Toy Monte Carlo for the Chromatic Correction in the Focusing DIRC Data

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Outline

- Compare Resolutions of Focusing DIRC with BaBar DIRC.
- Toy Monte Carlo:
  - In this example photons will be generated from beam position 1 in bar and the SOB path length will not be taken into account.
  - Reconstruct using ultimate Focusing DIRC resolutions (using 6x6mm pixels).
  - Apply Method1 of β resolution calculation.
- Show results as function of photon path length.
- Show new method (Method2) of calculating β resolution.

Resolution Comparison With BaBar DIRC

Angular (θ) Resolution

	BaBar DIRC (mrad)	Focusing DIRC (mrad)
Tracking	~1	~1
Transport Along Bar	~3	~3
Bar Size	~4.1	~.5
Pixel Size	~5.5	~5.5
Other	~2.4	~2.4
Total σ_θ =	**~7.9**	**~6.8**

- Pixel Size resolution is for 6x6mm pads (slot4).
- Chromatic Smearing is irrelevant in this model.

Timing Resolution

σ_T=	**~1700 ps**	**~100 ps**

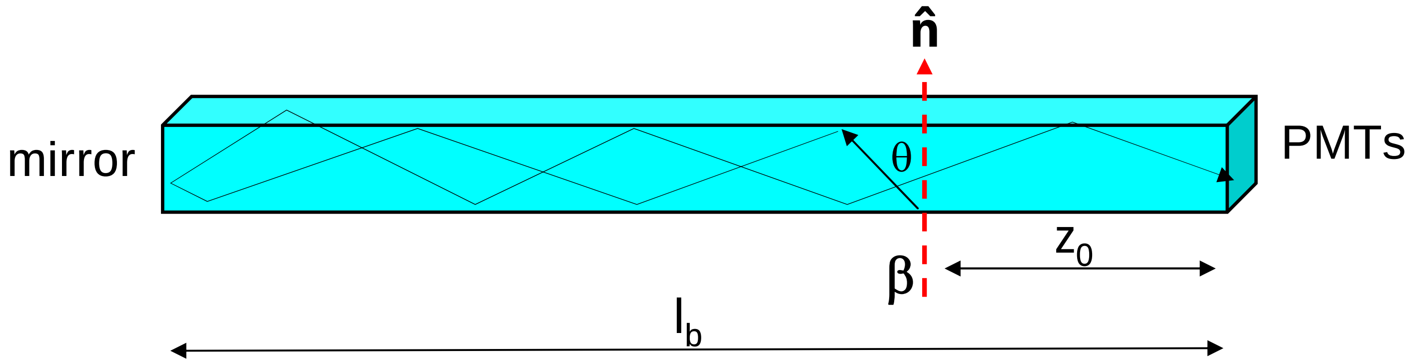
Photon Path Length Resolution

σ_L/L=	**>1%**	**~1%**

- Path length resolution depends both θ and ϕ resolution.

Toy Monte Carlo

Photon Track Description



The photon track is fully described by the following variables.

$$\mathbf{z_0}, \hat{\mathbf{n}}, \beta, \lambda, \theta, \varphi, \mathbf{L}, \mathbf{v}, \mathbf{T}$$

not all independent.

In this toy Monte Carlo I specialize to photons with the following parameters:

1. z_0 for beam position 1
2. $\hat{n}$ normal to the bar.
3. $\beta=1$ for 10GeV electrons
4. φ fixed for indirect photons traveling straight down the bar, so no side bounces only up down bounces. These parameters are adequate for photons detected in slot 4.

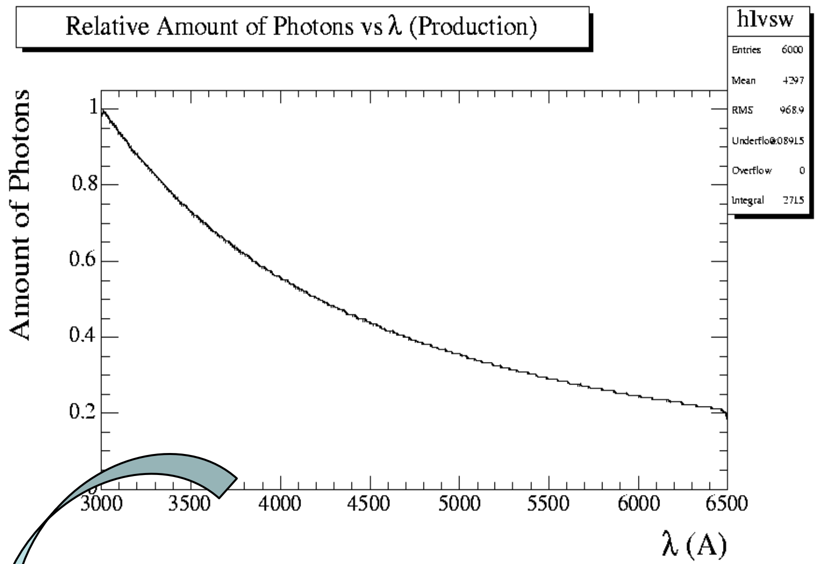
We are left with the following variables to vary: λ, θ, **L, v, T**

