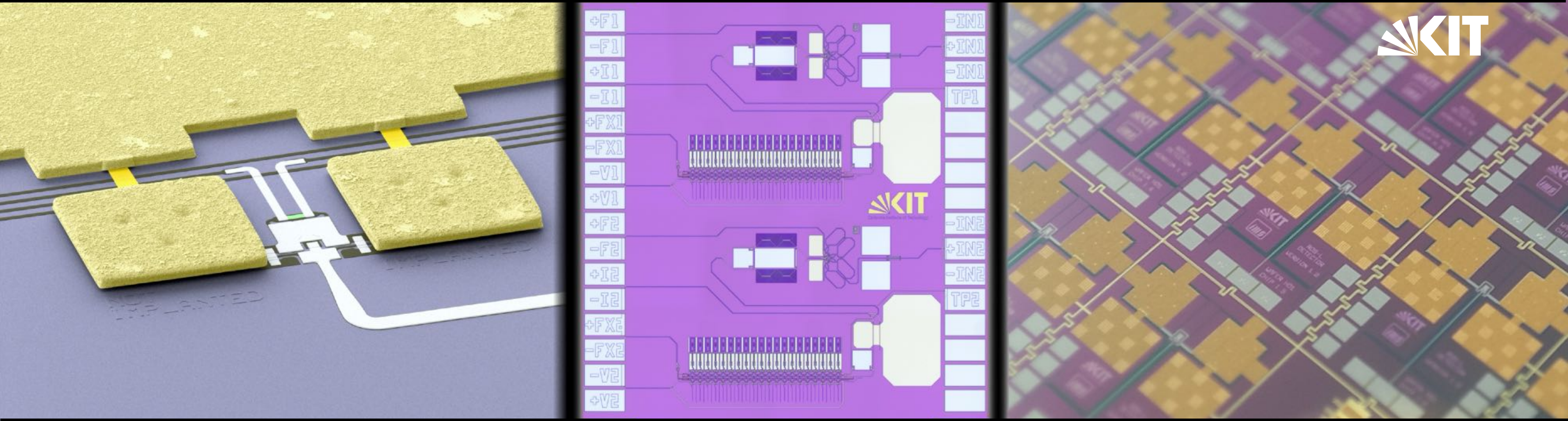
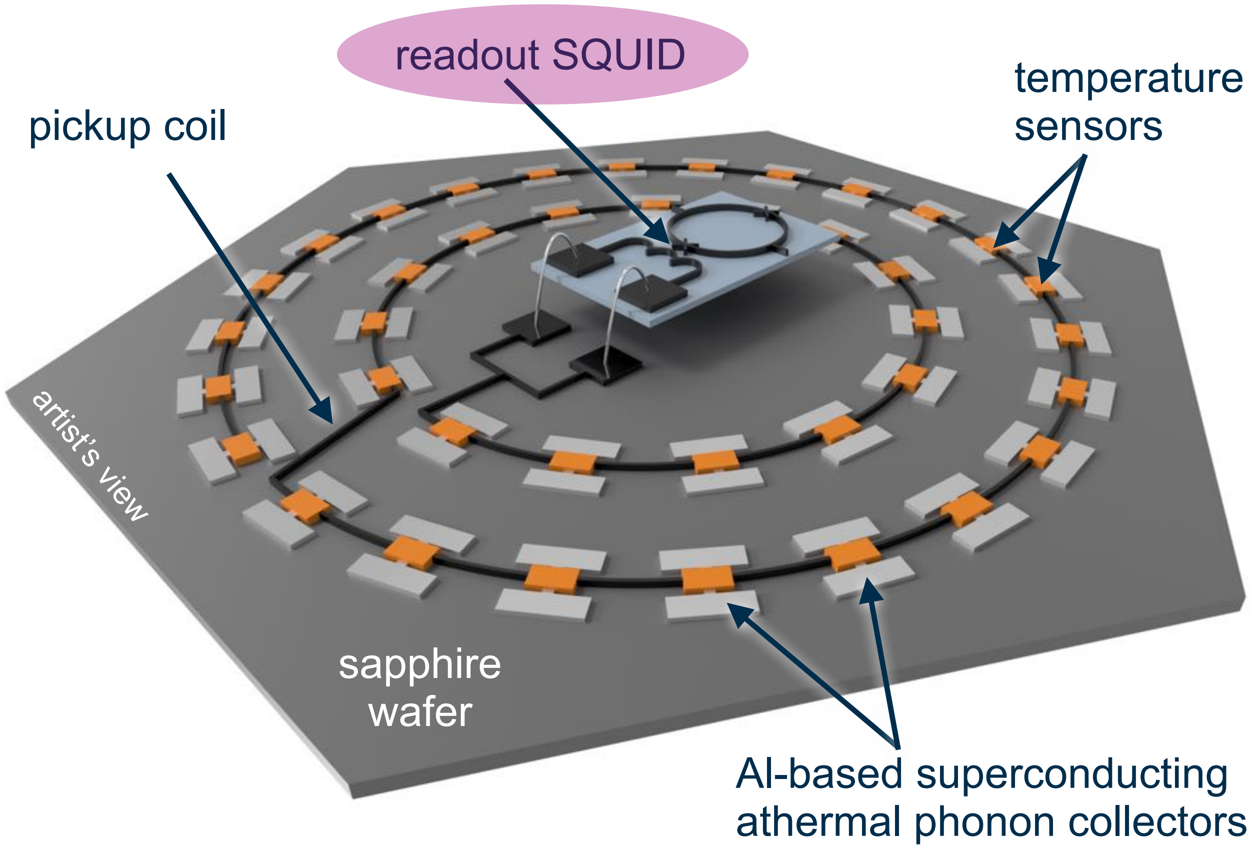


