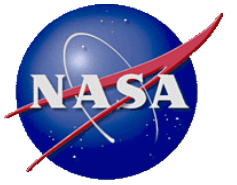
National Aeronautics and Space Administration



NASA Observations for IADC WG1 Action Item 23.2: INVESTIGATION OF HIGH AREA TO MASS DEBRIS IN HIGHER EARTH ORBITS

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Johnson Space Center, Houston, Texas.

AI 23.2

- **Optical observations of High Area to Mass Ratio (HAMR) objects**
  - Astrometry
  - Photometry

- **NASA will report on calibrated photometry of 5 HAMR objects plus calibration objects. Multiple observation sequences.**

- **TLEs provided by ESA and ROSCOSMOS delegations.**

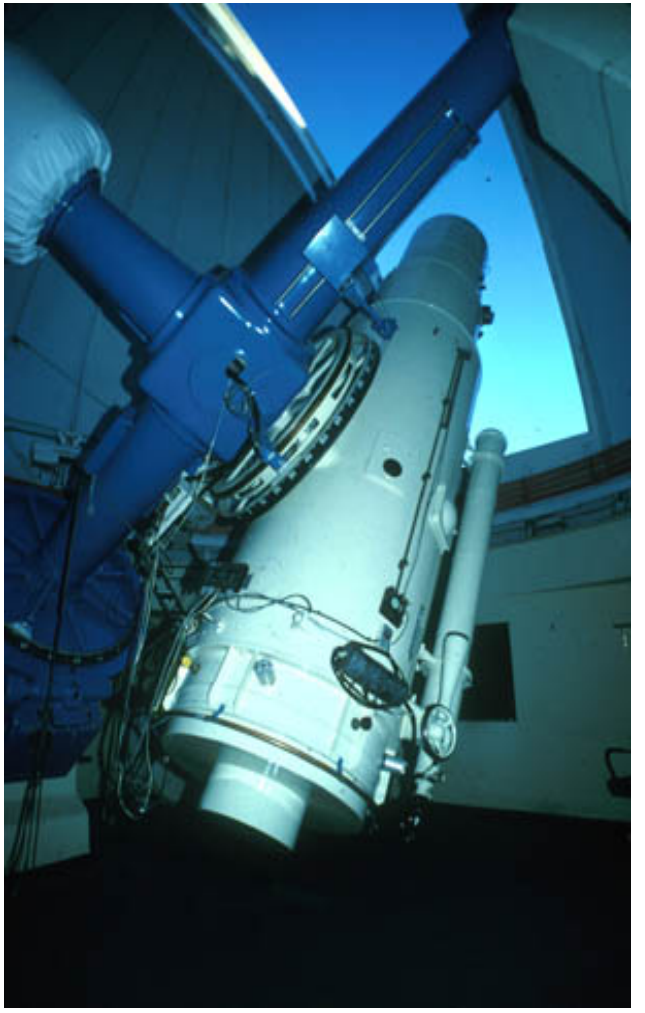
- **All observations obtained with MODEST: 0.6-m Curtis-Schmidt telescope at Cerro Tololo Inter-American Observatory, Chile. IADC code 10222**

- **All reported observations obtained on photometric nights, and calibrated with observations of Landolt (2009) standard stars.**

