



LISE⁺⁺

Designing and evaluating rare-isotope beams

A practical guide to production, separator tuning and identification

What a LISE⁺⁺ result means

The reported rate belongs to a specified configuration

Production

Reaction yields for each isotope depend on the beam, target and selected physics models.

Transport

Charge states, momentum and angular distributions determine which ions reach an observation point.

Experiment

The full transmitted cocktail, detector response and rate limits determine whether the setting is useful.

Minimum inputs for a reproducible calculation

Primary beam	Projectile, kinetic energy per nucleon, intensity and beam profile.
Production target	Material, thickness, position and depth-dependent energy loss.
Physics choices	Production mechanism, cross-section model, mass table, momentum and charge-state prescriptions.
Beamline	Optics file, wedge and slit settings, apertures and detector materials.

Production mechanisms at a glance

Fragmentation

Fast projectile loses nucleons; excited remnants de-excite into projectile-like residues.

Projectile fission

Excited heavy projectile fissions after electromagnetic or nuclear interactions.

Fusion reactions

Compound nucleus forms and decays by evaporation or fission.

Secondary reactions

Fragments can react again in a thick target or a downstream material.

[Reaction mechanisms: pages, presentations, and papers](#)

Cross section and delivered rate

Cross section σ	A reaction property for producing a selected isotope under defined beam and target conditions.
Charge fraction f_ϕ	Only the accepted ionic charge states follow the selected rigidity.
Transmission T	Separator acceptance and material losses filter the production distribution.
Delivered rate	For a thin target, $R \approx I \times n_t \times \sigma \times f_\phi \times T$; thick targets require depth integration.

Target thickness changes more than yield

Compare the predicted rate after the separator, not only at the target

More production

A thicker target presents more nuclei to the primary beam. Products born at different depths have different initial energies and material paths.

More degradation

Energy loss, straggling, scattering and charge changing broaden the distributions. Secondary reactions may remove or create products.

Momentum and angular acceptance

Longitudinal momentum

Model-dependent centroid and width set the fraction within the first rigidity window.

Angular spread

Finite angular acceptance and collimation reduce transmission, especially after thick materials.

Dispersion

A focal-plane position corresponds to a momentum or rigidity range only for its optics configuration.

Check

Plot distributions at target exit and at each aperture; inspect tails and competing species.

Charge states and magnetic rigidity

Rigidity

$B\rho = p/q$: equal rigidity does not imply equal isotope or charge.

Target exit

Predict charge fractions after the target at the relevant energy and material thickness.

Downstream materials

Wedges, degraders and detectors can change q ; follow each populated charge state.

Operational check

Inspect A/q and the full cocktail after every significant material.

A separator setting is a sequence

First selection

Set the desired fragment near the useful momentum and rigidity acceptance.

Energy degrader

A wedge changes energies differently across species; its location and profile matter.

Intermediate apertures

Slits reject contaminants while removing a calculable part of the desired beam.

Final selection

Retune downstream rigidities and check rate, purity and beam spot at the experiment.

Segmented and extended configurations

The file and separator configuration must match the proposed experiment

Segmented calculation

A compact representation helps scan settings and compare reaction or material choices. Confirm the optics and focal planes represented by the selected configuration.

Extended calculation

Element-by-element geometry and optics resolve apertures, trajectories, materials and detector locations. Use it when local distributions or acceptance determine the result.

How to evaluate a candidate setting

Desired isotope	Rate at the experiment and fraction surviving each selection.
Cocktail	Total rate and largest contaminant species at the relevant focal planes.
Separation	Compare A/q , Z , time of flight and energy-loss observables with expected resolution.
Limits	Check slit heating, detector rate capability, backgrounds and available rigidity range.

