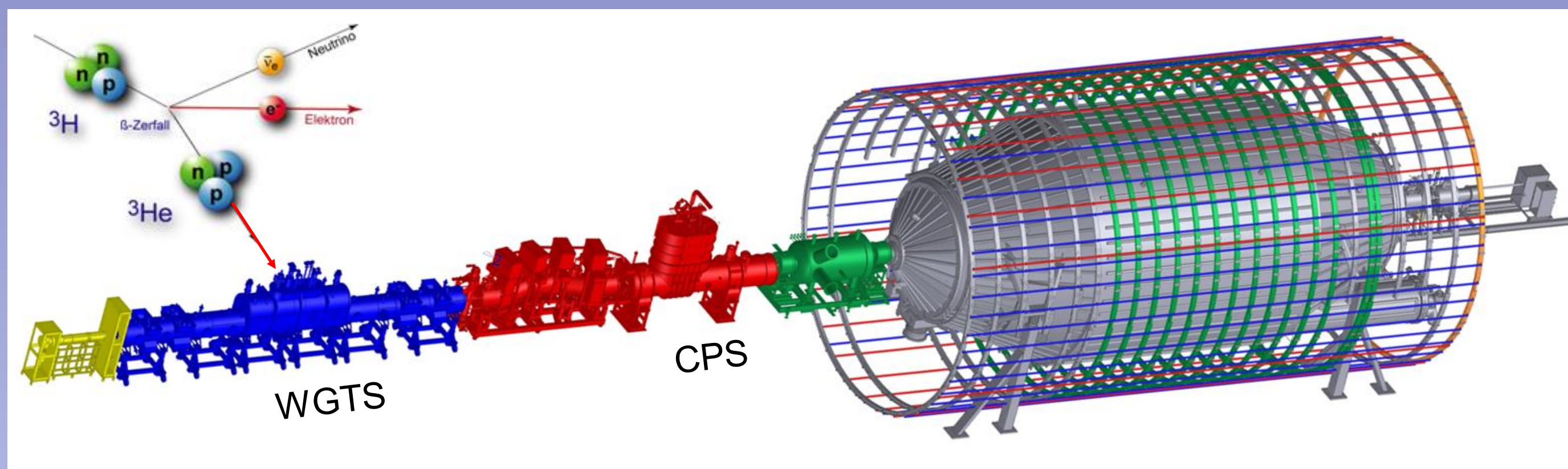


# Tests of by-pass diodes at cryogenic temperatures for the KATRIN magnets

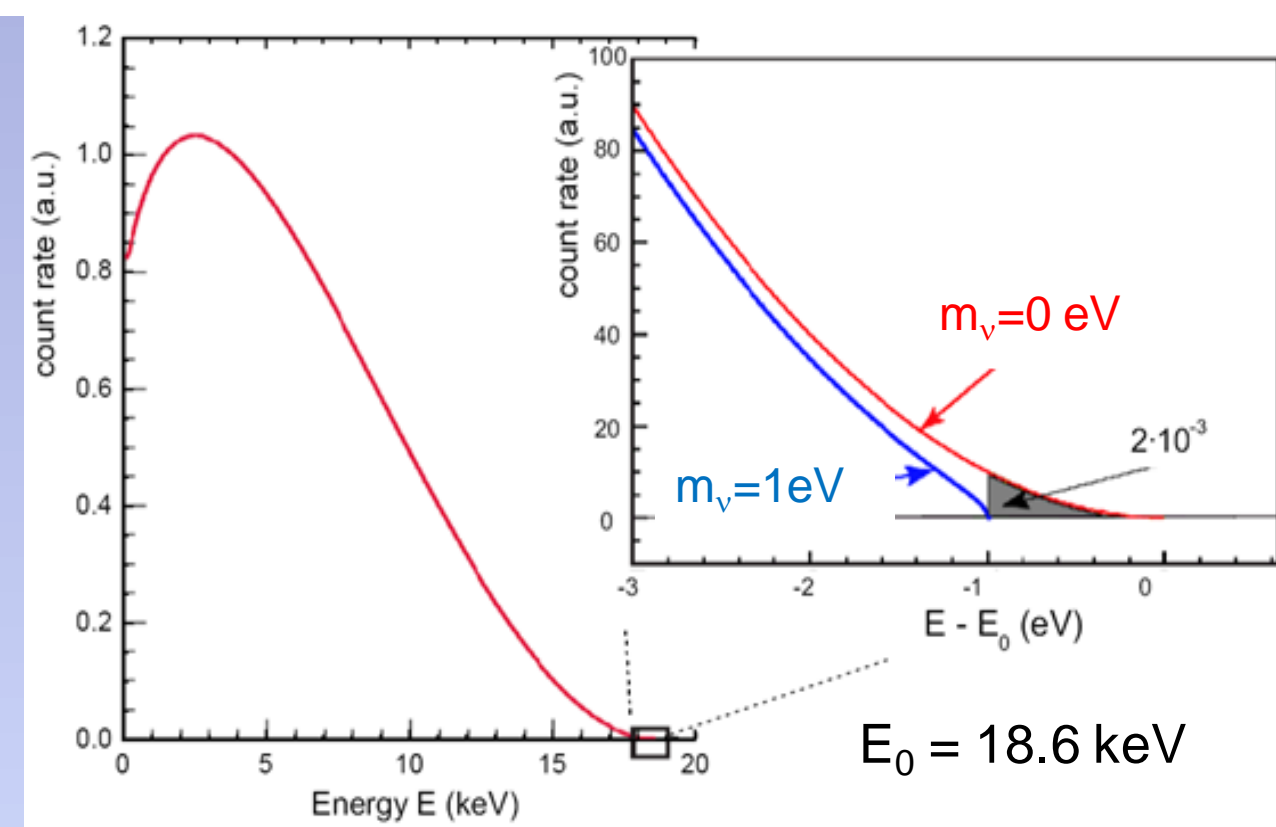
W. GIL<sup>a)</sup>, H. Bolz<sup>b)</sup>, A. Jansen<sup>b)</sup>, K. Müller<sup>b)</sup>, M. Steidl<sup>b)</sup>, and D. Hagedorn<sup>c)</sup>

