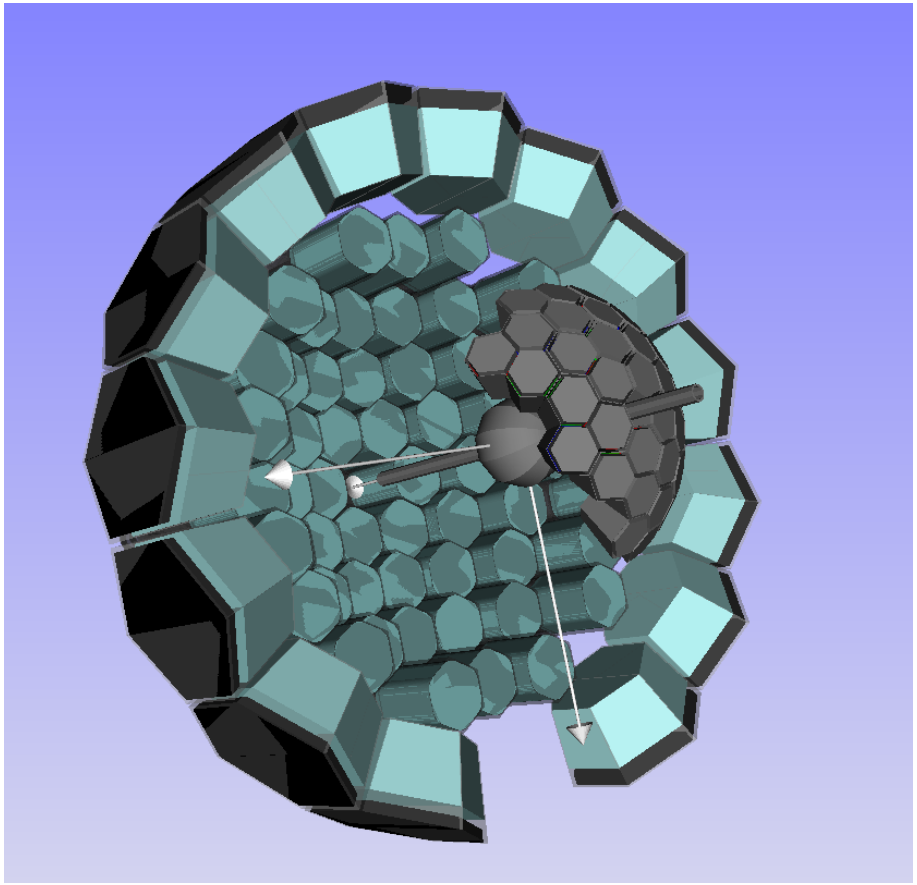
N = Z AGATA campaign



Grześ Jaworski

on behalf of N=Z, NEDA, NW & DIAMANT collaborations

AGATA Week, Milano, September 14th, 2017

Outline

→ Physics

→ Key instrumentation (under construction):
  * NEDA + Neutron Wall
  * DIAMANT
  * Plunger – see talk of Joa Ljungvall
  * new target chamber – see talk of Nadine Redon

→ Mechanics.

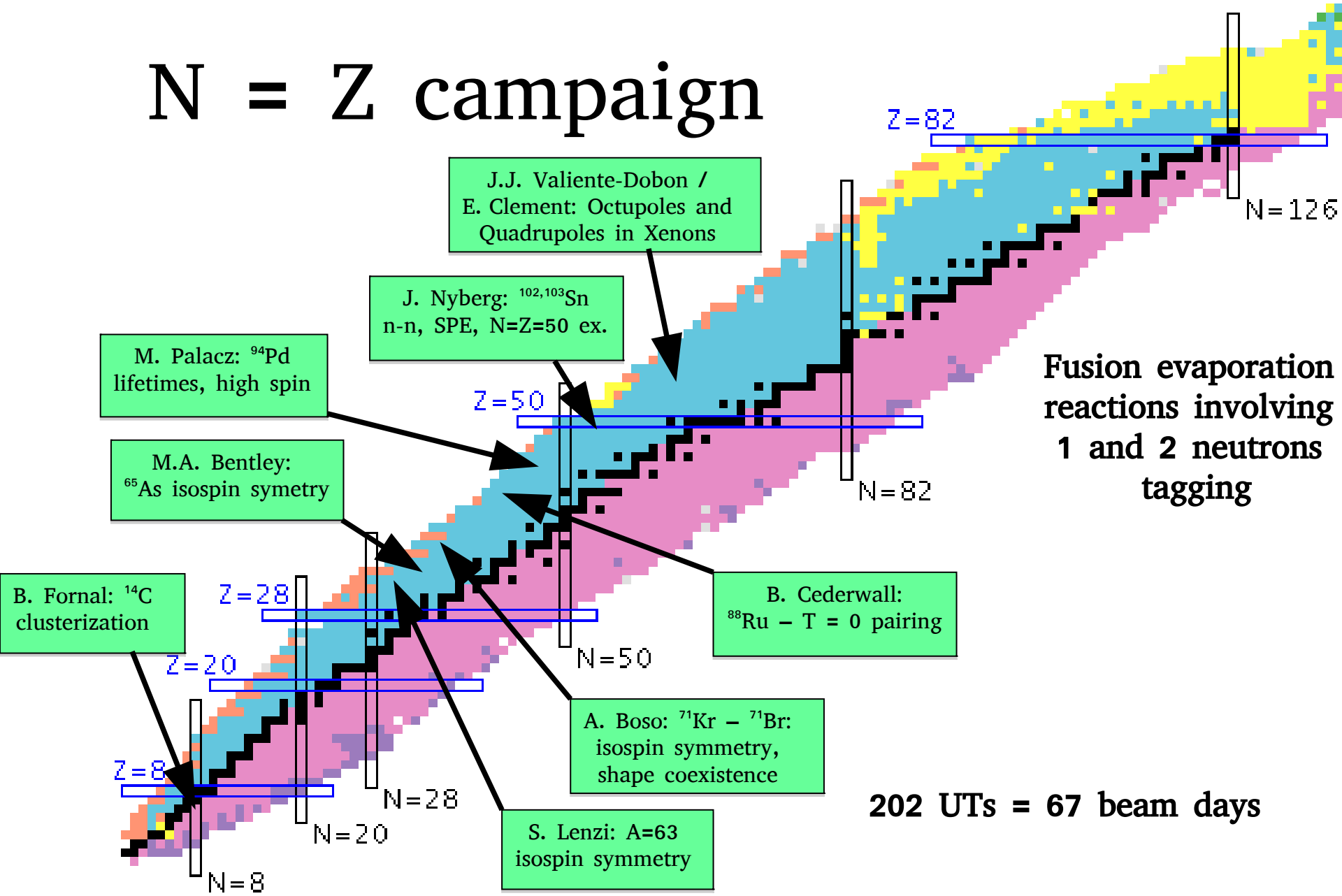
→ Electronics.

→ DAQ

→ Global integration and commissioning

→ Calendar

N = Z campaign



Fusion evaporation reactions involving 1 and 2 neutrons tagging

202 UTs = 67 beam days

GANIL 2018: AGATA + NEDA

M. Bentley: In beam gamma-proton coincidence spectroscopy in ^{65}As – isospin symmetry at the limits of proton binding. (+ DIAMANT) – 20 UTs

A. Boso: Isospin symmetry breaking and shape coexistence in mirror nuclei ^{71}Kr – ^{71}Br. (+ DIAMANT) – 20 UTs

B. Cederwall: Search for isoscalar pairing in ^{88}Ru. (+ DIAMANT) – 36 UTs

B. Fornal, S. Leoni & M. Ciemała: Gamma decay from near-threshold states in ^{14}C: a probe of clusterization phenomena in open quantum systems. (+ DIAMANT + DSSD + $LaBr_3$ + PARIS) – 22 UTs

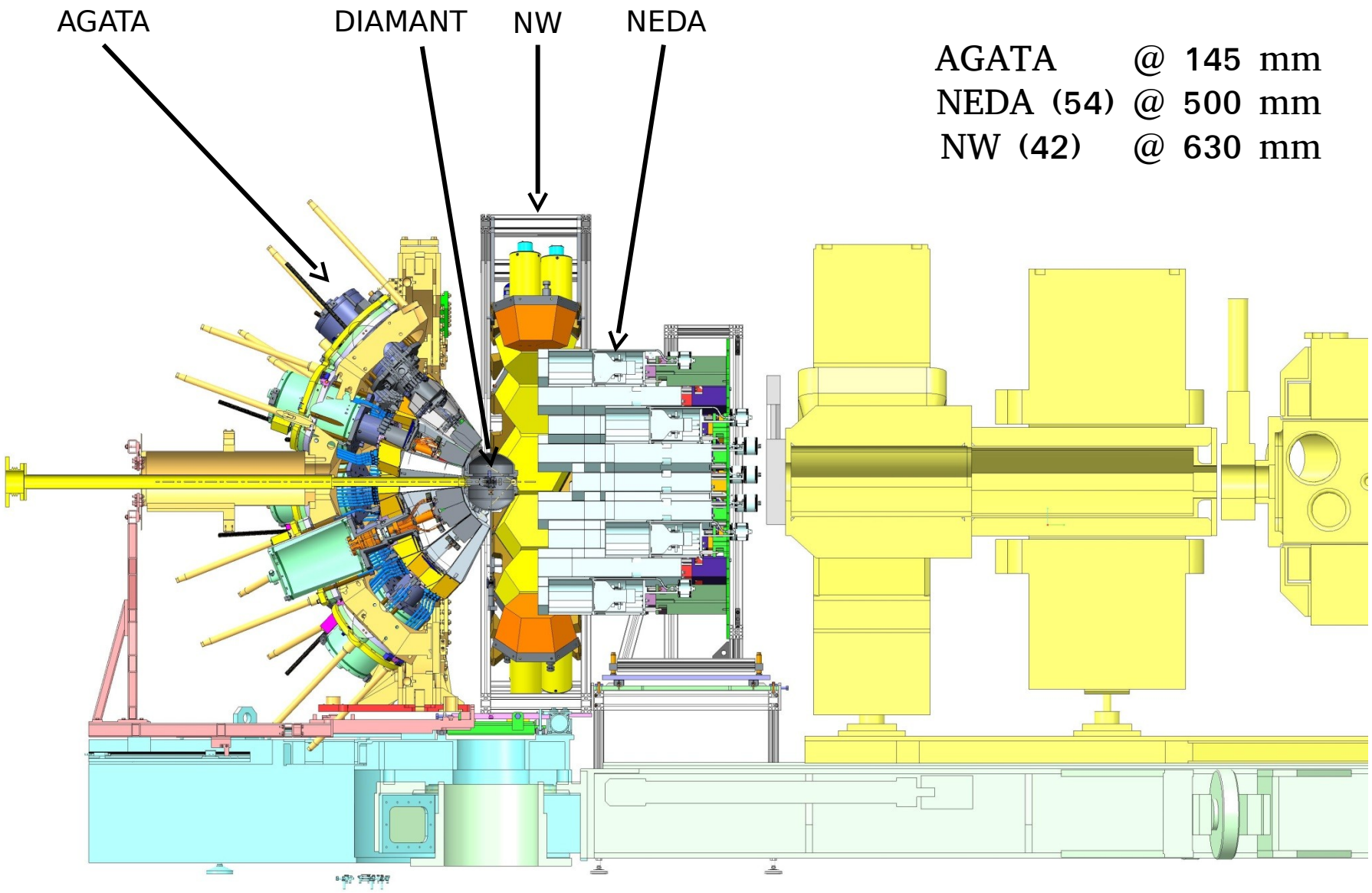
S. Lenzi: Effects of Isospin Symmetry Breaking in the A=63 mirror nuclei. (+ DIAMANT) – 17 UTs

J. Nyberg: Studies of excited states in ^{102,103}Sn to deduce two-body neutron interactions, single-particle energies and N = Z = 50 core excitations. (+ DIAMANT) – 32 UTs

M. Palacz: Purity of the $g^n_{9/2}$ configuration based on lifetime measurements and energies of excited states in ^{94}Pd. (+ FATIMA) – 23 UTs

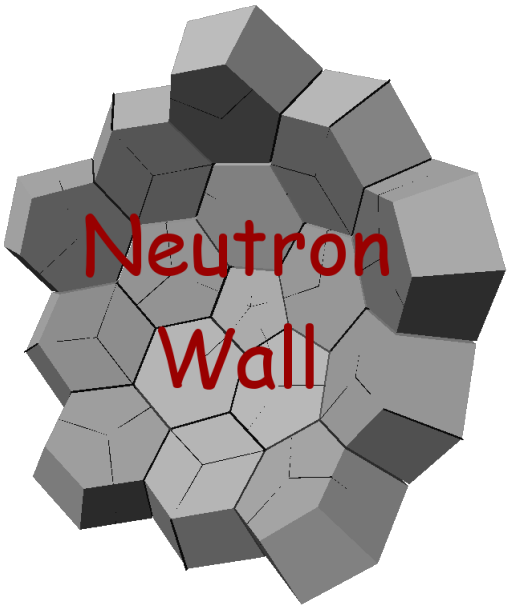
J.J. Valiente Dobon & E. Clément: Shell evolution of neutron-deficient Xe isotopes: Octupole and Quadrupole Correlations above ^{100}Sn. (+ DIAMANT + Plunger) – 32 UTs

202 UTs = 67 beam days


AGATA
DIAMANT
NW
NEDA
AGATA @ 145 mm
NEDA (54) @ 500 mm
NW (42) @ 630 mm

Status of

NE DA &



Detector production

Self production [hand made], using:

→ Detector vessels and PMT housings are made by welding flanges to hexagonal profiles;

→ EJ520 TiO_2 paint; TorrSeal; 5” 5mm BK7 glass;

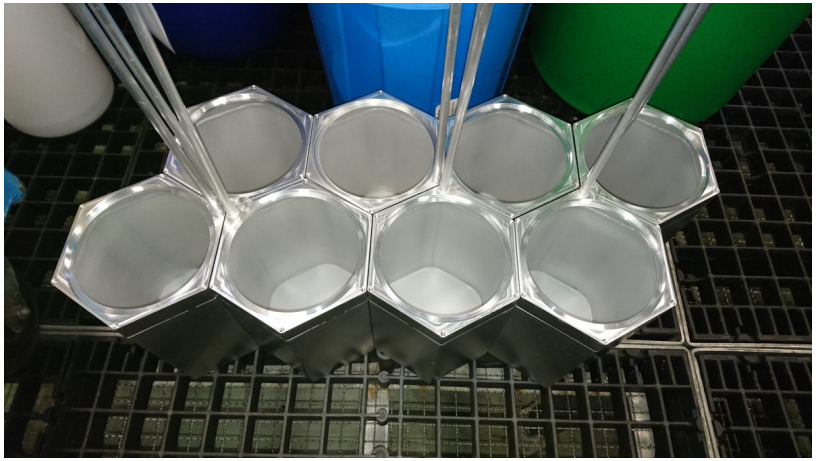
→ Expansion bellow – ΔT = 40 K;

→ EJ301 (BC501A) liquid scintillator.

→ SBA R11833-100HA 5” PMT (32% Q.E.)

→ custom transistorized VD provided by Świerk

→ mu-metal shielding (1 mm)



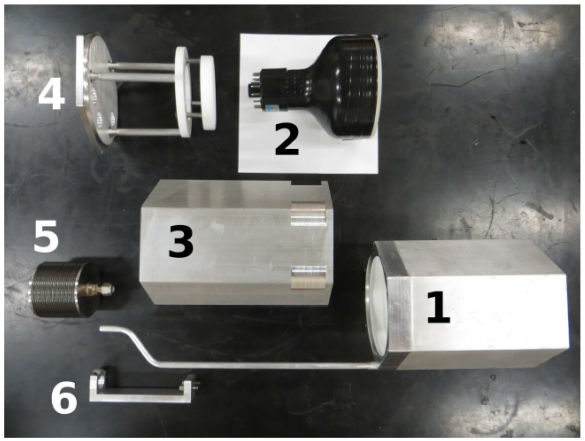
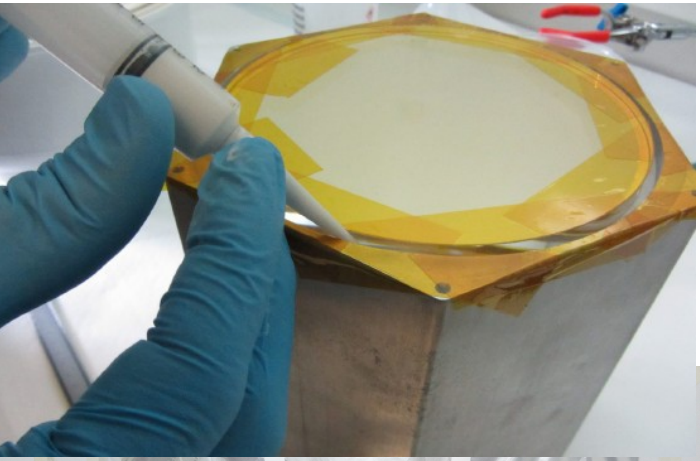
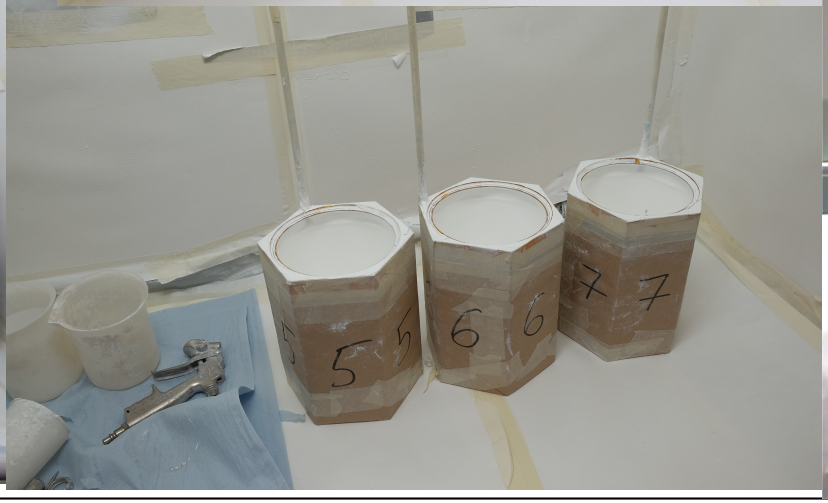


Fig. 1. Elements used for the construction of the NEDA detector: detector cell, with extension pipe (1); PMT (2); PMT housing (3); PMT pusher (4); the bellow (5) and the support for the bellow (6).

Detector production





Production – current status

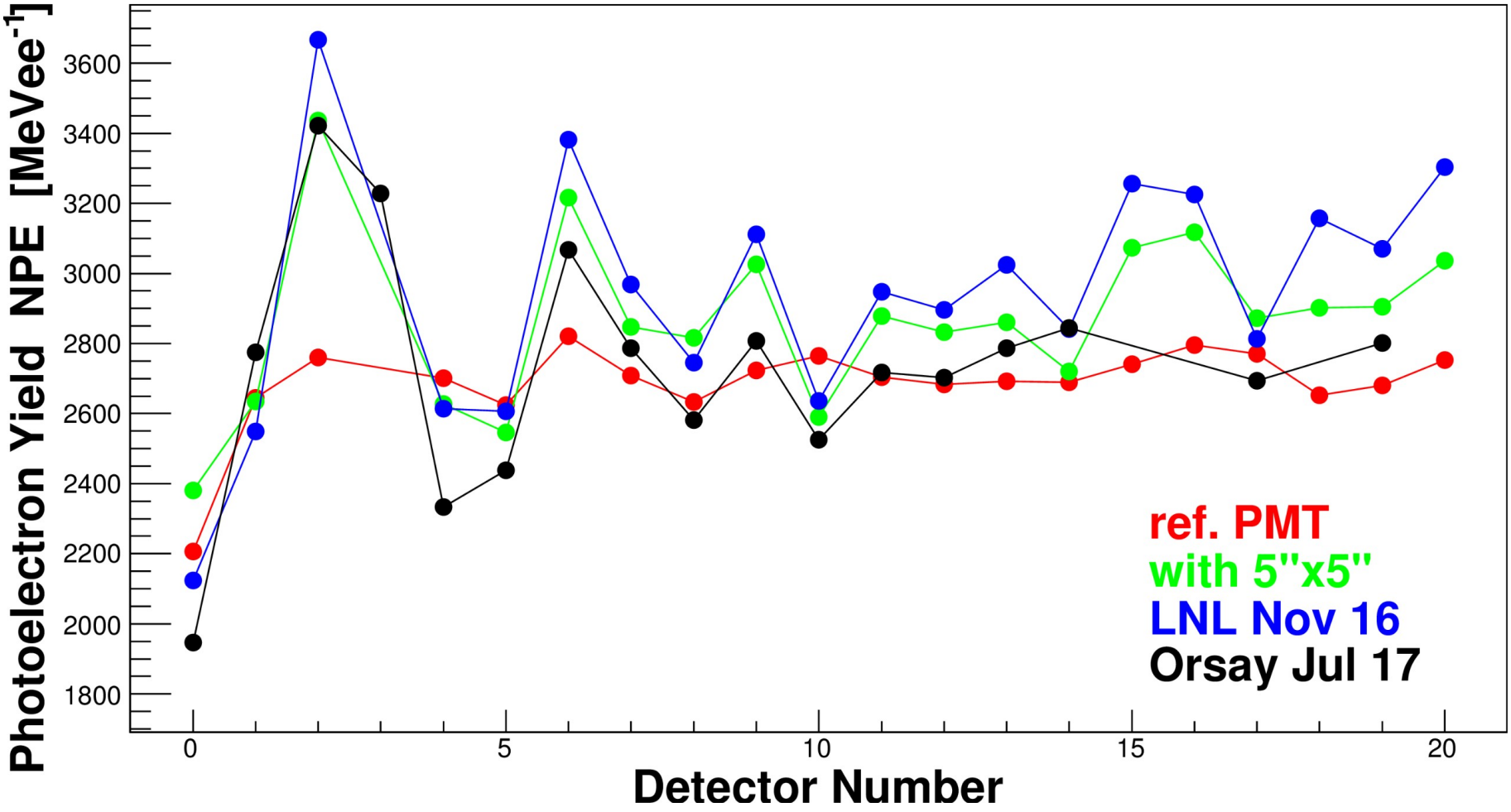
→ 20 detectors finished (2400-2600 phe/MeVee);
→ 15 detectors to be finished in no time;
→ 17 on various stages of the production;
→ 10 detectors under recovery.

Delay due to:
→ issue with closing of the detector
→ issues with leaking after mechanical damage
→ issues with the glue

Have:
→ 99.5 liters of EJ301;
→ 2.6 liters of paint;
→ 272 g of the glue;
→ 14 glass windows;
→ 7.45 kg of the grease.
→ 60 PMTs;
→ 75 VDs.

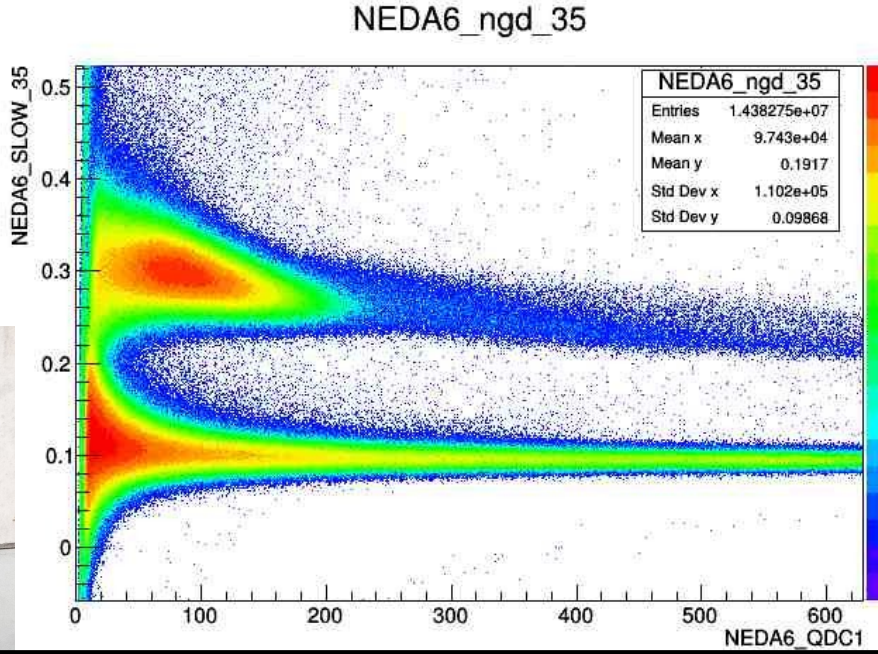
GOAL:
→ 62 detectors in beg. of 2018

Light Yield

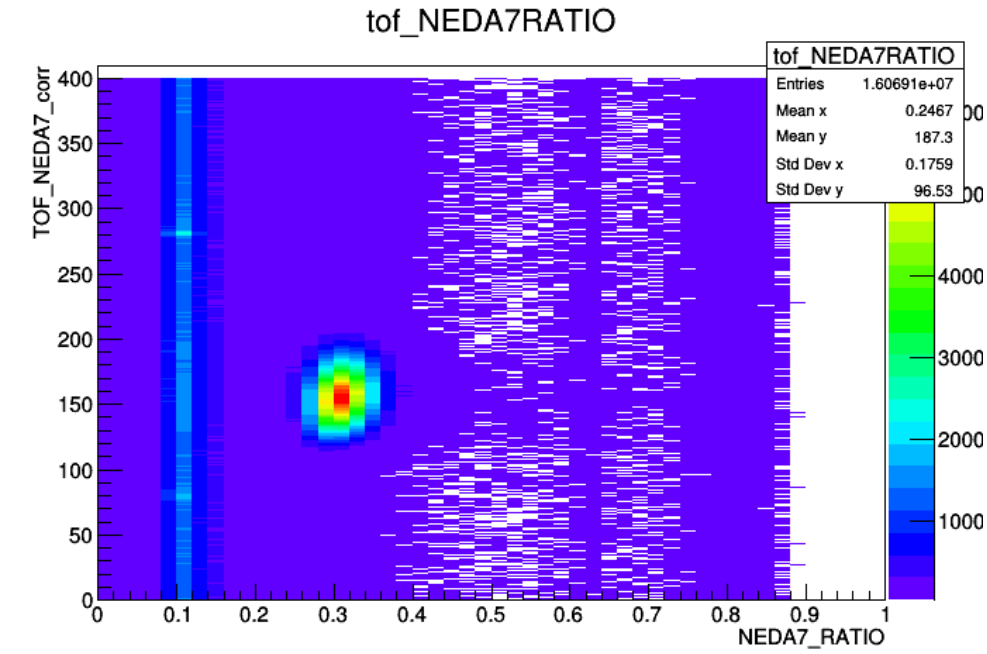

Photoelectron Yield NPE [MeVee^{-1}]
3600
3400
3200
3000
2800
2600
2400
2200
2000
1800
0
5
10
15
20
Detector Number
ref. PMT
with 5"x5"
LNL Nov 16
Orsay Jul 17

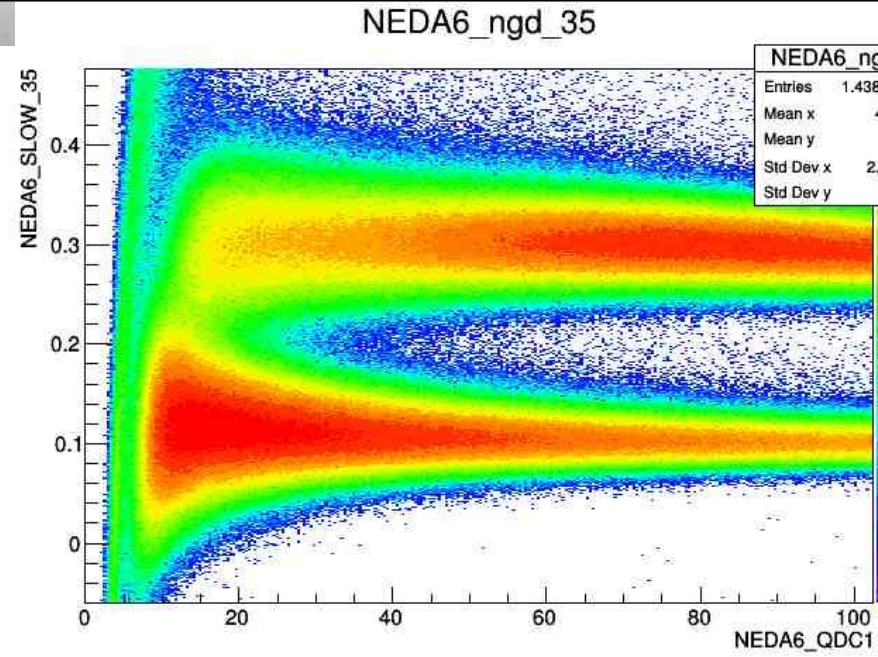
$p(^7Li,n)^7Be$ LICORNE @ ALTO

Dec. 2016



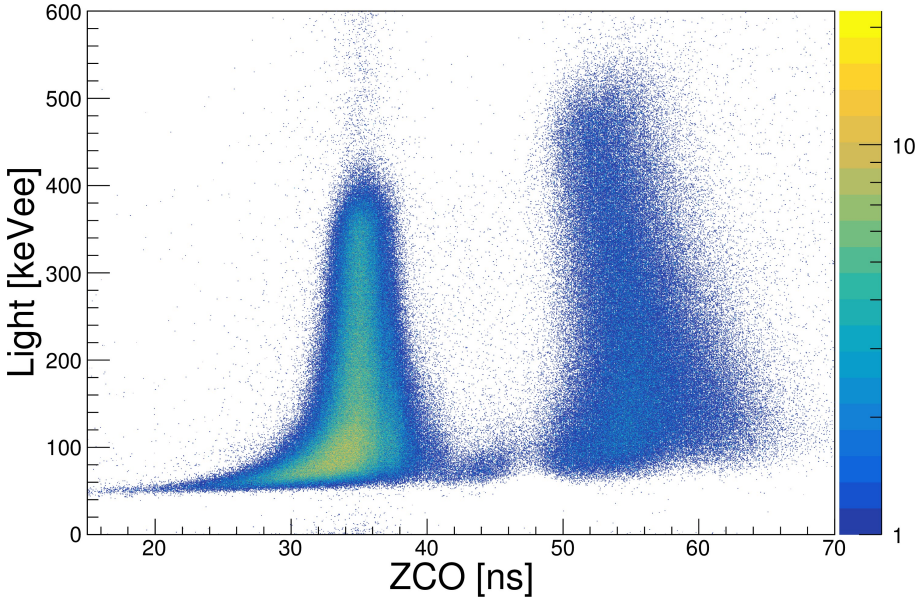
FOM = 1.88 for (50-200)keVe

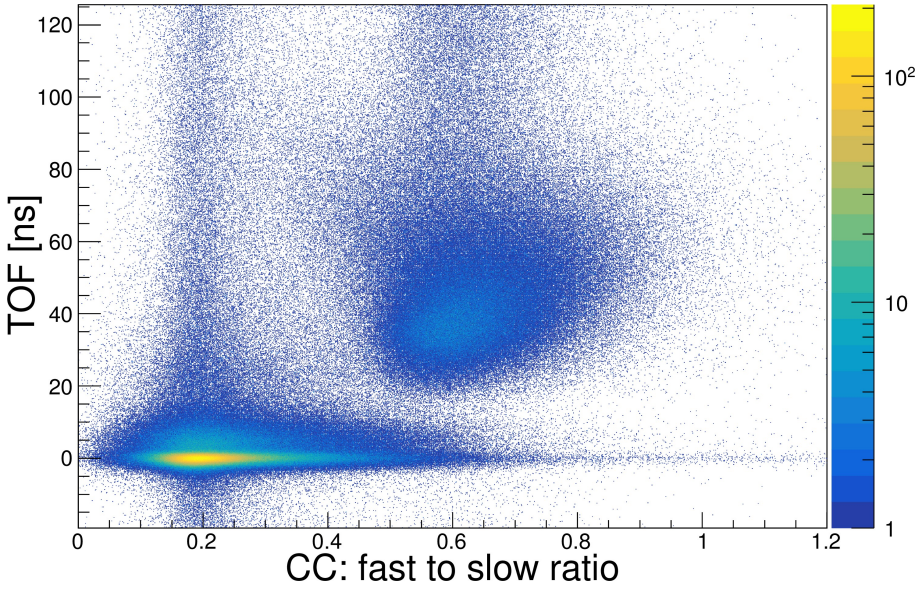




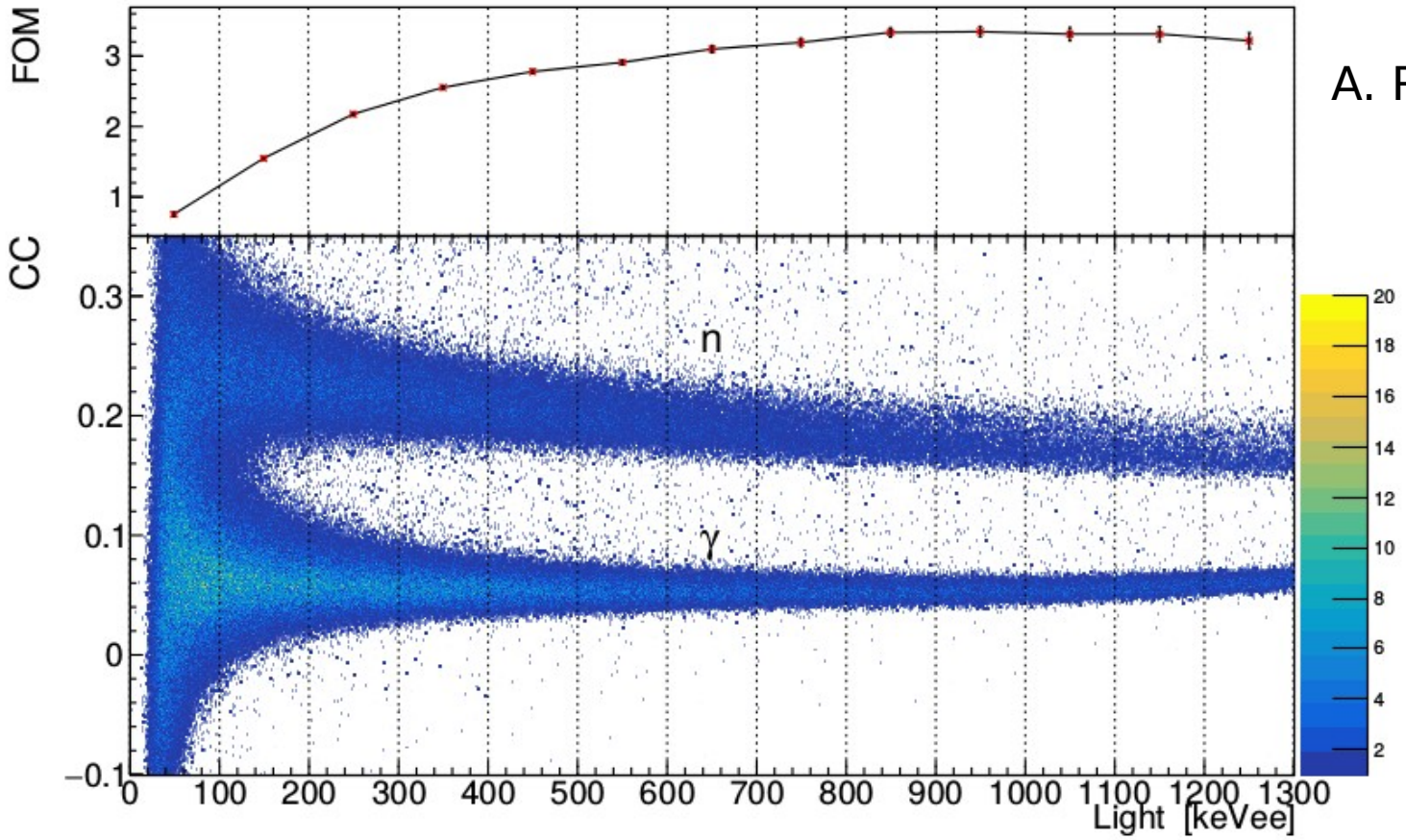
Characterisation: NEDA #21

A. Raggio





Characterisation: NEDA #21



A. Raggio

Figure 3.15: 2-D density plot of CC vs Light. The top line shows the FOM value for each energy gate.

