EMIR commissioning after the upgrade of bands 3 and 4 in November 2011

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C. Kramer, S. Trevino, M. Gonzalez, G. Paubert, F. Damour, C. Buchbender, N. Billot, S. Navarro

In early November 2011, the mixers of bands 3 and 4 of EMIR were replaced by 2SB mixers with 8GHz per sideband. At the same time, the IF switching box was adapted to allow for selecting these newly available bands.

We observed line rich sources, to test 12 different setups of EMIR band combinations, from single-band setups to dual-band E0/E2, E1/E3, and E0/E1 setups. The 12 setups tested are those which had been requested for observing projects in winter 2011/12.

We identified individual lines in each of the bands. For each setup, we give below the receiver/backend commands (from `rec.pako`), and a plot of the resulting spectra, showing the full spectrum and and a smaller frequency range showing some identified lines. Only few spikes show up. Two problems were identified: (1) The current upper frequency limit of E3 is only 334 GHz instead of the expected 352 GHz. (2) A broad spurious signal shows-up in the vertical polarisation of E2.

As the bandpass slopes are large, power levels have to be carefully adjusted on the hot load, for the FTS, and for the continuum backends bbc.

To identify lines, we made use of new features within the GILDAS package, “go browse” and line catalogues provided with `astro` and also via `weeds` from the CDMS and JPL databases. Scripts are available on the `t07-11` account.

Contents

1 Overview of EMIR setups tested

The labeling of the setups follows that on the EMIR homepage.

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    1. E0 32GHz mode, dual-pol
    2. E2 32GHz mode, dual-pol
    3. E3 32GHz mode, dual-pol
2. E0/E2
    1. E0: UI+UO, E2: UI+UO (dual-pol)
    2. E0: LI+LO, E2: LI+LO (dual-pol)
    3. E0VUO, E2VUI, E2HUI, E2HLI
    4. E2HLI, E2HUI, E0VUI
3. E1/E3.
    1. E1LI, E3LI, E3LO (dual-pol)
    2. E1UI, E3LI, E3VLO (dual-pol)
4. E0/E1.
    1. E0/E1 dual-pol
        1. EOLI, E0LO, E1LI (dual-pol)
        2. E0LI, E0LO, E1UI (dual-pol)
    2. E0LOH, E0LIV, E0UIH, E1LIV

2 EMIR band combinations

1. Single bands

   1 Setup 1.1. E0 lower and inner sidebands

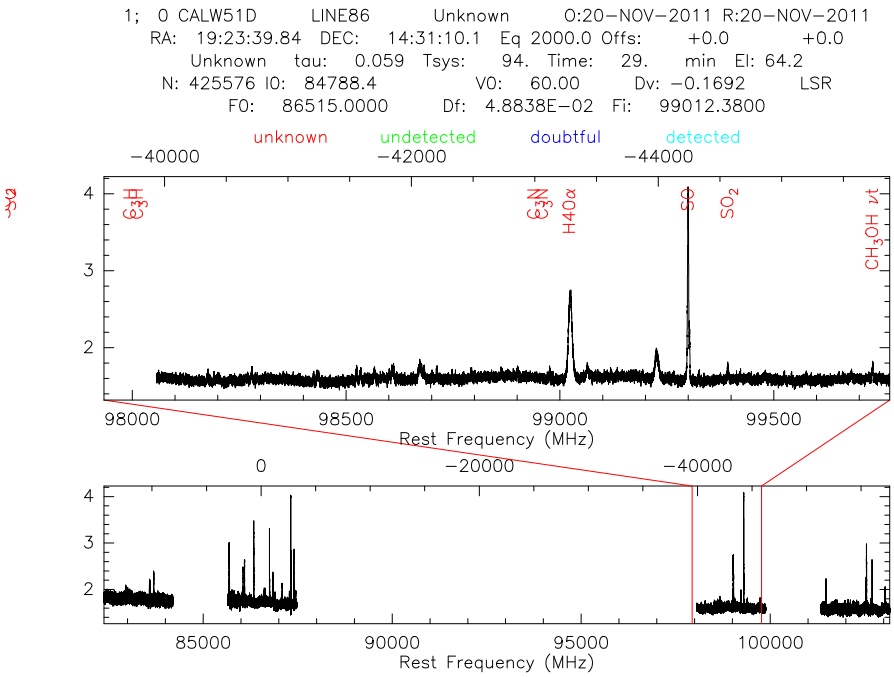

Figure 1: Setup 1.1. E0 lower and inner sidebands. FTS at 50kHz resolution.

```
RECEIVER E090  line90 90.000 LI /hor LI UI /ver LI UI
BACKEND VESPA 1 0.040 120.0 0.0 /rece E090 hor LI
BACKEND VESPA 2 0.040 120.0 0.0 /rece E090 ver LI
BACKEND VESPA 3 0.040 120.0 0.0 /rece E090 hor UI
BACKEND VESPA 4 0.040 120.0 0.0 /rece E090 ver UI
BACKEND FTS /fine /DEF
BACKEND WILMA /DEF
```