## Introduction

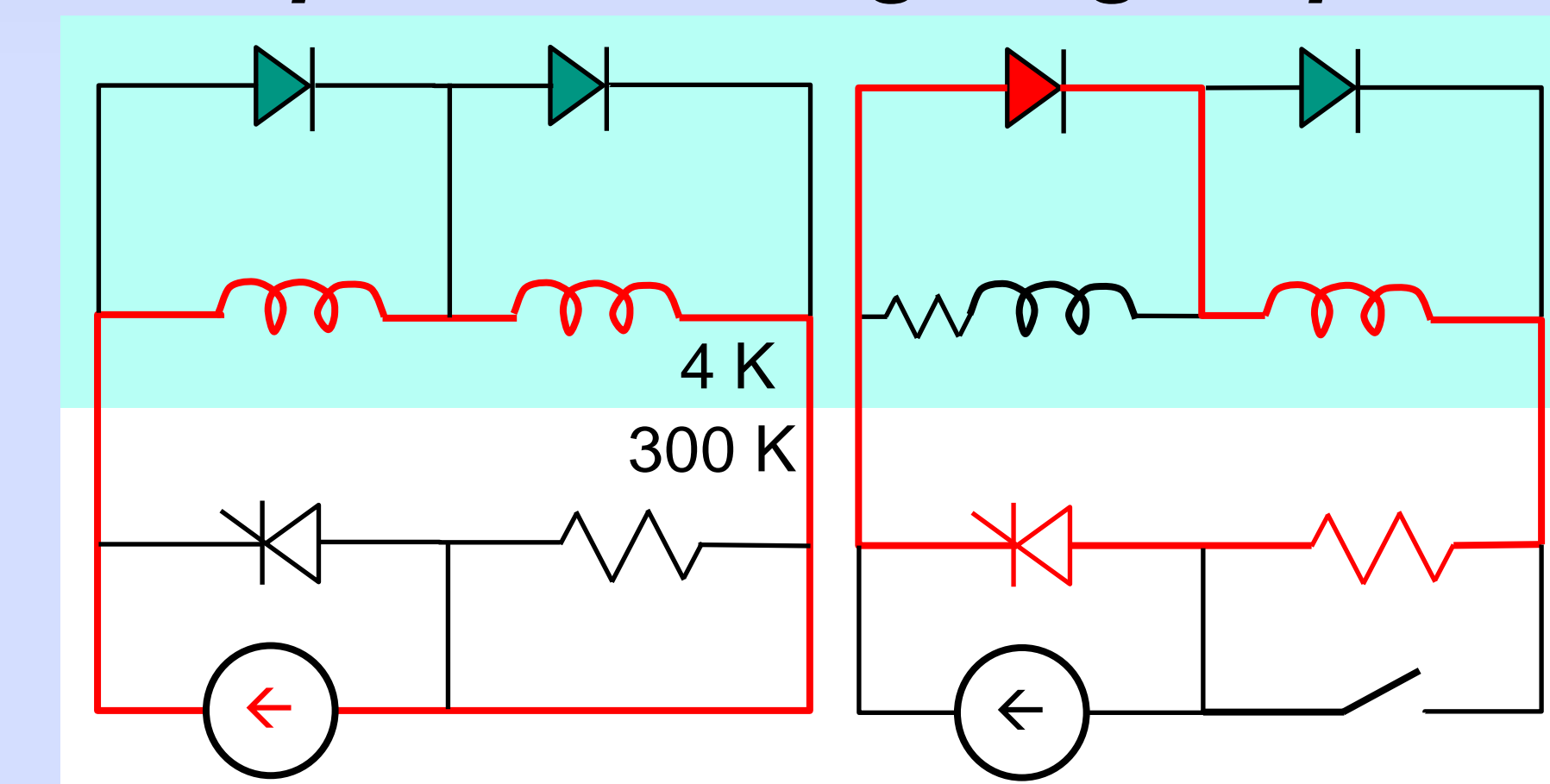
KATRIN: Karlsruhe Tritium Neutrino experiment



- determination of the absolute scale of the neutrino mass ( $m_{\nu}$ )
- ten times improved sensitivity of  $0.2 \text{ eV}/c^2$
- complex magnet systems



By-pass diodes for superconducting magnet protection

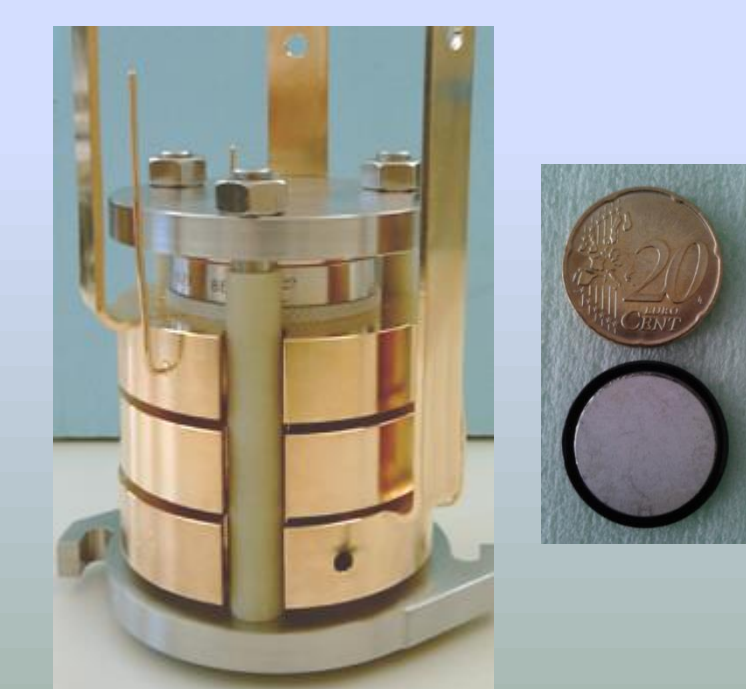


a) Standard operation b) One module quench

TABLE 1). Design parameters of diode stacks of two main magnet systems of KATRIN.

