Finanziato dall'Unione europea NextGenerationEU
Ministero dell'Università e della Ricerca
Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA
THE Tuscany Health Ecosystem

Correlation Study of Integrating Current Transformer Charge and Lanex Screen Emission Signal in High-Energy Beam Measurements

Milestones 1.1 and 1.6

Cascade grant LPA-STAR

D. Gregocki, F. Avella, F.Baffigi, G. Bandini, G. Benincasa, F. Brandi, M. Ezzat, A. Fregosi, L. Fulgentini, P. Koester, L. Labate, D. Palla, M. C. V. Panaino, S. Piccinini, M. Salvadori, S. G. Vlachos & L. A. Gizzi.

Table of contents:

01 -Motivation

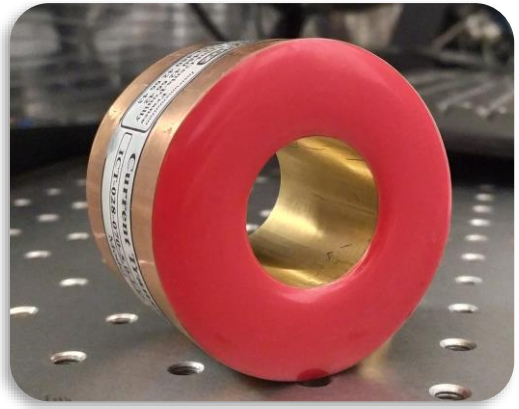
- Integrating current transformers (**ICT**) have been used as reliable charge diagnostics in the radio-frequency acceleration's community
- Quickly gained popularity also in laser-plasma acceleration (LPA) field thanks to **nondestructive, energy independent** (and compact) **charge measurement**
  - **However,** in some cases
    - ICT measurements **overestimated charge** by more than an order of magnitude[1].
    - ICT measurements **overestimated charge** by 3-4 times[2].
    - Charge measurement **consistent with calibration** – Measurement at large distance (**4m**) from interaction region[3].
  - Main **unwanted contributor** to charge overestimation **was** electro-magnetic pulse (**EMP**) **signal**
    - Can we correlate ICT charge and Lanex screen emission signal?
    - Is EMP influence observed also in our case?

[1]*Glinec et al., Rev. Sci. Instrum. 77, 103301 (2006)*
[2]*B. Hidding et al., Rev. Sci. Instrum. 78, 083301 (2007)*
[3]*K. Nakamura et al., PRST-AB 14, 062801 (2011)*

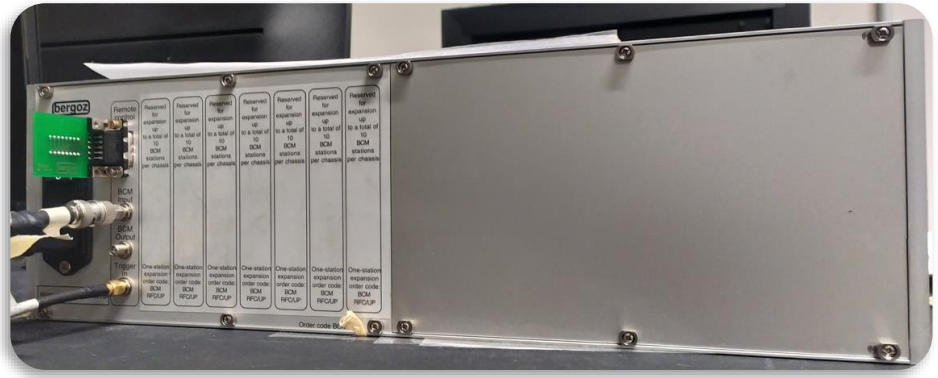
02 – General description

- ICT consists of a coil with magnetic core shaped into a loop through which electron bunches can pass
- Electron charge induces a voltage in the coil
- Integrating over this voltage produces an output voltage proportional to the electron beam charge
- Integrator (part of the ICT controller) consists of op-amp, filter …

