# 16882 - High-resolution ACS/WFC Imaging of Compact Stellar Systems in the Virgo Cluster in Support of JWST Cycle 1 Science

Cycle: 29, Proposal Category: GO

(Availability Mode: SUPPORTED)

**INVESTIGATORS**



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**VISITS**

| *Visit* | *Targets used in Visit* | *Configurations used in Visit* | *Orbits Used* | *Last Orbit Planner Run* | *OP Current with Visit?* |
|---|---|---|---|---|---|
| 01 | (8) UCD761-OFFSET | ACS/WFC | 1 | 07-Jan-2022 17:00:51.0 | yes |
| 02 | (2) UCD218 | ACS/WFC | 1 | 07-Jan-2022 17:00:52.0 | yes |
| 03 | (3) UCD736 | ACS/WFC | 1 | 07-Jan-2022 17:00:53.0 | yes |
| 04 | (4) UCDE372 | ACS/WFC | 1 | 07-Jan-2022 17:00:53.0 | yes |

| *Visit* | *Targets used in Visit* | *Configurations used in Visit* | *Orbits Used* | *Last Orbit Planner Run* | *OP Current with Visit?* |
|---|---|---|---|---|---|
| 05 | (5) UCDE374 | ACS/WFC | 1 | 07-Jan-2022 17:00:54.0 | yes |

5 Total Orbits Used

**ABSTRACT**

A rich system of thousands of compact stellar systems (CSSs) including globular clusters (GCs), nuclear star clusters (NSCs), ultra-compact dwarf galaxies (UCDs), and compact elliptical galaxies (cEs) permeate the nearby (16.7 Mpc) Virgo galaxy cluster. CSSs are very useful as they are observationally easily accessible, and effectively trace the descendants of former diffuse systems disrupted in violent galaxy cluster environment. CSSs have interconnected (often galactic) formation histories, and - in a growing number of examples - have recently been found to harbor super-massive black holes (SMBHs), confirming their utility in representing remnant nuclei of formerly more massive galaxies tidally stripped of their outer stellar sheaths. These discoveries imply that CSSs may represent a rich population of targets in which to search for so-called "intermediate"-mass BHs (IMBHs) - a class whose demographics are generally unknown. A systematic search for massive BHs in CSSs in a cluster environment has been prohibitively expensive using current ground- or space-based facilities; however, this opportunity has been opened up with the imminent launch of JWST, on which >40 hours were awarded in Cycle 1 to conduct such a search. Here we propose preparatory HST+ACS/WFC3 observations to obtain high-resolution imaging for a small number of the planned JWST targets for which archival HST imaging is not available. These images will be crucial in maximizing the scientific value of the upcoming JWST observations by enabling the construction of 3D de-projected CSS luminosity profiles, a necessary component for stellar dynamical modeling and meaningfully constraining central BH properties.

**OBSERVING DESCRIPTION**

This is a straight-forward imaging program to maximize the scientific potential of upcoming JWST Cycle 1 observations. Specifically, we request five orbits using HST+ACS/WFC to obtain deep imaging of five compact stellar systems (CSSs) in the Virgo galaxy cluster in the two F475W and F850LP filters. These filters are chosen to provide color informations to estimate color/metallicity profiles, given their high throughput and ability to enable precise age/metallicity estimates based on their modelled stellar populations. We choose these filters to complement the large-scale, already completed ACSVCS program (HST GO-9401).

