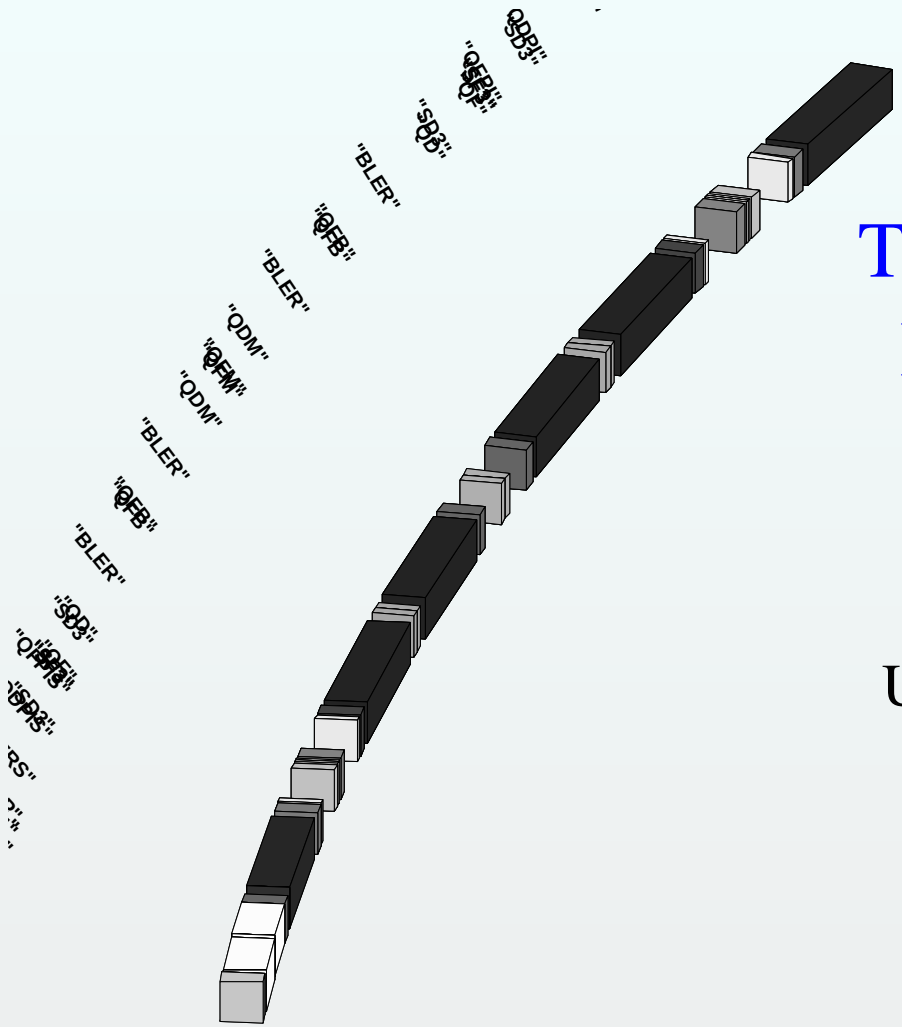


TOLERANCES AND IMPERFECTIONS

Simone Liuzzo

Universitá di Pisa & L.N.F.

3 dicembre 2009

Objectives

Objective

Obtain tollerance table for various machine misalignments

Analyze

- Magnet Installation
- Monitor Errors
- Correction Method
- Correctors Pattern

Obtain

machine performance
$\rightarrow$ **Effective** ϵ_y

Typical Expected Errors (ILC Damping Ring)

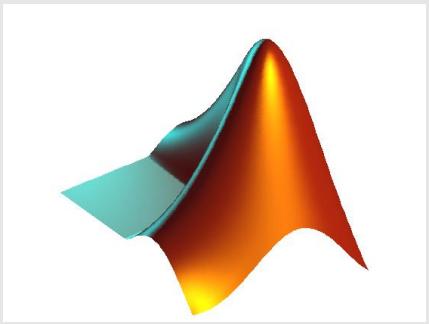
rms BPM vertical misalignment	50 μm
rms vertical corrector tilt	500μrad
rms quadrupole vertical misalignment	50 μm
rms quadrupole tilt	200 μrad
rms sextupole vertical misalignment	100 μm
BPM horizontal resolution	10 μm
BPM vertical resolution	10 μm
systematic BPM gain error	0.01
systematic BPM coupling error	0.01

Tools

Tools used for simulation are:

MADX

MATLAB



MADX

LOOP:

0. reset
1. misalign
2. correct
3. store results

```
@ SEQUENCE          %07s "RING_V9"
@ PARTICLE          %08s "POSITRON"
@ MASS              %le       0.00051099891
@ CHARGE            %le                  1
@ ENERGY            %le                6.7
@ PC                %le          6.699999981
@ GAMMA             %le          13111.57396
@ KBUNCH            %le                  1
@ BCURRENT          %le      0.002083880464
@ SIGE              %le     0.0006152951332
@ SIGT              %le      0.005022518317
@ NPART             %le             5.74e+10
@ EX                %le     1.728893117e-09
@ EY                %le     5.174439727e-38
@ ET                %le     3.088697333e-06
@ LENGTH            %le          1323.031379
@ ALFA              %le                    0
@ ORBIT5            %le       0.01104555267
@ GAMMATR           %le                    0
@ Q1                %le           44.5456548
@ Q2                %le          19.33872199
@ DQ1               %le                    0
@ DQ2               %le                    0
```

MADX

LOOP:

0

reset

↓

1

misalign

↓

2

correct

↓

3

store results

x_plane
Want to correct orbit of a single ring
188 monitors and 172 correctors found in input
188 monitors and 172 correctors enabled

start SVD correction using 172 correctors

CORRECTION SUMMARY:

rms before correction: 0.054057 mm
rms after correction: 0.001179 mm

ptp before correction: 0.268263 mm
ptp after correction: 0.016879 mm

y_plane
Want to correct orbit of a single ring
116 monitors and 100 correctors found in input
116 monitors and 100 correctors enabled

start SVD correction using 100 correctors

CORRECTION SUMMARY:

rms before correction: 0.320471 mm
rms after correction: 0.003550 mm

ptp before correction: 1.173135 mm
ptp after correction: 0.038068 mm

MADX

Useful:

MACRO
LOOPS
CORRECT S.V.D.
EALIGN

↓

but

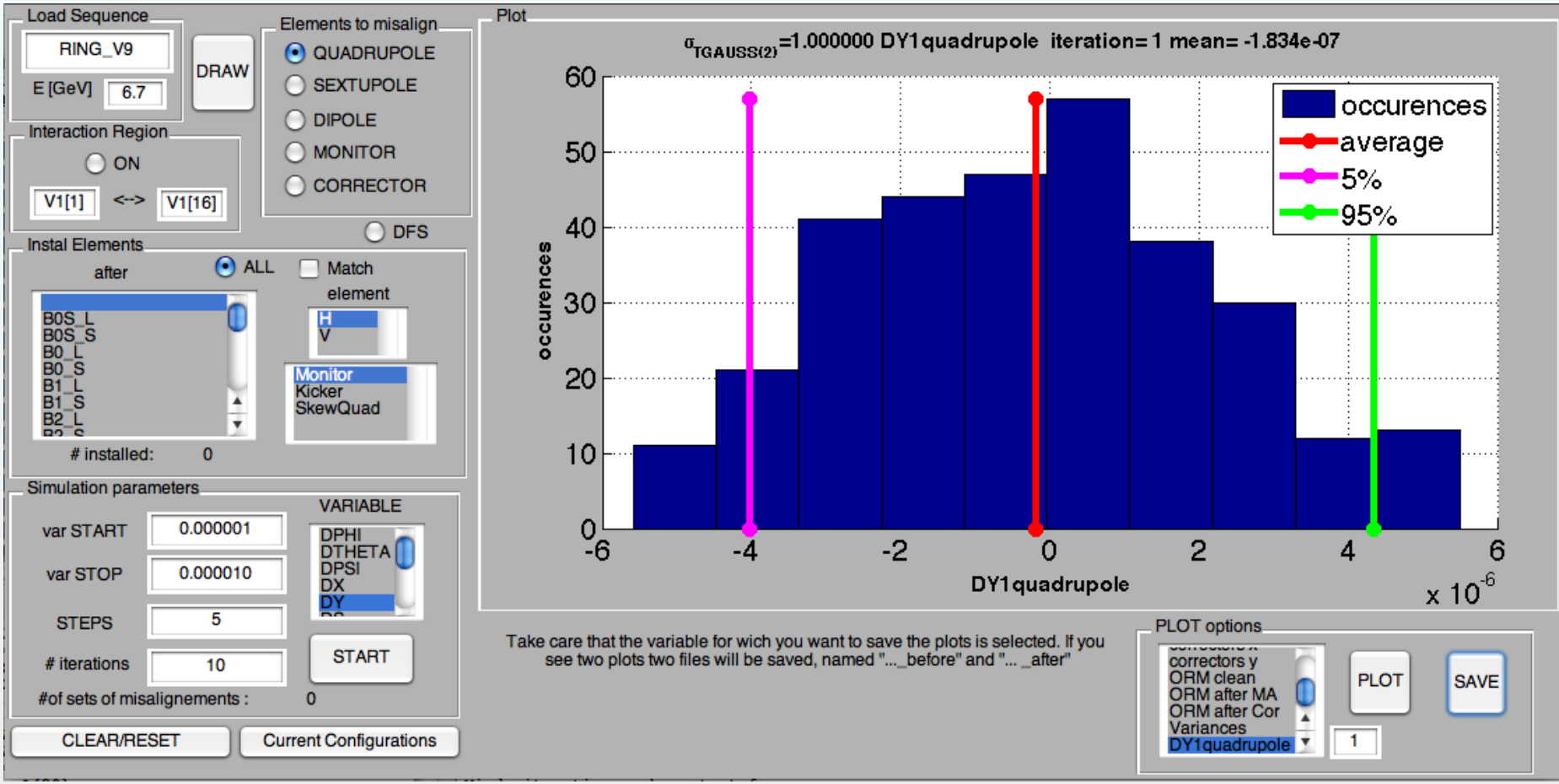
MADX does the job, but it is quite boring to change settings for next analysis.

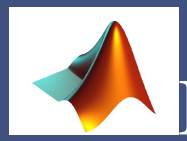
↓

so

MATLAB
as an interactive input editor for MADX
as a plotter for MADX output

MATLAB

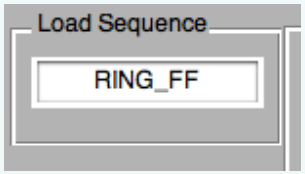

Load Sequence
RING_V9
E [GeV] 6.7
DRAW
Interaction Region
ON
V1[1] <--> V1[16]
Elements to misalign
QUADRUPOLE
SEXTUPOLE
DIPOLE
MONITOR
CORRECTOR
DFS
Instal Elements
after
ALL
Match
element
B0S_L
B0S_S
B0_L
B0_S
B1_L
B1_S
B2_L
H
V
Monitor
Kicker
SkewQuad
installed: 0
Simulation parameters
VARIABLE
var START 0.000001
var STOP 0.000010
STEPS 5
iterations 10
DPHI
DTHETA
DPSI
DX
DY
START
#of sets of misalignements : 0
CLEAR/RESET
Current Configurations
Plot
σTGAUSS(2)=1.000000 DY1quadrupole iteration=1 mean= -1.834e-07
occurences
average
5%
95%
occurences
DY1quadrupole
x 10-6
Take care that the variable for wich you want to save the plots is selected. If you see two plots two files will be saved, named "..._before" and "... _after"
PLOT options
correctors y
ORM clean
ORM after MA
ORM after Cor
Variances
DY1quadrupole
PLOT
SAVE
1

