

Status and Overview of the CLEAR Facility at CERN

33rd Linear Accelerator Conference (LINAC 2026)

Antonio Gilardi

21/08/2026

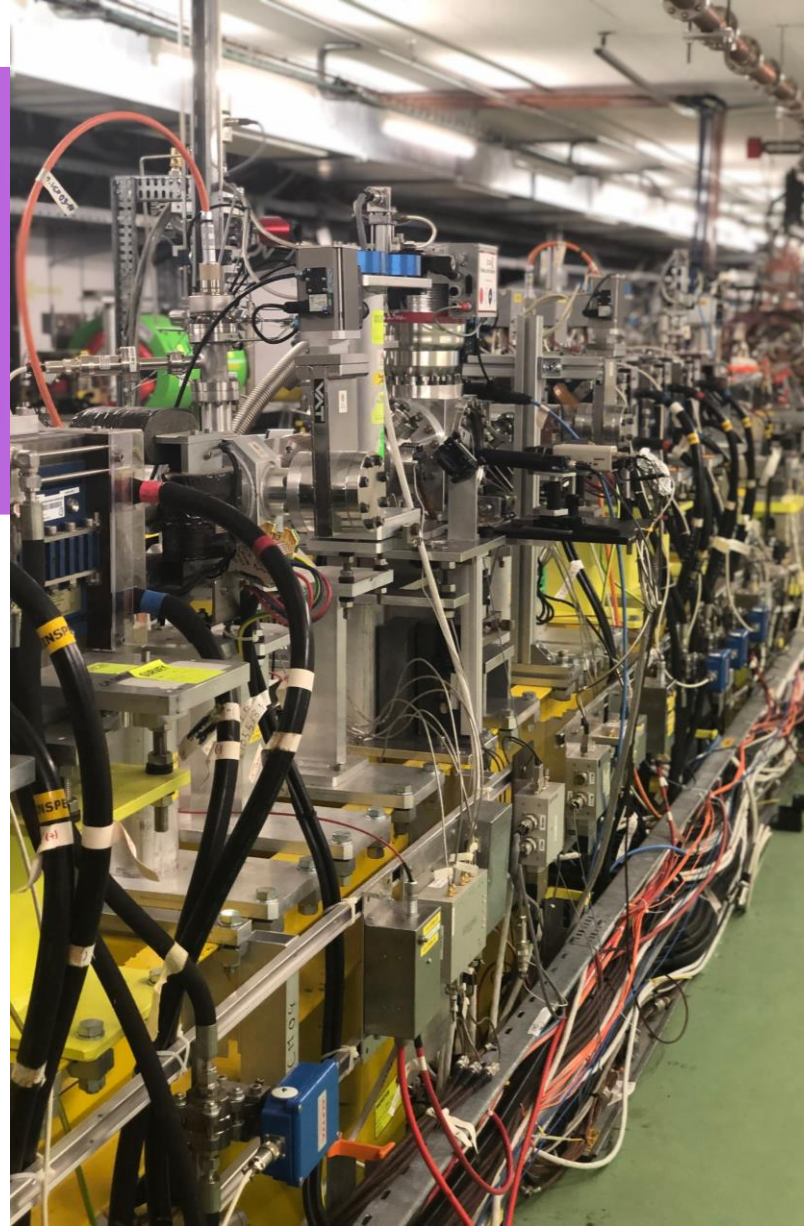


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Everything I am reporting here is the result of a tremendous team effort.

None of this would have been possible without the hard work, dedication, and collaboration of our team.



Facility Introduction

FLEXIBLE

WHAT

- CLEAR operates as an independent accelerator, which allows it to run even when the broader CERN accelerator complex is shut down (e.g., LS3) .
- Each year, CLEAR typically operates for about **30–40 weeks**, usually from **March through December**.
- The operation is generally structured in **two shifts during daytime**, running **five days per week**, with **no night or weekend shifts** (apart from occasional exceptions).
- In some cases, **remote supervision has been used for overnight or weekend operation**, mainly for **low-charge studies**.

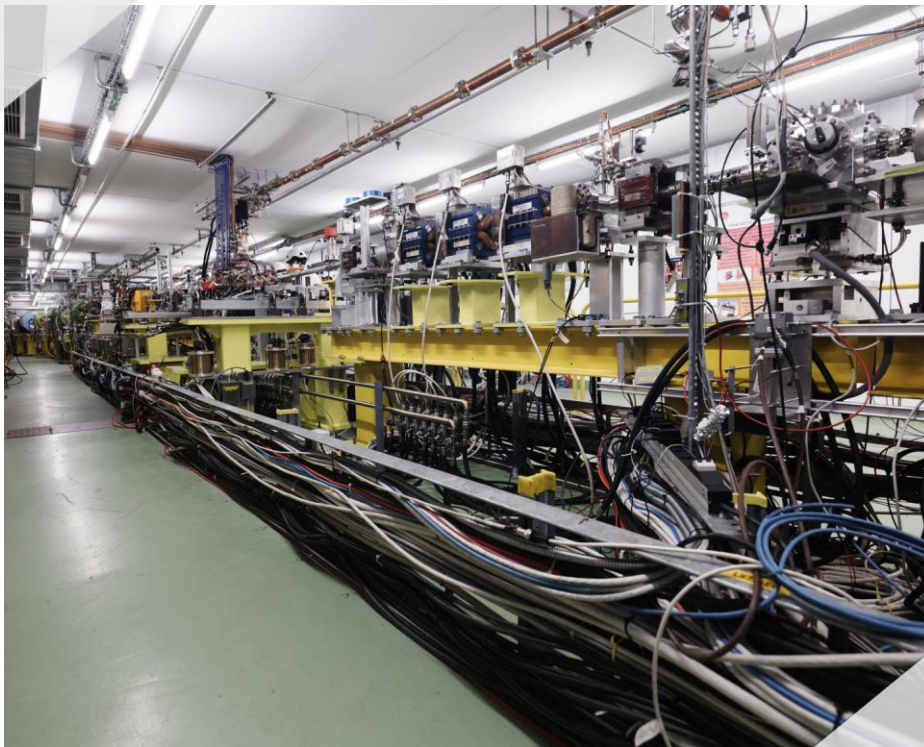
CLEAR operates as a user facility, but in most cases it goes beyond simply delivering a beam according to user specifications.

When needed (often), we actively support users in refining their experimental setup, optimizing methodologies, adapting measurement strategies, and analyzing and interpreting the results.

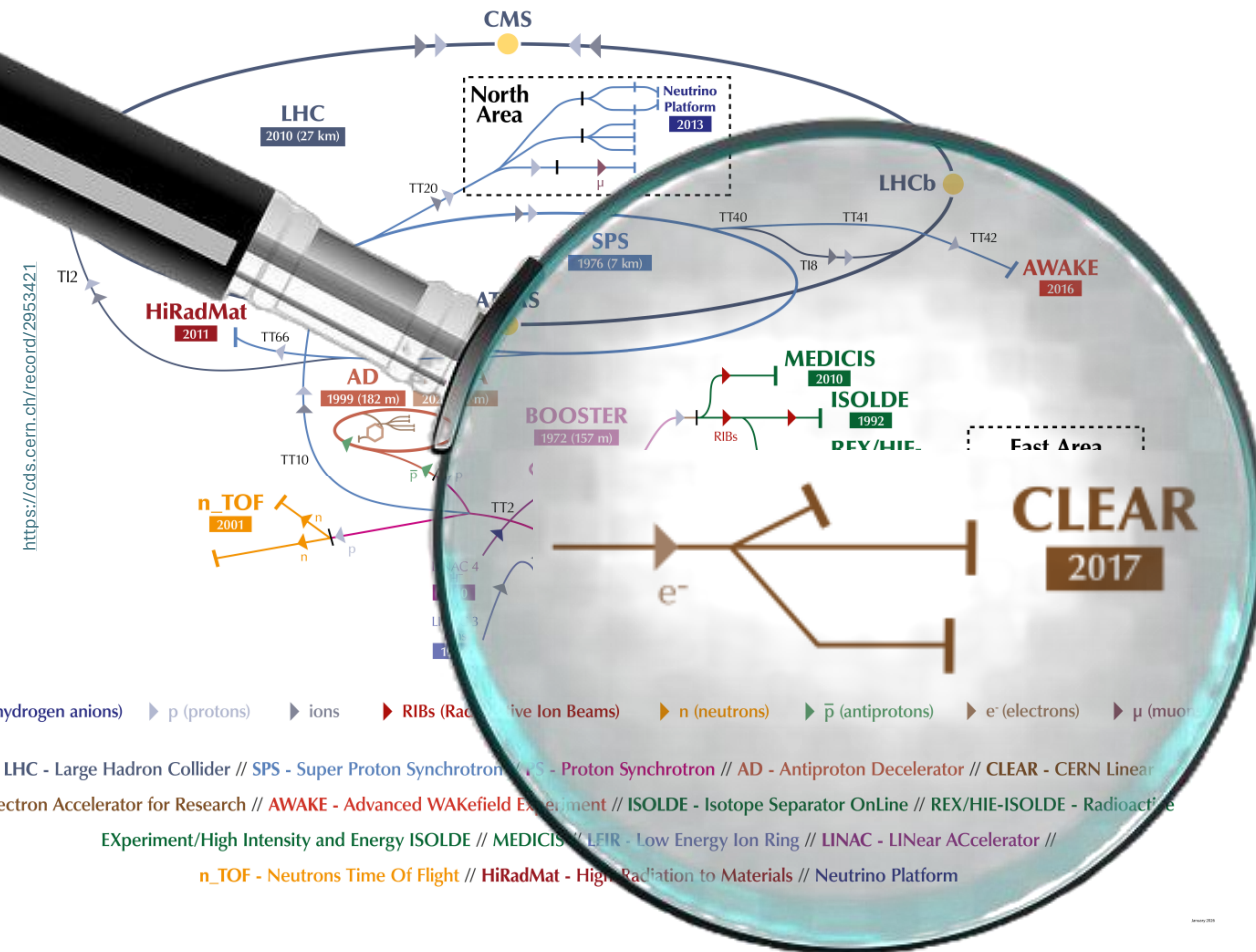
As a result, many CLEAR experiments develop into fully collaborative efforts

Facility Introduction

WHERE



The CERN accelerator complex
Complexe des accélérateurs du CERN



Facility Introduction

WHEN

2017-2030

Start with beam August 2017

- 19 weeks of operation in 2017
- 36 weeks in 2018
- 38 weeks in 2019
- 34 weeks in 2020
- 35 weeks in 2021
- 37 weeks in 2022
- 38 weeks in 2023
- 39 weeks in 2024
- 32 weeks in 2025
- ...



