two interactions in each event matter
- In big part of first–order interactions large energy is deposited, while in higher order deposited energy is small.
- Higher order interactions are close to the beam axis.

Bibliography

NIST XCOM

Photon cross section database

http://physics.nist.gov/PhysRefData/Xcom/Text/intro.html