

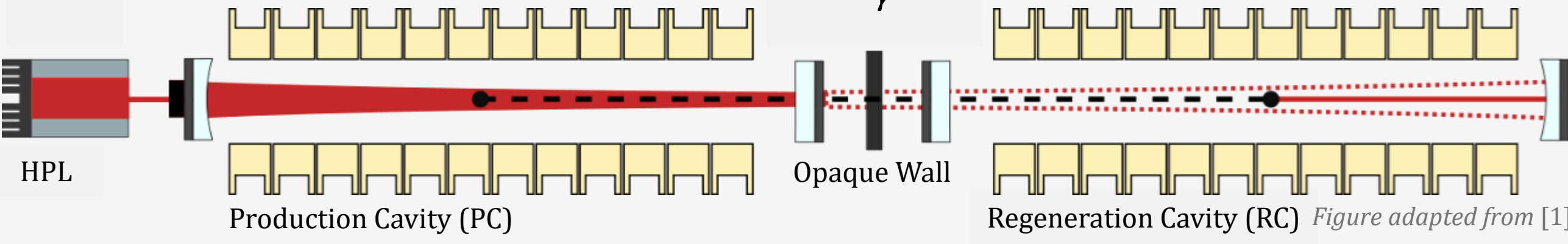
Cryogenic Optical Filter Bench for Blackbody Suppression in Single-photon Detectors



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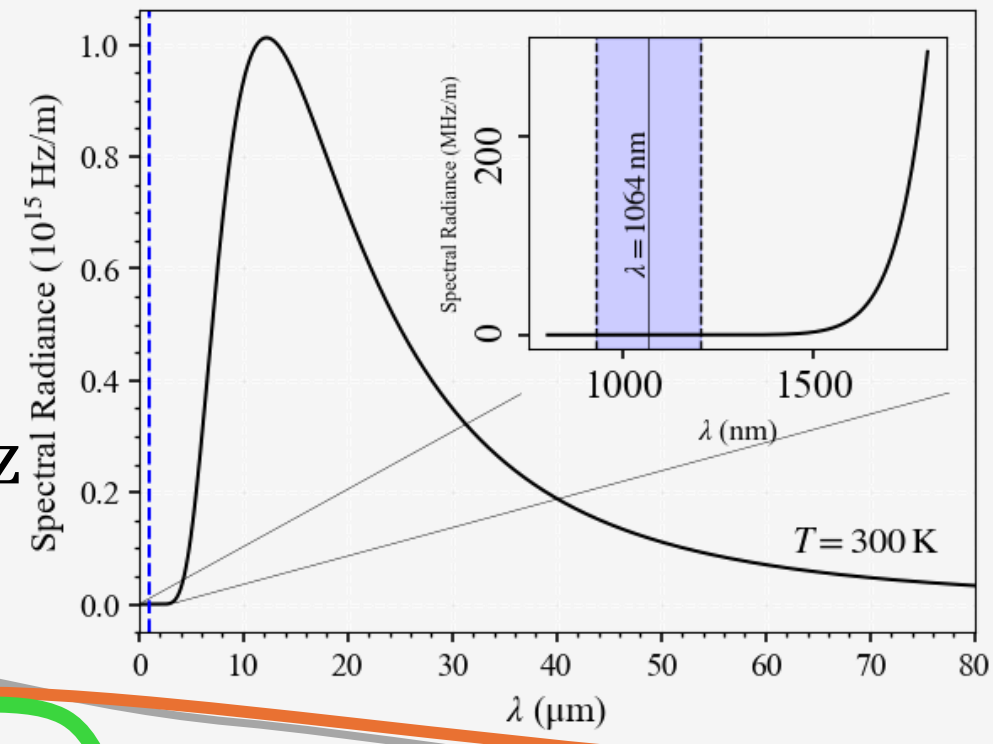
ALPS II expected signal photon rate of photon-axion conversion:

$$\dot{N}_s = \beta^{RC} \beta^{PC} \mathcal{P}_{\gamma \rightarrow a}^2 \frac{P_{\text{laser}}}{E_\gamma} \approx 1 \text{ photon/day} \approx 10^{-5} \text{ Hz}$$



