

iTPC Granite Tables and Components

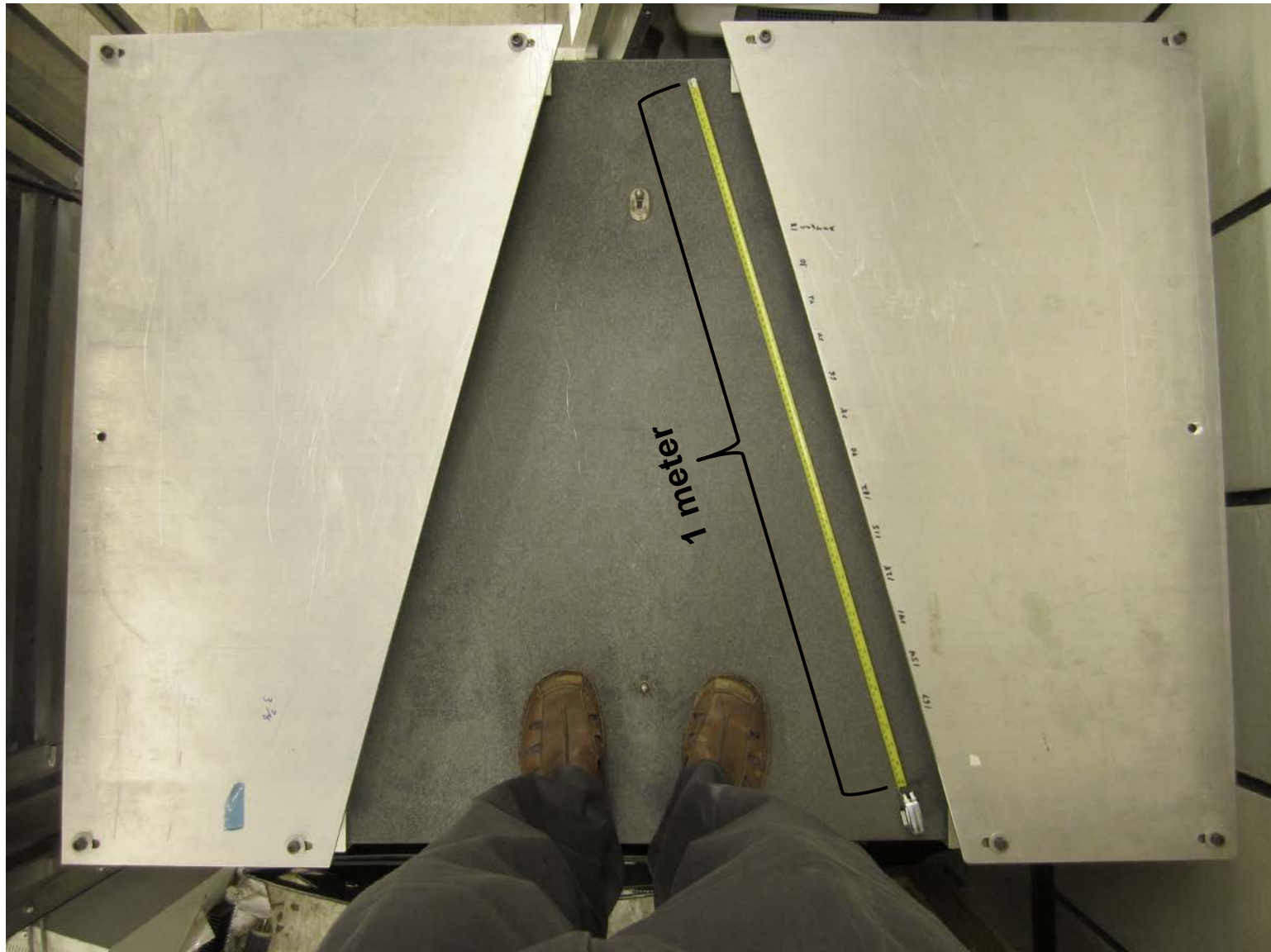
Jim Thomas

August 17th, 2014

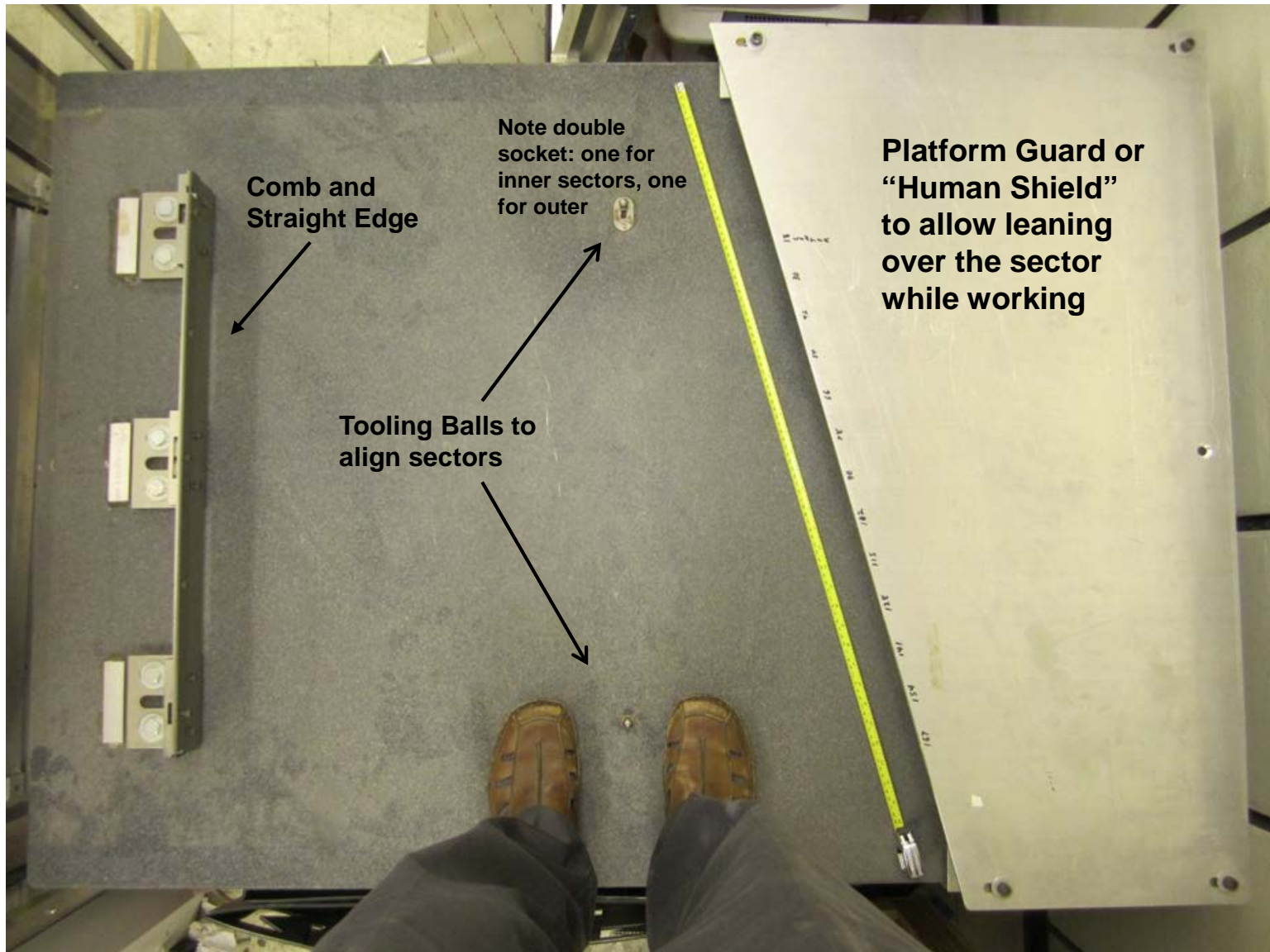


- This is a photo from the web ... but the granite table at BNL is similar
- Black granite is preferred
 - contains less water and thus parts don't rust so quickly
- Dimensions (at BNL)
 - 60 x 42 x 8 inches
 - 36 inches off the floor (floor to top surface) although this is probably not critical
- Grade A surface plate, see:
 - <http://www.precisiongraniteusa.com/Products.aspx>
Grade A "Inspection Grade" is defined here
 - http://precisiongraniteusa.com/pdffiles/fed_spec.pdf
- Manufactured by Mojave Granite
 - 1651 Miller Ave, Los Angeles CA

