Study of different geometry for Mu2e Calorimeter

Antonio De Maria

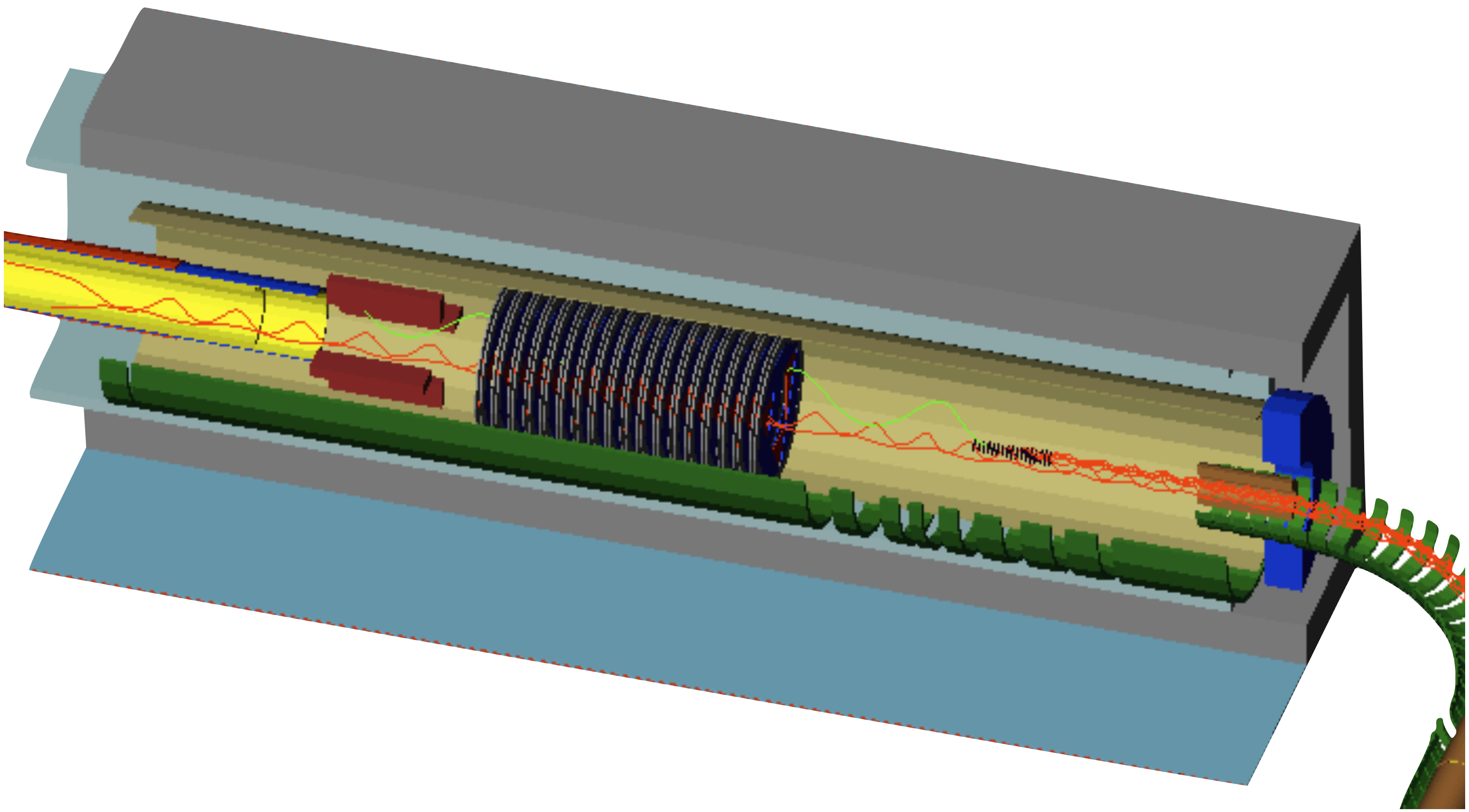
09/26/2012

Mu2e goal

$$R_{\mu e} = \frac{\mu^- + Al \rightarrow e^- + Al}{\mu^- + Al \rightarrow \nu_\mu + Mg}$$

with a single-event-sensitivity (s.e.s.) estimated to be 2.3×10^{-17} for two years of data taking. Assuming $R_{\mu e} \approx 10^{-15}$, Mu2e might observe 50 signal events with a background of < 0.5 events.

