Silicon diode as R2E detector

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With the special thanks to external facilities and R2E members' involved in the irradiation test campaigns.

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https://indico.cern.ch/event/971222/

Outline

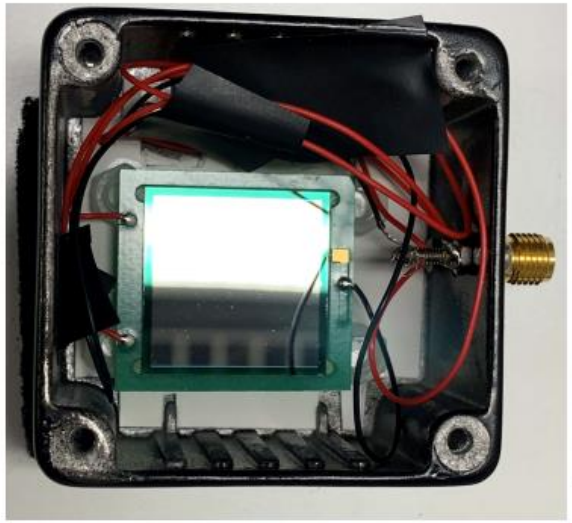
- Introduction:
  - presentation of the setup,
  - data processing,

- Examples of the diode applications:
  - energy deposition measurements,
  - flux monitor,
  - beam's contamination detection,
  - low-radiation areas monitoring,
  - (future) particle/reaction identification

