EUROPEAN UNION

Project co-financed by the European Regional Development Fund through the Competitiveness Operational Programme
"Investing in Sustainable Development"

Extreme Light Infrastructure-Nuclear Physics
(ELI-NP) - Phase II

MACRO Tools for Real-time Analysis of Laser-driven Experiments at ELI-NP

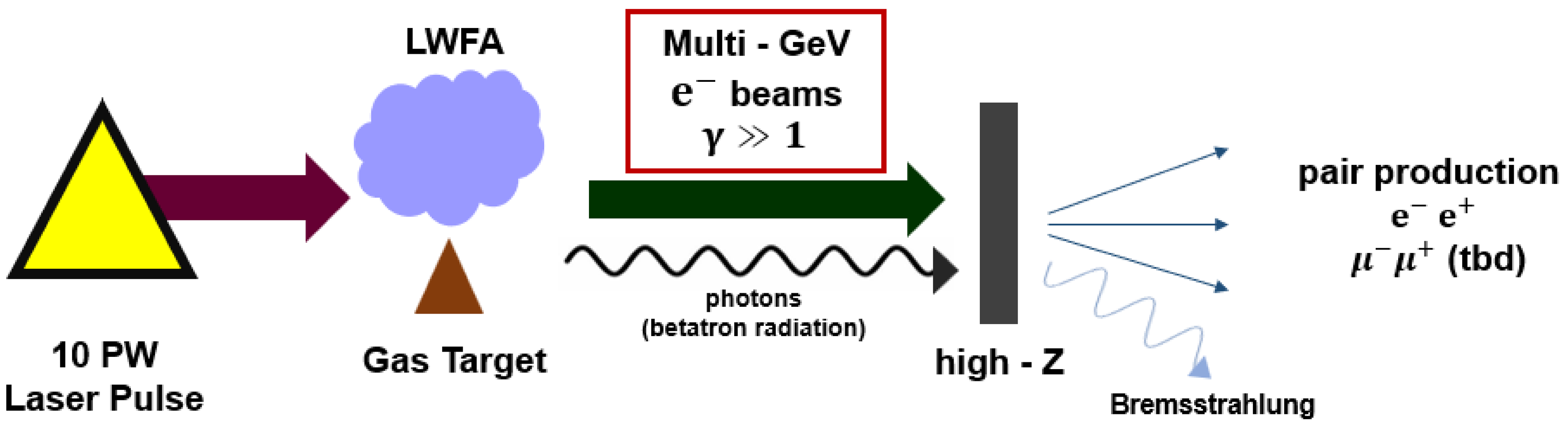
D. Catana[1, 2], P. Ghenuche[2], D. Doria[2]

[1] ELI-NP, "Horia Hulubei" National Institute for Physics and Nuclear Engineering, 30 Reactorului Street, RO-077125 Bucharest-Magurele, Romania
[2] Faculty of Physics, University of Bucharest, Atomistilor 405, RO- 077125 Magurele, Romania;
Presenting author: diana.catana@eli-np.ro

Abstract

Swift macro-tools can be helpful when real-time analysis is key, such as fast image recording and processing, for instance, when studying multi-parametric phenomena such as in LWFA. Such an approach is central to quickly optimizing physical outputs via fast diagnostics, especially during tight beamtime schedules. In LWFA investigations, where high repetition rate shots can be carried out, fast processing can help achieve desirable results such as high-quality laser-plasma interaction, suitable plasma parameters, and stable quasi-monoenergetic electron beams with high cut-off energy. During the commissioning activities of the ELI-NP 10 PW experimental area, we have developed and begun applying such real-time analysis tools. In this work, we will present some of our experimental results and illustrate the codes employed during the experimental runs and corresponding outputs. Currently, ELI-NP is also working on developing machine learning tools and AI algorithms to be provided to the Users during the experimental campaigns.

