Advanced tuning algorithms for high-frequency SIS mixers

Hesper, Ronald; Barkhof, Jan; Vos, Tobias; Baryshev, Andrey

DOI:
10.5281/zenodo.3240311

Advanced Tuning Algorithms for High-Frequency SIS Mixers

NOVA Sub-mm Instrumentation Group

kapteyn astronomical institute

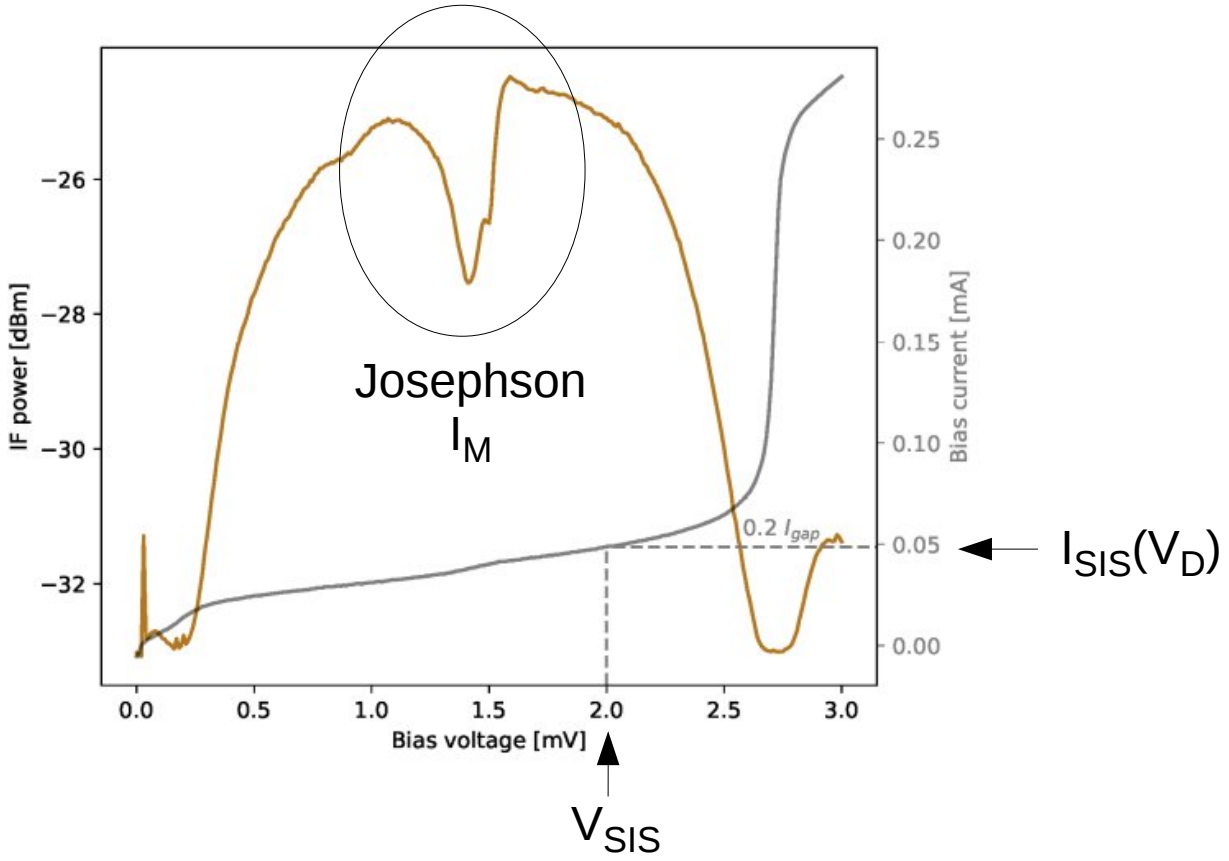
Ronald Hesper
Jan Barkhof
Tobias Vos
Andrey Baryshev

ALMA Development Workshop, ESO 2019-06-05

Tuning SIS mixers

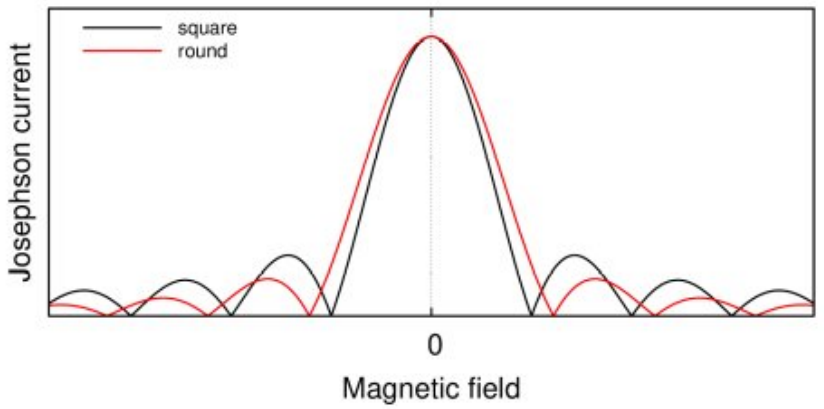
The main tuning parameters of SIS mixers:

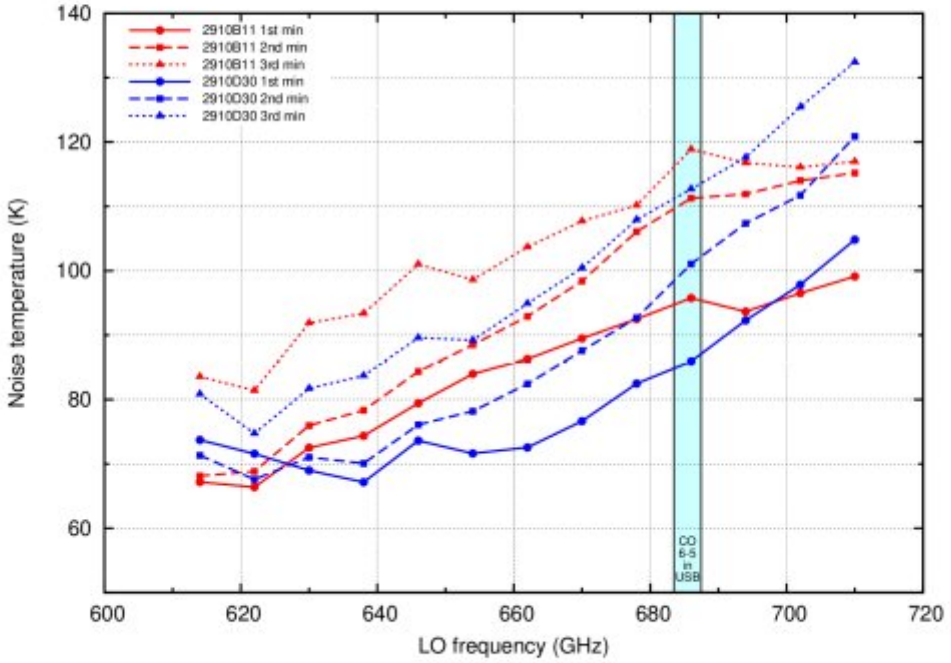
- Bias voltage (V_{SIS})
- Bias current (I_{SIS}), set by LO power (V_D)
- Josephson suppression, set by magnetic field (I_M)



