Jitter Detection and Correction with ISOCAM

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INTRODUCTION

- **Old problem: many other people have worked on it, Olivier Boulade, Hervé Aussel, J.L. Starck, Matt Delaney, ... See report of J.L. Starck on image registration and report of Hervé Aussel on distortion.**

- **Vocabulary: a jitter is a sub-pixel shift (not to be confused with wheel "jitter"), other key-words: image registration, image warping, substepping, microscanning, shift and addd, co-addition of images.**

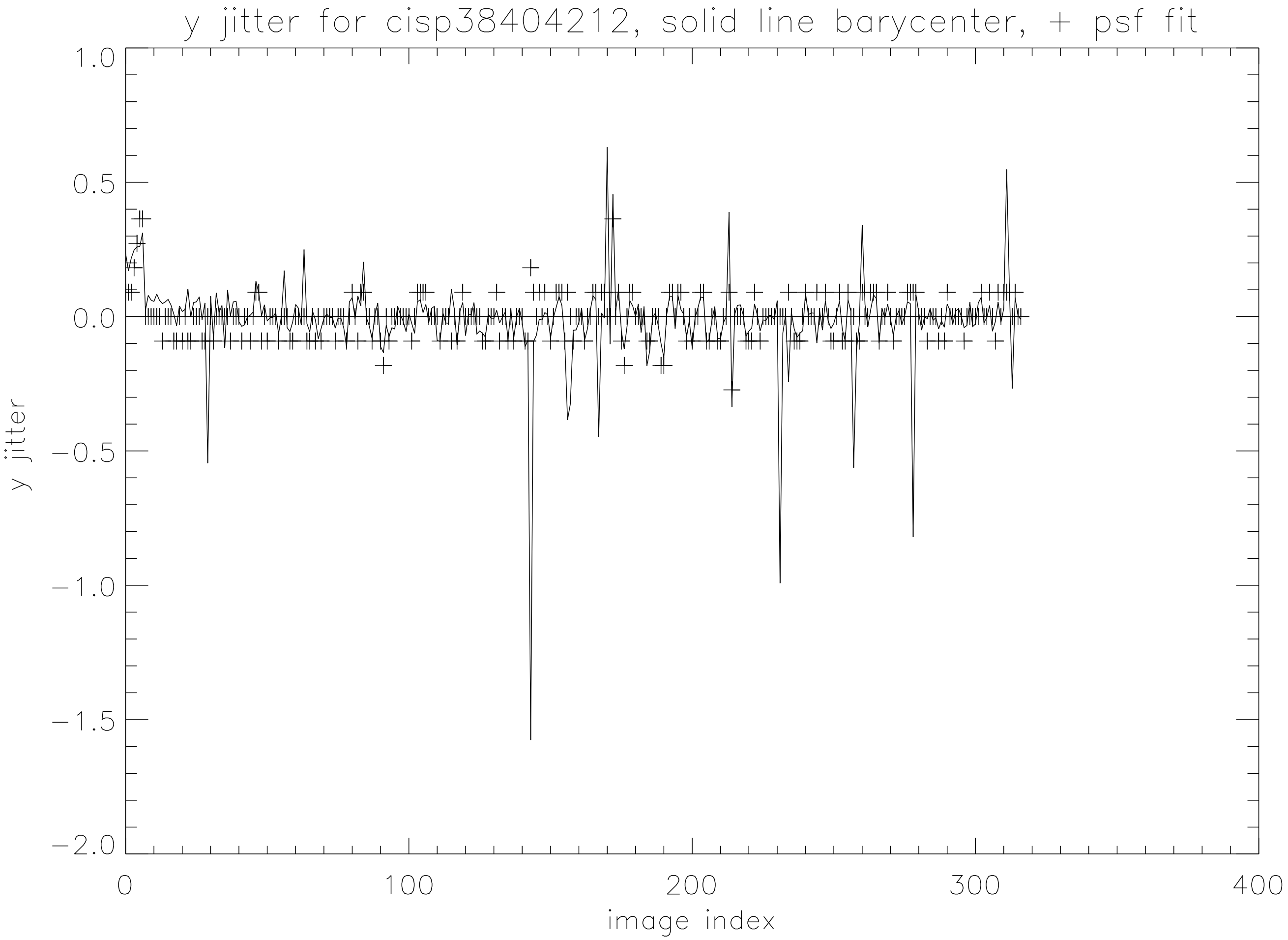
- **This talk is not about deconvolution or super-resolution**

