Tests en source du chip AlphaRad3 pour un futur dosimètre électronique neutrons

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Contexte: dosimétrie *opérationnelle* neutrons

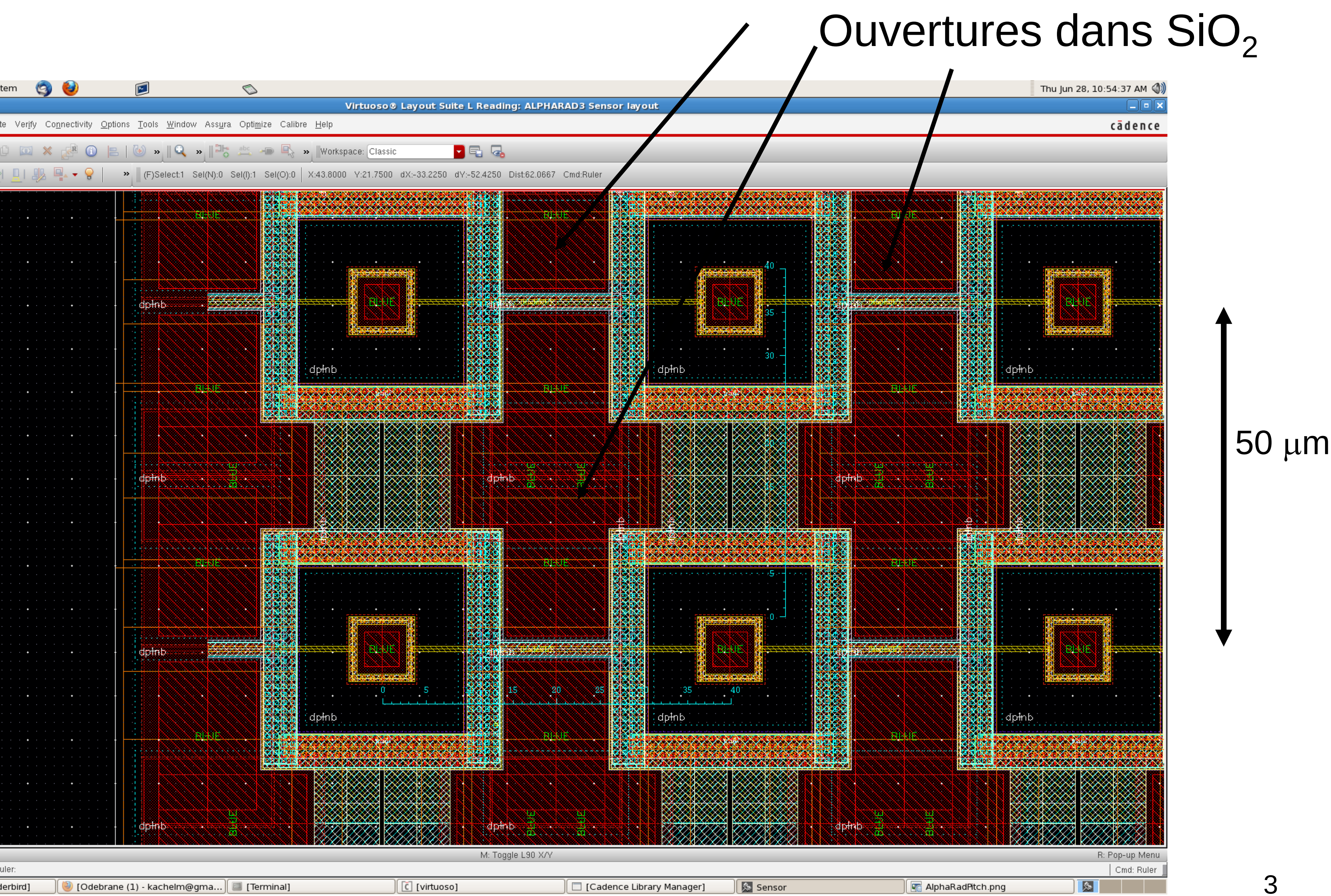
L’existant (IPHC): chips AlphaRad2 (thèse YZ)
et AlphaRad3: fenêtres dans l’oxyde !

Fait (stage A.Gallo) : tests source alpha

Reste à faire:

