Gas jet target for nuclear astrophysics

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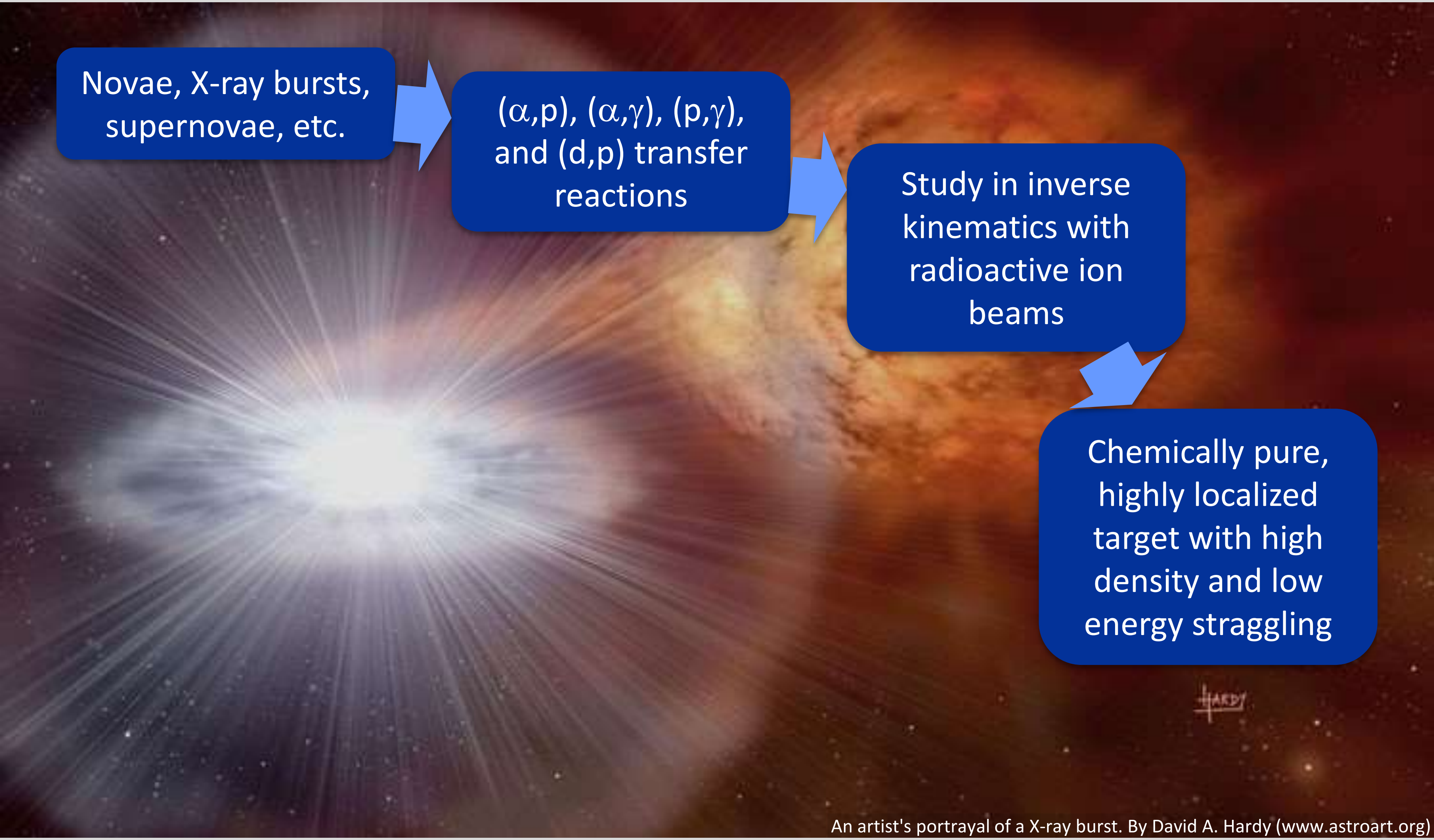
Why a gas jet target?

Novae, X-ray bursts, supernovae, etc.

(α,p), (α,γ), (p,γ), and (d,p) transfer reactions

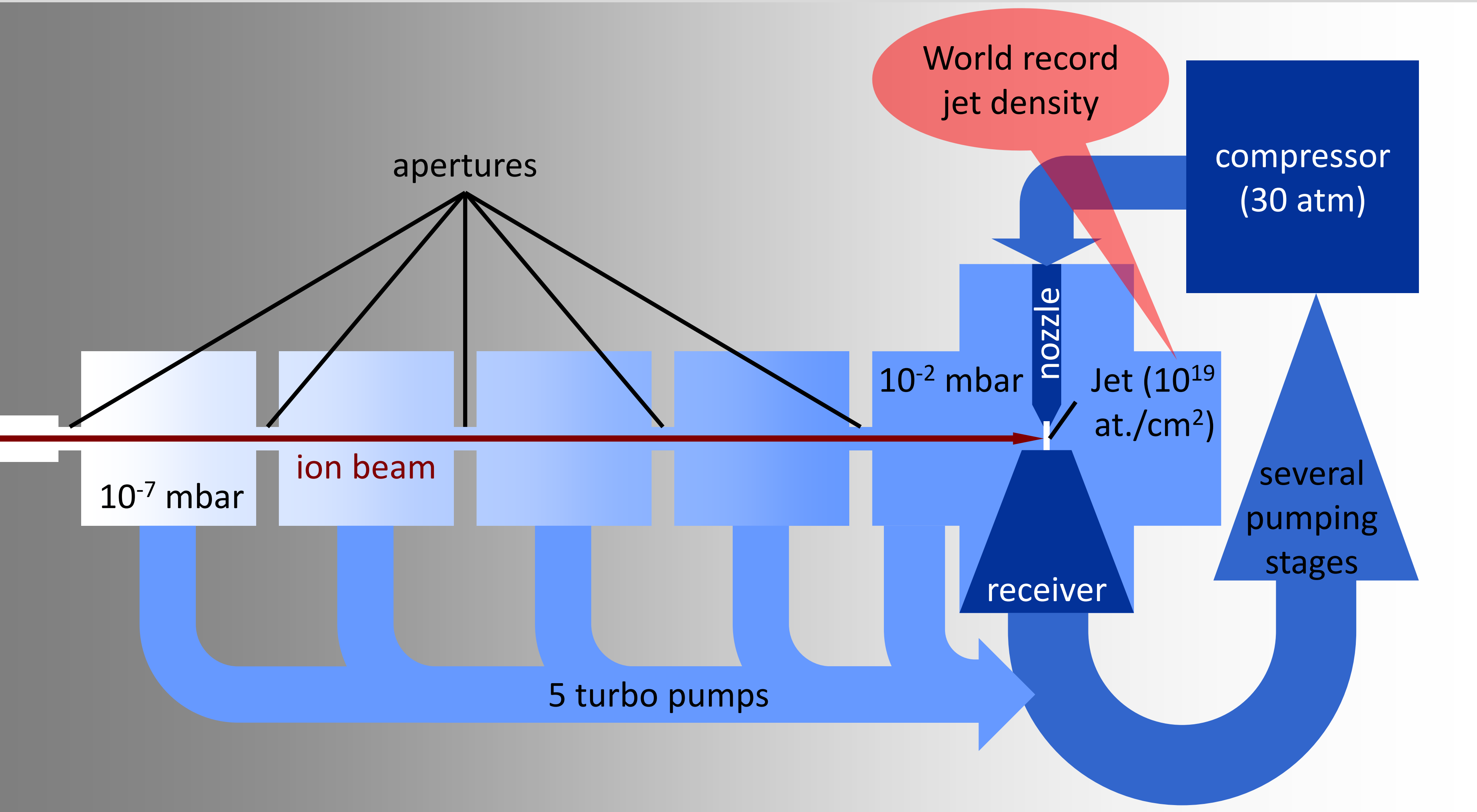
Study in inverse kinematics with radioactive ion beams

Chemically pure, highly localized target with high density and low energy straggling



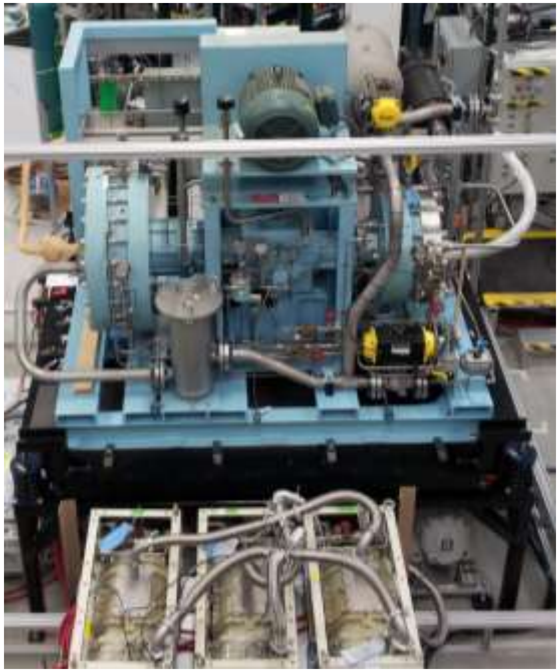
An artist's portrayal of a X-ray burst. By David A. Hardy (www.astroart.org)

