TOF Tray Mechanical Design

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☆ TOF Review, UT-Austin

April 24, 2006

Outline:

- Tray mechanical design
  TOFr, TOFr', TOFr5, &TOFrX
- Integration Volumes & Interfaces
- Changes w.r.t. TOFr5
- Action items from STAR Review

main focus of this meeting: Design of Tray Aluminum

i.e. what Oaks builds

top assy (meets w/ electronics)

bottom assy (meets w/ TPC rails)

cover assy (cooling)

re: tray metal: all "epsilon" changes w.r.t. TOFr5

re: electronics/cabling - important undefined areas - need to finalize here

MRPC placement scheme is *mostly* decoupled from the tray design

relationship is the lower brackets

Inner sides fabricated in-process at UT

tray design strongly coupled w/ the assembly procedure & needed fixtures

thus need to touch on these aspects here as well

tour of workspaces here at UT

Everyone please jot down action items as they occur to you.

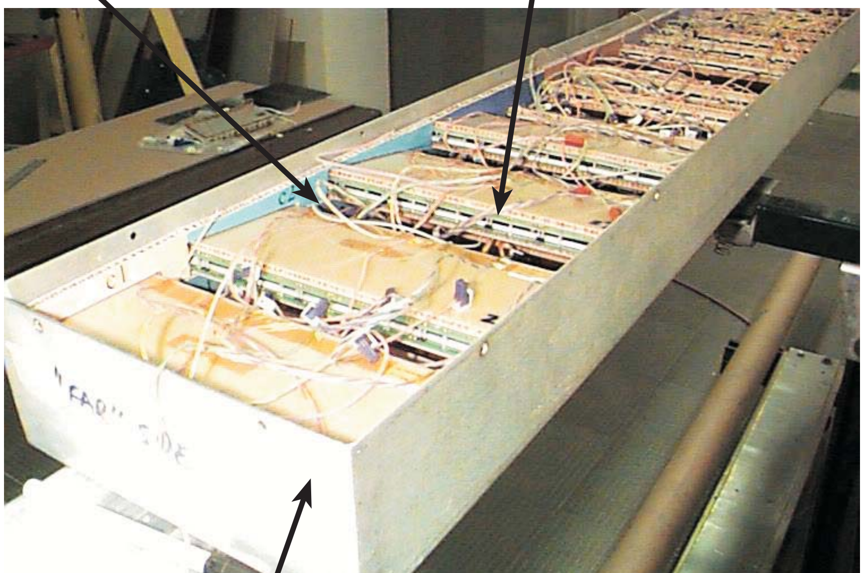
we'll collect these in the last phase of this meeting this afternoon

D&M: TOFr (Run-3)

first implementation of the MRPC technology in a collider experiment
readout uses (TOFp's extremely well-understood) CAMAC DAQ
→ do these detectors work at all for us?

welded/tapped rail assembly
(glued gaskets also)

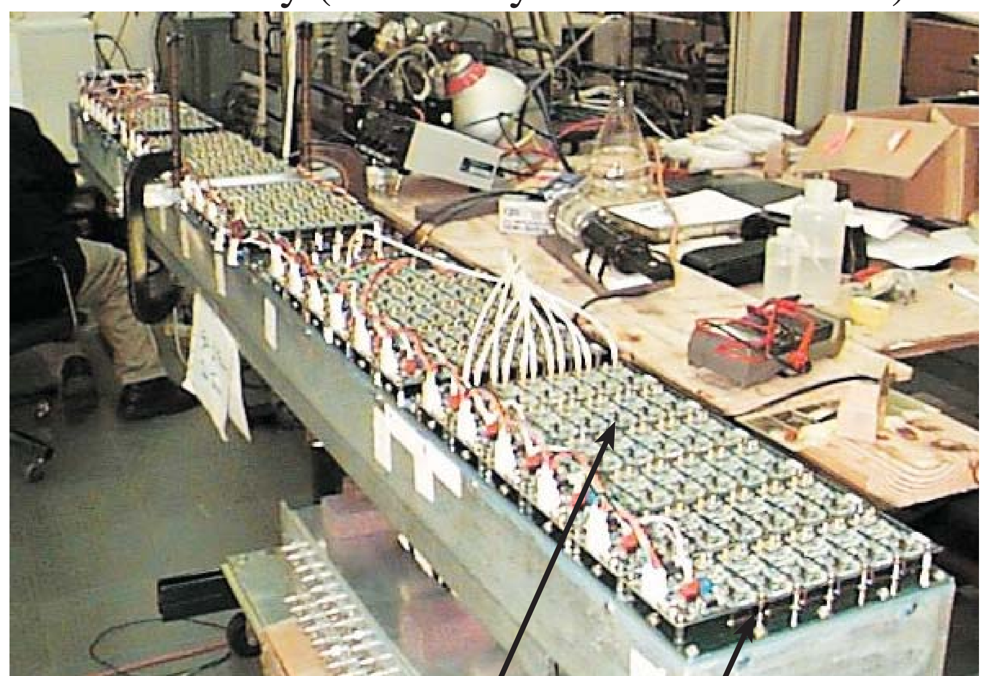
"sawtooths" USTC & CERN MRPCs



standard CTB tray

- fabrication extremely labor intensive...
  sawtooths, rail assy
- complicated gas sealing...
  gaskets, sealant (was also *wrong* sealant)
- MRPC placement w/in box too imprecise...
  each sawtooth placed individually
- overall, too tall

final TOFr tray (note many cables not shown!)

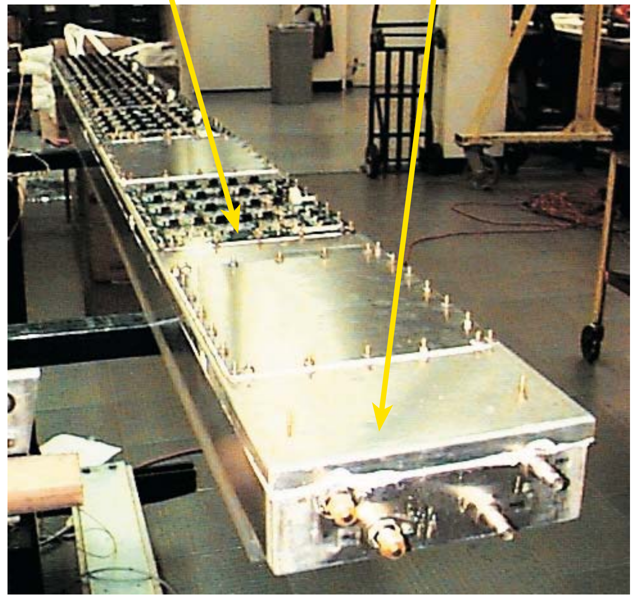


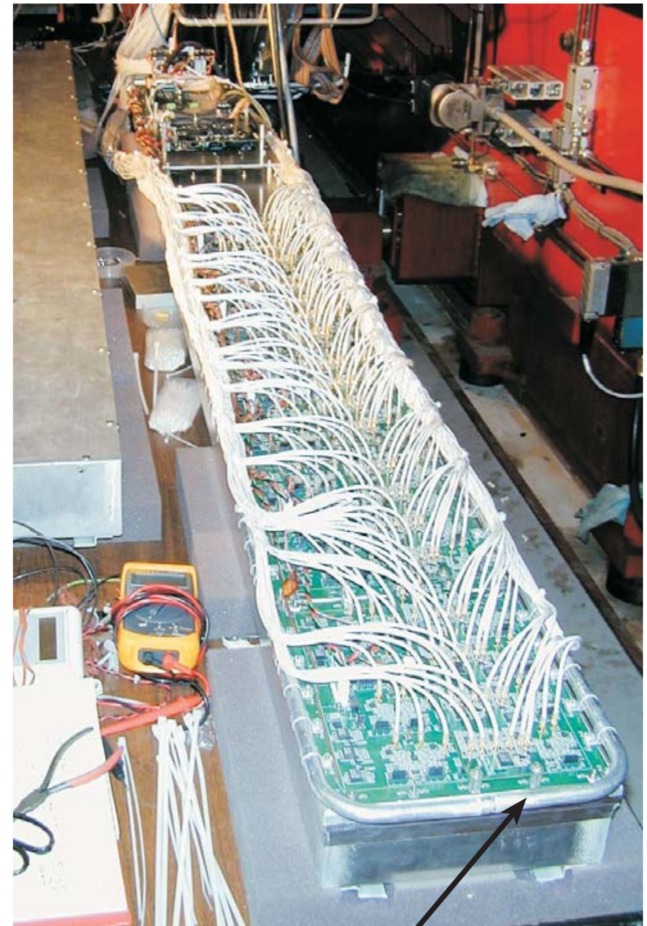
FEE layer F/T layer

D&M: TOFr' (Run-4)

completely new tray and electronics
    first system to use a TOF-specific box, not a recycled CTB box
one FEE layer, which also closes the gas volume
new batches of MRPCs (USTC, Tsinghua)