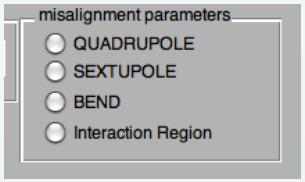


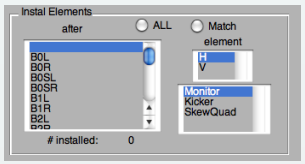
Used for:

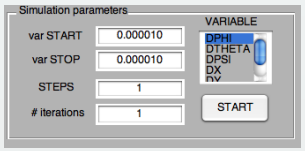
- interactivity with MADX
- analyze ANY sequence
- MULTIPLE errors in any element
- MULTIPLE error distributions
- EASY installation of Monitors, Correctors, Skew Quadrupoles at any location
- show and save plots

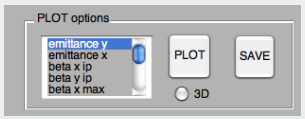
MATLAB











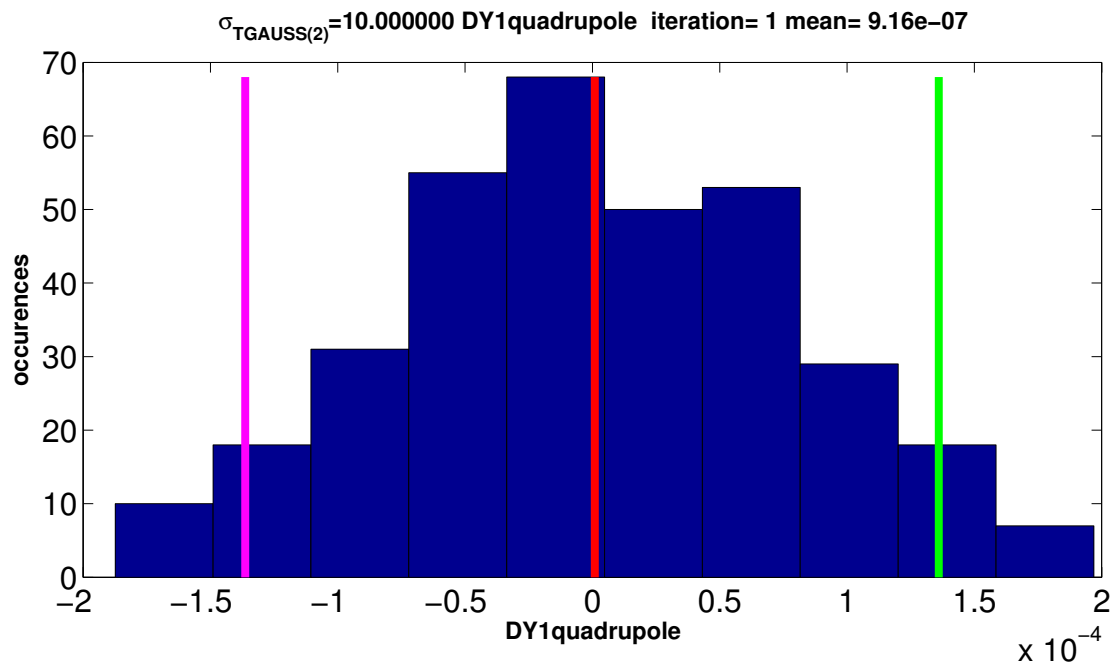
Example of procedure:

- load and draw schematic view of sequence
- place monitors and correctors or load prebuild file.
- exclude Interaction Region for first analysis
- misalign in Y sextupoles and/or quadrupoles
- tilt quadrupoles
- add monitor reading errors in vertical plane
- simulate N machines for M steps
- Compute theoretical and measured Orbit Response Matrix and Dispersion Response Matrix (to be used later for correction)
- plot histograms or bar plots (for multiple steps)

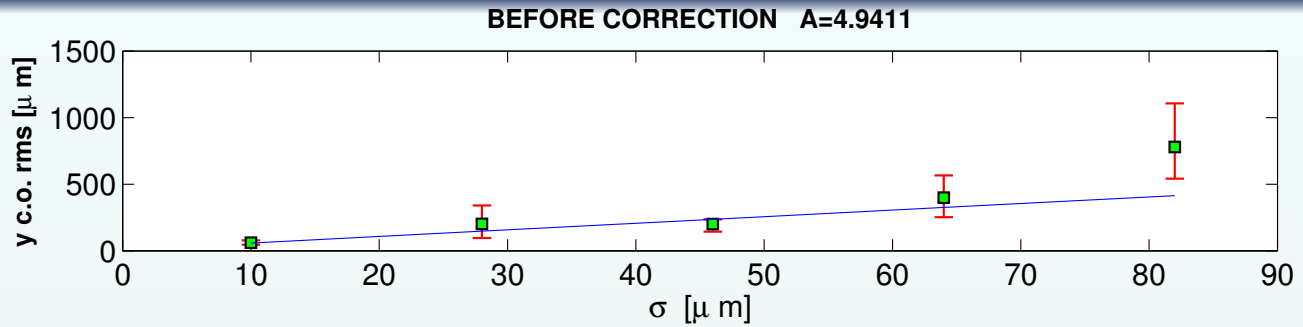
Δ y for quadrupoles

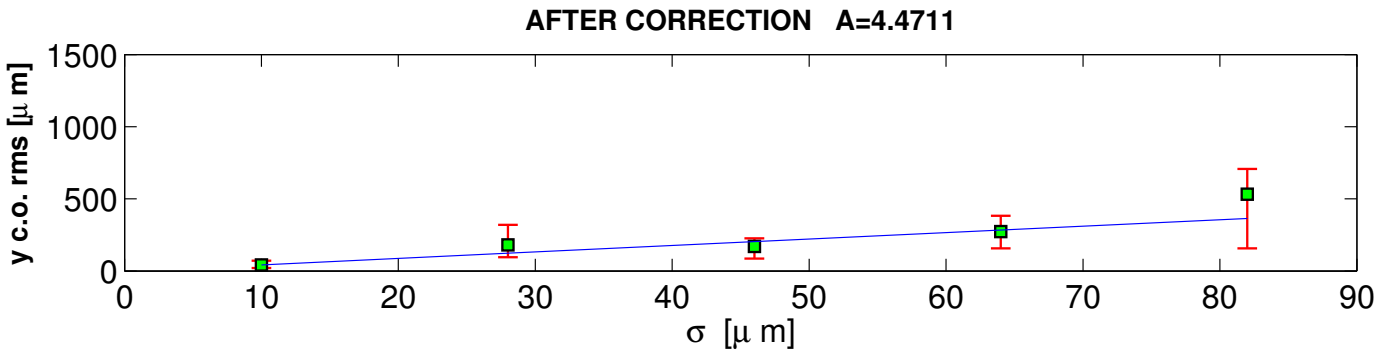
30 machine simulated in groups of 5
for Δy from 1 to $\simeq$82 μm. (20 min)

typical error distribution (σ=82 μ m):