1



2

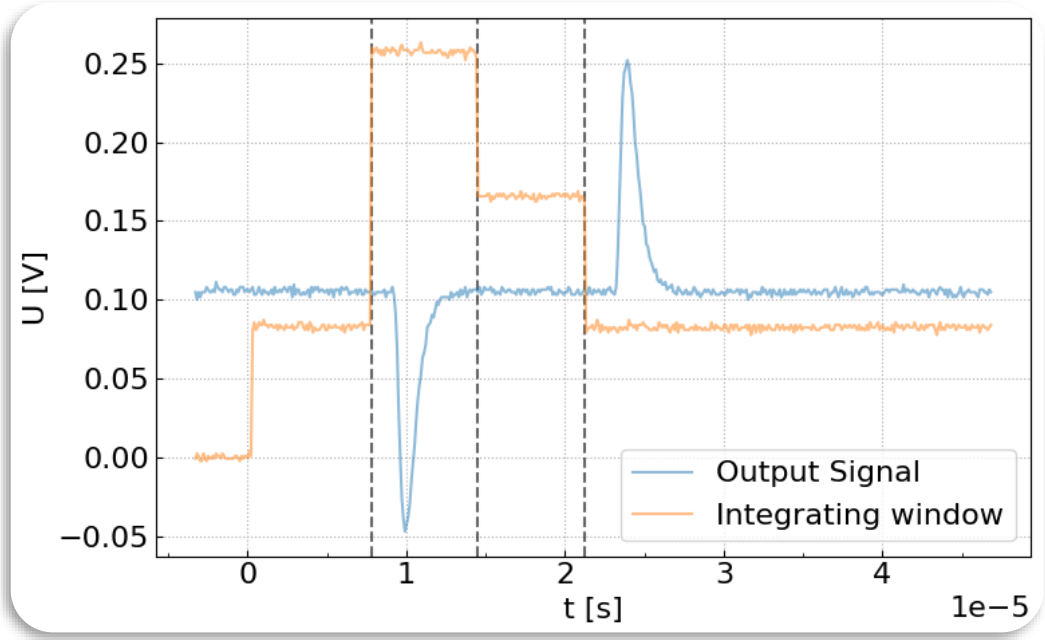


3

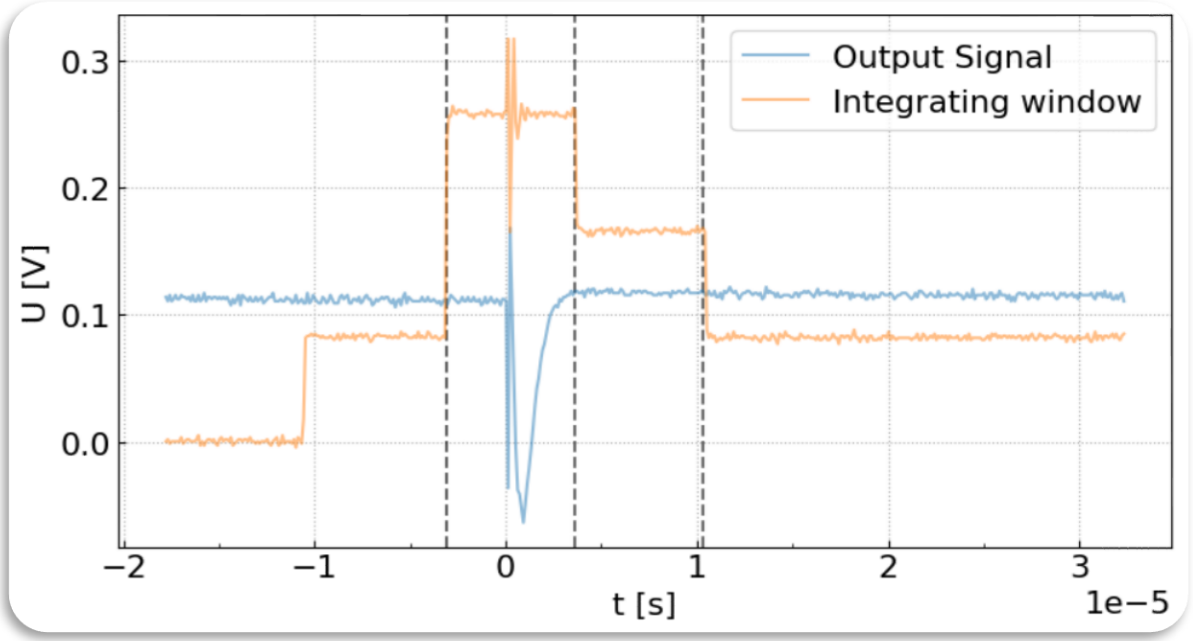
02 – General description

- One window integrates the signal, and the second one integrates the background for noise reduction