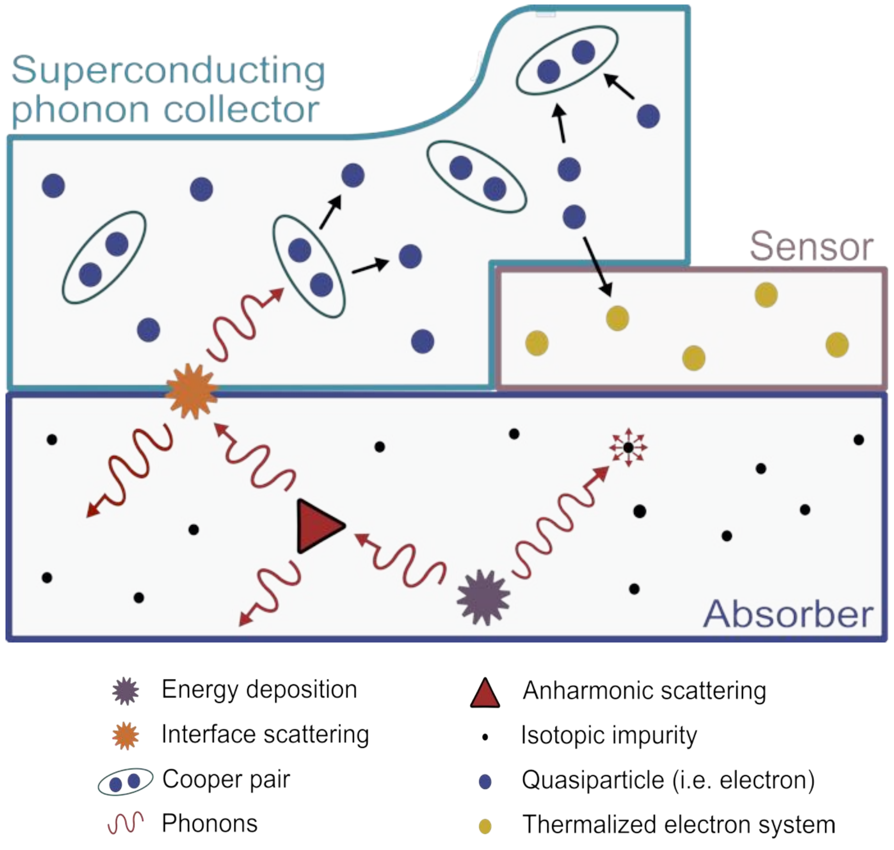
Update on SQUID development

Sebastian Kempf on behalf of Erik Frey, and Mathias Wegner
Institute of Micro- and Nanoelectronic Systems (IMS), Karlsruhe Institute of Technology (KIT)
DElight Collaboration Meeting | Freiburg | 2025-06-18

