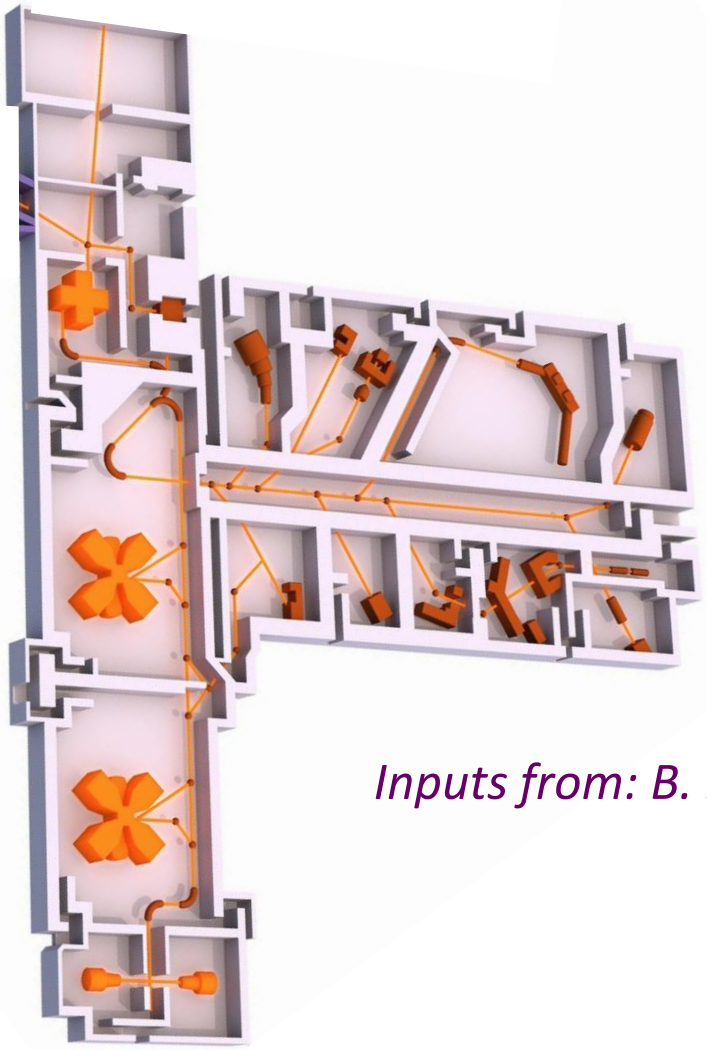


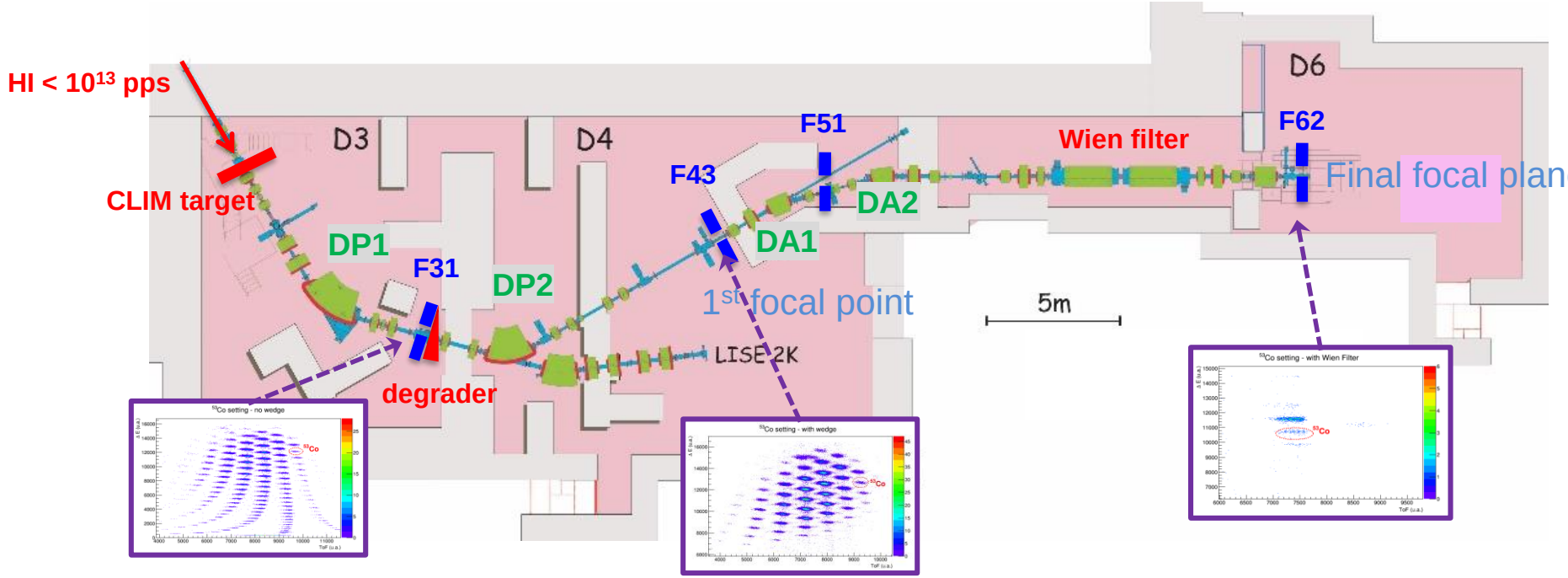
LISE upgrades

J.-C. Thomas, GANIL – on behalf of the LISE team

Inputs from: