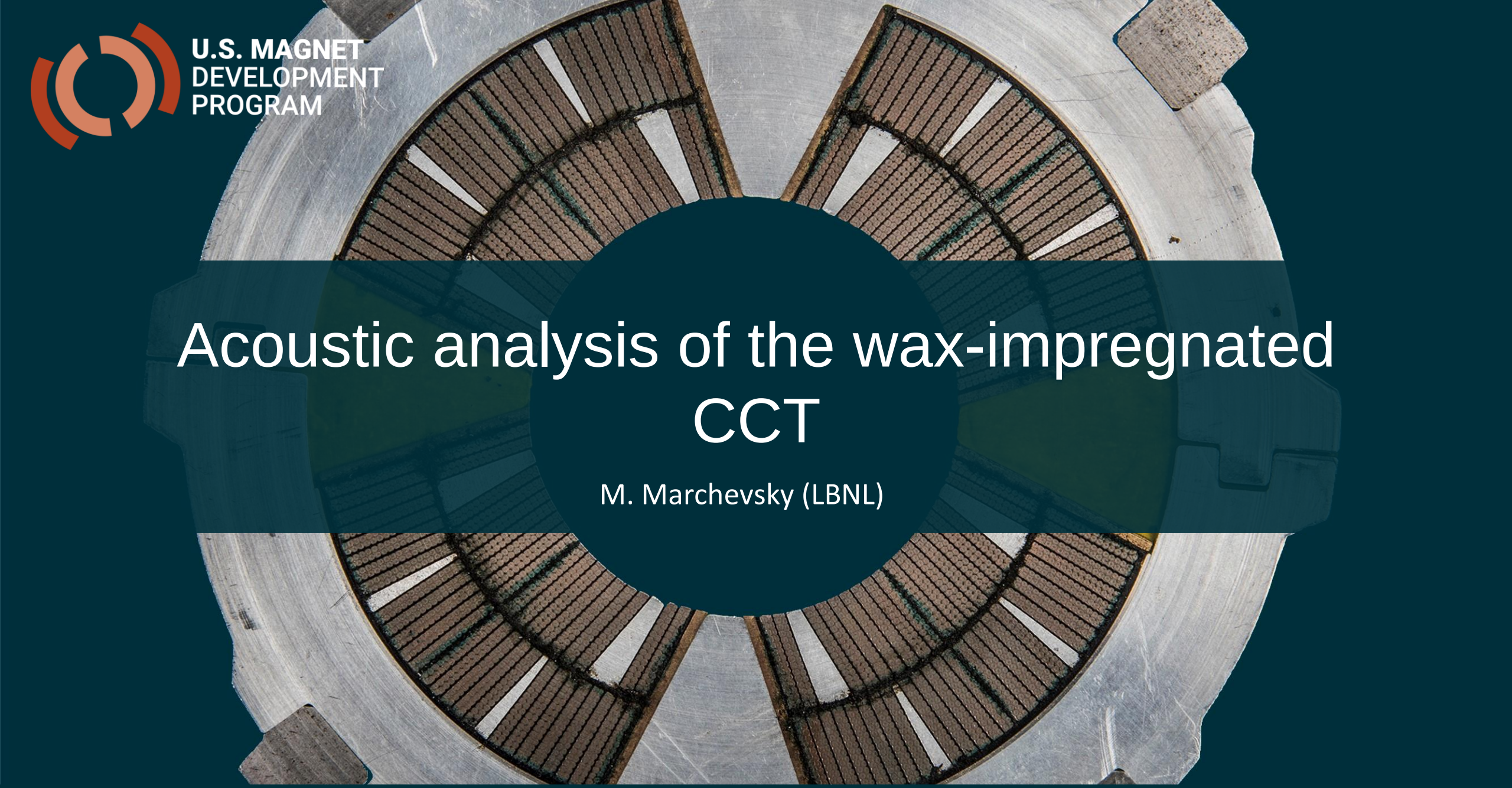


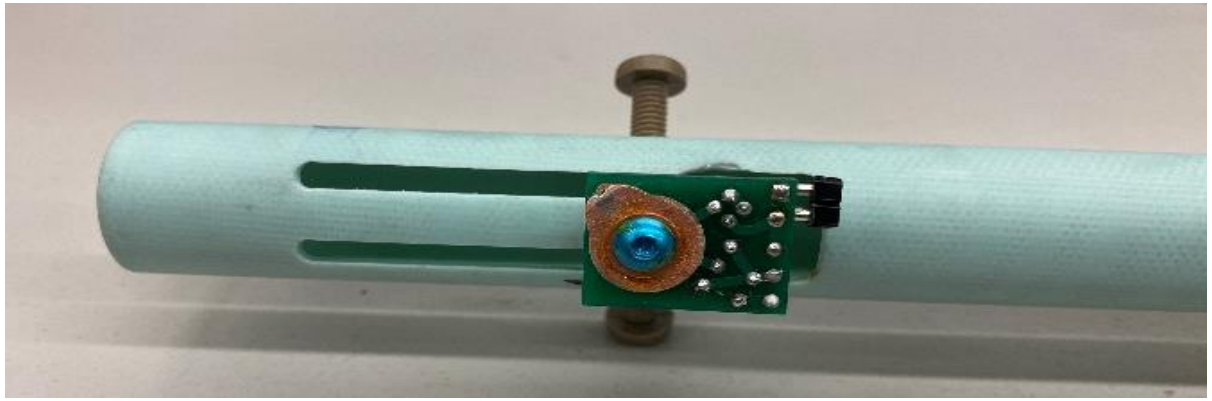
U.S. MAGNET DEVELOPMENT PROGRAM

Acoustic analysis of the wax-impregnated CCT

M. Marchevsky (LBNL)

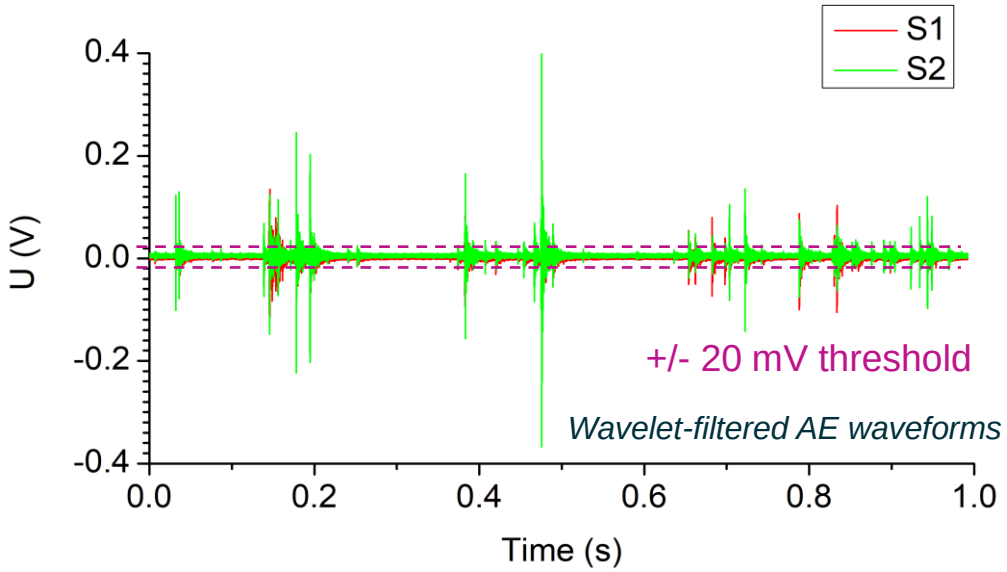
AE instrumentation for subscale CCTs

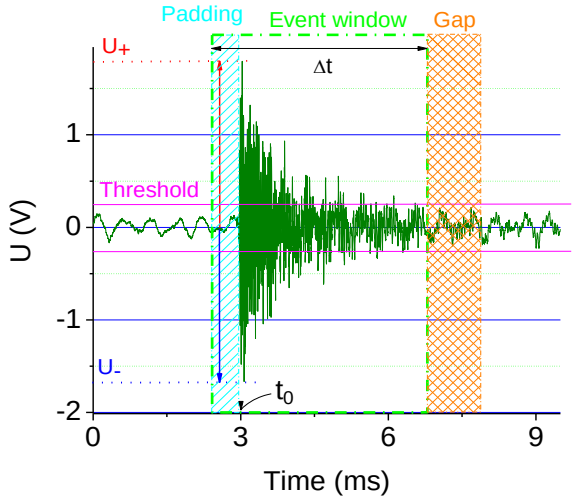
Bore tube



Installation in the magnet bore

