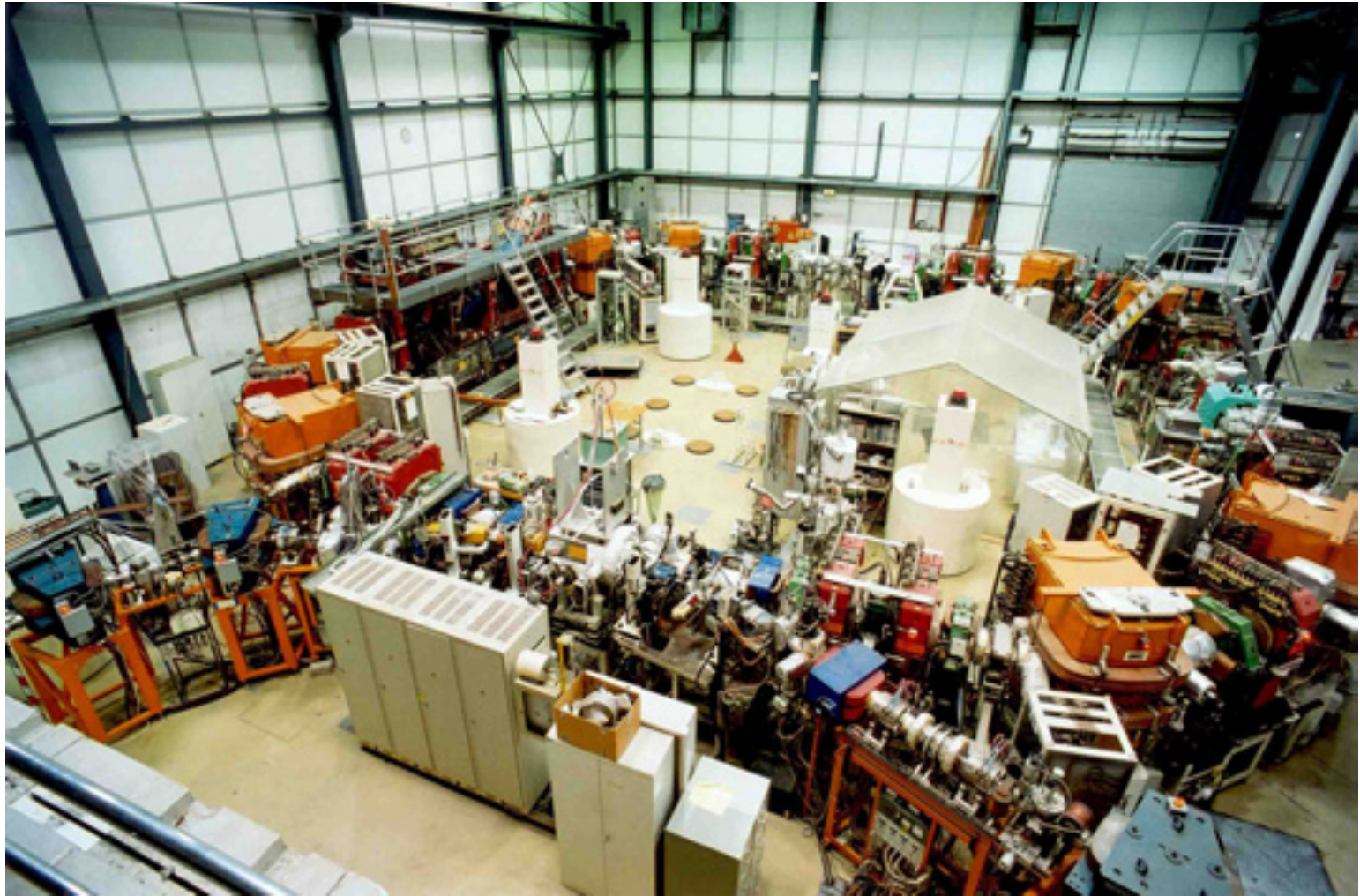


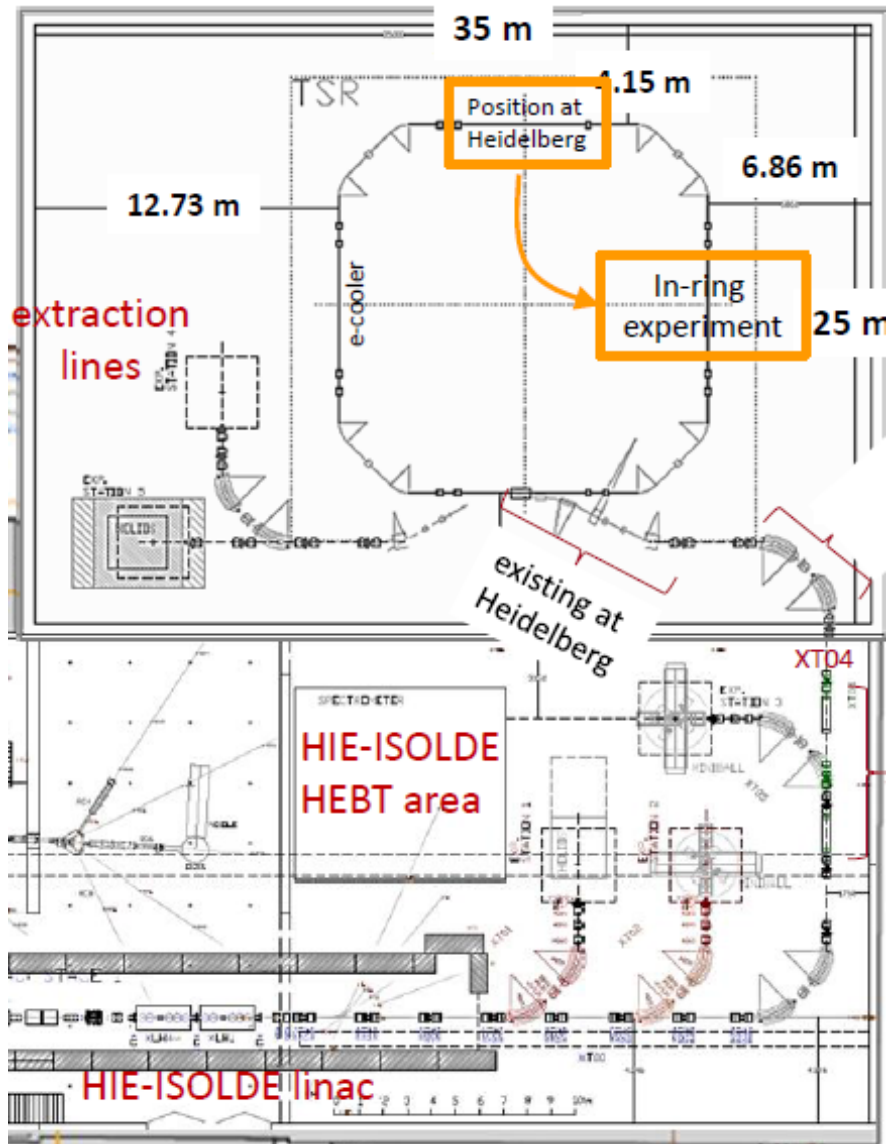
Spectrometer Systems for TSR@ISOLDE



UNIVERSITY OF
LIVERPOOL

Robert Page

Spectrometer Systems for TSR@ISOLDE