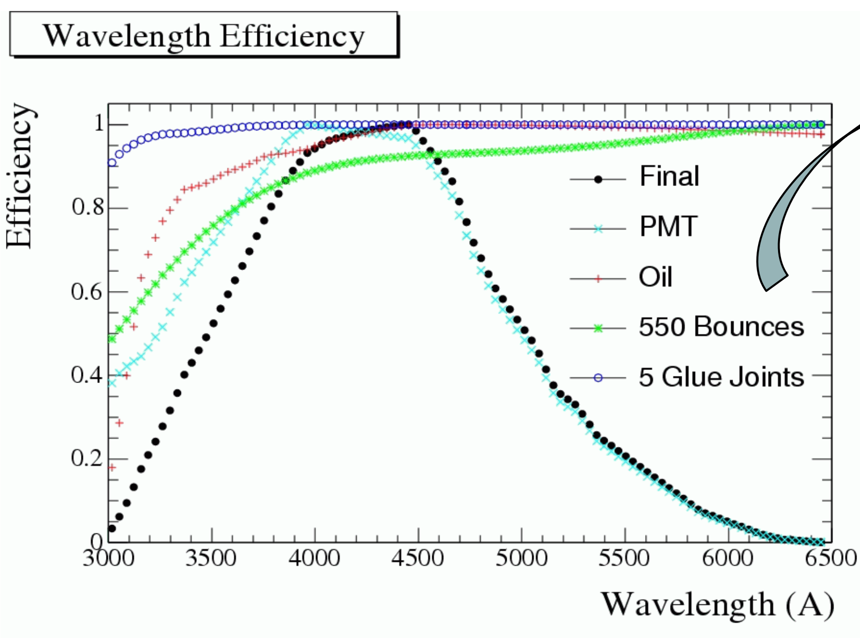
Wavelength Generation: λ

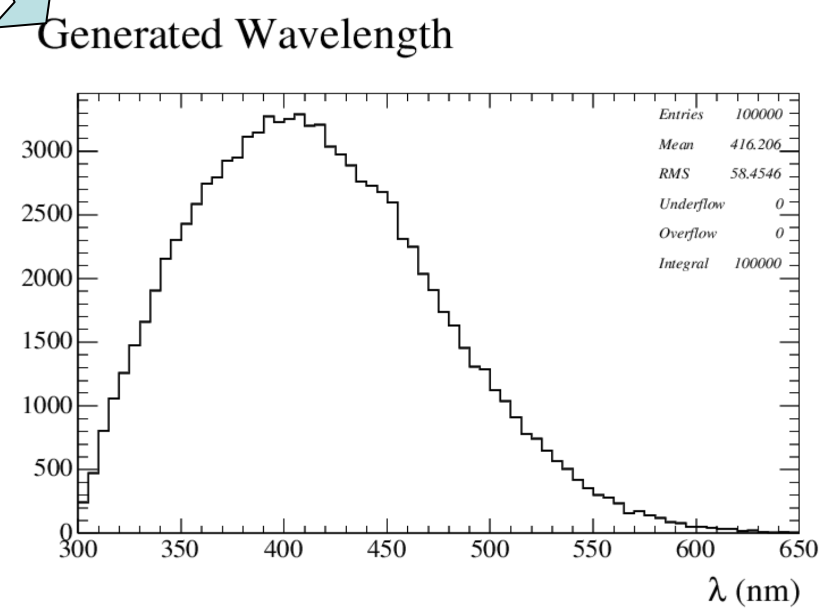
1. Determine wavelength distribution at production.

2. Find all wavelength dependent efficiencies in the detector.

3. Multiply above distributions to get final distribution.





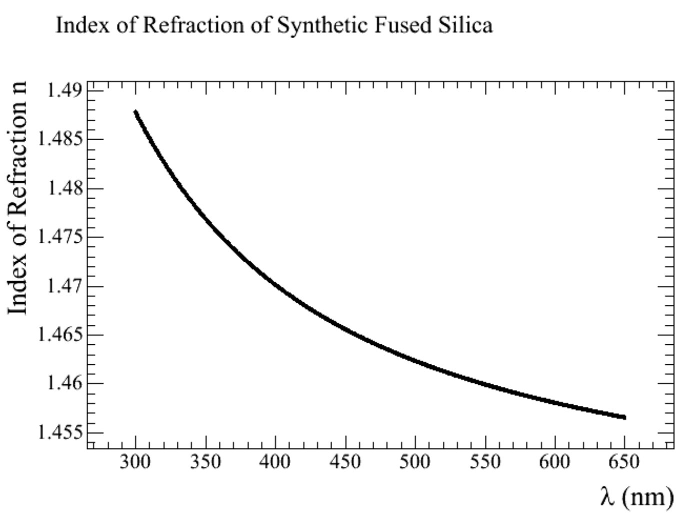


Generation of Theta θ

- The Angle θ at which the photons are produced is given by the Cherenkov equation:

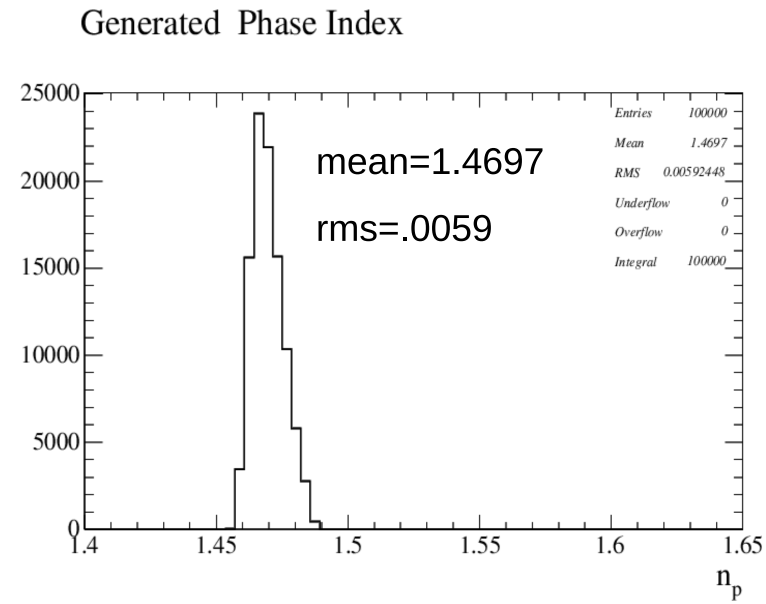
$$\cos(\theta) = \frac{1}{\beta n(\lambda)}$$

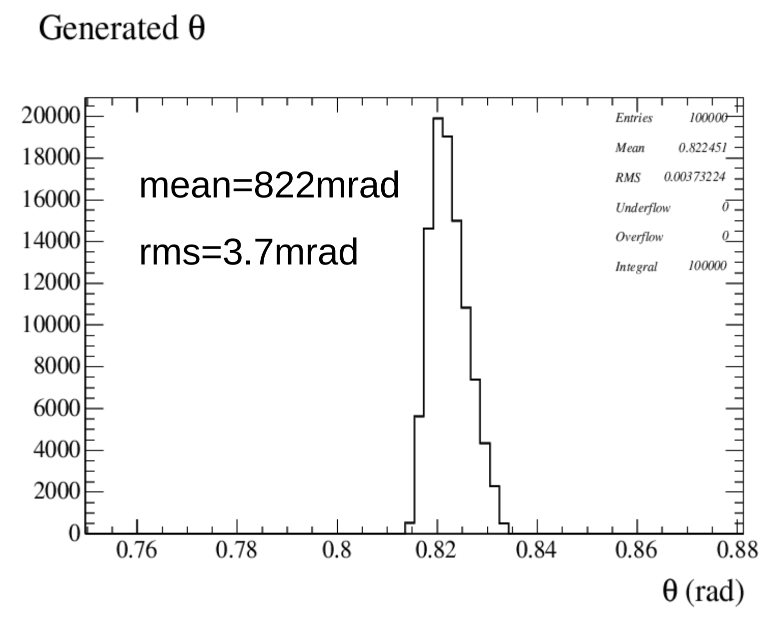
where $\beta=1$ and $n(\lambda)$ is the index of refraction of the bar:



$$n^2 = 1 + \frac{.6961663*\lambda^2}{\lambda^2 - .0684043^2} + \frac{.4079426*\lambda^2}{\lambda^2 - .1162414^2} + \frac{.8974794*\lambda^2}{\lambda^2 - 9.896161^2}$$

λ in μm in this formula.





