Test of the annular detector for (n, cp) studies: Preliminary Results

S. Goula, S. Amaducci, L. Cosentino, M. Mastromarco, G. Vecchio, P. Finocchiaro,
N. Patronis, C. Massimi, A. Mazzone, N. Colonna , S. Pomp, D. Tarrio

Motivation

- **Increasing worldwide need for (n, lcp)**
  - Nuclear Astrophysics
  - Nuclear Technologies

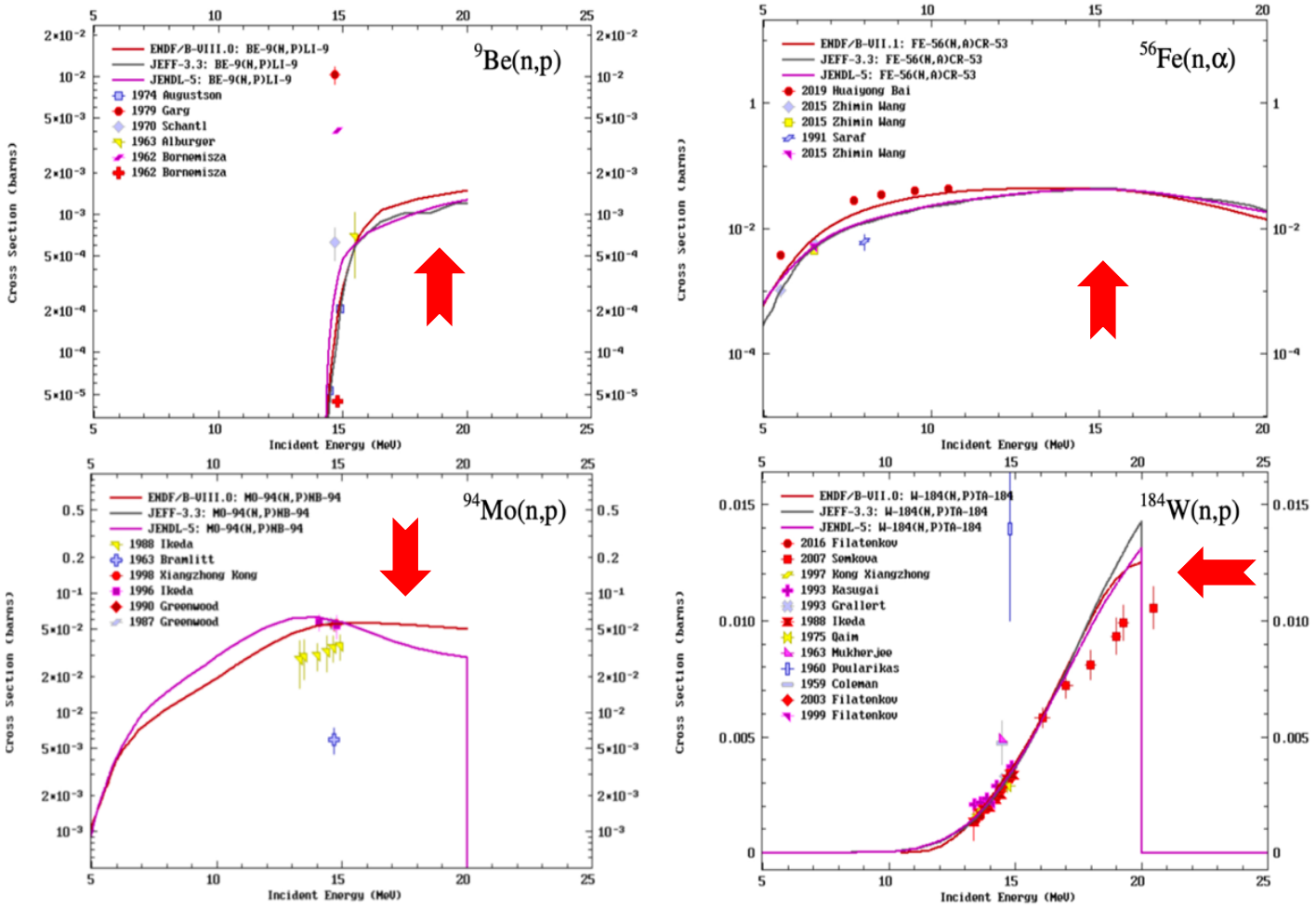
Lack or **discrepant/inconsistent** experimental data

At least **30 poorly known** cross-sections

- **The detection systems are setting a limit to the measured reactions**

Solution?

Use novel detectors!

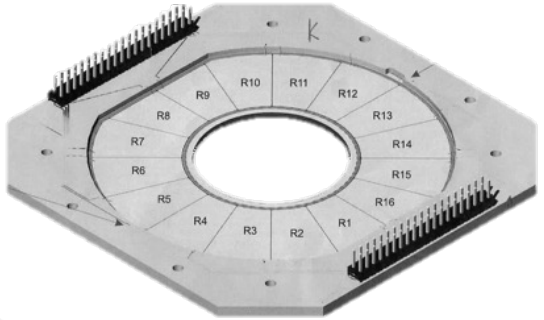


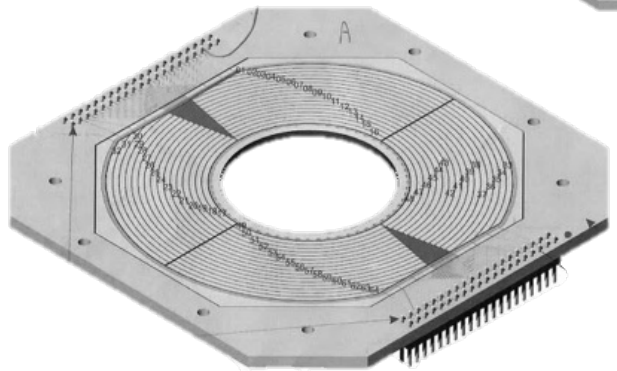
L. Cosentino et al., CERN-INTC-2022-019, INTC-P-629, https://cds.cern.ch/record/2809189

But.. why do we need the annular detector?

New detection apparatus **devoted** to particle discrimination

Chance to overcome the ΔE/E technique limitations



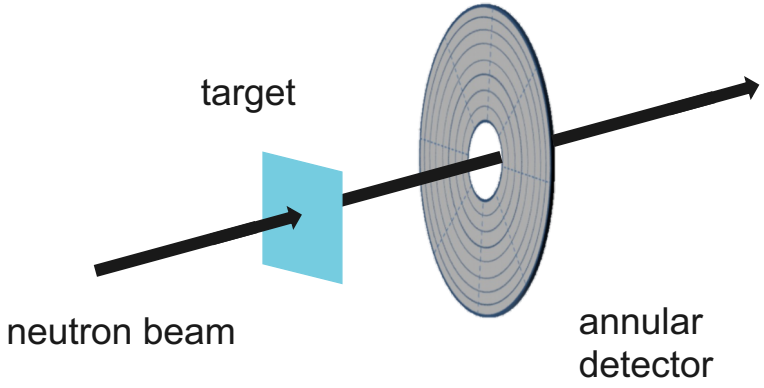


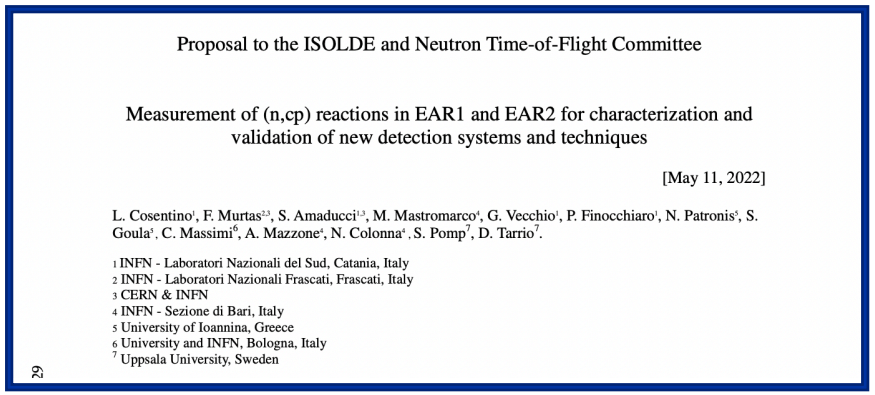
- Neutron Transmutation-Doped (**NTD**)
- **Segmentation**: θ & φ angles
  - Angular distribution & Good position-angular resolution
- **Digital-LNS** Pulse Shape Analysis based on signal shapes
  - Readout directly from preamplifiers
- Neutron energies thresholds for PSA:
  - ~ **2-3 MeV** till **tens of MeV**

Inner Ø: 46 mm
Outer Ø: 96 mm
Thickness: 305 μm
16 sectors – Rear part
16 strips – Front part

Annular Detector: Configuration

Principle of operation:




Proposal to the ISOLDE and Neutron Time-of-Flight Committee

Measurement of (n,cp) reactions in EAR1 and EAR2 for characterization and validation of new detection systems and techniques

