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European Network for radiation-detection based Research and Innovation addressing increasing societal CHallenges (ENRICH)

ENRICH

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IFIN-HH / ELI-NP

Electronics and Data Acquisition for Research and Education

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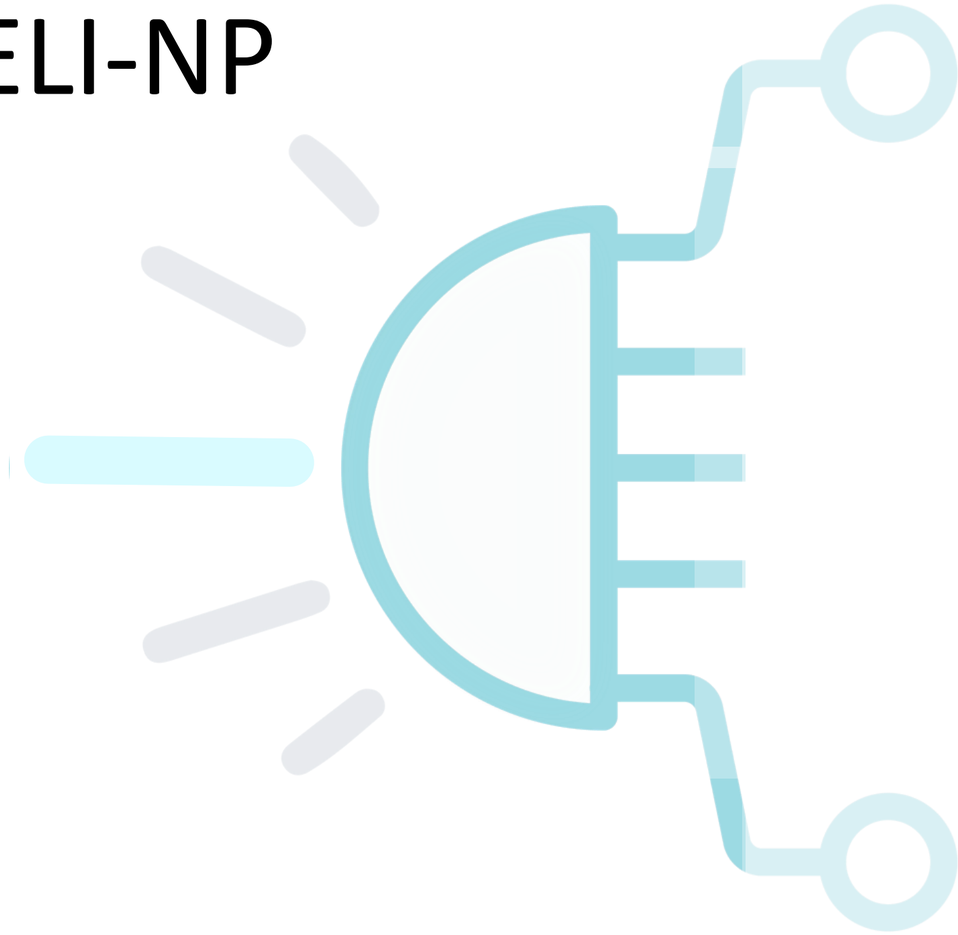
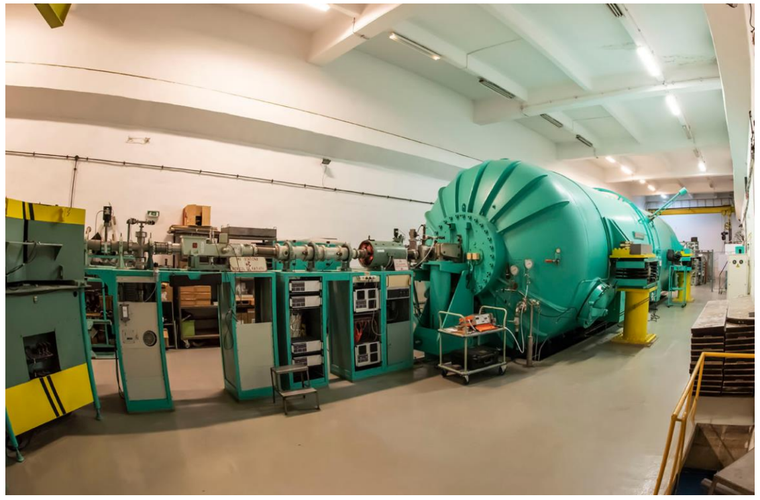
Overview

