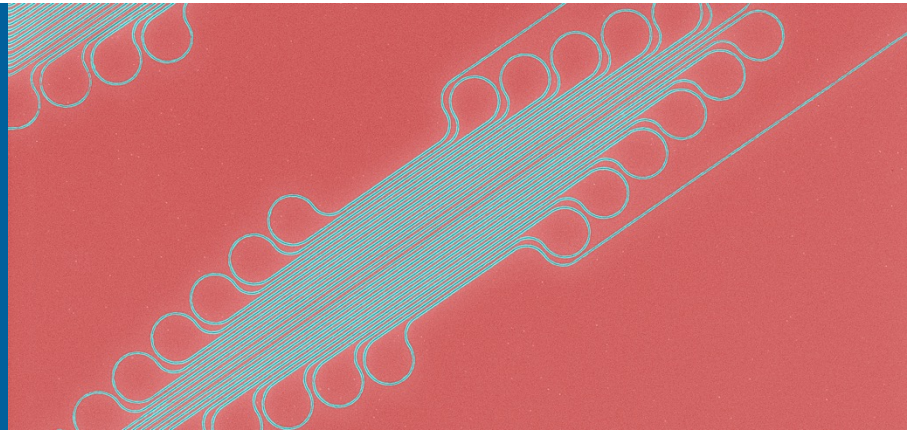
SUPERCONDUCTING NANOWIRE SINGLE PHOTON DETECTORS R&D AT ARGONNE



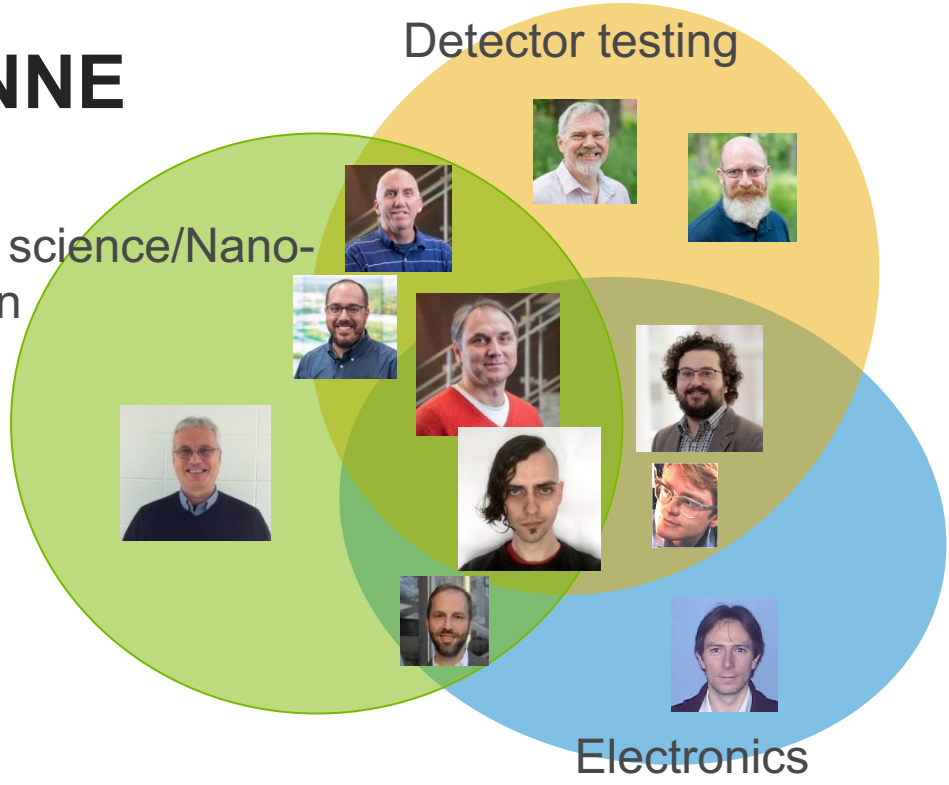
TOMAS POLAKOVIC
PHY

22/11/21

SN(SP)D R&D AT ARGONNE

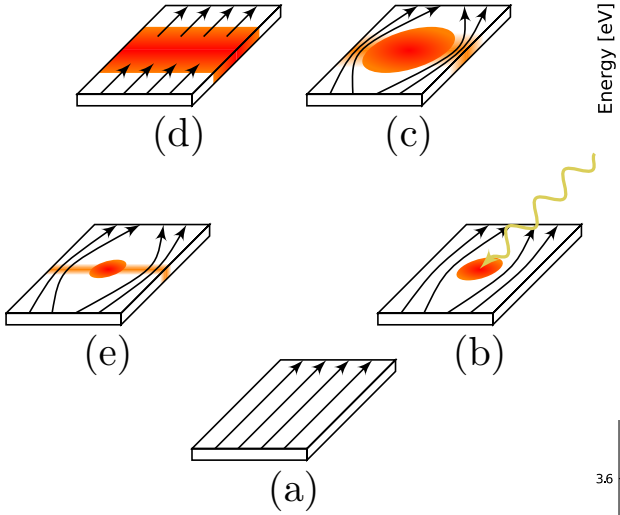
