

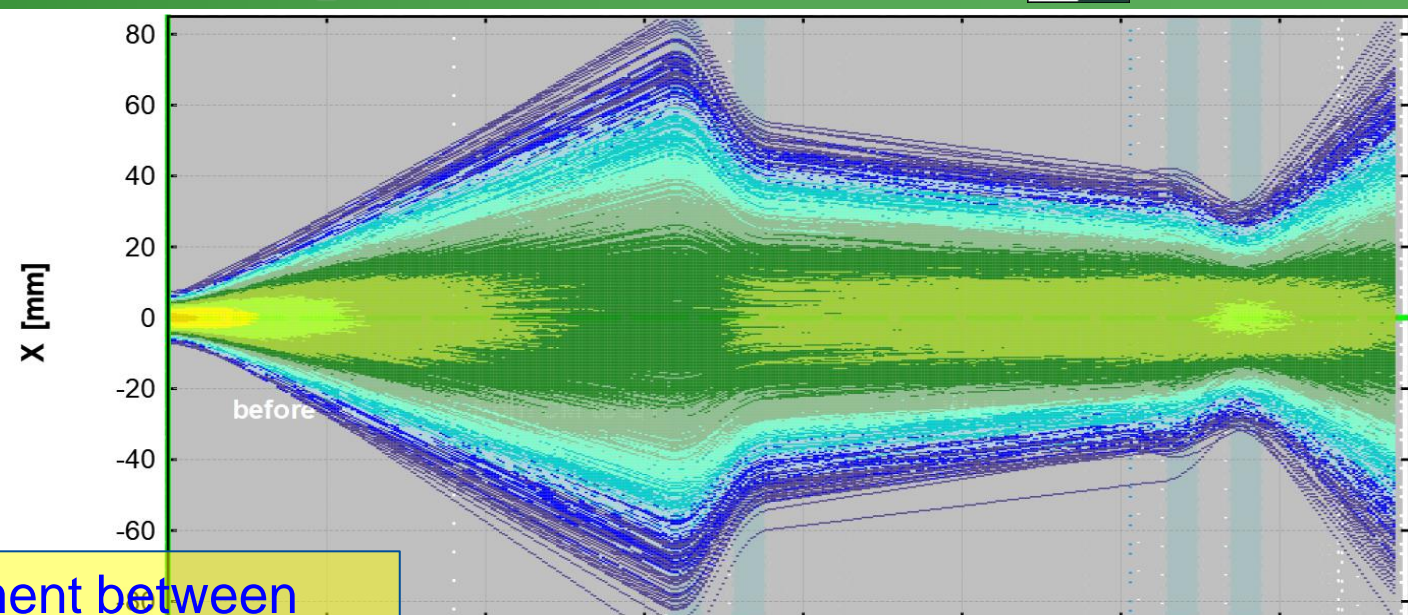
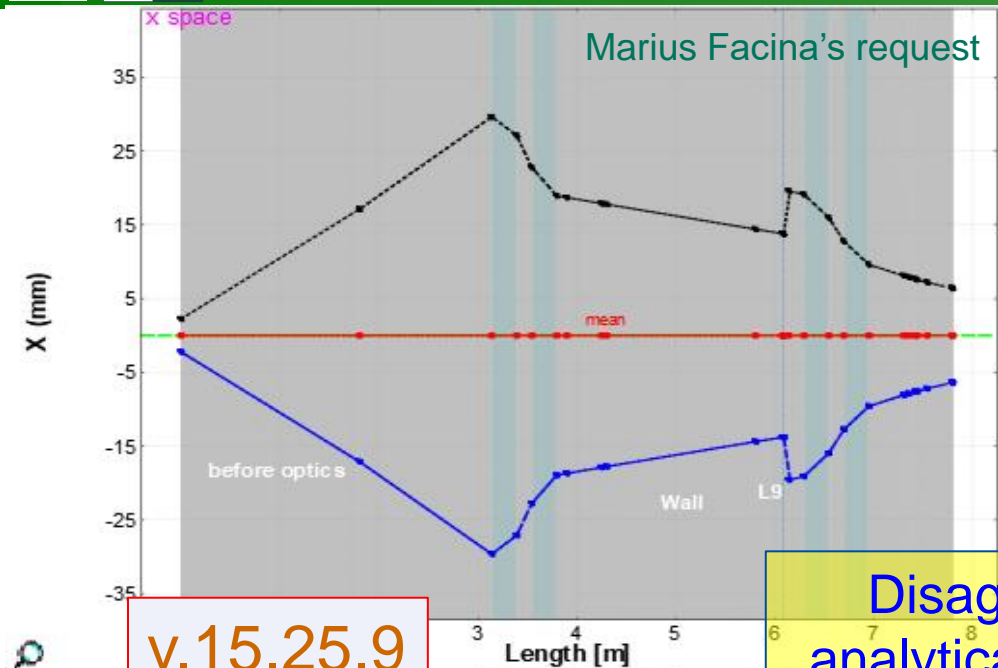
**LISE** ++  
*cute*

