Temperature Corrections to LHC Magnet Busbar Resistances & Summer in Review

Alex Tuna

13 August 2009

Advised by Mike Koratzinos, TE-MPE

Road Map

General Information

Preparatory Work

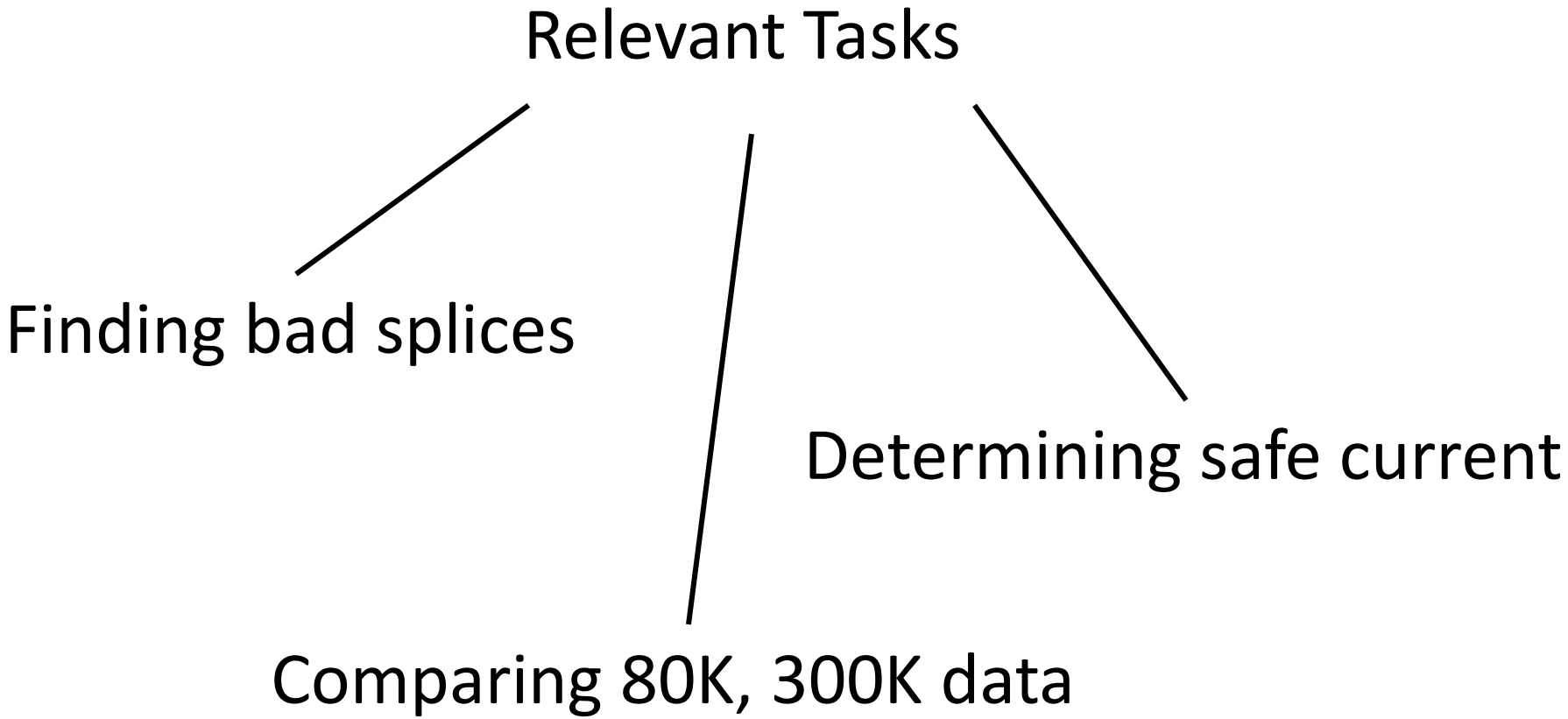
Temperature Correction

Cultural Experiences

The Crash – 19 September 2008

- Start-up tests began 10 Sept 2008
- Current in dipoles ramped up at 10 A/s
- Bad splice can't handle current
- At 9 kA, splice melts and arc forms
- He^2 cryostat punctured, spills into vacuum
- Temperature and pressure spikes
- Magnets displaced, incapacitated [1]

TE-MPE to the Rescue



TE-MPE to the Rescue

- After reviewing our approach to high current splices following the incident, it became apparent that splices where the copper stabilizer is discontinuous and is not in good contact with the superconducting wire pose a threat.
- These bad splices can only be measured at non-superconducting temperatures
- The measurement is easier at room temperature but is also possible at around 80K
- It was decided not to warm all sectors to room temperature, so some sectors were measured at 80K

