RI production for a beta-beam: *A* new approach

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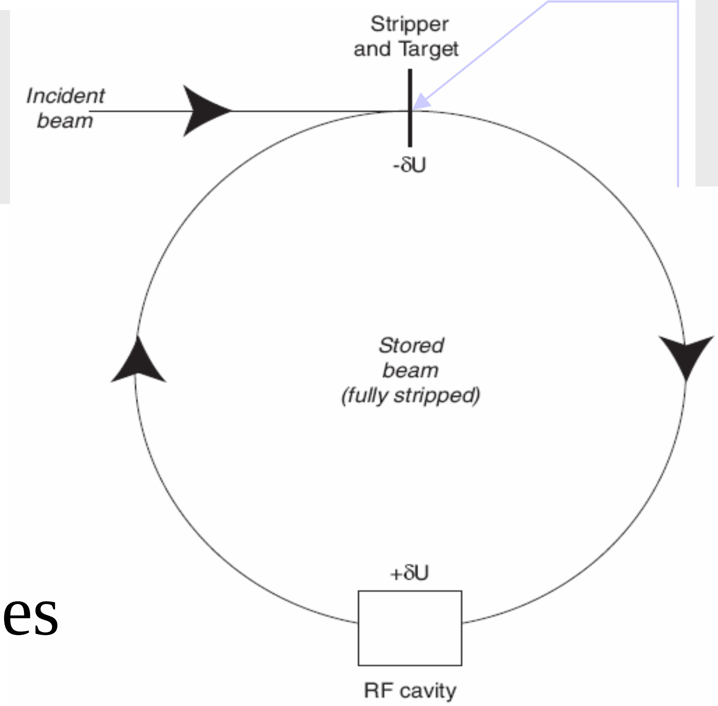
A new approach

Beam cooling with ionisation losses – C. Rubbia, A Ferrari, Y. Kadi and V. Vlachoudis in NIM A, In press

"Many other applications in a number of different fields may also take profit of **intense beams of radioactive ions**."

^{7}Li
^{6}Li



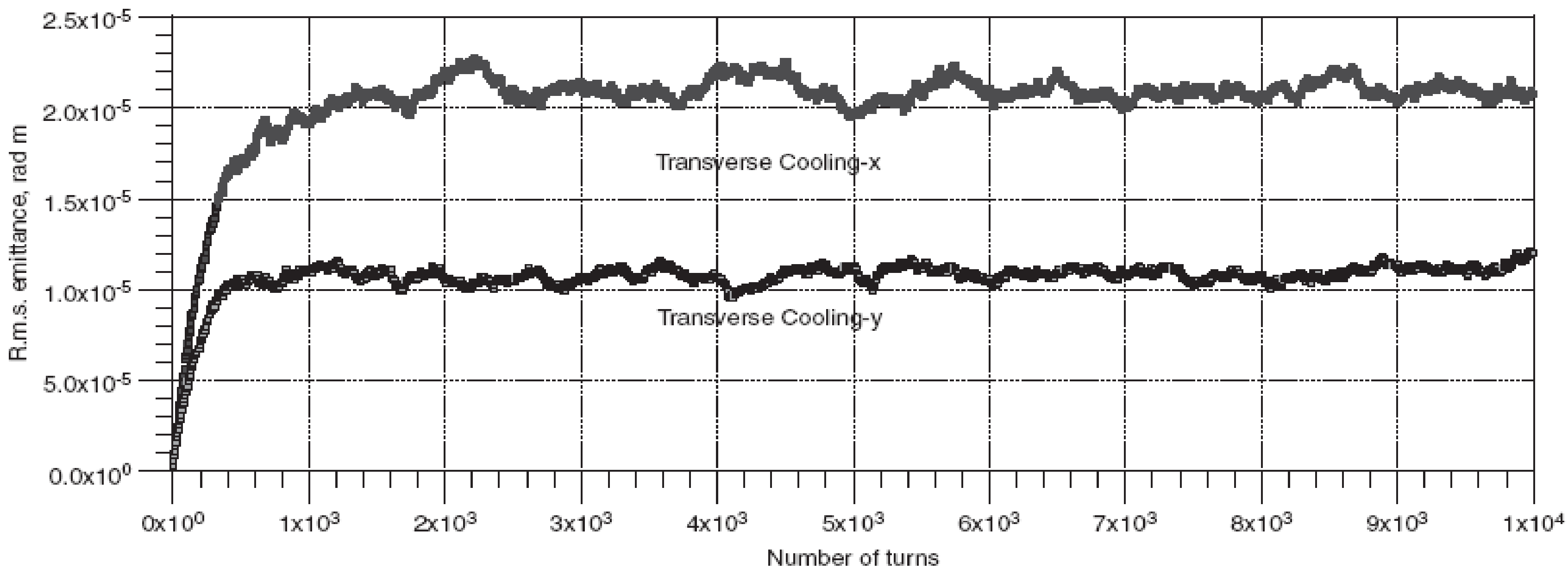
$^{7}Li(d,p)^{8}Li$
$^{6}Li(^{3}He,n)^{8}B$

