CNS, The University of Tokyo

The ultrafast dE-ToF single crystal diamond detector

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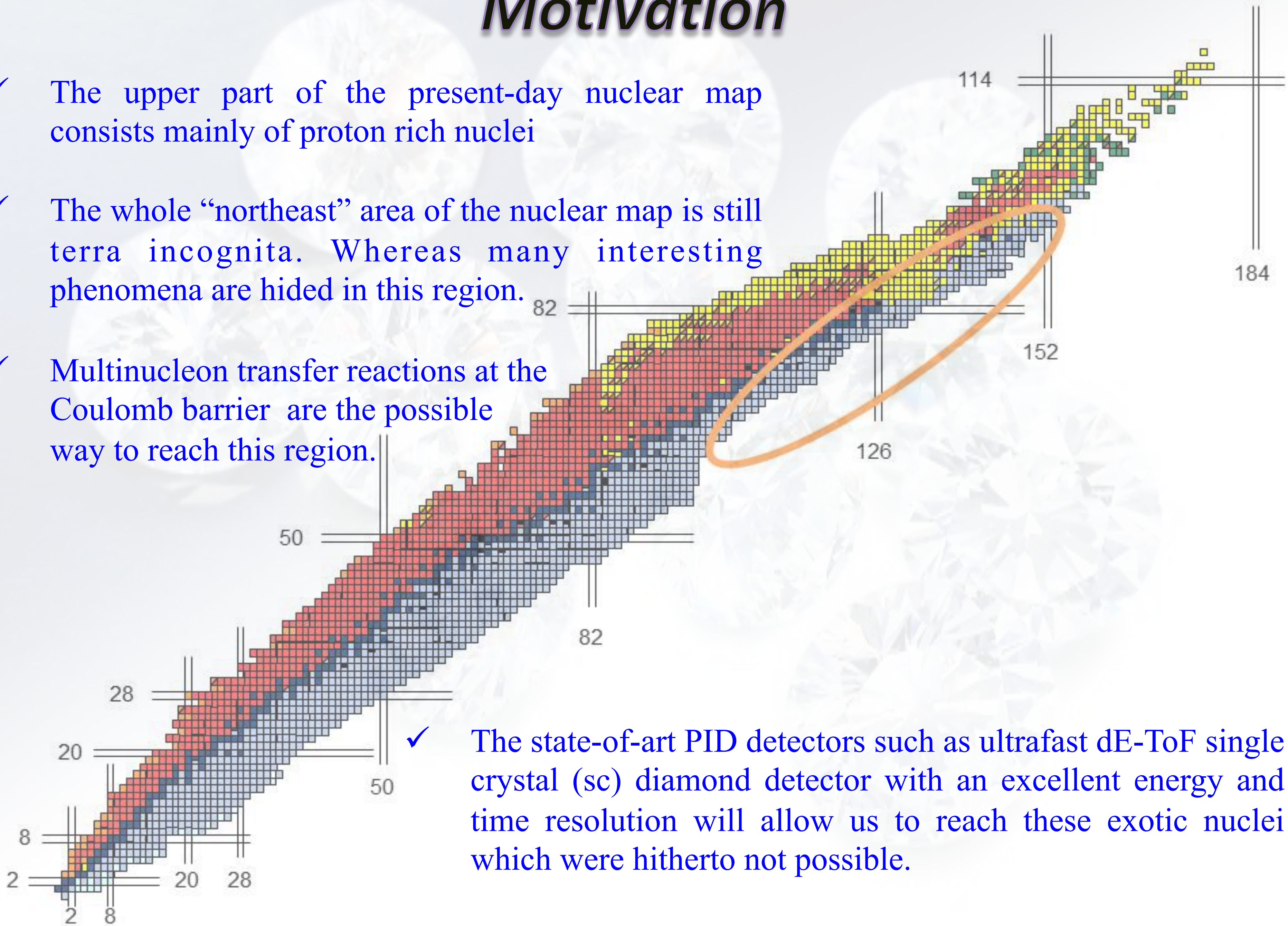
- *motivation*
- *problems and requirements*
- *results*
- *pulse height defect in sc diamonds*
- *summary and outlook*

Motivation

- ✓ The upper part of the present-day nuclear map consists mainly of proton rich nuclei

- ✓ The whole "northeast" area of the nuclear map is still terra incognita. Whereas many interesting phenomena are hided in this region.