Characterisation: NEDA #21

A. Raggio

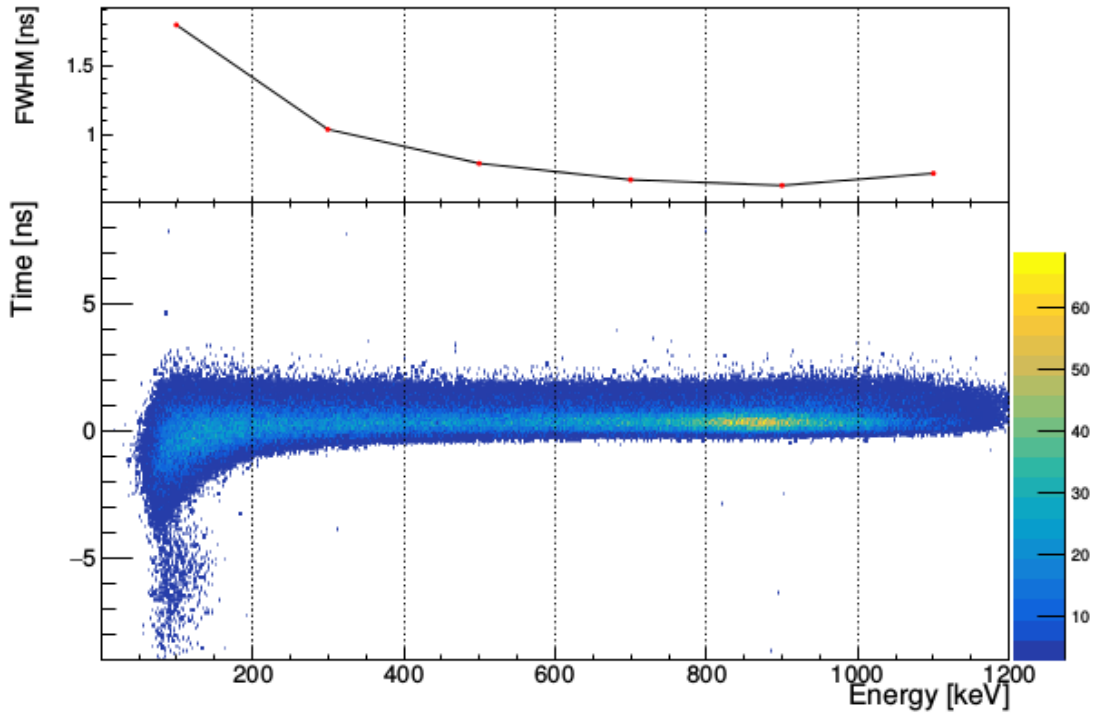
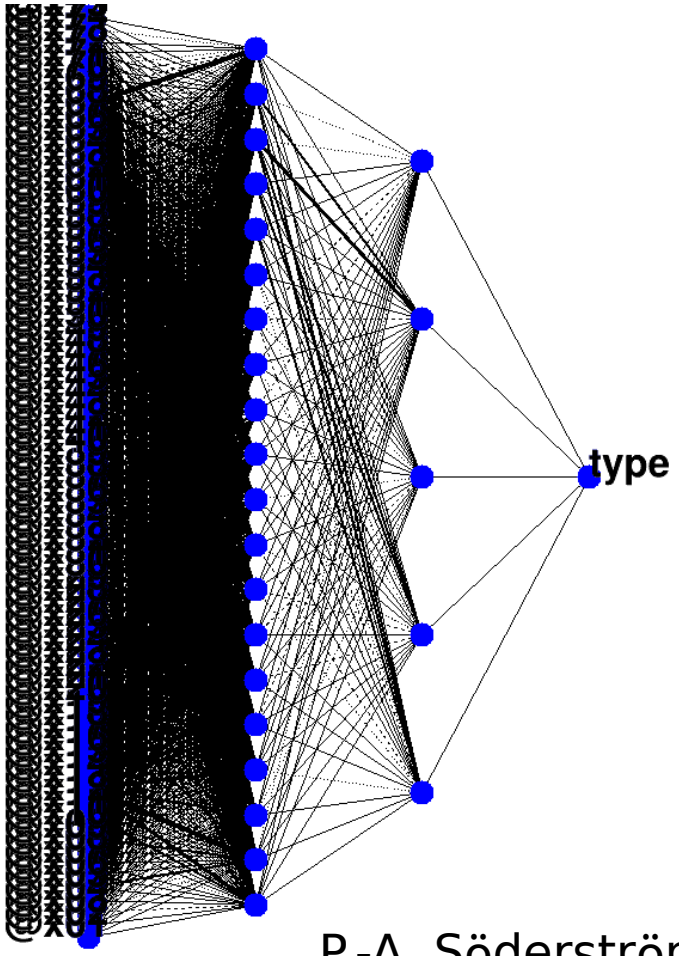
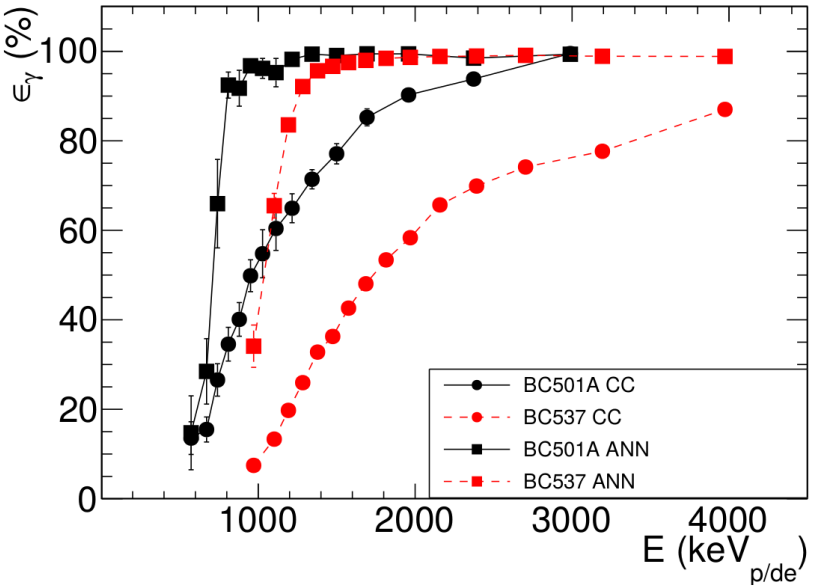


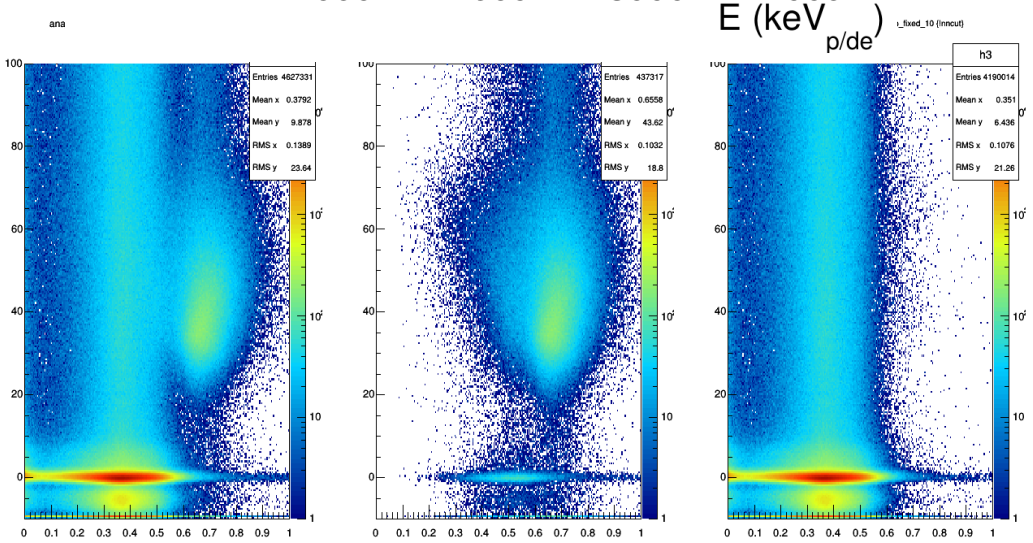
Figure 3.9: Digital timing distribution as a function of energy. The top line shows the FHWM for each corresponding energy gate.

Artificial Neural Networks

NEDA



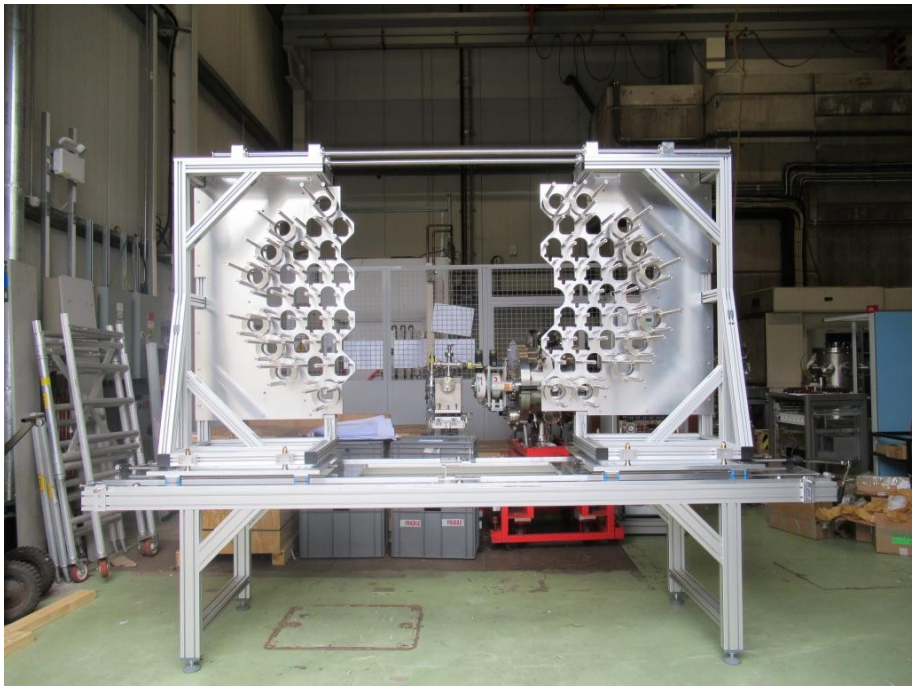




P.-A. Söderström

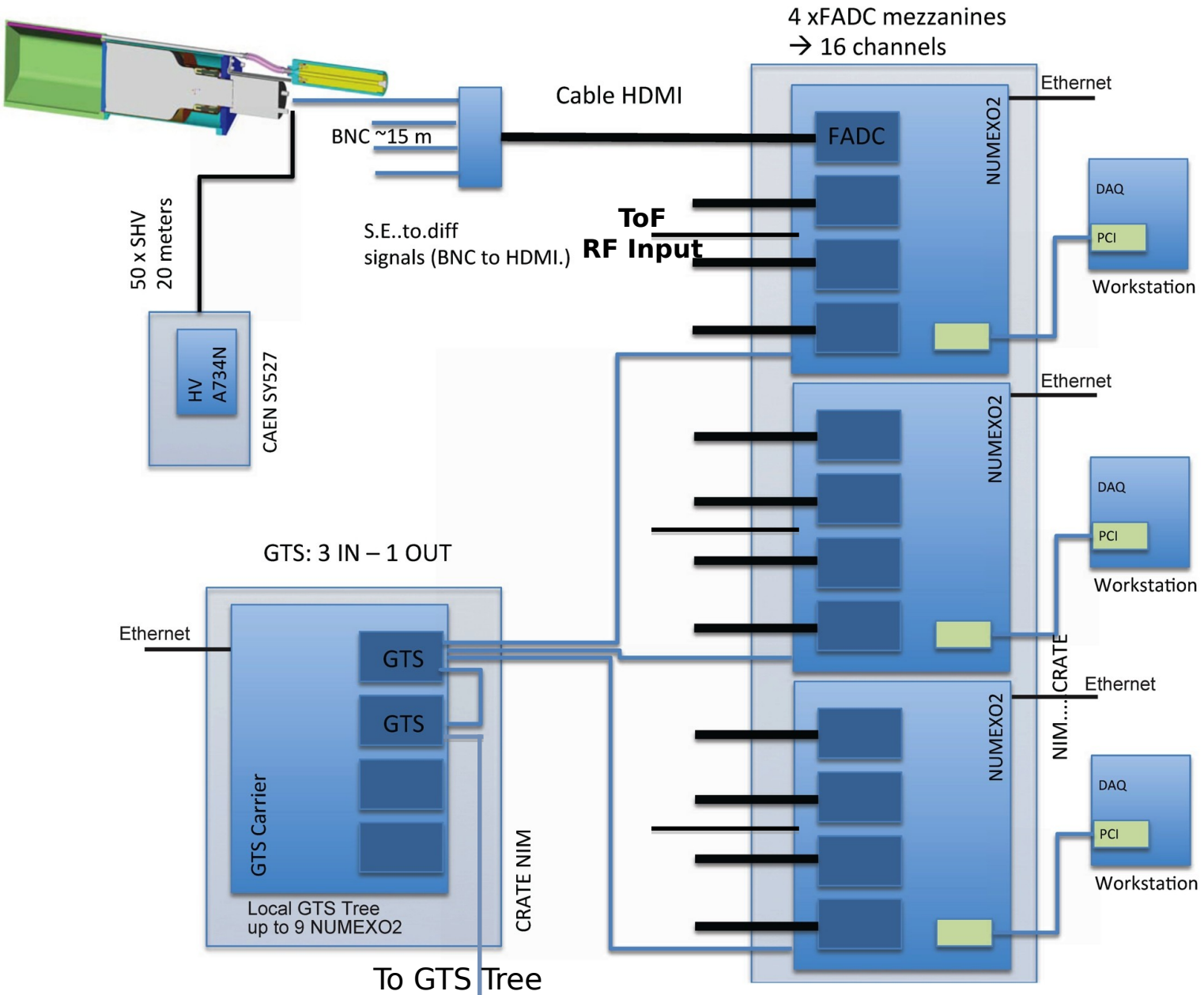
Mechanics

Ian Burrows, Mike Cordwell, Alant Grant



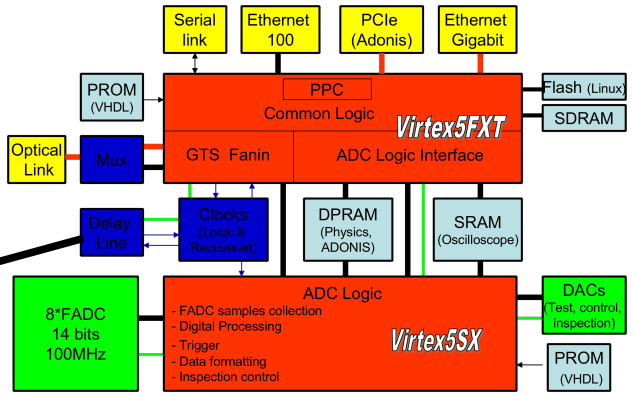
→ NEDA & NW support structures designed in Daresbury
→ NEDA structure machined and tested in Daresbury
→ NWall structure machined by Warsaw, Padova & Daresbury
→ 16 NEDA detectors mounted on the structure in G2 as we speak

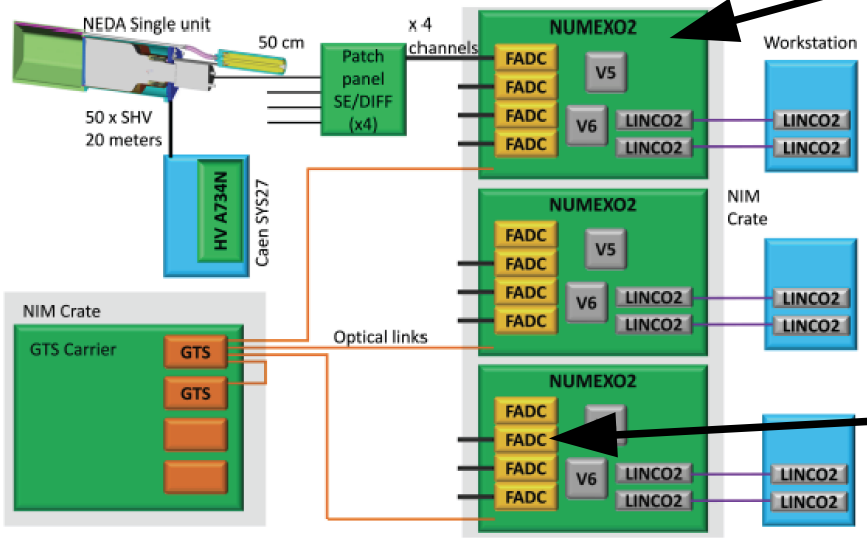
NEDA Front-end Electronics Design.

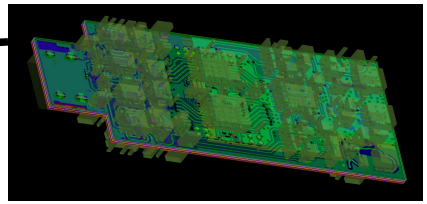


Electronics

- → NUMEXO2 board
- → GTS on board
- → GTS logic trigger tree
- → 200 MHz, 14 b (11.3 enob) Mezzanines FADC







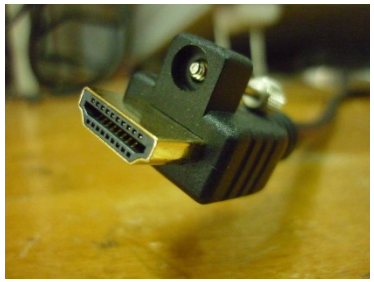


Figure 20: Global electronics layout for 48 NEDA detectors

Electronics

Have:
- Numexo2 (16 ch) x7
- ADC mezzanines (4 ch) x25
- GTS mezzanines (tree 3-1) x4
- NIM GTS Carriers (4 mezzanines) x1
- NIM crates 2kW (12 ch) x1
- RG58-blue MM11/50 150 cables 15 m
- SHV cables
- HDMI cables x40
- Linco2 (8 ch) x13
- optical fiber MPO MPO (16 ch) x7
- optical adapter MPO to LC (16 ch) x7

Currently addressed issues:

→ DAQ

→ PCIe buffering and validating timestamps

→ synchronization of the reset sequence

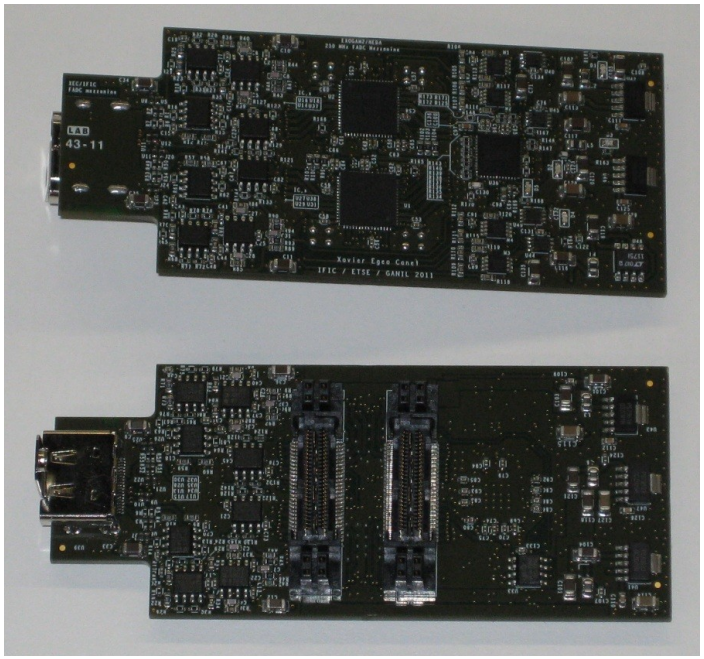
→ validating the firmware – NGD, TDC on FPGA