Detector Solenoid



The detector has three main components: the stopping target, the tracker and the calorimeter.

Calorimeter's features

- Radiation length :

$$X_0(g/cm^2) \approx \frac{716 \cdot A}{Z(Z+1)\ln(287/\sqrt{Z})} g/cm^2$$

- Longitudinal shower development:

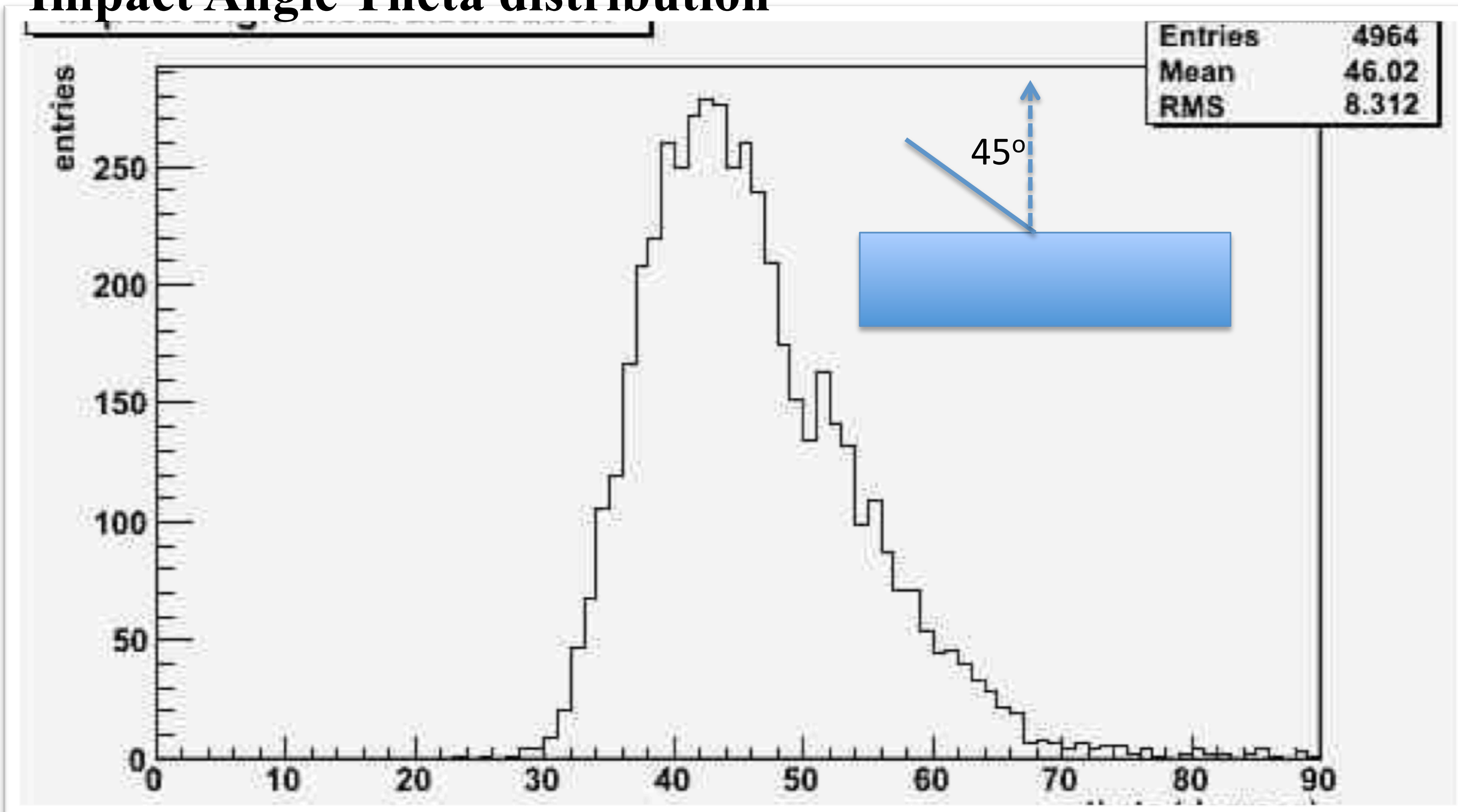
$$\frac{dE}{dt} = E_0 b \frac{(bt)^{a-1} e^{-bt}}{\Gamma(a)}$$