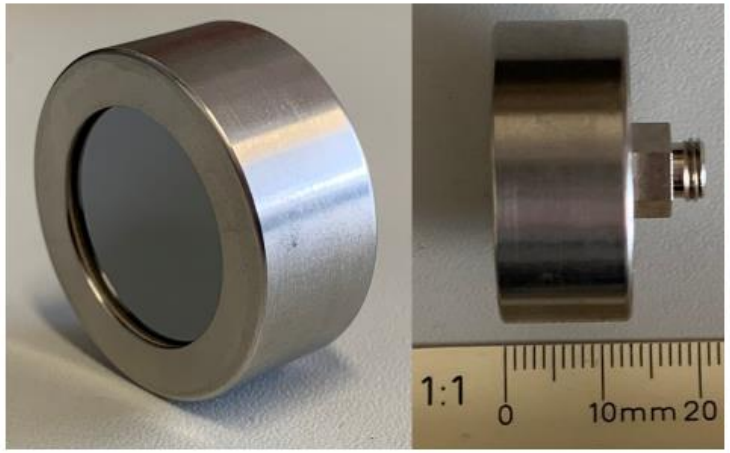
- Conclusions

Introduction: Si solid state detectors currently used in R2E

Thickness: 300 um
Active area: 4 cm^2

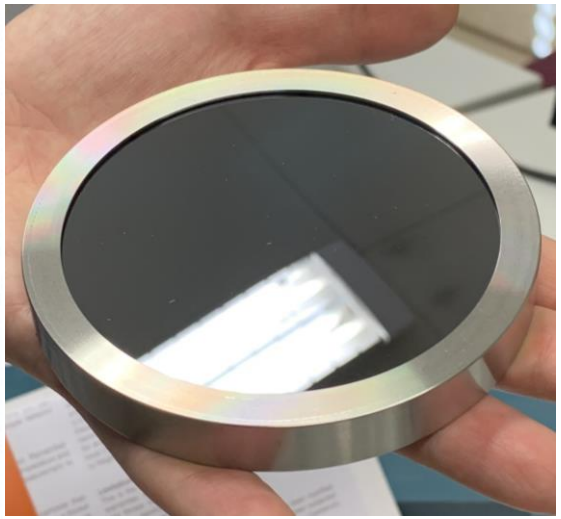


Thickness: 1004 um
Active area: 3 cm^2



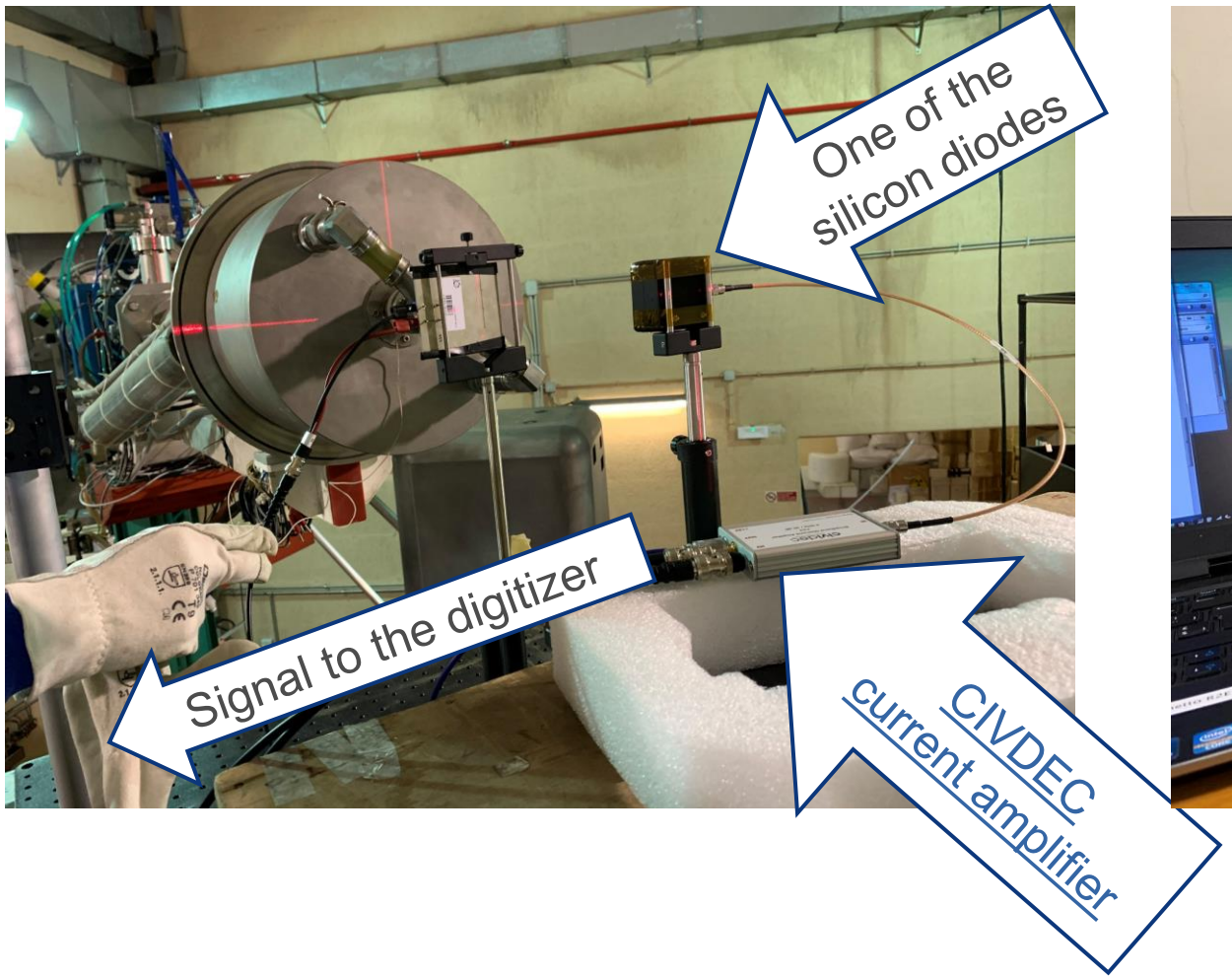
Thickness: 300 um
Active area: 0.5 cm^2

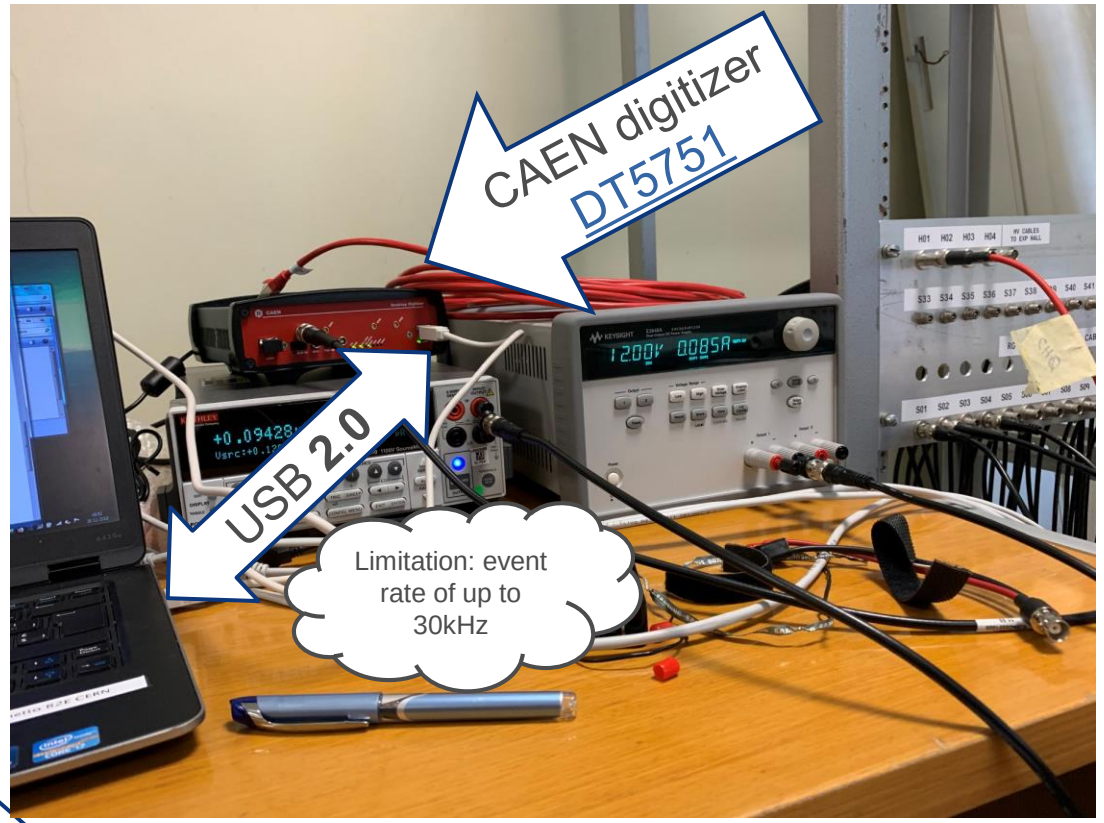
Thickness: 500 um
Active area: 50 cm^2



Introduction: typical diode setup

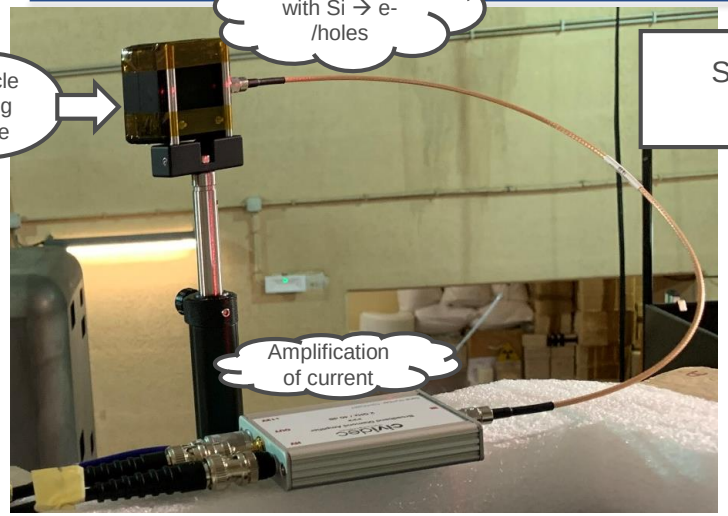
ENEA-FNG
(Frascati, IT)