Items \ Magnets	WGTS doublet	CPS
Quantity of diodes in one diode stack	6	2
Max. design temperature at diode (K)	< 400	< 400
Max. design temperature at heat sink (K)	< 370	< 370
Temp. at diode u. adiabatic calculation (K)	< 186	< 220
Temp. at heat sink u. adiabatic calculation (K)	< 181	< 215

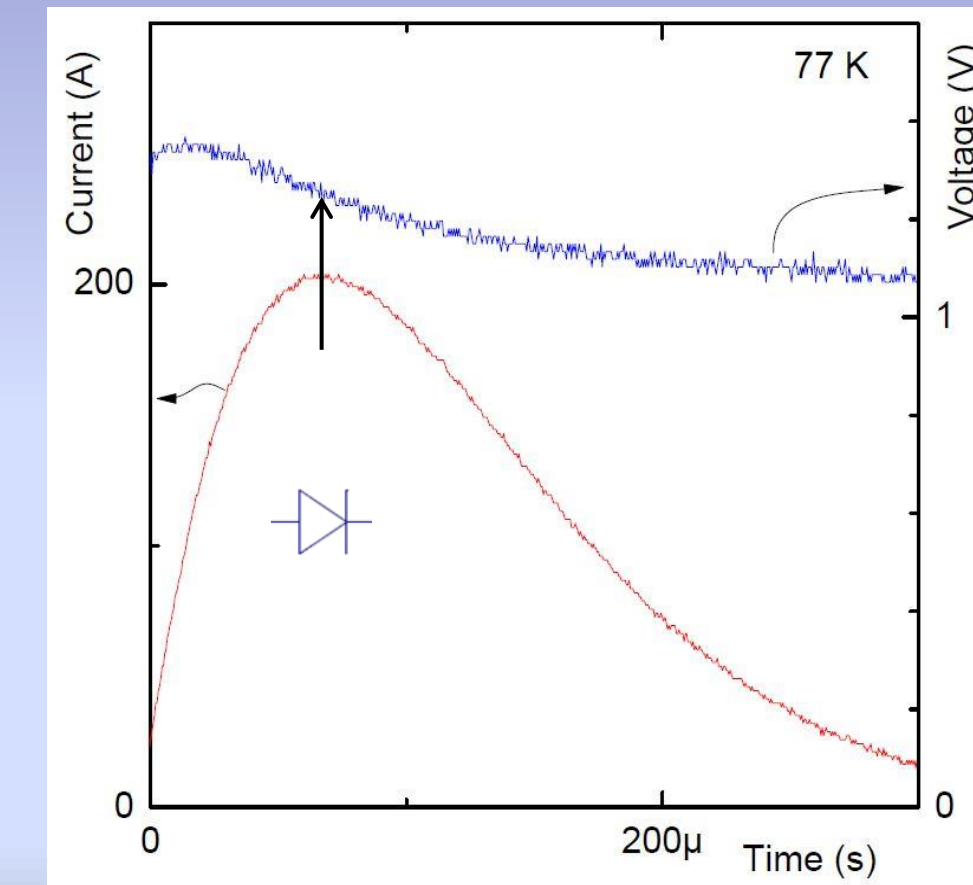
WGTS ; CPS  
 $I \text{ (A)} = 310 ; 200$   
 $E \text{ (MJ)} = 1.6 ; 3.5$   
 $MIITs \text{ (MA}^2\text{s)} = < 4 ; < 10$   
 $MIITs = \int I(t)^2 dt$



