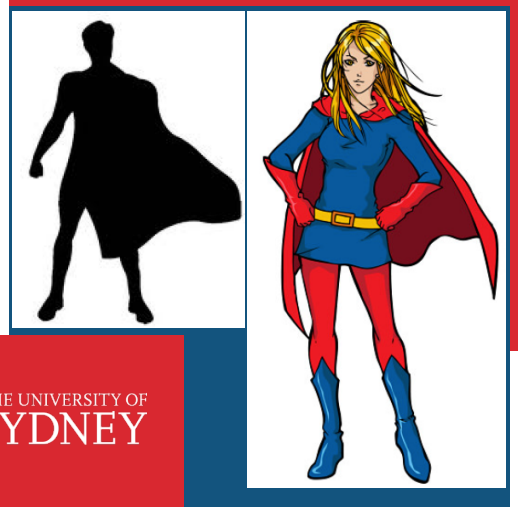
Compact Continuum Source Finding

For the next generation of radio surveys.



Paul Hancock
with Tara Murphy, Bryan Gaensler, Andrew Hopkins, James Curran
SIfA + CAASTRO

THE UNIVERSITY OF SYDNEY

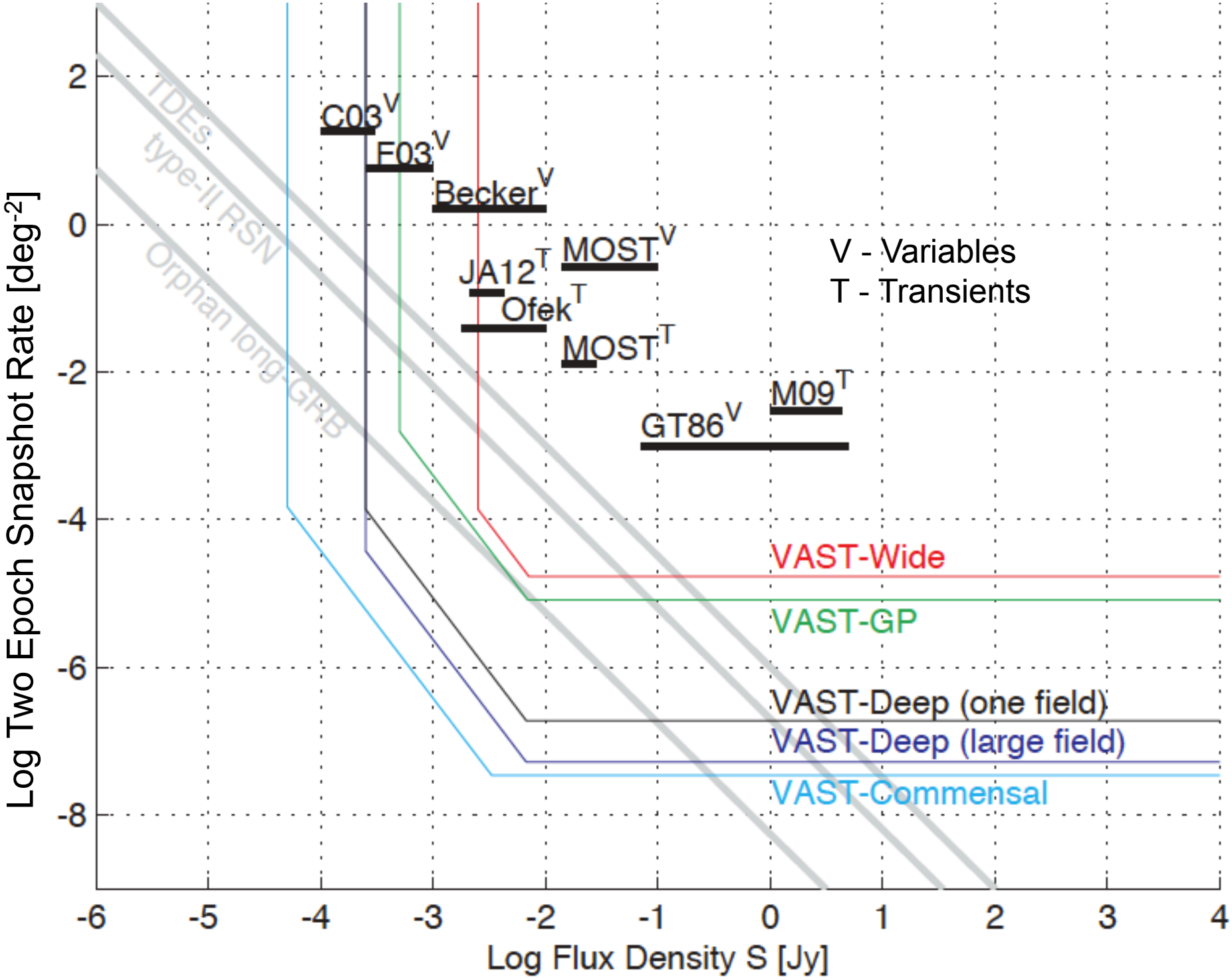
CAASTRO
ARC CENTRE OF EXCELLENCE FOR ALL-SKY ASTROPHYSICS