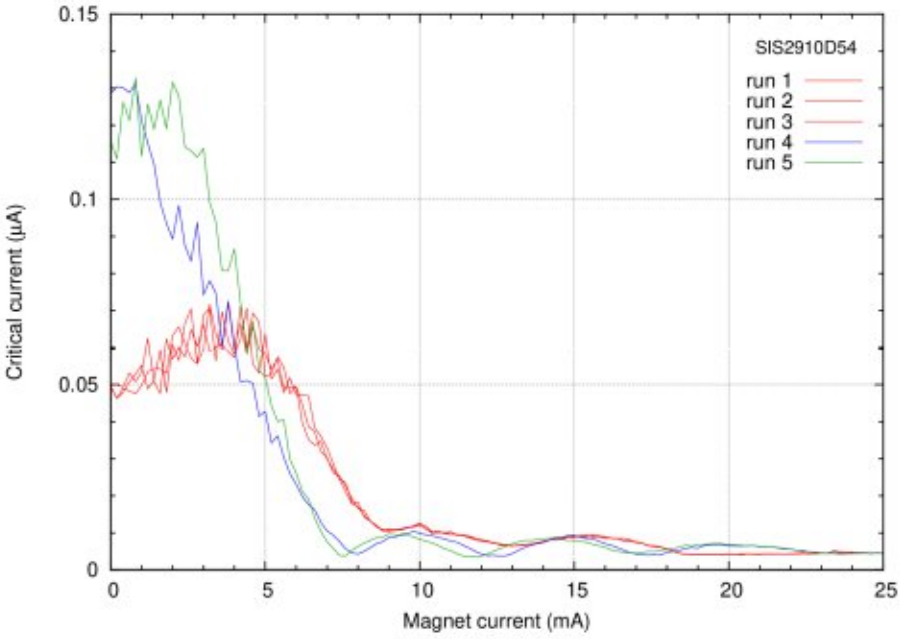
Josephson suppression

Ideal





Reality: multiple states, hysteresis



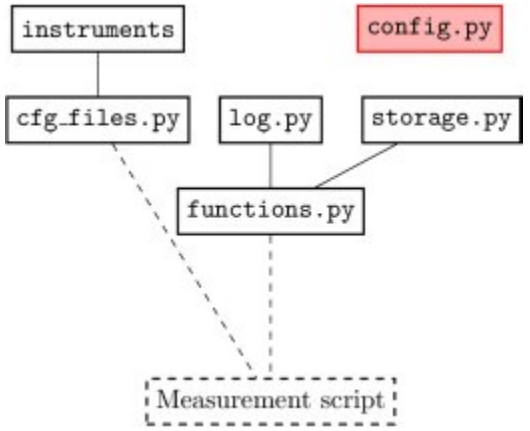
Delivered tunings: usually 2nd minimum

Significant noise temperature improvement possible in many (most?) mixers going to first minimum

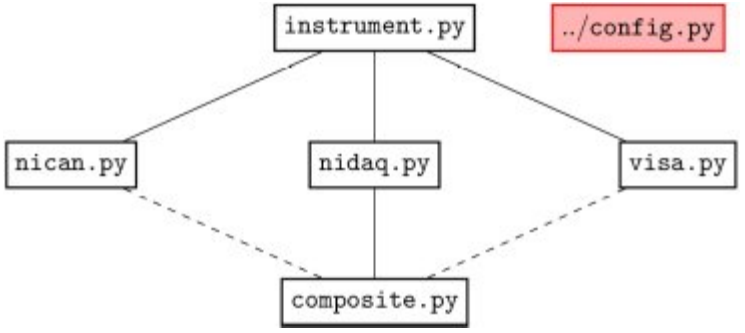
Software infrastructure

The engineering software package (“Rodrigo”) used for Band 9 and Band 5 qualification is not suitable as-is for adaptive algorithms (no conditionals or loops).

→ new Python-based engineering package (“NOVAsoft”)