Recent Developments

CERN The Bulletin

Current plan: Cool all sectors

Accelerate beams to 3.5 TeV

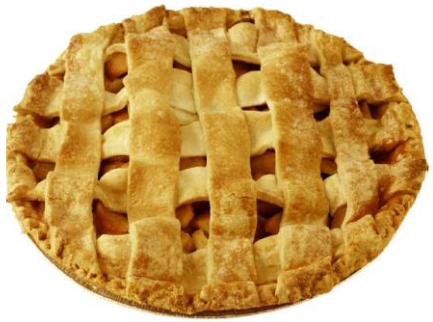
Shut down, fix, and hope for 7 TeV

Introduction to TE-MPE

Odd jobs

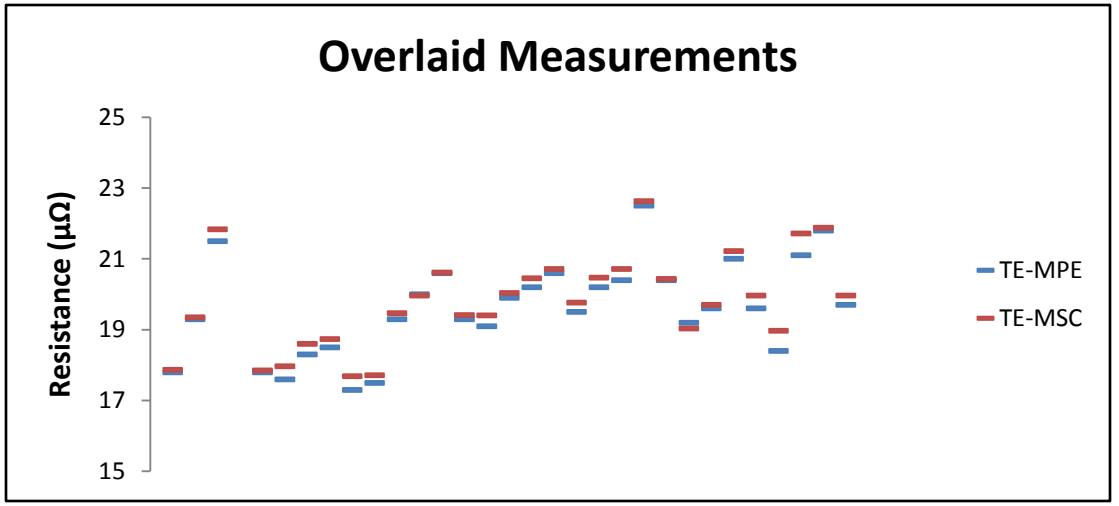
Comparing data

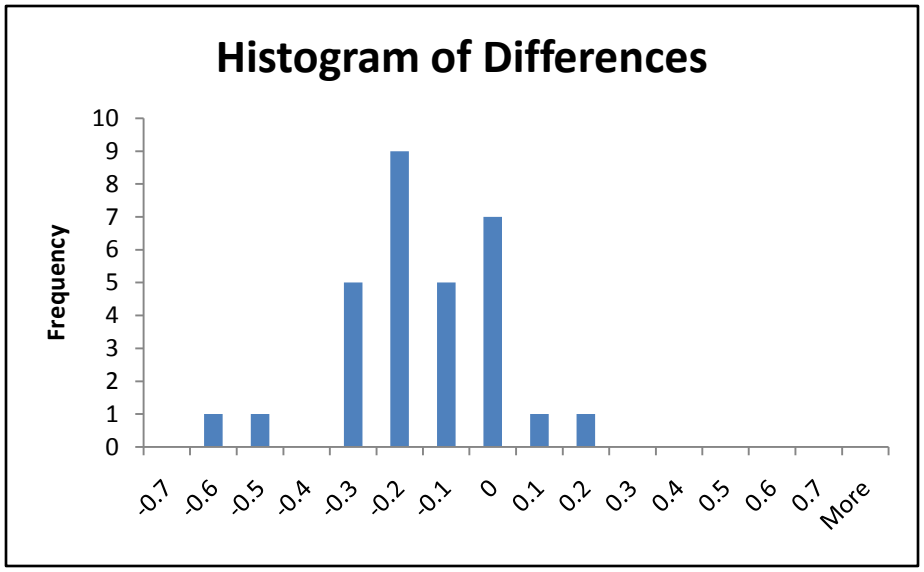
80K vs 300K

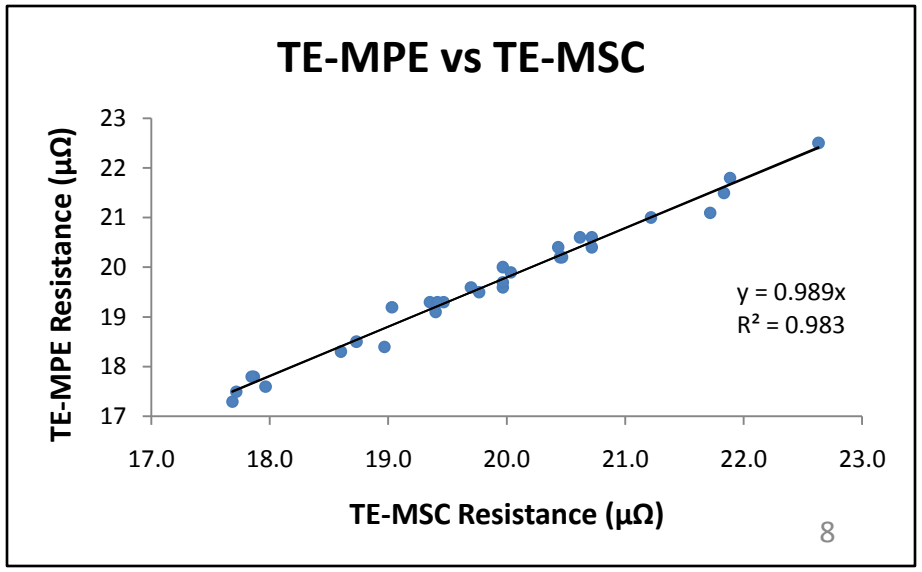


Comparing Data