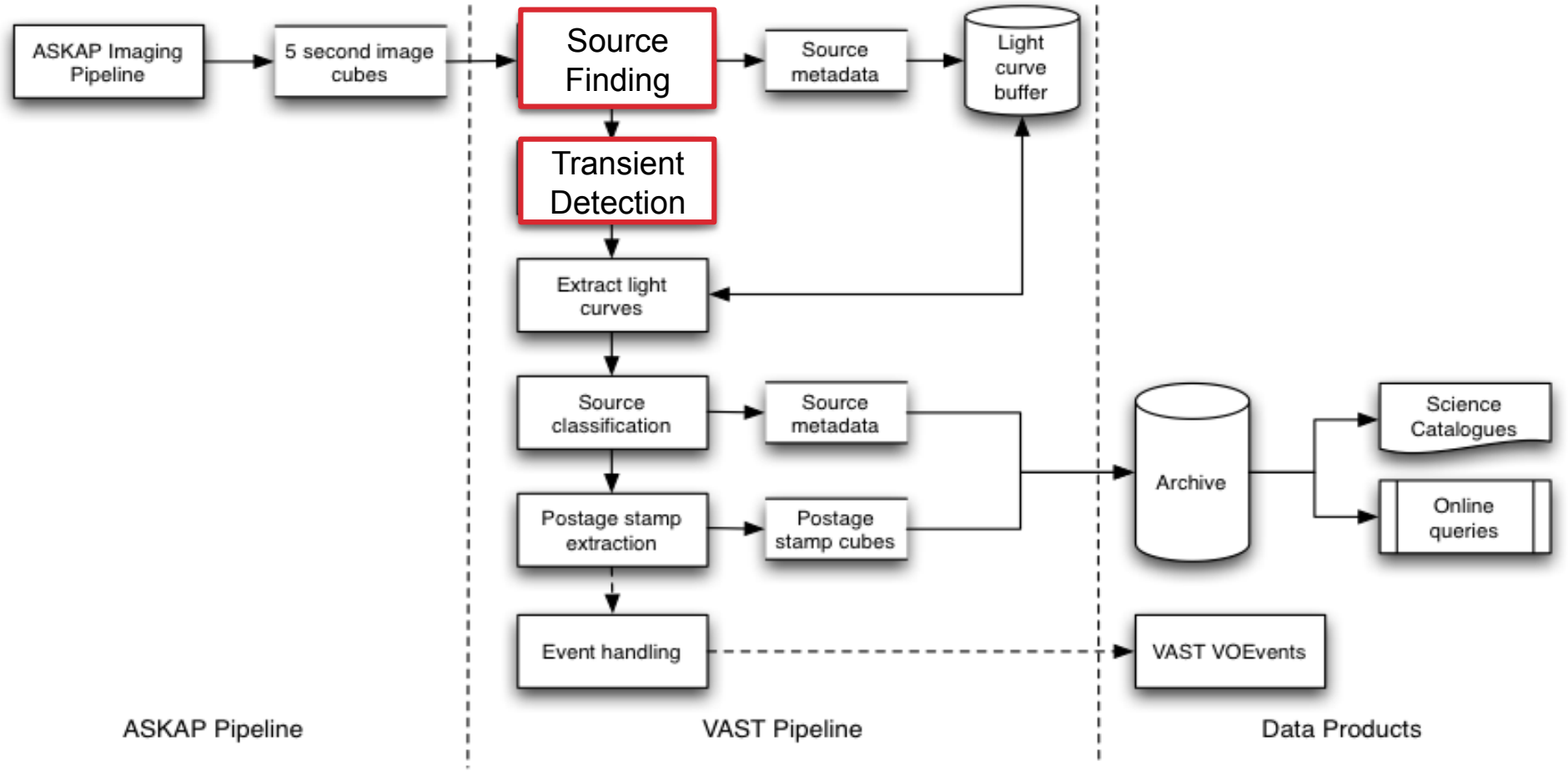
VAST:
An ASKAP Survey for Variables and Slow Transients

- VAST - Deep
  - Low cadence, deep observations of 100,000 sq degrees
- VAST - Wide
  - High cadence, shallower observations of 100,000 sq degrees
- VAST - Commensal
  - Piggyback on the continuum observations of other projects for more time/sky coverage

VAST science goals

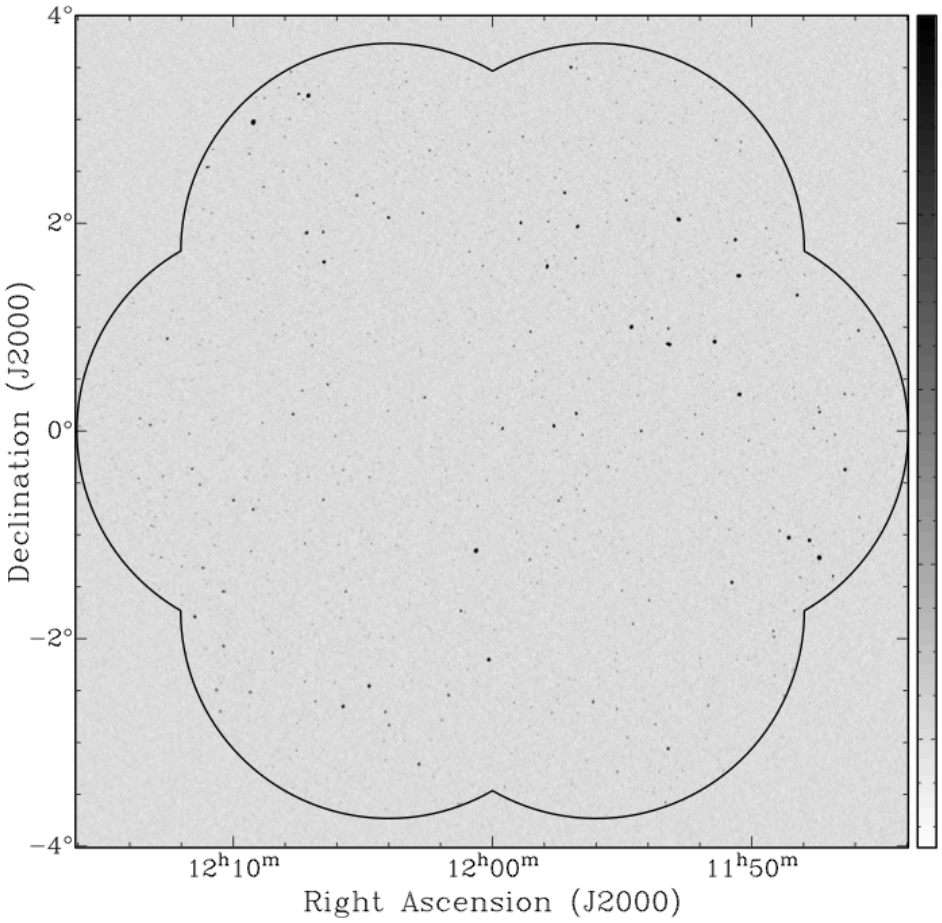
- Propagation Effects
  - Scintillation
  - Extreme Scattering Events (ESEs)
- Intrinsic variability
  - Rotating Radio Transients (RRATs)
  - Intra Day Variables (IDVs)
  - Quasar/Blazar activity
- Transient events
  - Novae, Supernovae and GRBs
  - Magnetar and brown dwarf flares
  - Tidal Distruption Eventes (TDEs)
  - The “BURPER”