tests en sources n/p + simulations

Qualification

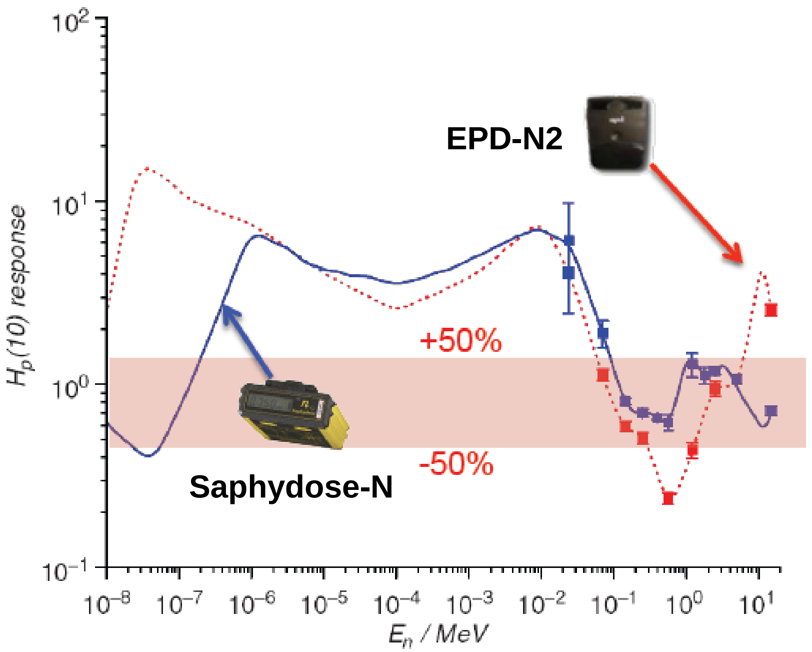

Ouvertures dans SiO_2
50 μm

- International norm IEC 1323, 1995
  → Neutron electronic dosemeters mandatory

- EVIDOS (Evaluation of Individual DOSimetry) EU survey: 2001-2005

==> 2 neutron dosemeters:

– Saphymo-IRSN: Saphydose-N (ISO)



[1] M. Reginatto et al, Rad. Prot. Dos. 125 (2007) 285-288

Electronic Personal Dosimetry

Requirements:

– Real-time + high sensitivity

(→ alarm @ 20 mSv..)

– Low P consumption → 24h portability

– Cheap (→ 65000 workers in UE)

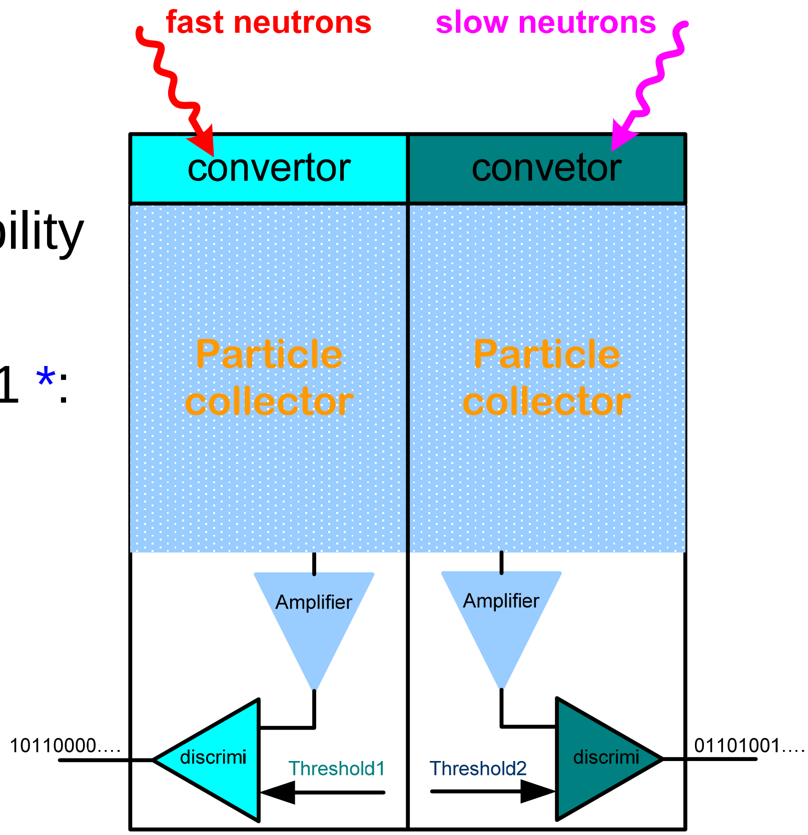
– Smartness (n/γ discrim. OK @ 1/1 *: what about 1/10 or 1/100..?)

– Growing demand:

a) UE recommandations

b) **dismantling** is just starting..

c) cyclotrons everywhere !