Comparing TE-MPE (speed) and in TE-MSC (accuracy) measurement methods

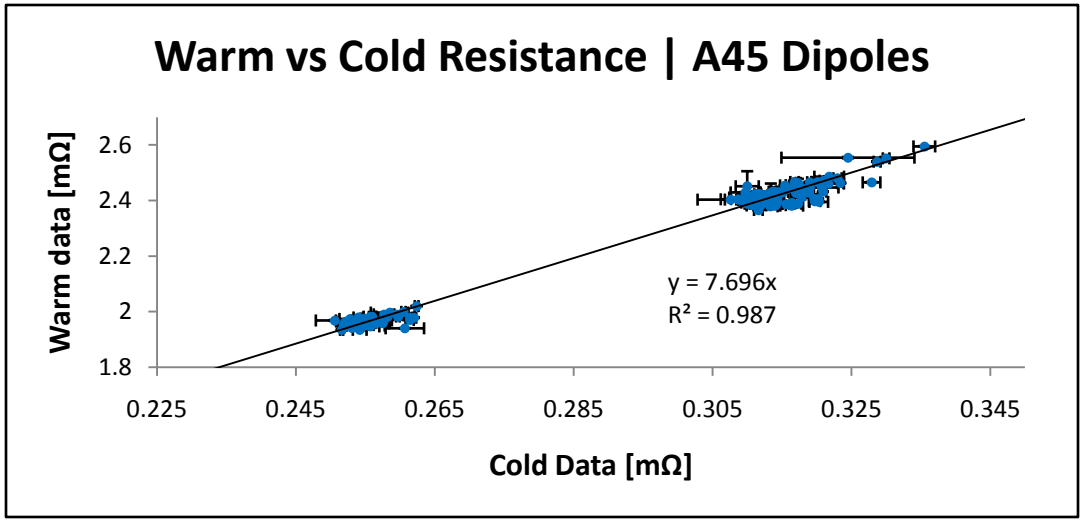


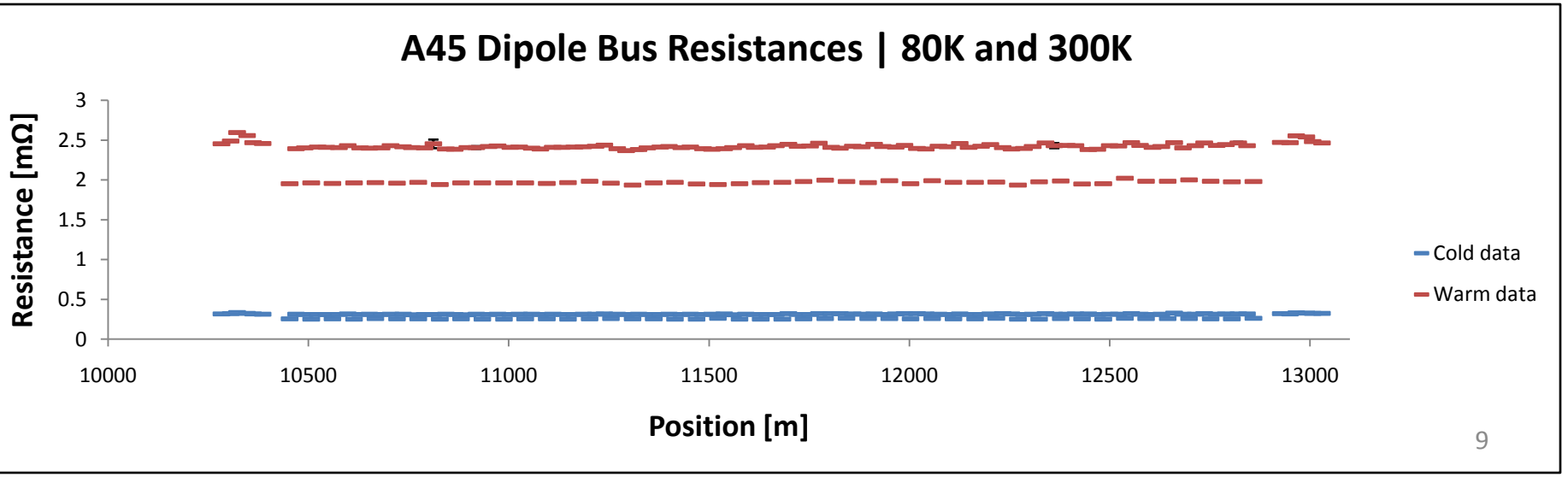




80K vs 300K

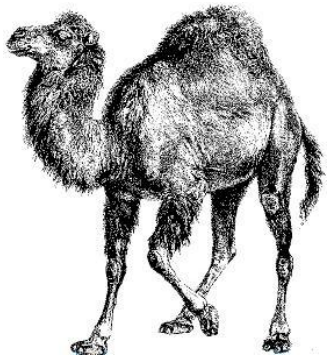
Projecting 80K measurements to 300K





Skills Learned

Microsoft Excel

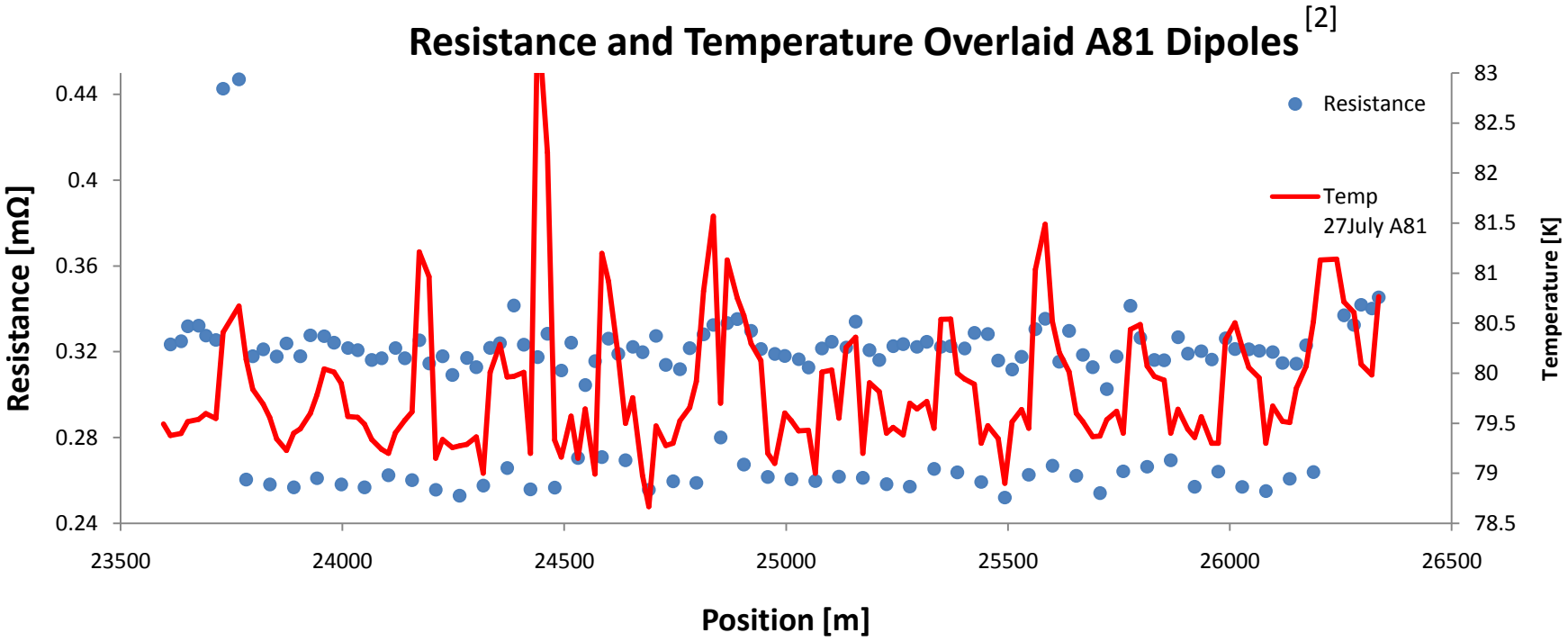


Perl

Timber

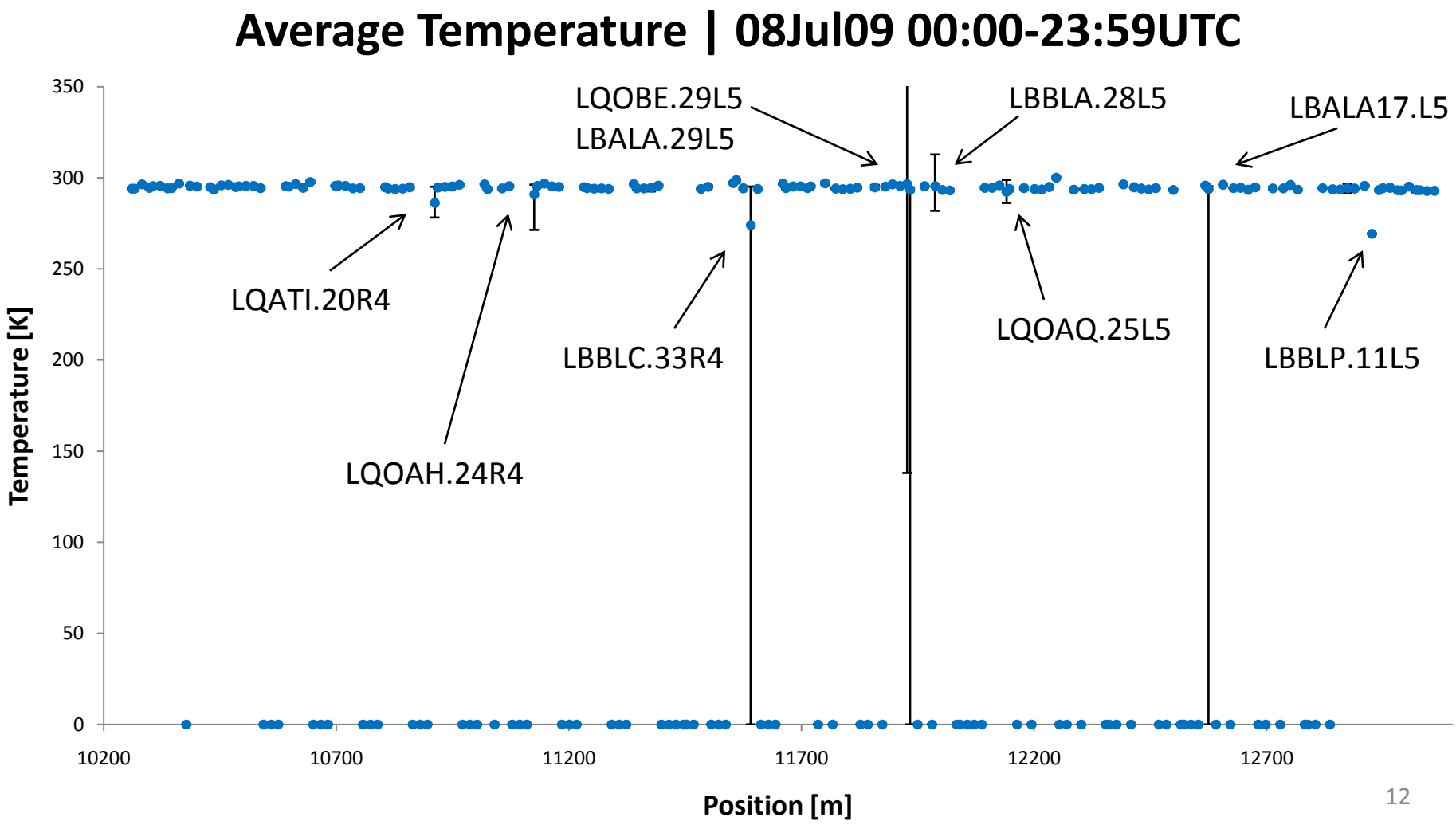
LHC Magnets

Main Project – Temperature Correction

