Copper Strap Magnetic Loop Antenna 17 m - 80 m Bands

Building Guide

Revision	1
Date	November 28, 2021

Jaakko Koivuniemi, AC1BB

Notice

Copper strap has sharp edges. Use eye protection goggles and gloves when handling the strap. It needs support structure made from good electrical insulator. Be careful and use good construction techniques when drilling holes and cutting materials. High voltages are present at vacuum capacitor.

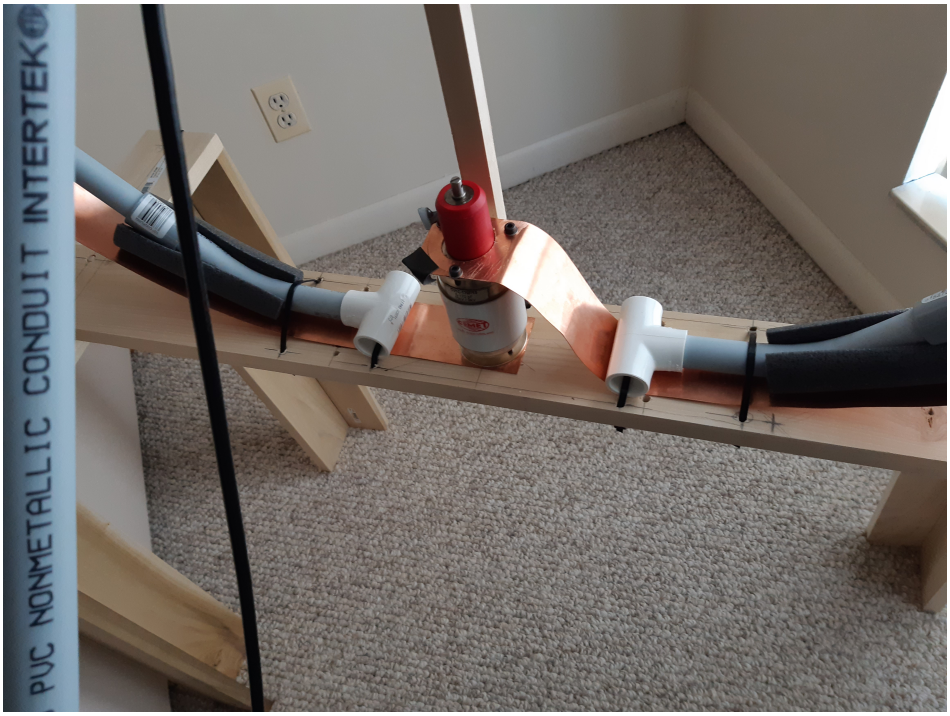

Figure 1: The vacuum capacitor is bolted on Copper strap with stainless steel M4 screws.

Small strap loop

The AA5TB and KE4PT Small HF Loop Antenna Calculator https://www.aa5tb.com/loop.html can be used to get first idea of magnetic loop performance. In this model length of Copper strap gives the circumference of similar circular loop antenna. The equivalent Copper pipe diameter can be estimated by assuming the both sides of strap conduct RF current. Small loop is build with 2 inch wide, 0.025 inch thick and 10 feet long Copper strap. Variable vacuum capacitor was 5 - 170 pF / 15 kV (Comet CVBA-170BC/15). The strap is bolted to top and bottom flanges of the capacitor with M4 screws. Fig. 2 shows how 1 1/4 inch hole can be cut to Copper sheet. Support structure for the 1 m diameter loop was made from 1/2 inch PVC piping. The feed loop made from solid Copper AWG12 wire had diameter of 8 inch. Photo of this antenna is on the front page. Excitation loop was connected to Electraft BL2 balun. Fig. 1 shows how the variable capacitor is connected to the strap. The wood frame helps to isolate antenna from surrounding lossy materials and is easy to construct, but may have some dielectric losses too. Bands 17 m - 30 m are in tuning range with SWR below 2.