→ debugging the read-out from NUMEXO

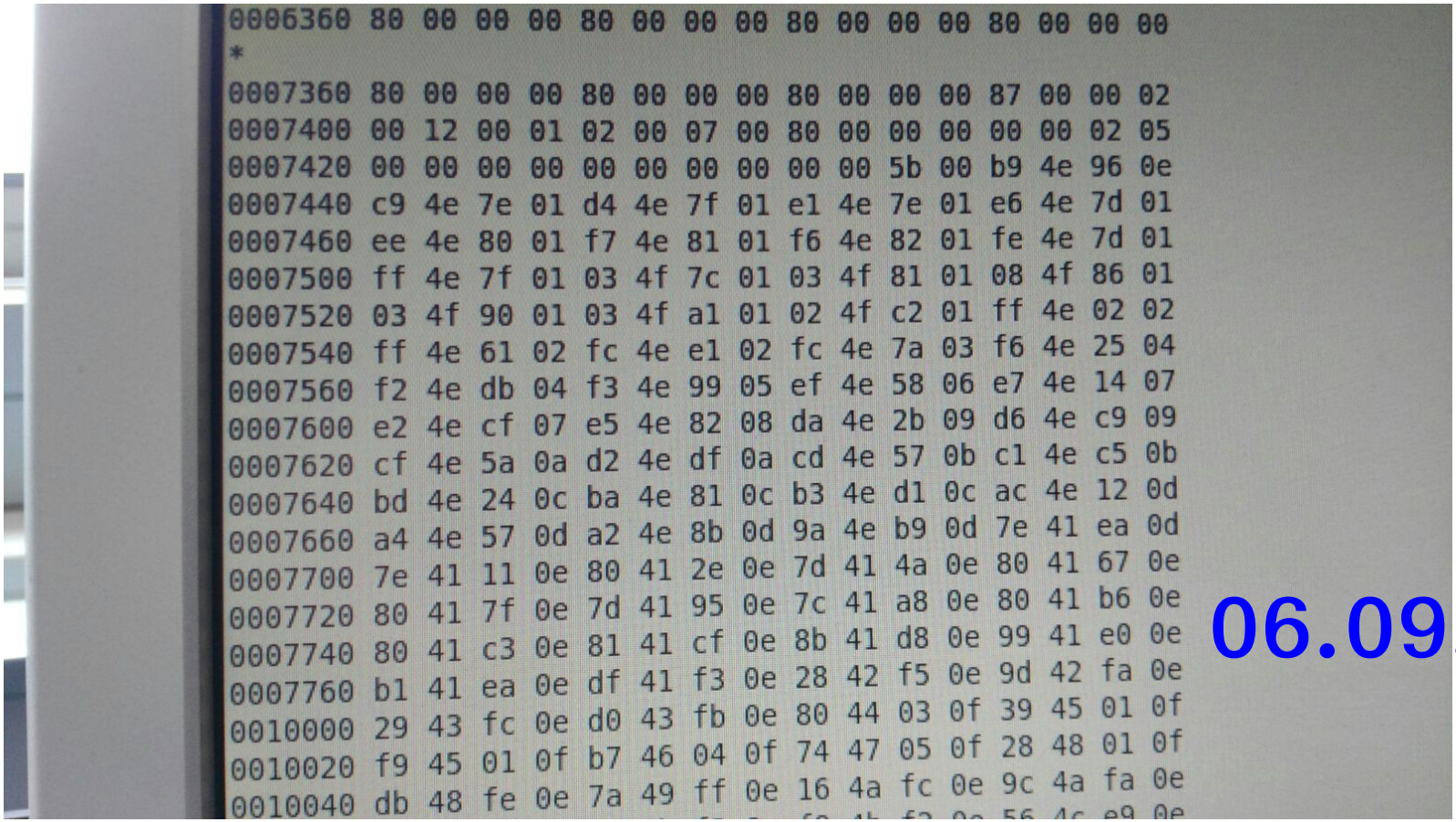
→ trigger processor

→ workstations and storage disk server

→ SEDIFF – should arrive tomorrow



First NEDA data dumped

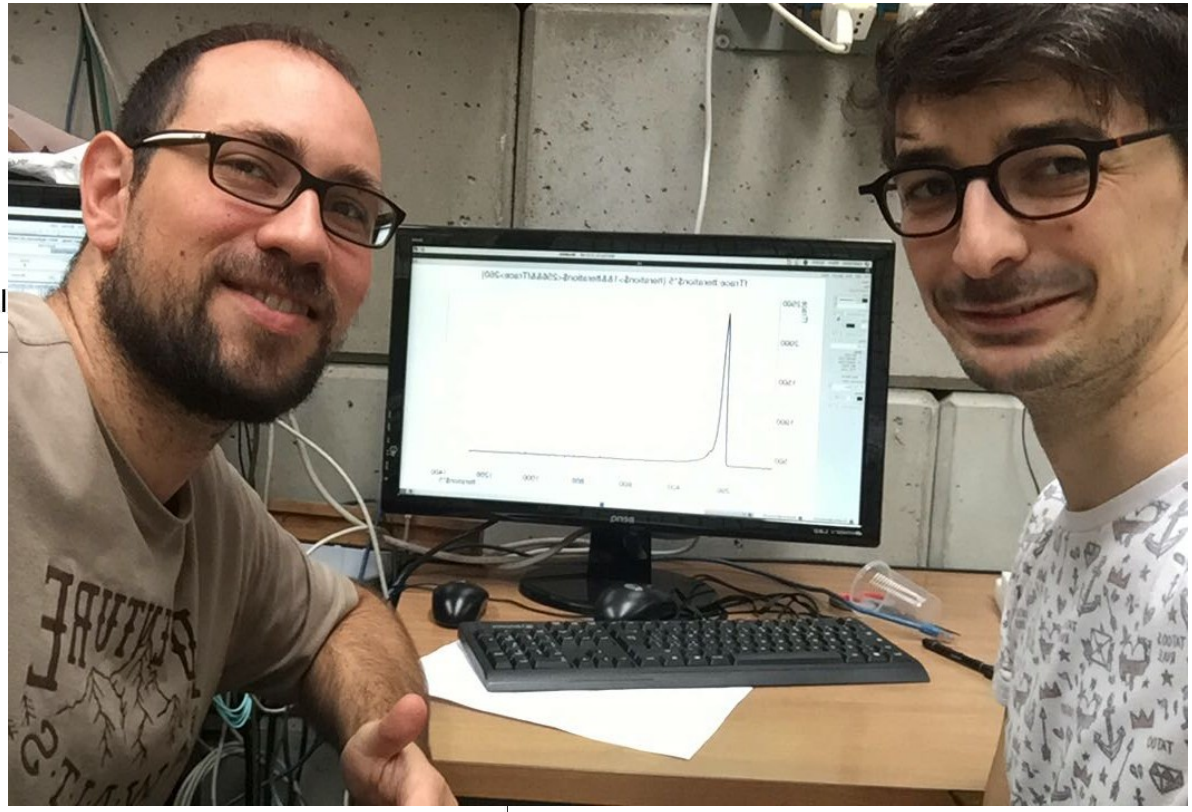


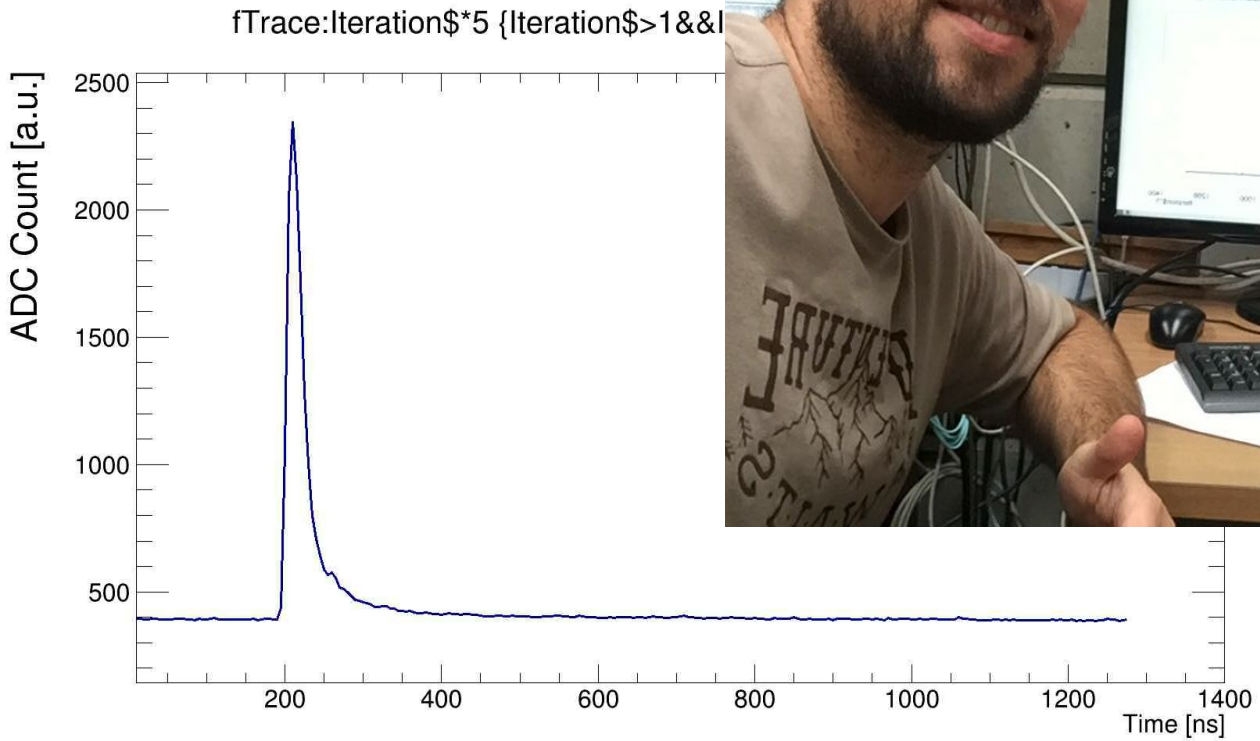
```
0006360 80 00 00 00 80 00 00 00 80 00 00 00 80 00 00 00
*
0007360 80 00 00 00 80 00 00 00 80 00 00 00 87 00 00 02
0007400 00 12 00 01 02 00 07 00 80 00 00 00 00 00 02 05
0007420 00 00 00 00 00 00 00 00 00 00 5b 00 b9 4e 96 0e
0007440 c9 4e 7e 01 d4 4e 7f 01 e1 4e 7e 01 e6 4e 7d 01
0007460 ee 4e 80 01 f7 4e 81 01 f6 4e 82 01 fe 4e 7d 01
0007500 ff 4e 7f 01 03 4f 7c 01 03 4f 81 01 08 4f 86 01
0007520 03 4f 90 01 03 4f a1 01 02 4f c2 01 ff 4e 02 02
0007540 ff 4e 61 02 fc 4e e1 02 fc 4e 7a 03 f6 4e 25 04
0007560 f2 4e db 04 f3 4e 99 05 ef 4e 58 06 e7 4e 14 07
0007600 e2 4e cf 07 e5 4e 82 08 da 4e 2b 09 d6 4e c9 09
0007620 cf 4e 5a 0a d2 4e df 0a cd 4e 57 0b c1 4e c5 0b
0007640 bd 4e 24 0c ba 4e 81 0c b3 4e d1 0c ac 4e 12 0d
0007660 a4 4e 57 0d a2 4e 8b 0d 9a 4e b9 0d 7e 41 ea 0d
0007700 7e 41 11 0e 80 41 2e 0e 7d 41 4a 0e 80 41 67 0e
0007720 80 41 7f 0e 7d 41 95 0e 7c 41 a8 0e 80 41 b6 0e
0007740 80 41 c3 0e 81 41 cf 0e 8b 41 d8 0e 99 41 e0 0e
0007760 b1 41 ea 0e df 41 f3 0e 28 42 f5 0e 9d 42 fa 0e
0010000 29 43 fc 0e d0 43 fb 0e 80 44 03 0f 39 45 01 0f
0010020 f9 45 01 0f b7 46 04 0f 74 47 05 0f 28 48 01 0f
0010040 db 48 fe 0e 7a 49 ff 0e 16 4a fc 0e 9c 4a fa 0e
```

06.09.2017

Acknowledges: GANIL, Valencia, Daresbury, Kraków, CERN, LNL.

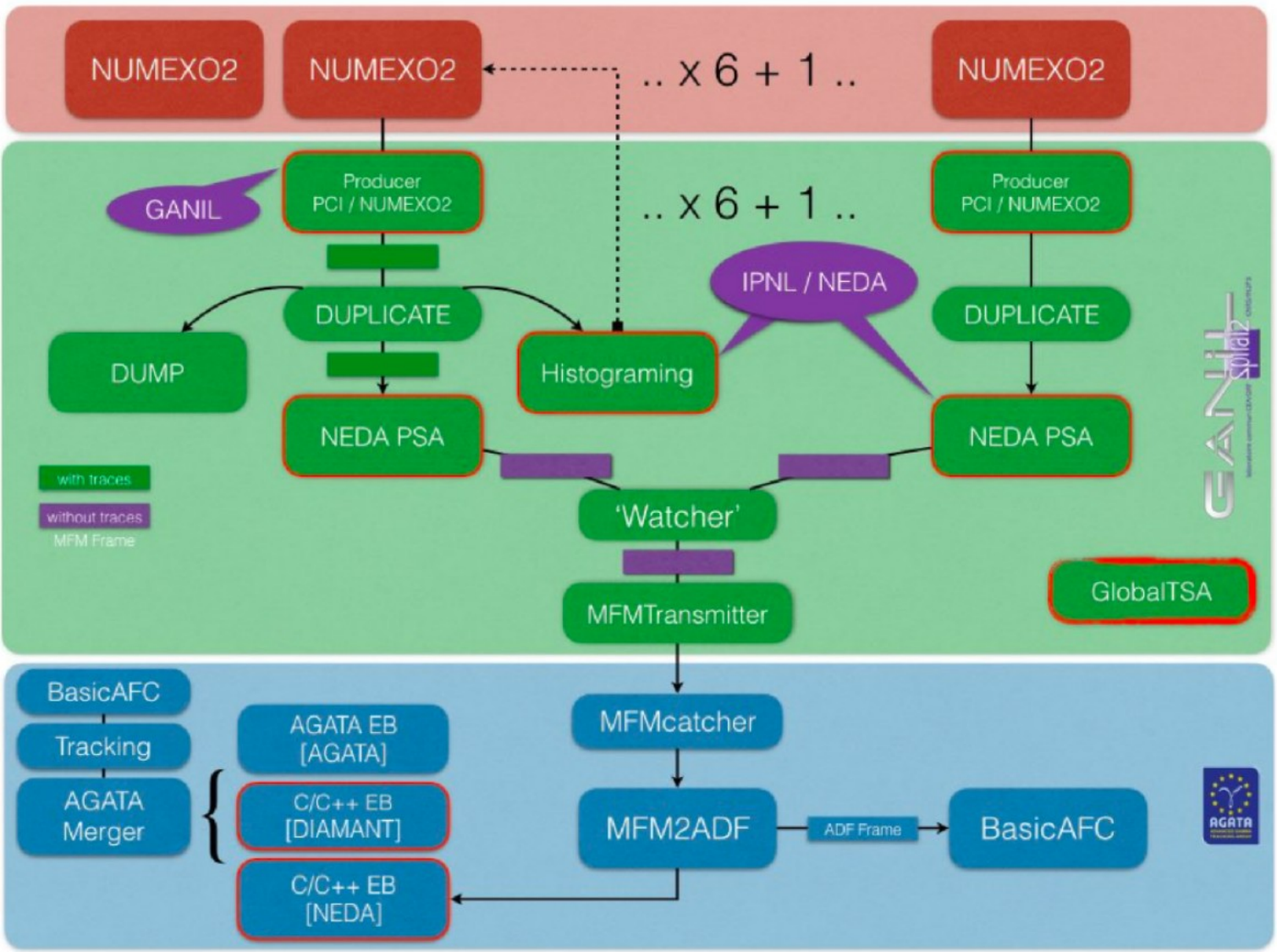
First NEDA waveform from PCIe and NUMEXO2





13.09.2017

DAQ



O. Stezowski
A. Goasduff
F. Saillant

DAQ

→ Samtec boards mounted and tested on 1 DAQ server

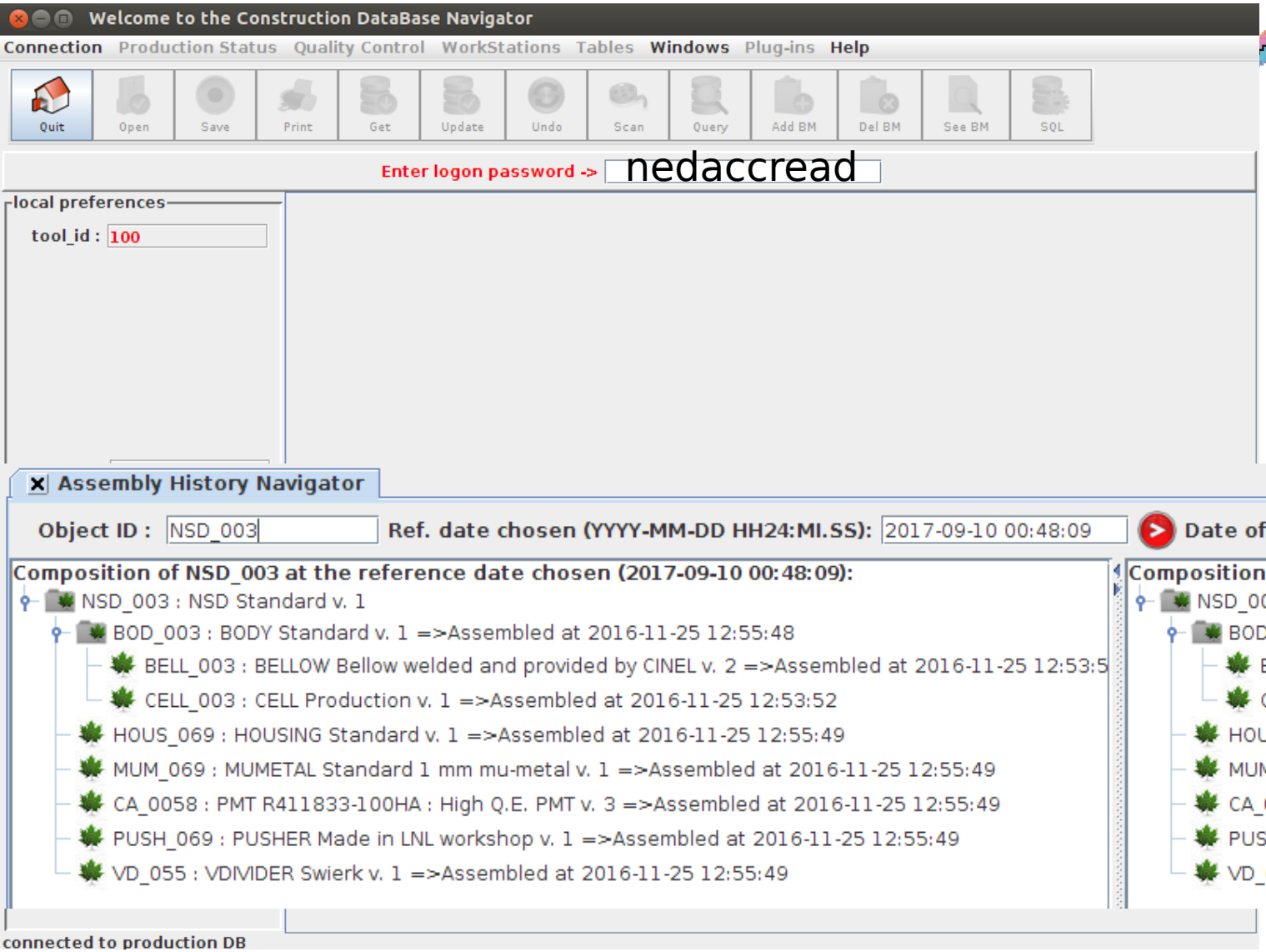
→ Delivery of DAQ Server mid-(end-) September to LNL
  * Installation and configuration of the servers (ASAP)
  * Installation and test of the Samtec board (ASAP)
  * Data transfer test with 1 NUMEXO and NEDA

→ Test data taking with NWALL detectors + NUMEXO2 (without trigger processor)
  * Availability of the SEDIFF?
  * First test with 16 detectors on 1 NUMEXO
  * Quality check of the FPGA n/g discrimination for NWALL

→ The amount of data produced by NEDA
  * Request the storage on the grid (to be done)

O. Stezowski
A. Goasduff
F. Saillant

DB



NEDA

C. Aufranc
A. Goasduff
O. Stezowski
G. Jaworski

DB

→ Based on the tools developed for AGATA

→ Reachable from wherever using the BigBrowser software
https://lyosvn.in2p3.fr/constructiondb/wiki/Download

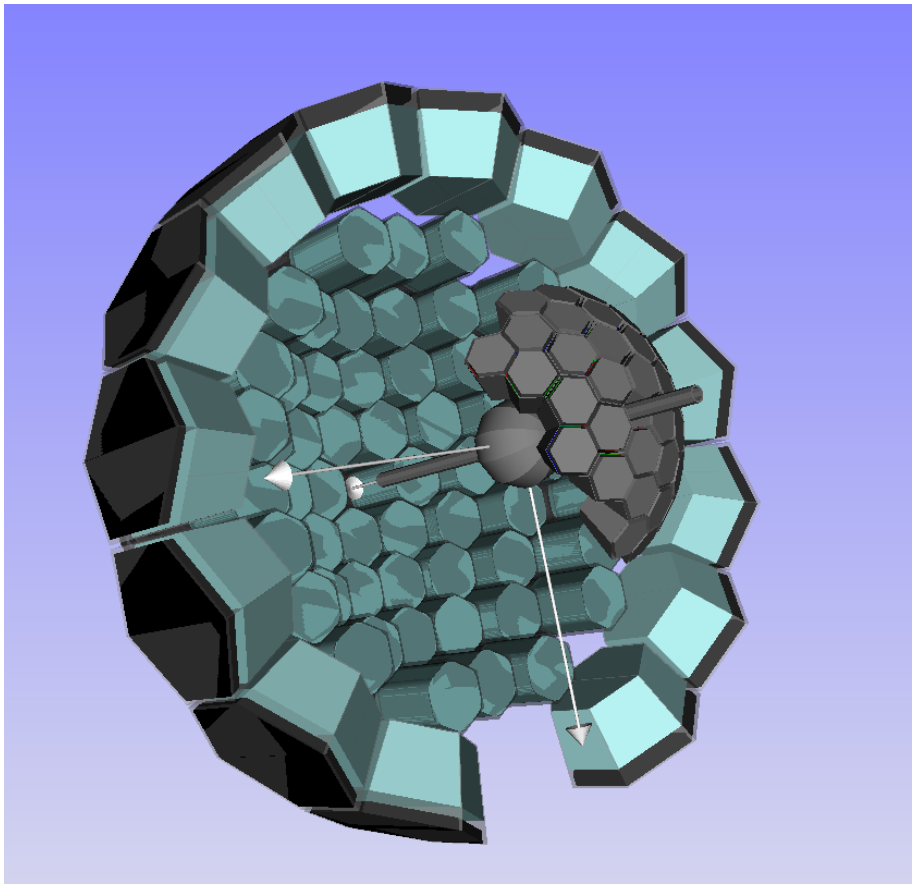
→ Included in the DB: Detectors (PMT, BODY, PUSHER, CELL, BELLOW, VD & CATs, …), Cables (OF, HDMI, AN, HV, Ethernet, …), Crates (NIM, HV), NUMEXO2, FADC, GTS carrier, GTS mezzanine, DAQ Server, Samtec PCIE, HV Cards, Racks

→ Possibility to include and control the fill chain: Detector (with its constituents) → AN cable → SEDIFF → HDMI cable → FADC → NUMEXO2 → OF → PCIE → DAQServer

→ Will make debugging easier

→ Inventory and transfers under control

NEDA & NW @ GANIL in AGATA Simulation Code



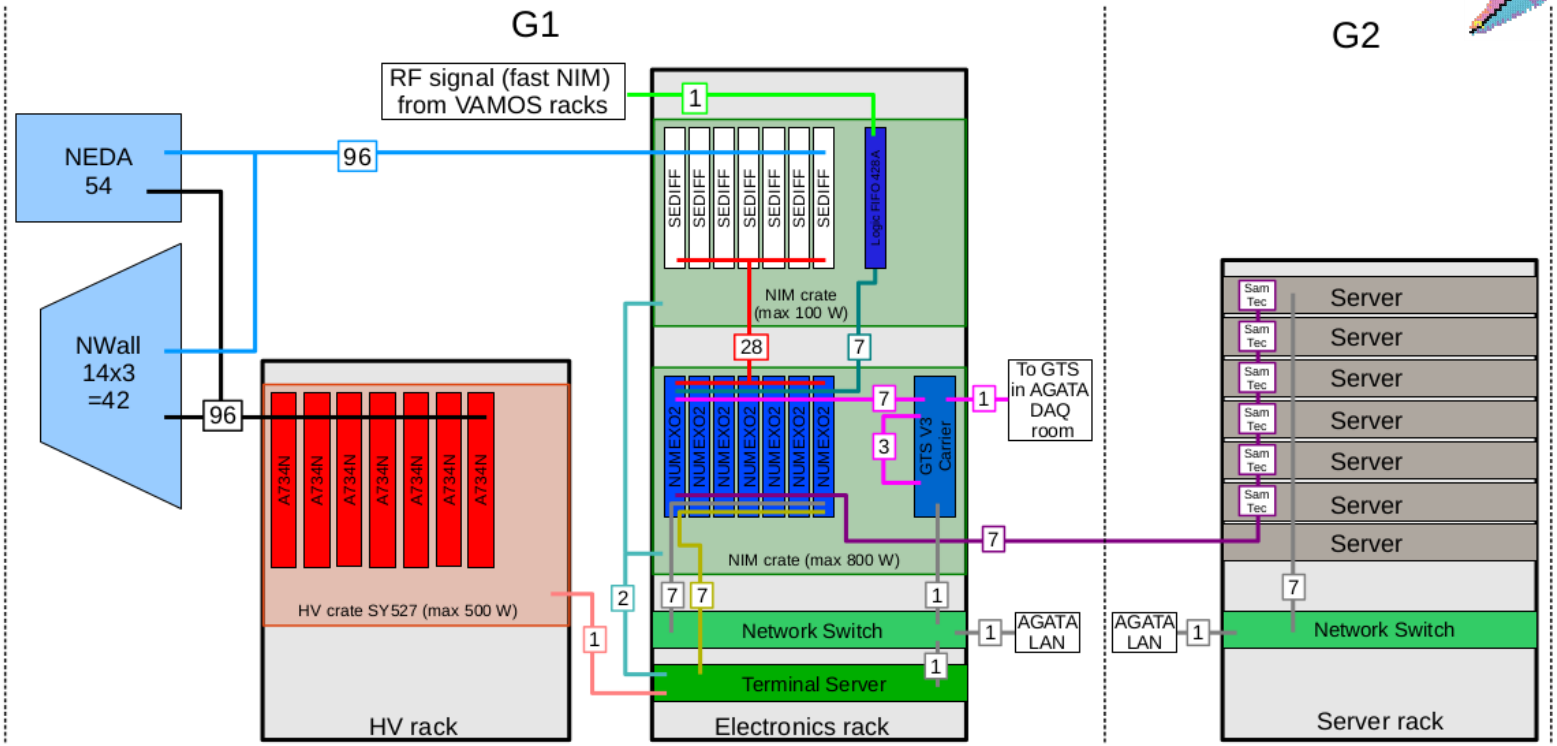
→ NEDA finally available as AGATA's ancillary
→ included in the GANIL trunk
→ NEDA & NW N=Z 2018 campaign geometry ready
→ ancillary ID = 12 for NEDA
→ light production and interaction time sorting restored.

→ Unclear if neutron energy deposit can be trusted within g.4.10 nor g.4.9

A. Goasduff, G. Jaworski

Infrastructure

NEDA and NWall equipment for the AGATA@GANIL campaign 2018



J. Nyberg

Cables and connectors [installed spares in square brackets]:

96 [+14]	Double-shielded coax BNC-MM1150-LEMO from detectors to SEDIFF units (15 m)
96 [+14]	Single-shielded coax SHV-RG174-SHV from detectors to HV units (20 m)
1	Single-shielded coax BNC-RG58-BNC from VAMOS racks to LeCroy 428A logic FIFO (~15 m)
7	Single-shielded coax Lemo-RG174-Lemo from Lecroy 428A logic FIFO to NUMEXO2 (~1 m)
28	HDMI Real Cable INFINITE II from SEDIFF to NUMEXO2 (1.5 m)
7	Optical fibres MPO-MPO (~20 m?), plus MPO-to-SAMTEC data transfer from NUMEXO2 to servers (10 m)
11	Optical fibres OM3 duplex LC-50/125-C for GTS signals (7x0.5 m, 3x0.1m, 1x60m)
18	Network cables Cat5e or Cat6
1	RS232 cable with DB9-RJ45 connector from HV crate to terminal server
2	RS232 cable with ???-RJ45 connector from NIM crate to terminal server (uncertain if NIM crates have such an output)
7	RS232 cable with RJ45-RJ45 connectors from NUMEXO2 rear panel to terminal server

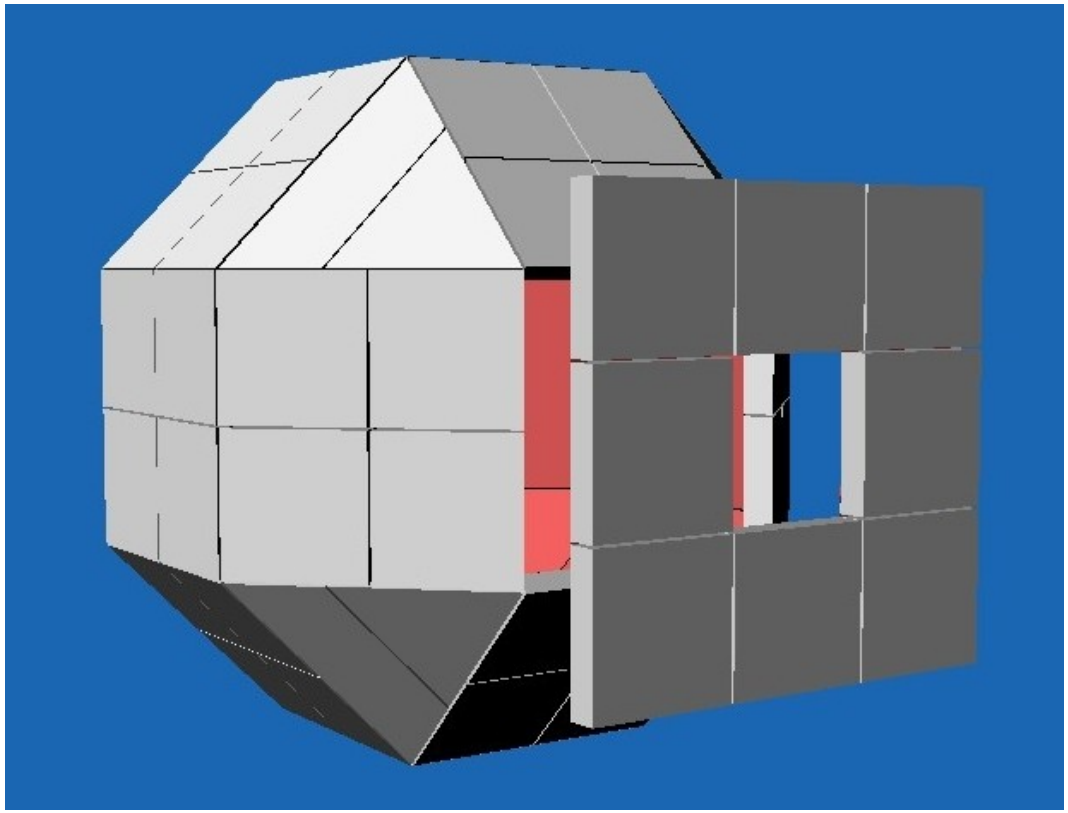
Infrastructure

→ Cables – all available, mostly in LNL, about to be shipped
→ Racks – 3 racks for the HV, NIM electronics and servers @ GANIL
→ Crates – in LNL, Valencia → to go to GANIL

TODO:
→ ship
→ new version of the scheme for the in-beam commissionings in Nov. 2017

	2017				2018			
	9	10	11	12	1	2	3	4
Detector production								
Production								
Characterisation (Npe, NGD)								
Shipment together with Neutron Wall								
Mechanical structure & pieces								
NEDA installation in G2								
NEDA & NWALL installation in G1								
absorbers								
Electronics – Hardware								
PMTs – CAT								
VDs	Have, tested							
NUMEXO 2, FADC mezzanines	Have, tested							
SEDIFF – checking the prototype								
SEDIFF – mass production								
Signal cables (x150 RG58-blue MM11/50, 15m)	have							
SHV cables (x150)	have							
HDMI cables	have							
NIM GTS carriers, GTS mezzanines, NIM crates	have							
HV cards – buying / repairing...	tested							
MPO fibres, MPO-LC adapters	have							
Electronics – Firmware								
FPGA – NGD – validation								
FPGA – TDC – validation								
FPGA – GTS – validation								
Firmware integration								
DAQ								
OS installation								
Samtec test								
Narval – producer								
Narval – watcher								
Narval – PSA filter								
Narval – assembler	have							
Narval – time sorting								
Narval – event builder								
Target Chamber								
Pieces arrive, testing in the lab,mounting in GANIL								
Plunger								
Cabling, source test, debugging								
In beam tests (x3)								

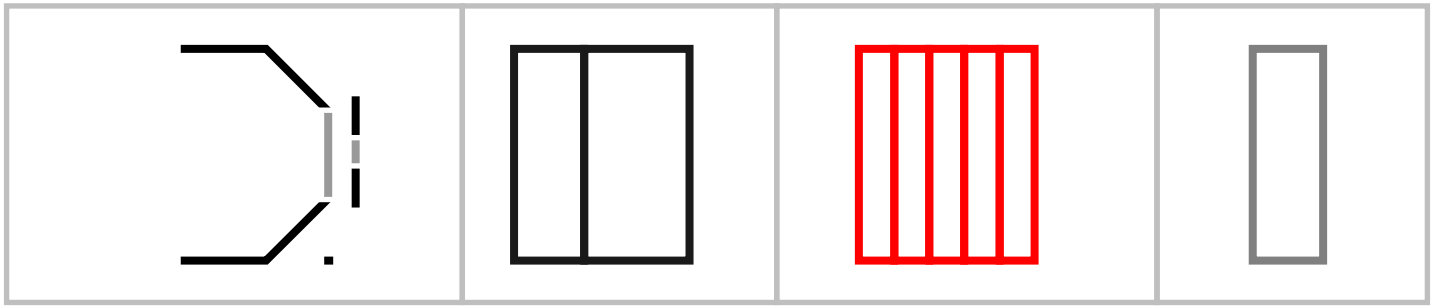
Status of DIAMANT



Istvan Kuti

Configuration for the 2018 campaign

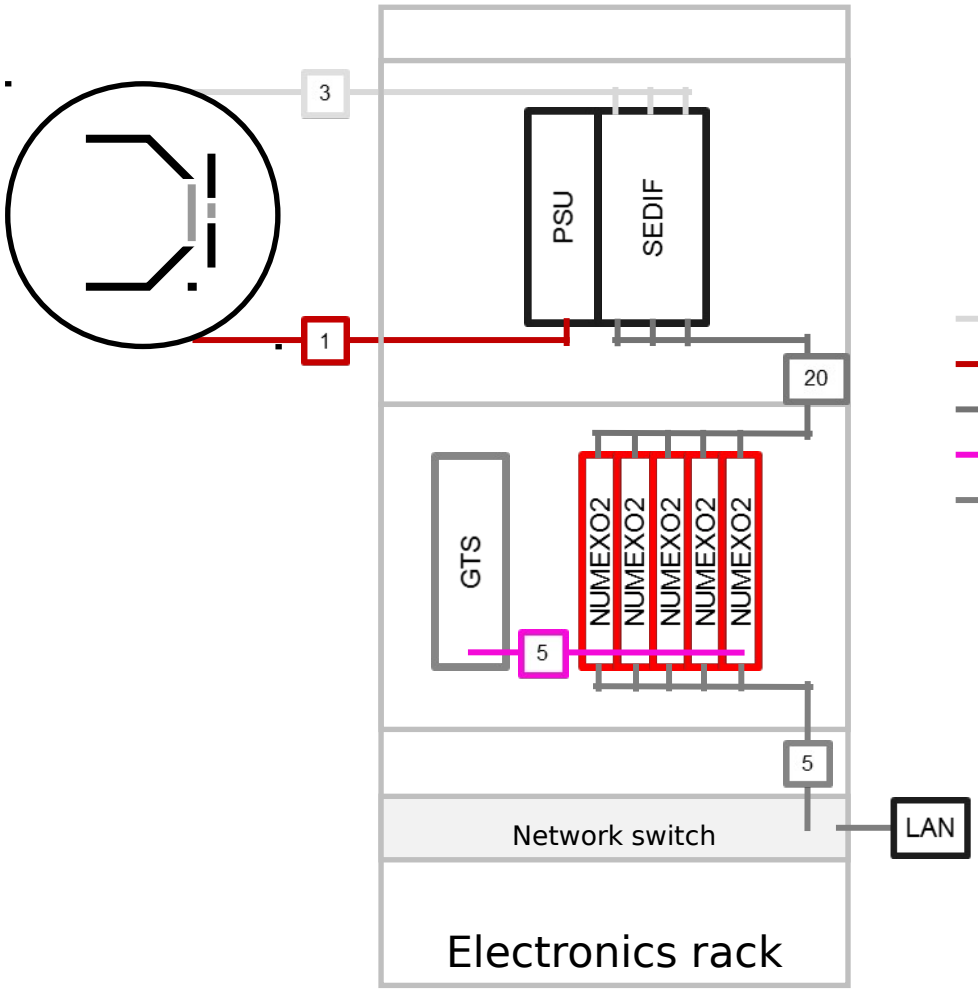
FW config (plunger)



CsI	2nd stage	NUMEXO2	GTS
56+8(24) channels	1 double NIM 1 triple NIM	5 single NIM	1 double NIM