Blackbody - γ
Photons from bbs
within energy res-
olution of system:

$$\dot{N}_b \approx 7 \cdot 10^{-5} \text{ Hz}$$

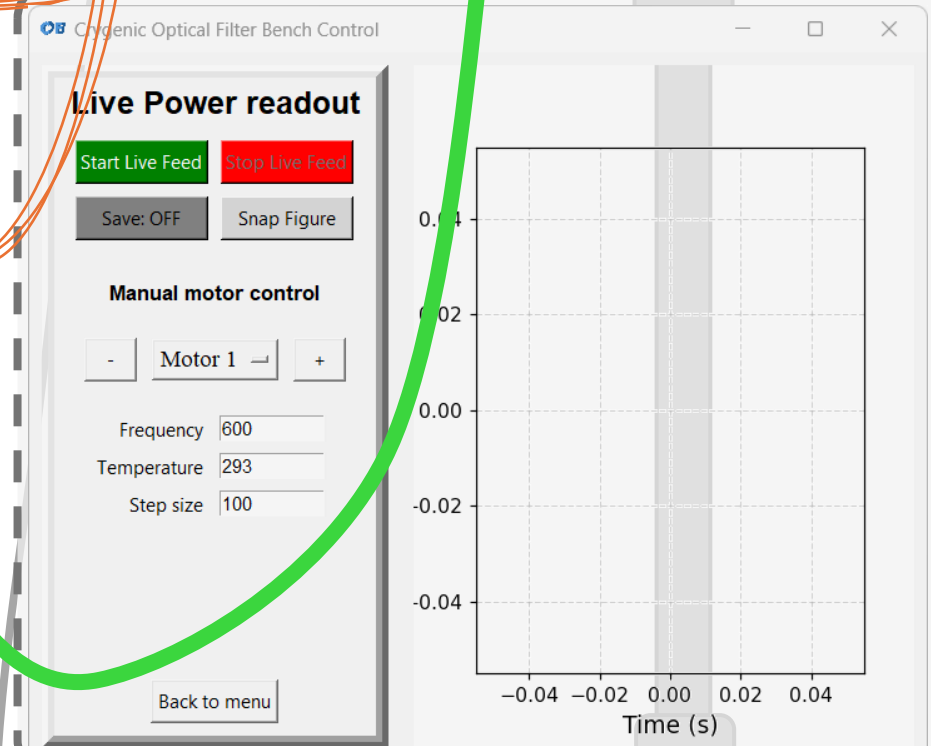
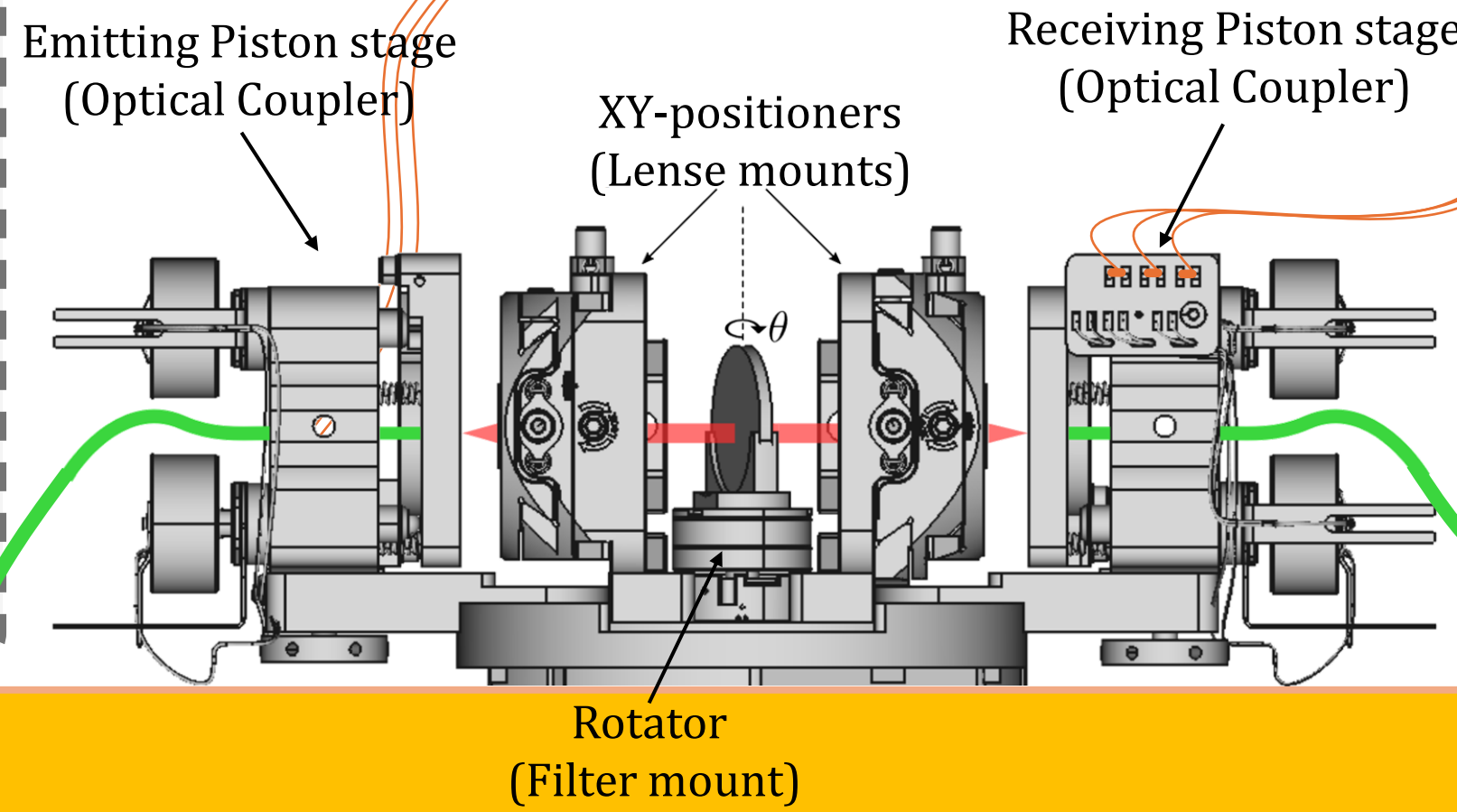


