17782 - A First Attempt to Detect Extragalactic Antimatter: Positronium Lyman alpha toward M31*

Cycle: 32, Proposal Category: GO

(Availability Mode: SUPPORTED)

INVESTIGATORS

Name	*Institution*
Prof. Jeremy Darling (PI) (Contact)	**University of Colorado at Boulder**

VISITS

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
01	(1) M31STAR	COS/NUV	3	22-Jul-2025 18:00:15.0	yes
03	(1) M31STAR	COS/NUV	1	22-Jul-2025 18:00:16.0	yes
02	(1) M31STAR	COS/NUV	3	22-Jul-2025 18:00:17.0	yes

7 Total Orbits Used

ABSTRACT

We propose to attempt the first direct detection of antimatter outside the Galaxy by observing the positronium Lyman-alpha transition toward M31*. The existence of antimatter in the form of positrons has been observed in the Galaxy via 511 keV annihilation photons for half a century, but the astrophysical engines producing the positrons have yet to be identified. Numerous plausible sources of positrons have been proposed, some of which are distributed and some of which are pointlike such as massive black holes, stellar-mass black holes, and compact X-ray binaries. Studies of the annihilation gamma-ray spectrum show that nearly all annihilation events are preceded by the formation of an electron-positron bound state called Positronium (Ps), a hydrogen-like "atom" where the proton is replaced by the positron. Positronium has quantum transitions with half the energy of hydrogen: its Lyman alpha line has a wavelength 243 nm. There will therefore be Ps "recombination" emission lines that precede annihilation. These

are faint but within the reach of HST, and ground-based observations have thus far been unable to adequately remove terrestrial atmospheric spectral features, despite custom-built spectrometers. We propose to expand the study of the sources of antimatter beyond the Galaxy by observing M31* in the Ps Lyman-alpha transition. Successful detection will provide important insight into positron production mechanisms and the general physics of high-energy phenomena. Theory alone has so far been unable to identify the dominant mechanism for antimatter production.

OBSERVING DESCRIPTION

The plan is to obtain a spectrum of M31* in the Ps Lyman alpha transition at 243 nm. We split the observations into two visits of 3 orbits each, and spread the four FP-POS settings over the two visits (six orbits). For each visit and orbit, we do two COS exposures with G230L, TIME-TAG mode, wavelength 3360 A, placing Segment A on the 243 nm Ps transition. The M31* nuclear environment is extended in the NUV and will not reward an aquisition obervation, even for peak-finding. We use the radio coordinates for M31*, which are good to less than 0.25". The default pointing by HST will be perfectly adequate to obtain a spectrum of the nuclear region to search for antimatter.

Proposal 17782 - Visit 01 - A First Attempt to Detect Extragalactic Antimatter: Positronium Lyman alpha toward M31*

Visit

Proposal 17782, Visit 01, failed

Tue Jul 22 22:00:17 GMT 2025

Diagnostic Status: Warning

Scientific Instruments: COS/NUV

Special Requirements: (none)

Diagnostics

(Visit 01) Warning (Form): A target acquisition should probably be performed before doing spectroscopy or coronography with STIS or COS.

