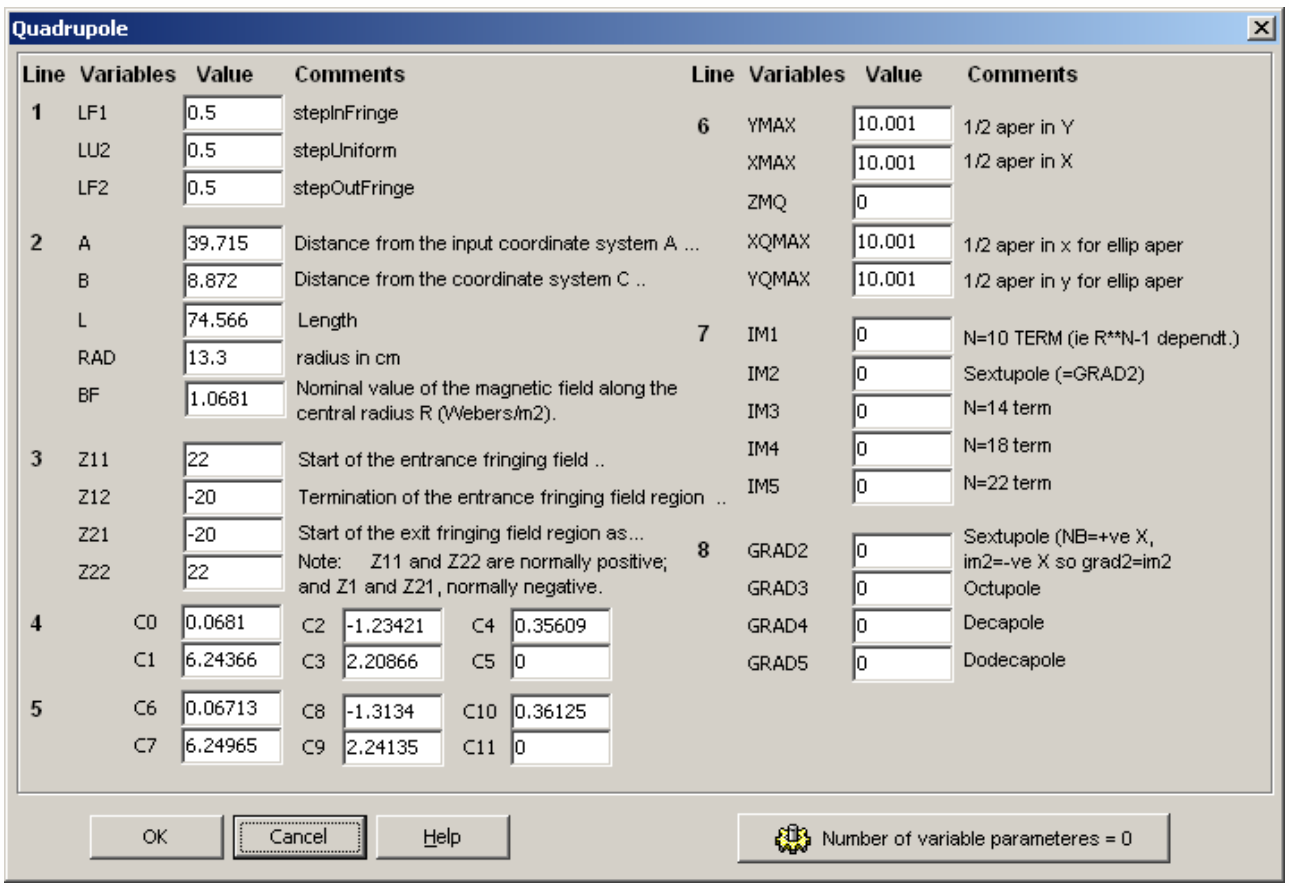
# MOTER for the A1900

**Overview:**

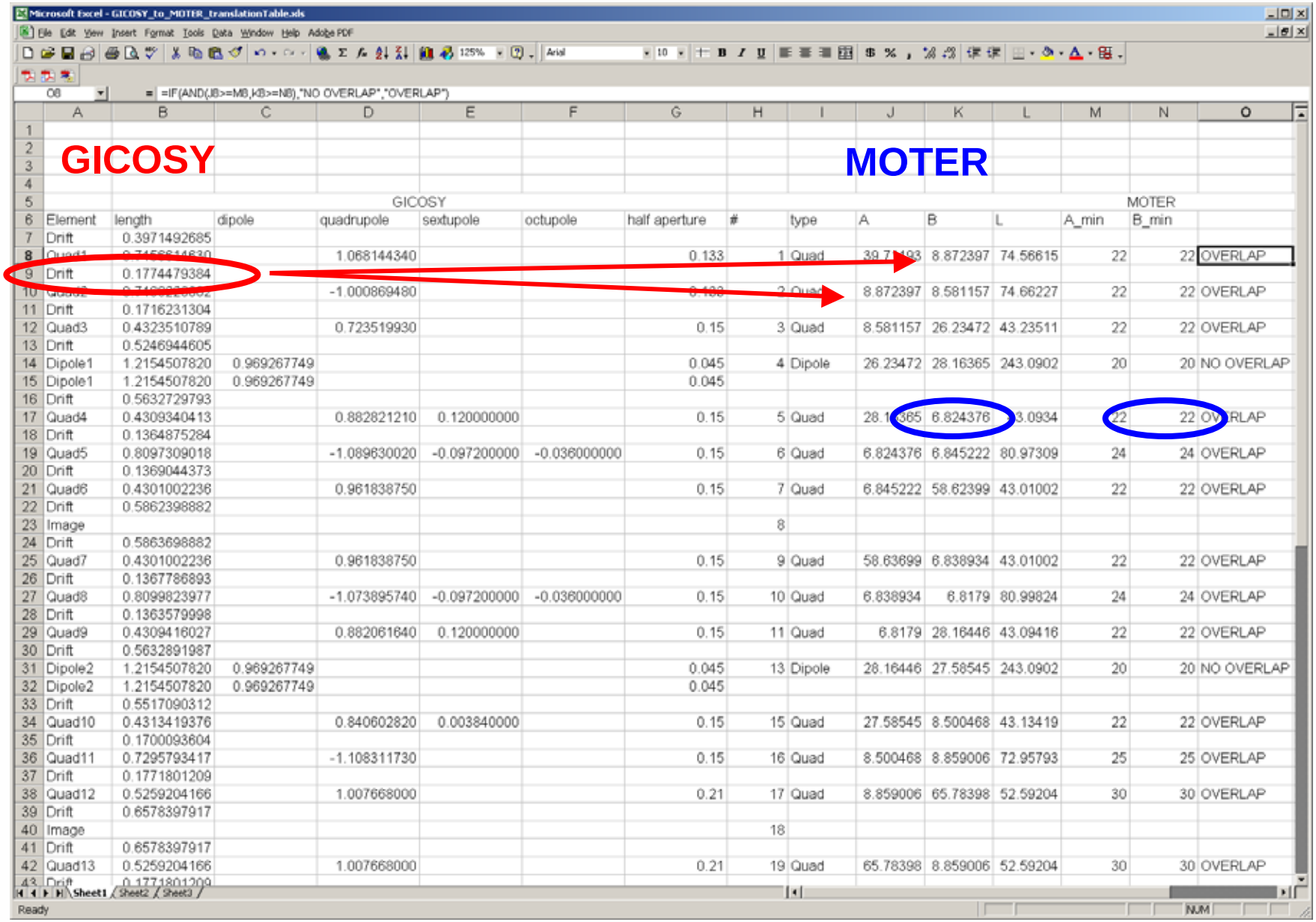
- **From GICOSY to MOTER**
- **Dipoles and Fringe Fields**
- **The A1900, as calculated**
  - **I.e. optics prior to 2007 vault reconfiguration**
  - **Ray tracing a few selected particles**
  - **Observations**
  - **A look at optical properties**
  - **Tracing more (random) particles**
- **The A1900 with and without “std. Ratios”**

# GICOSY to MOTER

- **MOTER is different from transfer map based optics codes**
  - **Magnetic elements include drifts up- and downstream**
  - **Fringe fields are NOT squeezed into zero-length effective descriptions**



# GICOSY to MOTER




Microsoft Excel - GICOSY_to_MOTER_translationTable.xls

=IF(AND(J8>=M8,K8>=N8),"NO OVERLAP","OVERLAP")

| | Element | GICOSY length | GICOSY dipole | GICOSY quadrupole | GICOSY sextupole | GICOSY octupole | GICOSY half aperture | # | type | MOTER A | MOTER B | MOTER L | MOTER A_min | MOTER B_min | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 | Drift | 0.3971492685 | | | | | | | | | | | | | |
| 8 | Quad1 | [illegible] | | 1.068144340 | | | 0.133 | 1 | Quad | 39.71193 | 8.872397 | 74.56615 | 22 | 22 | OVERLAP |
| 9 | Drift | 0.1774479384 | | | | | | | | | | | | | |
| 10 | Quad2 | [illegible] | | -1.000869480 | | | 0.133 | 2 | Quad | 8.872397 | 8.581157 | 74.66227 | 22 | 22 | OVERLAP |
| 11 | Drift | 0.1716231304 | | | | | | | | | | | | | |
| 12 | Quad3 | 0.4323510789 | | 0.723519930 | | | 0.15 | 3 | Quad | 8.581157 | 26.23472 | 43.23511 | 22 | 22 | OVERLAP |
| 13 | Drift | 0.5246944605 | | | | | | | | | | | | | |
| 14 | Dipole1 | 1.2154507820 | 0.969267749 | | | | 0.045 | 4 | Dipole | 26.23472 | 28.16365 | 243.0902 | 20 | 20 | NO OVERLAP |
| 15 | Dipole1 | 1.2154507820 | 0.969267749 | | | | 0.045 | | | | | | | | |
| 16 | Drift | 0.5632729793 | | | | | | | | | | | | | |
| 17 | Quad4 | 0.4309340413 | | 0.882821210 | 0.120000000 | | 0.15 | 5 | Quad | 28.16365 | 6.824376 | 43.0934 | 22 | 22 | OVERLAP |
| 18 | Drift | 0.1364875284 | | | | | | | | | | | | | |
| 19 | Quad5 | 0.8097309018 | | -1.089630020 | -0.097200000 | -0.036000000 | 0.15 | 6 | Quad | 6.824376 | 6.845222 | 80.97309 | 24 | 24 | OVERLAP |
| 20 | Drift | 0.1369044373 | | | | | | | | | | | | | |
| 21 | Quad6 | 0.4301002236 | | 0.961838750 | | | 0.15 | 7 | Quad | 6.845222 | 58.62399 | 43.01002 | 22 | 22 | OVERLAP |
| 22 | Drift | 0.5862398882 | | | | | | | | | | | | | |
| 23 | Image | | | | | | | 8 | | | | | | | |
| 24 | Drift | 0.5863698882 | | | | | | | | | | | | | |
| 25 | Quad7 | 0.4301002236 | | 0.961838750 | | | 0.15 | 9 | Quad | 58.63699 | 6.838934 | 43.01002 | 22 | 22 | OVERLAP |
| 26 | Drift | 0.1367786893 | | | | | | | | | | | | | |
| 27 | Quad8 | 0.8099823977 | | -1.073895740 | -0.097200000 | -0.036000000 | 0.15 | 10 | Quad | 6.838934 | 6.8179 | 80.99824 | 24 | 24 | OVERLAP |
| 28 | Drift | 0.1363579998 | | | | | | | | | | | | | |
| 29 | Quad9 | 0.4309416027 | | 0.882061640 | 0.120000000 | | 0.15 | 11 | Quad | 6.8179 | 28.16446 | 43.09416 | 22 | 22 | OVERLAP |
| 30 | Drift | 0.5632891987 | | | | | | | | | | | | | |
| 31 | Dipole2 | 1.2154507820 | 0.969267749 | | | | 0.045 | 13 | Dipole | 28.16446 | 27.58545 | 243.0902 | 20 | 20 | NO OVERLAP |
| 32 | Dipole2 | 1.2154507820 | 0.969267749 | | | | 0.045 | | | | | | | | |
| 33 | Drift | 0.5517090312 | | | | | | | | | | | | | |
| 34 | Quad10 | 0.4313419376 | | 0.840602820 | 0.003840000 | | 0.15 | 15 | Quad | 27.58545 | 8.500468 | 43.13419 | 22 | 22 | OVERLAP |
| 35 | Drift | 0.1700093604 | | | | | | | | | | | | | |
| 36 | Quad11 | 0.7295793417 | | -1.108311730 | | | 0.15 | 16 | Quad | 8.500468 | 8.859006 | 72.95793 | 25 | 25 | OVERLAP |
| 37 | Drift | 0.1771801209 | | | | | | | | | | | | | |
| 38 | Quad12 | 0.5259204166 | | 1.007668000 | | | 0.21 | 17 | Quad | 8.859006 | 65.78398 | 52.59204 | 30 | 30 | OVERLAP |
| 39 | Drift | 0.6578397917 | | | | | | | | | | | | | |
| 40 | Image | | | | | | | 18 | | | | | | | |
| 41 | Drift | 0.6578397917 | | | | | | | | | | | | | |
| 42 | Quad13 | 0.5259204166 | | 1.007668000 | | | 0.21 | 19 | Quad | 65.78398 | 8.859006 | 52.59204 | 30 | 30 | OVERLAP |
| 43 | Drift | 0.1771801209 | | | | | | | | | | | | | |

Sheet1 Sheet2 Sheet3

Ready NUM

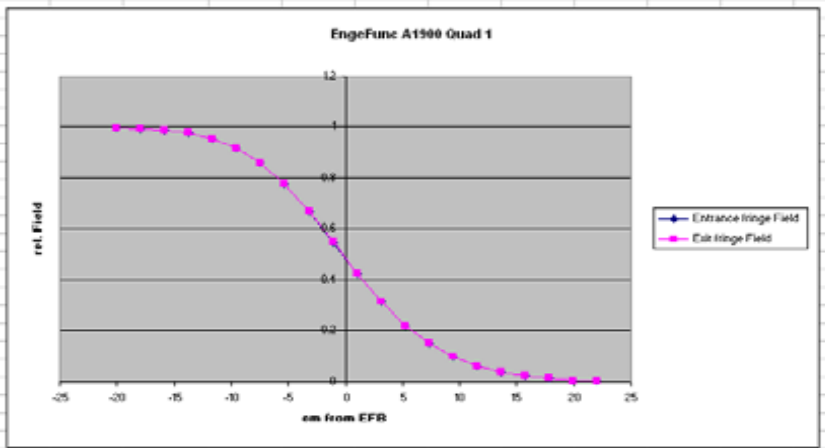
# Enge Coefficients for the A1900

Microsoft Excel - A1900EngeCoefficientsG19W4M6_3Tm_correctedDipoles_FFextend2080514.xls

File Edit View Insert Format Tools Data Window Help Adobe PDF

Q4

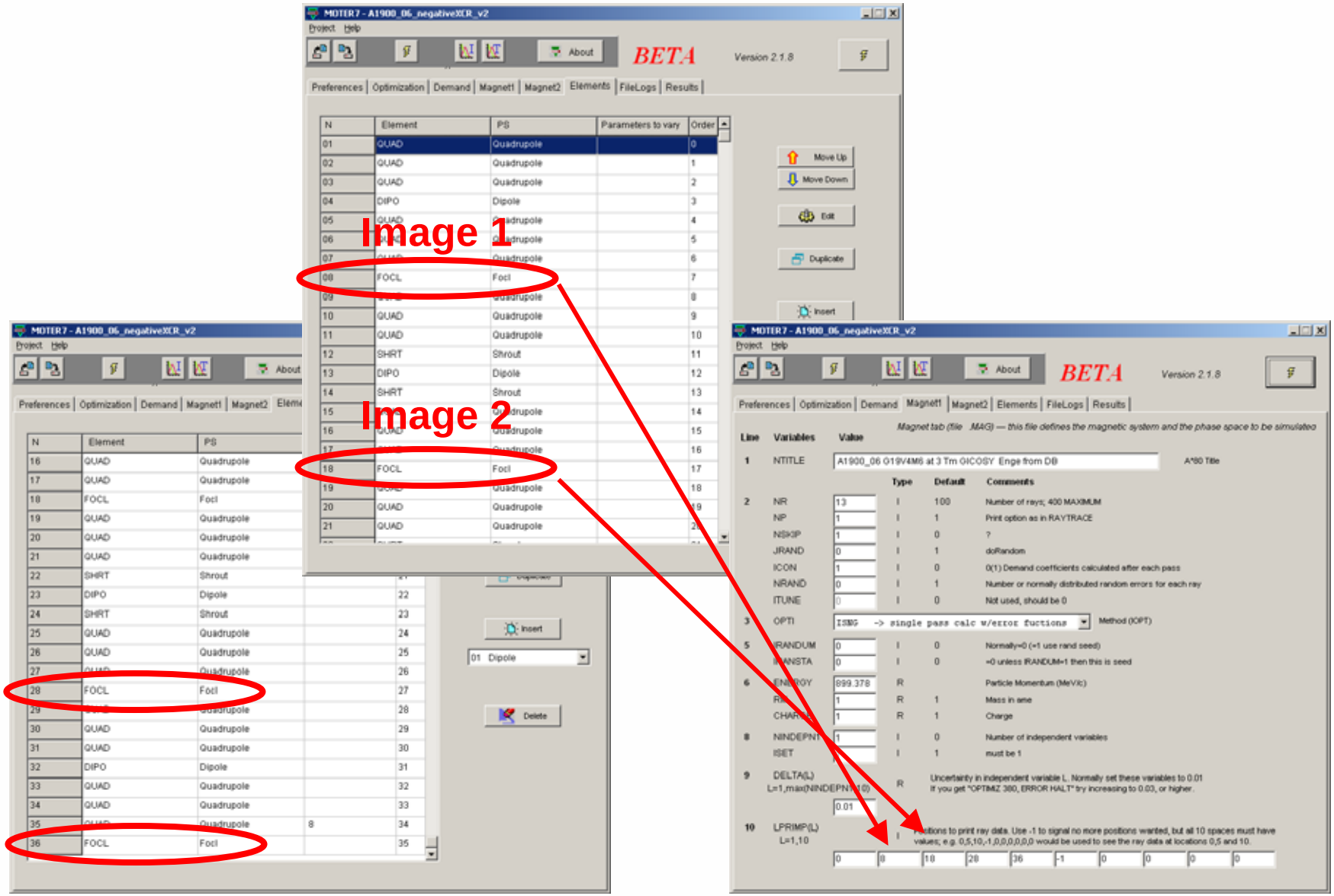
| | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.0 | 1 | | | | | | | max | 2.3 | 1.1 | higher | | | | | | | |
| 2 | | 0.06809 | 6.24388 | -1.23385 | 2.20652 | 0.35571 | 0 | | | Main Field | 1.0671 | | 1.1 | representative | | | | | |
| 3 | | 0.06713 | 6.24965 | -1.31341 | 2.24135 | 0.36125 | 0 | | min | 1 | 1 | lower | | | | | | | |
| 4 | 1.1 | 1.1 | | | | | | | | | | | | | | | | | |
| 5 | | 0.0681 | 6.24366 | -1.23421 | 2.20866 | 0.35609 | 0 | | radius | 13.3 | cm | | 4 | | | | | | |
| 6 | | 0.06713 | 6.24965 | -1.3134 | 2.24135 | 0.36125 | 0 | | Z11 | 22 | | | 0.0681 | 6.24366 | -1.23421 | 2.20866 | 0.35609 | 0 | |
| 7 | 1.2 | 1.2 | | | | | | | Z12 | -20 | | | 0.06713 | 6.24965 | -1.3134 | 2.24135 | 0.36125 | 0 | |
| 8 | | 0.0681 | 6.24363 | -1.23428 | 2.20898 | 0.35616 | 0 | | Z21 | -20 | | | | | | | | | |
| 9 | | 0.06713 | 6.24965 | -1.31341 | 2.24135 | 0.36125 | 0 | | Z22 | 22 | | | | | | | | | |
| 10 | 1.3 | 1.3 | | | | | | | steps | 20 | | | | | | | | | |
| 11 | | 0.0681 | 6.24362 | -1.23429 | 2.20905 | 0.35617 | 0 | | | | | | | | | | | | |
| 12 | | 0.06713 | 6.24965 | -1.31341 | 2.24135 | 0.36125 | 0 | | | | | | | | | | | | |
| 13 | 1.4 | 1.4 | | | | | | | | z | s | S | EngeFunc | | | z | s | S | EngeFunc |
| 14 | | 0.06362 | 6.20052 | -1.14501 | 2.14019 | 0.34541 | 0 | | | 22 | 0.02707 | 5.80394 | 0.00301 | | | -20 | -0.75188 | -6.21159 | 0.999 |
| 15 | | 0.05879 | 6.19399 | -1.13856 | 2.15858 | 0.34557 | 0 | | | 19.9 | 0.74812 | 5.08468 | 0.00615 | | | -17.9 | -0.67293 | -5.34214 | 0.99524 |
| 16 | 1.5 | 1.5 | | | | | | | | 17.8 | 0.66917 | 4.42675 | 0.01181 | | | -15.8 | -0.59398 | -4.5332 | 0.98937 |
| 17 | | 0.05528 | 6.13519 | -0.98932 | 2.1675 | 0.34464 | 0 | | | 15.7 | 0.59023 | 3.82066 | 0.02144 | | | -13.7 | -0.51504 | -3.78086 | 0.97771 |
| 18 | | 0.04835 | 6.1247 | -0.93894 | 2.07627 | 0.32953 | 0 | | | 13.6 | 0.51128 | 3.25724 | 0.03707 | | | -11.6 | -0.43609 | -3.08087 | 0.9561 |
| 19 | 1.6 | 1.6 | | | | | | | | 11.5 | 0.43233 | 2.72766 | 0.06136 | | | -9.5 | -0.35714 | -2.42063 | 0.91098 |
| 20 | | 0.04301 | 6.08011 | -0.78597 | 1.92542 | 0.30578 | 0 | | | 9.4 | 0.35338 | 2.2234 | 0.09767 | | | -7.4 | -0.2782 | -1.81923 | 0.86047 |
| 21 | | 0.03569 | 6.05751 | -0.7258 | 1.91784 | 0.30243 | 0 | | | 7.3 | 0.27444 | 1.7363 | 0.14978 | | | -5.3 | -0.19925 | -1.2474 | 0.77685 |
| 22 | 1.7 | 1.7 | | | | | | | | 5.2 | 0.19549 | 1.25852 | 0.22123 | | | -3.2 | -0.1203 | -0.70754 | 0.66986 |
| 23 | | 0.02555 | 6.02633 | -0.52338 | 1.41979 | 0.22807 | 0 | | | 3.1 | 0.11654 | 0.78255 | 0.31377 | | | -1.1 | -0.04135 | -0.19371 | 0.54828 |
| 24 | | 0.01059 | 5.98556 | -0.46311 | 1.6222 | 0.2548 | 0 | | | 1 | 0.03759 | 0.3012 | 0.42526 | | | 1 | 0.03759 | 0.30035 | 0.42547 |
| 25 | 1.8 | 1.8 | | | | | | | | -1.1 | -0.04135 | -0.19236 | 0.54794 | | | 3.1 | 0.11654 | 0.78125 | 0.31405 |
| 26 | | 0.00284 | 5.94326 | -0.19142 | 1.00927 | 0.16251 | 0 | | | -3.2 | -0.1203 | -0.70465 | 0.66922 | | | 5.2 | 0.19549 | 1.25595 | 0.22167 |
| 27 | | -0.00297 | 5.90237 | -0.15405 | 1.22483 | 0.19166 | 0 | | | -5.3 | -0.19925 | -1.24184 | 0.77588 | | | 7.3 | 0.27444 | 1.73172 | 0.15037 |
| 28 | 1.9 | 1.9 | | | | | | | | -7.4 | -0.2782 | -1.8098 | 0.85934 | | | 9.4 | 0.35338 | 2.21619 | 0.09831 |
| 29 | | -0.01925 | 5.84097 | 0.10914 | 0.70209 | 0.11235 | 0 | | | -9.5 | -0.35714 | -2.41402 | 0.91709 | | | 11.5 | 0.43233 | 2.7173 | 0.06196 |
| 30 | | -0.02453 | 5.81144 | 0.13324 | 0.68990 | 0.13775 | 0 | | | -11.6 | -0.43609 | -3.05971 | 0.9552 | | | 13.6 | 0.51128 | 3.24336 | 0.03757 |
| 31 | 2.0 | 2 | | | | | | | | -13.7 | -0.51504 | -3.7517 | 0.97706 | | | 15.7 | 0.59023 | 3.80299 | 0.02182 |
| 32 | | -0.03698 | 5.7582 | 0.33141 | 0.5508 | 0.08517 | 0 | | | -15.8 | -0.59398 | -4.49453 | 0.98895 | | | 17.8 | 0.66917 | 4.40516 | 0.01207 |
| 33 | | -0.0425 | 5.7241 | 0.35392 | 0.69816 | 0.10558 | 0 | | | -17.9 | -0.67293 | -5.29238 | 0.995 | | | 19.9 | 0.74812 | 5.05917 | 0.00631 |
| 34 | 2.1 | 2.1 | | | | | | | | -20 | -0.75188 | -6.14911 | 0.99707 | | | 22 | 0.82707 | 5.77467 | 0.0031 |
| 35 | | -0.04919 | 5.6006 | 0.47431 | 0.50716 | 0.07505 | 0 | | | | | | | | | | | | |
| 36 | | -0.05524 | 5.65588 | 0.5005 | 0.62943 | 0.09255 | 0 | | | | | | | | | | | | |
| 37 | 2.2 | 2.2 | | | | | | | | | | | | | | | | | |
| 38 | | -0.05723 | 5.64412 | 0.56471 | 0.5083 | 0.07407 | 0 | | | | | | | | | | | | |
| 39 | | -0.06375 | 5.61112 | 0.59541 | 0.62103 | 0.09028 | 0 | | | | | | | | | | | | |
| 40 | 2.3 | 2.3 | | | | | | | | | | | | | | | | | |
| 41 | | -0.06277 | 5.61826 | 0.62596 | 0.52306 | 0.07485 | 0 | | | | | | | | | | | | |
| 42 | | -0.06965 | 5.58416 | 0.66088 | 0.63536 | 0.08989 | 0 | | | | | | | | | | | | |



