Caractérisation et Qualification d’un Dosimètre Personnel Électronique Neutrons

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Contexte: dosimétrie opérationnelle N

L’existant (IPHC): chips AlphaRad2 et 3

Ce qui reste à faire:

a) système complet

b) tests en sources + simulations

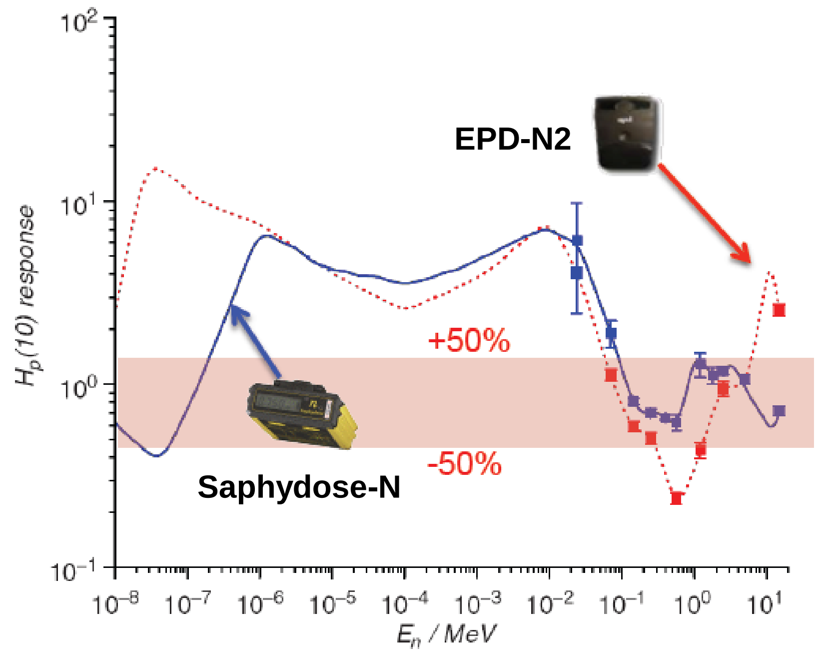
Qualification

- 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

<u>Requirements:</u>

– Real-time + high sensitivity

(→ alarm @ 20 mSv..)

– Low P consumption → 24h portability

– Cheap (→ 65000 workers in UE)

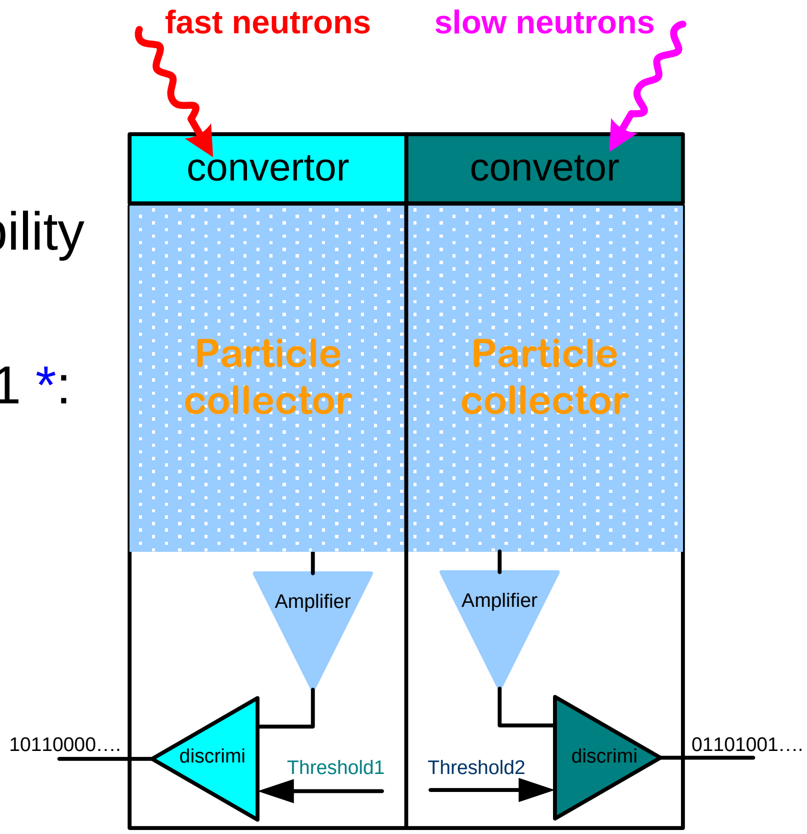
– Smartness (n/γ discrim. OK @ 1/1 *: what about 1/10 or 1/100..?)