B. Blank, O. Kamalou, F. Marie-Saillenfest, O. Sorlin and V. Watt-Morel

Introduction

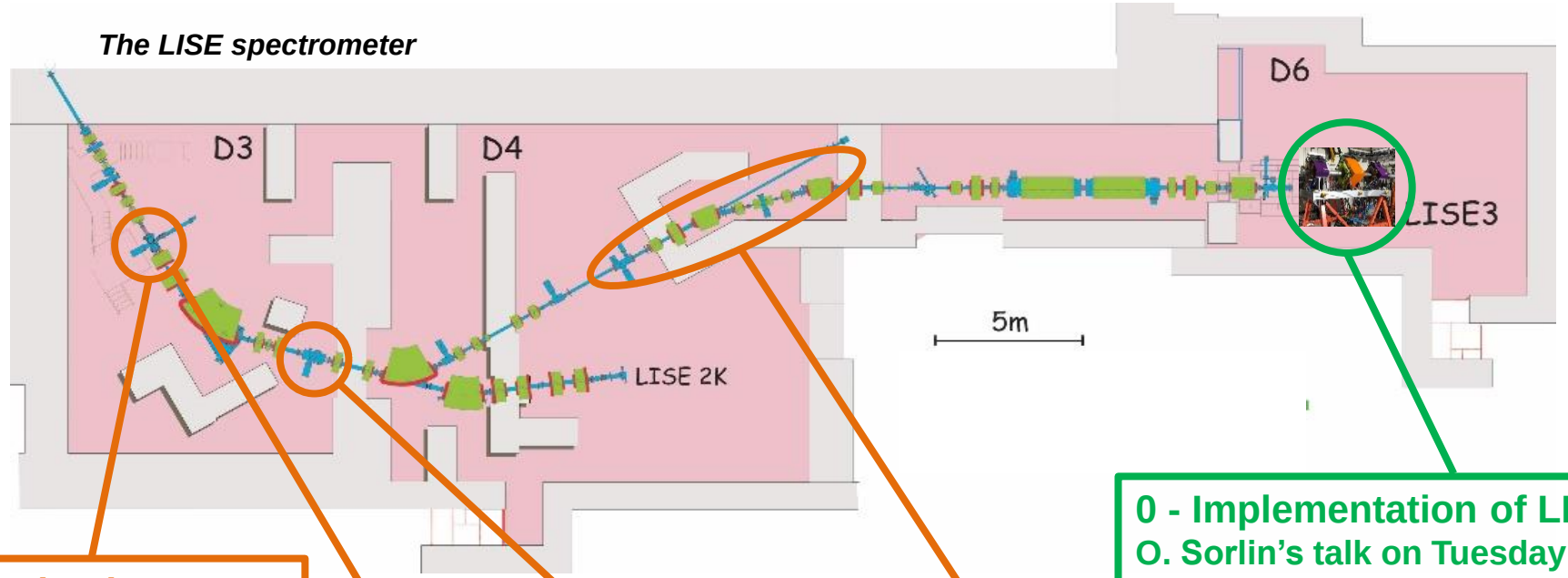
LISE: a fragment separator for (mainly) decay and direct reaction studies