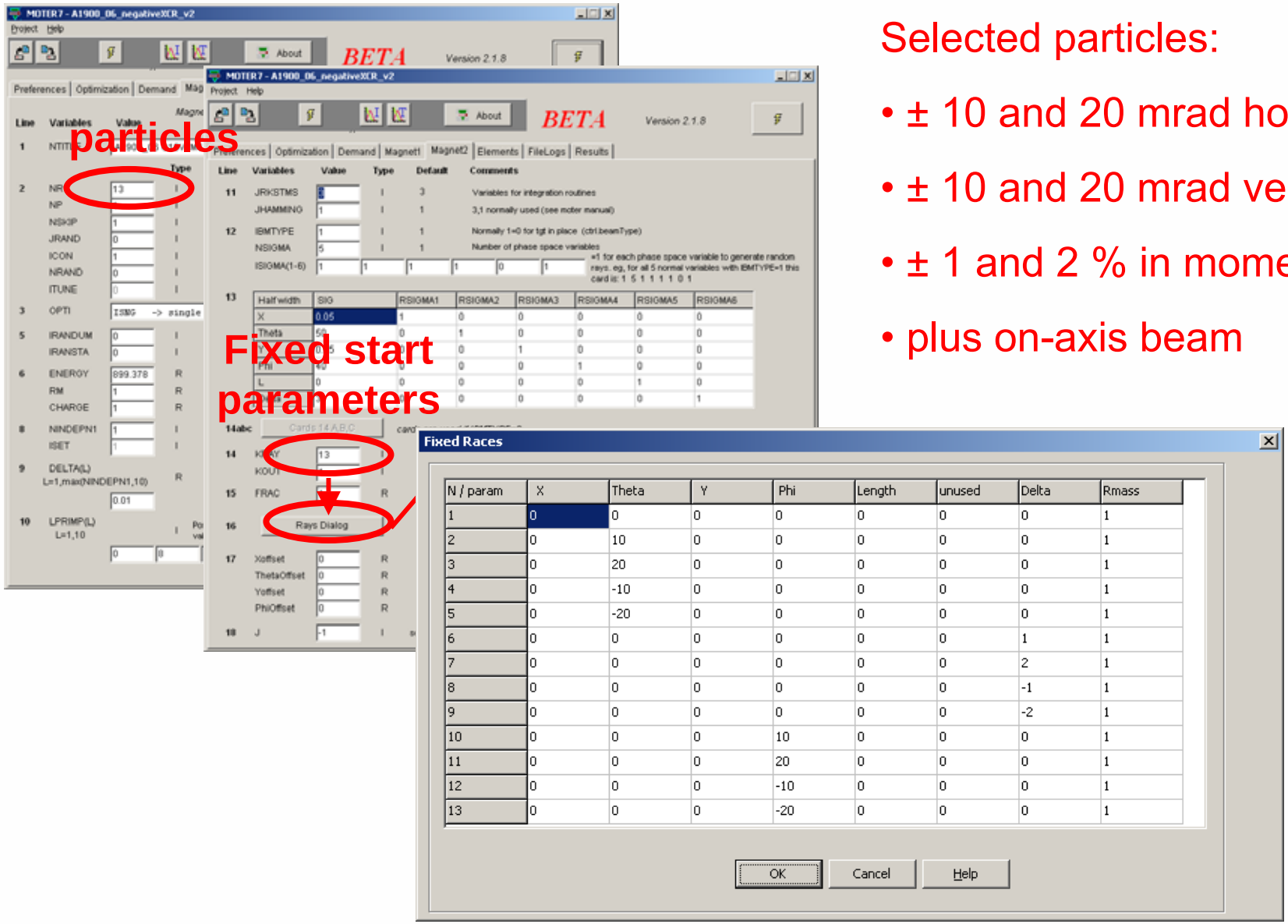

Summary | Quad 1 | Quad 2 | Quad 3 | Dipole 1 | Quad 4 | Quad 5 | Quad 6 | Quad 7 | Quad 8 | Quad 9 | Dipole 2 | Quad 10 | Quad 11 | Quad 12 | Quad

Ready NUM

# A1900 elements and focal planes



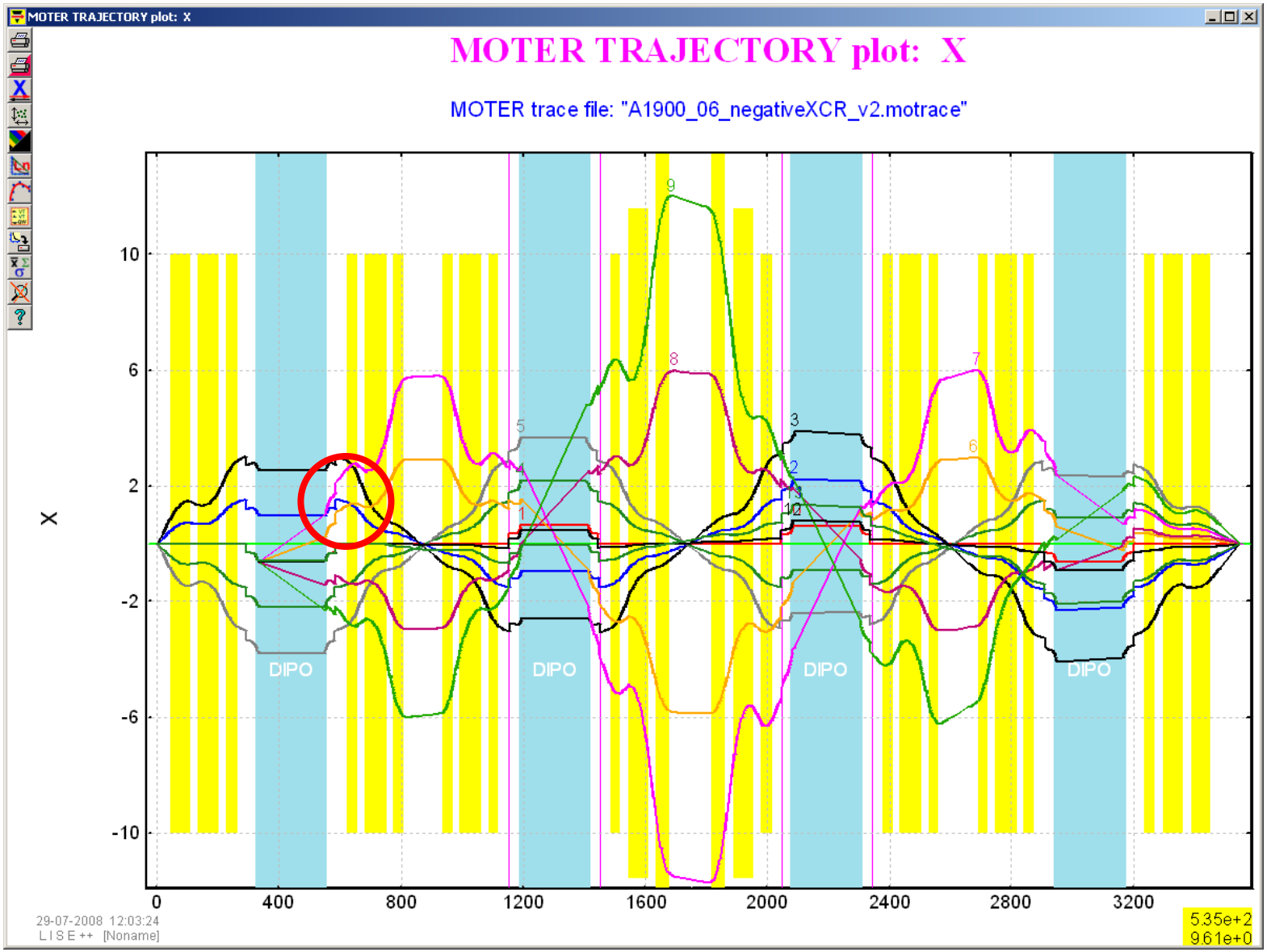
# Selected particles



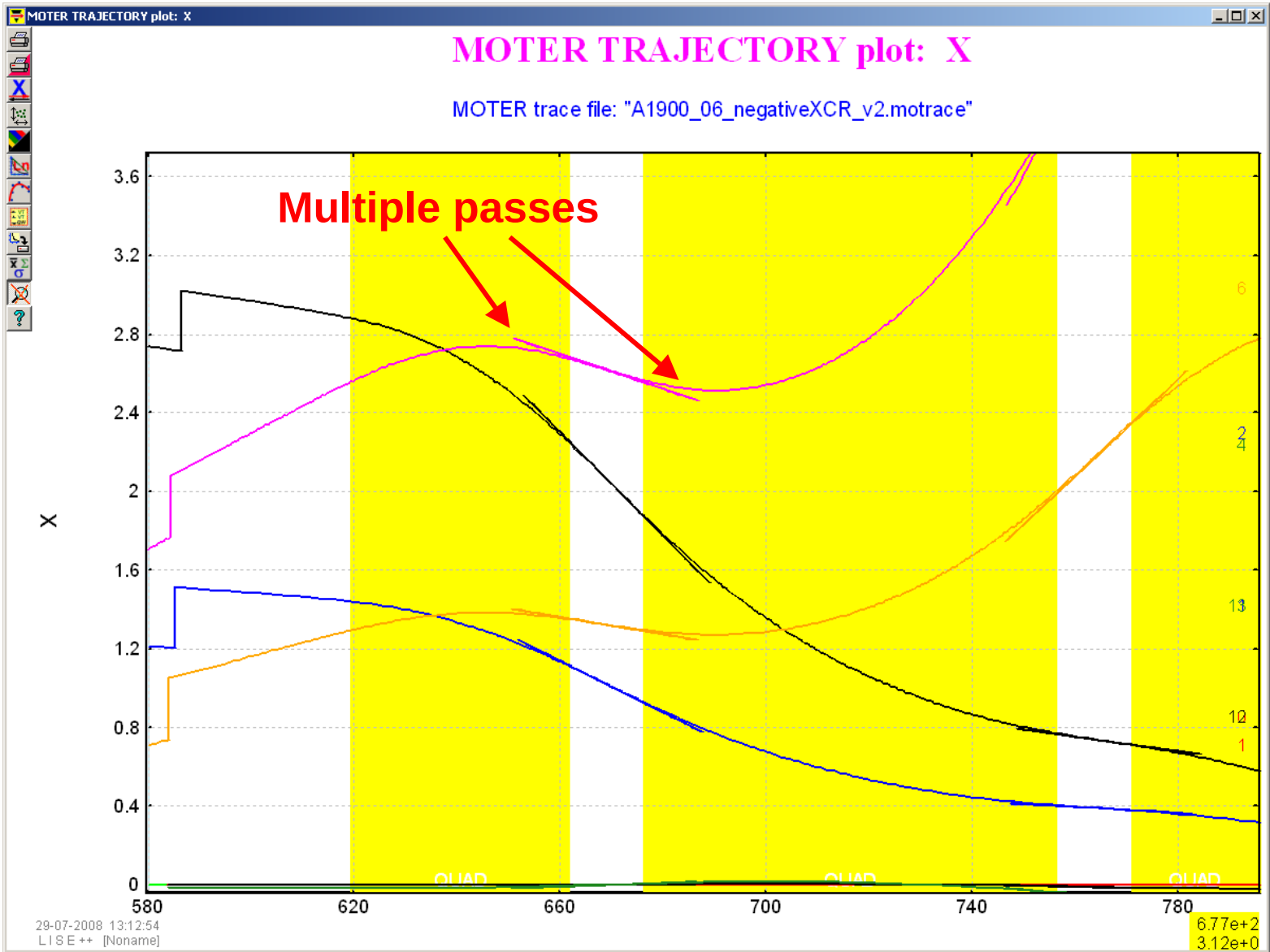

Selected particles:

- ± 10 and 20 mrad horiz.
- ± 10 and 20 mrad vert.
- ± 1 and 2 % in momentum
- plus on-axis beam

# Trajectories of selected particles

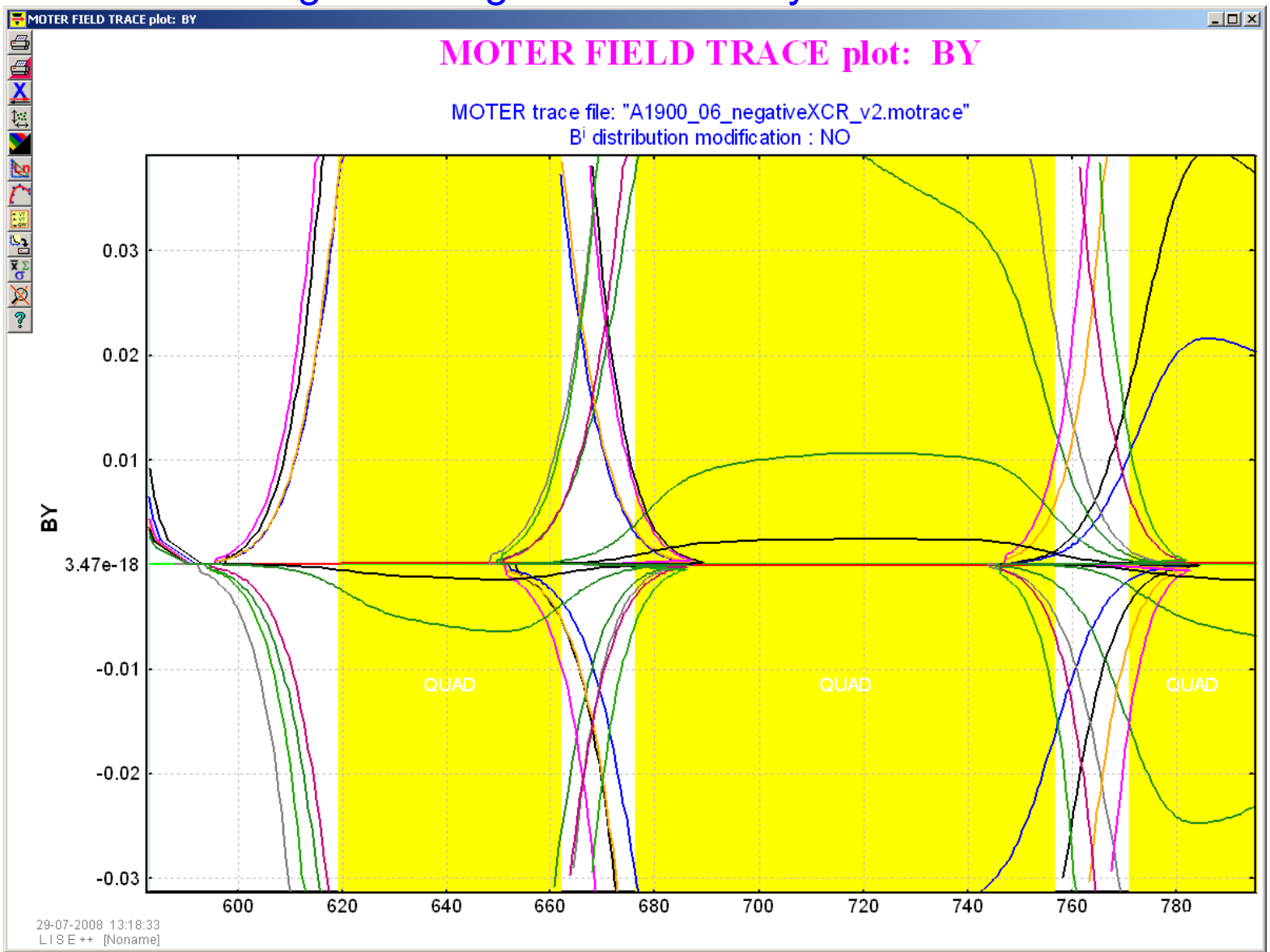


# Overlapping fringe fields: trajectories

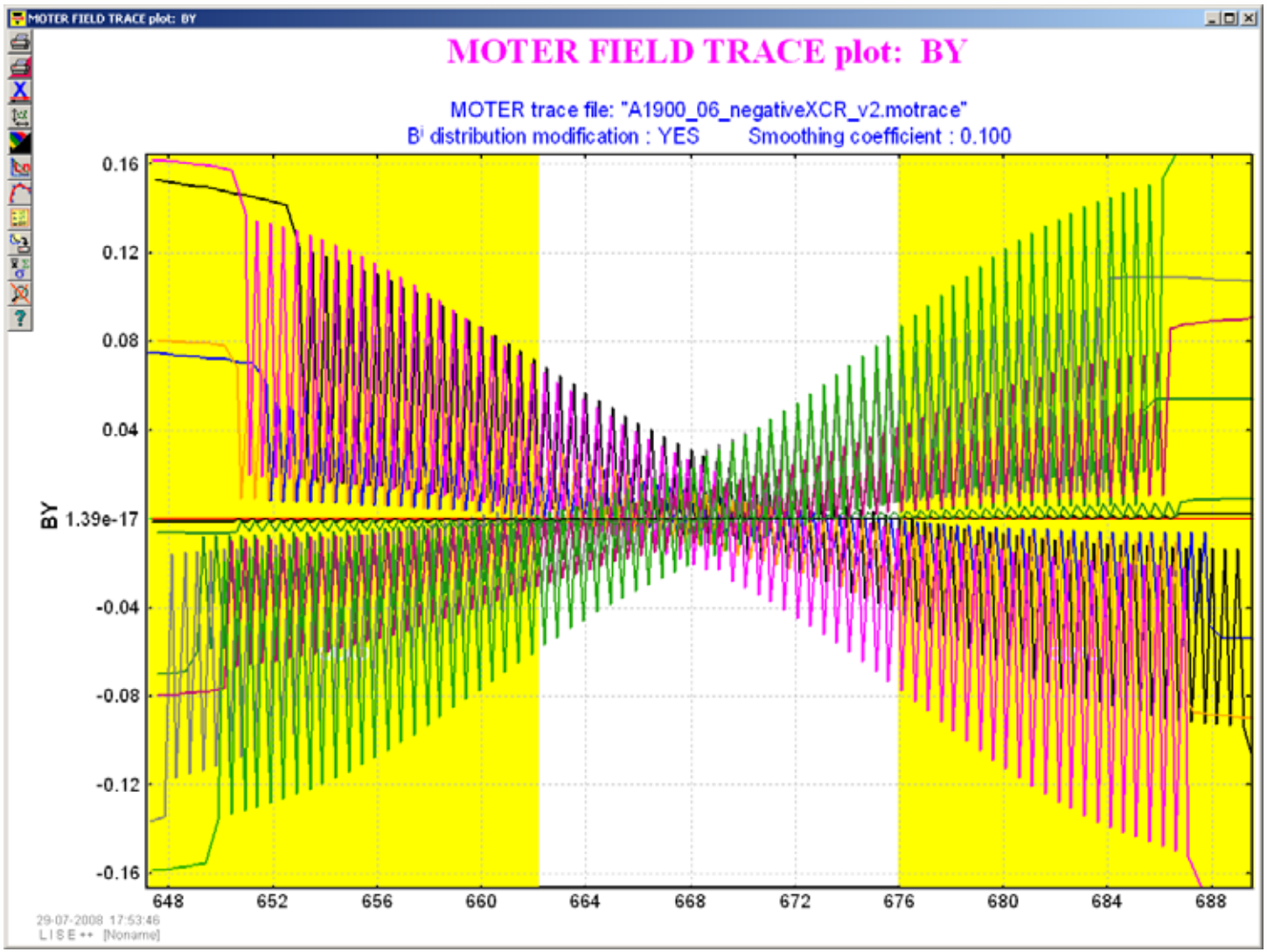


# Overlapping fringe fields: fields

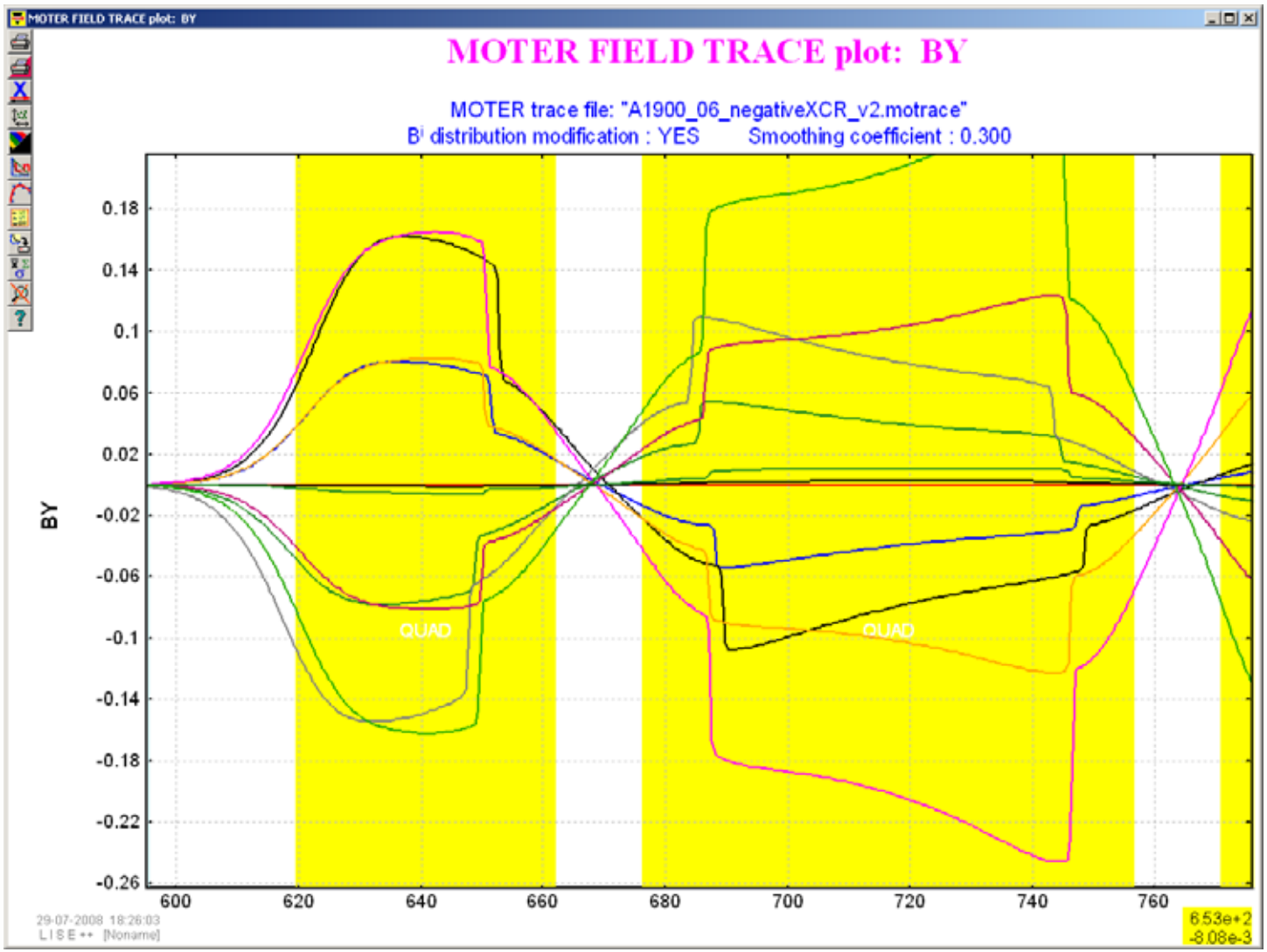
Particle going through 1st fringe field, then back through a drift, and then forward through 2nd fringe field: certainly unrealistic