Granite Table with platform guards installed



Comb and Tooling Balls exposed – note: table has 2 combs



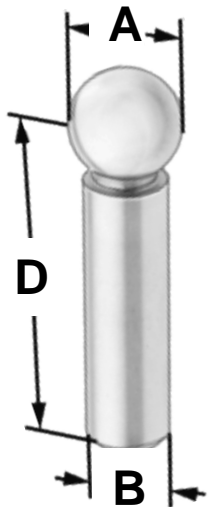
Comb and
Straight Edge

Note double
socket: one for
inner sectors, one
for outer

Tooling Balls to
align sectors

Platform Guard or
“Human Shield”
to allow leaning
over the sector
while working

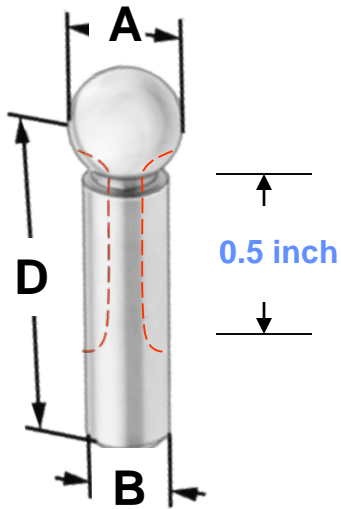
Tooling Ball #1 (lower ball in the figure)



- The tooling ball is a $\frac{1}{2}$ inch diameter ball sitting on top of a $\frac{3}{8}$ inch diameter cylindrical shaft.
 - It is made from one piece of steel (not two pieces welded together). See McMaster-Carr (.com) part number 8484A15.
- Two of these tooling balls are inserted, vertically, into the granite table to align the sector with respect to the combs.
 - The top of the ball is 0.780 ± 0.020 inches off the surface of the table (~2 cm, its height is not critical). The tooling ball shafts are to be pushed into $\frac{3}{8}$ inch diameter bronze sleeves that were previously drilled & epoxied into the granite table. Slip fit, not press fit. For example: shaft is $0.3750 +0.0000 - 0.0005$, so sleeve should be 0.3753 ± 0.0002 .
- The tolerances on the ball are very precise in order to provide a good match to the bronze sleeve in the sector strongback.
 - The ball is 0.5000 ± 0.0002 inches. The bronze sleeve in the strongback is bored to a diameter of 0.5003 ± 0.0002 inches. See drawings 24A3685B and 24A0212C.
- For an inner sector, the two balls are spaced 25.280 ± 0.001 inches apart on the table. This is the most precise dimension on the granite table. The ball and shaft must be vertical.
 - The alignment and spacing must be right or the sector will not fit over the tooling balls. An alignment jig that matches the sleeves in the sectors should be used when drilling and epoxying the sleeves for the balls into the table.

Check the master drawings before believing any dimension quoted here

Tooling Ball #2

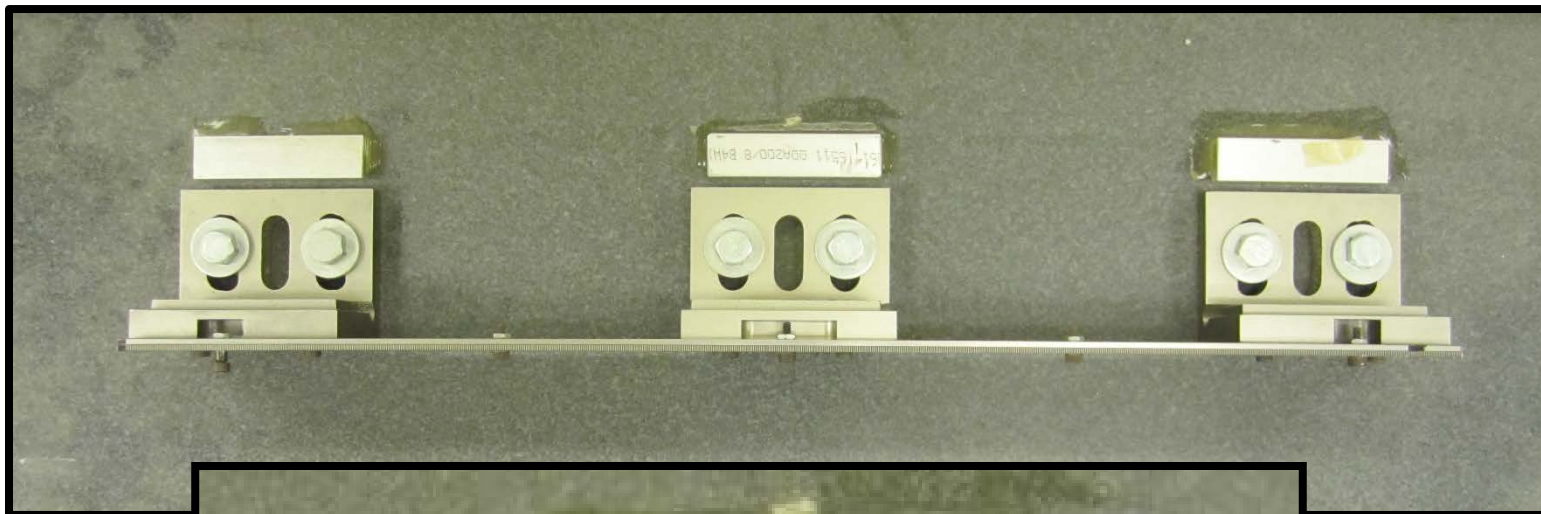


- Tooling Ball #2 is very similar to tooling ball #1 except that the shaft under the ball has been modified to make it flexible.
 - The 3/8 inch diameter shaft has been machined down to a thickness of 0.067 inches (perhaps the goal was 1/16 inch ... but I measured 0.067). See drawing to the left.
 - The pin is inserted into a steel fixture (or bronze sleeve) that was previously drilled, located precisely, and epoxied into the granite table.
 - The pin is inserted into the table so the thin axis of the tooling ball is perpendicular to the line between the two tooling balls. This allows the ball to flex in the direction of the other tooling ball.



- Alternatively, a “Diamond Pin” can be used.
 - The diamond has different dimensions on the long and short axes: they differ by 0.002 inches, or more. If the appropriate dimensions can be found (is 0.002 inch appropriate?) then a diamond pin would replace the need for a flexible pin. See:
http://www.invert-a-bolt.com/shop_locatingpins.shtml
- More details about tooling balls and alignment pins:
 - <http://us.misumi-ec.com/maker/misumi/mech/tech/locatingpinshowtheyareused/>

Detail: Comb, straight edge and mount



??what is this??
Epoxyed to
table ??

**Mounting
block
(or “Angle
Plate”)**

**Straight
Edge**

Comb

Teeth on the comb



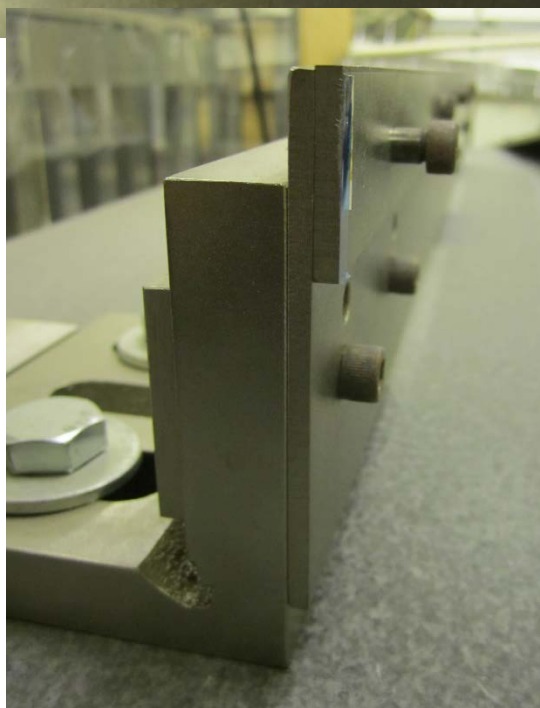
Comb plate and top of straight edge plate shown at left. “Bottom” of comb is below the level of the straight edge.

