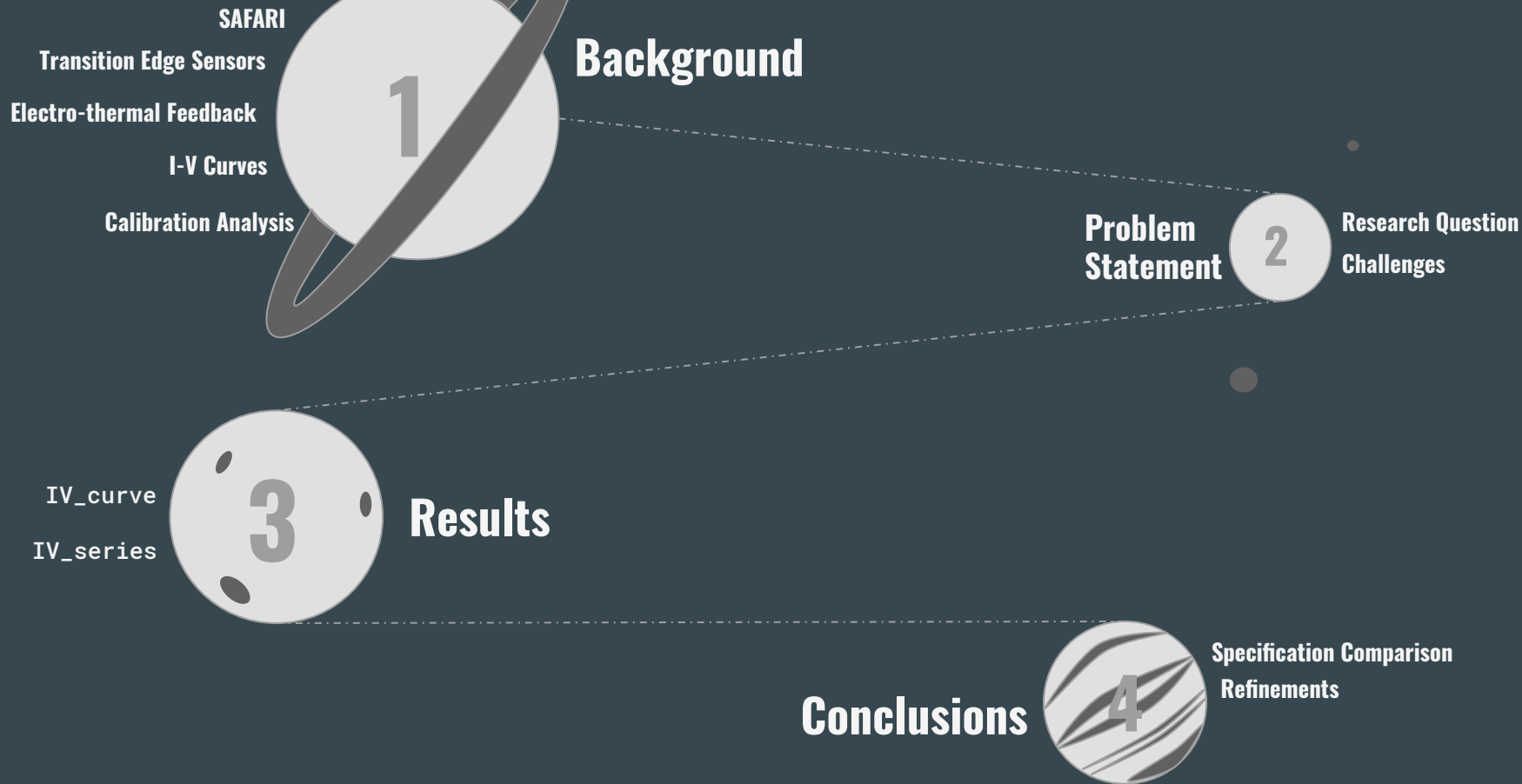


# Design of Software Routines for Automatic Calibration of Transition Edge Sensors

...

Callum Blair





Background  
...