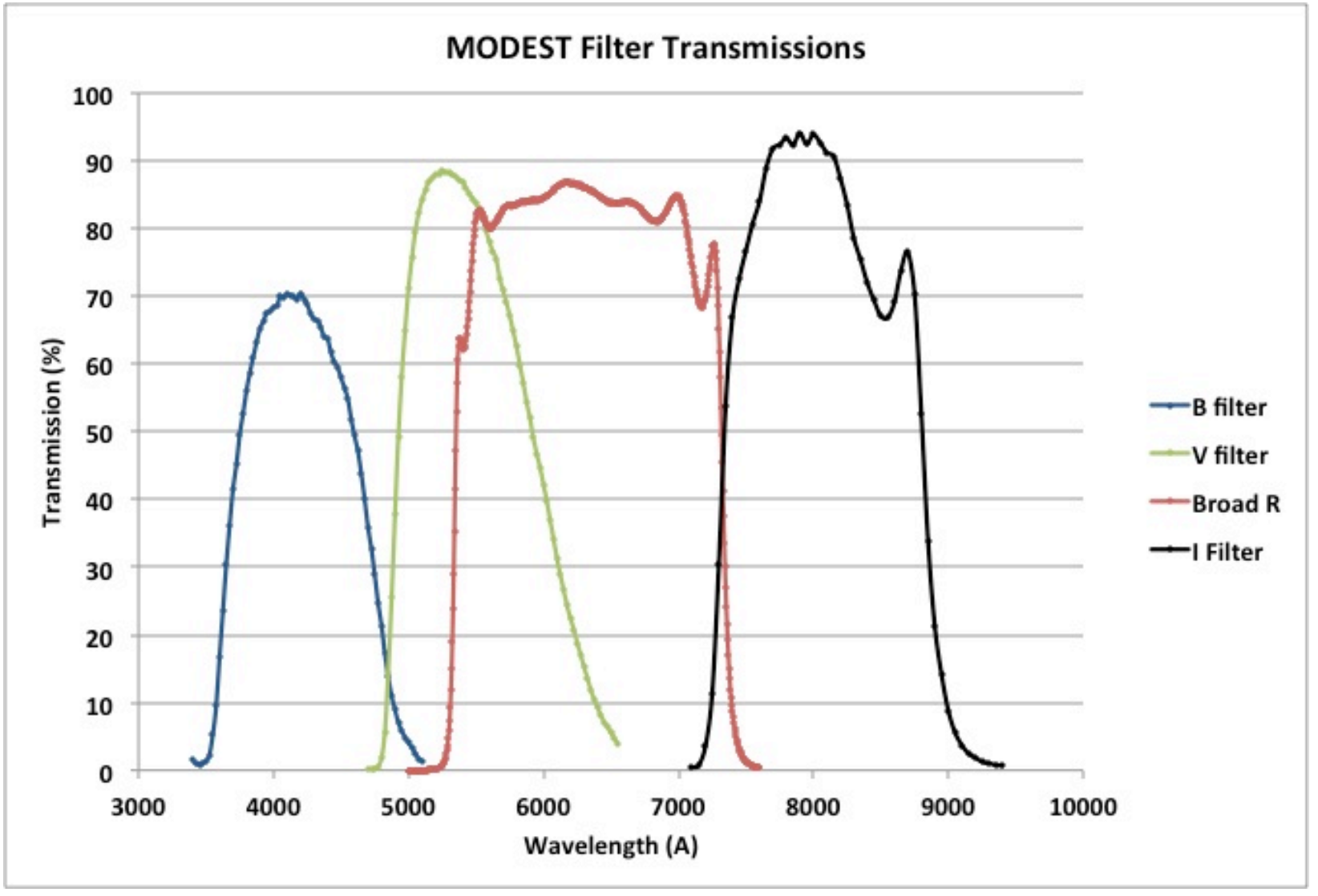
- **Each filter reduced independently for zeropoint, extinction, and color term.**

MODEST 0.6-m, Cerro Tololo, Chile

W 70.8 S 30.2



MODEST Filters



Photometric reduction

- **Landolt (2009) standard stars used for absolute calibration: observed stars with a minimum of 6 observations on 3 different nights by Landolt.**

