Matthew Jones/ Riei Ishiziki Purdue University

Photon Transport Monte Carlo (Note 7620)

- Review
  - Point response hypothesis
  - Response uniformity
- Pulse parameterization (1)
- Comparison with Monte Carlo
  - Variation of time with β and path length
- Pulse parameterization (2)
  - Variation of time with β, path length, $\cot(\theta)$
- Other projections
- Summary

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Physical Pulse Model

- Point response hypothesis:
  - If $f(t;\vec{x})$ is the response when all light is produced at point $\vec{x}$ at time t, then the response from a track is:

$$F(t) = \int_0^s \frac{dQ}{ds} f(t - t_0 - s/\beta c, \vec{x}_0 + s\hat{u})\, ds$$

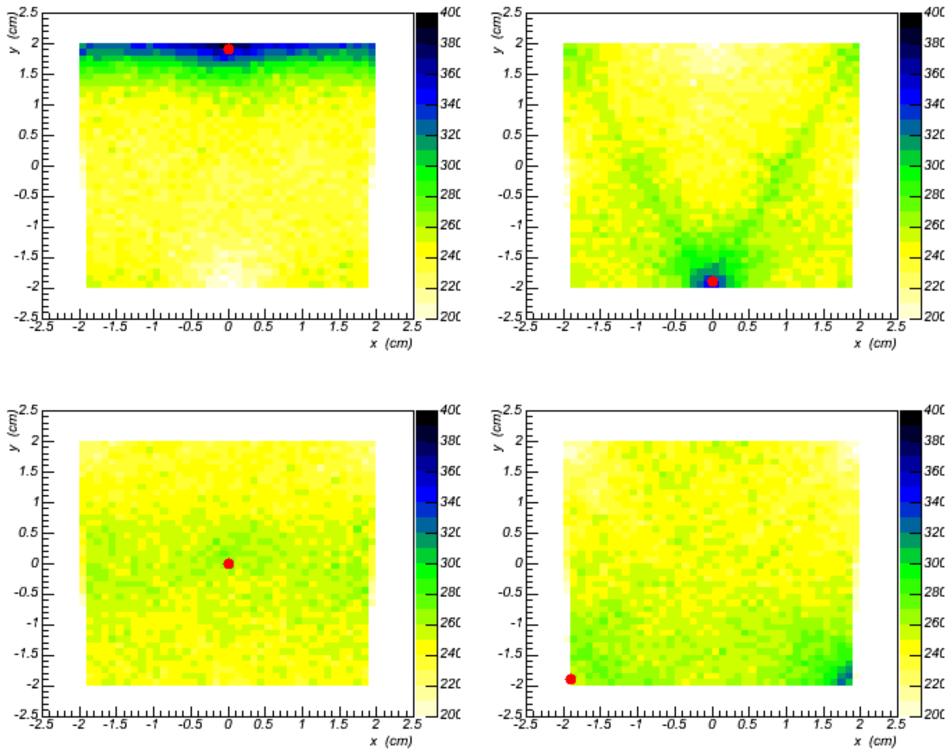
  - Simplifying assumptions:
    - This time, *dQ/ds* is a constant.
    - Response factors into two parts:

$$f(t,\vec{x}) = Q(x,y,z) f'(t,z)$$

  - Calculate both *Q(x,y,z)* and *f'(t,z)* using the Monte Carlo, parameterize for convenience.

Light Acceptance

- Significant non-uniformities:

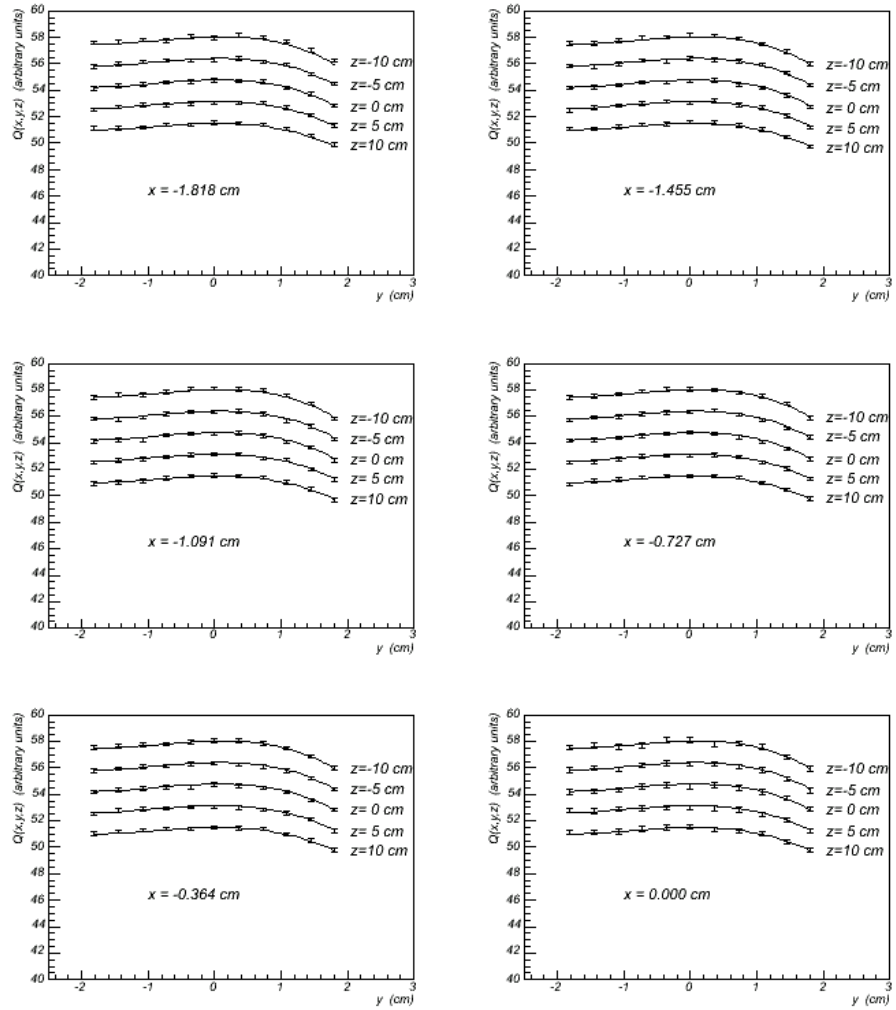


- Presumably, these can only be calculated using a photon transport Monte Carlo

Parameterization of *Q(x,y,z)*

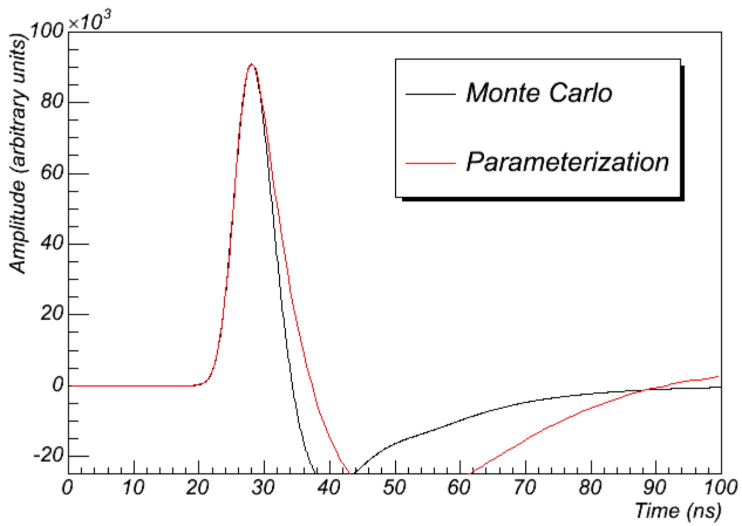
- Possible to have large local variations.
- These get averaged out across the bar.
- Average variation is smooth.
- Dependence on *x* is very small.
- Fit with a polynomial:

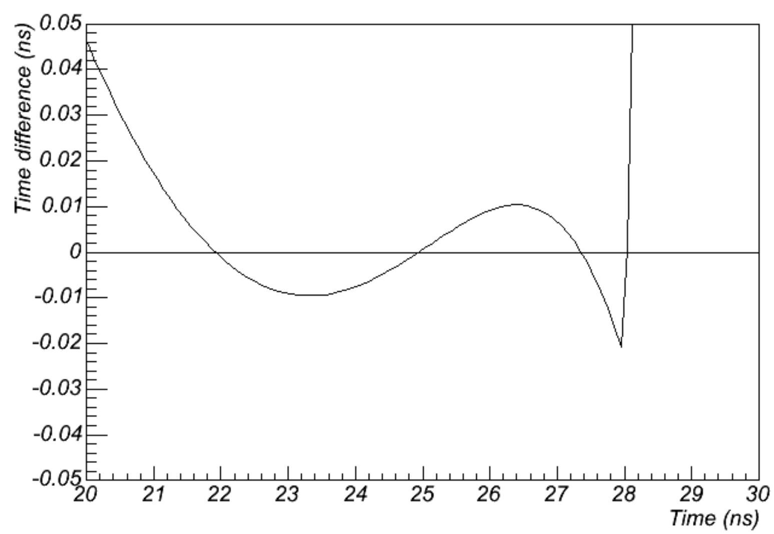
  χ^2/dof = 108/165



Normalized Response (1)

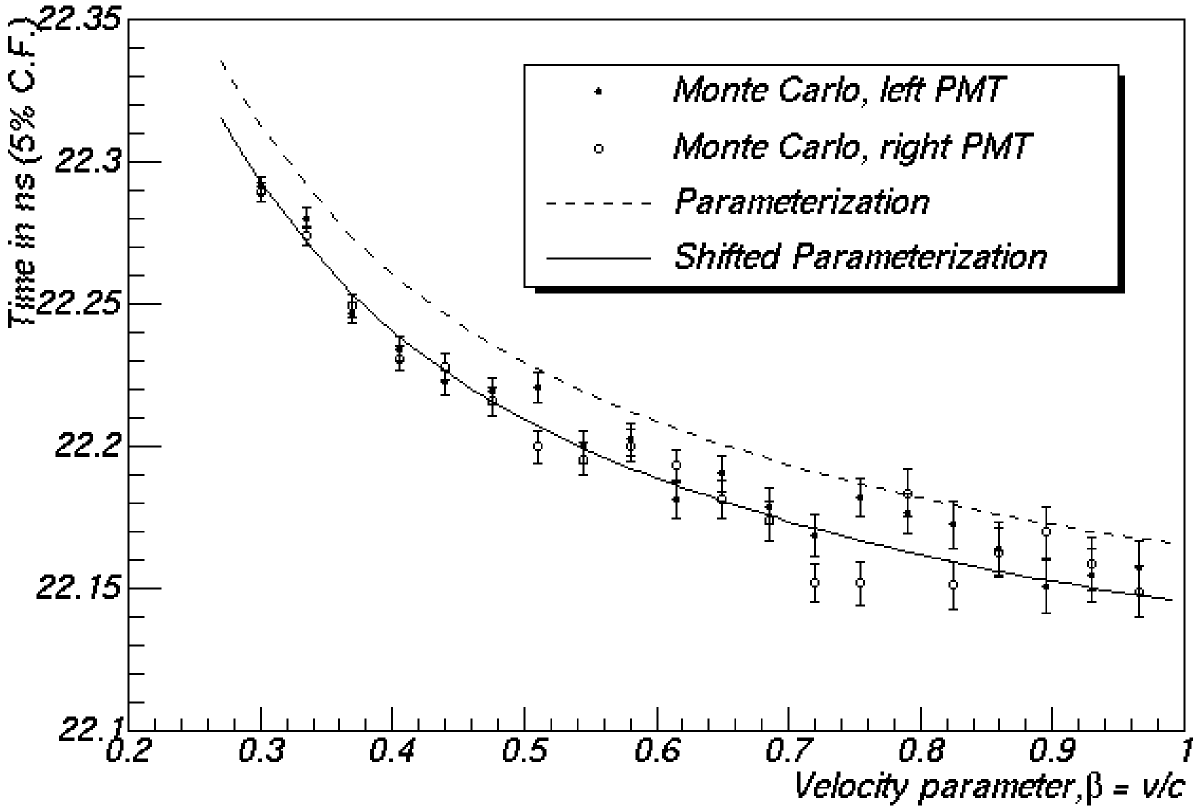
- Average pulse over x,y at fixed z
- "Fit" using some analytic function (Gaussian + 3-pole shaping)
- Essentially, minimize Kolmogorov statistic over limited range in amplitude (1%-95%):





