# THE GENESIS OF NEDA


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(Άκης Πιπίδης)


EGAN

European Gamma and Ancillary detectors Network

INFN

Istituto Nazionale di Fisica Nucleare

Laboratori Nazionali di Legnaro

CAPACITIES

European Nuclear Science and Applications Research

ENSAR

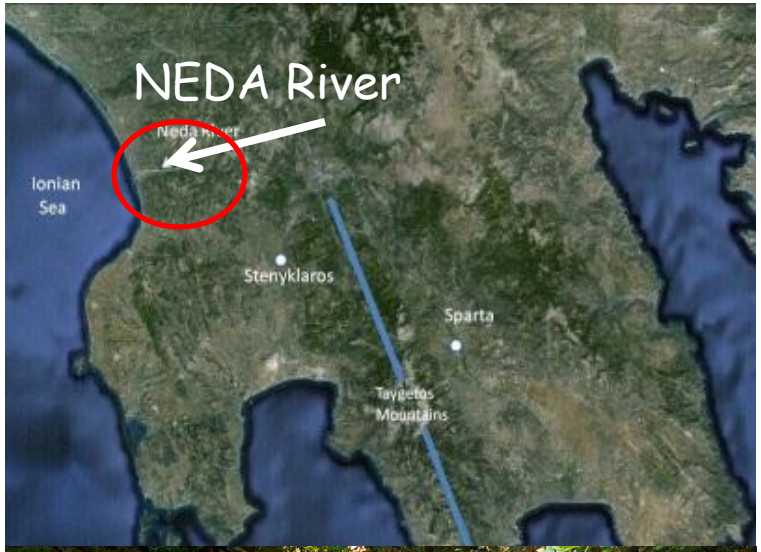
Within the Seventh Framework Programme of the European Commission

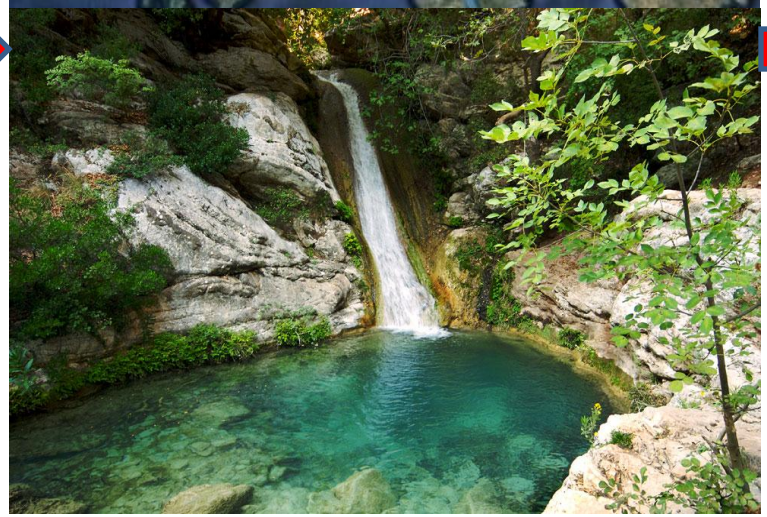
# TIME EVOLUTION OF NEDA(t) (NEutron Detector Array)


NEDA nymph

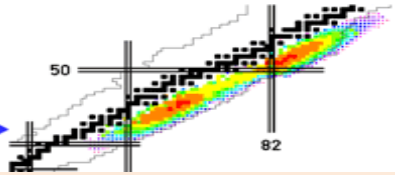
Zeus' "babysitter"

(480 B.C., British Museum)



# WHAT WAS THE SCOPE BEHIND THE FIRST "TEST-DRIVE" ?




- Characterize the NEDA prototypes (BC501A & BC537 ⟶ deuterated).

**How?**

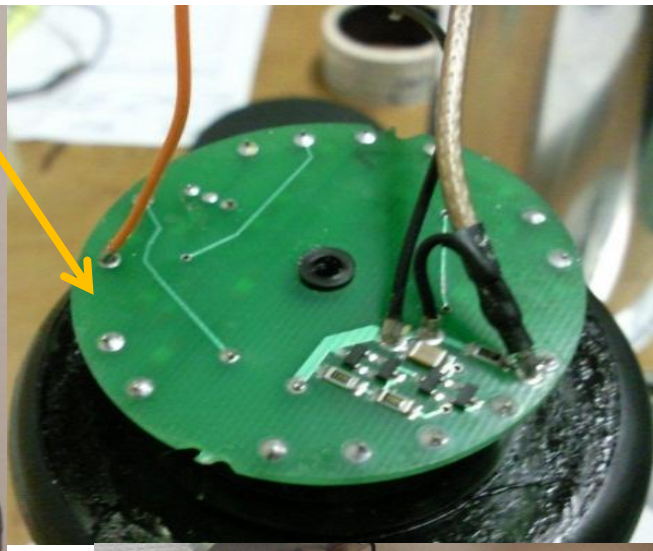
- By studying the discrimination between neutrons & $\gamma$ rays, via Pulse-Shape Analysis.
- By using Analog Electronics, as the basis, and do it like in the 21st Century (i.e. Digitally).
- By testing different PSD algorithms & Fine-Tuning them.

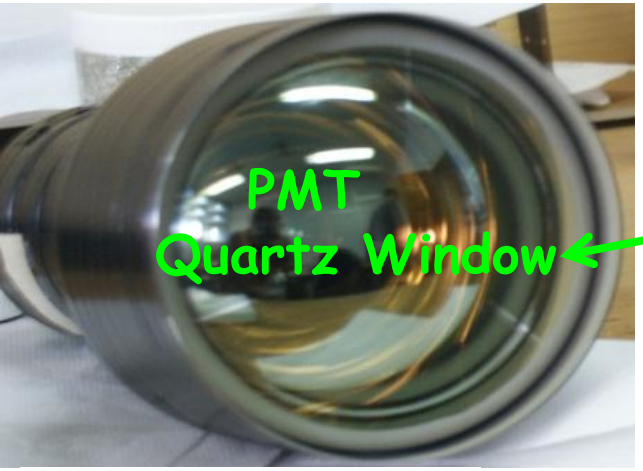
***But, First…***

- Design, Assemble & Build the Prototypes.