**v.15.26.1**

10/30/21

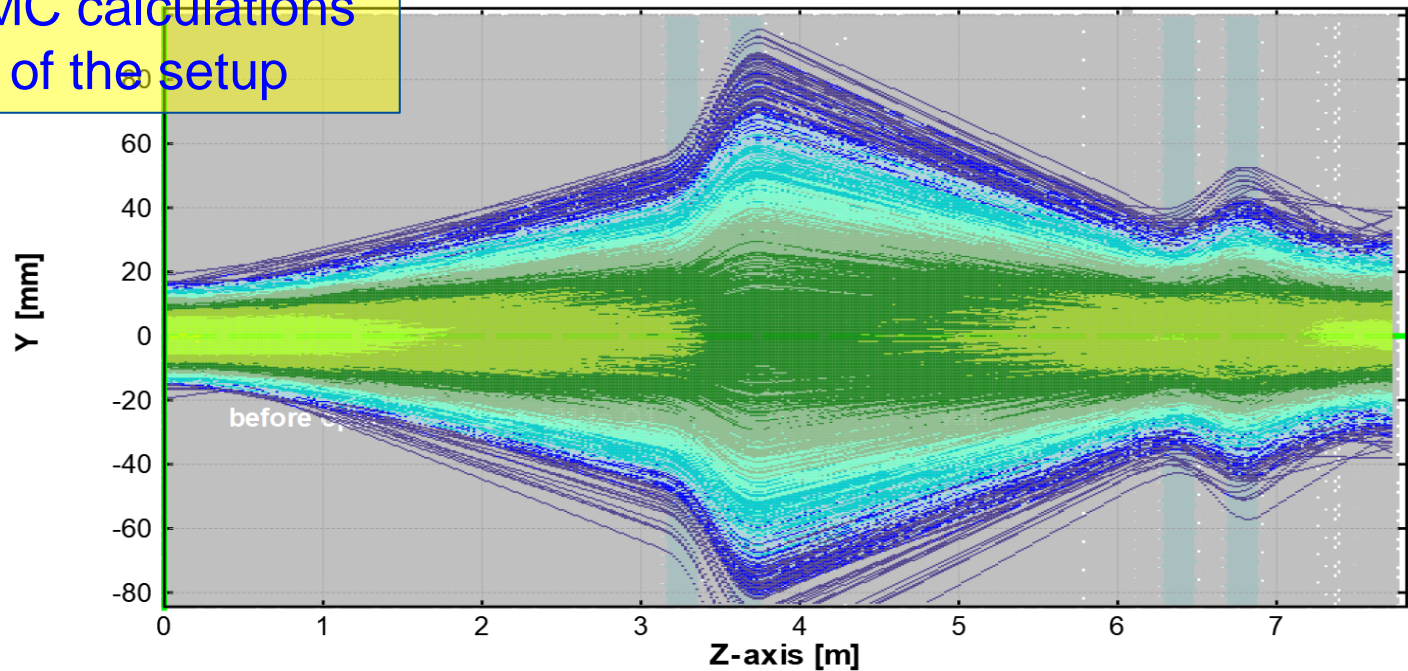
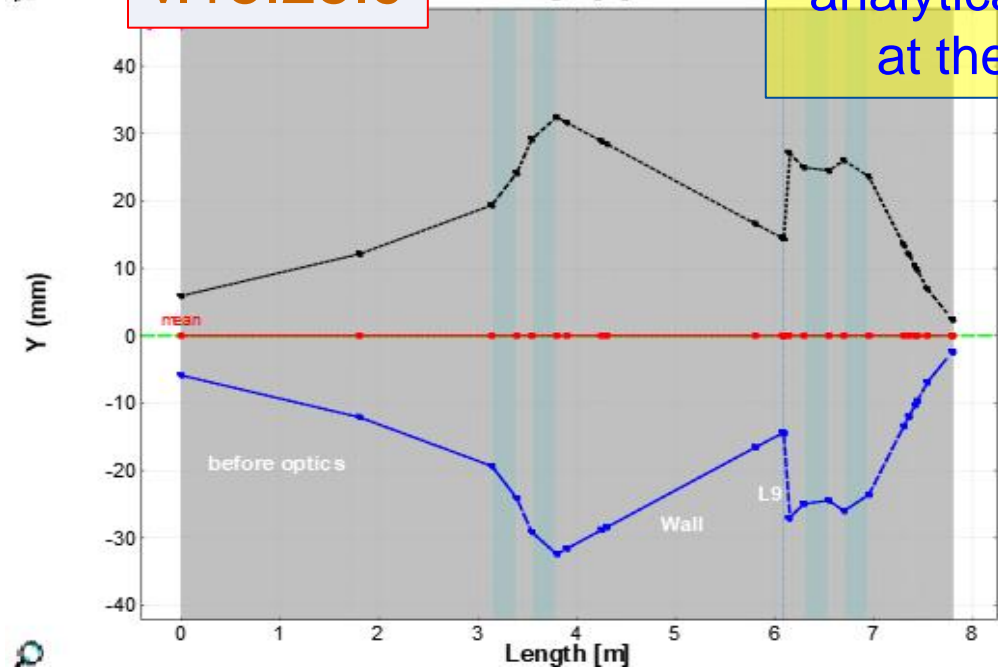
- User's request (disagreement in analytical and MC results)
- Reason of the disagreement (problem)
- Solution of the problem
- v.15.26.1 results
- Angular envelopes comparison
- Matrix envelope and Angular straggling contribution
- Visualization of Angular straggling contribution values in matrices
- How strong is the impact of angular straggling contribution at higher energy?