– Growing demand:

a) UE recommandations

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

c) cyclotrons everywhere !

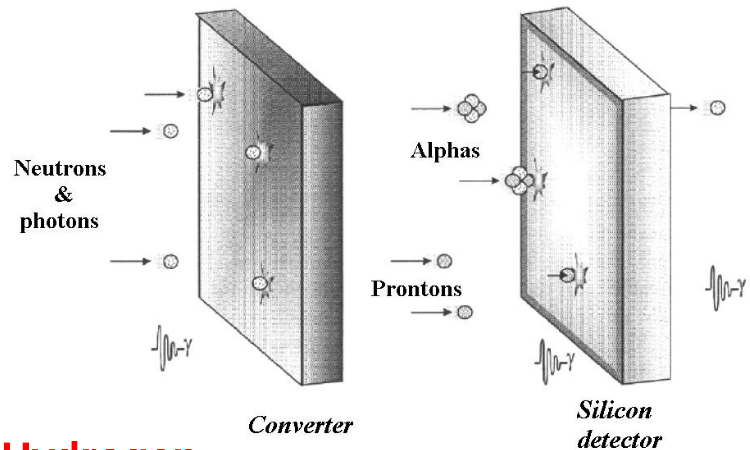


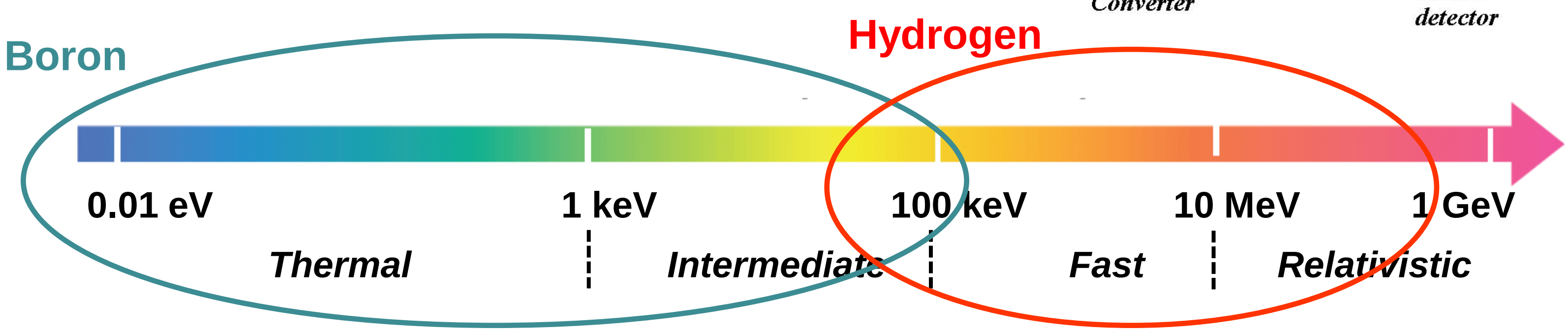
<u> Thèse Ying Zhang (19/09/2012)</u>*

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

