A PID model ensuring 25 years of service life

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I Introduction

II PID-s modeling:
How do we ensure a 25 year service life with respect to PID-s ?

- need to have reproducible tests
- need to understand progression of PID-s in the field
  → **PID-s model**
- need to derive parameters for tests
- need to establish process control in production

III Conclusion and Outlook

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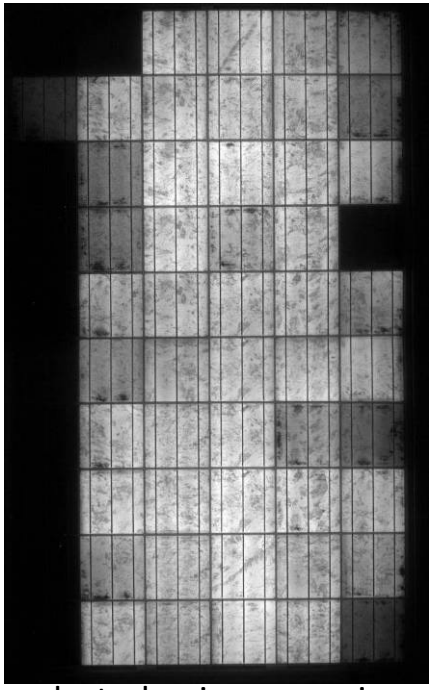
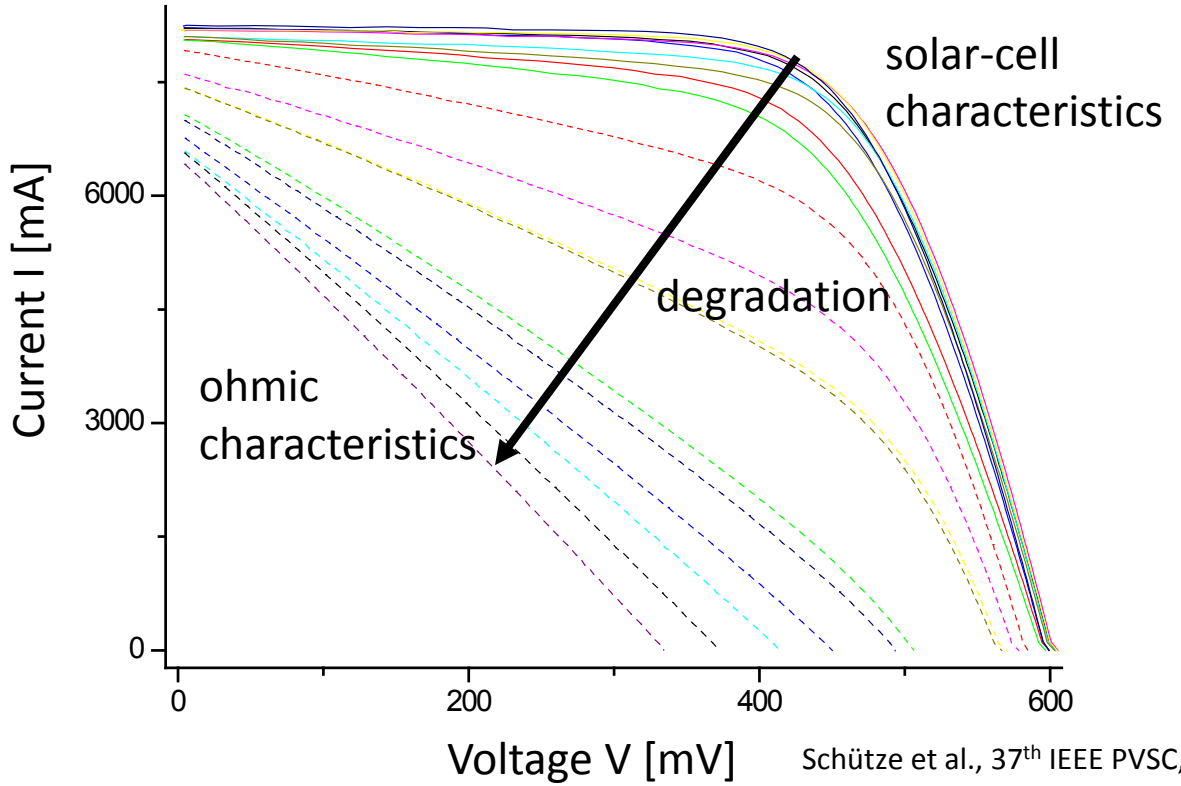
INTRODUCTION

PID-s CHARACTERISTICS



electroluminescence image



Schütze et al., 37th IEEE PVSC, 2011

PID-s → Potential induced degradation by shunting of solar cell

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PID-s MODELING FOR 25 YEARS SERVICE LIFE

How do we ensure a 25 year service life with respect to PID-s ?

- need to have reproducible tests
- need to understand progression of PID-s in the field → PID-s model
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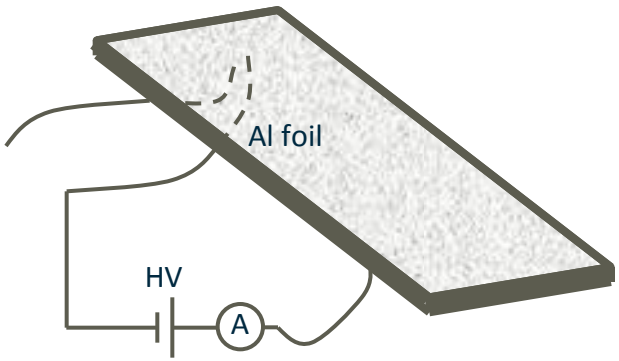
LABORATORY PID TEST METHODS

Al foil test



temperature: 25 °C
voltage: -1 kV
contacting: Al-foil

climate chamber test (DH)

temperature: 60 °C
voltage: -1 kV
contacting: indirect via humidity

→ reproducible, but continuous PID stress

PID-s MODELING FOR 25 YEARS SERVICE LIFE

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- need to have reproducible tests ✓
- need to understand progression of PID-s in the field → PID-s model
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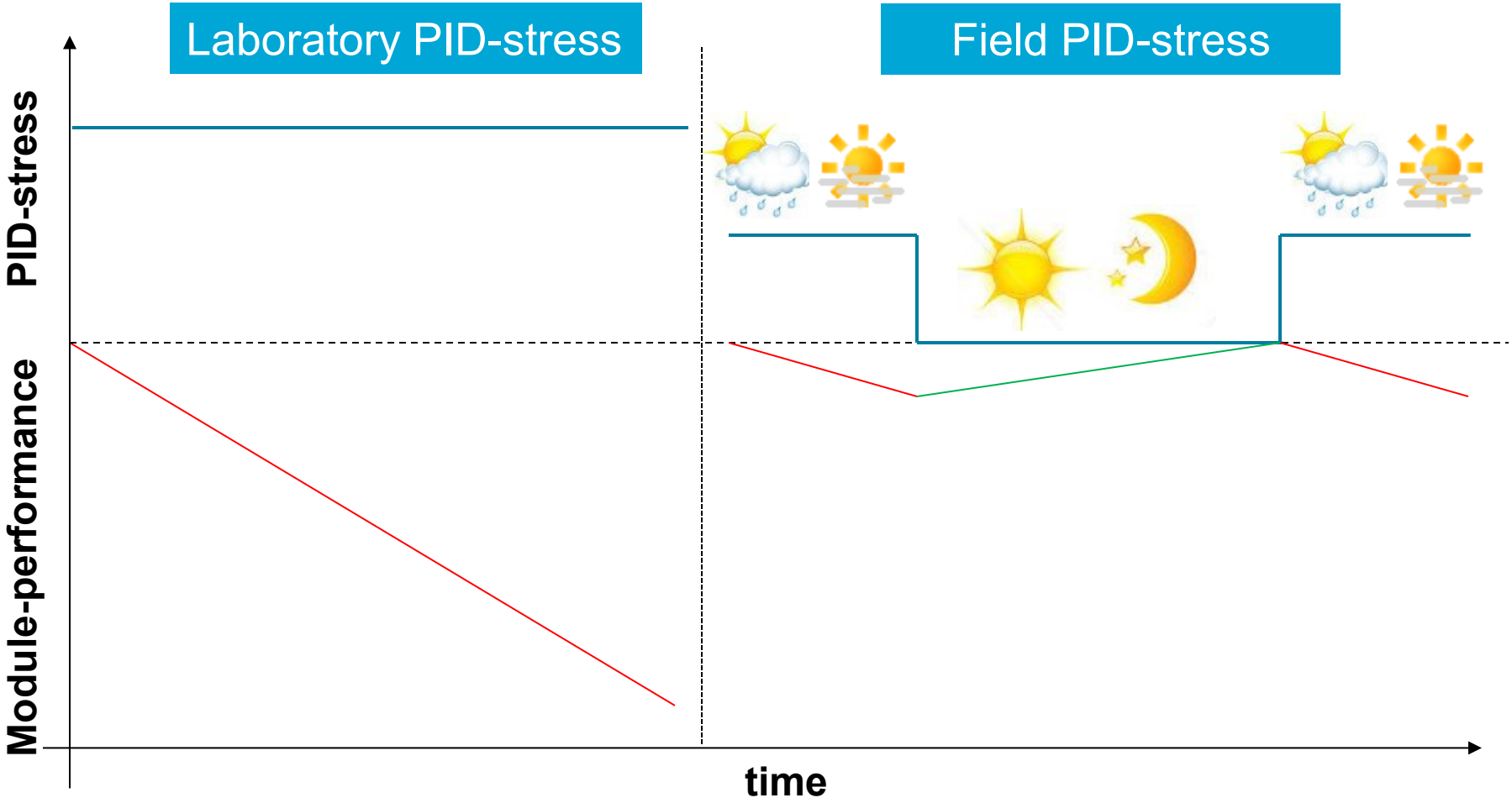
PROGRESSION OF PID-s