Main features ---------- **No 0° spectrometer after D6**

- **Beam power loss in the production target: < 800 W**
- **Angular acceptance: 1 msr (3.5 on LISE2K)**
- **$\Delta p/p \leq \pm 2.5$ %**
- **Secondary beams at ~30 (light RIBs) to ~50 MeV/u**
- **$B_{\rho 2} \leq 3.2$ T.m (4.3 T.m on LISE 2K)**

Possible upgrades



0 - Implementation of LISE QD6 + ZDD
O. Sorlin's talk on Tuesday (« brochette » mode)

1 – Production target

2 - Angular acceptance

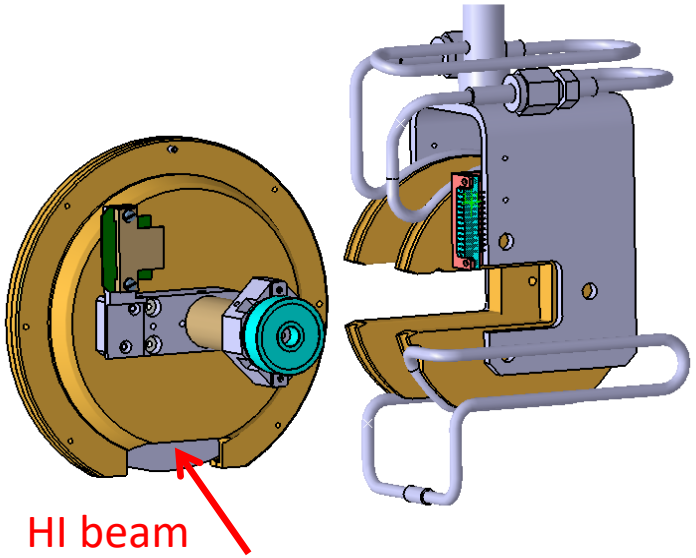
3 - Momentum acceptance

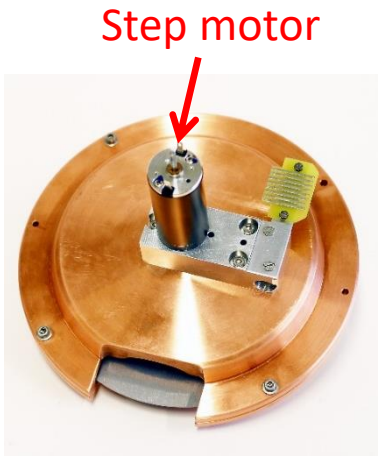
4 – Slowing down

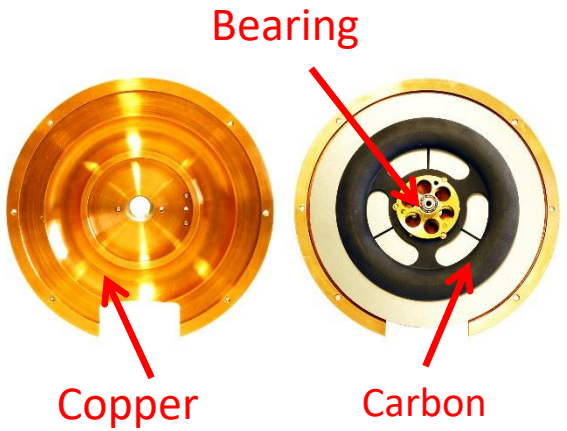
++ CYREN project / New injector, B. Jacquot's talk