Ideal signal for integration



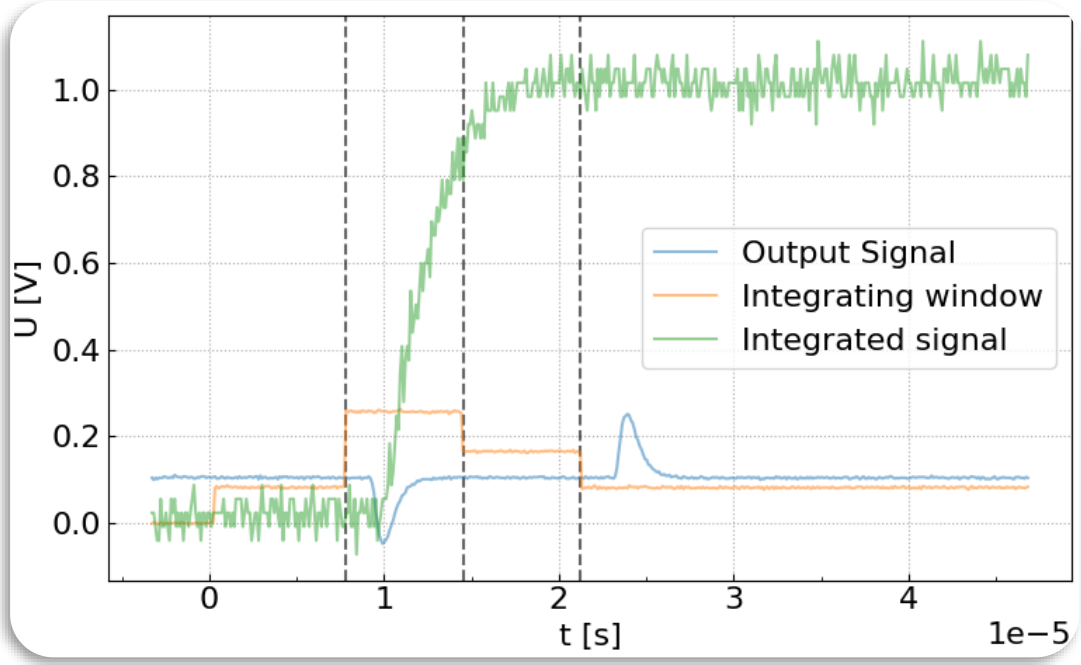
Signal from LPA generated electrons



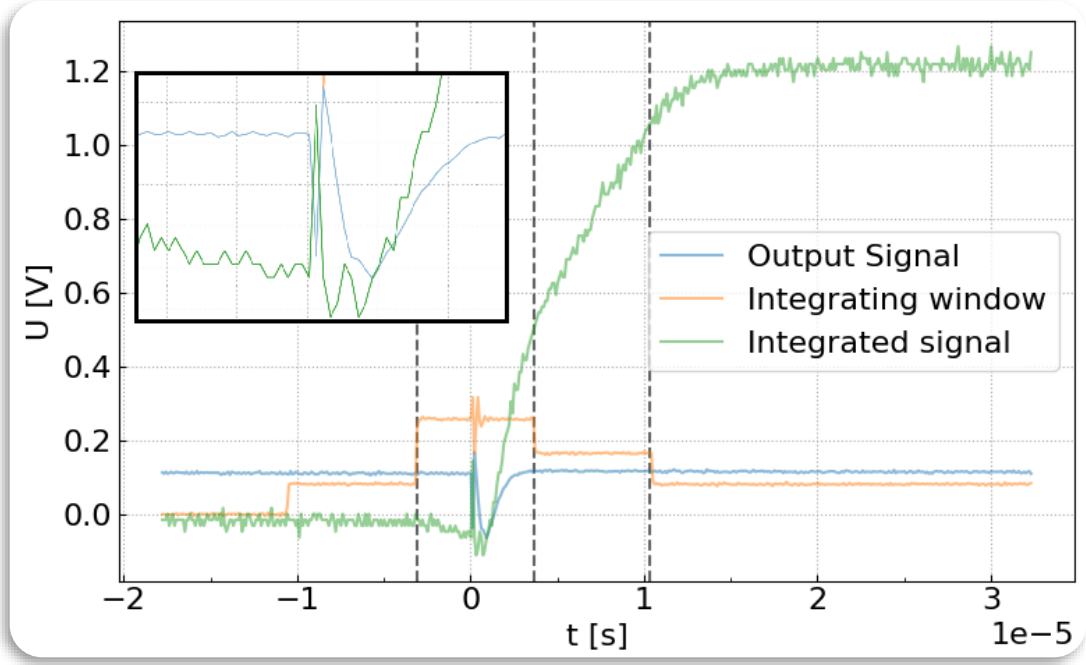
02 – General description

- One window integrates the signal, and the second one integrates the background for noise reduction

Ideal signal for integration (Example)