Jitter Detection

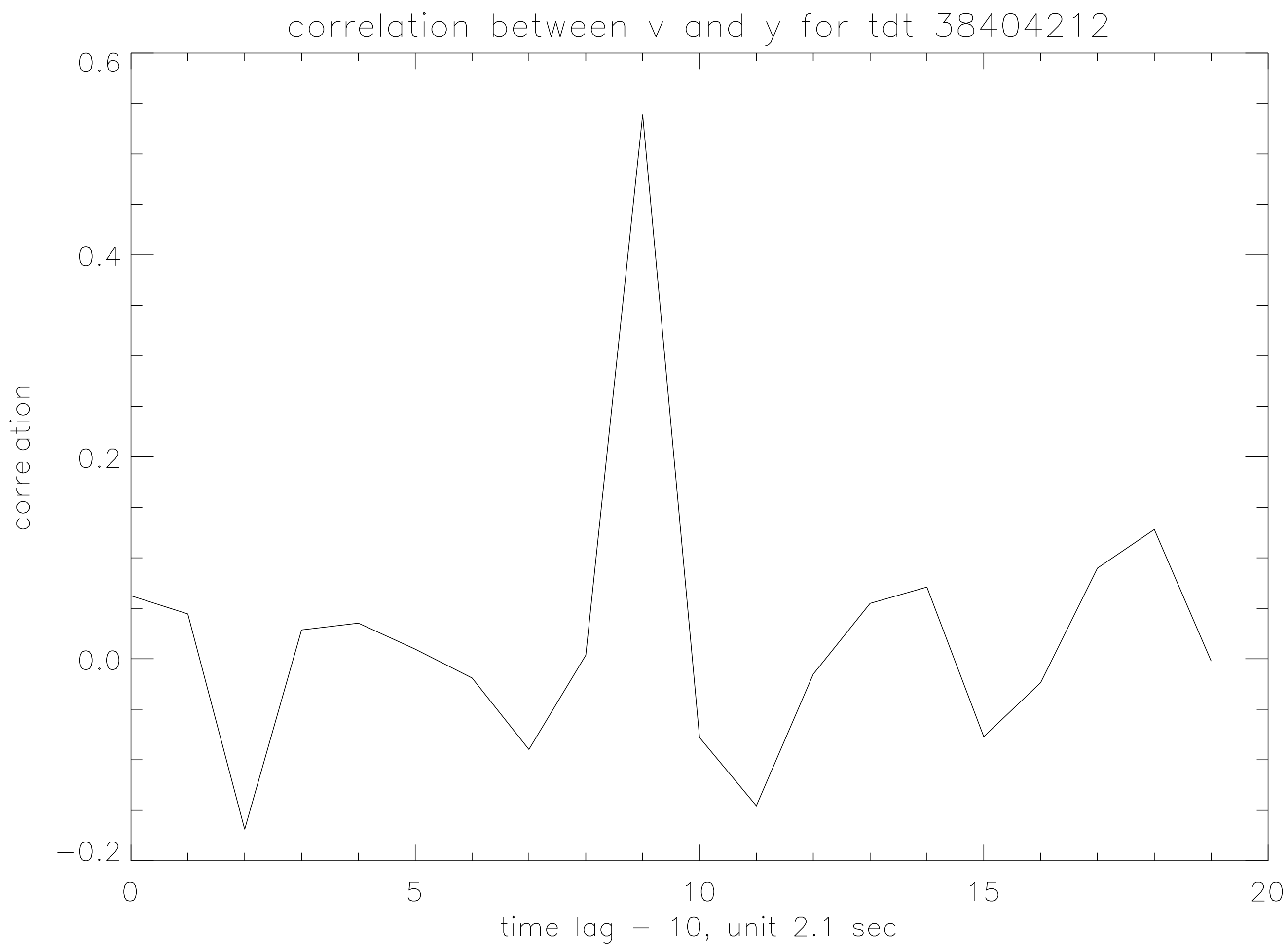
The jitter is the deviation to the "mean" pointing coordinates. It is given in CIA in pixel units along the axes of the image, tags name u and v. Precision relative pointing is about 0.5 " $\Longrightarrow$ 0.33 pixels at pfov 1.5" $\Longrightarrow$ a sub-pixel shift. How to measure it:

1. **Correlation of 2 images (after dark and flat correction): not good on the whole image (sensible to flat residues) if bright source, use a box centered on the source**
2. **Barycenter need a bright source, dark corrected (flat correction optional) barycenter made on a box centered on the source little underestimation of the jitter (see figure 1)**
3. **PSF fit need a bright star, dark corrected (flat correction optional) fit made on a box centered on the source Quick and precise, the best (thanks, Hervé Aussel)**
4. **Gaussian fit need a bright star, dark corrected (flat correction optional) fit made on a box centered on the source, a bit worst than PSF fit.**
5. **Astrometry use ra and dec of IIPH previous work done by O.B. no correlation, with OLP7 good correlation for tdt 384 04212 (see figures)**

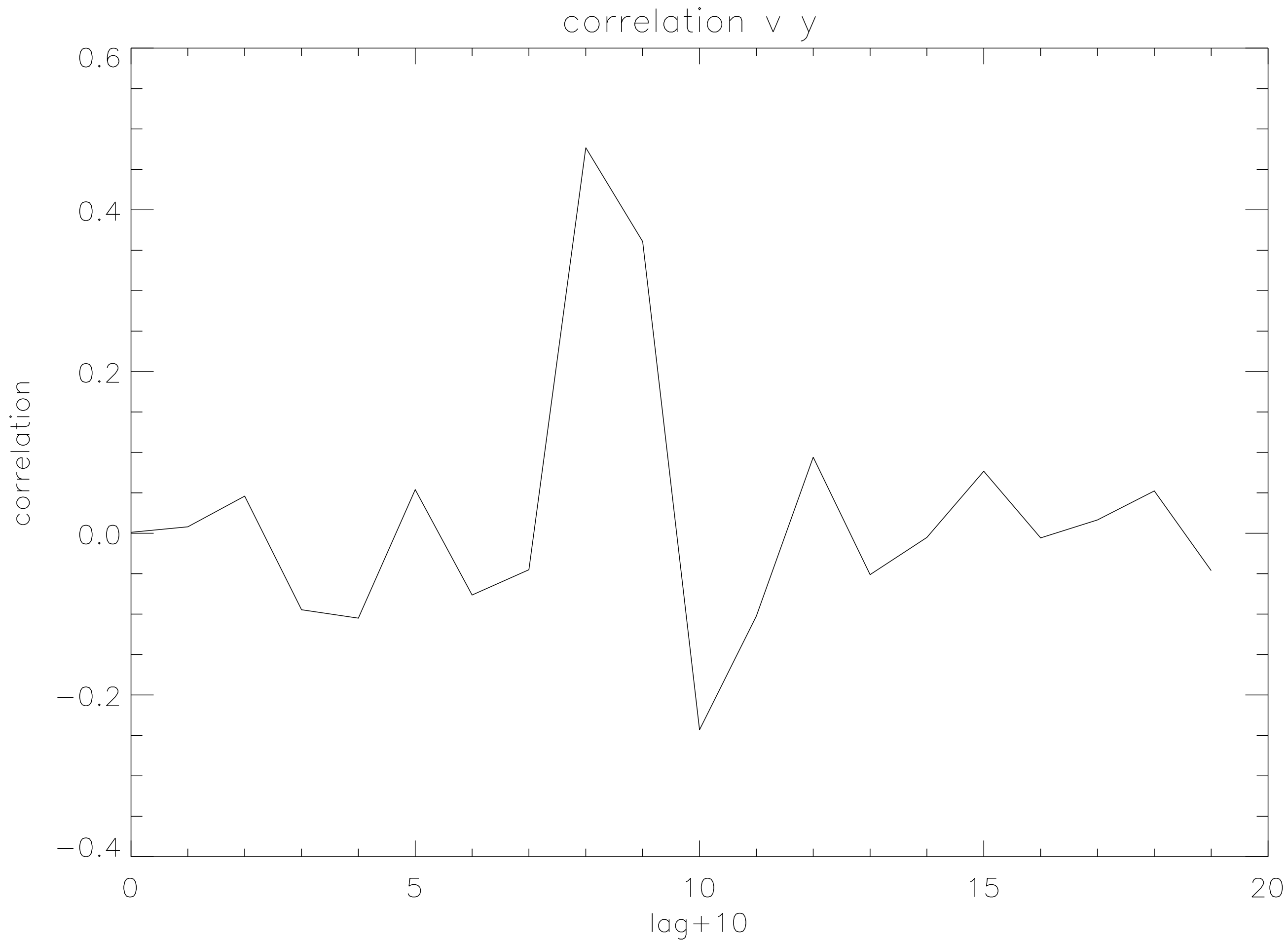
$\Longrightarrow$ Warning be careful with the glitches and deglitching !



