Possibility of bringing TRIμP to HIE-ISOLDE

Dual magnetic Spectrometer

Olof TENGBLAD

ISCC Oct. 22nd 2013

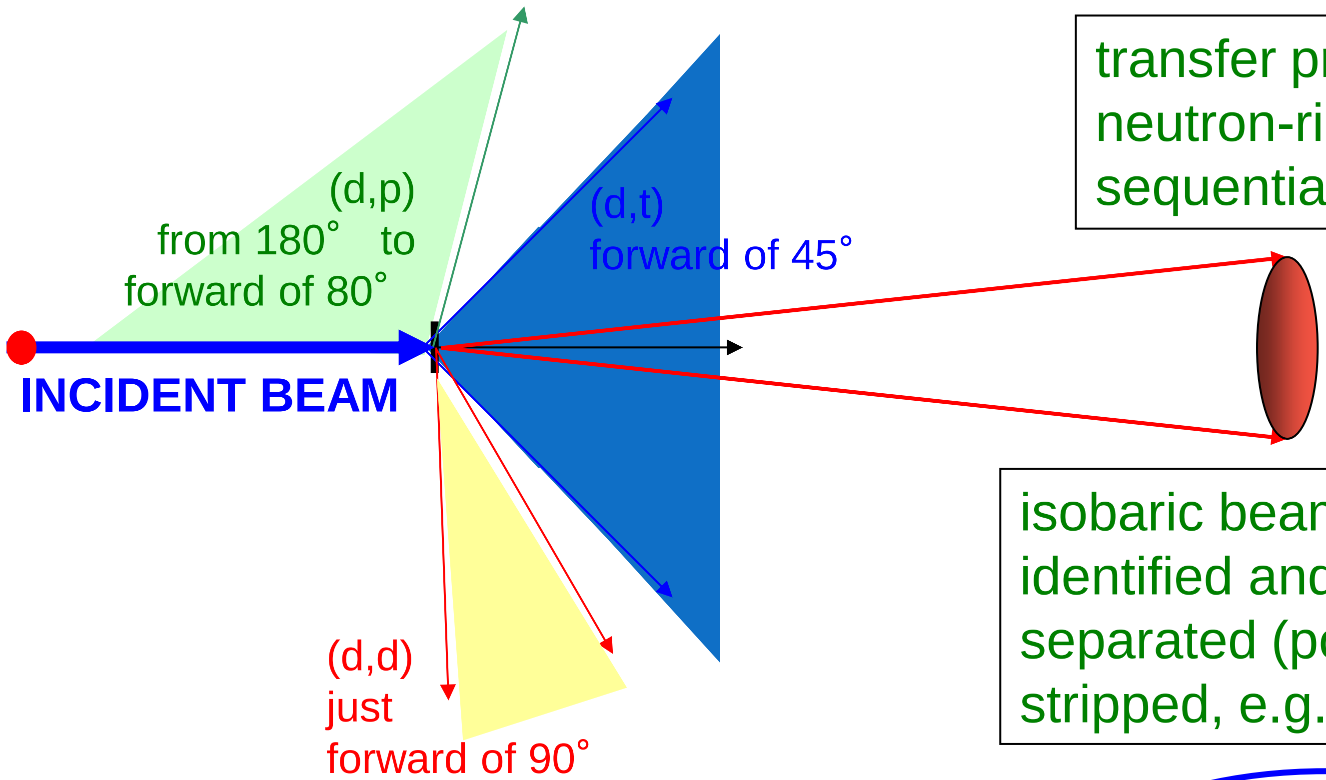
There will be a presentation during the ISOLDE workshop 25-27 November by **Lorens Willman** from the TRIμP collaboration at KVI.
But as not everyone will be present I will give some background and some explanation to what the TRIμP is and how it could fit at HIE-ISOLDE.

Zero-degree spectrometer @ Hie-Isolde

- **Workshop in LUND March 2011 where it was expressed a strong interest for having a Zero- degree spectrometer coupled to HIE-ISOLDE.**
- **The initiative was postpone due to the rapid advance of the TSR project and two such projects on the same time was too much**

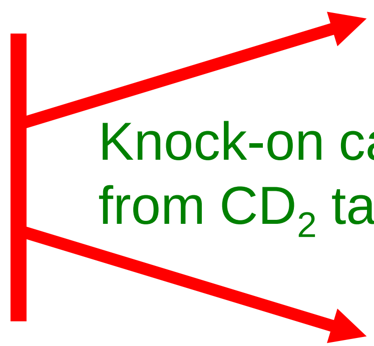
WHY a Zero-degree spectrometer

USING RADIOACTIVE BEAMS in INVERSE KINEMATICS



transfer products on neutron-rich side can sequentially n-decay

isobaric beams can be identified and/or physically separated (possibly further stripped, e.g. $^{15}N^{3+}/^{21}O^{4+}$)