- 3 FWPs + 2 LDRDs
- Relatively broad focus
- Not localized just to ANL

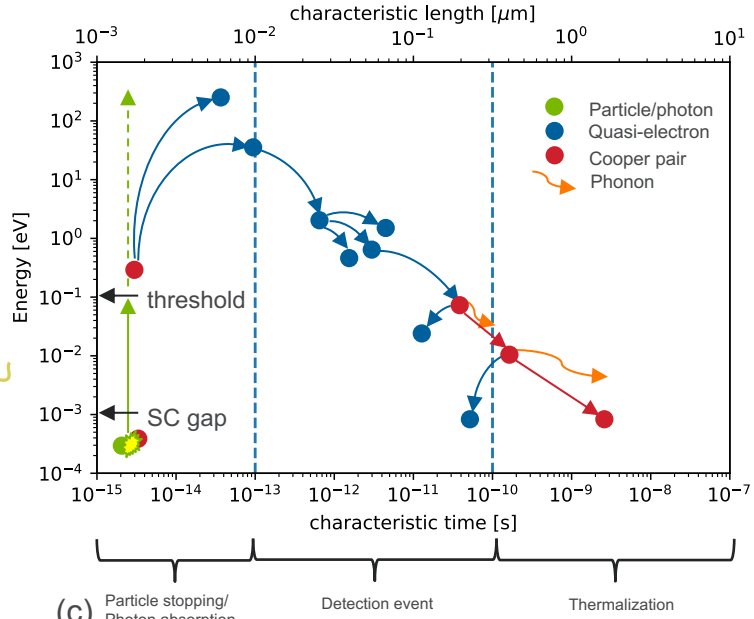
- Most of our applications outside QIS

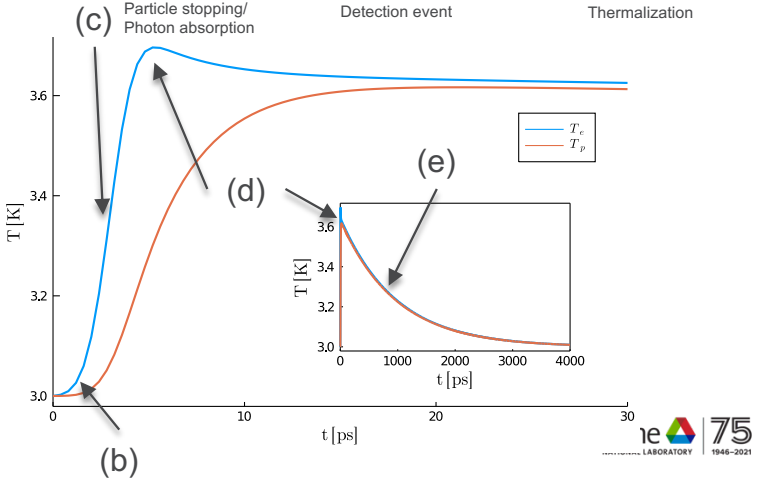


WHAT'S A SNSPD?