# Averaging ????


MOTER FIELD TRACE plot: BY
MOTER FIELD TRACE plot: BY
MOTER trace file: "A1900_06_negativeXCR_v2.motrace"
B' distribution modification : YES
Smoothing coefficient : 0.100
BY
0.16
0.12
0.08
0.04
1.39e-17
-0.04
-0.08
-0.12
-0.16
648
652
656
660
664
668
672
676
680
684
688
29-07-2008 17:53:46
LISE++ [Noname]

# Averaging ???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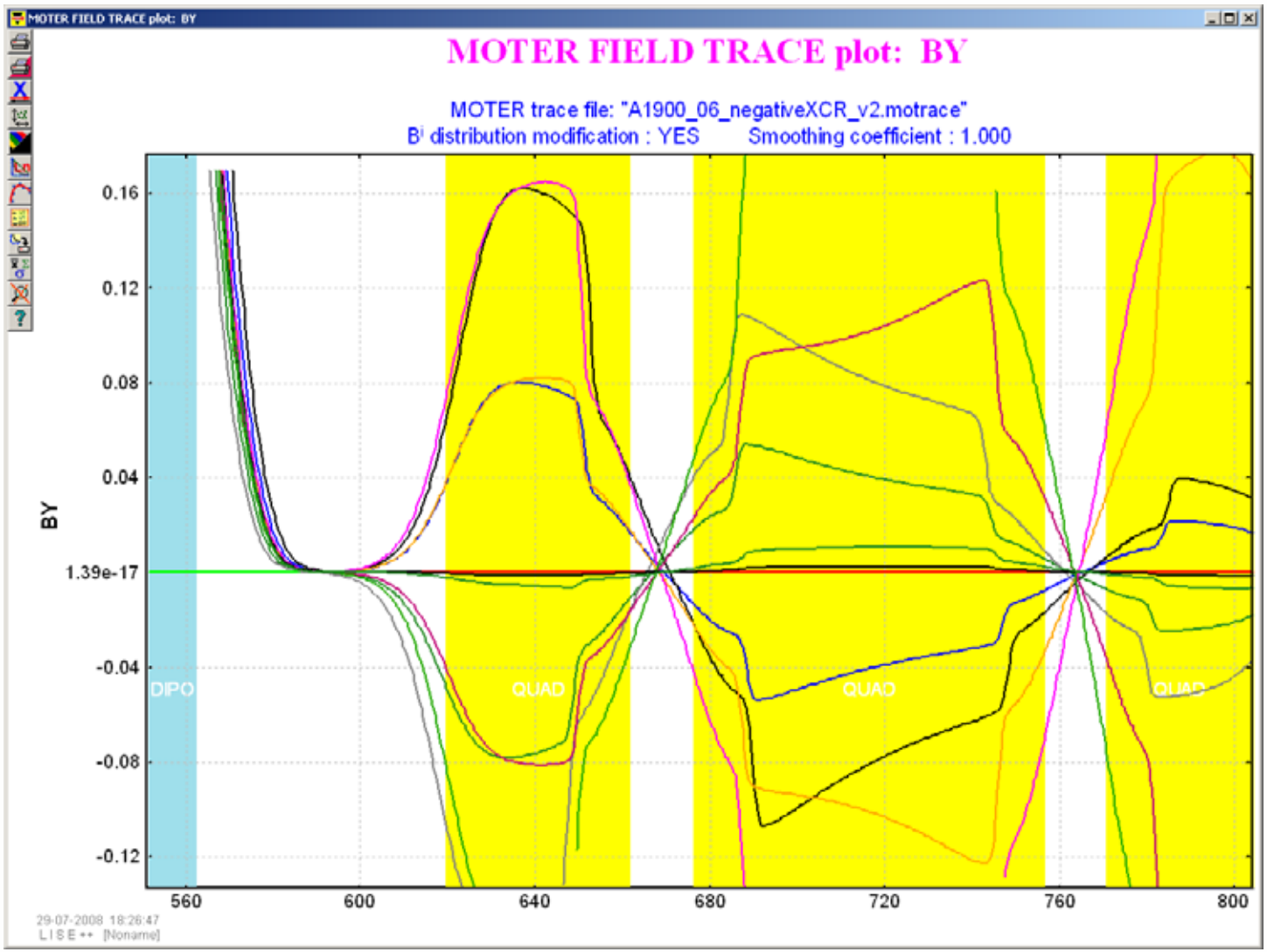
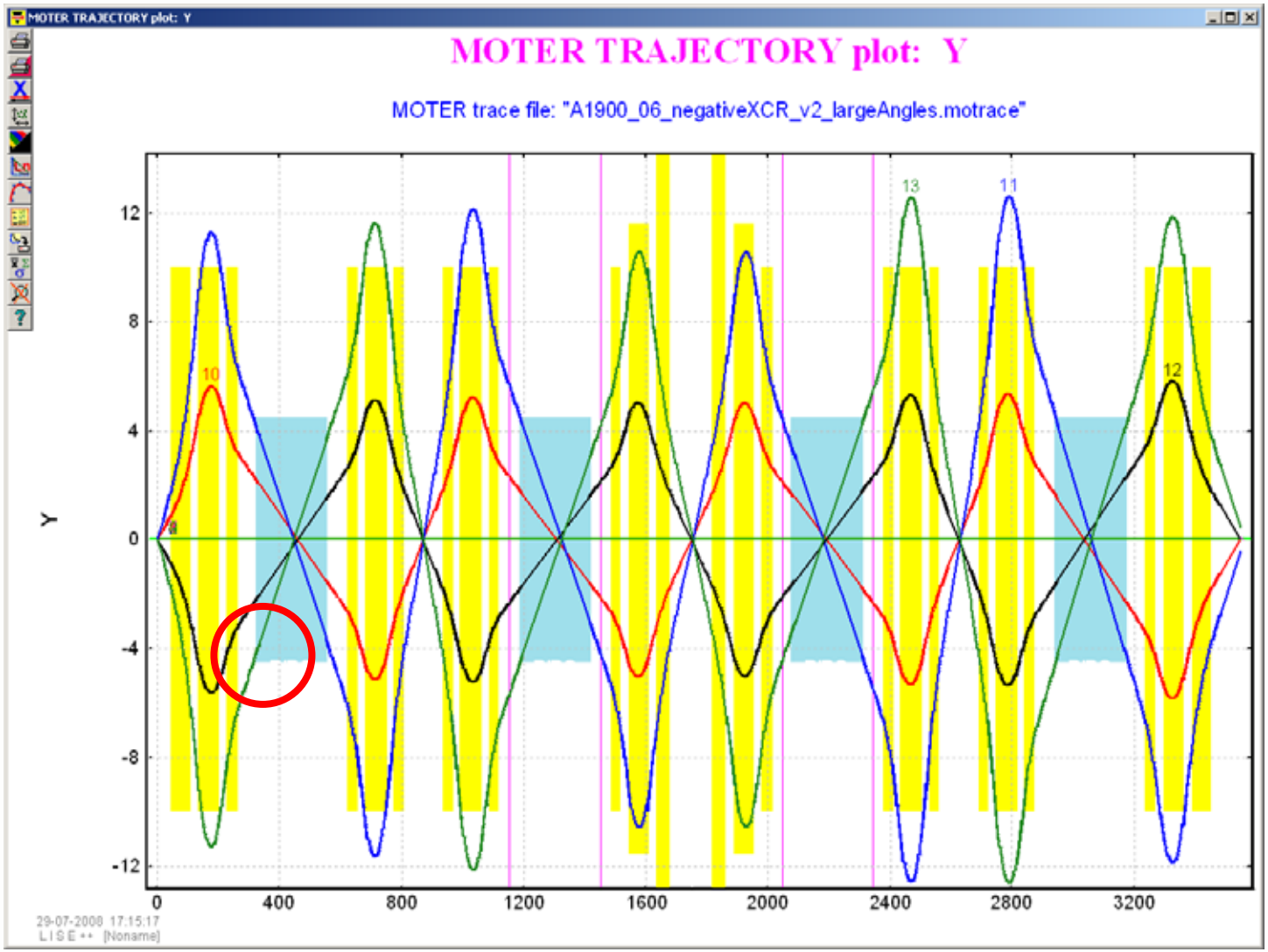
MOTER trace file: "A1900_06_negativeXCR_v2.motrace"
Bi distribution modification : YES
Smoothing coefficient : 0.300
BY
0.18
0.14
0.1
0.06
0.02
-0.02
-0.06
-0.1
-0.14
-0.18
-0.22
-0.26
600
620
640
660
680
700
720
740
760
QUAD
QUAD
29-07-2008 18:26:03
LISE++ [Noname]
6.53e+2
-8.08e-3

# Averaging ???

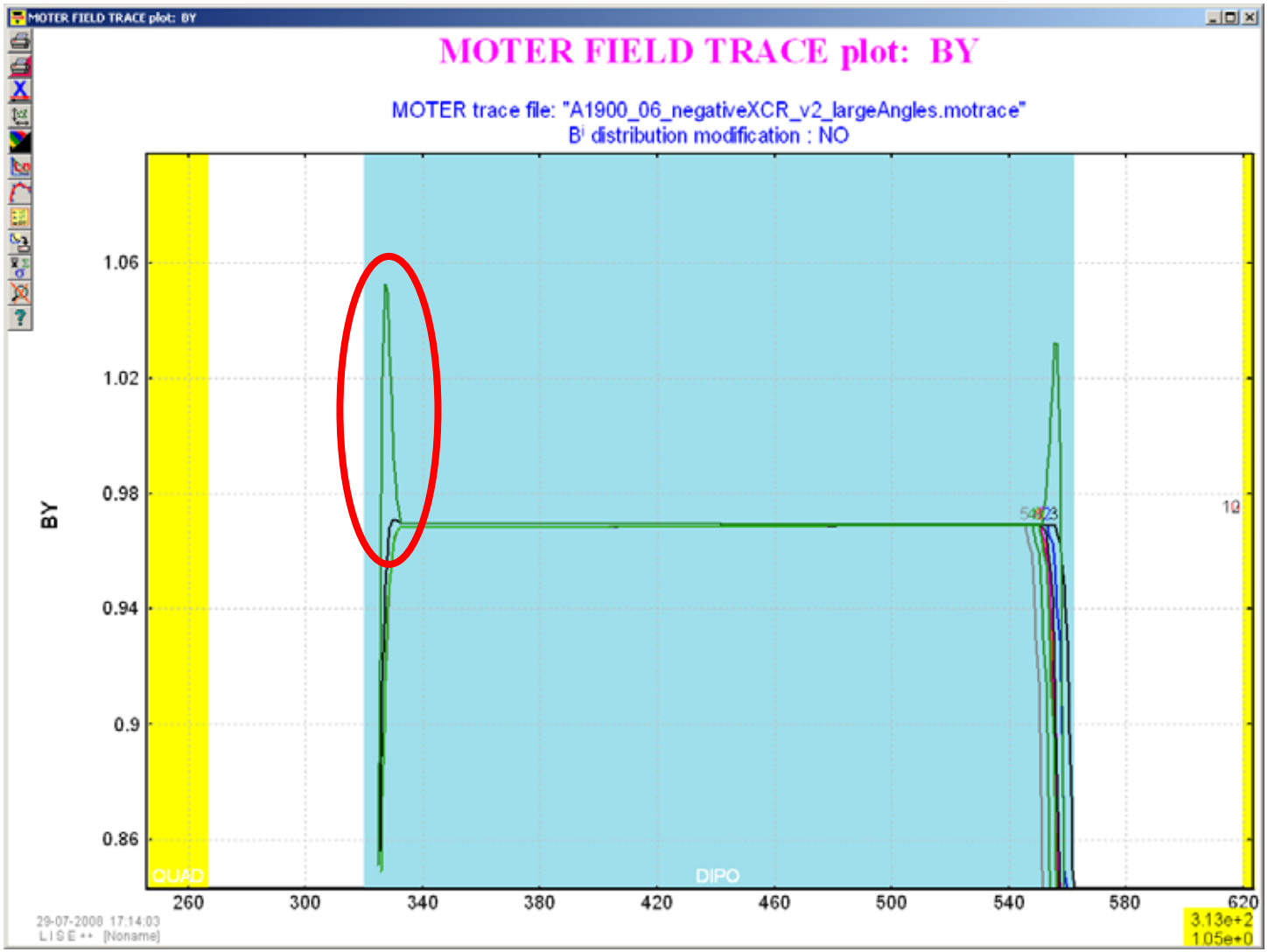

MOTER FIELD TRACE plot: BY
MOTER FIELD TRACE plot: BY
MOTER trace file: "A1900_06_negativeXCR_v2.motrace"
B' distribution modification : YES
Smoothing coefficient : 1.000
BY
0.16
0.12
0.08
0.04
1.39e-17
-0.04
-0.08
-0.12
DIPO
QUAD
QUAD
QUAD
560
600
640
680
720
760
800
29-07-2008 18:26:47
LISE++ [Noname]

# Trajectories for large angles …



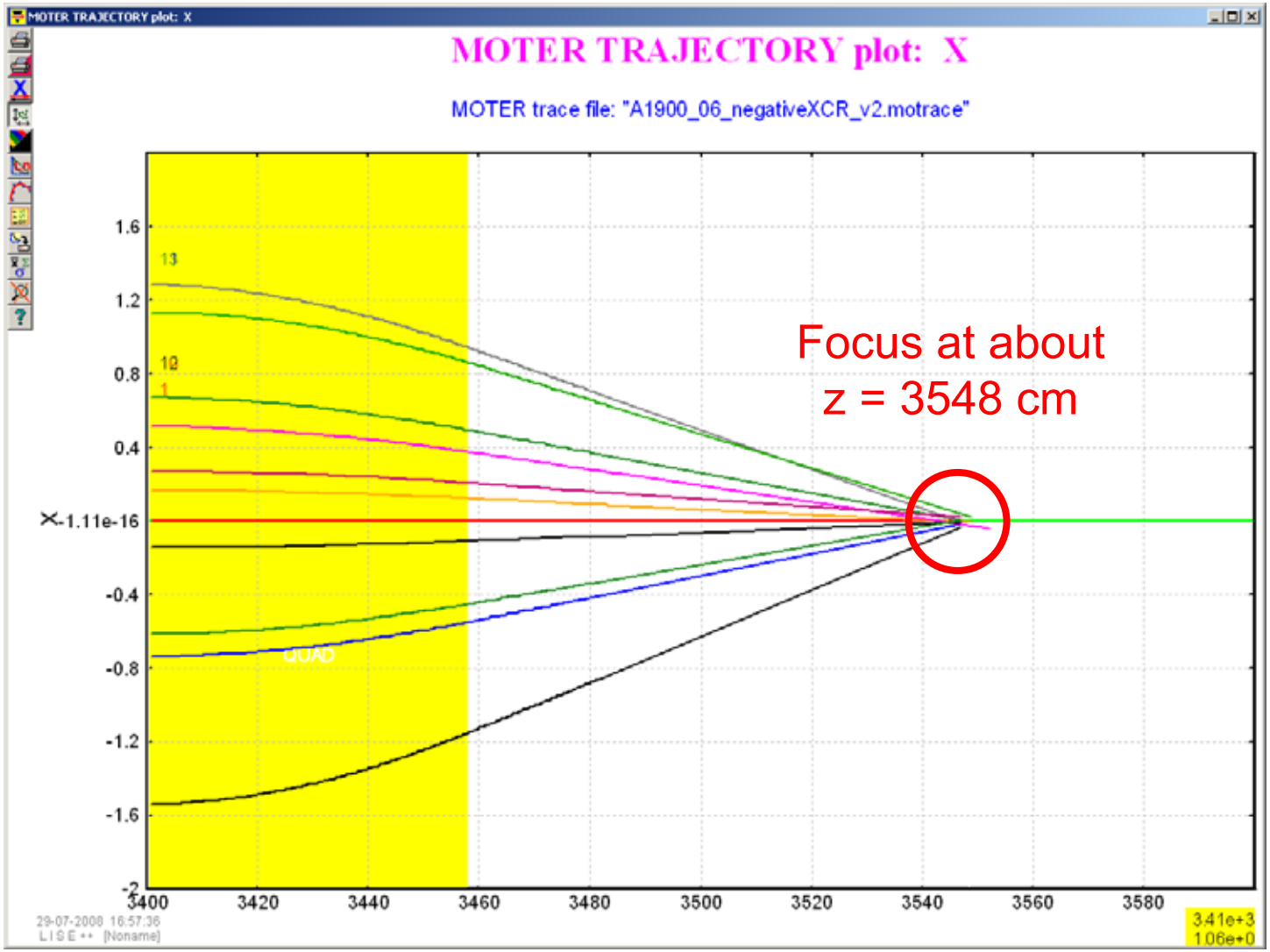
# … reveal edge effect in dipole field

Field kind of overshooting close to the edge of the yoke

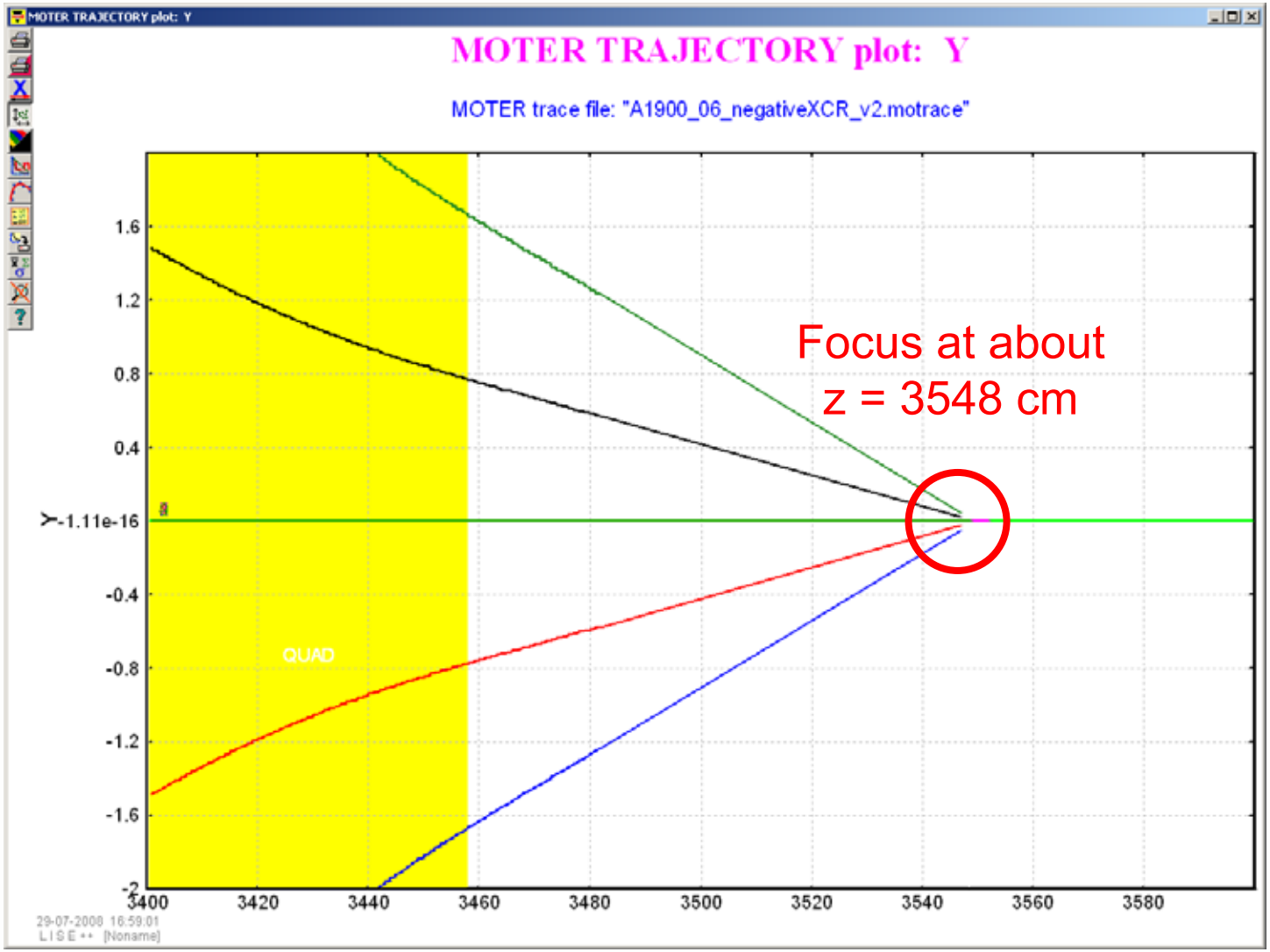


# Final Focus in X

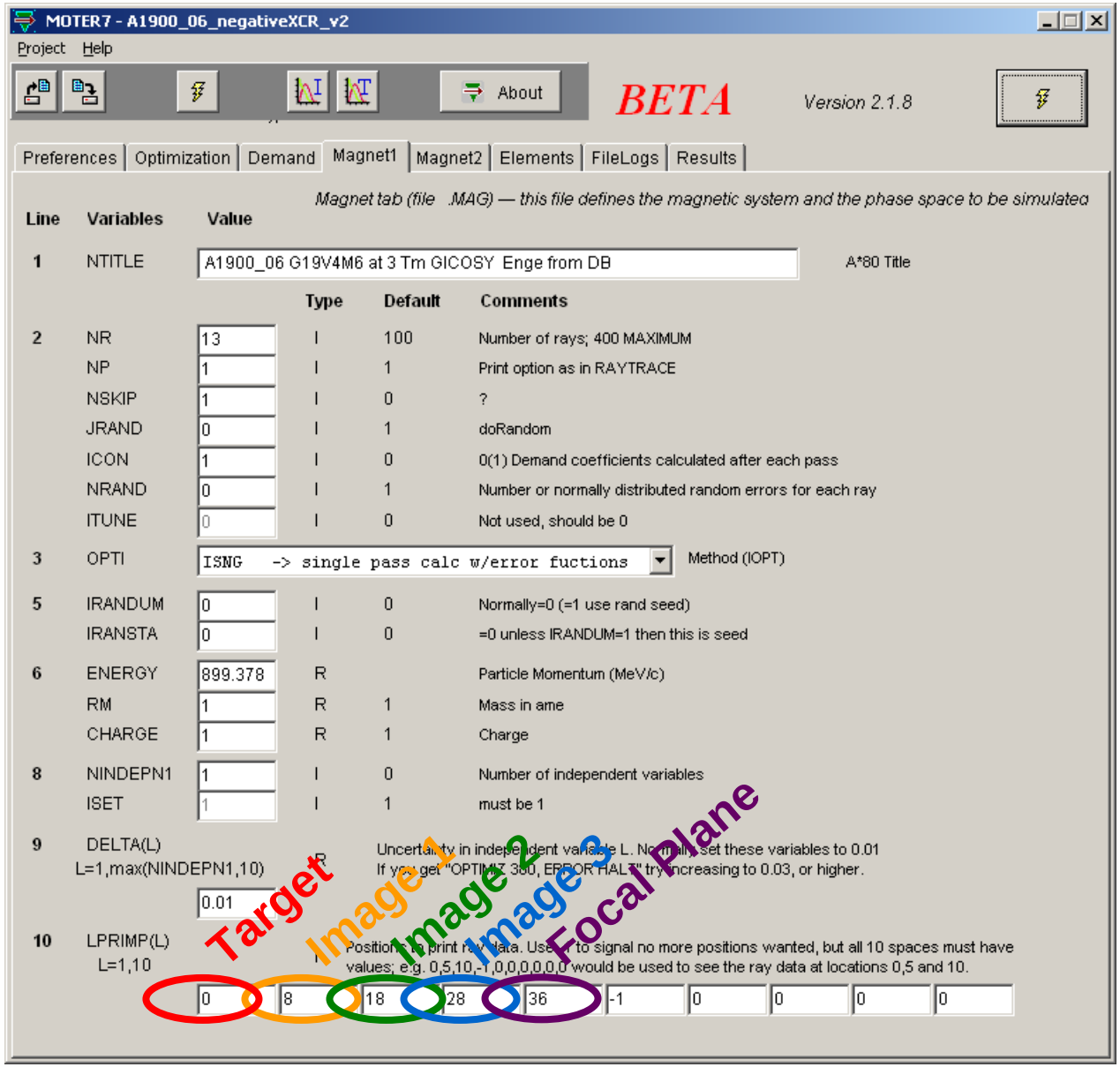
For the ‘original’ A1900 optics (prior to vault reconfiguration)