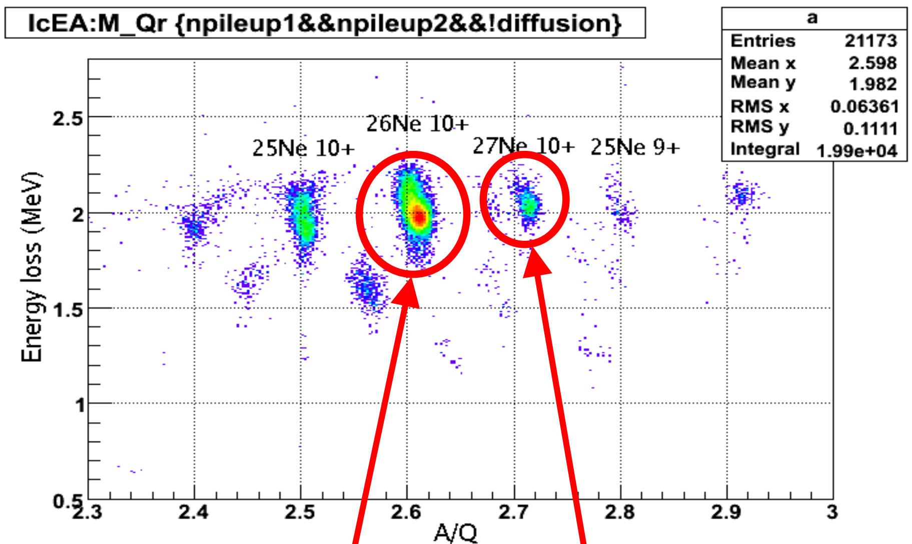
Knock-on carbons from CD_2 targets

fusion-evaporation products from reactions on C in CD_2 targets

Wilton Catford
University of Surrey, UK

ZERO DEGREE = SPECTROMETER

Wilton Catford
University of Surrey, UK

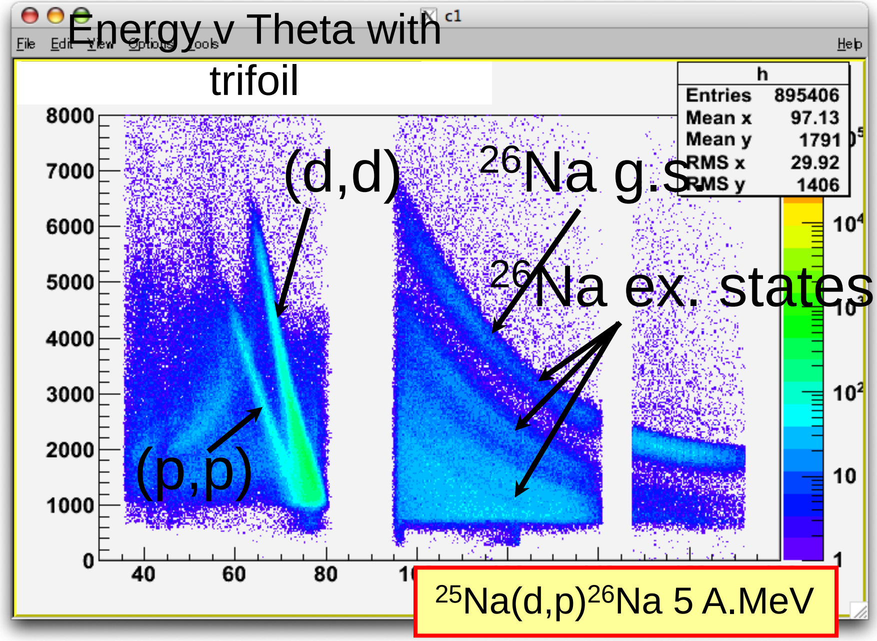


^{26}Ne(d,p)^{27}Ne

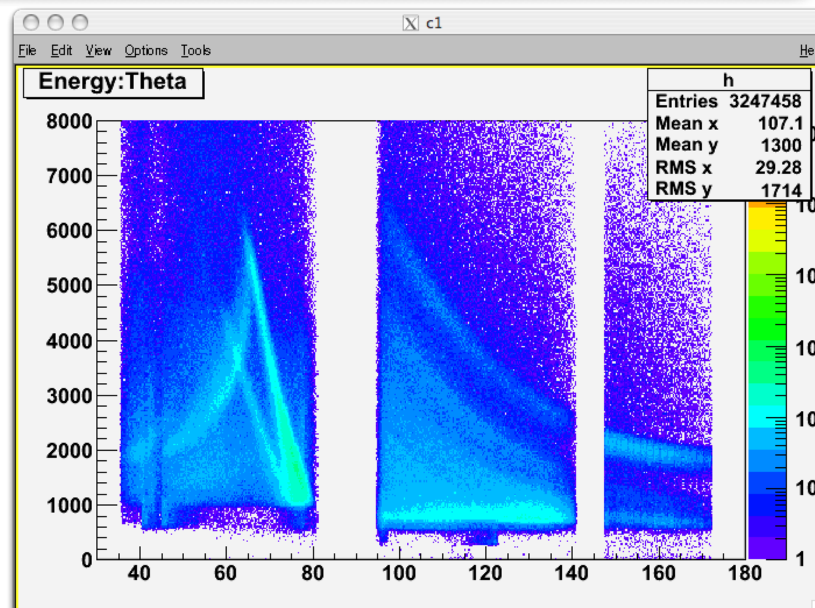
^{26}Ne(d,p)^{27}Ne$\rightarrow$^{26}Ne+n