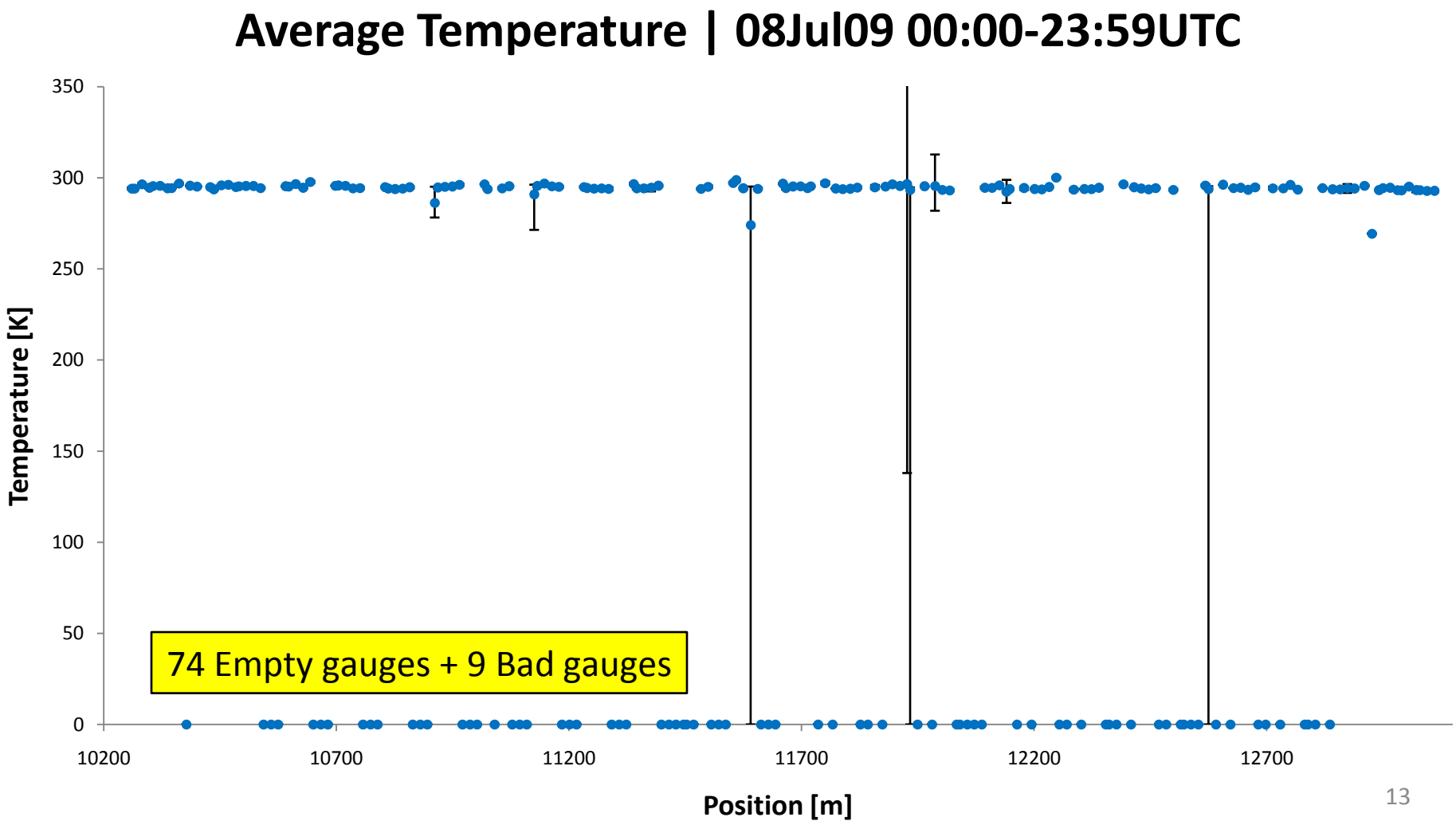


Temperature fluctuations result in resistance fluctuations

First Step – Temp. Gauges



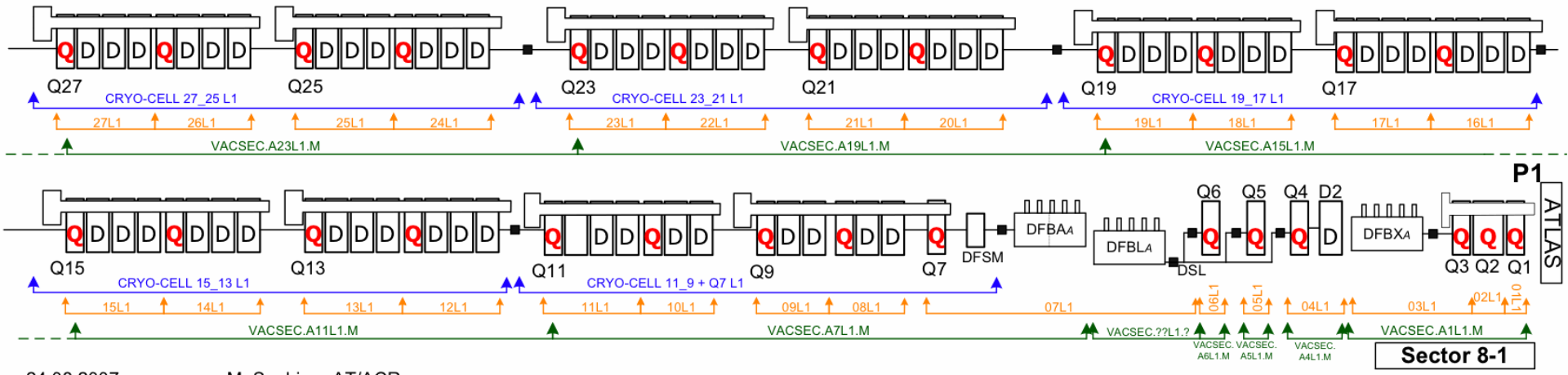
Next Step – Fill in blanks?



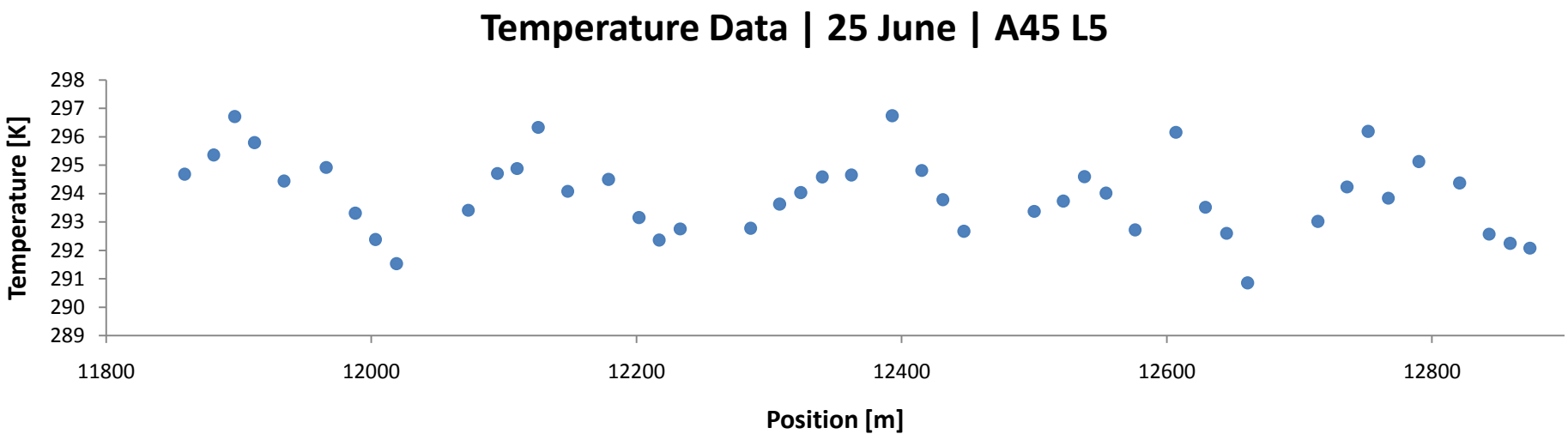
Filling in blanks – Temp. fitting

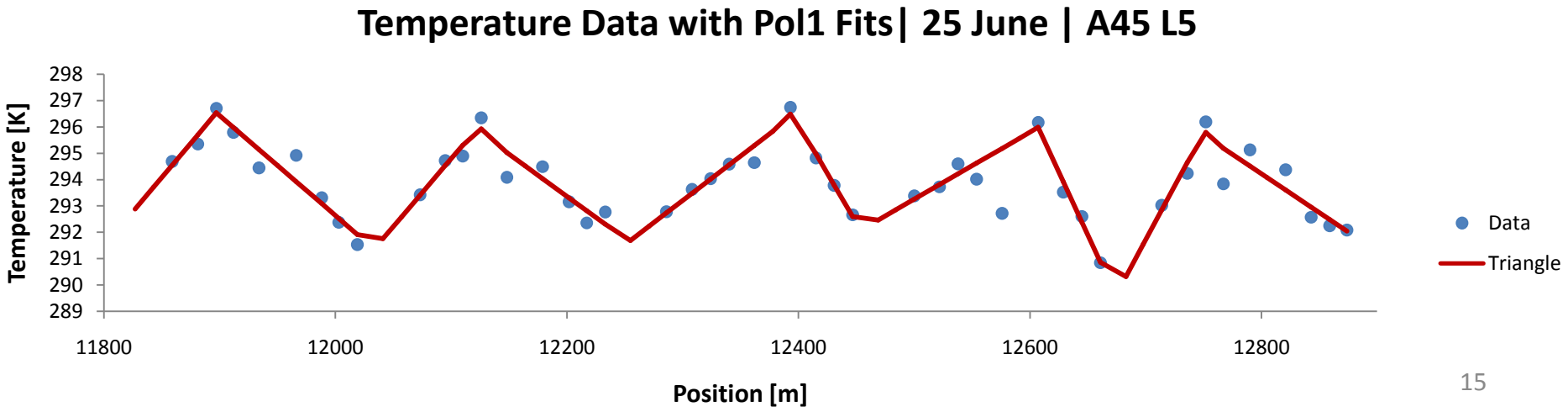
Temperature patterns form in cryogenic subsectors at both 80K and 300K