# Reason of User's Request



v.15.25.9

Disagreement between analytical & MC calculations at the end of the setup



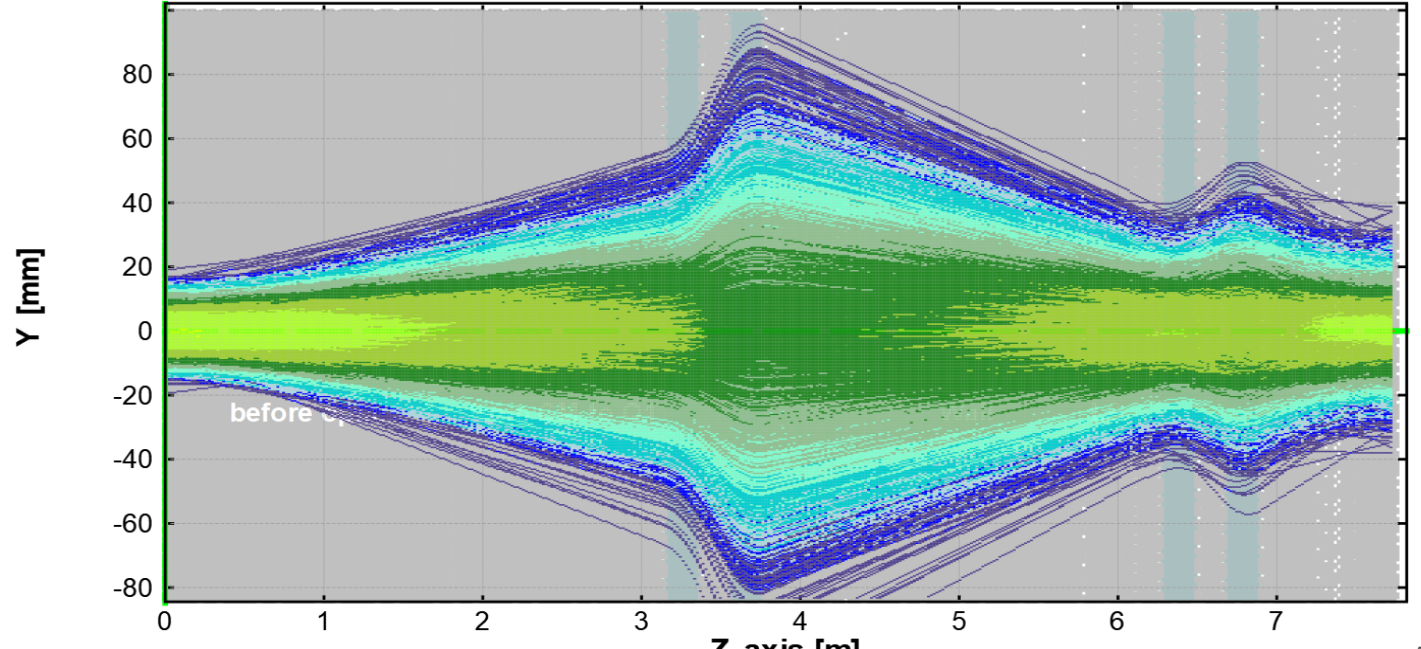
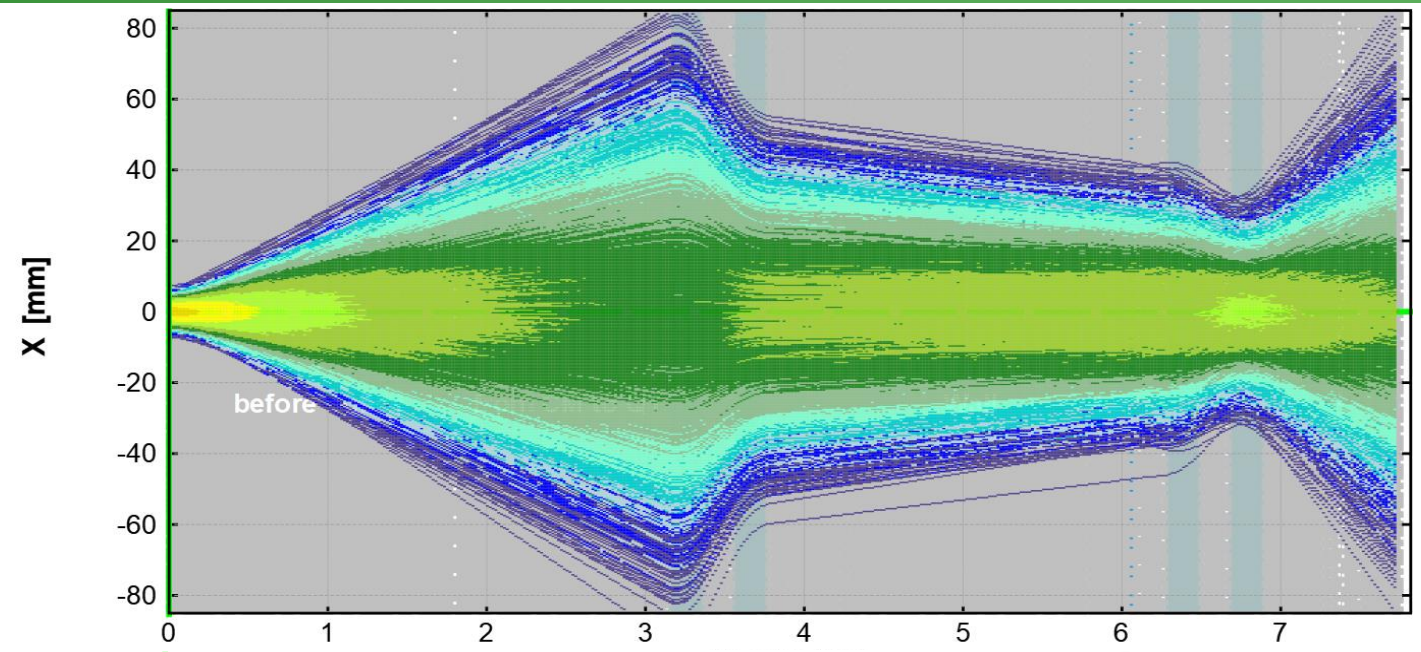
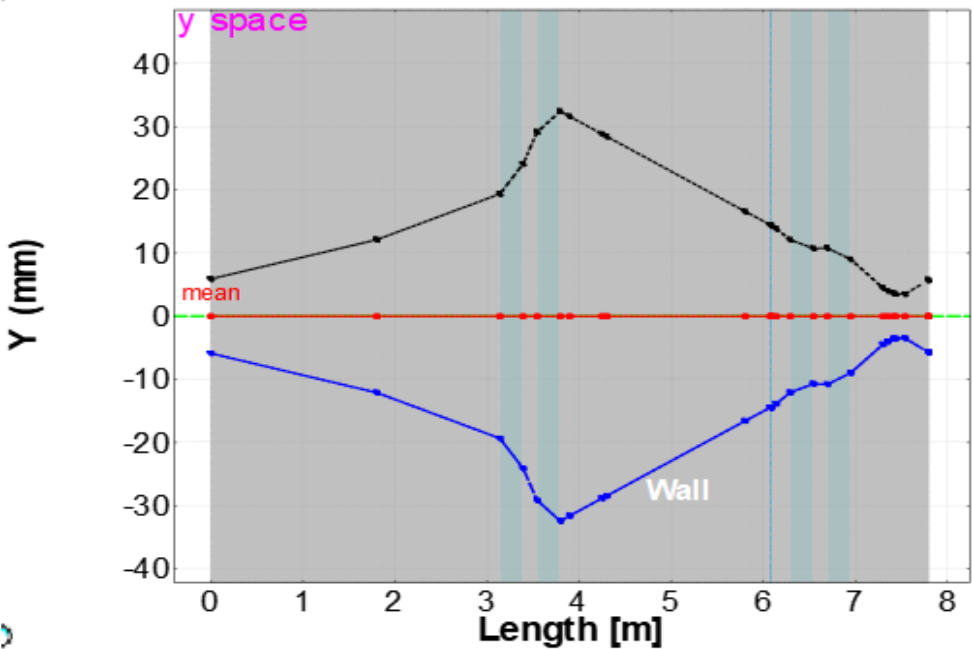
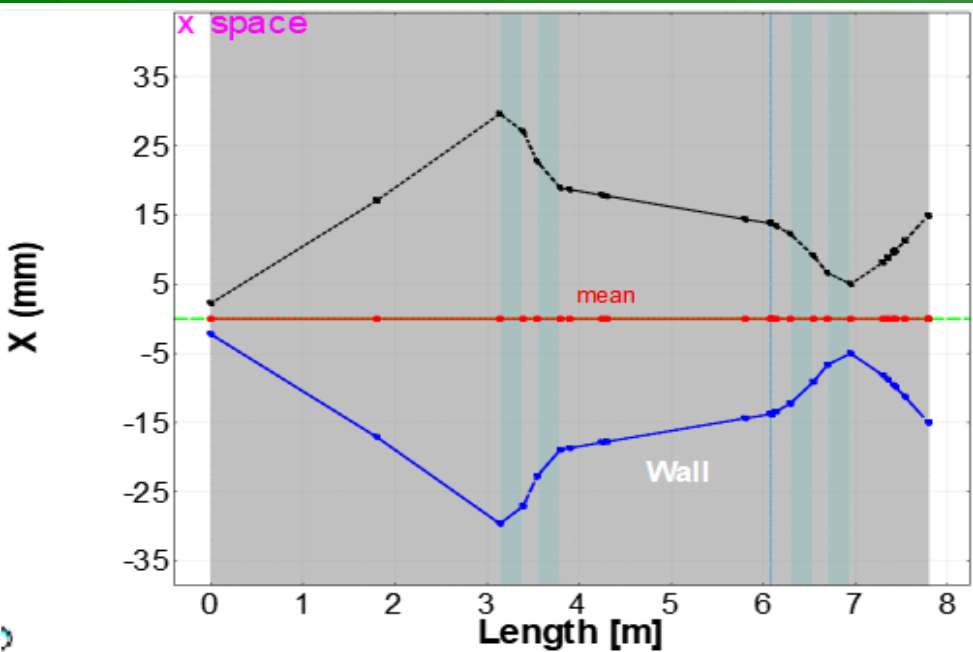
- The code did not use properly the angular straggling contribution in ion optics in the case of transmission analytical solution
- LISE was taken into account the angular straggling contribution as product ( $T_n = T_c \cdot F$ ) of the current beam angle emittance ( $T_c$ ) and the factor  $F$ , where  $F = \text{Width}(T_c \cdot M \otimes S) / \text{Width}(T_c \cdot M)$ , where  $M$  is the global Angular magnification from target to this block,  $S$  is normal distribution, which sigma corresponds to the plane angular straggling value
- This disagreement could be observed due to simultaneous coincidence of several factors:
  - Light Z beam
  - Low energy beam
  - No target
  - Narrow initial angular emittance
  - Heavy Z material in line
  - Material location in non-focal plane

- The Compound block (material, wedge) has got the optical matrix feature in the new version
- If the corresponding option has been set in the Preference dialog, LISE calculates the factor F as ratio  $F = \text{Width}(A \otimes S) / \text{Width}(A)$ , where A is the current angular distribution in front of this material, and S is normal distribution, which sigma corresponds to the plane angular straggling value
- Then it is assumed F is angular magnification in the corresponding plane and being set to the local optical matrix  $(\theta/\theta, \varphi/\varphi)$
- LISE recalculates global optical matrices starting this block
- All material matrices are set again be unitary after completion of ion transmission calculation
- The Last calculated material matrix angular magnification values are kept at material block area to retrieve in order to plot the matrix envelope or to show matrices in a window