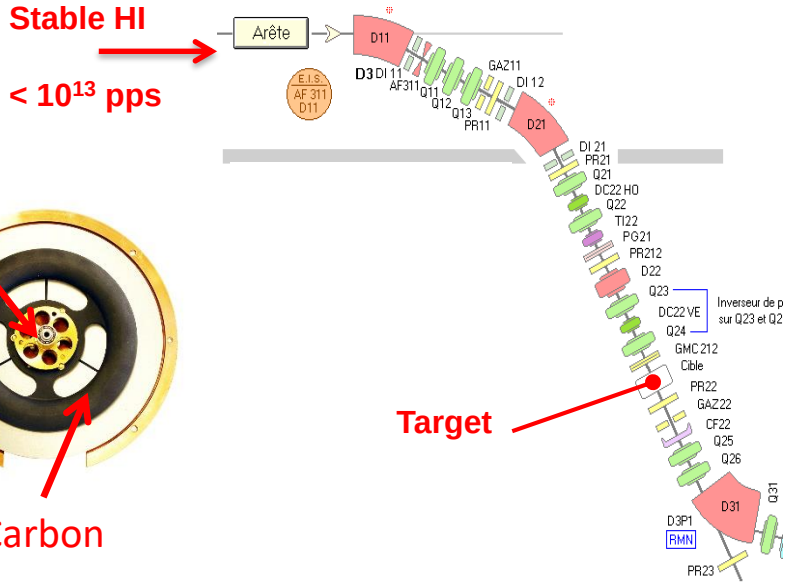
High power production target 1/2

CLIM: « Cible Lise Intensité Maximale »









- **Specification: up to 800 W beam power deposited**
  e.g. 3.3 kW of $^{32}S^{16+}$ @ 95 MeV/A (i.e. 6 10^{12} pps) in 2 mm of Be @ 40° (today: 1.6 kW)

- **Inclination up to 40°**
- **3 different radial impact positions -> stack of up to 3 targets**

High power production target 2/2

Context: recurring issues with the operation of CLIM with Be targets in recent years

- E823-2022 – $^{48}Ca^{19+}$, 60 MeV/u, 500 W: rotation breakdown after ~3 days for ~100 W of beam power deposit
- E796-2020 – $^{22}Ne^{10+}$, 60 MeV/u, 900 W: rotation breakdown after ~10 hours for ~250 W of beam power deposit
- …

Opportunity 1: Thicker Be targets -> higher yields + lower energy (≤ 30 MeV/u) for light fragments

Opportunity 2: CYREN -> higher beam intensities

=> even higher power deposit

-> CLIM upgrade required to at least reach the original specifications ($P_{deposited}$ ≤ 800 W)

Planned actions:

- 2023:
  - replacement of the metallic bearings -> ceramic (NFS)
  - design study of a CLIM++ prototype:
    - * online target temperature monitoring
    - * rotation without bearings + CW motors
    - * mechanical modifications -> better power dissipation (+ thermal calculations)
- 2024: offline and online tests + full conception if successful -> operation of CLIM++ in 2025 (objective)

NB: Manpower availability in the CYREN/S3/DESIR/NEWGAIN context? (mechanics, electro-technics, safety,...)

Improved angular acceptance?

Context: current angular acceptance of 1 msr, i.e. ± 18 mrad (± 1°) in X' and Y'

- Typical emittance of RIBs after the production target (3σ emittance of 2.25 mm * 5.25 mrad ~12 mm.mrad):
  - ^{58}Ni@74.5 MeV/A -> ^{48}Ni: X' = Y' ~55 mrad (3σ), i.e., ~37% transmission
  - ^{22}Ne@60 MeV/A -> ^{19}N : X' = Y' ~120 mrad (3σ), i.e., ~9% transmission

  -> RIB intensity gain of 2.5 (^{48}Ni) to 4 (^{19}N) expected for an angular acceptance increased to ± 40 mrad

-> Modification of the beam optics before and after the production target (double focalization)?
-> Modifications of the LISE beam line beyond to ensure a good transmission?

- A similar study in the past for the replacement of SISSI, using standard quadripôles

  -> Feasibility at LISE?

B. Jacquot et al., GANIL internal report, 2007

Improved momentum acceptance?

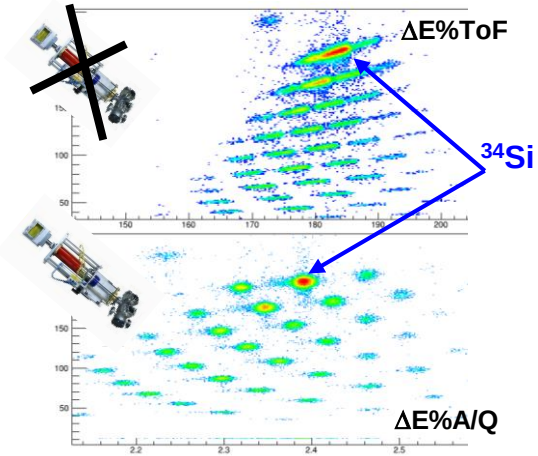
Context: Δp/p limited to ±2.5 %, but most of the time set (F31) to ±0.6 %

