# IR multipolar correction and DA studies for the LHC upgrade

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# Motivation & Goal

- Large spectrum of LHC upgrade options
- IR multipolar errors could deteriorate DA:
  - Error routines still being debugged!

Therefore we would like:

- General IR multipolar correction package that is:
  - optics independent and
  - corrector order/type independent
  - Existing Stephane's filter could not be upgraded by us

Why not use MADX-PTC to get IR map coefficients?

# The map & the observable

$$\vec{x}_f = \sum_{jklmn} \vec{X}_{jklmn}\, x_0^j\, p_{x0}^k\, y_0^l\, p_{y0}^m\, \delta_0^n$$

To assess how much two maps, $X$ and $X'$ deviate from each other the following quantity is defined:

$$\chi^2 = \sum_{jklmn} ||\vec{X}_{jklmn} - \vec{X}'_{jklmn}||$$

Weighting can be implemented. To disentangle the contribution of the different orders on $\chi^2$:

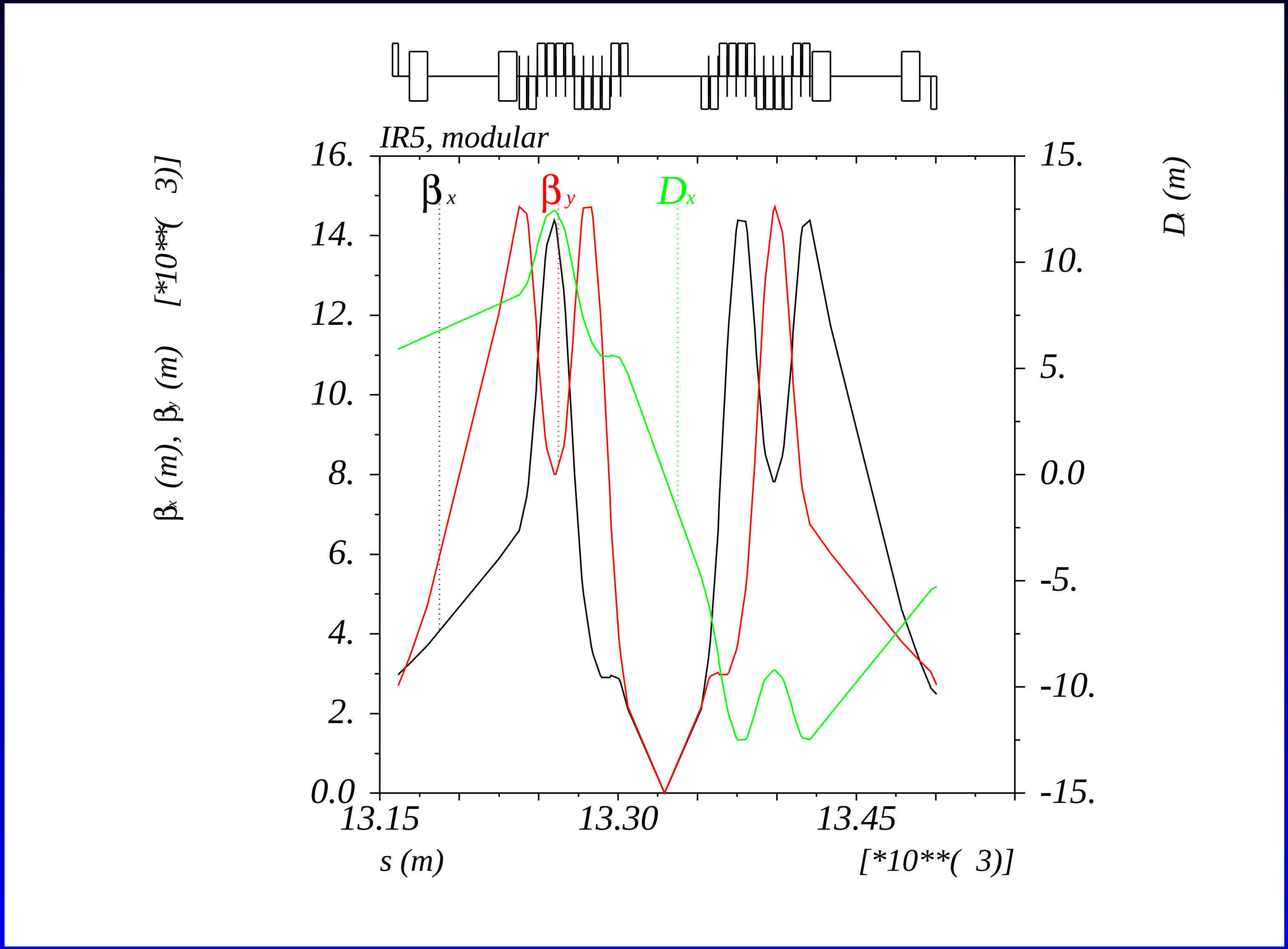
$$\chi_q^2 = \sum_{j+k+l+m+n=q} ||\vec{X}_{jklmn} - \vec{X}'_{jklmn}||$$