Log Two Epoch Snapshot Rate [deg^{-2}]
Log Flux Density S [Jy]
2
0
-2
-4
-6
-8
-6
-5
-4
-3
-2
-1
0
1
2
3
4
TDEs
type-II RSN
Orphan long-GRB
C03^{V}
F03^{V}
Becker^{V}
JA12^{T}
MOST^{V}
Ofek^{T}
MOST^{T}
GT86^{V}
M09^{T}
V - Variables
T - Transients
VAST-Wide
VAST-GP
VAST-Deep (one field)
VAST-Deep (large field)
VAST-Commensal

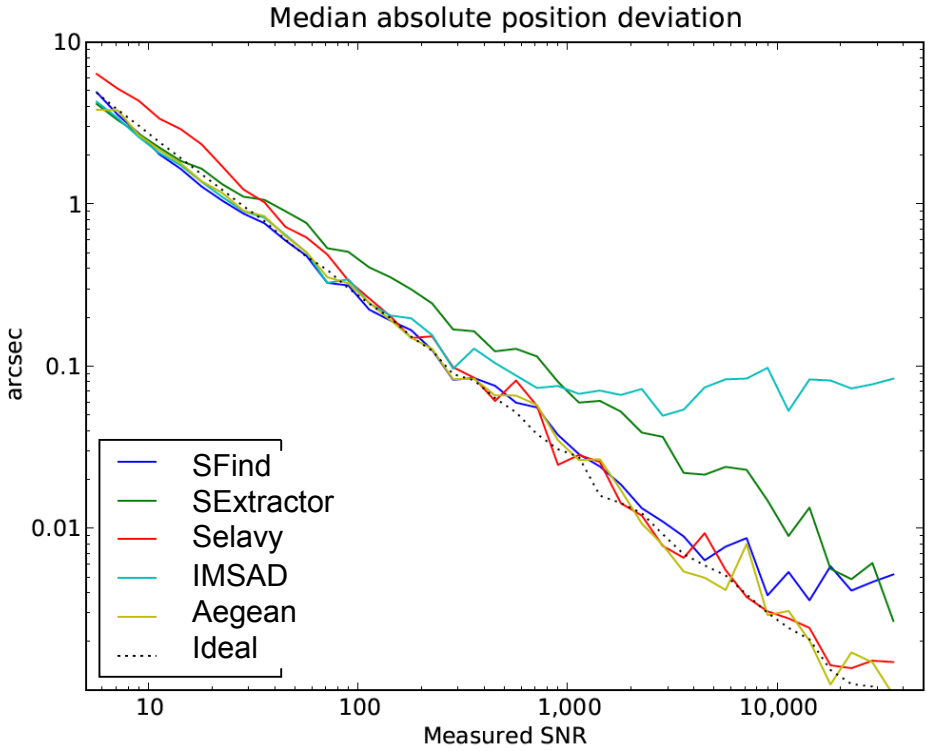

ASKAP Imaging Pipeline
5 second image cubes
Source Finding
Source metadata
Light curve buffer
Transient Detection
Extract light curves
Source classification
Source metadata
Postage stamp extraction
Postage stamp cubes
Event handling
Archive
Science Catalogues
Online queries
VAST VOEvents
ASKAP Pipeline
VAST Pipeline
Data Products

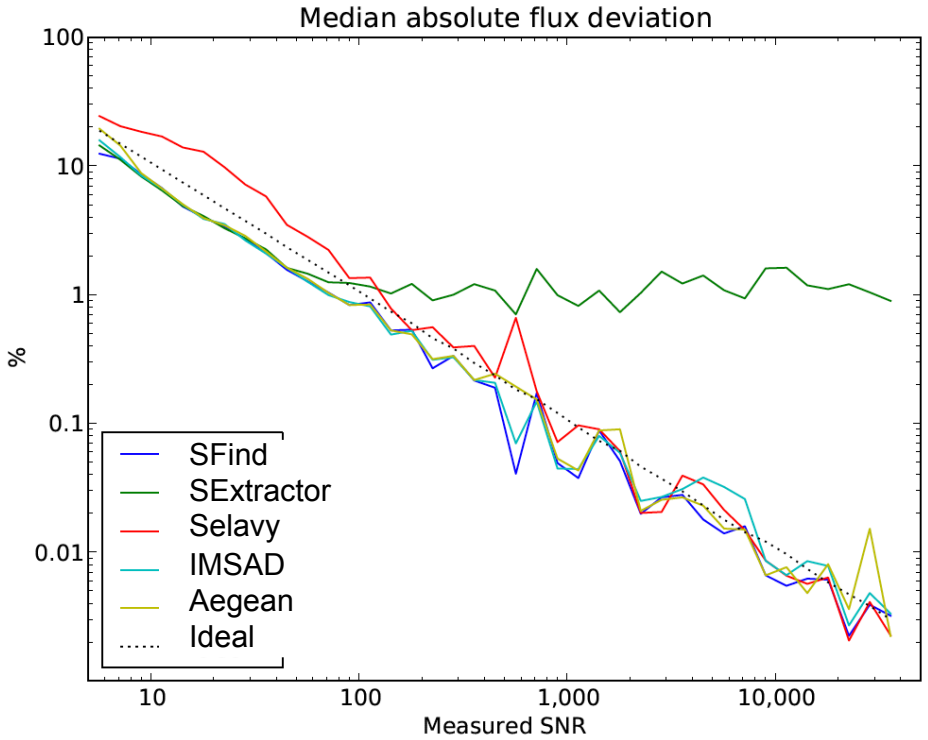
Test Setup

- Source Finders:
  - SFind - Hopkins et al. (2002)
  - SExtactor - Bertin & Arnouts (1996)
  - IMSAD - Sault et al. (1995)
  - Selavy - Whiting et al. (2012)
  - Aegean - Hancock et al. (2012)
- Data:
  - 10 Simulated images
    - 25μJy rms across the field
    - 10” beam, 5pix per beam
    - Compact sources (0-3 x beam size)
  - www.physics.usyd.edu.au/~hancock/simulations