Teeth on the comb have an asymmetrical shape – one edge is vertical but the other is well-rounded.

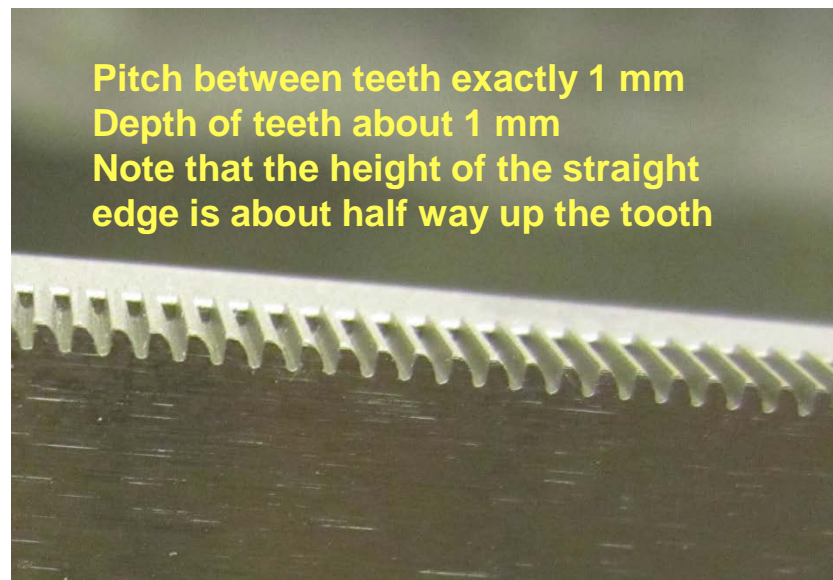
Wires will rest on the top surface of the straight edge

Wires are laid on the straight edge then “slid” to contact the vertical sides of comb

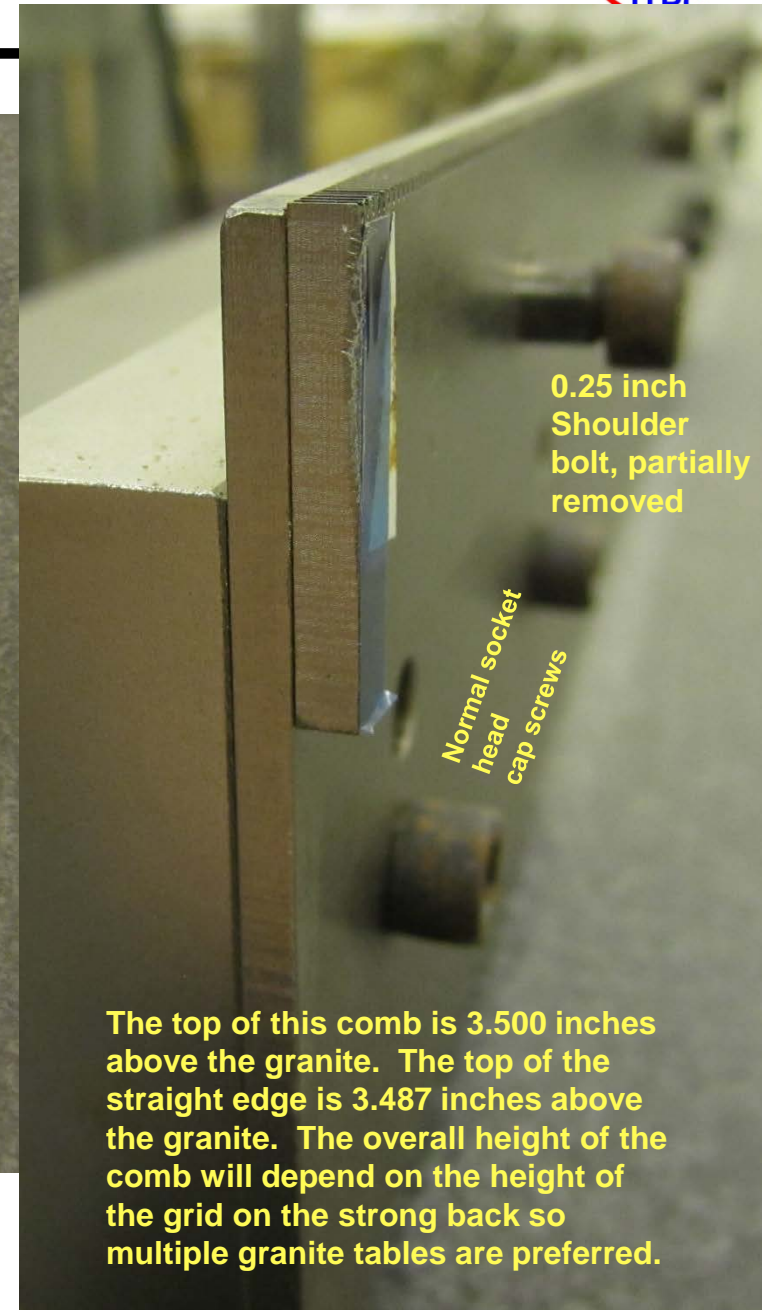
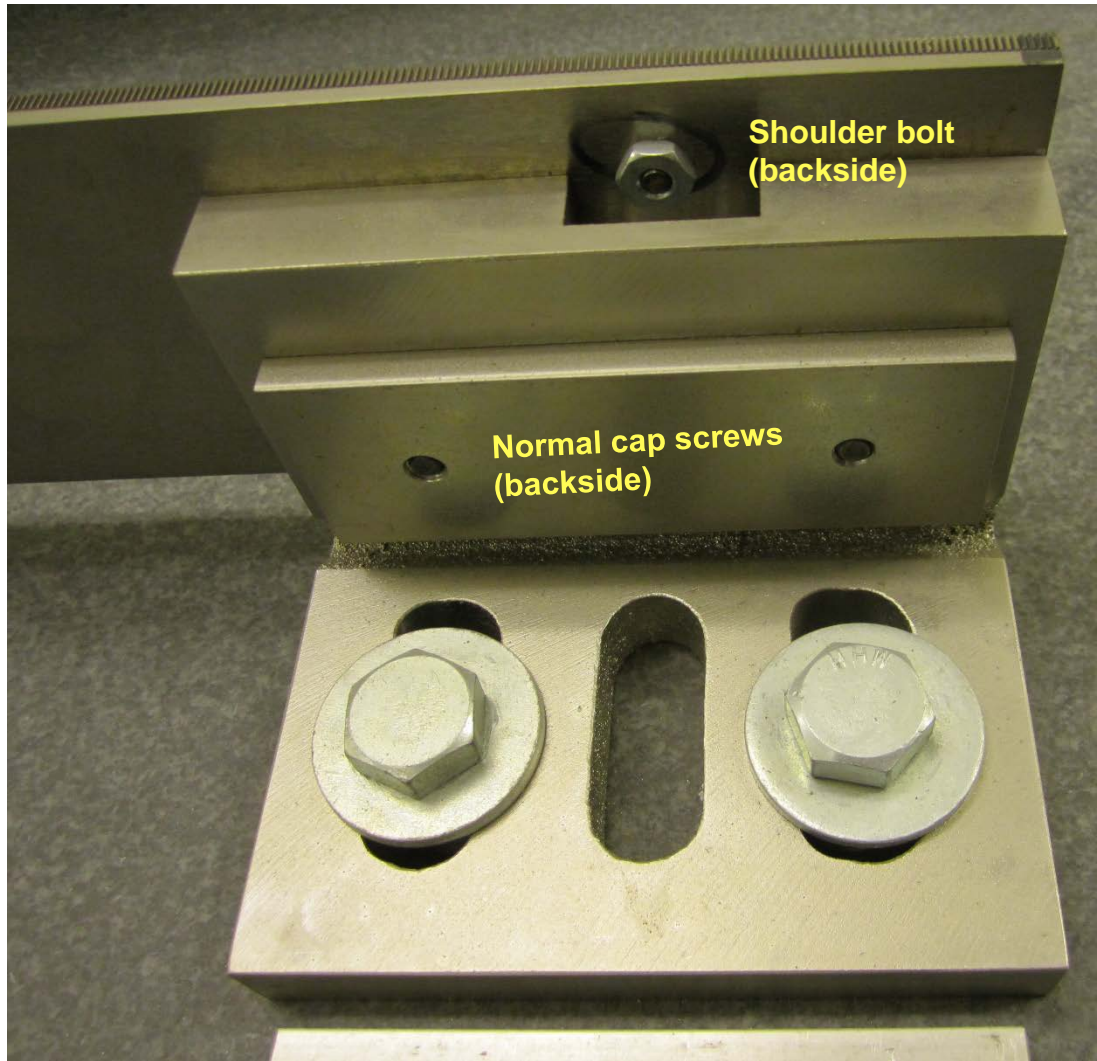
Loose wires are pushed into contact with the comb using a brush



