EDGES WA Site Trip Summary Feb 2024
LoCo EDGES Memo #202

Date: Mar 29, 2024
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Dates on-site: Feb 19, 2024 to March 1, 2024
Team on-site: Akshatha Vydula and Nivedita Mahesh

Primary goals of the trip:

1. Ground Plane Resonance testing in the inner 10mX10m for EDGES-3
2. Installation of Receiver-1 to low2-45
3. Ground Plane survey to measure undulations using theodolite for EDGES-3

A detailed triplog on a daily cadence can be found on the EDGES shared on Google Drive.
Pictures from this trip can be found in the EDGES shared Google Drive folder.
Some 'fun' pictures from the trip can be found on the Google Photos link.

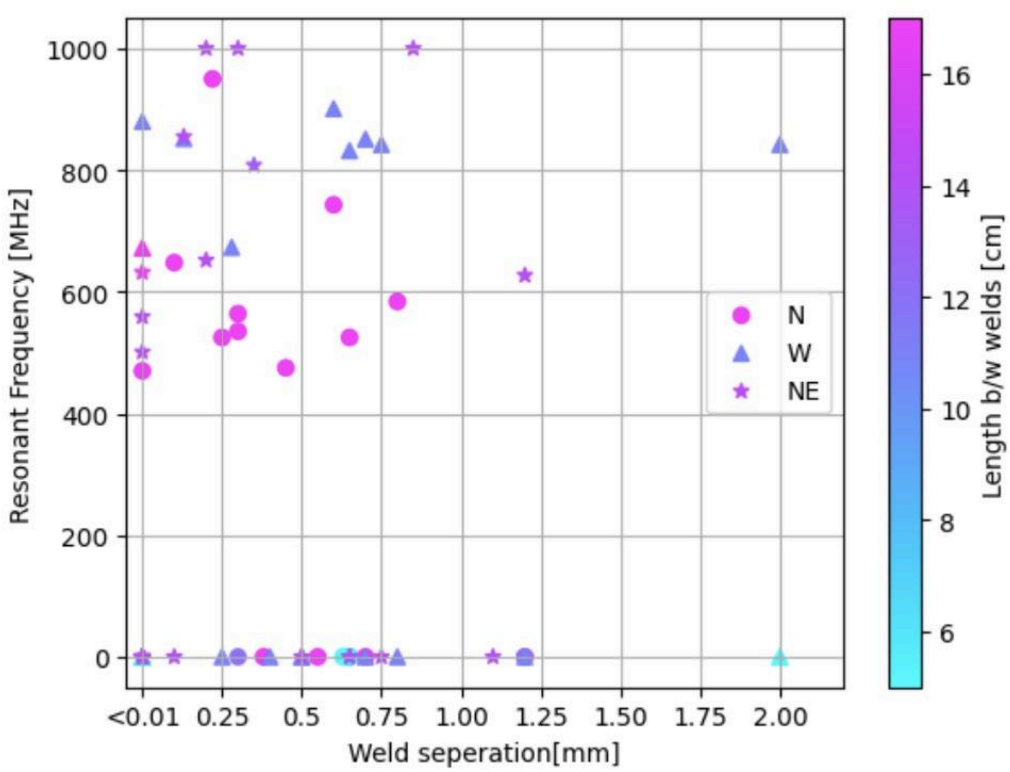
Work done towards Goal #1:

Here, we summarize some of the findings of resonance testing. For detailed plots and pictures of the tests performed on-site, please refer to Memo #201.

- We followed the procedure outlined in MIT EDGES Memo 435 to look for resonance in the ground plane caused due to slot capacitance in the slots created from welding.
- Effects of galvanized iron coating:
    - We find no difference in measurements with and without using clamps for establishing electrical contact.
    - We tested by scraping the layer of galvanized iron and then connecting the crocodile clips and saw no difference in measurements. A continuity test using a multimeter, in some cases, showed discontinuity, but repeating the test at the same spot after using alligator clips showed continuity. This suggests that the claws on crocodile clips scrape a layer as they hold the wire mesh, just enough to establish electrical contact.
    - Apart from initial testing for five spots, we don't use any clamps for the remainder of the exercise. We left these clamps as is—a total of 10 (slots 1 through 5 as listed in Memo #201).
- Effects of Ferrites:
    - We find that the position of ferrites on the cable makes a big difference to the S11 measurement. The cable + alligator clips used has an inherent resonant frequency of ~325 MHz, which shows up in the S11 measurements if the two ferrites are not maintained, one at each end of the cable.