2 Setup 1.2. E2 lower and inner sidebands

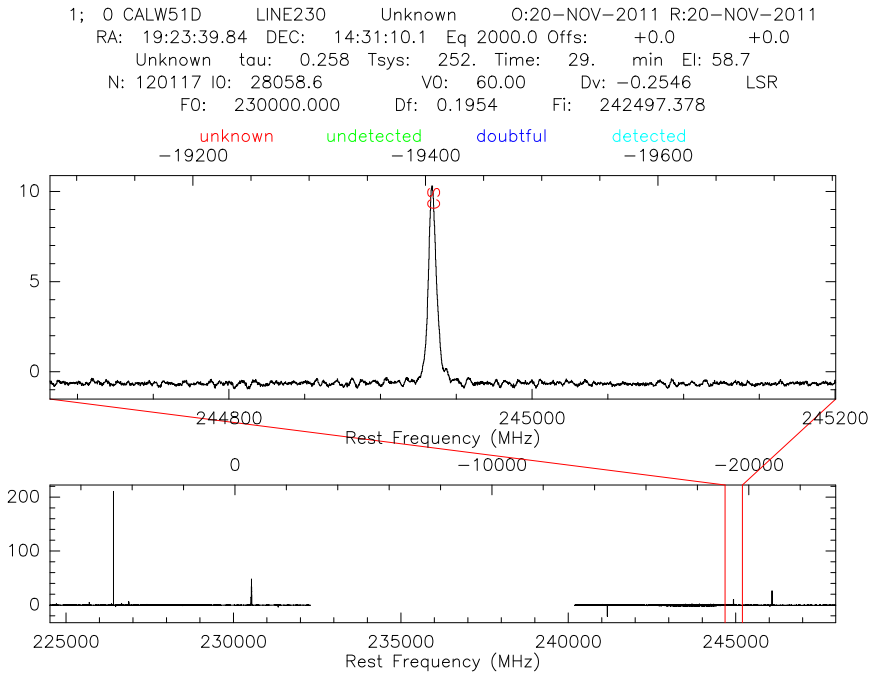

Figure 2: Setup 1.1. E2 lower and inner sidebands. FTS at 200kHz resolution.

```
RECEIVER E230  line230 230.000 LI /hor LI UI /ver LI UI
BACKEND VESPA 1 0.040 120.0 0.0 /rece E230 hor LI
BACKEND VESPA 2 0.040 120.0 0.0 /rece E230 ver LI
BACKEND VESPA 3 0.040 120.0 0.0 /rece E230 hor UI
BACKEND VESPA 4 0.040 120.0 0.0 /rece E230 ver UI
BACKEND FTS /DEF
BACKEND WILMA /DEF
```

3 Setup 1.3. E3 lower and inner sidebands

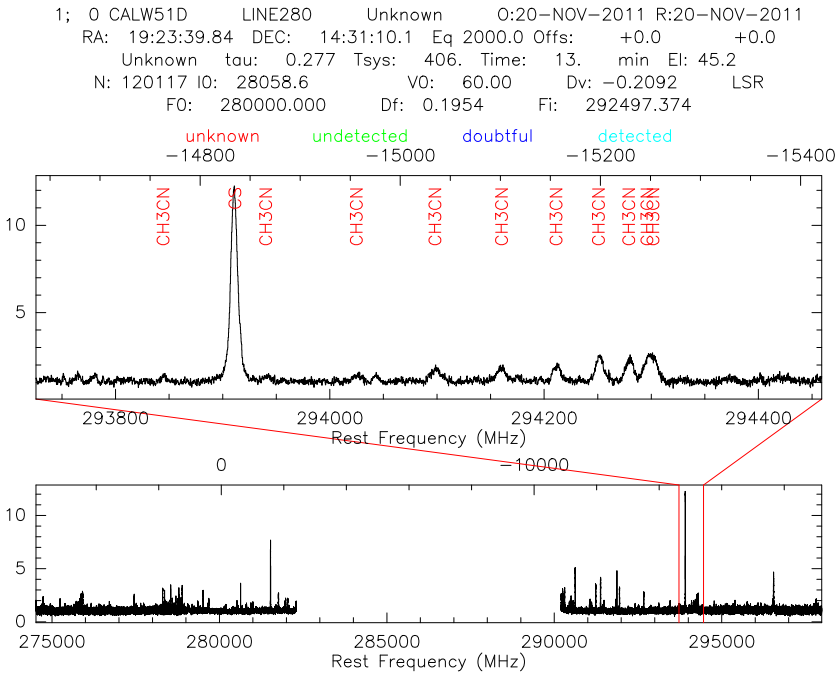

Figure 3: Setup 1.3. E3 lower and inner sidebands. FTS at 200kHz resolution.

```
RECEIVER E330  line300 300.000 LI /hor LI UI /ver LI UI
BACKEND VESPA 1 0.040 120.0 0.0 /rece E330 hor LI
BACKEND VESPA 2 0.040 120.0 0.0 /rece E330 ver LI
BACKEND VESPA 3 0.040 120.0 0.0 /rece E330 hor UI
BACKEND VESPA 4 0.040 120.0 0.0 /rece E330 ver UI
BACKEND FTS /DEF
BACKEND WILMA /DEF
```