We request a single orbit for each target, where visibility for targets in Virgo is about 3200s. Working within this constreaint and being mindful of telescope overheads, we will split each visit into exposures of 800s in F475W, and 1280s in F850LP, and apply CR-SPLIT2 to aid in cosmic ray removal. These exposure times will reach depths sufficient to reach old, metal-poor stellar popluations in each filter while fitting each target into a

single HST orbit. Using this setup, we run two simulations in the ACS Imaging ETC, for each filter and respective exposure time. Given that we have ground-based measured photometric profiles for all our targets, we adopt an extended source with size and luminosity corresponding to UCDe372 - our most extended and faintest target - so that the ETC estimate will be under-estimates of the expected data quality for the remaining targets. Specifically, we assume a source with a half-light radius of 0.415" and integrated g'=19.4 mag, and use a 0.1" circular aperture for signal extraction. Furthermore, we assume a Brzual + Charlot (2003) 12 Gyr-old SSP spectrum to model the expected old stellar pop0ulations of our targets. We assume E(B-V)=0.024, and otherwise standard presciptions for background levels. With this setup, we achieve S/N=100 and 150 for F475W and F850LP, respectively.

Finally, for target UCD761, we will acquire on a nearby star and apply an offset so that the detector field of view will also include a nearby dwarf galaxy that has not recieved attention from a space-based telescope and thus adds ancillary science to our program.

## Visit

**Proposal 16882, Visit 01, implementation** Fri Jan 07 22:00:54 GMT 2022

**Diagnostic Status: No Diagnostics**

Scientific Instruments: ACS/WFC

Special Requirements: (none)

## Patterns

| # | Primary Pattern | | Secondary Pattern | Exposures |
|---|---|---|---|---|
| (1) | Pattern Type=ACS-WFC-DITHER-LINE<br>Purpose=DITHER<br>Number Of Points=2<br>Point Spacing=3.034<br>Line Spacing= | Coordinate Frame=POS-TARG<br>Pattern Orientation=85.29<br>Angle Between Sides=<br>Center Pattern=false | | (1-2) |

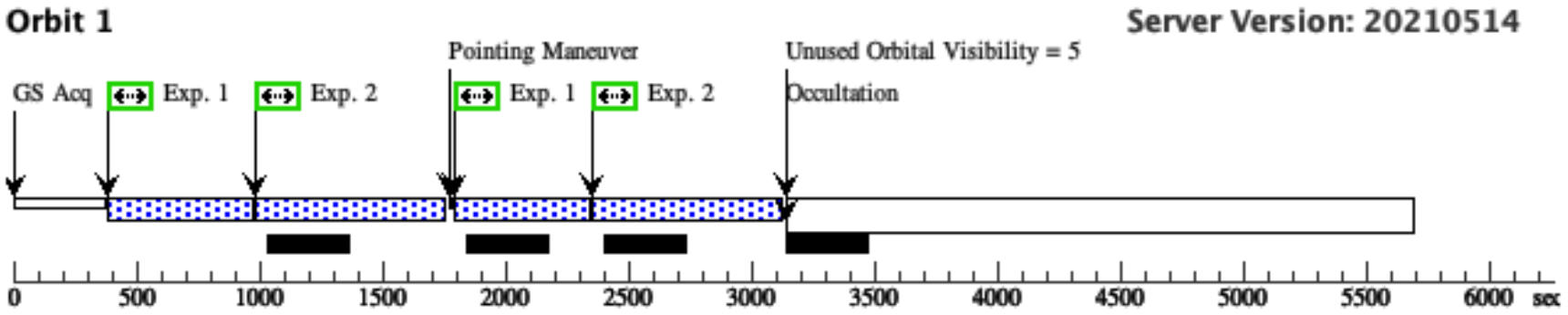
## Fixed Targets

| # | Name | Target Coordinates | Targ. Coord. Corrections | Fluxes | Miscellaneous |
|---|---|---|---|---|---|
| (8) | UCD761-OFFSET | Offset from UCD761-OFFSETSTAR<br>RA Offset: -1.5 Secs<br>Dec Offset: 28.0 Arcsec | | V=13.30 | Offset Position (UCD761-OFFSET) |
| *Comments:*<br>*Category=UNIDENTIFIED*<br>*Description=[UNDESIGNATED]*<br>*Extended=NO* | | | | | |
| (9) | UCD761-OFFSETSTAR | RA: 12 43 56.5340 (190.9855583d)<br>Dec: +11 26 26.58 (11.44072d)<br>Equinox: J2000 | Epoch of Position: 2000 | V=13.30+/-0.1 | Reference Frame: ICRS |
| *Comments: This is an offset star from target UCD761, meant to be acquired on, then offset from (to target UCD761-OFFSET) so that a nearby dwarf galaxy can be included as an ancillary science target.*<br>*Category=STAR*<br>*Description=[UNDESIGNATED]*<br>*Extended=NO* | | | | | |

