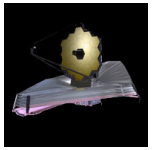

# 4762 - Panchromatic characterizations of the super-Eddington accretion black hole, host, and environment: Epicenter of red dots, mergers, and dusty starbursts at z=7.2

Cycle: 3, Proposal Category: GO

**INVESTIGATORS**

| ***Name*** | ***Institution*** |
|---|---|
| **Dr. Seiji Fujimoto (PI) (CSA Member)** | **University of Toronto** |
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|---|---|
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| Dr. Masafusa Onoue (CoI) | Kavli Inst for the Physics and Mathematics of the Universe |
| Dr. Kohei Inayoshi (CoI) | Peking University |
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| Prof. Steven L. Finkelstein (CoI) (US Admin CoI) | University of Texas at Austin |

**OBSERVATIONS**

| ***Folder*** | ***Observation*** | ***Label*** | ***Observing Template*** | ***Science Target*** |
|---|---|---|---|---|
| MIRI + NIRSPec | | | | |
| | 2 | MRS PaA | MIRI Medium Resolution Spectroscopy | (1) GNZ7Q |
| | 1 | MIRI F1280W Host | MIRI Imaging | (1) GNZ7Q |
| | 8 | MIRI F1280W Host | MIRI Imaging | (1) GNZ7Q |
| | 4 | MIRI LRS Ha + PaB + MIRcontiniuum | MIRI Low Resolution Spectroscopy | (1) GNZ7Q |
| | 6 | NIRSpec MSA LyA to OIII | NIRSpec MultiObject Spectroscopy | (3) gdn_imgv7.4_aw1.0_gnz7q |
| | 9 | MIRI LRS Ha + PaB + MIRcontiniuum_Repeat | MIRI Low Resolution Spectroscopy | (7) GNZ7Q-updated2 |
| GN-GrismR | | | | |
| | 7 | FRESCO_GN_wide-WEST | NIRCam Wide Field Slitless Spectroscopy | (4) GOODS-N-CENTER-WEST |

**ABSTRACT**

A remarkable outcome from JWST is the high abundance of low-mass BHs, such represented by red point sources, so-called red dots. However, the limited survey volume of JWST is still sensitive to the abundant ``faint'' populations, where most represent less active accretion. Here we propose in-depth JWST observations for the first, best candidate of the rapid growing young quasar embedded in a dusty starburst host (SFR=1,600 Msun/yr) at z=7.2, GNz7q, discovered with moderate UV luminosity as a quasar (Muv= -23) but still >10-100x brighter than those recent red dots. The latest NIRCam grism observations detect the broad Balmer line feature, suggesting a super-Eddington accretion (Eddington ratio~16) taking place in a low-mass black hole (logMBH~6.9 Msun), while the interpretation is still inconclusive with the current S/N. Interestingly, the recent JWST and NOEMA observations also unveil the area around GNz7q highly overdense (delta>=5-100) harboring unique systems such as multiple red dots, a merging galaxy, and dusty starbursts, with possible filamentary structures. We request NIRSpec, MIRI, and NIRCam F410M grism observations to
1) confirm the low MBH and uniquely high accretion,
2) look for signatures of significant outflows and a young quasar age,
3) spectroscopically and spatially separate the quasar and host to get independent measures of SFR and Mstar of the host,
4) quantify their co-evolution stage via MBH/Mstar, and
5) comprehensively map out surrounding objects to examine the overdense/filamentary structure.
Our program will achieve the first comprehensive characterizations of the rapid growing system in the early universe from BH, host, to its environment.

**OBSERVING DESCRIPTION**

This is NIRSpec G140M/F100LP, G395M/F290LP, NIRCam/F410M grism spectroscopy, and MIRI F1280W imaging & LRS and MRS spectroscopic observations for the super-Eddington accretion BH candidate GNz7q at z=7.2, its host, and surrounding galaxies. We will detect

For GNz7q & its host:
- G140M/F100LP: Lya (+Halo), Si IV, CIV, CIII]
- G395M/F290LP: H-beta, [OIII]
- LRS: H-alpha, Pa-beta
- MRS: Pa-alpha
- F1280W: (quasar)+stellar continuum

For z~7.2 galaxies surrounding GNz7q.

