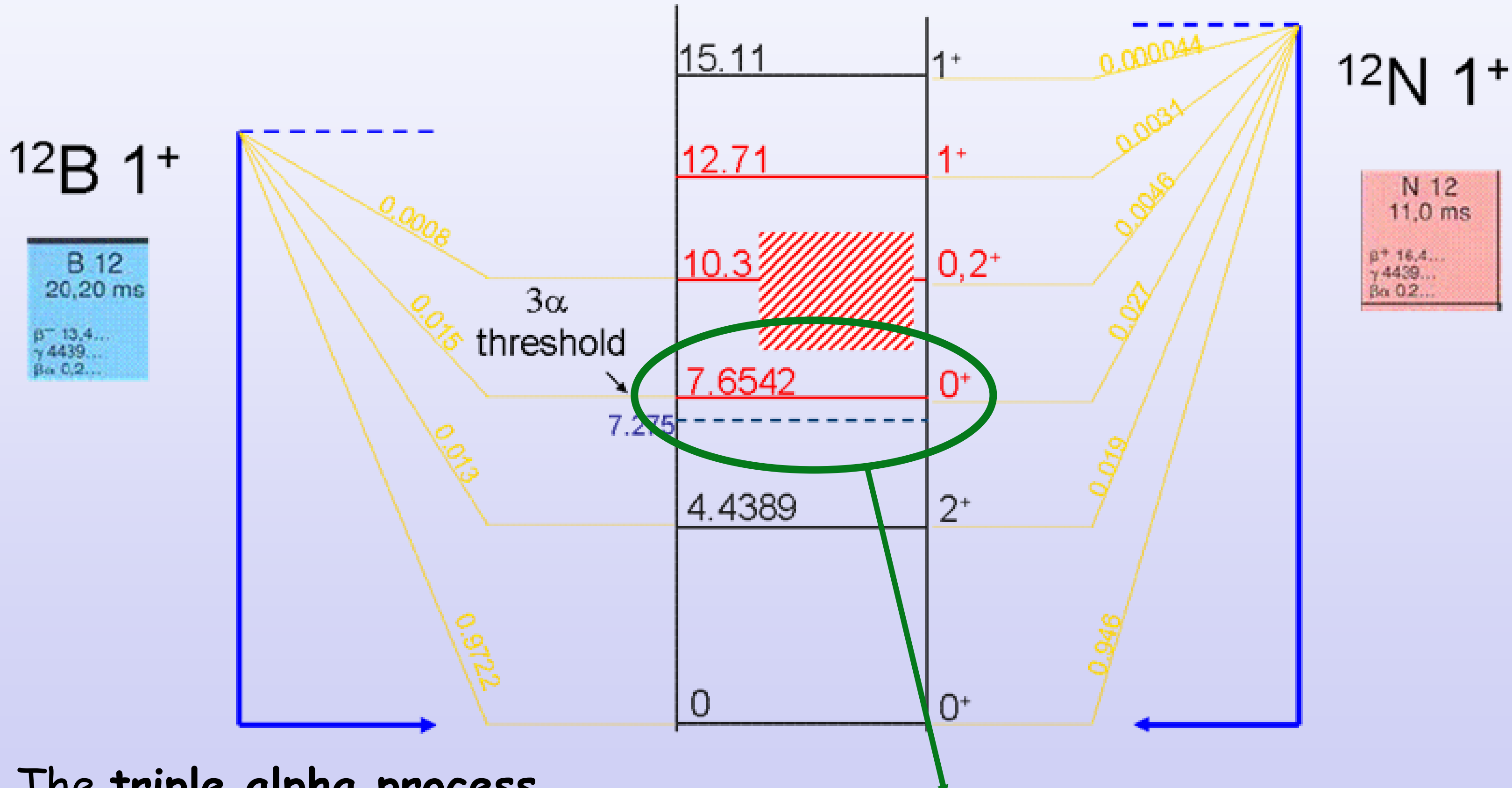
- DLEP activity report
  - An example of what we are studying

activity	status
– Detectors	
• Monolithic DE-E telescope;	prototype
• DSSSD + PAD telescope:	results
– Readout	
• Multiplexed analog readout	prototype
• Digitizing tests	test
– Algorithms	
• Neural Network	test

The β-decay of ^{12}N and ^{12}B

Nuclear structure; decay mechanism, clustering
Astrophysical interest; He : C : O abundances