Y rms Closed Orbit Before (After precorrection to find Closed Orbit) and After Correction

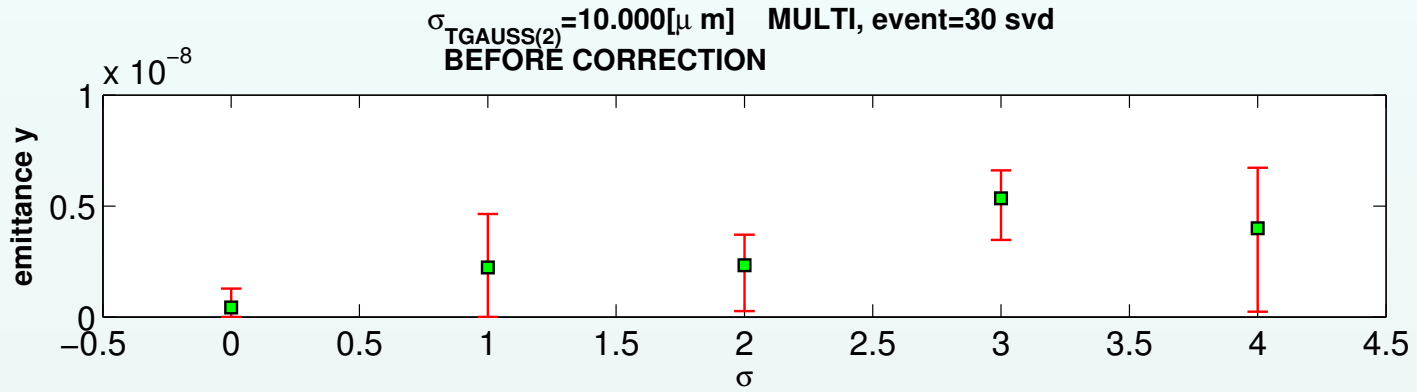




A = Ampilification Factor

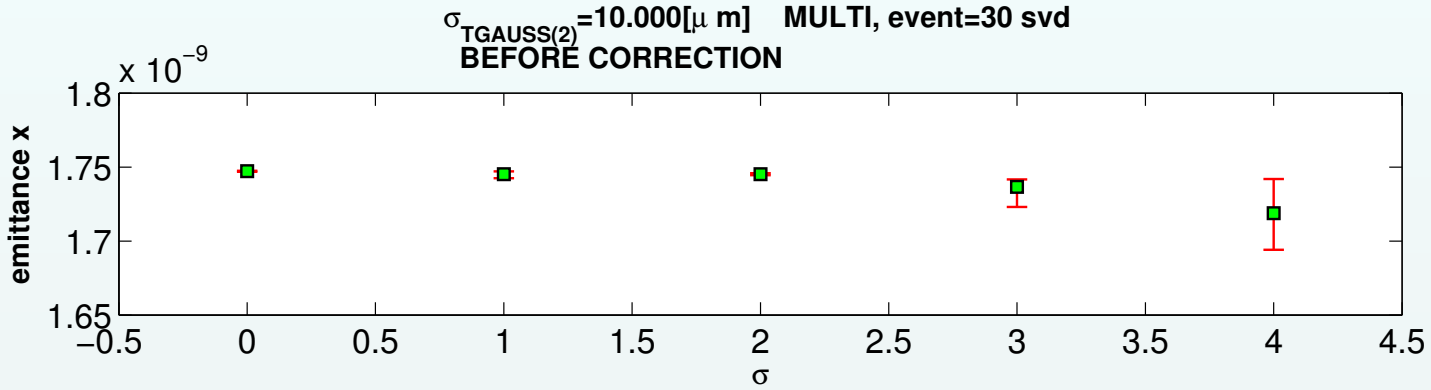
$$\sqrt{\langle y_{CO}\rangle^2} = \mathcal{A}\sqrt{\langle \Delta y_{quad}\rangle^2}$$