with sufficient heat sinks

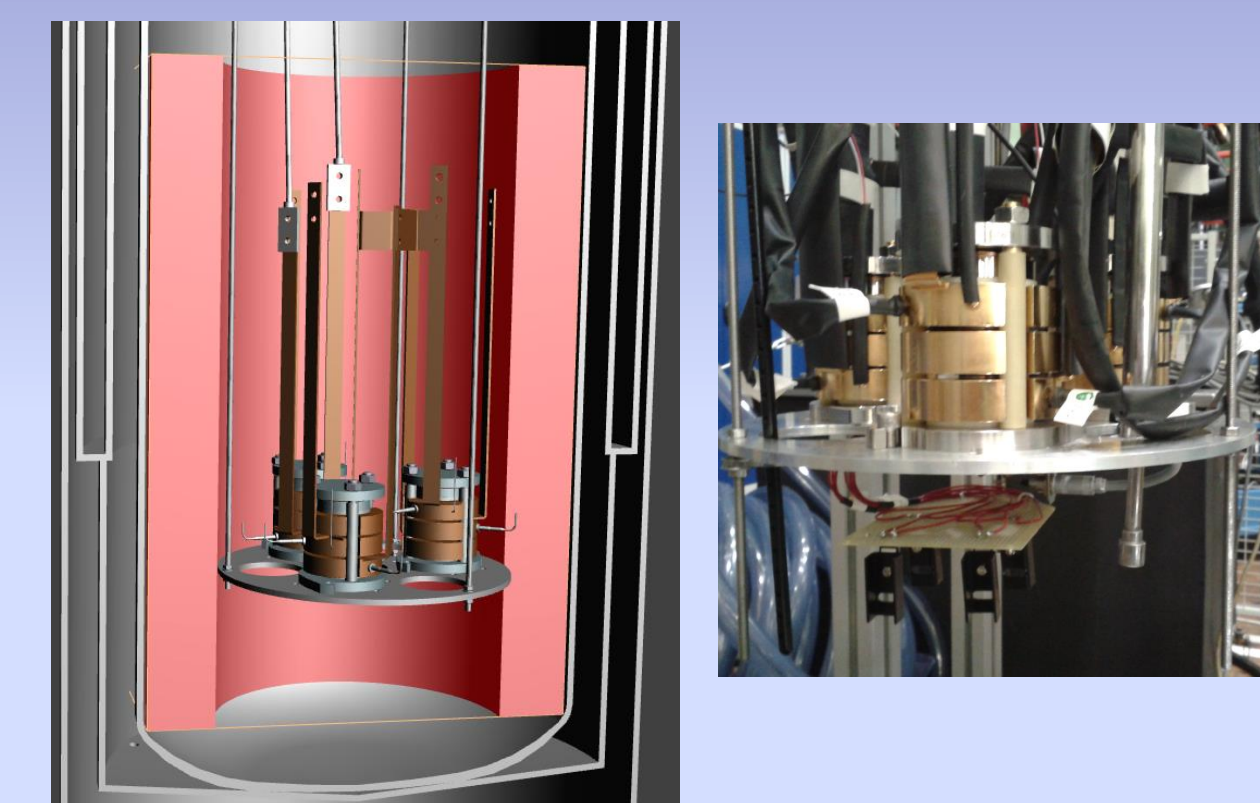
## Experimental set-up

Pulse test at 290 K and 77 K



for diode characteristics