2. E0/E2

1 E0/E2: E0: UI+UO, E2: UI+UO

Possible application: 12CO, 13CO 1-0, 12CO 2-1

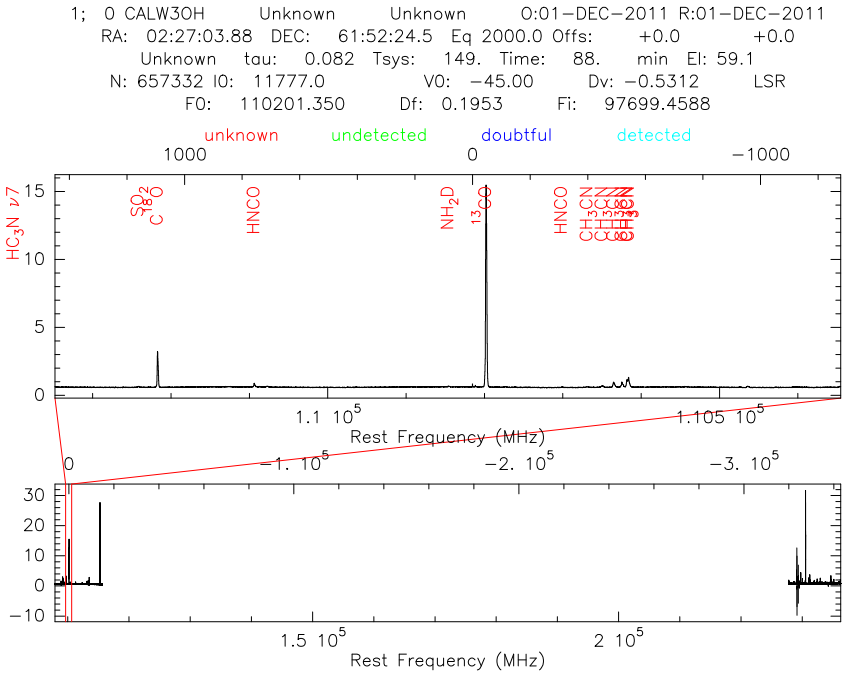

Figure 4: Setup 2.1.

```
RECEIVER E090 13CO(1-0) 110.20135 UI /hor UI /ver UI
RECEIVER E230 12CO(2-1) 230.53799 UI /hor UI /ver UI
BACKEND VESPA 1 0.040 120.0 0.0 /rece E090 hor UI
BACKEND VESPA 2 0.040 120.0 0.0 /rece E090 ver UI
BACKEND VESPA 3 0.040 120.0 0.0 /rece E230 hor UI
BACKEND VESPA 4 0.040 120.0 0.0 /rece E230 ver UI
BACKEND FTS /DEF
BACKEND WILMA /DEF
```

2 E0/E2: E0: LI+LO, E2: LI+LO

Possible application: HCN, HCO+ 1-0, 13CO 2-1

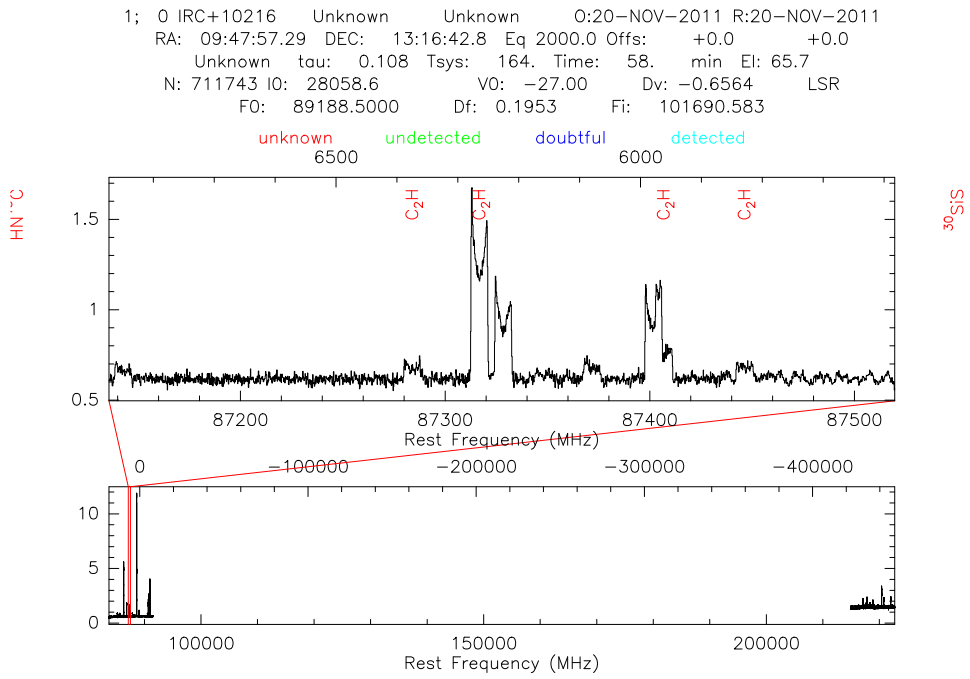

Figure 5: Setup 2.2.

```
RECEIVER E090 HCO+(1-0) 89.1885 LI /hor LI /ver LI
RECEIVER E230 13CO(2-1) 220.3987 LI /hor LI /ver LI
BACKEND VESPA 1 0.040 120.0 0.0 /rece E090 hor LI
BACKEND VESPA 2 0.040 120.0 0.0 /rece E090 ver LI
BACKEND VESPA 3 0.040 120.0 0.0 /rece E230 hor LI
BACKEND VESPA 4 0.040 120.0 0.0 /rece E230 ver LI
BACKEND FTS /DEF
BACKEND WILMA /DEF
```

3 E0/E2: E0VUO, E2VUI, E2HUI, E2HLI

This is a special setup as only single polarisations are used and only 4 out of 8 cables. It may be useful to observe simultaneously 12CO 1-0, 12CO 2-1, 13CO & C18O 2-1