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

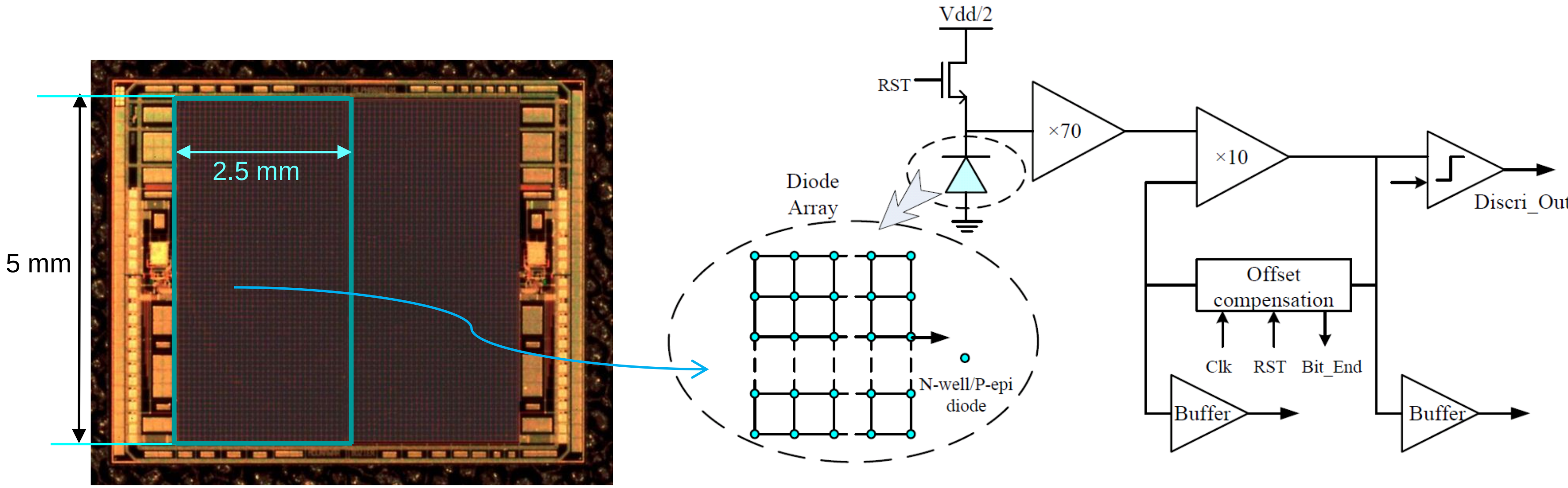
    $(CH_2)_n$ converter





- **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%)

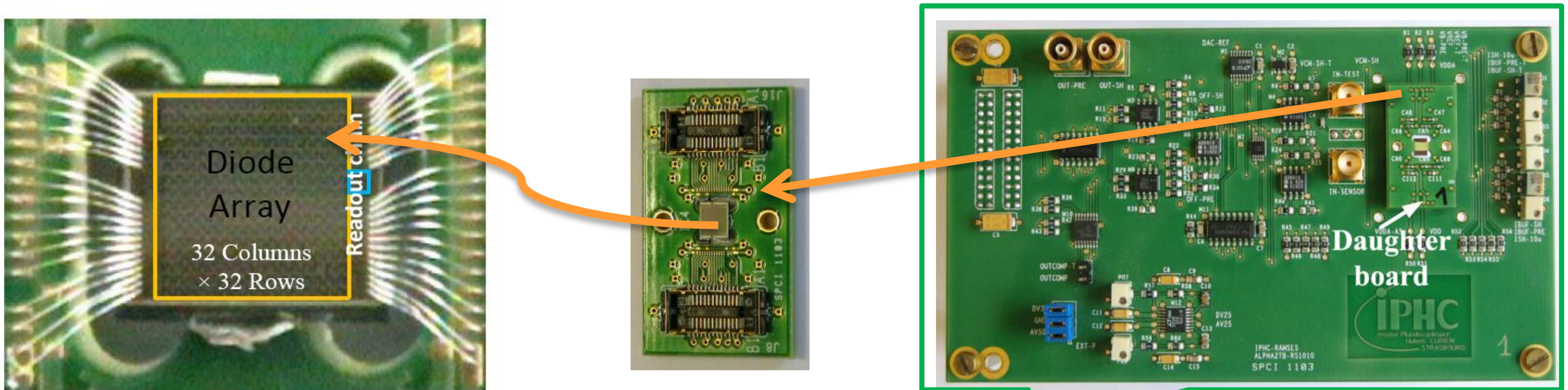
→ → Fast counting on a large area achieved <u>without</u> pixellization