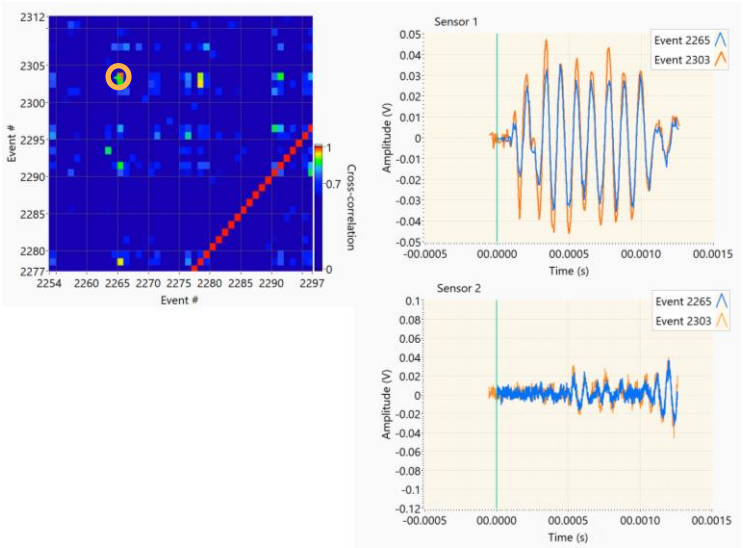
AE event separation and analysis





$$E = \int_{t_0}^{t_0+\Delta t} U^2(t)dt$$

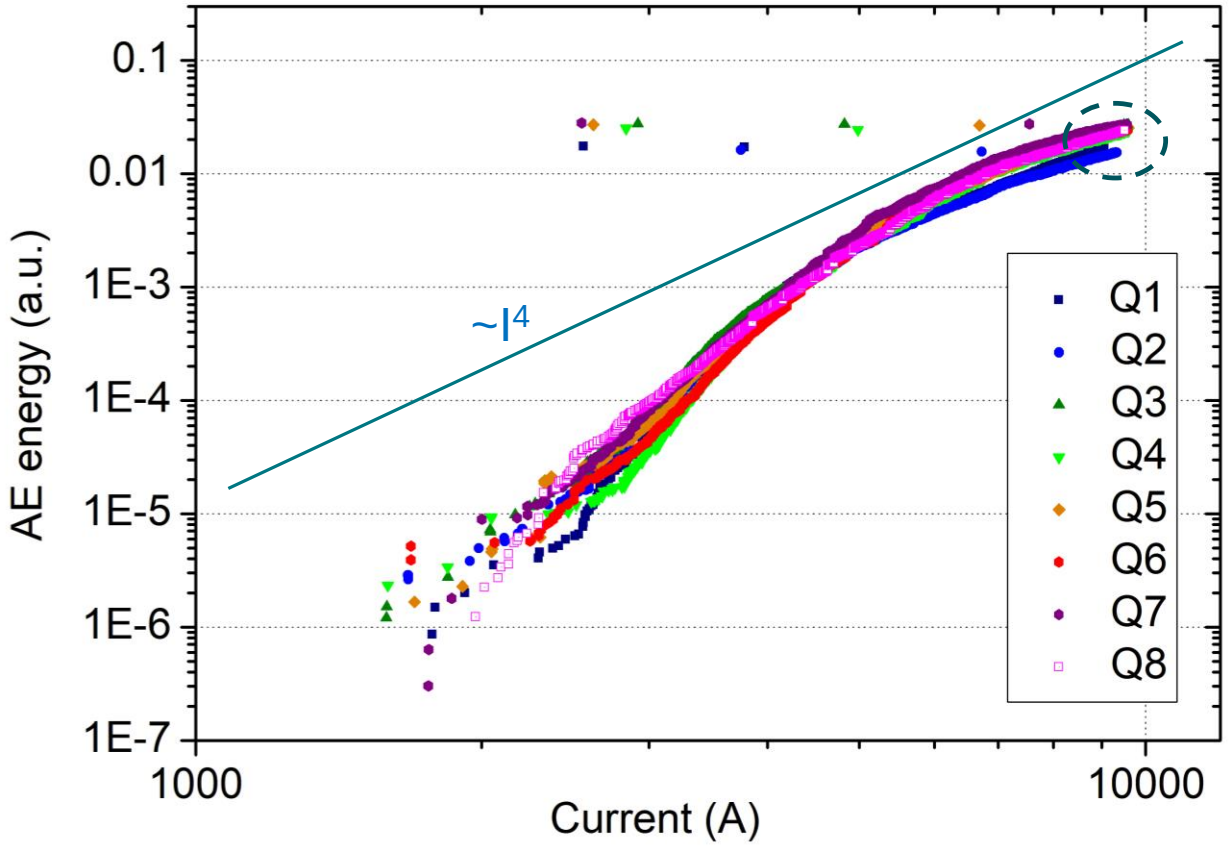
- AE event energy

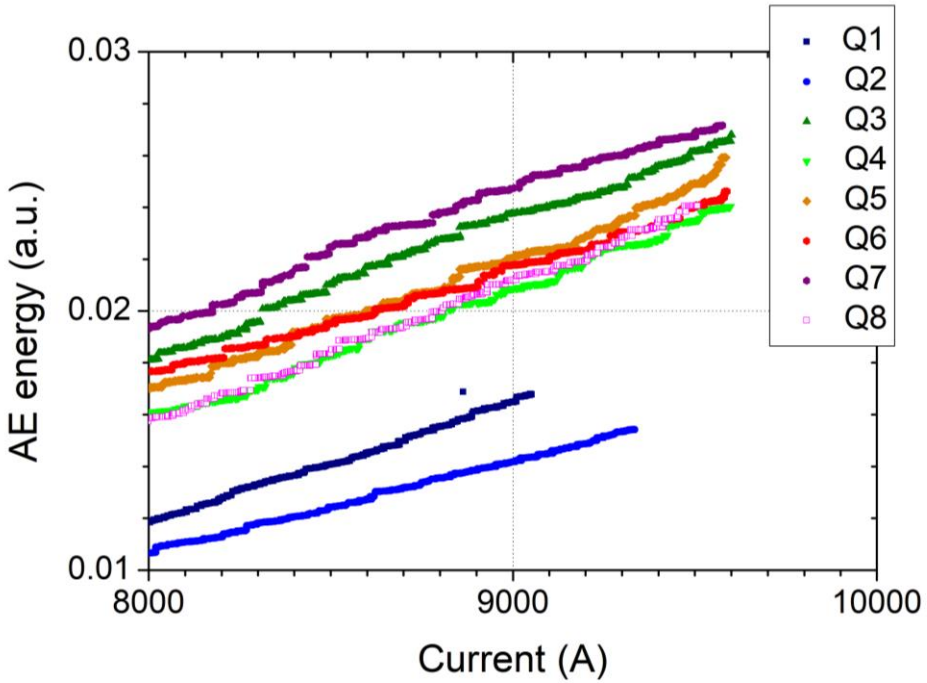


$$A_{ij} = \max_{\tau}\left\{\frac{\int U_i(t)U_j(t-\tau)dt}{\left\{\int U_i(t)U_i(t-\tau)dt\right\}^{1/2}\left\{\int U_j(t)U_j(t-\tau)dt\right\}^{1/2}}\right\}$$