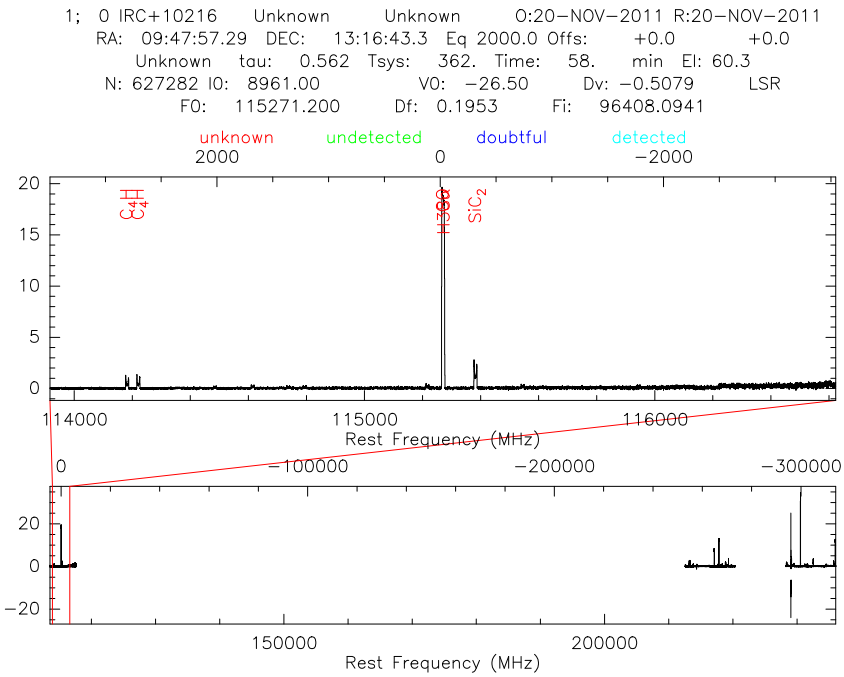

Figure 6: Setup 2.3.

```
RECEIVER E090 12CO(1-0) 115.2712 UO /ver UO /hor none
RECEIVER E230 12CO(2-1) 230.53799 UI /hor UI LI /ver UI
BACKEND VESPA 1 0.040 120.0 0.0 /rece E090 ver UO
BACKEND VESPA 2 0.040 120.0 0.0 /rece E230 hor LI
BACKEND VESPA 3 0.040 120.0 0.0 /rece E230 hor UI
BACKEND VESPA 4 0.040 120.0 0.0 /rece E230 ver UI
BACKEND FTS /DEF
BACKEND WILMA /DEF
```

4 E2HLI, E2HUI, E0VUI (or any other E0V band)

This is another special setup which may be useful to observe simultaneously in single-polarisation mode, 12CO & 13CO 2-1, plus one E0 band.

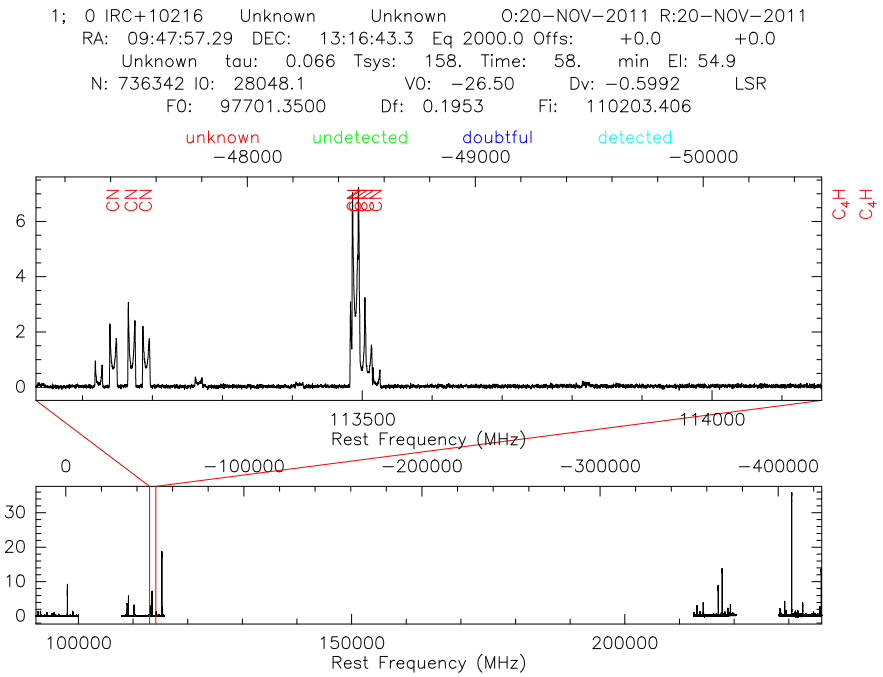

Figure 7: Setup 2.4.

```
RECEIVER E090 13CO(1-0) 110.20135 UI /ver UI LI /hor none
RECEIVER E230 12CO(2-1) 230.53799 UI /hor UI LI /ver none
BACKEND VESPA 1 0.040 120.0 0.0 /rece E090 ver LI
BACKEND VESPA 2 0.040 120.0 0.0 /rece E090 ver UI
BACKEND VESPA 3 0.040 120.0 0.0 /rece E230 hor LI
BACKEND VESPA 4 0.040 120.0 0.0 /rece E230 hor UI
BACKEND FTS /DEF
BACKEND WILMA /DEF
```

3. E1/E3.

   Using the inner lower or upper band of E1, only the lower inner and outer band of E3 can be observed simultaneously.

