Grid Update and Discussion: April 5, 2024

- design parameters and tolerances
- adopted design
- ability to adjust frame elements by brute force
- a flat construction table with weight sensors
- spring testing
- material purchases
- wire-fabrication table
- thinking about testing
- sequence
- what to do if as-installed barrel wall has different dimensions

Functional Requirements:

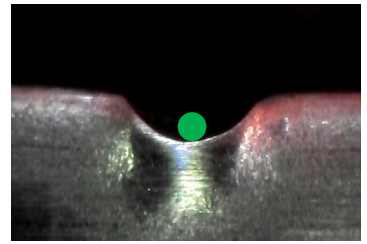
- must provide electric field separation between TPC and gas-phase region for S2 signal with minimal blockage between the two regions
- no broken wires after installation
- must be able to hold 6 kV wrt anode during normal operation
- must not introduce radioactivity above normal bulk stainless-steel levels and electro-polished and washed surfaces; with wires kept in Rn reduced environment as much as possible.
- must be planar to within 0.5 mm at an average distance below the anode of 10 +/- 1 mm during normal operation
- must fit within the 100mm wide grid-channel in the barrel walls during installation and during cool-down, and in normal operation
- must be ready for mating to the anode in Alberta in time for joint transport to LNGS and installation

Resulting specifications:

- use approximately 0.2mm diameter 304 stainless-steel spring-temper wire
- single plane of wires spaced every 3 mm having 3+/-0.3N tension during normal operating conditions (with a 40mm available range at each end of wire spanning tensions between 2 and 4N).
- grid-frame and barrel-walls at room temperature, with wires at cryogenic temperatures, must fit within the grid-channel
- grid-frame with entire detector at cryogenic temperatures must fit within grid-channel
- grid-frame vertical planarity must be within +/- 1mm at all temperatures
- bridge-plate resting on barrel walls must support grid-wires at 10.0 +/- 0.5 mm below the anode at all sides of the octagon

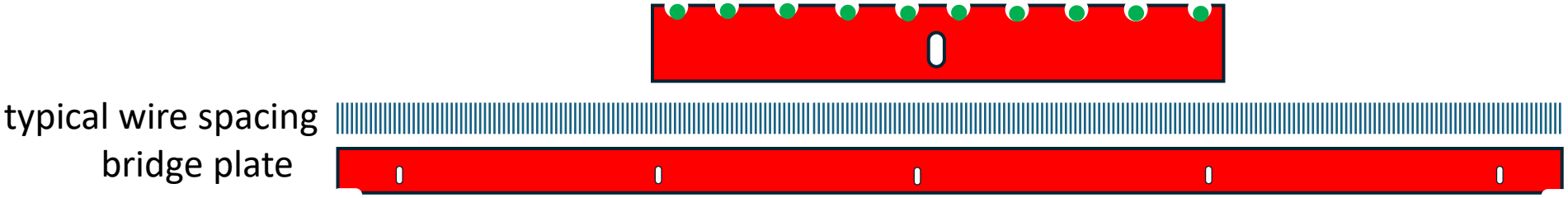
Adopted Design

- Grid-frame rests directly on shelf in TPC barrel wall
- 'Bridge-plate' (about 77 cm long – two per straight section of octagon) is used to space the grid wires 3mm apart horizontally and ensure 28.0mm space from barrel wall shelf to wire plane.
- During dry-fit we will map the shelf height, and then trim bridge-plates to match as needed.) Bridge-plate will hang by top of slots during construction and be pushed up by about 3mm when frame is lowered onto shelf during final assembly.