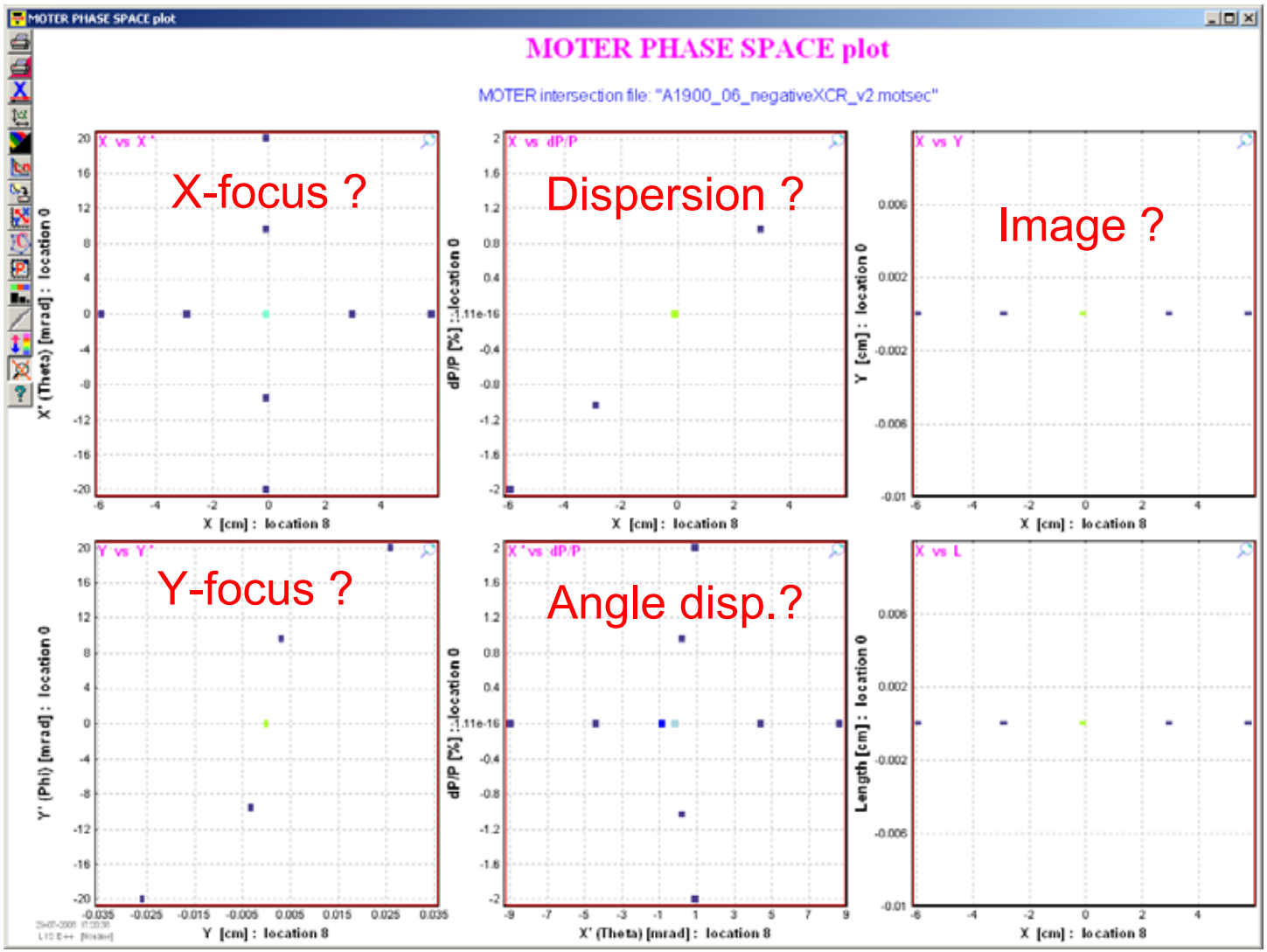
# Final Focus in Y



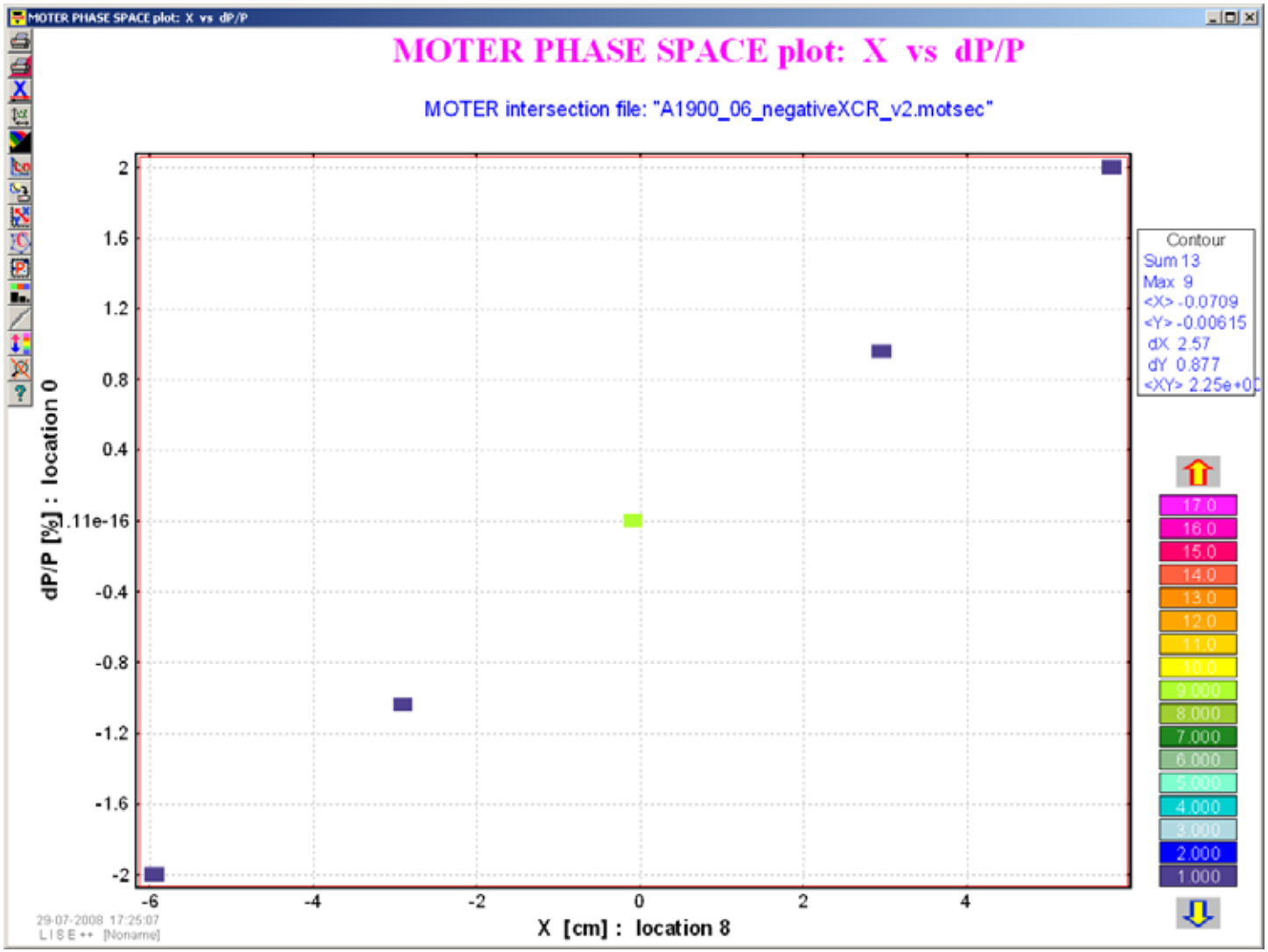
# Results in focal planes



# Image 1 vs. target

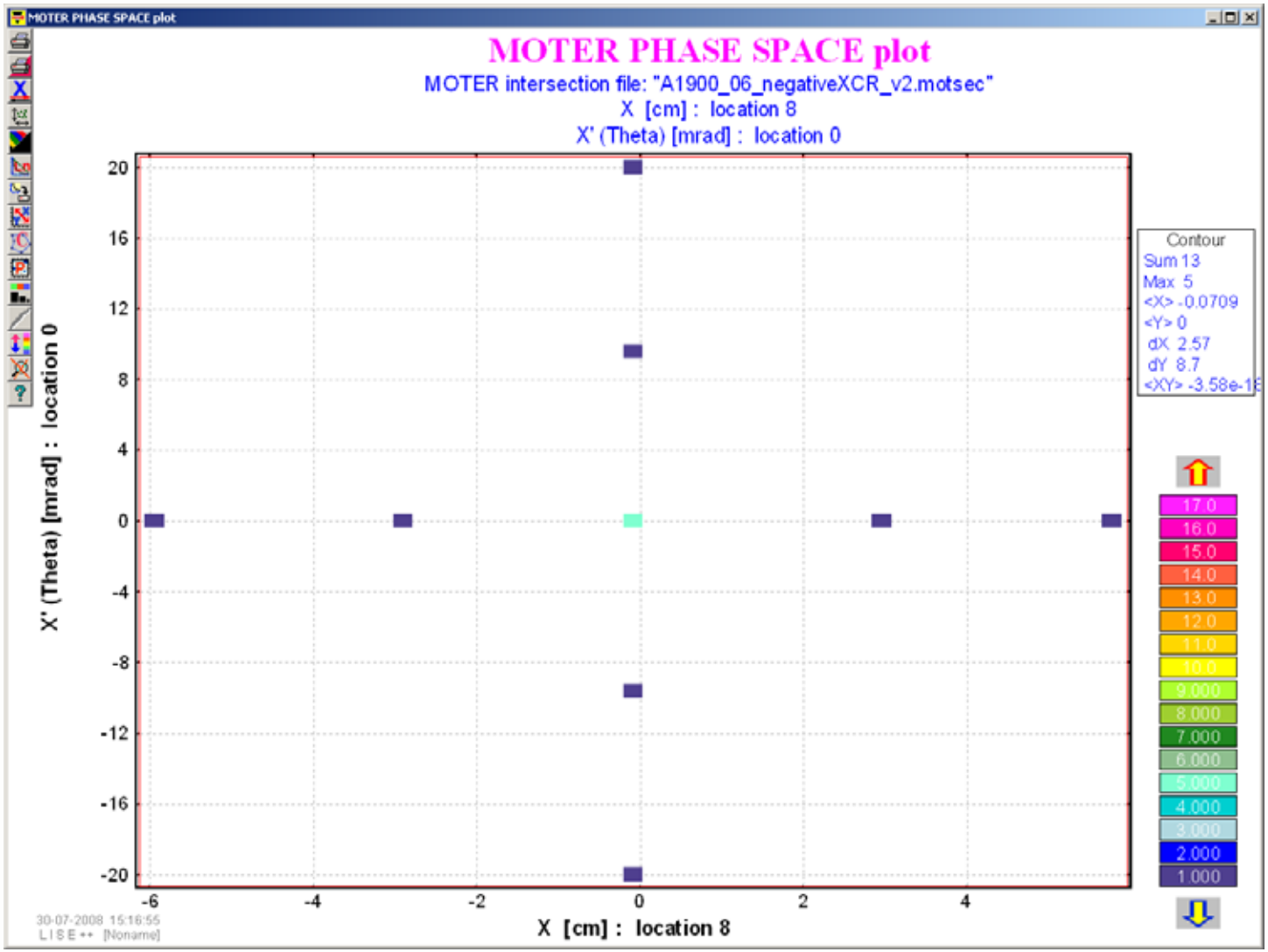


# Image 1: dispersion



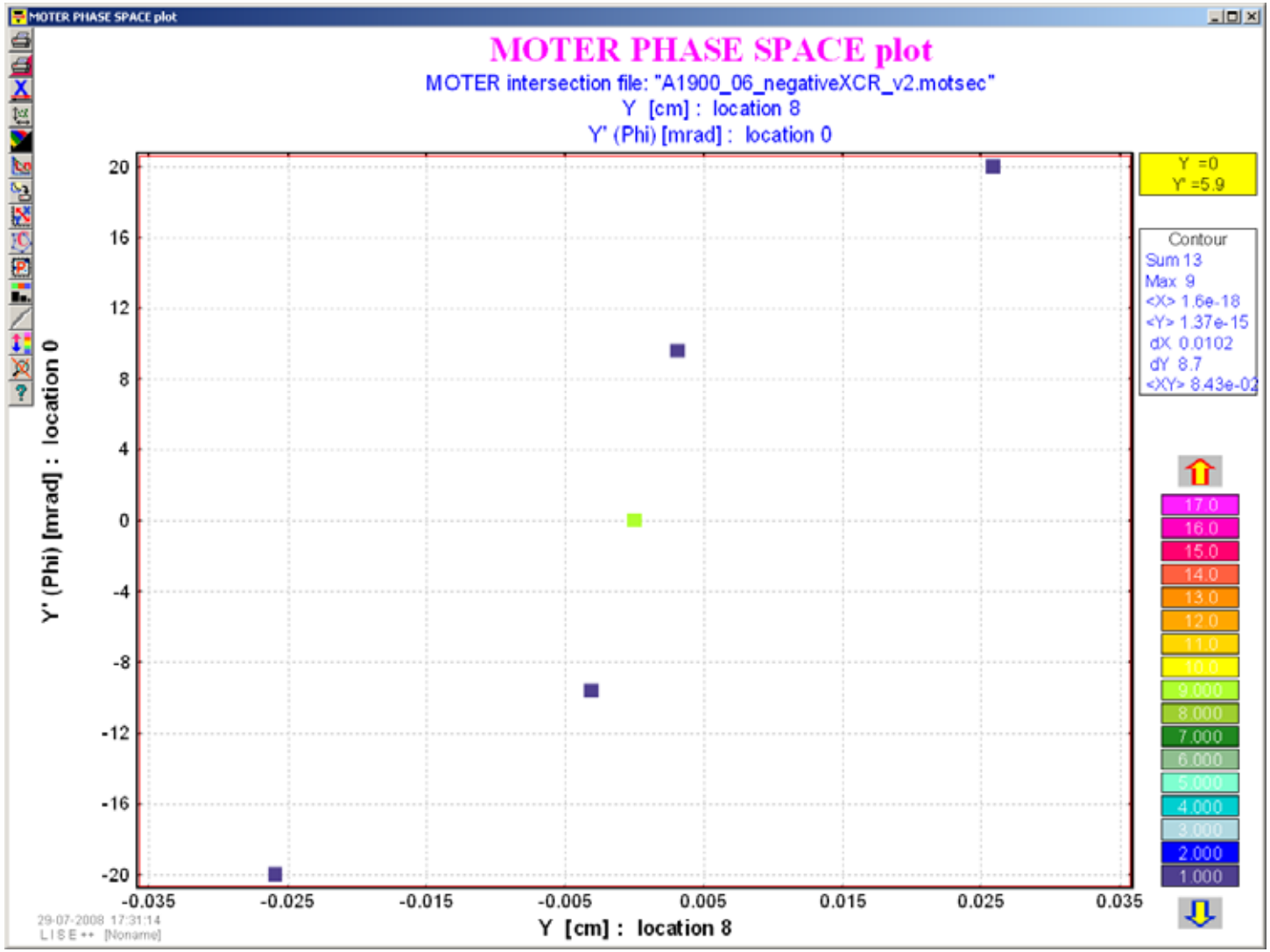

Dispersion ✓

# Image 1: X-focus




X-focus ✓

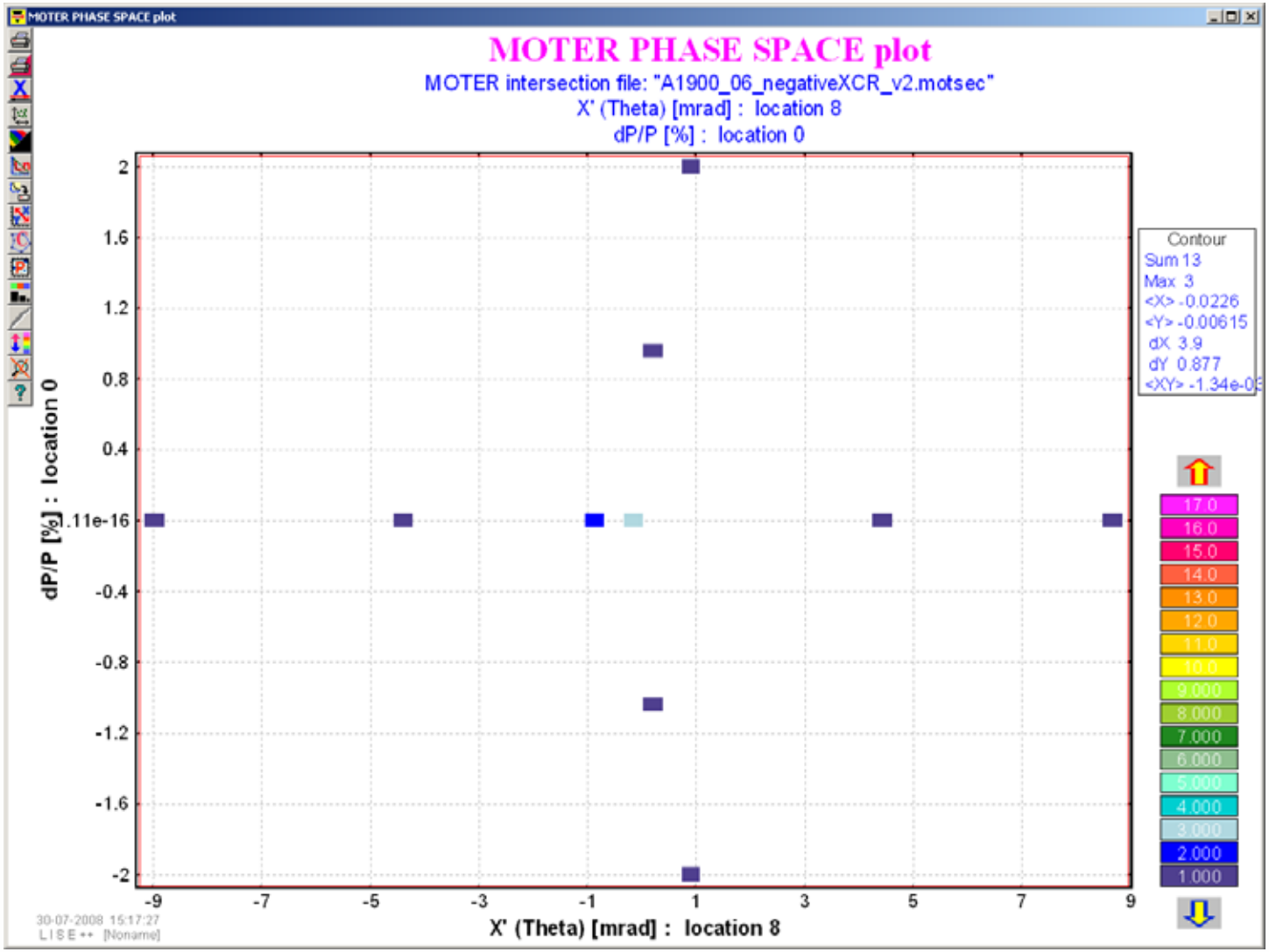
# Image 1: Y-focus




Y-focus: Small (y,bbb)?

