Source detection over large areas of the sky

- ✓ Look for a fast method to find sources over the whole sky
- ✓ Provide list of positions, allowing to run maximum likelihood locally

- ✓ 6 days data set
- ✓ Work in Galactic coordinates
- ✓ 3 energy bands (30 MeV / 100 MeV / 1 GeV / 10 GeV)
- ✓ Pixel adapted to each band (0.5° / 0.2° / 0.1°)
- ✓ Cartesian projection around the Galactic plane
- ✓ Polar projection (r = 90-b or 90+b, θ=l) around the poles

Source detection using wavelets

Iterative algorithm:

- Select relevant scales
- WT
- Threshold for each scale
- Detect relevant strucure to compute multiresolution support M
- Reconstruct solution S
- Compute residuals
- WT on residuals
- Detect structures belonging to M
- Reconstruct and update solution S
- Iterate until convergence

Can be applied to CWT (reconstruction via wavelet packets)
dyadic WT (a-trou algorithm)

First tests using MR1 software package (developped by J.L. Starck).

Actual source detection on the smoothed image with SExtractor.

Source detection using wavelets

DC1 sky with mr_filter using iterative filter, Poisson noise, 4 sigma threshold

100 MeV – 1 GeV: keep scales 0.8° and 1.6°. 87 sources at |b| < 30°

1 GeV – 10 GeV: keep scales 0.4° and 0.8°. 126 sources at |b| < 30°

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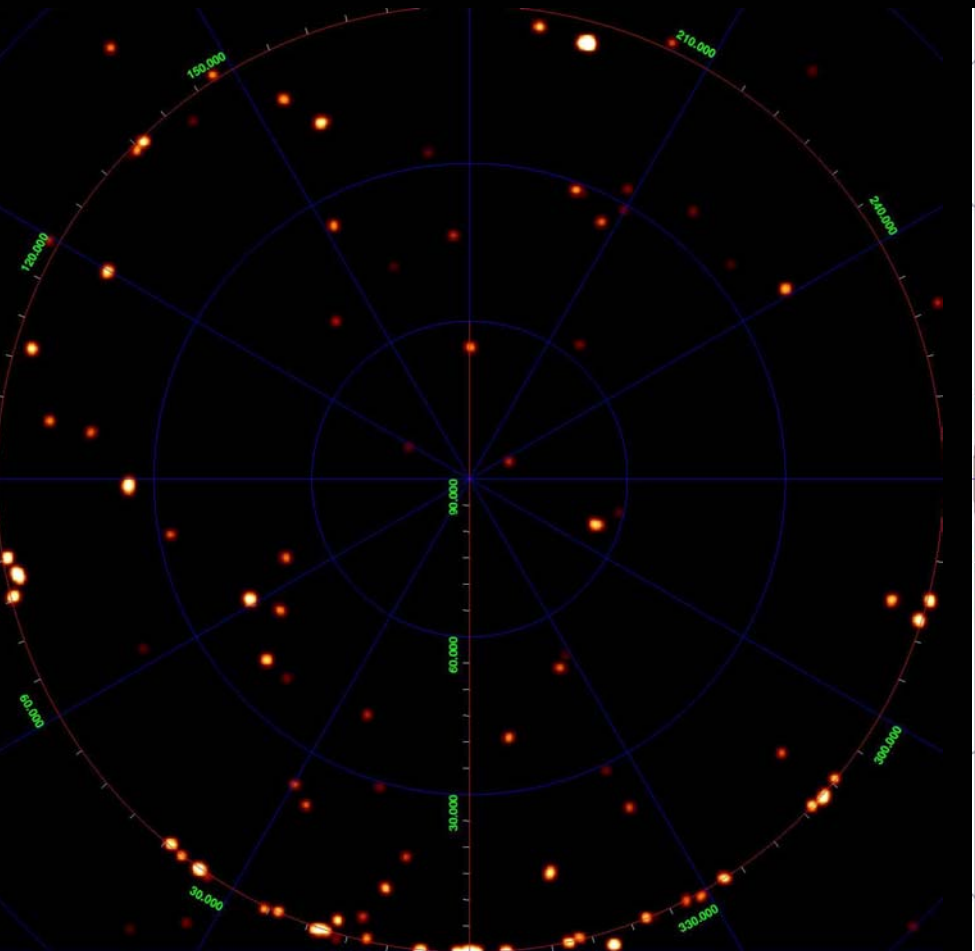
1 GeV – 10 GeV