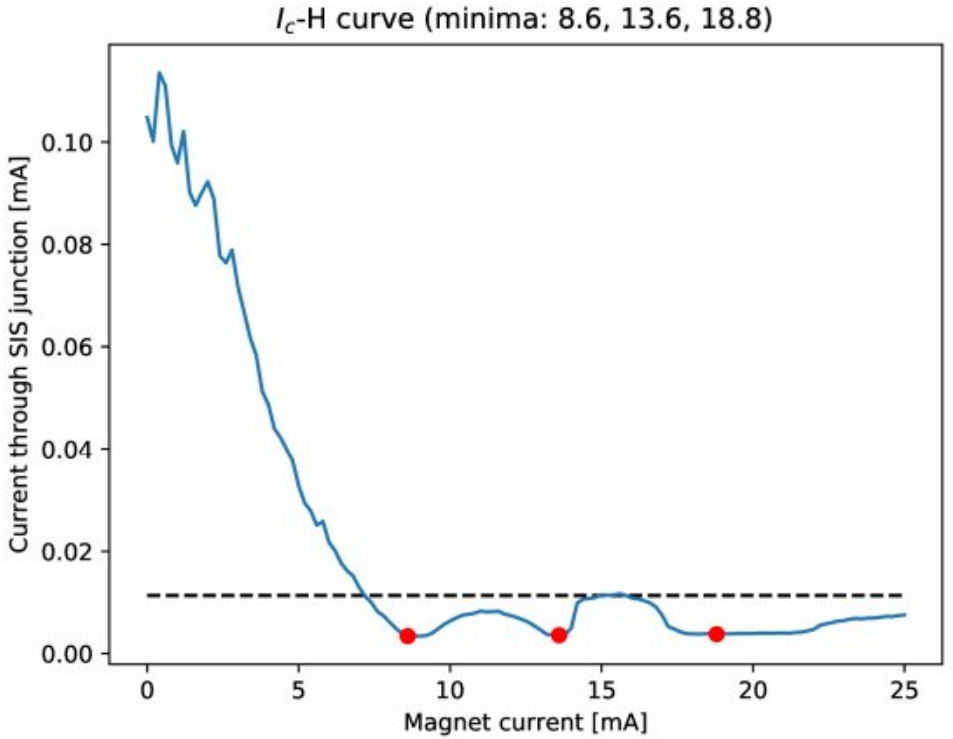
Top-level structure

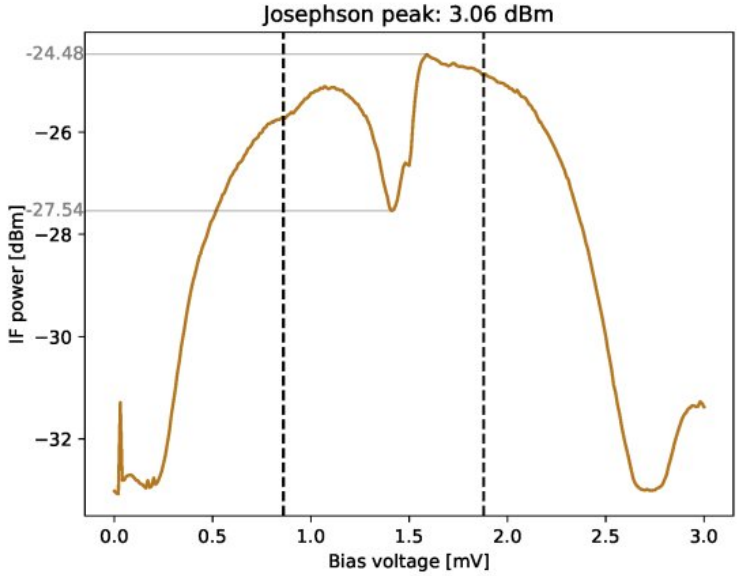


Structure of instrument sub-package

- Maintains “look & feel” of Rodrigo (configuration, file formats, basic scripts)
- ... but unlocks full programming language facilities
- Open source (GPL)

Automating human decisions





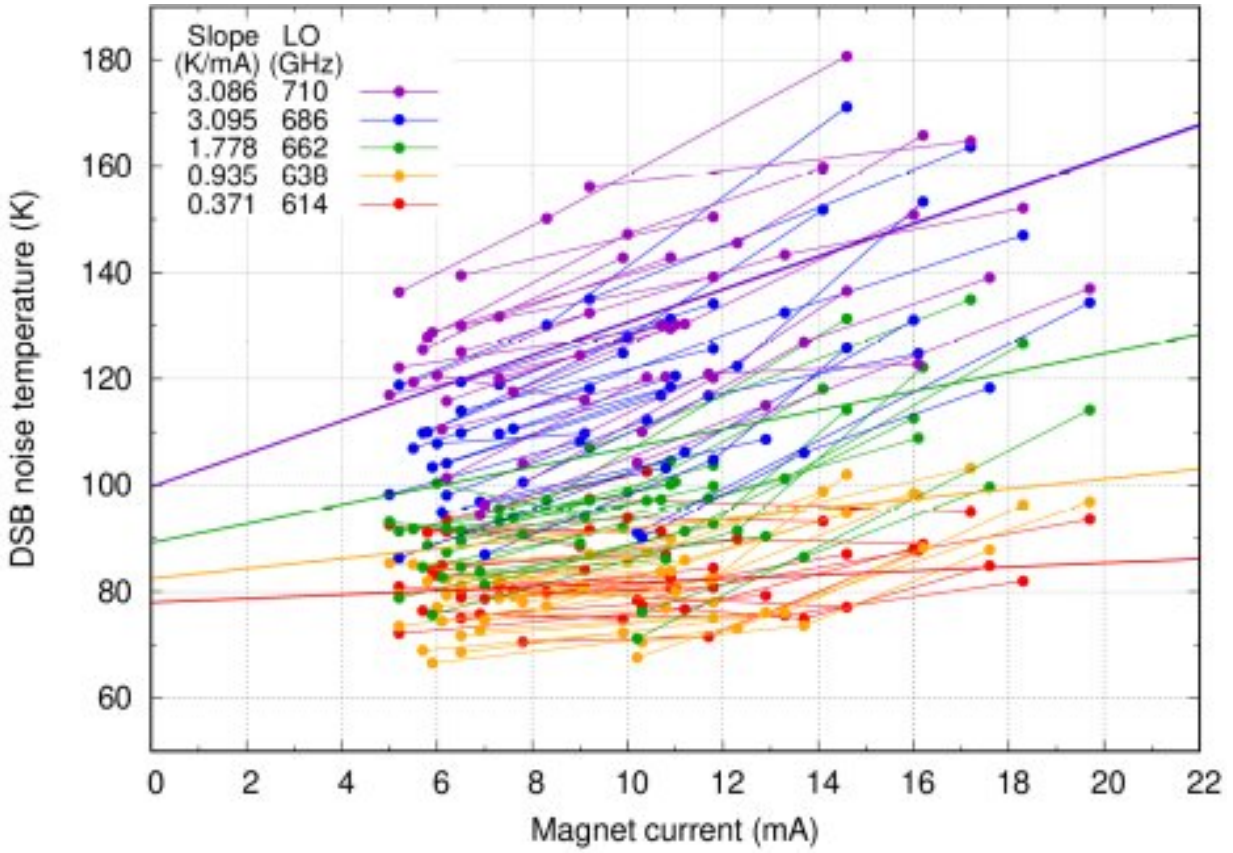
Formerly, the minima were found by eye. The new algorithm finds them by filtering and differentiating, within limiting values.