Large strap loop

Larger loop is build from 2 inch x 0.012 inch x 25 feet Copper strap (Georgia Copper) with same 170 pF variable capacitor, see Fig. 3. This loop was temporarily mounted on building interior wall with 1/2” PVC pipe support bar on top as shown in Figs. 5 and 6. Feed loop shape and size had to be

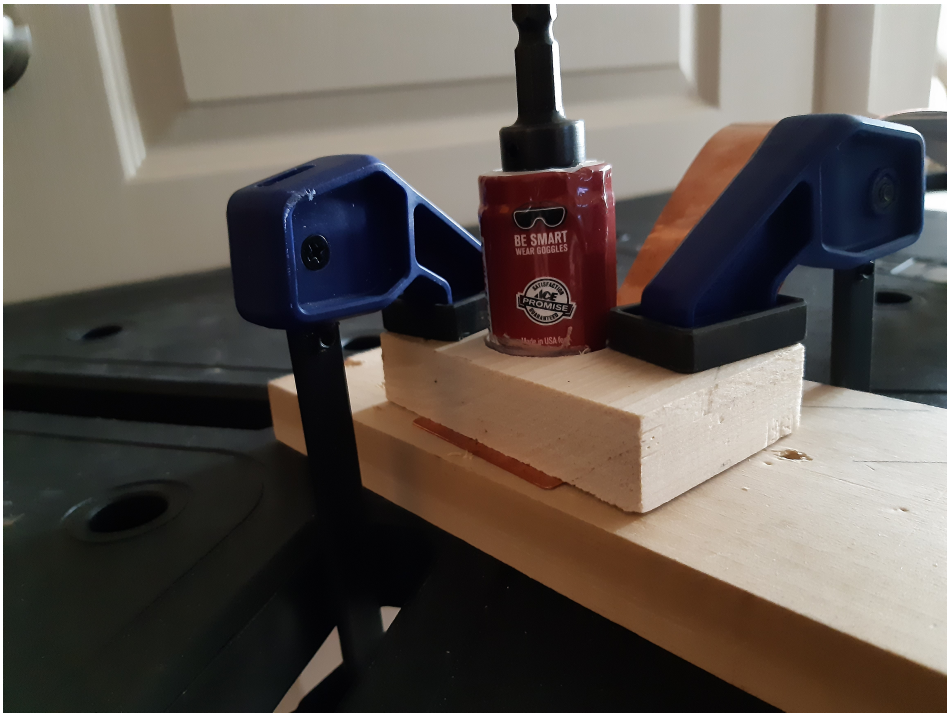

Figure 2: The 1 1/4 inch hole to Copper strap can be drilled with hole saw by clamping the strap between two pieces of wood. After 1/4 inch pilot hole has been drilled the saw can cut the hole with slow speed to Copper. Use care and personal protective equipment in this work. And take your time to do this job.