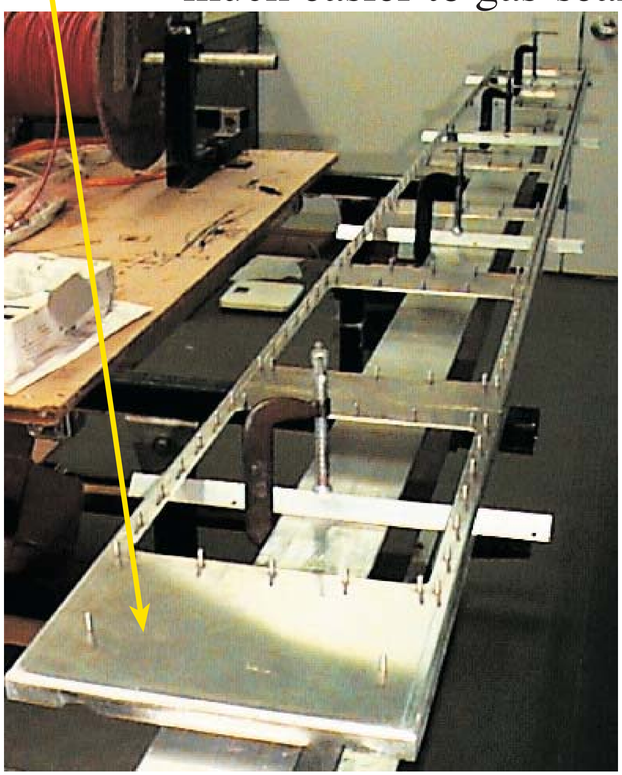
TFEE   "Shoebox" top





"last minute" cooling loop

top assy now fabbed out of house
- stamped, braked, welded
- PEM studs
  - positioned to few mils
  - no tapping
  - much easier to gas-seal

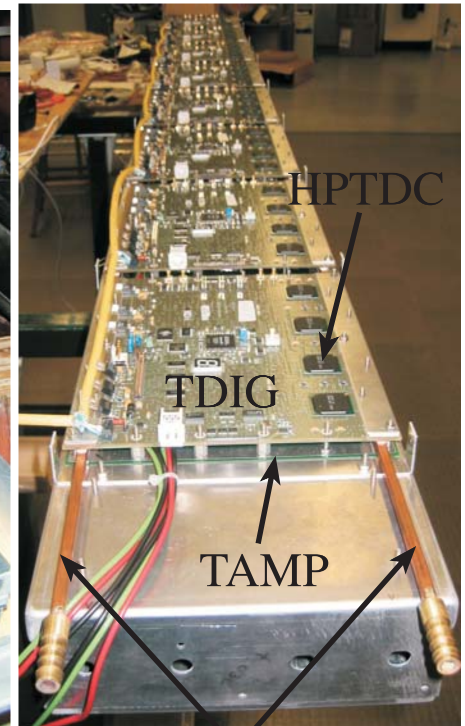


- fabrication ~~extremely~~ labor intensive...
  - sawtooths, ~~rail assy~~
- ~~complicated gas sealing~~...
  - ~~gaskets~~, *less* sealant (but the correct sealant this time)
- MRPC placement w/in box too imprecise...
  - each sawtooth placed individually
- overall, too tall

FEE dumped a lot of heat into the box
- increased MRPC current draw, & noise rates...
- timing seemed o.k. but...

D&M: TOFr5 (Run-5)

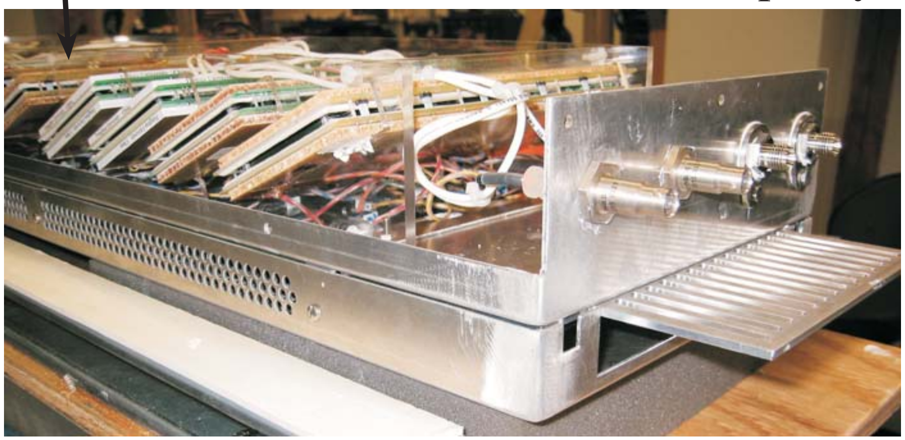
First attempt at on-board digitization
Back to two layers of on-board electronics
Integrated cooling loop
new batches of MRPCs (USTC & Tsinghua)

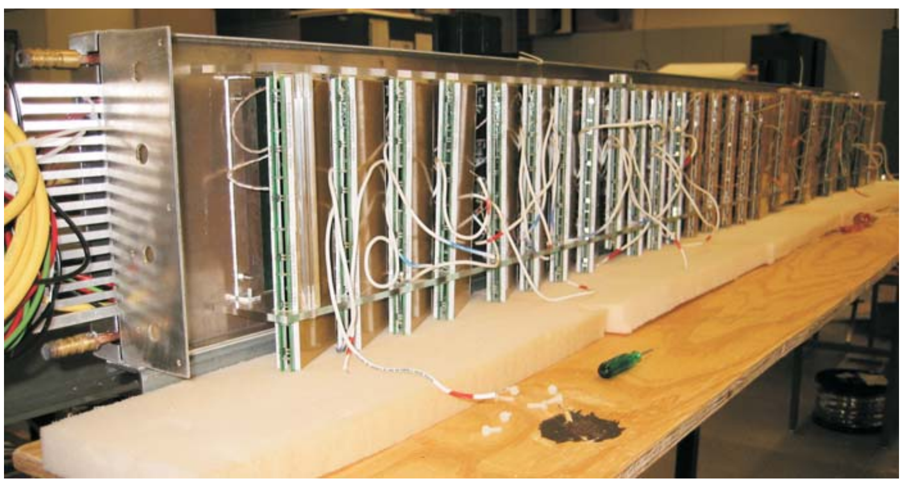


perf. cover assy

cooling loop

"Inner Sides" instead of sawtooths...
 lexan machined on hurco machine to few mils
 MRPCs held in reveals cut into the inner sides
 Inner sides bolt to underside of top assy





- ~~fabrication extremely labor intensive~~...
  ~~sawtooths, rail assy~~
- ~~complicated gas sealing~~...
  ~~gaskets~~, *less* sealant
- ~~MRPC placement w/in box too imprecise~~...
  ~~each sawtooth placed individually~~
- ~~overall, too tall~~

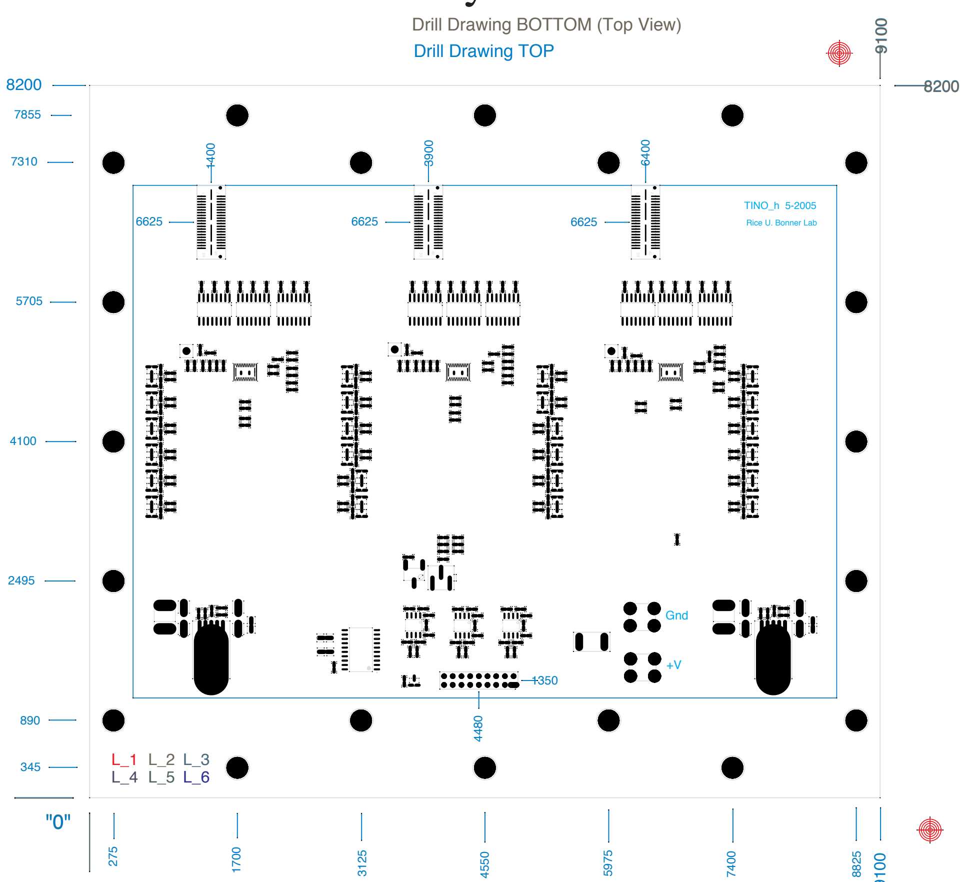
small tweaks to box & inner sides design
integration of TINO, TDIG version 2, & cooling

TOFr5 cooling loop tests & efficiency/power estimates:
http://wjllope.rice.edu/~TOF/TOFr5/Ttests/TOFr5_T_tests.htm

Mechanical Design Summary

3 generations of TOFr trays
(all rebuilt from the ground up)
all met the physics goals

subsequent trays will be sensibly simplified variants of the TOFr5 design:
- simple, quick, & repeatable to assemble
- gas-tight (by simplified design)
- very precise detector positioning
- open-box MRPC→FEE testing
  - air-core transformer tests
  - time-domain reflectometry tests



Next Generation Tray = Final Tray....