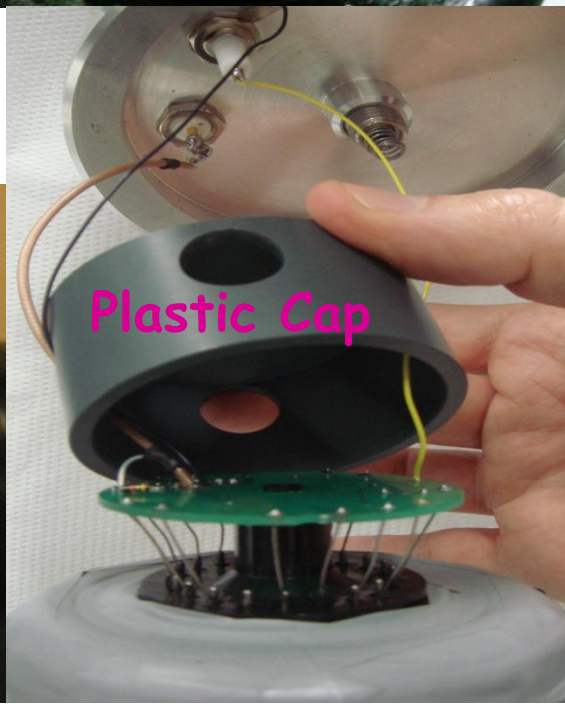
# ASSEMBLING A PROTOTYPE










Optical Grease

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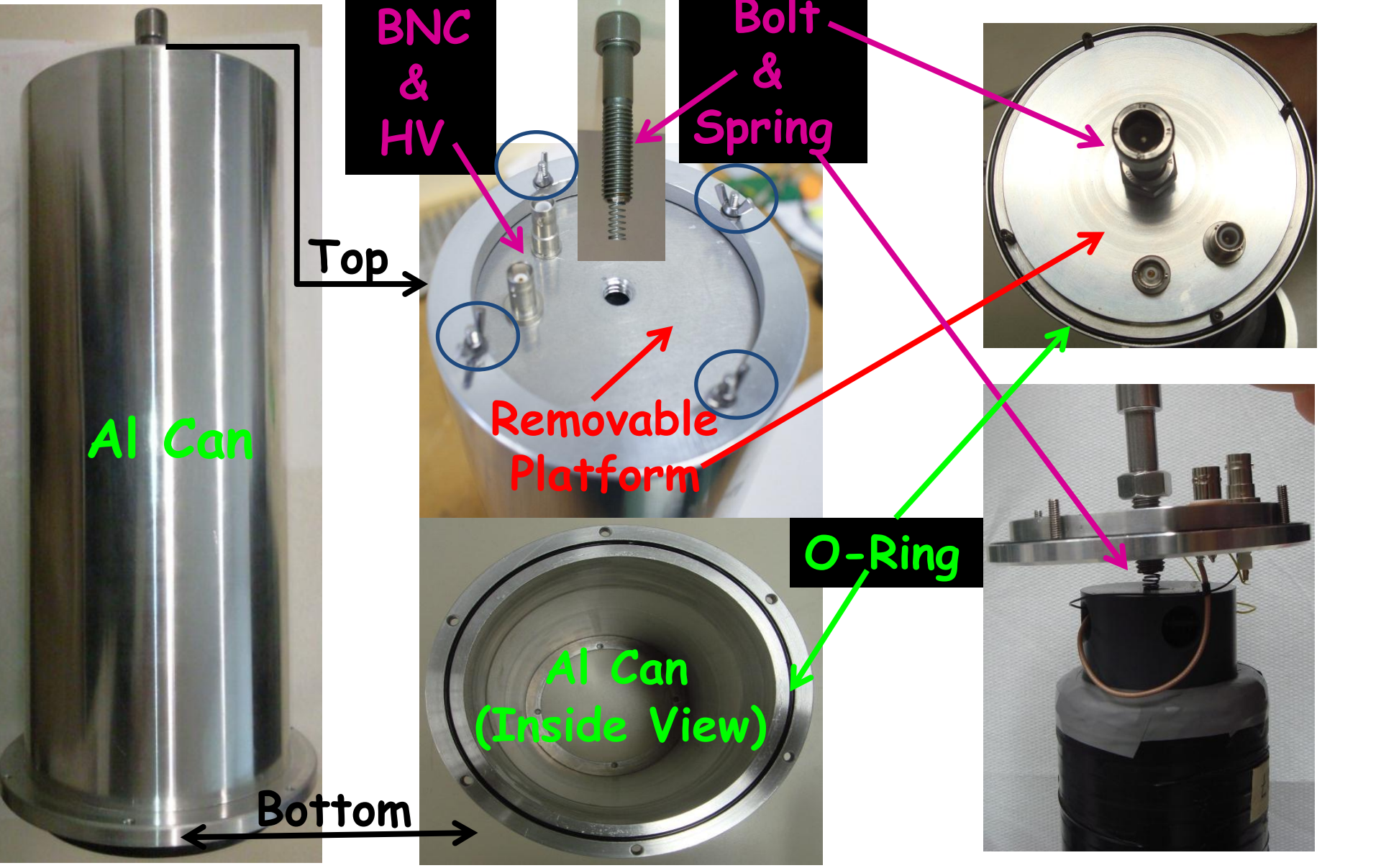
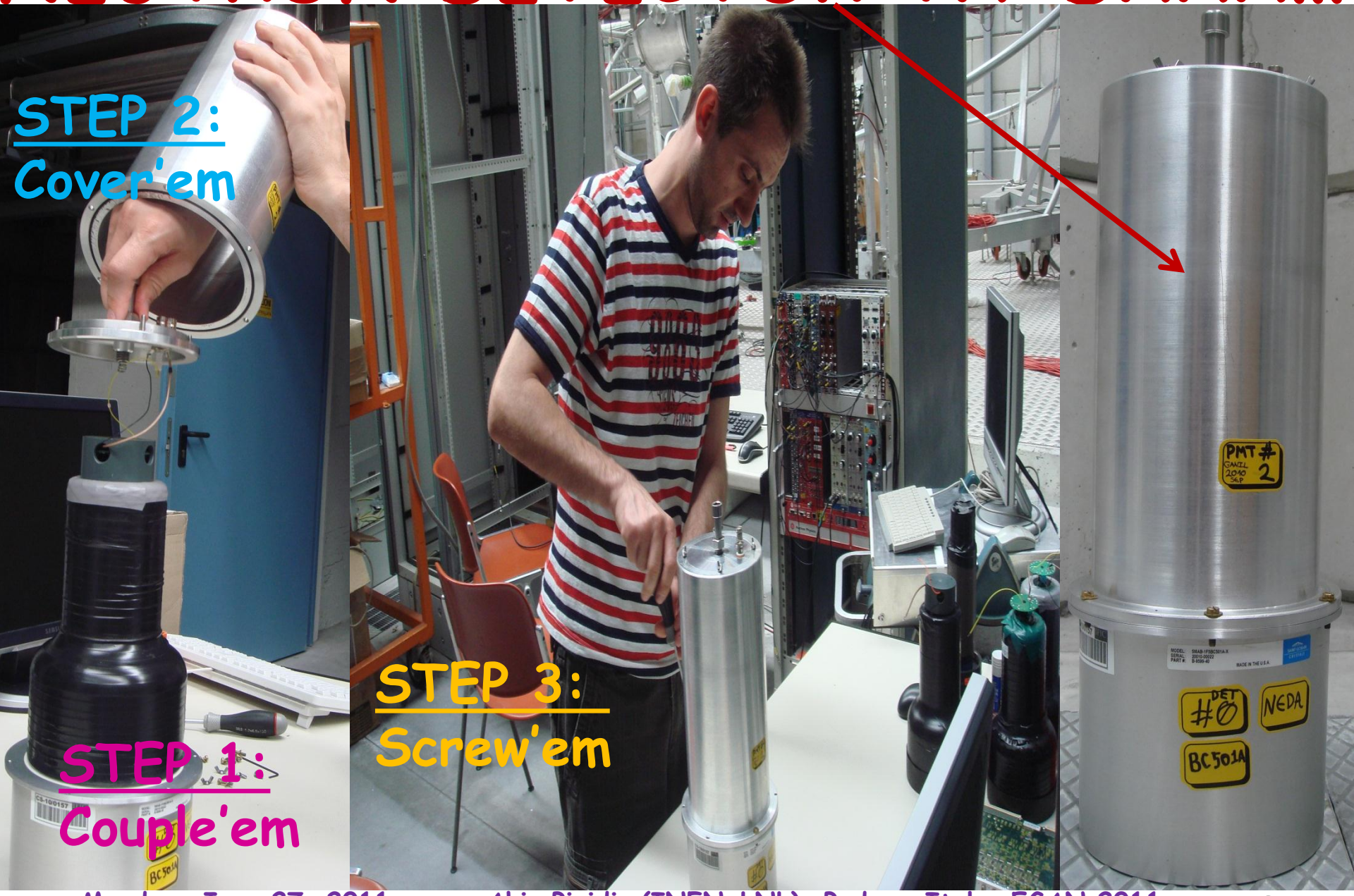
# DESIGNING & MANUFACTURING