64(80) channels:
10 NIM slots
5x 1Gbps

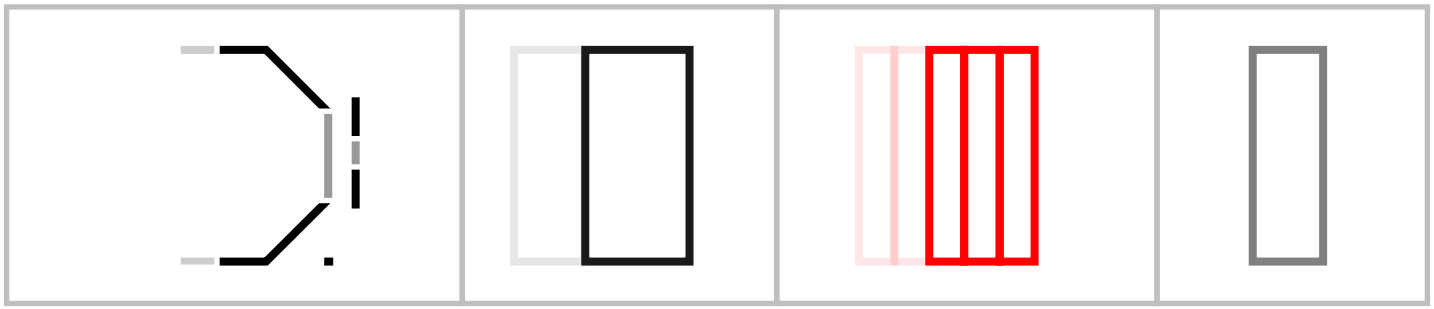
Cabling schematics for the 2018 campaign



3	SCSI-SCSI	Shielded flat cable	1 m
1	Molex-DIN	4-wire power cable	1 m
20	HDMI-HDMI	SEDIF to NUMEXO2	12m
5	OM3-OM3	GTS optical	0.5m
6	RJ45-RJ45	NUMEXO2 to switch	1.5m

Configuration for the autumn tests

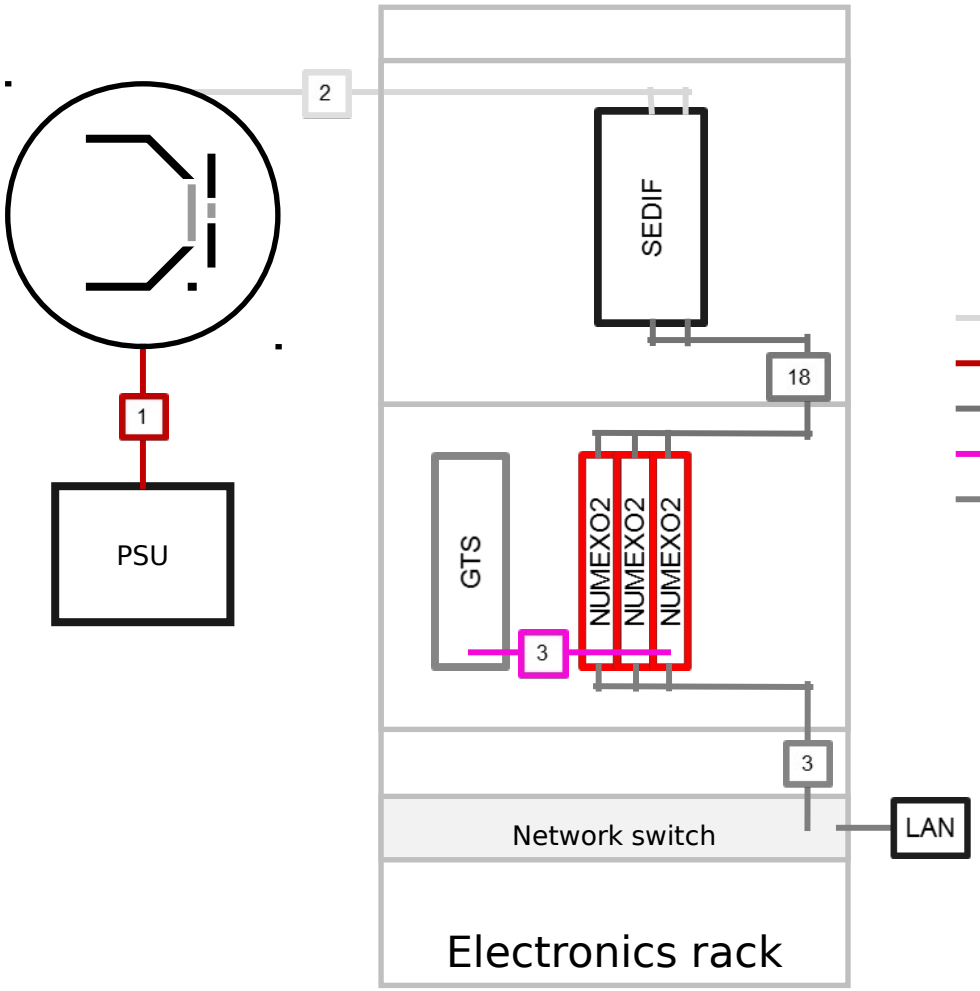
FW config (plunger), reduced channel number



CsI	2nd stage	NUMEXO2	GTS
56+8 channels, 48 used	1 triple NIM	3 single NIM	1 double NIM

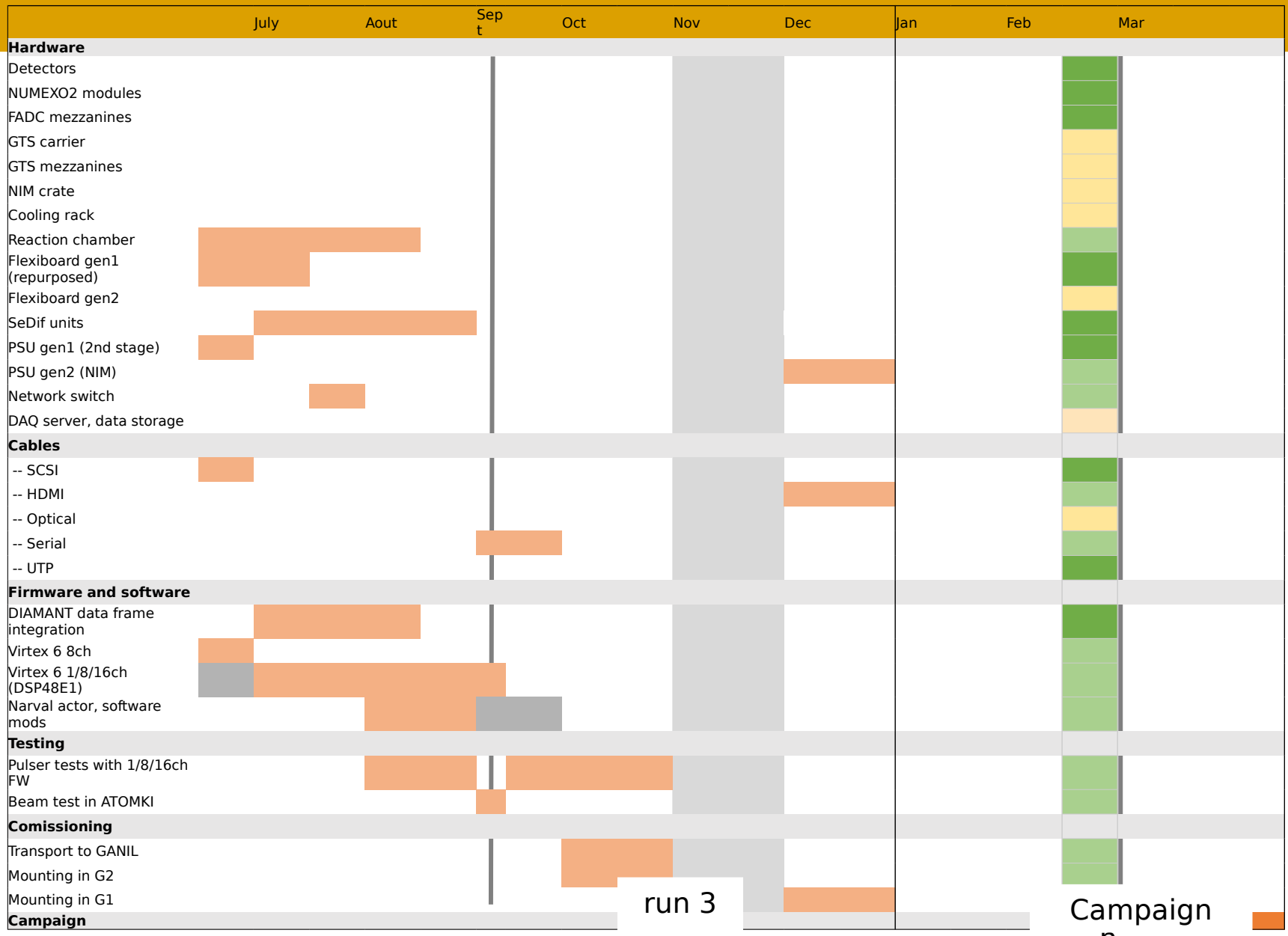
48 channels:
6 NIM slots
3x 1Gbps

Cabling schematics for the atumn tests



2	SCSI-SCSI	Shielded flat cable	3.5 m
1	Molex-DIN	4-wire power cable	3.5 m
18	HDMI-HDMI	SEDIF to NUMEXO2	1.5m
3	OM3-OM3	GTS optical	0.5m
3	RJ45-RJ45	NUMEXO2 to switch	1.5m

Timeline


available / ready
not ready yet, progressing as planned
missing, but resolvable / no problem
might be a problem
July
Aout
Sept
Oct
Nov
Dec
Jan
Feb
Mar
Hardware
Detectors
NUMEXO2 modules
FADC mezzanines
GTS carrier
GTS mezzanines
NIM crate
Cooling rack
Reaction chamber
Flexiboard gen1 (repurposed)
Flexiboard gen2
SeDif units
PSU gen1 (2nd stage)
PSU gen2 (NIM)
Network switch
DAQ server, data storage
Cables
-- SCSI
-- HDMI
-- Optical
-- Serial
-- UTP
Firmware and software
DIAMANT data frame integration
Virtex 6 8ch
Virtex 6 1/8/16ch (DSP48E1)
Narval actor, software mods
Testing
Pulser tests with 1/8/16ch FW
Beam test in ATOMKI
Comissioning
Transport to GANIL
Mounting in G2
Mounting in G1
Campaign
run 3
Campaign

Status

Firmware

→ using DSP48E1 slices 16ch routed
→ 31% occupied slices, using 57% of the DSP48E1's
→ pretrigger filter, dcfd, 2 trapeze… everything except pileup handling implemented
→ testing method: 1ch -> quicker compiling
→ delay due to issues with integration and testing (flashing, broken hw, trigger, late beamtime)

Software

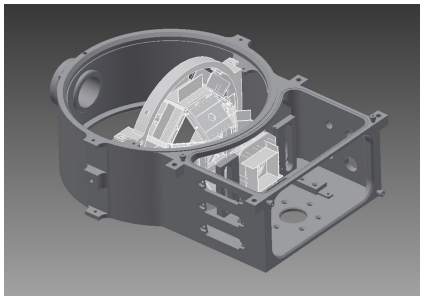
→ NARVAL actors (in-place division, producer) → will get help from A.Goasduff
→ got the modified GECO, V5, embedded sw and lots of help from GANIL GAP
→ data frame similar to EXOGAM2
→ DAQ will benefit of the NEDA developments

Tests

→ pulser tests of firmware with DSP48E1 filters finished last week:
signal passthrough, valid trigger & trapezes, some problems with data readout
→ testing new SeDif units and mezzanines (week 37 first half)
→ in beam test ongoing right now → beamtime: 13th-15th, but delay expected
→ planning to record trace data for further tests

Status

Hardware:
56ch FlexiBoard + 8ch ForwardWall (24ch ChessBoard) – 64 (80) ch,
16ch/NUMEXO2



→ all of the NUMEXO2s are ready
→ all FADC mezzanines are ready
→ GTS, crates, racks: help from EXOGAM2

→ detectors ready (chessboard is not priority right now)
→ FlexiBoard: the current FB will be cut & used
→ chamber: plans from Lyon are being finalized -> manufacturing
funds are also allocated in ATOMKI for some parts
(vc. feedthrough, inner mount),
final design & manufacturing in progress

→ power supply: for run3, the gen1 2nd stage will be used,
NIM PSU funded, will be ready Q4 2017

SeDif: 4 redesigned carrier board manufactured (4)
20 new mezzanines manufactured (30)
→ enough for 96ch (w/ spares)

N=Z campaign preparation calendar

Instalation and debugging:

→ structure and 17 detectors mounting – mid. Sept.
→ cabling, mounting infrastructure items – 1st week of Oct.
→ basic DAQ, configuration of NUMEXOs, absorbers – 2nd week of Oct.
→ trigger processor, source tests – 3rd week of Oct.
→ debugging fun continues until:

In-beam tests:

→ 5th Nov – 2UTs, pilot, CIME, ^{36}Ar+^{58}Ni (?) – trigger processor, NGD, ε_{1n}
→ 11th Nov – 3UTs, pilot, CSS, ^{78}Kr+^{58}Ni (?) – trigger processor, ε_{1n}, $p_{\gamma \to n}$
→ 24th Nov – 4th Dec – 2UTs, parasitic, CSS, ^{124}Xe+^{12}C – neutron fold

Installing in G1 and commissioning? - Jan-Feb 2018

Campaign – Feb-Mar 2018

Summary and outlook

- NEDA:
  - 17 detectors and mechanics ready in GANIL – will be tested in October
  - Production, repair and characterisation ongoing – manpower available?
  - Hardware: all ready (except sediff – Sept/Oct)
  - Firmware: ^{252}Cf & gamma sources tests @ LNL ongoing
  - Software: getting ready for November
- DIAMANT:
  - Detectors existing.
  - Hardware: all ready (including sediff which was the last issue)
  - Firmware: 8ch and 13ch versions running. Add filter for trigger request. 16ch version compiling. Pulser tests in August. In-beam tests in ATOMKI ongoing now.
  - Software: will benefit from NEDA development
- Target chamber with many constraints (DIAMANT, plunger, target loader, thickness,...) - pieces being machined now – mounted in G2 in October.
- *EXOGAM2 TP_V1 running. Requires extensive tests. Connection to EXOGAM2 and AGATA. Collaboration with IPHC*
- Plunger – will be ready latest in January 2018.
- In-beam test of NEDA+DIAMANT+EXOGAM2+target chamber in November, x3
- AGATA+NEDA+DIAMANT will be taking data in 2018 → 8 experiments approved
- Necessity of a beam comissioning in G1 with AGATA → beginning of 2018. Have to prove that it works in G2 first. Each exp should send sb.

Backup slides follow

Collaboration

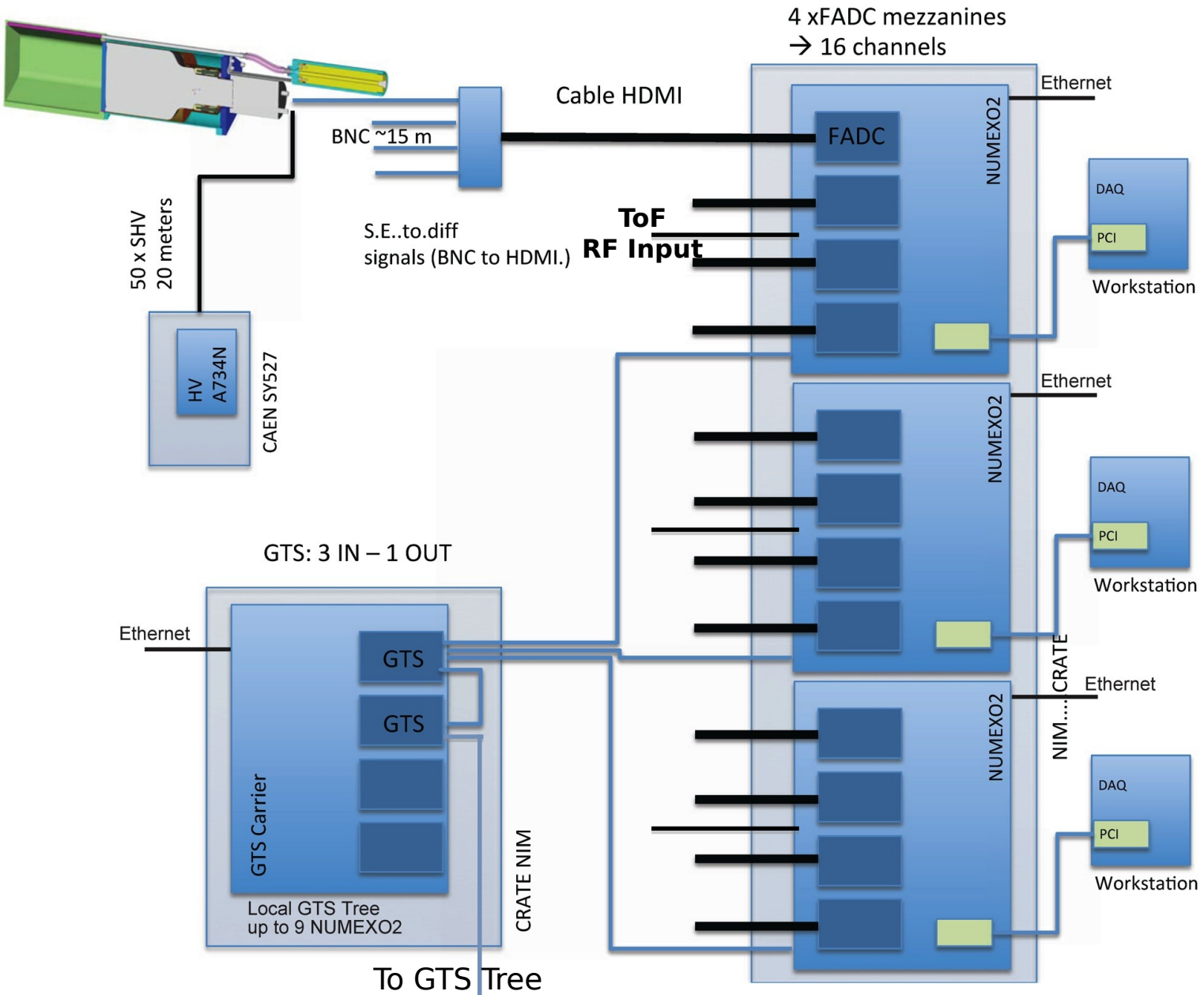
G. de Angelis, S. Carturan, E. Clement, X. Egea, N. Erduran, S. Ertürk, G. de France, A. Gadea, A. Goasduff, V. Gonzalez, K. Hadyńska-Klęk, T. Hüyük, M. Jastrząb, V. Modamio, M. Moszyński, A. Di Nitto, J. Nyberg, M. Palacz, E. Sanchis, B. Saygi, P.-A. Söderström, D. Testov, A. Triossi, J.J. Valiente Dobon, R. Wadsworth and G. J.

Notes to the NEDA FEE

A. Gadea (IFIC, CSIC-Univ. Valencia)

for the NEDA FEE collaboration

NEDA Front-end Electronics Design.



NEDA Front-end Electronics

Cabling and Fibres

Signal:

- BNC-LEMO cables to electronics rack → 100's produced
- HDMI short cable 4-to-1 → crosstalk checking completed at Cracow, cables purchased
- LEMO RF- 7 cables needed

Note: we are using RF and not gamma Tref

Readout

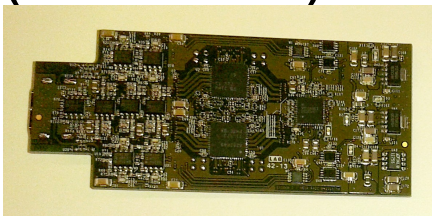
- SAMTEC – NUMEXO fibers PCI interface
- Extensions MPO-MPO for SAMTEC fibers

GTS

- LC/LC fibers to build the GTS tree and to connect to the NUMEXO2 boards: 1 LC/LC fiber to connect to the AGAVA fiber + 4 LC/LC fibers for the GTS tree + 7 LC/LC fibers for the connection GTS – NUMEXO2

NEDA FEE Hardware available.

- Single-Ended to differential adapter: pre-production ongoing production in October
- NUMEXO2 motherboards: 6 production (Uni. York) + 1 pre-production (UVEG-



- FADC Mezzanines 4 channels: 45 production + 5 pre-production (UVEG-IFIC)
- SAMTEC PCI Interfaces: 7 procured (IFIC-UVEG)

- GTS Mezzanines: 9 available (GANI
- NIM GTS-Carrier: 3 available (GANIL)
- NIM Crates available (IFIC, LNL)

NEDA FEE summary of hardware missing

- Single Ended-Differential adapter: Fist prototyping failed. Now pre-production on-going. 1 pre-production ready in September. Production before end of October

- DAQ hardware (Servers procurement by INFN-LNL on-going)

NEDA FEE Firmware Status: Virtex 5

The firmware of NEDA is a version of the NUMEXO2 Firmware with additions and changes in the Virtex5 and Virtex6 firmwares for the PCIe readout without the ADONIS mode.

Virtex5:

- GTS multiple trigger request firmware (A.Triossi) Ready
- PCI buffering and validated data timestamp: ADC_Interface (A.Triossi) debuging ongoing
- New PCIe with FIFO exclusion (A. Boujrad, L. Legeard)

- Issues with FIFO management (May-June 2017)
- Issues with Linux booting (June-July 2017) Other cards?
- Recent Issues:
  - Numexo2_fifo_pcie and Andrea's IP main clock
  - Enabling and configuring the PCIe in NEDA case
  - Synchronization of the reset sequence
  - Use of PCIe Clock in the project

NEDA FEE Firmware Status: Virtex 6

Virtex6:

- FADC data processing, PSA, Trigger request, data formatting (X.Egea) Ready
- ToF TDC (M. Kogimtzis) Ready
- Register Server (F.Saillant team) Ready

- Extended testing missing

Note: re-done the structure of the Virtex6 firmware and extended the frame. Integration now completed and working on the testing. Now working on the data transfer Virtex6-Virtex5-PCIe with Validation/Rejection. Trailer on Data frame added.
To add counters to evaluate data misalignment been evaluated.

NEDA FEE Software Status

Control Software:

- NEDA version of the GECO control/GUI completed (F.Saillant team)
- GTS EPICS software for NUMEXO2 being done (F.Saillant)
- EGC/RunControl integration to be done/discussed → Action (Integrated as EXOGAM2)

DAQ Software (see Alain Goasduff discussion) :

- NEDA Narval actor will be done (L. Legeard and C. Maugeais, F.Saillant team)

Trigger Processor

Trigger Processor

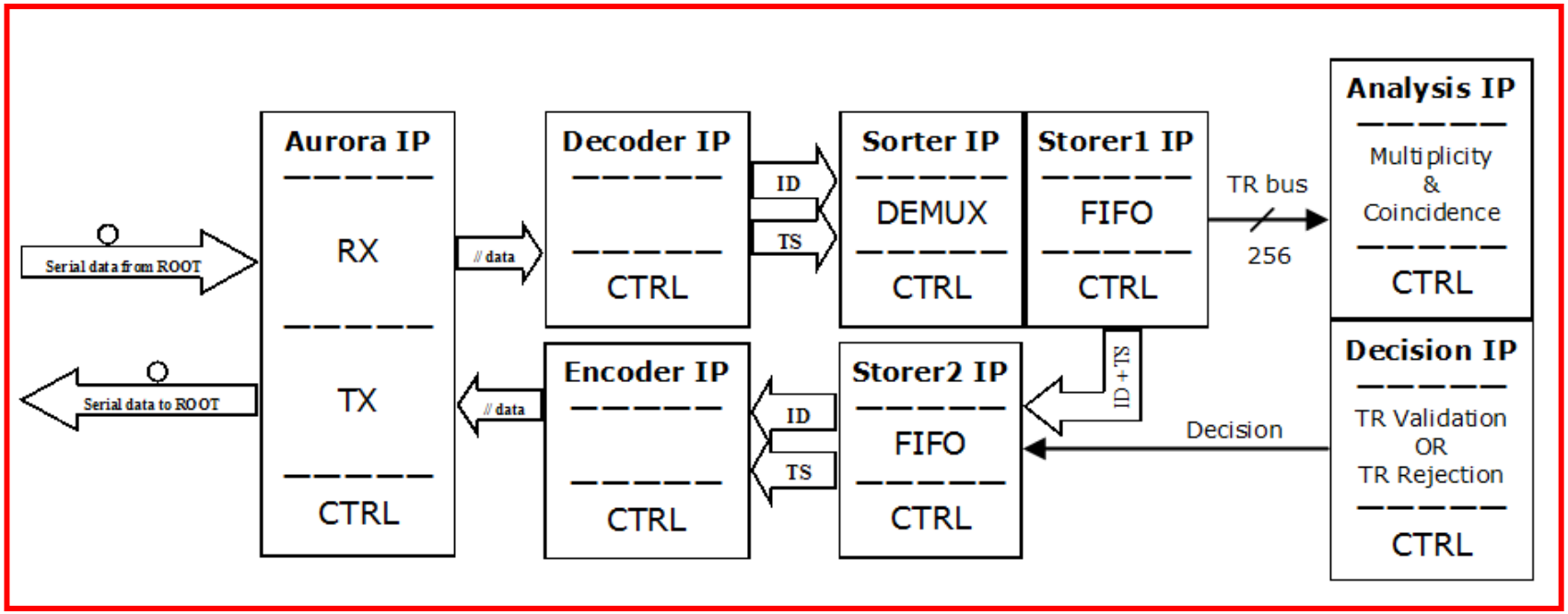
- AGATA Trigger not compliant with AGATA+NEDA+DIAMANT needs (limited to max 40 TRs)

- Development of the EXOGAM2 Trigger Processor. Specs:
  - Full compatibility with GTS
  - Extension to 256 TRs (max possible for GTS)
  - Multiple simultaneous trigger capabilities
  - Define precise trigger timing
  - No dead time; continuous coincidence analysis
  - Validate data not participating to trigger decision
  - Flexibility (easy to change trigger conditions)
  - Generate an event pattern

Trigger Processor

Main steps of the trigger processing cycle:

1)SORTING: To sort the TR labels issued from the GTS leaves messages and to dispatch them into partitions
2)MULTIPLICITY: To perform the multiplicity of each partition and to issue the multiplicity result
3)COINCIDENCE: To combine the multiplicity results of partitions in time coincidence windows
4)DECISION: To source the event validation or reject result
5)EVENT PARAMETERS: To register the event TR pattern, the event number and the event time stamp.
6)REPLY MESSAGE: To send back to each GTS leaves the validation or reject messages



Trigger Processor

Partitionning:
- TR labels (up to 256) are assigned to partitions
- Up to 32 partitions can be built

Multiplicity:
- Partition Multiplicity Window: Width
- Threshold
- Acceptance window: Width

Coincidence:
- Partition Coincidence Window: Delay and Width

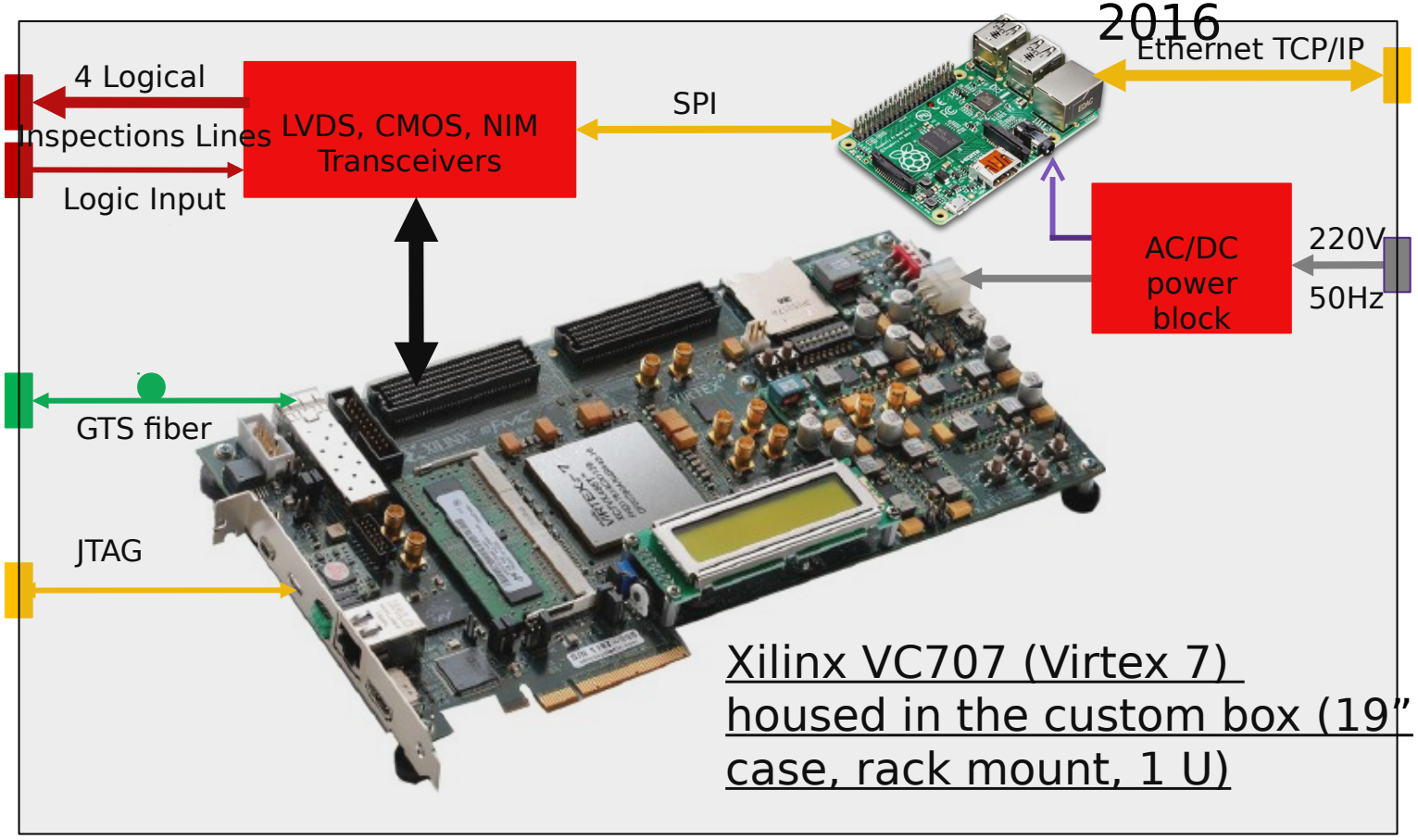
Logical Equation:
- Coincidence Windows are OR/AND combined in the Logical Equation

$$LE = \overset{n=31}{\underset{n=0}{OR}} \left[\overset{p=31}{\underset{p=0}{AND}} \left(ENp \ AND \ CWp \right) \right]$$

(LE = 1 => event validation is sourced)