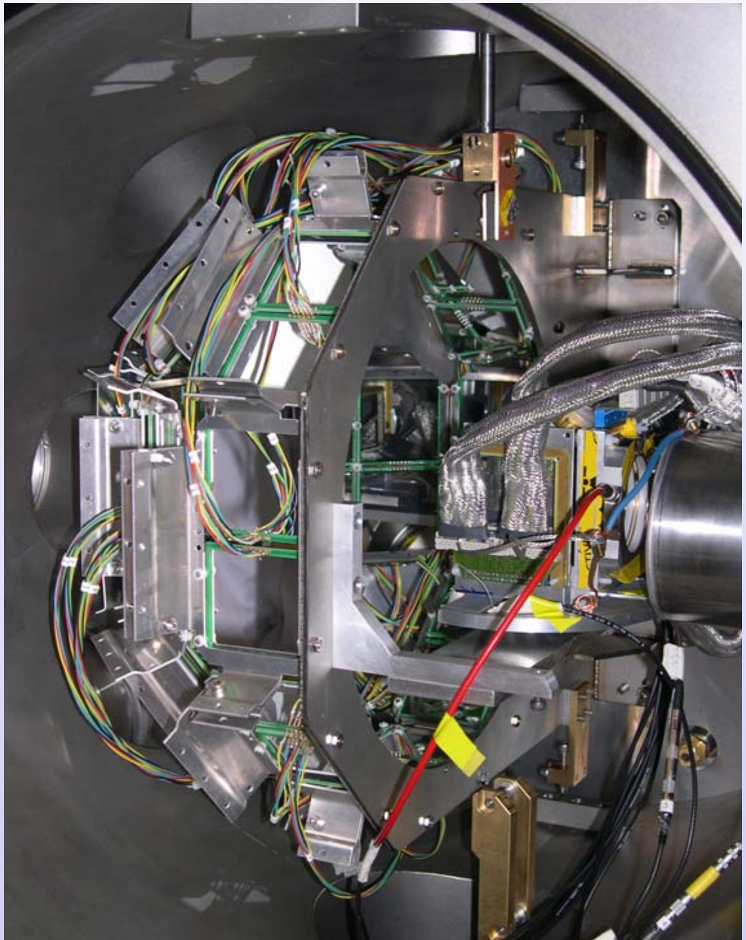
The **triple alpha process**

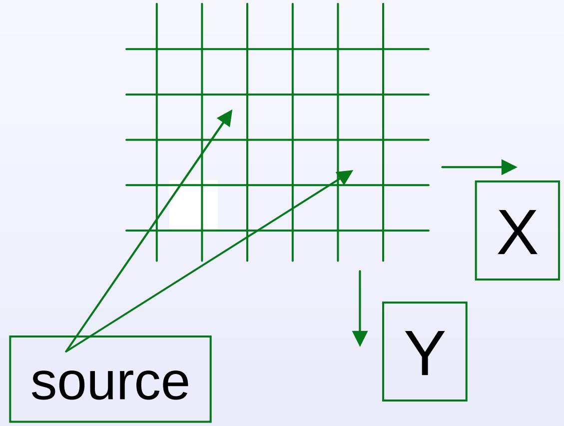
$^{4}He + {}^{4}He \leftrightarrow {}^{8}Be$

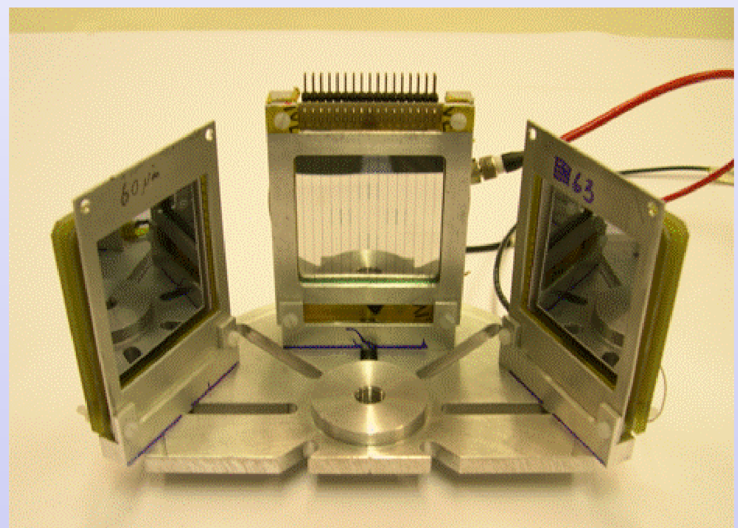
$^{8}Be + {}^{4}He \leftrightarrow {}^{12}C + \gamma + 7.367$ MeV

Hoyle state
0.3795 MeV > 3α threshold

Exp. Set-up @ JYFL & ISOLDE



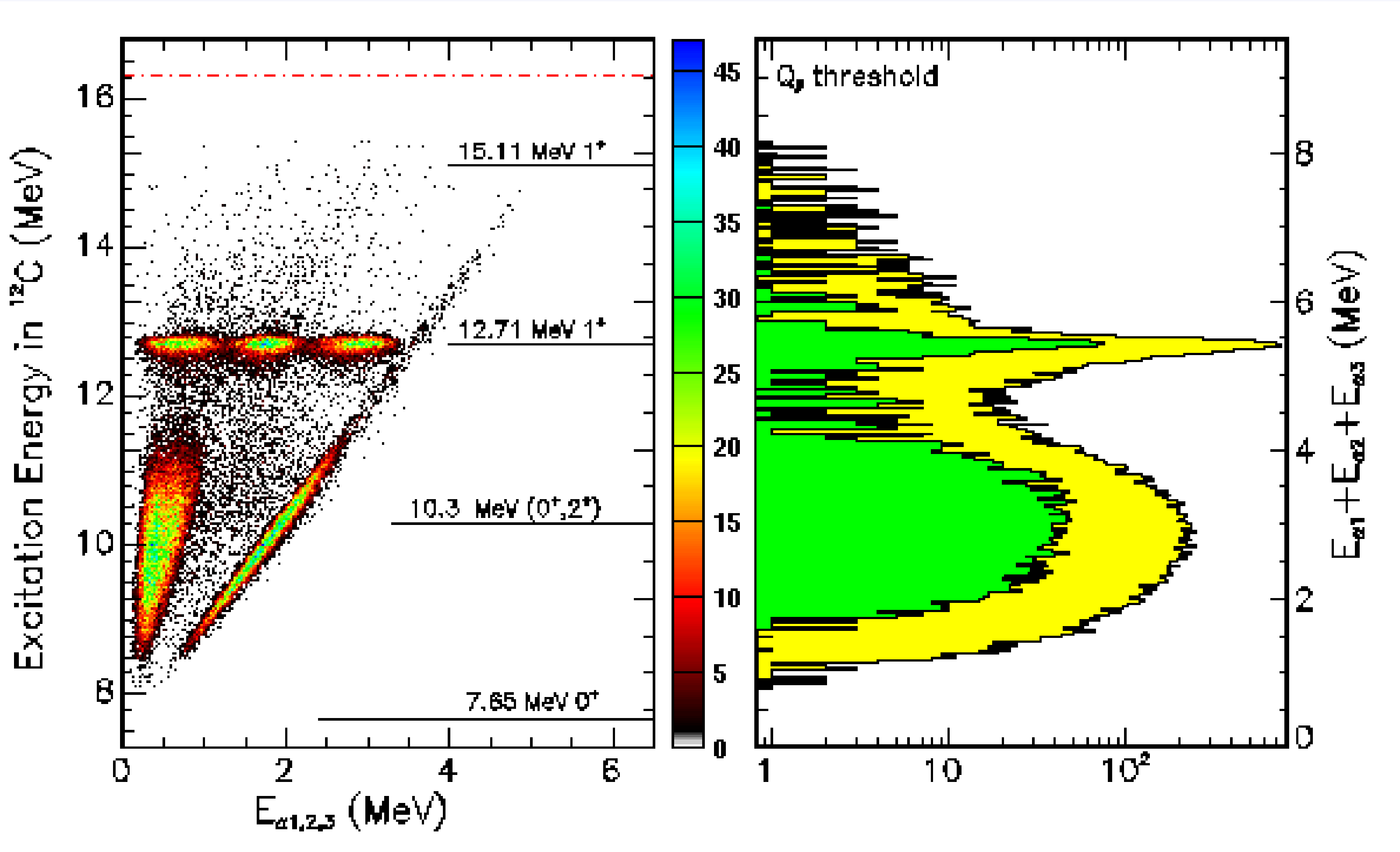




ISOLDE Si-Ball: 36x4 quadrants of 1000 micron Si
L.M. Fraile & J.Äystö, NIMA513 (2003) 287.