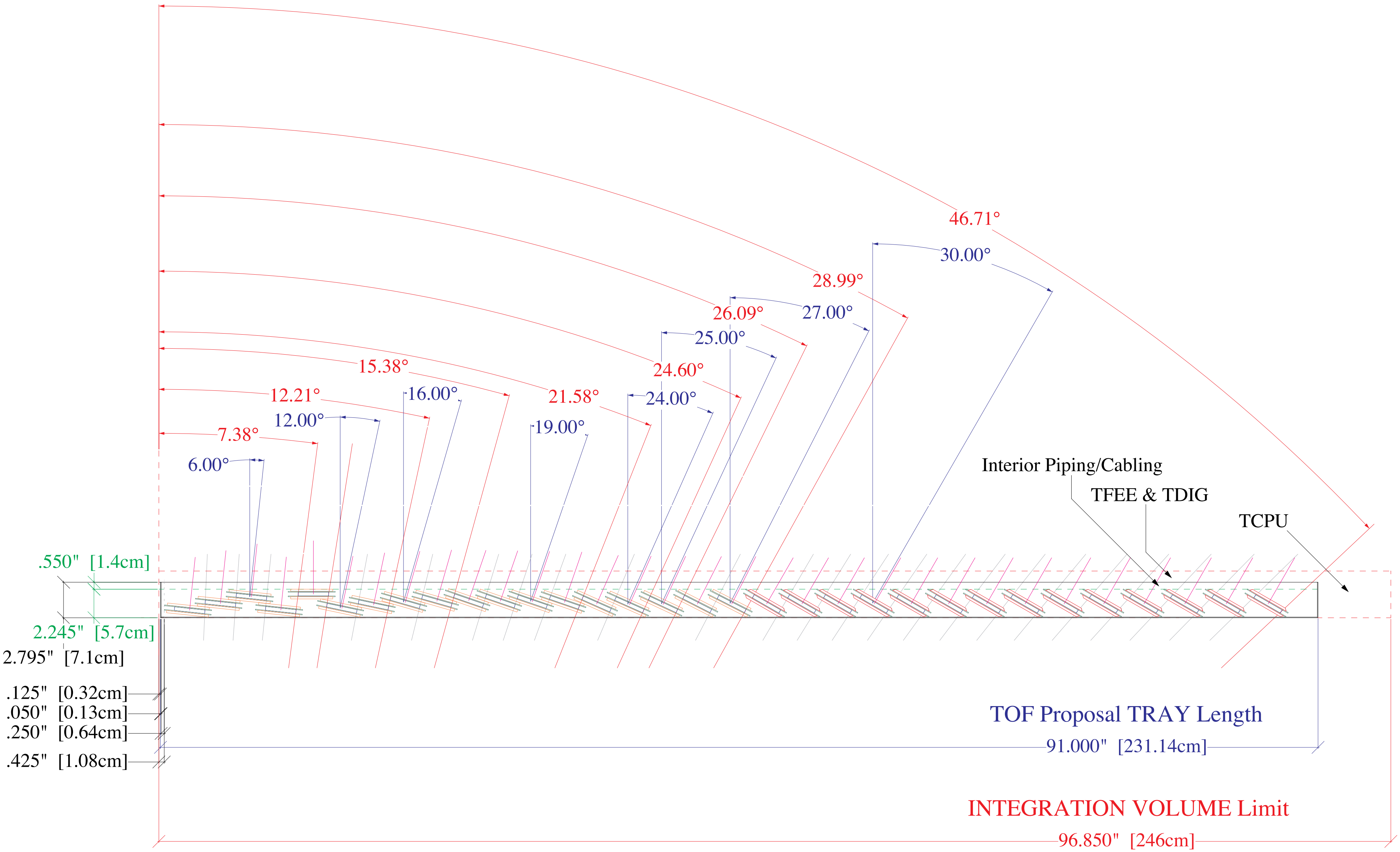
simpler cooling loop design
- 1/4” square → 1/4”x3/8” rectangular
- 2 shims/TDIG disappear...

only small tweaks to mechanical design

TINO
- lower power
- no ringing?
- fully differential
- multiplicity outputs on-chip
- now only need positive LV

next TDIG
- accepts signals from TINO
- address timing cross-talk
- multiplicity
- stretching for start-side ToT

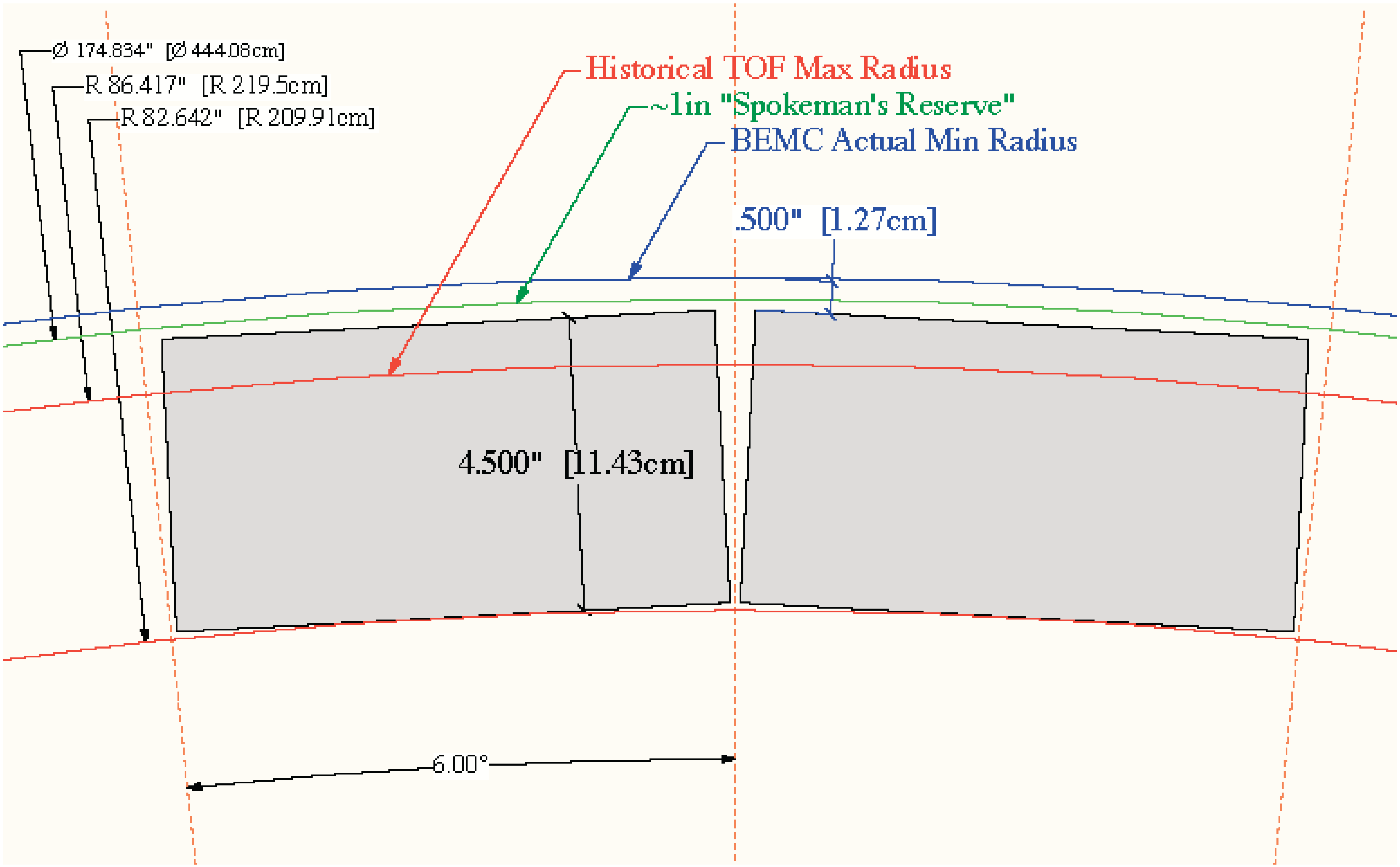
Integration Volumes...