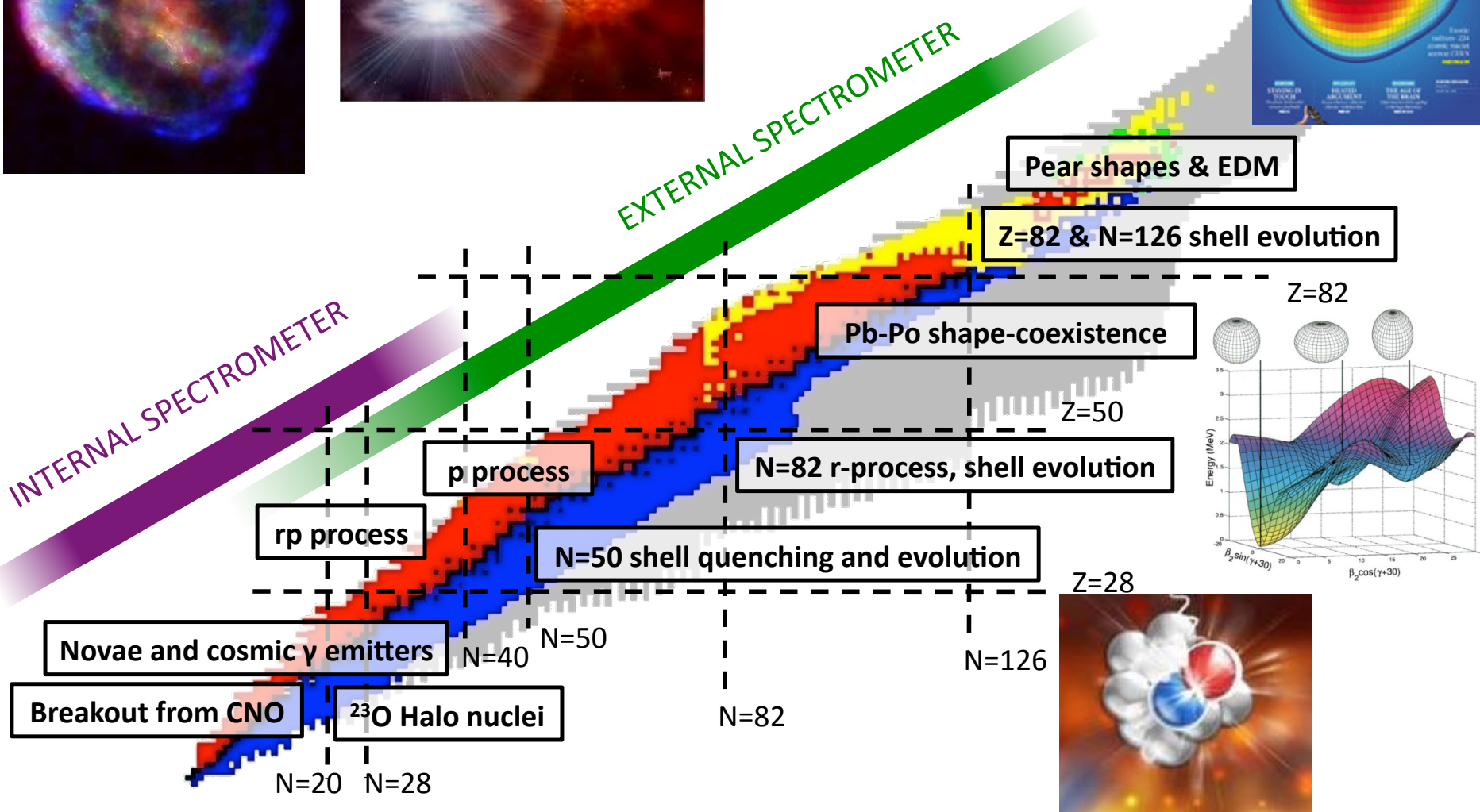
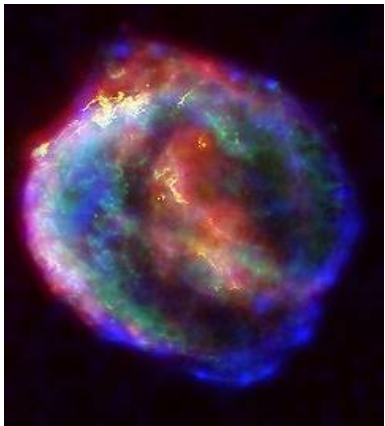


UK STFC funded project
~£5M investment
Internal spectrometer
External spectrometer
Completion 2019

