# $LISE^{++}_{cute}$ , the latest generation of the $LISE^{++}$ package, has been released

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The $LISE^{++}$ software for fragment separator simulations has undergone a major update. The package developed in our laboratory and widely used in rare isotope beam facilities predicts intensities and purities for the planning and running of experiments using in-flight separators, and is essential for radioactive beam production where its results can be quickly compared to on-line data.

$LISE^{++}$ version 16 is named $LISE^{++}_{cute}$ to indicate a major step forward from the previous Borland-based versions. It has been ported by the LISE++ transportation team to the Qt-framework in order to support modern compilers and computing methods. The benefits include 64-bit operation, and make $LISE^{++}$ available on three different platforms: Windows, macOS and Linux. In addition, the porting gives us the ability to take advantage of future computational improvements. The $LISE^{++}_{cute}$ package remains essentially identical for all platforms, keeping all previous versions functionality with implementation of new features and utilities. The pronunciation is still [lis plʌs plʌs] or now also [lees kyo͞ot].

$LISE^{++}$ version 16 is now the official production version. It has been accepted by the Accelerator Physics department and will be used for the preparation of FRIB experiments. The new version and its documentation, including the recommendations on the package installation on different operating systems, are available for download on the $LISE^{++}$ website. In addition to porting to the new platform, new main features and modifications have been added, mostly devoted to improving models and implementing other codes involved in rare isotope production at FRIB.

- GEMINI++ code implementation
- ETACHA4 code porting, updates, graphs (see Fig.1)
- 3-D Monte Carlo transmission output (see Fig.2) including 3-D envelopes
- Update of the minimization procedure of the $LISE^{++}$ Abrasion-Ablation model to adjust its parameters based on experimental projectile-fragmentation cross-sections
- Angular straggling contribution to ion optics

- The new utility “Power deposition and rate analysis in blocks”
- The new utility “Beam energy scanning” determines optimal beam energy for current given separator settings
- Implementation of new version 1.4 of the energy loss code ATIMA
- Shape calculation of two angle wedge to pass neighbors isotopes besides a setting fragment in the case of thick momentum compression degrader
- The LISE package installer on Windows has been signed with the MSU digital certificate, thereby eliminating the “unknown publisher” message.