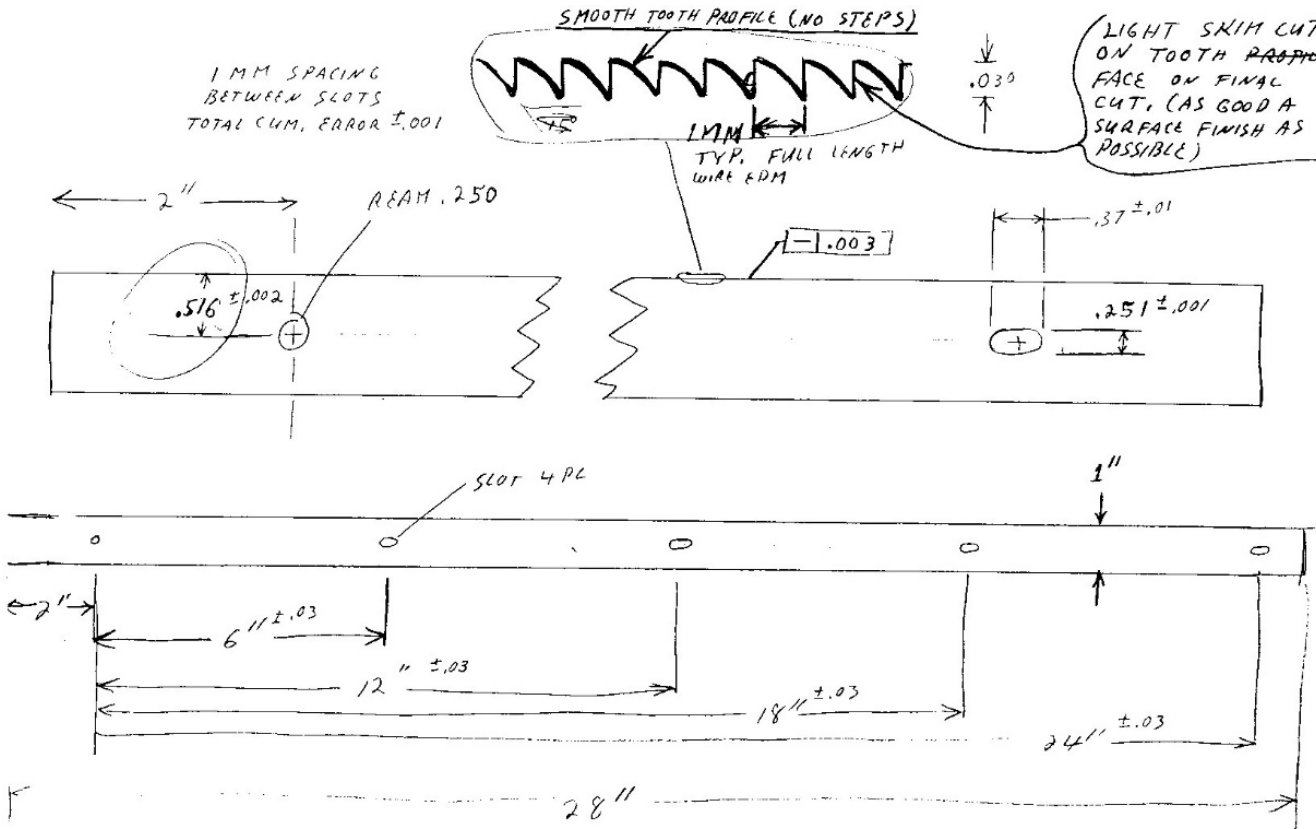
Pitch between teeth exactly 1 mm
Depth of teeth about 1 mm
Note that the height of the straight edge is about half way up the tooth



Comb, Straight Edge & Mounts



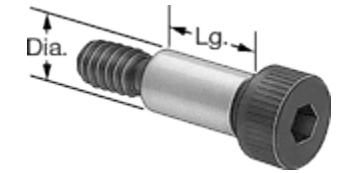
Fabrication of the Comb (1 mm pitch, 0.030 inch deep)



- (from Jon Wirth) The comb is made from oil hardening flat stock, 1/8 inch thick, 1 inch wide and 28 inches long. Five mounting holes were drilled under-size before hardening. After hardening, the comb blank went to the wire EDM to cut the teeth and finish cut the mounting holes to accept 1/4" shoulder bolts.

- The comb was nickel plated after fabrication to prevent rusting of the comb

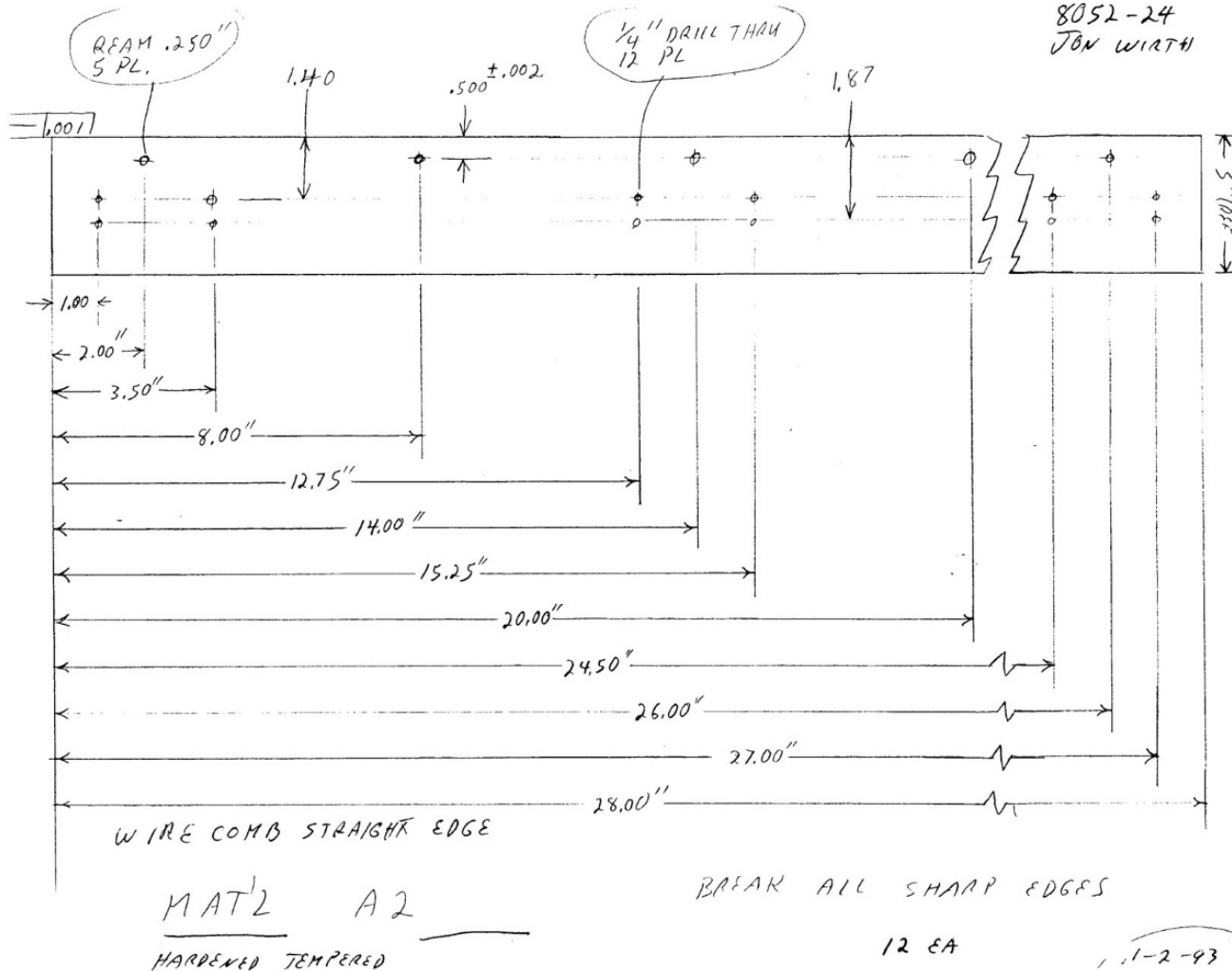
- Use a shoulder bolt to align and fasten the comb to the straight edge. See McMaster [91259A171](#)