3 DSSSD telescopes
60 + 1500 micron Si

Triple coincidence in the β-decay of ^{12}N

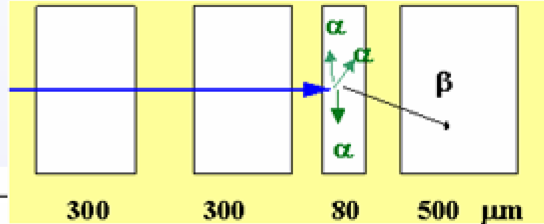


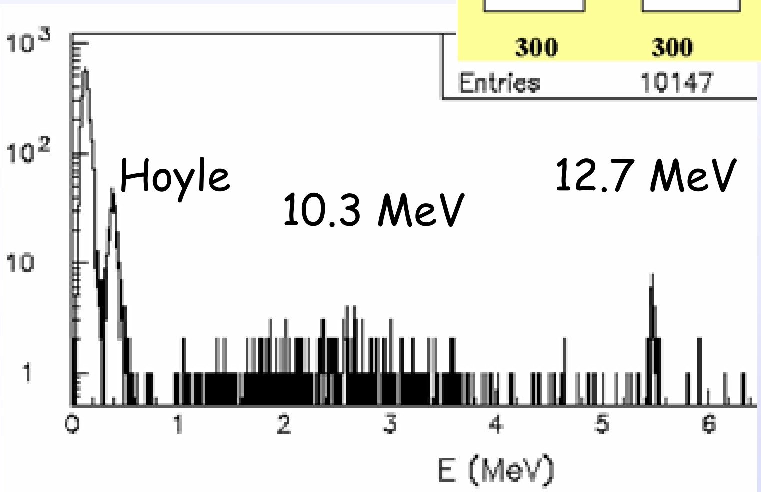
H. Fynbo et al., Revised rates for the stellar triple-α process from measurements of ^{12}C nuclear resonances Nature 433 (2005) 136

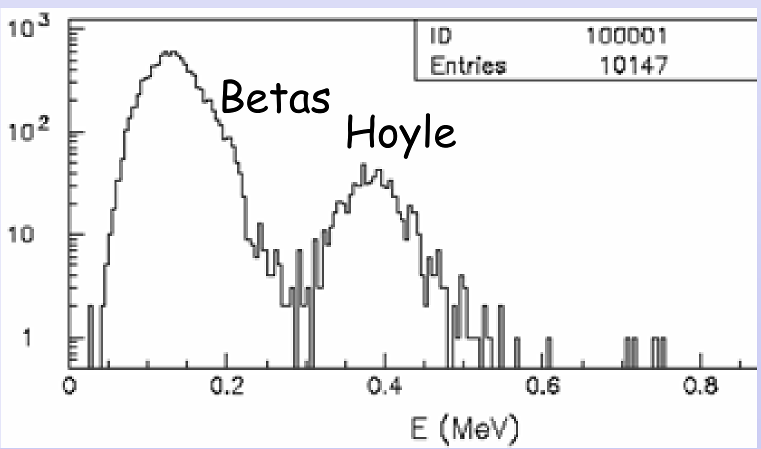
C.Aa. Diget et al., Properties of the ^{12}C 10 MeV state determined through β-decay, Nucl.Phys. A 760(2005)3-18

Study the decay by implantation method @ KVI 3-4 april 2006

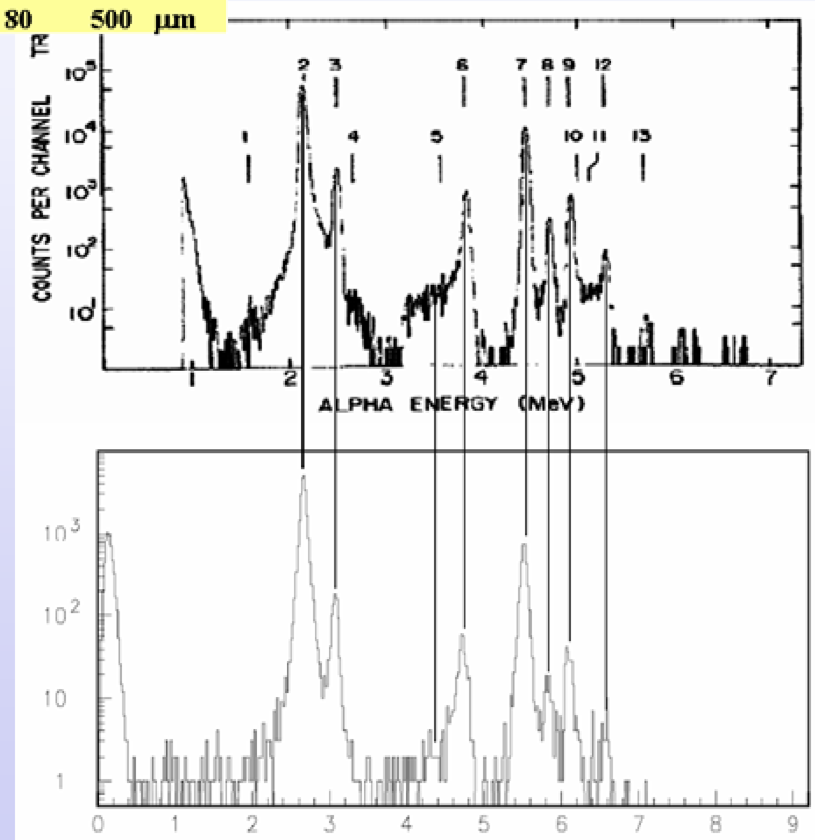
$^{12}N \rightarrow 3\alpha$







$^{20}Na \rightarrow {}^{16}O + \alpha$



H. Fynbo & R. Raabe

Reaction studies@low energy accelerator

β-delayed particle emission

$^{9}C \rightarrow {}^{9}B^* \rightarrow p + \alpha + \alpha$	ISOLDE
$^{9}Li \rightarrow {}^{9}Be^* \rightarrow n + \alpha + \alpha$	ISOLDE
$^{12}N \rightarrow {}^{12}C^* \rightarrow \alpha + \alpha + \alpha$	Jyväskylä
$^{12}B \rightarrow {}^{12}C^* \rightarrow \alpha + \alpha + \alpha$	ISOLDE