Guess – temperature can be fitted piecewise

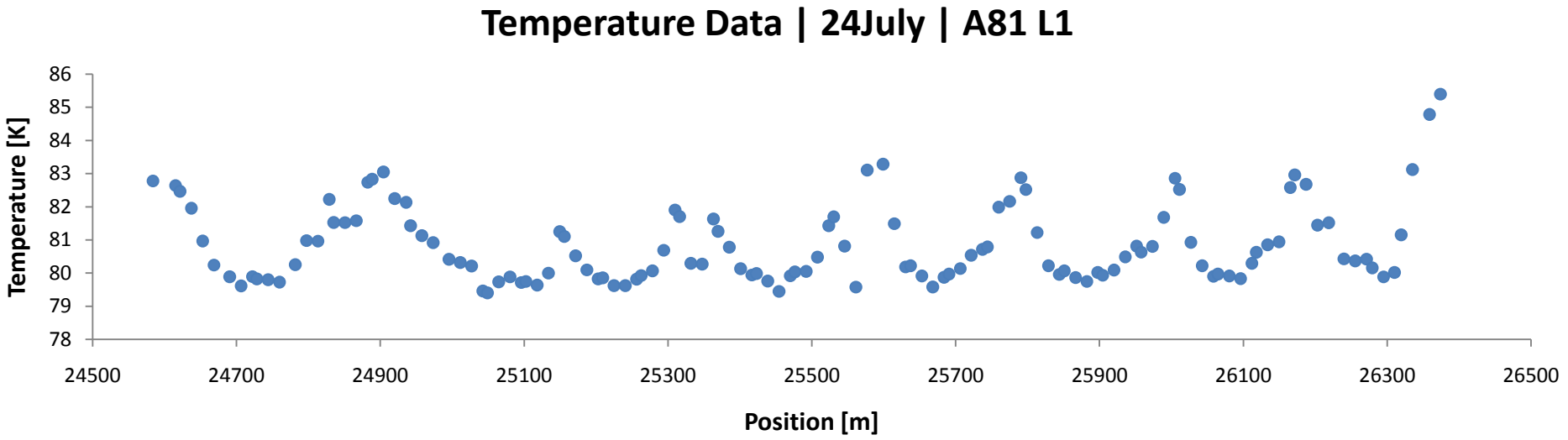


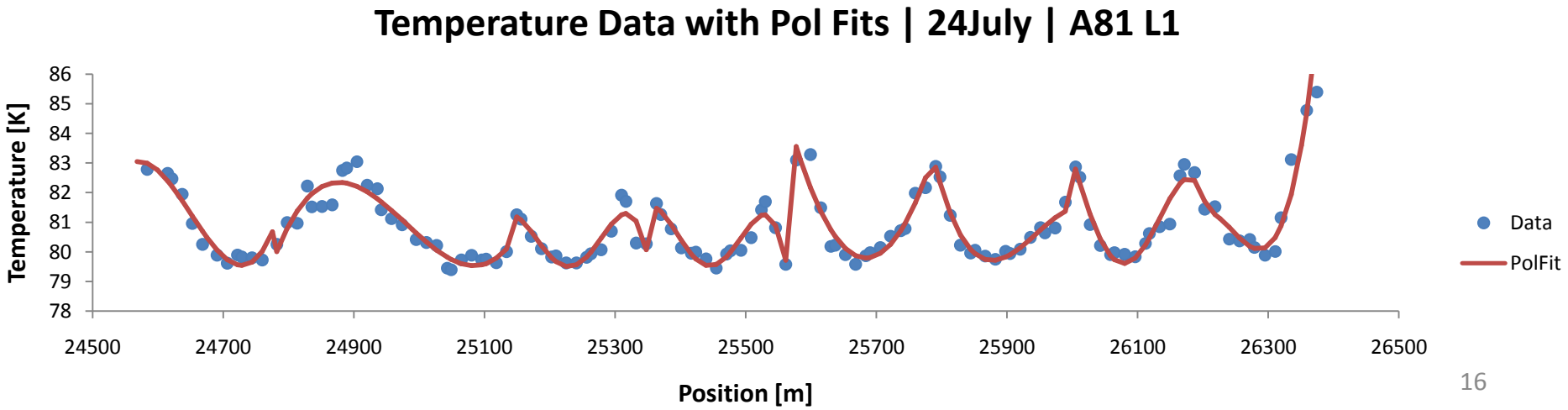
300K Data


Temperature Data | 25 June | A45 L5
Temperature [K]
298
297
296
295
294
293
292
291
290
289
11800
12000
12200
12400
12600
12800
Position [m]


Temperature Data with Pol1 Fits| 25 June | A45 L5
Temperature [K]
298
297
296
295
294
293
292
291
290
289
11800
12000
12200
12400
12600
12800
Position [m]
Data
Triangle

80K Data


Temperature Data | 24July | A81 L1
Temperature [K]
86
85
84
83
82
81
80
79
78
24500
24700
24900
25100
25300
25500
25700
25900
26100
26300
26500
Position [m]


Temperature Data with Pol Fits | 24July | A81 L1
Temperature [K]
86
85
84
83
82
81
80
79
78
24500
24700
24900
25100
25300
25500
25700
25900
26100
26300
26500
Position [m]
Data
PolFit

Plots of ΔR vs ΔT

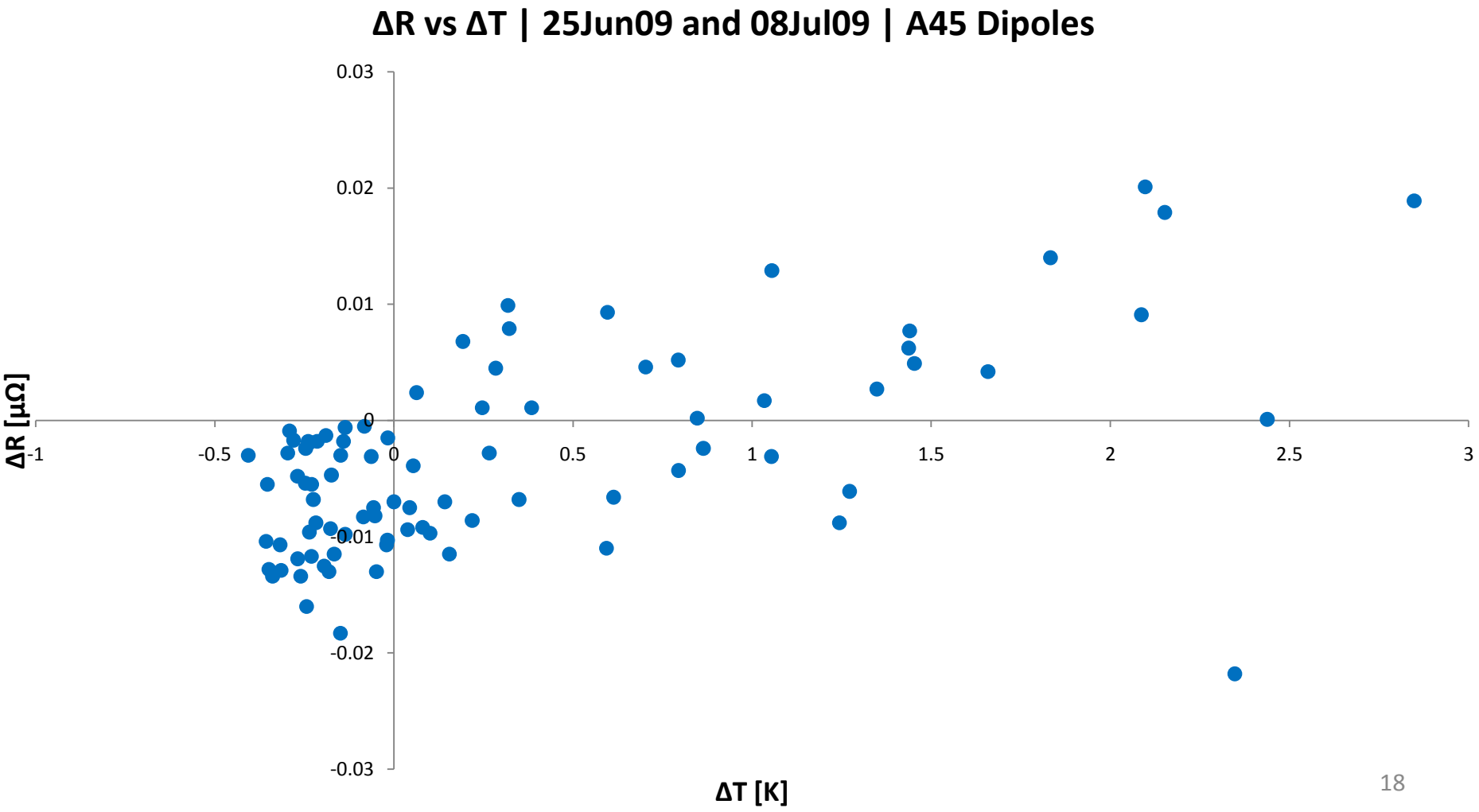
Small temperature change -> small resistance change

