

NEDENSAA

Catania, February 20th, 2013

Development of new materials

→ strong interaction between **physicists** and **chemists**

France

Strasbourg :

- IPHC
- IPCMS

L. Stuttgé et al
L. Douce, E. Bouajila et al

Caen :

- LPC
- LCMT

F. Delaunay et al
T.-N. Pham et al

Saclay :

- CEA

M. Hamel et al

Italy

Legnaro :

- LNL

A. Quaranta et al

country	institution	site	laboratory	number of people	
				physicists	chemists
F	CNRS	Strasbourg	IPHC	1	
			IPCMS		3
	CEA	Caen	LPC	1	
			LCMT		2
I	INFN	Saclay	LCAE	1	1
	INFN	Legnaro	LNL*	2	
		total		5	6

*: 1 postdoc funded by NEDENSAA

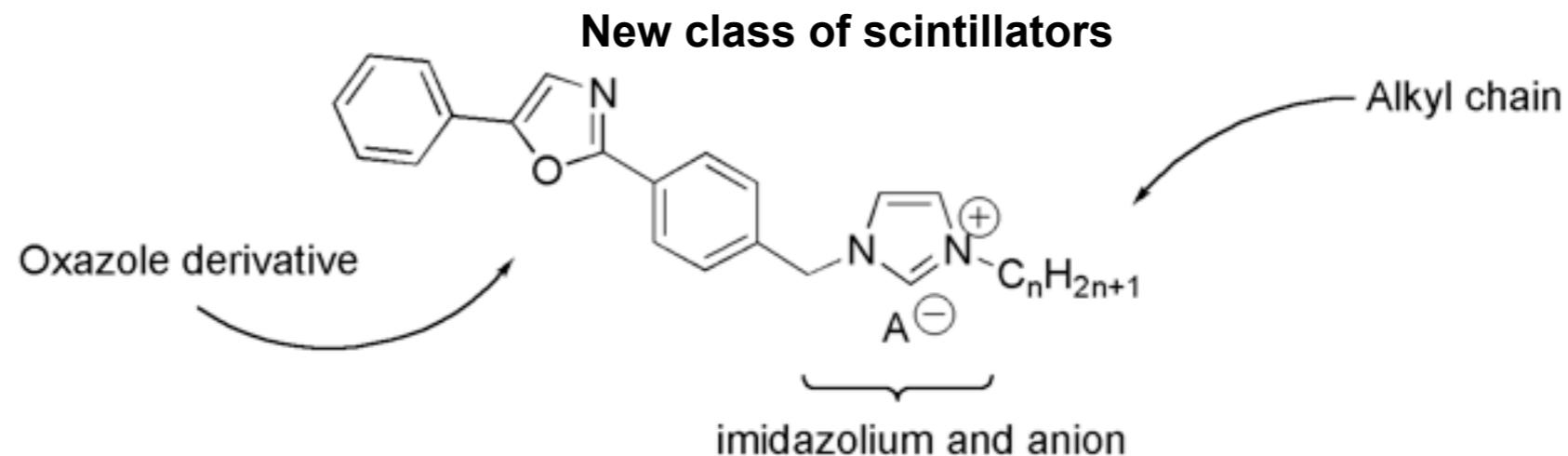
objective:

- develop a new material for neutron detection
 - solid → usable under vacuum
shape and dimensions adaptable to need
 - performances ≥ existing detectors: n/γ discrimination, intrinsic efficiency, energy resolution, ...

1- Investigation in Strasbourg

IPCMS → synthesis of new components based on organic ionic compounds

L. Douce, E. Bouajila (postdoctoral fellow), J. Fouchet (PhD)



advantage of ionic compounds:

- excellent thermal and chemical stability
- non flammable, non volatile → usable under vacuum
- possible act on the properties of the ionic liquid by changing:
 - anion
 - alkyl chain (length)

IPHC → characterisation of new components

L. Stuttgé

pulse shape analysis → n-γ discrimination

tof in coincidence measurements → energy range of detected neutrons

2- Investigation in Caen

LCMT → polymer chemistry

T.-N. Pham, F. Alix (postdoctoral fellow)

- ⇒ definition and synthesis of candidate materials
- ⇒ temporal stability of materials (transparency, deformation)
- ⇒ techniques of fluophore incorporation

LPC → characterisation of new components

F. Delaunay

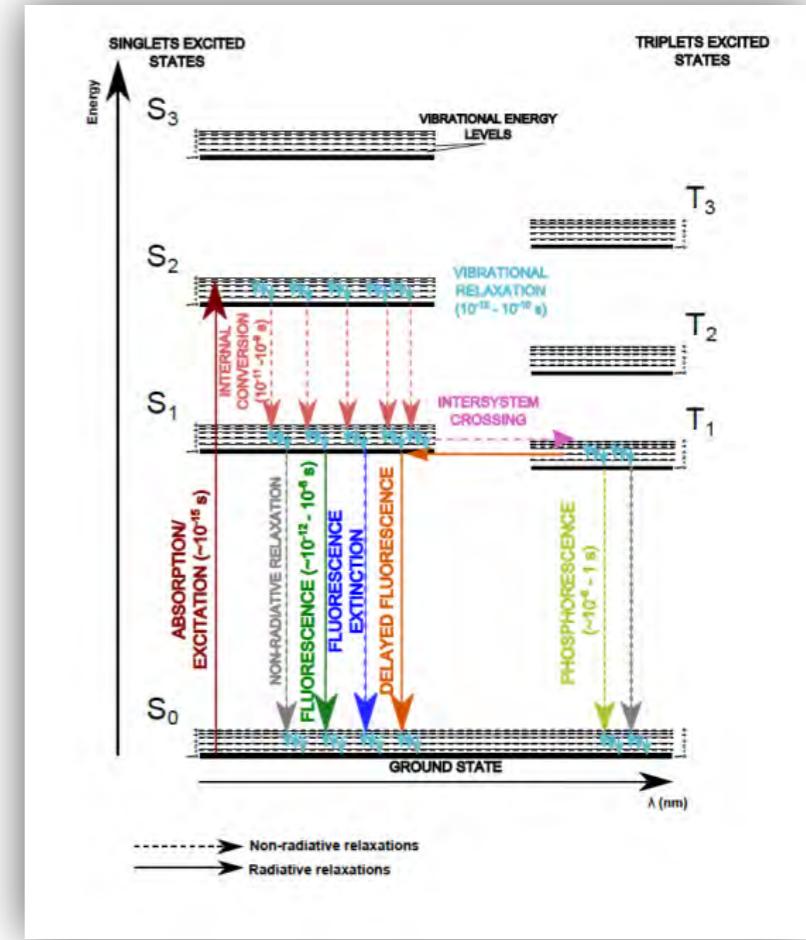
- ⇒ characterisation of samples: scintillation, discrimination
- ⇒ scintillation and discrimination mechanisms

3- Investigation in Saclay

→ fundamental research

P. Blanc, PhD thesis in photo-physics

- ⇒ structure/activity relationship
- ⇒ energy transfers
- ⇒ theory on scintillation
- ⇒ triplet-triplet annihilation
- ⇒ optical and nuclear measurements



→ new materials

M. Hamel, PhD in organic chemistry

- ⇒ development of new scintillators
- ⇒ chemical modifications
- ⇒ fluorescence tests

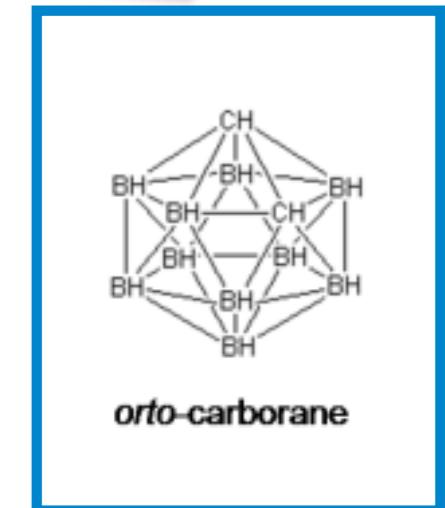
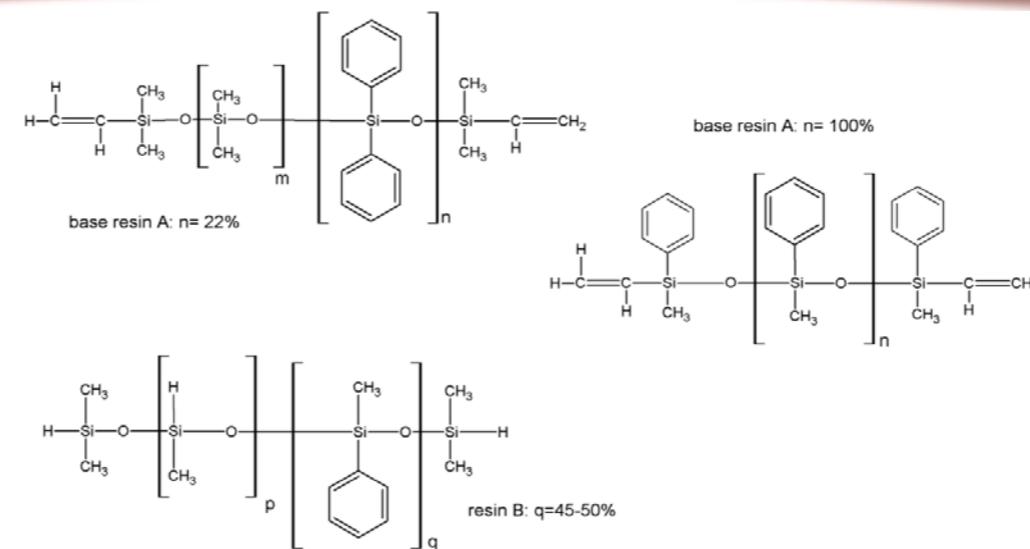
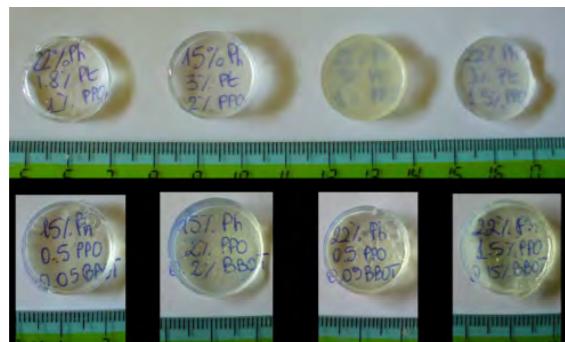