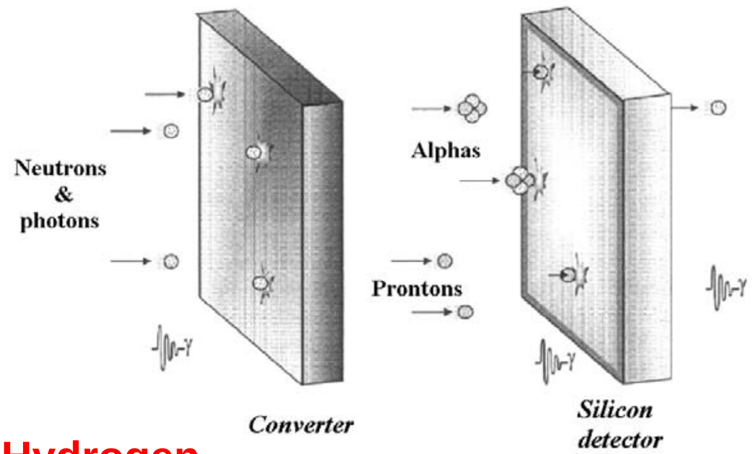


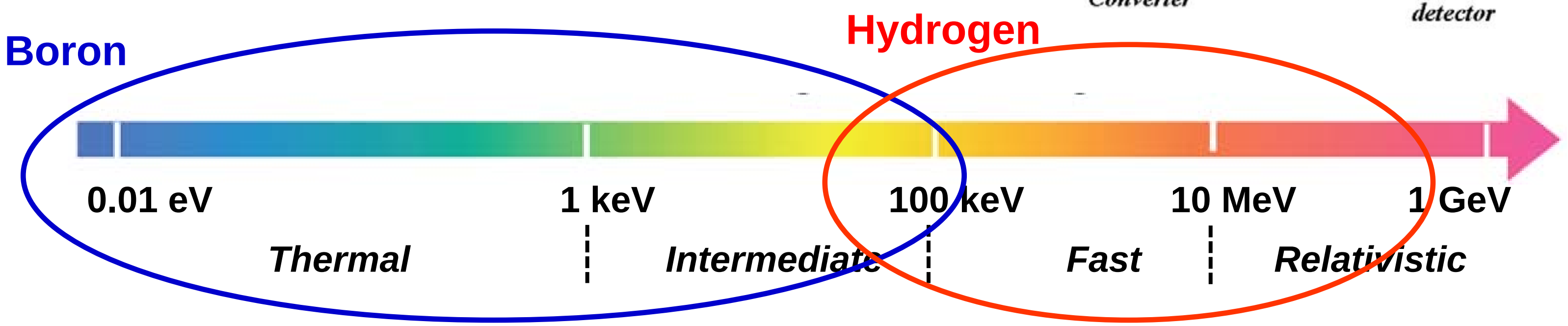
** Thèse Ying Zhang (19/09/2012)*

- **Detection of <u>charged</u> particles → neutron converters needed !**
  - Thermal neutrons: n+ $^{10}B \rightarrow {}^{7}Li + \alpha$

    Boron converter
  - Fast neutrons: n + H → n + **p**

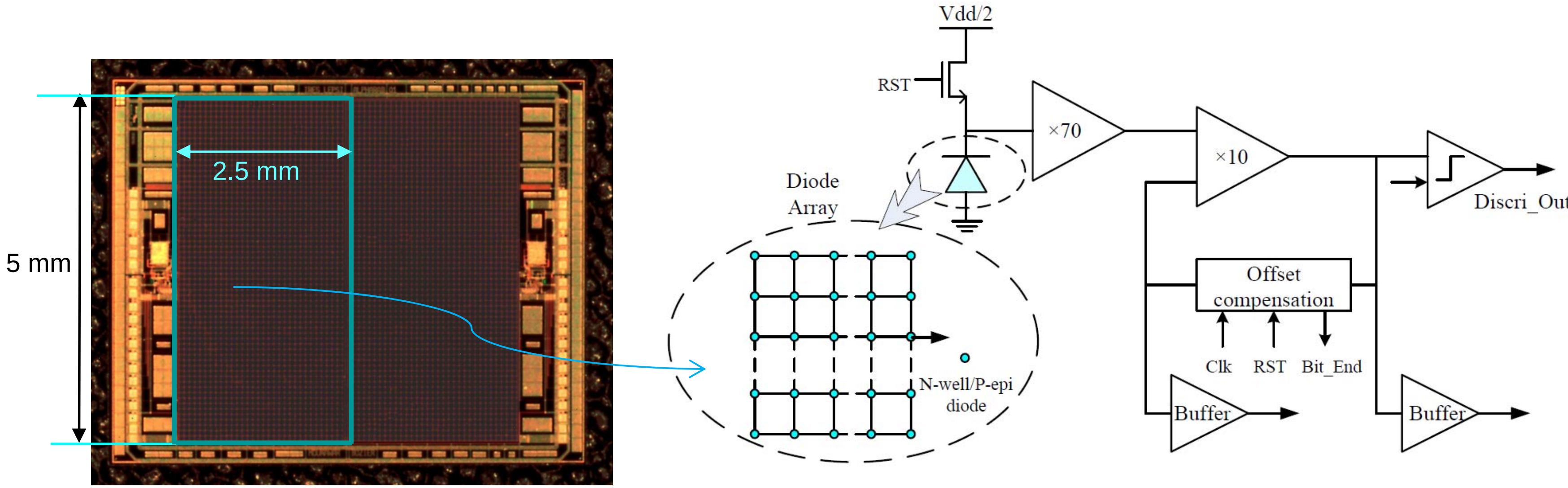
    $(CH_2)_n$ converter





- **Wide energy range → two converters of different nature**

AlphaRad1: dedicated chip for direct α detection (2006)



- 32 × 64 diodes in parallel with a single output
- High detection efficiency for 5 MeV alpha particles (~100%)

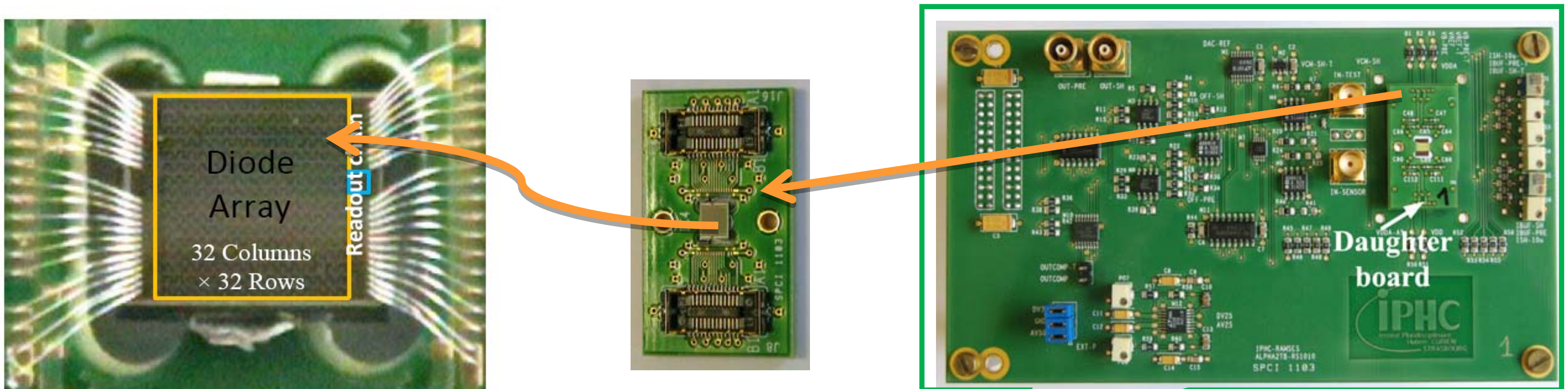
→ → Fast counting on a large area achieved <u>without</u> pixellization