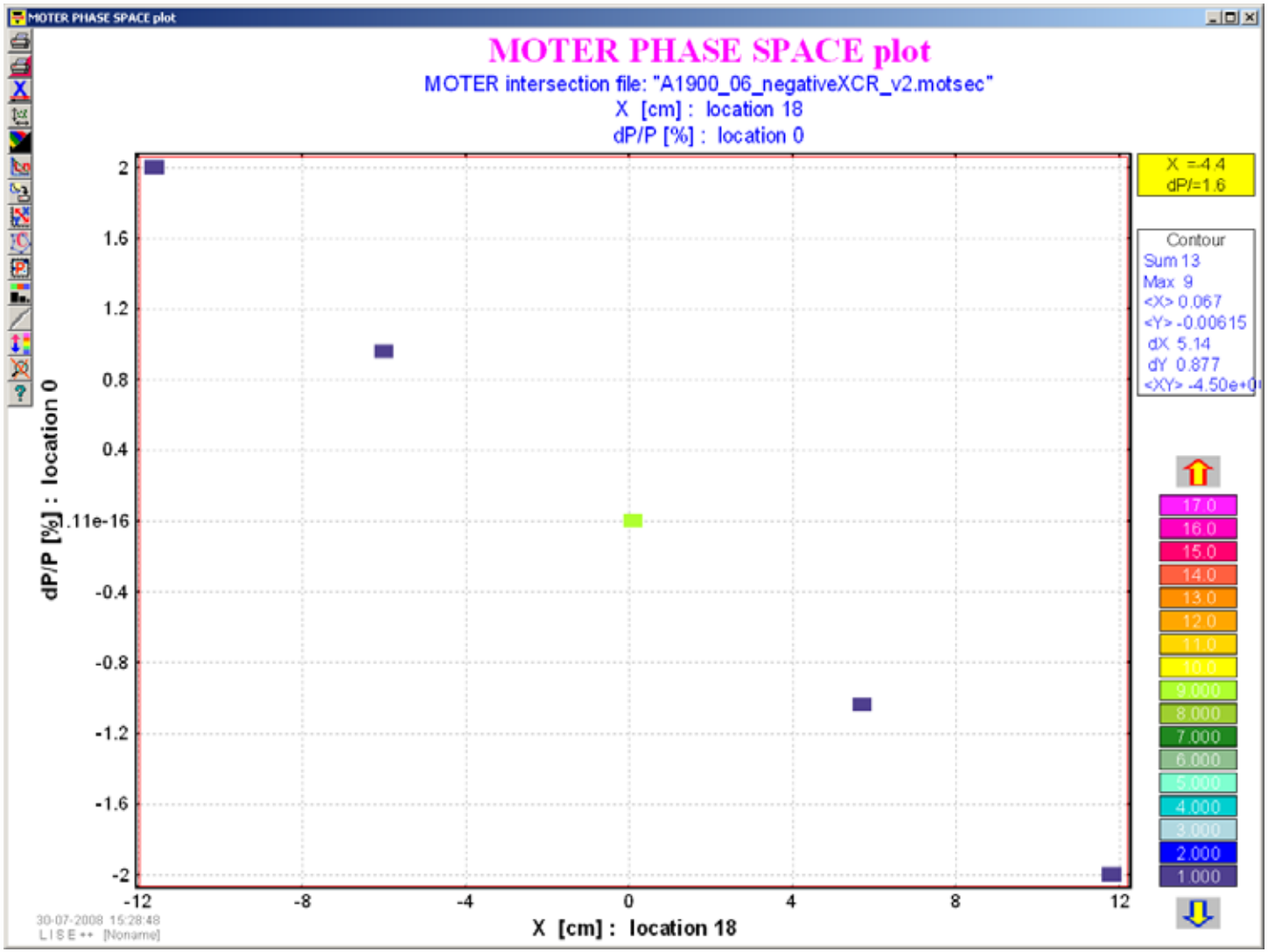
GICOSY: 20 mrad → 0.3 mm ✓

# Image 1: angular dispersion



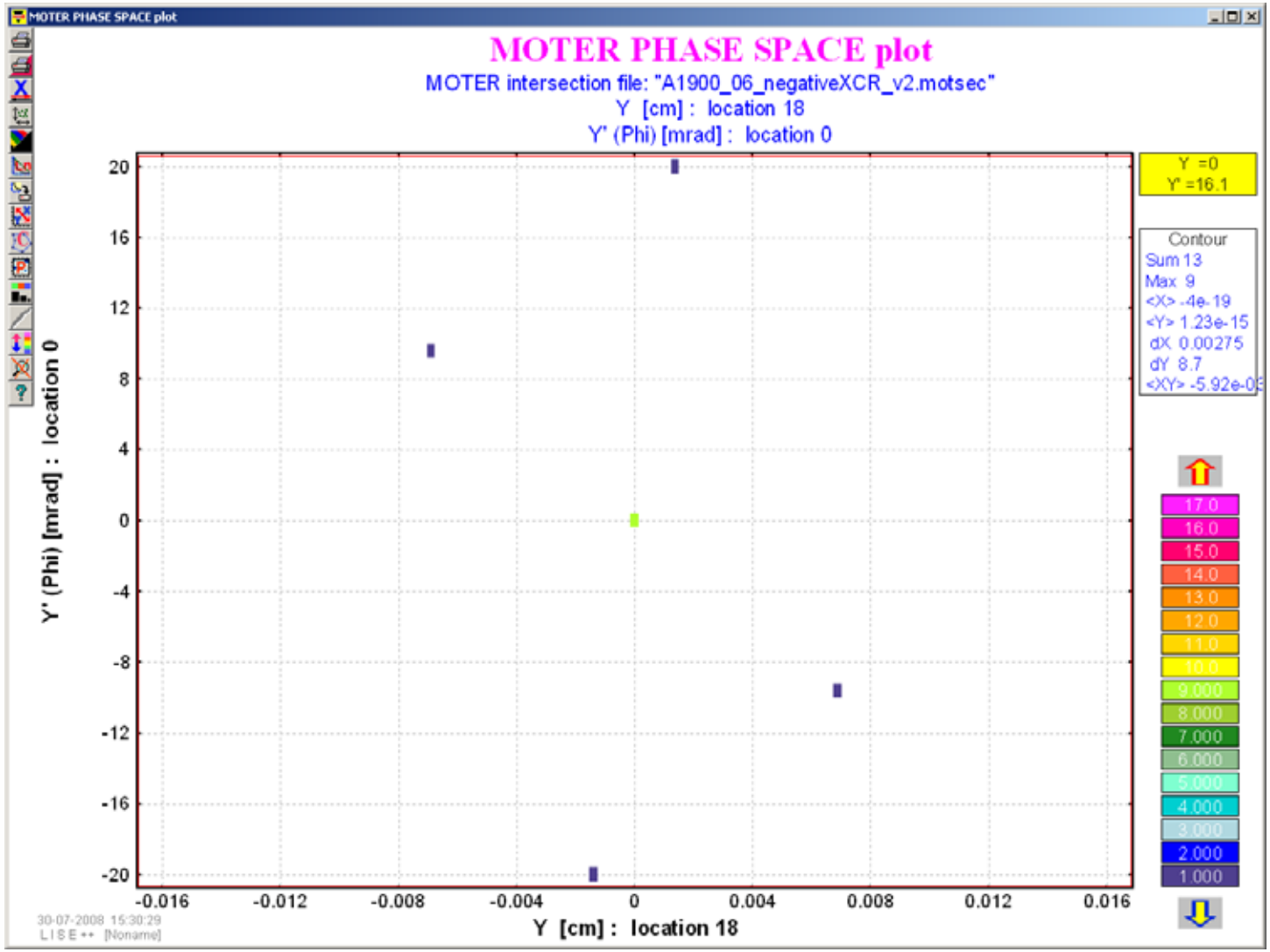

Angular dispersion: Some (a,dd)?
GICOSY: 2% → 0.8 mrad ✓

# Image 2: dispersion



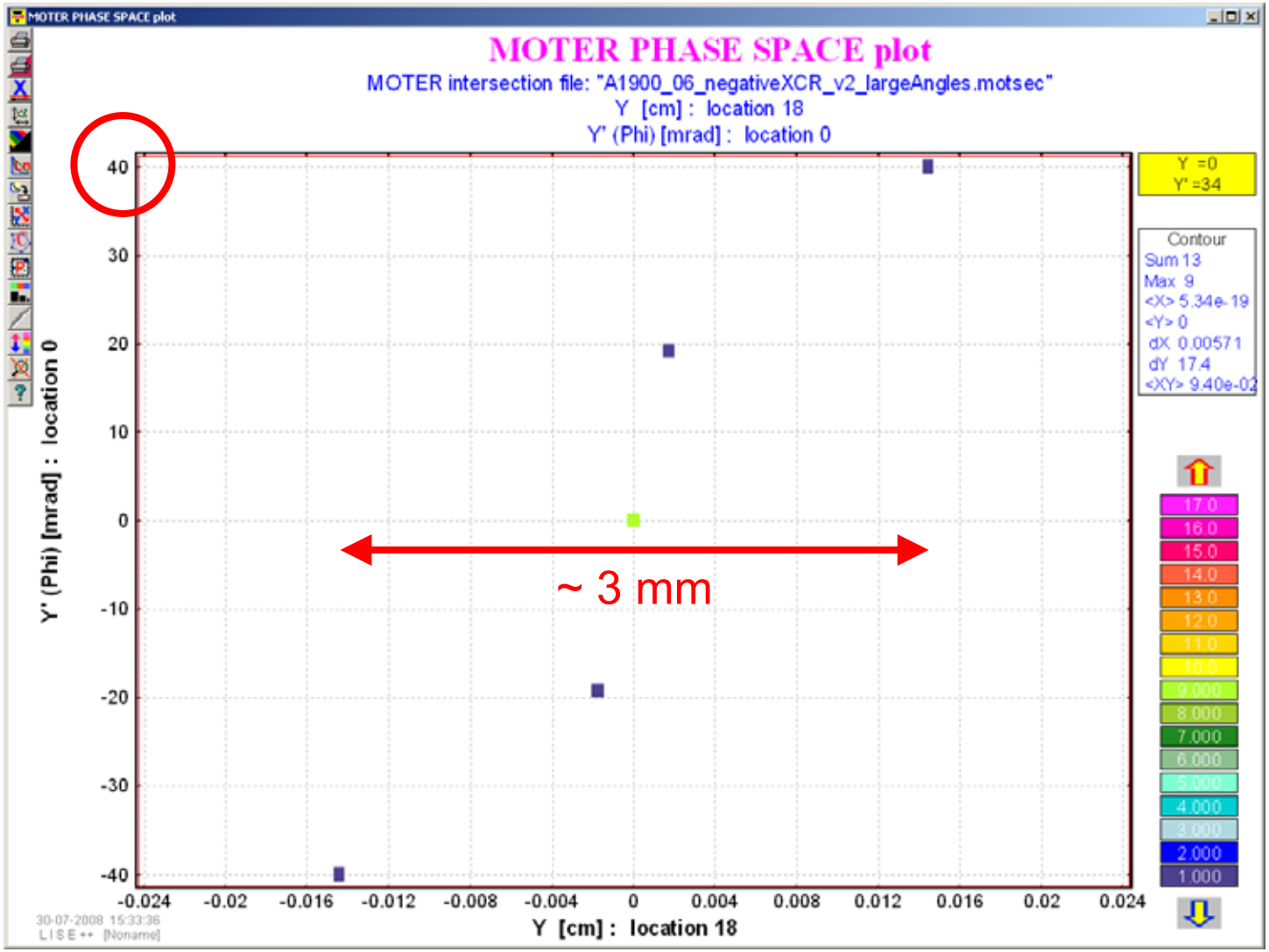

Dispersion ✓

# Image 2: Y-focus




Y-focus: at least two terms, but small

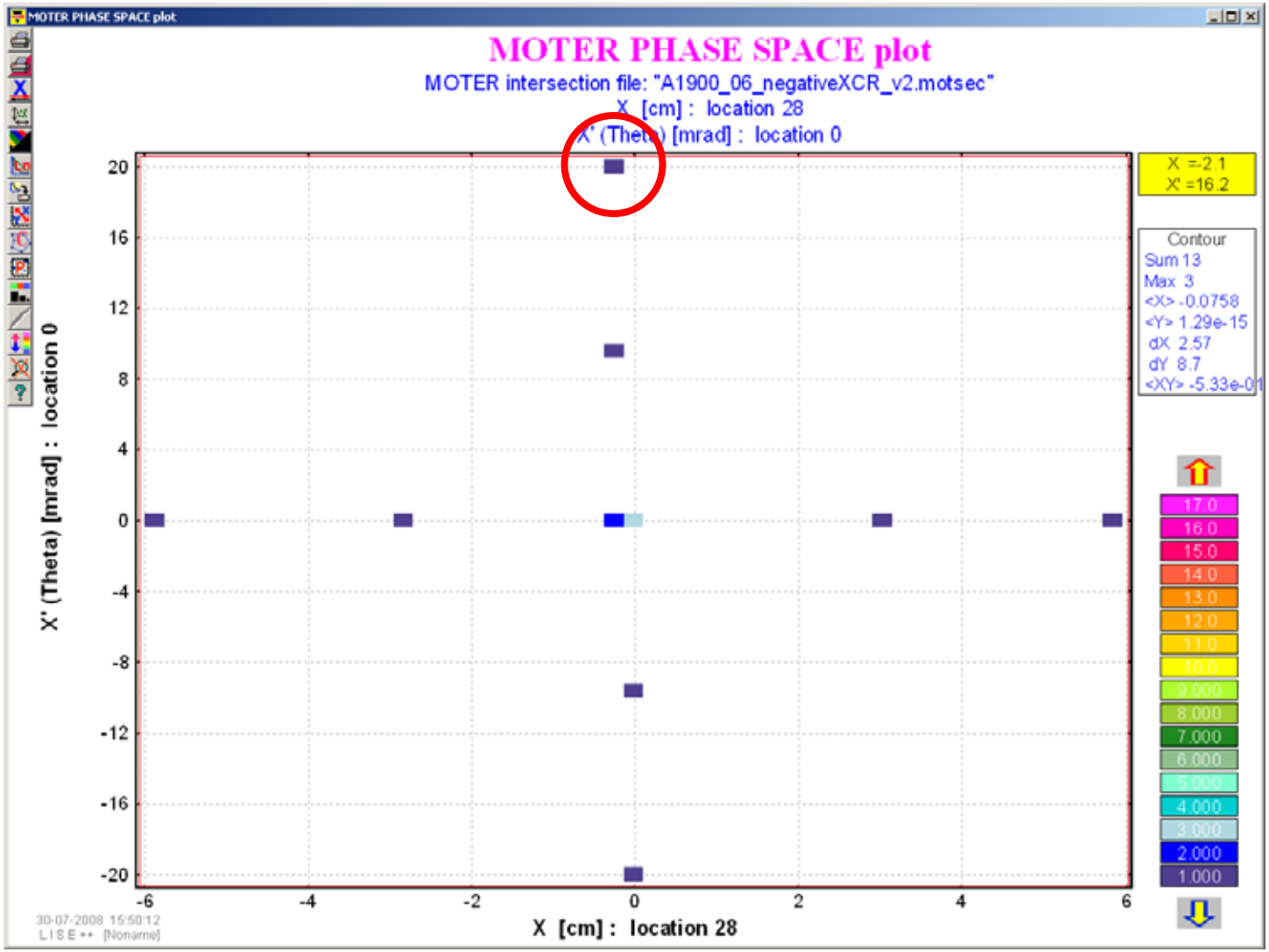
# Image 2: Y-focus (large angles)




Y-focus: aberrations small also for larger angles

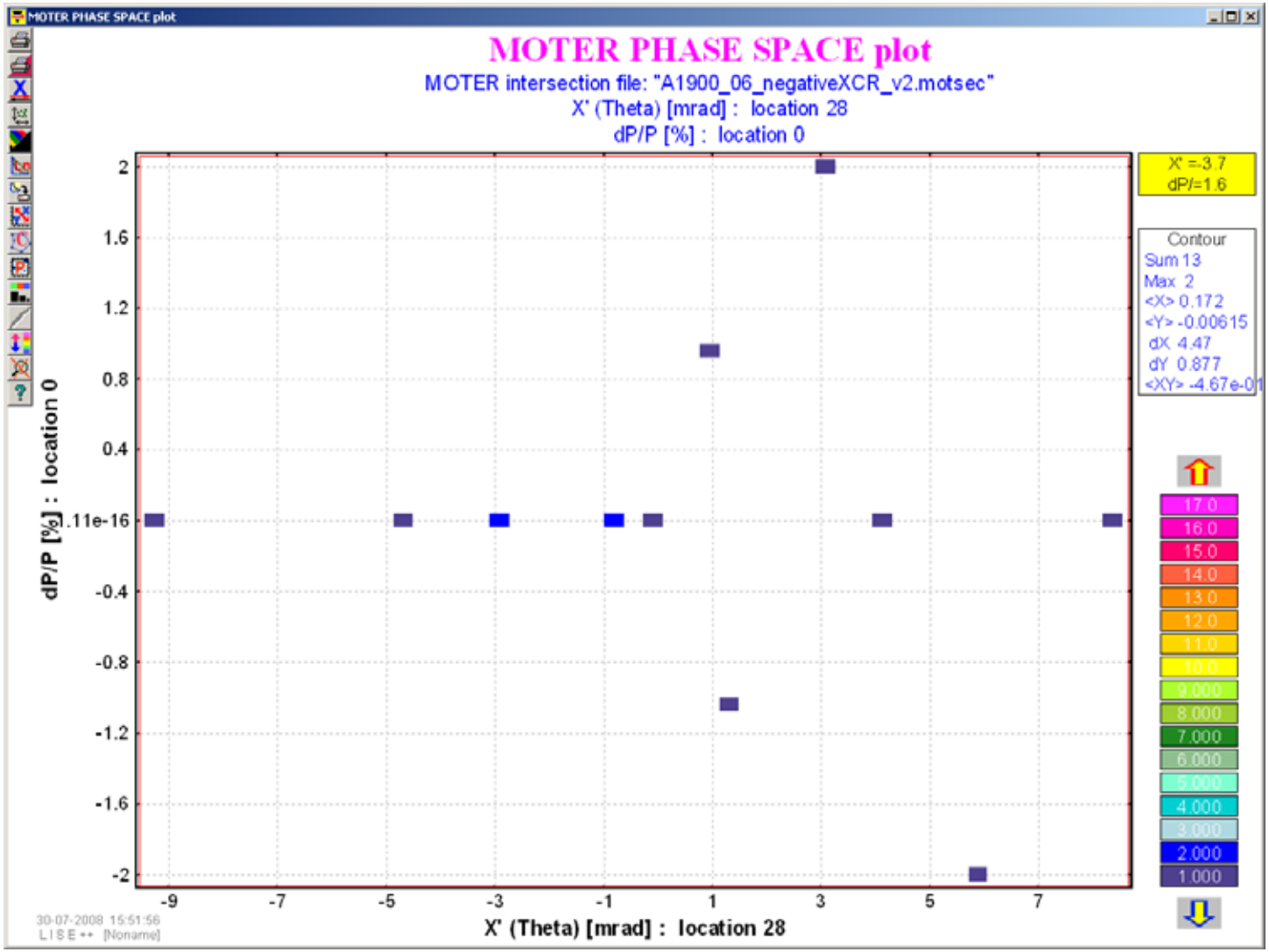
GICOSY, (y,bbb) only expects about twice this aberration

# Image 3: X-focus




X-focus: small aberrations visible

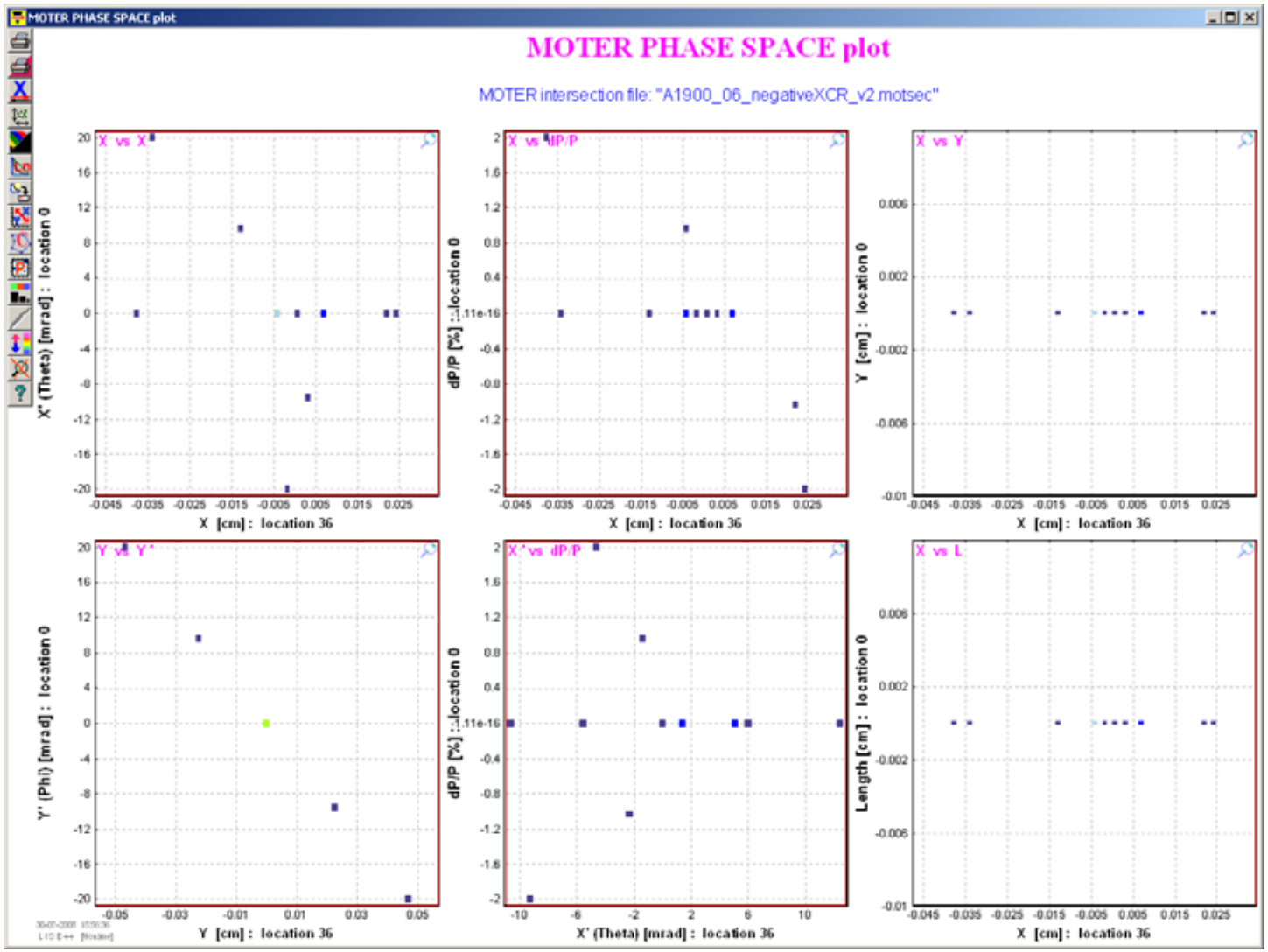
# Image 3: angular dispersion



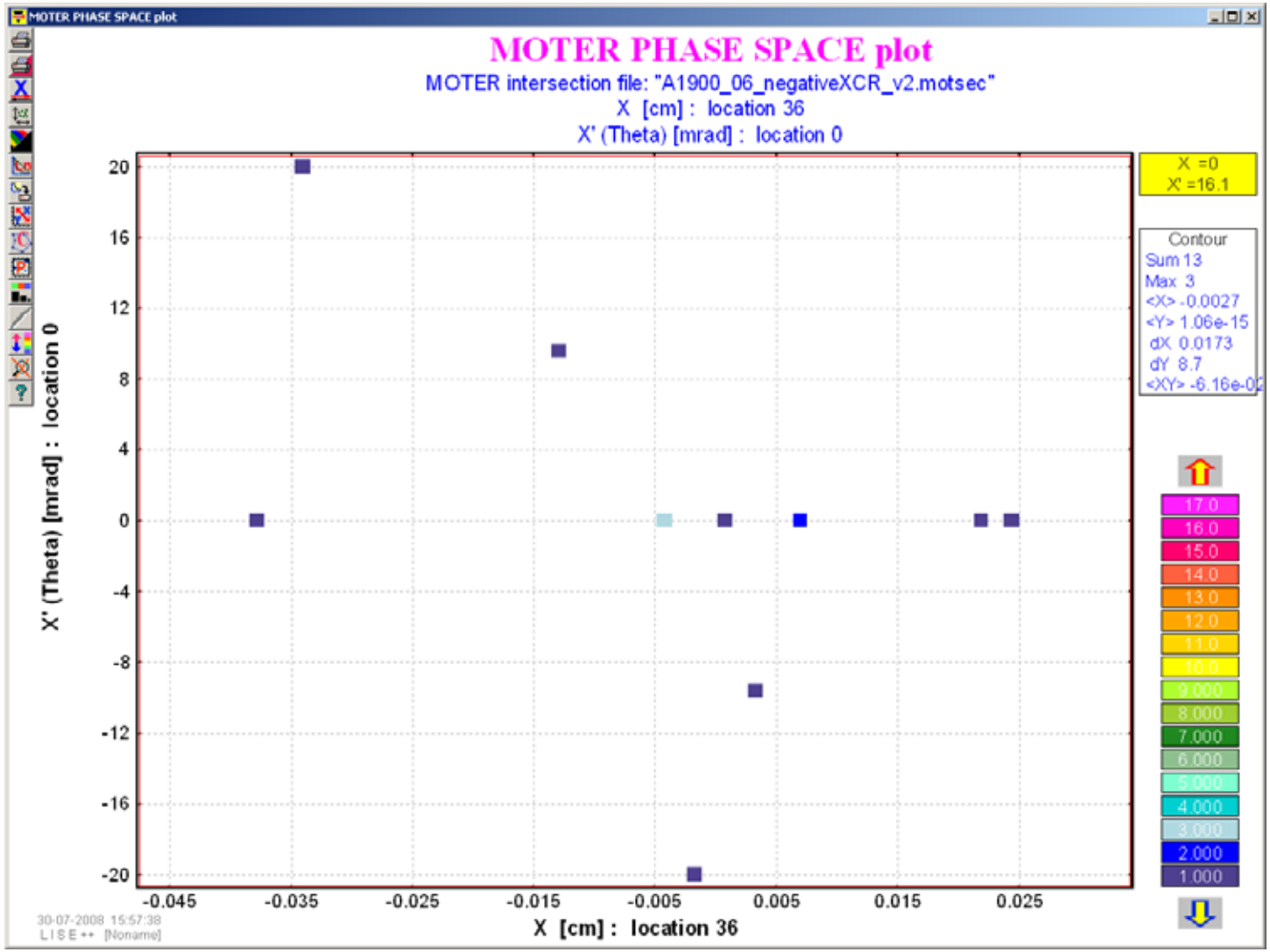

Angular dispersion: visible aberrations

GICOSY (±2%) : (a,dd) → +4.5 mrad, (a,ddd) → ∓0.25 mrad

# Focal Plane


MOTER PHASE SPACE plot
MOTER PHASE SPACE plot
MOTER intersection file: "A1900_06_negativeXCR_v2.motsec"
X vs X
X vs dP/P
X vs Y
Y vs Y'
X' vs dP/P
X vs L
X' (Theta) [mrad] : location 0
dP/P [%] : location 0
Y [cm] : location 0
Length [cm] : location 0
Y' (Phi) [mrad] : location 0
X [cm] : location 36
Y [cm] : location 36
X' (Theta) [mrad] : location 36