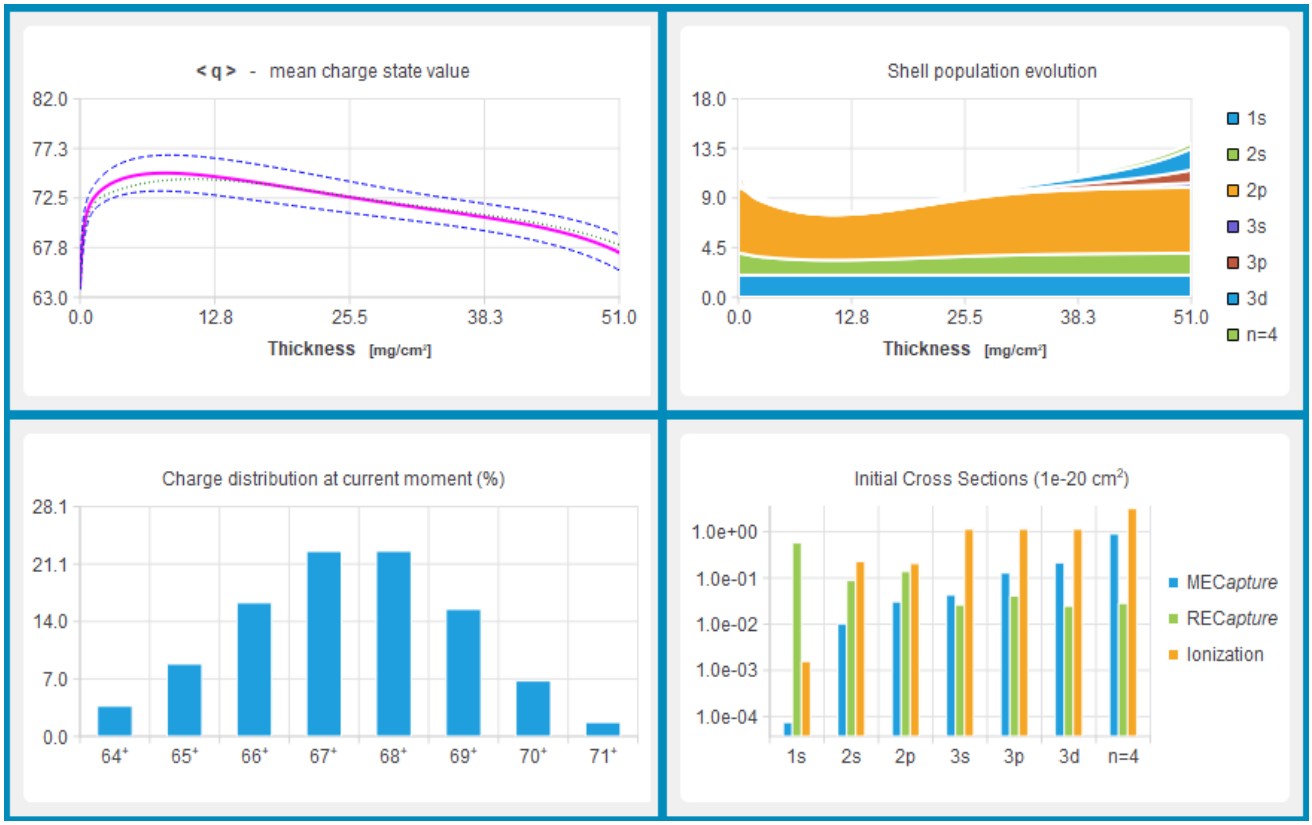


***Fig.1.*** *ETACHA4-GUI charge state evolution plots for a $^{207}$Pb projectile at energy 28.9 MeV/u with initial ionic charge $64^{+}$ going through a carbon degrader of thickness 51 mg/cm$^2$.*

