MICRON (Miniaturised aCceleRatOrs Network)

Giuseppe Torrisi

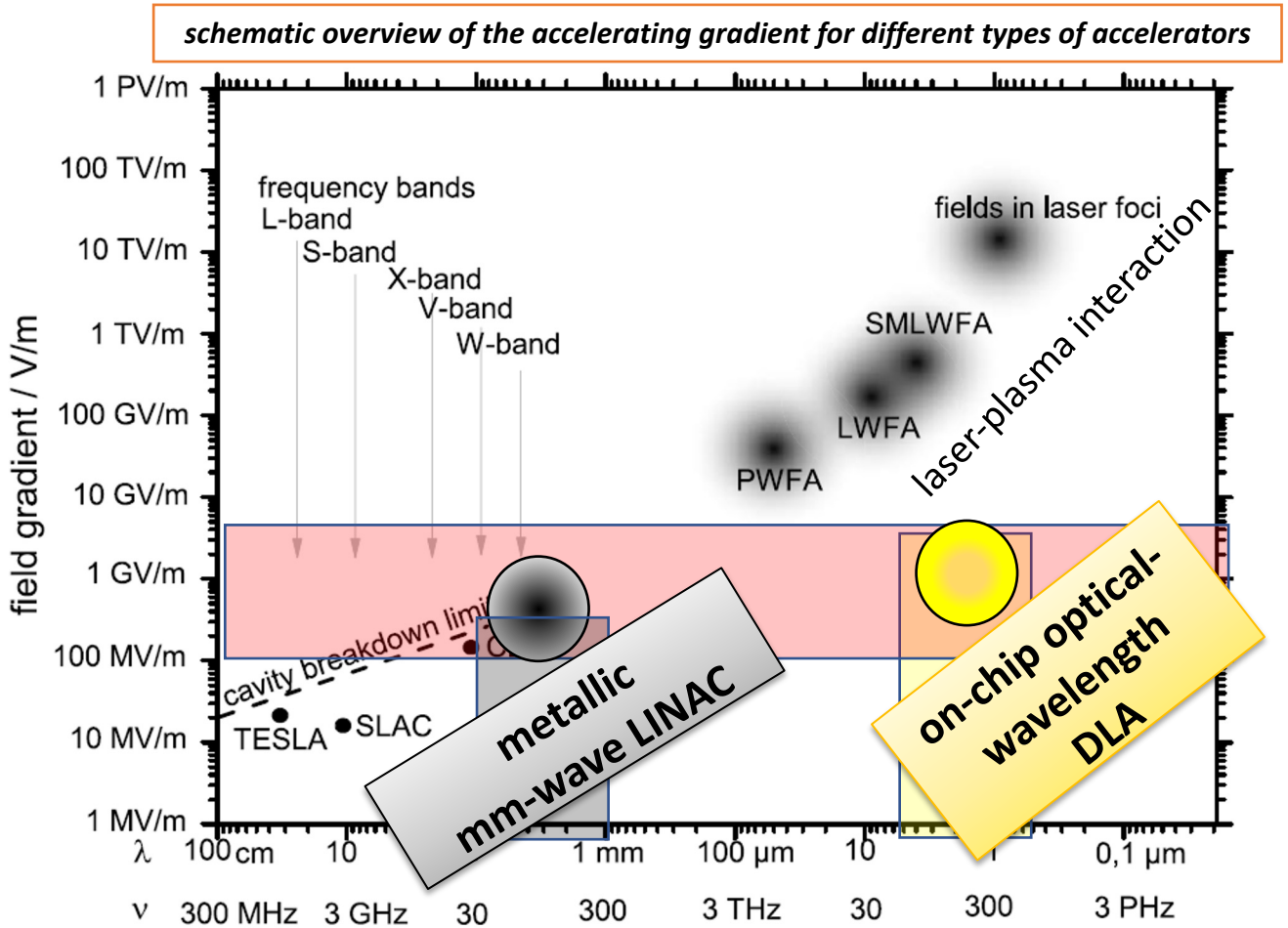
Obiettivi generali

High accelerating gradients enable compact/miniaturized particle accelerators

MAIN GOAL of the PROPOSAL: Miniaturization of Accelerating Structures

1) **Feasibility studies supported/driven by fabricability proofs for optical dielectric accelerating structures**. *(simpler power feeding network, achieving of MeV scale energy, beam quality) as valid alternative/solution with respect to the side-pumped dual pillar phase reset devices.*