- Our institute: IFIN-HH and ELI-NP
- Instrumentation for
  - Nuclear physics
  - Laser nuclear physics
  - Education
- Conclusions

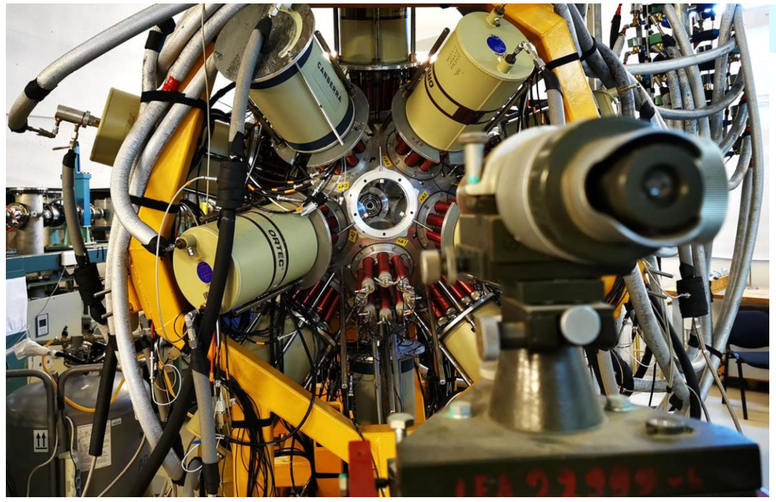


Our institute: IFIN-HH and ELI-NP

- Horia Hulubei National Institute for R&D in Physics and Nuclear Engineering (IFIN-HH)
  - Several accelerators and instrumentation, open to users
  - Main goals:
    - Fundamental nuclear physics and applications
    - Reference expertise in nuclear physics
    - Scientific education
  - https://www.nipne.ro



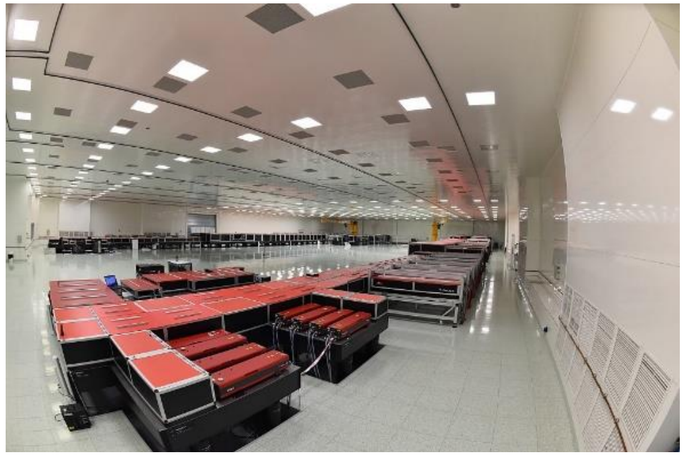
9 MV Tandem accelerator



ROSPHERE array

Our institute: IFIN-HH and ELI-NP

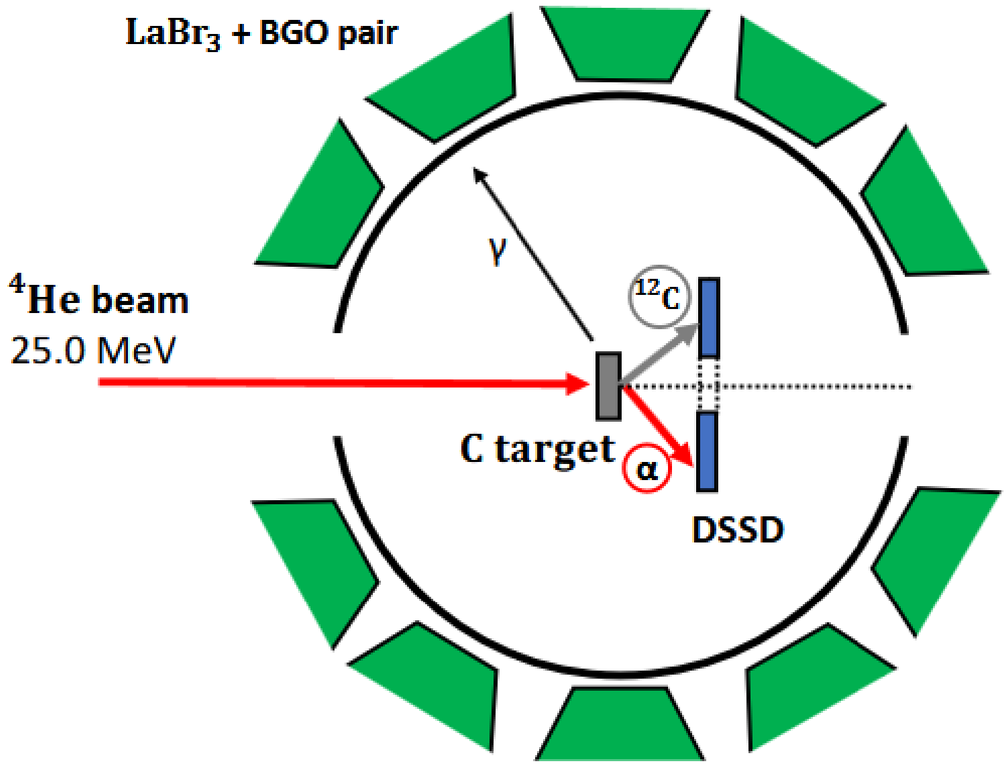
- Extreme Light Infrastructure – Nuclear Physics, Project implemented by IFIN-HH
  - 2x 10 PW lasers, femtosecond pulses, open to users
  - Tunable γ ray beam being implemented
  - Dedicated detectors and spectroscopy lab
  - Main goals:
    - Fundamental nuclear physics and applications
    - Laser-driven particle acceleration
  - https://www.eli-np.ro