- **Photometric equation solved for in each filter**

$$mag_{calibrated} = mag_{instrumental} - kX + a(B - V) + zp$$

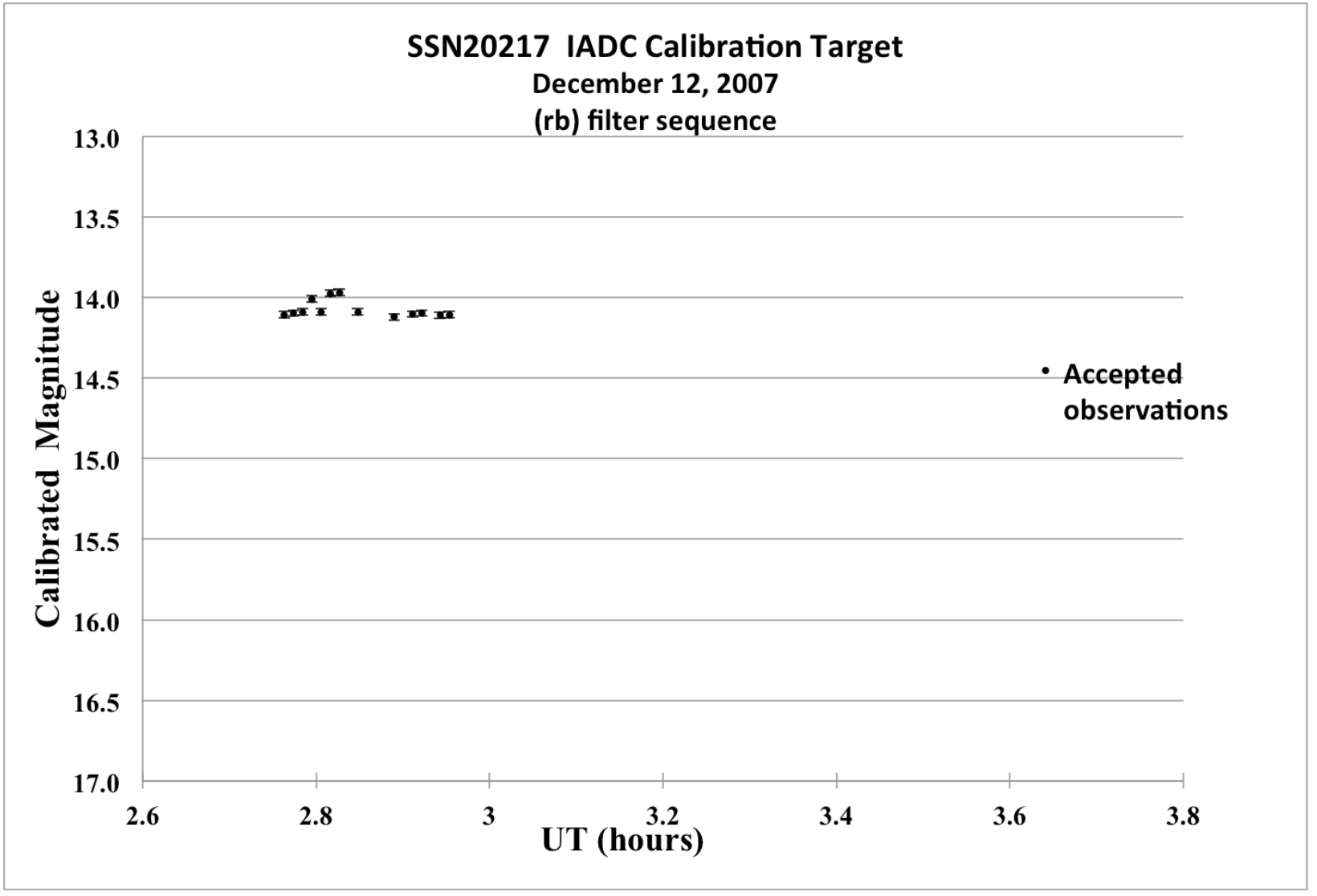
- **Separate extinction (k), color term (a), and zeropoint (zp) solved for each filter independently.**

