RECENT DEVELOPMENTS FOR THE HYDE DETECTOR AT FAIR

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for

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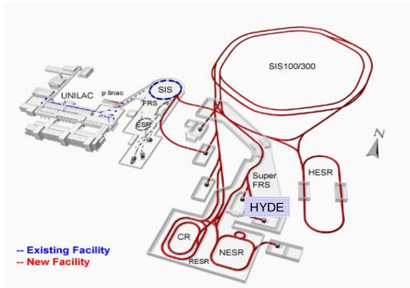
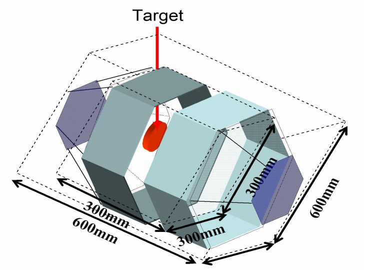
Motivation

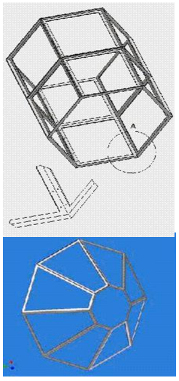
In the Low-Energy Branch (LEB) of the new FAIR facility [1] at GSI (Darmstadt, Germany), it is proposed to study properties and phenomena of exotic nuclei employing low-energy beams from the Super-FRS at energies ranging from about 100 MeV/u down to a few MeV/u. Part of this research activity will concentrate in the study of nuclear reactions in the range of 5-30 MeV/u. For such studies it is foreseen to build a dedicated charged particle array (HYDE). The R&D stage (2006-2009) is dedicated to investigate particle identification techniques using thin mono-cristal diamond detectors and digital pulse shape analysis techniques with silicon detectors (DPSA). Part of the research is carried out in collaboration with SPIRAL2 groups.



The HYDE Preliminary conceptual design

In the preliminary design, HYDE is made of two structures, two barrels and two cones. These should fit inside the AGATA chamber to select the relevant reaction channels.



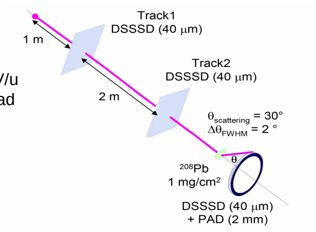


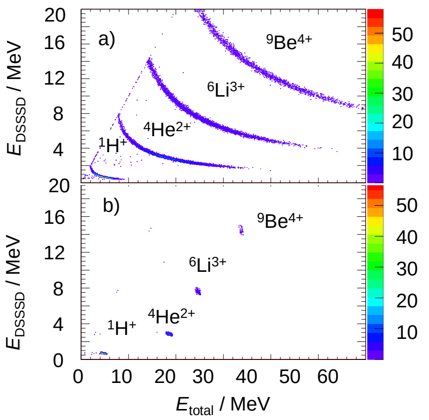
The goal is to have a prototype ready for 2010, when first beams are produced at FAIR.

Simulations

Simulations of detector performance are carried out using GEANT4. Beam properties at FAIR/LEB are predicted to be extreme due to the deceleration process from energies of some GeV/u down to few MeV/u.

$\langle E \rangle$ = 5 MeV/u
ΔE_{FWHM} = 3 MeV/u
$\varepsilon = 20\ \pi$ mm mrad
$\Delta x,y_{FWHM}$= 3 cm

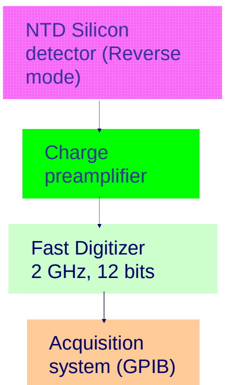


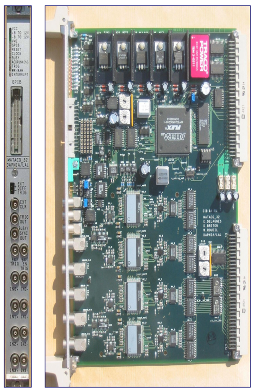


a) Particle identification spectrum ($\Delta E/Et$) for elastic events at the scattering angle of 30(2)º, using a "cocktail beam" of H, He, Li and Be. The beam is assumed to have an average energy of 5 MeV/u and a spread (FWHM) of 3 MeV/u. The detectors are conventional 40um/2mm Si-telescopes and the target is ^{208}Pb (1 mg/cm^2).
b) A tracking system was used.