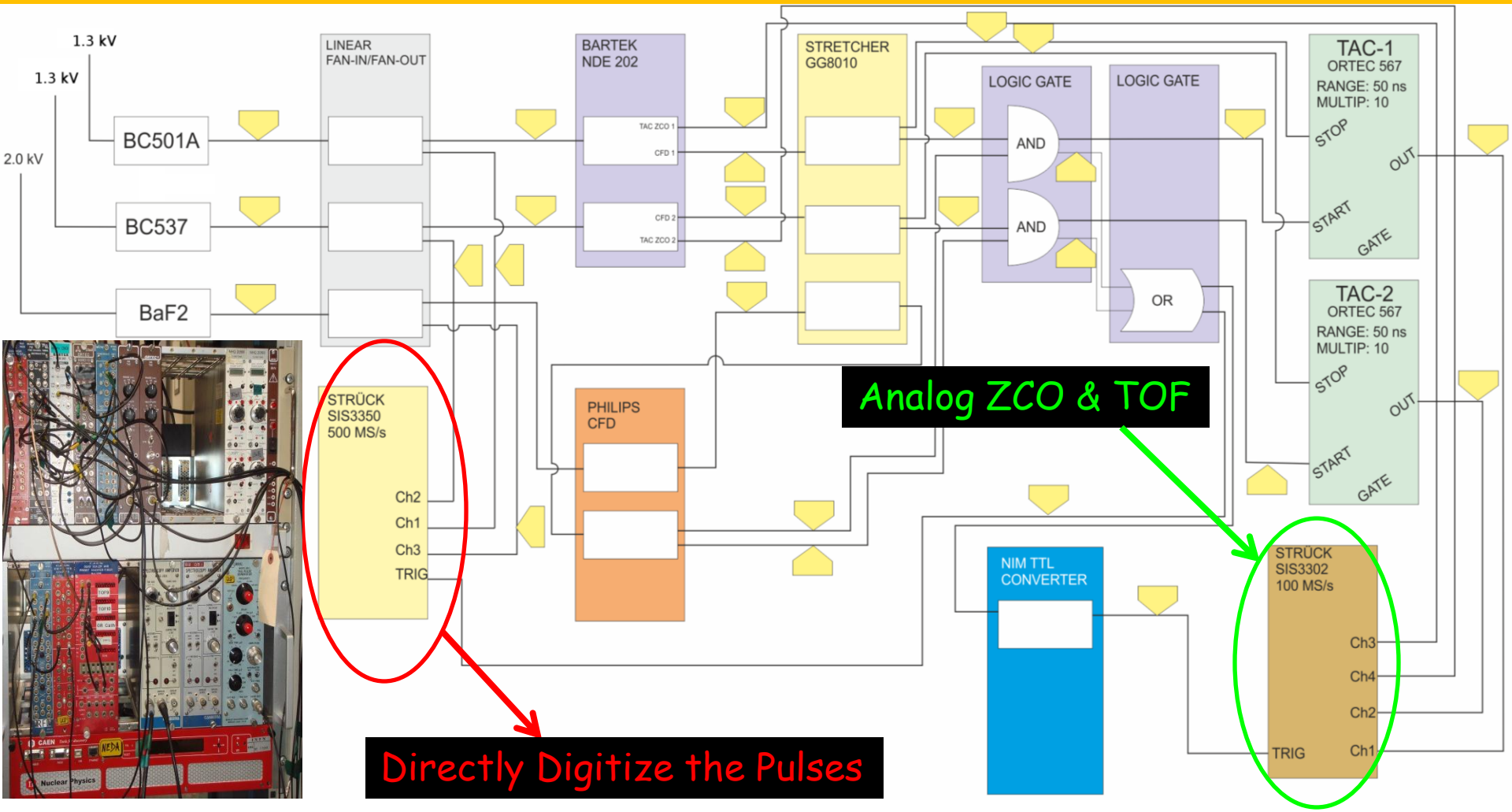
# NEUTRON DETECTOR: TA-DAAA!!!



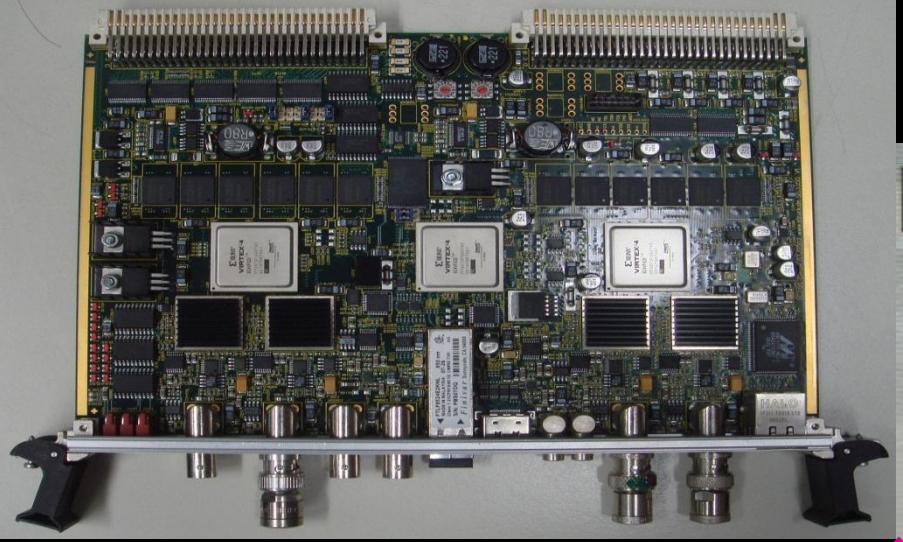
# LET THE TESTIN' BEGIN…

***DATA Acquisition , Online Analysis & Visualization*** *: GASIFIC Software*

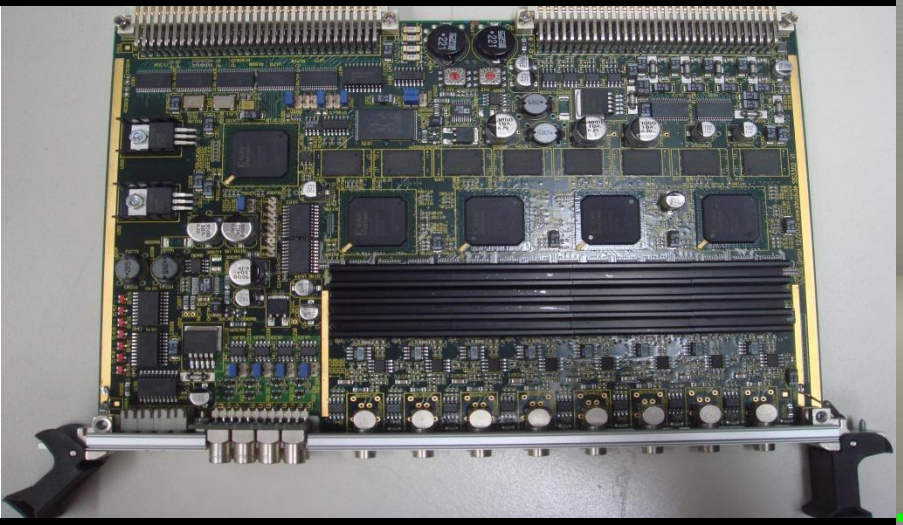
*Courtesy of J. Agramunt IFIC-CSIC (University of Valencia, Spain)*