Missed opportunities

See also: Development of FFAG accelerators and their applications for intense secondary particle production, Y. Mori, NIM A562(2006)591

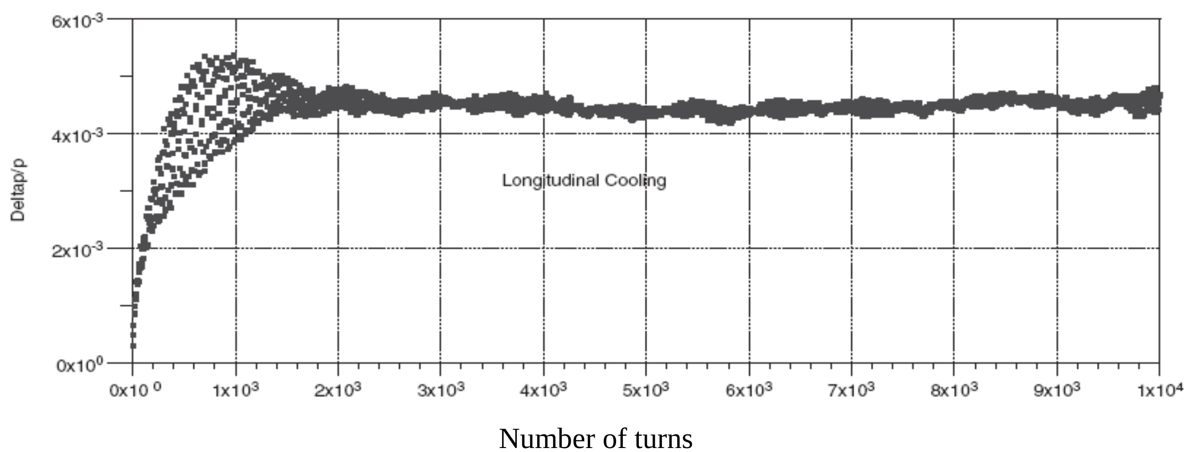
Transverse cooling in paper by Carlo Rubbia et al.

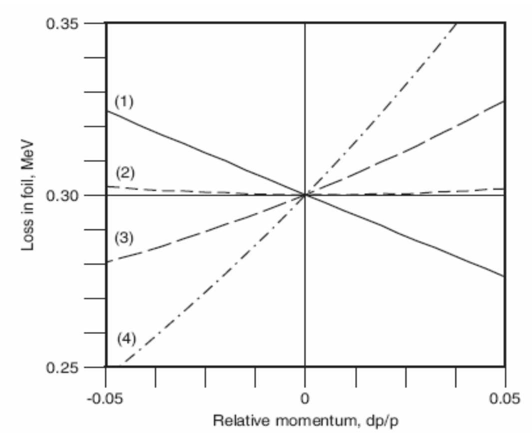
"In these conditions, like in the similar case of the synchrotron radiation, the transverse emittance will converge to zero. In the case of ionisation cooling, a finite equilibrium emittance is due to the presence of the multiple Coulomb scattering."



Longitudinal cooling in paper by Carlo Rubbia et al.

"In order to introduce a change in the dU/dE term — making it positive in order to achieve longitudinal cooling — the gas target may be located in a point of the lattice with a chromatic dispersion. The thickness of the foil must be wedge-shaped in order to introduce an appropriate energy loss change, proportionally to the displacement from the equilibrium orbit position."