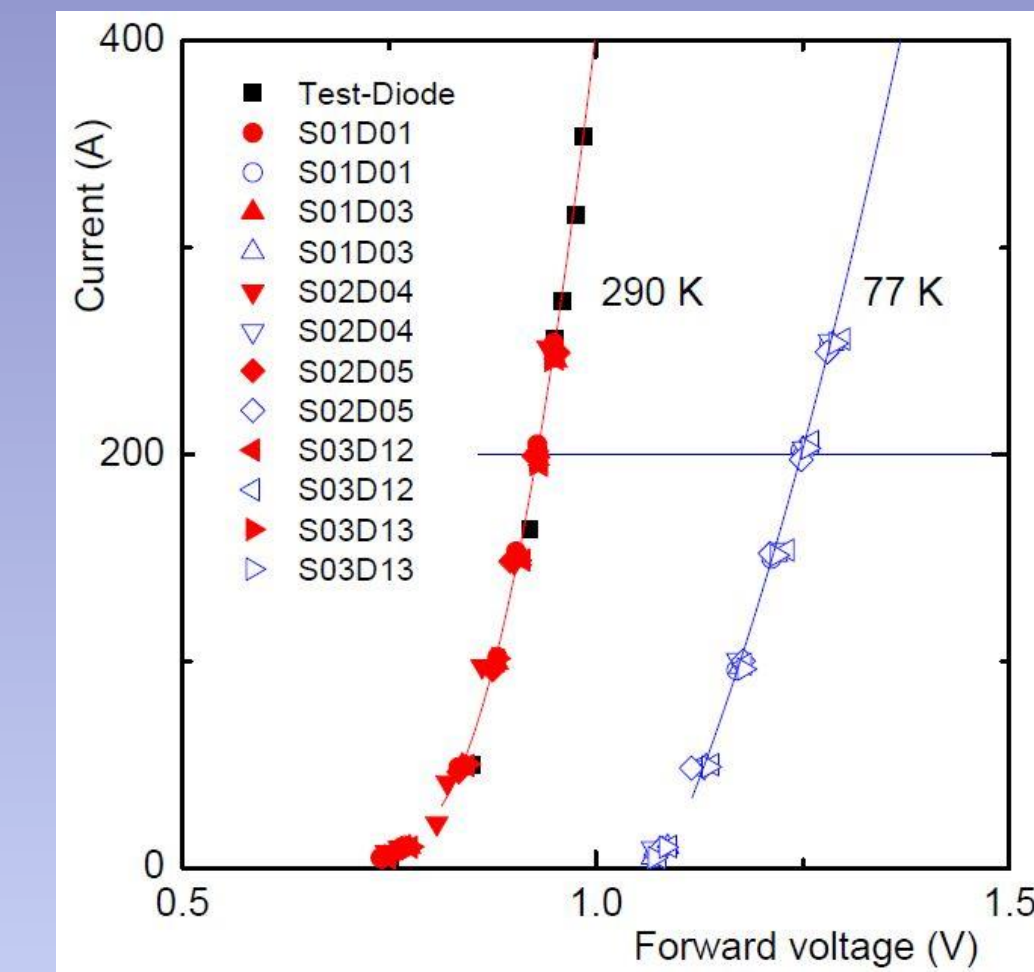
Endurance test at 4.2 K



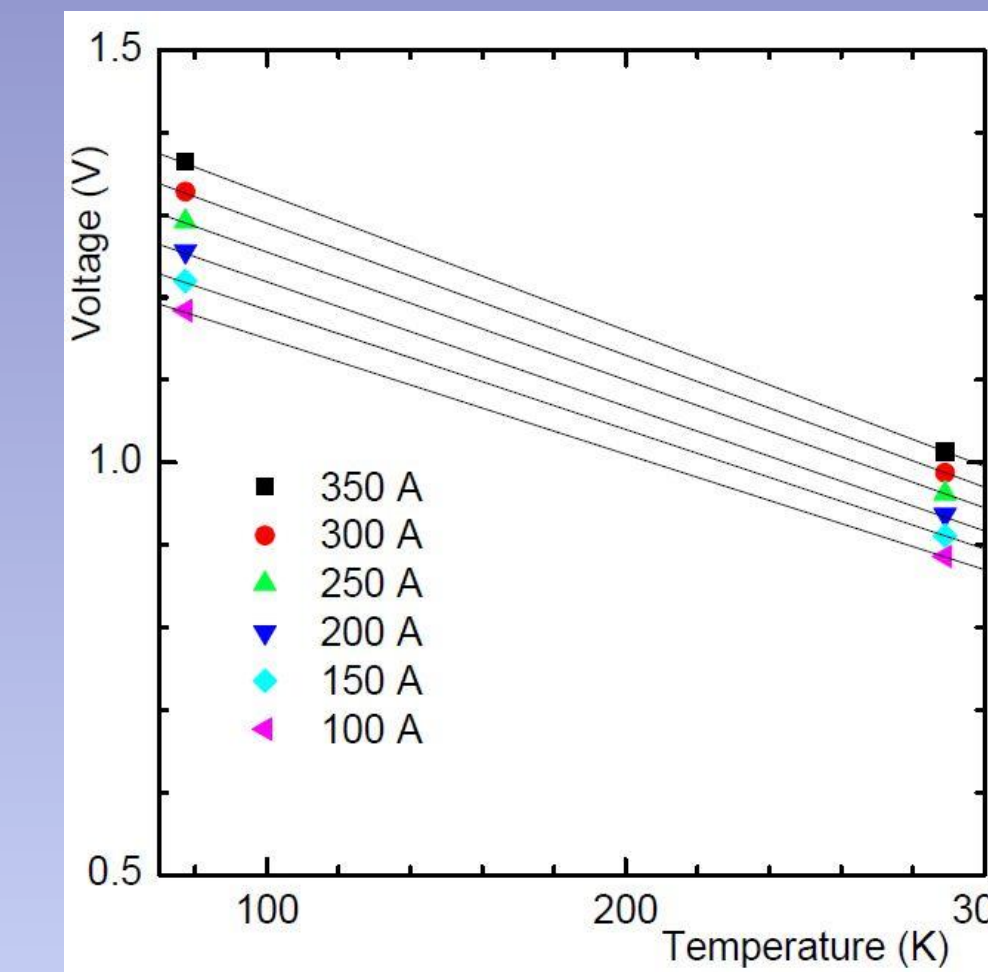
under quasi-adiabatic condition