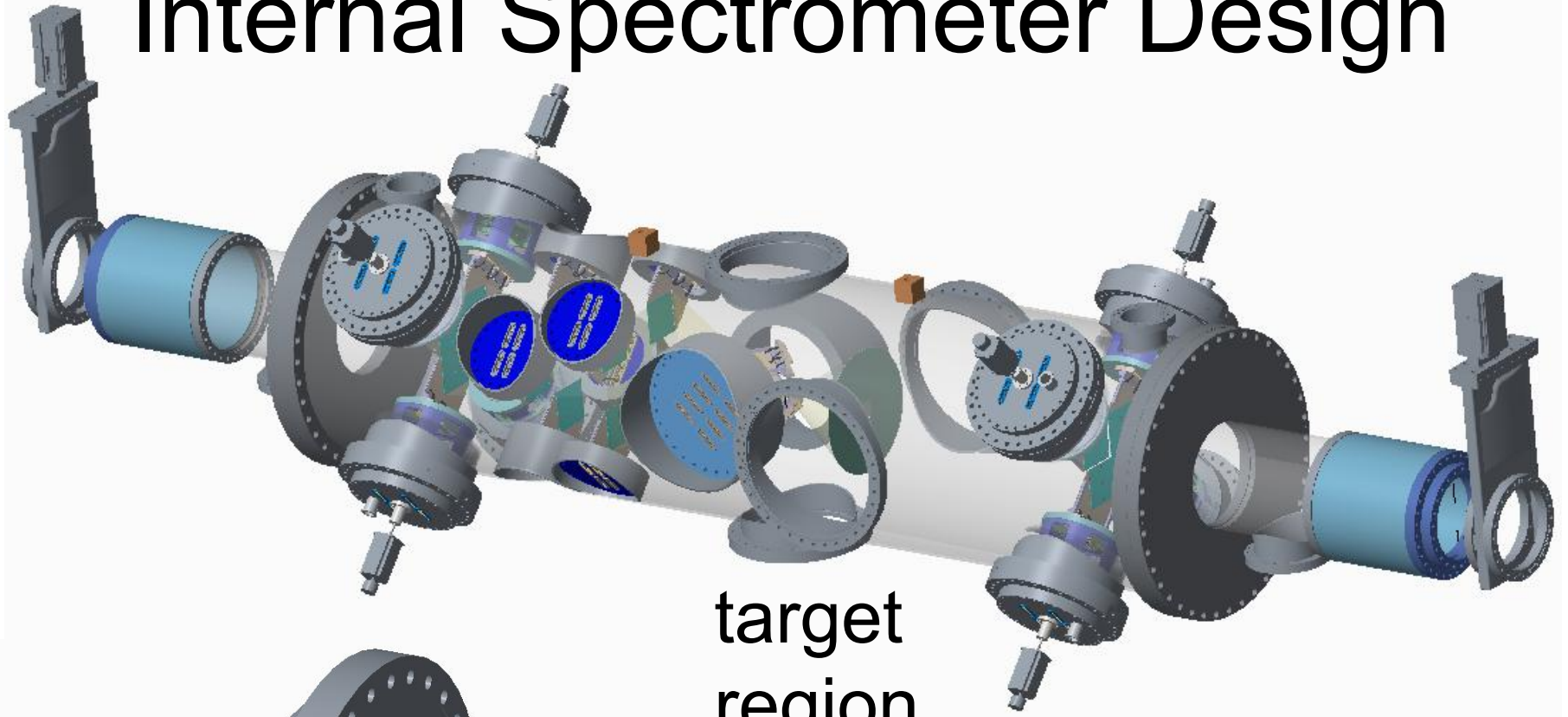
Collaborator contributions
TSR (MPIK Heidelberg)
Beam lines & building (CERN)
Gas jet target (Aarhus/Lund)
Active target (Leuven)
...

New ideas are welcome!