2x 10 PW Lasers

Detectors and spectroscopy lab

Instrumentation for nuclear physics



- **Goal**: γ decay probability of the Hoyle state (excited state of ^{12}C) is important to understand nucleosynthesis of carbon
- **Experiment**: α particle hits and excites ^{12}C.

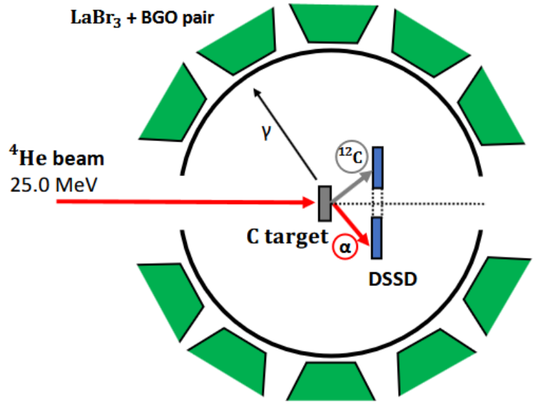
Measure:

- recoil α particle (for excitation energy)
- recoil ^{12}C
- emitted γ ray

This gives a very clean signal

- **Instrumentation**: Pulse-shape discrimination between ^{12}C and α which both hit silicon detector
- **Challenge**: Increasing beam current saturates DAQ