DELight detection scheme: LAMCAL technology

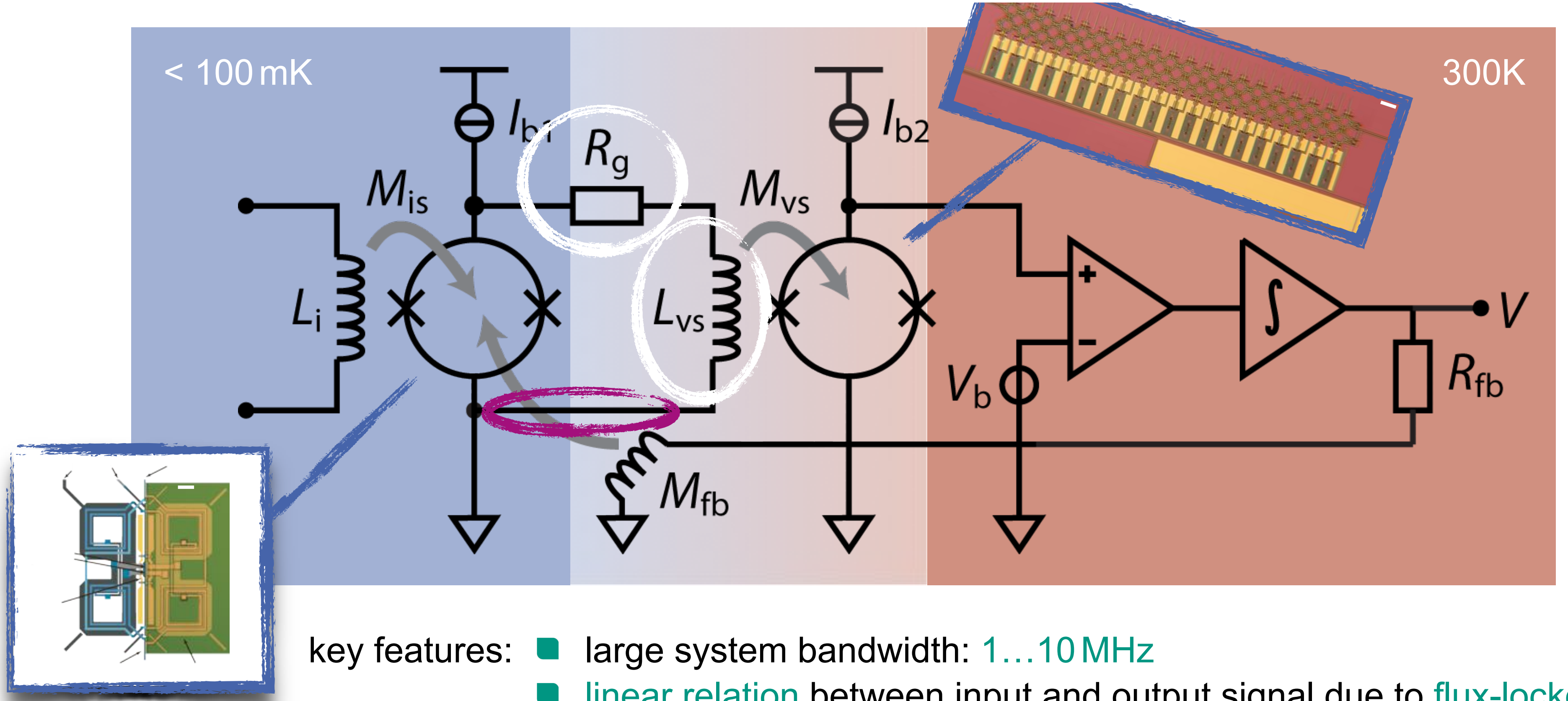
LAMCALs: large-area cryogenic microcalorimeters based on athermal phonon detection using paramagnetic temperature sensors (MMC technology)