(Visit 01) Warning (Orbit Planner): ORBITAL VISIBILITY OVERRUN

(Visit 01) Warning (Orbit Planner): ORBITAL VISIBILITY OVERRUN

(Visit 01) Warning (Orbit Planner): ORBITAL VISIBILITY OVERRUN

Fixed Targets

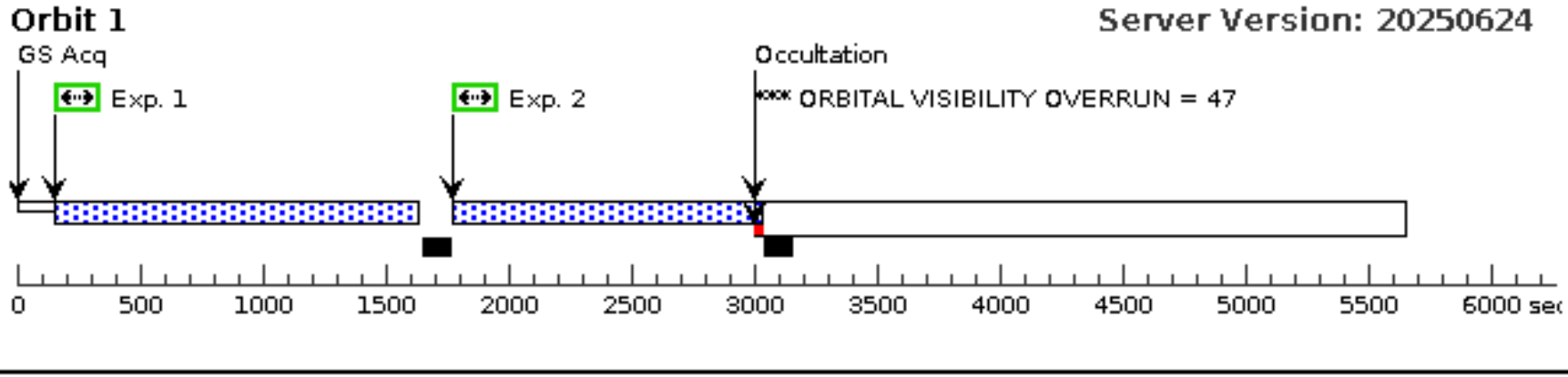
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	M31STAR	RA: 00 42 44.3440 (10.6847667d) Dec: +41 16 8.54 (41.26904d) Equinox: J2000	Proper Motion RA: 0 Proper Motion Dec: 0 Epoch of Position: 2000	V=12 The HST-measured FUV flux at 2000 A is 1e-15 erg/s/cm^2/A; we use this to estimate the 2430 A continuum.	Reference Frame: ICRS

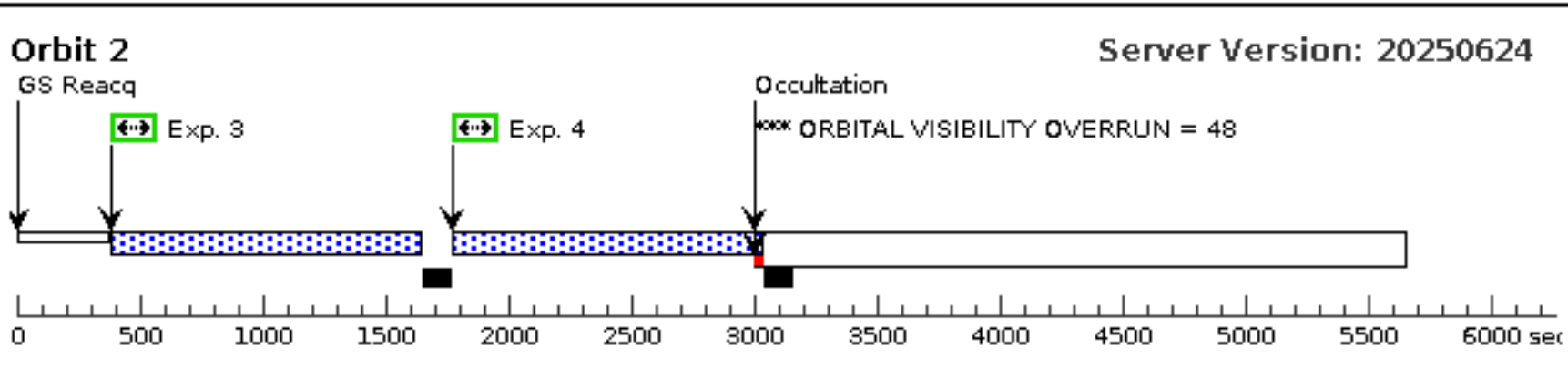
Comments:
Category=GALAXY
Description=[NUCLEUS]
Extended=NO