- **2) Fabrication and "cold" RF test of Ka-band metallic structures**: *to investigate the processes, materials, technology and welding procedure used to manufacture accelerating components in order to achieve the maximum*



Attività 2023

MILESTONES for Dielectric structures

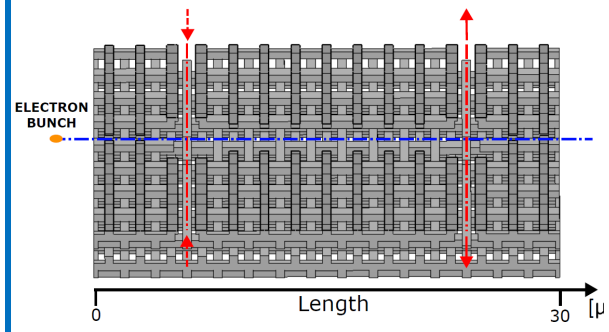
1) Couple EM fields from Ansys HFSS/CST MW Studio to ASTRA/PIC-CST beam dynamic code **(100%)**
2) Selection of one or more dielectric electromagnetic structure **(70%)**

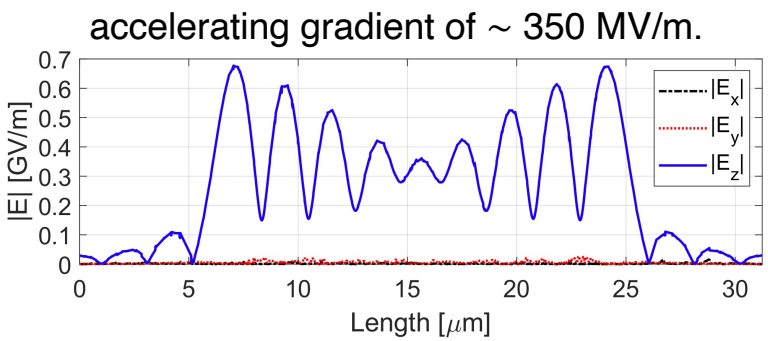
MILESTONES for Metallic structures

1) Evaluation of the Beam dynamics parameters **(100%)**
2) Prototype Mechanical Draw Ka-band metallic prototype **(80%)**

Attività 2023 MILESTONES for Dielectric structures

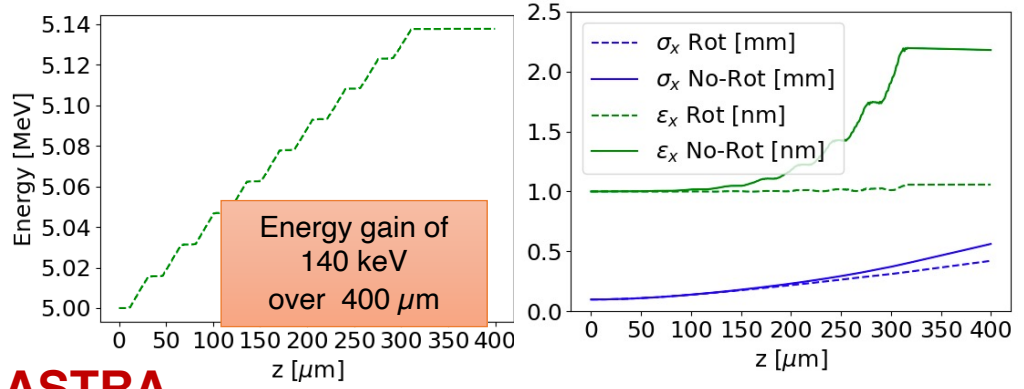
1) couple EM fields from **Ansys HFSS/CST MW Studio** to **ASTRA/PIC-CST** beam dynamic code **(100%)**