There are several parameters to tweak in order to get reliable identification of minima → should be tested on sufficient #mixers

The suppression can be verified by the p-p range of the Josephson structure in the power curve.

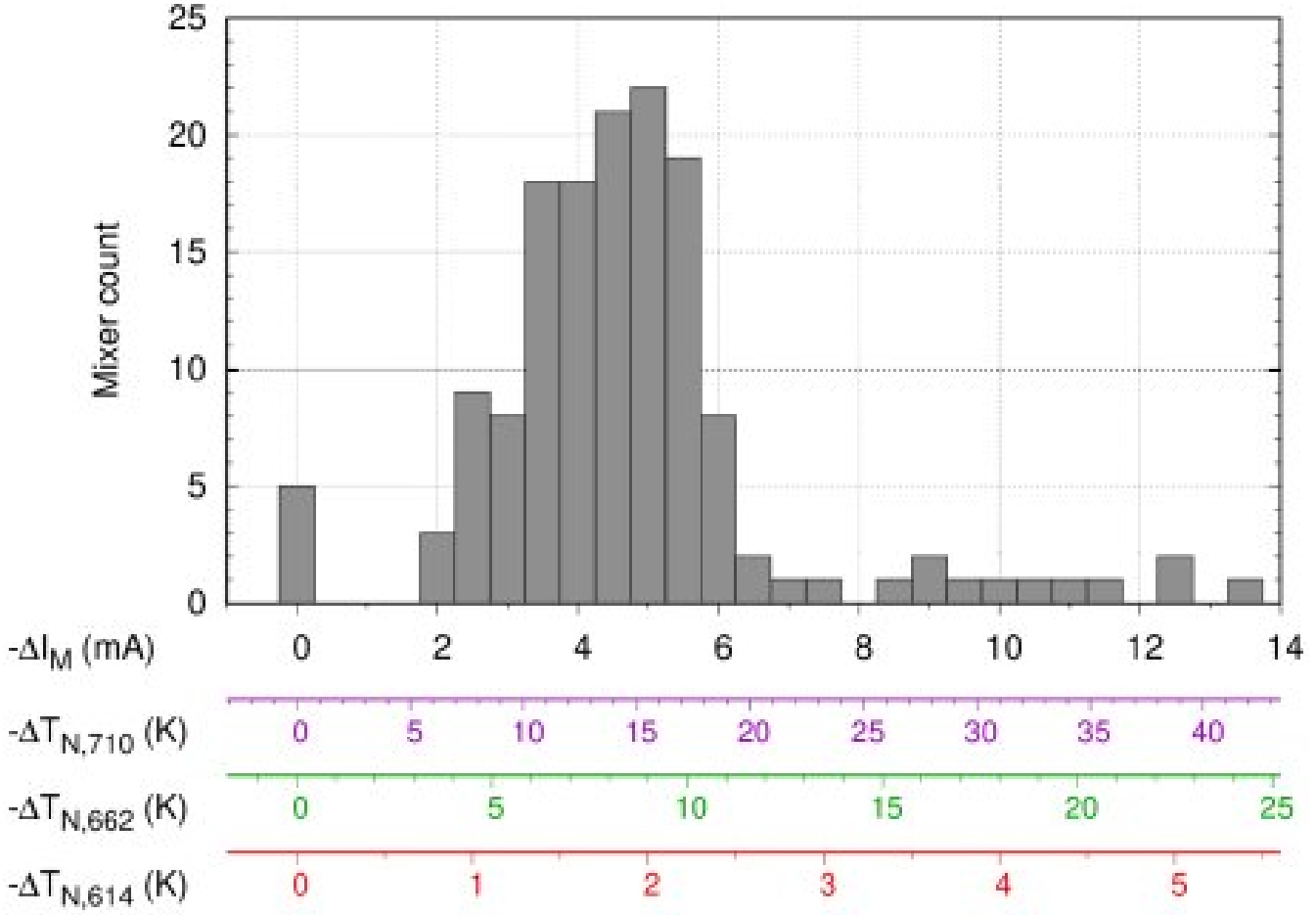
How many mixers can be improved? By how much?