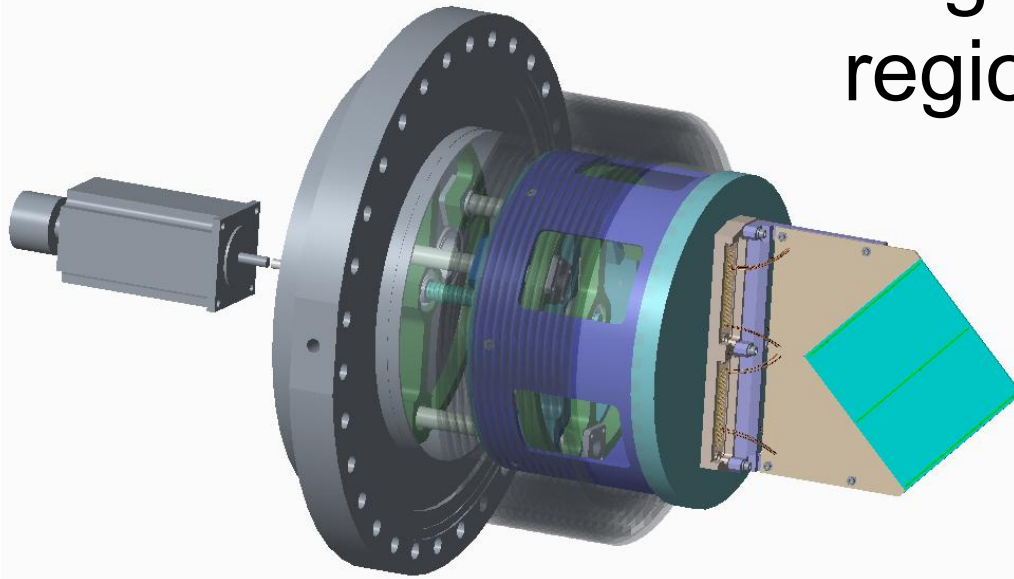
Physics Motivation



Internal Spectrometer Design

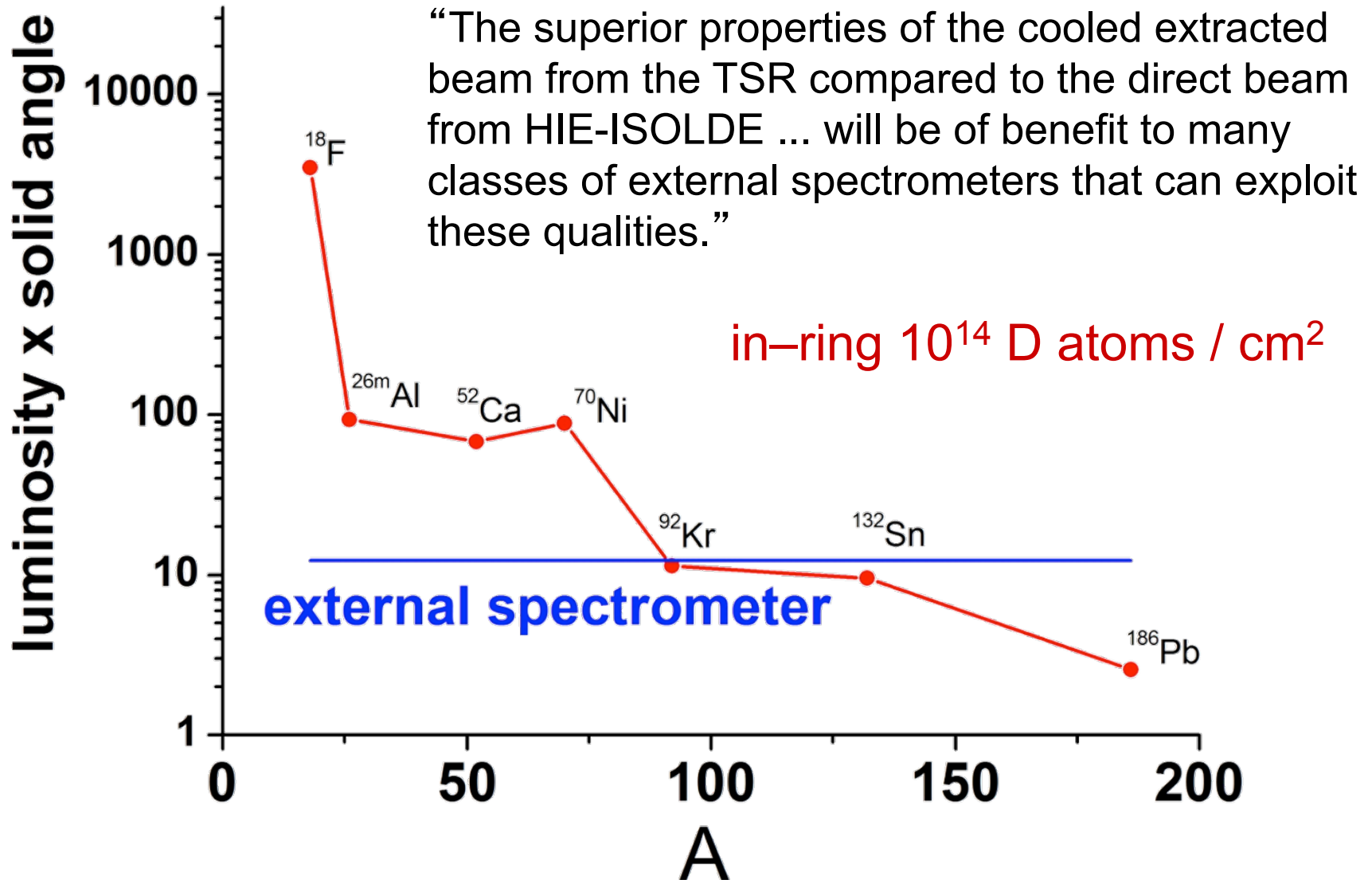


target
region

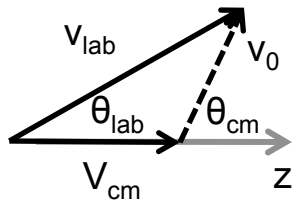
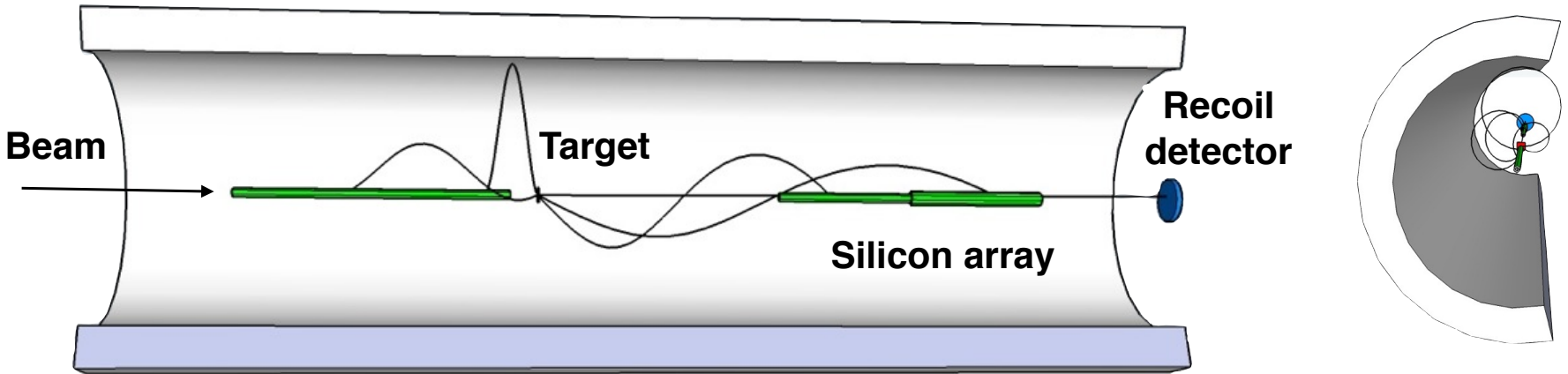


DSSDs nearest beam
axis move in/out

Why an External Spectrometer?

