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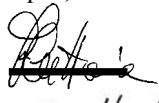
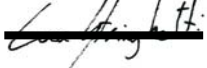
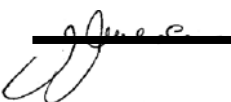


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# 1 ACRONYMS

|       |                                     |
|-------|-------------------------------------|
| BEM   | Back End Module                     |
| BEU   | Back End Unit                       |
| DAE   | Data Acquisition Electronics        |
| FEM   | Front End Module                    |
| LNA   | Low Noise Amplifier                 |
| PH/SW | Phase Switch                        |
| P/S   | Phase Shifter                       |
| RAA   | Radiometer Array Assembly           |
| RCA   | Radiometer Chain Assembly           |
| REBA  | Radiometric Electronic Box Assembly |
| S/C   | Spacecraft                          |
| TBC   | To Be Checked                       |
| TBD   | To Be Defined                       |
| TBW   | To Be Written                       |



## **2 INTRODUCTION**

### **2.1 Purpose and Scope**

This Note shows the strategy to proposed to tune the LFI LNA's (Vg1 & Vg2) in the test campaign at Satellite Level to be performed in CSL (Centre Spatiale de Liege) during the next Summer 2008 .

The baseline option was accepted to be the MATRIX scheme , mixing together Vg1 and Vg2 values. The main limit to this method is given ( in CSL ) by the time required to explore a large range of parameters, since in CSL it is limited and strictly related with the 4K cooler cooldown profile.

This note wants to give an overview of the philosophy and possible advantages or limits related with one or another strategy..



---

## **3 APPLICABLE AND REFERENCE DOCUMENTS**

### **3.1 Reference Documents**

- [RD 1] Technical Note on Bias Tuning –DRAFT, F.Cuttaia, 07/01/2008
- [RD 2] Note on matrix definition for tuning, F .Cuttaia , 31/03/2008
- [RD 3] PL-LFI- PST-TN-084: RCA27 Flight Spare Tuning Results



## 4 BASELINE MATRIX TUNING

At present, the baseline ACA matrix tuning foresees that:

- the LFI will be switched on using the 'tuned' bias identified during the RAA test campaign
  - currents will be compared with previous data to check that the LFI behaves as expected and that the grounding is representative of similar electrical conditions: on the contrary, a recovery action must be thought ( in advance!!) to set the instrument in similar conditions.
  - a unique table for all the ACAs, with the above optimized Vg1 and VG2, is used as starting point - - for each leg, the two extreme values and the number of steps of variation is provided for Vg1 and VG2
- It means that the a unique tuning table can be foreseen with the following information:

| RCA # | Detector ID | SCOS Parameter | Start Values |     |     |     | Stop Values |     |     |     | Step | Step |
|-------|-------------|----------------|--------------|-----|-----|-----|-------------|-----|-----|-----|------|------|
|       |             |                | VG1          |     | VG2 |     | VG1         |     | VG2 |     | VG1  | VG2  |
|       |             |                | DEC          | HEX | DEC | HEX | DEC         | HEX | DEC | HEX | DEC  | DEC  |
| CH27  | 00          | 00             |              | 0   |     | 0   |             | 0   |     | 0   | 7    | 7    |
|       | 01          | 01             |              | 0   |     | 0   |             | 0   |     | 0   | 7    | 7    |
|       | 02          | 10             |              | 0   |     | 0   |             | 0   |     | 0   | 7    | 7    |
|       | 03          | 11             |              | 0   |     | 0   |             | 0   |     | 0   | 7    | 7    |

The method to apply the bias change foresees two FOR cycles cascaded:

```

For i=0,n1_step
  For j=0,n2_step
    → apply Vg1(i), Vg2(j)
  
```

It produces [n1\*n2] combinations of Vg1, Vg2

This is repeated for each ACA (4) of each RCA (11) , following the scheme in Table 1 (channels of the same frequency- with the same integration time- but not belonging to the same power group and bias tray are matched) :

|                                    |
|------------------------------------|
| <u>RCA Under Tests in parallel</u> |
| <u>RCA 18 + RCA 21</u>             |
| <u>RCA 19 + RCA 22</u>             |
| <u>RCA 20 + RCA 23</u>             |
| <u>RCA 25 + RCA 24</u>             |
| <u>RCA 26 + RCA 27</u>             |
| <u>RCA 28</u>                      |

**Table 1 groups of channels to be tuned simultaneously**

The BASELINE Vg1 and Vg2 values are THE SAME used during RAA test campaign (7 for Vg1 and 7 for Vg2) , mixed in all possible combinations (49 combinations per ACA)

### 4.1 Limits from this method:

- 1) The bias variation explored by subdividing the full range in n1 and n2 steps (in the table above n1=n2=7) is not necessary linear (since the steps are given in DEC or HEX): so it is possible that each step differs from the others in terms of voltage applied.
- 2) The change in the total drain current flowing in the LNA can be also abrupt, depending on the combination each time i change to i+1. The expected behaviour for the drain current, following the bias order reported in Figure 2, is displayed below (Figure 1). It was observed (Technical Note on Bias Tuning –DRAFT, F.Cuttaia, 07/01/2008) that , especially for certain 70 GHz LNA's, the drain current drift due to bias



changes is related with the amplitude of the change: hence, a very smooth change would be preferred (since the integration time per step was reduced to 20 seconds to fit the maximum time allocated for the test)

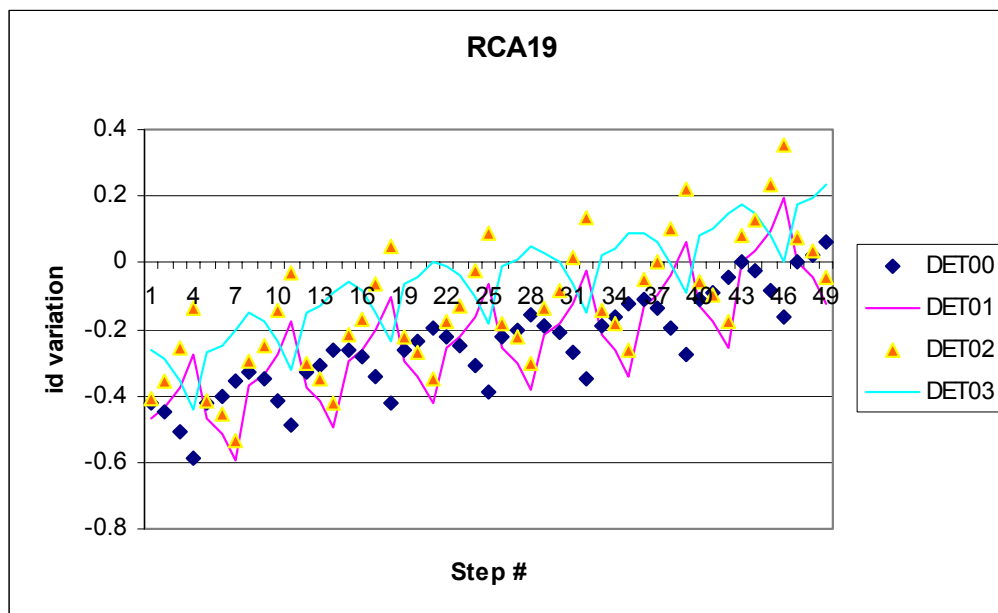


Figure 1 Id variation vs Vg1-Vg2 configuration (step #) for the 4 ACAs of RCA 19

- 3) Among the possible 49 combinations of Vg1 and Vg2 available for each leg, many are not useful since set the instrument in a status very far from the tuned one: hence, they should be discarded: several (the number and values depending on the ACA and RCA) Vg1-Vg2 combinations produce unacceptable currents (  $|\Delta id| > 40\%$  ) as several Vg1 or Vg2 independent changes (  $|\Delta id| > 25\%$  ). Superposing the two parameters the range of parameters to be explored (among those used in RAA calibrations) reduces sensibly.
- 4) The range explored during RAA calibrations in many cases is not symmetrical around the 'tuned value' that, in several cases: it was found to be the extreme (lowest or highest) value applied in the full range. In some cases could be then useful to symmetrise it around the expected optimum bias.



| RCA 19 |        |     |             |        |     |             |        |     |             |        |     |             |
|--------|--------|-----|-------------|--------|-----|-------------|--------|-----|-------------|--------|-----|-------------|
| STEP # | DET 00 |     |             | DET 01 |     |             | DET 02 |     |             | DET 03 |     |             |
|        | Vg1    | Vg2 | Id expected | Vg1    | Vg2 | Id expected | Vg1    | Vg2 | Id expected | Vg1    | Vg2 | Id expected |
| 1      | 168    | 201 | 10.86       | 166    | 193 | 3.12        | 172    | 204 | 9.22        | 159    | 201 | 10.41       |
| 2      | 168    | 196 | 9.76        | 166    | 198 | 4.81        | 172    | 209 | 9.92        | 159    | 196 | 9.95        |
| 3      | 168    | 186 | 7.79        | 166    | 208 | 6.03        | 172    | 219 | 11.35       | 159    | 186 | 9.12        |
| 4      | 168    | 171 | 5.43        | 166    | 223 | 6.69        | 172    | 234 | 13.51       | 159    | 171 | 7.98        |
| 5      | 168    | 206 | 9.58        | 166    | 188 | 7.37        | 172    | 199 | 9.19        | 159    | 206 | 10.45       |
| 6      | 168    | 216 | 12.00       | 166    | 178 | 8.72        | 172    | 189 | 8.55        | 159    | 216 | 10.87       |
| 7      | 168    | 231 | 14.31       | 166    | 163 | 10.82       | 172    | 174 | 11.86       | 159    | 231 | 11.81       |
| 8      | 183    | 201 | 12.48       | 181    | 193 | 4.81        | 187    | 204 | 11.12       | 174    | 201 | 11.87       |
| 9      | 183    | 196 | 11.37       | 181    | 198 | 6.50        | 187    | 209 | 11.81       | 174    | 196 | 11.42       |
| 10     | 183    | 186 | 9.41        | 181    | 208 | 7.73        | 187    | 219 | 13.25       | 174    | 186 | 10.58       |
| 11     | 183    | 171 | 7.05        | 181    | 223 | 8.39        | 187    | 234 | 15.41       | 174    | 171 | 9.44        |
| 12     | 183    | 206 | 11.20       | 181    | 188 | 9.06        | 187    | 199 | 11.09       | 174    | 206 | 11.92       |
| 13     | 183    | 216 | 13.62       | 181    | 178 | 10.42       | 187    | 189 | 10.44       | 174    | 216 | 12.33       |
| 14     | 183    | 231 | 15.93       | 181    | 163 | 12.52       | 187    | 174 | 13.75       | 174    | 231 | 13.27       |
| 15     | 193    | 201 | 13.80       | 191    | 193 | 6.03        | 197    | 204 | 12.62       | 184    | 201 | 12.97       |
| 16     | 193    | 196 | 12.69       | 191    | 198 | 7.73        | 197    | 209 | 13.32       | 184    | 196 | 12.51       |
| 17     | 193    | 186 | 10.73       | 191    | 208 | 8.95        | 197    | 219 | 14.75       | 184    | 186 | 11.68       |
| 18     | 193    | 171 | 8.37        | 191    | 223 | 9.61        | 197    | 234 | 16.91       | 184    | 171 | 10.54       |
| 19     | 193    | 206 | 12.52       | 191    | 188 | 10.29       | 197    | 199 | 12.59       | 184    | 206 | 13.01       |
| 20     | 193    | 216 | 14.94       | 191    | 178 | 11.64       | 197    | 189 | 11.94       | 184    | 216 | 13.43       |
| 21     | 193    | 231 | 17.25       | 191    | 163 | 13.74       | 197    | 174 | 15.25       | 184    | 231 | 14.37       |
| 22     | 198    | 201 | 14.50       | 196    | 193 | 6.69        | 202    | 204 | 13.41       | 189    | 201 | 13.55       |
| 23     | 198    | 196 | 13.40       | 196    | 198 | 8.39        | 202    | 209 | 14.11       | 189    | 196 | 13.10       |
| 24     | 198    | 186 | 11.43       | 196    | 208 | 9.61        | 202    | 219 | 15.54       | 189    | 186 | 12.27       |
| 25     | 198    | 171 | 9.07        | 196    | 223 | 10.27       | 202    | 234 | 17.71       | 189    | 171 | 11.12       |
| 26     | 198    | 206 | 13.23       | 196    | 188 | 10.95       | 202    | 199 | 13.38       | 189    | 206 | 13.60       |
| 27     | 198    | 216 | 15.64       | 196    | 178 | 12.30       | 202    | 189 | 12.74       | 189    | 216 | 14.01       |
| 28     | 198    | 231 | 17.95       | 196    | 163 | 14.40       | 202    | 174 | 16.05       | 189    | 231 | 14.95       |
| 29     | 203    | 201 | 15.27       | 201    | 193 | 7.37        | 207    | 204 | 14.24       | 194    | 201 | 14.14       |
| 30     | 203    | 196 | 14.17       | 201    | 198 | 9.06        | 207    | 209 | 14.93       | 194    | 196 | 13.68       |
| 31     | 203    | 186 | 12.20       | 201    | 208 | 10.29       | 207    | 219 | 16.37       | 194    | 186 | 12.85       |
| 32     | 203    | 171 | 9.84        | 201    | 223 | 10.95       | 207    | 234 | 18.53       | 194    | 171 | 11.71       |
| 33     | 203    | 206 | 14.00       | 201    | 188 | 11.62       | 207    | 199 | 14.21       | 194    | 206 | 14.18       |
| 34     | 203    | 216 | 16.42       | 201    | 178 | 12.98       | 207    | 189 | 13.56       | 194    | 216 | 14.60       |
| 35     | 203    | 231 | 18.73       | 201    | 163 | 15.08       | 207    | 174 | 16.87       | 194    | 231 | 15.54       |
| 36     | 213    | 201 | 16.87       | 211    | 193 | 8.72        | 217    | 204 | 15.95       | 204    | 201 | 15.35       |
| 37     | 213    | 196 | 15.77       | 211    | 198 | 10.42       | 217    | 209 | 16.65       | 204    | 196 | 14.90       |
| 38     | 213    | 186 | 13.80       | 211    | 208 | 11.64       | 217    | 219 | 18.08       | 204    | 186 | 14.07       |
| 39     | 213    | 171 | 11.44       | 211    | 223 | 12.30       | 217    | 234 | 20.24       | 204    | 171 | 12.92       |
| 40     | 213    | 206 | 15.60       | 211    | 188 | 12.98       | 217    | 199 | 15.92       | 204    | 206 | 15.40       |
| 41     | 213    | 216 | 18.02       | 211    | 178 | 14.33       | 217    | 189 | 15.28       | 204    | 216 | 15.81       |
| 42     | 213    | 231 | 20.33       | 211    | 163 | 16.43       | 217    | 174 | 18.59       | 204    | 231 | 16.75       |
| 43     | 228    | 201 | 19.41       | 226    | 193 | 10.82       | 232    | 204 | 18.61       | 219    | 201 | 17.26       |
| 44     | 228    | 196 | 18.31       | 226    | 198 | 12.52       | 232    | 209 | 19.31       | 219    | 196 | 16.80       |
| 45     | 228    | 186 | 16.34       | 226    | 208 | 13.74       | 232    | 219 | 20.74       | 219    | 186 | 15.97       |
| 46     | 228    | 171 | 13.98       | 226    | 223 | 14.40       | 232    | 234 | 22.91       | 219    | 171 | 14.82       |
| 47     | 228    | 206 | 18.14       | 226    | 188 | 15.08       | 232    | 199 | 18.59       | 219    | 206 | 17.30       |
| 48     | 228    | 216 | 20.56       | 226    | 178 | 16.43       | 232    | 189 | 17.94       | 219    | 216 | 17.72       |
| 49     | 228    | 231 | 22.87       | 226    | 163 | 18.53       | 232    | 174 | 21.25       | 219    | 231 | 18.65       |

Figure 2 expected currents for the bias variation following the order described above (numbers based on Vg1 and Vg2 bias applied during instrument level test campaign).



## 5 METHOD USED FOR CURRENTS CALCULATIONS

We have not a model able to predict the drain current of any bias combination. LABEN's model is able to recalculate the equivalent bias when you switch ON / OFF an ACA in the same power group, given a fixed current, but not to calculate the expected current 'a priori' when you change a bias.

Hence, at present, we have just, from experimental data, for each leg:

- Currents corresponding to 7 Vg1 steps with fixed Vg2 ( set to the optimized value indicated from RCA tuning)
- Currents corresponding to 7 Vg2 steps with fixed Vg1 ( set to the optimized value indicated from RAA Vg1 tuning)

To have a simple guess of the expected current change due to the 49 bias combinations we can suppose that Vg1 and Vg2 changes produce independent current changes and then can be tabulated and mixed together obtaining the total current variations just by summing them.

This should be true for 30 GHz and 44 GHz channels , since Vg1 and Vg2 stages are physically separated; for 70 GHz channels it is not absolutely true, since Vg1 and Vg2 are somehow interconnected . However it seems that , at the first order (to be verified the uncertainty with Hylinen) , this method could provide a reasonable result also for 70 GHz.

Expected currents have been calculated for all the legs and compared (%) with the nominal currents ( tuned bias).

The model for expected currents calculation was tested on the Flight Spares. Results are encouraging, as displayed in the two plots below (Figure 3 and Figure 4) , , showing comparison between measured data (red line) and calculated currents following the above method.

Differences are always within 5% w.r.t. the nominal (tuned ) bias when covering a range in current [-40% : + 60%]. The difference between measured and calculated data is about linear, as shown by Figure 4, with a spread of about 5%. It must also be noted that comparison between measured currents corresponding to the same bias couple Vg1Vg2 in the classic tuning ( used to calculate expected currents) and in the matrix tuning gives already a difference by about 2.2% that must be considered as the uncertainty related with the current reading between two similar configurations in different times. These results will be fully commented in the

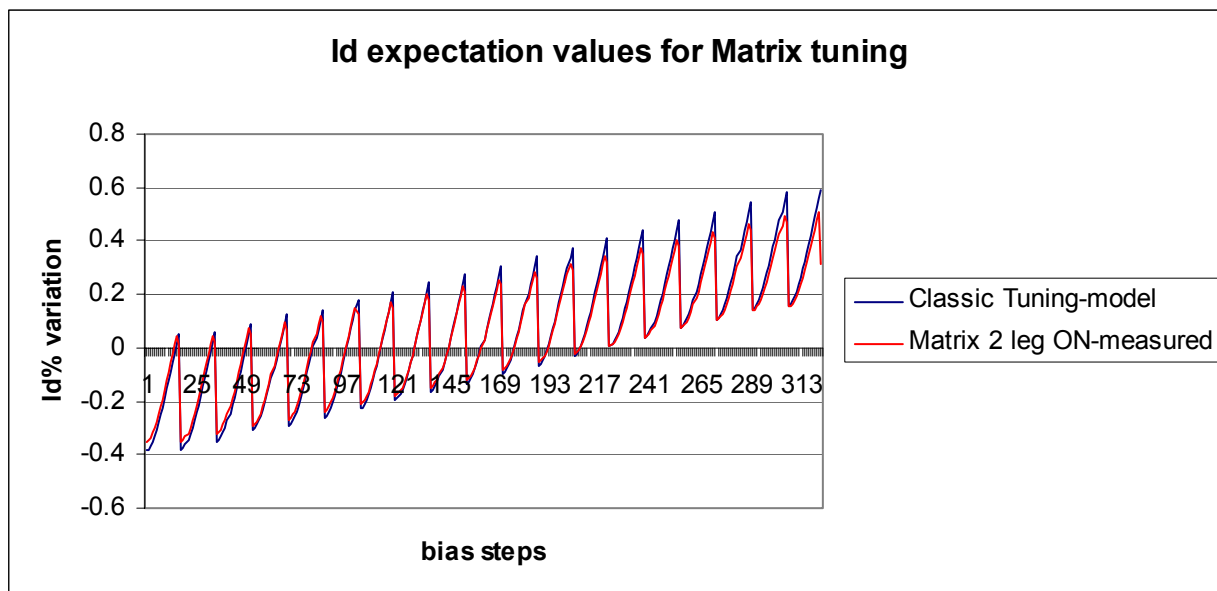


Figure 3

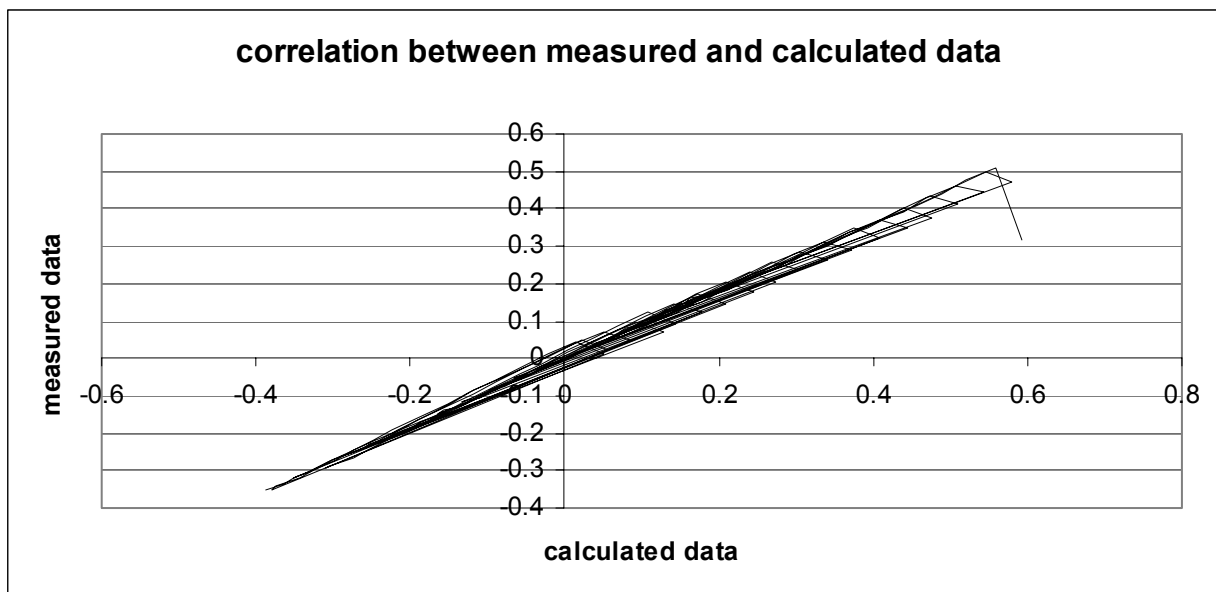


Figure 4

### 5.1 Criteria to discriminate 'unbelievable' results:

Many combinations produce currents far from the expected ones .

As described before, two criteria can be superposed to eliminate what is not-realistic.

In [RD 2][RD 1], performances ( noise Temperature and Isolation) are plotted for each channel versus currents. In particular, it comes out that a range in current between  $[-10\% : +10\%]$  of the nominal value ( corresponding to tuned bias) should be satisfactory to explore a meaningful region. Look for example at Figure 5 and Figure 6.

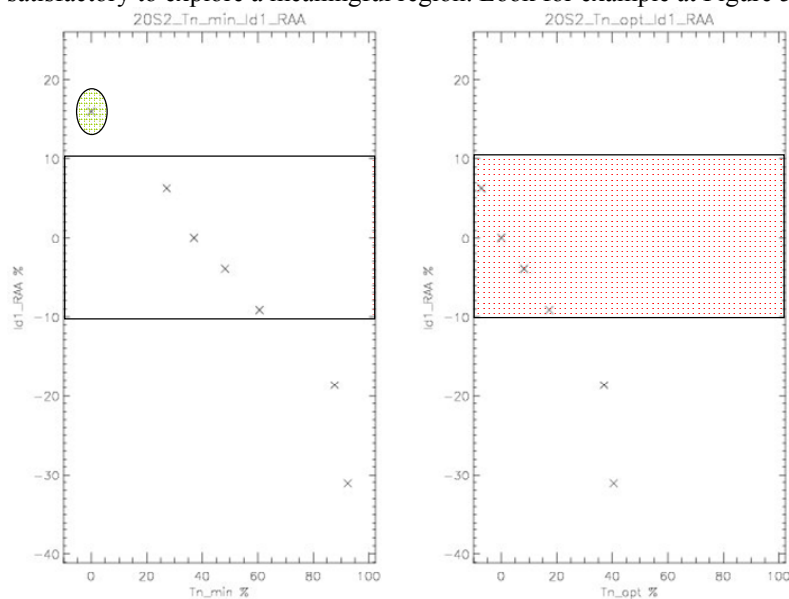
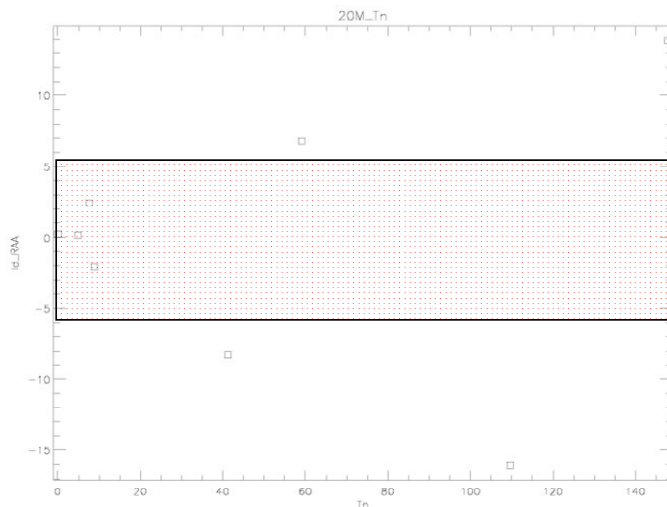


Figure 5 Noise temperature dependence with drain current during Vg1 tuning.



**Figure 6 Isolation dependence with drain current during Vg2 Tuning.**

The criterion for ISO variation with current could be also tighter ,  $[-5\% : +5\%]$ , but to be conservative we can use the same of Vg1.

The second criterion to match with the above is that constraining the total current variation caused by simultaneous variations of Vg1 and Vg2. This requirement will be stronger than the sum of Vg1 and Vg2 req. and softer than Vg1 or Vg2 alone.

Variations will be referred to the nominal (RAA tuned bias) drain current for that leg.



## 6 PHYLOSOPHY FOR CSL

In order to define the range, the number of points and the values to be applied it is important to understand and define in advance the scope of the tests.

It is important to notice that:

A calibration was already done during the RAA test campaign, using a different strategy (classic tuning with separated Vg1 and Vg2 ramps).

A new calibration (the final one) will be done in flight (CPV), in principle using the Matrix tuning.

Matrix tuning have been tested during the FS (flight spare) test campaign , but just on ½ FEM (30 GHz).

Scope of the CSL test campaign can be double:

- Investigate functionality and capability to run the test for the 1<sup>st</sup> time
- Investigate performances and try to get as much information as possible , to use these data as input for CPV phase ( and, in case of any failure in tuning during CPV, as final values)

Depending on the scope, the range to be explored can be enlarged, just avoiding those values that evidently produce unbelievable results, or restricted, exploring a narrow spaced grid. A parametric analysis is provided in APPENDIX 3



## 7 PROPOSAL

The proposal for CSL is something mixing the two possible objectives; this can be obtained matching different steps, as follows.

Relaxing something more requirements on  $V_{g1}$  and  $V_{g2}$  tuning  $I_d$  currents: up to  $[-15\% : +15\%]$

Putting a requirement on total current variation  $[-25\% : +25\%]$

Symmetrising the interval around the expected tuned value.

Applying also all the  $V_{g1}$  and  $V_{g2}$  combinations (13) already explored during the RAA test campaign, to have a check of repeatability.

Ordering the bias application in time in terms of expected drain currents, in order to have not an abrupt variation producing a slow drift and requiring an integration time longer ( especially 70 GHz channels ).

The requirements can be eventually enlarged by adding the uncertainty in drain currents, characteristic of each leg, observed when switching on the LFI with nominal tuned bias.

From a technical point of view, it could be solved as follows.

### 7.1 Proposed implementation:

Since we need to customize tables for each leg, we propose to write a dedicated table for each couple (except the case of RCA 28 that is tuned alone) of legs.

Here are two possibilities:

- 1) FIRST CASE: the table contains just the bias of the legs under tuning. Each row corresponds to a couple of  $V_{g1}$  and  $V_{g2}$  to be applied (step #). It means that each table has the shape as below (the table can also be double, containing the parameters of both channels to be tuned simultaneously, but the RCA 28)



| RCA 19 |        |     |             |        |     |             |        |     |             |        |     |             |
|--------|--------|-----|-------------|--------|-----|-------------|--------|-----|-------------|--------|-----|-------------|
| STEP # | DET 00 |     |             | DET 01 |     |             | DET 02 |     |             | DET 03 |     |             |
|        | Vg1    | Vg2 | Id expected | Vg1    | Vg2 | Id expected | Vg1    | Vg2 | Id expected | Vg1    | Vg2 | Id expected |
| 1      | 168    | 171 | 5.43        | 166    | 193 | 3.12        | 172    | 189 | 8.55        | 159    | 171 | 7.98        |
| 2      | 183    | 171 | 7.05        | 166    | 198 | 4.81        | 172    | 199 | 9.19        | 159    | 186 | 9.12        |
| 3      | 168    | 186 | 7.79        | 181    | 193 | 4.81        | 172    | 204 | 9.22        | 174    | 171 | 9.44        |
| 4      | 193    | 171 | 8.37        | 166    | 208 | 6.03        | 172    | 209 | 9.92        | 159    | 196 | 9.95        |
| 5      | 198    | 171 | 9.07        | 191    | 193 | 6.03        | 187    | 189 | 10.44       | 159    | 201 | 10.41       |
| 6      | 183    | 186 | 9.41        | 181    | 198 | 6.50        | 187    | 199 | 11.09       | 159    | 206 | 10.45       |
| 7      | 168    | 206 | 9.58        | 166    | 223 | 6.69        | 187    | 204 | 11.12       | 184    | 171 | 10.54       |
| 8      | 168    | 196 | 9.76        | 196    | 193 | 6.69        | 172    | 219 | 11.35       | 174    | 186 | 10.58       |
| 9      | 203    | 171 | 9.84        | 166    | 188 | 7.37        | 187    | 209 | 11.81       | 159    | 216 | 10.87       |
| 10     | 193    | 186 | 10.73       | 201    | 193 | 7.37        | 172    | 174 | 11.86       | 189    | 171 | 11.12       |
| 11     | 168    | 201 | 10.86       | 181    | 208 | 7.73        | 197    | 189 | 11.94       | 174    | 196 | 11.42       |
| 12     | 183    | 206 | 11.20       | 191    | 198 | 7.73        | 197    | 199 | 12.59       | 184    | 186 | 11.68       |
| 13     | 183    | 196 | 11.37       | 181    | 223 | 8.39        | 197    | 204 | 12.62       | 194    | 171 | 11.71       |
| 14     | 198    | 186 | 11.43       | 196    | 198 | 8.39        | 202    | 189 | 12.74       | 159    | 231 | 11.81       |
| 15     | 213    | 171 | 11.44       | 166    | 178 | 8.72        | 187    | 219 | 13.25       | 174    | 201 | 11.87       |
| 16     | 168    | 216 | 12.00       | 211    | 193 | 8.72        | 197    | 209 | 13.32       | 174    | 206 | 11.92       |
| 17     | 203    | 186 | 12.20       | 191    | 208 | 8.95        | 202    | 199 | 13.38       | 189    | 186 | 12.27       |
| 18     | 183    | 201 | 12.48       | 181    | 188 | 9.06        | 202    | 204 | 13.41       | 174    | 216 | 12.33       |
| 19     | 193    | 206 | 12.52       | 201    | 198 | 9.06        | 172    | 234 | 13.51       | 184    | 196 | 12.51       |
| 20     | 193    | 196 | 12.69       | 191    | 223 | 9.61        | 207    | 189 | 13.56       | 194    | 186 | 12.85       |
| 21     | 198    | 206 | 13.23       | 196    | 208 | 9.61        | 187    | 174 | 13.75       | 204    | 171 | 12.92       |
| 22     | 198    | 196 | 13.40       | 196    | 223 | 10.27       | 202    | 209 | 14.11       | 184    | 201 | 12.97       |
| 23     | 183    | 216 | 13.62       | 191    | 188 | 10.29       | 207    | 199 | 14.21       | 184    | 206 | 13.01       |
| 24     | 193    | 201 | 13.80       | 201    | 208 | 10.29       | 207    | 204 | 14.24       | 189    | 196 | 13.10       |
| 25     | 213    | 186 | 13.80       | 181    | 178 | 10.42       | 197    | 219 | 14.75       | 174    | 231 | 13.27       |
| 26     | 228    | 171 | 13.98       | 211    | 198 | 10.42       | 207    | 209 | 14.93       | 184    | 216 | 13.43       |
| 27     | 203    | 206 | 14.00       | 166    | 163 | 10.82       | 197    | 174 | 15.25       | 189    | 201 | 13.55       |
| 28     | 203    | 196 | 14.17       | 226    | 193 | 10.82       | 217    | 189 | 15.28       | 189    | 206 | 13.60       |
| 29     | 168    | 231 | 14.31       | 196    | 188 | 10.95       | 187    | 234 | 15.41       | 194    | 196 | 13.68       |
| 30     | 198    | 201 | 14.50       | 201    | 223 | 10.95       | 202    | 219 | 15.54       | 189    | 216 | 14.01       |
| 31     | 193    | 216 | 14.94       | 201    | 188 | 11.62       | 217    | 199 | 15.92       | 204    | 186 | 14.07       |
| 32     | 203    | 201 | 15.27       | 191    | 178 | 11.64       | 217    | 204 | 15.95       | 194    | 201 | 14.14       |
| 33     | 213    | 206 | 15.60       | 211    | 208 | 11.64       | 202    | 174 | 16.05       | 194    | 206 | 14.18       |
| 34     | 198    | 216 | 15.64       | 196    | 178 | 12.30       | 207    | 219 | 16.37       | 184    | 231 | 14.37       |
| 35     | 213    | 196 | 15.77       | 211    | 223 | 12.30       | 217    | 209 | 16.65       | 194    | 216 | 14.60       |
| 36     | 183    | 231 | 15.93       | 181    | 163 | 12.52       | 207    | 174 | 16.87       | 219    | 171 | 14.82       |
| 37     | 228    | 186 | 16.34       | 226    | 198 | 12.52       | 197    | 234 | 16.91       | 204    | 196 | 14.90       |
| 38     | 203    | 216 | 16.42       | 201    | 178 | 12.98       | 202    | 234 | 17.71       | 189    | 231 | 14.95       |
| 39     | 213    | 201 | 16.87       | 211    | 188 | 12.98       | 232    | 189 | 17.94       | 204    | 201 | 15.35       |
| 40     | 193    | 231 | 17.25       | 191    | 163 | 13.74       | 217    | 219 | 18.08       | 204    | 206 | 15.40       |
| 41     | 198    | 231 | 17.95       | 226    | 208 | 13.74       | 207    | 234 | 18.53       | 194    | 231 | 15.54       |
| 42     | 213    | 216 | 18.02       | 211    | 178 | 14.33       | 217    | 174 | 18.59       | 204    | 216 | 15.81       |
| 43     | 228    | 206 | 18.14       | 196    | 163 | 14.40       | 232    | 199 | 18.59       | 219    | 186 | 15.97       |
| 44     | 228    | 196 | 18.31       | 226    | 223 | 14.40       | 232    | 204 | 18.61       | 204    | 231 | 16.75       |
| 45     | 203    | 231 | 18.73       | 201    | 163 | 15.08       | 232    | 209 | 19.31       | 219    | 196 | 16.80       |
| 46     | 228    | 201 | 19.41       | 226    | 188 | 15.08       | 217    | 234 | 20.24       | 219    | 201 | 17.26       |
| 47     | 213    | 231 | 20.33       | 211    | 163 | 16.43       | 232    | 219 | 20.74       | 219    | 206 | 17.30       |
| 48     | 228    | 216 | 20.56       | 226    | 178 | 16.43       | 232    | 174 | 21.25       | 219    | 216 | 17.72       |
| 49     | 228    | 231 | 22.87       | 226    | 163 | 18.53       | 232    | 234 | 22.91       | 219    | 231 | 18.65       |

Figure 7 ORDERED TABLE (id increasing for each leg) representing the bias to be changed in the RCA 19 for each leg ( DET #); also expectation currents are displayed, but shall not be used as input parameters ( just to compare with results)

In this case we need:

- a) a unique reference table with the bias of all RCA (11\* 4 legs) in 'nominal' conditions

+

- b) 5 ( groups of RCA tuned simultaneously) + 1 ( RCA 28) = 6 tables containing just the bias to be varied at the same time (step #); The RCA # and the detector number # will be selected by SW, example:

For i=0,5

For j=0,3

For k=0, 48

number of groups from table 1

number of ACA (DET #)

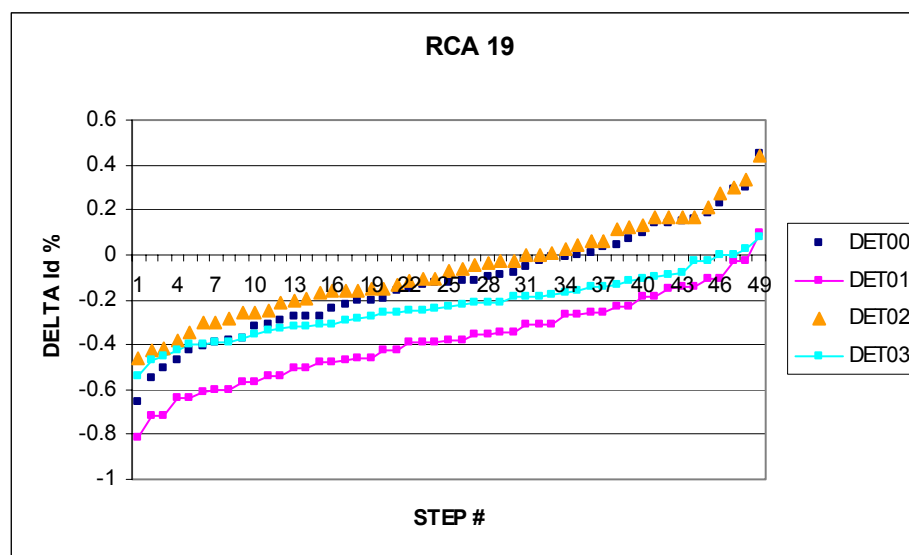
number of steps (raws ) in FIG.2



- apply: group (i), ACA (j),  $V_{g1}(k)$ ,  $V_{g2}(k)$
- For  $l=0,5$  with  $l \neq i$  apply the standard table to channels not under tuning (table at point a)
- 2) **SECOND CASE**: the table contains the bias to be applied to all the RCA# for each step #. It means that a table for each leg is required. It is:  
 $4(\text{ACAs}) * [5 (\text{groups of RCA tuned simultaneously}) + 1 (\text{RCA 28})] = 24 \text{ tables}$

At this point, the difference between 1 and 2 it is just a problem of SW implementation but in both cases this solutions will allow to:

- 1) have a custom grid of values among witch to move, discarding in advance all the nonsense couple of bias. Include
- 2) include particular values important to be verified ( as the values explored during instrument level and RCA level tests ), to check for method validity and differences.
- 3) Have a regular variation of bias , producing an expected regular variation of currents , as displayed in the figure below, after having reordered the couple of bias as in Fig 2 .



**Figure 8 Example (RCA19) drain current variation after reordering of bias couples.**

Both implementations described above are equivalent and allow to have a time margin to set the final bias , while THASF is writing the procedure to send TCs.

Attached to this document, in the **APPENDIX**, you can find the justification of many numbers given in this document :



### APPENDIX 1)

analysis displaying the Noise temperature vs. Drain current for all channels (RAA Tun). Noise Temperature variations (%) are referred to the minimum value registered ( left panel) that not always is coincident with that chosen (left panel); drain current variations consistent with the Tn considered in the panel ( minimum Tn on the left and optimized Tn on the right).

It is evident that, in all cases, a variation by 10% in drain current is sufficient to produce a variation by 40 % in noise temperature (70 GHz channels) while in the case of 30 GHz and 44 GHz channels the response is quite flat .

### APPENDIX 2)

analysis displaying the Noise temperature and Isolation vs. Drain current for all channels (RAA Vg2 Tun) and the Noise temperature vs. Isolation

It comes out that a variation in drain current also by 5% is able to produce a large variation in noise temperature and much higher in Isolation ( as it is evident from the plots displaying Noise temperature vs Isolation)

### APPENDIX 3)

Results (tables) from Excel file (attached to this document, "SUMMARY\_1.4.xls" ) containing all the combinations of bias explored during RAA calibration, ordered considering parametric requirements in terms of Id (Vg1), Id (Vg2) and total current deviation from the nominal (tuned ) value. It is possible to change requirements from sheet "SUMMARY\_COMBIN\_<X.X"; the useful combinations Vg1Vg2 obtained, responding to requirements set, are reported in sheets from 'riepilogo 19' to riepilogo 28'.

The starting point, that is the Vg1 and Vg2 bias vectors applied during RAA tests , are reported in sheet 'MATRIX LABEN', containing also the electrical configuration of the channels belonging to the same power group.

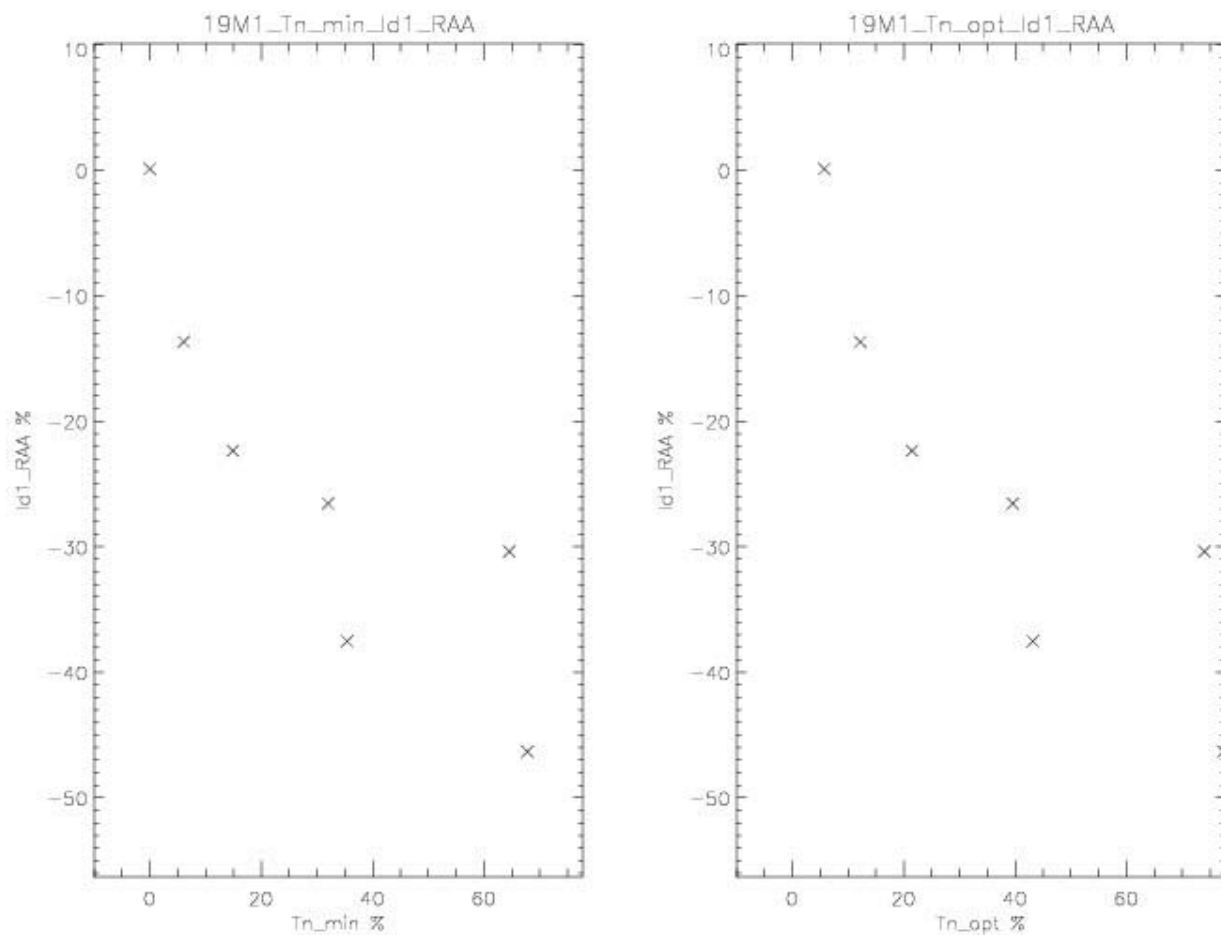
Most significant results are displayed in the plots contained in APPENDIX 3: in all cases it is evident that for 30 GHz channels could be set a much tighter requirement, due to the flatness of the response in the range explored.

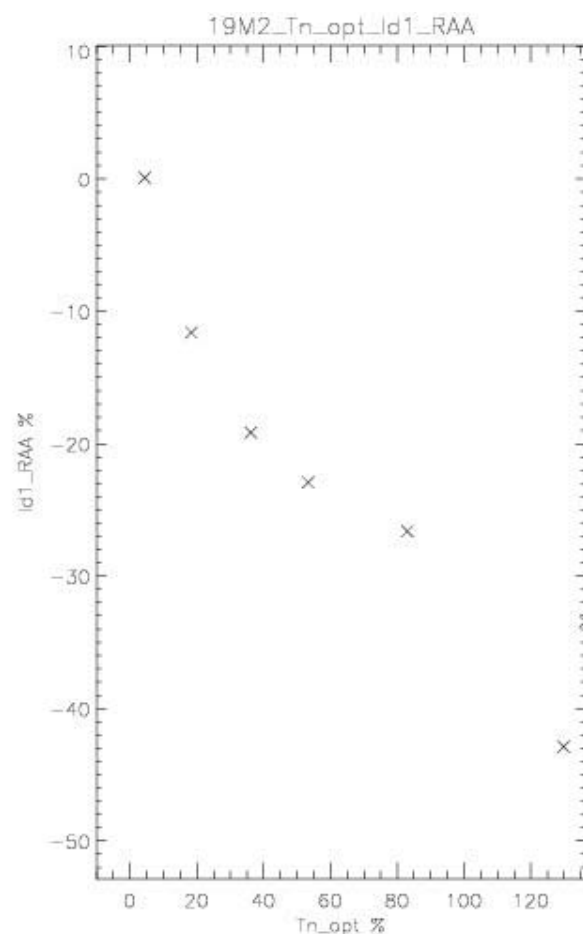
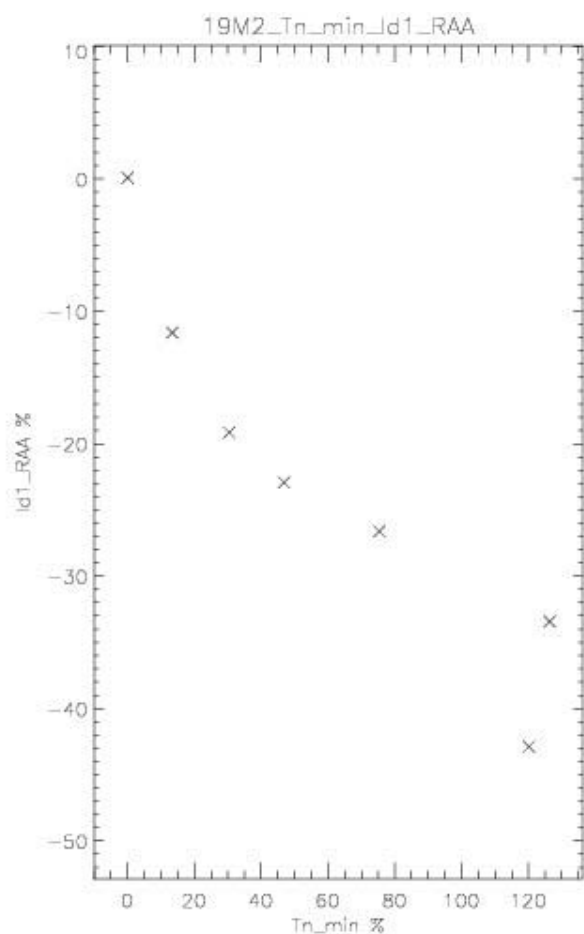
The number of useful combinations is here explored and displayed when varying requirements.

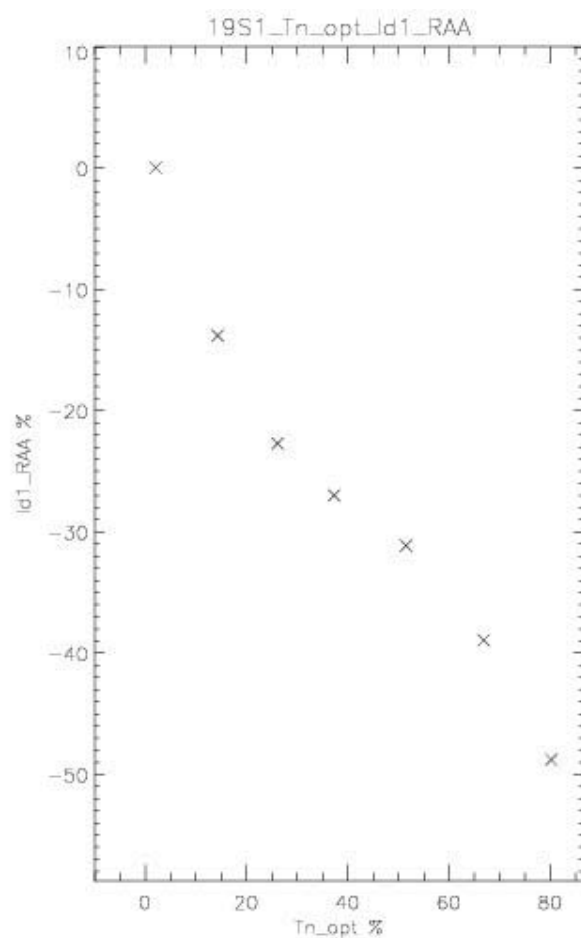
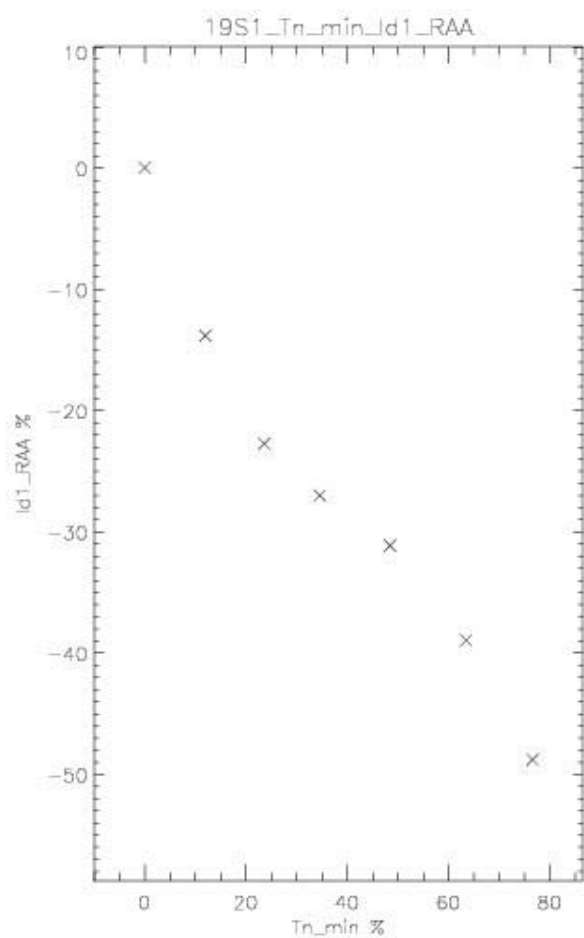
The expected (calculated as shown above) unordered and ordered drain current variation with Vg1Vg2 combination is displayed too in the further plots.