# SRON, SPICA and SAFARI



- SRON

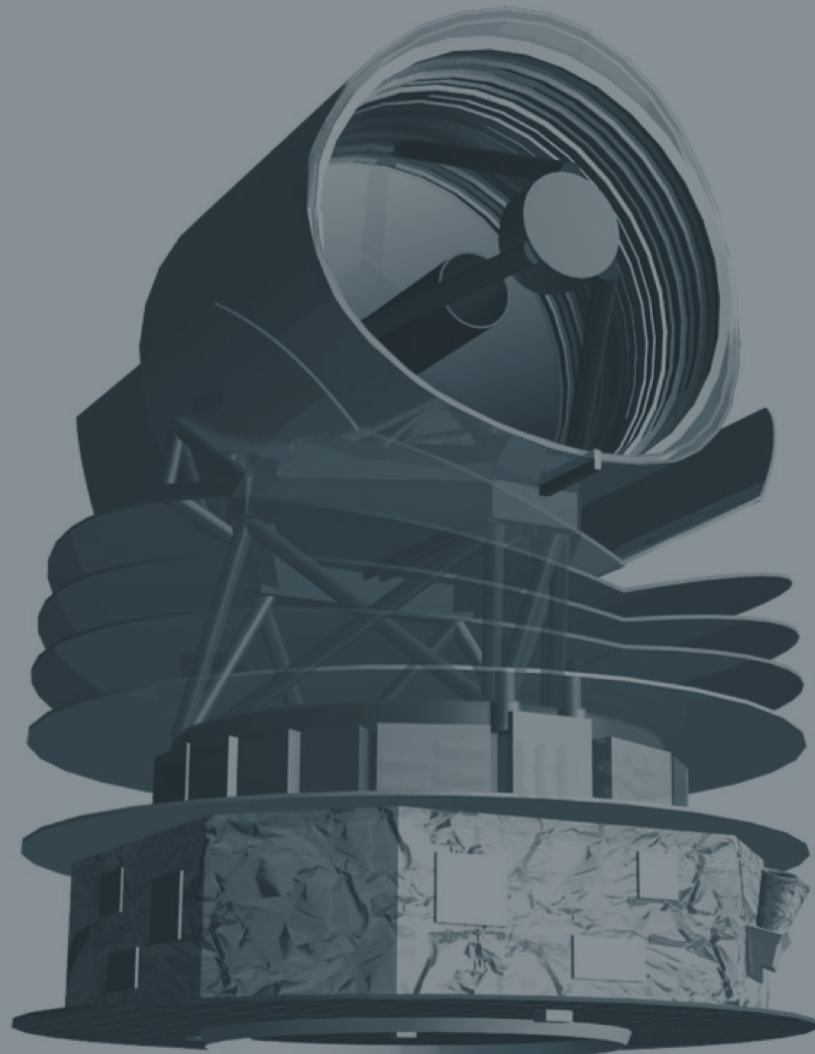
The Netherlands Institute for Space Research

