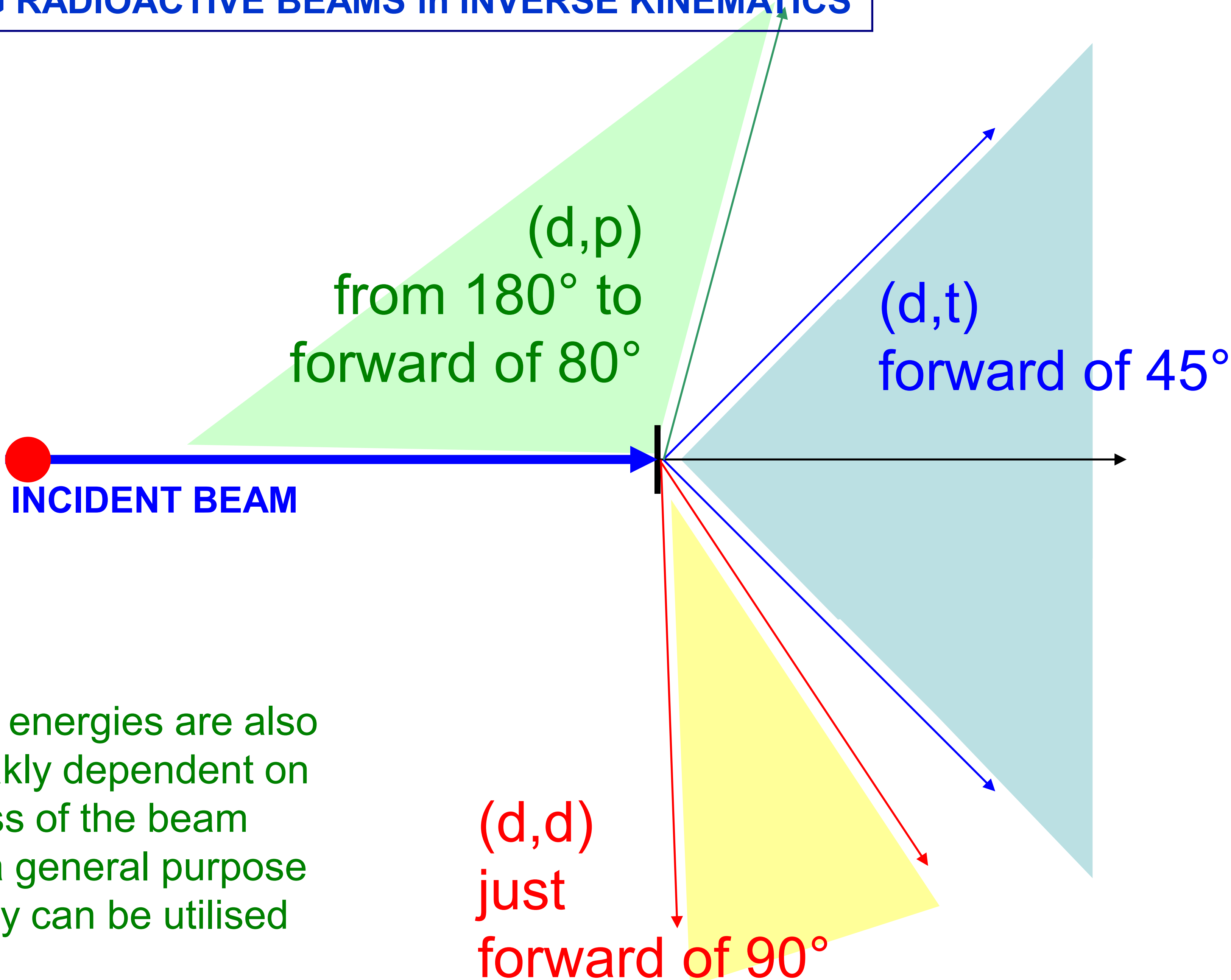
REQUIREMENTS for Zero-Degree Ion Selection in TRANSFER

Wilton Catford

University of Surrey, UK

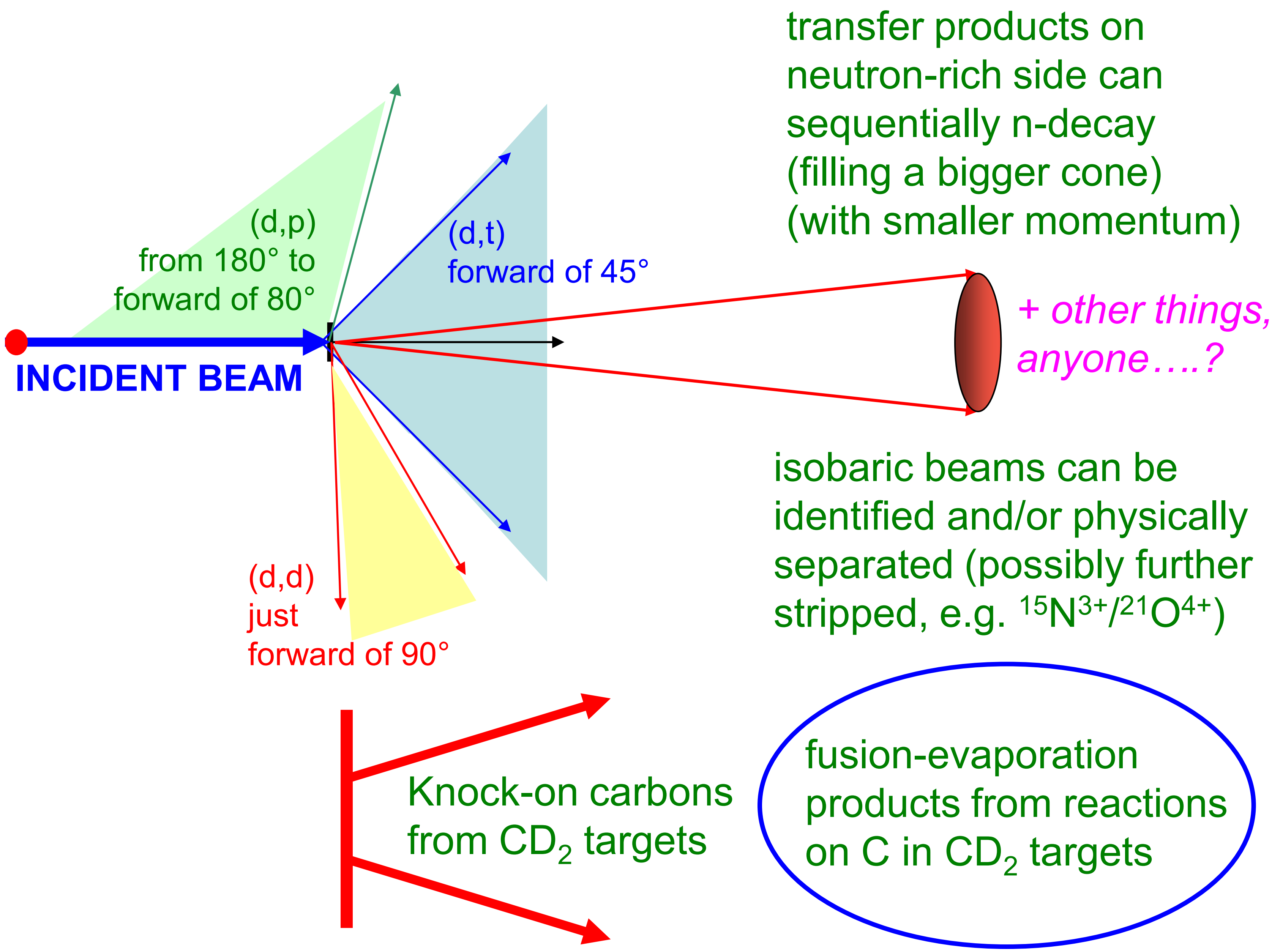
[redacted] & SHARC collabs

USING RADIOACTIVE BEAMS in INVERSE KINEMATICS



The energies are also weakly dependent on mass of the beam so a general purpose array can be utilised

USING RADIOACTIVE BEAMS in INVERSE KINEMATICS



What would an ideal zero-degree device achieve?

- identification of reaction products
- physical separation of reaction products of interest, from the beam
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- 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*

- to avoid compromising the placement of gamma-ray detectors
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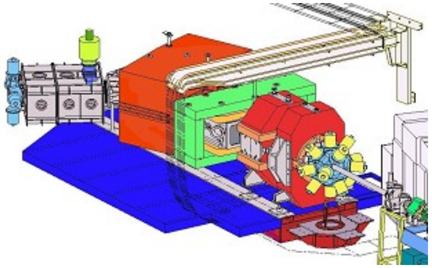
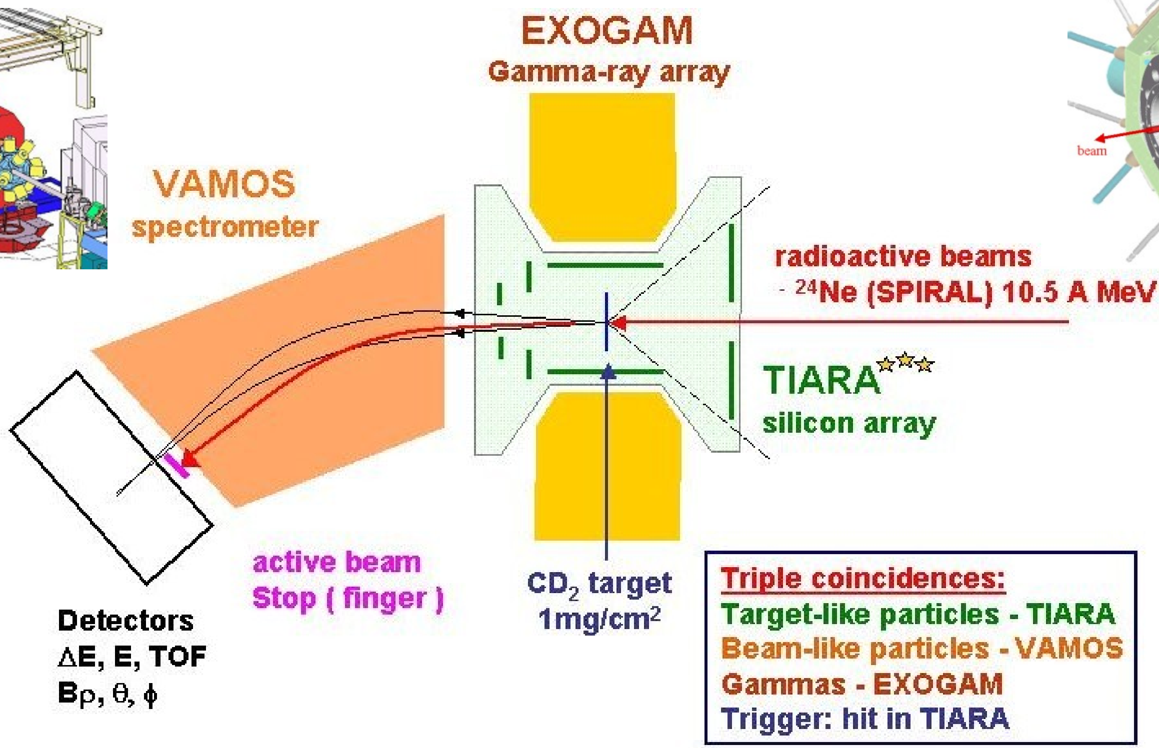
What are we prepared to lose? What is the compromise?