But small ΔR can mask excess resistance, esp. at low T

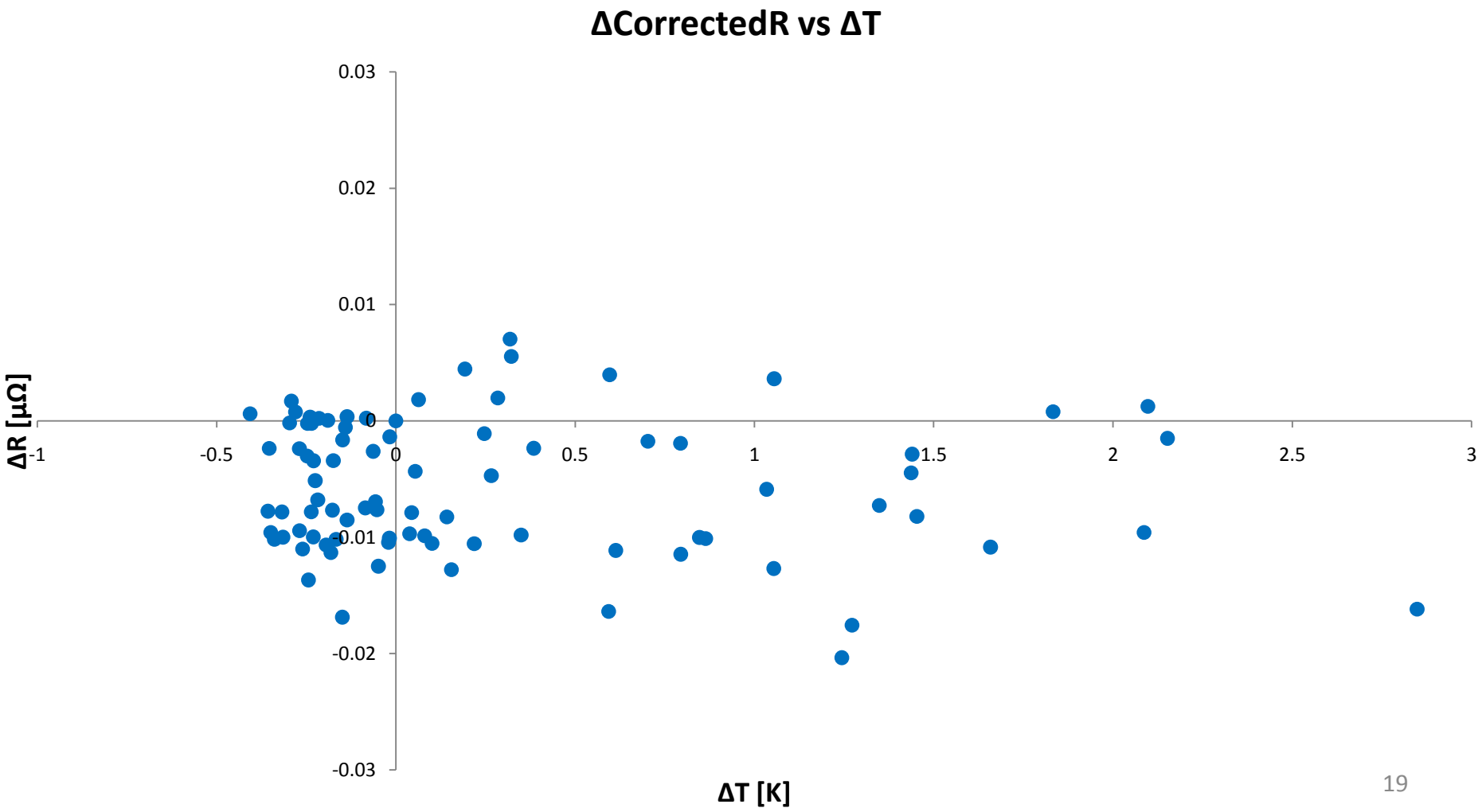
ΔR vs ΔT should be linear, ΔCorrectedR vs ΔT should be flat

