Beam Dynamics and Alignment Model (On going work)

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The Simulation

- Present Simulations are using Merlin (a C++ based library for particle tracking)
- A package is being build to include the alignment model
- The Main Linac lattice corresponds to the positron side (no undulator).
- The beam based alignment here is Dispersion Free Steering (DFS)
  - The energy adjustment of the test beam set to
    - Initial Beam Energy = -20%
    - Constant Gradient = -20%
  - The constrains (weight) of the algorithm are fixed.
- The present study is not including the latest updates which can be found in the alignment paper (v05 or v06).

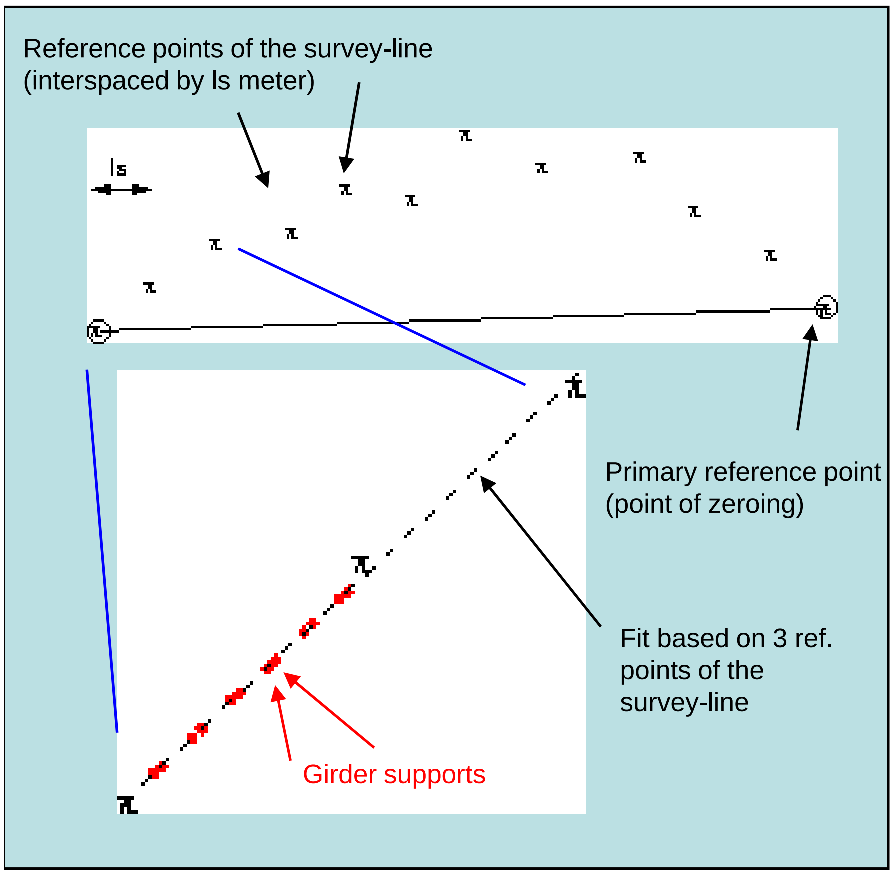
Alignment model

- Present model in Merlin includes reference points from the survey-line and primary reference points

$$\theta_{j,n+1} = \theta_{j,n} + G(a_\theta, t_\theta) + \Delta\theta_{systematic}$$

$$y_{0,j,n+1} = y_{0,j,n} + G(a_y, t_y) + l_{step}\theta_{j,n+1} + \Delta y_{systematic}$$

