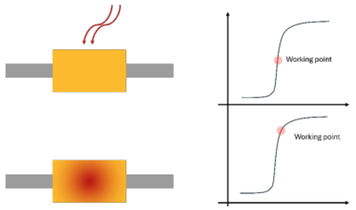
# Tavola rotonda

## strategia e prospettive future per l'R&D sui rivelatori

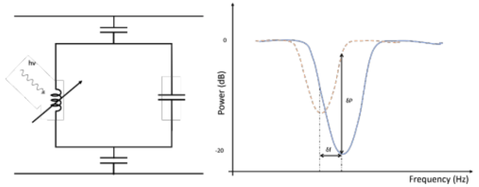
# Quantum Technologies – Superconducting circuits for Quantum Sensing

## *Superconducting photon detectors*

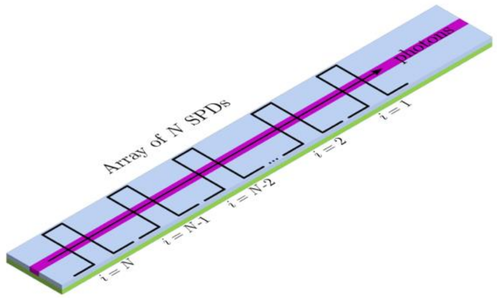
TESs




KIDs




SNSPDs
(also in integrated photonic circuits)

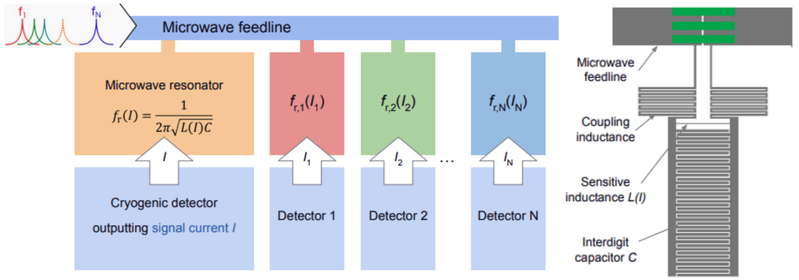



High resolution & scalable (arrays)

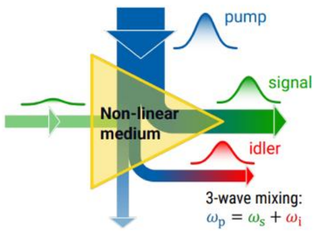
Sensitive to magnetic field;
Challenging low-noise multiplexing

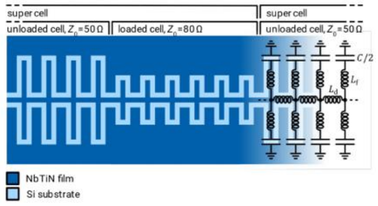
## *Quantum-limited read-out*
*with high kinetic inductance circuits*

KICS Tunable resonators for frequency multiplexing of arrays of detectors/qubits



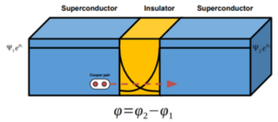

TWPAs: quantum-limited and wideband (several GHz) superconducting amplifiers



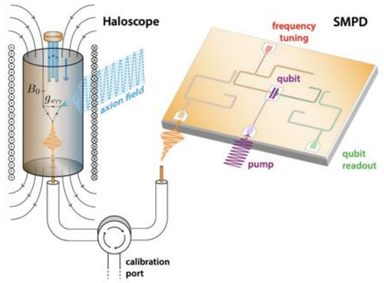

## *Quantum circuits*

Josephson junctions – based devices



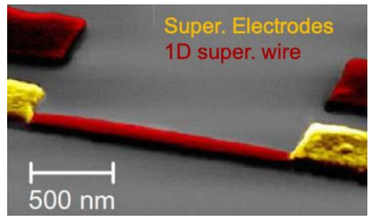

Transmon qubits

Microwave photon counters for dark matter searches




Novel proposed devices

- Josephson escape sensor
- Superconducting thermoelectric detector
- Non local superconducting detector




**Advantages**: high sensitivity, high resolution, high SNR ⇒ new detection schemes and new experimental approaches
**Challenges**: resilience to high magnetic field ⇒ interest of the community in exploring new materials; R&D still in progress

# Summary of the Gaseous Detector Session



- There is a strong commitment to the use and development of **MPGD detectors** across various applications, including: Large-area muon systems, inner trackers, TPCs, and astroparticle physics.