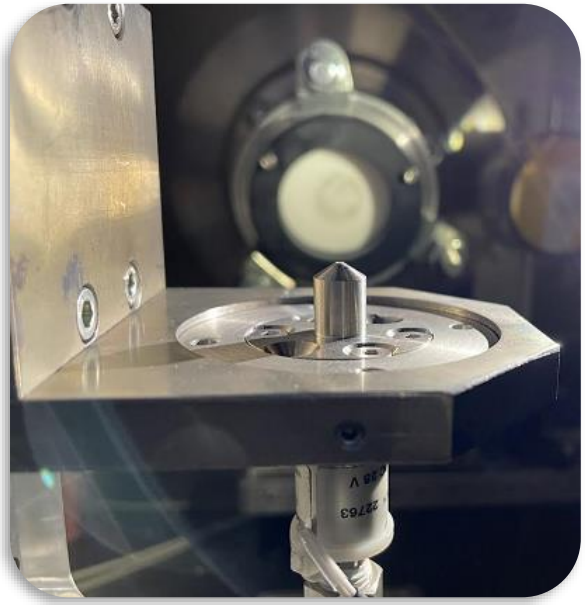


Signal from LPA generated electrons

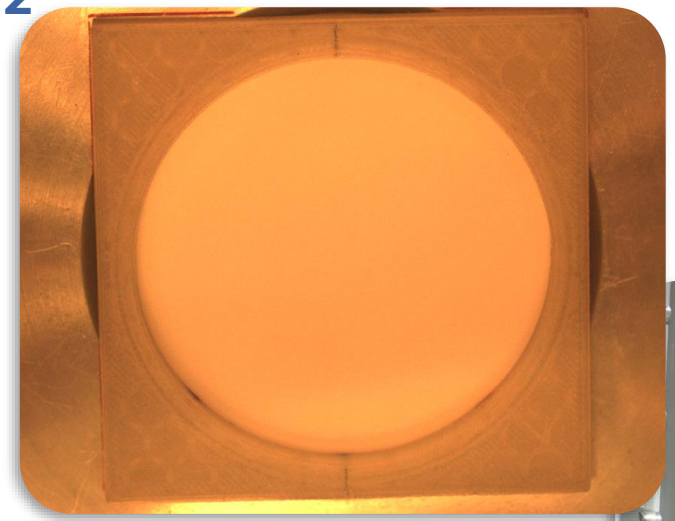


03 – Experimental setup

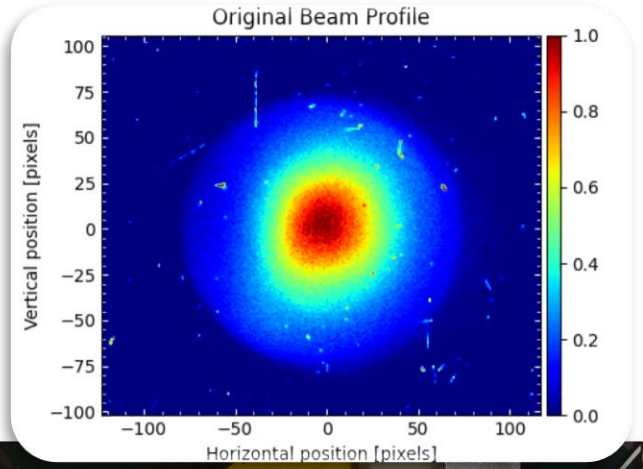
1



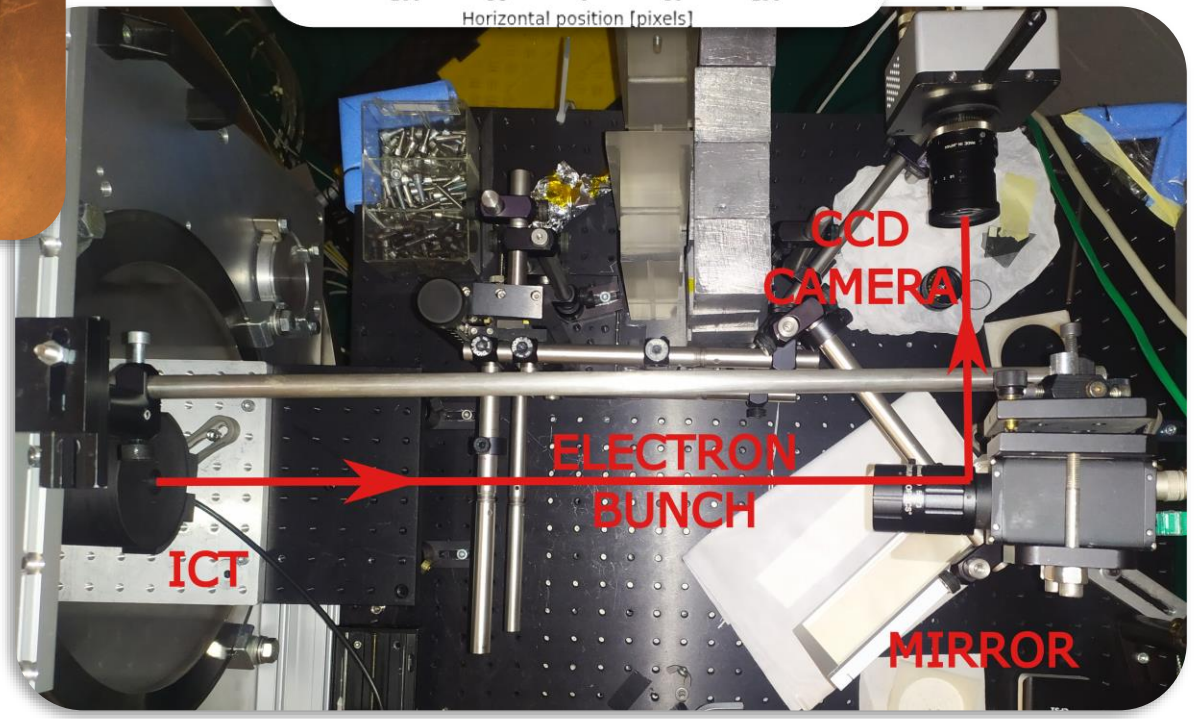
2



4

