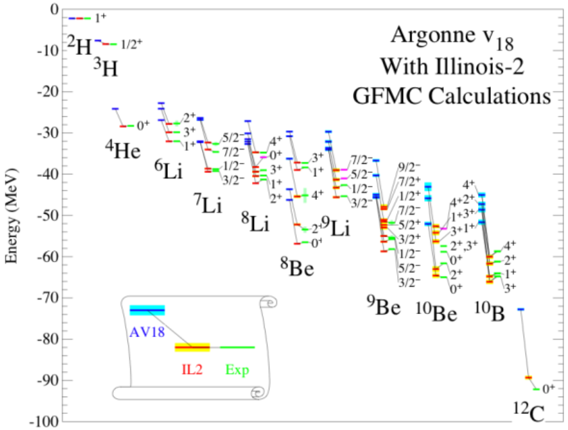
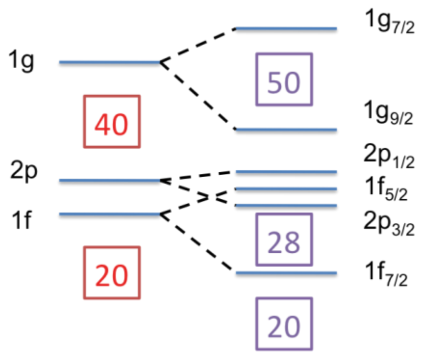
HELIOS@HIE-ISOLDE

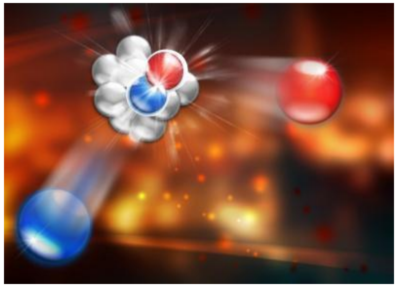
tests of ab-initio methods

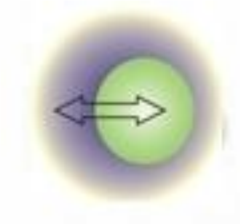


shell closures

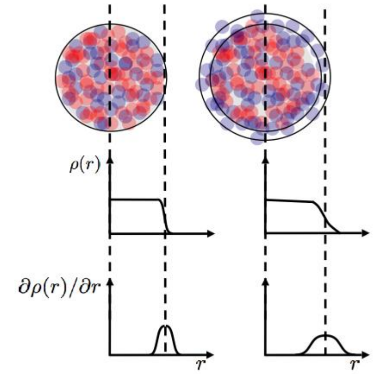


np pairing



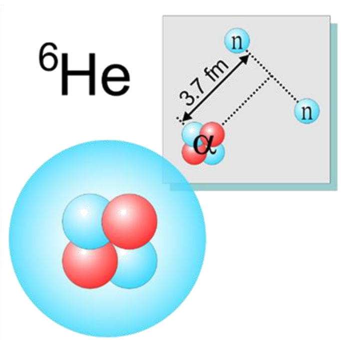


evolution of collectivity



single-particle evolution

halos and clustering



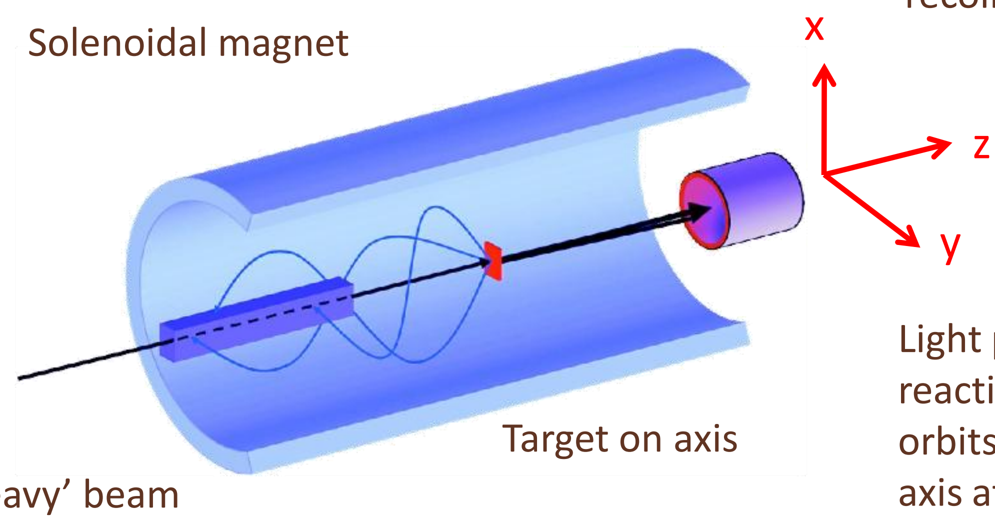
Single-Nucleon, PAIR and CLUSTER TRANSFER