WHO

Roberto



Wilfrid



Davide



Antonio



Camilla



Alex



Giacomo



Sabrina



Johan



Francisco

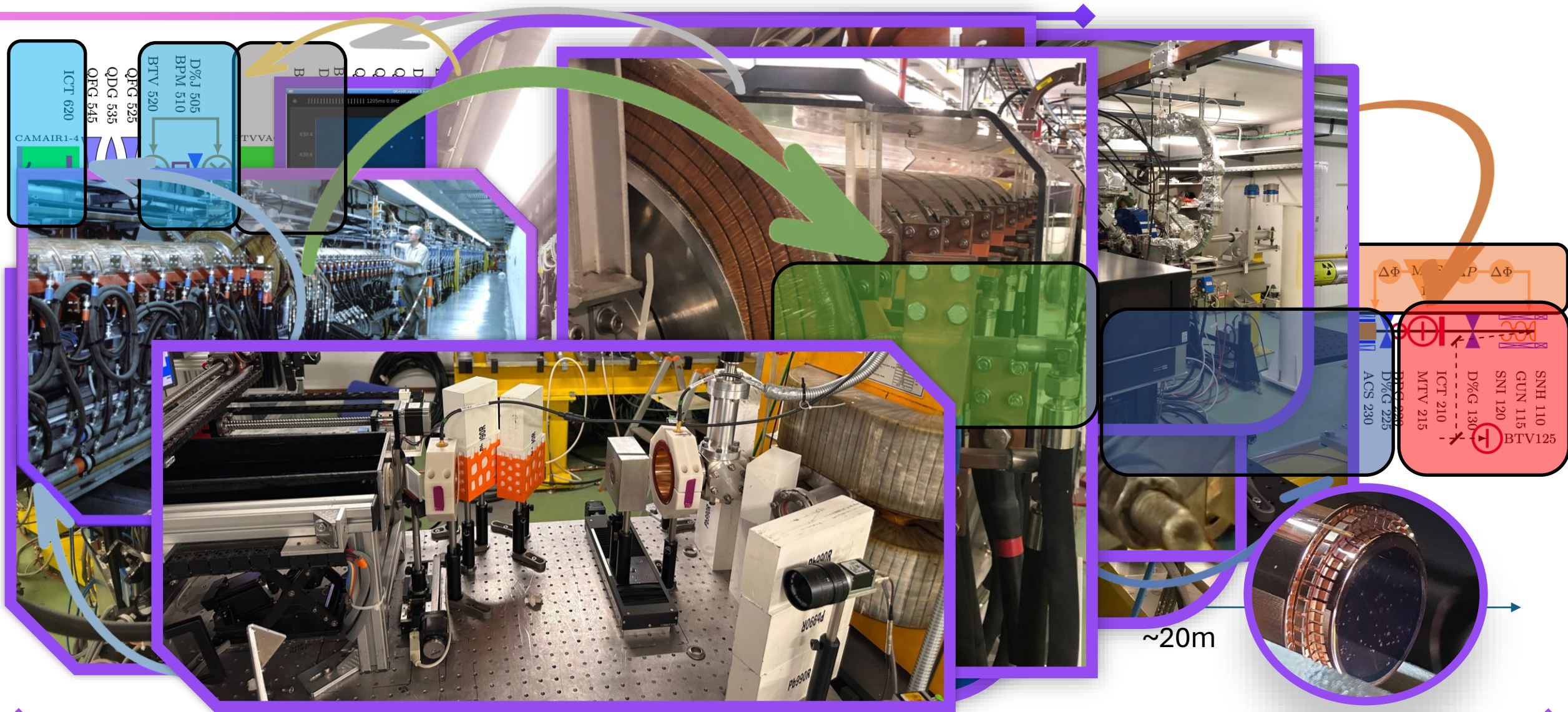


Sara



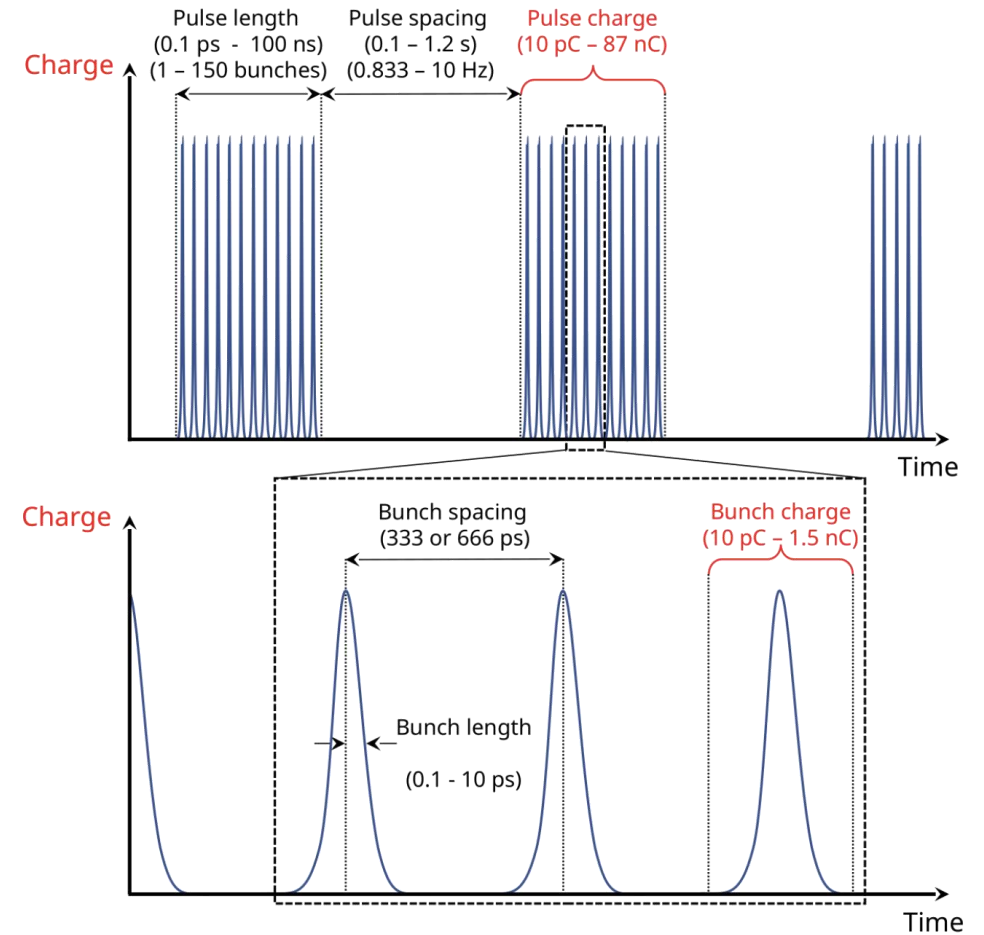
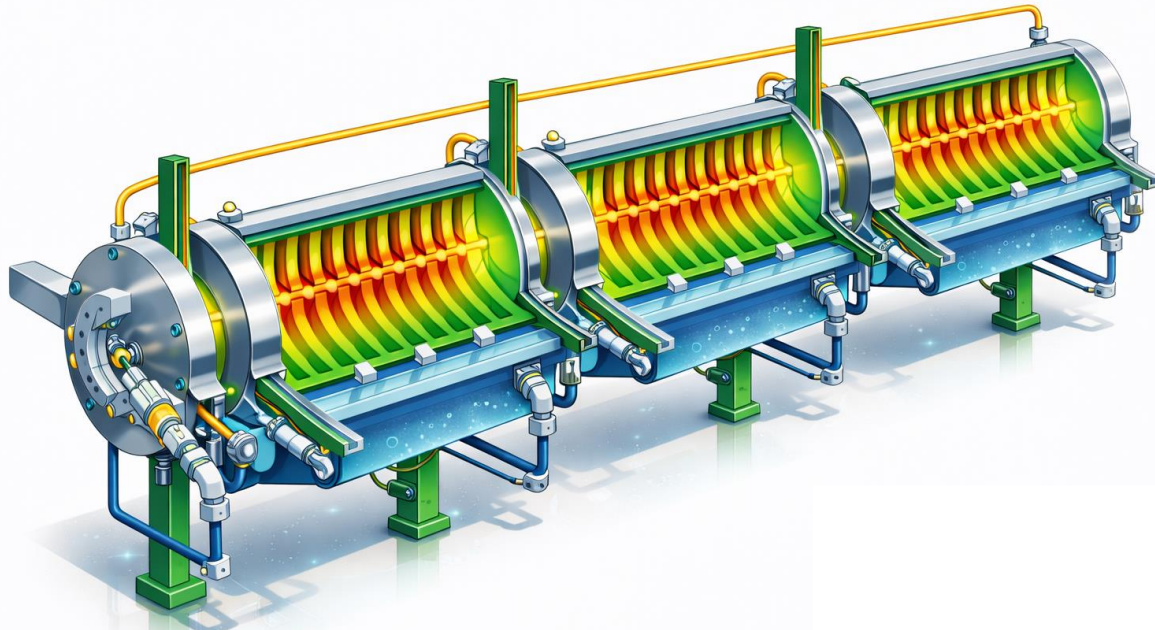
Ciara

Main Features & Parameters



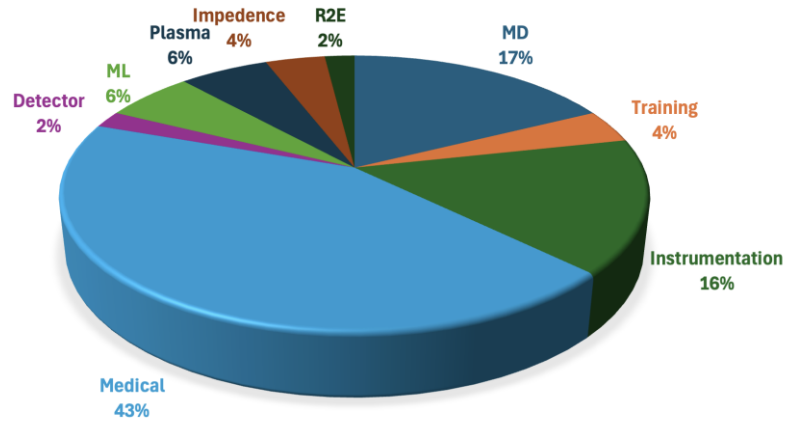
Main Features & Parameters

Beam parameter	Value range
Energy	20 MeV to 220 MeV
Bunch charge	0.01 nC to 1.5 nC
Normalised emittances	3 μm for 0.05 nC per bunch; 20 μm for 0.4 nC per bunch (both planes)
Bunch length	$\sim 100 \mu\text{m}$ to 1200 μm
Relative energy spread	$< 0.2\%$ rms ($< 1 \text{ MeV FWHM}$)
Repetition rate	0.833 Hz to 10 Hz
Number of micro-bunches in train	1–150
Micro-bunch spacing	1.5 GHz or 3.0 GHz



Experimental Program

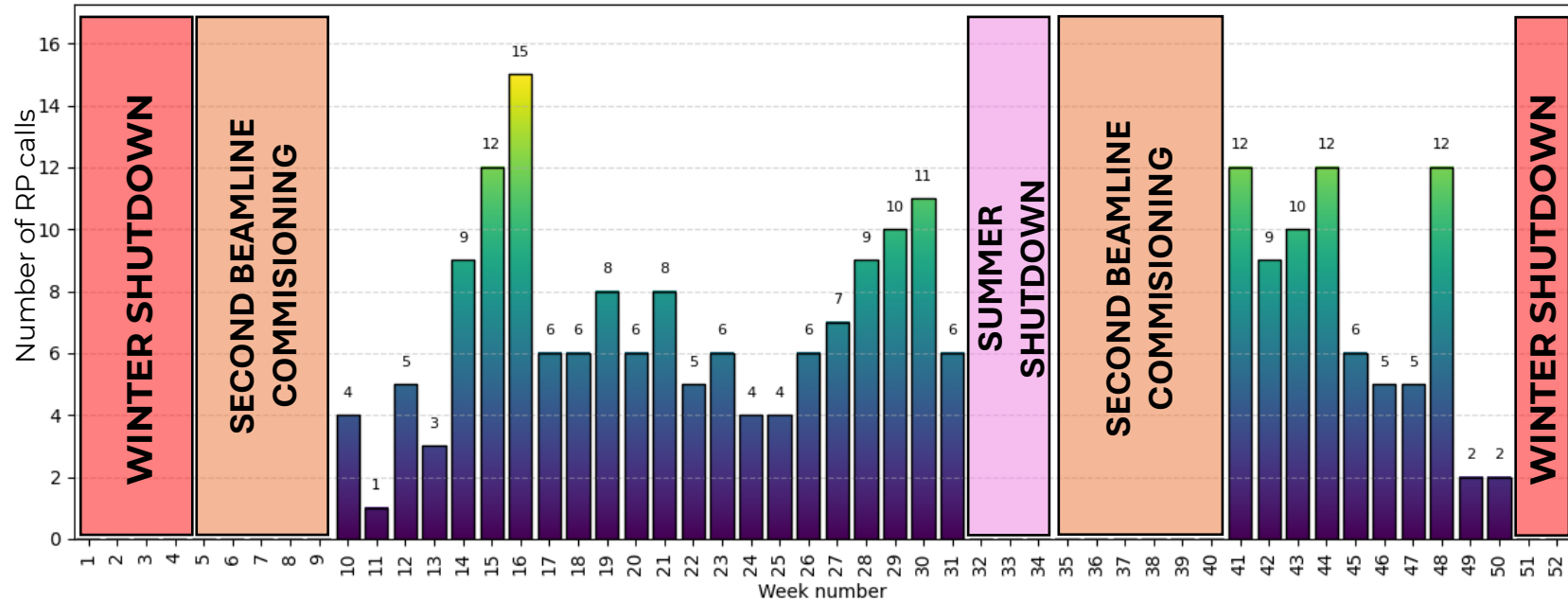
EXPERIMENT TYPE DISTRIBUTION



EXPERIMENT ORIGIN DISTRIBUTION



CLEAR RP Calls in 2025



Selected Results

THz GENERATION

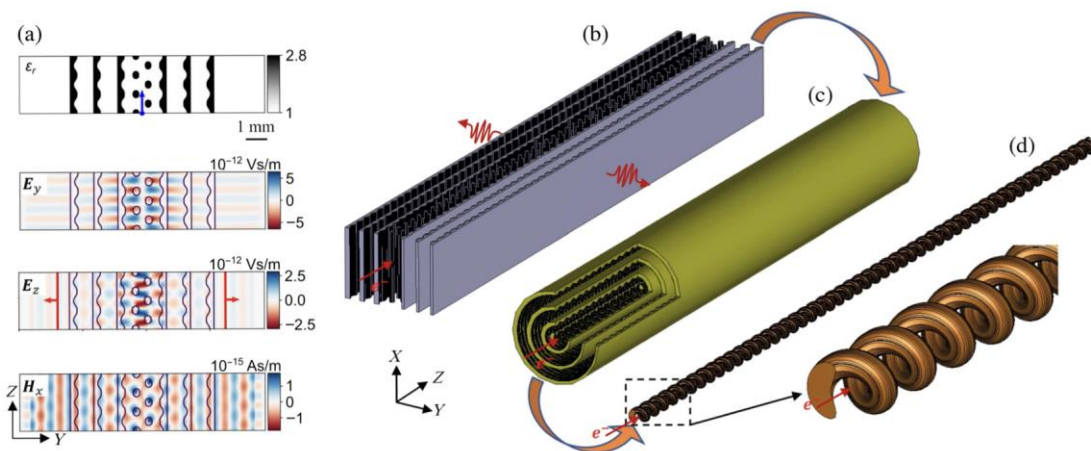


FIG. 1. Evolution of the THz radiator design. (a) 2D optimized structural morphology developed through inverse design. (b) Extruded structure. (c) Multilayer helically rotated structure. (d) Single-layer helically rotated structure.

doi:10.1103/PhysRevAccelBeams.28.054501

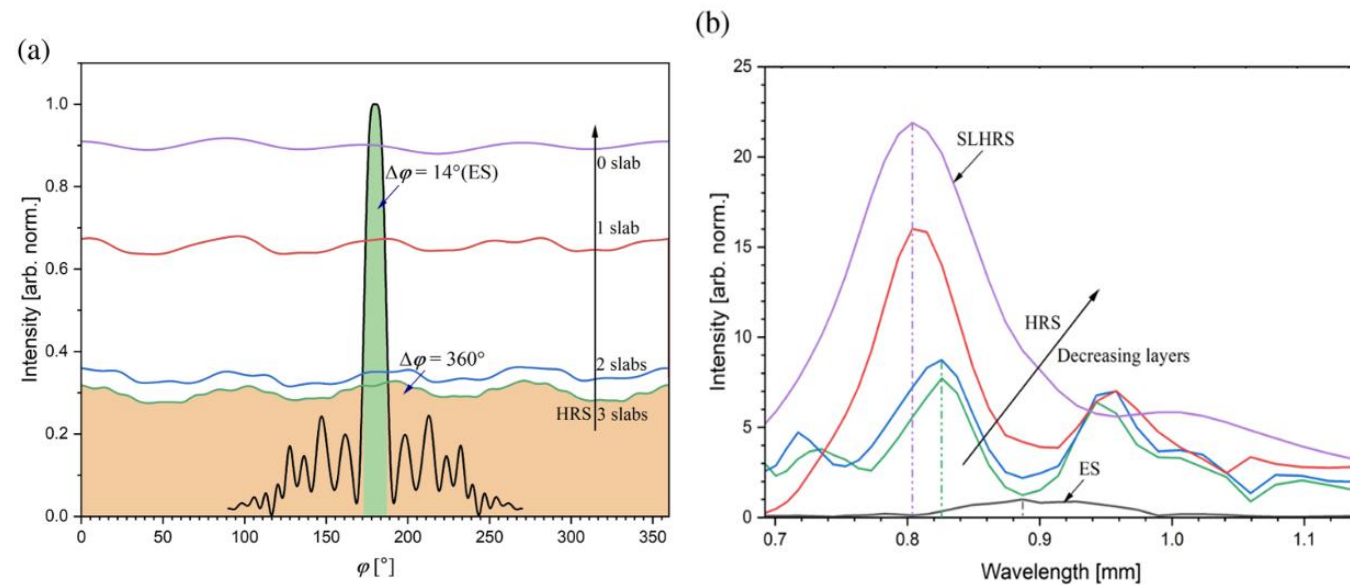
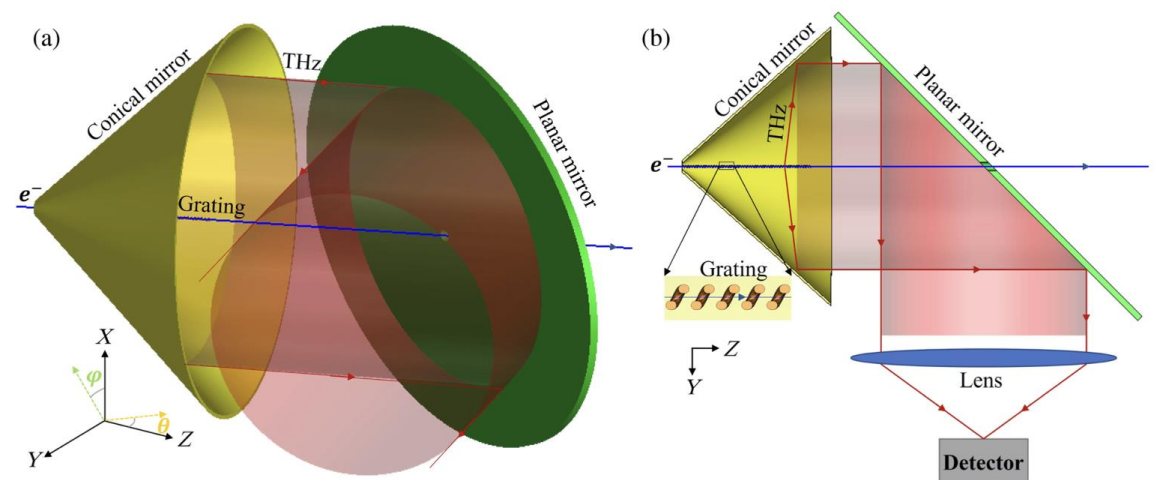