- F410M grism: OIII+Hbeta

in order to

(i) obtain M_BH and lambda_Edd via the most robust tracer Hbeta,
(ii) verify signatures of strong outflow and young quasar age,
(iii) spectroscopically and spatially separate quasar and host components and carefully evaluate star-formation SFR and stellar mass M_star of the host,
(iv) obtain M_BH/M_star, and
(v) fully map out the surrounding galaxies around GNz7q at the same redshift

**Fixed Targets**

| # | Name | Target Coordinates | Targ. Coord. Corrections | Miscellaneous |
|---|---|---|---|---|
| (1) | GNZ7Q | RA: 12 36 16.9549 (189.0706454d)<br>Dec: +62 12 32.23 (62.20895d)<br>Equinox: J2000 | Proper Motion RA: 0<br>Proper Motion Dec: 0<br>Epoch of Position: 2000 | |
| *Comments:*<br>*Category=Galaxy*<br>*Description=[High-redshift galaxies, Quasars, Starburst galaxies]*<br>*Extended=NO* | | | | |
| (3) | gdn_imgv7.4_aw1.0_gnz7q | RA: 12 36 32.9305 (189.1372104d)<br>Dec: +62 13 41.35 (62.22815d)<br>Equinox: J2000 | | |
| *Comments:*<br>*Description=[]* | | | | |
| (4) | GOODS-N-CENTER-WEST | RA: 12 36 13.0000 (189.0541667d)<br>Dec: +62 11 35.25 (62.19312d)<br>Equinox: J2000 | | |
| *Comments:*<br>*Category=Unidentified*<br>*Description=[Blank field]* | | | | |
| (7) | GNZ7Q-updated2 | RA: 12 36 16.9546 (189.0706442d)<br>Dec: +62 12 32.23 (62.20895d)<br>Equinox: J2000 | Proper Motion RA: 0<br>Proper Motion Dec: 0<br>Epoch of Position: 2025 | |
| *Comments:*<br>*Category=Galaxy*<br>*Description=[High-redshift galaxies, Quasars, Starburst galaxies]*<br>*Extended=NO* | | | | |
| (8) | TKRS-4459-updated2 | RA: 12 36 14.0392 (189.0584967d)<br>Dec: +62 11 59.12 (62.19976d)<br>Equinox: J2000 | Proper Motion RA: 0<br>Proper Motion Dec: 0<br>Parallax: 0"<br>Epoch of Position: 2025 | |
| *Comments: This star is in the GAIA catalog with a nontrivial proper motion (pmra, pmdec) = (-4.116, -0.218 mas/yr). The coordinates provided for the TA target here and for the primary target were measured from a NIRCam F444W image obtained 7 Feb. 2025, itself aligned to the GAIA frame.*<br>*Category=Star*<br>*Description=[A dwarfs, A stars]*<br>*Extended=NO* | | | | |

## Observation

**Proposal 4762, Observation 2: MRS PaA** Tue Apr 15 17:00:18 GMT 2025

**Diagnostic Status: Warning**

Observing Template: MIRI Medium Resolution Spectroscopy

## Diagnostics

(Visit 2:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

## Fixed Targets

| # | Name | Target Coordinates | Targ. Coord. Corrections | Miscellaneous |
|---|---|---|---|---|
| (1) | GNZ7Q | RA: 12 36 16.9549 (189.0706454d) | Proper Motion RA: 0 | |
| | | Dec: +62 12 32.23 (62.20895d) | Proper Motion Dec: 0 | |
| | | Equinox: J2000 | Epoch of Position: 2000 | |

*Comments:*
*Category=Galaxy*
*Description=[High-redshift galaxies, Quasars, Starburst galaxies]*
*Extended=NO*

## Acquisition

| # | Target |
|---|---|
| 1 | NONE |

## Template

| AcqFilter | Primary Channel | Simultaneous Imaging | Imager Subarray | Grating Wheel Direction |
|---|---|---|---|---|
| F1500W | Channel 3 | YES | FULL | Allow Auto Reorder |