EXOGAM2 TP_V1

Completed end of 2016



TCP/IP protocol

- Linux OS in RASPBERRY PI
- SPI link to/from VC707

=> It is a temporary solution because of its very low bandwidth

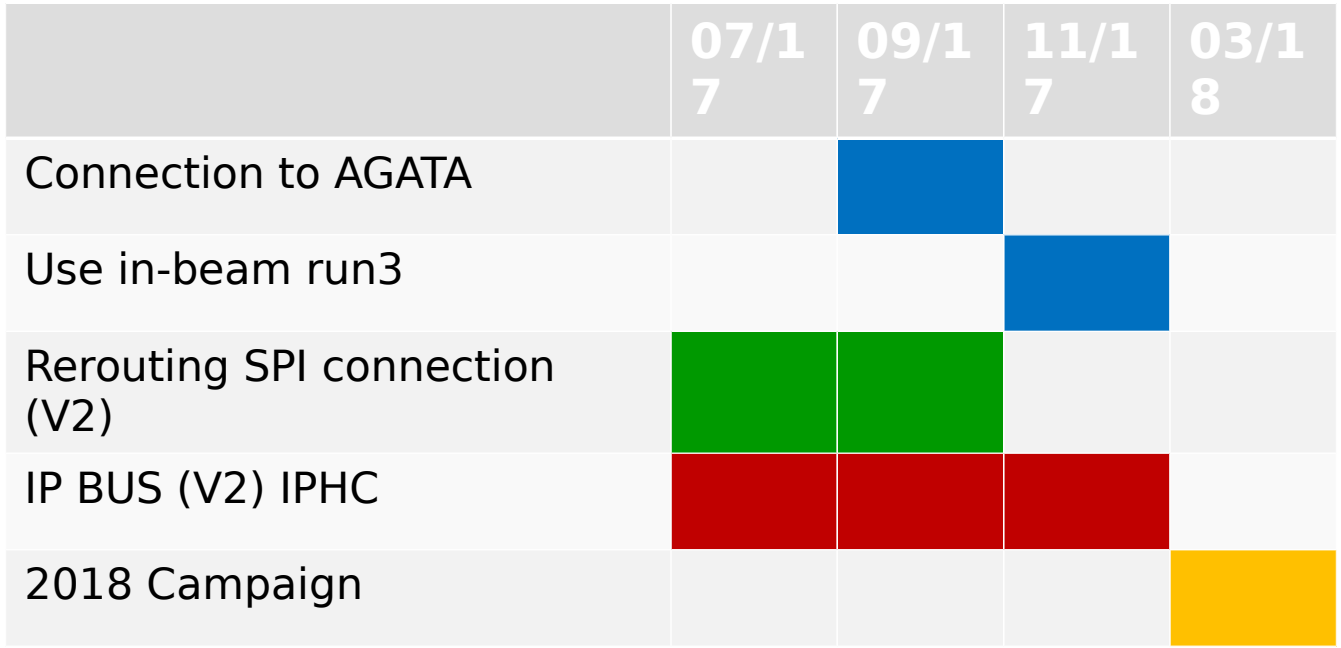
EXOGAM2 TP_V1

- **VHDL implementation of 2 partitions in the Virtex 7 successf**

- Partition 1 : 8 TR; MW width = 4T; AW witdh = 10T; CW witdh 10T, CW delay = 101T; Multiplicit
- Partition 2: 1 TR; MW width = 2T; AW witdh = 2T; CW witdh 10T, CW delay = 6T; Multiplicit
- Validation: LE = CW1 AND CW2

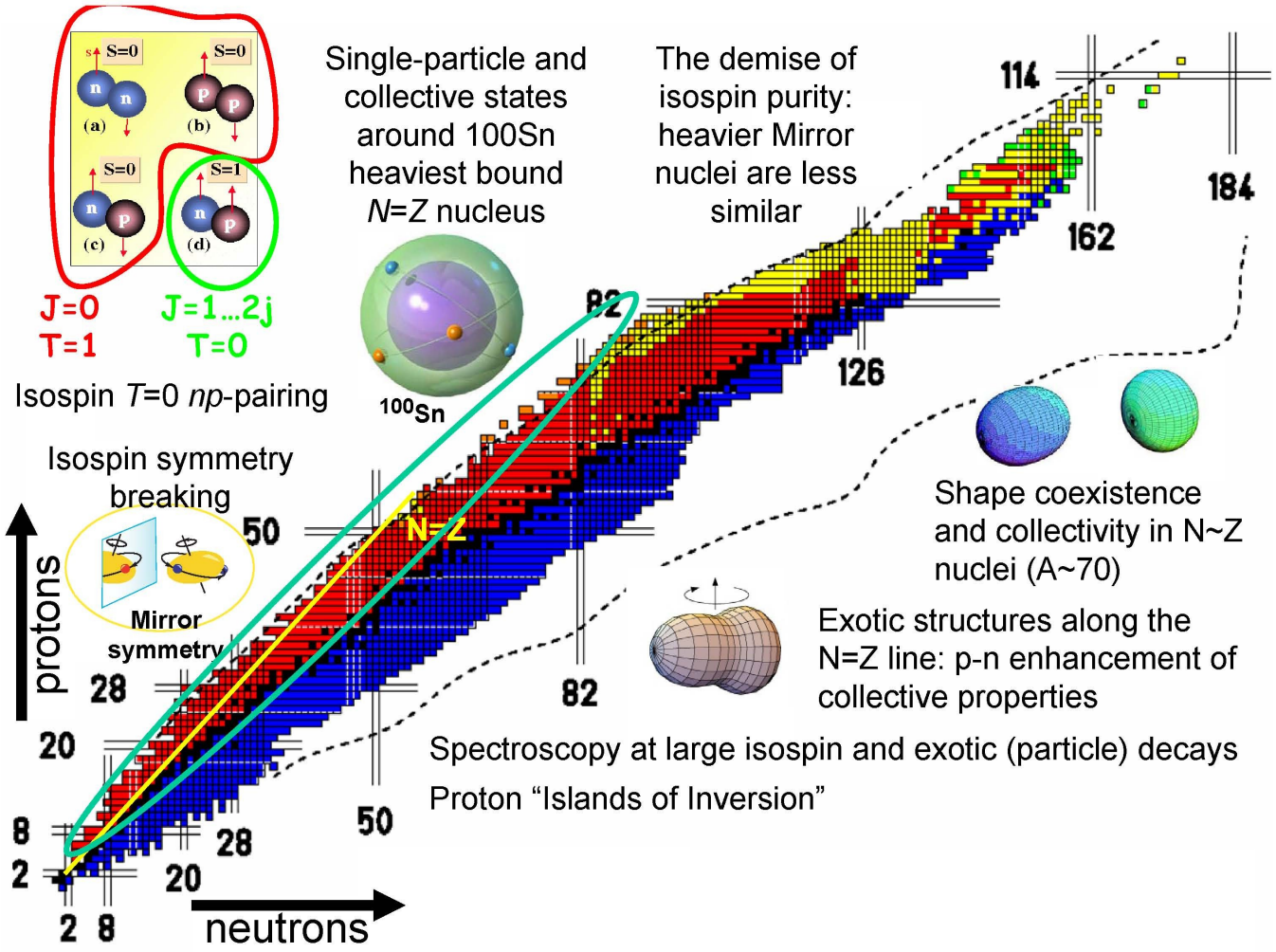
- **VC707, connected to the GTS tree, has been successfully tested**
- **Connected to AGATA with 32 leaves through GTS NIM carrier**
  - ⇒ Similar performance as AGATA TP (rejection rate ~1%)
- **Next step (EXOGAM2 TP_V2):**
  - ⇒ Connect to EXOGAM2 for long term tests (rejection =f(rate); multipartition; reliability;…)
  - ⇒ Connect to AGATA (check 10 μs latency vs idle cycle)
  - ⇒ Replace Raspberry PI by IP BUS protocol

Workflow



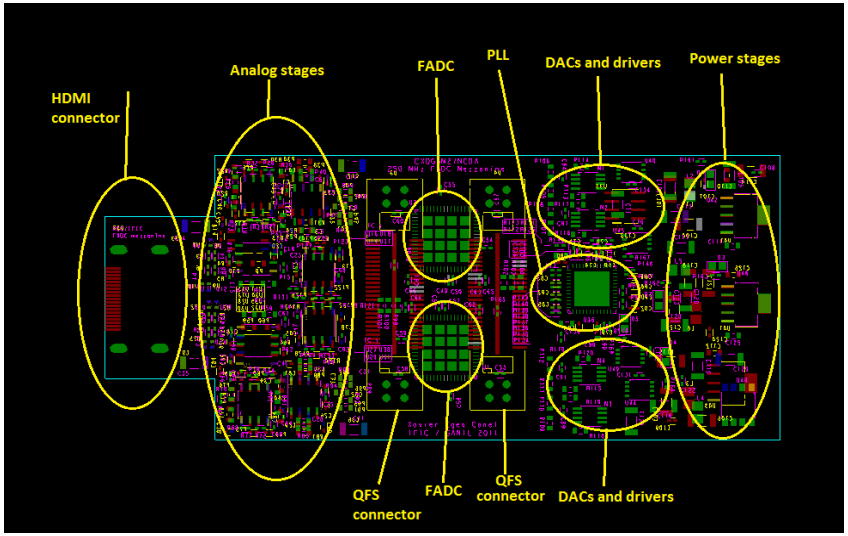
- 2 EXOGAM2 TP_V1 exist
  - 1 permanently online for tests
  - 1 for rerouting SPI
- 1 Being built at IPHC for IP BUS protocol implementation

Physics with NEDA



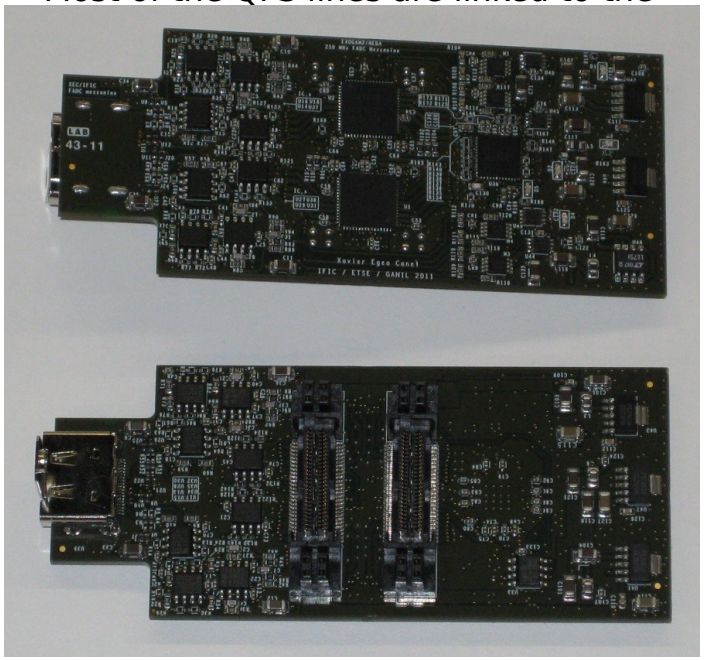
FADC Mezzanine

X. Egea and A. Gadea (IFIC,CSIC, Valencia)



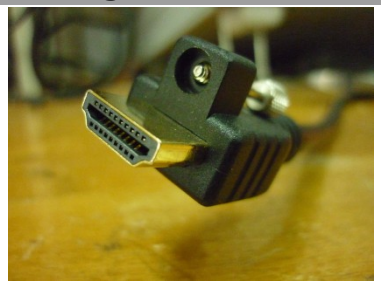
- **4-channel acquisition with a sampling rate of 250 Msps and 14-bit resoltion.**
- Use of a PLL for jitter cleaning and clock synchronization
- 6 W power consumption at 250 MHz.
- Possibility to use a variable offset by using a 16-bit digital-to-analog converter.
- Includes 2 QFS-026-04,75-LD-PC4 connectors, and thorugh them, differential signals, control lines and power lines are transmitted by using the same connector.
- Includes an HDMI PCB receptacle, which will link the front-end electronics with the FADC mezzanine.

- 10 layers have been used in order to make possible this design by using high-speed layout techniques.
- The FADC follows an easy and straigthforward placement and routing. Besides, symmetry has been provided in order to make an easier design.
- The board dimensions fit on the NIM standard, where 4 of these will be inserted into the crate. (42mm wide + 98.5 mm long)
- Most of the QFS lines are linked to the

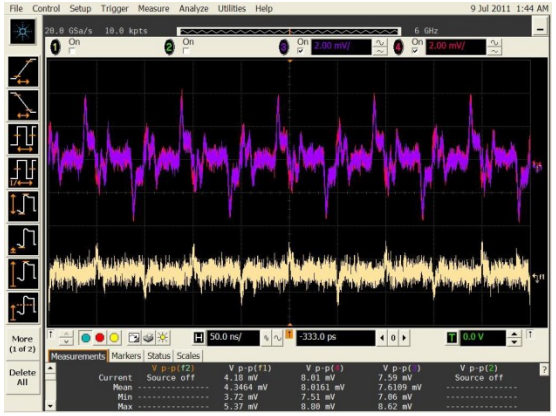


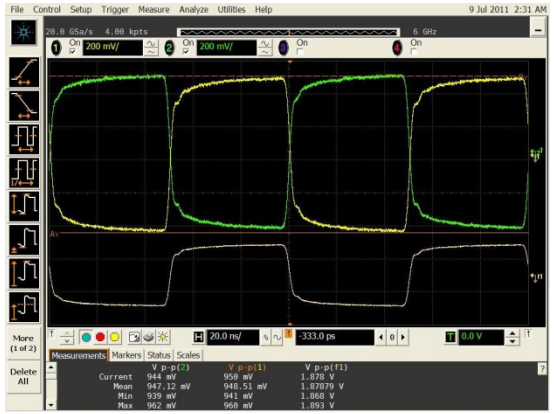
HDMI NEDA cables

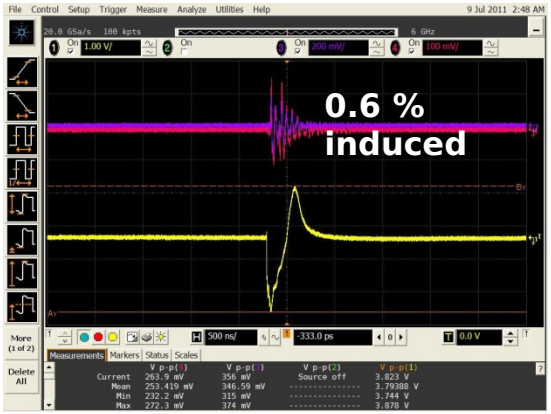
X. Egea (LNL), M. Tripon (GANIL), M. Jastrząb (Kraków)

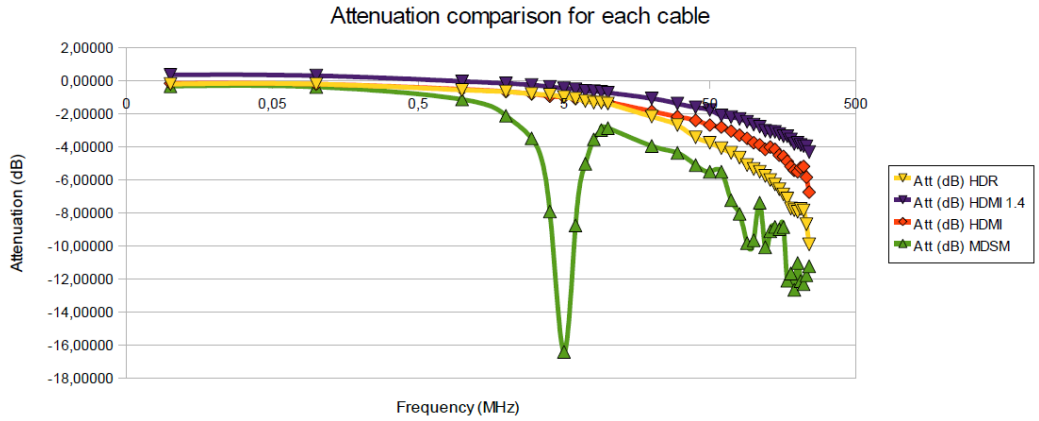


- Several tests have been applied to different cables in order to test their performance.
- Among them we may mention the bandwidth, crosstalk, impednace and reflections, and EMC (electromagnetic compatibility).
- On the picture on the left it is shown the **HDMI cable.**
- The HDMI 1.4 version, including a double shield, makes an important improvement against high-voltage peaks.



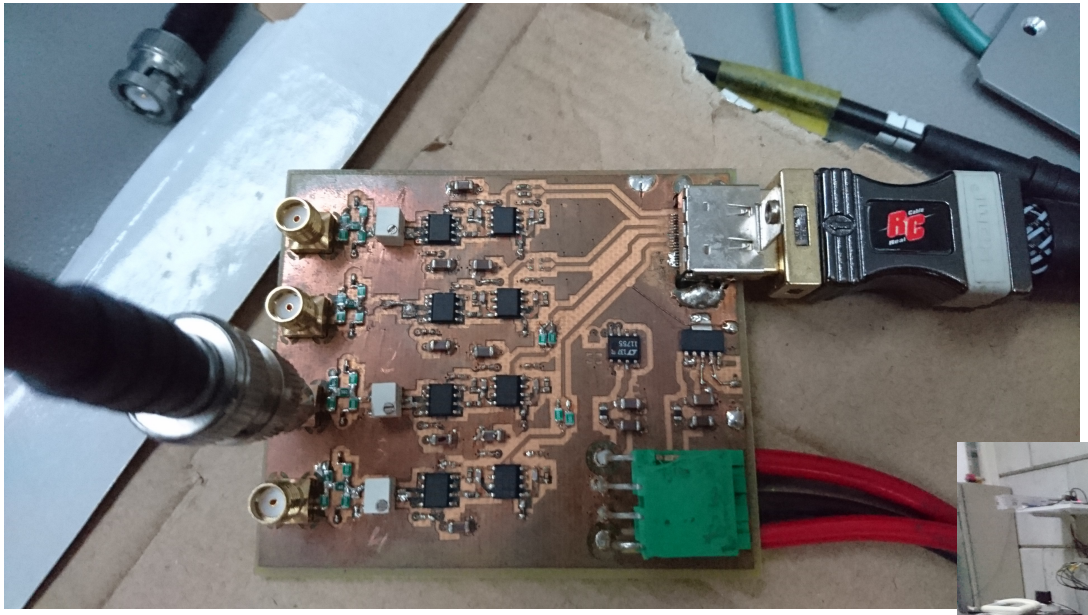




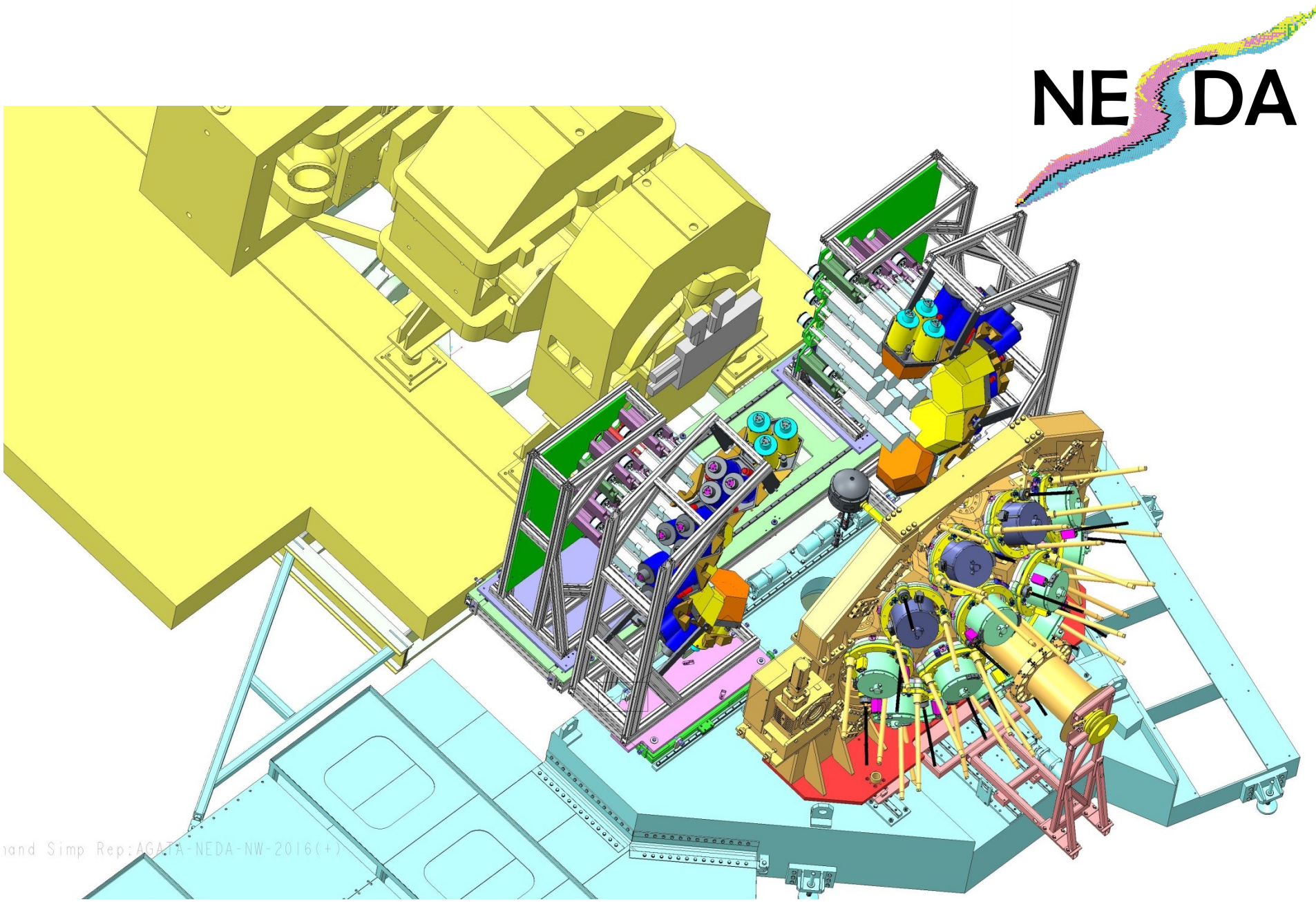


- Top → (From left to right): Crosstalk, reflections and EMC measurements. Bottom → Bandwidth
- The HDMI 1.4 has a big stiffness and it might be a little bit problematic mechanically.

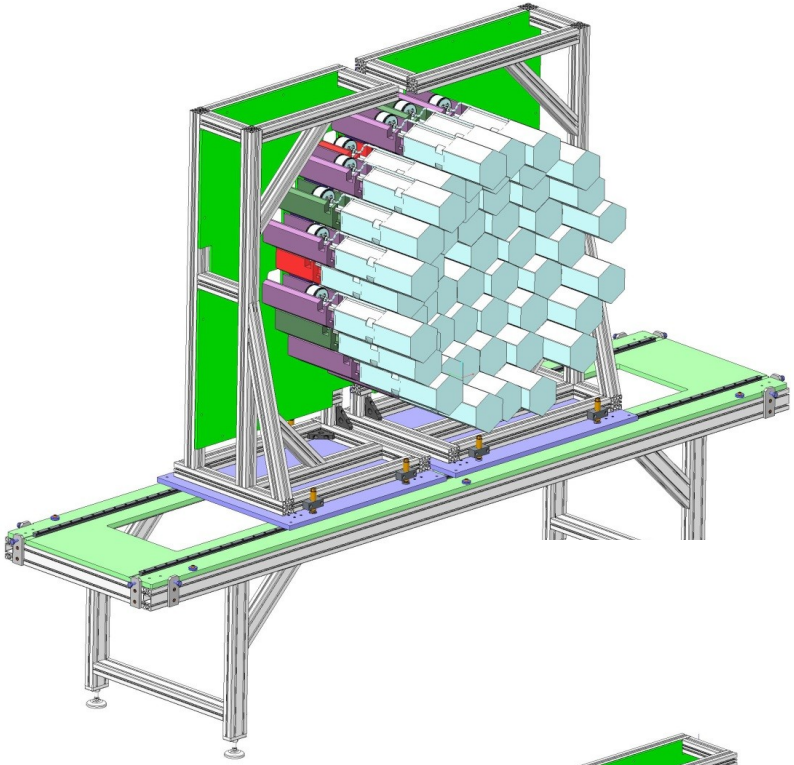
Single ended to differential converter

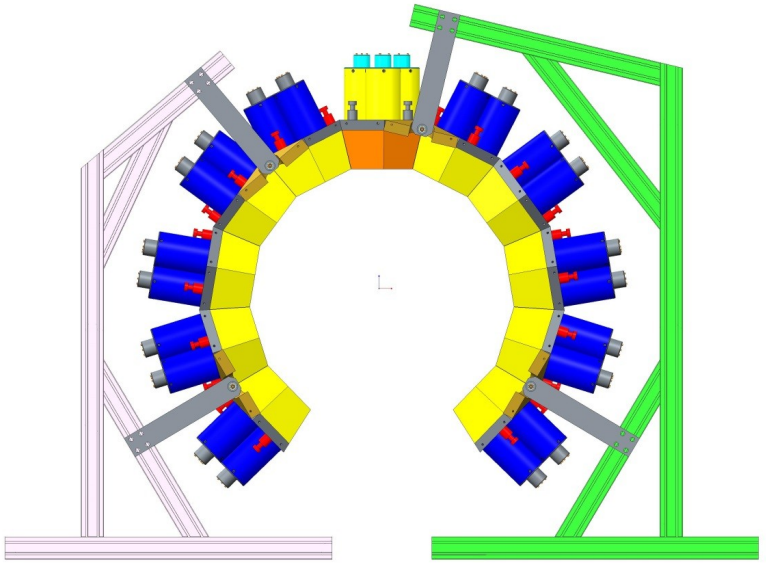


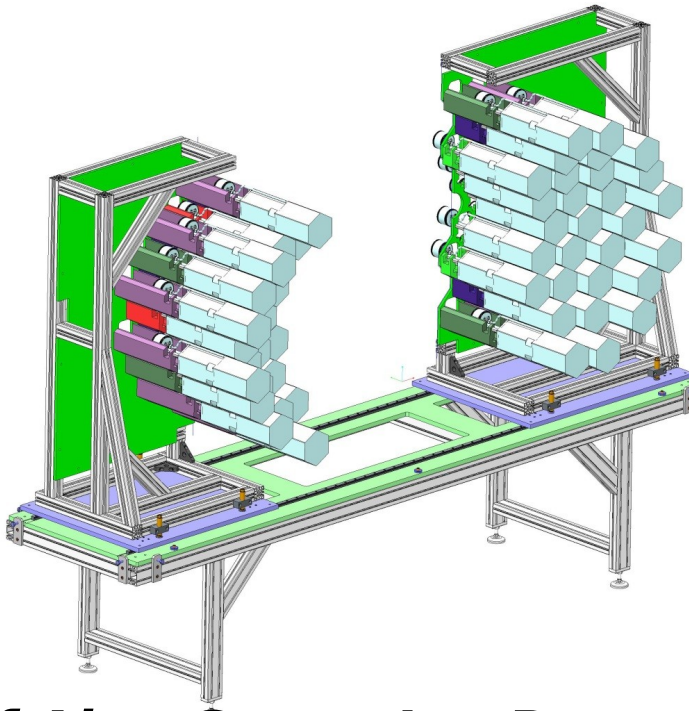
X. Egea



Courtesy of Alan Grant, Ian Burrows & Mike Cordwell

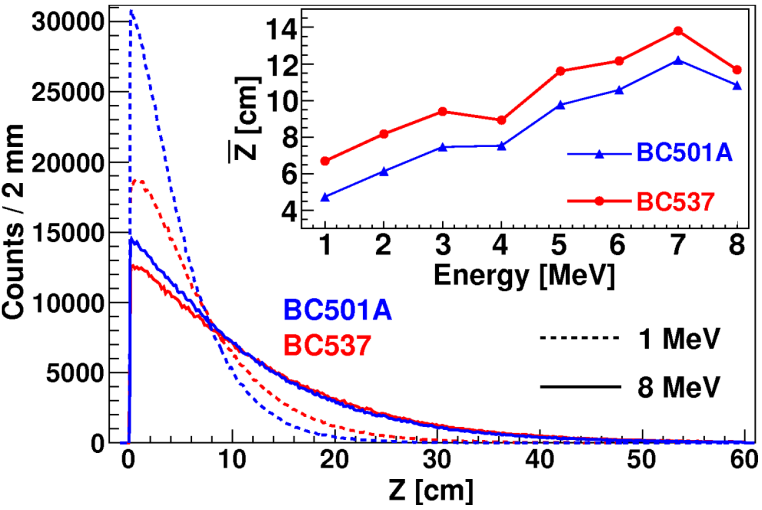


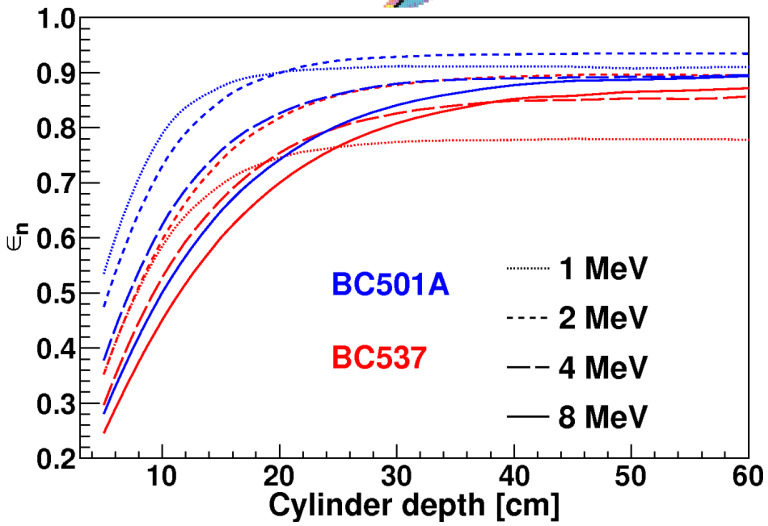


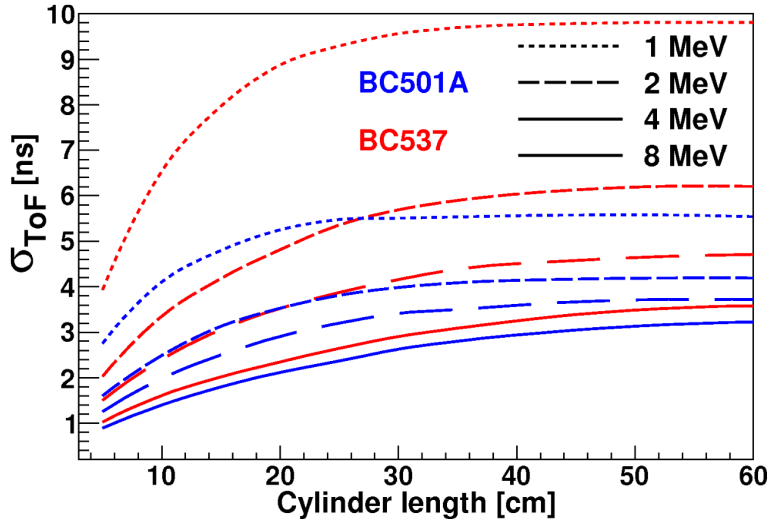


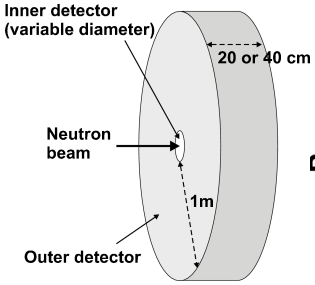
Courtesy of Alan Grant, Ian Burrows & Mike Cordwell