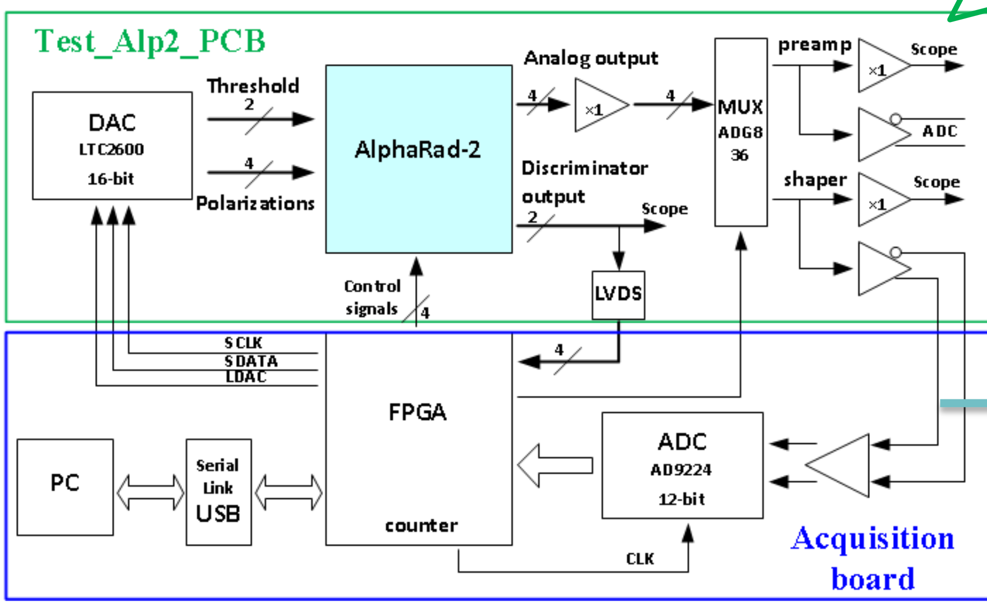
<u>Drawbacks</u>

- 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)





Test options:

- Oscilloscope
- ADC outputs

Digitalize analog signals
(output of CSA/shaper)

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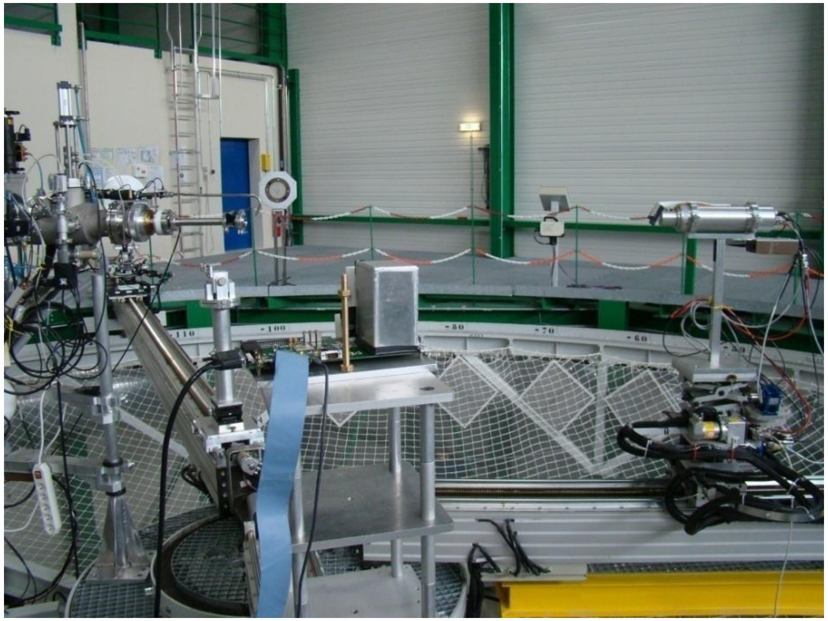
Experimental tests (LMDN Cadarache)