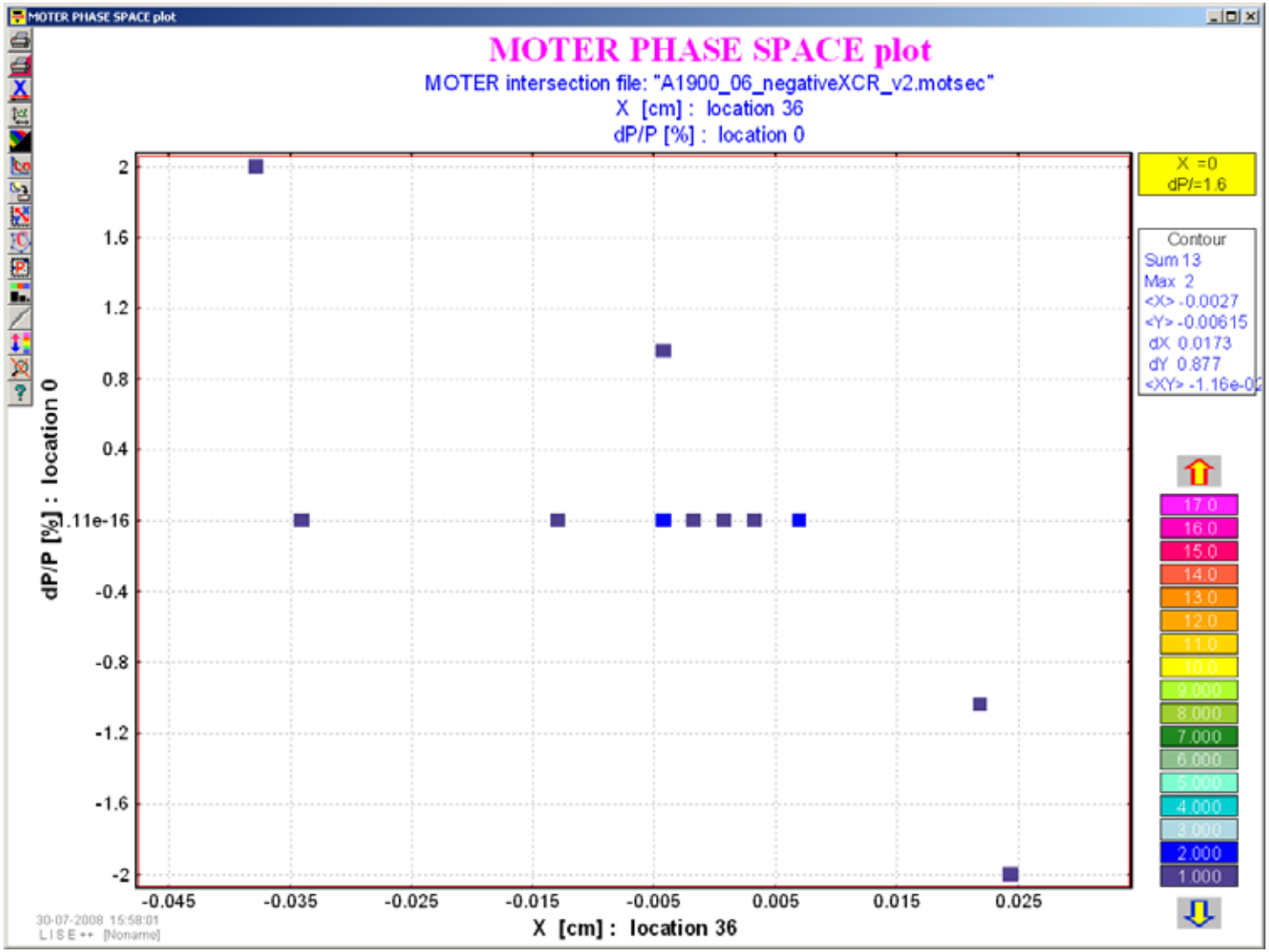
# Focal Plane: X-focus




X-focus: aberrations, but small

GICOSY (±20 mrad) : (x,aa) → -0.2 mm, (x,aaa) → ±0.06 mm

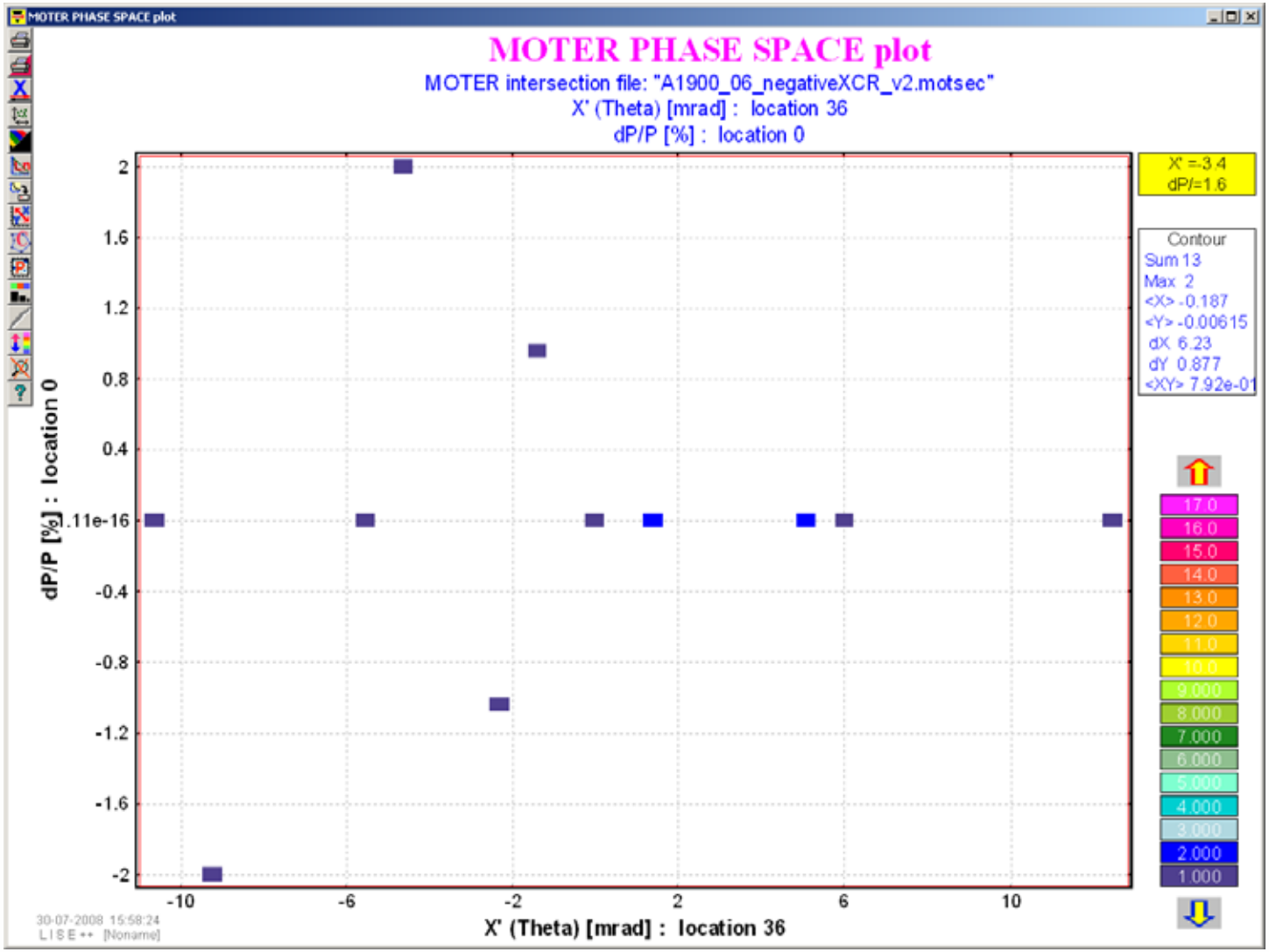
# Focal Plane: dispersion




Essentially dispersion-free

GICOSY: all $(x,p^n)$ yield < 0.5 mm

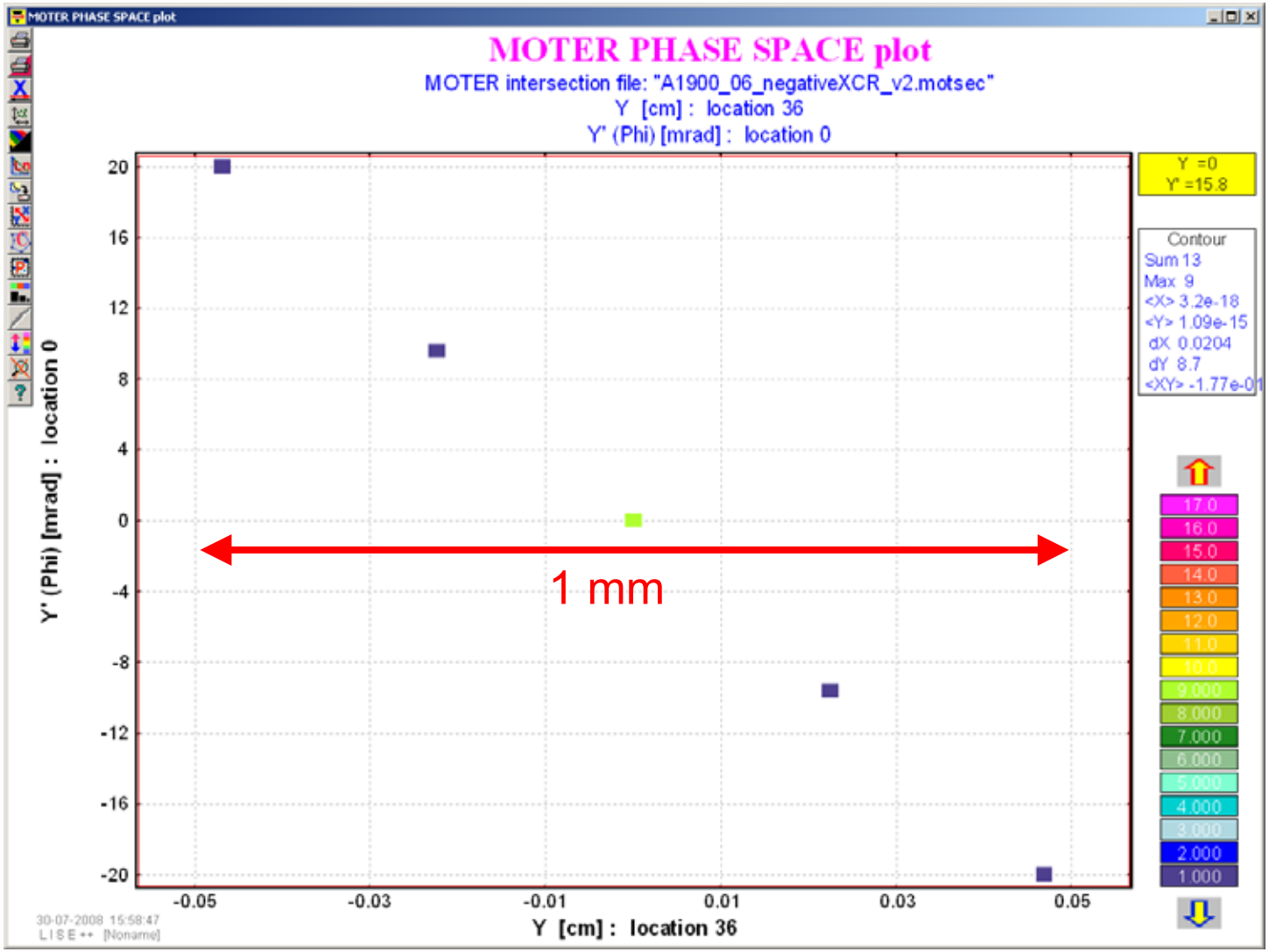
# Focal Plane: angular dispersion




But not fully achromatic

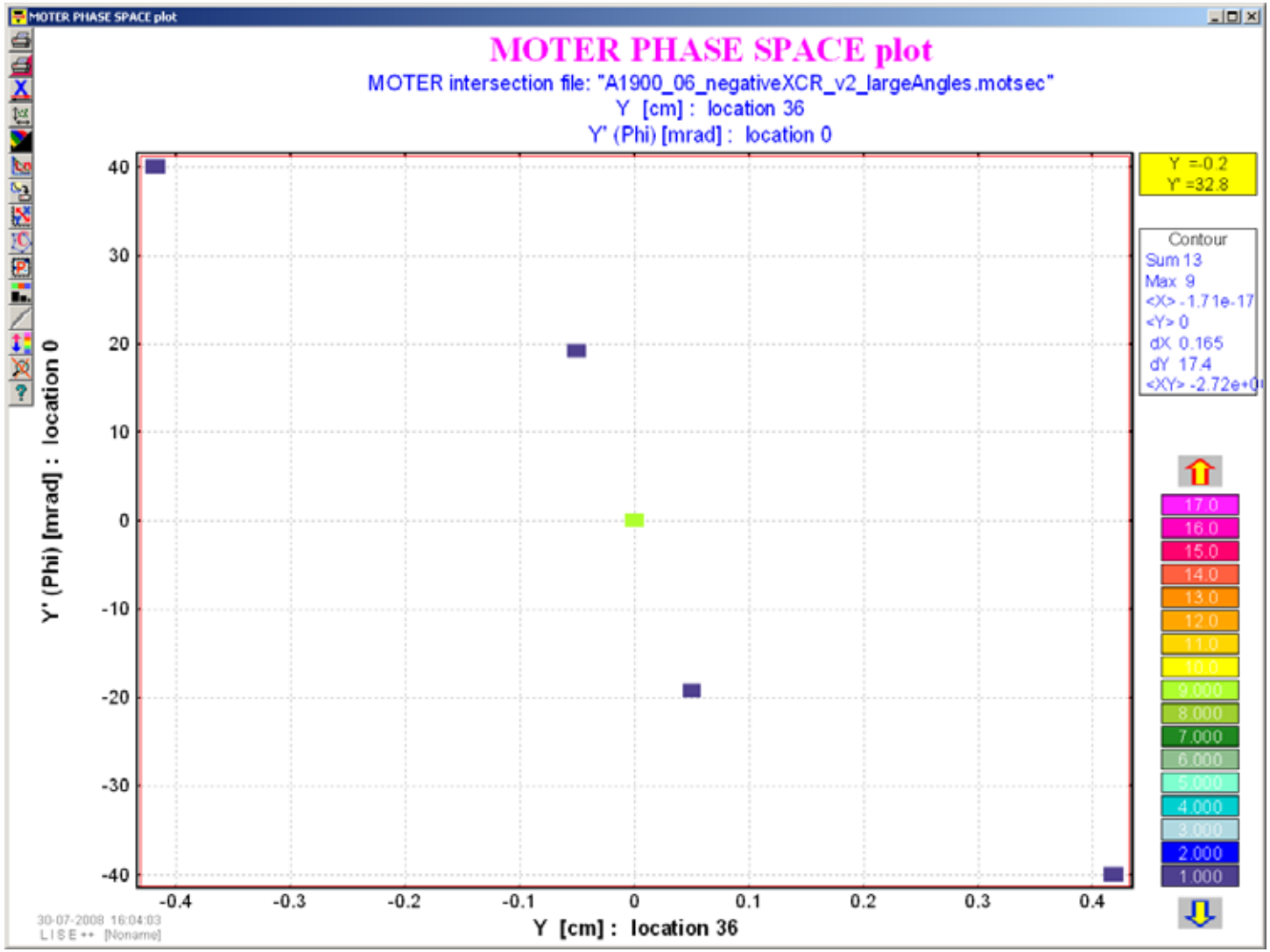
GICOSY (±2%) : (a,dd) → -7 mrad, (a,ddd) → ±2.6 mrad

# Focal Plane: Y-focus




Y-focus: very slightly underfocused

# Focal Plane: Y-focus

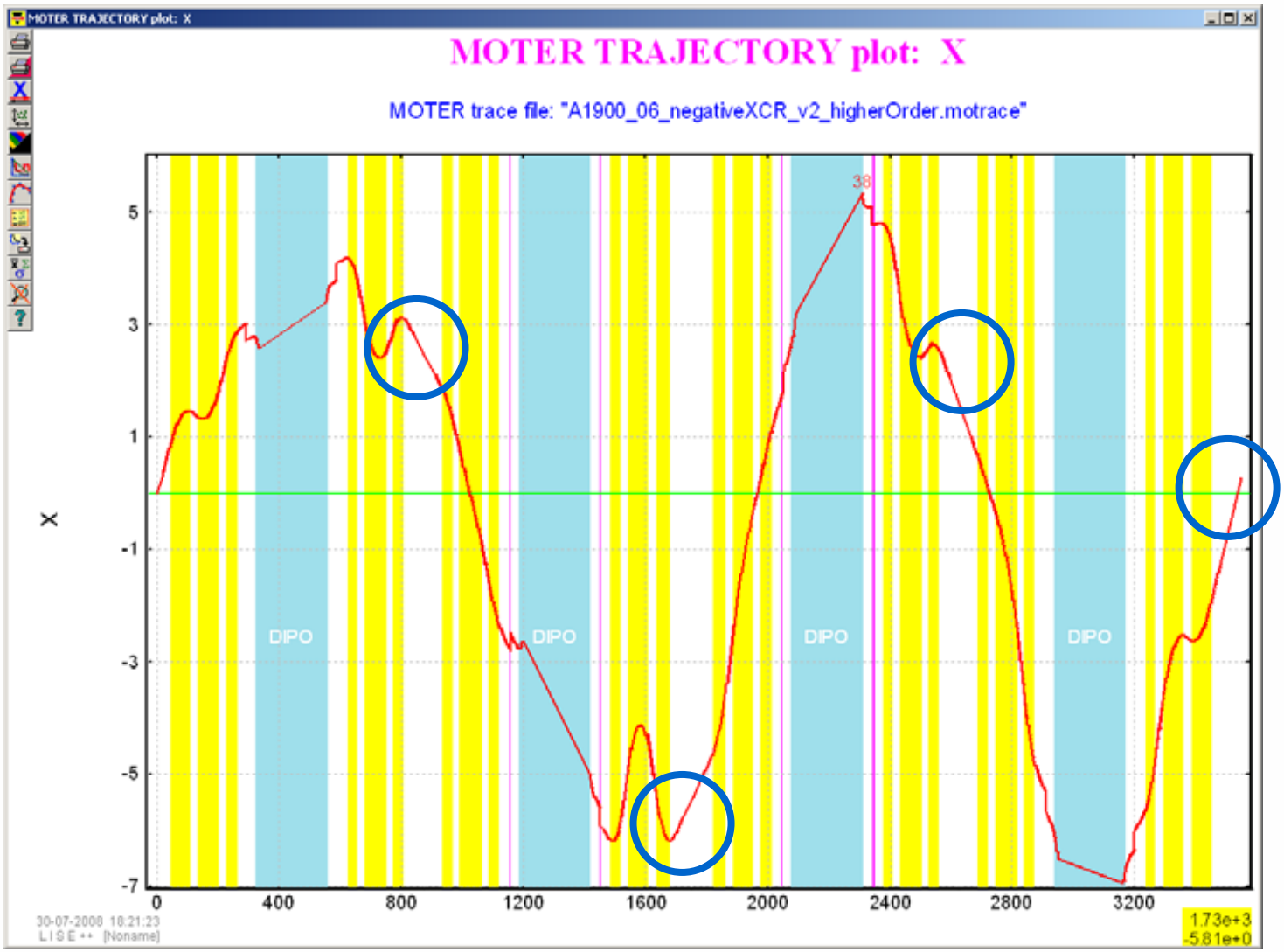



Y-focus: for larger angles also aberrations

GICOSY (±40 mrad) : (y,b) → ∓6 mm, (y,bbb) → ±7.5 mm

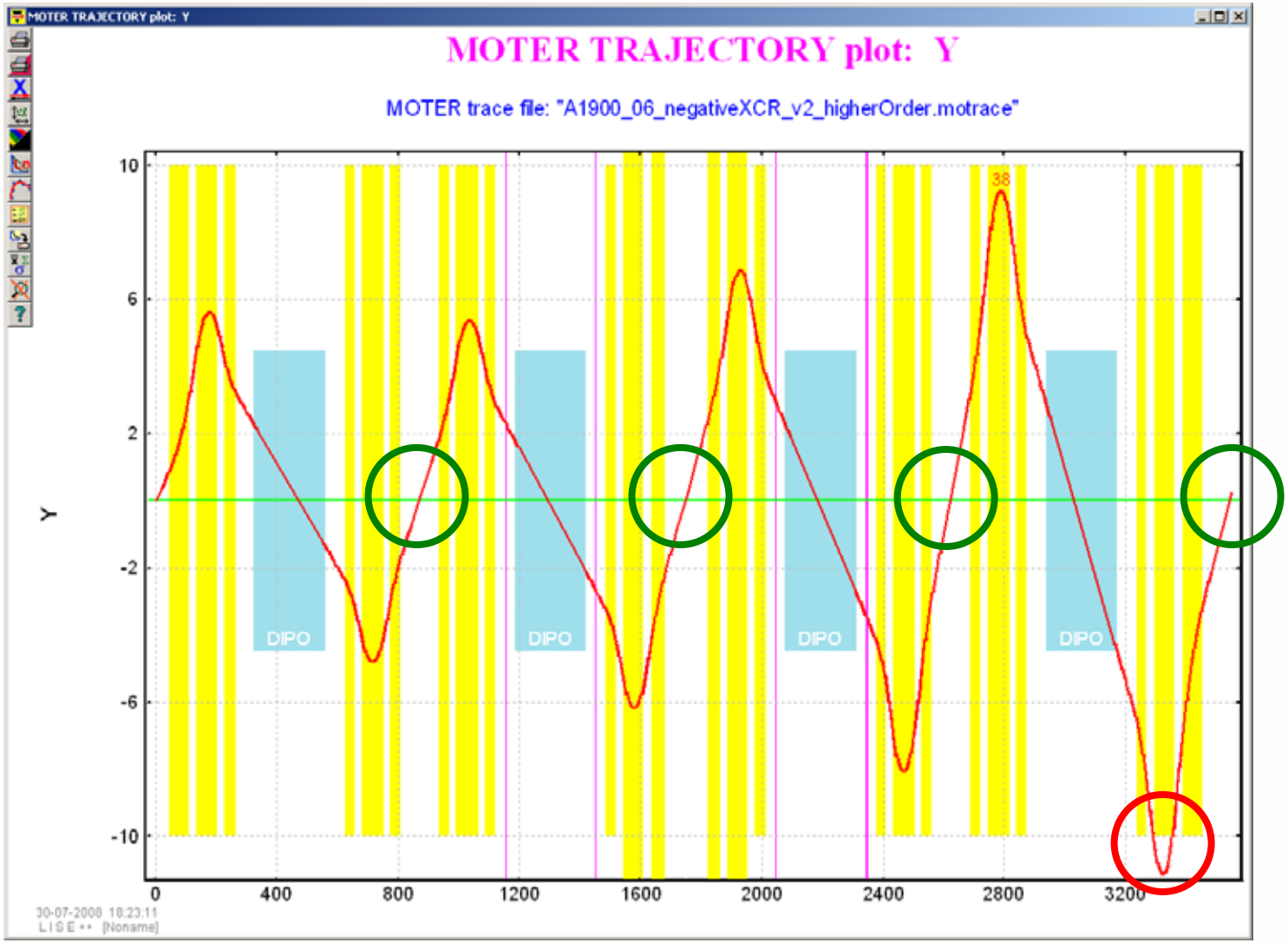
# Single Particles

So far only one non-zero coordinate per particle, now multiple:



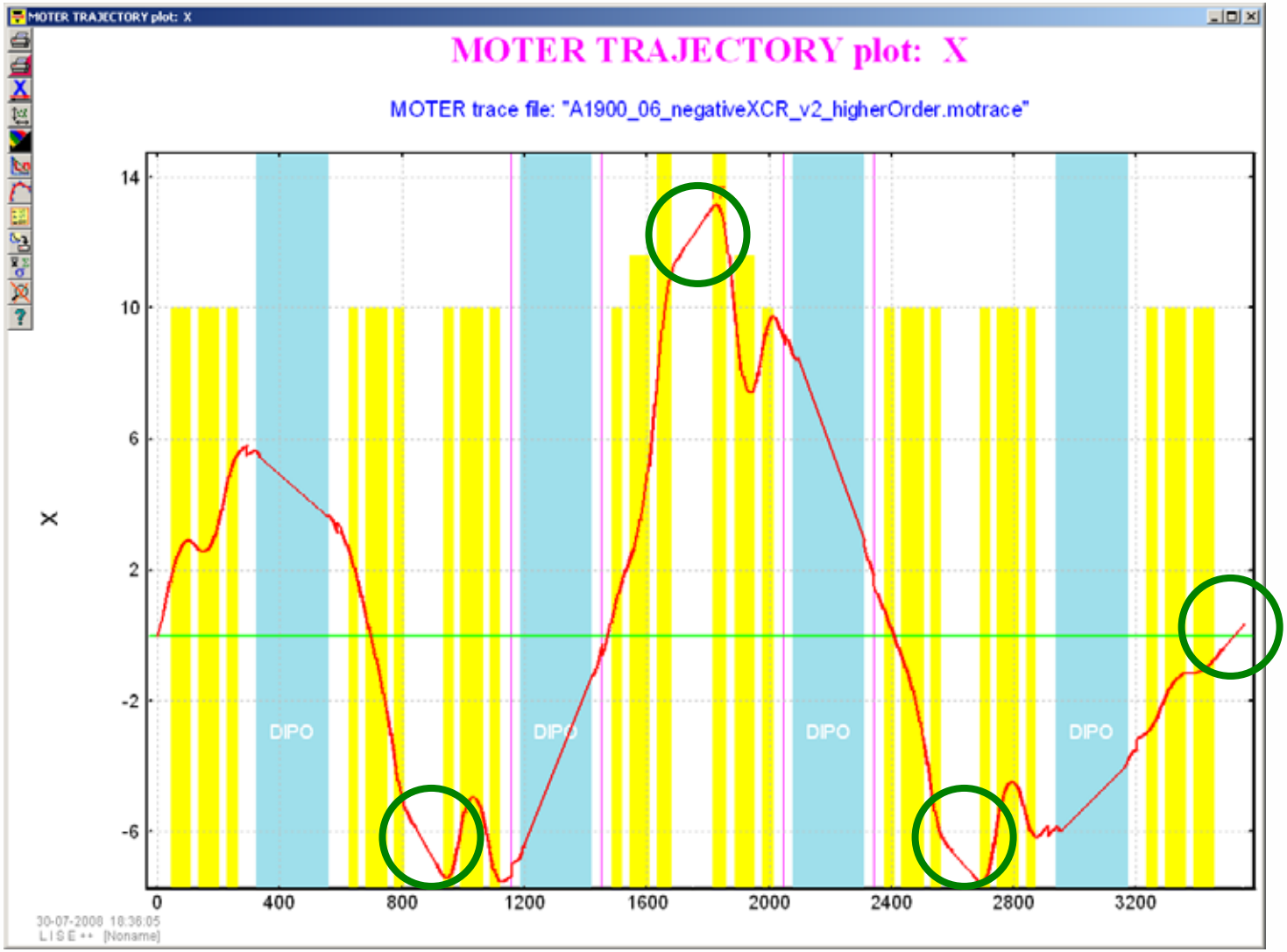

Initial: + 20 mrad (x), + 20 mrad (y), + 1 % (dp/p)