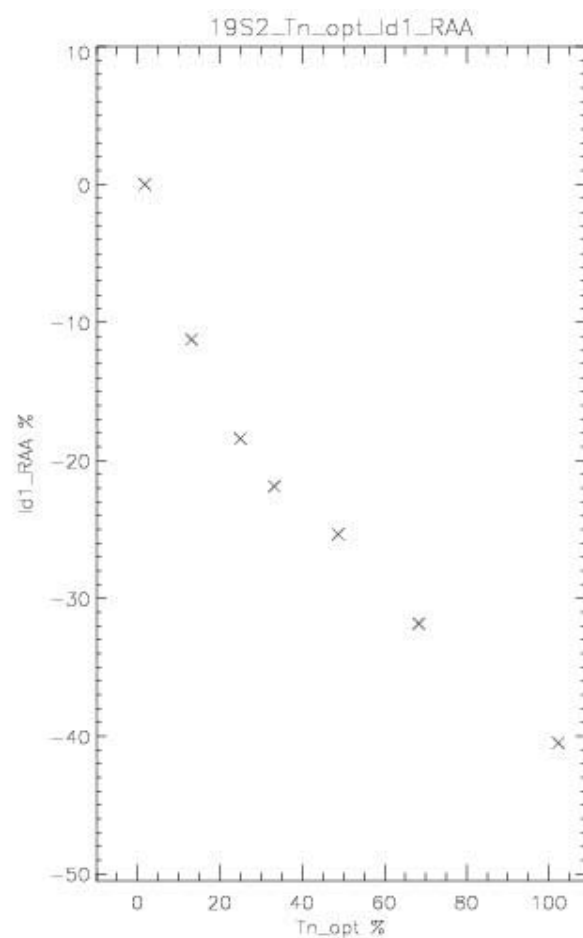
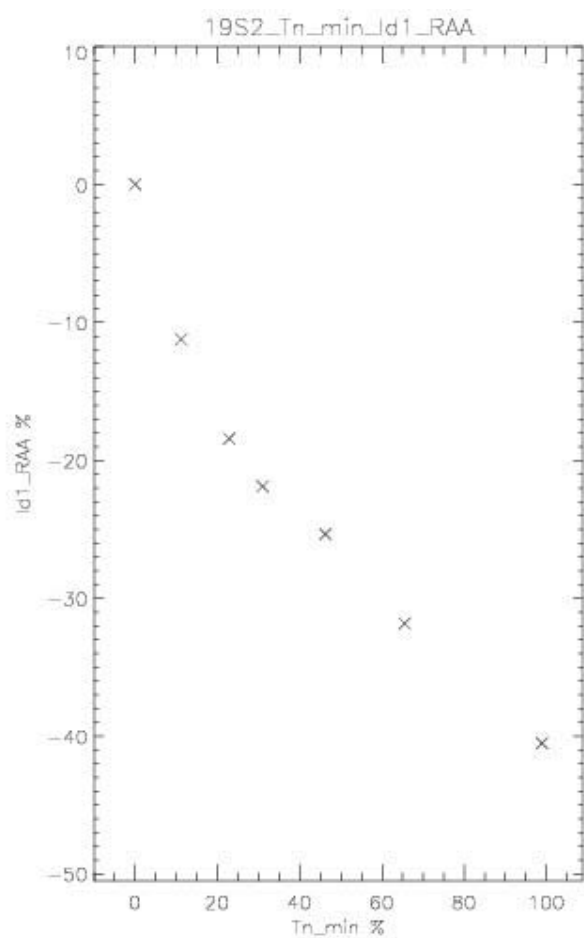


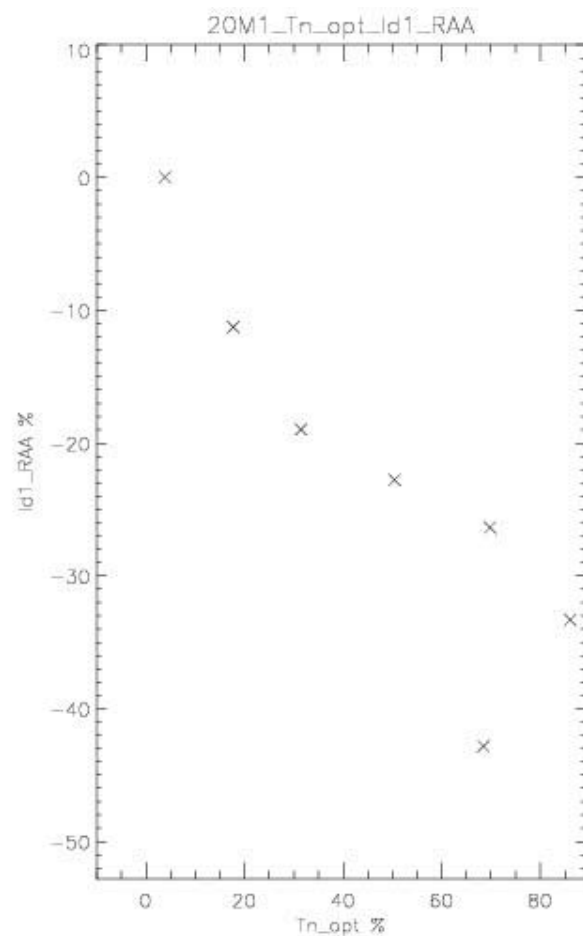
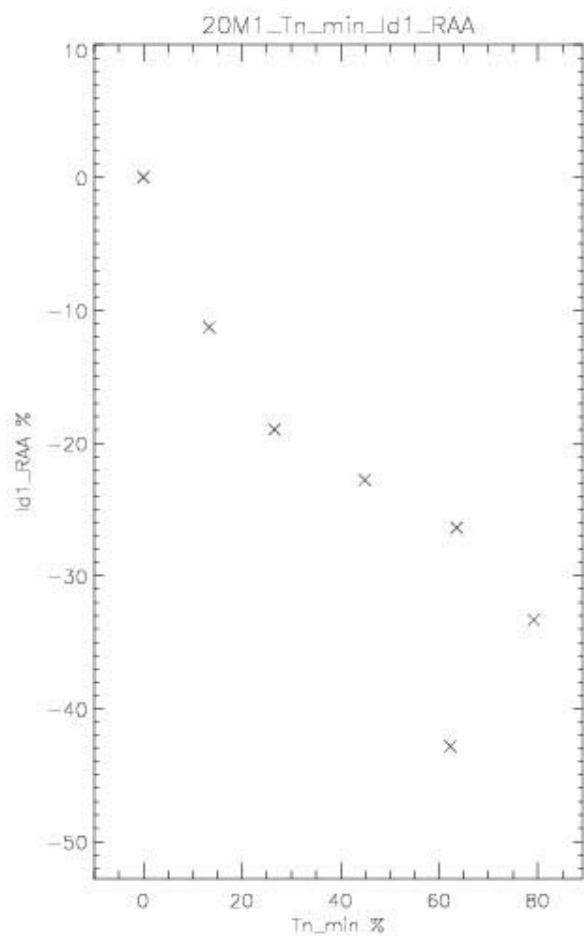
## 8 APPENDIX 1: VG1 RAA TUNING. Noise Temperature susceptibility LNA to drain current

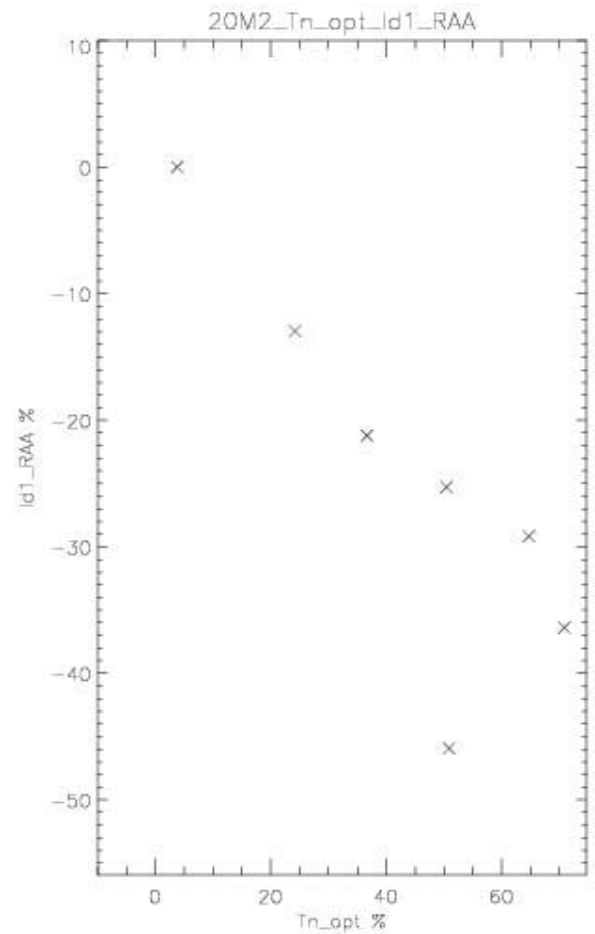
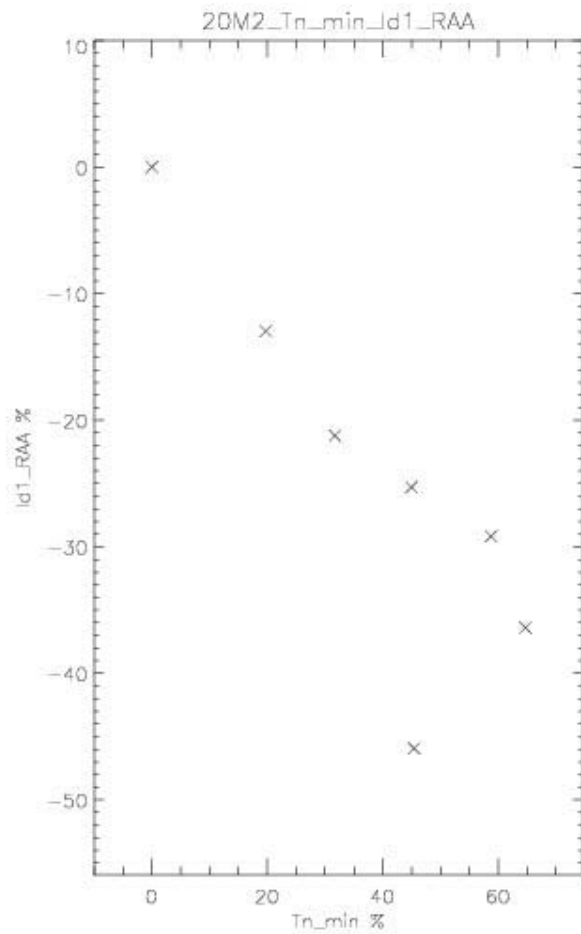


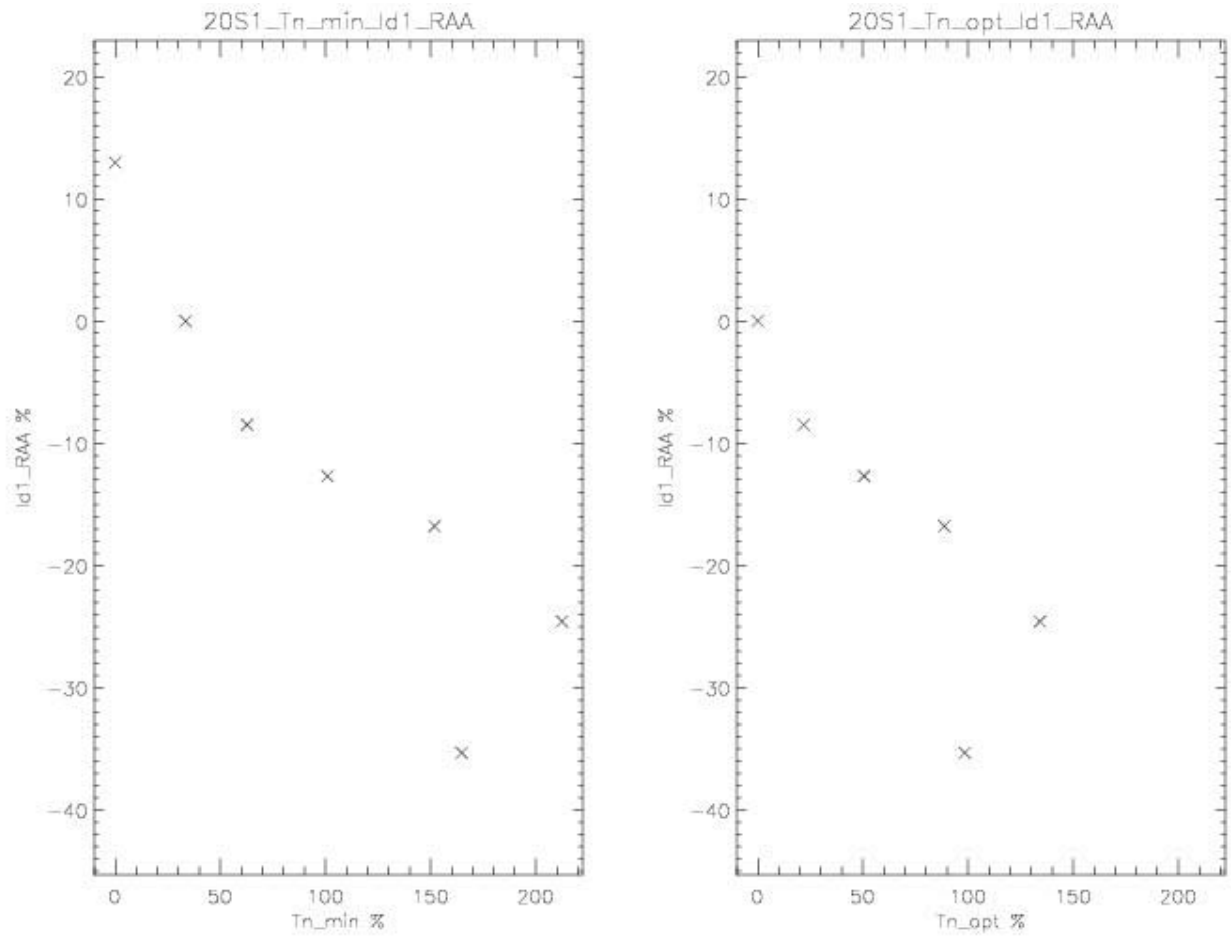


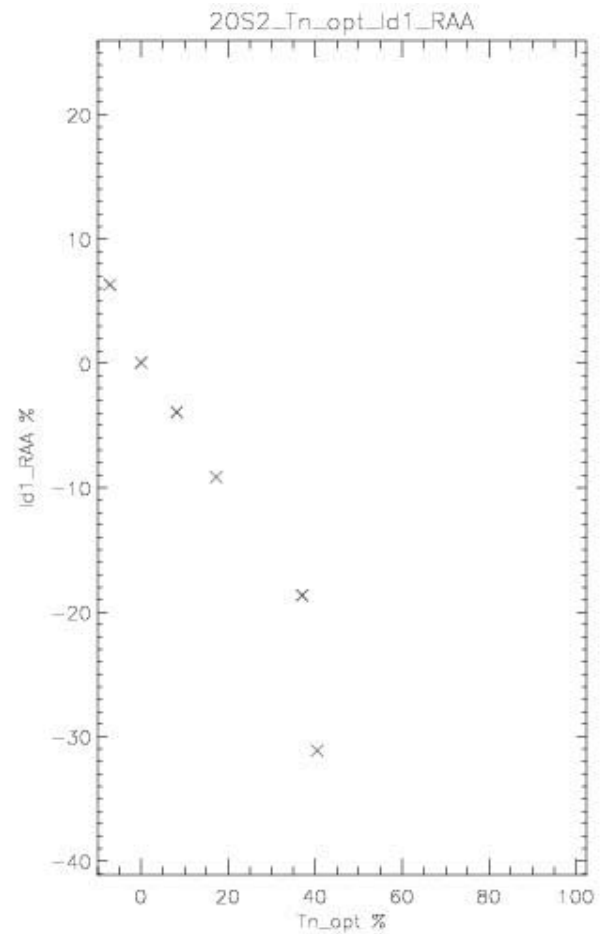
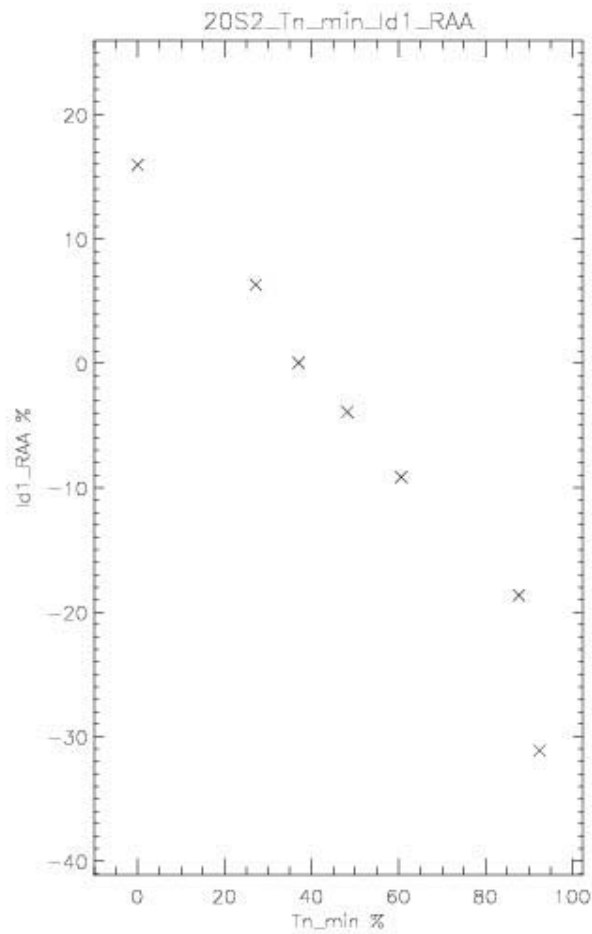


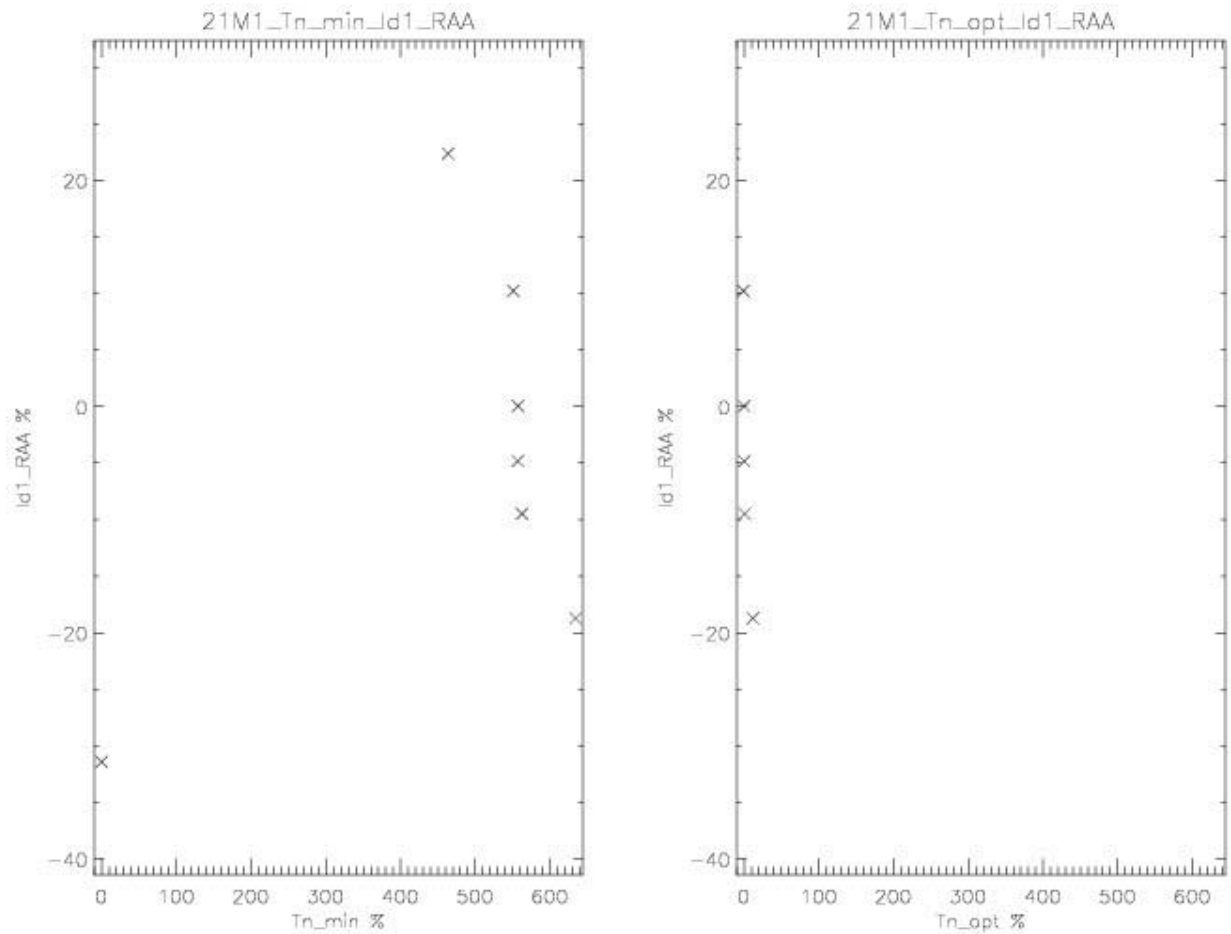


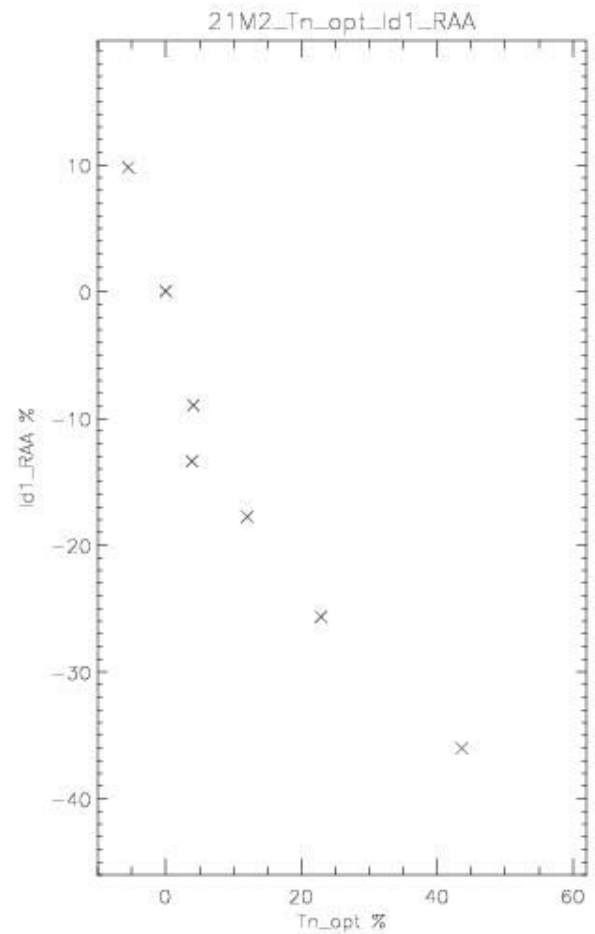
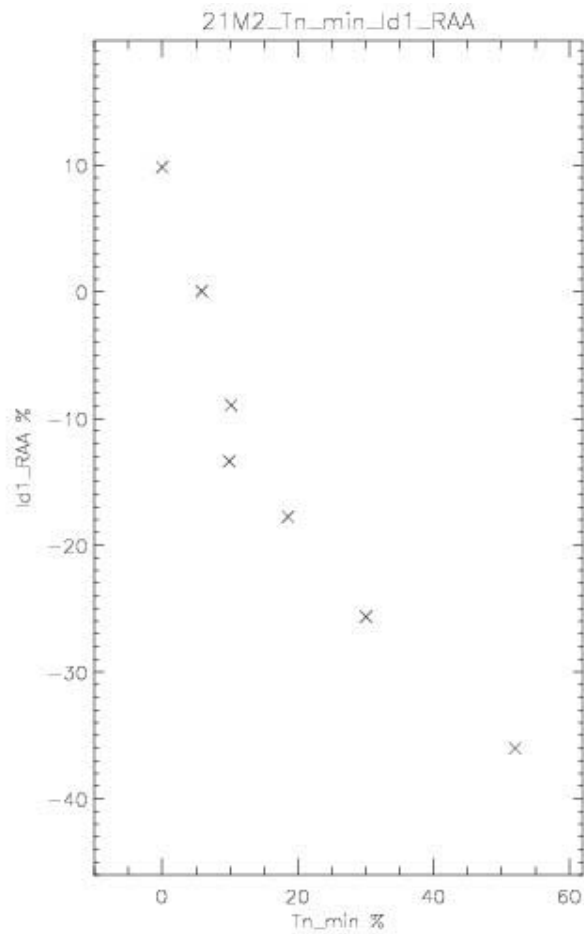


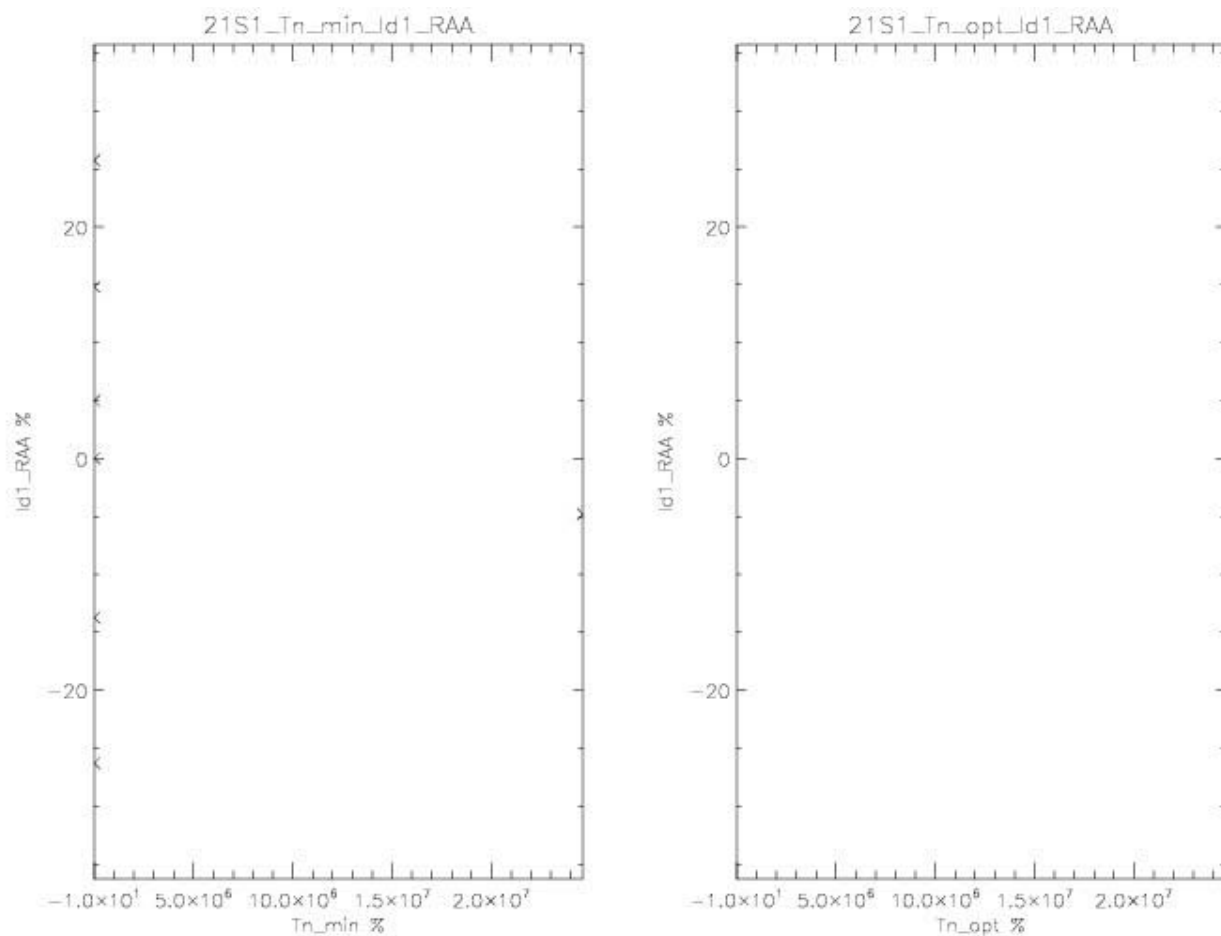


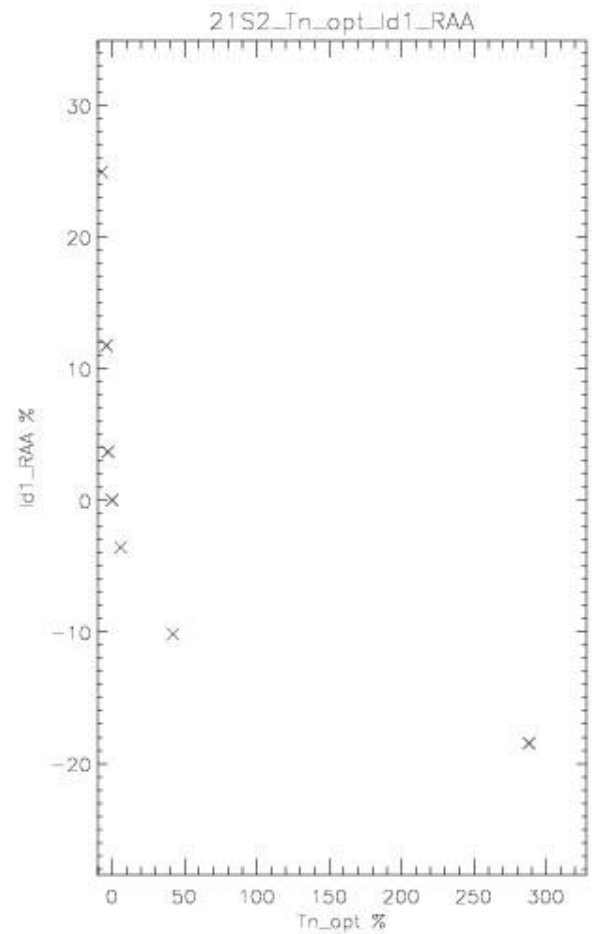
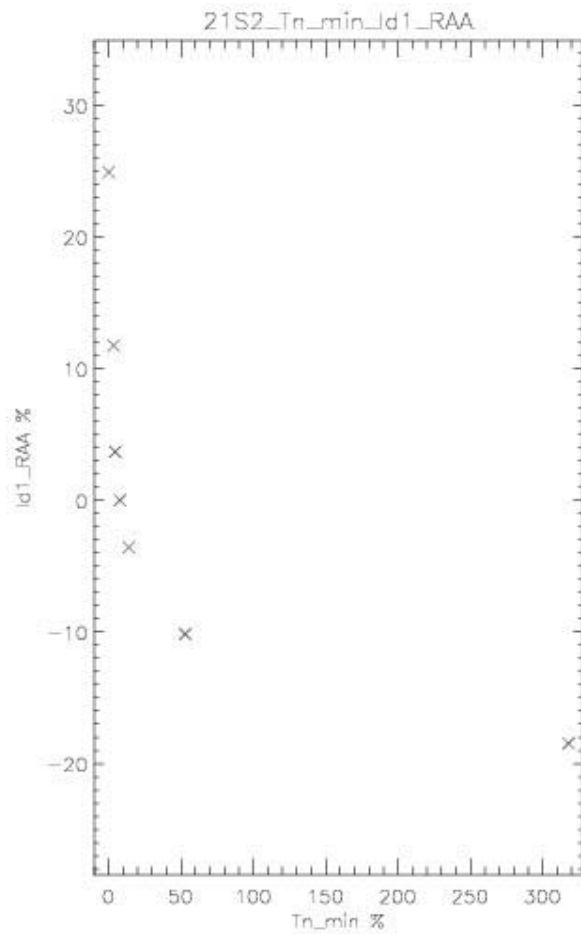


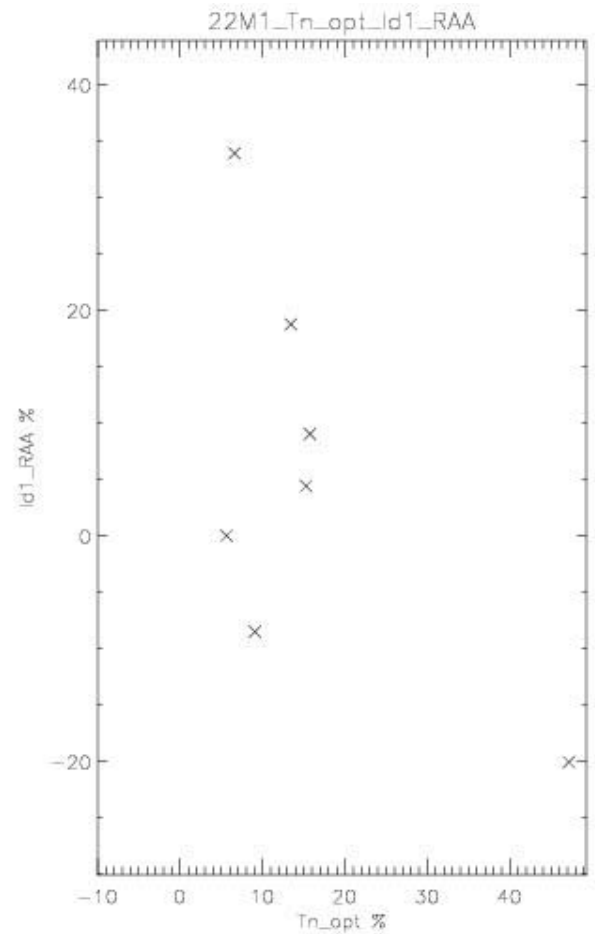
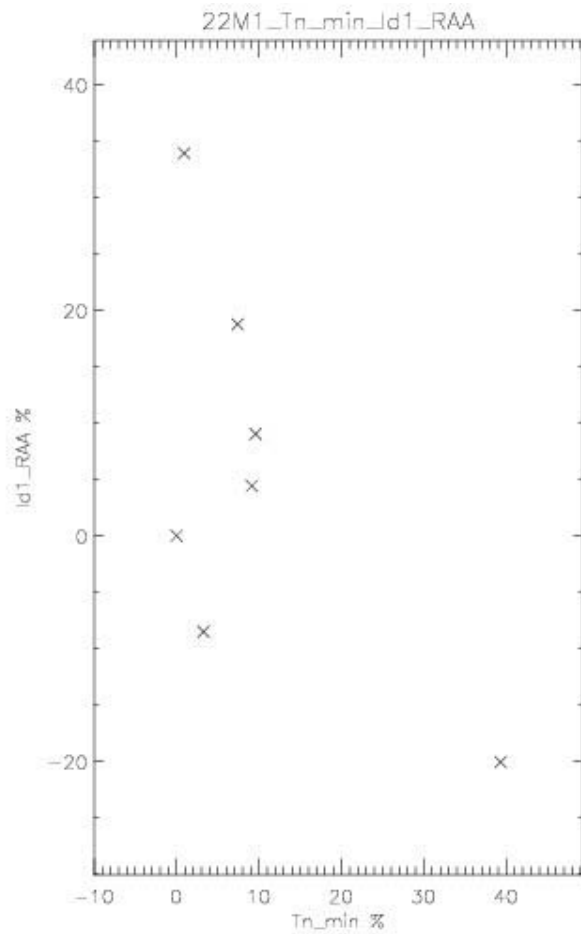


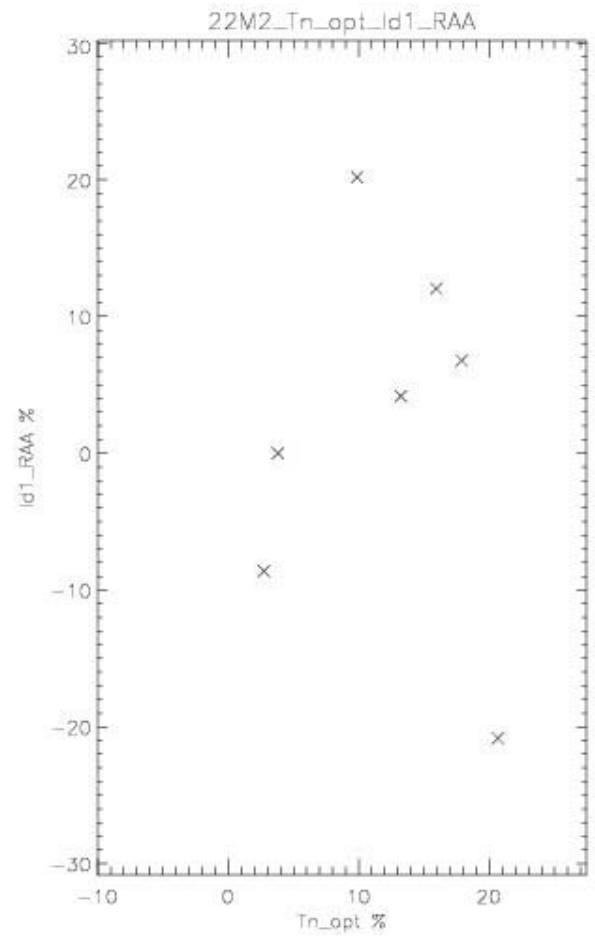
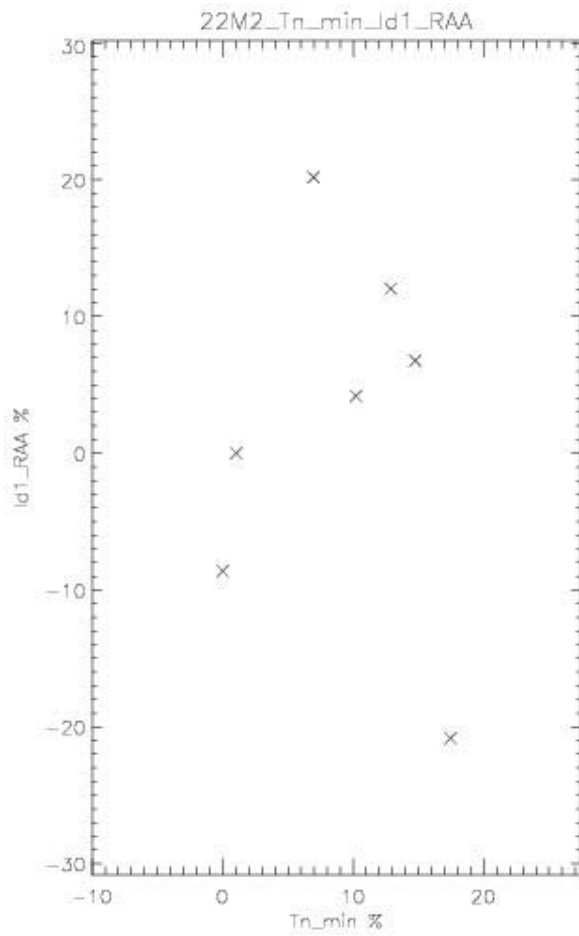


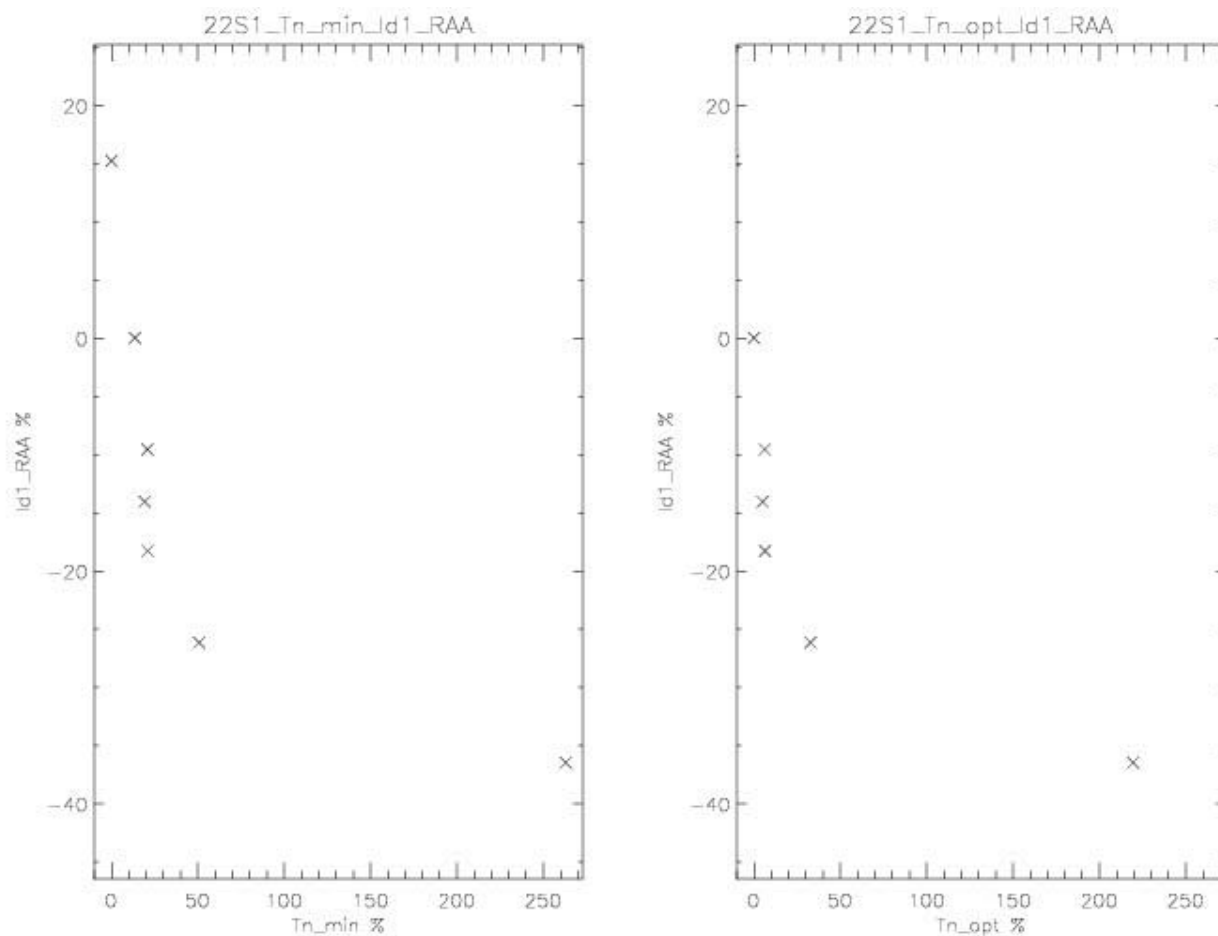


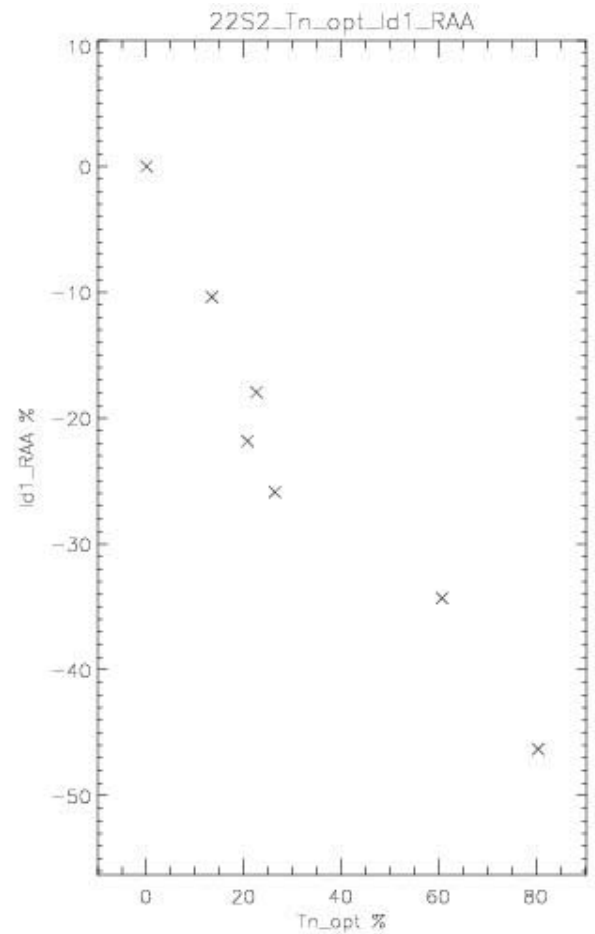
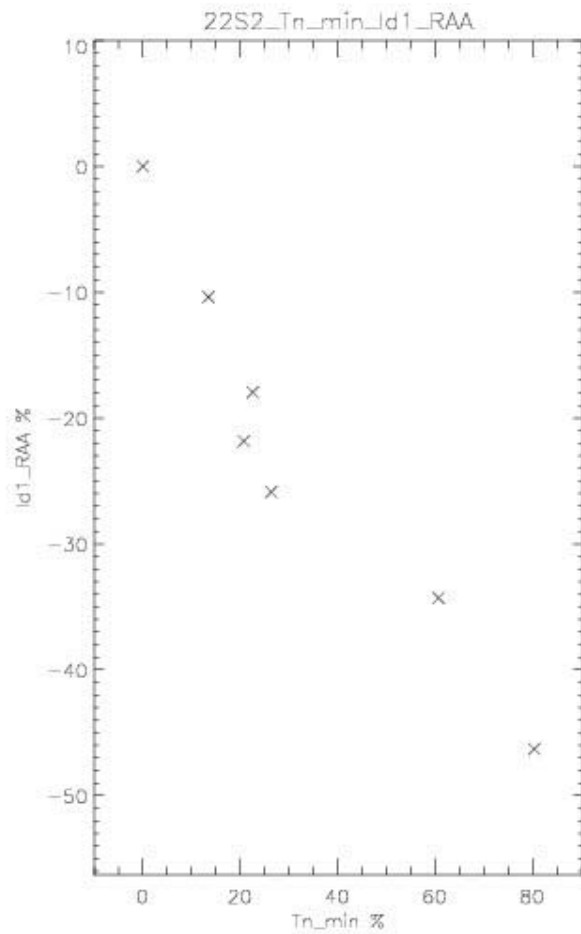


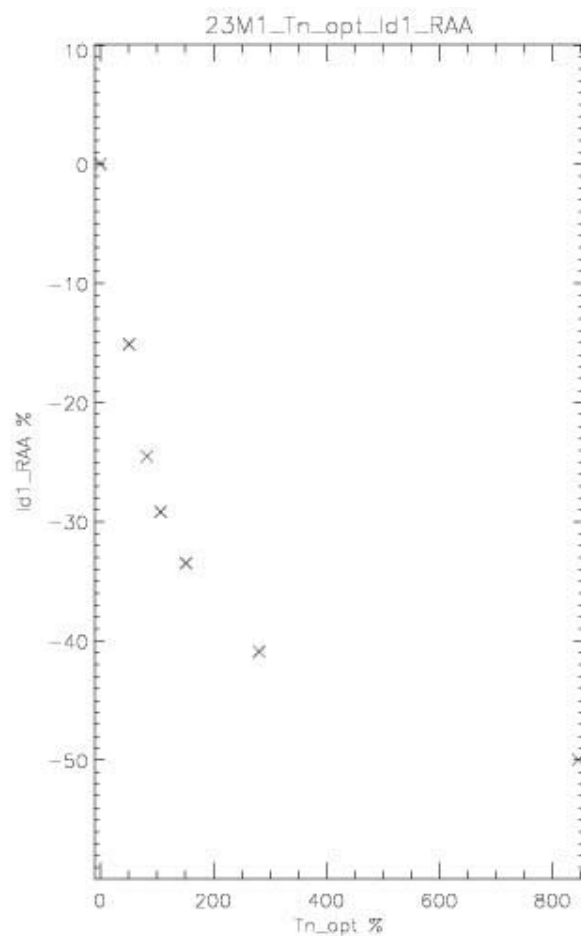
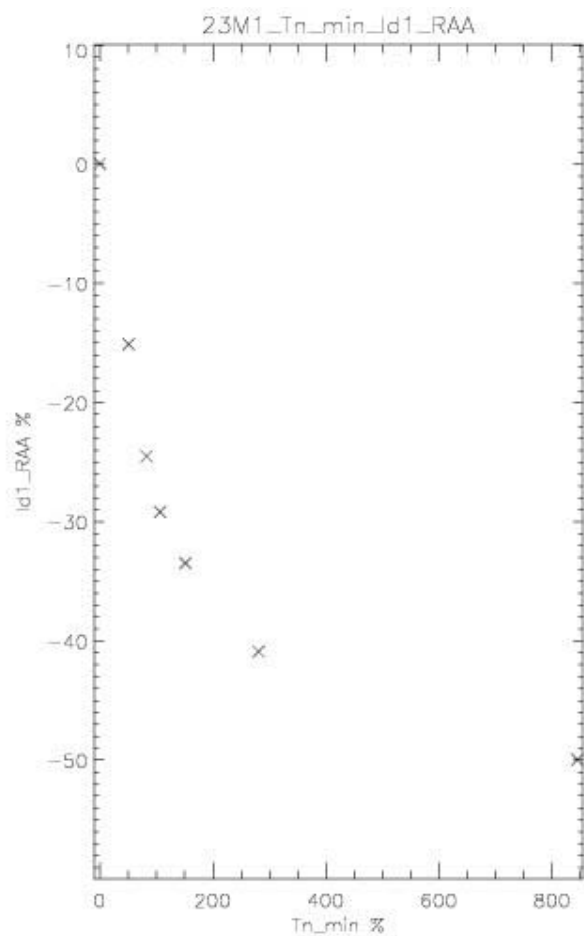