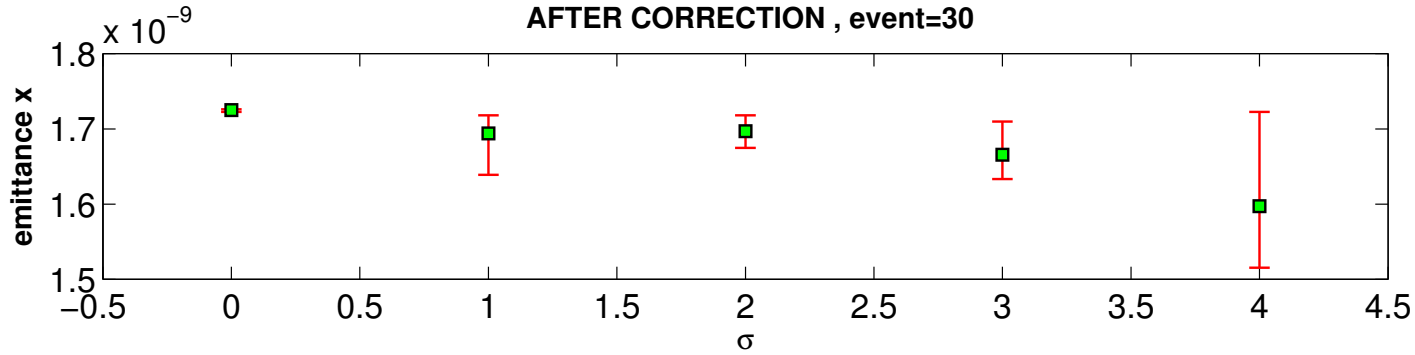
ϵ_y Before And After Correction



SCALE : Steps from 10 μ m to 82 μ m

ϵ_x Before And After Correction



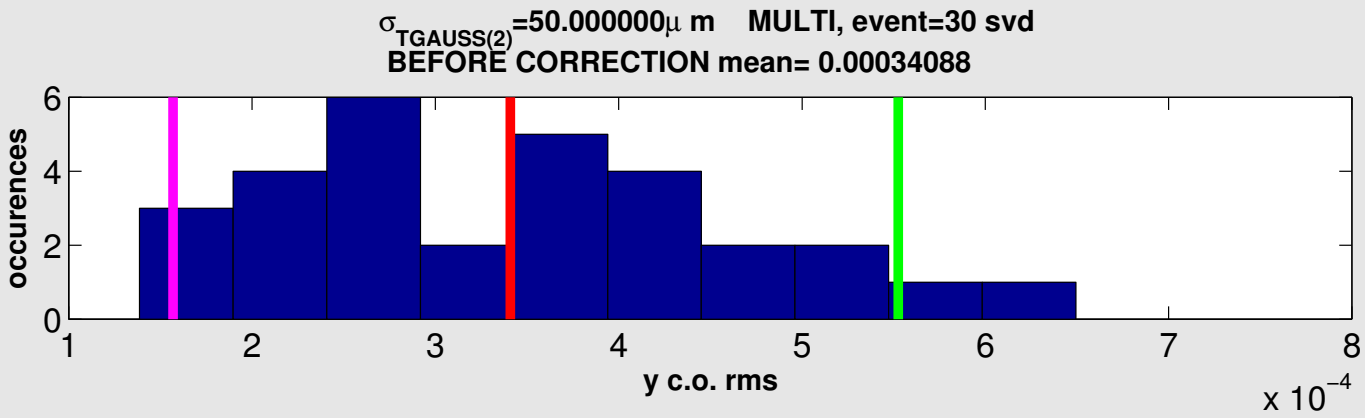


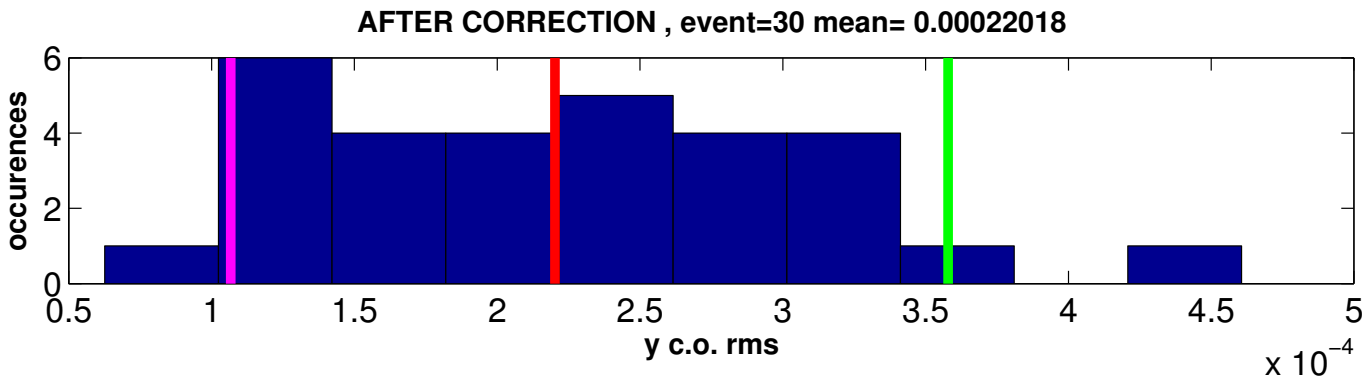
SCALE : Steps from 10 μ m to 82 μ m

ϵ_y After Correction With And Without Monitor Errors

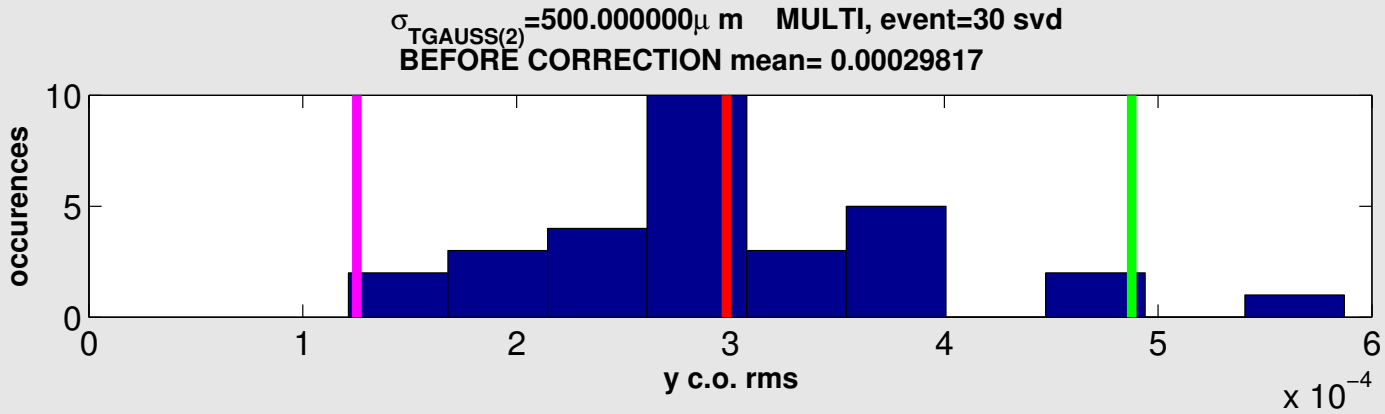
30 machine simulated with quadrupoles $\Delta y = 50\ \mu m$.

