Final Analysis of ELAIS 15 $\mu$m Fields

Data Reduction with the LARI Method

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Exploiting the ISO Data Archive: Infrared Astronomy in the Internet Age

Sigüenza, 24-27 June 2002
The ELAIS Survey

- Largest ISO Open Time single project (375 h)
- Up to 12 deg$^2$ mapped in four ISO-CAM/PHOT bands (7, 15, 90, 175 $\mu$m)
- IRAS $I_{100} < 1.5$ mJy/sr, no IRAS $S_{12} > 0.6$ Jy sources, $|\beta| > 40^\circ$

### ISO-CAM ISOPHOT

<table>
<thead>
<tr>
<th></th>
<th>ISO-CAM</th>
<th>ISO-PHOT</th>
<th>Field</th>
<th>Wavelength/$\mu$m</th>
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<tbody>
<tr>
<td>Detector</td>
<td>LW</td>
<td>LW</td>
<td>C100</td>
<td>C200</td>
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<tr>
<td>Filter</td>
<td>LW2</td>
<td>LW3</td>
<td>C90</td>
<td>C160</td>
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<tr>
<td>$\lambda/\mu$m</td>
<td>6.75</td>
<td>15</td>
<td>95.1</td>
<td>174</td>
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<tr>
<td>$\Delta \lambda/\mu$m</td>
<td>3.5</td>
<td>6</td>
<td>51.4</td>
<td>89.4</td>
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<tr>
<td>Gain</td>
<td>2</td>
<td>2</td>
<td>n/a</td>
<td>n/a</td>
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<tr>
<td>$TINT/s$</td>
<td>2</td>
<td>2</td>
<td>20</td>
<td>32</td>
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<tr>
<td>$NEXP$</td>
<td>10</td>
<td>10</td>
<td>n/a</td>
<td>n/a</td>
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<tr>
<td>$NSTAB$</td>
<td>80</td>
<td>80</td>
<td>n/a</td>
<td>n/a</td>
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<tr>
<td>$PFOV/''$</td>
<td>6</td>
<td>6</td>
<td>43.5</td>
<td>84.5</td>
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<tr>
<td>$NPIX$</td>
<td>32</td>
<td>32</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>$M, N$</td>
<td>28, 14</td>
<td>28, 14</td>
<td>13, 13</td>
<td></td>
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<tr>
<td>$dM, dN/''$</td>
<td>90, 180</td>
<td>90,180</td>
<td>96, 96</td>
<td></td>
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</tbody>
</table>

$^*$X1 $|$ X2 $|$ X3 $|$ X4 $|$ X5 $|$ X6
# ELAIS within ISO Extragalactic Surveys

<table>
<thead>
<tr>
<th>Name</th>
<th>$\lambda$ (µm)</th>
<th>Integration (s)</th>
<th>Area (deg$^2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHT Serendipity Survey</td>
<td>175</td>
<td>0.5</td>
<td>7000</td>
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<tr>
<td>CAM Parallel Mode</td>
<td>7</td>
<td>150</td>
<td>33</td>
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<tr>
<td><strong>ELAIS</strong></td>
<td>7, 15, 90, 175</td>
<td>40, 40, 24, 128</td>
<td>6, 11, 12, 1</td>
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<tr>
<td>CAM Shallow</td>
<td>15</td>
<td>180</td>
<td>1.3</td>
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<tr>
<td>FIRBACK</td>
<td>175</td>
<td>256, 128</td>
<td>1, 3</td>
</tr>
<tr>
<td>IR Back</td>
<td>90, 135, 175</td>
<td>23, 27, 27</td>
<td>1, 1, 1</td>
</tr>
<tr>
<td>SA 57</td>
<td>60, 90</td>
<td>150, 50</td>
<td>0.42, 0.42</td>
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<td>CAM Deep</td>
<td>7, 15, 90</td>
<td>800, 990, 144</td>
<td>0.28, 0.28, 0.28</td>
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<tr>
<td>Comet fields</td>
<td>12</td>
<td>302</td>
<td>0.11</td>
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<tr>
<td>CFRS</td>
<td>7, 15, 60, 90</td>
<td>720, 1000, 3000, 3000</td>
<td>0.067, 0.067, 0.067</td>
</tr>
<tr>
<td>CAM Ultra-Deep</td>
<td>7</td>
<td>3520</td>
<td>0.013</td>
</tr>
<tr>
<td><strong>ISOHDF South</strong></td>
<td>7, 15</td>
<td>$&gt; 6400$, $&gt; 6400$</td>
<td>$4.7 \cdot 10^{-3}$, $4.7 \cdot 10^{-3}$</td>
</tr>
<tr>
<td>Deep SSA13</td>
<td>7</td>
<td>34000</td>
<td>$2.5 \cdot 10^{-3}$</td>
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<tr>
<td><strong>Deep Lockman</strong></td>
<td>7, 90, 175</td>
<td>44640, 48, 128</td>
<td>$2.5 \cdot 10^{-3}$, 1.2, 1</td>
</tr>
<tr>
<td><strong>ISOHDF North</strong></td>
<td>7, 15</td>
<td>12800, 6400</td>
<td>$1.4 \cdot 10^{-3}$, 4.2 $\cdot 10^{-3}$</td>
</tr>
</tbody>
</table>