- Due to the difficulty with cocktail beams to identify ions evt/evt (ToF overlap)
- If overcome, would allow taking more RIB intensity (detector limit = 2.10^5 pps)

Solution on the n-rich side: position measurement at the 1st dispersive focal plane (F31) with CAVIAR -> A/Q (i.e. B_ρ) determination evt/evt

Usually impossible on the n-deficient side: strong contamination by less exotic species and detector count rate limitation ~10^6 pps

E798-2022 - Id. plot

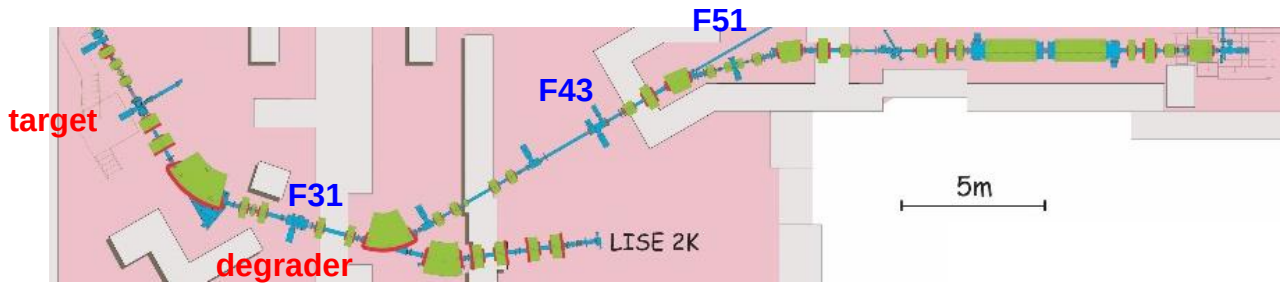


^{36}Si -> ^{34}Si without wedge
F31 = [0,+45] mm

Unsuccessful attempt to use CAVIAR at the 2nd dispersive focal plane (F51)

- Most probably due to the partial overlap of ion trajectories due to the energy degrader (angular straggling)

A combined position measurement in F43 and F51 might help "a bit"
-> to be tested online



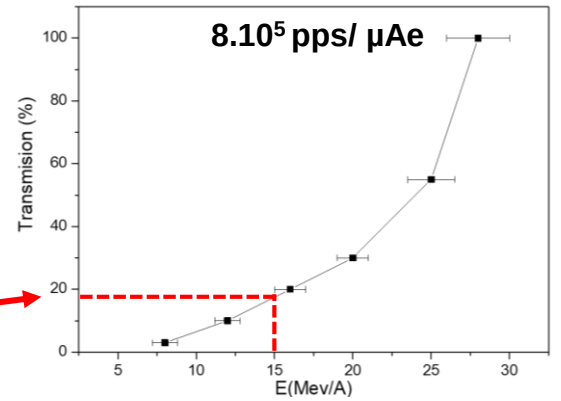
Secondary beams slowing down? - 1/3

Context: E < 30 MeV/u RIBs for direct reaction studies -> nuclear structure and astrophysics

- E628-2014 ^{16}C(d,p); E748-2017 ^{10,12}Be(d,^{3}He); E796-2021 ^{20}O(d,^{3}He), using ACTAR TPC and MUST2 at 17 to 36 MeV/u
  - requires to lower the primary beam (^{18}O, ^{22}Ne) energy down to 60 MeV/u while 95 MeV/u are available
    -> secondary beam intensity « loss » ≥ 3
  - requires the use of a RIB slower in F43 (typically 1 mm of Be)

But: it does not work for "high Z" RIBS (losses in the achromatic deviation)

- Slowing-down induced emittance increased (limited angular acceptance)
- Charge state distribution below 30 MeV/u after the energy degrader
  -> e.g., less than 20 % transmission expected for ^{56}Ni^{28+} @ 15 MeV/A