- **Typical errors in photometric solution for each night < 0.02 mag.**

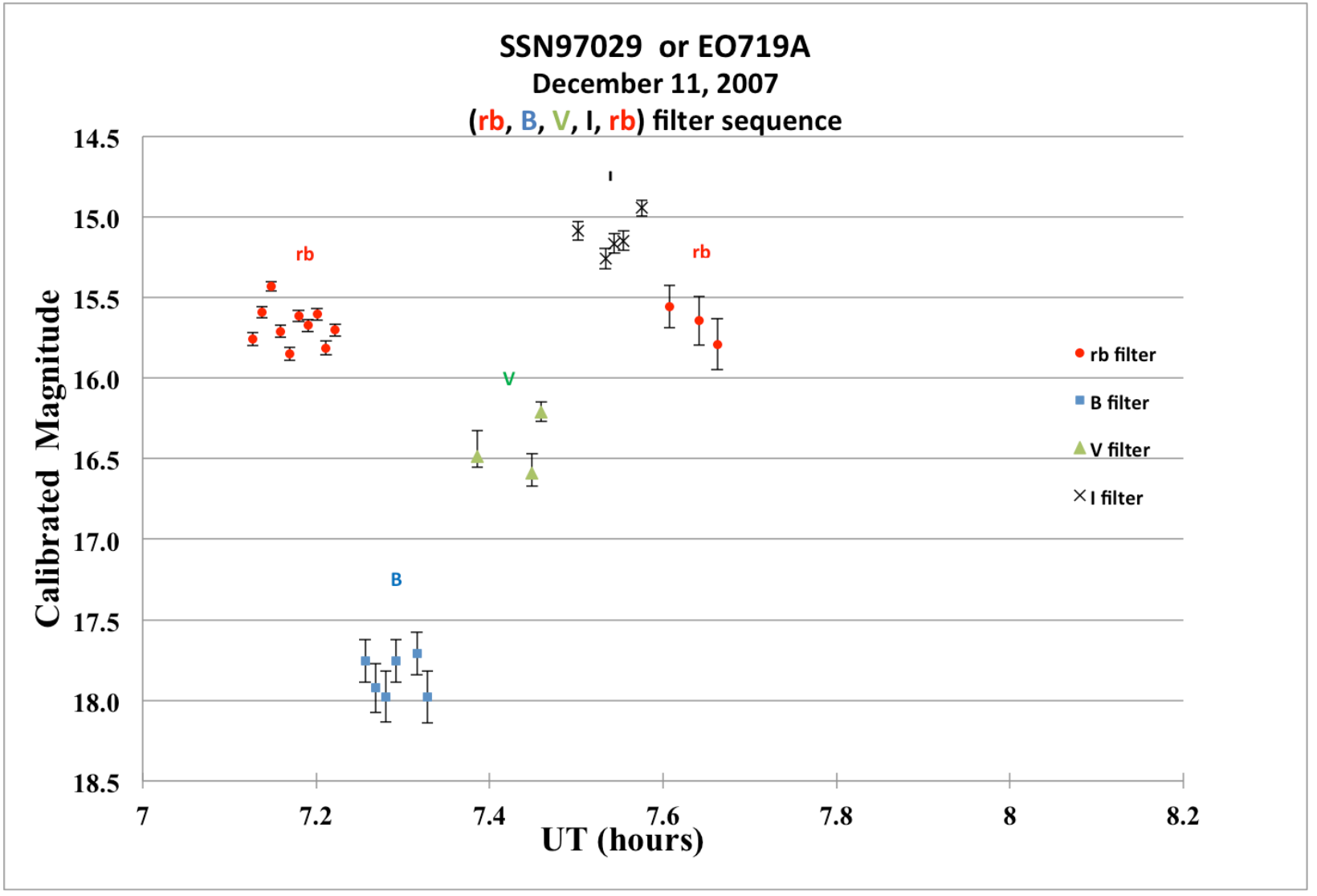
- **All observations manually reviewed for star streaks in photometric aperture.**

