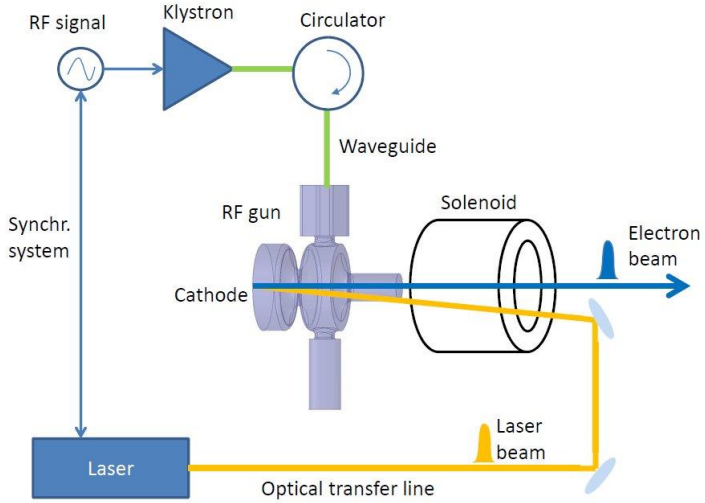
David Alesini, INFN-LNF, Frascati, Rome, Italy

I.FAST Period 2 Review, 15.07.2024

Task 7.4 structure and objectives

- **Design, realization and high power test of two different C-band (5.712 GHz) RF electron guns** operating at very high gradient cathode peak field (>160 MV/m):
  ⇒ Standing Wave (**SW**) gun (**INFN** (IT), **COMEB** (IT))
  ⇒ Travelling Wave (**TW**) gun (**PSI** (SW); **VLD** (NE))

- **Comparison** of the performances, **beam dynamics** simulations to exploit the device potentialities
- **Research Institutions** involved: **INFN** (IT), **PSI** (SW);
- **Private Companies** involved: **VLD** (NE), **COMEB** (IT)



INFN Istituto Nazionale di Fisica Nucleare

- Coordination
- Design and low power test of the SW Gun
- Solenoid design and procurement
- RF circulator procurement

COMEB

- mechanical construction and assembly of the SW gun

SW GUN

PAUL SCHERRER INSTITUT PSI

- design, brazing and low power characterization of the TW Gun
- hosting and setting up the facility to perform the high-power test

VDL

- mechanical construction of the TW gun components

TW GUN

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Summary of activities in P2: SW GUN

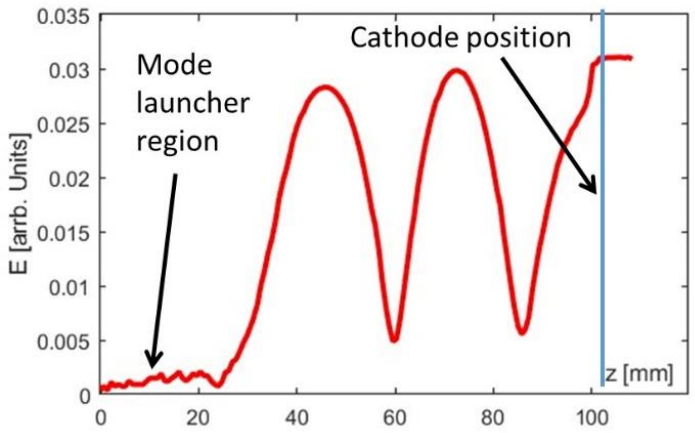
INFN
Istituto Nazionale di Fisica Nucleare

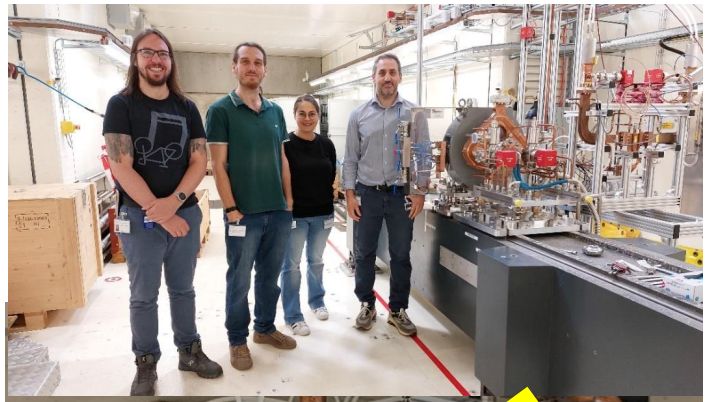
⇒ **Full design of the gun, solenoid, vacuum and laser inj. chamber:** completed

⇒ **RF measurements** on the C band gun fabricated by COMEB: completed

⇒ **Installation** of the C band GUN at PSI for high power test (in coll. with PSI)

⇒ **High power** test ongoing

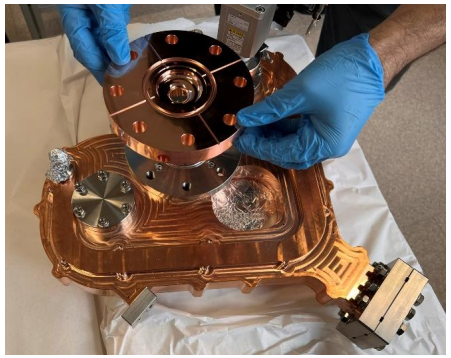




IPAC 24 Oral presentation
160 MV/m cathode peak field reached!