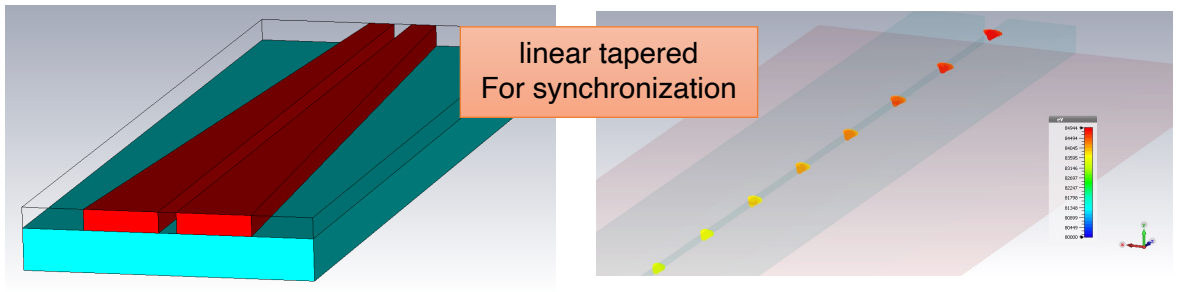


***Relativistic* (β=1)** *Silicon woodpile at* λ= 5 μm **[1]**

Ansys HFSS

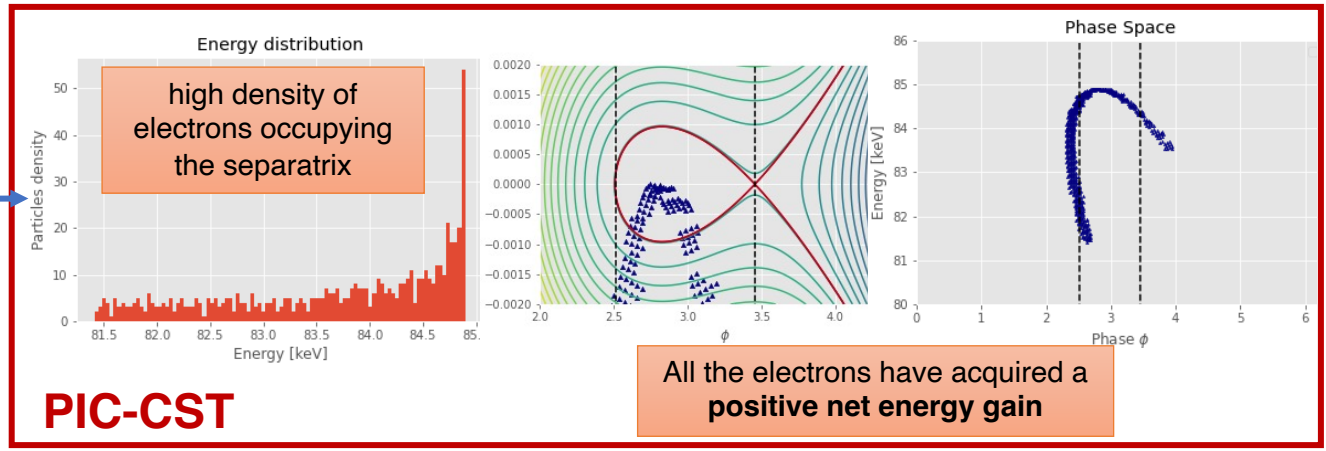


ASTRA



Subrelativistic $(0.4 < \beta < 0.75)$ *Silicon on Silica slotted waveguide* λ= 1.55 μm **[2]**

CST MW Studio



PIC-CST

[1] G. S. Mauro et al., "*MeV scale simulations and fabrication tests of woodpile-based waveguide for Dielectric Laser Accelerators*, 14th IPAC '23, Venezia (Italy), May 7-12, 2023

[2] A. Leiva Genre, Master Thesis DFA-UniCT, "Modelling of Tapered Co-propagating Structures for Dielectric Laser-driven Accelerators" (DLA)

Attività 2023 MILESTONES for Dielectric structures

2) Selection of one or more dielectric electromagnetic structure **(70%)**

The first woodpile structure prototypes have been printed employing **Laser Nanofab's FemtoBond** 4B resin
The fabrication followed **two main different routes:**
a) **polymerization of the "negative" sacrificial structure.** This "negative" structure is subsequently infiltrated with Si by means of a Chemical Vapour Deposition (CVD) technique and finally the original printed "negative" volume is removed by chemical etching;

b) the second route involves the **direct polymerization** of the "final" positive structure followed by a **pirolysis to obtain a dielectric material with the final desired Properties** of by or **perform the double inversion process.**