This is computed with the Python code MAPCLASS.

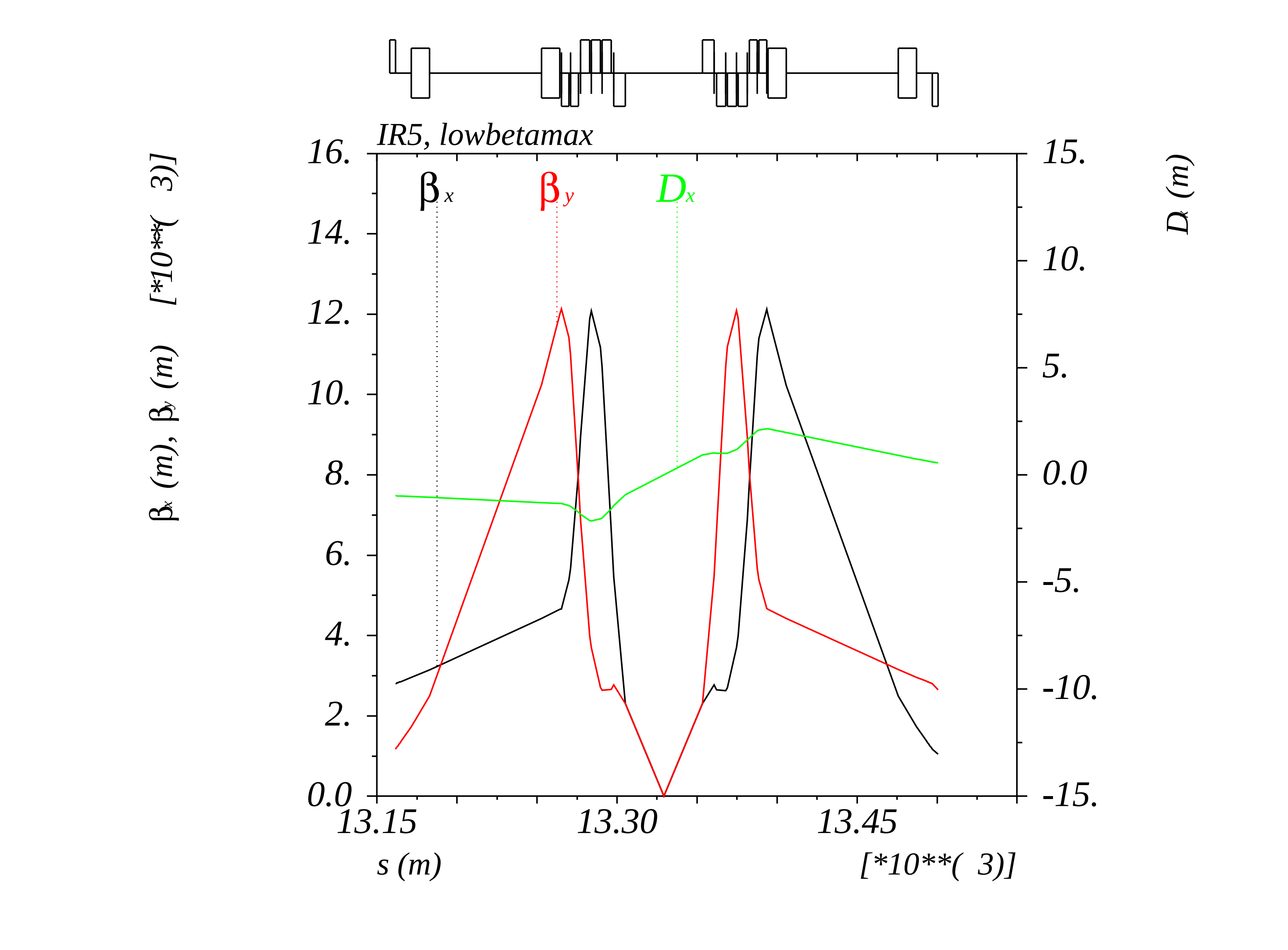
# Correction

- MADX provides $\vec{X}_{jklmn}$ to arbitrary order.
- $\vec{X}_{jklmn}$ is the IR transfer map without errors
- $\vec{X}'_{jklmn}$ is the IR transfer map with errors
- Correction of order $q$ is achieved by minimizing $\chi_q^2$ using $2q$-pole correctors.
- 2 correctors per IR side and per corrector type have been assumed hereafter.