COMEB

⇒ **Realization of the C band SW gun**



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Summary of activities in P2: TW GUN

PAUL SCHERRER INSTITUT

PSI

⇒ **RF power station refurbished and prepared for the high power test of the guns:** completed

⇒ **Installation of the C band SW gun in collaboration with INFN:** completed

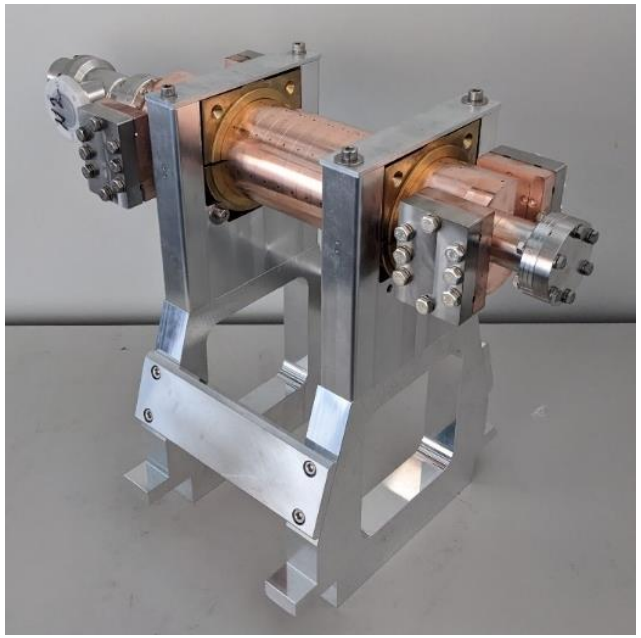
⇒ **High power RF test of the C band gun:** in progress

⇒ **Design and brazing of the TW gun:** completed

⇒ **Preparation of the cathodes**: completed

⇒ **RF low power test of the TW gun:** in progress

⇒ **Installation of the TW gun and high power test**: to be done



VDL

⇒ **Realization of the C band TW gun components:** done

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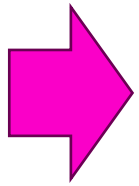
Deliverables and Milestones Task 7.4

- **Milestone MS28: Electromagnetic and mechanical design of the two guns (M24)**
  ⇒DONE

- **Deliverable D7.4: mechanical realization and low power rf tests of the two guns (M38)**
  ⇒The SW GUN is completed (mechanical realization, low and high power RF test)
  ⇒The TW GUN has been fabricated and is now under low power rf characterization



We asked to posticipate to M40 to complete the low power RF test of the TW gun.

- **Milestone MS29: high power rf tests of the two guns (M46)**
  ⇒SW gun has been tested at high power.
  ⇒TW gun will be installed in Autumn for the high power test.

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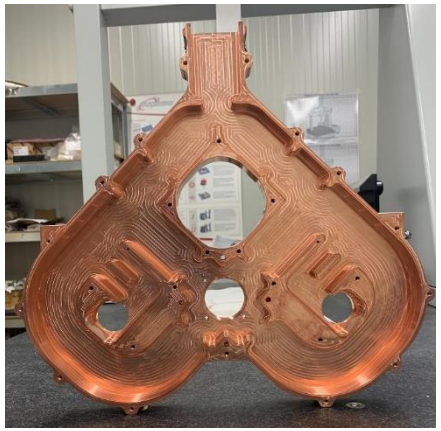
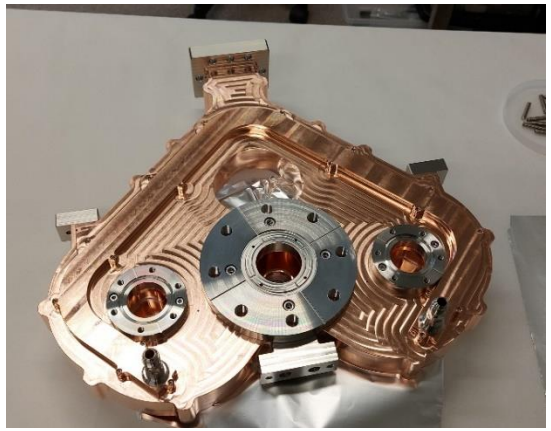
Thank you for your attention!

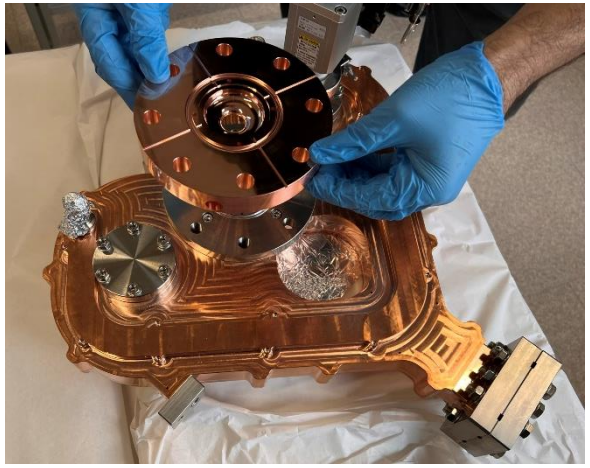
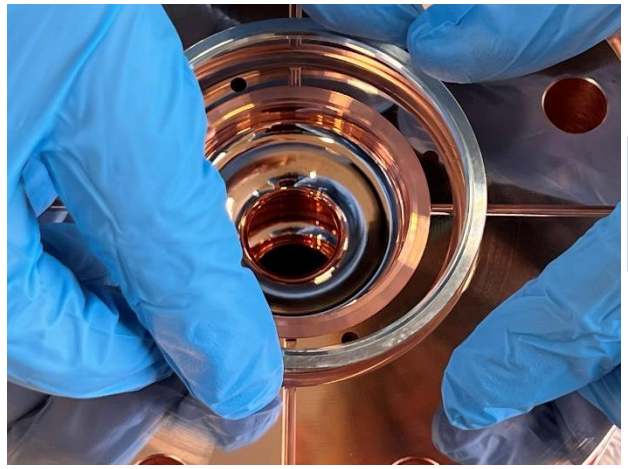
This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under GA No 101004730.

MORE SLIDES

C-BAND GUN ASSEMBLY

⇒ The **mode launcher** has been machined with precision internal dimensions of **±8 μm** and it has then been brazed
⇒ The **SW cells and cathode** have been machined with a precision of **±2 μm** and roughness below 30 nm.
⇒ The gun has been **finally assembled**, in all the mounting procedure the gun has been flushed with dry nitrogen. The mounting procedure foresaw the use of two special gaskets. The external one, in aluminum for vacuum seal and the internal one with a special copper gasket for the rf contact.

