Update on Alignement Model for Merlin

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The present model

- Random walk (y):

$$\theta_{j,n+1} = \theta_{j,n} + a_\theta + \Delta\theta_{syst}$$

$$y_{0,j,n+1} = y_{0,j,n} + a_y + l_{step}\,\theta_{j,n} + \Delta y_{syst}$$

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

$$0 \le n \le N_{rfpt}$$

- Errors (stat. and sys.):

$$\sigma_{y,n,stat.} = \sqrt{l_{step}^2 a_\theta^2 \frac{n(n+1)(2n+1)}{6} + a_y^2 \frac{n(n+1)}{2}}$$

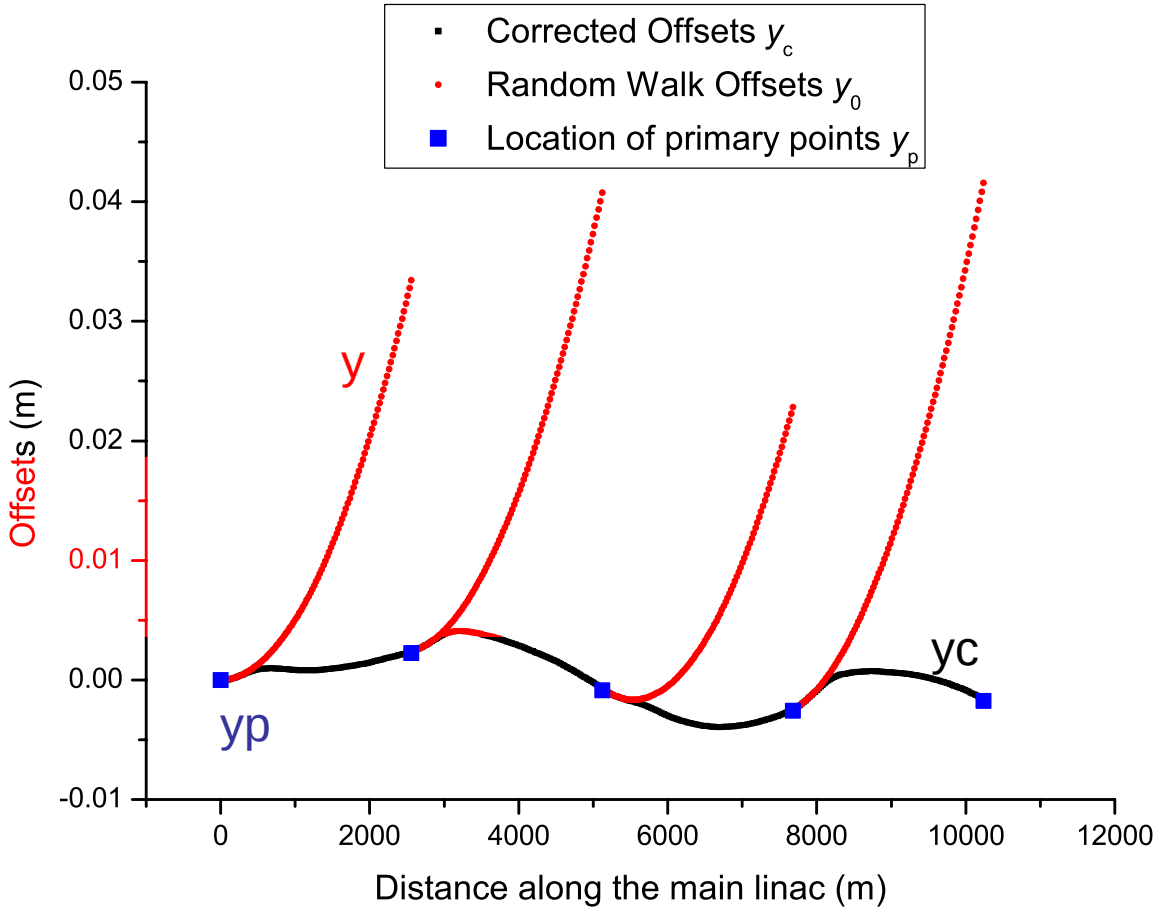
$$\sigma_{y,n,syst.} = l_{step}\Delta\theta_{systematic} n\frac{(n+1)}{2} + n\Delta y_{systematic}$$

- Correction (yc):