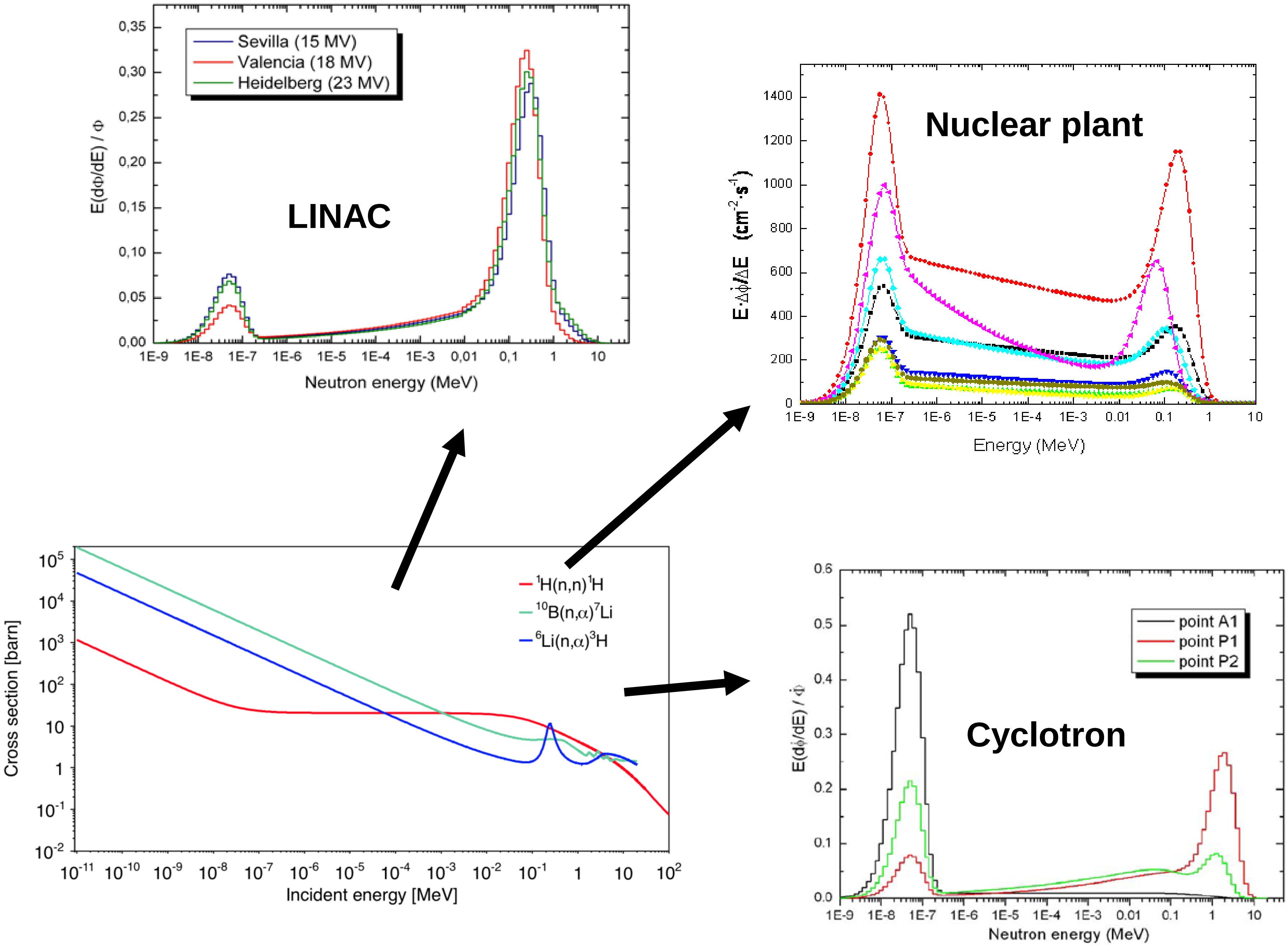
Van Gogh: AmBe source , A = 370 GBq

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

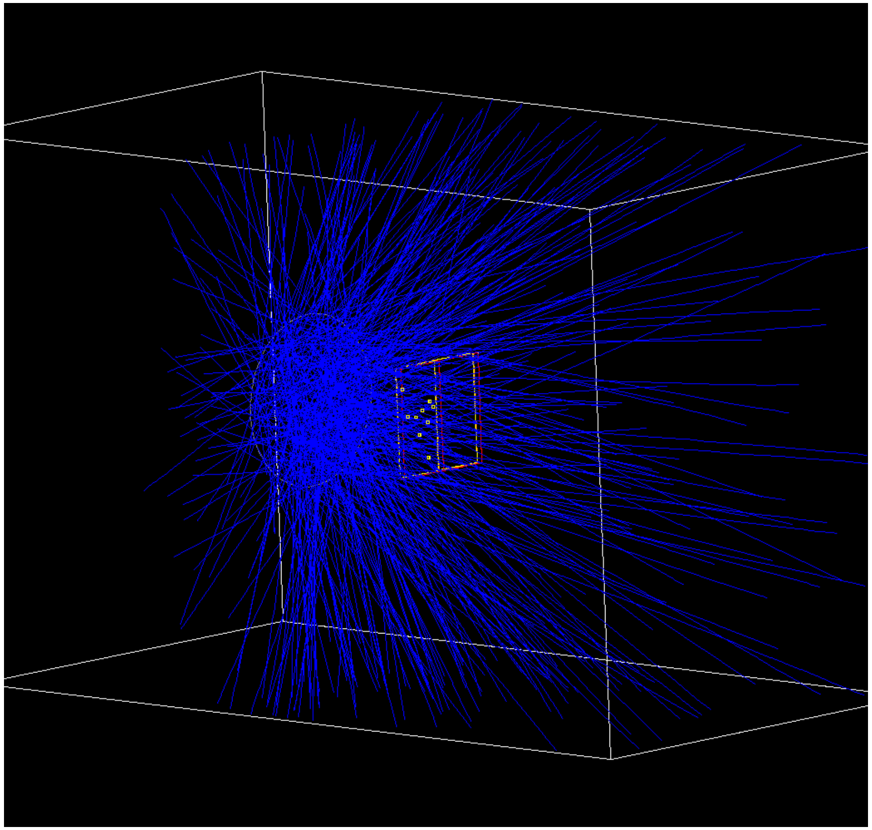
AMANDE facility : mono-E neutrons
(3 keV-20 MeV)



detector source


LINAC
Sevilla (15 MV)
Valencia (18 MV)
Heidelberg (23 MV)
E(dΦ/dE) / Φ
Neutron energy (MeV)
Nuclear plant
E·Δφ̇/ΔE (cm⁻²·s⁻¹)
Energy (MeV)
¹H(n,n)¹H
¹⁰B(n,α)⁷Li
⁶Li(n,α)³H
Cross section [barn]
Incident energy [MeV]
Cyclotron
point A1
point P1
point P2
E(dφ̇/dE) / φ̇
Neutron energy (MeV)