- Different choices are complementary in exploring the Depth-Area plane
- ELAIS furtherly bridges the gap between IRAS and ISO deep surveys
ELAIS Science Rationale

- SFH in the Universe
- Starbursts and AGNs
- ULIRGs
- CIRB Resolution
- Dust in normal galaxies
- Serendipity...
ELAIS CAM 15 μm Dataset

For both instruments the data stream from each detector pixel was treated as an independent scan of the sky. These data streams were filtered to remove glitches and transients and averaged to produce a single measurement at each pointing position. Significant outliers remaining in the data streams were flagged as potential sources. For the ISOCAM observations the redundancy of the pointings was used to provide confirmation of candidate sources. The data stream surrounding all remaining candidates was then examined independently by at least two observers to remove spurious detections. Sources that were acceptable to two or more observers were classified as good and those acceptable to only one observer were classified as marginal.

The fraction of spurious detections was high as a result of the non-Gaussian nature of the noise and relatively low thresholds applied. More than 13,000 ISOPHOT source candidates were examined as were just over 15,000 ISOCAM 15-μm candidates. At 6.7 μm the rejected fraction was lower and the candidate list was only 3,000. The final numbers of objects in the Preliminary Catalogue Version 1.3 are tabulated in Table 8.

The 'eye-balling' technique while laborious ensured that the resulting catalogues are highly reliable, as discussed in greater detail in Serjeant et al. (2000) and Efstathiou et al. (2000). The subsets of the Preliminary Catalogues that were released to the community were those ISOPHOT sources that had been confirmed by four observers, and those ISOCAM sources that had been confirmed by two observers with fluxes above 4 mJy, these subsets are exceptionally reliable.

A 'final analysis' process has been developed which uses the transient correction techniques of Lari (in preparation). These...
The Data Analyses

Available automated methods useless

Aaargh! ⇓ Aaargh!

Preliminary Analysis based on “eye-balling”

...mumbling... ⇓ ...mumbling...

...mumbling... ⇓ ...mumbling...

...mumbling... ⇓ ...mumbling...

...mumbling... ⇓ ...mumbling...

The LARI Method and Final Analysis I (Lari et al. 2001)

...mumbling... ⇓ ...mumbling...

Final Analysis II (see poster by Lari et al. and talks by Fadda & Rodighiero)
Raster Maps

- $40' \times 40'$ maps
- $\approx 90$ sources each
Astrometric Accuracy

- $\approx 50$ ELAIS-USNO identifications per raster
- $\sigma_{RA}$ and $\sigma_{DEC} \approx 1''$
Optical Identifications

95 % of 15 μm sources have unambiguous optical counterparts (Gonzalez-Solares 2002, IAC, PhD Thesis)
Mosaiced Maps
Individual Sources

UGC 10459

⇐ ELAISC15_J163525+405542
Final Analysis II Results

Final IA checks and simulations still to be performed

BUT

- 5-$\sigma$ detections down to $\simeq 0.4$ mJy
- Completeness: $> 99 \%$ at 3 mJy and $> 90 \%$ at 2 mJy
- $\simeq 150$ sources/deg$^2$
- Improved astrometric and photometric accuracy
- Mosaiced Maps

<table>
<thead>
<tr>
<th></th>
<th>S1</th>
<th>N1</th>
<th>N2</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>PA</td>
<td>189</td>
<td>129</td>
<td>141</td>
<td>459</td>
</tr>
<tr>
<td>FA-I</td>
<td>$\simeq 450$</td>
<td>$\simeq 350$</td>
<td>$\simeq 400$</td>
<td>$\simeq 1200$</td>
</tr>
<tr>
<td>FA-II</td>
<td>$\simeq 700$</td>
<td>$\simeq 550$</td>
<td>$\simeq 550$</td>
<td>$\simeq 1800$</td>
</tr>
</tbody>
</table>
FA-I Extragalactic 15 μm Source Counts

Slope change at $S_{15\,\mu m} \approx 2\,\text{mJy} \Rightarrow \text{Strong Evolution!}$

Further Optical Follow Up: ESIS

- ESO-SIRTF Imaging Survey
- ESO Large Program (P.I. Alberto Franceschini)
- $6.25 \text{ deg}^2$ centered on S1
- $BVR$ (WFI) + $IZ$ (VIMOS)
- Optical identifications, colors, photometric redshifts and rough morphologies of 200,000 SWIRE sources
Is there clustering out there?
Future Work

- Finalization of 15 $\mu$m catalogues (!Flux Calibration!)
- Overall Extragalactic source counts
- Multi-wavelength identifications (PHOT data at 90 $\mu$m!)
- Optical follow-up
- Clustering?
- ...
Lessons to be learnt

- Good understanding of the instrumentation is VERY important
- Software development must be timely
- Even so, new instrumentation leads to new software needs

... but most importantly ...

Try and be realistic about timing!

A “Final Analysis” process has been developed...
...we do not expect the “Final Analysis” to be finished until early 2000,
hence the release of our “Preliminary” products.

(Oliver et al. 2001)