TOFr5 actual length (bottom assy) = 90.000"
TOFr5 actual length (top assy) = 90.180"

CTB length = 95.1"

Final Trays need to add length to allow for TCPU mount.
total length = 95.000"
allows ~2: for cabling bends



Ø 174.834" [Ø 444.08cm]
R 86.417" [R 219.5cm]
R 82.642" [R 209.91cm]
Historical TOF Max Radius
~1in "Spokeman's Reserve"
BEMC Actual Min Radius
.500" [1.27cm]
4.500" [11.43cm]
6.00°

Mechanical mounting

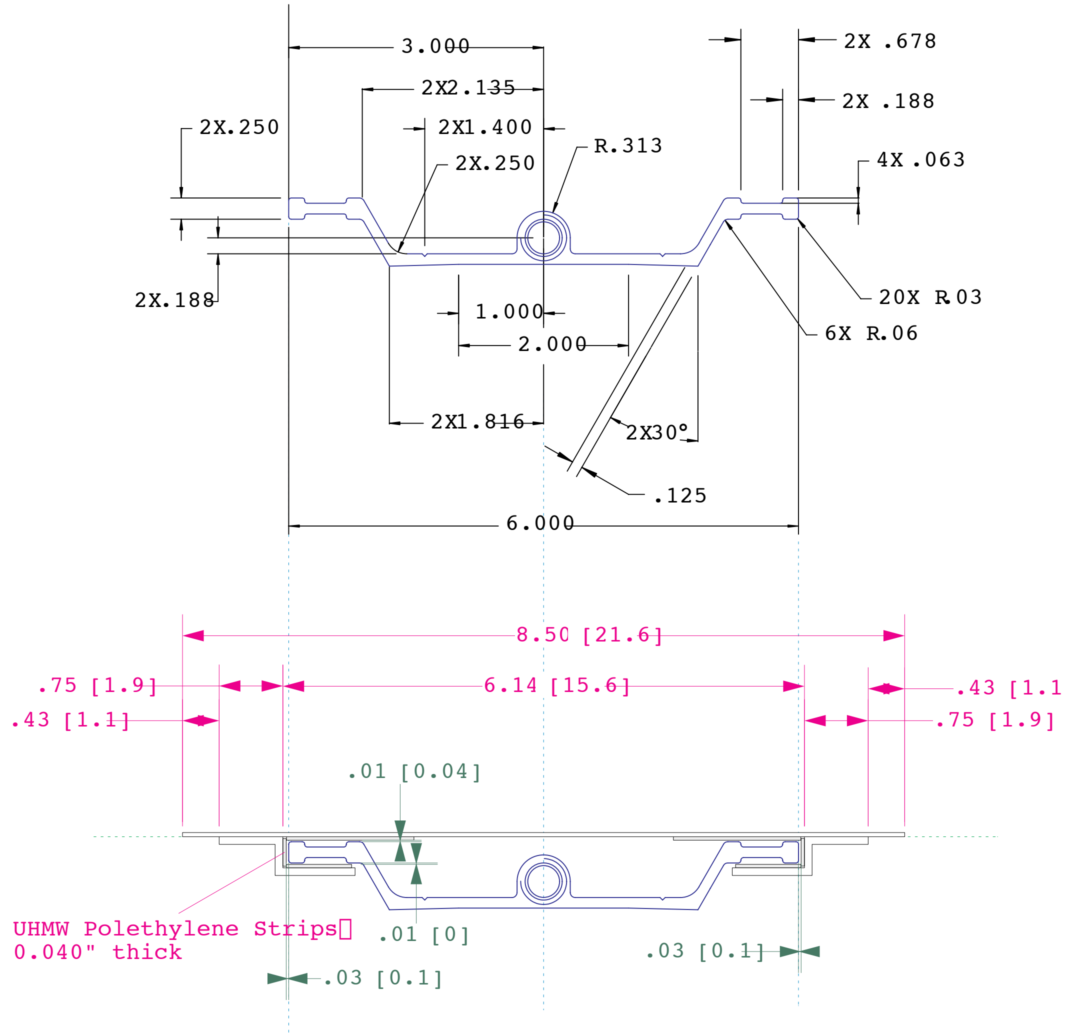
“Feet” under TOF boxes register on “rails” glued to the TPC OFC.

same idea as CTB:
same manufacturer too (Oaks Precision)
- braked 90mil-thick Al feet
- UHMW polyethylene strips ‘inside’...
- feet attachment to tray bottom

CTB:	pop-rivets
TOFr:	pop-rivets
TOFrp:	plug-welds
TOFr5:	plug-welds

measured tray weight = 74 lb.

from STAR Drawing TPC125-D-1:

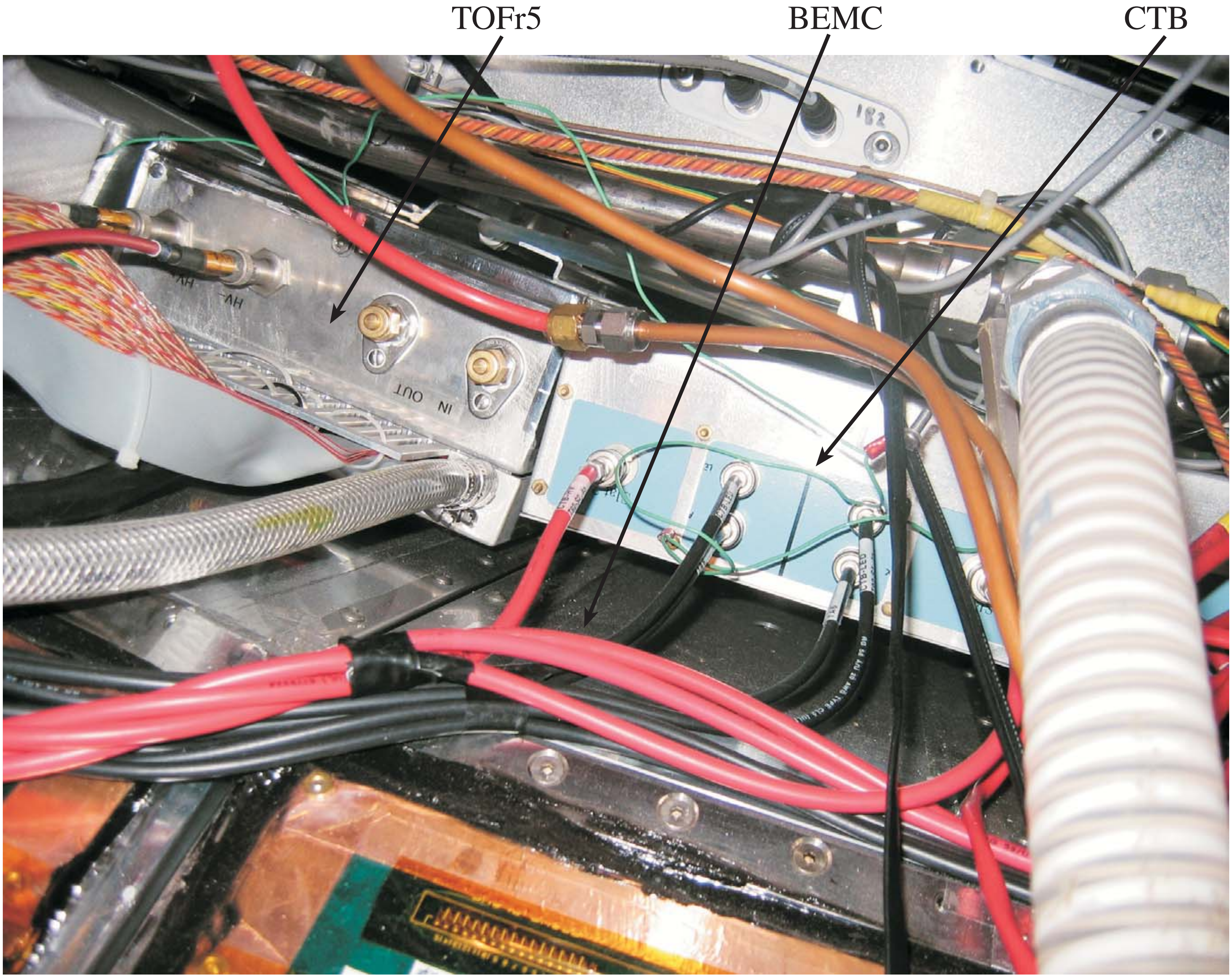


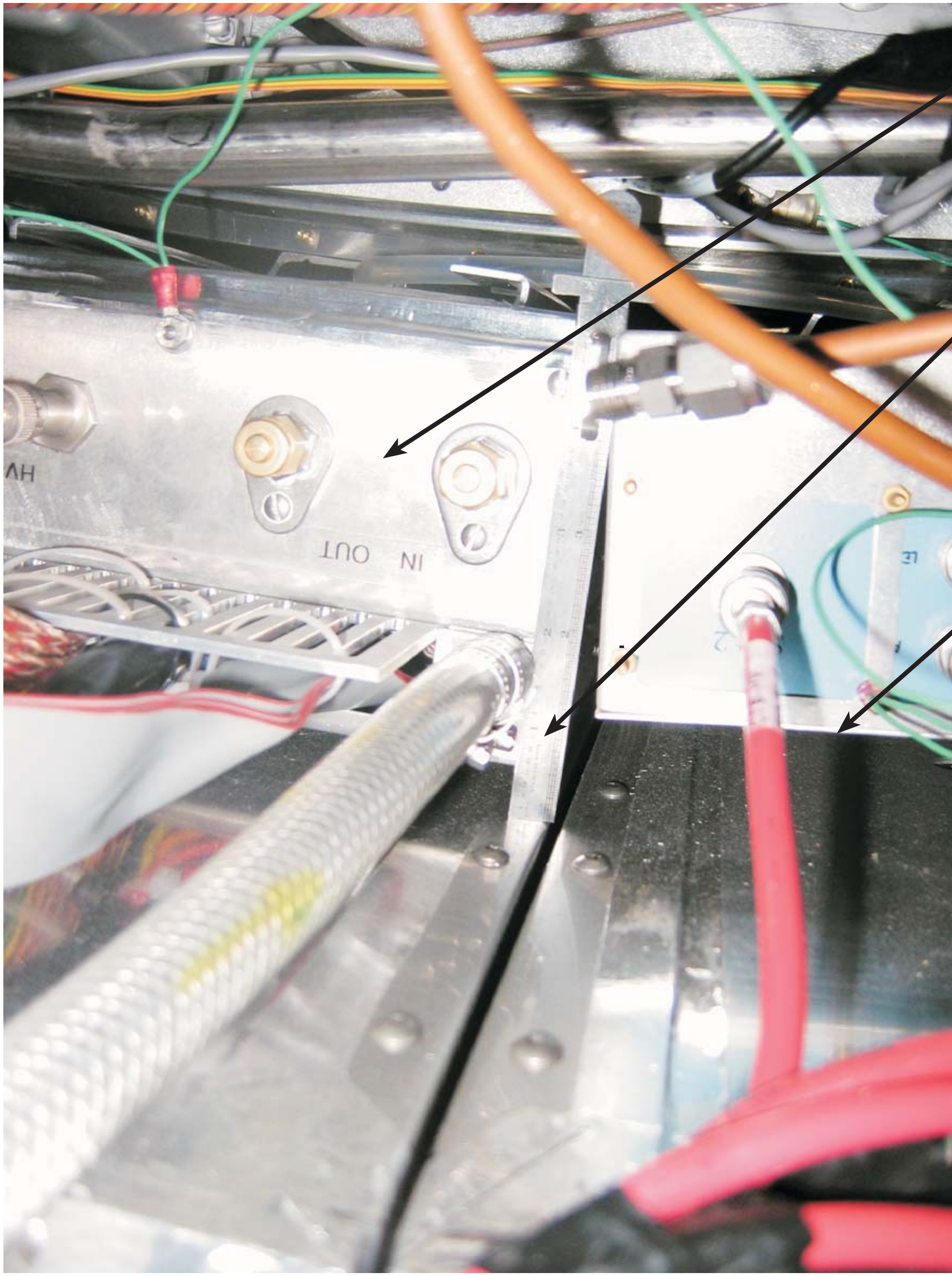
as manufactured:
nominal +/-18mil
height variation...

implies STAR phi-dependence
on tray positions to
- +/-18mil in R
- +/-30mil in phi

action item: select one tray from initial production
mount on a rail (these exist @ Rice) as if in 3 or 9 o’clock posn (100% load on 1 rail)
load tray and show one rail can support 3*75 = 225lbs without failure of the welds.

TOFr5 “height” as installed (for Run-6).





TOFr5 (as just installed for Run-6)

measured gap to BEMC is ~0.5”

CTB

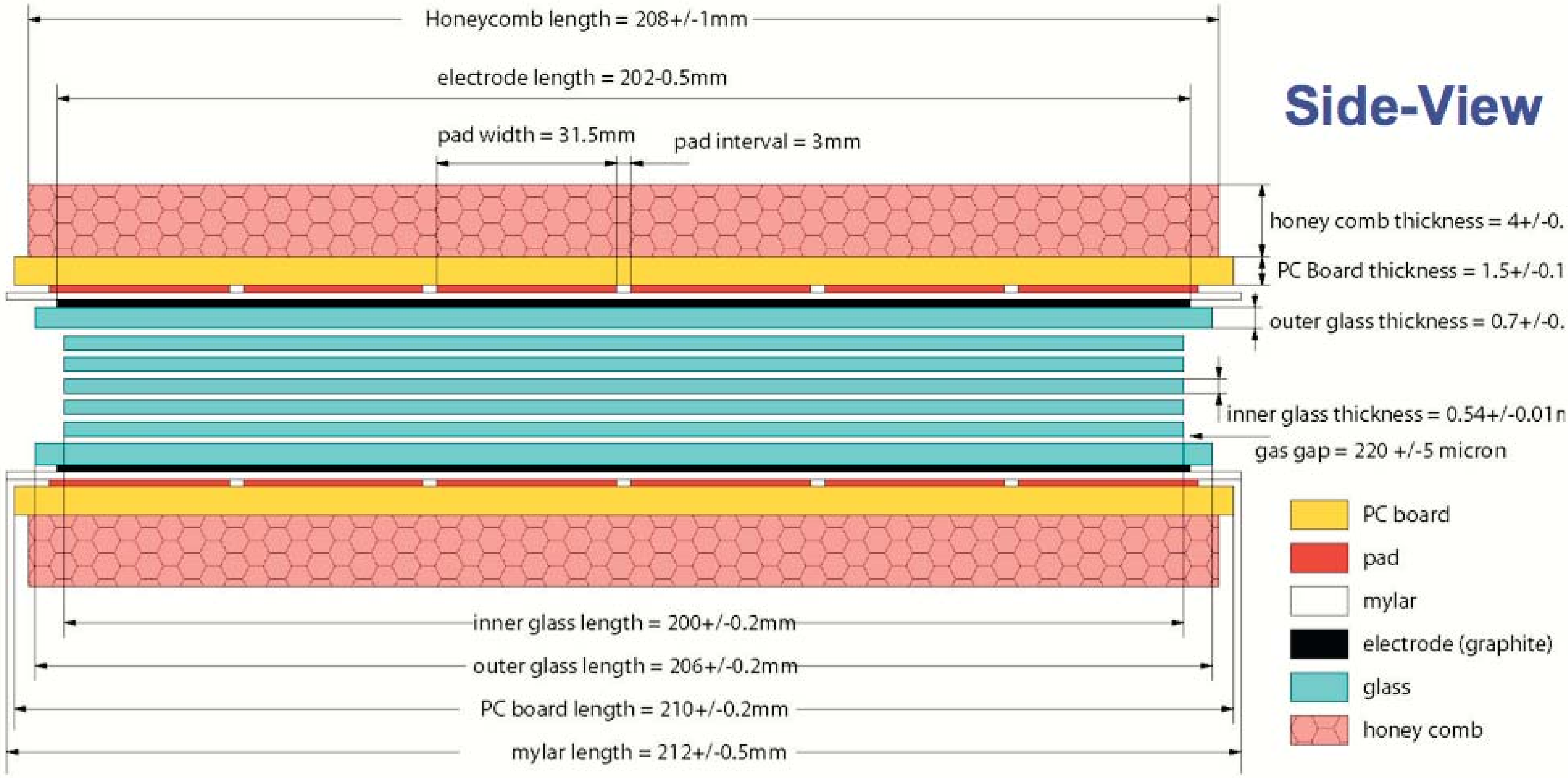
measurements i made before
run-5 show ~3/16” max variation
in radial distance between CTB & EMC

measured each end of ~4 CTB trays
at both ~4 and ~8 o’clock posns
on both east and west...

+/-36mil radial variation due to
rail/strip geometry

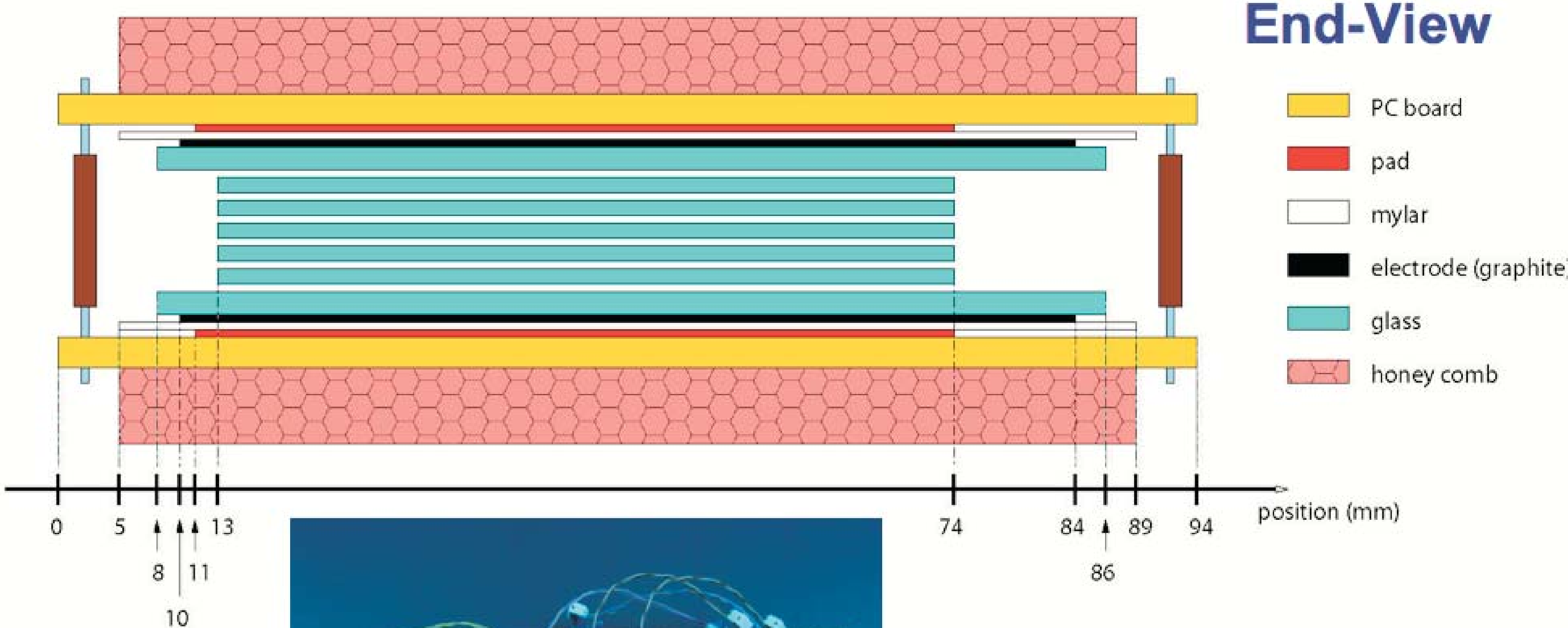
budget is ~400mils (BEMC screws).