- One of the fastest and most sensitive single photon detector technologies
- <10 ps timing jitter
- 1-10 GHz count rate
- 100% detection efficiency up to 1200 nm
- Compact
- Simple readout



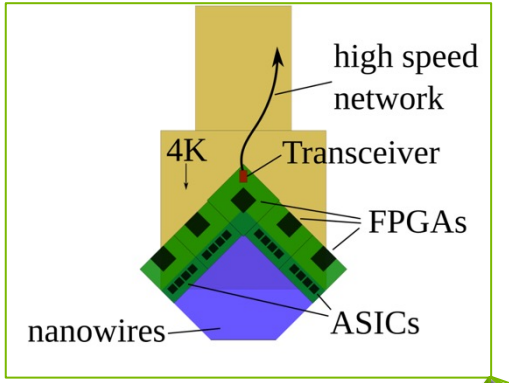


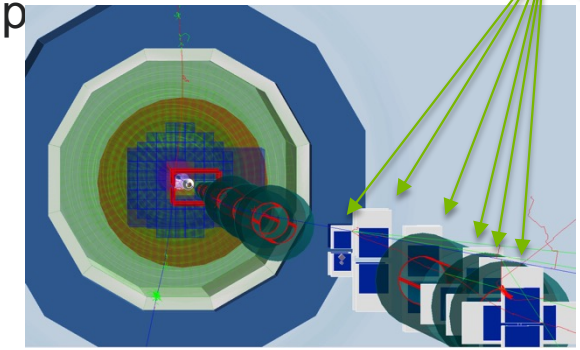


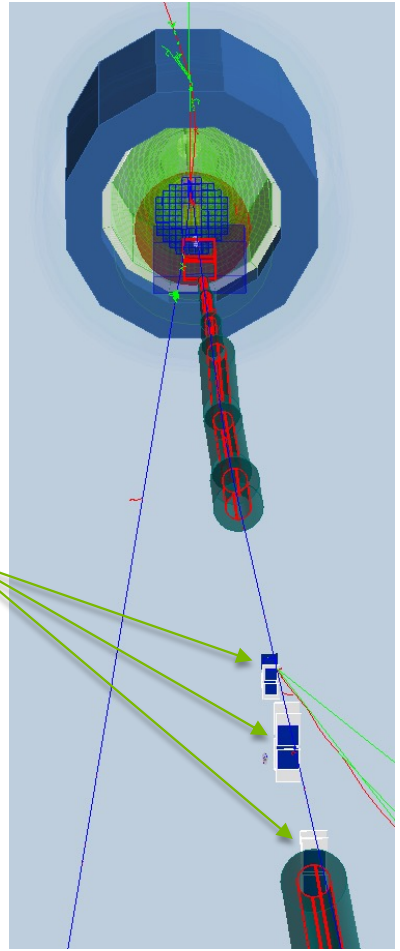
WHY A SNSPD FROM US?

- Strong programmatic support for nanowire detectors of particles
- Multiple applications to high-profile experiments

