

Purpose:

*Minimization of optics of existed separators
First step: quad fields*

First version v.9.10.100 from 05/22/15
Update v.9.10.119 from 06/23/15
Update v.9.10.156 from 07/27/15

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7. Update 1 (v. 9.10.119):
improving minimization procedure
8. Update 2 (v. 9.10.156) :
2nd order optics minimization of existed separators

Recently the first stage of optics minimization procedure was introduced, based on the “levmar” package by M.I.A. Lourakis using the Levenberg-Marquardt nonlinear least square algorithm. At this stage only the quadrupole fields can be varied to minimize user constraints for matrix and beam ellipse elements. In the future this minimization procedure will be used to define curved profile shape, fragment spatial distributions in Monte Carlo mode, and optimize intensity/purity combination.

Based on

levmar: Levenberg-Marquardt nonlinear least squares algorithms in C/C++. M.I.A. Lourakis July 2004. <http://users.ics.forth.gr/~lourakis/levmar>

Minimization for

- *E-blocks (extended configurations)*
- *with non-linked matrices*
- *set the option “Allow remote matrices recalculation”*

levmar : Levenberg-Marquardt nonlinear least squares algorithms in C/C++

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If you are looking for a general-purpose sparse Levenberg-Marquardt C/C++ implementation, please have a look at [sparseLM](#).

Introduction

This site provides [GPL](#) native ANSI C implementations of the [Levenberg-Marquardt optimization algorithm](#), usable also from C++, [Matlab](#), [Perl](#), [Python](#), [Haskell](#) and [Tcl](#) and explains their use. Both [unconstrained](#) and [constrained](#) (under linear equations, inequality and box constraints) Levenberg-Marquardt variants are included. The [Levenberg-Marquardt](#) (LM) algorithm is an iterative technique that finds a local minimum of a function that is expressed as the sum of squares of nonlinear functions. It has become a standard technique for nonlinear least-squares problems and can be thought of as a combination of [steepest descent](#) and the [Gauss-Newton](#) method. When the current solution is far from the correct one, the algorithm behaves like a steepest descent method: slow, but guaranteed to converge. When the current solution is close to the correct solution, it becomes a Gauss-Newton method.

Technical Overview

levmar includes double and single precision LM C/C++ implementations, both with analytic and finite difference approximated Jacobians. It is provided free of charge, under the terms of the [GNU General Public License](#). The mathematical theory behind unconstrained levmar is described in detail in the lecture notes entitled [Methods for Non-Linear Least Squares Problems](#), by K. Madsen, H.B. Nielsen and O. Tingleff, Technical University of Denmark; [Matlab implementations](#) of the algorithms presented in the lecture notes are also available. Note however that the formulation of the minimization problem adopted here is slightly different from that described in the [lecture notes](#). There is also a [short note](#), providing a quick overview of the material in the lecture notes.

To deal with linear equation constraints, levmar employs variable elimination based on QR factorization, as described in ch. 15 of the book [Numerical Optimization](#) by Nocedal and Wright. For the box-constrained case, levmar implements the algorithm proposed by C. Kanzow, N. Yamashita and M. Fukushima, [Levenberg-Marquardt methods for constrained nonlinear equations with strong local convergence properties](#), Journal of Computational and Applied Mathematics 172, 2004, pp. 375-397.

levmar provides the following two options regarding the solution of the linear systems formed by the augmented [normal equations](#):

1. If you have [LAPACK](#) (or an equivalent vendor library such as Intel's MKL, AMD's AMCL, Sun's performance library, IBM's ESSL, SGI's SCSL, NAG, ...), the included LAPACK-based solvers can be used. This is the default option. The employed solver is based on the LU decomposition. Additionally, for experimenting with other approaches, linear solvers based on the Cholesky and QR decompositions have been supplied.
2. If LAPACK is unavailable, a LAPACK-free, LU-based linear systems solver can be used by undefining HAVE_LAPACK in levmar.h.

- Unconstrained optimization
 - dlevmar_der(): double precision, analytic Jacobian
 - dlevmar_dif(): double precision, finite difference approximated Jacobian
 - slevmar_der(): single precision, analytic Jacobian
 - slevmar_dif(): single precision, finite difference approximated Jacobian
- Constrained optimization
 - dlevmar_lec_der(): double precision, linear equation constraints, analytic Jacobian
 - dlevmar_lec_dif(): double precision, linear equation constraints, finite difference approximated Jacobian
 - slevmar_lec_der(): single precision, linear equation constraints, analytic Jacobian
 - slevmar_lec_dif(): single precision, linear equation constraints, finite difference approximated Jacobian
 - dlevmar_bc_der(): double precision, box constraints, analytic Jacobian
 - dlevmar_bc_dif(): double precision, box constraints, finite difference approximated Jacobian
 - slevmar_bc_der(): single precision, box constraints, analytic Jacobian
 - slevmar_bc_dif(): single precision, box constraints, finite difference approximated Jacobian
 - dlevmar_blec_der(): double precision, box & linear equation constraints, analytic Jacobian
 - dlevmar_blec_dif(): double precision, box & linear equation constraints, finite difference approximated Jacobian
 - slevmar_blec_der(): single precision, box & linear equation constraints, analytic Jacobian
 - slevmar_blec_dif(): single precision, box & linear equation constraints, finite difference approximated Jacobian
 - dlevmar_bleic_der(): double precision, box, linear equation & inequality constraints, analytic Jacobian
 - dlevmar_bleic_dif(): double precision, box, linear equation & inequality constraints, finite difference approximated Jacobian
 - slevmar_bleic_der(): single precision, box, linear equation & inequality constraints, analytic Jacobian
 - slevmar_bleic_dif(): single precision, box, linear equation & inequality constraints, finite difference approximated Jacobian
- Convenience wrappers xlevmar_blic_der()/xlevmar_blic_dif(), xlevmar_leic_der()/xlevmar_leic_dif() & xlevmar_lic_der()/xlevmar_lic_dif() are also provided.

LevMar package info

LEVMAR :
Levenberg-Marquardt
nonlinear least squares
algorithms by M.I.A.Lourakis

? levmar link



LISE++

1. Select a optical block to minimize,
Check in a parameter to minimize,
Set bounds constraint
2. Create a block "Fitting constraints"
Set constraints
3. Run minimization

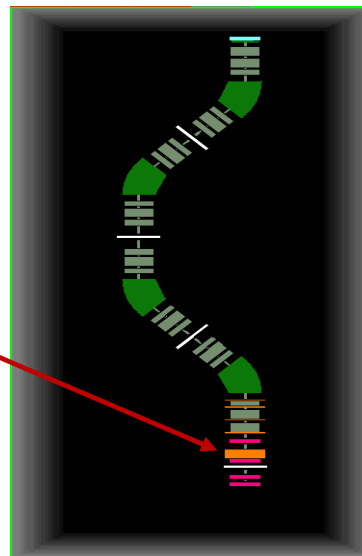
Transport

Command
`5.01 "q1B" 0.7 -1.86164 9.75 ;`

Command
`10.0 "fit1" -2.6 0.0 .001 ;`

3. Run minimization

M	FP_PPAC0	AI	2 mg/cm ²
d	z104	standard	43.2 cm
F	focusX	constraint	R 12 = 0
F	focusY	constraint	R 34 = 0
F	X-dispers	constraint	R 16 = 0
F	T-dispers	constraint	R 26 = 0
F	sigmaX	constraint	s 1 = 2
F	sigmaY	constraint	s 3 = 1
M	FP_PPAC1	AI	2 mg/cm ²
S	Image4(105)	slits	
	-150	H	+150
	-150	V	+150



files\examples\NSCL\
 A1900_extended_LISE_FIT.Ipp

The next file is to append
 standard constraint blocks
 files\examples\
 FITconstraints.Ipp

First order matrix elements: View & Print

Optics settings: FAST EDITING

Optics settings: View & Print

or

File Options Experiment Settings Physics Models Calculations

Set-Up

Optics settings (fast editing)

Block	Given Name	Start(m)	Length(m)	B0(kG)	Br(Tm)cor/*real	DriftM/*Angle	Rapp(cm)*R(...)	Leff(m)*Ldip(m)	2 nd order	CalcMatr/*Z-Q	AngAcc.Apps.Slits	COSY Fit	SE
	drift	z089	28.783	0.5640		standard					-- HV --	-	e
	= Dipole	D4	29.347	2.4300	+9.6965 * 3.0000	* +45.0	* 3.0939	* 2.4299	yes	* 0	-- HV --	-	S
	drift	z097	31.777	0.5260		standard					-- HV --	-	e
	Fit	sigY	32.303	0.0000							-- -- --	s3 < 50	e
	<Quad	Q098-8TA	32.303	0.4300	+7.0851 3.0000	QUAD	15.0000	0.4300	yes	1 R	-- HV --	FIT	e
	Fit	sigY	32.733	0.0000							-- -- --	s3 < 50	e
	drift	z099	32.733	0.1720		standard					-- HV --	-	e
	<Quad	Q100-8TB	32.905	0.7480	-8.1167 3.0000	QUAD	13.3000	0.7480	yes	1 R	-- HV --	FIT	e
	Fit	sigY	33.653	0.0000							-- -- --	s3 < 50	e
	drift	z101	33.653	0.1756		standard					-- HV --	-	e
	<Quad	Q102-8TC	33.828	0.7480	+4.2117 3.0000	QUAD	13.3000	0.7480	yes	1 R	-- HV --	FIT	e
	Fit	sigY	34.576	0.0000							-- -- --	s3 < 50	e
	drift	z103	34.576	0.3750		standard					-- HV --	-	e
	drift	z104	34.951	0.4320		standard					-- HV --	-	e
	Fit	focusX	35.383	0.0000							-- -- --	R12 = 0	e
	Fit	focusY	35.383	0.0000							-- -- --	R34 = 0	e
	Fit	X-dispers	35.383	0.0000							-- -- --	R16 = 0	e
	Fit	T-dispers	35.383	0.0000							-- -- --	R26 = 0	e
	Fit	sigmaX	35.383	0.0000							-- -- --	s1 < 2	e
	Fit	sigmaY	35.383	0.0000							-- -- --	s3 < 1	e
	slits	Image4(105)	35.383	0.0000		SLITS					-- -- HV	-	e
	drift	z105	35.383	0.3490		standard					-- -- --	-	e
	drift	z106	35.732	0.0890		standard					-- -- --	-	e

Selected block: Dispersive (M-dipole)

Block Length [m]: 0.0001

Let call automatically:

Block name = tuning

Charge State (Z-Q) = 0

Length after this block [m]: 0.0001

Selected Block Edit

Multipole Edit

Cuts (Acceptances)

Optical Matrix

Angular acceptance (mrad)

Horizontal ±: Use

Vertical ±: Use

Shape: Rectangle Ellipse

Inside Aperture (mm)

X = min: -50 max: 50 Use:

Y = min: -50 max: 50 Use:

Shape: Rectangle Ellipse

Slits (mm) after this BLOCK

X = min: max: Use:

Y = min: max: Use:

Shape: Rectangle Ellipse

1-st order Matrix Elements

Matrix Plot

Beam-Sigma Plot

View

Quit Help

Spectrometer design

Block	Given Name	Z-Q	Length,m	Enable
Q	<Quad> Q041-3TB		0.812	+
d	drift z042		0.136	+
Q	<Quad> Q043-3TC		0.43	+
d	drift z044		0.563	+
D	= Dipole D2	0	2.43	+
d	drift z052		0.552	+
Q	<Quad> Q053-4TA		0.43	+
d	drift z054		0.17	+
Q	<Quad> Q055-4TB		0.732	+
d	drift z056		0.176	+
Q	<Quad> Q057-4TC		0.526	+
d	drift z058		0.658	+
S	_slits_ Image2(059)		0	+
W	Wedge Wedge			+
d	drift z060		0.658	+
Q	<Quad> Q062-5TA		0.526	+
d	drift z063		0.176	+
Q	<Quad> Q064-5TB		0.732	+
d	drift z065		0.17	+

Selected block:
 Enable Dispersive (M-dipole)
 Let call automatically Block Length [m] 0.0001
 Block name = tuning Length after this block [m] 0
 Charge State (Z-Q) = 0 Sequence number 3

Total:
 Number of Blocks 82
 Length [m] 35.821

Insert Mode:
 before
 after

Move element:

Insert block:

Materials:

Optical:

dispersive non-dispersive

dispersive RF-based special (no beam dynamics changes)

sigY

Desired parameters of element to fit:

Constraint: Upper limit is
 Desired Value = 50
 Desired Accuracy = 1
 Constraint name = sigY
 TRANSPORT notification: 102 3 3 50 1 "sigY"

Select Element to Fit:

Global Block matrix:

	X	Y	Z	X'	Y'	Z'
1. X	2.9295	-0.5429	0	0	0	0
2. Y	1.5168	0.0604	0	0	0	0
3. Y	0	0	-27.8909	-3.0216	0	0
4. F	0	0	25.4445	2.7207	0	0
5. L	-0.0014	0.0006	0	0	1	-10.8848
6. D	0	0	0	0	0	1

Beam (sigmas):

Dimension: mm (C) cm

Det = 1.00074
 Typical TRANSPORT constraints

42* possible selection for global matrix elements and beam sigma vector

(some matrix elements can be disabled if non rotation or solenoid blocks)

The "Fit constraint" dialog. For a constraint the user selects an element from an optical matrix or beam sigma vector, and set its desired value and precision (weight).

Equal to
Lower limit is
Upper limit is

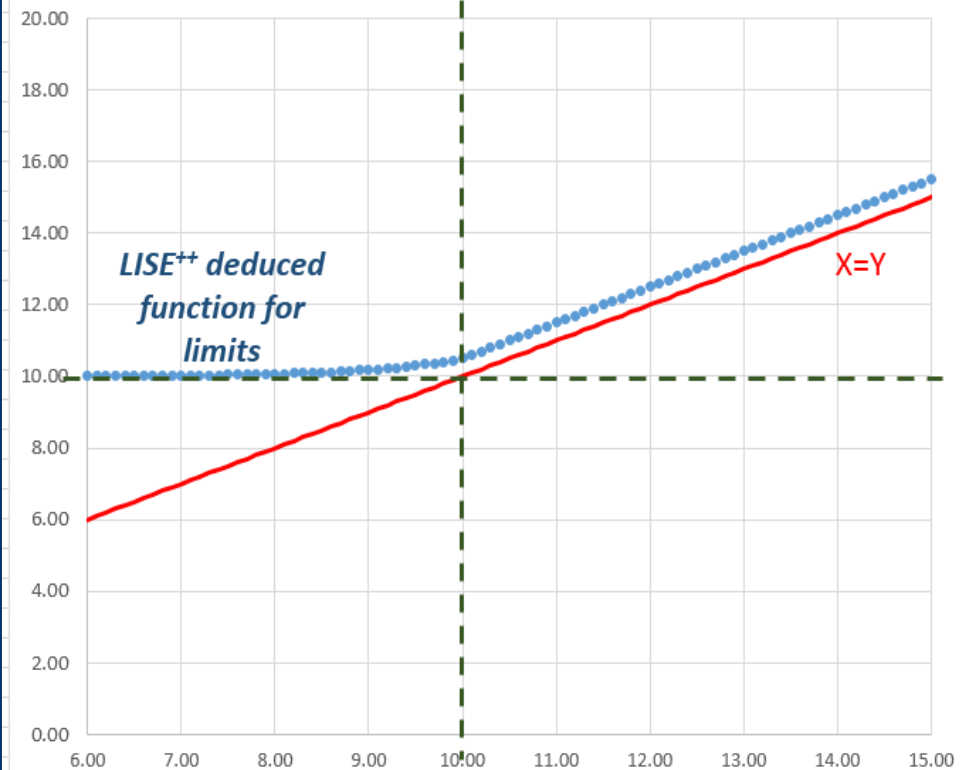
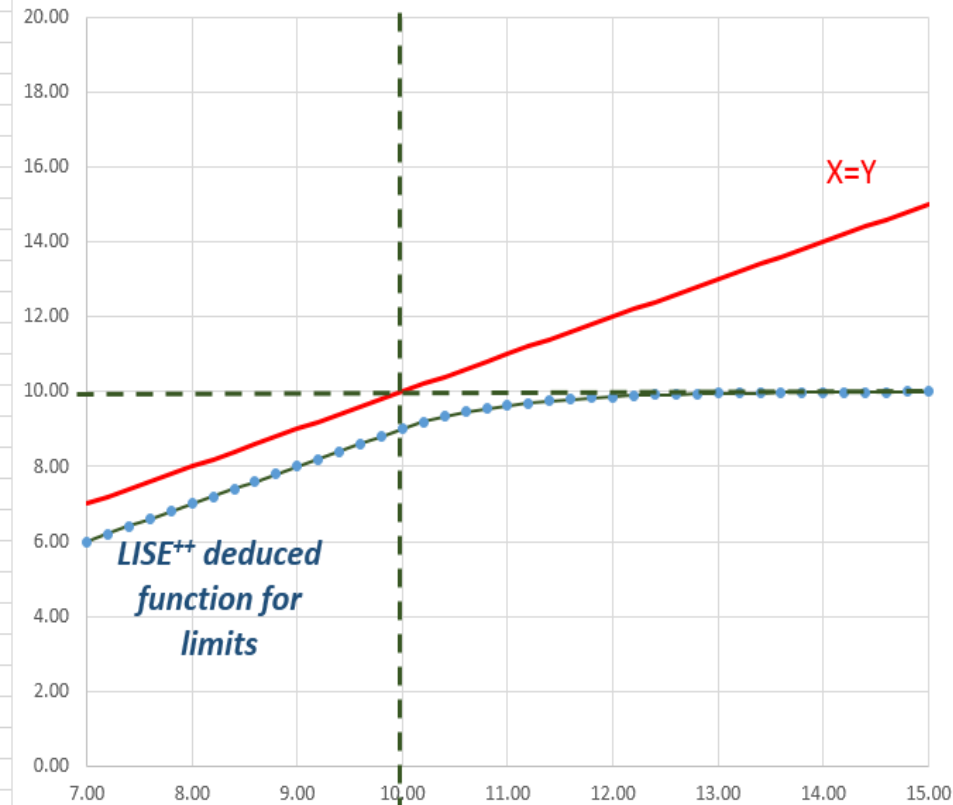
Inverse weight