- All dimensions are in inches

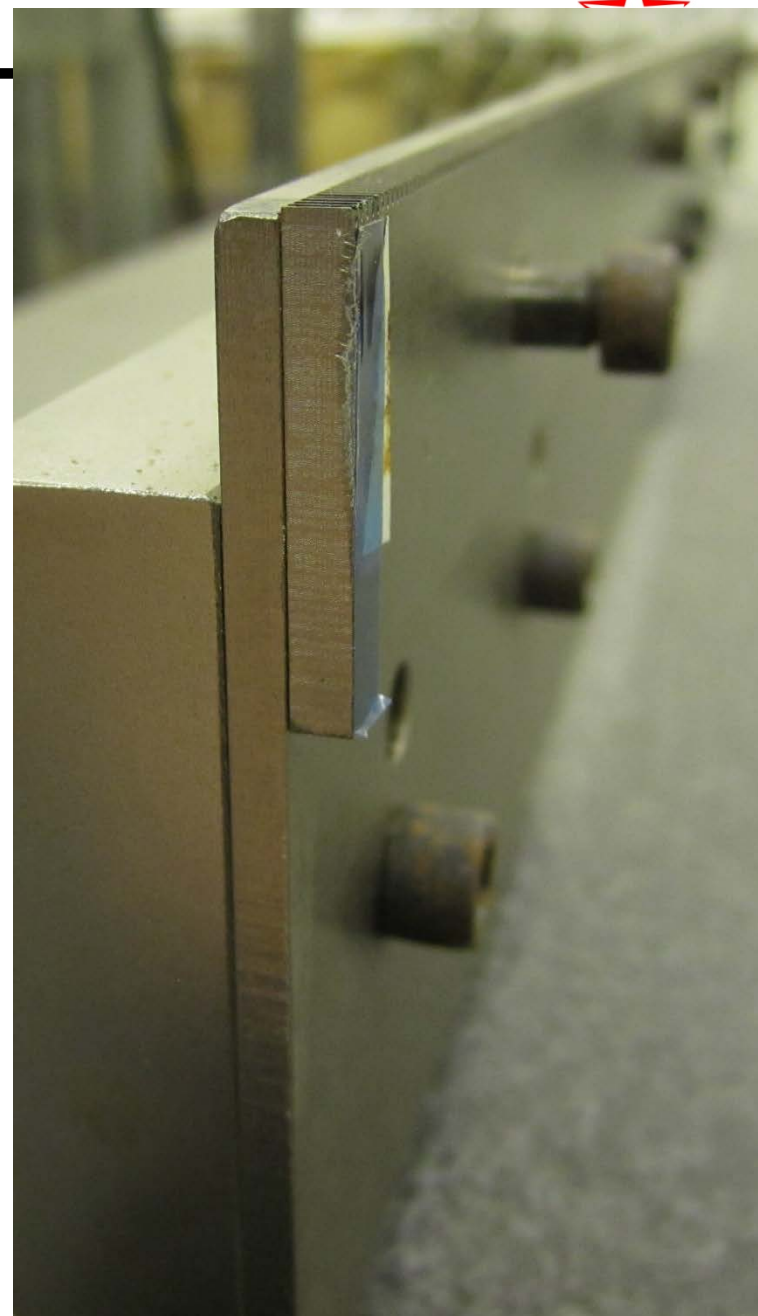
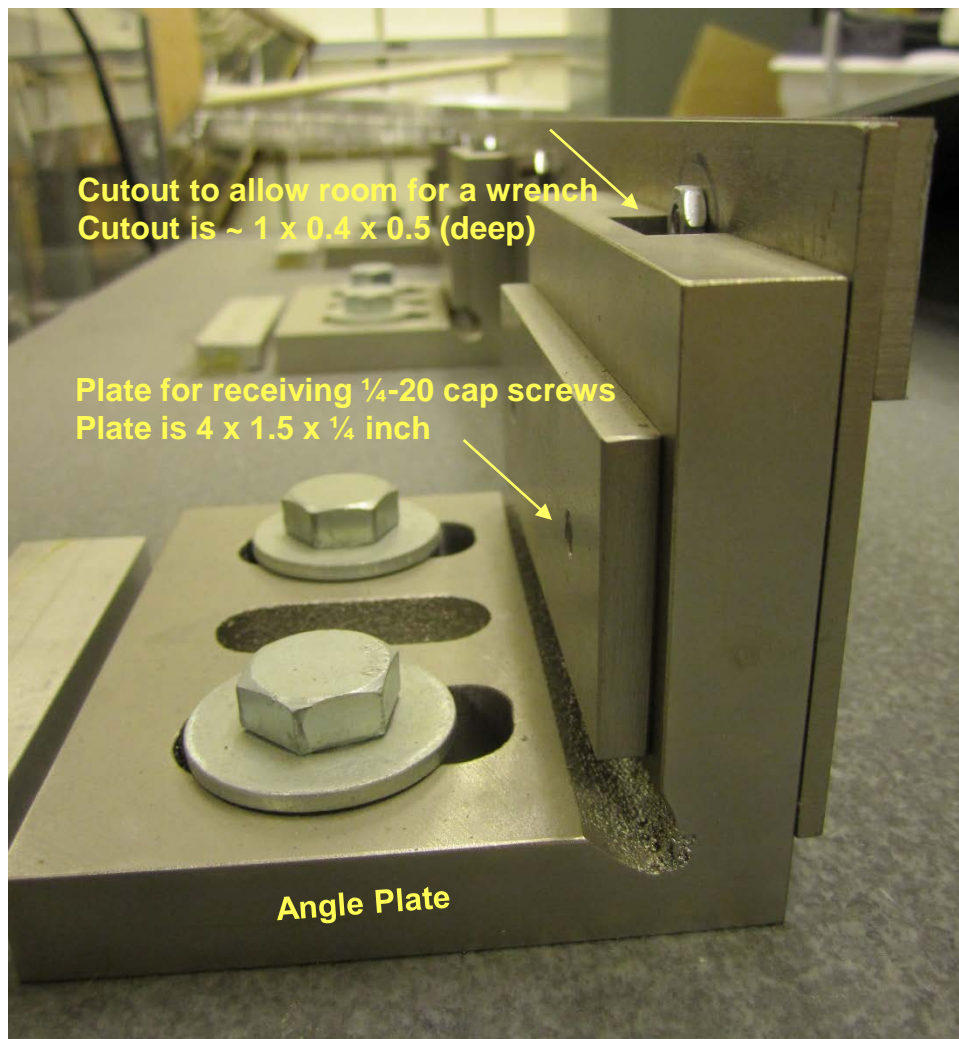
WIRE COMB
 JUN WIRTH
 8052-74
 A2 HARDENED-TEMPERED
 1/8" X 1" X 28"
 12 EA
 11-2-93