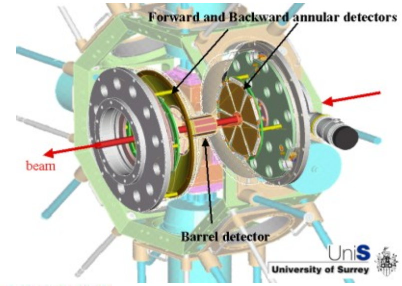
- accept limited mass identification of reaction products?
- forego physical separation?
- tolerate limited angular acceptance? angular resolution?
- relax the requirement of portability?

OUR EXPERIMENT TO STUDY $^{25}Ne\ d_{3/2}$

$^{24}Ne(d,p\gamma)$ N=16 replaces broken N=20

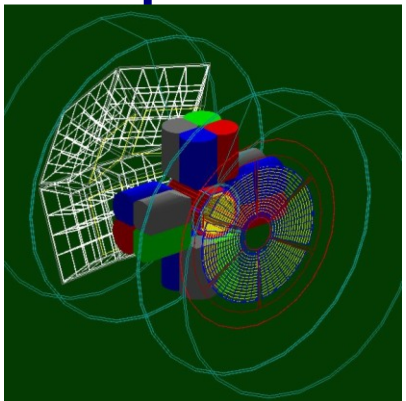


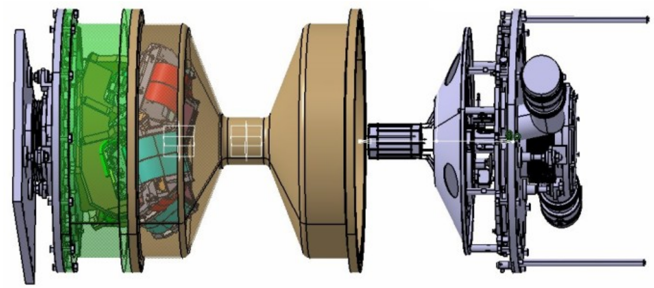




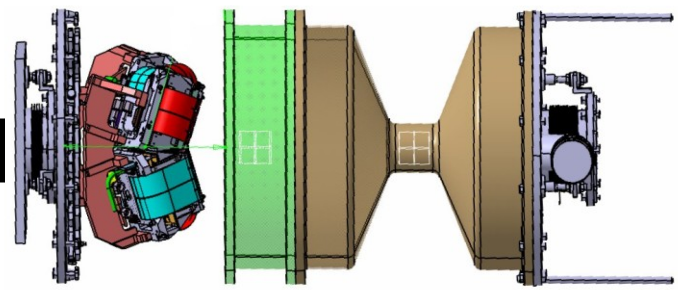
Schematic of the TIARA setup. A beam of 10^5 pps of ^{24}Ne at 10.5A MeV was provided from SPIRAL, limited to 8π mm.mrad to give a beam spot size of 1.5-2.0 mm. The target was 1.0 mg/cm^2 of $(CD_2)_n$ plastic. The TIARA array covered 90% of 4π with active silicon.

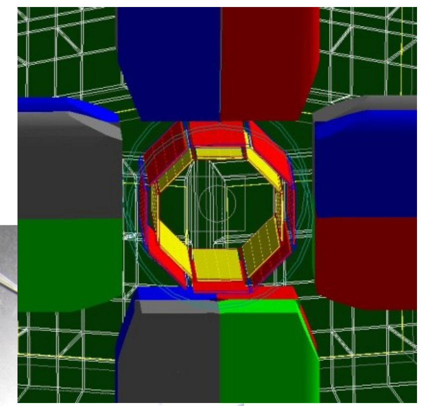
W.N. Catford *et al.*, Eur. Phys. J. **A25**, Suppl. 1, 245 (2005).



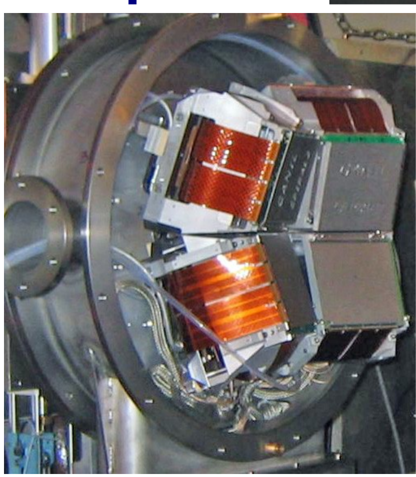


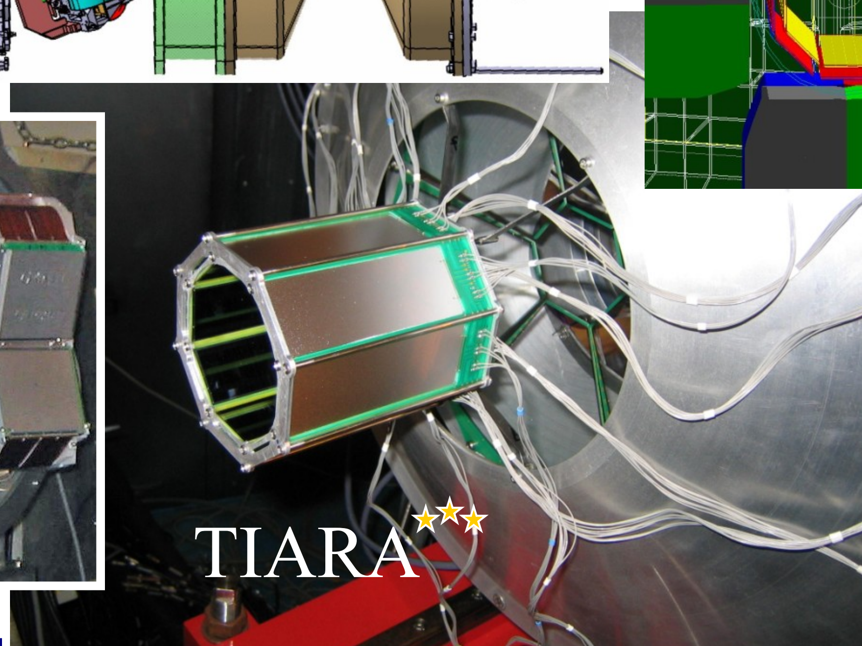
Recent experiments at SPIRAL merge the TIARA array with the French MUST2 telescopes at at the forward angles. The TIARA barrel has a second layer of Si added, to help with punchthrough.