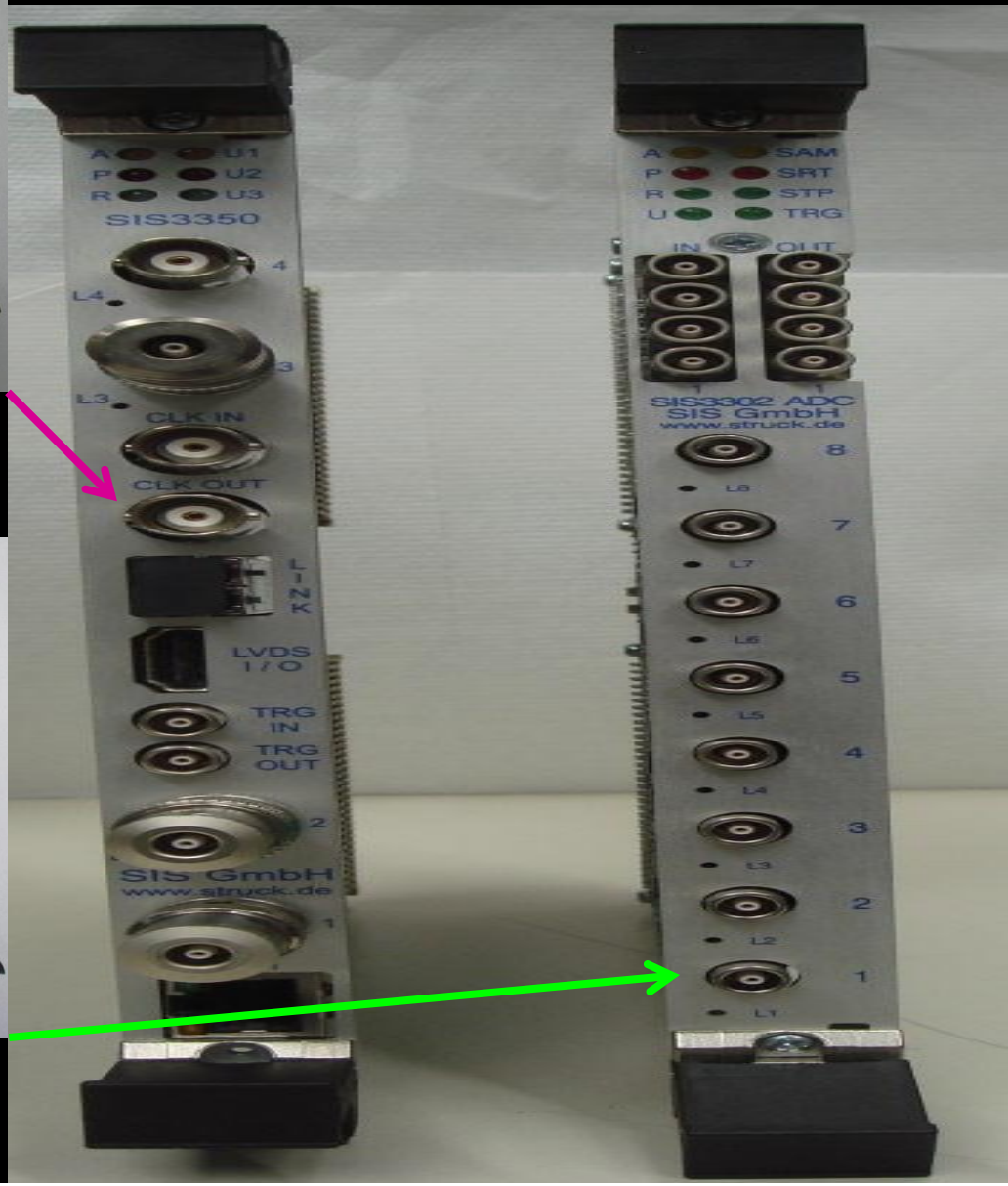
# STRUCK DIGITIZERS



STRUCK SIS3350 DIGITIZER
(500 MS/s, 12-bit, 4 Channels)