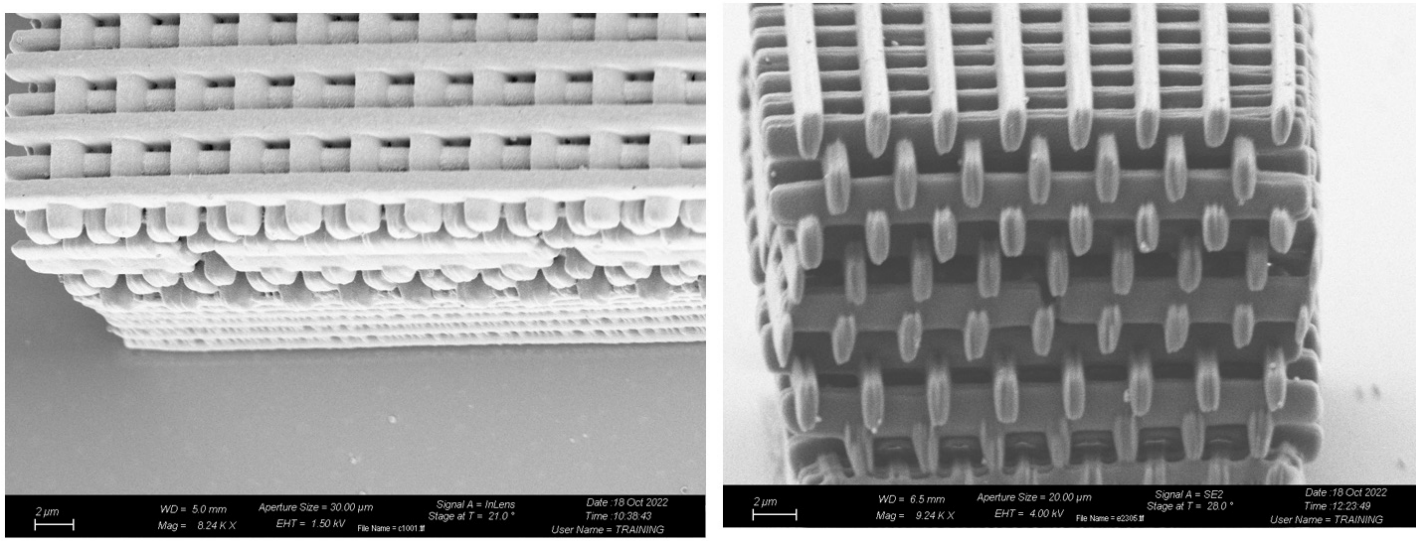
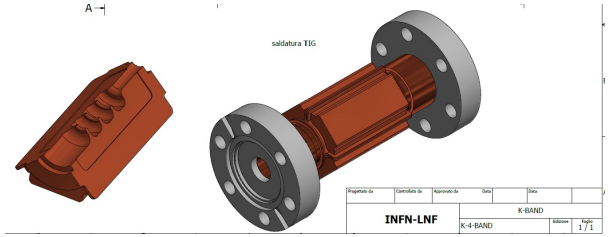


Figure 3: (a) Side and (b) front view of a woodpile prototype (λ0 = 5 µm) realized through the Two Photon Polymerization technique with b) method.

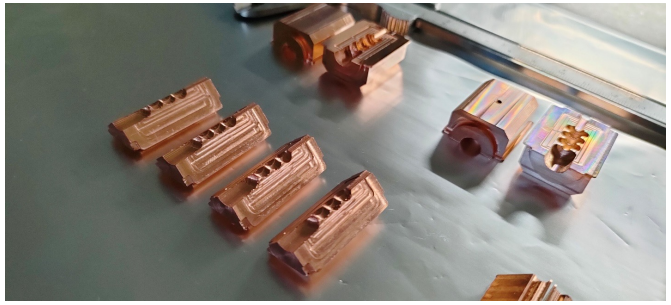
Attività 2023 MILESTONES for Metallic structures