LABORATORY ENVIRONMENT VS FIELD CONDITIONS



common PID-tests represent only one part of PID-s kinetics in the field

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MODELLING PID-s

Environmental data

MODELLING PID-s

Environmental data

Measured

- irradiation
- ambient temperature
- relative humidity
- rain data

Computed

- module temperature
- humidity at module surface

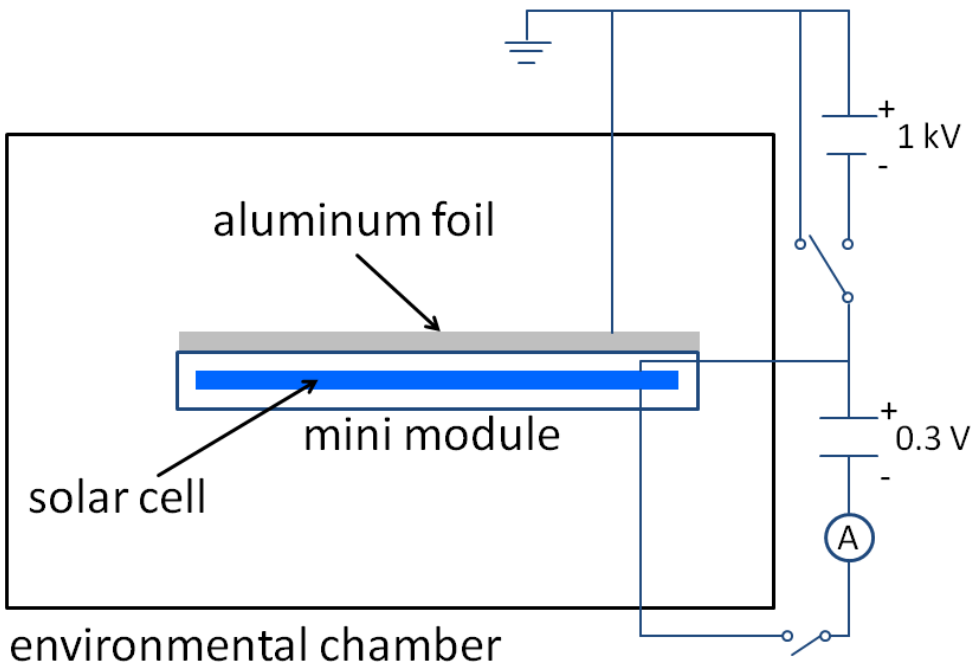
MODELLING PID-s

Environmental data

R_{sh}-kinetics from lab measurements

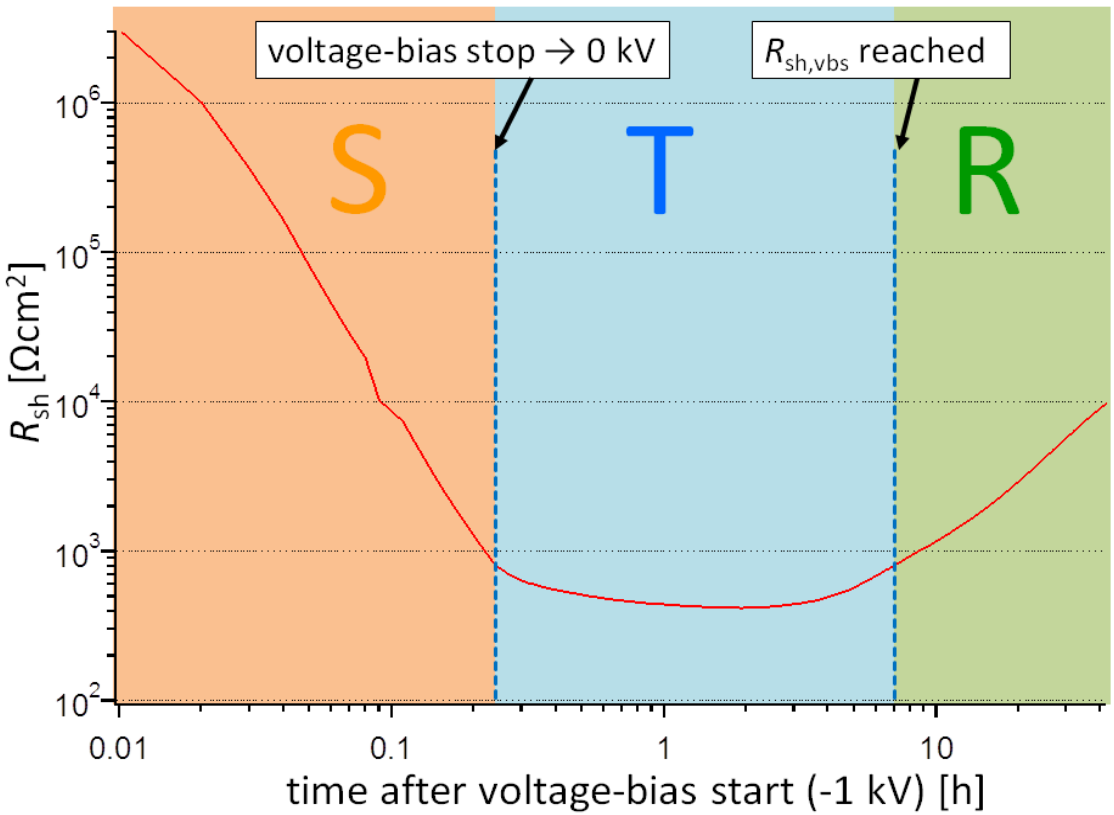
MODELLING PID-s

Measurement of shunt resistance (R_{sh})



MODELLING PID-s

R_{sh}-kinetics



Taubitz et al.,
27th EU PVSEC, 2012

→ shunting (S)-, transition (T)- and regeneration (R)-phase

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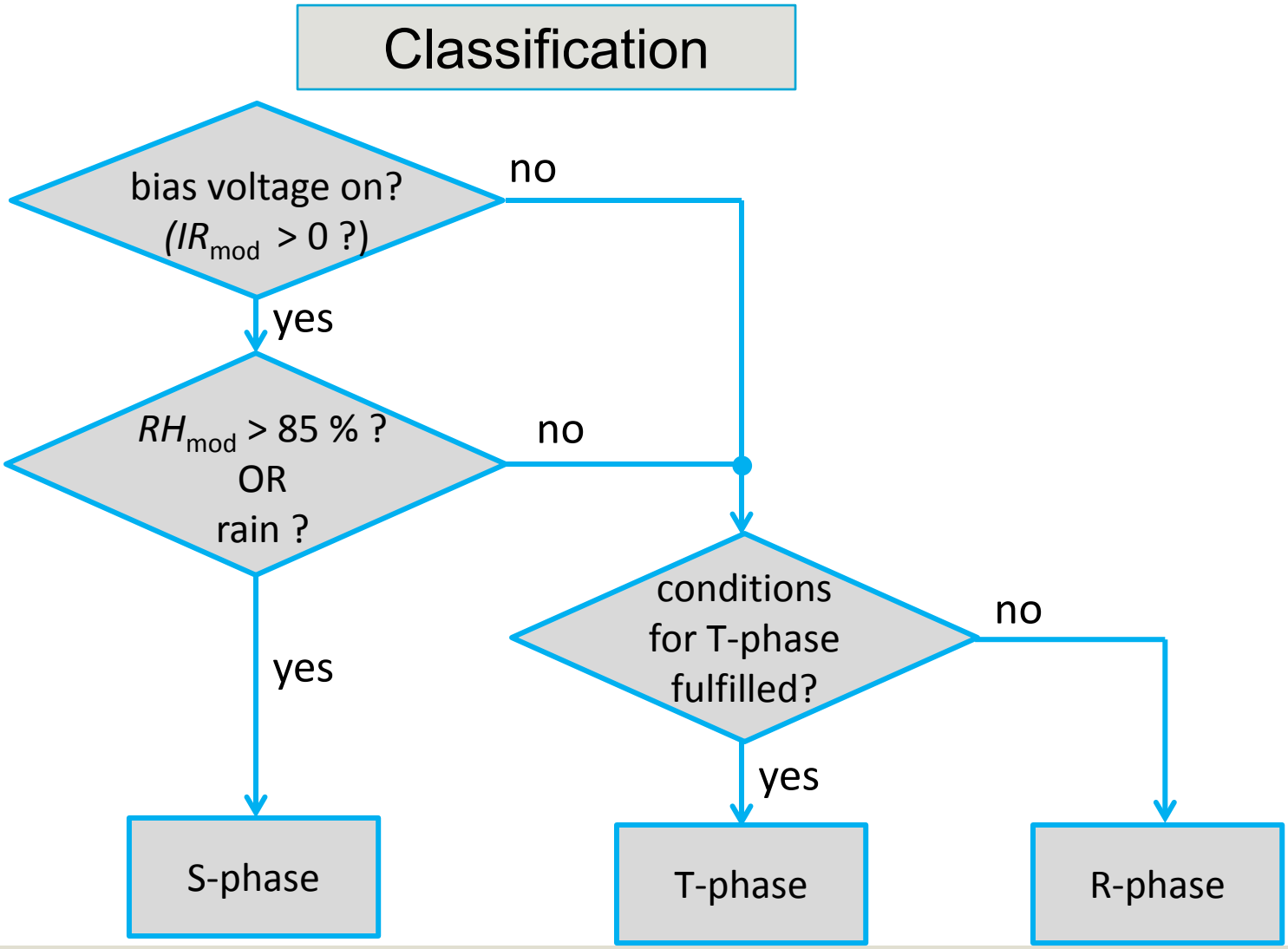
MODELLING PID-s