## Exposures

| # | Label | Target | Config,Mode,Aperture | Spectral Els. | Opt. Params. | Special Reqs. | Groups | Exp. Time (Total)/[Actual Dur.] | Orbit |
|---|---|---|---|---|---|---|---|---|---|
| 1 | | (8) UCD761-OFFSET | ACS/WFC, ACCUM, WFC | F475W | | | Pattern 1, Exps 1-2 in Visit 01 (1) | 800 Secs (770 Secs)<br>*[==>385 Secs (Pattern 1)]*<br>*[==>385 Secs (Pattern 2)]* | *[1]* |
| 2 | | (8) UCD761-OFFSET | ACS/WFC, ACCUM, WFC | F850LP | | | Pattern 1, Exps 1-2 in Visit 01 (1) | 1280 Secs (1220 Secs)<br>*[==>610 Secs (Pattern 1)]*<br>*[==>610 Secs (Pattern 2)]* | *[1]* |

## Orbit Structure



## Visit

**Proposal 16882, Visit 02, implementation** Fri Jan 07 22:00:54 GMT 2022

**Diagnostic Status: No Diagnostics**

Scientific Instruments: ACS/WFC

Special Requirements: (none)

## Patterns

| # | Primary Pattern | | Secondary Pattern | Exposures |
|---|---|---|---|---|
| (1) | Pattern Type=ACS-WFC-DITHER-LINE<br>Purpose=DITHER<br>Number Of Points=2<br>Point Spacing=3.034<br>Line Spacing= | Coordinate Frame=POS-TARG<br>Pattern Orientation=85.29<br>Angle Between Sides=<br>Center Pattern=false | | (1-2) |

## Fixed Targets

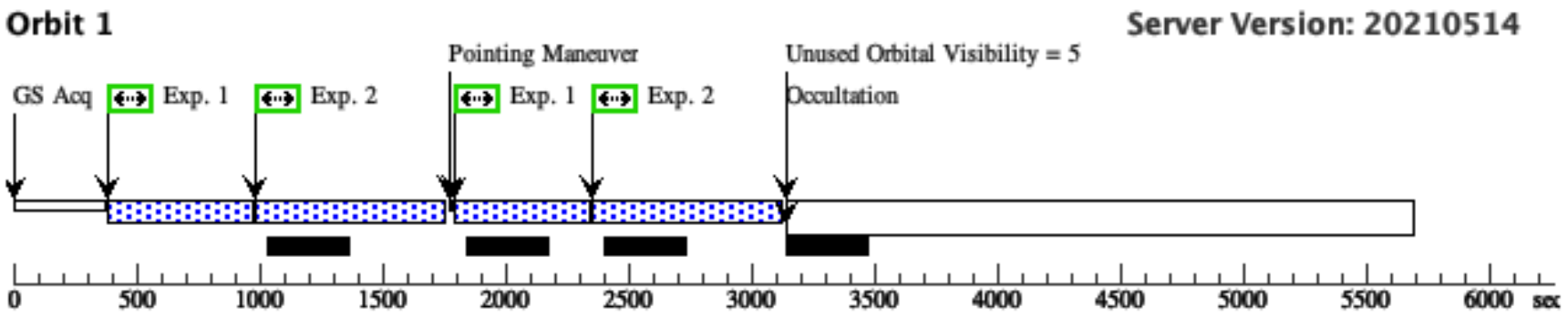
| # | Name | Target Coordinates | Targ. Coord. Corrections | Fluxes | Miscellaneous |
|---|---|---|---|---|---|
| (2) | UCD218 | RA: 12 26 36.4240 (186.6517667d)<br>Dec: +12 55 12.88 (12.92024d)<br>Equinox: J2000 | Radial Velocity: -93 km/sec | V=18.64+/-0.01 | Reference Frame: ICRS |