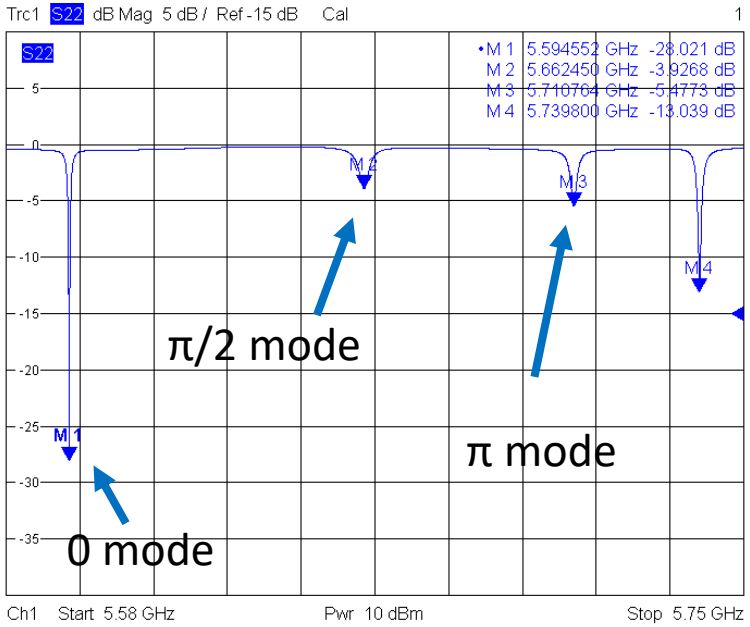




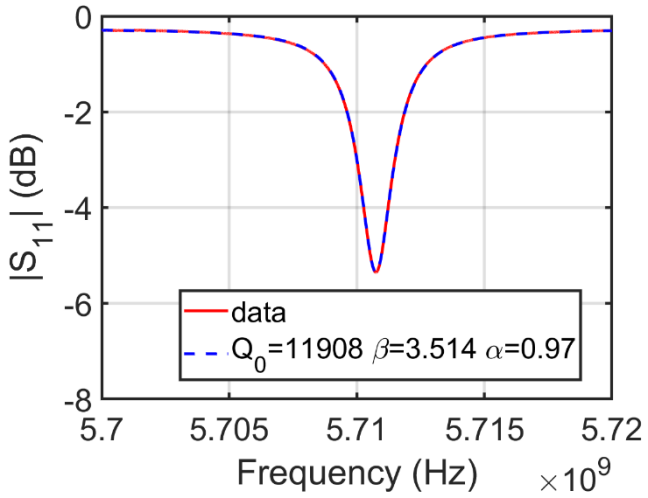

David Alesini, Design realization and high power RF test of the new brazed free C band photo-gun, IPAC 24

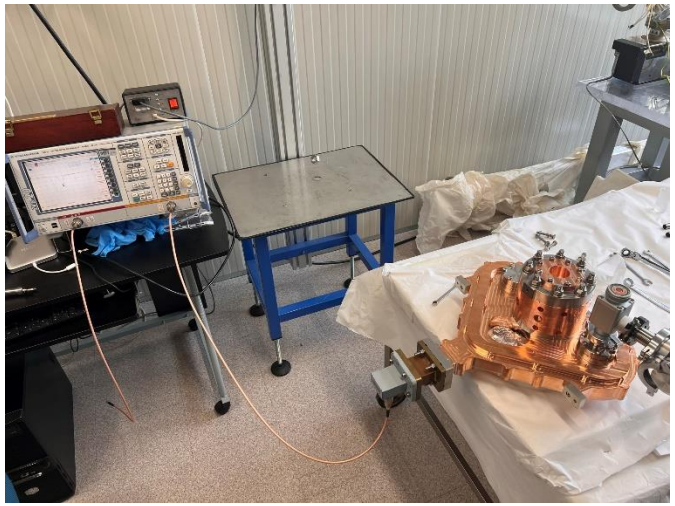
LOW POWER RF MEASUREMENTS

The assembled gun has been **RF tested**. The three modes are clearly visible in the plot. The frequency and quality factor of the working mode are the nominal ones while the coupling coefficient is slightly larger. The gun is **NOT TUNED**

Parameter	Unit	Design Value	Measured Value
Resonant frequency	GHz	5.712	5.712
Quality factor		11900	11900
Filling time	ns	166	147
Coupling coefficient		3	3.5
Mode sep. π-π/2	MHz	47	48.3

