Development of a re-entrant cBPM and acquisition system for the ILC main linac

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Introduction

Development of a **re-entrant cBPM for the ILC Main Linac**

Project in collaboration with KEK and CIEMAT: development of the cryostat for a BPM and a super-conducting quadrupole

The designed BPM will initially be tested at ATF (Accelerator Test Facility)

Global requirements:

- High precision BPM with a time nanometer resolution (< 369 ns) and a spatial resolution < 1 μm
- ILC beam bunch by bunch measurements (fast readout electronics)
- Low beam dynamics impact (wakefields studies)
- Ultra high-vacuum and cryogenic temperatures performance

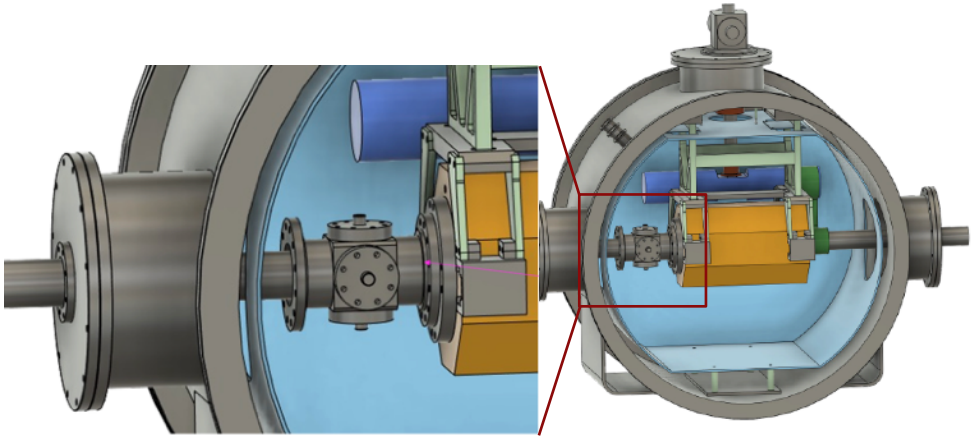
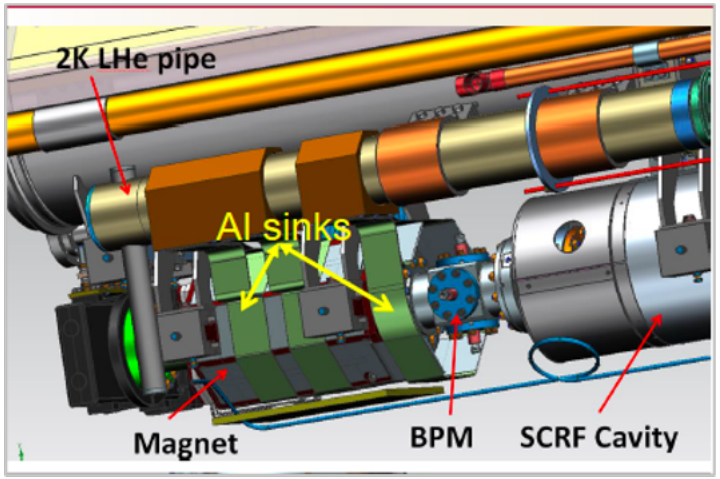


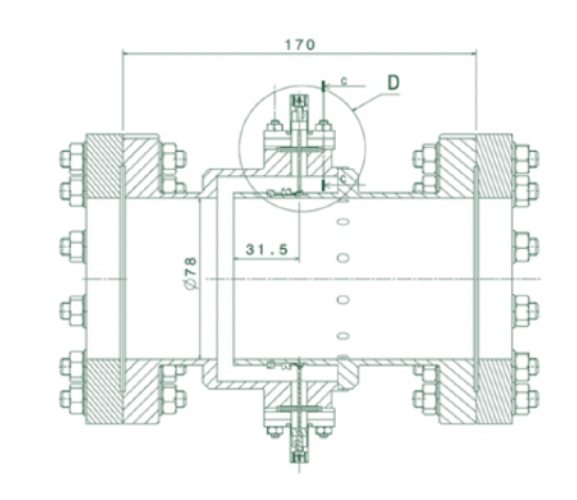
Figure: Cryostat accommodating BPM and SC quadrupole