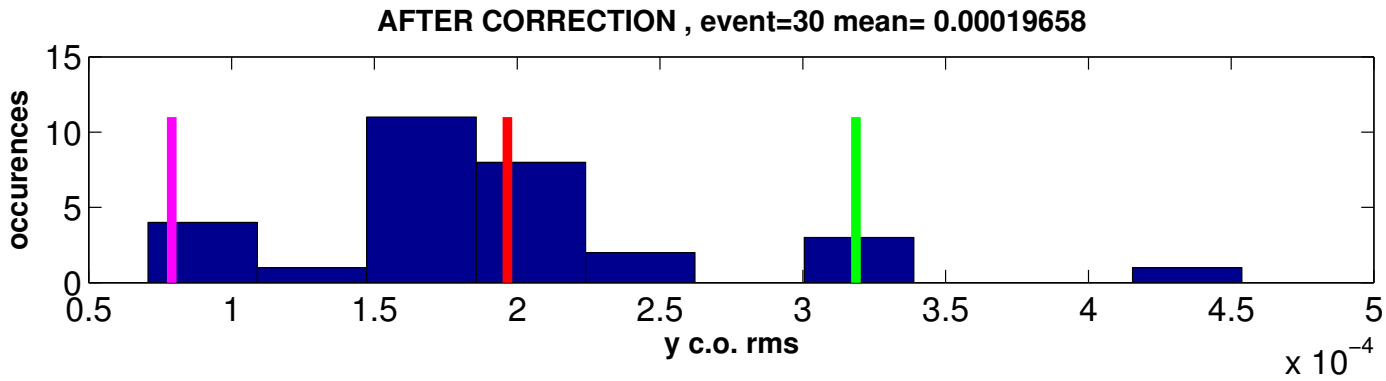
NO Monitor Errors





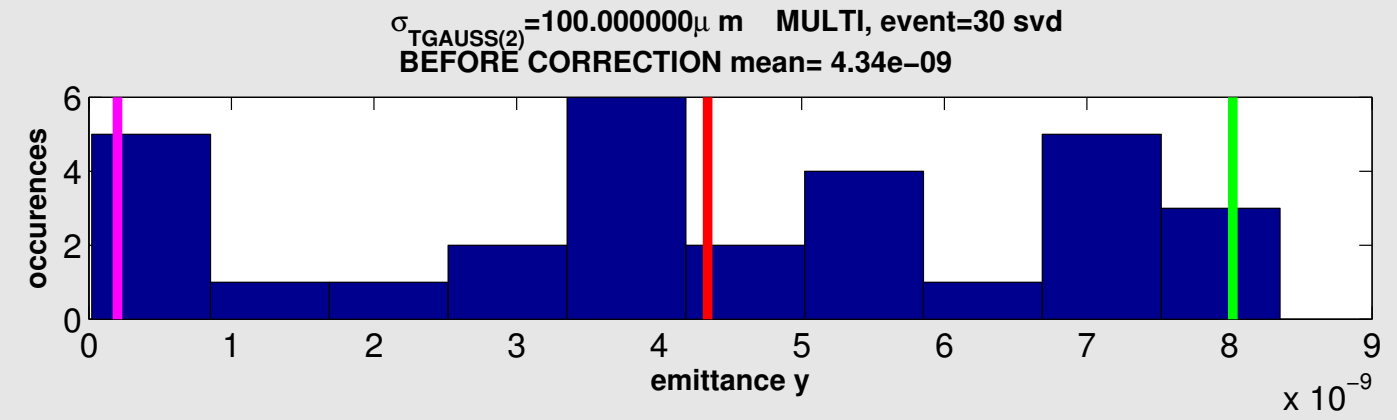
WITH Monitor Errors in Y 500μm

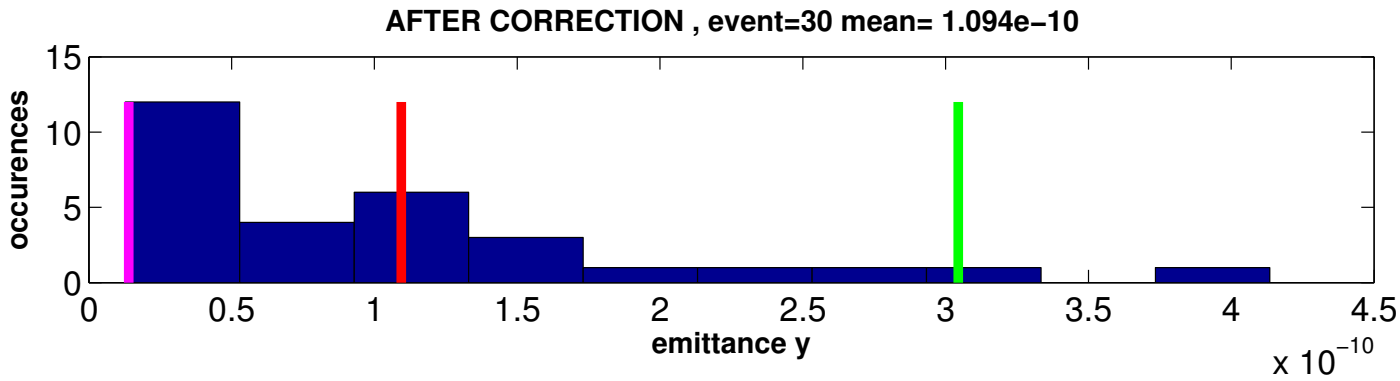




All Errors From ILC Typical Expected Errors Table

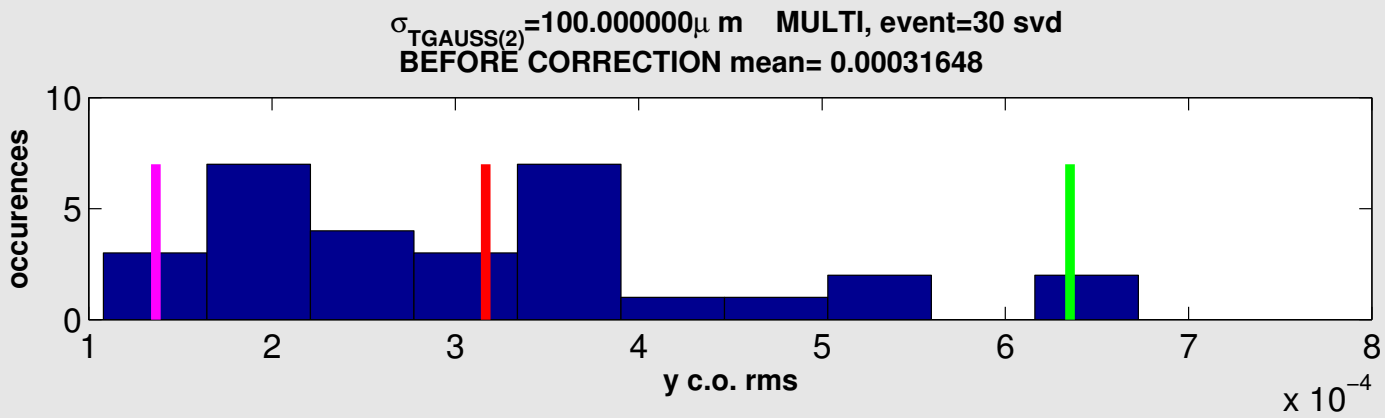
ϵ_y, 30 machines

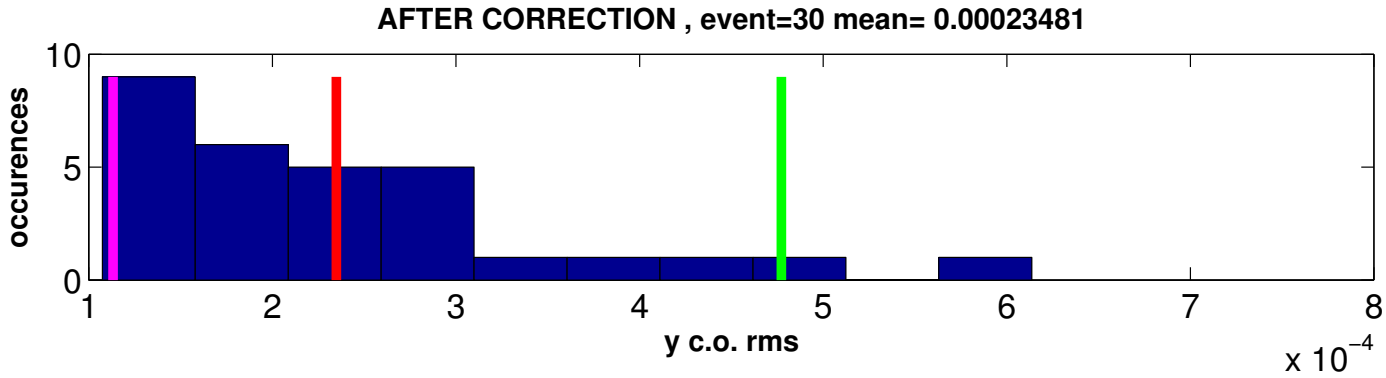




All Errors From ILC Typical Expected Errors Table

Y closed orbit, 30 machines