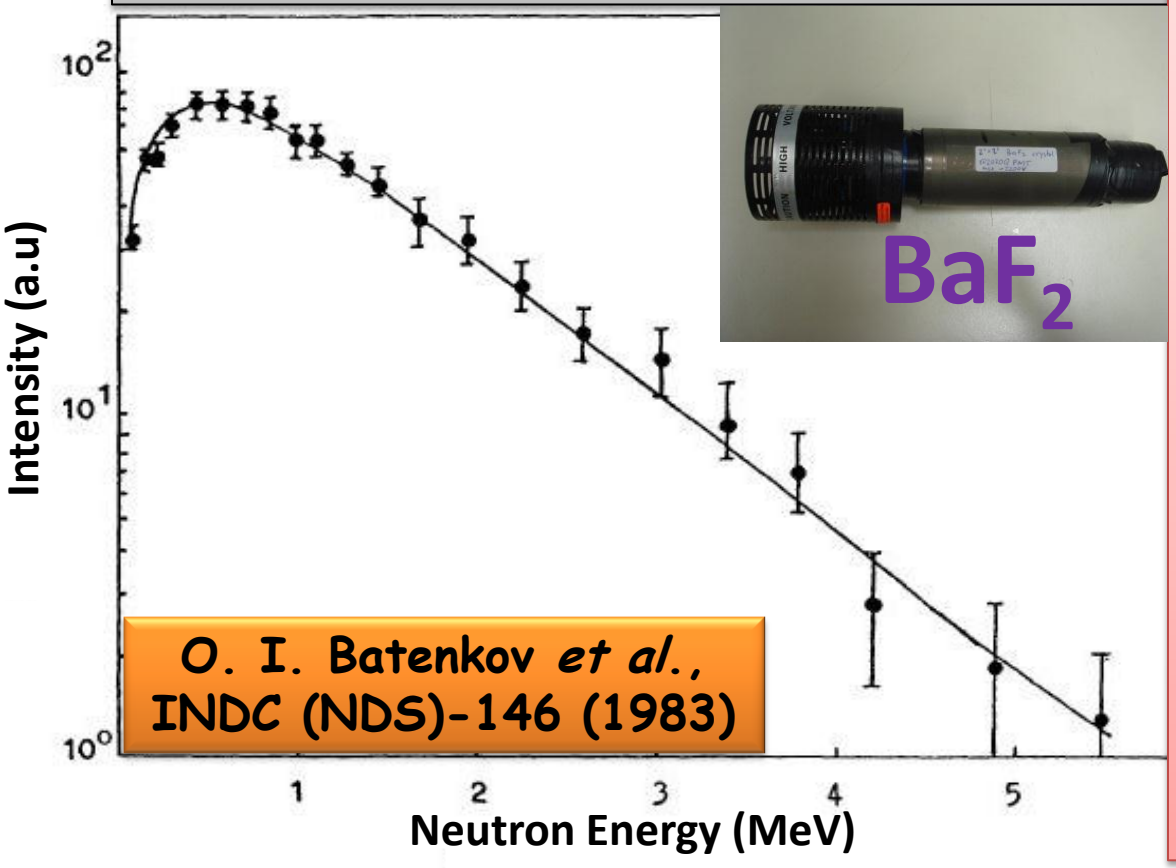


STRUCK SIS3302 DIGITIZER
(100 MS/s, 16-bit, 8 Channels)



# A SOURCE OF neutrons & γ's MIGHT ACTUALLY DO THE TRICK!

## $^{252}$Cf Spontaneous Fission Spectrum

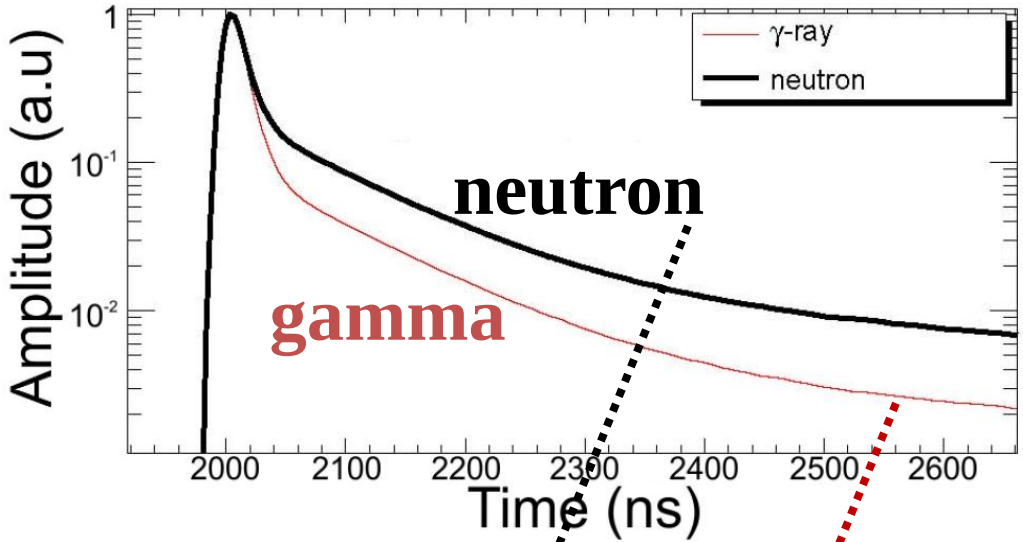


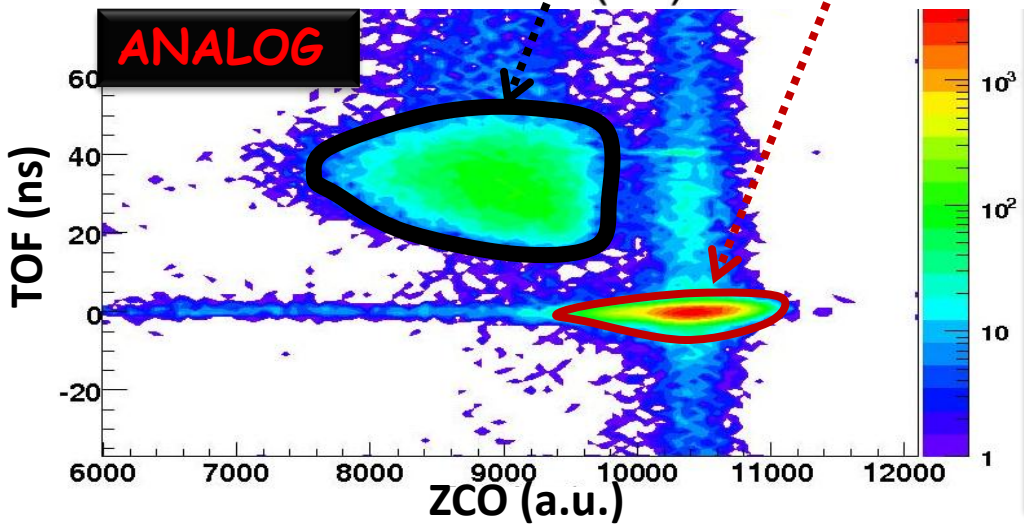




- $^{252}$Cf Source with an Activity of 2.1 MBq.
- Used a 3" x 3" BaF2, as a time reference, and recorded data in coincidence with BC501A/BC537.
- Distance = 50 cm between source and detectors.