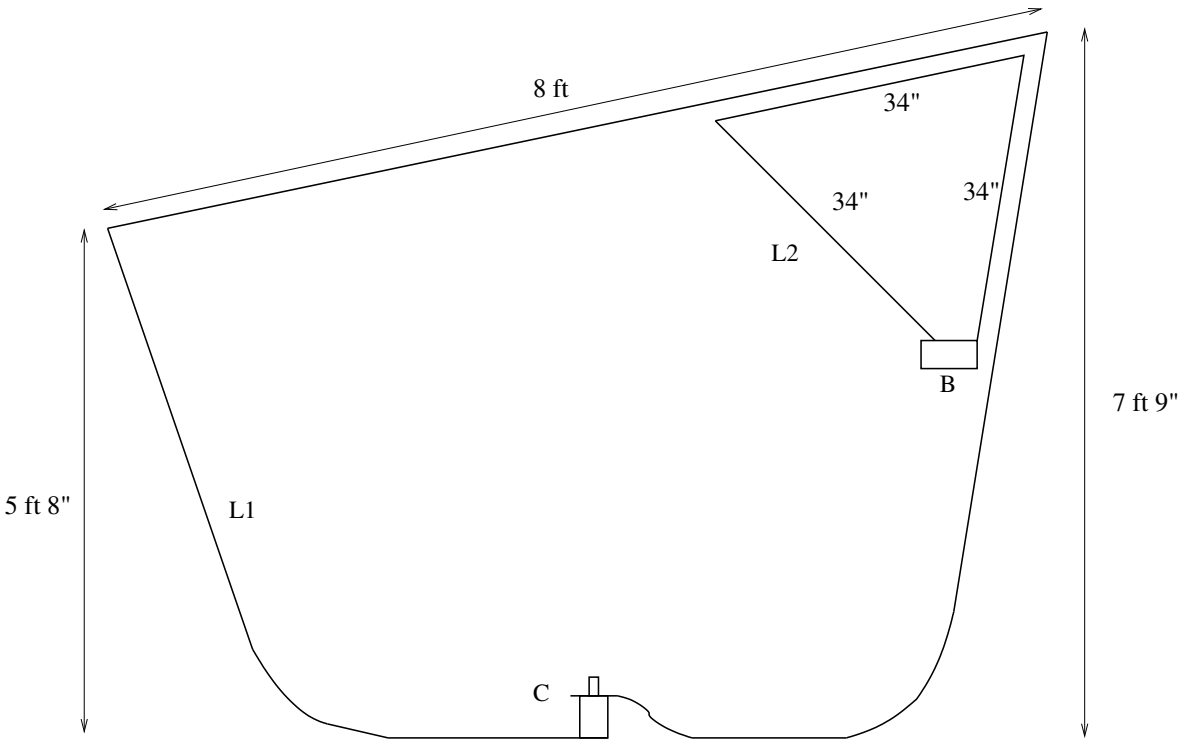

Figure 3: Loop **L1** shape is given by two fixed mounting points on wall for 25 feet long Copper strap. The vacuum capacitor **C** is fixed with three M4 socket head steel screws on 3.5 inch x 0.75 inch x 3 feet poplar wood base. Feed loop **L2** from solid Copper AWG12 wire is connected to 50 ohm coax with balun **B** (QRPGuys 1:1 Voltage Balun or Elecraft BL2). Different sizes of feed loop were tried and other positions inside the main loop were tested. Distance between feed loop **L2** and main loop **L1** needs to determined experimentally from minimum SWR. Best results seem to be when **L1** and **L2** almost touch each other, and balun and feed line are mounted orthogonal to loop plane.

found by experimenting. Minimum SWR is found by moving Copper wire closer to or further away from main loop strap. Balun isolates feed coax from the antenna and helps to reduce noise coupling back to loop from radio transceiver and ground lines. Fig. 4 shows cheat sheet for manual tuning of the loop. Bands 30 m - 60 m are in normal tuning range and 20 m maybe usable with 1:4 balun and small reduction in main loop area.

80 m strap loop

Calculation of 80 m loop can be seen from Fig. 8. Tuning capacitance needs to be increased from 170 pF to about 305 pF. This could be done with additional capacitance strap as shown in Fig. 9 for receiving antenna or at low power levels. When 170 pF vacuum capacitor was replaced with 5 - 500 pF/ 5 kV capacitor (Comet CV05C-500XIH/S) return loss -12.5 dB was measured at 3.59 MHz, see Fig. 10. Using 5 W power magnetic field about 0.9 A/m was measured at main loop center. The

	A	B	C	D	E	F
1	f[kHz]	Turns CCW	Rotation	Position	Balun Switch	SWR
2	14266	CW stop		/	1:1	7.0
3	14127	CW stop		/	1:4	2.4
4			+0.5			
5	14063	0.5		/	1:4	2.2
6			+2			
7	14063	2.5		/	1:1	5.8
8			+4.9			
9	10139	7.4		_	1:1	2.7
10			+4.5			
11	7123	11.9		/	1:1	2.1
12			+0.25			
13	7032	12.1		\	1:1	2
14			+6.0			
15	5348	18.1		|	1:1	1.8
16						

Figure 4: Cheat sheet to help in manual tuning when 170 pF vacuum capacitor was used with 25 feet Copper strap.

measurements were done with H- and E-probes described in https://github.com/oh7bf/NfHprobe and https://github.com/oh7bf/NfEprobe.The H-probe or E-probe was taped on tripod head and position was determined with tape measure. See plots in Fig. 11.