## Dithers

| # | Dither Type | Optimized For | Direction |
|---|---|---|---|
| 1 | 4-Point | POINT SOURCE | NEGATIVE |
| 2 | 4-Point | POINT SOURCE | POSITIVE |

## Spectral Elements

| # | Wavelength Range | Detector | Filter | Readout Pattern | Groups/Int | Integrations/Exp | Exposures/Dith | Dither | Total Dithers | Total Integrations | Total Exposure Time | ETC Wkbk.Calc ID |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | IMAGER | F770W | FASTR1 | 150 | 2 | 1 | Dither 1 | 4 | 8 | 3341.148 | |
| 1 | MEDIUM(B) | MRSLONG | | SLOWR1 | 17 | 2 | 1 | Dither 1 | 4 | 8 | 3344.589 | |
| 1 | MEDIUM(B) | MRSSHORT | | SLOWR1 | 17 | 2 | 1 | Dither 1 | 4 | 8 | 3344.589 | |
| 2 | | IMAGER | F1000W | FASTR1 | 150 | 2 | 1 | Dither 2 | 4 | 8 | 3341.148 | |
| 2 | MEDIUM(B) | MRSLONG | | SLOWR1 | 17 | 2 | 1 | Dither 2 | 4 | 8 | 3344.589 | |
| 2 | MEDIUM(B) | MRSSHORT | | SLOWR1 | 17 | 2 | 1 | Dither 2 | 4 | 8 | 3344.589 | |

| | |
|---|---|
| **Special Requirements** | Sequence Observations 1, 2, 4, 7 within 50 Days |

## Observation

**Proposal 4762, Observation 1: MIRI F1280W Host** Tue Apr 15 17:00:18 GMT 2025

**Diagnostic Status: Warning**

Observing Template: MIRI Imaging

## Diagnostics

(Visit 1:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

## Fixed Targets

| # | Name | Target Coordinates | Targ. Coord. Corrections | Miscellaneous |
|---|---|---|---|---|
| (1) | GNZ7Q | RA: 12 36 16.9549 (189.0706454d) | Proper Motion RA: 0 | |
| | | Dec: +62 12 32.23 (62.20895d) | Proper Motion Dec: 0 | |
| | | Equinox: J2000 | Epoch of Position: 2000 | |

*Comments:*
*Category=Galaxy*
*Description=[High-redshift galaxies, Quasars, Starburst galaxies]*
*Extended=NO*

## Template

| Subarray |
|---|
| FULL |

## Dithers

| # | Dither Type | Starting Point | Number of Points | Points | Starting Set | Number of Sets | Optimized For | Direction | Pattern Size |
|---|---|---|---|---|---|---|---|---|---|
| 1 | CYCLING | 1 | 6 | | | | | | DEFAULT |

## Spectral Elements

| # | Filter | Readout Pattern | Groups/Int | Integrations/Exp | Exposures/Dith | Dither | Total Dithers | Total Integrations | Total Exposure Time | ETC Wkbk.Calc ID |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | F1280W | FASTR1 | 40 | 6 | 1 | Dither 1 | 6 | 36 | 4079.309 | |

## Special Requirements

Sequence Observations 1, 2, 4, 7 within 50 Days

## Observation

**Proposal 4762, Observation 8: MIRI F1280W Host** Tue Apr 15 17:00:18 GMT 2025

**Diagnostic Status: Warning**

Observing Template: MIRI Imaging

## Diagnostics

(Visit 8:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

## Fixed Targets

| # | Name | Target Coordinates | Targ. Coord. Corrections | Miscellaneous |
|---|---|---|---|---|
| (1) | GNZ7Q | RA: 12 36 16.9549 (189.0706454d) | Proper Motion RA: 0 | |
| | | Dec: +62 12 32.23 (62.20895d) | Proper Motion Dec: 0 | |
| | | Equinox: J2000 | Epoch of Position: 2000 | |

*Comments:*
*Category=Galaxy*
*Description=[High-redshift galaxies, Quasars, Starburst galaxies]*
*Extended=NO*