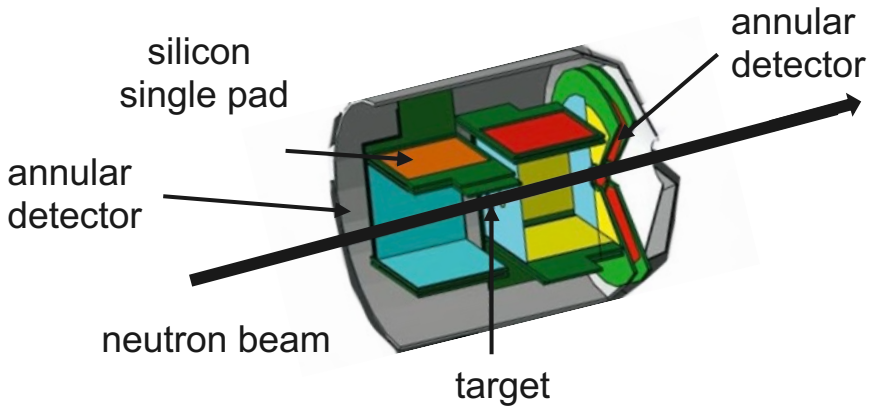
[May 11, 2022]

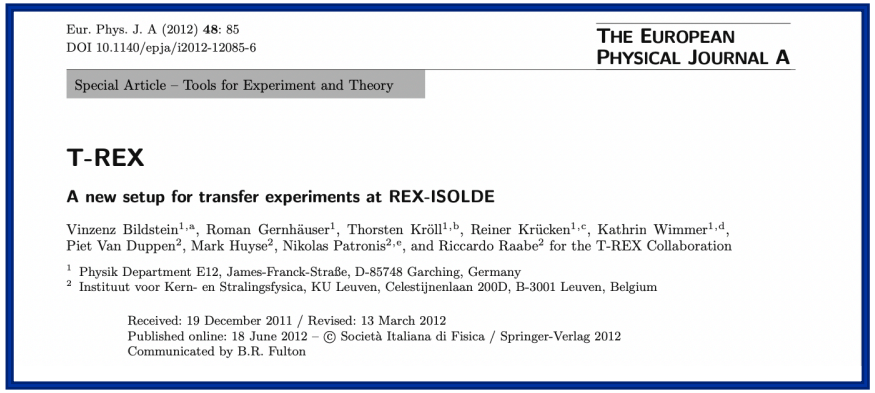
L. Cosentino[1], F. Murtas[2,3], S. Amaducci[1,3], M. Mastromarco[4], G. Vecchio[1], P. Finocchiaro[1], N. Patronis[5], S. Goula[2], C. Massimi[6], A. Mazzone[4], N. Colonna[4], S. Pomp[7], D. Tarrio[7].

1 INFN - Laboratori Nazionali del Sud, Catania, Italy
2 INFN - Laboratori Nazionali Frascati, Frascati, Italy
3 CERN & INFN
4 INFN - Sezione di Bari, Italy
5 University of Ioannina, Greece
6 University and INFN, Bologna, Italy
7 Uppsala University, Sweden

29

Possible modular configuration:




Eur. Phys. J. A (2012) 48: 85
DOI 10.1140/epja/i2012-12085-6

THE EUROPEAN PHYSICAL JOURNAL A

Special Article – Tools for Experiment and Theory

T-REX

A new setup for transfer experiments at REX-ISOLDE

Vinzenz Bildstein[1,a], Roman Gernhäuser[1], Thorsten Kröll[1,b], Reiner Krücken[1,c], Kathrin Wimmer[1,d], Piet Van Duppen[2], Mark Huyse[2], Nikolas Patronis[2,e], and Riccardo Raabe[2] for the T-REX Collaboration

[1] Physik Department E12, James-Franck-Straße, D-85748 Garching, Germany
[2] Instituut voor Kern- en Stralingsfysica, KU Leuven, Celestijnenlaan 200D, B-3001 Leuven, Belgium

Received: 19 December 2011 / Revised: 13 March 2012
Published online: 18 June 2012 – © Società Italiana di Fisica / Springer-Verlag 2012
Communicated by B.R. Fulton

ISOLDE / 2012

Validation test – EAR1

Days: **25-28** November

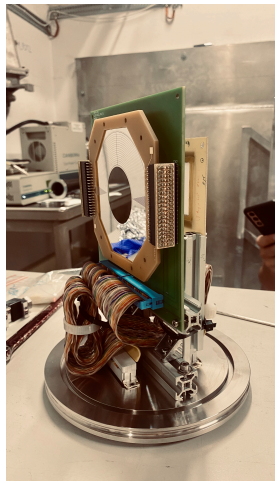
Purpose:

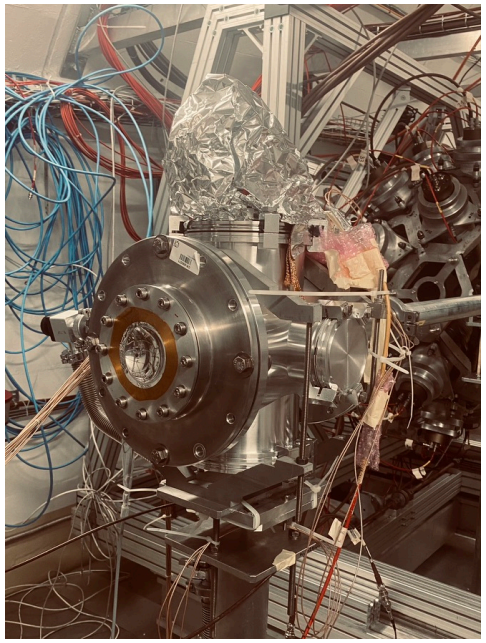
- γ - flash
- Response of the detector
- PSA software
  - Attempt for particle identification

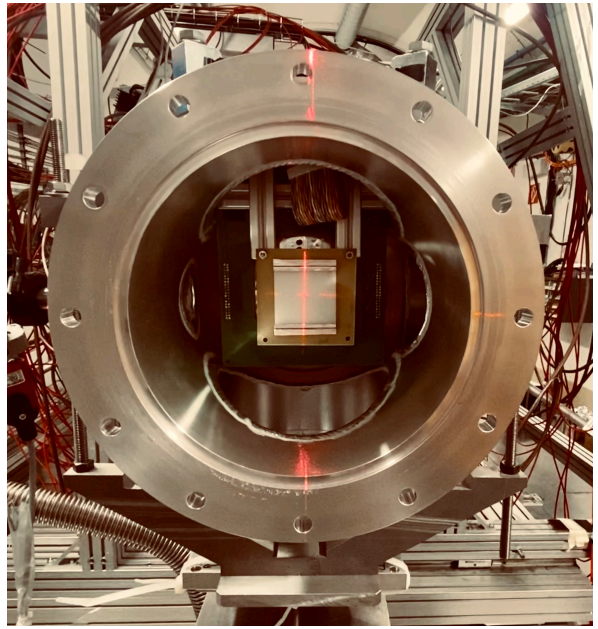
Setup:

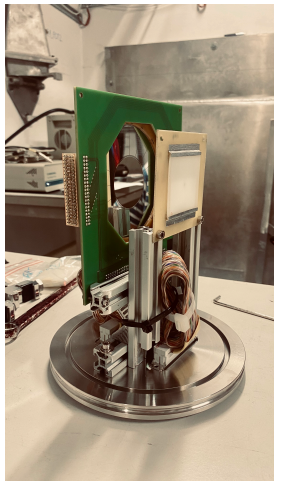
- Detector & Target: attached to the flange
- Used targets: **PE** (1mm) & **LiF** (400nm)
- Aluminum chamber in vacuum: ~10^{-3} mbar

Approx**. 2 days** of data taking!