Inelastic Scattering

IMPORTANCE LIES IN:

- well understood mechanism.
- inherent selectivity arising from direct connection between initial and final states via a particular degree of freedom.
- gives a quantitative understanding of nuclear structure in exotic nuclei, unobtainable in other ways.

HELIOS@HIE-ISOLDE



Heavy ejectile detected in recoil detector.

MEASURED QUANTITIES:

- position z
- cyclotron period T_{cyc}
- particle energy E_{lab}

Light particles from reaction follow helical orbits, returning to the axis after one orbit.

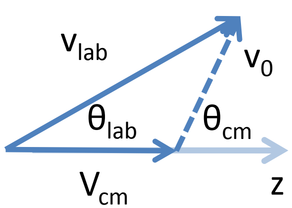
DEDUCED QUANTITIES:

Particle identification $$T_{\rm cyc} = \frac{2\pi}{B}\frac{m}{qe}$$

then replace with calculated number!

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

For a particular axial position, energies in CM and LAB related by a constant offset thus avoiding kinematic shift/compression.

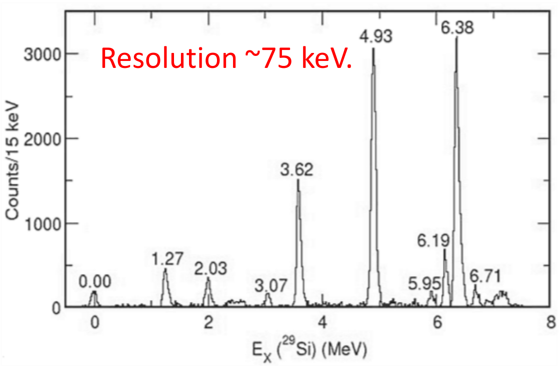


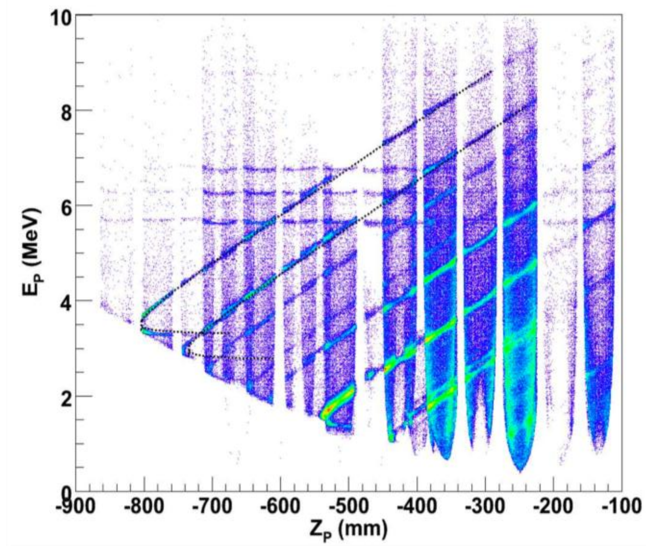
CM Angle: $$\cos\theta_{\rm cm} = \frac{v_{\rm lab}^2 - V_{\rm cm}^2 - v_0^2}{2v_0V_{\rm cm}}$$