TRANSPORT notification of selected constraint.
Second order constraint input under development

Desired optical condition	Typical fitting constraint
<u>Point to point imaging:</u>	
Horizontal plane $R(12) = 0$	10. -1. 2. 0. .0001 'F1';
Vertical plane $R(34) = 0$	10. -3. 4. 0. .0001 'F2';
<u>Parallel to point focus:</u>	
Horizontal plane $R(11) = 0$	10. -1. 1. 0. .0001 'F3';
Vertical plane $R(33) = 0$	10. -3. 3. 0. .0001 'F4';
<u>Point to parallel transformation:</u>	
Horizontal plane $R(22) = 0$	10. -2. 2. 0. .0001 'F5';
Vertical plane $R(44) = 0$	10. -4. 4. 0. .0001 'F6';
<u>Achromatic beam:</u>	

LowerLimit L= 10
Precision D= 1

UpperLimit L= 10
Precision D= 0.5



**Levmar functions for “equal_to” constraints are used.
Important to have limit constraints in LISE⁺⁺ for apertures
New Functions should continuous!**

In current version only M-Quad B-fields and E-Quad voltages

Set in it!

No matrix link to external file!

Experiment Settings | Physics Models | Calculations | Utilities | 1D-Plot | 2D-Plot | Databases | Help

- Projectile
- Target
- Stripper after Target
- Spectrometer Design
- Optics**
- Gamma registration
- Setting Fragment
- Tune spectrometer for the primary beam

- Tune spectrometer for setting fragment on beam axis
- Tune spectrometer for setting fragment at middle of slit
- OPTIMIZATION (optical element parameters fitting)**
- Manual recalculation of e-blocks matrices (only for Experts!)
- Update matrices linked with COSY files
- Envelope plot
- First order matrix elements : Plot
- First order matrix elements : View & Print
- Optics settings : FAST EDITING
- Optics settings : View & Print
- Brho(ErHo) Analyzer
- The First- and Second-Order Matrix Elements for an Ideal Magnet

The "Optics Fit" dialog. The left panel shows optical blocks with varying parameters, whereas blocks with fitting constraints.

Optics fit

Blocks with parameters to vary			Constraint blocks		
#01	Position@055:	Q084-7TA	#01	Position@063:	s3 < 50
#02	Position@057:	Q086-7TB	#02	Position@065:	s3 < 50
#03	Position@059:	Q088-7TC	#03	Position@068:	s3 < 50
#04	Position@064:	Q098-8TA	#04	Position@071:	s3 < 50
#05	Position@067:	Q100-8TB	#05	Position@075:	R12 = 0
#06	Position@070:	Q102-8TC	#06	Position@076:	R34 = 0
			#07	Position@077:	R16 = 0
			#08	Position@078:	R26 = 0
			#09	Position@079:	s1 < 2
			#10	Position@080:	s3 < 1

N iter = 500

Fit Settings Matrix Plot

Browse output file Beam-Sigma Plot

t4.fit

Levmar minimization settings

Options

Maximum number of iterations = 500

Use Lower & Upper bounds

LevMar package samples

Choose example = 5 (0-15)

Run minimization

Stopping thresholds

Options	Value	Stopping threshold	Default value
tau	1.00e-03	$\mu/\max(J^T J _i)$	1e-03
epsilon 1	1.00e-15	$\ J^T e\ _{inf}$	1e-15
epsilon 2	1.30e-15	$\ Dp\ _2$	1e-15
epsilon 3	1.00e-30	$\ e\ _2$	1e-20
delta	1.00e-06	approximation step *	1e-06

* delta - difference approximation step, used only in the Bounds mode. If delta < 0, the Jacobian is approximated with central differences which are more accurate (but slower) compared to the forward differences employed by default.

LevMar package info

LEVMar :
Levenberg-Marquardt
nonlinear least squares
algorithms by M.I.A.Lourakis

levmar link

Make default

Ok Cancel

For the first step use "50-100"

"levmar" package examples to play with settings

Levmar minimization settings

Options

Maximum number of iterations =

Use Lower & Upper bounds

Stopping thresholds

Options	Value	Stopping threshold	Default value
tau	<input type="text" value="1.00e-03"/>	$\mu/\max\{J^T J\}_{ii}$	1e-03
epsilon 1	<input type="text" value="1.00e-15"/>	$\ J^T e\ _{inf}$	1e-15
epsilon 2	<input type="text" value="1.30e-15"/>	$\ Dp\ _{L_2}$	1e-15
epsilon 3	<input type="text" value="1.00e-30"/>	$\ e\ _{L_2}$	1e-20
delta	<input type="text" value="1.00e-06"/>	approximation step *	1e-06

* delta -- difference approximation step, used only in the Bounds mode
If delta<0, the Jacobian is approximated with central differences which are more accurate (but slower!) compared to the forward differences employed by default.

LevMar package samples

Choose example = (0-15)

Run minimization

LevMar package info

LEVMAR :
Levenberg-Marquardt nonlinear least squares algorithms by M.I.A.Lourakis

levmar link

Make default

Ok

Cancel

"see the next page"

```

case 5:
/* Osborne's data fitting problem */
{
  double x33[]={
    8.44E-1, 9.08E-1, 9.32E-1, 9.36E-1, 9.25E-1, 9.08E-1, 8.81E-1,
    8.5E-1, 8.18E-1, 7.84E-1, 7.51E-1, 7.18E-1, 6.85E-1, 6.58E-1,
    6.28E-1, 6.03E-1, 5.8E-1, 5.58E-1, 5.38E-1, 5.22E-1, 5.06E-1,
    4.9E-1, 4.78E-1, 4.67E-1, 4.57E-1, 4.48E-1, 4.38E-1, 4.31E-1,
    4.24E-1, 4.2E-1, 4.14E-1, 4.11E-1, 4.06E-1};

  m=5; n=33;
  p[0]=0.5; p[1]=1.5; p[2]=-1.0; p[3]=1.0E-2; p[4]=2.0E-2;

  work=malloc((LM_DIF_WORKSZ(m, n)+m*m)*sizeof(double));
  if(!work){
    fprintf(stderr, "memory allocation request failed in main()\n");
    exit(1);
  }
  covar=work+LM_DIF_WORKSZ(m, n);

  if(box)
  {
    lb[0]=lb[1]=lb[2]=lb[3]=lb[4]= -20;
    ub[0]=ub[1]=ub[2]=ub[3]=ub[4]= 20;

    if(jacob) ret=dlevmar_bc_der(osborne, jacosborne, p, x33, m, n, lb, ub, NULL,
    else ret=dlevmar_bc_dif(osborne, p, x33, m, n, lb, ub, NULL,
  }
  else
  {
    if(jacob) ret=dlevmar_der(osborne, jacosborne, p, x33, m, n, N, opts, info, v
    else ret=dlevmar_dif(osborne, p, x33, m, n, N, opts, info, v
  }
}
break;

```

```

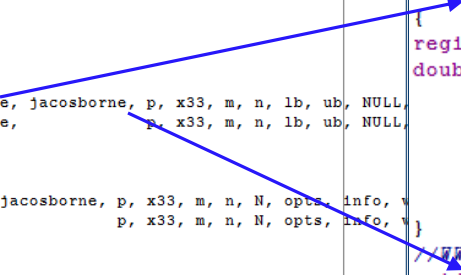
//%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
//%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
/* Osborne's problem, minimum at (0.3754, 1.9358, -1.4647, 0.0129, 0.02:
void osborne(double *p, double *x, int m, int n, void *data)
{
  register int i;
  double t;

  for(i=0; i<n; ++i){
    t=10*i;
    x[i]=p[0] + p[1]*exp(-p[3]*t) + p[2]*exp(-p[4]*t);
  }
//%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
void jacosborne(double *p, double *jac, int m, int n, void *data)
{
  register int i, j;
  double t, tmp1, tmp2;

  for(i=j=0; i<n; ++i){
    t=10*i;
    tmp1=exp(-p[3]*t);
    tmp2=exp(-p[4]*t);

    jac[j++]=1.0;
    jac[j++]=tmp1;
    jac[j++]=tmp2;
    jac[j++]=-p[1]*t*tmp1;
    jac[j++]=-p[2]*t*tmp2;
  }
//%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

```



```
/* Osborne's problem, minimum at (0.3754, 1.9358, -1.4647, 0.0129, 0.0221) */
```

```
c:\program files (x86)\lise\results\LevMar 5 00.log
Jacob: No, Box: No

==> Results for Osborne's problem(5):
Levenberg-Marquardt returned 90 in 90 iter, reason 2
Solution: 0.3754101 1.935847 -1.464687 0.01286753 0.0221227

Options info:
0: 1.000e-03      mu
1: 1.000e-15      epsilon1  ||J^T e||_inf
2: 1.000e-15      epsilon2  ||Dp||_2
3: 1.000e-20      epsilon3  ||e||_2
4: 1.000e-06      delta    approx.step

Minimization info:
0: 8.790e-01      ||e||_2 at initial p
1: 5.465e-05      ||e||_2
2: 4.899e-10      ||J^T e||_inf
3: 5.068e-31      ||Dp||_2
4: 2.233e+01      mu/max[J^T J]_ii
5: 90             # iterations
6: 2             # reason for terminating
7: 141           # function evaluations
8: 10           # Jacobian evaluations
9: 91           # linear systems solved, i.e. # attempts for reducing error

Termination reason: 2 - stopped by small Dp

Covariance of the fit :
+4.293184e-06 +4.168233e-04 -4.204934e-04 +8.751658e-07 -1.635539e-06
+4.168233e-04 +4.853246e-02 -4.884843e-02 +9.847883e-05 -1.962537e-04
```

```
c:\program files (x86)\lise\results\LevMar 5 01.log
Jacob: No, Box: Yes
Low Bounds:-20 -20 -20 -20 -20
Upp Bounds:+20 +20 +20 +20 +20

==> Results for Osborne's problem(5):
Levenberg-Marquardt returned 24 in 24 iter, reason 2
Solution: 0.3754098 1.935822 -1.464662 0.01286748 0.0221228

Options info:
0: 1.000e-03      mu
1: 1.000e-15      epsilon1  ||J^T e||_inf
2: 1.000e-15      epsilon2  ||Dp||_2
3: 1.000e-20      epsilon3  ||e||_2
4: 1.000e-06      delta    approx.step

Minimization info:
0: 8.790e-01      ||e||_2 at initial p
1: 5.465e-05      ||e||_2
2: 1.902e-07      ||J^T e||_inf
3: 3.009e-33      ||Dp||_2
4: 7.378e-11      mu/max[J^T J]_ii
5: 24             # iterations
6: 2             # reason for terminating
7: 983          # function evaluations
8: 24           # Jacobian evaluations
9: 24           # linear systems solved, i.e. # attempts for reducing error

Termination reason: 2 - stopped by small Dp

Covariance of the fit :
```

```
c:\program files (x86)\lise\results\LevMar 5 10.log
Jacob: Yes, Box: No

==> Results for Osborne's problem(5):
Levenberg-Marquardt returned 31 in 31 iter, reason 2
Solution: 0.3754101 1.935847 -1.464687 0.01286753 0.0221227

Options info:
0: 1.000e-03      mu
1: 1.000e-15      epsilon1  ||J^T e||_inf
2: 1.000e-15      epsilon2  ||Dp||_2
3: 1.000e-20      epsilon3  ||e||_2
4: 1.000e-06      delta    approx.step

Minimization info:
0: 8.790e-01      ||e||_2 at initial p
1: 5.465e-05      ||e||_2
2: 4.522e-09      ||J^T e||_inf
3: 5.227e-30      ||Dp||_2
4: 4.923e+01      mu/max[J^T J]_ii
5: 31             # iterations
6: 2             # reason for terminating
7: 40           # function evaluations
8: 31           # Jacobian evaluations
9: 40           # linear systems solved, i.e. # attempts for reducing error

Termination reason: 2 - stopped by small Dp

Covariance of the fit :
+4.294491e-06 +4.169215e-04 -4.205927e-04 +8.751991e-07 -1.636147e-06
+4.169215e-04 +4.853941e-02 -4.885547e-02 +9.847325e-05 -1.963069e-04
```

```
c:\program files (x86)\lise\results\LevMar 5 11.log
Jacob: Yes, Box: Yes
Low Bounds:-20 -20 -20 -20 -20
Upp Bounds:+20 +20 +20 +20 +20

==> Results for Osborne's problem(5):
Levenberg-Marquardt returned 28 in 28 iter, reason 2
Solution: 0.3754101 1.935847 -1.464687 0.01286753 0.0221227

Options info:
0: 1.000e-03      mu
1: 1.000e-15      epsilon1  ||J^T e||_inf
2: 1.000e-15      epsilon2  ||Dp||_2
3: 1.000e-20      epsilon3  ||e||_2
4: 1.000e-06      delta    approx.step

Minimization info:
0: 8.790e-01      ||e||_2 at initial p
1: 5.465e-05      ||e||_2
2: 1.435e-09      ||J^T e||_inf
3: 0.000e+00      ||Dp||_2
4: 7.488e-11      mu/max[J^T J]_ii
5: 28             # iterations
6: 2             # reason for terminating
7: 1359        # function evaluations
8: 28           # Jacobian evaluations
9: 28           # linear systems solved, i.e. # attempts for reducing error

Termination reason: 2 - stopped by small Dp

Covariance of the fit :
```