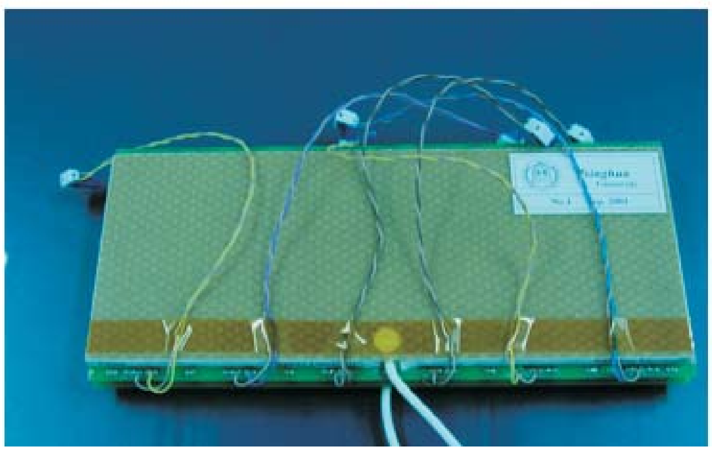
Side-View



Honeycomb length = 208+/-1mm
electrode length = 202-0.5mm
pad width = 31.5mm
pad interval = 3mm
honey comb thickness = 4+/-0.
PC Board thickness = 1.5+/-0.1
outer glass thickness = 0.7+/-0.
inner glass thickness = 0.54+/-0.01m
gas gap = 220 +/-5 micron
inner glass length = 200+/-0.2mm
outer glass length = 206+/-0.2mm
PC board length = 210+/-0.2mm
mylar length = 212+/-0.5mm
PC board
pad
mylar
electrode (graphite)
glass
honey comb

End-View


PC board
pad
mylar
electrode (graphite)
glass
honey comb
position (mm)
0
5
8
10
11
13
74
84
86
89
94



Results of recent MRPC Review

Mechanical tolerances:

	nominal	minimum	maximum
MRPC overall length	212.0 mm	211.5 mm	212.5 mm
width	94.0 mm	93.5 mm	94.5 mm
thickness	17.9 mm	16.9 mm	18.9 mm
HV lead length	18.0 cm	17.7 cm	18.5 cm
Signal lead length	22.8 cm	22.0 cm	23.0 cm
Thickness between two PCBs	9.7 mm	9.4 mm	10.0 mm

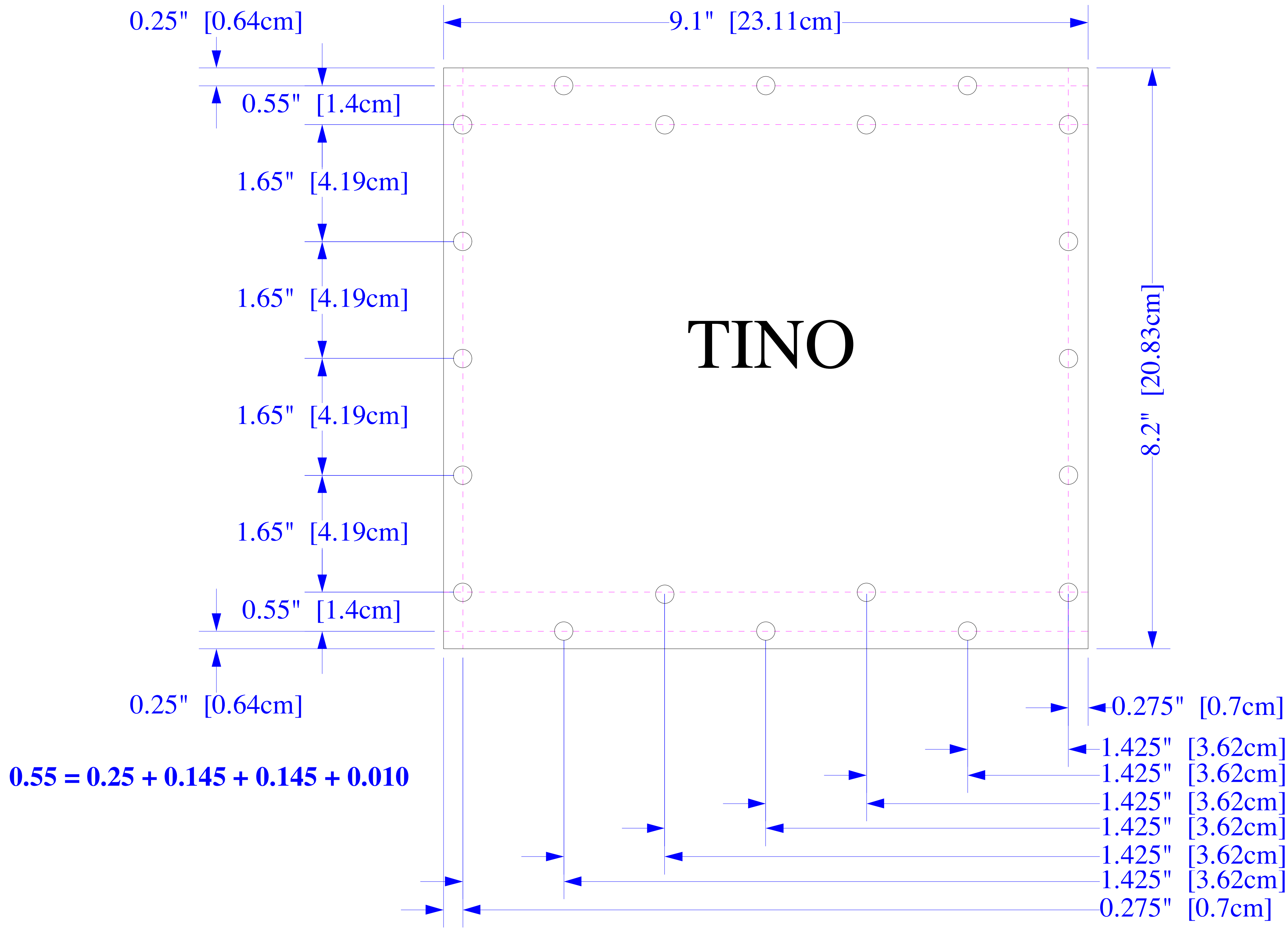
Thickness uniformity better than 0.15 mm per one module measured at six points around the module

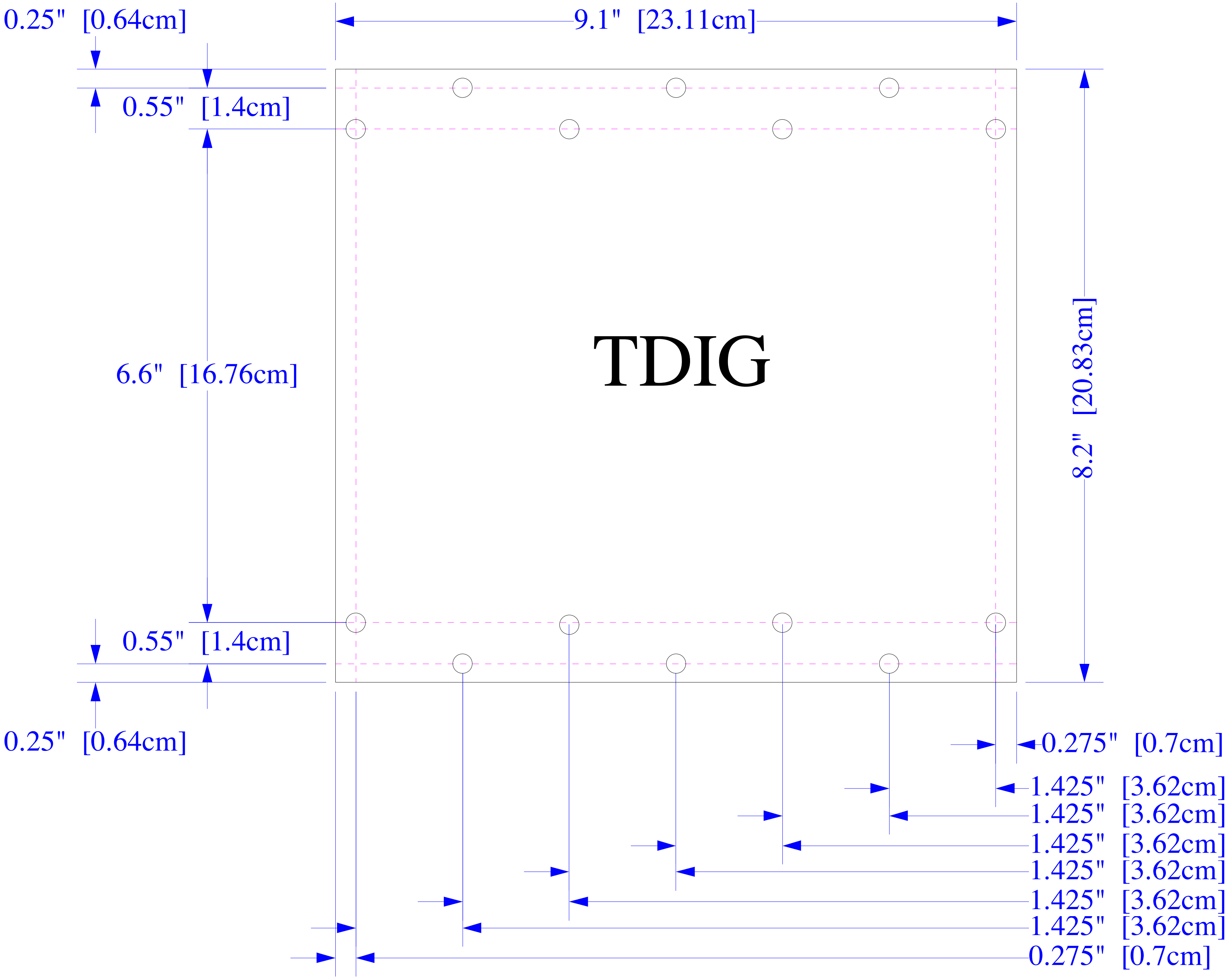
Tray bottom assy inner width	8.400” nominal,	8.390” minimum?
MRPC length	8.346” nominal,	8.366” maximum