Environmental data

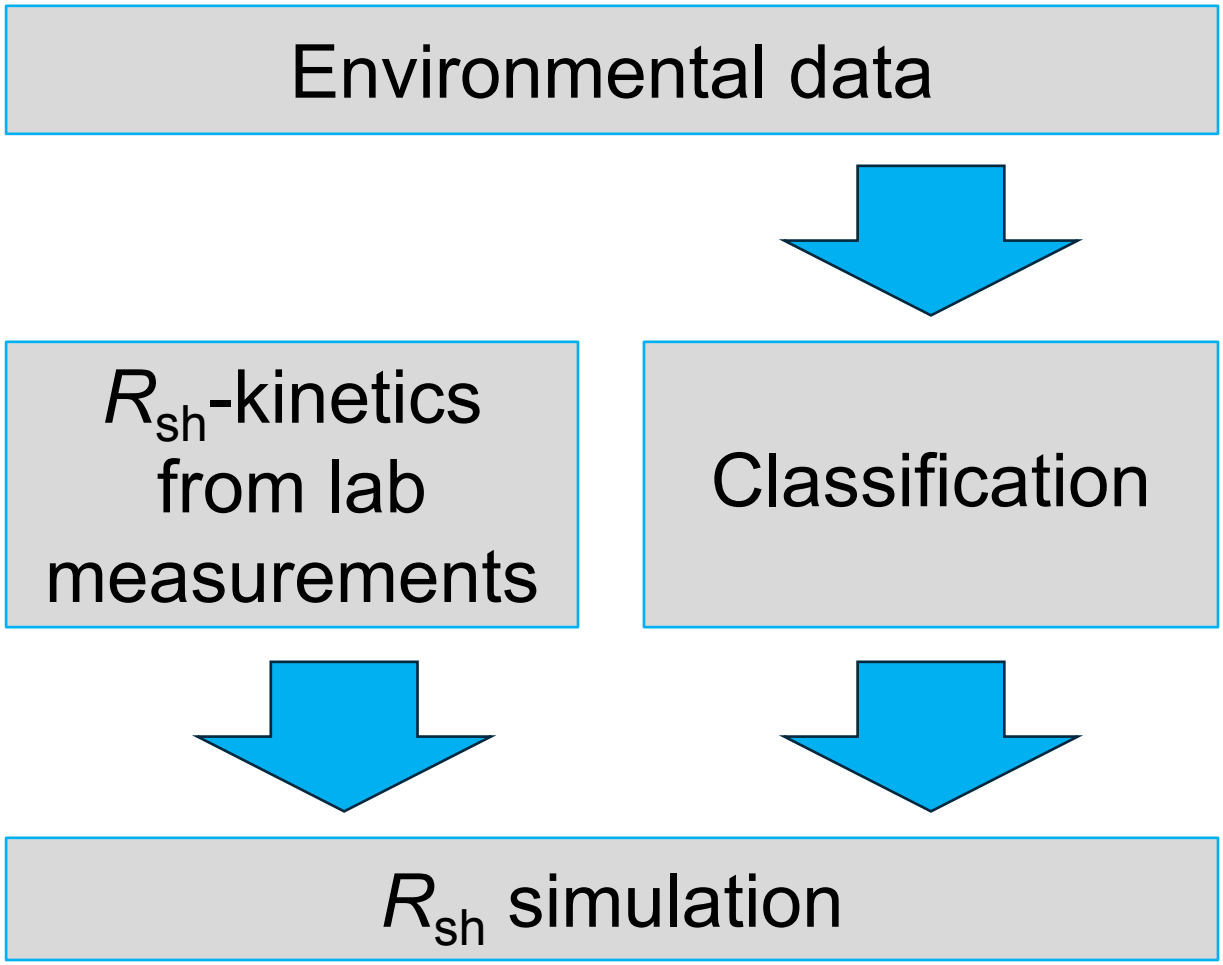
R_{sh}-kinetics from lab measurements

Classification

MODELLING PID-s

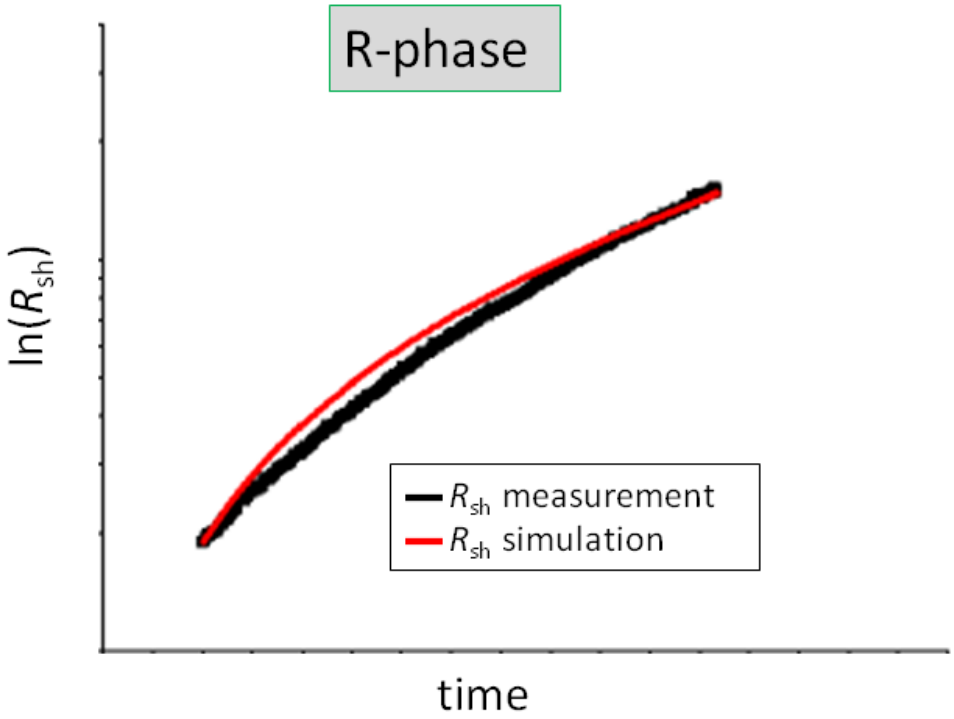


MODELLING PID-s



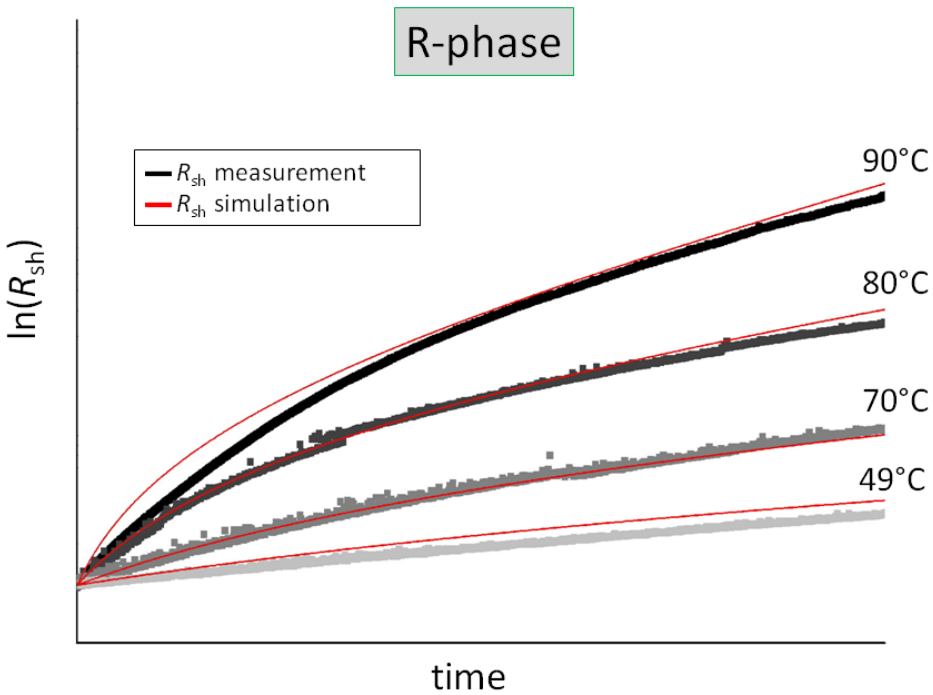
MODELLING PID-s

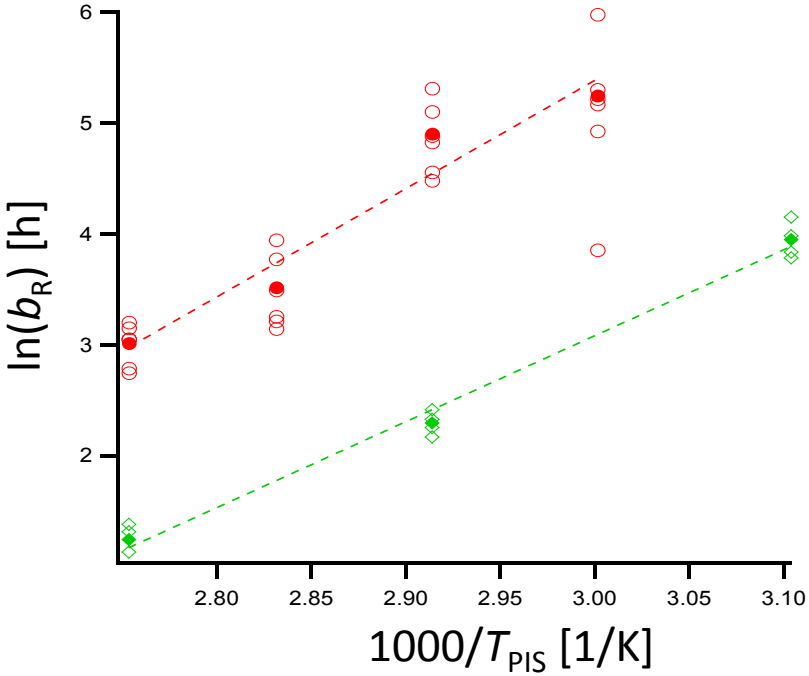
R_{sh} simulation



MODELLING PID-s

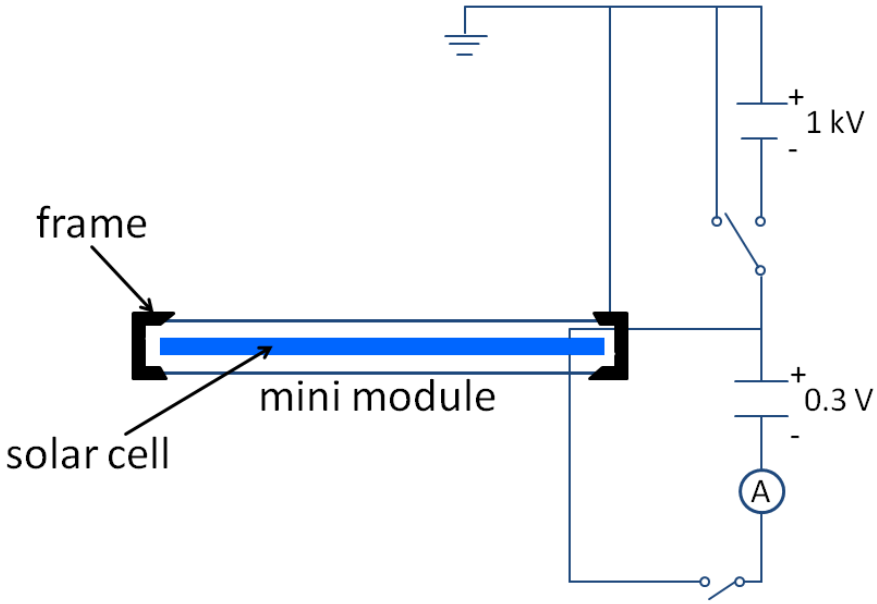
R_{sh} simulation





COMPARISON TO OUTDOOR MEASUREMENTS

Measurement of shunt resistance (R_{sh})



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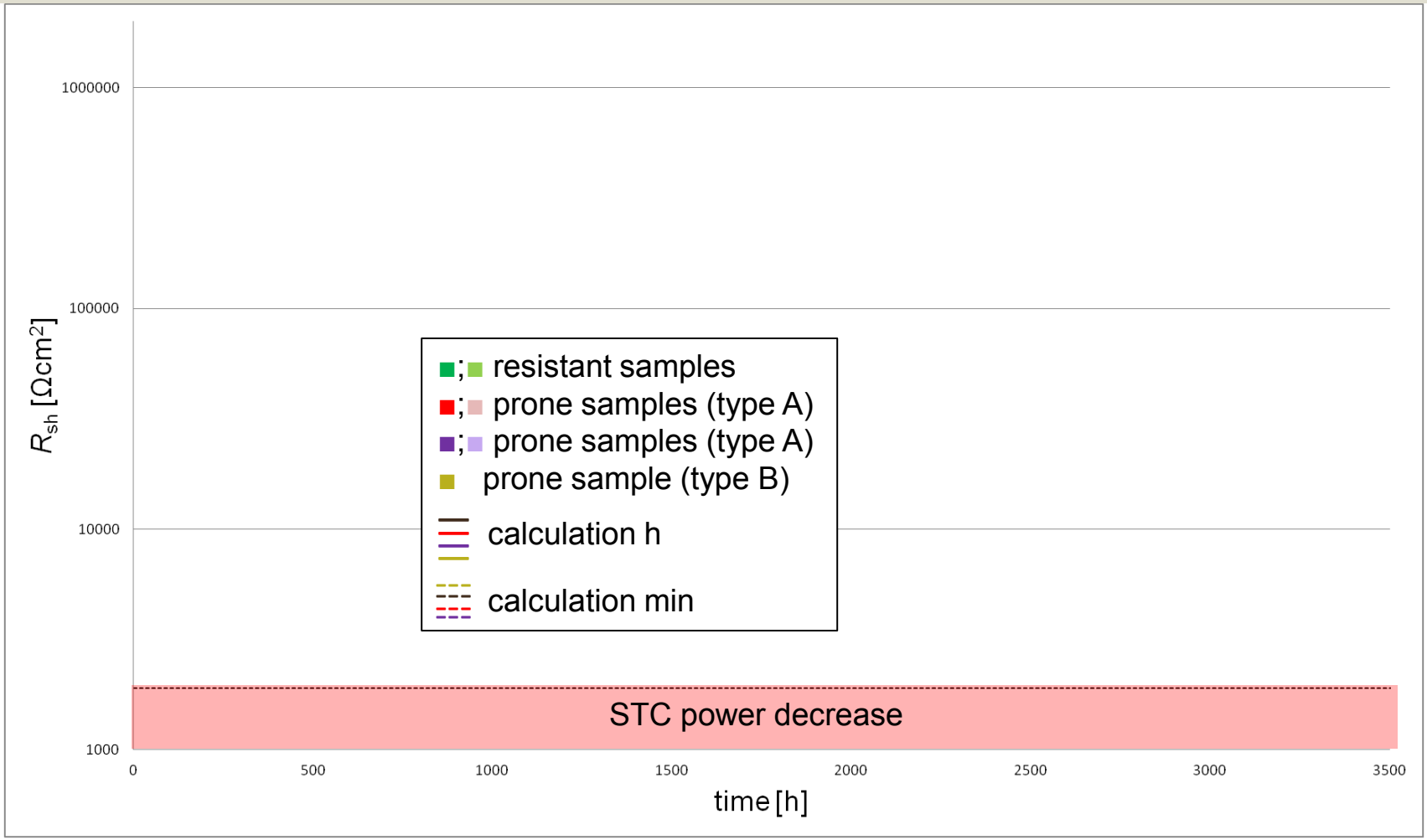

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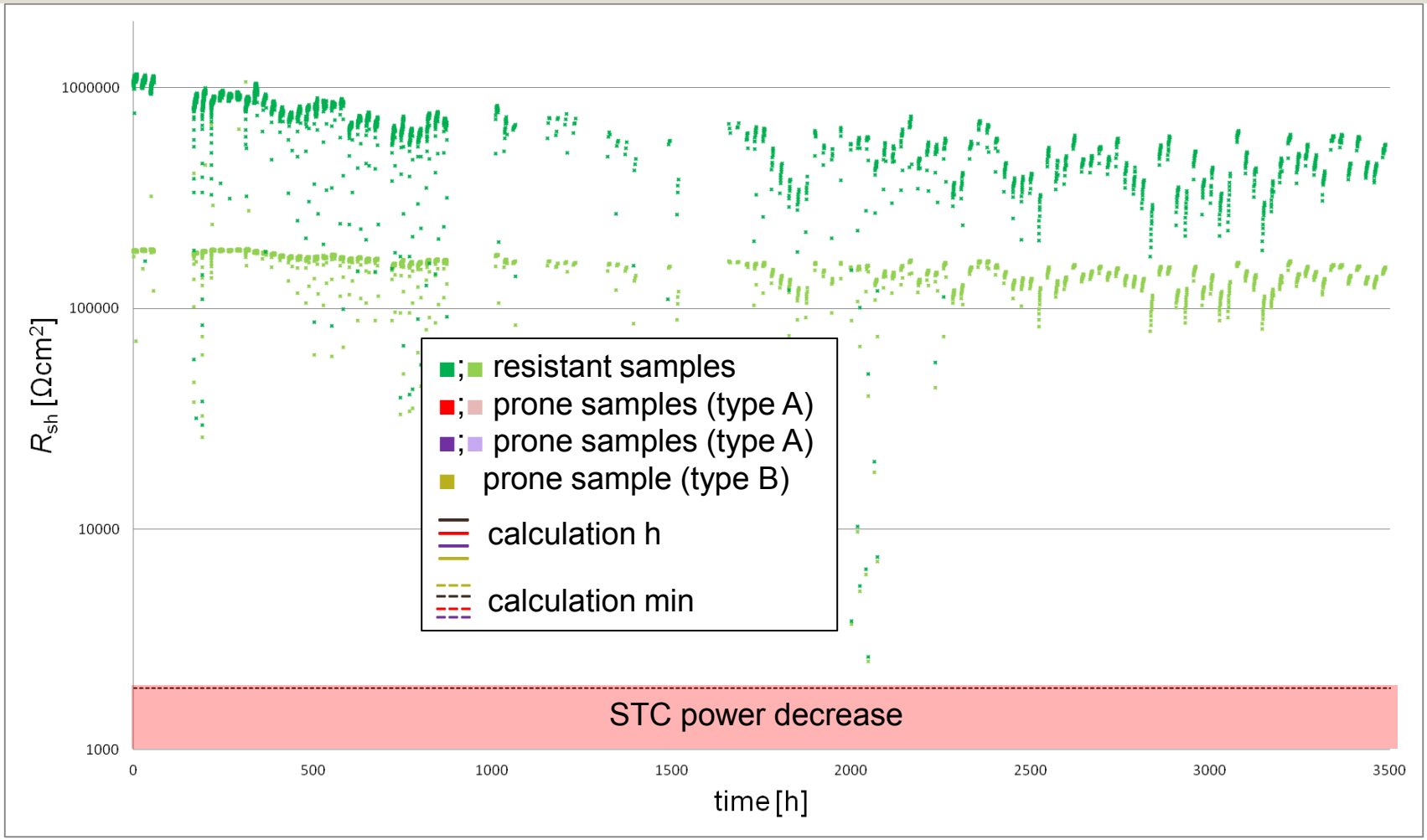