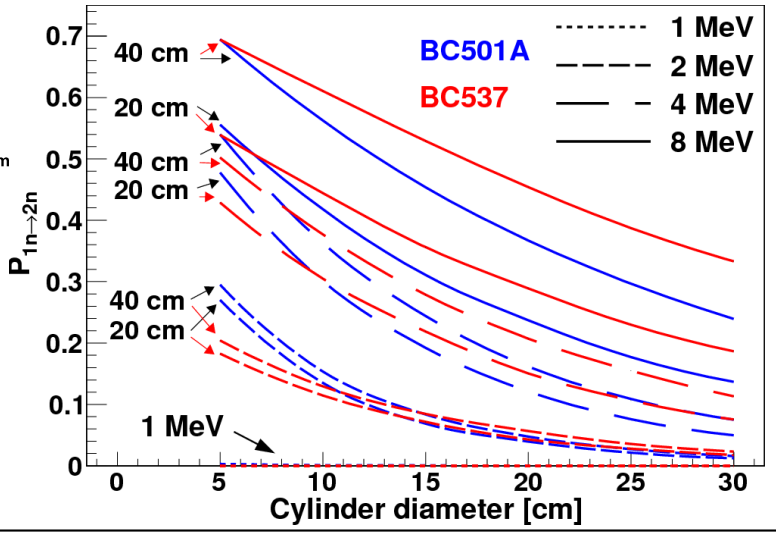
Single cell


Counts / 2 mm
Z [cm]
$\overline{Z}$ [cm]
Energy [MeV]
BC501A
BC537
1 MeV
8 MeV


ϵ_n
Cylinder depth [cm]
BC501A
BC537
1 MeV
2 MeV
4 MeV
8 MeV

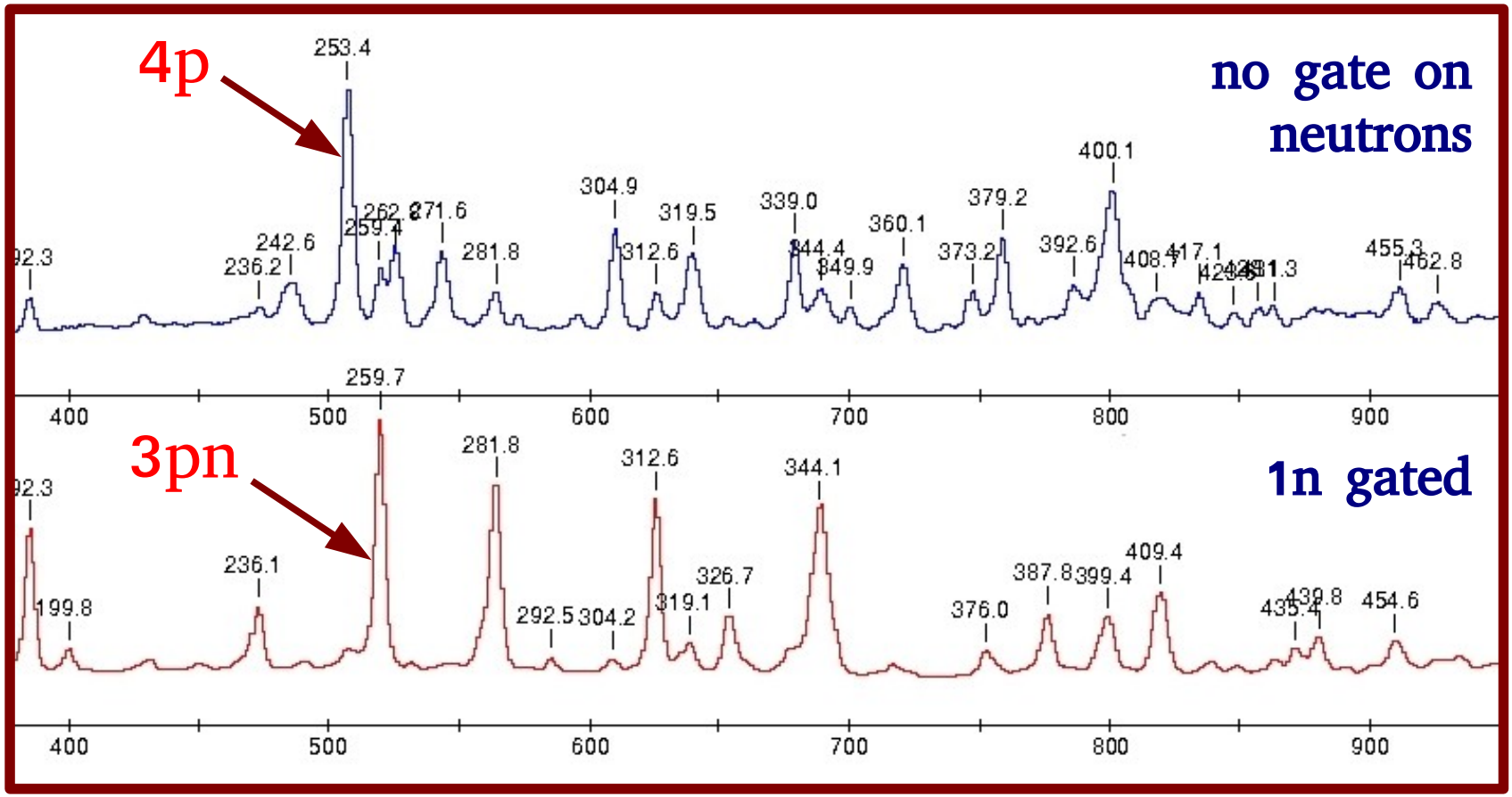

σ_{ToF} [ns]
Cylinder length [cm]
BC501A
BC537
1 MeV
2 MeV
4 MeV
8 MeV


Inner detector
(variable diameter)
20 or 40 cm
Neutron
beam
1m
Outer detector


$P_{1n\to2n}$
Cylinder diameter [cm]
BC501A
BC537
1 MeV
2 MeV
4 MeV
8 MeV
40 cm
20 cm
40 cm
20 cm
40 cm
20 cm
1 MeV

n selection

EXOGAM experiment: ^{58}Ni (240 MeV) + ^{54}Fe

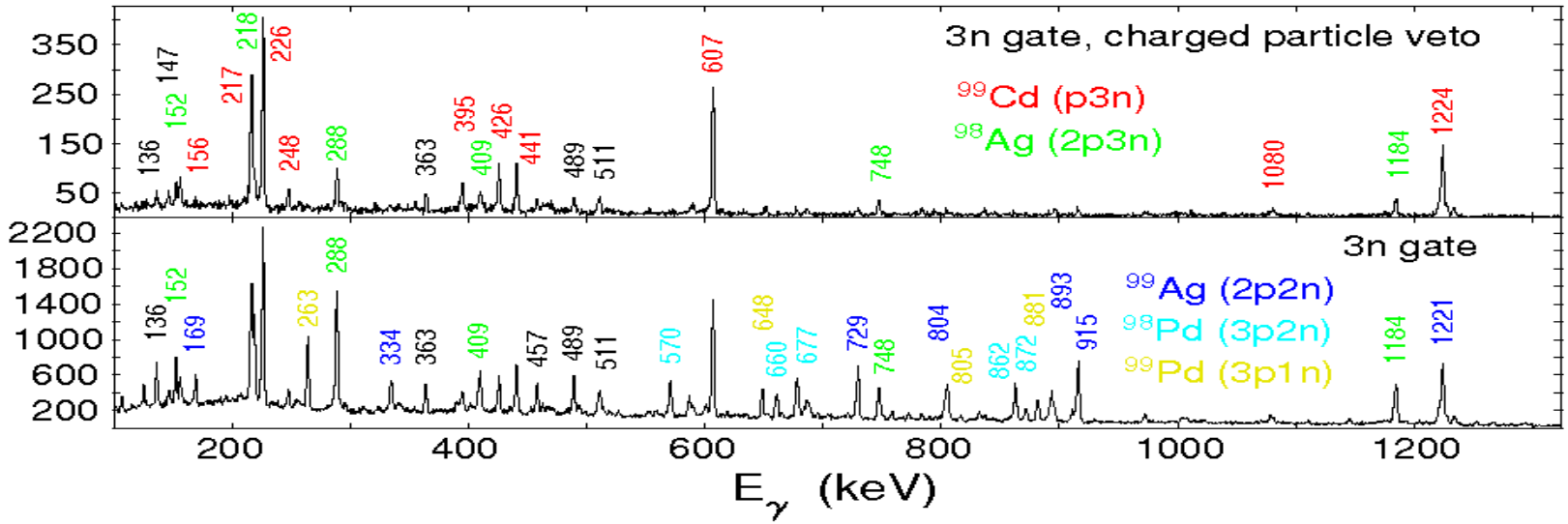


Why not NW?

An example:

Attempt to study ^{100}In – $1\nu\,1\pi^{-1}$ outside ^{100}Sn

3n evaporation channel – the only 3n case with NWall (+ EUROBALL)



^{100}In not observed, but observation only a matter of statistics.

10x statistics: → ½ a a year with EXOGAM + NWall,
→ 2-3 weeks with EXOGAM + NEDA.

Other crucial nuclei accessible in 3n evap. channels, including ^{101}Sn.

Single cell

Nuclear Instruments and Methods in Physics Research A 673 (2012) 64–72

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Nuclear Instruments and Methods in Physics Research A

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

Monte Carlo simulation of a single detector unit for the neutron detector array NEDA

G. Jaworski [a,b], M. Palacz [b,*], J. Nyberg [c], G. de Angelis [d], G. de France [e], A. Di Nitto [f], J. Egea [g,h], M.N. Erduran [i], S. Ertürk [j], E. Farnea [k], A. Gadea [h], V. González [g], A. Gottardo [l], T. Hüyük [h], J. Kownacki [b], A. Pipidis [d], B. Roeder [m], P.-A. Söderström [c], E. Sanchis [g], R. Tarnowski [b], A. Triossi [d], R. Wadsworth [n], J.J. Valiente Dobon [d]

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[g] Department of Electronic Engineering, University of Valencia, Burjassot (Valencia), Spain
[h] IFIC-CSIC, University of Valencia, Valencia, Spain
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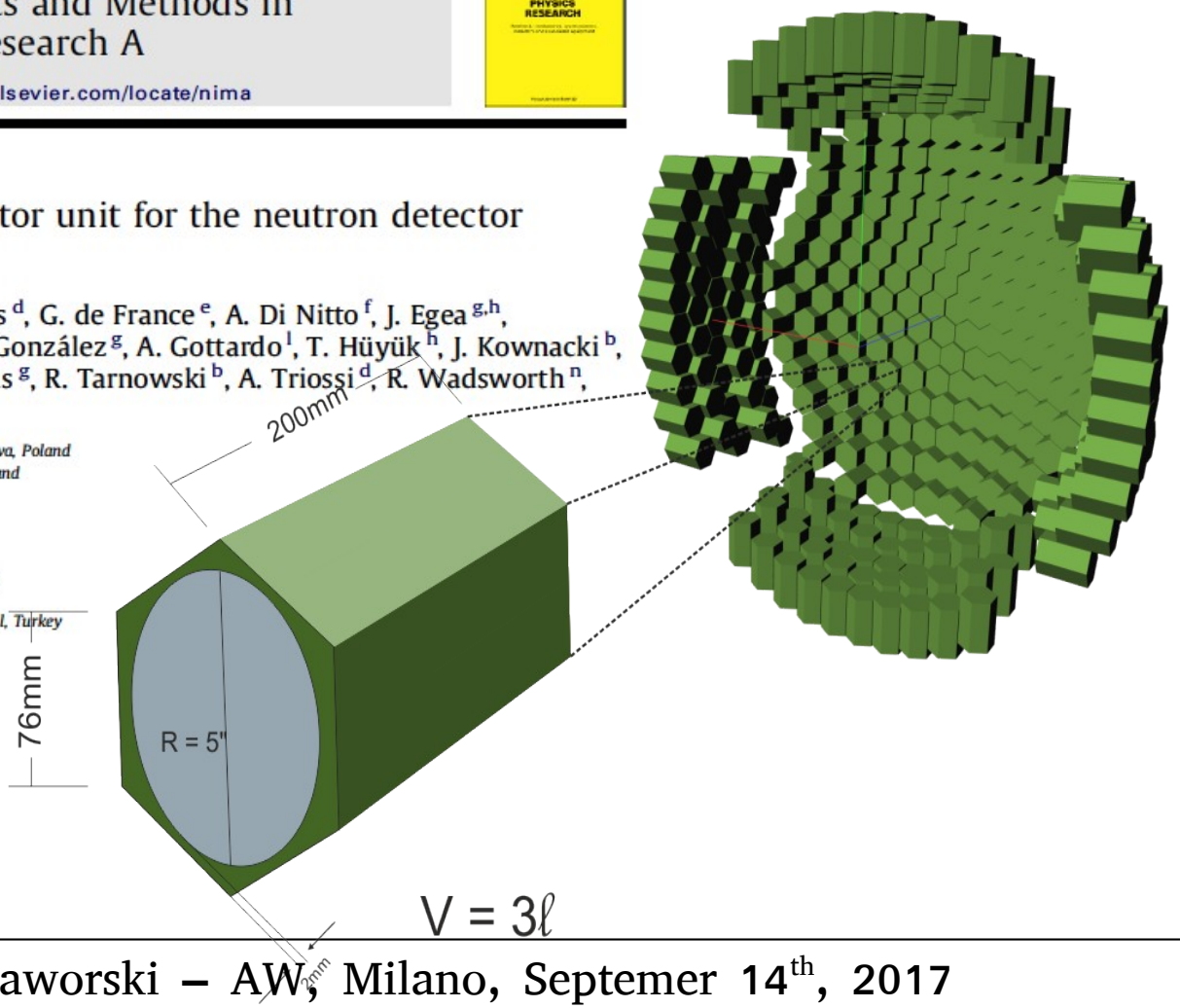
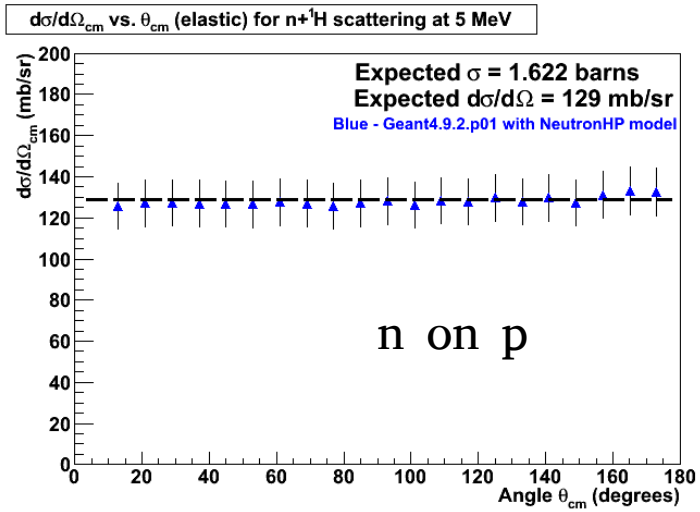
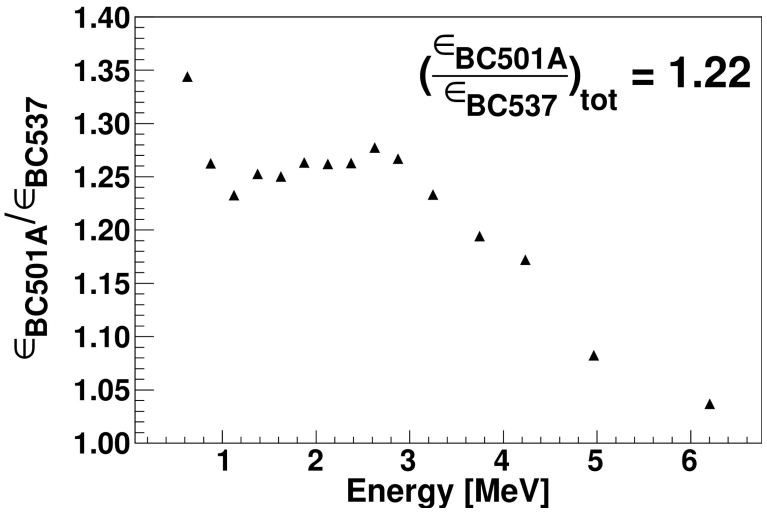
[j] Nigde Universitesi, Fen-Edebiyat Falkültesi, Fizik Bölümü, Nigde, Turkey
[k] INFN Sezione di Padova, Padua, Italy
[l] Padova University, Padua, Italy
[m] LPC-Caen, ENSICAEN, IN2P3/CNRS et Université de Caen, Caen, France
[n] Department of Physics, University of York, York, United Kingdom

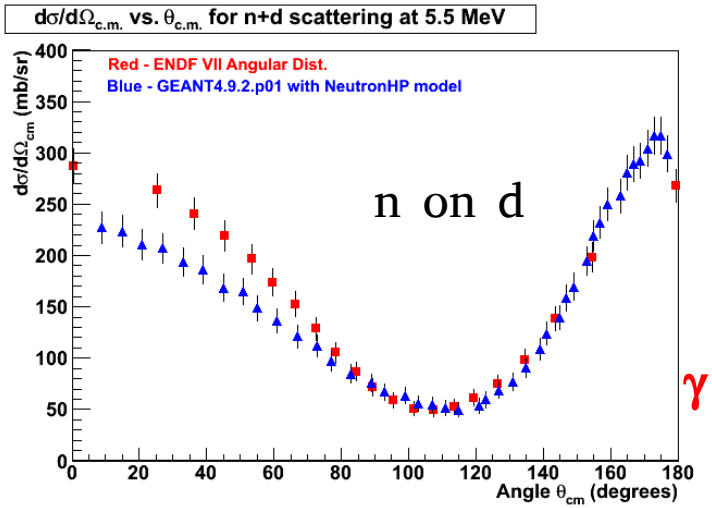


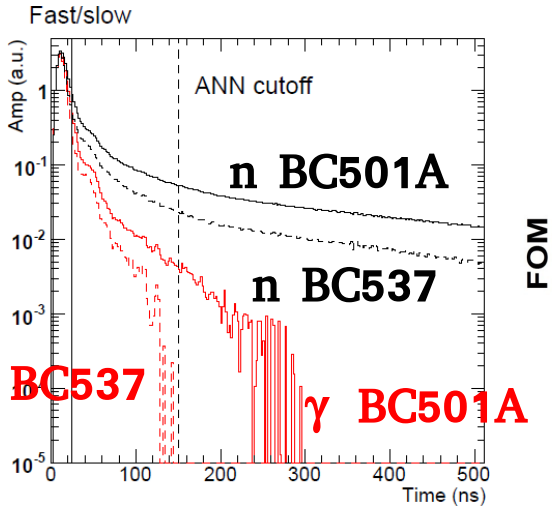
Scintillator

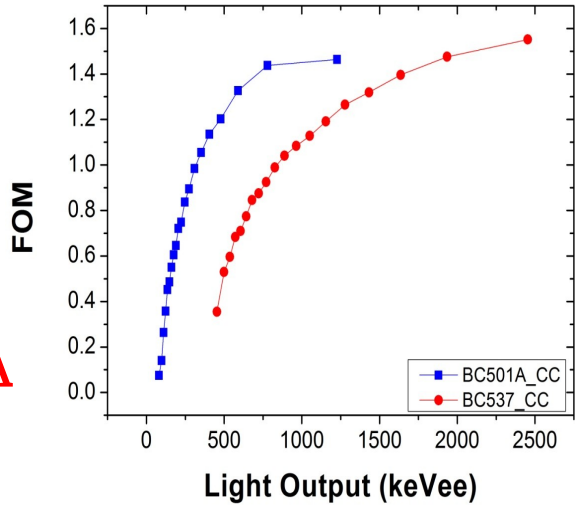
? BC501A / BC537 / EJ299 / … ?



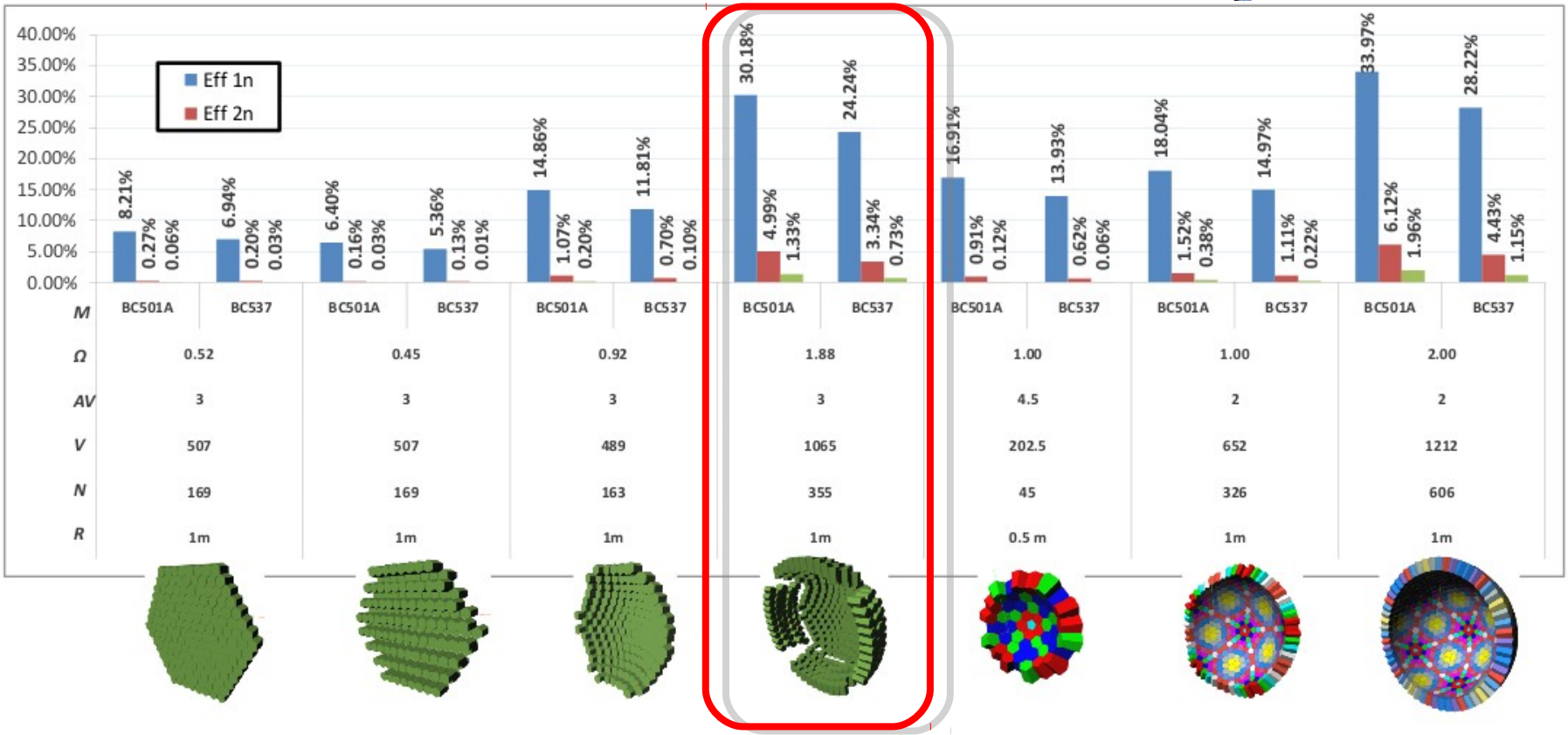








Full geometry



R	Distance from the origin / Radius (meter)	Simulated neutron source:	Cf-252
N	Granularity (Number of modules)	Depth of the detectors:	20 cm
V	Total Volume (liter)	Neutrons were shot in 2π solid angle	
AV	Average Volume (liter)	1E+7 statistics have been recorded	
Ω	Solid angle coverage (π)		
M	Material		

Timing

Digital timing algorithm for various 5” PMTs

Nuclear Instruments and Methods in Physics Research A 775 (2015) 71–76

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Nuclear Instruments and Methods in Physics Research A

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

Digital pulse-timing technique for the neutron detector array NEDA

V. Modamio [a,*], J.J. Valiente-Dobón [a], G. Jaworski [b,c], T. Hüyük [d], A. Triossi [a], J. Egea [d,e], A. Di Nitto [f], P.-A. Söderström [g], J. Agramunt Ros [d], G. de Angelis [a], G. de France [h], M.N. Erduran [i], S. Ertürk [j], A. Gadea [d], V. González [e], J. Kownacki [c], M. Moszynski [k], J. Nyberg [l], M. Palacz [c], E. Sanchis [e], R. Wadsworth [m]

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[j] Nigde Universitesi, Fen-Edebiyat Falkültesi, Fizik Bölümü, 51240 Nigde, Turkey
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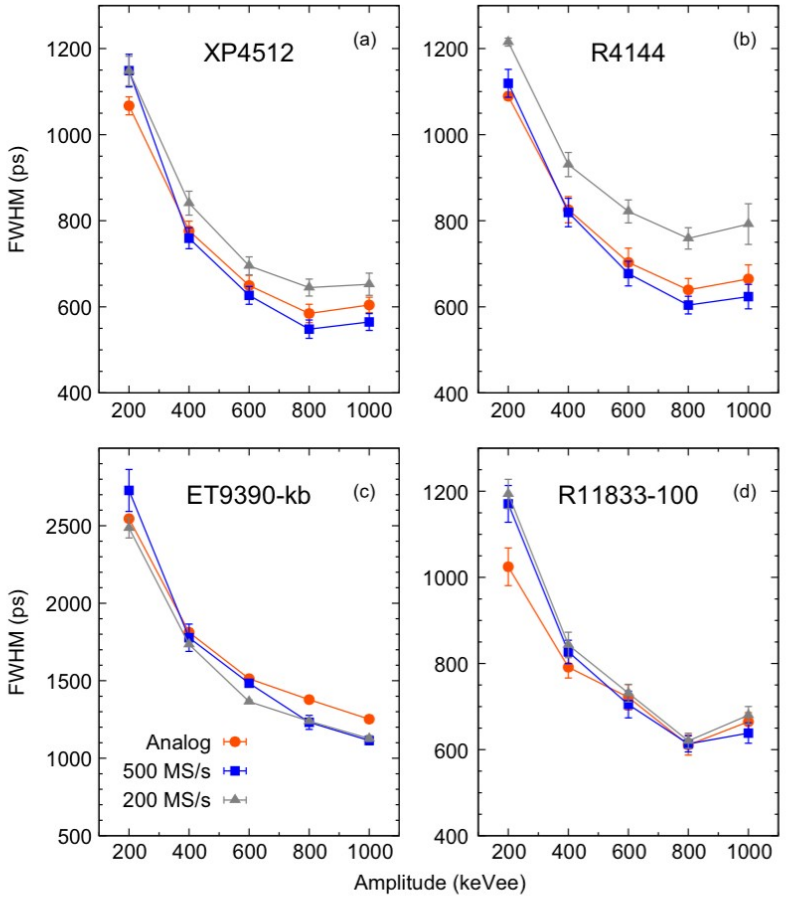
[l] Department of Physics and Astronomy, Uppsala University, SE-75120 Uppsala, Sweden
[m] Department of Physics, University of York, Heslington, YO1 5DD York, United Kingdom



PMT tests for best timing for NEDA

NGD

Digital PSA algorithm for various 5” PMTs

Nuclear Instruments and Methods in Physics Research A 767 (2014) 83–91

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Nuclear Instruments and Methods in Physics Research A

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

Test of digital neutron–gamma discrimination with four different photomultiplier tubes for the NEutron Detector Array (NEDA)

X.L. Luo [a,b,*], V. Modamio [c], J. Nyberg [b], J.J. Valiente-Dobón [c], Q. Nishada [b], G. de Angelis [c], J. Agramunt [d], F.J. Egea [d,e], M.N. Erduran [f], S. Ertürk [g], G. de France [h], A. Gadea [d], V. González [e], T. Hüyük [d], G. Jaworski [i,j], M. Moszyński [j,k], A. Di Nitto [l], M. Palacz [j], P.-A. Söderström [m], E. Sanchis [e], A. Triossi [c], R. Wadsworth [n]

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[e] Department of Electronic Engineering, University of Valencia, E-46071 Valencia, Spain
[f] Faculty of Engineering and Natural Sciences, Istanbul Sabahattin Zaim University, Istanbul, Turkey
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[k] National Centre for Nuclear Research, A. Soltana 7, PL 05-400 Otwock-Swierk, Poland
[l] Johannes Gutenberg-Universität Mainz, 55099 Mainz, Germany
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[n] Department of Physics, University of York, Heslington, York YO10 5DD, UK

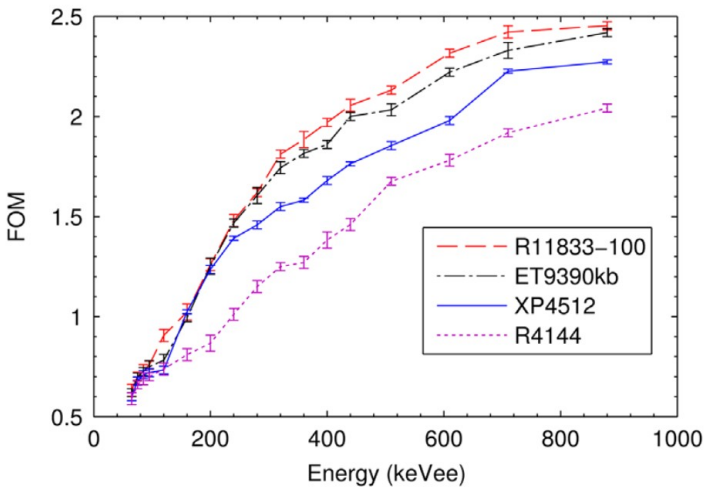
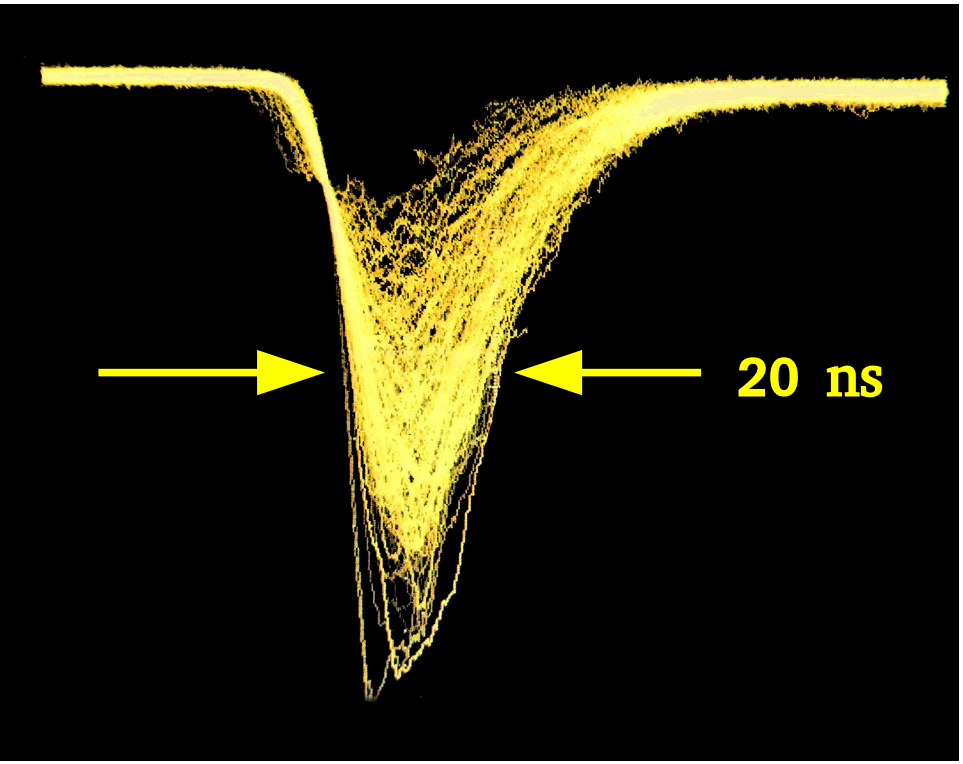


Fig. 10. FOM values of the IRT method for PMT ET9390kb, R11833-100, XP4512, and R4144 as a function of energy window (the widths of the windows are 10, 40, and 100 keVee in energy regions of 50–100, 100–500, and 500–1000 keVee, respectively).