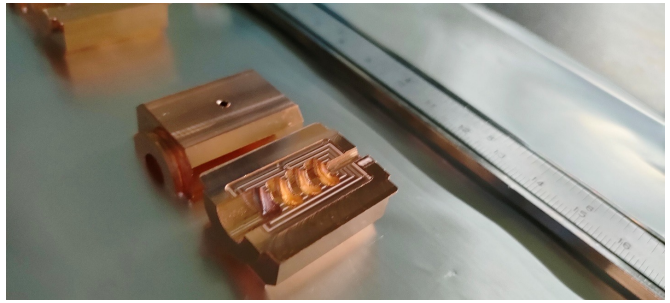
1) Evaluation of the Beam dynamics parameters **(80%)**
2) Prototype Mechanical Draw Ka-band metallic prototype **(80%)**

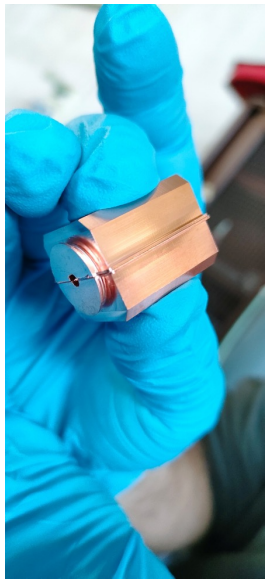
Drawing of the 4-quadrants structure prototype for TIG welding and morphological tests.



Machined sectors for the 4-quadrants Cavities

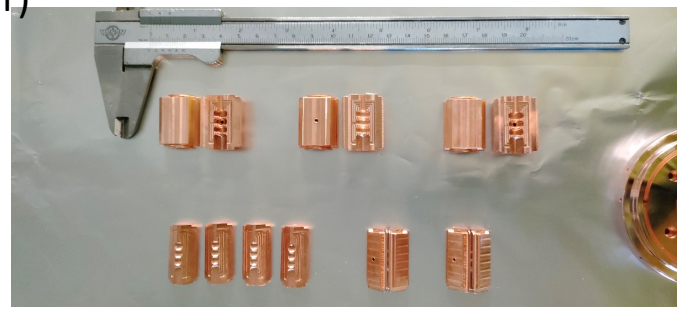






- ❑ All cavity sectors were manufactured by using a CNC 5-axis milling machine.
- ❑ Machining tool is crucial:
- ➢ Tungsten-carbide tool → Tolerance = +- 10 µm; Roughness with Ra = 1.6 µm.
- ➢ Diamond tool with spherical radius < 1 µm → Tolerance = +- 5 micron; Roughness with Ra < 80nm.

multi-cell cavity with mode launcher (this year)