## Template

| Subarray |
|---|
| FULL |

## Dithers

| # | Dither Type | Starting Point | Number of Points | Points | Starting Set | Number of Sets | Optimized For | Direction | Pattern Size |
|---|---|---|---|---|---|---|---|---|---|
| 1 | CYCLING | 1 | 6 | | | | | | DEFAULT |

## Spectral Elements

| # | Filter | Readout Pattern | Groups/Int | Integrations/Exp | Exposures/Dith | Dither | Total Dithers | Total Integrations | Total Exposure Time | ETC Wkbk.Calc ID |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | F1280W | FASTR1 | 40 | 6 | 1 | Dither 1 | 6 | 36 | 4079.309 | |

## Observation

**Proposal 4762, Observation 4: MIRI LRS Ha + PaB + MIRcontiniuum** Tue Apr 15 17:00:18 GMT 2025

**Diagnostic Status: Warning**

Observing Template: MIRI Low Resolution Spectroscopy

## Diagnostics

(Visit 4:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

## Fixed Targets

| # | Name | Target Coordinates | Targ. Coord. Corrections | Miscellaneous |
|---|---|---|---|---|
| (1) | GNZ7Q | RA: 12 36 16.9549 (189.0706454d) | Proper Motion RA: 0 | |
| | | Dec: +62 12 32.23 (62.20895d) | Proper Motion Dec: 0 | |
| | | Equinox: J2000 | Epoch of Position: 2000 | |

*Comments:*
*Category=Galaxy*
*Description=[High-redshift galaxies, Quasars, Starburst galaxies]*
*Extended=NO*

## Acquisition

| # | Target | Filter | Readout Pattern | Groups/Int | Integrations/Exp | Total Integrations | Total Exposure Time | ETC Wkbk.Calc ID |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 GNZ7Q | F560W | FASTGRPAVG8 | 10 | 1 | 1 | 222.003 | 55256.31 |

## Template

| Subarray | Obtain Verification Image? |
|---|---|
| FULL | false |

## Dithers

| # | Dither Type | No. Spectral Steps | Spectral Step Offset | No. Spatial Steps | Spatial Step Offset |
|---|---|---|---|---|---|
| 1 | MAPPING | 1 | 0.0 | 4 | 0.6 |

## Spectral Elements

| # | Readout Pattern | Groups/Int | Integrations/Exp | Total Integrations | Exposures/Dith | Total Dithers | Total Exposure Time | ETC Wkbk.Calc ID |
|---|---|---|---|---|---|---|---|---|
| 1 | FASTR1 | 150 | 4 | 16 | 1 | 4 | 6693.396 | 55256.36 |

| Special Requirements | Sequence Observations 1, 2, 4, 7 within 50 Days |
|---|---|

## Observation

**Proposal 4762, Observation 6: NIRSpec MSA LyA to OIII** Tue Apr 15 17:00:18 GMT 2025

**Diagnostic Status: Warning**

Observing Template: NIRSpec MultiObject Spectroscopy

## Diagnostics

(Visit 6:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

## Fixed Targets

| # | Name | Target Coordinates | Targ. Coord. Corrections | Miscellaneous |
|---|---|---|---|---|
| (3) | gdn_imgv7.4_aw1.0_gnz7q | RA: 12 36 32.9305 (189.1372104d)<br>Dec: +62 13 41.35 (62.22815d)<br>Equinox: J2000 | | |

*Comments:*
*Description=[]*

## Acquisition

| # | Reference Star Bin | Target | Filter | MSA Configuration | Readout Pattern | Groups/Int | Integrations/Exp | Total Integrations | Total Exposure Time | ETC Wkbk.Calc ID |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Filter: CLEAR; Readout: NRSRAPIDD6; 8 sources in 3 quads; [ Optimal TA Accuracy ] | SAME | CLEAR | Auto Acq MSA Config | NRSRAPIDD6 | 3 | 1 | 4 | 687.153 | |