Error weighted average fit (parabolic)

A bit of explanation

- Yp= location of primary points
  - Error on primary points are so far gaussian
- Y offset of the surveyline
  - Random walk
- Yc corrected offset of the survey line
  - parabola correction (weighted solution)



Yp(first)=0 (fixed)

The starting angle of the offset at the beginning of a primary section is the same as the last one from a previous section

Done with scilab: a mathematical tool

Survey line with errors

- A typical exemple:
  - 100 seeds

<u>Statistics:</u>

a_y=5 10^-6m

$a\theta$=55.4 10^-9 rad

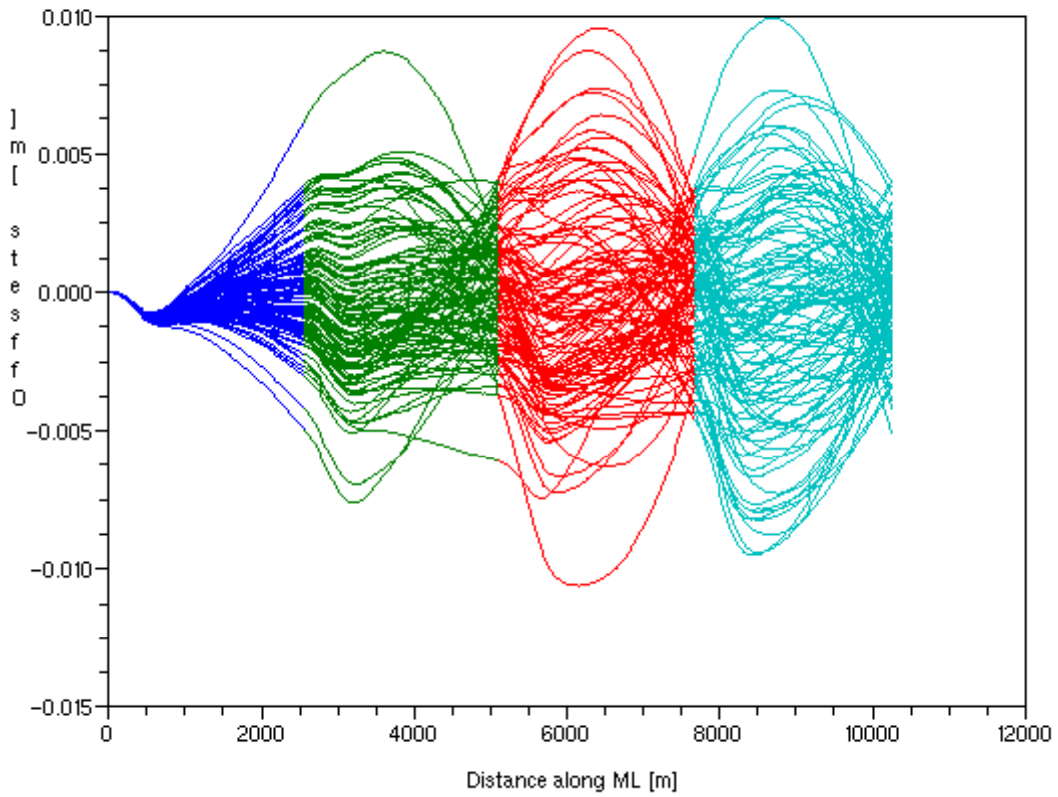
<u>Systematics:</u>

$\Delta\theta_{syst}$=260 10^-9 rad (- on this plot)