Recirculating gas system



The JENSA gas jet target at NSCL

Jet **E**xperiments in **N**uclear **S**tructure and **A**strophysics



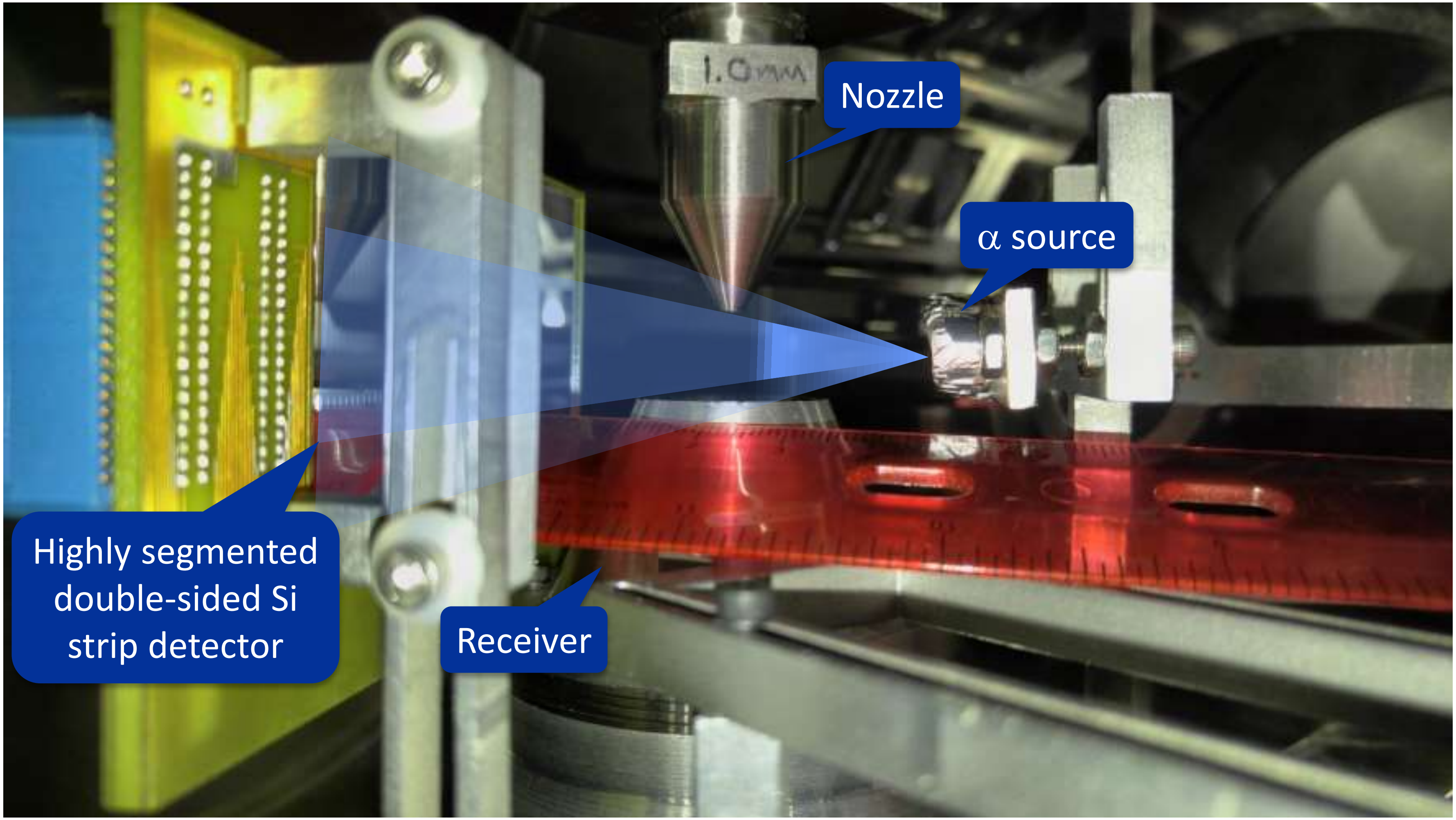
Diaphragm compressor

Target chamber and pumps

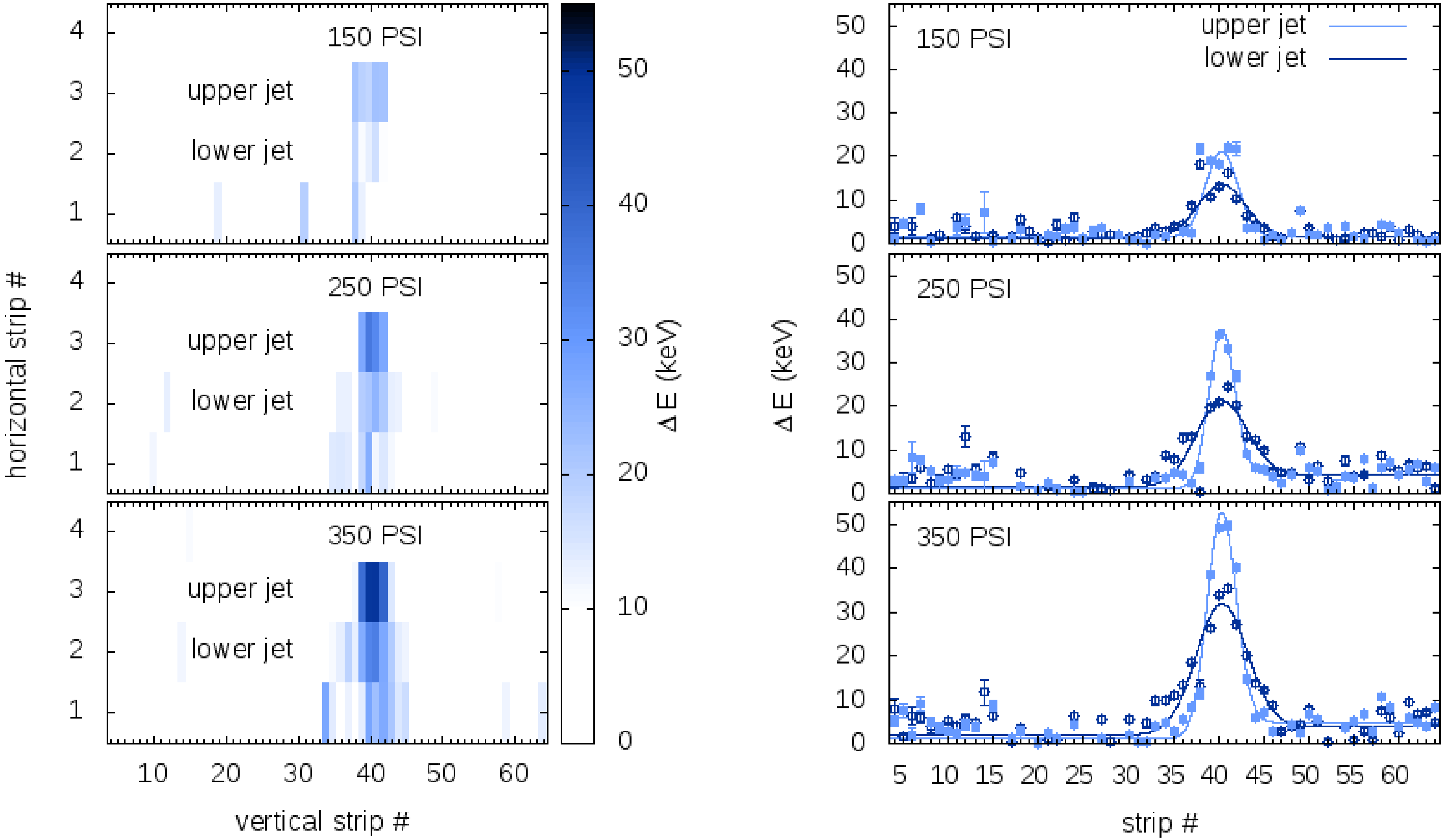
Nozzle, receiver and Si detectors

Commissioning

Setup for jet thickness study

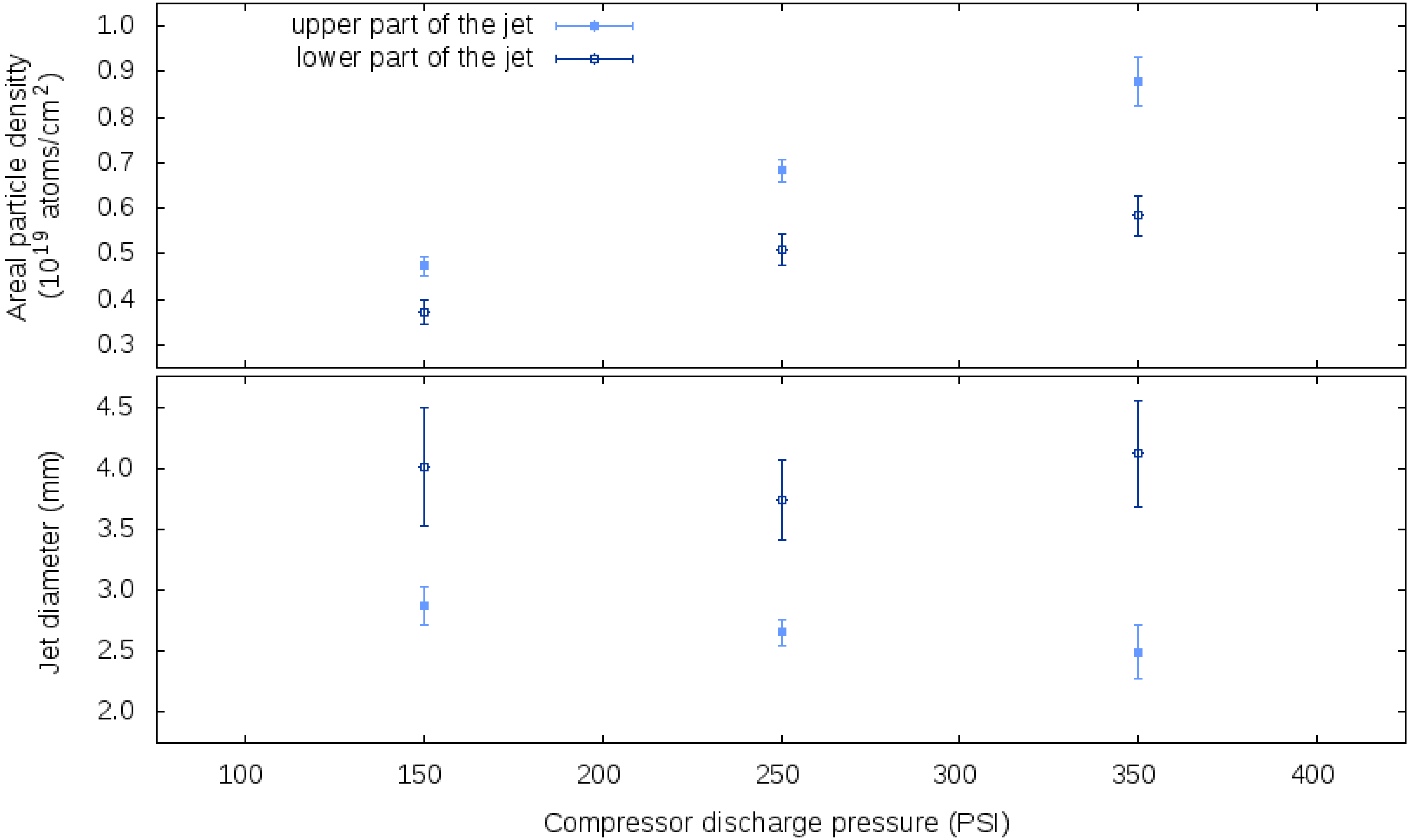