- ✓ Multinucleon transfer reactions at the Coulomb barrier are the possible way to reach this region.



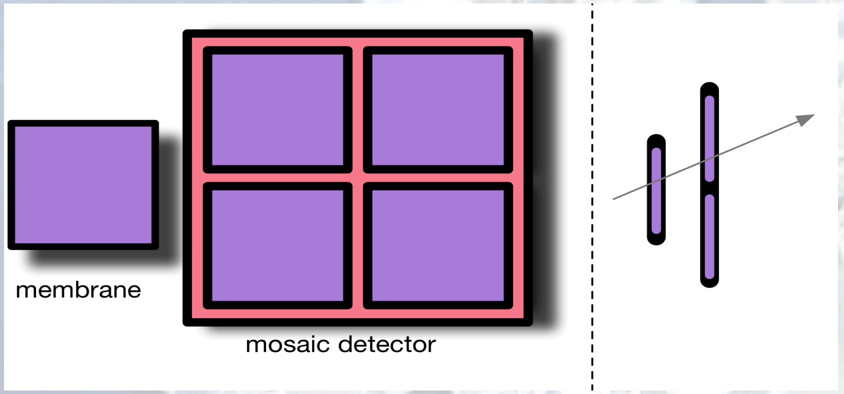
- ✓ The state-of-art PID detectors such as ultrafast dE-ToF single crystal (sc) diamond detector with an excellent energy and time resolution will allow us to reach these exotic nuclei which were hitherto not possible.

Problems and Requirements

- MNT reactions at the Coulomb barrier energies are a tool to study the north-east region of the nuclear chart
- low energies(about 5~10MeV/u)=>

  short ranges (typical example: Pb-like of 5MeV/u ~ 50um in Si) require thin detectors of few tens um thickness
- radiation hardness

our goal: ΔE-ToF telescope particle identification membrane dE-start + mosaic E-stop sc CVD diamond detectors

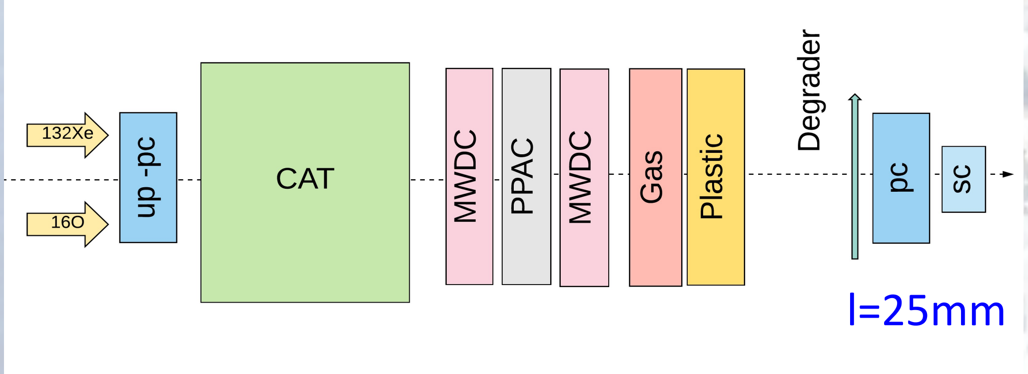


membrane is the thin detector of few um thickness

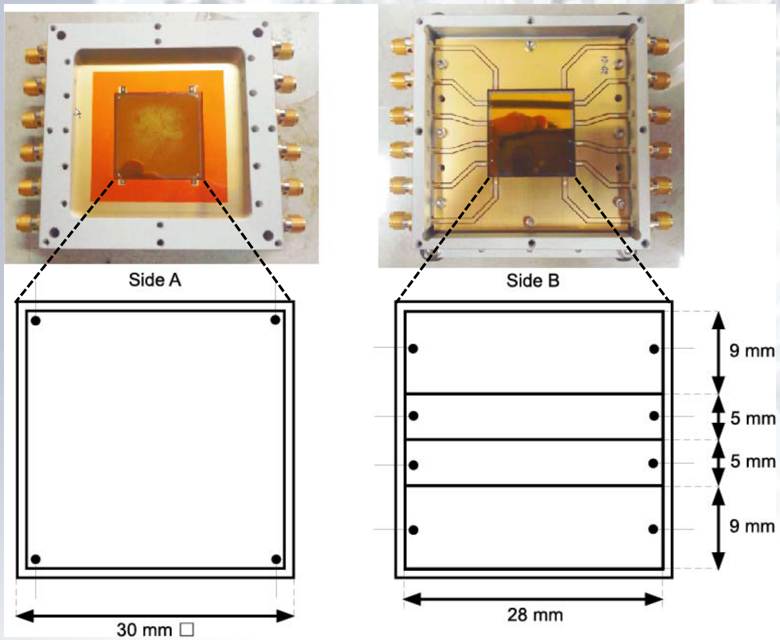
first step: experimental study of t, E,of the sc (results are in the following)