A Wuosmaa *et al*. NIM A **580** 1290 (2007)
J. Lighthall *et al*. NIM A **622** 97 (2010)

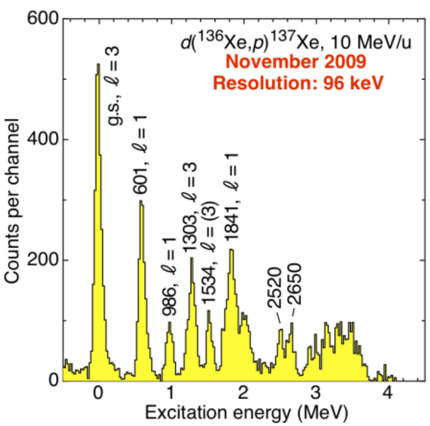
HELIOS@ANL

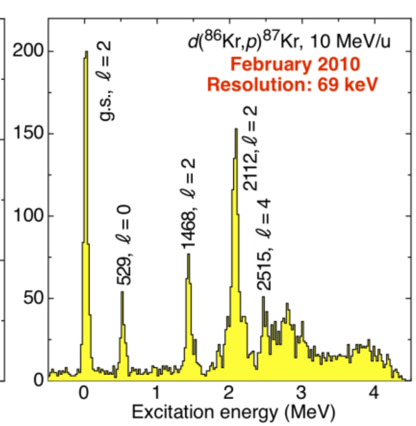
d(^{28}Si,p) @ 8 MeV/u, 10^{7-8} pps, 1.915 T
~100 μgcm^{-2} CD_2, no recoil detector.

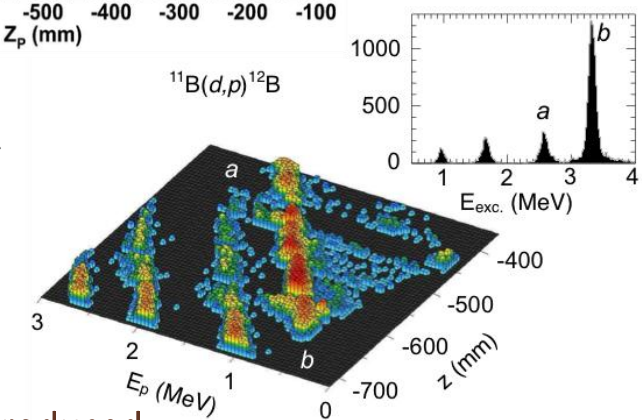




$$E_{\mathrm{cm}} = E_{\mathrm{lab}} + \frac{mV_{\mathrm{cm}}^2}{2} - \frac{mzV_{\mathrm{cm}}}{T_{\mathrm{cyc}}}$$

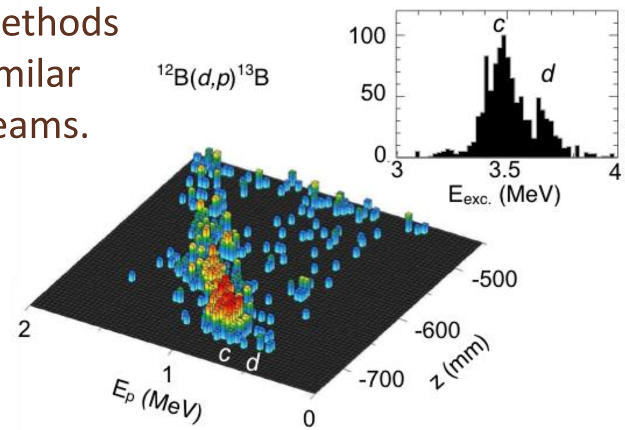






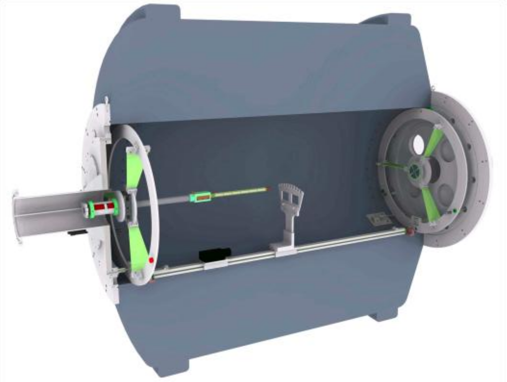
The ^{12}B beam produced using in-flight methods likely to be of similar quality to HIE beams.