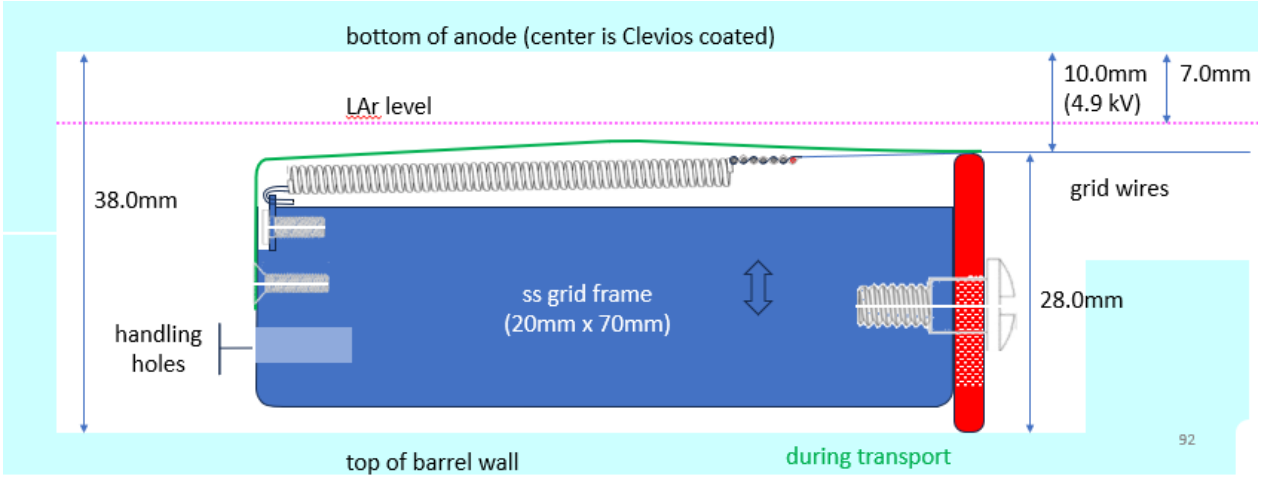


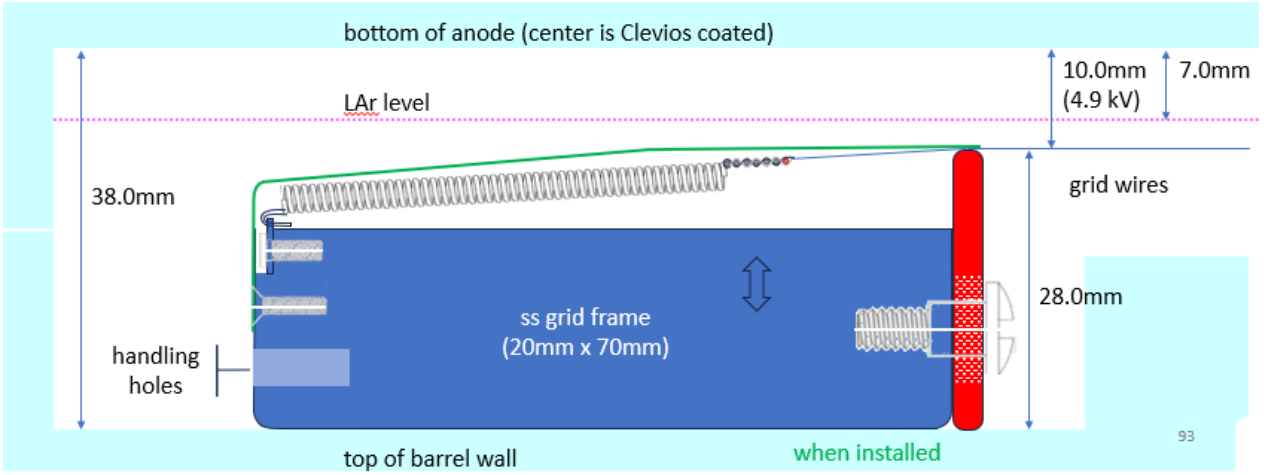
200 μm wire in swaged groove every 3mm along top edge of 'bridge plate'