   1 E1/E3: E1LI, E3LI, E3LO (dual-pol)

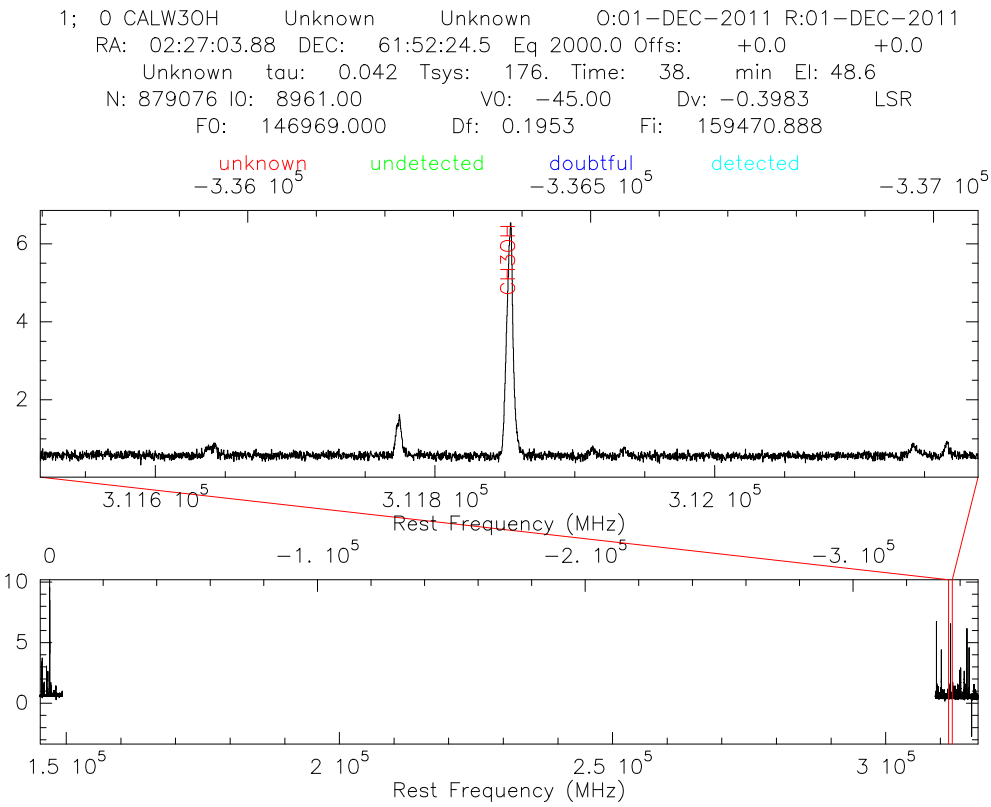

Figure 8: Setup 311.

```
RECEIVER E150  CS(3-2) 146.9690 LI /hor LI /ver LI
RECEIVER E330  noLine 314.587969 LI /hor LI /ver LI
BACKEND VESPA 1 0.040 120.0 0.0 /rece E150 hor LI
BACKEND VESPA 2 0.040 120.0 0.0 /rece E150 ver LI
BACKEND VESPA 3 0.040 120.0 0.0 /rece E330 hor LI
BACKEND VESPA 4 0.040 120.0 0.0 /rece E330 ver LI
BACKEND FTS /DEF
BACKEND WILMA /DEF
```

2 E1/E3: E1UI, E3LI, E3LO (dual-pol)

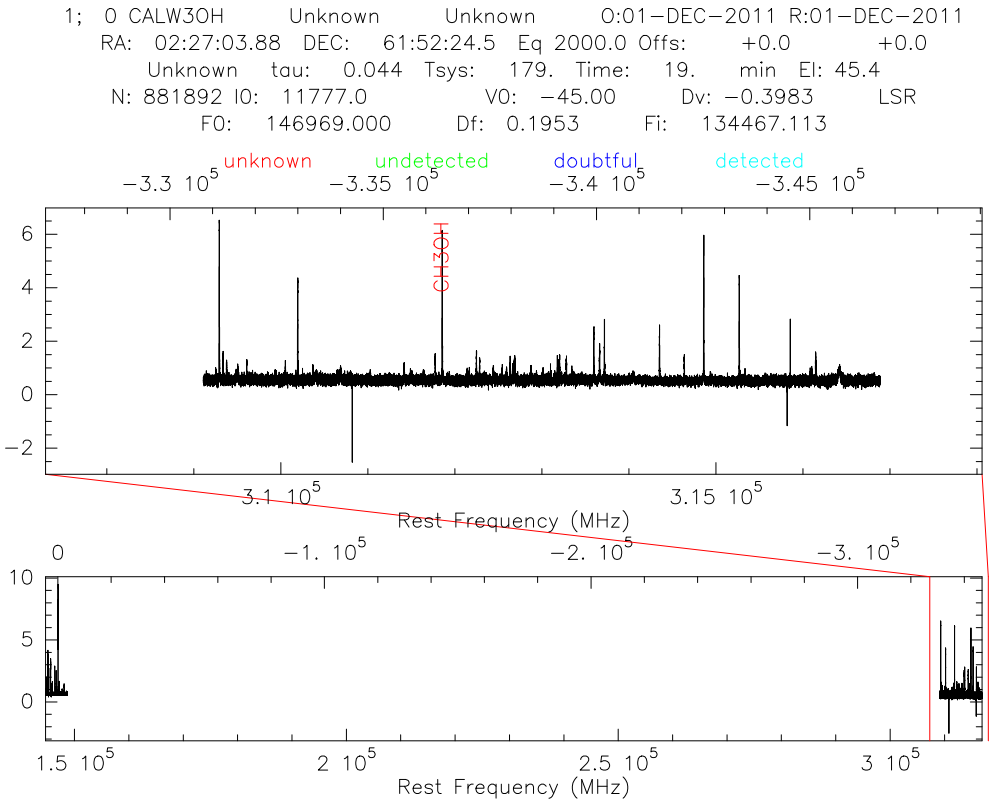

Figure 9: Setup 312.

```
RECEIVER E150  CS(3-2) 146.9690 UI /hor UI /ver UI
RECEIVER E330  NOLINE 314.587969 LI /hor LI /ver LI
BACKEND VESPA 1 0.040 120.0 0.0 /rece E150 hor UI
BACKEND VESPA 2 0.040 120.0 0.0 /rece E150 ver UI
BACKEND VESPA 3 0.040 120.0 0.0 /rece E330 hor LI
BACKEND VESPA 4 0.040 120.0 0.0 /rece E330 ver LI
BACKEND FTS /DEF
BACKEND WILMA /DEF
```

4. E0/E1.

   Together with E1, only the lower 8GHz band of E0 can be observed in dual-pol. Important application: CS 2-1, 3-2.