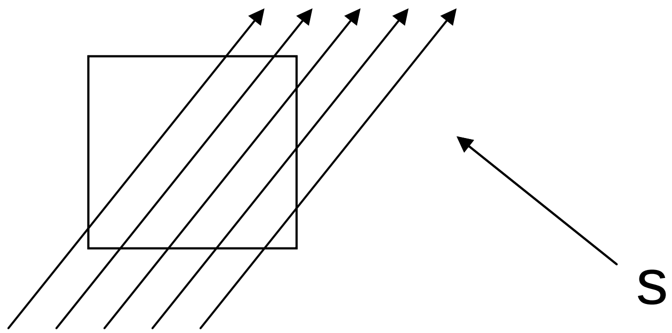
Comparison with Monte Carlo

- First study: variation with speed, v=βc
- Protons, perpendicular to bar at z=0:

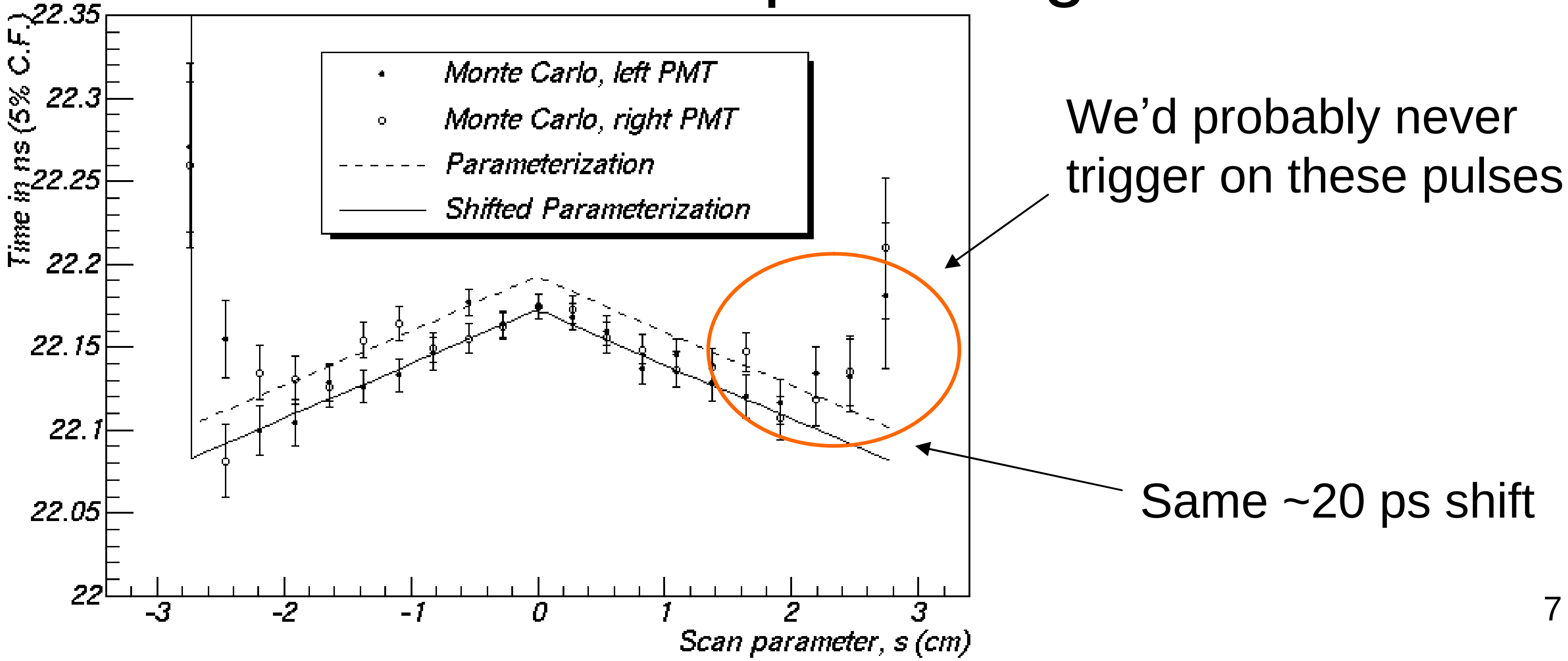


~20 ps offset removed by hand

Variation with path length



- 2 GeV/c muons at z=0, cot(θ)=0
- Significant variation of path length with 's'