Source detection using wavelets

North pole with mr_filter using iterative filter, Poisson noise, 4 sigma threshold

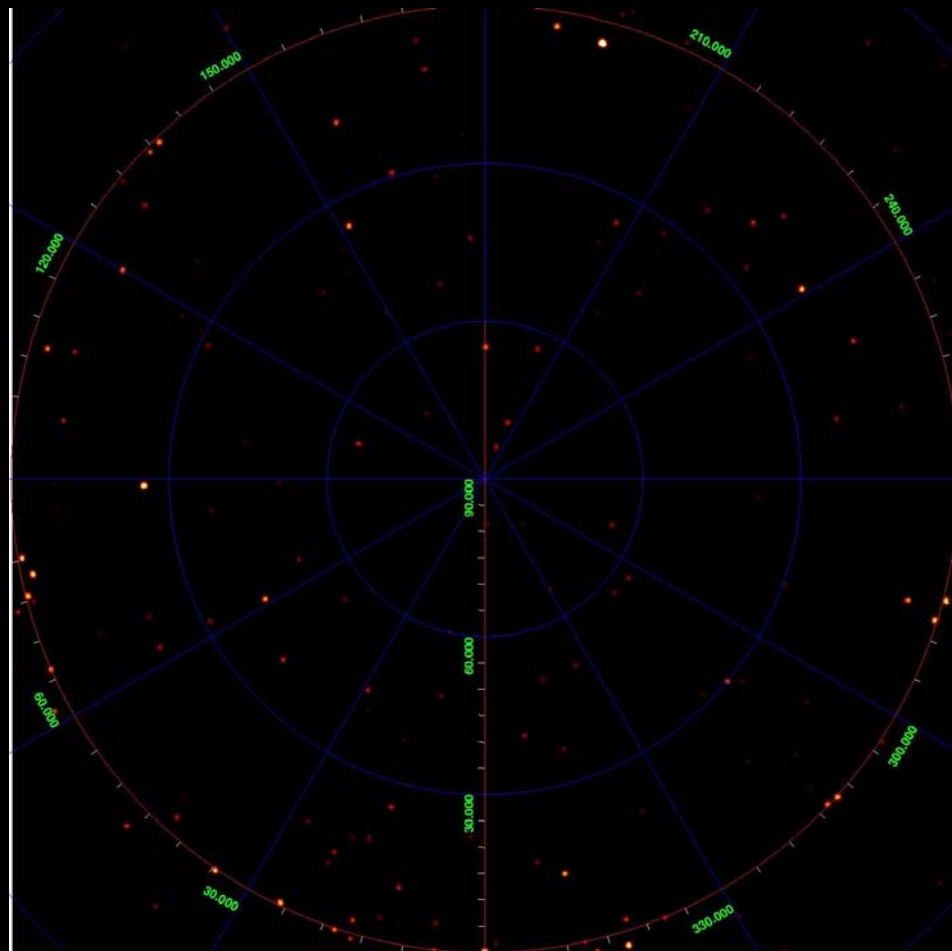
100 MeV – 1 GeV: scales 0.8° and 1.6°

23 sources at b > 30°



1 GeV – 10 GeV: scales 0.4° and 0.8°

47 sources at b > 30°



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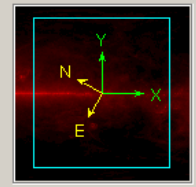