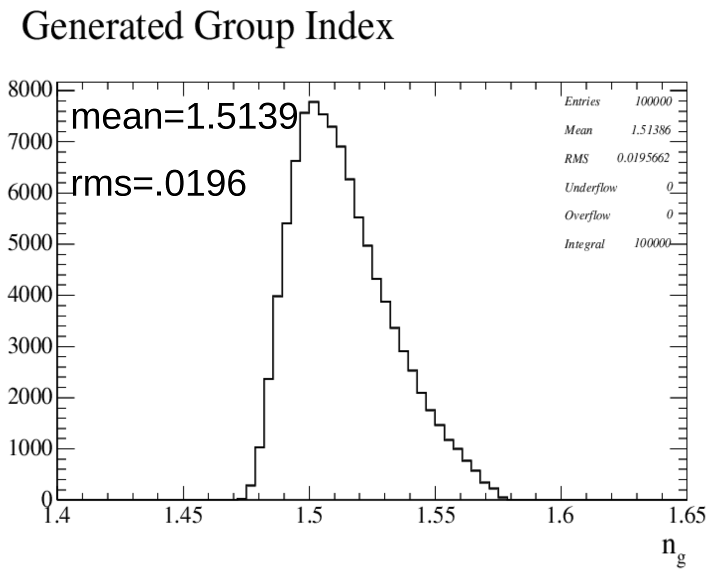
Generation of Photon Speed: v

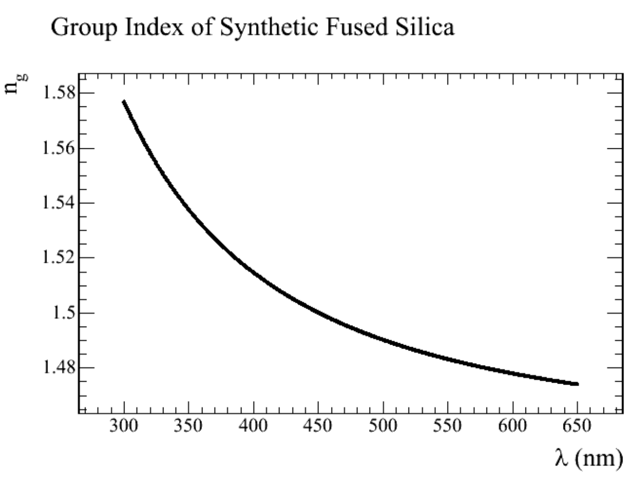
- The speed of a photon with a given wavelength traveling inside the bar is given by:

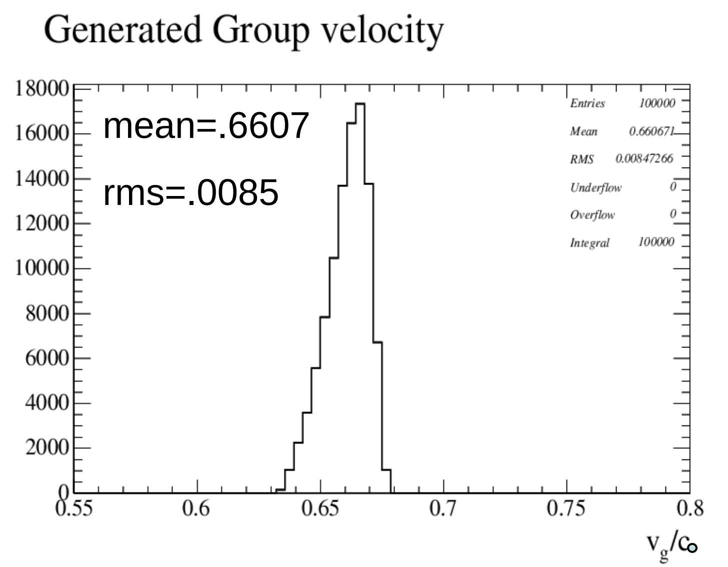
$$v = \frac{c_0}{n_g}$$

where

$$n_g \equiv \frac{n}{1 + \frac{\lambda}{n}\frac{dn}{d\lambda}}$$







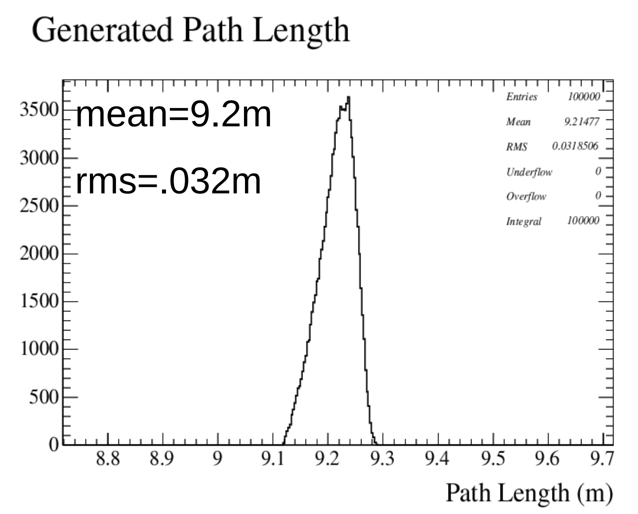
Generation of the Photon Path Length L and Propagation Time T

