Beam Loading Advanced Simulator (BLAS)

175 MHz Cavity Electromagnetic Simulation & Design of a Particle Accelerator Control System

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Motivation & Objectives

BLAS was designed and built by BTESA and CIEMAT with two clear goals: be able to test the **technology** used in large **particle accelerator** installations on a smaller scale and to bring closer these kind of technologies to the **universitary scope**.

The main goal of this project is to enhance the educational aspect of BLAS by enabling it to be used in universities. The world of particle accelerators is in blatant growth, especially in Granada with the arrive of **IFMIF-DONES**. So it is of relevance importance to make the fututе engineers familiar with the knowledge behing these particle accelerators. This work intends to explain several of the activities that can be elaborated with BLAS by simulating the **EM behaviour** of the cavity and implementing a **control system**.

BLAS

SSPA Drawer

- **S**olid **S**tate **P**ower **A**mplifier
- Driver ⟶ 500 W
- Amplifier ⟶ 2 kW
- Circulator
- Load ⟶ 50 Ω, 5 kW
- Directional couplers
- Control signals

RF Pillbox Cavity

- Acceleration geometry
- Material ⟶ Brass
- 175 MHz ⟶ IFMIF-DONES
- ⌀ = 1 m
- 3 configurable ports
- Nose cone
- 2 cylindrical tuners

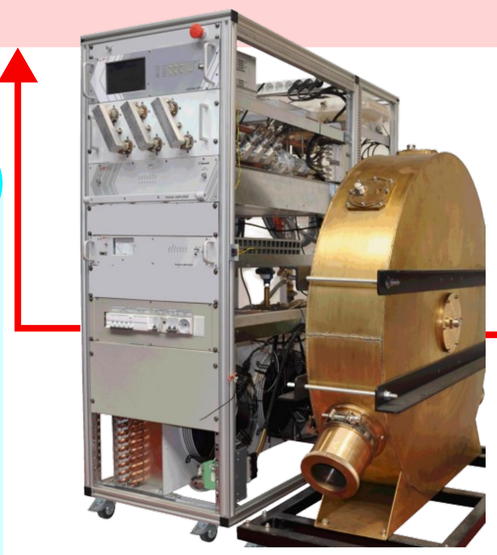

Fig.1: BLAS

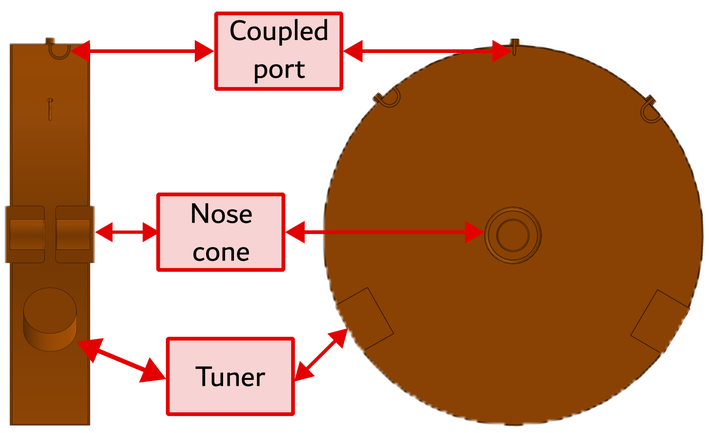

Fig.5: Pillbox cavity section view

EM SIM

Theory

$$TM_{010} : f_{c,010} = \frac{2.405c}{2\pi a\sqrt{\mu_r \epsilon_r}}$$

Eq.1: Resonant frequency

a = 500 mm ⟶ f = 229.66 MHz
↳ Radius

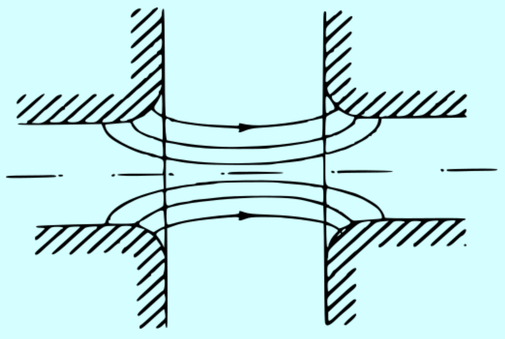

Fig.3: Cavity's electric field direction

The main goal of this chapter is to understand the cavity's components RF behaviour such as the **nose cone**, the **tuners** and the **configurable ports**. **Modal** and **eigenmode** simulations have been performed in order to obtain the **electric field** inside the cavity and the **resonant frequency,** respectively.

