SCUBA-2 WORKSHOP
SESSION
Focus on Calibration and CO contamination

JCMT Users meeting workshop, Nanjing 2017
SCUBA-2 OUTLINE OF SESSION

SCUBA-2 Calibration

• A reminder of how and why we calibrate
• A note on future updates to our WVM model and what this will mean

SCUBA-2 what’s in the dust?

• a guide to CO contamination estimation using SCUBA-2 and HARP data.
• How to convert HARP data from K to pW (conversion factor)
• Look at how to include information from a HARP CO map during SCUBA-2 reduction.
SCUBA-2
SCUBA-2

10240-pixel bolometer camera: 450 & 850 um simultaneously

Transition Edge Sensors
SCUBA-2

10240-pixel bolometer camera: 450 & 850 um simultaneously

Transition Edge Sensors
SCUBA-2

10240-pixel bolometer camera: 450 & 850 um simultaneously

Transition Edge Sensors

for more details see:
http://www.eaobservatory.org/jcmt/instrumentation/continuum/scuba-2/
SCUBA-2 DATA REDUCTION

http://www.eaobservatory.org/jcmt/science/reductionanalysis-tutorials/

JCMT Data Reduction/Analysis Tutorials

Contents [show]

Tutorials
There are now a number of tutorials offered for new users of the JCMT.

SCUBA-2 Tutorials

1. SCUBA-2 Data Reduction/Analysis Tutorial 1 – Simple reduction of a SCUBA-2 dataset using the ORAC-DR pipeline software using different data reduction recipes; an introduction to basic Gaia use.
2. SCUBA-2 Data Reduction/Analysis Tutorial 2 – Modification of the behavior of standard reduction recipes using a recpars (Recipe Parameters) file, standard imaging of a SCUBA-2 dataset using the makemap command and manual modification of the process by specifying a different dimmconfig file.
3. SCUBA-2 Data Reduction/Analysis Tutorial 3 – Creation and use of an external mask with a simple SCUBA-2 dataset. This is usually used to help recover/improve large scale structure and decrease the negative bowling in large Pong maps.
4. SCUBA-2 Data Reduction/Analysis Tutorial 4 – Use and modification of PICARD matched filters for point source detection in an already-reduced map.
5. SCUBA-2 Data Reduction/Analysis Tutorial 5 – Investigating the contamination in the 850micron
SCUBA-2 DATA REDUCTION

http://www.eaobservatory.org/jcmt/science/reductionanalysis-tutorials/

JCMT Data Reduction/Analysis

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Tutorials
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SCUBA-2 Tutorials
1. **SCUBA-2 Data Reduction/Analysis Tutorial 1** – Simple recipes using different data reduction methods
2. **SCUBA-2 Data Reduction/Analysis Tutorial 2** – Modification of standard ORAC-DR pipeline software using a `recpars` (Recipe Parameters) file, standard `makemap` command and manual modification of the process
3. **SCUBA-2 Data Reduction/Analysis Tutorial 3** – Creation and use of a `mapgen` map of the SCUBA-2 dataset. This is usually used to help recover/limit the negative bowling in large Pong maps.
4. **SCUBA-2 Data Reduction/Analysis Tutorial 4** – Use and manipulation of point source detection in an already-reduced map.
5. **SCUBA-2 Data Reduction/Analysis Tutorial 5** – Investigating the contamination in the 850 micron channel.

![Image of a graph or map with coordinates for G34.3+0.2]
SCUBA-2 CALIBRATION

Two step process:
1) calibrate to the raw data to pW
2) calibrate power to Flux Density
SCUBA-2 CALIBRATION

Two step process:
1) calibrate to the raw data to pW
2) calibrate power to Flux Density

1) done with a “fast flat”
2) observing a known source, a calibrator, to calculate a Flux Conversion Factor (FCF)
Two step process:
1) calibrate to the raw data to pW
2) calibrate power to Flux Density
   1) done with a “fast flat”

SCUBA-2 CALIBRATION

>> jcmtstate2cat s8a20120501_00068_*.sdf state.tst
>> topcat -f tst state.tst
SCUBA-2 CALIBRATION

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>> jcmmtstate2cat s8a20120501_00068_*.sdf state.tst
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2) calibrate power to Flux Density
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Our primary calibrators are Mars and Uranus, and commonly used secondary calibrators include CRL2688, and CRL618.
SCUBA-2 CALIBRATION

Two step process:
1) calibrate to the raw data to pW
2) calibrate power to Flux Density

1) done with a “fast flat”
2) observing a known source, a calibrator, to calculate a Flux Conversion Factor (FCF)

FCF values for any project (ideally) calculated using calibrator closest to project science data (in both time & space)

Both science & calibrator data should be reduced with latest version of Starlink, using same configuration file & same pixel size

General advice: reduce all calibrators taken near observations & watch out for major deviations!
SCUBA-2 CALIBRATION

http://www.eaobservatory.org/sc2cal

SCUBA-2 CALIBRATION

Nominal values:


Derived from *makemap* reductions of *Daisy* maps of calibrators using:

- *bright_compact dimmconfig* file
- 1 arcsec map pixel size
SCUBA-2 CALIBRATION

Nominal values:

<table>
<thead>
<tr>
<th>Beam</th>
<th>450μm FCF</th>
<th>850μm FCF</th>
</tr>
</thead>
<tbody>
<tr>
<td>491</td>
<td>537</td>
<td></td>
</tr>
<tr>
<td>4.71</td>
<td>2.34</td>
<td></td>
</tr>
</tbody>
</table>


Should be used in one of two ways:

• Check derived FCF values before applying to user data (preferred method)
• Apply as first pass at source & noise strength estimation (not recommended)