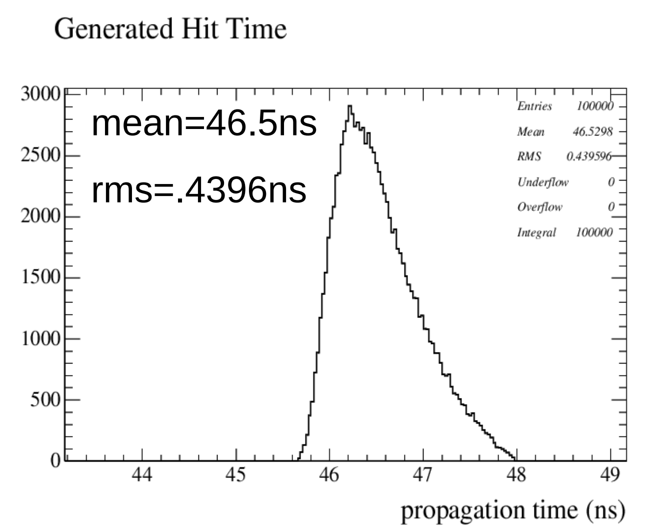
- Given that the particle track is perpendicular to the bar and that we are considering photons traveling straight down the bar, the total path length for indirect (mirror reflected) photons is given by:

$$L = \frac{(2 * l_b - z_0)}{\sin(\theta)}$$

- Finally the propagation time is given by:

$$T = \frac{L}{v}$$





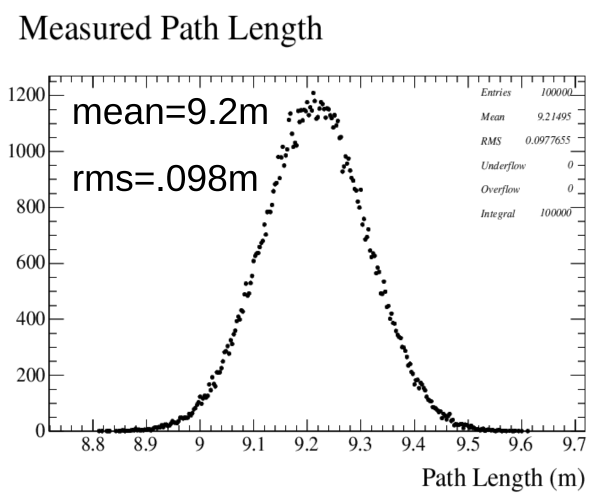
Reconstruction:

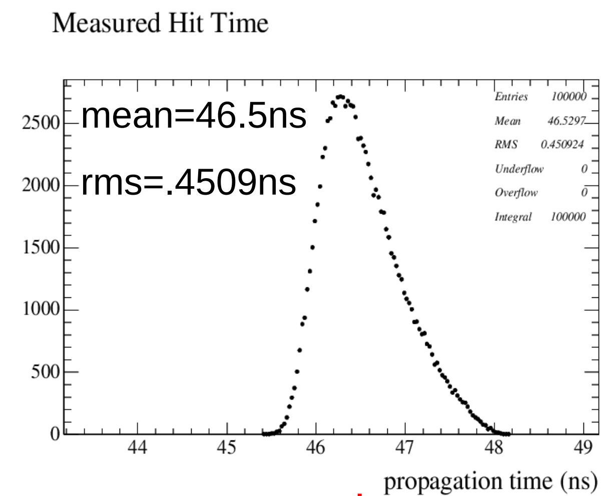
- With the Focusing DIRC we are able to measure the following observables :

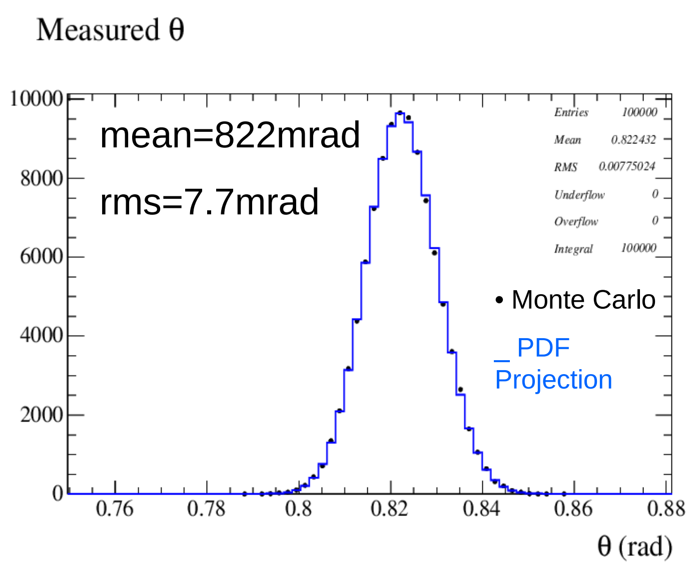
  θ , L , T

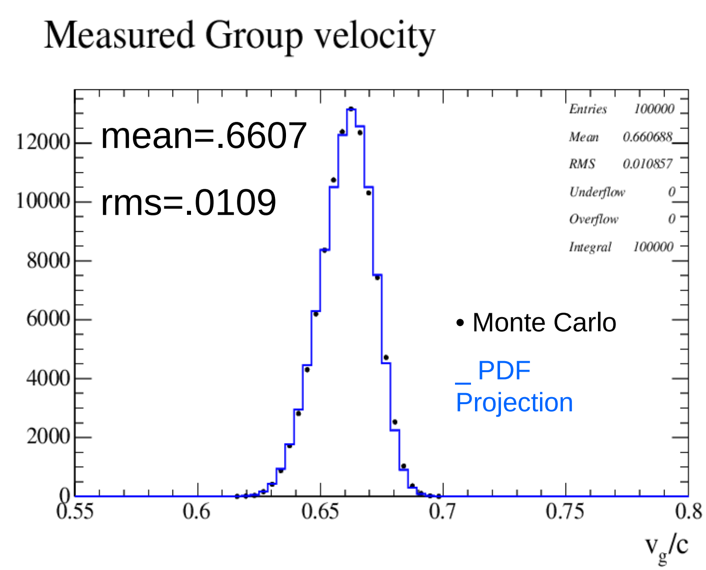
  from which we can calculate the necessary quantities:

  θ, v

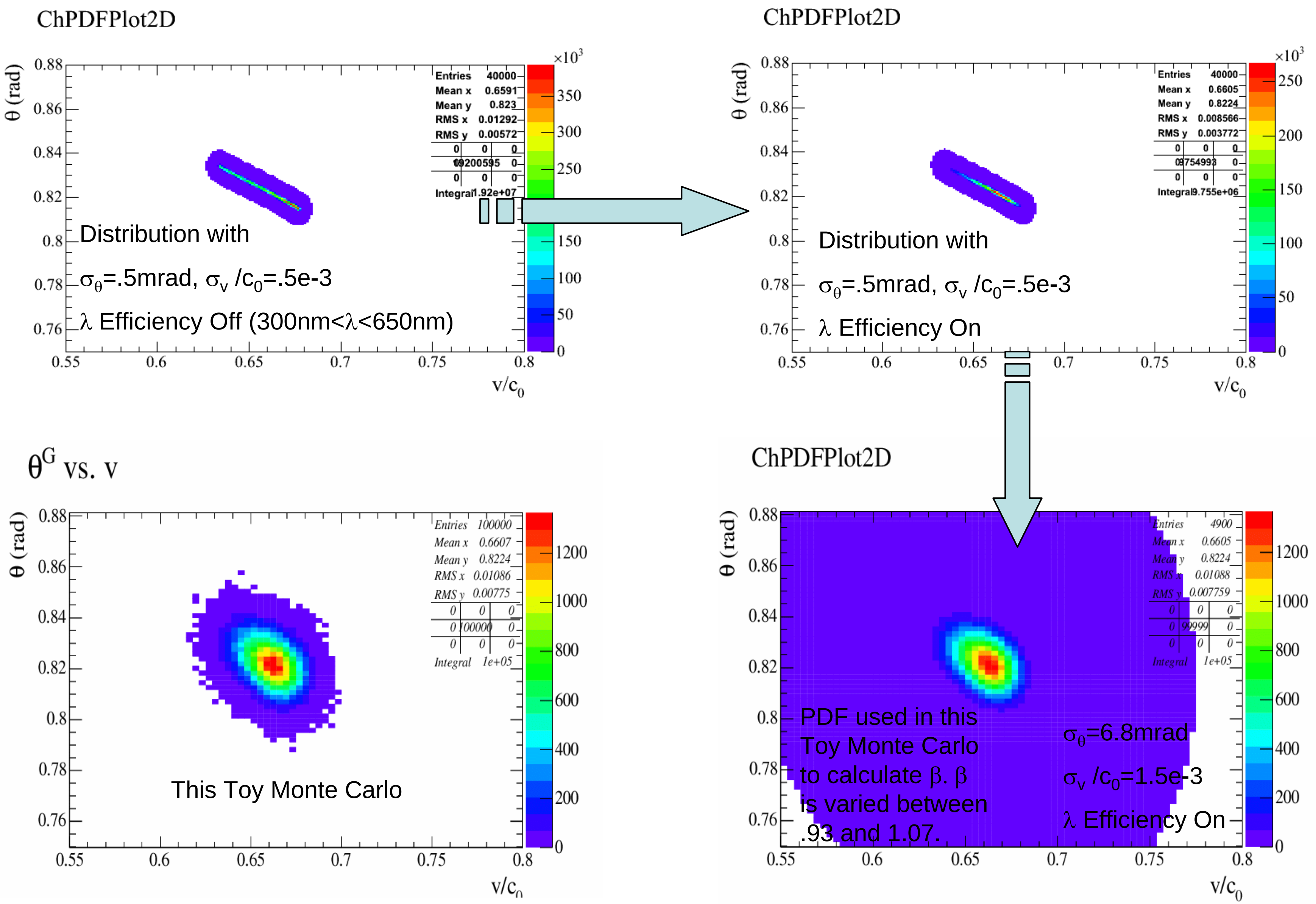






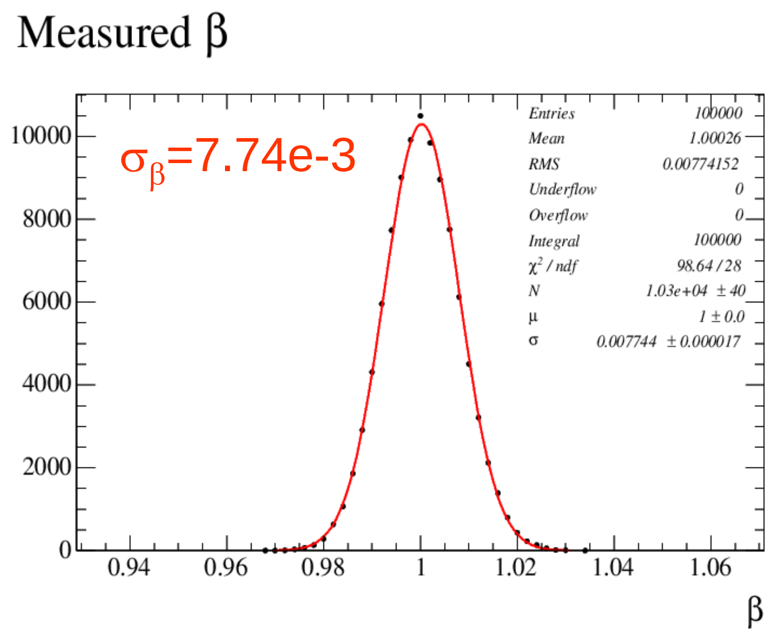


Correlation of θ with v

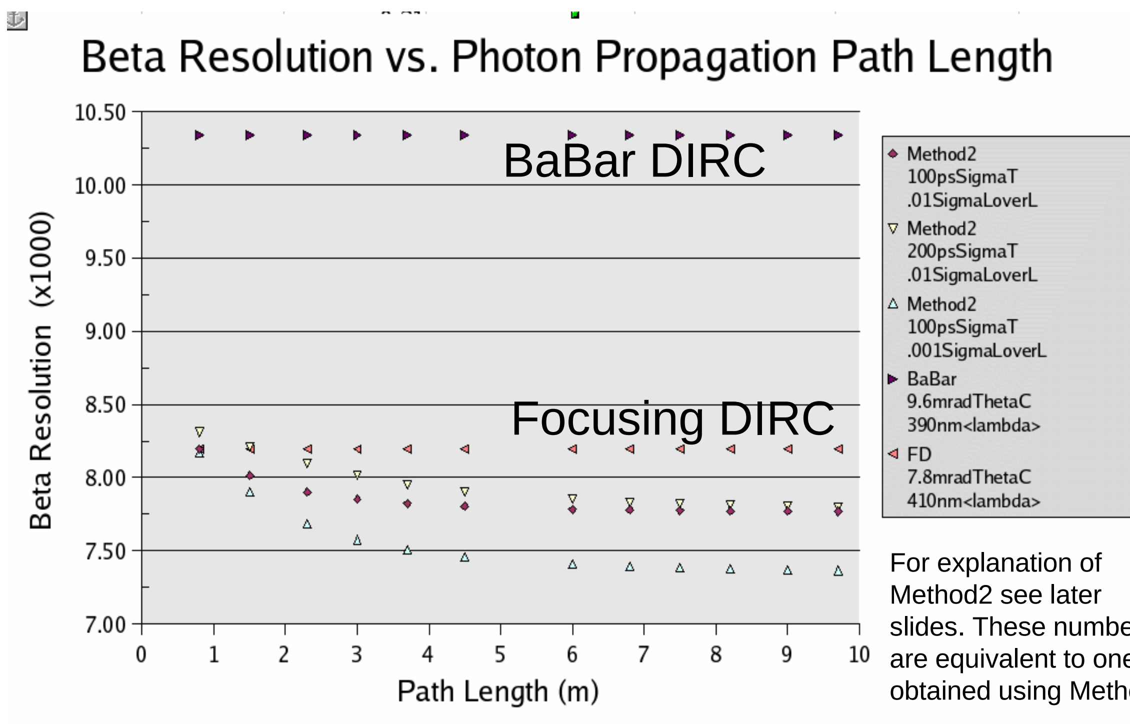


Results:

This Example:
σ_θ=6.8mrad
σ_T=100ps
σ_L / L=1%
L~9.2m



As Function of L:
σ_θ=6.8mrad



For explanation of Method2 see later slides. These numbers are equivalent to ones obtained using Method1.

Conclusions

- This toy Monte Carlo shows that this method of reconstructing our data actually works.
- The path length error is actually taking a significant amount of chromatic correction; about half of it. However there is not much we can do about, this error is determined by the pixel size as well as other angular smearing.