- SPICA

Space Infrared Telescope for Cosmology and Astrophysics

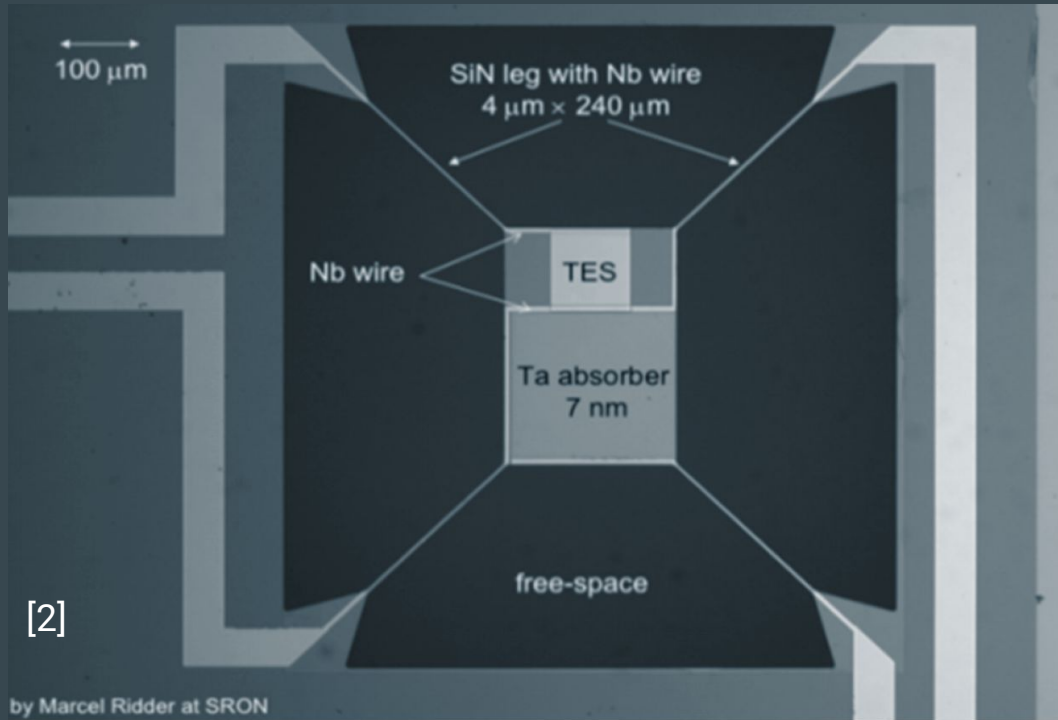
- SAFARI

SPICA Far-IR Spectrometer



# Transition Edge Sensor Bolometers

• • •



- Superconducting Film

Low Temperature

Zero Resistance Region

- Bolometer

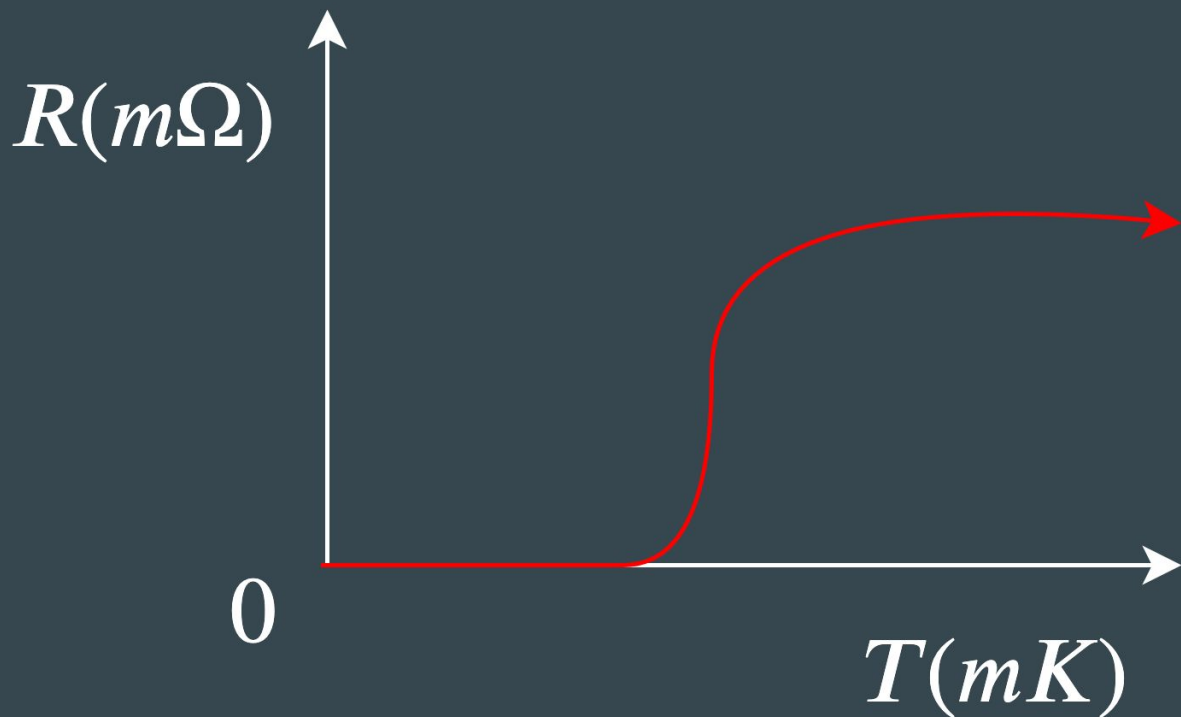
Measure power of incident radiation

Temperature dependant resistance

[2]