Δy_{syst}=5.3 10^-6 m

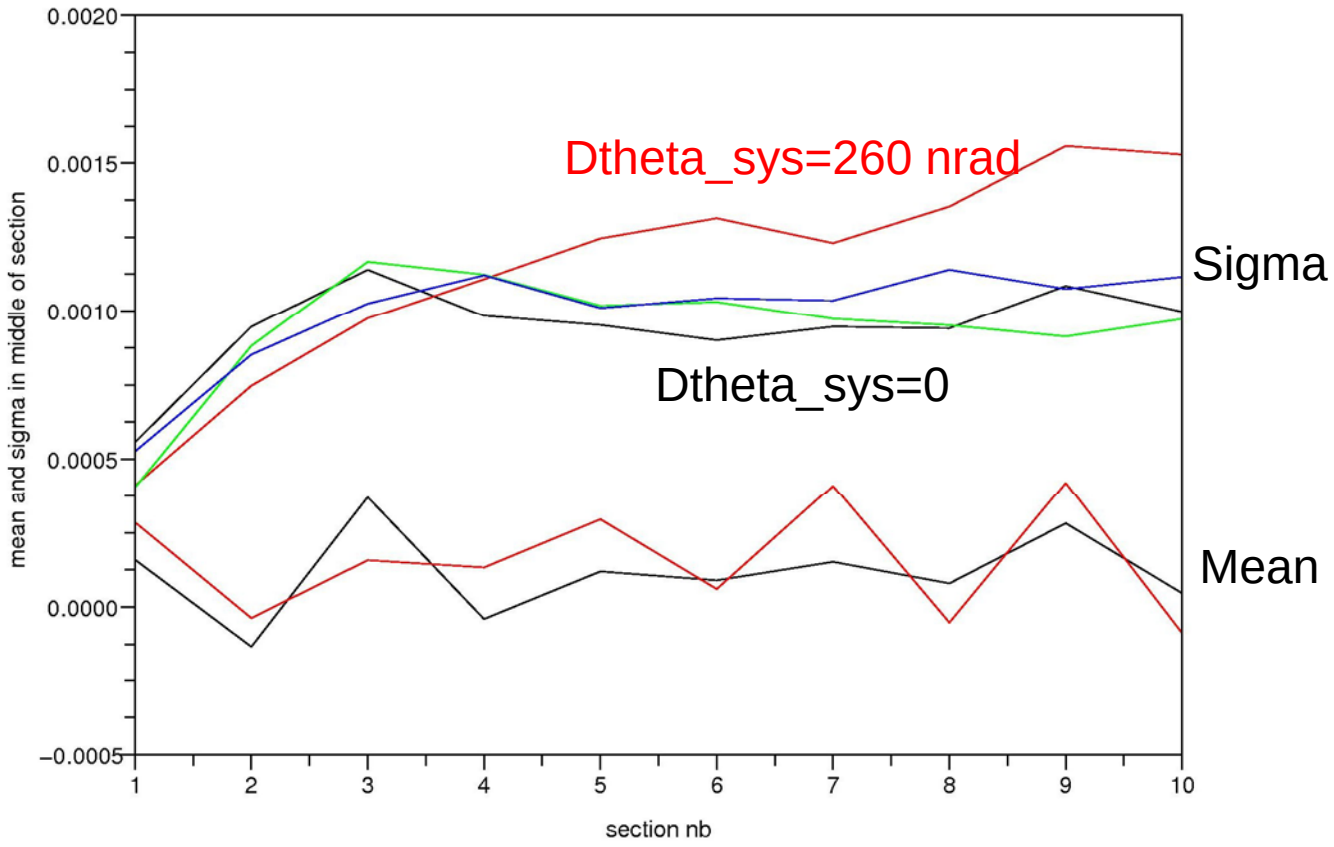
<u>Error on primary points:</u>

σ_{yp}=2.0 10-3 m



Study on the offsets distribution

- Standard deviation of the offsets in the middle of the sections (here 10 primary sections)
- Mean value of the offsets



Increase of the standard deviation in the middle of the primary section→not satisfying?

Note: with/without the first primary points at 0, do not modify this conclusion

To Beam Dynamics in ML

The interface between Scilab and Merlin is done (ugly but works)

Cross checking has to be done

- Lstep=25.098m
- Distance primary point= 2560m
- Least square fit for girders location wrt survey line.

Results of mean vertical emittance (100 seeds):

No errors from Surveyline ε_{yc}=20.71(+-0.05) nm*

With errors from Surveyline ε_{yc}=20.76 (+-0.06) nm

With errors from Surv+ standard errors on components ε_{yc} = 22.44 (+-0.17) nm

With errors from Surveyline x 10 + standard err = 29.91 nm

Most of the emittance dilution is in the present study coming from the uncorrelated errors on components.

It does not seems there is emittance jumps due to possible kinks between change of least sq. fit.