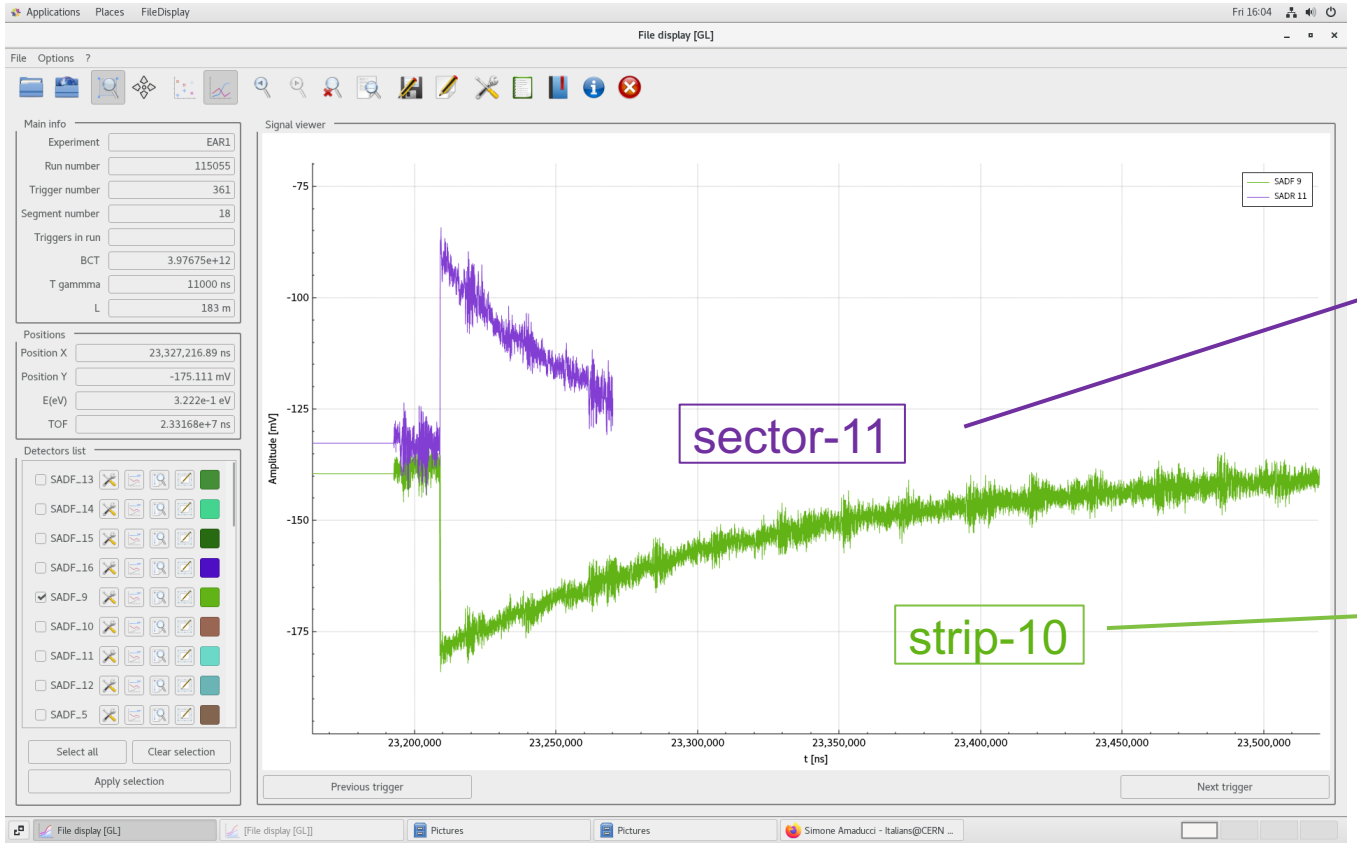


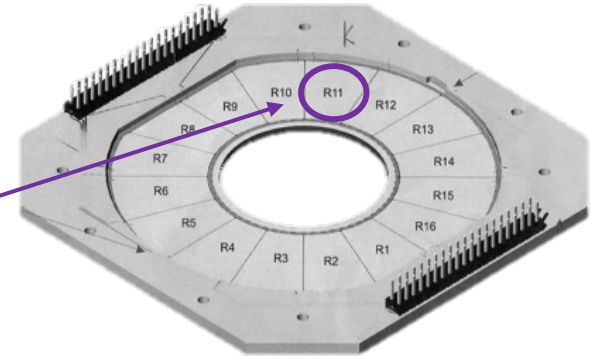


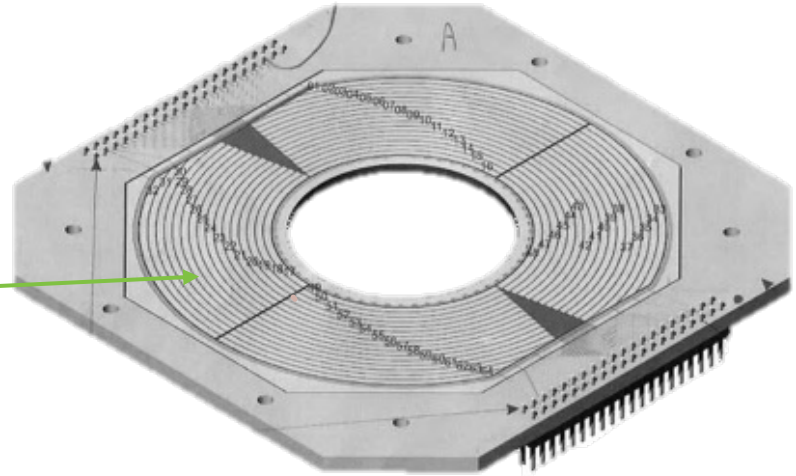


Raw Data - Low energy part

Simultaneous readout for both strips and sectors possible

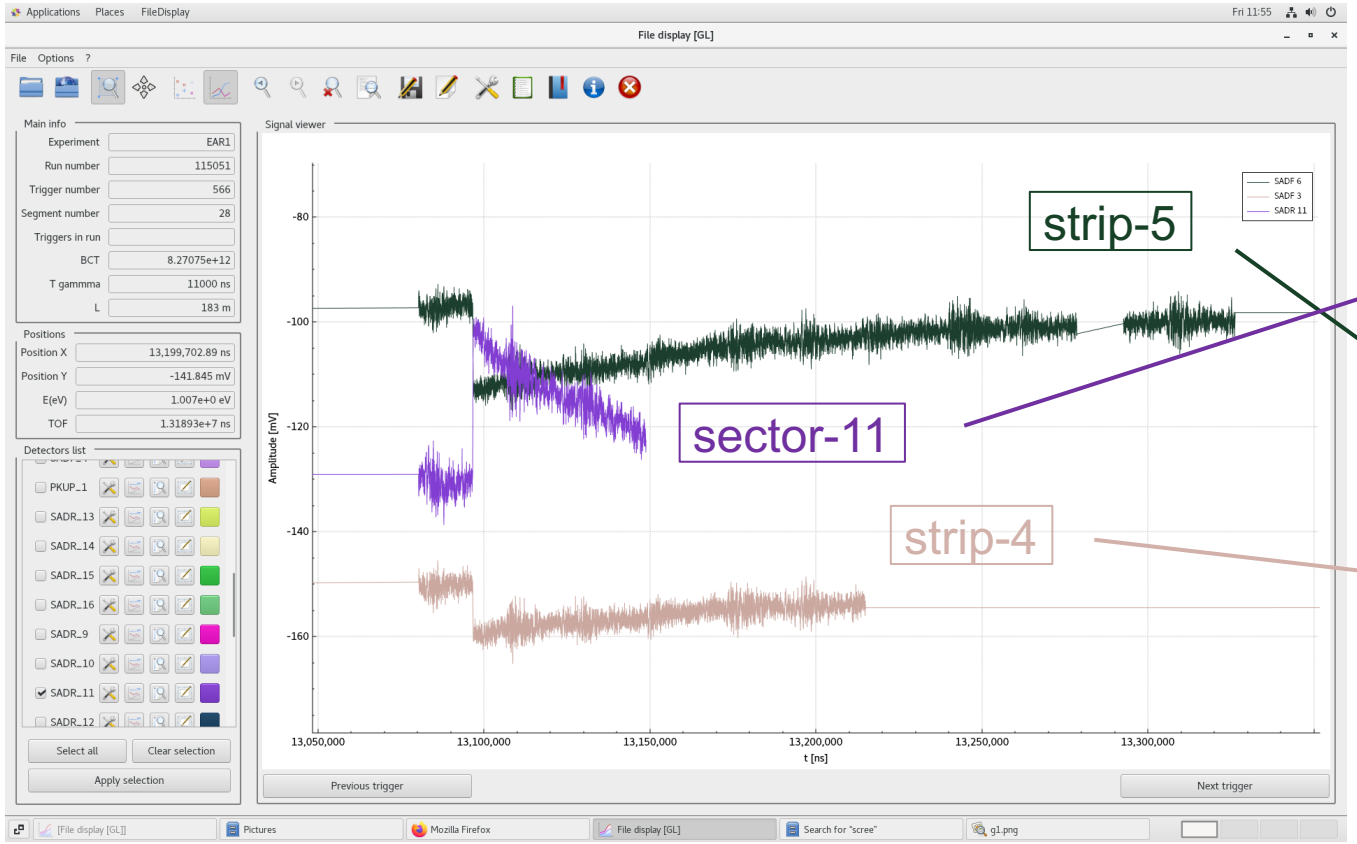


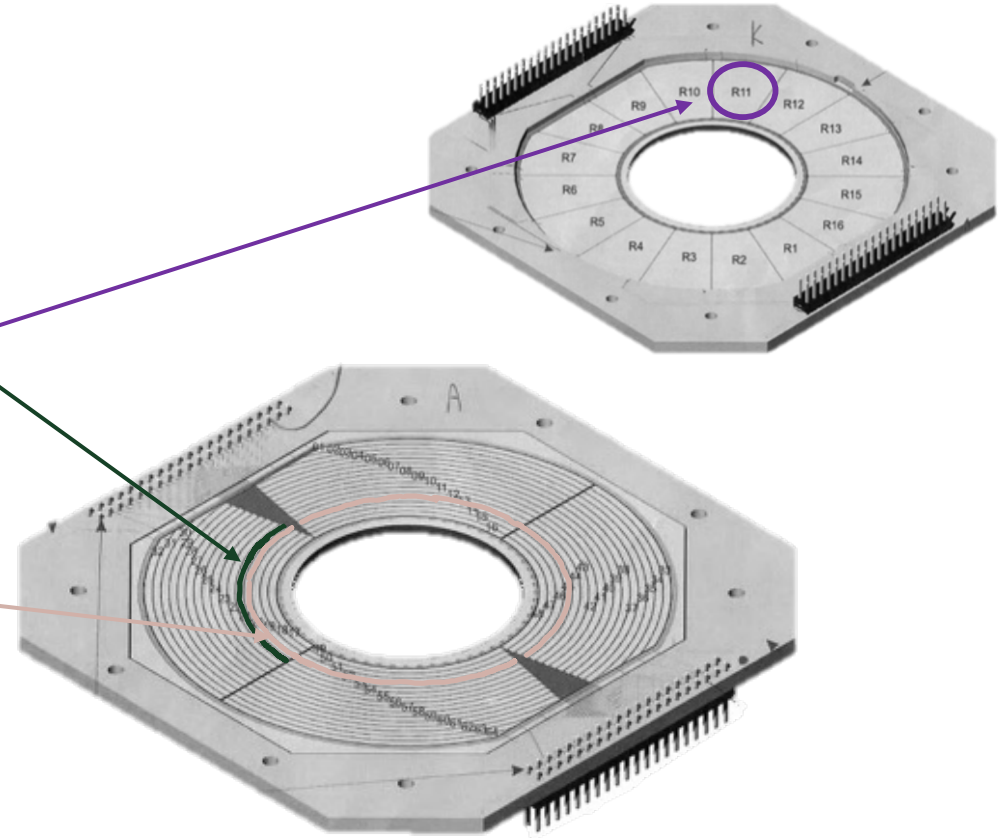




Raw Data - Low energy part

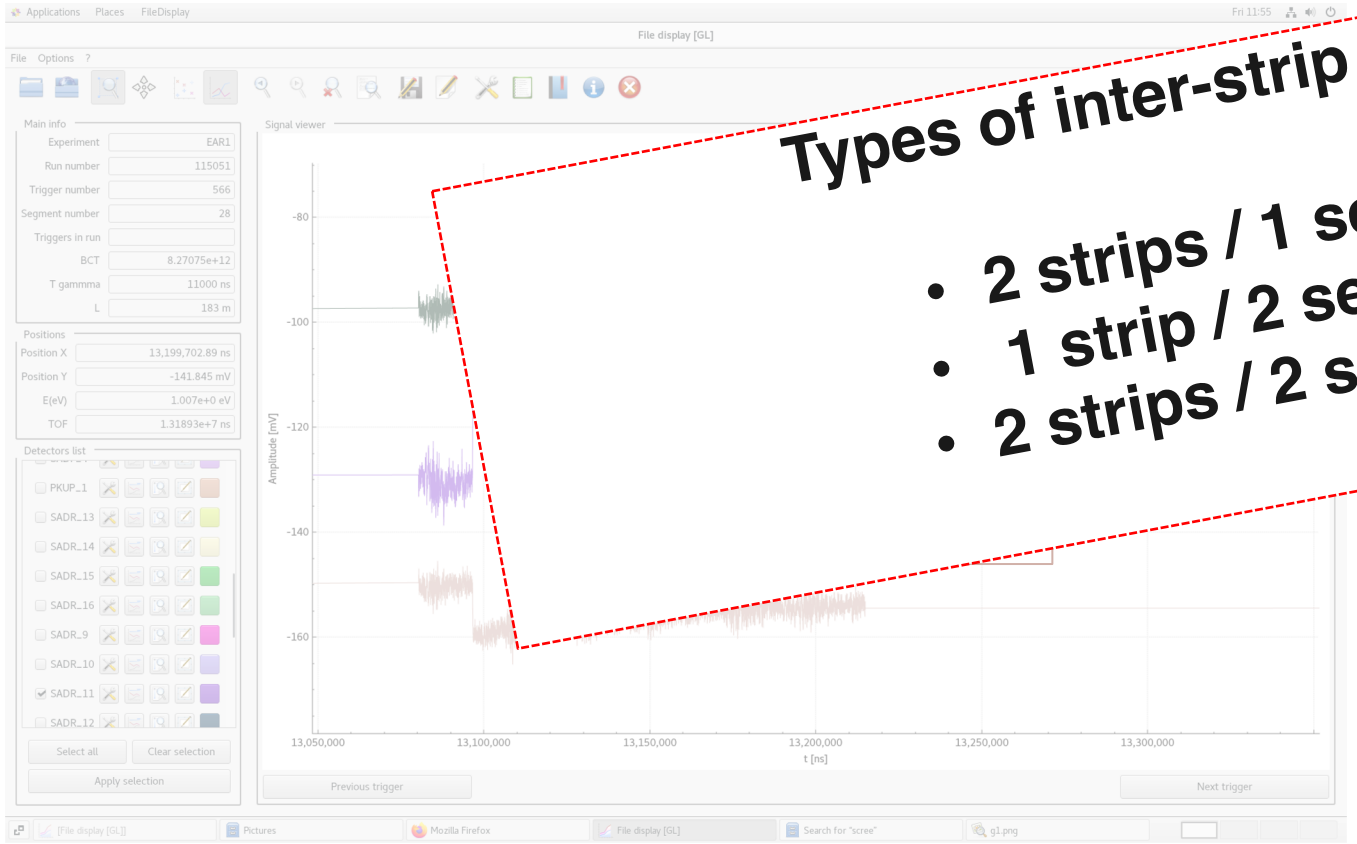