$$y_{0,j,0} = y_{P,j}$$



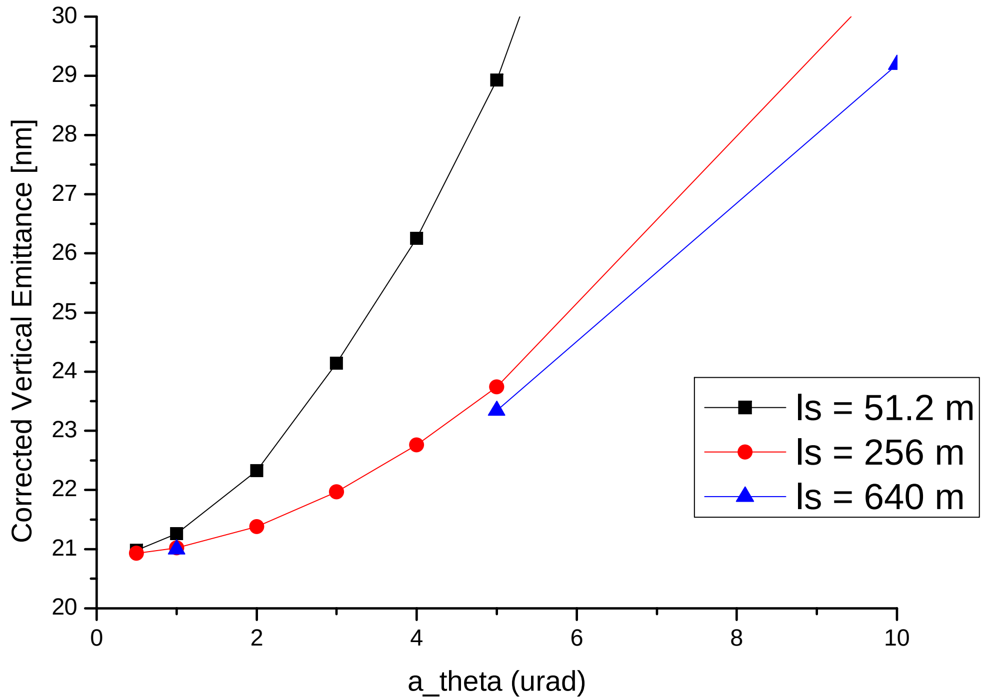
The offset of the ref. pts depends basically on 2 random gaussian distribution with standard deviation a_theta (angle) and a_y (vert. offset) and systematics.

The offsets are corrected such that “meet” the primary ref. points (as described in paper)

With the calculated offsets of the reference point of the survey line, the girders (supports) are positioned on a straight line fit based on 3 ref. point.

Result with the simplified model

- In this study:
  - only the angular error (a_theta) is included.
  - No errors on systematics.
  - No errors on the location of the primary ref. points (yp=0). Each primary ref. point are separated by 2560m (*)
- ls (l_{step}) is the distance between the reference points.



If we increase the distance between the ref. pts. the emittance growth is lower (counter intuitive)

*such that the last and 5th primary reference point corresponds to the end of the lattice.

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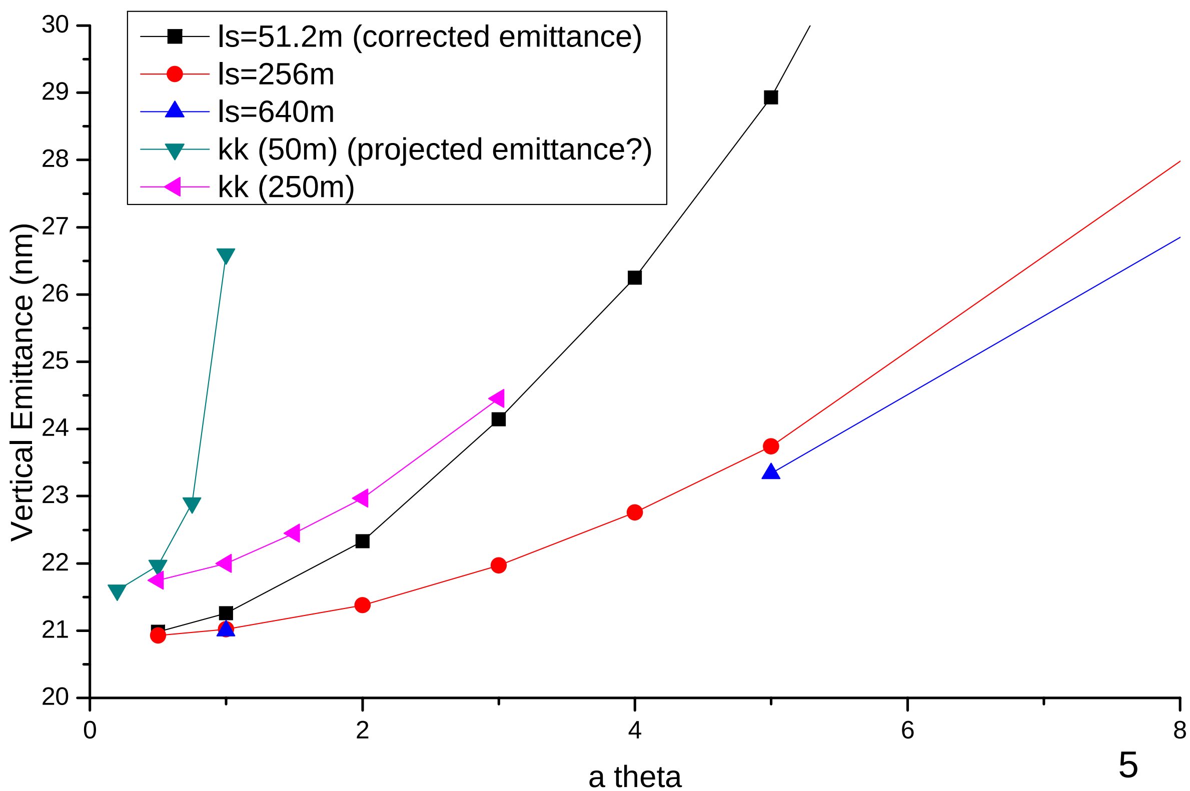
Comparison with K.Kubo study