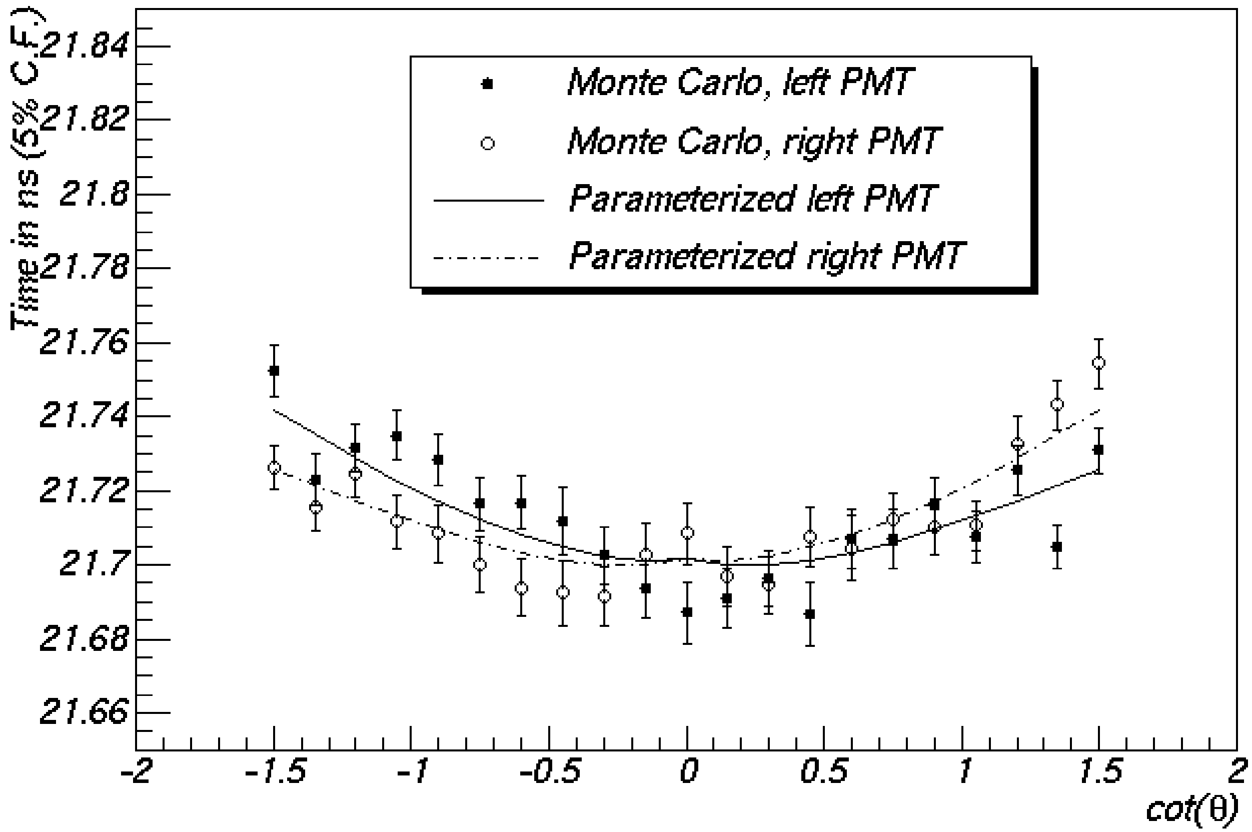


Pulse Parameterization (2)

- To study variation in time with cot(θ) we need to extend the parameterization in *z.*
- Two approaches:
  - Parameterize normalized pulse at each z and interpolate parameters
  - Just interpolate between average pulse shape calculated with Monte Carlo
- This next study used second approach
- Not clear which is better as far as precision/speed/motivation is concerned.