Key Needs Identified:

- Further development of MPGD technologies (GEM, Micromegas, µRWELL, etc.).
- Continued R&D efforts to enhance long-term stability and reliability, ensuring operation in both:
- High-rate environments (e.g., upgraded forward regions of existing LHC experiments, FCChh, etc.).
- Medium/low-rate environments (e.g., FCCee).
- Optimization of resistive structures and material studies (e.g., DLC coatings).
- Improvement of production processes, including industrialization.

Discussion on INFN Infrastructure for MPGD Prototyping:

Due to concerns about having CERN's MPT Workshop as the sole production site, along with the need to promote knowledge transfer to industry, the discussion addressed the necessity of a dedicated MPGD prototyping infrastructure within INFN.
This could foster synergy among different communities working on diverse applications but sharing common interests in development and production.
May be a topic worth further exploration, possibly through the creation of dedicated working groups or the organization of a thematic workshop.

→ Also, important starting point:
collecting and exchanging infos on available infrastructures, tools, production lines at Institutes/labs

# Calorimetry Session Summary

## 1) Evolving Existing Technology

- Development of new materials: plastics, crystals
- Advanced electronics: low power consumption, high-speed processing
- SiPMs for improved performance
- Meeting increasing demands: radiation hardness, speed, low jitter, low power
- *High-granularity calorimeters for future colliders*

## 2) Cross-Field Innovations

- Incorporating advancements from gas and silicon detectors
- Emergence of new concepts:
  → Gas-based hadronic calorimeters (Micromegas, uRWELL)
  → Tungsten-silicon calorimeters (Calice)

A Collaborative Effort: DRD6
• Small but significant advancements over the past 3-4 years
• Young and less young researchers leading R&D efforts

# Rivelatori liquidi

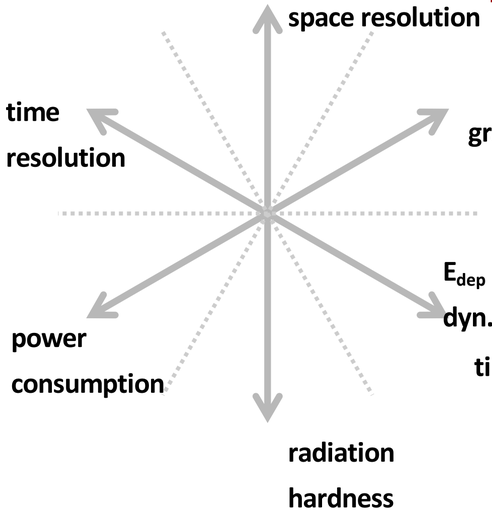
Punti su cui focalizzare l’attenzione INFN nei prossimi due/tre anni