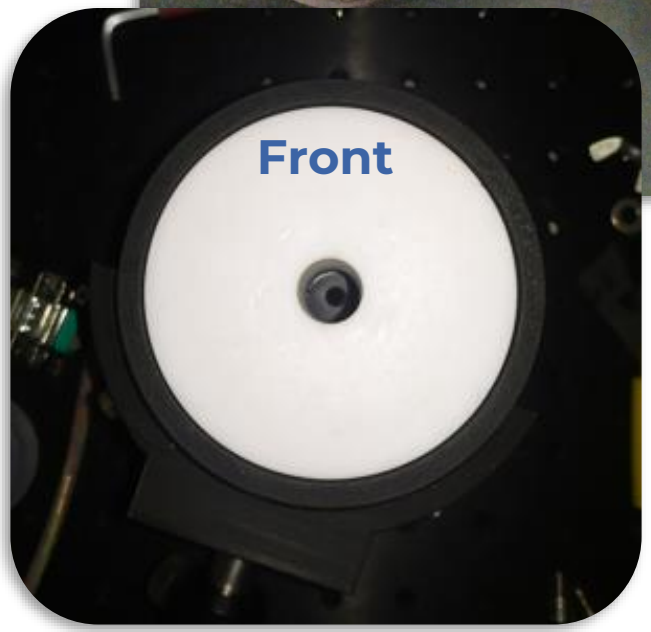


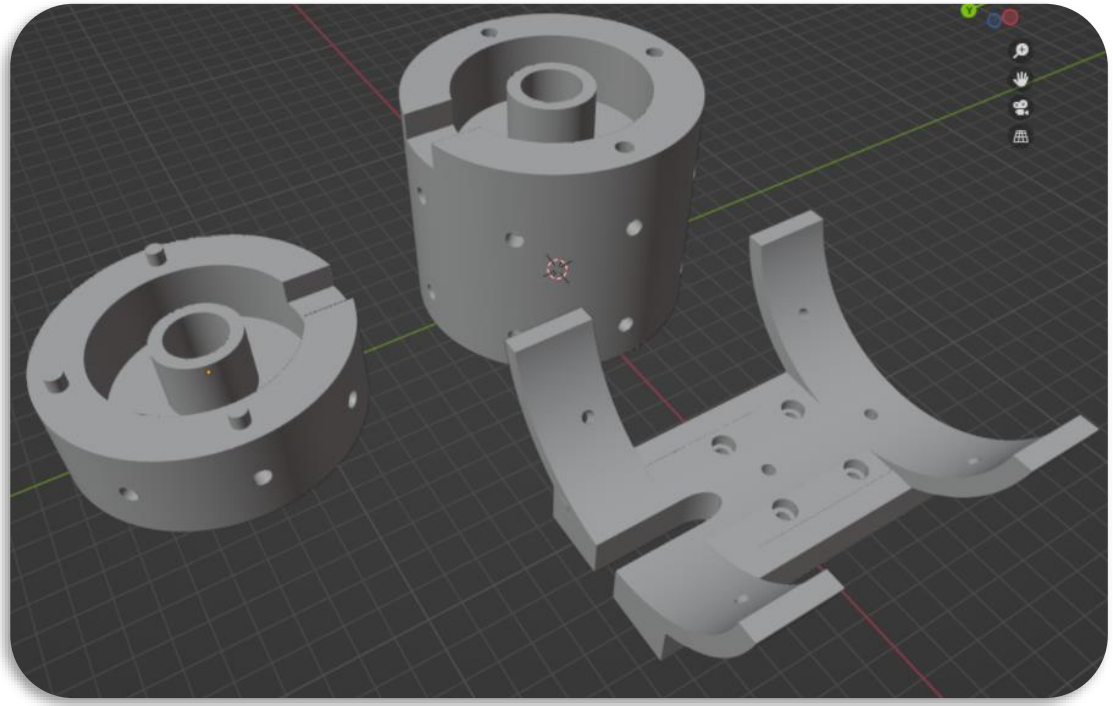
3



- LPA generated electrons passed through the Lanex screen after the vacuum-air transition
- Afterwards they passed through ICT
- Lanex emission signal was captured by CCD