# TEST THE neutron-γ DISCRIMINATION (ANALOG)



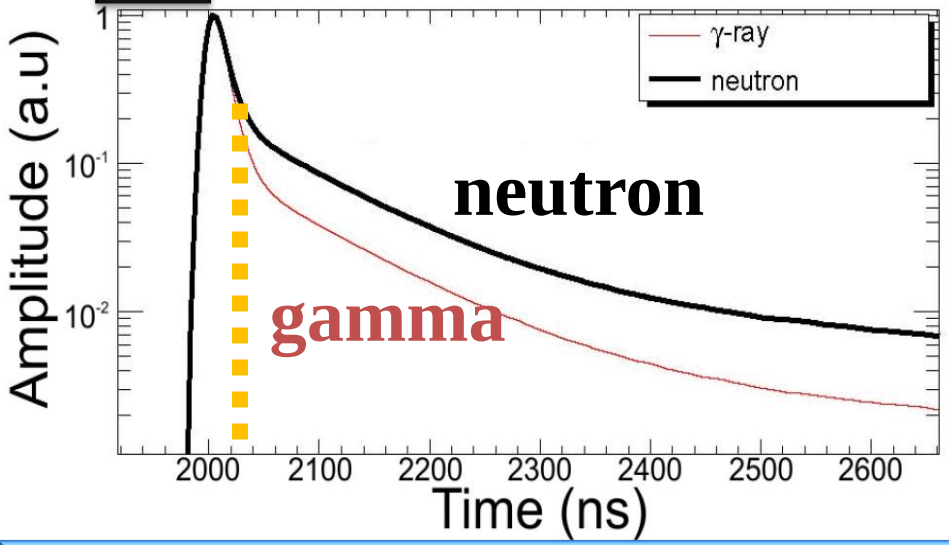




## How?

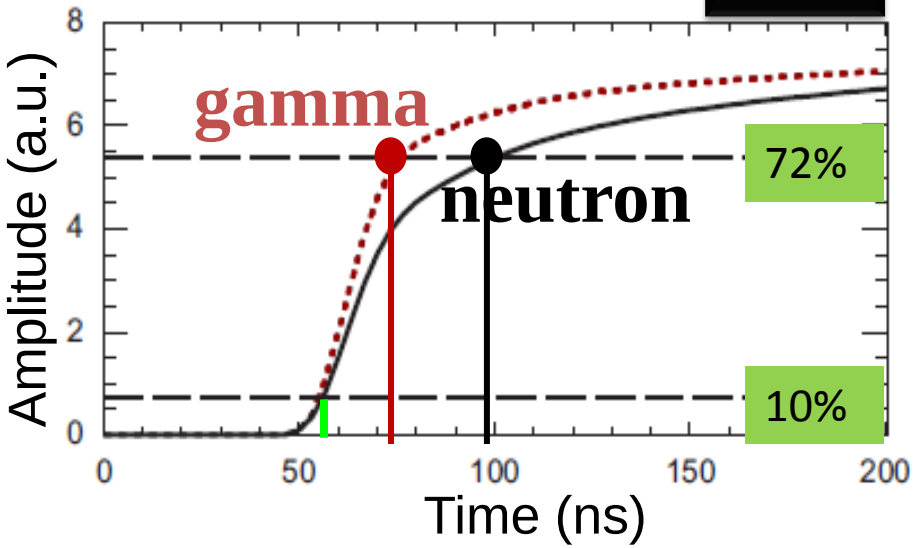
- Different pulse shapes, for different ionizing particles (tail).
- Use the Zero Cross-Over (ZCO) method, in PSD electronics.
- Signal is shaped to bipolar & the zero crossing is extracted.
- Usually apply 2-D gates, with TOF, for clean separation.