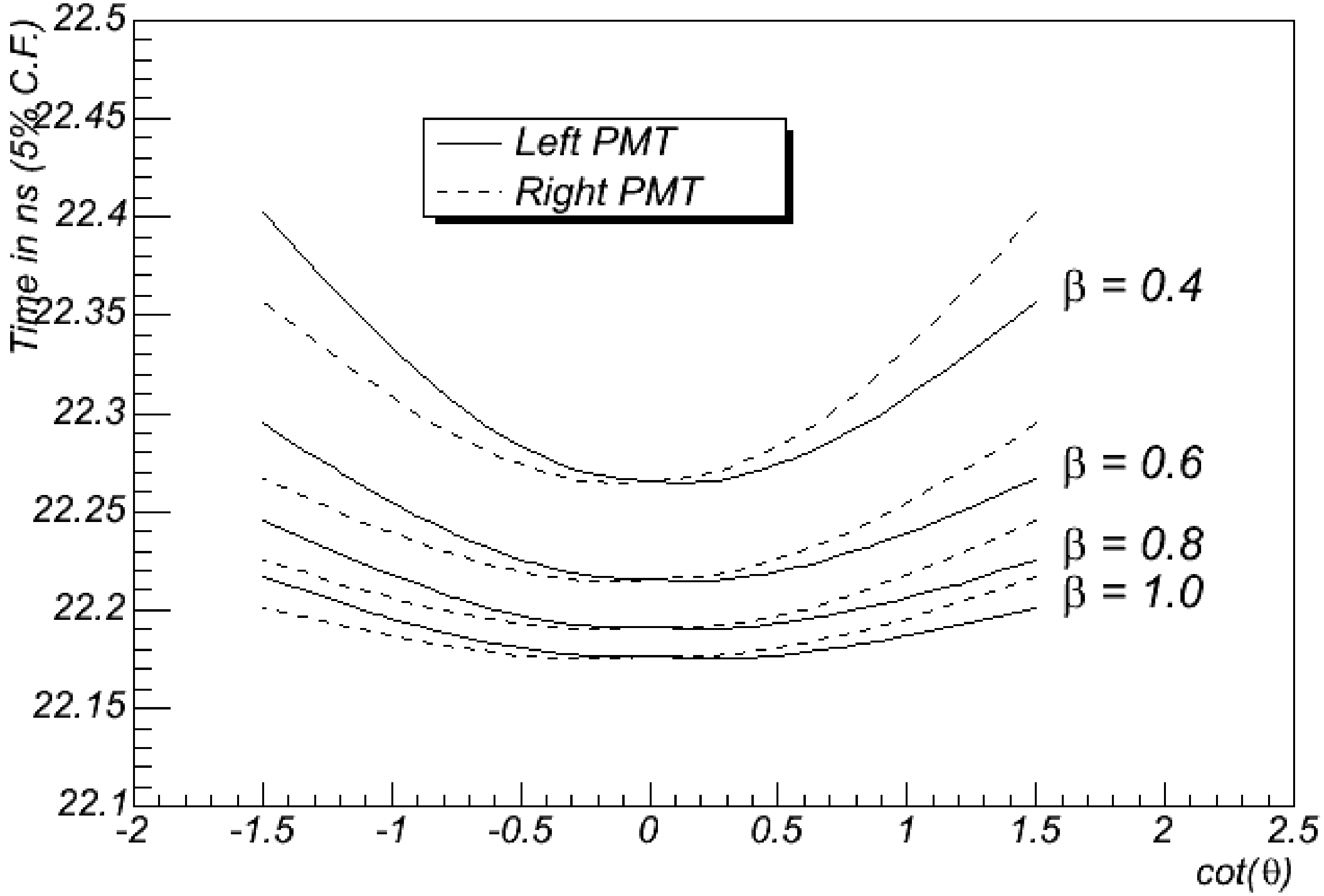
Variation with cos(θ)

- 2 GeV/c muons, passing through the center of the bar ($\vec{x} = (0,0,0)$)