- Transverse shower development:

$$R_M(g/cm^2) \approx 21 MeV \frac{X_0}{\varepsilon(MeV)}$$

Impact angle distribution

Impact Angle Theta distribution



Theta (degrees)

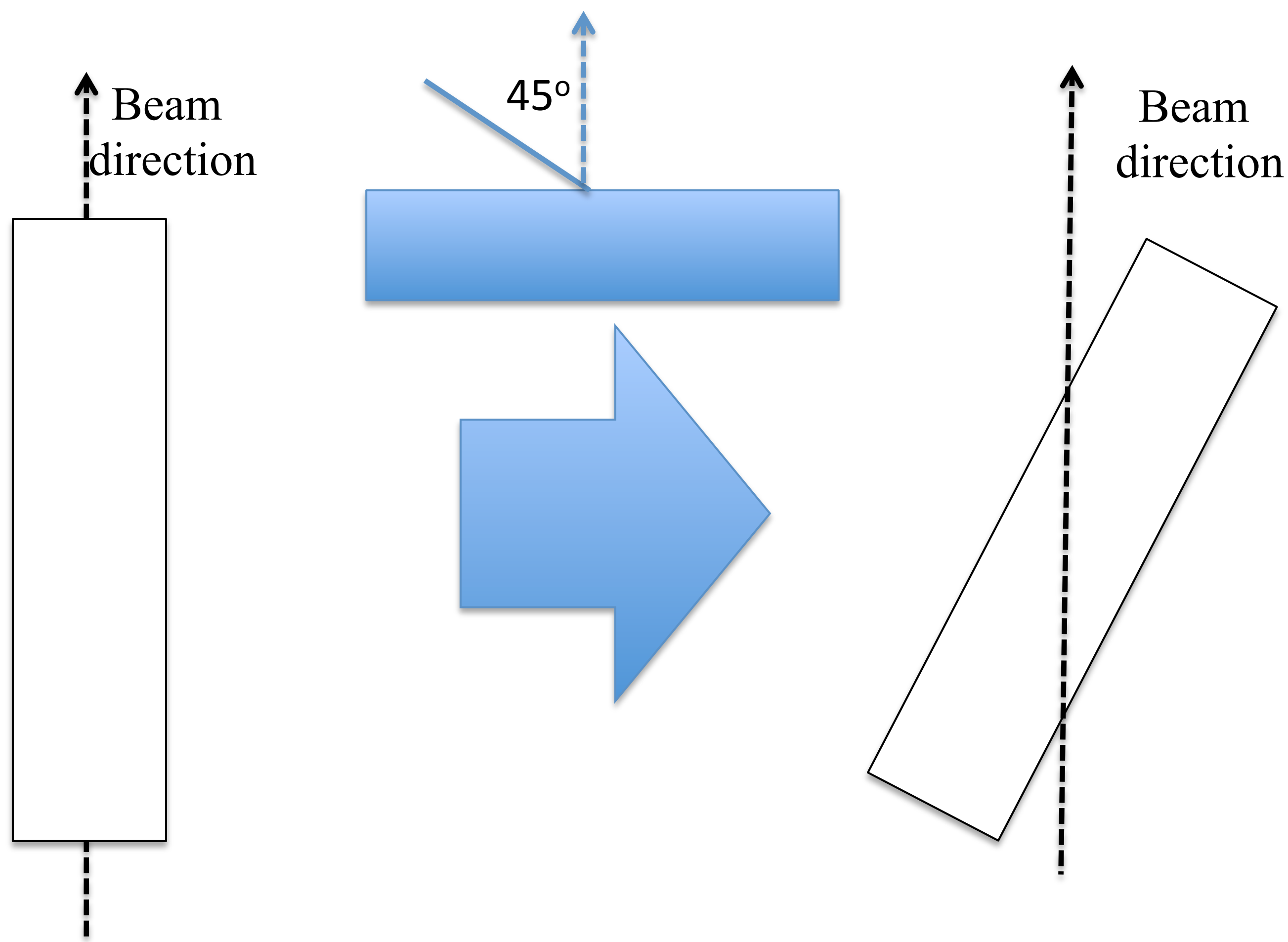
Baseline Geometry's Problem

- LYSO crystal's half size = 1.5 cm.
- Transverse distance covered from entry point to shower max is :

$$showerMax \cdot \sin(45°) \approx 3.6 \cdot cm \cdot \sin(45°) \approx 2.5 \cdot cm$$

Most of the energy deposited by conversion electron is contained in a cell near the first cell hit.