## Results

Forward Voltage-Current Characteristics



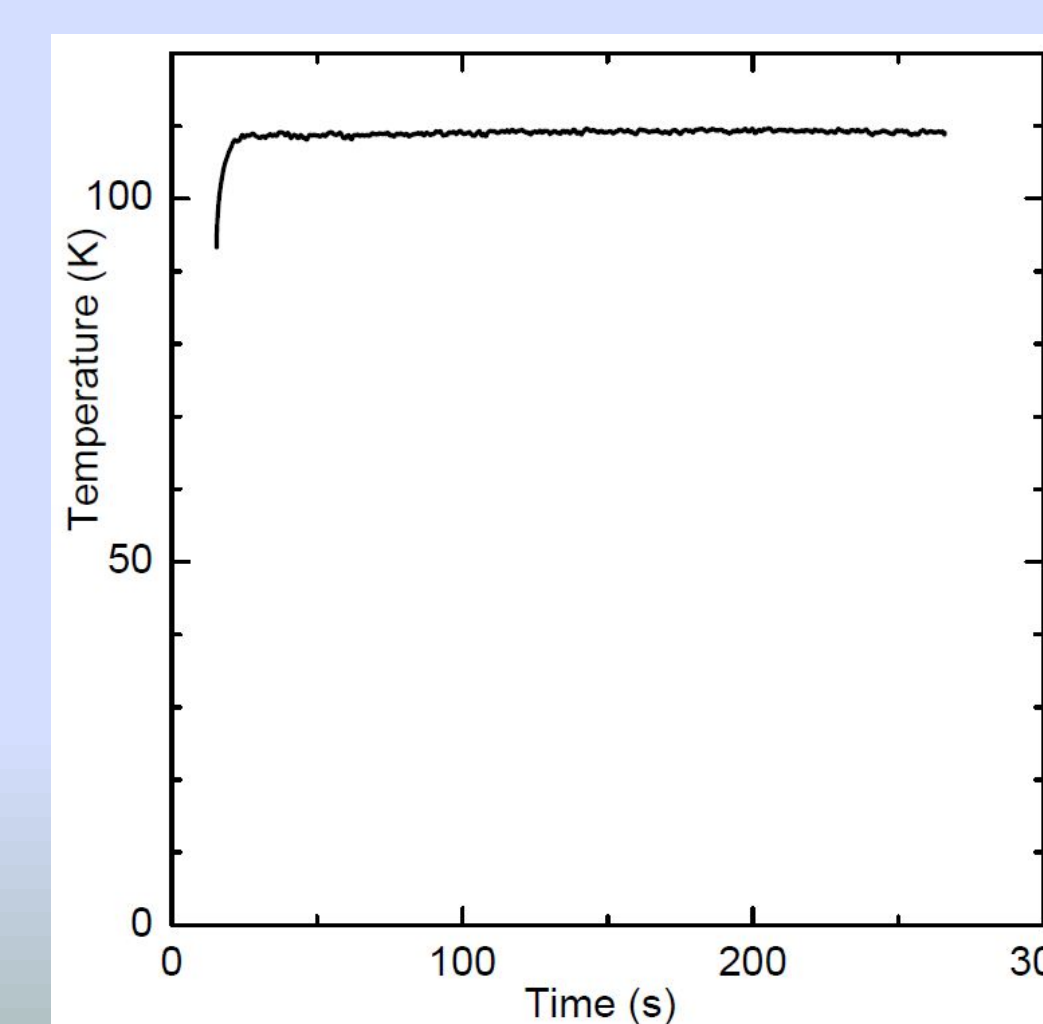
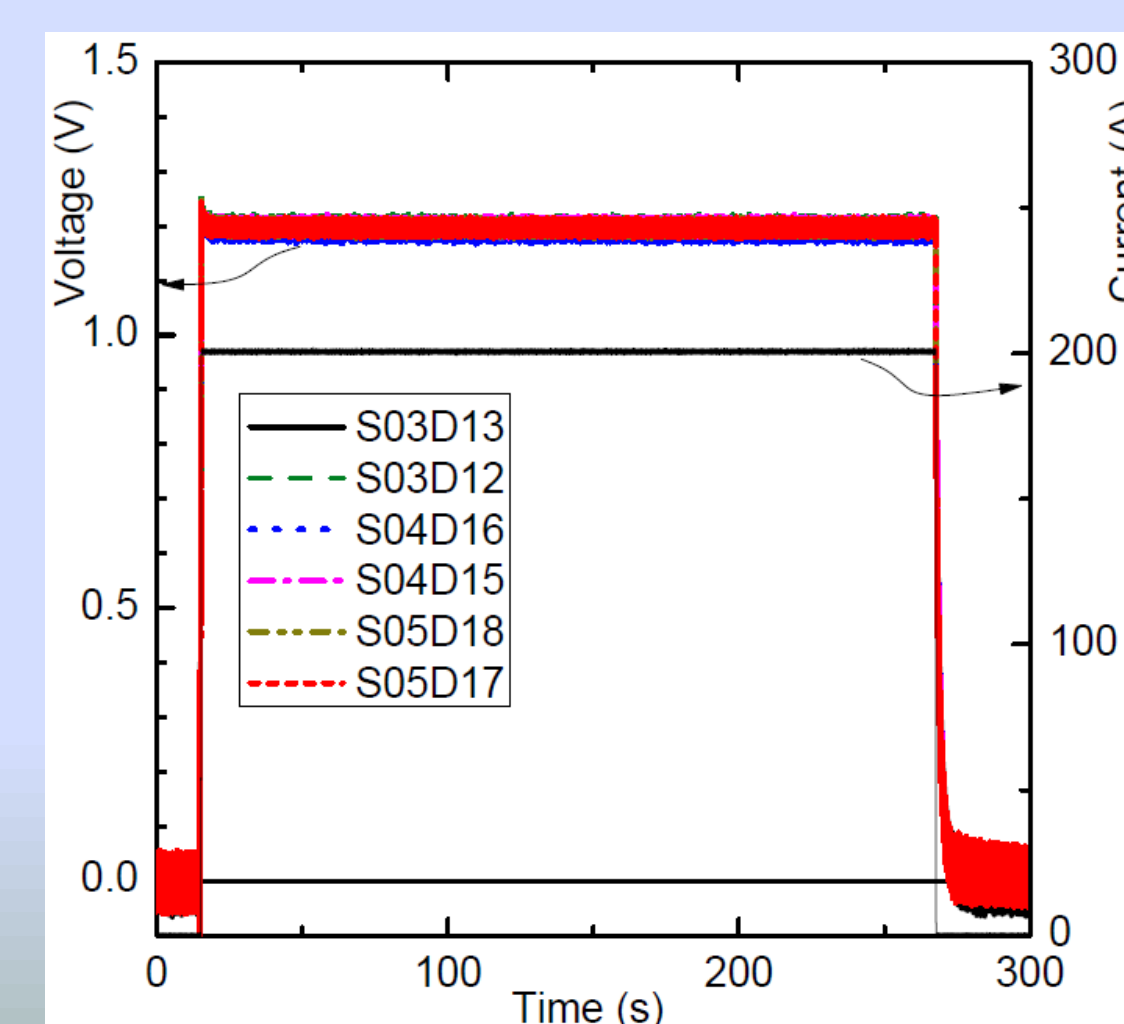
General calibration curve