4- Investigation in Legnaro

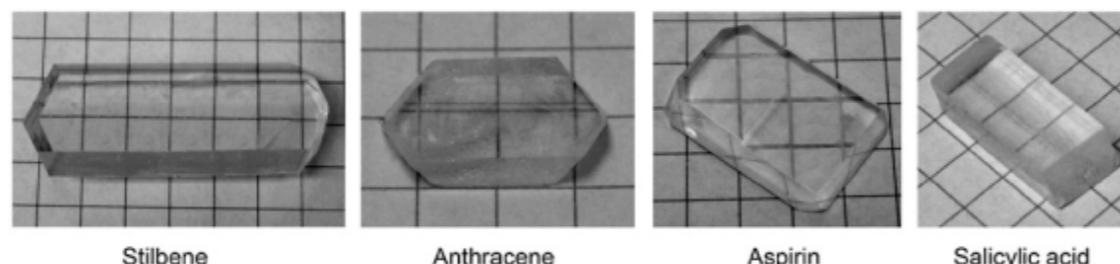
A.Quaranta, L. Jordan

→ polysiloxane based scintillators

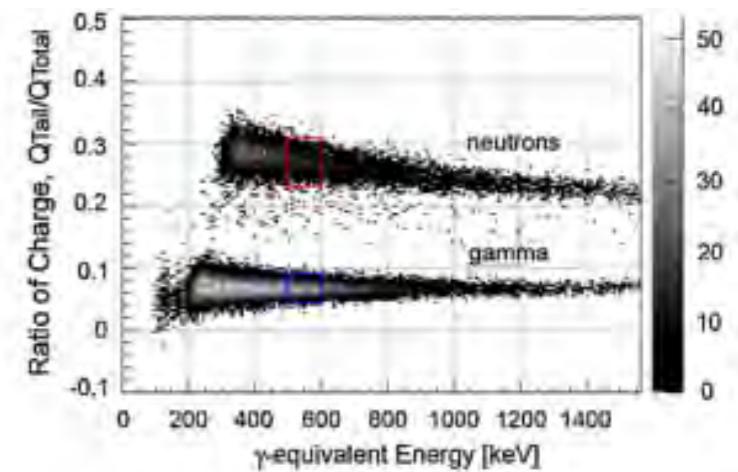
- wide temperature range of stability
- easy to handle → large volumes available
shapes tailored by the vessel
- high radiation hardness
- fluorescent dyes for activating the scintillation mechanism
- orto-carborane for boron enrichment



→ organic single crystal scintillators for n-γ discrimination



N. Zaitseva et al, J. Crystal Growth, 314 (2011) 163



tasks of WG1

task 1: synthesis and characterisation with sources :
light production, time constants, neutron-γ discrimination

.... 2012

task 2: tests under monoenergetic neutron beams to characterise
efficiency, energy and time resolution, resistance against radiations

.... 2013

task 3: prototype including detector + electronics and data acquisition

.... 2014

1 - Investigation in Strasbourg

→ synthesis of new components based on ionic liquids

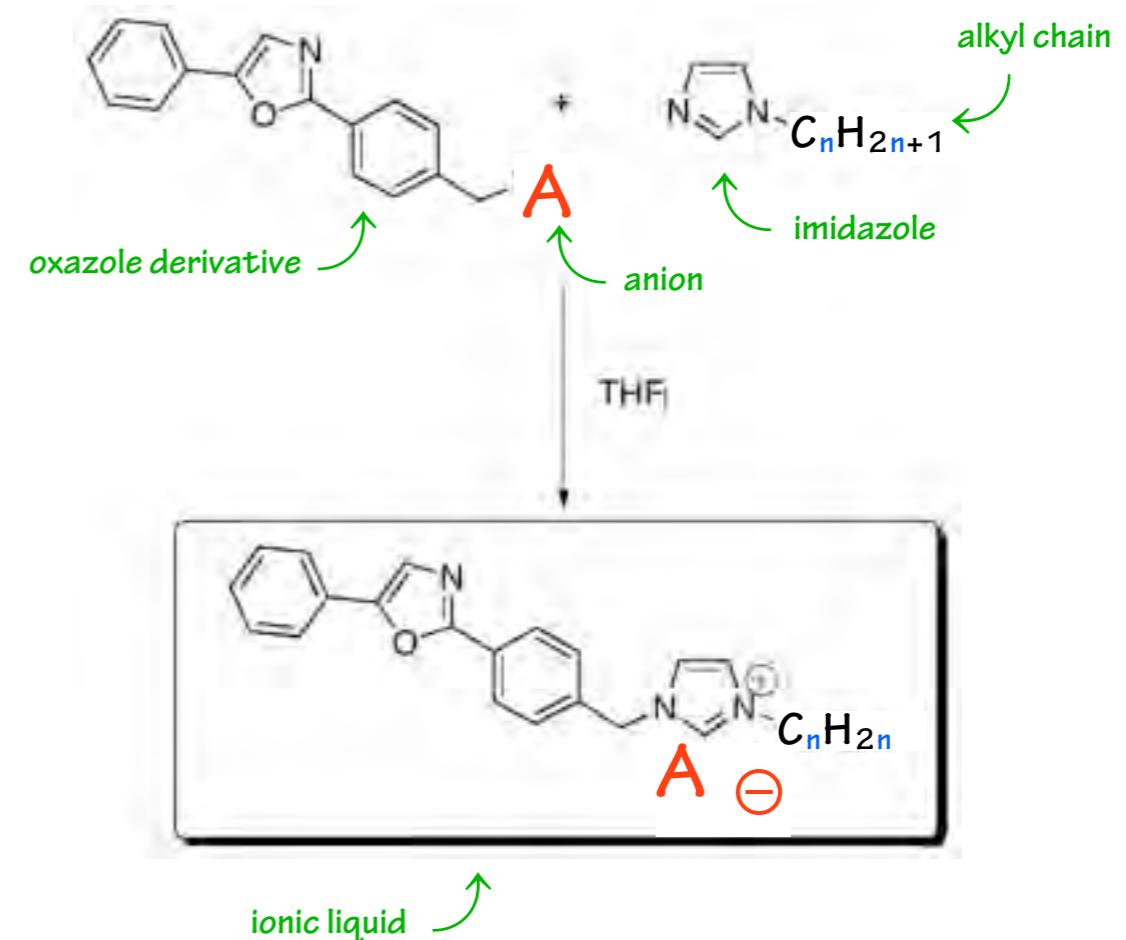
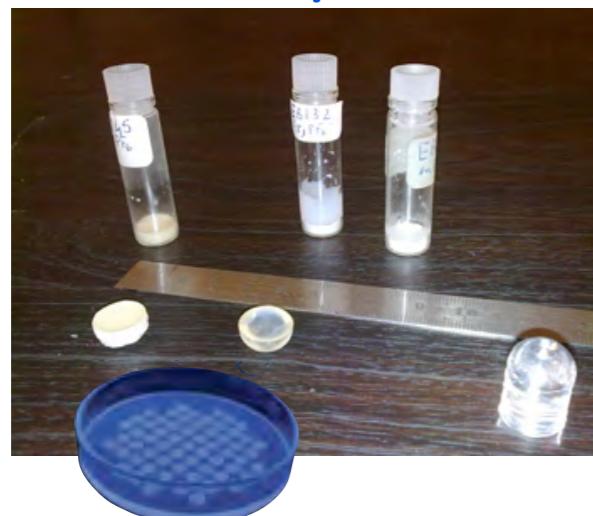
L. Douce, E. Bouajila, L. Stuttgé et al

problem:

- discriminating components not transparent
- transparent components not discriminating

→ ... !!!???