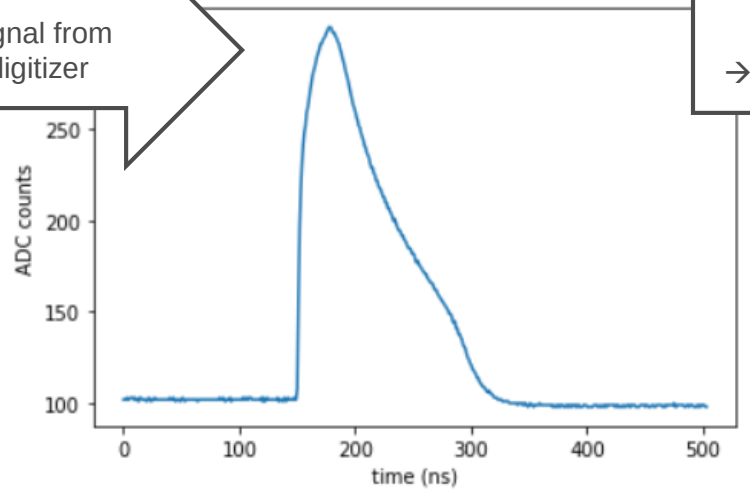


Setup inspired through the ESA and STFC collaborations

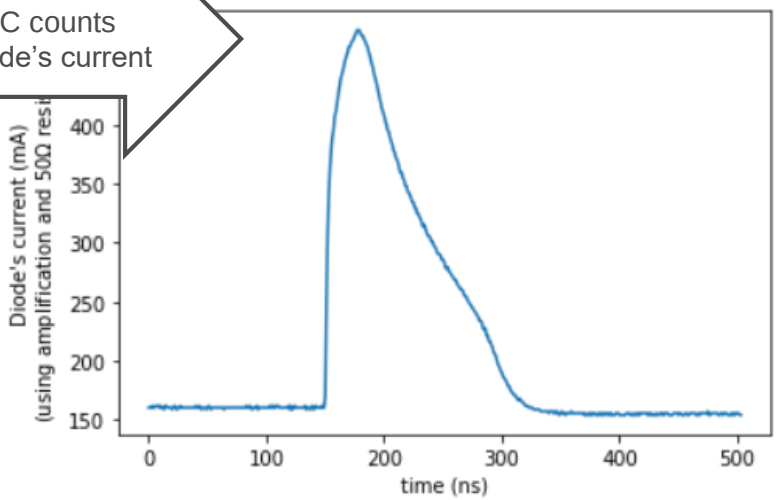
Introduction: scheme of the data processing