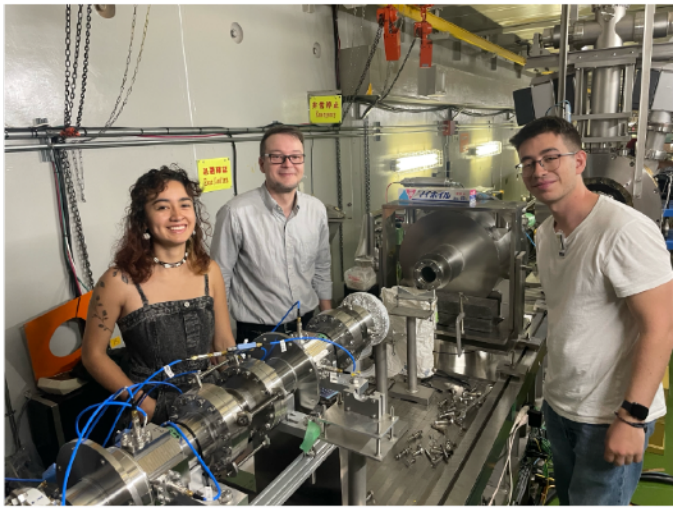


I. Progress on the CEA SACLAY cBPM

A. Installation

o Testing a first re-entrant cavity BPM prototype bought to CEA (C. Simon et al.) at ATF
o Installed at the end of the ATF linac (May 2025)
o Testing the electronics and DAQ system (based on RHUL scheme) as well as position reconstruction methods without additional reference cavity
o Test beams will be performed in May (15th -30th of May) for performance characterization (calibration and resolution measurements)





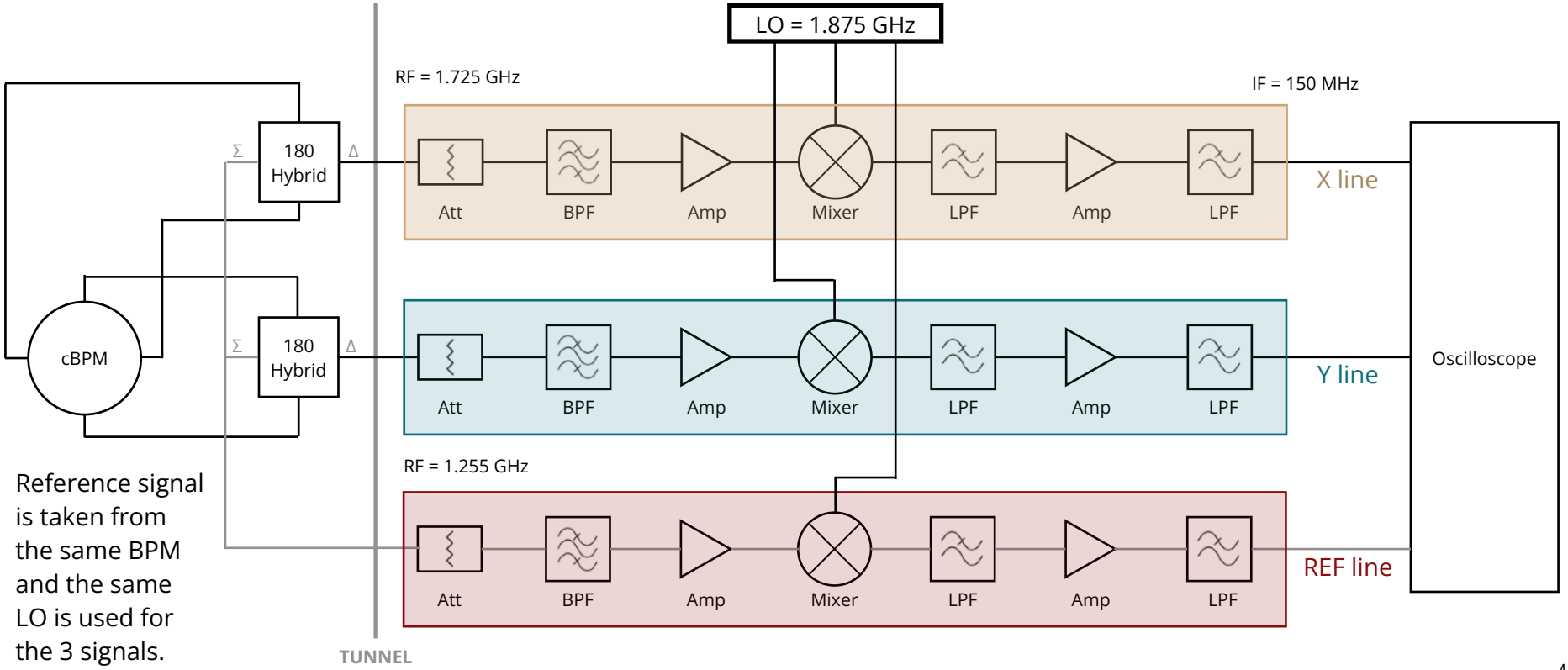
Fabricated cavity BPM by CEA (C. Simon et al.) currently under test at ATF2