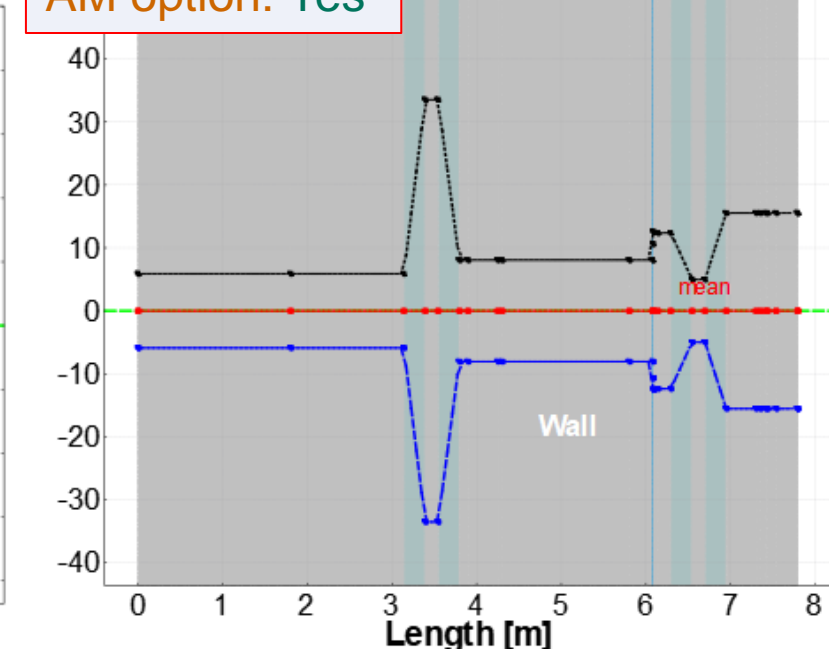
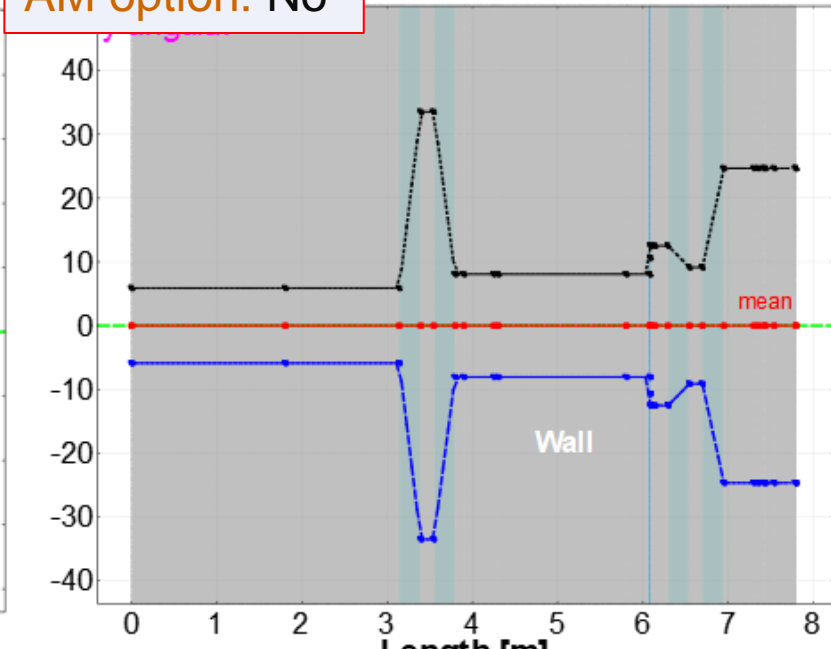
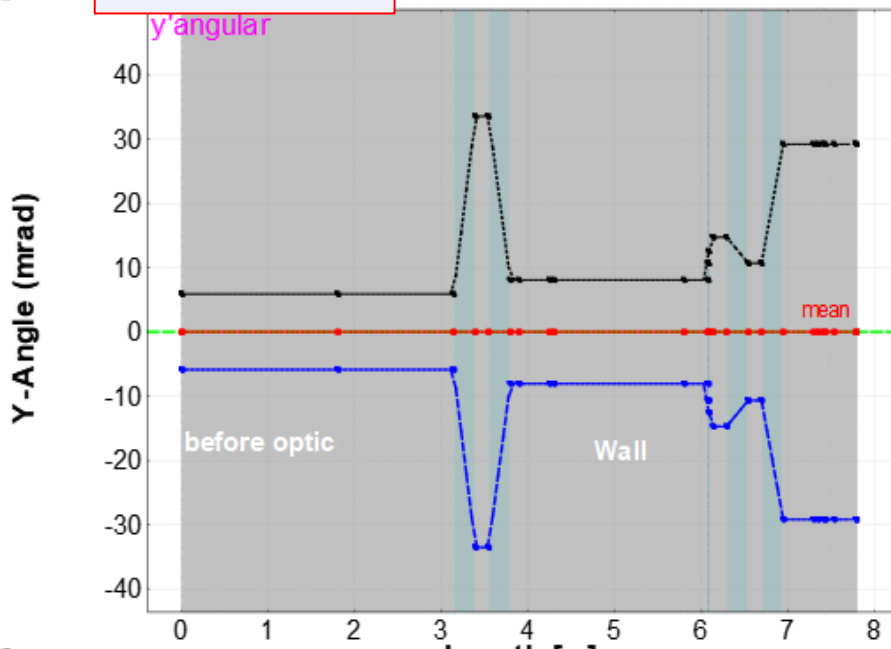
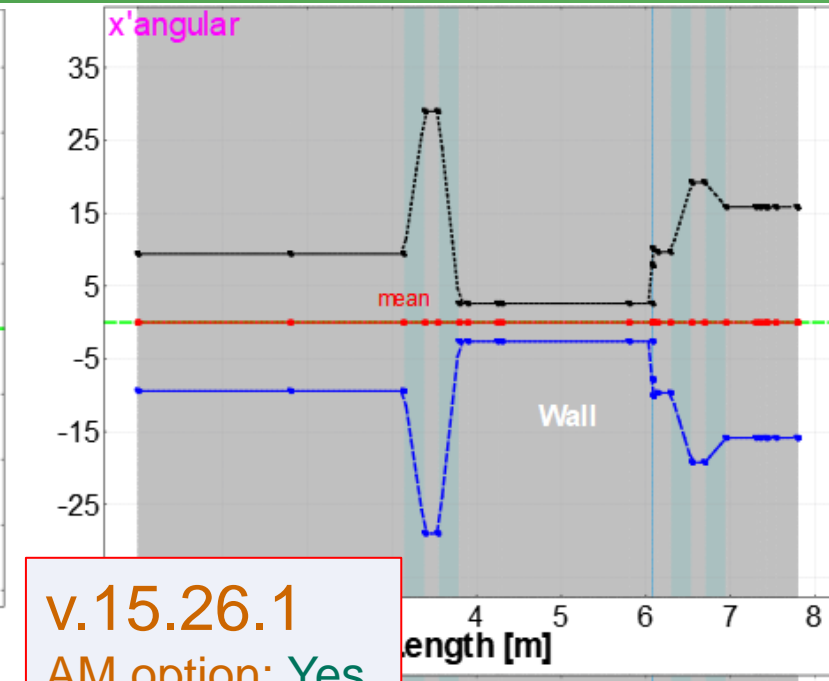
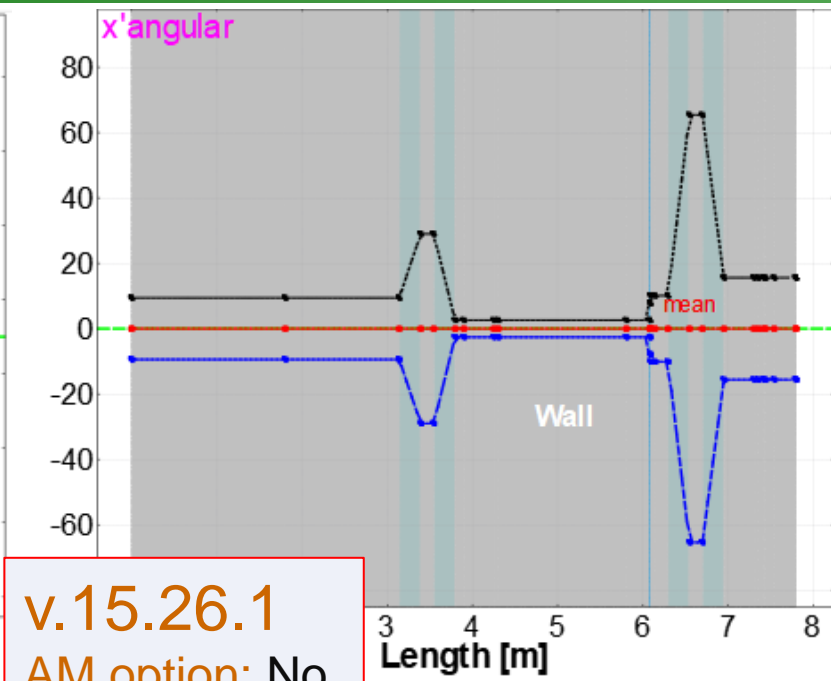
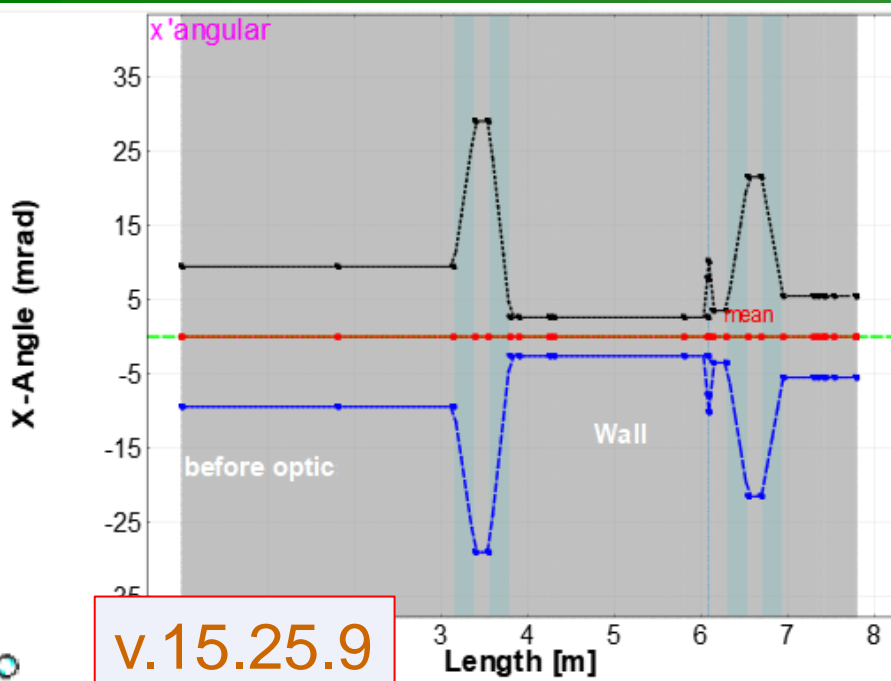
The screenshot shows the 'Preferences' dialog box with the following sections:

- Starting files and working directories:** Starting configuration at loading the program: A1900\_2019.lcn; Starting options file at loading the program: FRIB\_2021.lopt.
- Working directory:** Current user has administrative privileges: Yes; LISE++ working directory (options, config, etc) is: User My Documents.
- Calculation settings:** Calculation threshold: 1.0e-10 pps; Dimension of distribution (NP): calculation WITHOUT charge states: 64; calculation WITH charge states: 32; wedge calculation: 64.
- Calculate spectrometer settings using:** maximal, mean, left peak, right peak.
- Apply "Edge" effect in distrib. cuts:** Yes (default), No (It's recommended for extended configurations).
- Charge States:** No, Yes.
- Cross Section:** Fit, File, CS File Settings.
- Transmission information in the Table of Nuclides:** Display 1: Total: All reactions (pps); Display 2: TI transmission no SR (%).
- Utility options:** Navigation map, Spectrometer scheme, Balls animation, Show laboratory logos, Sound.
- Expert options:** Show Fitting constraint blocks in the Setup and Scheme windows, Use angular straggling contribution in optical matrices, Primary beam scattering in target (MC), Show Abrasion-Ablation in x-section plots.
- Debug options:** Show transmission calculation time, Charge State Optimization Debugging Mode, Distribution Debugging Mode (file 'distrib.bt'), Hold inclination angles of a target and a stripper together.



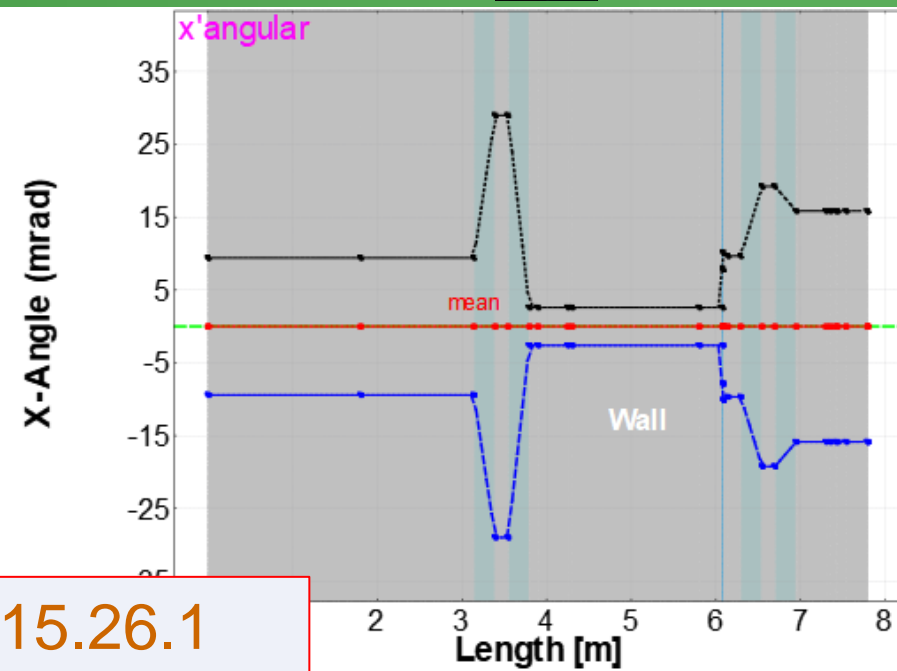
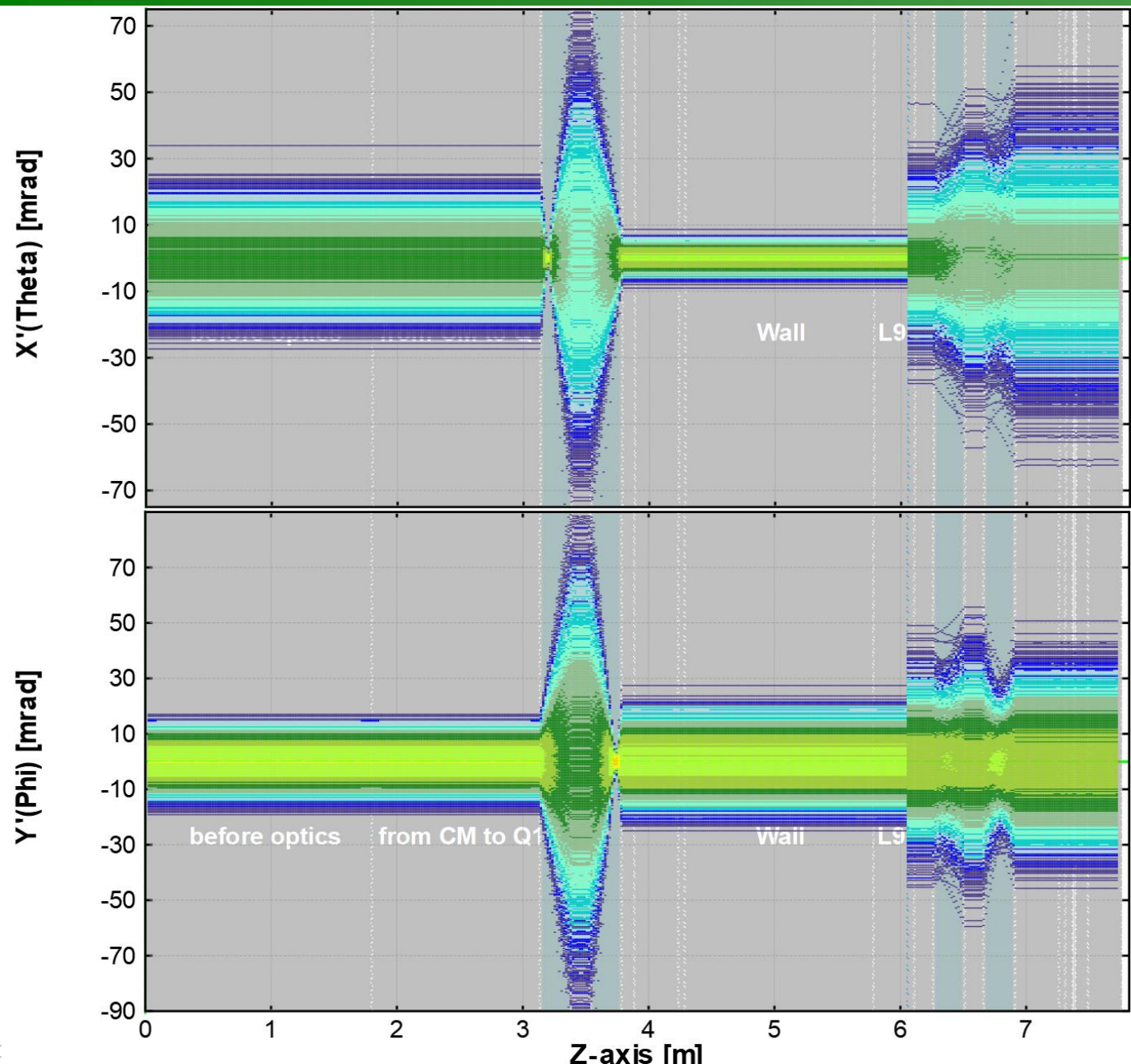