Schematic Description of the Experiment and Expected Outcomes

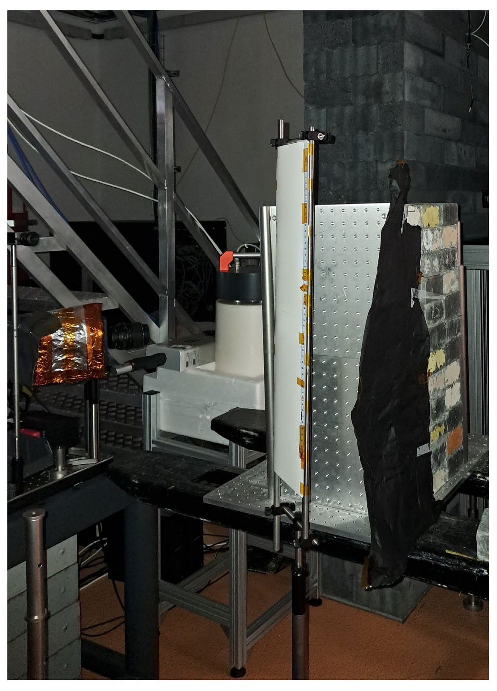


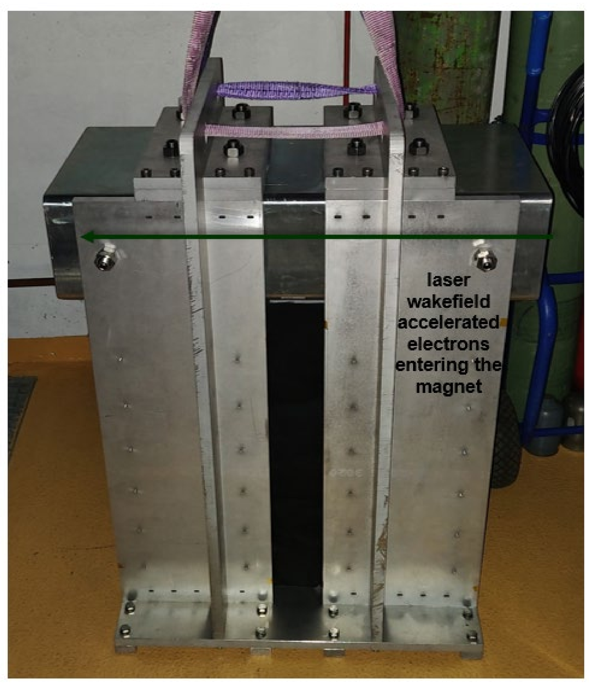
Outline

- Presenting MACRO tools for running fast diagnostics (for live online visualization)
- Output: image processing, electron energy spectra, total charge computation upon experimental calibrations
- Codes for electron energy estimation during continuous data acquisition (high-repetition rate shots)