Thanks to ATF Staff and technicians and to Toshihiro Matsumoto (KEK STF and LINAC) for help and providing required equipment

I. Progress on the CEA SACLAY cBPM

B. Read-out system

3 identical lines of down-conversion to 150 MHz:
- two for x and y signals (with RF = 1.725 GHz)
- one for reference signal (with RF = 1.255 GHz) (the tail of the monopole mode is taken)

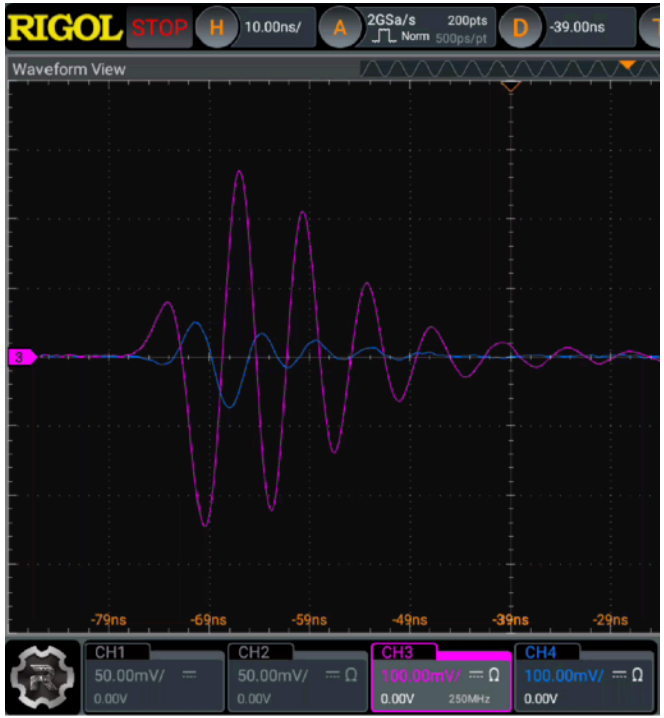


Reference signal is taken from the same BPM and the same LO is used for the 3 signals.

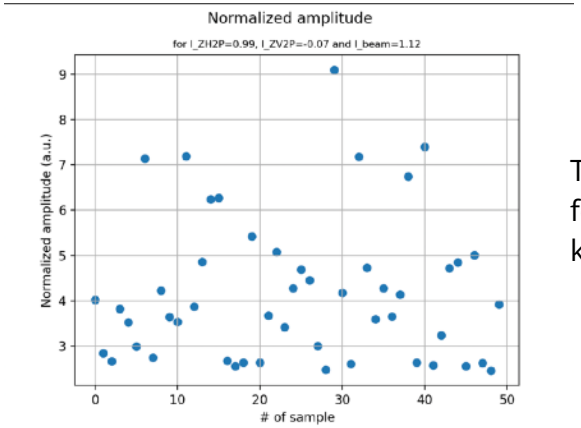
O. Friar, Building, Optimising and Measuring the Performance of Downconverting electronics using X-Microwave Modules, Major Project Report, 2022