Inter-strip event reconstruction possible:





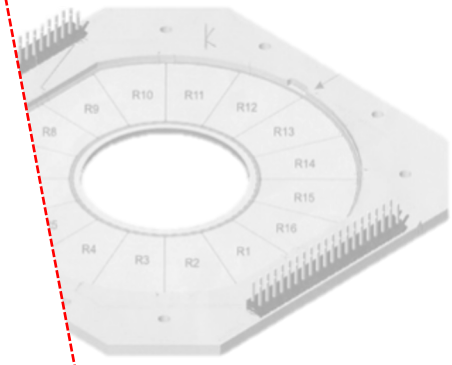
Raw Data - Low energy part

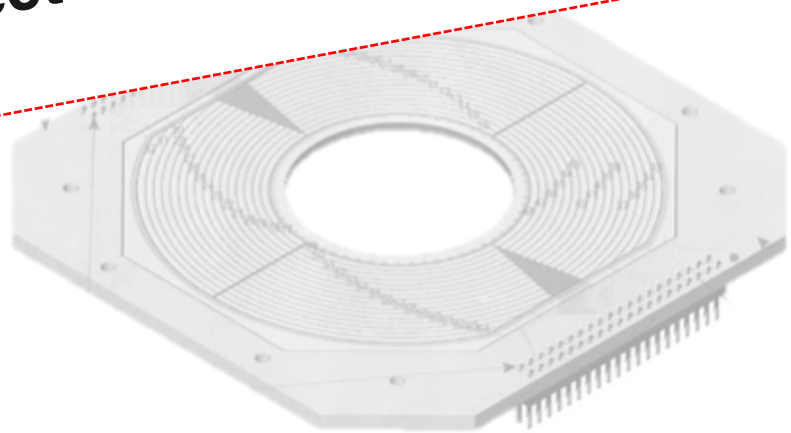
Inter-strip event reconstruction possible:



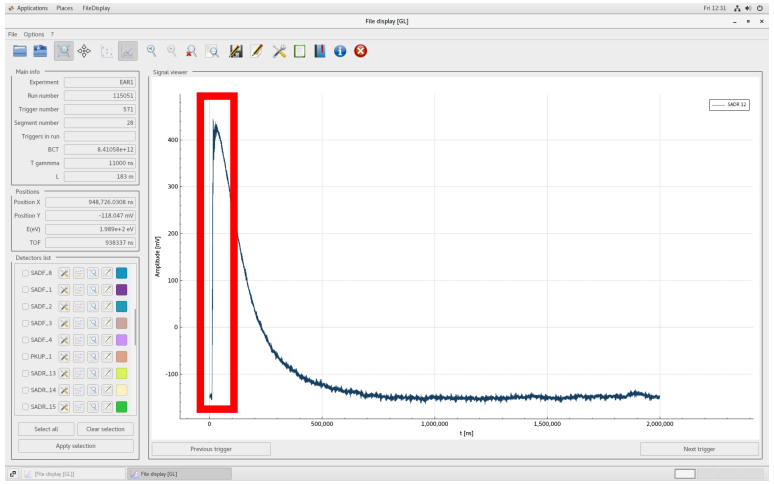
Types of inter-strip events:

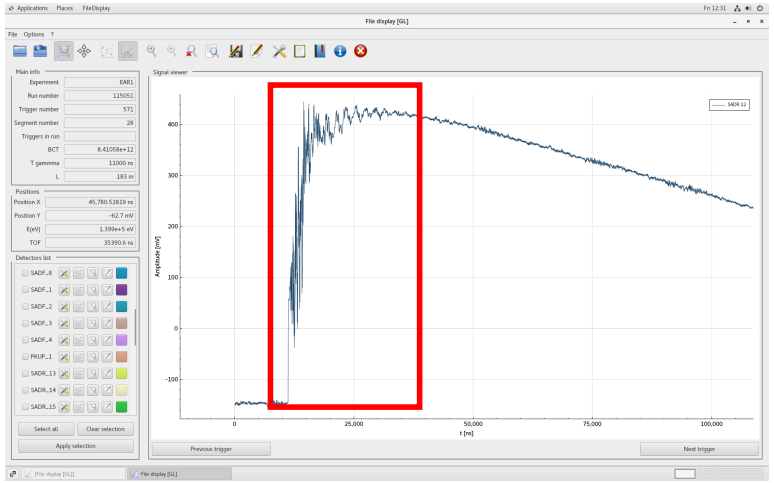
- 2 strips / 1 sector
- 1 strip / 2 sectors
- 2 strips / 2 sectors

