WA105

Muon backgrounds in 6x6x6

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SB Meeting

Overview

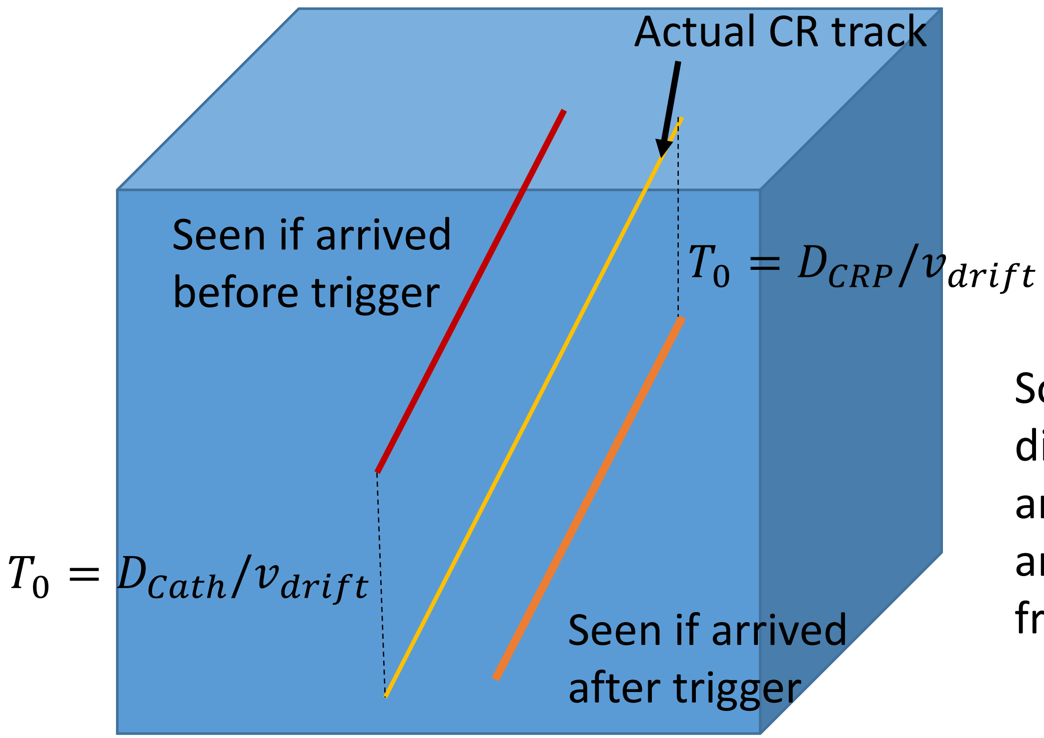
- Selection of CR for online analysis
- Mechanism to simulate beam halo

CR arrival time from 3D tracks

From 22.02.2017 presentation at the SB

It is possible to calculate T_0:

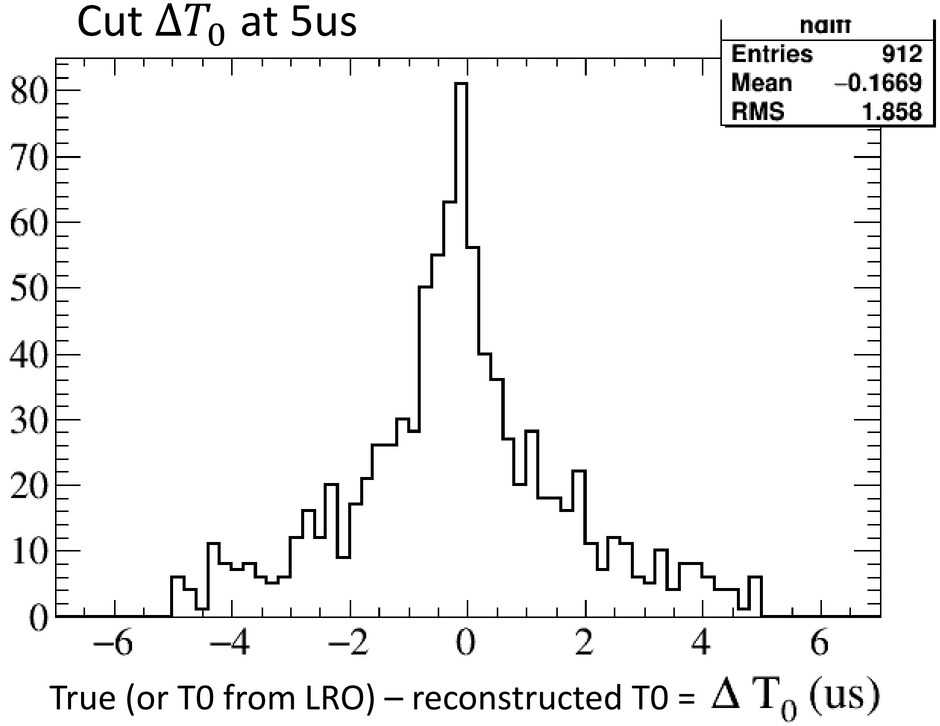
- For CR arriving before trigger that exit on the cathode side
- For CR arriving after trigger that enter on the CRP side