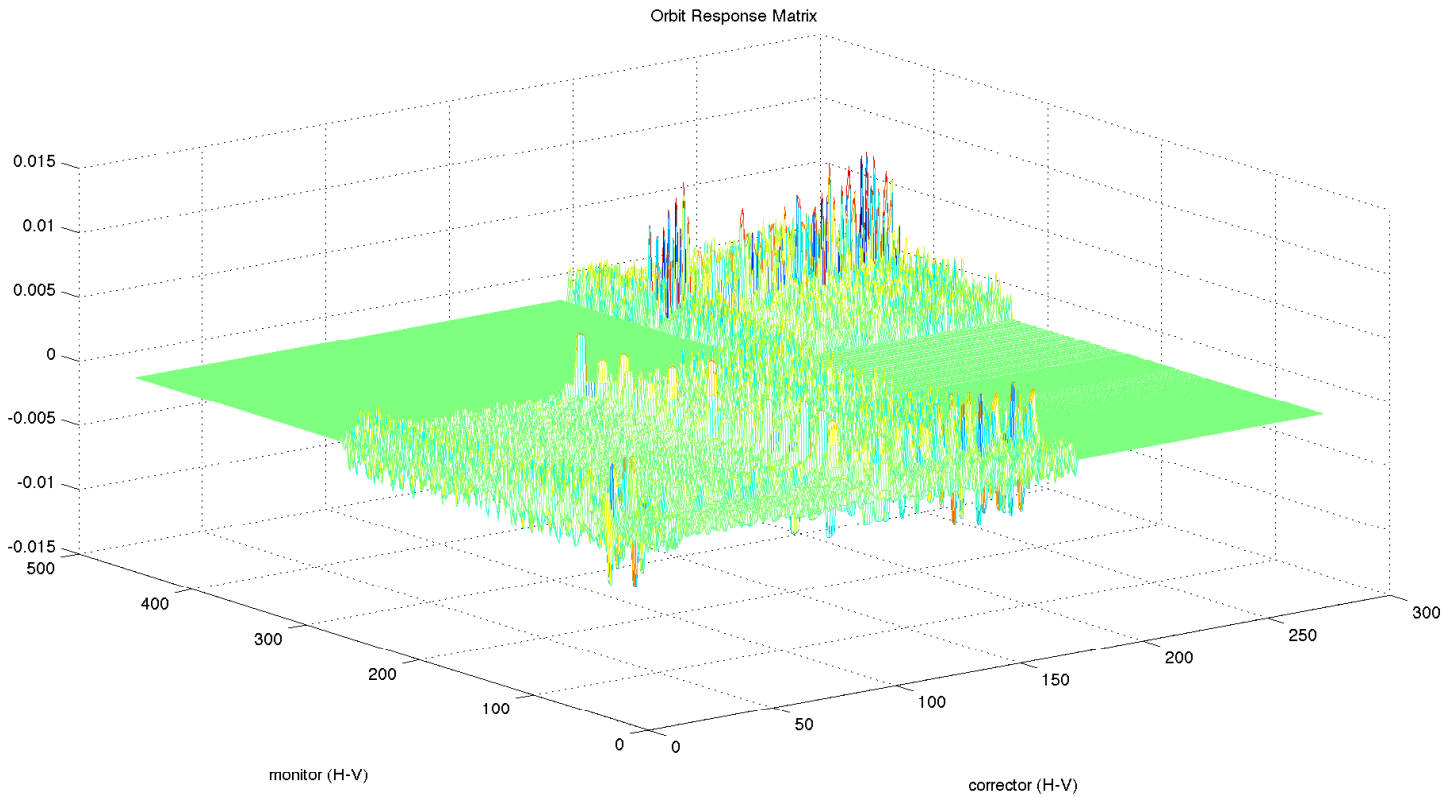


WORK IN PROGRESS

- Dispersion Free Steering
- Coupling Correction
- Optimize number of correctors

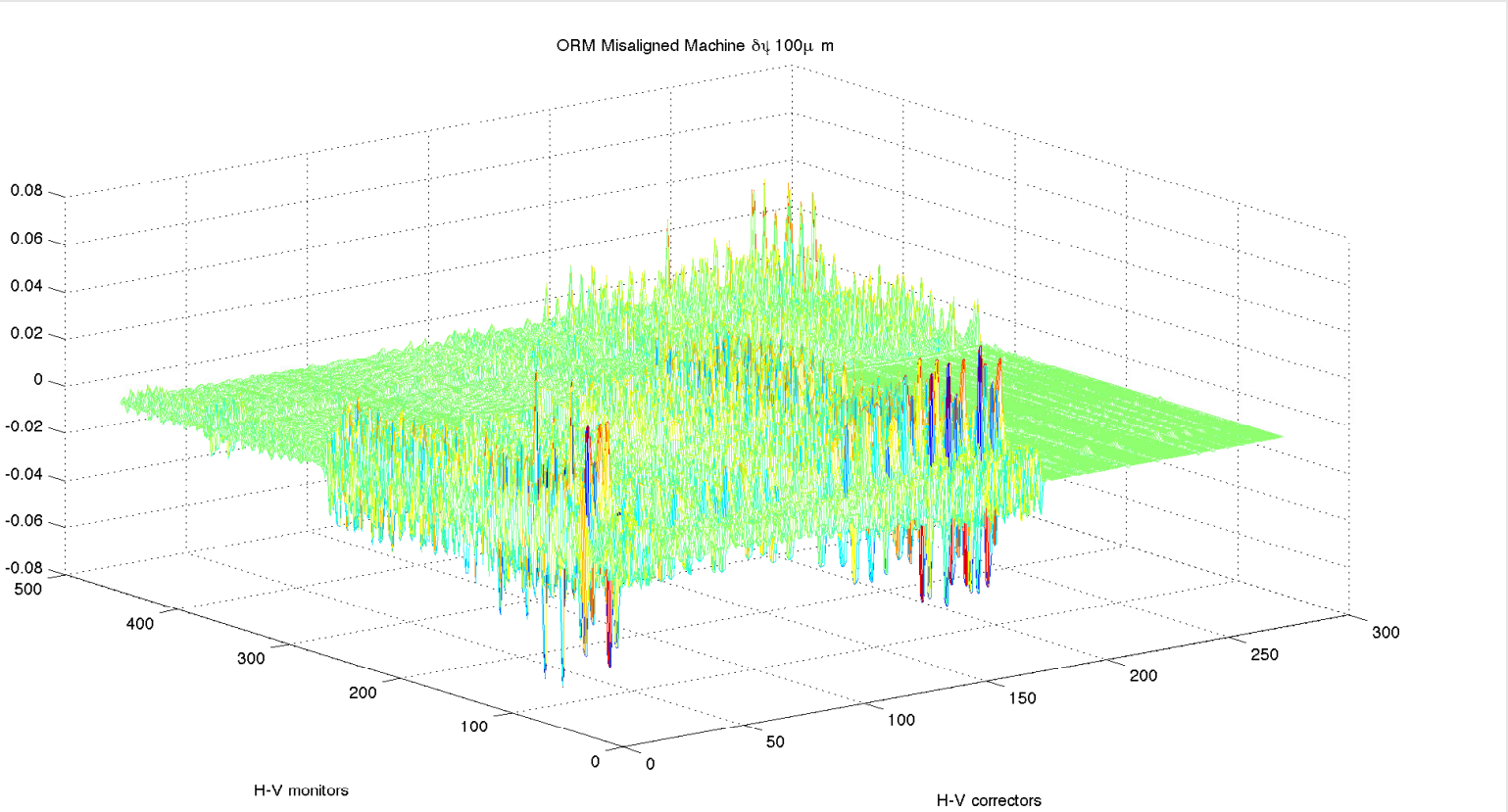
Dispersion Free Steering

$$\begin{pmatrix} \vec{M} \\ \vec{D} \\ \vec{0} \end{pmatrix} + \begin{pmatrix} \alpha \cdot ORM \\ (1-\alpha) \cdot DRM \\ \beta \cdot \mathbb{I} \end{pmatrix} \times \begin{pmatrix} \vec{K} \end{pmatrix} = 0;$$



Dispersion Free Steering

$$\begin{pmatrix} \vec{M} \\ \vec{D} \\ \vec{0} \end{pmatrix} + \begin{pmatrix} \alpha \cdot ORM \\ (1-\alpha) \cdot DRM \\ \beta \cdot \mathbb{I} \end{pmatrix} \times \begin{pmatrix} \vec{K} \end{pmatrix} = 0;$$



Definitions

Monitor Errors

GAIN

reading multiplied by a factor 1+ given error

MSCALX=0.1

reading=1.1*true reading

Reading

reading= true reading+ error