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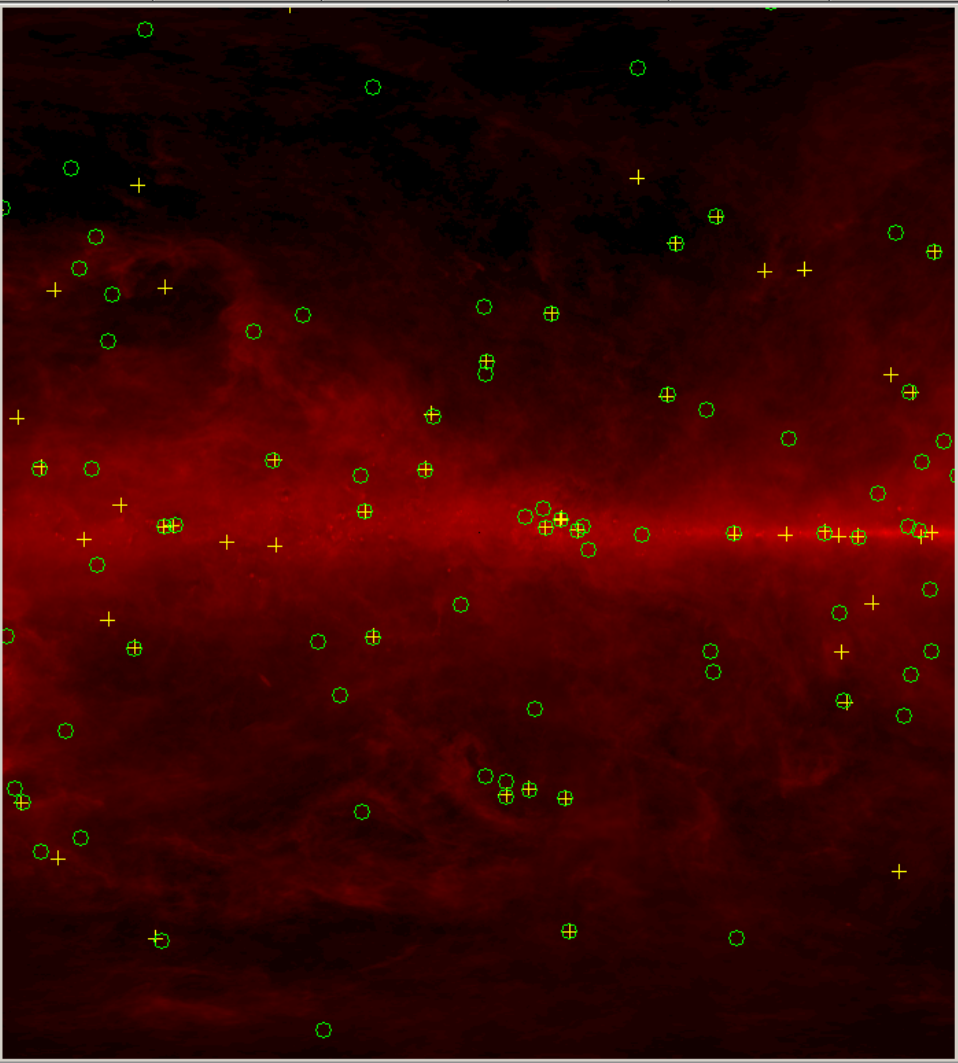