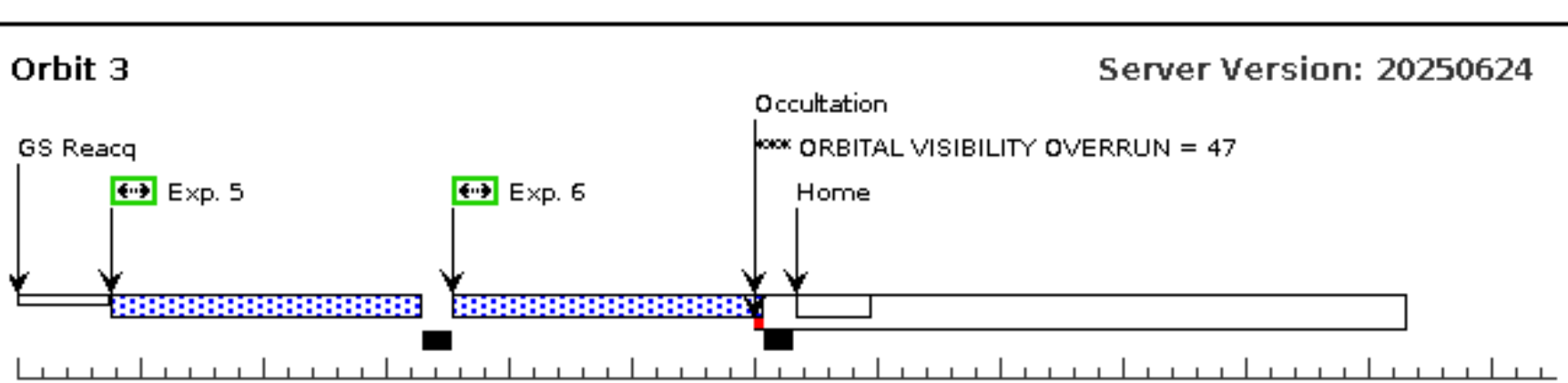
Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	(COS.sp.1932456)	(1) M31STAR	COS/NUV, TIME-TAG, PSA	G230L 3360 A	BUFFER-TIME=1193; FP-POS=1			1200 Secs (1244 Secs) *[==>1244.0 Secs]*	 ***[1]***
2	(COS.sp.1932456)	(1) M31STAR	COS/NUV, TIME-TAG, PSA	G230L 3360 A	BUFFER-TIME=1193; FP-POS=1			1200 Secs (1244 Secs) *[==>1244.0 Secs]*	 ***[1]***
3	(COS.sp.1932456)	(1) M31STAR	COS/NUV, TIME-TAG, PSA	G230L 3360 A	BUFFER-TIME=1193; FP-POS=1			1200 Secs (1244 Secs) *[==>1244.0 Secs]*	 ***[2]***
4	(COS.sp.1932456)	(1) M31STAR	COS/NUV, TIME-TAG, PSA	G230L 3360 A	BUFFER-TIME=1193; FP-POS=2			1200 Secs (1244 Secs) *[==>1244.0 Secs]*	 ***[2]***
5	(COS.sp.1932456)	(1) M31STAR	COS/NUV, TIME-TAG, PSA	G230L 3360 A	BUFFER-TIME=1193; FP-POS=2			1200 Secs (1245 Secs) *[==>1245.0 Secs]*	 ***[3]***
6	(COS.sp.1932456)	(1) M31STAR	COS/NUV, TIME-TAG, PSA	G230L 3360 A	BUFFER-TIME=1193; FP-POS=2			1200 Secs (1245 Secs) *[==>1245.0 Secs]*	 ***[3]***

Orbit Structure







Visit

Proposal 17782, Visit 03

Tue Jul 22 22:00:17 GMT 2025

Diagnostic Status: Warning

Scientific Instruments: COS/NUV

Special Requirements: (none)

Diagnostics

(Visit 03) Warning (Form): A target acquisition should probably be performed before doing spectroscopy or coronography with STIS or COS.

(Visit 03) Warning (Orbit Planner): ORBITAL VISIBILITY OVERRUN

Fixed Targets

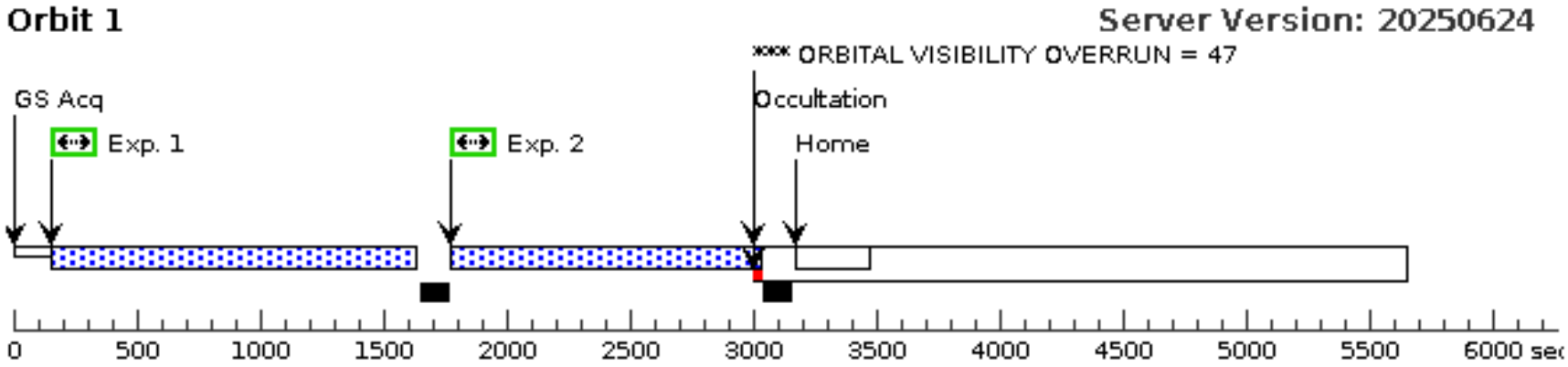
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	M31STAR	RA: 00 42 44.3440 (10.6847667d) Dec: +41 16 8.54 (41.26904d) Equinox: J2000	Proper Motion RA: 0 Proper Motion Dec: 0 Epoch of Position: 2000	V=12 The HST-measured FUV flux at 2000 A is 1e-15 erg/s/cm^2/A; we use this to estimate the 2430 A continuum.	Reference Frame: ICRS