- Interest from QIS slowly picking us up

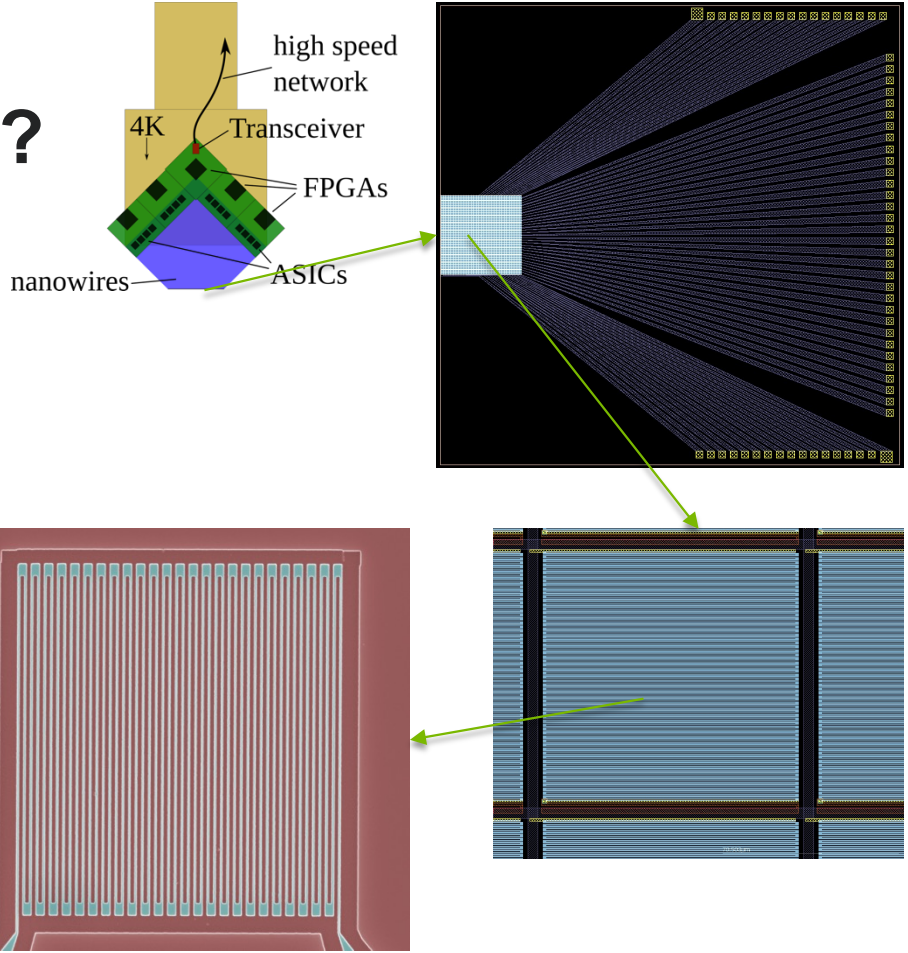






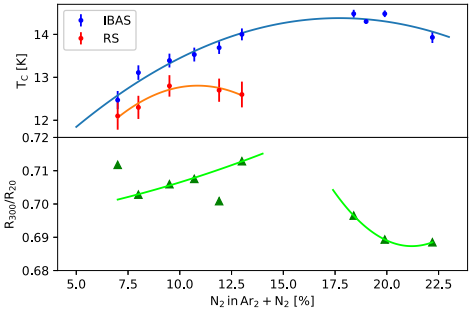
WHY A SNSPD FROM US?

- Working on solutions tailored to specific experiments and scale
  - Experience with detector systems and superconducting electronics at all scales
  - We can provide boutique detectors/devices where commercial solutions are not economical/viable

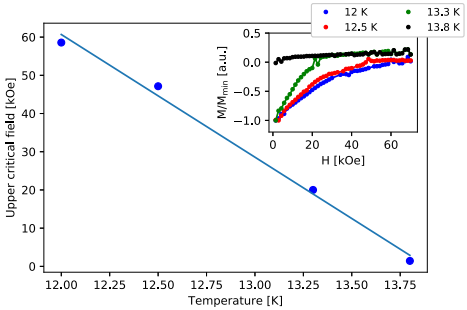


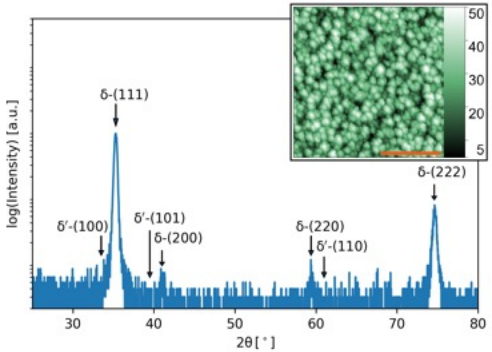
WHY A SNSPD FROM US?

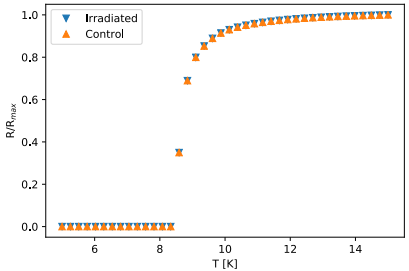
- Working on solutions tailored to specific experiments and scale
  - Materials design
    - Magnetic and radiation field tolerance
    - Exotic substrates
    - Non-standard process conditions