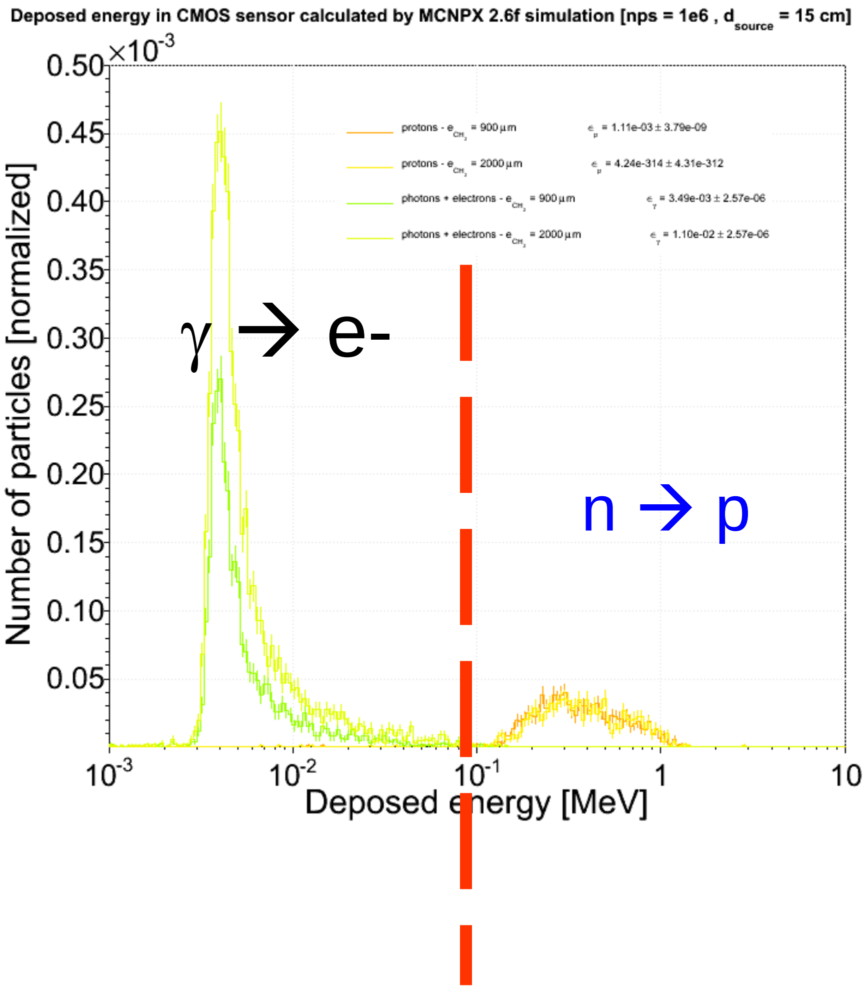
Simulation

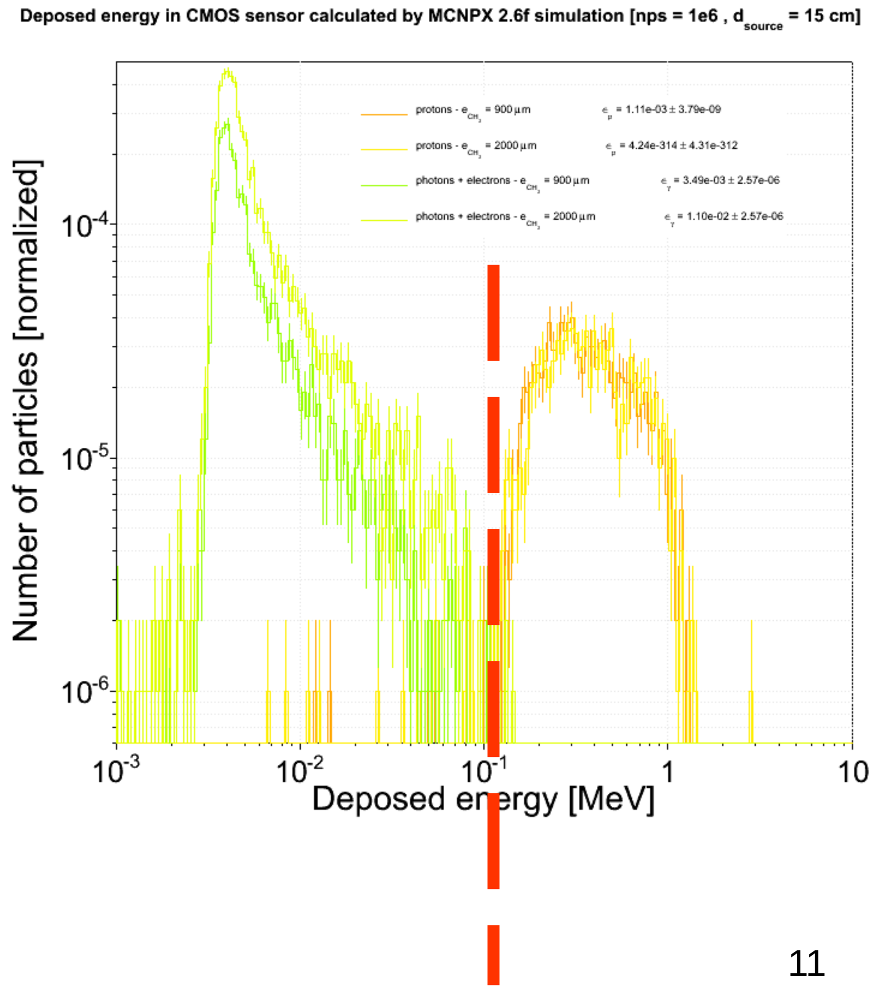


- GEANT IV

- MCNPX

Discrimination n/γ : Simulations…

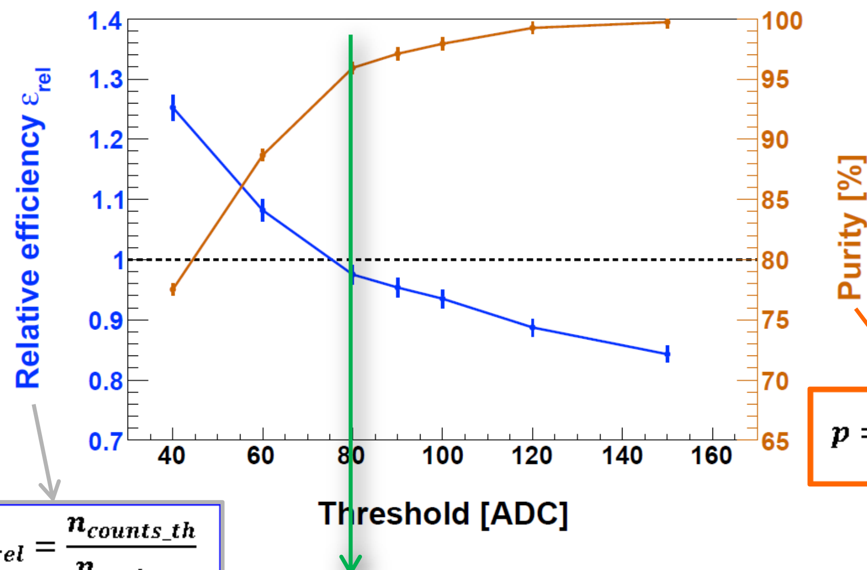




…and real life !

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

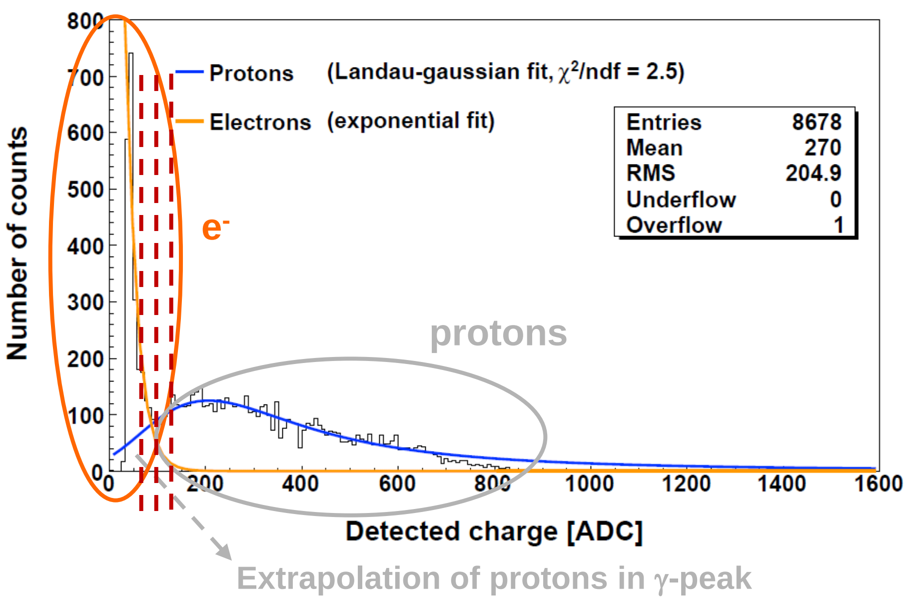
→ **Threshold for n/γ discrimination**



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

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

Q > 80 ADC ➡ High eff. + good purity



80 ADC

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

ε_{int} = (7.24 ± 0.32*)×10^{-4}

*statistical & source uncertainties

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Programme de travail

- Système complet portatif / autonome (PCB: 4 chips + 2 conv.) prêt au printemps 2013
- Réponse sur raies mono-E
- Réponse sur spectres étendus
- Réponse angulaire
- 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, …