



TIFPA



Istituto Nazionale di Fisica Nucleare

INFN TIFPA Proposal to join the ePIC Collaboration

Trento Institute for Fundamental Physics and Applications (TIFPA) -
INFN national centre

Mechanical Design, Vibrational Analysis & Optical Metrology

Enrico Serra – on behalf of the TIFPA Group

TIFPA Group & Collaborative Framework

Enrico Serra

Senior Technologist, INFN-TIFPA — PI



Michele Bonaldi

Senior Researcher, FBK Trento



Daniele Bortoluzzi

Full Professor of Mech. Eng., University of Trento



Antonio Borrielli

Senior Researcher, CNR IMEM



Carlo Zanoni

Senior Technologist, INFN-TIFPA (joining late 2026)



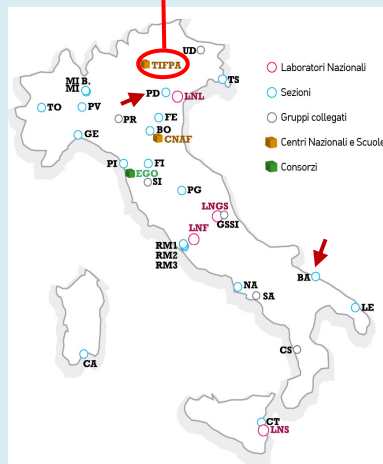
+ PhD student

Planned hire

Key Infrastructure

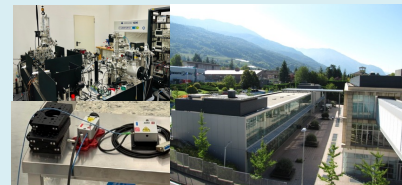
INFN National Network

TIFPA is part of the INFN network (ePIC SVT activities in collaboration with INFN Padova and Bari).



Optomechanical Labs -Trento

Precision mechanics - quantum sensing - optical metrology.



CMOS / N-MEMs Facility -Trento

FBK silicon foundry - nano/micro fabrication.



Proton Beam Line Facility- Trento

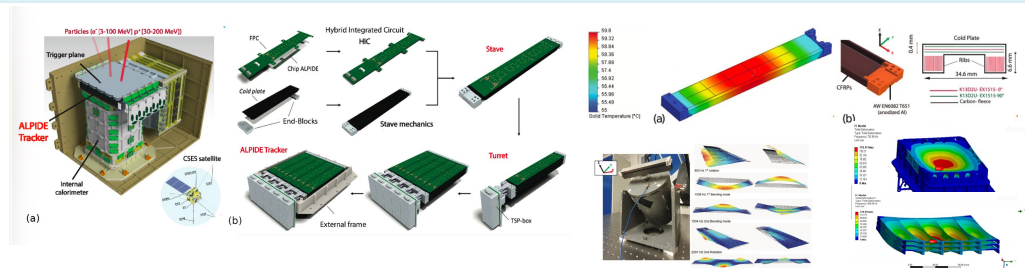
Radiation hardness testing for space and medical detectors.



Relevant Background for SVT

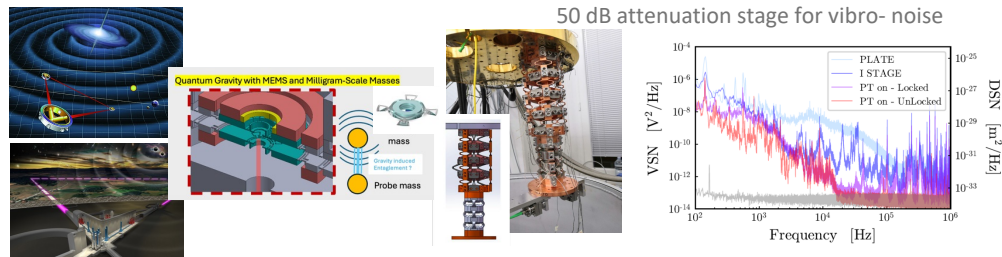
HEPD-02 (ALPIDE) Tracker

Structural and thermomechanical design and Finite Element analysis of a particle tracker for a scientific satellite. Integration of ALPIDE MAPs on a Carbon Fiber Reinforced Plastics frame. FEA tools for modelling SVT.