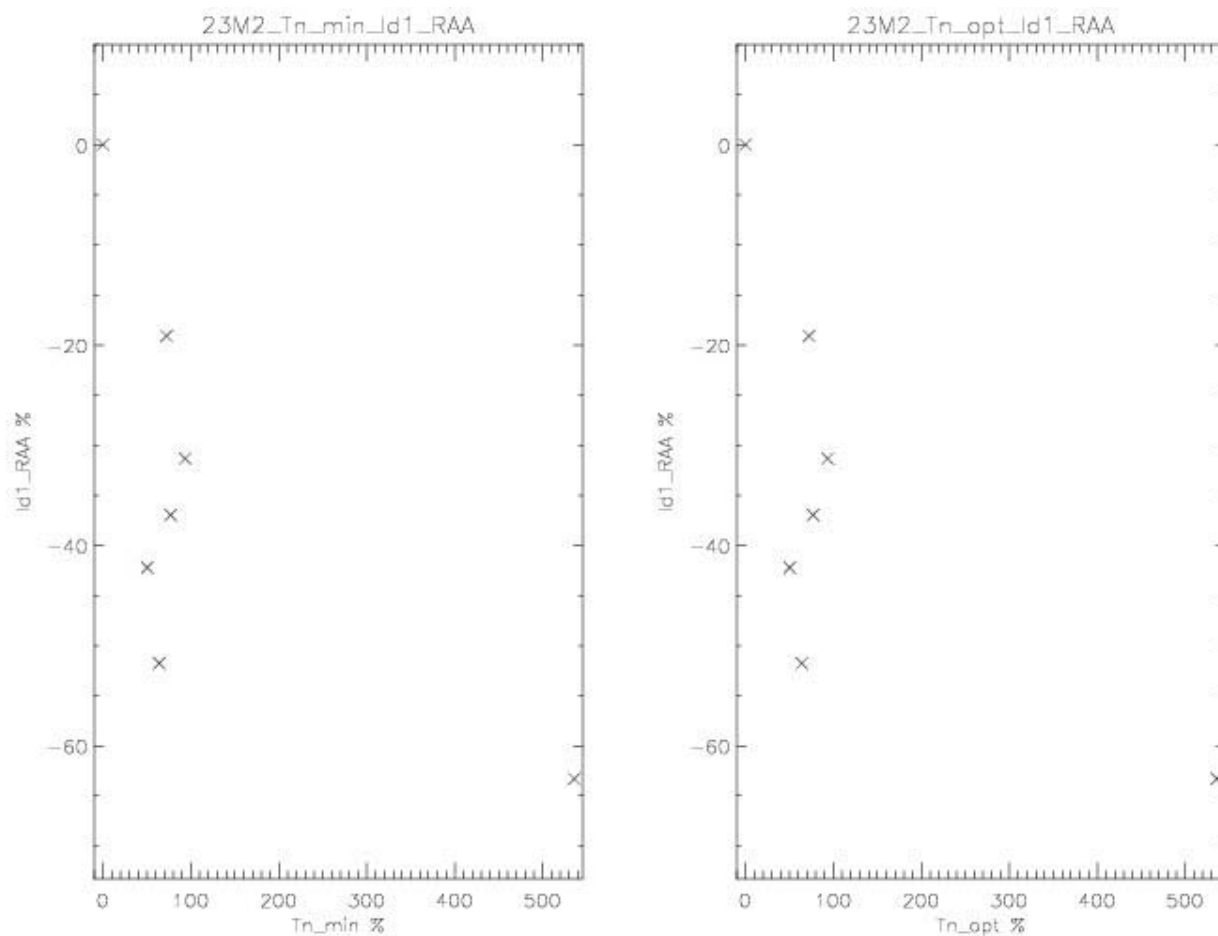


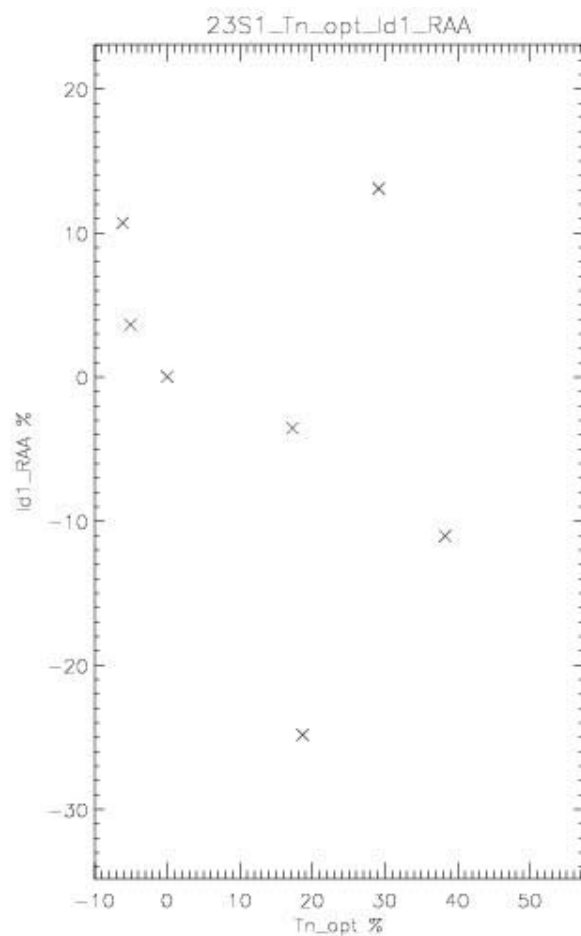
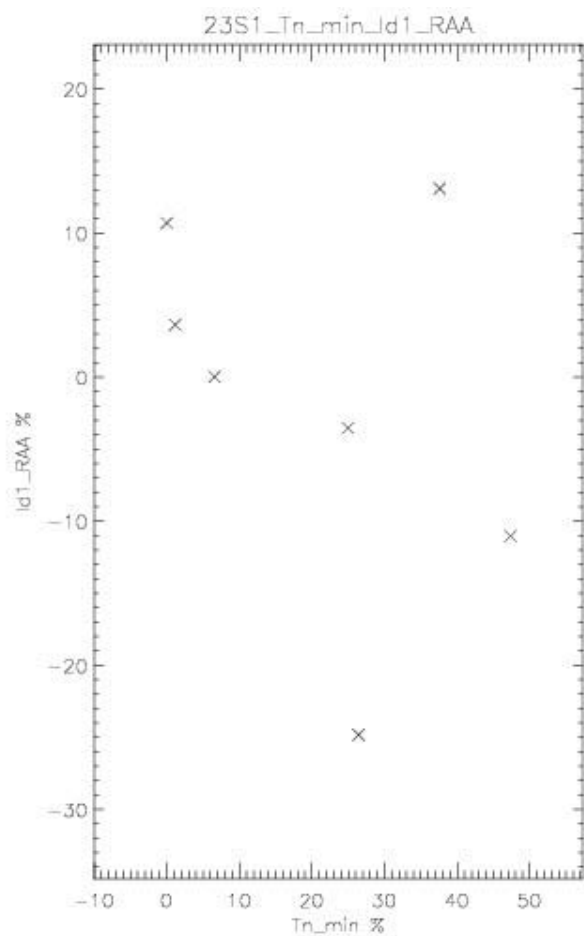


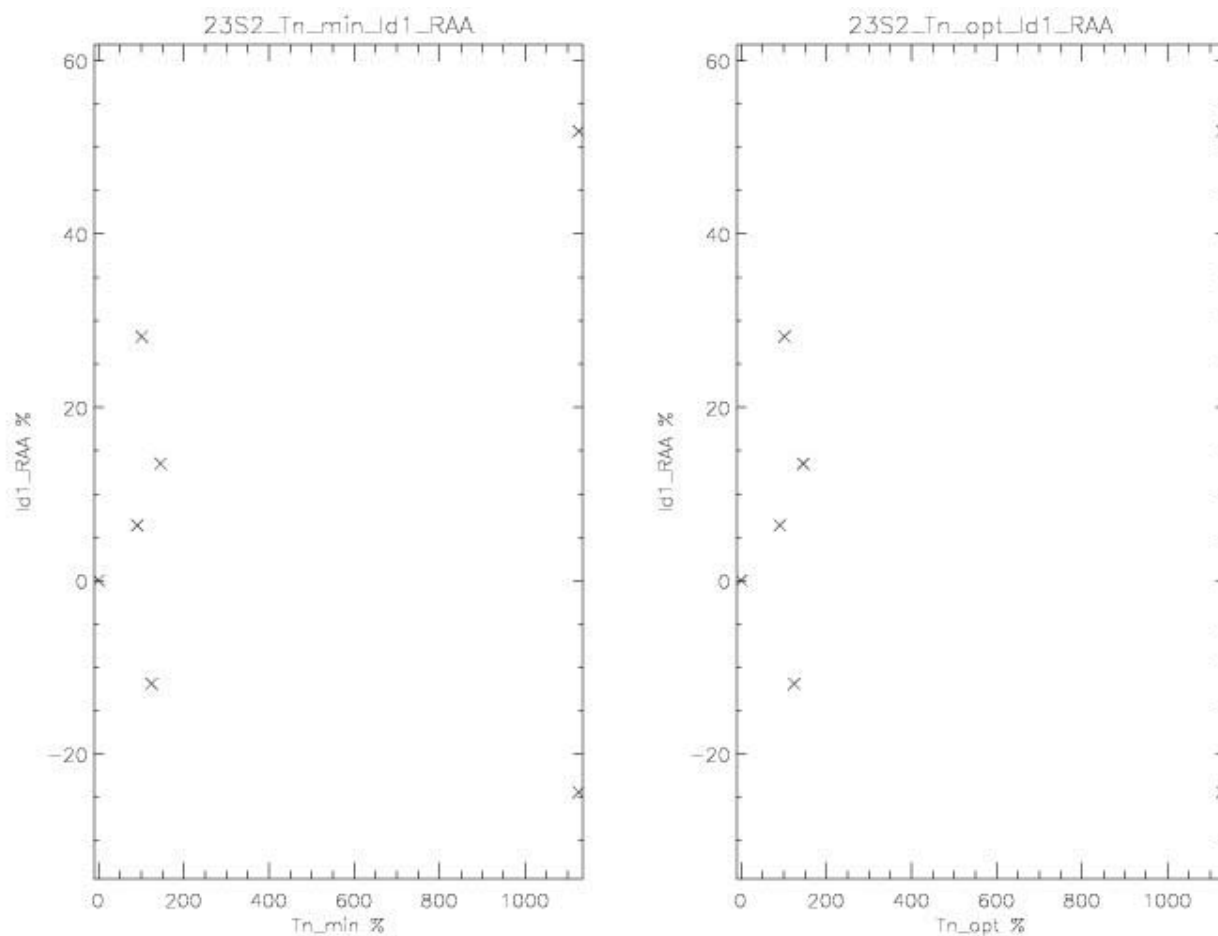


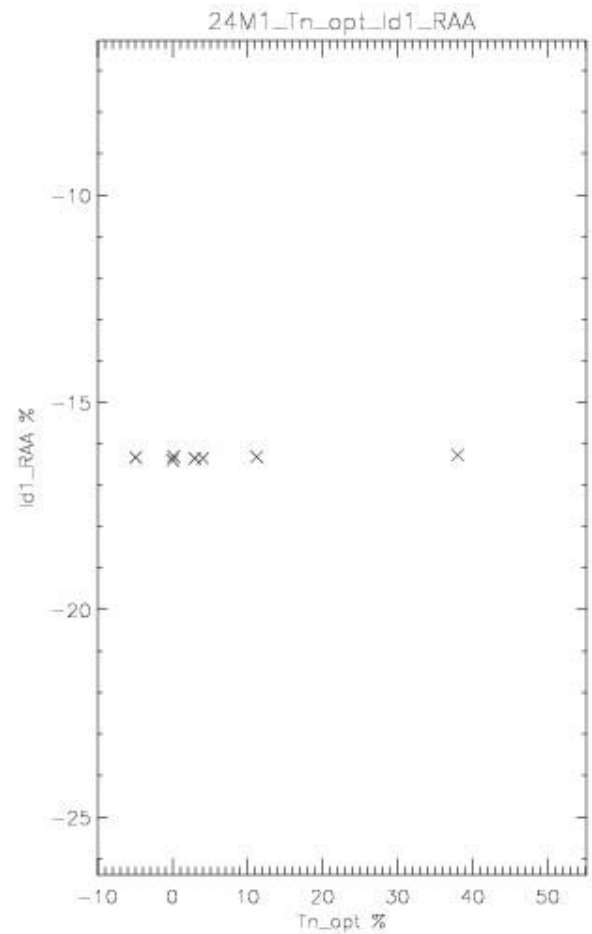
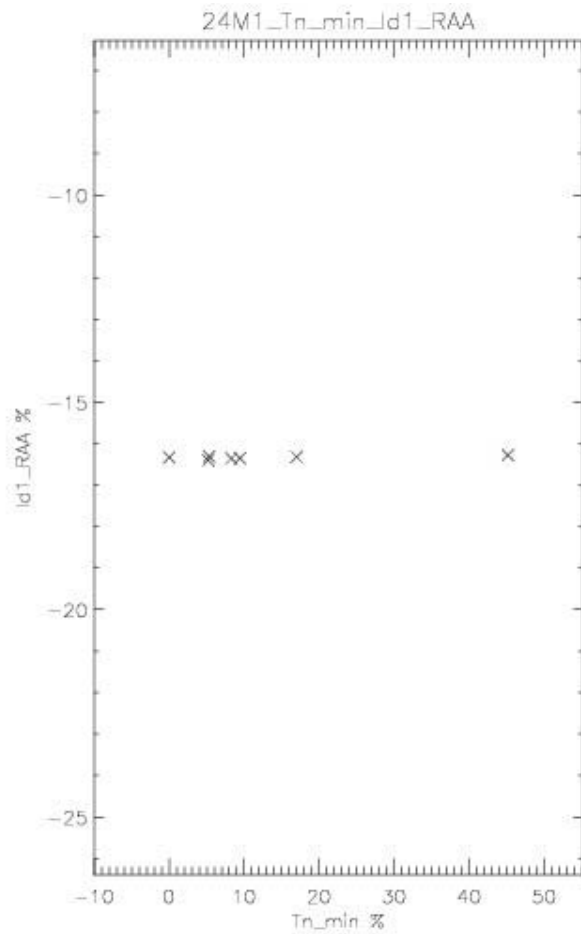


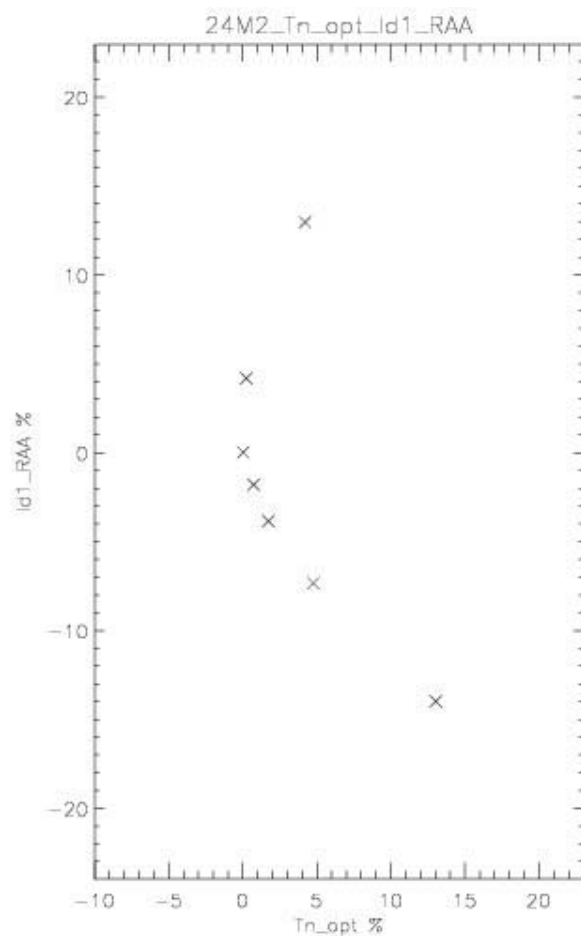
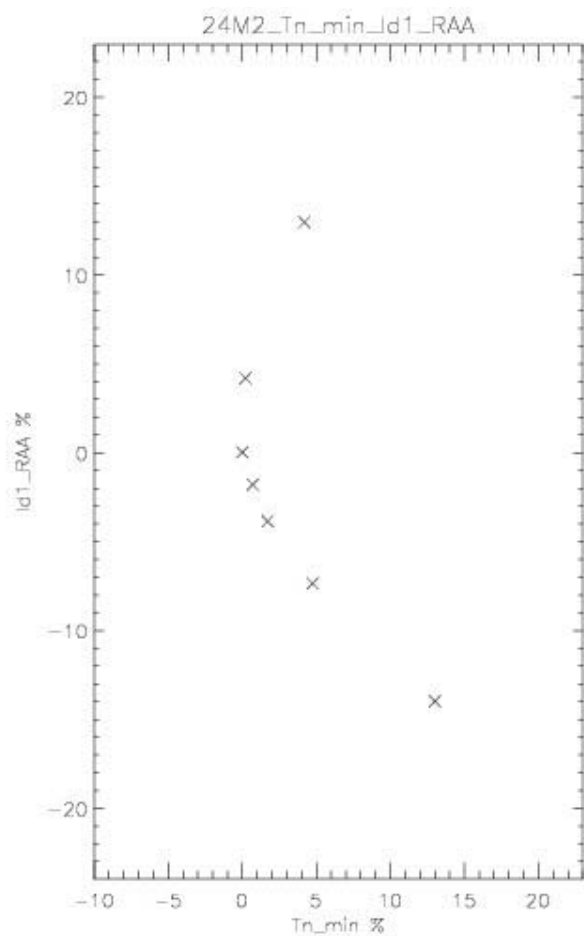


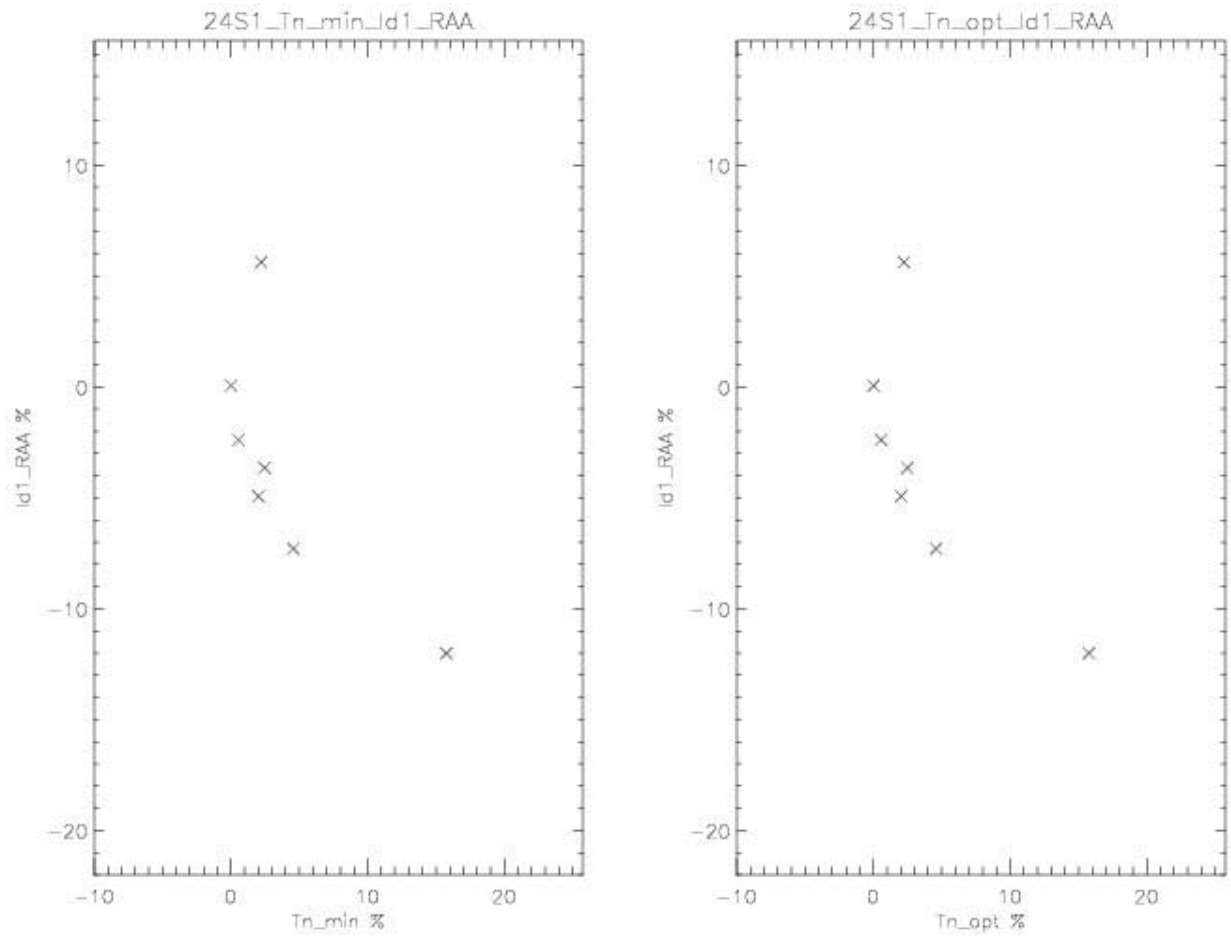


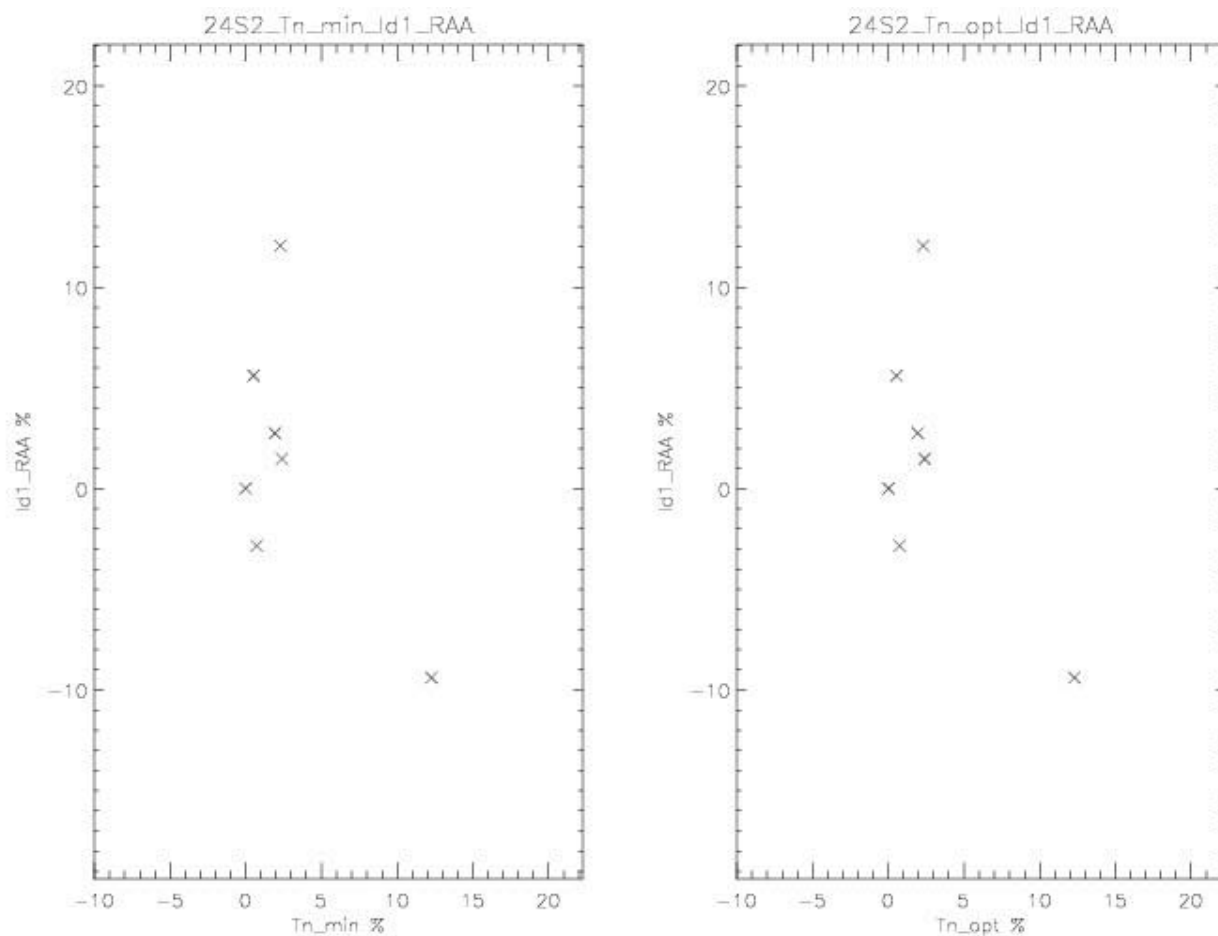


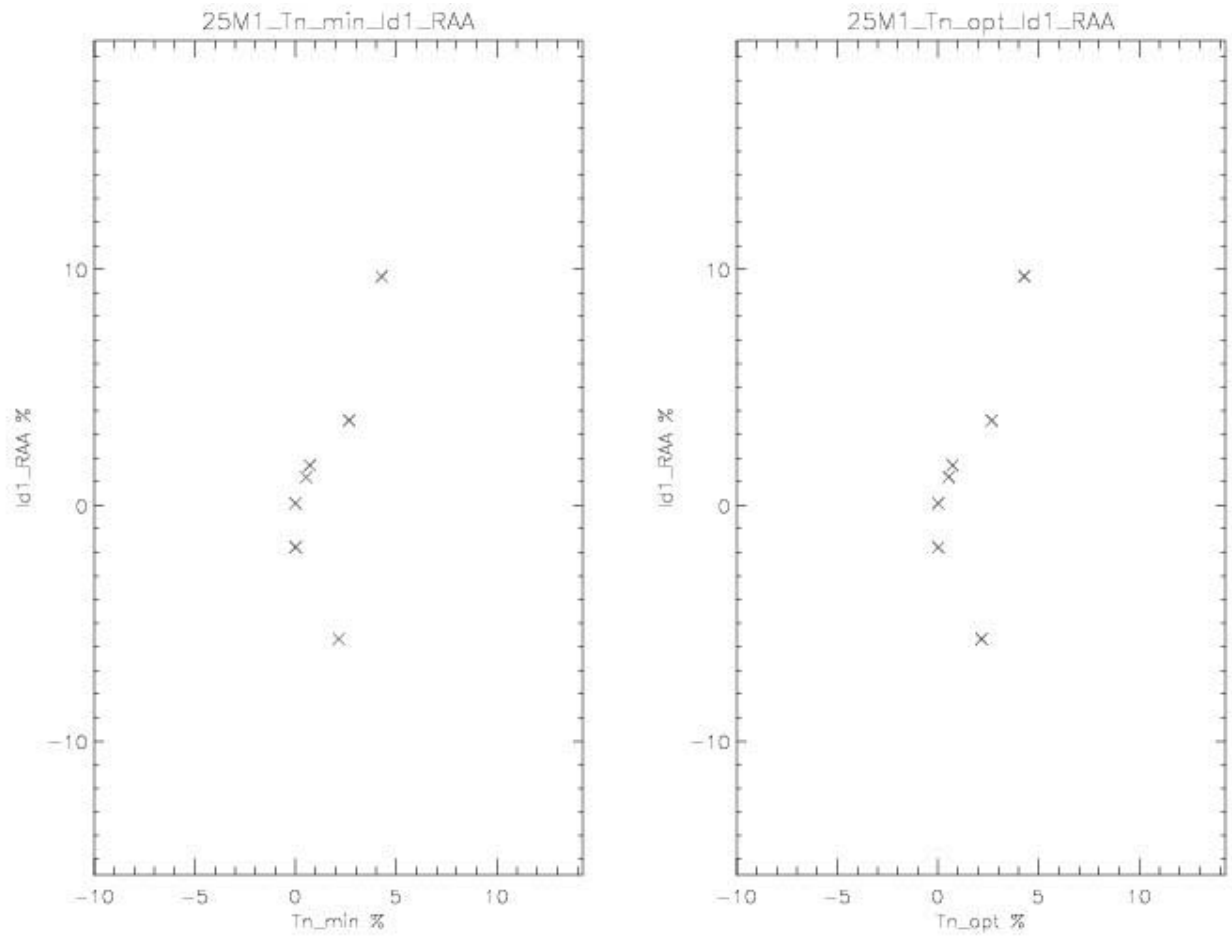


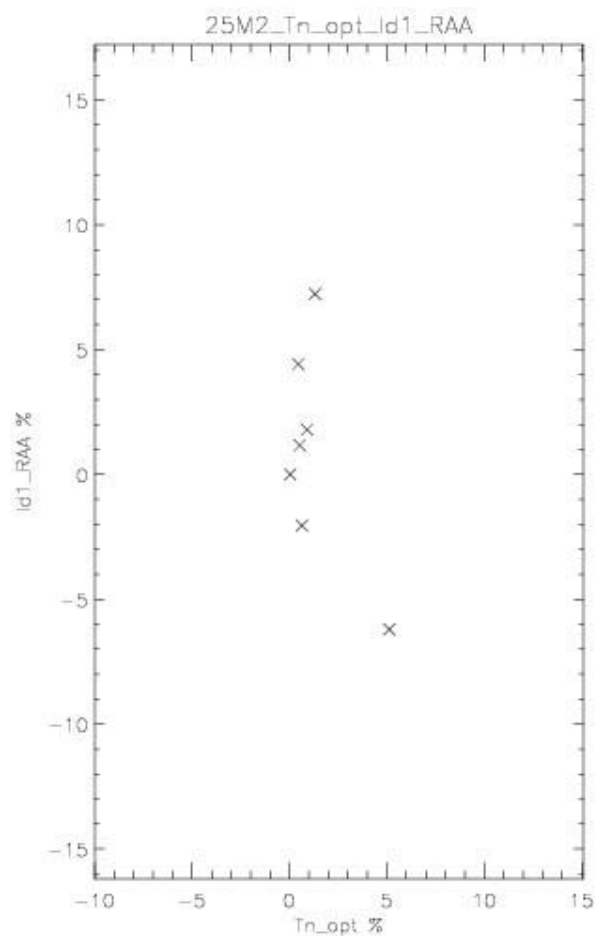
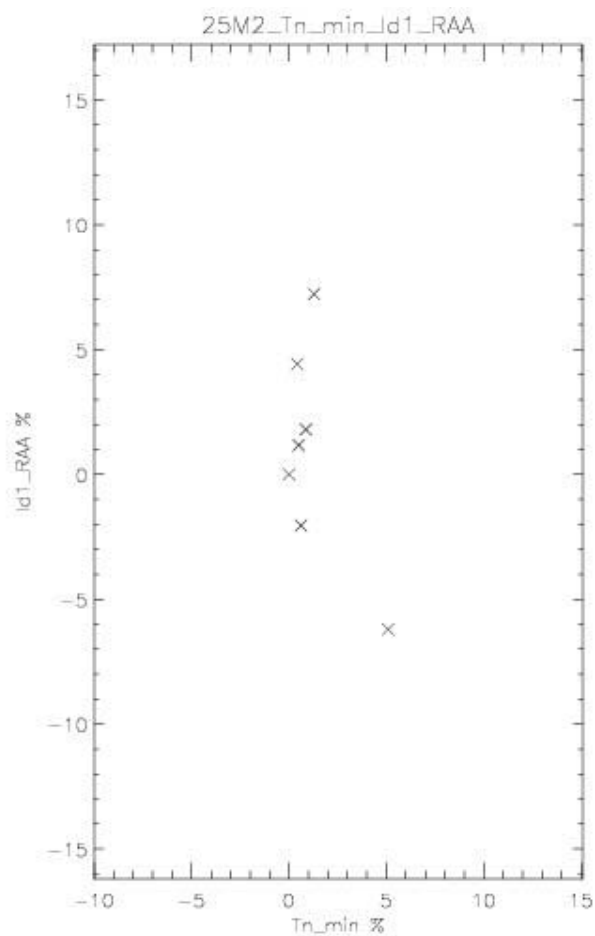


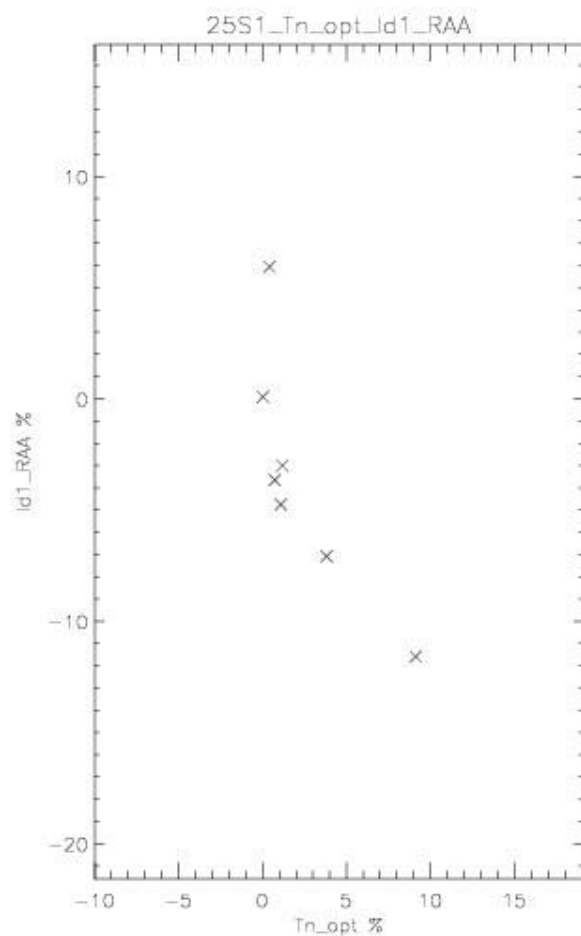
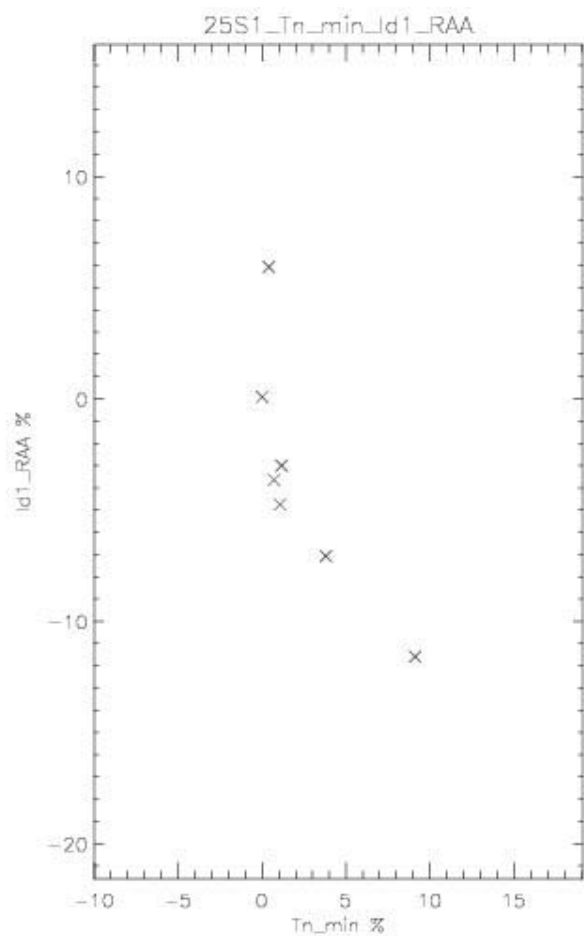


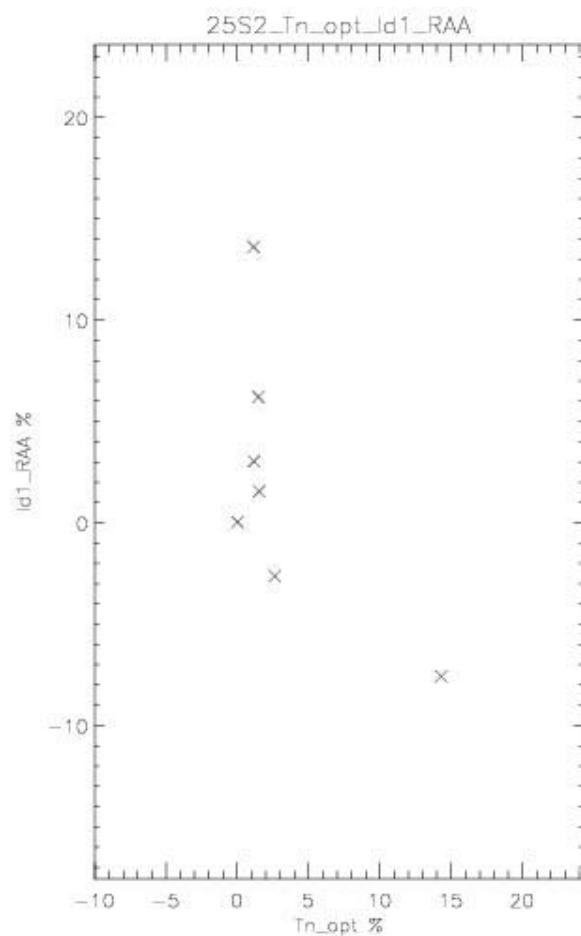
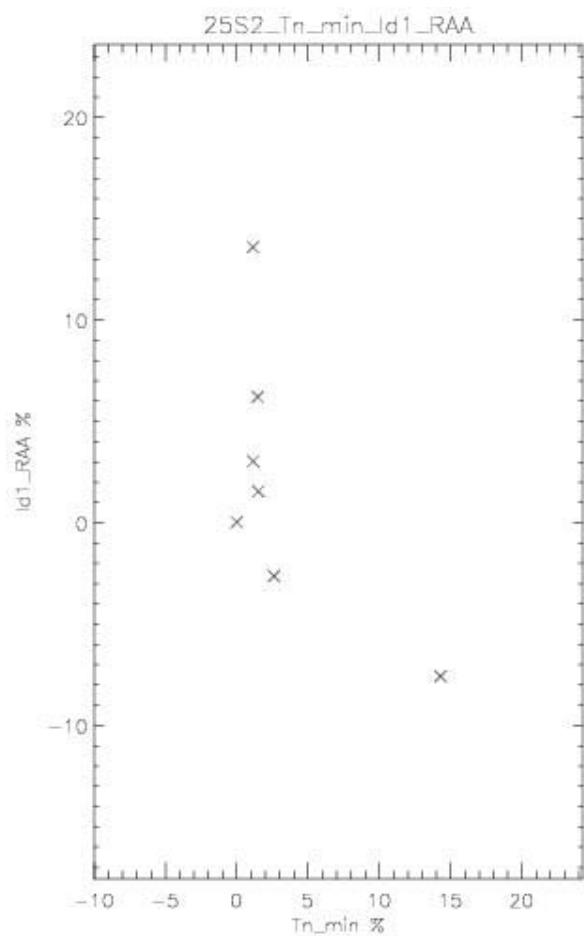


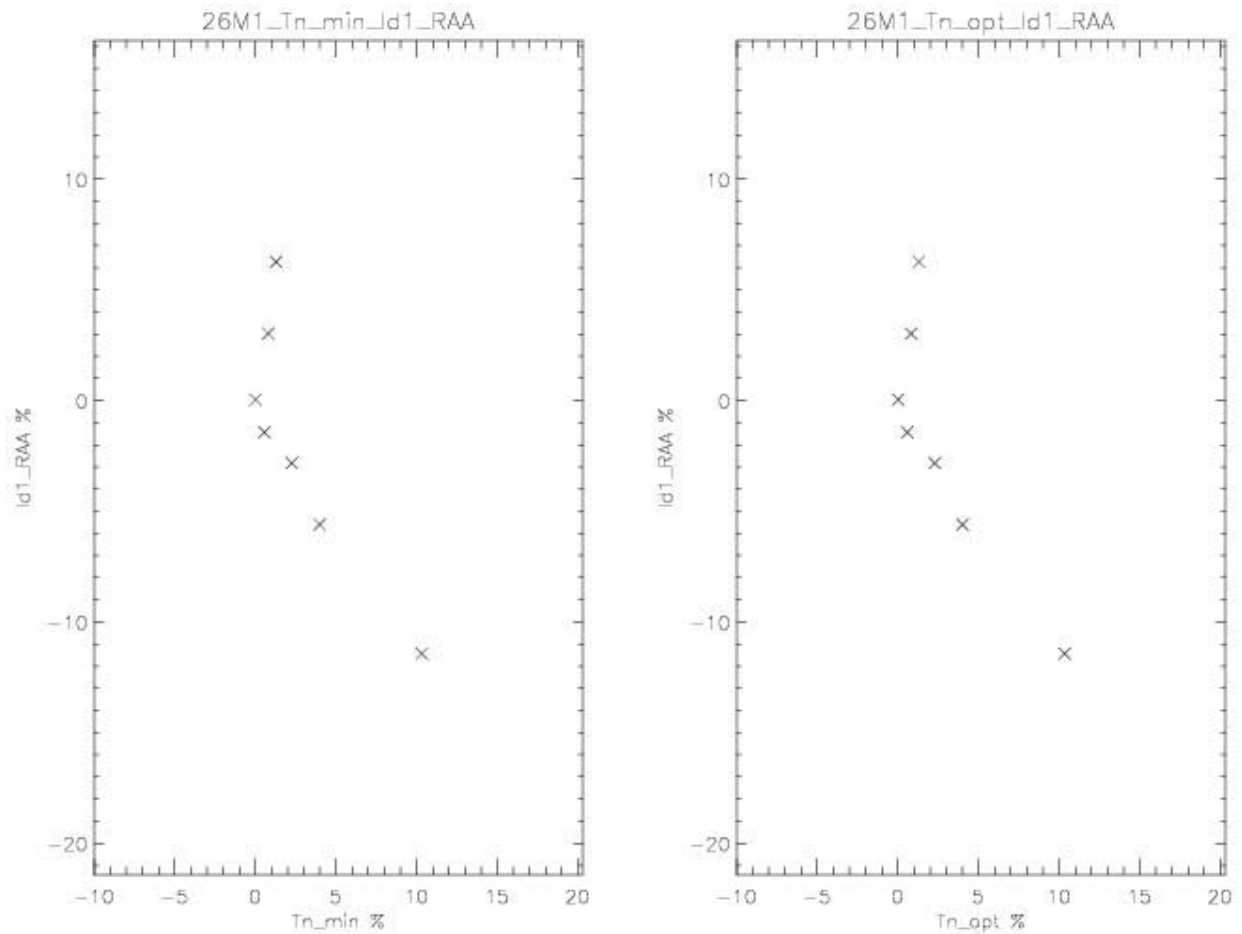


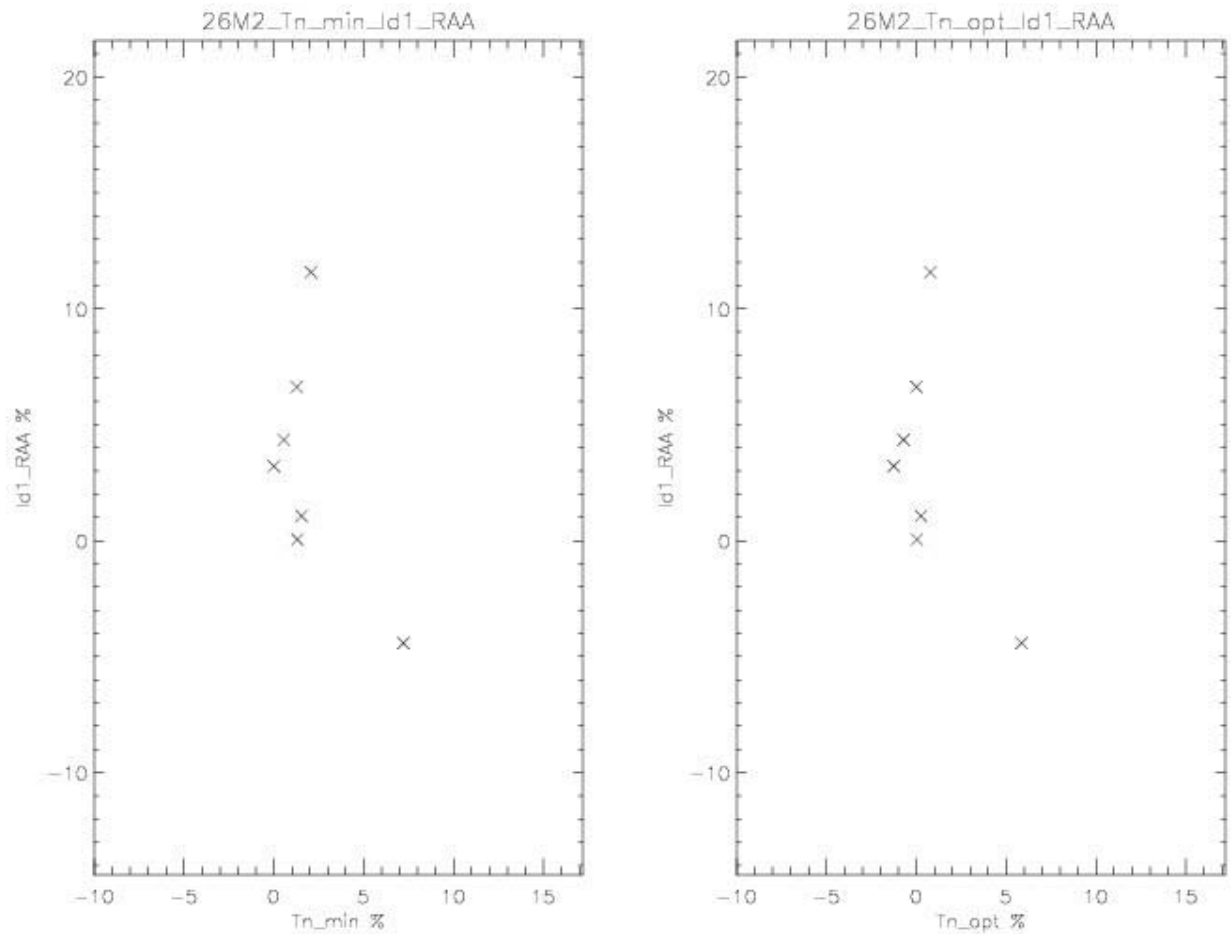


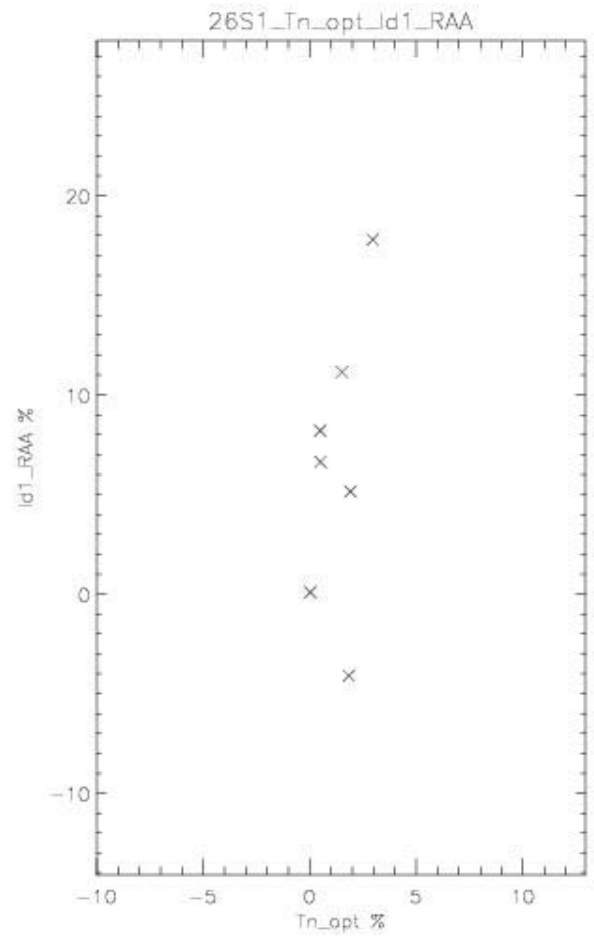
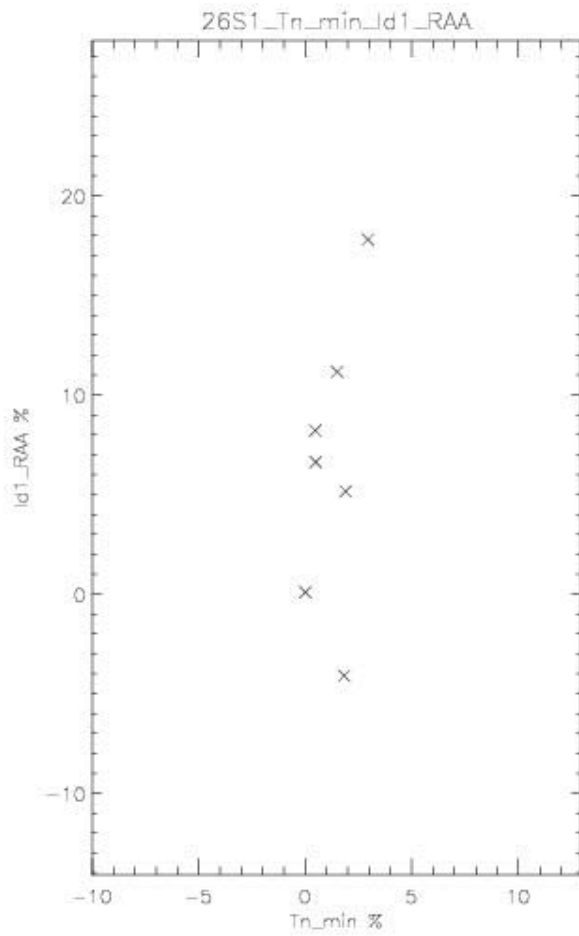


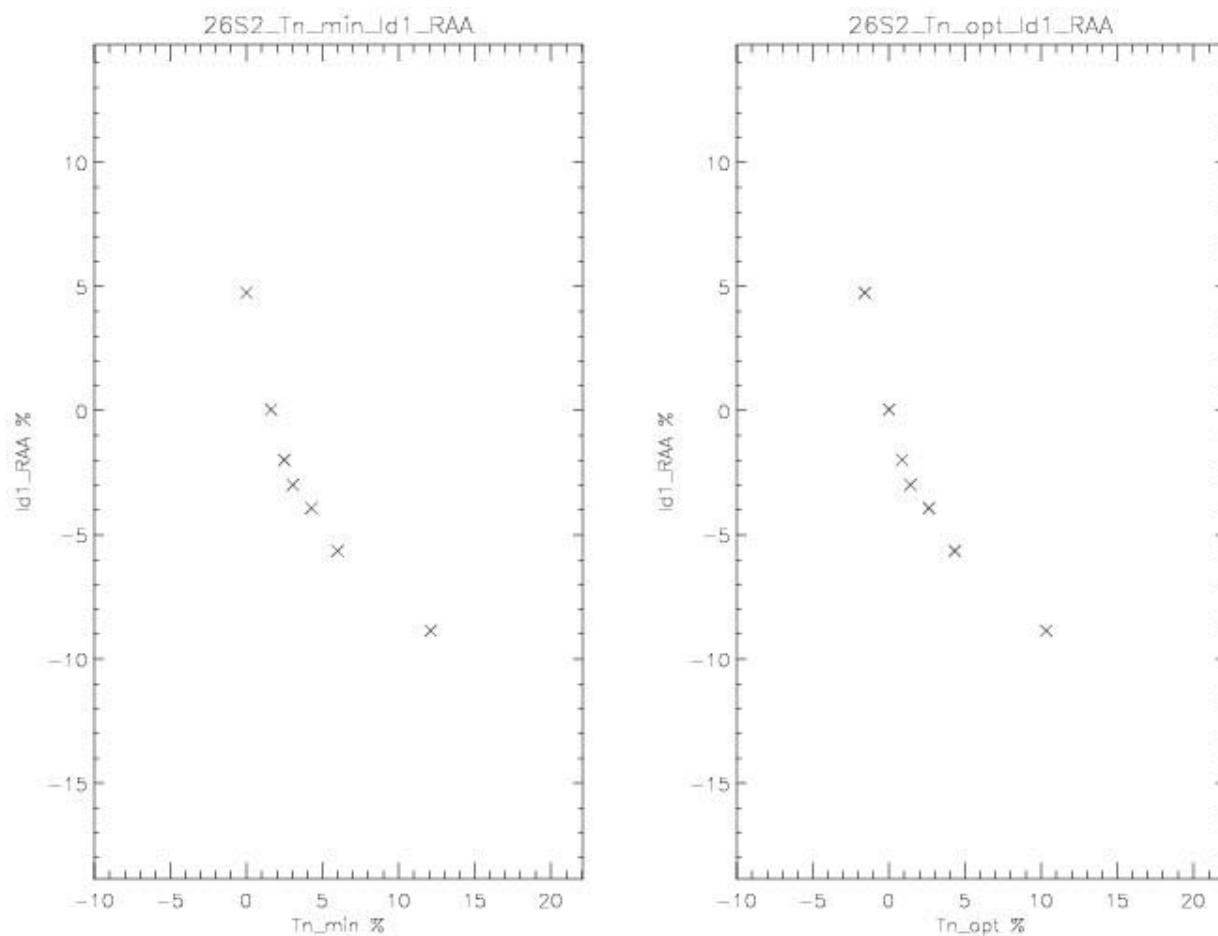


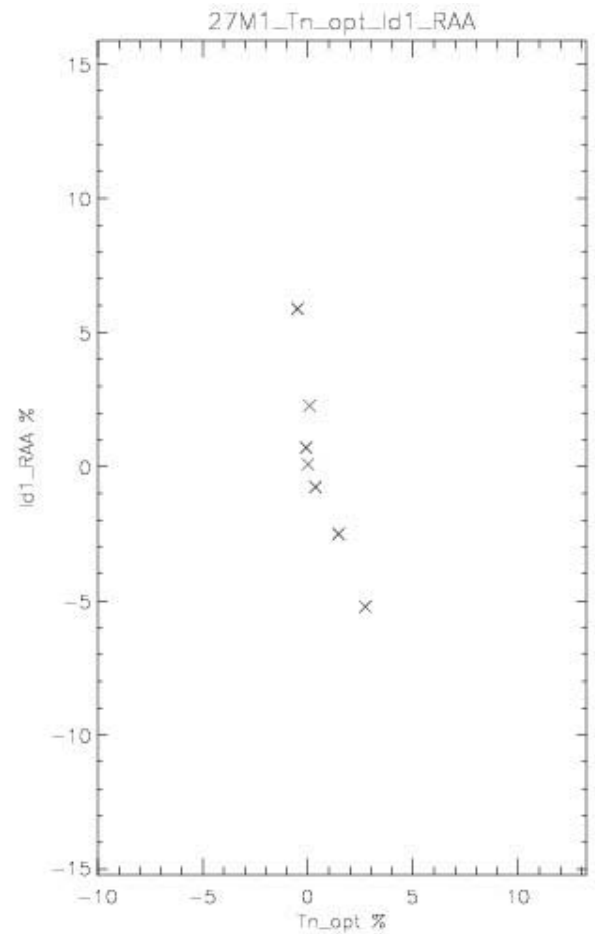
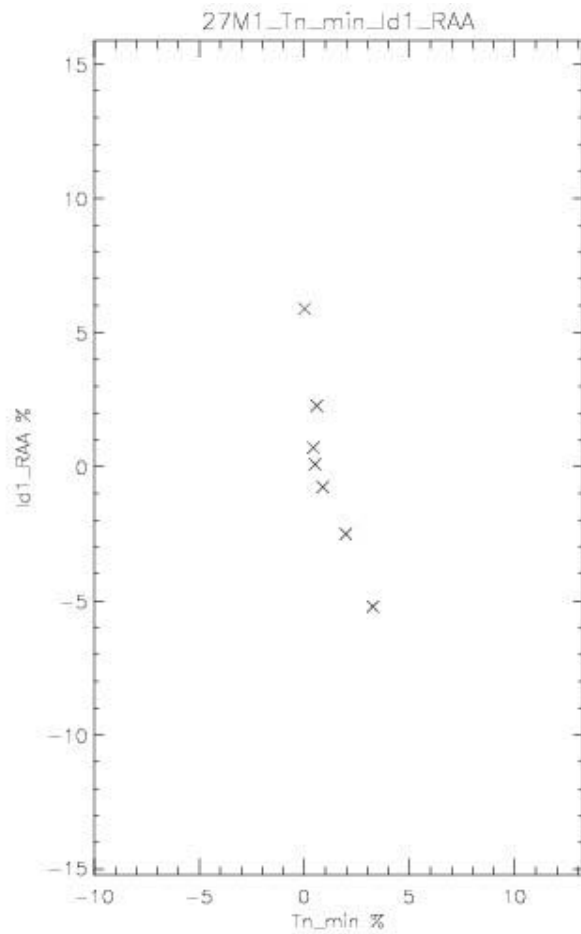