new components



$n = 8, \dots, 16$

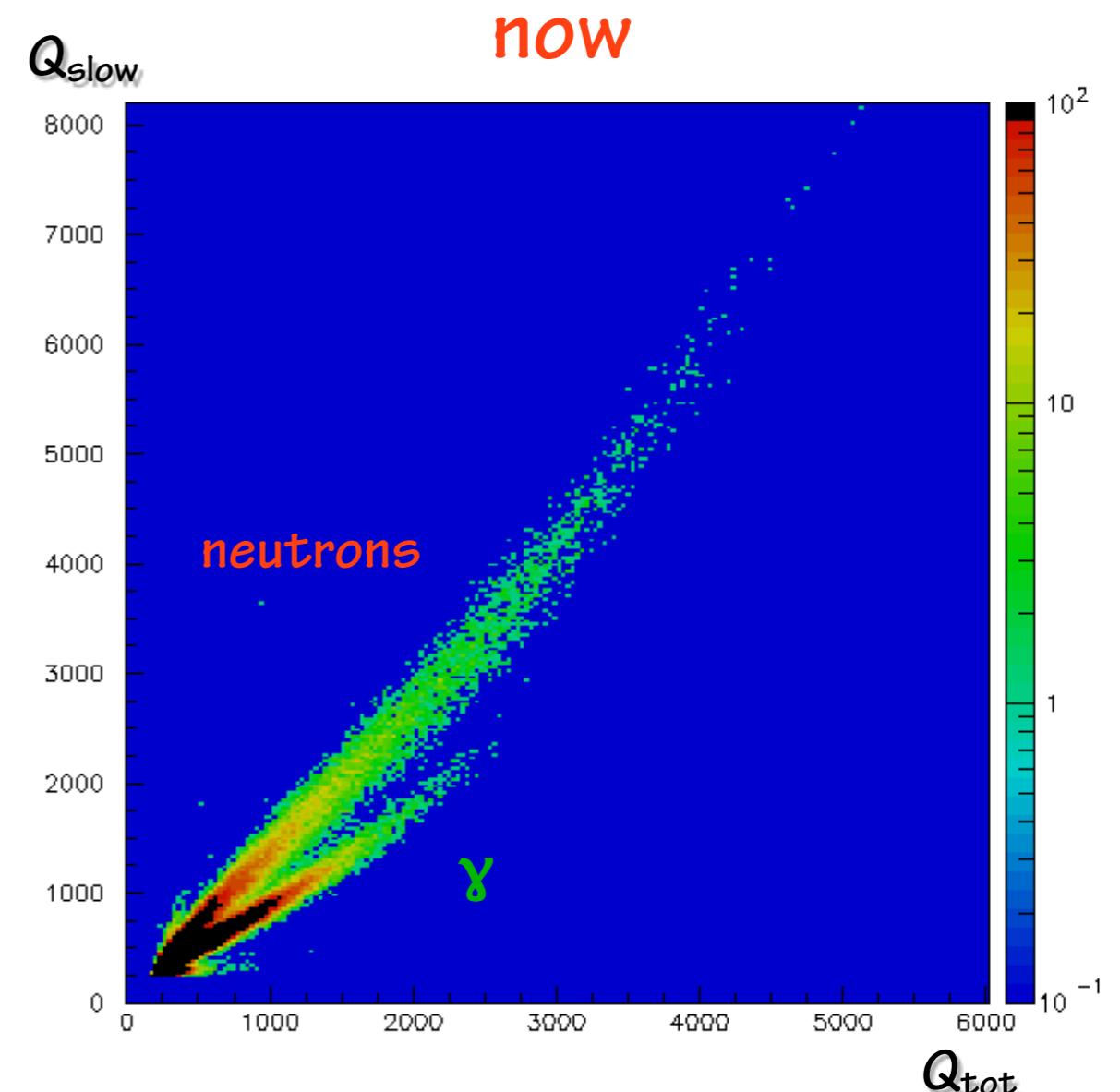
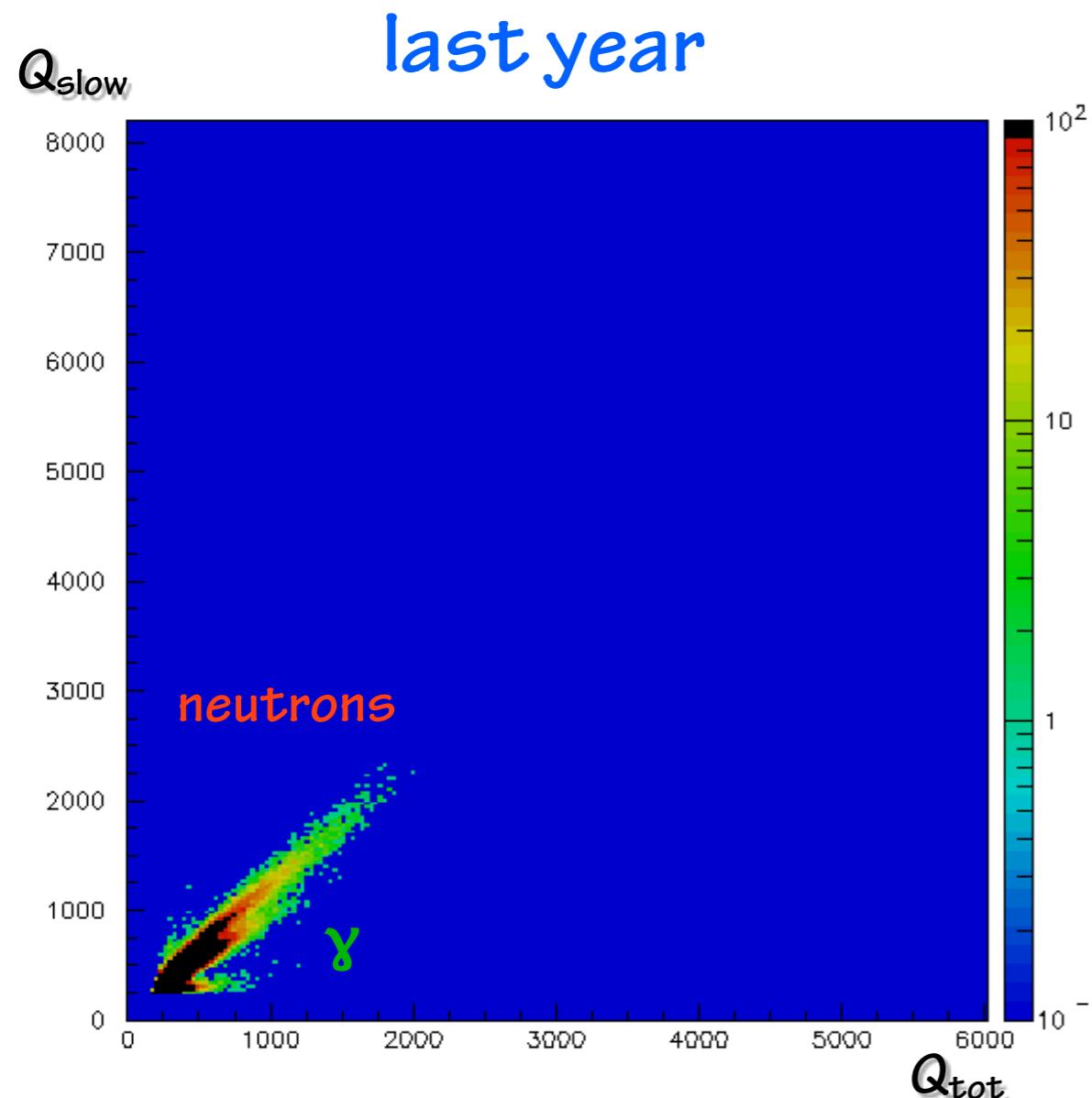
A: Br

Br → PF_6^- , TFSI^- , SO_4^{2-} , ...

1- Investigation in Strasbourg

→ synthesis of new components based on ionic liquids

L. Douce, E. Bouajila, J. Fouchet, L. Stuttgé et al



problem:

component «less opaque»