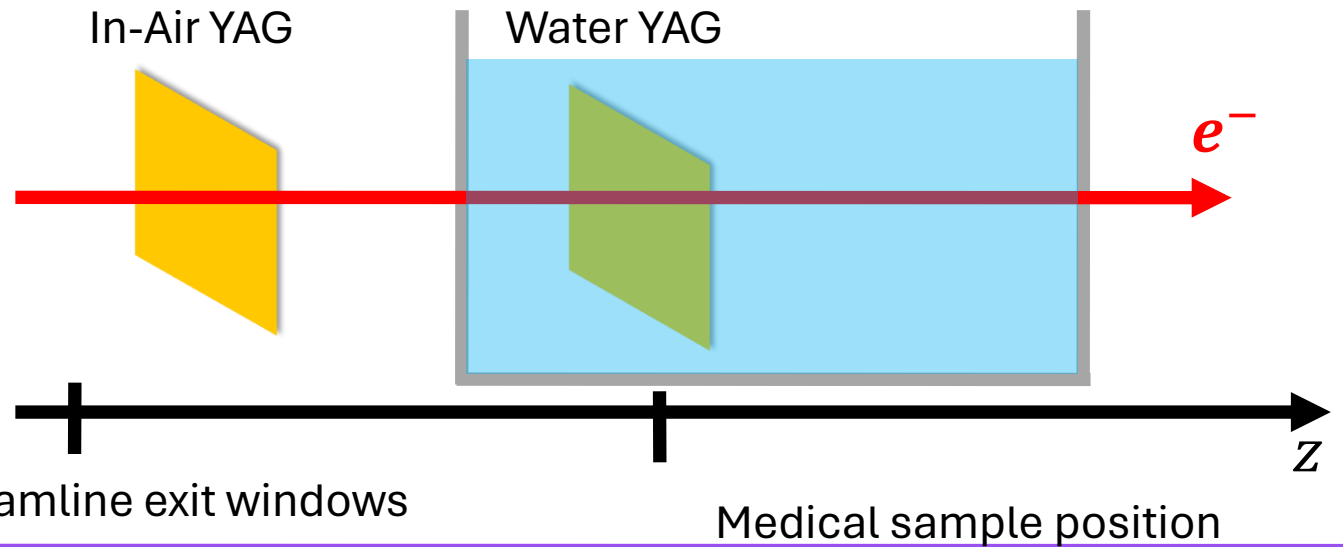
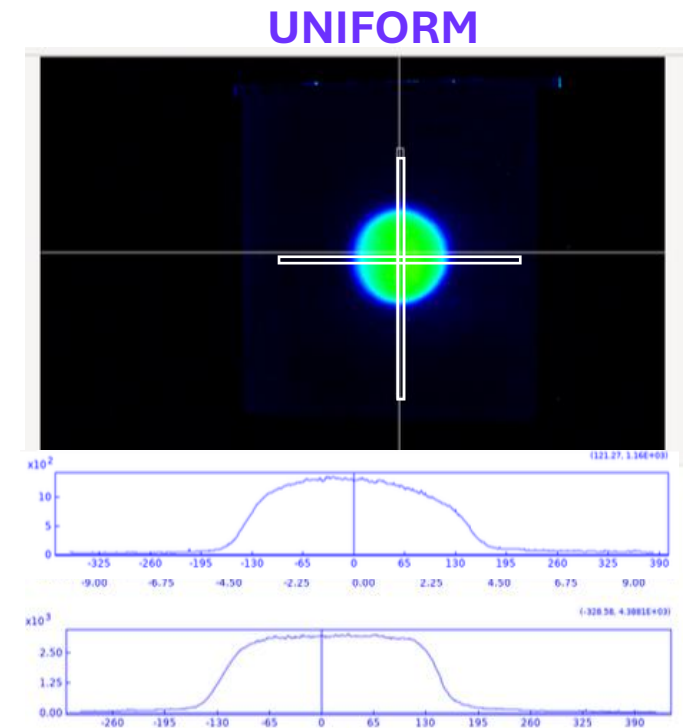
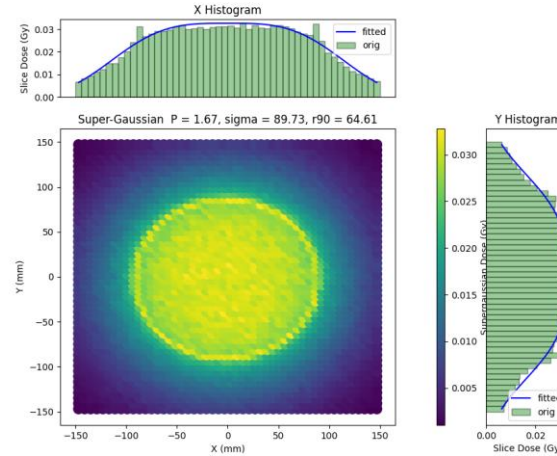
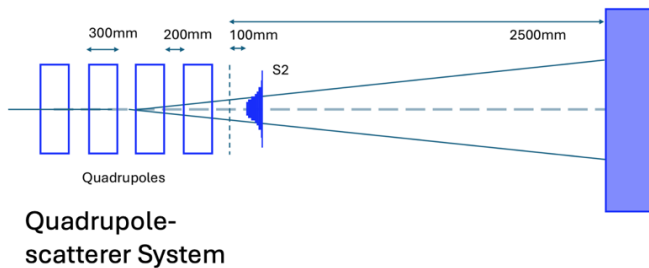
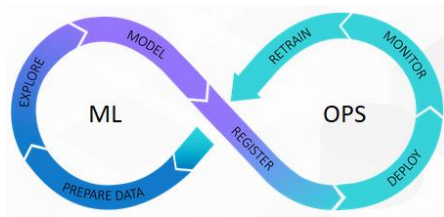
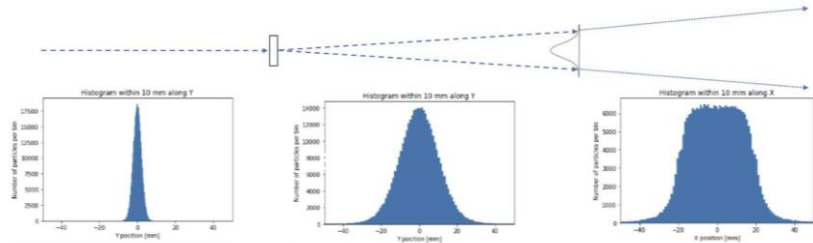
FIG. 4. Comparisons of SPR between the extruded and helically rotated structures. (a) Distributions of peak emission intensity along the azimuthal direction. (b) Emission spectrum.



Selected Results

MEDICAL APPLICATION

BEAM MANIPULATION



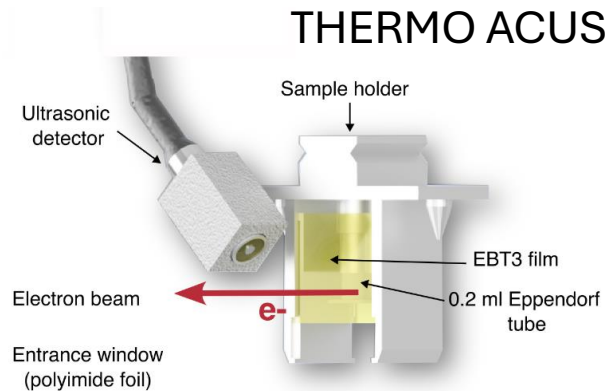
Selected Results

MEDICAL APPLICATION

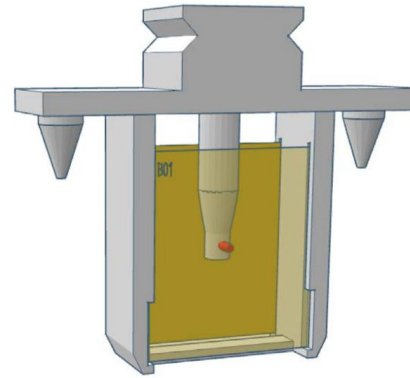
DOSIMETRY



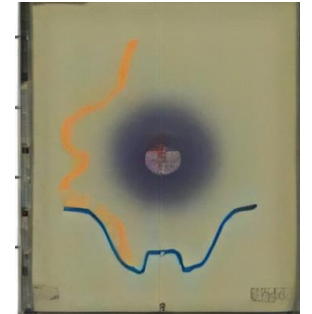
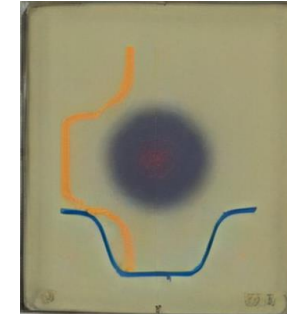
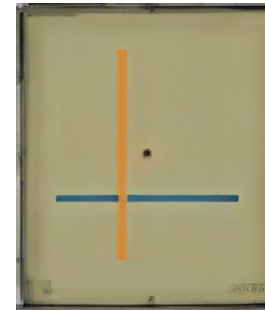
MICRO DIAMOND



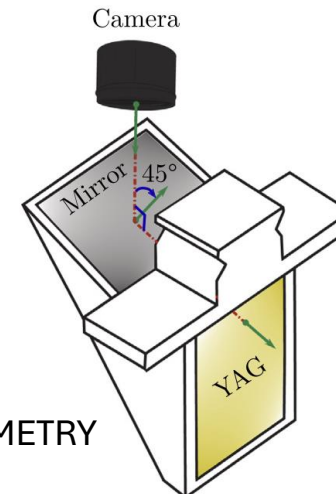
THERMO ACUSTIC



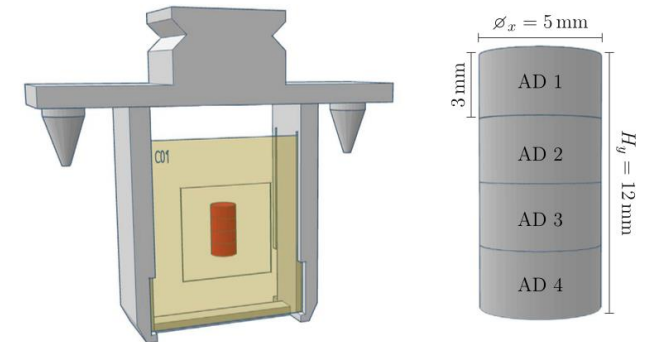
RADIO-PHOTO-LUMINESCENCE
(silver-doped phosphate glass)



RADIO-CHROMIC FILMS



OPTICAL DENSITY DOSIMETRY



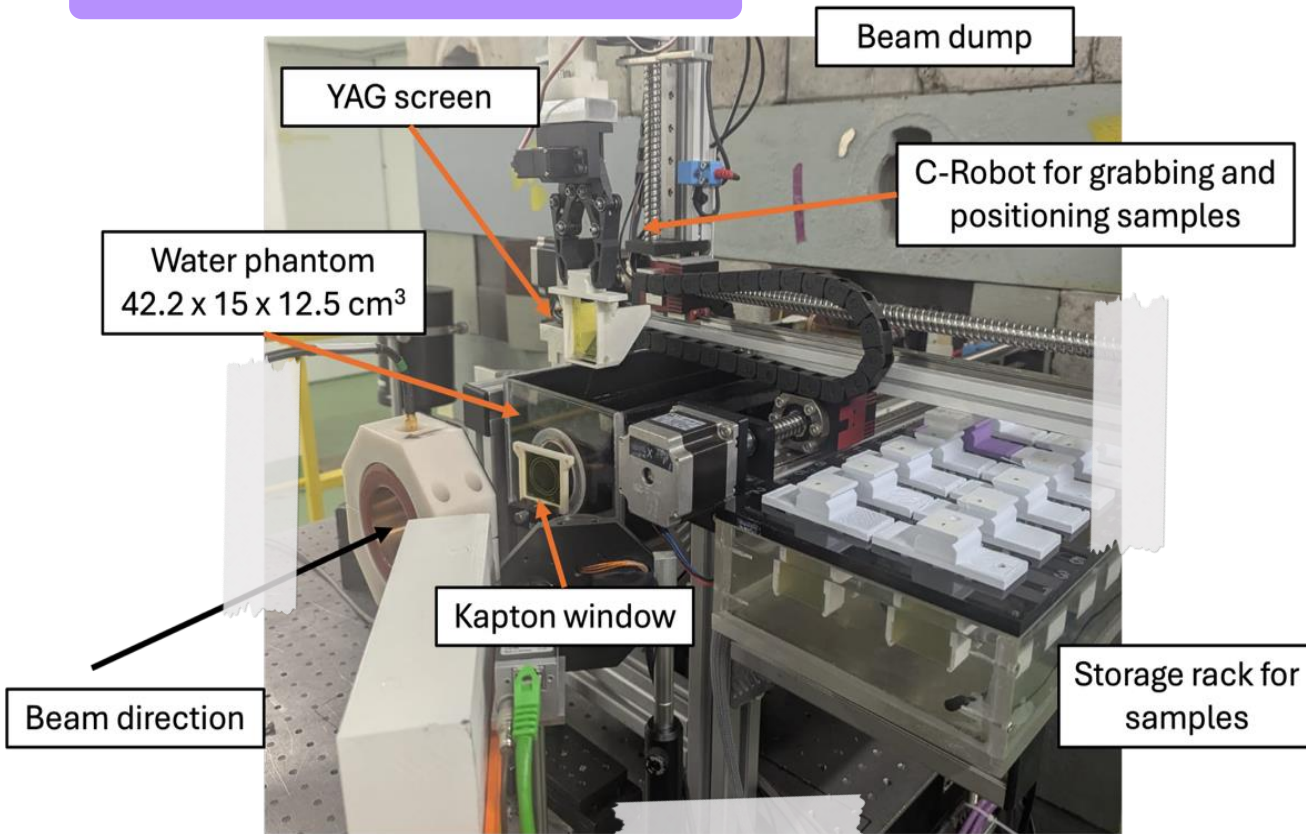
ALANINE

doi: 10.1016/j.nima.2024.169845
doi: 10.3389/fphy.2025.1597079

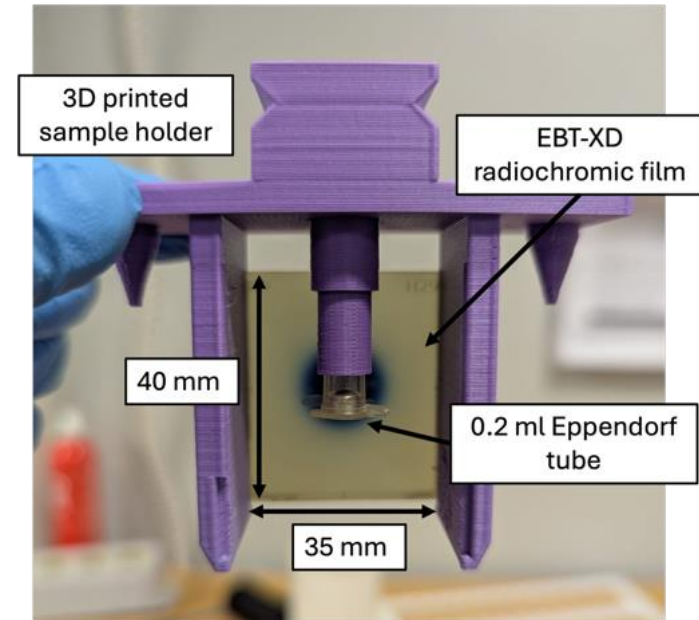
Selected Results

MEDICAL APPLICATION

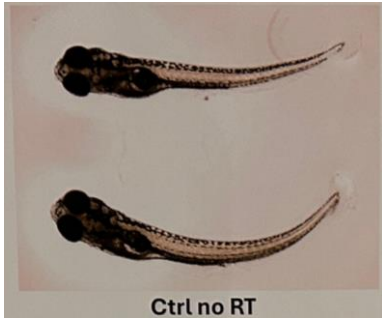
DOSIMETRY



All the medical experiment have used the CLEAR Robot to perform their irradiation.