# Temperature Resistance Relation

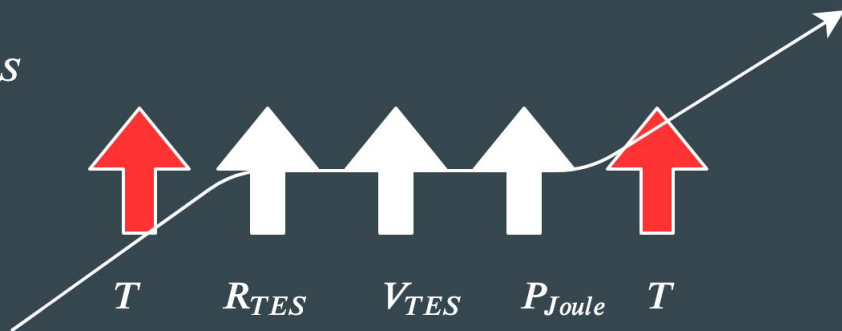
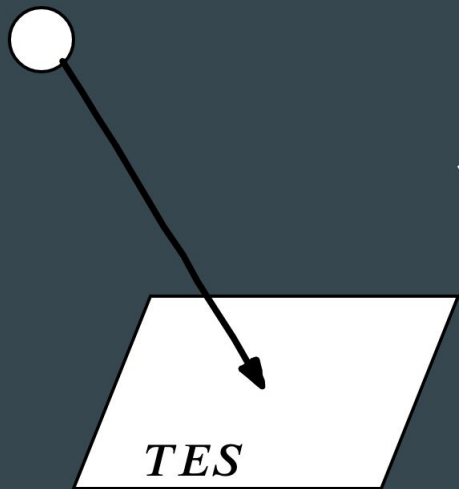
...



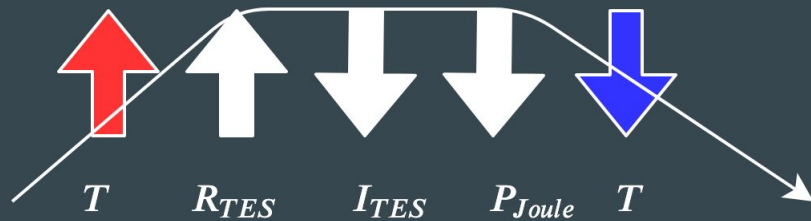
# Electro-thermal feedback

...

$$P_{Joule} = \frac{V_{TES}^2}{R_{TES}} = I_{TES}^2 \cdot R_{TES}$$



$$\frac{dI_{TES}}{dt} = 0$$



$$\frac{dV_{TES}}{dt} = 0$$

# IV Curves

...

- Ohmic

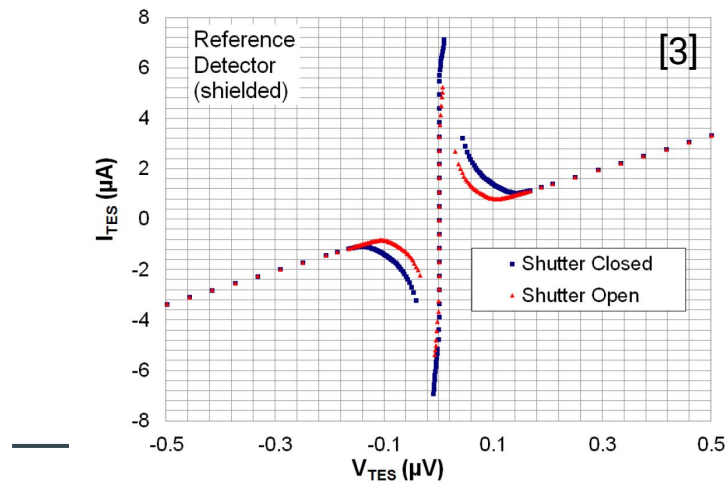
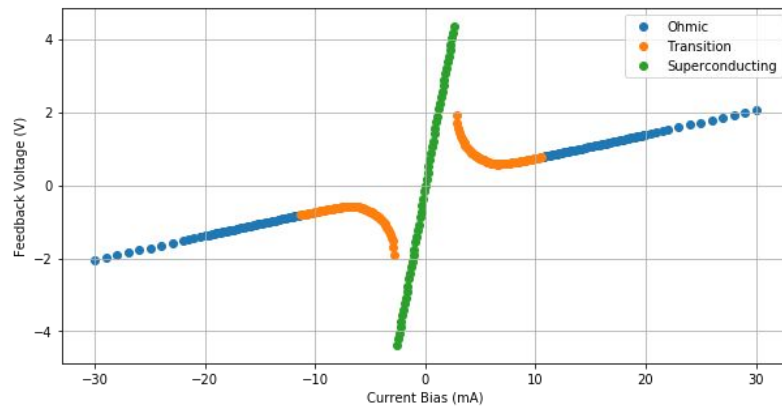
Approximates resistor

