IFIC cavity BPM R&D at ATF

N. Fuster Martínez on behalf of the AITANA accelerators team

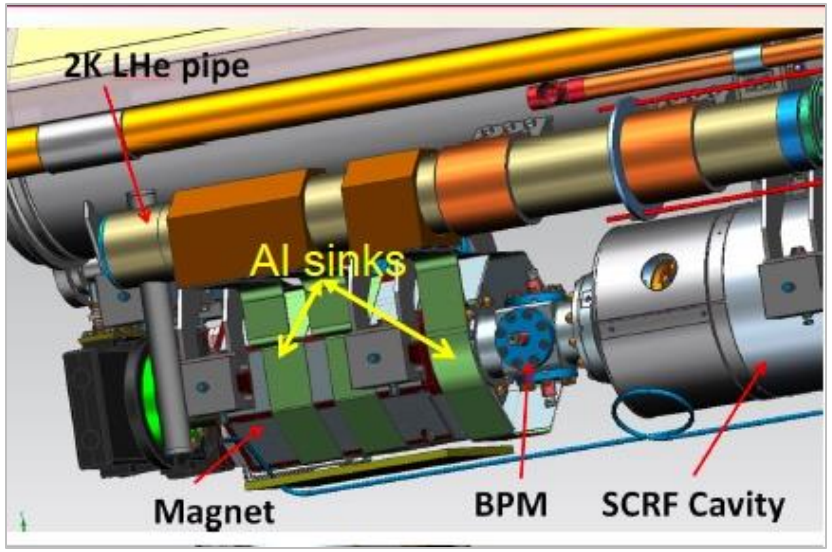
ATF/ATF2 International Collaboration Board and Technical Board meeting

24th of November 2025

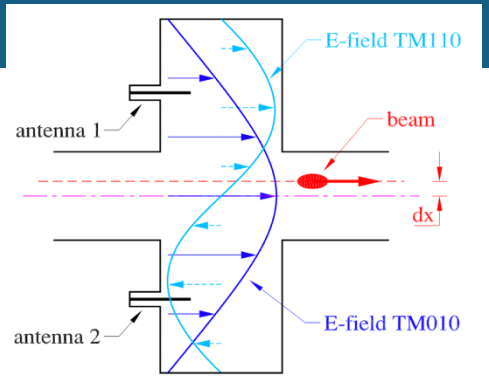
R&D of ILC linac re-entrant cavity BPMs

- R&D on the **cavity-BPM and splitable quadrupole magnet** module for the main linac of the ILC project was identified in 2020 by the **Spanish network for future colliders and INEUSTAR** (Spanish Science Industry Association) as one of the most promising Spanish contributions to the ILC project

- CIEMAT is working on a new splitable quadrupole magnets design and IFIC on the cavity BPM R&D