- Results from KK study and KK alignment model from Merlin

The emittance is growing faster as the error increase for the data from K.Kubo study (green and pink). Though the general trend is kept i.e. the emittance growth is slower with longer steps between reference points.



Note: kk data are the one I picked up from his slides so rather approximative on my plot.

I'm using BPM 5 um, and he's using 1 um.

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Offsets of the components

The average smoothness S_i of the offsets between a component *"i"* and the previous component *"i-1"* is calculated using:

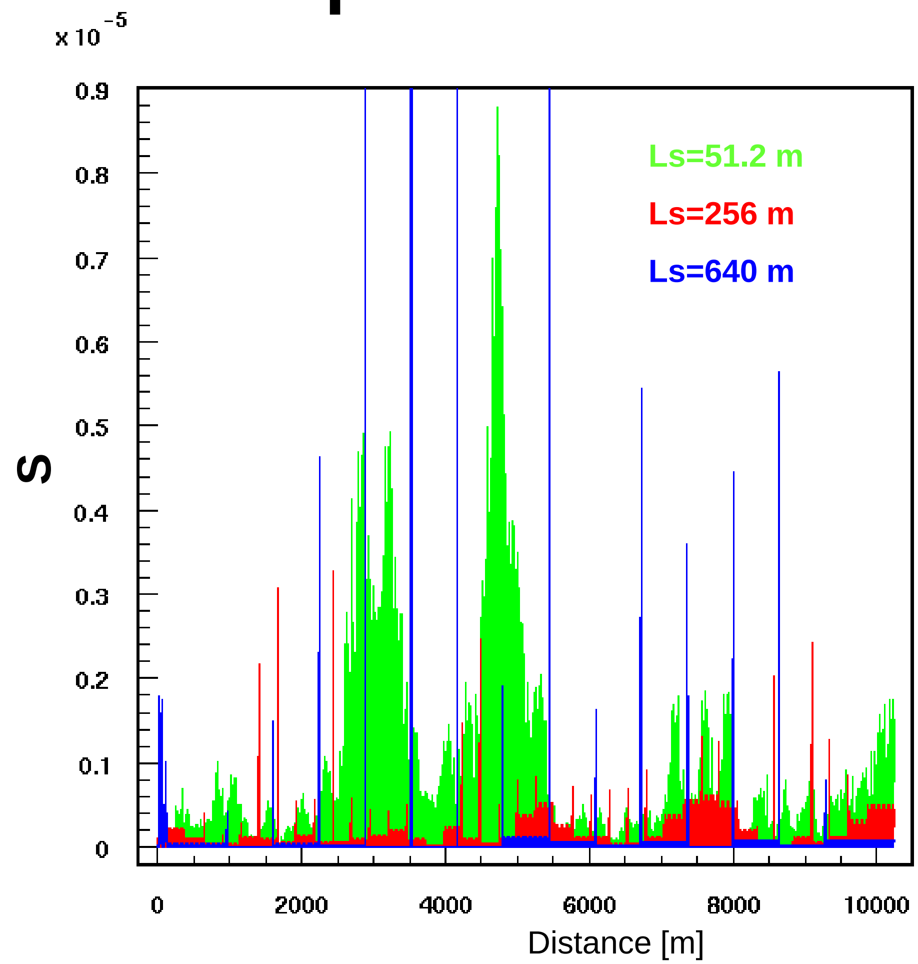
$$S_i = \frac{1}{Ns}\sum_{s=1}^{Ns=100}(y_{i,s} - y_{i-1,s})^2$$

Where the number of seed is *Ns=100*, the offset is *y*, the component is *i*, the seed number is *s.*

For ls=256 m, S is rather flat with some kicks every 256 m.