Resolution ~100 keV.



Ultimate resolution @ ISOLDE set by the HIE Linac longitudinal emittance giving ≳ 90 keV at A=100.

TECHNICAL PROS AND CONS



1. Removes kinematic shift and broadening.
2. Avoids kinematic compression of excited states.
3. Surface area of silicon needed CONSIDERABLY smaller than a conventional array.
4. Large classes of backgrounds to particle spectra are eliminated by field.
5. Particle-ID based on TOF, avoiding issues of EΔE measurements with low energy ions, esp. backward LAB angles.
6. Does not (necessarily) require coincident γ-ray measurements.
7. Suitable for measuring non-γ-emitting states e.g. ground and isomeric states.

Superior resolution of particle groups, where target effects do not dominate.

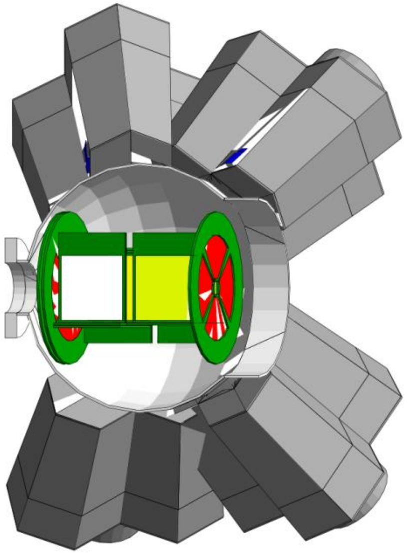
Fewer electronic channels, cheaper, easier to operate. Better solid-angle coverage for the same cost. NB: acceptance largely determined by length of silicon, bore and field of magnet.

Compared to a conventional system with same Ω (see comment above!), 1-mg target and 7% γ-ray efficiency….

…HELIOS would have x1 to 10 increase in statistics, if the thickest target that does not compromise HIE beam resolution is used.
But Ω likely higher also!

