

# Photometric Calibration (PCAL)

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# Overview



## Purpose of PCAL:

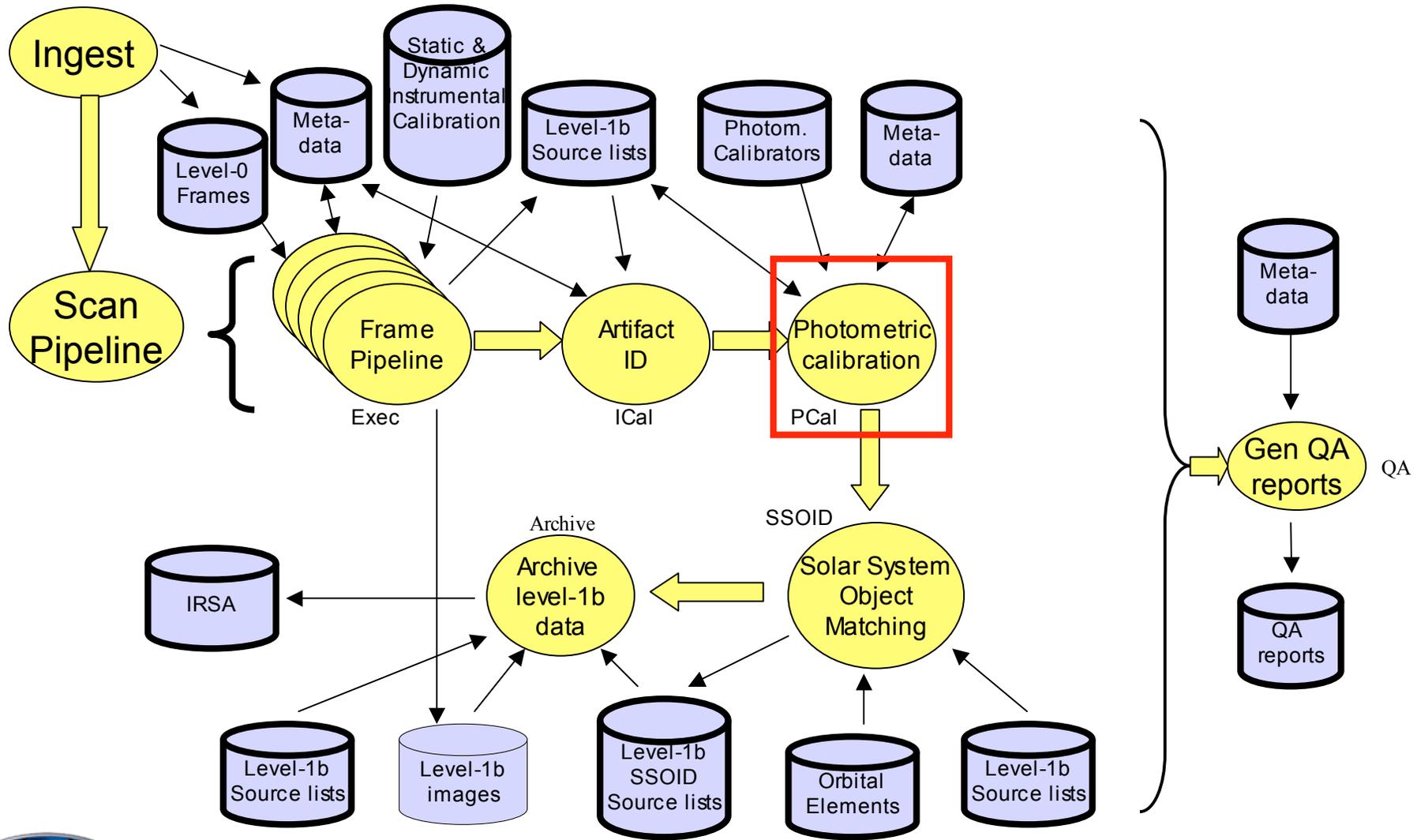
Convert instrumental (*e.g.* engineering units) source brightness measurements into physical units

## Overall requirements:

Put brightness measurements of all WISE sources onto a common, uniform scale defined by a network of photometric standard stars