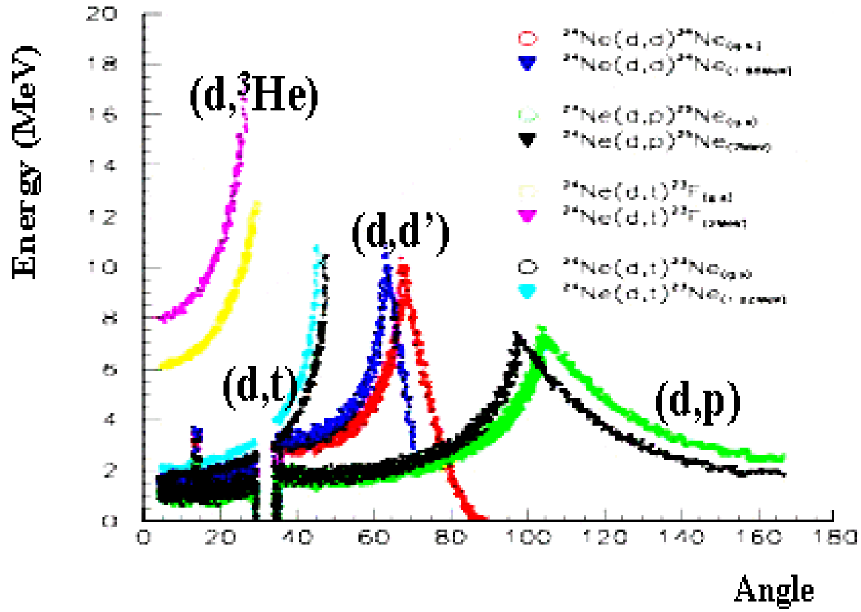


MUST2

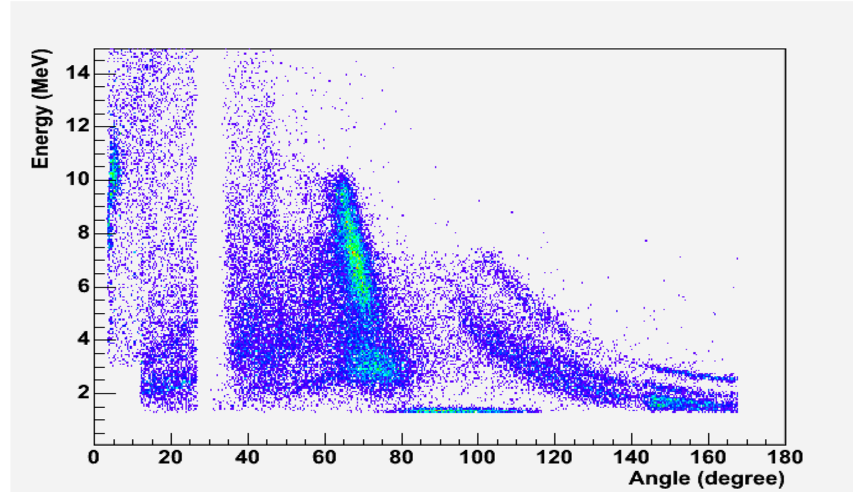




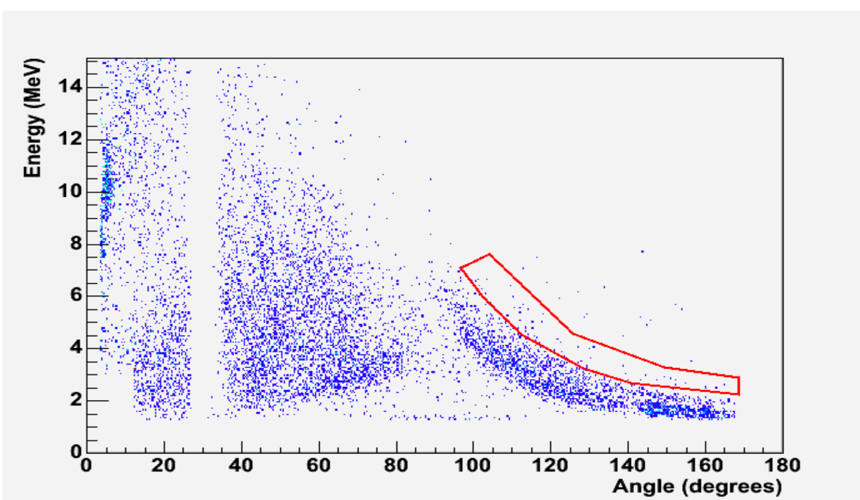
Geant4 Simulation



~ 10 A.MeV



Requiring Vamos FP Plastic



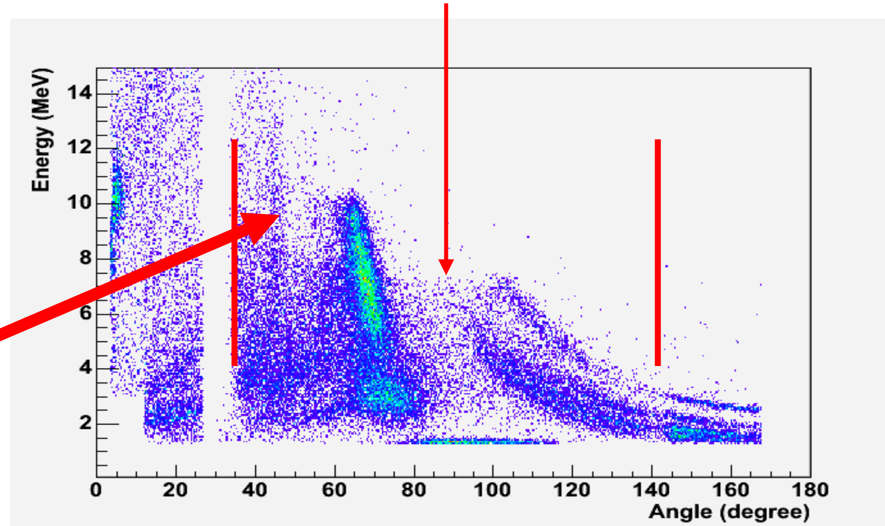
Vamos+Exogam

GATE ON
GAMMA COINCIDENCE
REMOVES
GROUND STATE

^{24}Ne (d,p) ^{25}Ne

(90 degrees)

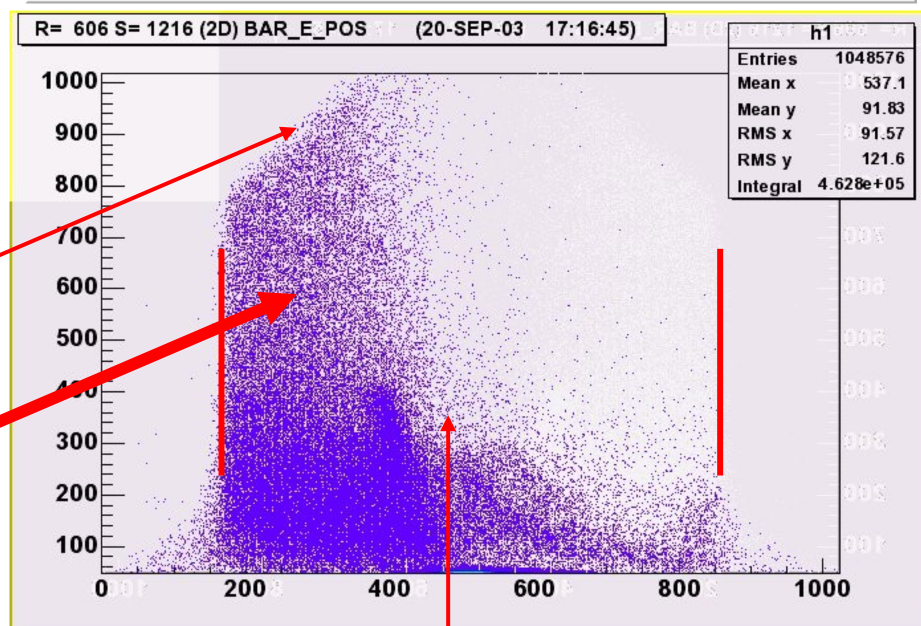
~ 10 A.MeV



Requiring Vamos (Focal Plane Plastic)

(d,t) tritons

BEAM



Without Vamos Requirement

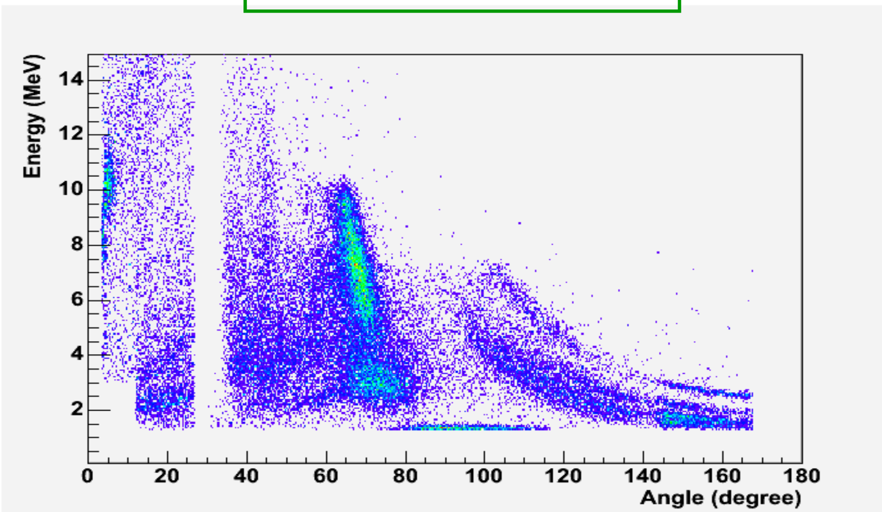
(saturation)

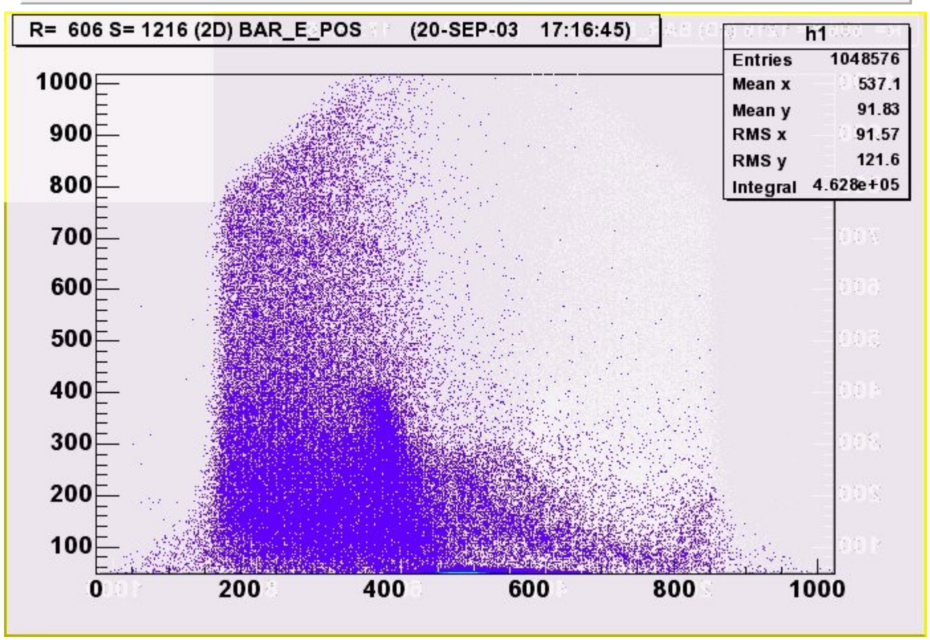
Knock-on carbon elastics

(90 degrees)