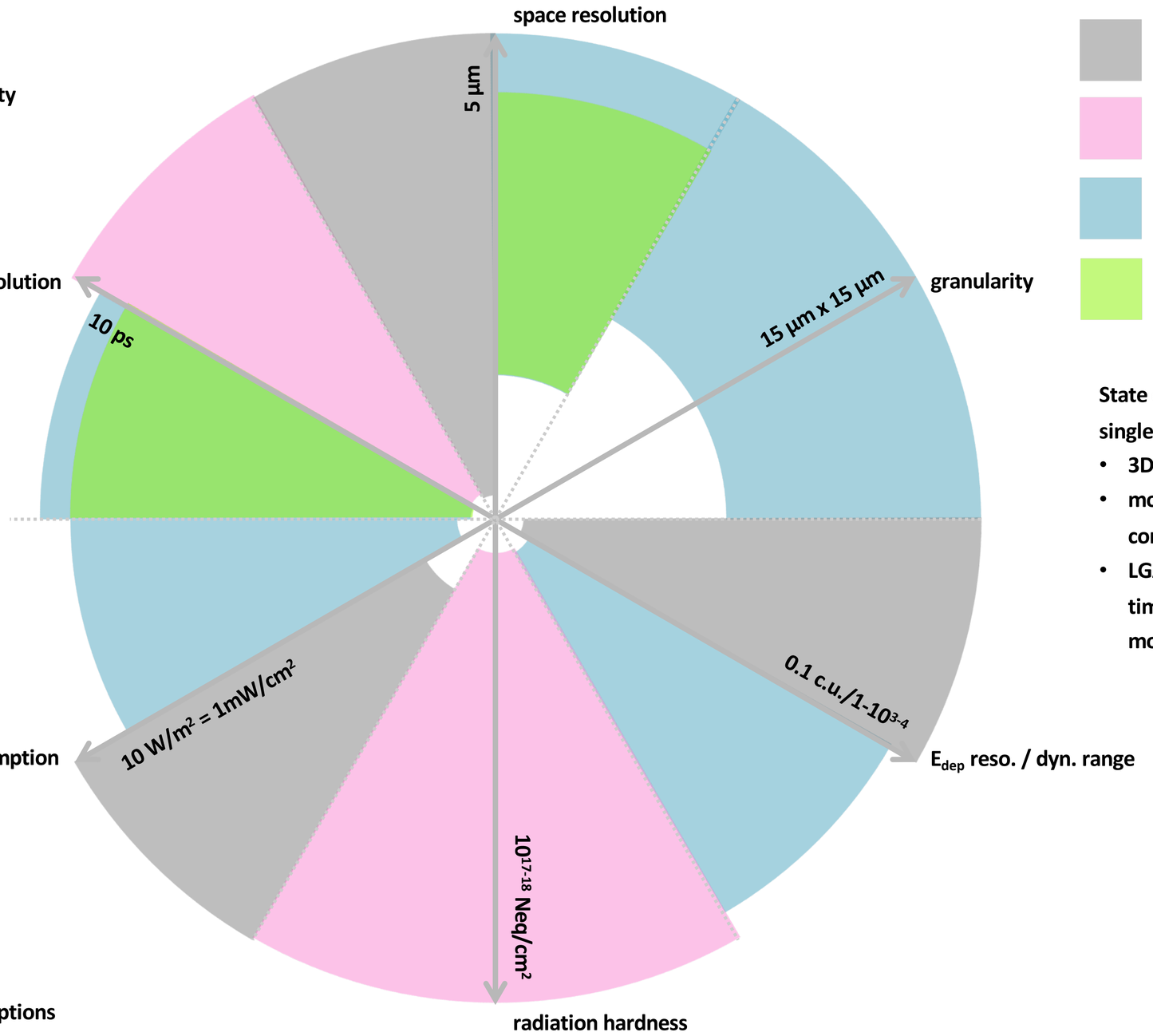
- Completamento e prestazione rivelatori in costruzione/completamento:
  - DUNE 1-2: DarkSide-20k: JUNO; HYPERK; KM3NET
    - SiPM, PMT, rivelazione luce UV
    - UAr
    - TPC
- R&D importanti per DUNE 3-4, LEGEND1000, SWGO
    - Pixel e luce-carica
    - Scintillazione e Cerenkov combinati

# PhotoPID highlights

- Solid state photon sensors widely used (i.e. SiPM)
  - New sensor technologies to cope the radiation load for future experiments needed
    - Ongoing activity in collaboration between FBK and CSN5 projects IBIS + IBIS_NEXT for the BSI configuration
  - Hybrid MCP-PMT embedded on Timepix4 solution well underway
    - In collaboration with Hamamatsu
  - Many groups are developing CMOS-SPAD 2D (digital SiPM)
    - integrating photo-sensor and electronic chain on the same chip
    - INFN CSN5 ASPIDES project
  - Look at the future developments also in 3D integration
  - Not limited to photon detection, also direct (through Cherenkov emission in a thin window) MIP detection for TOF applications
- Several large PID projects / upgrades in the upcoming future
  - RICH (ePIC-dRICH, ALICE3-RICH, LHCb RICH upgrade 2, …)
  - ToF (ALICE3 LGAD-TOF, SiPM coupled with thin window)
- Synergy with electronics and mechanic are crucial
  - high-performance cooling of sensors to very low temperatures
  - high-temperature annealing to mitigate radiation damage
- Many groups are using similar solution
  - Standard will help
- Young researchers should be involved since the beginning to face the challenges of present and future experiments

# Frontiers vs technologies




State of the art NOT coming (yet) from single technology:

- 3D for time and radiation damage
- monolithic for granularity, and power consumption
- LGAD (and RSD-LGAD) can improve time and spatial resolution of monolithic

based on the best of our knowledge and assumptions