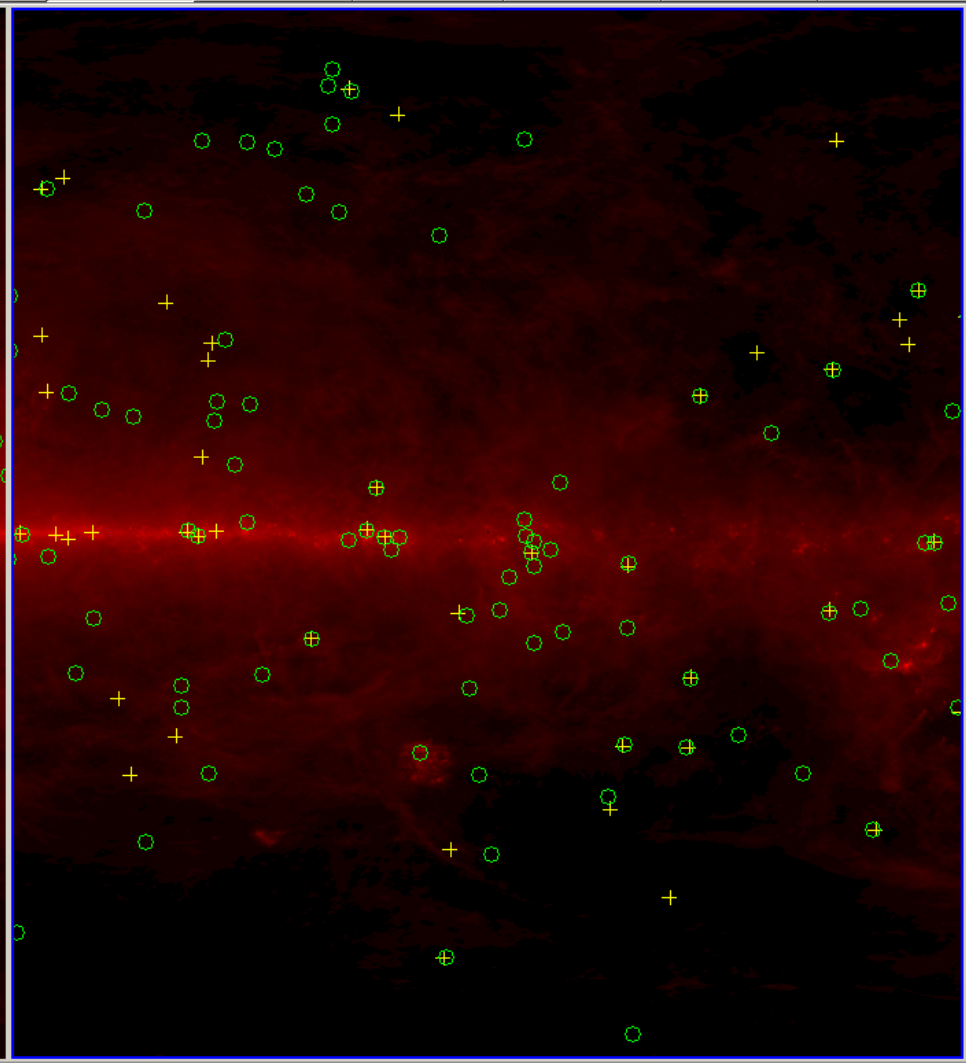

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Source detection using wavelets

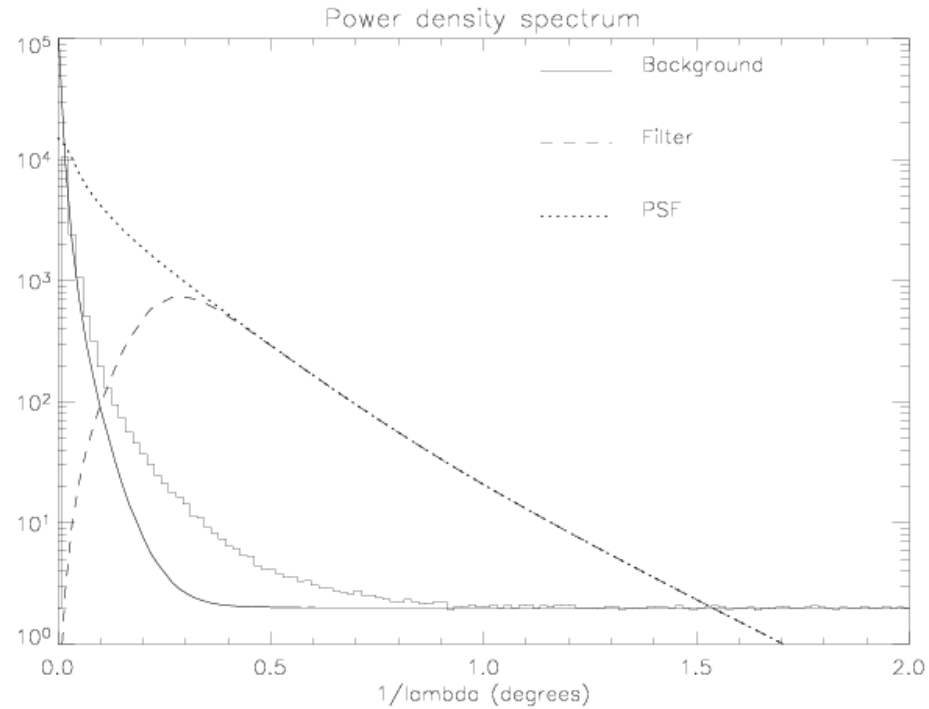
- ✓ Already existing maintained package, immediately available, fast
- ✓ Method already used in other contexts (for example, XMM large scale survey of M. Pierre et al.)
- ✓ Can detect extended sources as well (if any)