Two-stage dc-SQUIDs

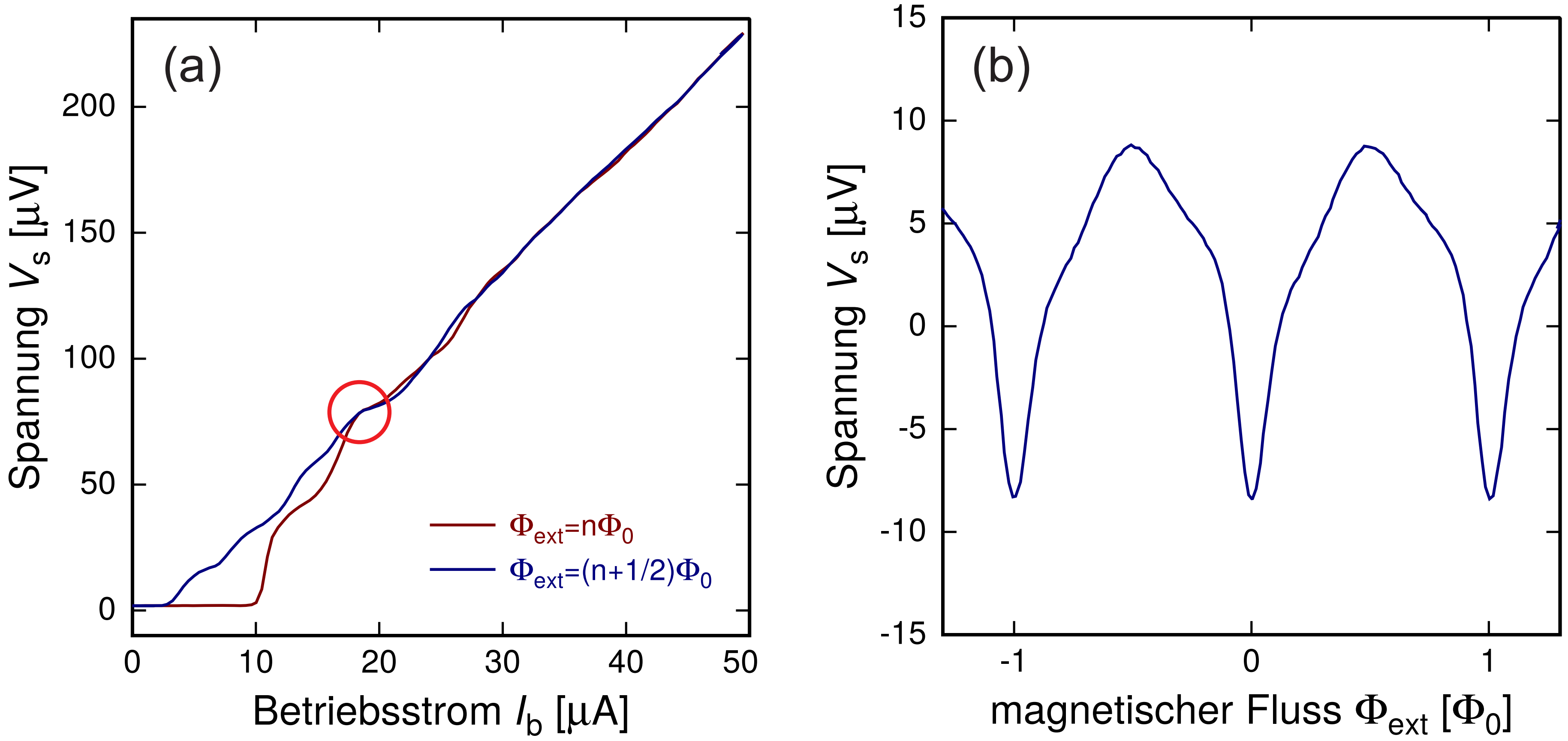
SQUID-based amplifier chain with ultrafast FLL feedback electronics



key features:
- large system bandwidth: 1…10 MHz
- linear relation between input and output signal due to flux-locked loop (FLL)
- impedance matched

Parasitics in two-stage dc-SQUIDs

resonances and parasitic capacitances might degrade SQUID performance and limit readout bandwidth