RESULTS from TIARA/MUST2 Nov2007

ZERO DEGREE = SCINTILLATOR



^{25}Na(d,p)^{26}Na 5 A.MeV



RESULTS from SHARC Aug2009

Original Proposal @ KVI

Trapped Radioactive Isotopes:
Micro-laboratories for fundamental Physics

27 August 1999 TRIμP

Aanvraag in het kader van het investeringsprogramma NWO-Groot

H.W. Wilschut, M.N. Harakeh, R. Hoekstra, R. Morgenstern

This is not some old equipment laying around.

Original proposal for funding in August 1999, to build a *"Microlaboratorie for fundamental Physics at KVI using Trapped radioactive Isotopes"*
2001 Start building – 2005 ready for Beam

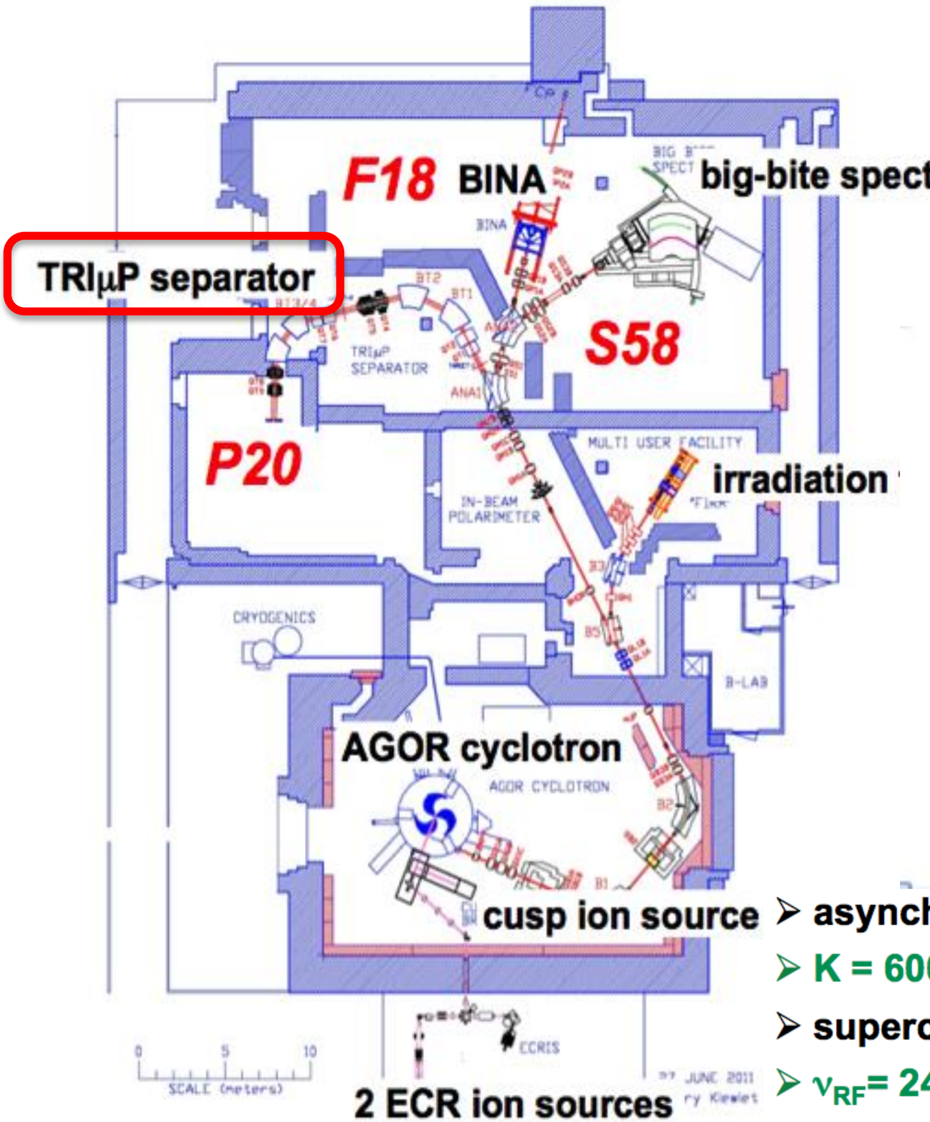
4.6 M€ project, where the Recoil separatar was 1.7 M€.