# DISCRIMINATION ALGORITHMS (DIGITAL)

CC



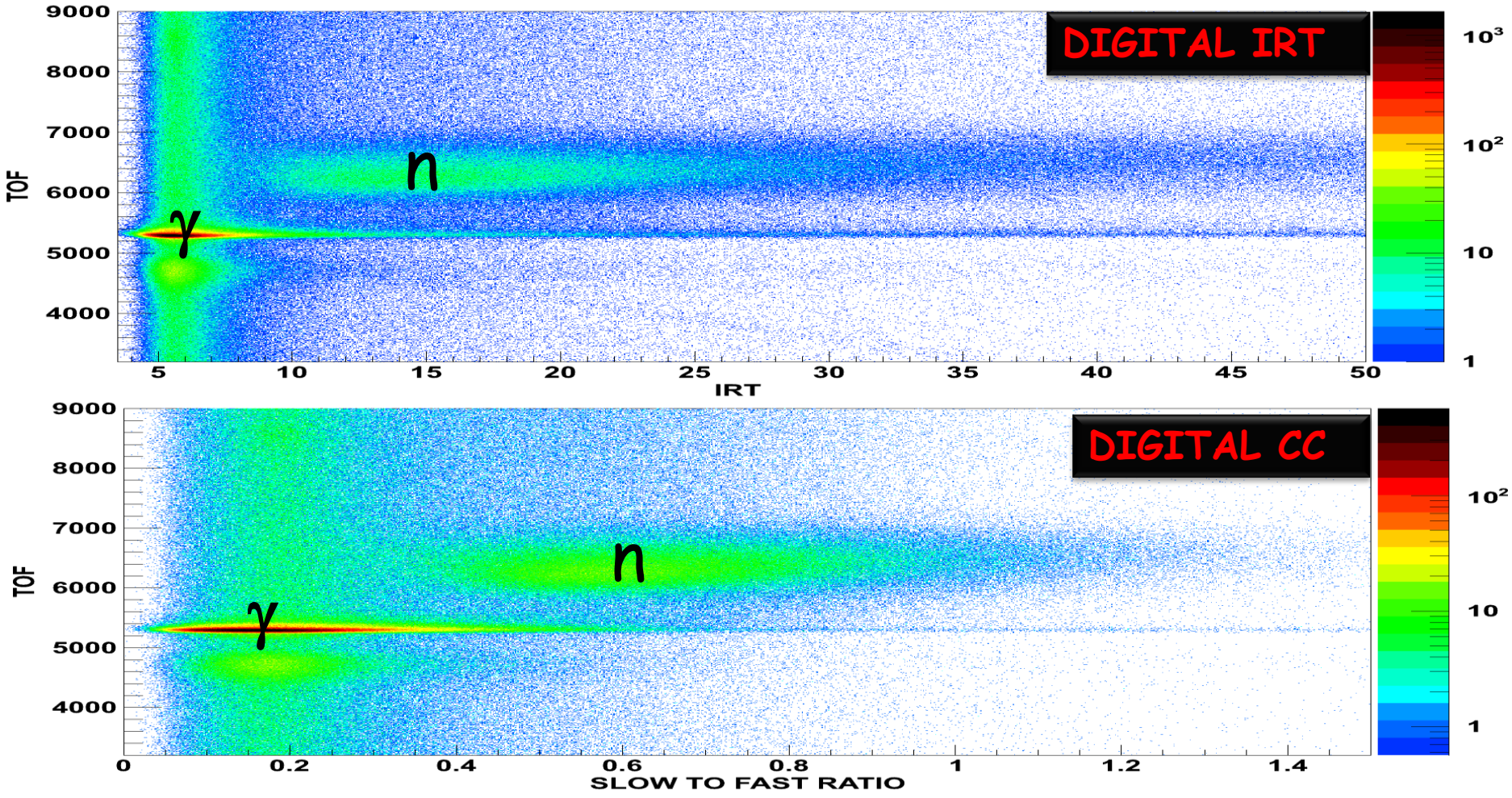

IRT



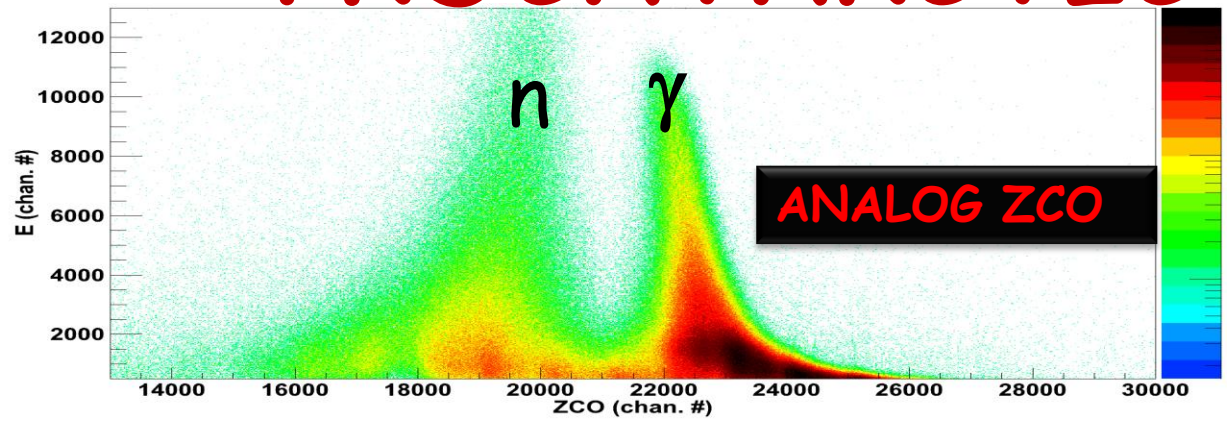

## Two types of algorithms:

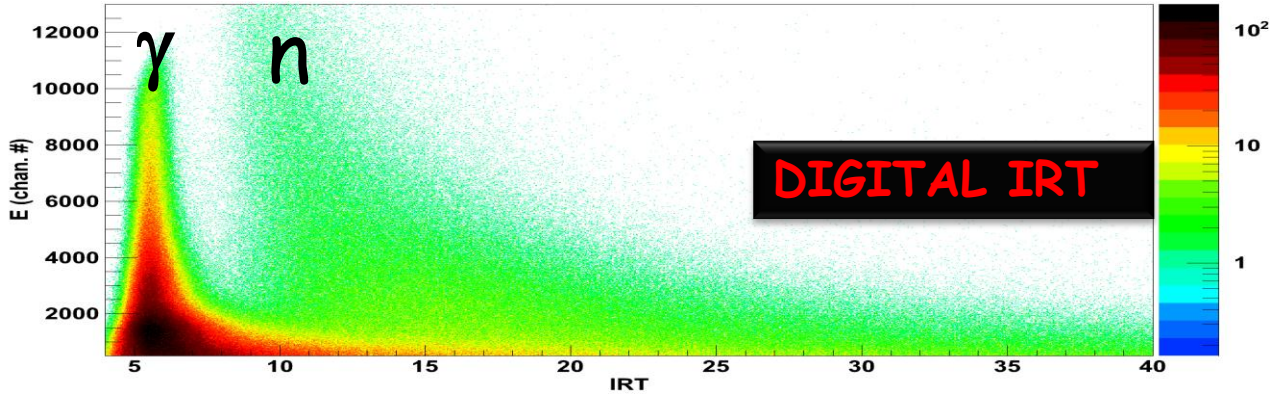
- One is based on the Charge Comparison (CC) method: "Slow-to-Fast Ratio", where the charge in the slow component is integrated & compared to the charge in the fast.
- One is based on the ZCO method: "*Integrated Rise Time*" (IRT), where the pulse is integrated and the RT is extracted from the time difference between 10% & 72% of the height.

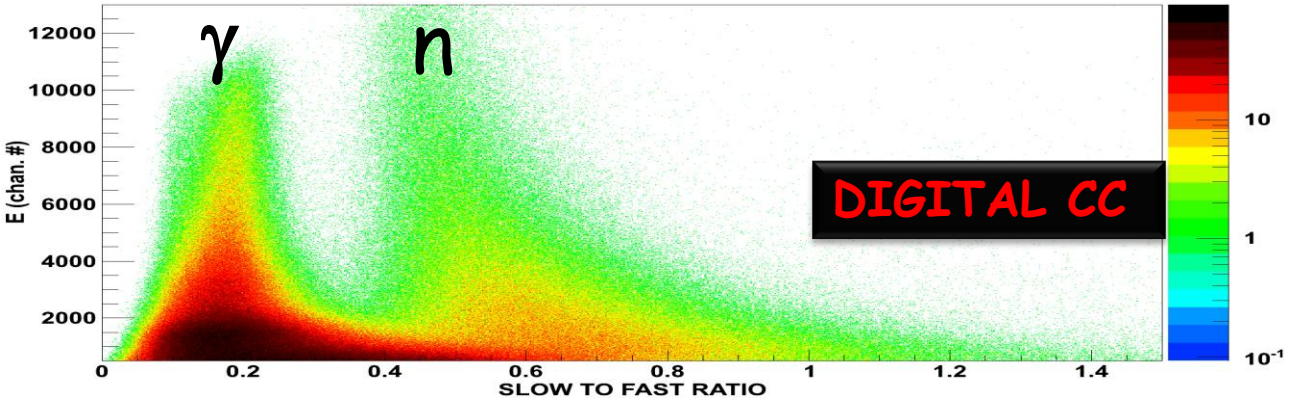
# QUALITATIVE RESULTS (PROCATARCTIC)



# PROCATARCTIC (cont.)




Digital discrimination works, but the algorithms need to be fine-tuned!

So…

To be continued.

# HOW TO QUANTIFY THE RESULTS ? FIGURE OF MERIT (FOM)

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journal homepage: www.elsevier.com/locate/nima


## Digital pulse-shape discrimination of fast neutrons and γ rays

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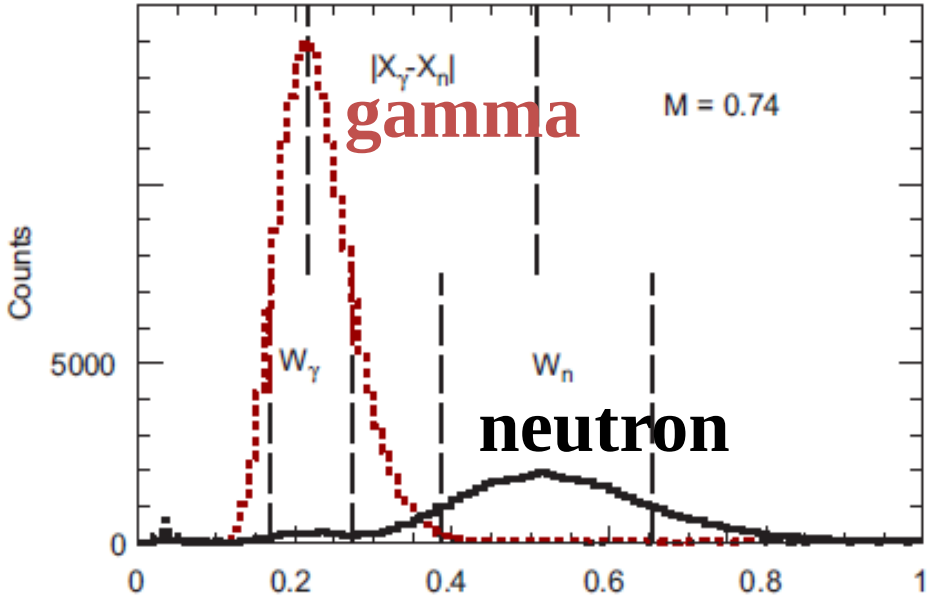
*Department of Physics and Astronomy, Uppsala University, SE-75121 Uppsala, Sweden*