$^{24}Ne\ (d,p)\ ^{25}Ne$

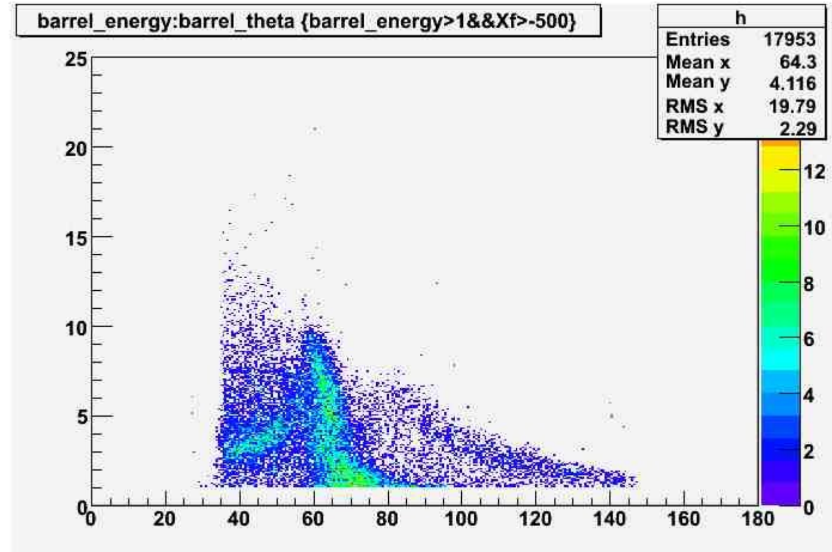
~ 10 A.MeV

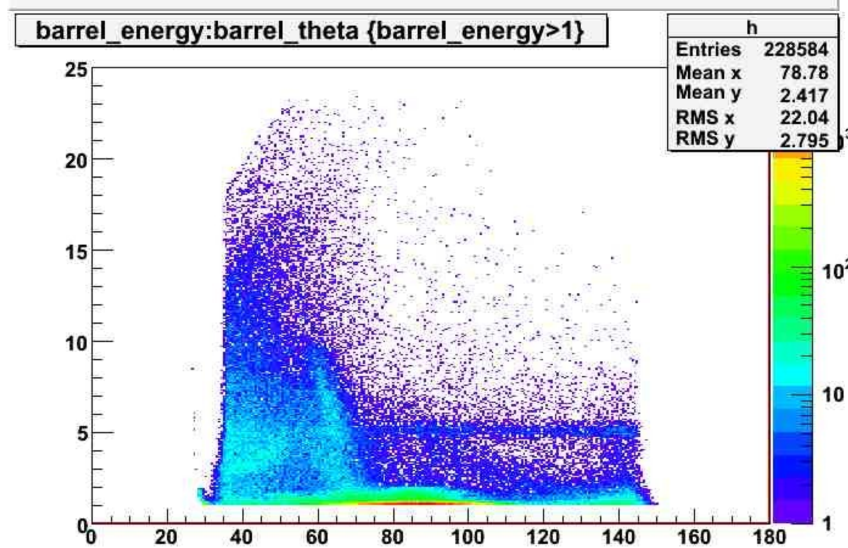




^{24}Ne (d,p) ^{25}Ne

~ 10 A.MeV



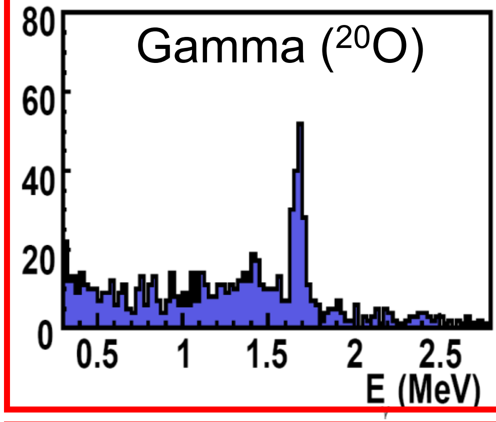


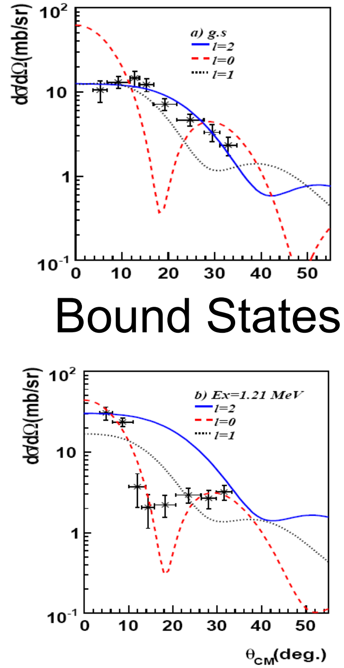
^{26}Ne (d,p) ^{27}Ne

$^{20}O(d,p)^{21}O$

10,000 pps

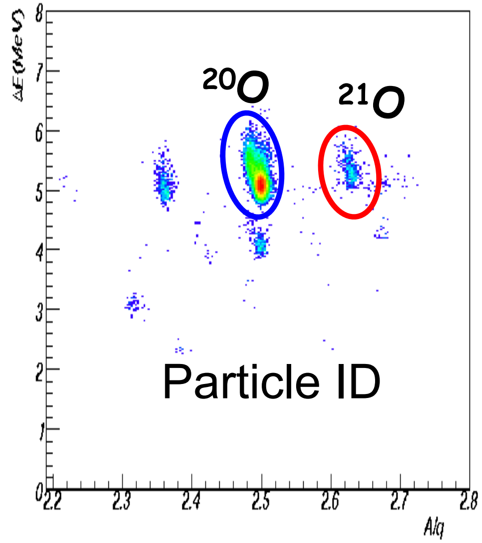
B Fernandez et al



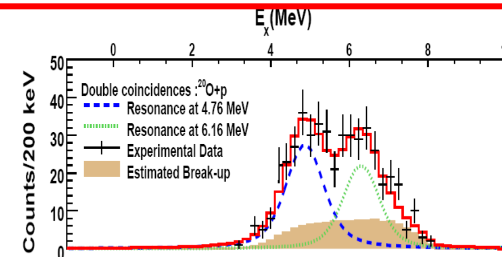


Bound States

VAMOS@ 0°



Particle ID



Unbound States

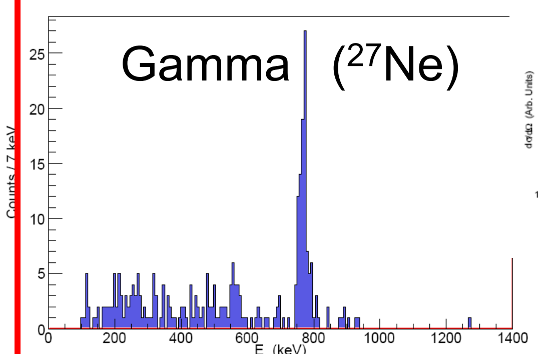
n + ^{20}O decay

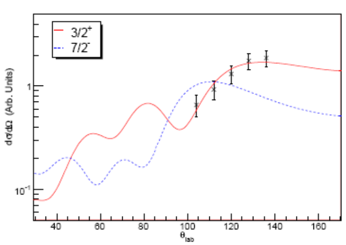
E_x(keV)	ℓ	J^π	br	$C^2S(0^+)$ ADWA/DWBA
0	2	$5/2^+$	-	0.34 ± 0.03
1213	0	$1/2^+$	-	0.77 ± 0.09
4760	2	$3/2^+$	-	0.58 ± 0.05
6160	2,3	$3/2^+, 7/2^-$	0.40	$0.20 \pm 0.04, 0.18 \pm 0.02$

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

2500 pps

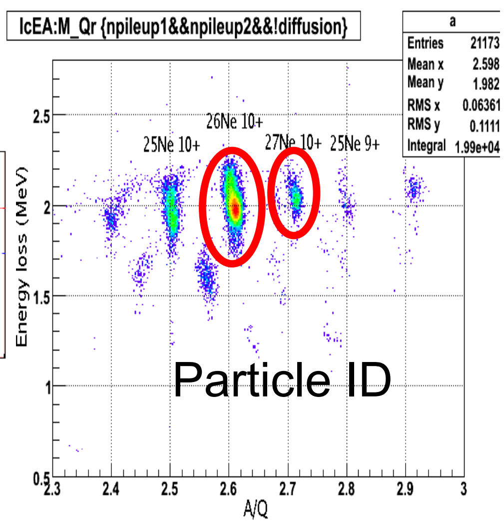
S M Brown et al

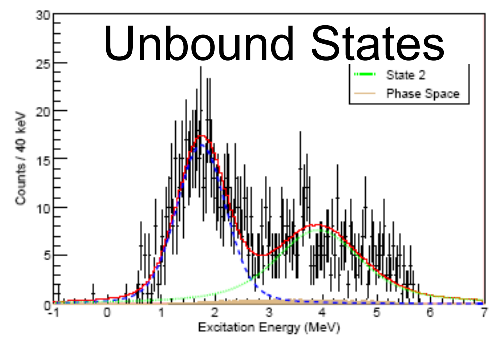




Bound State

VAMOS@ 0°

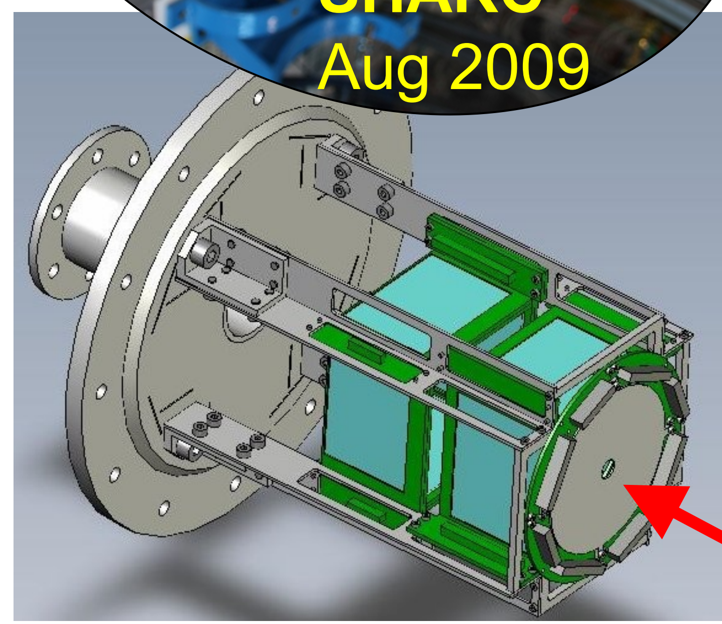




E_x(keV)	J^π	$C^2S(0^+)$
0	$3/2^+$	0.44 ± 0.22
765	$3/2^-$	0.64 ± 0.33
885	$1/2^+$	0.17 ± 0.14
1741	$7/2^-$	0.44 ± 0.22

Nucleon transfer
by (d,p) at 5 MeV/u
at ISAC2

Prototype of new type of experiment for us – where the states are so close together in this odd-odd nucleus that we will need to GATE on gamma transitions in order to separate the different final states



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At ISAC2 we have used the **isotone** of ^{24}Ne namely ^{25}Na as the projectile.