Fabrication of the Straight Edge



- (from Jon Wirth) The straight edge was fabricated from ground flat stock. 1/8 inch thick, 3 inches high and 28 inches long. Twelve holes (two sets of six) were drilled for 1/4-20 bolts to mount it to the angle plate on the granite table.
- Five holes are drilled and reamed for 0.250 inch shoulder bolts. Actually, four of the holes can be horizontal slots since one datum hole (on end) plus the horizontal slots is enough to constrain the position of the comb in both the horizontal and vertical directions.
- The straight edge was nickel plated after fabrication to prevent rusting of the parts

Angle Plate for mounting the combs



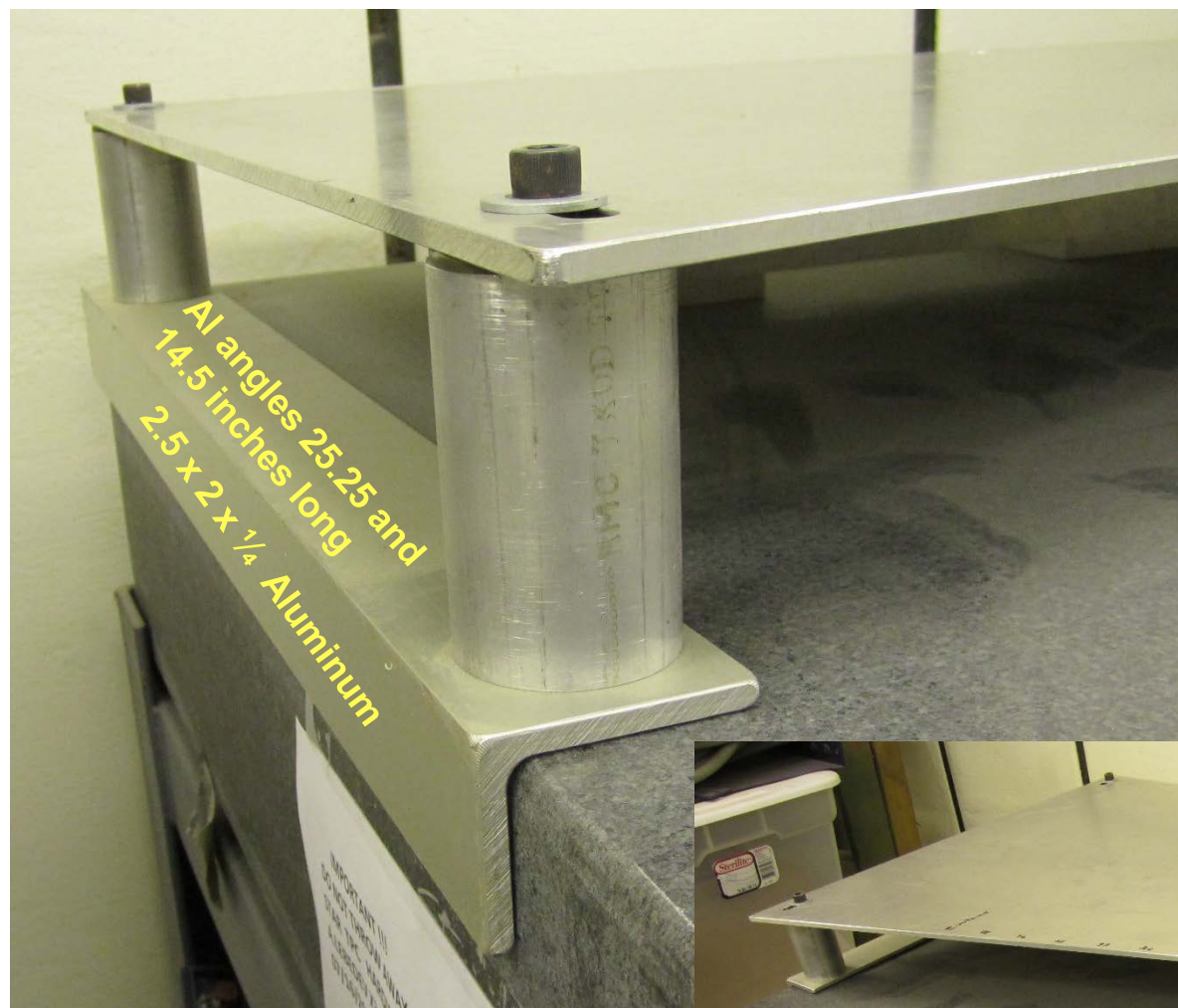
- The combs are mounted on the granite tables using commercially made “angle plates”. The sides are flat, parallel and the 90 degree angle is a very accurate
 - <http://www.mscdirect.com/product/details/70145214>
 - Dimensions: 3 x 3.5 x 4.5 inches, 5/8 inch thick
 - The slots are 9/16 inch wide from the manufacturer but the group of three slots on the table at BNL have been machined to 3/4” width to make room for the 1/2 inch diameter hold down bolts plus some wiggle room.
- The straight edge is bolted directly to the angle plate by passing two 1/4-20 bolts through the long horizontal slot (shown above)
 - These bolts screw into a steel plate 4 x 1.5 x 1/4 inches which covers the slot
 - No other holes have been drilled in the angle plate other than those shown above
- The top side of the angle plate has been cut out to make room for a wrench
 - The wrench tightens the shoulder bolt that fastens the comb to the straight edge (upper set)
 - The cut-outs are in different locations on the three angle plates, but they are typically 1 inch long (or longer), 0.4 inches wide, and 0.5 inches deep (down)



Platform Guards



Platform Guards (to keep humans out of the wires)