On going discussion for other correction: Use of spline function

* Error mainly due to BPM resolution and choice of weight as here lattice is flat

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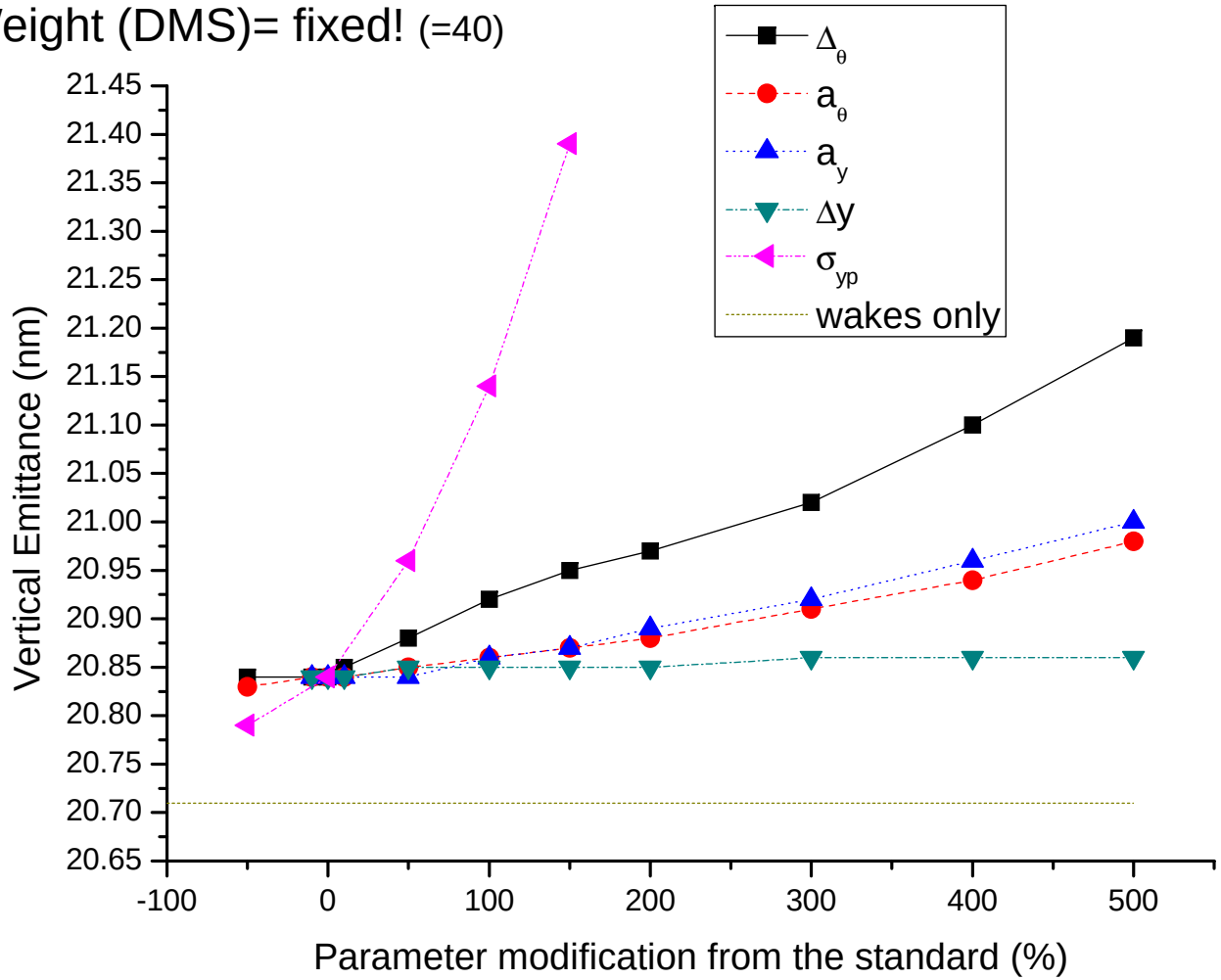
Systematics studies (1)

Weight (DMS)= fixed! (=40)



Standard here means:

a_y=5 10^-6m

a_θ=55.4 10^-9 rad

Δ_θ=260 10^-9 rad

Δy=5.3 10^-6 m

σ_{yp}=2.0 10-3 m (error on primary points)

The sensitivity of the emittance at the end of the linac to the parameters of the model is rather low accept for the primary points error (*).

The model here only uses the correction as given in the version 0.7 of the misalignment paper.

Emittance (or ε_{yc}) here is the vertical emittance with the energy correlation numerically removed

* Though still lower than independent error on components.