y jitter for tdt 384 04212 pfov 1.5” LW6 tint 2.1 s OLP4

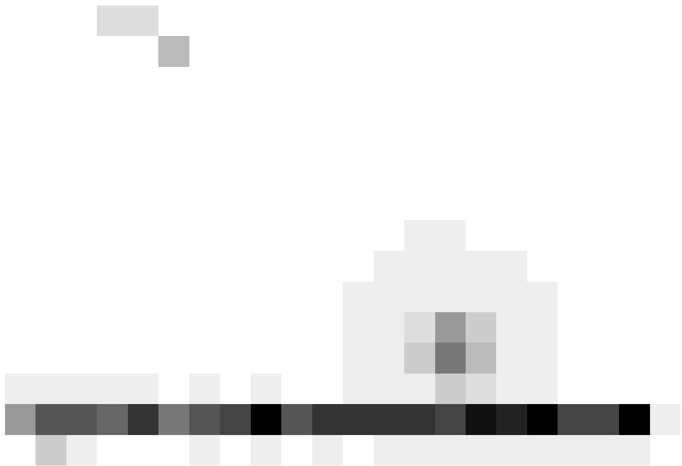


time lag for OLP4 of y jitter and v (astrometry jitter)

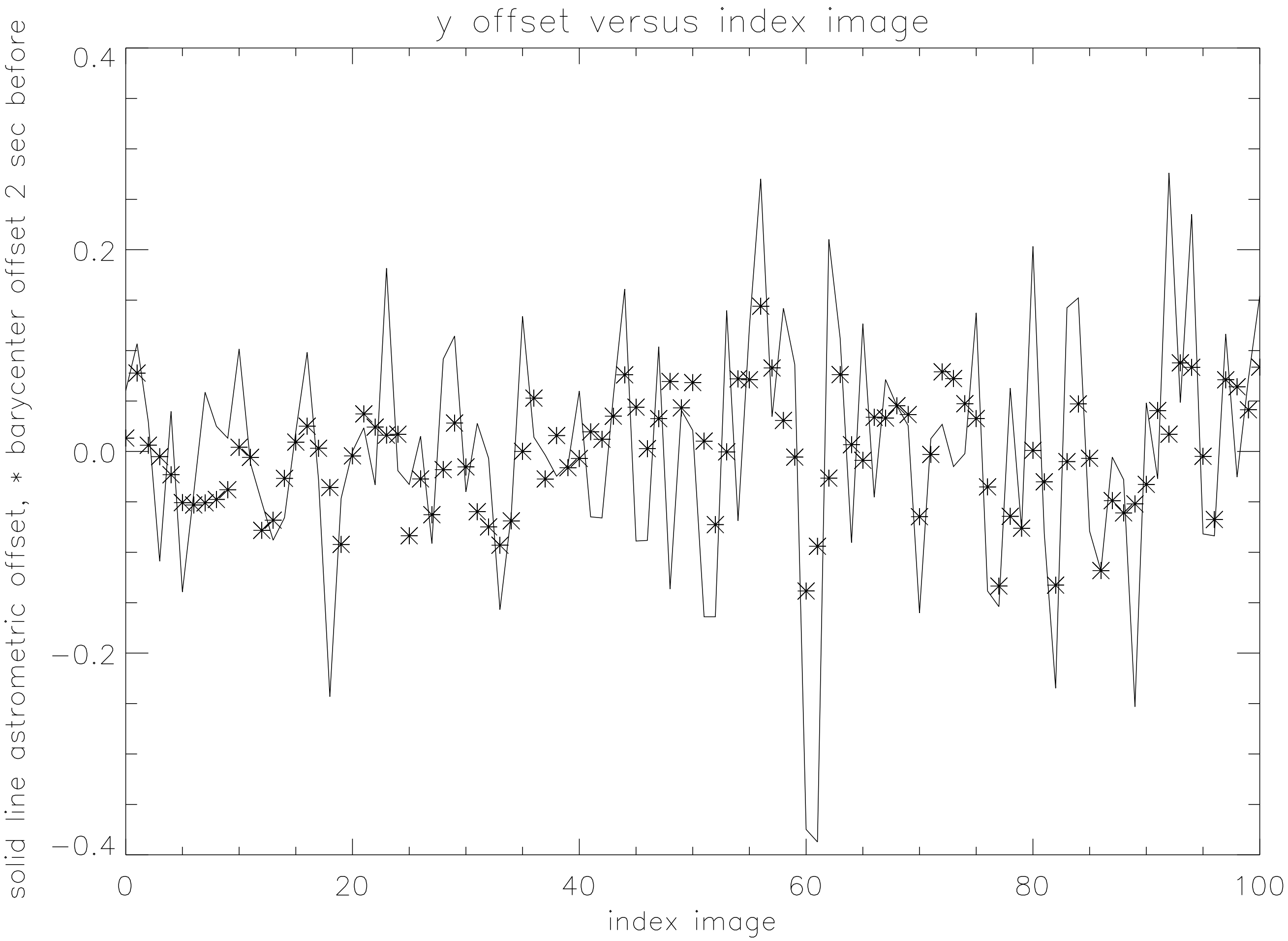


time lag for OLP4 of y jitter and v (astrometry jitter)

tdt 030 00301 pfov 1.5" tint 1.2 s



GLITCH tdt 384 04212 , 143 rd image, see yg page 4



y jitter and v (astrometry jitter) for OLP4, y (cam) advanced of 2.4 sec

tdt 030 00301 pfov 1.5" tint 1.2 s

Jitter Detection

The correlation of the astrometric jitter and the camera jitter (measured by fit psf or barycenter) is good, but with a time lag. This time lag depends upon the version of OLP used, and seems nill for OLP7, see table.

tdt	olp	time step	time lag	correlation
03000301	4.0	1.2 sec	2 units	correlate(x(2530-2:2630-2),u)= 0.63
38404212	4.0	2.1 sec	1 unit	correlate(x(9:315),u(10:316),)= 0.52
15403905	7.0	2.1 sec	0 unit	corr = 0.57
15403905	3.0	2.1 sec	0 unit	corr = 0.52
03000301	7.0	1.2 sec	1 unit	correlate(u(1000:3000), x(999:2999))= 0.65
38404212	7.0	2.1 sec	0 unit	corr = 0.36
55203636	7.0	2.1 sec	0 unit	corr = 0.58
51000804	7.0	1.2 sec	1 unit	correlate(u(2:195), x(1:194))= 0.7

Jitter Correction

The jitter can be taken in account when reducing the cube in an ”imagette” (one imagette per scd). To test the software, I used theoric PSF lw3 pfov 3” : this gives data with known offset. I took a subset with offset greater than 0.3 pixels plus the reference image.