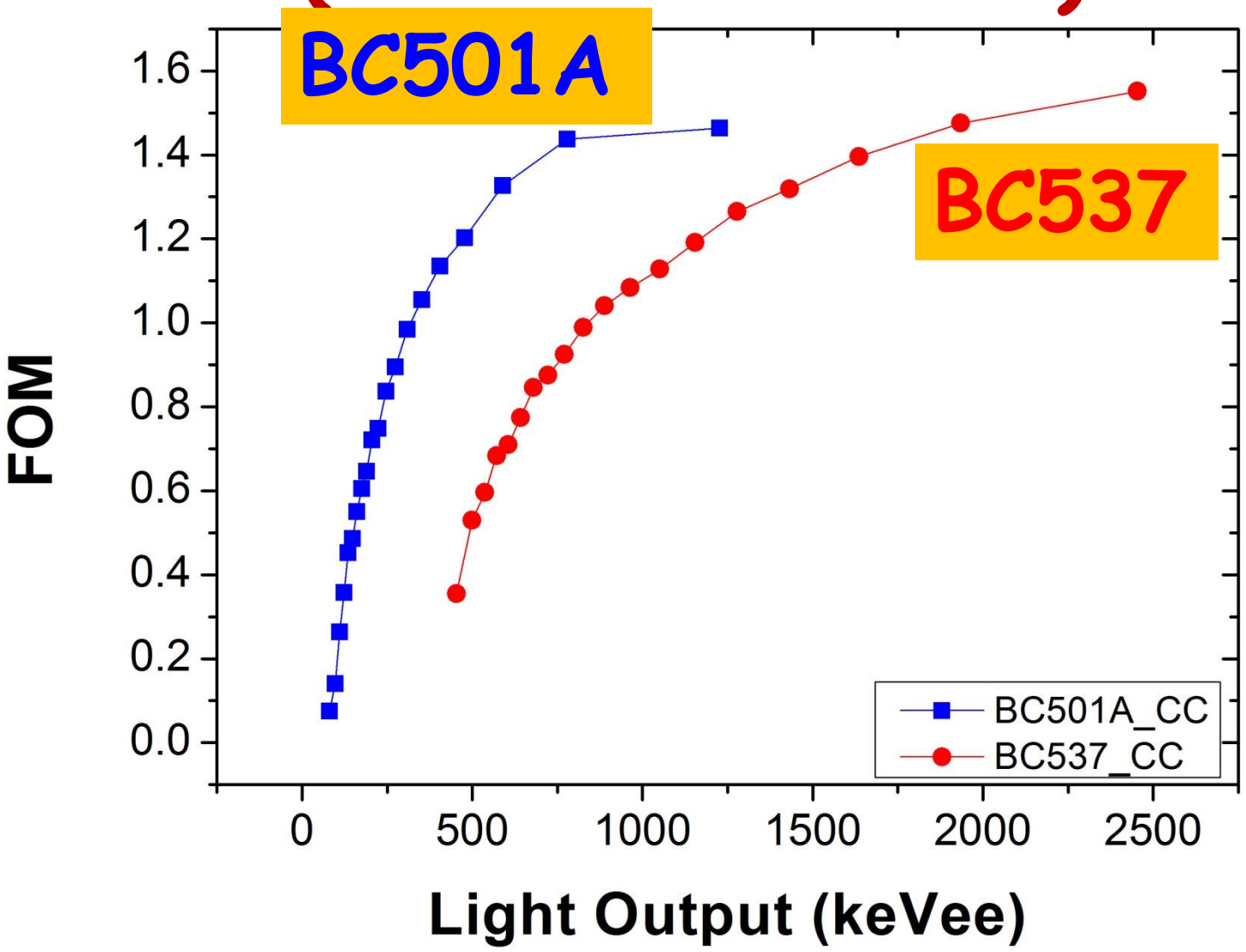



R. A. Winyard *et al.*, Nucl. Instrum. Meth., A95:141, 1971

$$\mathrm{FOM} = \frac{|X_\gamma - X_n|}{W_\gamma + W_n}$$

An increased value of the FOM corresponds to a better neutron-γ discrimination.

# QUANTITATIVE RESULTS (PROCATARCTIC)

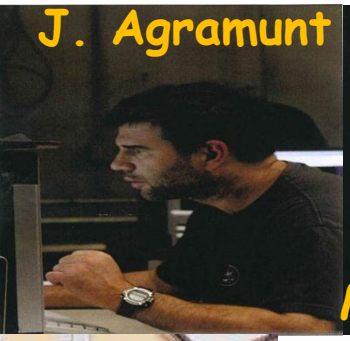


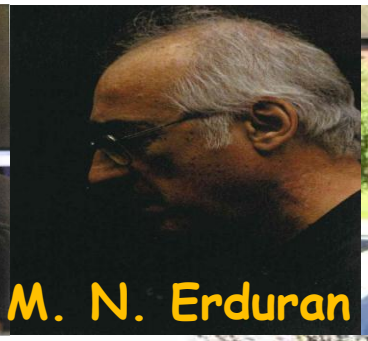
# NEXT STEPS…

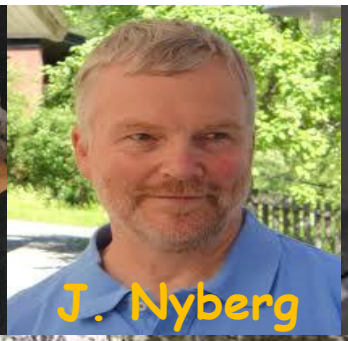
- X-Talk measurements (July 2011).
- Test new HAMAMATSU PMT's with high Q.E (first buy them)…Sometimes, brand-new is better than "brand-old".


- Investigate the optimal sampling frequency.
- Fine-Tune the digital algorithms, to achieve the best neutron-$\gamma$ discrimination.

# NEDA COLLABORATION





- G. de Angelis
- G. La Rana
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- J. L. Tain

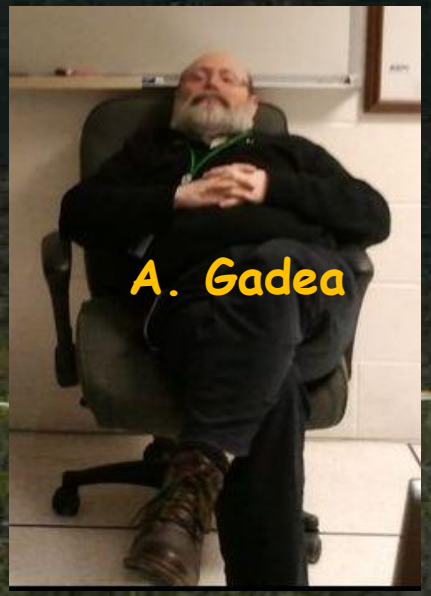

J. J. Valiente-Dobon

S. Erturk

G. Jaworski

A. Di Nitto

A. Pipidis

| PMT MODEL # | MATERIAL | STAGES # | Q.E. (%) | GAIN | ANODE R.T. (ns) | $e^-$ TRANSIT TIME (ns) | SUPPLY VOLTAGE (V) | AVERAGE ANODE I (mA) |
|---|---|---|---|---|---|---|---|---|
| HAMAMATSU R877-MOD (R11833-100) | SBA | 8 | 31.61 @ 420 nm<br>35 @ 380 nm | 5.0E+05<br>(2.0E+05) | 4 (4.3) | 45 | 1500 (max) | 0.1 |
| HAMAMATSU R4144 | BA | 8 | <22 @ 420 nm | 1.4E+06 | 1.5 | 35 | 3000 (max) | 0.2 |
| HAMAMATSU R1250 (*) | BA | 14 | <22 @ 420 nm | 1.4E+07 | 2.5 | 54 | 3000 (max) | 0.2 |
| PHOTONIS XP4512 (**) | BA | 10 | 24 @ 420 nm | 2.0E+07<br>5.0E+06 @ 1700V | 2.5 | 40 | 1450-2500<br>Typical: 2100 | 0.2 (max) |

(*) R1250 is the HAMAMATSU equivalent to our Photonis XP4512.

(**) *Photonis XP4512PA is the model # of the Neutron Wall PMT's. Unable to locate info on what the "PA" stands for. Perhaps it is a modified version of XP4512. Visually, it seems like XP4512PA has 14-dynodes, not 10 (could be wrong though)!*