The new array is **SHARC**
(Ch. Aa. Diget et al., York UK, Surrey, LPC Caen, TRIUMF, TIGRESS, CSM, LSU, …)
… which is compact and fits inside **TIGRESS**

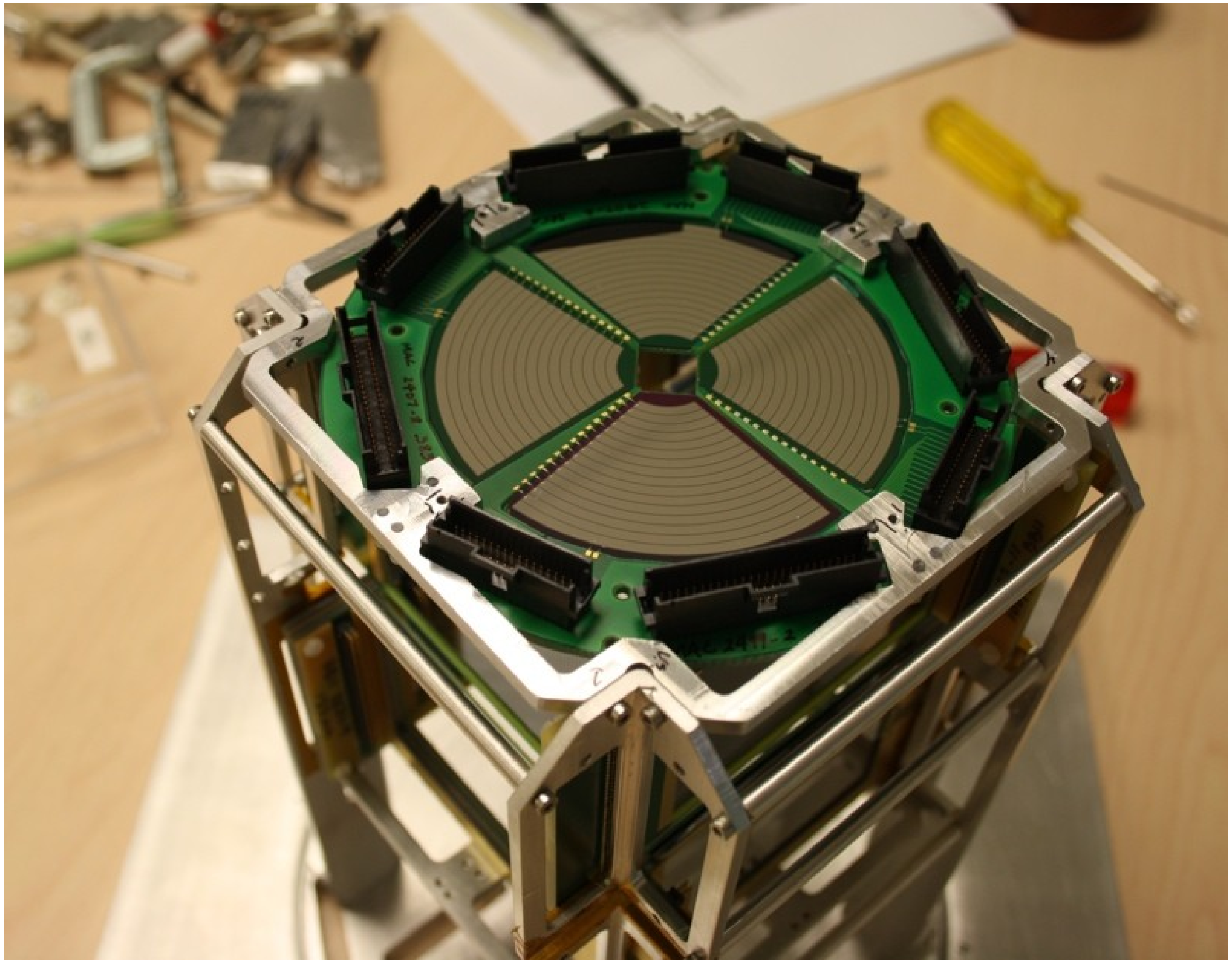
We used up to

3 x 10^{7} pps ^{25}Na

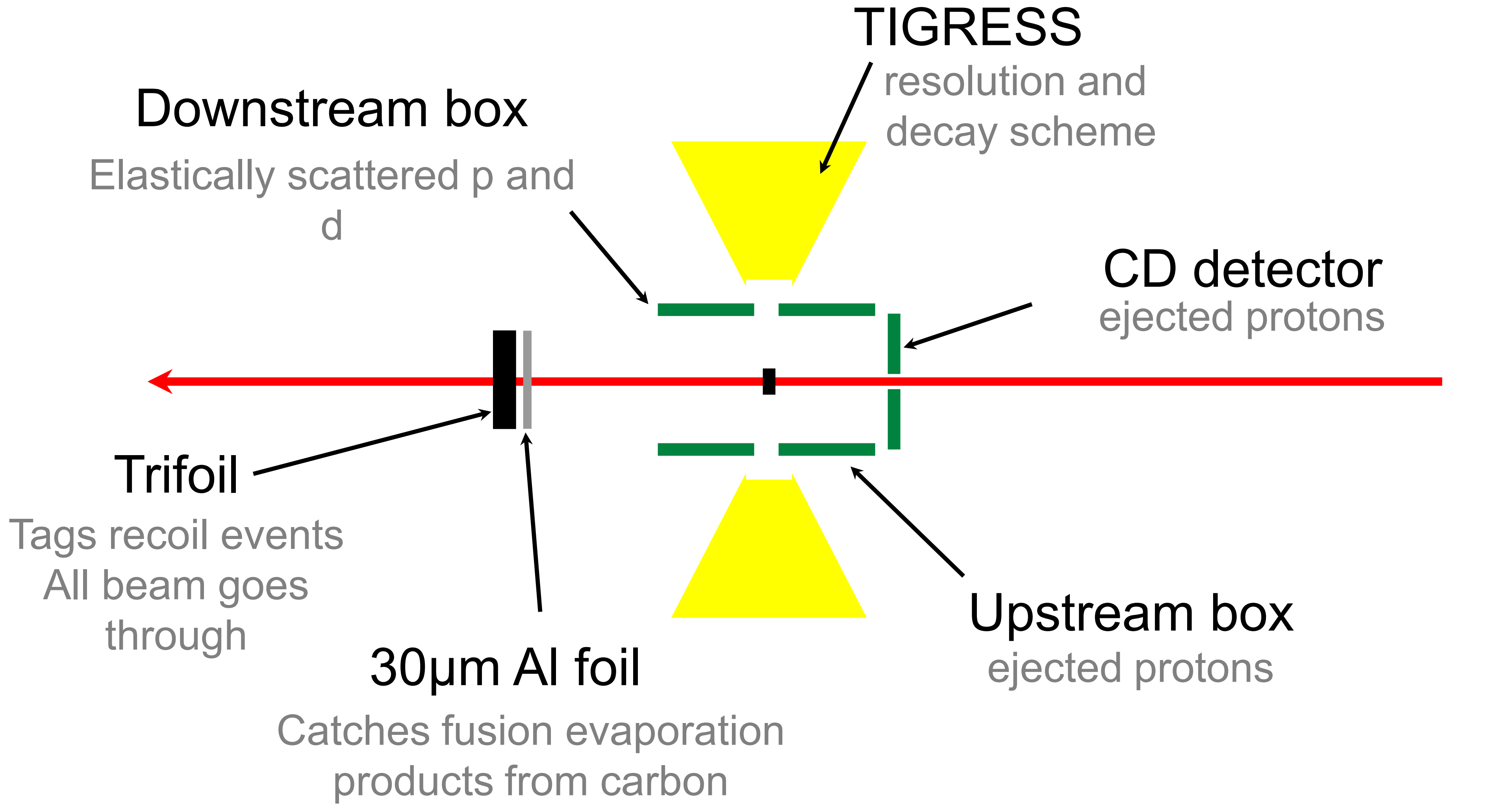
at 5.00 MeV/u.