MRPC maximum skewness not specified

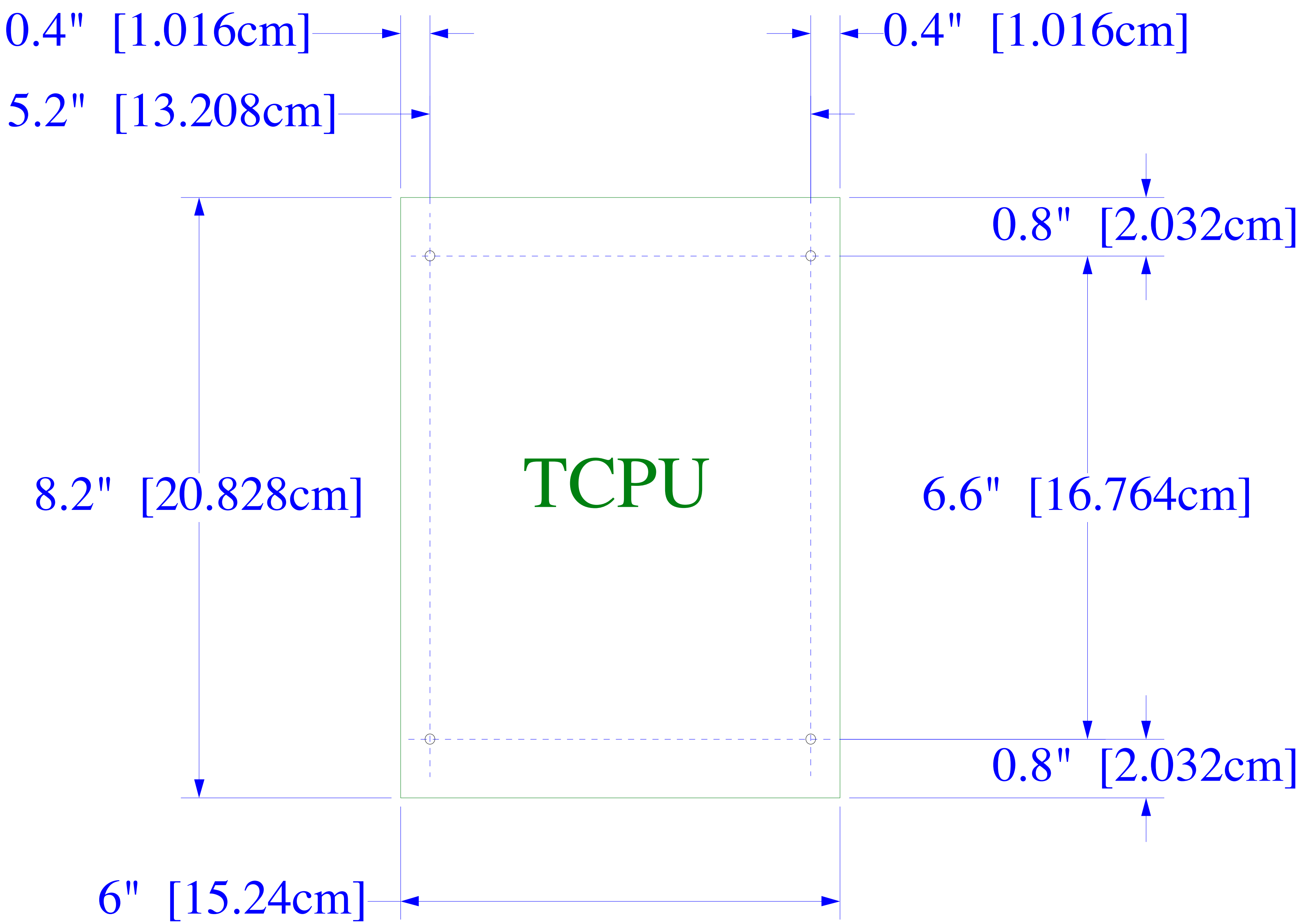
The materials for one MRPC module

Material	Type and manufacturer	Dimension (mm)	Tolerance (mm)	Quantity
Outer glass	Shenzhen	206×78×0.7	±0.2 , ±0.02 , ±0.01	2
Inner glass	Shenzhen	200×61×0.54	±0.2 , ±0.02 , ±0.01	5
Graphite tape	ESD EMI Engineering Corp. Japan, SR>200k ohm/□	202×74×0.13	-0.5	2
Mylar film	Dupont Corp.	212×84×0.35	±0.1	2
Honeycomb board	Aoxing Corp.	208×84×4.0	±1.0, ±0.2	2
PCB	Shenpu Corp. G10	210×94×1.5 6pads, 31.5×63/pad	±0.1 , ±0.15	2
L-shaped and cylinder supporter	Weishi Corp. Polycarbonate	Height:3.8	-0.05	4 4
Nylon wire	Japan	Diameter 0.22	±0.005	800cm
Double side tape	3M Corp., type 9690	210×84×0.13	±0.5	4
RTV	CAF4, France			
Nylon bolts	Shenzhen	Diameter 2.5×12		14
HV lead	15kV, USA	18cm	±0.5	2
Signal lead	34 ribbon cable, USA	22.8cm	±0.5	1
Plug connector	34 pin, AMP, USA			1


0.25" [0.64cm]
9.1" [23.11cm]
0.55" [1.4cm]
1.65" [4.19cm]
1.65" [4.19cm]
TINO
1.65" [4.19cm]
1.65" [4.19cm]
0.55" [1.4cm]
8.2" [20.83cm]
0.25" [0.64cm]
0.275" [0.7cm]
1.425" [3.62cm]
1.425" [3.62cm]
1.425" [3.62cm]
1.425" [3.62cm]
1.425" [3.62cm]
1.425" [3.62cm]
0.275" [0.7cm]
0.55 = 0.25 + 0.145 + 0.145 + 0.010



possible TINO PEM stud height issue!

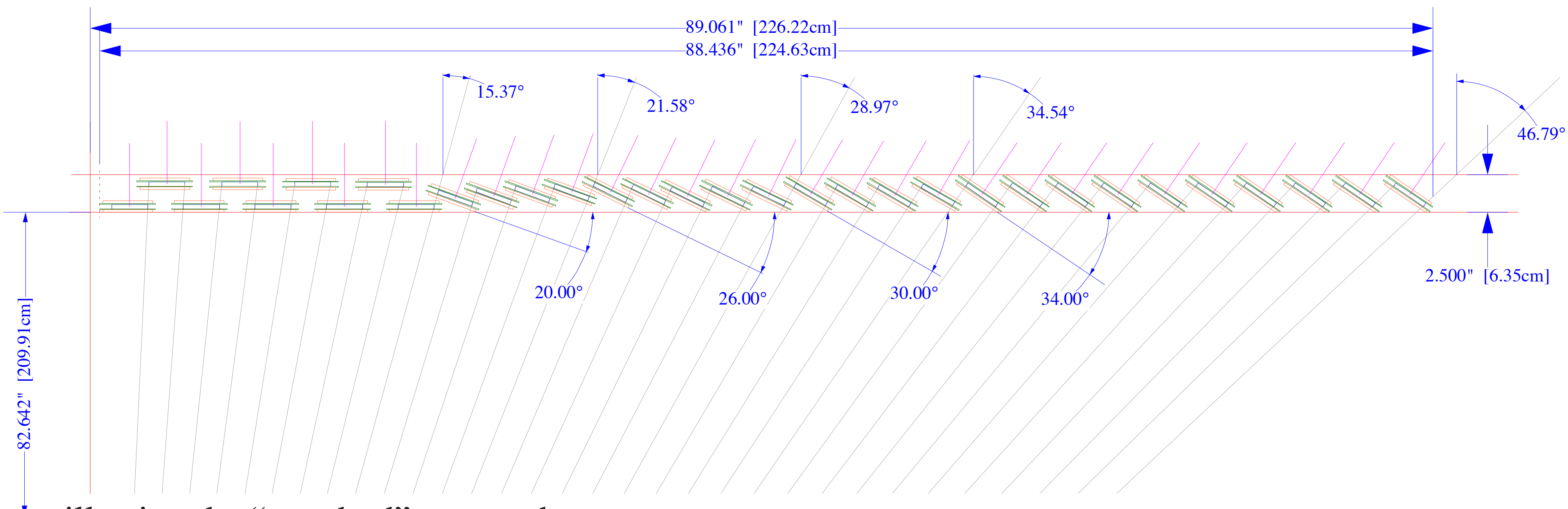


6” length along Z does not leave much room for pigtail cable strain-relief!
Height budget not specified at feedthrough end!
TCPU *above* cooling loop