swaged grooves at 45° for side wire planes



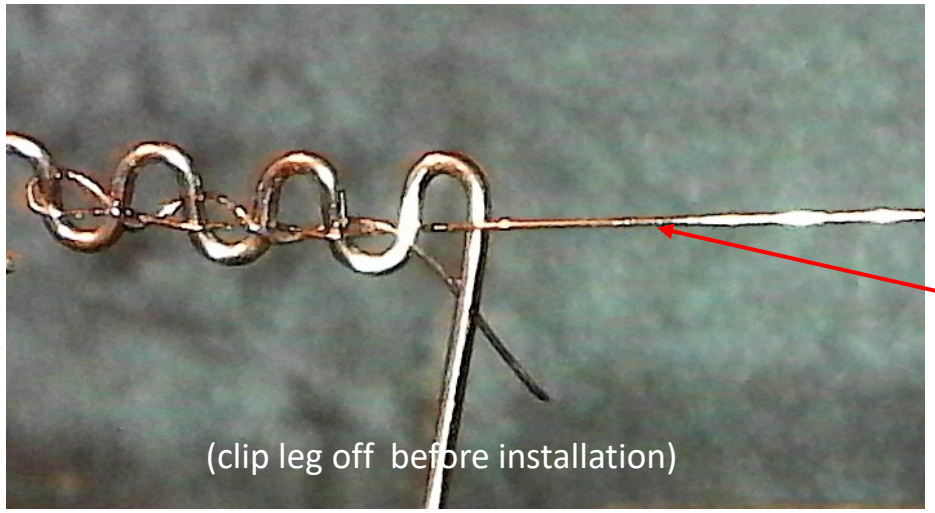
772.5 mm long (room temp); 257 wires



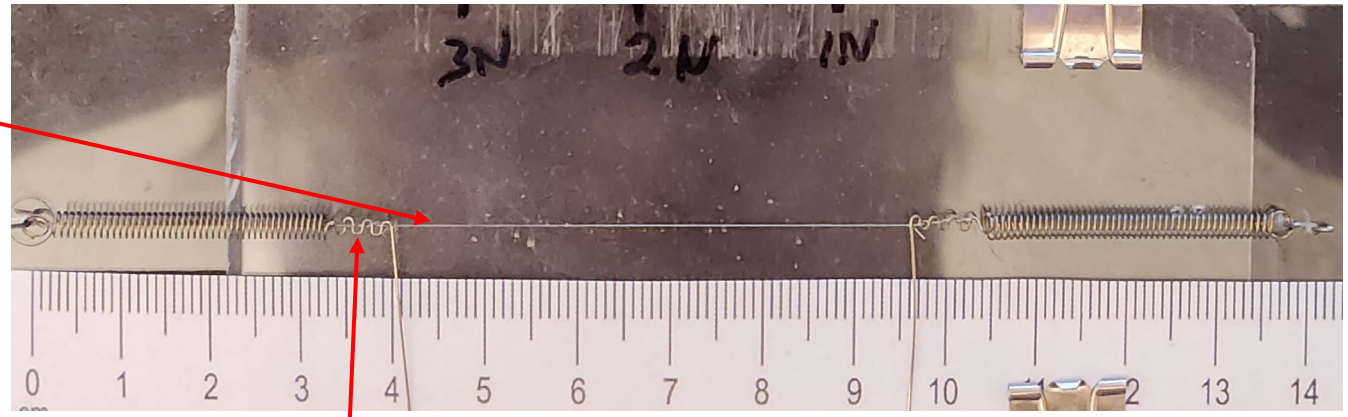


Grid-wire termination to springs:

use spring-tempered 304 ss wire @ 3N tension
(use 215 μm wire to be vertically neutral in operation)



tested up to 26N using 109μm wire (2.7GPa tensile strength)



PROS:

0.05 N/mm effective spring constant

no need to pre-stress frame when wiring

no concern about wires getting cold first

termination of wires to springs simple

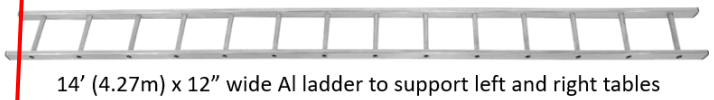
CONS:

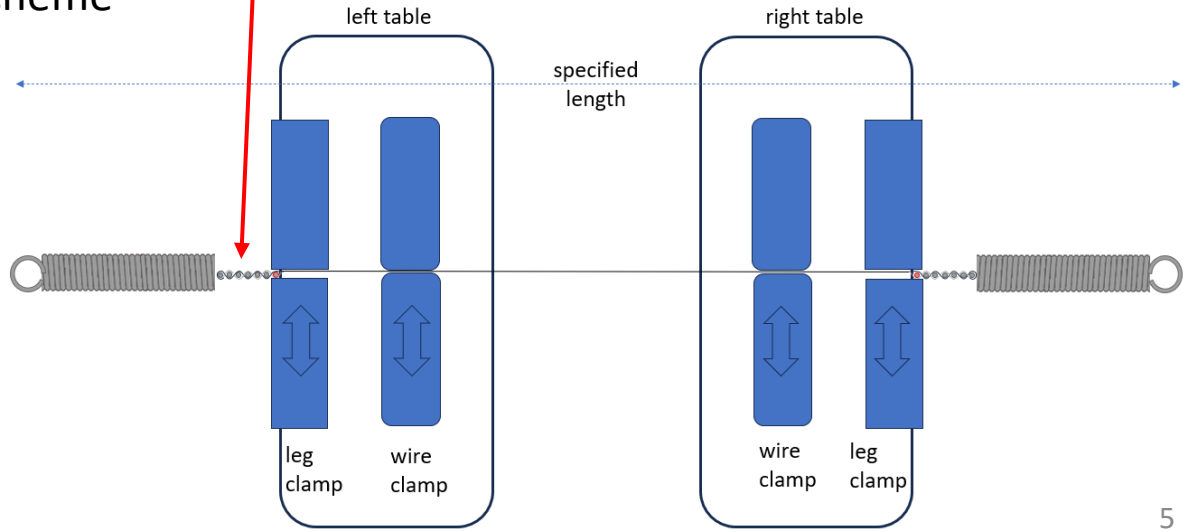
new technique

requires Faraday cage

has more confined volume for liquid argon

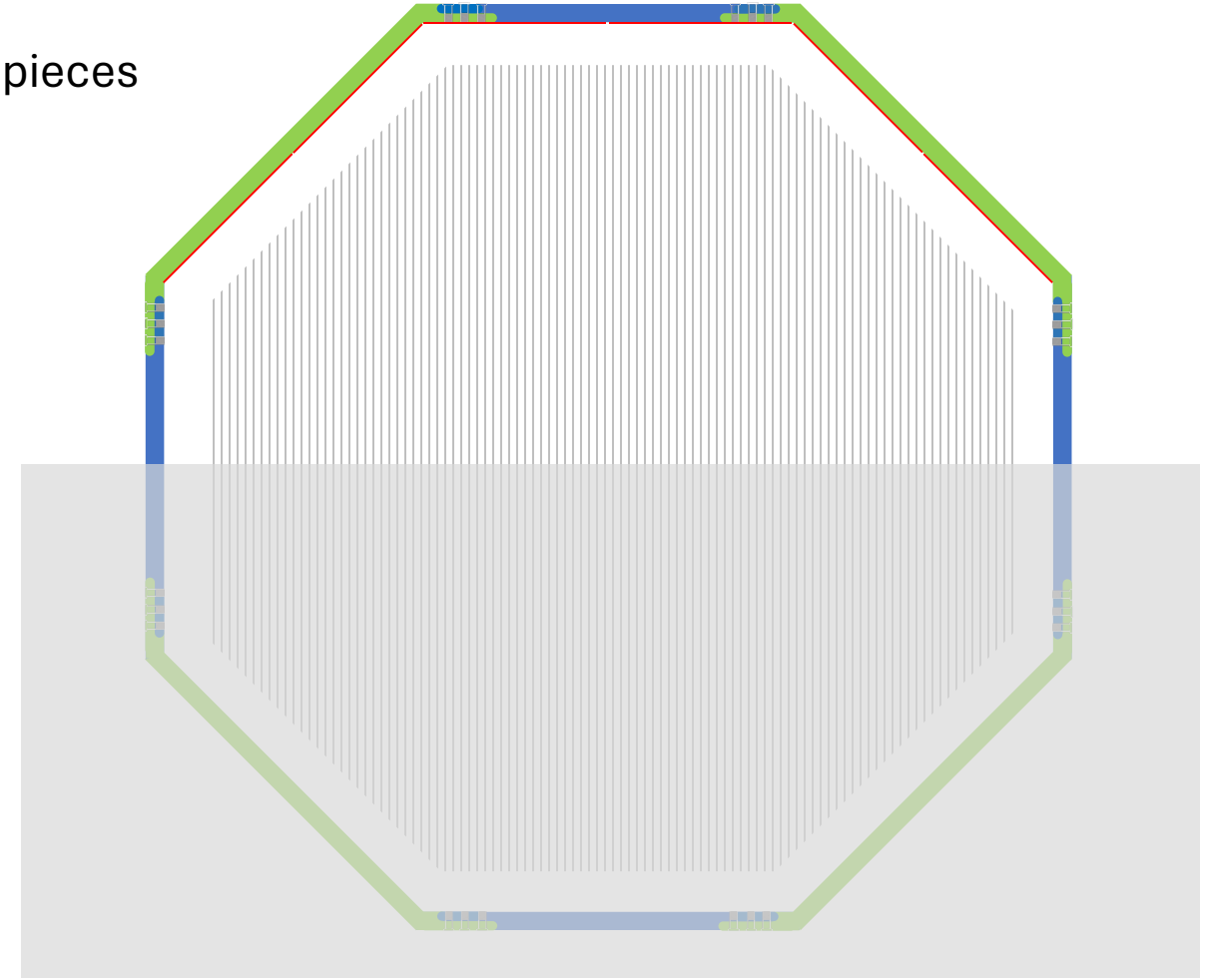
assembly scheme

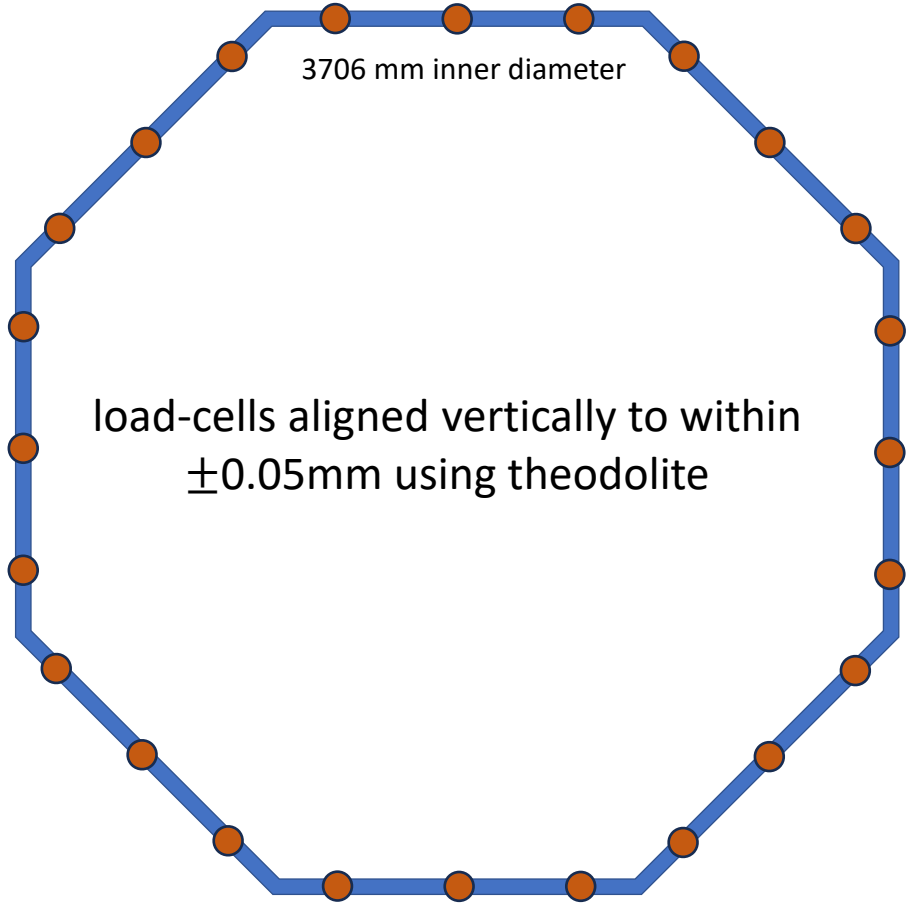




when done, release clamps, test, two person transfer to frame, and stretch to hook over frame pins

Water-jet cut from single large 0.75” 304 ss plate.
Lap joints (3 or 7 bolts each)
FEA predicts deflection under wire tension
Use FEA to cut the negative of this deflection as starting pieces
Under tension, returns to almost ideal octagon





typical load-cell
24 (48) around perimeter

Sequence:

