

# INFN-LASA for the PIP-II LB650 linac

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## INFN Contribution to PIP-II

- INFN firstly provided a **novel RF design for the LB650 cavities**, fully plug compatible with the Fermilab technical interfaces and performances specifications.
  - Cavity design meets the PIP-II project performance requirements
- INFN contribution aims to cover the needs of LB650 section, and this includes:
  - **38 SC cavities** required to equip **9 cryomodules** with 2 spares, delivered **as ready for string assembly**.
  - Qualification via vertical cold-test provided by INFN through a qualified partner cold-testing infrastructure
  - Compliance to the PIP-II System Engineering Plan and Technical Interfaces.



PIP-II LB650 Project Specifications	
Acc. Gradient	16.9 MV/m
Q <sub>0</sub>	2.4 10 <sup>10</sup>
RF rep rate	20 Hz to CW
Beta	0.61





# PIP-II LB650 Challenges

The successful cavity design from INFN-LASA is the result of an interplay of multiple, state-of-the-art competences in **electromagnetic**, **mechanical** and **technical** domains.

PIP-II **LB650 cavities** are among the key scientifical **challenges** of the project, requiring:

- an unprecedented quality factor for these resonators.
- Besides accelerating mode and passband, High-Order Modes risks have been assessed so that neither instabilities nor additional cryogenic losses are posing critical issues.
- PIP-II operational scenario is **an uncharted territory in terms of detuning control,** and this requires deep understanding of Lorentz Force detuning, pressure sensitivity and mechanical leading parameters as rigidities, yield limits, stresses.
- Extensive finite element analysis to evaluate the challenging mutual compliancy to both PED and ASME codes.



Kext [kN/mm

20



### **INFN** Prototypes

A total of **7 PIP-II LB650 cavities already produced** (single and multi cell), 3 of them shared with Fermilab for a joint development effort.

- First INFN single-cell with baseline recipe:
  - Developed with Zanon, novel EP and its diagnostic
  - 200 μm bulk EP + 800 °C HT + final EP + 120 °C
  - Vertical test at INFN-LASA
  - Hiqh-Q treatment and re-test coming next
- Second INFN single-cell treated at FNAL with doping
  - + 180  $\mu m$  bulk EP + 900 °C HT +N-Doping + final EP
  - Test at Fermilab-VTS, project goals met
- Two INFN 5-cell cavities in parallel
  - B61-EZ-001 from March at Fermilab VTS
  - B61-EZ-002 by June at LASA test stand







### IPAC'21 - May 24-28th, 2021 - Campinas, SP, Brazil





**IPAC**<sub>2</sub>

# Pre-Production phase, 2019-2021

- 7 LB650 prototype cavities produced and shared with Fermilab. Project goal met for single-cell and 2 INFN Bare LB650 Cavities to be soon qualified.
- **Electro-polishing** (EP) surface treatment developed and proved with novel diagnostic tools tools for a LB650 singlecell. Ongoing extension for multi-cell.
  - See M. Bertucci (INFN-LASA) et al. paper at this conference, THPAB351
- Test bench for chemical surface etching (EP and BCP) validation of fluid-dynamics simulation through Particle Image Velocimetry camera technique in collaboration with Politecnico di Milano.
  - See A. D'Ambros (INFN-LASA) et al paper at this conference, MOPAB394
- LASA SRF infrastructure upgrade for lower remnant magnetic field and better cryogenic performances ...





### Pre-Production phase, 2019-2021

INFN cold test **infrastructure at LASA is being upgraded** in view of the LB650 cavities vertical tests in order to align to state-of-the-art vertical cold test facilities :

- Cylindrical cryo-perm inner shield realized and installed in order to halve the currently measured 8 mG average remnant field in the cavity equator region.
- Extension of cryogenic plant performances:
  - Higher cryogenic power, up to 70 W at 32 mbar, thanks to an increased primary pumping skid throughput.
  - Sub-atmospheric refilling system installed to extend cavity testing time by means of **counter-flow heat-exchanger** followed by a **Joule-Thomson expander**.
  - Faster cool-down rate, now limited to about 1-1.5 K/min, via a different distribution of helium cold gas flow around the cavity.





Heat-Exchanger and its process lines



# Production phase, 2021-2025

- **Major contracts**, mainly cavity material, manufacturing and cold-testing, expected to be issued by 2022
- Two pre-series cavities to be qualified both as naked and as jacketed. Subsequent cavities will reach cold-testing infrastructure as ready for string assembly
- First Site Acceptance Review to take place under INFN responsibility at partner testing infrastructure after qualification cold-test. Final Site Acceptance Review to take place at string assembly site.
- Production cavities targeted to be delivered at string assembly site in 9 batches from May 2024 to July 2025
- INFN-Fermilab Project Planning Document (PPD) finalized. It accounts for:
  - Compliance to the PIP-II Tech. Review Plan
  - Scope of Work, Deliverable, Milestones
  - Project schedule
- Quality Assurance Plan, Risk Management Plan documents drafted and soon released