## Template

| TA Method | HFF Readout Mode | Obtain Confirmation Images | Science Aperture | Primary Candidate List | Filler Candidate List | Spectral Overlap Map | Spectral Overlap Threshold |
|---|---|---|---|---|---|---|---|
| MSATA | false | After Target ACQ | MSA Center | gdn_imgv7.4_aw1.0_gnz7q (3318 sources) | | jwst-nirspec-mr | 1.5 |

## Reference Stars

| Visit | ID | RA | Dec | Magnitude | Visit | ID | RA | Dec | Magnitude |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 25805 | 189.153454 | 62.189372 | 25.285472869873047 | 1 | 40189 | 189.139757 | 62.214526 | 24.337318420410156 |
| 1 | 37385 | 189.146246 | 62.209064 | 23.25459098815918 | 1 | 40623 | 189.159248 | 62.214458 | 23.686891555786133 |
| 1 | 37477 | 189.170405 | 62.209375 | 23.738527297973633 | 1 | 42749 | 189.151189 | 62.218356 | 25.113758087158203 |
| 1 | 39027 | 189.063657 | 62.212361 | 25.038501739501953 | 1 | 43319 | 189.170089 | 62.219214 | 24.250186920166016 |

## Confirmation

| # | Confirmation Type | Conf. Readout Pattern | Conf. Groups/Int | Conf. Integrations/Exp | Conf. Total Integrations | Conf. Total Exposure Time |
|---|---|---|---|---|---|---|
| 1 | After Target Acq | NRSIRS2RAPID | 10 | 1 | 1 | 160.478 |

**Spectral Elements**

| # | Exposure Specification | MSA Configuration | Nod Pattern | Pointing | Aperture PA | Dispersion Offset (Shutters) | Cross-Dispersion Offset (Shutters) | Total Dithers | Total Integrations | Total Exposure Time |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 (G140M/F070LP) | c1 | 3 Shutter Slitlet | 189.10903366666668 Degrees 62.19525166666664 Degrees | 273.50504430186686 | | | 3 | 6 | 7527.867 |
| 2 | 2 (G395M/F290LP) | c1 | 3 Shutter Slitlet | 189.10903366666668 Degrees 62.19525166666664 Degrees | 273.50504430186686 | | | 3 | 6 | 7527.867 |

**Special Requirements**

After Date 15-MAY-2025:00:00:00
MSA Scheduled Aperture PA 273.5299 to 273.5299 Degrees (V3 134.9553 to 134.9553)

## Observation

**Proposal 4762, Observation 9: MIRI LRS Ha + PaB + MIRcontiniuum_Repeat** Tue Apr 15 17:00:18 GMT 2025

**Diagnostic Status: Warning**

Observing Template: MIRI Low Resolution Spectroscopy

## Diagnostics

(Visit 9:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

## Fixed Targets

| # | Name | Target Coordinates | Targ. Coord. Corrections | Miscellaneous |
|---|---|---|---|---|
| (7) | GNZ7Q-updated2 | RA: 12 36 16.9546 (189.0706442d)<br>Dec: +62 12 32.23 (62.20895d)<br>Equinox: J2000 | Proper Motion RA: 0<br>Proper Motion Dec: 0<br>Epoch of Position: 2025 | |

*Comments:*
*Category=Galaxy*
*Description=[High-redshift galaxies, Quasars, Starburst galaxies]*
*Extended=NO*

## Acquisition

| # | Target | Filter | Readout Pattern | Groups/Int | Integrations/Exp | Total Integrations | Total Exposure Time | ETC Wkbk.Calc ID |
|---|---|---|---|---|---|---|---|---|
| 1 | 8 TKRS-4459-updated2 | F560W | FASTGRPAVG | 4 | 1 | 1 | 44.401 | 55256.31 |

## Template

| Subarray | Obtain Verification Image? |
|---|---|
| FULL | true |

## Dithers

| # | Dither Type | No. Spectral Steps | Spectral Step Offset | No. Spatial Steps | Spatial Step Offset |
|---|---|---|---|---|---|
| 1 | MAPPING | 1 | 0.0 | 4 | 0.6 |