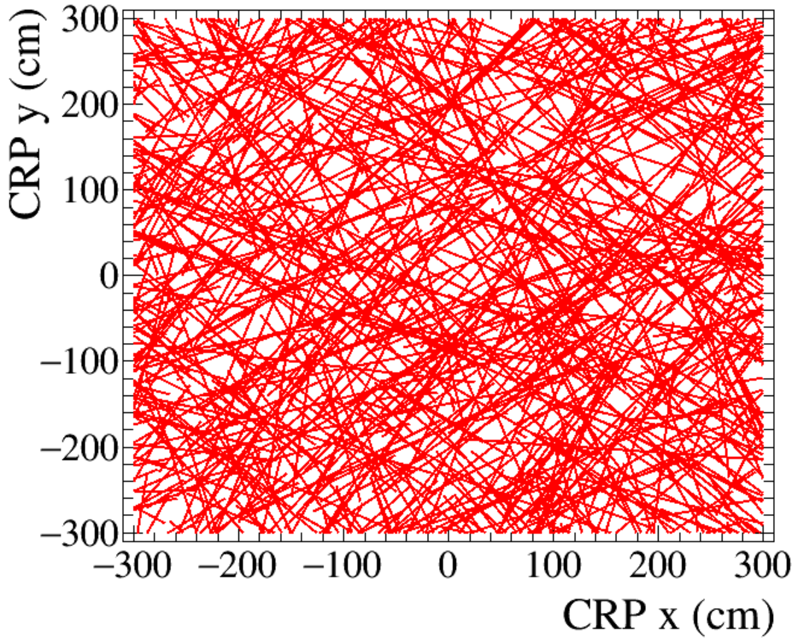
So from endpoints that appear to hang disconnected from either cathode or anode in 3D, we should be able to get T_0 and cross check it against T_0 reconstructed from PMTs

Tracks satisfying T0 selection cut

Cut ΔT_0 at 5us



CRP Area coverage



Distribution for 100 simulated CR background events (1s of data taking at 100Hz trig rate)
~900 tracks selected ➔ In principle 9 CR tracks per event for online analyses