1. Angular resolution 0.1 to 1 degree depending on reaction and scattering angle.

1. Use of γ-ray measurements would require development… e.g. $LaBr_3$ plus photodiode readout.

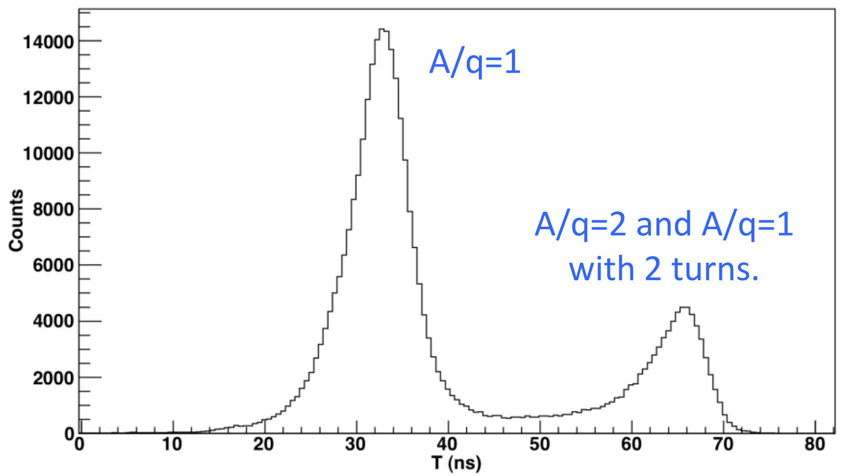


TECHNICAL ISSUE

Example: Particles from 6-MeV/A ^{28}Si on $(C_2D_4)_n$

Particle identification $$T_{\rm cyc} = \frac{2\pi}{B}\frac{m}{qe}$$

Particle	T_{cyc} (ns) at 3T
p	21.9
d / α	43.7
t	65.6
$^3He^{2+}$	32.8