- **Reaction studies @ CMAM tandem**

$^{3}He + {}^{6}Li \rightarrow {}^{9}B^* \rightarrow \alpha + \alpha + p$

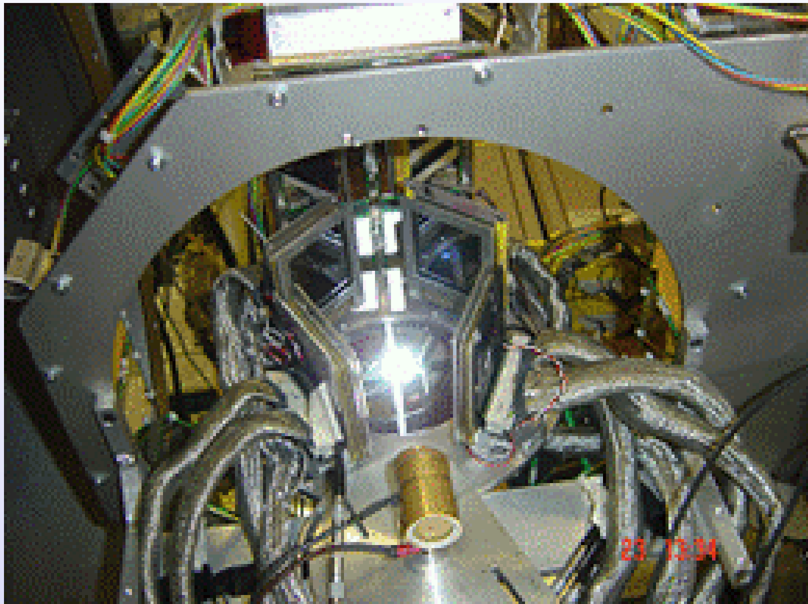
$d + {}^{7}Li \rightarrow {}^{9}Be^* \rightarrow \alpha + \alpha + n$

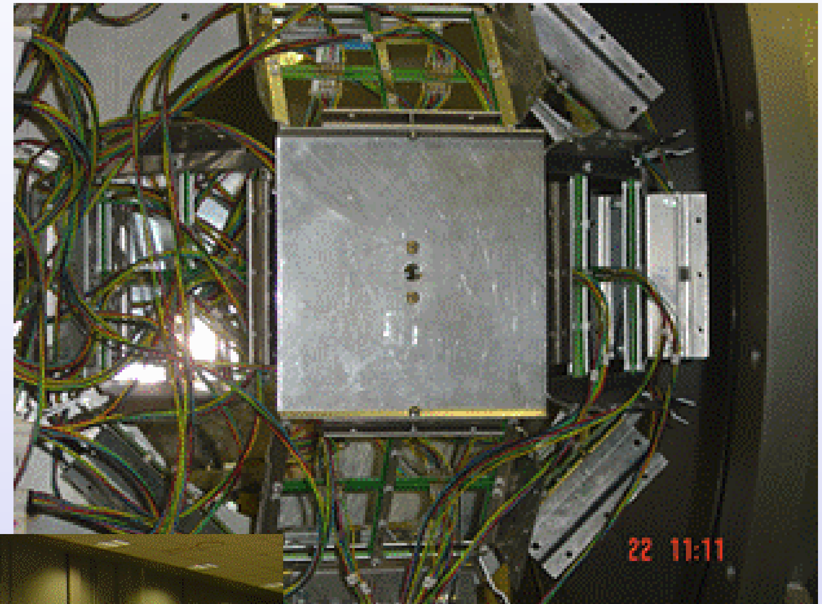
$p + {}^{11}B \rightarrow {}^{12}C^* \rightarrow \alpha + \alpha + \alpha$

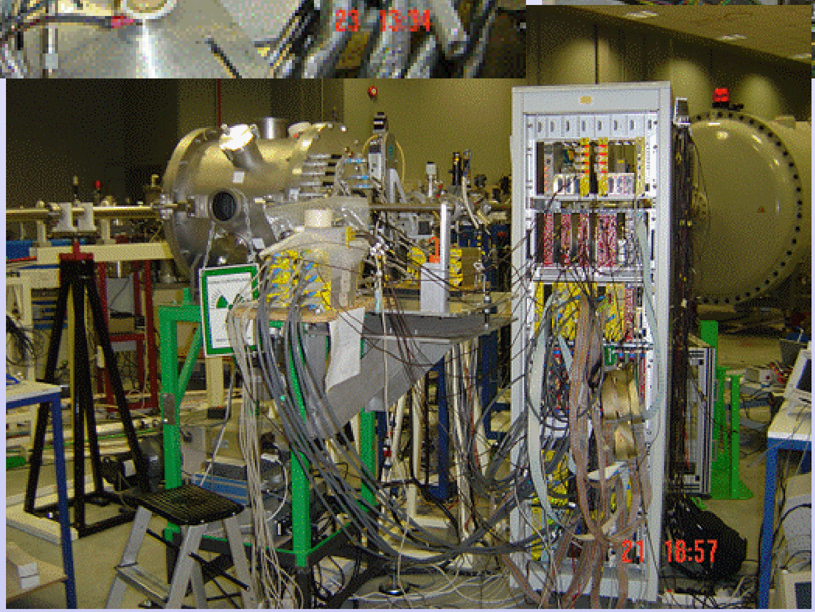
$^{3}He + {}^{10}B \rightarrow {}^{12}C^* \rightarrow \alpha + \alpha + \alpha + p$