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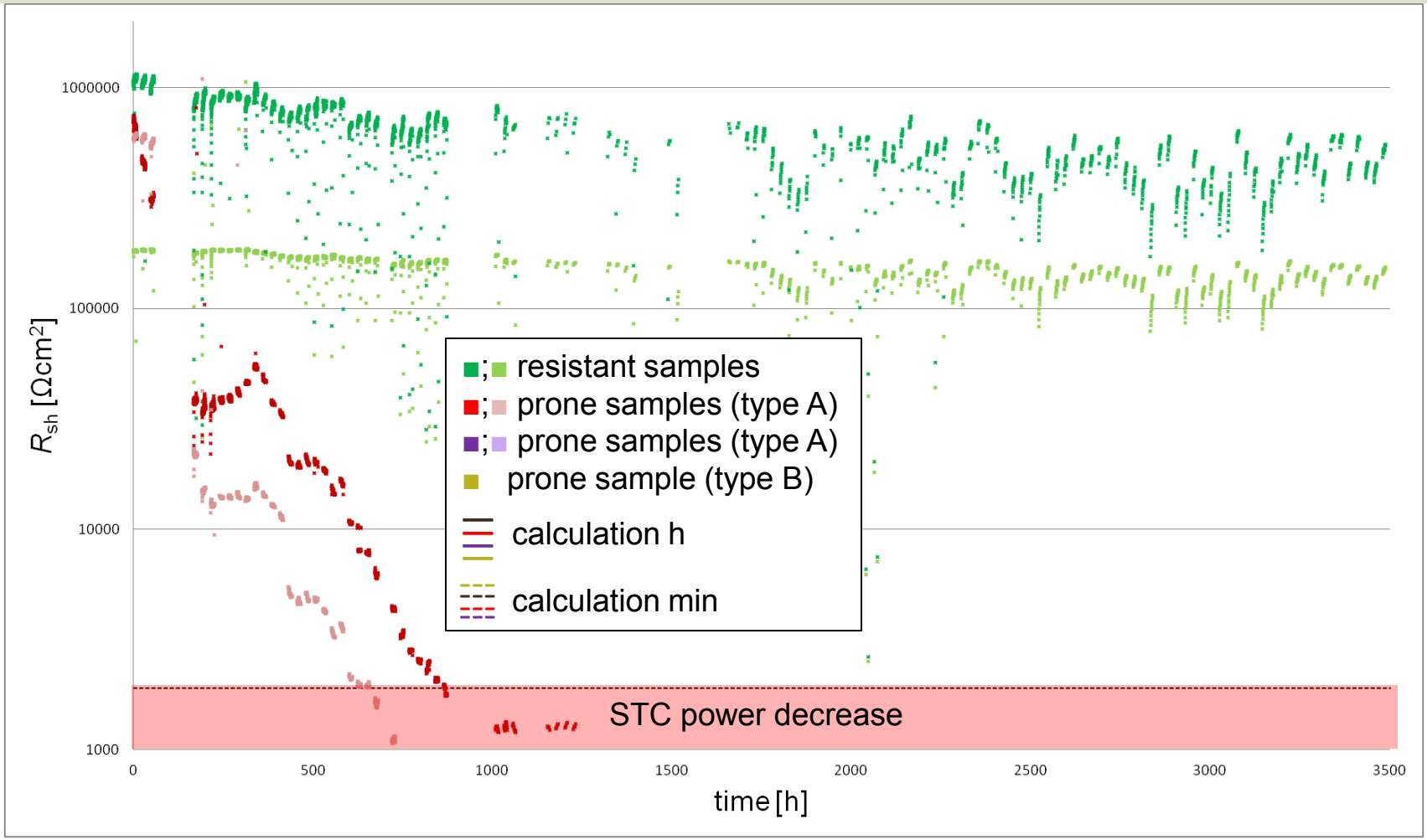

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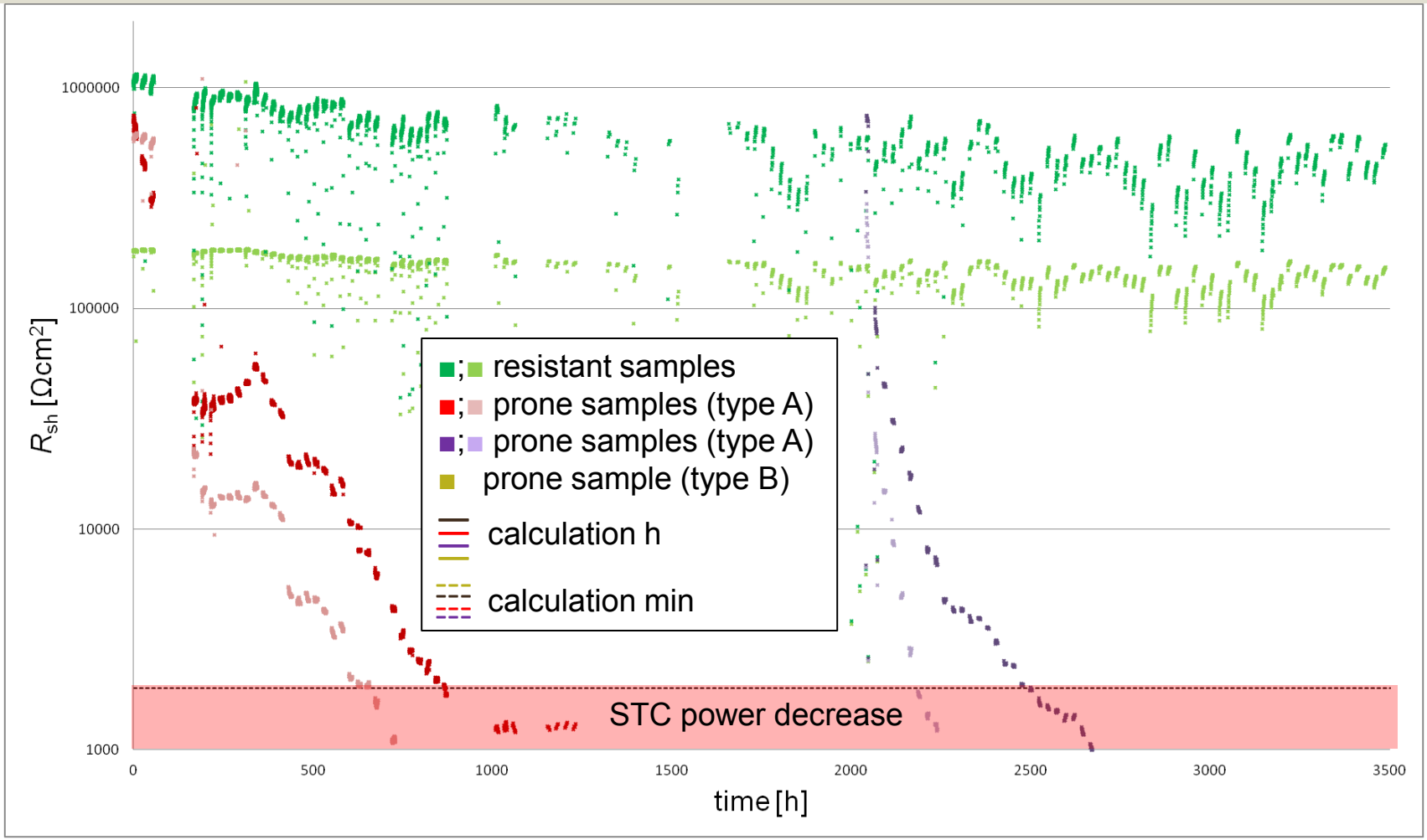

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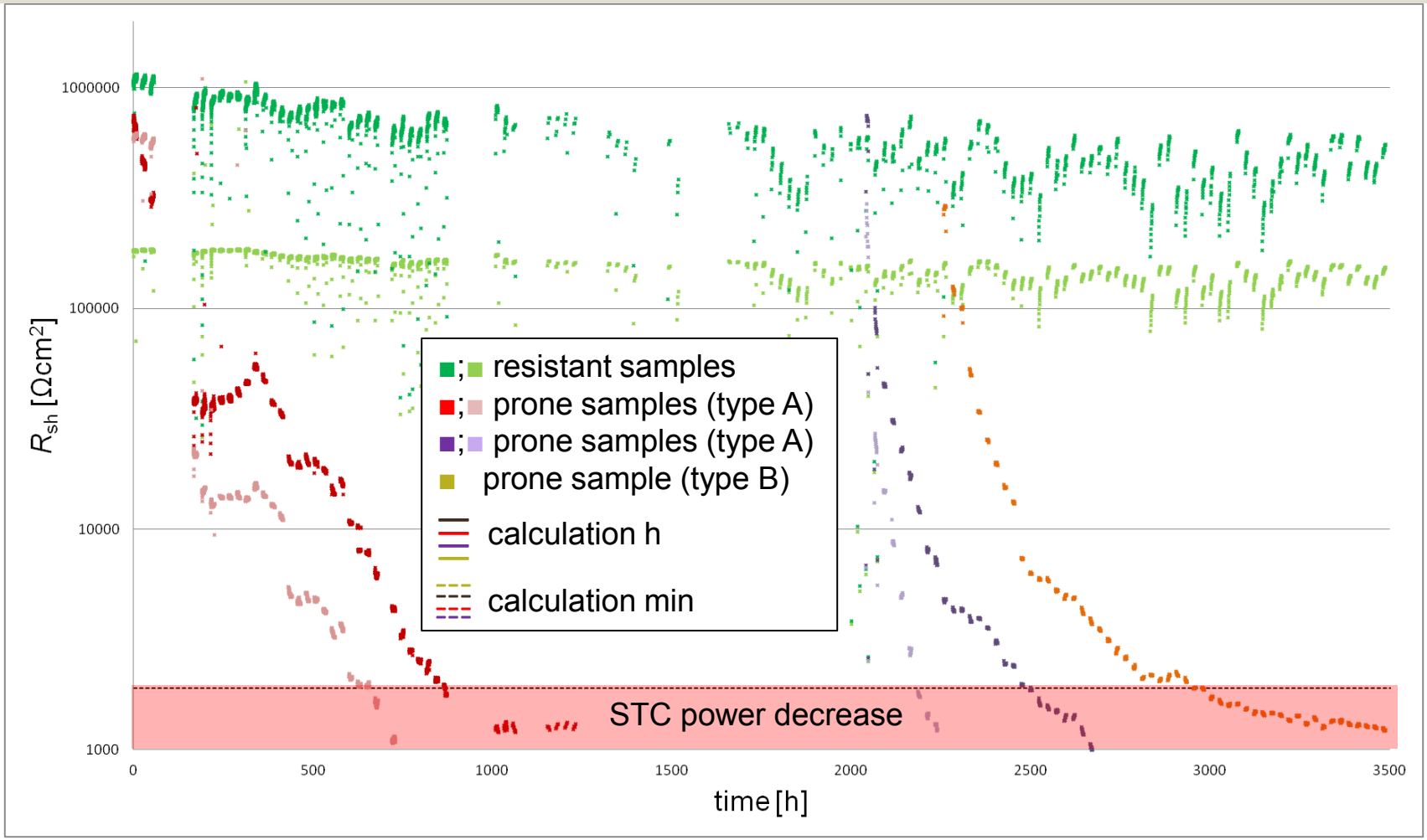