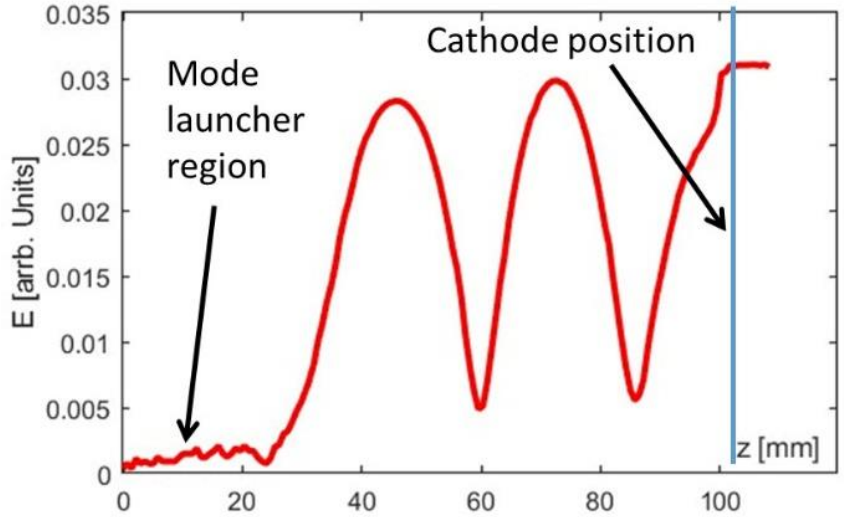






Bead-drop mesurement

w/o tuning



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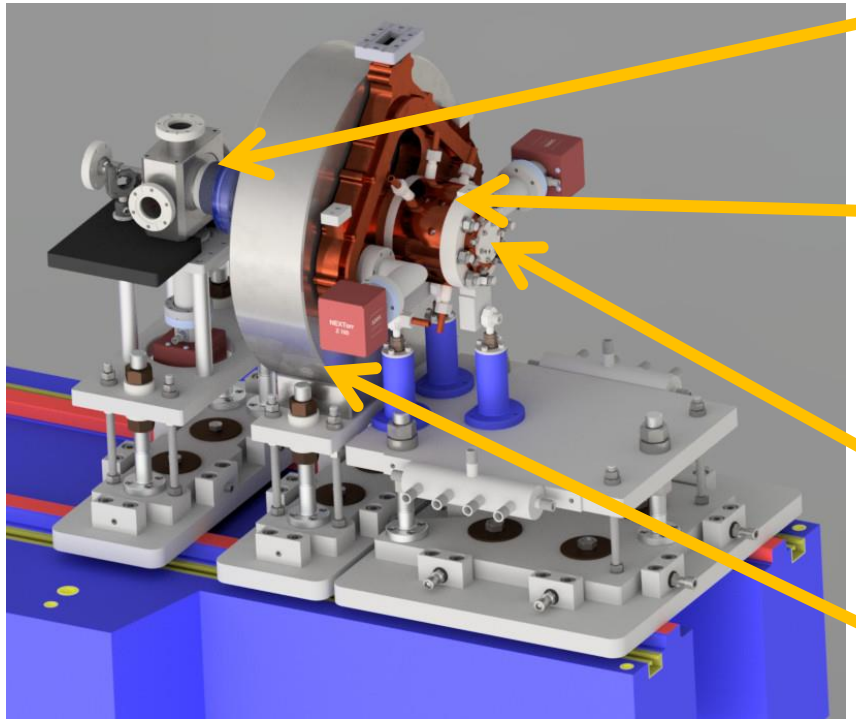
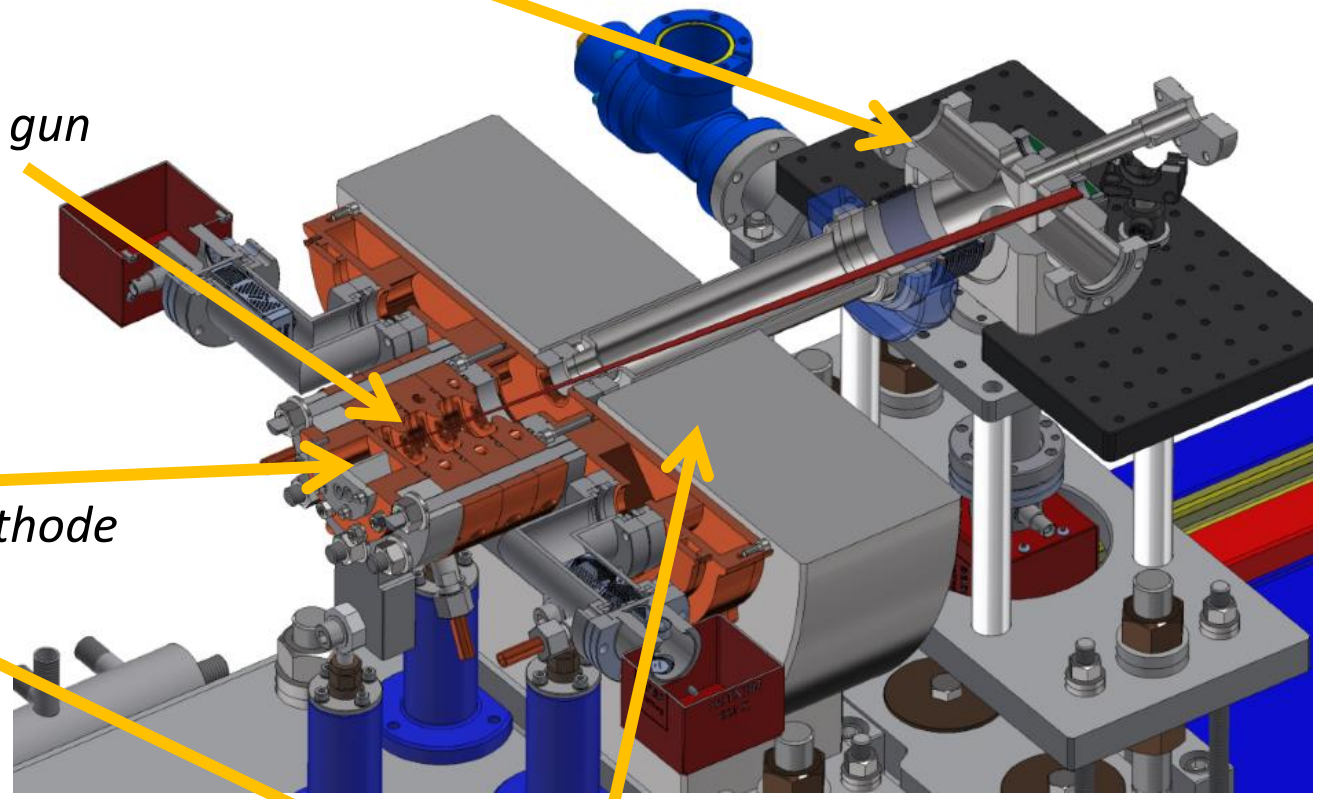
C BAND GUN LAYOUT



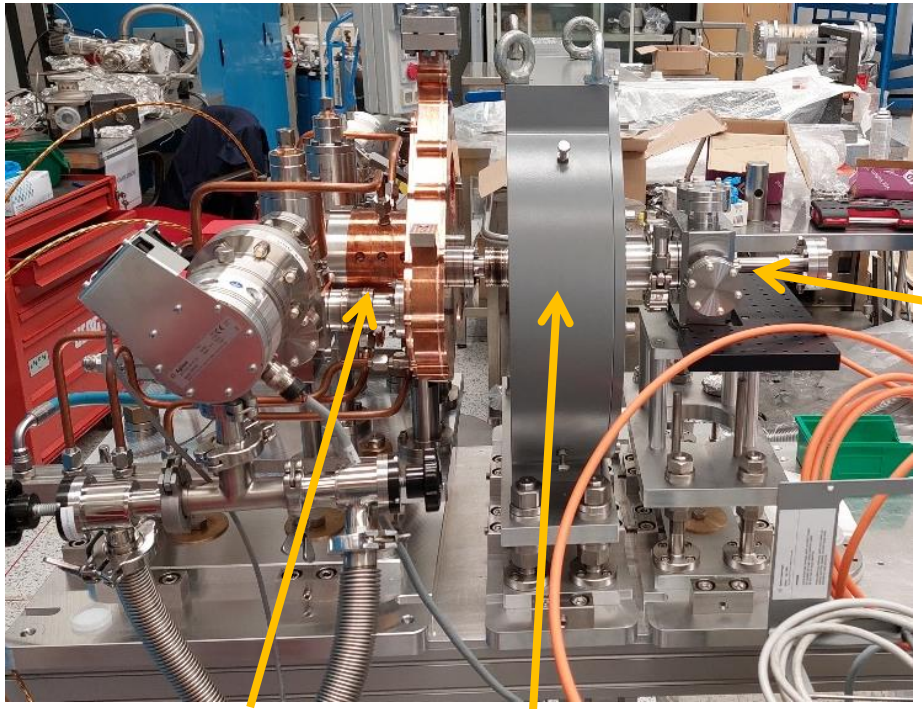


In its final layout, the gun is followed by an emittance compensating **solenoid** and by the **laser injection chamber** that allows a laser injection with the last mirror in air. Two pumping ports are integrated in the mode launcher.