300 K

Ultra Narrowband Filter

Reduces number of photons within the energy resolution of the system that is allowed to reach the detector.

- Expected reduction to: $\dot{N}_b \approx 10^{-7}$
- Energy resolution: $ER < 1\%$

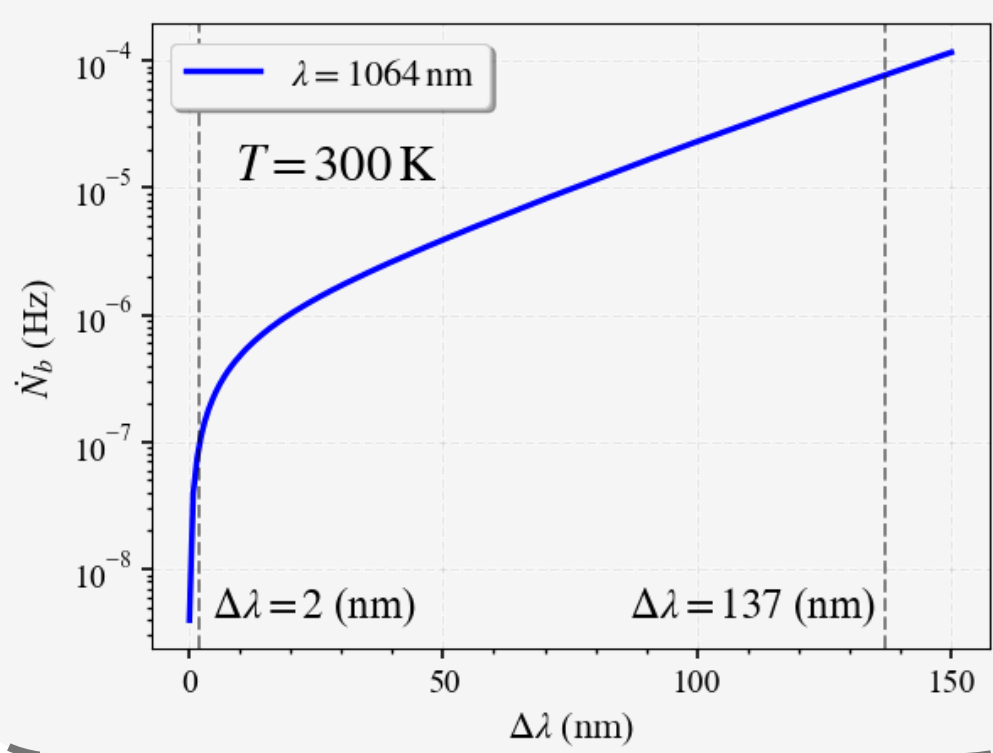
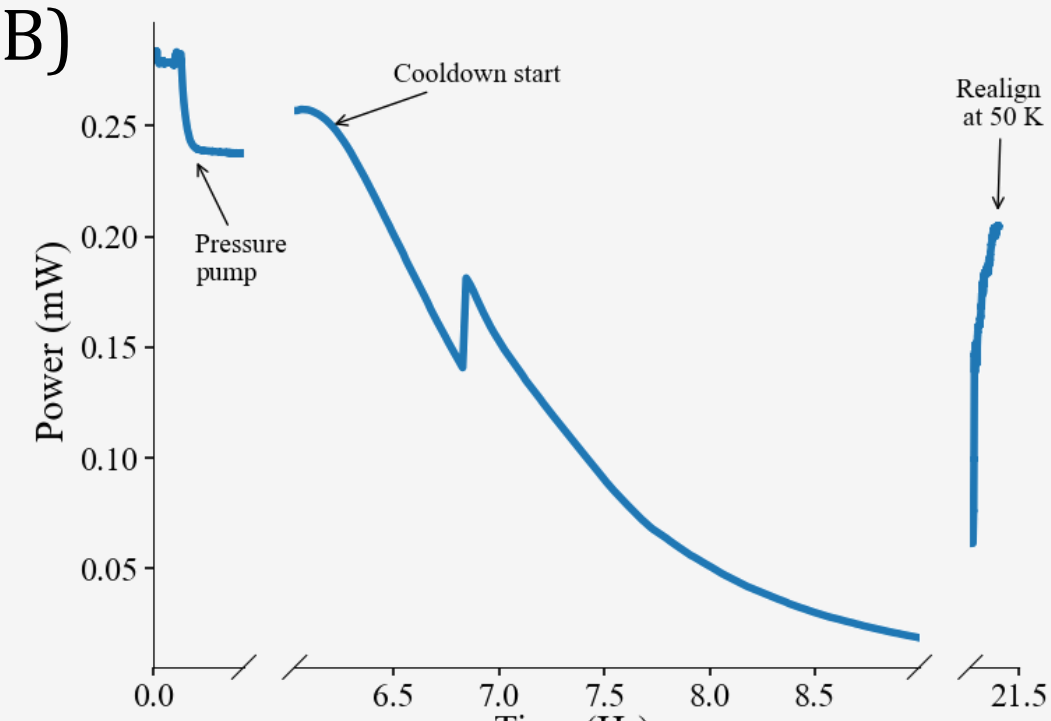


COFB GUI
Remote control,
automatic alignment,
accessible operation.

50 K

Operating a Cryogenic Optical Filter Bench (COFB)

- Misalignment during pumping and thermal contraction
- Limited room inside cryostat sets design limits.
- Requires in-situ control of beam output.
- Automation ideal for long experiments.
- Initial test exceeds 50% (without filter)



4 K

System Detection Efficiency (SDE)

Two methods of reducing \dot{N}_b :

