

LISE++ Distribution Mode Fix

Extended Optics with Wedge Thickness Defect

Technical report for LISE++ v18.3.12 | May 2026

Subject	LISE++ analytical Distribution-mode fix for extended optics configurations
Benchmark	230 MeV/u 70Zn -> 5 mm C target -> 59Cr, +/-50 mm PS, to DB5; FRIB_2026.lopt
Main symptom	Extended and segmented LISE files agreed in MC mode and optics maps, but disagreed in analytical Distribution mode when wedge thickness defect was enabled
Validated version	LISE++ 18.3.12, extended configuration debug output
Main result	Extended Distribution mode now gives $-\Delta X(P) = 7.79$ mm and $+\Delta X(P) = 7.80$ mm at FP, matching the segmented/MC expectation

Executive summary

The bug was caused by missing angular sideband propagation in the analytical Distribution mode for extended optics configurations. The existing calculation stored and transported $dX(P)$, but did not store the corresponding $dA(P)$. This caused the wedge-defect broadening to disappear when the optics were represented by many detailed elements rather than by a segmented/condensed block.

The fix adds `e4dAXd/e4dAXu/e4dAYd/e4dAYu` to `distrFour` and propagates these angular sidebands through `L_Trans_angle.cpp`. `TR_Optic_Slits()` then uses these sidebands when evaluating lower and upper momentum-defect rays. The benchmark now shows $-\Delta X(P) = 7.79$ mm and $+\Delta X(P) = 7.80$ mm at the focal plane for the extended file, as expected.

Original symptom

The benchmark showed that the condensed and extended preseparator models had approximately identical maps, but the extended model gave an incorrect narrow X distribution in analytical Distribution mode. The problem appeared only when the wedge thickness defect contribution had to be transported through an extended sequence of optics elements.

Configuration / method	wedge defect 1%, X-sigma at FP, mm	wedge defect 0%, X-sigma at FP, mm
extended - MC	7.94	3.59
extended - Distribution, before fix	1.47	1.42
segmented - MC	7.99	3.59
segmented - Distribution	7.94	3.74

Table 1. Original benchmark: the extended analytical Distribution result missed the wedge-defect broadening

Original X-distribution evidence

The figures below are extracted from the original Word request. They show the important visual symptom: the condensed model produced the expected broad X distribution, while the extended model produced a much narrower X distribution although the optics maps were equivalent.

$$A_{up} = A(P + dP)$$

$$dAXd = A_{center} - A_{down}$$

$$dAXu = A_{up} - A_{center}$$

The implementation keeps the same LISE sign convention already used in TR_Optic_Slits(): e4Pu is used for the lower momentum sideband and e4Pd for the upper momentum sideband.

TR_Optic_Slits()

The slit/optic transport now uses sideband-aware angular terms when calculating the lower and upper X/Y limits. The central angle term is no longer reused for P-dP and P+dP rays.

$$xa_d = (A - dAd) * Lsa$$

$$xa_u = (A + dAu) * Lsa$$

$$xN_d = xP_d + xk + xx_d + xa_d + xx_i + xa_i$$

$$xN_u = xP_u + xk + xx_u + xa_u + xx_i + xa_i$$

Verification with extended configuration, v18.3.12

After the update, the extended Distribution debug table shows that the wedge-defect contribution is now transported to the focal plane. The important column is -deltaX(P)/+deltaX(P), not only the intrinsic sX value.

Block name	sPd	sPu	sX, mm	sY, mm	dX/dP	-deltaX(P), mm	+deltaX(P), mm
PS_wedge	33.78	33.72	0.44	0.36	-2.20E-01	0	0
FSD2_SCD3	33.78	33.72	27.73	10.17	2.40E-01	1.49	1.49
to_DB0	33.78	33.72	0.76	1.72	1.90E-01	6.25	6.26
to_SCD4	33.78	33.72	30.54	7.27	3.50E-02	8.20	8.21
to FP	33.78	33.72	0.46	0.57	1.00E-02	7.79	7.80
correction_matrix	33.78	33.72	0.46	0.57	1.00E-02	7.79	7.80
PS_l_slits	24.07	24.03	0.46	0.57	1.00E-02	5.55	5.56

Table 2. Debug-table excerpt after the fix: the extended model now carries deltaX(P) to the focal plane

The value 7.79-7.80 mm at to FP/correction_matrix is the expected transported wedge-defect sideband. This is the value that was previously collapsed to about 0.46 mm in the extended analytical calculation.