How to correct it:

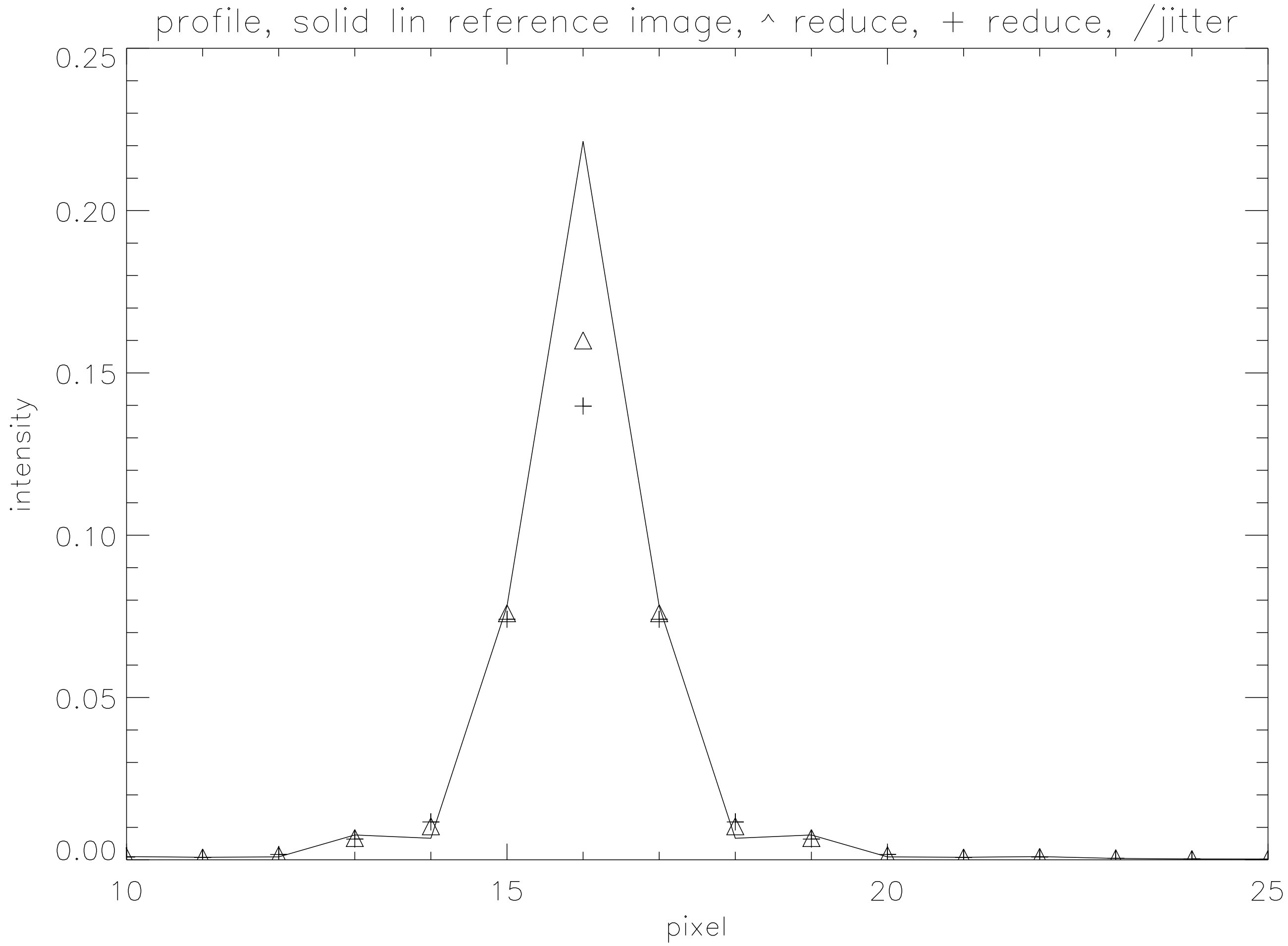
1. Reduce with default parameter, it does not correct , but it is one of the best!
2. Reduce,/jitter it corrects the jitter with the ”shift and add” algorithm: the worst
3. Projection it shrinks the pixel and then projects in the final image same than shift and add without demagnification
4. Projection, shrink 0.5 it projects the input pixel into a finer grid : drizzle
5. Eclipse whole package written by Devillard.
6. Bi-spectral given by Starck
7. Fourier dephasing fft, dephase, fft the best

