Photometric Calibration (PCAL)

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Overview

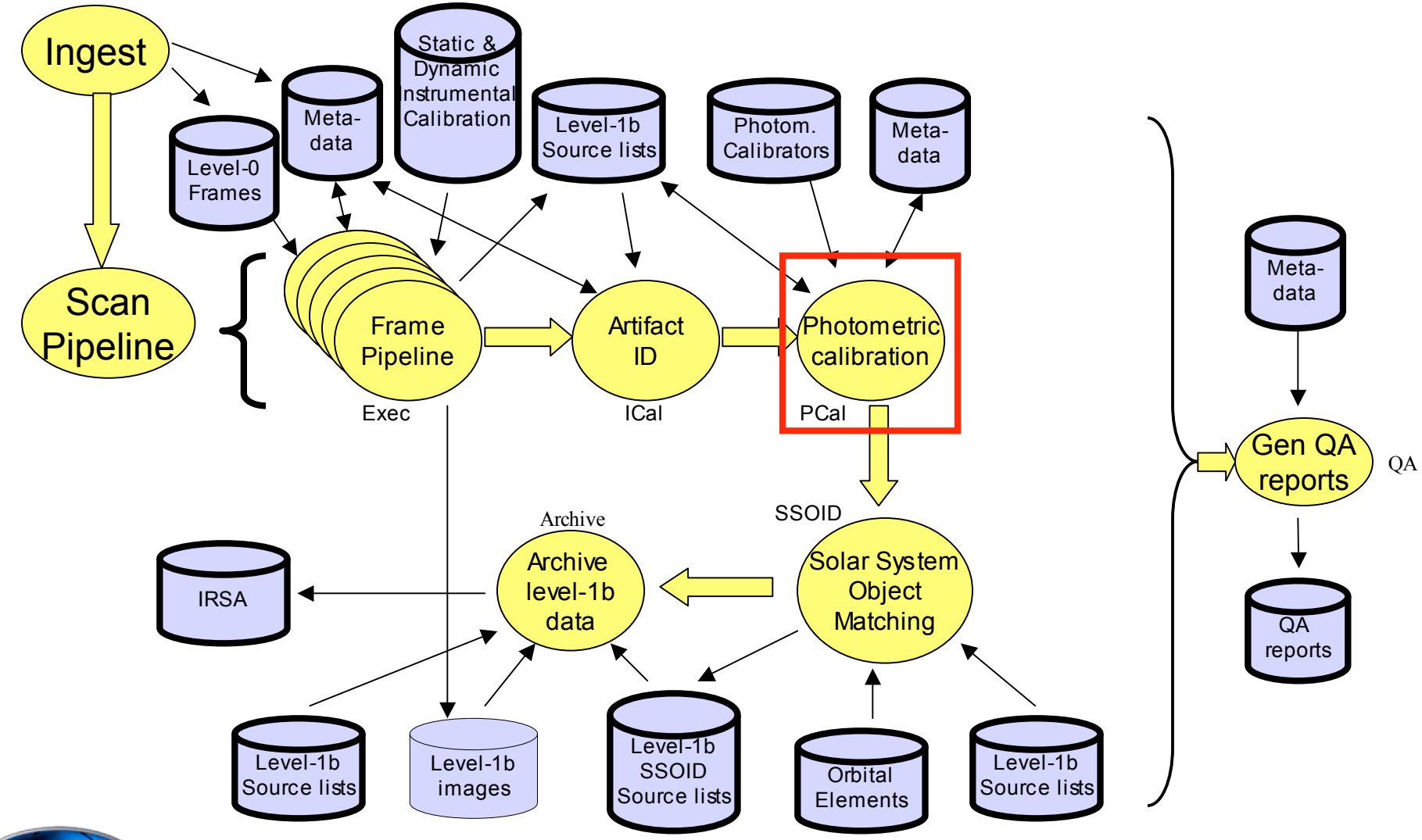
Purpose of PCAL:

Convert instrumental 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



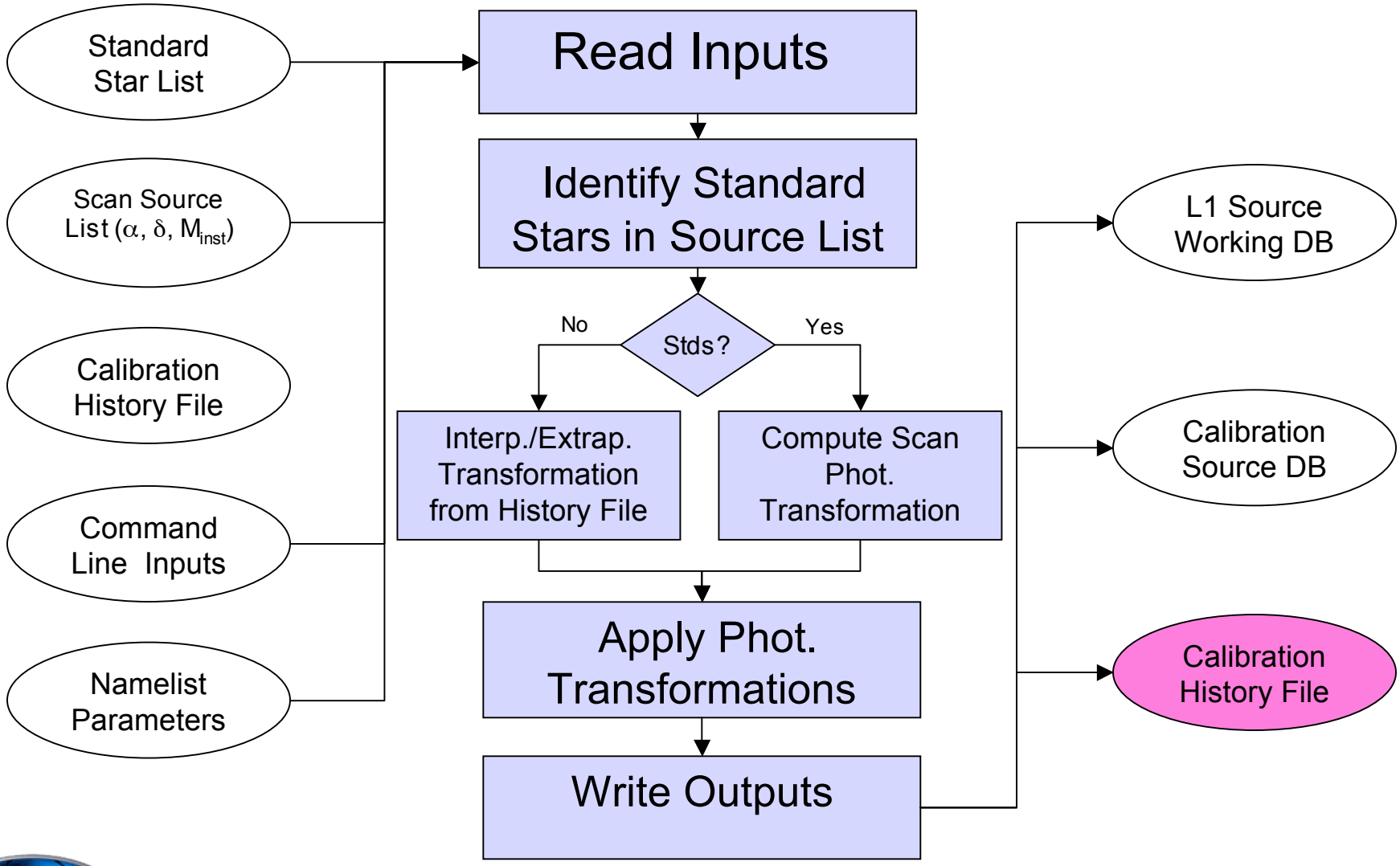
Driving Requirements

L4WSDC-012	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.
L4WSDC-013	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..
L4WSDC-015	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.
L4WSDC-022	The photometric calibration of the final WISE Image Atlas shall be tied to the photometric calibration of the final WISE Source Catalog.
L4WSDC-045	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.

Design Considerations

- Source brightnesses will be quoted in magnitudes in the WISE Source Catalog
  - Avoids need for absolute flux calibration
- Source brightness will be measured in natural WISE system (no transformations to existing photometric systems)
  - Calibration aims to be consistent with Spitzer by system adopting many of the same standards as used for IRAC and MIPS
- Effectively measure in-band fluxes/magnitudes (as opposed to monochromatic flux-density), so color-terms should not be necessary

Photometric Calibration Process Flow



Photometric Calibration Derived from Measurements of Standard Stars

- 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)
- 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 sets of ecliptic pole observations:

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

- Photometric transformations applied to source instrumental photometry and images
  - For preliminary processing: Calibration measurement made closest in time
  - For final processing: Calibration interpolated in time between

Optional Improvements

- Develop network of secondary standard stars in each polar region by bootstrapping from primary standard star network
  - Improves statistical accuracy of zeropoint measurement from individual pole obserations

- QA diagnostic in Multiframe pipeline 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 residual, if necessary

Photometric Calibration Receivables

- Standard star network
  - To be generated by the WISE Science Team and delivered to the WSDC (M. Cohen, T. Jarrett, D. Padgett)
  - Selection of point sources within the area covered by one WISE FOV centered on the north and south ecliptic poles
  - Accurate positions and flux densities in four WISE bands
  - Derived from existing Spitzer IRAC calibration network and from new Spitzer photometric (IRAC/MIPS) and spectroscopic (IRS) observations (WISE team submitted DDT proposal)
  - Supported with ground based optical photometry and spectroscopy
- Status
  - Spitzer IRAC and MIPS observations complete, data in hand
  - Reduction and analysis has been started

Recommendation: If photometric response of payload is stable (as seen in Spitzer IRAC and MIPS data), then applying zero points measured using a small number of stars from individual scans/orbits scan may actually *introduce* photometric scatter

Response: PCAL will be designed to optionally use a "library" zero point. While PCAL will always measure the zero point from every possible orbit as a QA diagnostic and for trending, we will have the option to apply a pre-determined zeropoint derived from long-term averages (or trended values)

IOC Tasks

- 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

Development Schedule

- Calibration Peer Review - conceptual design
- WSDS v1 (PCAL prototype 4/2/08) - Basic architecture; source table, calibration star table and output interfaces, matching algorithms
- WSDS v2 - zero-point computation, QA diagnostics
- WSDS v2 - Scan-scan overlap monitoring; use of secondary standards
- WSDS v3 -
- WSDS v3.5 - Parameter tuning; IOC zero point values; final standard star selection; secondary standard identification
- WSDS v4 - Final processing; trended zero points; disable scan zero point fitting if appropriate

Issues/Concerns

- Absence of bright WISE band 4 standard stars in the ecliptic pole “touchstone” fields