Box: No

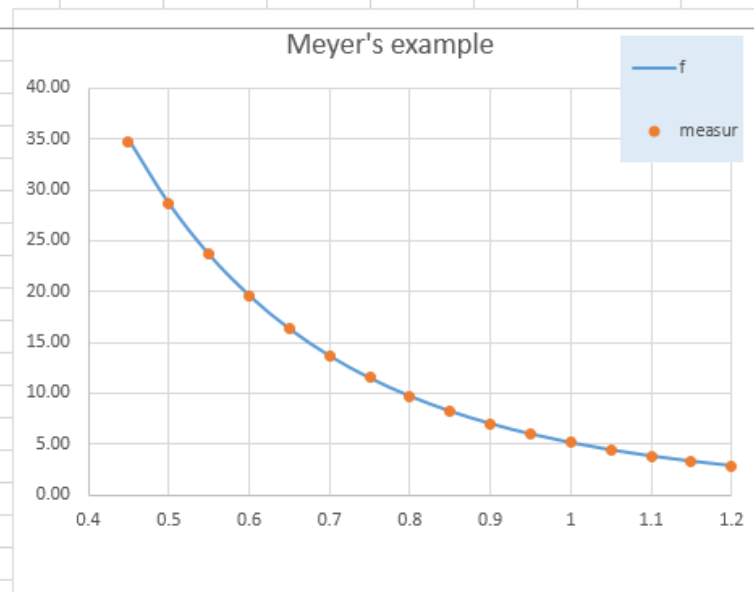
Jacobian: No

Box: Yes

Jacobian: Yes

With Boxes is slower!!

i	ui	f	measur	delta
0	0.45	34.92	34.78	5.49E-04
1	0.5	28.65	28.61	4.47E-05
2	0.55	23.63	23.65	2.15E-05
3	0.6	19.59	19.63	8.29E-05
4	0.65	16.32	16.37	1.35E-04
5	0.7	13.67	13.72	2.10E-04
6	0.75	11.49	11.54	1.77E-04
7	0.8	9.71	9.744	1.11E-04
8	0.85	8.24	8.261	5.74E-05
9	0.9	7.02	7.03	1.69E-05
10	0.95	6.00	6.005	4.68E-07
11	1	5.15	5.147	9.77E-06
12	1.05	4.44	4.427	4.58E-05
13	1.1	3.84	3.82	1.10E-04
14	1.15	3.33	3.307	1.95E-04
15	1.2	2.90	2.872	2.94E-04



f_excel	f_levmar	delta	delta/f
34.92	34.78	0.14	0.39%
28.65	28.61	0.04	0.13%
23.63	23.64	-0.02	-0.07%
19.59	19.63	-0.04	-0.22%
16.32	16.38	-0.05	-0.32%
13.67	13.72	-0.05	-0.37%
11.49	11.54	-0.04	-0.38%
9.71	9.74	-0.03	-0.35%
8.24	8.26	-0.02	-0.28%
7.02	7.03	-0.01	-0.17%
6.00	6.01	0.00	-0.04%
5.15	5.15	0.01	0.13%
4.44	4.43	0.01	0.33%
3.84	3.82	0.02	0.55%
3.33	3.31	0.03	0.79%
2.90	2.87	0.03	1.06%

p0	9.460866	2.48	8.85
p1	5.096541	6.15	4
p2	3.112559	3.45	2.5

LevMar	5.72E-06	init
p0	2.48	8.85
p1	6.18	4
p2	3.50	2.5

Excel	2.06E-03	init
p0	9.46	8.85
p1	5.10	4
p2	3.11	2.5

$$x[i]=p[0]*\exp(10.0*p[1]/(ui+p[2]) - 13.0)$$

Initial parameters for both cases

Levmar results

Excel results

Levmar chi-square result by 3 orders of magnitude is lower, than Excel's result!!!

You can get plots before fitting process and after to compare values

Optics fit

Blocks with parameters to vary			Constraint blocks		
#01	Position@055:	Q084-7TA	#01	Position@063:	$s3 < 50$
#02	Position@057:	Q086-7TB	#02	Position@065:	$s3 < 50$
#03	Position@059:	Q088-7TC	#03	Position@068:	$s3 < 50$
#04	Position@064:	Q098-8TA	#04	Position@071:	$s3 < 50$
#05	Position@067:	Q100-8TB	#05	Position@075:	$R12 = 0$
#06	Position@070:	Q102-8TC	#06	Position@076:	$R34 = 0$
			#07	Position@077:	$R16 = 0$
			#08	Position@078:	$R26 = 0$
			#09	Position@079:	$s1 < 2$
			#10	Position@080:	$s3 < 1$

N iter = 500

Fit

Restore previous values

Exit

Help

Fit Settings

Matrix Plot

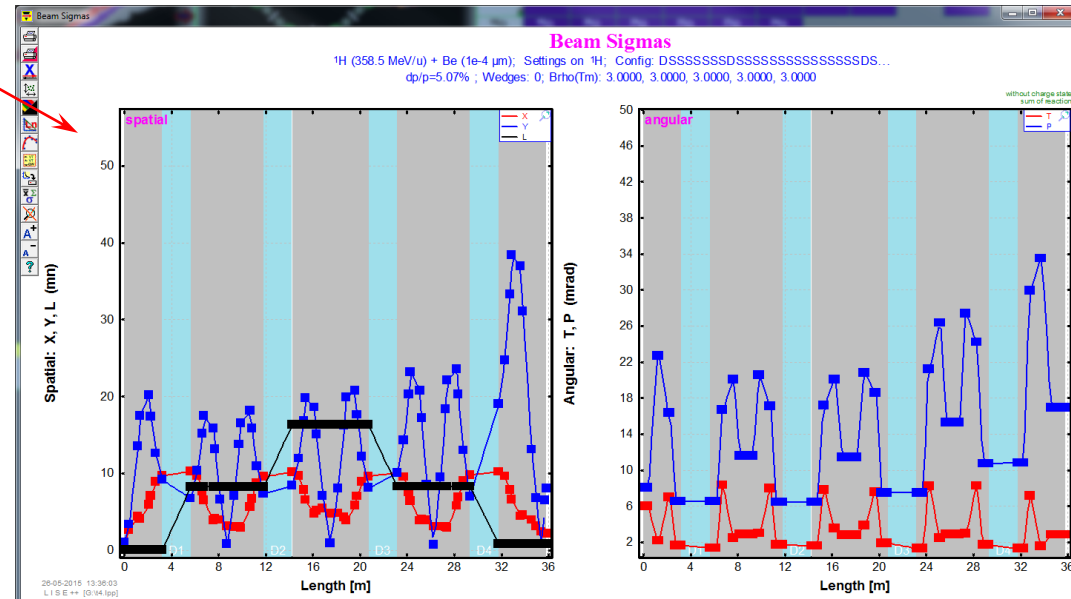
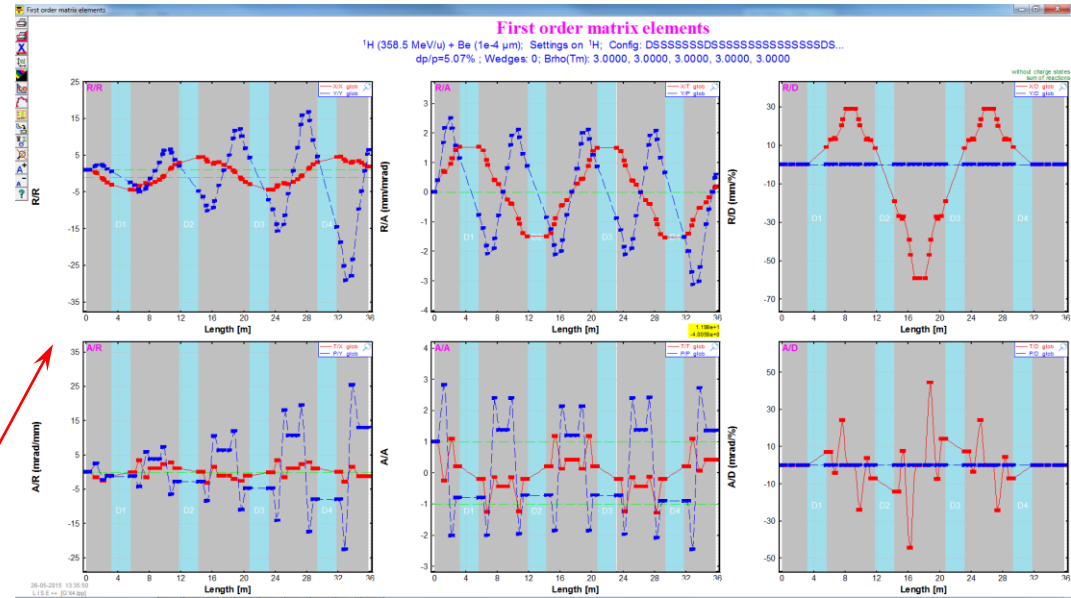
Browse output file

Beam-Sigma Plot

t4.fit

After fitting process it is possible to restore initial settings

Initial log-file name is LISE++ filename with the "fit" extension. Located by default in the directory "LISEresult"



```
t4.fit
Initial +641.499 and Final +641.173 LISE fit reduced values

Parameters:      LeftBound      Initial      RightBound      Final
#01: Q084-7TA   -1.000e+99 < +9.403e+00 < +1.000e+99    +8.916e+00
#02: Q086-7TB   -1.000e+99 < -1.083e+01 < +1.000e+99    -9.624e+00
#03: Q088-7TC   -1.000e+99 < +8.752e+00 < +1.000e+99    +7.892e+00
#04: Q098-8TA   -2.000e+01 < +7.085e+00 < +2.000e+01    +6.310e+00
#05: Q100-8TB   -4.000e+01 < -5.000e+00 < +2.000e+01    -6.152e+00
#06: Q102-8TC   -1.000e+01 < +4.212e+00 < +4.000e+01    +3.994e+00

-----
Fitting values:      Initial      Final      Precision (Fin-Des)/P      Desired
#01: sigY            +2.469e+01 +1.648e+00 1.000e+00 0.000e+00 < +5.00e+01
#02: sigY            +3.323e+01 +3.167e+00 1.000e+00 0.000e+00 < +5.00e+01
#03: sigY            +4.555e+01 +6.177e+00 1.000e+00 0.000e+00 < +5.00e+01
#04: sigY            +4.716e+01 +7.588e+00 1.000e+00 0.000e+00 < +5.00e+01
#05: focusX         +6.022e-01 -1.913e-06 1.000e-03 1.913e-03 = +0.00e+00
#06: focusY         -5.364e+00 -8.493e-01 5.000e-01 1.699e+00 = +0.00e+00
#07: X-dispers      -1.287e-13 -1.767e-06 1.000e-03 1.767e-03 = +0.00e+00
#08: T-dispers      +2.814e-13 -2.038e-05 1.000e-02 2.038e-03 = +0.00e+00
#09: sigmaX         +3.618e+00 +1.991e+00 1.000e-01 9.911e-01 < +2.00e+00
#10: sigmaY         +6.510e+01 +1.134e+01 1.000e-02 1.035e+03 < +1.00e+00

-----
==> Results for t4.fit:
Levenberg-Marquardt returned 500 in 500 iter, reason 3
Solution: 8.916349 -9.623625 7.891567 6.309539 -6.152035 3.993751

Minimization info:
0: 4.147e+07 ||e||_2 at initial p
1: 4.111e+07 ||e||_2
2: 2.840e+00 ||J^T e||_inf
3: 2.275e-06 ||Dp||_2
4: 2.378e-04 nu/max[J^T J]_ii
5: 500 # iterations
6: 3 reason for terminating
7: 4499 # function evaluations
8: 500 # Jacobian evaluations
9: 500 # linear systems solved, i.e. # attempts for reducing error

Termination reason: 3 - stopped by itaax
```

Appears automatically after fitting process completed

It is planning to use different colors and fonts to underline, to select key moments

```
==> "sigmaY" : last fitting block global optical matrix and sigma vector

----- G L O B A L -----
Format [nm-nrad]
----- matrix -----
+1.991e+00 -1.913e-06 0 0 0 -1.767e-06 1.99e+00
-1.482e+00 +5.025e-01 0 0 0 -2.038e-05 3.36e+00
0 0 -9.083e+00 -8.493e-01 0 0 1.13e+01
0 0 -3.325e+00 -4.210e-01 0 0 4.73e+00
-1.428e-03 +5.792e-04 0 0 1.0 -1.088e+01 7.62e-01
0 0 0 0 0 +1.000e+00 7.00e-02

-----
Covariance of the fit :
+3.071318e+15 -7.383656e+15 +5.433857e+15 +6.802513e+16 -1.067550e+17 +2.799623e+15
-7.383595e+15 +1.775066e+16 -1.306325e+16 -1.635389e+17 +2.566550e+17 -6.742622e+15
+5.433800e+15 -1.306322e+16 +9.613624e+15 +1.203536e+17 -1.888818e+17 +4.964434e+15
+7.835533e+16 -1.883748e+17 +1.386313e+17 +1.182920e+18 -9.006090e+17 -1.998218e+18
-1.408364e+17 +3.385910e+17 -2.491815e+17 -1.296397e+18 -1.118888e+18 +6.699783e+18
+4.149371e+16 -9.976589e+16 +7.342309e+16 -1.150617e+18 +5.385893e+18 -7.714485e+18
```

Multipole: Q100-8TB

Magnetic Multipole Settings

QUADrupole SEXTupole

L_{eff} (effective length) mode: <Keep> 0.748 m

B (field at pole tip) **-8.11665** 0 kG

Radius (half-aperture) 13.3 5 cm

Multipole fixed Brho-value corresponding to the setting fragment 3 Tm

Calculate 2nd order matrix elements

Allow remote matrices recalculation

Recalculate B(field) for the fragment current Brho

Calculate Optical matrix

Use in Fitting

Use Bounds constraints

Bounds (kG): lower -40, upper 20

Buttons: Recalculate B(field) for the fragment current Brho, Calculate Optical matrix, Edit optical matrix, OK, Cancel

Let's destroy it manually

Multipole: Q100-8TB

Magnetic Multipole Settings

QUADrupole SEXTupole

L_{eff} (effective length) mode: <Keep> 0.748 m

B (field at pole tip) **-4** 0 kG

Radius (half-aperture) 13.3 5 cm

Multipole fixed Brho-value corresponding to the setting fragment 3 Tm

Calculate 2nd order matrix elements

Allow remote matrices recalculation

Recalculate B(field) for the fragment current Brho

Calculate Optical matrix

Use in Fitting

Use Bounds constraints

Bounds (kG): lower -40, upper 20

Buttons: Recalculate B(field) for the fragment current Brho, Calculate Optical matrix, Edit optical matrix, OK, Cancel

Optics fit

Blocks with parameters to vary

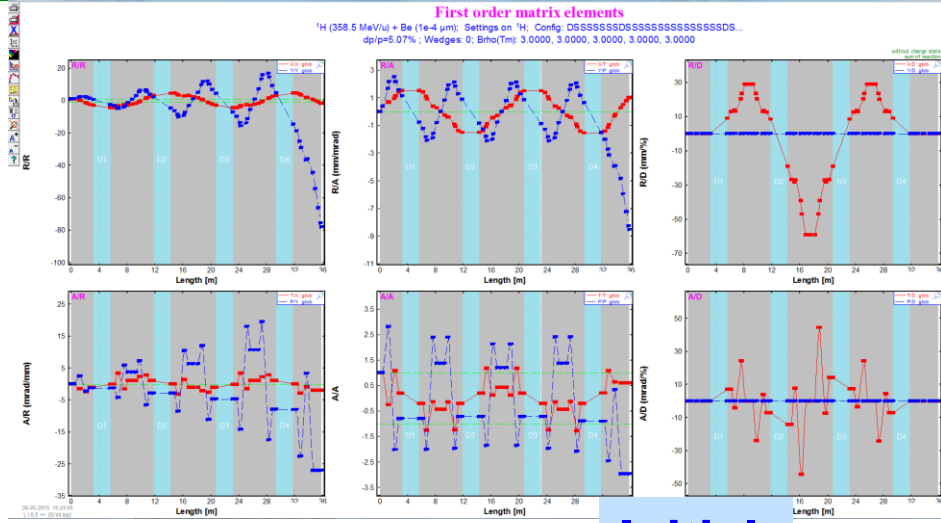
Constraint blocks

#01 Position@054: Q084-7TA	#01 Position@062: s3 < 50
#02 Position@056: Q086-7TB	#02 Position@064: s3 < 50
#03 Position@058: Q088-7TC	#03 Position@067: s3 < 50
#04 Position@063: Q098-8TA	#04 Position@070: s3 < 50
#05 Position@066: Q100-8TB	#05 Position@074: R12 = 0
#06 Position@069: Q102-8TC	#06 Position@075: R34 = 0
	#07 Position@076: R16 = 0
	#08 Position@077: R26 = 0
	#09 Position@078: s1 < 3
	#10 Position@079: s3 < 1