Execution times for online monitoring reconstruction CR background only

Stage	Time per event (s)
2D hits	20
2D tracks	20
Total	40

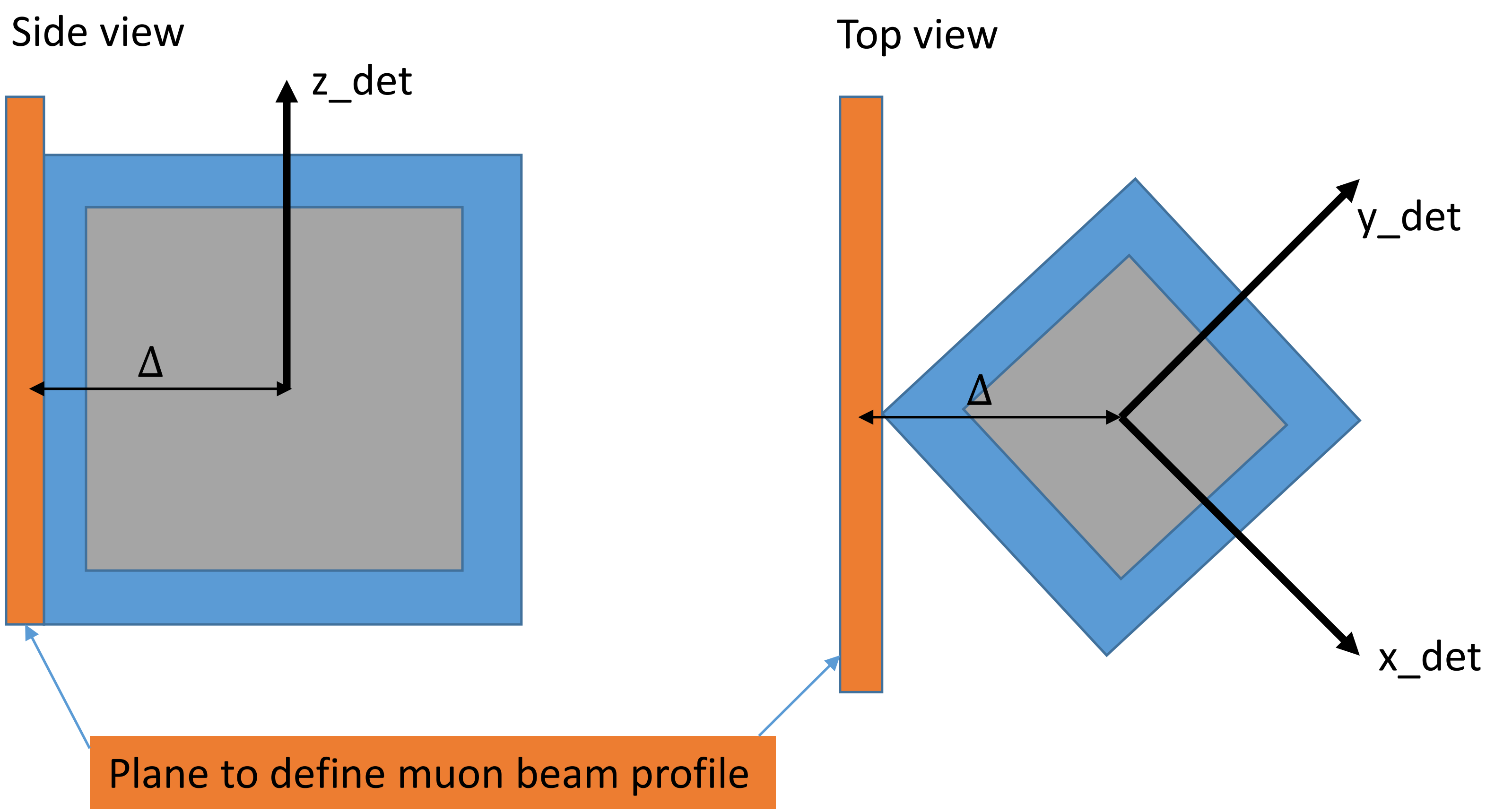
Hit reconstruction in each view

Track reconstruction in each view

Average number of hits per event: 40000
Average number of CR related track fragments per event: 630 (muons + electrons)

Mechanism to simulate beam halo background in 6x6x6

Simulation of muon halo: geometry



Profile definition in plane

y, y' -- position and angle along a given coordinate in the reference given plane
ϵ – emittance in units of [cm mrad]
α – Twiss parameter (dimensionless) if 0 no correlation between angle and position
$\bar{y}, \bar{y}'$ -- beam position and angle in the reference plane

$$B(y, y'; \bar{y}, \bar{y}', \sigma_y, \epsilon_y, \alpha_y) = \frac{1}{2\pi\sigma_y\sigma_{y'}\sqrt{1-\rho_{yy'}^2}} \exp\left(-\frac{1}{2(1-\rho_{yy'}^2)}\mathcal{F}\right)$$