... but still not transparent

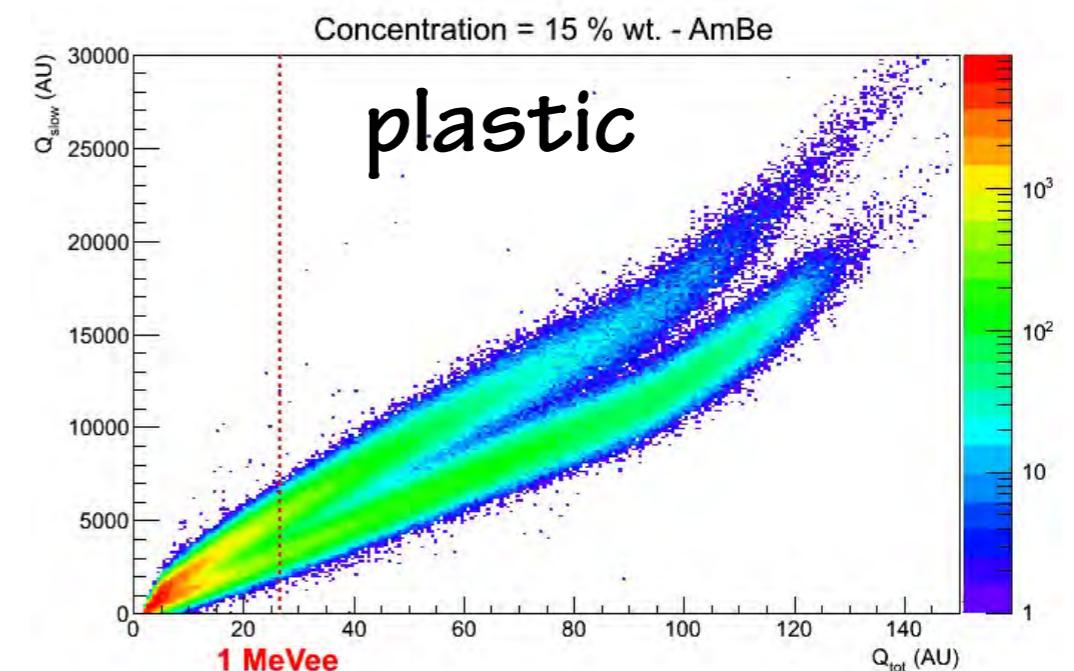
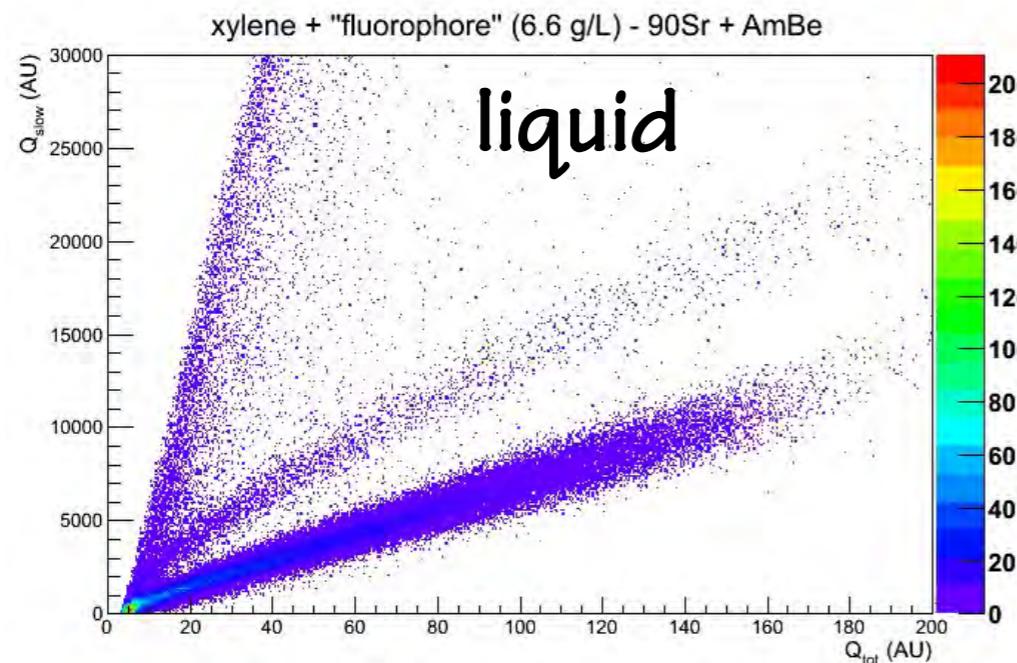
→ keep working ... some tracks

→ polymer chemistry

T.-N. Pham, F. Alix, F. Delaunay et al

in 2012: Search for alternative scintillator compositions

- Fluorophore with previously unreported discrimination properties
(in liquids and in plastics)



Behaviour in plastics consistent with results from Zaitseva et al

3- Investigation in Saclay

- photophysical comprehension
- chemistry of materials

P. Blanc, M. Hamel et al

- first observation of triplet states in a liquid scintillator using laser activation

- stabilization of the polymer matrix for scale up purpose
- biggest plastic scintillator obtained: $\varnothing=10.3\text{ cm}$ $h=11.4\text{ cm}$ ($4'' \times 4.5''$)

4- Investigation in Legnaro



A. Quaranta, L. Jordan et al

→ Alberto Quaranta will tell you tomorrow ...