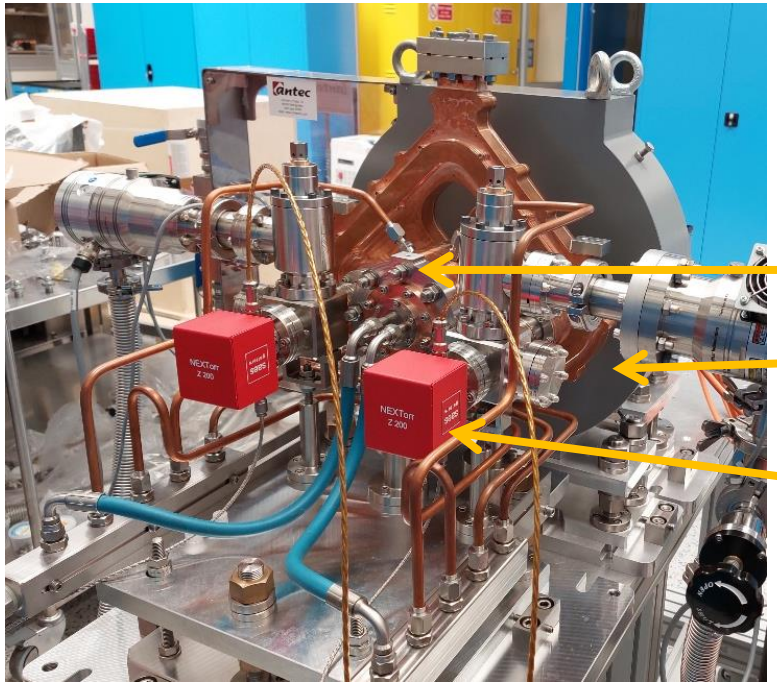
David Alesini, Design realization and high power RF test of the new brazed free C band photo-gun, IPAC 24

C-BAND GUN FINAL ASSEMBLY

The gun, after the final assembly and vacuum test has been **assembled in its final configuration** with the solenoid and vacuum chambers