with

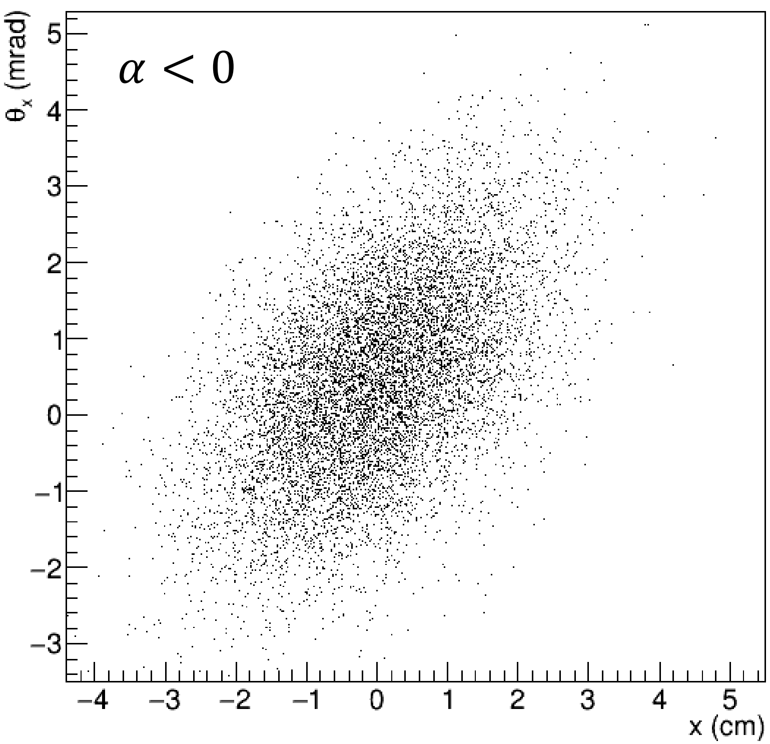
$$\mathcal{F} = \frac{(y-\bar{y})^2}{\sigma_y^2} + \frac{(y'-\bar{y}')^2}{\sigma_{y'}^2} - \frac{2\rho_{yy'}(y-\bar{y})(y'-\bar{y}')}{\sigma_y\sigma_{y'}},$$

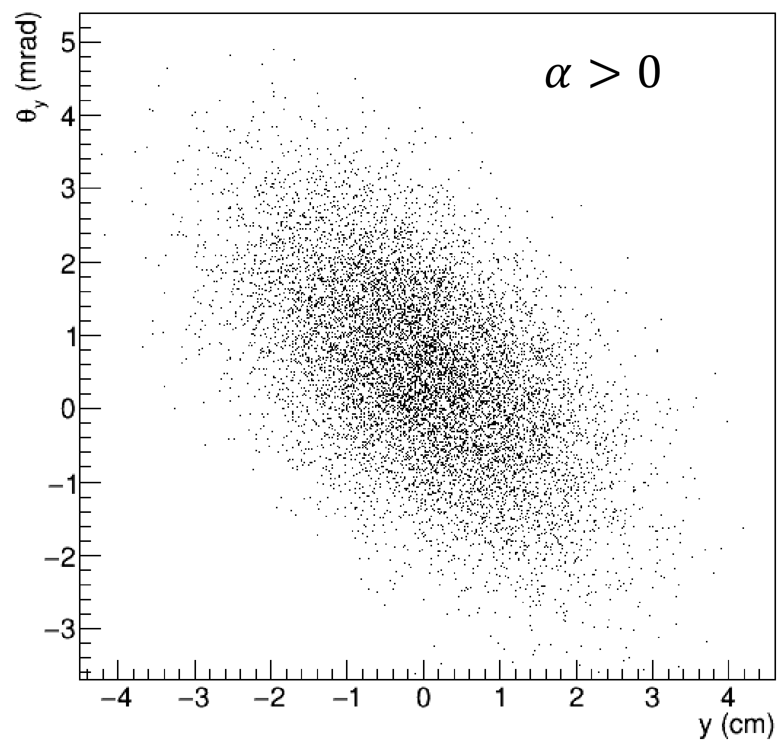
where

- $\sigma_{y'} = \epsilon_y\sqrt{1+\alpha_y^2}/4\sigma_y$
- $\rho_{yy'} = -\alpha_y/\sqrt{1+\alpha_y^2}.$

The area of the beam in y-y' plane the area of an ellipse given by $A = \epsilon\pi$