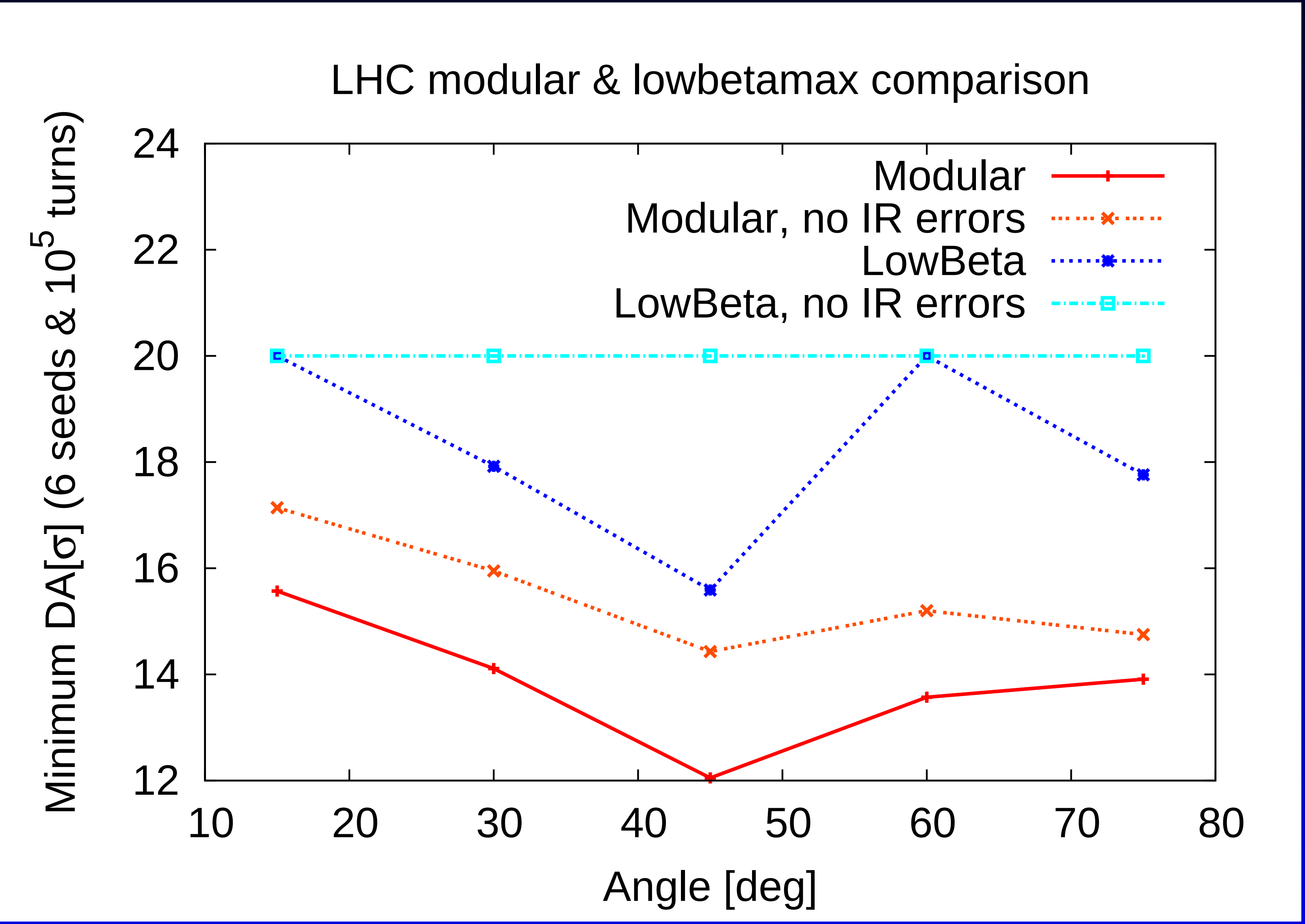
# Optics: modular



# Optics: lowbeta