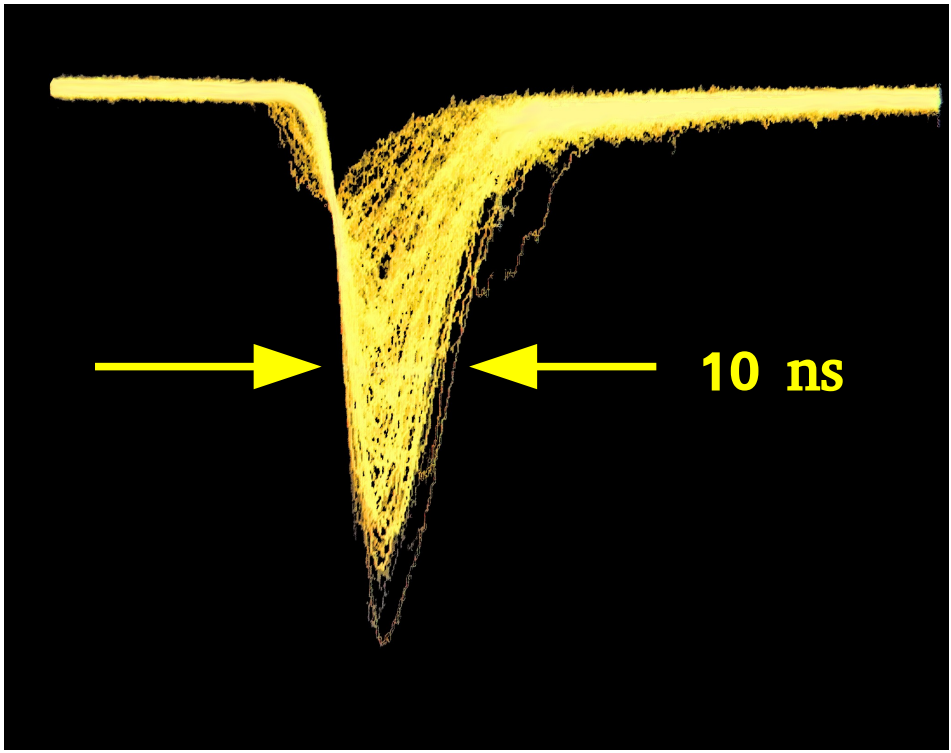
PMT tests for best NGD for NEDA

Light yield

NEDA

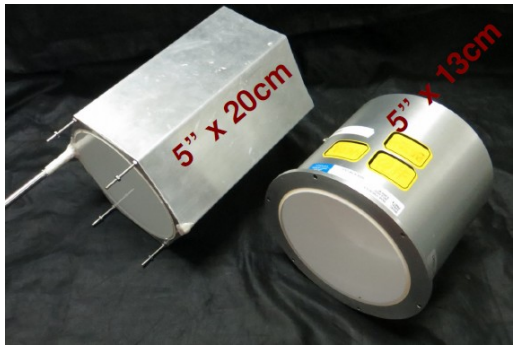


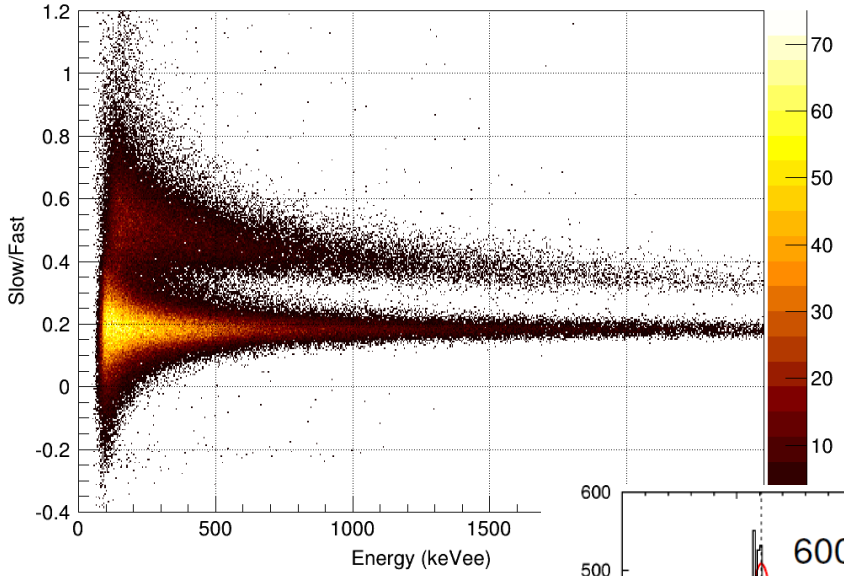
NWall

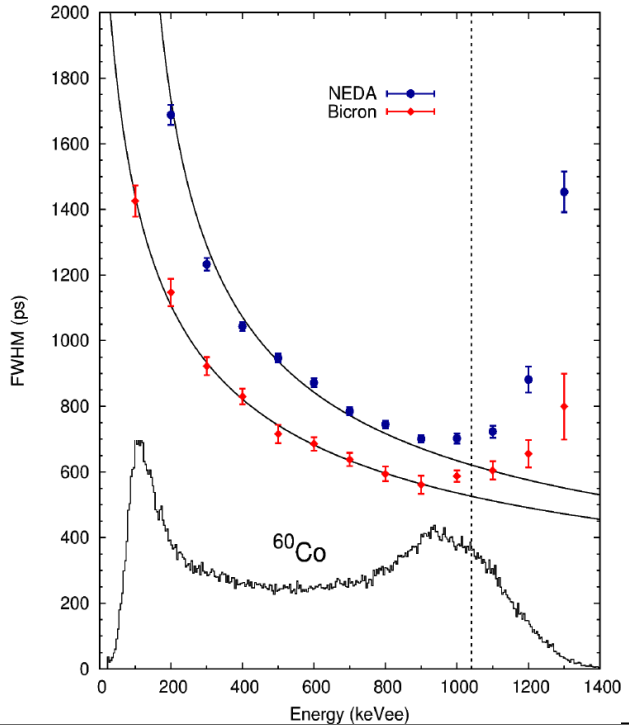


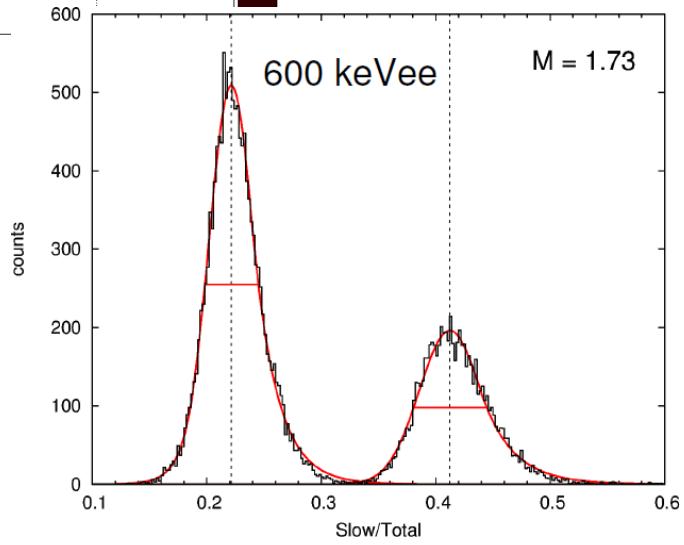
Quality starts from the initial signal.

Prototype

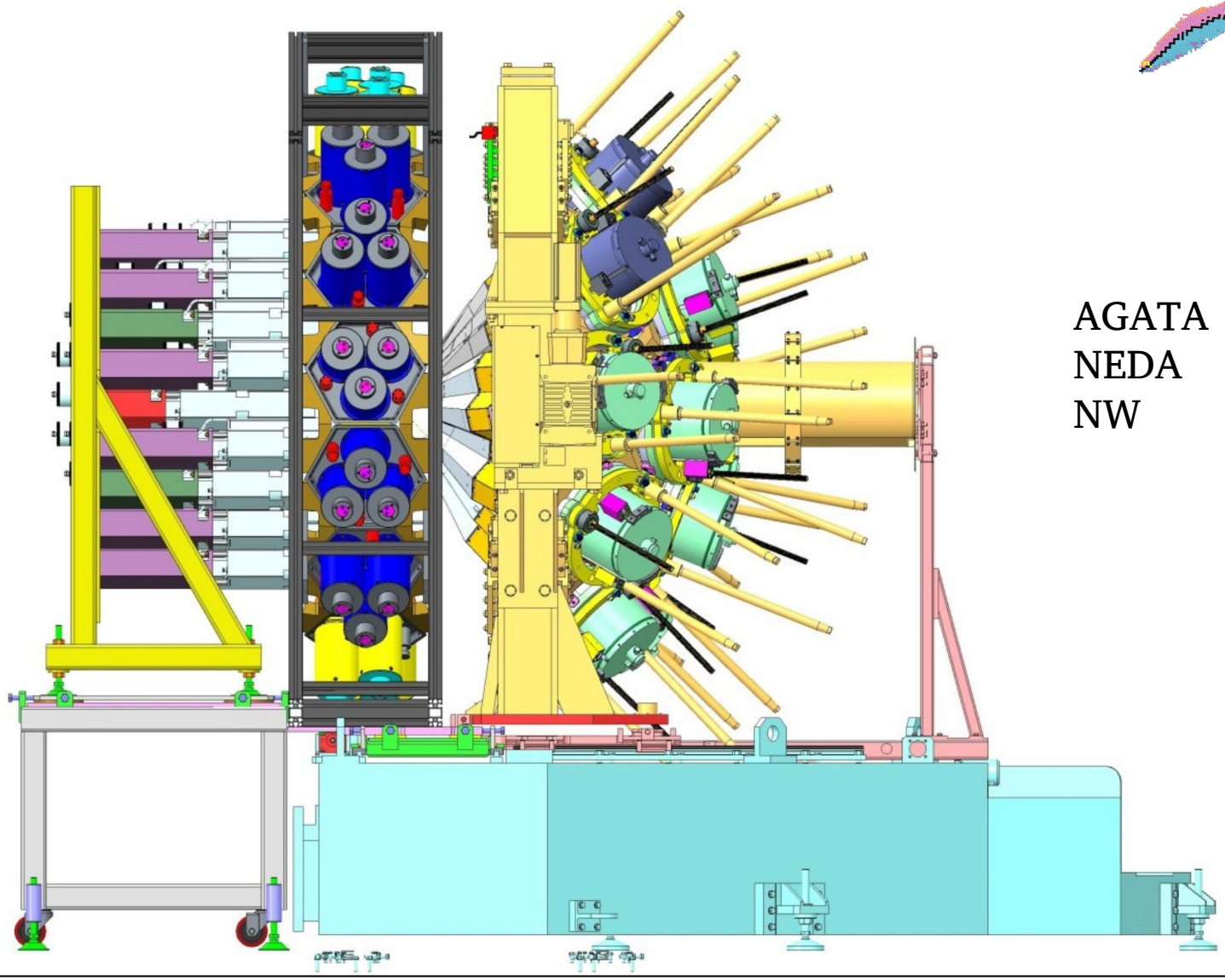

5" x 20cm
5" x 13cm


Slow/Fast
Energy (keVee)


NEDA
Bicron
^{60}Co
FWHM (ps)
Energy (keVee)


600 keVee
M = 1.73
counts
Slow/Total

GANIL 2018: AGATA + NEDA

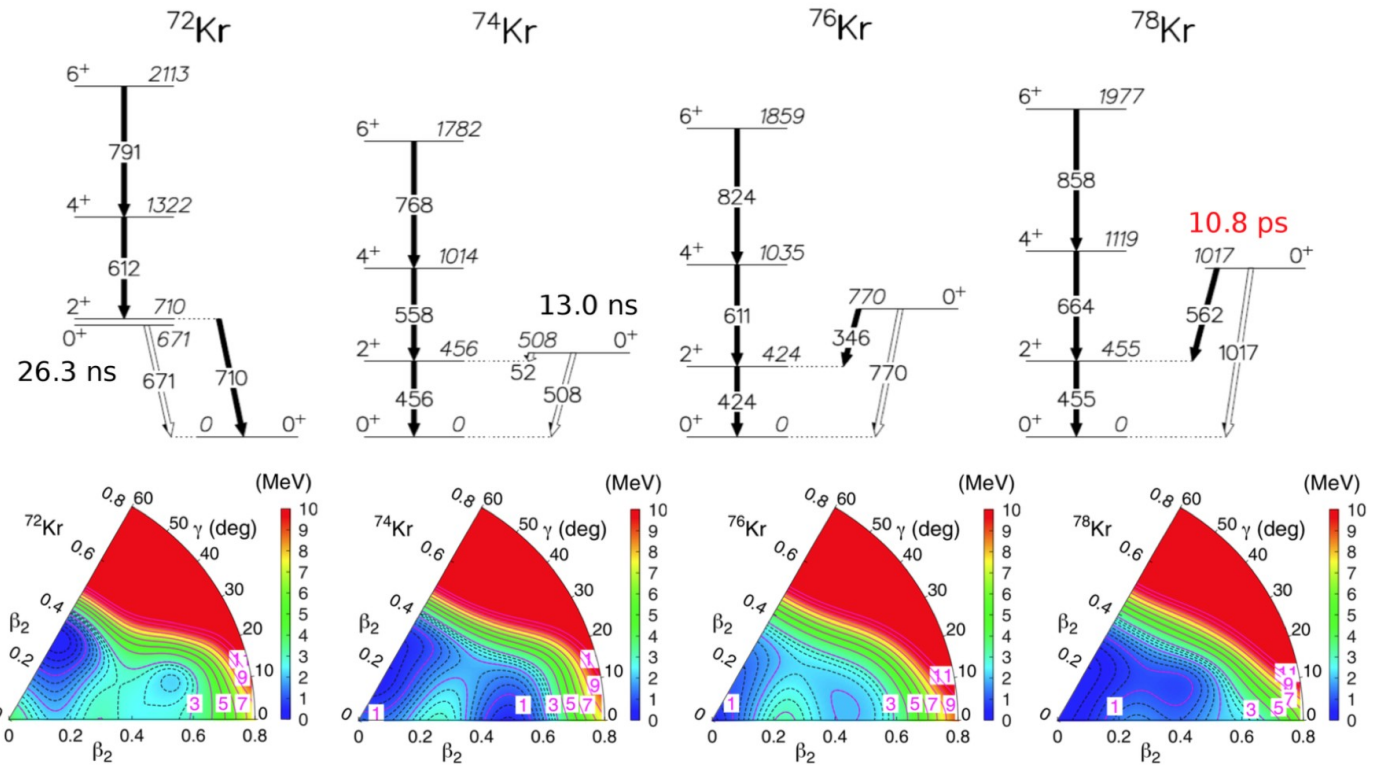


AGATA @ 145 mm
NEDA @ 570 mm
NW @ 650 mm

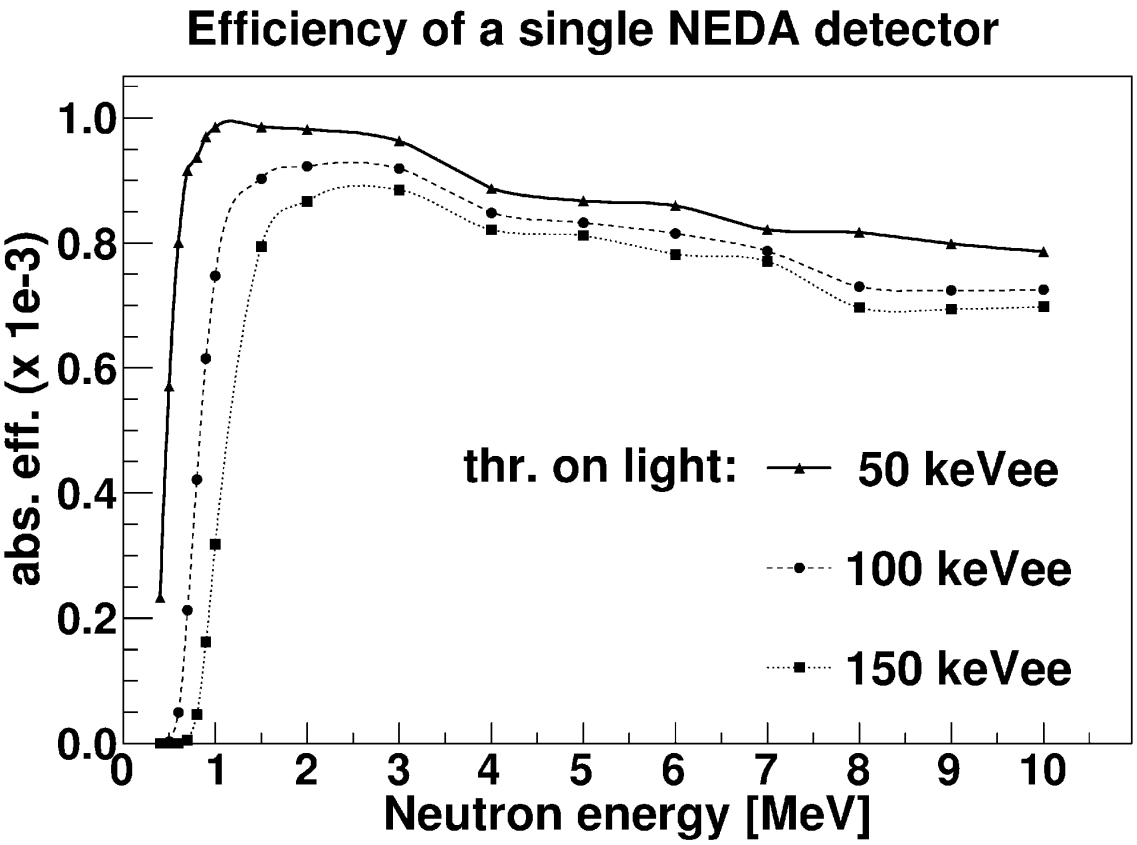
RIB: n tagging in transfer reactions

Lifetime measurements

Reachable via
(d,n)
(^{3}He,n)
(^{4}He,n)



E.Clement et al. Int.J.Mod.Phys. E20, 415 (2011)
T.R. Rodriguez Phys.Rev. C 90, 034306 (2014)


Efficiency of a single NEDA detector
abs. eff. (x 1e-3)
1.0
0.8
0.6
0.4
0.2
0.0
0
1
2
3
4
5
6
7
8
9
10
Neutron energy [MeV]
thr. on light:
50 keVee
100 keVee
150 keVee

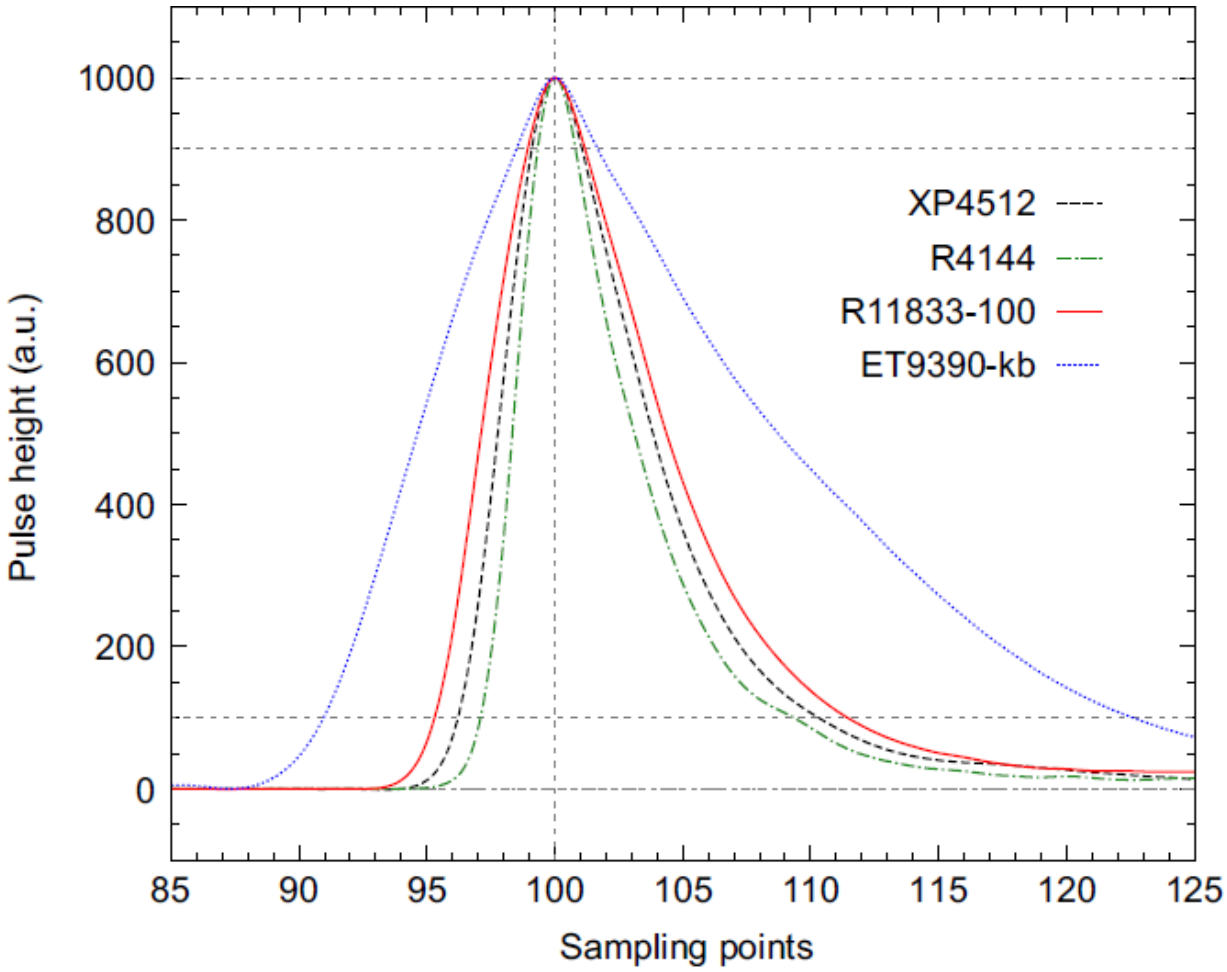


Fig. 2. Digitized waveforms averaged over 10^5 events for the four 5 in. PMTs coupled to a cylindrical 5 in. by 5 in. BC501A. The sampling frequency of the digitizer was 500 MS/s. The waveforms were normalized to a pulse height of 1000 and time aligned at the maximum of the signal. Dashed lines are drawn at 10%, 90%, at the maximum and at the baseline of the waveform to guide the eye.

Conclusions on deuterated vs proton-based scintillator

→ better light to energy correlation for deuterated scintillator only for small detectors – not NEDA case.

Proton-based BC501A:

→ gives more light;

→ has higher efficiency;

→ has better time resolution;

→ has better n/γ discrimination;

→ has smaller scattering probability ($p_{1n->2n}$);

→ is much less expensive.

NEDA decided to use standard proton based scintillator

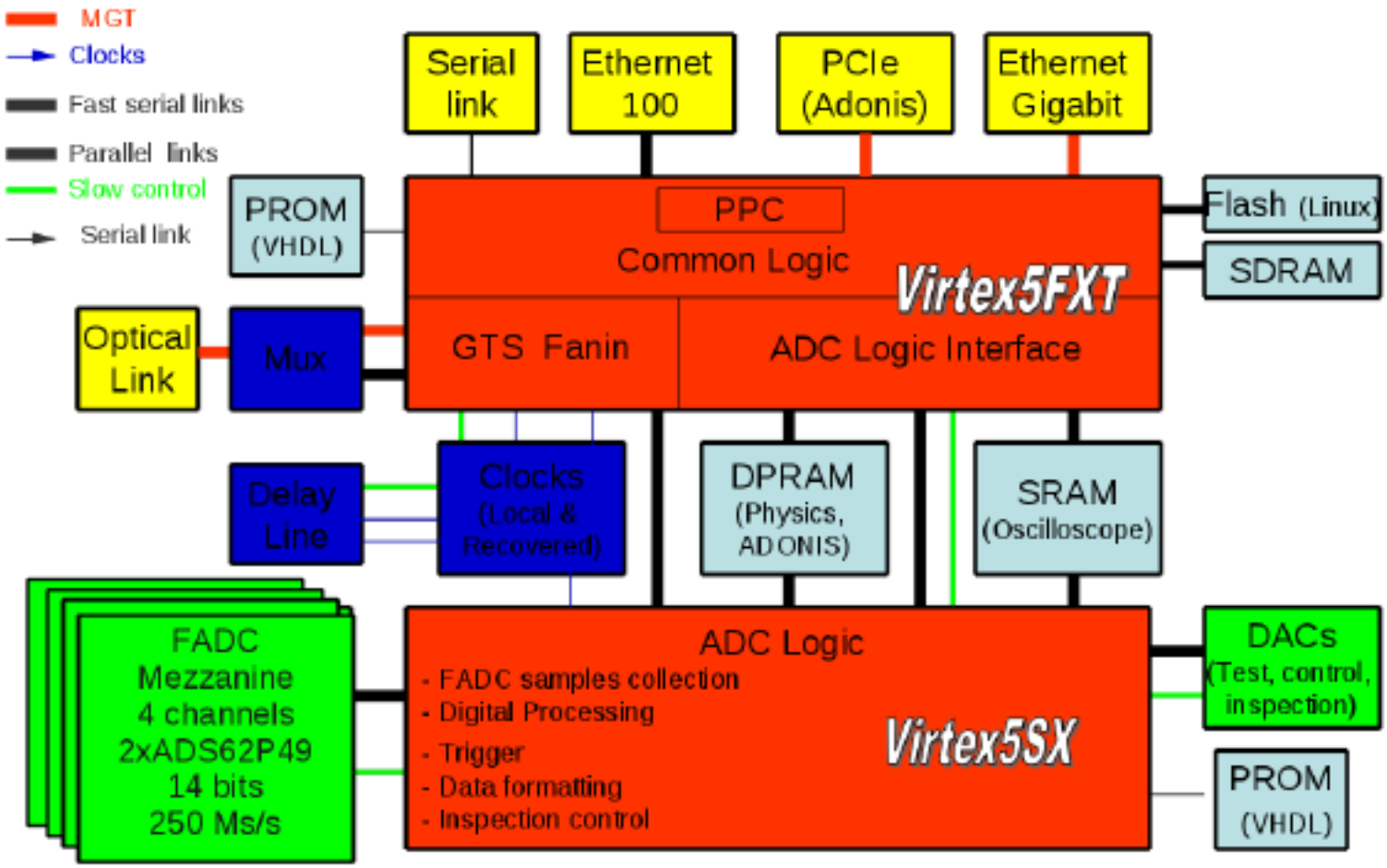
Physics with NEDA

NEDA will address the physics of neutron-rich as well as neutron-deficient nuclei, mainly in conjunction with gamma-ray detector arrays like AGATA, GALILEO, EXOGAM2 and PARIS.

- **Nuclear Structure**
  - Probe of the T=0 correlations in N=Z nuclei: the structure beyond ^{92}Pd (Uppsala, LNL, Padova, GANIL, Stockholm, York)
  - Coulomb Energy Differences in isobaric multiplets: T=0 versus T=1 states (Warsaw, LNL, Padova, GANIL, York)
  - Coulomb Energy Differences and Nuclear Shapes (York, Padova, GANIL)
  - Low-lying collective modes in proton rich nuclei (Valencia, Krakow, Istanbul, Milano, LNL, Padova)
- **Nuclear Astrophysics**
  - Element abundances in the Inhomogeneous Big Bang Model (Weizmann, Soreq, GANIL)
  - Isospin effects on the symmetry energy and stellar collapse (Naples, Debrecen, LNL, Florence)
- **Nuclear Reactions**
  - Level densities of neutron-rich nuclei (Naples, LNL, Florence)
  - Fission dynamics of neutron-rich intermediate fissility systems (Naples, Debrecen, LNL, GANIL)

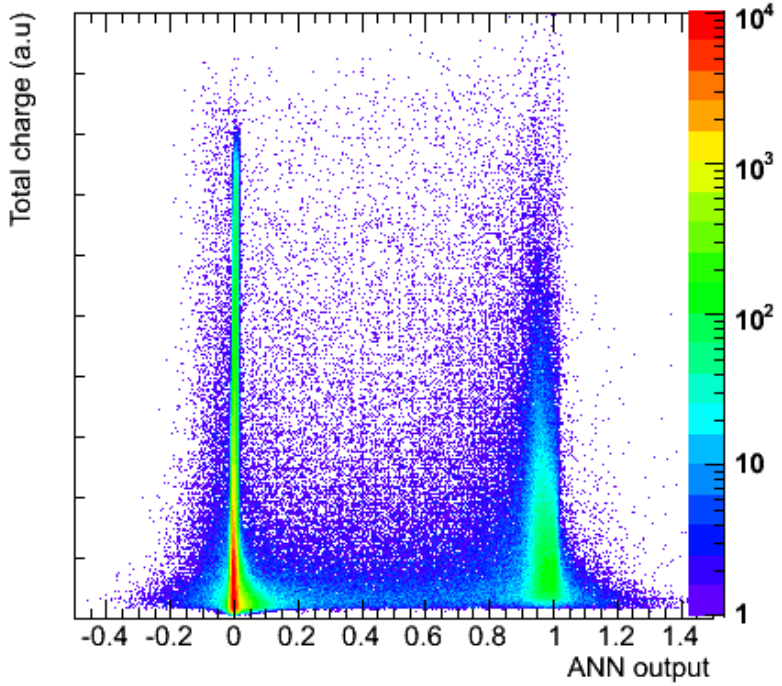
Digital electronics: EXOGAM2-NEDA-PARIS

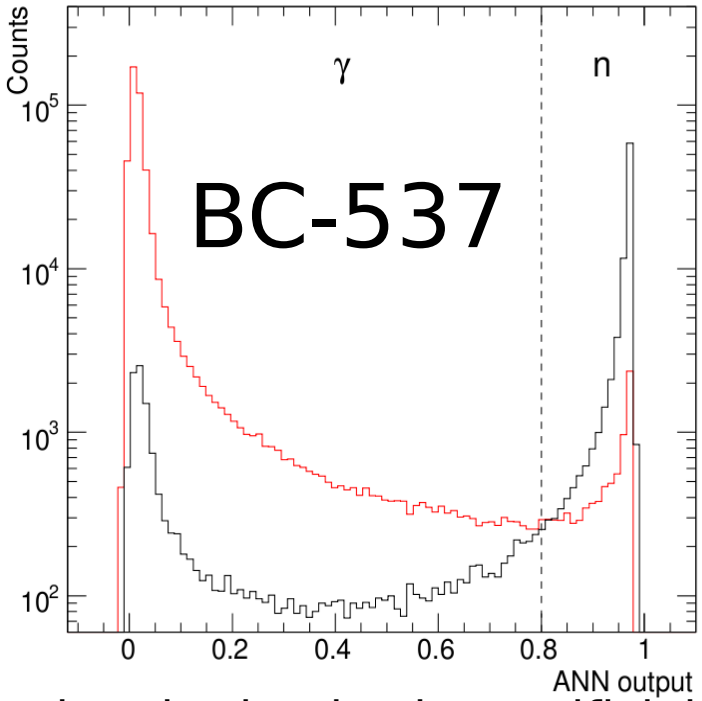
NUMEXO2



NEDA test: PSA Neural Network

P.-A. Söderström(Uppsala University, Uppsala, Sweden)



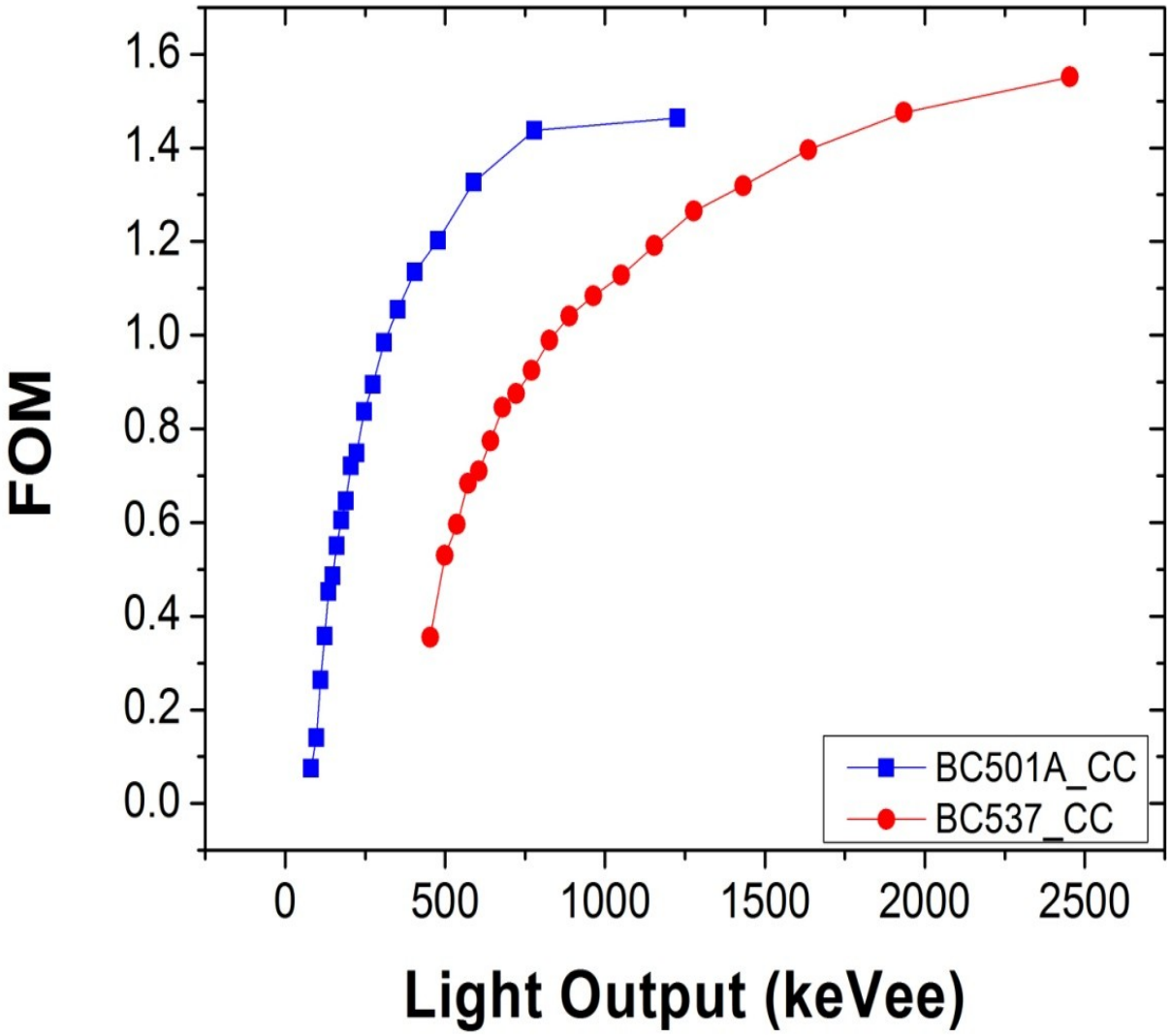


Full advantage of digital electronics can be obtained using artificial neural networks to perform pulse-shape discrimination. This method is currently being investigated both for BC537 and BC501A.