to get the best resolution simultaneously

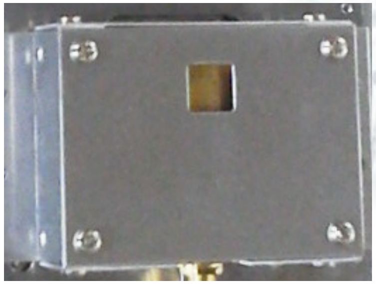
Experimental Setup at HIMAC



Beam parameters:
^{132}Xe (230MeV/u)
^{16}O (200MeV/u)
setup in the air
beam intensity:
- from 1kHz up to 1MHz



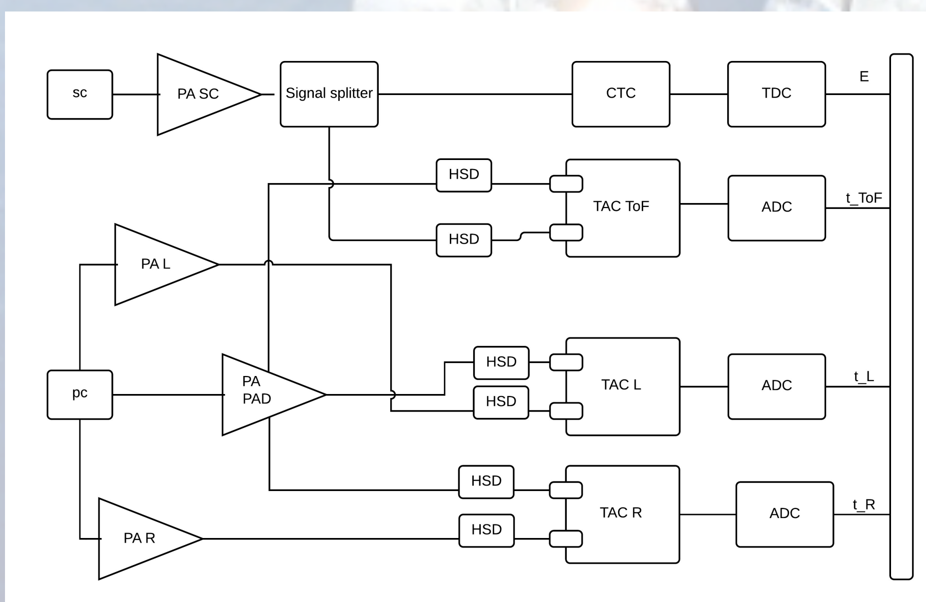
- pc: Polycrystalline CVD diamond
- Crystal size : 30×30×0.2 mm3
- Pad design
- – Effective area: 28×28 mm2
- – Side A: 1 pad (4 readouts)
- – Side B: 4 strips (8 readouts)
  - for correction of position dependence