Energy loss profiles



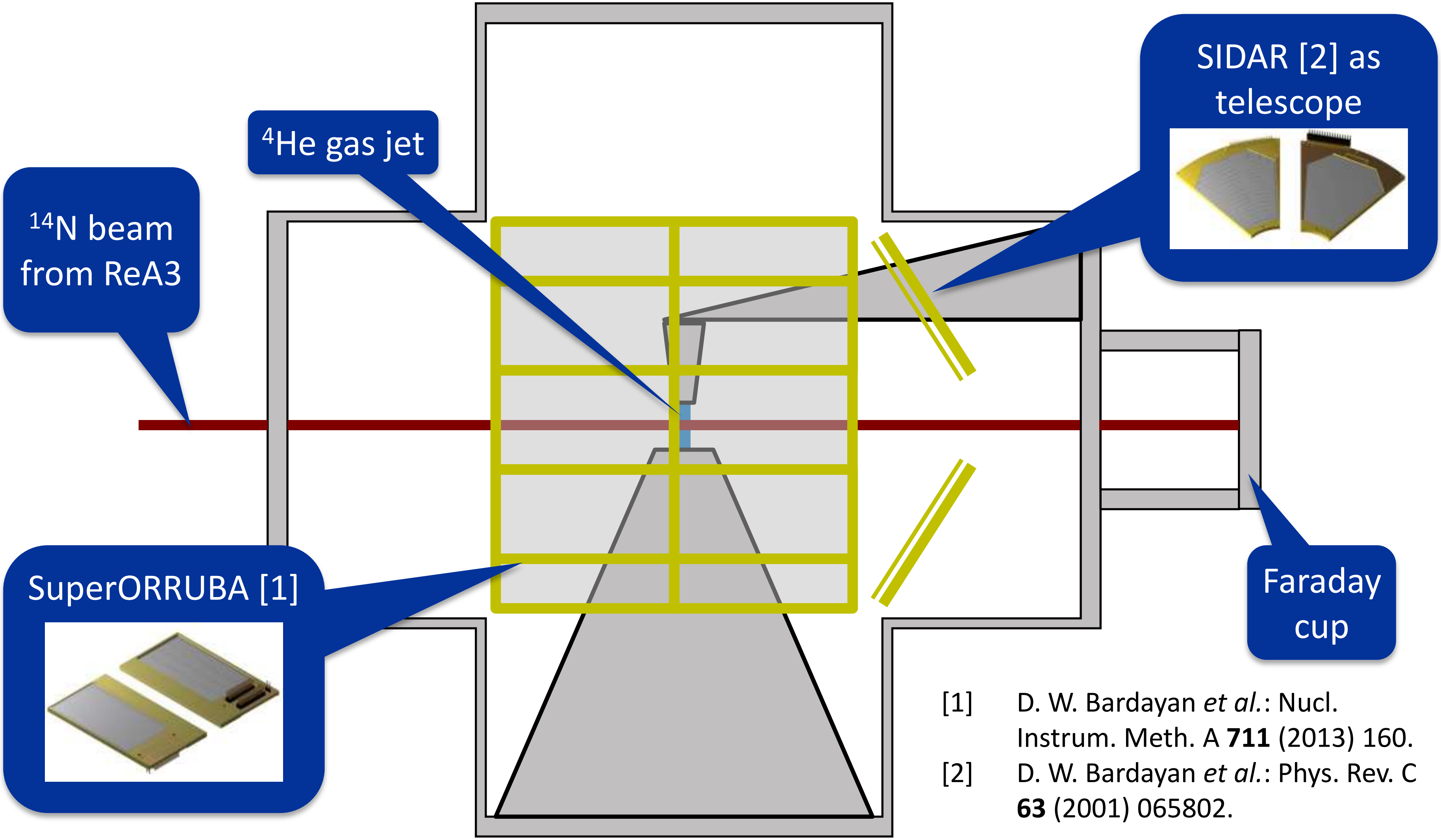
10^{19} atoms/cm^2 in less than 4 mm He jet

Density from measured energy loss and stopping power [1]



[1] C. Hanke and J. Laursen, Nuclear Instruments and Methods **151**, 253 (1978)

Setup for $^{4}He(^{14}N,p)^{17}O$ study

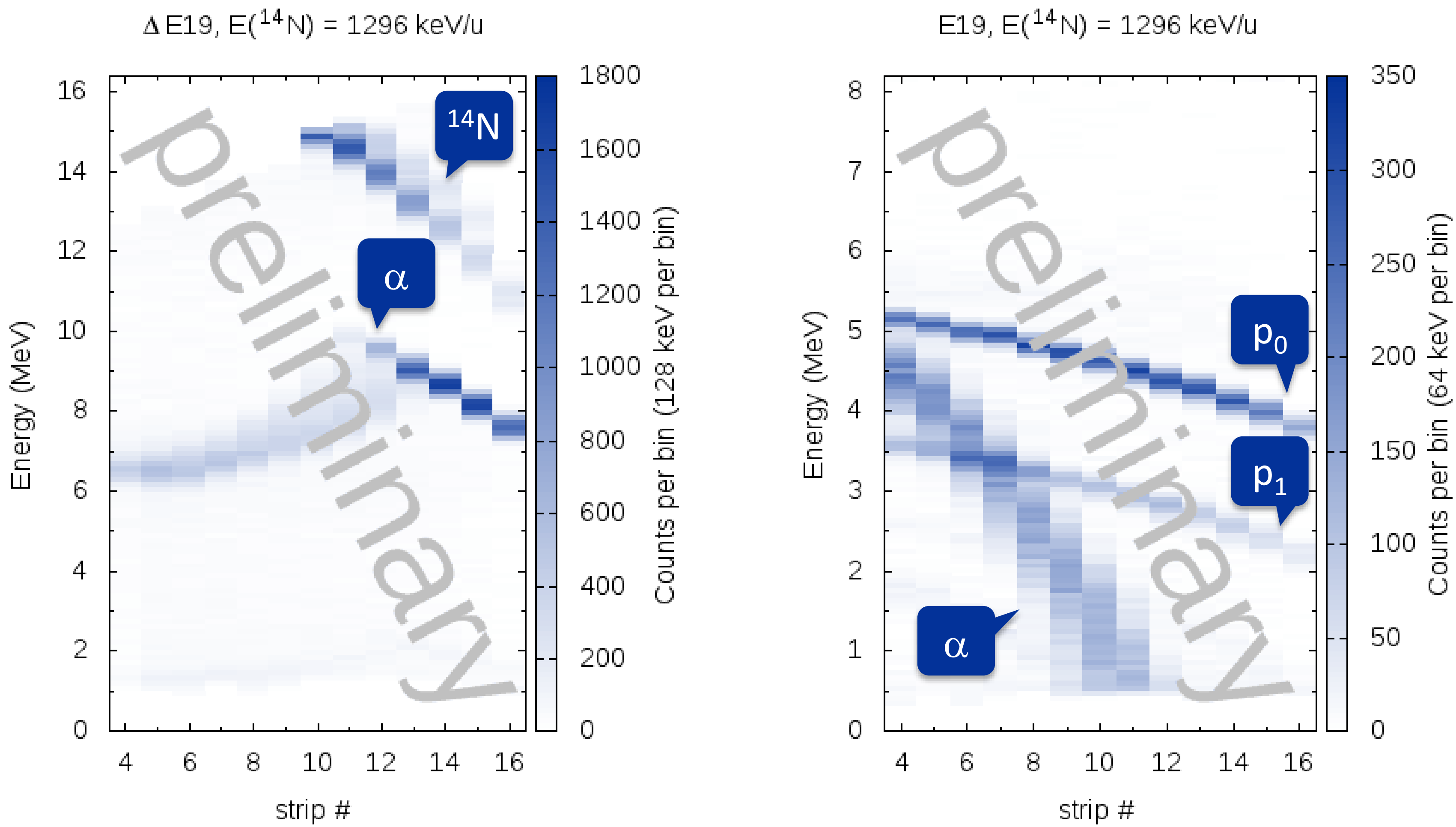


[1] D. W. Bardayan *et al.*: Nucl. Instrum. Meth. A **711** (2013) 160.