Hausmann's 64Cr settings

FRIB separator example: 82Se at 236.6 MeV/u, 10 kW (2020 tutorial)

Selection	64Cr rate	Purity
One wedge	~1,100 pps	A few percent
Two wedges	~900 pps	~50%
Two wedges and slit tuning	~700 pps	~80%
1% momentum acceptance	~180 pps	~98%

64Cr: reading the tradeoff

These are tutorial estimates from 2020

Starting point	82Se at 236.6 MeV/u; the tutorial uses a 10 kW primary-beam scenario.
Second wedge	Strong purity gain for a modest loss of 64Cr rate in this example.
Slit tuning	About 700 pps at ~80% purity after the second wedge and adjusted slits.
Narrow acceptance	~98% purity at ~180 pps; the preferred setting depends on experimental needs.

64Cr: repeat the calculation yourself

Set the source

Enter 82Se beam, target and chosen 64Cr reaction prescription in the LISE file.

Inspect first result

Calculate the full cocktail at each focal plane, including charge states.

Add selection

Compare one and two wedges; record their thickness, materials and rigidities.

Optimize

Vary slits and momentum acceptance; plot 64Cr rate versus total cocktail rate.

Particle identification and observables

A/q

Magnetic rigidity plus velocity constrain mass-to-charge ratio.

Z

Energy loss in matter gives nuclear-charge separation after correcting for velocity.

ToF and positions

Detector timing and tracking help resolve trajectories and correct observables.

Validation

Compare predicted widths and isotope spacing with measured detector performance.

When the predicted rate is wrong

Cross section

Test empirical and physical model predictions against nearby measured isotopes.

Charge states

Compare calculated fractions with observed charge-state populations.

Optics

Verify actual apertures, wedge position, field settings and detector materials.

Normalization

Check beam intensity, target areal density, live time and the quoted focal plane.

Saving and comparing calculations

Record

LISE⁺⁺ version, input file, mass table, model options and beamline configuration.

Compare

Make a table of desired rate, total rate and purity at the same focal plane.

Scan

Use Silent Mode or repeated runs to explore target, wedge and separator alternatives.

Report

State the assumptions and the dominant uncertainty with the final setting.

Where to go next

New user

Introduction page: tutorials and first-setting examples.

Beam tuning

Hausmann 64Cr tutorial: numerical rate–purity tradeoffs.

Reaction details

Reaction-mechanism references and the specialized AA page.

Technical depth

Documentation, publications, model notes and release history.

Beam setup and experimental tradeoffs

Click a title to open the original LISE presentation or guide

Making a 64Cr beam · M. Hausmann

Four settings compare wedges, slits, momentum acceptance, rate and purity.

lise.frib.msu.edu/doc/users_beams_making_64cr_youtube.pdf

LISE++ tutorial · D. Bazin

22Al example: target optimization, implantation range, wedge and PID.

lise.frib.msu.edu/doc/Tutorial4.pdf

LISE++ tutorial · P.-L. Tai

Further step-by-step exercises for beam preparation.

lise.frib.msu.edu/doc/Tai%20LISE%2B%2B%20tutorial.pdf

Extended configurations and optics

Click a title to open the original LISE presentation or guide

Extended versus segmented · practical guide

Choosing Distribution or Monte Carlo; apertures, cuts and angular acceptance.

lise.frib.msu.edu/doc/LISE_extended_vs_segmented_guide.pdf

S- and E-blocks · 2014 presentation

Construction and optical-block editing in extended configurations.

lise.frib.msu.edu/9_8/SE_blocks.pdf

LISE⁺⁺ for S3 · 2015 presentation

Geometry, corrections, optimization and S3 acceptances.

lise.frib.msu.edu/9_10/S3config.pdf

Files, output and batch calculations

Click a title to open the original LISE presentation or guide

LISE file format · practical guide

Edit and check configuration data recorded in a LISE file.

lise.frib.msu.edu/doc/LISE_file_manual_editing_guide.pdf

Results menu · output guide

Which quantities and tables the Results commands can produce.

lise.frib.msu.edu/doc/LISE_menu_results_options.pdf

Silent Mode · command-line flow

Batch workflow and output from the v18.8 update.

lise.frib.msu.edu/18/LISE_Silent_Mode_Command_Line_Flow.pdf