Jitter Correction

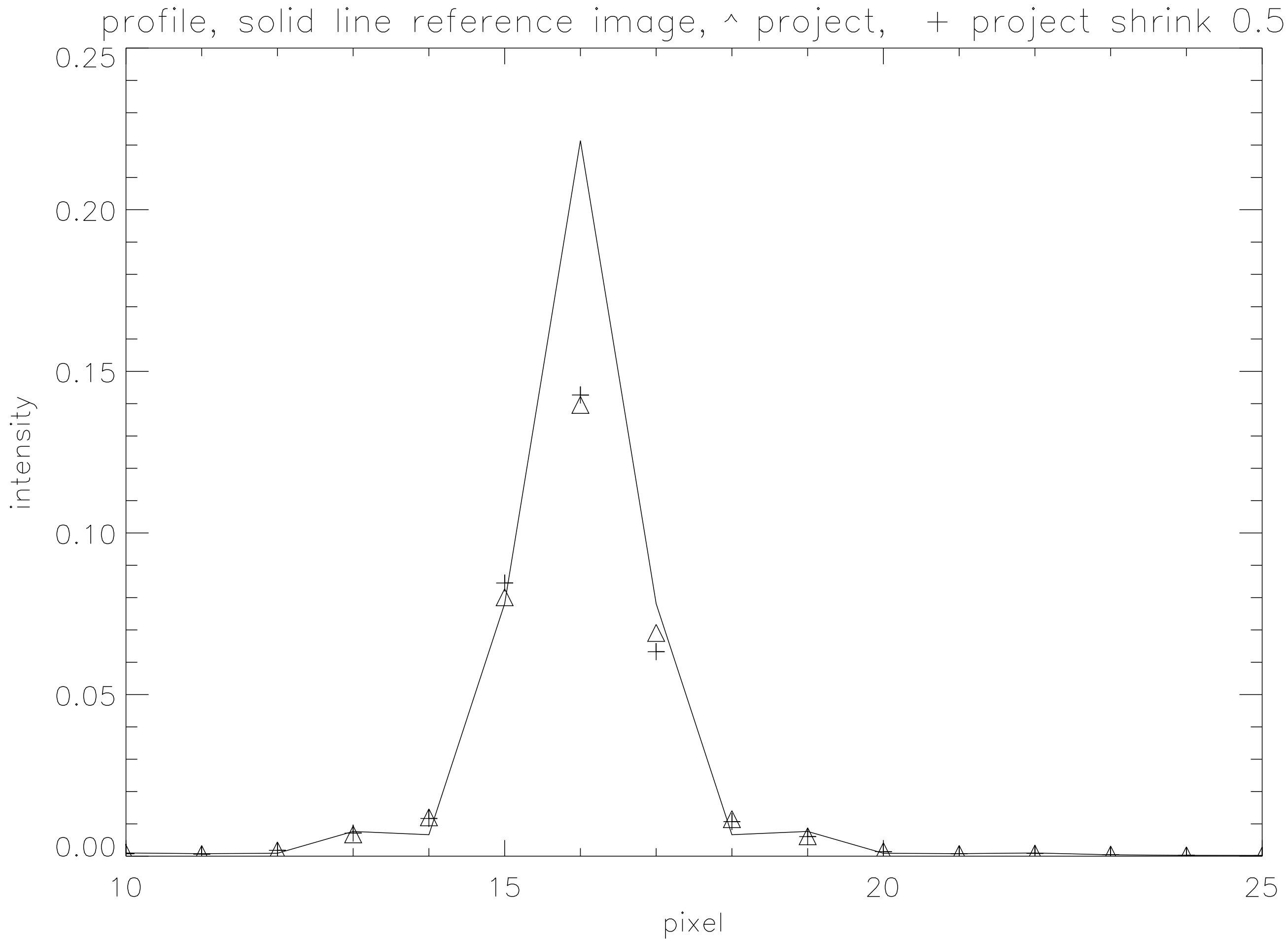
The efficency of the different jitter correction techniques can be evaluated by the value of the central pixel: a good method "unspread" the photons, see following table.

method	central pixel
average	0.160
shift and add	0.134
projection	0.140
projection with drizzle	0.144
eclipse	0.134
Fourrier dephasing	0.208
reference image	0.221

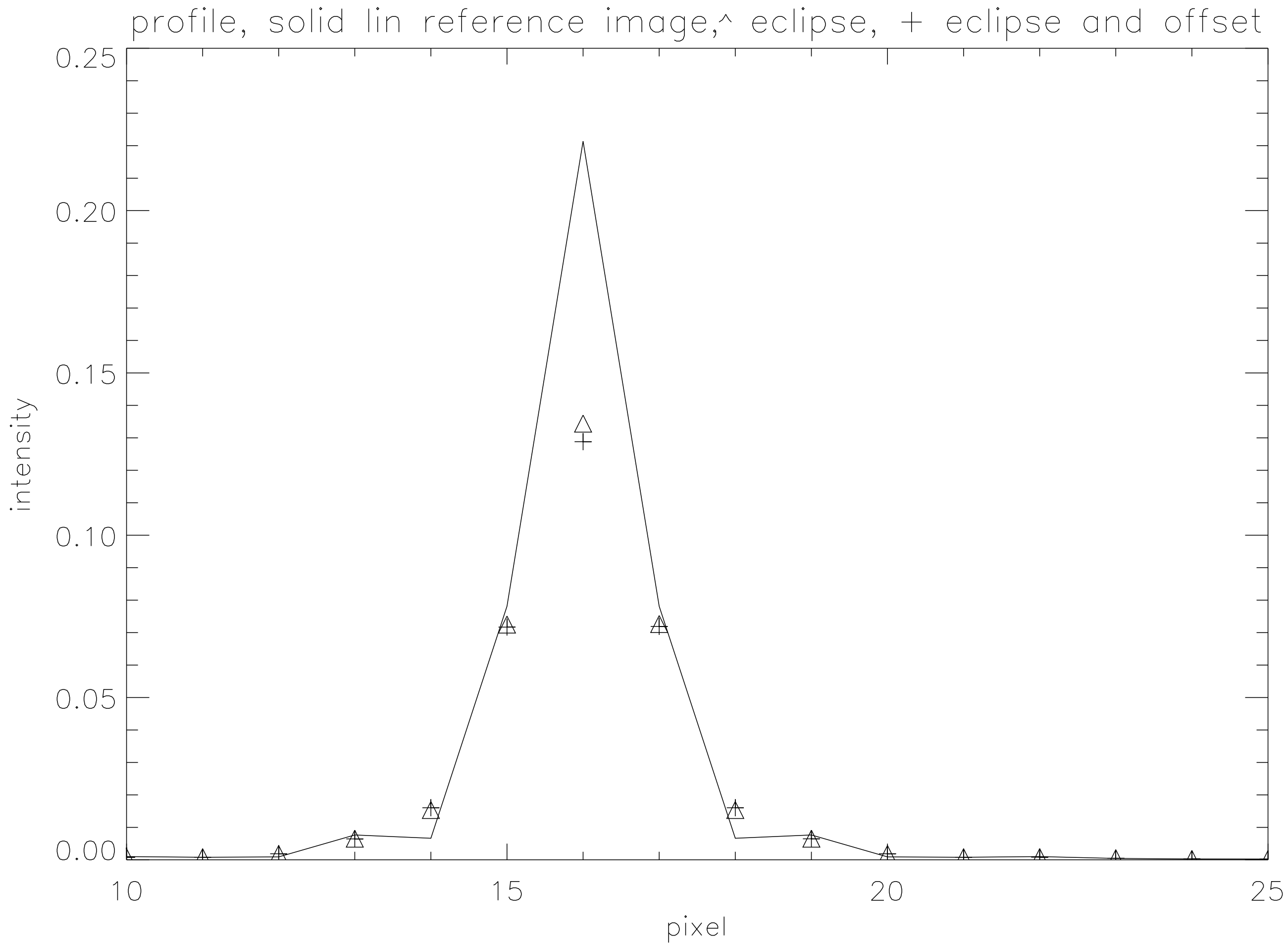
The following figures show a profile of the image obtained by processing the cube with the different methods.