These kicks corresponds to location where the line of fit is changed as the following ref. pts are taken into account.

Note: No additional errors than a_theta in this study.

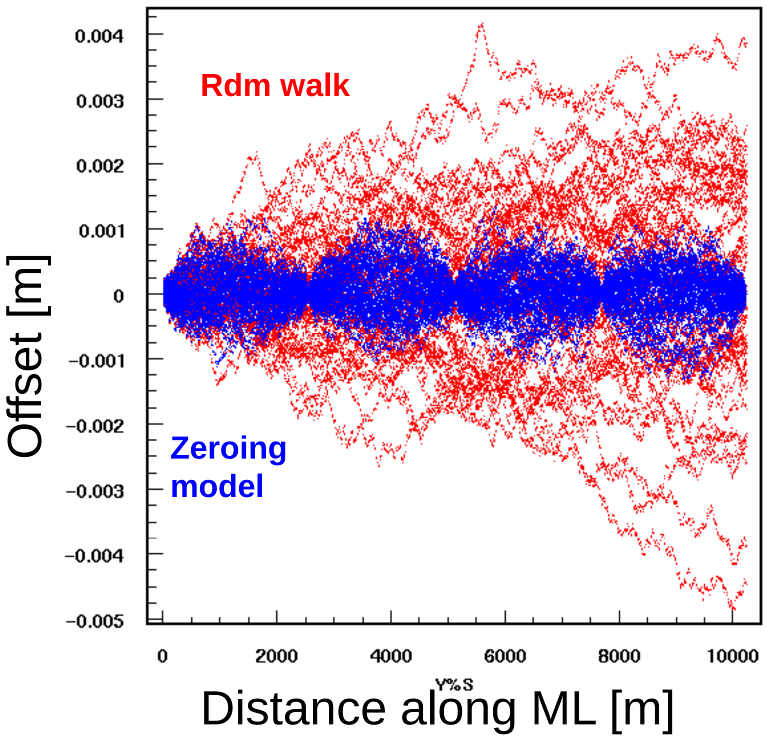


- The emittance growth is lower with longer steps: Seems to me an **artefact** due to the fact that the survey line is smoother (with some kicks)