[2] D. W. Bardayan *et al.*: Phys. Rev. C **63** (2001) 065802.

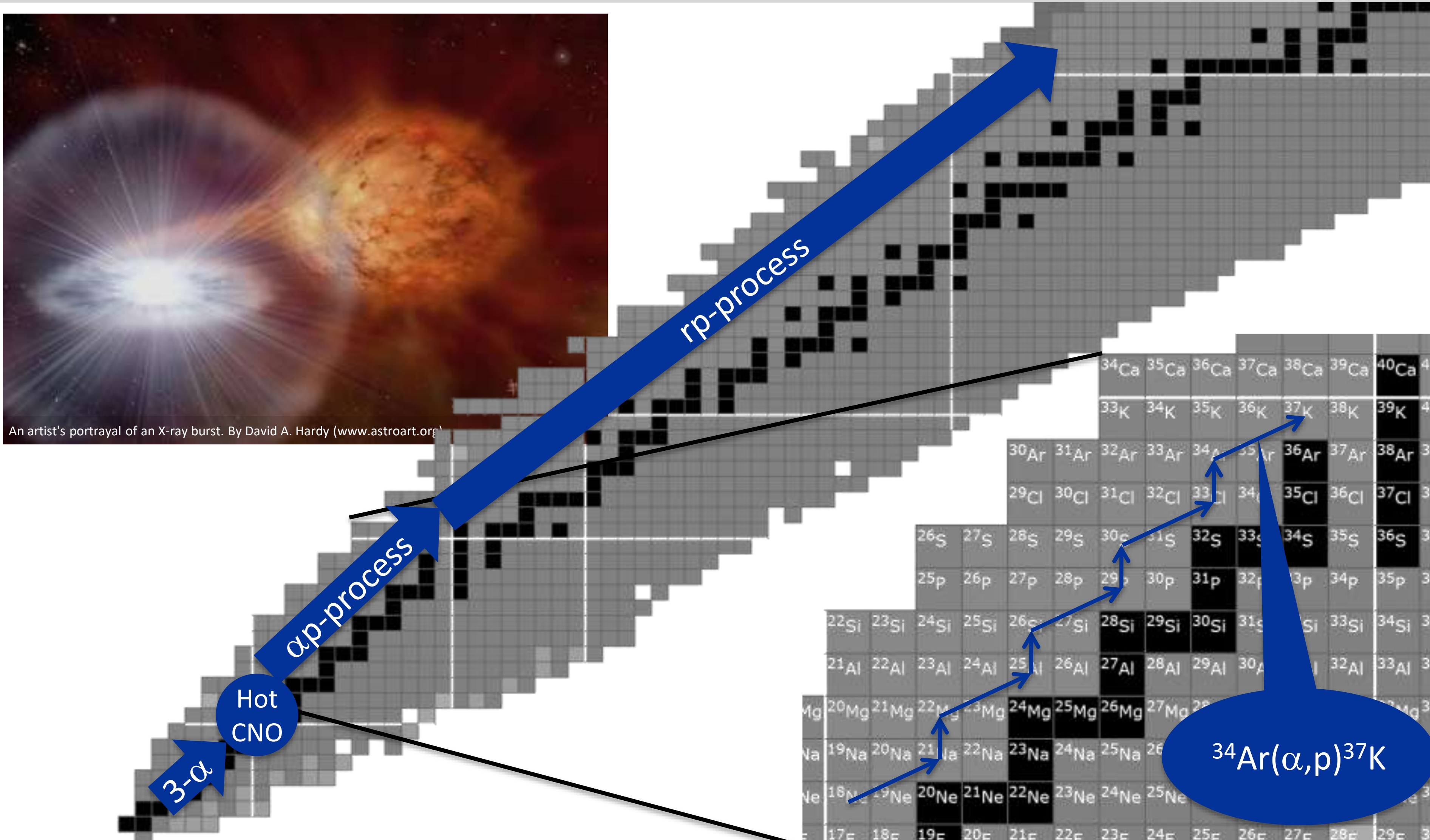
$^{4}He(^{14}N,p)^{17}O$ – preliminary results