1. Improve energy resolution of the system.
2. Reduce number of bb-photons that enter system through filtering.

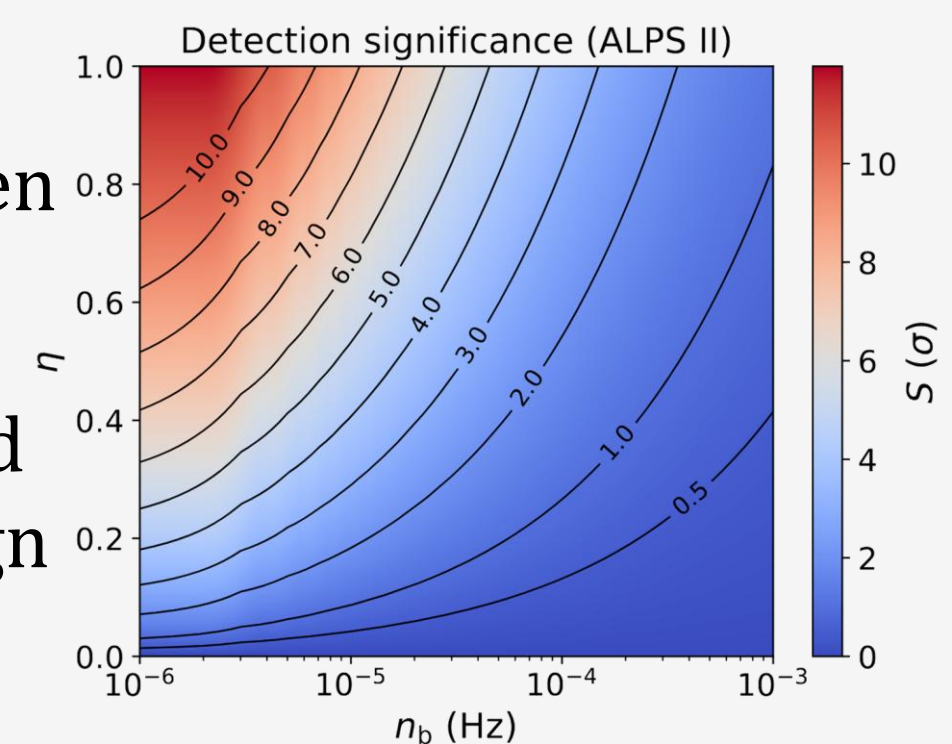
Reducing \dot{N}_b also reduces the systems affinity for detecting photons.

Fibre curling demonstrates suppressed transmission of photons below $E_\gamma \sim 0.9 \text{ eV}$



Reaching 5σ

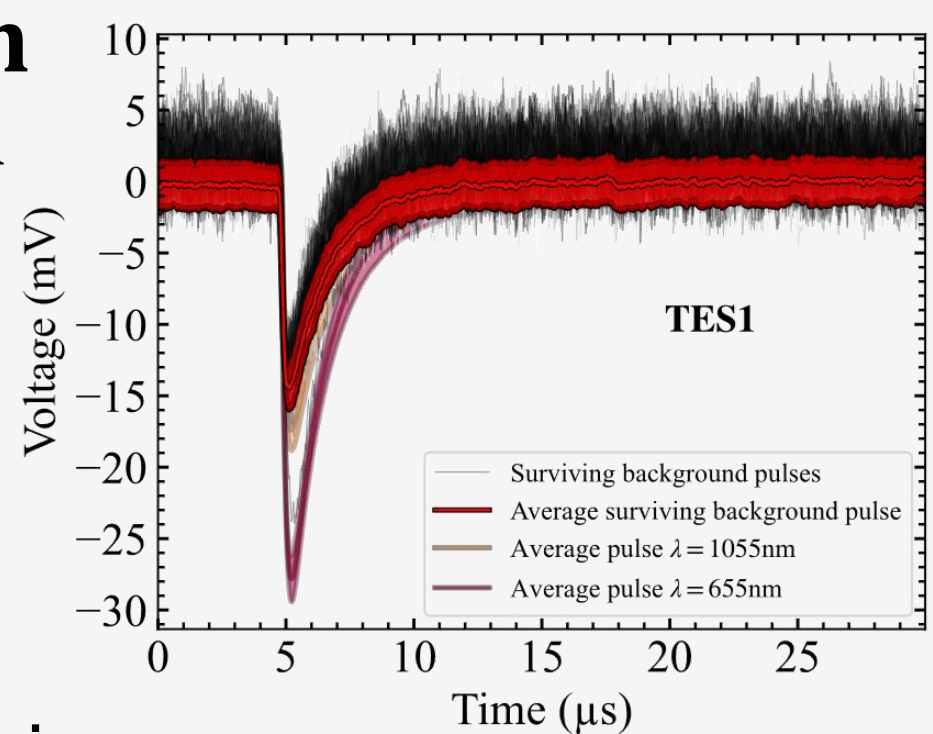
- Tradeoff between η vs \dot{N}_b
- ALPS II expected signal sets design criteria.