Positions and fluxes are easy to measure

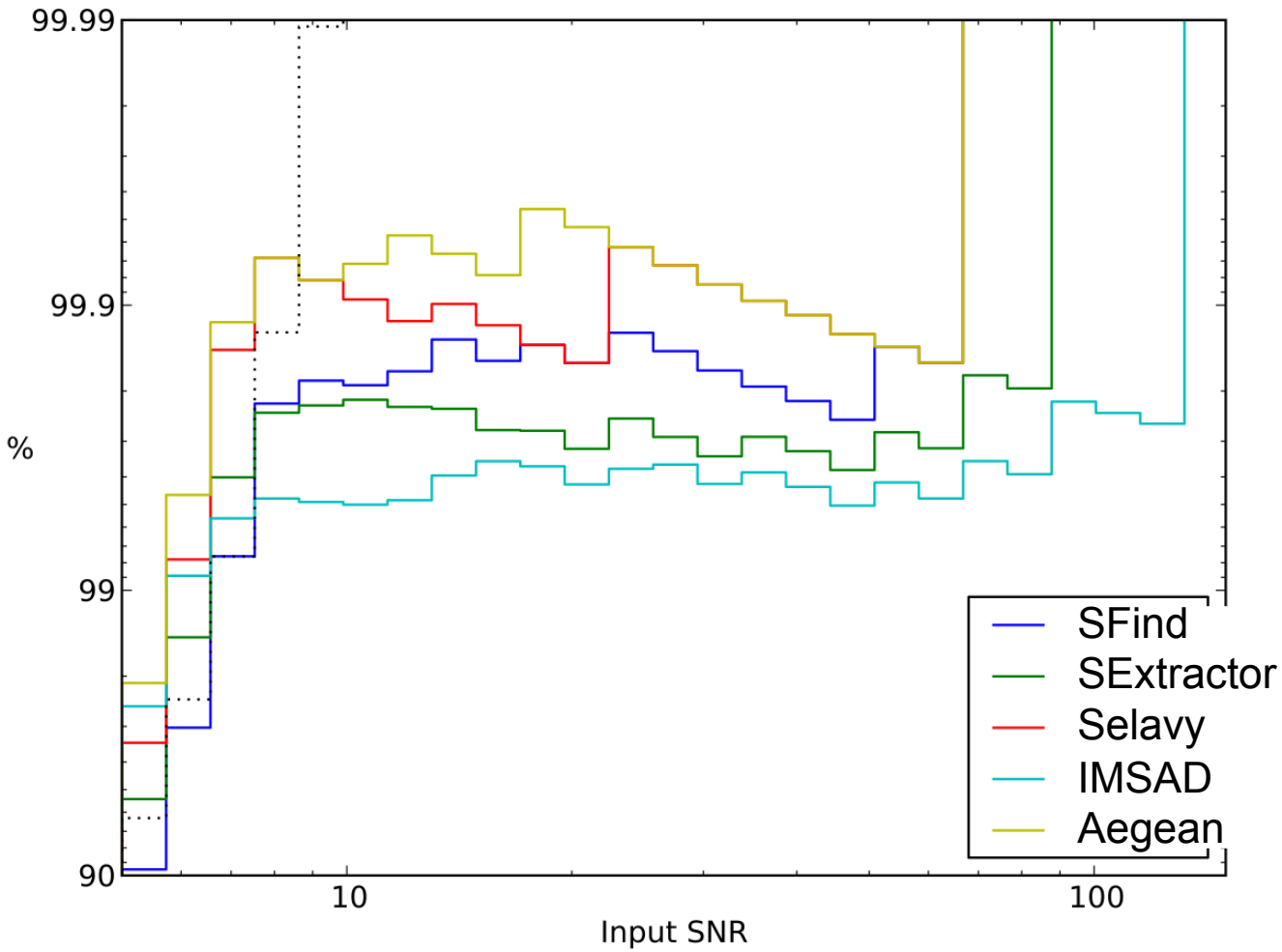




- Gaussian fitting is a solved problem for isolated compact sources
- Above deviations are *implementation* problems