   1 E0/E1 dual-pol

      1 E0/E1: EOLI, E0LO, E1LI (dual-pol)

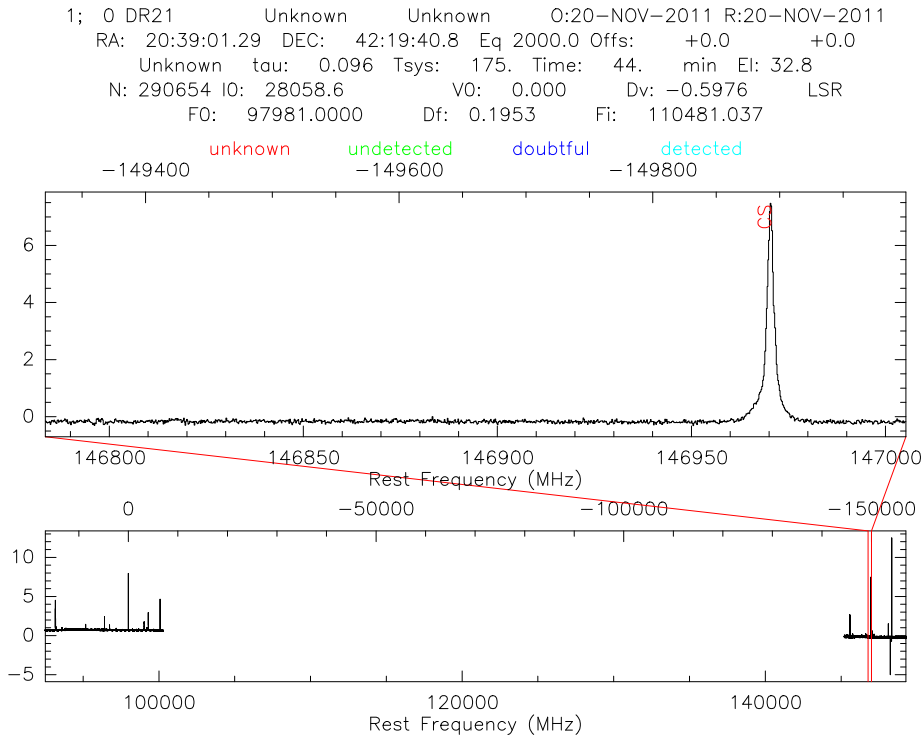

Figure 10: Setup 4.1.1.

```
RECEIVER E090  CS(1-0)  97.9810 LI /hor LI /ver LI
RECEIVER E150  CS(3-2) 146.9690 LI /hor LI /ver LI
BACKEND VESPA 1 0.040 120.0 0.0 /rece E090 hor LI
BACKEND VESPA 2 0.040 120.0 0.0 /rece E090 ver LI
BACKEND VESPA 3 0.040 120.0 0.0 /rece E150 hor LI
BACKEND VESPA 4 0.040 120.0 0.0 /rece E150 ver LI
BACKEND FTS /DEF
BACKEND WILMA /DEF
```

2 E0/E1: E0LI, E0LO, E1UI (dual-pol)

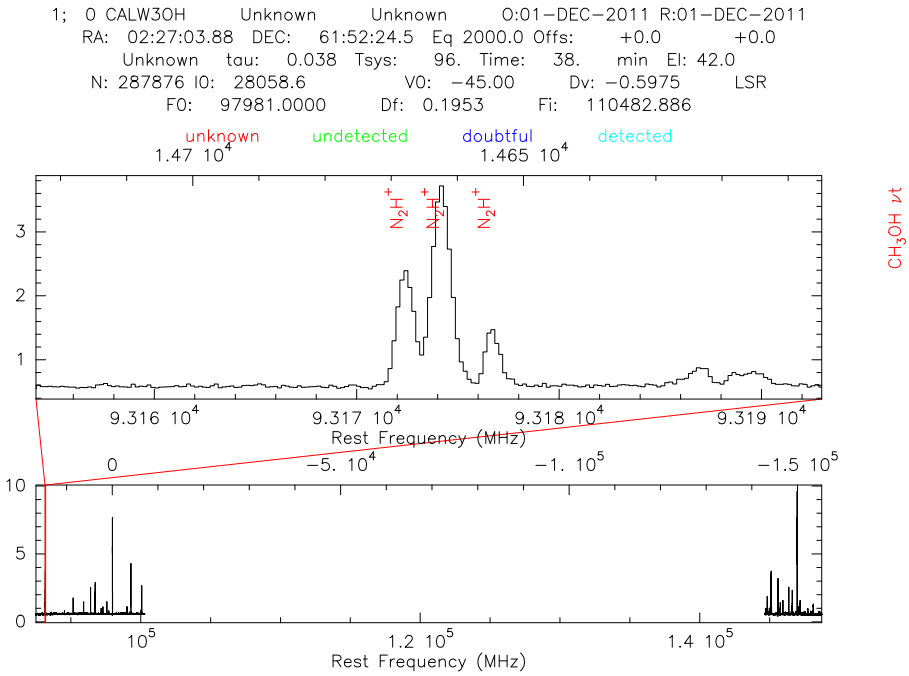

Figure 11: Setup 412.

```
RECEIVER E090  CS(1-0)  97.9810 LI /hor LI /ver LI
RECEIVER E150  CS(3-2) 146.9690 UI /hor UI /ver UI
BACKEND VESPA 1 0.040 120.0 0.0 /rece E090 hor LI
BACKEND VESPA 2 0.040 120.0 0.0 /rece E090 ver LI
BACKEND VESPA 3 0.040 120.0 0.0 /rece E150 hor UI
BACKEND VESPA 4 0.040 120.0 0.0 /rece E150 ver UI
BACKEND FTS /DEF
BACKEND WILMA /DEF
```

2 E0/E1: E0LOH, E0LIV, E0UIH, E1LIV

This is a special setup, as only one polarisation of E1LI is used. There was one winter proposal which had good reasons to argue for this setup.