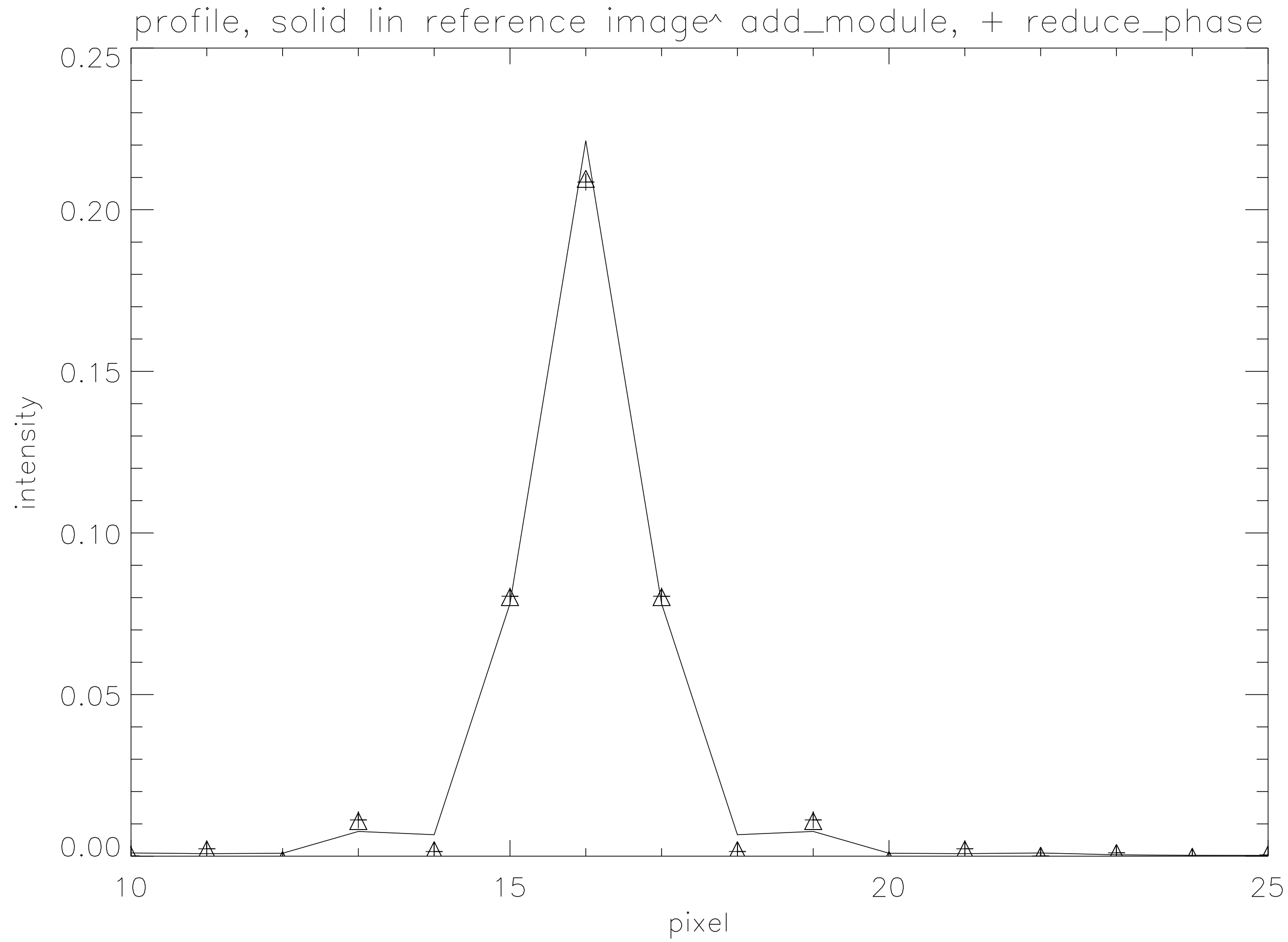
profile for jitter corrected image with reduce



profile for jitter corrected image with projection



profile for jitter corrected image with eclipse



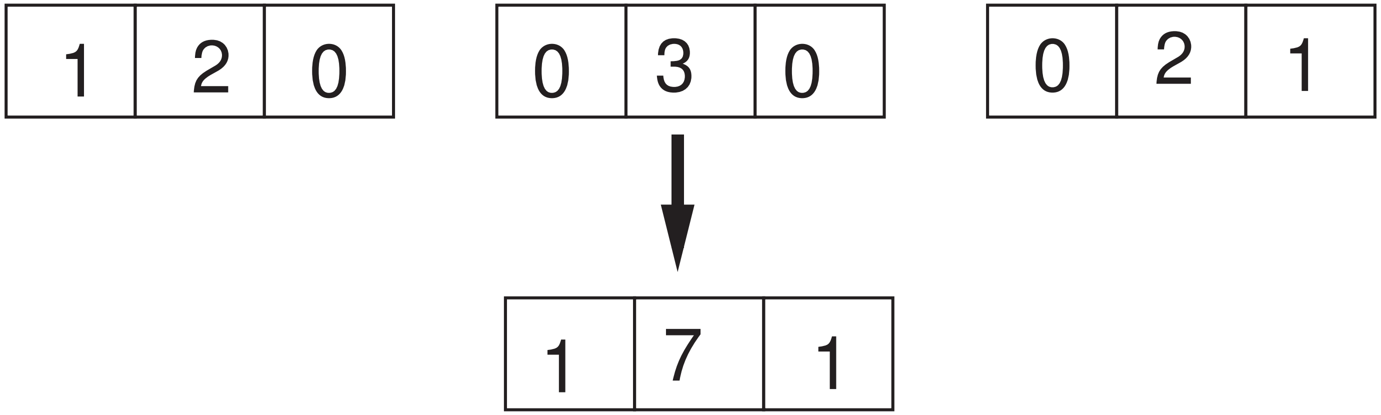
profile for jitter corrected image with Fourrier Dephasing

Jitter Correction

1. Reduce The bad results of shift and add (reduce, /jitter) is explained by the next figure. When we sum up to get back to the original size (so called convolution by the fat pixel), information is lost. Shift and add must keep the finer grid.
2. DrizzelFor the drizzle techniques, the pixels are shrank before projection onto the finer grid. This improves the result, but in a non predictable way.
3. InterpolationThe interpolation technique (eclipse) is illustrated by the following figure. In this technique there is no finer grid, but the shifting is done by computing the value of the image in the shifted position by interpolation.
4. Fourrier Dephasing in the Fourrier space, shifting is a dephasing. There are some tricks: the image must be centered, and the phase factor must be multiplied by a window, in order to avoid artifacts in the final image.