Segmented Si detector telescope



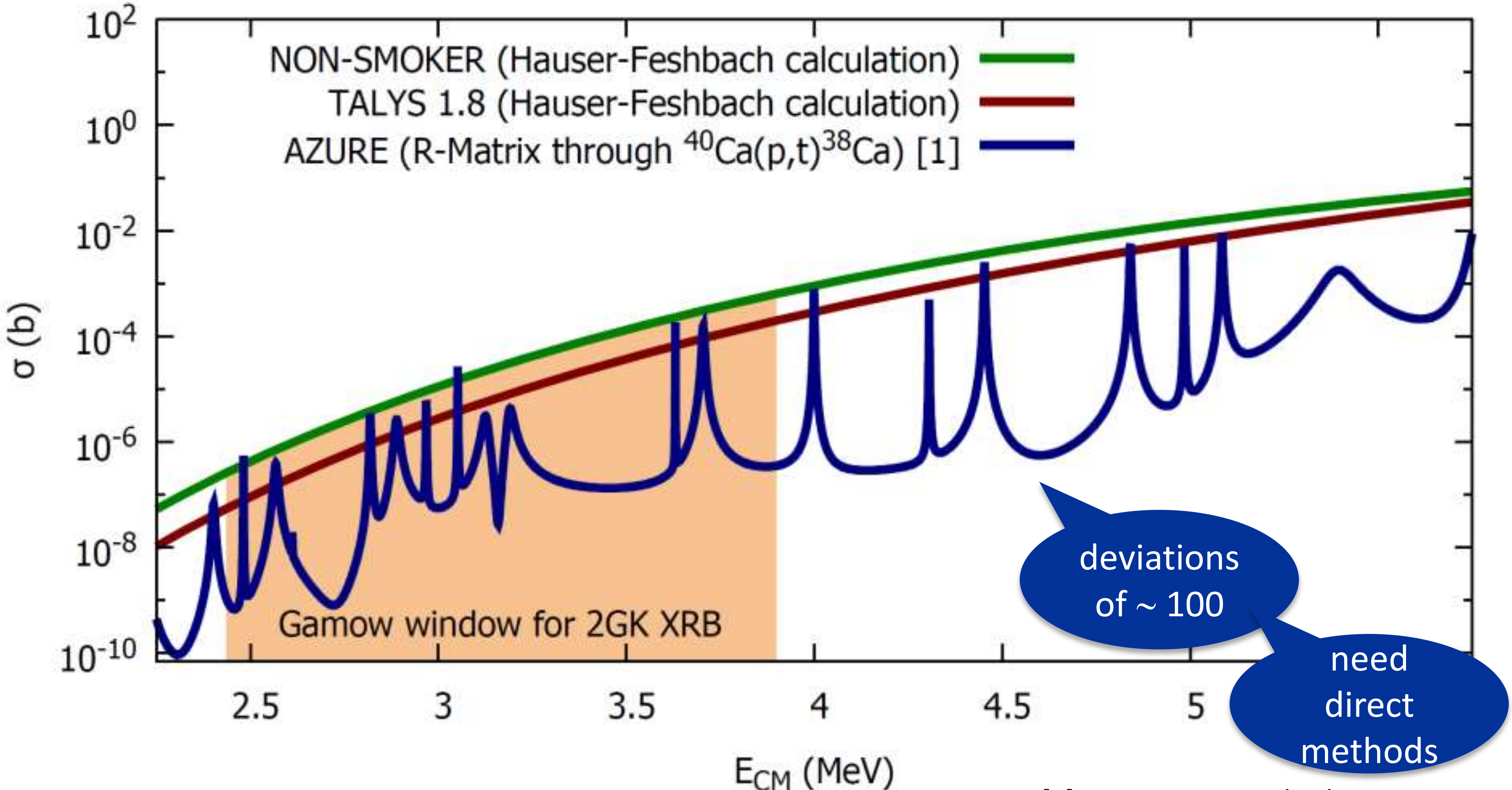
First RIB experiment

Type-I X-ray burst at ~1 GK



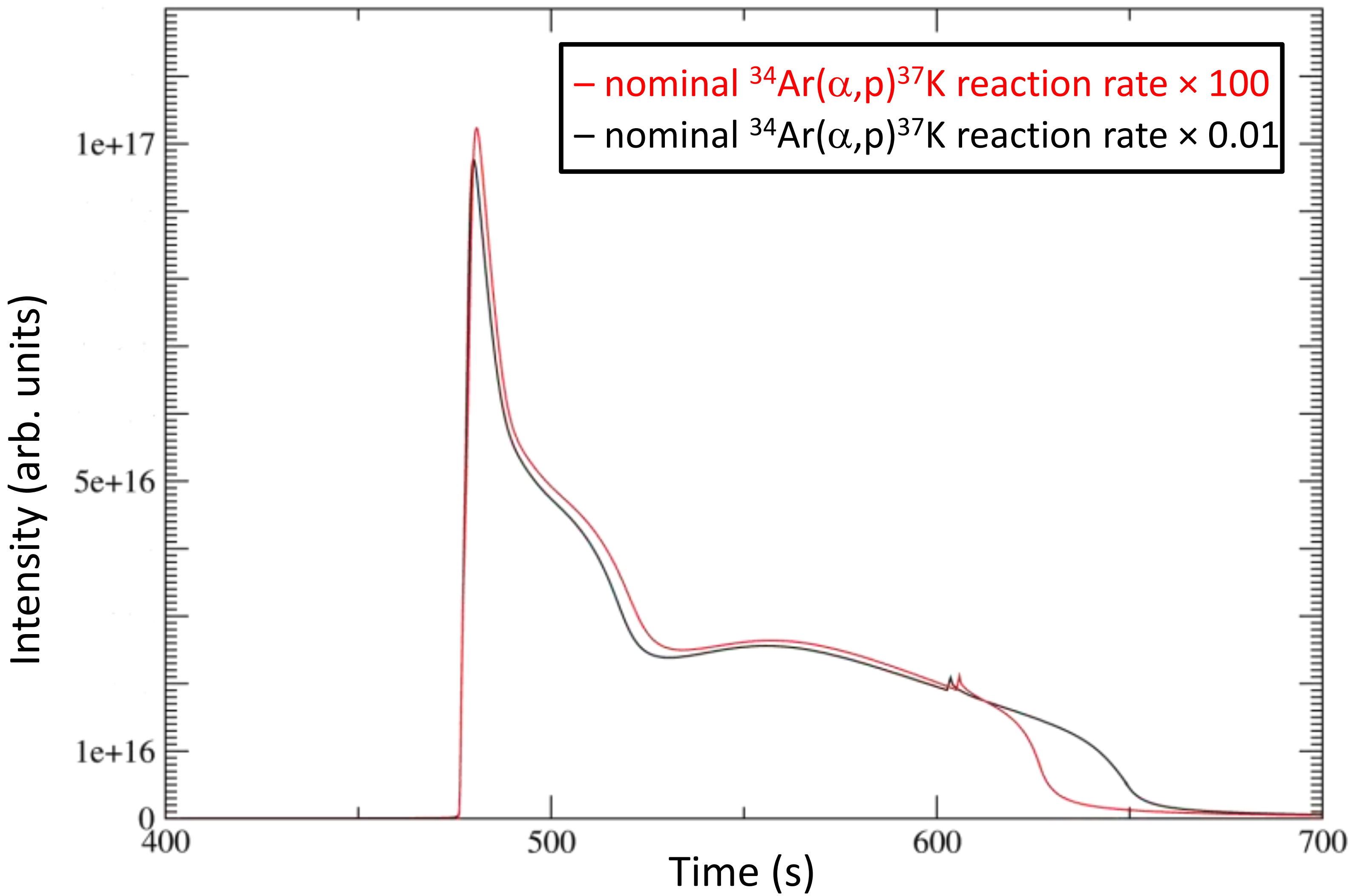
An artist's portrayal of an X-ray burst. By David A. Hardy (www.astroart.org)

$^{34}Ar(\alpha,p)^{37}K$ cross section

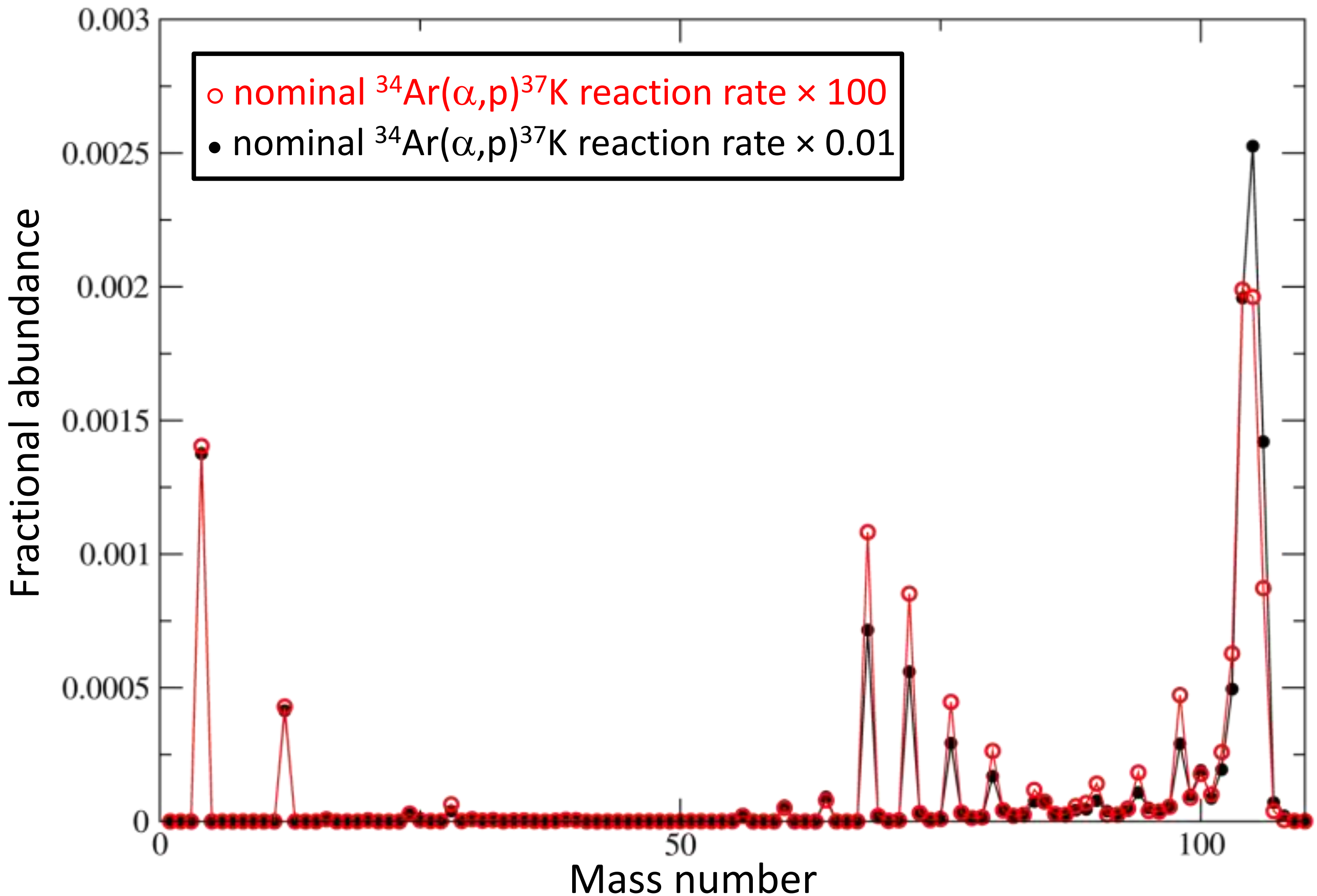


[1] A. M. Long *et al.*: Phys. Rev. C **95**, 055803 (2017).