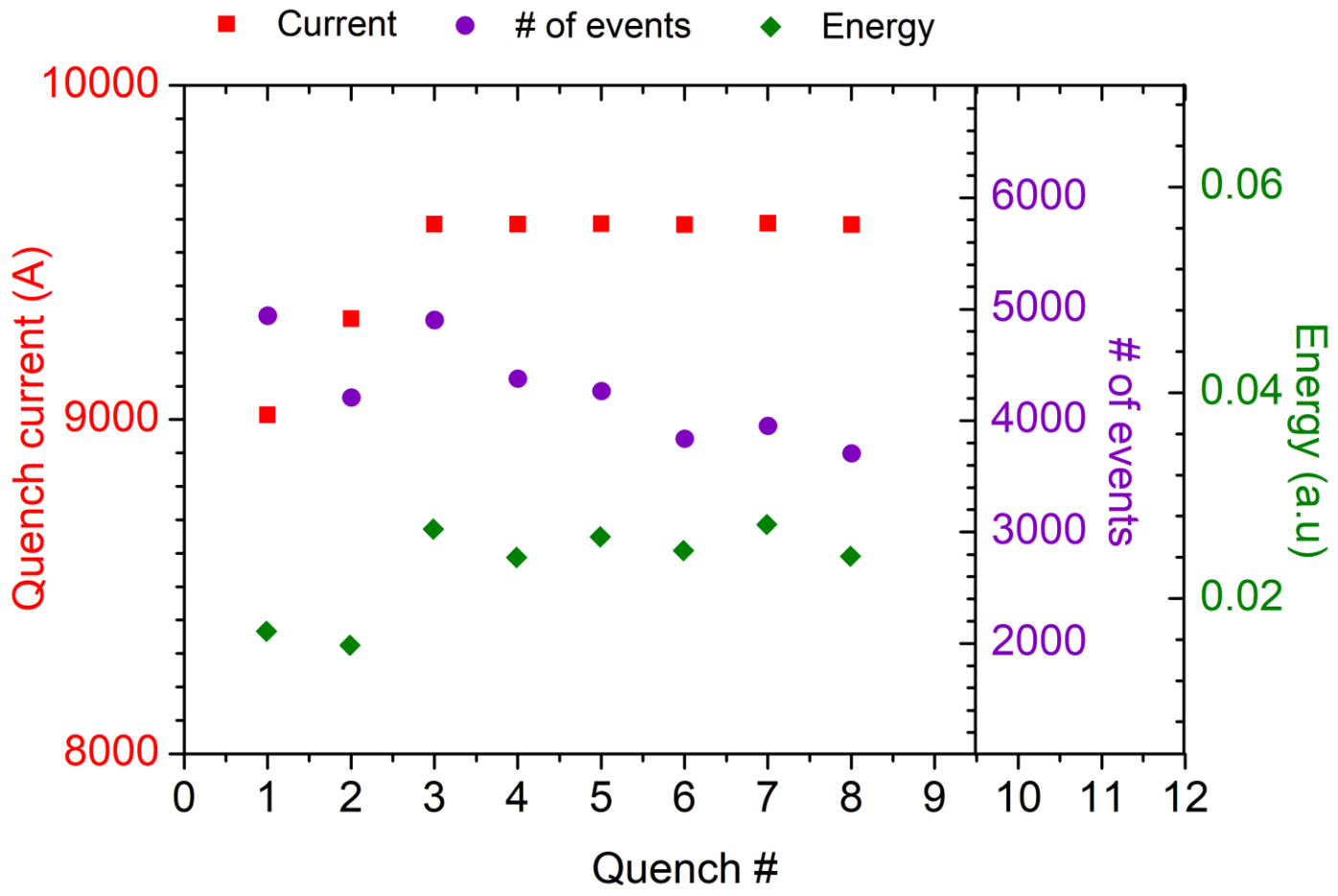
AE multiplets: events with A_{ij}>0.9

Cumulative AE energy release



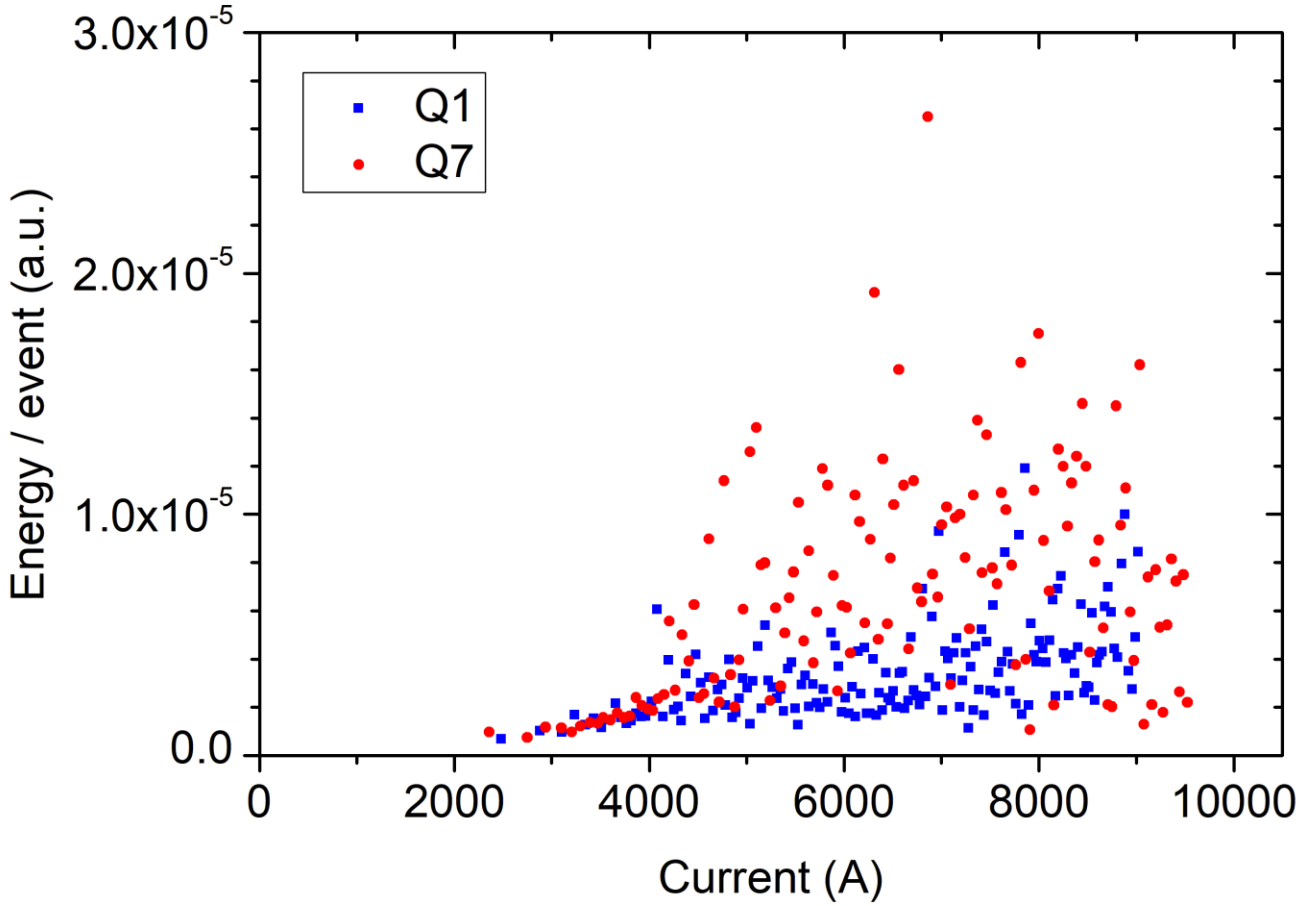


AE event and energy summary



- The number of AE events is decreasing with repeated quenching of the magnet
- The cumulative AE energy release remains approx. constant with repeated quenching of the magnet