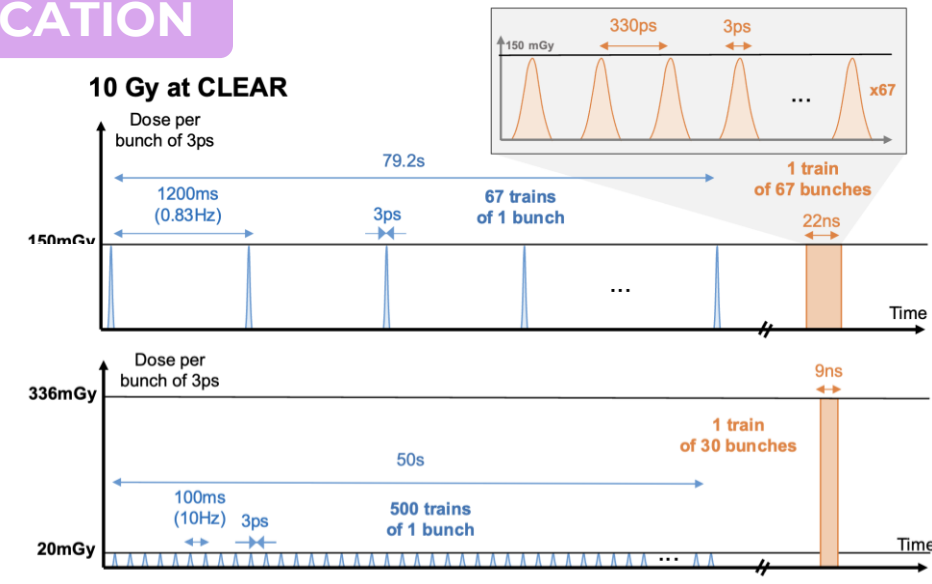


Selected Results

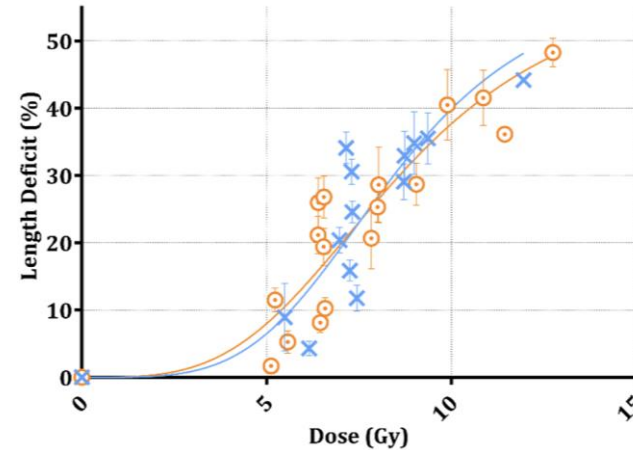


MEDICAL APPLICATION

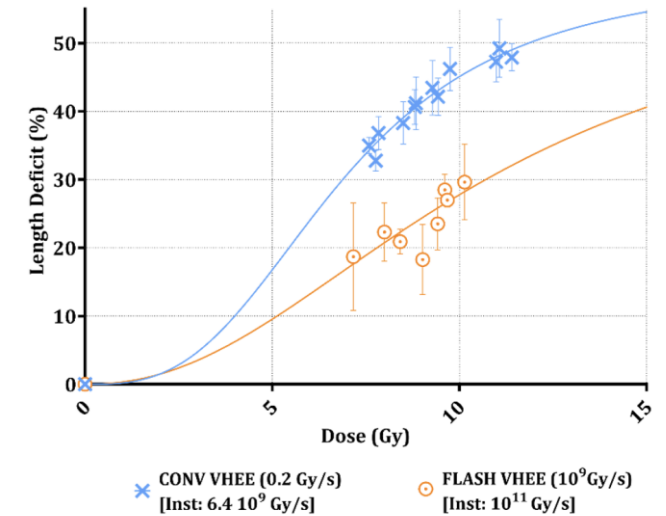
EXAMPLE #1



Same “instantaneous” dose rate



Factor ~ 15 in “instantaneous” dose rate



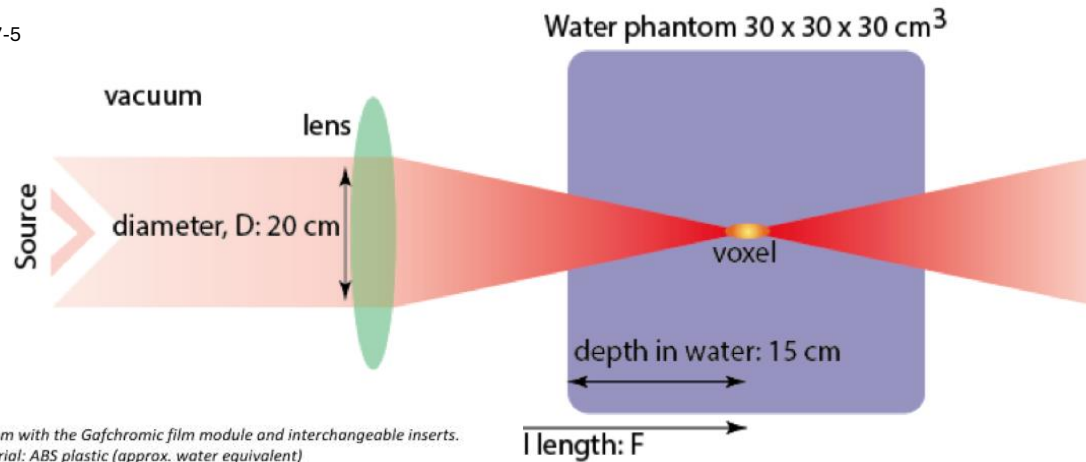
Forst observation of FLASH sparing effect with a VHEE beam!

Selected Results

MEDICAL APPLICATION

EXAMPLE #2

doi: 10.1038/s41598-024-60997-5

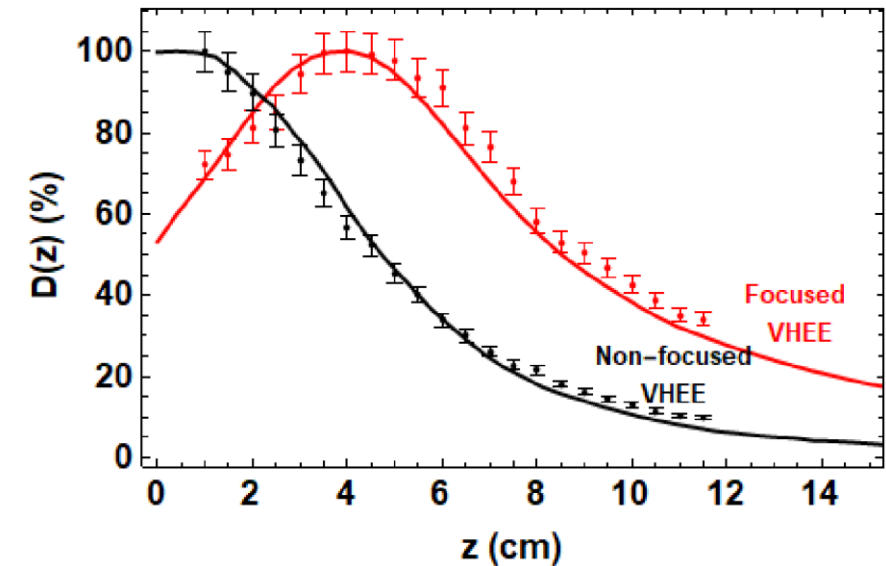
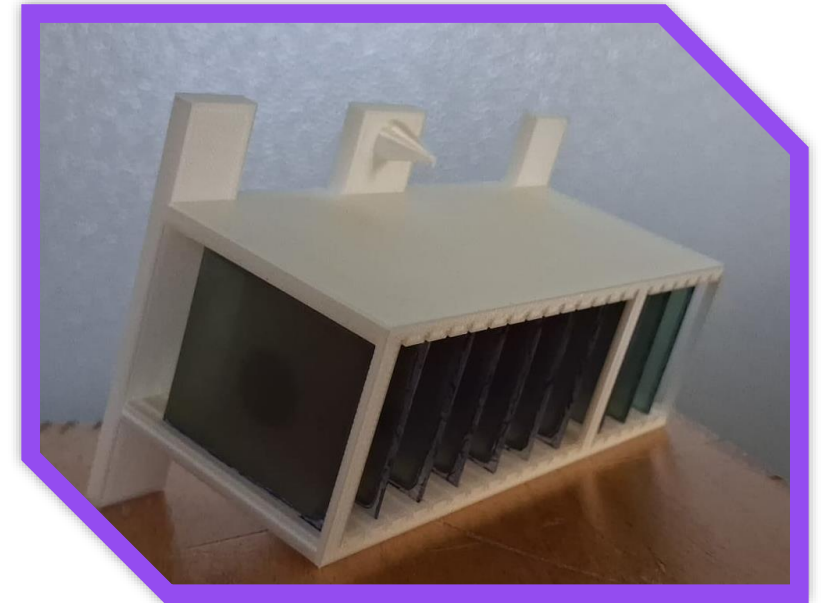
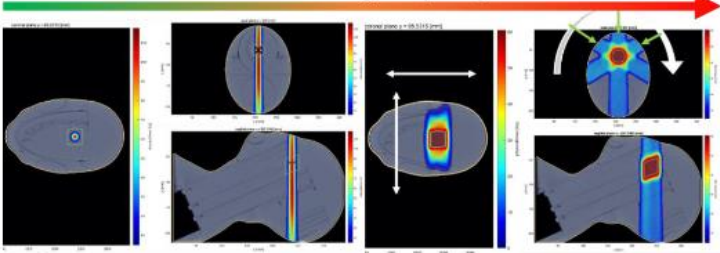


Marvin (head and neck) phantom with the Gafchromic film module and interchangeable inserts.

- Material: ABS plastic (approx. water equivalent)
- Dimensions: 41 × 21 × 33 cm³ - Weight: 9 kg.

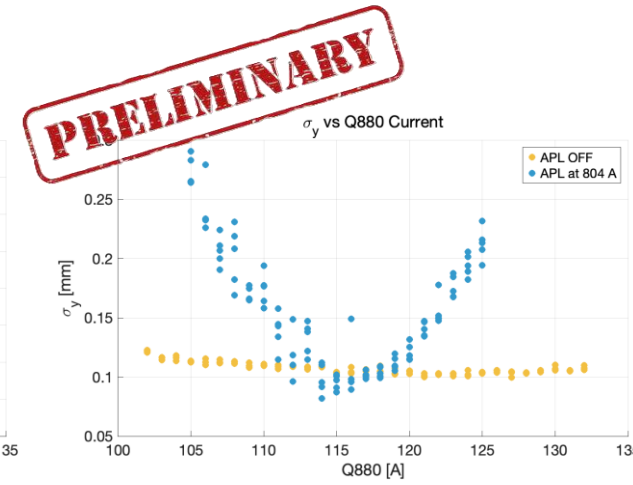
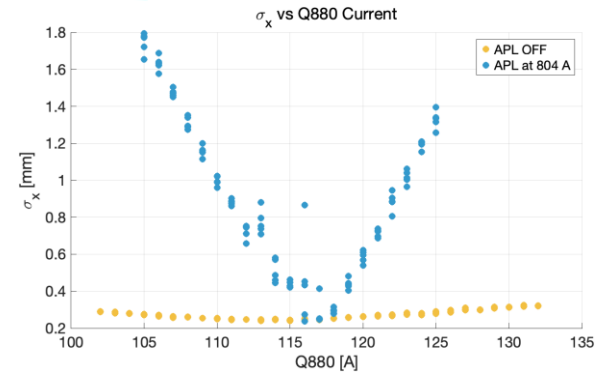
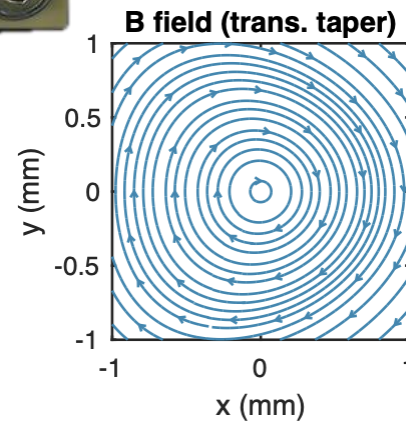
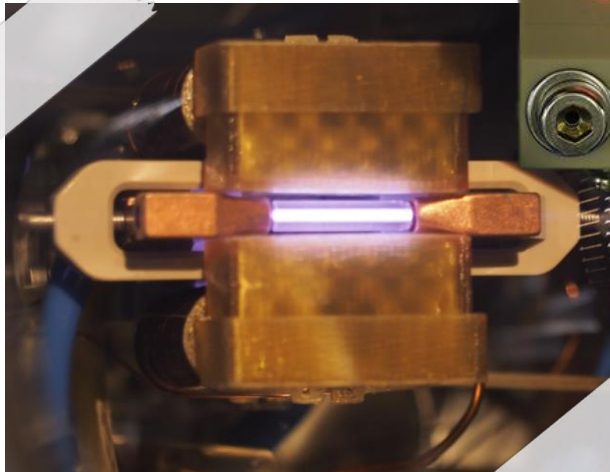
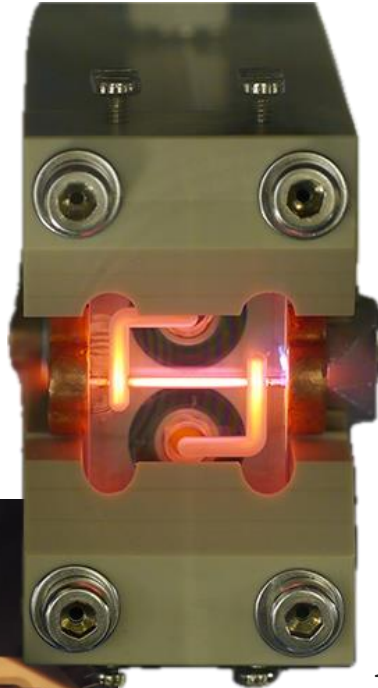
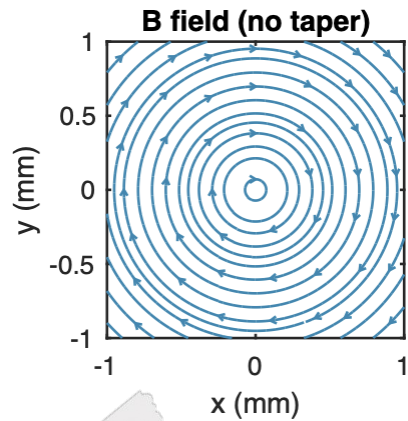


Increasing Complexity



Selected Results

SHARP

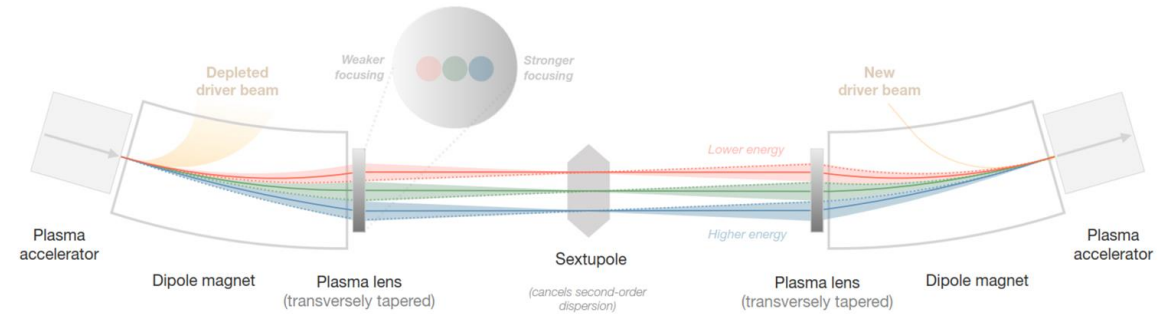


Quadrupole scans with & without APL

doi: 10.1088/1742-6596/3266/1/012014

doi:10.1016/j.nima.2025.170223

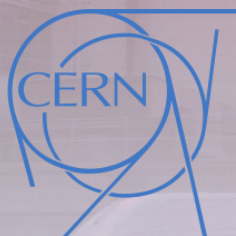
SPARTA



Conclusion & Outlook

- ❑ CLEAR provides a unique and highly flexible testbed for a wide range of accelerator studies. Furthermore, the team and the facility enable rapid iteration from idea to beam test.
- ❑ CLEAR will operate at least through 2030 (with no long shutdown currently foreseen), providing a stable platform for future studies. The facility welcomes new experimental proposals from anyone with a strong idea to test.
- ❑ Last year was an outstanding year — by far the most impactful for our infrastructure.
- ❑ Expect a general growth of user/request driven by facility schedule over the next year
- ❑ The scientific portfolio is broad, and all the results are impressive, each having a significant impact in its respective field. Let's keep the gradient.

Thanks
for the attention!

