Absolute Flux Calibration

Melanie Krips

by Arancha Castro-Carrizo
Outline

I. Primary/Secondary Flux Calibrators

II. Practical Tips to Calibrate the Fluxes of your Sources
What do we want in a flux calibrator?

- strong (>1 Jy) emission at mm wavelengths
- compact (<< 1”) emission at mm wavelengths
- emission should not be variable in time
- preferentially with long LST range (i.e., high declination source)
- no or only little sun-avoidance
- preferentially well known properties (such as SED, size)
Flux Calibrators

1. Quasars
2. Planets
3. Solar Bodies (Satellites, Asteroids, Dwarf Planets)
4. Radio Stars
5. Antenna Efficiencies?
Flux Calibrators

1. Quasars

1. Planets

2. Solar Bodies (Satellites, Asteroids, Dwarf Planets)

3. Radio Stars

4. Antenna Efficiencies?
Absolute Flux Calibration

**Flux Calibrators: Quasars**

### Absolute Flux Calibration

**Source: 3C484**

<table>
<thead>
<tr>
<th>(\nu(\text{GHz}))</th>
<th>Flx Calibrator</th>
<th>(\nu/100)</th>
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</thead>
<tbody>
<tr>
<td>90</td>
<td>100 x 110 x 230</td>
<td>MEAN(RMS)</td>
<td>12.37(6.62)</td>
<td>10.41(7.71)</td>
<td>13.15(9.77)</td>
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<tr>
<td>11.23(9.22)</td>
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<td>pwv @ 1mm &lt; 3.5 mm</td>
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<tr>
<td>F0, 10.41 n</td>
<td>- 1.64(\nu/90)</td>
<td>0.124 n</td>
<td>- 0.10(\nu/230)</td>
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<tr>
<td>F0, 12.78 n</td>
<td>0.31(\nu/110)</td>
<td>0.09(\nu/100/230)</td>
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<td></td>
</tr>
</tbody>
</table>

### Absolute Flux Calibration

**Source: 3C485**

<table>
<thead>
<tr>
<th>(\nu(\text{GHz}))</th>
<th>Flx Calibrator</th>
<th>(\nu/100)</th>
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</tr>
</thead>
<tbody>
<tr>
<td>90</td>
<td>100 x 110 x 230</td>
<td>MEAN(RMS)</td>
<td>4.58(1.31)</td>
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<td>2.88(1.06)</td>
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<td>pwv @ 1mm &lt; 3.5 mm</td>
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<td>F0, 4.48 n</td>
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<td>0.37(\nu/100/230)</td>
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</table>

### Absolute Flux Calibration

**Source: 3C273**

<table>
<thead>
<tr>
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<th>Flx Calibrator</th>
<th>(\nu/100)</th>
<th>(\nu/100)</th>
<th>(\nu/100)</th>
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</thead>
<tbody>
<tr>
<td>90</td>
<td>100 x 110 x 230</td>
<td>MEAN(RMS)</td>
<td>18.18(7.49)</td>
<td>15.50(7.94)</td>
<td>15.37(7.52)</td>
</tr>
<tr>
<td>12.68(8.12)</td>
<td></td>
<td>pwv @ 1mm &lt; 3.5 mm</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>F0, 15.50 n</td>
<td>- 1.51(\nu/90)</td>
<td>0.09(\nu/100/110)</td>
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<td></td>
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</tr>
<tr>
<td>F0, 16.84 n</td>
<td>- 0.84(\nu/110)</td>
<td>0.24(\nu/100/230)</td>
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<td></td>
</tr>
</tbody>
</table>
Flux Calibrators: Quasars

**Not suitable!**
Flux Calibrators

1. Quasars
2. Planets
   1. Solar Bodies (Satellites, Asteroids, Dwarf Planets)
   2. Radio Stars
3. Antenna Efficiencies?
Pro: most of the solar planets have strong mm-emission and reasonably well derived flux models

Contra:
1.) Fluxes not completely constant
2.) They start to be resolved ($\geq 3''$) already at 3mm
3.) Some of them have broad molecular line absorption (e.g., Mars, Jupiter, Saturn)
4.) Not always visible, i.e., more constraints due to sun-avoidance, short LST ranges
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(Kramer et al. 2008)
Flux Calibrators: Planets

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Kramer et al. (2008)

8.6GHz 90GHz

8.6GHz 90GHz

Uranus

Neptune

(e.g., Mars, Jupiter, Saturn)
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Kramer et al. (2008)