O. Kamalou, LISE 2019 Workshop

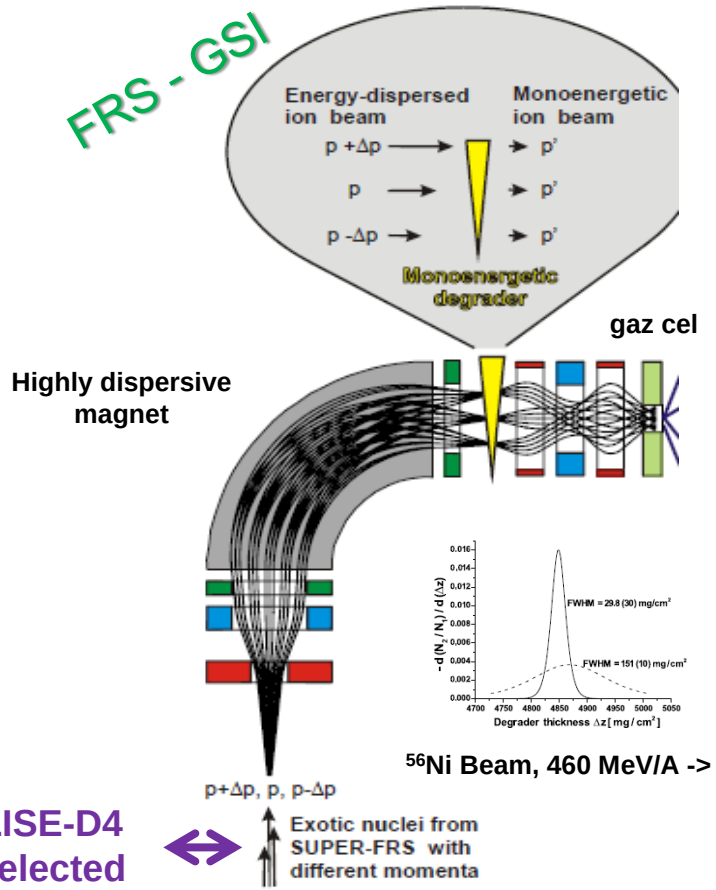
However: improving the LISE (Z ≤ 30) RIB yields in the 10 to 30 MeV/u range would allow performing transfer reactions and (in-)elastic scattering reactions using ^{25}Al,^{24,34}Si, ^{34}Ar, ^{48}Cr, ^{56,68}Ni,…

Secondary beams slowing down? - 2/3

LISE upgrade?

-> following RIB slower systems developed elsewhere, based on a monoenergetic degrader