Ch. DIGET, YORK / GEMMA WILSON & WNC, SURREY

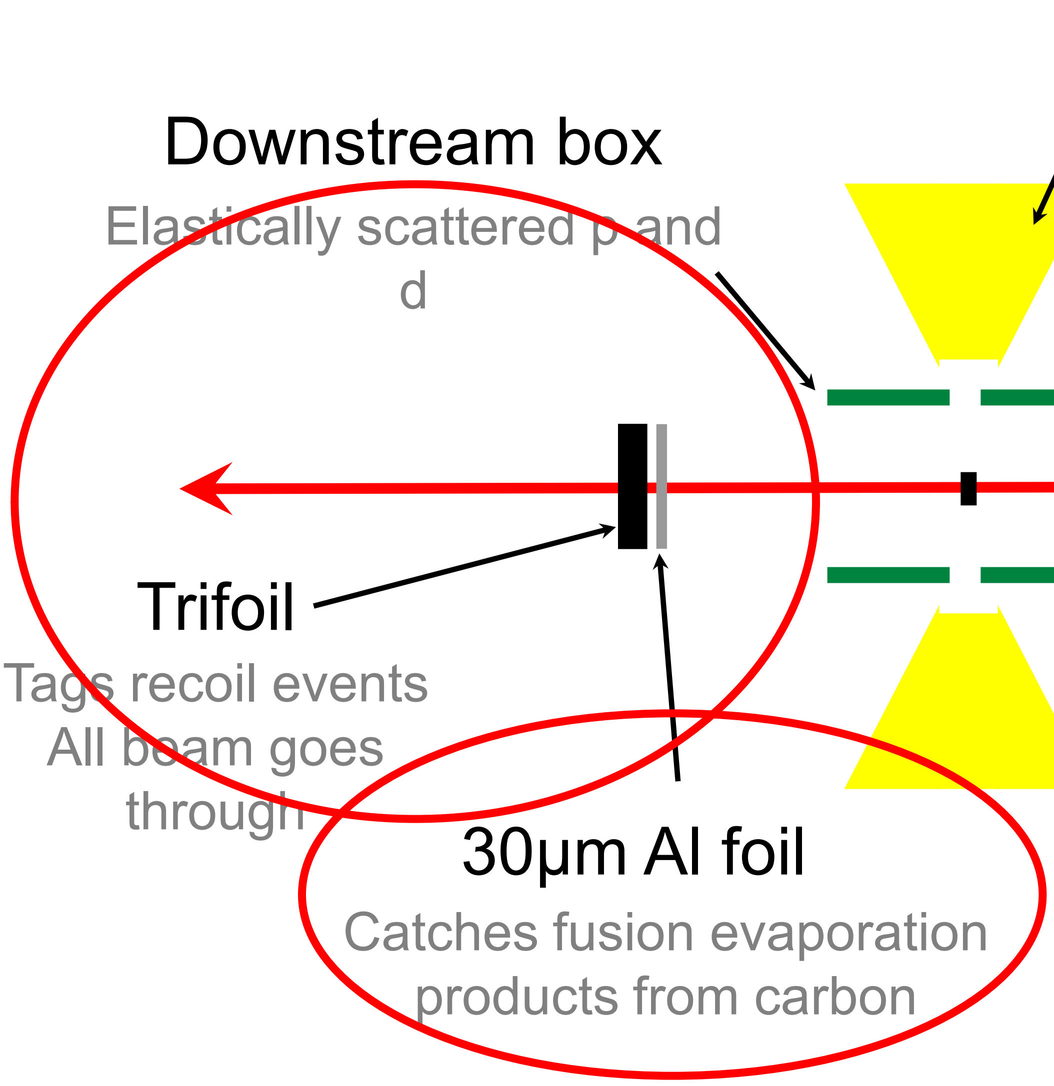
SHARC

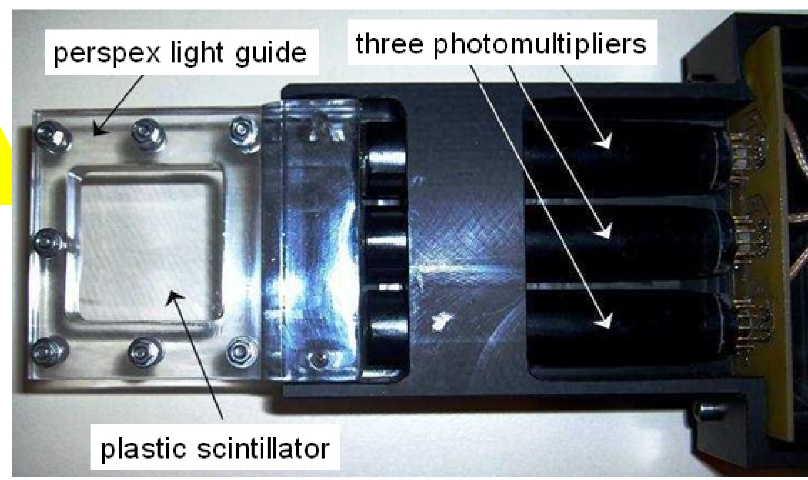


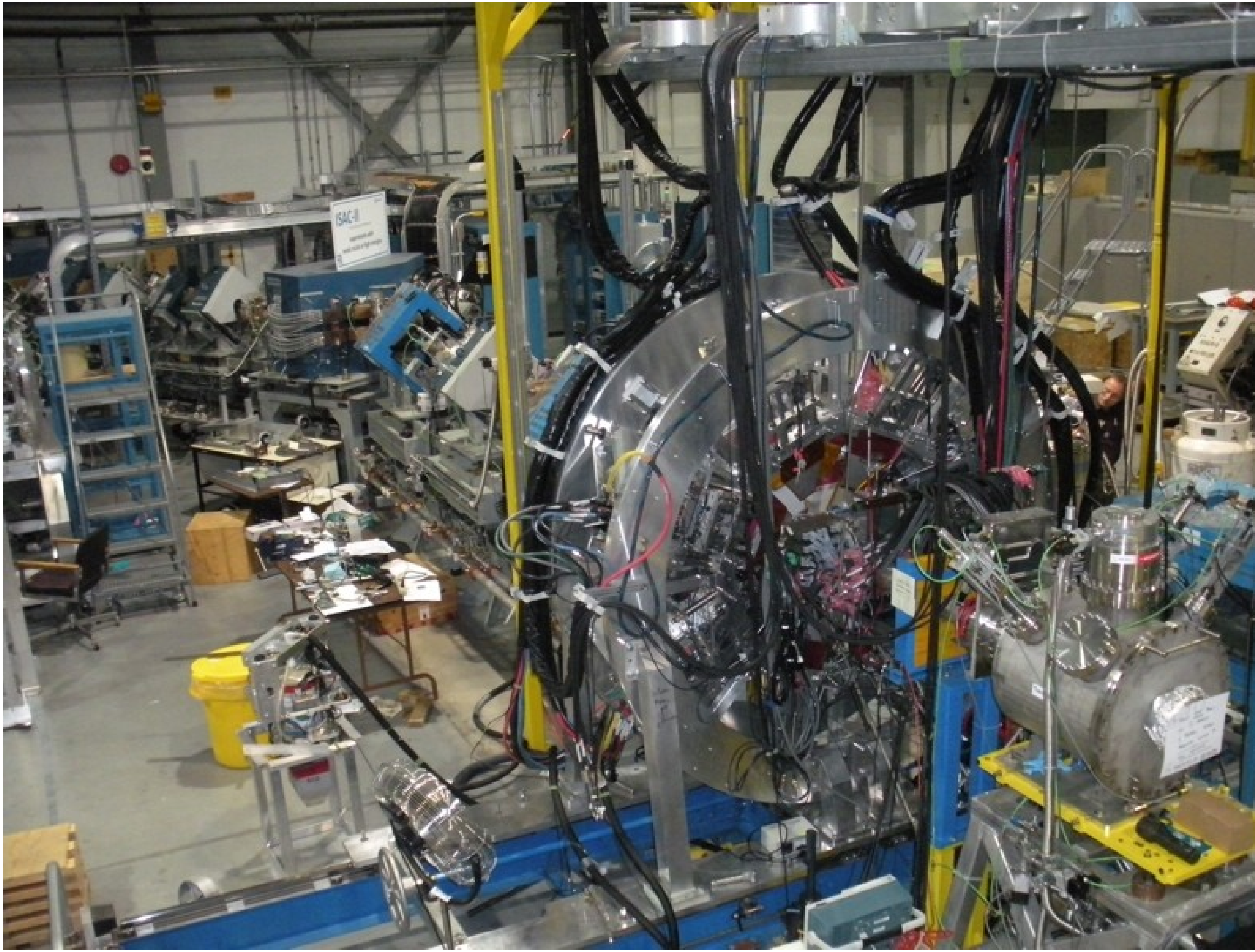
Schematic

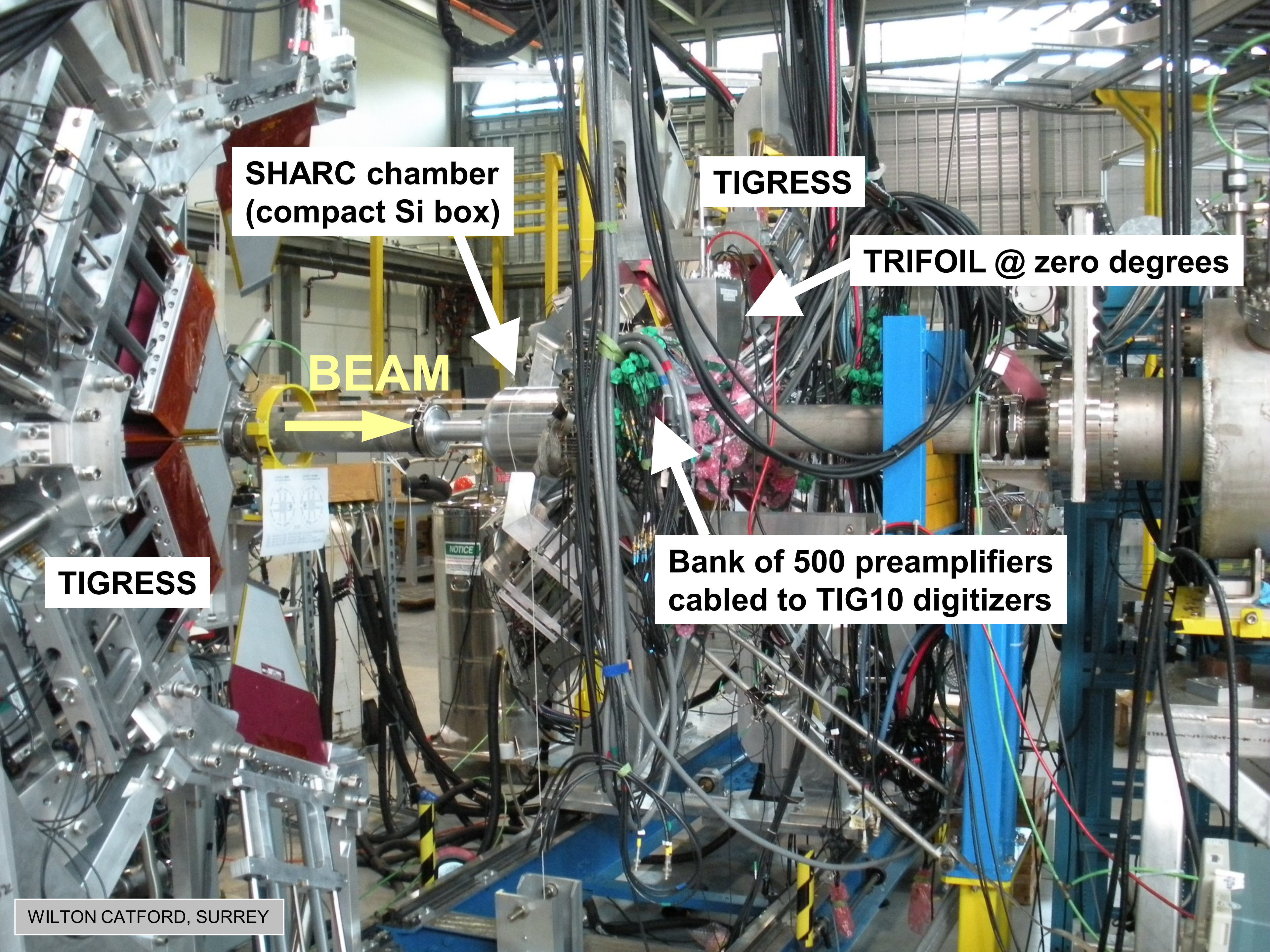

TIGRESS
resolution and
decay scheme
Downstream box
Elastically scattered p and
d
CD detector
ejected protons
Trifoil
Tags recoil events
All beam goes
through
30μm Al foil
Catches fusion evaporation
products from carbon
Upstream box
ejected protons