NEDENSAA

Catania, February 21th, 2013

NEDENSAA - WG1

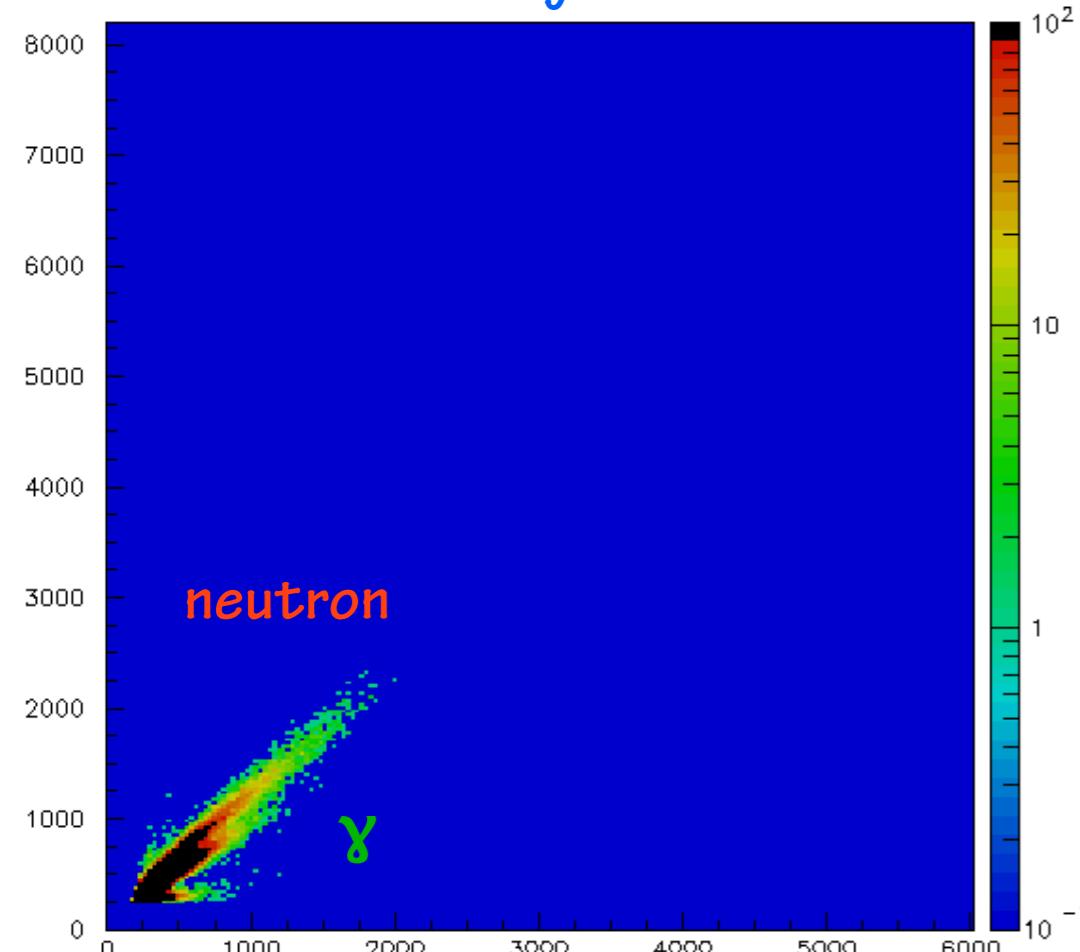
Development of new materials

→ synthesis of new components based on ionic liquids

L. Douce, E. Bouajila, J. Fouchet, L. Stuttgé et al

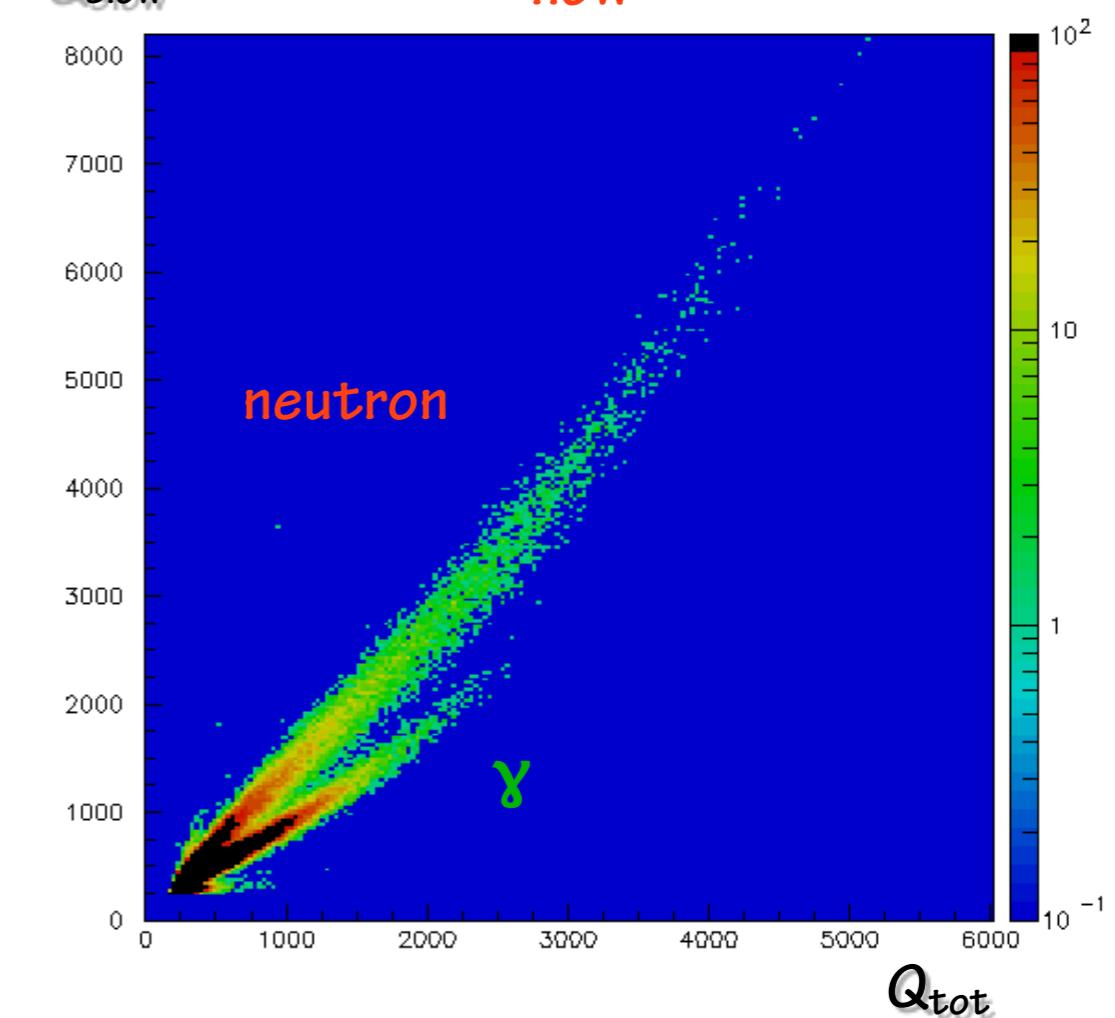
Q_{slow}

last year

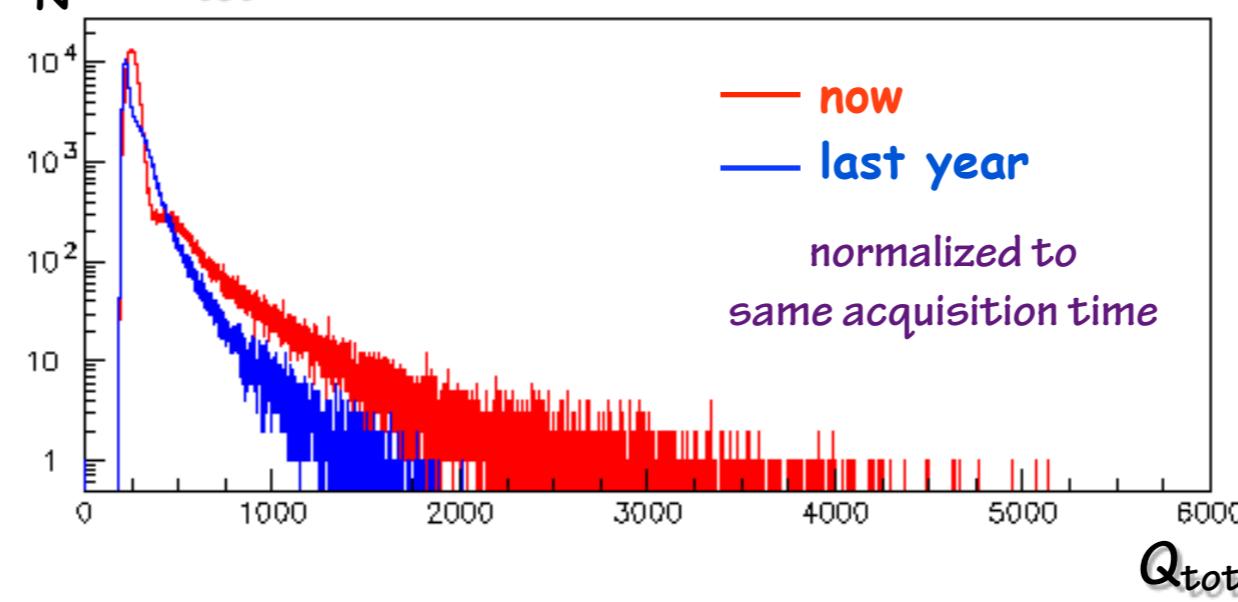


Q_{slow}

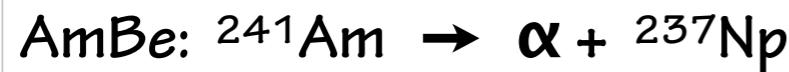
now



N Q_{tot}

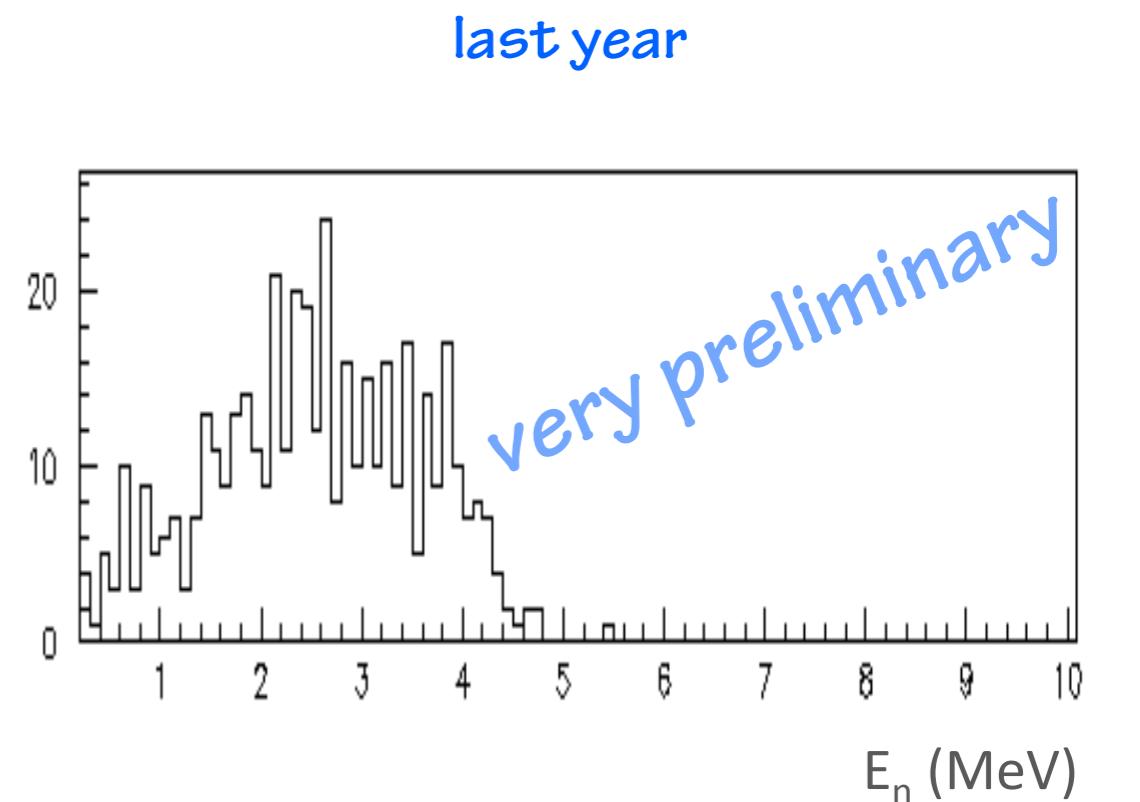
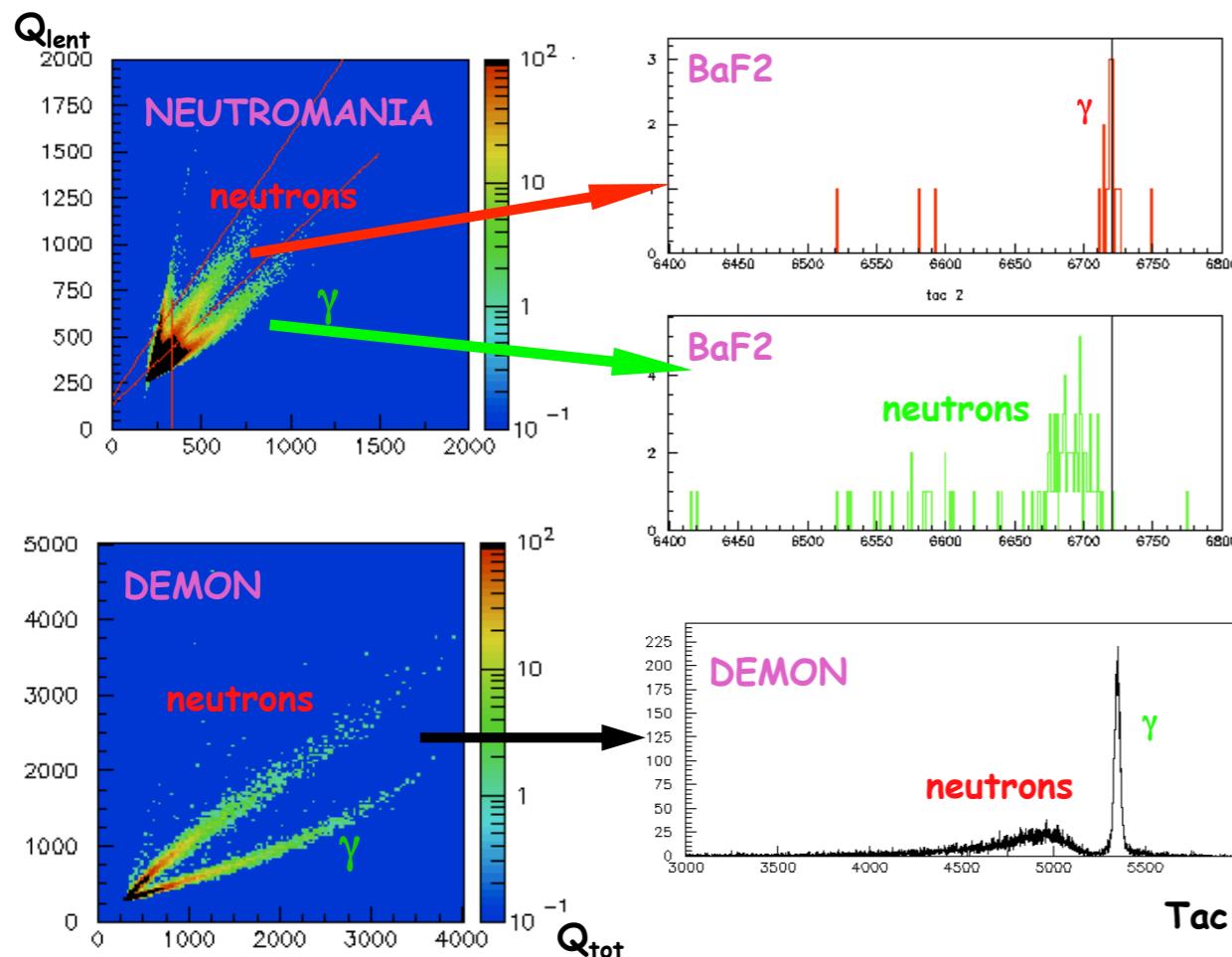
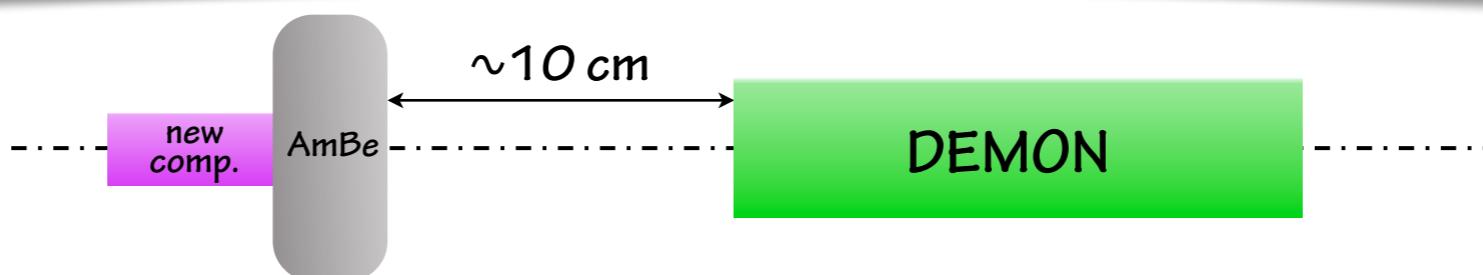