Instrumentation for nuclear physics

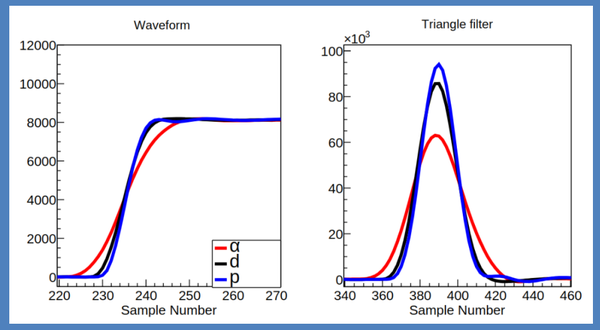


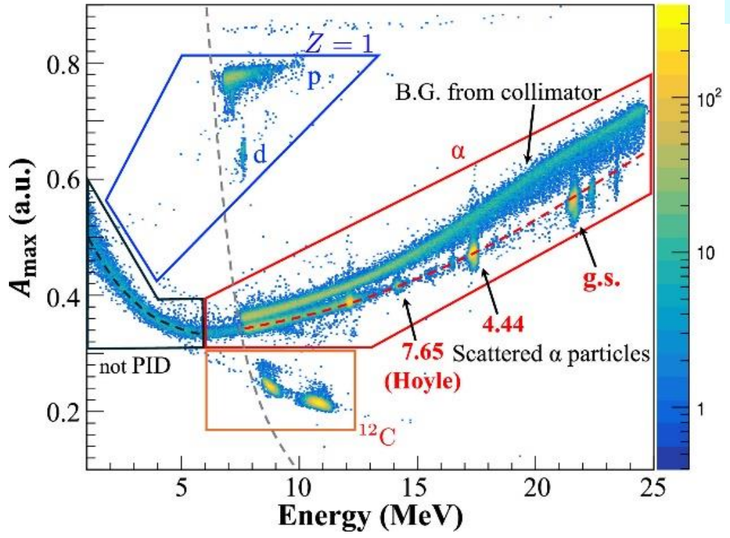
O(100) channels

CAEN V1730 digitizers + custom triggering

O(100) MB/s

Off-line pulse-shape analysis



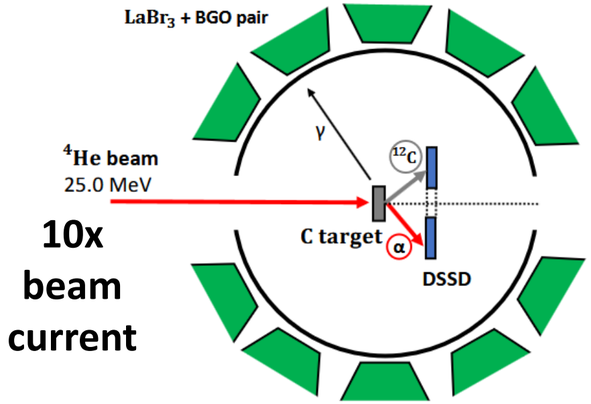


CAEN V1730

Previous experiment

https://doi.org/10.1016/j.physletb.2025.139893

Instrumentation for nuclear physics