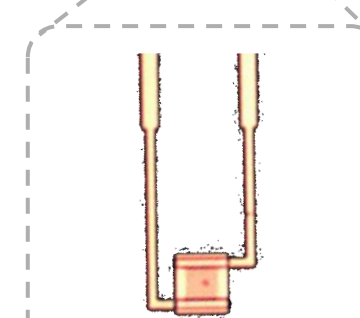
1 K

SQUID data acquisition

- Photon deposit energy on thin-film detector
- Temperature in detector increases proportionally
- Superconducting phase transitions sharply to Ohmic
- Resulting current response couples inductively to single-stage SQUID yielding a voltage pulse[3]

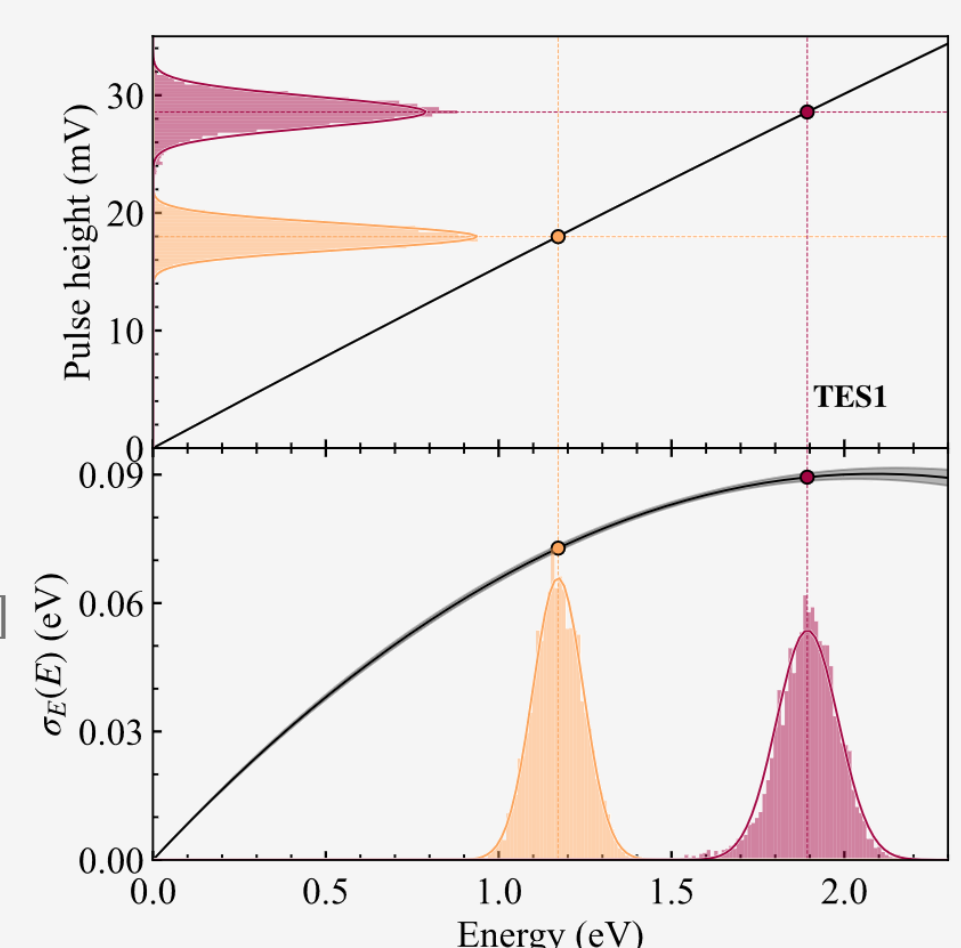


20 mK



Photon energy determined from height or integral of SQUID voltage response:

- Non-photon events are discarded.
- ER of system being developed at DESY for $E_\gamma \sim 1.165 \text{ eV}$ is 5.3%. [4]
- Optical filter improves ER significantly.



[1]: Oceano, Isabella. (2024). Axion and ALP search with the Any Light Particle Search II experiment at DESY. 117. 10.22323/1.449.0117.
[2]: Si Bitjukov and NV Krasnikov. New physics discovery potential in future experiments. Modern Physics Letters A, 13(40):3235–3249, 1998.
[3]: Manuel Meyer *et al.* Characterization of a Two-Channel Optical and Near-infrared Transition Edge Sensor System for Rare-Event Searches. Unpublished.
[4]: José Alejandro Rubiera Gimeno, *et al.* A tes system for alps ii - status and prospects. Proceedings of Science, 449:567, 2024.