- time of flight: coincidence new component - BaF₂

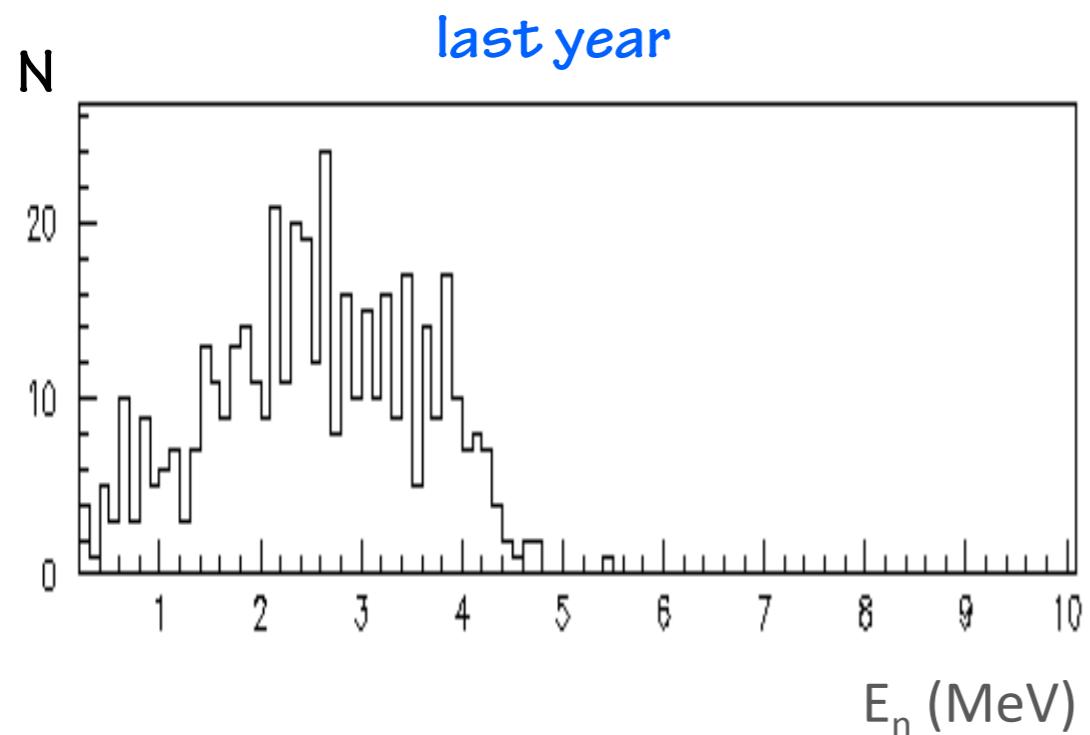


sample: n → DEMON: γ

sample: γ → DEMON: n

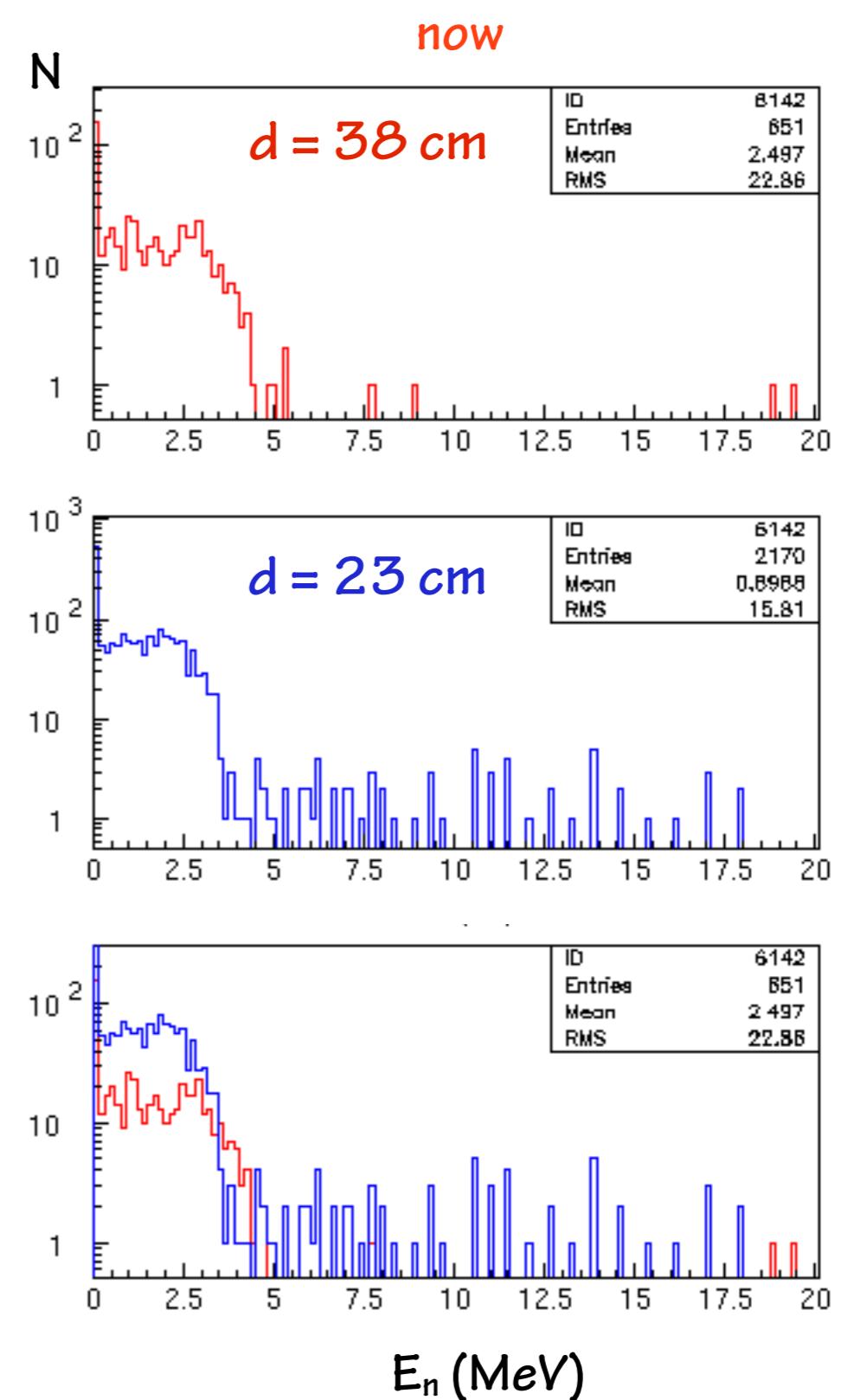


material transparent through 500 μm !!



many improvements
(melting zone,...)