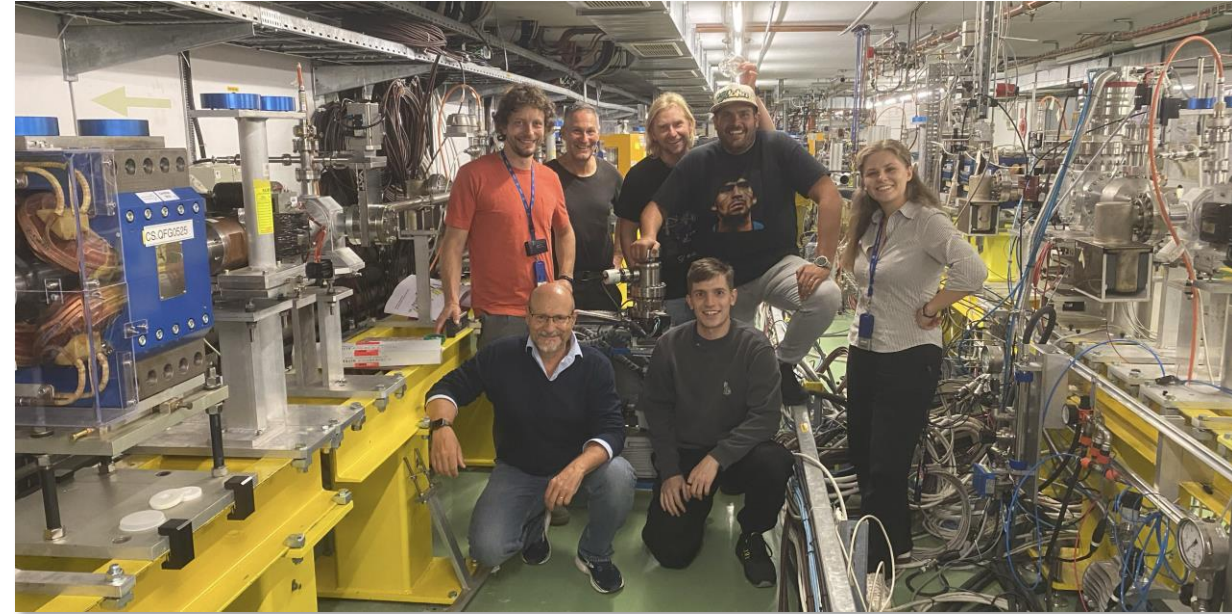


clear 

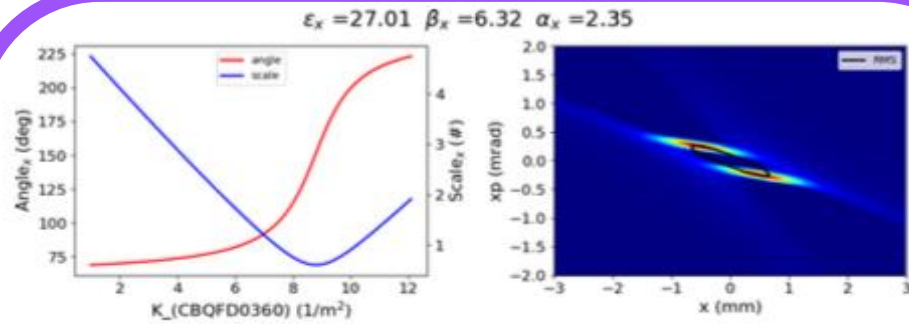
TEAM



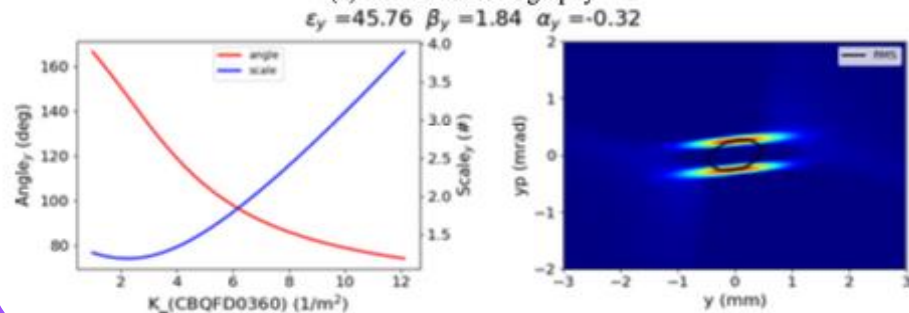
ADDITIONAL SLIDES



ADDITIONAL SLIDES

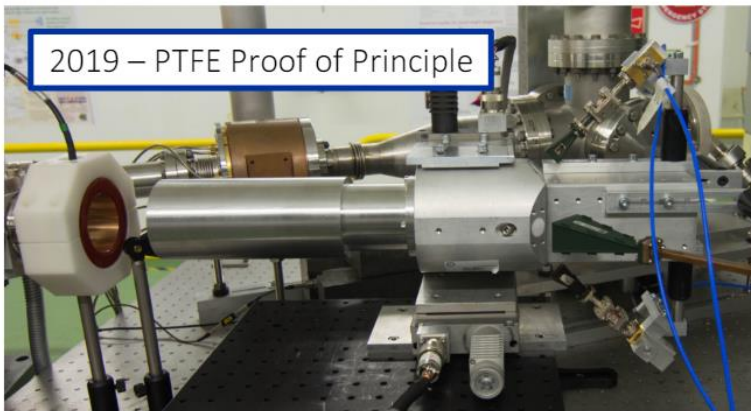


(a) Horizontal tomography

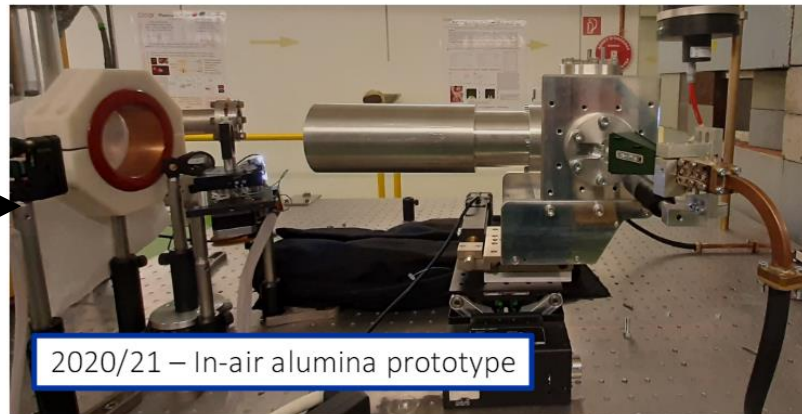


(b) Vertical tomography

2019 – PTFE Proof of Principle



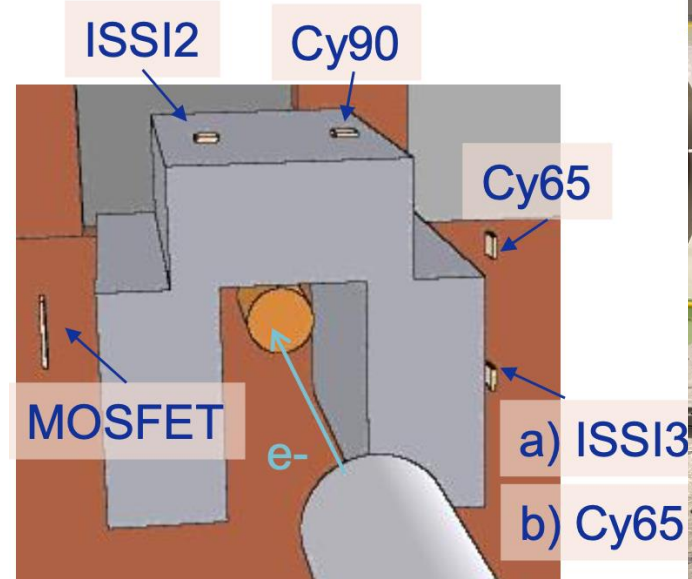
2020/21 – In-air alumina prototype



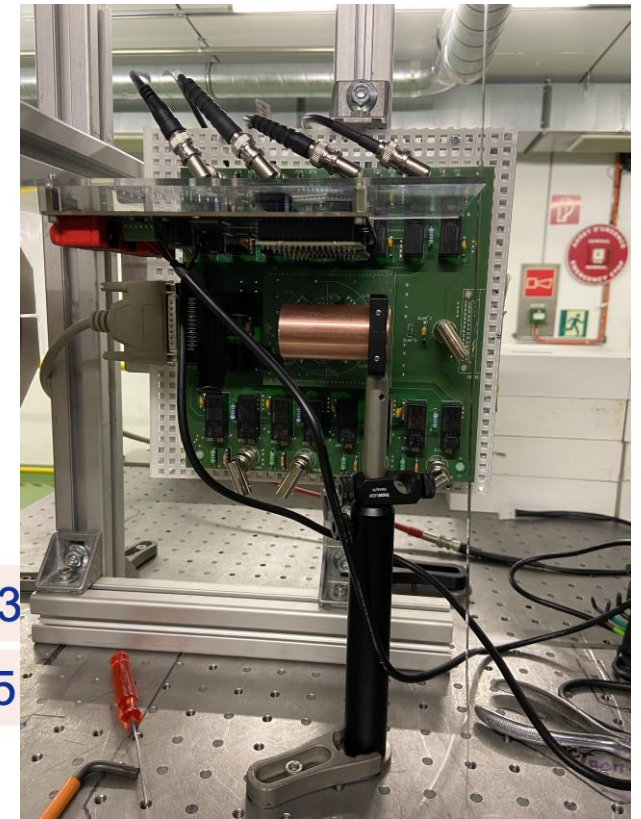
2022 – Vacuum version



ADDITIONAL SLIDES

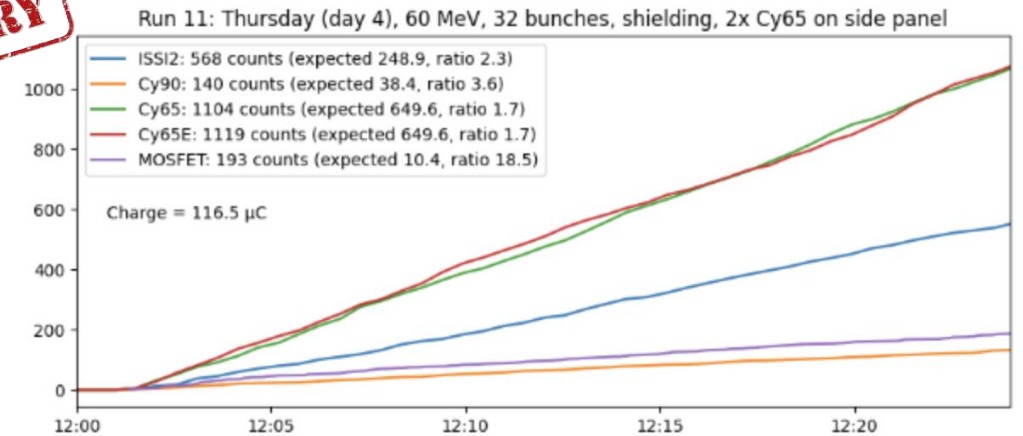


Courtesy G. Lerner & M. Cecchetto

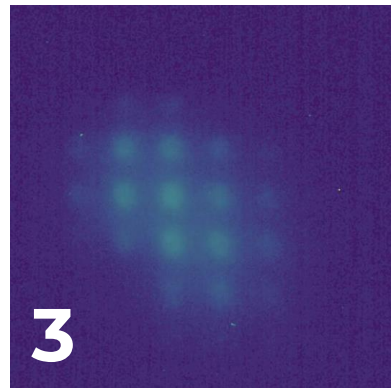
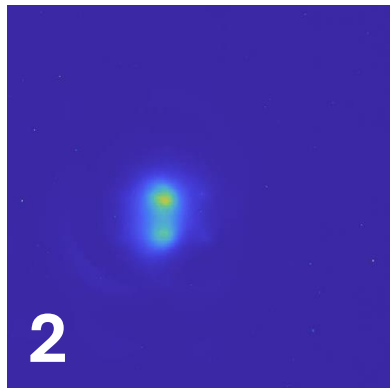
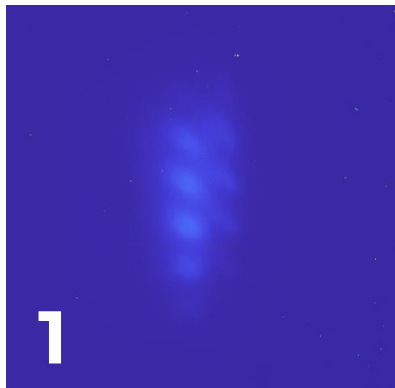
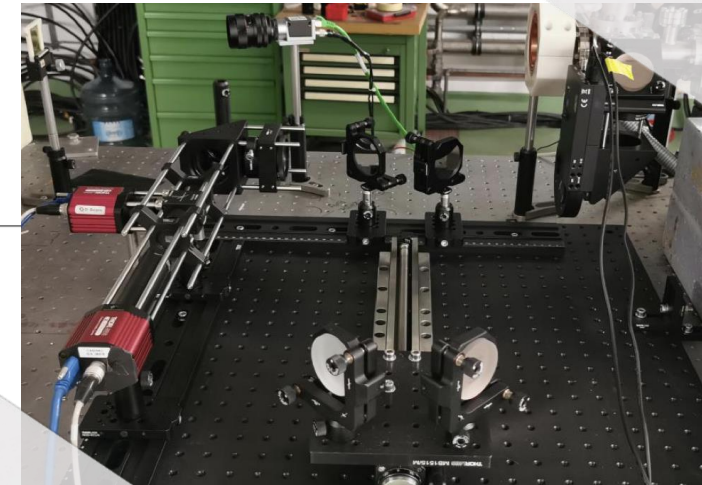
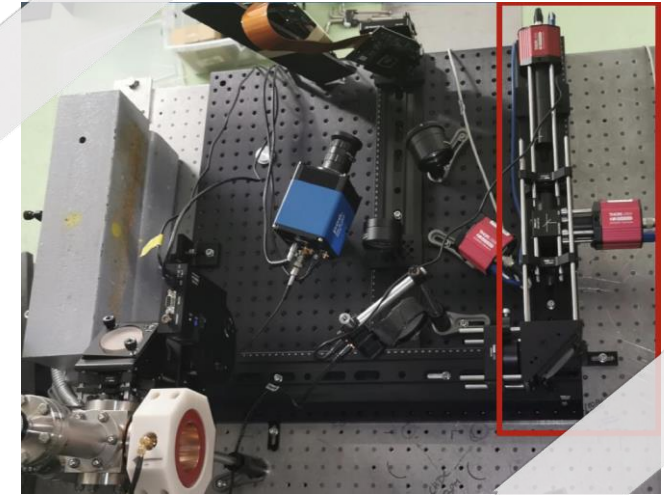
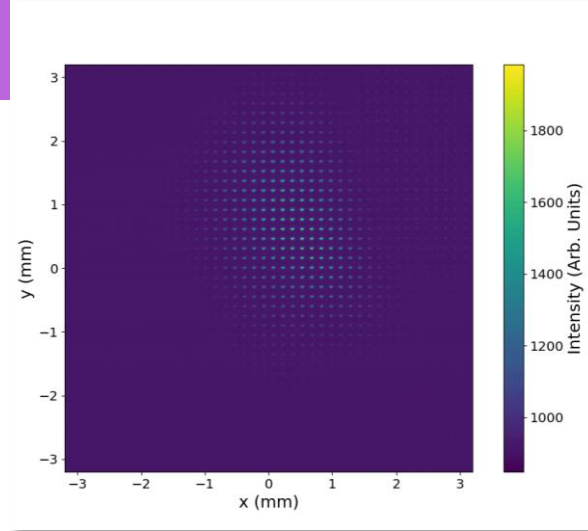
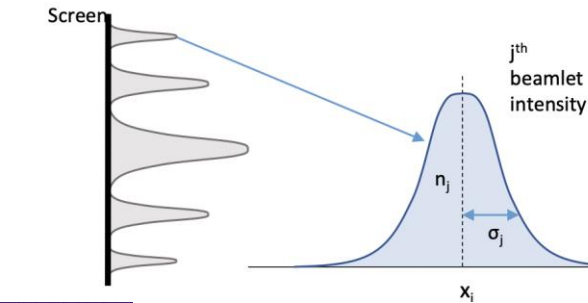
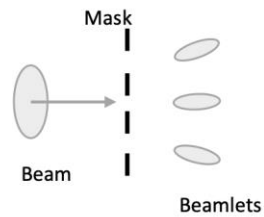
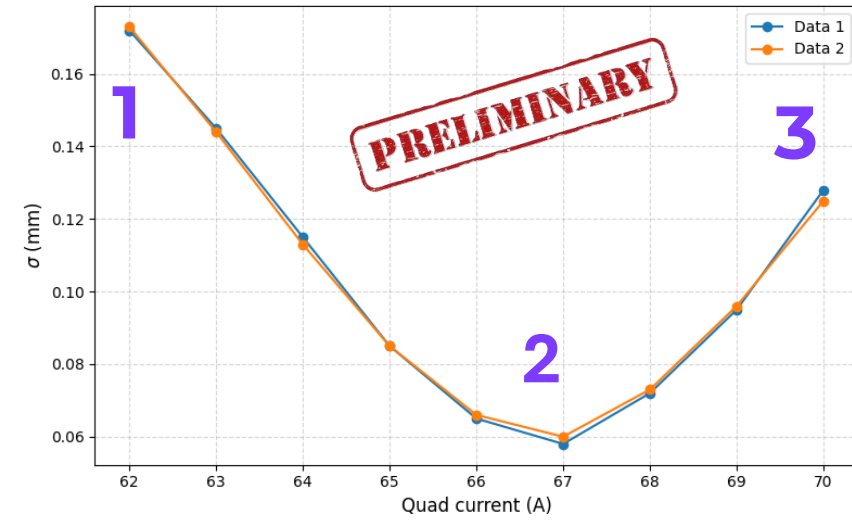