Figure 5: Temporary wall mounting of one loop corner. Opposite corner has similar mount. 1/2 inch PVC pipe supports the 2 inch wide Copper strap and feed loop. Plastic U-channel trim was added for protection from sharp metal edge.

Figure 6: Second temporary wall mounting of loop corner. The feed loop is kept in place with Velcro ties.

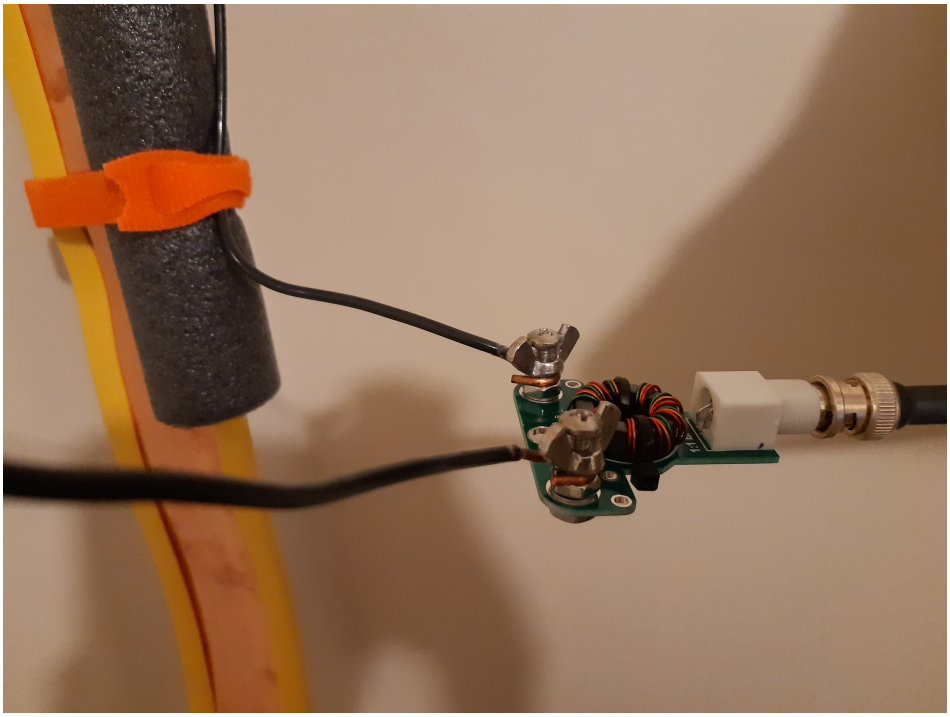

Figure 7: 1:1 voltage balun at feed loop.

Design Frequency =	3.5000	MHz	(see NOTE 5)
Loop Diameter =	8.000	feet	2.438 m
Conductor Diameter =	1.237	inches	31.420 mm
Conductor conductivity =	50	% of copper conductivity	
Added Loss Resistance =	80.000	milliohms	
RF Power =	5.000	Watts	

Calculated Results:

See Calc1 sheet for Null Depth =	-20log10(2*pi*D)		
Bandwidth =	7.939	kHz (-3 dB points)	
Efficiency =	7.604	%	-11.190 dB
Loop Area =	50.265	ft²	4.670 m²
Radiation Resistance =	12.815	mΩ	
Total Loss Resistance =	155.717	mΩ	
Loop Circumference =	25.133	ft	7.660 m
Wavelength Percentage =	8.943	% λ	
Loop dc Inductance =	6.757	µH	
Distributed Capacitance =	10.875	pF [Note 6 and 7]	
QL (Quality Factor) =	440.871		
QL (no loss) =	5797.835		Q(radiation)
Total tuning Capacitor =	306.004	pF	
Capacitor Voltage =	572.338	V rms	
Minimum Plate Spacing =	7.631	mils (1/1000 in)	0.194 mm

Figure 8: Calculated properties of 80 m magnetic loop using AA5TB and KE4PT Small HF Loop Antenna Calculator version 1.22e for circular loop with Copper tube conductor. The rectangular loop area is 36.3 square feet and efficiency was estimated to be 5.4 % (ARRL Antenna Book 2019, Chapter 5.3 Small Transmitting Loops). Skin depth is 35.3 μm at 3.5 MHz or about 10 % of strap thickness.