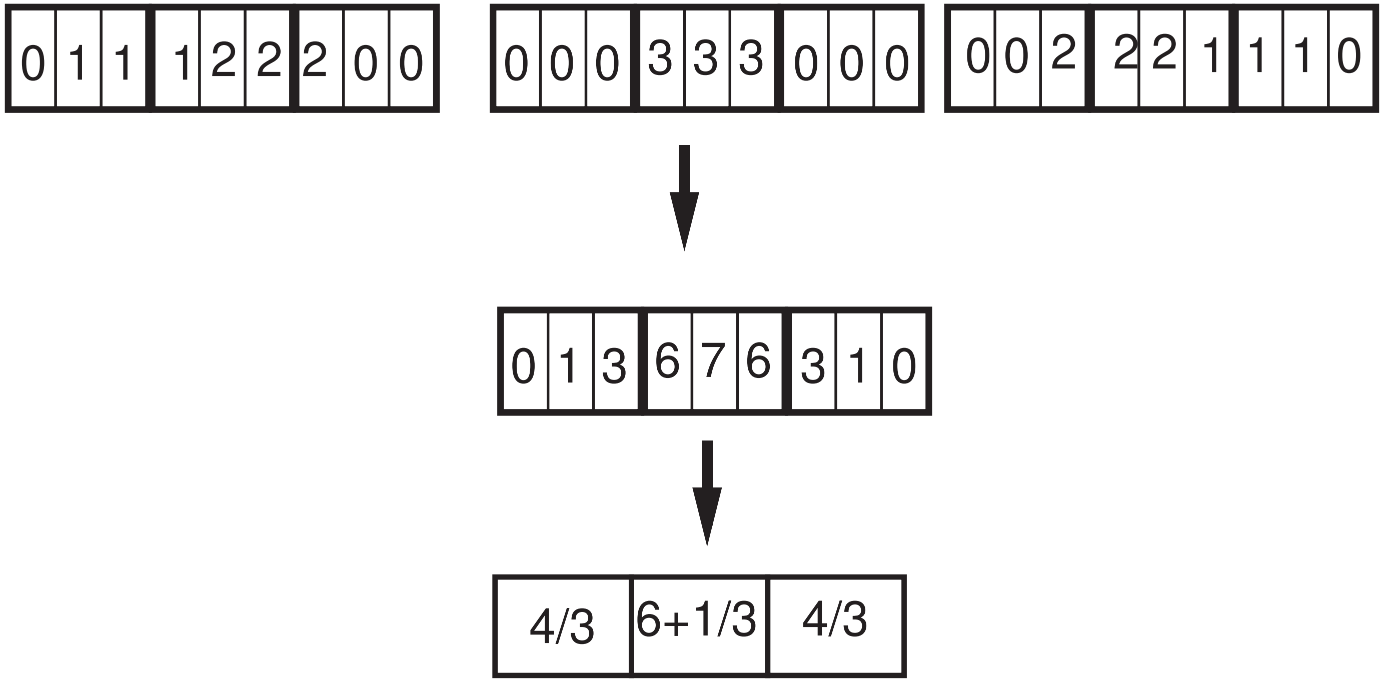
All these techniques gave a final image which is centered on the correct position.