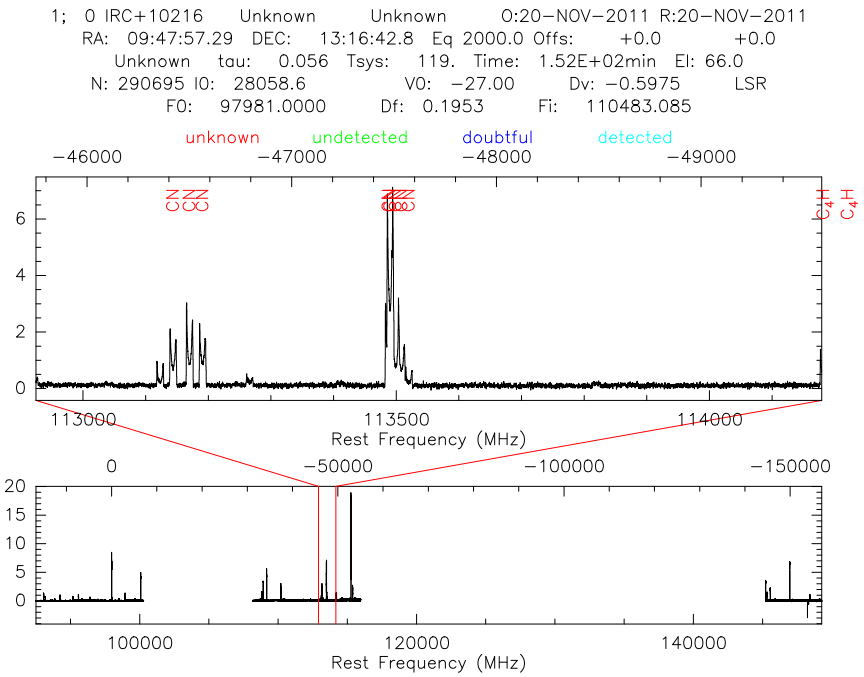

Figure 12: Setup 4.2.

```
RECEIVER E090  CS(1-0)  97.9810 LI /hor LO UI /ver LI
RECEIVER E150  CS(3-2) 146.9690 LI /hor none /ver LI
BACKEND VESPA 1 0.040 120.0 0.0 /rece E090 hor LO
BACKEND VESPA 2 0.040 120.0 0.0 /rece E090 hor UI
BACKEND VESPA 3 0.040 120.0 0.0 /rece E090 ver LI
BACKEND VESPA 4 0.040 120.0 0.0 /rece E150 ver LI
BACKEND FTS /DEF
BACKEND WILMA /DEF
```

3 Band edges of E2 and E3

The following tests were done on 21-Nov, with `cal /sky no`.

Testing the upper edge of E3, it was not possible to tune E3 to `352 UO` or `350 UO`. This needs to be further investigated.

Testing the lower edge, it was no problem to tune E3 to `277 LO`. The bandpasses on the hot load showed extra noise at frequencies near 279GHz.

Testing the lower edge of E2, we tuned to `202 LO`. This worked, though H had to be tweaked by hand.

The upper edge of E2 worked without problems (`274 UO`).

4 Spectral feature in the vertical polarisation of E2

The vertical polarisation of E2 shows a broad spectra feature. Summarizing what we know about this so far. It shows-up

- only in the vertical polarization, never in horizontal.
- on both sidebands: lower and upper.
- at the same IF frequency (about 4.8 GHz) on both sidebands.
- IF frequency of the feature doesn't change with small changes of LO frequency.
- its width is about 100 MHz

It was first noted when observing E0/E2, showing-up in E2UI near 229GHz (15-Nov by G.Paubert). This is seen with FTS and WILMA.

On 21-Nov, we did some tests on the hot and cold loads with "cal /sky no". The broad feature is reproduced. It does not disappear when switching off the Gunn of E0, and it seems stable in IF near 4.83 GHz. Further tests on 30-Nov, indicate that it stems from the amplifier of the new vertical mixer inside the cryostat.