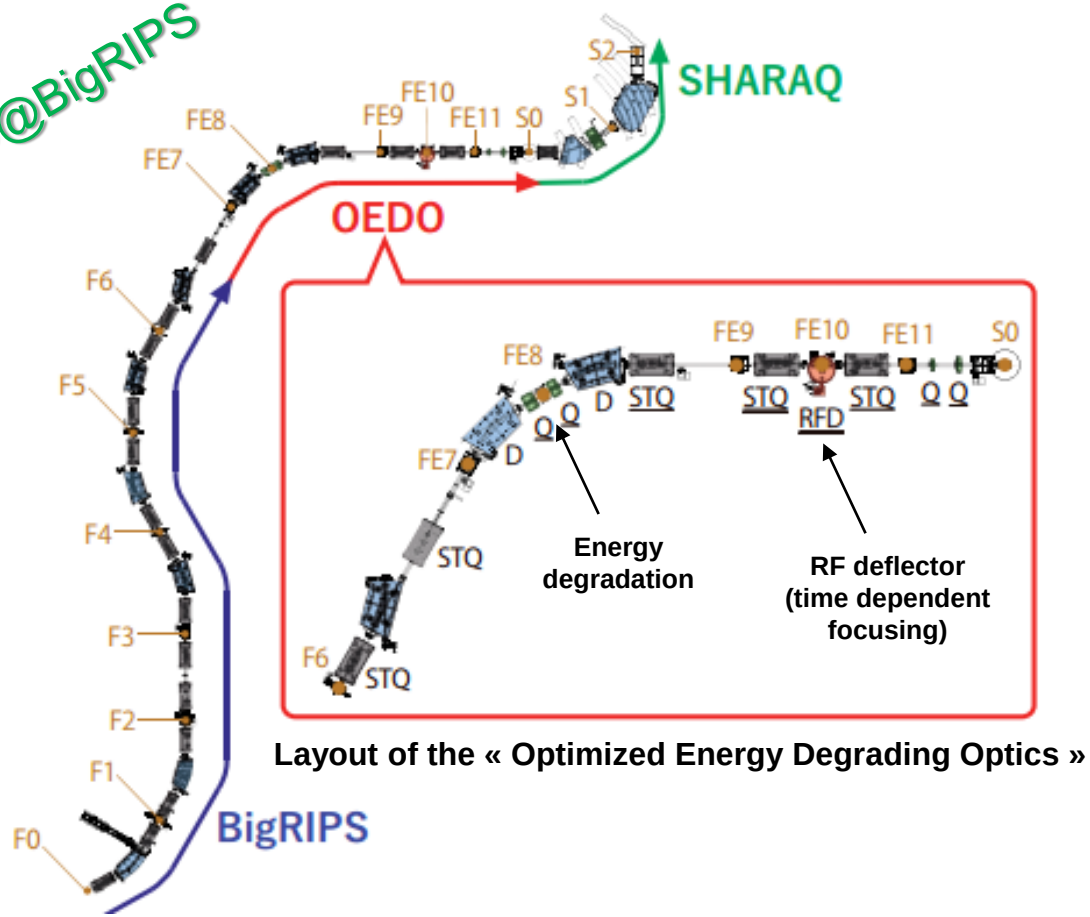
FRS - GSI



^{56}Ni Beam, 460 MeV/A -> 360 Mev/A

C. Sheidenberger et al, NIM B 204 (2003) 119

OEDO@BigRIPS



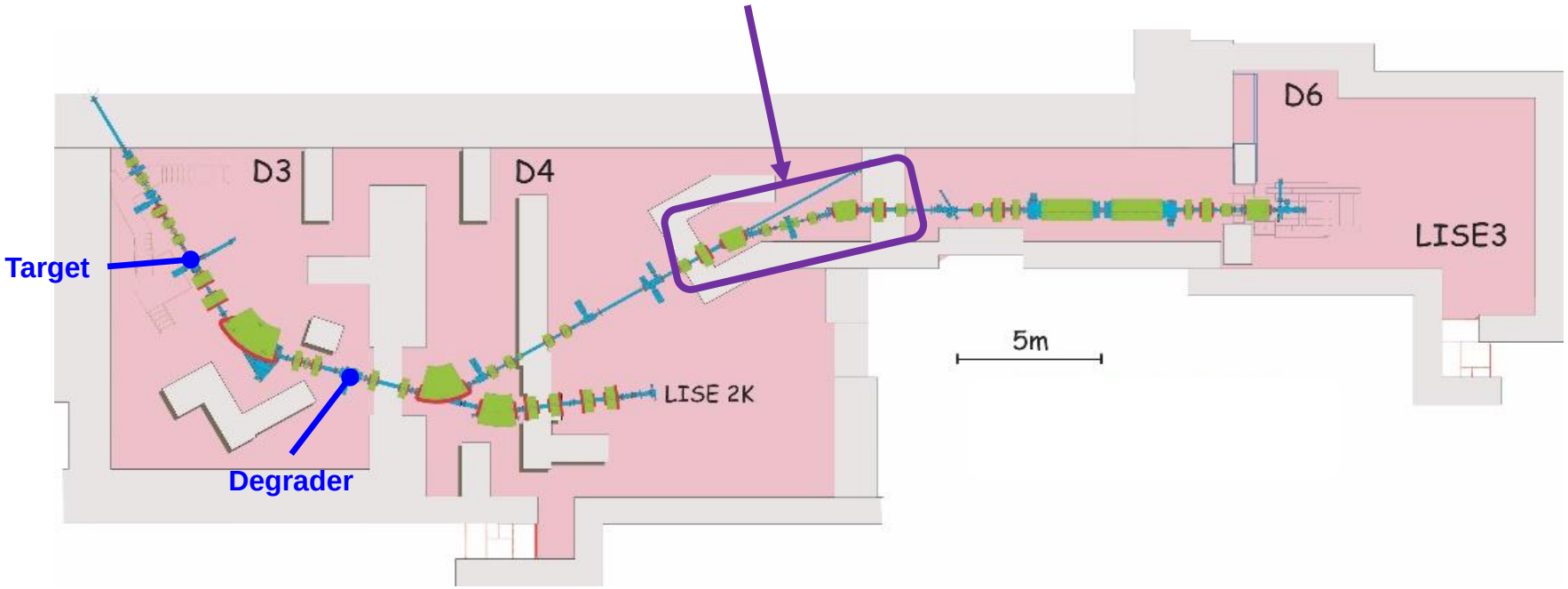
Layout of the « Optimized Energy Degrading Optics »

S. Michimasa et al, Prog. Theor. Exp. Phys. (2019) 043D01

Secondary beams slowing down? - 3/3

LISE upgrade?