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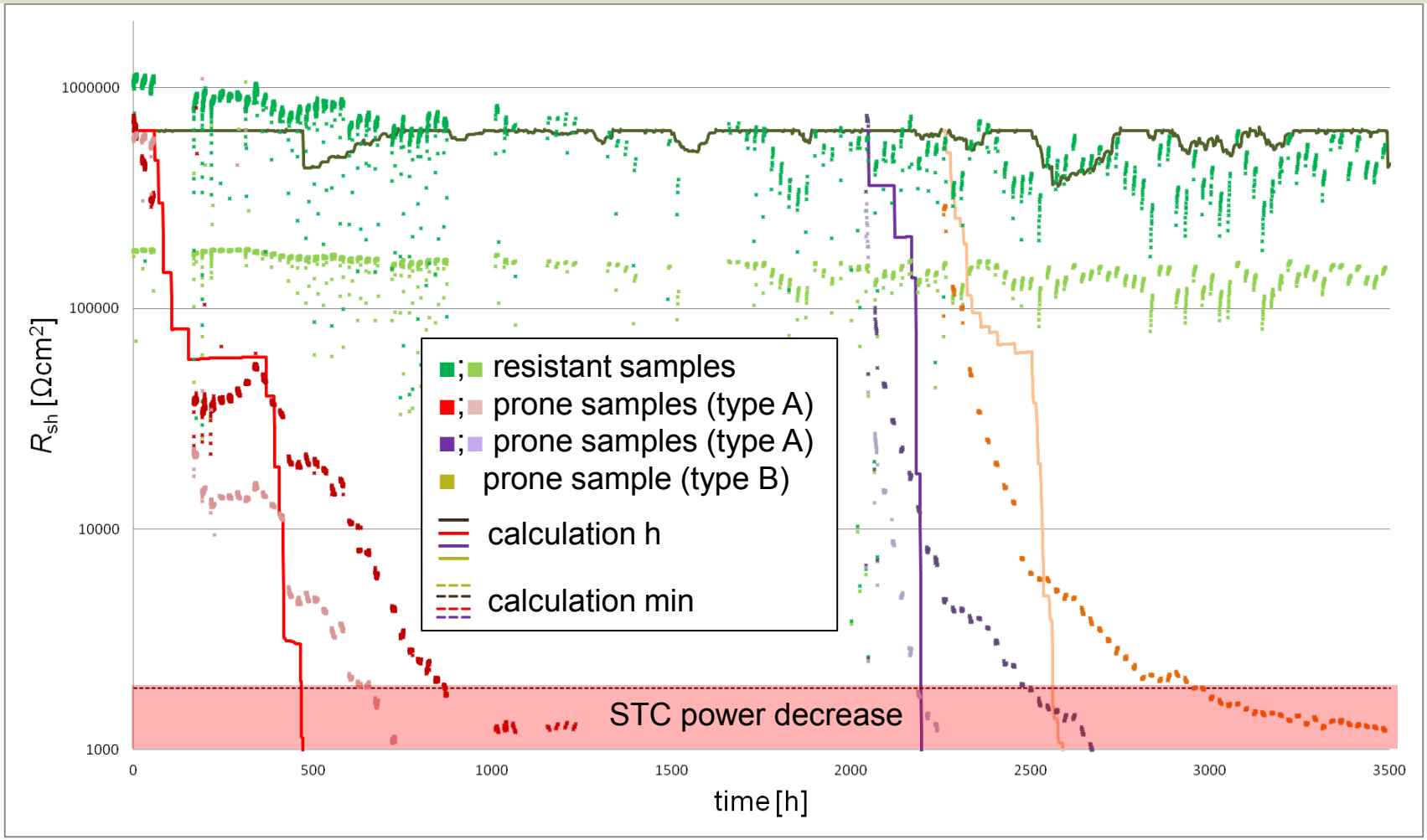

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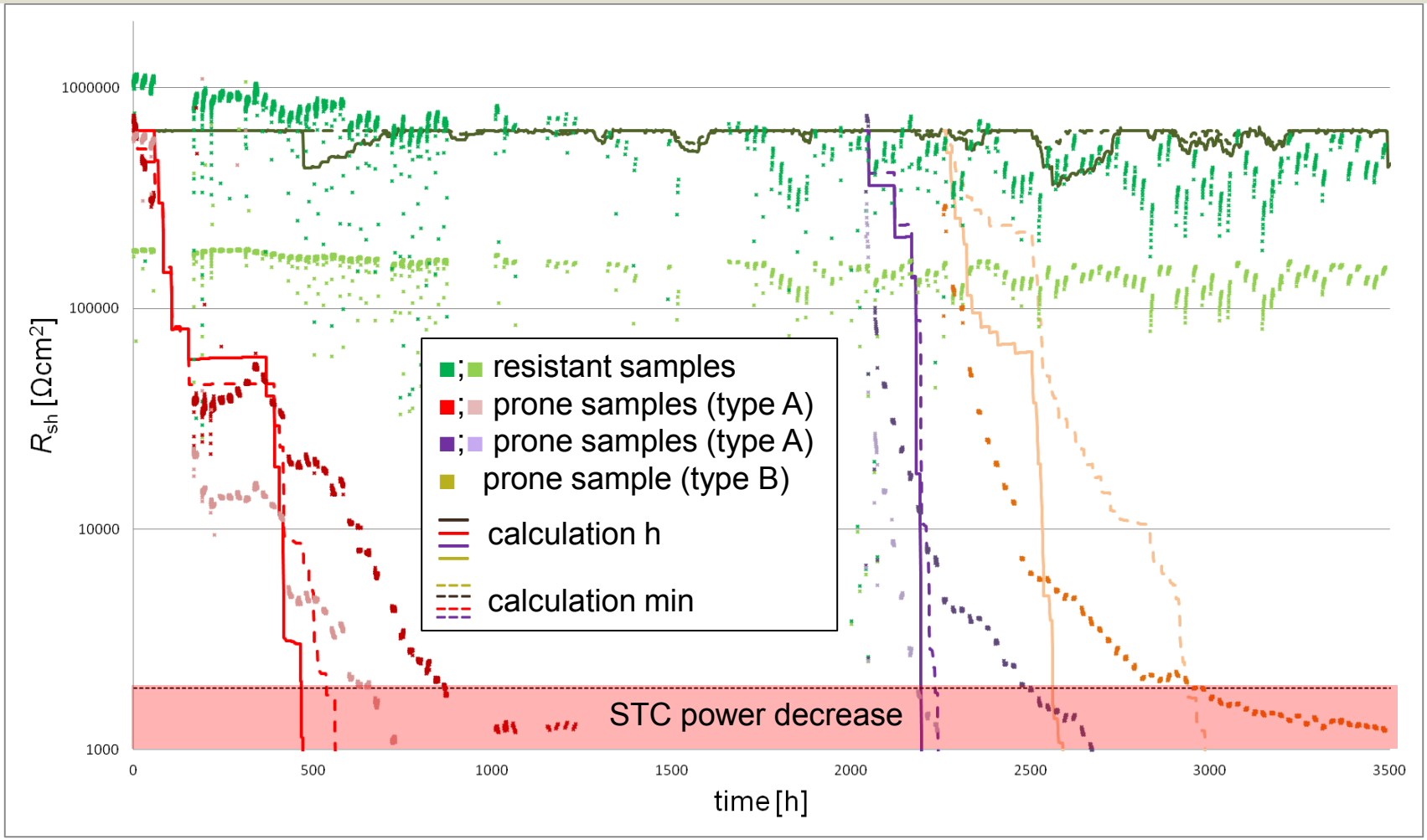

→ good qualitative agreement

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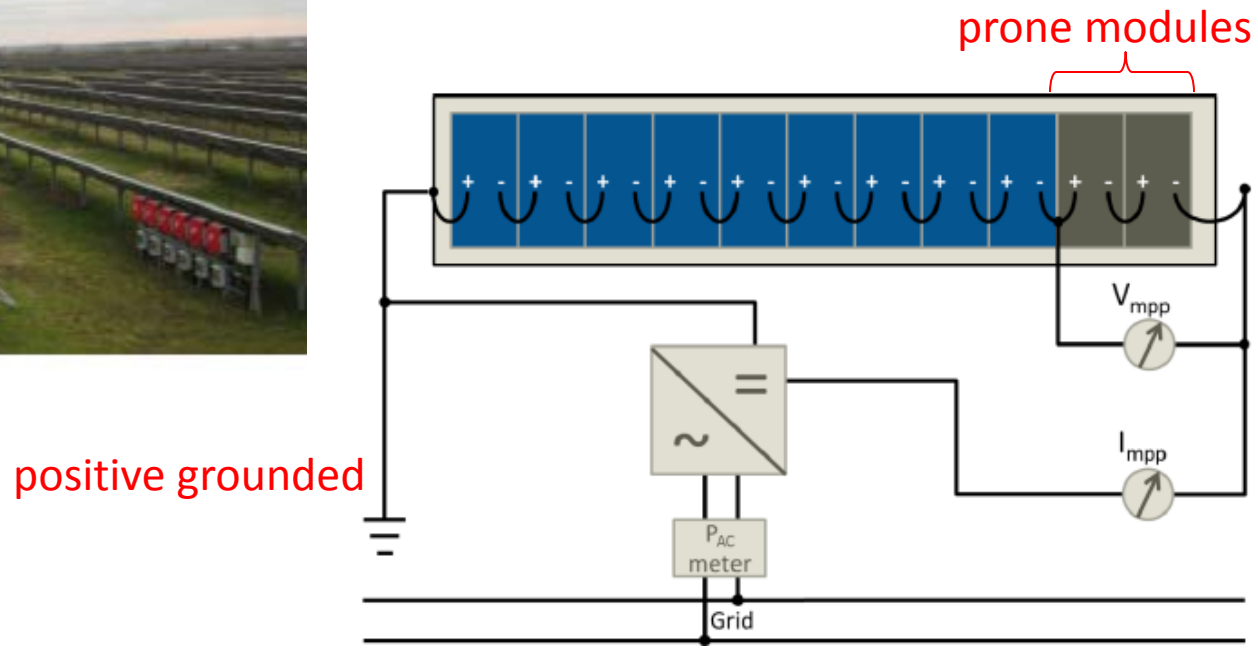
COMPARISON TO OUTDOOR MEASUREMENTS

Results for full size modules:

"Valletta" test site (Thalheim, Germany)