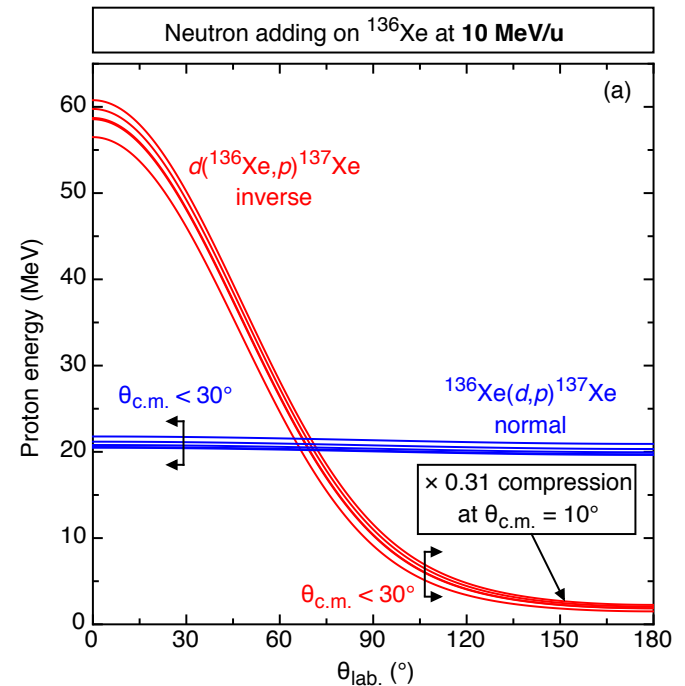


Solenoidal spectrometer concept

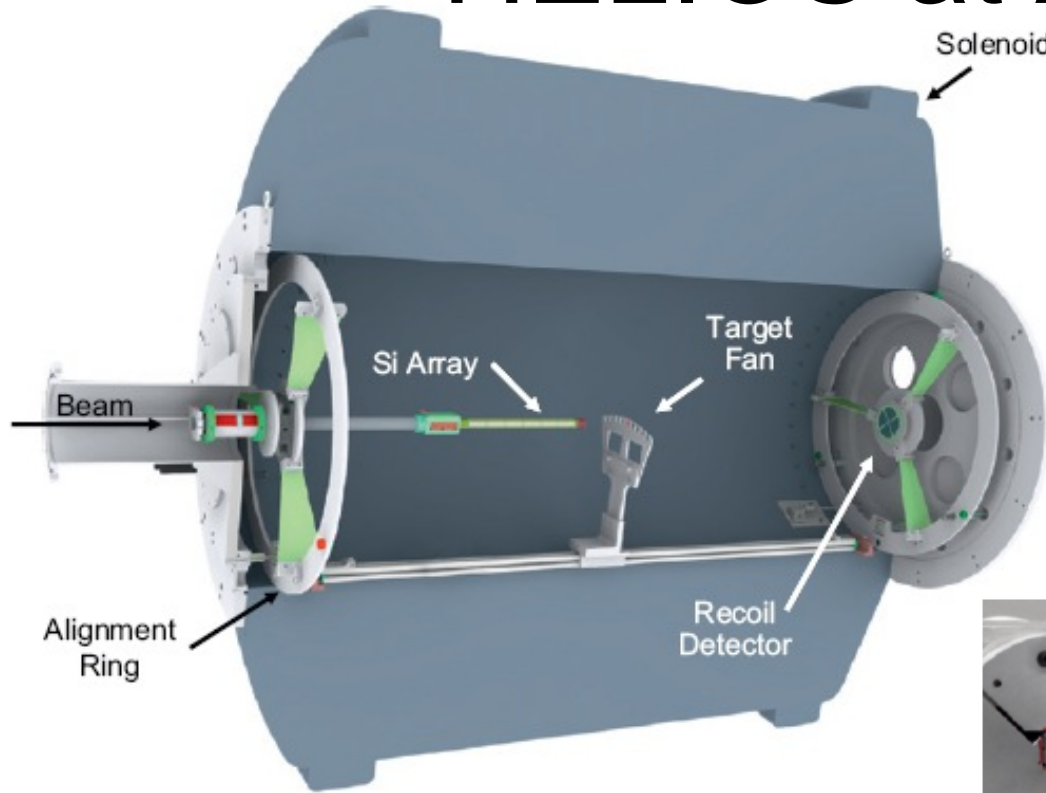


$$\text{CM Energy: } E_{cm} = E_{lab} + \frac{mV_{cm}^2}{2} - \frac{mzV_{cm}}{T_{cyc}}$$

$$\text{CM Angle: } \cos \theta_{cm} = \frac{v_{lab}^2 - V_{cm}^2 - v_0^2}{2v_0 V_{cm}}$$



HELIOS at Argonne



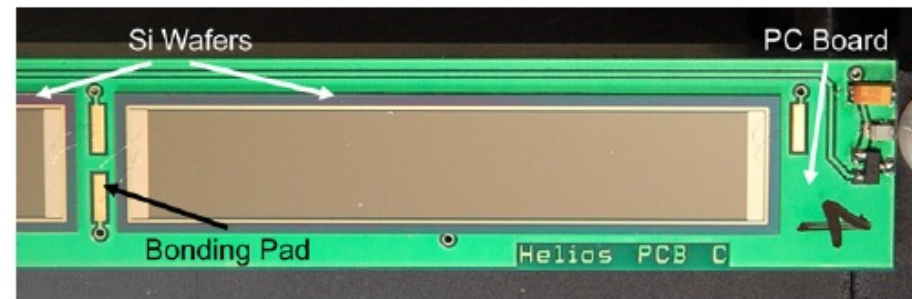
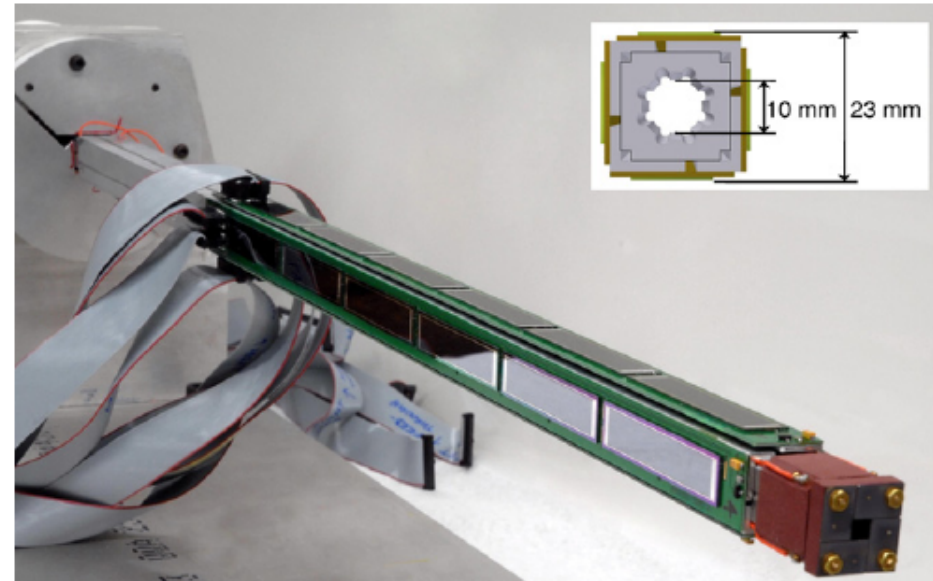
24 Si PSDs