- Transition

Strong temperature/resistance dependence

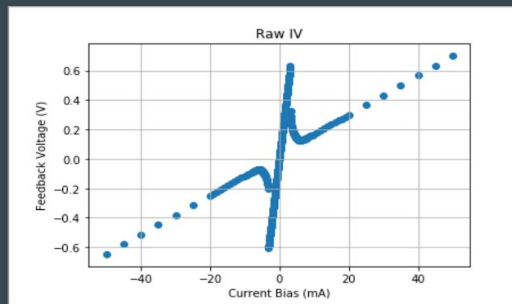
- Superconducting

Zero resistance

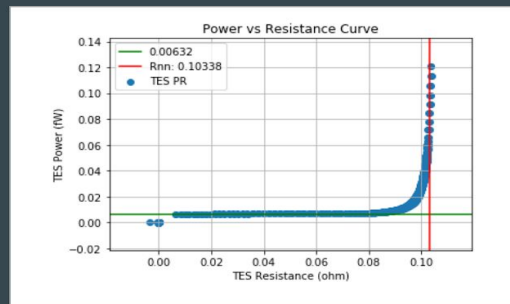




# Calibration Analysis

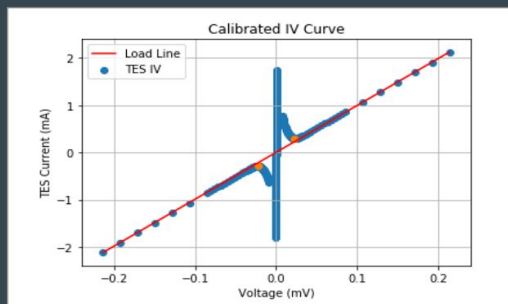


Raw Data

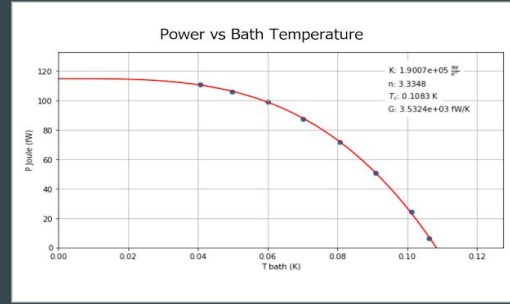


Readout

IV Curves



Parameters



...

**Can key aspects of the  
analysis be automated  
reliably?**

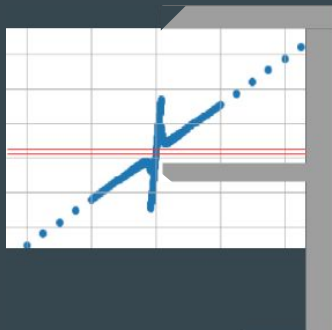
# Challenges

...

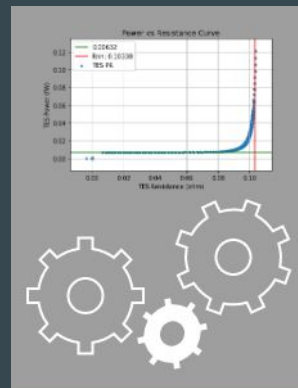
- Identify



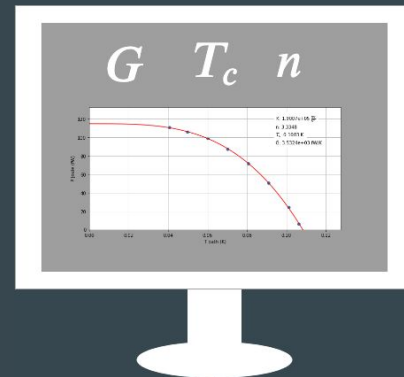
- Remove Offsets



- Find Critical Power



- Fit to model



# Results

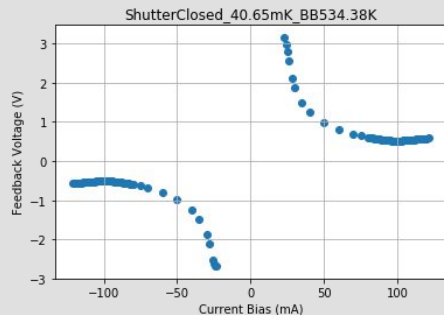
...