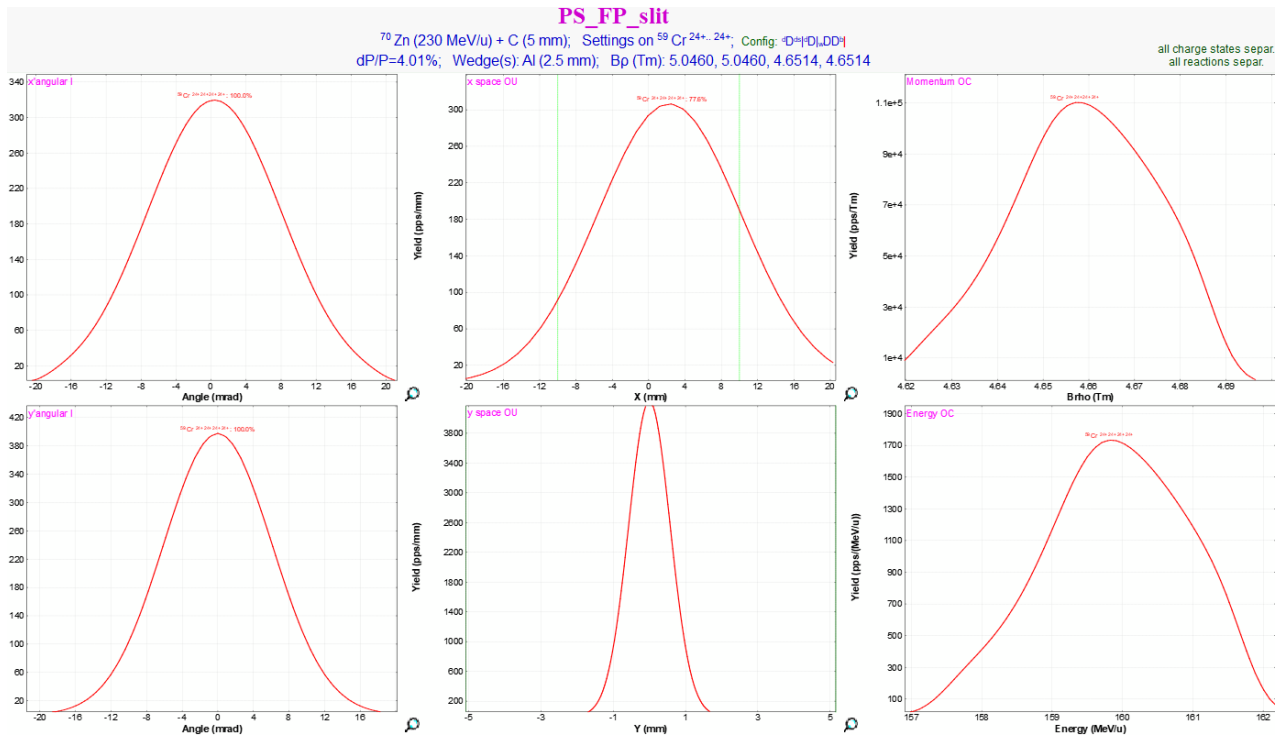
Files and areas to keep together

The update is logically distributed over several files/areas. They should be committed together:

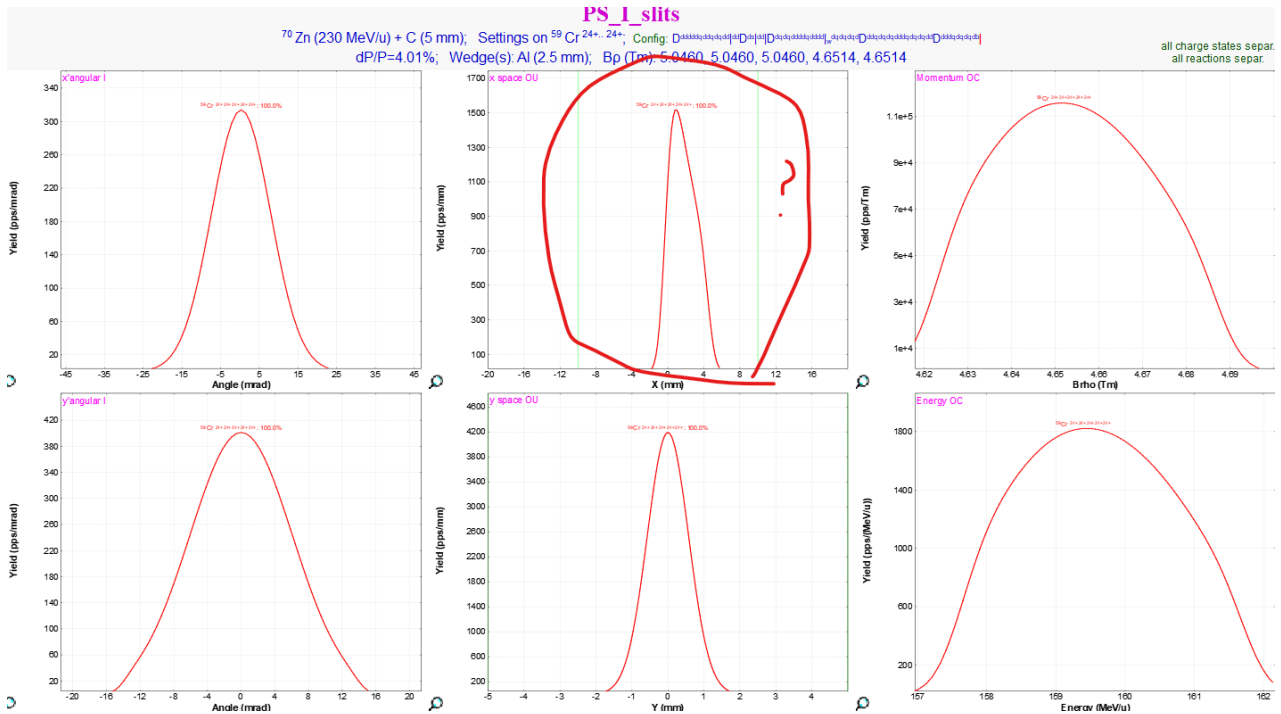
- o_Distr4.h: increase Ndistr4_XY and add e4dAXd/e4dAXu/e4dAYd/e4dAYu enum entries
- L_Distr4.cpp: add names for the new variables and exclude them from ChangeBase()
- Distribution initialization: initialize the new angular sidebands to zero
- L_Trans_angle.cpp: propagate angular sidebands in MakeDistr_A_from_P() and Make_A_OpticBlock()
- TR_Optic_Slits(): use dA sidebands when calculating lower/upper sideband positions

Appendix: original full distribution figures

The cropped panels in the main report were taken from these full original Distribution figures.



Appendix Figure A1. Condensed model original Distribution output



Appendix Figure A2. Extended model original Distribution output before fix