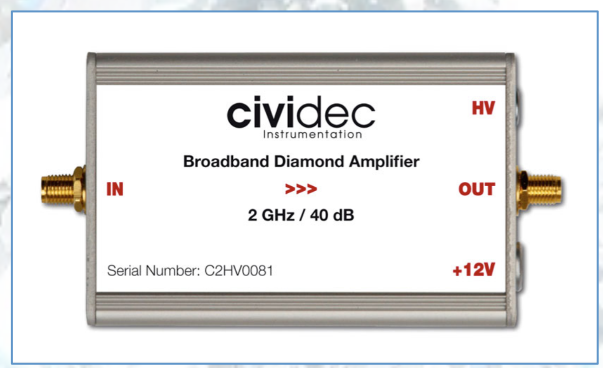


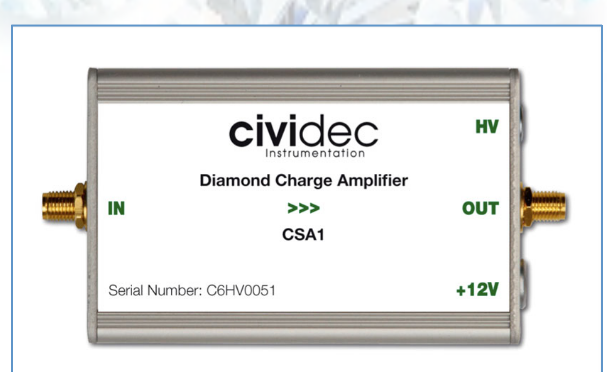
sc: Single crystal CVD diamond
4 mm x 4 mm x 140 um

S. Michimasa et al., NIM B 317 (2013) 710

Scheme of the electronics



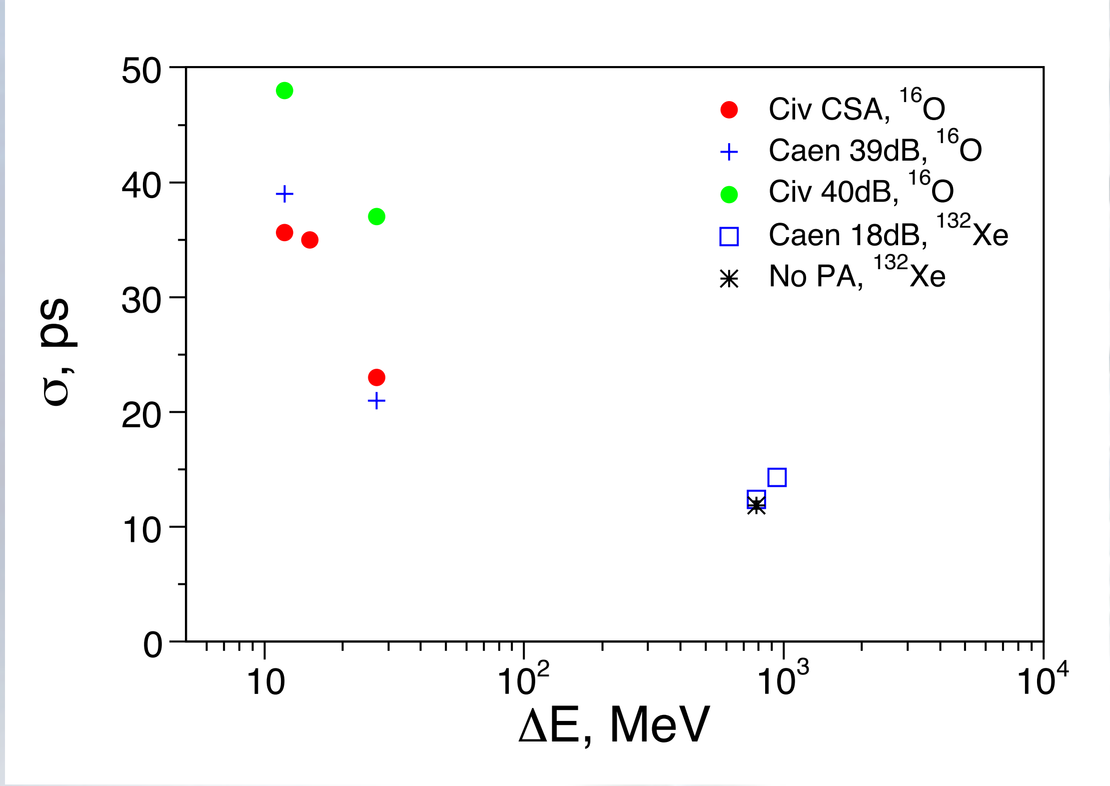




Energy:
CTC Fujidiamond
TDC V1290
Timing:
High speed discriminator Iwatsu
TAC ORTEC
ADC Iwatsu