## Input

Raw IV

Parameters

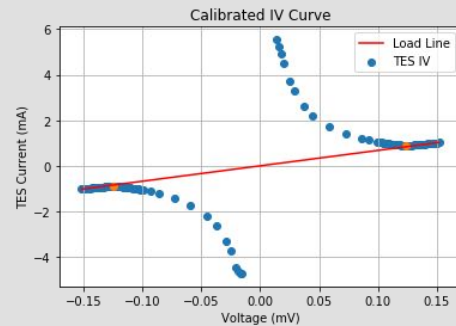
## IV\_Curve



calc\_IV()

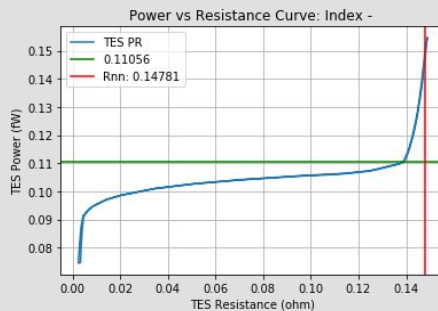
I\_TES

V\_bias



## Output

P\_readout



calc\_PR()

P\_TES()

R\_TES()

Input

Directory

Parameters

IV\_Series

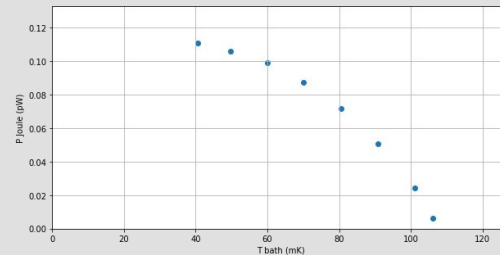
analyse\_IV()

P\_readout

T\_bath

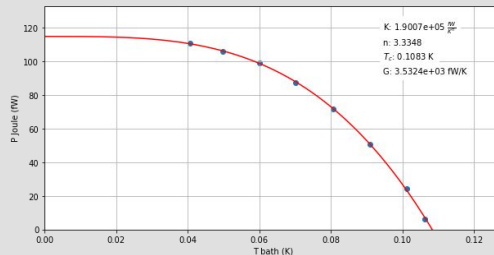
IV\_Curve

IV\_Curve



Output

$T_c$   $G$



curve\_fit()

# Conclusions

...

# Comparison to Specification

...

- Identifies Suitable Data

Using rule based testing of extracted features

- Calculates and Removes Offsets

Using optimization of power graphs

- Returns device parameters

Values for thermal conductance and critical temperature are saved in text format

**0.139**seconds

To create one instance of IV\_curve

**42.40**seconds

To analyse one IV\_series (18 points)

---

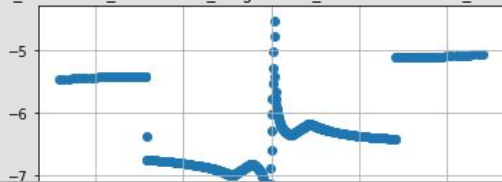


# Refinements and future work

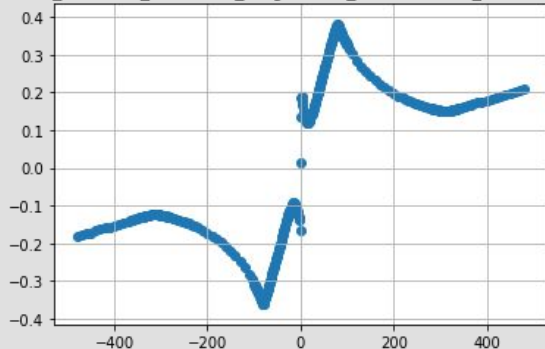
...

- Analysis for Additional Forms of Data

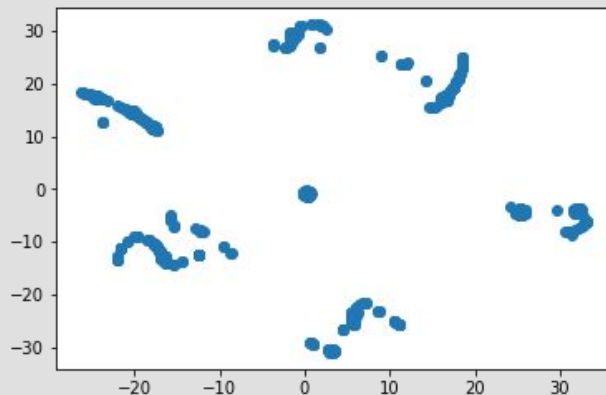
V17DShutterClosed\_101.30mK\_BB534.38K\_magnet0uA\_HTRV2724.70mV\_HTRI26.74mA\_PBB0pc.qdp