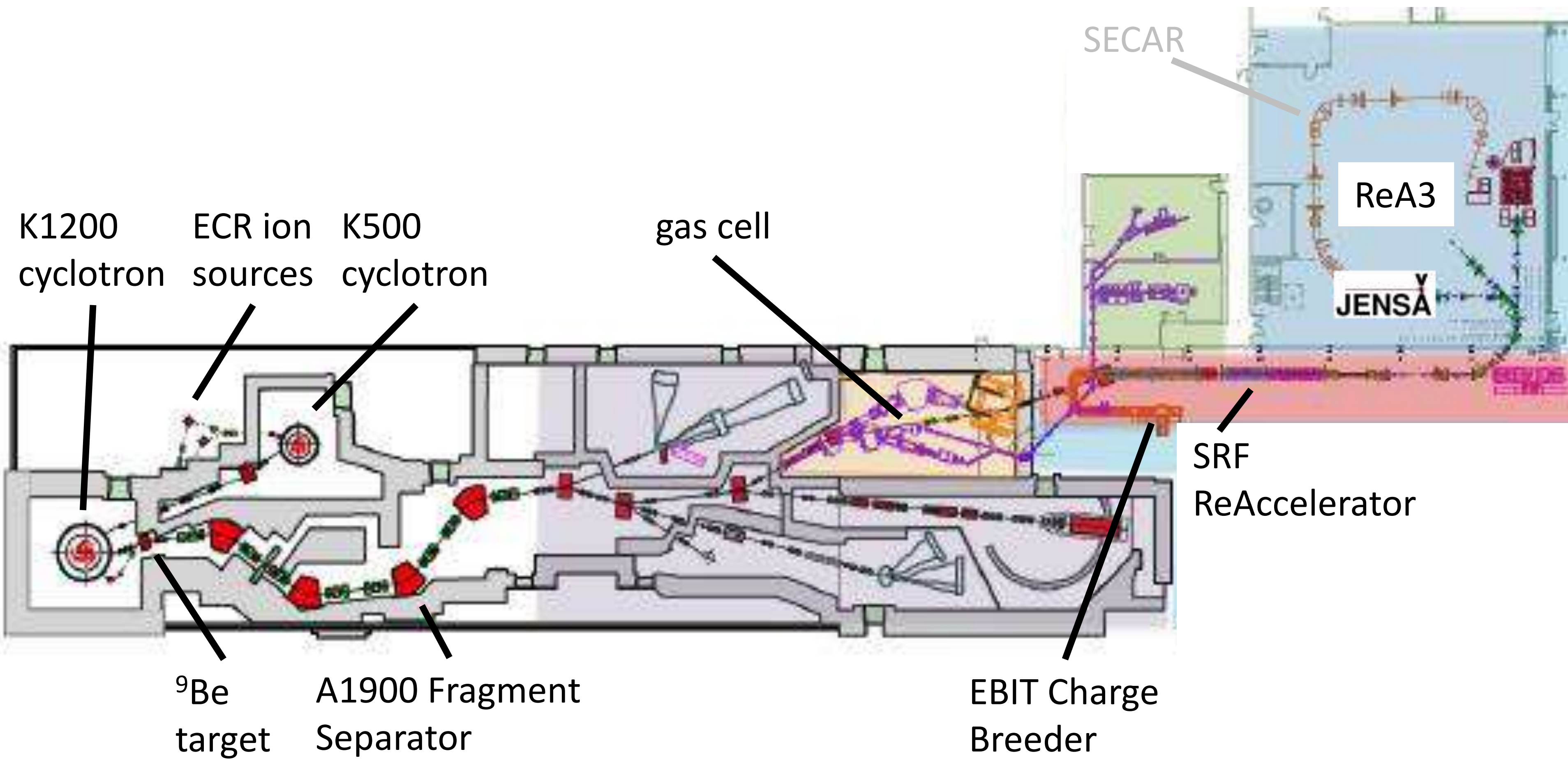
X-ray burst simulation – light curve



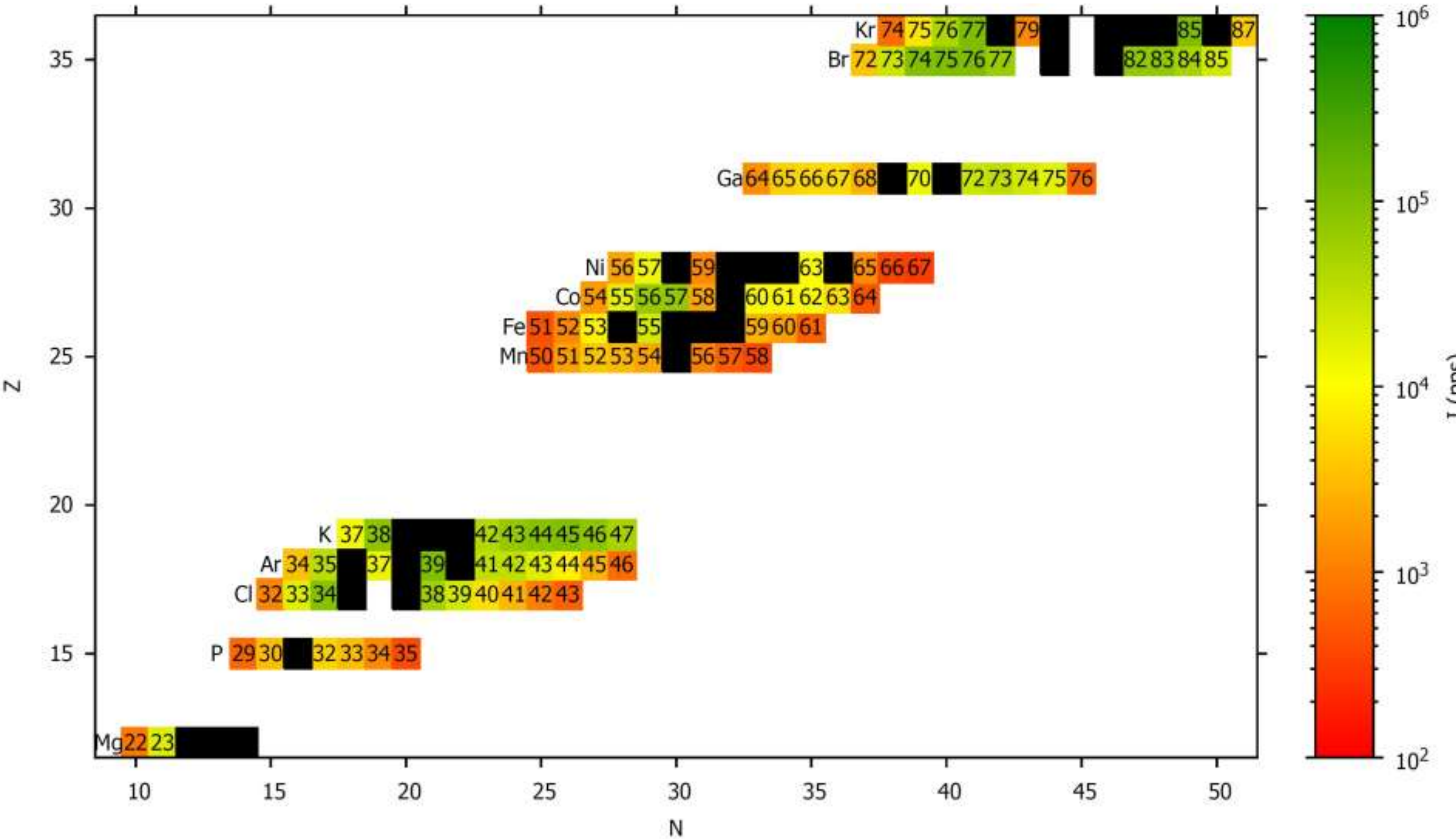
X-ray burst simulation – abundance plot



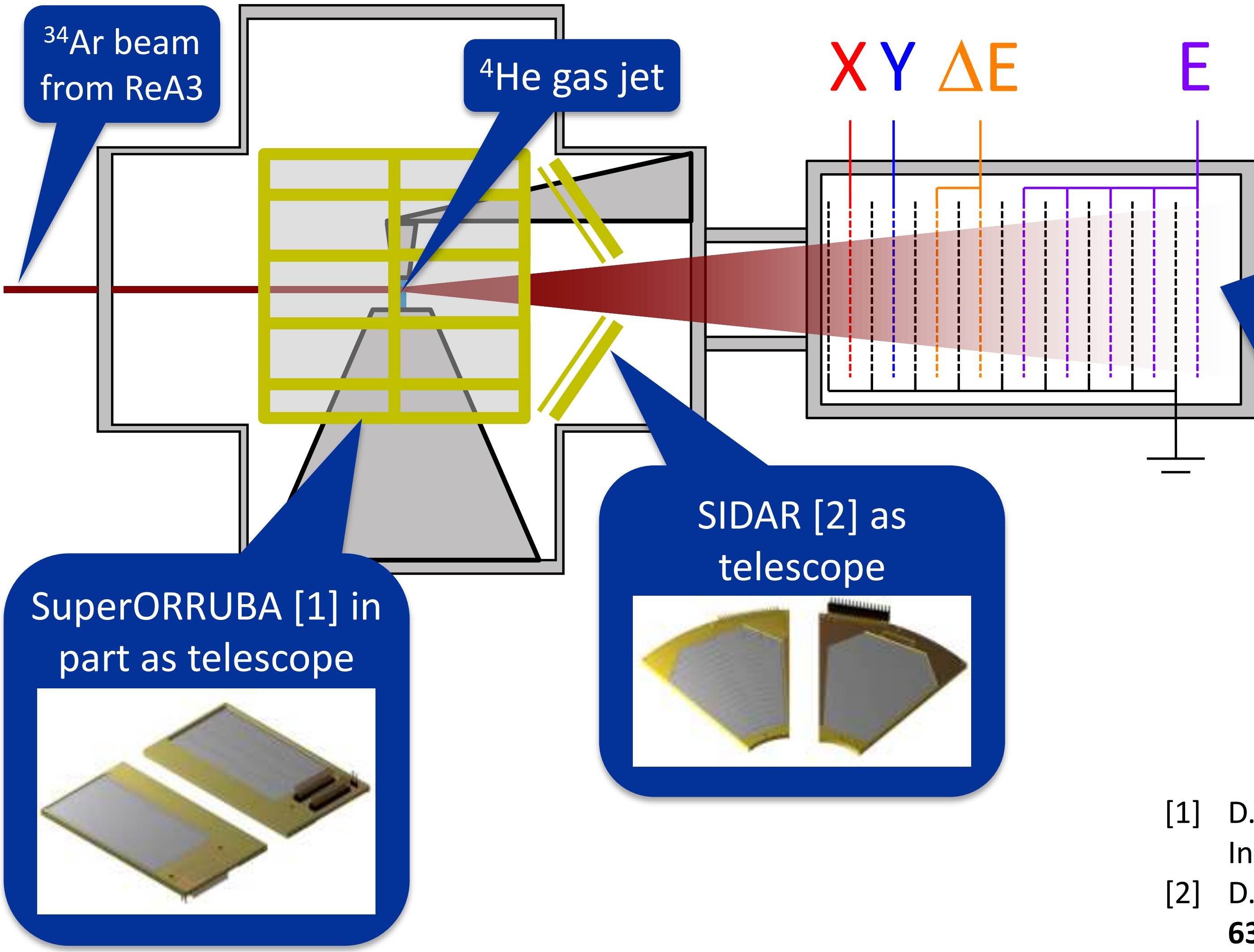
Rare isotope beams from ReA3 at NSCL



Available rare isotope beams at ReA3