12 mm × 56 mm × 0.7 mm

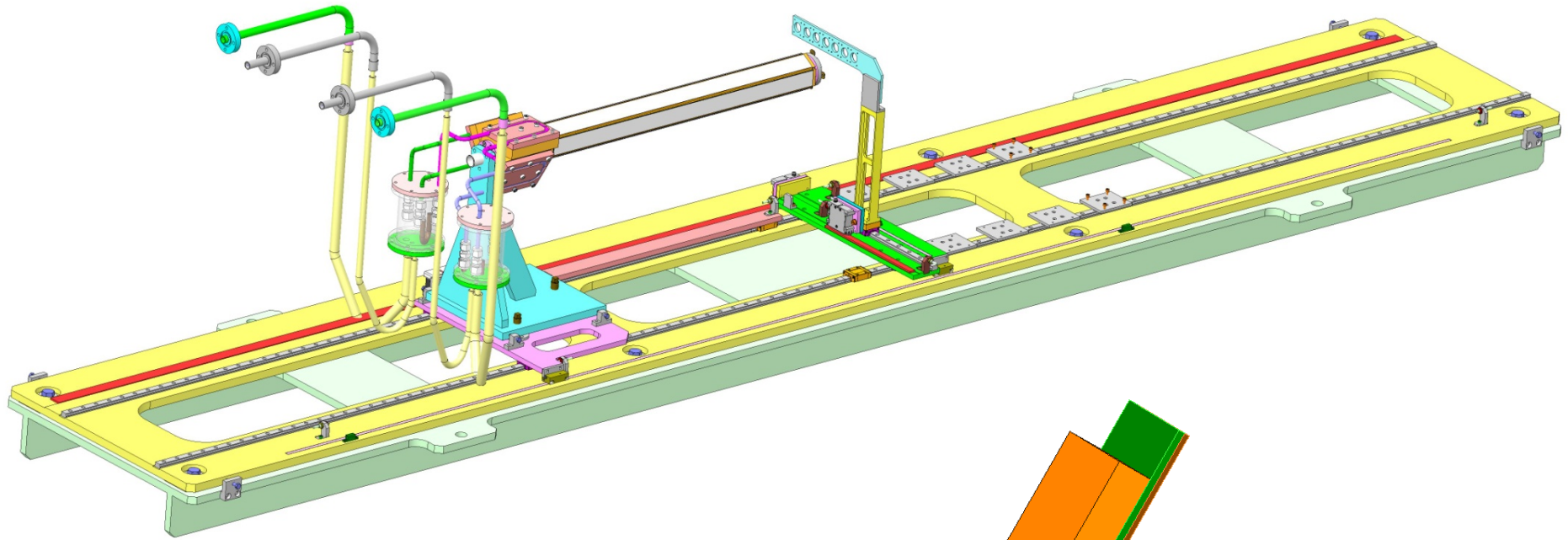
9 mm × 50.5 mm active area

square 23 mm × 710 mm

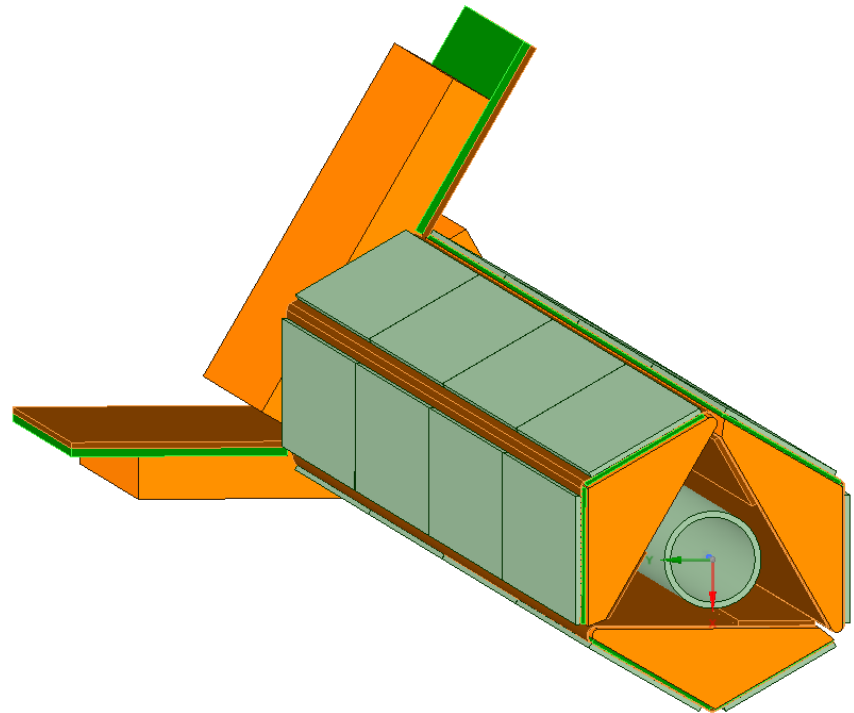
340 mm active length



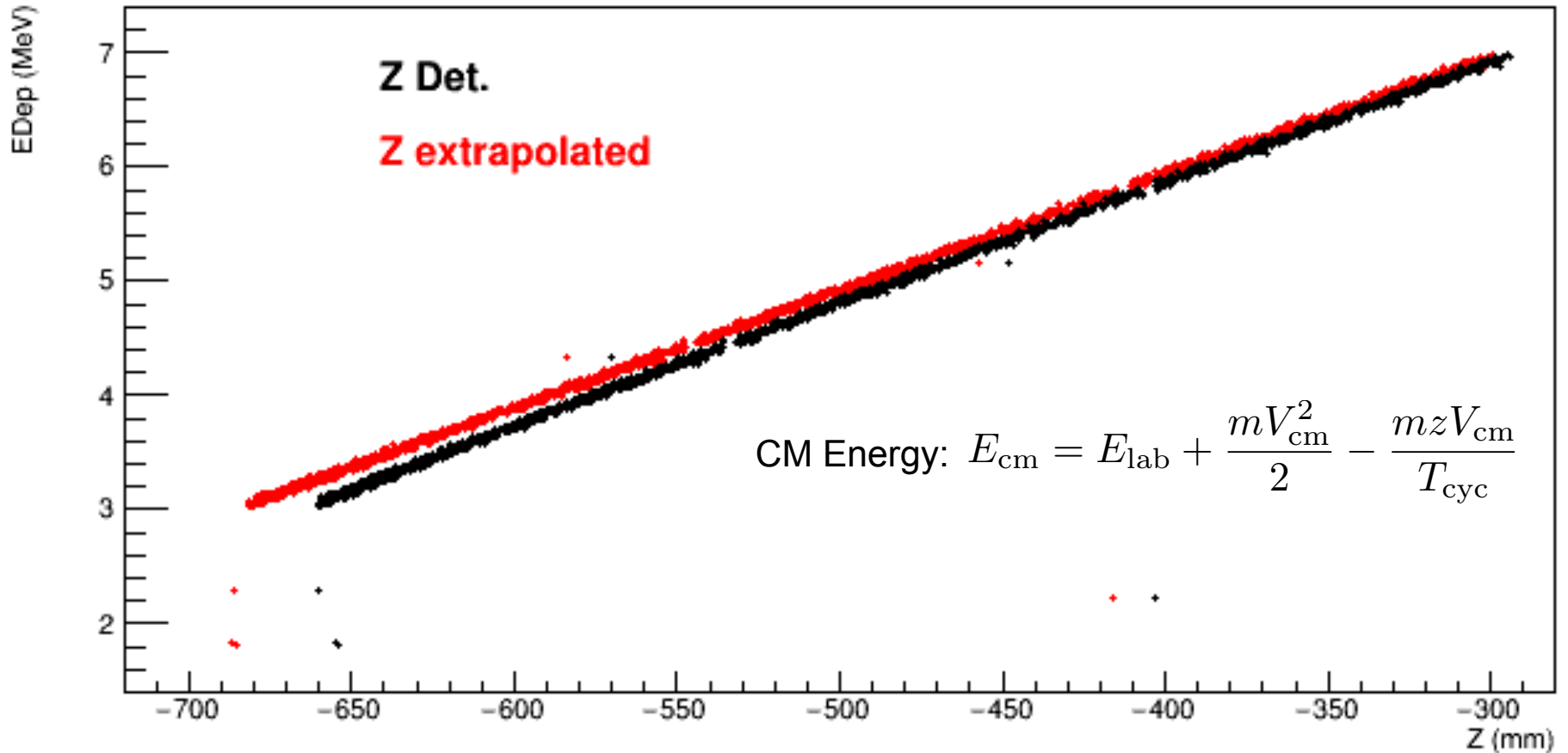
External Spectrometer Design



DSSDs + ASIC readout
1 mm thick
x: 128×0.95 mm
y: 11×2 mm



Reconstructing the z position



Algorithm devised by P. Butler
Implemented in GEANT4 by M. Labiche

Status of magnet procurement

- Magnet funding awarded (STFC/UoL)
- Magnet available from Brisbane (UQ)
 - OR66 4T ex-MRI magnet
 - “Active shield” reduces stray field
 - Installed February 2003
 - Discharged then warmed ~2013
- Order for magnet has been placed!
- To be delivered & paid by 31/3/2016