# WSDS Scan Pipeline Functional Block Diagram





# Driving Requirements



Phot Cal

<b>L4WSDC-012</b>	Flux measurements in the WISE Source Catalog shall have a SNR of five or more for point sources with fluxes of 0.12, 0.16, 0.65 and 2.6 mJy at 3.3, 4.7, 12 and 23 micrometers, respectively, assuming 8 independent exposures and where the noise flux errors due to zodiacal foreground emission, instrumental effects, source photon statistics, and neighboring sources.
<b>L4WSDC-013</b>	The root mean square error in relative photometric accuracy in the WISE Source Catalog shall be better than 7% in each band for unsaturated point sources with SNR>100, where the noise flux errors due to zodiacal foreground emission, instrumental effects, source photon statistics, and neighboring sources. This requirement shall not apply to sources that superimposed on an identified artifact..
<b>L4WSDC-015</b>	The WISE Source Catalog shall contain the measured in-band fluxes or flux upper-limits in the four WISE bands for objects detected in at least one band in the WISE Atlas Images.
<b>L4WSDC-022</b>	The photometric calibration of the final WISE Image Atlas shall be tied to the photometric calibration of the final WISE Source Catalog.
<b>L4WSDC-045</b>	The WSDS Pipeline processing shall measure the brightness of sources detected on the calibrated WISE images relative to the brightness of calibration stars measured on-orbit.