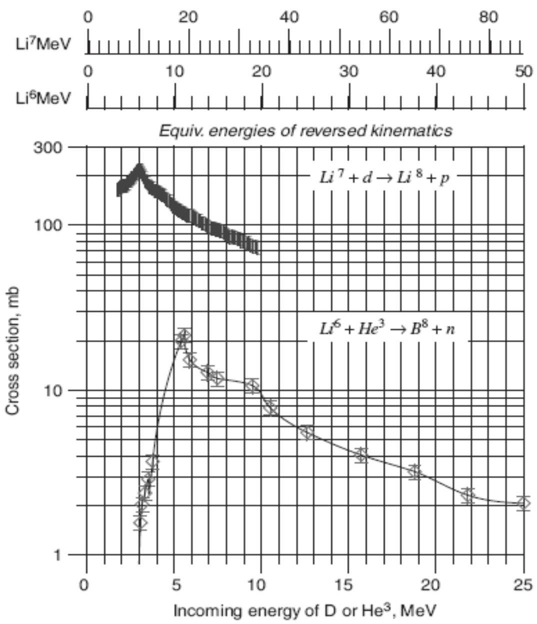


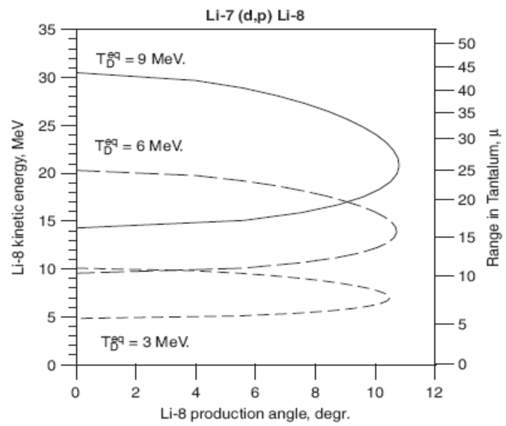


1) Without wedge, dU/dE<0
2) Wedge with dU/dE=0, no longitudinal cooling
3) Wedge with dU/dE=0.0094
4) Electrons, cooling through synchrotron radiation

Inverse kinematics production and ionisation parameters in paper by Carlo Rubbia et al.