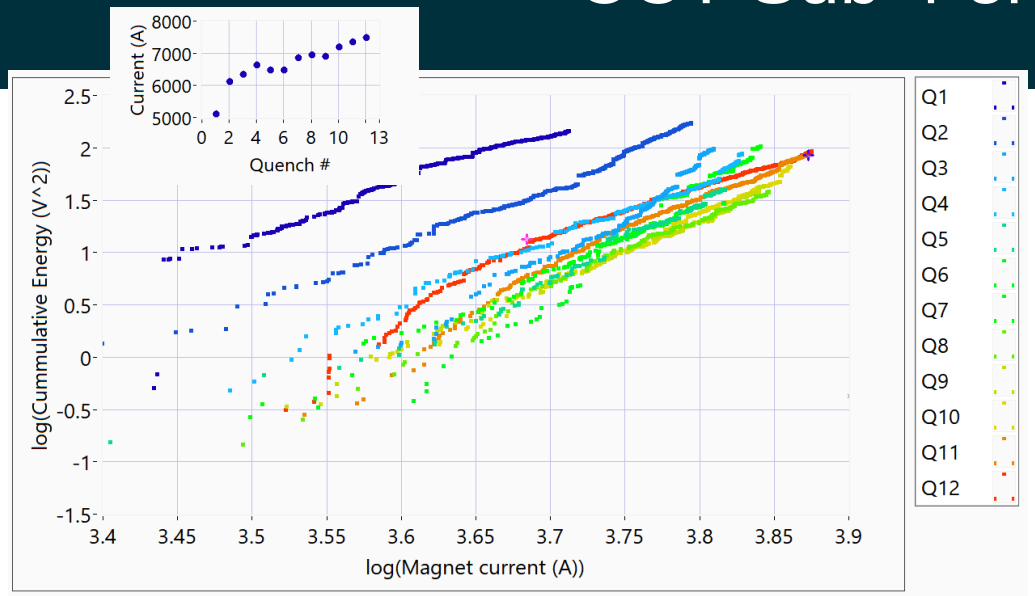
AE energy release per event



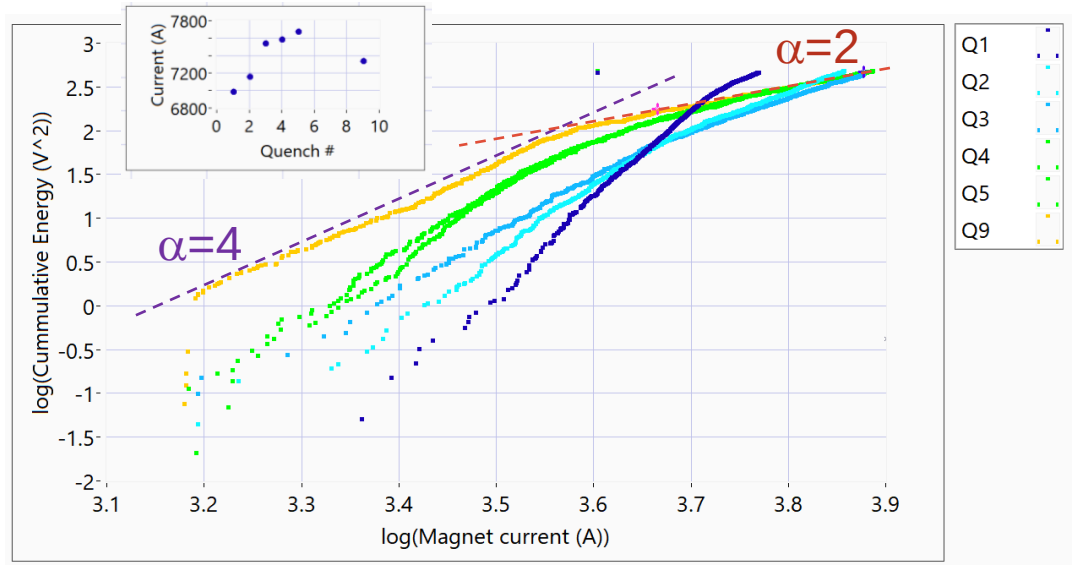
- Energy per AE event increases as “training” progresses