Status of magnet procurement



Status of procurement



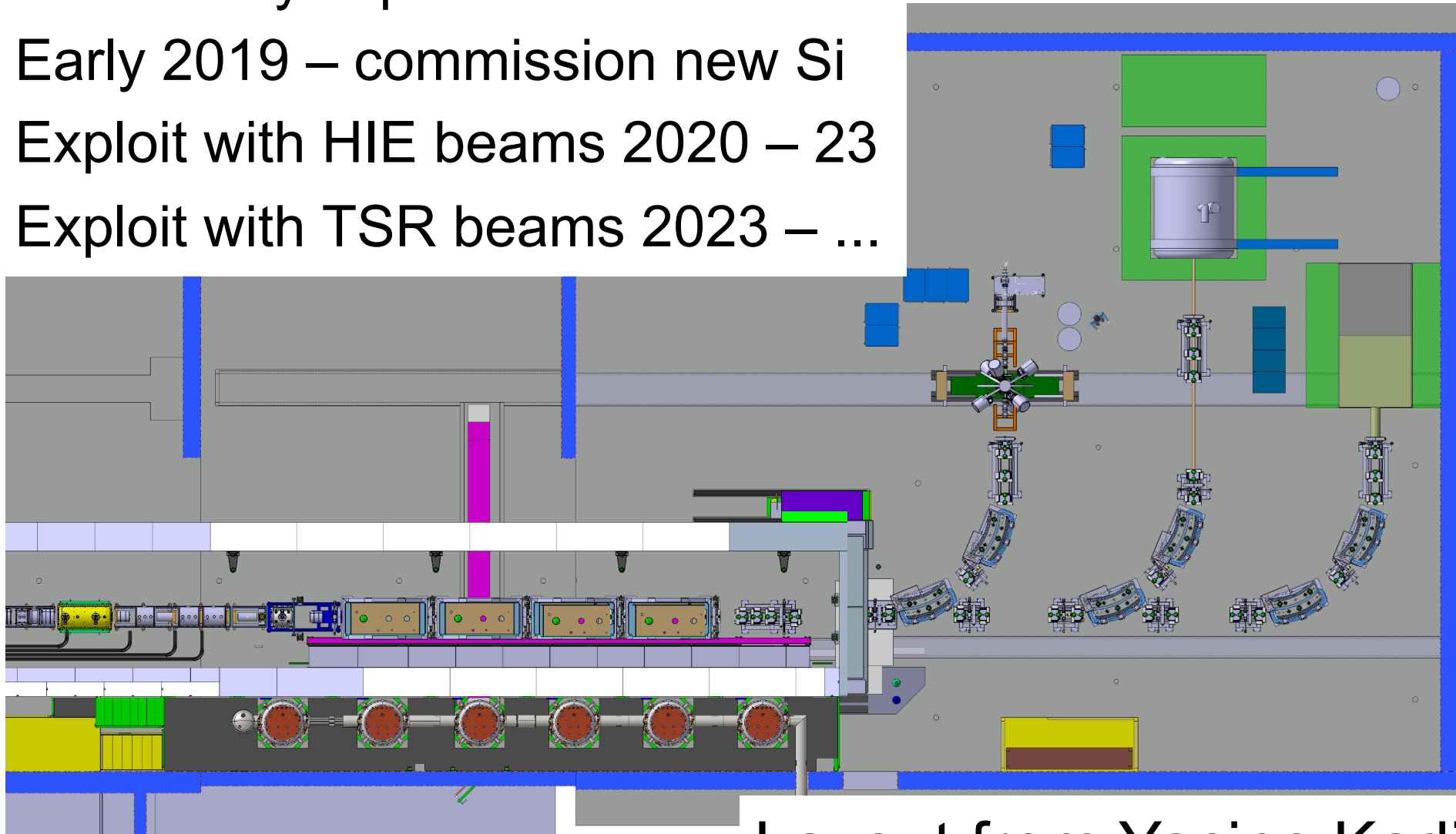
Installation in the ISOLDE Hall

Preliminary experiments 2017/18?

Early 2019 – commission new Si

Exploit with HIE beams 2020 – 23

Exploit with TSR beams 2023 – ...