DPSA

We are exploring the limits of low energy heavy ion identification with silicon detectors using Digital Pulse Shape Analysis techniques [4] in collaboration with research groups of HYDE, FAZIA and CEA-Saclay.
A first step is to build a data base on pulse shapes using stable beam facilities like the Tandem Van der Graaf in Sevilla (Spain) or the Cyclotron Accelerator in Warsaw (Poland) using NTD Silicon, Single PAD detectors (100-500 μm) and thin DSSSD detectors (down to 40 μm).
First tests has been performed using a charge preamplifier developed at Detector Lab of GSI and a fast digitizer (MATACQ) developed at CEA-Saclay.

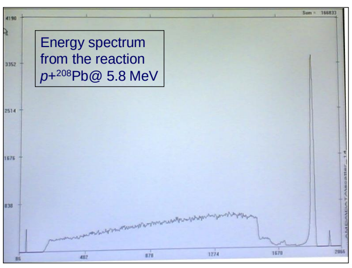


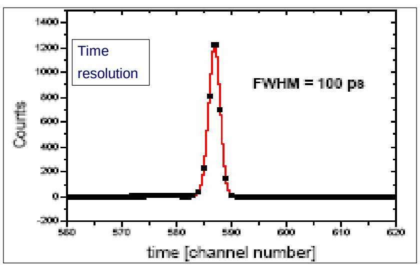


MATACQ board

Diamond detectors

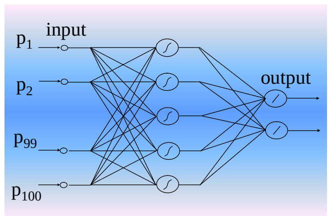
Mono-crystal diamonds show good performance for charged particle detection, like time response below 100 ps and energy resolution below 1% [2, 3]. Thickness down to 50 μm will be commercially available soon, so that fast diamond particle telescopes could be used for TOF and $\Delta E/E$ particle identification for HYDE.
Poly-crystal and mono-crystal diamond detectors has been recently tested at 3 MV local Tandem (C-N-A, Sevilla, Spain) with low energy (3 MeV/u) protons, alphas and ^{7}Li.





Neural networks

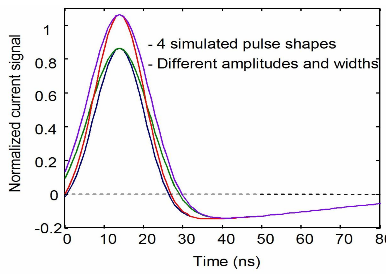
MuLtilayer Perceptron (MLP) neural networks are being applied to identify particles from their digitized pulse shapes of current signals.



MLP Results:

A MLP network with 7 neurons was trained to identify 4 different pulse shape types at simulation.

It showed high resolution, good performance by generalization to pulse shapes slightly different from the patterns used, and enough tolerance to noise.



Summary and Outlook

R&D period for the HYDE detector is in progress. We are working in a modular mechanical design which would allow HYDE to be fitted inside AGATA. Preliminary simulations with GEANT4 show that using a suitable tracking system, it is possible to perform particle identification and to achieve a reasonable energy resolution (<5%). Part of the research is dedicated to study response of solid state detectors for charged particles: fast mono-crystal diamond detectors and DPSA techniques for particle identification using neural networks.

References
[1] The FAIR Technical Report, www.gsi.de/fair.html
[2] I. Dawson et al., NIM A453 (2000) 461
[3] W. Adam et al., NIM A436(1999) 326
[4] L. Bardelli et al., NIM A521(2004)48
[5] J.J. Vega and R. Reynoso, NIM B 243 (2006) 232