*Comments:*
*Category=EXT-CLUSTER*
*Description=[GLOBULAR CLUSTER, NUCLEUS]*
*Extended=NO*

## Exposures

| # | Label | Target | Config,Mode,Aperture | Spectral Els. | Opt. Params. | Special Reqs. | Groups | Exp. Time (Total)/[Actual Dur.] | Orbit |
|---|---|---|---|---|---|---|---|---|---|
| 1 | | (2) UCD218 | ACS/WFC, ACCUM, WFC1-CTE | F475W | | | Pattern 1, Exps 1-2 in Visit 02 (1) | 800 Secs (770 Secs)<br>*[==>385.0 Secs (Pattern 1)]*<br>*[==>385.0 Secs (Pattern 2)]* | *[1]* |
| 2 | | (2) UCD218 | ACS/WFC, ACCUM, WFC1-CTE | F850LP | | | Pattern 1, Exps 1-2 in Visit 02 (1) | 1280 Secs (1220 Secs)<br>*[==>610.0 Secs (Pattern 1)]*<br>*[==>610.0 Secs (Pattern 2)]* | *[1]* |

## Orbit Structure



## Visit

**Proposal 16882, Visit 03, implementation** Fri Jan 07 22:00:54 GMT 2022

**Diagnostic Status: No Diagnostics**

Scientific Instruments: ACS/WFC

Special Requirements: (none)

## Patterns

| # | Primary Pattern | | Secondary Pattern | Exposures |
|---|---|---|---|---|
| (1) | Pattern Type=ACS-WFC-DITHER-LINE<br>Purpose=DITHER<br>Number Of Points=2<br>Point Spacing=3.034<br>Line Spacing= | Coordinate Frame=POS-TARG<br>Pattern Orientation=85.29<br>Angle Between Sides=<br>Center Pattern=false | | (1-2) |

## Fixed Targets

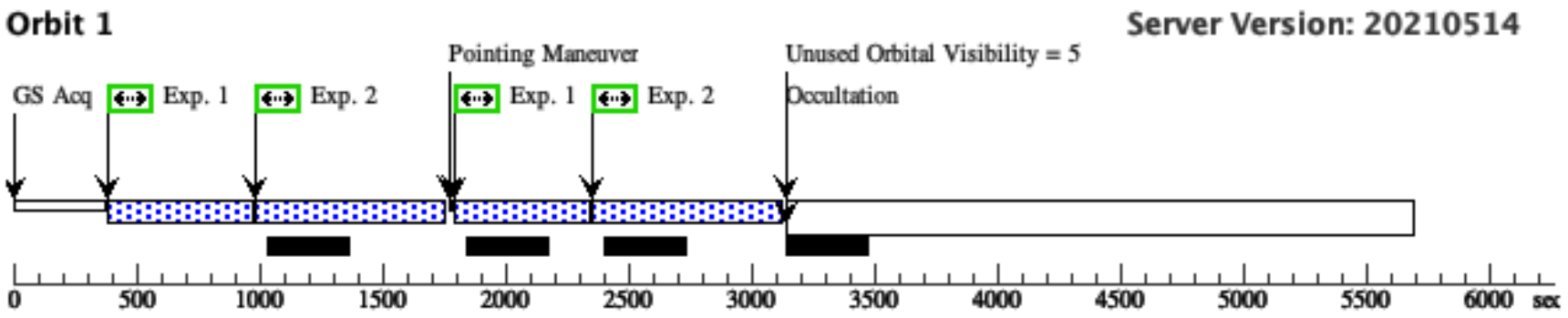
| # | Name | Target Coordinates | Targ. Coord. Corrections | Fluxes | Miscellaneous |
|---|---|---|---|---|---|
| (3) | UCD736 | RA: 12 42 51.1210 (190.7130042d)<br>Dec: +11 37 16.04 (11.62112d)<br>Equinox: J2000 | Radial Velocity: 536 km/sec | V=18.67+/-0.01 | Reference Frame: ICRS |