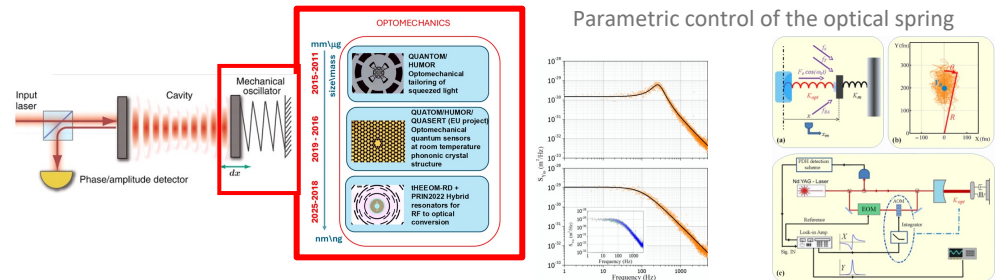
GWD & gravity

Insulation from environmental vibrations with spring-mass stages —ultra-precision mechanics for systems for LISA and Einstein Telescope. Exploring quantum gravity with MEMS. Comparable noise floor (seismic/cultural noise) as ePIC SVT for positional stability.



Quantum Sensing - Optomechanics

Development of MEMS-based force sensors sensitive to laser radiation pressure in Fabry Perot cavities. Use of low-noise lock-in amplifiers and FFT-based readout techniques for highly sensitive optical measurements. Expertise in in-house optical setups, with skills directly transferable to SVT vibration measurements.



Our Three Contributions to ePIC SVT

01

FEA – SVT Structural Dynamics & vibrations

FEA models of IB system & subsystems (L0–L1–L2). Modal analysis and dynamic response of prototypes. Benchmarking against analytical models. In collaboration with INFN-Padova.

02

CFD & Fluid–Structure Interaction

Aerodynamic load estimation on silicon layers. SST turbulence model. Coupled CFD–FSI for pressure gradients & deformation maps. Mock-up validation with INFN-Padova & INFN-Bari.

03

Optical Vibration Measurements

Contactless optical techniques: Laser Doppler Vibrometry, confocal sensors, interferometers. Wind-tunnel compatible in-house Lock-in / FFT setups.

01 | FEA – SVT Structural Dynamics & vibrations

Objectives

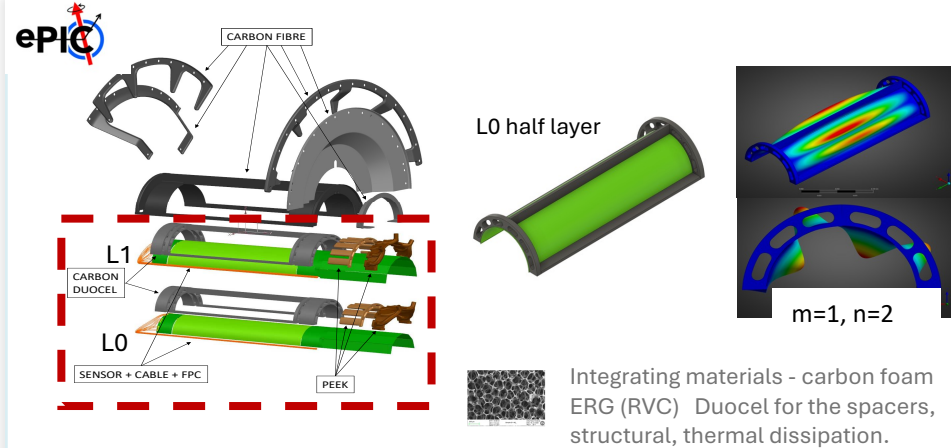
- Ensure short-term positional stability of sensors during operation
- Address vibration- and thermal-gradient-induced misalignments (local & global)
- Benchmark FEM results against analytical models

Current Status

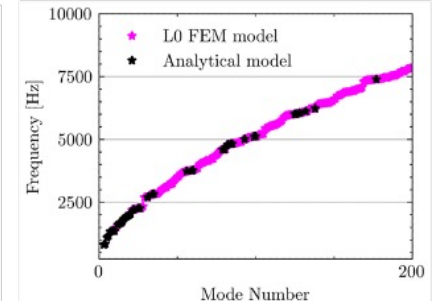
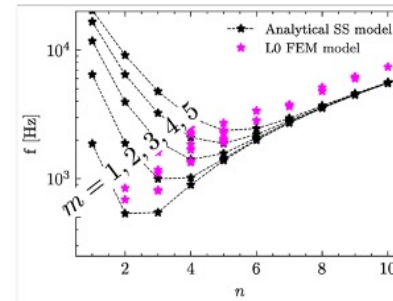
- participating in the ePIC Italy collaboration activities since 2025 (in particular on FEA studies), with formal membership since 2026
- FEM models of L0 stave: carbon fibre, carbon foam (ERG Duocel), PEEK, silicon sensor layers
- Modal analysis: FEM and analytical SS model development for evaluating internal resonances

Next Steps

- Extend model to full IB (L0 + L1 + support structure)
- Integrate thermal + vibrational loads in a coupled analysis
- Develop simulation tools for mock-up validation



Comparison of analytical & FEM model for dynamic response qualification.