For CHAMP+ upgrade ≈20 AlN SIS junctions were re-measured
In both 1st and 2nd minima (sometimes 3rd)



Averaged slopes of 1st-to-2nd minima lines, for 5 LO frequencies

Expected improvement for ALMA

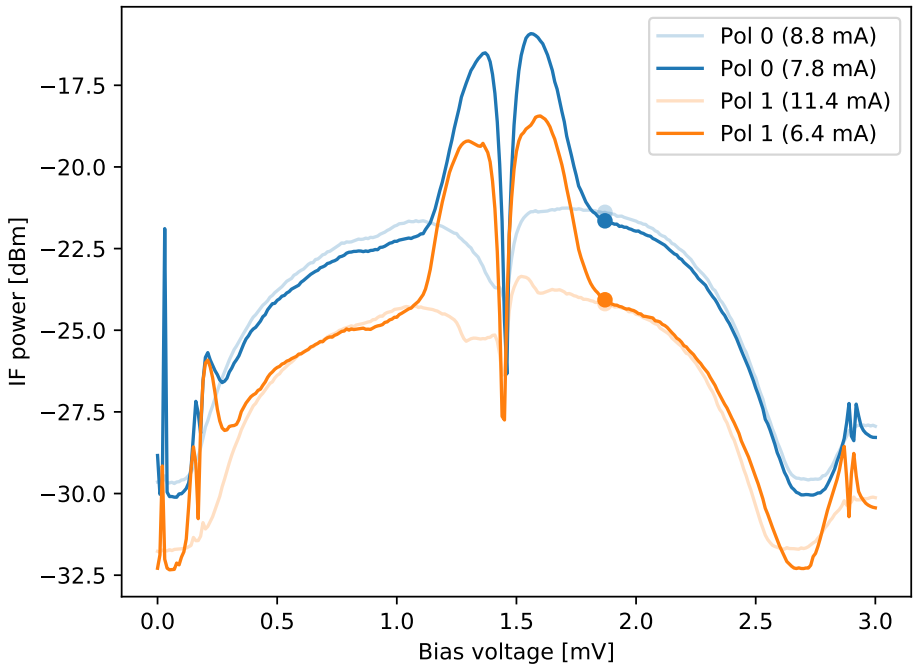


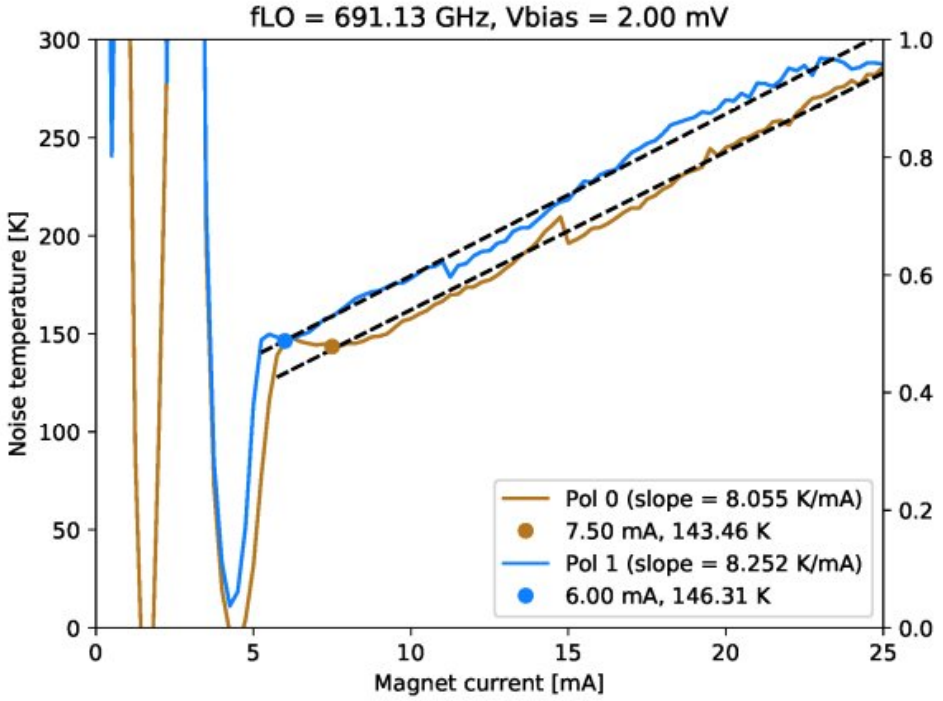
At the high end of the band (e.g., CO 6-5), about 10-15% noise temperature could be shaved off →5-7 antennas for free!