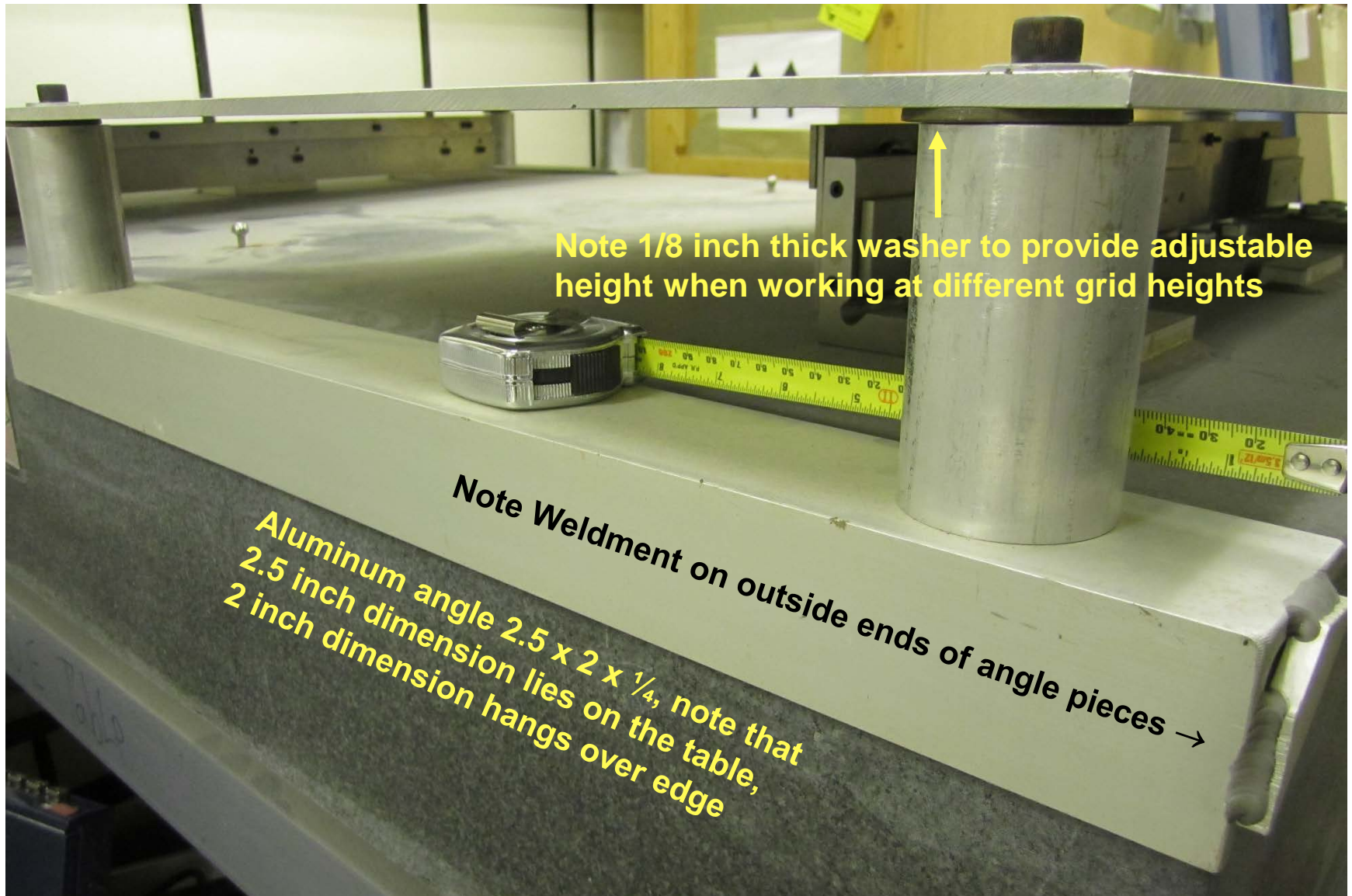


- **Plates:** $\frac{1}{4}$ inch thick Al
 - 42 x 24.625 x 13.375 inch
 - Hypotenuse 43.5 inch
 - Two 90° angles
- **Spacers:** 3.375 inch tall
 - 2 inches in diameter
 - solid but tapped for 3/8-16 (??) bolts
- **Slots:** 1 $\frac{1}{8}$ long, $\frac{7}{16}$ wide
 - Horizontal
 - 1 inch from all edges
 - 40 inches apart (long axis)



- **Outside edge of spacers are aligned with the edge of the granite table**

Platform Guard

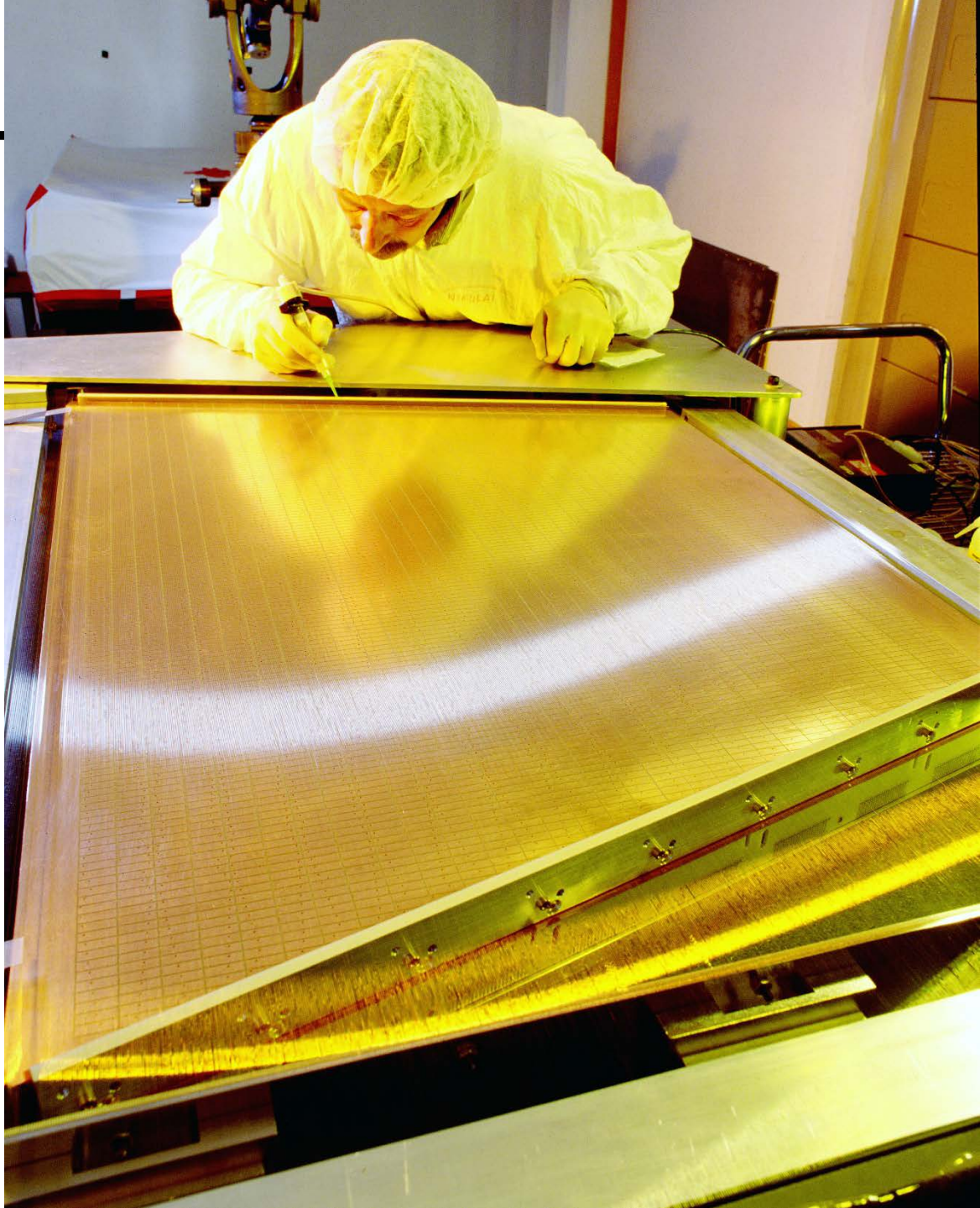


Note 1/8 inch thick washer to provide adjustable height when working at different grid heights

Note Weldment on outside ends of angle pieces →
Aluminum angle 2.5 x 2 x 1/4, note that
2.5 inch dimension lies on the table,
2 inch dimension hangs over edge