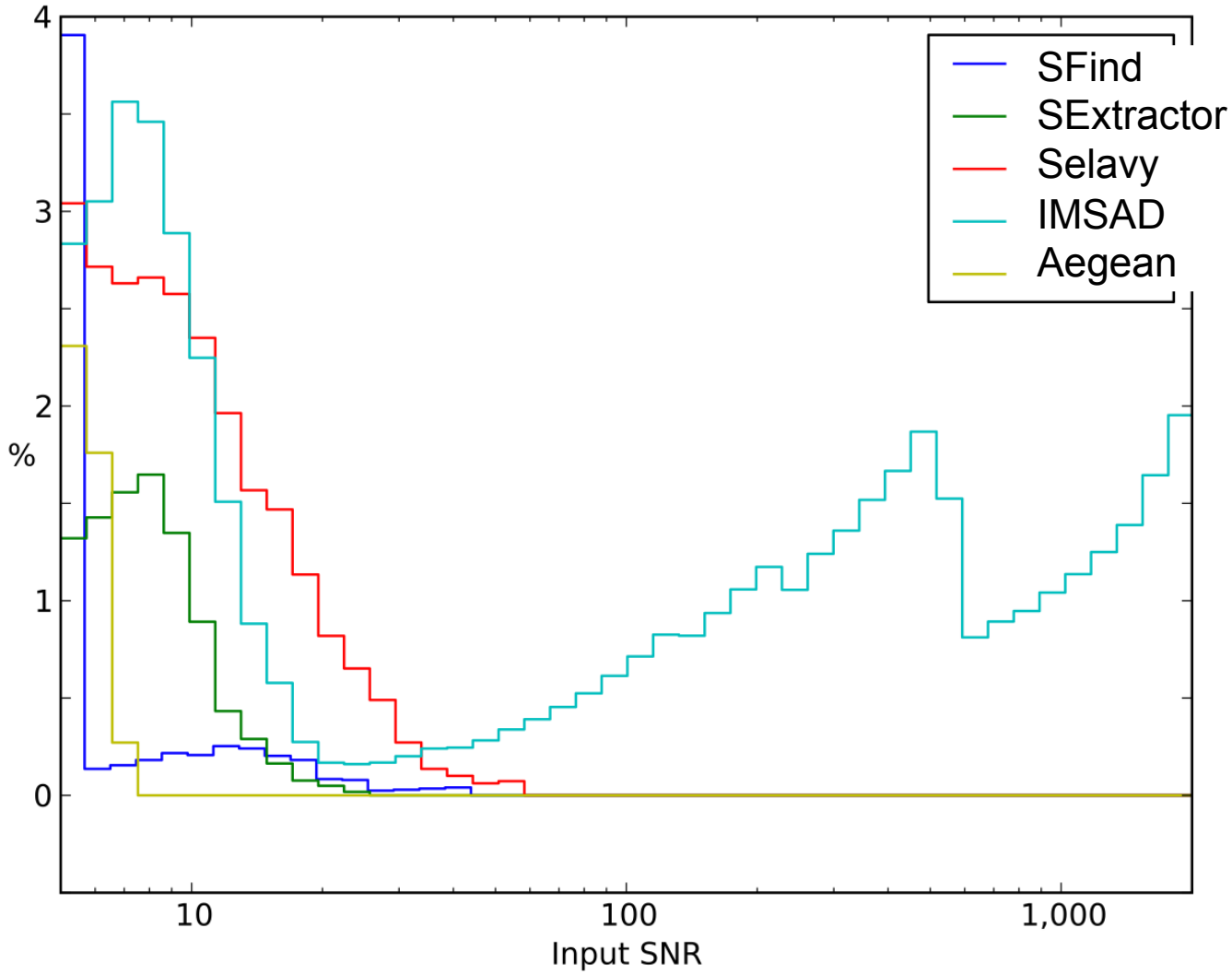
Completeness

- Aegean/Selavy are essentially the same in completeness
- Other source finders are less complete
- All source finders are still >99% complete at 7σ