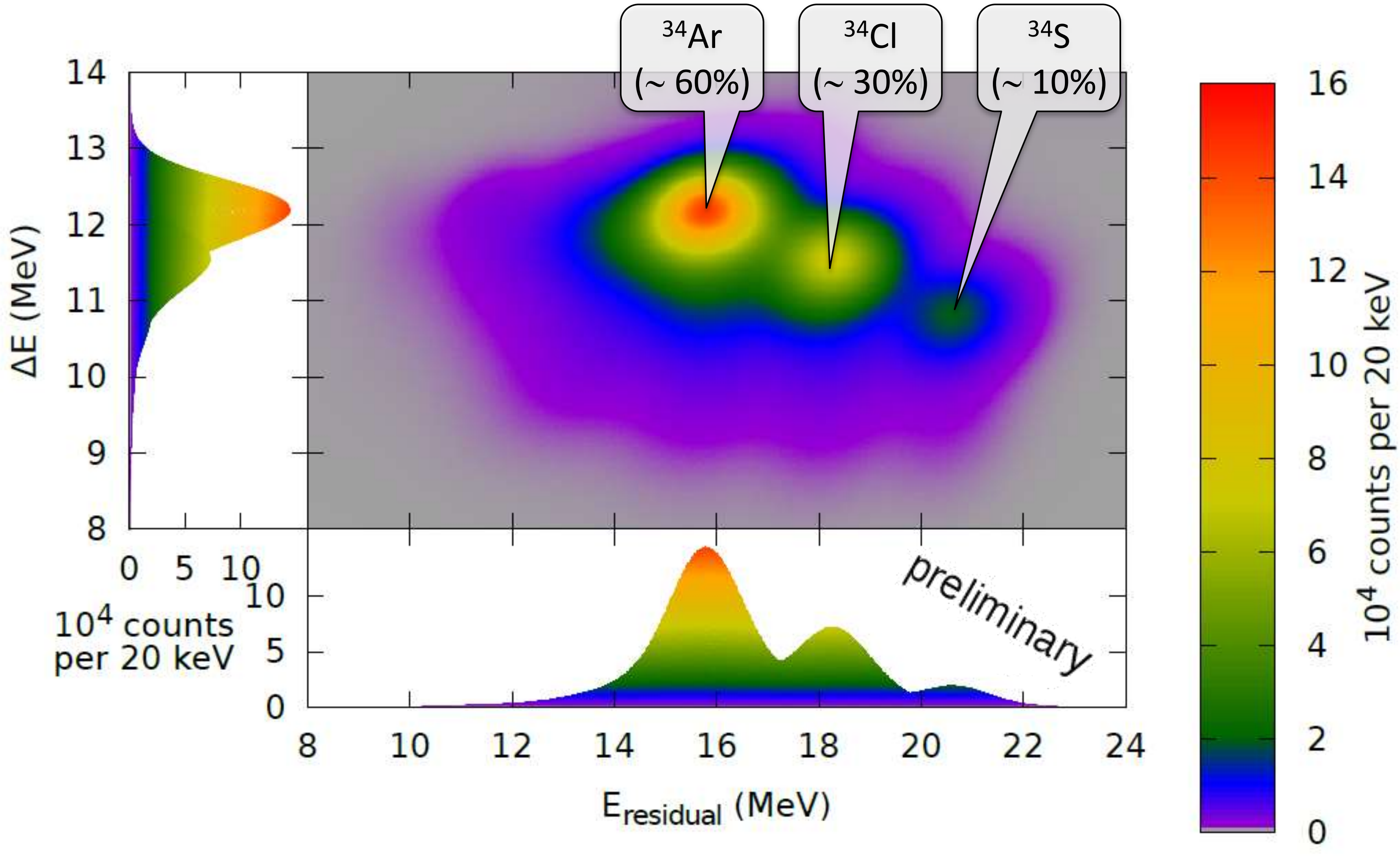
Setup for ^{34}Ar(α,p)^{37}K study



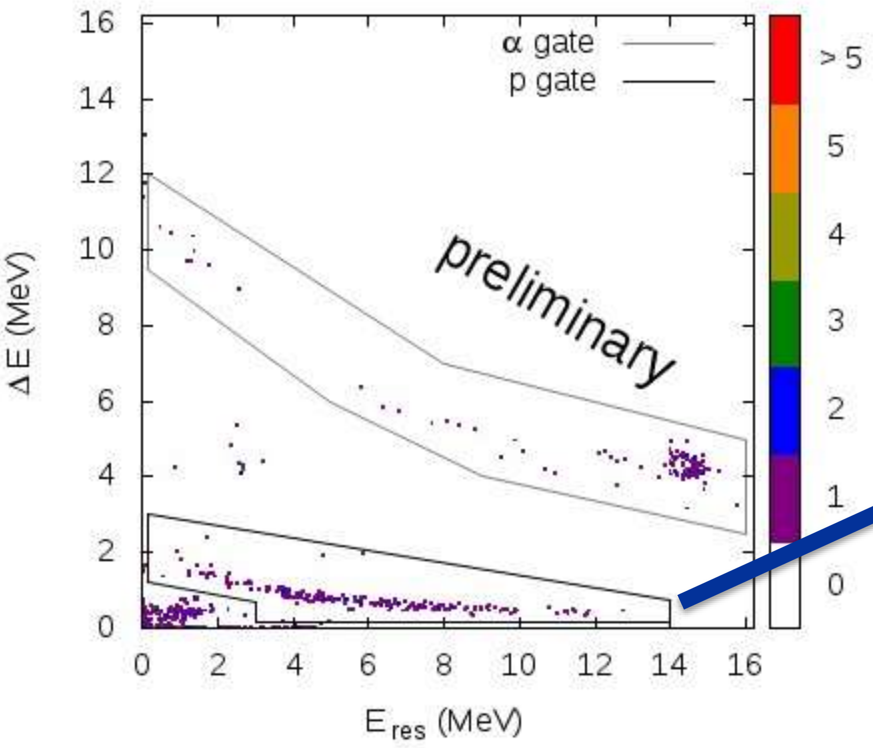
[1] D. W. Bardayan *et al.*: Nucl. Instrum. Meth. A **711**, 160 (2013).

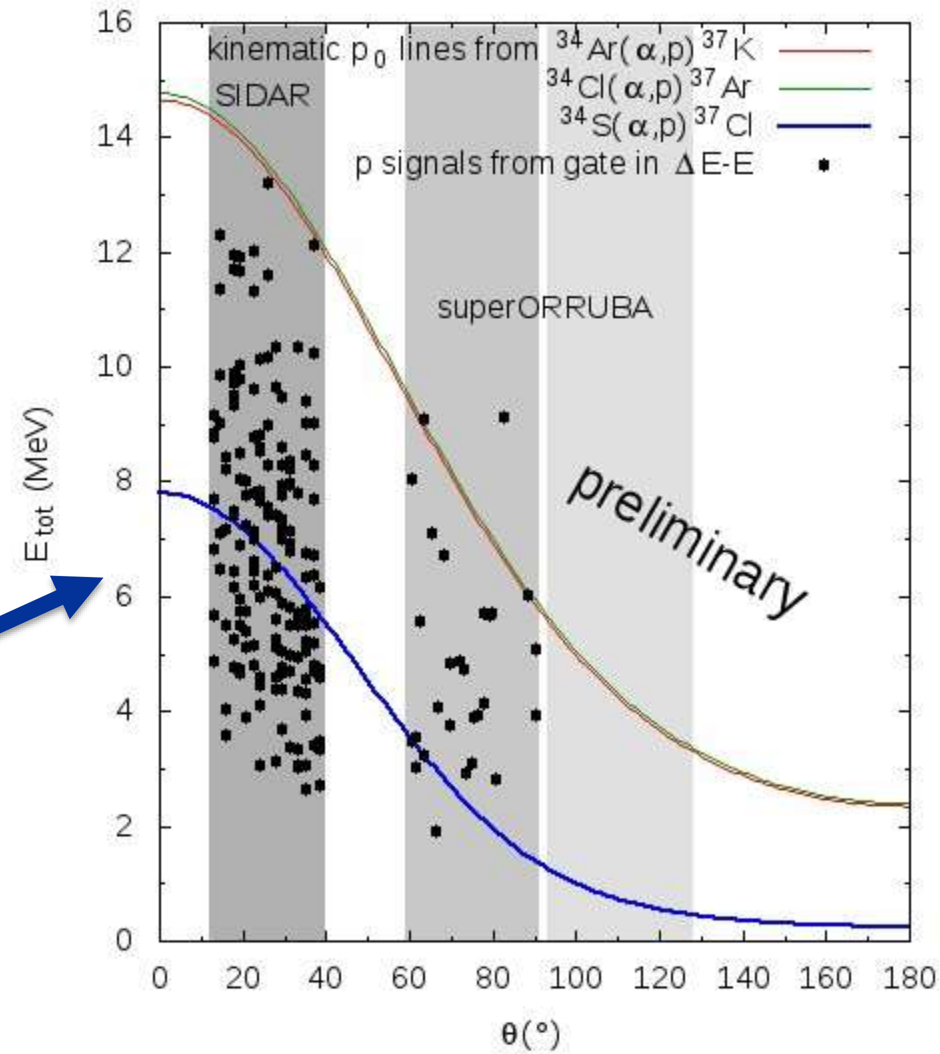
[2] D. W. Bardayan *et al.*: Phys. Rev. C **63**, 065802 (2001).