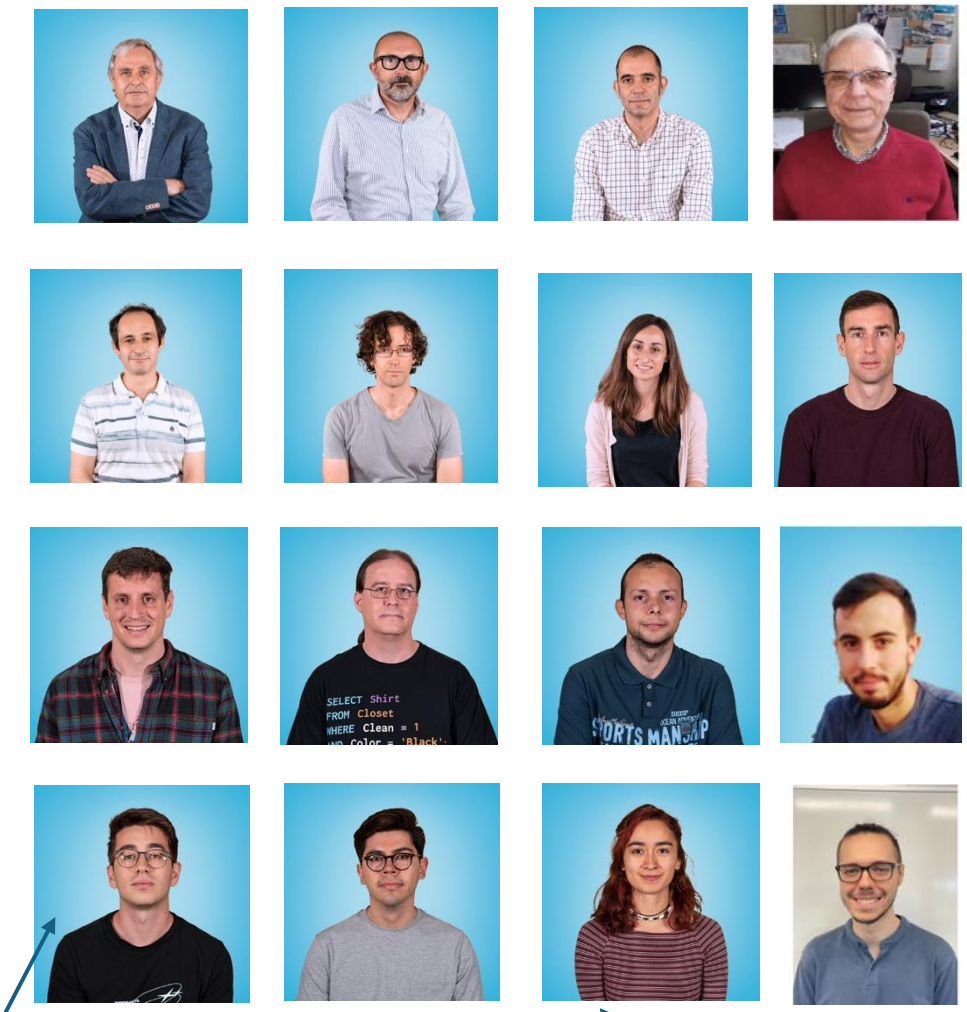
General requirements for the BPM performance:



- High precision 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

Accelerators IFIC team

- Juan Fuster Verdú: juan.fuster@ific.uv.es
- Benito Gimeno Martínez: benito.gimeno@uv.es
- Daniel Esperante Pereira: daniel.esperante@ific.uv.es
- Santiago Noguere Puchol: Santiago.Noguera@ific.uv.es
- Cesar Blanch Gutiérrez: cesar.blanch@ific.uv.es
- Daniel González-Iglesias: daniel.gonzalez-iglesias@uv.es
- Nuria Fuster Martínez: nuria.fuster@ific.uv.es
- Março Boronat Arevalo: boronat.arevalo@ific.uv.es
- Carlos Orero Canet: carlos.orero@ific.uv.es
- Abraham Menéndez: Abraham.menendez@uv.es
- Pablo Martín Luna: pamarlu@ific.uv.es
- Javier Olivares Herrador: javier.olivares.herrador@cern.ch
- Juan Carlos Fernández: juancarlos.fernandez@ific.uv.es
- Eduardo Martínez López: Eduardo.martinez@ific.uv.es
- Laura K. Pedraza: laura.pedraza@ific.uv.es
- José Reina Valero: jose.reina@ific.uv.es



Two dedicated PhD students for the project one oriented to the EM design and performance tests with and without beam and the other of the DAQ system development

Funding

- In 2022 several funding applications were approved for this project:
  - ✓ **Local government funding**: *"Tecnologías de RF para monitores de haz en aceleradores y para detectores de axiones de materia oscura", ASFAE/2022/013.* Funded by Valencian Government, Next Generation EU *(Start 2023 - **end 2025**)*
    - *PhD contract (3 years)*
    - *Cavity-BPM prototype*
  - ✓ **Local government funding:** *CDEIGENT 2021/012 (Start 2022 - **end mid 2028**)*
    - *To cover different expenses related to the project*
  - ✓ **National funding:** PID202-1122134NB-C21. WP3 (IFIC, CIEMAT) Accelerator Technology. *(Start 2023 - **end 2026**)*
    - *To cover different expenses related to the project*
  - ✓ **European funding: EAJADE,** Europe America Japan Accelerator Development and Exchange Programme *(Start 2023 - **end beginning 2027**)*
    - *Cover expenses related to trips to Japan*
- Currently applying for local government funding including this activity on the program.