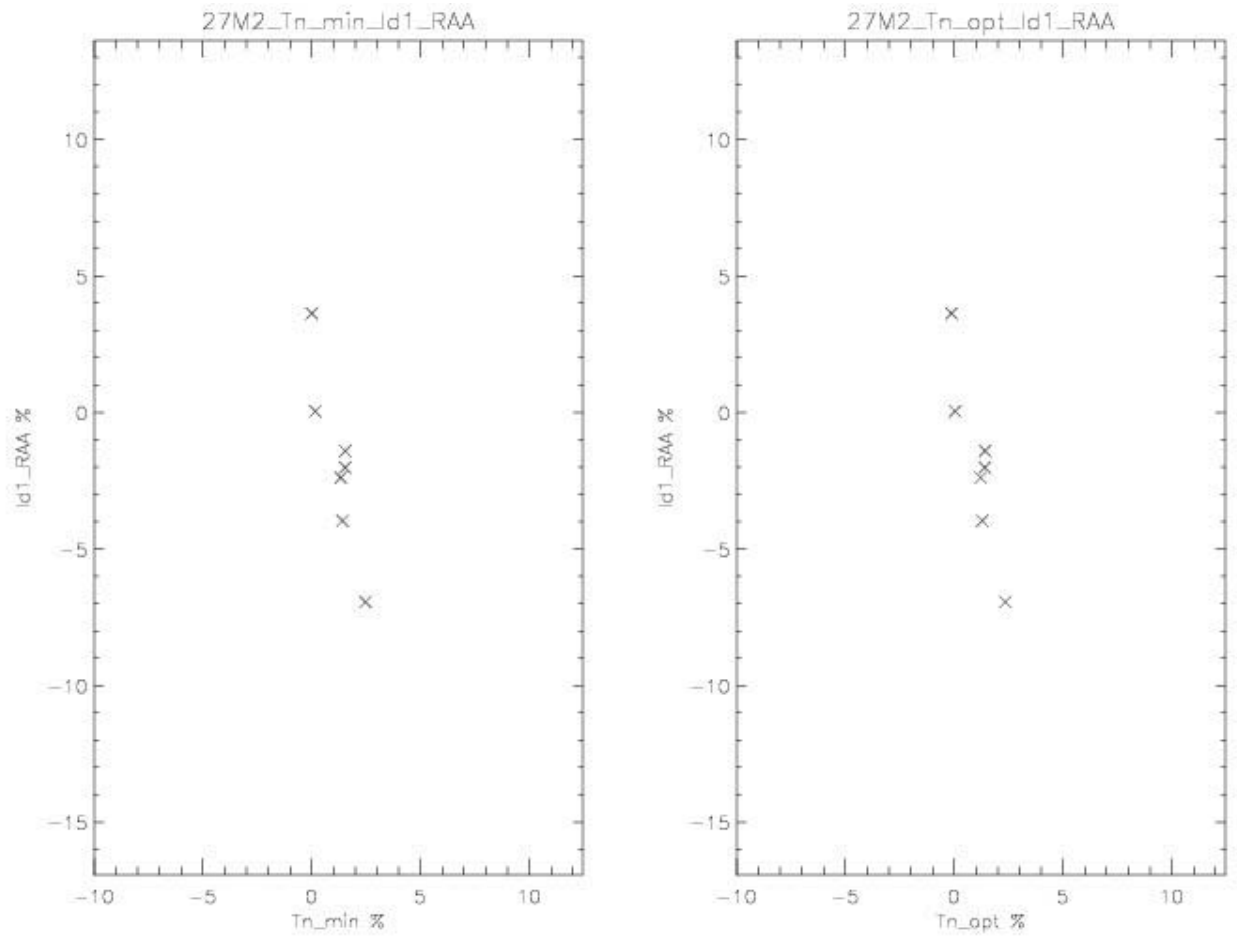


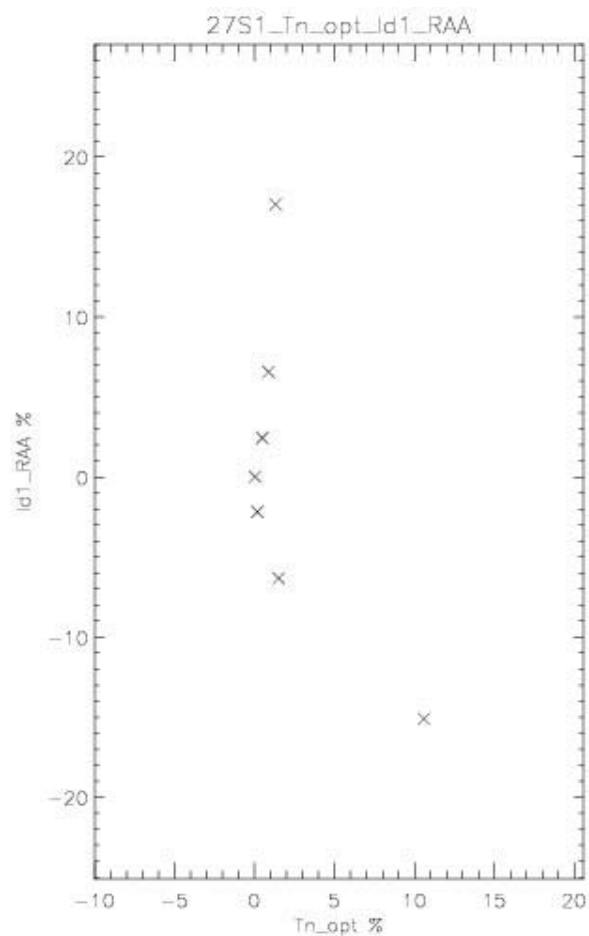
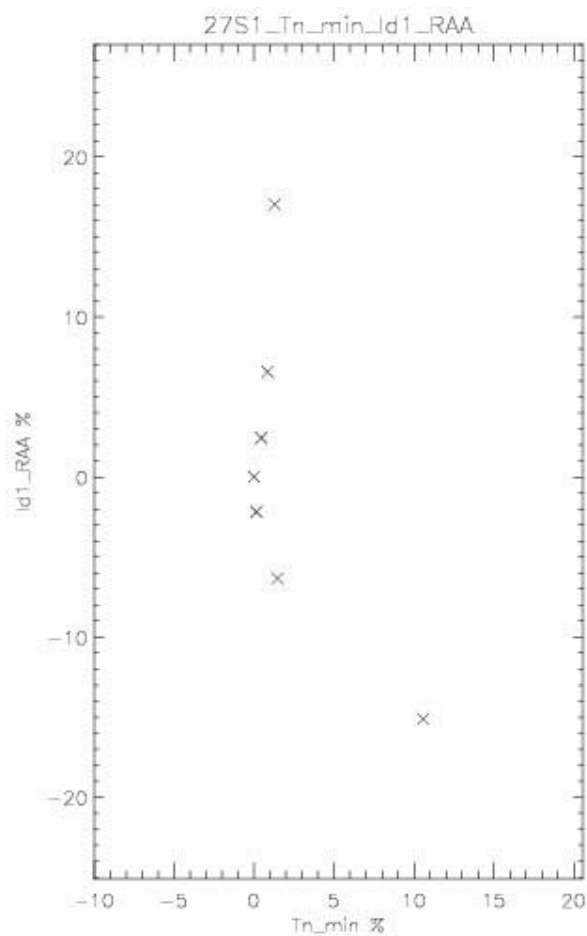


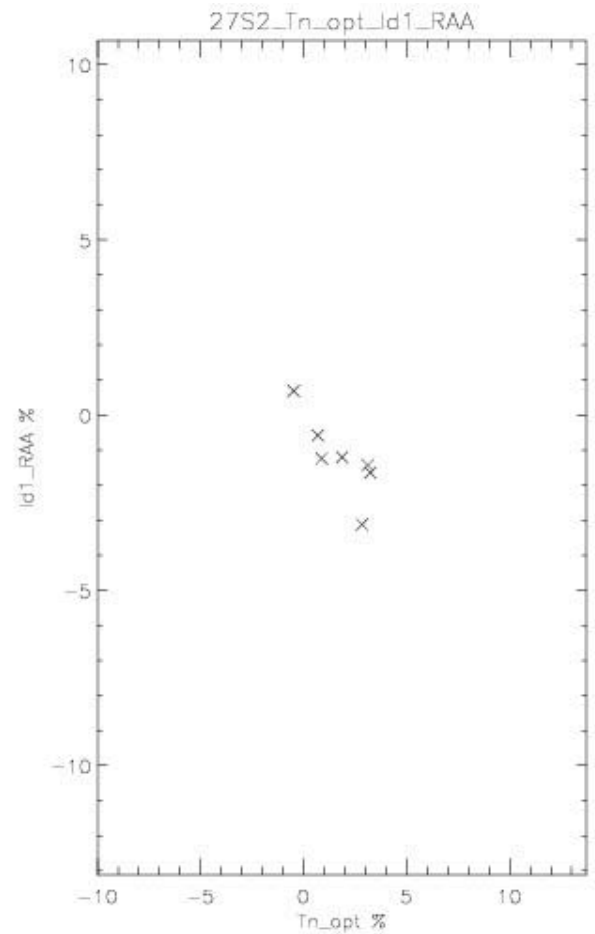
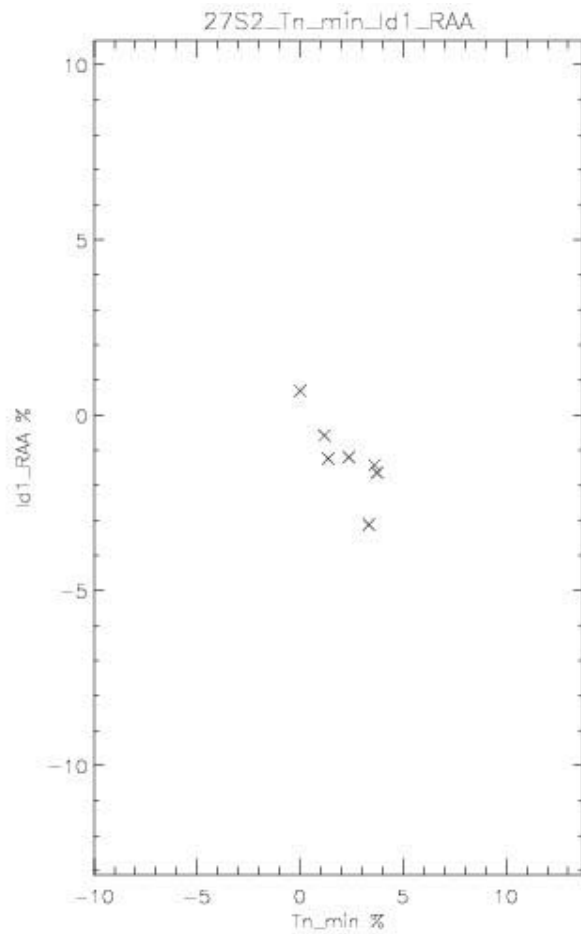


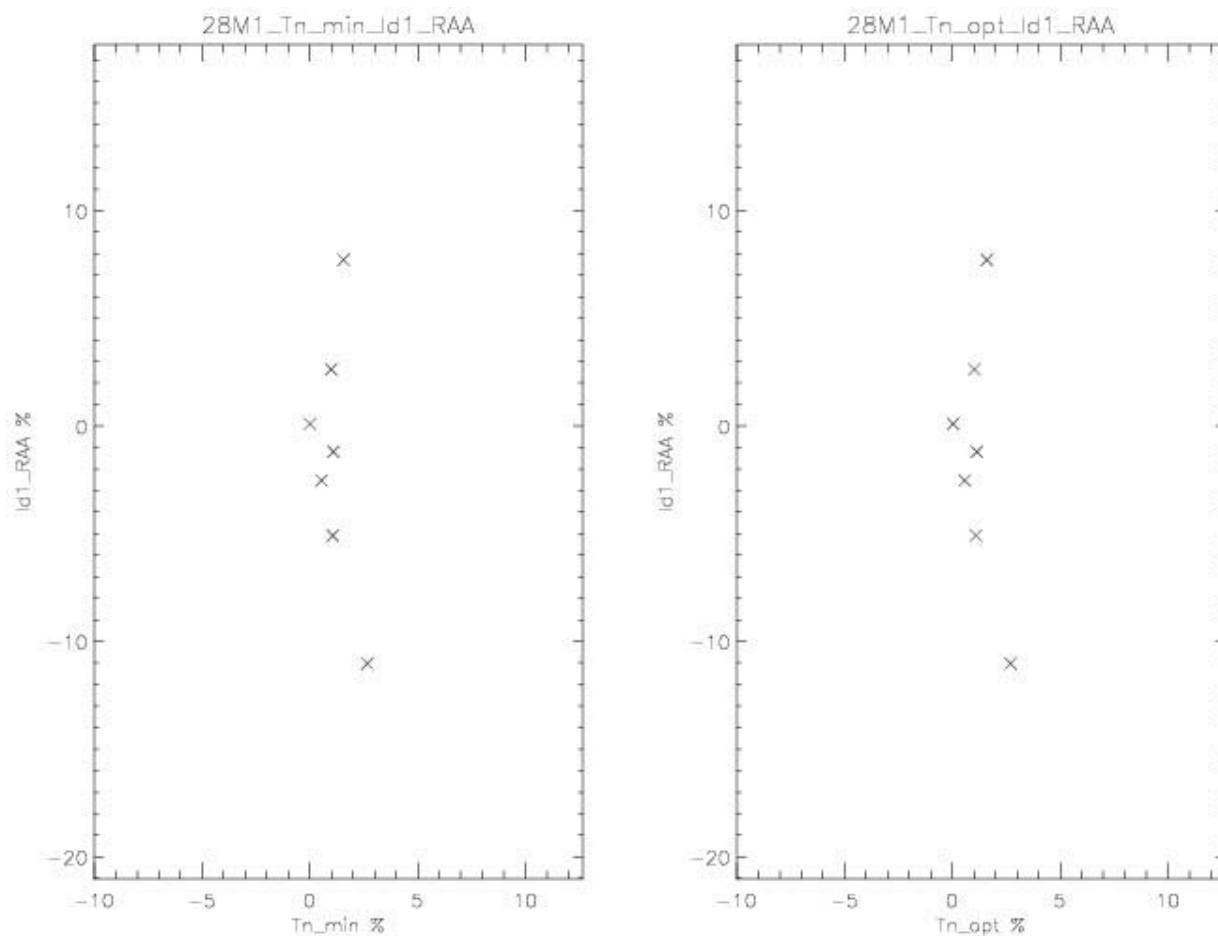








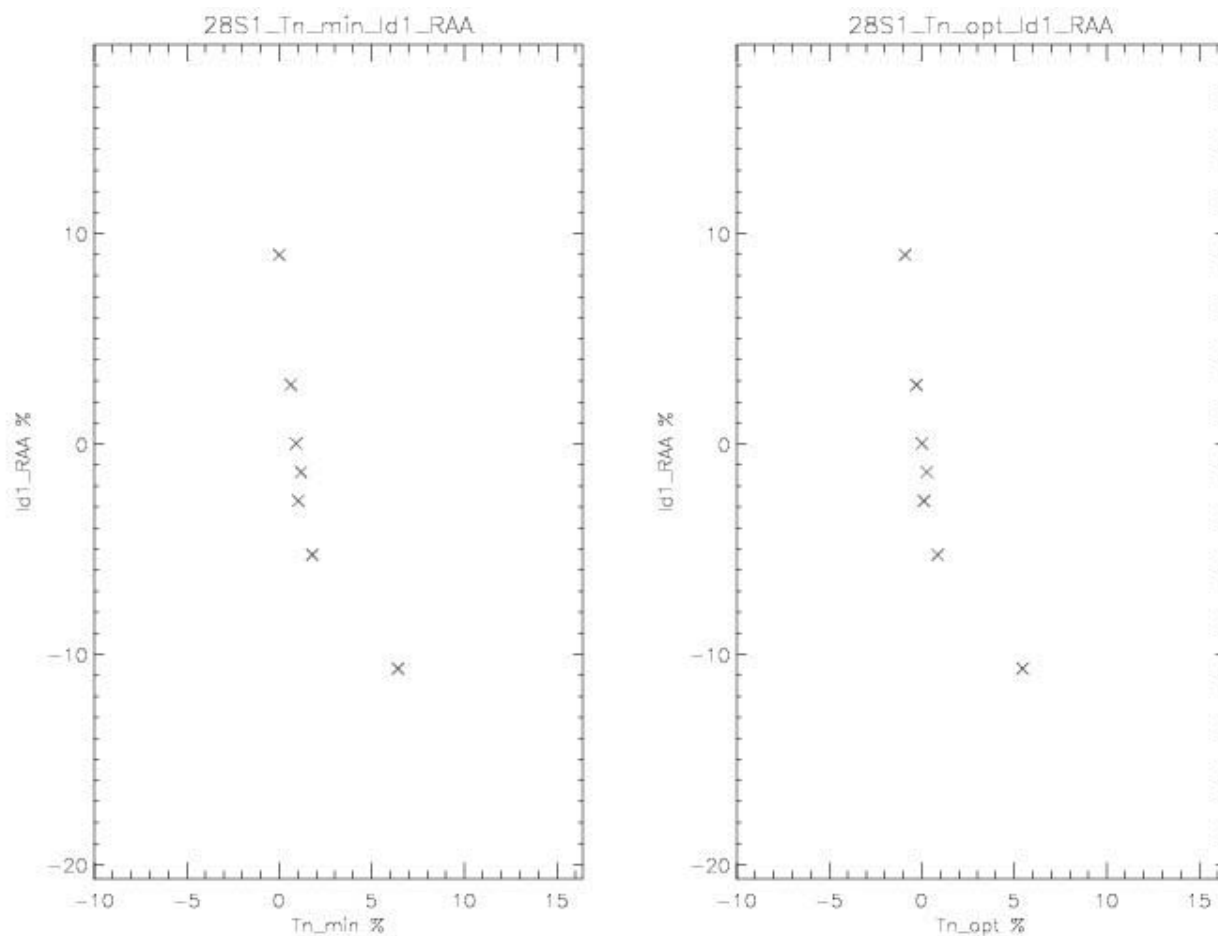


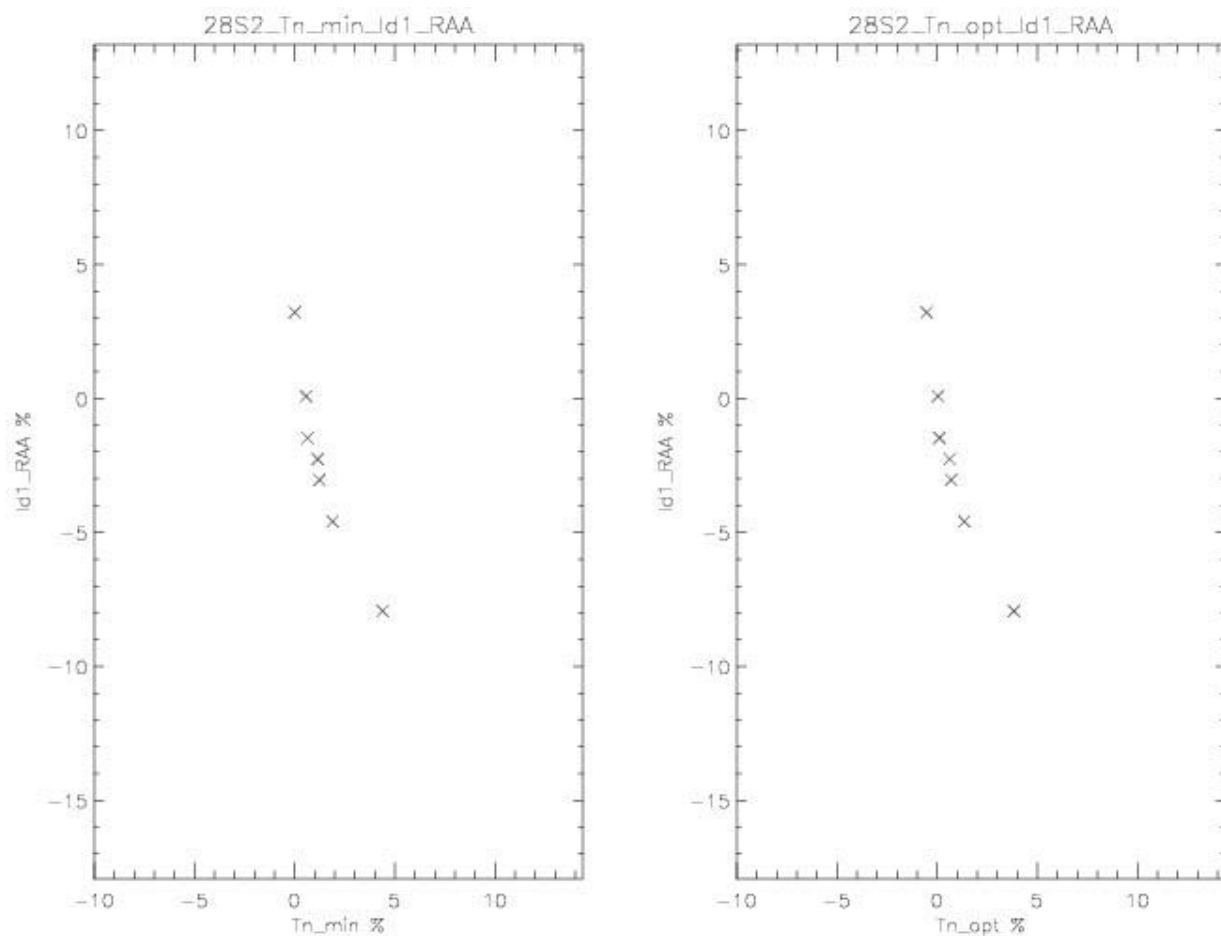




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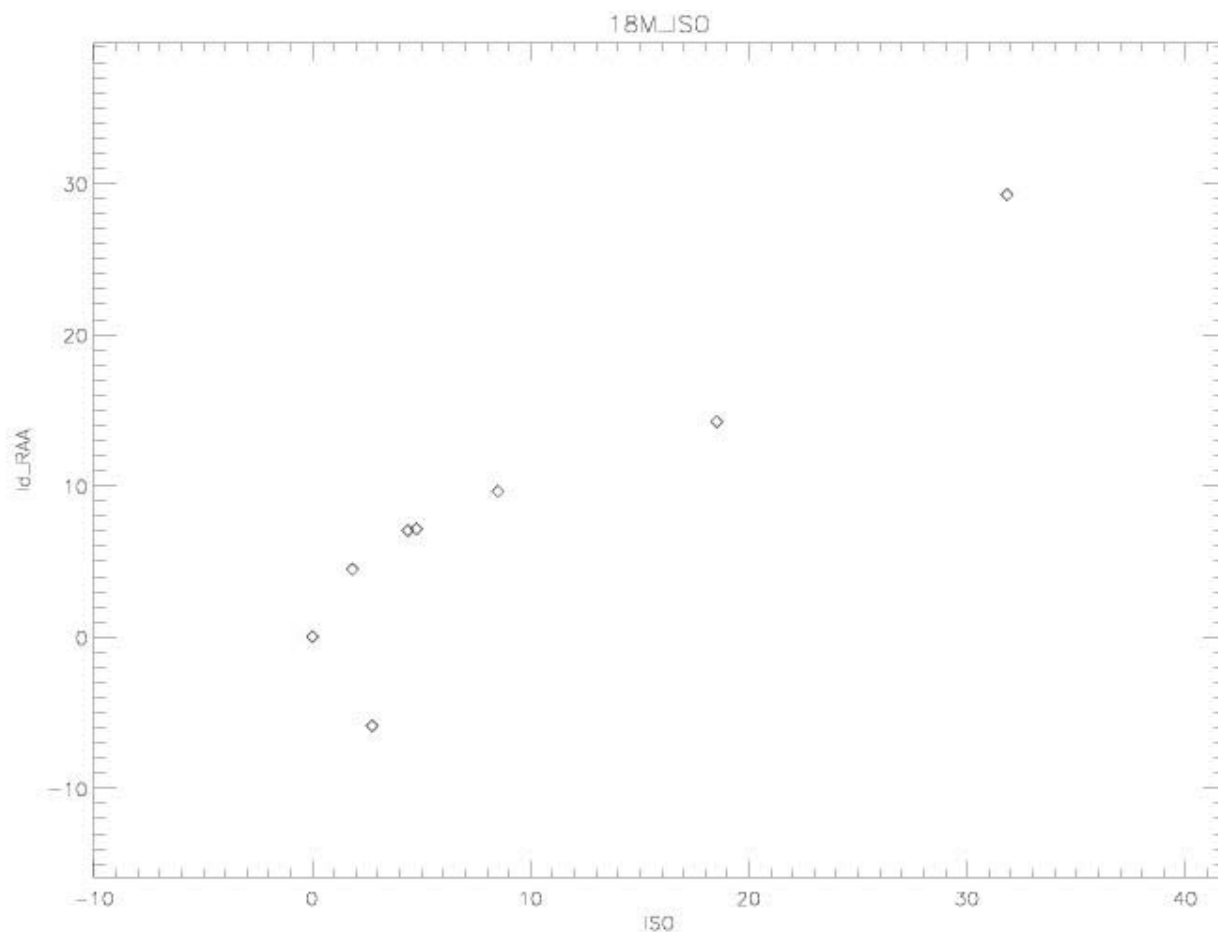


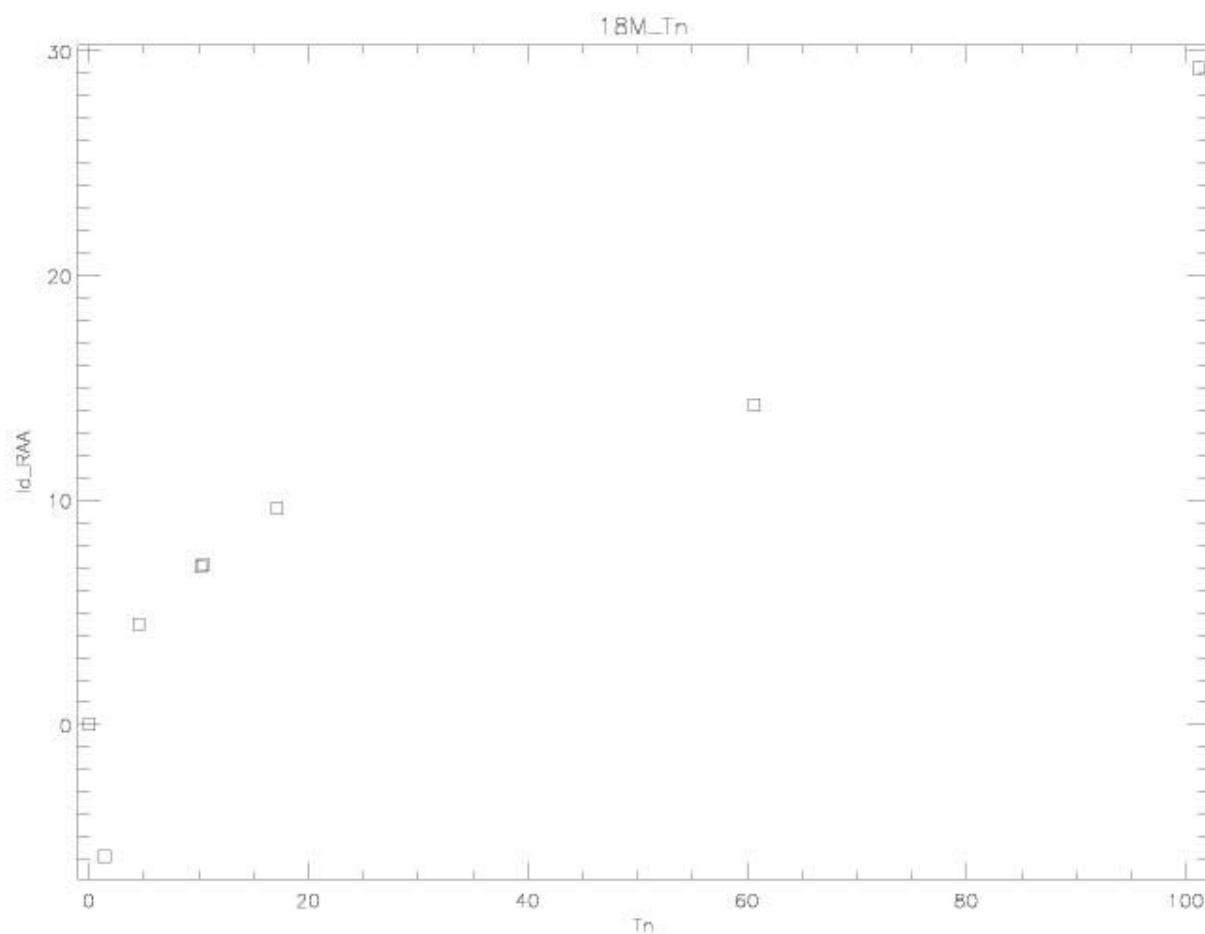


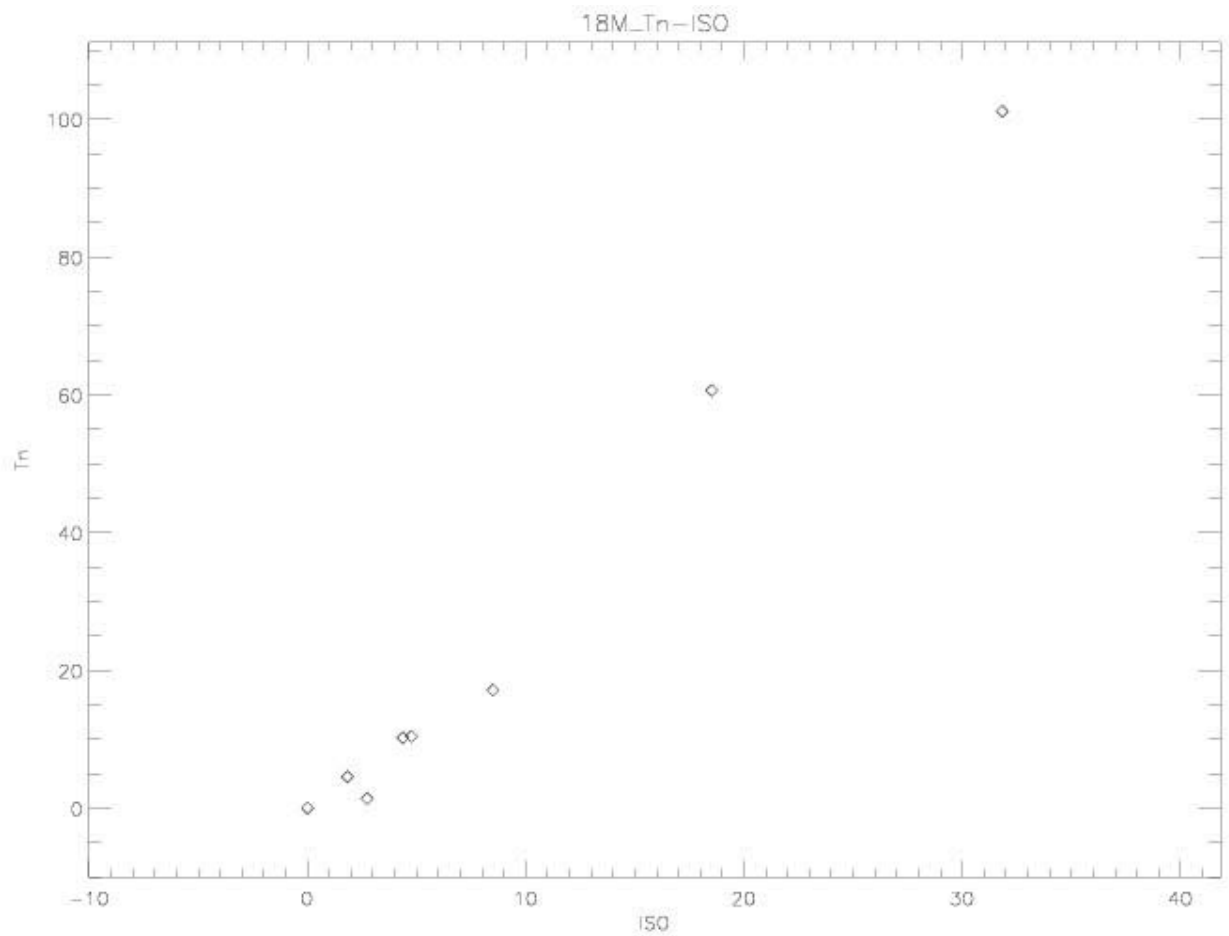


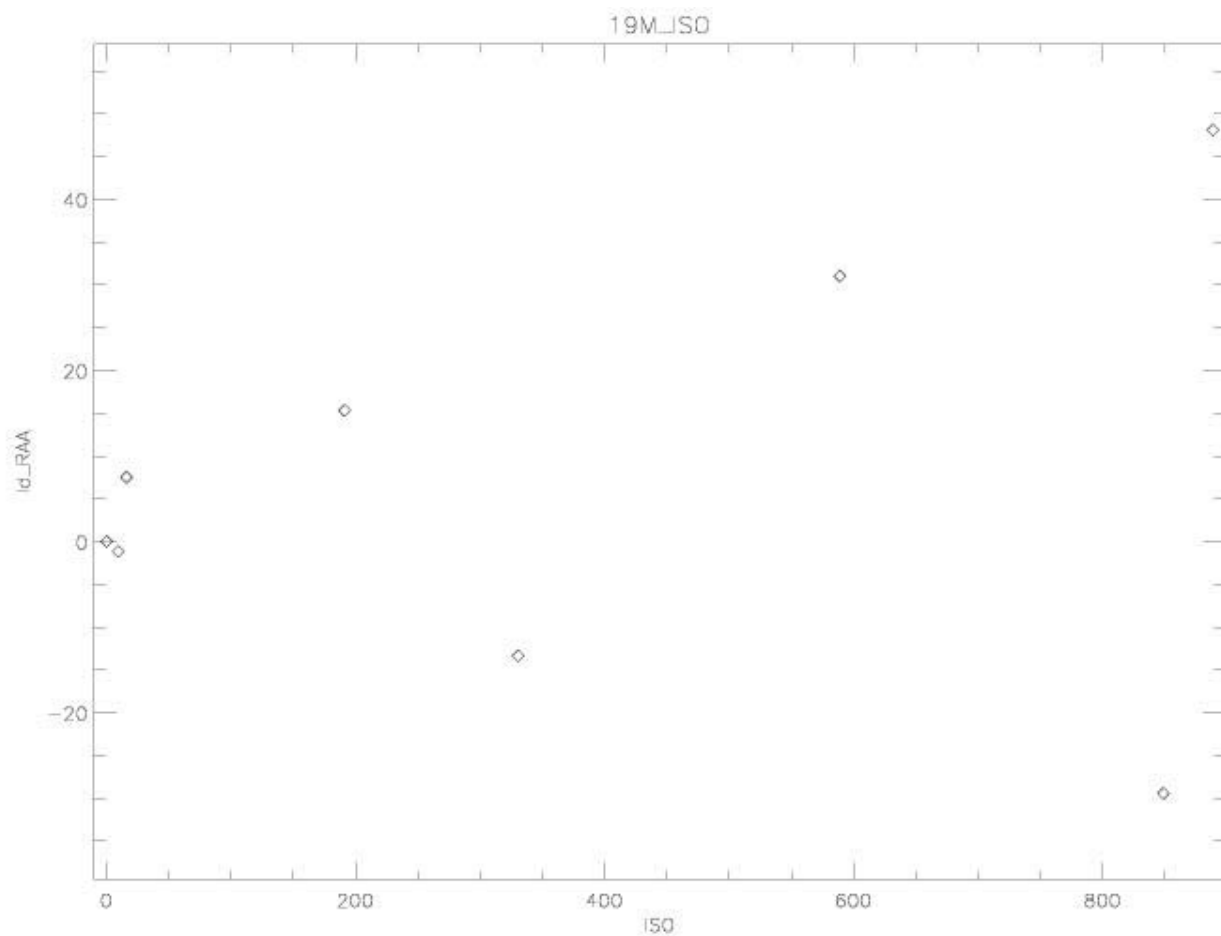


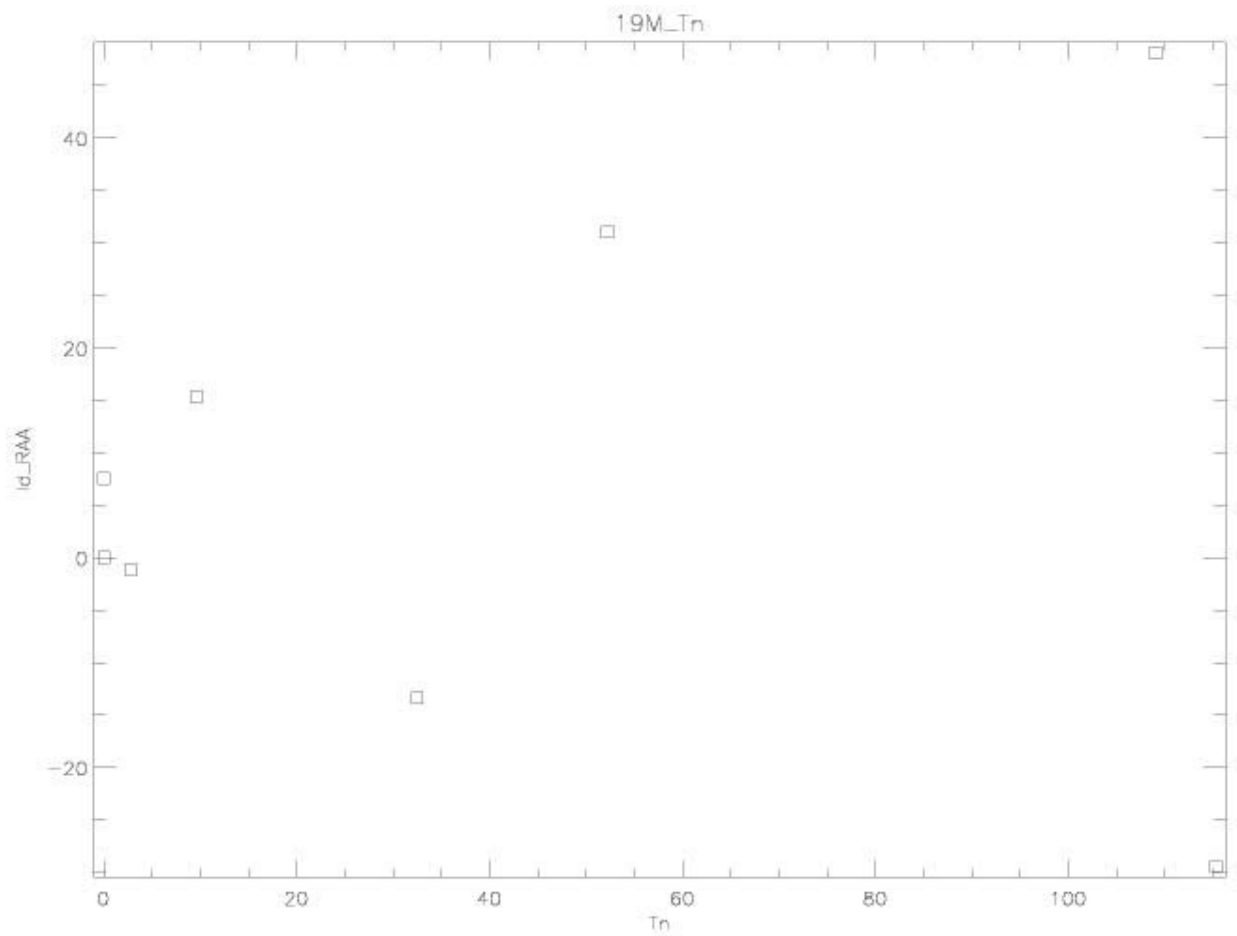
## 9 APPENDIX 2: Vg2 TUNING. Noise temperature and Isolation susceptibility to drain current.