$$V_f(T, I_f = 200 \text{ A}) = C_0(I) + C_1(I)T$$

between 77 K and 300 K

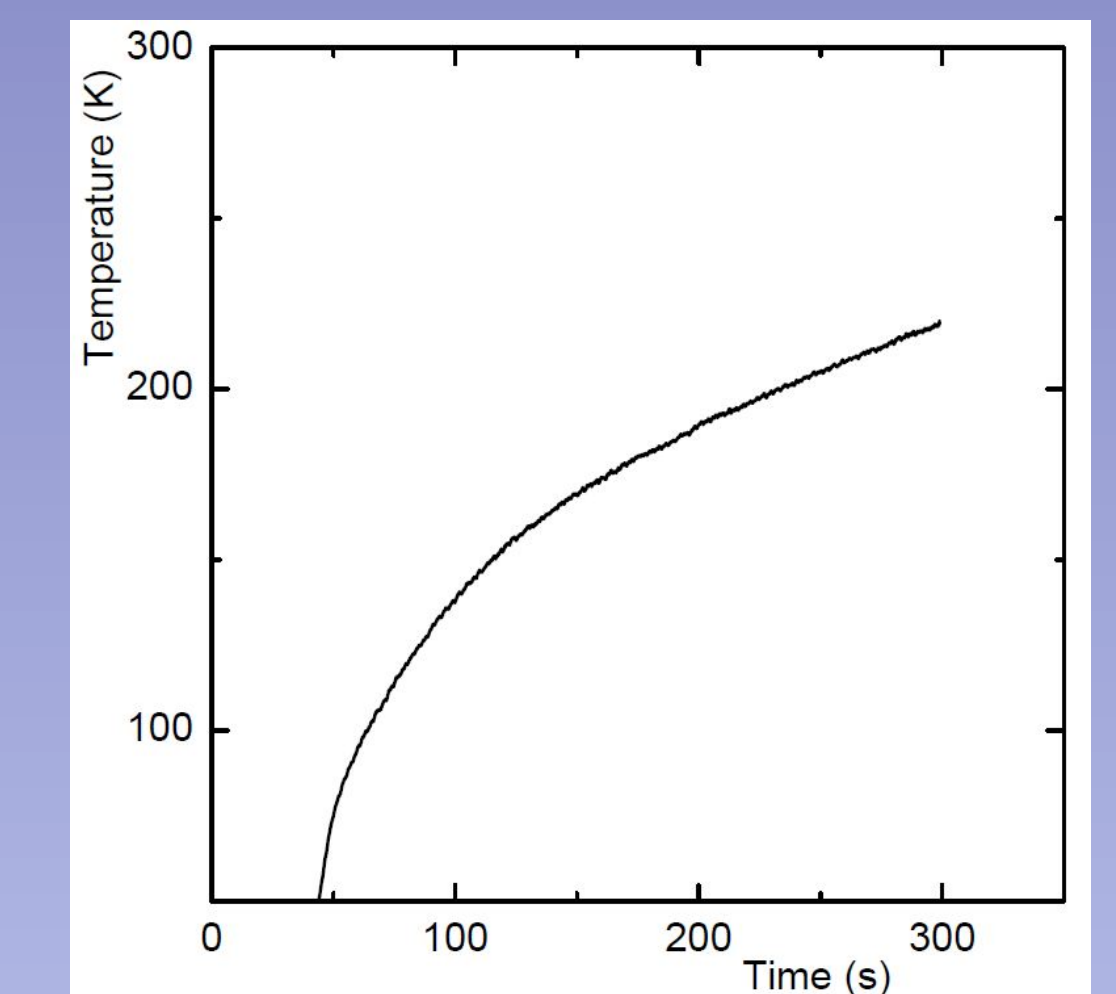
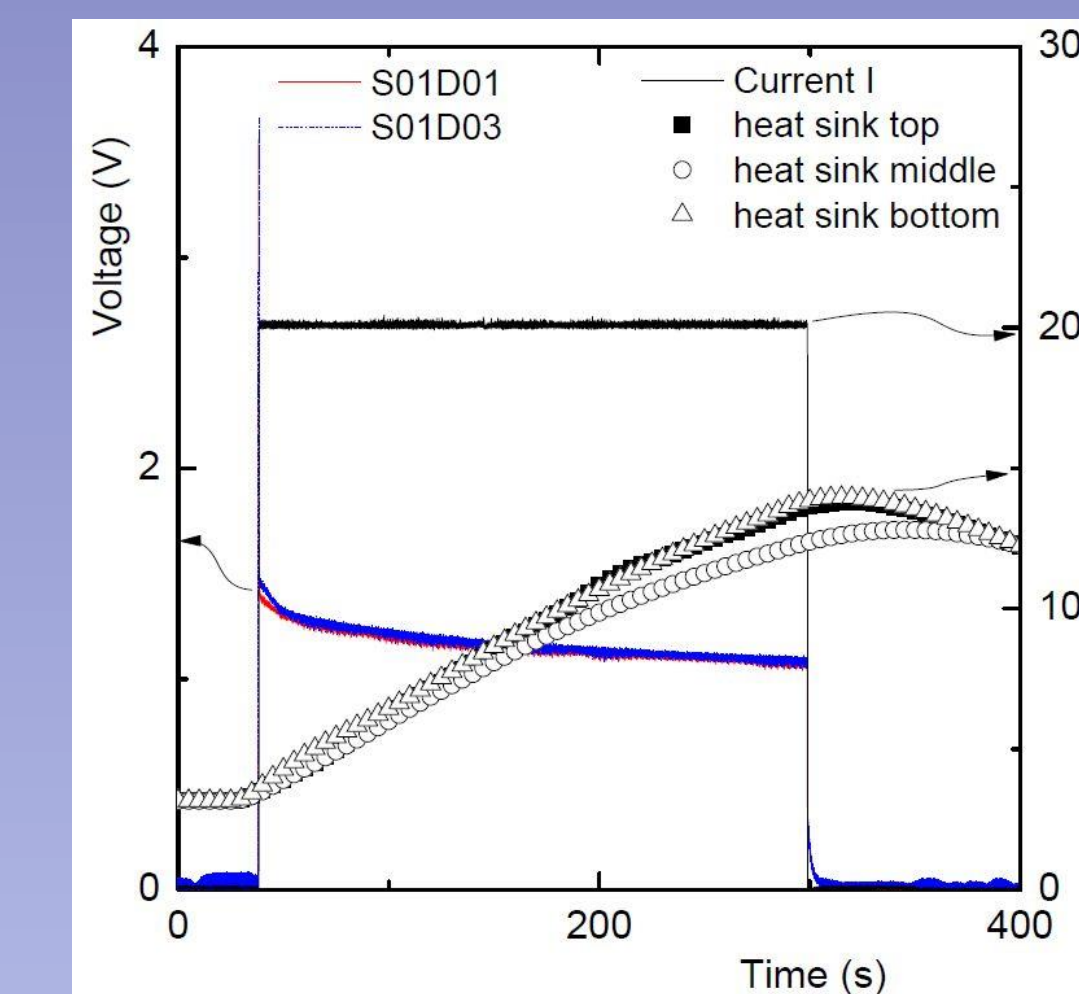
Current Endurance Test at 77 K