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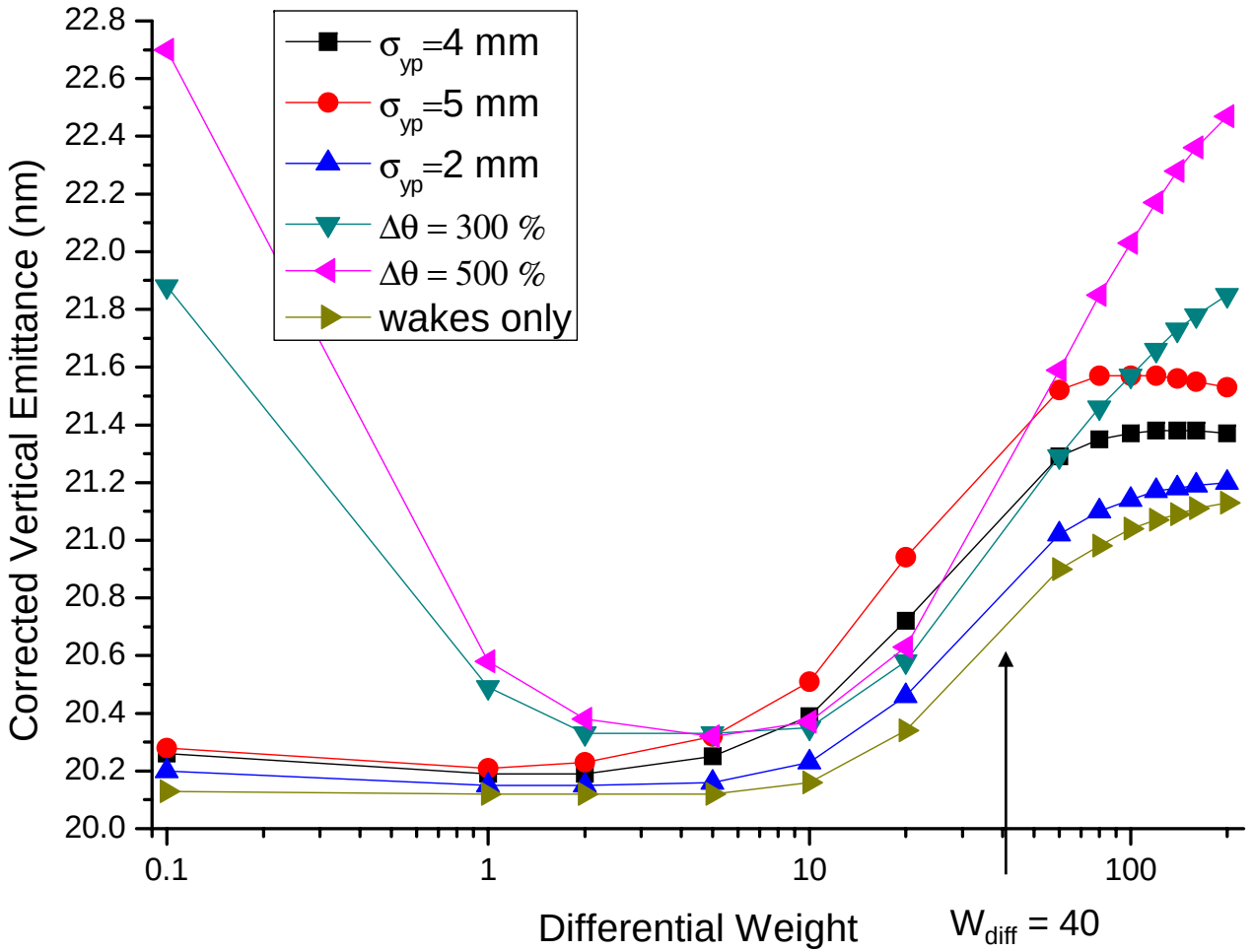
Systematics Studies (2)

The sensitivity of the emittance to the parameters value can be largely mitigated with a modification of the constrain (differential weight) on the Dispersion Match Steering (DMS) correction algorithm.