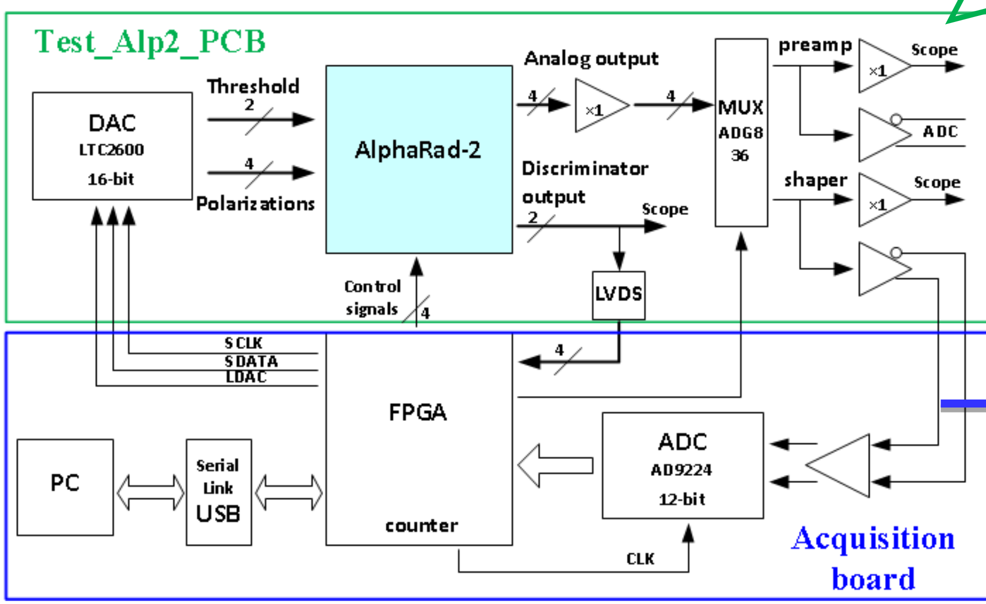
<u>Drawbacks</u>

- Equivalent noise charge (ENC) ~14 000 e^-
  - → too high for fast neutrons (threshold 50 000 e^-)
- Power consumption ~10 mW
  - → needs to be reduced !!

New chip dedicated to a neutron dosemeter

AlphaRad2 (2012): P< 1 mW !





Test options:

–Oscilloscope

–ADC outputs

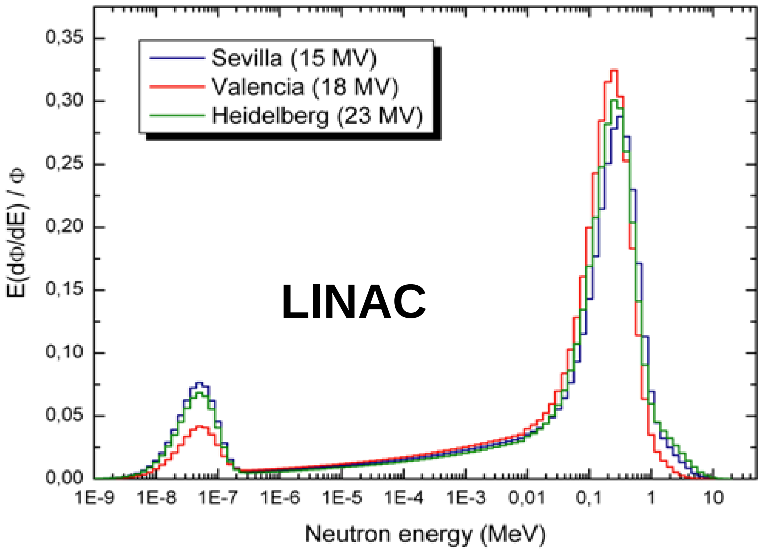
Digitalize analog signals
(output of CSA/shaper)

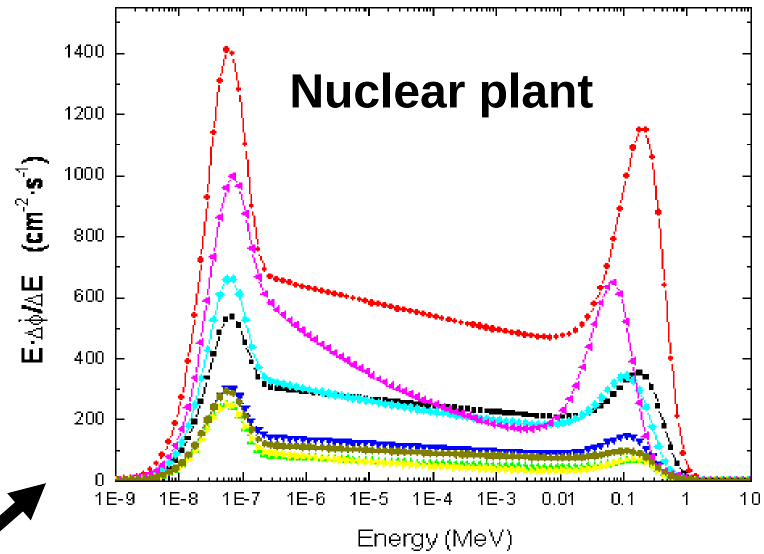
Experimental tests (LMDN Cadarache)