GENERALITAT VALENCIANA

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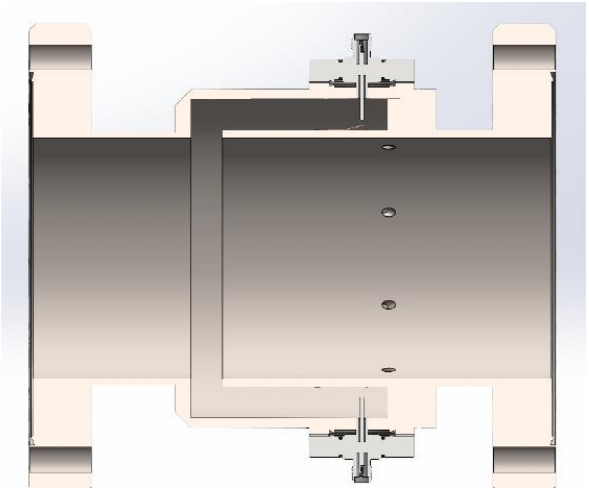
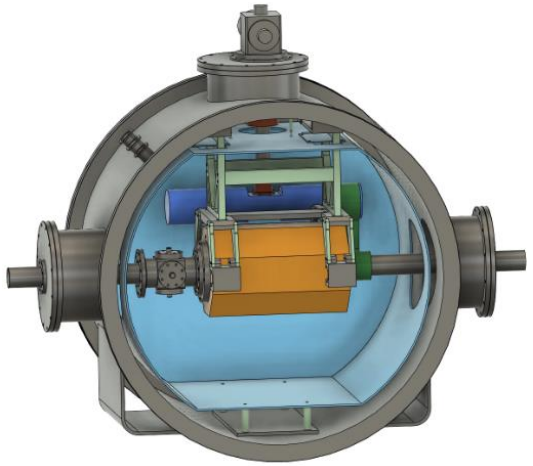
Aims

- ❑ Design, fabricate and test a new cavity BPM (PhD of Laura Karina Pedraza)
  - ✓ To promote the Spanish industrial participation in the ILC
  - ✓ To increase our knowledge in cryogenic instrumentation
  - ✓ Investigate/identify potential aspects to reduce fabrication cost
  - ✓ Integrate on the design the mechanical alignment strategy to the splitable quadrupole magnet

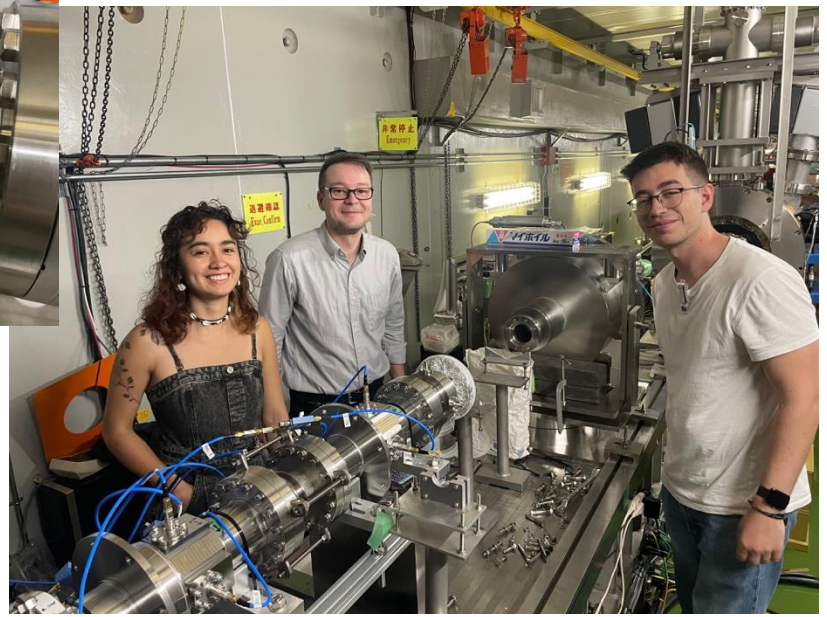


- ❑ DAQ system R&D for high-speed and low-resolution performance (PhD of Juan Carlos Fernández)
- ❑ Validate the new BPM design and DAQ system performance with beam
- ❑ To evaluate the alignment accuracy between the two subsystems
  - ✓ In synergy with the development of a test cryomodule and splitable quadrupole magnet by KEK (Akira-san, Tomohiro-san, Yasushi-san)