Experimental Set-Up

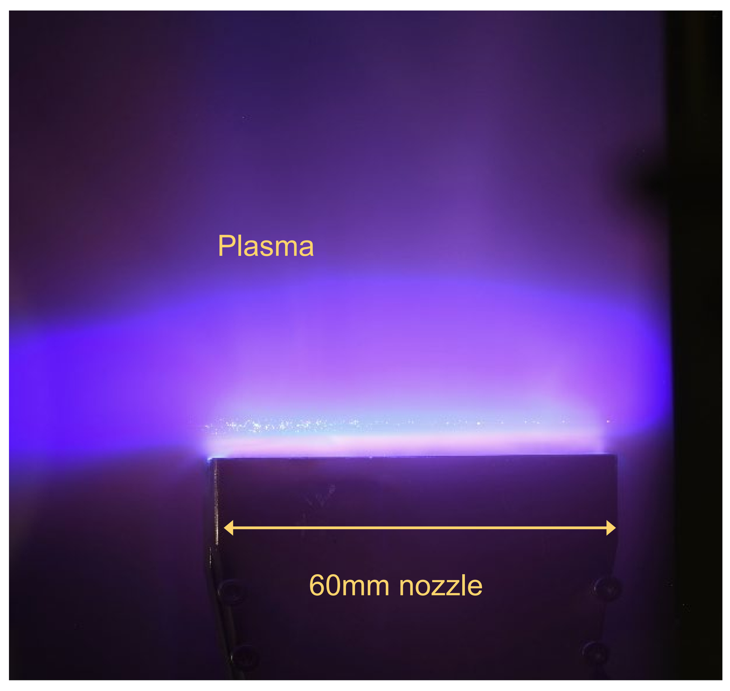

Setup inside the Interaction Chamber


Lanex Screen and beam dump



Lateral view of the magnet

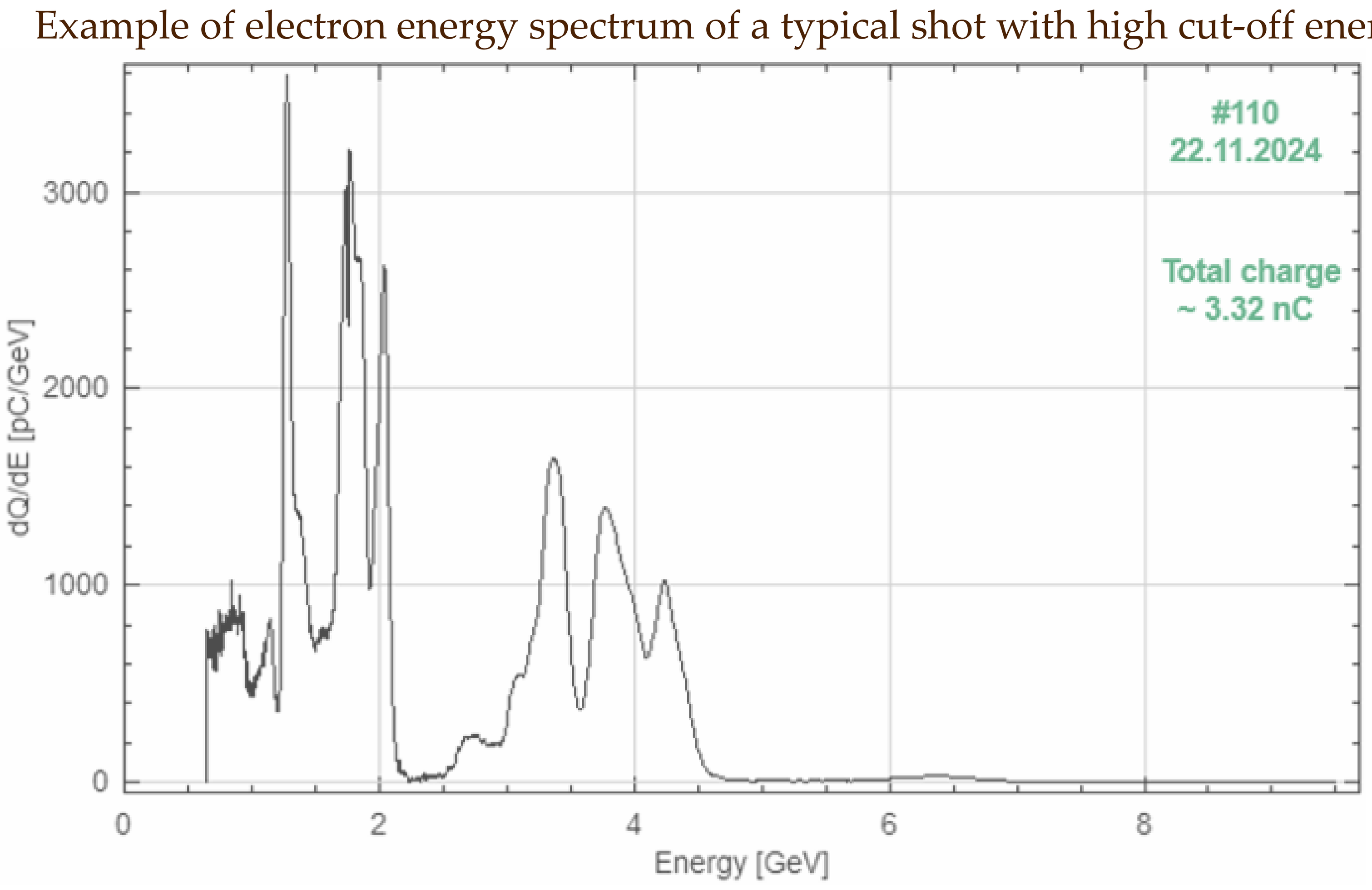

On-axis view of the magnet