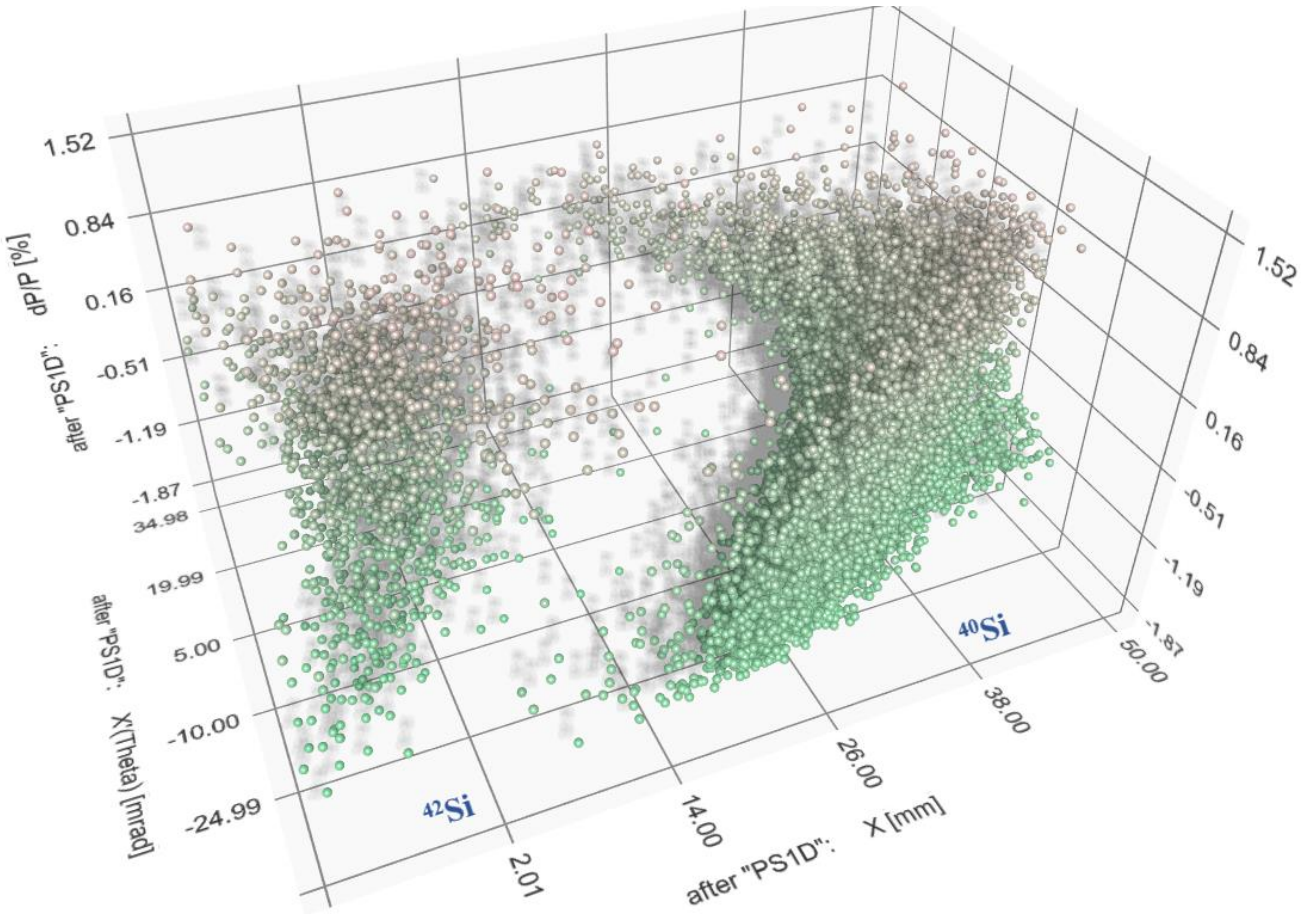


***Fig.2.*** *3-D plots of the X, X', dP/P distributions of $^{40}$Si and $^{42}$Si fragments in front of the ARIS presepator final focal plane slits (FS_F1S2:SLV_D1465) calculated by Monte Carlo method with 5$^{th}$ order maps use in the reaction $^{48}$Ca(251 MeV/u) + $^{12}$C(10mm). The separator set to produce $^{42}$Si uses a 6-mm special shape aluminum degrader located in the dispersive focal preseparator plane, which compress fragment momentum distributions by a factor 3. Calculated transmission through the next slits (± 8 mm) are 0.03% and 87.2% for $^{40}$Si and $^{42}$Si, respectively.*

The LISE$^{++}_{cute}$ package is deployed on FRIB Linux workstations, and can be accessed via Linux Terminal by typing "lise++" or eg "etacha4" to run the corresponding program.

The classic A1900 configuration is still used as default when starting LISE$^{++}$ due to the added complexities of the ARIS separator, such as rotation blocks, momentum compression, need for custom shape degraders, and 5$^{th}$ order COSY maps. The user has the option to change the default options to start with one of ARIS configurations that come with the package. The description on those configurations is available at the following link.

In the near future, the creation of a $\mathrm{LISE}^{++}_{core}$ library and code parallelization will be undertaken. This library will allow to integrate $\mathrm{LISE}^{++}$ calculations within control systems, in order to directly assist the tuning of fragment separators. This functionality will be tested at FRIB and FAIR. For example, the direct integration of $\mathrm{LISE}^{++}$ software with the ARIS controls at FRIB will enable operators to update inputs to calculations based on experimental measurements.

To take advantage of modern computing architecture, parallel computing methods are essential in achieving faster computation. As a first step, the $\mathrm{LISE}^{++}$ code parallelization process will be implemented on the Monte Carlo and "Distribution" analytical methods for fragment transmission calculation.

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The Greensheet is available online here:

https://groups.nscl.msu.edu/userinfo/greensheets/2021/The%20Greensheet11%2012%2021.pdf