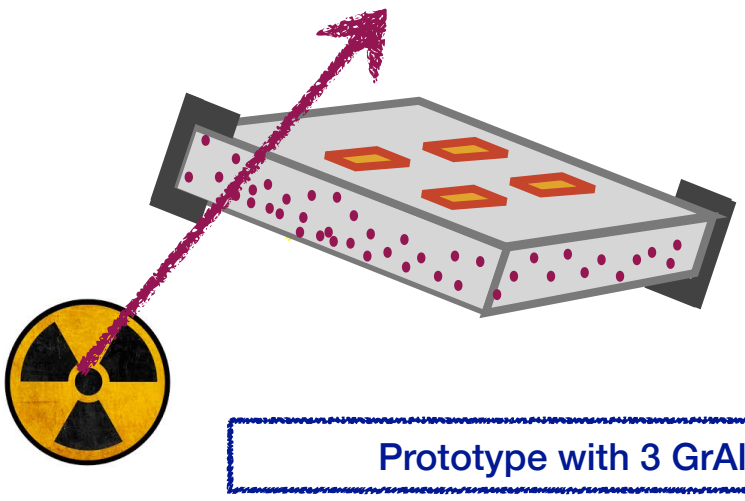
DEMETRA

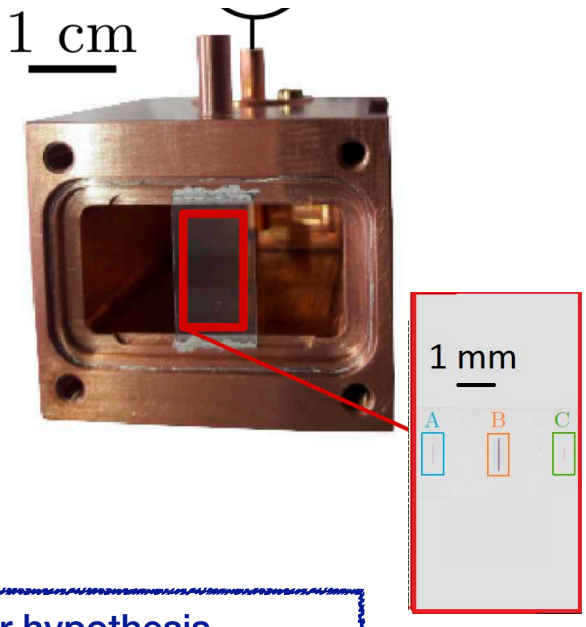
Suppression of the relaxation induced by radioactivity in superconducting qubits

- Superconducting circuits: one of the leading technologies for quantum processors
- Possible limit: coherence time. Goal: few ms — obtained: 100 μs
- **Quasiparticles** are one of the main source of decoherence



DEMETRA Hypothesis:

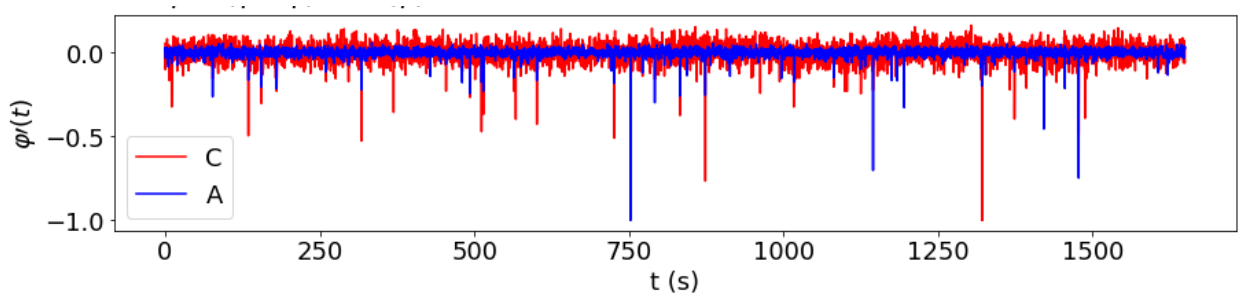
- Radioactivity creates phonons in the qubit substrate
- Phonons enter the qubit breaking Cooper pairs into quasiparticles
- This phenomenon is actually the working principle of phonon-mediated Kinetic Inductance Detectors (KIDs)



Prototype with 3 GrAl resonators deposited on sapphire to prove our hypothesis

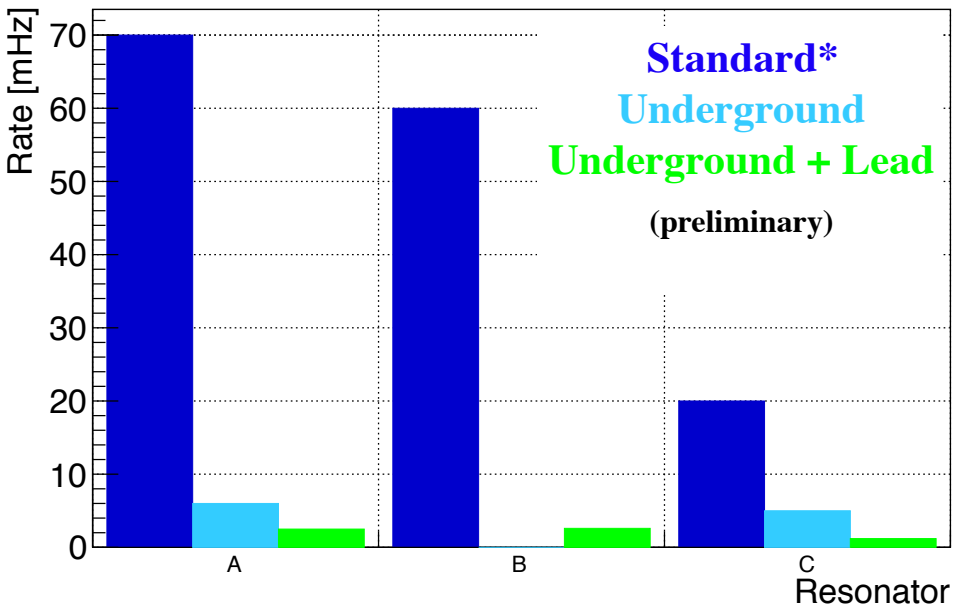
Prototype exposed to an intense ThO_2 γ-source