Rotated Vane Geometry



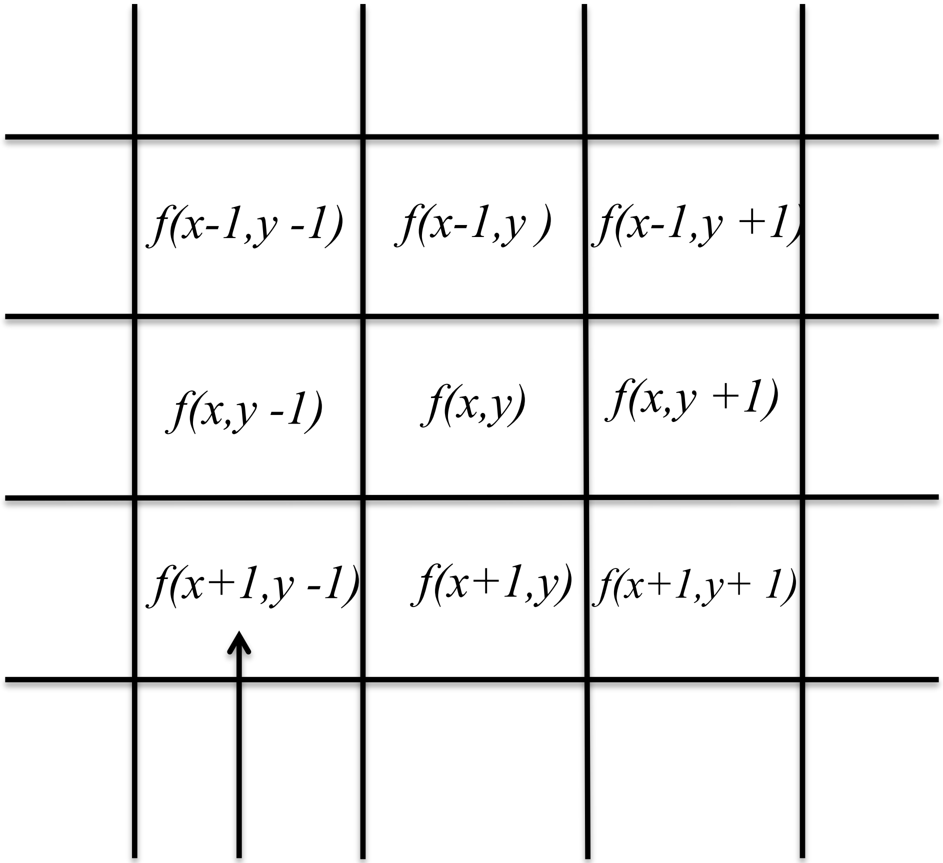
baseline

rotation of vane by an angle ≈ 45°

Simulation’s features

- 10000 conversion electrons generated for every run.
- Events with maximum energy deposit in the calorimeter’s edges crystals were not considered.

Clustering Algorithm



Elementary LYSO cell

w(-1,-1)	w(-1,0)	w(-1,1)
w(0,-1)	w(0,0)	w(0,1)
w(1,-1)	w(1,0)	w(1,1)