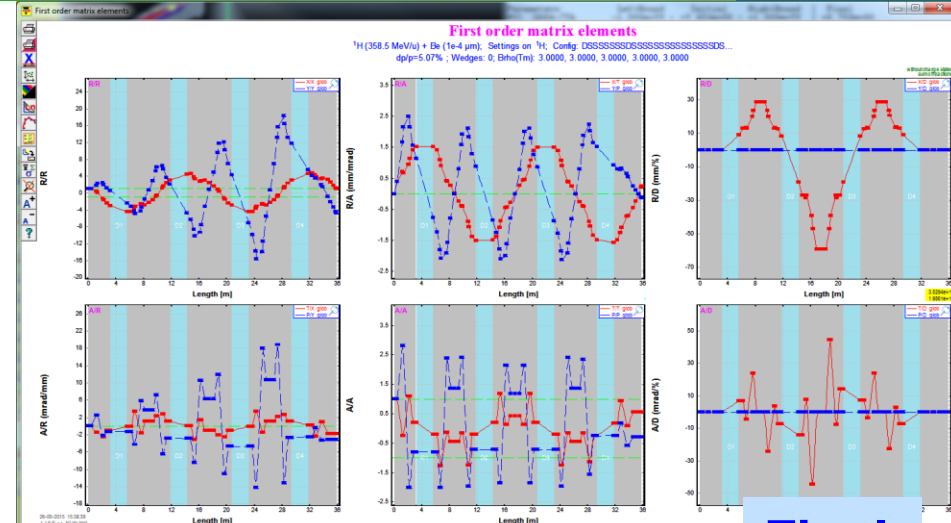
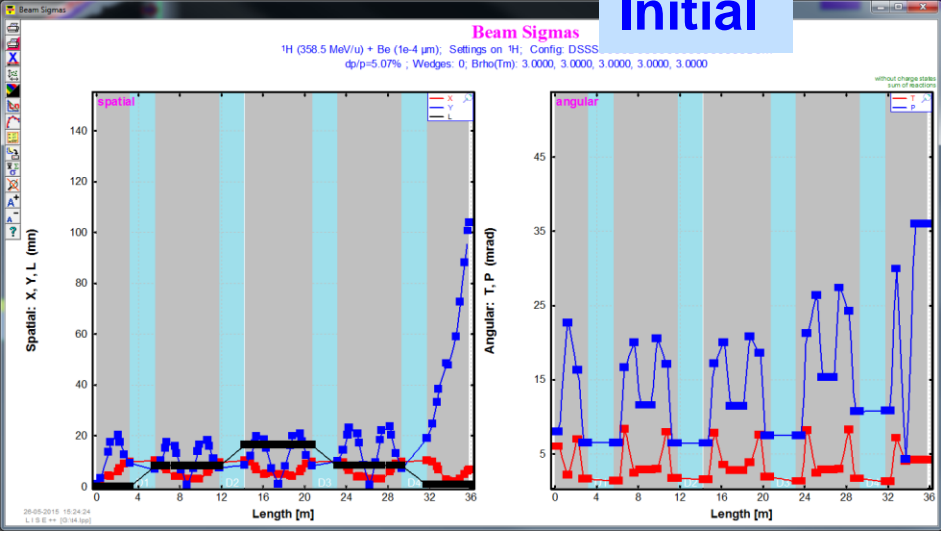
N iter = 500

Buttons: Fit, Restore previous values, Fit Settings, Matrix Plot, Browse output file, Beam-Sigma Plot, t4.fit, Exit, Help

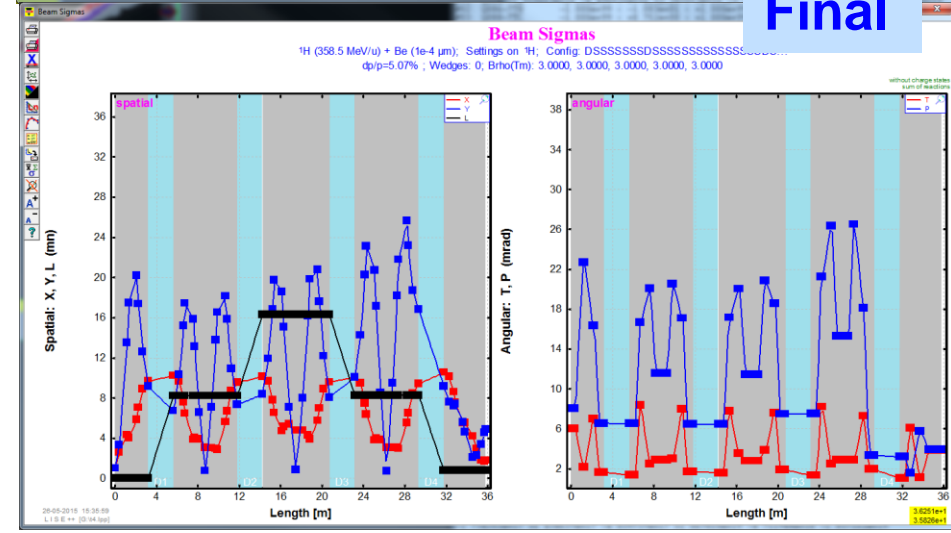
Example for A1900 (1)



Initial



Final



Initial +870.782 and Final +870.318 LISE fit reduced values

Parameters:	LeftBound	Initial	RightBound	Final
#01: Q084-7TA	-1.000e+99	< +9.403e+00	< +1.000e+99	+8.750e+00
#02: Q086-7TB	-1.000e+99	< -1.083e+01	< +1.000e+99	-9.228e+00
#03: Q088-7TC	-1.000e+99	< +8.752e+00	< +1.000e+99	+7.597e+00
#04: Q098-8TA	-2.000e+01	< +7.085e+00	< +2.000e+01	+5.738e+00
#05: Q100-8TB	-4.000e+01	< -4.000e+00	< +2.000e+01	-5.247e+00
#06: Q102-81C	-1.000e+01	< +4.212e+00	< +4.000e+01	+4.103e+00

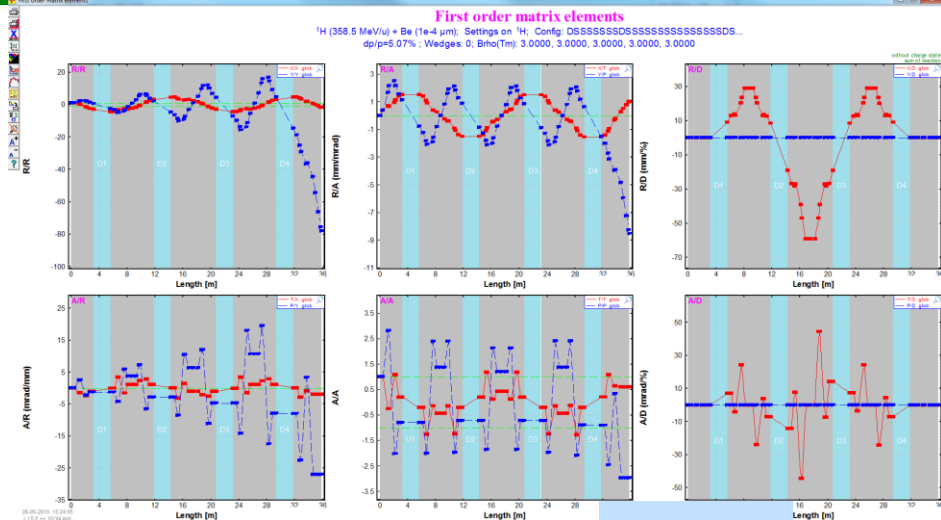
Fitting values:

	Initial	Final	Precision	(Fin-Des)/P	Desired
#01: sigY	+2.469e+01	+7.589e+00	1.000e+00	0.000e+00	< +5.00e+01
#02: sigY	+3.323e+01	+7.188e+00	1.000e+00	0.000e+00	< +5.00e+01
#03: sigY	+4.846e+01	+5.595e+00	1.000e+00	0.000e+00	< +5.00e+01
#04: sigY	+5.902e+01	+2.098e+00	1.000e+00	0.000e+00	< +5.00e+01
#05: focusX	+7.758e-01	+5.198e-05	1.000e-03	5.198e-02	= +0.00e+00
#06: focusY	-7.236e+00	+3.918e-05	5.000e-01	7.836e-05	= +0.00e+00
#07: X-dispers	+7.190e-05	+3.171e-15	1.000e-03	3.171e-12	= +0.00e+00
#08: T-dispers	-1.354e-04	-3.960e-15	1.000e-02	3.960e-13	= +0.00e+00
#09: sigmaX	+4.744e+00	+1.789e+00	1.000e-01	2.952e-01	< +3.00e+00
#10: sigmaY	+8.802e+01	+3.395e+00	1.000e-02	2.405e+02	< +1.00e+00

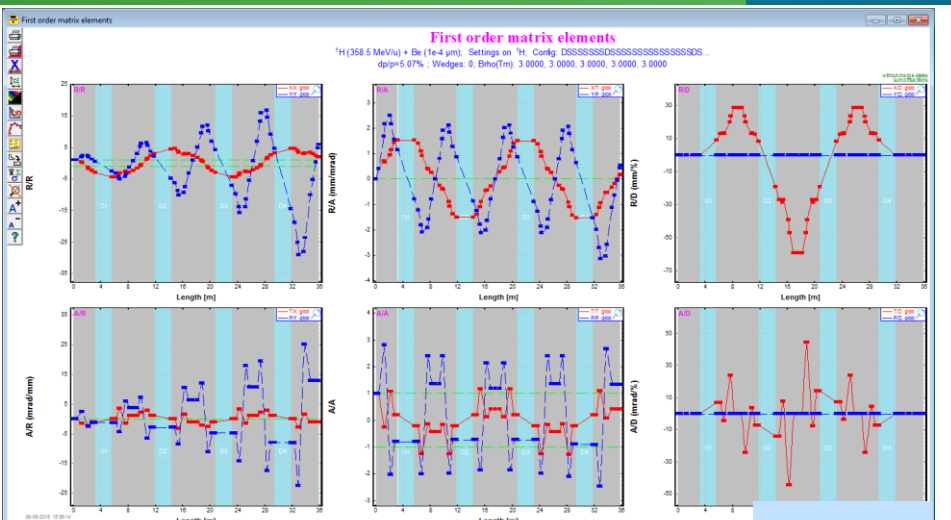
The Quad field value was not restored exactly

The last constaint was not succesfull

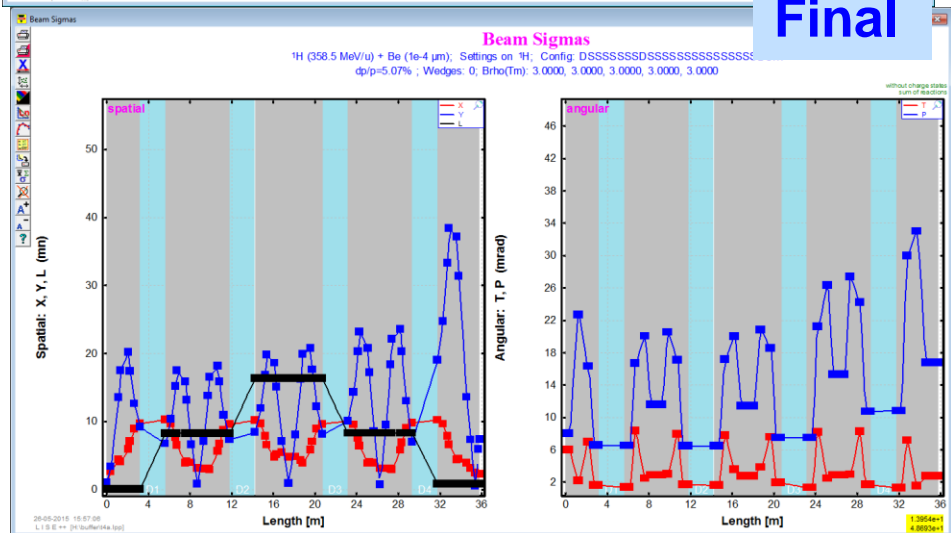
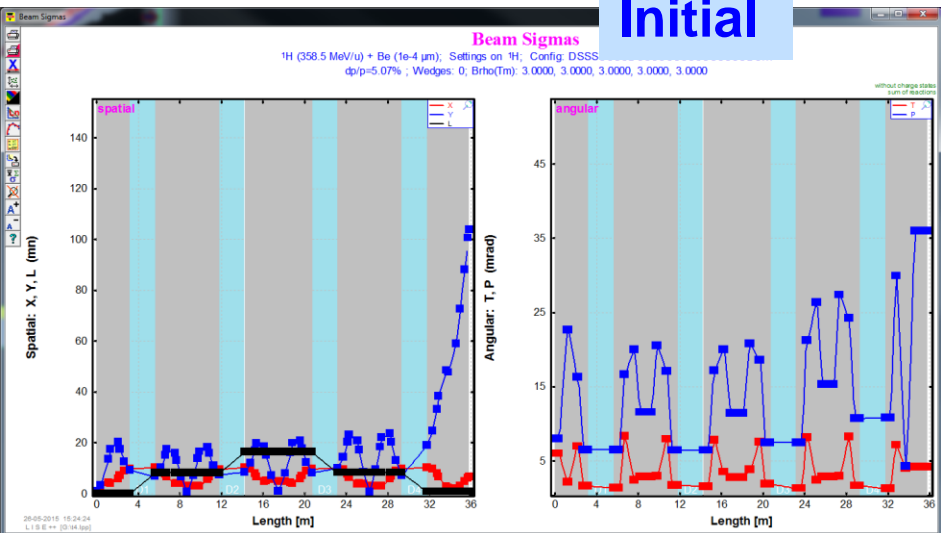
Example for A1900 (2) -- only last triplet to use in fit



Initial



Final



Fitting values:	Initial	Final	Precision	(Fin-Des)/P	Desired
#01: sigY	+2.469e+01	+2.469e+01	1.000e+00	1.014e-11	< +5.00e+01
#02: sigY	+3.323e+01	+3.323e+01	1.000e+00	5.224e-08	< +5.00e+01
*#03: sigY	+4.846e+01	+3.711e+01	1.000e+00	2.536e-06	< +5.00e+01
#04: sigY	+5.902e+01	+1.355e+01	1.000e+00	0.000e+00	< +5.00e+01
#05: focusX	-7.758e-01	-1.178e-06	1.000e-03	1.178e-03	= +0.00e+00
#06: focusY	-7.236e+00	-4.717e-02	5.000e-01	9.434e-02	= +0.00e+00
#07: X-dispers	+7.190e-05	+3.588e-04	1.000e-03	3.588e-01	= +0.00e+00
#08: T-dispers	-1.354e-04	-5.358e-05	1.000e-02	5.358e-03	= +0.00e+00
#09: sigmaX	+4.744e+00	+2.414e+00	1.000e-01	5.564e-01	< +3.00e+00
#10: sigmaY	+8.802e+01	+4.777e-01	1.000e-02	5.931e-01	< +1.00e+00

Initial +870.782 and Final +870.376 LISE fit reduced values

Parameters:	LeftBound	Initial	RightBound	Final
#01: Q100-8TB	-4.000e+01	< -4.000e+00	< +2.000e+01	-8.040e+00
#02: Q102-8TC	-1.000e+01	< +4.212e+00	< +4.000e+01	+4.040e+00