CCT Sub 4 energy release evolution

1st

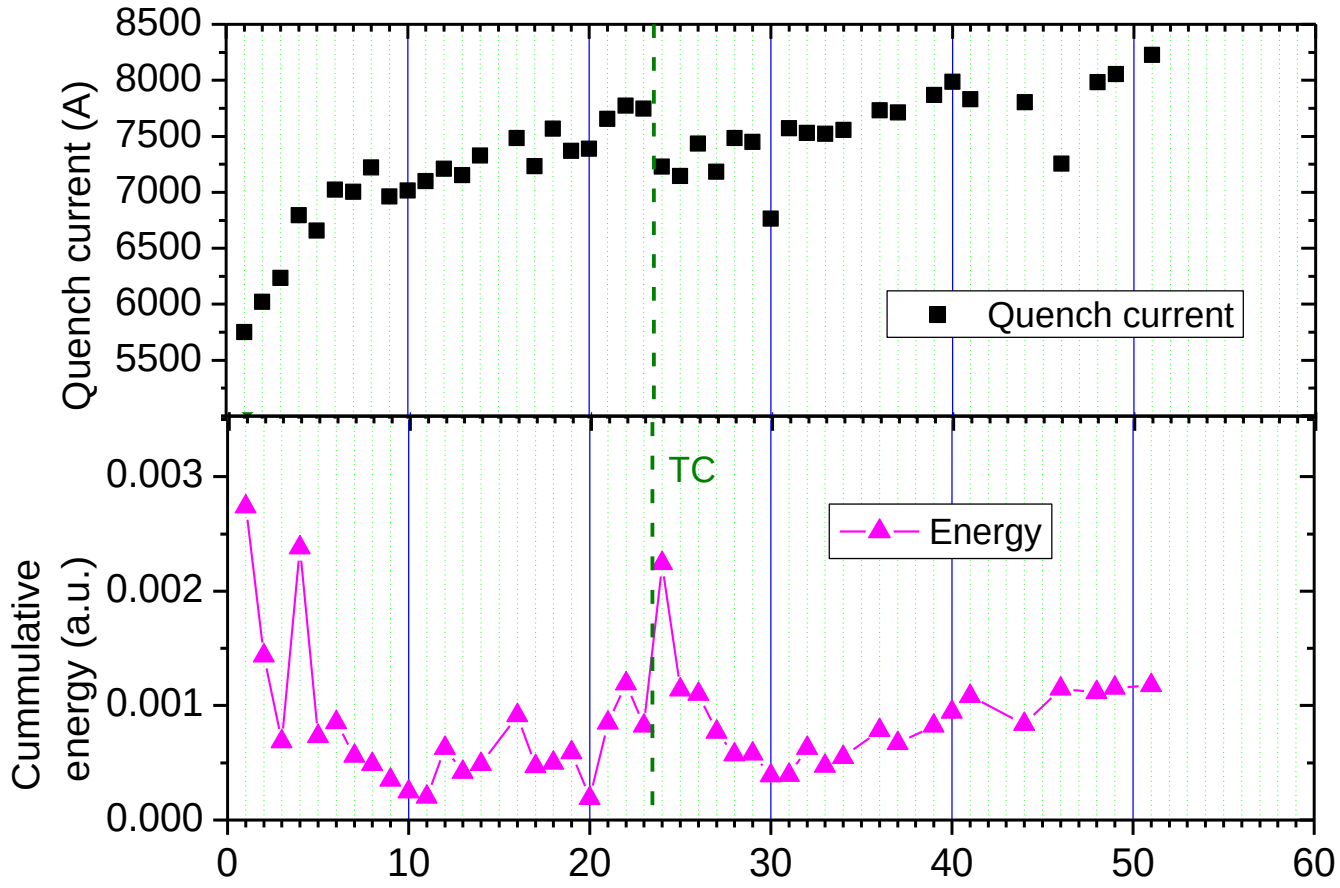


TC

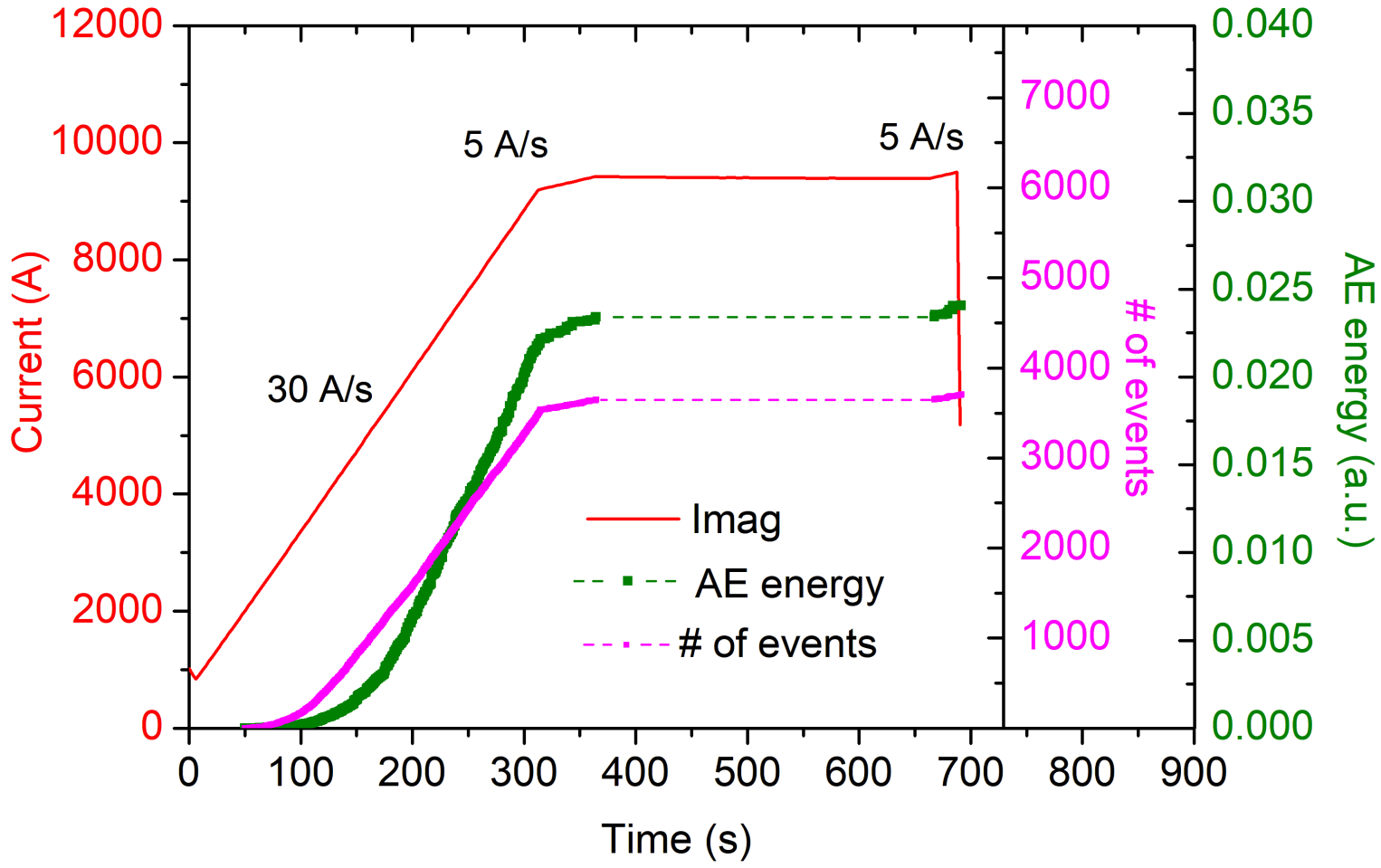


- In the first training cycle elastic energy is released proportionally to accumulation **(~ I^4)**
- Post thermal cycle, ~I^4 release rate is recovered over the first couple quenches, then transitions to ~ I^2 scaling

AE energy release (Sub 2)