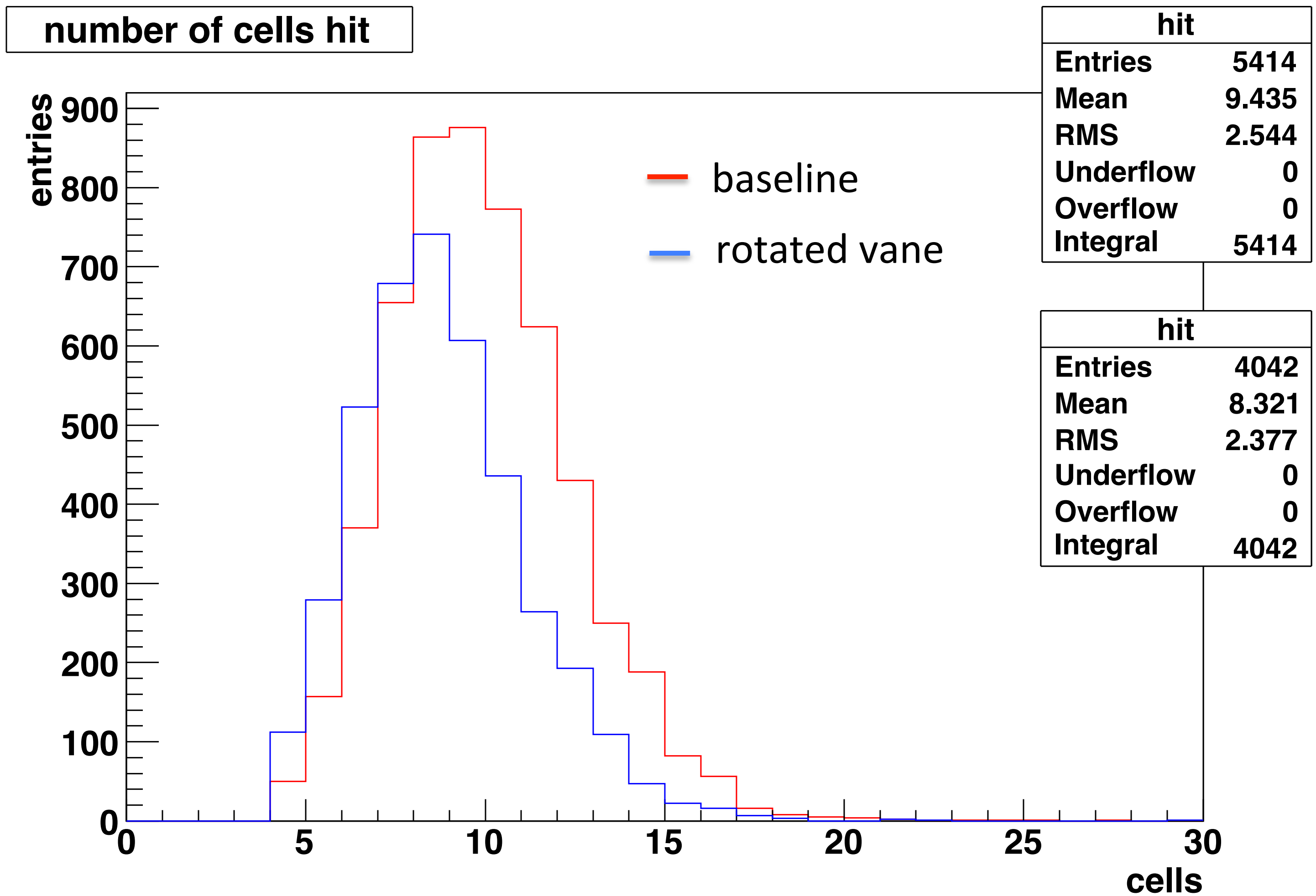
convolution matrix

Clustering Algorithm

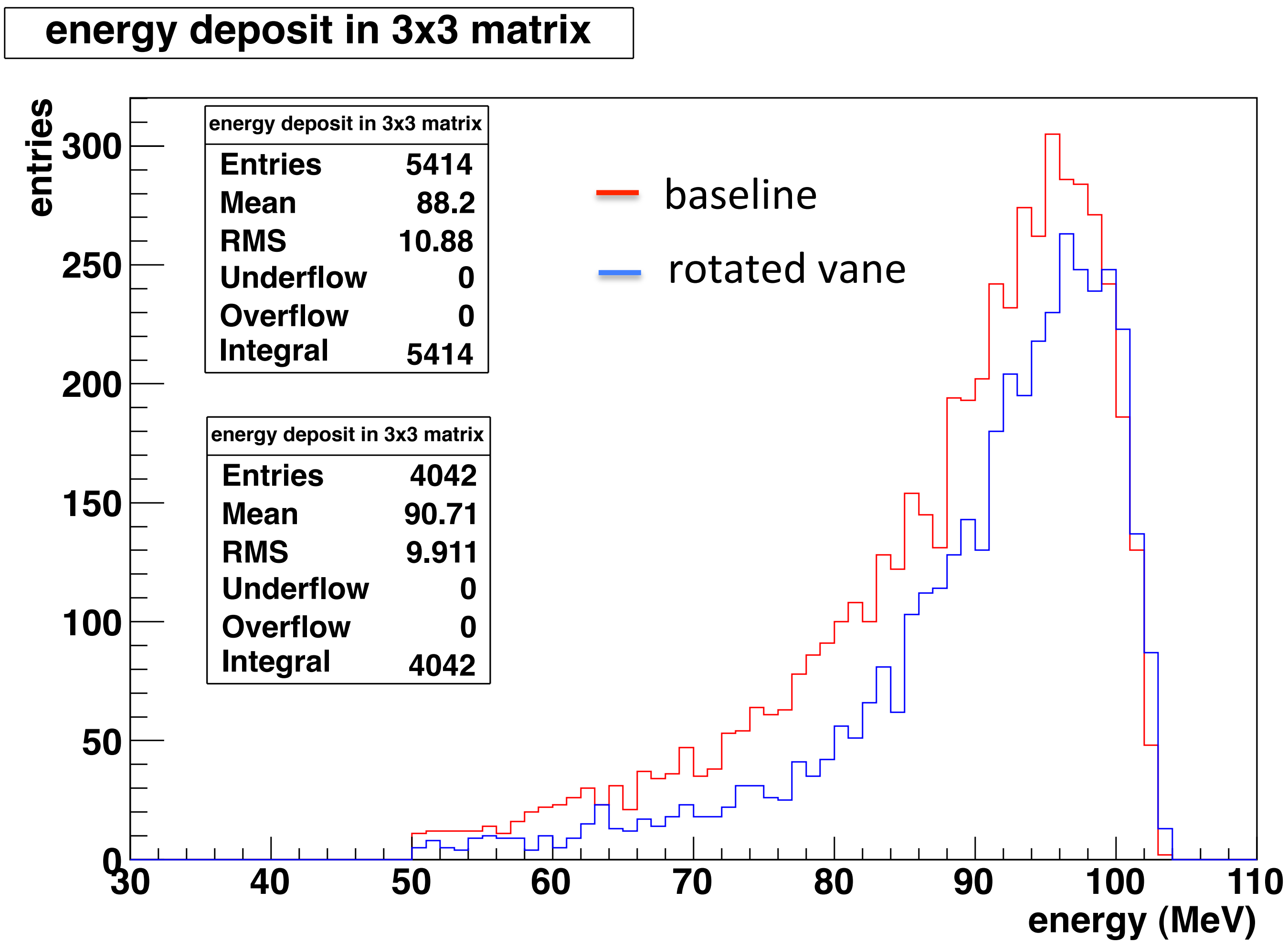
$$S_{3\cdot 3} = \sum_{s=-1}^{1} \sum_{t=-1}^{1} w(s,t) f(x+s, y+t)$$

where w(s,t)=1 are the coefficients of the convolution matrix; f(x+s,y+t) are the values of energy contained in the group of cells under examination; f(x,y) is the energy contained in the central cell.

Number of cells hit



Energy deposit in 3x3 matrix



Maximum energy cell = first hit cell

- Baseline geometry:

$$\frac{evt_{E\_\max=E\_fhit}}{tot\_evt} = \frac{2331}{5414} = 43\%$$

- Rotated vane geometry:

$$\frac{evt_{E\_\max=E\_fhit}}{tot\_evt} = \frac{2535}{4042} = 63\%$$

Conclusions and next steps

- In this two months I have learned Mu2e software, writing some code files used to obtain data for event analysis.
- Next steps are:
  - Study of calorimeter's acceptance with the rotated vane geometry.
  - Implementation and development of position reconstruction algorithms.
  - Study of calorimeter's energy resolution.