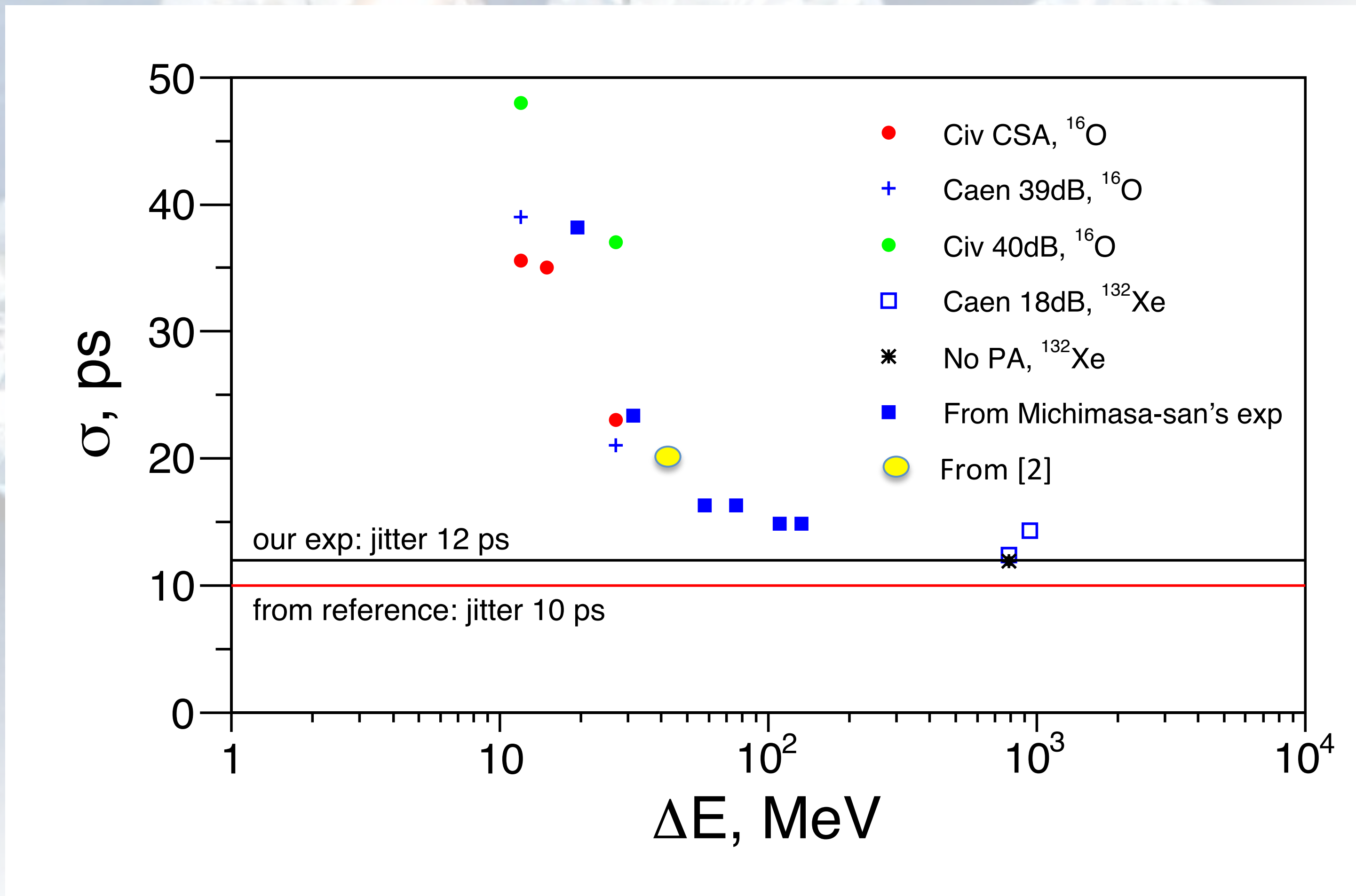
PAs: Cividec 40dB, Cividec CSA, Caen A1423B