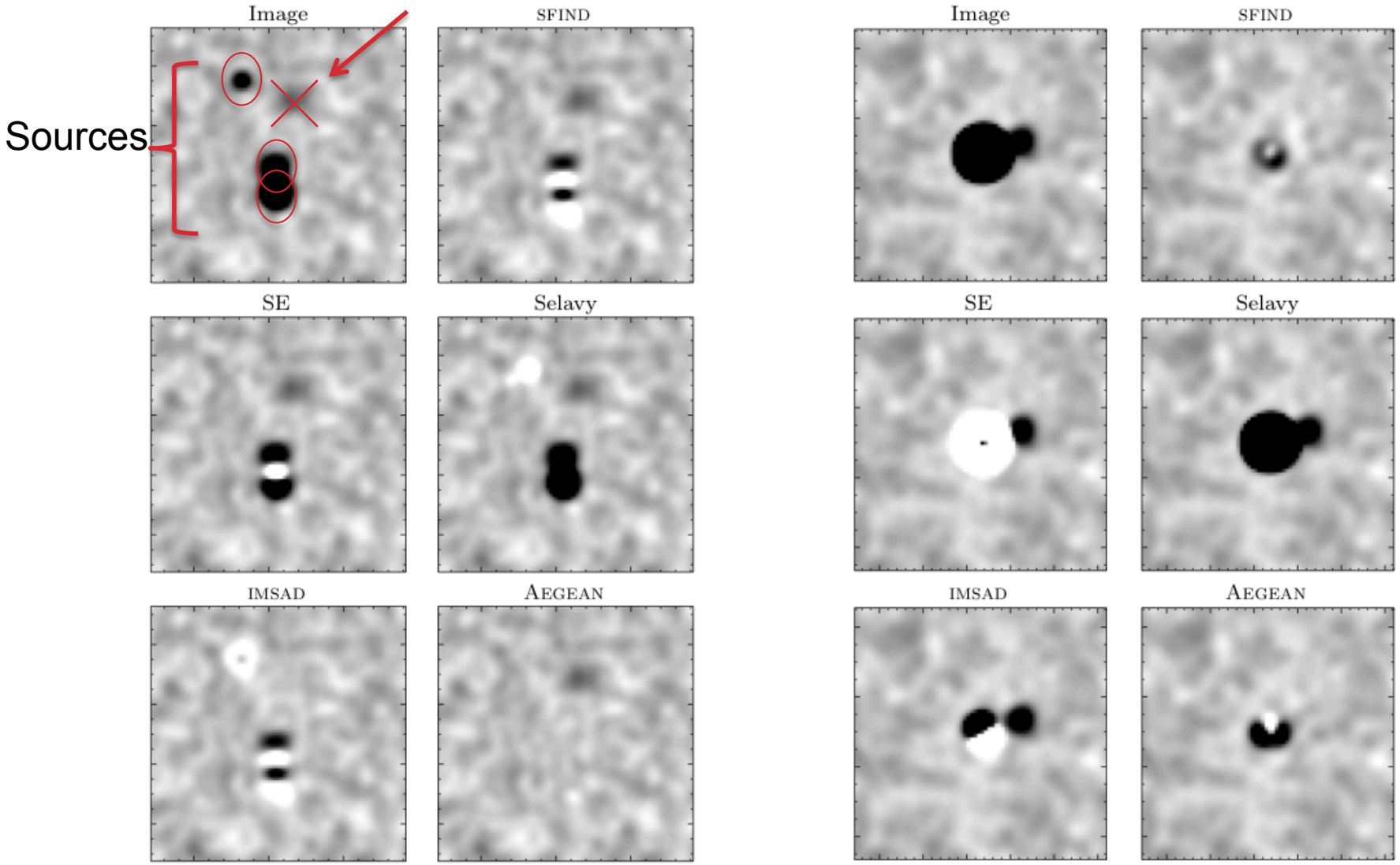


False Detection Rate

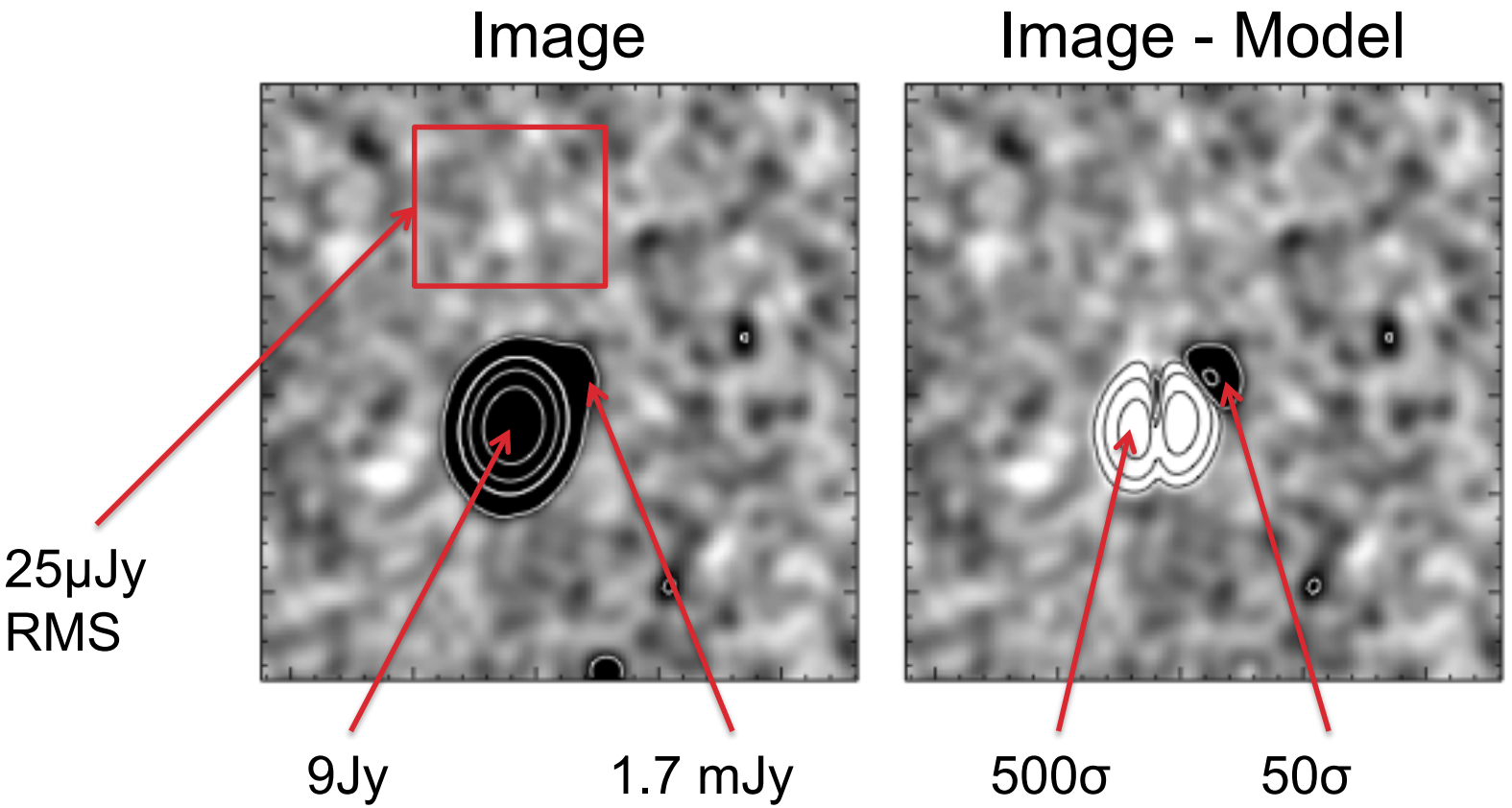
- Aegean achieves the high completeness without sacrificing reliability.



Sources That Are Not Well Fit (~1%)