test setup



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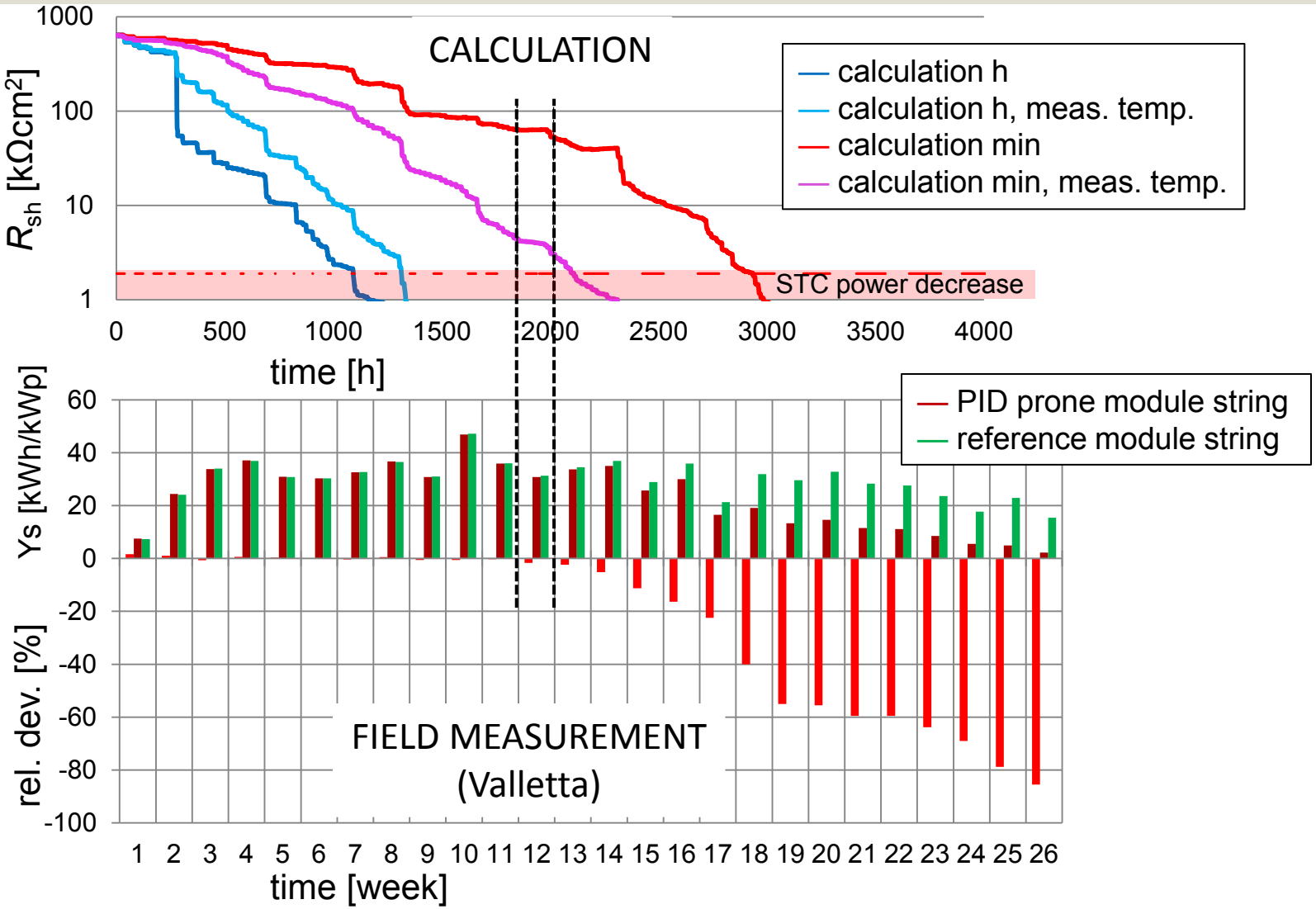

PID-s MODELING FOR 25 YEARS SERVICE LIFE

How do we ensure a 25 year service life with respect to PID-s ?

- Need to have reproducible tests ✓
- Need to understand progression of PID-s in the field → PID-s model ✓
- Need to derive parameters for tests
- Need to establish process control

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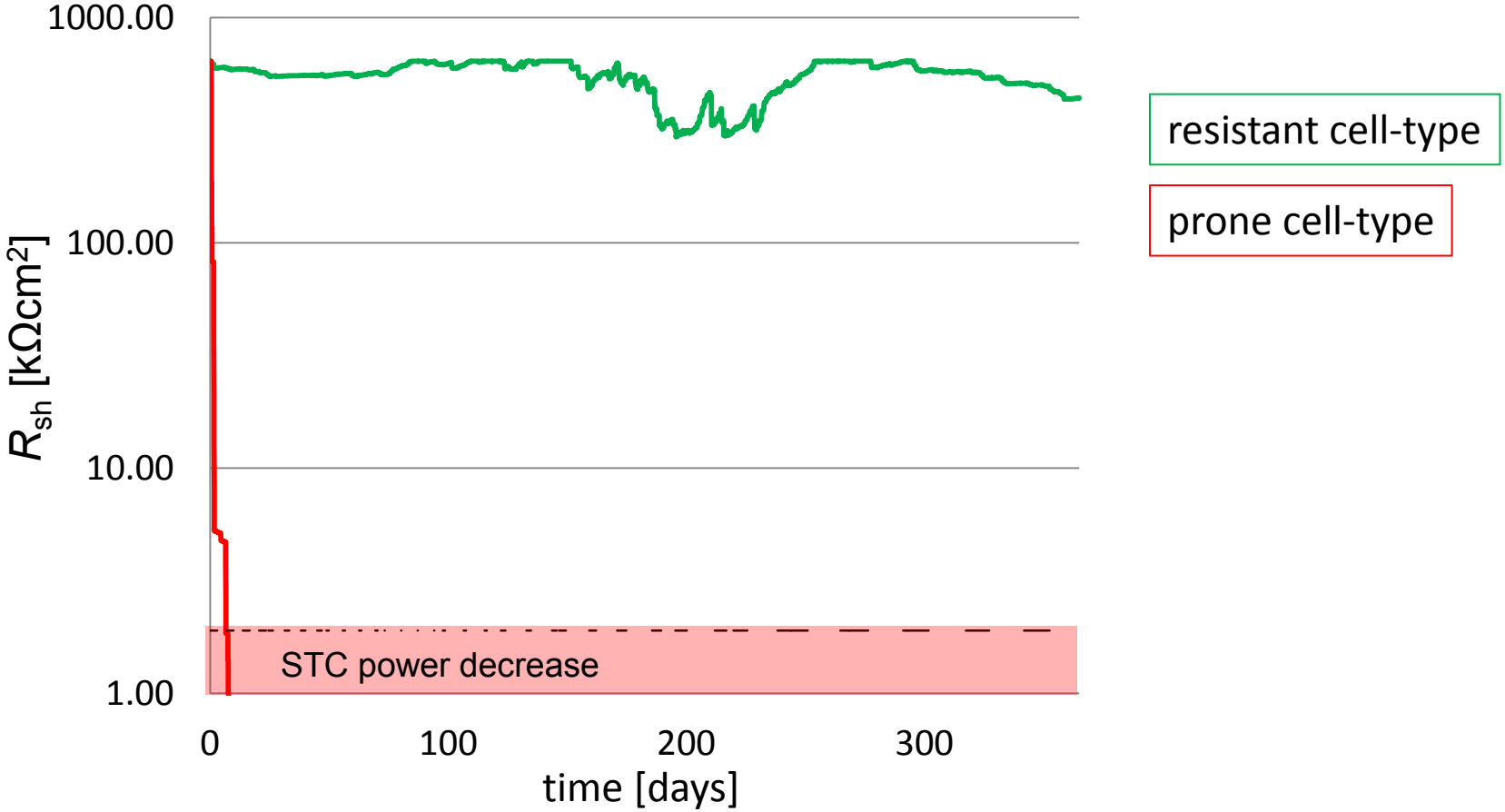
LONG TERM PREDICTION POSSIBLE



→ parameters necessary for 25 years service life can be derived

Thalheim, Germany weather data of 2012 used

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PROCESS CONTROL: PRODUCTION MONITORING

module level monitoring (Al-foil test, 168h)

- weekly sampling: random cells from production are tested on module level
- monthly sampling: random modules from every conversion site

cell level testing (PID cell tester, 24h)

- weekly sampling: PID-test on cell level (feedback < 48h) → fast reaction possible

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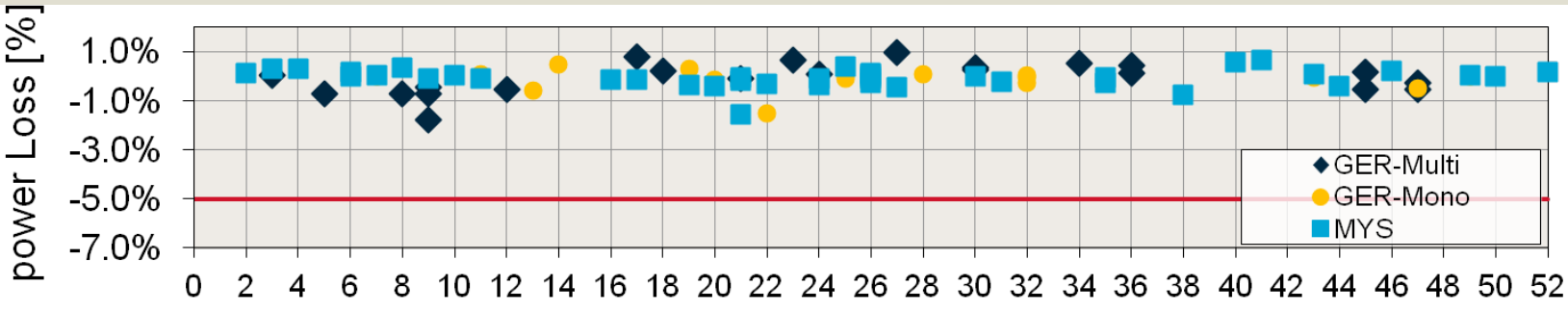
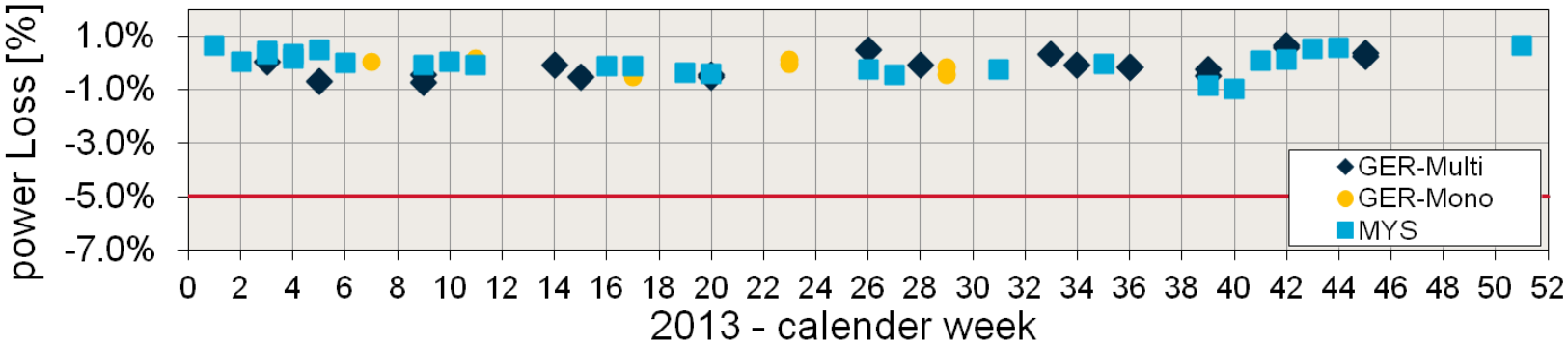
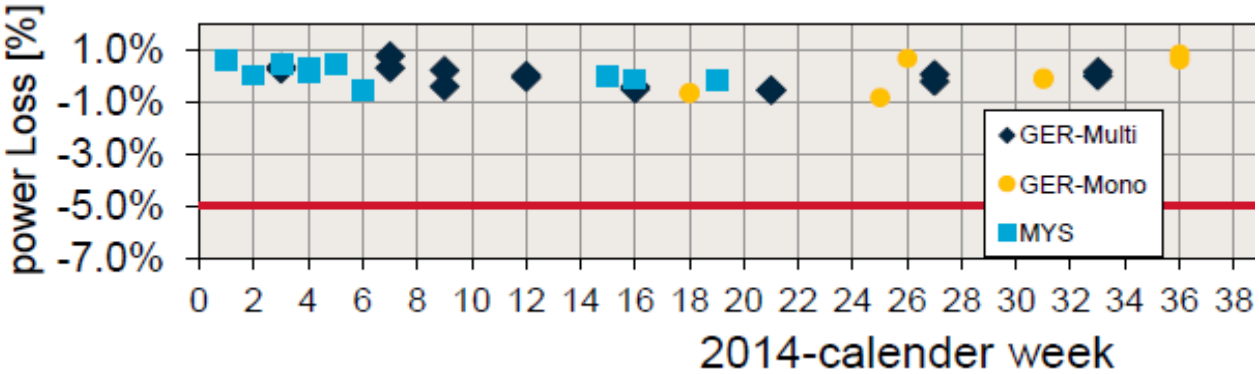
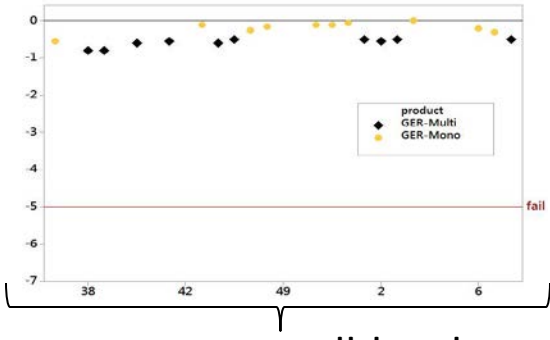
PROCESS CONTROL: MONITORING DATA CELL PRODUCTION