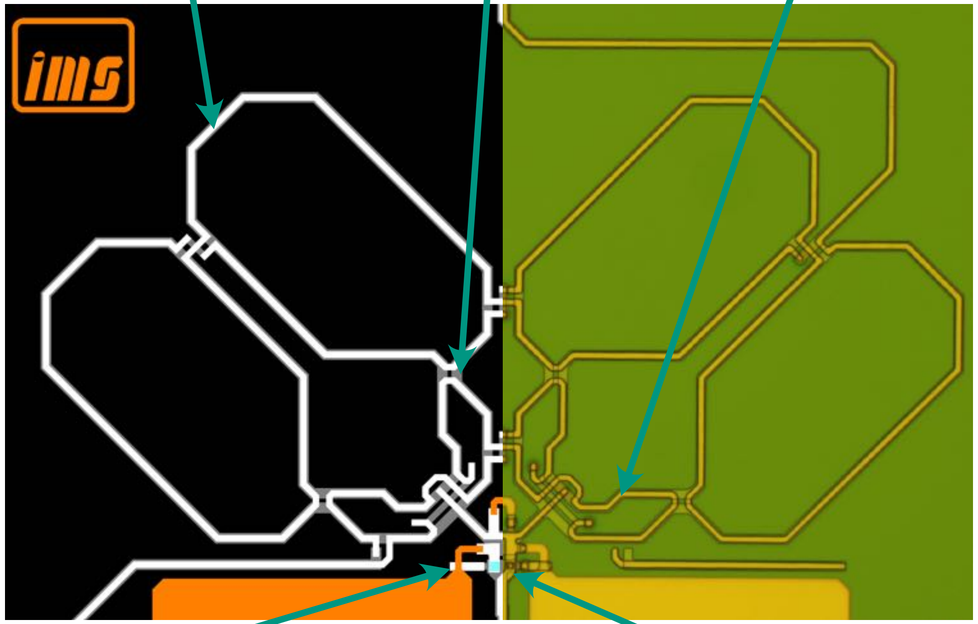
Sensor SQUID and SQUID array design

Front-end dc-SQUID design

1.62 nH input coil
$1/M_{in} = 6.10\,\mu A/\Phi_0$

SQUID coil
L_S = 124 pH

Feedback coil
$1/M_{fb} = 40.5\,\mu A/\Phi_0$



Shunt resistor

Josephson junction

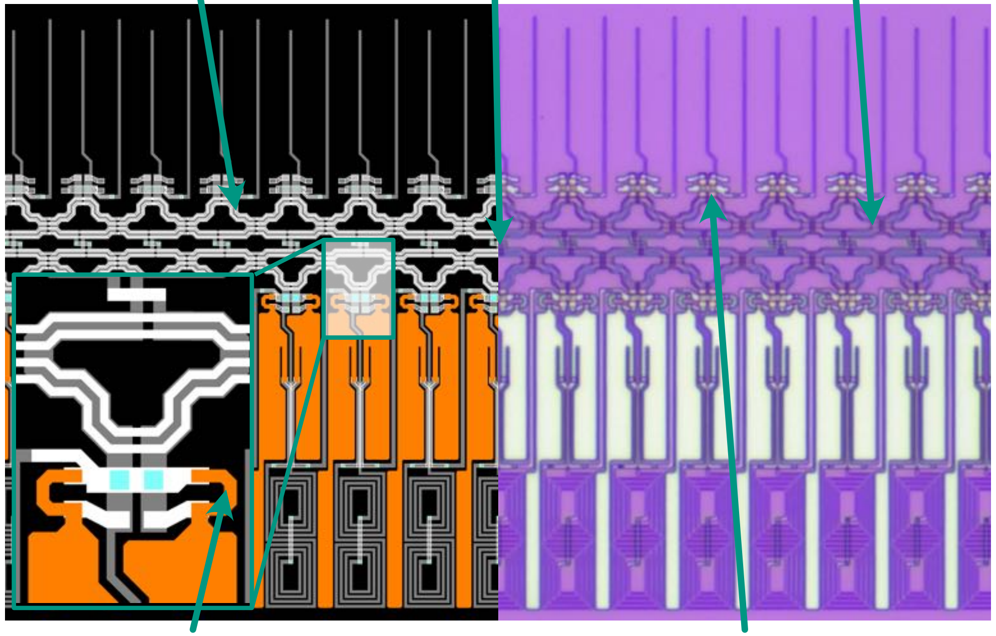
N = 16 series SQUID array design

(simulated values correspond to single SQUID cell)

Input coil
$k_{in} = 0.700$

SQUID coil
L_S = 121 pH

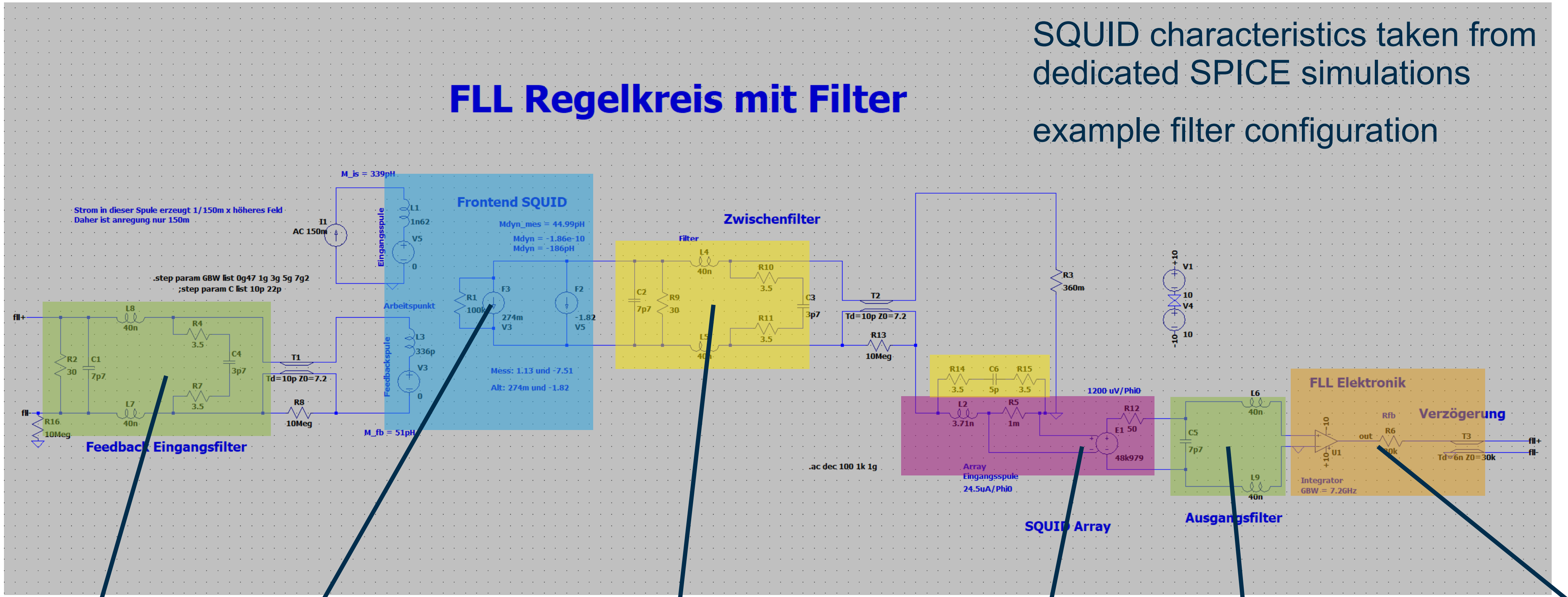
Feedback coil
$1/M_{fb} = 44.8\,\mu A/\Phi_0$



