## A preliminary comparison of MAARSY head echo measurements simultaneously detected with optical instrumentation

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The measurement of fundamental meteoroid properties, such as mass, bulk density and chemistry from meteor observations is difficult. Arguably the most fundamental of these characteristics, meteoroid mass. remains particularly challenging, despite its obvious importance to almost all meteor studies. Poorly constrained luminous, ionization and acoustic efficiencies may lead to order of magnitude uncertainties in meteoroid mass. Inference of mass from deceleration measurements are complicated by fragmentation and require high precision metric data.

Absolute mass estimates and technique specific uncertainites can best be validated through multiinstrumental, simultaneous measurements of the same events. In this study we summarize the initial results of a two year (Sept, 2014 - April, 2016) campaign of simultaneous optical and head echo measurements from Andoya, Norway. Continuous radar head echo observations by the Middle Atmosphere Alomar Radar System (MAARSY) are correlated with automated meteor optical measurements from two stations. Each optical station consists of a wide field (15x11 degrees) NTSC video frame rate camera co-aligned with a narrow-field (6 degree circular field of view) image intensified digital video system operating at 50 fps. The former detects meteors to peak R magnitude +4, the latter to V magnitudes of +9. The optical systems overlap a common atmospheric volume in the MAARSY main beam at 95 km altitude.

Over 200 events were simultaneously detected as head echoes by MAARSY and one or more optical cameras, based on a comparison of absolute timing and direction between optical and radar detected meteors. Reduction of a subset of 66 of the highest quality simultaneous events (where both optical / radar data provide independent trajectory solutions and the intersection geometry for optical stations is good and trail lengths are long enough for reliable speed determination) allow for an estimate of astrometric consistency in trajectory.

We find a median radiant and speed difference of 1.4 deg and 0.3 km/s, respectively, between head echo and optical meteor trajectory estimates. On average the radar head echoes show initial detections  $\sim$ 2km higher than optical first detection, but the optical trajectory ends on average  $\sim$ 2 km lower than head echoes detectable to the radar.

Initial photometric, ionization and mass comparisons will be presented and systametic differences between optical and radar head echo measurements noted to date will be highlighted together with possble explanations.



Figure 1. A video stack showing an example wide-field optical Quadrantid (peak R-magnitude +3) detected also by MAARSY on Jan 4, 2016. The optical trail is indicated as a series of black dots (one per video field) in this case moving from the center of the field of view to the lower left of the image. The equivalent plane of sky location per pulse measured from MAARSY interferometry of the head echo is shown as a series of green points. The inner blue circle shows the location of the half power point of the main beam of MAARSY, while the outer purple circle shows the location of the first null of the the radar beam. Here the head echo is visible earlier (to the upper right) than the first optical registartion of the meteor.