# Single Particles



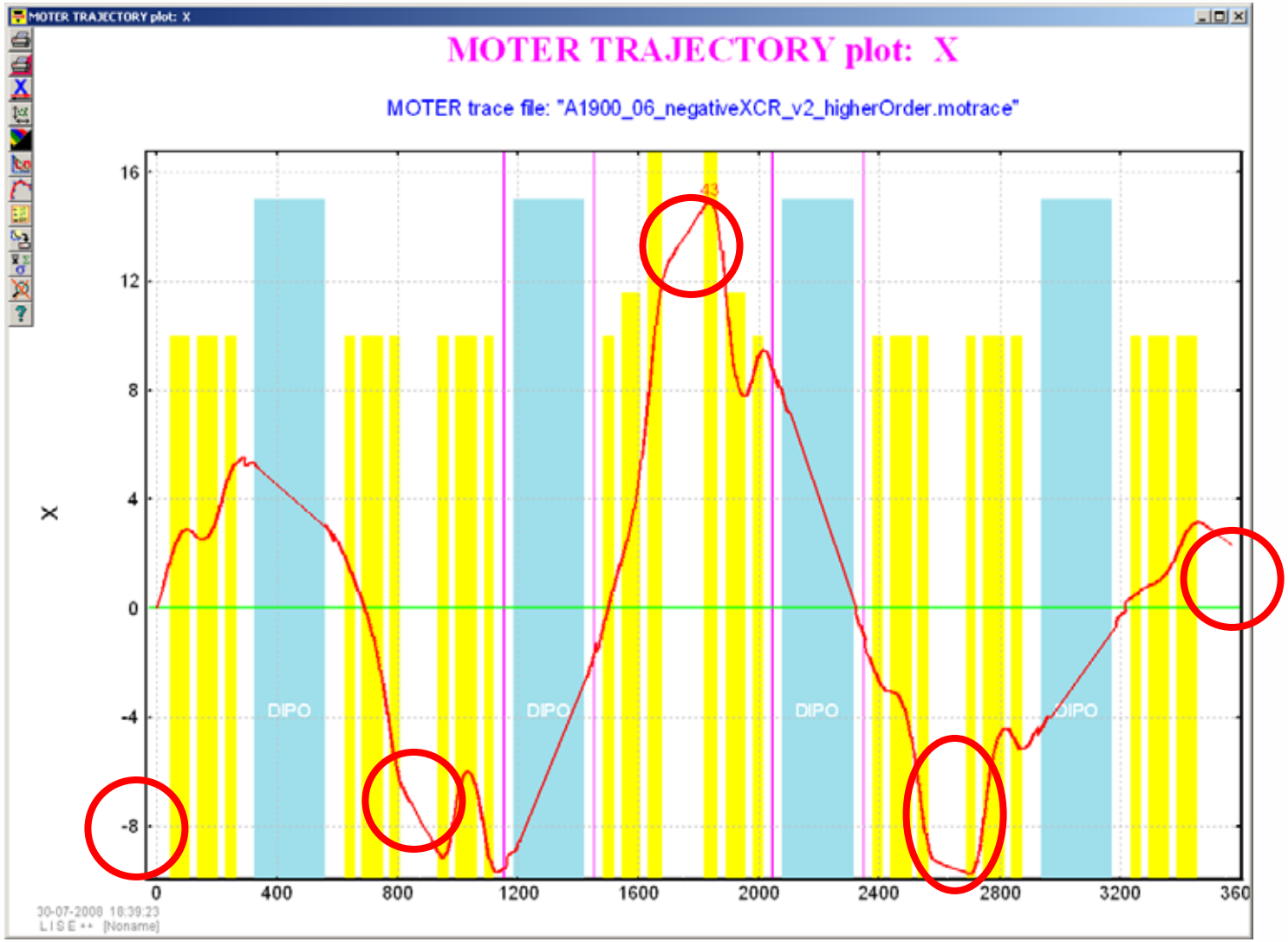

Initial: + 20 mrad (x), + 20 mrad (y), + 1 % (dp/p)

# Single Particles



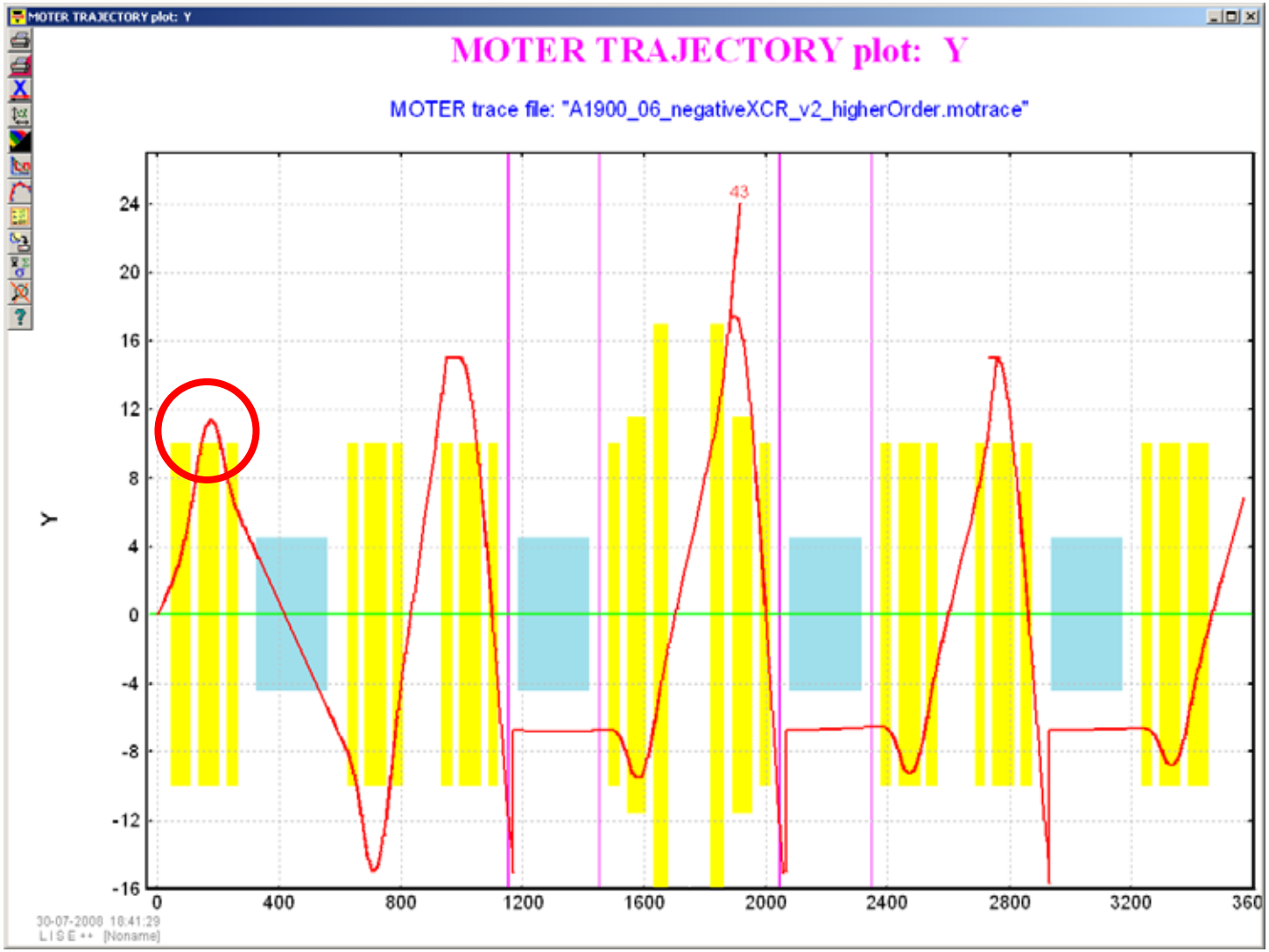

Initial: + 40 mrad (x), ± 0 mrad (y), - 2 % (dp/p)

# Extreme Particle: plenty aberrations



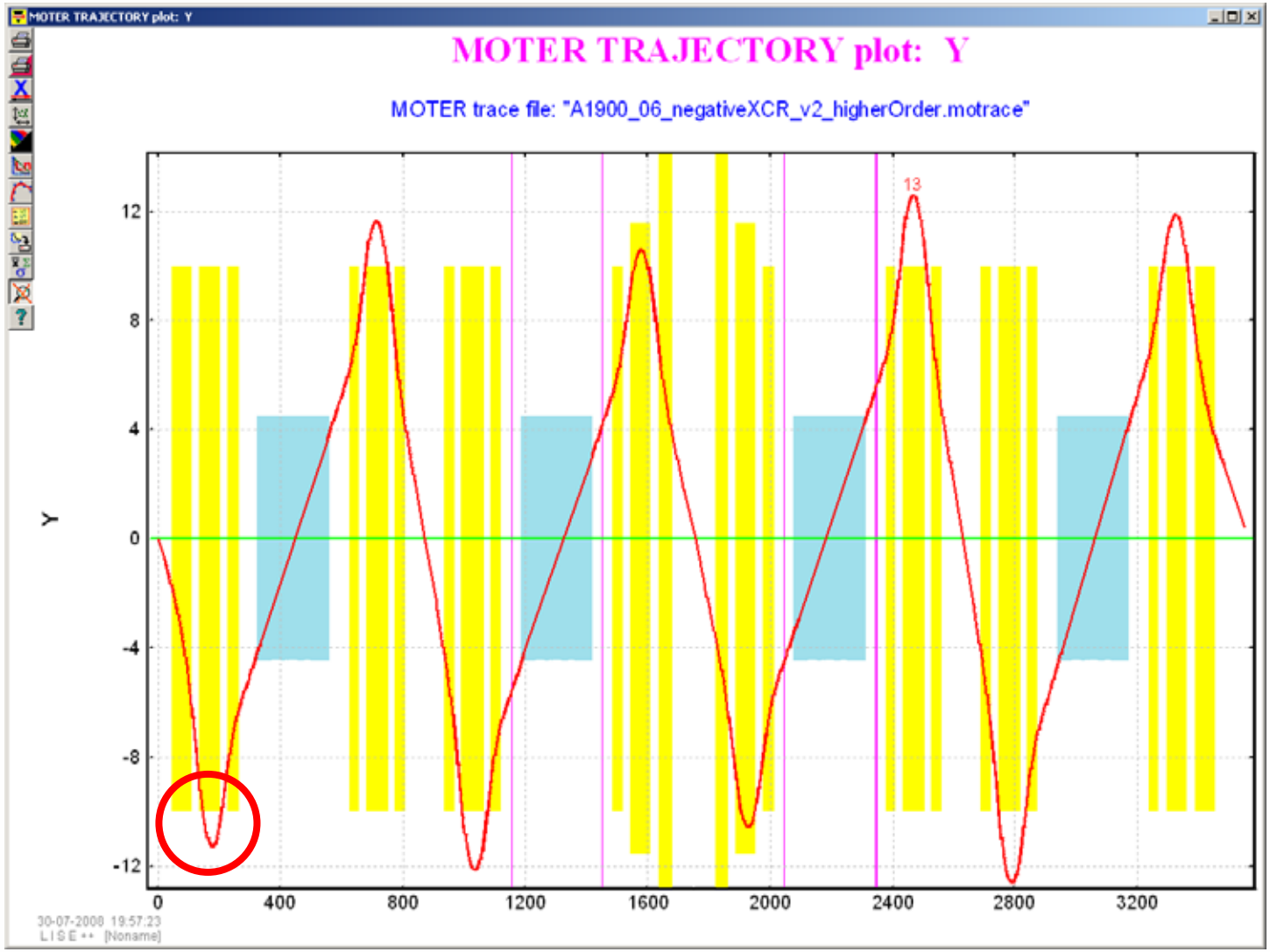

Initial: + 40 mrad (x), + 40 mrad (y), - 2 % (dp/p)

# Extreme particle: doesn't make it!




Initial: + 40 mrad (x), + 40 mrad (y), - 2 % (dp/p)

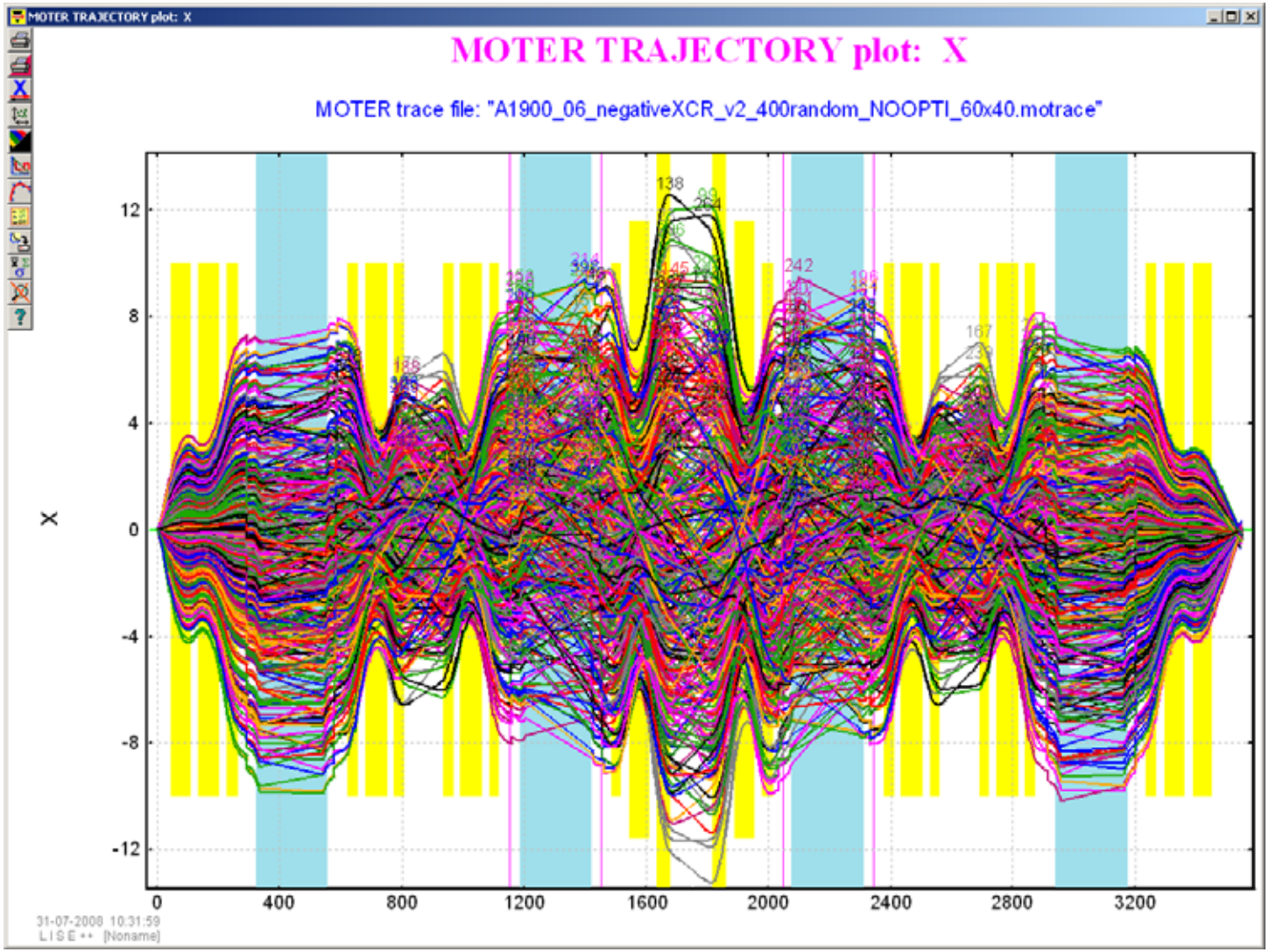
# A1900 vertical angle acceptance




Initial: 0 mrad (x), - 40 mrad (y), 0 % (dp/p)

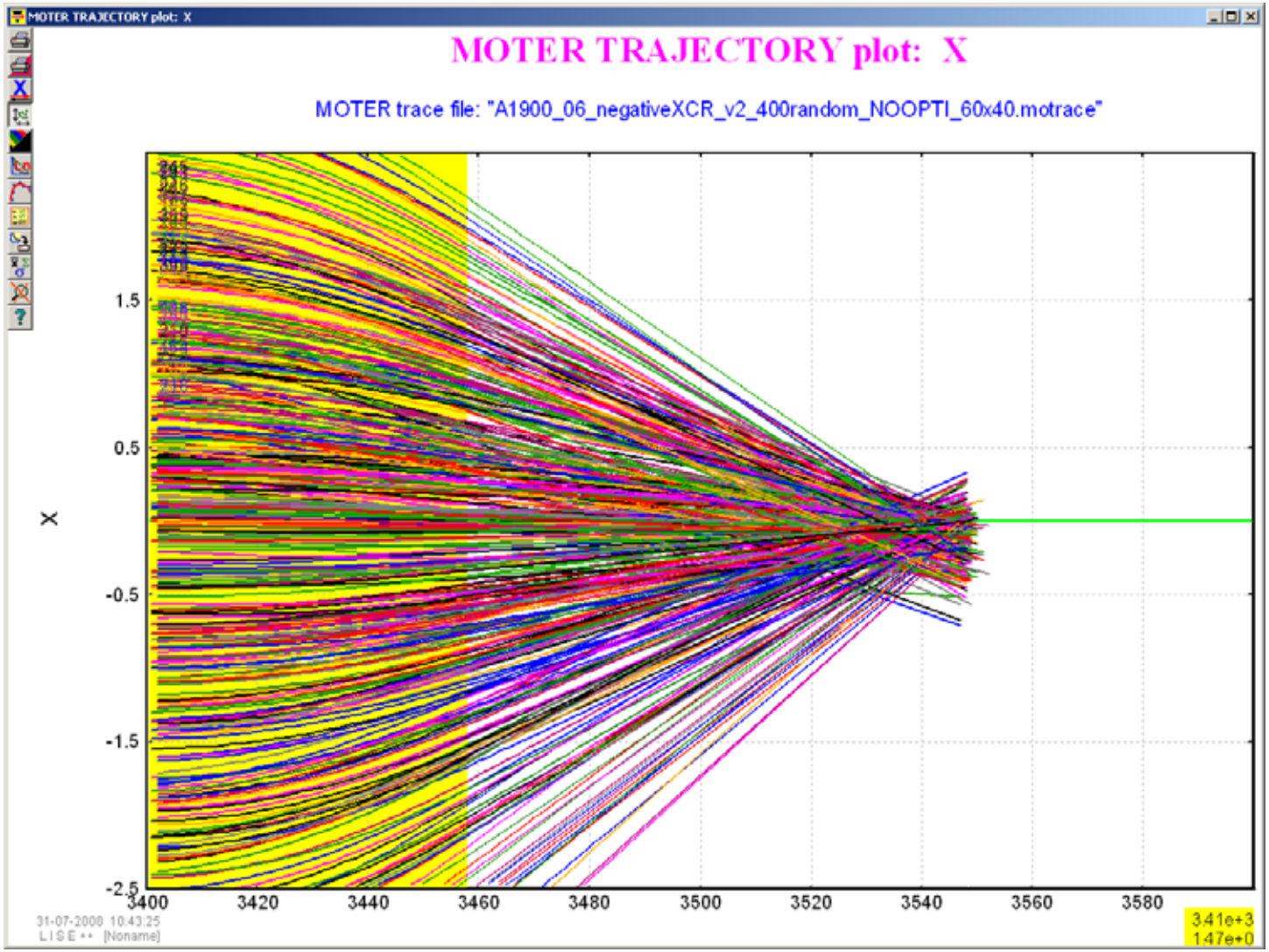
casting some doubt about ± 40 mrad vertical angle acceptance

# Ray tracing random particles



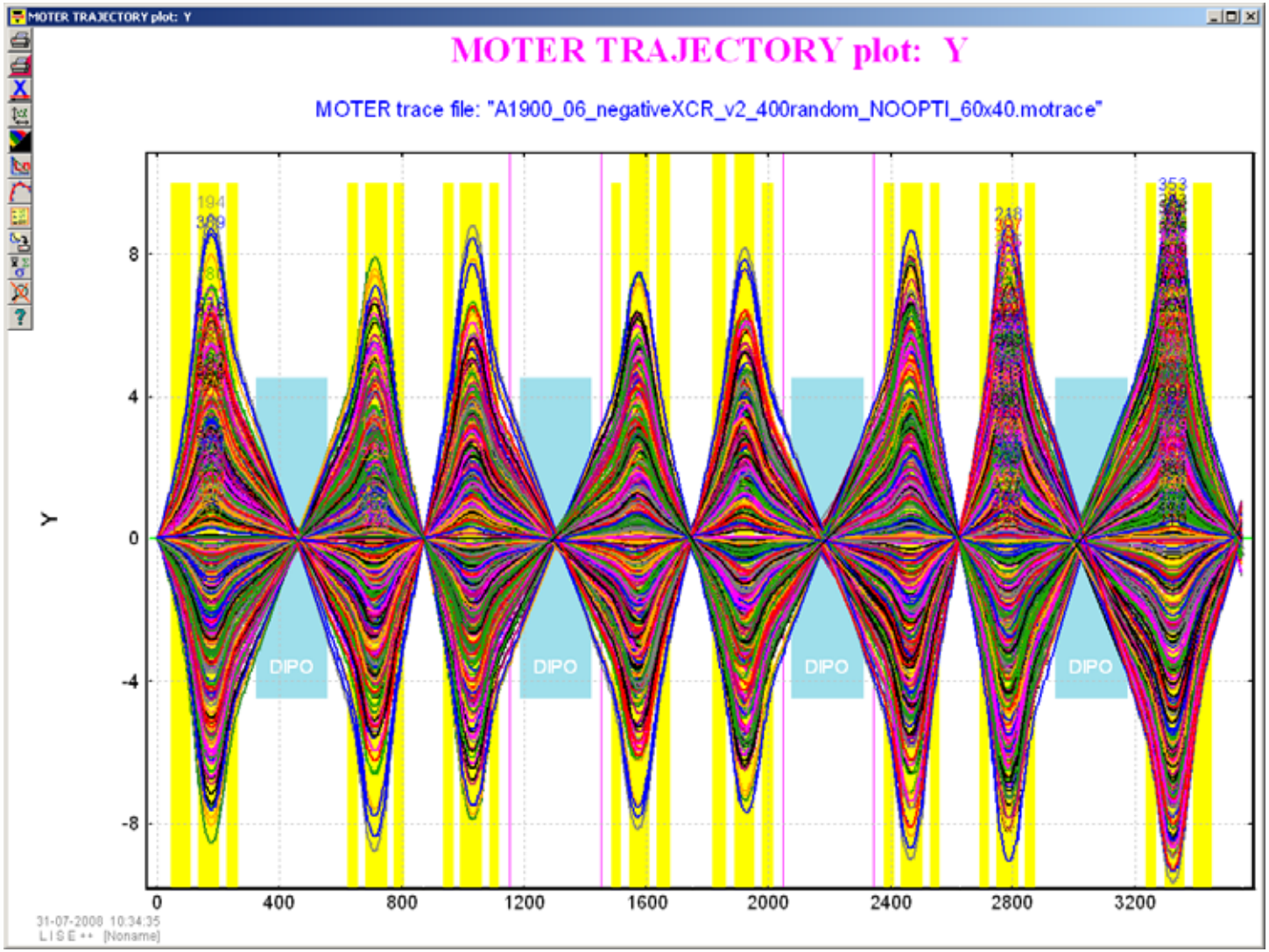

Initial Phase space: ± 60 mrad (x), ± 40 mrad (y), ± 2.5 % (dp/p)