β-delayed		Reactions
Feed states of definite spin & parity	⇐ Selection rules ⇒	Feeds many different states
Defined by the Q-value	⇐ Energy window ⇒	accelerator energy
Clean the operator is known	⇐ Feed mechanism ⇒	Not trivial, resonance or direct reactions.
F & GT transitions feed states of well defined spin	⇐ Isospin ⇒	Depends on beam and target chosen

^{3}He @ 2,45 MeV → ^{10}B → p α α α
CMAM Madrid tandem, 20 March 2006







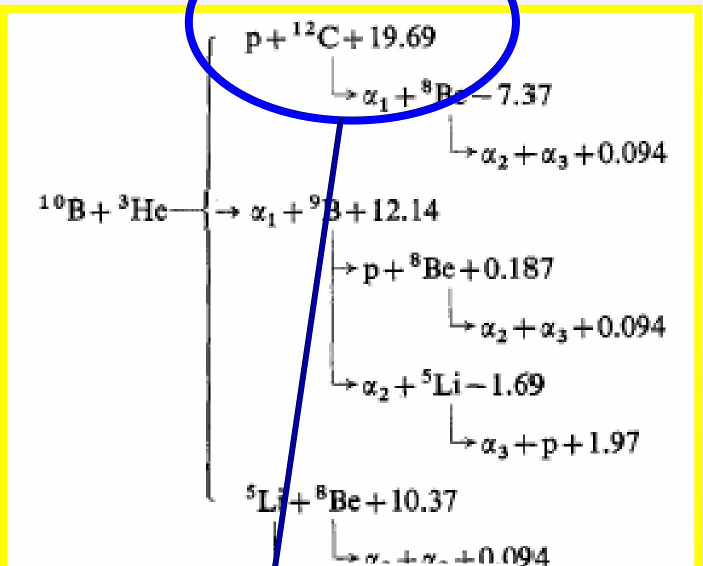
CMAM-Tandetron