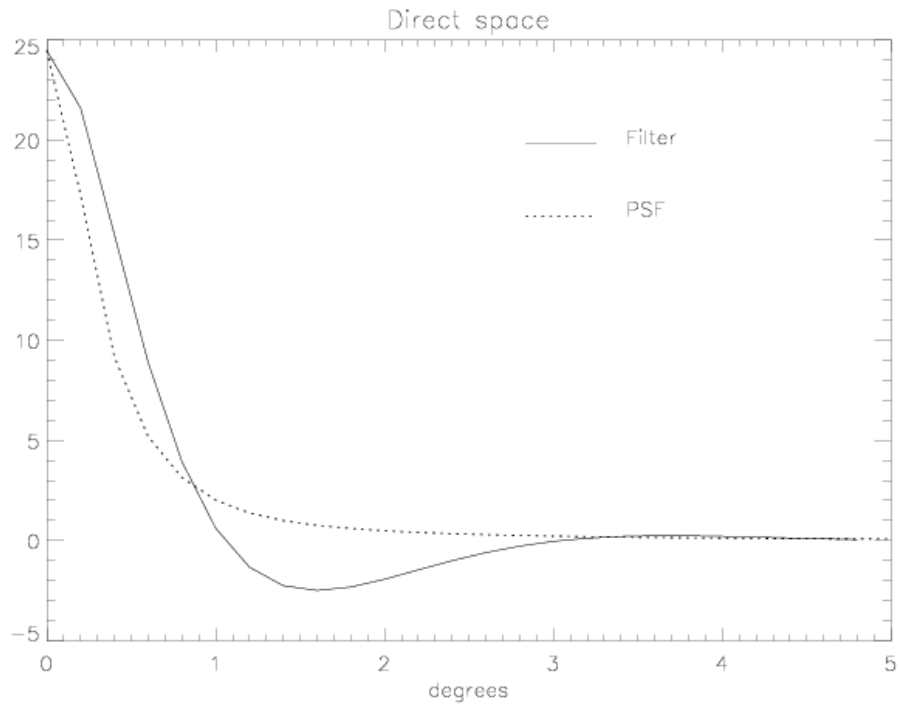
Open issues:

- ✓ Finds too many sources in the Galactic plane ?
- ✓ Optimize pixel size / reconstruction scales
- ✓ Optimize threshold level
- ✓ How far can we go in geometrical distortions due to sphericity

Source detection using optimal filter

Idea: Determine optimal filter using (known) power density spectrum of the background (Galactic diffuse emission) and Point Spread Function.
Generalisation of the matched filter technique (Vio et al., A&A 391, 789).
PSF averaged over off-axis angle and energy.