Best overall weight =~5

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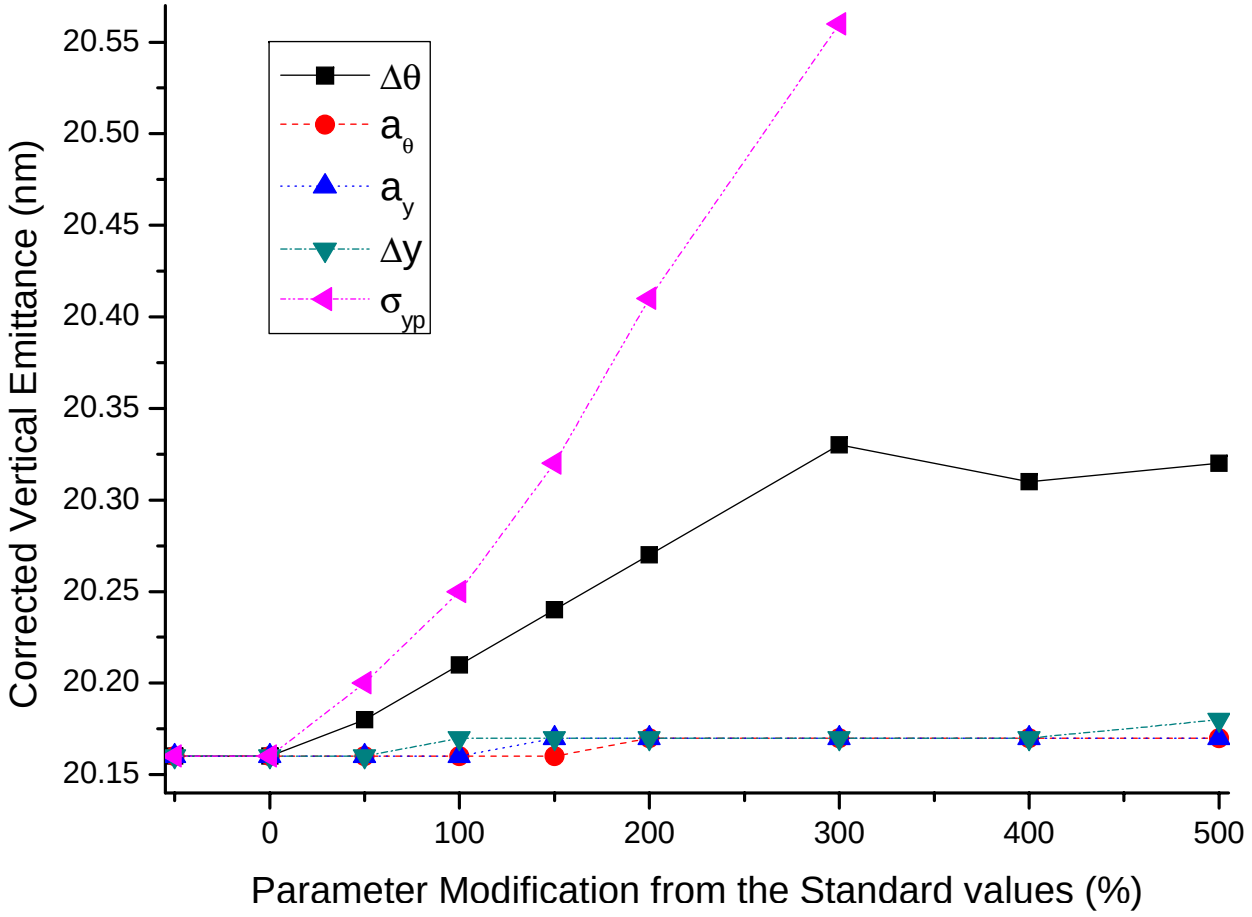
Systematics Studies (3) - Mitigation

Weight= 5
The sensitivity is here reduced. Though again it requires a scan through the constrain of the DMS.

Even with 300% of increase for $\Delta\theta$, the emittance growth is only of 2.75% (with wakes)→no major impact

For uncorrelated errors the emittance growth was ~12.5% (with wakes and for the mean value).



For 500% $\Delta\theta$, ε_{yc}=21.90 nm. Can this be mitigated further with weight?

- Outlook:
  - More work as to be done by including uncorrelated errors
    - This study will call for a check on the DMS weight mitigation

- Note:
  - Some of the results here are being included in an EPAC paper (THPC030)
  - The lattice is the simple positron side (no positron source insertion) and concerns only the Main Linac