- 8.6GHz
- 90GHz

Uranus

- 8%
Flux Calibrators: Planets

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---

Kramer et al. (2008)

8.6GHz

90GHz
 Flux Calibrators: Planets

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Absolute Flux Calibration

**Flux Calibrators: Planets**

![Graph showing absolute flux calibration for planets](image)

**NEPTUNE** = \(< 21.2 \text{ Jy/K} > @ 26.6^\circ\)

**URANUS** = \(< 22.6 \text{ Jy/K} > @ 40.3^\circ\)

uv-radius (m)
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**Flux Calibrators: Planets**

- Absolute Flux Calibration
- Flux Calibrators: Planets
- Mars
- Uranus
- Neptune
- Jupiter
- Saturn

![Graph showing temperature (K) vs. uv-radius (m) for Neptune and Uranus at 230GHz.]

**NEPTUNE** = $< 29.5 \text{ Jy/K}> @ 28.4^\circ$

**URANUS** = $< 27.8 \text{ Jy/K}> @ 40.6^\circ$
- Pro: most of the solar planets have strong mm-emission and reasonably well derived flux models
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Absolute Flux Calibration

Flux Calibrators: Planets

- NEPTUNE = $\langle 38.8 \text{ Jy/K} \rangle$ @ 30.6°
- URANUS = $\langle 40.9 \text{ Jy/K} \rangle$ @ 35°
Flux Calibrators: Planets

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Absolute Flux Calibration

Flux Calibrators: Planets

- Mars
- Uranus
- Neptune
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Absolute Flux Calibration

Flux Calibrators: Planets

Mars
Cavalie et al. (2009)
Marten et al. (2005)

Urano

Neptuno

Cavalie et al. (2009)
Marten et al. (2005)
Flux Calibrators: Planets

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Absolute Flux Calibration
Flux Calibrators: Planets
Absolute Flux Calibration

Flux Calibrators

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2. Planets
3. Solar Bodies (Satellites, Asteroids, Dwarf Planets)
   1. Radio Stars
   2. Antenna Efficiencies?
Flux Calibrators: Satellites

• Pro:
  - They are quite compact (hence better for extended configurations and/or higher frequencies than planets) and still sufficiently bright (>500mJy@3mm)

• Already regularly used at the SMA: Titan, Ganymede, Callisto

• Contra:
  - Titan also shows broad molecular lines
  - they are not always useable especially when they are too close to their ‘mother’-planet (or each other); one needs at least 3xPB
  - flux models not as well constrained as for planets
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- **Pro:**
  - bright and relatively small solar bodies

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  - Fluxes not (yet) well determined; some of them known to vary quite significantly within a day
  - irregular shapes
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Absolute Flux Calibration

Moulet et al. (2010)
Flux Calibrators

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4. Radio Stars

1. Antenna Efficiencies?
Absolute Flux Calibration

Flux Calibrators: Radio Stars

Number of radio bright stars:
• MWC349 (binary star)
• CRL618 (PPN)
• W3OH (HII region)
• NGC7072 (young PN)
• NGC7538 (HII region)
• K3-50A (HII-region)
• ......
Flux Calibrators: Radio Stars

Pardo et al. (2009)

CRL618
Absolute Flux Calibration

Flux Calibrators: Radio Stars

Number of radio bright stars:
- MWC349
- CRL618
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- NGC7072
- NGC7538
- K3-50A

Pardo et al. (2009)

Too many lines!
Flux Calibrators: Radio Stars

- MWC349
- CRL618
- W3OH
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- NGC7538
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- ...

Nakashima et al. (2010)
Flux Calibrators: Radio Stars

- MWC349
- CRL618
- W3OH
- NGC7072
- NGC7538
- K3-50A

Too extended!

Nakashima et al. (2010)
Number of radio bright stars:
- MWC349
- CRL618
- W3OH
- NGC7072
- NGC7538
- K3-50A
Flux Calibrators: MWC349

Some facts:
- binary stellar system: MWC349A (Be) & MWC349B (B0 type III)
- the two stars are separated by 2.4″± 0.1″ and possibly interact
- MWC349A the brightest radio continuum star
- radio continuum produced by “ionised bipolar flow that photoevaporates from the surface of a neutral Keplerian disk”
- size of flow decreases with frequency
- strong but highly variable hydrogen maser emission (RRLs) from the near-edge-on disk (~0.065″=80AU@1.2kpc)
- at declination of >40deg -> visible for ~13h per day
Some facts:

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• size of flow decreases with frequency
• strong but highly variable hydrogen maser emission (RRLs) from the near-edge-on disk (∼0.065”=80AU@1.2kpc)
• at declination of >40deg -> visible for ∼13h per day

Flux Calibrators: MWC349
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- Binary stellar system: MWC349A (Be) & MWC349B (B0 type III)
- The two stars are separated by $2.4'' \pm 0.1''$ and possibly interact
- MWC349A is the brightest radio continuum star
- Radio continuum produced by "ionised bipolar flow that photoevaporates from the surface of a neutral Keplerian disk"
- Size of flow decreases with frequency
- Strong but highly variable hydrogen maser emission (RRLs) from the near-edge-on disk ($\approx 0.065'' = 80\text{AU} @ 1.2\text{kpc}$)
- At declination of $>40\text{deg}$ -> visible for $\approx 13\text{h}$ per day
Some facts:

• binary stellar system: MWC349A (Be) & MWC349B (B0 type III)
• the two stars are separated by 2.4”± 0.1” and possibly interact
• MWC349A the brightest radio continuum star
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- MWC349A the brightest radio continuum star
- radio continuum produced by “ionised bipolar flow that photoevaporates from the surface of a neutral Keplerian disk”
- size of flow decreases with frequency
- strong but highly variable hydrogen maser emission (RRLs) from the near-edge-on disk (~0.065”=80AU@1kpc)
- at declination of >40deg -> visible for ~13h per day

Flux Calibrators: MWC349
Some facts:

• Binary stellar system: MWC349A (Be) & MWC349B (B0 type III)
• The two stars are separated by $2.4'' \pm 0.1''$ and possibly interact
• MWC349A the brightest radio continuum star
• Radio continuum produced by “ionised bipolar flow that photoevaporates from the surface of a neutral Keplerian disk”
• Size of flow decreases with frequency
• Strong but highly variable hydrogen maser emission (RRLs) from the near-edge-on disk ($\sim 0.065'' = 80$ AU @ 1.2 kpc)
• At declination of $>40$ deg -> visible for $\sim 13$ h per day

Absolute Flux Calibration

Flux Calibrators: MWC349
Some facts:

- Binary stellar system: MWC349A (Be) & MWC349B (B0 type III)
- The two stars are separated by 2.4" ± 0.1" and possibly interact.
- MWC349A is the brightest radio continuum star.
- Radio continuum produced by “ionised bipolar flow that photoevaporates from the surface of a neutral Keplerian disk”.
- Size of flow decreases with frequency.
- Strong but highly variable hydrogen maser emission (RRLs) from the near-edge-on disk (~0.065" = 80AU @ 1.2kpc) at declination of >40deg.
- Visible for ~13h per day.

Weintroub et al. (2008)

Martin-Pintado et al. (1994)
Some facts:

- binary stellar system: MWC349A (Be) & MWC349B (B0 type III)
- the two stars are separated by 2.4" ± 0.1" and possibly interact
- MWC349A the brightest radio continuum star
- radio continuum produced by “ionised bipolar flow that photoevaporates from the surface of a neutral Keplerian disk”
- size of flow decreases with frequency
- strong but highly variable hydrogen maser emission (RRLs) from the near-edge-on disk (~0.065"=80AU@1.2kpc)
- at declination of >40deg => visible for ~13h per day
Some facts:

- Binary stellar system: MWC349A (Be) & MWC349B (B0 type III)
- The two stars are separated by 2.4" ± 0.1" and possibly interact.
- MWC349A is the brightest radio continuum star.
- Radio continuum produced by an ionised bipolar flow that photoevaporates from the surface of a neutral Keplerian disk.
- The size of the flow decreases with frequency.
- Strong but highly variable hydrogen maser emission (RRLs) from the near-edge-on disk (~0.065" = 80 AU @ 1.2 kpc) at declination of >40 deg.

Visible for ~13h per day

Tafoya et al. (2004)
How to calibrate a calibrator?