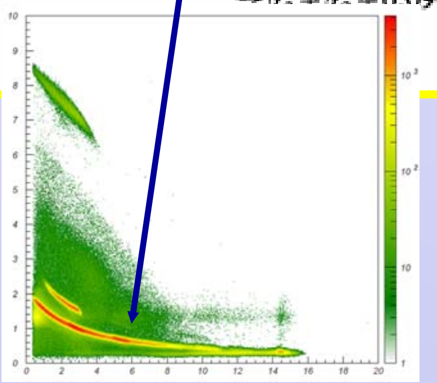
Terminal voltage
100 V – 5 MV

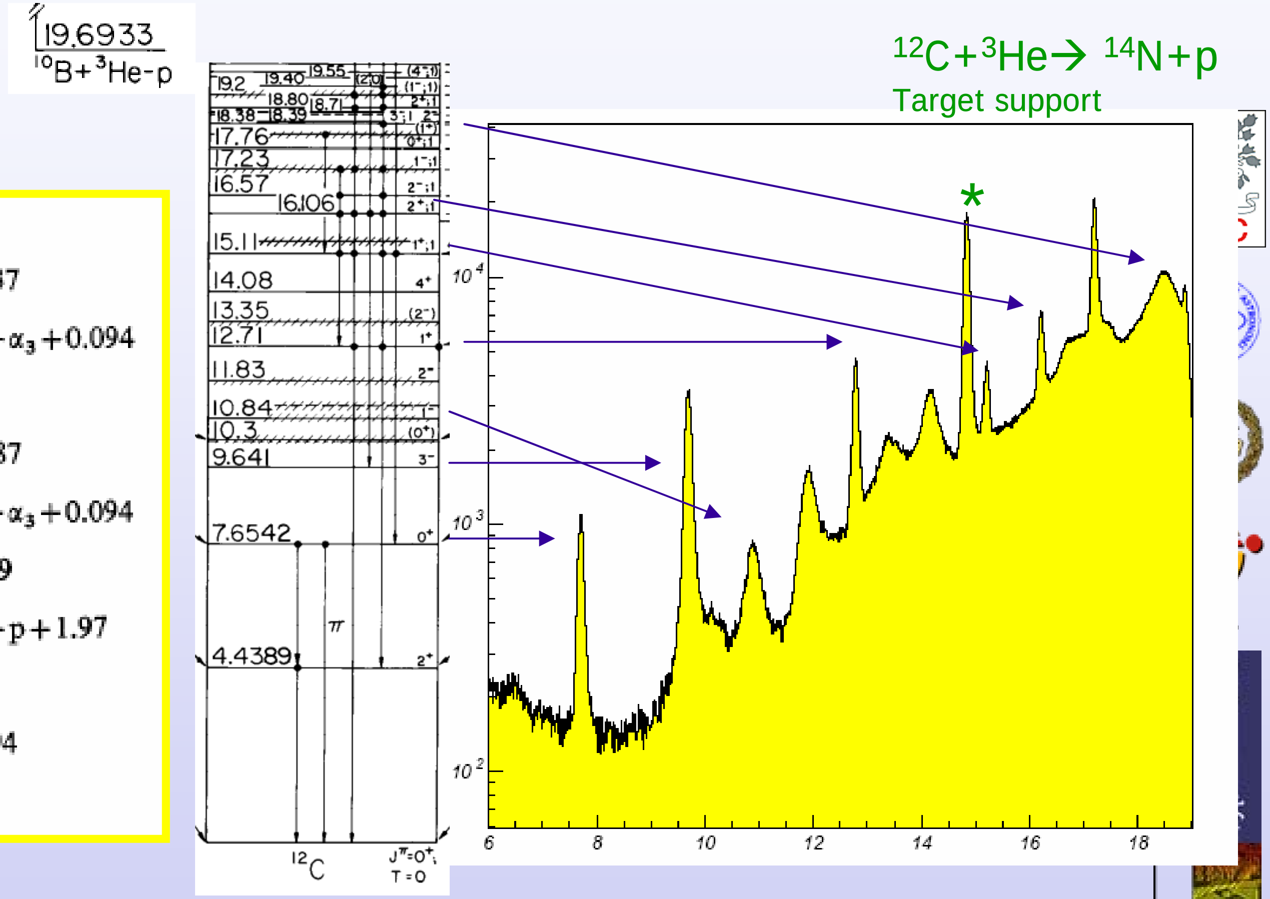
Energy *E*

$$E = V^{*}(q + 1)\ \mathrm{MeV}$$

$^{10}B + {}^{3}He \rightarrow p + {}^{12}C^{*} \rightarrow \alpha + {}^{8}Be$







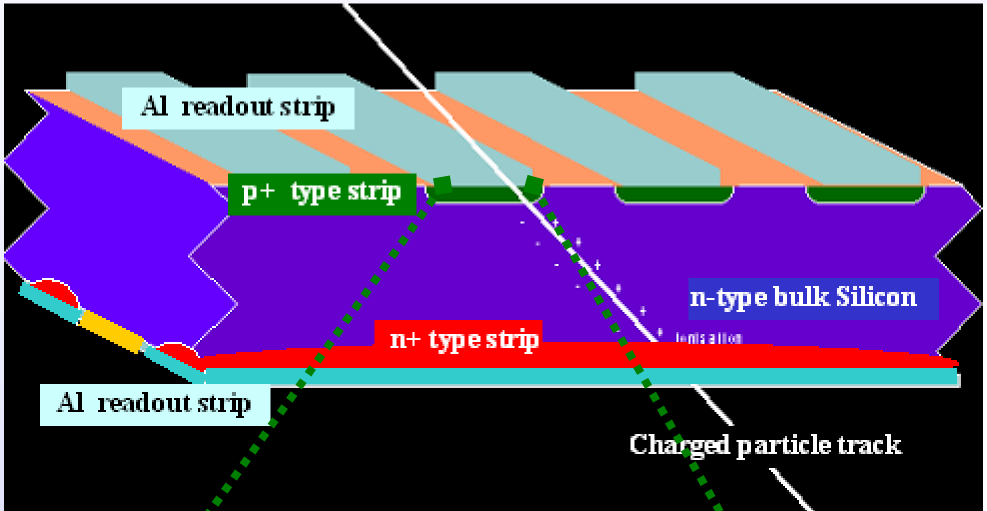
Preliminary data CSIC

Task & deliverables

- Design and prototyping of
  Detectors & Front end electronics for low energy Charged particle detection

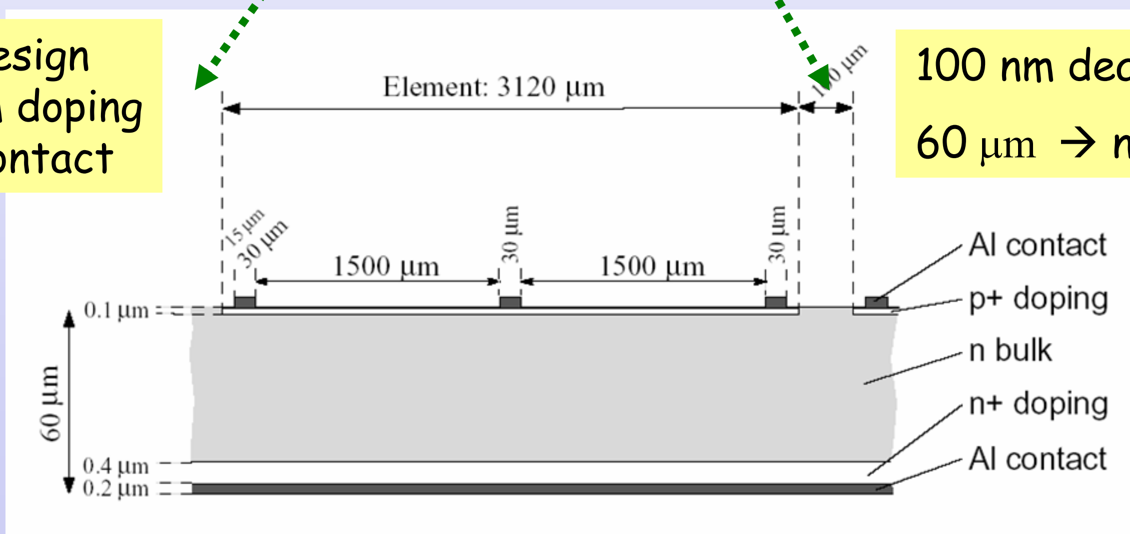
- Algorithms for digital
  particle identification