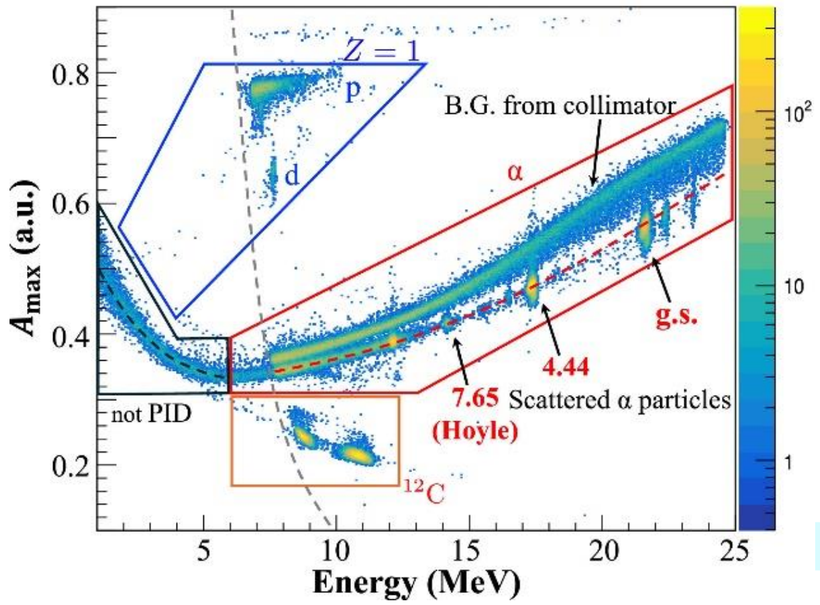


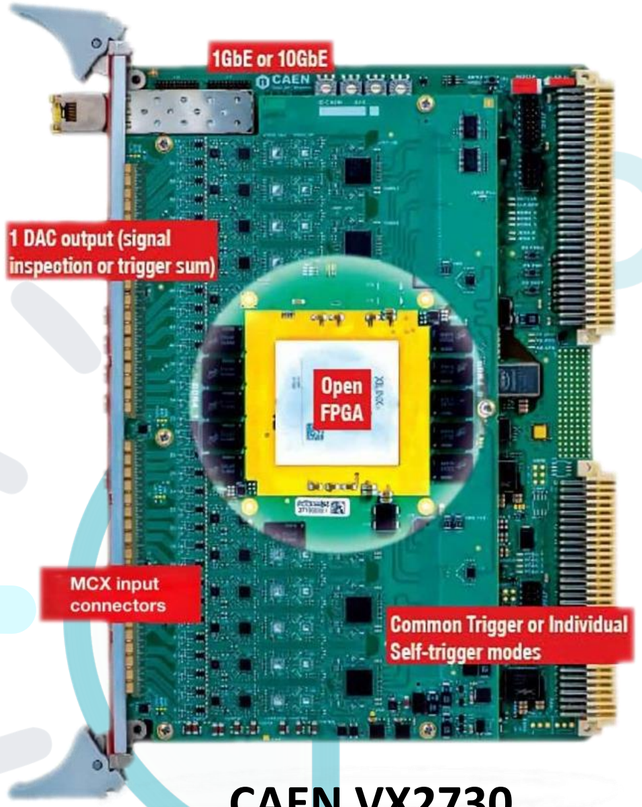
10x beam current

O(100) channels

CAEN VX2730 digitizers, Pulse-shape analysis in FPGA

O(10) MB/s



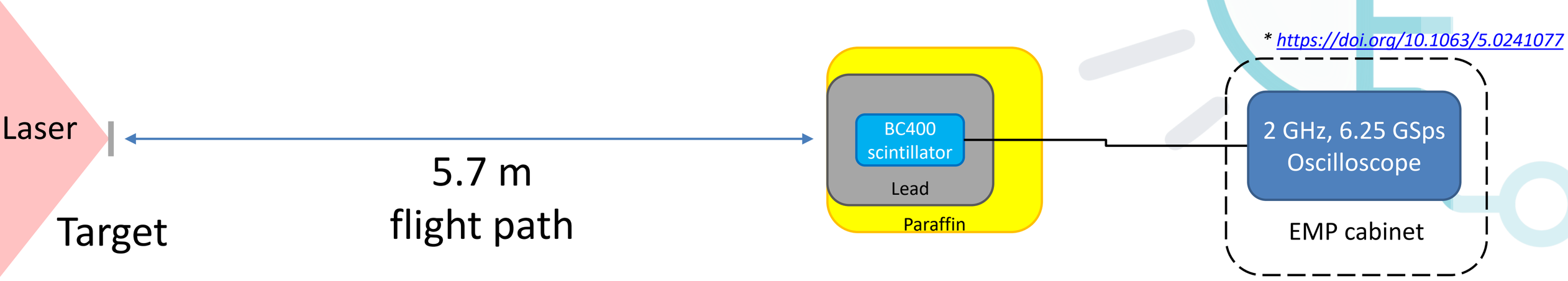


CAEN VX2730

Planned future experiment,
https://www.scientificbulletin.upb.ro/static/pdfs/full0e1_897365.pdf

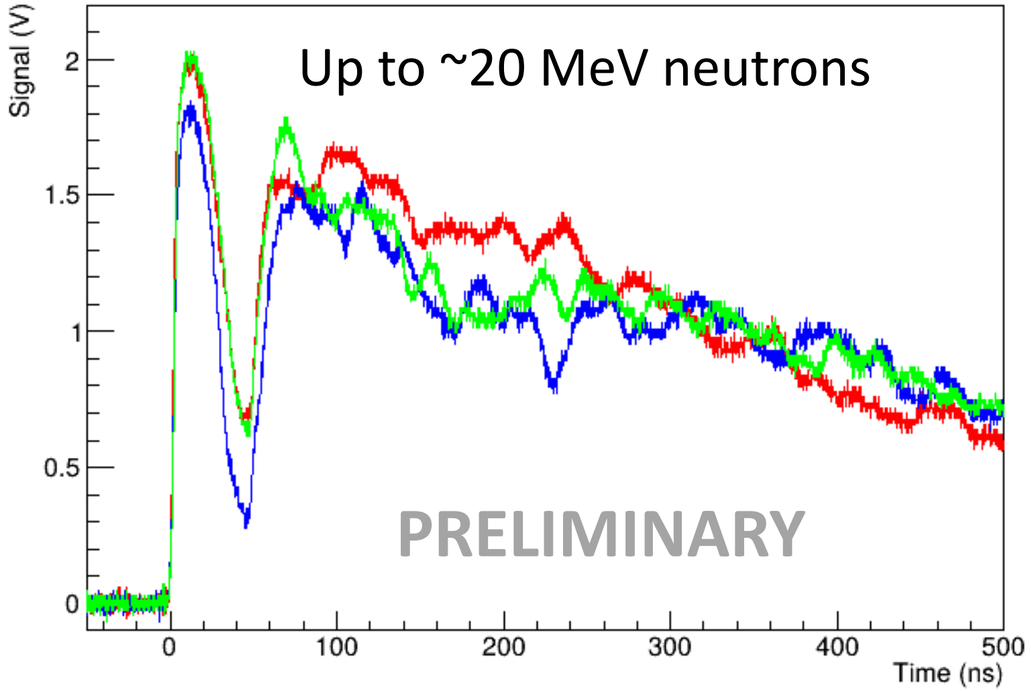
Instrumentation for laser nuclear physics