transparency: $\sim 500 \mu\text{m}$



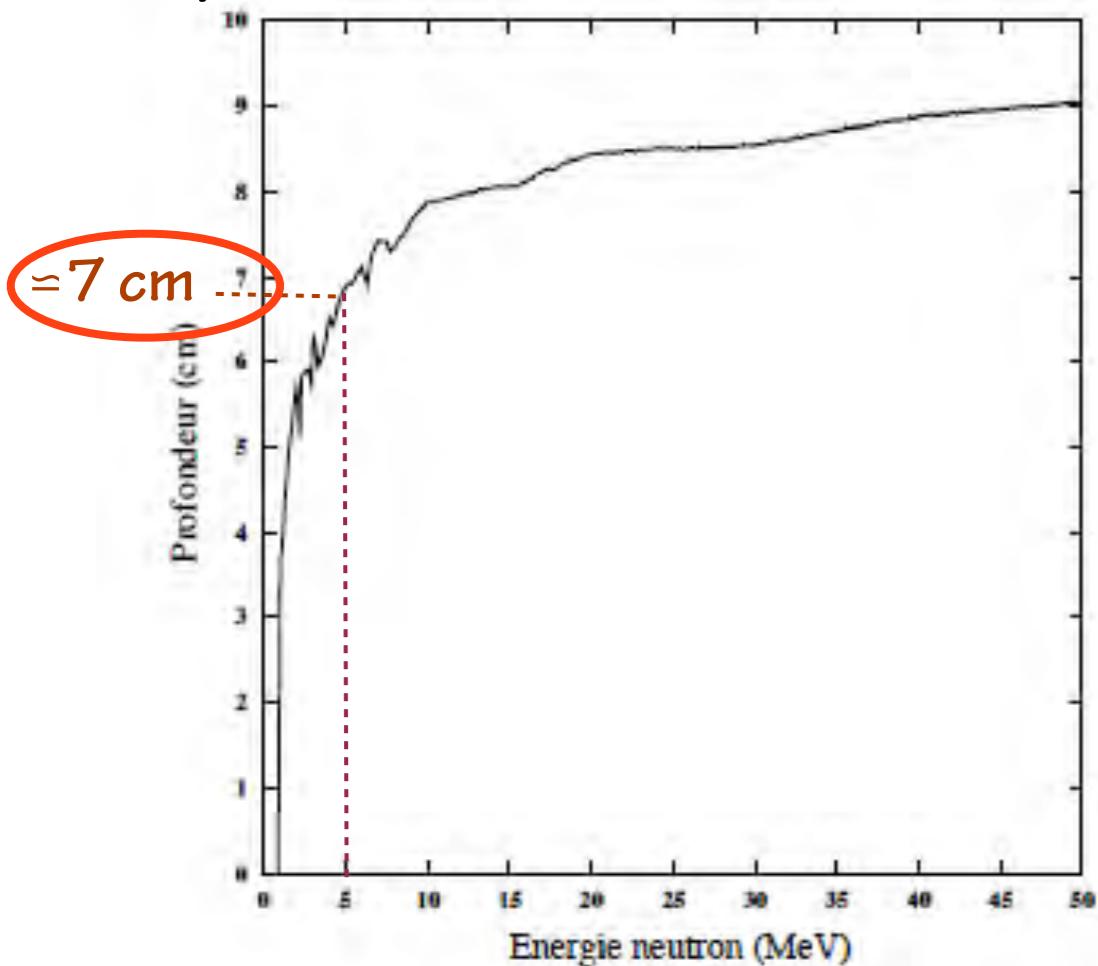
no optimisation



optimisation
possible

Depth

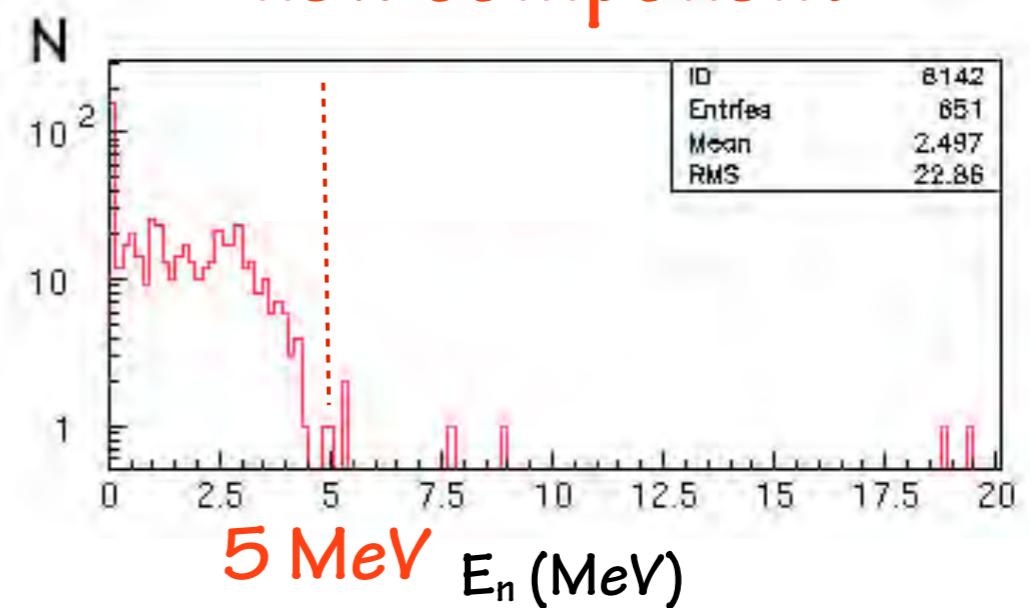
NE213



- ✓ a few % of active material
- ✓ density: ~ 0.9



new component



thickness: $\sim 500 \mu\text{m}$

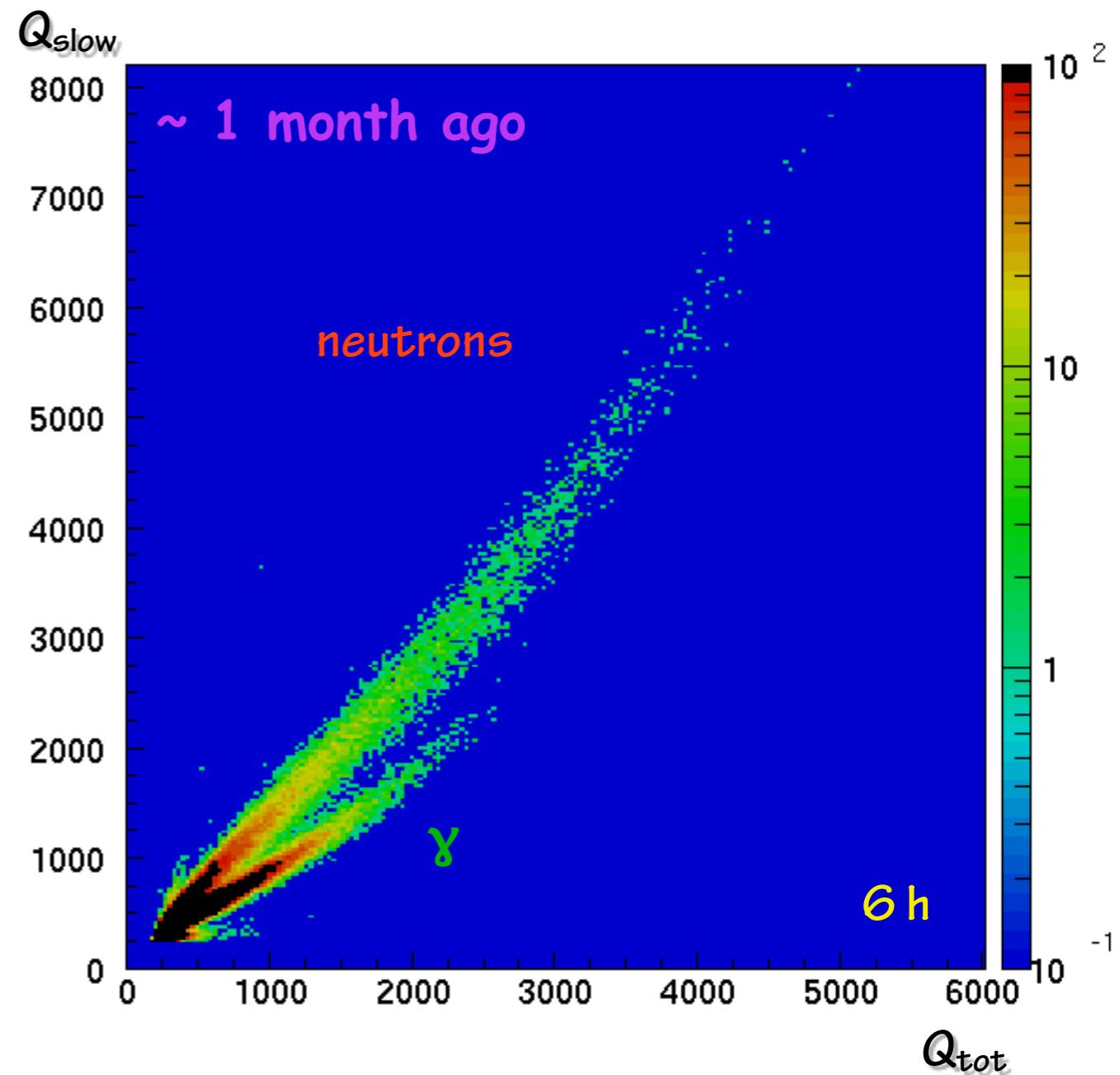
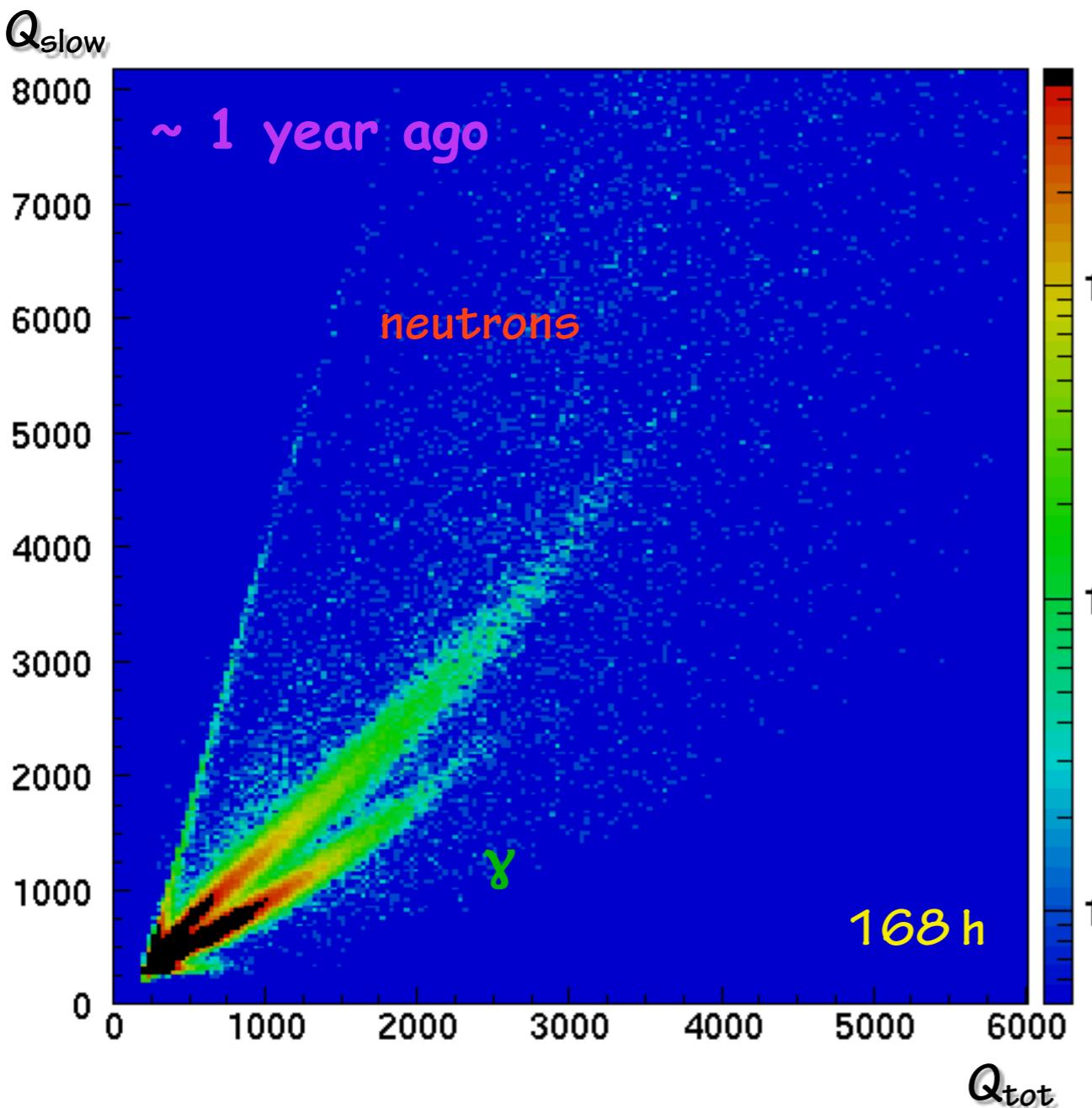
- ✓ 100 % of active material
- ✓ density: ~ 1.4
- ✓ $\sim 10 \times$ more H than in NE213