- **For object reductions: assumed solar color. True color unknown.**

AI 23.2 Calibrated Results



AI 23.2 Calibrated Results



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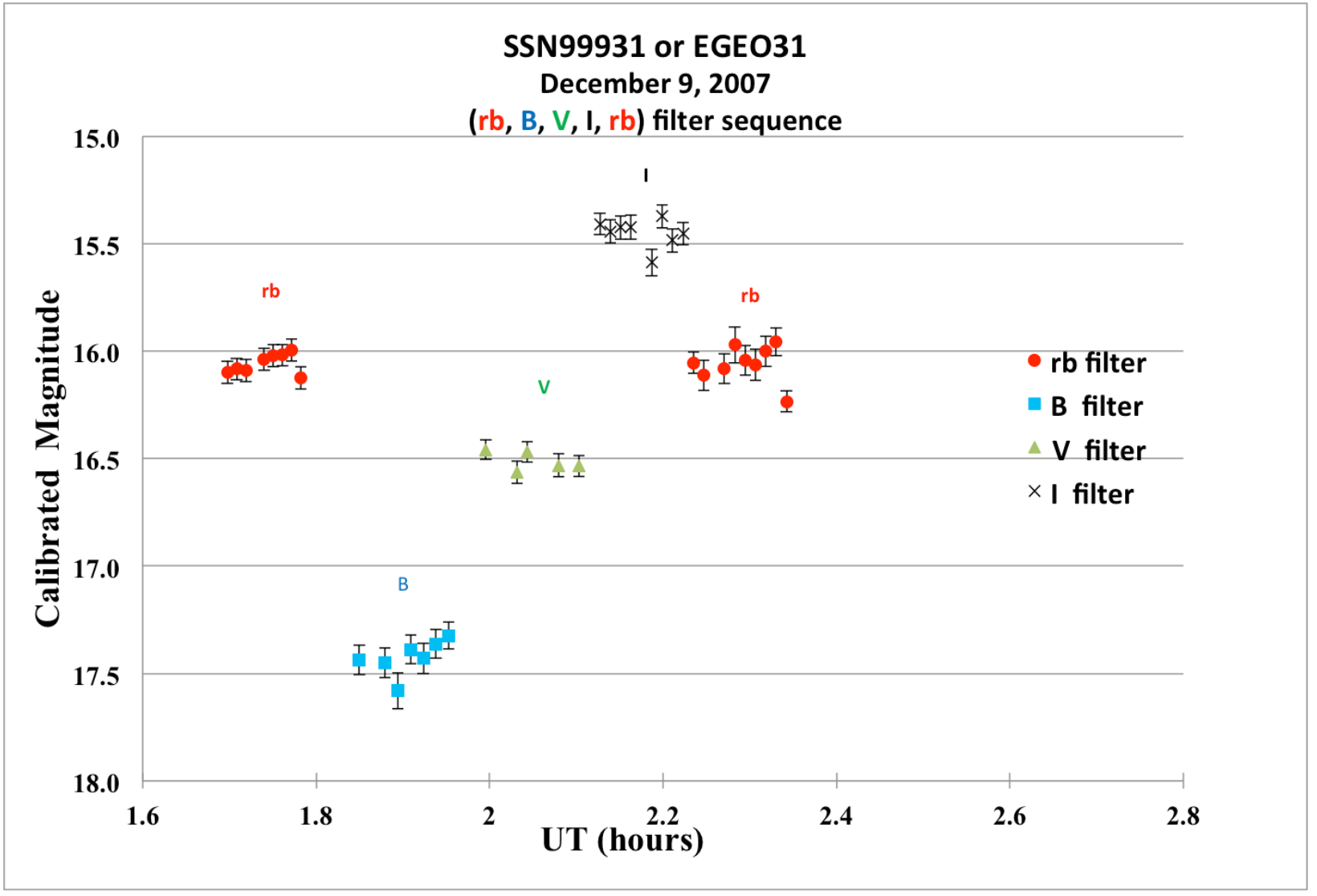