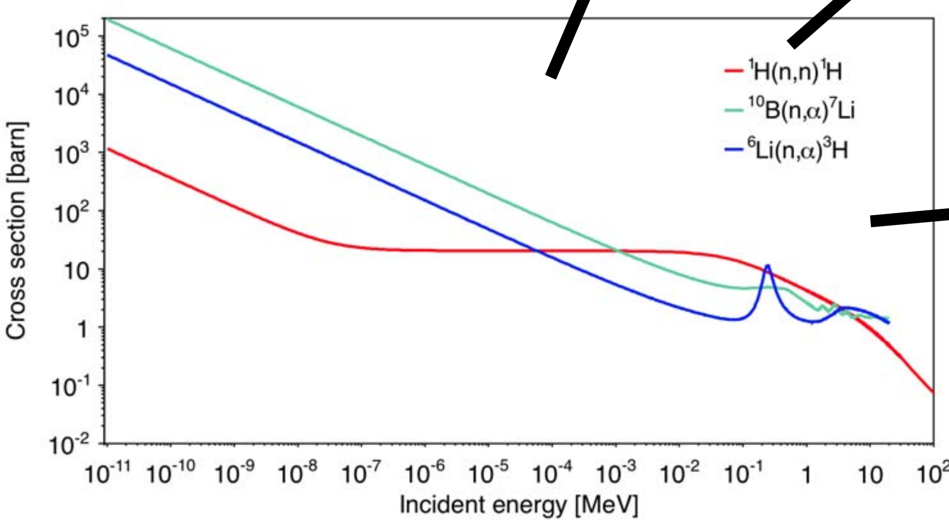
Van Gogh: AmBe source , A = 370 GBq

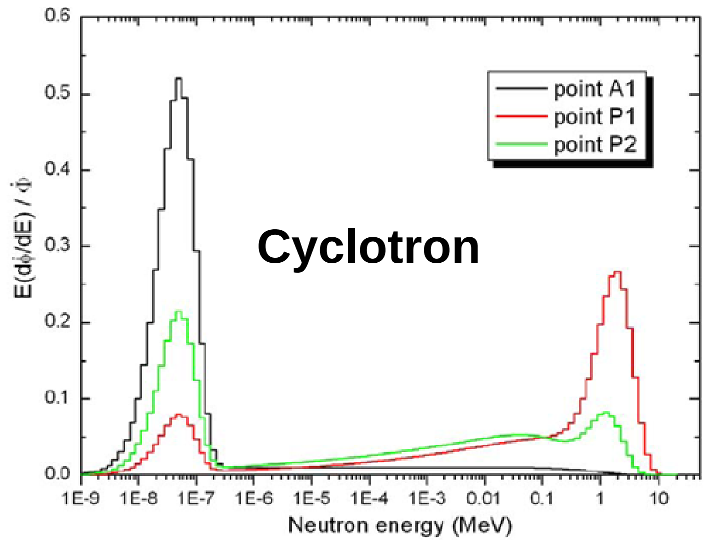
Fast n + γ 4.438 MeV, fluences well defined(4%)

AMANDE facility : mono-E neutrons
(3 keV-20 MeV)


LINAC
Sevilla (15 MV)
Valencia (18 MV)
Heidelberg (23 MV)
E(dΦ/dE) / Φ
Neutron energy (MeV)
0,00
0,05
0,10
0,15
0,20
0,25
0,30
0,35
1E-9 1E-8 1E-7 1E-6 1E-5 1E-4 1E-3 0,01 0,1 1 10


Nuclear plant
E·Δφ̇/ΔE (cm⁻²·s⁻¹)
Energy (MeV)
0
200
400
600
800
1000
1200
1400
1E-9 1E-8 1E-7 1E-6 1E-5 1E-4 1E-3 0.01 0.1 1 10