new test on cell-level

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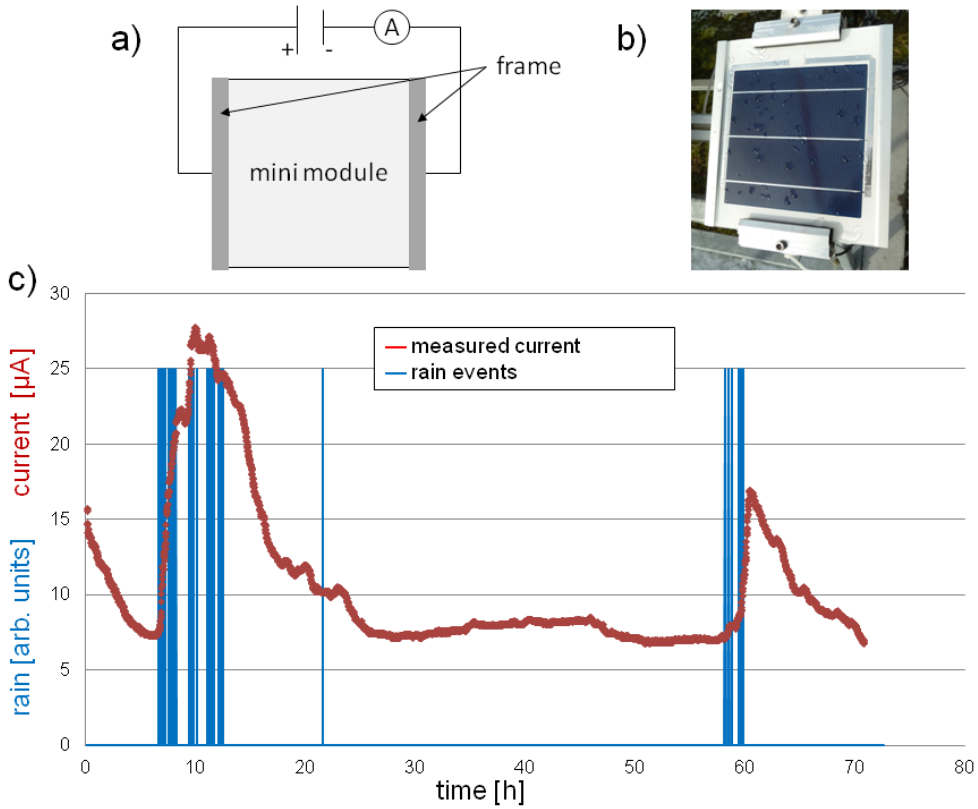
III Conclusion and Outlook

CONCLUSION

- reproducible PID tests are available (Al-foil, climate chamber)
- laboratory PID-tests represent only part of PID-s kinetics in field
- studying regeneration properties is essential
- PID-s model based on laboratory tests and meteorological data can describe long term progression
→allows for prediction of time of PID-s onset in specific location
- good qualitative agreement with outdoor measurements
- continuous production monitoring is essential

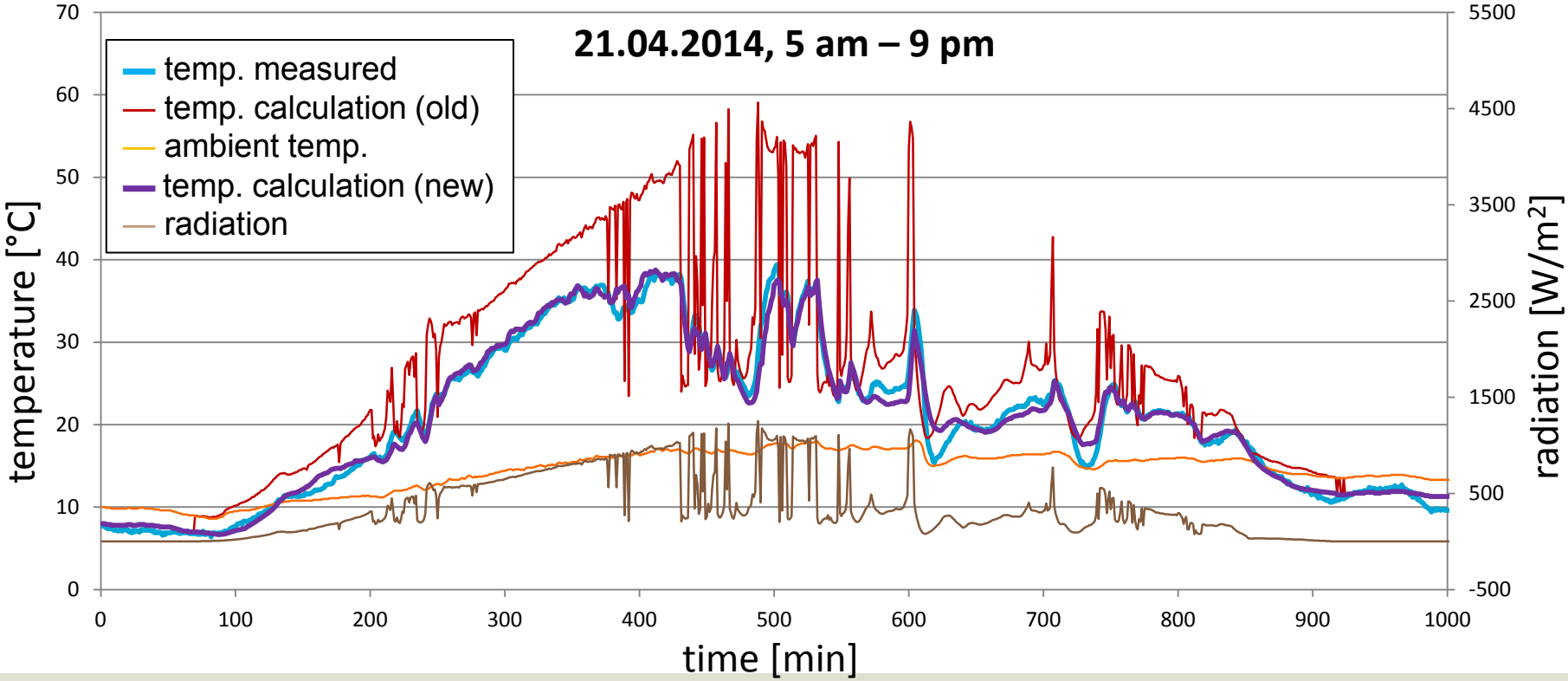
OUTLOOK

- new PID test sites in different climates planned
- improvement of model calculations:
  - detailed investigation of interplay between meteorological conditions and PID-s



OUTLOOK

- new PID test sites in Malaysia and USA planed
- improvement of model calculations:
  - detailed investigation of interplay between meteorological conditions and PID-s
  - revision of model equations



Thank you

Golden, 24.02.2015

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ACKNOWLEDGEMENT

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Thanks to co-authors:

Christian Taubitz
Matthias Schütze
Marcel Kröber

SOLARVALLEY Mitteldeutschland

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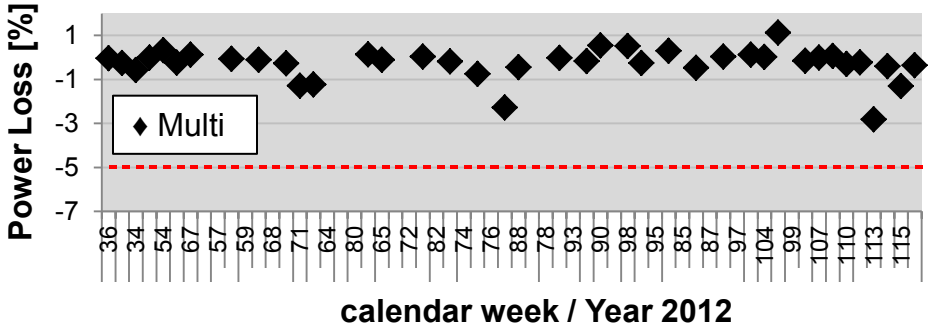
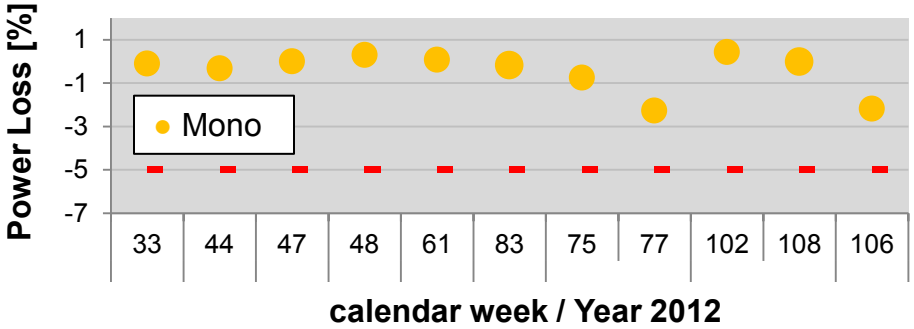
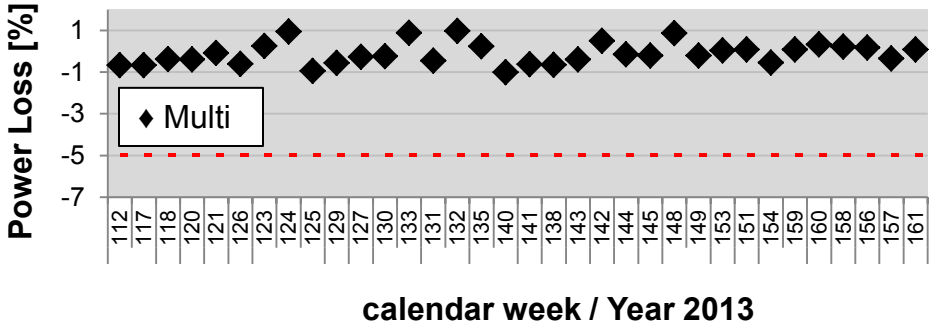
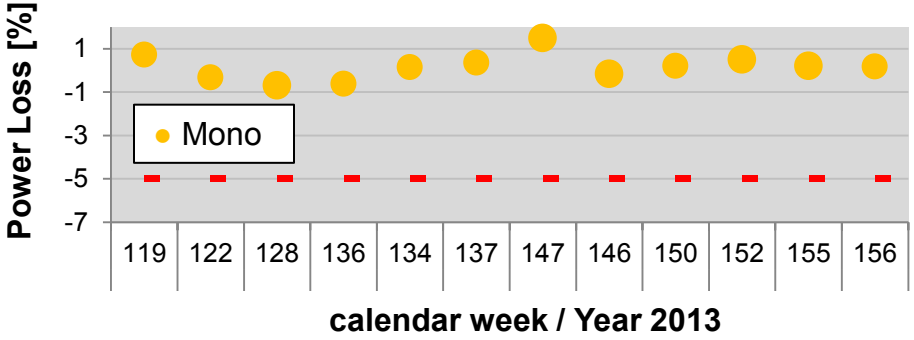
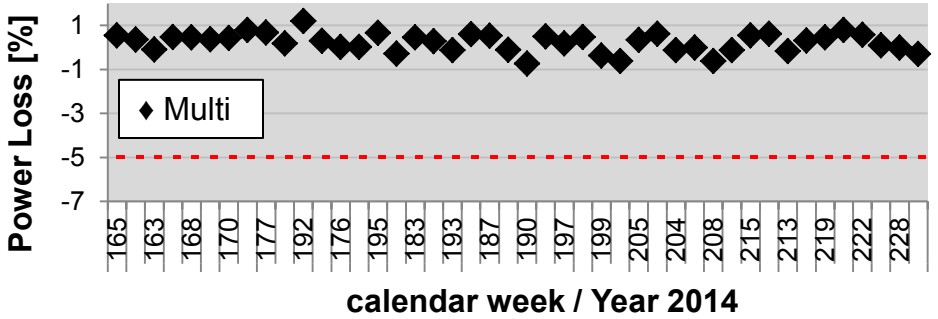
PROCESS CONTROL: MONITORING DATA MODULE PRODUCTION