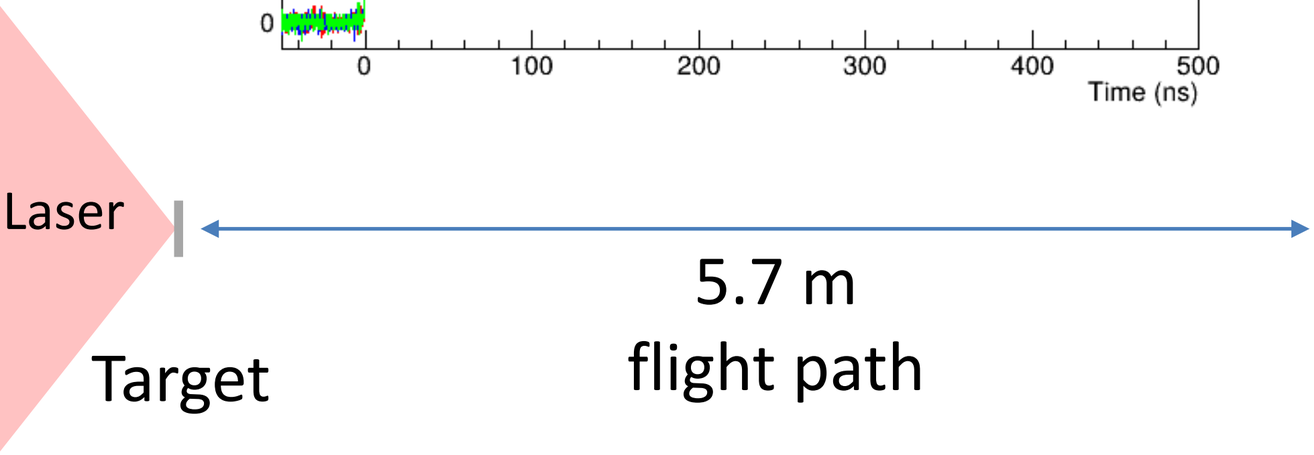
- **Goal**: Accelerate protons O(100 MeV), measure accompanying particles too
- **Experiment**: 10 PW laser focused on solid target
- **Instrumentation**: Fast neutron diagnostics - plastic scintillator shielded against γ rays and scattered neutrons
- **Challenge**: γ flash, can only study collective effects. EMP is not as big of a problem as we expected*