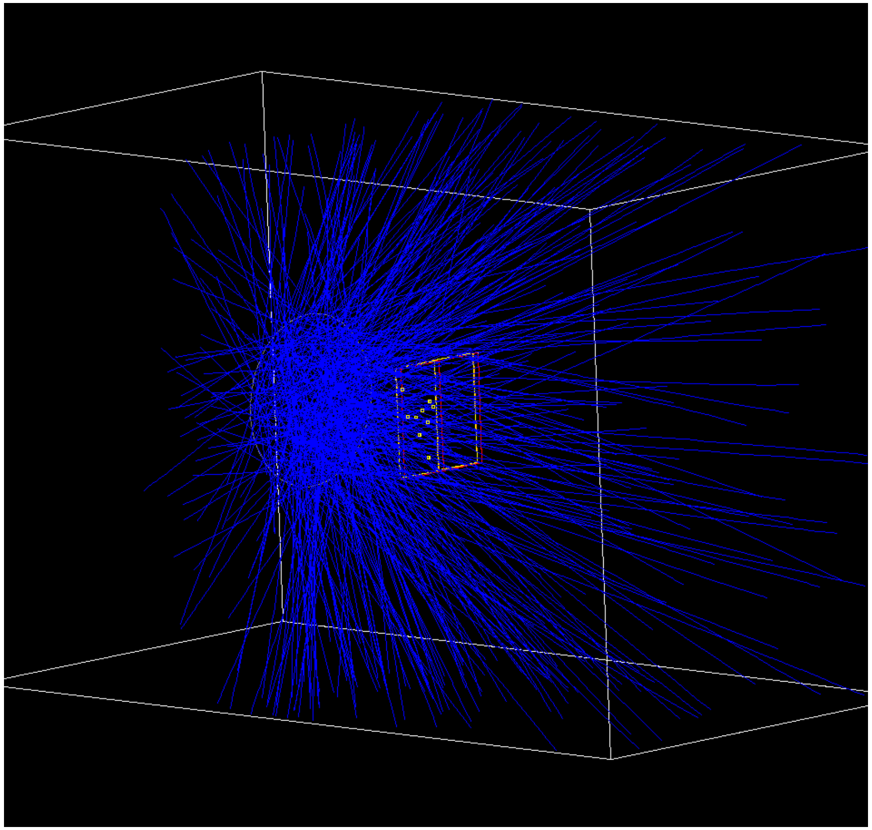

1H(n,n)1H
10B(n,α)7Li
6Li(n,α)3H
Cross section [barn]
Incident energy [MeV]
10^5
10^4
10^3
10^2
10
1
10^-1
10^-2
10^-11 10^-10 10^-9 10^-8 10^-7 10^-6 10^-5 10^-4 10^-3 10^-2 10^-1 1 10 10^2


Cyclotron
point A1
point P1
point P2
E(dφ̇/dE) / φ̇
Neutron energy (MeV)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
1E-9 1E-8 1E-7 1E-6 1E-5 1E-4 1E-3 0.01 0.1 1 10