# Angular envelopes comparison

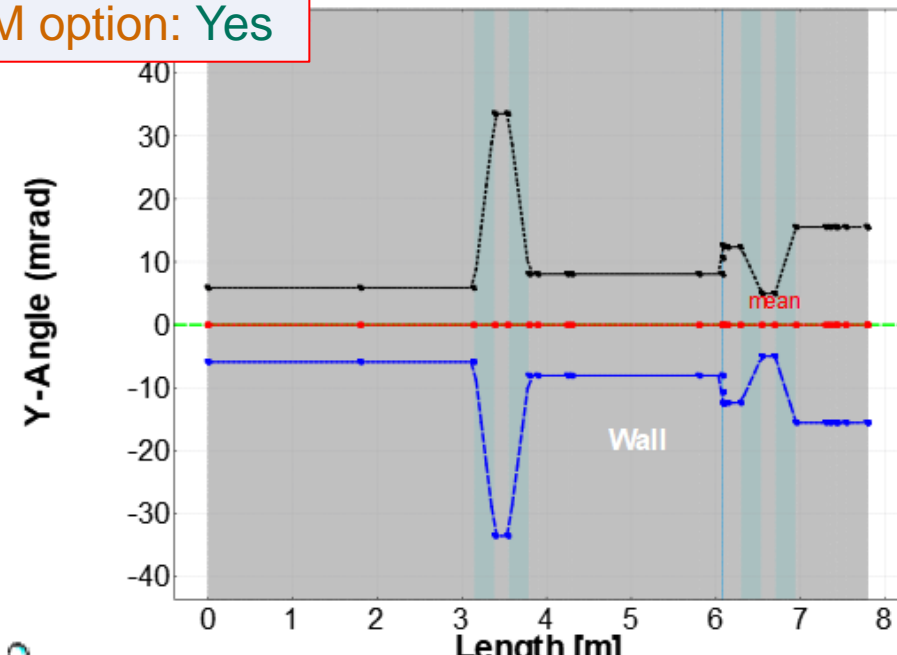


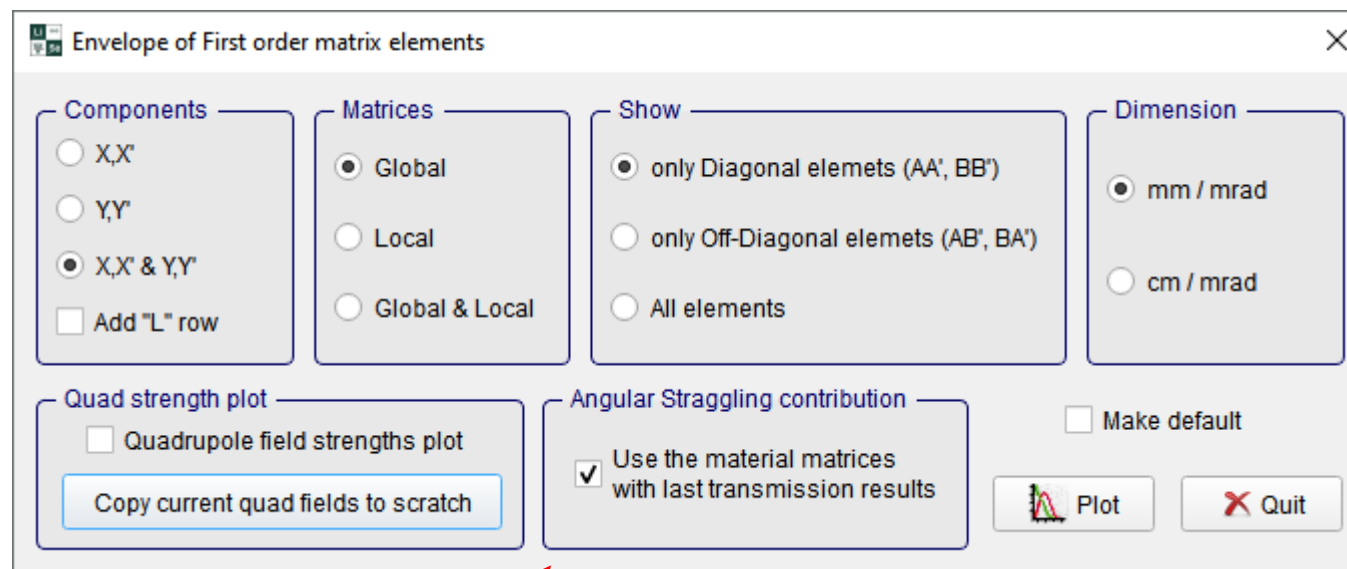
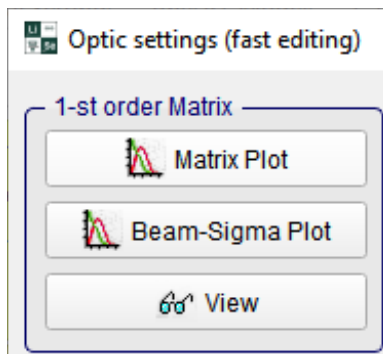