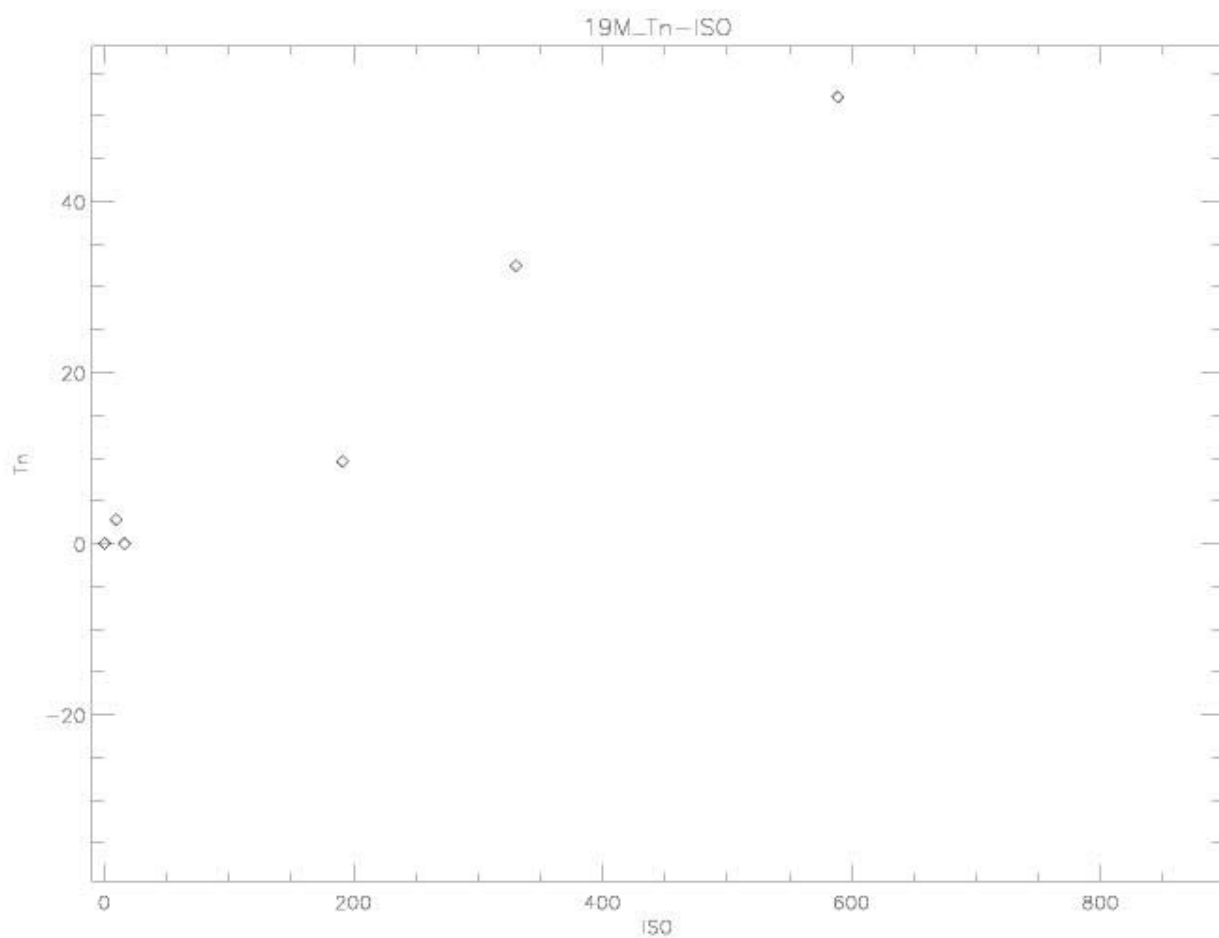


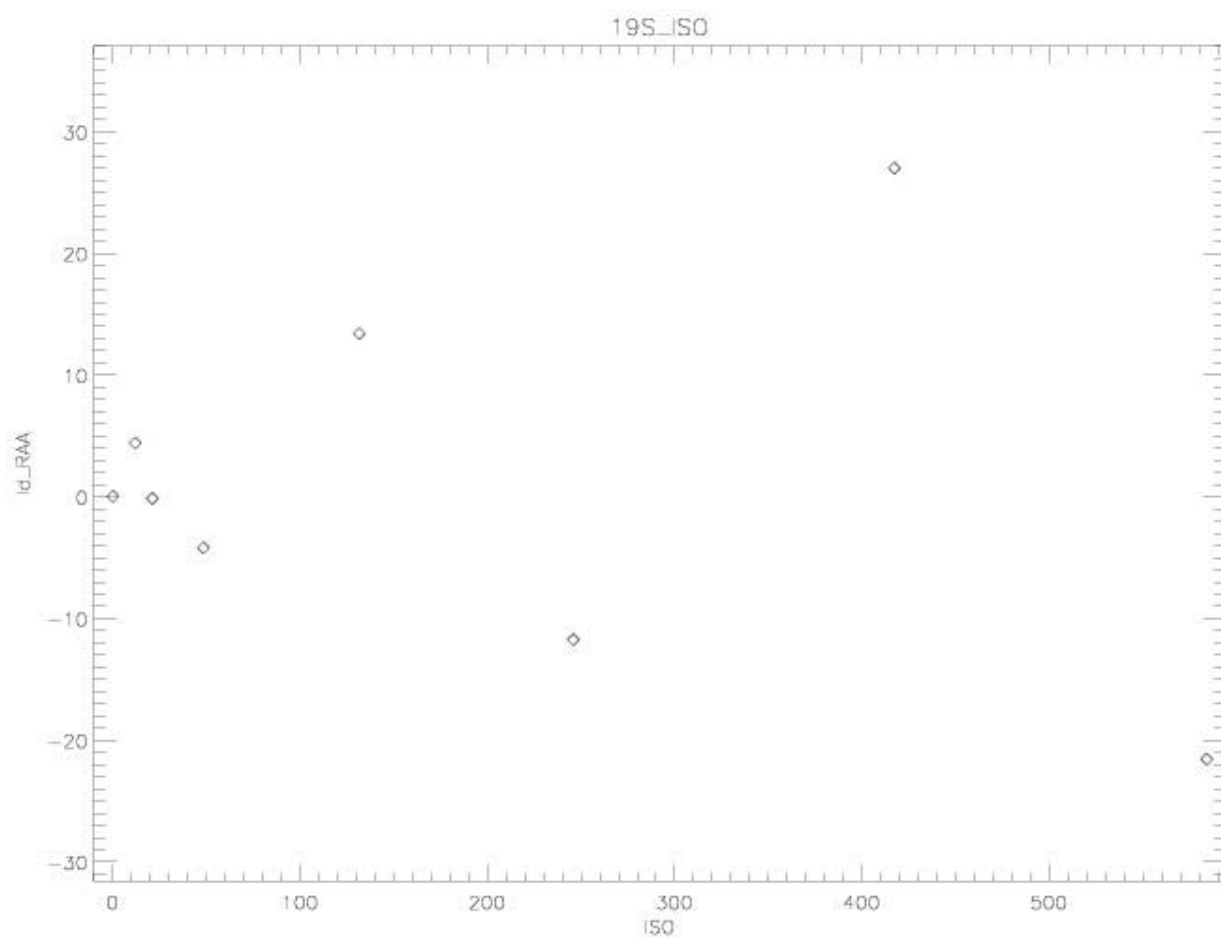


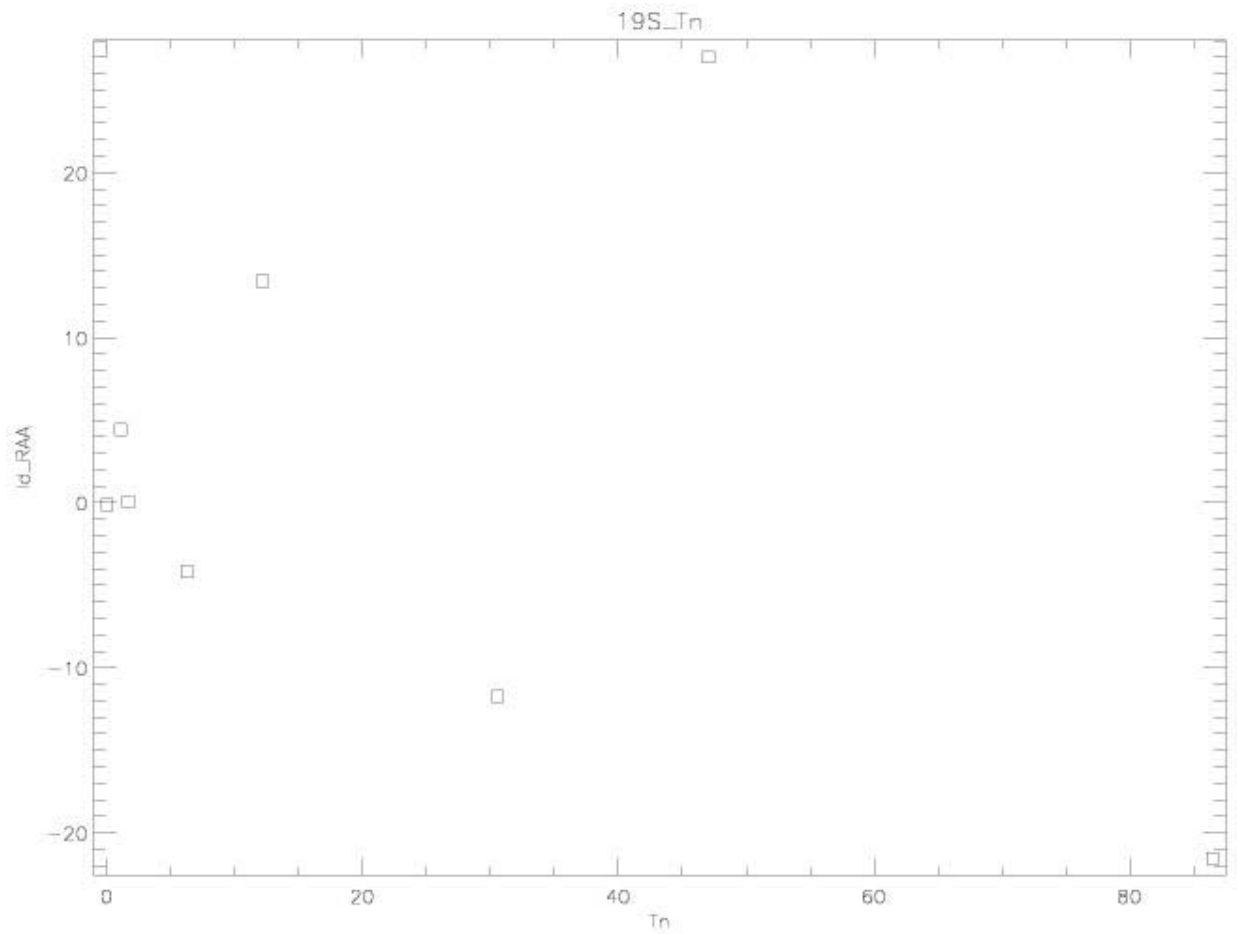


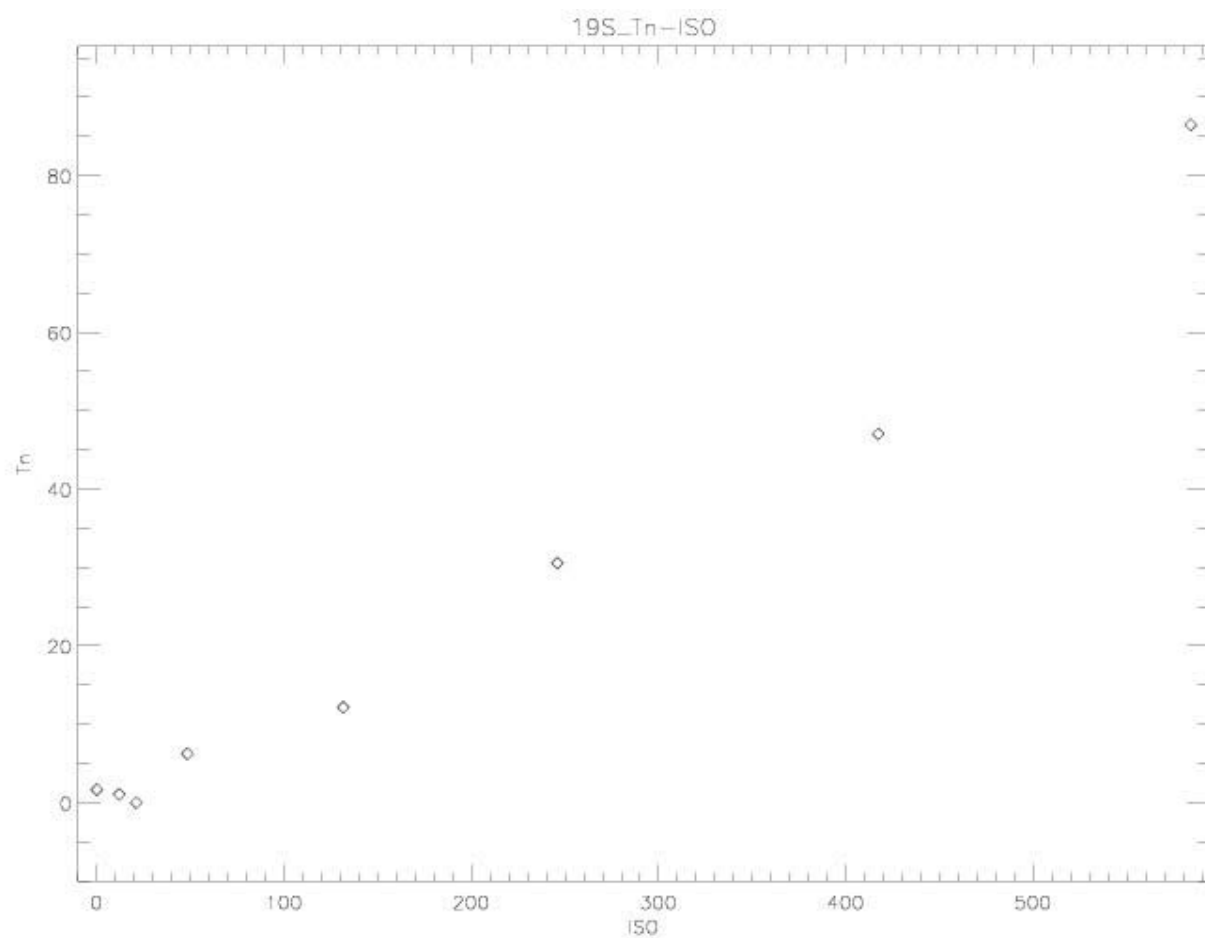


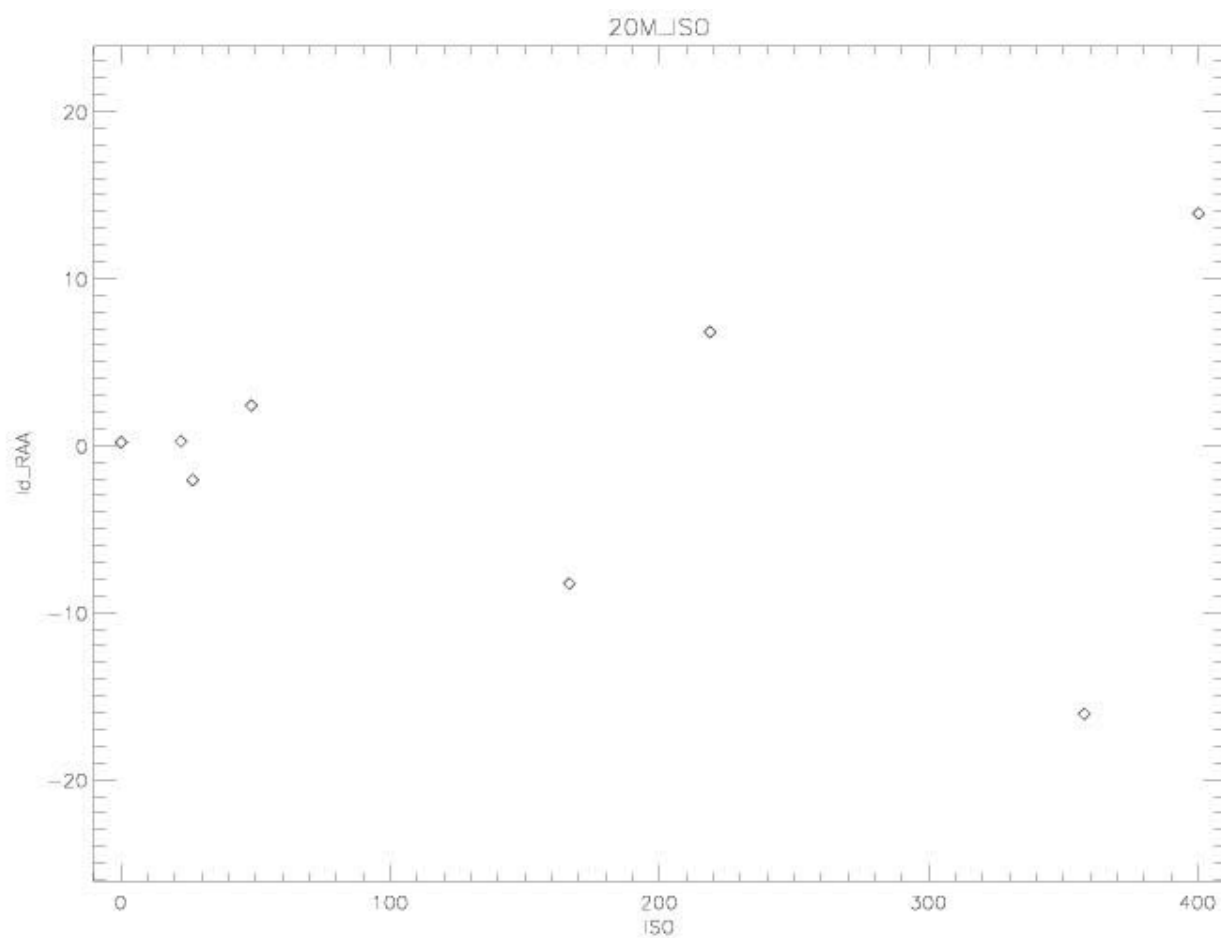


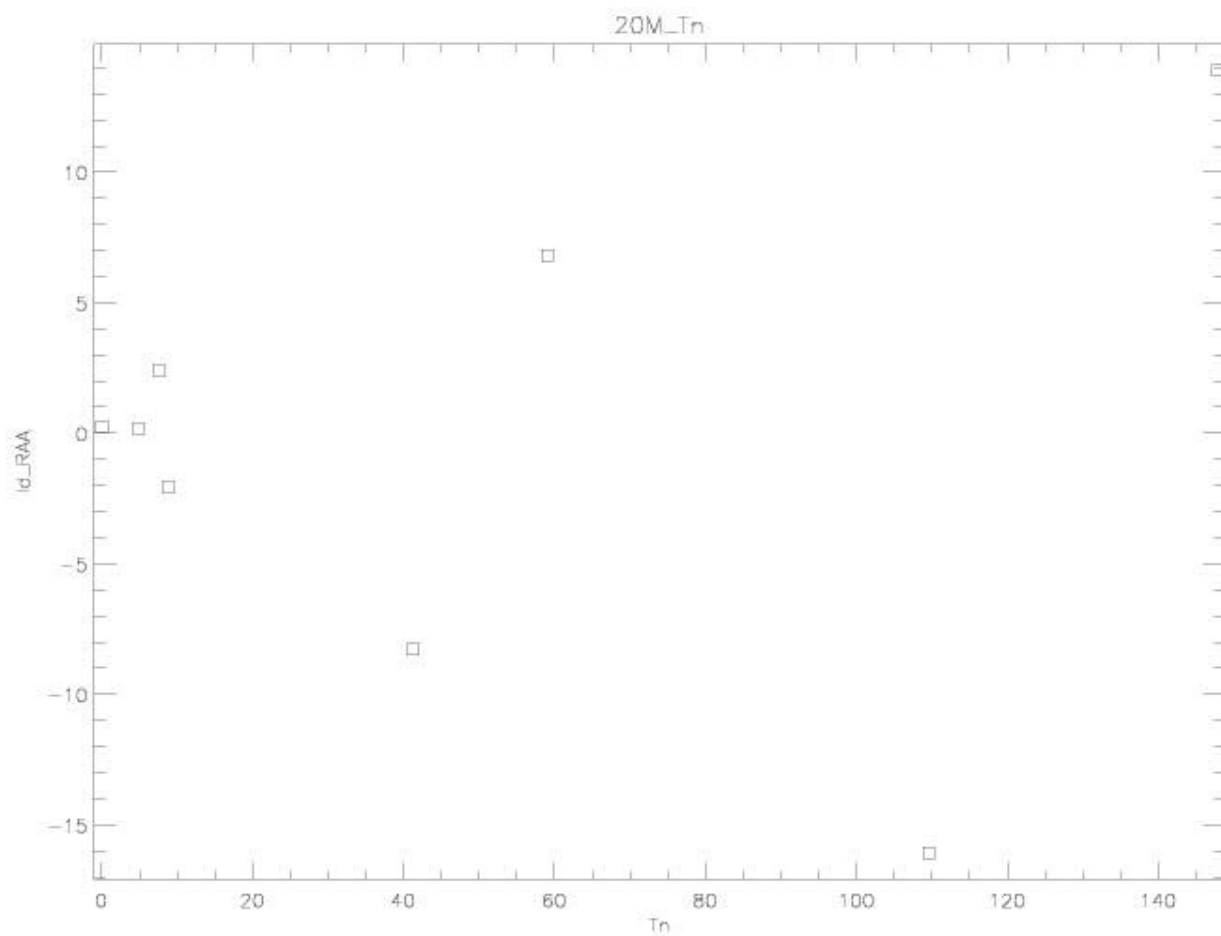


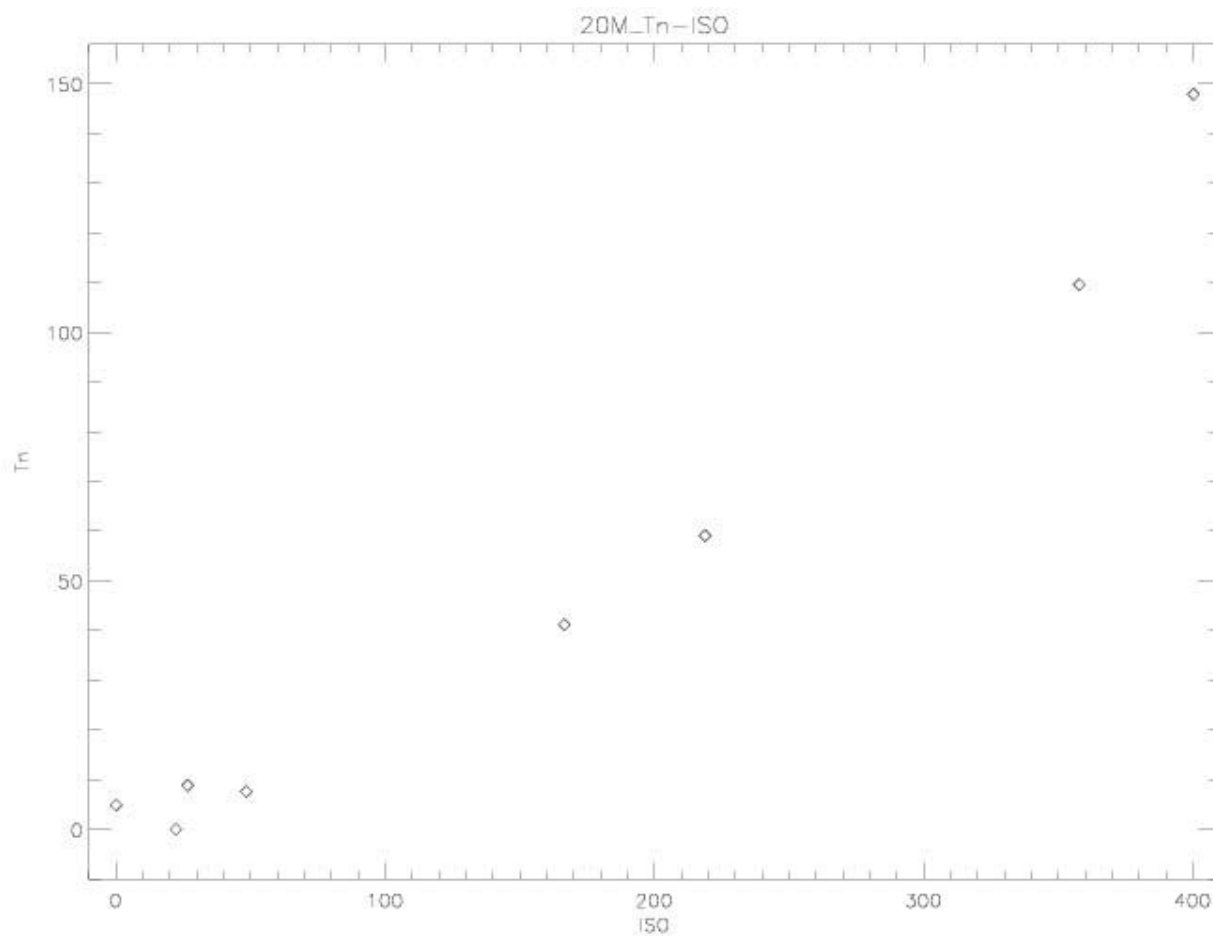


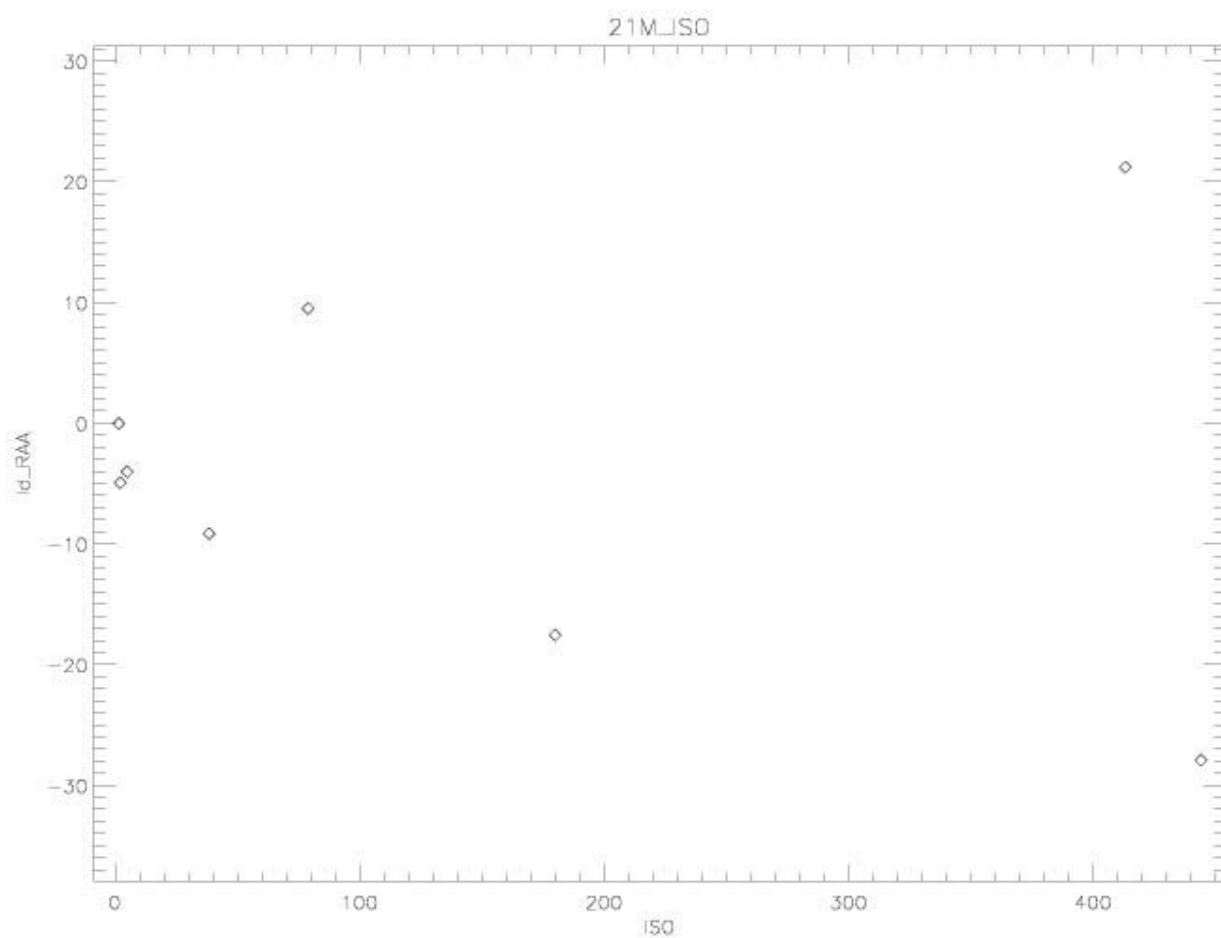


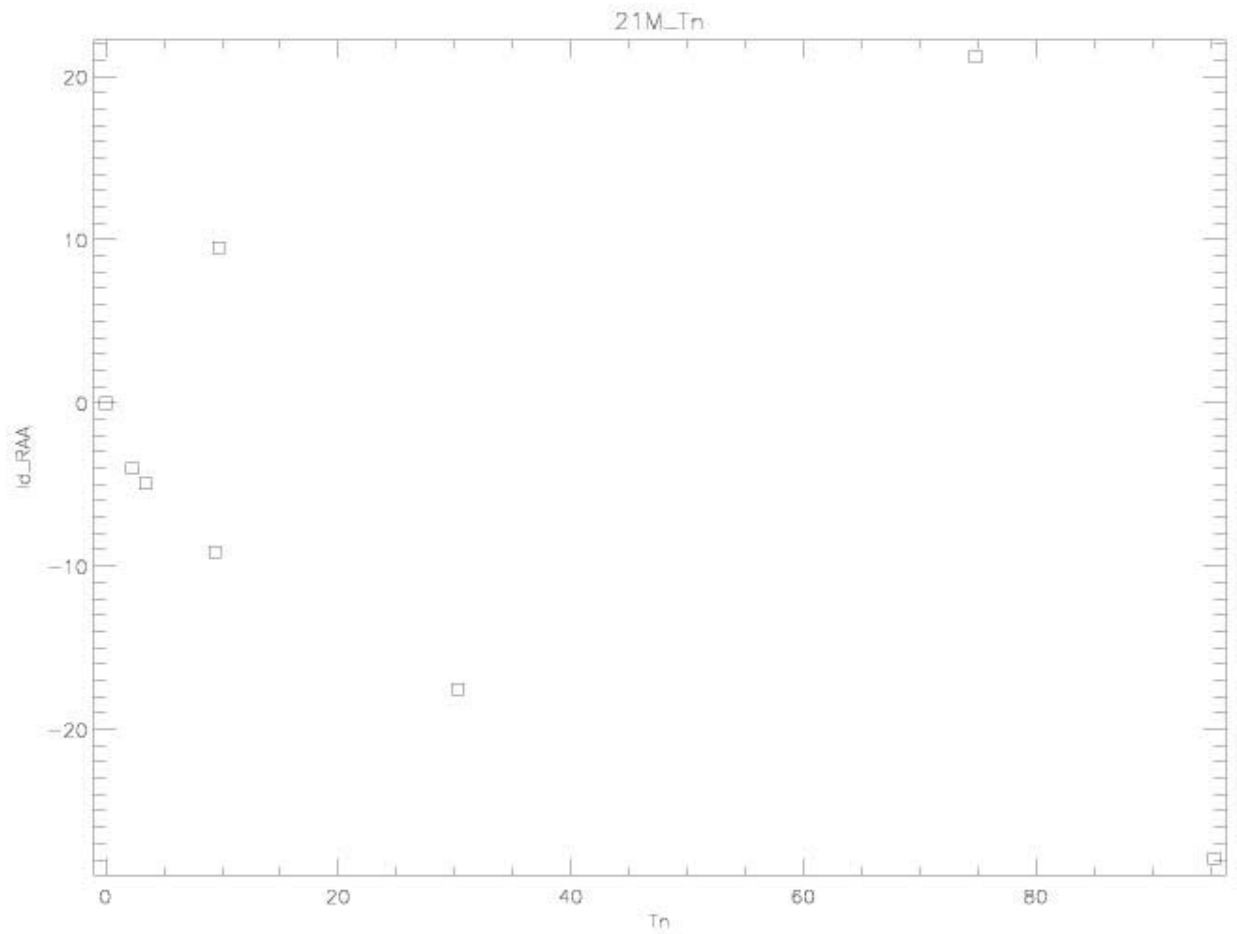


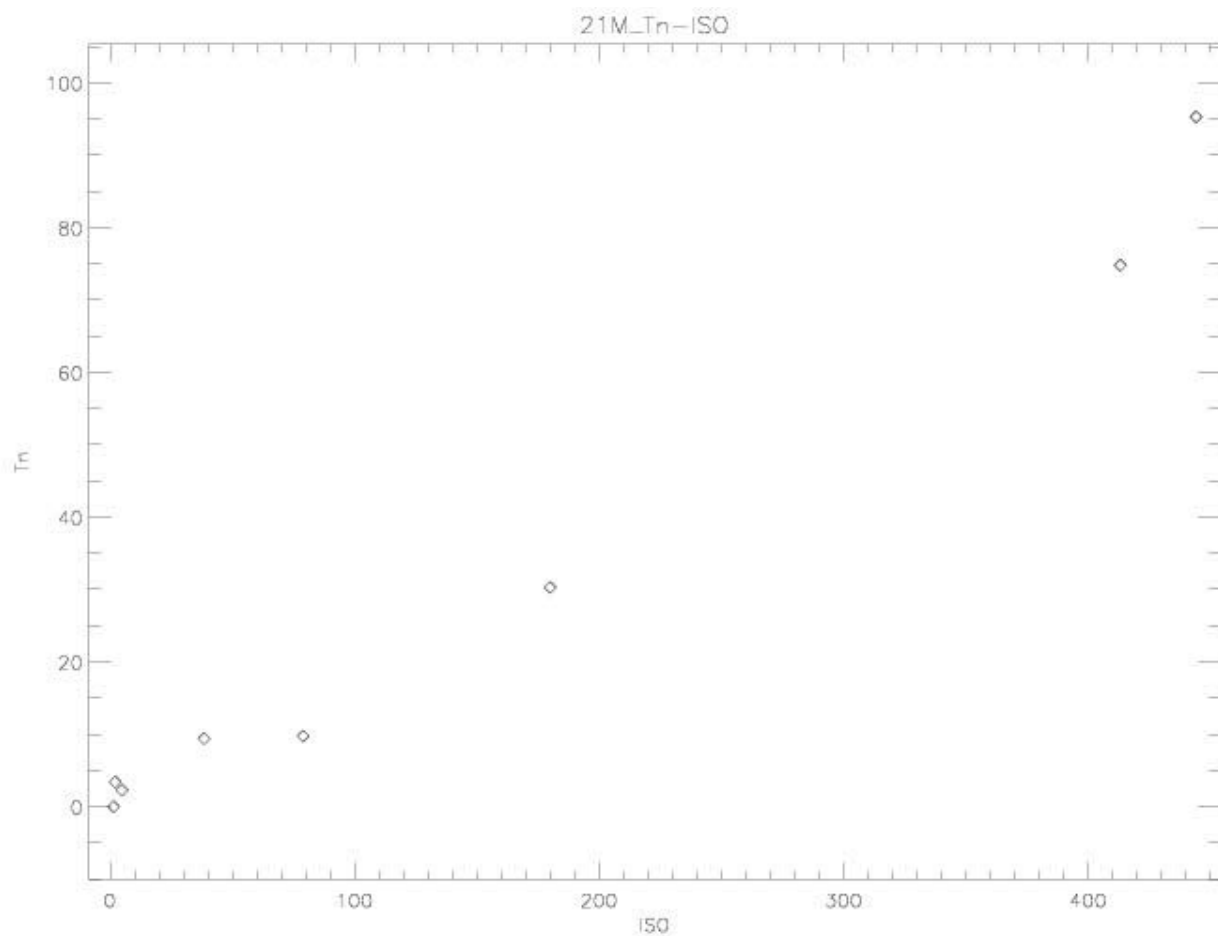


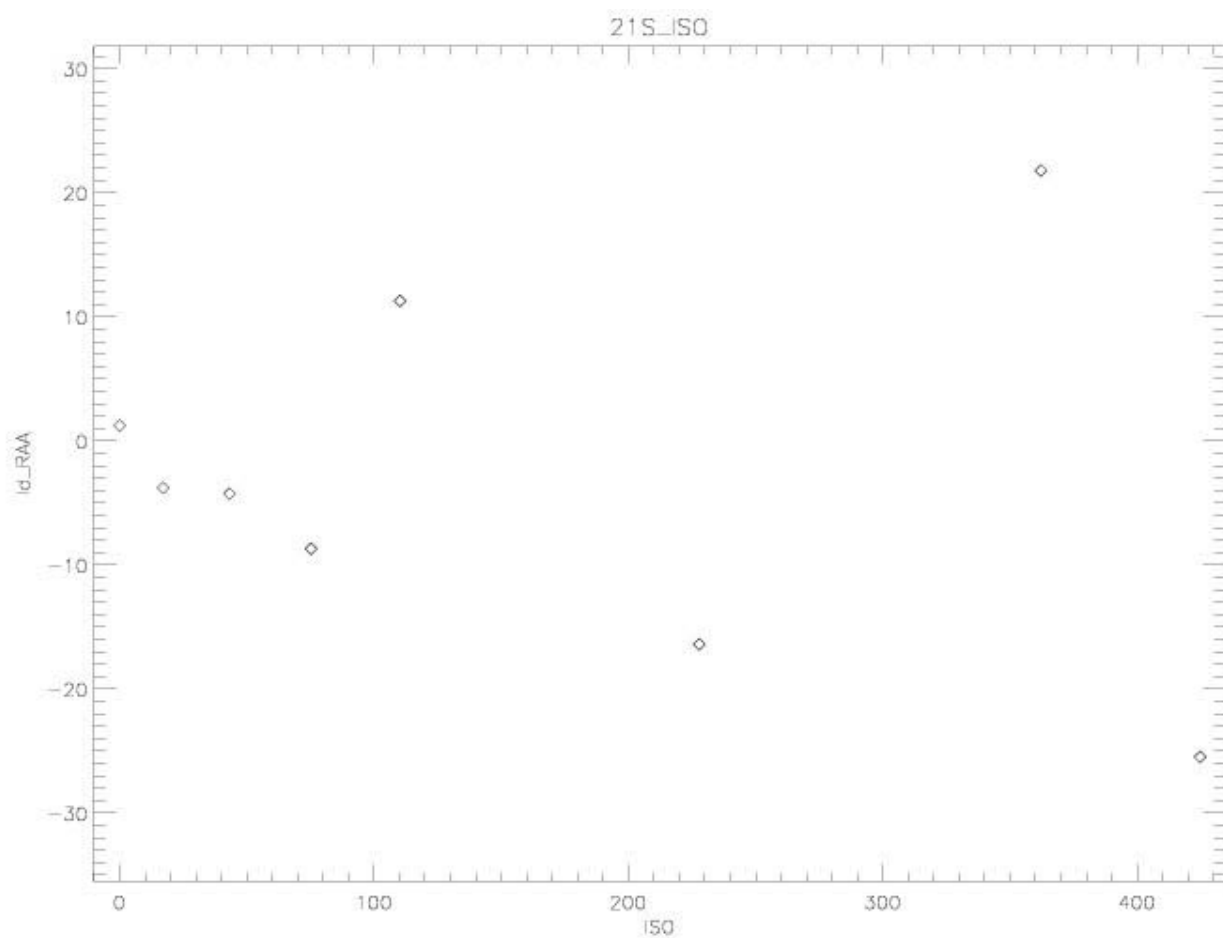


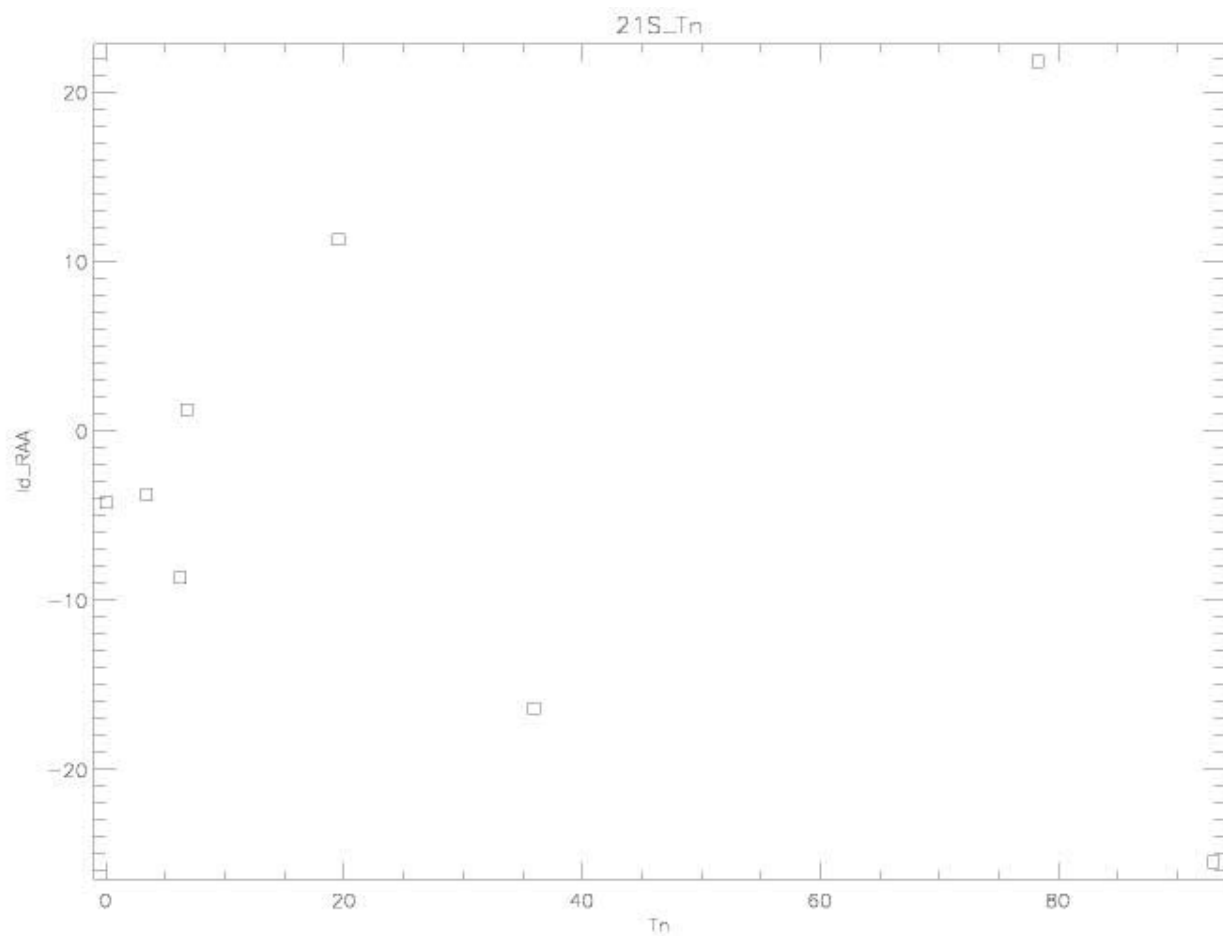


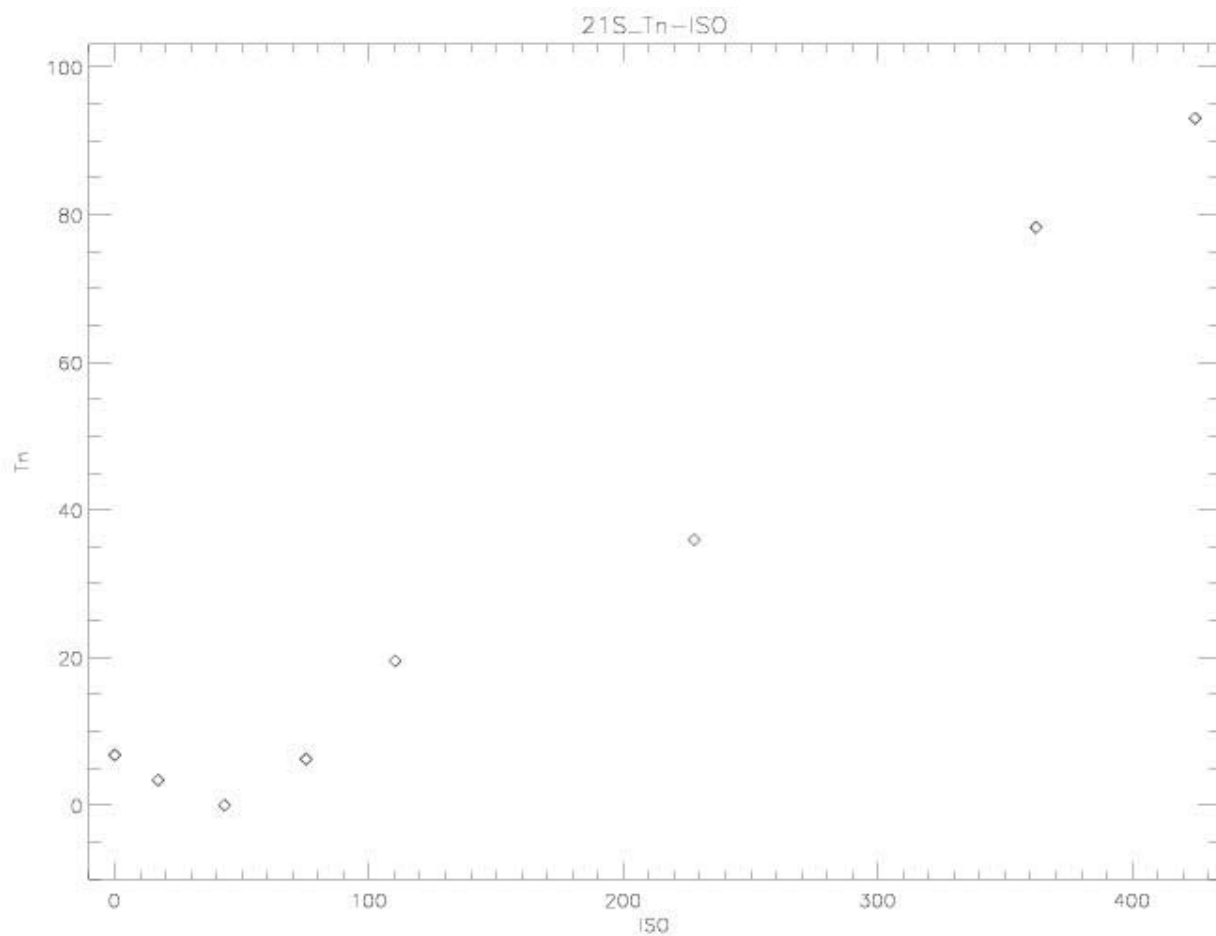


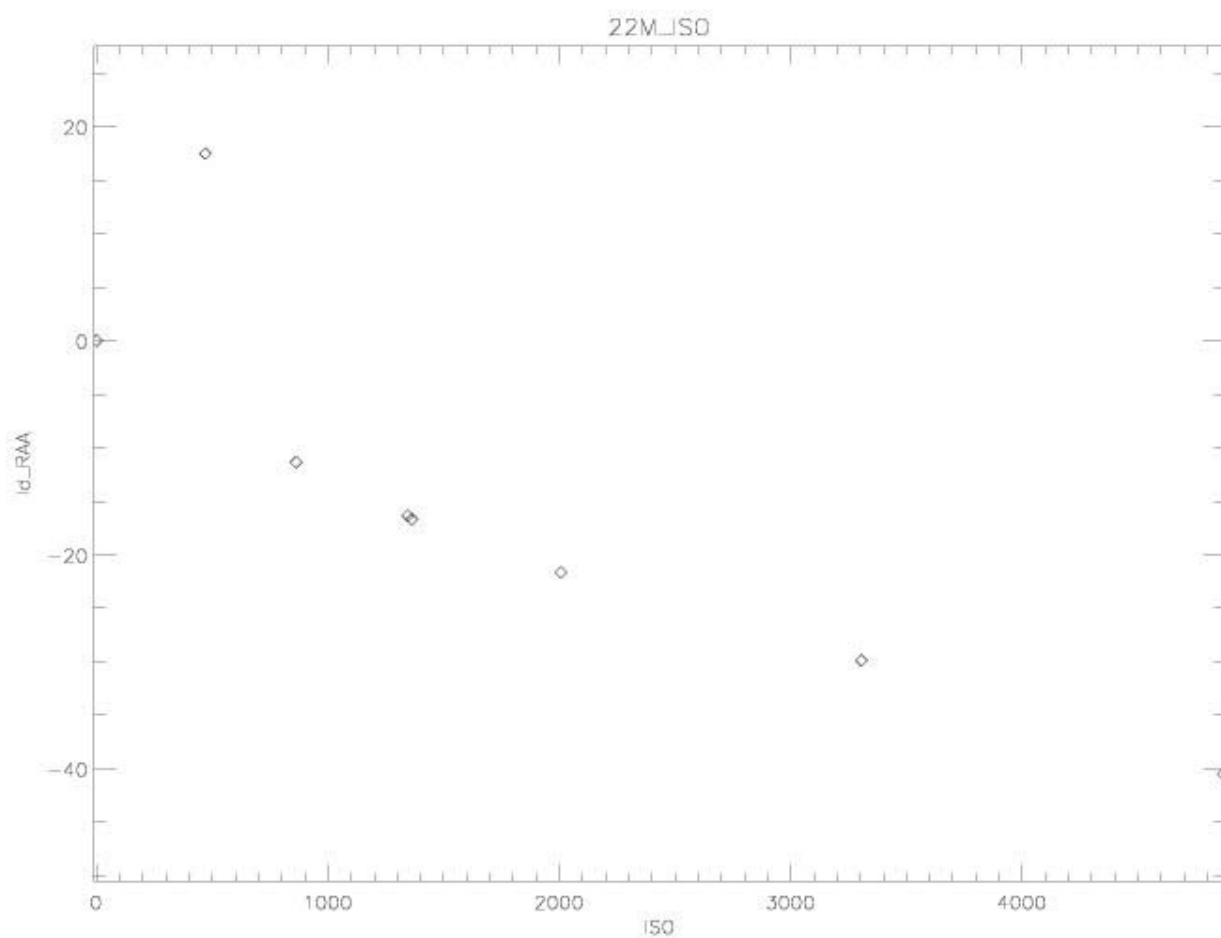


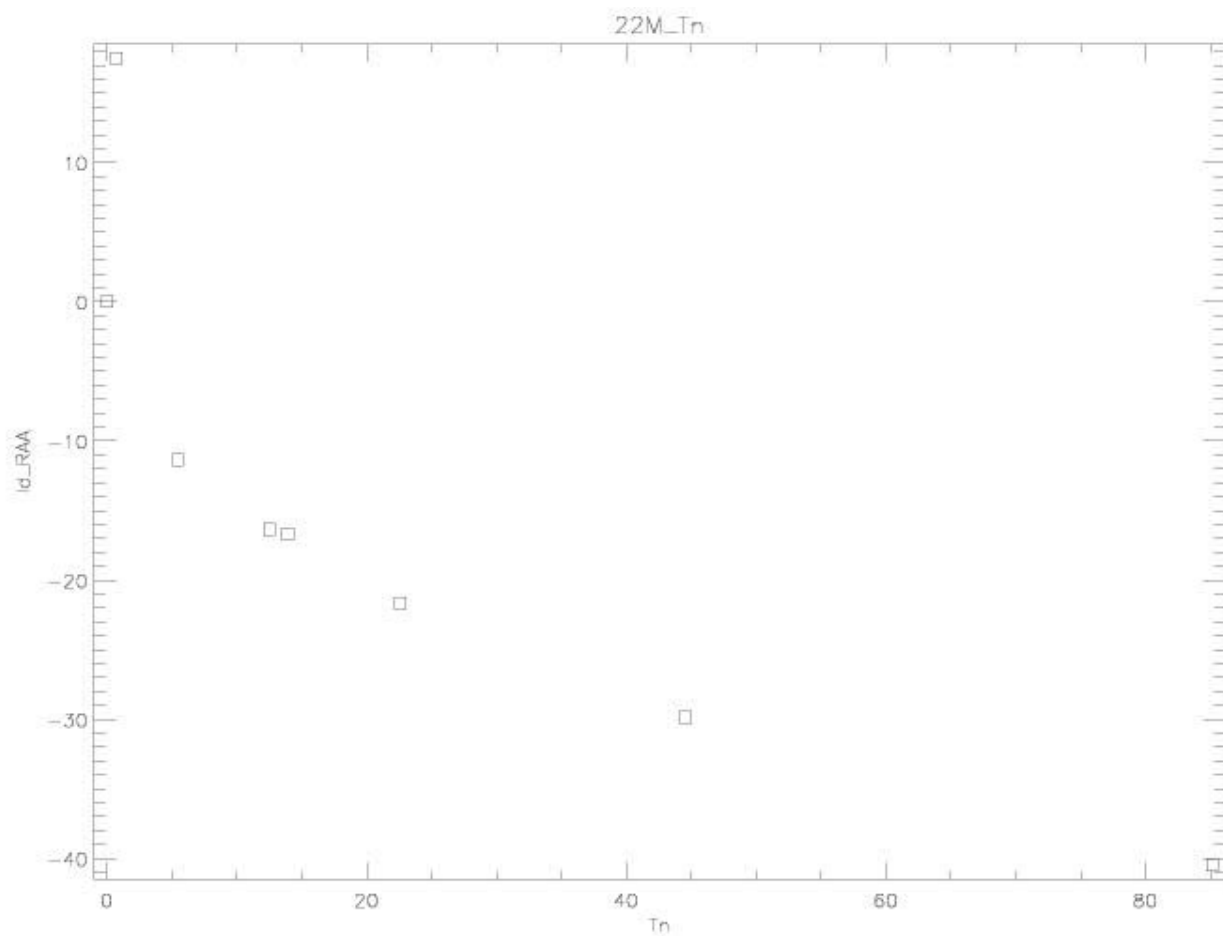


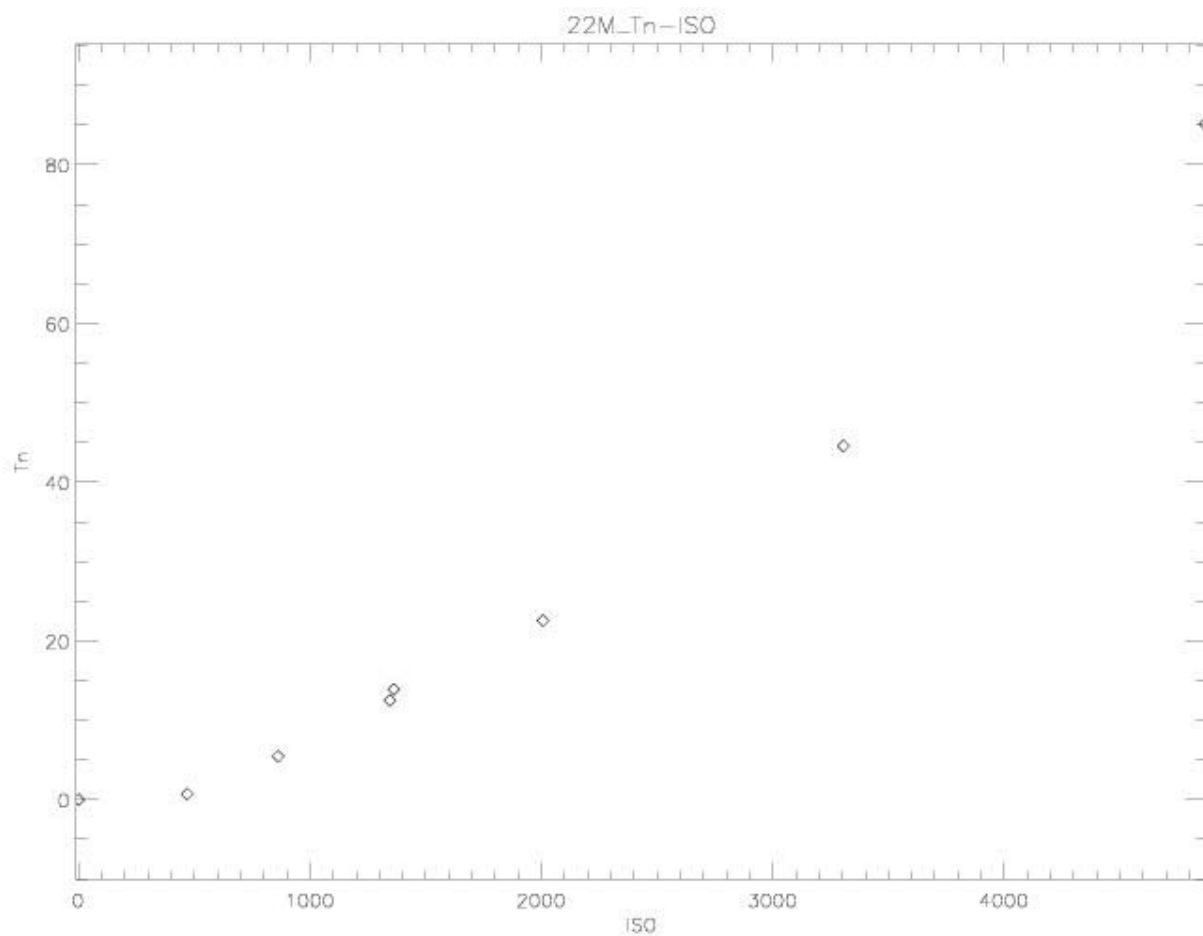


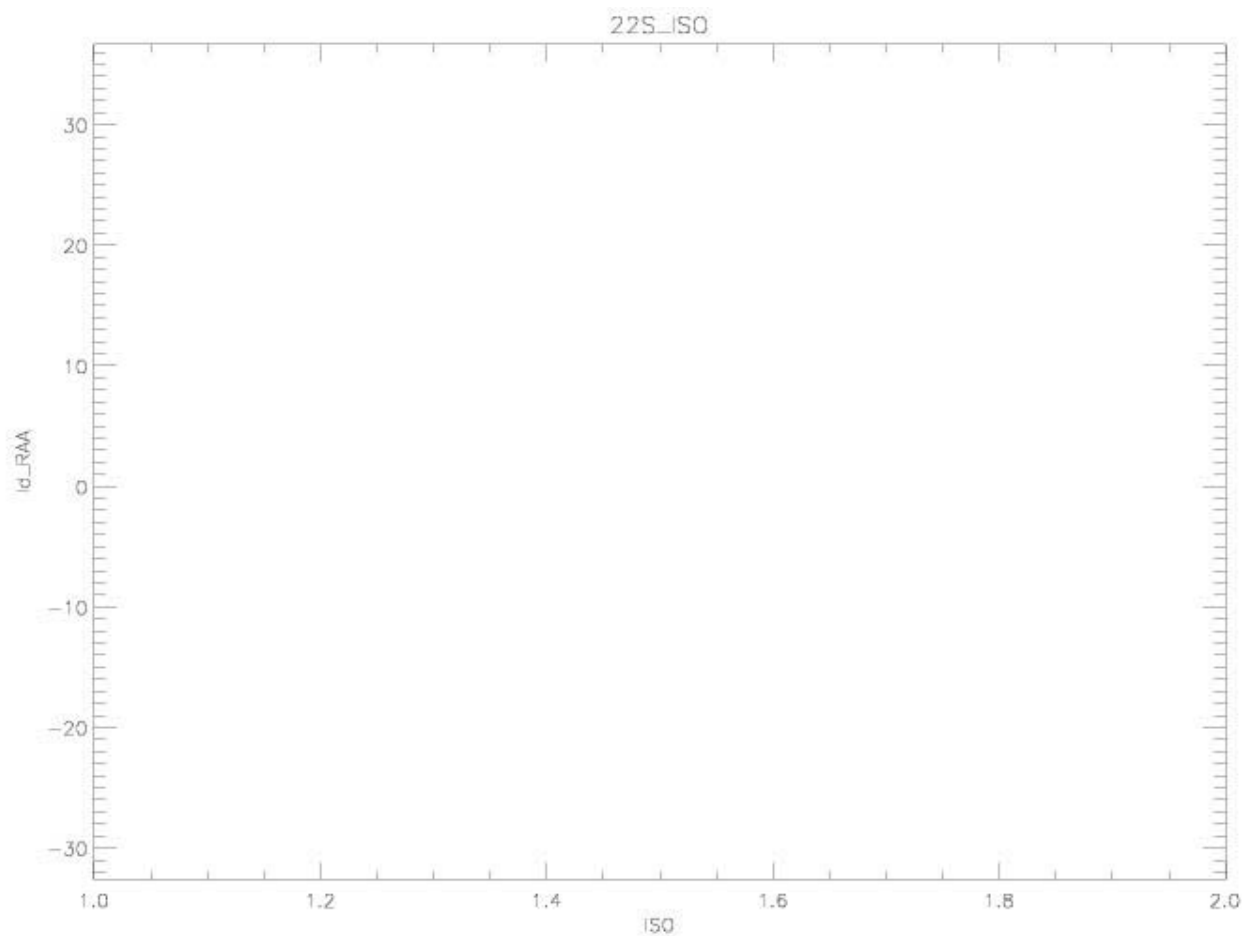


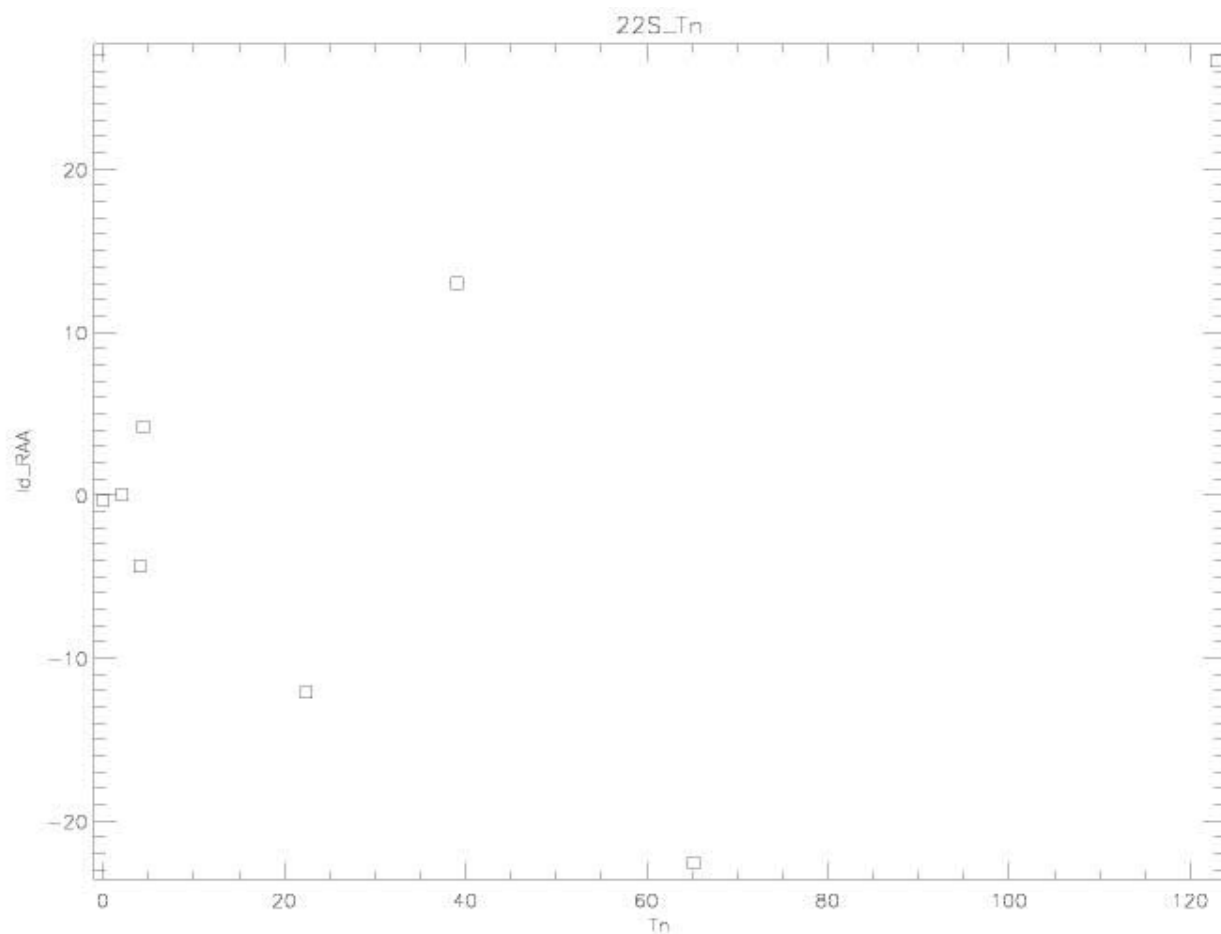


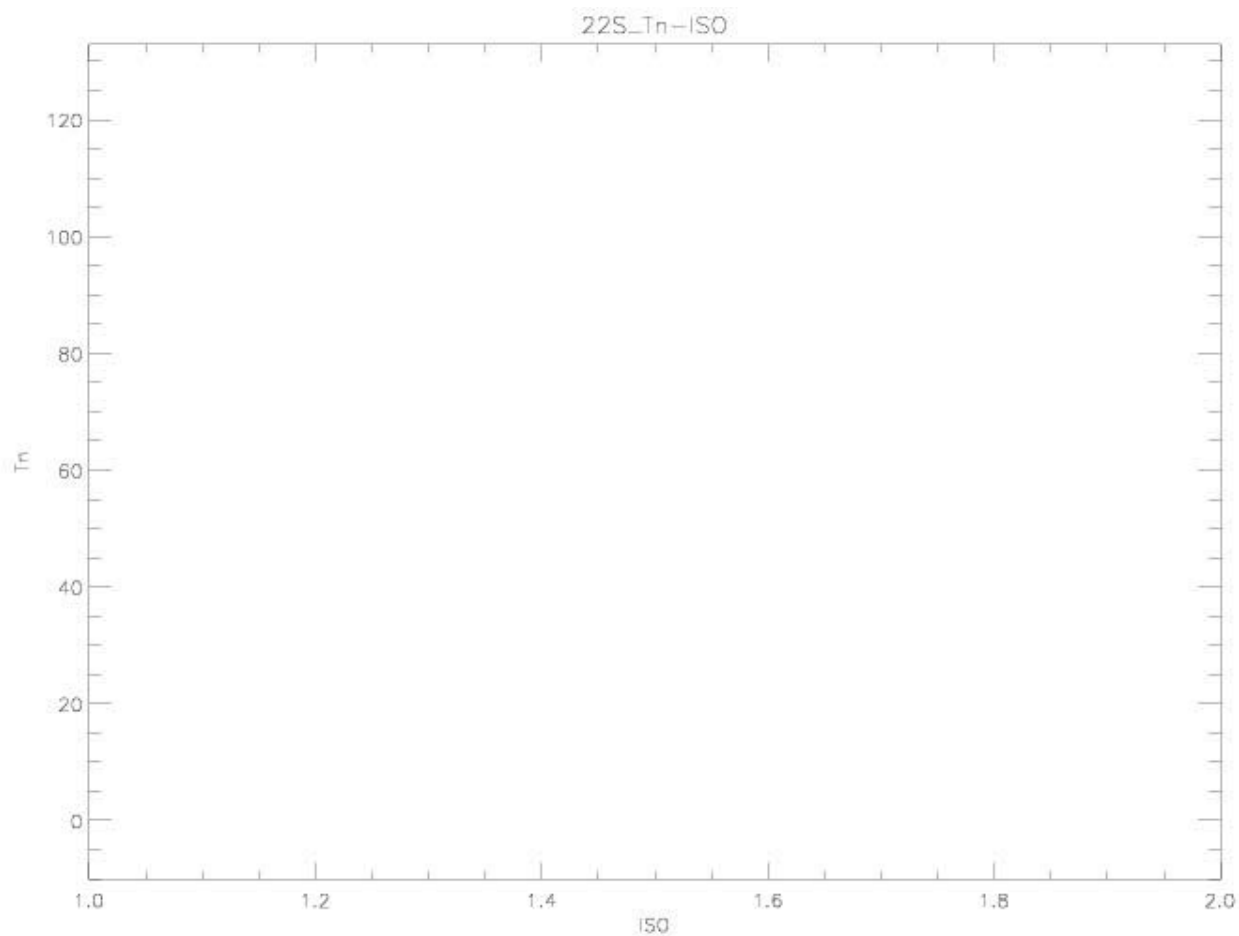


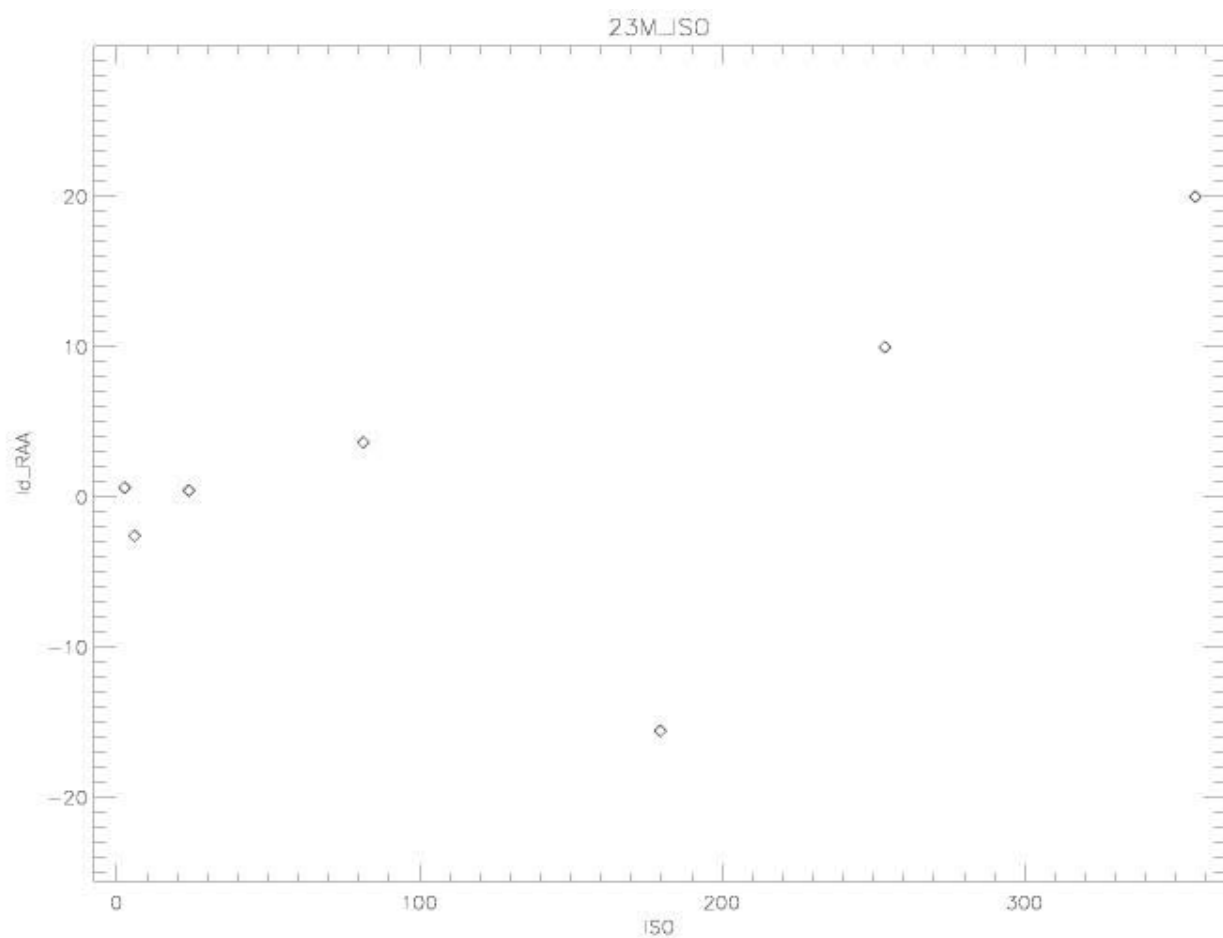


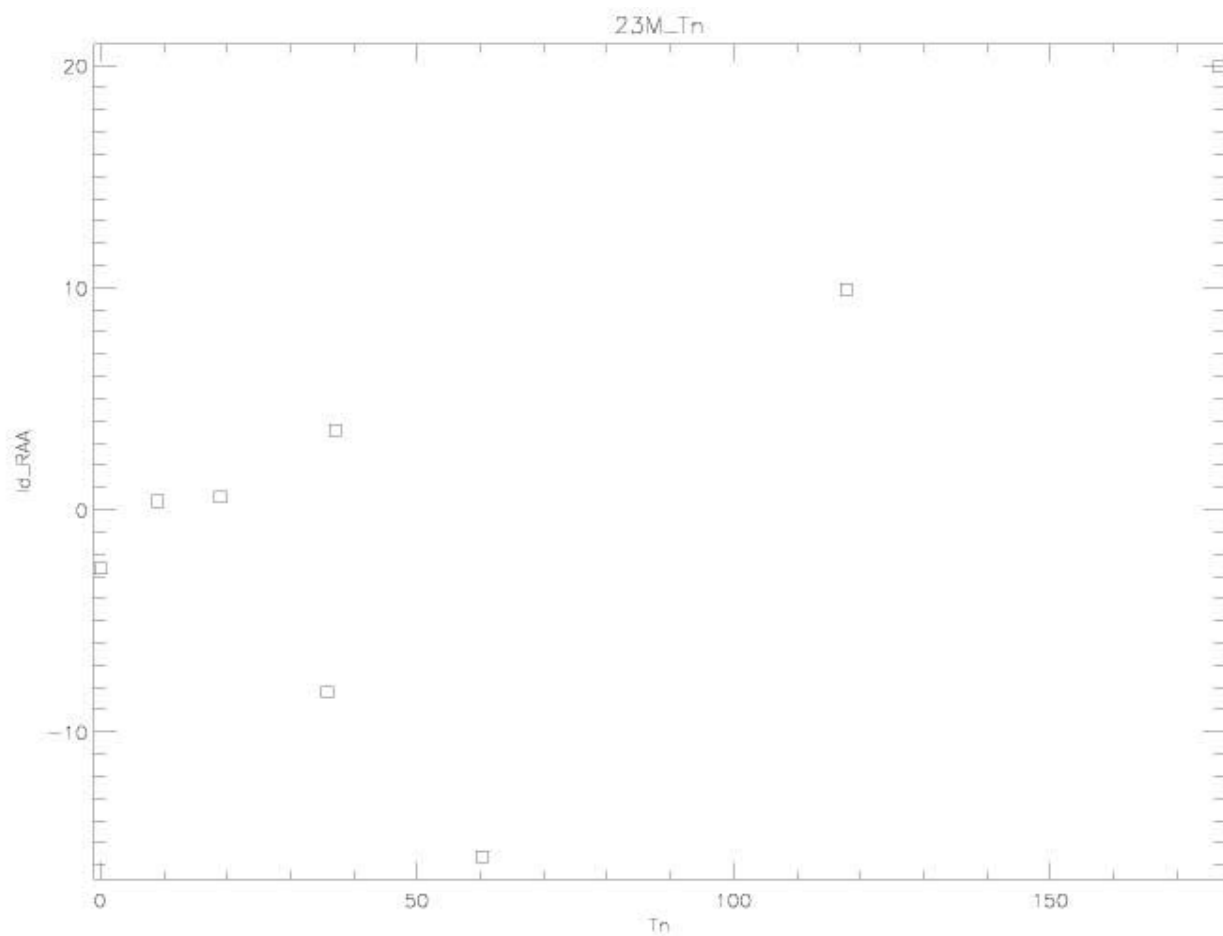


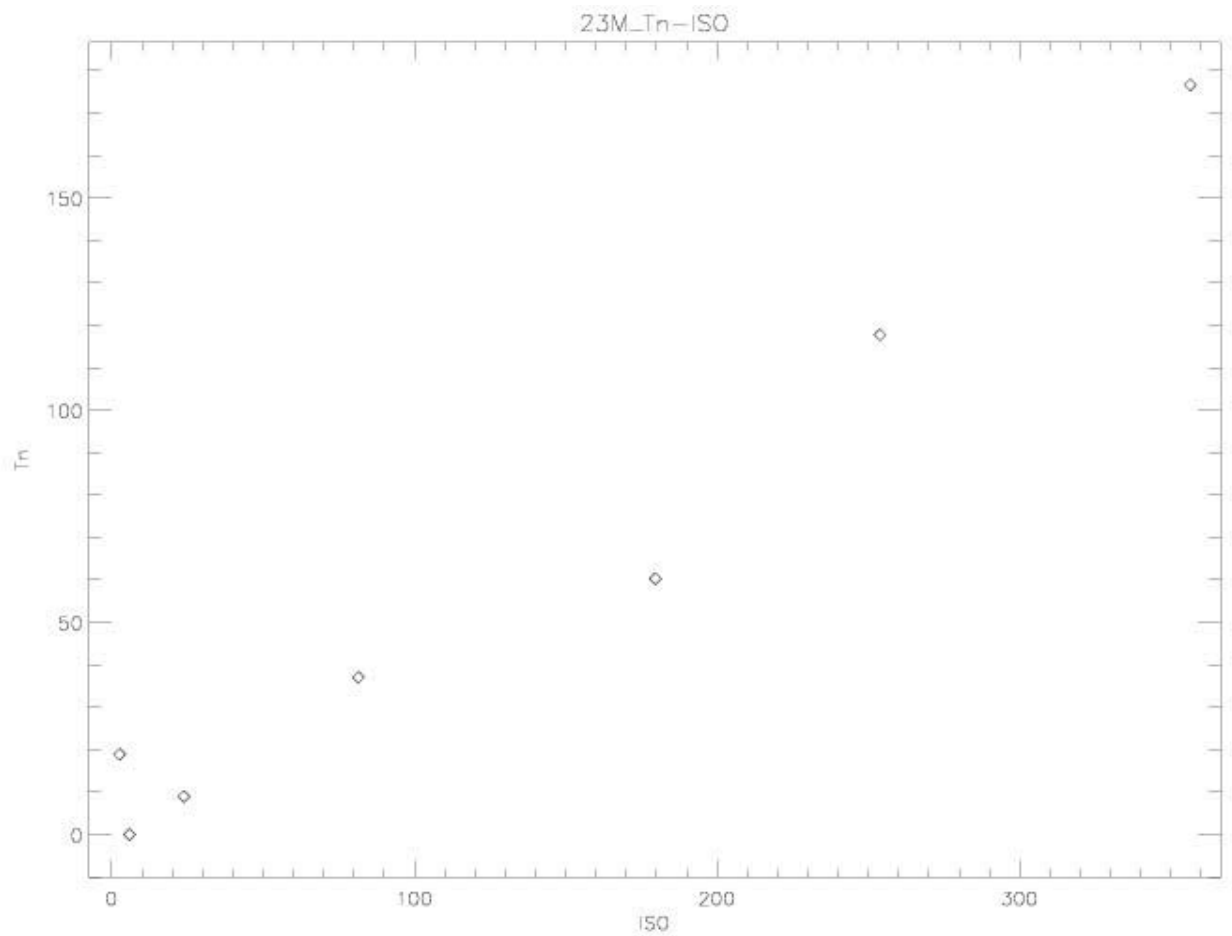


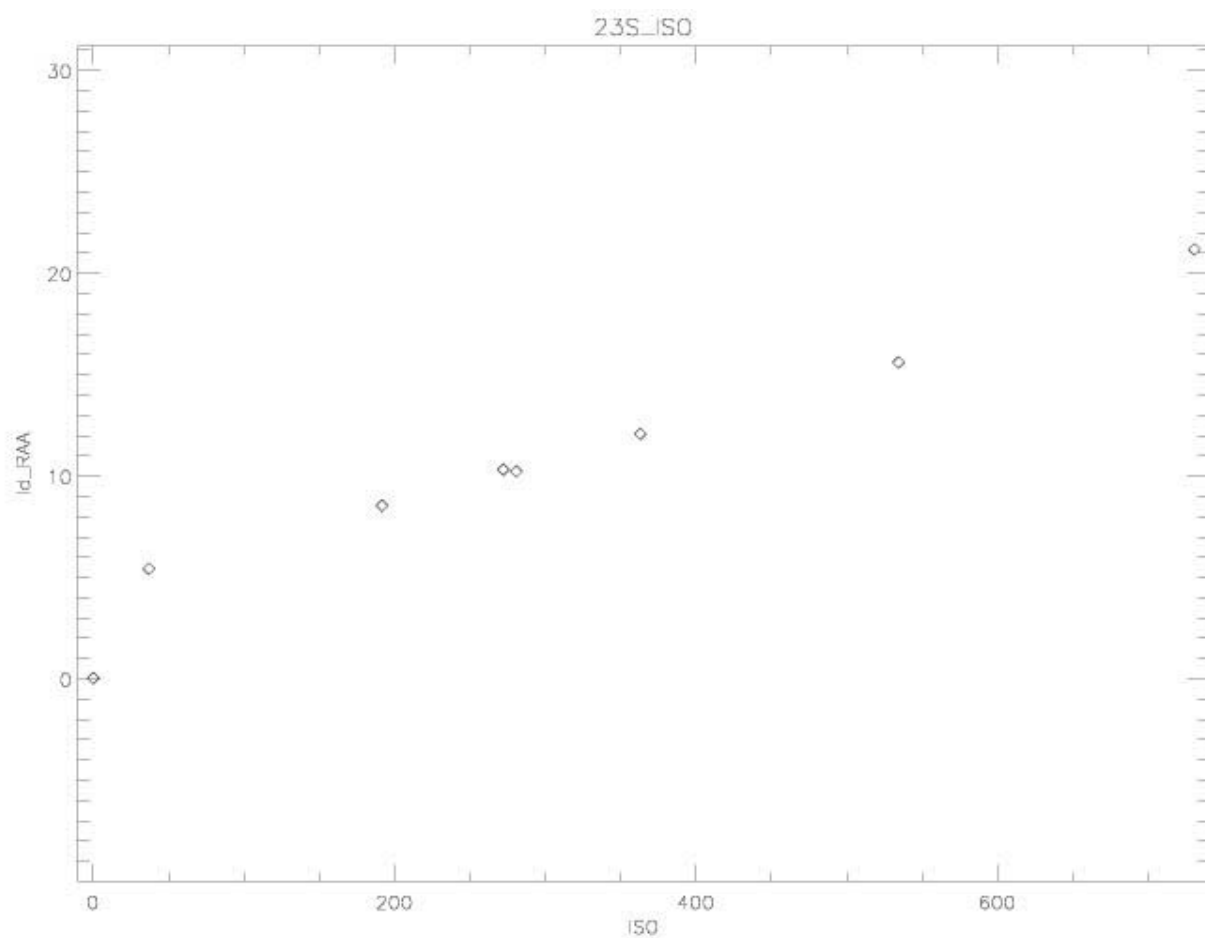


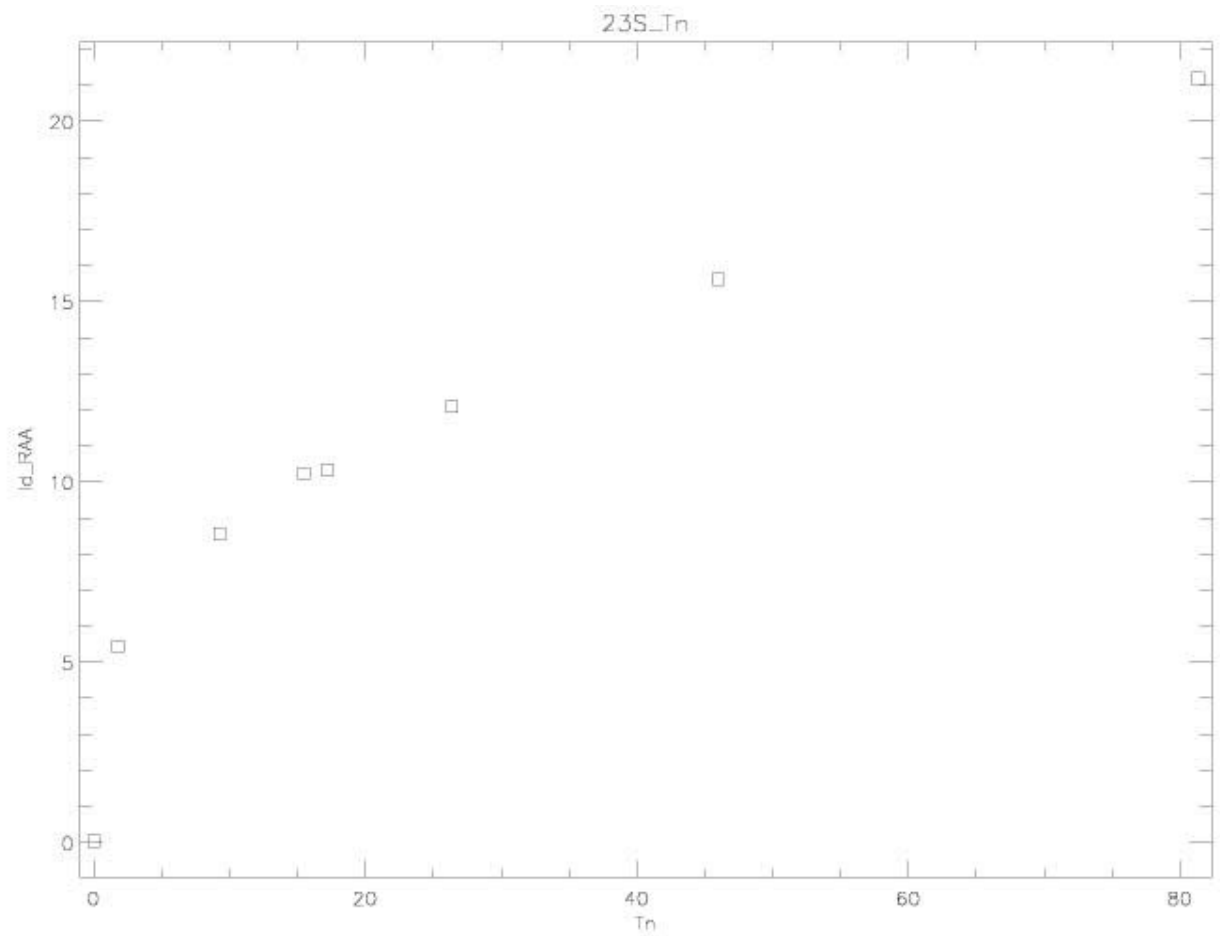


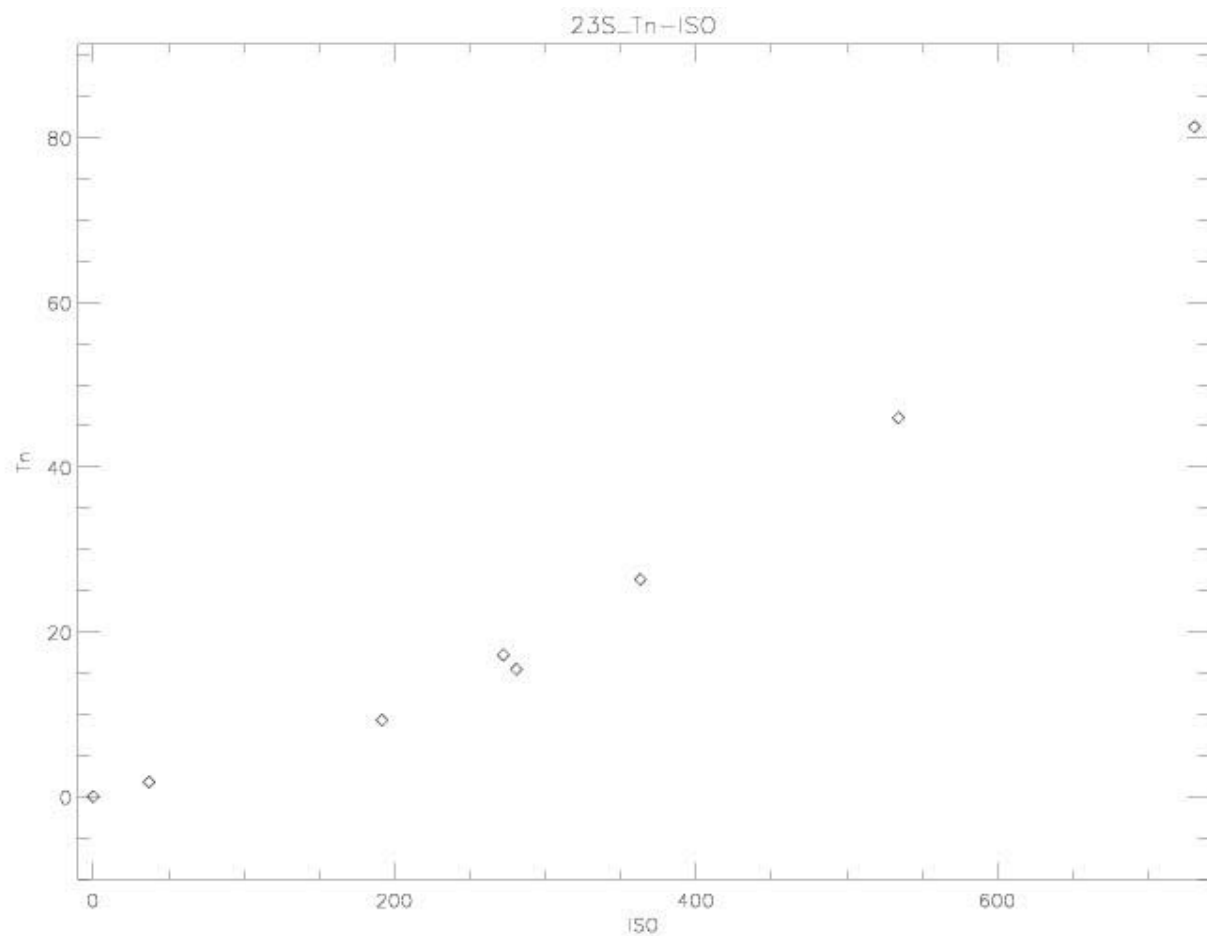


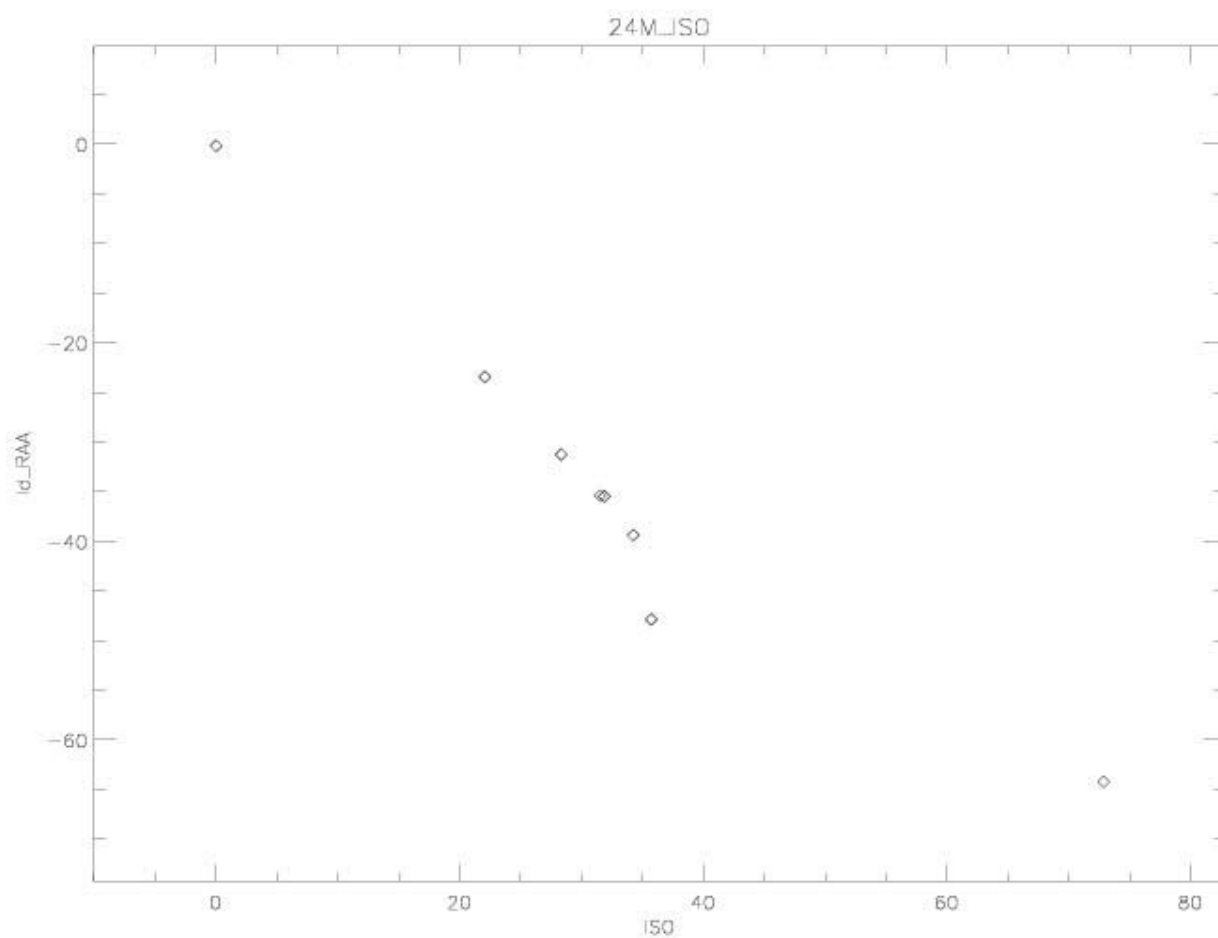


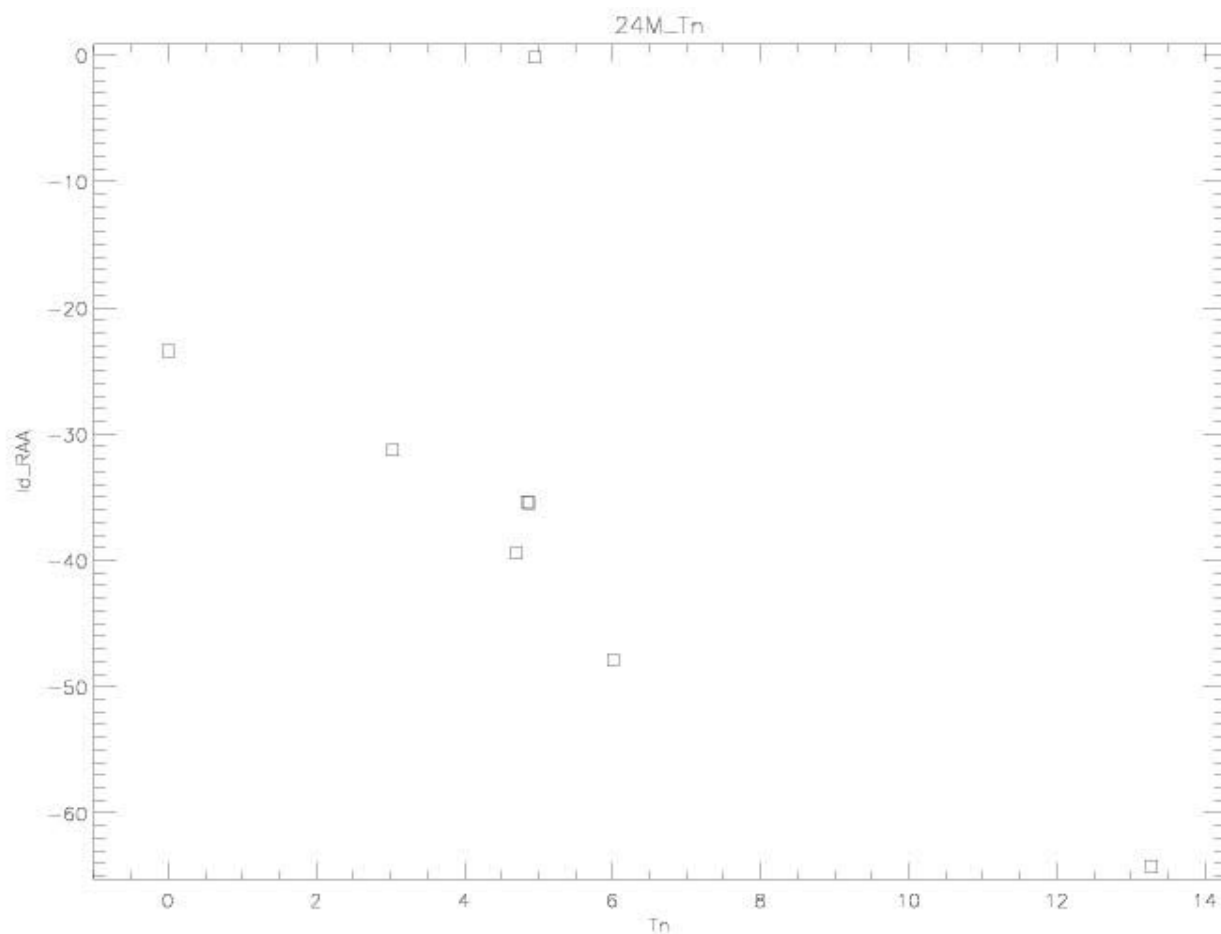


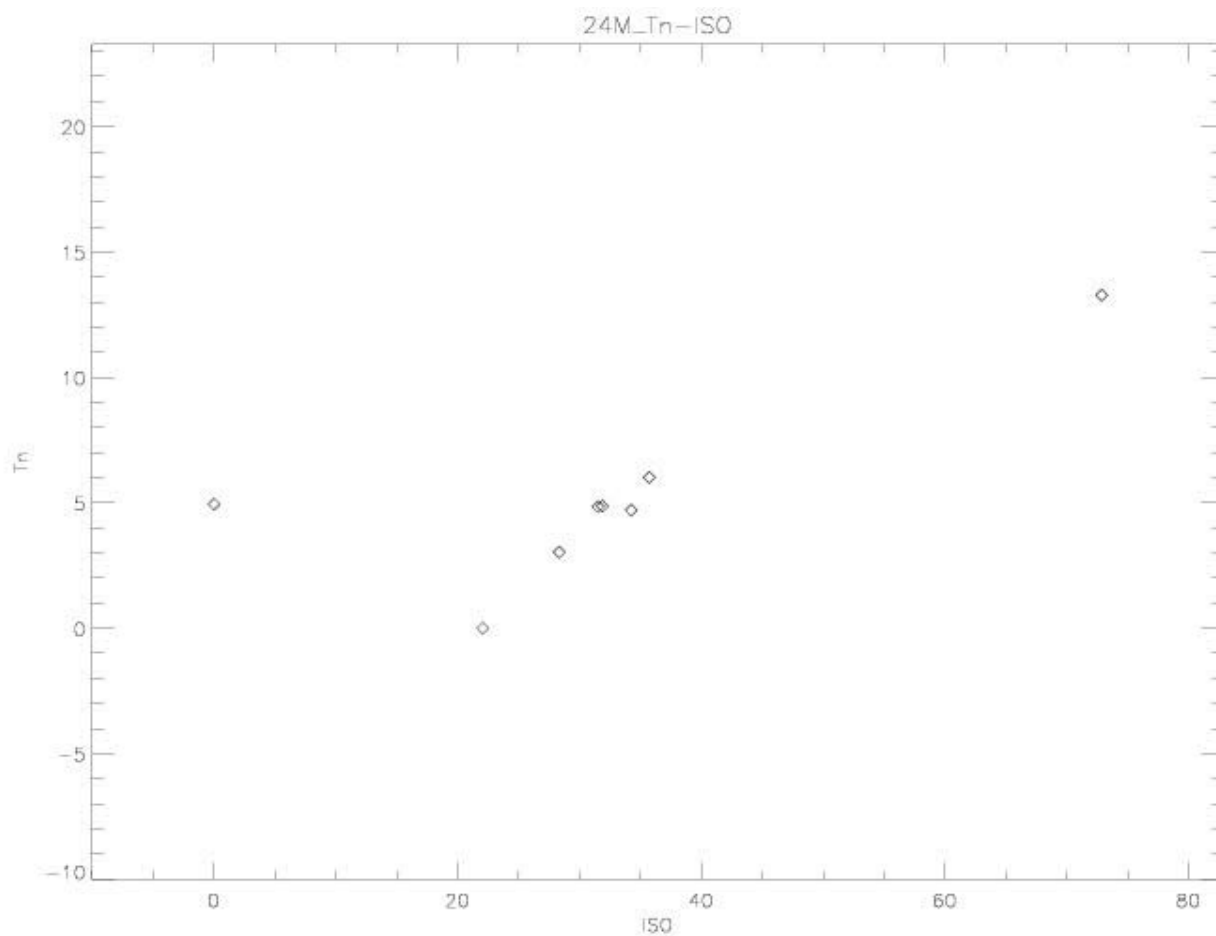


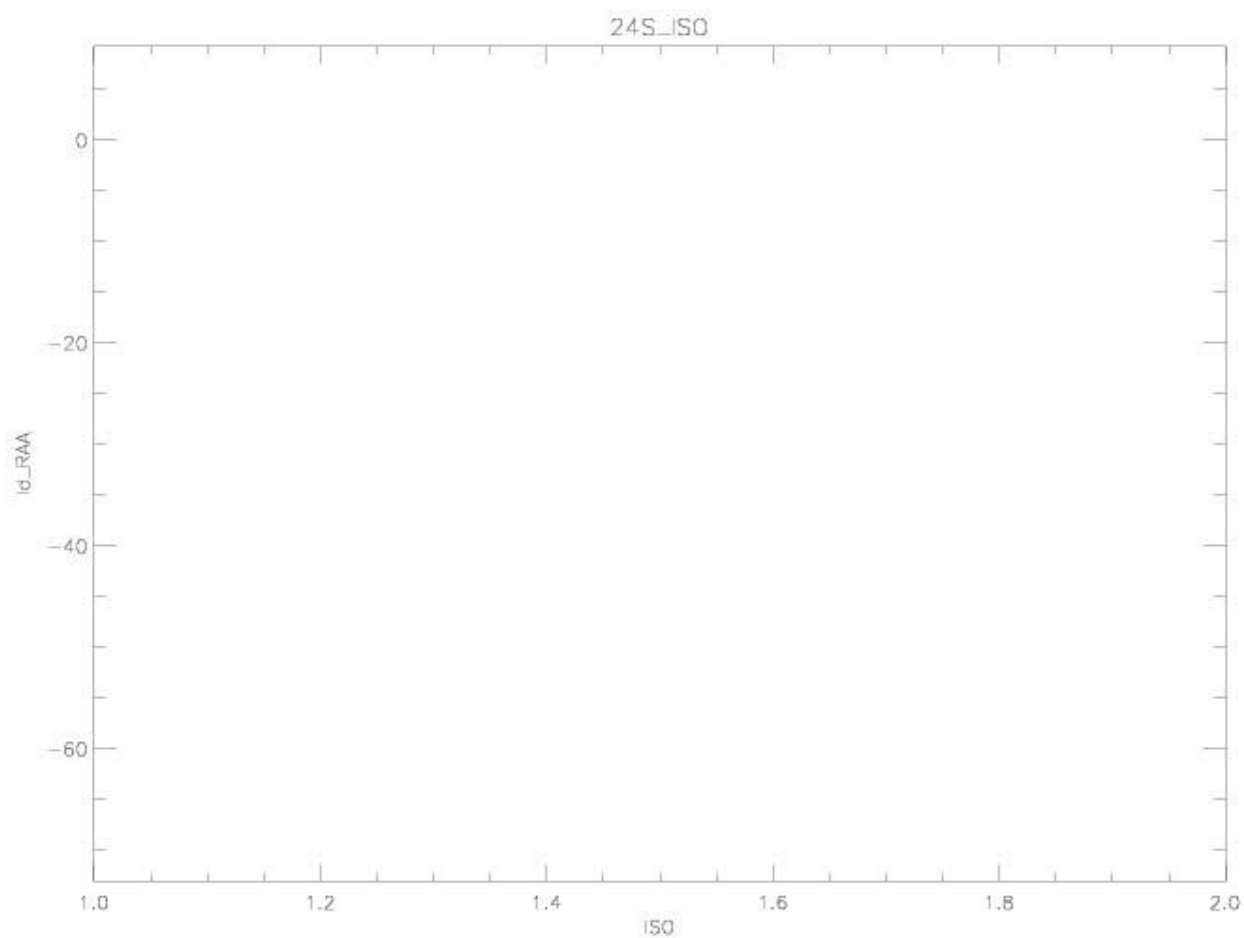


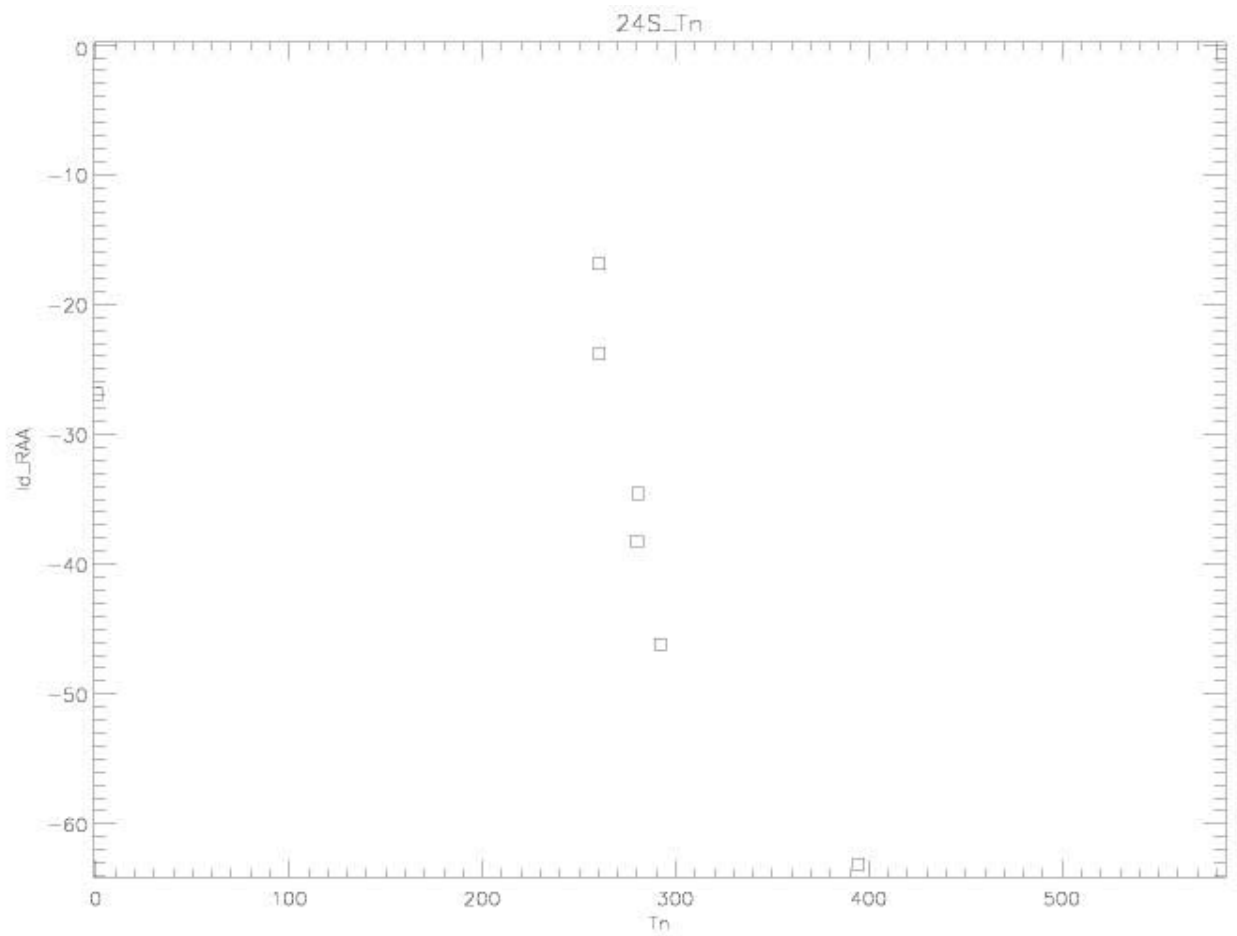


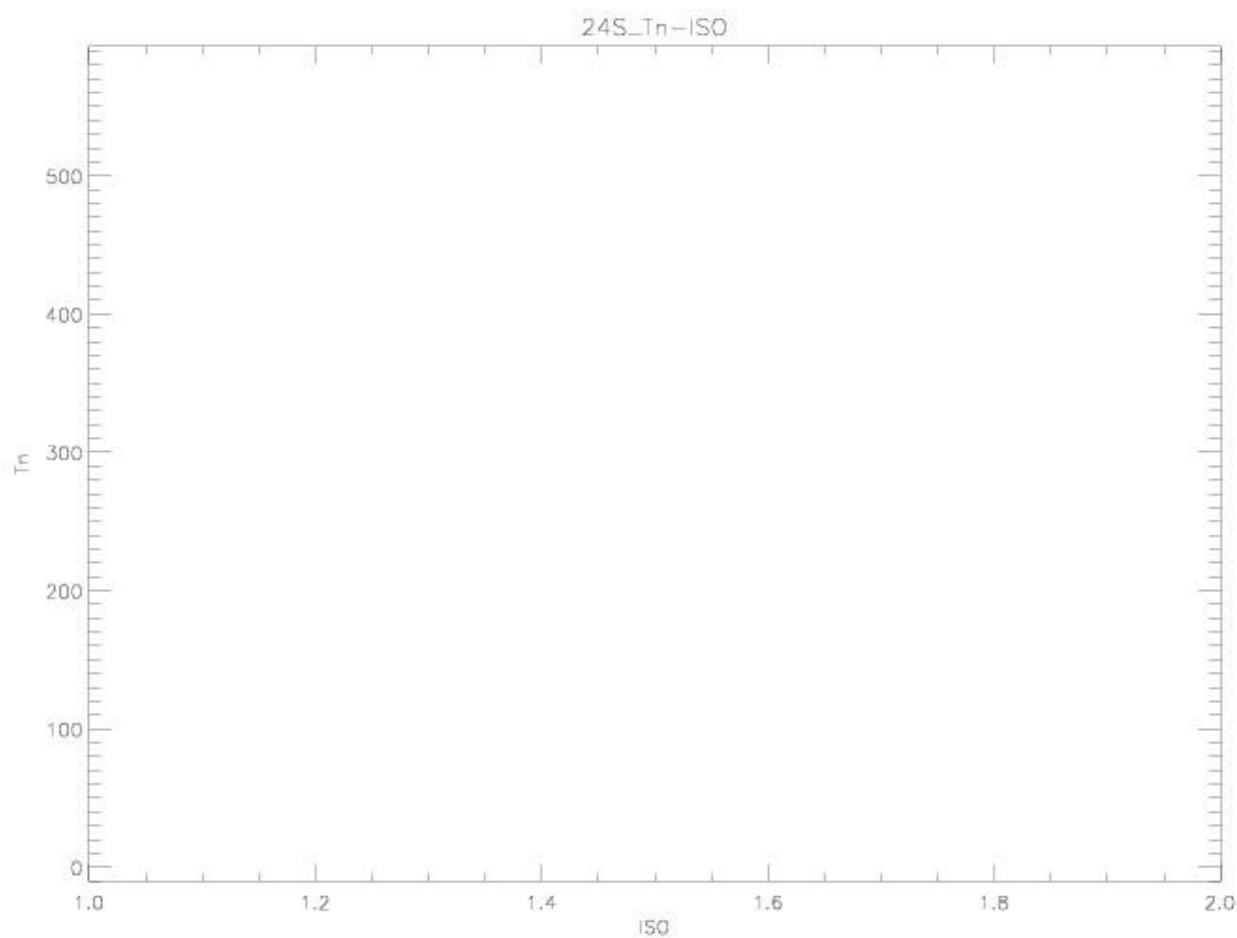


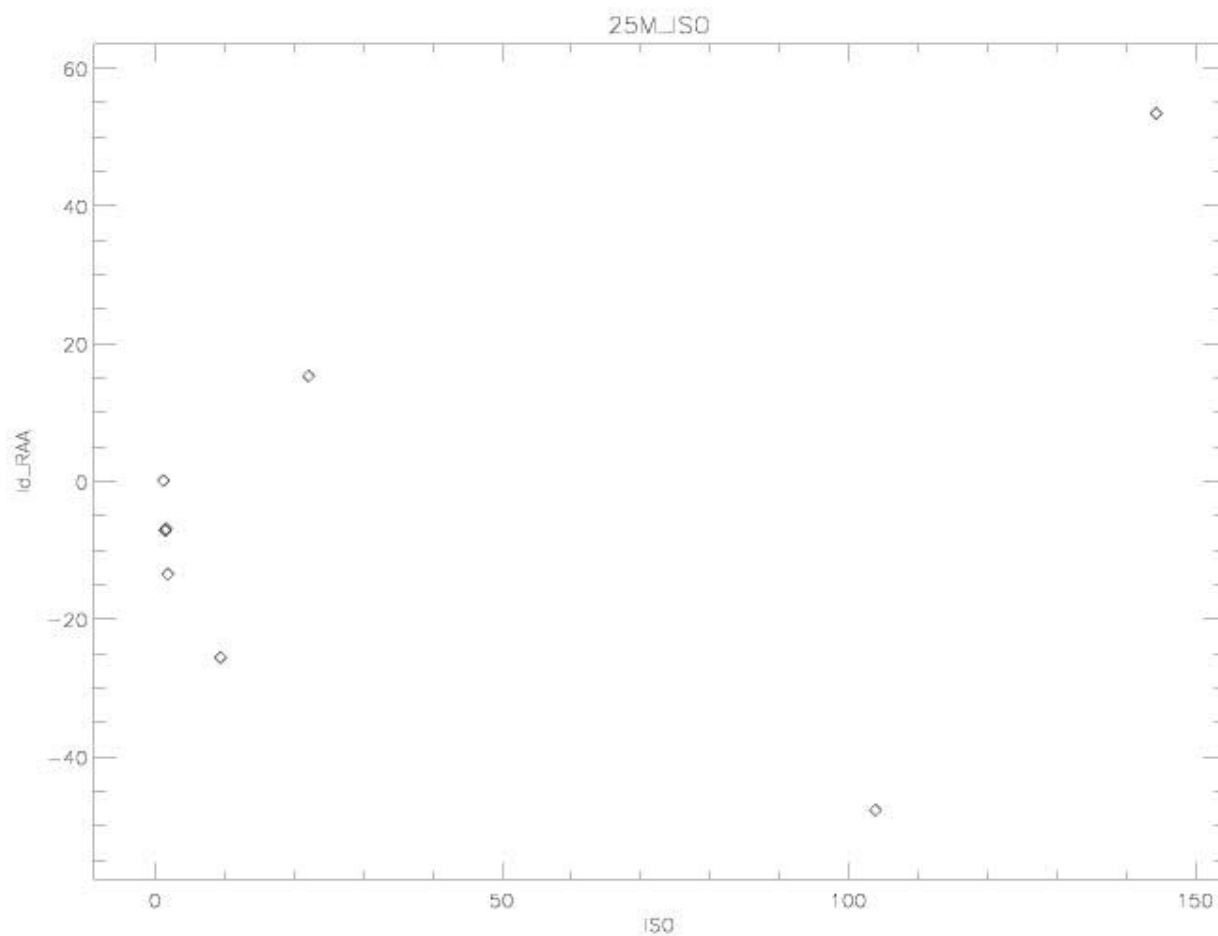


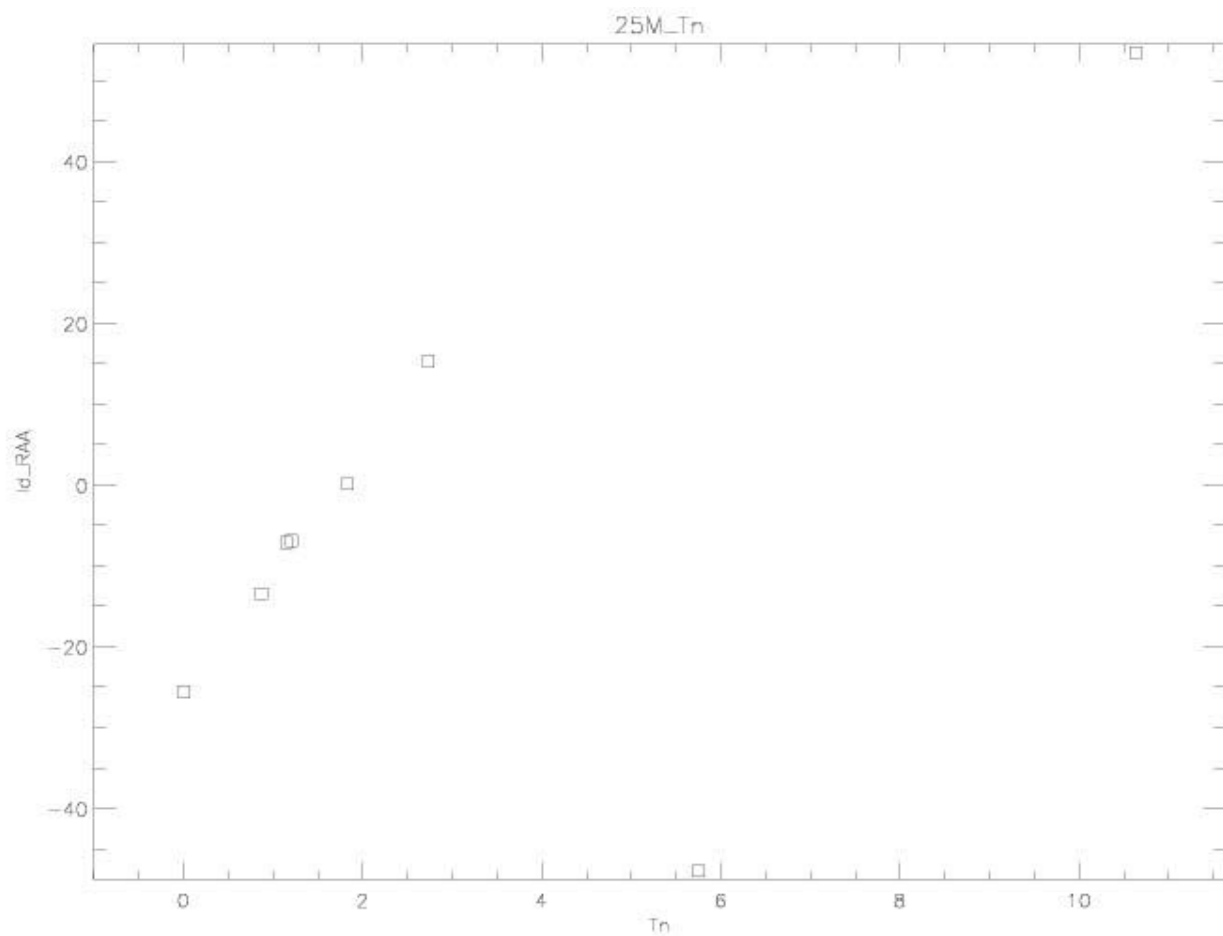


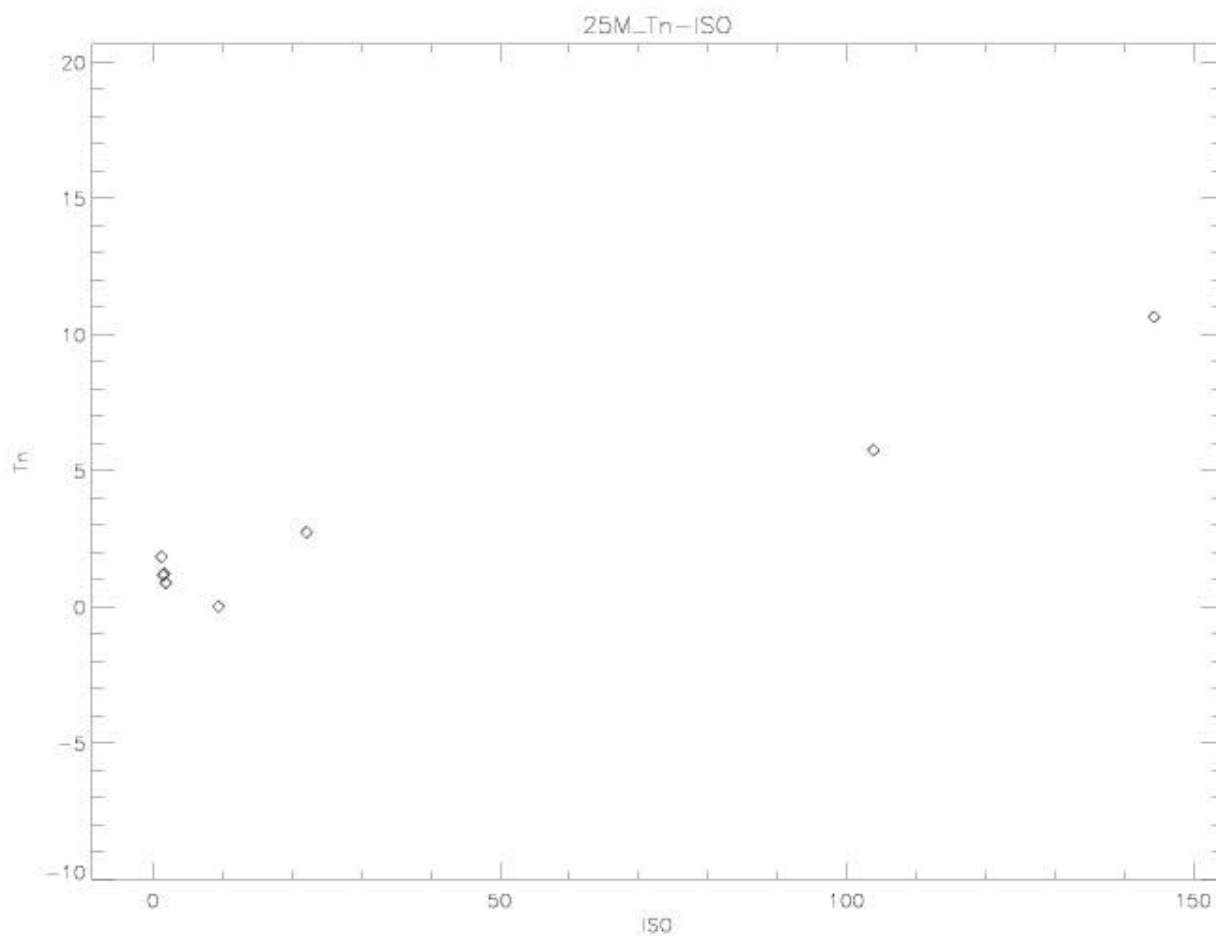


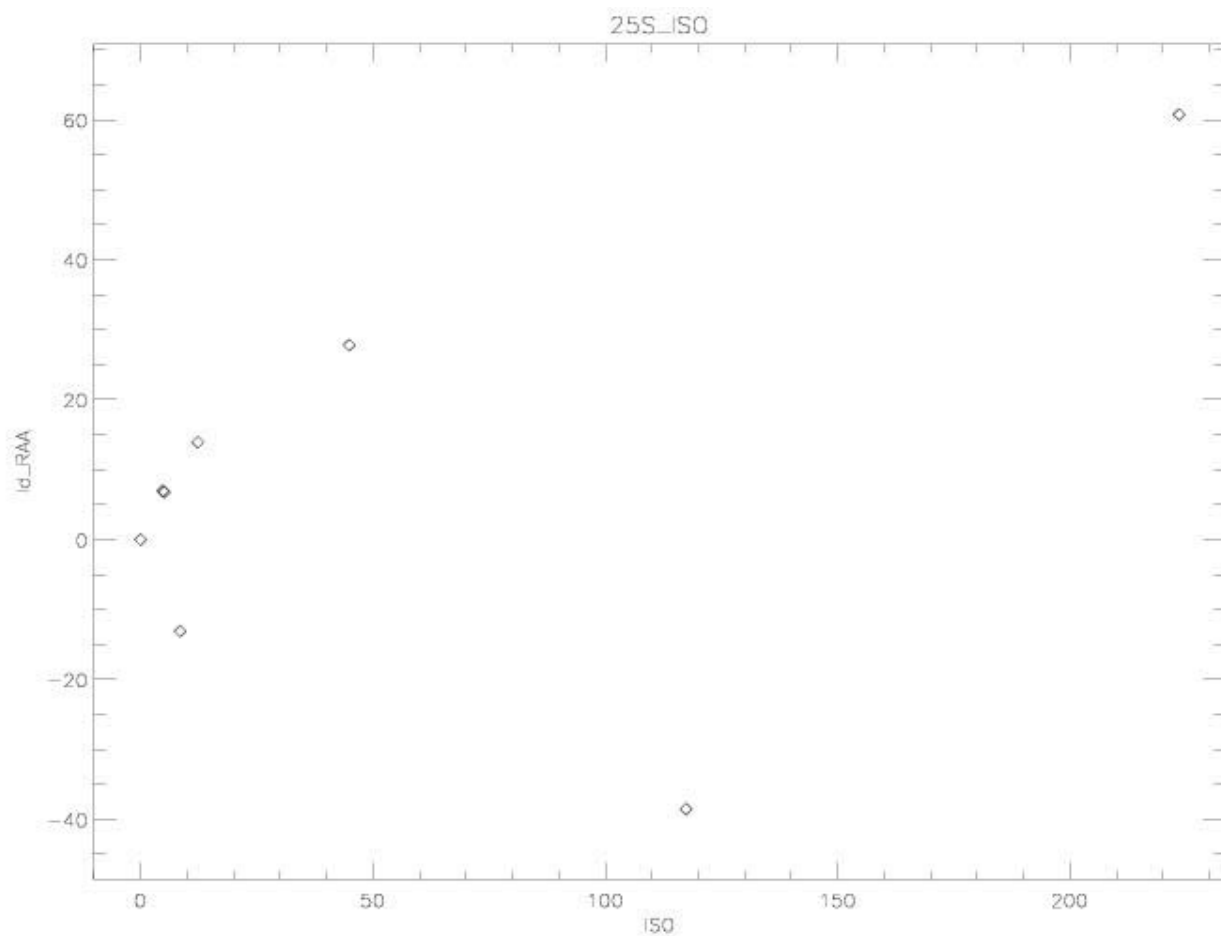


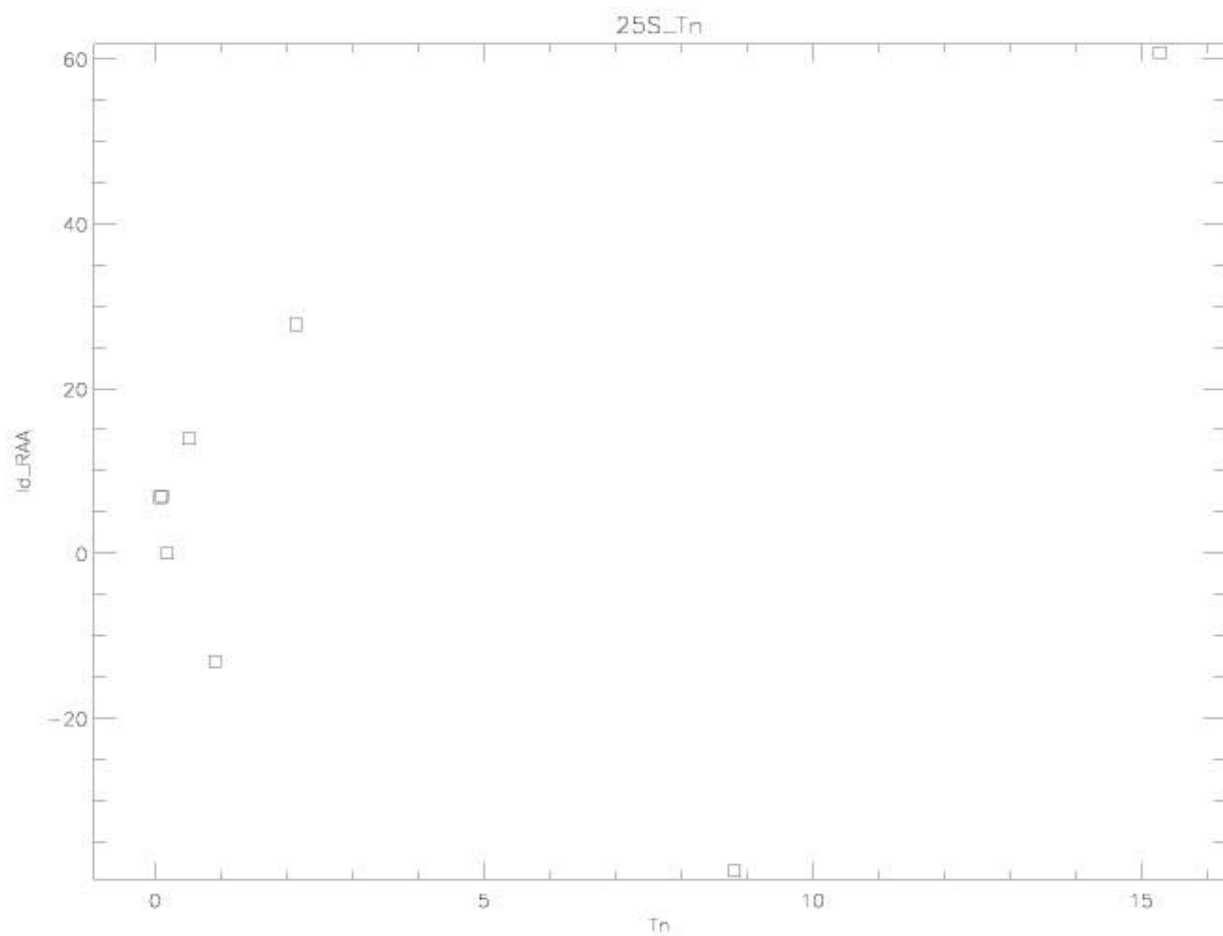


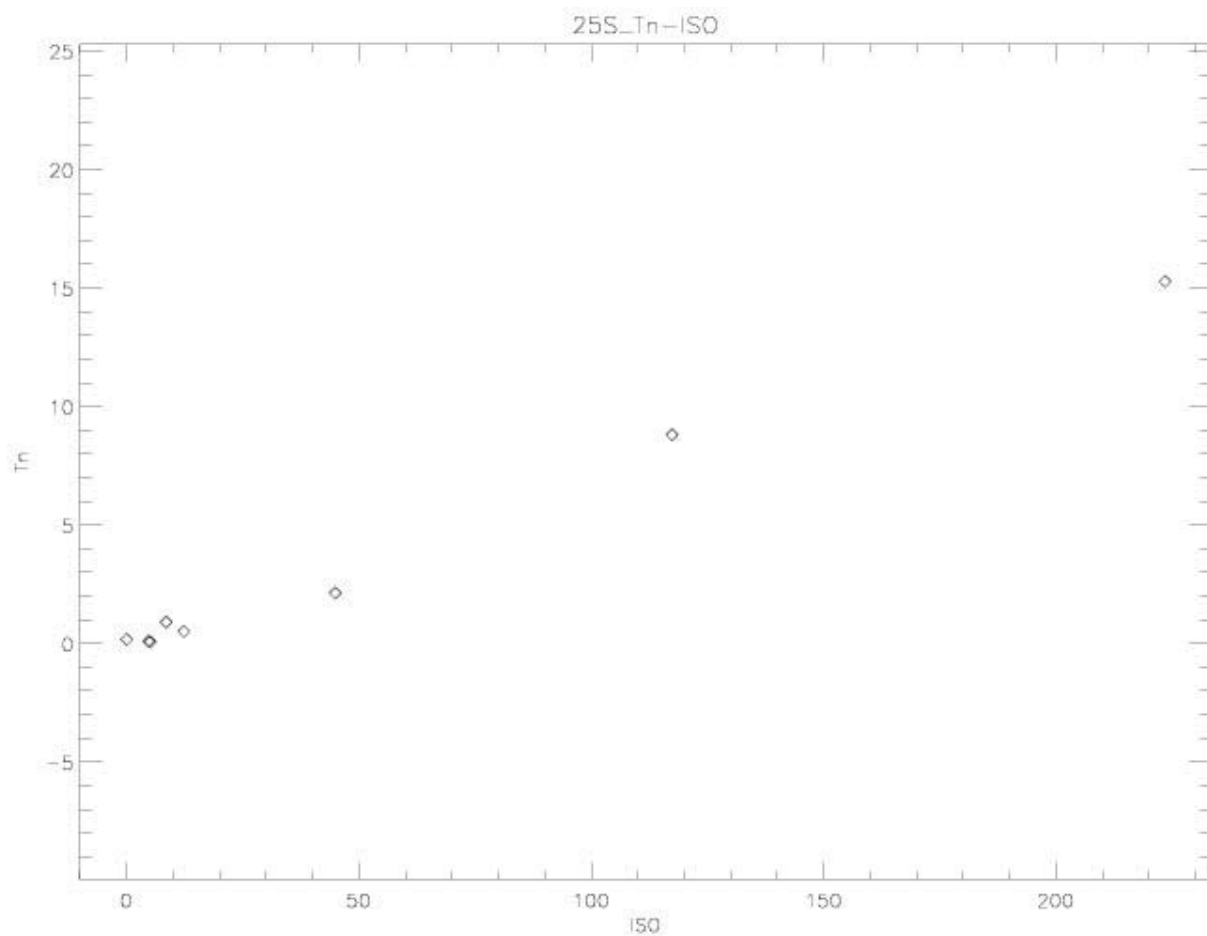


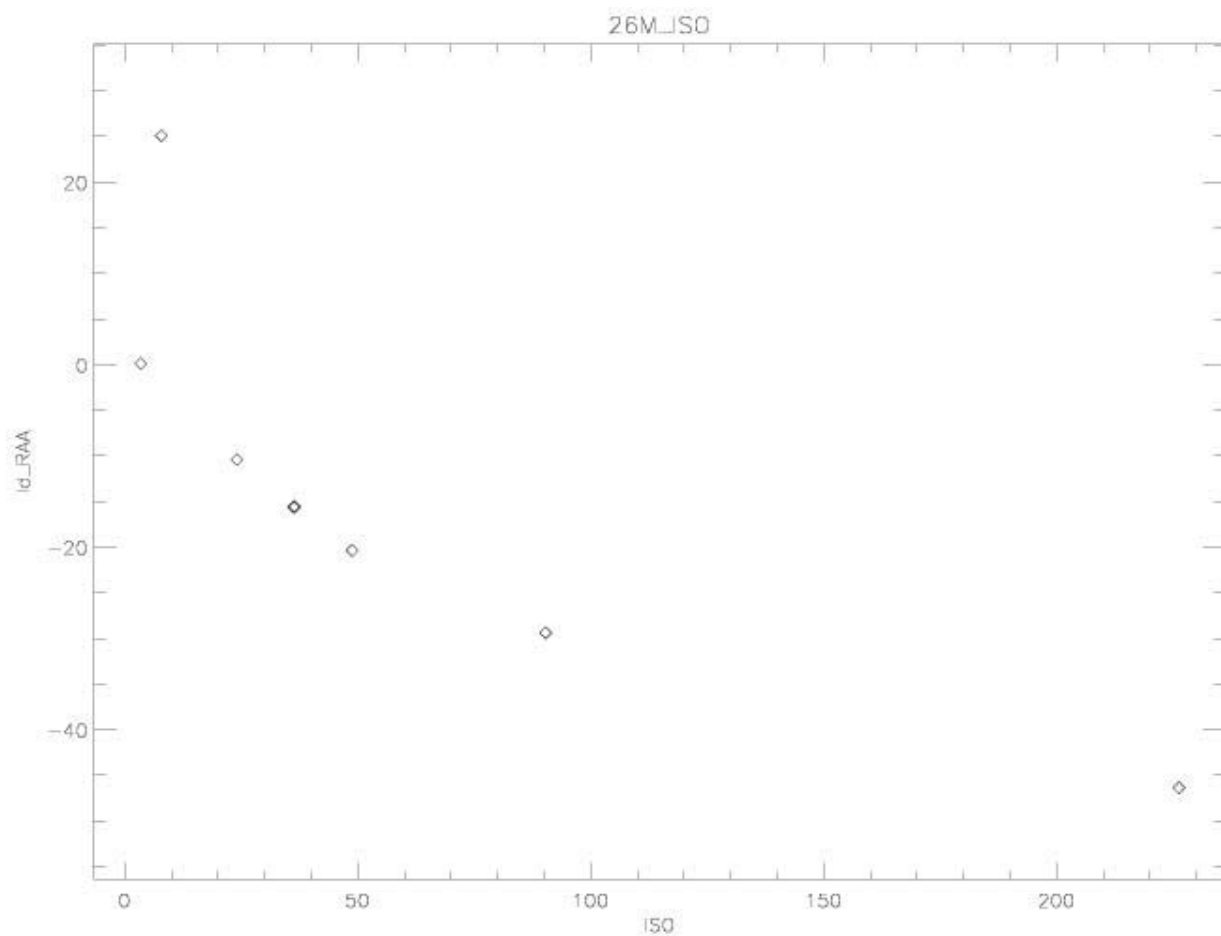


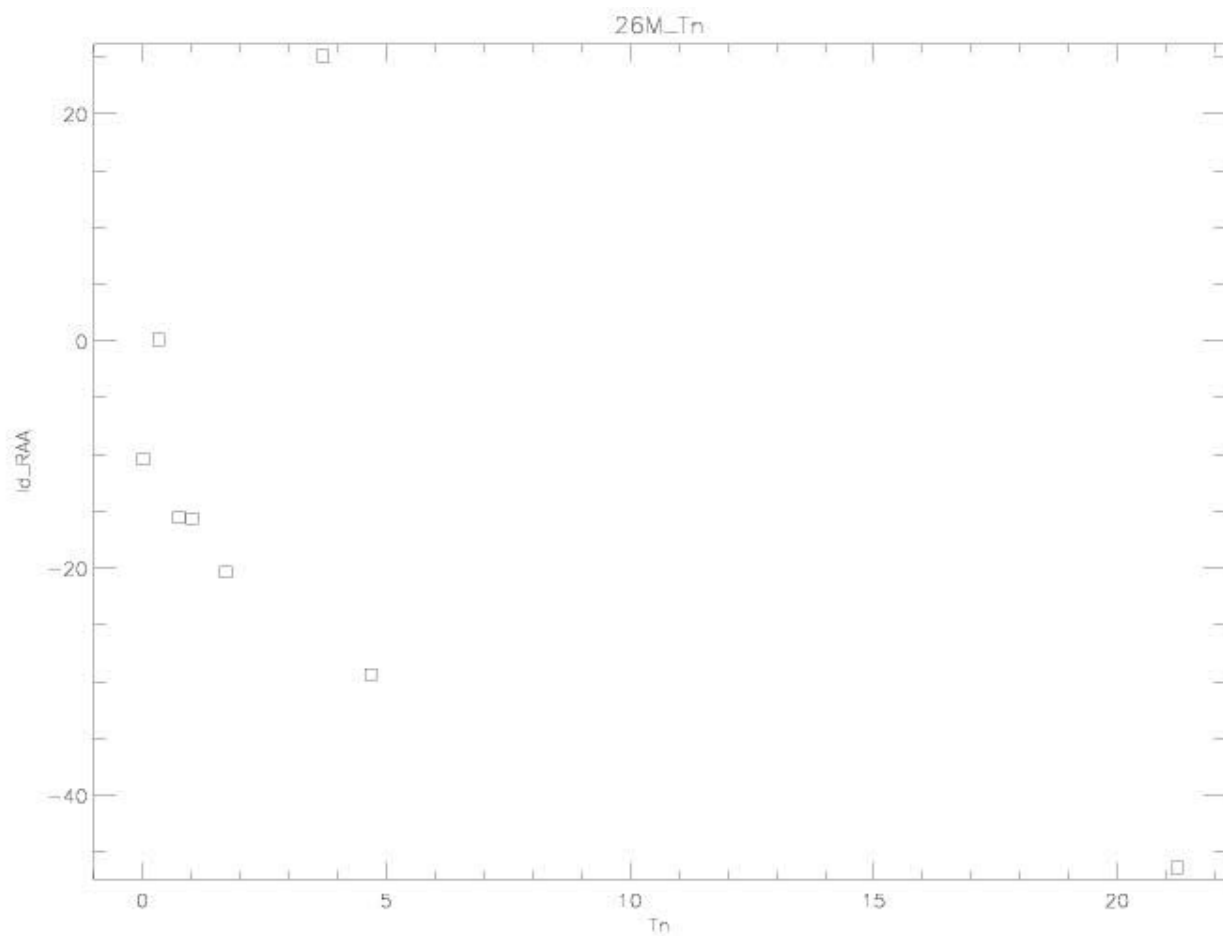


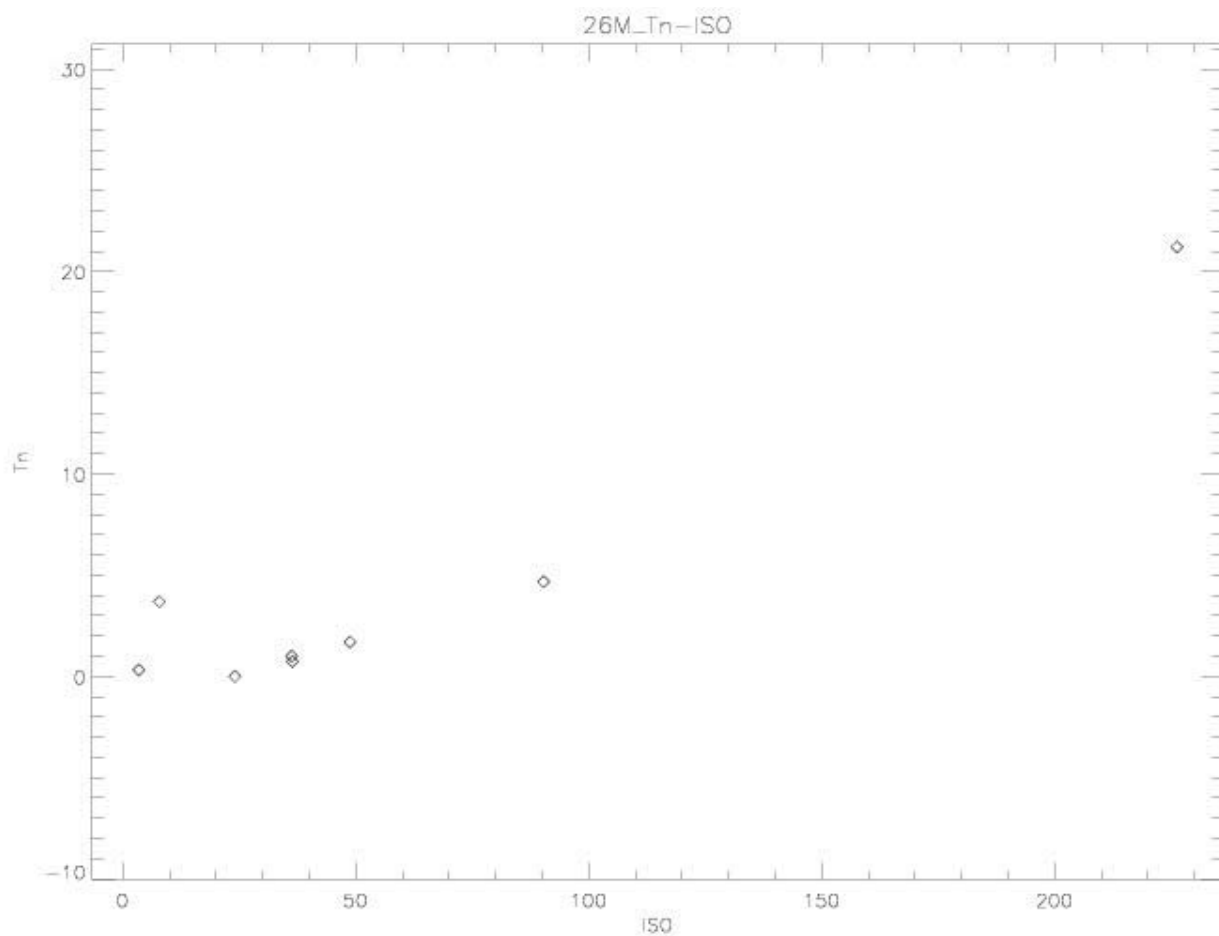


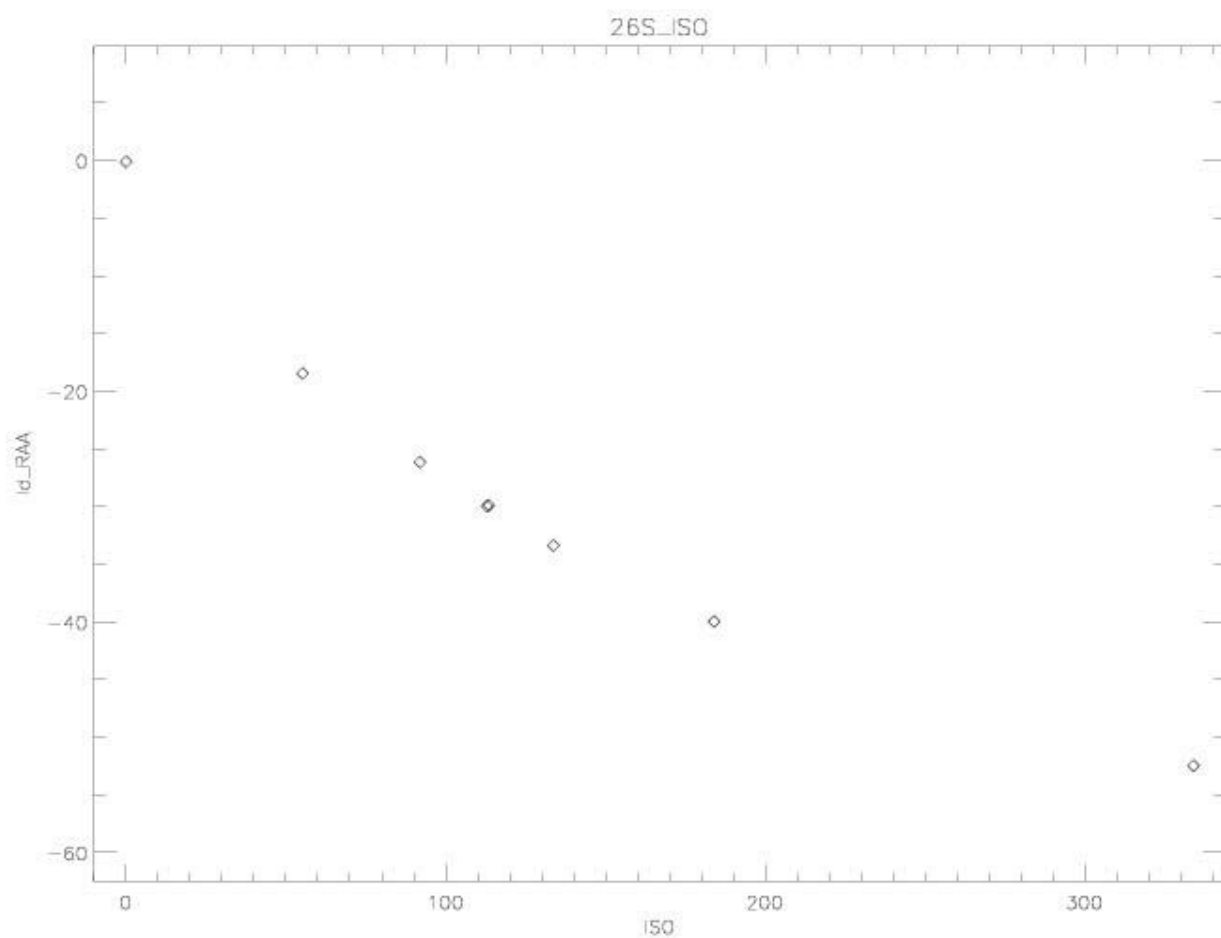


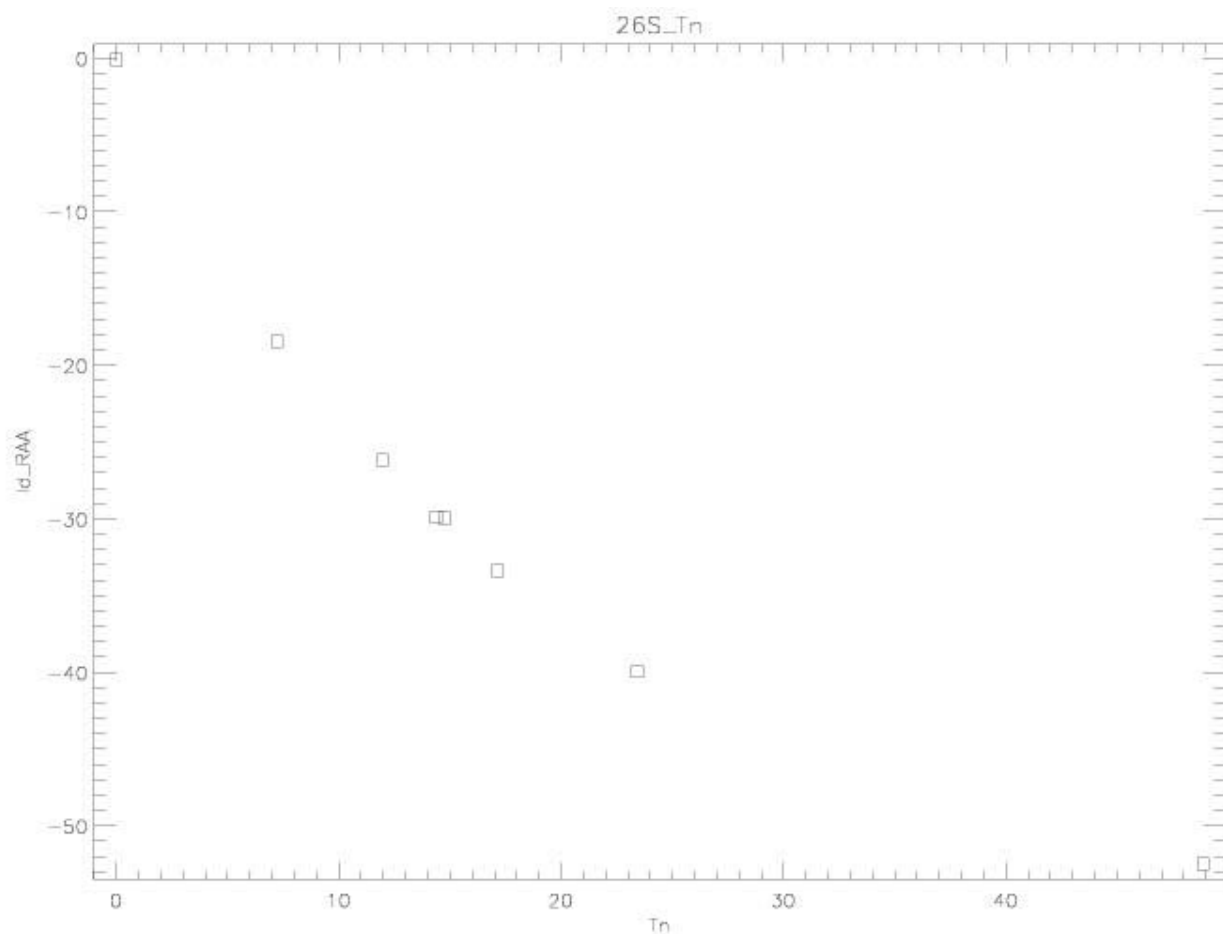


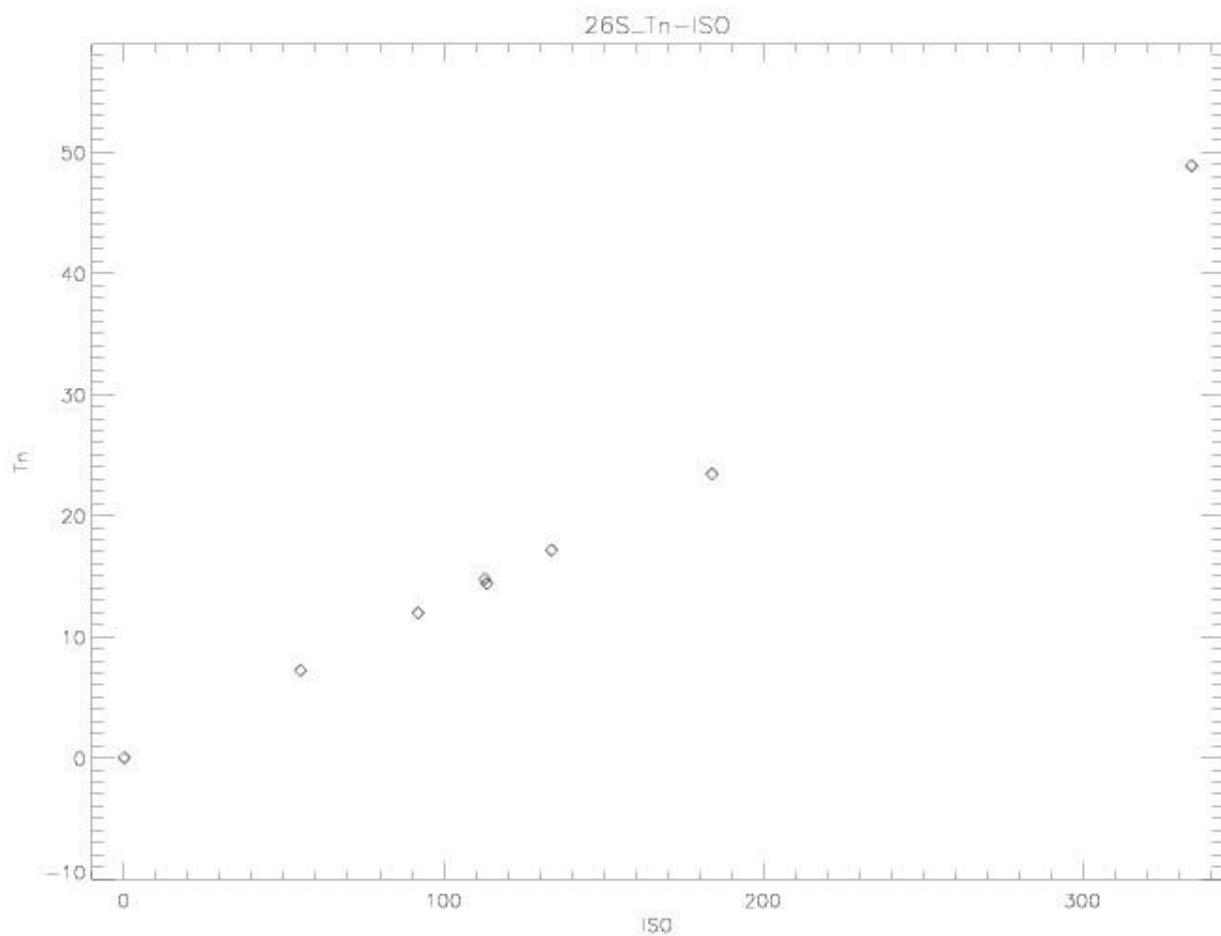


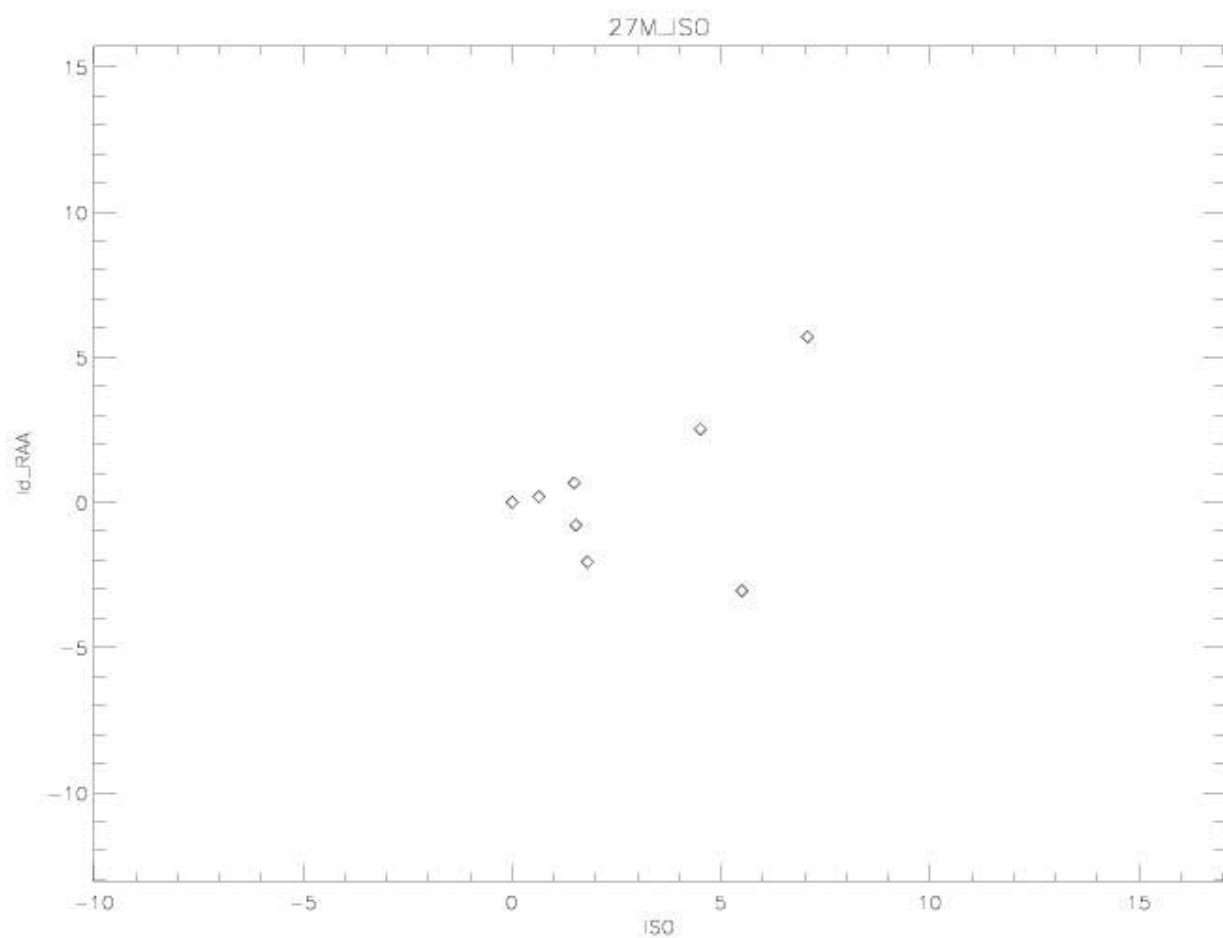


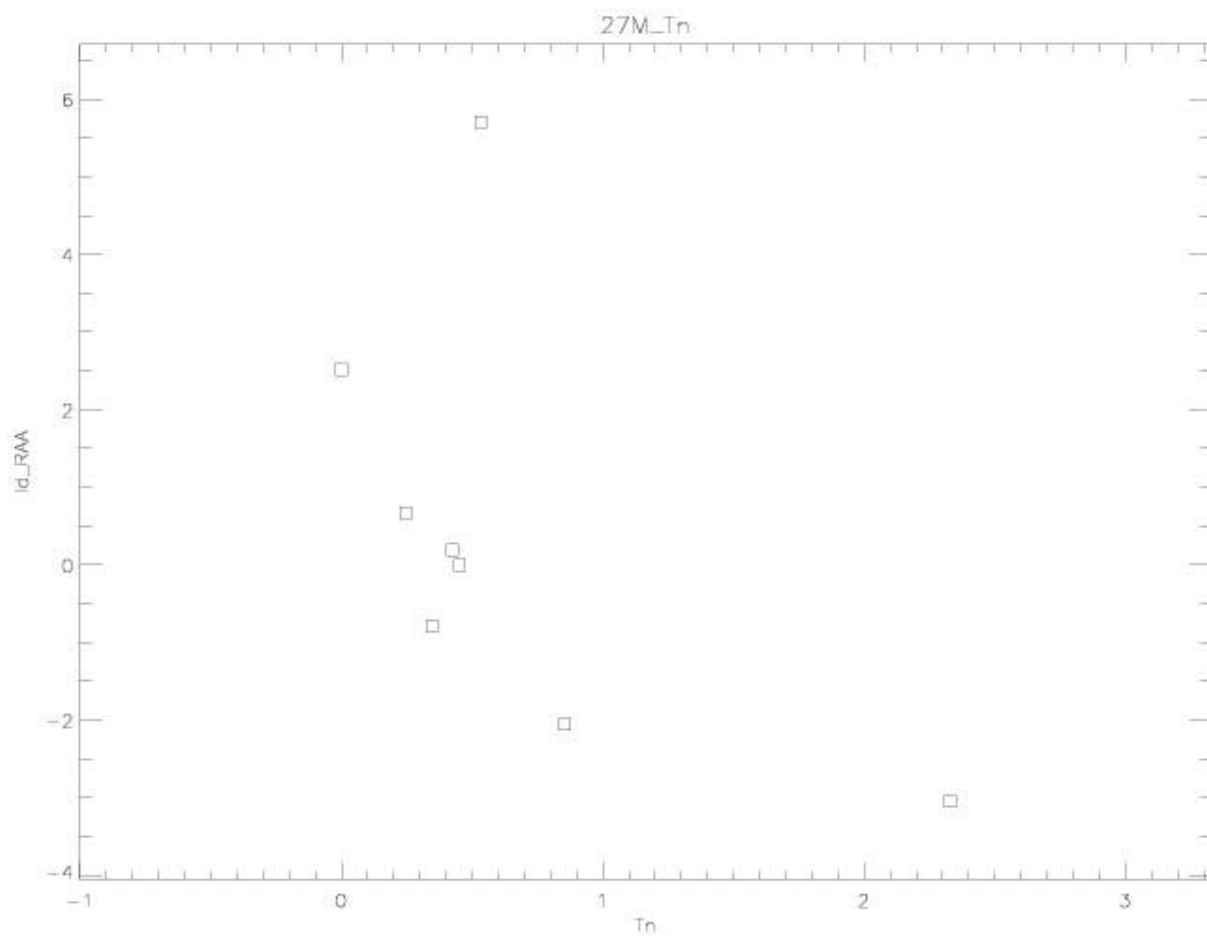


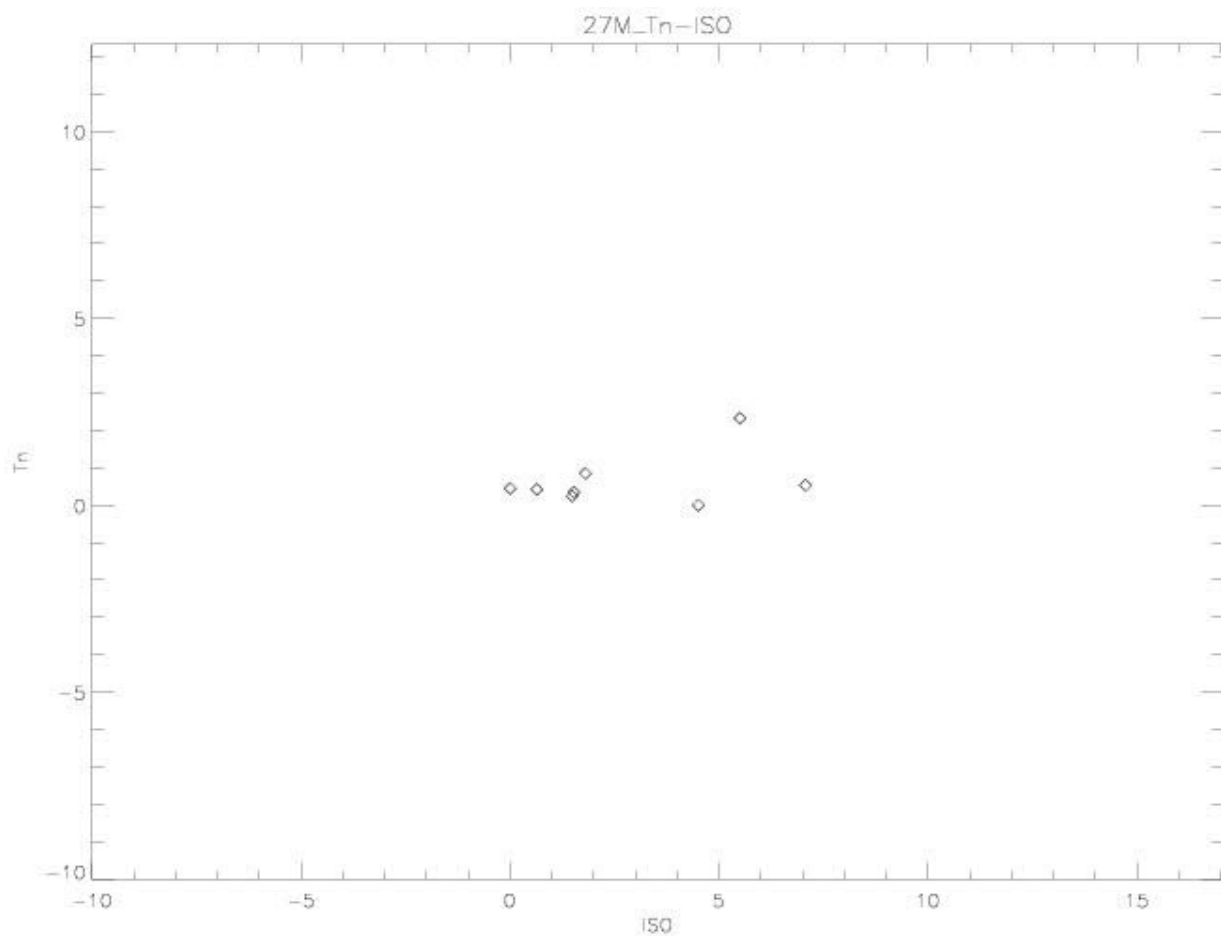


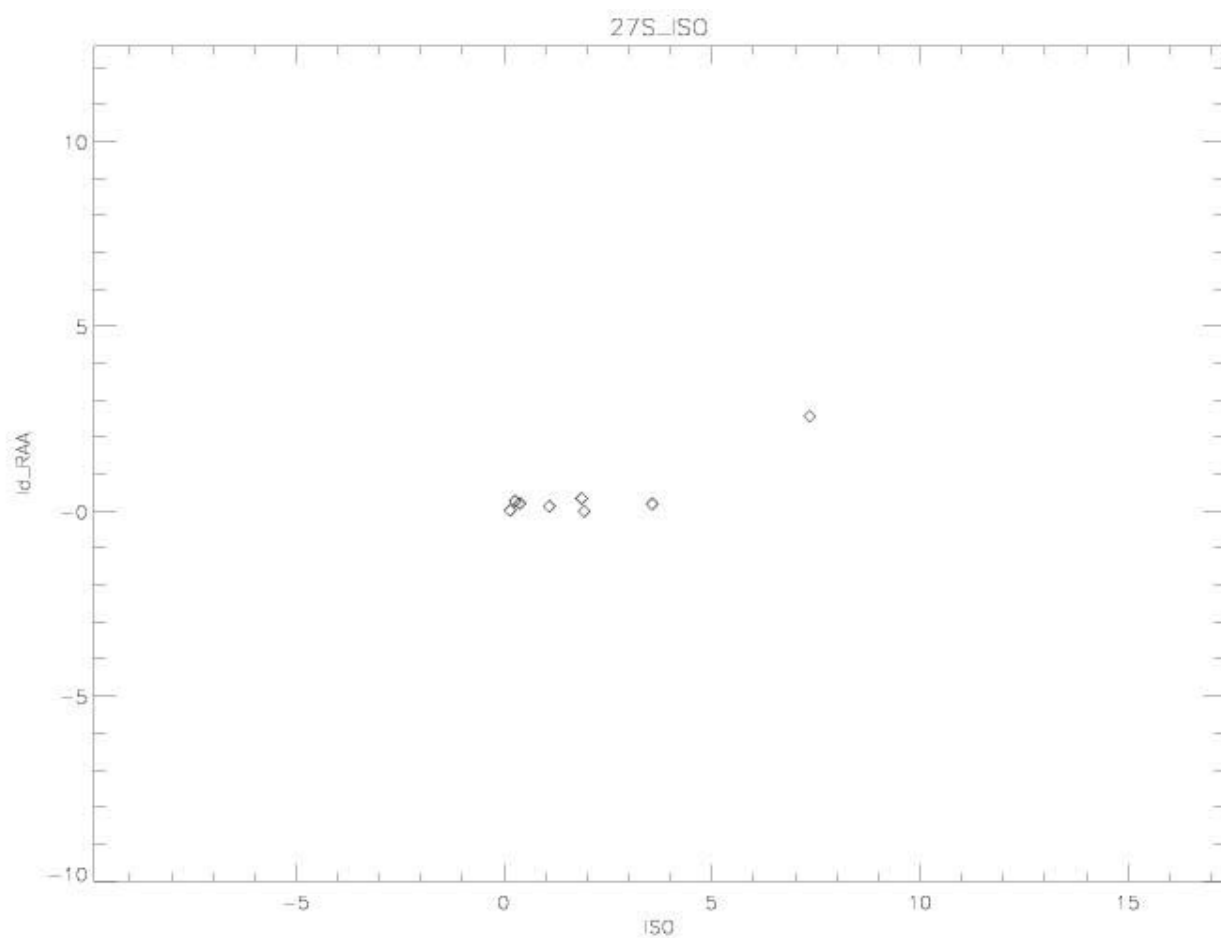


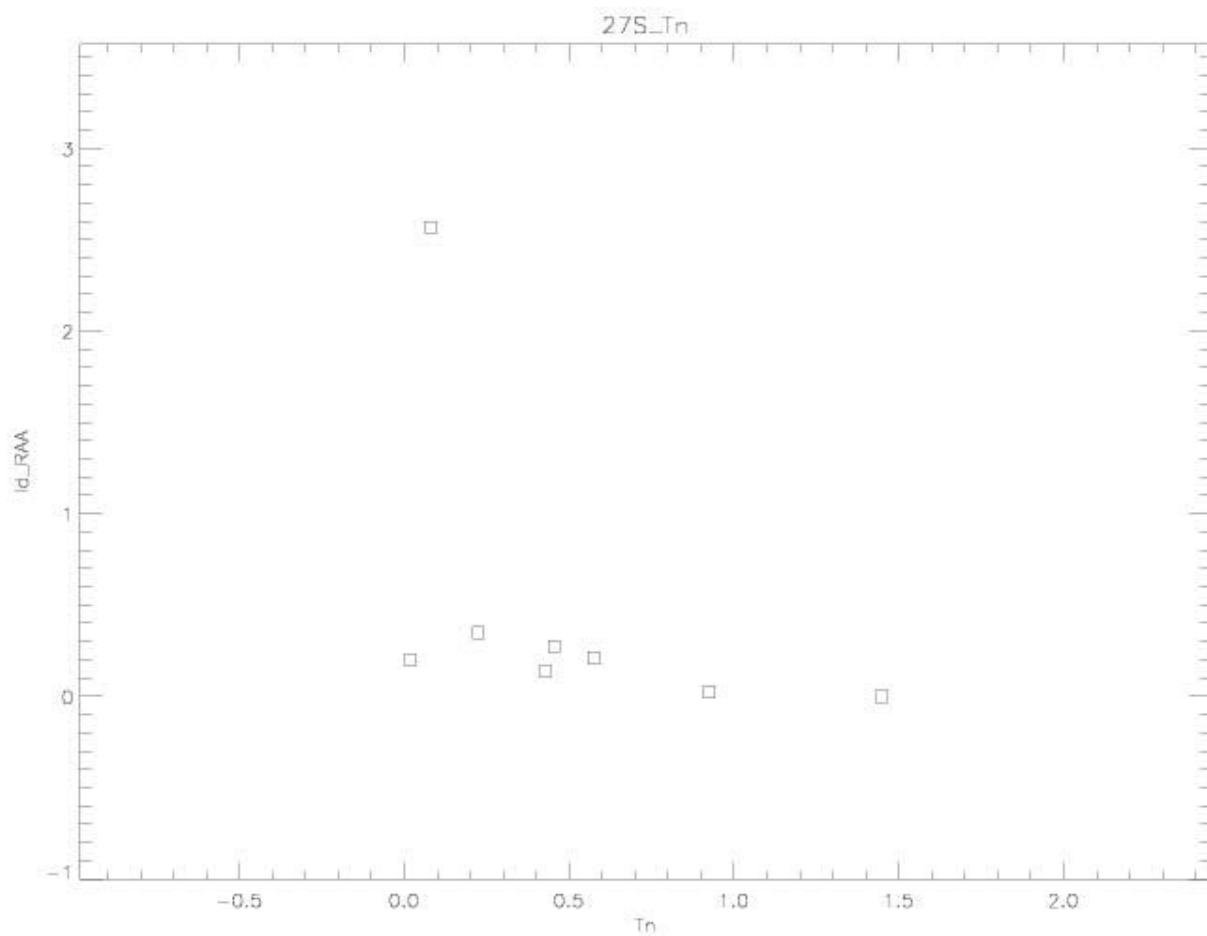


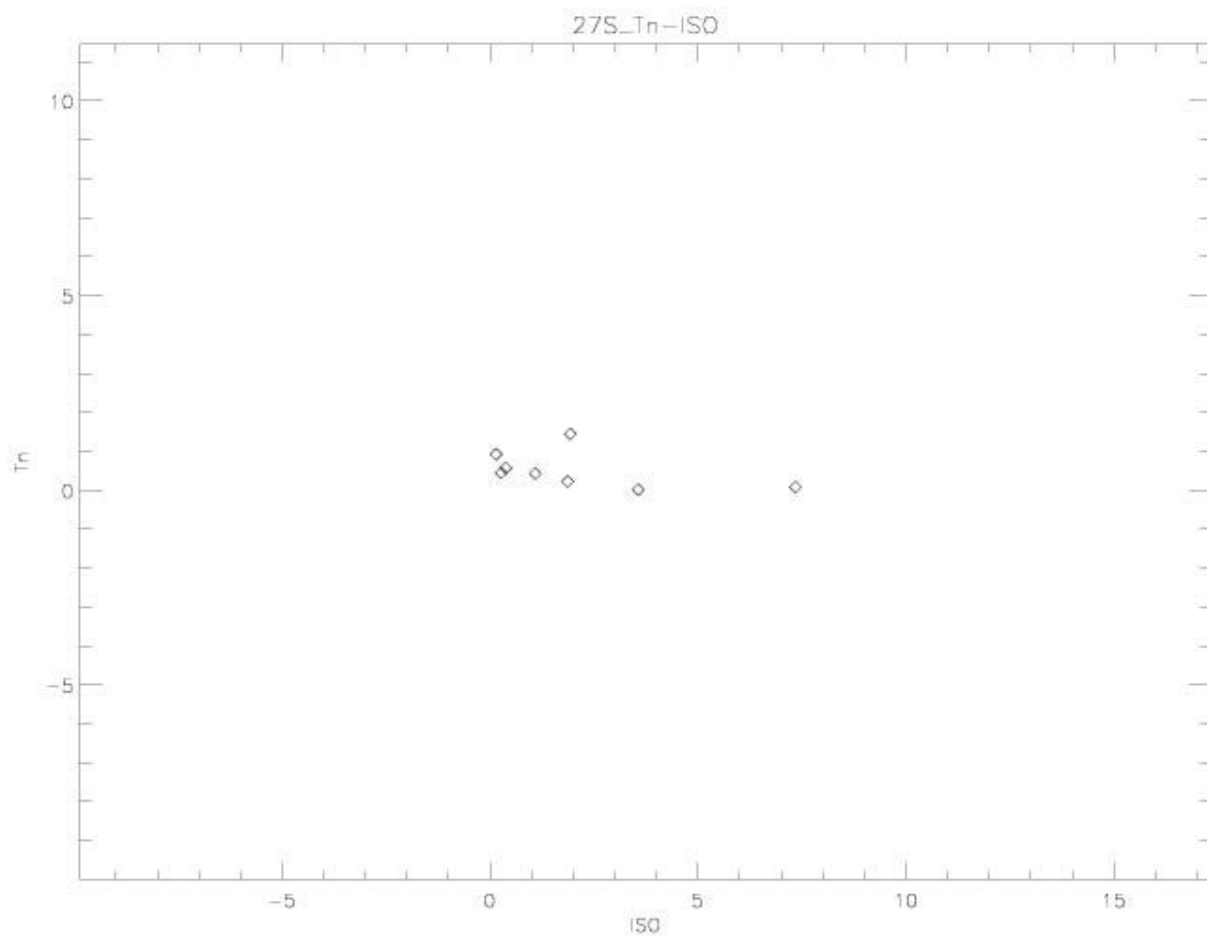


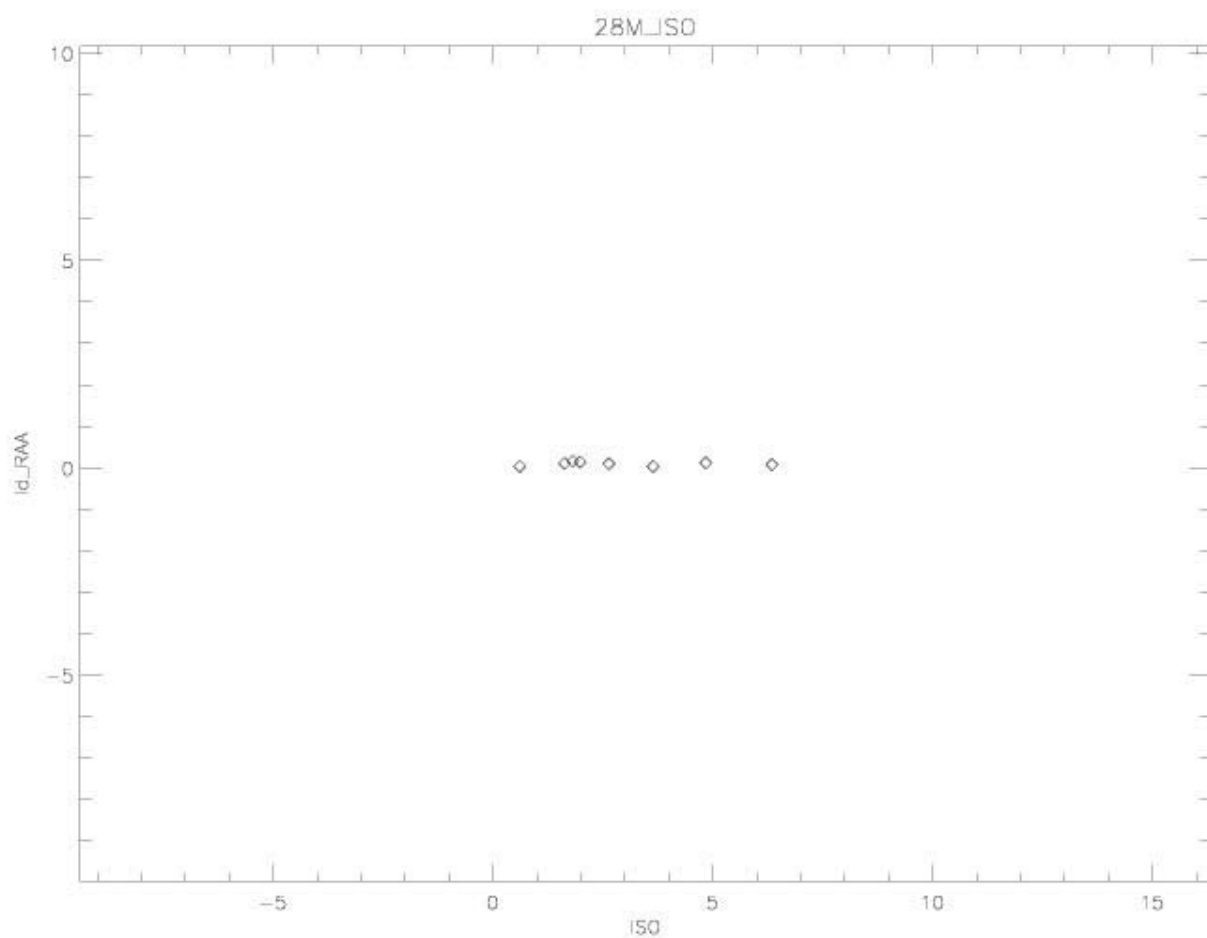


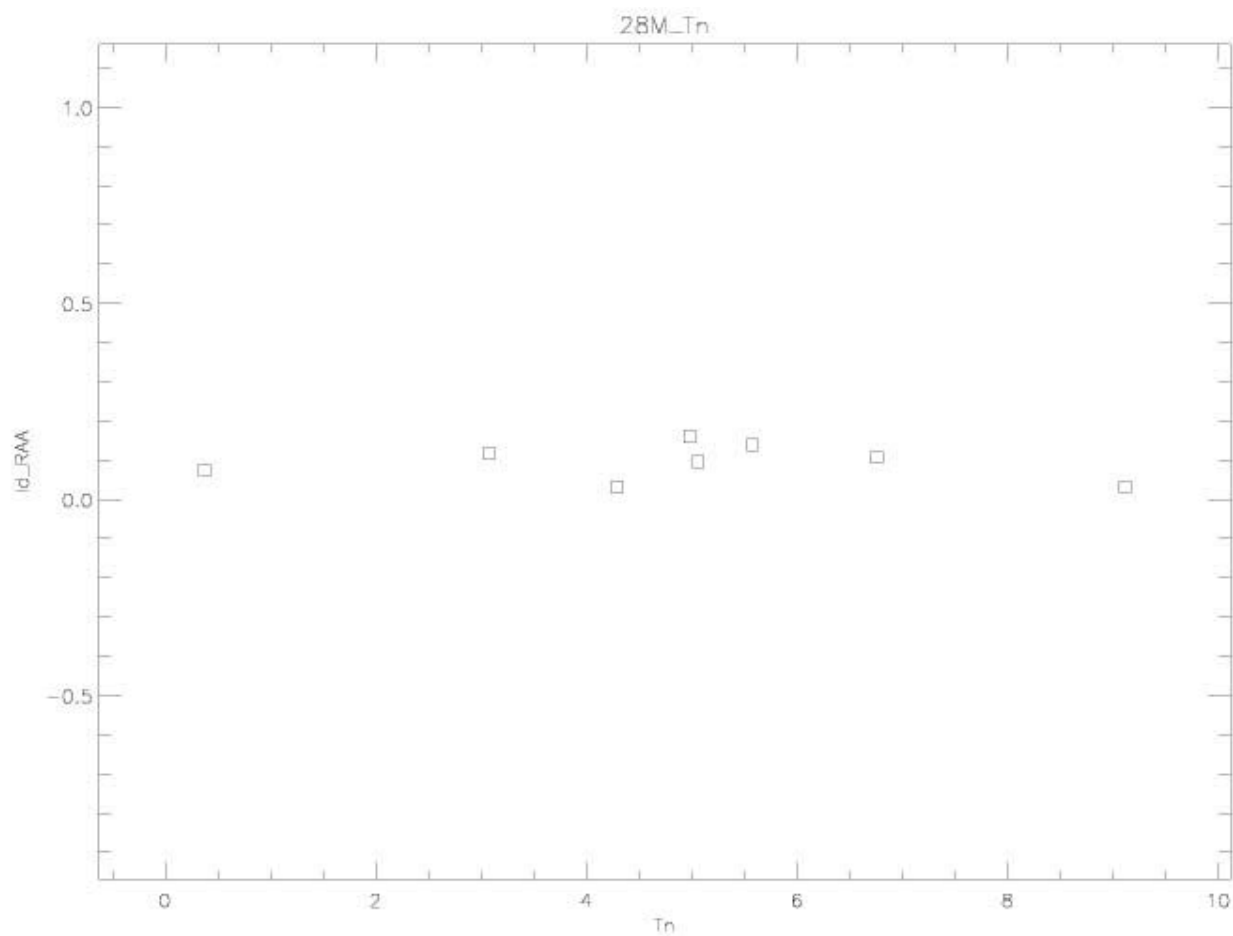