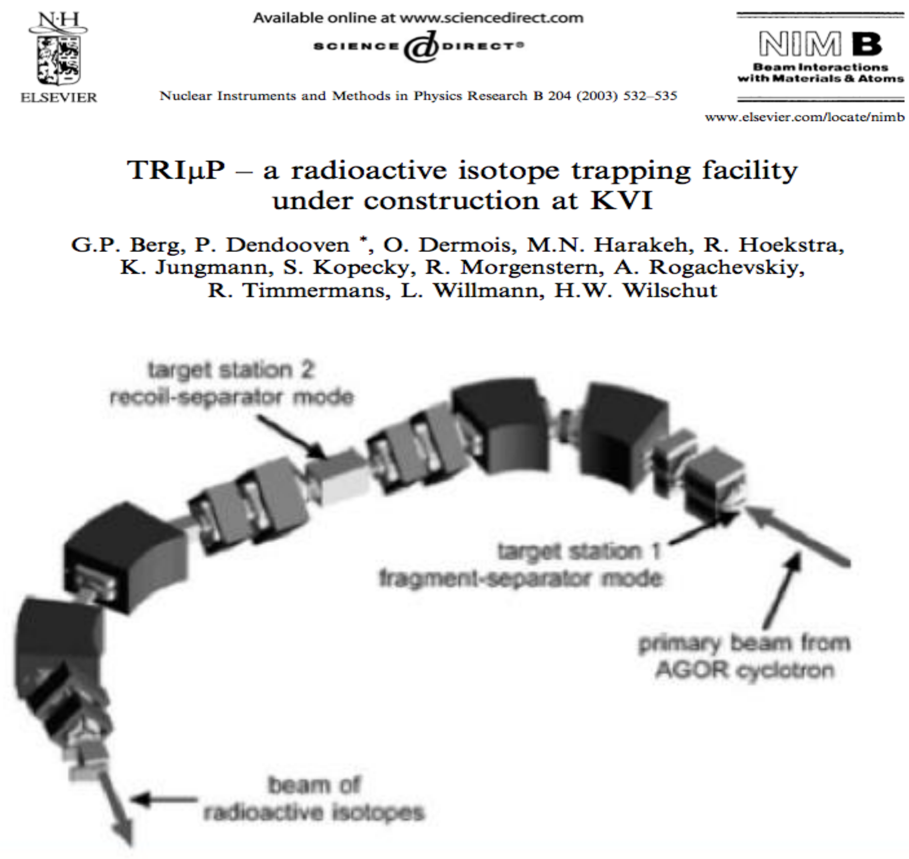
item	cost (kEUR)	year
Recoil Separator	**1715**	**2003**
Initialization[1]	25	2000
Dipole	250	2001
Q-doublet	400	|
Power supplies	120	|
Vacuum box	100	|
Pumps, diagnostics	100	2002
Installation	720	
RFQ cooler	**725**	**2004**
Initialization	25	2000
Vacuum box, internal and external mechanics	150	2002
RF generator, associated electronics	100	|
Circulation pumps, controls and diagnostics	150	2003
Installation	300	
MOT	**900**	**2003**
Initialization[2]	25	1999
Multipurpose laser system	200	2001
Vacuum chambers and equipement	100	|
Optics including modulators	100	|
Power supplies, electronics and diagnostics	100	2002
Installation	375	

Penning trap	**725**	**2005**
Initialization	25	2002
Superconducting solenoid	130	2003
Cryocooler for solenoid	100	|
Trap structure, gas purification, diagnostics	25	|
Vacuum parts including pumps	90	|
Electronics and control	55	2004
Installation	300	
Liquid hydrogen target	**140**	**2004**
Helium compressor	25	2003
Cold head	25	|
Controls	30	2003
Installation	60	
Infrastructure KVI	**400**	**2004**
Modification B-lab	50	2001
High-energy beam-line total	100	2002
Low-energy beam-lines total	100	2003
Installation	150	
Grand total	4605	2003[3]

TRIμP@KVI

The radioactive nuclei are produced using beams from the superconducting cyclotron AGOR.
The high energy radioactive beam is transformed to a low-energy.
High quality bunched beam by the combined fragment and recoil-separator.





