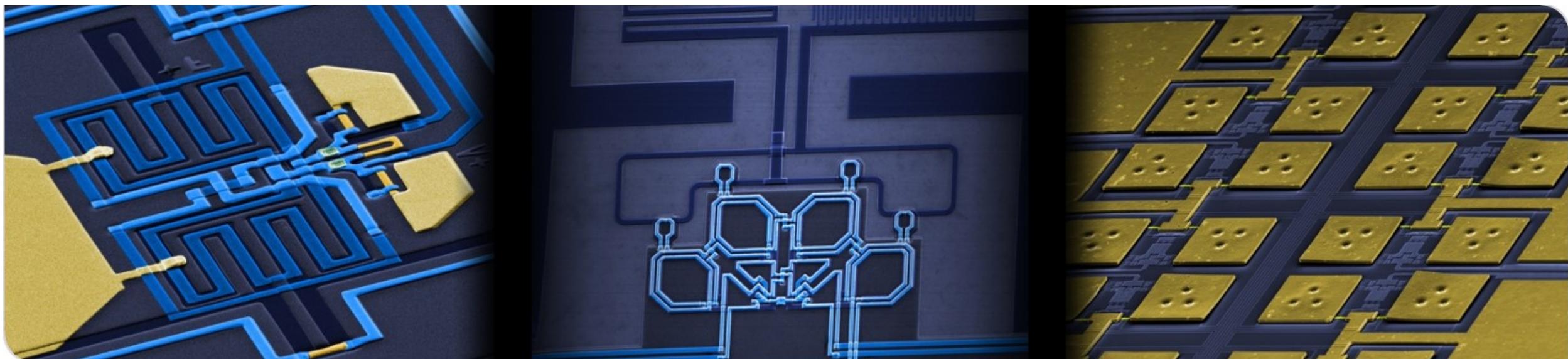


Project P2: MMC-based detection system

Sebastian Kempf

DELight Collaboration Meeting | Karlsruhe | September 13, 2024



Things that were evaluated positively...

- „The project draws on a **wealth of previous work** on the development and applications of MMCs and SQUID-based readout systems carried out by S. Kempf (the P2 applicant) and C. Enss (one of the P2 co-applicants), who have worked together for many years.“
 - review panel confirm that required expertise for P2 is existing
- „The **preliminary work** carried out by the applicants is excellent, and given the length of time they have already been within the particular area of research, **their expertise is very high**. The explanations of the operating principles and technicalities of the sensors and readout systems are sound and **demonstrate a high level of expertise**.“
 - infrastructure will allow for setting up the detection system
- „In addition to its primary objective of designing, fabricating, installing, and calibrating the MMC-based system for DELight, **this project's studies and results will impact other uses of MMCs and will expand the scope of application of these calorimeters**.“
 - detector R&D will positively influence other MMC-based applications (wider use of MMCs)

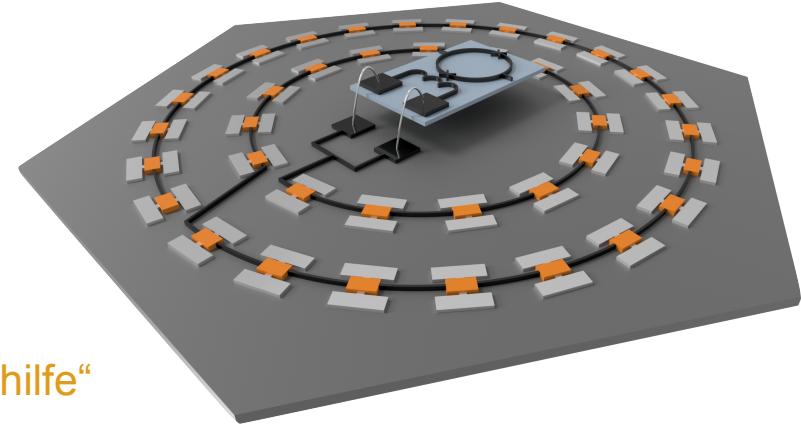
Things that were criticized...