## Pointing Verification

| # | PV Readout Pattern | PV Groups/Int | PV Integrations/Exp | PV Total Integrations | PV Exposures/Dith | PV Total Dithers | PV Total Exposure Time | PV ETC Wkbk.Calc ID | Filter |
|---|---|---|---|---|---|---|---|---|---|
| 1 | FASTR1 | 60 | 1 | 1 | 1 | 1 | 166.502 | | F560W |

**Spectral Elements**

| # | Readout Pattern | Groups/Int | Integrations/Exp | Total Integrations | Exposures/Dith | Total Dithers | Total Exposure Time | ETC Wkbk.Calc ID |
|---|---|---|---|---|---|---|---|---|
| 1 | FASTR1 | 50 | 12 | 48 | 1 | 4 | 6782.198 | 55256.36 |

## Observation

**Proposal 4762, Observation 7: FRESCO_GN_wide-WEST** Tue Apr 15 17:00:18 GMT 2025

**Diagnostic Status: Warning**

Observing Template: NIRCam Wide Field Slitless Spectroscopy

## Diagnostics

(FRESCO_GN_wide-WEST (Obs 7)) Warning (Form): For Module=ALL the default target location is in the gap between the modules.

(FRESCO_GN_wide-WEST (Obs 7)) Warning (Form): Use of only one of GRISMR or GRISMC may result in spectral overlap from multiple sources that can't be corrected. Users should address this issue in their proposal text.

(Visit 7:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

(Visit 7:2) Warning (Form): Overheads are provisional until the Visit Planner has been run.

## Fixed Targets

| # | Name | Target Coordinates | Targ. Coord. Corrections | Miscellaneous |
|---|---|---|---|---|
| (4) | GOODS-N-CENTER-WEST | RA: 12 36 13.0000 (189.0541667d)<br>Dec: +62 11 35.25 (62.19312d)<br>Equinox: J2000 | | |

*Comments:*
*Category=Unidentified*
*Description=[Blank field]*

## Template

| Module | Subarray | Grism (Long Wavelength) |
|---|---|---|
| ALL | FULL | GRISMR |

## Mosaic

| Rows | Columns | Row Overlap % | Column Overlap % | Row shift (deg) | Column shift (deg) | Tile Order |
|---|---|---|---|---|---|---|
| 1 | 2 | 10.0 | 64.7 | 0.0 | 0.0 | DEFAULT |

## Dithers

| # | Primary Dither Type | Primary Dithers | Subpixel Positions |
|---|---|---|---|
| 1 | INTRAMODULEBOX | 4 | NONE |

## Direct Image

| # | Short Filter | Long Filter | Readout Pattern | Groups/Int | Integrations/Exp | Total Integrations | Total Exposure Time | ETC Wkbk.Calc ID | Grism (Long Wavelength) | Exposure Type | Total Dithers |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | F150W | F356W | SHALLOW2 | 5 | 1 | 1 | 236.209 | | GRISMR | Direct Image | 1 |
| 2 | F182M | F444W | SHALLOW4 | 6 | 1 | 1 | 311.366 | | GRISMR | Direct Image | 1 |

## Spectral Elements

| # | Short Filter | Long Filter | Readout Pattern | Groups/Int | Integrations/Exp | Total Integrations | Total Exposure Time | ETC Wkbk.Calc ID | Grism (Long Wavelength) | Exposure Type | Total Dithers |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | F210M | F410M | MEDIUM2 | 7 | 1 | 4 | 2662.719 | | GRISMR | Grism (Long Wavelength) | 4 |
| 2 | F182M | F410M | MEDIUM2 | 7 | 1 | 4 | 2662.719 | | GRISMR | Grism (Long Wavelength) | 4 |
| 3 | F182M | F444W | SHALLOW4 | 6 | 1 | 2 | 622.733 | | | Out of Field | 2 |

| Special Requirements | |
|---|---|
| | Sequence Visits within 1 Days<br>Aperture PA Range 227 to 233 Degrees (V3 227.0 to 233.0)<br>Visits Same PA<br>Background Limited. Background no more than 30th percentile above minimum<br><br>Sequence Observations 1, 2, 4, 7 within 50 Days |