Detectors – ultra thin window



200 nm Al
400 nm doping

New design
100 nm doping
Grid contact



100 nm dead layer

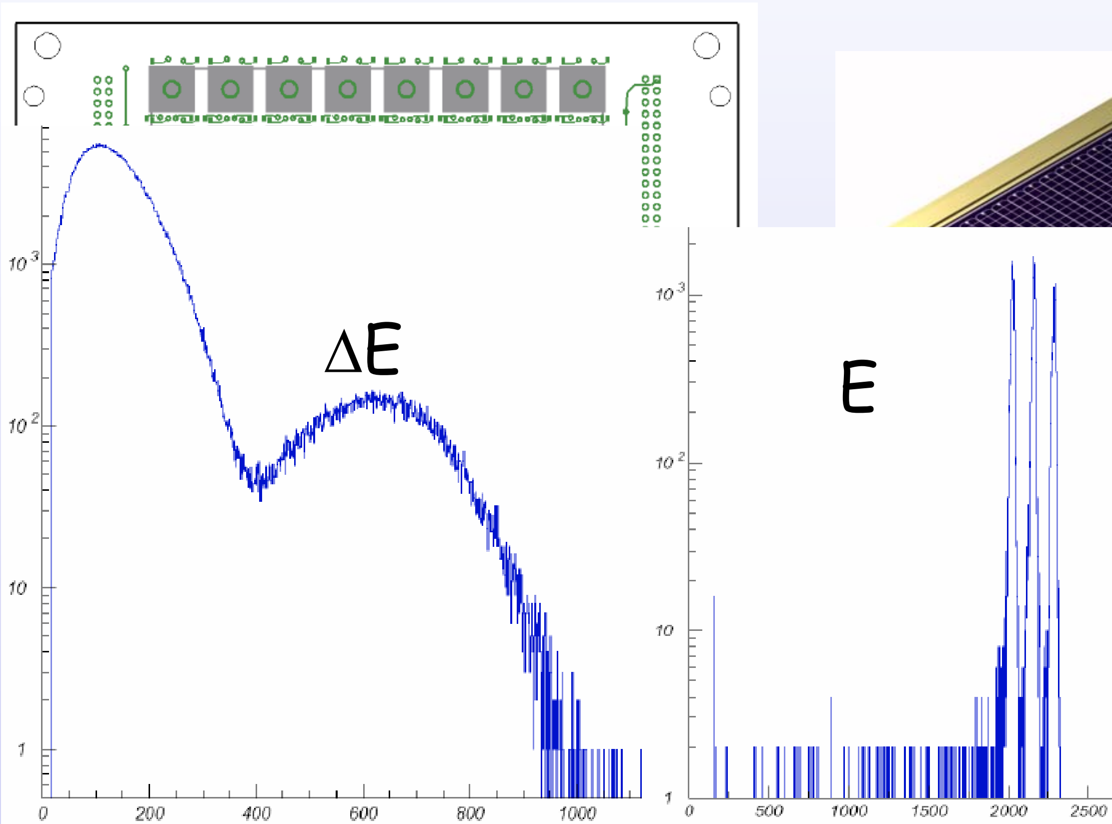
60 µm → no β response

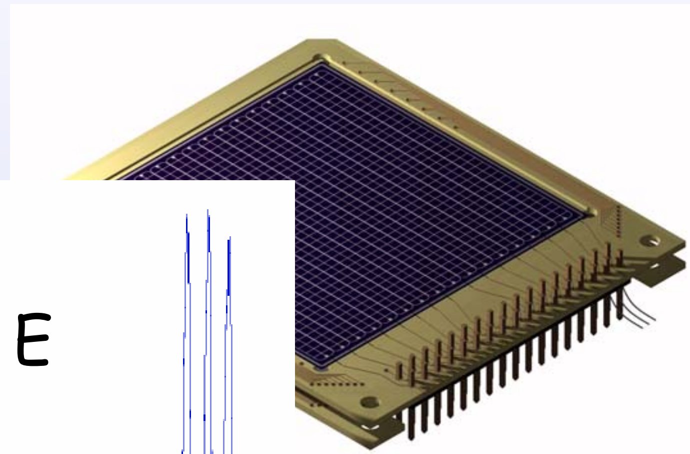
Novel thin wind

Developed in cooperation with our industrial partner Micron Semiconductor

Tengblad et.al. Nucl. Instr. Meth A525 (2004) 458

Detectors - monolithic Si telescope



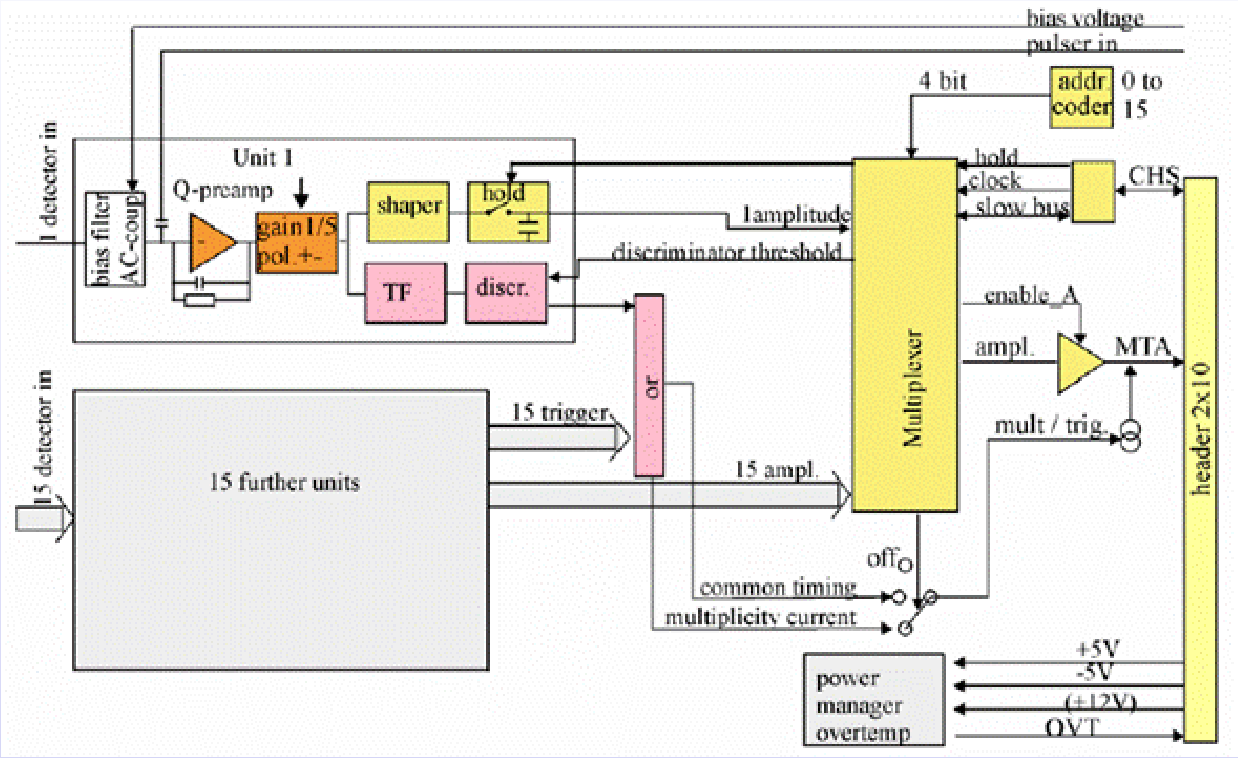


… elements á 9 mm²
…annels

ΔE stage 1 μm
E stage 400 ± 15 μm

Solid Angle 20% of the DSSSD

Readout - Multiplexing



32 x 16ch cards = 512ch multiplexed to 2 readout busses. Estimated cost 145€/ch, 12 bit ADC included

The prototype array was designed and its compact electronics developed in cooperation with our industrial partner http://www.mesytec.com/

Pulse Shape Discrimination (PSD) with Artificial Neural Networks (ANN)

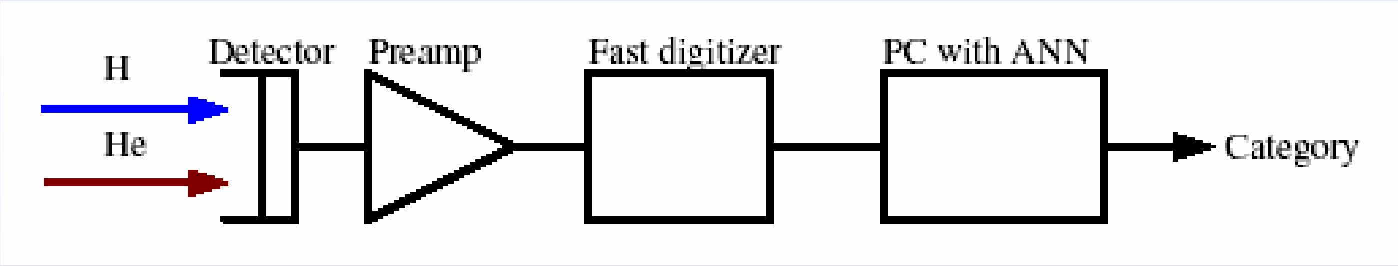
Objective:
Discriminate particles by analyzing their associated pulses in Si detectors.