→ ↗ 20% → 600 μm → 25 MeV

→ 1 mm → several 100 MeV?

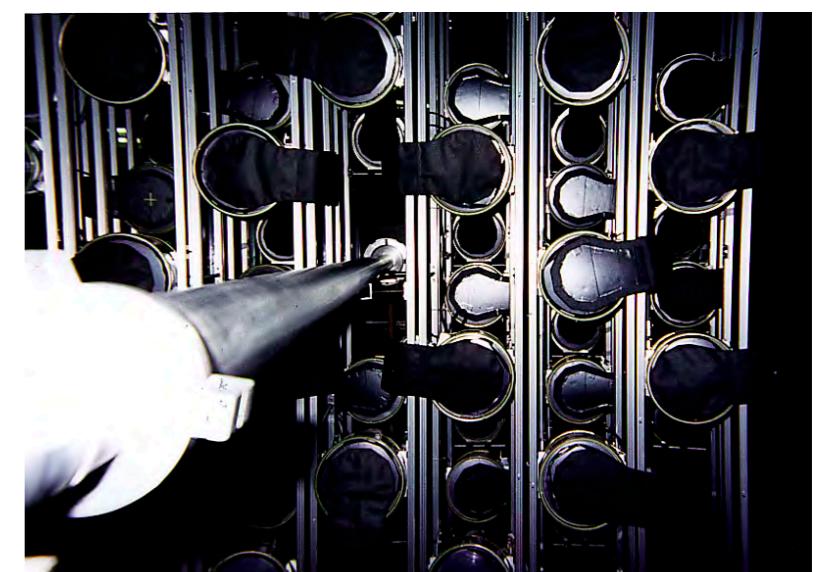
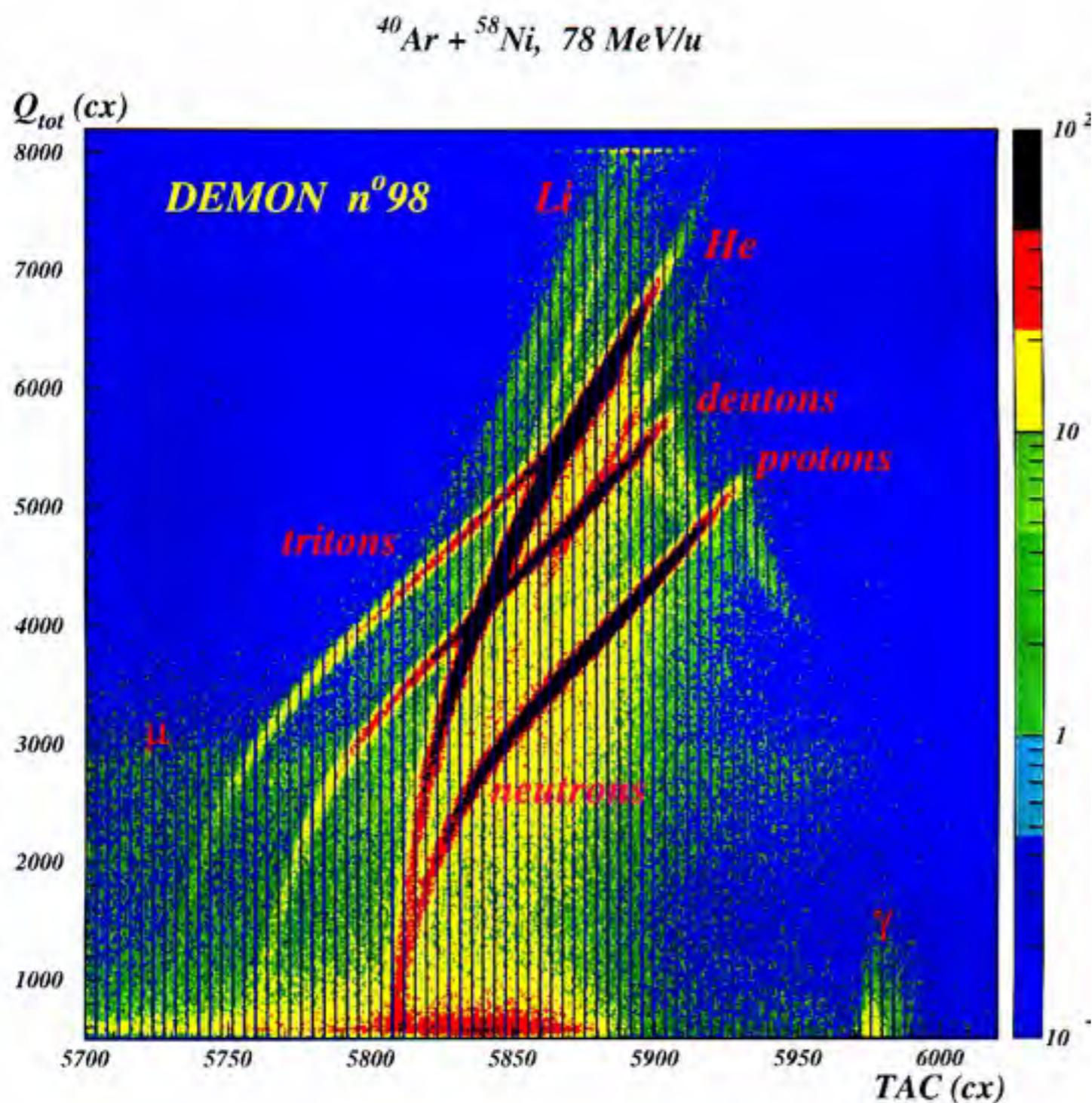
- ↘ size of future detectors
- very tiny self supported detectors

stability in time



nn, np, pp interferometry with DEMON at GANIL

J. Pluta et al, 1998



collaboration FAZIA: + neutron detector

→ neutron detection + E of LCP

→ vacuum mandatory → no dead zone

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2- Investigation in Caen