# Angular envelopes comparison



v.15.26.1  
AM option: Yes





The Angular Straggling contribution frame is visible

if  Use angular straggling contribution in optical matrices

set in the Preference dialog

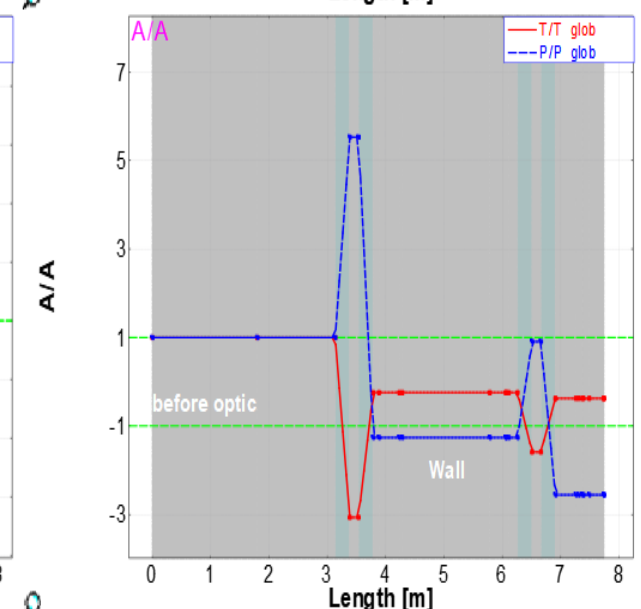
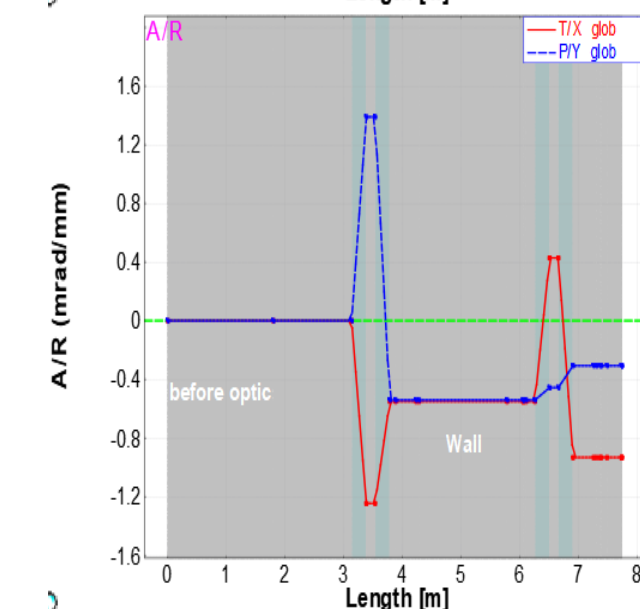
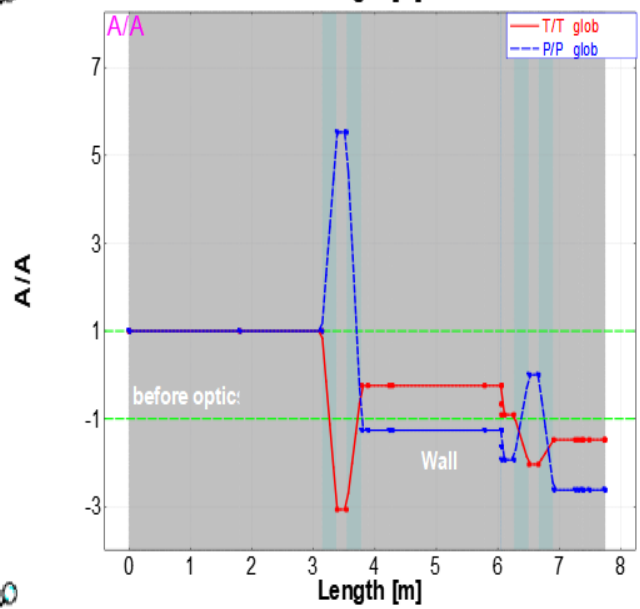
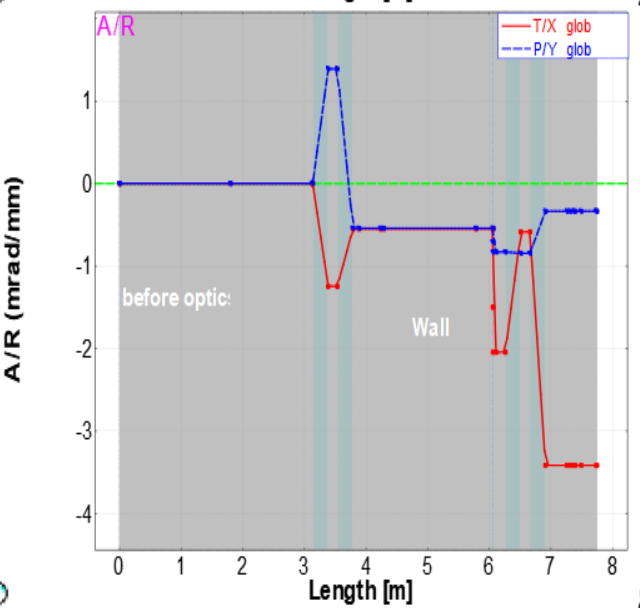
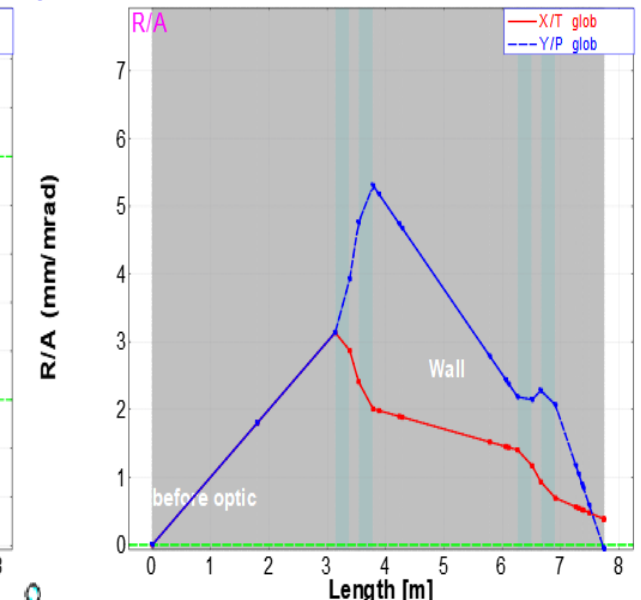
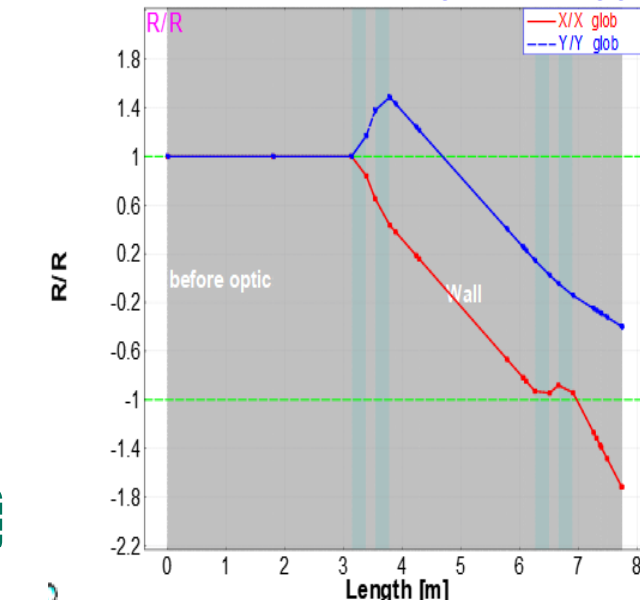
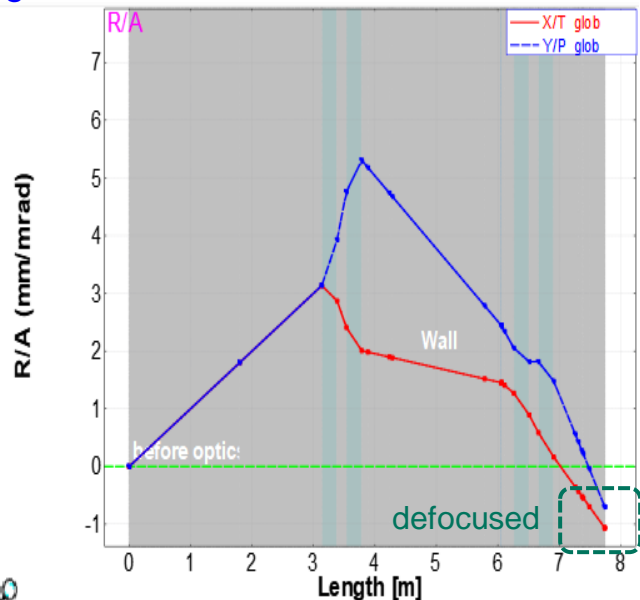
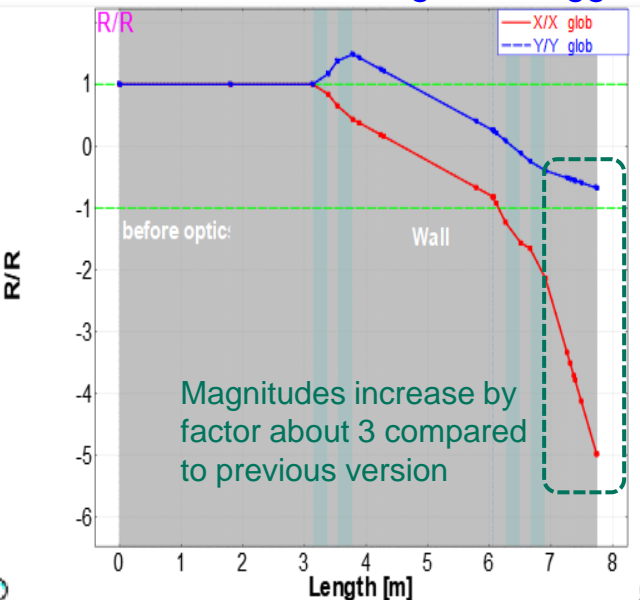