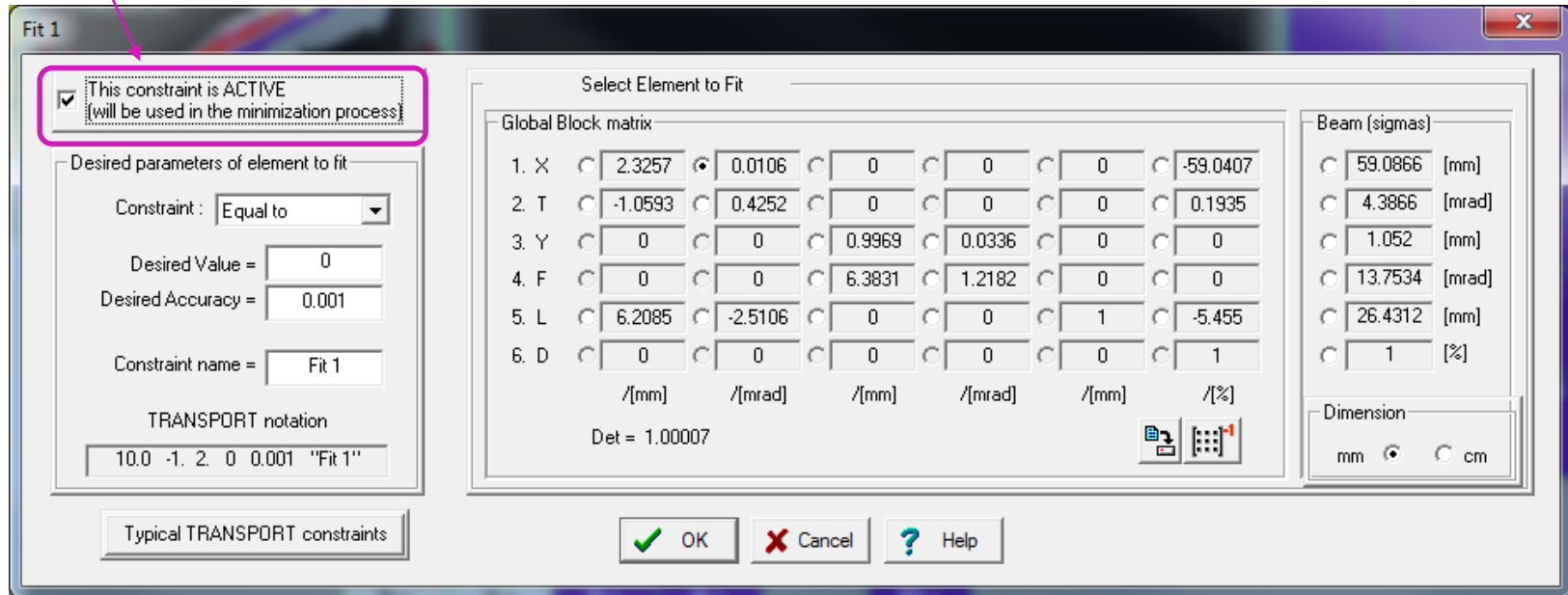
The Quad field value was restored

All constraints are good!

Update
v.9.10.119
from 06/23/15

1. Fitting constraint block : new option “Active”
2. Change the Fitting option "Active" in the “Fast Edit Optics” dialog
3. New Option in the Preferences dialog: show "Fit" blocks in the Scheme and Setup windows
4. Appearance of Fitting constraint blocks in Menus, Dialog, Windows
5. Call the "Fast Edit Optics" dialog from the Optics optimization dialog
6. User Break in the Minimization process
7. Miscellaneous for fitting procedure
8. Miscellaneous for v.9.10.119

New option



- If it is not “active”, then the block will still enable in the Setup and FastEditOptics dialogs, but it won’t be shown in The Scheme and Setup windows
- This property it can be easily changed from the “Fast Edit Optics” dialog (see the next slide)

Application for Fitting constraint blocks

Optics settings (fast editing)

Block	Given Name	Start(m)	Length(m)	B0(kG)	Br(Tm)cor*/real	DriftM*/Angle	Rapp(cm)*/R(...)	Leff(m)*/Ldip(m)	2nd order	CalcMatr*/Z-Q	AngAccApps,Slits	COSYIFit	SE
Fit	Fit 7	16.385	0.0000									s1 < 150	e
Fit	Fit 8	16.385	0.0000									s3 < 150	e
drift	DR37	16.385	0.1584			standard							e
<Quad>	SC_Q36	16.543	0.3782	+4.2659	1.0000	MULT	15.0000	0.3782	yes	1 R	-- HV --	FIT	e
Fit	Fit 9	16.921	0.0000									s1 < 150	e
Fit	Fit 10	16.921	0.0000									s3 < 150	e
drift	DR38	16.921	0.6854			standard							e
=ElecDip	ElecDip 1	17.607	1.5359	0.0kV	1.0051	* -22.0	* 4.0000	* 1.5359	yes	* 1 R	-- H --		E
drift	DR41	19.143	0.6853			standard							e
<Quad>	SC_Q41	19.828	0.3782	+3.0592	1.0051	MULT	15.0000	0.3782	yes	1 R	-- HV --	FIT	e
Fit	Fit 11	20.206	0.0000									s1 < 150	e
Fit	Fit 12	20.206	0.0000									s3 < 150	e
drift	DR42	20.206	0.1584			standard							e
<Quad>	SC_Q42	20.365	0.3782	-6.2604	1.0051	MULT	15.0000	0.3782	yes	1 R	-- HV --	FIT	e
Fit	Fit 13	20.743	0.0000									s1 < 150	e
Fit	Fit 14	20.743	0.0000									s3 < 150	e
drift	DR43	20.743	0.1584			standard							e
<Quad>	SC_Q43	20.901	0.3782	+4.6019	1.0051	MULT	15.0000	0.3782	yes	1 R	-- HV --	FIT	e
drift	DR44	21.279	0.5634			standard							e
Fit	foc3 x	21.849	0.0000									R12 = 0	e
Fit	focy 3	21.849	0.0000									// R34 = 0	no
slits	F3	21.849	0.0000			SLITS							e
drift	DR45	21.849	0.6894			standard							e

Selected block: focy 3

Block Length [m]: 0

Length after this block [m]: 21.8487

Use in the FIT process:

Angular acceptance (mrad): Horizontal \pm , Vertical \pm

Inside Aperture (mm): X = -50 to 50, Y = -50 to 50

Slits (mm) after this BLOCK: X =, Y =

1-st order Matrix Elements: Matrix Plot, Beam-Sigma Plot, View

Quit, Help

Selected block: focy 3

Block Length [m]: 0

Length after this block [m]: 21.8487

Use in the FIT process:

Angular acceptance (mrad): Horizontal \pm , Vertical \pm

Inside Aperture (mm): X = -50 to 50, Y = -50 to 50

Slits (mm) after this BLOCK: X =, Y =

1-st order Matrix Elements: Matrix Plot, Beam-Sigma Plot, View

Quit, Help

R12 = 0
R34 = 0

Preferences

Starting files and working directories

Starting configuration at loading the program: A1900_2015.lcn Browse

Starting options file at loading the program: A1900_2015.lopt Browse

Working directory

Current user has administrative privileges: Yes

LISE++ working directory (options, config, etc) is: User \ My Documents LISE++ root directory

Options dialogs

Target optimization options

Scheme options

Plot options

Calculation settings

Calculation threshold = 1.0e-10 pps

Dimension of distribution (NP) recommended

calculation WITHOUT charge states	64	64
calculation WITH charge states	32	32
wedge calculation	32	16

Calculate spectrometer settings using

maximal mean

value of the momentum distribution

left peak right peak

Charge States Calculation

No Yes

Apply the "Edge" effect in distribution cuts

Yes (default) No (recommended for extended configurations)

Cross Section

Fit File CS File Settings

Transmission information in the Table of Nuclides

Display 1: Total: All reactions (pps)

Display 2: Total ion transmission (%)

Utility options

- Navigation map
- Spectrometer scheme
- Sound
- 3D-Balls Animation
- Primary beam seeking in a target
- Show Fitting constraint blocks in the Setup and Scheme windows

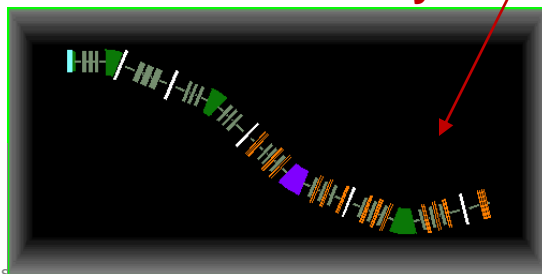
Debug & expert options

- Show transmission calculation time
- Charge State Optimization Debugging Mode
- Distribution Debugging Mode (file 'distrib.txt')
- Check LIZ-file consistency (Configurations)
- Check LIZ-file consistency (Options)
- Hold angles of an inclination of a target and a stripper together

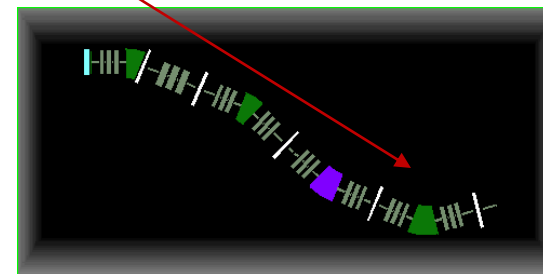
Make default

OK Cancel Help

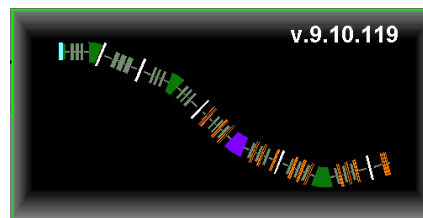
yes



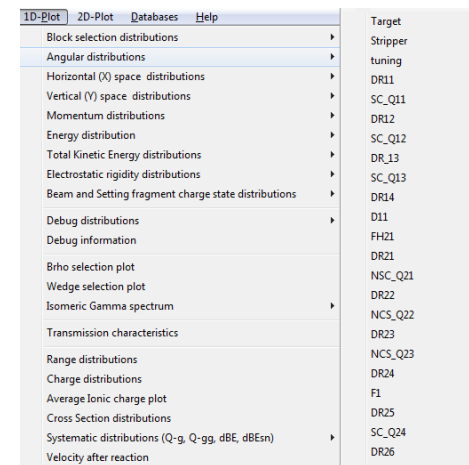
no



Setup scheme



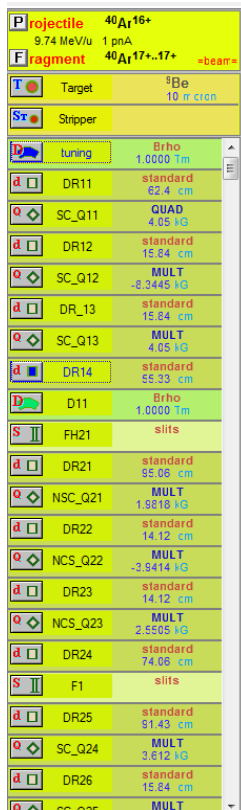
Menus



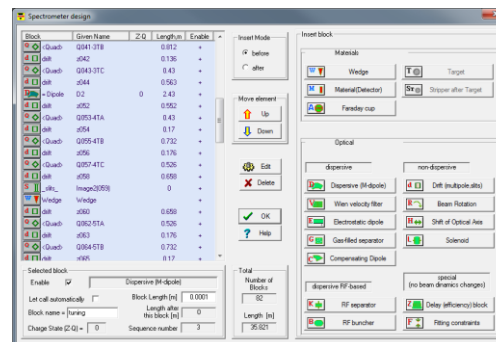
Window	Show
Setup window	only Active*
Setup scheme	only Active*
Setup dialog ("Spectrometer design")	always
Optics settings dialog (fast editing)	always
Menus	never
Monte Carlo calculation of fragment transmission	never

* - show only "Active", if the corresponding option is set the "Preferences" dialog

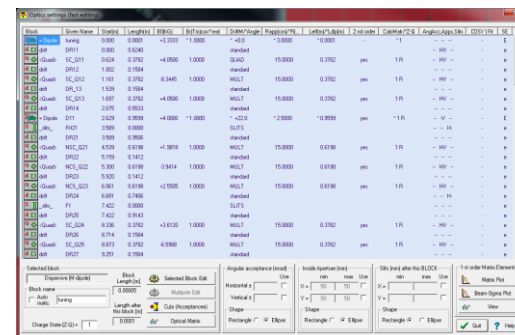
Setup window



Setup dialog ("Spectrometer design")



Optics settings (fast editing)



Monte Carlo calculation of fragment transmission



Call the "Fast Edit Optics" dialog from the Optics optimization dialog

Optics fit

Blocks with parameters to vary

```
#01 Position@030: SC_Q31
#02 Position@032: SC_Q32
#03 Position@034: SC_Q33
#04 Position@042: SC_Q34
#05 Position@044: SC_Q35
#06 Position@048: SC_Q36
#07 Position@054: SC_Q41
#08 Position@058: SC_Q42
#09 Position@062: SC_Q43
#10 Position@068: SC_Q44
#11 Position@072: SC_Q45
#12 Position@076: SC_Q46
#13 Position@082: SC_Q51
#14 Position@086: SC_Q52
#15 Position@090: SC_Q53
```

Active Constraint blocks

```
#01 @038: R16 = 0 disp2
#02 @039: R12 = 0 foc2 x
#03 @040: R34 = 0 foc2 y
#04 @045: s1 < 150 Fit 7
#05 @046: s3 < 150 Fit 8
#06 @049: s1 < 150 Fit 9
#07 @050: s3 < 150 Fit 10
#08 @055: s1 < 150 Fit 11
#09 @056: s3 < 150 Fit 12
#10 @059: s1 < 150 Fit 13
#11 @060: s3 < 150 Fit 14
#12 @064: R12 = 0 foc3 x
#13 @065: R34 = 0 foc3 y
#14 @069: s1 < 150 Fit 17
#15 @070: s3 < 150 Fit 18
#16 @073: s1 < 150 Fit 19
#17 @074: s3 < 150 Fit 20
```

N iter = 30

FIT

Exit

Help

Restore previous values

Optics Settings (fast editing)

Fit Settings

Browse output file

Matrix Plot

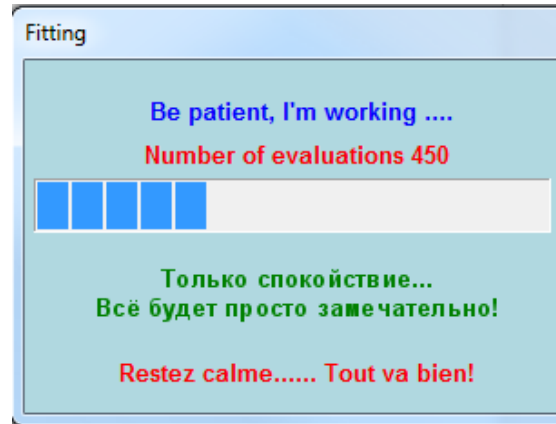
Beam-Sigma Plot

eS3_dispersive v4_5.fit

Block	Given Name	Start(z)	Length(m)	BEG(D)	BE(T) (m)/rad	DeltA(M) (m) / angle	Frapp(m) (%)	Let(m) / (L) (mm)	2 nd order	CalcMatr(2Q)	AngularApert.Sits	CDVY(1/F)	SE
0	Dipole	turning	0.000	0.000	-3.3333	-1.0000	* +0.0	* -0.0001		* 1			E
1	DR11	0.000	0.6240				standard						E
2	SC_Q11	0.624	0.3782	+4.0500	1.0000		QUAD	15.0000	0.3782	yes	1 R		E
3	DR12	1.002	0.1584				standard						E
4	SC_Q12	1.161	0.3782	8.3445	1.0000		MULT	15.0000	0.3782	yes	1 R		E
5	DR_13	1.539	0.1584				standard						E
6	SC_Q13	1.697	0.3782	+4.0500	1.0000		MULT	15.0000	0.3782	yes	1 R		E
7	DR14	2.075	0.5533				standard						E
8	Dipole	D11	2.629	0.9599	+4.0000	+1.0000	* +22.0	* 2.5000	* 0.9599	yes	* 1 R		E
9	FR21	3.589	0.0000				SLITS						E
10	DR21	3.589	0.9506				standard						E
11	NSC_Q21	4.539	0.6198	+1.9819	1.0000		MULT	15.0000	0.6198	yes	1 R		E
12	DR22	5.159	0.1412				standard						E
13	NSC_Q22	5.300	0.6198	-3.9414	1.0000		MULT	15.0000	0.6198	yes	1 R		E
14	DR23	5.920	0.1412				standard						E
15	NSC_Q23	6.061	0.6198	-2.5505	1.0000		MULT	15.0000	0.6198	yes	1 R		E
16	DR24	6.681	0.7406				standard						E
17	FR1	7.422	0.0000				SLITS						E
18	DR25	7.422	0.9143				standard						E
19	SC_Q24	8.336	0.3782	+3.6120	1.0000		MULT	15.0000	0.3782	yes	1 R		E
20	DR26	8.714	0.1584				standard						E
21	SC_Q25	8.873	0.3782	-6.5988	1.0000		MULT	15.0000	0.3782	yes	1 R		E
22	DR27	9.251	0.1584				standard						E

Without leaving the "Optics fit" dialog it is possible to load the "Fast Optics Edit" dialog where you can set/unset "Active" properties, modify Fitting constraint block parameters, or enter a Quad field value.