Profile definition cont'd



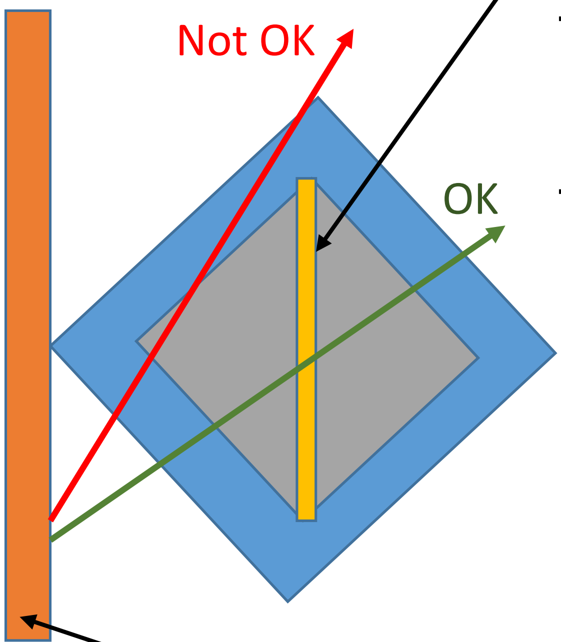


Since there are no focusing / bending optics for muon hale I would imagine $\alpha \approx 0$

MC procedure

- Assume a constant rate for halo background
  - Arrival times are then distributed according to Poisson distribution within +/- 4ms around the beam trigger
- Simulation of the spatial distribution is more challenging
  - Currently done in brute force way → simply generate N muons on plane and transport only those that intersect with the plane of the detector
  - Depending on the rates might consume a lot of CPU for useless random draws (but at least we do not transport them)

MC procedure



Intersection with this plane $600\sqrt{2} \times 600$ cm2 defines whether to accept or reject the randomly drawn vector

→ not general enough for all direction, but steep angles should not be realistic I would think (more generally could check for the intersection with the two front faces)

→ The plane coordinates wrt BHP is (800 cm, 0, 0)

If the direction is accepted, the coordinates are transformed into detector coordinate system and the muon is added to the MC transport stack

Currently no momentum distribution is assumed (easy to include though) and starting momentum is set to 10GeV

The beam profile is defined in this plane (Beam Halo Plane or BHP) and random vector are drawn according to the specified multi-Gaussian distribution

MC procedure

Basically we draw random samples from 4x4 covariance matrix using the standard method relying on the Cholesky decomposition of cov matrix

$$\begin{bmatrix} \sigma_x^2 & \rho_x\sigma_x\sigma_{\theta_x} & & 0 \\ \rho_x\sigma_x\sigma_{\theta_x} & \sigma_{\theta_x}^2 & & \\ & & \sigma_y^2 & \rho_y\sigma_y\sigma_{\theta_y} \\ 0 & & \rho_y\sigma_y\sigma_{\theta_y} & \sigma_{\theta_y}^2 \end{bmatrix}$$

σ_θ , ρ are calculated from the emittance and Twiss α specified via input card

$$\begin{bmatrix} \bar{x} \\ \bar{\theta}_x \\ \bar{y} \\ \bar{\theta}_y \end{bmatrix}$$

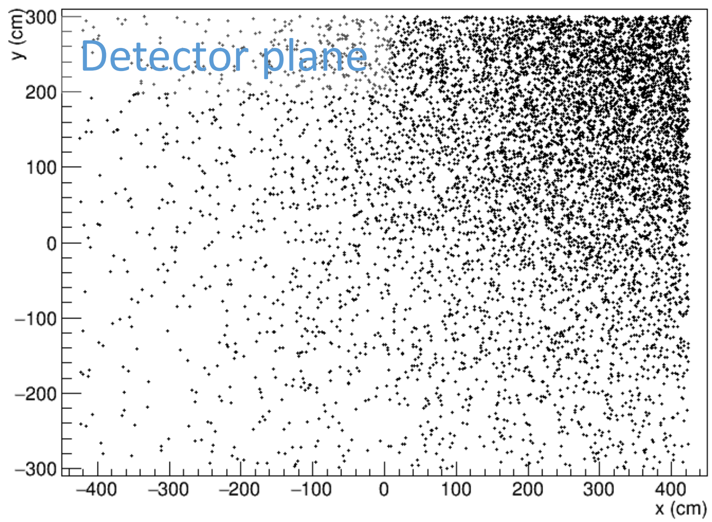
Around the specified mean values of the distribution

If ρ_x and ρ_y are zero ➔ simply sampling from four independent Gaussian distributions