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Nuclear Instruments and Methods in Physics Research B 204 (2003) 532–535
NIM B Beam Interactions with Materials & Atoms
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TRIμP – a radioactive isotope trapping facility under construction at KVI

G.P. Berg, P. Dendooven *, O. Dermois, M.N. Harakeh, R. Hoekstra, K. Jungmann, S. Kopecky, R. Morgenstern, A. Rogachevskiy, R. Timmermans, L. Willmann, H.W. Wilschut

- asynchronous cyclotron
- K = 600 MeV/u
- superconducting B = 1.7 – 4.1 T
- ν_{RF}= 24 - 62 MHz

TRIμP test beam report 2006

Available online at www.sciencedirect.com

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Nuclear Instruments and Methods in Physics Research A 560 (2006) 169–181

NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH Section A

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Dual magnetic separator for TRIμP

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Abstract

The TRIμP facility, under construction at KVI, requires the production and separation of short-lived and rare isotopes. Direct reactions, fragmentation and fusion–evaporation reactions in normal and inverse kinematics are foreseen to produce nuclides of interest with a variety of heavy-ion beams from the superconducting cyclotron AGOR. For this purpose, we have designed, constructed and commissioned a versatile magnetic separator that allows efficient injection into an ion catcher, i.e., gas-filled stopper/cooler or thermal ionizer, from which a low energy radioactive beam will be extracted.

The separator performance was tested with the production and clean separation of ^{21}Na ions, where a beam purity of 99.5% could be achieved. For fusion–evaporation products, some of the features of its operation as a gas-filled recoil separator were tested.

PACS: 07.55.−w; 07.55.+h; 29.30.−h; 41.85.−p; 1.75.−i; 25.70.Mn; 25.70.−z

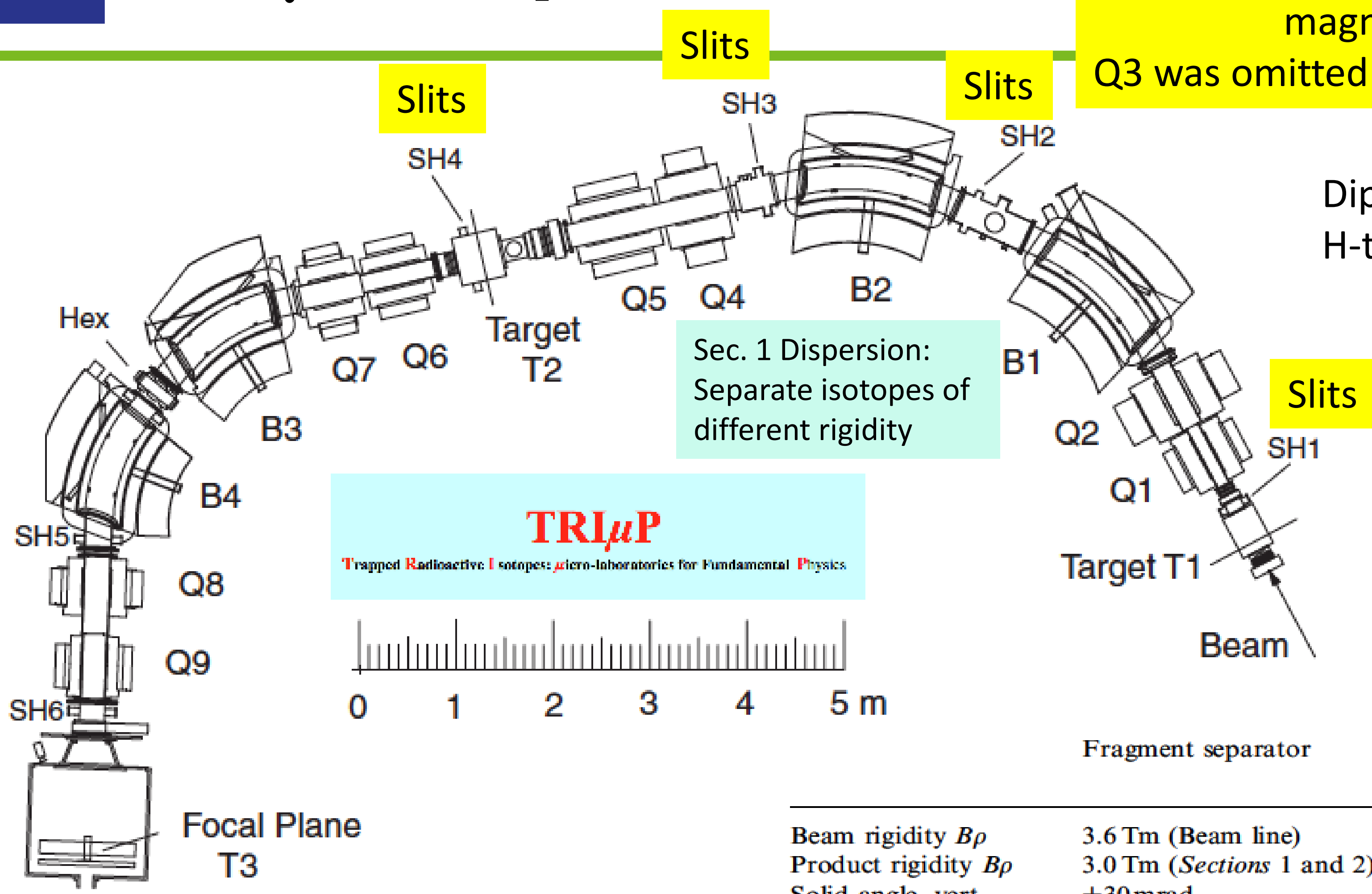
Keywords: Magnetic separator; Gas-filled separator; Secondary radioactive isotopes