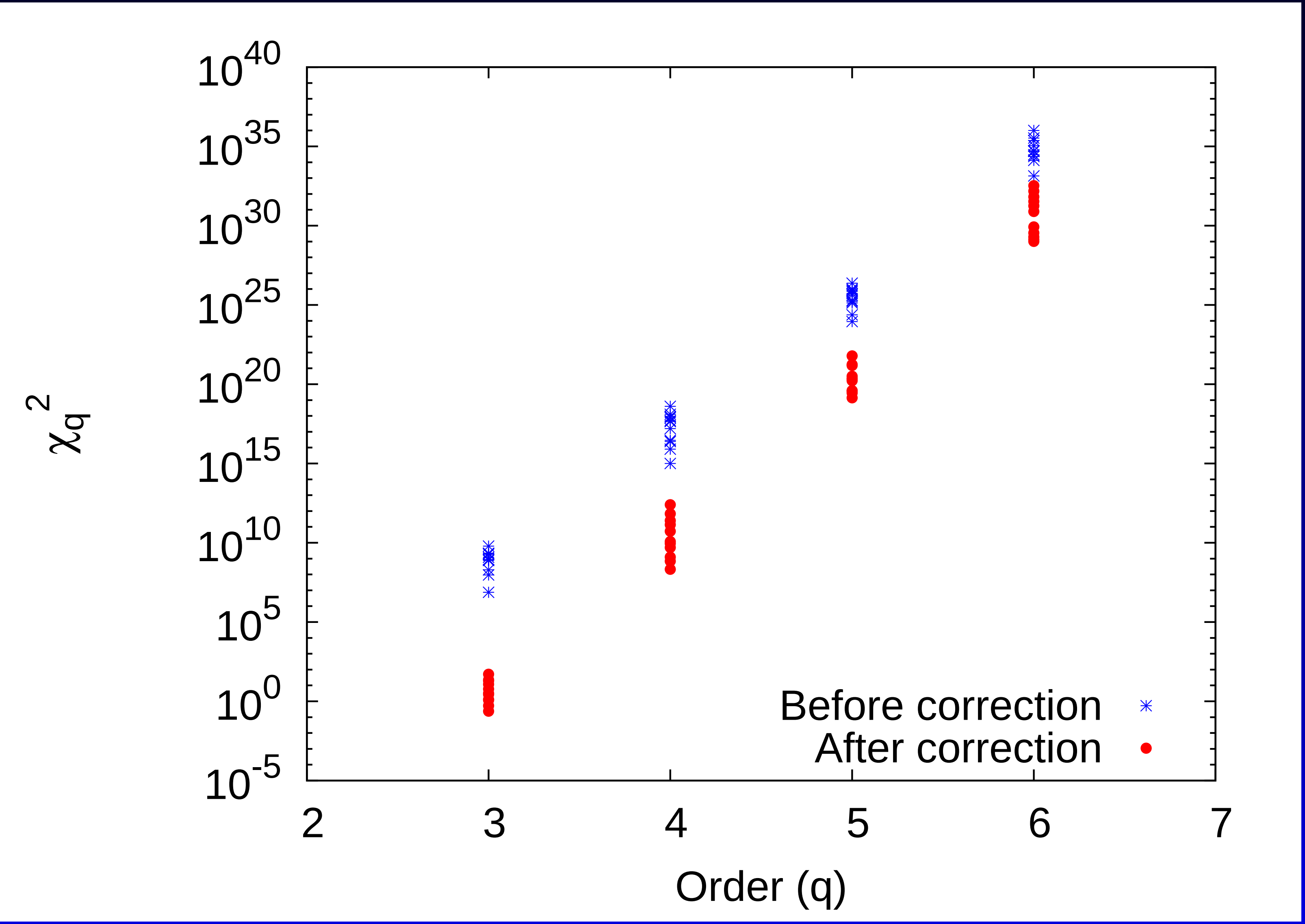


# DA comparison: modular & lowbeta