<table>
<thead>
<tr>
<th>ANTELLA</th>
<th>3c454.3@46°</th>
<th>mwc349@72°</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>21.5 Jy/K</td>
<td>21.3 Jy/K</td>
</tr>
<tr>
<td>2</td>
<td>22.3 Jy/K</td>
<td>22.5 Jy/K</td>
</tr>
<tr>
<td>3</td>
<td>21.7 Jy/K</td>
<td>22.1 Jy/K</td>
</tr>
<tr>
<td>5</td>
<td>22.1 Jy/K</td>
<td>22.4 Jy/K</td>
</tr>
<tr>
<td>6</td>
<td>22 Jy/K</td>
<td>21.9 Jy/K</td>
</tr>
<tr>
<td>Weighted Av.</td>
<td>21.8 Jy/K</td>
<td>21.9 Jy/K</td>
</tr>
</tbody>
</table>

SOURCE  | FLUX  | MAJOR  | MINOR  | PA   |
-------|-------|--------|--------|------|
URANUS  | 7.4   | 3.64   | 3.53   | 255  |
NEPTUNE | 2.7   | 2.27   | 2.21   | 340  |
3c454.3 | 26.51 (Neptune) | 3c454.3 | 28.16 (Uranus) |

Flagged:
- L02 C02 for Line Frequency: 86243 MHz
- L03 C03 for Line Frequency: 86243 MHz
- L06 C06 for Line Frequency: 86243 MHz
- L07 C07 for Line Frequency: 86243 MHz
How to calibrate a calibrator?

16-NOV-2008 @ 260 GHz (LO1REF=1888 MHz)

ANTENNA 3c454.3@52° mwc349@75°

<table>
<thead>
<tr>
<th></th>
<th>Jy/K</th>
<th>Jy/K</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>39.9</td>
<td>41.2</td>
</tr>
<tr>
<td>2</td>
<td>34.6</td>
<td>35.8</td>
</tr>
<tr>
<td>3</td>
<td>41.8</td>
<td>45.3</td>
</tr>
<tr>
<td>4</td>
<td>51.4</td>
<td>50.4</td>
</tr>
<tr>
<td>5</td>
<td>34.5</td>
<td>34.9</td>
</tr>
<tr>
<td>6</td>
<td>39.9</td>
<td>40.5</td>
</tr>
</tbody>
</table>

Weighted Av. 38 Jy/K 39.3 Jy/K

MWC349 = 2.3 Jy @ 75.5°; Fitted size: 0.14''

NEPTUNE = < 38.8 Jy/K @ 30.6°

MWC349 = 2.19 Jy @ 75.5°

URANUS = < 40.9 Jy/K @ 35°

MWC349 = 2.3 Jy @ 75.5°

SOURCE FLUX MAJOR MINOR PA
URANUS 41.1 3.56 3.45 255
NEPTUNE 15.4 2.23 2.17 340
3c454.3 13.76 (Neptune)
3c454.3 14.5 (Uranus)
Flux of MWC348: SED

\[ f(\nu[\text{GHz}]) = f_{100} \left( \frac{\nu}{100} \right)^{\alpha} \]

- \( f_{100} = 1.17 \pm 0.01 \text{ Jy (PdBI)} \)
- \( f_{100} = 1.16 \pm 0.01 \text{ Jy (PdBI+VLA)} \)

\( \alpha = 0.6 \pm 0.01 \)

Graph shows the relationship between observed frequency (\( \nu_{\text{obs}} \) in GHz) and flux (in Jy) with error bars.

Data sources:
- URANUS (2008)
- NEPTUNE (2008)
- 3C286 (Tafoya et al. 2004)
Flux of MWC348: SED

\[ f(\nu[\text{GHz}]) = f_{100} \left( \frac{\nu}{100} \right) ^ \alpha \]

- \( f_{100} = 1.17 \pm 0.01 \text{ Jy (PdBI)} \)
- \( 0.6 \pm 0.01 \)  
- \( f_{100} = 1.16 \pm 0.01 \text{ Jy (PdBI+VLA)} \)

**Graph:**
- Flux in Jy
- \( \nu_{\text{obs}} \) in GHz

**Legend:**
- URANUS <2008
- NEPTUNE <2008
- MARS <2008
- URANUS (2008)
- NEPTUNE (2008)
- 3C286 (Tafoya et al. 2004)
Flux of MWC348: Time variability?

Absolute Flux Calibration
Flux of MWC348: Using satellites?

Using SMA model!

Absolute Flux Calibration
Flux of MWC348: Using satellites?

Values too high, SMA model not accurate enough for $\lambda > 1\text{mm}$!
Flux of MWC348: Using satellites?

- GANYMEDE: $< 23 \text{ Jy/K}$ at 250 m
- MWC349: $< 1.21 \text{ Jy}$ at 48.5 m

Temperature (K) vs. uv-radius (m) graph.
Flux of MWC348: Using satellites?