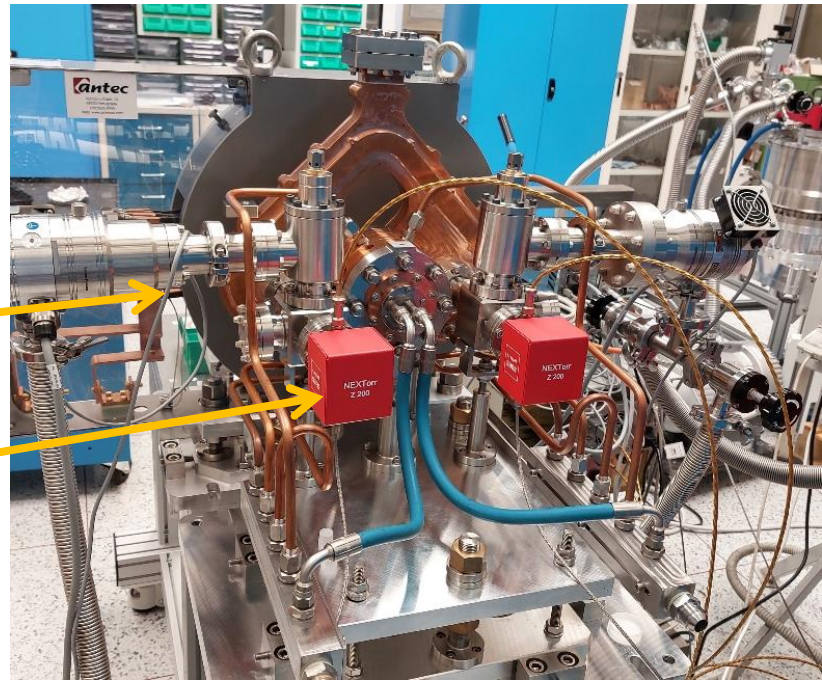
Laser injection chamber



gun

solenoid

Pumping system



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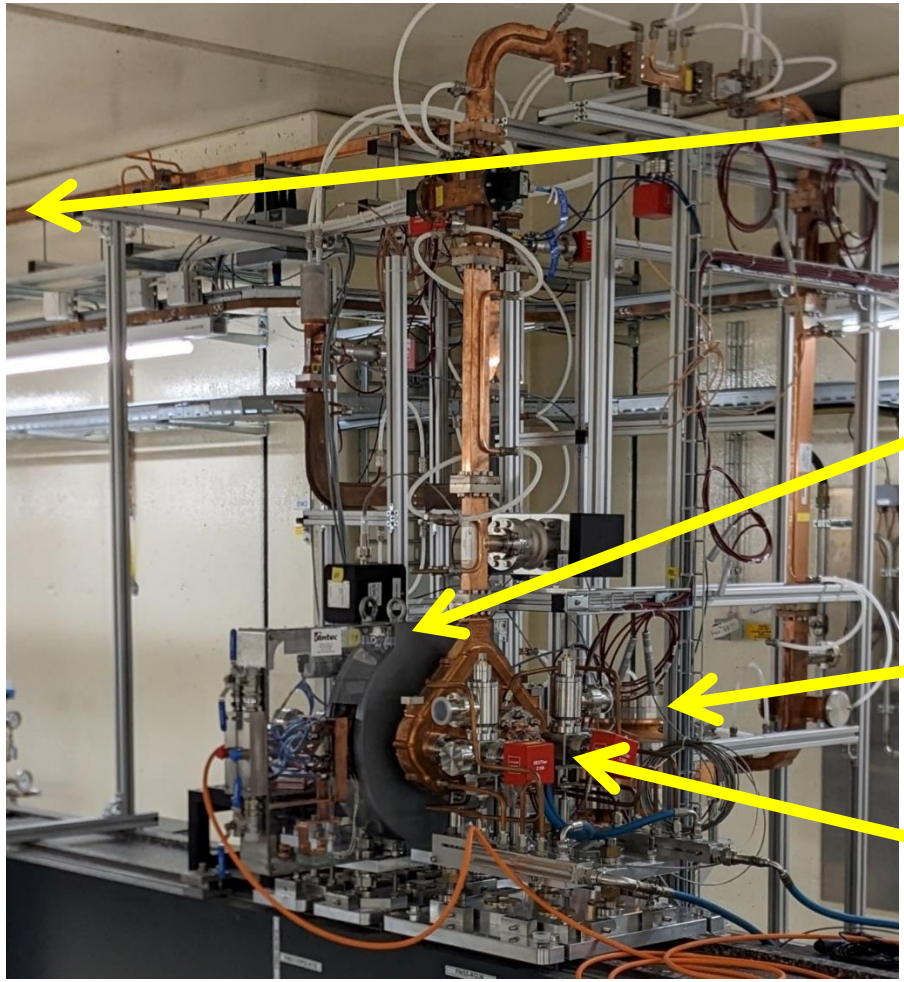
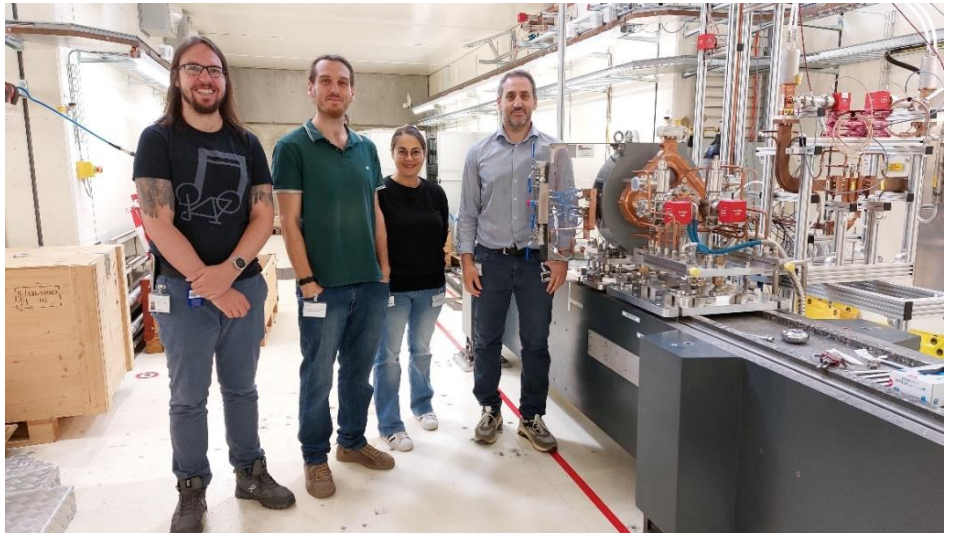
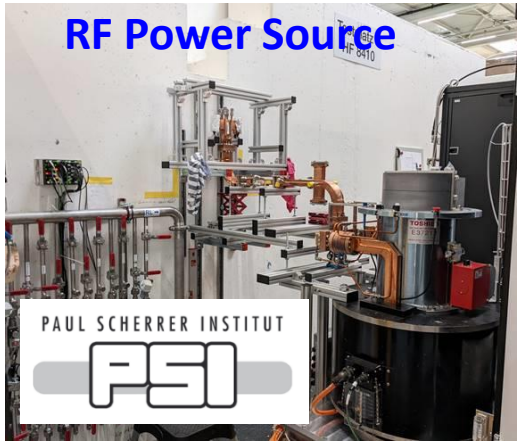
INSTALLATION AT PSI FOR HIGH POWER TEST

The whole system has then been transported to **PSI and installed in the High Power Test Stand** [T. Lucas, WEPC69]. The original gun feeding scheme foresaw the use of **a new in-vacuum isolator that experienced some delays** due to the difficulties that have been encountered during its realization. For this reason we have developed an **alternative scheme using power dividers and a BOC-type** pulse compressor