Shunt resistor

Josephson junction

Stability simulations and parameter optimization



SQUID characteristics taken from dedicated SPICE simulations

example filter configuration

feedback circuit with input filter

sensor SQUID

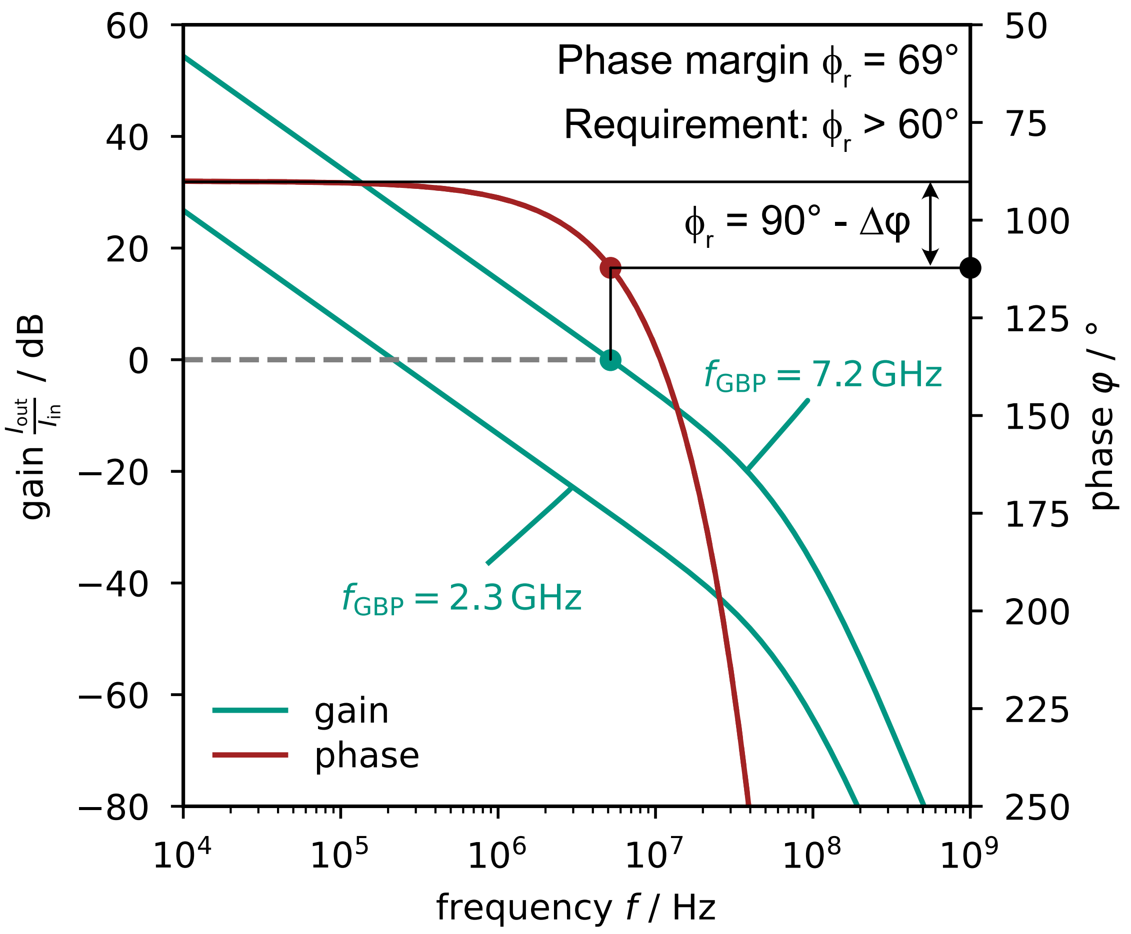
filter stage in between sensor SQUID and SQUID array

