



# 6568 - A Search for Extragalactic Antimatter: Positronium in Maffei 1 and M87

Cycle: 3, Proposal Category: GO

## INVESTIGATORS

<i>Name</i>	<i>Institution</i>
<b>Prof. Jeremy Darling (PI)</b>	<b>University of Colorado at Boulder</b>

## OBSERVATIONS

<i>Folder</i>	<i>Observation</i>	<i>Label</i>	<i>Observing Template</i>	<i>Science Target</i>
Observation Folder				
	2	Maffei 1	NIRSpec IFU Spectroscopy	(2) Maffei 1

## ABSTRACT

Electron-positron annihilation photons have been observed toward the Galactic Center for decades, but the antimatter engines that create the positrons remain ambiguous. It is inferred from the gamma-ray spectrum that >90% of annihilation events first form a positronium (Ps) bound state that behaves like hydrogen with a light nucleus. Ps will show "recombination" lines that have twice the wavelength of hydrogen recombination lines, and it will also have fine structure transitions. These have not been observed in the Galaxy due to strong dust obscuration and a relatively weak nuclear continuum. Elliptical galaxies should have stronger positron production, whatever the source(s) may be, and less obscuration. We therefore propose to search for recombination and fine structure lines of Ps using JWST and the VLA, respectively, toward M87 and Maffei 1. This is a high-risk proposal with the goals of (1) addressing the source(s) of antimatter production in galaxies, (2) making the first detection of Ps in ANY astrophysical setting, and (3) making the first extragalactic detection of electron-positron annihilation. The two observatories are needed to both characterize the bound state formation process and excitation, the antimatter engines, and to provide confirmation of weak or confusing spectral signals. NRAO ID = VLA/24B-372

## OBSERVING DESCRIPTION

## JWST Proposal 6568 (Created: Tuesday, November 26, 2024, 9:00:09AM Eastern Standard Time) - Overview

We propose to obtain NIRSpec G395H/F290LP IFU spectra of the nuclei of nearby elliptical galaxies M87 and Maffei 1 to search for the Paschen alpha "recombination" emission line of positronium at 3.75 microns. IFU observations will use a 4-point nod to minimize backgrounds and maximize S/N. The spectral resolution may slightly resolve the emission line, so spectral smoothing can be used to enhance S/N. The emission line is expected to be faint but detectable with  $S/N \sim 12$  in 4 ks if the source of electron-positron annihilation not diffuse. If the annihilation is from several dominant point sources, the S/N will be reduced correspondingly, but detection should still be possible. Modifying previous JWST observations using the NIRSpec IFU in program 1939 that did not include the positronium line, we use 12 groups per integration and 7 integrations per exposure with NRSRAPID readout. Nearby and in-IFU dither pattern sources will not saturate the detector. The two targets, including overheads, will require 4.7 hours.

Note: In the original NRAO proposal, we made an error in the JWST time calculation and requested time for only one of two targets (10 ksec on-source, 4.7 hours total). The setup in the APT requested here reduces the time on source in order to maintain the total requested JWST observing time. Since this science is exploratory and the Ps line strength is not known a priori, the science case remains the same but the S/N on the fiducial Ps Pa-alpha line is 1.6 times lower (now 12, was 20). I apologize for the error.

Proposal 6568 - Targets - A Search for Extragalactic Antimatter: Positronium in Maffei 1 and M87

Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
	(2)	Maffei1	RA: 02 36 35.4662 (39.1477758d) Dec: +59 39 17.51 (59.65486d) Equinox: J2000	Epoch of Position: 2000	
<i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i> Category=Galaxy Description=[Active galactic nuclei, Elliptical galaxies]					

Proposal 6568 - Observation 2 - A Search for Extragalactic Antimatter: Positronium in Maffei 1 and M87

Tue Nov 26 14:00:09 GMT 2024

<b>Observation</b>	<p><b>Proposal 6568, Observation 2: Maffei 1</b></p> <p><b>Diagnostic Status: Warning</b></p> <p>Observing Template: NIRSspec IFU Spectroscopy</p> <p><i>Comments: We employ the 4-point nod here but used the 2-point nod in the ETC with twice the integration time because the ETC does not offer a 4-point nod mode.</i></p>											
	<p>(Visit 2:1) Warning (Form): Data Excess over lower threshold</p> <p>(Visit 2:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.</p>											
<b>Diagnosics</b>												
<b>Fixed Targets</b>	<b>#</b>	<b>Name</b>	<b>Target Coordinates</b>			<b>Targ. Coord. Corrections</b>			<b>Miscellaneous</b>			
	(2)	Maffei1	RA: 02 36 35.4662 (39.1477758d) Dec: +59 39 17.51 (59.65486d) Equinox: J2000			Epoch of Position: 2000						
<p><i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i></p> <p><i>Category=Galaxy</i></p> <p><i>Description=[Active galactic nuclei, Elliptical galaxies]</i></p>												
<b>Template</b>	<b>TA Method</b>						<b>HFF Readout Mode</b>					
	NONE						false					
<b>Dithers</b>	<b>#</b>	<b>Dither Type</b>		<b>Size</b>	<b>Starting Point</b>			<b>Number of Points</b>	<b>Points</b>			
	1	4-POINT-NOD										
<b>Spectral Elements</b>	<b>#</b>	<b>Grating/Filter</b>	<b>Readout Pattern</b>	<b>Groups/Int</b>	<b>Integrations/Exp</b>	<b>Leakcal</b>	<b>Dither</b>	<b>Autocal</b>	<b>Total Dithers</b>	<b>Total Integrations</b>	<b>Total Exposure Time</b>	<b>ETC Wkbk.Calc ID</b>
	1	G395H/F290LP	NRSIRS2RAPID	18	5	false	true	NONE	4	20	5543.778	191917
	2	G395H/F290LP	NRSIRS2RAPID	18	5	true	true	NONE	4	20	5543.778	191917