Charged-Lepton Flavour-Violation (CLFV)

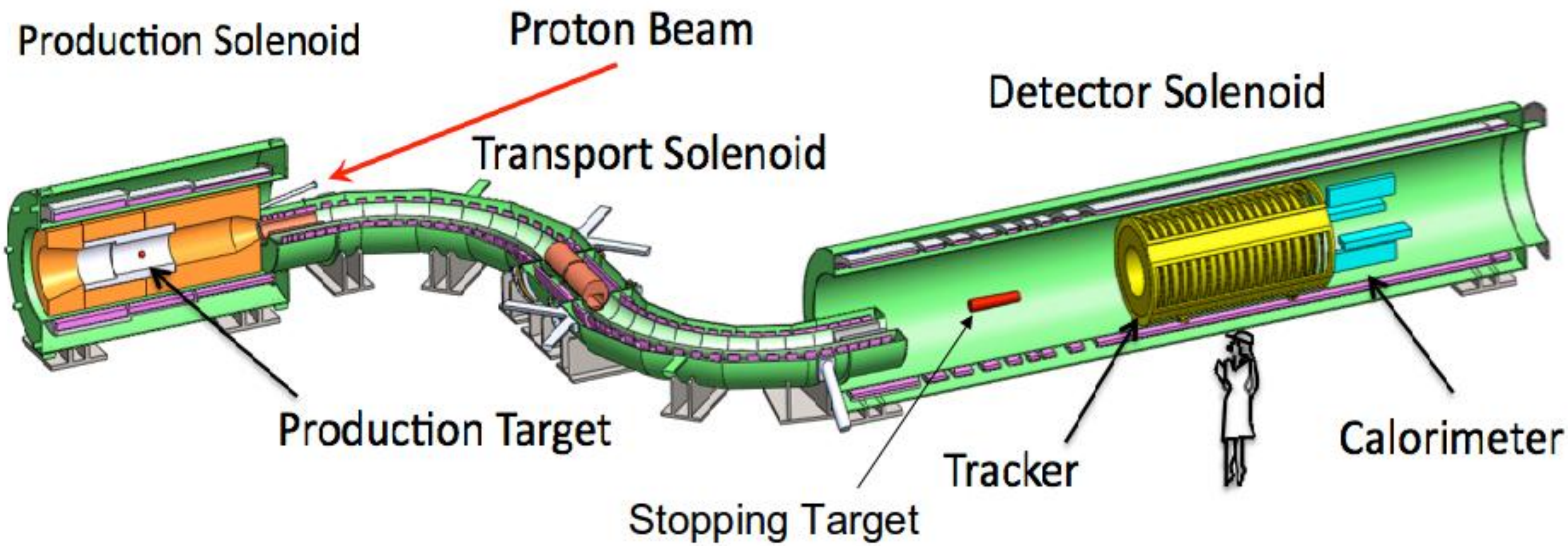
CLFV processes for which the theoretical predictions are verified with the next generation of experiments

$\mu^+ \rightarrow e^+ \gamma$ with current limit 2.4×10^{-12}, established by MEG experiment

$\mu^+ \rightarrow e^+ e^- e^+$ with current limit 1.0×10^{-12}

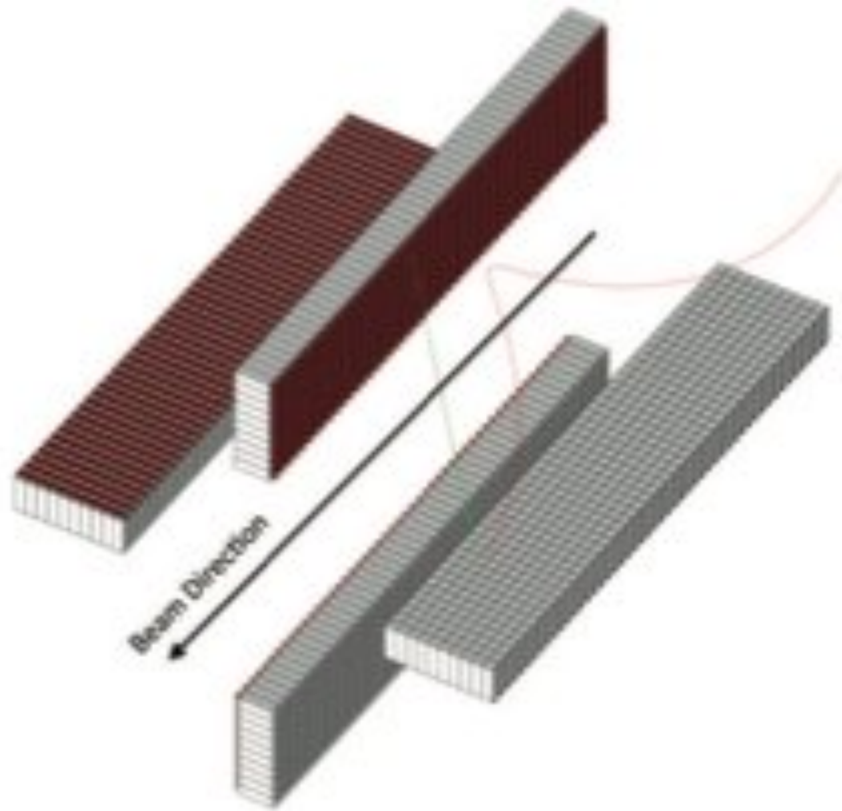
$\mu^- N_{A,Z} \rightarrow e^- N_{A,Z}$ with a branching that depends on the material