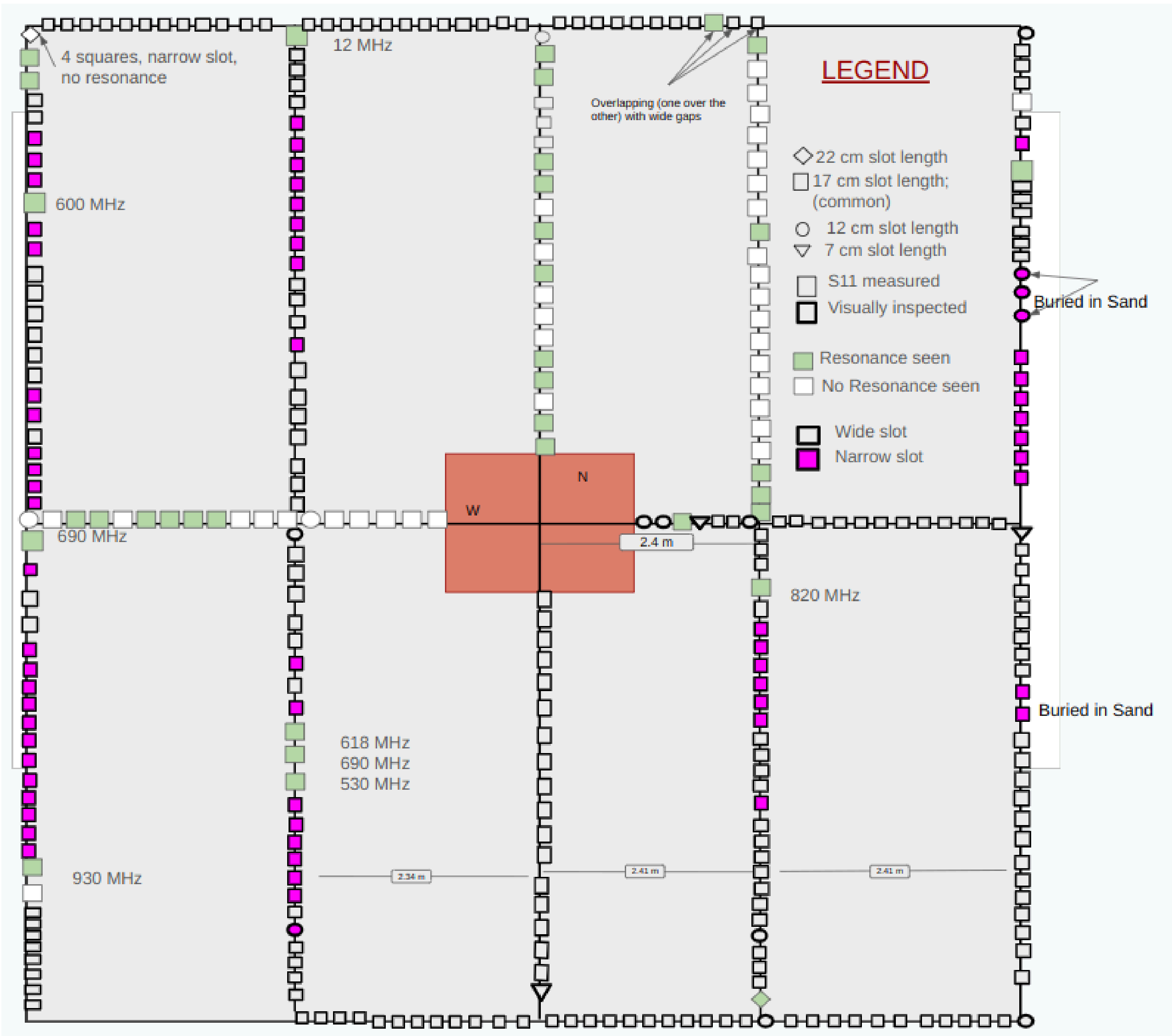
- In the first two days of testing, before this was established, we reported one slot to show a resonance at 178 MHz, but it is likely the internal cable resonance rather than that due to the slot (see slot six reported in Memo 201).
- Memo 201 also shows the effect of different placements of ferrites on the S11 measurement, indicating that it is due to the cable.