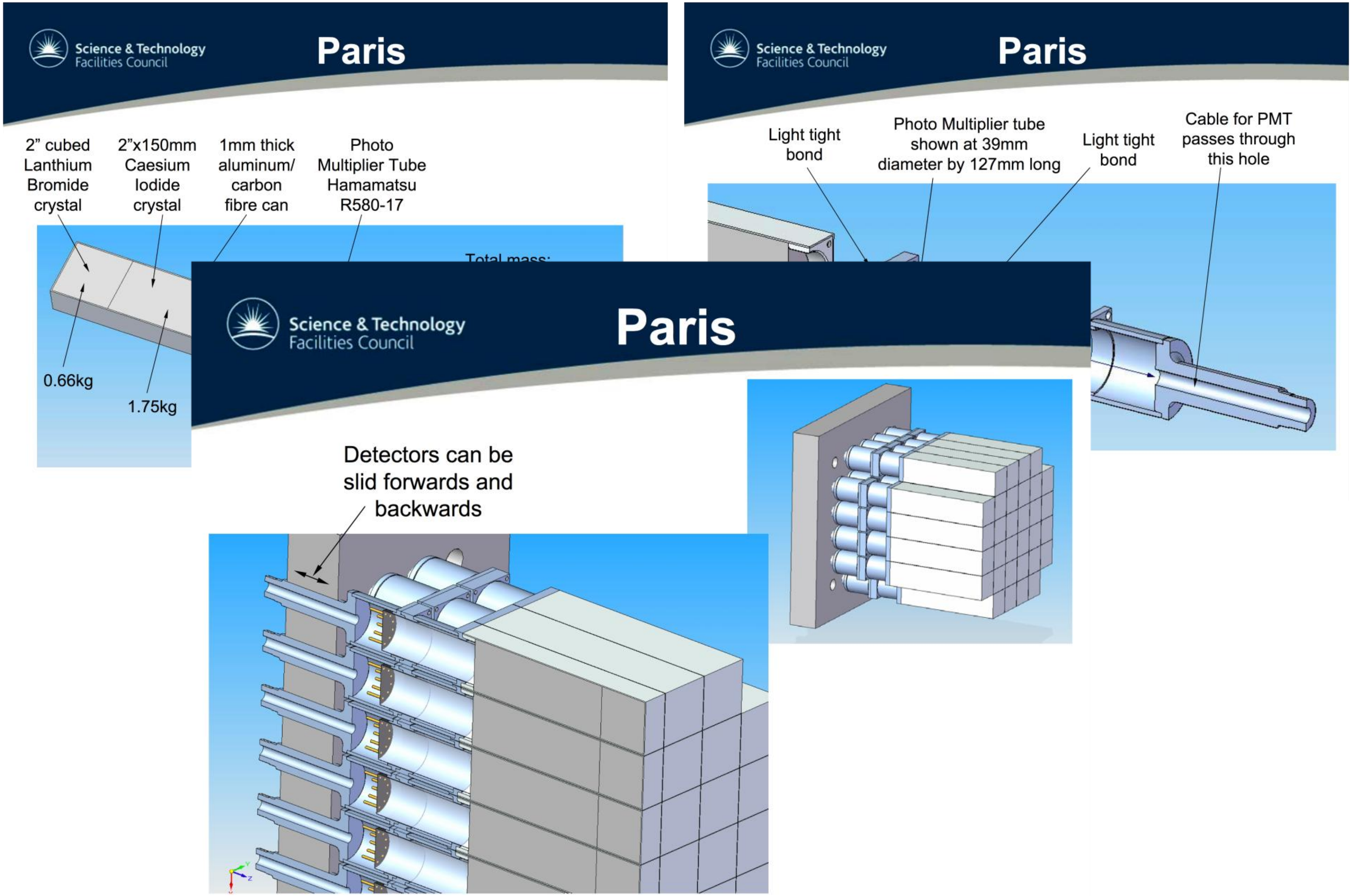


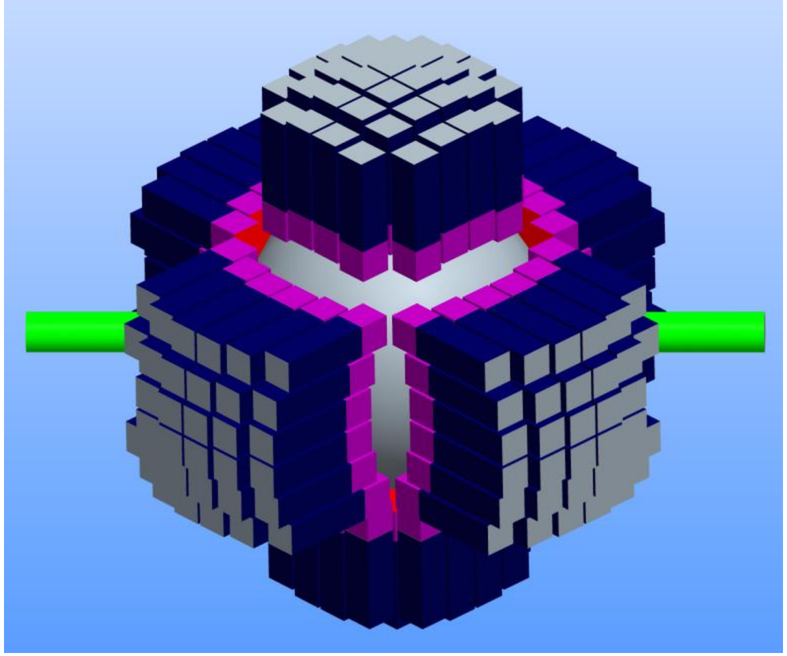
Difficult with a 10-ns repetition rate and current EBIS duty cycle.

...BUT VERY MANY OTHER EXPERIMENTS WOULD ALSO BENEFIT FROM TIME-OF-FLIGHT MEASUREMENTS...

SOLUTION?? Include a multi-harmonic pre-buncher into the design of the HIE-LINAC

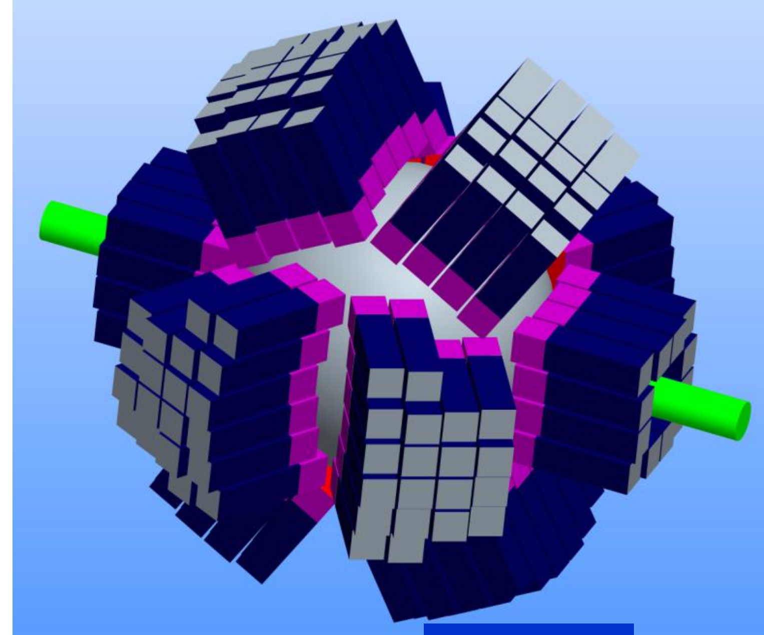
OTHER REQUIREMENTS: 6.5 x 4 m^2 foot print, approx 250 litres LHe per month.