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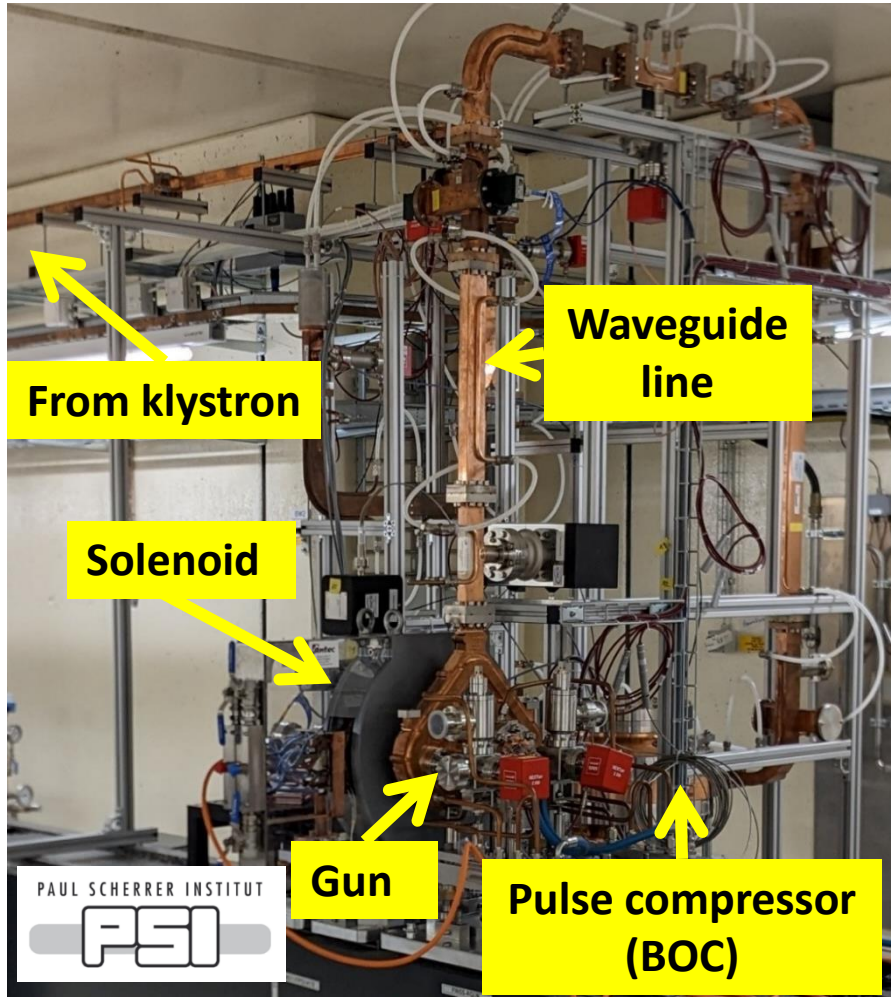
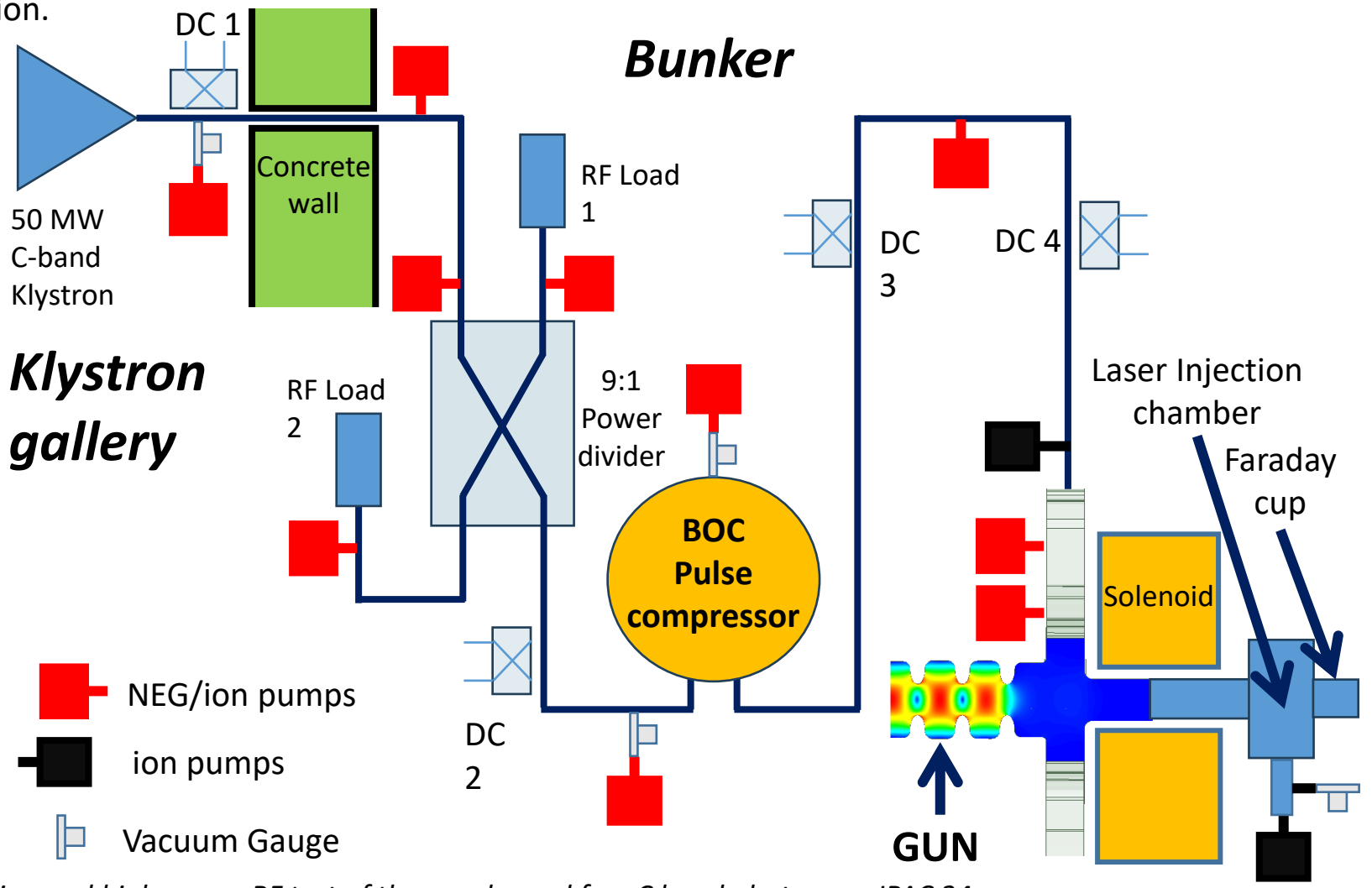
HIGH POWER TEST SCHEMATIC LAYOUT

In the setup there are eight **NEG-ion pumps** and **four directional couplers**. The vacuum is also monitored through four **vacuum gauges**; one in the laser injection chamber, two near the BOC and one near the klystron window. These have been used to monitor the local vacuum in the regions expected to suffer the most from high power operation.