I. Progress on the CEA SACLAY cBPM

C. Measurements on 19/05



Position and reference signals at oscilloscope

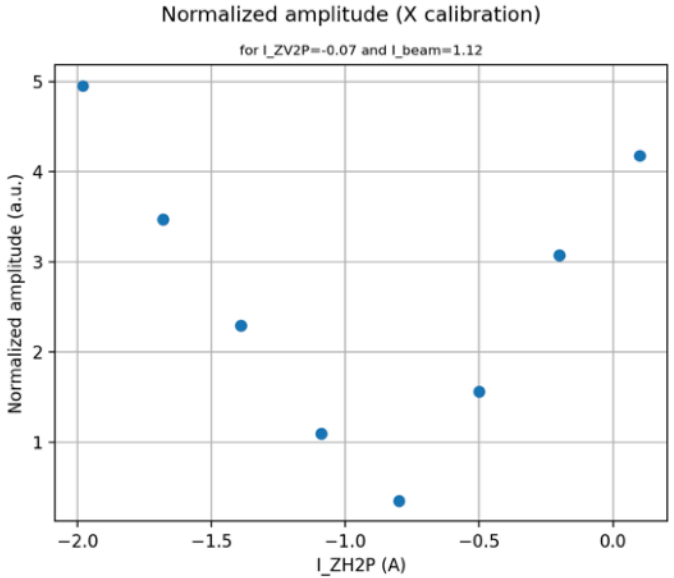


Taking and processing 50 waveforms for each beam position (translated in kicker intensity)

For a sweep of kicker values, by taking the average amplitude:

√ Confirm amplitude dependence on beam position

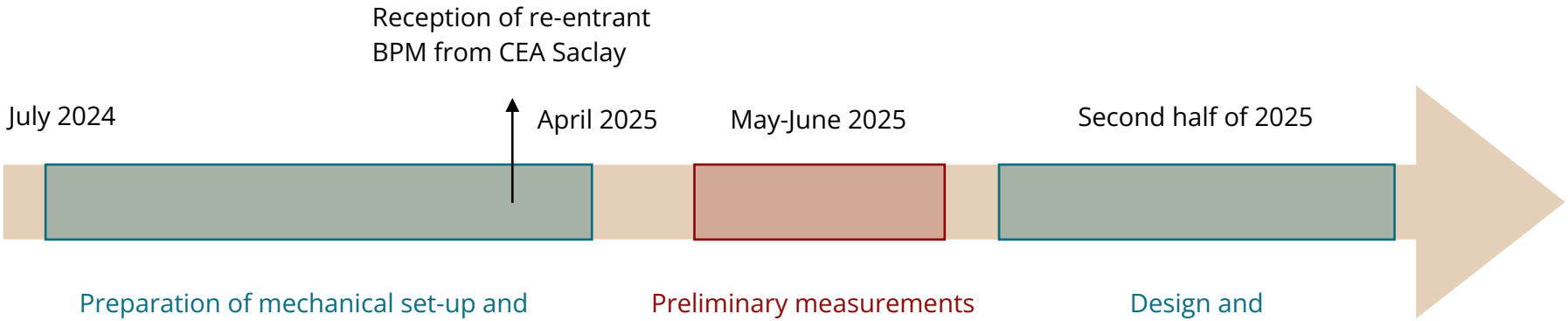
- Perform calibration by estimating beam position at measurement point
- Measure resolution



II. Design of a new re-entrant cBPM

A. Time-line

New special mechanical design for ease cleaning and alignment with splittable quadrupole magnet and DAQ system R&D



Preparation of mechanical set-up and development of read-out system for cBPM

In parallel, design of the **new** cBPM with comercial feedthroughs and alignment with quadrupole magnet