Simple disk model does NOT fit data!
Flux of MWC348: Using satellites?

Possible, but need better models!!!!!
Flux of MWC348: Using satellites?

Using SMA model!

Absolute Flux Calibration
Size of MWC348

MWC349 = <1.2 Jy>@3mm; <1.5 Jy>@2mm; <1.9 Jy>@1mm;
Size of MWC348

Fit: $\theta \propto \nu^{-0.62\pm0.03}$ (fitted to cm and mm data)

Fit: $\theta \propto \nu^{-0.72\pm0.03}$ (Tafaya et al. 2004)
Primary Flux Calibrators

1. Quasars
2. Planets
3. Solar Bodies (Satellites, Asteroids, Dwarf Planets)
4. Radio Stars
5. Antenna Efficiencies?
“By-product” of calibration

12-OCT-2008 @ 86.2 GHz (LO1REF=1853 MHz)

**ANTENNA**

<table>
<thead>
<tr>
<th></th>
<th>3c454.3 @ 46°</th>
<th>mwc349 @ 72°</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>21.5 Jy/K</td>
<td>21.3 Jy/K</td>
</tr>
<tr>
<td>2</td>
<td>22.3 Jy/K</td>
<td>22.5 Jy/K</td>
</tr>
<tr>
<td>3</td>
<td>21.7 Jy/K</td>
<td>22.1 Jy/K</td>
</tr>
<tr>
<td>4</td>
<td>22.1 Jy/K</td>
<td>22.4 Jy/K</td>
</tr>
<tr>
<td>6</td>
<td>22 Jy/K</td>
<td>21.9 Jy/K</td>
</tr>
<tr>
<td>Weighted Av.</td>
<td>21.8 Jy/K</td>
<td>21.9 Jy/K</td>
</tr>
</tbody>
</table>

**SOURCE**

<table>
<thead>
<tr>
<th></th>
<th>FLUX</th>
<th>MAJOR</th>
<th>MINOR</th>
<th>PA</th>
</tr>
</thead>
<tbody>
<tr>
<td>URBANUS</td>
<td>7.4</td>
<td>3.64</td>
<td>3.53</td>
<td>255</td>
</tr>
<tr>
<td>NEPTUNE</td>
<td>2.7</td>
<td>2.27</td>
<td>2.21</td>
<td>340</td>
</tr>
<tr>
<td>3c454.3</td>
<td>26.51</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3c454.3</td>
<td>28.16</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Flagged:**

- L02 C02 for Line Frequency: 86243 MHz
- L02 C02 for Line Frequency: 86243 MHz
- L06 C06 for Line Frequency: 86243 MHz
- L07 C07 for Line Frequency: 86243 MHz

**Graphs:**

- **MWC349:** $<1.1$ Jy @ 71.7°; Fitted size: 0''
- **NEPTUNE:** $<21.2$ Jy/K @ 26.6°
- **MWC349:** $<1.09$ Jy @ 71.7°
- **URANUS:** $<22.6$ Jy/K @ 40.3°
- **MWC349:** $<1.16$ Jy @ 71.7°

**Baseline (m):**

- 0 to 80
“By-product” of calibration: getting antenna efficiencies!

<table>
<thead>
<tr>
<th>ANTENNA</th>
<th>3c454.3@46°</th>
<th>mwc349@72°</th>
</tr>
</thead>
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<td>22.1 Jy/K</td>
</tr>
<tr>
<td>5</td>
<td>22.1 Jy/K</td>
<td>22.4 Jy/K</td>
</tr>
<tr>
<td>6</td>
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</tr>
</tbody>
</table>

Weighted Av. 21.8 Jy/K 21.9 Jy/K

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<th>PA</th>
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<td>NEPTUNE</td>
<td>2.7</td>
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<td>2.21</td>
<td>340</td>
</tr>
<tr>
<td>3c454.3</td>
<td>26.51</td>
<td></td>
<td></td>
<td>(Neptune)</td>
</tr>
<tr>
<td>3c454.3</td>
<td>28.16</td>
<td></td>
<td></td>
<td>(Uranus)</td>
</tr>
</tbody>
</table>

Flagged:
- L02 C02 for Line Frequency: 86243 MHz
- L03 C03 for Line Frequency: 86243 MHz
- L06 C06 for Line Frequency: 86243 MHz
- L07 C07 for Line Frequency: 86243 MHz
Antenna Efficiencies: Interferometrically
Antenna Efficiencies: Interferometrically + Holo