ISOLDE

TRIμP separator

B1-B4 4 dipole- &
Q1-Q9 8 quadrupole-magnets
Q3 was omitted in final design

Dipole magnets
H-type DANFYSIK



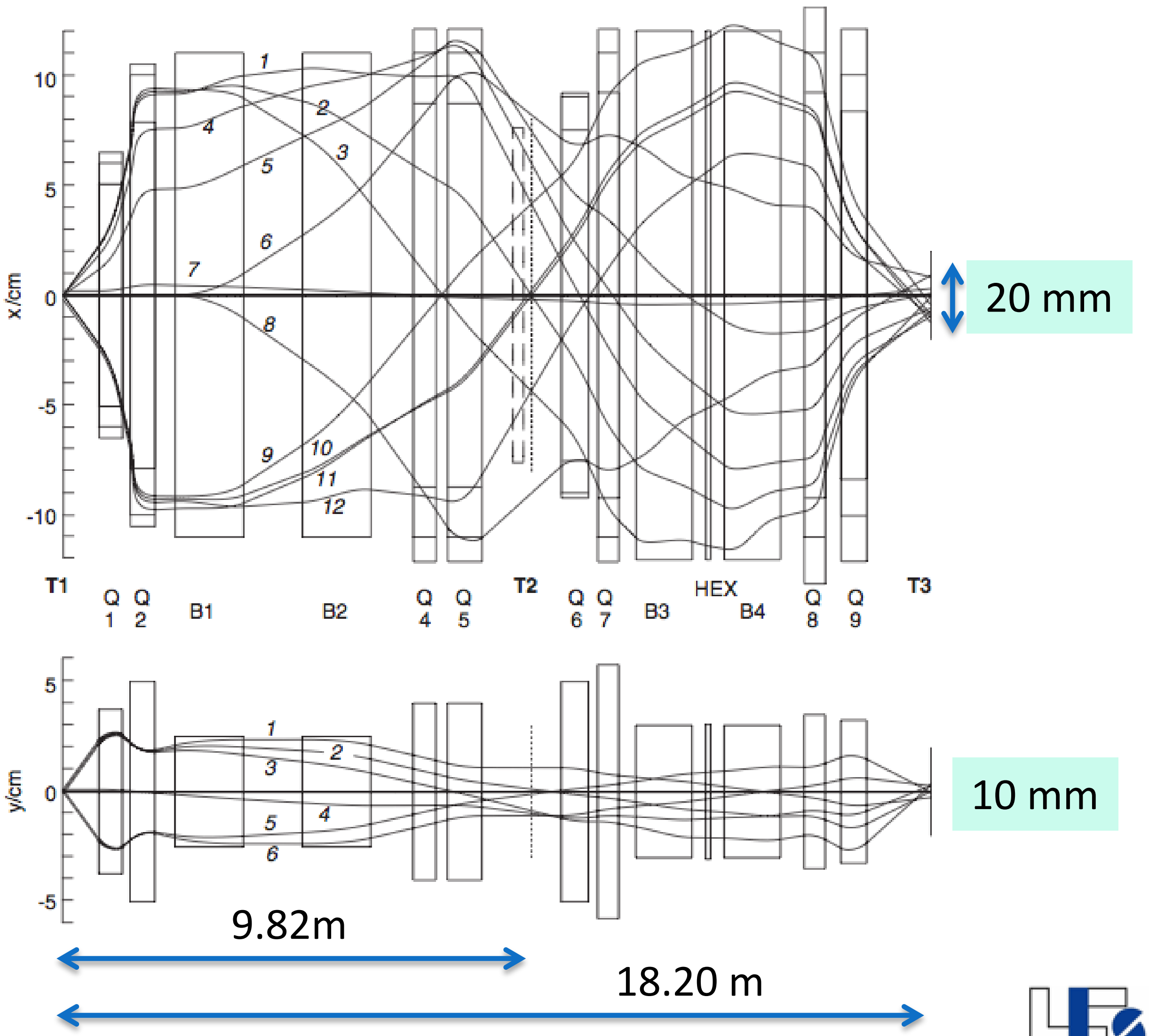
Sec. 1 Dispersion:
Separate isotopes of different rigidity

Sec. 2 reversed:
→ Achromatic image

	Fragment separator	Gas-filled separator
Beam rigidity $B\rho$	3.6 Tm (Beam line)	3.6 Tm (*Section* 1)
Product rigidity $B\rho$	3.0 Tm (*Sections* 1 and 2)	3.0 Tm (*Section* 2)
Solid angle, vert., horiz.	±30 mrad	±30 mrad
Momentum acceptance	±2.0%	±2.5%
Resolving power p/dp	≈ 1000	≈ 2000 (no gas filling)
Momentum dispersion	3.9 cm/%	8.0 cm/%
Bending radius	220 cm	180 cm