Time resolution versus energy deposit



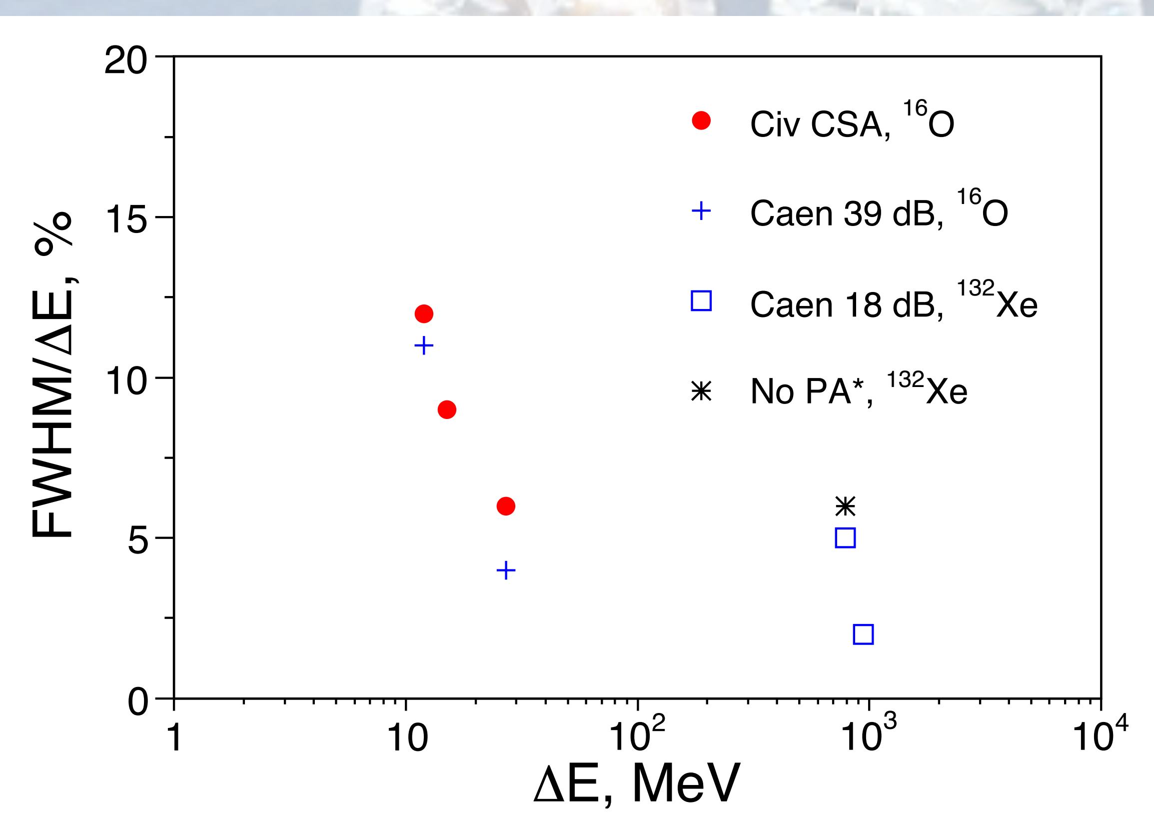
ΔE, MeV	σ,ps, w/o correction	σ, ps w/ correction
^{16}O	Caen 39dB	
12	124	39
27	62	21
	Cividec CSA	
12	101	35
27	52	23
	Cividec 40dB	
12	148	48
27	58	37
^{132}Xe	Caen 18dB	
786	38	12
945	36	14