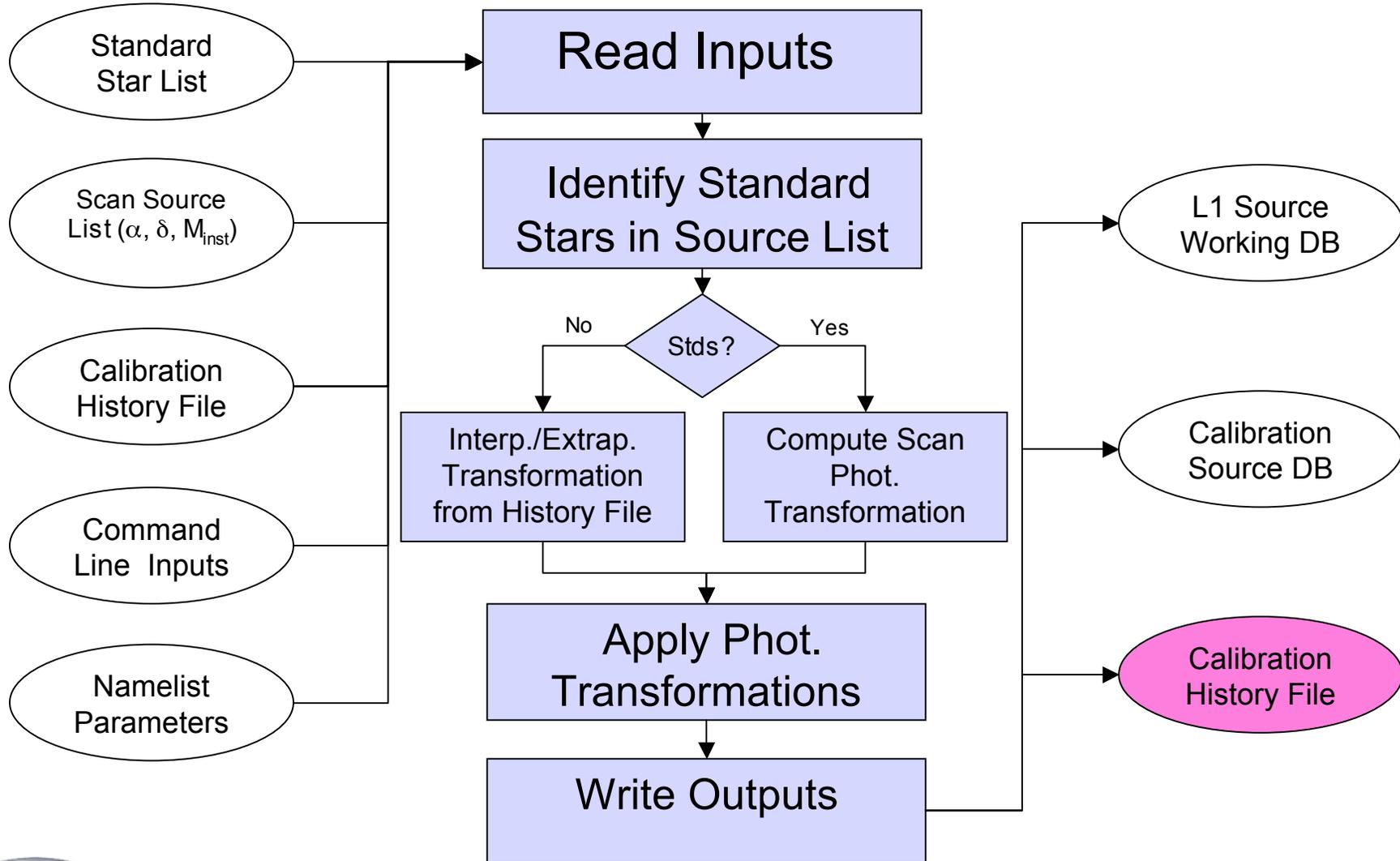




# Photometric Calibration Process Flow



Phot Cal





# Photometric Calibration Derived from Measurements of Standard Stars



Phot Cal

- Primary standard stars located within 1 WISE FOV of the north and south ecliptic poles
  - Measured during every pole passage if WISE is not performing downlink maneuver or other engineering activity (typically ~20-25 times/day)
  - Bootstrap calibration to large number of secondary standards in each field
- There may also be “occasional” standards outside of the polar fields
- Photometric zero point offset (ZP) for a given scan/orbit is equal to the average difference between the “true” and measured instrumental magnitudes for all standard stars in one or more scans:

$$ZP = \langle m_{\text{true}} - m_{\text{inst}} \rangle$$

- Photometric transformations applied to source instrumental photometry and images for all sources detected in appropriate period
  - For preliminary processing: Calibration measurement made closest in time
  - For final processing: Calibration interpolated in time between observations





# Optional Improvements



Phot Cal

- Derive color-terms to convert in-band flux measurements to monochromatic flux densities
  - WISE Source Catalog will quote effective in-band fluxes/magnitudes (as opposed to monochromatic flux-density), so color-terms are not required. Optionally provide a flux density for each band.
- Derive sub-scan timescale zero point corrections using photometric residuals of sources in cross-scan (*i.e.* orbit-to-orbit) overlap regions
  - Multiframe pipeline QA will monitor photometric calibration stability between pole passages using photometric residuals of sources in orbit-to-orbit overlap regions. Consider deriving and applying short timescale ZP corrections from these residuals, if necessary.





# Photometric Calibration Receivables



- Standard star network
  - To be generated by the WISE Science Team and delivered to the WSDC
  - Accurate positions and flux densities in four WISE bands for several high SNR (in WISE measurements) point sources within the area covered by one WISE FOV centered on the north and south ecliptic poles
  - Additional standards distributed around sky (particularly for 23 $\mu$ m because suitable objects not available in ecliptic pole fields)
  - Derived from existing Spitzer IRAC calibration network and from new Spitzer photometric (IRAC/MIPS) and spectroscopic (IRS) observations (WISE team submitted DDT proposal), and supported with ground based optical photometry and spectroscopy
- Status
  - Spitzer IRAC and MIPS observations complete, data in hand, reduction and analysis has been started
  - Preliminary list delivered (positions, approximate fluxes) - 6/08
  - Final list delivered (final fluxes) - 5/09





# Calibration Peer Review Recommendations (9/28/07)



Recommendation	Response
The Board recommends an increase in the priority in the selection of more secondary standards scattered throughout the sky that can be used to monitor these latent image or varying background calibration effects	PCAL will be designed to use standard stars at arbitrary positions on sky available, and incorporate into photometric solutions.
Applying zero point measured for each scan may introduce photometric scatter if system is highly stable (e.g. IRAC and MIPS on Spitzer)	PCAL will be designed to optionally use a “library” zero point. Zero point will always be measured from every possible orbit as a QA diagnostic and for trending, but will have option to apply a pre-determined zeropoint derived from long-term averages (or trended values)





## IOC Tasks



Phot Cal

- Determine initial *instrumental* zero points
- Filter primary calibration star network, if necessary
  - Confusion, contamination from artifacts, outliers in zp solution
- Develop secondary standards in “touchstone” fields (NEP, SEP) by bootstrapping calibration from primary standards
- Optimize zero point determination time window, modulo annealing, and other survey activities

Requires off-line analysis of standard scan/frame pipeline output and existing astronomical analysis software packages





# Development Schedule



Phot Cal

- WSDS v1 (prototype 4/29/08) - Basic architecture; source table, calibration star table and output interfaces,
- WSDS v2 (12/17/08) - Standard star matching algorithms, basic zero-point computation, QA diagnostics
- WSDS v3 (7/7/09) - Final standard star list update, Scan-scan overlap monitoring; use of secondary standards
- WSDS v3.5 (12/30/09) - Parameter tuning; IOC zero point values; standard star filtering; secondary standard calibration
- WSDS v4 (9/20/10) - Final processing; trended zero points; disable scan zero point fitting if appropriate





## Liens/Concerns



- Absence of bright WISE band 4 standard stars in the ecliptic pole “touchstone” fields
- How to optimally use “occasional” standards
- Update of zero points during Multiframe pipeline