Some examples

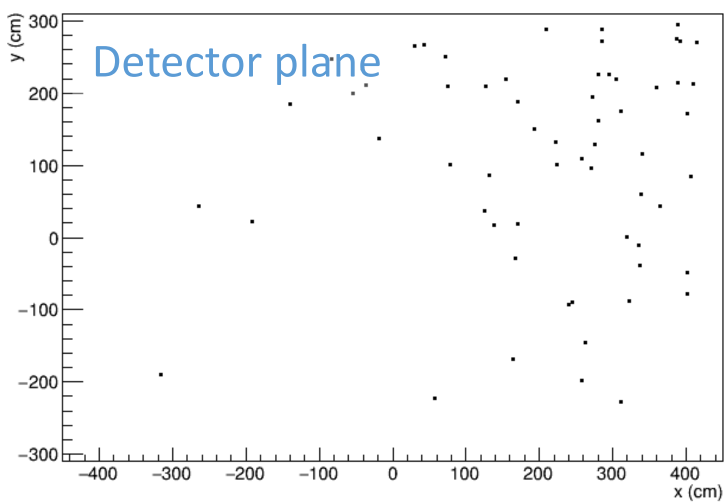
This is just an example to test the code and not representative of the actual values for the parameters to be used

```
double x0 = 450.;
double y0 = 350.;

double thx0 = 0.0;
double thy0 = 0.0;

double sgmx = 30.0;
double sgmy = 30.0;

double epsx = 40.0;
double epsy = 40.0;

double alphx =  0.0;
double alphy =  0.0;
```



Rate = 5.0E+6 muons/s

➔ 1MHz rate in the detector



Rate = 5.0E+4 muons/s

➔ ~10kHz rate in the detector

Similar to the CR flux rate

Enabling of simulation of muon halo

Similar to the CR background simulation need to set
IFILE WA105_MCEVENT

Then specify the parameters for muon beam halo

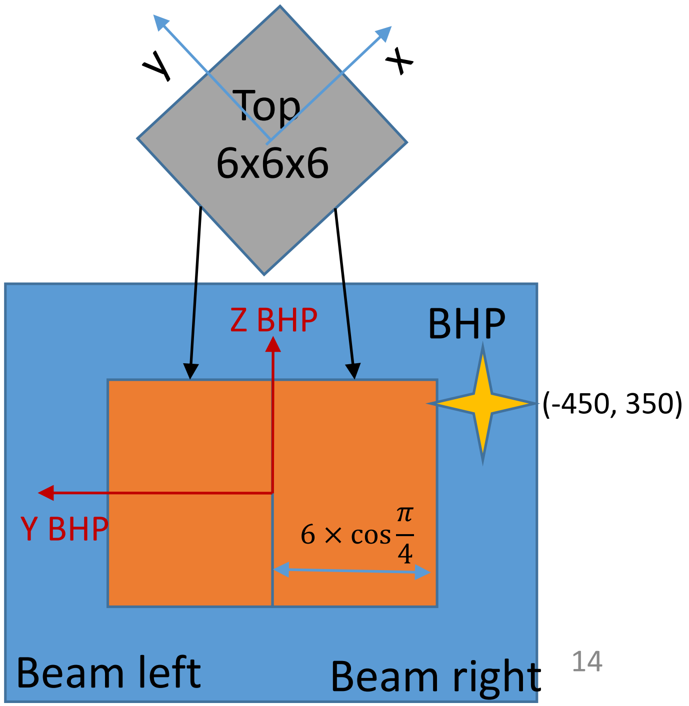
```
# beam halo properties
WA105MC_BH 5.0E+4 -450.0 0.0 30.0 40.0 0.0 350.0 0.0 30.0 40.0 0.0
# time window
WA105MC_BHWIN -4.0 8.0
```

Start time and duration in ms (WA105MC_BHWIN)