Jitter Correction



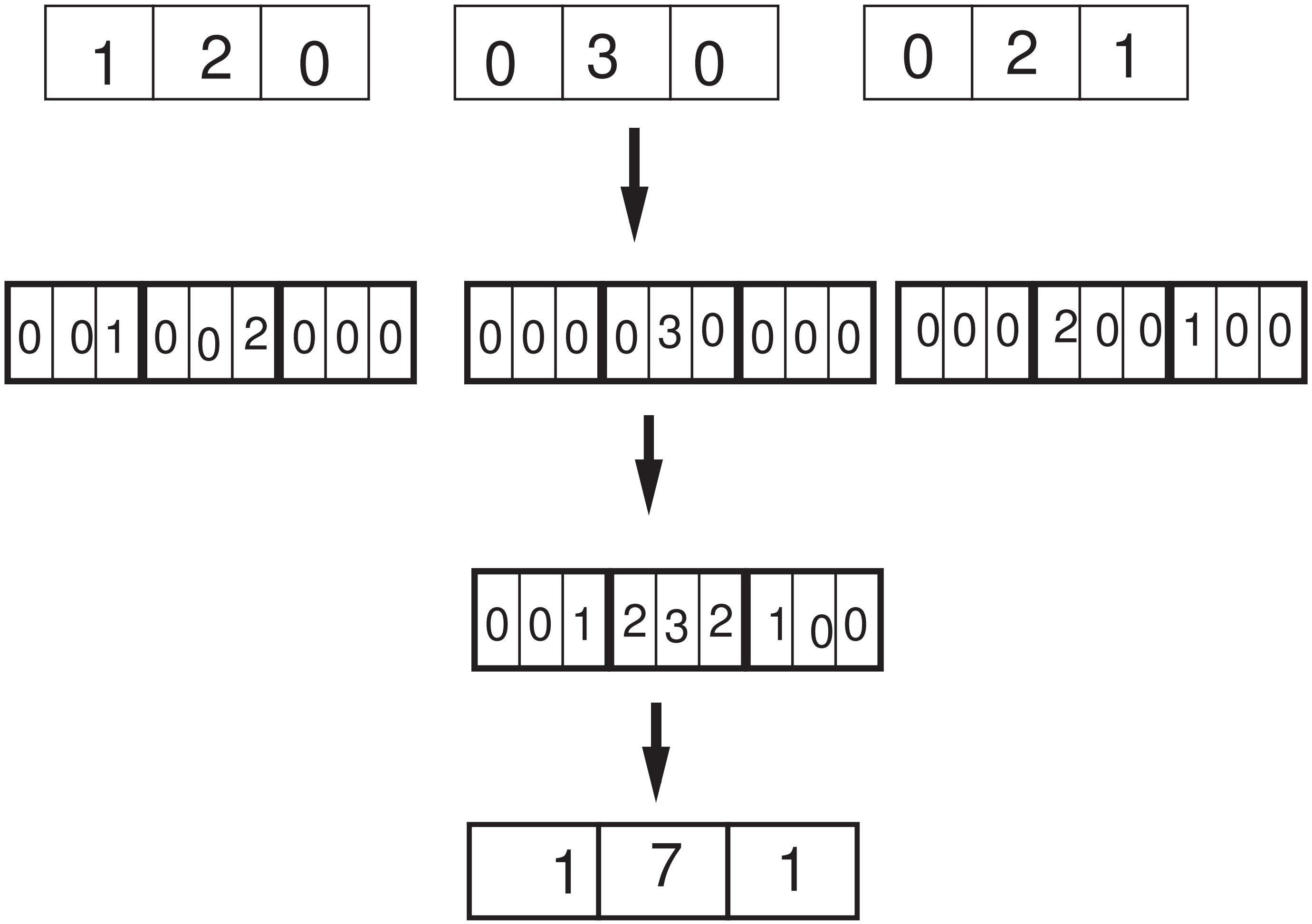
Reduce

Jitter Correction

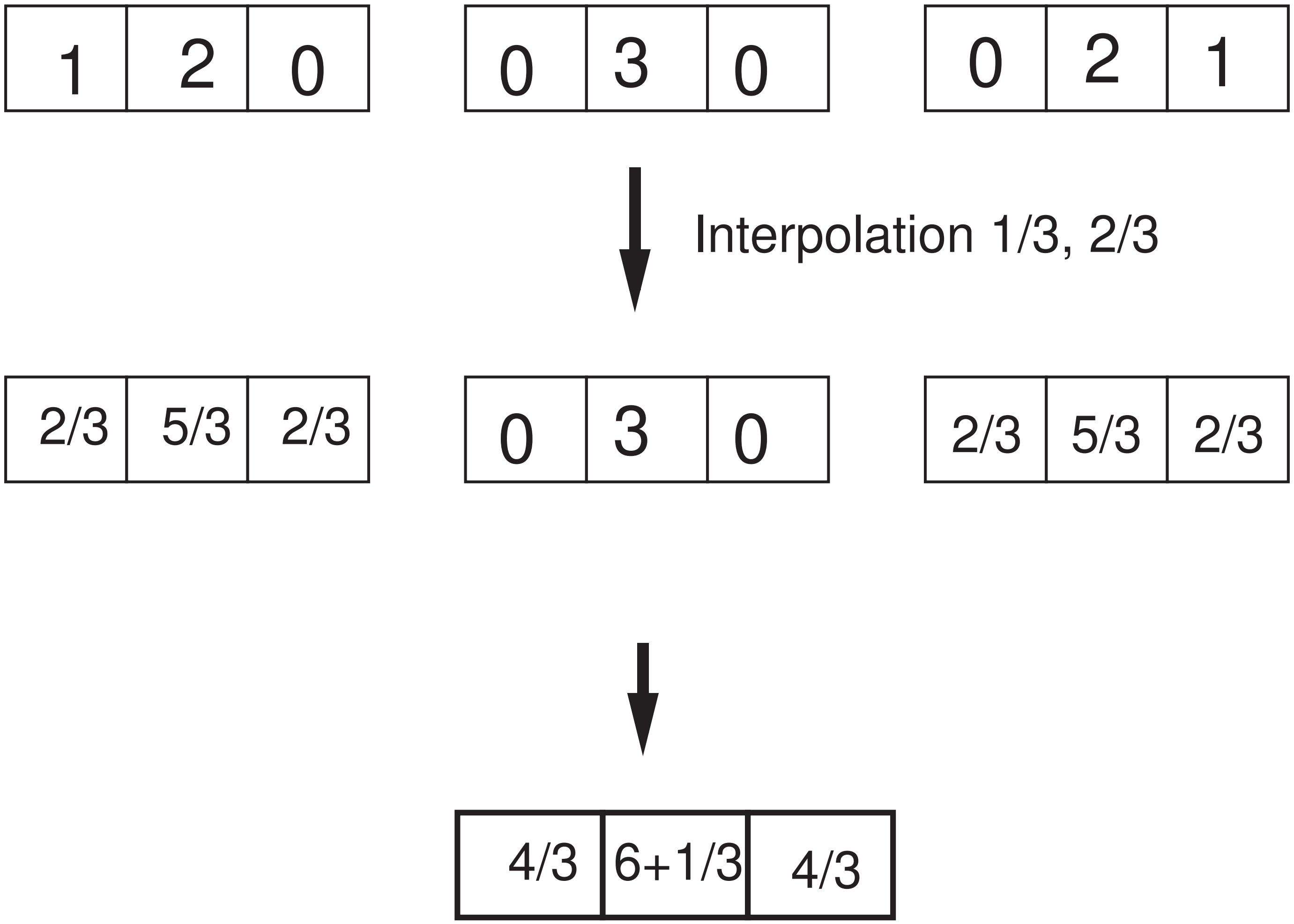


Shift and Add

Jitter Correction



Jitter Correction



Jitter Correction

Conclusion

As the results of this study show, this is not useful !
In some cases, it can be worth to do something:

1. **Bright source for deglitching, perhaps a jitter correction can help (if there is jitter, i.e. pfov 1.5 ")**
2. **CVF there is a known shift from filter cvf1 to filter cvf2**
3. **Polarization there are known shifts between the polarizers filters**
4. **Micro-scan there is a shift of a non interger number of pixels, perhaps it can improve projection.**

Bibliography

There is a lot of work in this domain, from many fields (from medical imaging to movie makers !). I just use the following:

1. Drizzle see for example Richar Hook, ADASS 1997 (ASP)
2. eclipse Nicolas Devillard technical report, http:/www.eso.org/eclipse
3. CIA modules compute_jitter, fit_isopsf, reduce_cube, project_cube
4. MR/1 module mr_fusion
5. Fourrier Dephasing Tod R. Lauer preprint Oct 1998, to appear in PASP