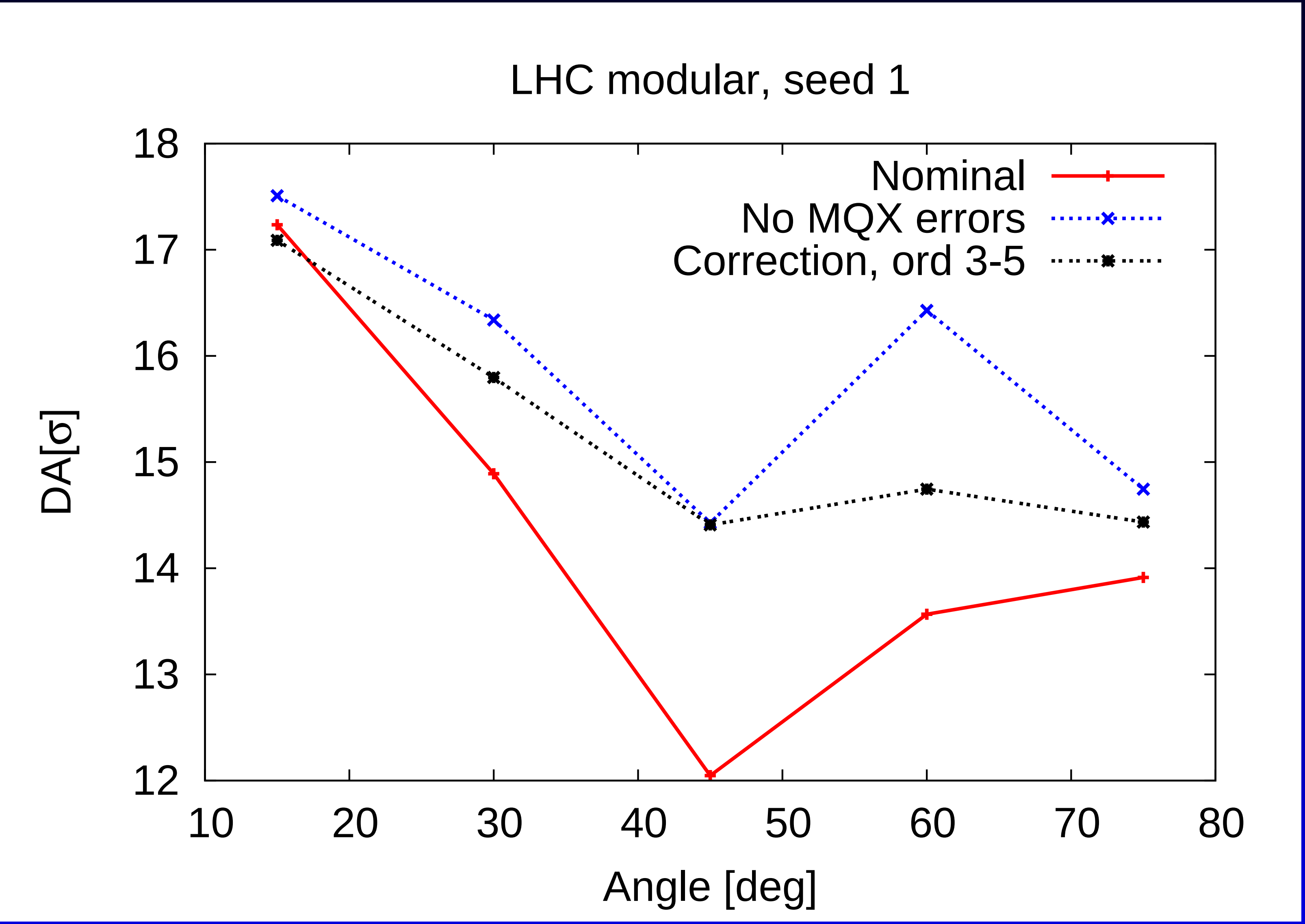



LowBetaMax case needs verification...