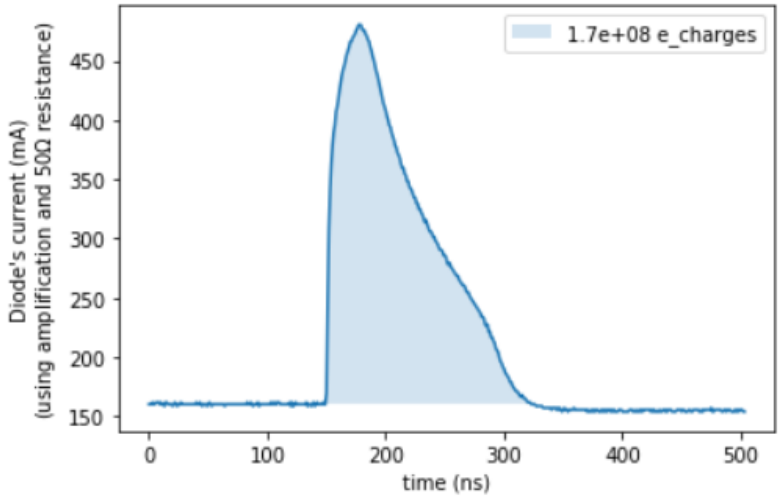
Signal from digitizer



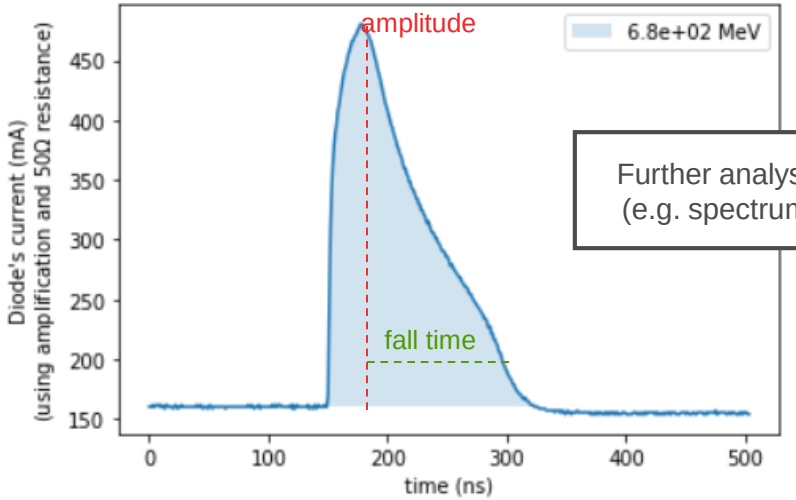
ADC counts → diode's current



diode's current → integration → charges



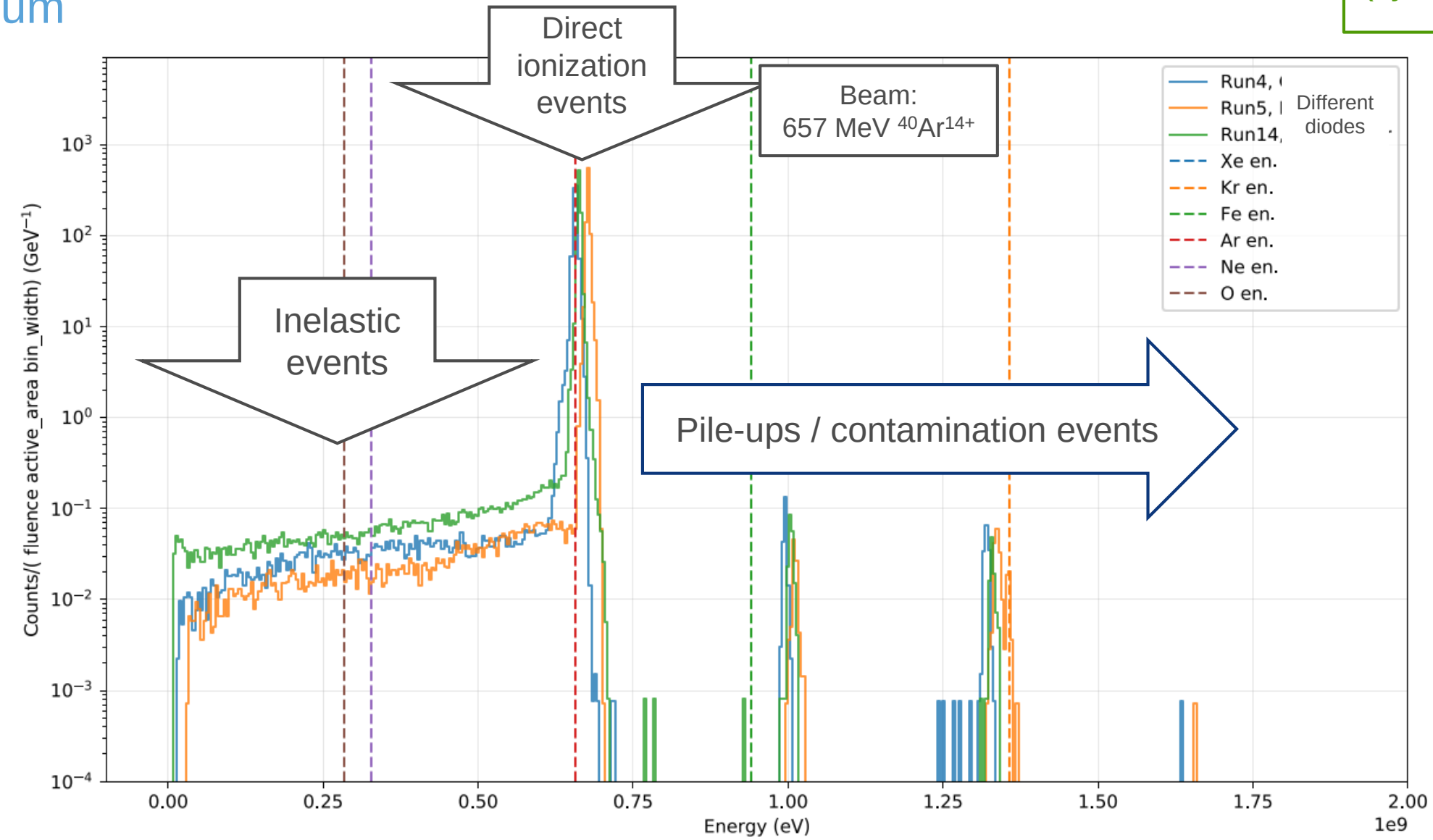
Charges → energy



Further analysis (e.g. spectrum)

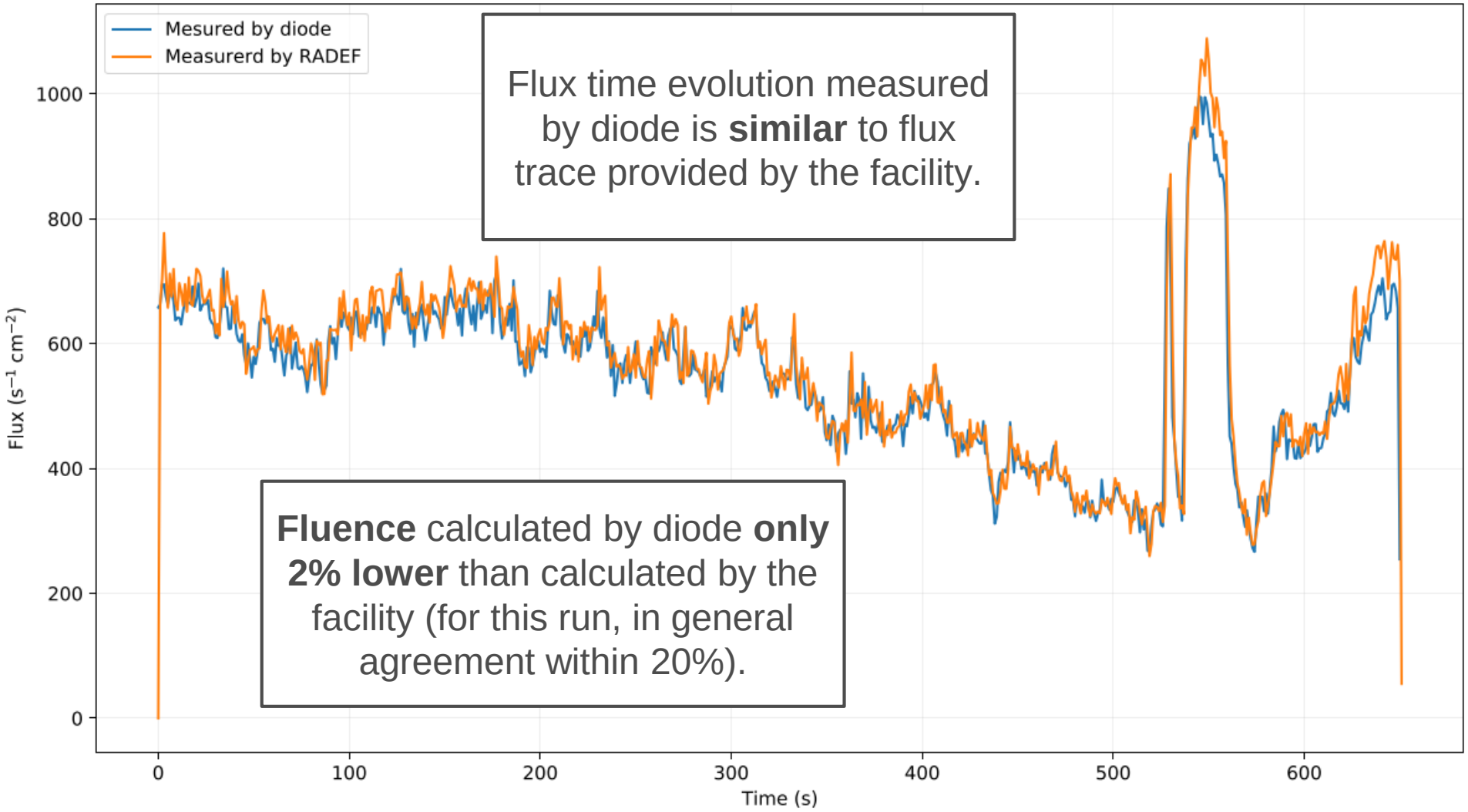
Example of diode application: determination of (Si-deposited) energy spectrum

RADEF
(Jyväskylä, FIN)



Example of diode application: flux monitor (for charged particles)