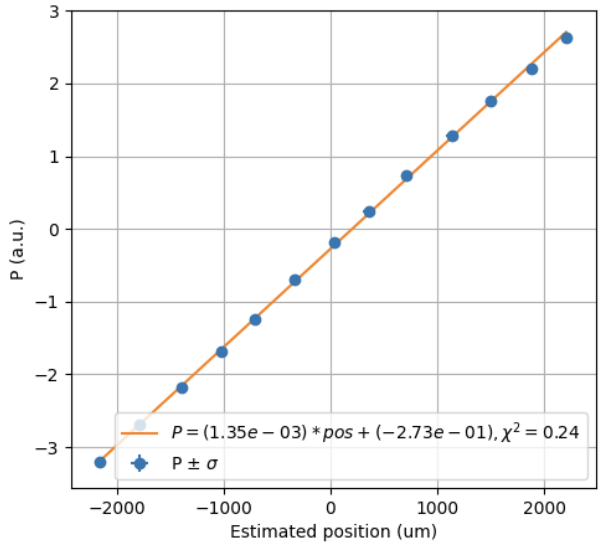


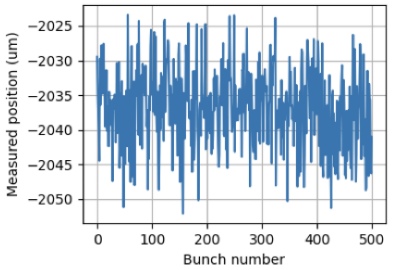
Progress and status I

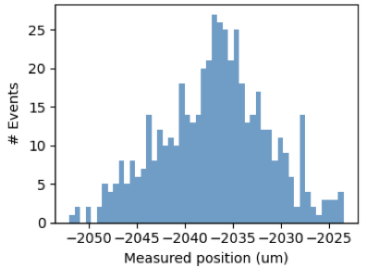
- A first re-entrant cavity BPM prototype was bought to CEA (C. Simon et al.)
  - ✓ Expected resolution < 10 μm for 20 pC to 1 nC beam charge
- Installed at the end of the ATF linac in May 2025
- Test beams performed in May-June 2025 for performance characterization
  - ✓ Analysis on-going (L. K. Pedraza presentation on LCWS25 23th October)
- Current preliminary DAQ system based on RHUL scheme analog signal acquisition + oscilloscope
- New tests are expected in December 2025
  - ✓ Little DAQ system improvement to be tested