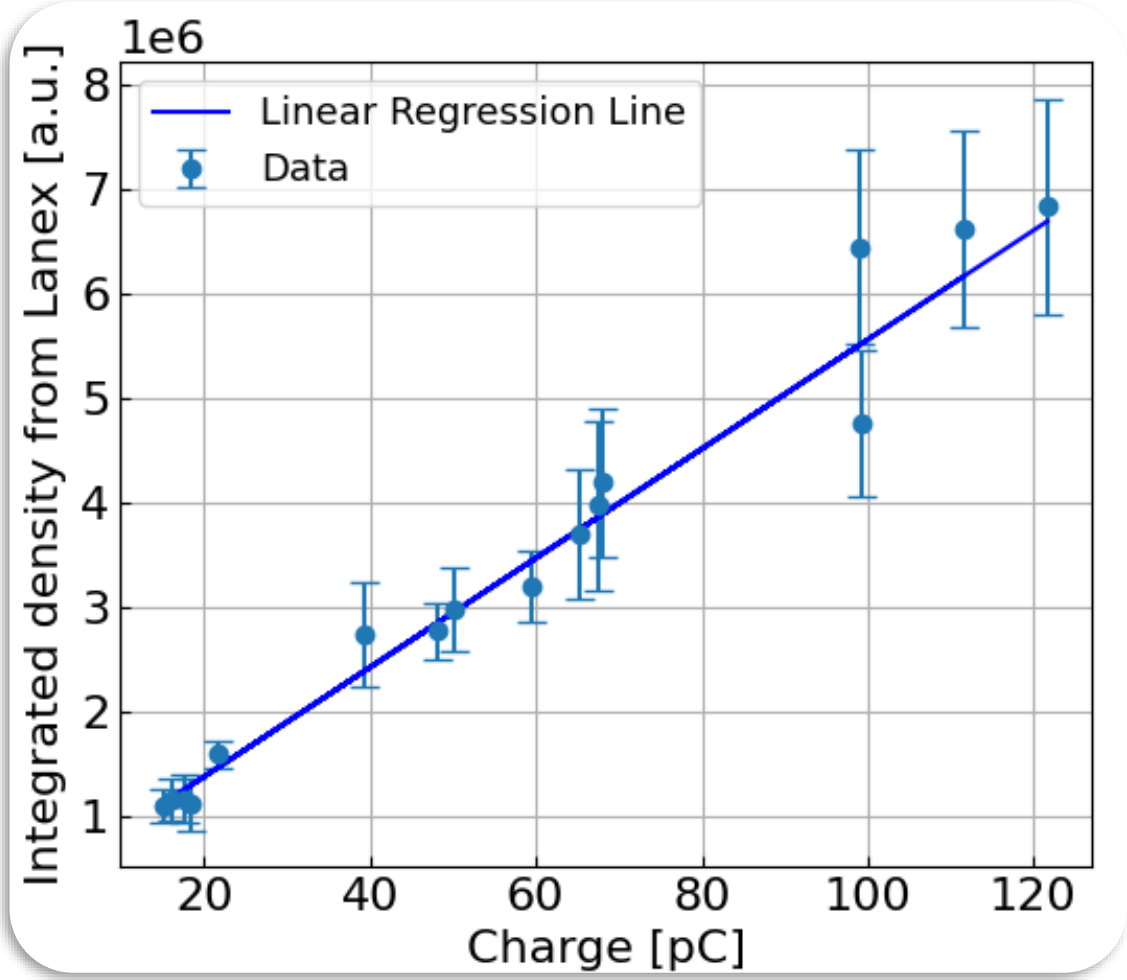
03 – Experimental setup





- ICT mount/shielding was designed in Blender
- 3D printed with PLA filament
- The front part allows the main shielding to be replaced

04 – Results



- From the linear regression:
  - $R^2 = 0.97$
  - $\chi^2 = 3.06$
  - Pearson coefficient = 0.98
  - $y = 54602 \cdot x + 260277$

- **Correlation** between the electron charge and Lanex emission signal **is present**

Summary

- ICTs provide noninvasive, energy-independent charge measurements
- In laser-plasma acceleration, EMP signals can influence ICT results
- During the experiment, EMP signal spikes were observed
  - However, correlation between the ICT charge and Lanex emission signal was still preserved

- At the moment, an experiment aimed at retrieving the charge from the radiochromic films is being conducted
  - To assess whether the ICT is overestimating the measured charge