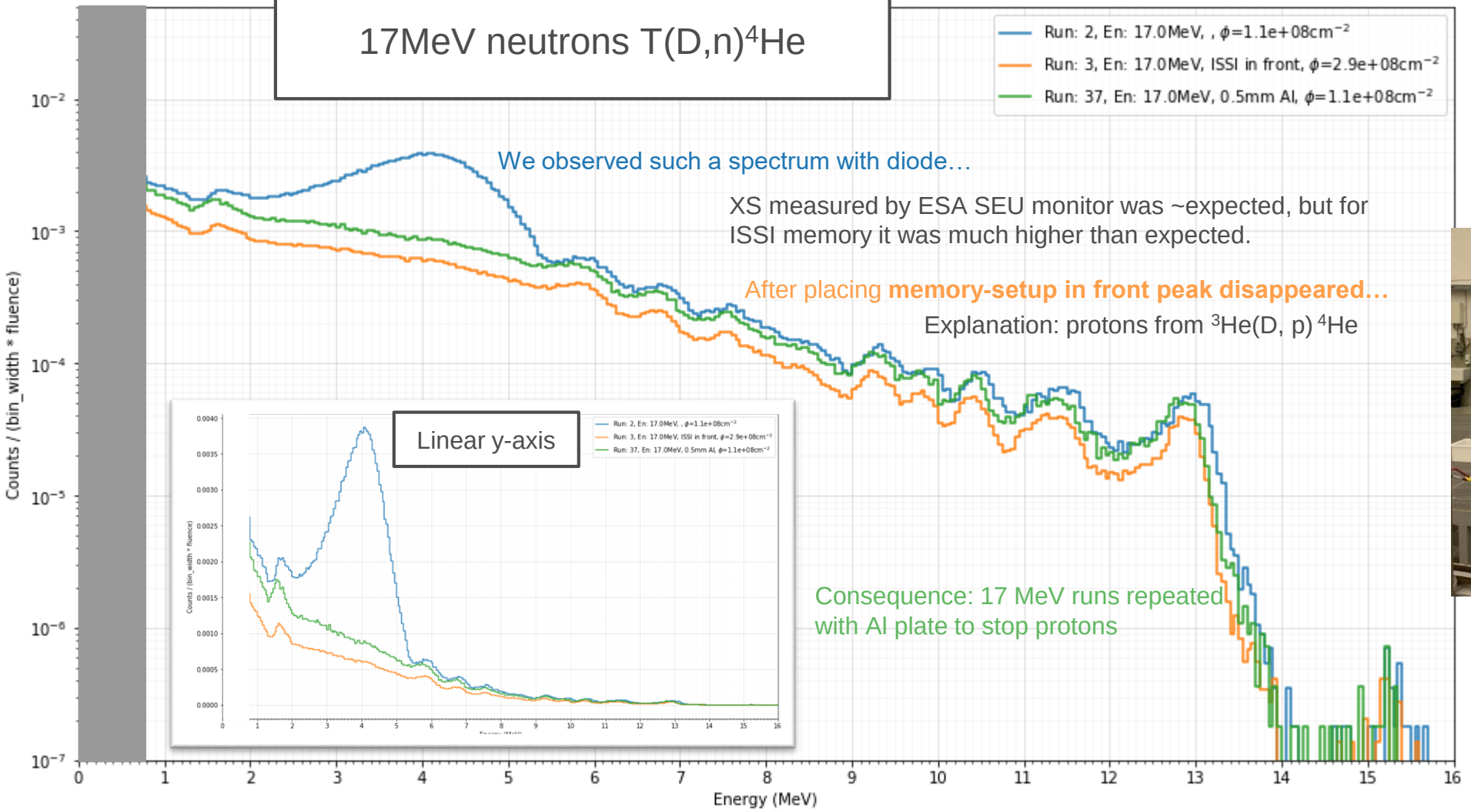
RADEF
(Jyväskylä, FIN)



Example of diode application: contamination detection (1)

PTB
(Braunschweig, DE)

17MeV neutrons T(D,n)^{4}He



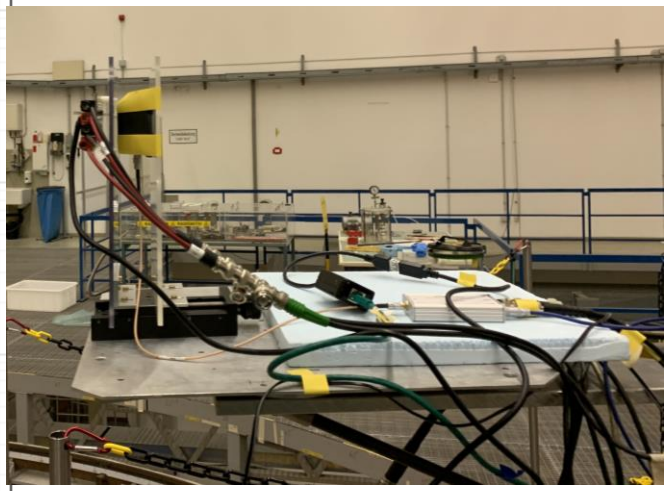
We observed such a spectrum with diode…

XS measured by ESA SEU monitor was ~expected, but for ISSI memory it was much higher than expected.

After placing **memory-setup in front peak disappeared…**

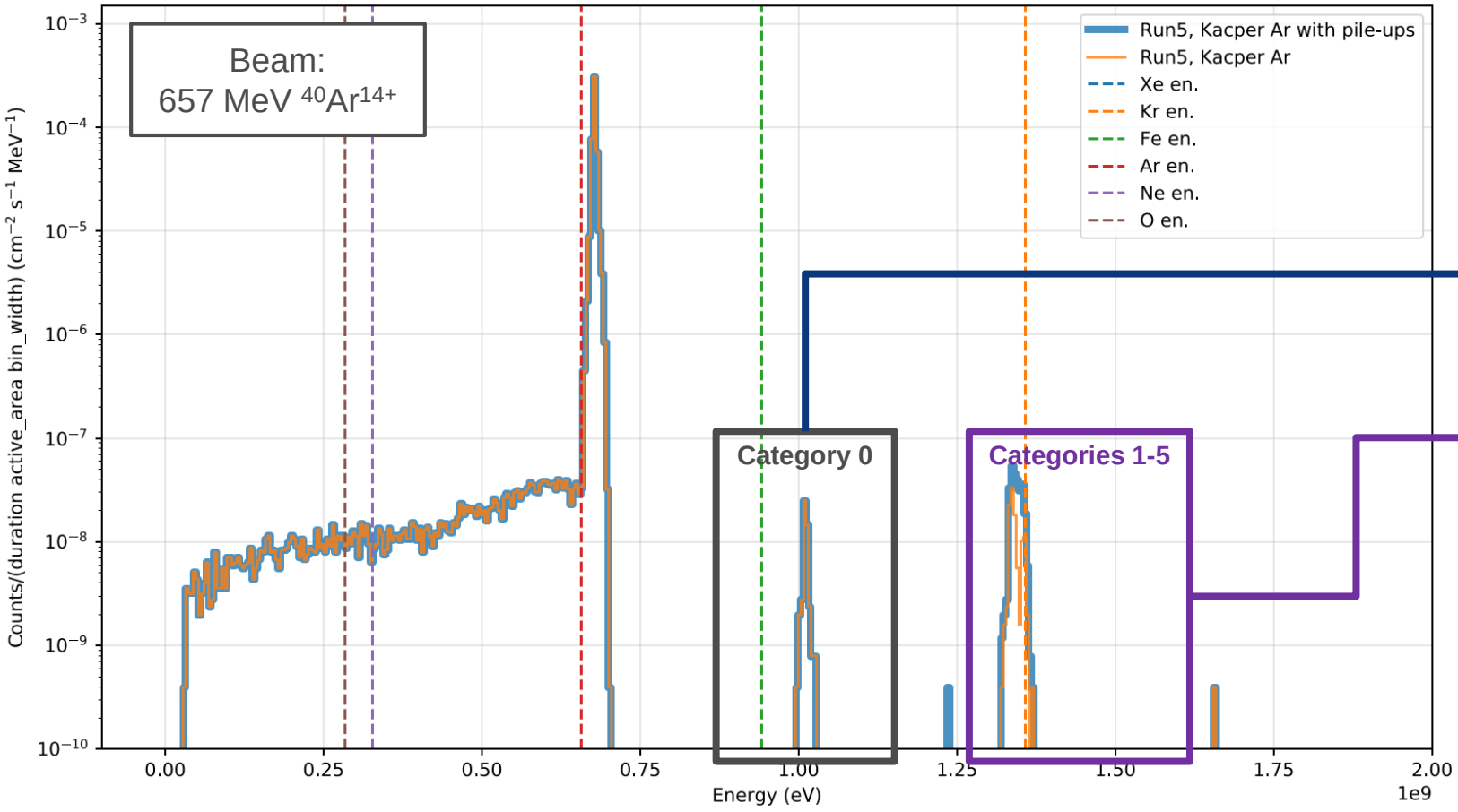
Explanation: protons from ^{3}He(D, p) ^{4}He