Absolute Flux Calibration

Ant1

Ant2

Ant3

Ant4

Ant5

Ant6

Antenna efficiencies (Jy/K)

Frequency (GHz)
Antenna Efficiencies: Interferometrically + Holo

Just phase noise?
Antenna Efficiencies: Interferometrically + Holo + SD
Antenna Efficiencies: Interferometrically + Holo + SD
Antenna Efficiencies: Interferometrically + Holo + SD

Absolute Flux Calibration

Ant1

Ant2

100µm
75µm

~50µm

Ant3

Ant4

Ant5

Ant6
Antenna Efficiencies: Interferometrically + Holo + SD
Antenna Efficiencies: Interferometrically + Holo + SD

OK for low frequencies but not for frequencies >210GHz!
Practical Tips

Checklist:
- Antenna Shadowing
- Pointing/Focus Problems
- Tracking Problems
- Do phases of different spectral windows overlap?
- Noisy data
- Has Flux Calibrator Lines?
- Is Flux Calibrator Extended?
- Check Elevation of your source
- Check whether source is polarised (only important when using NC with one polarisation)
Practical Tips
Practical Tips: Shadowing

First Look
Practical Tips: Shadowing
Practical Tips: Pointing/Focus

First Look
Practical Tips: Pointing/Focus

First Look
Practical Tips : Pointing/Focus

First Look
Practical Tips: Tracking

First Look
Practical Tips
Practical Tips

These scan ranges should be excluded!!!!
Motivation

Absolute Flux Calibration

![Image of calibration software interface with file name myfile.hpbc and receiver band 1 settings]

The calibrators recommended for phase and amplitude calibration are: 1538+149 1611+343

1538+149 is found to be polarized at 90.2x sigma
Averaged polarization mode is selected for the amplitude calibration
You can change it with "let do_avpol no" before the amplitude calibration

1611+343 is found to be polarized at 72.5x sigma
Averaged polarization mode is selected for the amplitude calibration
You can change it with "let do_avpol no" before the amplitude calibration

LSB tuning for receiver 1
Motivation

Absolute Flux Calibration

![Image of Standard calibration package for NGR dialog box]

- Use previous settings: Yes
- File name: myfile.hp
- First and last scan: 0 10000

The calibrators recommended for phase and amplitude calibration are:
1538+149 1611+343

1538+149 is found to be polarized at 90.2 x sigma
Averaged polarization mode is selected for the amplitude calibration
You can change it with "let do_avpol no" before the amplitude calibration

1611+343 is found to be polarized at 72.5 x sigma
Averaged polarization mode is selected for the amplitude calibration
You can change it with "let do_avpol no" before the amplitude calibration
Motivation

**Standard calibration package for NGR**

- **SELECT**
- **AUTOFLAG**
- **PHCOR**
- **RF**
- **PHASE**
- **FLUX**

Use previous settings? ☑ Yes

File name: **myfile.hpb**

First and last scan: 0 10000

**Flux Receiver 1**

- **Frequency**: 90.8 GHz
- **Efficiencies**: 22.16, 23.45, 21.91, 20.59, 21.42, 21.65
- **Scan list**: 8619, 9161
- **Calibrator J1310+323**
  - Input Flux: 1.072
  - Fixed flux? No
  - Solved Flux: 1.072
  - Flux in File: 1.072
- **Calibrator 3C345**
  - Input Flux: 3.171
  - Fixed flux? No
  - Solved Flux: 3.171
  - Flux in File: 3.171
- **Source MWC349, Model Flux 1.13 Jy**
  - Input Flux: 0.908
  - Fixed flux? No
  - Solved Flux: 0.908
  - Flux in File: 0.908
- **Calibrator 1538+149**
  - Input Flux: 0.688
  - Fixed flux? No
  - Solved Flux: 0.688
  - Flux in File: 0.688
- **Calibrator 1611+343**

LSB tuning for receiver 1

CLIC>
Motivation

Absolute Flux Calibration

Standard calibration package for NGR

**SELECT**  **AUTOFLAG**  **PHCOR**  **RF**  **PHASE**  **FLUX**

*Use previous settings?* Yes

*File name* myfile.hpb

*First and last scan* 0 10000

**RECEIVER BAND = 1**

I-LISTE,[9149] Source # 1 1538+149 30 Observations
I-LISTE,[9149] Source # 2 1611+343 30 Observations
1538+149, at 5.1 degrees from the source
1611+343, at 15.8 degrees from the source
The calibrators recommended for phase and amplitude calibration are:
1538+149 1611+343