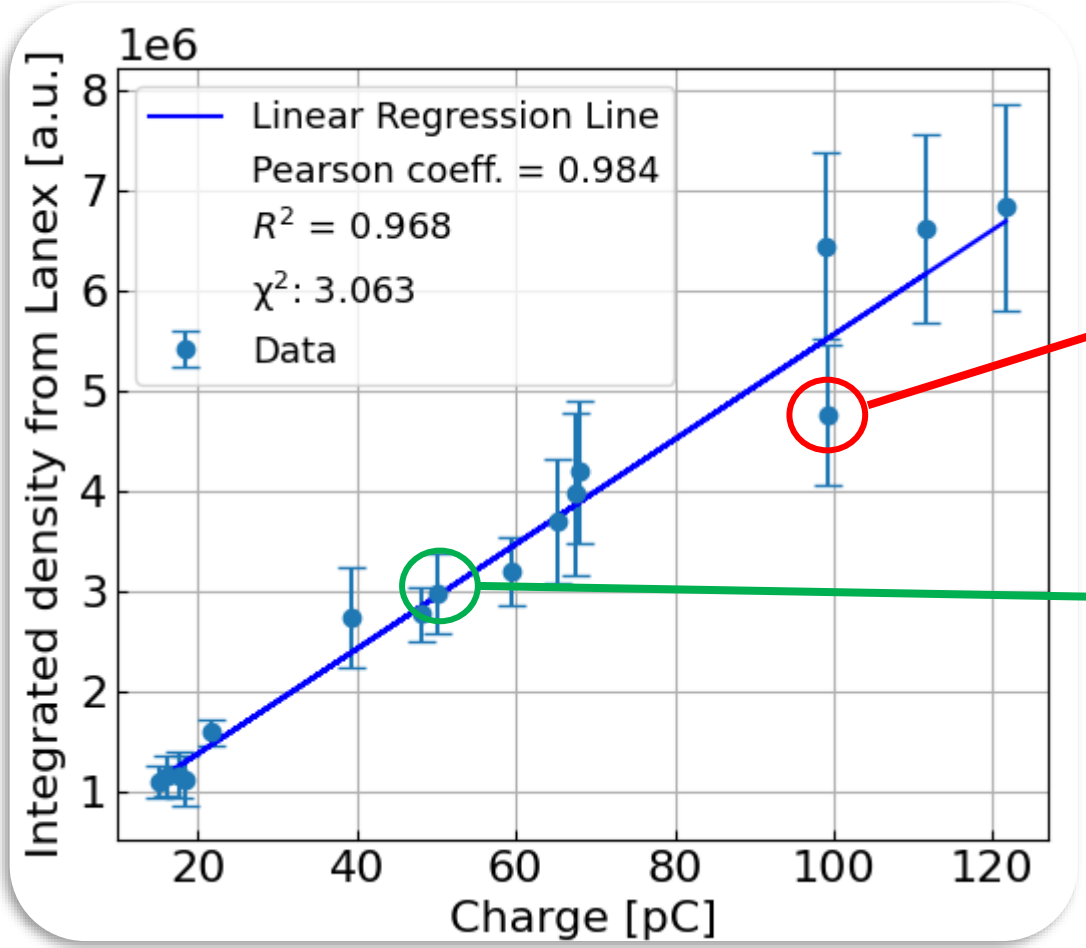
Acknowledgement

Experimental investigation on biomedicine
This work was supported by the PNRR MUR project ECS00000017-"Tuscany Health Ecosystem & the LPA – STAR project, funded by the European Union – Next Generation EU

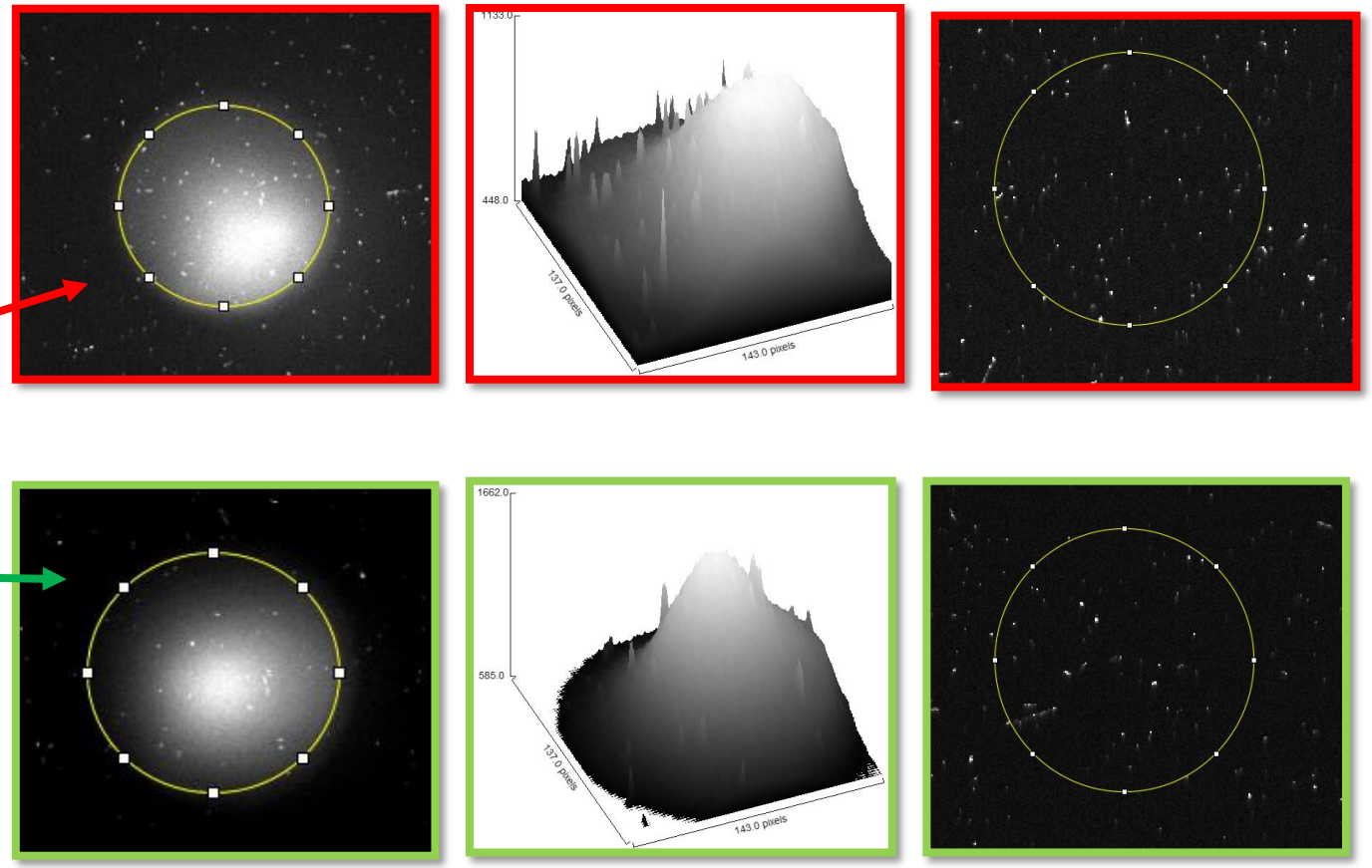
Laser Development
This work was supported by the EU Horizon IFAST, under Grant Agreement No.101004730

Infrastructure Development
This work was supported by the PNRR MUR project IR0000016-I-PHOQS, funded by the European Union – Next Generation EU and EuPRAXIA Advanced Photon Sources – EuAps (IR0000030, CUP I93C21000160006).