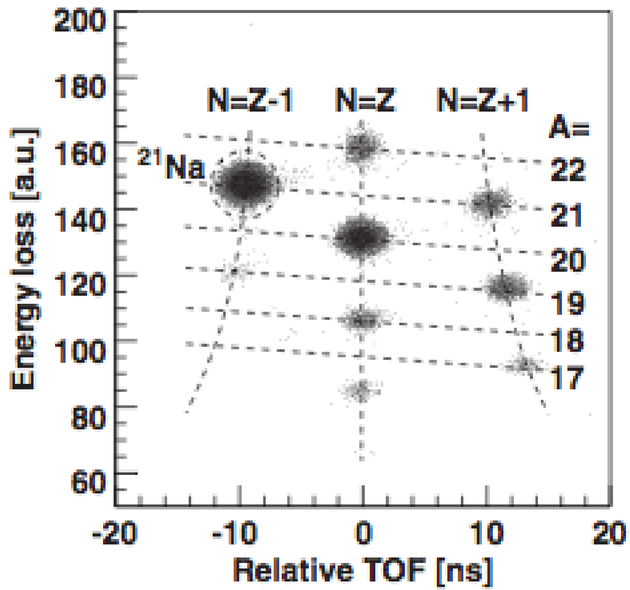
Fragmentation mode

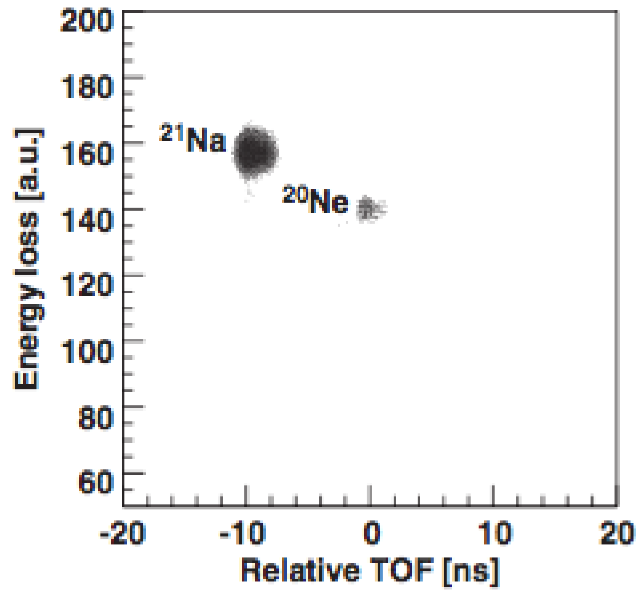
Target spot size
+/-2 mm horizontal
+/- 1 mm vertical



$^{21}Ne^{7+}$ @ 43 MeV/u on 20 mg/cm^2 polyethylen target
The emerging primary beam now $^{21}Ne^{10+}$ is stopped in slits SH2

$^{21}Ne(p,n)^{21}Na$





The time of flight vs. energy loss in a 100 mm silicon detector shows various nuclides at the intermediate plane (T2).

At the final focal plane (T3) there is only ^{21}Na and a small contamination of stable ^{20}Ne which could be reduced to below 0.5 %

TRIμP is new equipment still in use & with an existing collaboration.

P20 ENSAR supported experiment in 2013.

^{15}N from AGOR on Deuterated gas target @ T1 → the produced ^{16}N was separated and transported and slowed down to be implanted in a micro strip detector to measure. $^{16}N \rightarrow \beta + {}^{16}O + \alpha$ measure the summed deposit energy

ENSAR-supported experiments

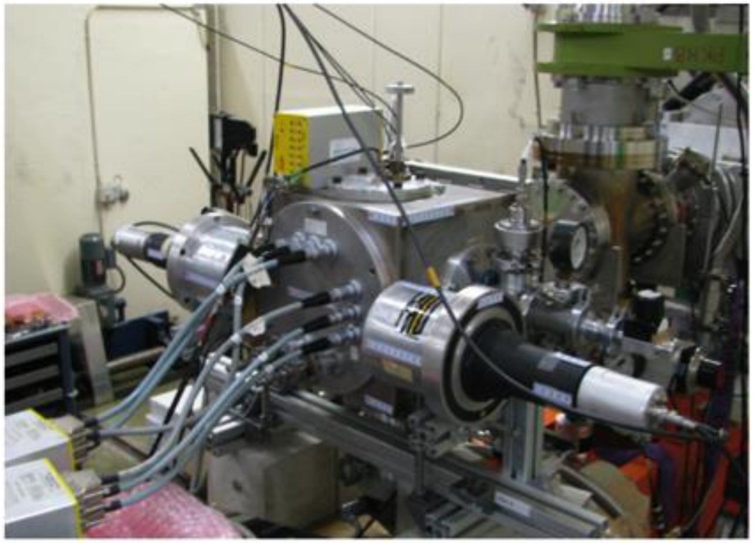
university of groningen

KVI

P20 R. Raabe & H. Fynbo

β-delayed α-decay study of ^{16}N using the implantation method

to extract information relevant for the determination of the reaction rate of the very important $^{12}C(\alpha,\gamma)^{16}O$ reaction, a key reaction in helium burning