^{25}Na(d,p)^{26}Na at 5.00 MeV/A: proton-neutron coupling

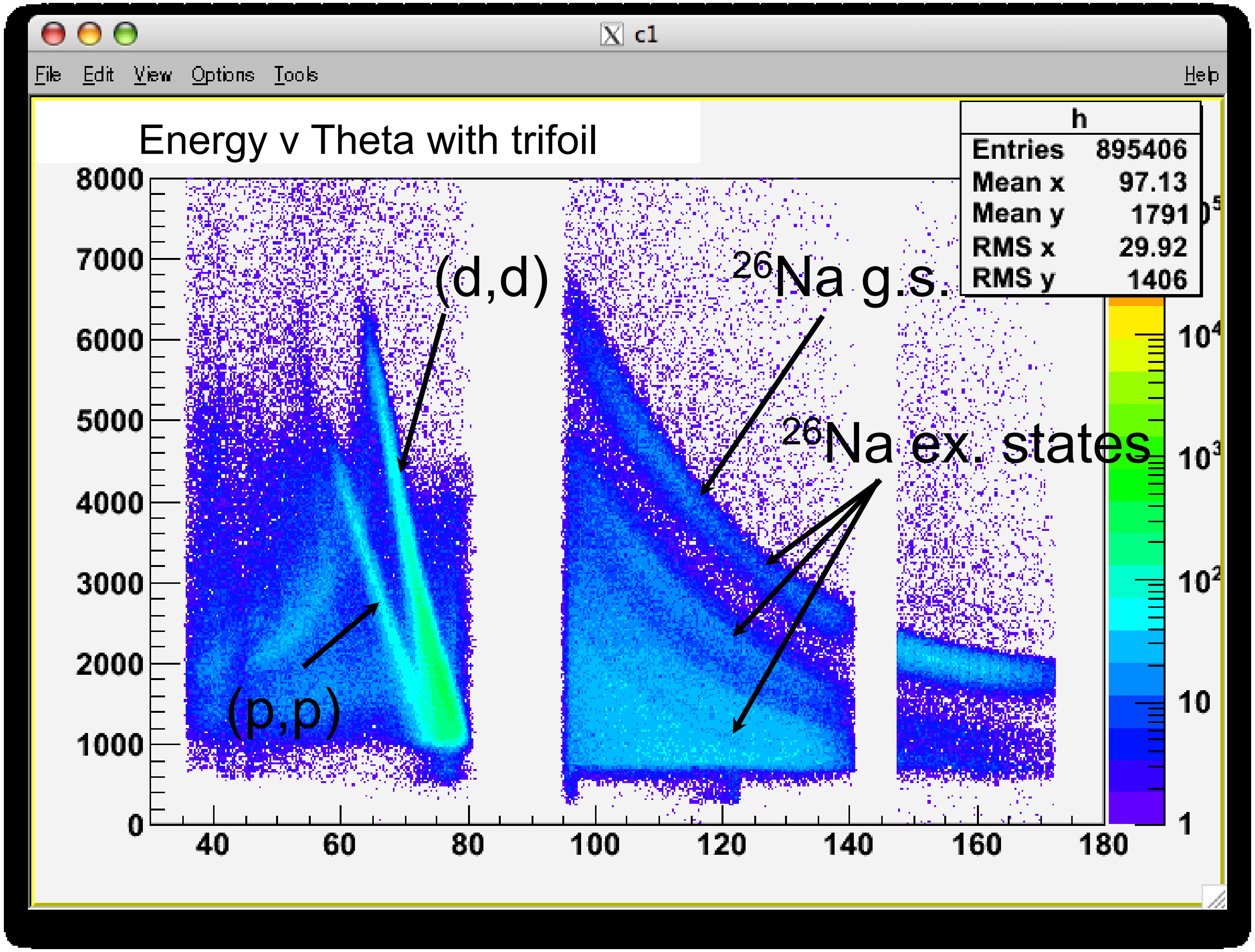




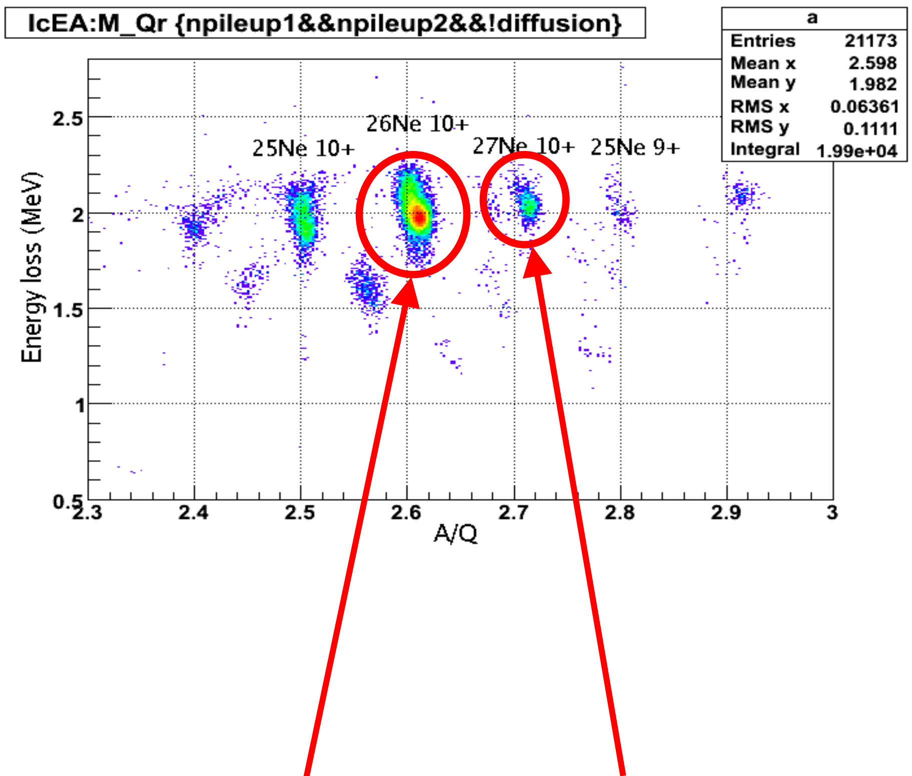

ISAC-II


SHARC chamber
(compact Si box)
TIGRESS
TRIFOIL @ zero degrees
BEAM
TIGRESS
Bank of 500 preamplifiers
cabled to TIG10 digitizers
WILTON CATFORD, SURREY