To calibrate science data, always re-reduce calibrator observations with same pixel size as science data & **Always reduce archival SCUBA-2 data with latest Starlink release!**
SCUBA-2 CALIBRATION

An inspection of the calibrators data taken between March 2015 and November 2016 - calibrators taken with the Black Water Vapor Monitor installed at the telescope indicates an issue with the Water Vapor Monitor as a function of transmission.
The Water Vapor Monitor self calibrates by looking at known warm and hot loads. The sky opacity it calculates is needed for SCUBA-2 reductions - the extinction model.
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Staff check the performance/calibrate using ambient & LNe.
SCUBA-2 CALIBRATION

* work in progress *

by updating/improving our atmospheric model produced by our Water Vapor Monitor we will remove this transmission dependency.
SCUBA-2 CALIBRATION

Stay tuned!
if in doubt contact your support scientist

With new filters the SCUBA-2 FCFs may improve SCUBA-2’s performance.

Currently need to implement change in the WVM and obtained a larger number of observations to investigate the impact of the new filters.
SCUBA-2 WHAT’S IN THE DUST
SCUBA-2 WHAT’S IN THE DUST

M104 the sombrero Galaxy as observed by the NGLS team

NGC1333 as observed by the Transient team

object G17.37+2.26 as observed by the SCOPE team
Contamination in the SCUBA-2 850micron band can come from CO (3-2) line. Contamination in the 450micron band can come from CO (6-5) line (to a lesser extent).
M104 the sombrero Galaxy as observed by the NGLS team.

NGC1333 as observed by the Transient team

Object G17.37+2.26 as observed by the SCOPE team

Johnstone, D., Boonman, A. M. S., & van Dishoeck, E. F. 2003, A&A, 412, 157 - first to discuss typically found at 850 microns of the order of 10% depending on the environment - higher values in regions where shocks are present.
SCUBA-2 WHAT'S IN THE DUST

![Graph showing transmission as a function of frequency for SCUBA-2 at 850micron and 450micron wavelengths, with different dust size distributions represented.](image-url)
The primary culprit at 850: line emission from $^{12}$CO (3-2)

The primary culprit at 450: line emission from $^{12}$CO (6-5)
SCUBA-2 WHAT’S IN THE DUST

on a positive note at 850um we can estimate this from HARP data
on a positive note at 850µm we can estimate this from HARP data
They key to estimating the contamination from CO (3-2) in SCUBA-2 850 data is two fold:

1. how to convert HARP line intensities into pseudo-flux densities
2. how to subtract HARP line data from raw SCUBA-2 data
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The conversion requires knowledge of
• SCUBA-2 filter profiles
• SCUBA-2 beam size
• Transmission of the atmosphere
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The C Factor
(\textit{the C function})
SCUBA-2 WHAT’S IN THE DUST

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- SCUBA-2 beam size
- Transmission of the atmosphere

SCUBA-2 THE C FACTOR

Convert HARP line intensities into pseudo-fluxes from $K/km/s$ to $mJy/beam$ need the conversion ($C$) factor

$$C_{850} = \alpha + \beta \text{PWV} - \gamma (\text{PWV}^2) + \delta (\text{PWV}^3) - \varepsilon (\text{PWV}^4) \quad mJy/beam / K/km/s$$

$\text{PWV}$ is Precipitable Water Vapor

$\text{Tau}_{225GHz} = 0.04 \text{PWV} + 0.017$

<table>
<thead>
<tr>
<th>coefficient</th>
<th>850 $\mu m$</th>
<th>450 $\mu m$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$</td>
<td>0.574</td>
<td>0.761</td>
</tr>
<tr>
<td>$\beta$</td>
<td>0.1151</td>
<td>0.0193</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>0.0485</td>
<td>0.0506</td>
</tr>
<tr>
<td>$\delta$</td>
<td>0.0109</td>
<td>0.0141</td>
</tr>
<tr>
<td>$\varepsilon$</td>
<td>0.000856</td>
<td>0.00125</td>
</tr>
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not a simple factor, but rather a function that is dependent on PWV
SCUBA-2 WHAT’S IN THE DUST

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Parsons et al. submitted
SCUBA-2 THE C FACTOR

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\[ C_{850} = \alpha + \beta \text{PWV} - \gamma (\text{PWV}^2) + \delta (\text{PWV}^3) - \epsilon (\text{PWV}^4) \text{ mJy/beam / K/km/s} \]

This will require downloading SCUBA-2 and HARP data (If not done so already SCUBA-2 tutorial 1 and Heterodyne tutorial 1 will be repeated in part of this tutorial 5)

http://www.eaobservatory.org/jcmt/science/reductionanalysis-tutorials/

See tutorial 5 for more details (inspecting G34.3+0.2)

\[ \text{Tau}_{225\text{GHz}} = 0.04 \text{PWV} + 0.017 \]
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SCUBA-2 TUTORIAL 5

This tutorial follows a six step process:

STEP 1: Creating a HARP reference input file
STEP 2: Masking noise regions in the HARP CO (3-2) integrated intensity map
STEP 3: Convert the HARP integrated data from K to pW
STEP 4: Creating SCUBA-2 850 micron emission reference map
STEP 5: Creating SCUBA-2 with HARP CO subtracted from the 850 micron emission
STEP 6: Comparing SCUBA-2 reductions

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http://www.eaobservatory.org/jcmt/scier
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we find a median contamination of 2% within the G34.3+0.2

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SCUBA-2 WHAT’S IN THE DUST

Parsons et al. submitted
SCUBA-2 WHAT’S IN THE DUST

Parsons et al. submitted

SCUBA-2 WHAT’S IN THE DUST

Parsons et al. submitted


Rumble http://adsabs.harvard.edu/abs/2016MNRAS.460.4150R
Dust contamination from free-free emission