Press the "Escape" button to cancel the minimization procedure

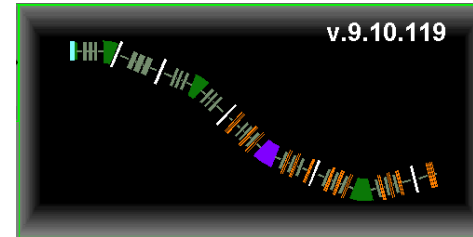


```
#26: foc4 x      +1.036e-02  +2.328e-03  1.000e-03  2.328e+00  | = +0.00e+00
#27: foc4 y      +7.946e-02  -3.101e-02  1.000e-01  3.101e-01  | = +0.00e+00
#28: disp4      +1.077e+01  +1.048e-02  1.000e-02  1.048e+00  | = +0.00e+00
#29: beamy4     +3.799e+00  +1.446e+01  1.000e-01  3.913e-03  | < +2.00e+01
```

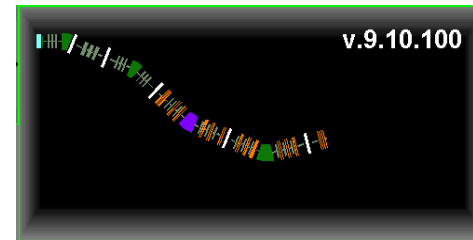
==> Results for eS3_dispersive v4_5.fit:
Termination reason: USER BREAK after 600 evaluations!

```
Minimization info:
0: 1.160e+06      ||e||_2 at initial p
1: 1.153e+02      ||e||_2
2: 3.298e+03      ||J^T e||_inf
3: 7.967e-29      ||Dp||_2
4: 1.377e-05      mu/max[J^T J]_ii
5: 300            # iterations
```

- New functions BLOCKnext and BLOCKprevious with "noFit" options



- Corrections for Separator scheme in the case of Fitting block



- “SetFocus” back in the Fast Edit Optics dialog

f11: SC_Q45	-1.0e+01	<	-6.060e+00	<	+0.0e+00	-6.406e+00
f12: SC_Q46	+0.0e+00	<	+3.296e+00	<	+1.0e+01	+2.890e+00
f13: SC_Q51	+0.0e+00	<	+2.517e+00	<	+1.0e+01	+2.798e+00
f14: SC_Q52	-1.0e+01	<	-5.905e+00	<	+0.0e+00	-5.845e+00
f15: SC_Q53	+0.0e+00	<	+3.202e+00	<	+1.0e+01	+3.456e+00

Fitting values:						
	Initial	Final	Precision	(Fin-Des)/P	Desired	
f01: disp2	+1.158e-01	+8.581e-02	1.0e-02	+8.581e+00	=	0
f02: foc2 x	+3.150e-04	-3.143e-04	1.0e-03	+3.143e-01	=	0
f03: foc2 y	+5.912e-01	+6.146e-01	1.0e-01	+6.146e+00	=	0
f04: Fit 7	+2.487e+01	+3.303e+01	1.0e-01	0	<	150
f05: Fit 8	+2.314e+01	+3.266e+01	1.0e-01	0	<	150
f06: Fit 9	+3.827e+01	+5.153e+01	1.0e-01	0	<	150
f07: Fit 10	+1.665e+01	+2.289e+01	1.0e-01	0	<	150
f08: Fit 11	+1.014e+02	+8.777e+01	1.0e-01	0	<	150
f09: Fit 12	+2.119e+01	+2.143e+01	1.0e-01	0	<	150
f10: Fit 13	+1.433e+02	+1.278e+02	1.0e-01	0	<	150
f11: Fit 14	+2.145e+01	+2.170e+01	1.0e-01	0	<	150
f12: foc3 x	-5.376e-03	-2.484e-03	1.0e-02	+2.484e-01	=	0
f13: foc3 y	-5.088e-02	-4.954e-02	1.0e-01	+4.954e-01	=	0
f14: Fit 17	+1.487e+02	+1.239e+02	1.0e-01	0	<	150
f15: Fit 18	+2.367e+00	+2.228e+00	1.0e-01	0	<	150
f16: Fit 19	+6.993e+01	+6.356e+01	1.0e-01	0	<	150
f17: Fit 20	+5.935e+00	+6.123e-01	1.0e-01	0	<	150
f18: Fit 21	+2.821e+01	+3.745e+01	1.0e-01	0	<	150

- Minimization output modification

Purpose:

2nd order optics minimization of existed separators

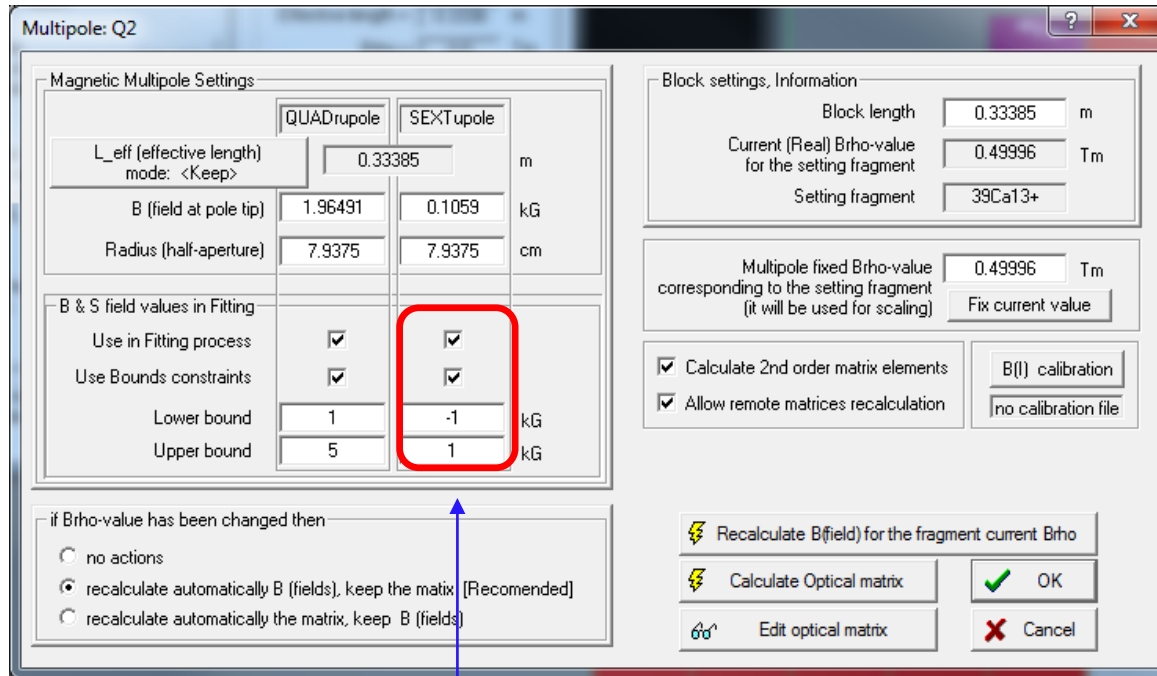
v.9.10.156
from 07/27/15

1. Introduction: First order optics minimization in LISE⁺⁺ (links)
2. Modification of M-multipole blocks for 2nd order optimization
3. Modification of the “Fitting constraints” block for 2nd order
 - *Aberrations list*
4. Run new minimization version
 - *High order truncation problem*
5. “OptBeam” : New Beam sigma vector used only in the Optics Optimization

Additionally:

[v.9.10.142](#) [22-07-15](#)

[Using LISE⁺⁺ optics minimization for the DRAGON2000 extended configuration development](#)



New feature: using sextupole fields in the Optimization process.
Evidently, it has an effect only in the 2nd order optimization

Block	Given Name	Start(m)	Length(m)	B0(kG)*U	B1(Tm)cor/real	DriftM/*Angle	Rapp(cm)*R(...)	Leff(m)*Ldip(m)	2 nd order	CalcMatr/*Z-Q	AngAcc.Apps.Slits	CDSY Fit	SE
Dipole	tuning	0.000	0.0000	+1.6665	* 0.5000	* +0.0	* 3.0000	* 0.0000	-	* 7	HV --	-	S
drift	t-q1	0.000	1.0689			standard					-- HV --	-	e
<Quad>	Q1	1.069	0.2523	-2.1576	0.5000	QUAD	5.3975	0.2523	yes	1 R	-- HV --	fit - Q	e
drift	q1-q2	1.321	0.2569			standard					-- -- --	-	e
<Quad>	Q2	1.578	0.3338	+1.9649	0.5000	MULT	7.9375	0.3338	yes	1 R	-- HV --	fit - QS	e
Fit	Fit 1	1.912	0.0000								-- -- --	R12 = 0	e
drift	d3-md1	1.912	0.6381			standard					-- HV --	-	e
Dipole	MD1	2.550	0.8727	+4.9996	* 0.5000	* +50.0	* 1.0000	* 0.8727	yes	* 7 R	-- V --	-	E
drift	md1-slits	3.423	0.3079			standard					-- -- --	-	e
Fit	Fit XT	3.731	0.0000								-- -- --	R12 = 0	e
Fit	Fit XX	3.731	0.0000								-- -- --	// R11 = ...	no
Fit	Fit YP	3.731	0.0000								-- -- --	R34 = 0	e
Fit	T122	3.731	0.0000								-- -- --	T122 = 0	e
slits	CHARGE slits	3.731	0.0000			SLITS					-- -- --	-	e
drift	slits-sm1	3.731	0.2720			standard					HV HV --	-	e
drift	SM1	4.003	0.2560			standard					-- HV --	-	e
drift	sm1-s1	4.259	0.1862			standard					-- HV --	-	e
<Quad>	S1	4.445	0.1875	+0.1372	0.5000	SEXT	7.9375	0.1875	yes	1 R	-- HV --	fit - S	e
drift	s1-q3	4.632	0.1614			standard					-- HV --	-	e
<Quad>	Q3	4.794	0.3338	+1.7749	0.5000	QUAD	7.9375	0.3338	yes	1 R	-- HV --	fit - Q	e
drift	q3-q4	5.127	0.2162			standard					-- HV --	-	e
<Quad>	Q4	5.344	0.3338	-2.2980	0.5000	QUAD	7.9375	0.3338	yes	1 R	-- HV --	fit - Q	e
drift	q4-q5	5.677	0.2162			standard					-- HV --	-	e

Selected block: Drift (multipole,slits)

Block name: Q2

Block Length [m]: 0.33385

Length after this block [m]: 1.9119

Use in the FIT process: Q S

Angular acceptance (mrad): Horizontal Vertical

Inside Aperture (mm): X = [-75, 75] Y = [-75, 75]

Slits (mm) after this BLOCK: X = [] Y = []

1-st order Matrix Elements: Matrix Plot, Beam-Sigma Plot, View

Buttons: Quit, Help

It is possible to change quickly the use of Quadrupole and/or Sextupole fields from the Optics settings dialog

Optics fit

Blocks with parameters to vary

#01-q	Position@005: Q1
#02-q	Position@007: Q2
#03-s	Position@007: Q2
#04-s	Position@020: S1
#05-q	Position@022: Q3
#06-q	Position@024: Q4
#07-q	Position@026: Q5
#08-s	Position@028: S2
#09-q	Position@044: Q6
#10-q	Position@046: Q7
#11-q	Position@059: Q8
#12-q	Position@069: Q9
#13-q	Position@071: Q10

Active Constraint blocks

#01	@008: R12 = 0	Fit 1
#02	@012: R12 = 0	Fit XT
#03	@014: R34 = 0	Fit YP
#04	@015: T122 = 0	T122
#05	@033: R12 = 0	Mass_XA
#06	@034: R16 = 0	Mass_XD
#07	@035: R44 = 0	Mass_PP
#08	@036: R26 = 0	Mass_TD
#09	@038: T122 = 0	M122
#10	@053: R12 = 0	Charge2XT
#11	@054: R44 = 0	Charge2PP
#12	@073: R12 = 0	Fin XT
#13	@074: R16 = 0	Fin XD
#14	@075: R34 = 0	Fin YP
#15	@077: R26 = 0	Fin TD
#16	@078: T122 = 0	F122

N iter = 1000

FIT | Restore previous values | **Optics Settings (fast editing)** | Fit Settings

Show initial conditions | Browse output file

Exit | Matrix Plot | Beam-Sigma Plot

Help | aberration_check.fit

c:\program files (x86)\lise\results\aberration_check.fit_init

Initial +94.1859 LISE fit reduced values

Parameters:	LeftBound	Initial	RightBound
#01-q: Q1	-5.0e+00	-2.158e+00	-1.0e+00
#02-q: Q2	+1.0e+00	+1.965e+00	+5.0e+00
#03-s: S2	-1.0e+00	+1.059e-01	+1.0e+00
#04-s: S1	-1.0e+00	+1.372e-01	+1.0e+00
#05-q: Q3	+1.0e+00	+1.775e+00	+5.0e+00
#06-q: Q4	-5.0e+00	-2.298e+00	-1.0e+00
#07-q: Q5	+0.0e+00	+1.263e+00	+5.0e+00
#08-s: S2	-1.0e+00	-2.974e-01	+1.0e+00
#09-q: Q6	-5.0e+00	-1.458e+00	+0.0e+00
#10-q: Q7	+1.0e+00	+1.751e+00	+5.0e+00
#11-q: Q8	+0.0e+00	+1.238e+00	+5.0e+00
#12-q: Q9	-5.0e+00	-9.564e-01	+0.0e+00
#13-q: Q10	+0.0e+00	+1.066e+00	+5.0e+00

Constraint values:	Initial	Final	Precision	(Init-Des)/P	Desired
#01: Fit 1	+2.978e+00		1.0e-03	+2.978e+03	= 0
#02: Fit XT	+1.101e-05		1.0e-03	+1.101e-02	= 0
#03: Fit YP	+2.796e-05		1.0e-02	+2.796e-03	= 0
#04: T122	-5.116e-09		1.0e-01	+5.116e-08	= 0
#05: Mass_XA	-4.284e-05		1.0e-03	+4.284e-02	= 0
#06: Mass_XD	-2.271e-04		1.0e-03	+2.271e-01	= 0
#07: Mass_PP	+4.431e-04		1.0e-01	+4.431e-03	= 0
#08: Mass_TD	+3.174e-01		1.0e+00	+3.174e-01	= 0
#09: M122	+1.627e-04		1.0e-03	+1.627e-01	= 0
#10: Charge2 XT	+2.844e-05		1.0e-03	+2.844e-02	= 0
#11: Charge2 PP	-8.730e-04		1.0e-01	+8.730e-03	= 0
#12: Fin XT	-1.052e-04		1.0e-03	+1.052e-01	= 0
#13: Fin XD	-7.852e-04		1.0e-03	+7.852e-01	= 0
#14: Fin YP	+8.599e-06		1.0e-03	+8.599e-03	= 0
#15: Fin TD	-5.760e-01		1.0e+00	+5.760e-01	= 0
#16: F122	-1.236e-04		1.0e-03	+1.236e-01	= 0