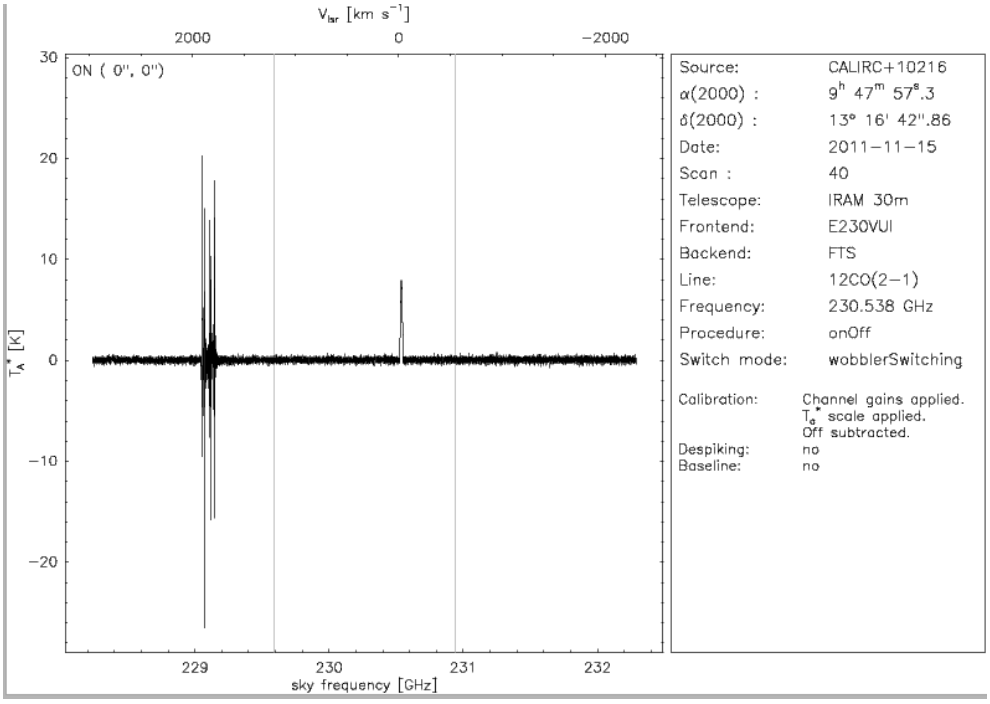

Figure 13: E2VUI with FTS

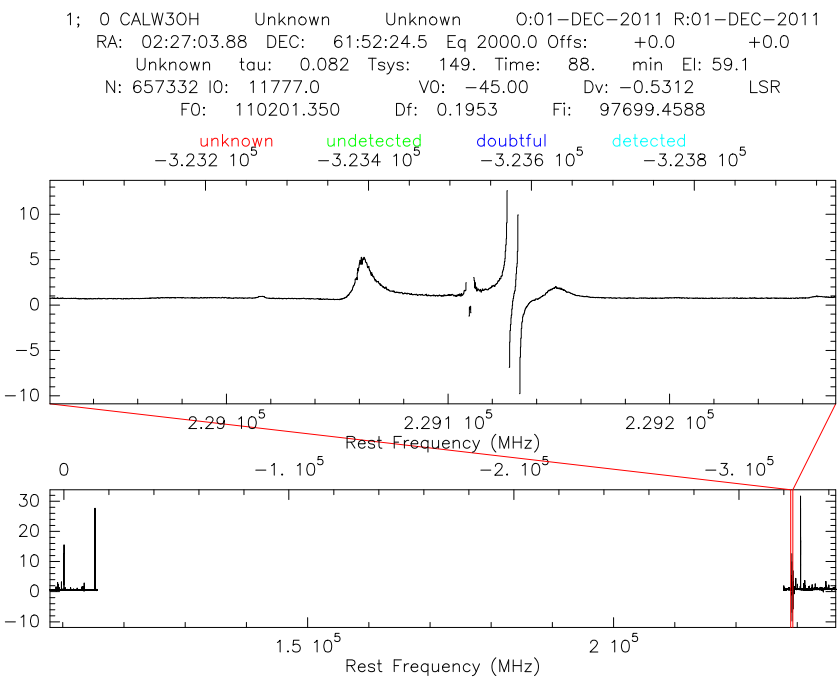

Figure 14: This feature showed-up also on 30-Nov in Setup 2.1. in E2VUI.

5 Power levels

When the power levels are too low, FTS spectra show a typical comb like structure, as reported by G.Paubert.

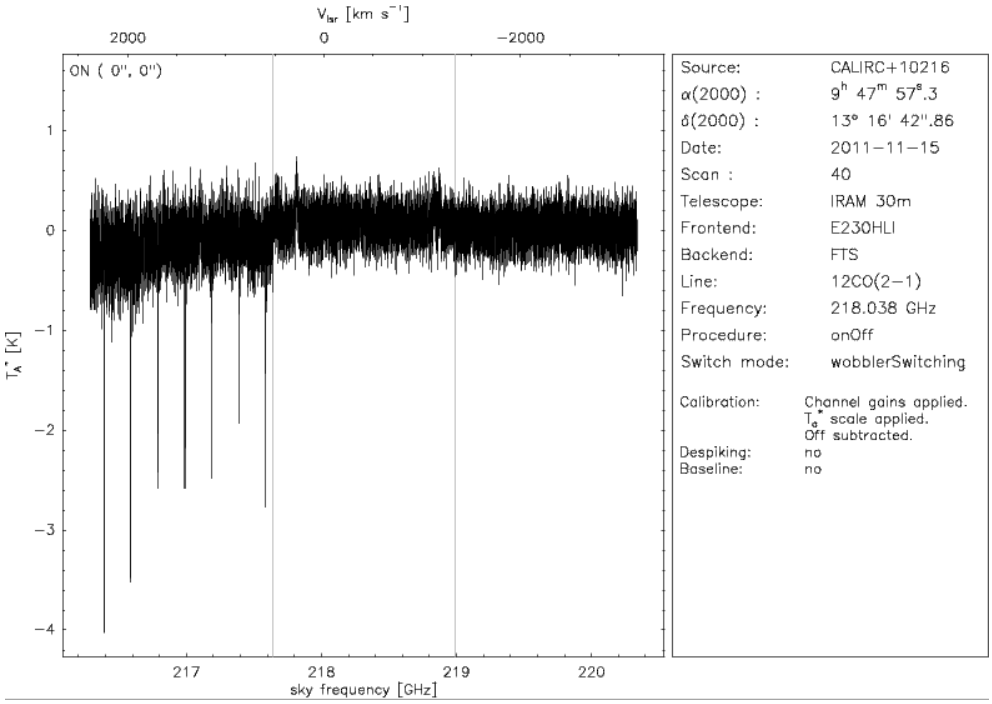

Figure 15: E2HLI with FTS