1538+149 is found to be polarized at 90.2xsigma
Averaged polarization mode is selected for the amplitude calibration
You can change it with "let do_avpol no" before the amplitude calibration

1611+343 is found to be polarized at 72.5xsigma
Averaged polarization mode is selected for the amplitude calibration
You can change it with "let do_avpol no" before the amplitude calibration

LSB tuning for receiver 1

CLIC>
Motivation

Absolute Flux Calibration

Standard calibration package for NGR

- **SELECT**
- **AUTOFLAG**
- **PHCOR**
- **RF**
- **PHASE**
- **FLUX**

Use previous settings? **Yes**

File name: **myfile.hpb**

First and last scan: 0 10000

**Receiver Band = 1**

**Calibrator J1310+323**
- Input Flux?: 1.072
- Fixed flux?: No
- Solved Flux: 1.072
- Flux in File: 1.072

**Calibrator 3C345**
- Input Flux?: 3.171
- Fixed flux?: No
- Solved Flux: 3.171
- Flux in File: 3.171

**Source MWC349, Model Flux 1.13 Jy**
- Input Flux?: 0.908
- Fixed flux?: No
- Solved Flux: 0.908
- Flux in File: 0.908

**Calibrator 1538+149**
- Input Flux?: 0.688
- Fixed flux?: No
- Solved Flux: 0.688
- Flux in File: 0.688

**Calibrator 1611+343**
- Input Flux?:
- Fixed flux?: No
- Solved Flux: 0.688
- Flux in File: 0.688

The calibrators recommended for phase and amplitude calibration are:

1538+149, at 5.1 degrees from the source
1611+343, at 15.8 degrees from the source

The calibrators are 1538+149 and 1611+343.

1538+149 is found to be polarized at 90.2xsigma
Averaged polarization mode is selected for the amplitude calibration
You can change it with "let do_avpol no" before the amplitude calibration

1611+343 is found to be polarized at 72.5xsigma
Averaged polarization mode is selected for the amplitude calibration
You can change it with "let do_avpol no" before the amplitude calibration

LSB tuning for receiver 1

CLIC>
Motivation

Absolute Flux Calibration

Standard calibration package for NGR

SELECT AUTOFLAG PHCOR RF PHASE FLUX

Use previous settings? Yes

Flux Receiver 1

SOLVE 1.8 GHz
SOLVE SIMPLY

Scan list:
B619 9161

Calibrator J1310+323

Input Flux? 1.072

krips@bure6b:~/project/w04c - Shell - Konsole

3C345 is not considered for flux calibration, since phases are too instable
MWC349 is not considered for flux calibration, since phases are too instable

CALIB_FLAGGED is a logical Array of dimensions 5
F T F F F
CAL_SOURCE is a character* 20 Array of dimensions 5
J1310+323 3C345 MWC349 1538+149 1611+343

Source MWC349, Model Flux 1.13 Jy

No calibrator is considered for flux calibration ..., fixing the strongest

The flux of 1611+343 is fixed to 2.185 Jy
Phases are Degrees Continuous 10
Motivation

1.) Choice of flux calibrator!!

BC345 is not considered for flux calibration, since phases are too unstable
MWC349 is not considered for flux calibration, since phases are too unstable

CALIB_FLAGGED is a logical Array of dimensions 5
F T F F F
CAL_SOURCE is a character* 20 Array of dimensions 5
J1310+323
BC345
MWC349
1538+149
1611+343

Source MWC349, Model Flux 1.13 Jy

No calibrator is considered for flux calibration ..., fixing the strongest
No calibrator is considered for flux calibration ..., fixing the strongest
No calibrator is considered for flux calibration ..., fixing the strongest
No calibrator is considered for flux calibration ..., fixing the strongest

The flux of 1611+343 is fixed to 2.185 Jy
Phases are Degrees Continuous 10
Motivation

Absolute Flux Calibration

FILE: myfile.hpb

RF: Fr.(\AA)  
Am: Scaled  
Ph: Rel.(\AA) Atr  

No calibrator is used. 
No calibrator is used. 
No calibrator is used. 
No calibrator is used. 

No calibrator is used. 