$^{7}Li(d,p)^{8}Li$
$^{6}Li(^{3}He,n)^{8}B$





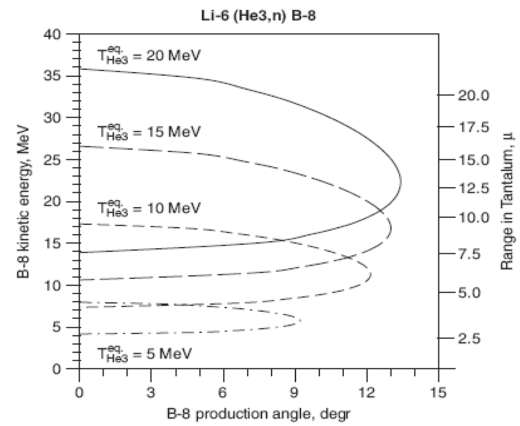
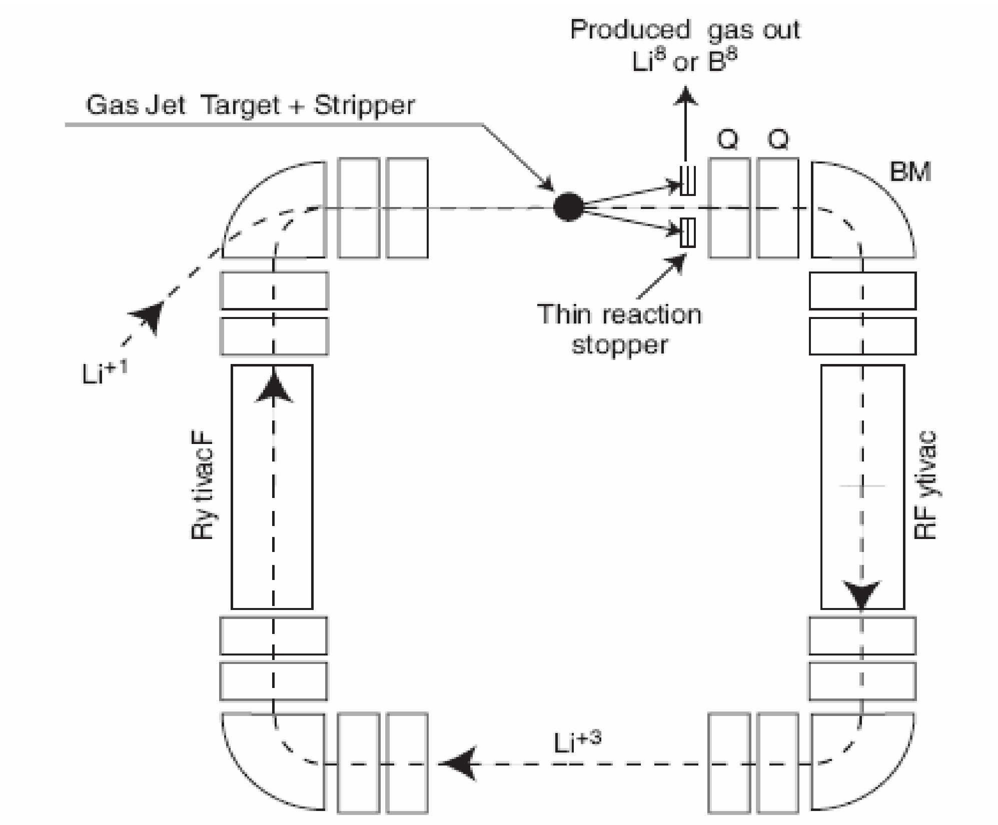


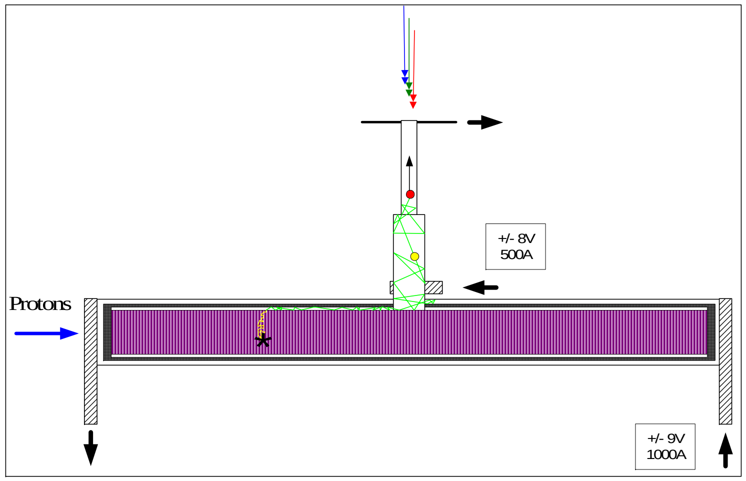
Table 1
Some ionisation parameters for ^{6}Li and ^{7}Li in the energy interval of interest

Energy, T (MeV)	dE/dx (MeV/(mg/cm^2))		$\sqrt{\langle Z\rangle^2}$		δE (keV) for loss of 0.3 MeV	
	^{6}Li	^{7}Li	^{6}Li	^{7}Li	^{6}Li	^{7}Li
5	3.356	3.355	2.94	2.89	10.646	9.866
10	2.120	2.014	3.00	3.00	11.751	10.205
15	1.660	1.573	3.00	3.00	13.340	11.714
20	1.356	1.329	3.00	3.00	14.752	12.999
25	1.116	1.092	3.00	3.00	16.102	14.174
30	0.965	0.890	3.00	3.00	17.331	15.323
35	0.861	0.778	3.00	3.00	18.428	16.309

Collection in paper by Carlo Rubbia et al.

"The technique of using very thin targets in order to produce secondary neutral beams has been in use for many years. Probably the best known and most successful source of radioactive beams is ISOLDE."