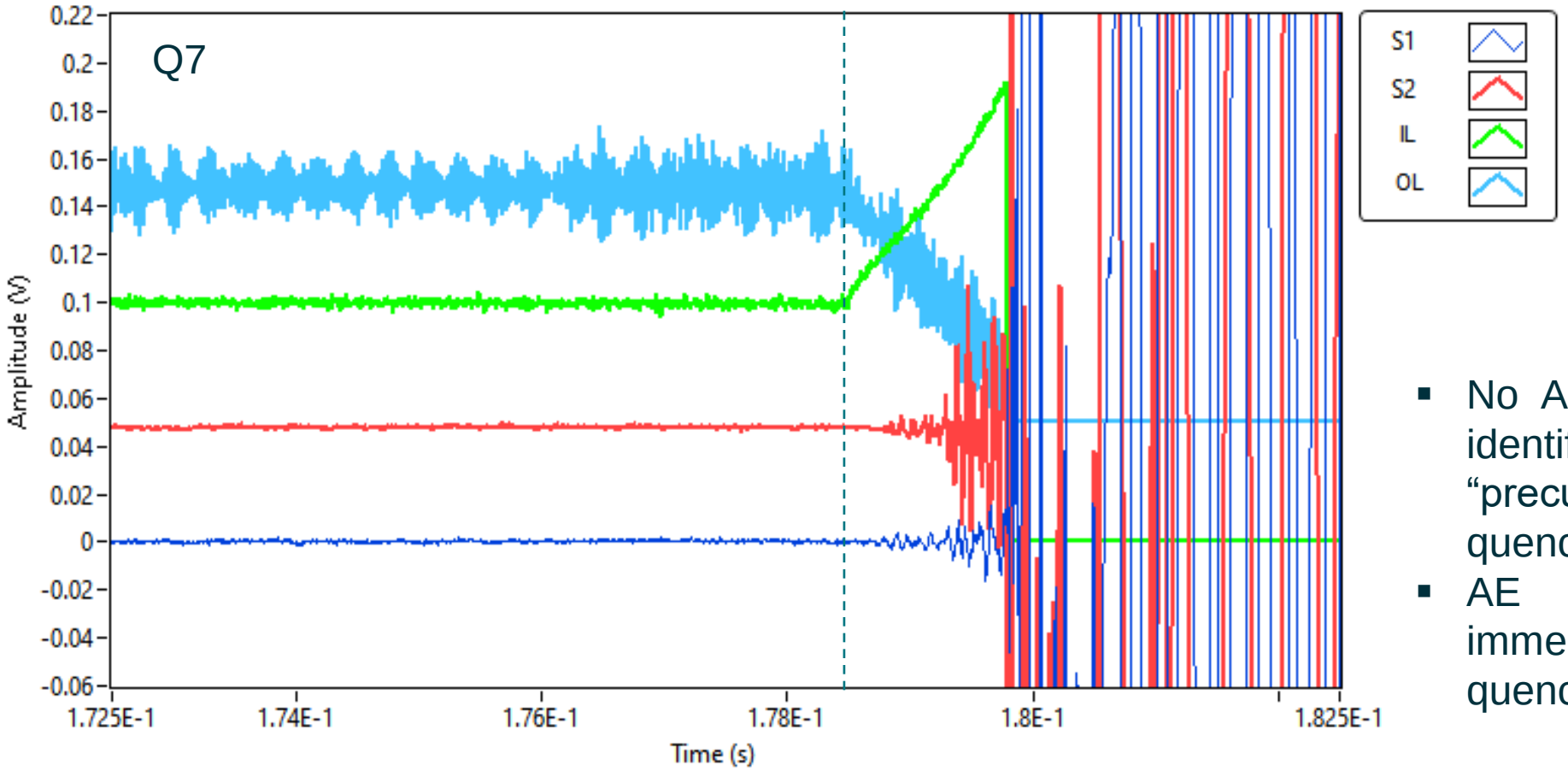


No AE events during a 5+ min holding at 50 A below short sample limit



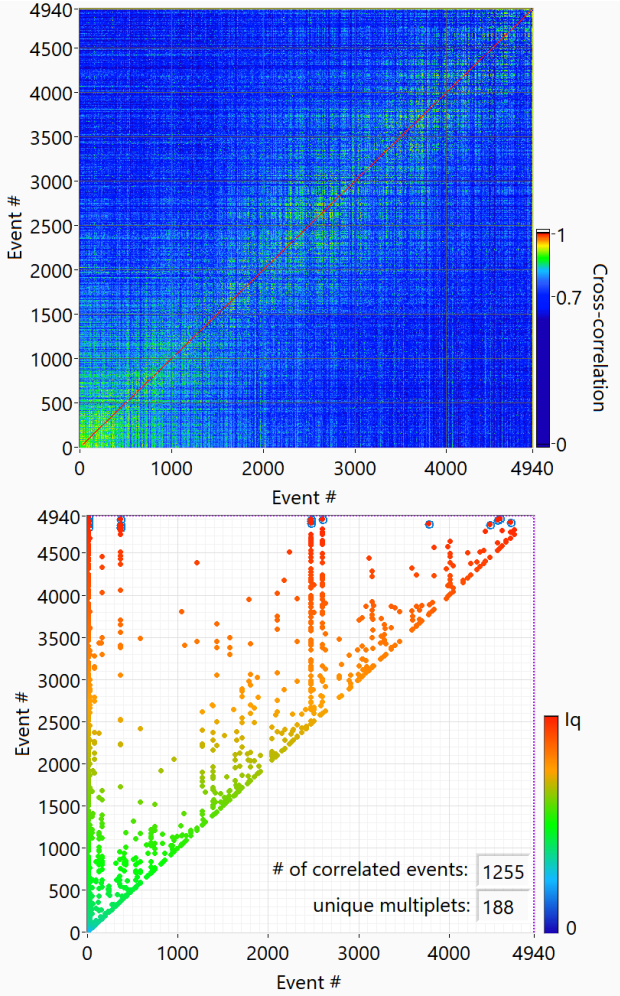
The magnet remains “silent” during the hold

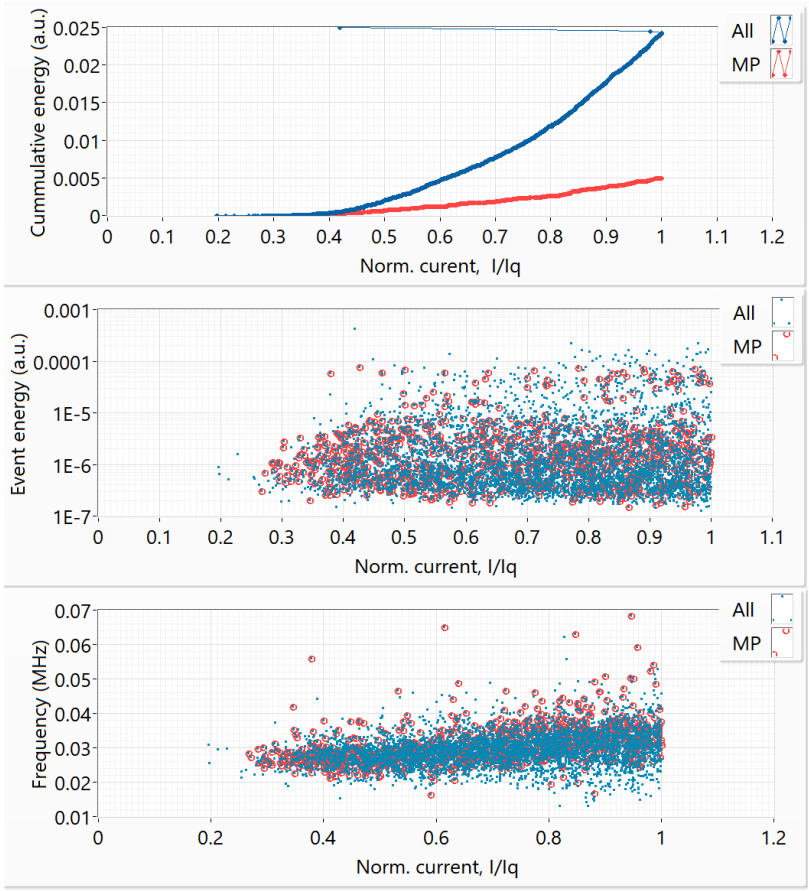
No AE precursor to the quench