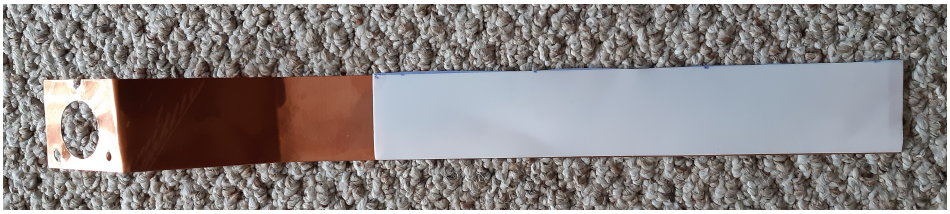

Figure 9: Additional capacitance can be done for low power levels using 0.031 inch PTFE Sheet between straps.

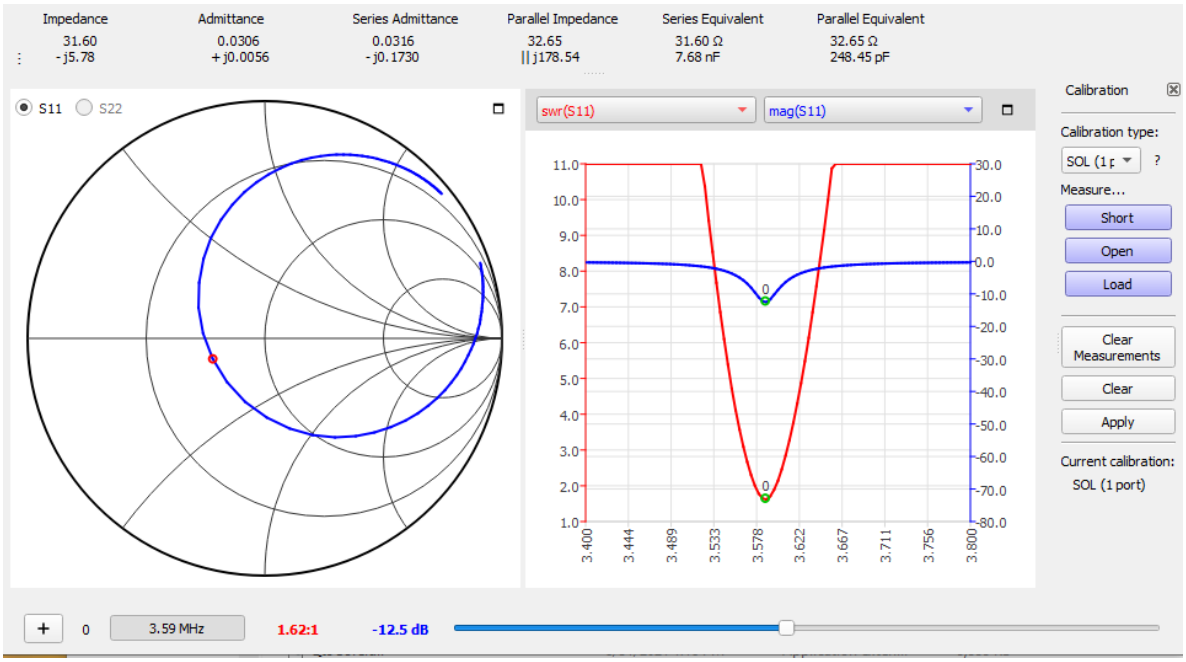

Figure 10: nanoVNA gives return loss of -12.5 dB and SWR 1.6 on 3.59 MHz frequency with tuning capacitance 294 pF and 25 feet Copper strap.