- Ideally, to be set in the achromatic deviation
- Keeping the possibility to transport RIBs at their nominal energy (~50 MeV/u) towards D6



-> Beam optics studies required to evaluate the feasibility, manpower and costs

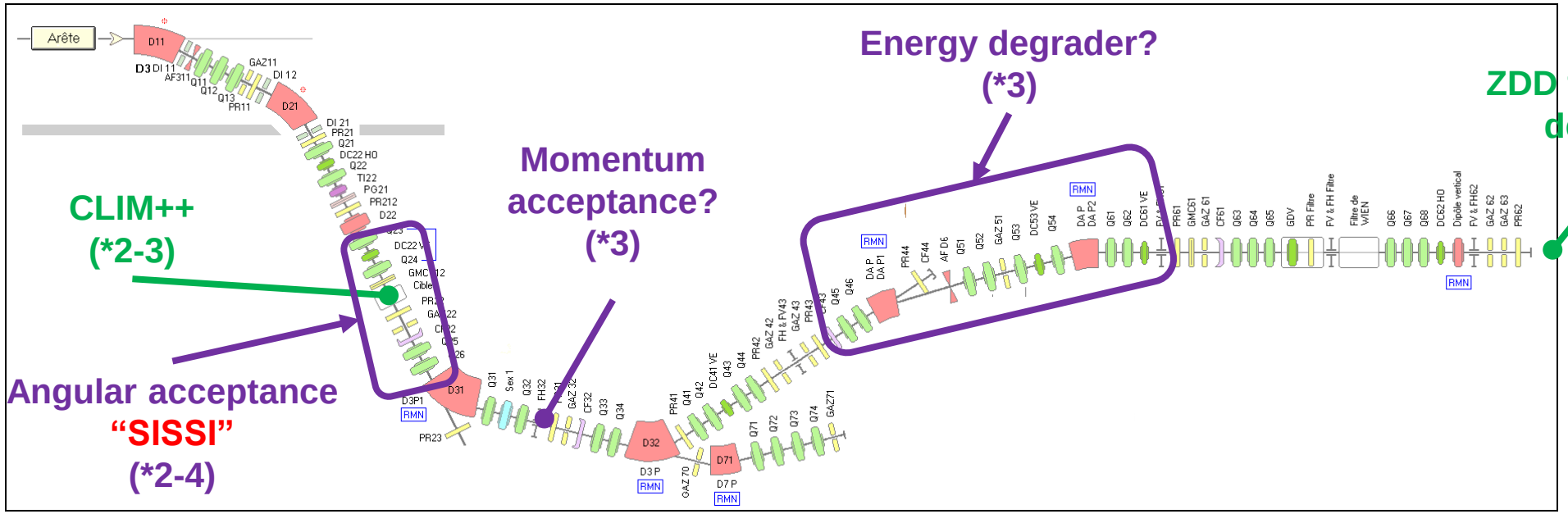
Conclusion about possible LISE Upgrades

LISE main limitations to be overcome

- Beam power losses in the production target < 300 W -> to be addressed in the near future (CLIM++)
- Angular acceptance: 1 msr
- $\Delta p/p \leq \pm 2.5$ %
- Secondary beams at ~30 (light RIBs) to ~50 MeV/u

-> to be studied

CYREN*2-5



RIBs intensity gain > 10-30?

++ Mini-recoil spectrometer project, T. Kurtukian-Nieto talk

Beam optics studies required to evaluate the feasibility, manpower and costs

Thank you for your attention

Thanks to: B. Blank, G. de France, O. Kamalou, F. Marie-Saillenfest, O. Sorlin and V. Watt-Morel

Next update: LISE Workshop, February 2023, GANIL