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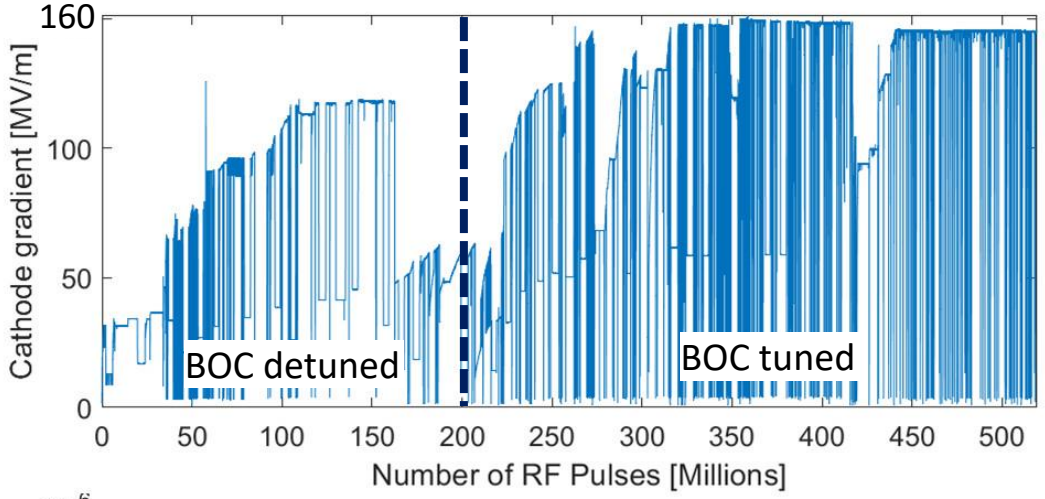
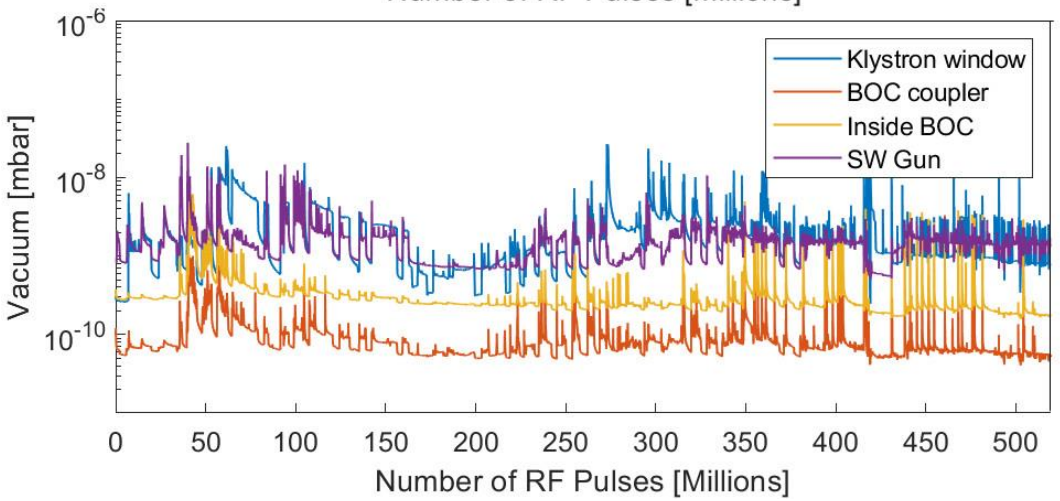
HIGH POWER TEST RESULTS (SO FAR)

RF conditioning began in **February 2024**. The conditioning was done in a semi-automatic way, monitoring the **vacuum** at the different vacuum pumps and the **reflected power** to the klystron and progressively increasing the power from the klystron and pulse length keeping the repetition rate at **100 Hz**

±5% (precise power calibration ongoing)



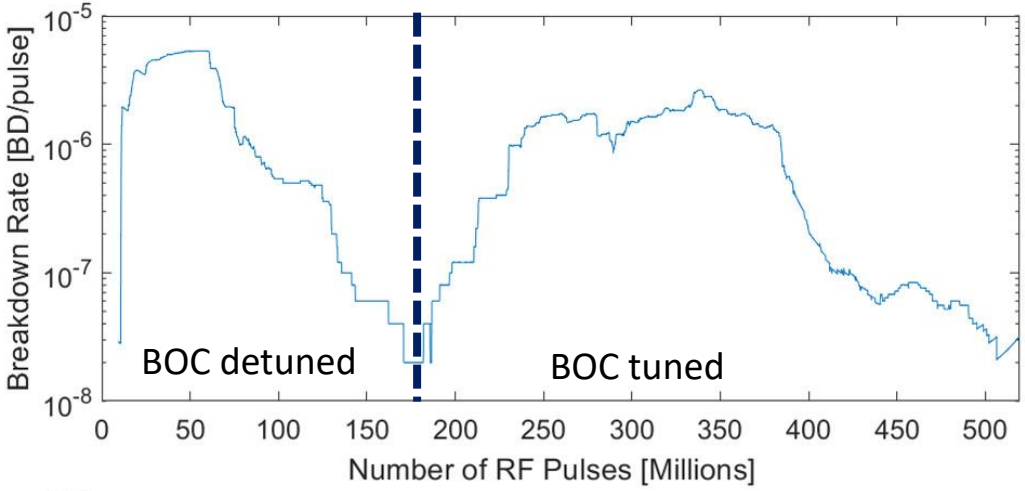


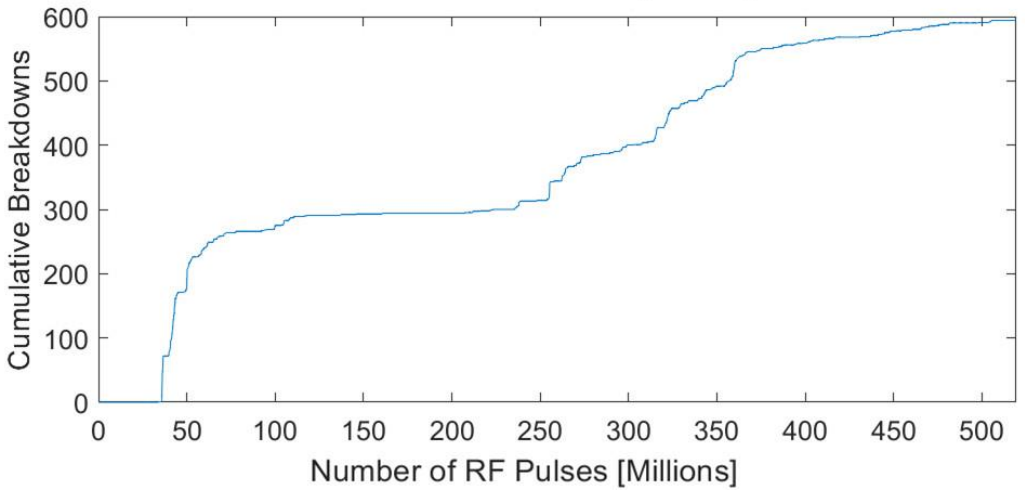
⇒Conditioning dominated by the vacuum activity in the **waveguide**

⇒final maximum input power limited by a vacuum **activity in the ceramic of the klystron** probably due to the reflected power

⇒we reached so far a cathode peak field is about **160 MV/m** (±5% precise power calibration ongoing)

⇒**no limitation due to the gun**.





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