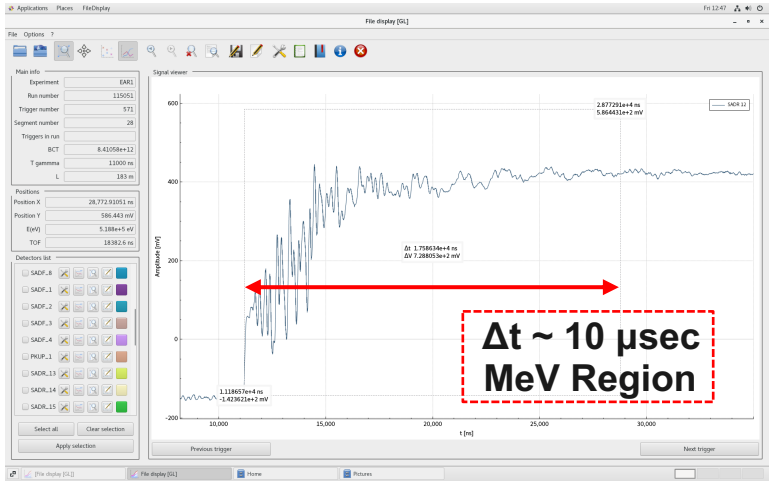




Raw Data - High energy part



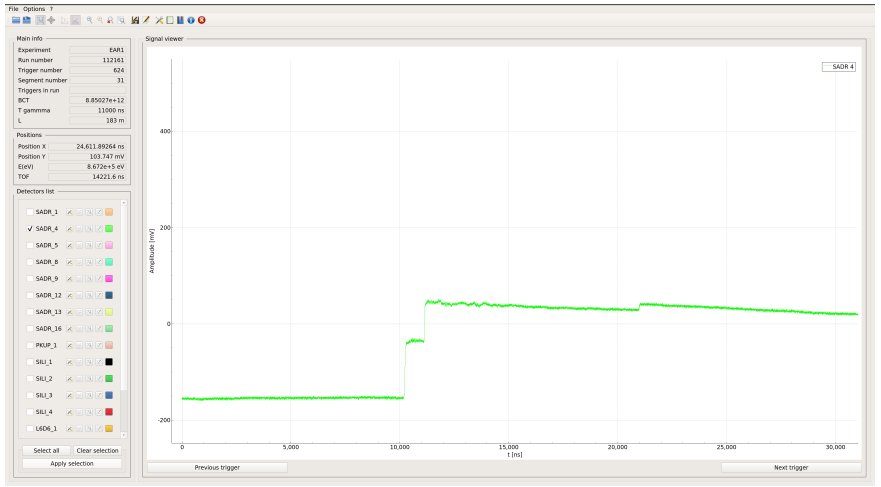




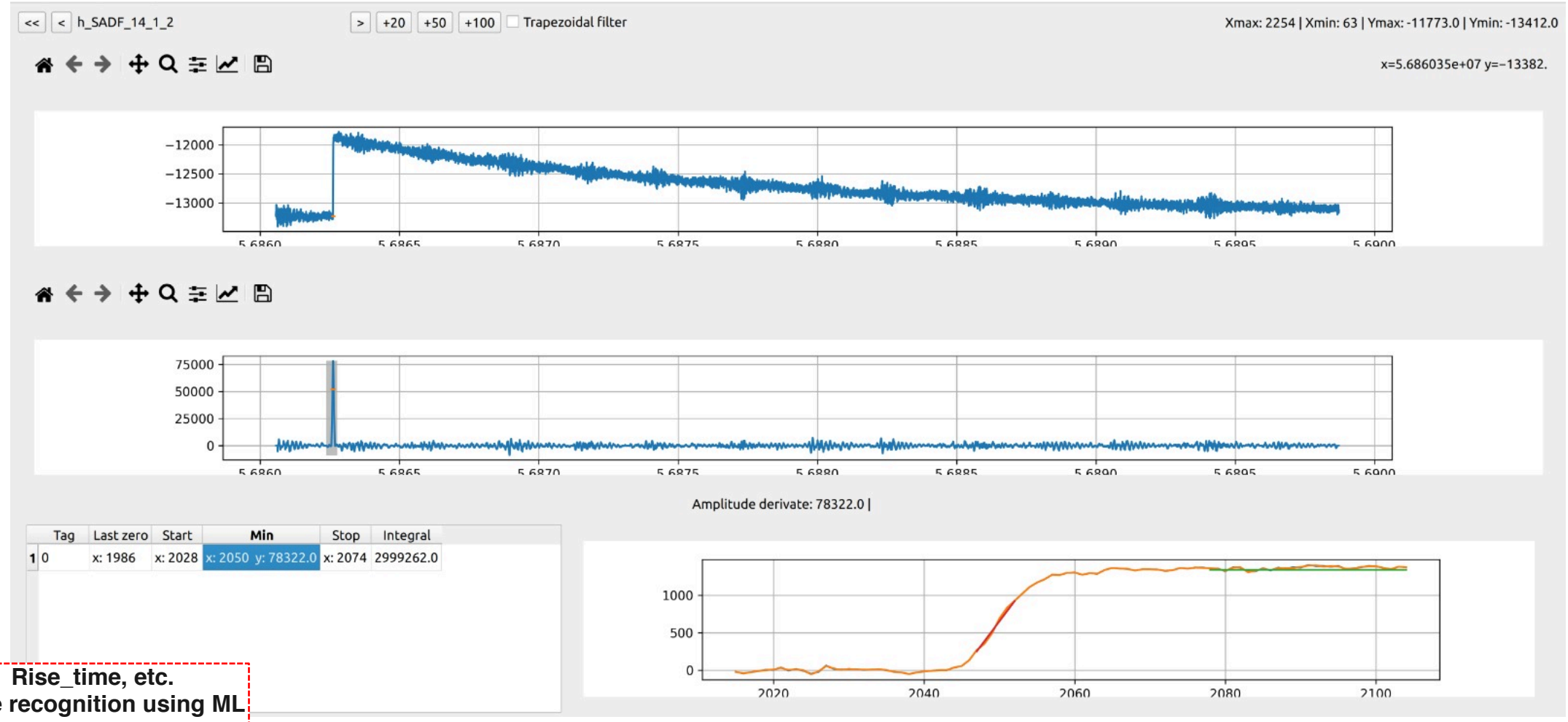
Previous year's setup:

NOT the ideal one

- Working in **air**



PSA Routine

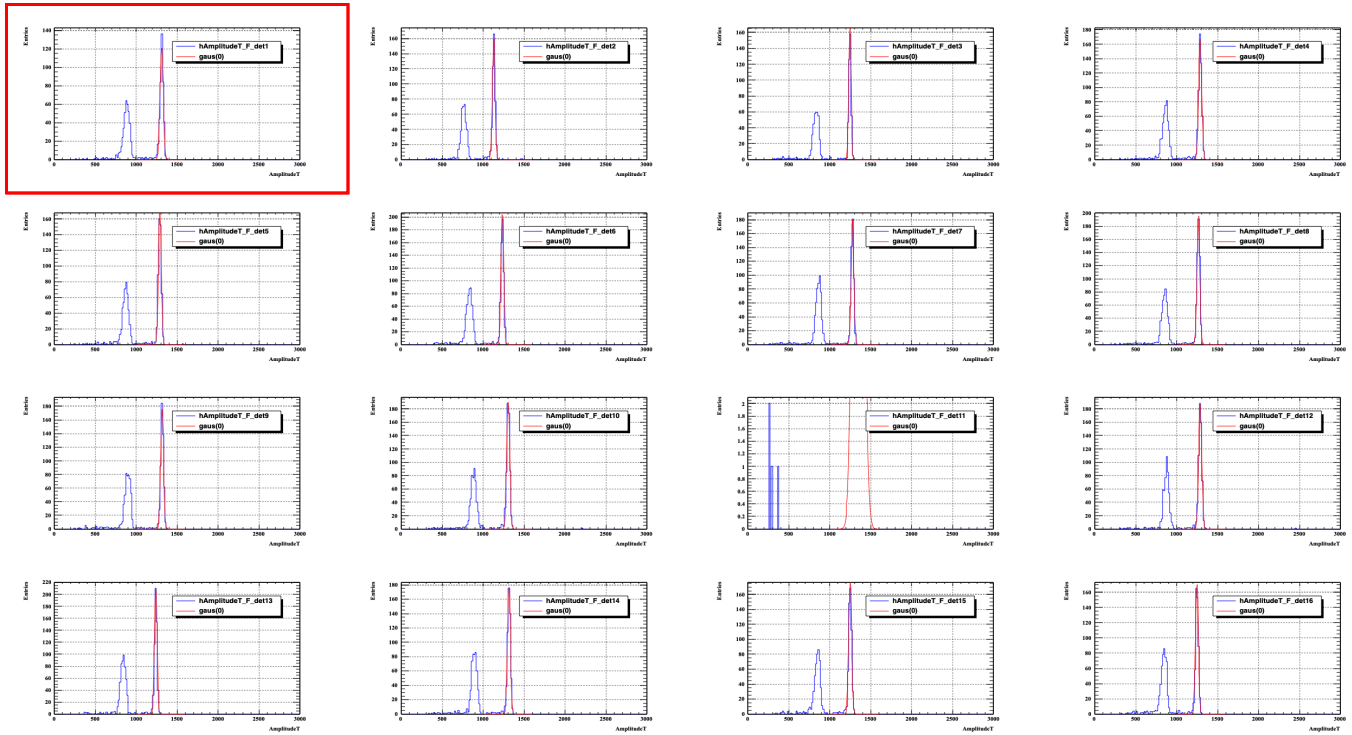


- **Rise_time, etc.**
- **Pulse recognition using ML**

Courtesy: G. Vecchio

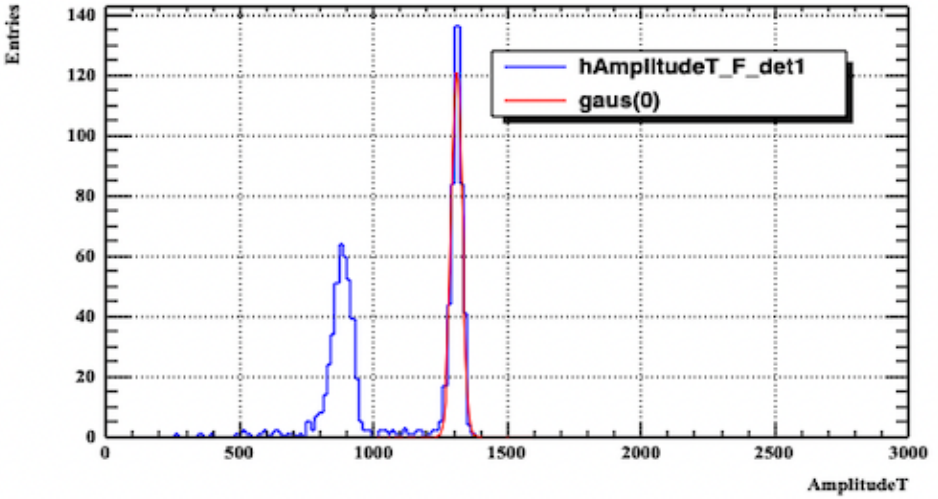
Amplitude Spectra: Energy condition < 1keV