Science & Technology Facilities Council
Paris
2” cubed Lanthium Bromide crystal
2”x150mm Caesium Iodide crystal
1mm thick aluminum/ carbon fibre can
Photo Multiplier Tube Hamamatsu R580-17
Total mass:
0.66kg
1.75kg
Science & Technology Facilities Council
Paris
Light tight bond
Photo Multiplier tube shown at 39mm diameter by 127mm long
Light tight bond
Cable for PMT passes through this hole
Science & Technology Facilities Council
Paris
Detectors can be slid forwards and backwards

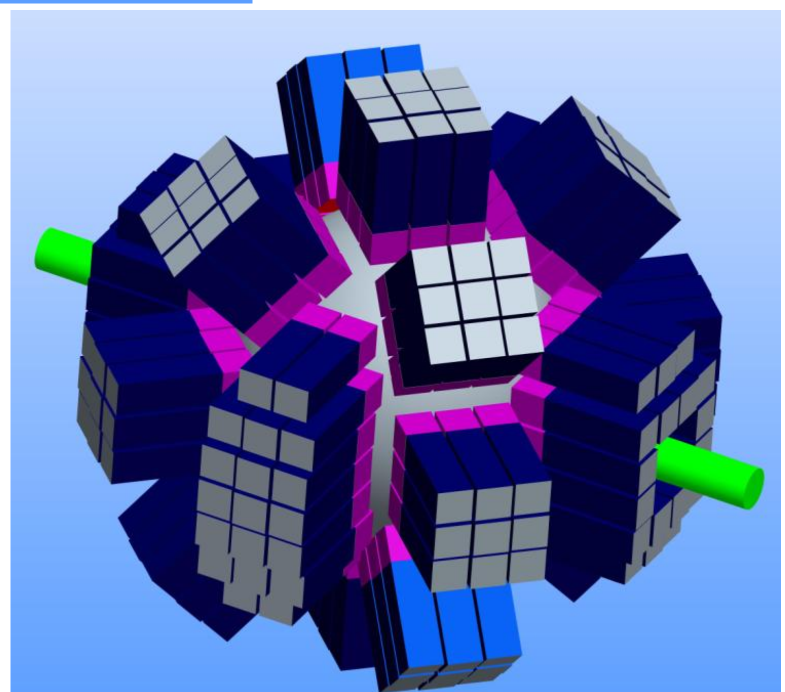


Cube
6 faces

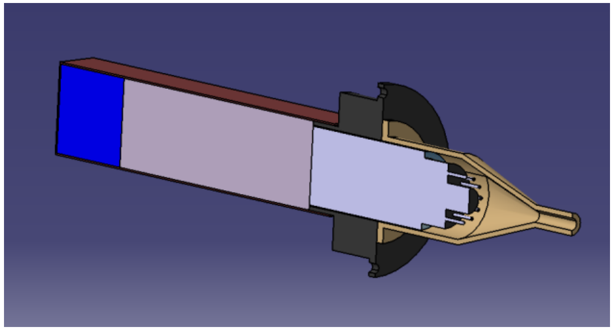
200 elements

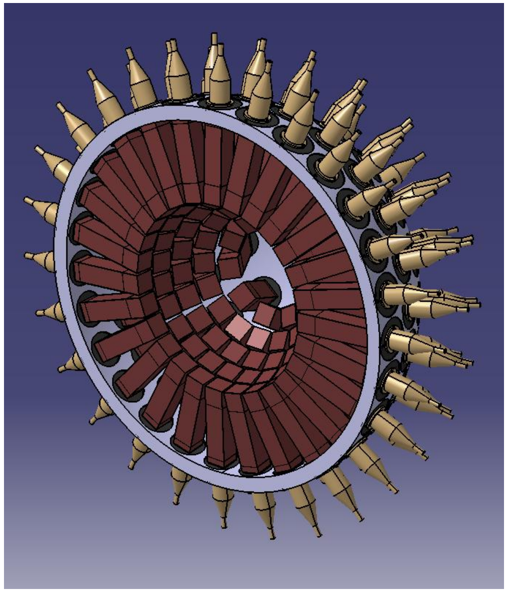


Decagon
10 faces



Octadegon
18 faces





200 elements