Attività 2024

- DIELECTRIC

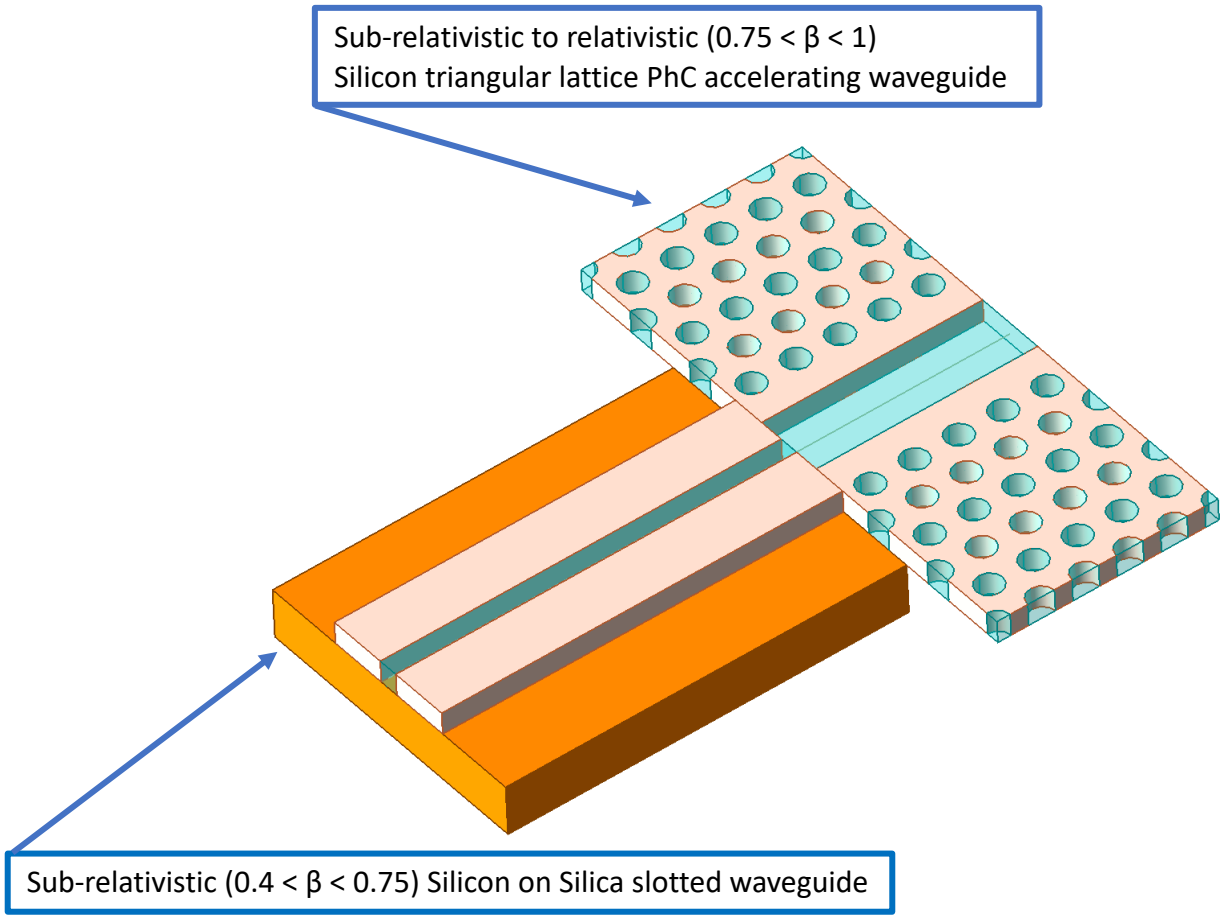
- Sub-relativistic to relativistic PhC-based transition design (M 25)
- Fabrication and SEM characterization on the selected dielectric prototype @INFN-Bo and CNR/PoliTo (M 33)
- Report of the dielectric study (Final full-wave design, S2E-BD results, thermal analysis, fabricability highlight, towards beam experiment