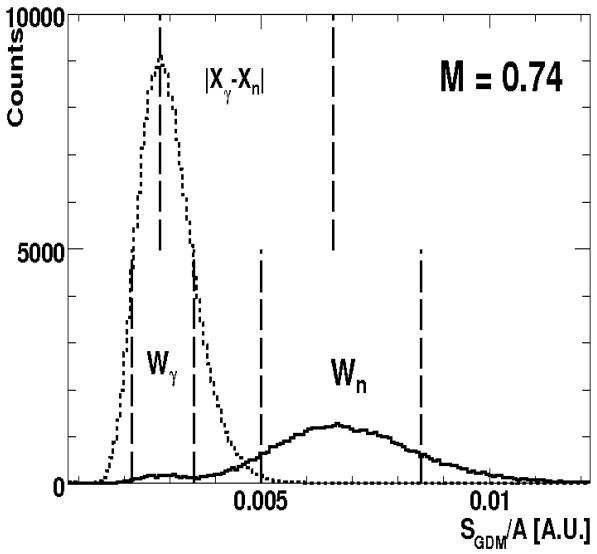
+ Optimal discrimination over a large ene
- Slower implementation limits counting ra

Monday and Thursday talk by G. Jaworski

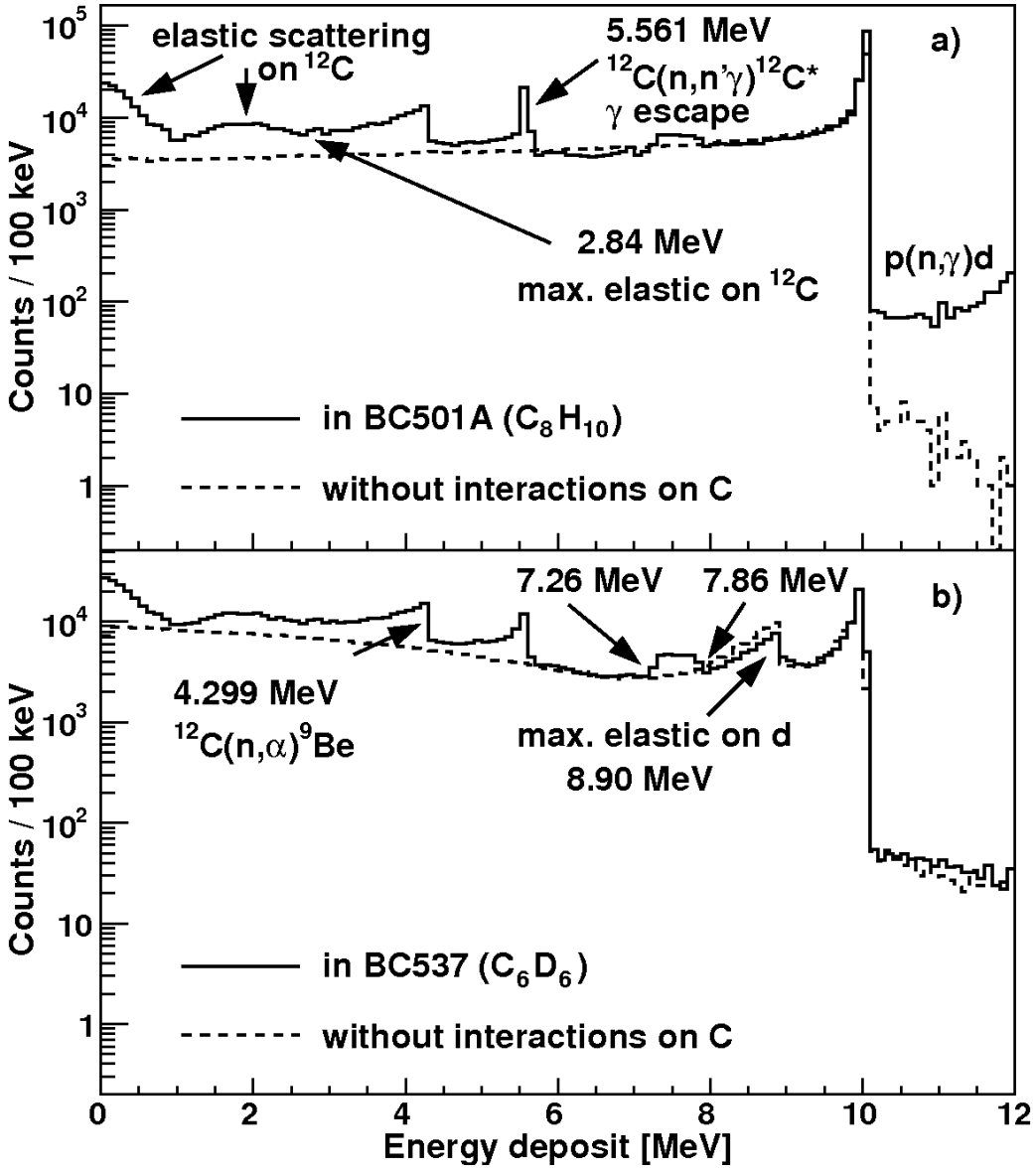
NEDA test: PSA Charge Comparison

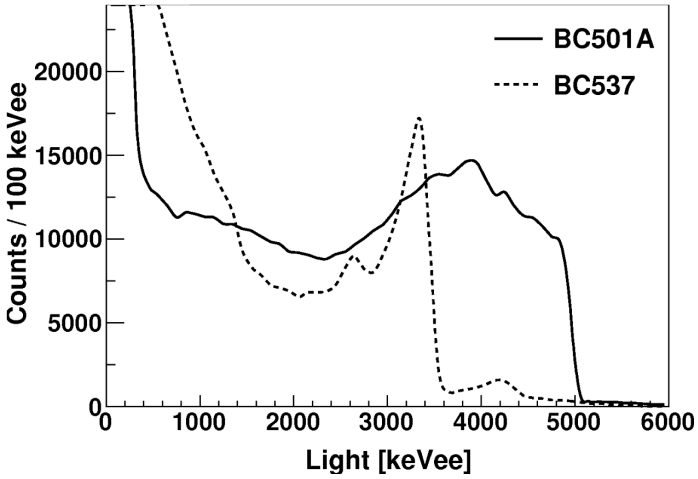


$$M = \frac{|X_\gamma - X_n|}{W_\gamma + W_n}.$$



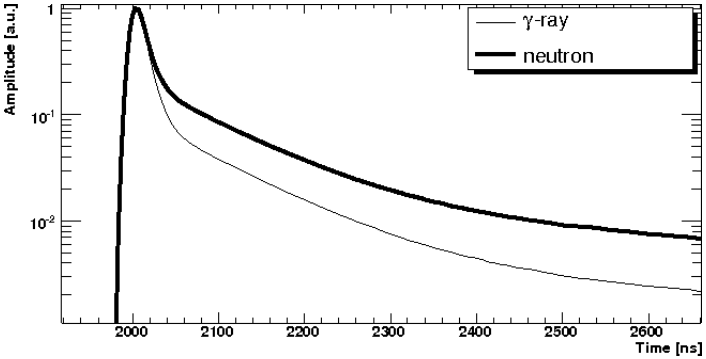
Interactions of neutrons in the scintillator





G.Jaworski et al. NIM A673 (2012) 64

Neutron – gamma discrimination

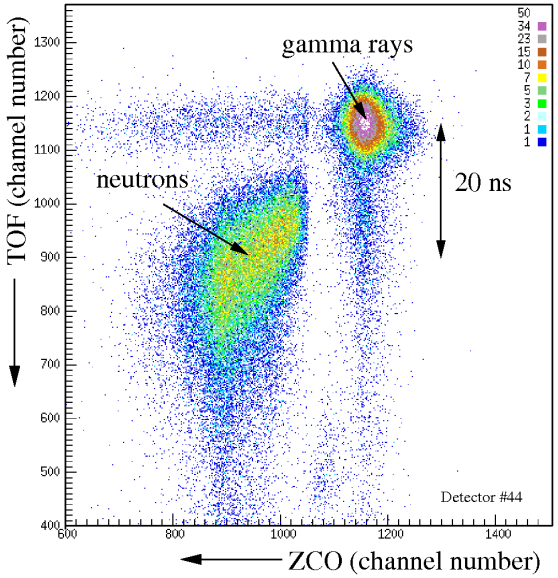


Liquid scintillators give a difference in signal pulse shapes for neutrons and gamma rays:

- neutrons (recoiling protons) - slow light component (τ~300 ns)
- γ rays (electrons) - fast light component (τ~3 ns)

Pulse shape combined with TOF gives w γ-ray as neutron interpretation probability ~0.1 %.

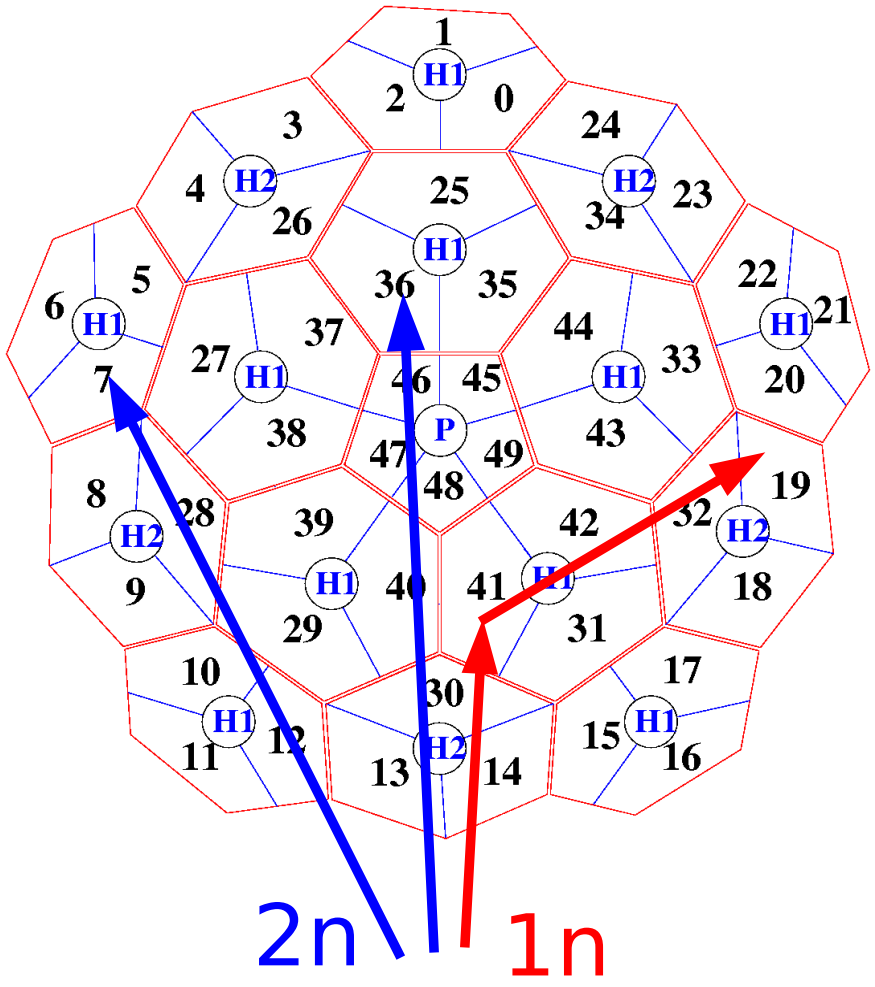
Present NWall: pulse shape discrimination analog.
NEDA will use digital techniques.

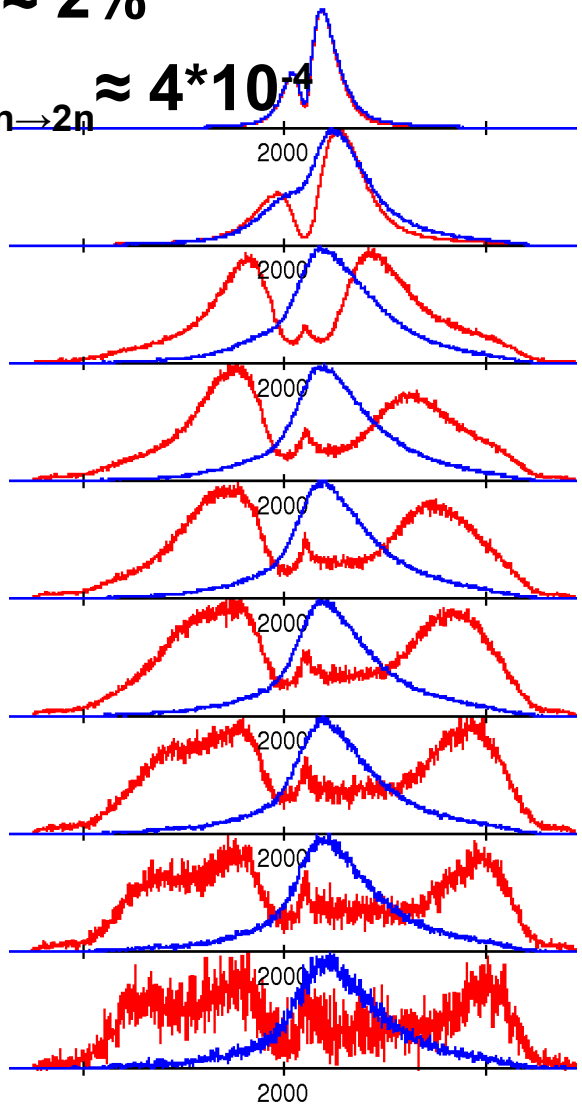


1n/2n/3n discrimination

$\varepsilon_{2n} \approx 2\%$

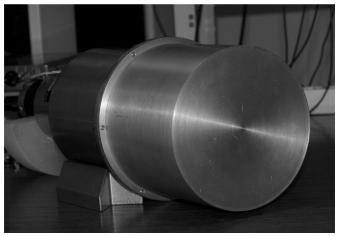
$P_{1n \rightarrow 2n} \approx 4*10^{-4}$

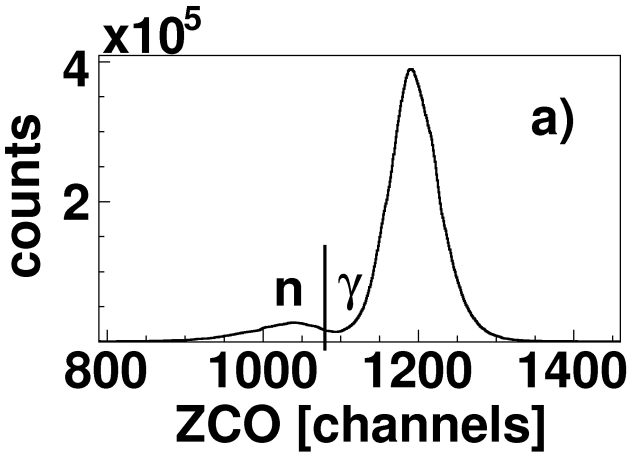


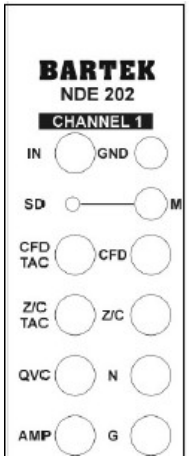


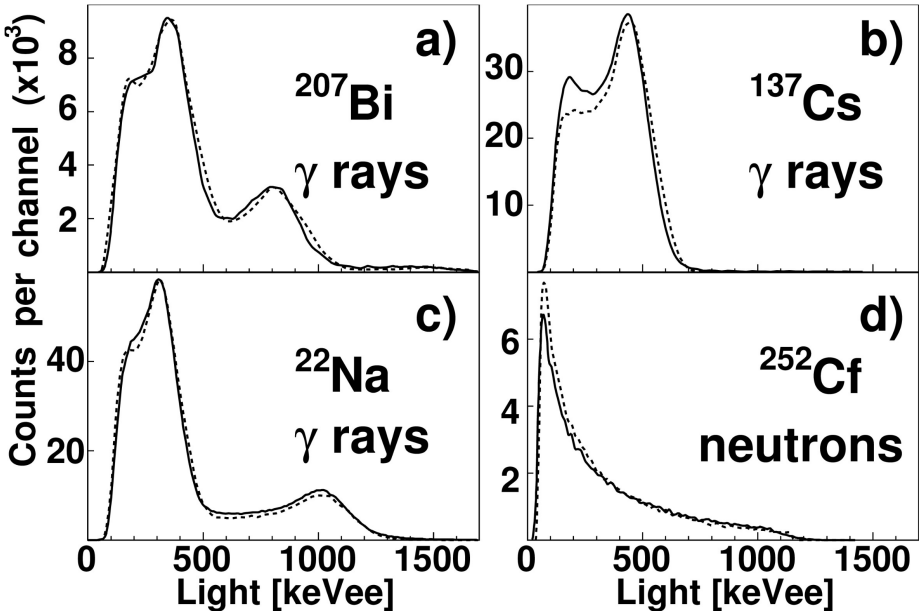
J. Ljungvall et al. NIM A528 (2004) 741

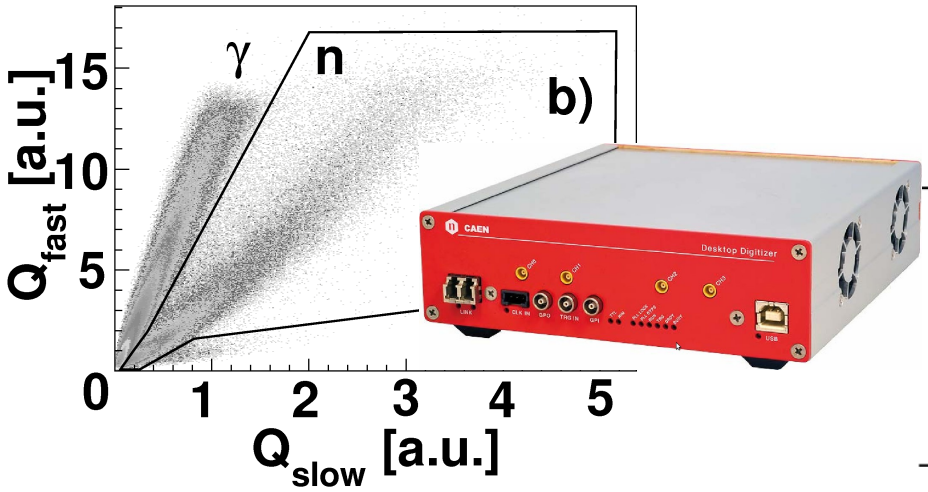
Validation of the simulations









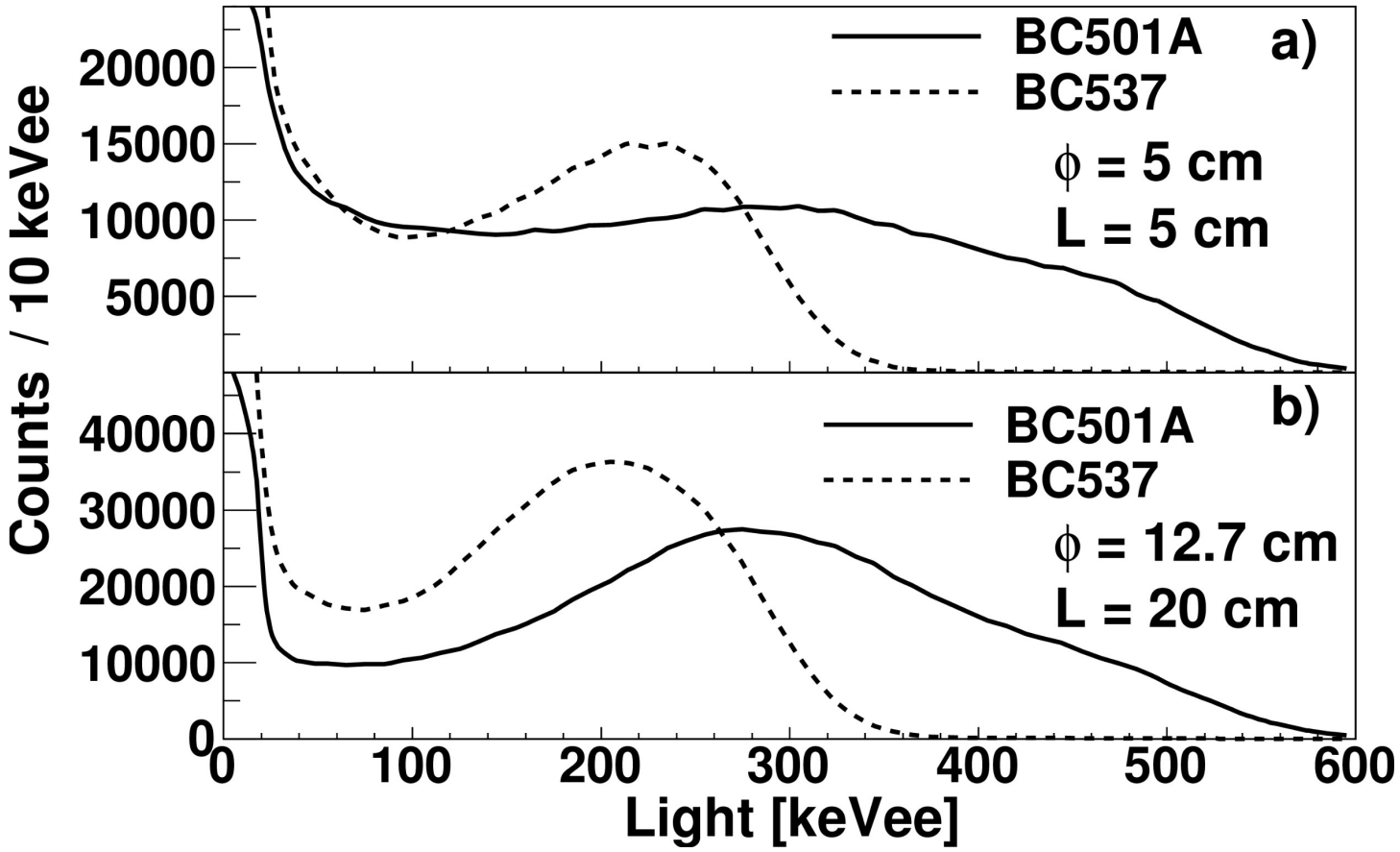


Detector and radioactive source	Efficiency (%) Absolute Exp.	Sim.
NORDBALL:		
^{137}Cs γ rays, 50 cm	0.30(1)	0.285(1)
^{252}Cf neutrons, 51 cm	0.174(9)	0.241(2)
Cylindrical:		
^{252}Cf neutrons, 5 cm	6.1(3)	6.64(2)

Geant 4 simulations

Light to energy dependence

Light output for 2 MeV neutrons
Instrumental response function included



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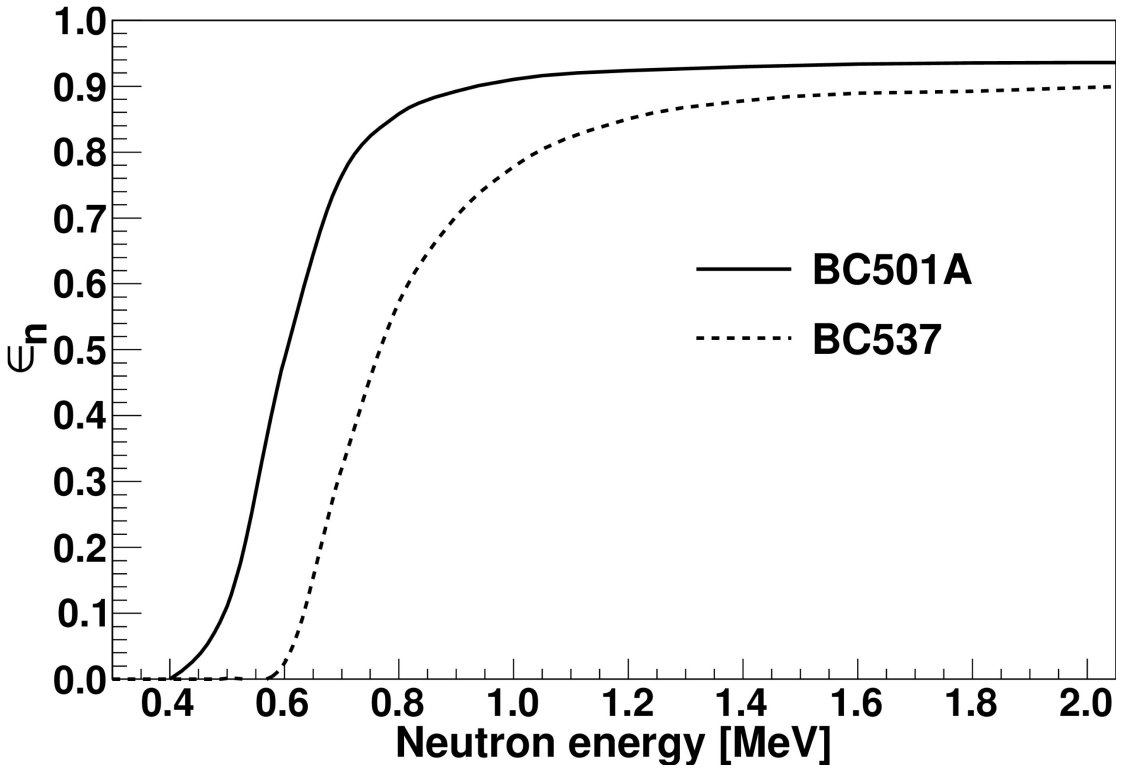
Geant 4 simulations

Neutron detection efficiency



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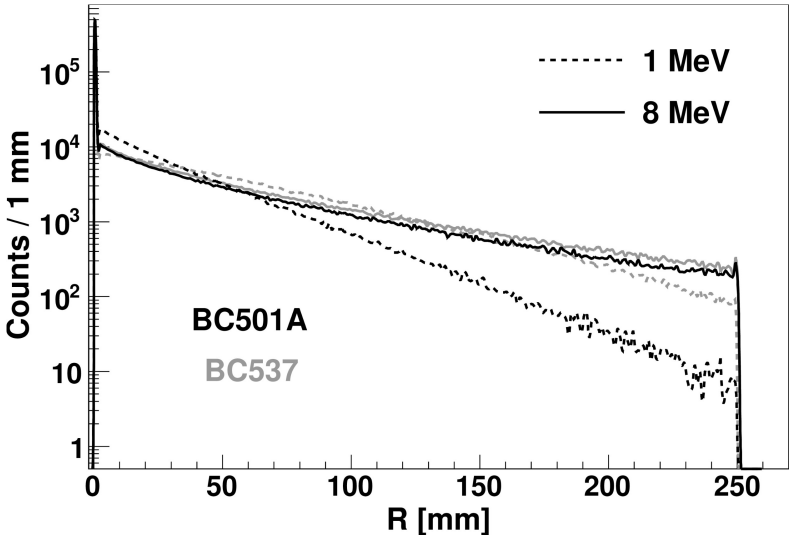
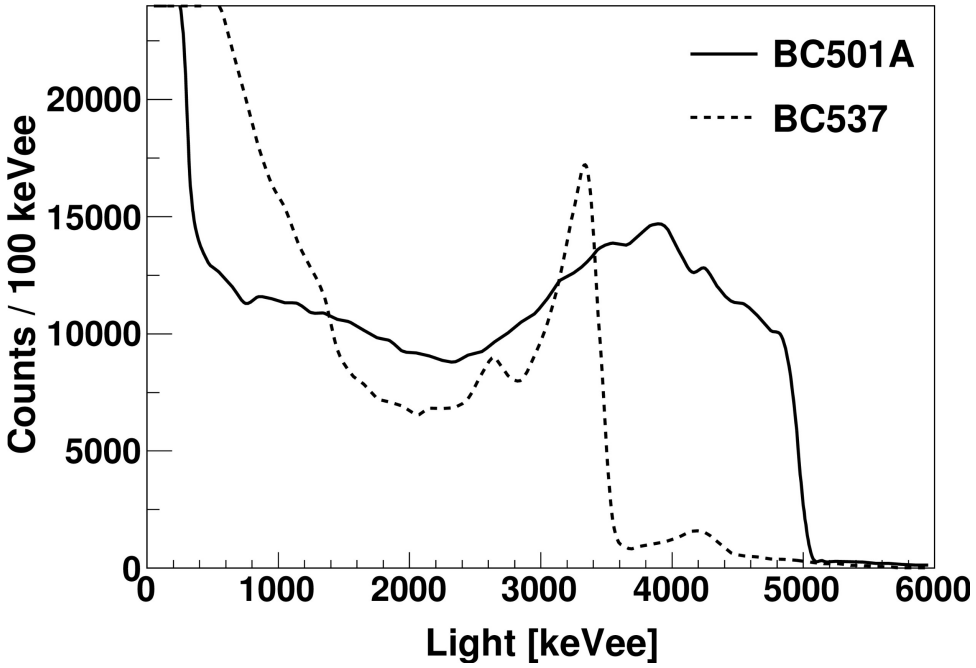
Transverse position of the sig. interaction



Light output for 10 MeV neutrons
An instrumental response function not included



Influence of the 100 ns detection time limit on the p(1n→2n).