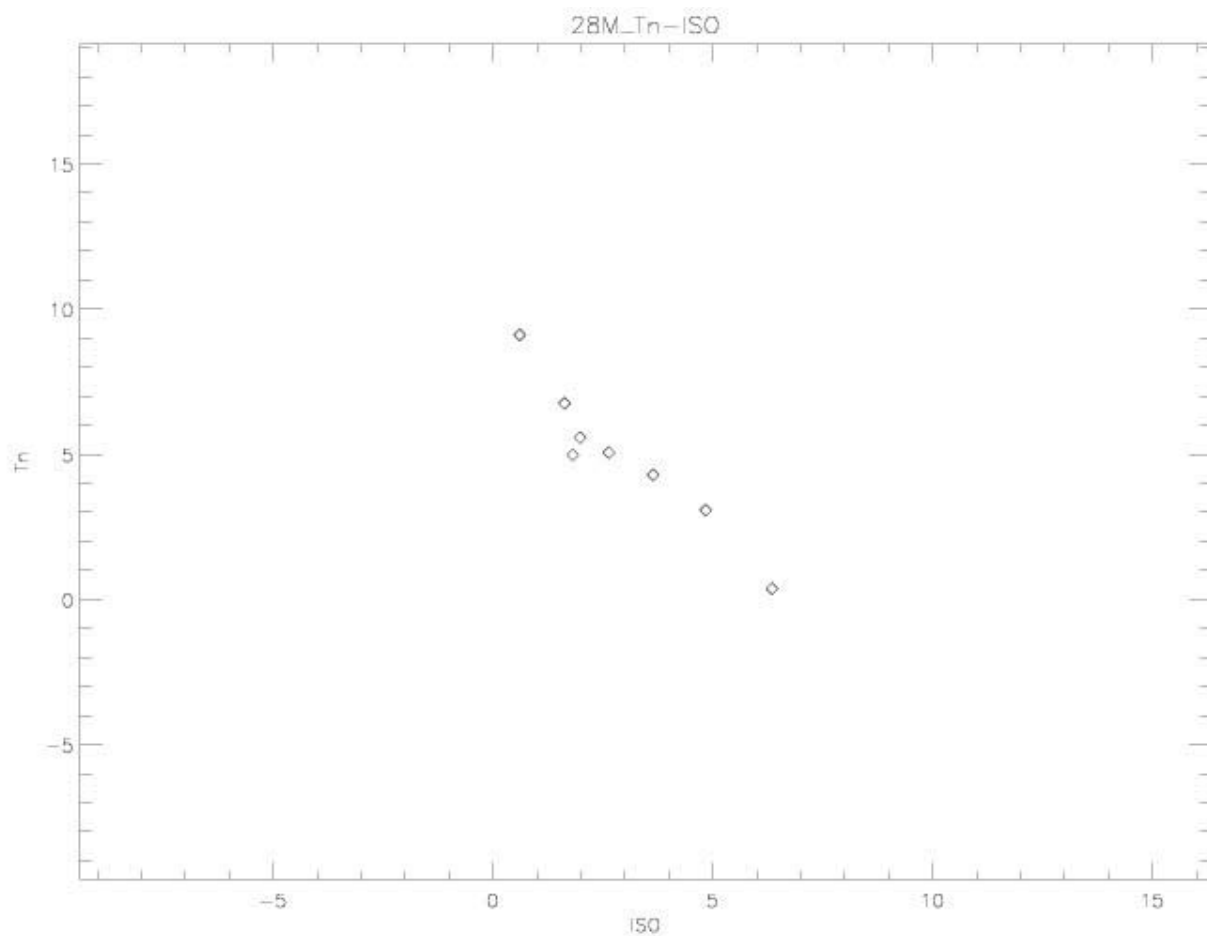


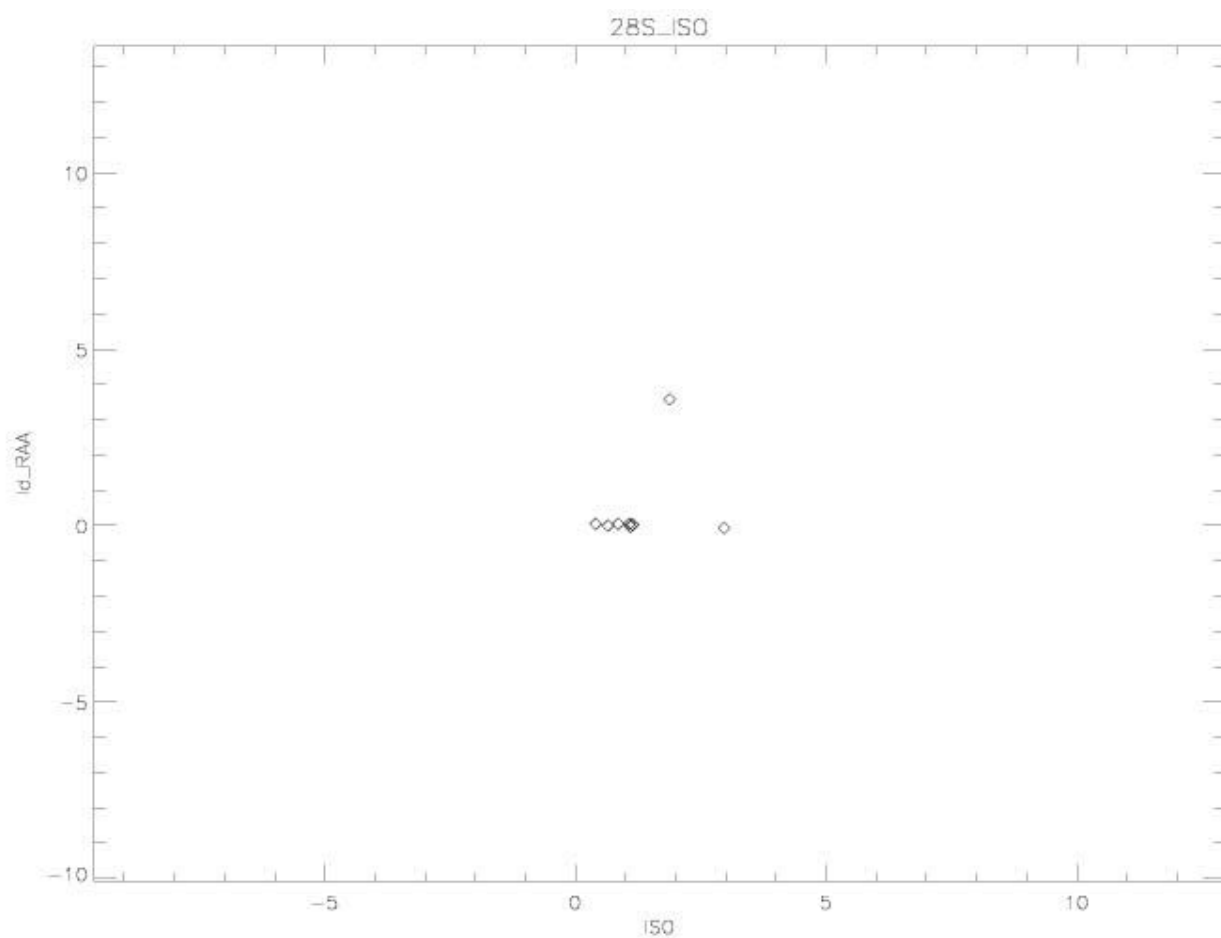


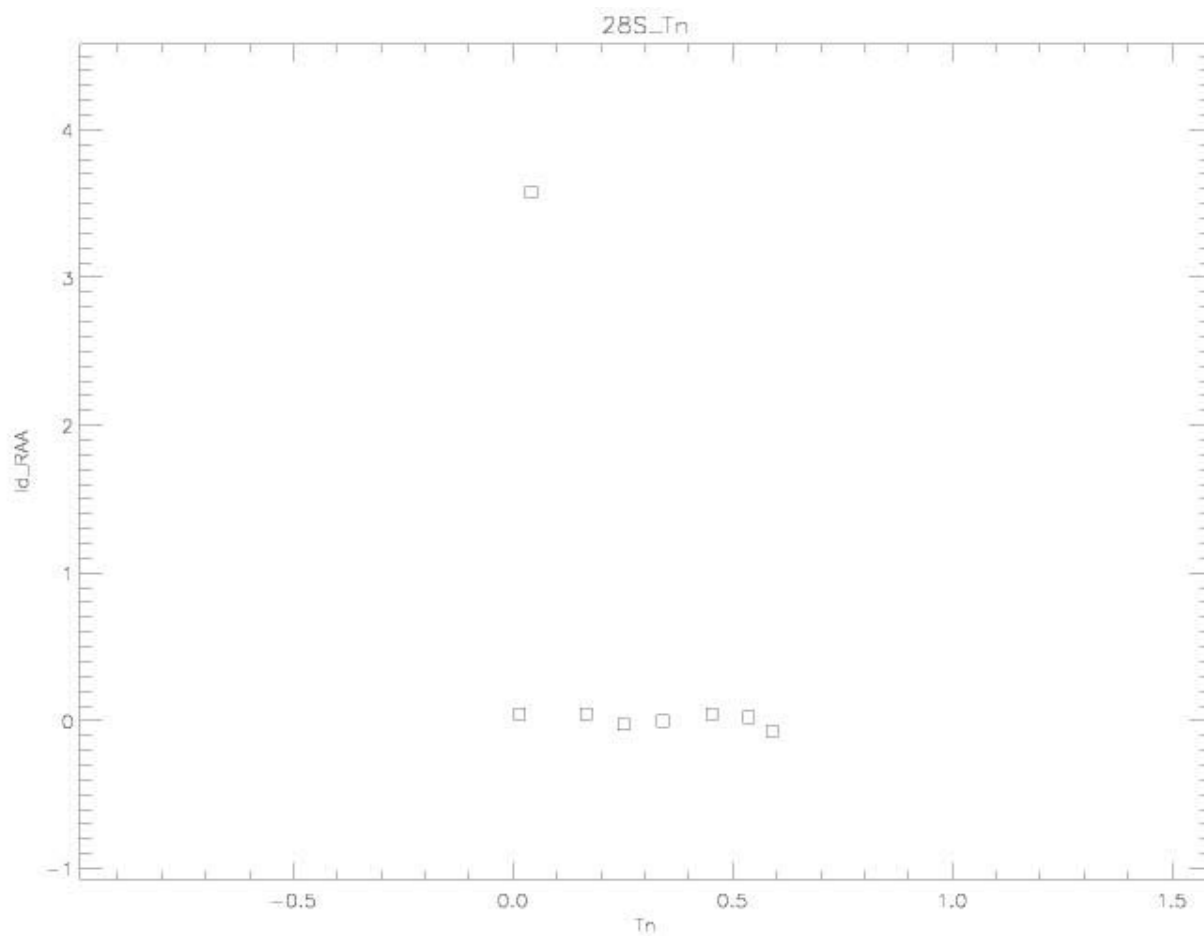


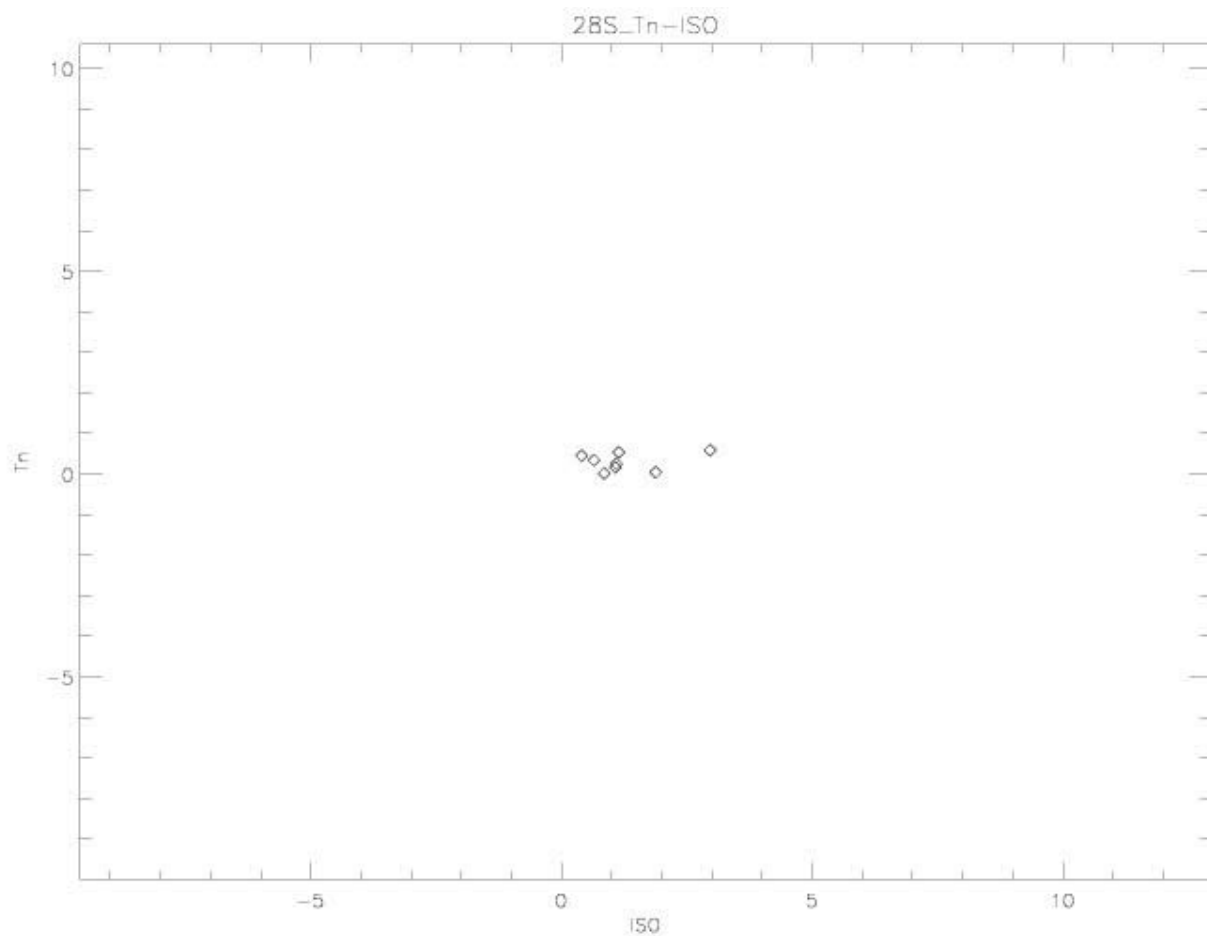














## 10 APPENDIX 3 : parametric analysis of matrix grid with requirements changes

| I(Vg1)= I(Vg2)=10%, Itot req=15% |        |        |        |        |
|----------------------------------|--------|--------|--------|--------|
| RCA #                            | DET 00 | DET 01 | DET 02 | DET 03 |
| RCA18                            | #RIF!  | #RIF!  | #RIF!  | #RIF!  |
| RCA19                            | 3      | 4      | 4      | 6      |
| RCA20                            | 6      | 5      | 7      | 23     |
| RCA21                            | 14     | 7      | 15     | 9      |
| RCA22                            | 3      | 4      | 3      | 3      |
| RCA23                            | 4      | 2      | 12     | 3      |
| RCA24                            | 14     | 28     | 12     | 12     |
| RCA25                            | 14     | 20     | 12     | 12     |
| RCA26                            | 13     | 6      | 7      | 6      |
| RCA27                            | 49     | 42     | 35     | 42     |
| RCA28                            | 42     | 40     | 42     | 42     |

| I(Vg1)=I(Vg2) = 15%;Itot = 25% |        |        |        |        |
|--------------------------------|--------|--------|--------|--------|
| RCA #                          | DET 00 | DET 01 | DET 02 | DET 03 |
| RCA18                          |        |        |        |        |
| RCA19                          | 10     | 4      | 10     | 13     |
| RCA20                          | 12     | 11     | 20     | 35     |
| RCA21                          | 20     | 20     | 34     | 19     |
| RCA22                          | 8      | 15     | 10     | 6      |
| RCA23                          | 11     | 2      | 33     | 8      |
| RCA24                          | 28     | 42     | 28     | 27     |
| RCA25                          | 21     | 28     | 28     | 27     |
| RCA26                          | 21     | 14     | 7      | 7      |
| RCA27                          | 49     | 42     | 42     | 49     |