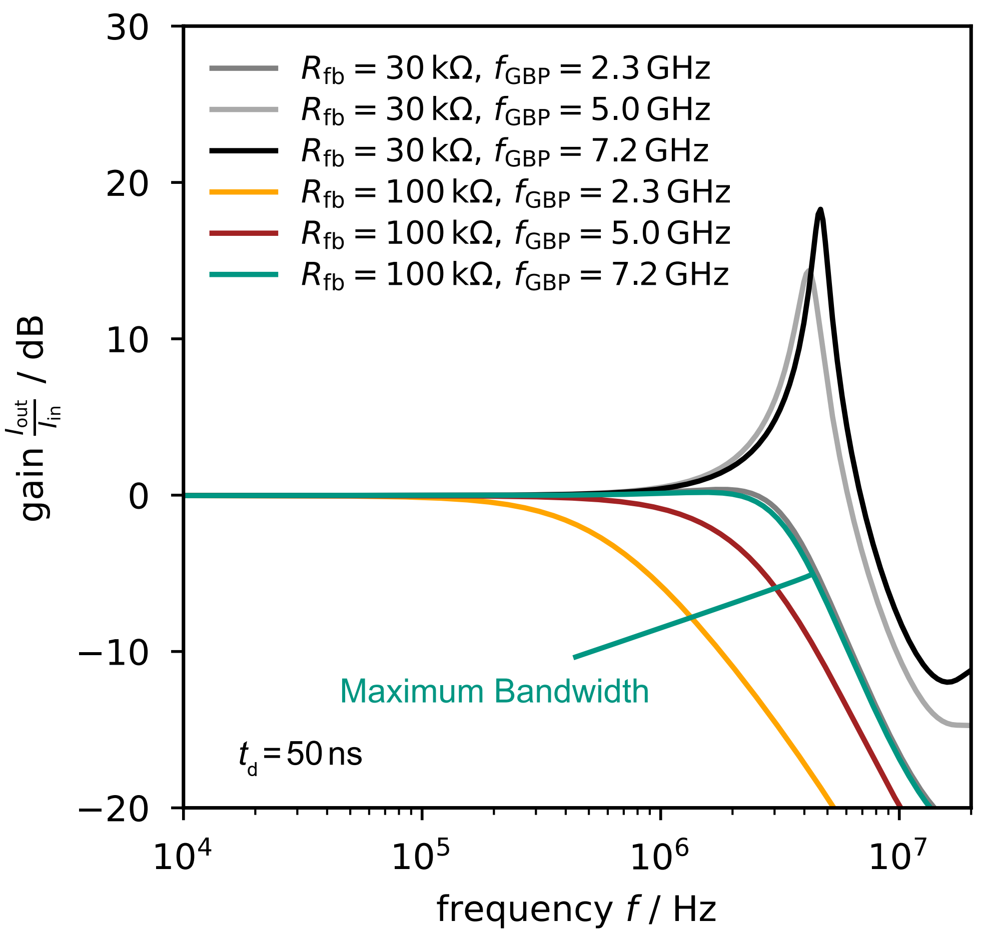
SQUID array

output filter circuit

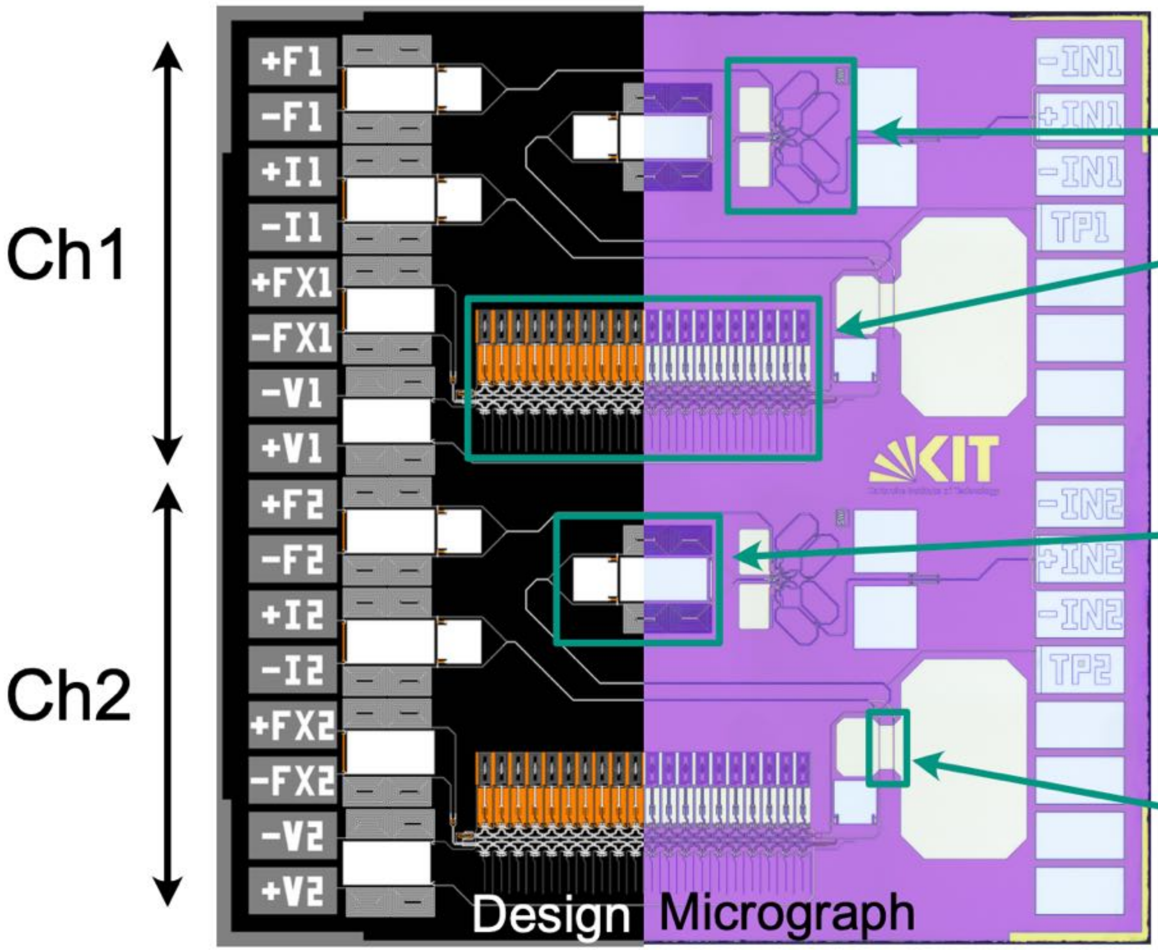
FLL electronics + cable delay

Stability simulations and parameter optimization





Integrated two-stage dc-SQUIDs



Gradiometric front-end dc-SQUID

Series SQUID array consisting of:

- 16 identical dc-SQUID cells
- 4 non-functional, symmetry generating SQUID-like cells

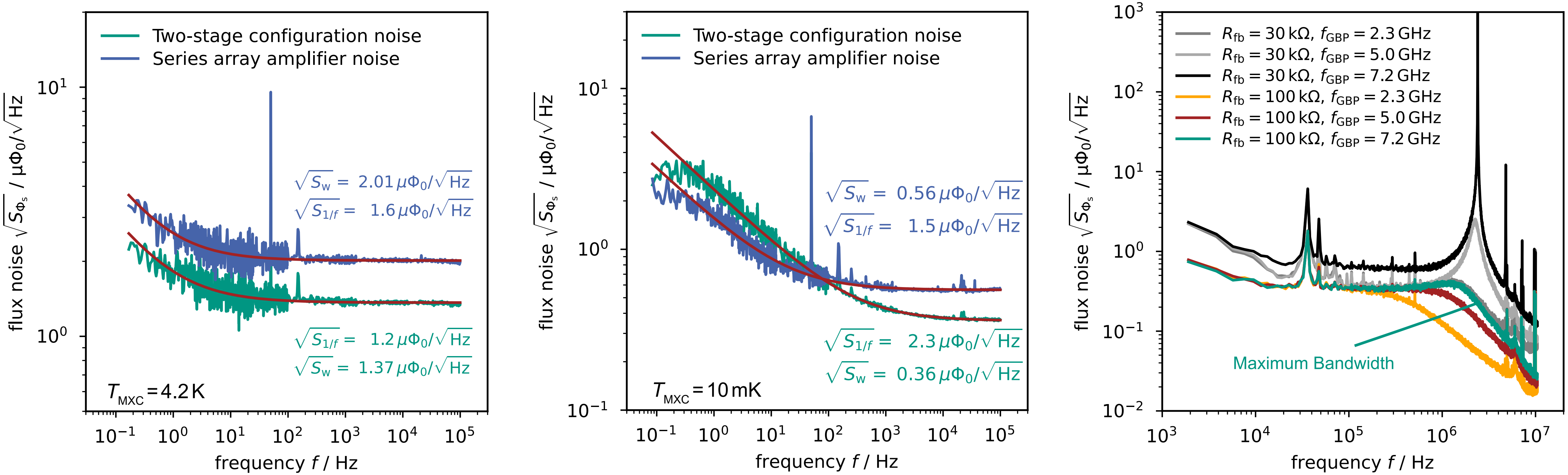
Identical filtering circuits attached to:

- SQUID bias lines
- feedback coils
- front-end/array interconnect

Bias resistor with large cooling fin for front-end voltage bias operation

Integrated two-stage dc-SQUIDs
Noise performance and bandwidth

within noise and bandwidth specs for DELight
(but no impedance matching yet)



next: sensor SQUID design revision for flexible impedance matching
adaption of SQUID array to multi-channel FLL electronics