PRELIMINARY

- 3 different setups
- 5 different energies (28MeV, 32MeV, 40MeV, 60MeV, 80MeV)

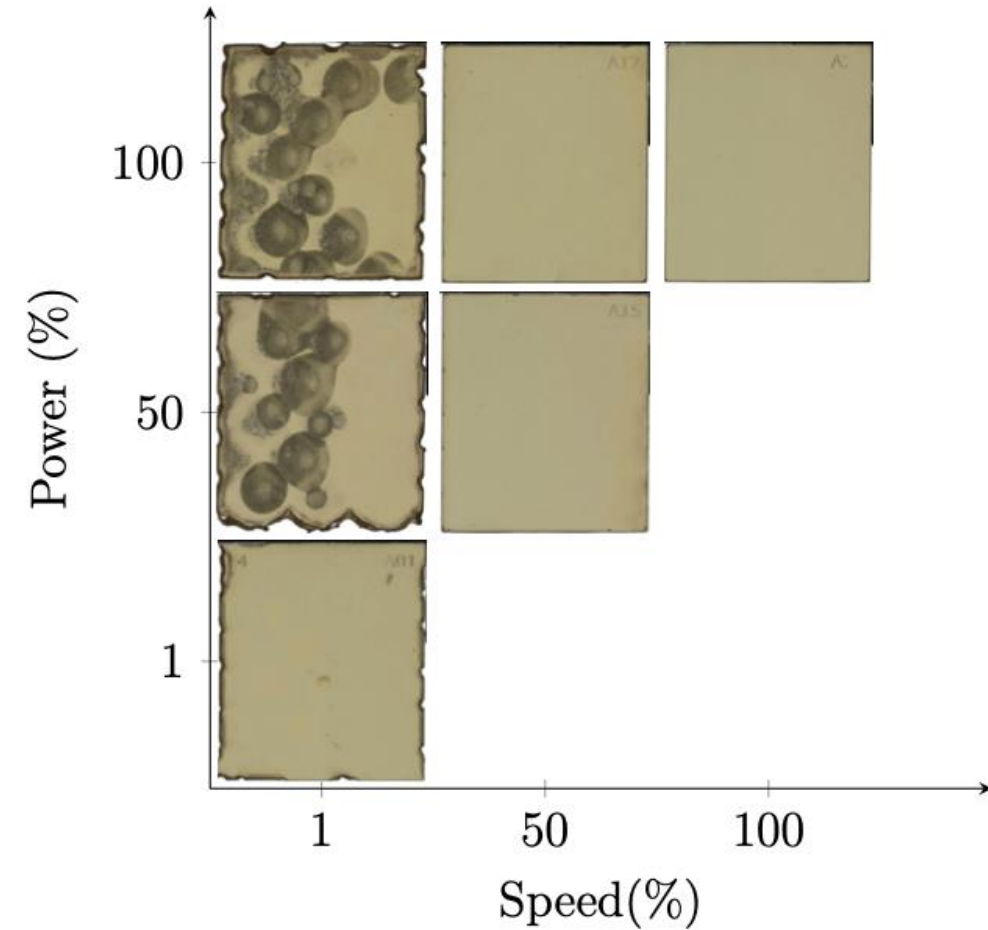
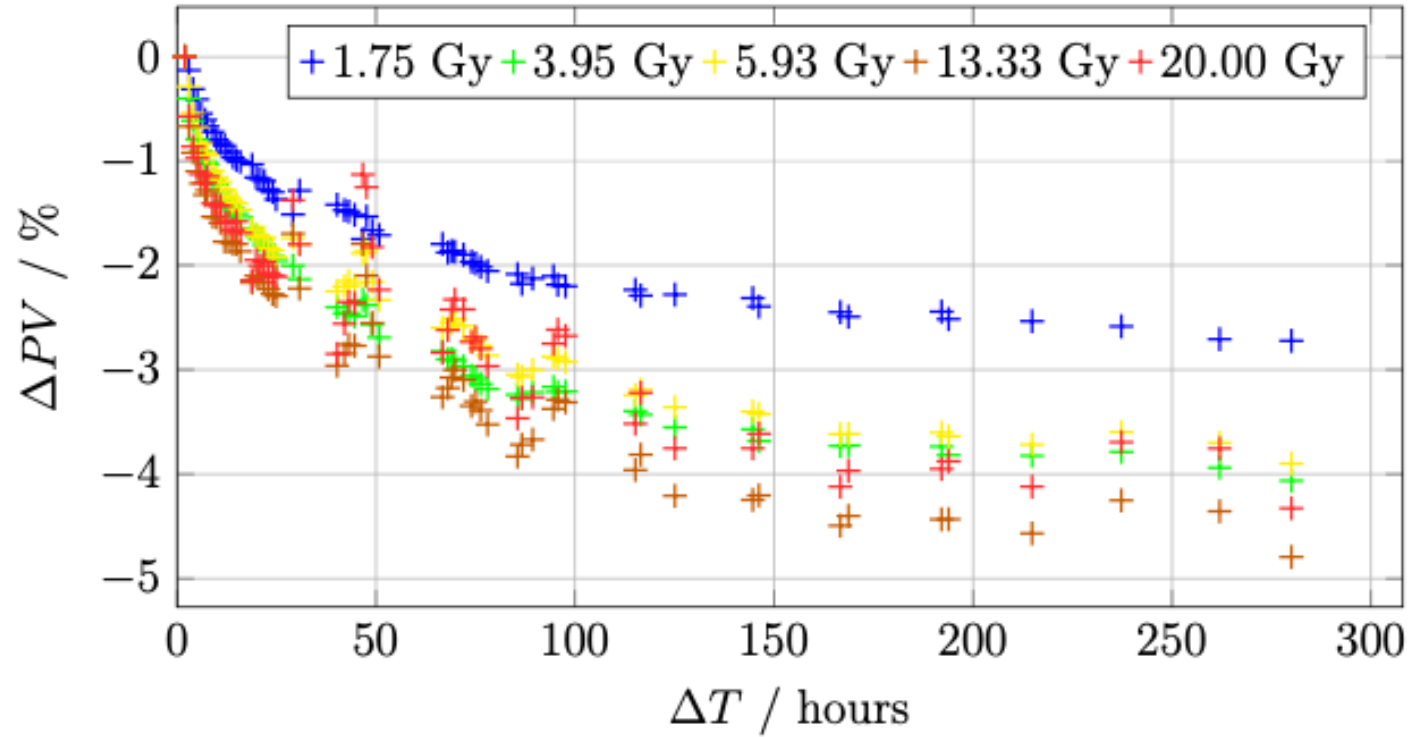


ADDITIONAL SLIDES

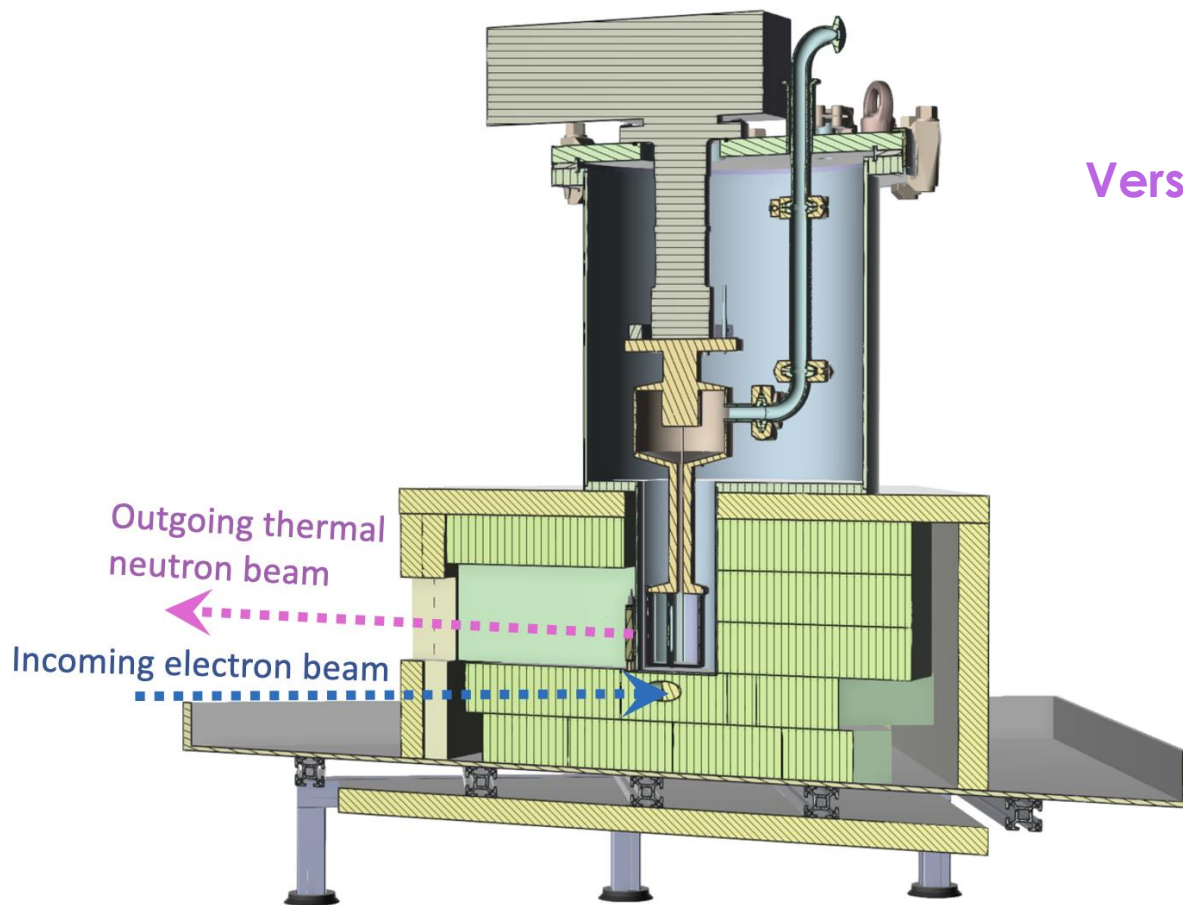


Courtesy of J. Wolfenden

ADDITIONAL SLIDES



doi: 10.3389/fphy.2025.1597079

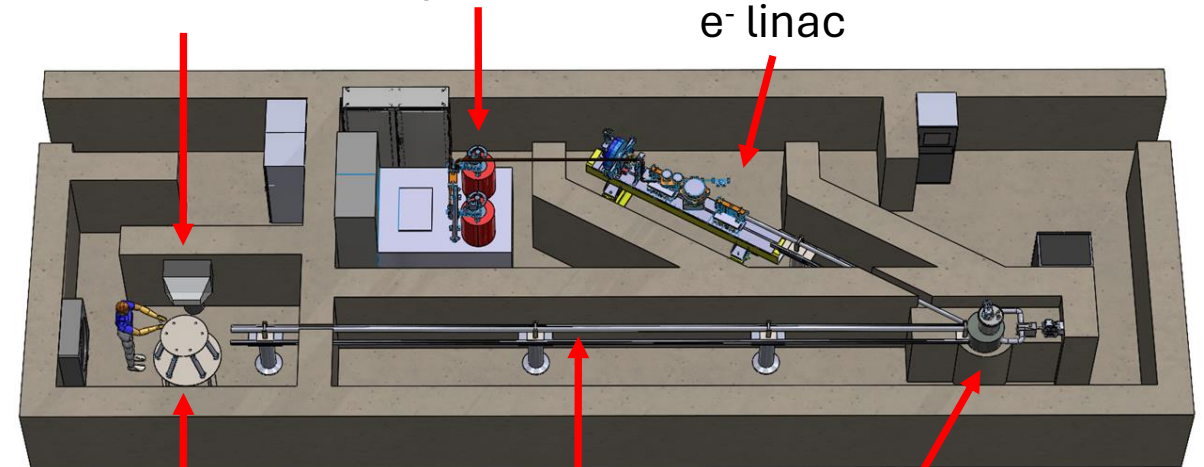


Versatile Ultra-Compact Advanced Neutron generator

Neutron Detector

Klystrons

e^- linac



Test Stand

Neutron Guide

TMR

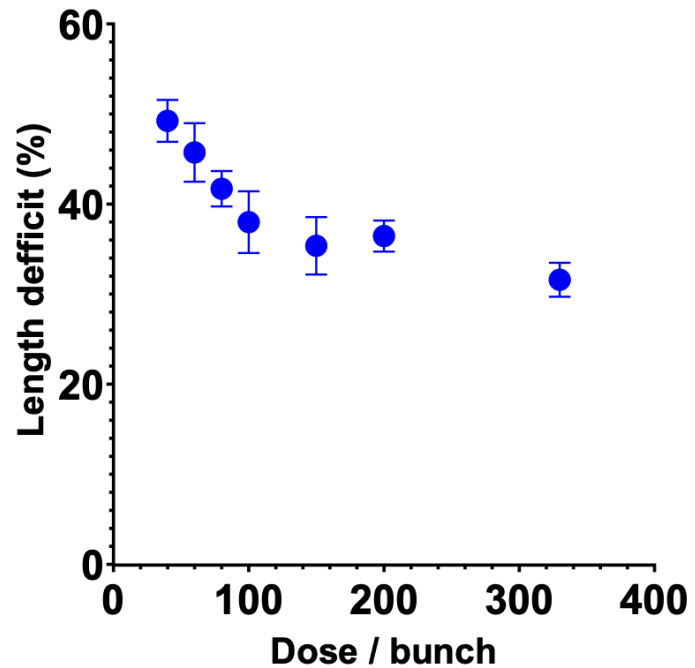
(Target-Moderator-Reflector)