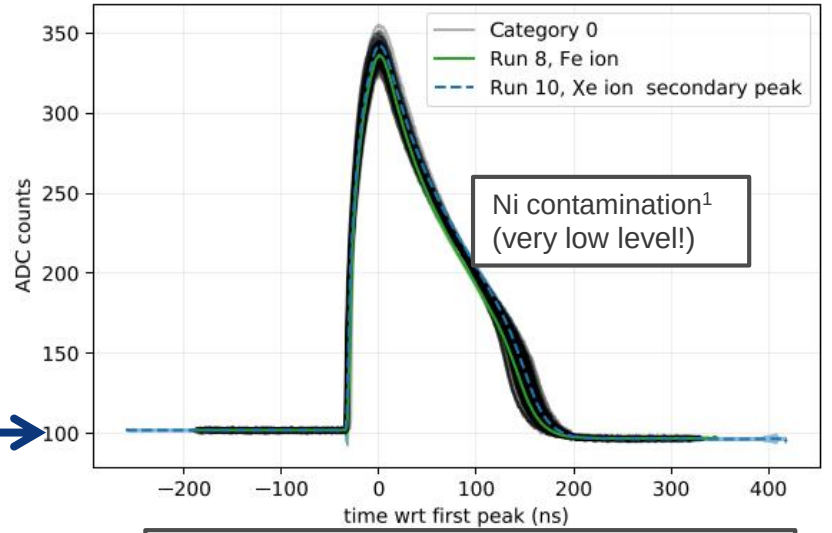
Consequence: 17 MeV runs repeated with Al plate to stop protons



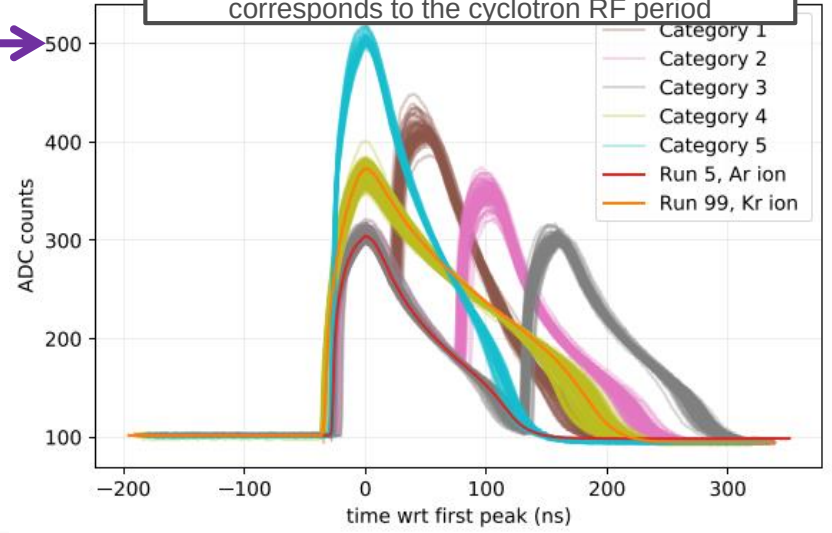
Example of diode application: pile-up/contamination discrimination (2)

RADEF
(Jyväskylä, FIN)





the time difference between the peaks of ~50ns corresponds to the cyclotron RF period