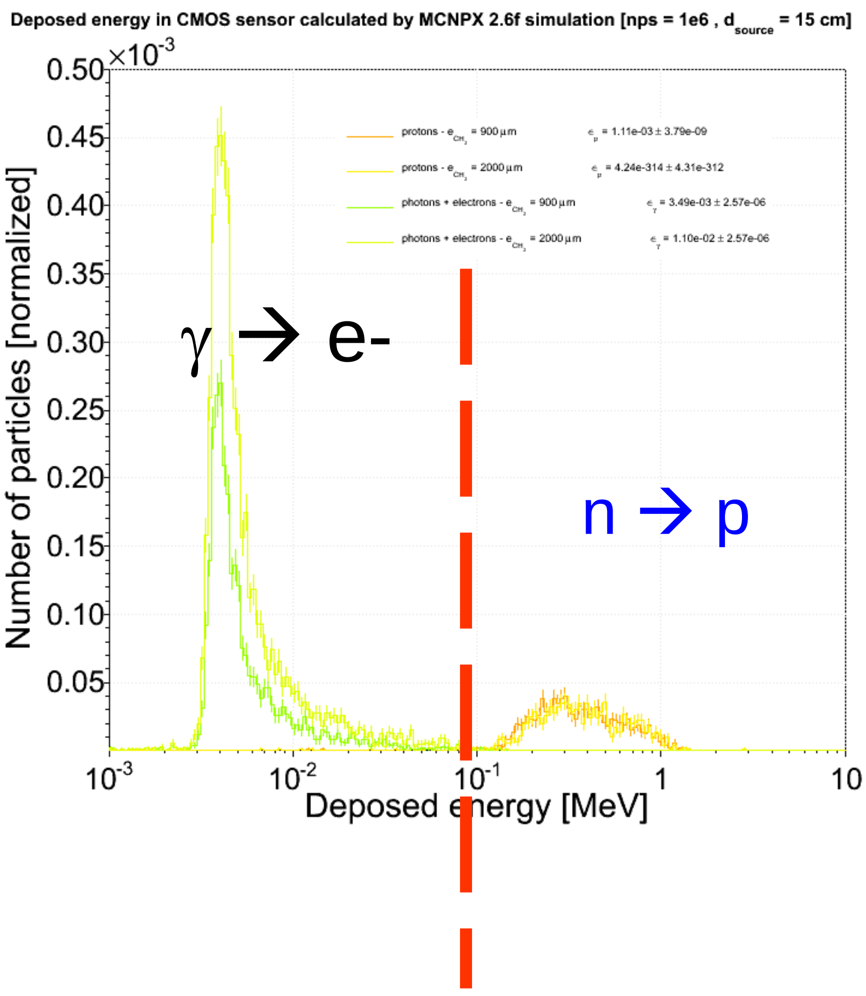
Outils

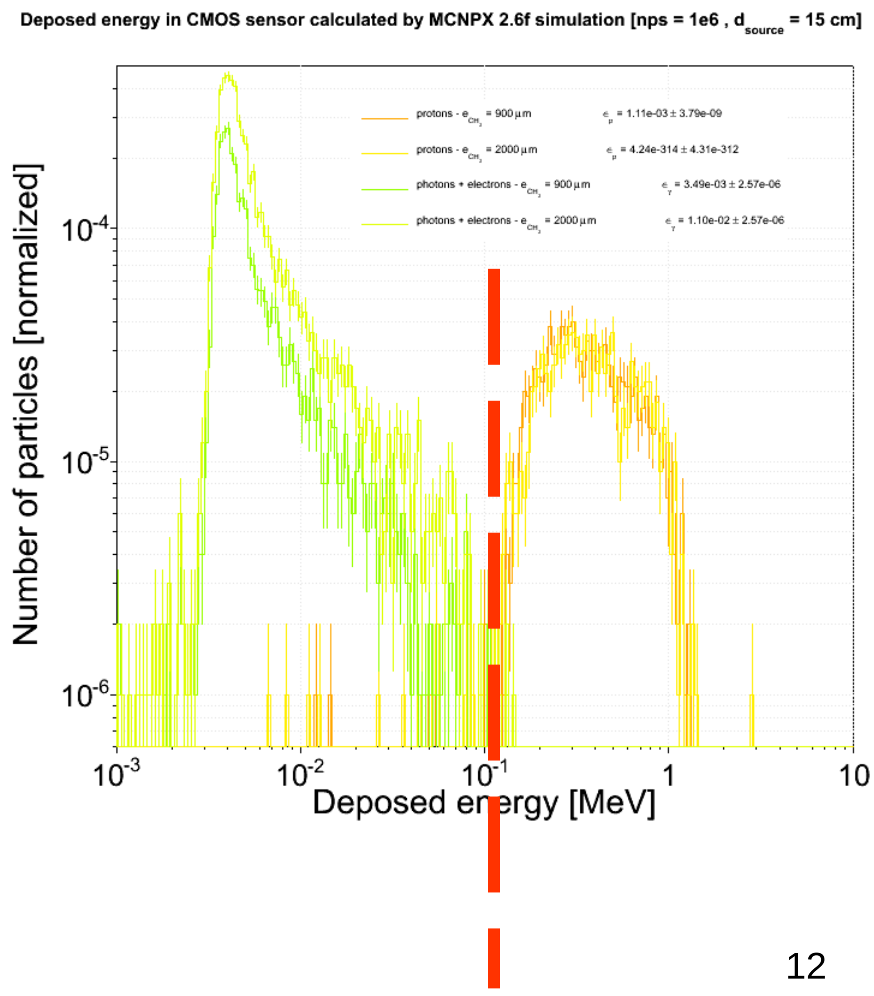
- <u>Hard/soft:</u>
  * table XYZ ~μm
  * acq Labview

- <u>Simulations</u>
  * GEANT IV
  * MCNPX



Discrimination n/γ : Simulations…

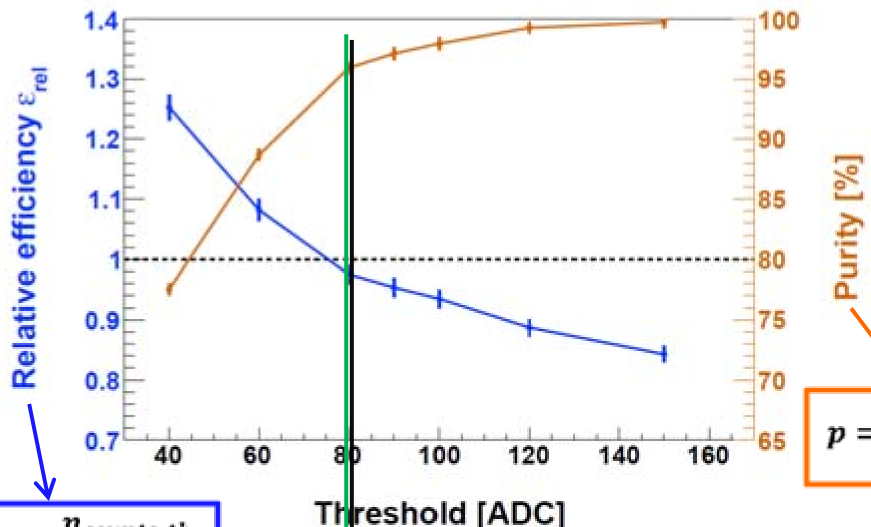




…and real life !