ADDITIONAL SLIDES

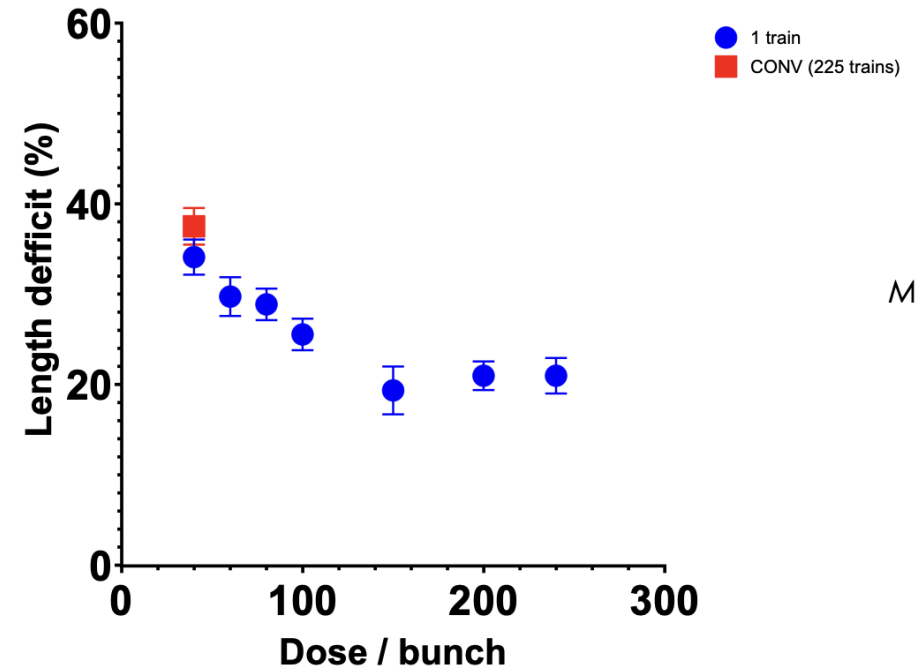
ADDITIONAL SLIDES

doi: 10.1016/j.radonc.2025.110942

2025.07.03_CERN_Flat_ABWT_4hpf_9Gy_Dose bunch
escalation_1train_curve

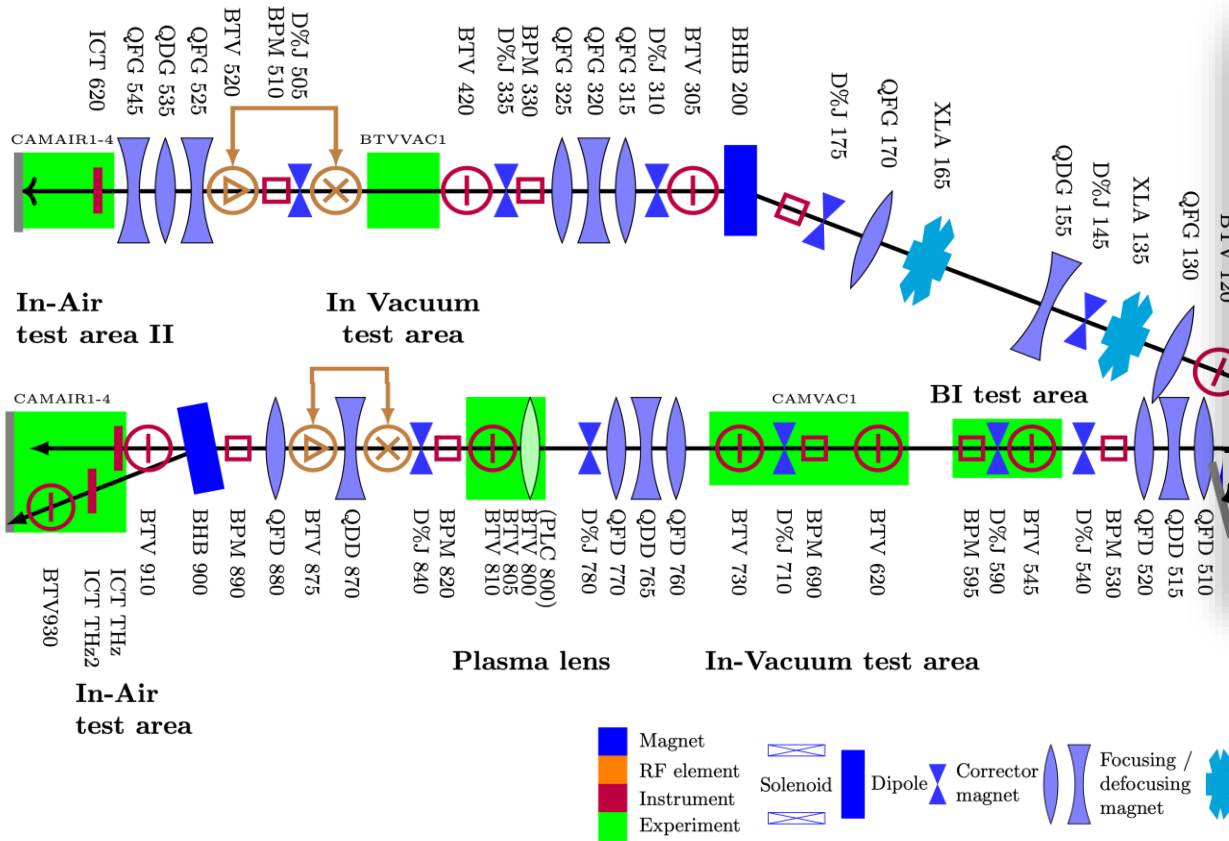


2025.07.16_CERN_Flat_ABWT_4hpf_9Gy_Dose bunch
escalation_1train_curve



ZFE

Main Features & Parameters



~20m



VESPER

EOS

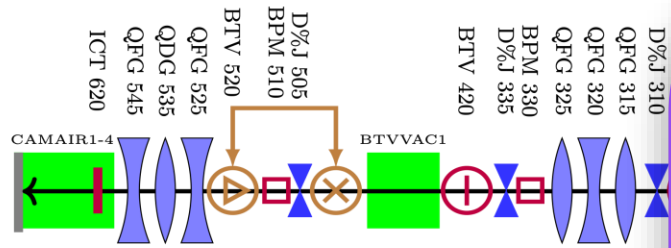
Scattering System



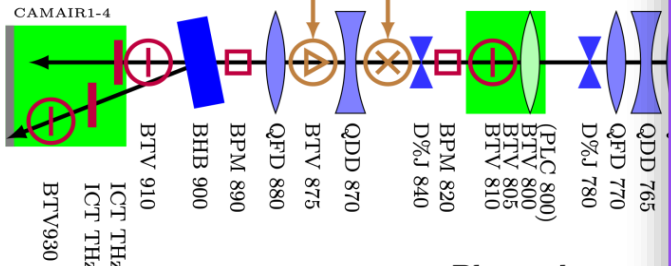
~20m



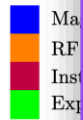
Main Features & Parameters



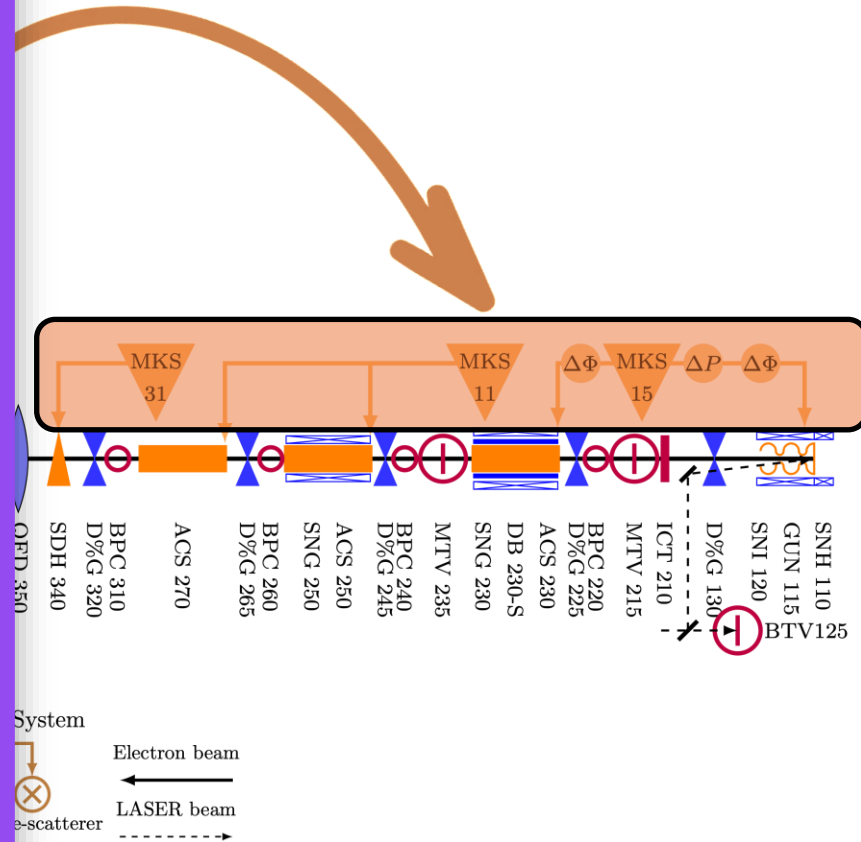
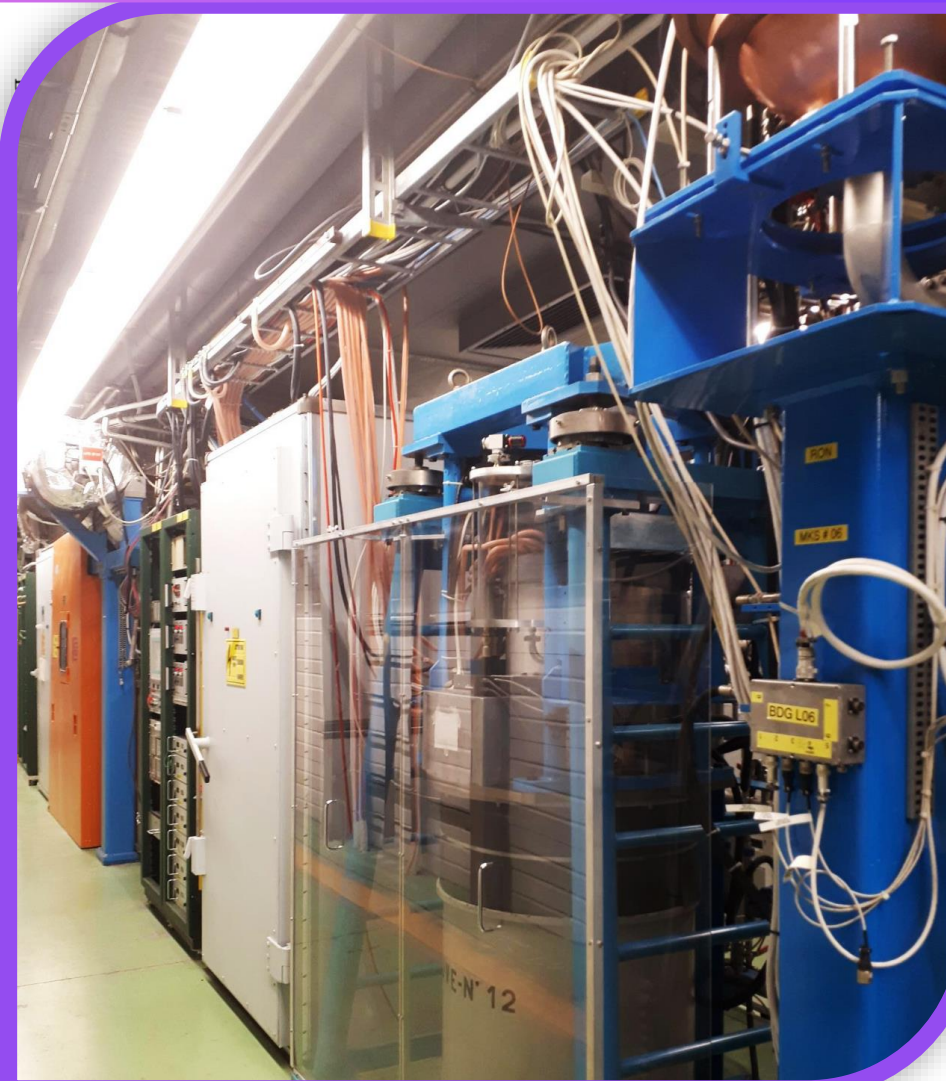
In-Air test area II



Plasma lens

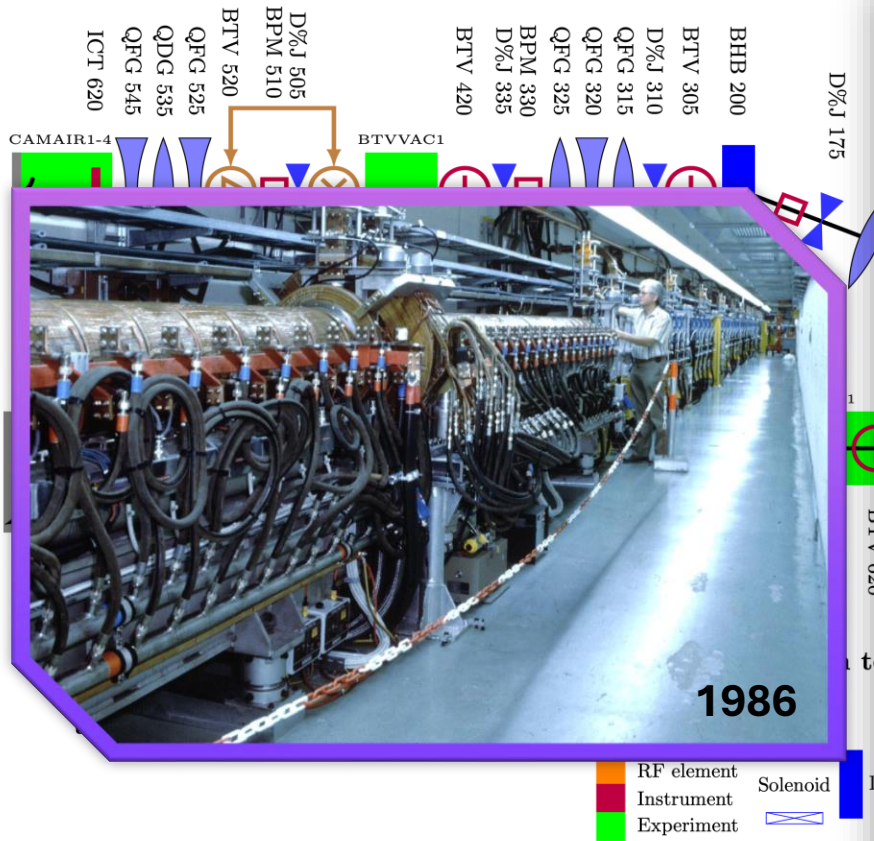


~20m



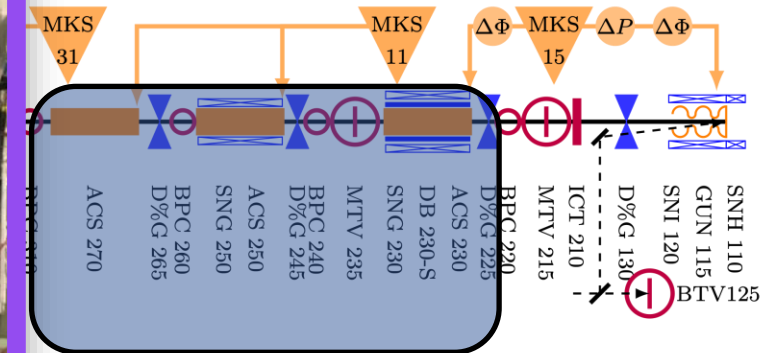
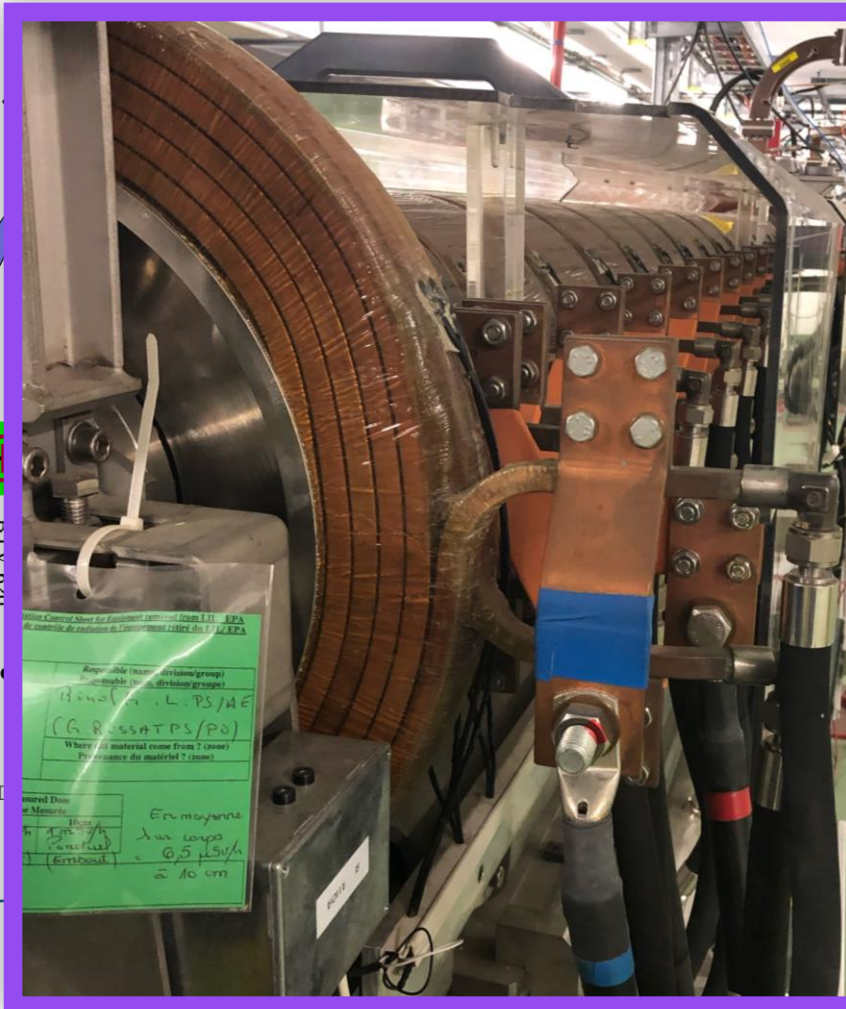
~20m