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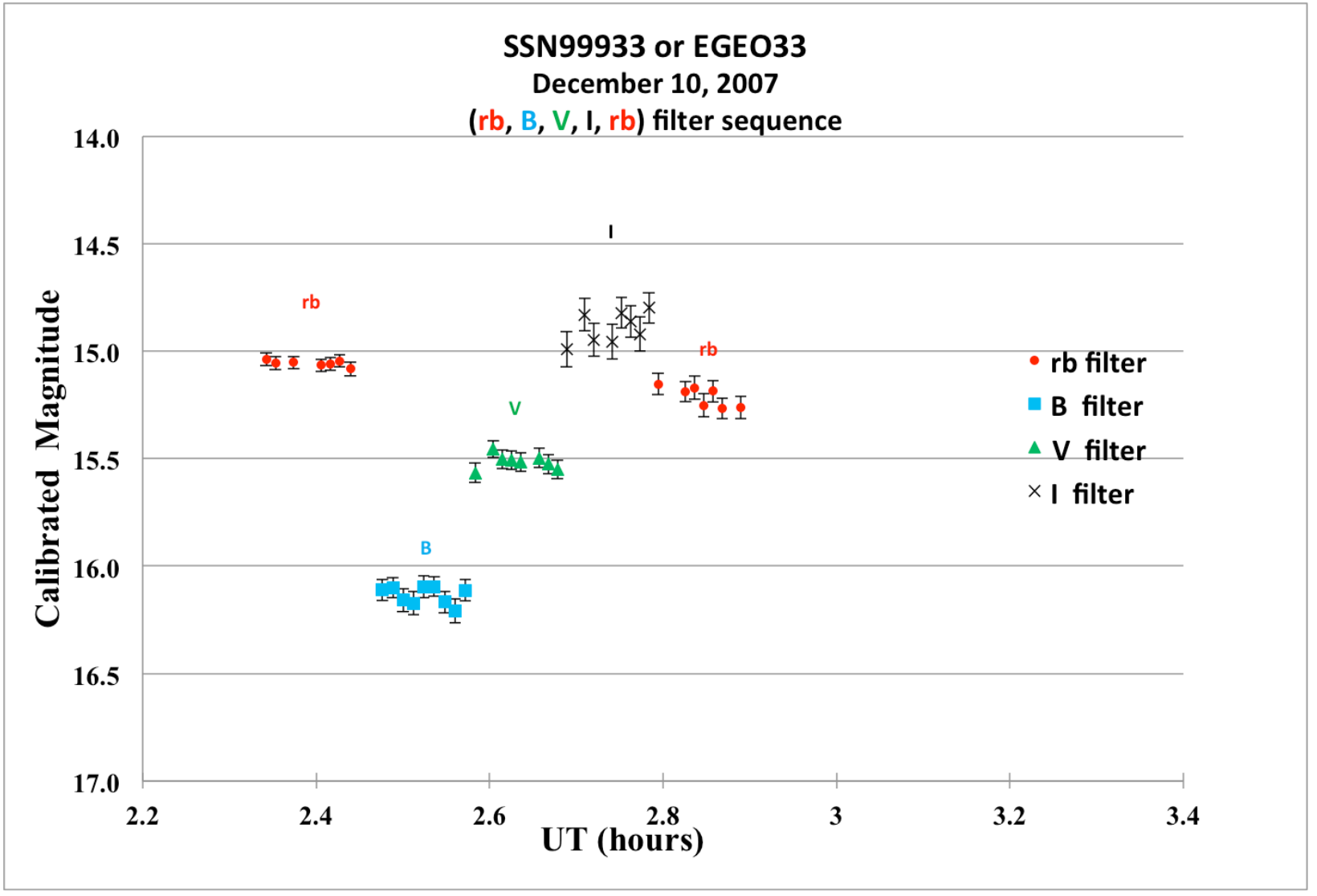