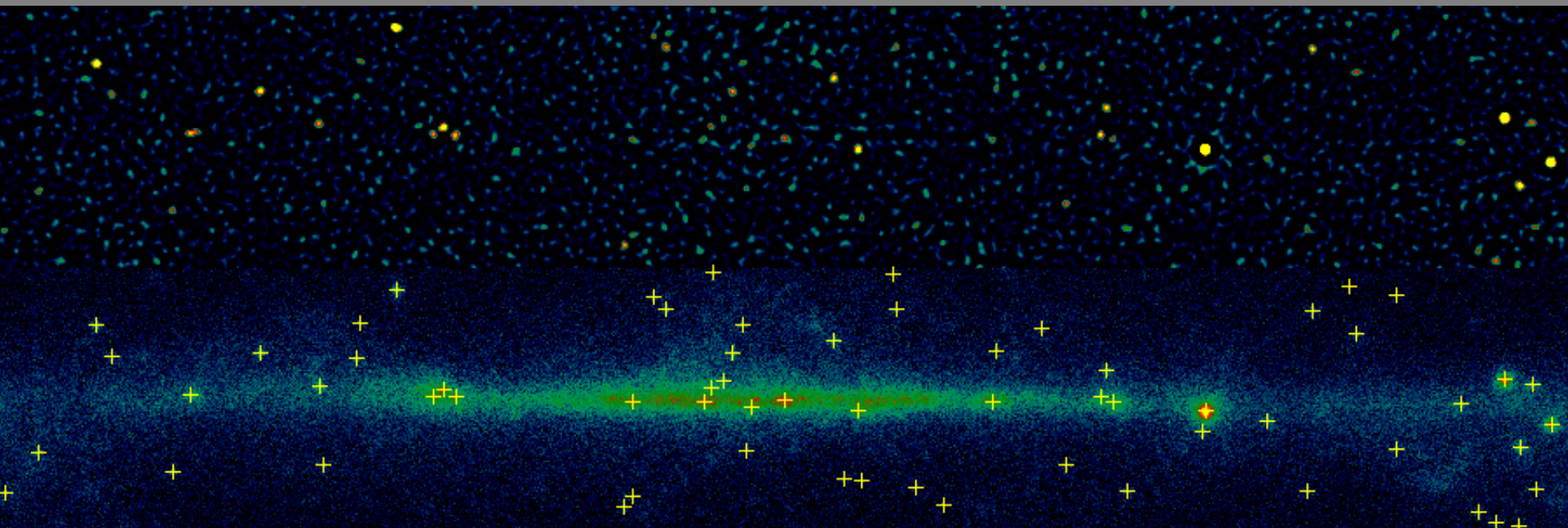




Source detection using optimal filter

- ✓ Threshold at 5 sigma
- ✓ Apply on Galactic plane +/- 30° in 100 MeV – 1 GeV band
- ✓ 63 sources found (8 not found by wavelet method)

- ✓ Below: Raw map + sources
- ✓ Above: Filtered map (between 0 and 10 sigma)



Source detection using optimal filter

Many open issues to investigate:

- ✓ PSF varies with energy. Probably better to use specific filter at each energy (split each decade in 10) and combine the images later (how ?).
- ✓ Is the PSF variation with off-axis angle an issue ?
- ✓ Not the same structure in latitude (sharper) and longitude. Use different filter in both directions ?
- ✓ Optimal filter depends on amplitude of background (balance with Poisson noise). Use smaller areas ?
- ✓ Galactic power density spectrum must be extrapolated to shorter wavelengths
- ✓ Should use Poisson-based threshold

Source detection over large areas of the sky

It works … very fast … but there is still a long way to go.

Several general issues:

- ✓ The strength of the background must be estimated. Use theoretical model or get it from the data ? If the latter, sources must be subtracted (iteration)
- ✓ Is cartesian geometry all right (paving the sky with moderately large pieces) ? Should we investigate convolution in spherical geometry ?
- ✓ How to deal best with the energy information ?
- ✓ How should we set the detection threshold ? Low enough and let likelihood reject the false detections, or high enough and use likelihood for characterisation only ?
- ✓ Should we implement additional cuts on the data (e.g. on off-axis angle) ?
- ✓ Are those methods able to separate barely resolved sources ?
- ✓ How best to detect variable sources ?