For this set of parameters particles in the active volume is 8kHz

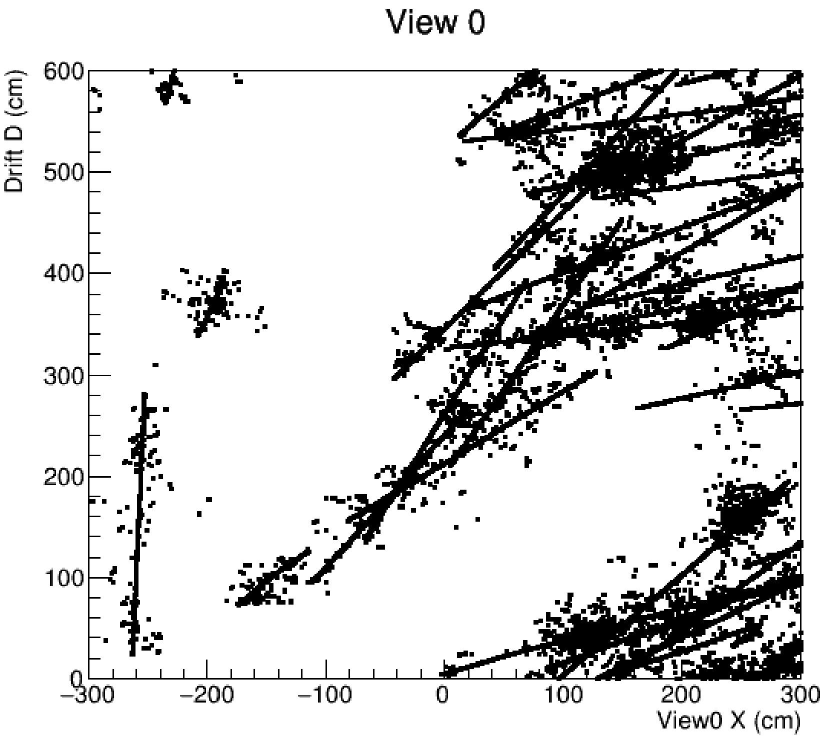
The card WA105MC_BH parameters are:

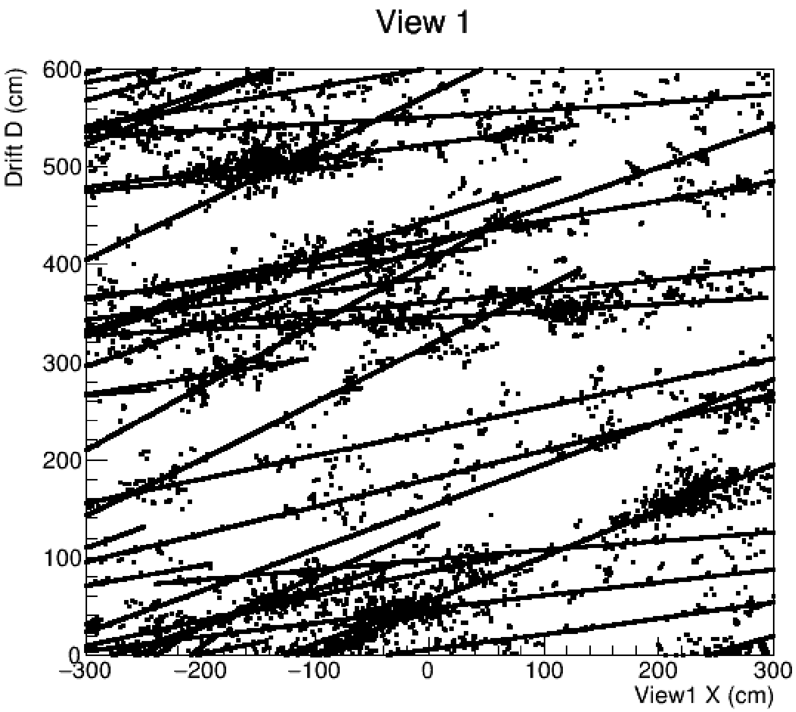
1. Rate in Hz
2. Y0 in Beam Halo Plane (BHP) in cm
3. ThetaY0 in (BHP) in mrad
4. Sigma in Y in cm
5. Emittance in Y in cm x mrad
6. Twiss alpha in Y
7. Z0 in cm
8. ThetaZ0 in mrad
9. Sigma in Z in cm
10. Emittance in Z in cm x mrad
11. Twiss alpha in Z