$T@Diode < 110 \text{ K}$

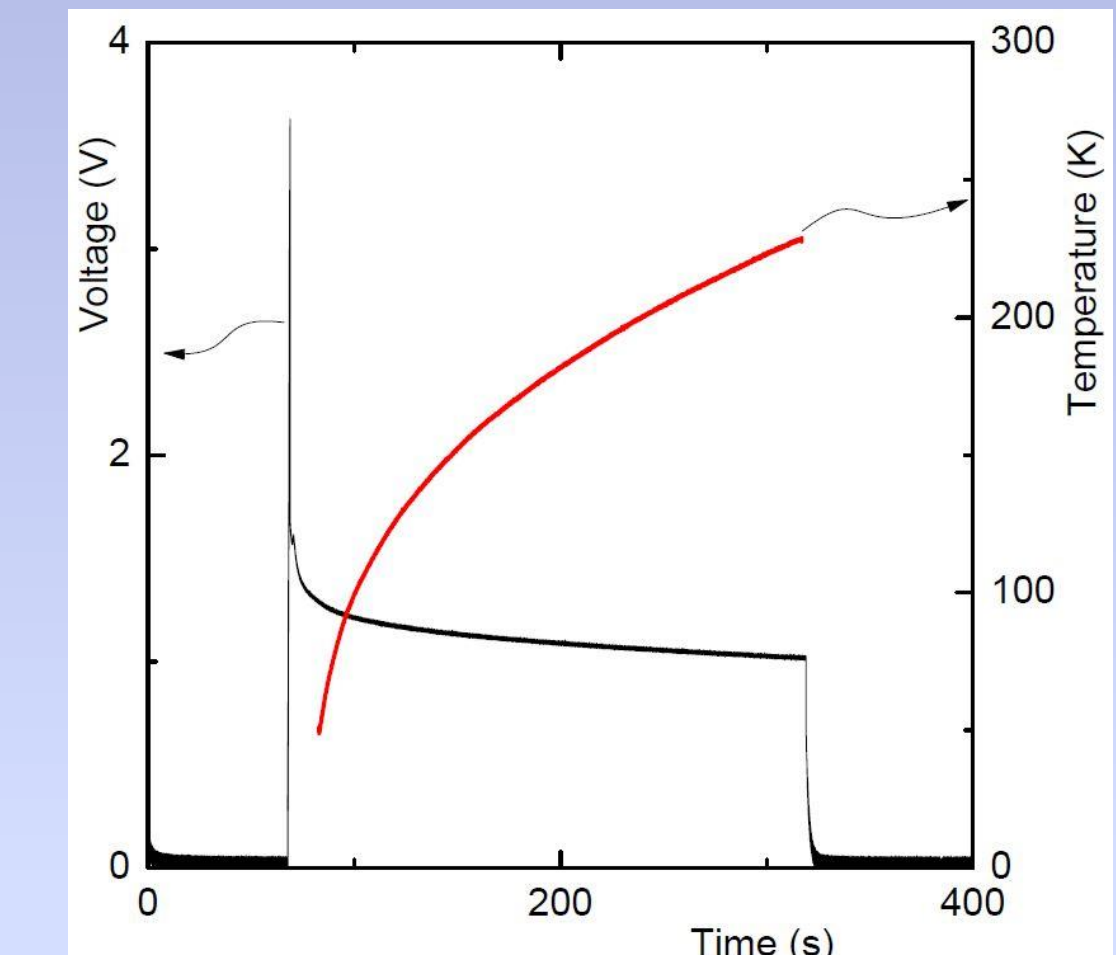
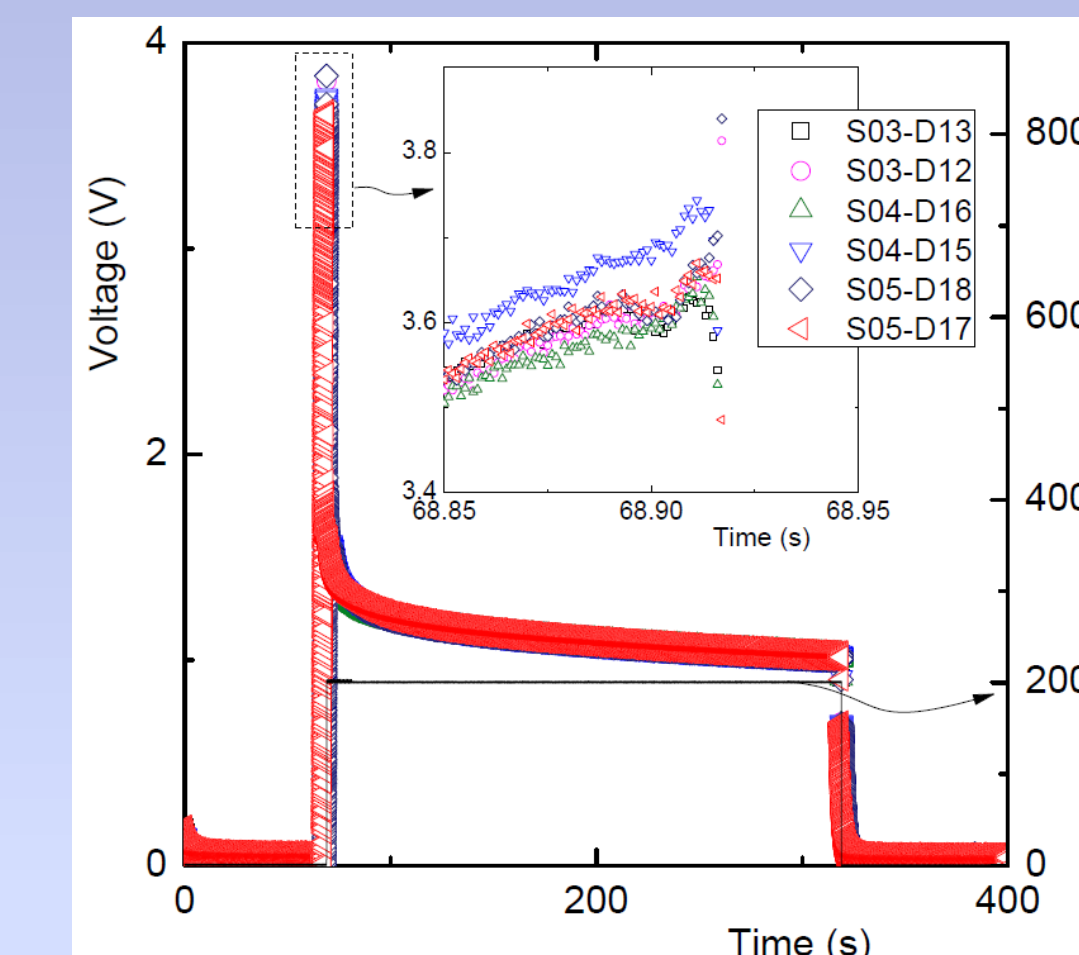
Current Endurance Test at 4.2 K

a) One stack



$T@Diode < 219 \text{ K}$

b) Three stacks



$T@Diode < 228 \text{ K}$

→ Good agreement with the simulation under adiabatic condition!

TABLE 2). Summary of current endurance tests at 4.2 K.

Max. Temp. of (K) \ Test with	One diode stack	Three diode stacks
Heat sinks	140	200
Diodes	219±10	228±10
Bus bars	45	70

## Conclusion

✓ Successful cold tests at 4.2 K under quasi-adiabatic condition

- CPS-diode stacks test by end of June, 2013
- WGTS-diode stacks test by end of 2013