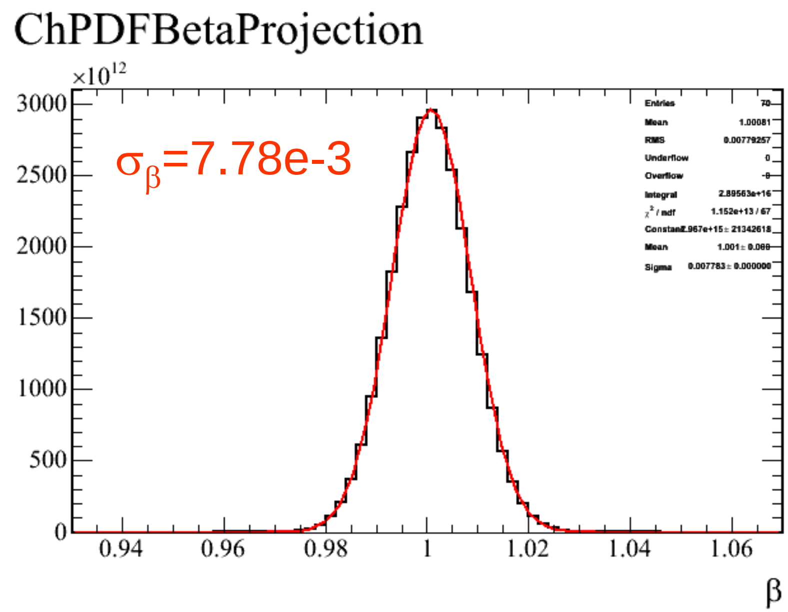
Method 2 of β Resolution Calculation

- Suppose you had a detector fixed at some angle θ_0 and which could only detect photons with speed v_0. Also assume this detector has errors in the measurements of θ_0 and v_0 equal to σ_θ and σ_v respectively. Consider the following question:
  - What is the β of the particle which produced your measurements?
  - Answer: As you might expect there is not a unique β which produced your measurements because you have errors. Rather there is a distribution of β's which can generate (θ_0, v_0), this distribution of β's is given by the PDF evaluated at $\theta=\theta_0$ and $v=v_0$:

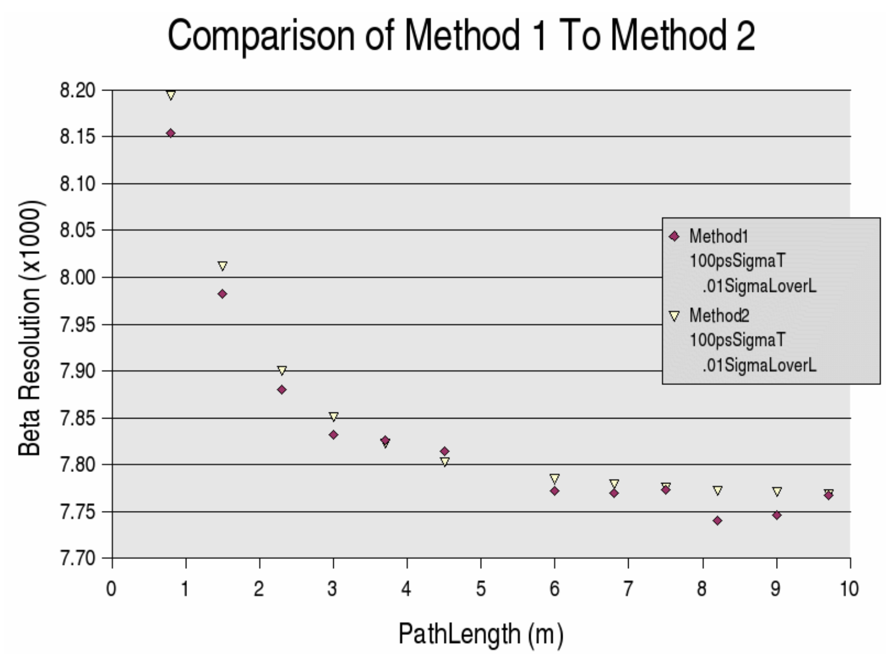
    PDF($\beta,\theta=\theta_0,v=v_0$).
- Comments:
  - In this method we are using the PDF in "reverse mode". Earlier I used the PDF with fixed $\beta=1$ to generate a 2D distribution which describes our measurements of θ and v, now I am doing the opposite. I know, for example that θ=822mrad and v=.66c corresponds to $\beta=1$, so I can use the PDF to generate a Gaussian distribution centered at $\beta=1$, the sigma of this distribution is non other than the β resolution of a detector which can measure θ an v with resolutions σ_θ and σ_v.
  - This method provides a very quick way of calculating the β resolution. In fact the β resolutions in the previous slides (as a function of path length) were calculated using this method, Method1 is very time consuming.
  - I believe what is going on behind this method is that we are just projecting the PDF onto the β axis.

Example:

This Example:
σ_θ=6.8mrad
σ_T=100ps
σ_L / L=1%
L~9.2m
θ_0=.822mrad
v_0=.66c



As Function of L:
σ_θ=6.8mrad
σ_T=100ps
σ_L / L=1%
θ_0=.822mrad
v_0=.66c



The small differences (~.6%) can be caused by statistics and/or fit errors.