H-field dependence of the noise temperature

Question: what actually determines the noise temperature:

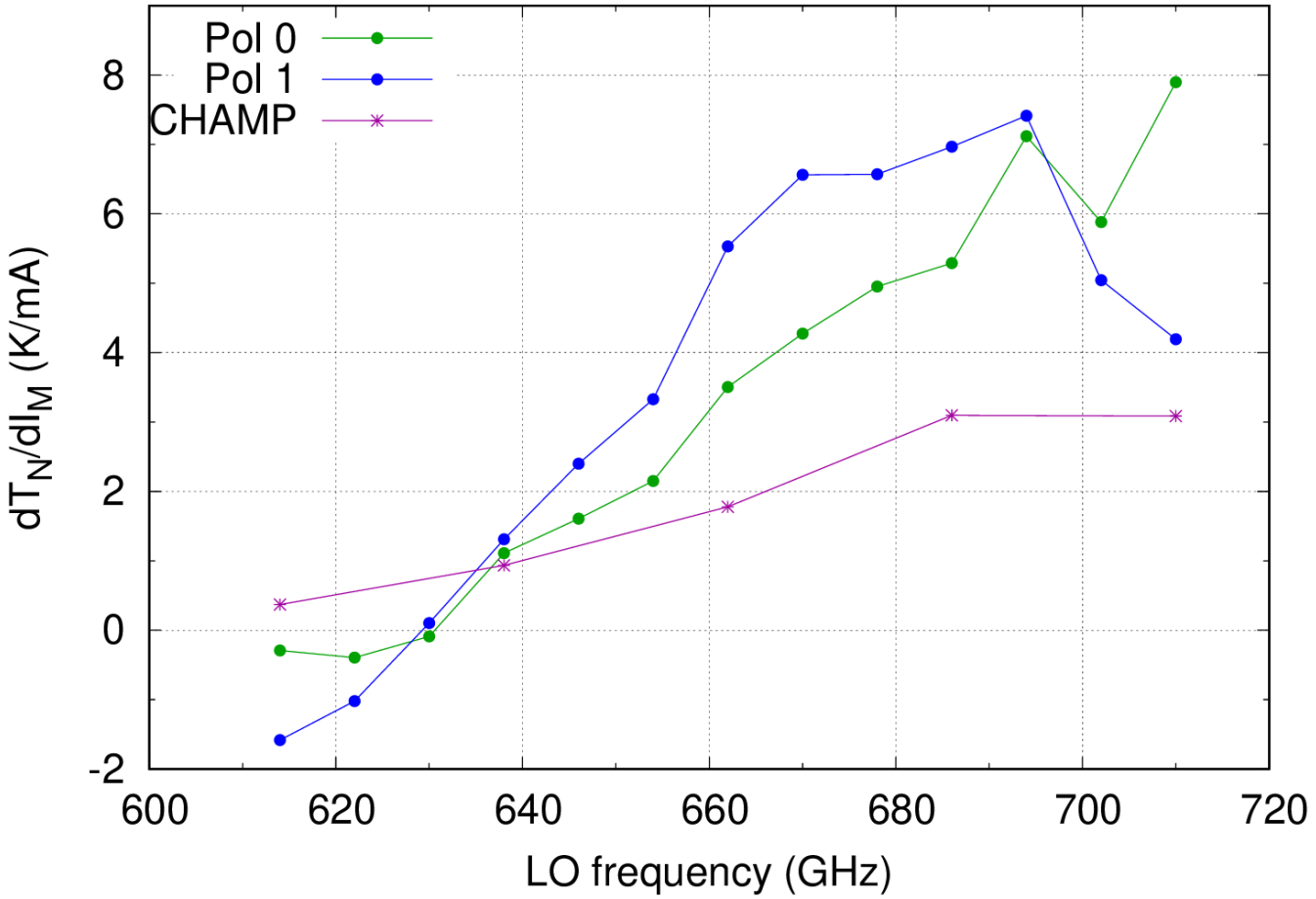
- The magnetic field?
- The supercurrent?





As long as the bias voltage stays out of the Josephson region, there is a straight relationship between T_N and I_M, no sign of minima.