V17DShutterClosed\_95.81mK\_BB26.01K\_magnet0uA\_HTRV1.27mV\_HTRI-0.24mA\_PBB35pc.qdp



- Automatic Identification with Clustering



# References



[1] “Spica/safari.” [Online]. Available: <https://www.sron.nl/missions-astrophysics/spica-safari>

[2] M. D. Audley et al. “Optical performance of an ultra-sensitive horn-coupled transition-edge sensor bolometer with hemispherical backshort in the far infrared,” Review of Scientific Instruments, vol. 87, no. 4, p. 043103, 2016. [Online]. Available: <https://doi.org/10.1063/1.4945302>

[3] M. D. Audley, G. Lange, J. Gao, P. Khosropanah, R. Hijmering, and M. Ridder, “Optical performance of prototype horn-coupled tes bolometer arrays for safari,” 07 2016, p. 991408.

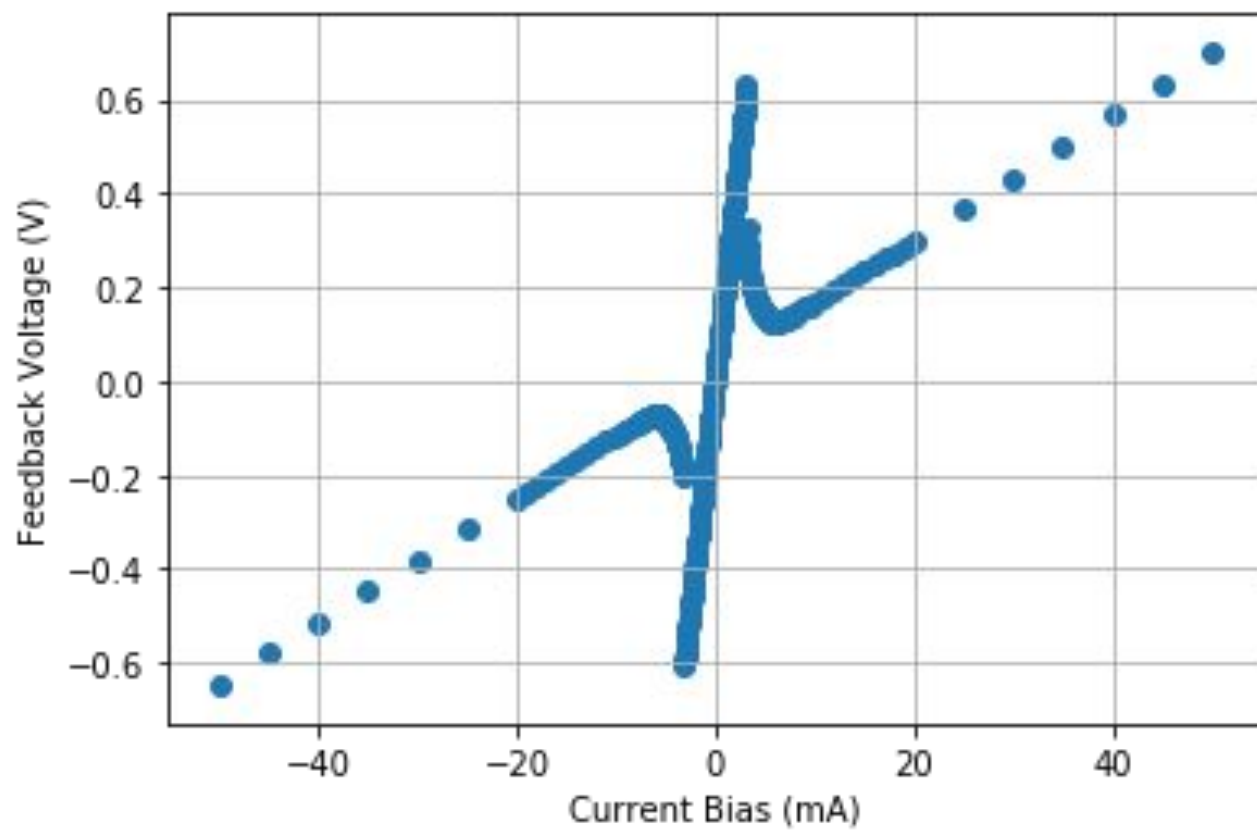
[Title Background] [Online]. Available: [https://www.sron.nl/images/missions/tesdetector\\_safari\\_2.jpg](https://www.sron.nl/images/missions/tesdetector_safari_2.jpg)