*Comments:*
*Category=EXT-CLUSTER*
*Description=[GLOBULAR CLUSTER, NUCLEUS]*
*Extended=NO*

## Exposures

| # | Label | Target | Config,Mode,Aperture | Spectral Els. | Opt. Params. | Special Reqs. | Groups | Exp. Time (Total)/[Actual Dur.] | Orbit |
|---|---|---|---|---|---|---|---|---|---|
| 1 | | (3) UCD736 | ACS/WFC, ACCUM, WFC1-CTE | F475W | | | Pattern 1, Exps 1-2 in Visit 03 (1) | 800 Secs (770 Secs)<br>*[==>385 Secs (Pattern 1)]*<br>*[==>385 Secs (Pattern 2)]* | *[1]* |
| 2 | | (3) UCD736 | ACS/WFC, ACCUM, WFC1-CTE | F850LP | | | Pattern 1, Exps 1-2 in Visit 03 (1) | 1280 Secs (1220 Secs)<br>*[==>610 Secs (Pattern 1)]*<br>*[==>610 Secs (Pattern 2)]* | *[1]* |

## Orbit Structure



## Visit

**Proposal 16882, Visit 04, implementation** Fri Jan 07 22:00:54 GMT 2022

**Diagnostic Status: No Diagnostics**

Scientific Instruments: ACS/WFC

Special Requirements: (none)

## Patterns

| # | Primary Pattern | | Secondary Pattern | Exposures |
|---|---|---|---|---|
| (1) | Pattern Type=ACS-WFC-DITHER-LINE<br>Purpose=DITHER<br>Number Of Points=2<br>Point Spacing=3.034<br>Line Spacing= | Coordinate Frame=POS-TARG<br>Pattern Orientation=85.29<br>Angle Between Sides=<br>Center Pattern=false | | (1-2) |

## Fixed Targets

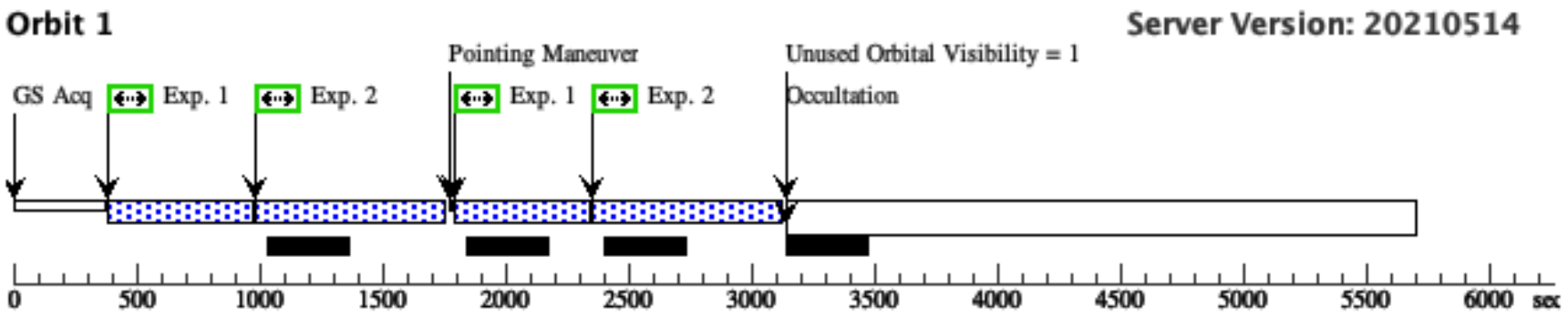
| # | Name | Target Coordinates | Targ. Coord. Corrections | Fluxes | Miscellaneous |
|---|---|---|---|---|---|
| (4) | UCDE372 | RA: 12 30 18.0570 (187.5752375d)<br>Dec: +07 50 24.89 (7.84025d)<br>Equinox: J2000 | Radial Velocity: 1070 km/sec | V=19.22+/-0.01 | Reference Frame: ICRS |