straighten and remove any warp or twist using brute force to nearest 0.5 mm

check each side alone to ensure nearly equal weight on three load-cells

bolt sides together, checking to make sure each load-cell still bears weight

check geometry

add bridge-plates

add grid wires

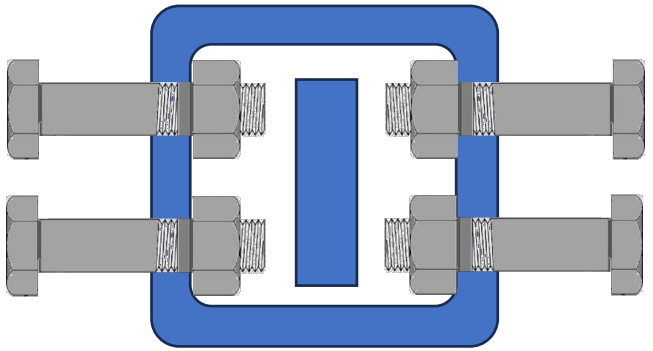
add Faraday cage

check geometry

testing

disassembly, electro-polishing, precision cleaning, rewiring, mount under anode

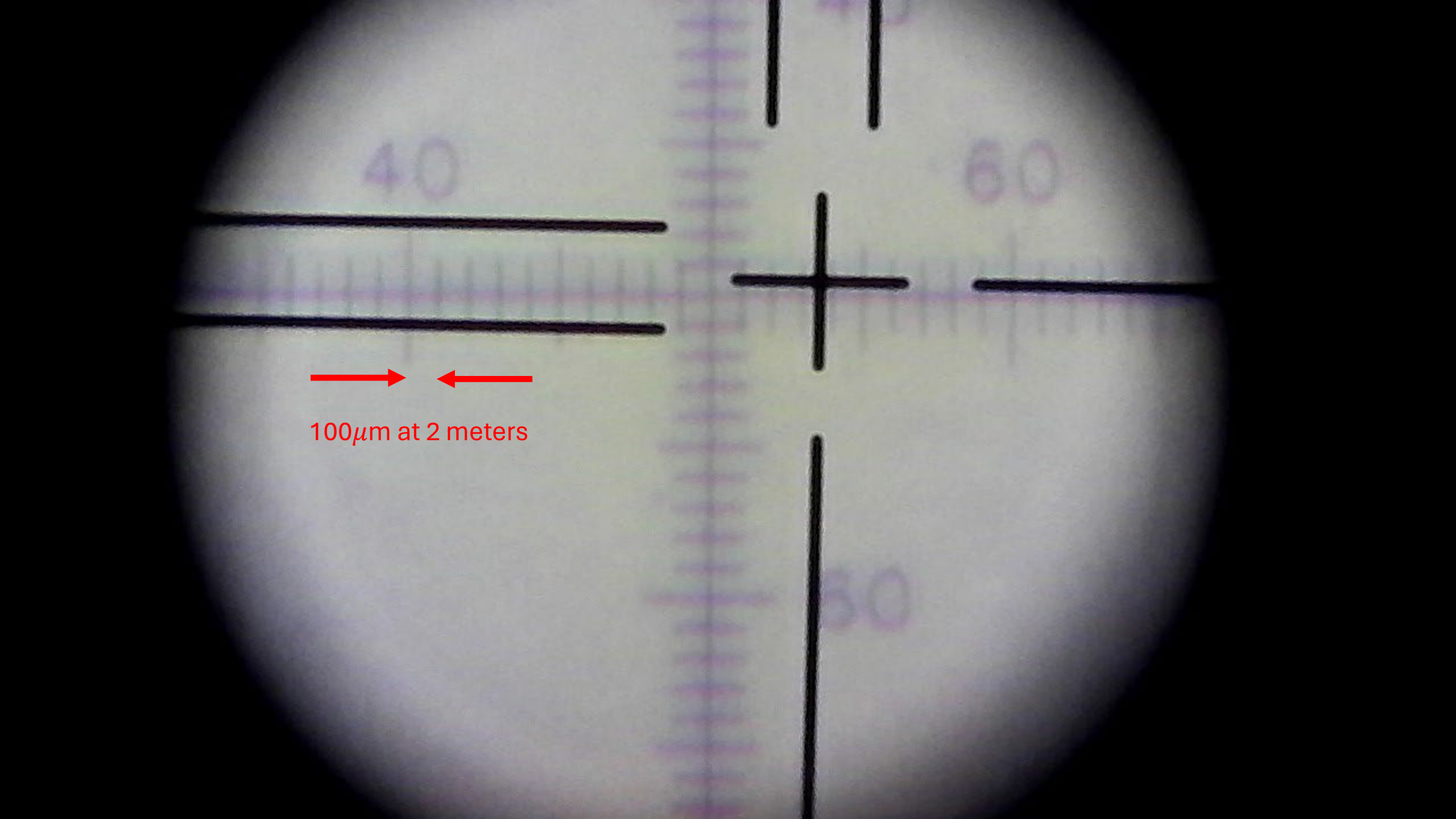
hydraulic pipe bender to adjust along length



‘twist’ removal as needed


ACETONE


DEVCON
Epoxy Resin
DEVCON
5 Minute Epoxy


40
60
100μm at 2 meters

Aspirational Grid schedule:

2023	Q4	concepts/testing; FEA grid-frames
2024	Q1	finish design; design support frame for fabrication
2024	Q2	material screening/ordering
2024	Q3	support frame and grid elements fabrication
2024	Q4	assembly testing /performance testing
2025	Q1	disassembly, cleaning/electropolishing
2025	Q2	shipping/receiving
2025	Q3	re-assembly and installation (must choose best location)
2025	Q4	grid-power supply tested and integrated into detector control system
2026	Q1	
2026	Q2	bias testing of grid (and TPC)
2026	Q3	
2026	Q4	experimental operations begin

Grid Testing Requirements:

Cryo-testing of all elements; radio-purity of elements; achieved geometry; etc.
Define what else is needed? Electrical isolation. Holding voltage at which stages?

Current Focus:

Interplay between anode and grid-wires during installation
how to mitigate risk of failure due to a wire breaking?
best method for installation (for example, maybe attach anode to grid first)