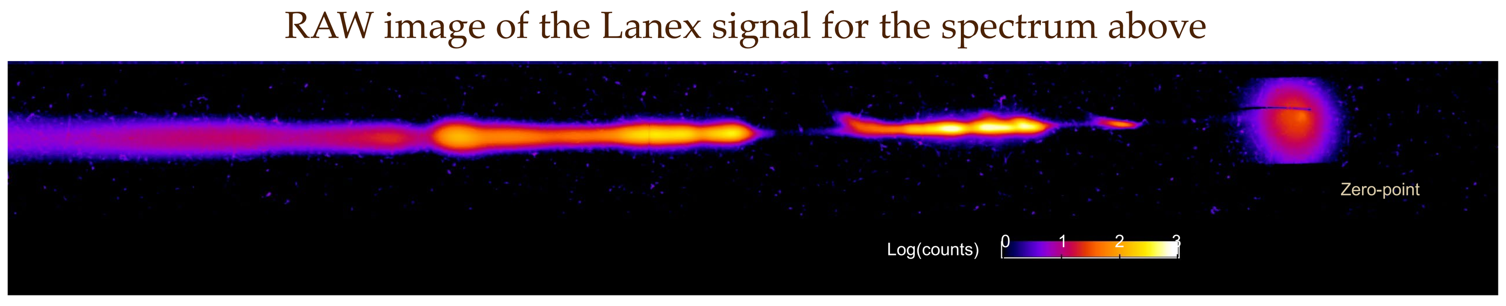
Imaging of plasma from gas target

Data Analysis via ImageJ MACRO code

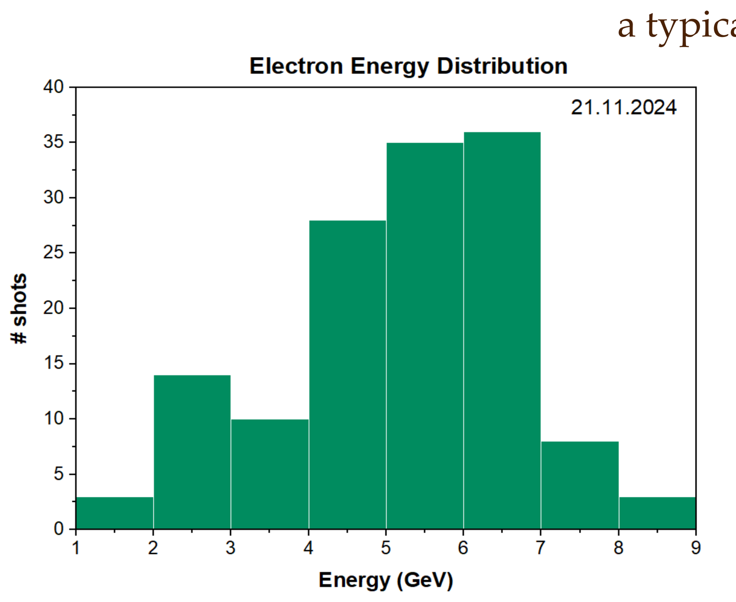
Example of electron energy spectrum of a typical shot with high cut-off energy