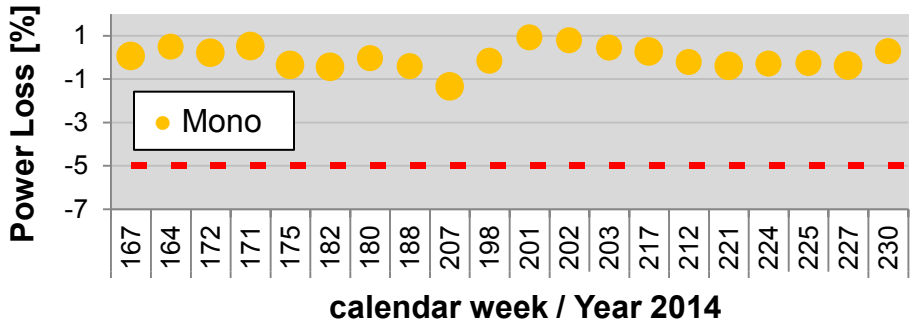












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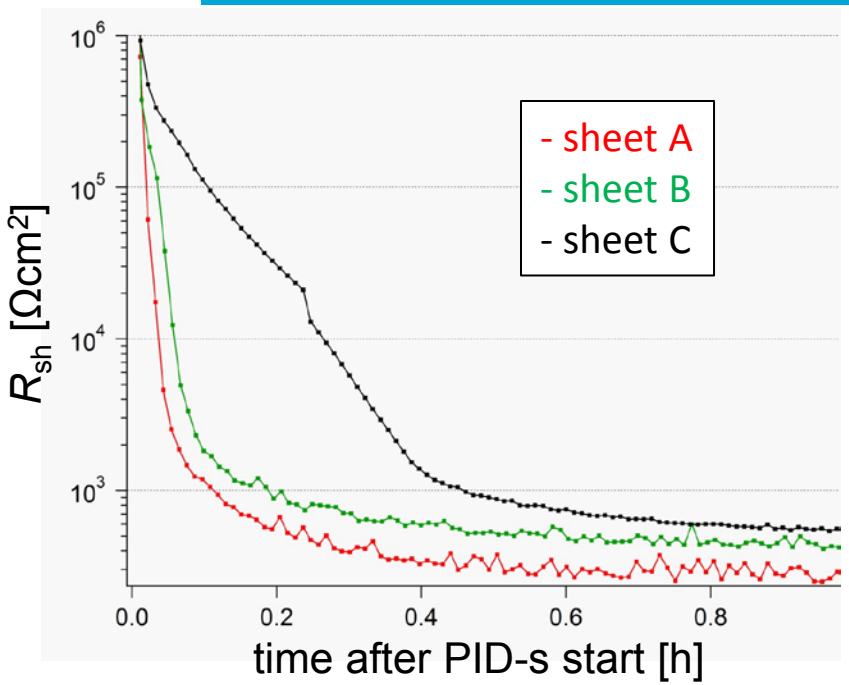
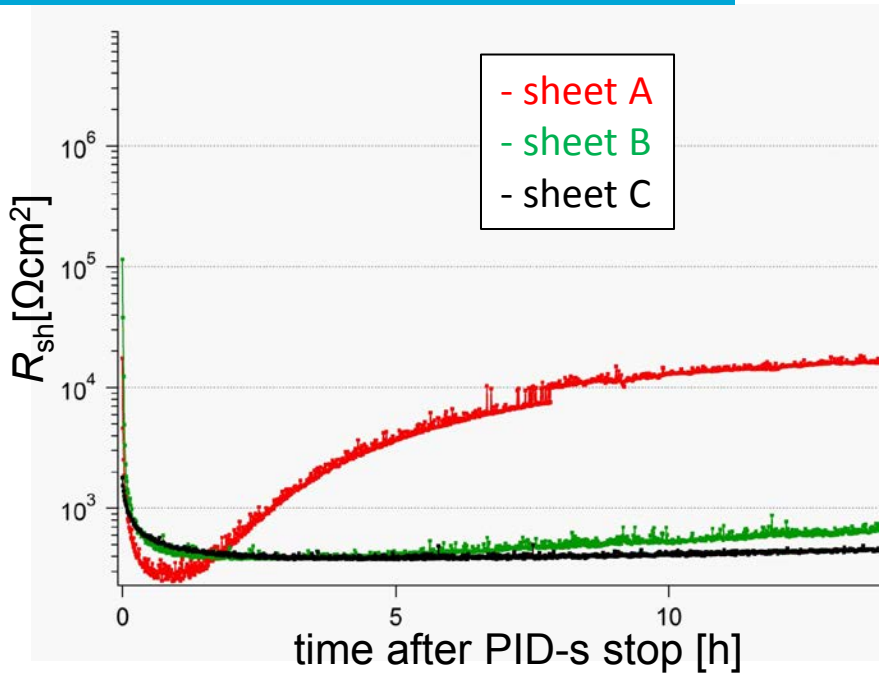
ENCAPSULANT INFLUENCE ON PID-s

Investigation of degradation and regeneration behavior





→ Decrease in shunting can also lead to a decrease in regeneration

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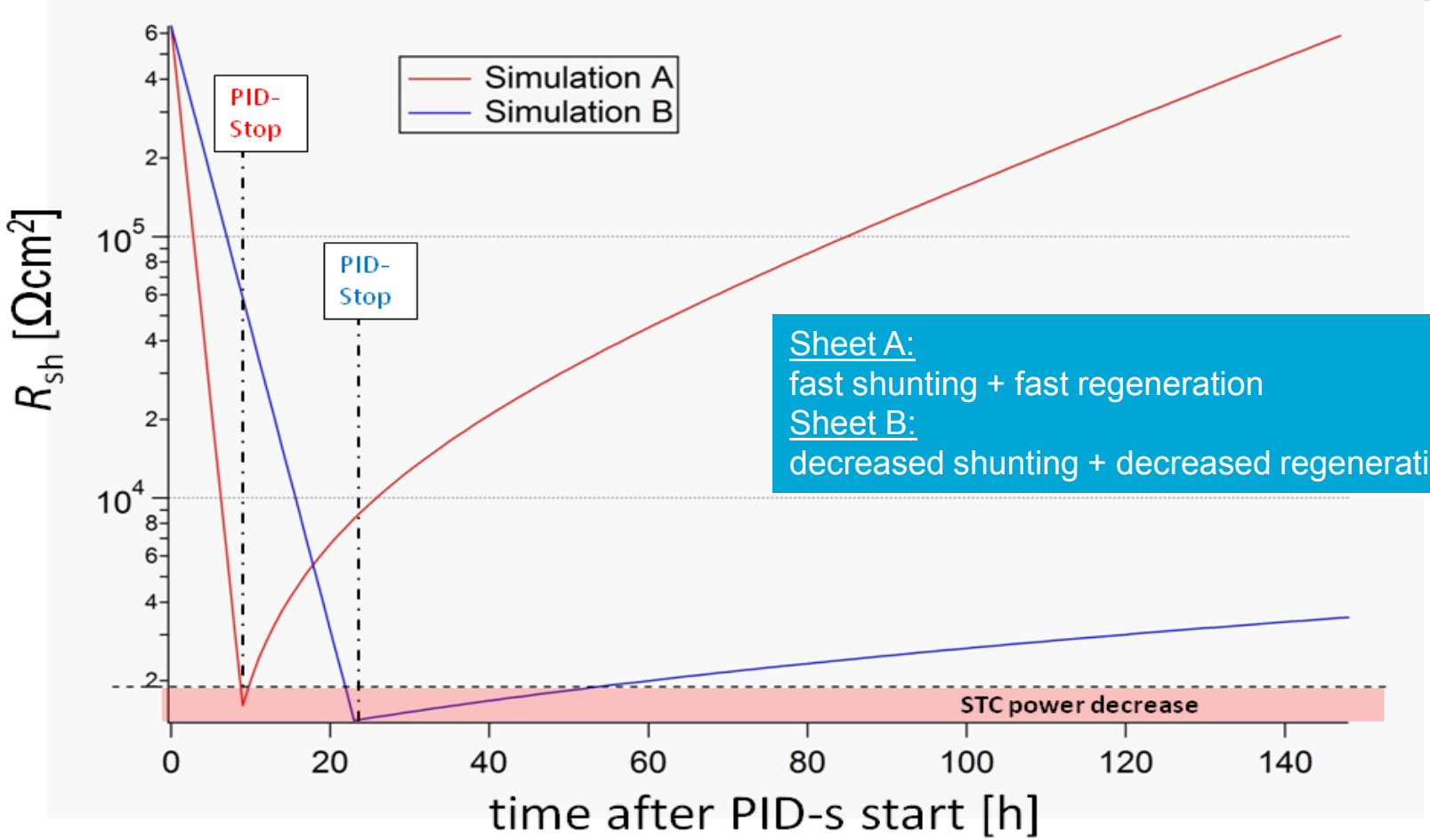
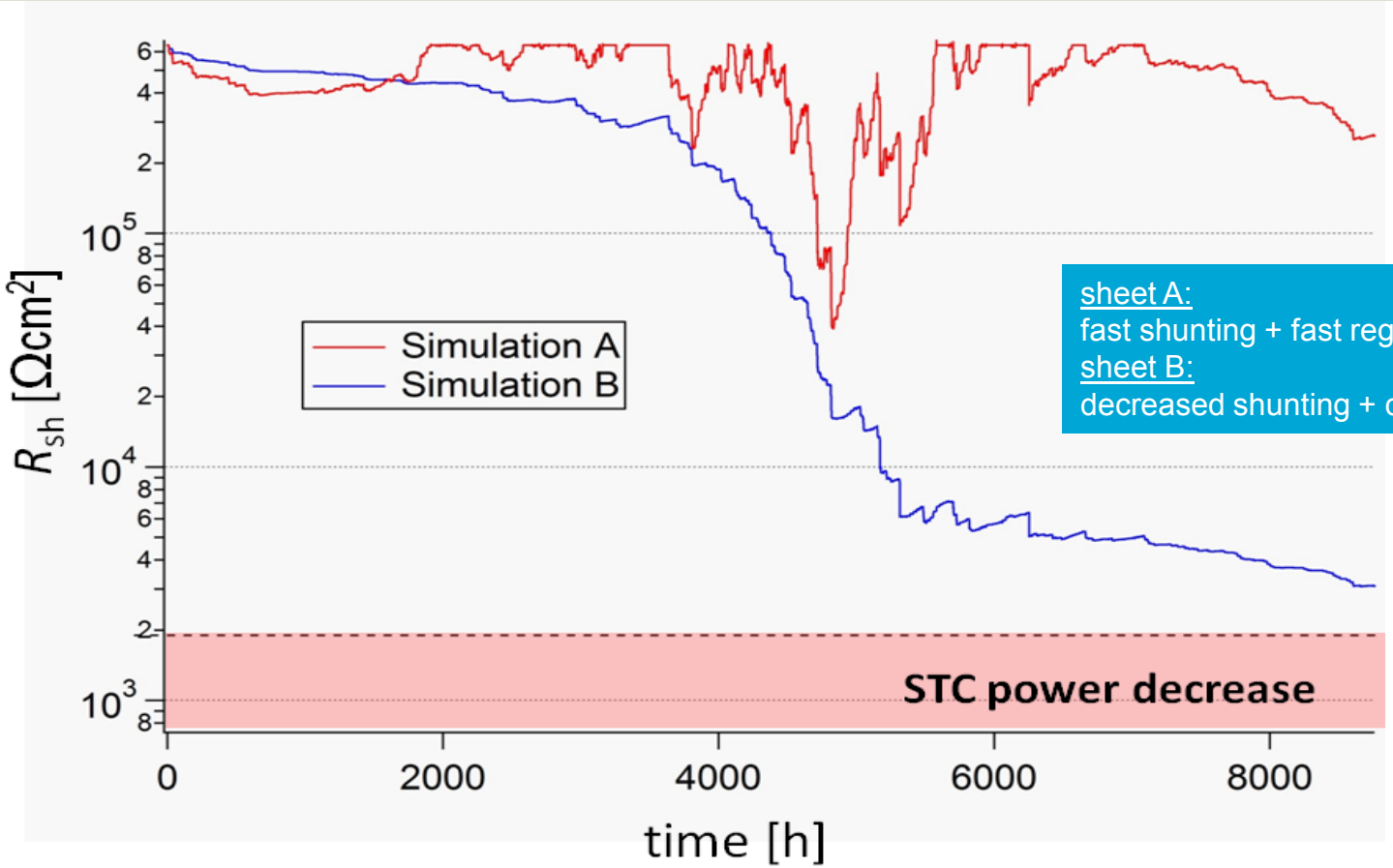
INFLUENCE ON PROGRESSION



Simulation of R_{sh}-kinetics during shunting and regeneration at 49°C

INFLUENCE ON LONG TERM PROGRESSION



sheet A:
fast shunting + fast regeneration
sheet B:
decreased shunting + decreased regeneration

Model-calculations of R_{sh}-kinetics using weather data measured for Thalheim 2012 .

→ A module performing better in PID testing might actually fail earlier in the field