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

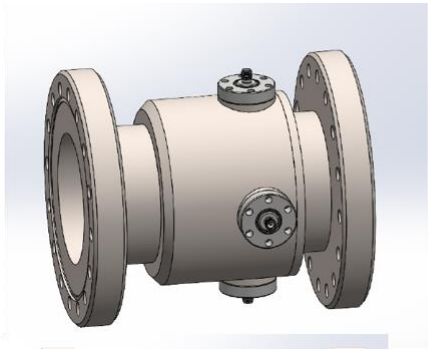


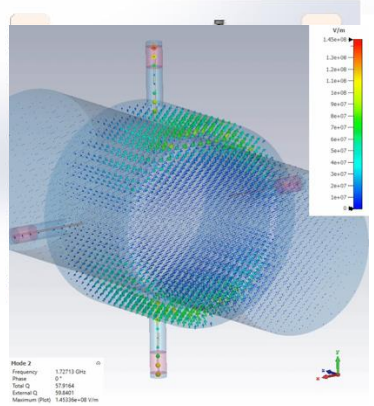


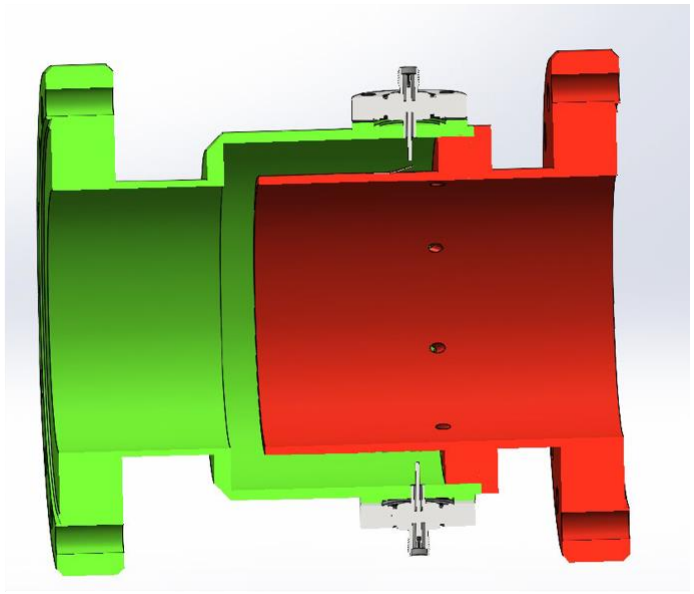


Progress and status II

- New cavity BPM design under construction by *Neptury Technologies*
  - ✓ Commercial feedthroughs
  - ✓ Improved signal length and sensitivity (QL, R/Q)







- To evaluate the alignment accuracy between the two subsystems in collaboration with Akira-san, Tomohiro-san, Yasushi-san.
  - ✓ Build a dummy model of the new cavity BPM design including the mechanical flange and pins for its precise alignment with the splitable magnet
  - ✓ Investigate how to evaluate the alignment accuracy to meet the ILC requirements (~10 μm level)
    - Design and build a test-stand for precise electromagnetic centre measurements at IFIC

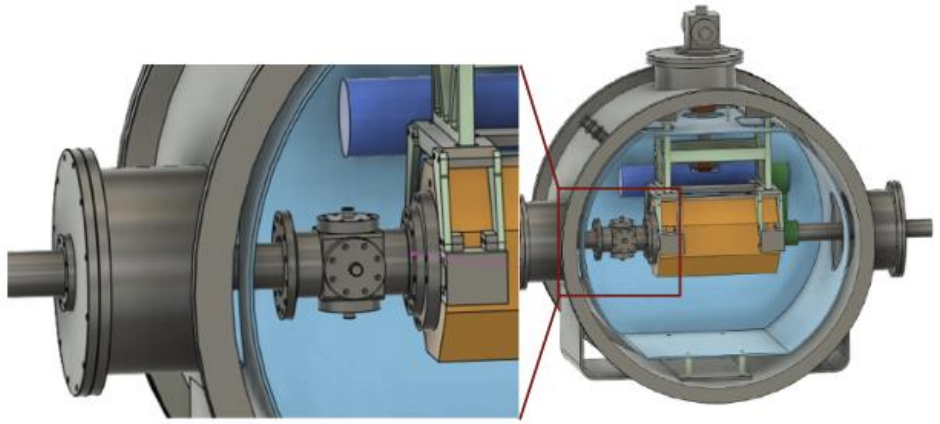


Figure: Cryostat accommodating BPM and SC quadrupole

Tentative plan in the next two years

	2025		2026		2027	
	Oct - Dec		Jan - Jun	Jul - Dec	Jan - Jun	Jul - Dec
Finalize CEA BPM performance characterization						
Test with beam the new cavity BPM						
Develop and test the partially o fully digital DAQ system						
Investigate how to evaluate the BPM-spQM alignment accuracy						
Mechanical design of dummy model BPM-flanges-beam pipe						
Construction of dummy model BPM-flanges-beam pipe						
Test dummy model at test cryostat at KEK						

❑ **Request to ATF:**

- ✓ Beam time along 2025, 2026 and 2027 (once or twice per year)
- ✓ Installation of new prototype in 2026 (probably replacing the current under test)

❑ **Contribution to ATF:**

- ✓ Enhance the use of ATF beam for the development of beam instrumentation in the context of future linear colliders: main linac BPM system
- ✓ Open to find short-term collaborative activities in the context of training of Staff/PhD students at ATF within the EAJADE program

Thank you for your attention

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