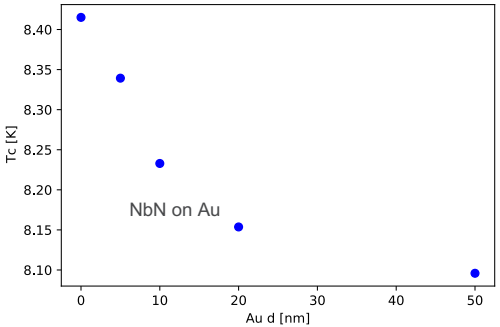


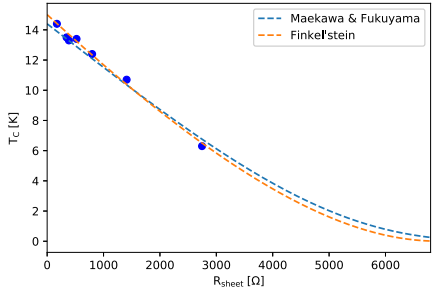
doi.org/10.1063/1.5031904



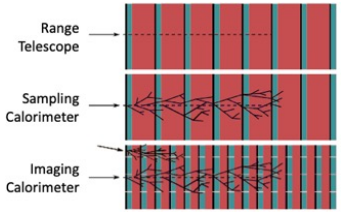


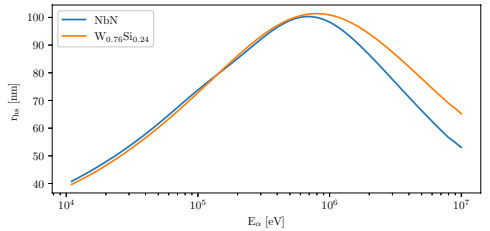




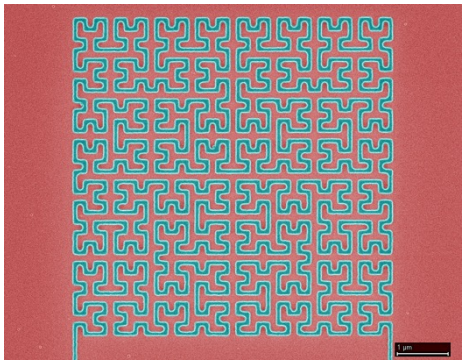


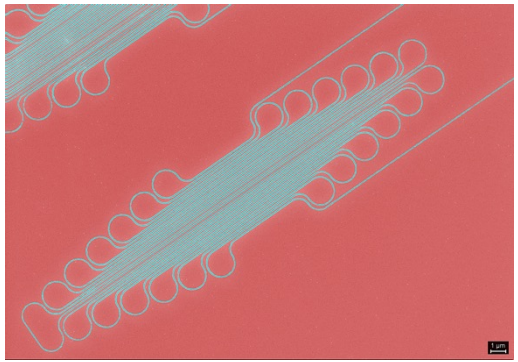
WHY A SNSPD FROM US?





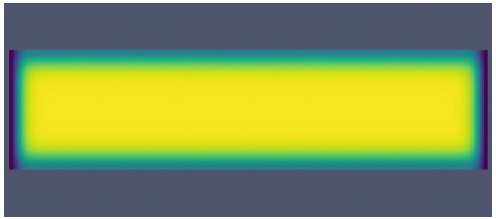
- Working on solutions tailored to specific experiments and scale
- Detector design for niche applications
  - Capability to make complicated geometries
  - Multi-layered detectors
  - Detection of light and charged particles