==> "F122" : last fitting block global optical matrix and sigma vector

Format [mm-mrad]					Beam(sigma)	
G	L	O	B	A	L	
+9.115e-01	-1.052e-04	0	0	0	-7.852e-04	1.05e-02
+2.838e-01	+1.097e+00	0	0	0	-5.760e-01	1.10e+02
0	0	-1.146e+00	+8.599e-06	0	0	0
0	0	-1.525e+00	-8.724e-01	0	0	0
+5.247e-02	-9.829e-05	0	0	1.0	-9.640e+00	9.83e-03
0	0	0	0	0	+1.000e+00	0

Chars "q" and "s" show what component ("q"uadrupole or "s"extupole) of multipole is used in the Optimization process

New feature: Selection of 2nd order matrix element for the "Optimization" process

```

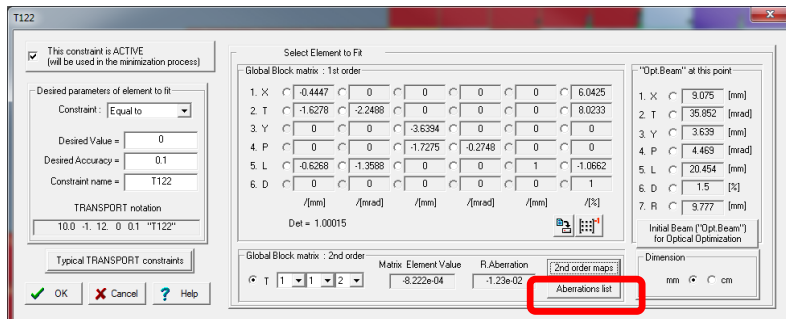
Block: "T122" Matrices: "GLOBAL"
transport format [mm-mrad]

* TRANSFORM 1 *
1 [X]: -4.4470e-01 0 0 0 0 +6.0425e+00
2 [T]: -1.6278e+00 -2.2488e+00 0 0 0 +8.0233e+00
3 [Y]: 0 0 -3.6394e+00 0 0 0
4 [F]: 0 0 -1.7275e+00 -2.7480e-01 0 0
5 [L]: -6.2680e-01 -1.3588e+00 0 0 +1.0000e+00 -1.0662e+00
6 [D]: 0 0 0 0 0 +1.0000e+00

* TRANSFORM 2 *
1 1: -1.4514e-03
1 2: -8.2225e-04 -5.1162e-09
1 3: 0 0 +1.5162e-03
1 4: 0 0 +3.2205e-04 -1.0056e-03
1 5: 0 0 0 0 0
1 6: +1.4137e-02 +5.8617e-04 0 0 0 -5.4986e-02

2 1: -1.8740e-04
2 2: -2.0000e-04 -4.3467e-04
2 3: 0 0 -4.2184e-05
2 4: 0 0 -1.2638e-04 -4.4552e-04
2 5: 0 0 0 0 0
2 6: +1.6955e-02 +1.3696e-02 0 0 0 -8.3502e-02
    
```


"Fit constraint" block for 2nd order optimization : Aberrations List



The Aberration list purpose : show a 2nd element to pay attention. Aberration value is:

1st order : $V_1 = (a|b)*s(b)$
 2nd order : $V_2 = (a|bc)*s(b)*s(c)$

* TRANSFORM 1 *

1 [X]:	-4.4470e-01	0	0	0	0	+9.0638e+00
2 [T]:	-1.6278e+00	-3.3732e+01	0	0	0	+1.2035e+01
3 [Y]:	0	0	-3.6394e+00	0	0	0
4 [F]:	0	0	-1.7275e+00	-4.1220e+00	0	0
5 [L]:	-6.2680e-01	-2.0382e+01	0	0	0	-1.5993e+00
6 [D]:	0	0	0	0	0	+1.5000e+00

* TRANSFORM 2 *

1 1:	-1.4514e-03					
1 2:	-1.2334e-02	-1.1512e-06				
1 3:	0		+1.5162e-03			
1 4:	0		+4.8308e-03			
1 5:	0		0			
1 6:	+2.1206e-02	+1.3189e-02	0	0	0	-1.2372e-01

Block: "T122" Aberrations (Elements normalized on Phase Space)

Block: "T122" Aberrations (Elements normalized on Phase Space)
 1st order : (a|b)*s(b); 2nd order : (a|bc)*s(b)*s(c)

Transport Format (mm*mmrad)

* TRANSFORM 1 *

1 [X]:	-4.4470e-01	0	0	0	0	+9.0638e+00
2 [T]:	-1.6278e+00	-3.3732e+01	0	0	0	+1.2035e+01
3 [Y]:	0	0	-3.6394e+00	0	0	0
4 [F]:	0	0	-1.7275e+00	-4.1220e+00	0	0
5 [L]:	-6.2680e-01	-2.0382e+01	0	0	0	-1.5993e+00
6 [D]:	0	0	0	0	0	+1.5000e+00

* TRANSFORM 2 *

1 1:	-1.4514e-03					
1 2:	-1.2334e-02	-1.1512e-06				
1 3:	0		+1.5162e-03			
1 4:	0		+4.8308e-03			
1 5:	0		0			
1 6:	+2.1206e-02	+1.3189e-02	0	0	0	-1.2372e-01

* Aberration analysis * (Target absolute value)

1st order		2nd order		status
index	value	index	value	
1 [X]:	16	144	-2.26e-01	
2 [T]:	22	226	+3.08e-01	
3 [Y]:	33	346	+1.79e+00	attention
4 [F]:	44	446	+9.82e-01	
5 [L]:	52	526	+2.62e-01	
6 [D]:	66	000	+0.00e+00	

The Aberration analysis table at the bottom of the window

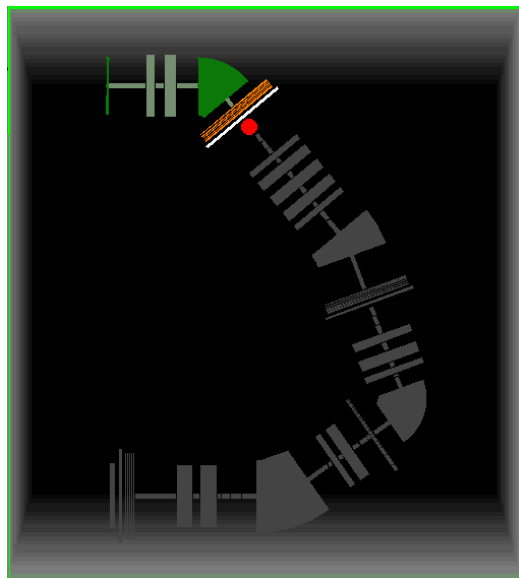
* Aberration analysis * (Target absolute value)

1st order		2nd order		status
index	value	index	value	
1 [X]:	16	144	-2.26e-01	
2 [T]:	22	226	+3.08e-01	
3 [Y]:	33	346	+1.79e+00	attention
4 [F]:	44	446	+9.82e-01	
5 [L]:	52	526	+2.62e-01	
6 [D]:	66	000	+0.00e+00	

Comparison of absolute largest 1st and 2nd orders aberrations

Status messages
 $V_1 < 3 V_2$ attention
 $V_1 < V_2$ Critical
 $V_1 < V_2/3$ VERY critical

The 1st part of DRAGON2000 : Target – Charge Slits



Q1

Magnetic Multipole Settings		QUADrupole	SEXTupole	
L_eff (effective length) mode: <Keep>		0.2523		m
B (field at pole tip)	-2.1578	0		kG
Radius (half-aperture)	5.3975	5.3975		cm
B & S field values in Fitting				
Use in Fitting process	<input checked="" type="checkbox"/>	<input type="checkbox"/>		
Use Bounds constraints	<input checked="" type="checkbox"/>	<input type="checkbox"/>		
Lower bound	-5	-100		kG
Upper bound	-1	100		kG

Q2

Magnetic Multipole Settings		QUADrupole	SEXTupole	
L_eff (effective length) mode: <Keep>		0.33385		m
B (field at pole tip)	1.96503	0.106		kG
Radius (half-aperture)	7.9375	7.9375		cm
B & S field values in Fitting				
Use in Fitting process	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		
Use Bounds constraints	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		
Lower bound	1	-1		kG
Upper bound	5	1		kG

Initial settings

Beam vector used for Optical Optimization	
"Opt.Beam"	
1. X	2 mm
2. T	20 mrad
3. Y	2 mm
4. P	20 mrad
5. L	0 mm
6. D	2 %
<input checked="" type="radio"/> mm <input type="radio"/> cm	
<input checked="" type="button"/> Ok <input type="button"/> Cancel	

Aberration list @ Charge Slits

Block: "Fit YP" Aberrations (Elements normalized on Phase Space)

Block: "Fit YP" Aberrations (Elements normalized on Phase Space)
1st order : (a/b)*beam(b); 2nd order : (a/b/c)*beam(b)*beam(c)
transport format [mm-mrad]

* TRANSFORM 1 *

1 [X]:	-8.9000e-01	-1.0000e-02	0	0	0	+1.2085e+01
2 [T]:	-3.2558e+00	-4.4978e+01	0	0	0	+1.6047e+01
3 [Y]:	0	0	-7.2784e+00	+4.0000e-03	0	0
4 [F]:	0	0	-3.4548e+00	-5.4940e+00	0	0
5 [L]:	-1.2532e+00	-2.7170e+01	0	0	0	-2.1324e+00
6 [D]:	0	0	0	0	0	+2.0000e+00

* TRANSFORM 2 *

1 1:	-5.8101e-03					
1 2:	-3.2928e-02	-8.9324e-05				
1 3:	0	0	+6.0714e-03			
1 4:	0	0	+1.2939e-02	-4.0210e-01		
1 5:	0	0	0	0	0	
1 6:	+5.6559e-02	+2.3549e-02	0	0	0	-2.1994e-01

2 1:	-7.5022e-04					
2 2:	-8.0057e-03	-1.7388e-01				
2 3:	0	0	-1.6769e-04			
2 4:	0	0	-5.0458e-03	-1.7819e-01		
2 5:	0	0	0	0	0	
2 6:	+6.7822e-02	+5.4786e-01	0	0	0	-3.3401e-01

3 1:	0	0	0	0	0	0
3 2:	0	0	0	0	0	0
3 3:	+1.7870e-02	+3.5159e-02	0	0	0	0
3 4:	+9.7387e-02	+4.3065e-01	0	0	0	0
3 5:	0	0	0	0	0	0
3 6:	0	0	+1.6097e-01	+3.1863e+00	0	0

4 1:	0	0	0	0	0	0
4 2:	0	0	0	0	0	0
4 3:	+6.1427e-03	+1.0628e-02	0	0	0	0
4 4:	-5.2666e-03	+7.9210e-02	0	0	0	0
4 5:	0	0	0	0	0	0
4 6:	0	0	+9.0040e-02	+1.7458e+00	0	0

* Aberration analysis * (Absolute largest value)

index	1st order		2nd order		status
	index	value	index	value	
1 [X]:	16	+1.21e+01	144	-4.02e-01	
2 [T]:	22	-4.50e+01	228	+5.48e-01	
3 [Y]:	33	-7.28e+00	346	+3.19e+00	attention
4 [F]:	44	-5.49e+00	446	+1.75e+00	
5 [L]:	52	-2.72e+01	526	+4.66e-01	
6 [D]:	66	+2.00e+00	000	+0.00e+00	

Let's try to neglect the element T144 in the optimization using Q1 & Q2 multipoles!

Let's try to neglect the element T144 in the optimization using Q1 & Q2 multipoles!

T122

This constraint is ACTIVE (will be used in the minimization process)

Desired parameters of element to fit

Constraint: Equal to

Desired Value = 0

Desired Accuracy = 0.001

Constraint name = T144

TRANSPORT notation

10.0 -1.44 0 0.001 "T144"

Typical TRANSPORT constraints

OK Cancel Help

Select Element to Fit

Global Block matrix : 1st order

1. X	-0.445	-0.0004	0	0	0	6.0425
2. T	-1.6279	-2.2488	0	0	0	8.0233
3. Y	0	0	-3.6393	0.0003	0	0
4. P	0	0	-1.7275	-0.2746	0	0
5. L	-0.6266	-1.3585	0	0	1	-1.0662
6. D	0	0	0	0	0	1

Det = 0.99993

Global Block matrix : 2nd order

Matrix Element Value	R.Aberration
-1.005e-03	-4.02e-01

2nd order maps

Aberations list

"Opt.Beam" at this point

1. X	12.118 [mm]
2. T	47.864 [mrad]
3. Y	7.279 [mm]
4. P	6.489 [mrad]
5. L	27.283 [mm]
6. D	2 [%]
7. R	14.136 [mm]

Initial Beam ("Opt.Beam") for Optical Optimization

Dimension

mm cm

Optics fit

Blocks with parameters to vary

- #01-q Position@005: Q1
- #02-q Position@007: Q2
- #03-s Position@007: Q2

Active Constraint blocks

- #01 @011: R12 = 0 Fit XT
- #02 @013: R34 = 0 Fit YP
- #03 @016: T144 = 0 T144

N iter = 1000

FIT Restore previous values Optics Settings (fast editing) Fit Settings

Exit Help Browse output file Matrix Plot Beam-Sigma Plot

Show initial conditions

aberration_check.fit

```

c:\user\c\lise_pp_910\results\aberration_check.fit
Initial +0.0343823 and Final +9.08292e-14 LISE fit reduced values
Parameters:      LeftBound  Initial  RightBound  Final
#01-q: Q1        -5.0e+00 < -2.158e+00 < -1.0e+00   -2.158e+00
#02-q: Q2        +1.0e+00 < +1.965e+00 < +5.0e+00   +1.965e+00
#03-s: Q2        -1.0e+00 < +1.060e-01 < +1.0e+00   +4.281e-01
-----
Constraint values:  Initial  Final  Precision (Fin-Des)/P  Desired
#01: Fit XT        -4.024e-04  -2.850e-15  1.0e-03  0  = 0
#02: Fit YP        +3.113e-04  +1.123e-15  1.0e-02  0  = 0
#03: T144          -1.005e-03  -9.109e-18  1.0e-03  0  = 0
-----
=> Results for aberration_check.fit:
Levenberg-Marquardt returned 3 in 3 iter, reason 6
Termination reason: 6 - stopped by small ||e||_2

Minimization info:
0: 1.173e+00  ||e||_2 at initial p
1: 8.136e-24  ||e||_2
2: 2.574e-07  ||J^T e||_inf
3: 1.895e-19  ||Dp||_2
4: 2.180e-12  m/ max[J^T J] ii
    
```

During the optimization the T144 element has been changed from 1.00e-3 to -9.1e-18

Sextupole field Q2-s has been changed from 0.106 kG to 0.428 kG

Quadrupole fields Q1-q & Q2-q have not been changed

Let's create the Beam vector for optimization with large X' component

First order X-sigma is small @ Charge Slits

Block: "T144" Aberrations (Elements r
1st order : (a/b)*beam

```

* TRANSFORM 1 *
1 [X]: -4.4500e-01 -4.0000e-02 0
2 [T]: -1.6279e+00 -2.2488e+02 0
3 [Y]: 0 0 0
4 [F]: 0 0 0
5 [L]: -6.2660e-01 -1.3585e+02 0
6 [D]: 0 0 0

* TRANSFORM 2 *
1 1: -1.4525e-03
1 2: -8.2320e-02 -2.2331e-03
1 3: 0 0 0
1 4: 0 0 0
1 5: 0 0 0
1 6: 0 0 0

2 1: -1.8755e-04
2 2: -2.0014e-02 -4.3470e+00
2 3: 0 0 0
2 4: 0 0 0
2 5: 0 0 0
2 6: 0 0 0
    
```

Aberration list @ Charge Slits

* Aberration analysis * (Absolute largest value)

1st order		2nd order		status
index	value	index	value	
1 [X]:	11 -4.45e-01	112	-8.23e-02	
2 [T]:	22 -2.25e+02	222	-4.35e+00	
3 [Y]:	00 +0.00e+00	000	+0.00e+00	
4 [F]:	00 +0.00e+00	000	+0.00e+00	
5 [L]:	52 -1.36e+02	522	+1.64e+00	
6 [D]:	00 +0.00e+00	000	+0.00e+00	

No large aberrations with using GLOBAL matrices!