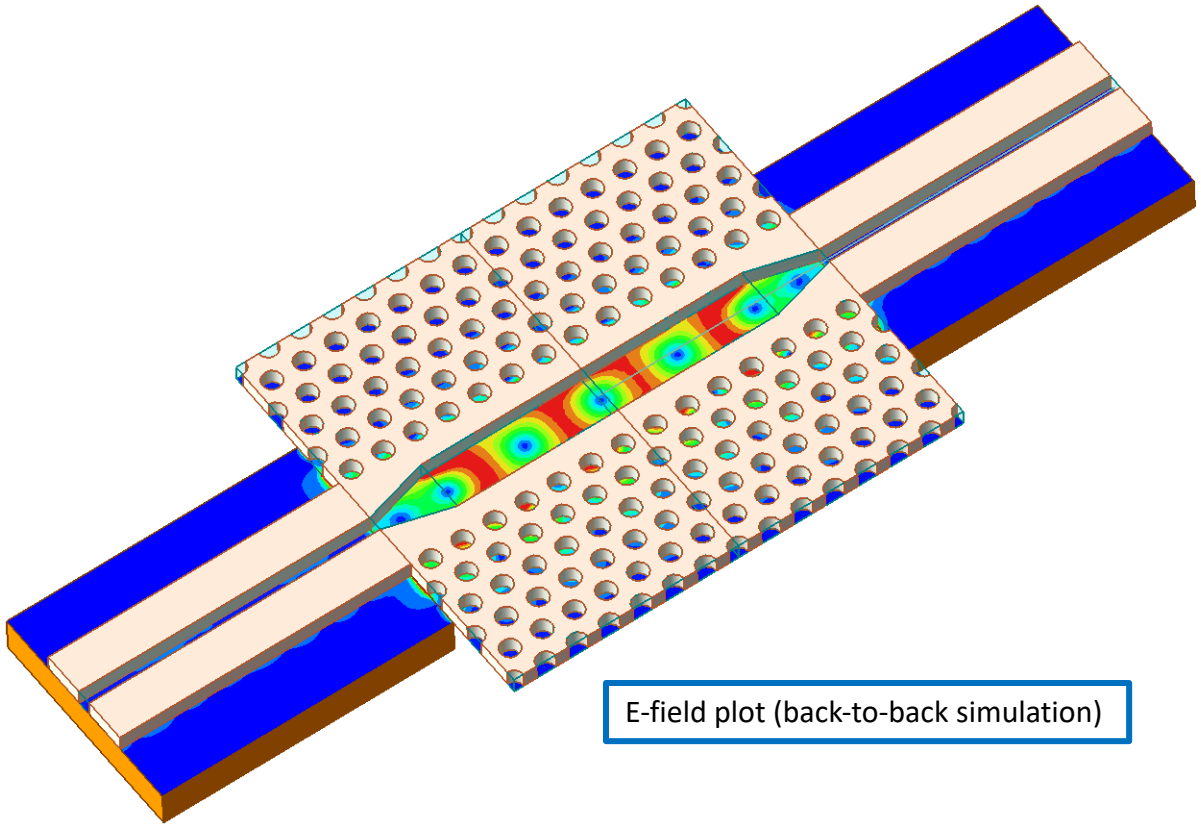
- METALLIC

- Procurement of the RF System components for measurement (M28)
- Wakefields effects in Ka-band multi-section metallic accelerating structures (M28)
- Report of the RF characterization on the metallic prototype (M36)

Attività 2024

- Preliminary example of sub-relativistic to relativistic PhC-based transition design.





output scientifico 2023

- **Invited Talk** @IEEE Conference on Antenna Measurements and Applications (CAMA), Genova, Novembre 2023 *G. Torrisi et al., "Design and fabrication of integrated optics accelerating structures"*
- **Invited Lecture** @the "International School of Particle Accelerators - ERICE_2023 27 July to 2 August 2023 Ettore Majorana Center, *G. Torrisi,* "*Co-propagating/Colinear waveguides for Dielectric Laser Accelerators: Design, Results and Perspectives*"

- **Oral Talk** @D-Photon 2023 Conference, Bari (Italy) July 11-13, 2023, *G. Sorbello et al;* "*Design and fabrication of integrated optics accelerating structures*"
- **Poster** at 14th Particle Accelerator Conference (IPAC '23), Venezia (Italy), May 7-12, 2023 (G. S. Mauro et al.) "*MeV scale simulations and fabrication tests of woodpile-based waveguide for Dielectric Laser Accelerators*".
- **Poster** at 14th Particle Accelerator Conference (IPAC '23), Venezia (Italy), May 7-12, 2023 (A. Leiva Genre et al.) "*Simulation of tapered co-propagating structures for dielectric laser accelerator*"

- **PRIN "Dielectric Optical acceleratorS for hEalth (DOSE)"** finanziato con 232 k€ su PE7 (Capofila UniBS)
- EIC **Pathfinder MODAL** waiting for final decion

- **Master Thesis DFA-UniCT,** *"Modelling of Tapered Co-propagating Structures for Dielectric Laser-driven Accelerators"* **(DLA)** A. Leiva Genre. Supervisors: Prof. Dr. David Mascali, (Academic year 2022/2023)--> **ongoing Paper for PRAB**
- **In preparation, paper for Optics Express**
- **Submitted Talk and Grant Master Graduating student (Poster)** @HG2023, 16–20 Oct 2023 LNF

Budget

UNIT	CONSUMO	MISSIONI
BO	2 k€ (Femtobond, resina per TPP, Zircolite, resina per stereolitografia)	2 k€
LNF	20 k€ (Componenti RF, transizioni coax-guida cavo)	3 k€
LNS		3 k€ (meas. @LNF,BO)
MI		3 k€
RM1	12 k€ (Licenza CST)	1 k€

FTE @LNS

- ...

Giuseppe Torrisi	10%
Gianluigi Cosentino	5%
Gino Sorbello	30%
Giorgio S. Mauro	6%
Santi Pavone	25%
Loreto Di Donato	30%
David Mascali	1%
Nunzio Salerno	50%