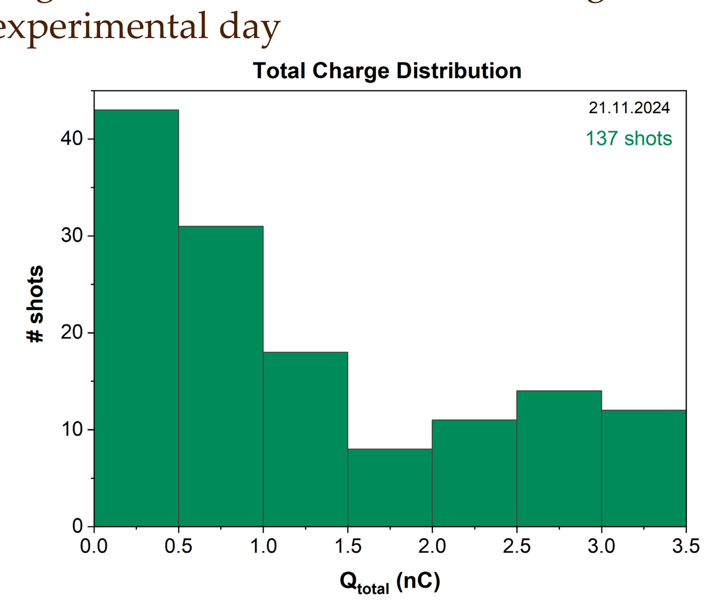


RAW image of the Lanex signal for the spectrum above



Distributions of electron cut-off energies and total electron beam charges of a typical experimental day