The flux of 1611+343 is unknown. 
Phases are given in degrees.
Motivation

2.) Exclude bad fluxes!!
# Motivation

## Absolute Flux Calibration

### myfile.hpb

### Standard calibration package for NGR

<table>
<thead>
<tr>
<th>SELECT</th>
<th>AUTOFLAG</th>
<th>PHCOR</th>
<th>RF</th>
<th>PHASE</th>
<th>FLUX</th>
</tr>
</thead>
</table>

Use previous settings? ✔ Yes

### SOLVE

<table>
<thead>
<tr>
<th>SOLVE</th>
<th>0.8 GHz</th>
</tr>
</thead>
</table>

| SOLVE SIMPLY | 22.16 23.45 21.91 20.59 21.42 21.65 |

| Scan | 8619 9161 |

| Calibrator | J1310+323 |

| Input Flux? | 1.072 |

### Flux and efficiency result for receiver 1 at 90.8 GHz:

<table>
<thead>
<tr>
<th>in file</th>
<th>solve flux</th>
</tr>
</thead>
<tbody>
<tr>
<td>J1310+323</td>
<td>read: 1.07 Jy</td>
</tr>
<tr>
<td>3C345</td>
<td>read: 3.17 Jy</td>
</tr>
<tr>
<td>MWC349</td>
<td>read: 0.91 Jy</td>
</tr>
<tr>
<td>1538+149</td>
<td>read: 0.69 Jy</td>
</tr>
<tr>
<td>1611+343</td>
<td>read: 2.19 Jy</td>
</tr>
</tbody>
</table>

| Antenna 1 (A1) | 22.2 Jy/K (0.99) |
| Antenna 2 (A2) | 23.4 Jy/K (0.93) |
| Antenna 3 (A3) | 21.9 Jy/K (1.00) |
| Antenna 4 (A4) | 20.6 Jy/K (1.06) |
| Antenna 5 (A5) | 21.4 Jy/K (1.02) |
| Antenna 6 (A6) | 21.7 Jy/K (1.01) |

Phases are Degrees Continuous 10


Plot type is BARS
Motivation

Absolute Flux Calibration

3.) Check Antenna efficiencies
And found source fluxes!!!
Motivation

Absolute Flux Calibration

Standard calibration package for NGR

SELECT  AUTOFLAG  PHCOR  RF  PHASE  FLUX

Use previous settings? Yes

SOLVE
SOLVE SIMPLY

Calibrator J1310+323

Input Flux? 1.072

kris@bure6b:/~/project/w04c - Shell - Konsole

I-LISTE,[8620] Source # 1 J1310+323 1 Observations
I-LISTE,[8620] Source # 2 3C345 4 Observations
I-LISTE,[8620] Source # 3 MWC349 3 Observations
I-LISTE,[8620] Source # 4 1538+149 36 Observations
I-LISTE,[8620] Source # 5 1611+343 36 Observations
I-SOLVE_FLUX,[8620] Average fluxes will use the best 3 antennas

Amplitudes are absolute
Amplitude Calibration is antenna-based
Amplitudes are divided by assumed calibrator flux
Amplitudes are expressed in kelvins
I-SCALING,[8637] MWC349 has known structure
I-SCALING,[8638] MWC349 has known structure
I-SOLVE_FLUX,[9161] Reference sources:
I-SOLVE_FLUX,[9161] 1611+343 Flux = 2.1850 Jy
I-SOLVE_FLUX,[9161] Average efficiencies:
I-SOLVE_FLUX,[9161] Ant. 1 22.165 +, 0.003 Jy/K (0.99)
I-SOLVE_FLUX,[9161] Ant. 2 23.452 +, 0.003 Jy/K (0.93)
I-SOLVE_FLUX,[9161] Ant. 3 21.911 +, 0.003 Jy/K (1.00)
I-SOLVE_FLUX,[9161] Ant. 4 20.588 +, 0.002 Jy/K (1.06)
I-SOLVE_FLUX,[9161] Ant. 5 21.419 +, 0.003 Jy/K (1.02)
I-SOLVE_FLUX,[9161] Ant. 6 21.648 +, 0.003 Jy/K (1.01)
I-SOLVE_FLUX,[9161] Sources, Fluxes and errors:
I-SOLVE_FLUX,[9161] J1310+323 Ant 1 1.3902 +, 0.0016
Motivation

Absolute Flux Calibration

It only takes the three best Antennas!

I-SOLVE_FLUX,[8620] Average fluxes will use the best 3 antennas

Amplitudes are absolute
Amplitude Calibration is antenna-based
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I-SOLVE_FLUX,[9161] J1310+323 Ant 1 1.3902 +/- .0016
Motivation

Absolute Flux Calibration

It automatically considers extension of MWC349!
Questions?