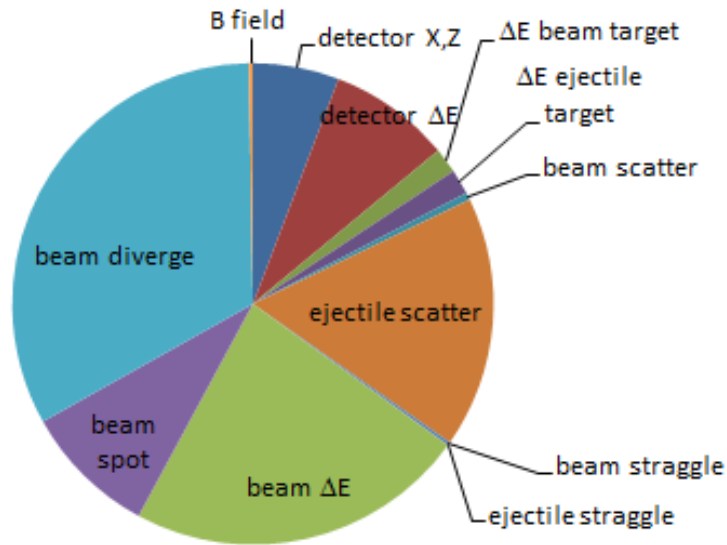


Layout from Yacine Kadi

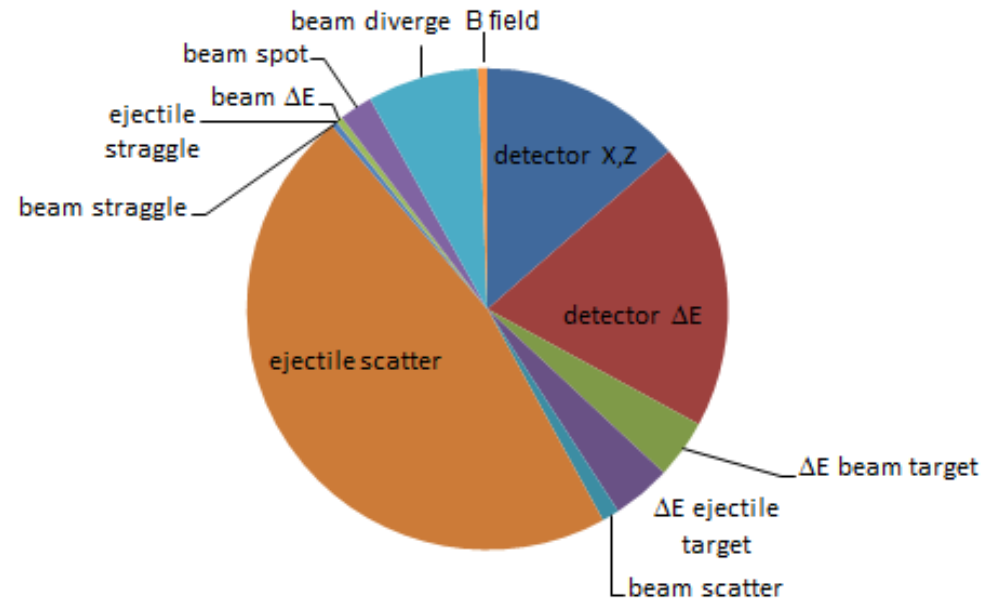
Q-value resolution

EXTERNAL SPECTROMETER: $d(^{24}\text{Ne},p)^{25}\text{Ne}$ @ 10 MeV/u

HIE-ISOLDE beam: 38 keV



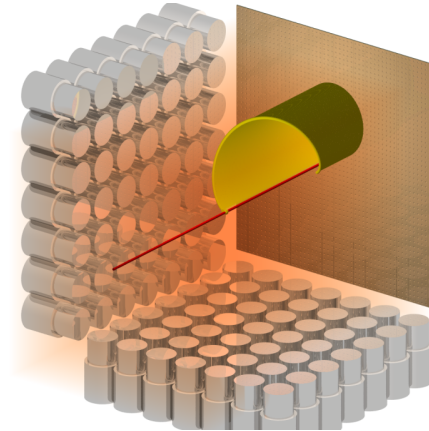
Cooled TSR beam: 22 keV



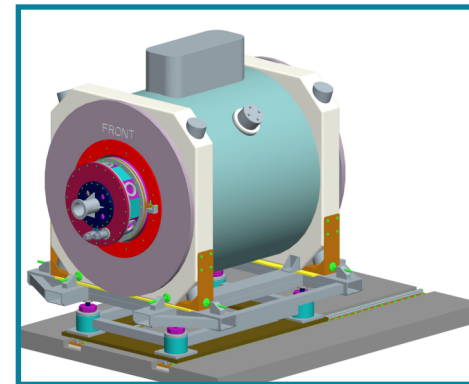
Calculations by P.A. Butler

SpecMAT: Spectroscopy in a Magnetic Active Target

- Active target: Time-projection chamber where detection gas is the target
- Magnetic field parallel to beam direction to confine emitted particles
- Array of γ -ray detectors within the field
LaBr₃ preferred for best compromise efficiency/resolution



- **Active target:**
High luminosity, large dynamic range, high resolution, versatile
- **Gamma-ray in coincidence**
unique improvement of one order of magnitude in resolution



- Challenge: place the array of γ -ray detectors within the magnetic field

SpecMAT programme: transfer reactions in n-rich Ni and n-deficient Pb regions

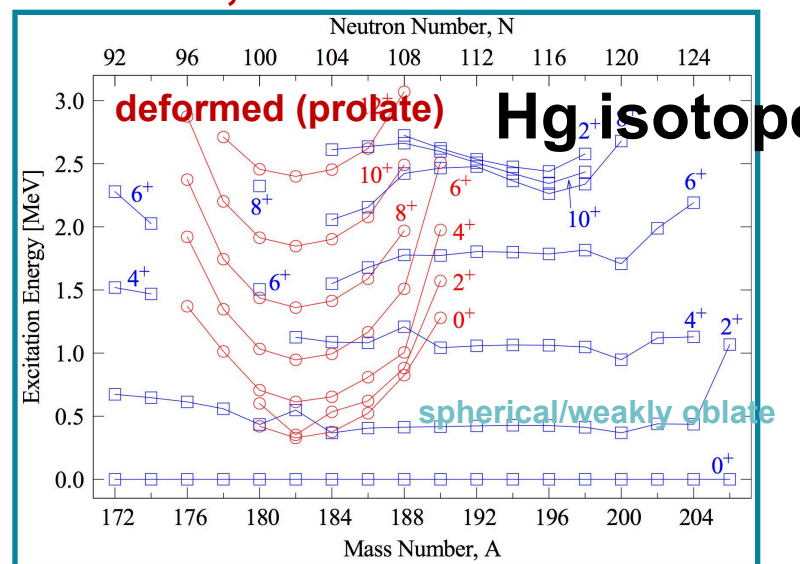
- Shell evolution towards ^{78}Ni
 - Migration of $\pi f_{7/2}$, $\pi f_{5/2}$ as $\nu g_{9/2}$ is filled
 - Migration of $\nu g_{9/2}$ and $\nu d_{5/2}$ as $\pi f_{5/2}$ is emptied
 - (Non-)magicity of $N=40$

^{68}Zn	^{69}Zn	^{70}Zn	^{71}Zn	^{72}Zn	^{73}Zn	^{74}Zn	^{75}Zn	^{76}Zn	^{77}Zn	^{78}Zn	^{79}Zn	^{80}Zn	^{81}Zn
^{67}Cu	^{68}Cu	^{69}Cu	^{70}Cu	^{71}Cu	^{72}Cu	^{73}Cu	^{74}Cu	^{75}Cu	^{76}Cu	^{77}Cu	^{78}Cu	^{79}Cu	^{80}Cu
^{66}Ni	^{67}Ni	^{68}Ni	^{69}Ni	^{70}Ni	^{71}Ni	^{72}Ni	^{73}Ni	^{74}Ni	^{75}Ni	^{76}Ni	^{77}Ni	^{78}Ni	
^{65}Co	^{66}Co	^{67}Co	^{68}Co	^{69}Co	^{70}Co	^{71}Co	^{72}Co	^{73}Co	^{74}Co	^{75}Co			

(d,p) and (d, ^3He) transfers on ^{68}Ni , ^{70}Ni , ^{78}Zn , ^{80}Zn

- Shape coexistence “west” of ^{208}Pb
 - States characterised by different shapes appear at low excitation energy
 - Example: n-deficient Pb region ^{186}Pb triple-shape coexistence
 - Hg nuclei: “parabolic intrusion” at mid-shell

(d,p) and (p,d) transfers on $^{184,185g,185m}\text{Hg}$ (possibly ^{182}Hg), ^{188}Pb , ^{196}Po



Data: NNDC, figure courtesy of L. Gaffney
Original figure in R. Julin et al., J. Phys. G 27 (2001) R109

Conclusions

- Design work is underway
- Magnet purchase proceeding
- Discussions on ISOLDE integration started

Thanks to: Peter Butler, Sean Freeman, Tom Davinson, Marc Labiche, Ian Lazarus, Alan Grant, Mike Cordwell, Dave Seddon, Jim Thornhill, Dave Wells, John Simpson, Riccardo Raabe, Phil Woods, ...



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