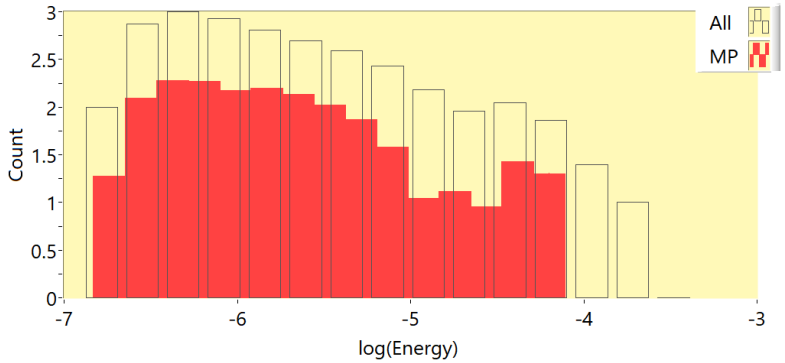
- No AE event can be identified as “precursor” to the quench
- AE begins almost immediately after quench starts

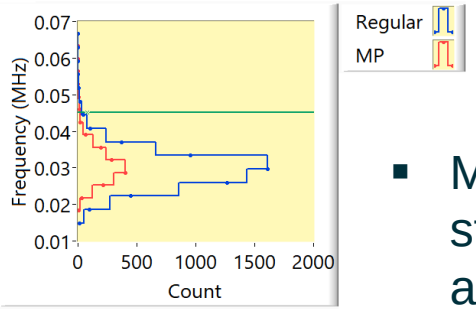
Multiplet analysis: Quench #1





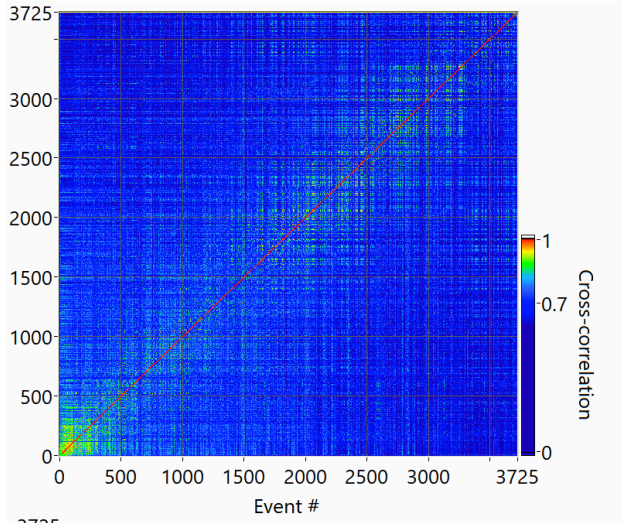
~ 20% of energy is released in multiplets