- „Although the basic (detector) design will build on previous work of the team, several new features related to the aforementioned options will be investigated. In this respect, the **risks on a pathway** to a full detector with SQUID electronics as well as the **intrinsic MMC backgrounds** could have been anticipated in more detail.“
 - many new detector features, e.g. athermal detection mode, superconducting phonon collectors, sapphire substrates, distributed temperature sensors
 - risk that the proposed detector design doesn't work
 - intrinsic MMC background (low energy excess, LEE) not explained in detail
- „However, a **detailed analysis of success rate**, what **mitigating strategies** might be followed, and **how that impacts on contingency** could have been worked out in greater detail.“
 - what happens if either LEE is too high or new detector features doesn't work as intended?
- critical question during on-site review: „There are many R&D topics within the proposal. Too much? Which strategy you want to pursue?“
 - risk that „something“ fails; too much topics, tasks, sub-projects

Plans / changes / suggestions for the next proposal

- only one **baseline** detector (no generic detector R&D):
 - MMC-based wafer calorimeter (based on 3inch wafer)
 - integrated detector design
 - athermal detection mode
 - superconducting phonon collectors (Al)
 - sapphire substrate

 mention plan for „Sachbeihilfe“



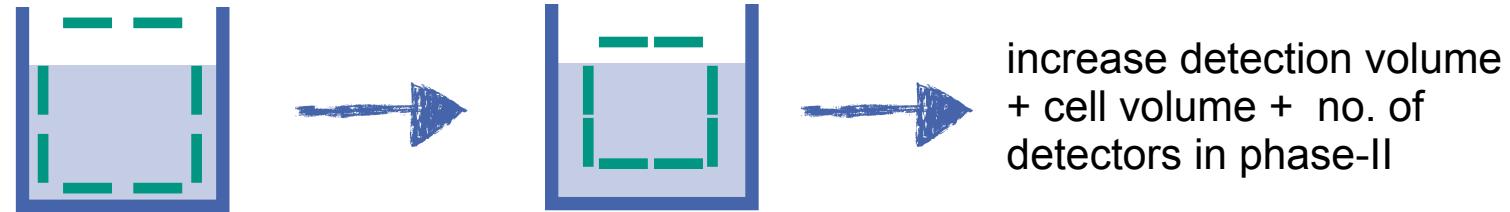
- R&D program focused on getting the proposed detector running (quasiparticle lifetime etc.); mention preliminary work (simulations, technology advancements, first MMCs on sapphire etc.) as well as recent achievements
- comprehensive study of low energy excess (LEE) in MMC based detectors
 - using existing detectors + new, dedicated detectors developed within RU
 - comparison of „distributed“ and „lumped“ wafer calorimeters
 - investigation of areal scaling (1inch, 2inch, 3inch)
 - investigation of detector mounting (**collaboration with P1**)
- SQUIDs: no changes compared to last proposal but mention latest achievements (cross-type junction quality, noise measurements)

 additional interplay / collaboration with P5 + P6

 mention „Sachbeihilfe“ (if submitted)

Plans / changes / suggestions for the next proposal

- 100% areal coverage of detection area



increase detection volume
+ cell volume + no. of
detectors in phase-II

- R&D for phase to: Athermal detection mode in Si-on-sapphire.
Or two separate detectors stacked on top of each other

 eV photon sensor
 wafer calorimeter

- we need to get a number of efficiency and include it in our sensitivity study!?!?

minor things...

- emphasize that HSS + KCOP will be already in operation (and settled) with the beginning of RU
- emphasize that second cryostat for characterization will be available at KIT
- emphasize that CMP technology will be available at KIT (polishing of wafers etc.)
- emphasize that the results of this project will not only support DELight but also various other MMC-based applications

Risks and mitigation strategies

- athermal detection mode doesn't work at all →
 - thermal detection mode with reduced detector speed
(and potential strong position dependence: feature / bug?)
 - detector will have reduced sensitivity due to large heat capacity; estimation how big the impact would be;
compensated by shrinkage of detector size (if required)
- quasiparticle lifetime in superconducting phonon collectors too low →
 - normal conducting phonon collectors
 - detector will have reduced sensitivity due to larger heat capacity; estimation how big the impact would be;
compensated by shrinkage of detector size (if required)
- fabrication technology doesn't work →
 - excluded due to on-going R&D efforts
- „nothing works at all“ →
 - thermal (lumped) MMC with Si absorber
 - detector will have reduced sensitivity due to large heat capacity and potential position dependance; estimation how big the impact would be; compensated by shrinkage of detector size (if required)

Risks and mitigation strategies

- low energy excess (LEE) too „large“
 - use similar geometry + material (Si) than QETs (well-known studied geometry)
 - sensitivity will be reduced....
- quasiparticle lifetime in superconducting phonon collectors too low
 - normal conducting phonon collectors
 - detector will have reduced sensitivity due to larger heat capacity; estimation how big the impact would be; compensated by shrinkage of detector size (if required)
- fabrication technology doesn't work
 - excluded due to on-going R&D efforts
- „nothing works at all“
 - thermal (lumped) MMC with Si absorber
 - detector will have reduced sensitivity due to large heat capacity and potential position dependance; estimation how big the impact would be; compensated by shrinkage of detector size (if required)