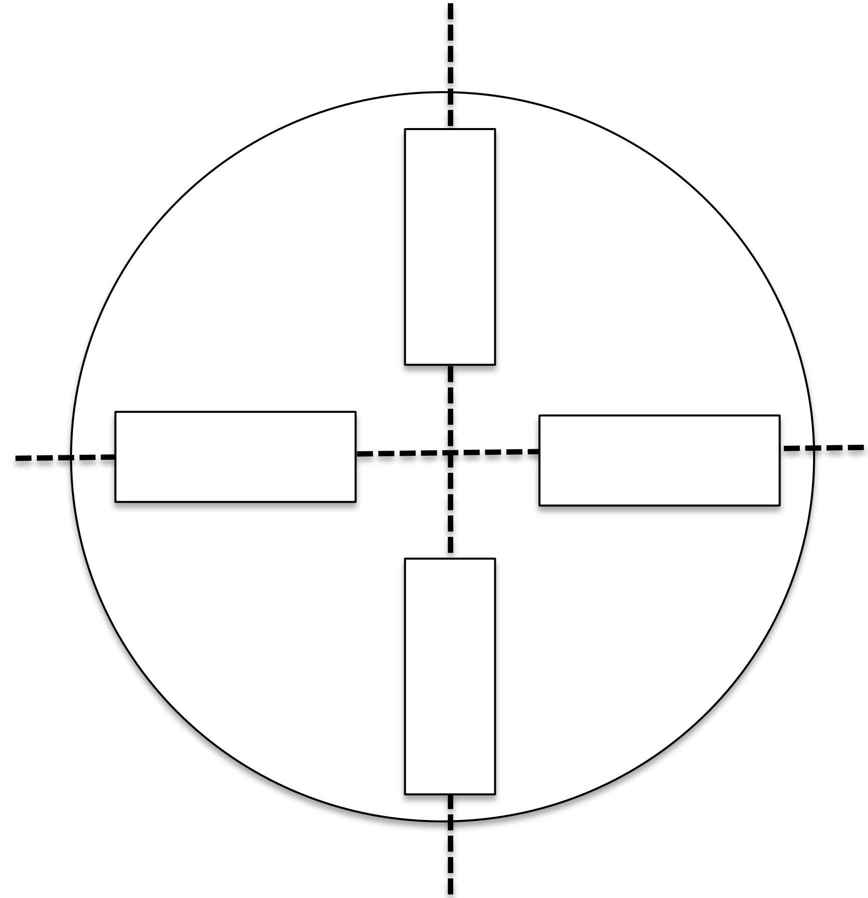
The Mu2e apparatus



The beamline of Mu2e has two main components: the production target (PT) and the Transport Solenoid (TS). The detector has three main components: the stopping target, the tracker and the calorimeter.

Calorimeter





The calorimeter is used to select the signal events and to confirm the position and energy measurements provided by the tracker

Backgrounds

Categories	Source	Events	Rate
Intrinsic	μ Decay in Orbit	0.225	≈ 55%
	Radiative μ Capture	<0.002	
Late arriving	Radiative π Capture	0.072	≈ 40%
	Beam Electrons	0.036	
	μ Decay in Flight	<0.063	
	π Decay in Flight	<0.001	
Miscellaneous	Cosmic Ray	0.016	≈ 5%
	Pattern recognition Errors	<0.002	
Total		≈ 0.42	