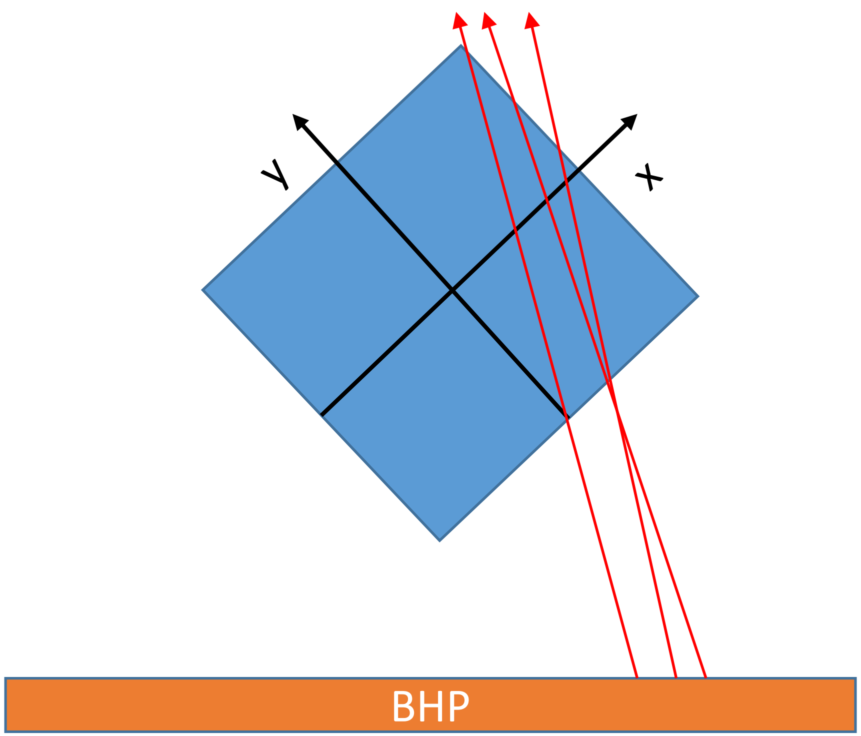
The coordinate system is a bit odd, but this is to simplify transformations to the coordinate system of detector geometry

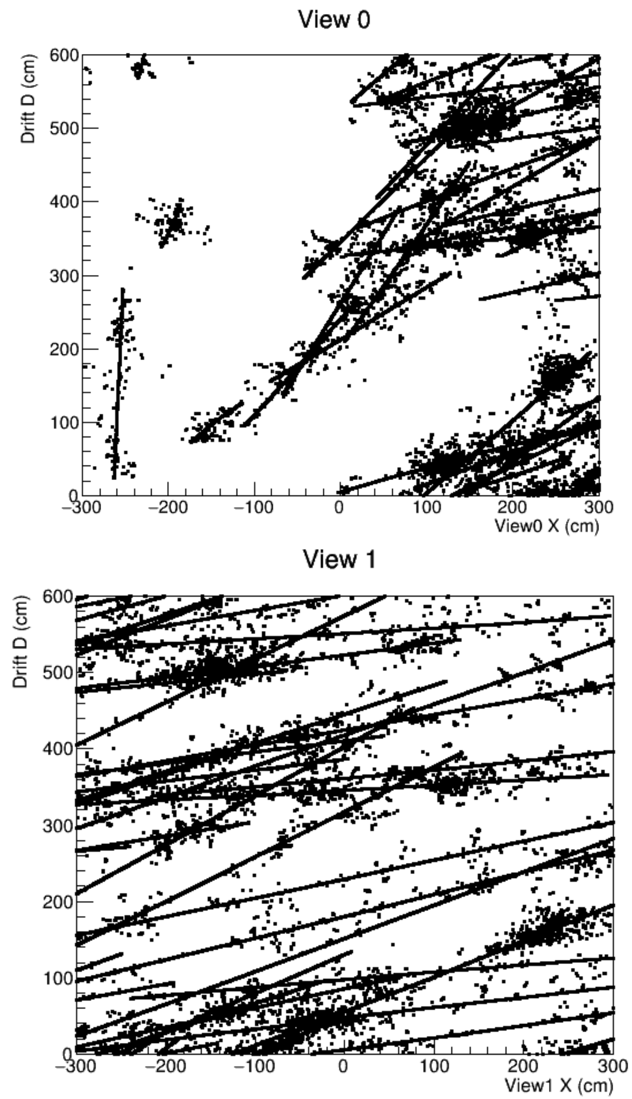
View from the CRP





View from the CRP





With mean beam position set on the beam right most of the particle trajectories will cross on the positive X side of the CRP

Summary

- Mechanism to simulate overlapping beam halo background has been prepared
- The halo profile is specified in terms of mean position, angle, and spatial and angular divergences
- The rate is assumed to be constant over the drift window → arrival times are sampled from Poisson distribution
- Mono-energetic muon flux composed of 50:50 mu+ and mu- is currently implemented
- Easy to generalize to more appropriate distributions/compositions