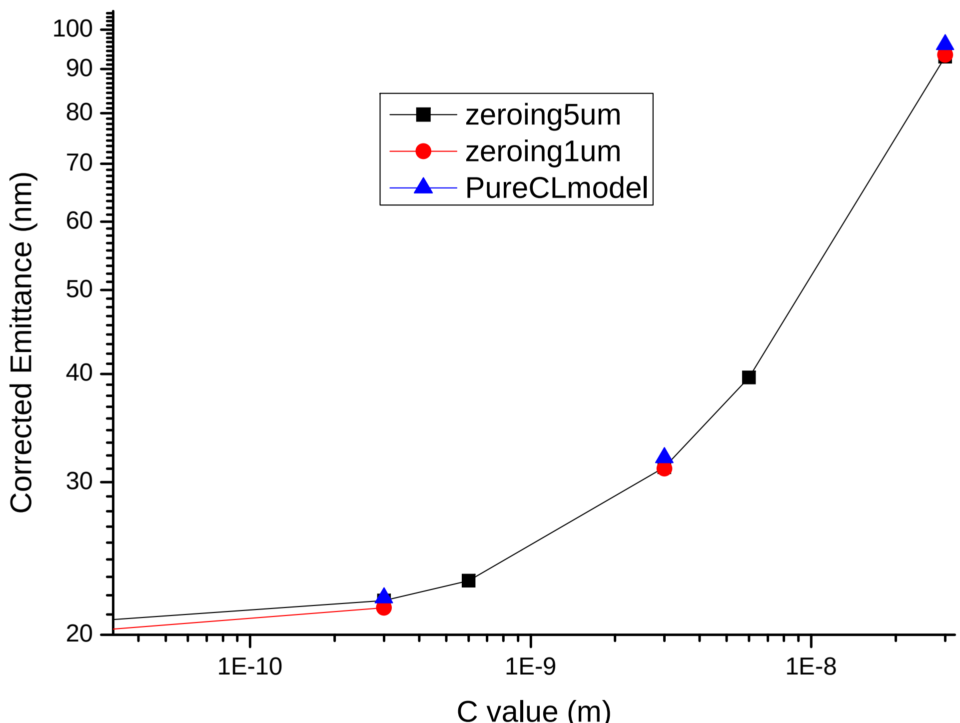
Using CL model

- CL model

The random walk model (ATL based) is used. The vertical offset of each component is corrected such that it is zeroed at a primary reference point. (Every 2560m)



The final vertical emittance at the end of the ML is checked for the random walk CL model, for a zeroing model with bpm resolution of 5 micrometre and 1 micrometre



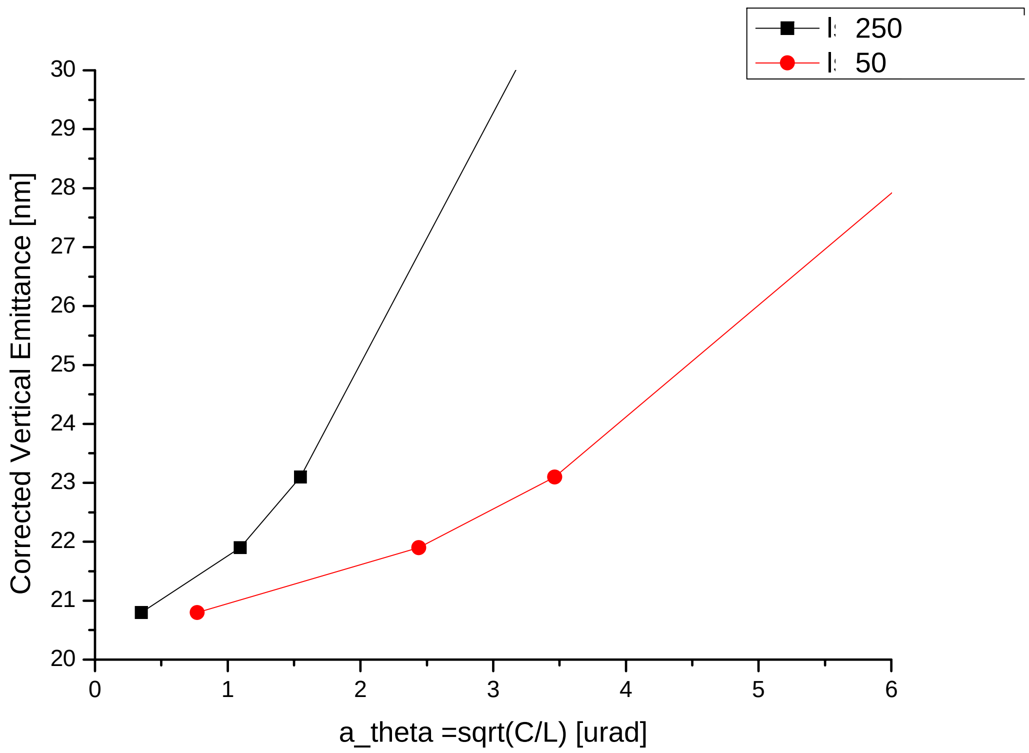
No major intrinsic difference observed in emittance results between the zeroing and the random walk CL model.

Using CL model

- **“Zeroed” random walk CL model**

(Simple transformation of the previous plot)

The zeroing is done every 2560m



Note: In this simulation, there is no points ,interspaced by a fixed distance, which serves as reference for the girder supports. The girder support are moved directly according to the zeroed random walk model.

If we decrease the distance L between reference point then the emittance decreases by “math” for a fixed angular error as defined here

$$\sigma^2 = CL$$

$$\sigma = a_\theta L$$

So according to this definition

$$a_\theta = \sqrt{C / L}$$

If C=6e-10, Corrected Emittance = ~23 nm:

•L=50 m, then a_theta=3.46e-6 rad

•L=250 m, a_theta= 1.54e-6 rad

- The alignment of the components on a straight fit from the survey line is not here judicious (maybe an additional random walk between the components?).
- Still a lot of errors to be included in the study.
- From the CL model, zeroing at the primary reference point do not change dramatically the results.