MRPC positioning: next possibility

MRPC positioning TOFr != TOFr' != TOFr5 !=(?) TOF
- no complaints heard from PWGs over any of these generations
- but simple analyses to date don't care much about such subtleties
  - just pay the dues experimentally and address these in the offline corrections
- full system requires are more judicious choice
  - hence the new simulations work
  - time scale for final decision slightly more relaxed as this is an Inner Sides design issue

Assume:
- align edges of inner glass stacks with straight-line projections from X=Y=Z=0
- Tray Rmin = 209.91cm (worth confirming!)



still using the "standard" approach
- ~2.5" of vertical space exists for MRPC positioning
- Place MRPCs in some small number of eta-groups, w/in each the MRPCs are at the same angle
- minimize maximum deviation from normal incidence for straight-line tracks from Z=0
- try not to get "trapped"

New MRPC Positioning Scheme

Allows notches in Inner Sides Reveals

Highest-eta modules now more normal

Using new code to simulate
- eta acceptance
- phi acceptance
- mean angles of incidence

vs Zvtx

Y	Z	ang	Y	Z	ang
0.589	2.613	0	0.734	2.913	0
2.087	5.079	0	1.75	5.332	0
0.589	7.364	0	0.634	7.694	0
2.081	9.915	0	2.161	10.156	0
0.589	12.116	0	0.79	13.222	-6
2.07	14.75	0	1.395	15.67	-6
0.589	16.868	0	1.976	18.106	-6
2.055	19.583	0	0.79	20.404	-6
0.589	21.62	0	1.324	23.612	-6
1.142	24.209	-20	1.976	26.102	-6
1.279	26.753	-20	0.79	28.365	-6
1.407	29.322	-20	1.404	30.87	-6
1.527	31.918	-20	1.976	34.125	-6
1.522	34.489	-26	0.79	36.352	-6
1.391	37.035	-26	1.976	38.982	-6
1.25	39.605	-26	0.79	41.18	-6
1.277	42.287	-26	1.037	44.395	-16
1.29	44.996	-26	1.219	46.891	-16
1.39	47.789	-30	1.419	49.392	-16
1.313	50.522	-30	1.619	51.902	-16
1.304	53.336	-30	1.509	55.086	-19
1.361	56.233	-30	1.599	57.59	-19
1.371	59.135	-34	1.658	60.092	-19
1.371	62.092	-34	1.709	62.599	-19
1.371	65.096	-34	1.518	66.035	-22
1.371	68.148	-34	1.518	68.543	-22
1.371	71.25	-34	1.518	71.062	-22
1.371	74.402	-34	1.518	73.591	-22
1.371	77.604	-34	1.466	77.105	-24
1.371	80.858	-34	1.466	79.656	-24
1.371	84.165	-34	1.466	82.219	-24
1.371	87.525	-34	1.466	84.794	-24

Modifications TOFr5 → TOF

- new MRPC positioning (modify Reveal posns), hence TINO posn'ing &bracket posn'ing
- rectangular Cu cooling loop (improves thermal path, no need for Al shim pieces)
- change Inner Sides from Acrylic to Lexan (bulk material in-hand)
- gas tube slot in Inner Sides
- reflect mount holes in Inner Sides (helpful for fabrication)
- TINO hole footprint and hole pattern, simplify Big Holes
- PEM stud lengths to match TDIG hole pattern (potential issue here)
- extend length of Bottom, Top, & Cover to provide TCPU mount
- new PEM studs for TCPU mount and cable pigtail strain relief (poorly defined region now)
- align Top to Bottom side screws with Upper & Lower Brackets (eases Inner Sides install)
- notches in Inner Sides Reveals (eases MRPC removal)
- counter-sink side screws for Top to Bottom fastening
- shorten PEM studs for lower brackets
- decrease lower bracket hole diameter
- move Inner Sides outwards ~1/4"
-
-

Unchanged

- all heights
- rail dimensions and attachment (weld)
- gas sealing technique (shoe-box top & DC730)
- all fabrication and testing procedures

Working with Oaks

- Following this meeting, will meet with Larry to discuss updated design
- Will request a quote for Eight (8) trays
  6 for first batch of final trays, 2 for cooling/power and rail strength tests
- Unperforated Cover will be the new default, will also build One (1) perforated cover
- need to try to suppress bottom assy arc from welding
- need to try to close small Z-gap at feedthrough end of tray

Oaks Tolerances are +/-15mils standard

Critical Dimensions

• Bottom Assy Inner width	= 8.400" -0.005" +0.020"
• Feet Inner Height	= 0.366" -0.010" +0.010"
• Feet Inner Separation	= 6.140" -0.005" +0.020"
• Bottom Assy Flatness	< 50mils at mid-length

Will provide gauges for
- Bottom Assy inner width
- Feet inner separation

Lead time should be ~1 month

Trays will be delivered to Rice
measured carefully to check tolerances, then 6 trays sent to UT.

Near-term Plans/Needs

- Complete MRPC positioning simulations
  - lay out Inner Sides
- Finalize Electronics hole patterns
  - possible issue with TDIG hole pattern
- Finalize TCPU design
  - possible issue: area left for cable strain relief
- Specify all pigtail cabling (number, diameters, strain-relief method, & all connectors)

Fabricate new tray hardware

- Cooling loop and inner sides by UT machine shop (A. Schroeder et al.)
- All tray aluminum at Oaks Precision
  - Use one tray to test feet strength
  - Use one tray to test Heat, Temperature, and Power efficiency of new cooling loop
    - need full complement of final electronics for this test.

Slightly Longer Term

- Specify and fabricate tray assembly tables (work w/ Jerry et al.)
  - 3 total: One with pivot "L", Two are just flat tables (w/ specific dimensions & height)
- Specify and fabricate tray installation fixture (work w/ STSG)

Tray Materials

Item	Material	Qty/tray	Rating or Comment
Tray Mechanical			
Bottom Assy	Welded Aluminum, 50mil	1	same CTB, TOFp, & all 3 TOFr's
Top Assy	Welded Aluminum, 90mil	1	same as TOFr' & TOFr5
Cover Assy	Welded Aluminum, 50mil	1	same as TOFr5, but unperforated
Feet	Braked Aluminum, 90mil, welded on	2	same as CTB, TOFp, & all 3 TOFr's
Standoff strips	UHMW Polyethylene	4	same as CTB, TOFp, & all 3 TOFr's
Inner Sides	Lexan, ~90"x~3"x1/4", milled reveals	2	same design as TOFr5 (TOFr5 used acrylic)
Sealant	DC 730 Freon-Resistent Sealant	~2 oz	same as TOFr' & TOFr5
Hardware	teflon (inner sides) or SS (tray body)	~40	same as TOFr5
Tape	Kapton, 2mil-thick	~20ft	same as all 3 TOFr's
HV			
F/T connectors	Kings 1064 (Reynolds-equiv)	2	10 kV
Interior Bus	Rowe R790-1522	~10' x 2	15 kV, 5A
Fusion tape	Rowe GL30R67WO	~20	~3 layers per splice, 40mil/layer, 12 kV/layer
Gas			
F/T connectors	Swagelok SS for 1/4" tubing	2	same as all 3 TOFr's
interior tubing	generic 1/4" polyflow, ~90"	1	same as all 3 TOFr's
Water			
barb fittings	custom (UT shop), Brass	2	same as TOFr5
hose to fittings	Vinyl braided, two hose clamps per fitting	2	200 psi (1.5x max pump pressure in STAR)
cooling loop	custom, Copper, 1/4"x3/8", 40mil wall	1	must be leakless @ >200 psi (UT test)

tray total weight 75 pounds
tray total volume 40 liters

integrated & efficient water path
electronics completely enclosed in solid metal box

“Mechanical” Action Items from STAR Review, January 26-27, 2006

mechanical specifications agreement between the U.S. and Chinese collaborators dealing with the individual MRPC modules.

actual average weight, and some measure for the expected distribution of the weights (e.g. rms), of the final TOF trays is not known.

the Finite Element Array (FEA) analysis indicates that the weight of the TOF array will not distort the vessel to a degree that causes concern, the committee felt that this calculation should be empirically checked if practicable.

not clear ... whether the distortion of the STAR magnetic field due to the material in the TOF trays had been studied

not clear whether the difference in radiation length between the existing CTB trays and the TOF trays had been documented and circulated

staging and testing the TOF trays at BNL requires an area to be identified. The necessary area (e.g. how many m2 and any constraints on shape of area) should be specified, and then identified and allocated

mechanical structure designed and built to store the trays during this testing/stageing process.

what will be done with the CTB trays as they are removed

some problems encountered in the past in sliding prototype TOF trays onto the rails on the TPC gas vessel. The cause of this past problem had been diagnosed by the TOF group (detached and crumpled Teflon tape).

a few electronics boxes (e.g. HV distribution and THUB boxes) which had not yet reached final design, and which had to be located and mounted somewhere on the STAR magnet. The locating of these boxes, and schemes for mounting them, should be determined and documented