Time resolution versus energy deposit



1. S. Michimasa et al., NIM B 317 (2013) 710
2. A. Stolz et al. / Diamond & Related Materials 15 (2006) 807–810

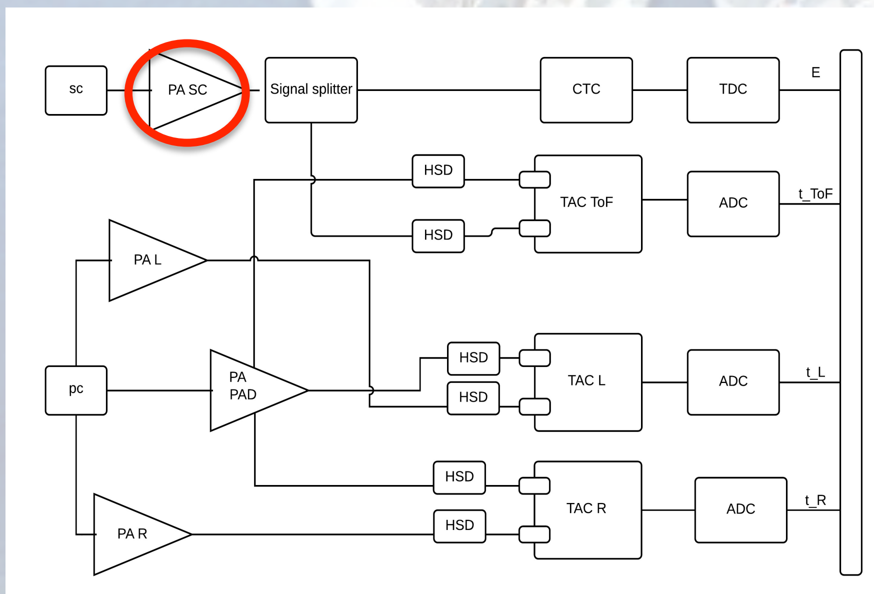
Energy resolution versus energy deposit

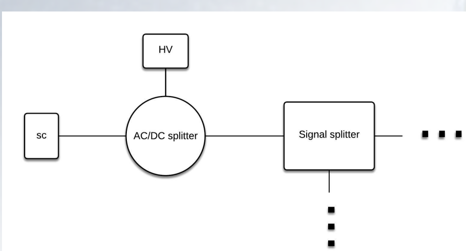


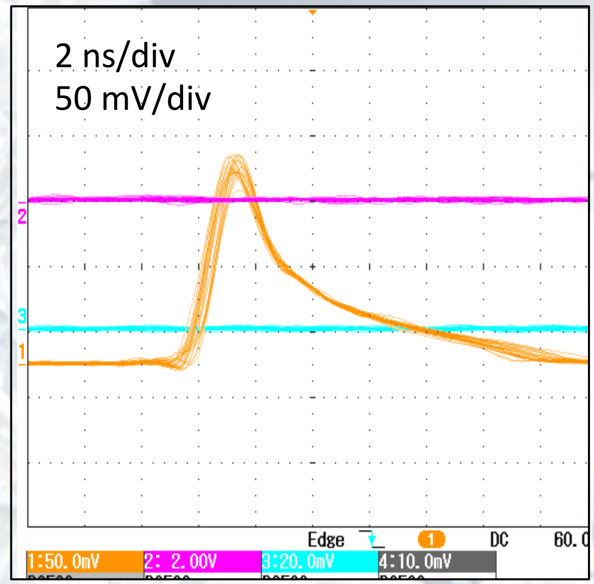
	σ, MeV	FWHM/ΔE, %
^{16}O	Caen 39dB	
12	0.584	11
27	0.471	4
	Civ CSA	
12	0.634	12
27	0.655	6
	Civ 40dB	
12	1384 channel	8.4*
27	out of range	
^{132}Xe	Caen 18dB	
786	18	5.5
945	7.6	2!!!

Scheme of the electronics

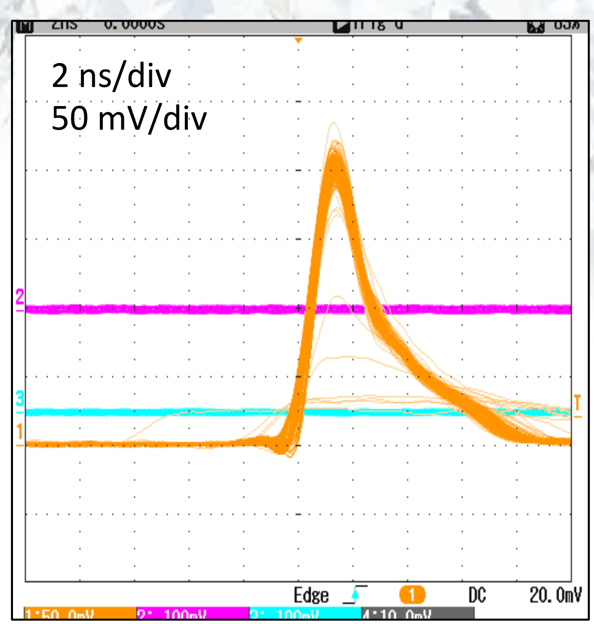
^{132}Xe@(122&91)MeV/u by sc w/o any PA







ΔE = 790MeV
(F=1V/um)