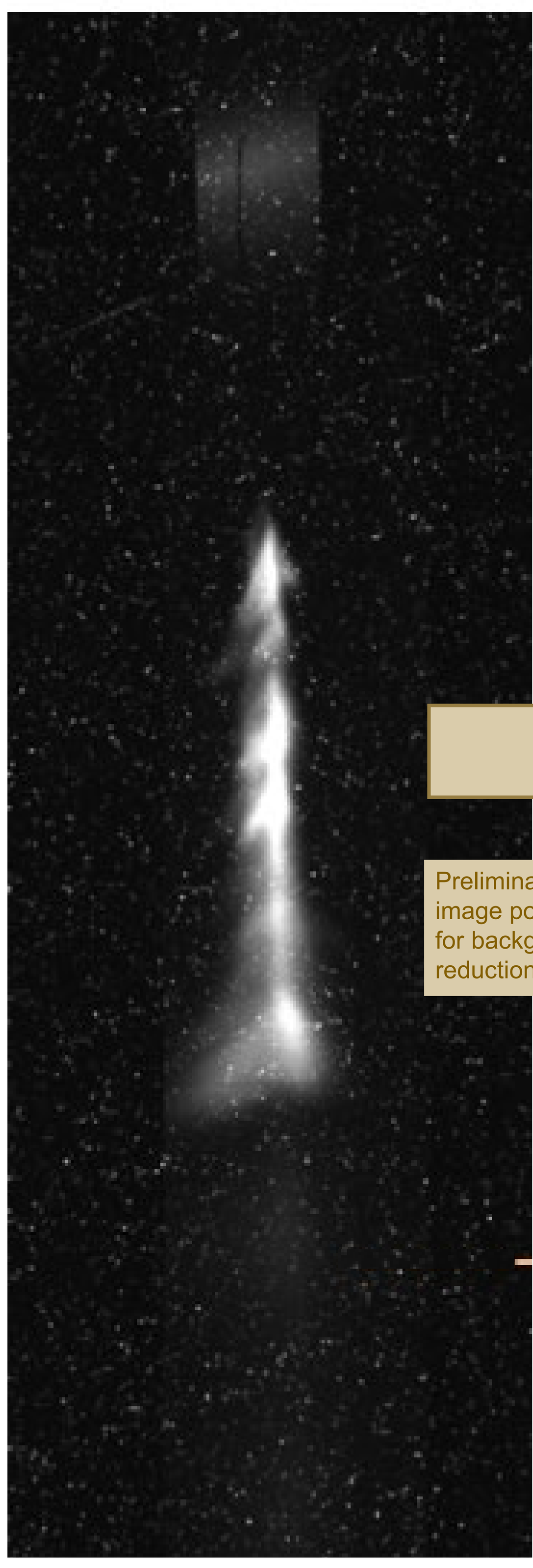


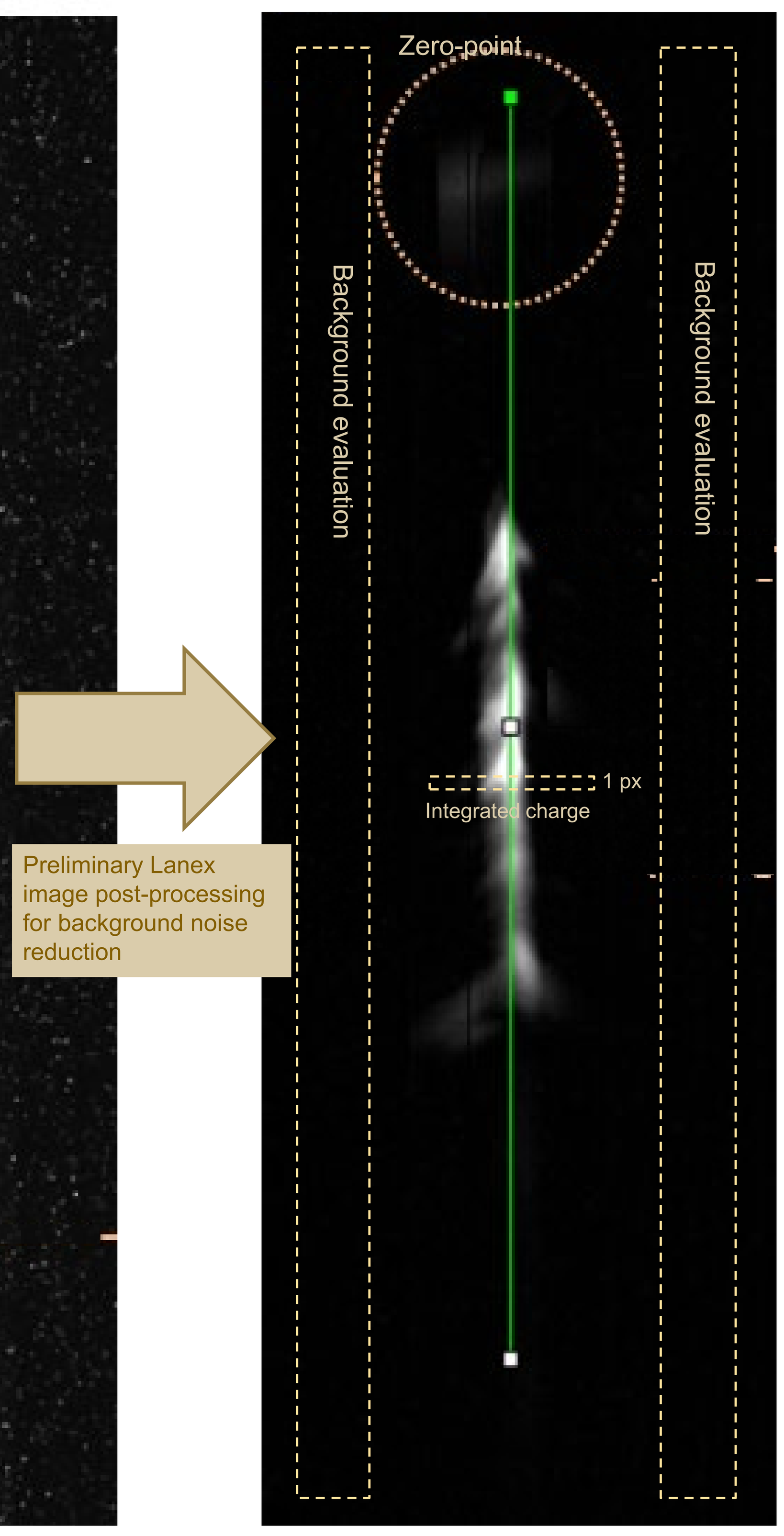


In this example, 137 shots were fired, and different parameters were scanned to find optimal electron acceleration conditions.

Preliminary MACRO : Electron energy estimations for real-time monitoring

Original Lanex Image





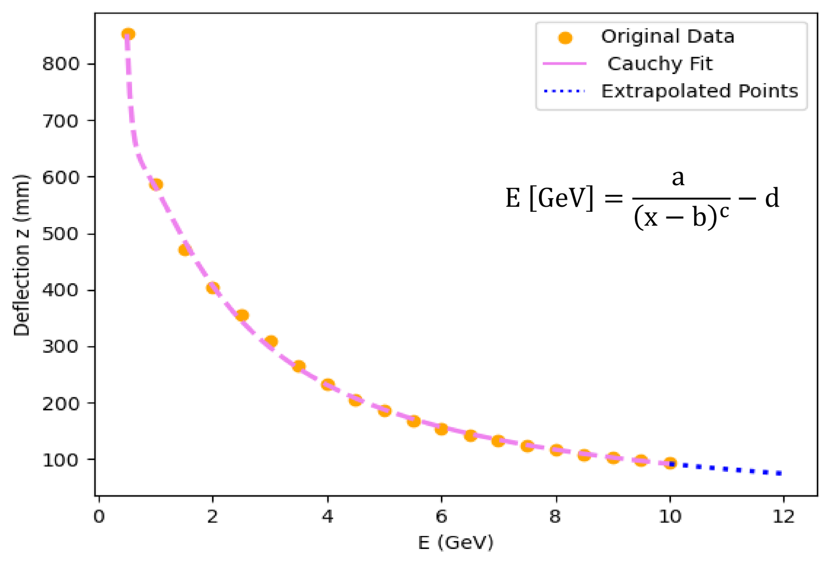
Search for zero-point with boundary conditions

Log
File Edit Font
1st max : x=1295, y=370 with intensity 423
2nd max : x=1355, y=850 with intensity 2602
h: 480 pixels.
4.8915 GeV

Background subtraction using an average background from the left-side and right-side background signal

Retrieving the energy spectrum using the energy-distance dispersion curve and integrating over the total charge at a given distance from the zero-point (i.e., summing pixel horizontally)

The energy-distance dispersion curve



Highlights

- We developed a set of MACRO tools (JavaScript) for RAW Lanex image processing and electron energy spectra analysis derived from particle tracking models. The MACRO infers with good accuracy the charge distribution and total charge (nC) for each shot.
- The preliminary scanning code yields a good live estimation of electron beam cut-off energy as the input data (shot entries) is continuously acquired at high repetition rate.
- Systematic improvements of the MACROs with the implementation of real magnetic field configuration, advanced experimental conditions, and a user-friendly interface are in progress. We are also aiming to train regressive and artificial neural network algorithms for increased real-time analysis accuracy'.

Acknowledgments

Extreme Light Infrastructure Nuclear Physics (ELI-NP) team acknowledges the support of the Romanian Government and the European Union through the European Regional Development Fund - the Competitiveness Operational Programme II (1/07.07.2016, COP, ID 1334), and the Romanian Ministry of Research, Innovation and Digitalization: PN23210105 (the Program Nucleu) and ELI-RO Project 21/2024 LGS. Accessing the ELI -NP facility is supported by the IOSIN funds for research infrastructures of national interest funded by the Romanian Ministry of Research, Innovation and Digitalization.