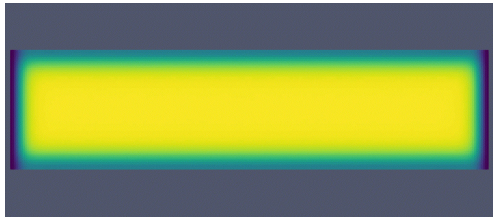


Simulation

Photon

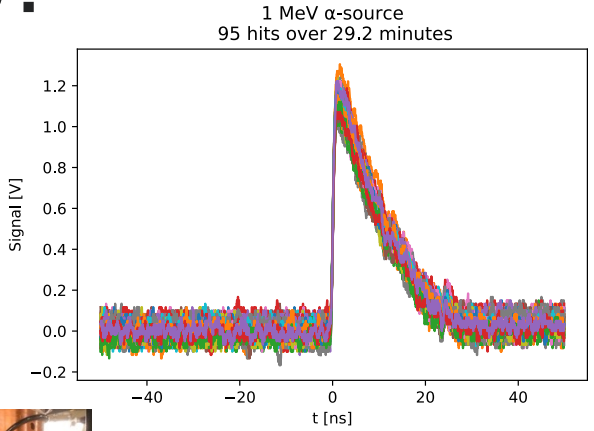


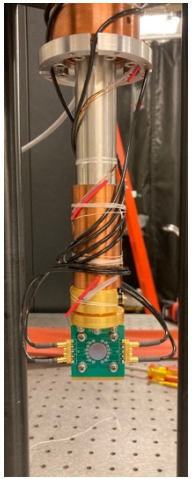
α particle

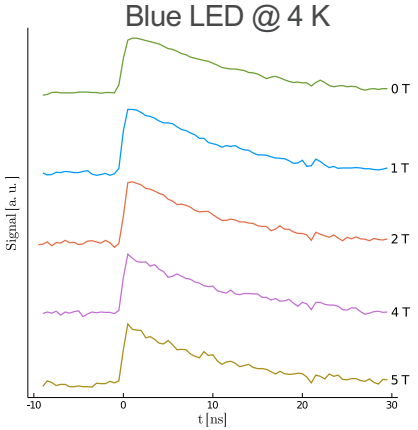


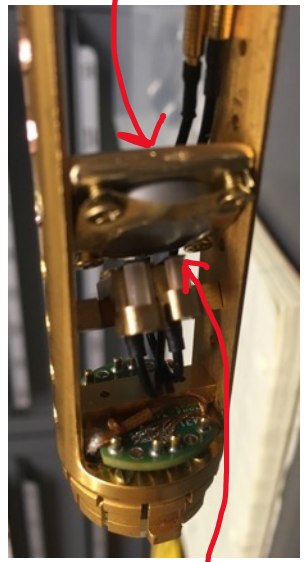
WHY A SNSPD FROM US?

- Working on solutions tailored to specific experiments and scale
- In-house detector testing and characterization
  - Multiple dedicated cryostats (>3 K) with magnetic field, particle sources (α, β^+, γ)
- Currently working with FNAL on dedicated beamline testing setup
  - Test beam and irradiation facility