Main Features & Parameters



1986

~20m

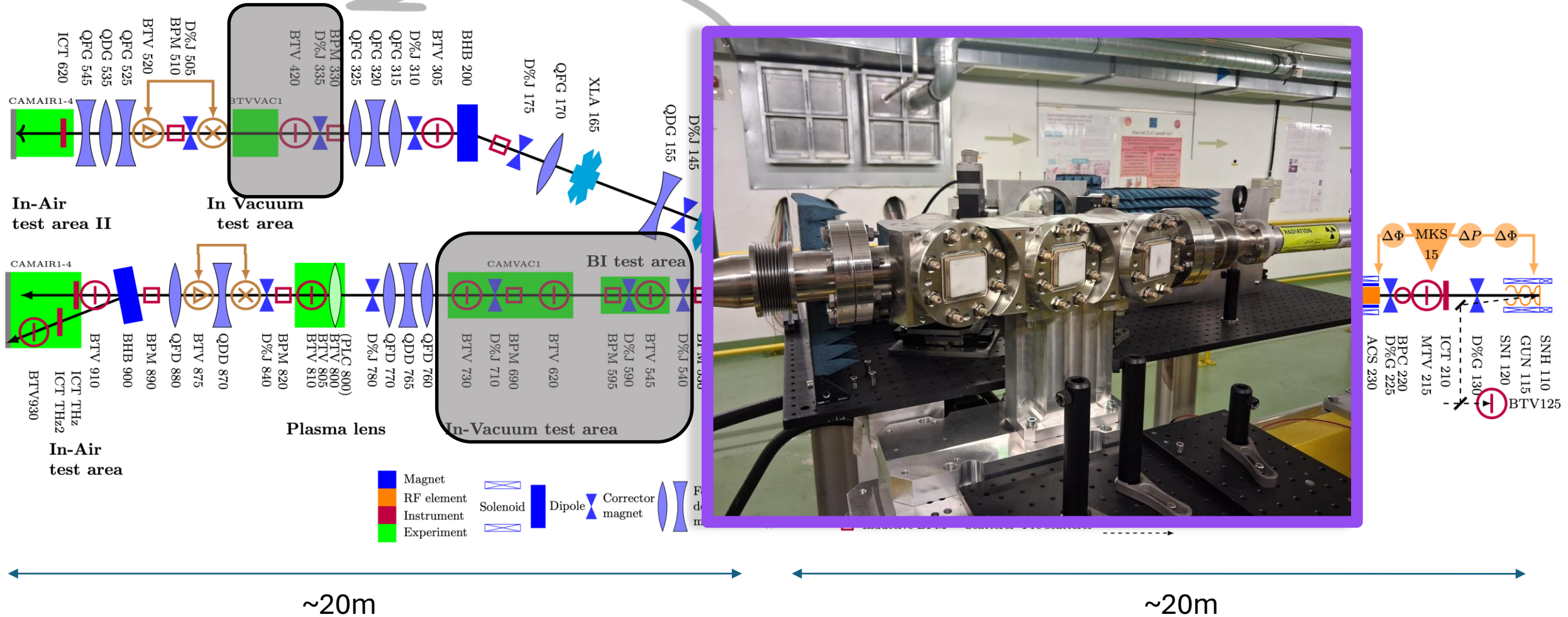


Electron beam
LASER beam

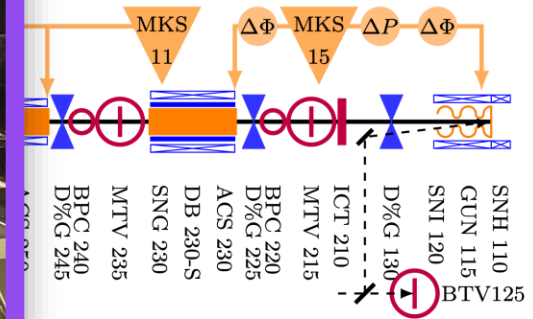
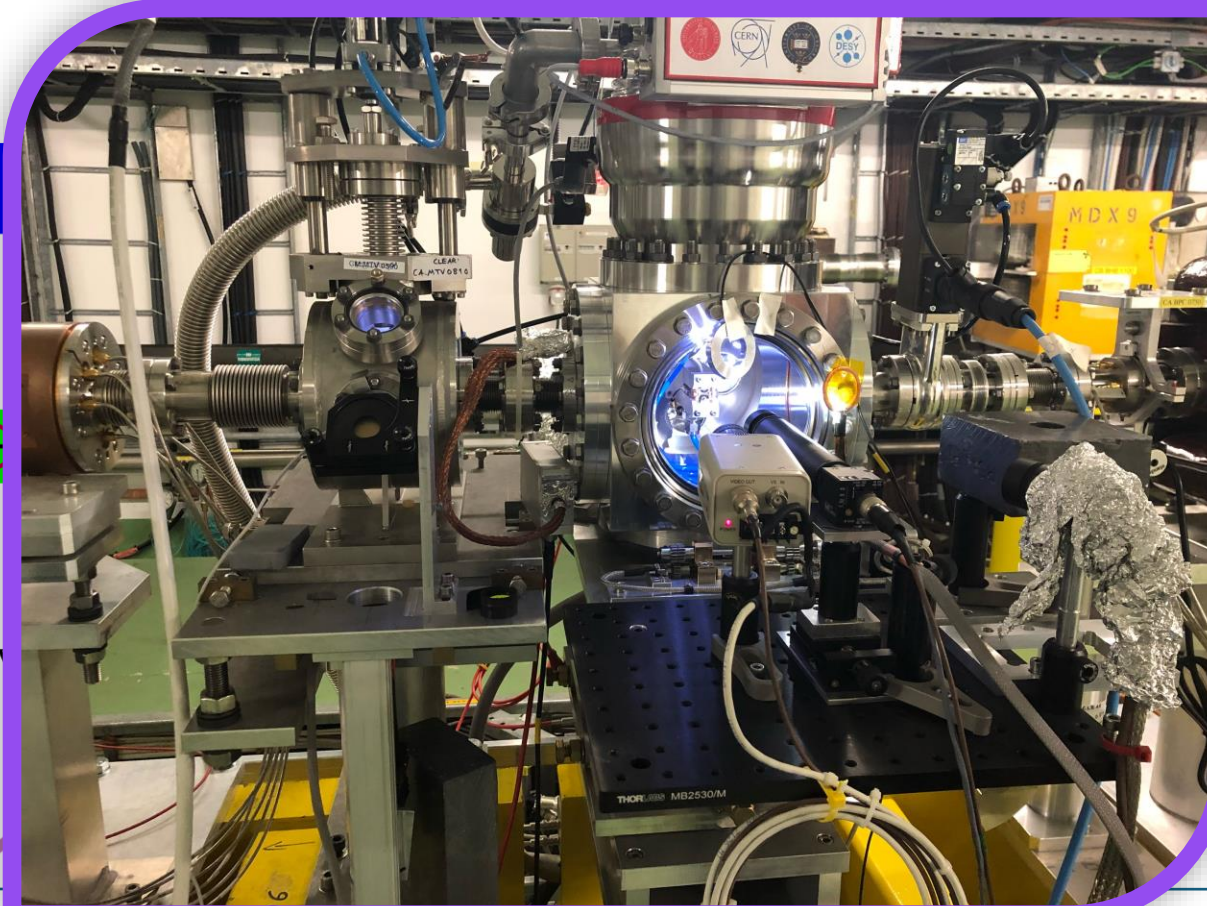
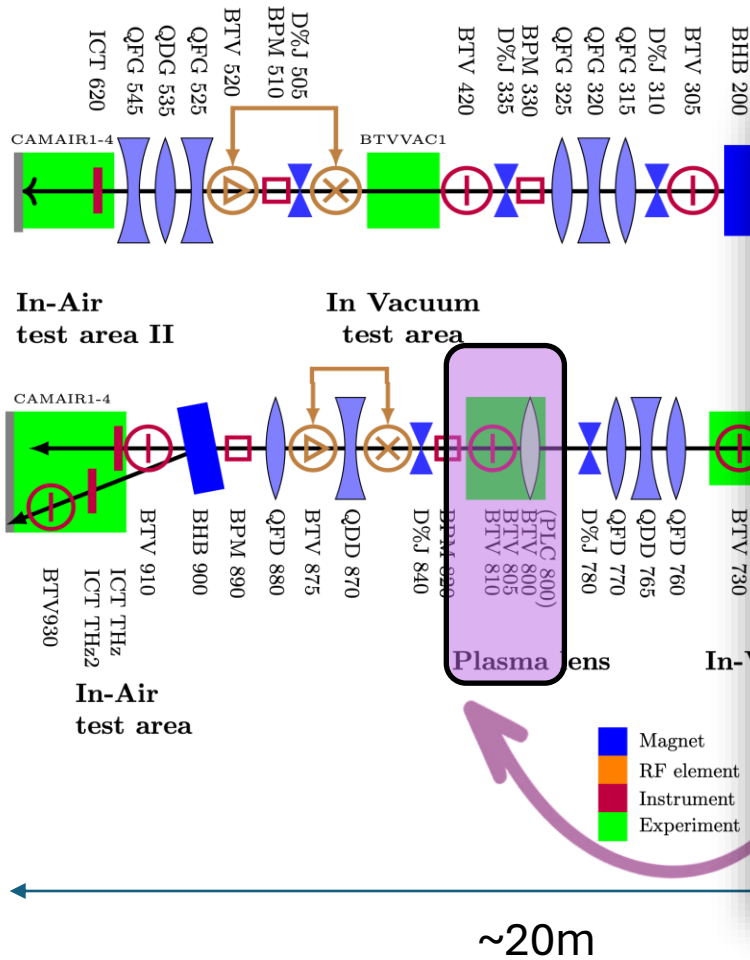
~20m

The diagram illustrates the FEL beamline layout, showing the electron beam path (solid line) and the laser beam path (dashed line). The layout is divided into several sections: In-Air test area II, In Vacuum test area, VESPER, EOS, and a final section with various diagnostics. The electron beam path starts from the left, passes through a series of bending magnets (B), quadrupoles (Q), and dipole magnets (D), and ends at the right. The laser beam path starts from the right, passes through a series of mirrors and lenses, and ends at the left. A large green arrow indicates the direction of the electron beam. A legend at the bottom identifies the symbols used: blue oval for focusing/focusing magnet, blue star for sextupole, red circle with a dot for BTV screen, red circle with a cross for cavity BPM, red square for inductive BPM, and orange triangle for scattering system. A scale bar at the bottom indicates a length of approximately 20 meters.

Main Features & Parameters

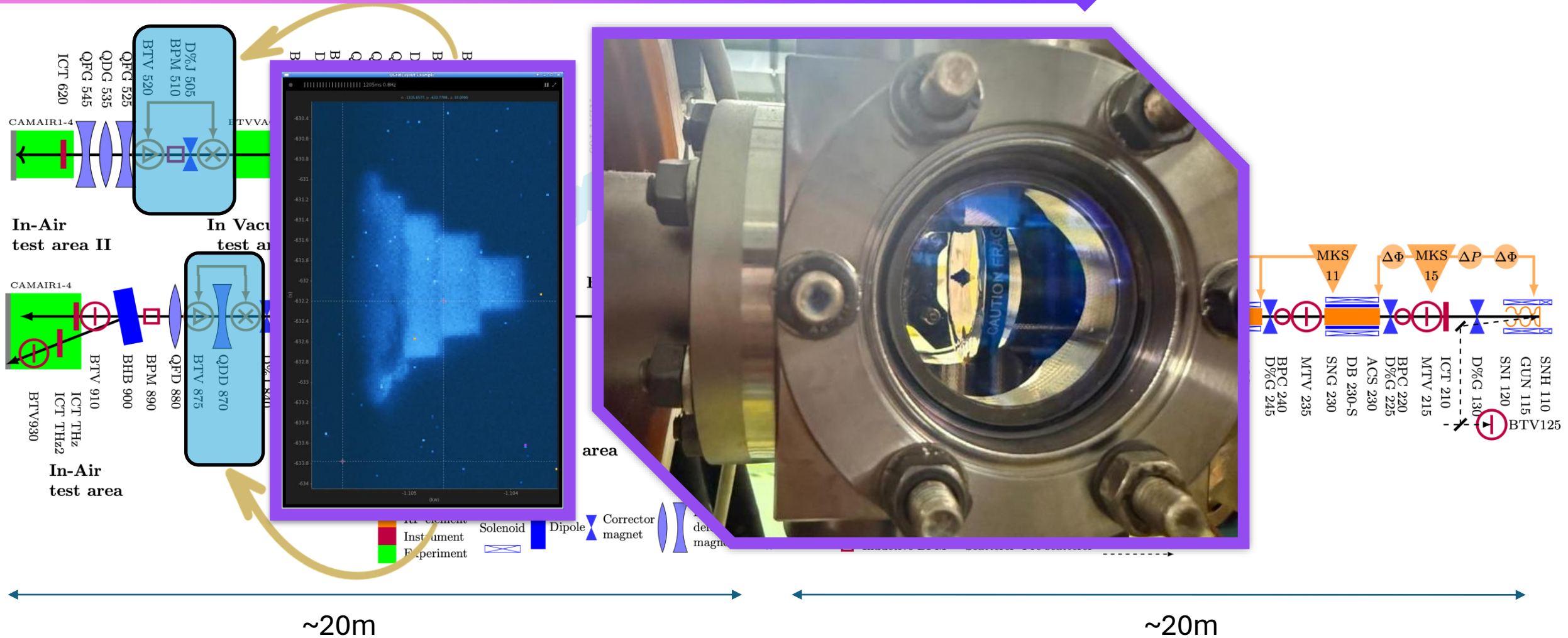


Main Features & Parameters



~20m

Main Features & Parameters



Main Features & Parameters