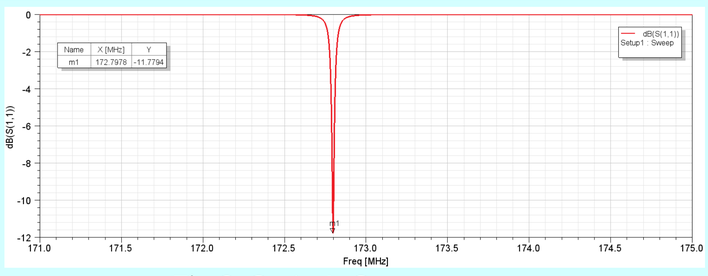

Fig.2: Cavity's S_{11} parameter

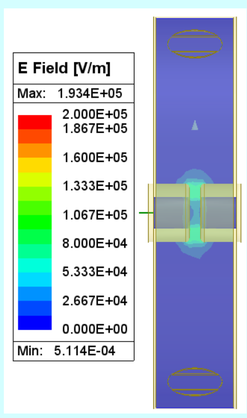

Fig.4: Cavity's electric field values

The cavity's resonant frequency is **172.8 MHz** which can be modified by inserting the cylindrical tuners. Every increase of 50 mm in the inserted length, tends to i**ncrease the frequency** in 0.5 MHz.

Control System

Software

EPICS has been implemented to control and monitor **BLAS** and the **measurement equipment** of the laboratory. Moreover, a **GUI** has been designed to ease the operation of BLAS.

Hardware

In oder to monitor the different signals coming from BLAS two PCBs have been designed and built. A **main PCB,** connected to a Raspberry Pi 4, where the control signals are processed and an **RF voltmeter.**

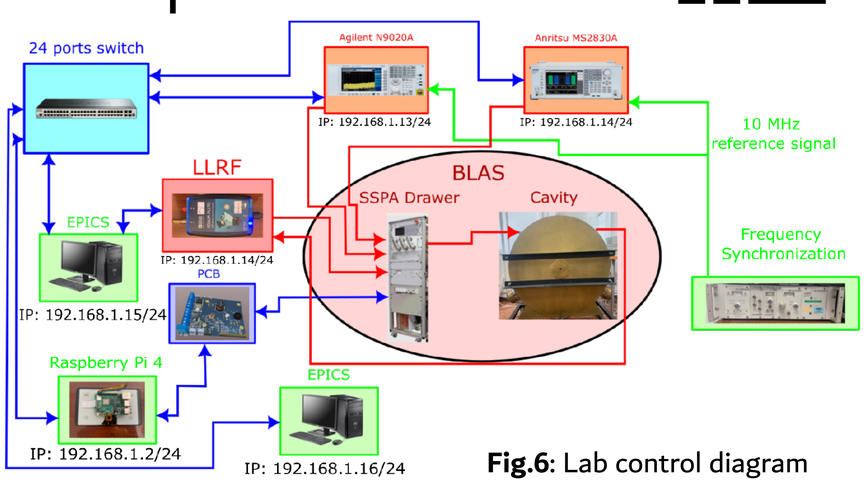

Fig.6: Lab control diagram

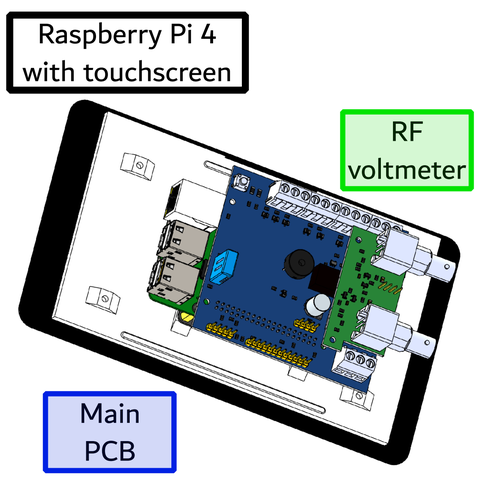

Fig.7: Control system hardware assembly

Conclusions

This **multidisciplinar** project has achieved its goal of getting closer the technology used in **particle accelerators** to the **universitary world**. Having elaborated and implemented several activities from different knowledge fields from the **telecommunication engineering** scope.

Diverse simulations have been performed to study the **RF behaviour** of the cavity having good correlation with the real world characterization of the cavity. On the other hand, a complete control system has been implemented using **EPICS** and the electronics designed to monitor different signals coming from the accelerator.

References

[1] A. Pérez. "Remote BLAS monitoring using EPICS". URSI 2022.

[2] Thomas P. Wangler. "RF Linear Accelerators.". Wiley-VCH, 2008.

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