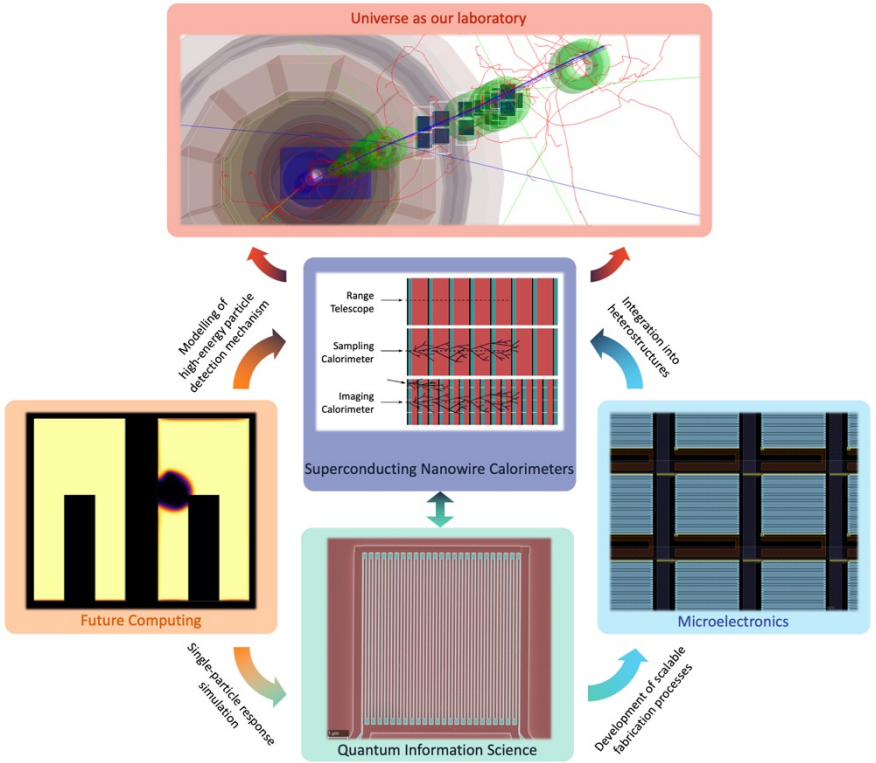


doi.org/10.1016/j.nima.2020.163543

PROJECTS WITHIN THE R&D EFFORT

Novel Energy-Resolving Quantum Detectors

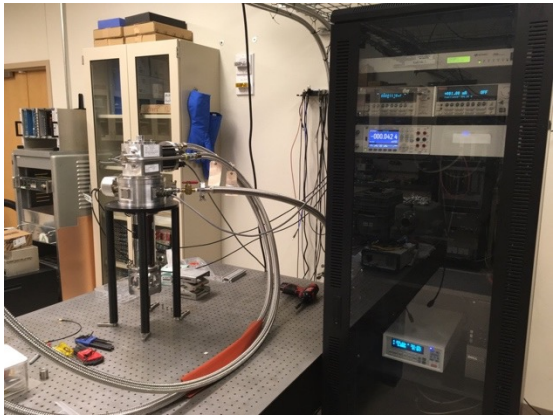
- LDRD at PHY/MSD
- Nanowire-based particle detectors
- For EIC, SoLID, smaller experiments



PROJECTS WITHIN THE R&D EFFORT

Beamline Testbed for Superconducting Nanowire Particle Detectors + Superconducting Quantum Detectors for Nuclear Physics and QIS

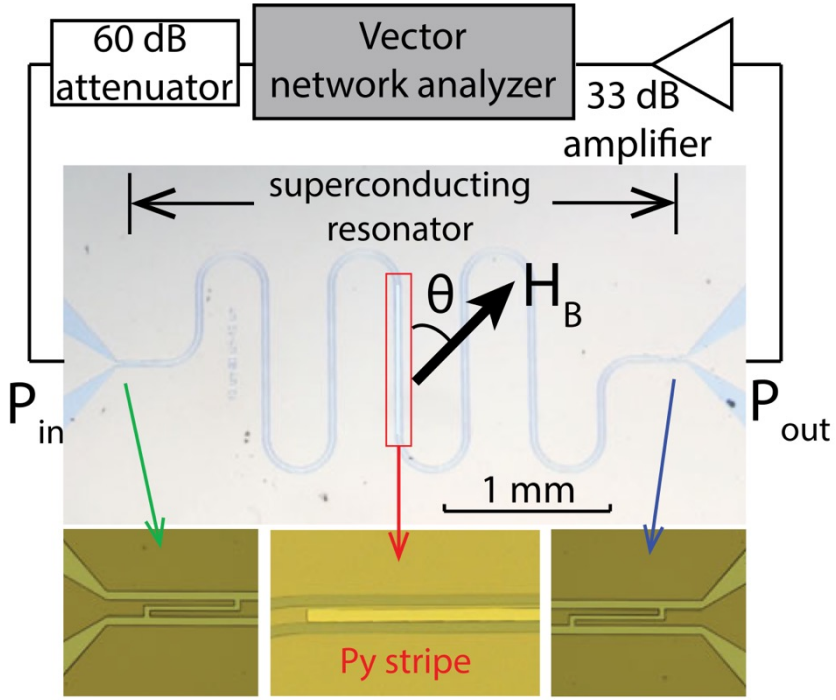
- FWPs at PHY/MSD
- Generic R&D projects that seeded the original effort
- Development of testbeds and nanofabrication processes for SNSPD design