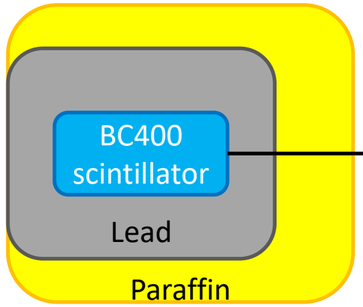


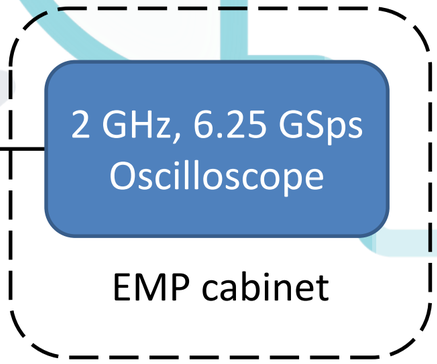
* https://doi.org/10.1063/5.0241077

Instrumentation for laser nuclear physics

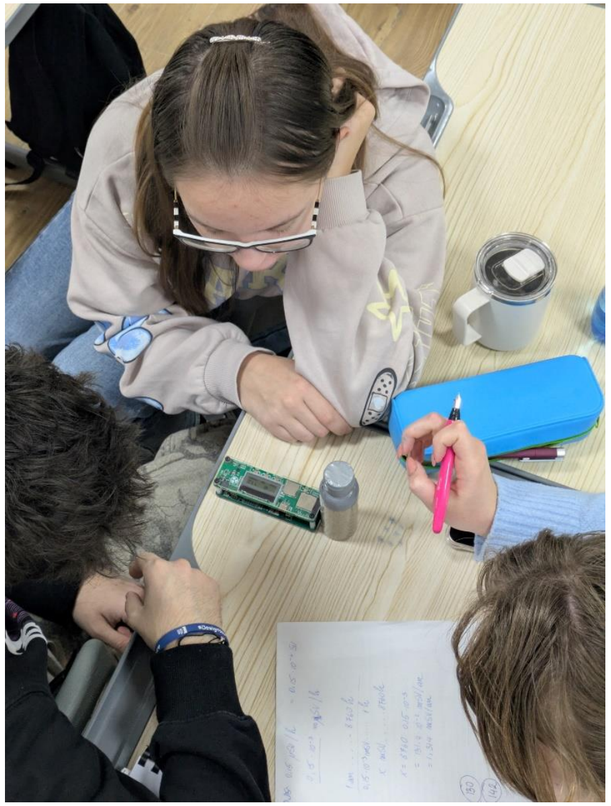


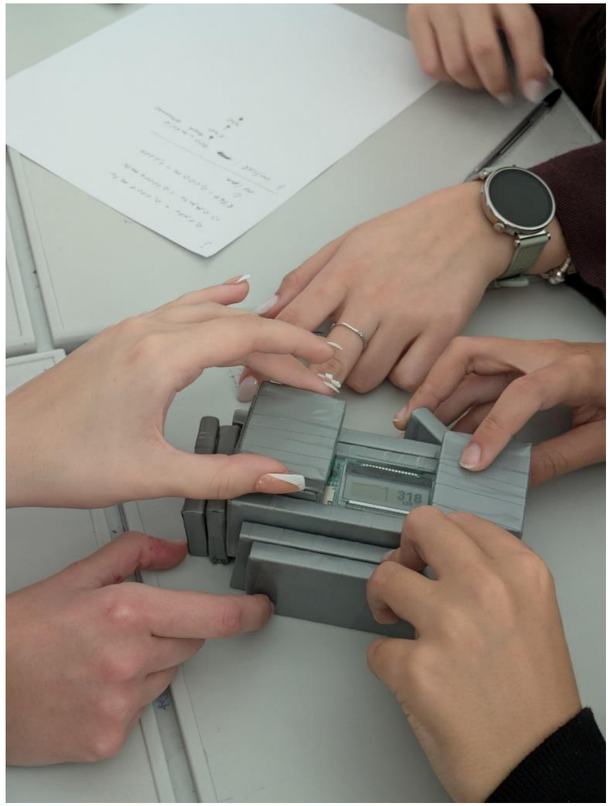






Instrumentation for education



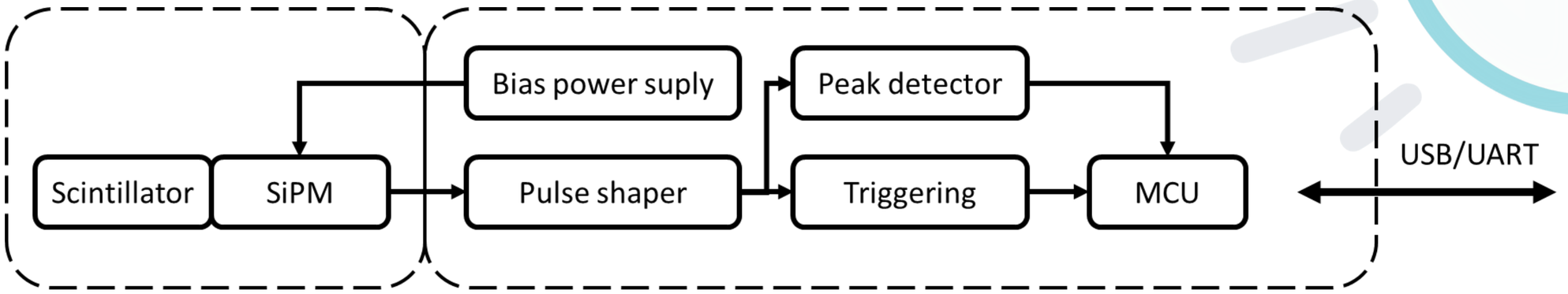


- **Goal**: Obtain more students and job applicants
- **Experiment**: Go to high-schools and see if they're interested
- **Instrumentation**: Open-source radiation detectors
- **Challenge**: Balancing scientific rigor with intuitive understanding