Amplitude extracted using the Trapezoidal Filter - 16 Strips - Front



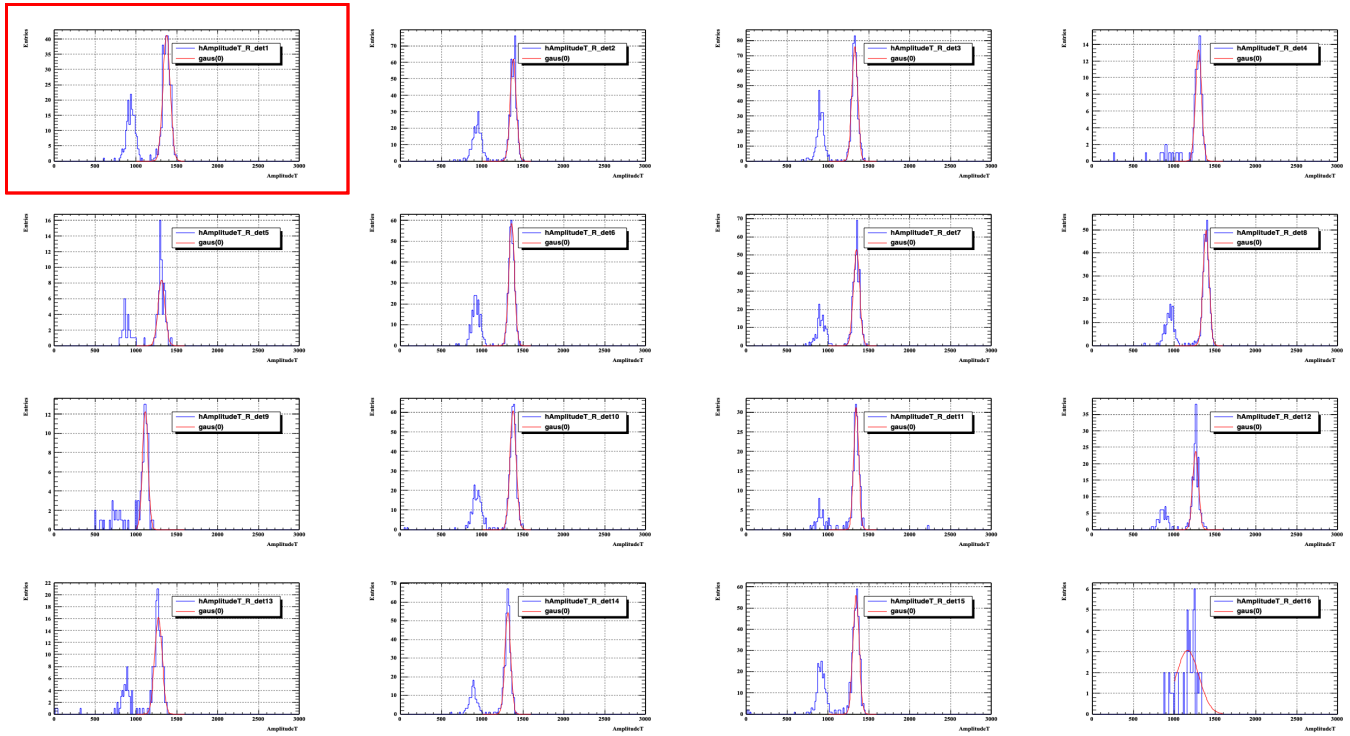
- $V_{bias} = V_{depletion}$

Reaction: $^{6}Li(n, t)^{4}He$



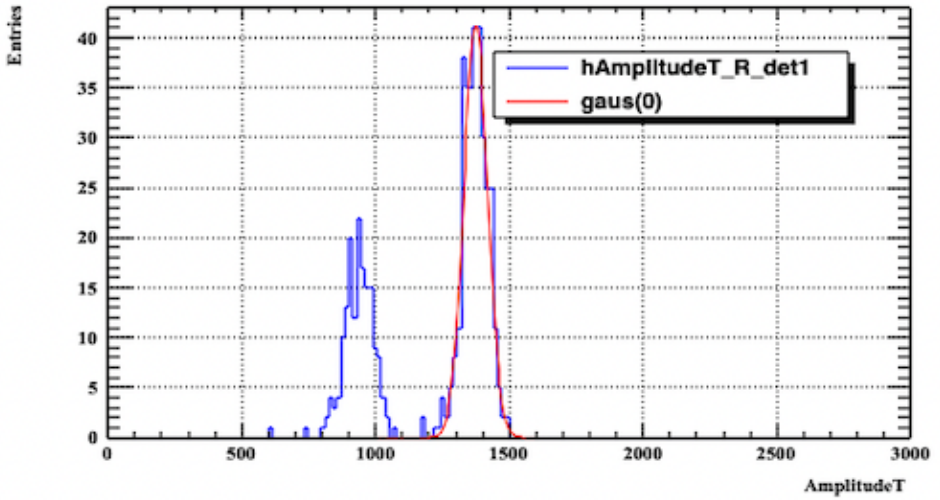
Amplitude Spectra: Energy condition < 1keV

Amplitude extracted using the Trapezoidal Filter - 16 Sectors - Rear



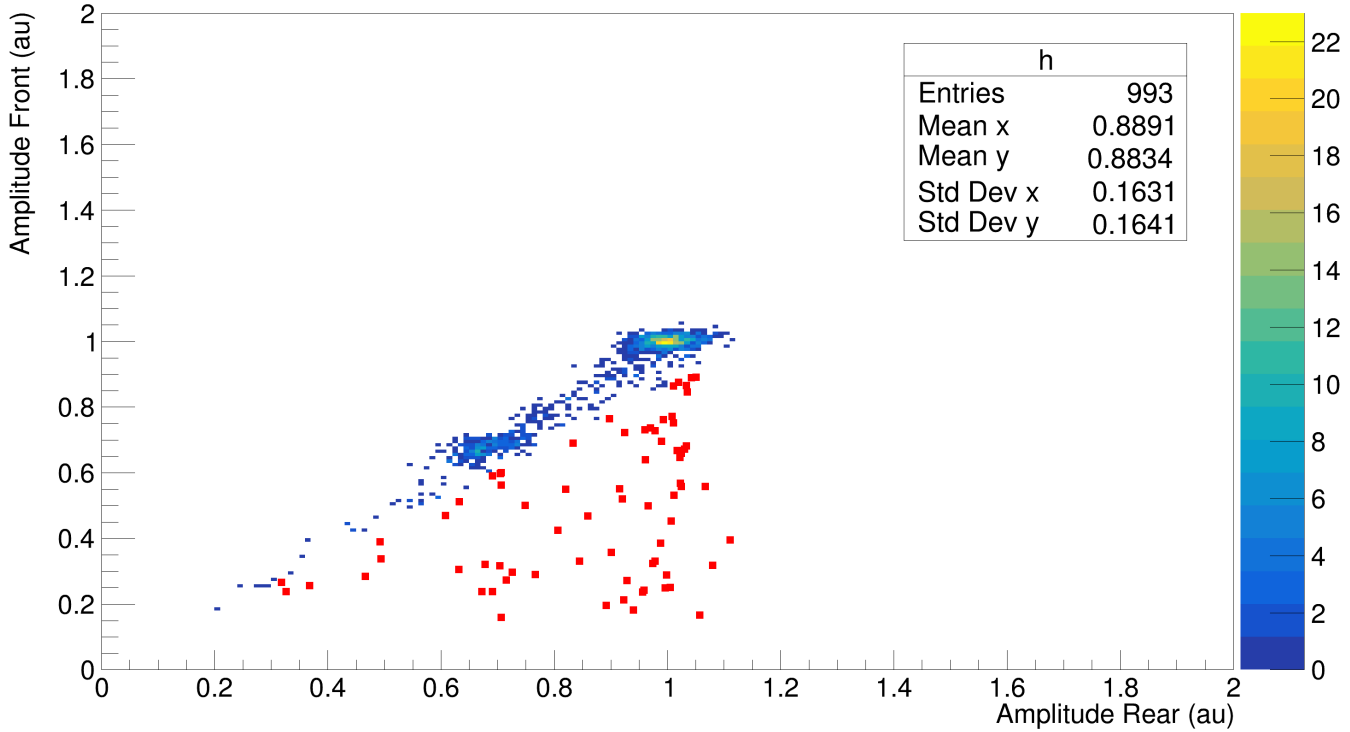
- $V_{bias} = V_{depletion}$

Reaction: $^{6}Li(n, t)^{4}He$



Reconstruction of inter-strip events

Interstrip events: ~ 5 %



Courtsesy: S. Amaducci

Conclusions & Pespectives

- **Detector's behaviour: promising in the low-energy part**
- **Observed challenges: Noise in the high-energy region**
  - Looking for mitigation solutions
    - …Grounding? …Beam-related? …Chamber?
- **Analysis with the usage of the TF in the high-energy region**
  - Further investigation is planned in ILL to improve the analysis routine used for the PS technique
- **Looking forward to the physics measurements planned for May 2023**

UNIVERSITY of IOANNINA

CERN

nTOF

INFN
Istituto Nazionale di Fisica Nucleare

Thank you!