- Rate of quasiparticle bursts increased by x100: radioactivity matters
- Majority of bursts in time-coincidence in all the resonators: interactions are in the substrate



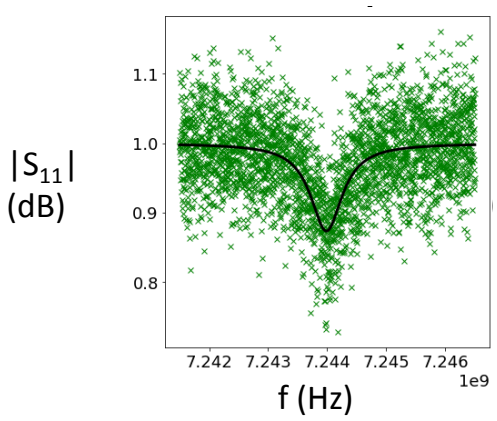
Prototype operated in deep underground laboratory

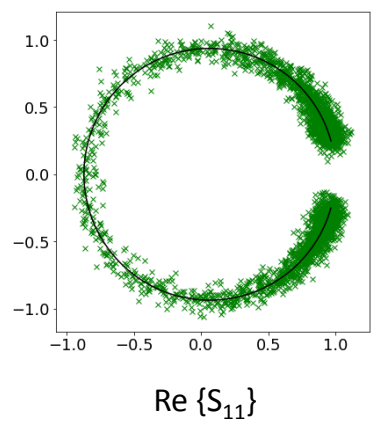
- Same device operated at LNGS (depth: 3600 m.w.e.) in the HallC R&D Facility
- Rate of quasiparticles bursts drops underground
- Lead shield around the cryostat: further x2 suppression



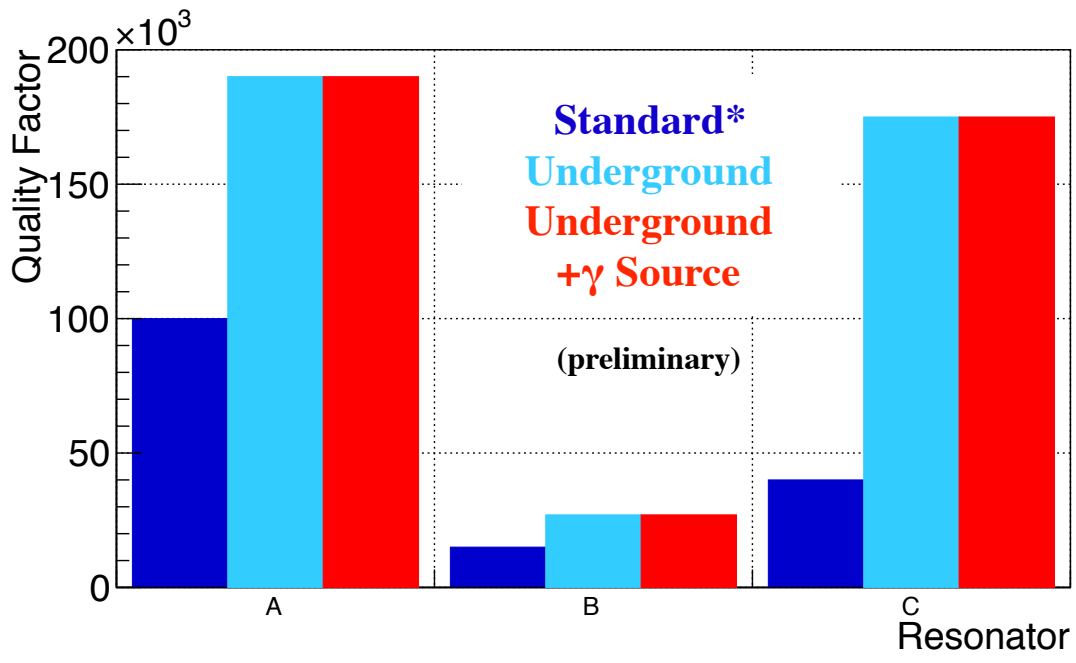
- More than one order of magnitude suppression
- Still a lot of room for improvement

We can act on the rate of quasiparticles bursts. Does this change other general features of the resonators?





Focus on some parameters, such as the internal Q, extracted from a fit to the resonance in the real and imaginary plane



- The underground operation resulted in an improvement
- Adding a source did not result in a worsening.
- Tests runs to be done soon to understand this result

*Standard indicates operation above-ground without radiation shields

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