| RCA28                          | 49     | 49     | 49     | 49     |

| I(Vg1)= I(Vg2)=20%, Itot req=30% |        |        |        |        |
|----------------------------------|--------|--------|--------|--------|
| RCA #                            | DET 00 | DET 01 | DET 02 | DET 03 |
| RCA18                            |        |        |        |        |
| RCA19                            | 23     | 12     | 22     | 20     |
| RCA20                            | 20     | 14     | 28     | 41     |
| RCA21                            | 29     | 30     | 35     | 29     |
| RCA22                            | 18     | 19     | 19     | 10     |
| RCA23                            | 12     | 3      | 41     | 9      |
| RCA24                            | 28     | 42     | 28     | 28     |
| RCA25                            | 28     | 28     | 28     | 28     |
| RCA26                            | 28     | 14     | 14     | 7      |
| RCA27                            | 49     | 49     | 49     | 49     |
| RCA28                            | 49     | 49     | 49     | 49     |

Figure 9 allowed combinations per channel considering different requirements of individual drain currents (corresponding to Vg1 and Vg2 tuning) coupled with total drain current; channel 18 data are missing or partial.



| ltot req=10% |        |        |        |        |
|--------------|--------|--------|--------|--------|
| RCA #        | DET 00 | DET 01 | DET 02 | DET 03 |
| RCA18        |        |        |        |        |
| RCA19        | 12     | 3      | 13     | 8      |
| RCA20        | 8      | 10     | 15     | 24     |
| RCA21        | 17     | 19     | 20     | 13     |
| RCA22        | 15     | 10     | 11     | 8      |
| RCA23        | 10     | 5      | 18     | 11     |
| RCA24        | 16     | 30     | 18     | 15     |
| RCA25        | 14     | 18     | 18     | 15     |
| RCA26        | 12     | 10     | 9      | 6      |
| RCA27        | 48     | 40     | 35     | 41     |
| RCA28        | 42     | 34     | 42     | 42     |

| ltot req=20% |        |        |        |        |
|--------------|--------|--------|--------|--------|
| RCA #        | DET 00 | DET 01 | DET 02 | DET 03 |