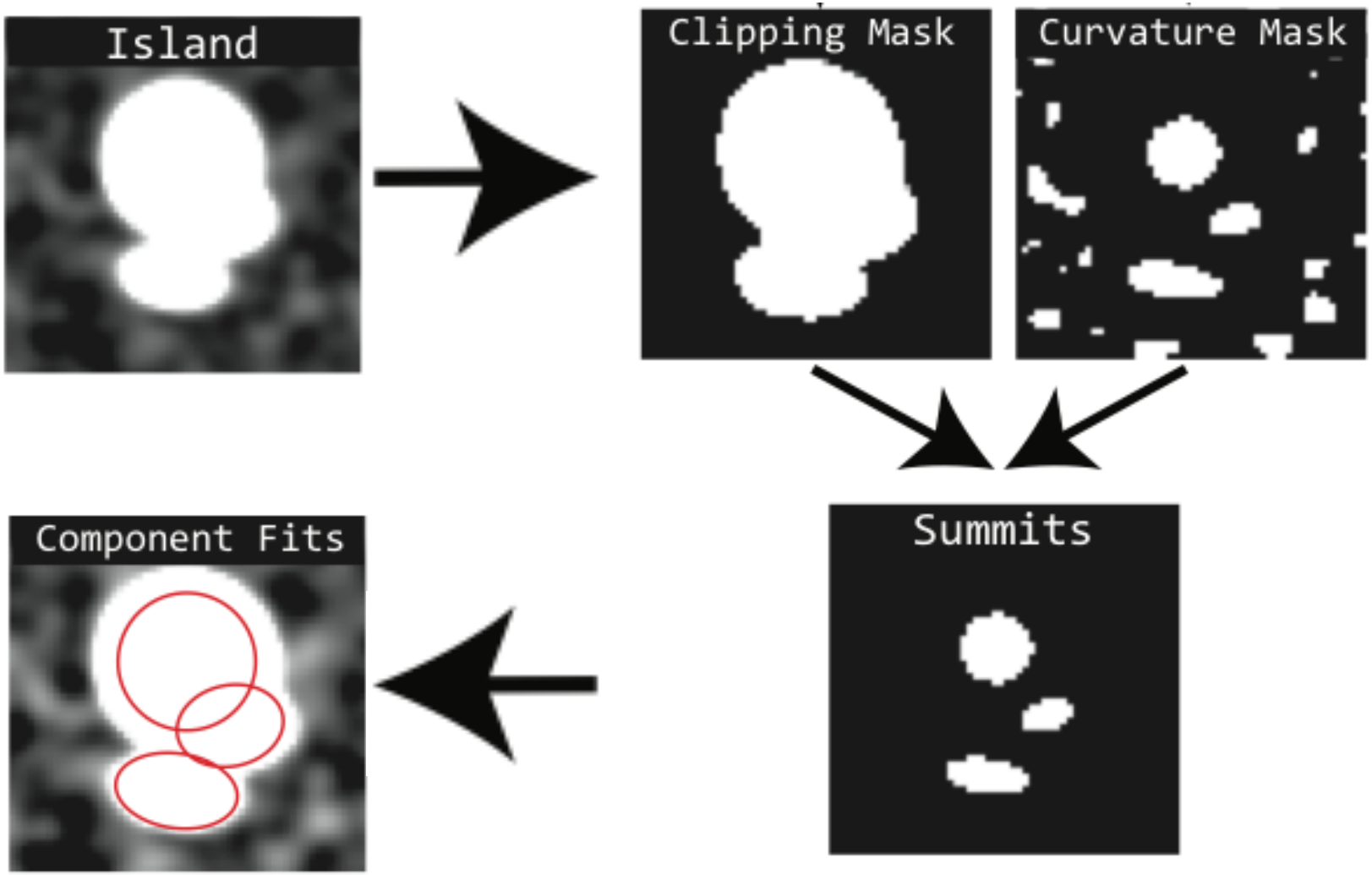


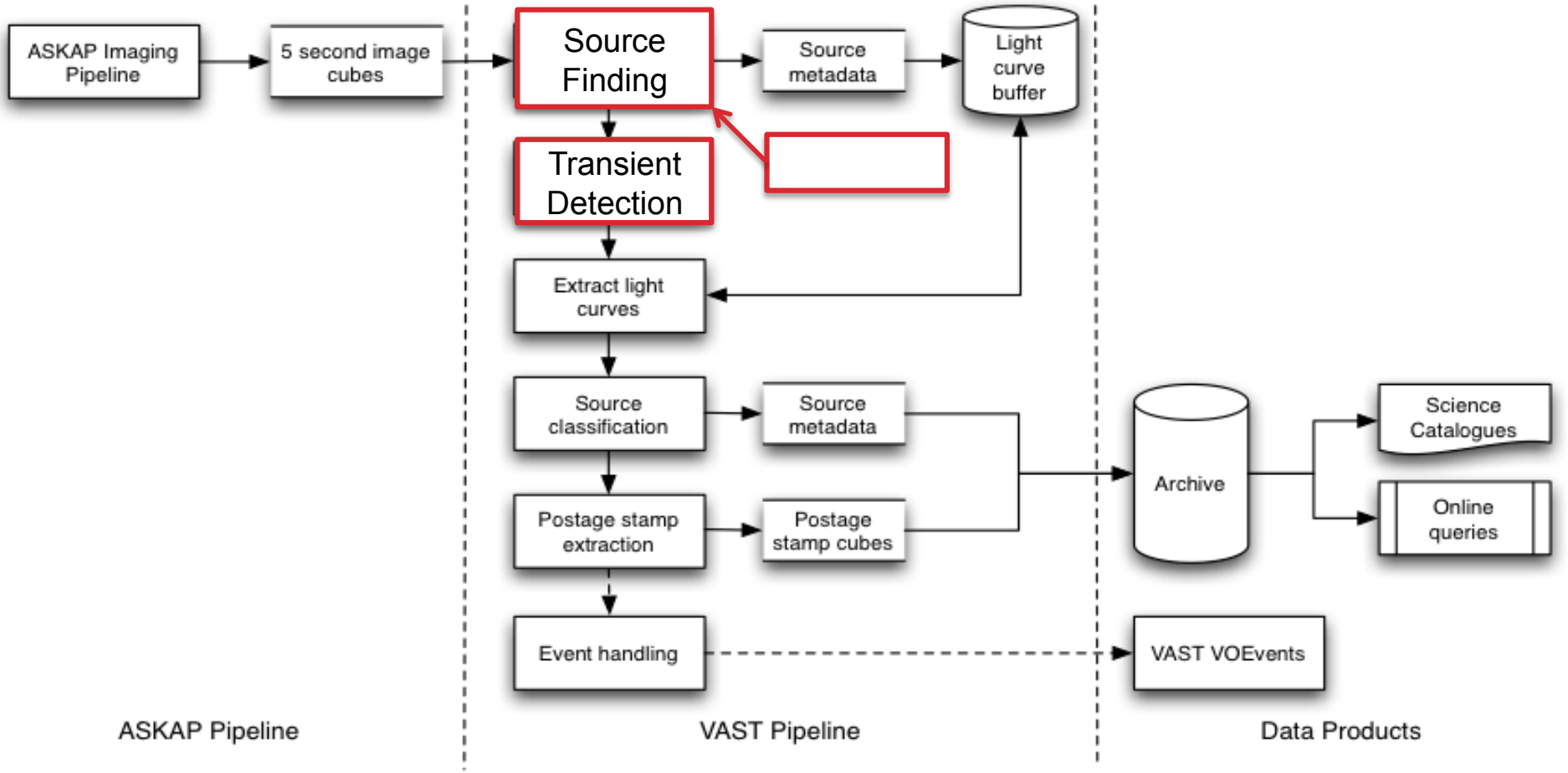
Iterative component estimation is doomed to fail