~3000 pps at 1.625 MeV/u for 108 hours

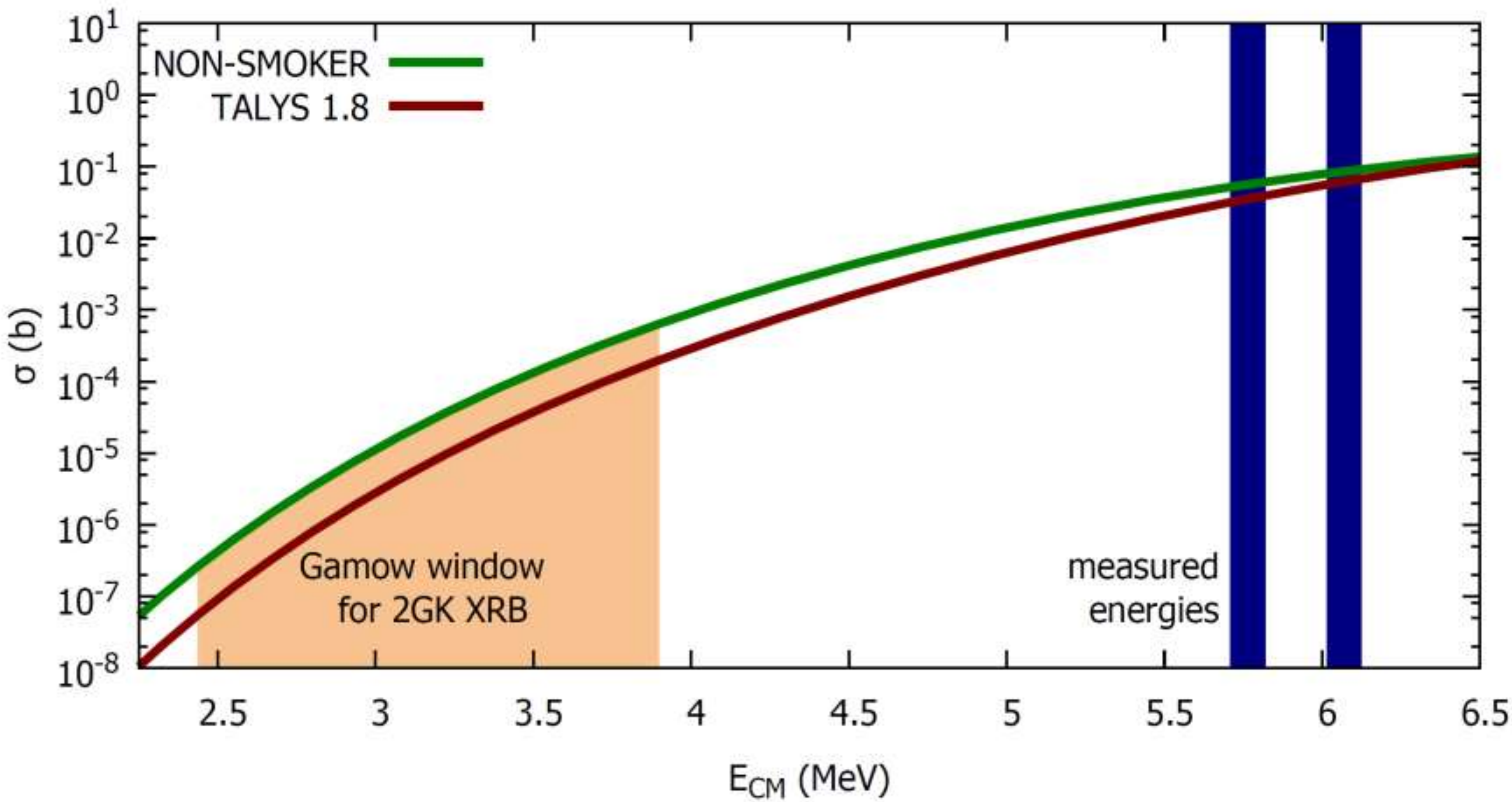


Proton signals in Si detectors





Cross section at 5.82 and 6.12 MeV (CM)



Si protons (and PSIC recoils), target thickness and effective beam current

$^{34}Ar(\alpha,p)^{37}K$ cross section

Outlook

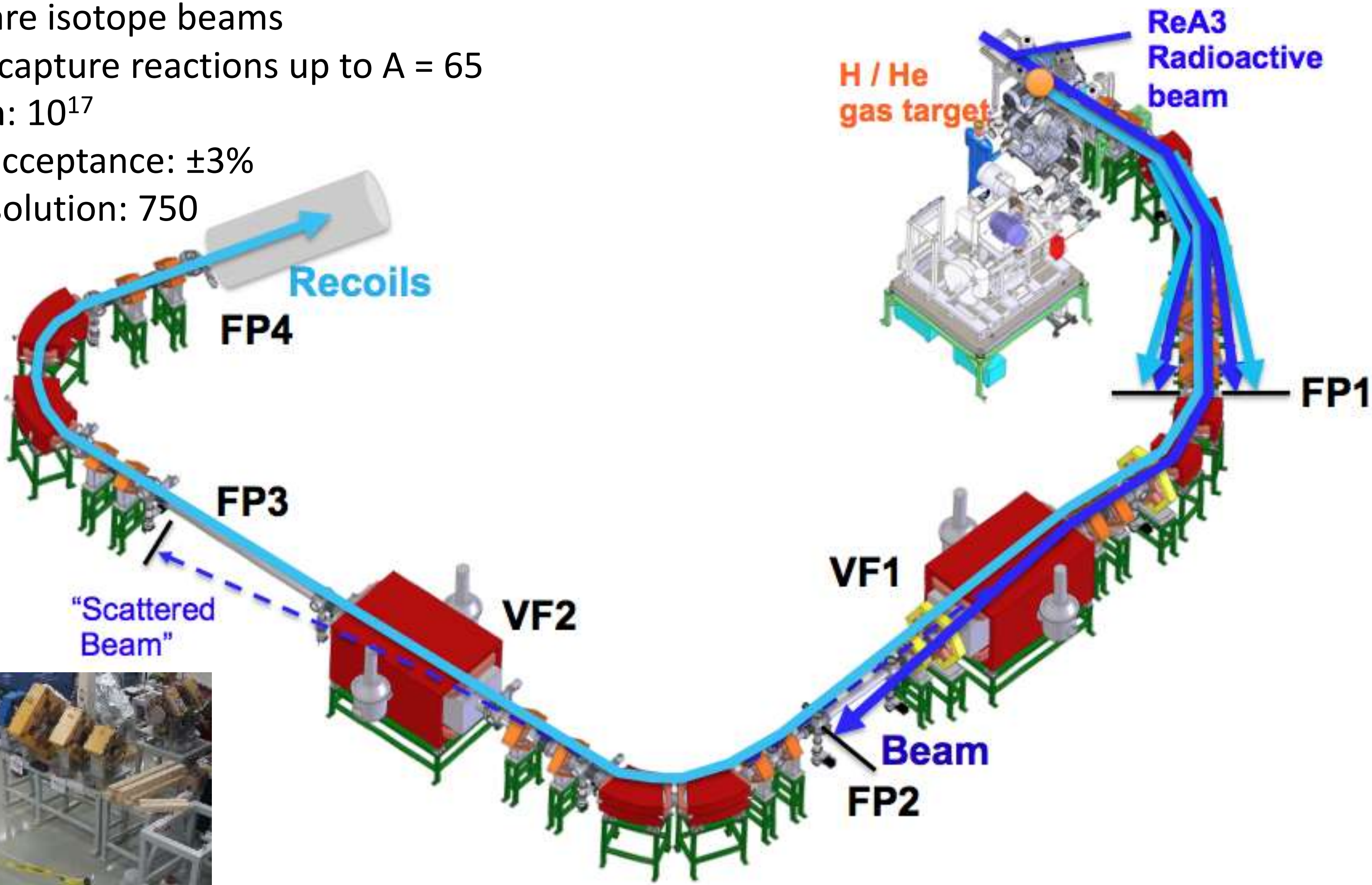
For (α,p)
Si detectors work

For (α,γ) and (p,γ)
not enough sensitivity with γ-ray detectors

Must use recoil separator with JENSA

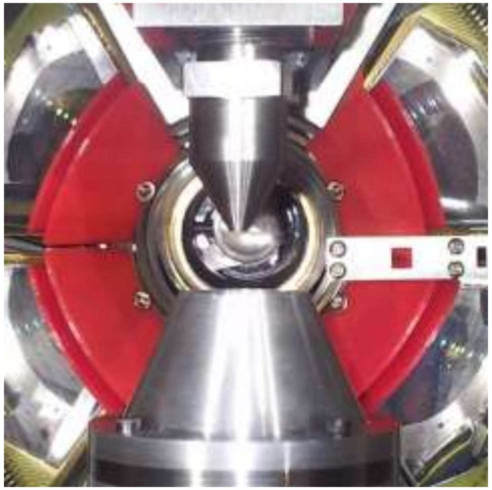
Separator for Capture Reactions (SECAR)

- p rich, rare isotope beams
- α and p capture reactions up to A = 65
- rejection: 10^{17}
- energy acceptance: ±3%
- mass resolution: 750



Summary

- JENSA gas jet target successfully commissioned at NSCL
- He densities up to 10^{19} atoms/cm^2 demonstrated
- **First** rare isotope beam experiment with JENSA
- **First** (α,p) study with a rare isotope beam A>20
- **First** direct study of ^{34}Ar(α,p)^{37}K



JENSA collaboration

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