*Comments:*
*Category=EXT-CLUSTER*
*Description=[GLOBULAR CLUSTER, NUCLEUS]*
*Extended=NO*

## Exposures

| # | Label | Target | Config,Mode,Aperture | Spectral Els. | Opt. Params. | Special Reqs. | Groups | Exp. Time (Total)/[Actual Dur.] | Orbit |
|---|---|---|---|---|---|---|---|---|---|
| 1 | | (4) UCDE372 | ACS/WFC, ACCUM, WFC1-CTE | F475W | | | Pattern 1, Exps 1-2 in Visit 04 (1) | 800 Secs (770 Secs)<br>*[==>385 Secs (Pattern 1)]*<br>*[==>385 Secs (Pattern 2)]* | *[1]* |
| 2 | | (4) UCDE372 | ACS/WFC, ACCUM, WFC1-CTE | F850LP | | | Pattern 1, Exps 1-2 in Visit 04 (1) | 1280 Secs (1220 Secs)<br>*[==>610 Secs (Pattern 1)]*<br>*[==>610 Secs (Pattern 2)]* | *[1]* |

## Orbit Structure



## Visit

**Proposal 16882, Visit 05, implementation** Fri Jan 07 22:00:54 GMT 2022

**Diagnostic Status: No Diagnostics**

Scientific Instruments: ACS/WFC

Special Requirements: (none)

## Patterns

| # | Primary Pattern | | Secondary Pattern | Exposures |
|---|---|---|---|---|
| (1) | Pattern Type=ACS-WFC-DITHER-LINE<br>Purpose=DITHER<br>Number Of Points=2<br>Point Spacing=3.034<br>Line Spacing= | Coordinate Frame=POS-TARG<br>Pattern Orientation=85.29<br>Angle Between Sides=<br>Center Pattern=false | | (1-2) |

## Fixed Targets

| # | Name | Target Coordinates | Targ. Coord. Corrections | Fluxes | Miscellaneous |
|---|---|---|---|---|---|
| (5) | UCDE374 | RA: 12 30 20.0460 (187.5835250d)<br>Dec: +11 55 18.68 (11.92186d)<br>Equinox: J2000 | Radial Velocity: 1406 km/sec | V=19.11+/-0.01 | Reference Frame: ICRS |

*Comments:*
*Category=EXT-CLUSTER*
*Description=[GLOBULAR CLUSTER, NUCLEUS]*
*Extended=NO*

## Exposures

| # | Label | Target | Config,Mode,Aperture | Spectral Els. | Opt. Params. | Special Reqs. | Groups | Exp. Time (Total)/[Actual Dur.] | Orbit |
|---|---|---|---|---|---|---|---|---|---|
| 1 | | (5) UCDE374 | ACS/WFC, ACCUM, WFC1-CTE | F475W | | | Pattern 1, Exps 1-2 in Visit 05 (1) | 800 Secs (770 Secs)<br>*[==>385 Secs (Pattern 1)]*<br>*[==>385 Secs (Pattern 2)]* | *[1]* |
| 2 | | (5) UCDE374 | ACS/WFC, ACCUM, WFC1-CTE | F850LP | | | Pattern 1, Exps 1-2 in Visit 05 (1) | 1280 Secs (1220 Secs)<br>*[==>610 Secs (Pattern 1)]*<br>*[==>610 Secs (Pattern 2)]* | *[1]* |

## Orbit Structure