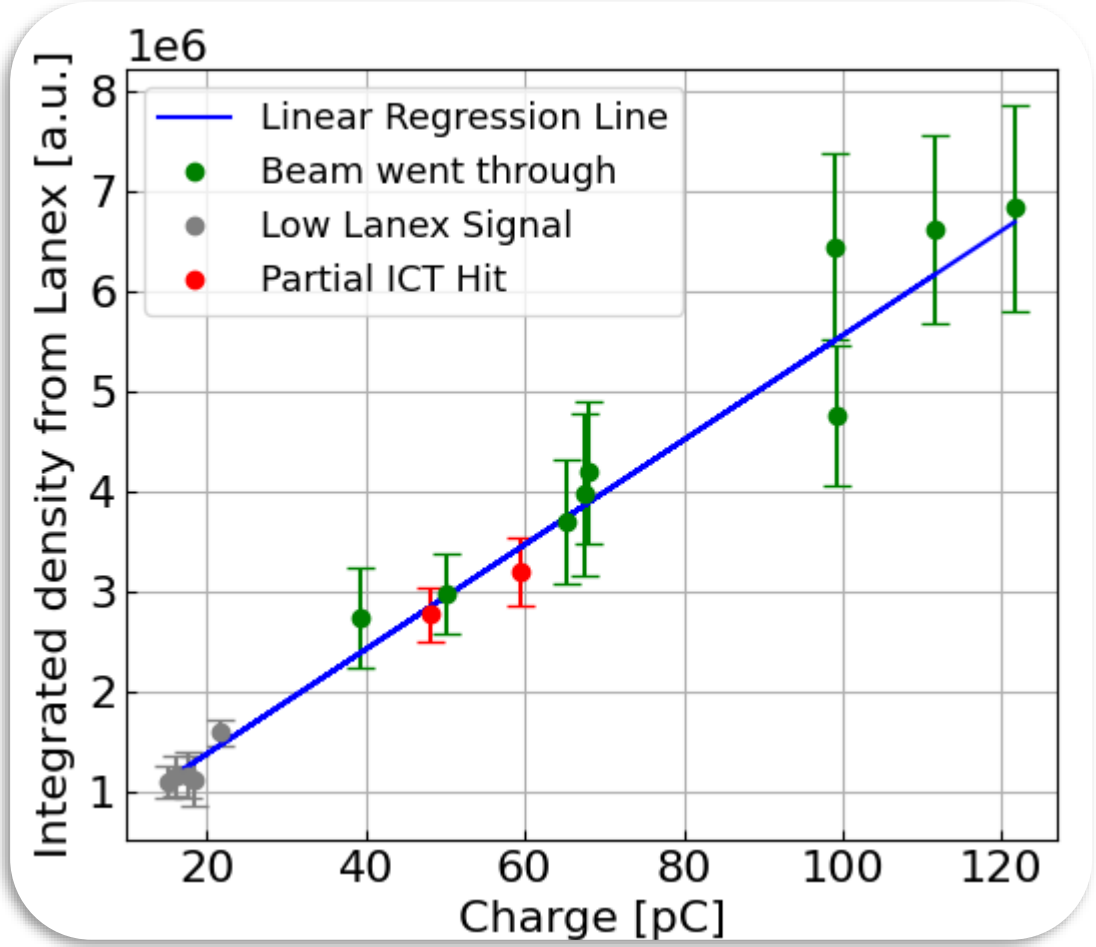
Backups



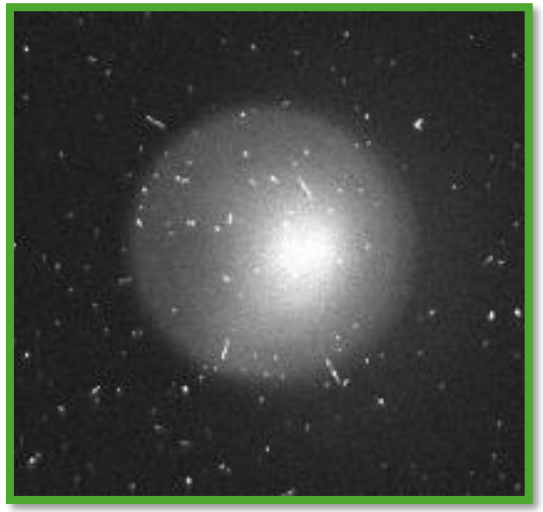
Background



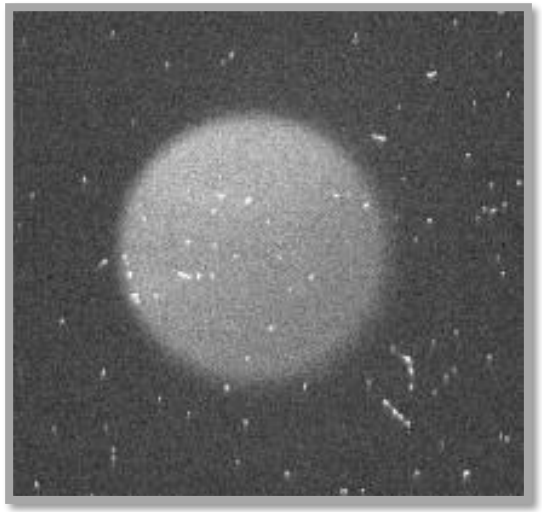
Backups



Beam went through



Low Lanex Signal



Partial ICT hit