02 | CFD & Fluid–Structure Interaction Analysis

Objectives

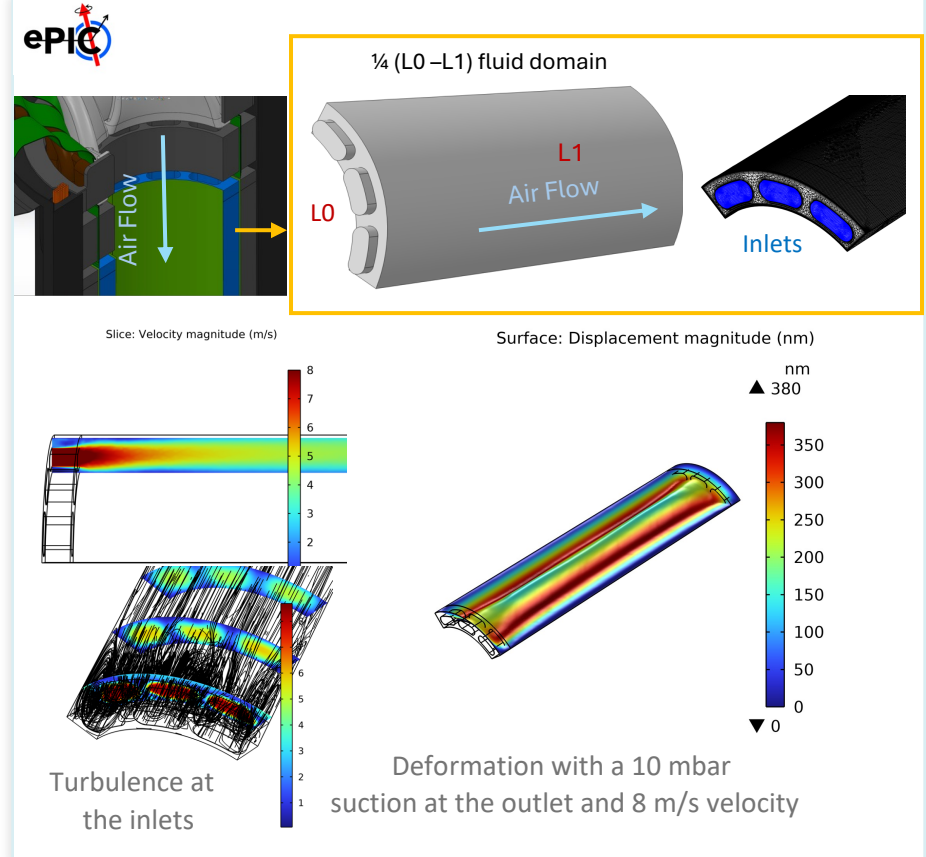
- Estimate aerodynamic loads on silicon layers L0–L1 under operating cooling airflow
- Compute resulting deformations via coupled CFD–FSI
- Refine model for integration with thermal and vibrational analyses

Approach & Tools

- SST (Shear Stress Transport) turbulence model
- Two-way CFD : coupling pressure field <-> structural deformation
- Displacement maps at nm level on thin Si layers

Validation Plan

- Mock-up wind-tunnel test: measure pressure & displacements
- Cross-validate CFD predictions with optical measurements
- Collaboration: INFN-Padova (mechanical design) + INFN-Bari (mock-up testing)



Summary & Next Steps

◆ **Strong, directly relevant expertise**

Precision mechanics, FEA of particle trackers (HEPD-02/ALICE), optomechanics at LISA/GW sensitivity levels, and in-house optical metrology.

◆ **Three concrete, ongoing contributions**

FEA structural dynamics of the IB (active since 2025) — CFD–FSI aerodynamic loads on Si layers — Optical vibration measurement campaigns on SVT mock-ups.

◆ **Growing team with clear roadmap**

Carlo Zanoni joining in late 2026, PhD student in planning. A full coupled model aiming at evaluating thermal, aeroelastic displacements and mock-up validation targeted by 2027 to support construction phase.

We look forward to joining and contributing to the successful realisation of the Silicon Vertex Tracker.