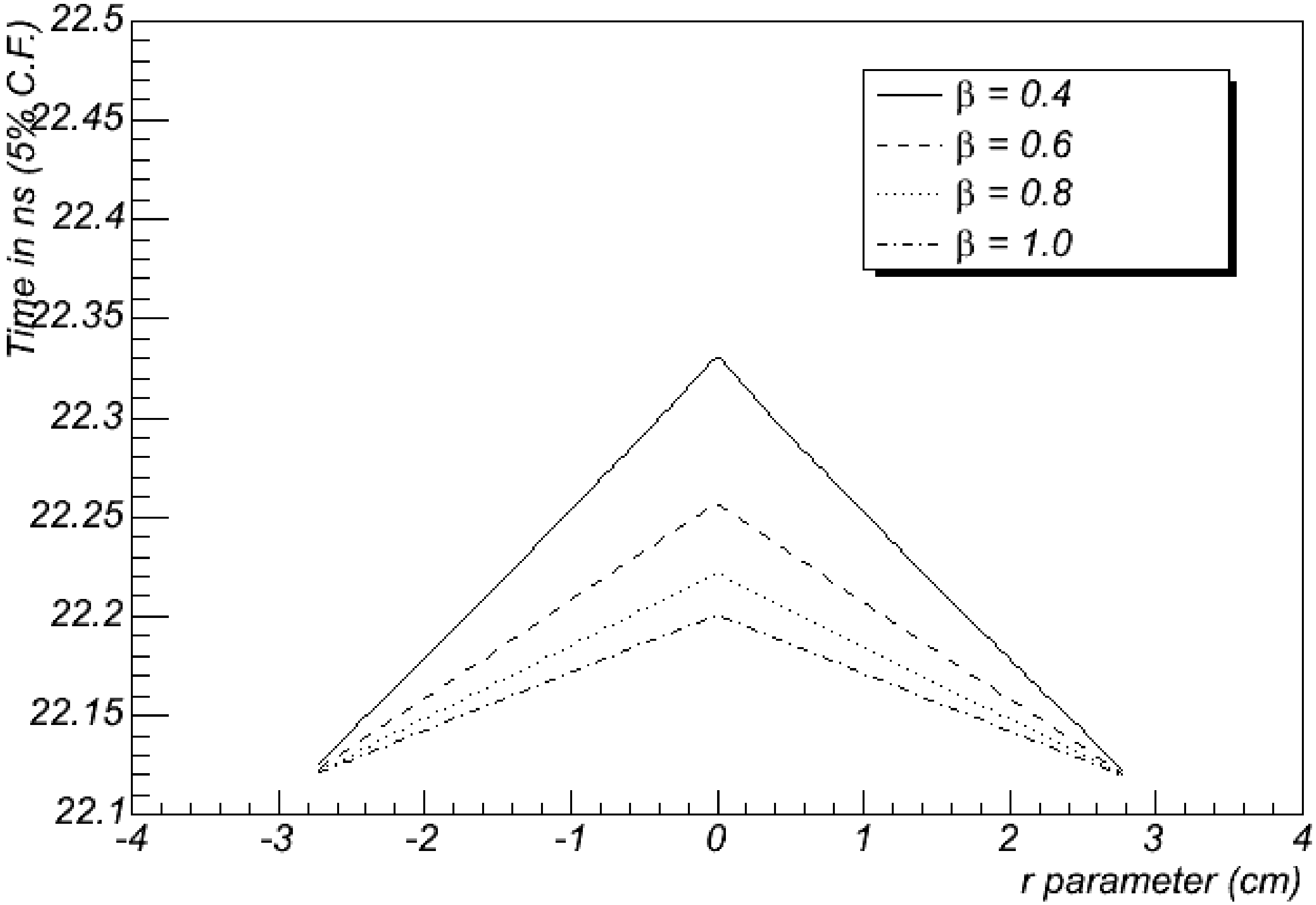
More Track Configurations

- Variation with polar angle and velocity:



More Track Configurations

- Variation with path length and velocity:



Summary

- This model accurately reproduces all three sources of bias studied so far with no free parameters (well, except for the constant shift which might be a historical artifact.)
- This source of biases is now well understood.
- This model suggests a way to calibrate the detector that is intrinsically free of these sources of biases.
- Charge information not included yet – incorporate this next.