- Selection of slots:
  - Based on bench testing in the lab, we initially selected slots that are longer than a typical 3 square length and have little to no spacing between them (visually in contact). We also inspected the slots where the mesh edges overlapped along the z-axis (Ref. memo 201 for pictures). We saw no resonance below 500 MHz.
  - We also tested every slot on three weld lines: the center of the antenna extending North, the first line east of the antenna extending north, center of the antenna extending west. The slots seen on these three weld lines were representative of all types of slots on the ground plane – lengths varying from one square length to 4 squares, widths from ~3mm to meshes entirely in contact with each other (<measurable width with a feeler gauge). Of all these slots, we did not see any resonance below 500 MHz.
  - The plot here shows the observed resonant frequency plotted against the slot length and the separation. Data points on this plot are from the three weld lines stated.



- After examining the S11 of each slot from the first three weld lines, we visually examined all the slots within the inner 10m X 10m and performed S11 measurements for those slots that are longer than the typical 3square length and visually appear to be in contact. None of the slots inspected showed resonance below 500 MHz.

- The map here shows each inspected slot within the inner 10m X 10m ground plane.



- To reduce the gaps in the slots, we used wire twisters and clamps from Spots 1-6, as noted in Memo 201.
- We checked for possible resonances between the metal plate and the mesh of the ground plane. We measured the S11 at a few points by connecting one end of the alligator clips to a nut on the metal plate and the other to mesh wire. Still, no resonances were reported in the S11 measurement.
- We found seven (three triangle and four rectangle pieces) unused ground plane mesh panels lying close to the EDGES-3 and EDGES2-45 ground planes. It was N-W of EDGES-3 and North of EDGES2. Given each mesh panel is about 5m x 2.5 m and they were close to the EDGES-3 system, we speculate that they could have scattering effects

on the data and it would be worth checking if that caused the 60 MHz resonance. These were moved to the pile east of the hut, where the rest of the unused ground plane meshes are kept.

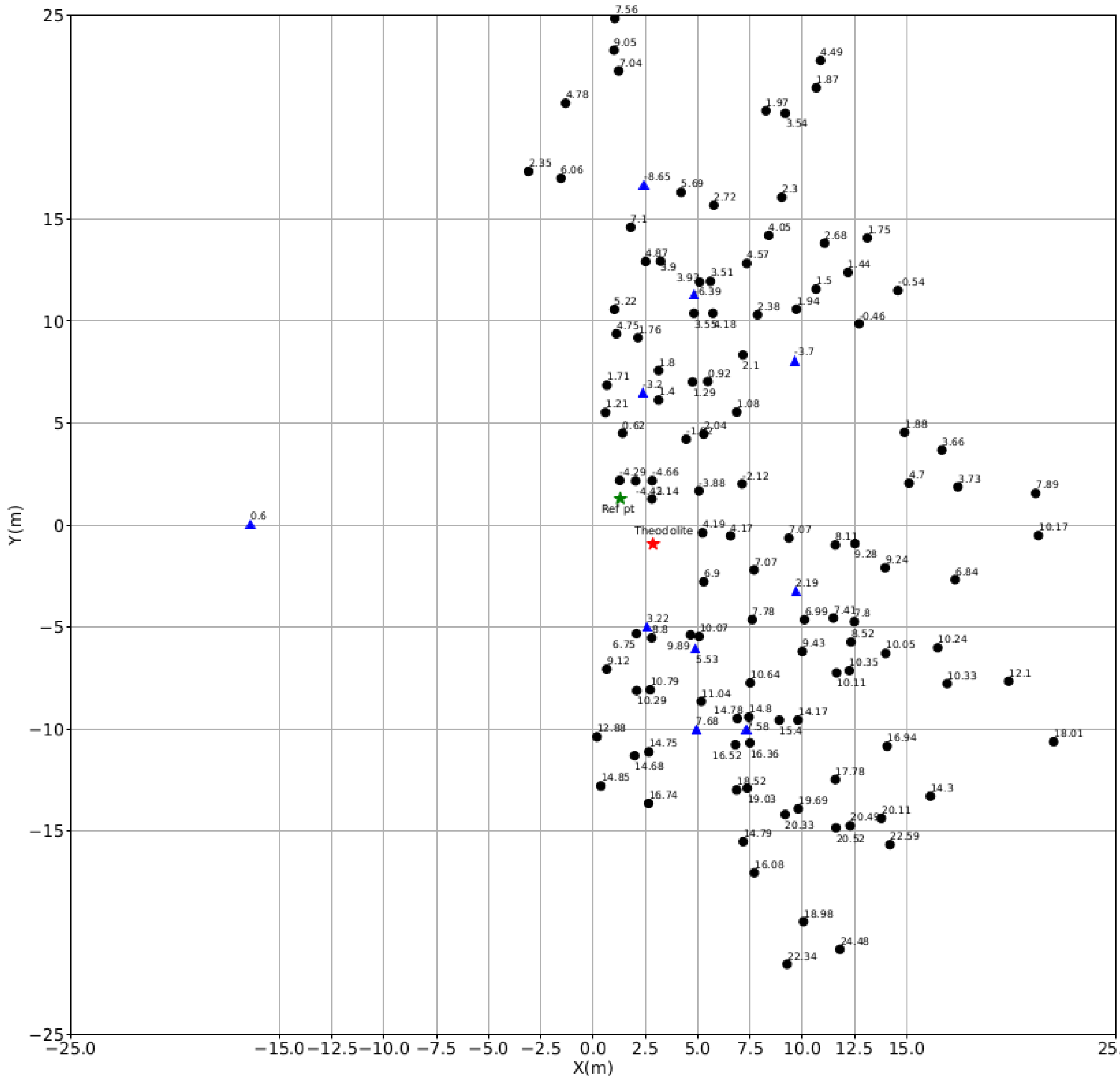
Work done towards Goal #2:

- Receiver-1 was calibrated in the ASU lab with the out-of-band noise source turned off and then taken to the field to be installed with the EDGES low2-45 antenna.
- Receiver-2 was retrieved from the pit under the low2-45 system and currently sits in the ASU basement lab.
- Air circulation system currently in place for EDGES-2:
  - One of the conduits going to pad 4 is connected to a one-way fan using a 12 V supply. The airflow is set up such that the air flows out of the receiver and into the hut. The second leg of the 3D printed leg of the receiver box is not connected to any conduit.
  - 12 V supply was taken from the Schaffner filters coming out from the cabinet. A few connectors connected to the same 12 V supply from the Schaffner have U-type fork connectors. We made it work for now, but in the future, note that this connection is crowded. U-type could also be replaced with O-type.
  - Additional repairs were done to the conduit pipe in the pit using PVC pipes since it was damaged.
- Backend changes:
  - Replaced the 15dB attenuator in the backend with a 1dB attenuator. Noted that the ADC min and max range are between +/-0.22V after the attenuator replacement.
- Computer issues:
  - Rx-box was switched on on Friday, Feb 23, 2024. When we first started collecting data by running fastspec, we noticed issues where we suspected the 3-port switch wasn't switching. Since the power levels of p0, p1, and p2 were all the same and orbcomm pickup was seen in all three spectra, we suspect that the switch was only looking at the antenna. We were able to successfully get an S11 measurement of the antenna via the ethernet and VNA, confirming that the receiver is indeed connected and the ethernet port is working fine.
  - This issue resurfaced multiple times the following week, and upon some debugging, we noticed that the parallel port on edges-1 computer was not sending the intended voltages to enable switching. So we replaced the PCI card from edges-2 computer to edges-1 computer. The potentially faulty PCI card sits on the PC rack and edges-2 does not have any PCI card. After this replacement, the system worked nominally.

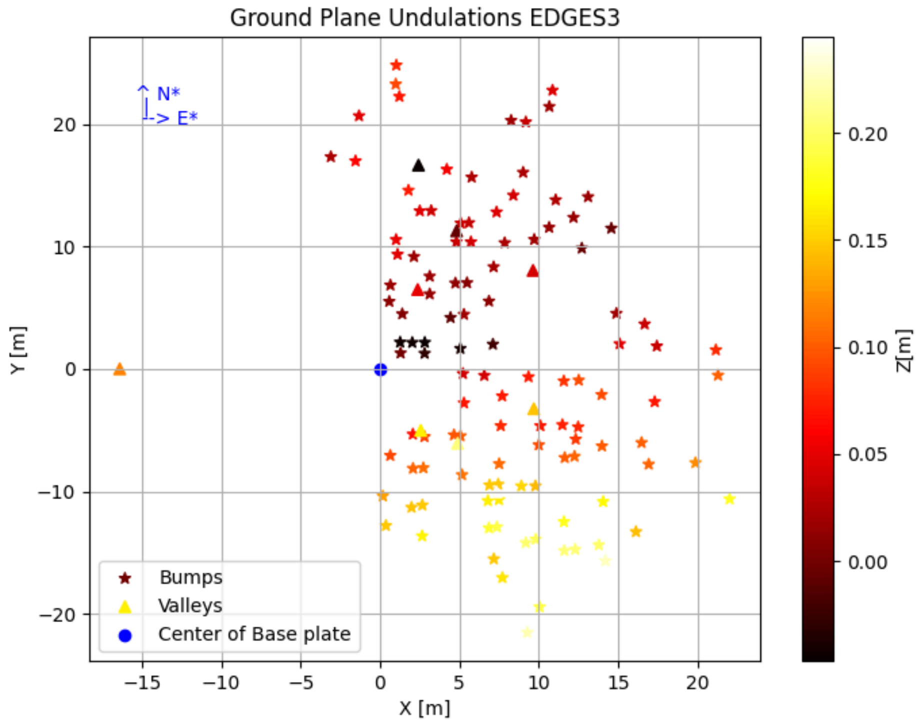
Work done towards Goal #3:

- We used Theodolite T2000 to measure the undulations in the GP.
- Measurement dates: From Wednesday, Feb 28, 2024, to March 1, 2024.

- Set up:
  - We used an external battery (12 V, 7A) to power the theodolite.
  - A metal staff was used to set a reference point in measurement.
  - A platform that fits within the wire mesh of the GP was used to stand on and hold the metal staff on the GP to avoid errors in measurement due to body weight pressing down the GP.
  - The reference point of all the measurements is on the NE corner of the baseplate (1.3m, 1.3m).
  - The tripod was set up on the SE of the base plate, with a distance from the center of the antenna being 2.87 m towards E and 0.93 m towards S.
  - A heavy metal weight was used to secure the tripod's position overnight so measurements could be resumed from the same position of the theodolite over multiple days.
- Selection of points:
  - We measured 124 points on the east half of the GP by gridding the area using the mesh sheets, as shown in the figure below. A higher-resolution image can be found here.
  - We selected ~3-4 points on each mesh sheet that appeared to have the highest ground undulations. Similarly, we selected ~7-8 points on each triangle. The idea was we would measure the height of the bumps on the ground plane from the reference point (green filled circle in the figure below)
  - While performing the measurements, we realized the ground plane might have an overall slope, so we selected 10 points spread over the East half of the GP that represented the lowest points/valleys of the GP (ex: parts of the GP that appeared to be buried in the soil). These 10 measurements are indicated by blue triangles in the figure below and in the high-resolution PDF.
  - The height of the GP at the measured points are given annotated in centimeters in the figure below and here
  - The figure also shows that we made one measurement of a low/valley point (indicated by the blue triangle) on the west side of the GP so that we could estimate the slope of the ground plane along EW.
  - Overall, the measurements reveal quite a few undulations on the GP that are> 10cm.
  - All undulations towards the South seem to be larger, but that could also be due to the fact that the GP is sloping from S to N, indicated by the blue triangle measurements.



The figure shows the x,y, and z points measured relative to the center of the baseplate.

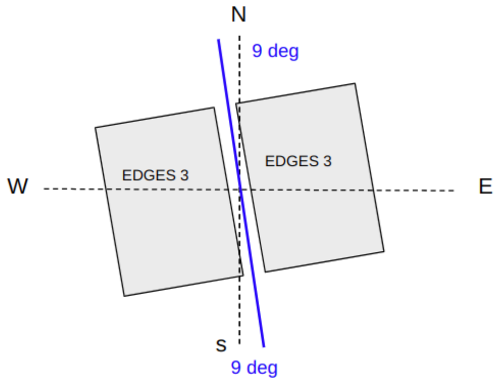


Additional updates:

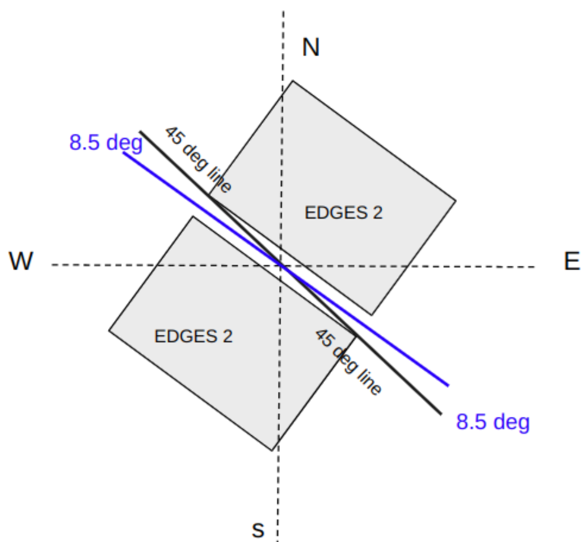
Antenna Orientations:

- We used the Suunto M3 compass and a phone to measure the orientations of the EDGES-3 and EDGES-2 45 relative to N.
- We learned that placing the compass close to the baseline or the panels (in the case of low-2 45) affected the compass, causing its North to be off from the actual N by 20-30 deg.
- To overcome this, we used a long wooden staff. We placed the wooden staff along the base of the legs so that its axis extended about half a meter away from the antenna and any metal. Then, we aligned the compass to the staff's axis.
- We measured the orientation in all four directions for both antennas by aligning the wooden staff to the corresponding legs.

- EDGES-3 Orientation:
  - Ideally, the excitation axis of the EDGES 3 antenna should be aligned EW, and the axis perpendicular to the excitation is expected to be NS
  - However, our measurements indicated that the antenna's orientation was offset by -9deg. This is shown in the diagram below, where the axis perpendicular (blue) to the excitation axis is -9 deg from the true North. This number differs from what was reported in the previous site visit memo#406. They had measured an offset of 21 deg.



- Low2-45 orientation:
  - Ideally, the excitation axis of the EDGES 2 low-45 antenna should be aligned along -45 from EW, and the axis perpendicular to the excitation is expected to be -45 deg from NS
  - However, our measurements indicated that the antenna's orientation was offset by -8.5 deg. This is shown in the diagram below, where the axis perpendicular (blue) to the excitation axis is -53.5 deg from the true North or -8.5 deg from the expected 45 deg line.

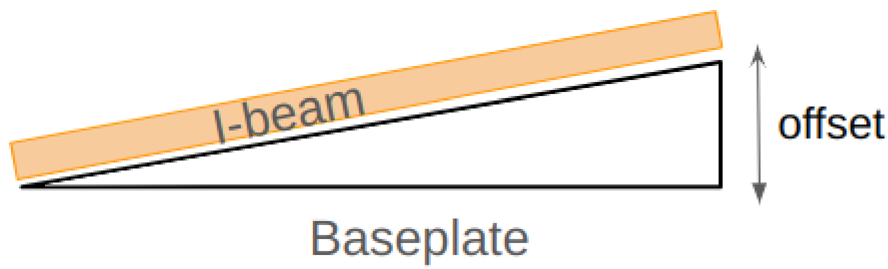


EDGES-3 roll and Tilt:

- To measure EDGES-3's roll and tilt, we used an I-beam level, which is basically a measuring stick with a spirit level.
- We carried out the measurement by placing the I-beam level at different points on the baseplate.

- To measure the tilt, we placed the I-beam level perpendicular to the excitation axis (so, roughly NS). To measure the roll, we placed the I-beam level along the excitation axis (so, roughly EW).

- We measured the height (offset) of the beam that needed to be lifted until the bubble in the spirit level was centered. As shown in the diagram below, we now have a right-angle triangle, whose angle we can calculate to determine the roll/tilt. The length of the beam was 1.68m. All the measurements are indicated in the table below:



Roll Measurement	Repeats	Offset (cm)	Roll (deg)	Tilt Measurement	Repeats	Offset (cm)	Tilt (deg)
Parallel to excitation Southside	1st	0	0	Perpendicular to excitation East side	1st	1.8	0.61
	2nd	0.1	0.034		2nd	2.1	0.72
	3rd	0.1	0.034		3rd	2.6	0.89
Parallel to excitation Northside	1st	0.3	0.10	Perpendicular to excitation West side	1st	2.6	0.89
	2nd	0	0		2nd	2.7	0.92
	3rd	0.2	0.068		3rd	2.65	0.92

- The roll is almost non-negligible. The maximum tilt is about ~1 deg. The baseplate slopes from N to S in terms of tilt.

We identified the cables going to Pad3. We noticed one ferrite on the green and yellow cables but no ferrites on the black and red cables. We added one ferrite each on the red and black cables.

Clamping the EDGES-3 GP with tent spikes

- We attempted to clamp down a few bumps of the GP using tent spikes (shown in the figure below) - a.) it was not easy, b.) It doesn't seem to help pull down the metal mesh

- We noticed a few tent spikes on the EDGES 3 ground plane that must have been hammered in before(picture below). But as you can see, that spike doesn't seem to be holding the ground plane down (at least currently). It is possible it came out of the ground with time and weather.

- Small bushes on the EDGES-3 ground plane were taken out.