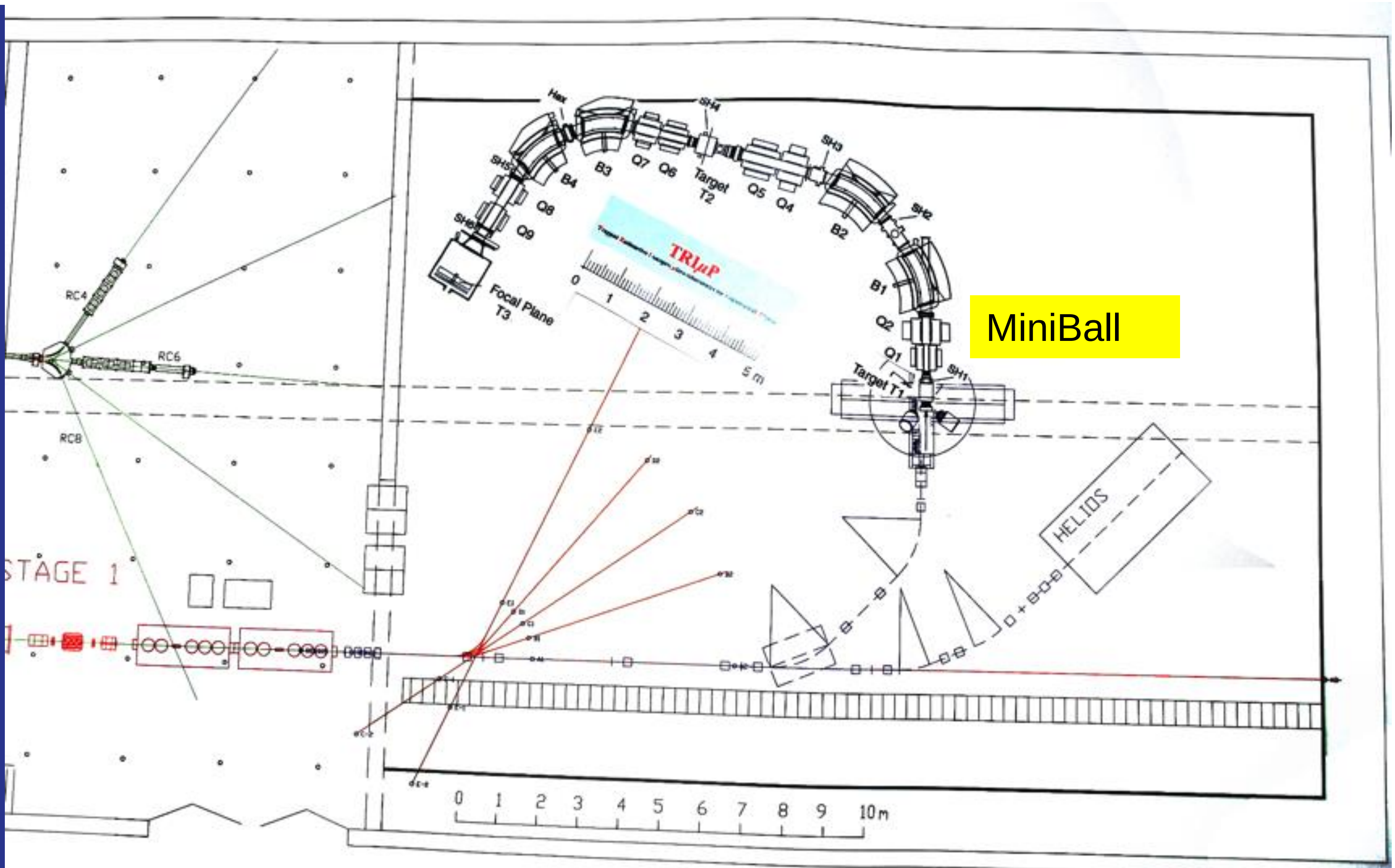
H. Fynbo, priv. comm.

$^{15}N(d,p)^{16}N$

^{16}N separated & implanted in a DSSSD. For beta decay study

ISOLDE

TRIμP with MiniBall



What would an ideal zero-degree device achieve?

- **identification of reaction products**

- **physical separation of reaction products ←→ beam**
- **physical separation of reaction products ←→ fusion-evaporation**

- **physical separation of isobaric beams or other beam contaminants**

- **large enough angular acceptance to pick up sequential decay products**

- **excellent angular resolution to allow kinematic reconstruction – *missing-p***