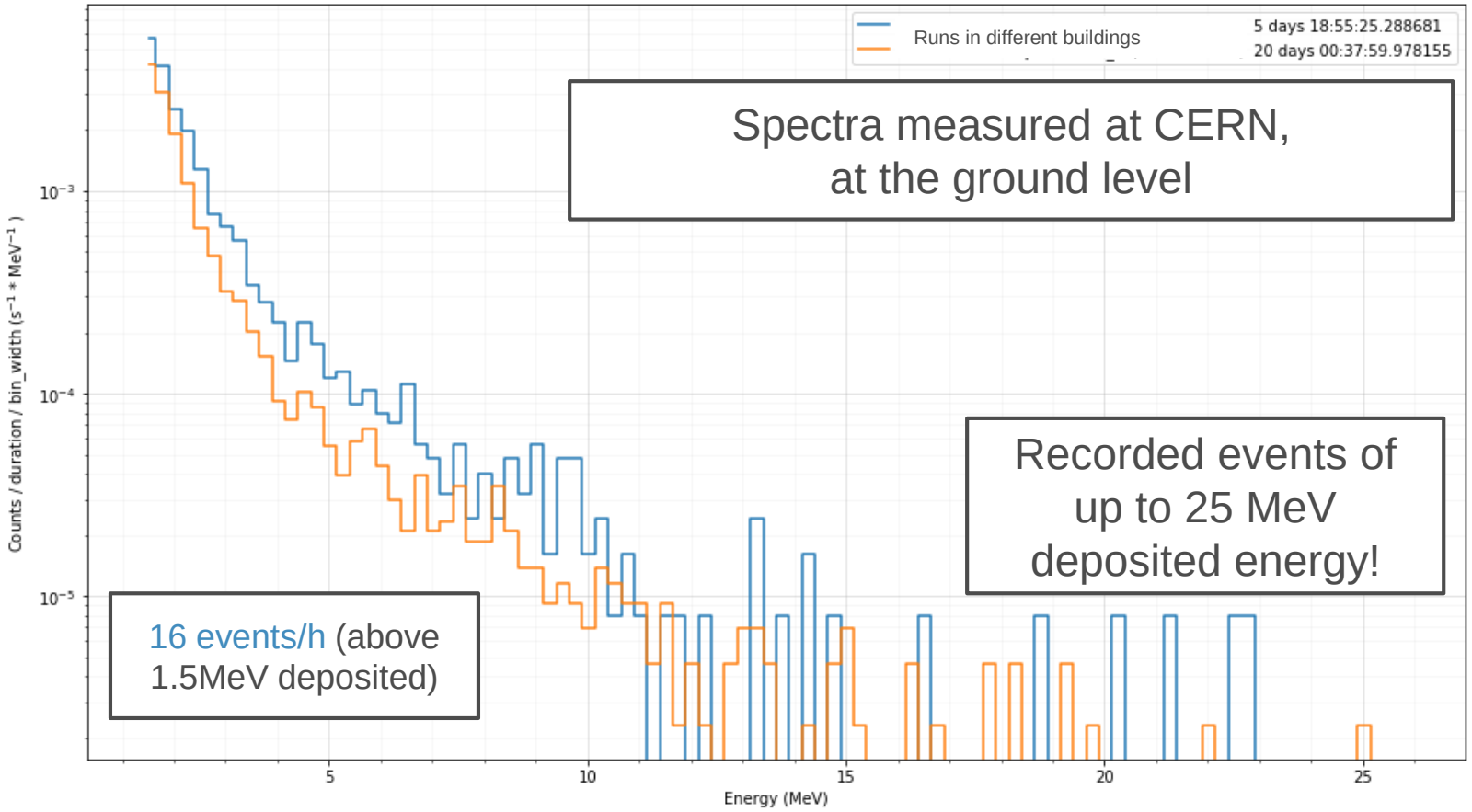


[1]Information provided by the facility after we have observed it

Example of the diode application: low–radiation areas

Ground level
(CERN, CH/FR)

- Large silicon volume:
  - Higher sensitivity → monitoring of low-radiation areas with critical equipment:
    - shielded alcoves
    - LHC arcs
- Applications in the mixed-filed radiation are under the investigation.



Example of the diode application: pulse shape discrimination

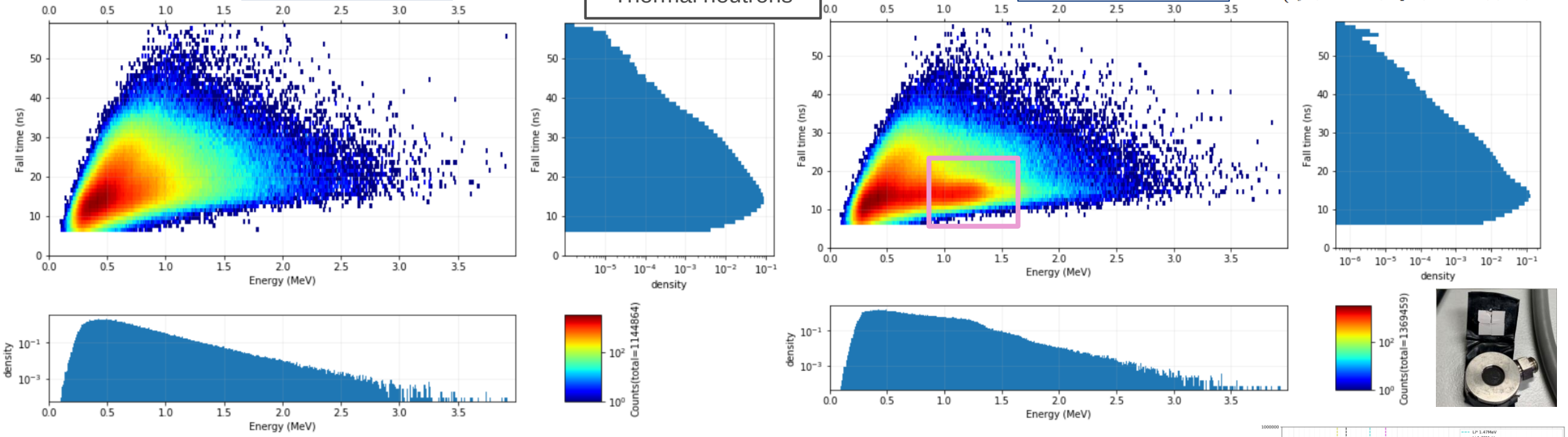
D50
(Grenoble, FR)

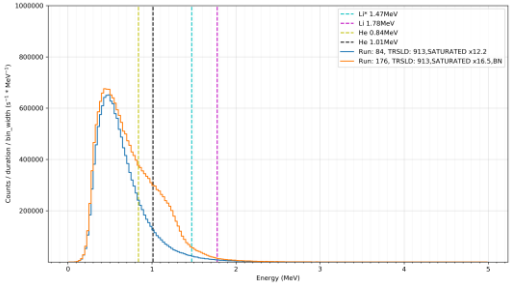
Without BN

Beam:
Thermal neutrons

With BN

$$^{1}_{0}n + {}^{10}_{5}B \rightarrow \begin{cases} {}^{7}_{3}Li^{*}(1.4721\ MeV) + {}^{4}_{2}He(0.8398\ MeV)\ (93.7\%) \\ {}^{7}_{3}Li(1.7762\ MeV) + {}^{4}_{2}He(1.0133\ MeV)\ (6.3\%) \end{cases}$$





Future goal: particle/reaction identification based on the pulse shape

Outlook & Conclusions

- During several test campaigns, especially in PTB and RADEF (contaminations had been detected), diode setup demonstrated its capabilities in terms of **beam quality control and beam diagnostics** → became an **essential tool for all future R2E irradiation campaigns,**

- Applications to mixed-field radiation are being investigated:
  - Potentially to be **embedded in next generation of RadMon**:
    - Not only counts, but the energy deposition distribution,
    - High sensitivity due to large volume → especially useful in low radiation areas (e.g. LHC arcs, shielded alcoves),

- **Benchmark** of event-by-event energy deposition distribution with **Monte Carlo codes**,

- **Future goal:** identification particle/reaction, through both:
  - Pulse shape analysis,
  - Use of the combination of different diodes / shielings and MC codes,

Thank you for
your attention!