PROJECTS WITHIN THE R&D EFFORT

Hybrid Magnonic Devices

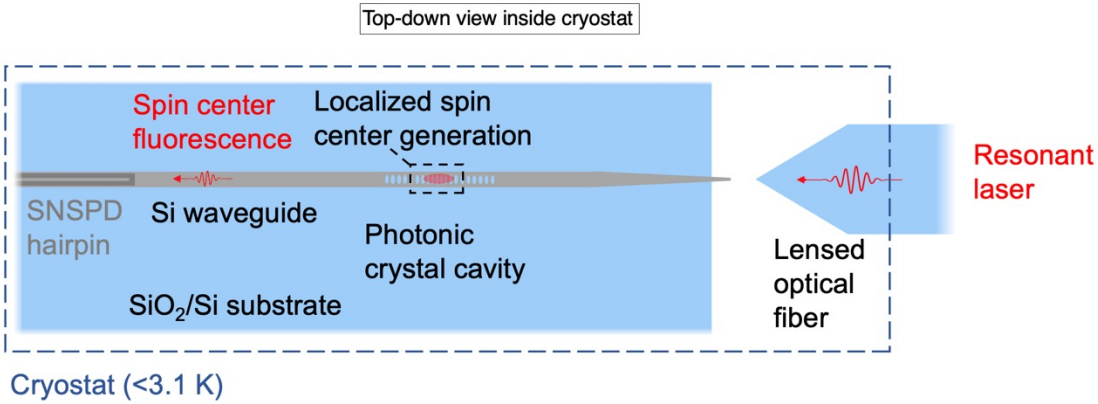
- Yi Li will tell you more in 5 minutes
- Utilizes the high magnetic field tolerance of our superconductors



PROJECTS WITHIN THE R&D EFFORT

On-chip Quantum Sensing Platform for Optical Spectroscopy of Single Spin Defects in Silicon

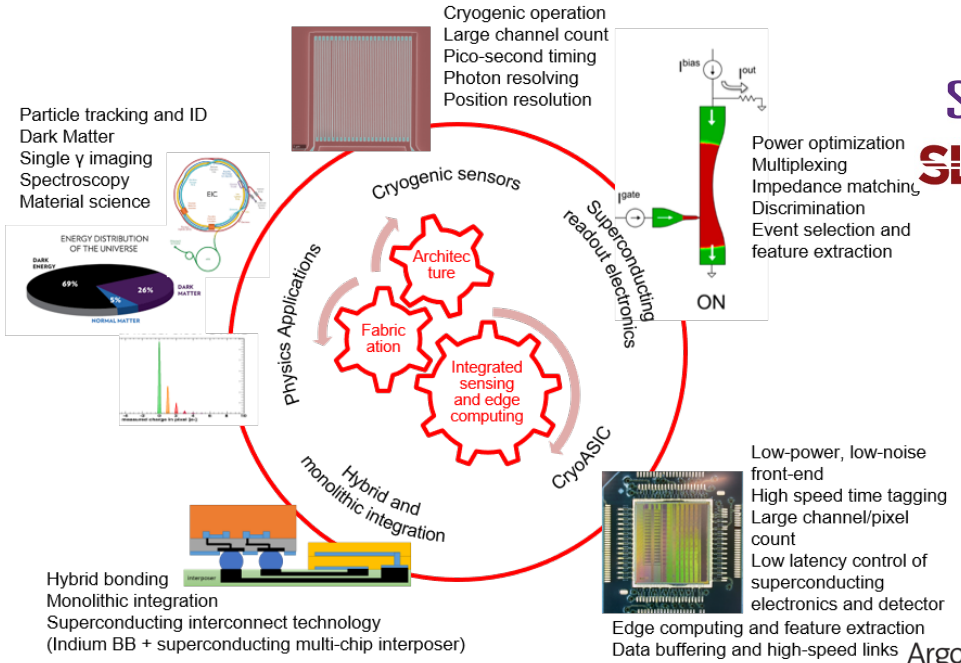
- LDRD at CNM/MSD
- Coupling of nanowires to photonic crystal cavities
- Used for development of spin defect-based quantum sensors



PROJECTS WITHIN THE R&D EFFORT

Hybrid Cryogenic Detector Architectures for Sensing and Edge Computing Enabled by New Fabrication Processes

- Large collaboration focused on hybrid and monolithic integration of superconducting and cryo-CMOS devices
- Supposed to provide electronics for later stages of our other projects



WE'RE HIRING!

Postdoc Openings

- Hybrid Superconducting Sensor Integration and Detector R&D
  - https://argonne.wd1.myworkdayjobs.com/en-US/Argonne_Careers/job/Argonne-National-Laboratory/Postdoctoral-Appointee---Hybrid-Superconducting-Sensor-Integration-and-Detector-R-D_411850
- Detector Readout Electronics
  - https://argonne.wd1.myworkdayjobs.com/en-US/Argonne_Careers/job/Argonne-National-Laboratory/Postdoctoral-Appointee---Detector-Readout-Electronics_411714