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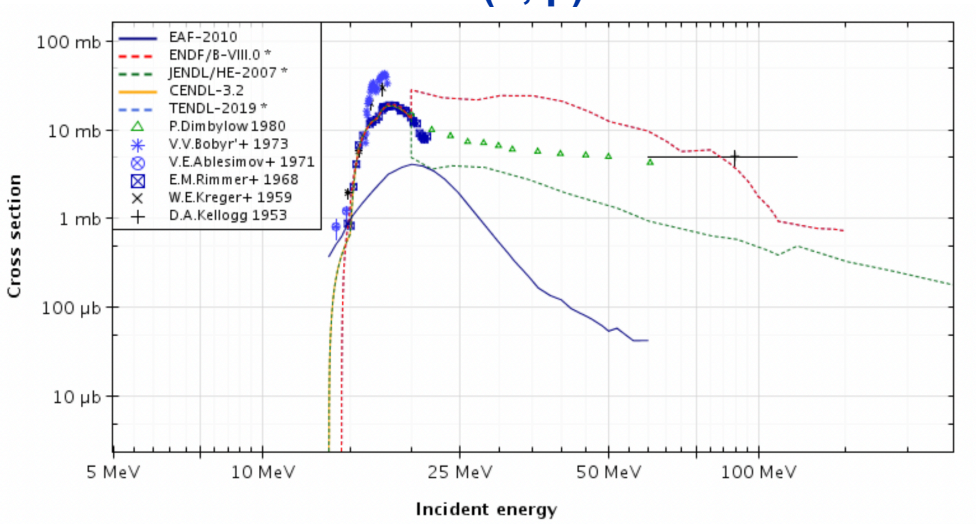
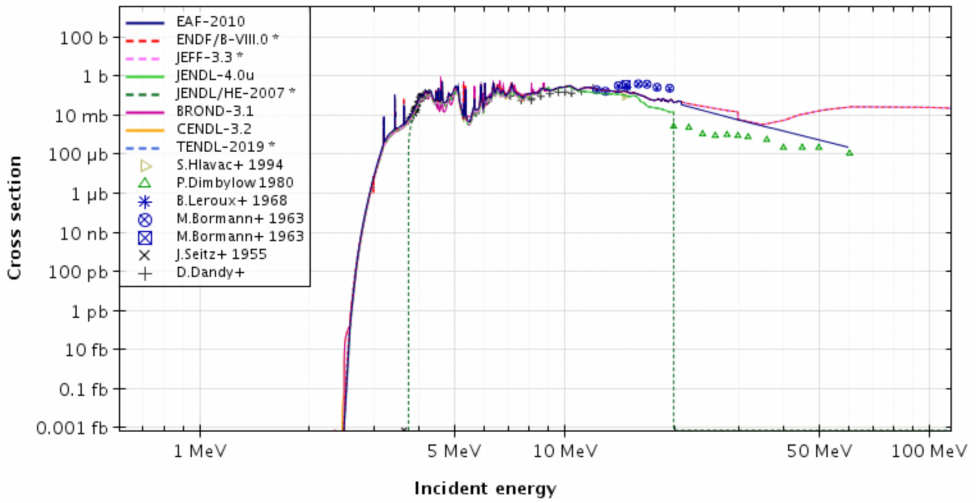
home.cern