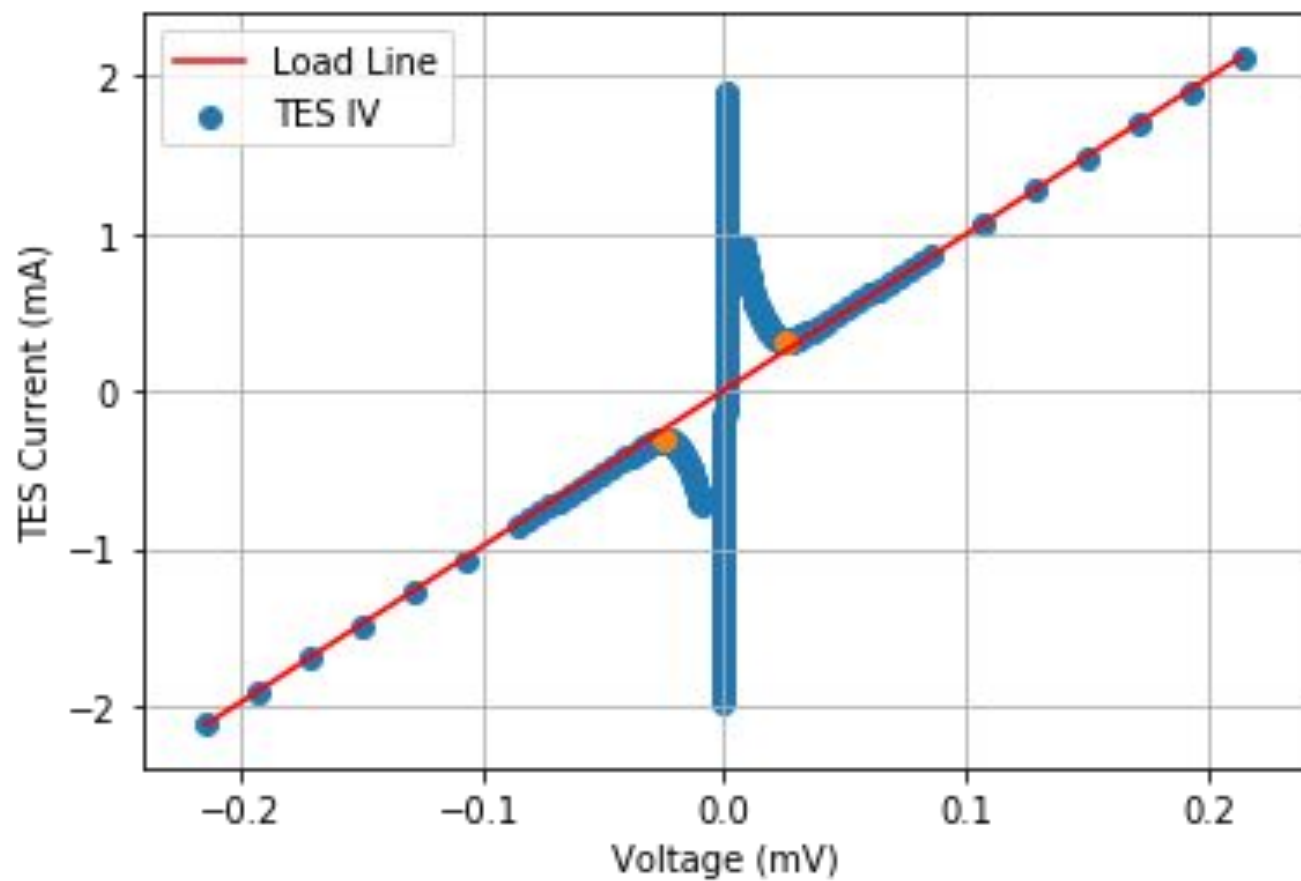
# Questions

...

Raw IV



Calibrated IV Curve



Power vs Resistance Curve