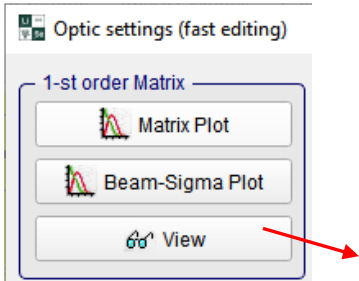
YES

NO

With angular straggling contribution in matrices

Without angular straggling contribution in matrices

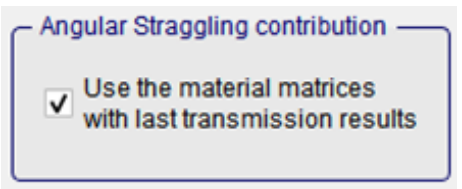




**YES**

With angular straggling contribution in matrices

Should be set in the "Matrix plot" dialog



11. Block "L9": Drift, Start: 5.785 m, Length : 0.275 m									
#standard									
+1.000e+00	+2.750e-02	0	0	0	0	-8.191e-01	+1.452e-01	0	0
0	+1.000e+00	0	0	0	0	-5.510e+00	-2.443e-01	0	0
0	0	+1.000e+00	+2.750e-02	0	0	0	0	+2.545e-01	+2.439e-01
0	0	0	+1.000e+00	0	0	0	0	-5.416e+00	-1.260e+00
0	0	0	0	1.0	0	0	0	0	1.0
-----									
12. Block "fake slit": Drift, Start: 6.060 m, Length : 0.000 m --- SLITS ---									
-----									
13. Block "Havar 10 um": Material, Start: 6.060 m, Length : 0.000 m									
: Co42Cr20Ni13Fe19W (10 micron)									
+1.000e+00	0	0	0	0	0	-8.191e-01	+1.452e-01	0	0
0	+2.721e+00	0	0	0	0	-1.499e+01	-6.647e-01	0	0
0	0	+1.000e+00	0	0	0	0	0	+2.545e-01	+2.439e-01
0	0	0	+1.301e+00	0	0	0	0	-7.046e+00	-1.640e+00
0	0	0	0	1.0	0	0	0	0	1.0
-----									
14. Block "Helium 1 atm": Material, Start: 6.060 m, Length : 0.000 m									
: He (10 mm)									
+1.000e+00	0	0	0	0	0	-8.191e-01	+1.452e-01	0	0
0	+1.000e+00	0	0	0	0	-1.499e+01	-6.647e-01	0	0
0	0	+1.000e+00	0	0	0	0	0	+2.545e-01	+2.439e-01
0	0	0	+1.000e+00	0	0	0	0	-7.046e+00	-1.640e+00
0	0	0	0	1.0	0	0	0	0	1.0
-----									
15. Block "Havar 10 um": Material, Start: 6.060 m, Length : 0.000 m									
: Co42Cr20Ni13Fe19W (10 micron)									
+1.000e+00	0	0	0	0	0	-8.191e-01	+1.452e-01	0	0
0	+1.364e+00	0	0	0	0	-2.045e+01	-9.066e-01	0	0
0	0	+1.000e+00	0	0	0	0	0	+2.545e-01	+2.439e-01
0	0	0	+1.179e+00	0	0	0	0	-8.309e+00	-1.934e+00
0	0	0	0	1.0	0	0	0	0	1.0

$\theta/\theta$  product is about 4!

compare

compare

To optimize ion optics with taken into account the angular straggling contribution, the user should manually create a matrix after materials

for example:  $^{82}\text{Se}$  (250 MeV/u)  $\rightarrow$   $^{60}\text{Ca}$ , Preseparator wedge is Al 3mm<sup>t</sup>

7. Block "PS\_wdg": Wedge, Start: 18.407 m, Length : 0.000 m  
: Al (3 mm)

+1.000e+00	0	0	0	0	0	0	0	+1.280e+00	+7.655e-06	0	-2.430e+00	+1.727e-01
0	+1.017e+00	0	0	0	0	0	0	+1.038e+00	+7.962e-01	0	+1.019e-06	+1.863e+00
0	0	+1.000e+00	0	0	0	+1.139e+00	+7.948e-07	0	0	0	0	+2.666e-02
0	0	0	+1.015e+00	0	0	-1.380e+01	+8.925e-01	0	0	0	0	+2.113e+00
0	0	0	0	1.0	0	0	0	-2.475e-01	-1.898e-01	1.0	+9.163e-01	+6.316e+00

Tiny magnification is less than 2% in the case of  $^{60}\text{Ca}$

the magnification is only 0.5% for tritons due to the broad angular distribution after reaction.  
5% magnification in the case of  $^{78}\text{Ni}$ .