Preliminary Analysis: E vs θ



ZERO DEGREE = SPECTROMETER

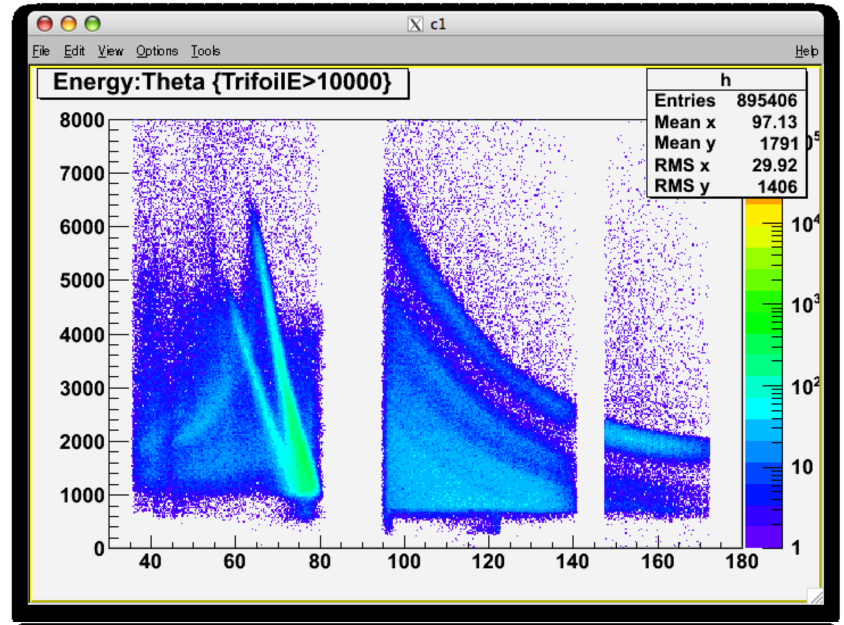


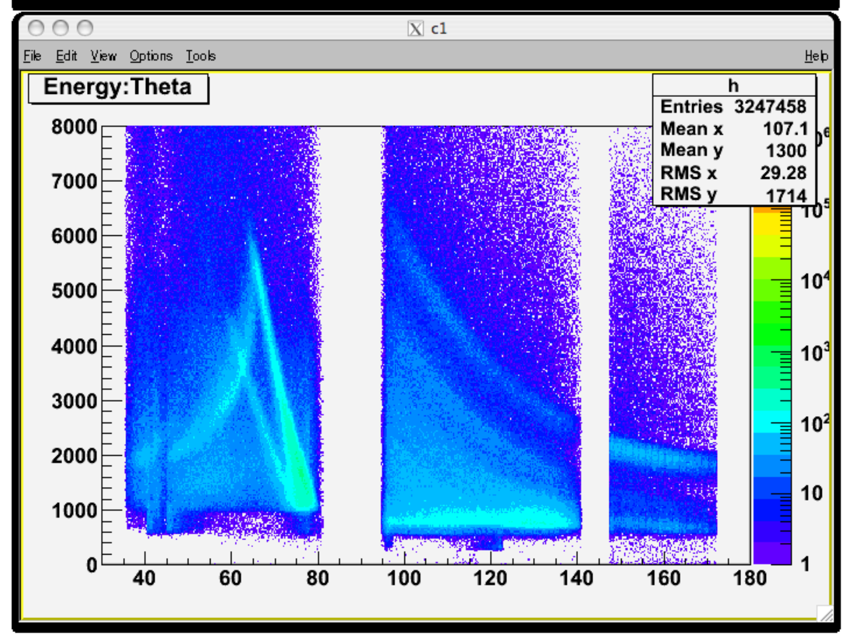
$^{26}Ne(d,p)^{27}Ne$

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

RESULTS from TIARA/MUST2 Nov2007

ZERO DEGREE = SCINTILLATOR

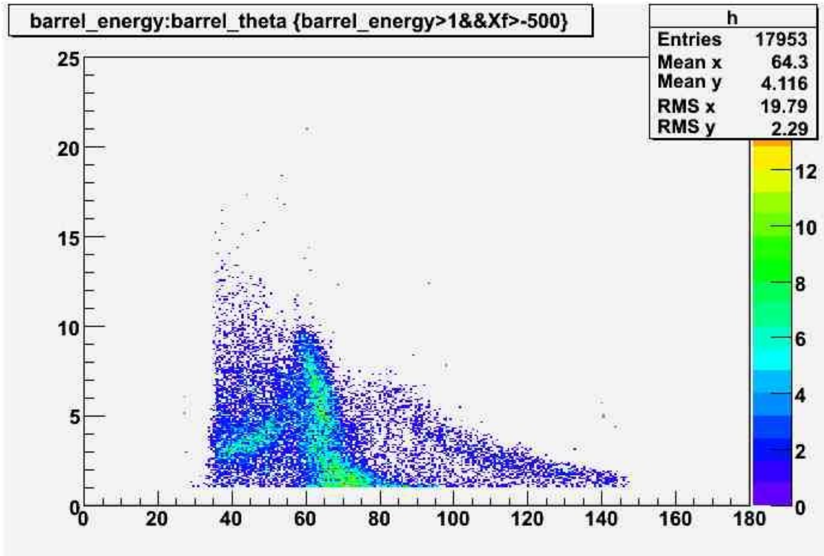


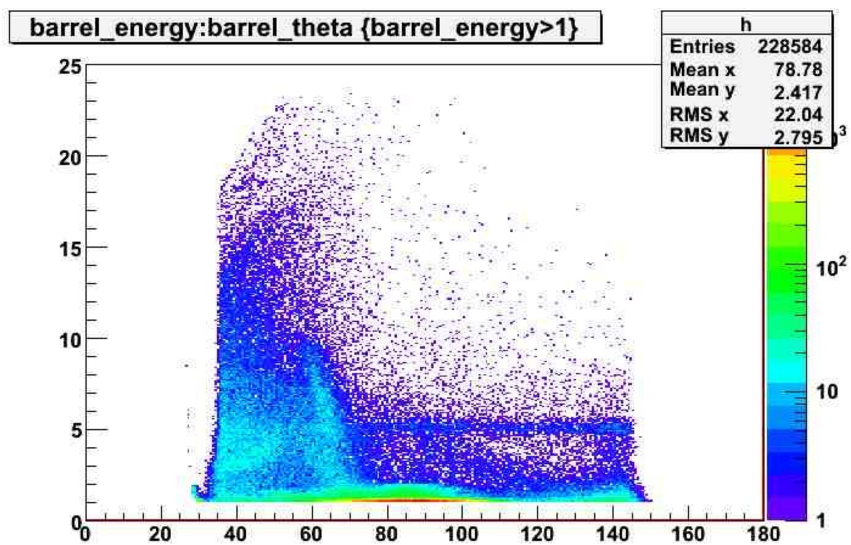


RESULTS from SHARC Aug2009

ZERO DEGREE = SPECTROMETER

$^{26}Ne(d,p)^{27}Ne$ 10 A.MeV

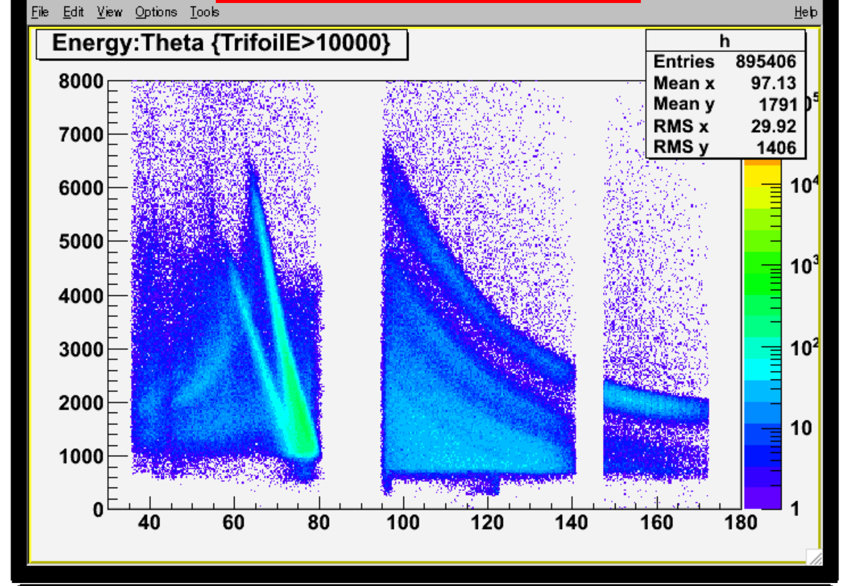


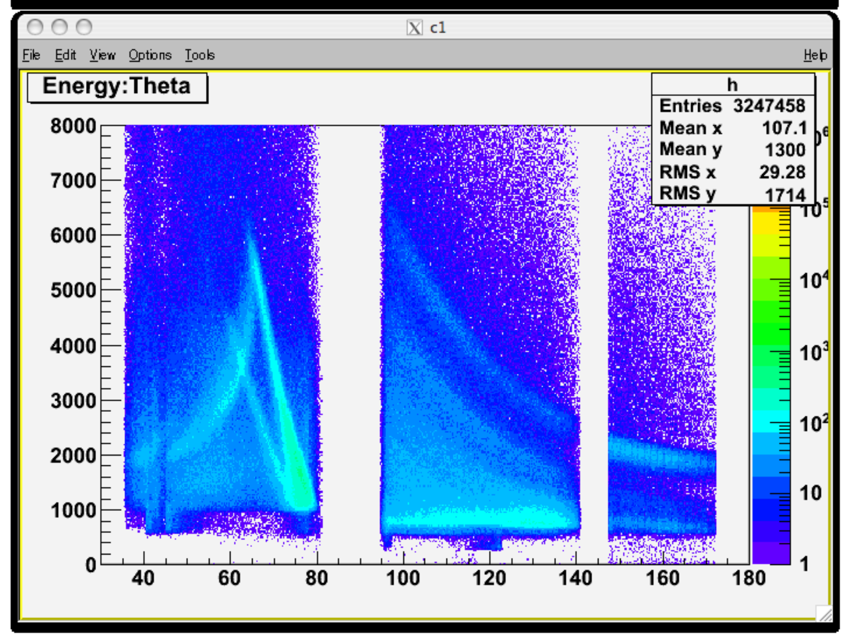


RESULTS from TIARA/MUST2 Nov2007

ZERO DEGREE = SCINTILLATOR

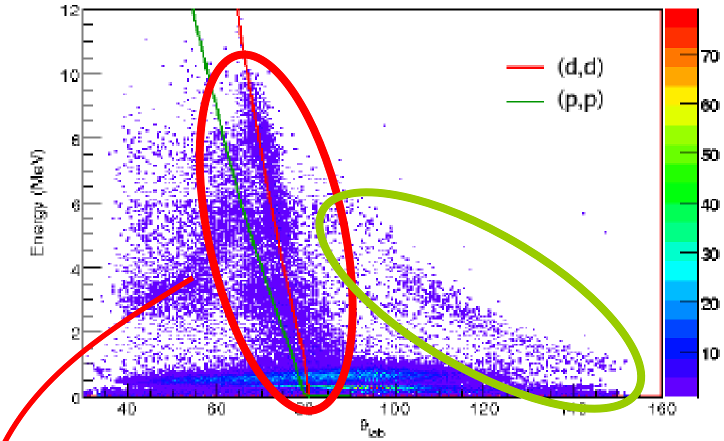
$^{25}Na(d,p)^{26}Na$ 5 A.MeV



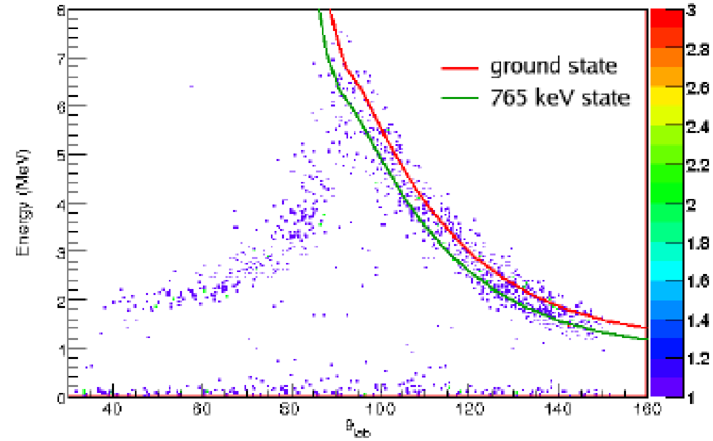


RESULTS from SHARC Aug2009

MISSING MOMENTUM using ^{26}Ne beam to study (d,p) with VAMOS



^{26}Ne ions in VAMOS



^{27}Ne ions in VAMOS

Figure 4.20: Measured kinematics in the Barrel after angle corrections. The red and green lines are kinematics calculations for reaction channels expected in the data.

(d,d)
(p,p)

(d,p)

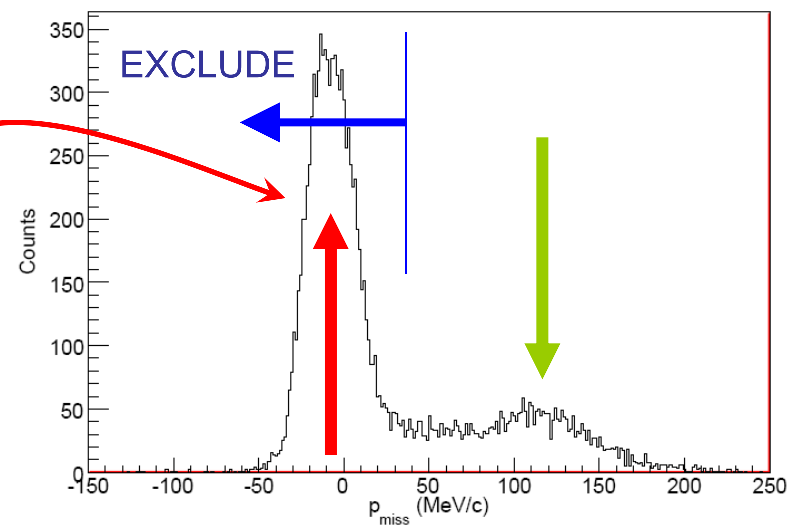


Figure 5.2: Missing momentum spectrum for ^{26}Ne coincidences, determined from the measurements in TIARA and VAMOS using Equation 5.2.

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