| RCA18        |        |        |        |        |
| RCA19        | 26     | 10     | 31     | 20     |
| RCA20        | 19     | 20     | 28     | 38     |
| RCA21        | 28     | 33     | 37     | 30     |
| RCA22        | 26     | 21     | 24     | 19     |
| RCA23        | 19     | 7      | 37     | 23     |
| RCA24        | 29     | 42     | 30     | 28     |
| RCA25        | 27     | 29     | 29     | 26     |
| RCA26        | 29     | 19     | 22     | 8      |
| RCA27        | 49     | 49     | 49     | 49     |
| RCA28        | 49     | 48     | 49     | 49     |

| ltot req=30% |        |        |        |        |
|--------------|--------|--------|--------|--------|
| RCA #        | DET 00 | DET 01 | DET 02 | DET 03 |
| RCA18        |        |        |        |        |
| RCA19        | 36     | 16     | 39     | 33     |
| RCA20        | 31     | 33     | 38     | 46     |
| RCA21        | 39     | 42     | 47     | 36     |
| RCA22        | 37     | 31     | 35     | 27     |
| RCA23        | 32     | 9      | 48     | 32     |
| RCA24        | 35     | 49     | 36     | 34     |
| RCA25        | 34     | 39     | 35     | 34     |
| RCA26        | 41     | 28     | 38     | 12     |
| RCA27        | 49     | 49     | 49     | 49     |
| RCA28        | 49     | 49     | 49     | 49     |

Figure 10 allowed combinations per channel considering different requirements of total drain current; channel 18 data are missing or partial.

Drain current behaviour with  $V_{g1}$ - $V_{g2}$  combinations (from 1 to 49, not ordered and ordered in Id)

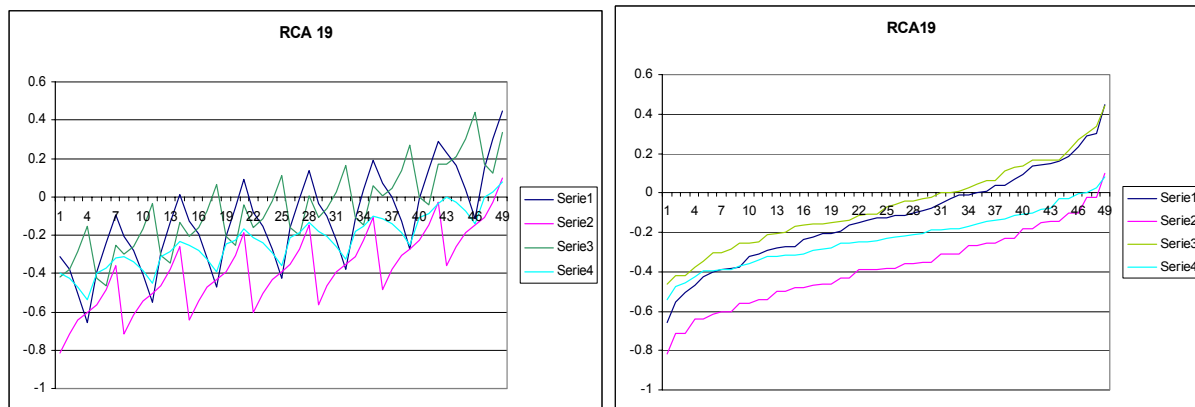


Figure 11 RCA 19

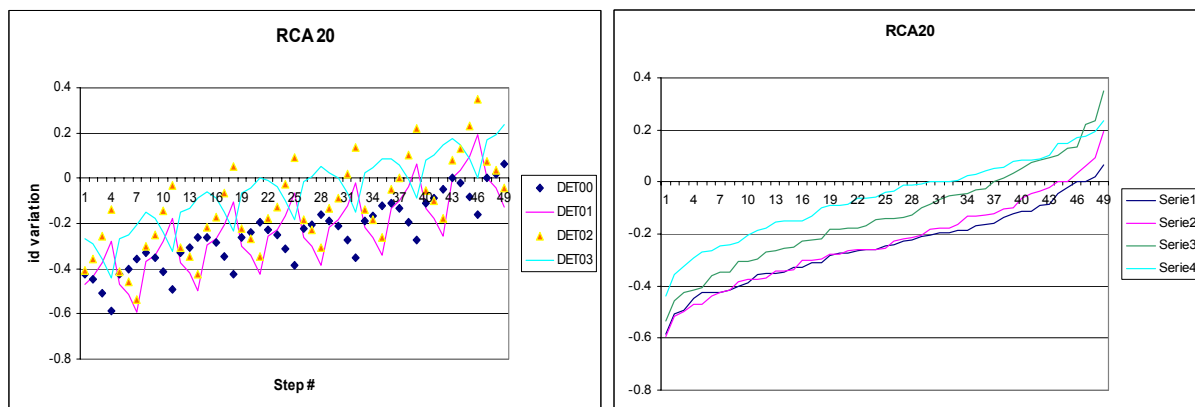


Figure 12 RCA 20

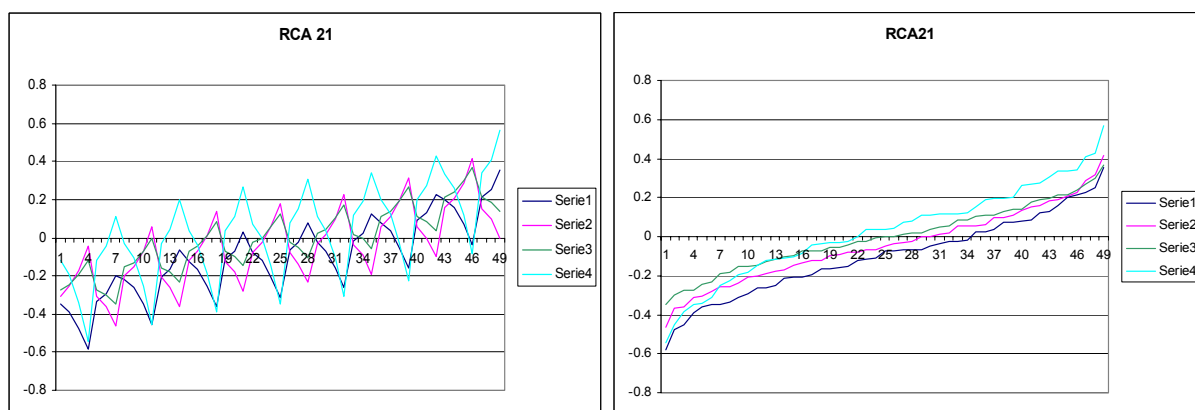


Figure 13 RCA 21

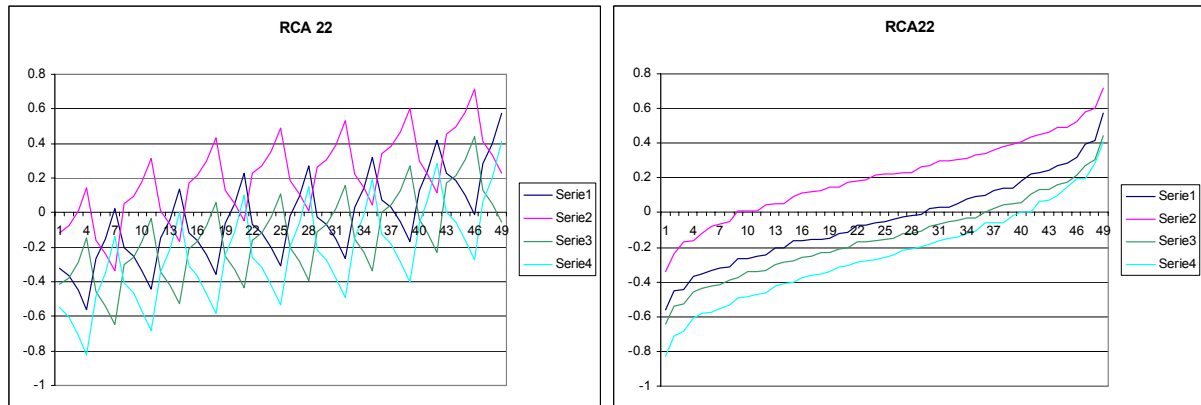


Figure 14 RCA 22

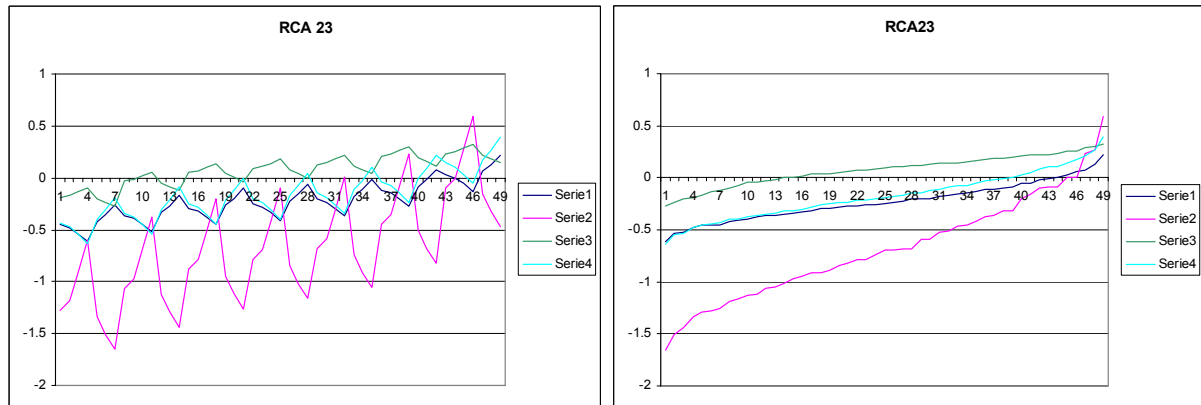


Figure 15 RCA 23

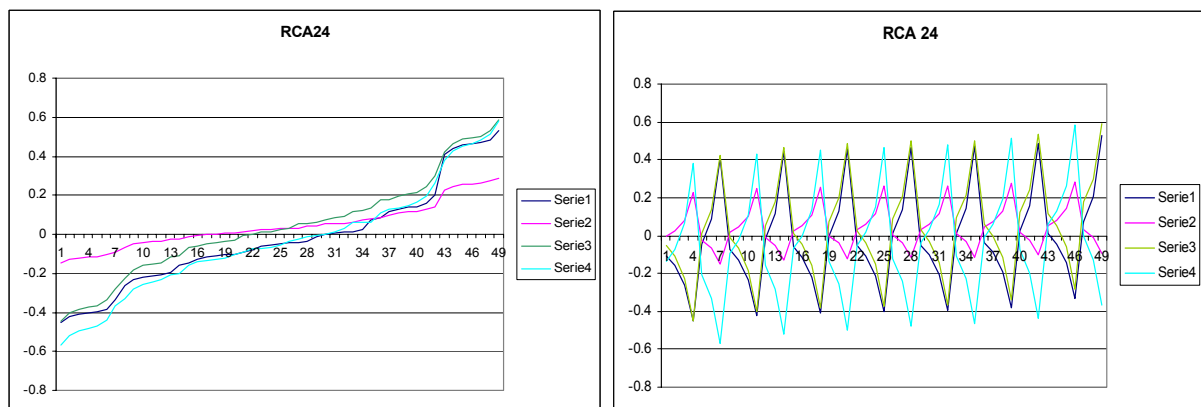


Figure 16 RCA 24

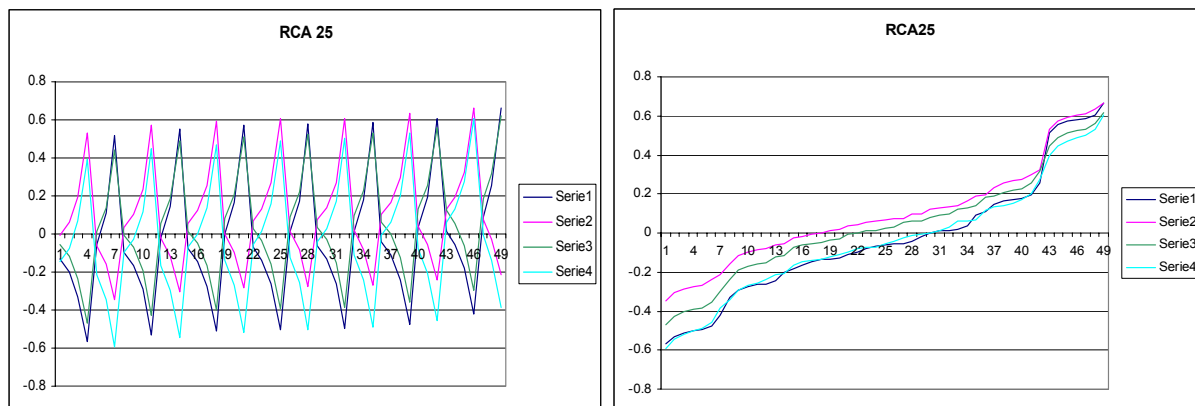


Figure 17 RCA 25

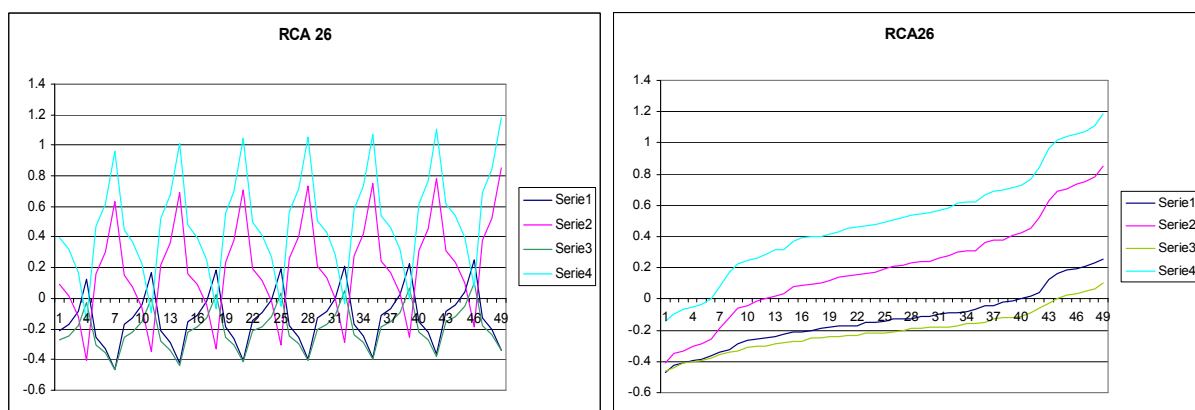


Figure 18 RCA 26

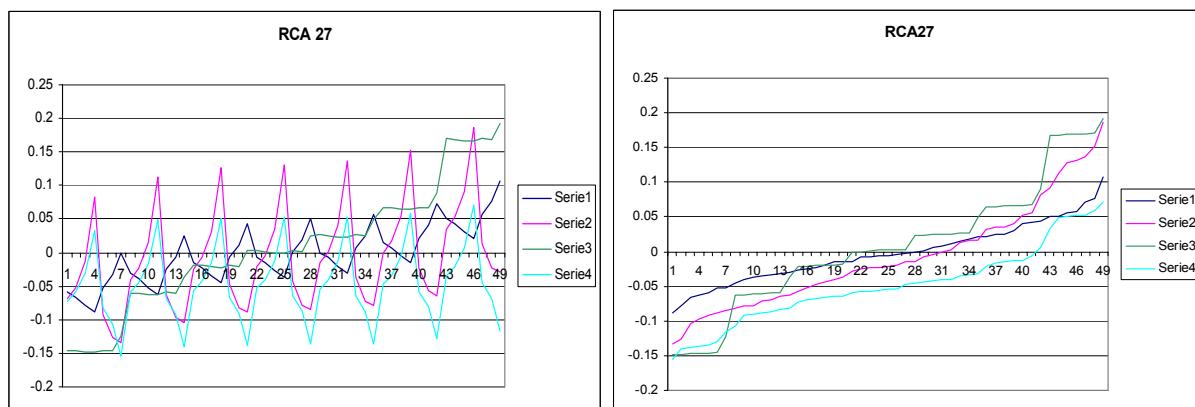


Figure 19 RCA 27

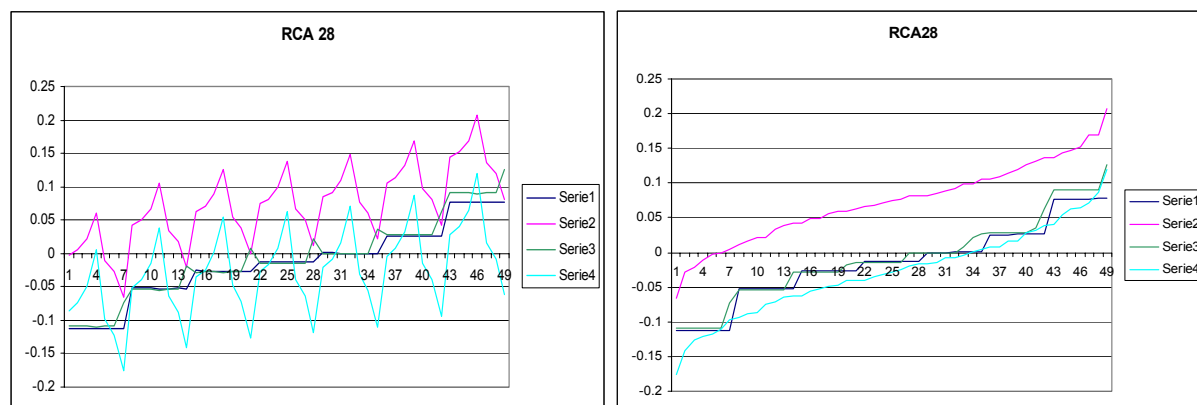


Figure 20 RCA 28