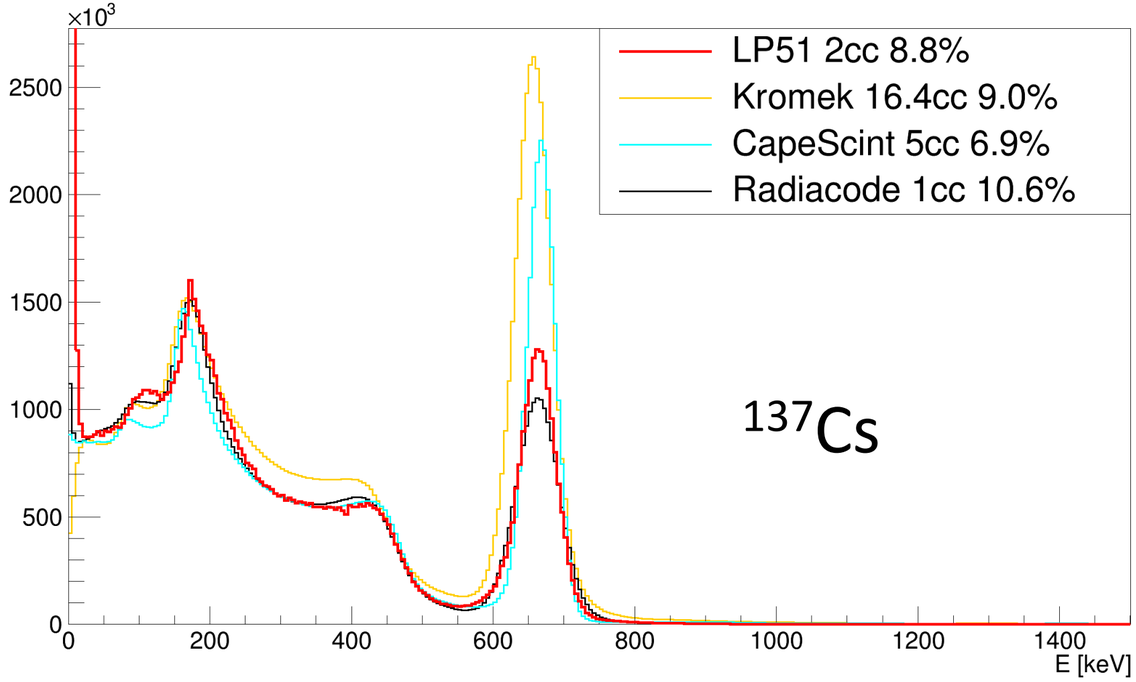
https://ifa-mg.ro/proiecte/rise/
https://github.com/mihaicuciuc/pomelo

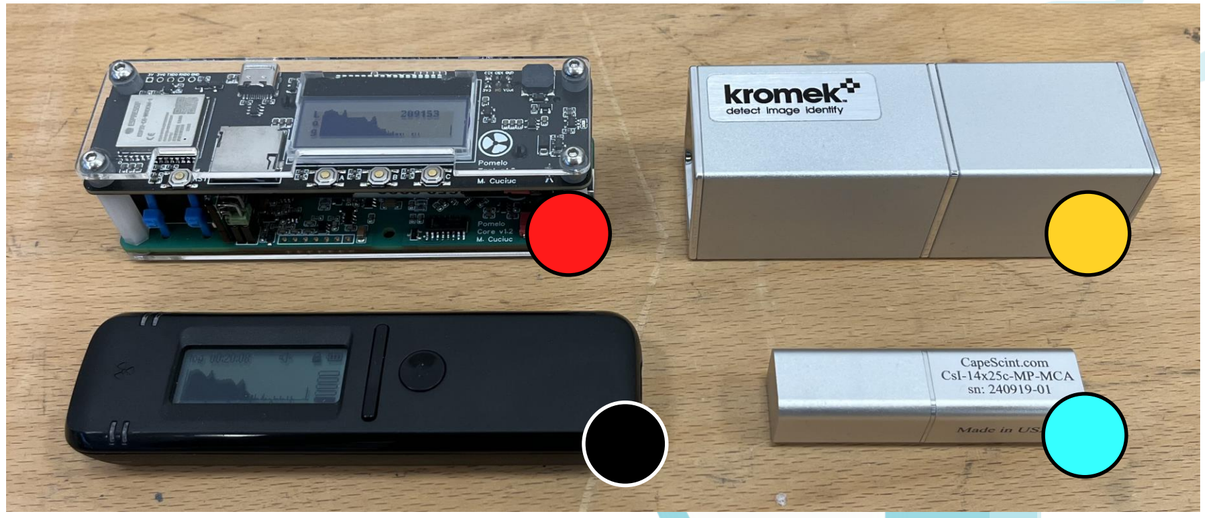
Instrumentation for education

- Developed an end-to-end gamma spectrometer focusing on low power consumption
  - 2cc CsI(Tl) scintillator
  - SiPM readout + custom bias supply
  - Temperature compensation
  - Analog front-end + digital readout (USB)
  - ~5mA while measuring background



Instrumentation for education





Compared against commercial products

Conclusions

- We have a lot of inputs
  - Research in classical/novel accelerators
  - New developments in high-performance electronics
  - Specialized components become main-stream
  - Incrasing demand of specialized radiation detection from other fields
- We are expected to set directions
  - Higher performance/lower noise electronics
  - New detector developments
  - Advanced algorithms

- I think we can optimize our impact
  - Can old technologies help with new challenges? (e.g. passive dosimeters for ultrashort pulses)
  - What can be done today that was prohibitively expensive yesterday?

Acknowledgements

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