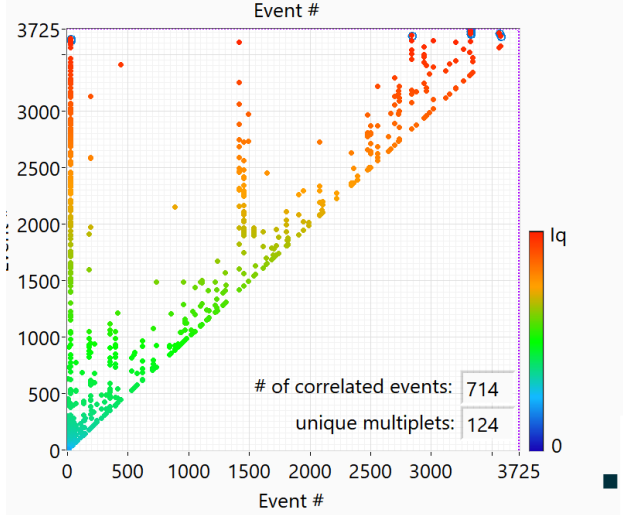


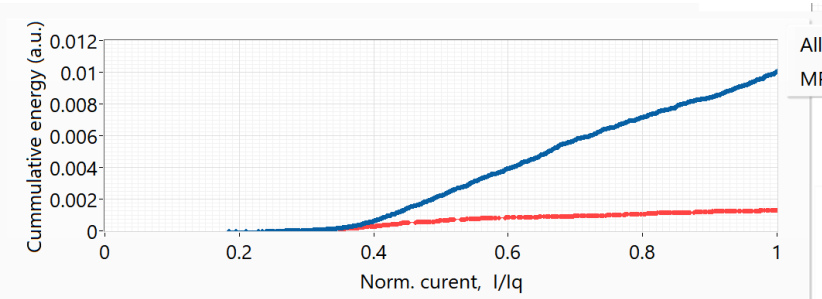


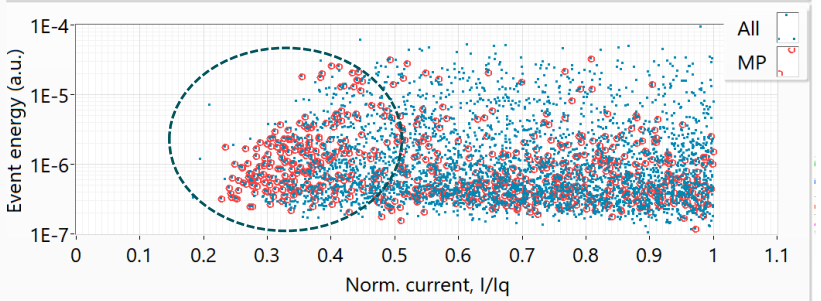
- Multiplet frequency statistics is the same as the rest of AEs

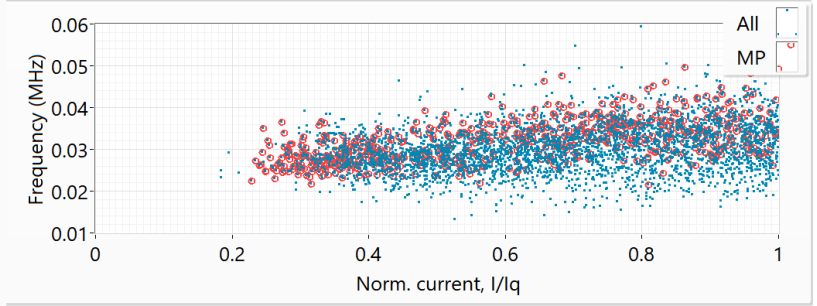
Multiplet analysis: Quench #7



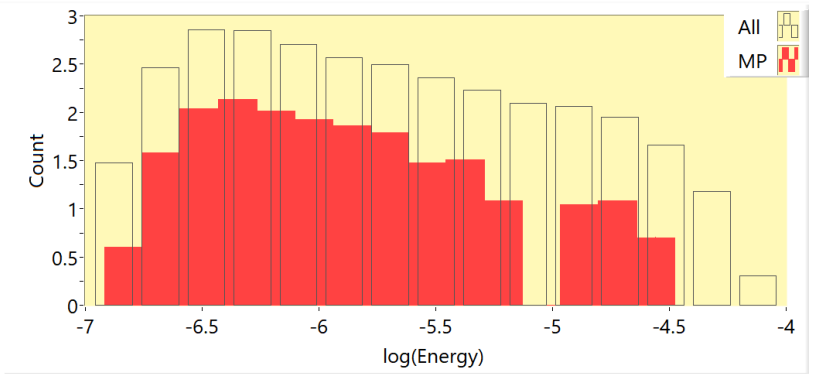


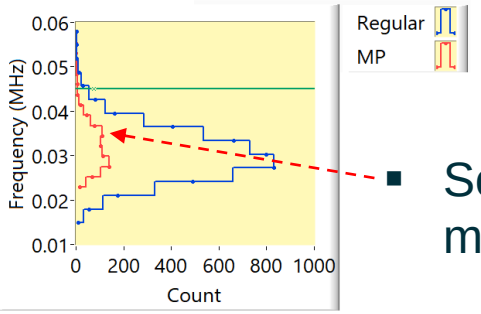






~ 12% of energy is released in multiplets





- Some higher frequency multiplets are seen

- The absolute amount of correlated events has decreased

Preliminary conclusions

- Wax-impregnated magnets are “noisy” - emit lots of AE!
- AE energy release statistics is similar to “well-trained” epoxy magnets
- As ”training” of the wax magnet progresses, the amount of AE events per ramp decreases and energy release per event increases, indicating mechanically the magnet is changing with every consecutive quench even if there is no change in quench current
- Wax magnet is “quiet” while current holding (50 A below short sample limit)
- Wax magnets exhibit a fraction of well-correlated AE multiplets, similar to the epoxy ones – indicating presence of stress concentration points. The amount of AE multiplets decreases as “training” progresses