^{12}C (n, p) ^{12}B



^{16}O (n, α) ^{13}C

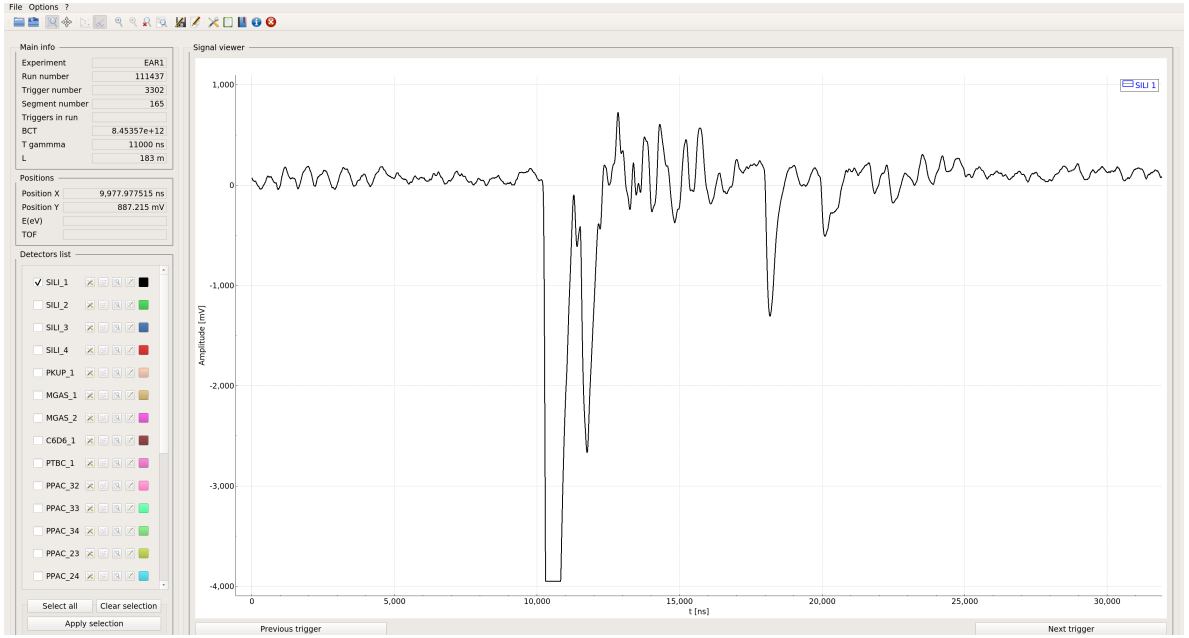


https://www.oecd-nea.org/jcms/pl_39910/janis

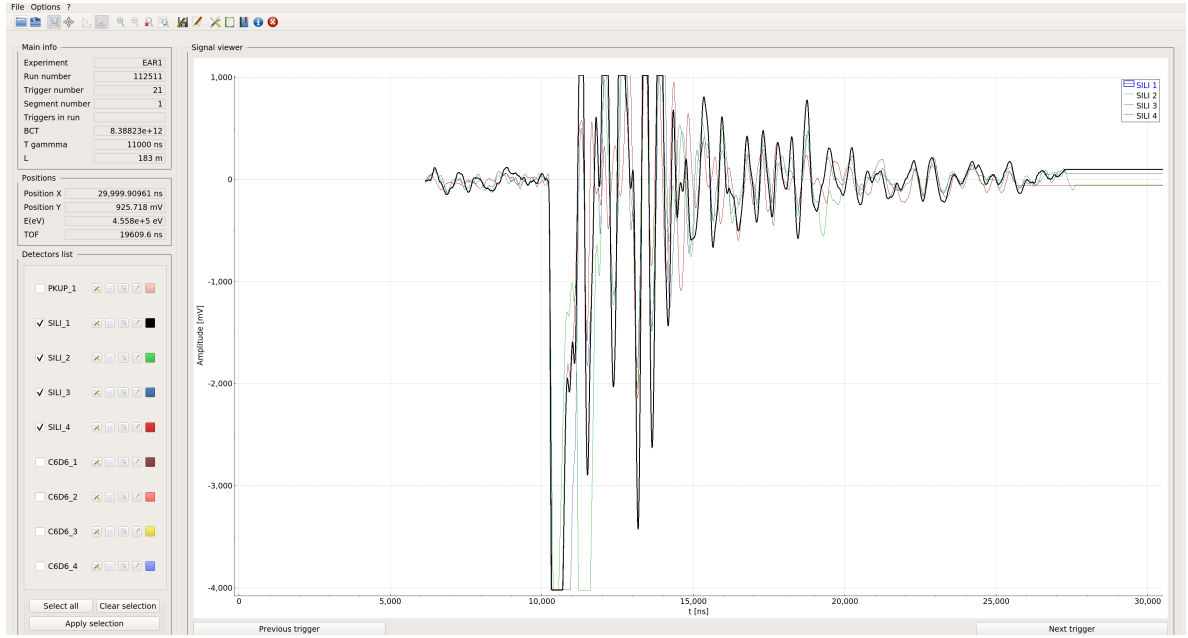
Extra Slides

High-frequency noise: Direct comparison

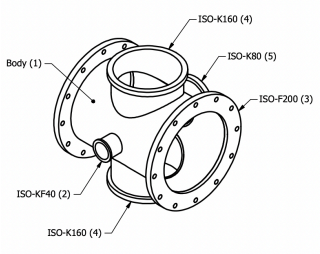
SiMon1 2021: Commisioning

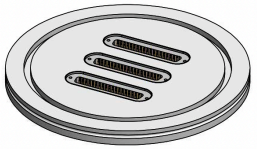


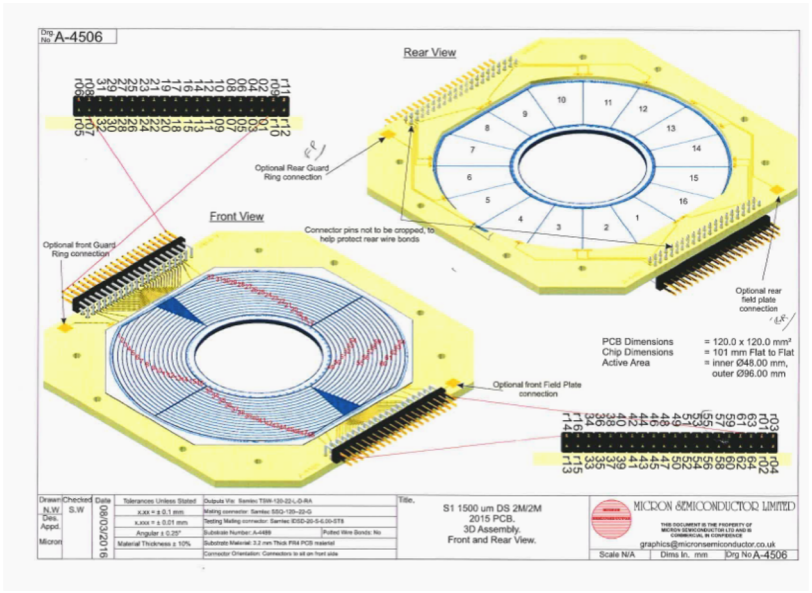
SiMon1 2022: ^{79}Se experiment



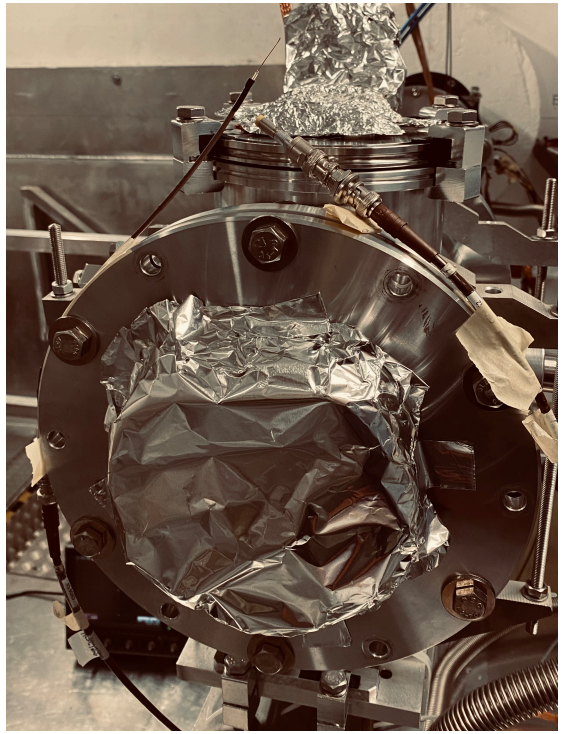
More Photos

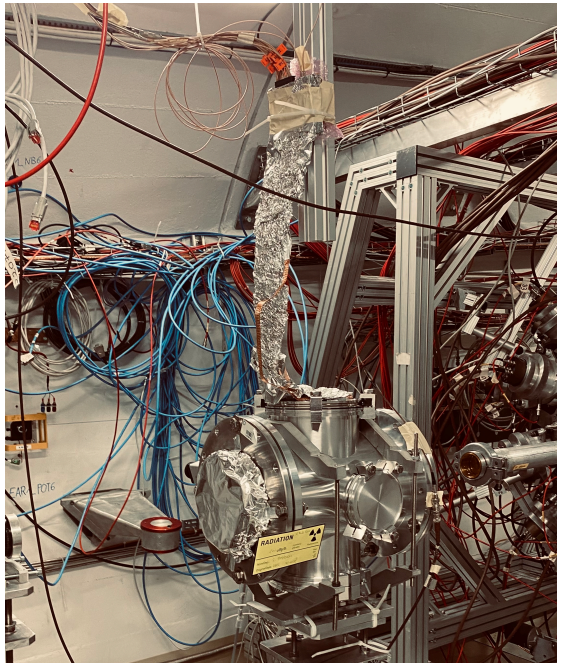

ISO-K160 (4)
Body (1)
ISO-K80 (5)
ISO-F200 (3)
ISO-KF40 (2)
ISO-K160 (4)

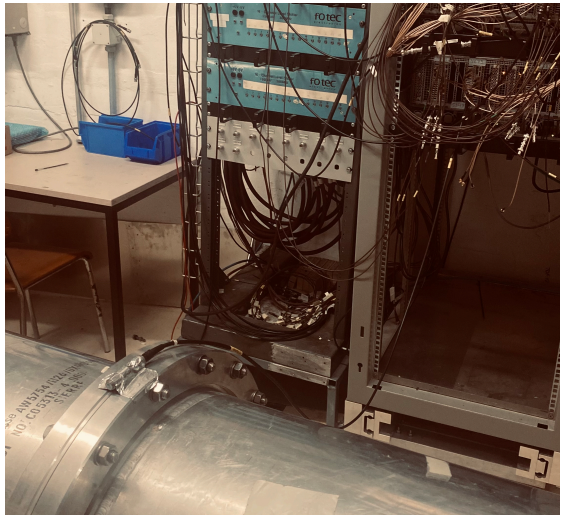



Drg No A-4506
Rear View
Optional Rear Guard Ring connection
Front View
Optional front Guard Ring connection
Connector pins not to be cropped, to help protect rear wire bonds
Optional rear field plate connection
Optional front Field Plate connection
PCB Dimensions = 120.0 x 120.0 mm²
Chip Dimensions = 101 mm Flat to Flat
Active Area = inner Ø48.00 mm, outer Ø96.00 mm
S1 1500 um DS 2M/2M
2015 PCB.
3D Assembly.
Front and Rear View.
MICRON SEMICONDUCTOR LIMITED
graphics@micronsemiconductor.co.uk
Scale N/A
Dims In. mm
Drg No A-4506

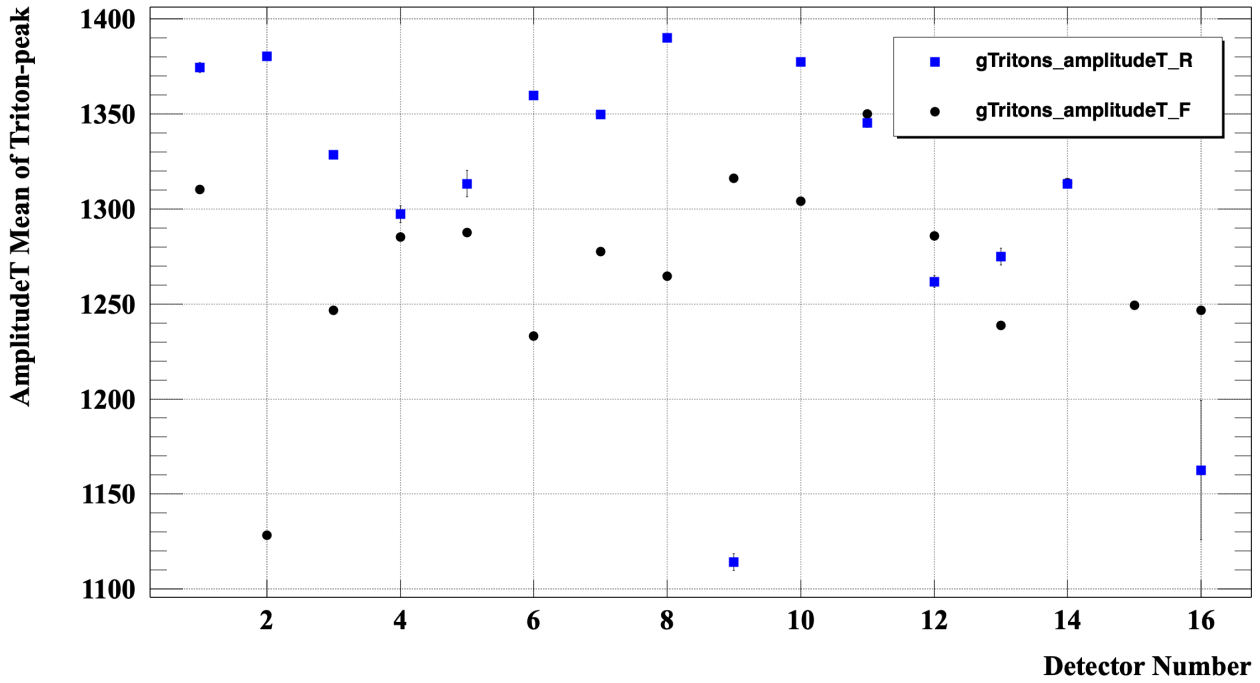

EG&G
ORTEC
710
QUAD BIAS SUPPLY
11.0
MASTER ON OFF
VOLTS
CURRENT
OVERLOAD RESET
VOLTAGE
RANGE




RADIATION


fotec
fotec

Gain-Difference: Front & Rear Side



Neutron Transmutation-Doping in Si (**NTD**)

- **Natural Si:**
  - ^{28}Si & ^{29}Si + n → stable Si-isotopes
  - ^{30}Si + n → ^{31}Si → (β^-) ^{31}P