- Typical approach:
  - Hardware: analog systems recording samples of the pulse at a limited number (<10) of times
  - Software: fitting the sampled pulses to models which account for the different pulses from different particles

- Proposed approach
  - Hardware: fast digitizers (~1GHz) allowing direct digital processing
  - of the pulses
  - Software: Use of ANNs for classification of pulses

Example

- Suppose we want to discriminate protons from alphas
- Assume that the pulses obtained are indeed different

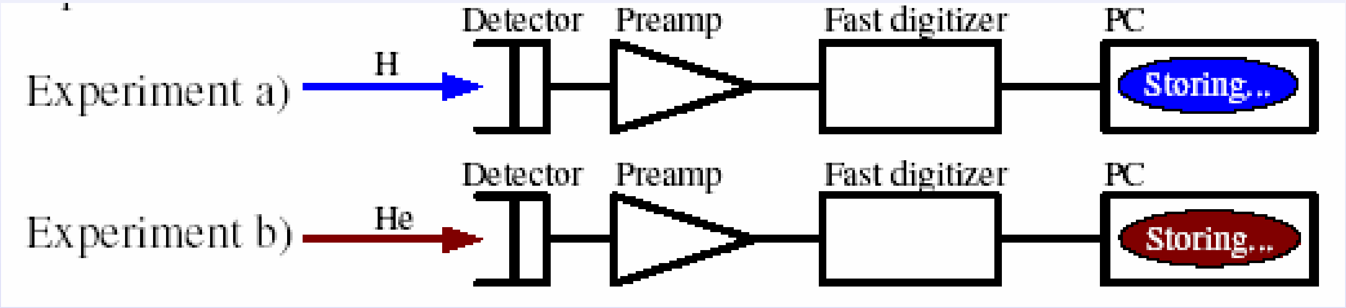


Steps to be done:

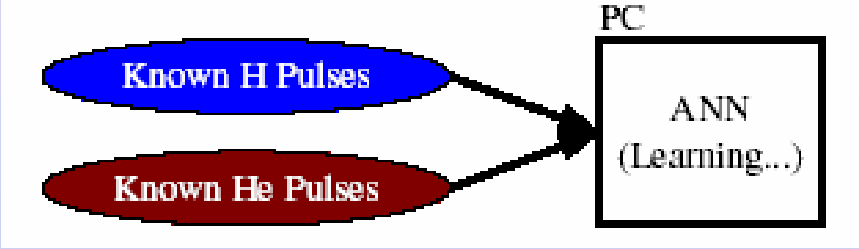
1. Training
2. Testing
3. Running in real conditions

Training

A set of pulses for training must be acquired under controlled conditions (i.e. so that only one kind of particle at a time is present) and stored for training. This can be done with RBS technique.

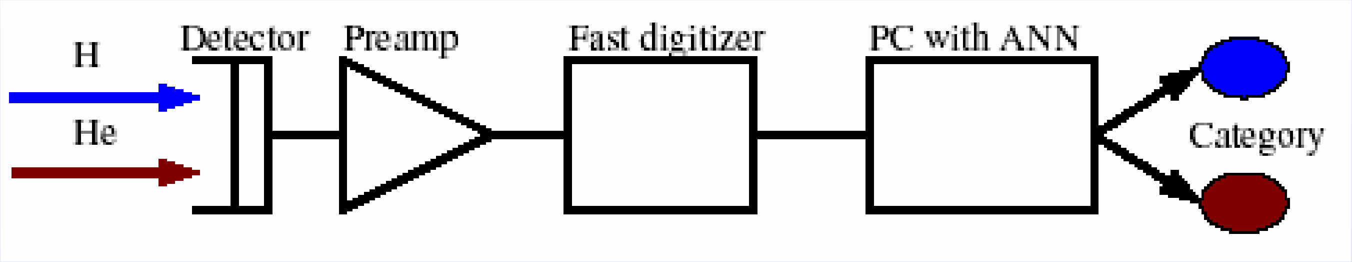


After these experiments, we can show the ANN several examples of protons and several examples of alphas covering the energy range of interest. This is the actual training.



Running under real conditions

Online for classifying events:



Alternatively, the digitized pulses can be stored an processed offline (for debugging or further analysis)

In certain conditions, the trained ANN (which is just a simple function) can be hard coded into a programmable chip and built into a module (hence not needing a PC and being even faster).

Test with constructed pulses have been carried out leading to promising results.

Collaborators

- H.O.U. Fynbo, C. Aa. Diget, S.G. Pedersen, K. Riisager,
  Department of Physics and Astronomy, Århus University, Denmark
- M.J.G. Borge, M. Madurga Flores, M. Alcorta, D. Obradors,
  O. Tengblad, M. Turrion
  Instituto Estructura de la Materia, CSIC, Madrid, Spain
- J. Äystö, W. Huang, J. Huikari, A. Jokinen, P. Jones,
  Department of Physics, University of Jyväskylä, Finland
- B. Jonson, T. Nilsson, G. Nyman, H. Johansson
  Fundamental Physics, Chalmers Univ. of Technology, Göteborg, Sweden
- K. Riisager, L.M. Fraile, , H. Jeppesen
  ISOLDE, EP-Division, CERN, Geneva, Switzerland
- B. Fulton, P. Joshi, S.Fox
  University of York, United Kingdom.
- P. Dendooven
- R. Raabe