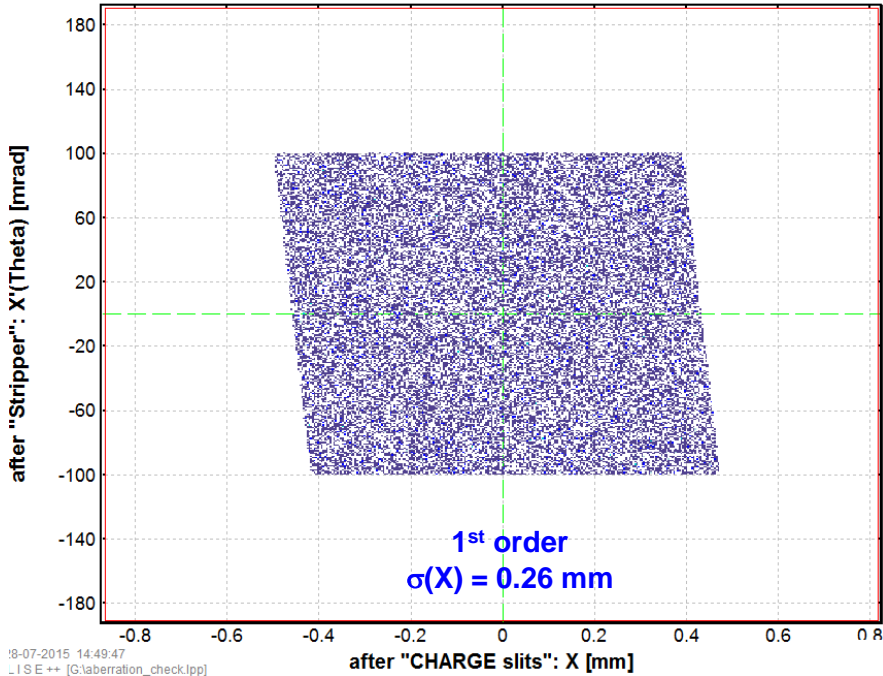
But Let's run Monte Carlo calculation
the similar beam emittance

1. X	mm	1	Rectangle uniform
2. T	mrad	100	Rectangle uniform
3. Y	mm	0	Rectangle uniform
4. P	mrad	0	Rectangle uniform
5. L	mm	0	Gaussian
6. D	%	0	Rectangle uniform

³⁹Ca : Monte Carlo Transmission Plot

³⁹Ca (1.3 MeV/u) + ; Transmitted Fragment ³⁹Ca^{13+..13+} (beam); Optics Order
dp/p=100.00% ; Brho(Tm): 0.5000, 0.5000

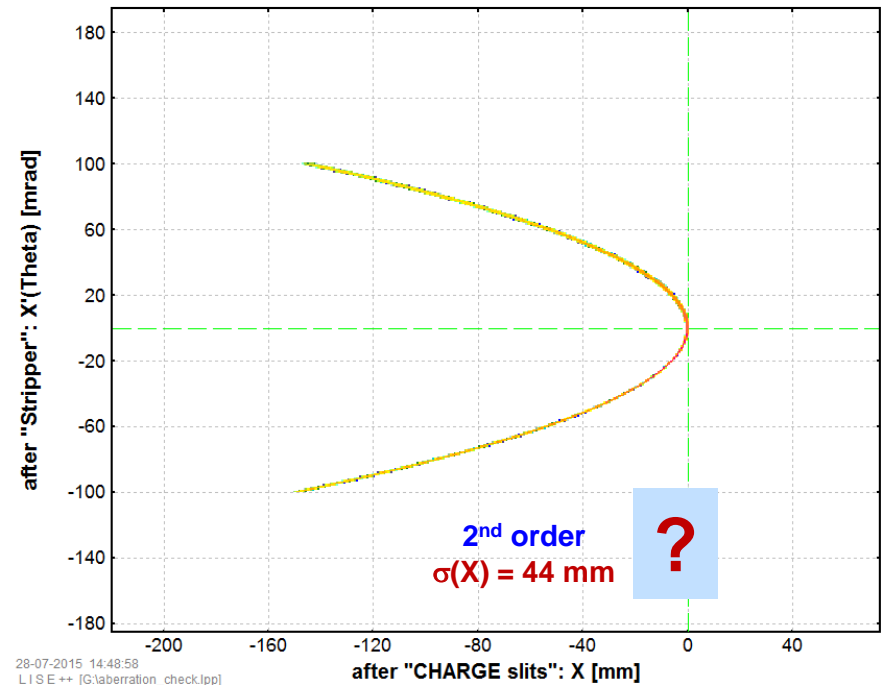
AngAccept: Off; Bounds: Off; "CHARGE slits" - last block for MC calc; no gates; Config:



³⁹Ca : Monte Carlo Transmission Plot

³⁹Ca (1.3 MeV/u) + ; Transmitted Fragment ³⁹Ca^{13+..13+} (beam); Optics Ord
dp/p=100.00% ; Brho(Tm): 0.5000, 0.5000

AngAccept: Off; Bounds: Off; "CHARGE slits" - last block for MC calc; no gates; Config:

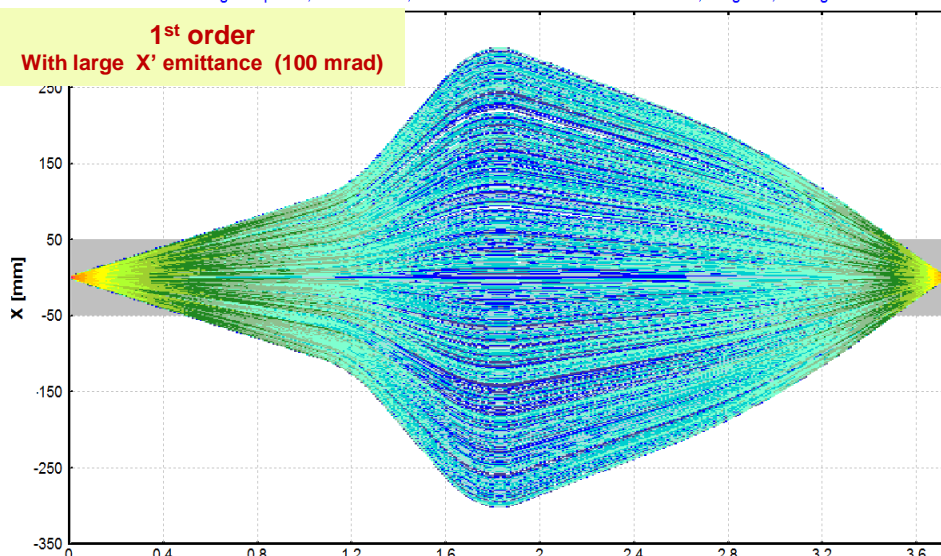


- We did not observe large values in the Aberration list calculated with the Global matrices
- Large aberrations have been observed in Monte Carlo calculations where local 2nd order matrices are used
- It is happen due to truncation of high order values with matrices multiplication
- Recommendation: not to use large Beam sigma values for optimization. 2nd order optic optimization operates with small emittances
- For large emittance the LISE++ optimization should be updated to work with Monte Carlo results.

³⁹Ca : MC Transmission Plot - Envelope (only passed)

³⁹Ca (1.3 MeV/u) + ; Transmitted Fragment ³⁹Ca^{13+..13+} (beam); Optics Order: 1
dp/p=100.00% ; Brho(Tm): 0.5000, 0.5000

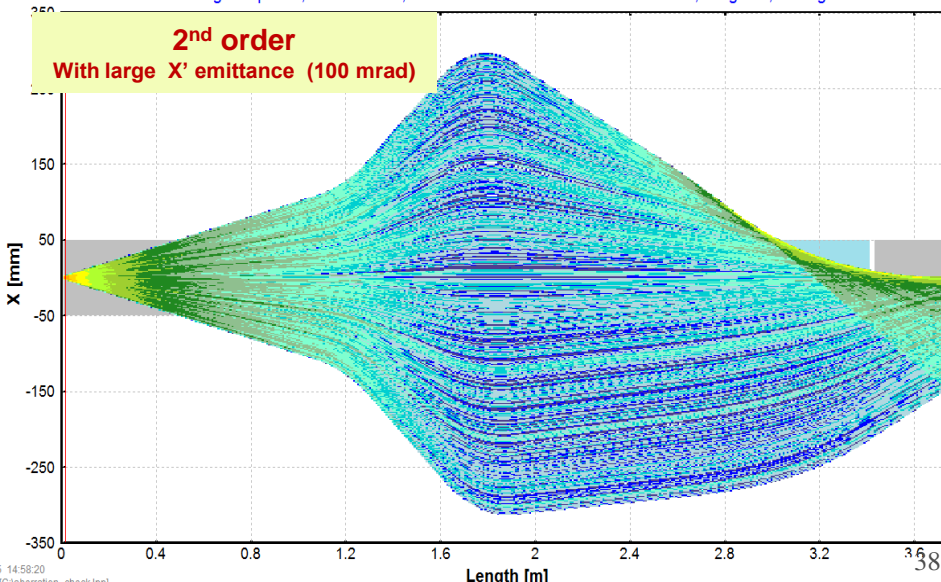
AngAccept: Off; Bounds: Off; "CHARGE slits" - last block for MC calc; no gates; Config: DSSSSSDSSA



³⁹Ca : MC Transmission Plot - Envelope (only passed)

³⁹Ca (1.3 MeV/u) + ; Transmitted Fragment ³⁹Ca^{13+..13+} (beam); Optics Order: 2
dp/p=100.00% ; Brho(Tm): 0.5000, 0.5000

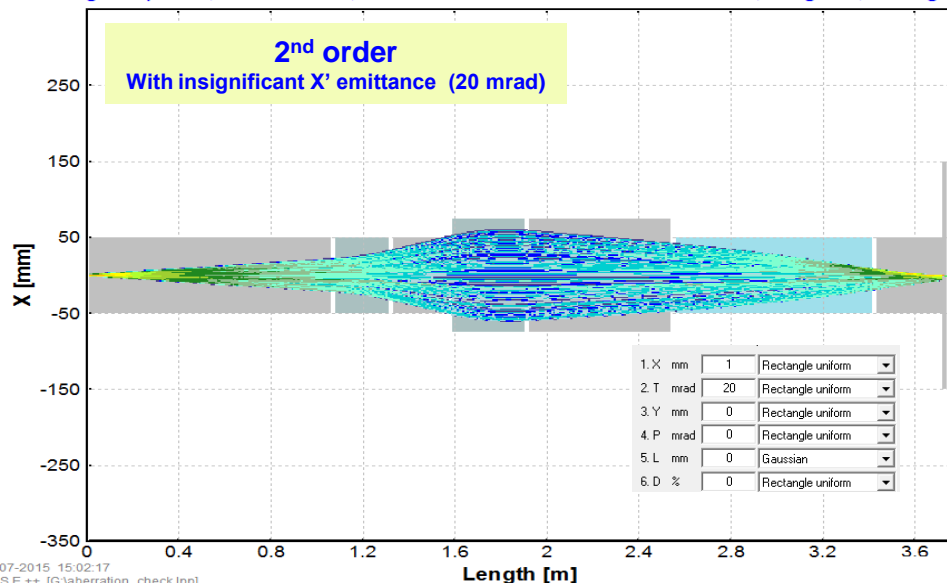
AngAccept: Off; Bounds: Off; "CHARGE slits" - last block for MC calc; no gates; Config: DSSSSSDSSA



³⁹Ca : MC Transmission Plot - Envelope (only pass

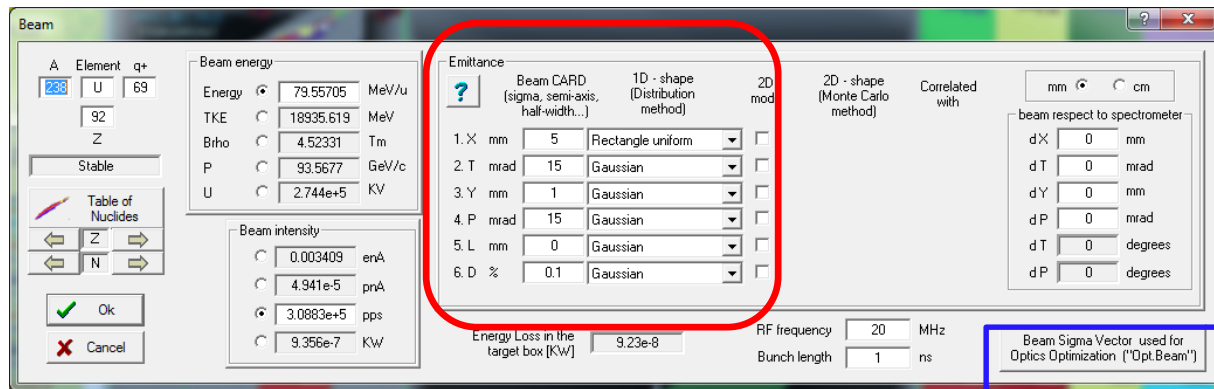
³⁹Ca (1.3 MeV/u) + ; Transmitted Fragment ³⁹Ca^{13+..13+} (beam); Optics Order: 2
dp/p=100.00% ; Brho(Tm): 0.5000, 0.5000

AngAccept: Off; Bounds: Off; "CHARGE slits" - last block for MC calc; no gates; Config: L



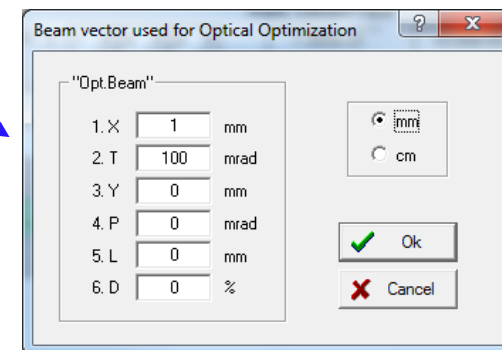
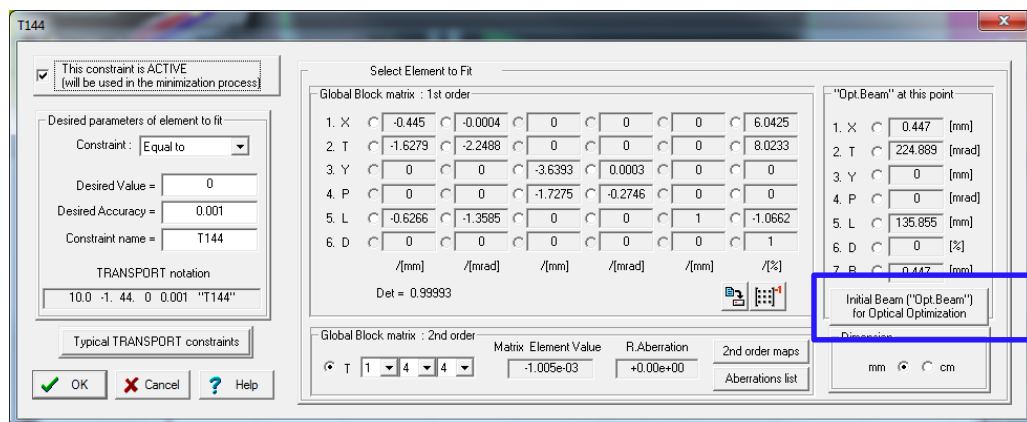
“Main” Beam emittance is used for transmission calculations in both (“Distribution” and MC) modes, for matrices in Optics Block dialogs and so on.

“Beam” dialog



New Beam sigma vector (“OptBeam”) used only for optics optimization in the Fit Constraint block dialog and the Optics Fit dialog. Access to the dialog to this bema vector modification can be done through the Beam or Fit Constraint block dialogs

“Fit constraint” dialog



This new beam vector for optimization has been created to avoid additional beam emittance editing due to switching between fragment transmission calculations and the optimization mode, which done for the primary beam

to
Drs. M.Hausmann, and M.Portilio (NSCL/MSU),
for fruitful discussions.