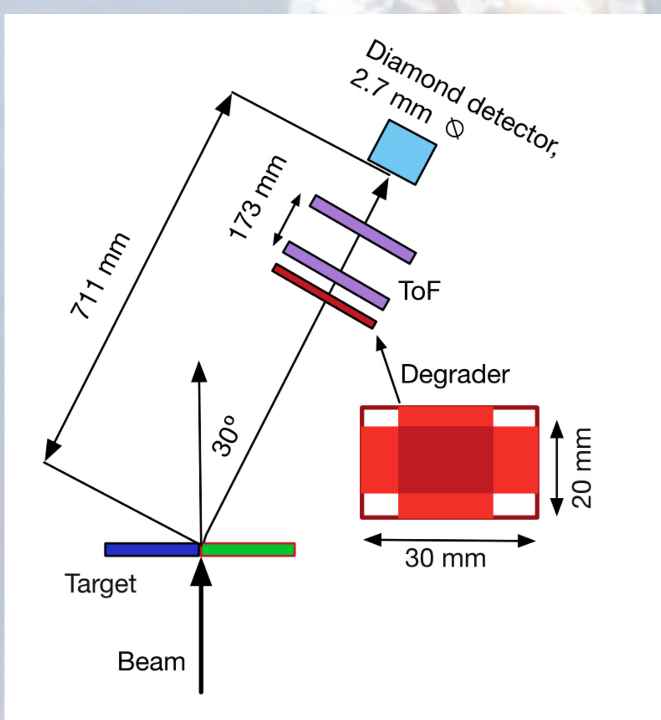


ΔE = 950MeV
(F=2V/um)

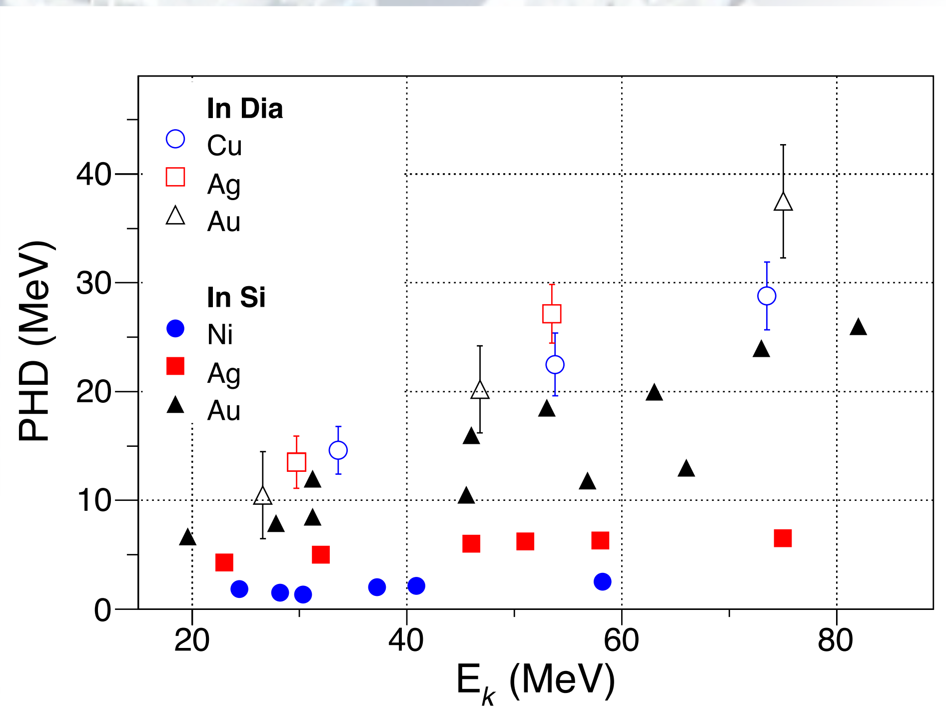
w/o PA

^{132}Xe	σ, MeV	FWHM/ΔE, %	σ,ps w/o correction	σ, ps w/ correction
	2 V/um			
786	19	5.7	35	12
945	140	35	127	47
	1 V/um			
786	26	7.6	37	14

Comparisons of PHD in the sc diamond and the Si



Scheme of setup in JINR, Dubna



PHD vs the kinetic energy in sc diamond and in Si

O. Beliuskina et al., Eur. Phys. J. A (2017) 53: 32 DOI 10.1140/epja/i2017-12223-8

Summary

- Best timing and energy resolutions:

  12 ps and 2%

- PHD was studied. It is significant in diamonds and has to be taken into account.

- next:
  - to get best energy resolution
  - membrane timing/energy tests
  - dE-ToF tests

Thank you for the attention!