Comments:
Category=GALAXY
Description=[NUCLEUS]
Extended=NO

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	(COS.sp.193 2456)	(1) M31STAR	COS/NUV, TIME-TAG, PSA	G230L 3360 A	BUFFER-TIME=1193; FP-POS=2			1200 Secs (1244 Secs) *[==>1244.0 Secs]*	 ***[1]***
2	(COS.sp.193 2456)	(1) M31STAR	COS/NUV, TIME-TAG, PSA	G230L 3360 A	BUFFER-TIME=1193; FP-POS=2			1200 Secs (1244 Secs) *[==>1244.0 Secs]*	 ***[1]***

Orbit Structure



Proposal 17782 - Visit 02 - A First Attempt to Detect Extragalactic Antimatter: Positronium Lyman alpha toward M31*

Visit

Proposal 17782, Visit 02, scheduling Tue Jul 22 22:00:17 GMT 2025

Diagnostic Status: Warning

Scientific Instruments: COS/NUV

Special Requirements: (none)

Diagnostics

(Visit 02) Warning (Form): A target acquisition should probably be performed before doing spectroscopy or coronography with STIS or COS.

(Visit 02) Warning (Orbit Planner): ORBITAL VISIBILITY OVERRUN

(Visit 02) Warning (Orbit Planner): ORBITAL VISIBILITY OVERRUN

(Visit 02) Warning (Orbit Planner): ORBITAL VISIBILITY OVERRUN

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	M31STAR	RA: 00 42 44.3440 (10.6847667d) Dec: +41 16 8.54 (41.26904d) Equinox: J2000	Proper Motion RA: 0 Proper Motion Dec: 0 Epoch of Position: 2000	V=12 The HST-measured FUV flux at 2000 A is 1e-15 erg/s/cm^2/A; we use this to estimate the 2430 A continuum.	Reference Frame: ICRS

Comments:
Category=GALAXY
Description=[NUCLEUS]
Extended=NO

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	(COS.sp.1932456)	(1) M31STAR	COS/NUV, TIME-TAG, PSA	G230L 3360 A	BUFFER-TIME=1193; FP-POS=3			1200 Secs (1244 Secs) *[==>1244.0 Secs]*	 ***[1]***
2	(COS.sp.1932456)	(1) M31STAR	COS/NUV, TIME-TAG, PSA	G230L 3360 A	BUFFER-TIME=1193; FP-POS=3			1200 Secs (1244 Secs) *[==>1244.0 Secs]*	 ***[1]***
3	(COS.sp.1932456)	(1) M31STAR	COS/NUV, TIME-TAG, PSA	G230L 3360 A	BUFFER-TIME=1193; FP-POS=3			1200 Secs (1244 Secs) *[==>1244.0 Secs]*	 ***[2]***
4	(COS.sp.1932456)	(1) M31STAR	COS/NUV, TIME-TAG, PSA	G230L 3360 A	BUFFER-TIME=1193; FP-POS=4			1200 Secs (1244 Secs) *[==>1244.0 Secs]*	 ***[2]***
5	(COS.sp.1932456)	(1) M31STAR	COS/NUV, TIME-TAG, PSA	G230L 3360 A	BUFFER-TIME=1193; FP-POS=4			1200 Secs (1245 Secs) *[==>1245.0 Secs]*	 ***[3]***
6	(COS.sp.1932456)	(1) M31STAR	COS/NUV, TIME-TAG, PSA	G230L 3360 A	BUFFER-TIME=1193; FP-POS=4			1200 Secs (1245 Secs) *[==>1245.0 Secs]*	 ***[3]***

Orbit Structure