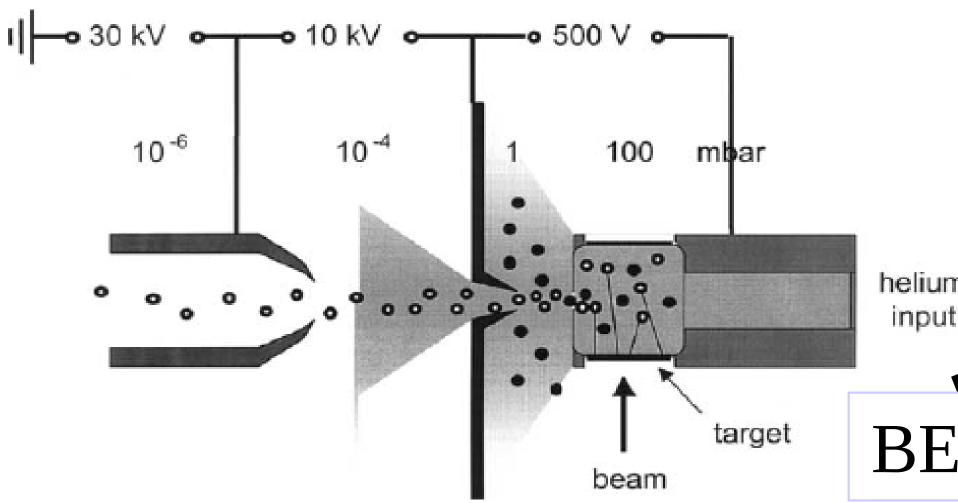


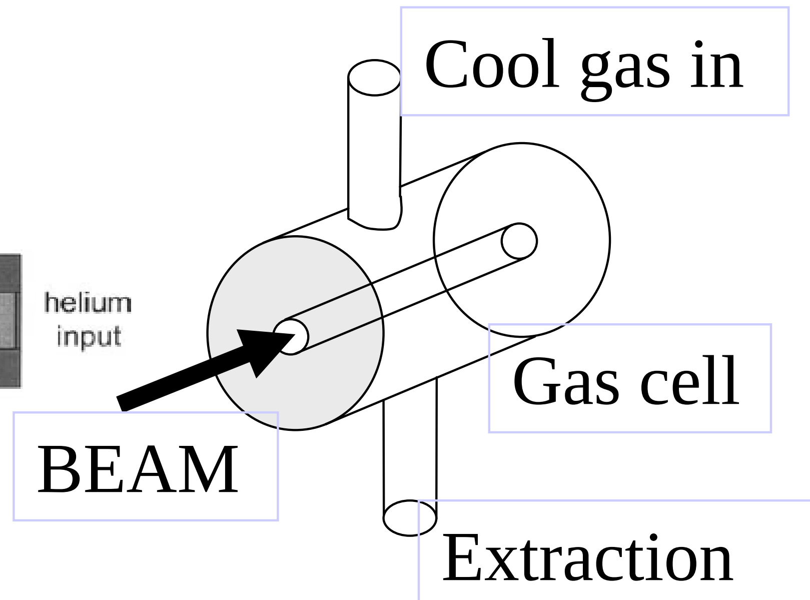


Reactions to study for our application

- $^{20}Ne(p,T)^{18}Ne$
  - H.Backhausen et al, RCA,29(1981)1
- $^{16}O(^{3}He,n)^{18}Ne$
  - V.Tatischeff et al, PRC,68(2003)025804
- $^{12}C(CO_2,^{6}He)^{18}Ne$?
  - K.I.Hahn et al, PRC,54(1996)1999
- $^{7}Li(T,A)^{6}He$

- IGISOL technique (Ion Guide)





- Figure from Juha Aysto, Nucl.Phys. A693(2001)477
- At 200 Torr of ^{4}He, 10% efficiency, space charge limit at 10^8 ions cm^{-3} (peak 10^{10} ions cm^{-3}?), Private communication Ari Jokinen

What about the intensities?

- Cross section similar or larger compared to those studied in detail in C. Rubbia et al.'s paper
- Heavier ions in the ring will require further beam dynamics study
- Space charge effects will set the limit for the IGISOL type device. With a 1000 cm^3 gas cell, is 10^{11} ions s^{-1} realistic?
- Collection with foils as proposed by C. Rubia et al?