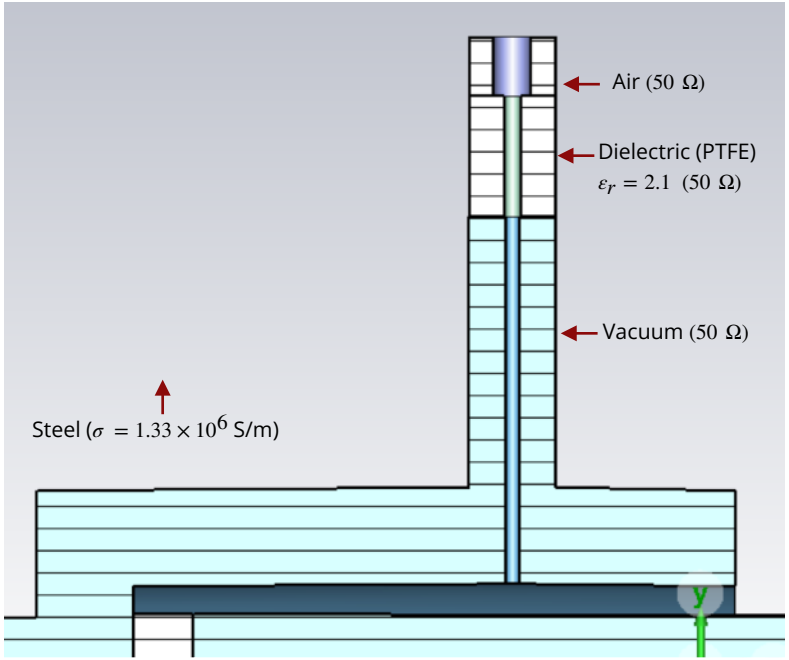
Preliminary measurements at with CEA Saclay BPM:
- Mechanical installation of the cBPM
- On-line measurements
- Test of the DAQ system
- Resolution measurements

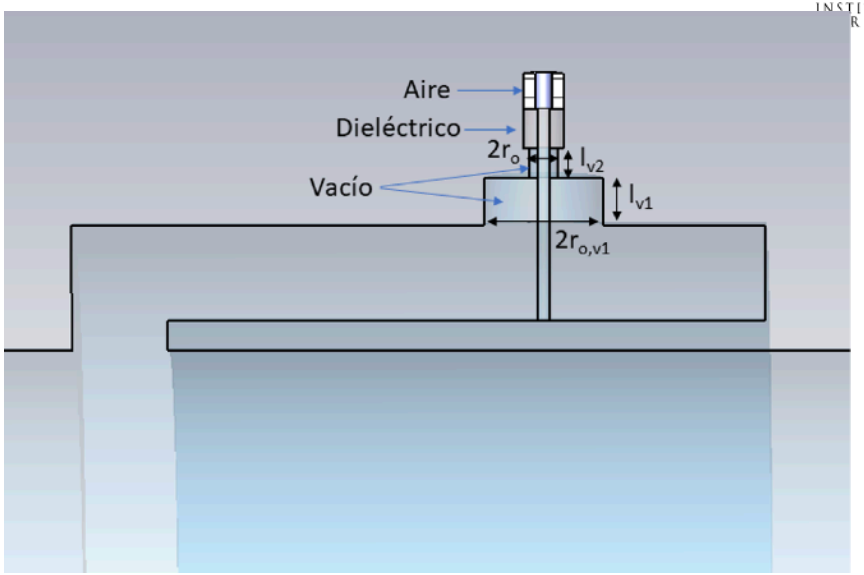
Design and construction of **new design** of the cBPM

Expected time of manufacturing: end of 2025

II. Design of a new re-entrant cBPM

B. Progress on the new design





Including impedance transition on the cBPM body to implement commercial feedthrough

Mode	Monopole						Dipole (on x)						(on y)
	Freq (GHz)	Q_L	R/Q (Ω) @ 10 mm	S_{11} (dB)	S_{12} (dB)	P_out (dBm)	Freq (GHz)	Q_L	R/Q (Ω) @ 10 mm	S_{11} (dB)	S_{12} (dB)	P_out for δx=1 μm (dBm)	P_out for δx=1 μm (dBm)
With 106-50-50 Ohms	1.241	19.1	41.65	-5.69	-6.47	55.14	1.716	34.1	3.81	-22.02	-28.79	-35.03	-57.7
With 106-32-50 Ohms	1.253	21.06	41.66	-5.65	-6.59	54.78	1.724	48.89	3.85	-20.0	-32.6	-36.61	-59.06

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Thank you for your attention

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