Platform Guards

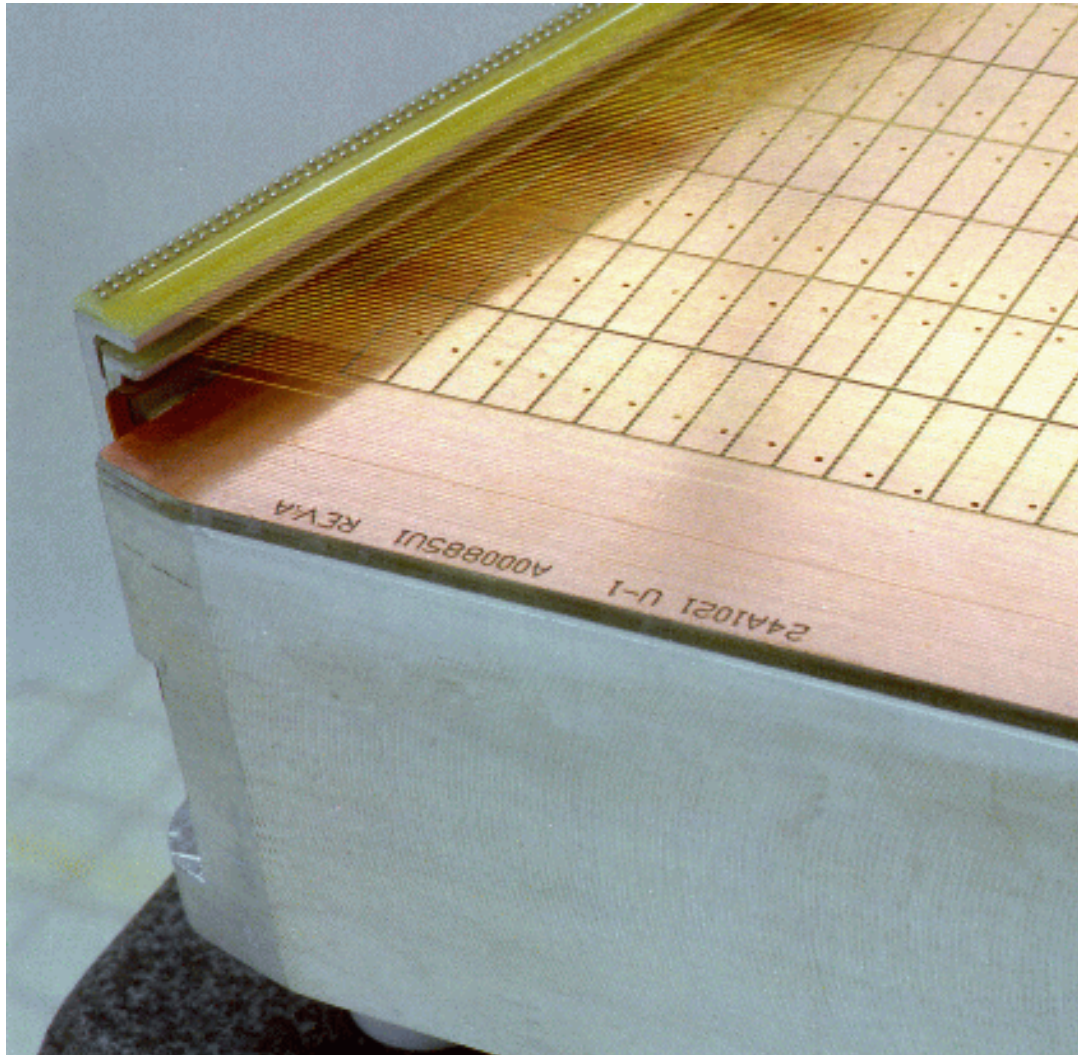
- The guards protect the wire planes, provide a hand-rest for gluing the wire planes and for soldering the gated grid
- Comments
 - Plates are $\frac{1}{4}$ inch thick: the plates bend by about 2 to 3 mm when a person leans on them
 - 2 inch diameter cylinders + washers were used to adjust the elevation of the platform guards.
 - There will probably be 3 different granite tables in use to build the iTPC sectors (one for each grid height). Each table may have different size spacers for the platform guards



- All dimensions in these slides are inches unless otherwise noted
- Inch dimensions quoted to 3 decimal places may suggest two different sets of error bars
 - A number such as 0.501 implies that three significant digits are important. Usually, a tolerance (error bar) will be quoted alongside the primary number
 - A number such as 0.0625, 0.125, 0.375 is the decimal representation for 1/16, 1/8 and 3/8 inch (etc.) English hardware is commonly measured in 1/8 and 1/16 inch units. The error bar on these measurements is usually not specified but it is not usually better than 1/64 or sometimes even 1/16 of an inch unless otherwise specified. Good engineering judgment is sometimes required in determining English fractional tolerances.

Backup Slides

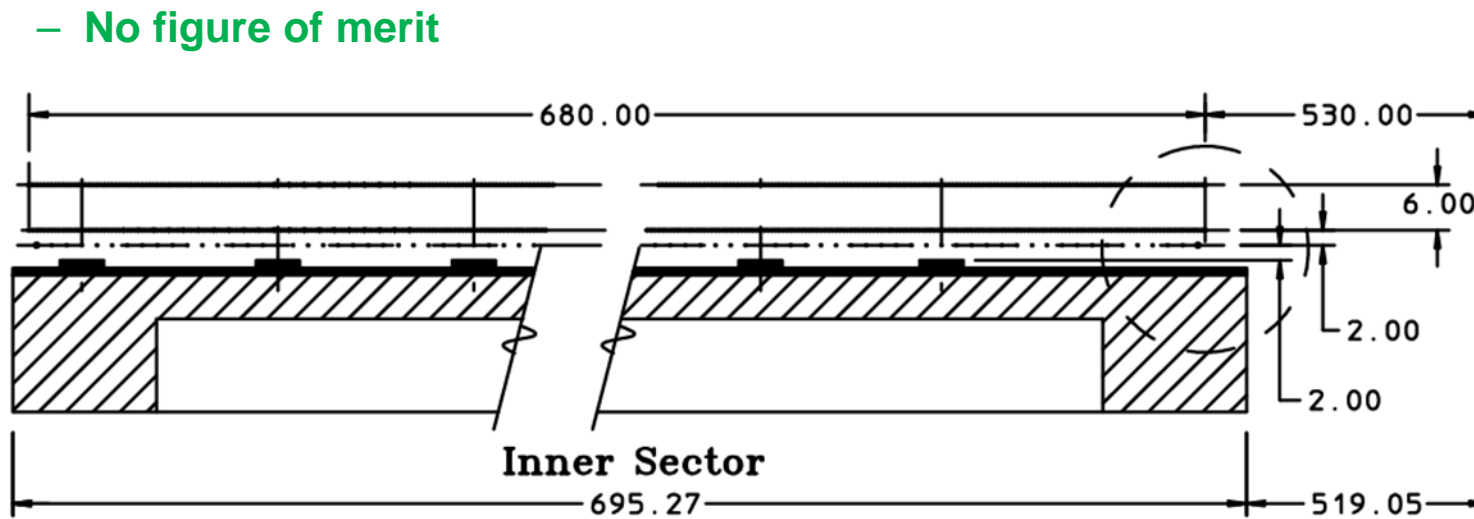
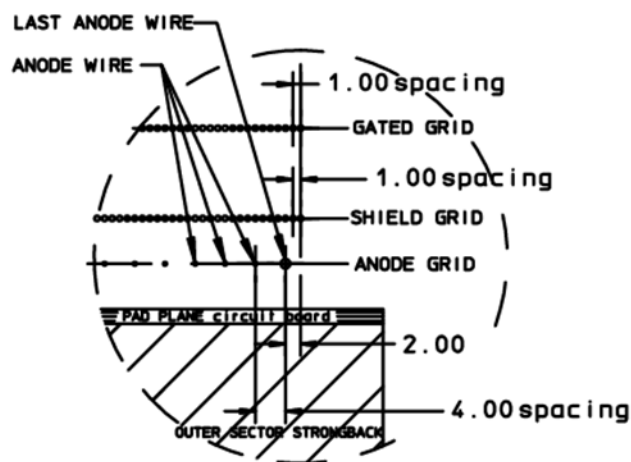
New Pad Plane – new strongbacks (outer shown)



- Avoid “missing rows”
- Hermetic coverage $\eta > 1$
- Increased segmentation
- Better dE/dx & tracking for tracks that leave thru the endcaps
- Optimized installation schedule: no down time
- One goal of this proposal is to relearn the lost arts
- Recover 2D drawings and recast in 3D – cheaper and more efficient fab

Our concern is about the inner sectors

- The inner sectors are affected the most due to $1/r^2$ distribution of charge in the TPC
- We expect a gain shift on anode wires due to charge, gain & dirt
 - Figure of merit is 1 mC / cm
- Malter effect on the cathode wires due to build up of insulating oxide layers ... leads to breakdown
 - No figure of merit



Aging of the anode wires and tripping on the cathode wires