Model = Correct value of all parameters, but Major axis is 0.05% too large.

What Aegean Does Differently

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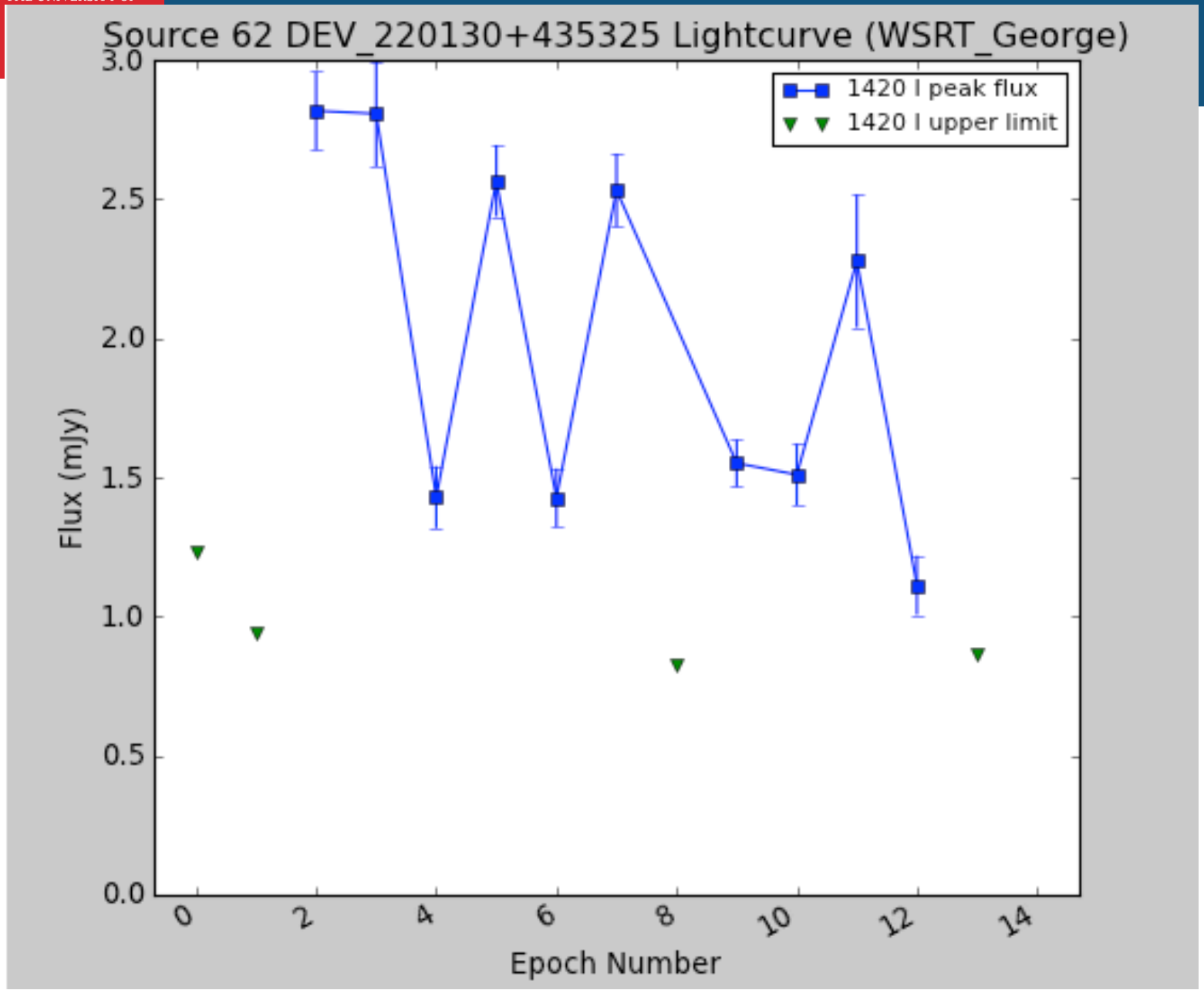
Source 62 DEV_220130+435325 Lightcurve (WSRT_George)
1420 I peak flux
1420 I upper limit
Flux (mJy)
Epoch Number
0.0
0.5
1.0
1.5
2.0
2.5
3.0
0
2
4
6
8
10
12
14

In Summary:

- VAST will be the best probe of the variable and transient universe
- VAST will rely on an automated real time pipeline to produce light curves and detect transient events
- Source finding is a crucial part of this pipeline
- Aegean will provide the most complete and reliable catalogue of sources

- Simulated Data: www.physics.usyd.edu.au/~hancock/index.php/Data/SourceFindingSimulation
- Aegean Code: www.physics.usyd.edu.au/~hancock/index.php/Programs/Aegean
- Source finding paper: Hancock et al. 2012, MNRAS

› Summary

- Current source finders are very good for single component islands
- Fitting multiple Gaussians requires good parameter estimates
- Aegean uses a good estimation algorithm