Indicates success of temperature correction

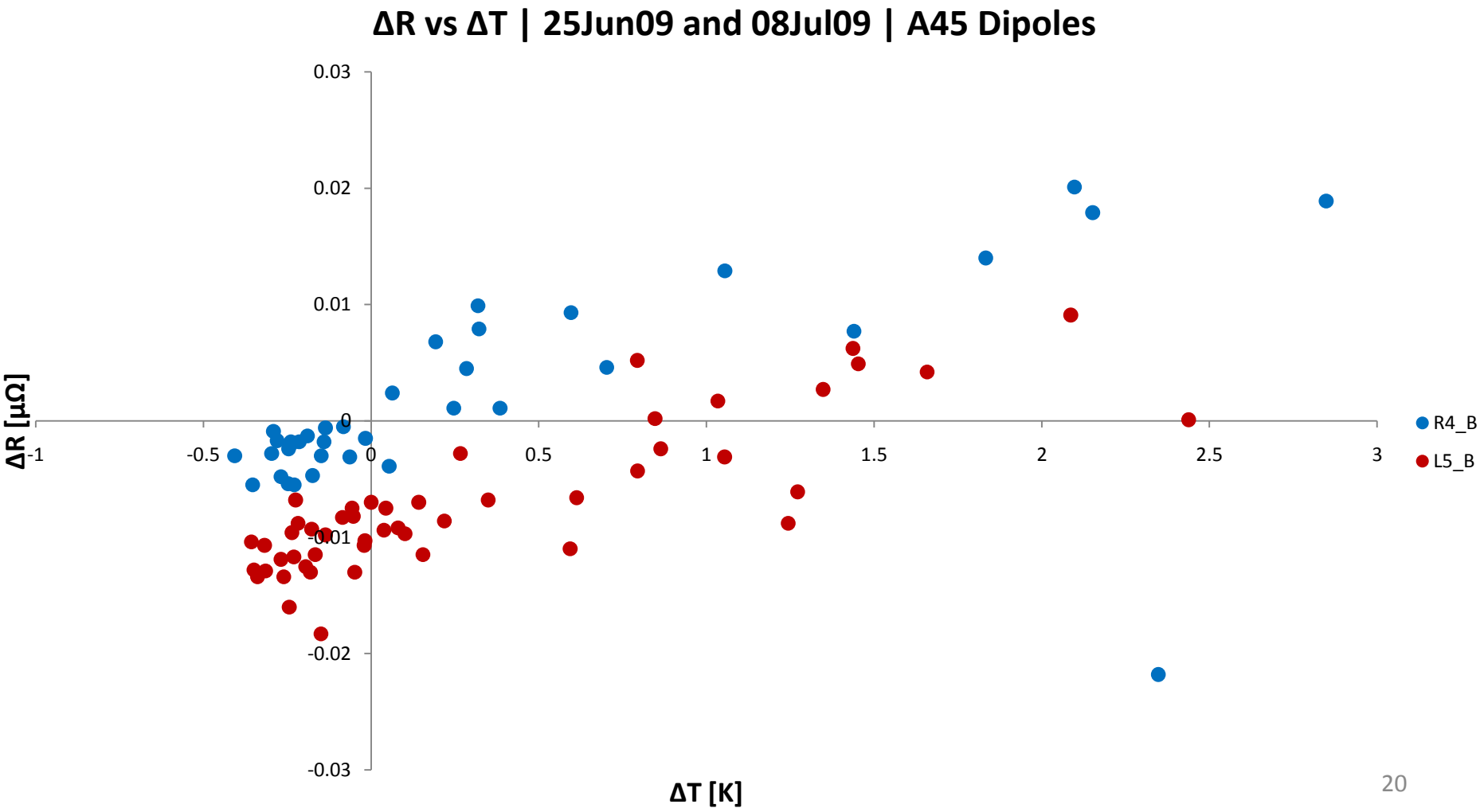
Raw Temperature Data



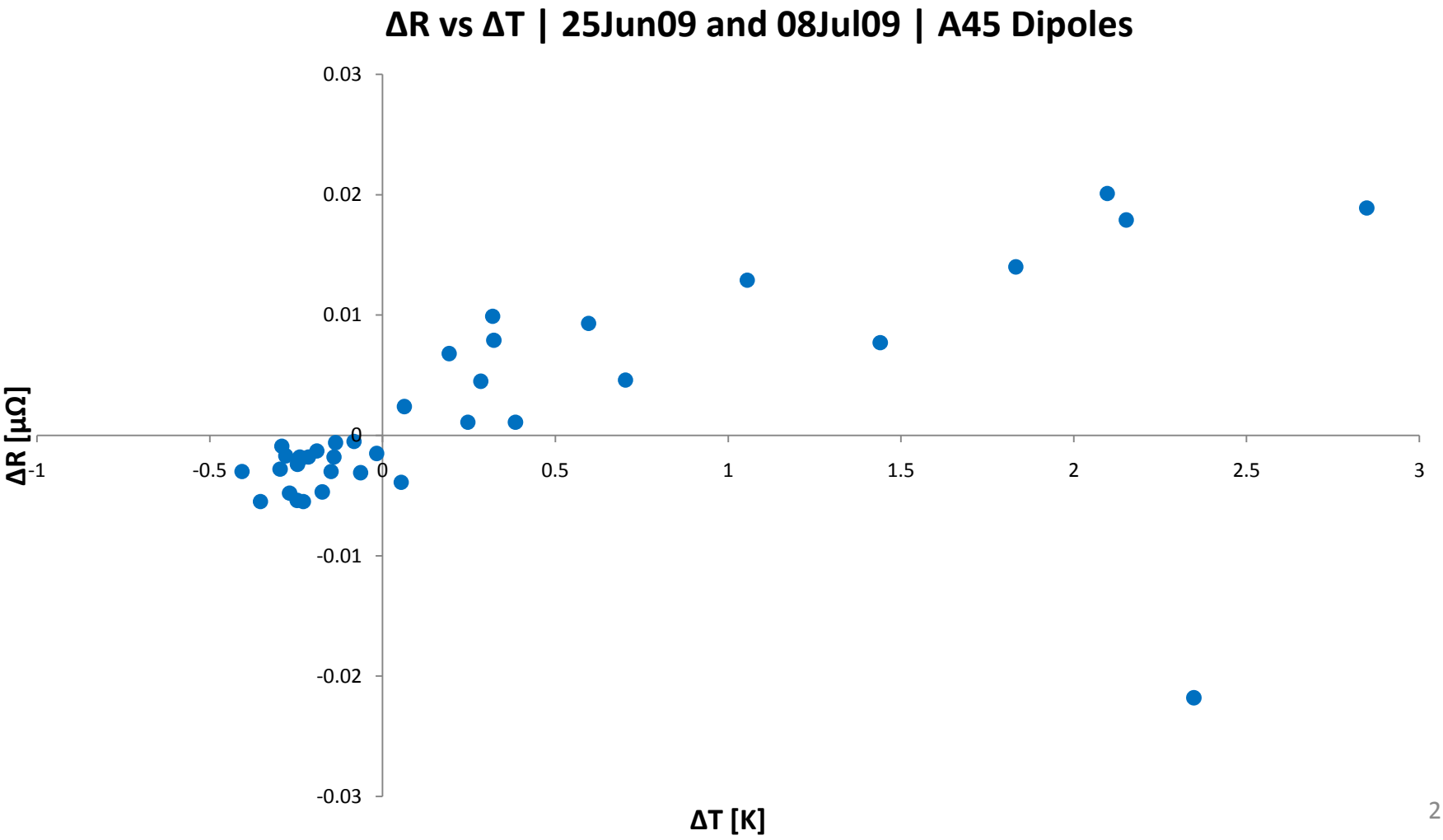
Raw Temperature Data



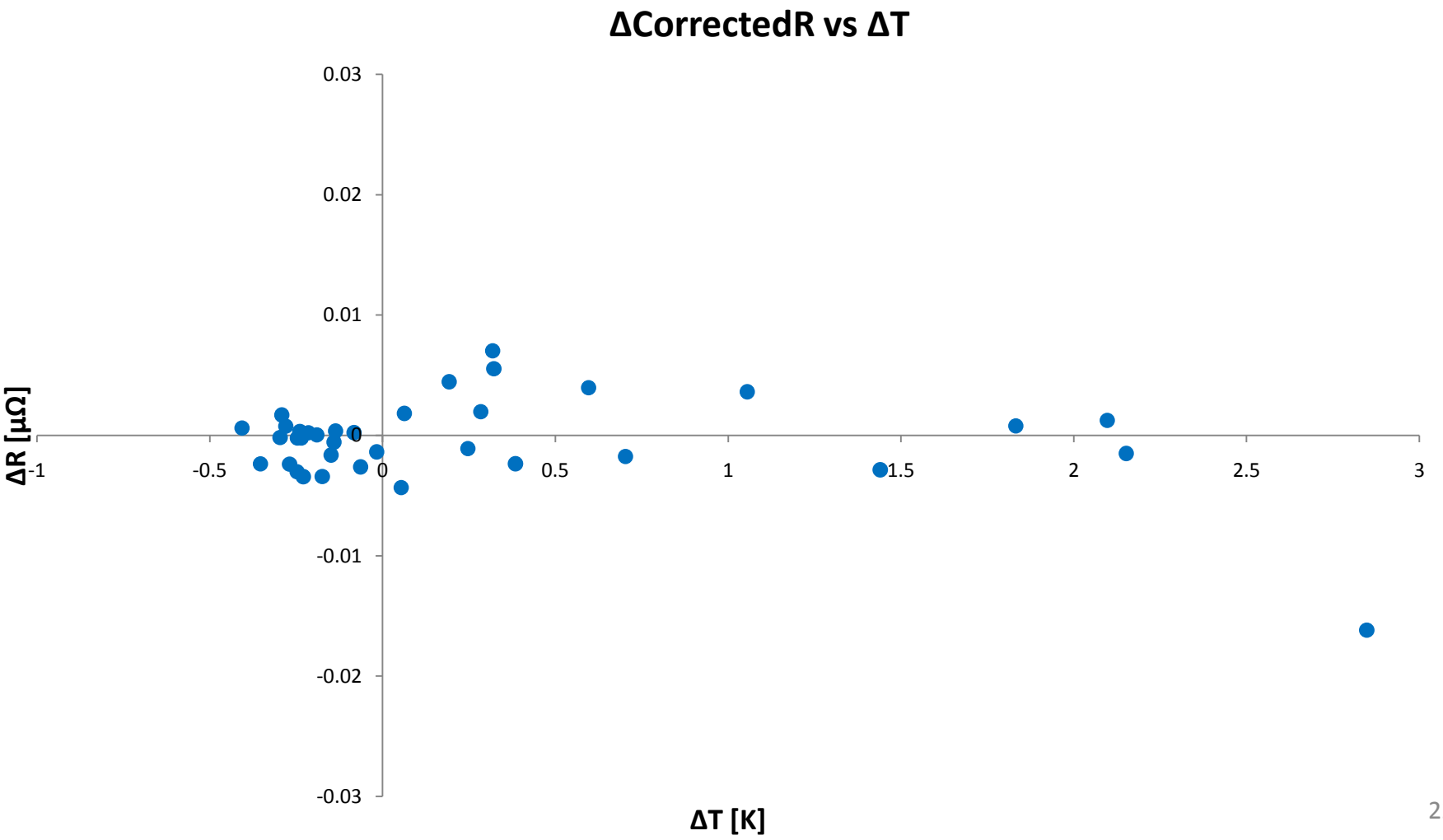
Raw Temperature Data – Sys. Bias?



