Guide to NRES Target Acquisition Strategies

Summary: This document describes the two methods of NRES target acquisition as well as their limitations. Users should   request the BRIGHTEST acquisition mode unless (i) the field is crowded, or (ii) the target is faint.

Background

NRES target acquisition is an automatic process and depends on image analysis by software. The position of the fiber (that feeds the spectrograph) in the image has already been measured. To place and then keep a star on the fiber, every NRES observation involves three phases:

1. GROSS acquisition, to place the target star *near* the fiber.
2. FINE acquisition, to center the star on the input fiber.
3. Guiding on the target during the science exposure.

The behavior in the acquisition process can be selected by the observer. There are two acquisition strategies: BRIGHTEST and WCS.

BRIGHTEST acquisition mode

The default acquisition mode, BRIGHTEST, operates as follows:

1. GROSS acquisition:
   a. If the target star is identified as a single isolated very bright star in a UCAC4 catalog query, the brightest object in the acquisition image is identified and moved to the fiber pinhole[1]. The star must be the brightest star by 2 magnitudes within 12' field of view and be brighter than about 6th mag.
   b. If the target is not the single, brightest star, a WCS solution is derived and pointing offsets are applied to place the target coordinates on the fiber pinhole. If the WCS solution fails on the guide camera, an offset field is observed and a WCS solution is derived there[2].

2. FINE acquisition:
   The brightest object nearest to the fiber pinhole is identified and placed onto the pinhole; light lost into the science fiber is taken into account when centering the target.

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[1] This special treatment of isolated extremely bright stars addresses the problem that an astrometric solution often fails around those stars - either because of limitations in the reference catalogs, or difficulties extracting stars from an image dominated by a very bright source.

[2] In general, the conditions that prevent a WCS solution to the target field (e.g. high stellar density, bright moon light) will often also foil a WCS solution at the offset field.

This acquisition mode works well for most isolated, bright stars. Known limitations of this mode are:

- Stars near (about < 10" separation) the target will confuse the fine acquisition, and will likely cause the fiber pinhole to be positioned between the two objects.

- Fine acquisition depends on the visibility of the wings of the target's PSF around the fiber pinhole. For fainter targets (>10th magnitude), the PSF wings are not visible around the pinhole, and the acquisition can fail even though (in fact, *because*) the target was successfully centered on the fiber.

WCS acquisition mode

The alternative acquisition mode, WCS, operates as follows:

1. GROSS acquisition:
   A WCS solution is derived and pointing offsets are applied to place the target coordinate on the fiber pinhole. If the WCS solution fails on the guide camera, an offset field is observed, and a WCS solution is derived there.

2. FINE acquisition:
   A WCS solution is derived and pointing offsets are applied to place the target coordinate on the fiber pinhole.

The limitations of this mode are:

- Success depends on a valid astrometric solution of the acquisition images, which has proven to be difficult around very bright stars or in sparsely populated fields.

- The target coordinates must be accurate and include a proper motion description since there will be no attempt made to identify the target in the image.

Selecting of Acquisition modes

The acquisition mode can be selected in the Configuration section of the request compose page by choosing the "Acquire Mode" via a drop down menu. The choices are *Brightest Object NRES* and *Target Coordinates NRES*:

For API requests, the `acquisition_config` field should be populated in the `configuration` field of a request and set to either `WCS` or `BRIGHTEST`:

```
"configurations": [
    {
        "id": 5728211,
        "constraints": {
            "max_airmass": 3.0,
            "min_lunar_distance": 20.0,
            },
        "instrument_configs": [
            {
                "exposure_time": 120.0,
                "exposure_count": 1,
                "bin_x": 1,
                "bin_y": 1,
            }
        ],
        "acquisition_config": {
            "mode": "WCS"
        }
    }
    ...
```

For most targets, the default BRIGHTEST acquisition mode should work satisfactorily. The WCS acquisition mode should be selected for targets fainter than ~10th magnitude and targets which might be confused with nearby (<10") stars.