- AmBe source, d = 20 cm
- 310-min exposure
- 500 µm-thick $(CH_2)_n$ converter

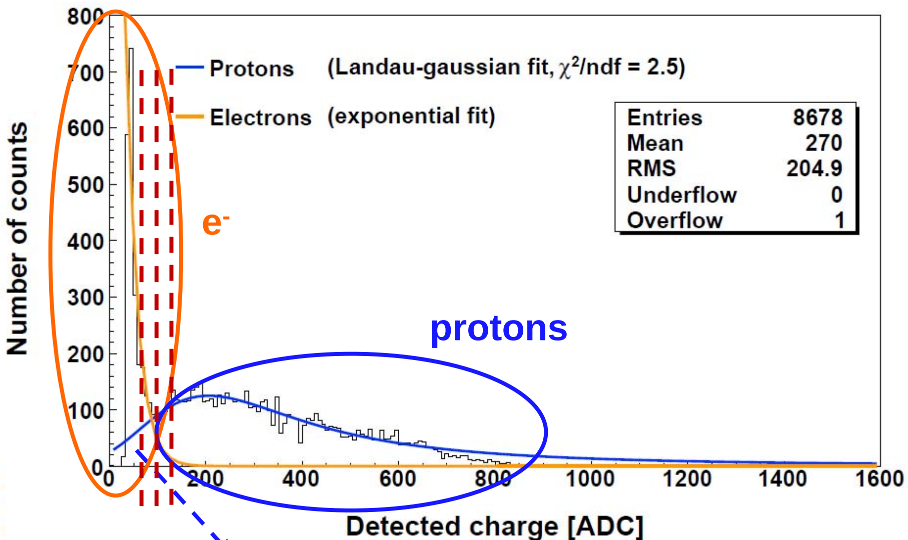
→ Threshold for n/γ discrimination



$$\varepsilon_{rel} = \frac{n_{counts\_th}}{n_{protons}}$$

$$p = 1 - \frac{n_{electrons}}{n_{counts\_th}}$$

Q > 80 ADC ➡ High eff. + good purity



Extrapolation of protons in γ-peak

80 ADC

$$\varepsilon_{int} = \frac{n_{det.protons}}{n_{neutrons}}$$

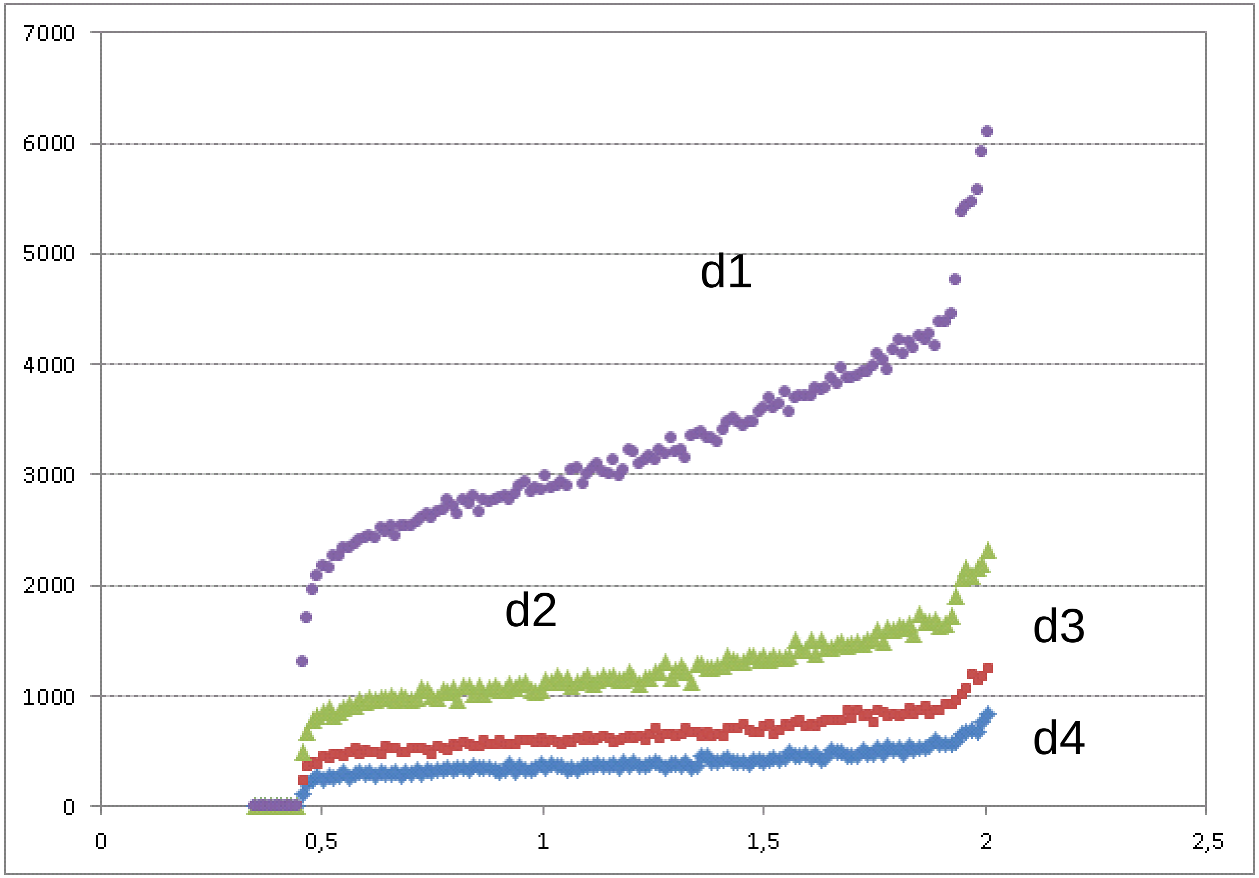
$$\varepsilon_{int} = (7.24 \pm 0.32^{*}) \times 10^{-4}$$

*statistical & source uncertainties

Programme de travail

- Système complet portatif et autonome =PCB: 4 chips + 2 types convert.: ready ! (mars 2013)
- Réponse raies mono-E (α puis n) ((et même p!))
- Réponse sur spectres étendus
- Réponse angulaire (if dosim.perso)
- Influence n lents diffusés → *Fantômes anthropom.*
- Discri n / γ dans combinaisons artificielles de sources mixtes (1/10, 1/100, 1/1000)
- Influence T°; radhardness; blindage EM, …

Stage M2 A.Gallo (2014)



Taux comptage

V_{seuil}

Efficacité circuit AlphaRad3 aux α de 5.5 MeV