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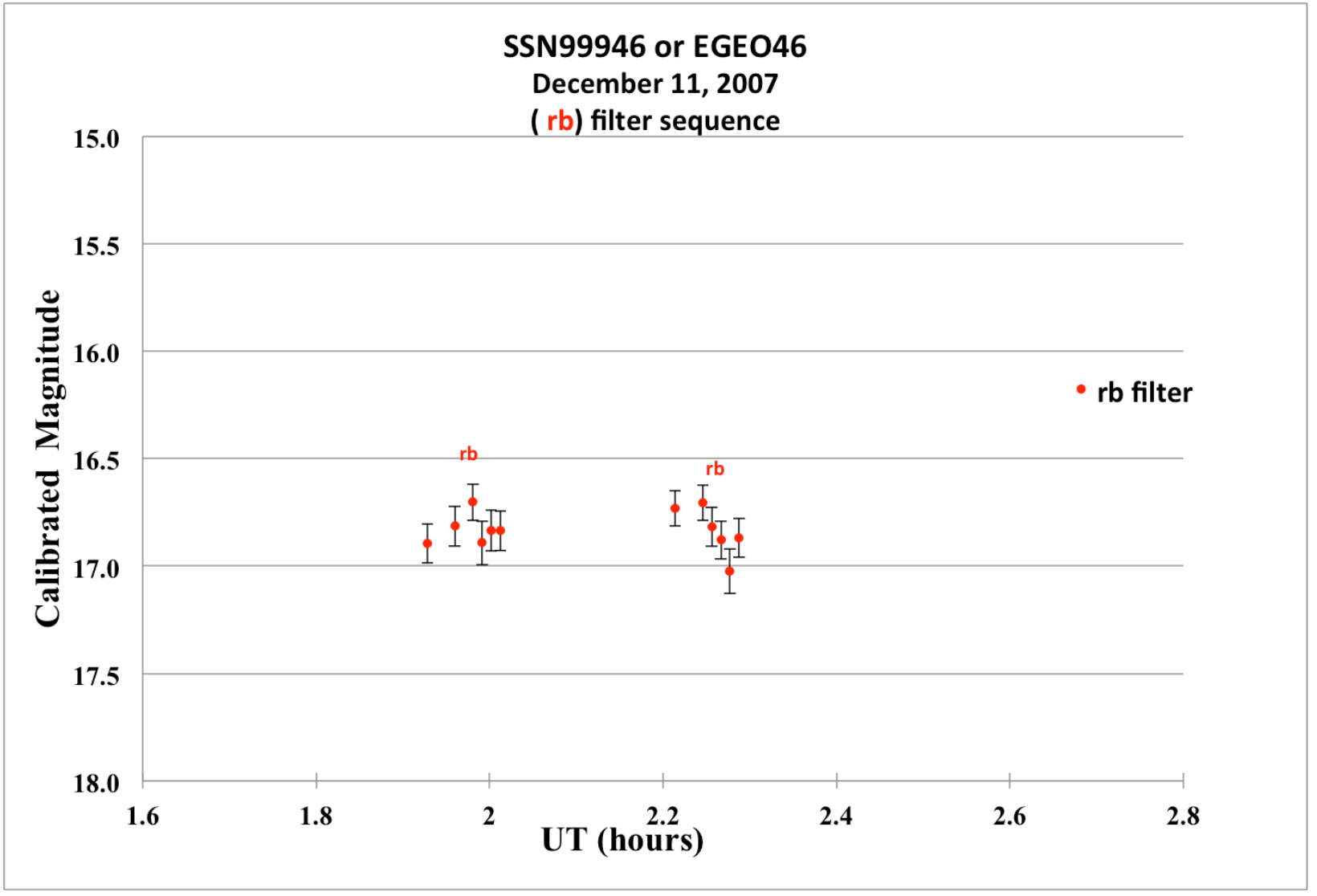
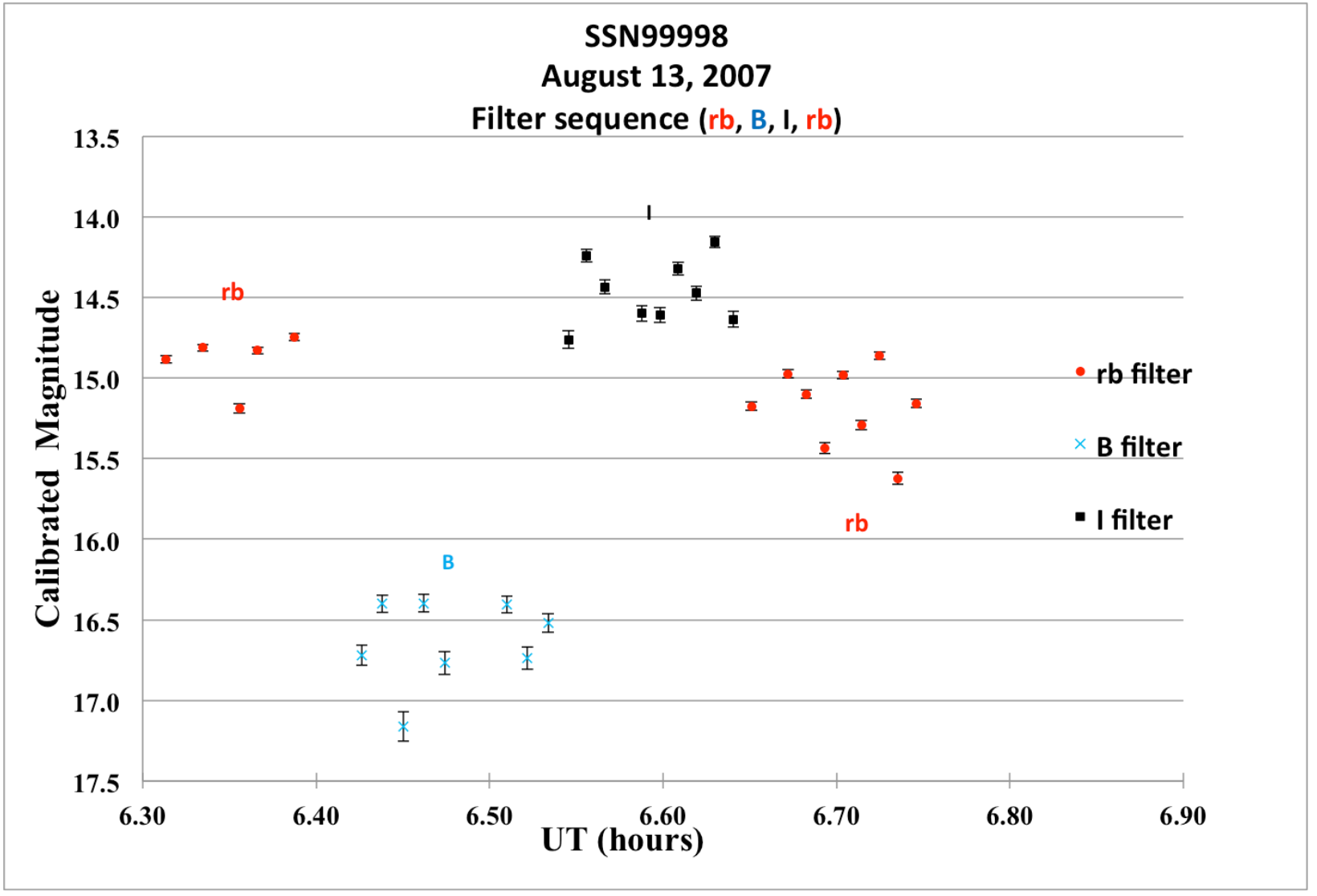
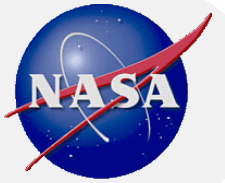


Al 23.2 Calibrated Results



Summary



- **Primary shortcoming is that observations in each filter are obtained independently. If object is tumbling, then the object presents different aspect to observer at different times and in different filter.**

- **Variability in excess of photometric errors common – note plot of 99998 just presented.**

- **No correction for changing topocentric solar phase angle has been applied.**