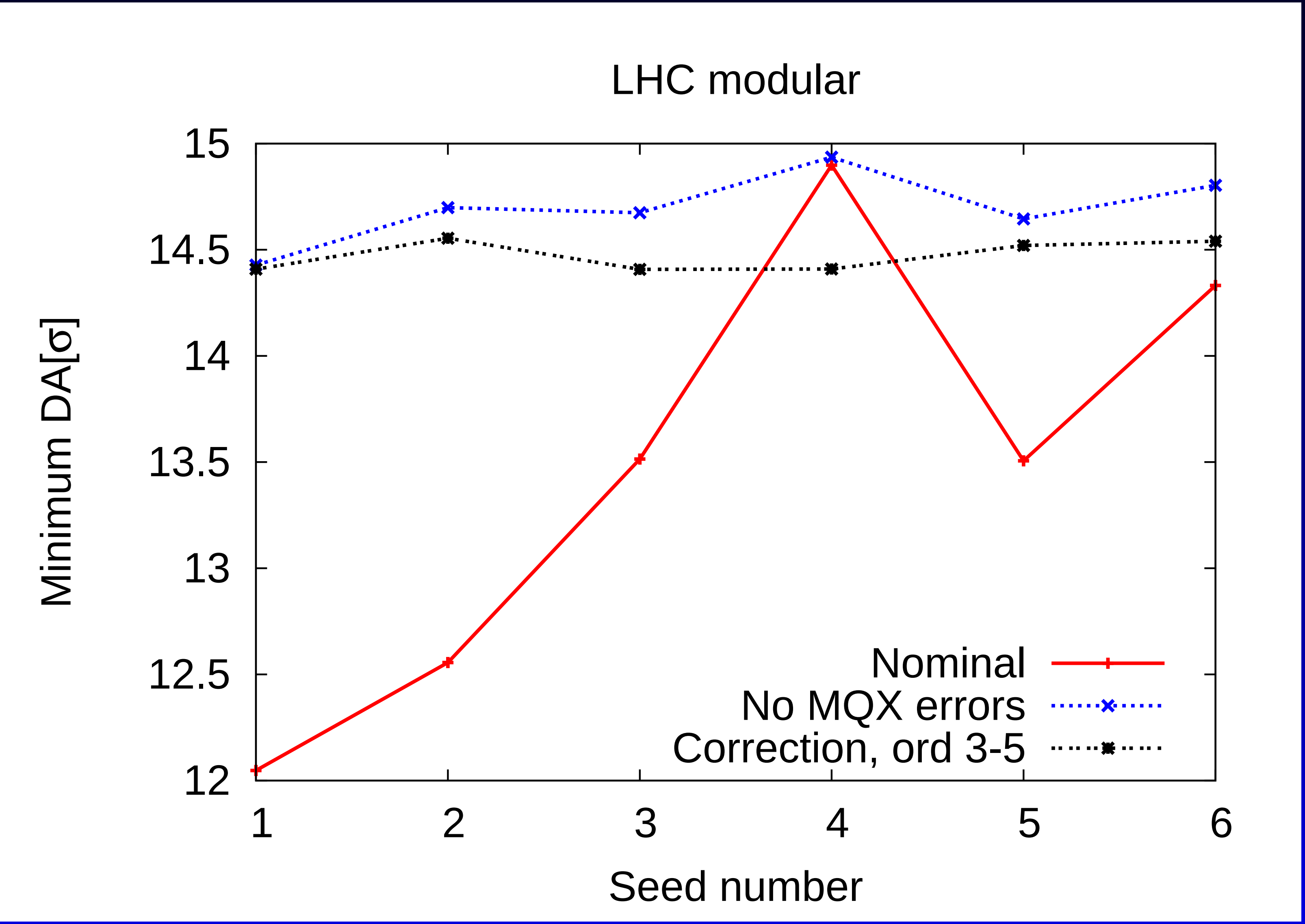
# Correction: $\chi_q^2$ for the modular



# Correction versus angle



# Correction versus seed



# Conclusions

- A general correction package has been developed based on the computation of map coefficients
- It works for the modular option: raises minimum DA from $12\sigma$ to $14.5\sigma$
- It needs more tests and refinements
- Studies for lowbetamax and compact pending