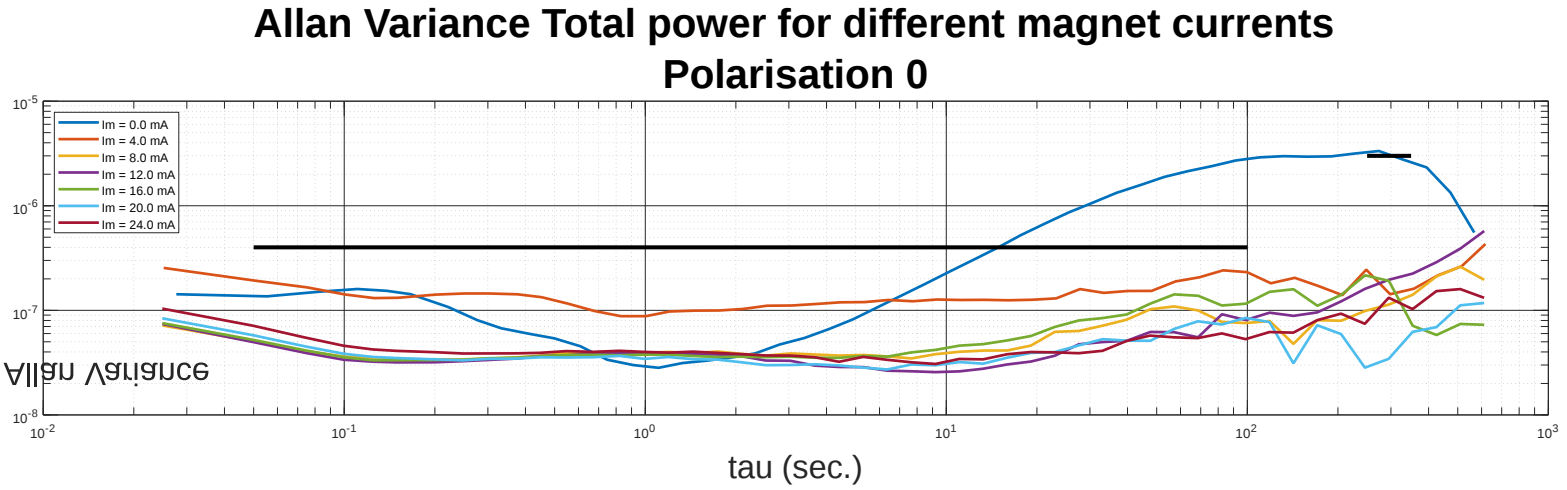
T_N vs. I_M



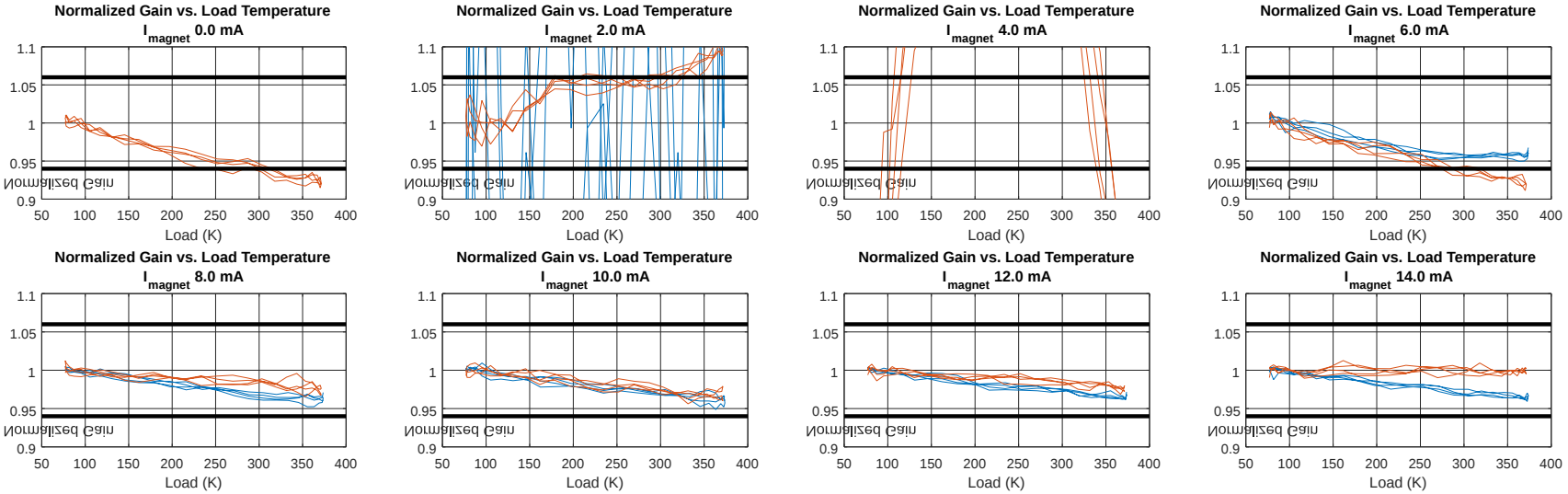
Discrepancy between CHAMP data and recent measurements

Tuning? To be investigated

Do other performance properties suffer from low magnet current?



Compression



Conclusions

A new engineering software infrastructure was developed, with full higher-level language facilities.

The traditional “by eye” optimizations for SIS voltage, pumping level and Josephson suppression were automated.

For a good suppression, it is not necessary to go to a minimum in critical current. The lowest current giving good stability and compression level should be usable in most cases.

The existing ALMA Band 9 mixers can probably be improved by 10-15% on average, yielding a performance increase worth several antennas.