Observing strategy redshift 6-8 (photometry)

Due to their filters, James Webb Space Telescope and E-ELT were considered for the survey used to observe galaxies between a redshift of 6 and 8.5. Both had the ability to do the colour photometry needed to identify the high redshift candidates. E-ELT had a larger field of view, and a larger primary mirror, but James Webb was able to resolve faint objects faster due to its low background. The following section outlines the motivation behind the choice of telescope for this survey.

Results for E-ELT

Table 1 shows the number of galaxies observable for survey times of 0.1, 0.2, and 0.5 million seconds. The number of galaxies that would be observed at different magnitudes is presented, and the table also displays the time taken to observe 1FoV down to each magnitude, and the number of galaxies in that field of view. The red number indicates how many FoVs were possible given the set total observing time. N/A indicates that there were either no galaxies at this magnitude, or that the time taken to get to this magnitude was larger than the intended total survey time. The total number of galaxies is also plotted against the magnitude in figure 1.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| magnitude | Time for 1 FoV | No. of galaxies in 1 FoV | Galaxies in total observing time of: | | |
| 0.1mil | 0.2mil | 0.5mil |
| 27 | 2.35E3 | 0.015 | 0.63 (42) | 1.28 (85) | 3.18 (212) |
| 28 | 1.48E4 | 1.11 | 6.60 (6) | 14.43 (13) | 36.63 (33) |
| 28.5 | 3.72E4 | 4.56 | 9.12 (2) | 22.80 (5) | 59.28 (13) |
| 29 | 9.34E4 | 13.97 | 13.97 (1) | 27.94 (2) | 69.85 (5) |
| 29.5 | 2.32E5 | 34.71 | N/A | N/A | 69.42 (1) |
| 30 | 5.89E5 | 74.12 | N/A | N/A | N/A |

**Table 1: Number of galaxies for set total observing time given different magnitudes/ survey areas**

**Figure 1 Number of galaxies expected for different magnitudes, given set overall observing time (E-ELT 6-8.5)**

The program predicts that the total number of galaxies will be highest between a magnitude of 29 and 29.5. For a survey of 0.1 million seconds per filter, it would be expected that around 14 galaxies would be found, but this would have a large error due to cosmic variance. If the survey time was doubled, this number would be increased to around 28 galaxies, with 2 pointings and slightly reduced cosmic variance. With a total exposure length of 0.5 million seconds, and 1 pointing at 29.5 mag, the maximum number of galaxies peaked at around 70. This data was then compared to JWST for the same magnitudes and survey times to decide which telescope would be better equipped to find galaxies in this redshift range.

Comparison

The number of galaxies at each magnitude was plotted for both James Webb and E-ELT. Figure 2 shows the comparison for the two telescopes each with the shutter open for 0.1 million seconds. Figure 3 then displays the equivalent result but for a total time of 0.5 million seconds.

**Figures 2 and 3: JWST vs ELT: comparison of number of galaxies observed given same set observing time**

It was apparent that JWST would be able to view significantly more galaxies given the same total observation time. This was true at all magnitudes, but the difference became more significant at higher magnitudes. In figure 3 it can be seen that at a magnitude of 29.5, the difference was even more pronounced, since E-ELT had already peaked, whereas JWST had continued to see more galaxies as a result of the increase in magnitude from 29. Therefore it was concluded by extrapolation that at no point was E-ELT likely to observe more galaxies than JWST. James Webb was therefore chosen over E-ELT to conduct the 6 to 8.5 redshift survey.

Results for JWST

Table 2 and figure 4 present the same information as shown for ELT, but instead using James Webb observing times and field of view.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| magnitude | Time for 1 FoV | No. of galaxies in 1 FoV | Galaxies in total observing time of: | | |
| 0.1mil | 0.2mil | 0.5mil |
| 27 | 4.31E2 | 0.0029 | 0.67 (232) | 1.335 (464) | 3.36 (1160) |
| 28 | 1.16E3 | 0.214 | 18 (86) | 36.81 (172) | 92.23 (431) |
| 28.5 | 1.97E3 | 0.881 | 44.05 (50) | 88.98 (101) | 222.89 (253) |
| 29 | 3.46E3 | 2.697 | 75.52 (28) | 153.73 (57) | 388.37 (144) |
| 29.5 | 6.44E3 | 6.702 | 91.05 (15) | 188.17 (31) | 467.39 (77) |
| 30 | 1.29E4 | 14.312 | 100.18 (7) | 214.68 (15) | 543.86 (38) |
| 30.5 | 2.78E4 | 27.380 | 82.14 (3) | 191.66 (7) | 465.46 (17) |
| 31 | 6.43E4 | 48.346 | 48.35 (1) | 145.04 (3) | 388.42 (7) |
| 32 | 3.8E5 | 128.461 | N/A | N/A | 128.46 (1) |

**Table 2: Number of galaxies for set total observing time given different magnitudes/ survey areas**

**Figure 4: Number of galaxies expected for different magnitudes, given set overall observing time (JW 6-8.5)**

The results showed clearly that for any survey time, the most beneficial survey depth was around magnitude 30 as it yielded the most galaxies between redshift 6 and 8.5 (figure?). For a survey of 0.1million seconds, approximately 100 galaxies would be expected at magnitude 30. It was decided that this was a large enough sample, as spectroscopically confirming more than 100 is unfeasible.

Total Time for Survey

With each filter taking 0.1 million seconds, and 3 filters needed to do colour analysis, the shutter will be open for around 0.3 million seconds. On top of this are the overhead times, which as a crude approximation double the survey time to 0.6million seconds. Spectroscopy will be used to confirm the most promising candidates out of those observed using photometry, which will further add time to the survey.