# Ray tracing random particles



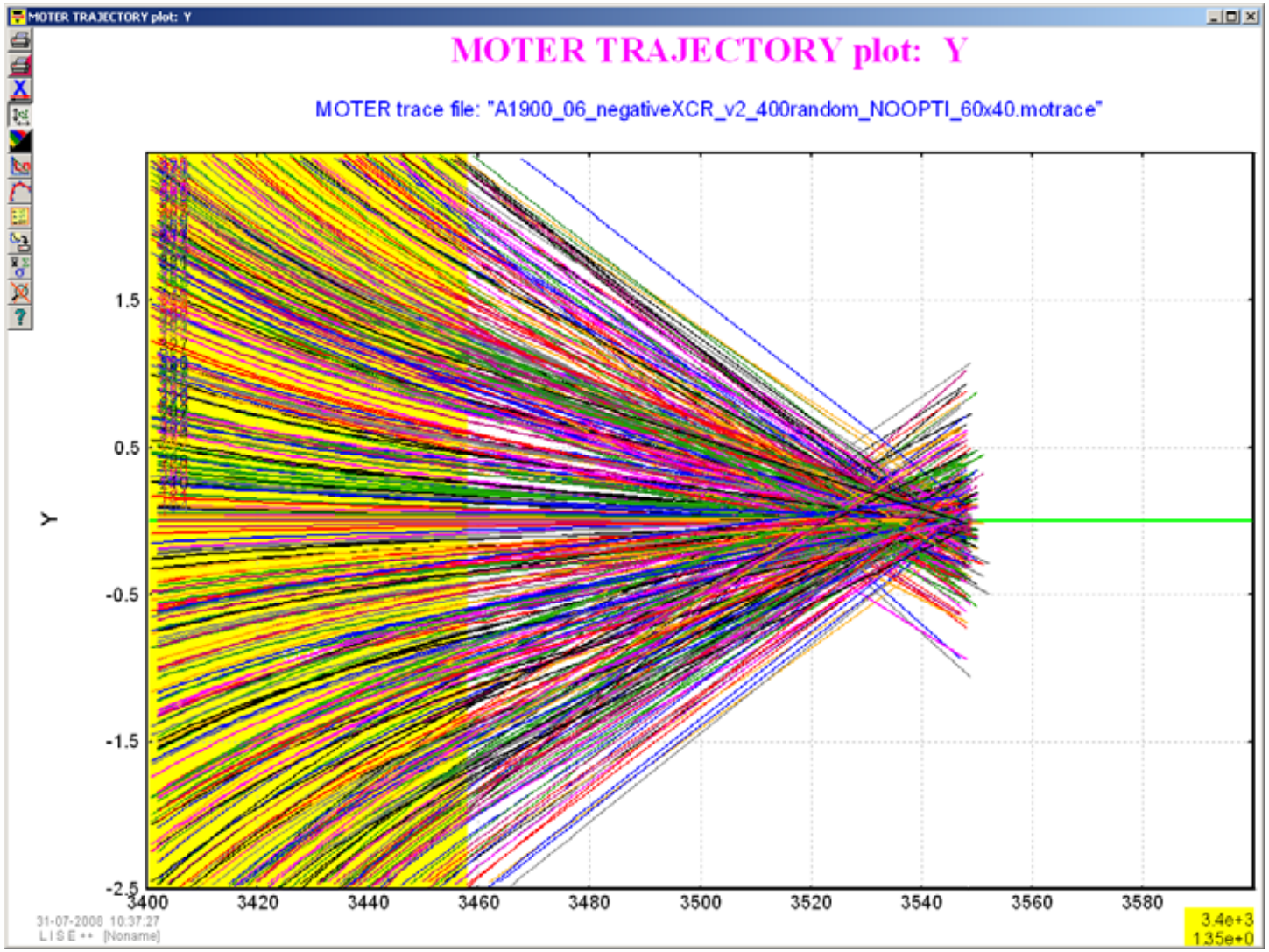

Initial Phase space: ± 60 mrad (x), ± 40 mrad (y), ± 2.5 % (dp/p)

# Ray tracing random particles



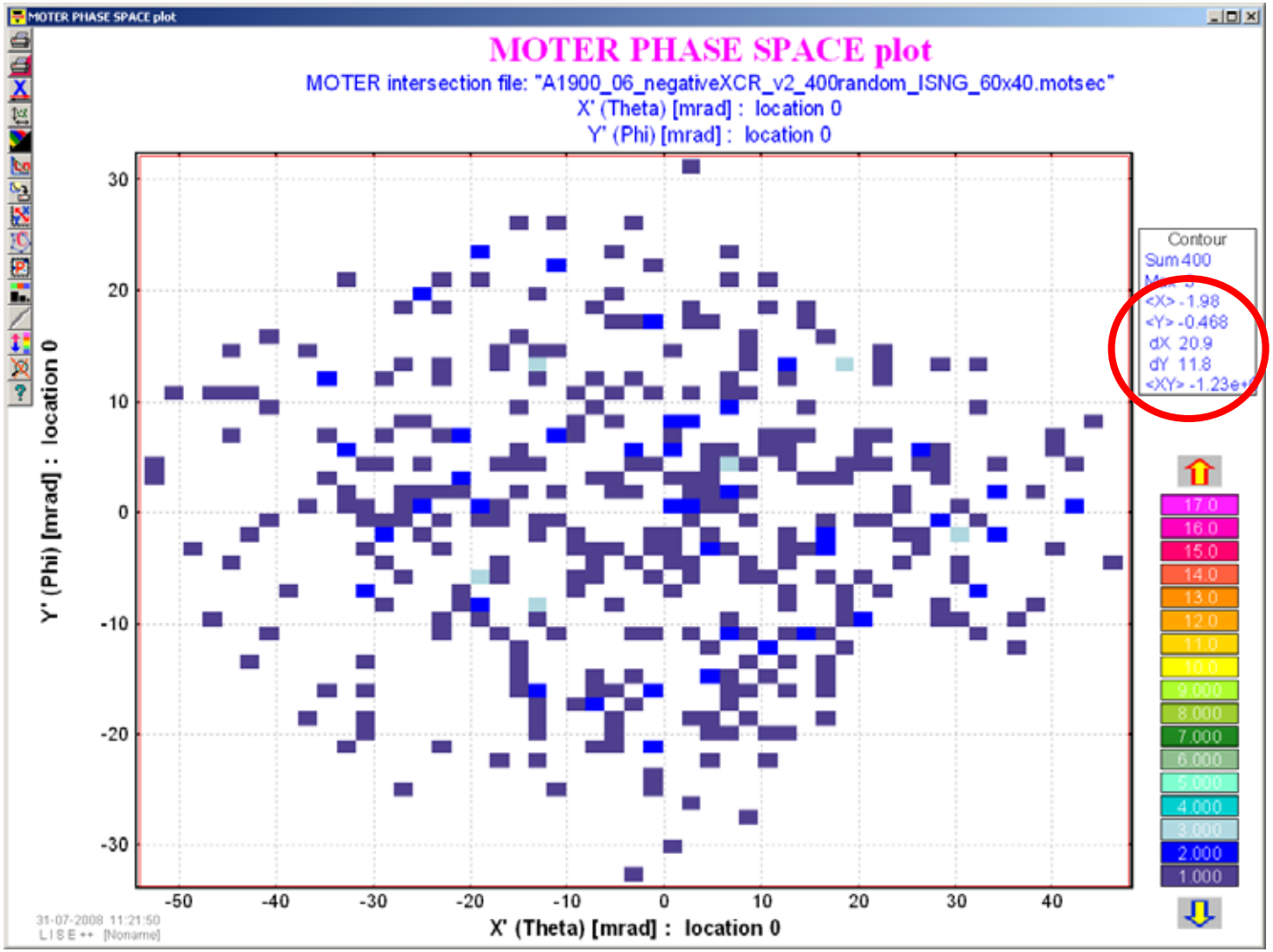

Initial Phase space: ± 60 mrad (x), ± 40 mrad (y), ± 2.5 % (dp/p)

# Ray tracing random particles



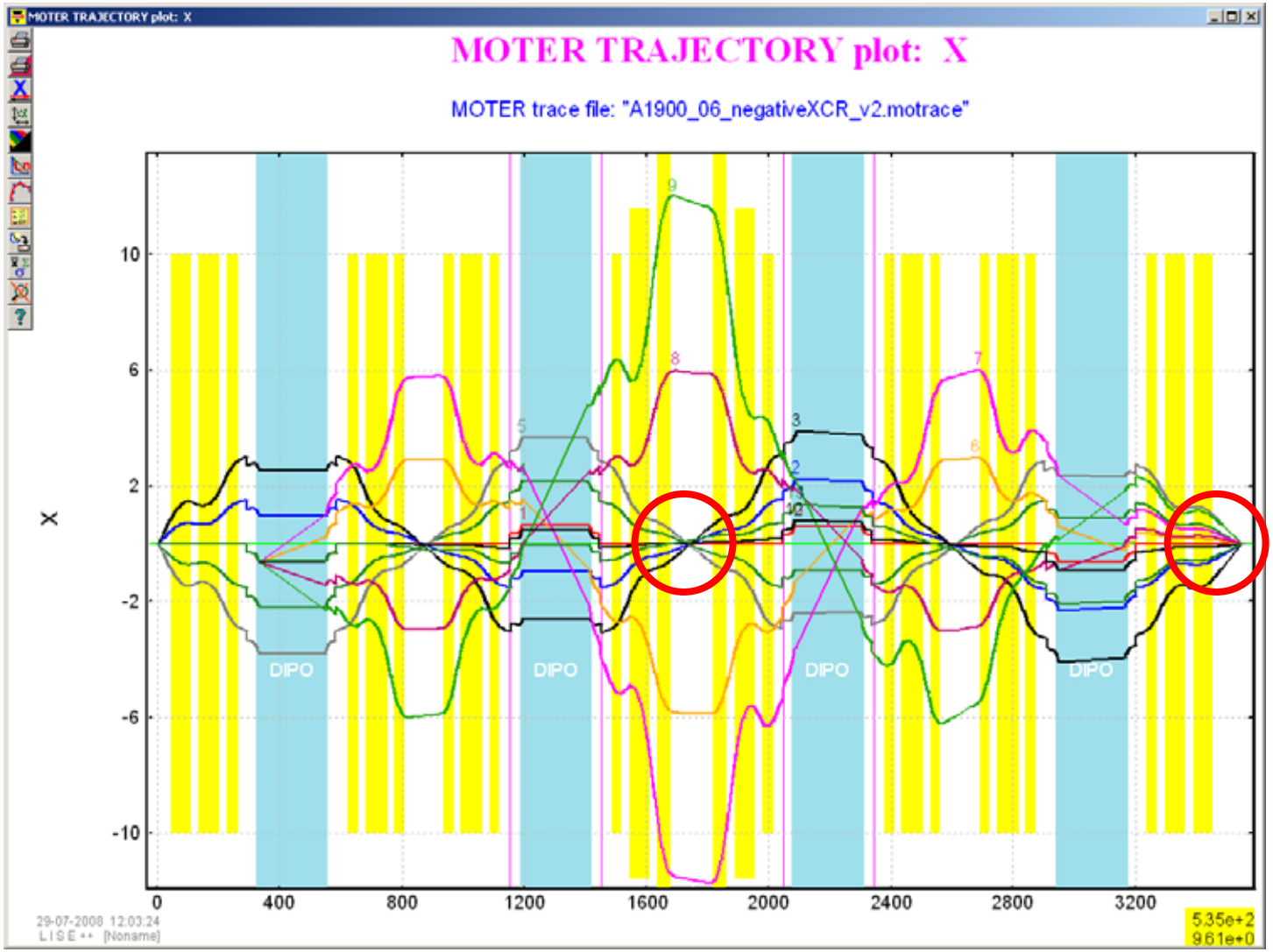

Initial Phase space: ± 60 mrad (x), ± 40 mrad (y), ± 2.5 % (dp/p)

# Initial angular distributions



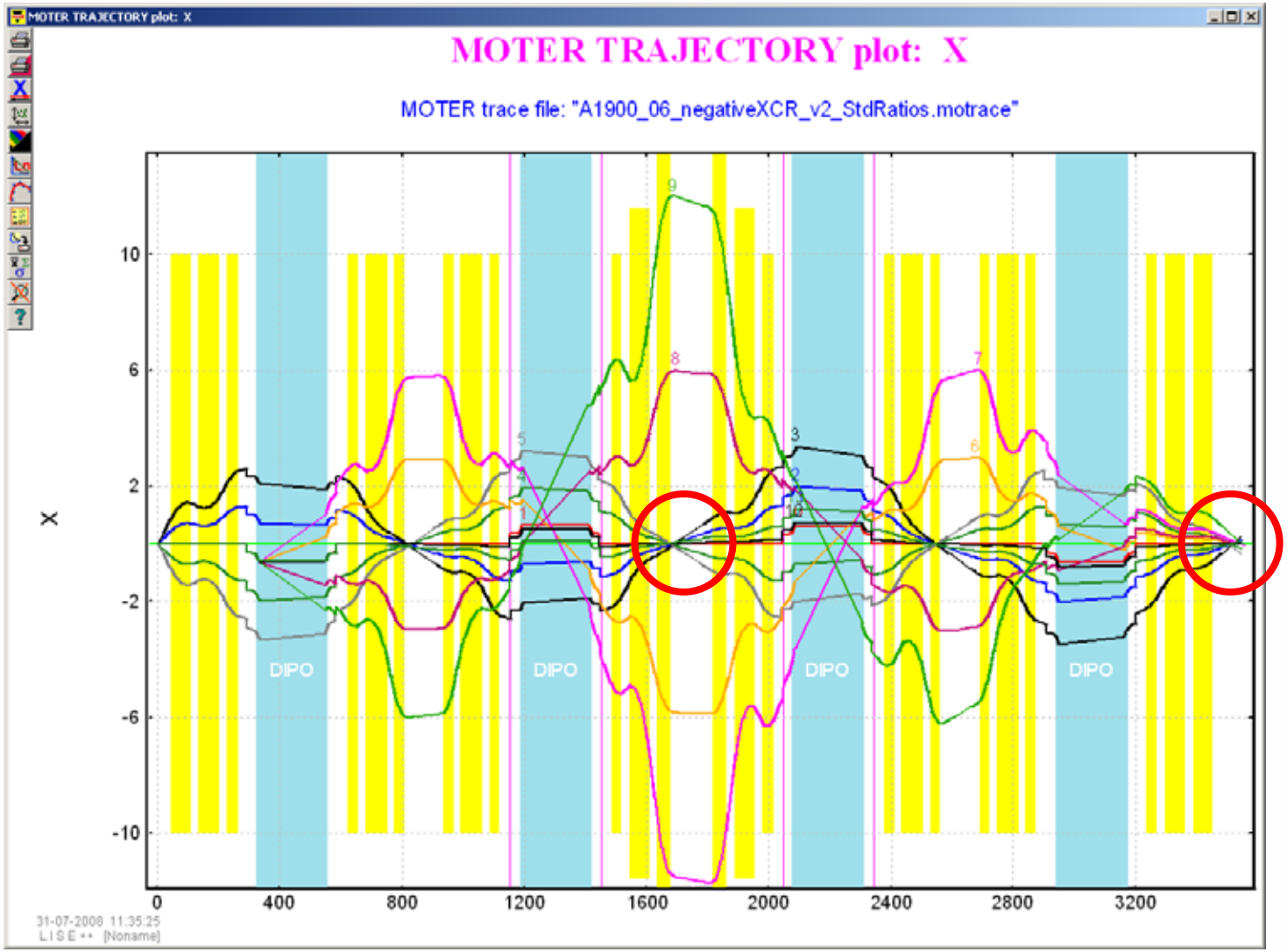

Initial Phase space: ± 60 mrad (x), ± 40 mrad (y), ± 2.5 % (dp/p)

# A1900, X-trajectories, again



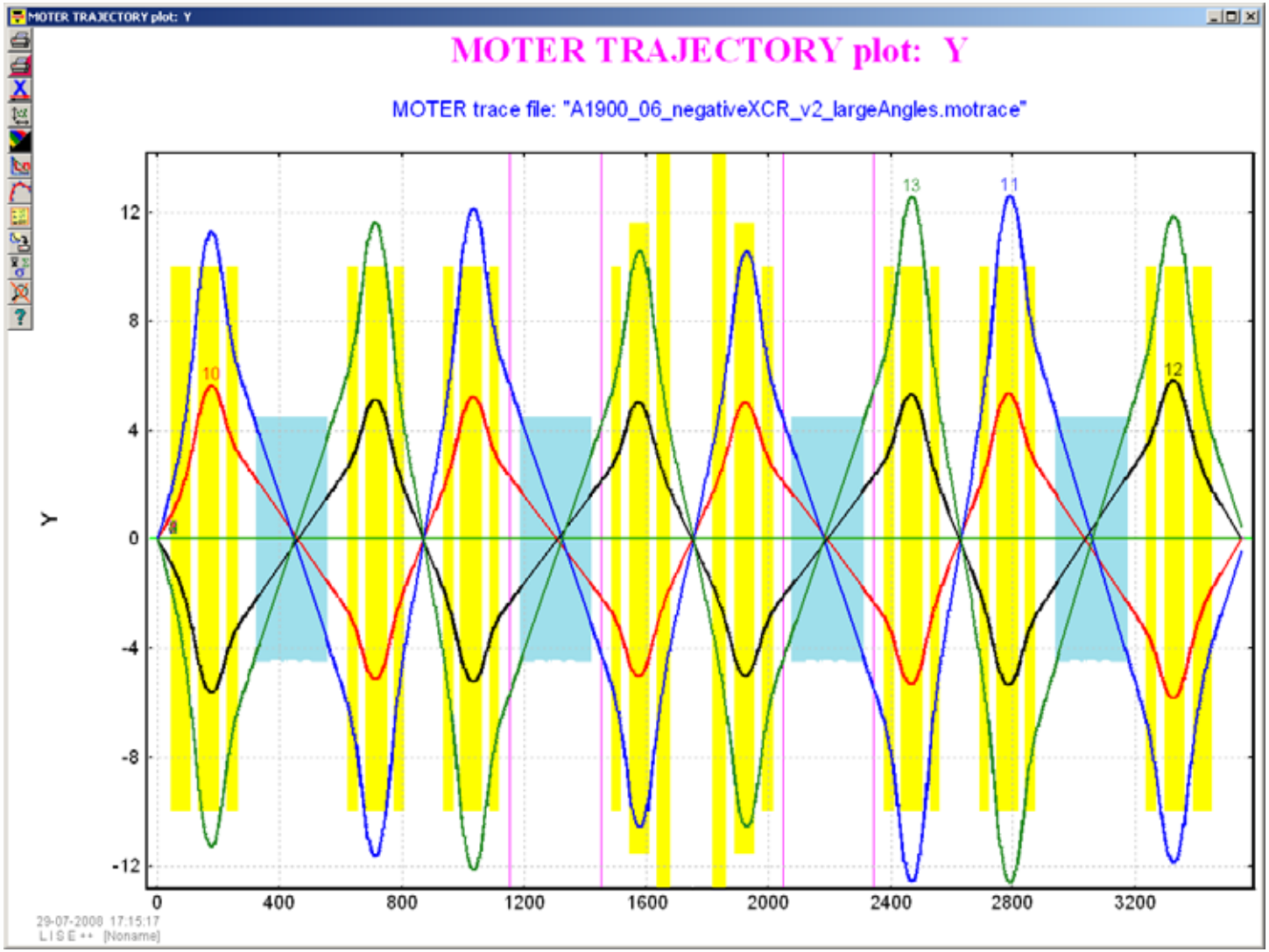

Without any non-unit ratios (±10,20 mrad, ±1,2%)

# And the same with “Std. Ratios”



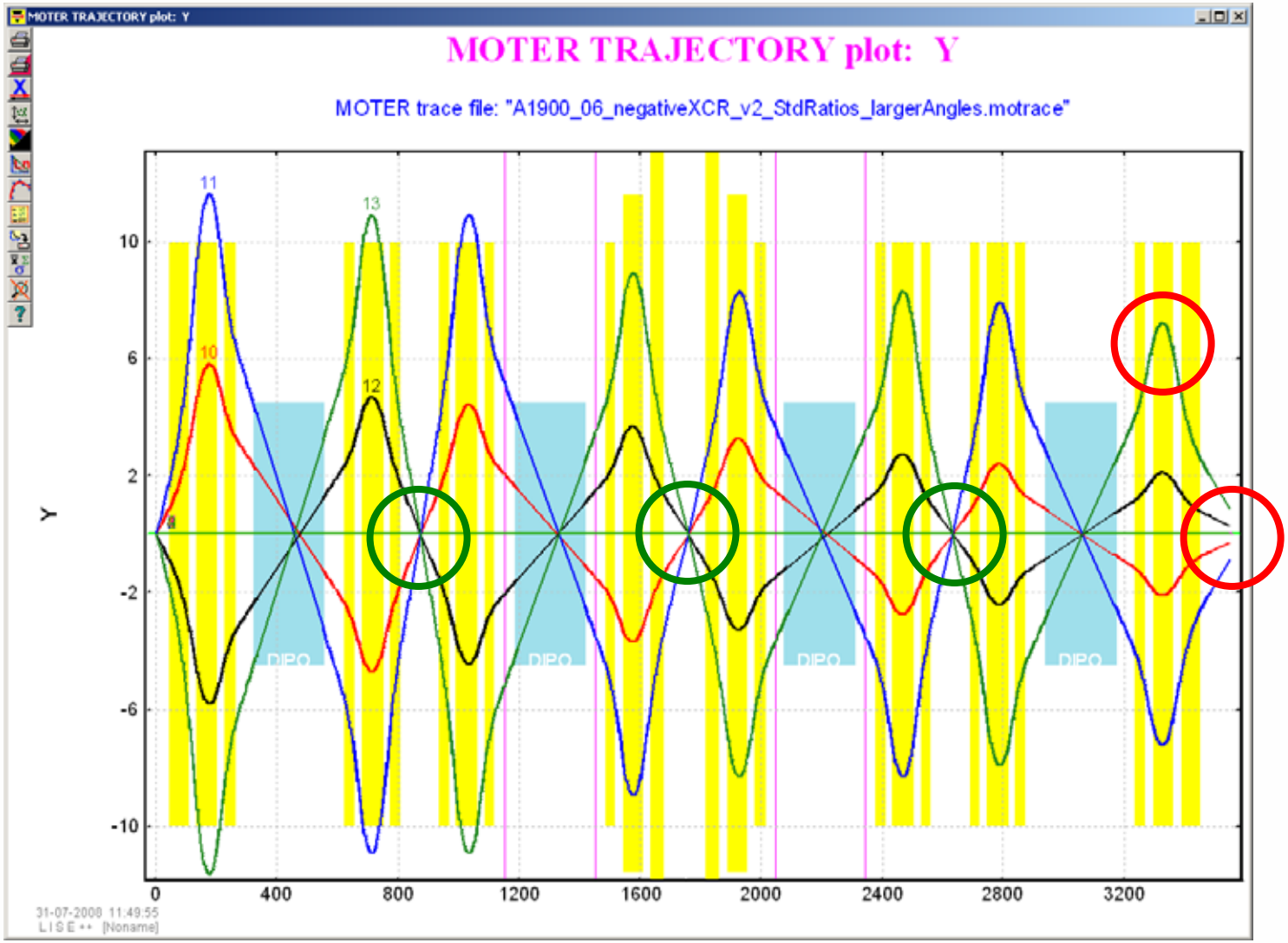

With the “standard ratios” applied to triplet 1 (same particles)

# “Untweaked” Y focusing




Without any non-unit ratios (±20,40 mrad, ±1,2%)

# And the same with “Std. Ratios”




With the “standard ratios” applied to triplet 1 (same particles)