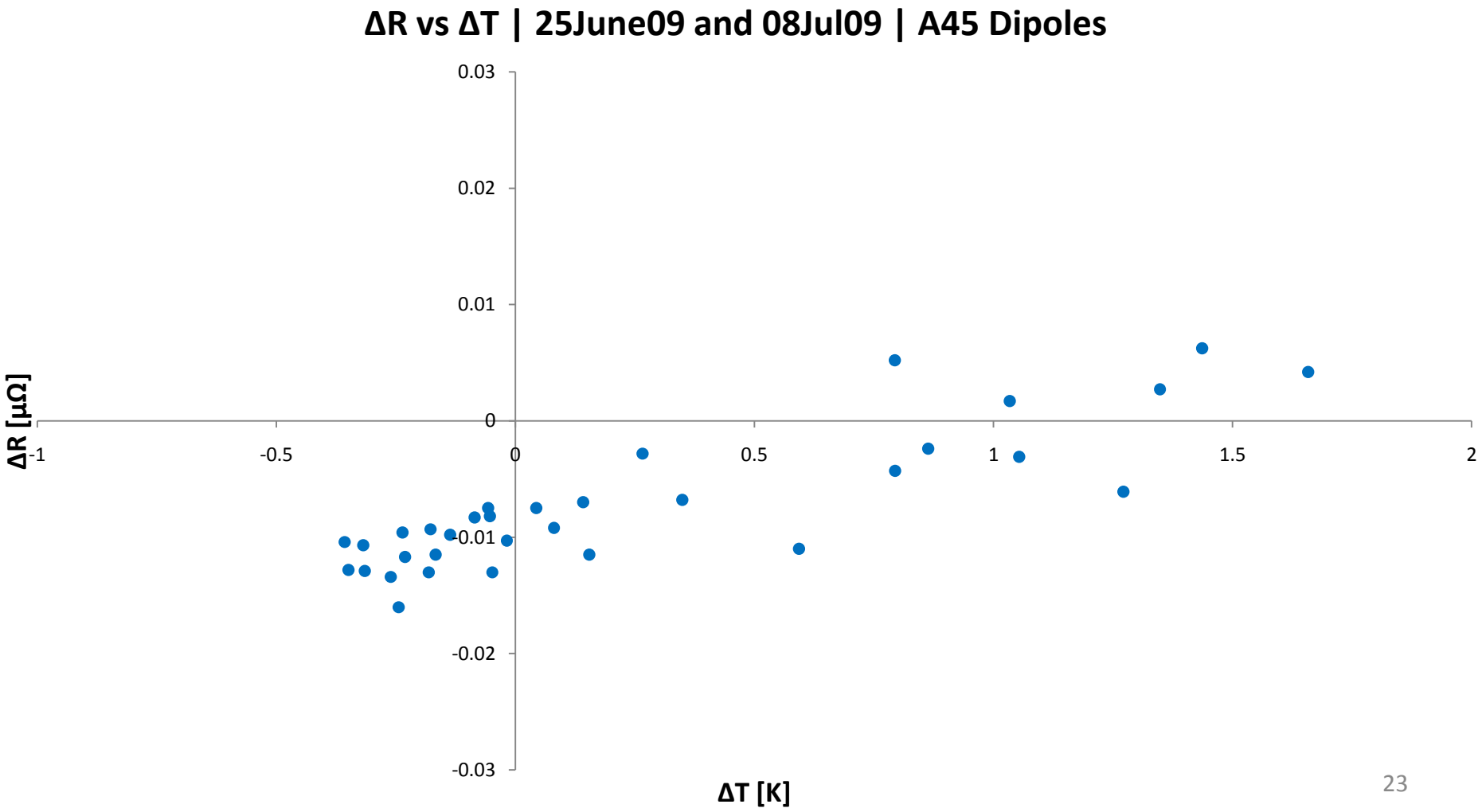
Raw Temperature Data – Just R4



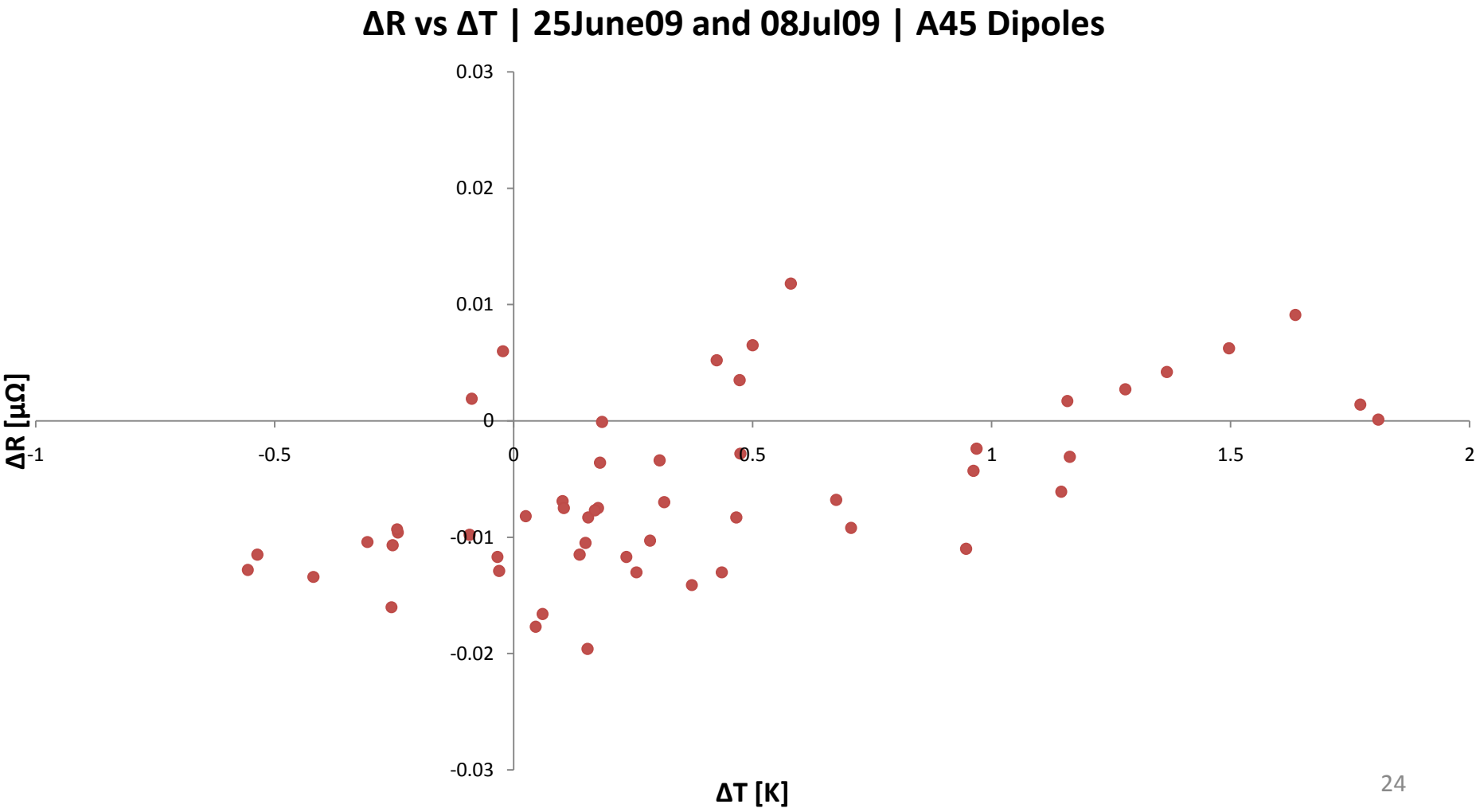
Raw Temperature Data – Just R4



Raw Temperature Data – Just L5



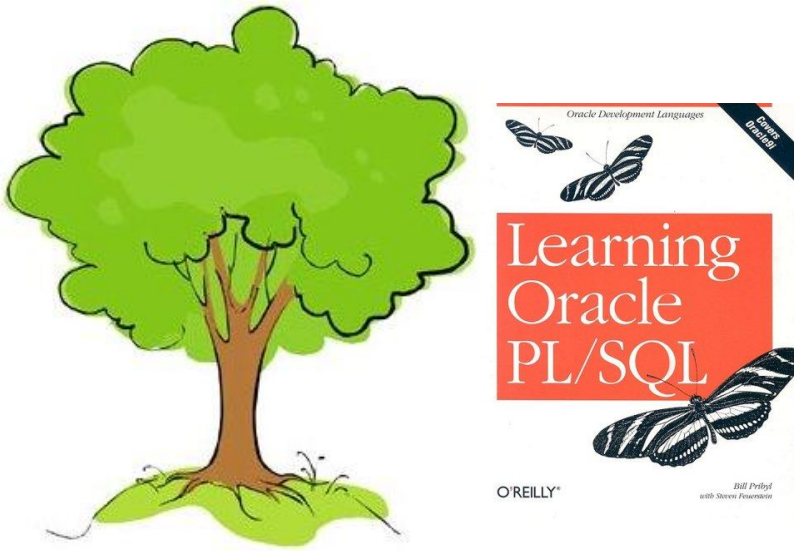
Fitted Temperature Data – Just L5



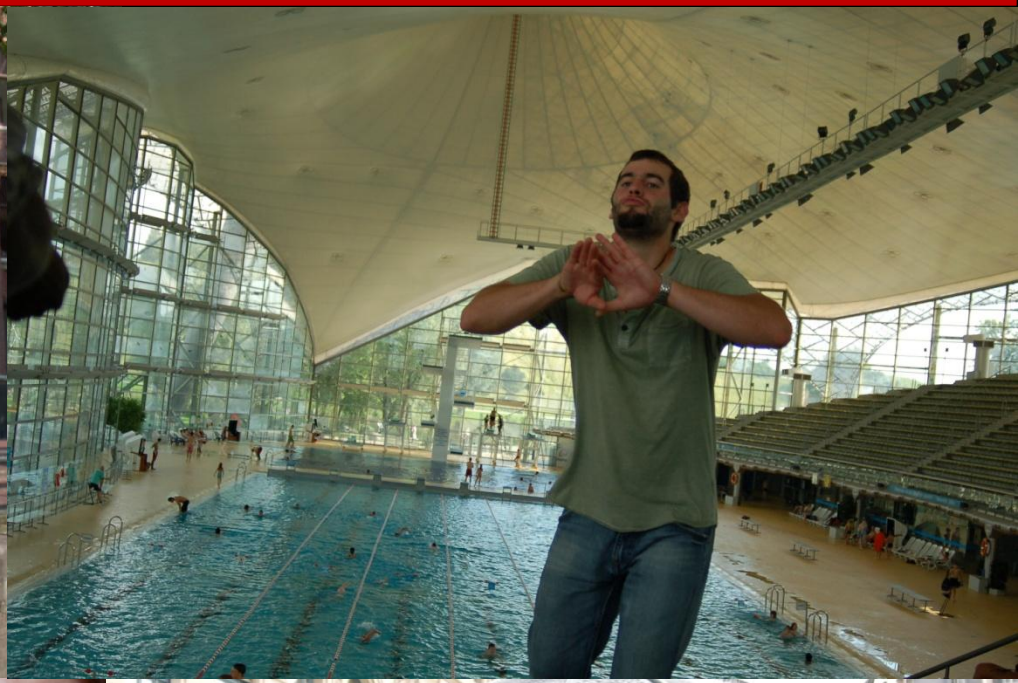
Some side projects

Calibrating new Biddle

CLI/Scripting for Timber



Cultural Experiences



Cultural Experiences

Acknowledgements

- Mike Koratzinos, TE-MPE, advisor
- Bob Flora and Howie Pfeffer, TE-MPE, colleagues
- Kent Wootton, fellow TE summer student
- All the REU students
- All the REU program coordinators

Sources

- [1] CERN Press Release. <http://press.web.cern.ch/press/PressReleases/Releases2008/PR14.08E.html>. 10 Aug 2009.
- [2] Mike Koratzinos' public storage. "RB_80k_generic_official". 31 July 2009.