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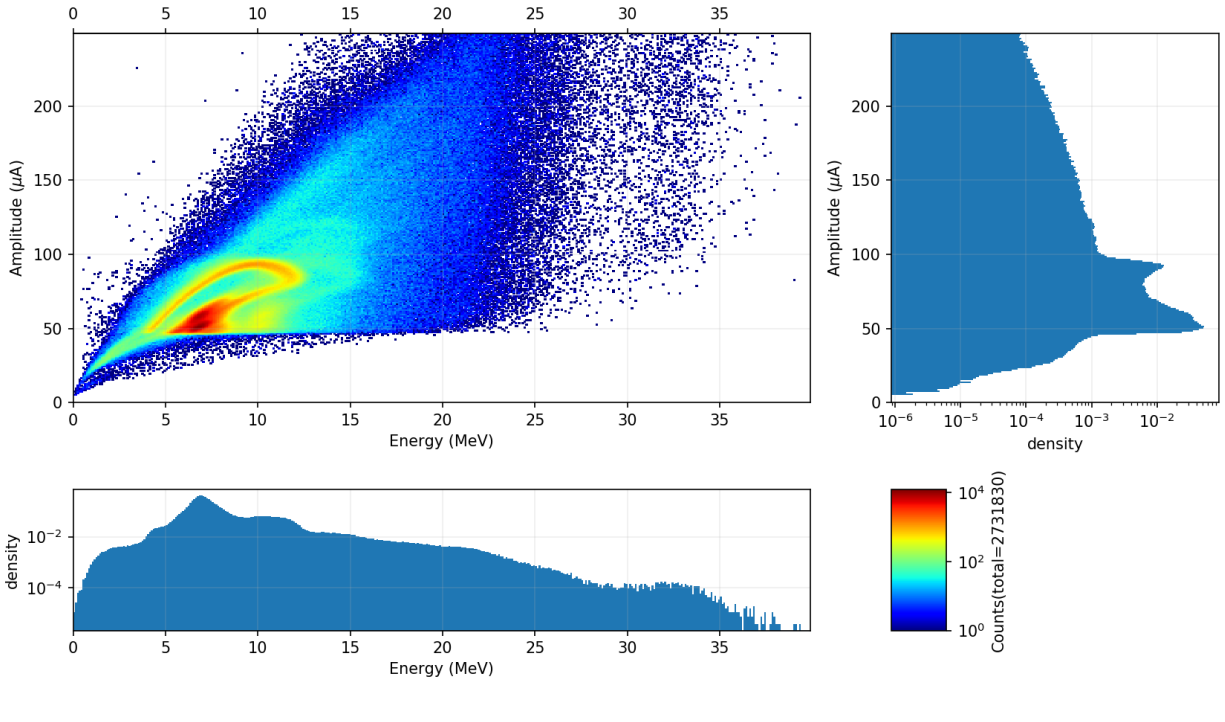
Example of the diode application: pulse shape discrimination

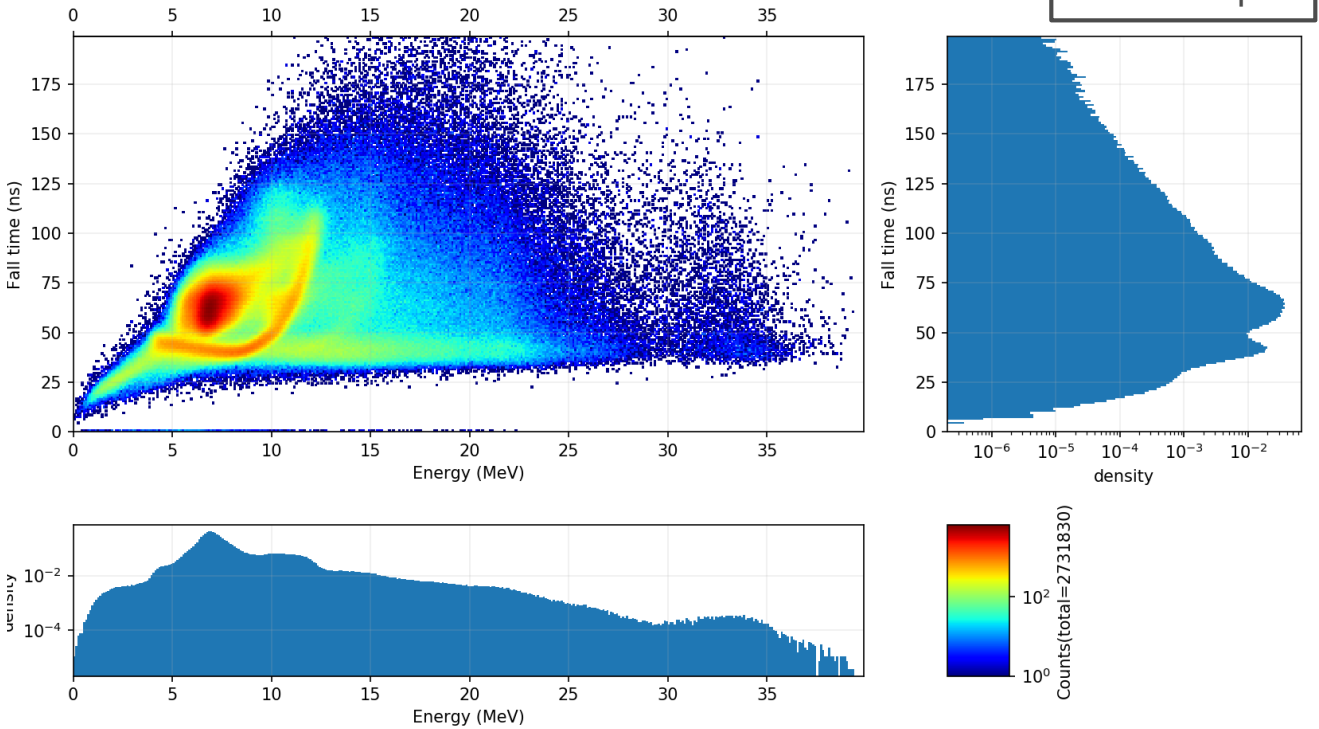
PSI
(Villigen, CH)

Beam:
30MeV p

Amplitude vs energy



Fall time vs energy



Future goal: particle/reaction identification based on the pulse shape

Example of the diode application: pulse shape discrimination

RADEF
(Jyväskylä, FIN)

Beam:
1358 MeV $^{83}Kr^{29+}$