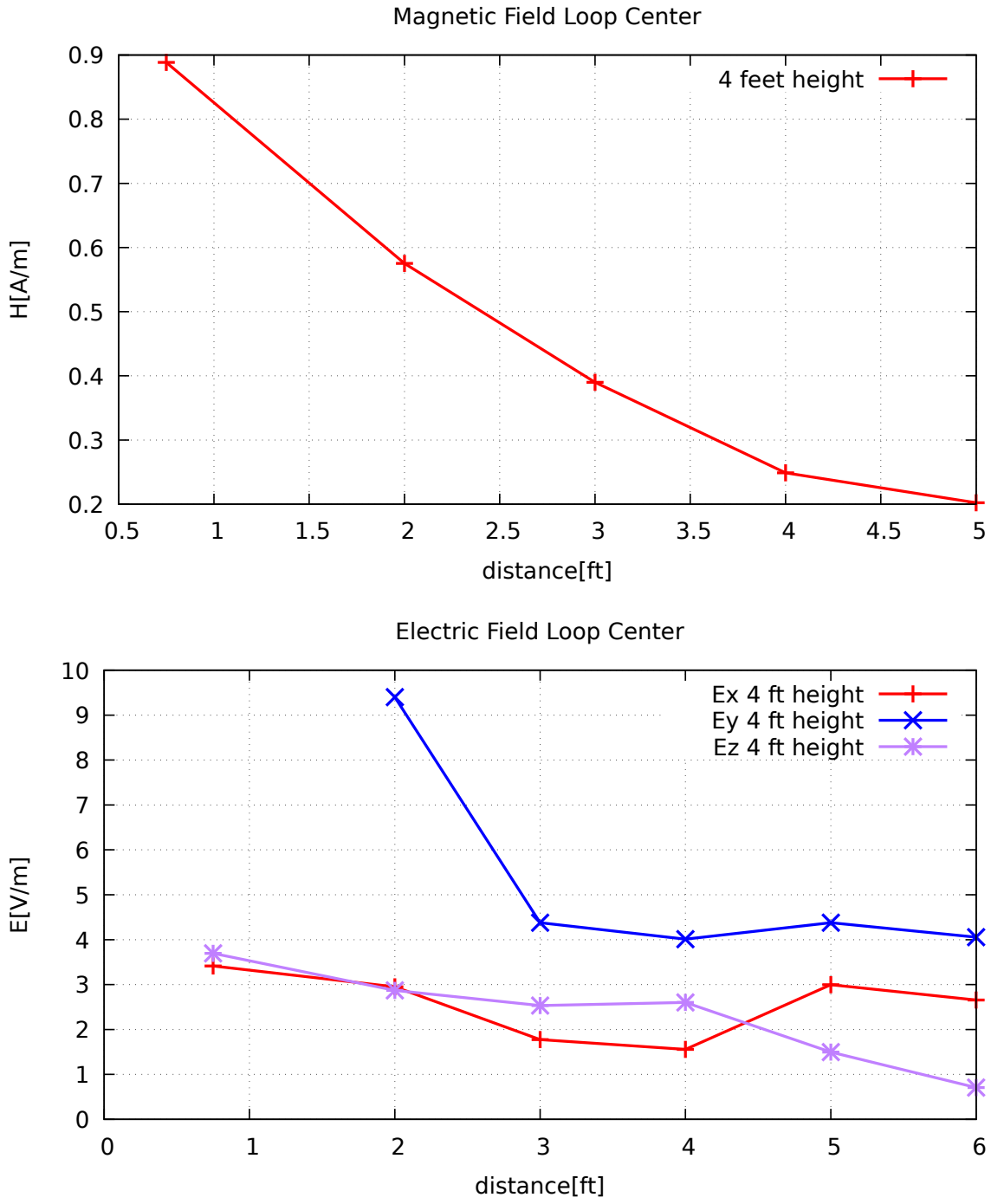

Figure 11: *Top:* Measured near magnetic field H_z on loop central axis with 5 W power at 3564 kHz. Detection limit is 0.17 A/m. At 6 feet distance H_z is below this limit. *Bottom:* Measured electric field on loop central axis. Here E_x is horizontal, E_y vertical and E_z transverse to loop plane. E_y has large ambient reception and attempt was done to subtract this background from measured field at 3564 kHz. E_y shoots up when approaching the loop center.