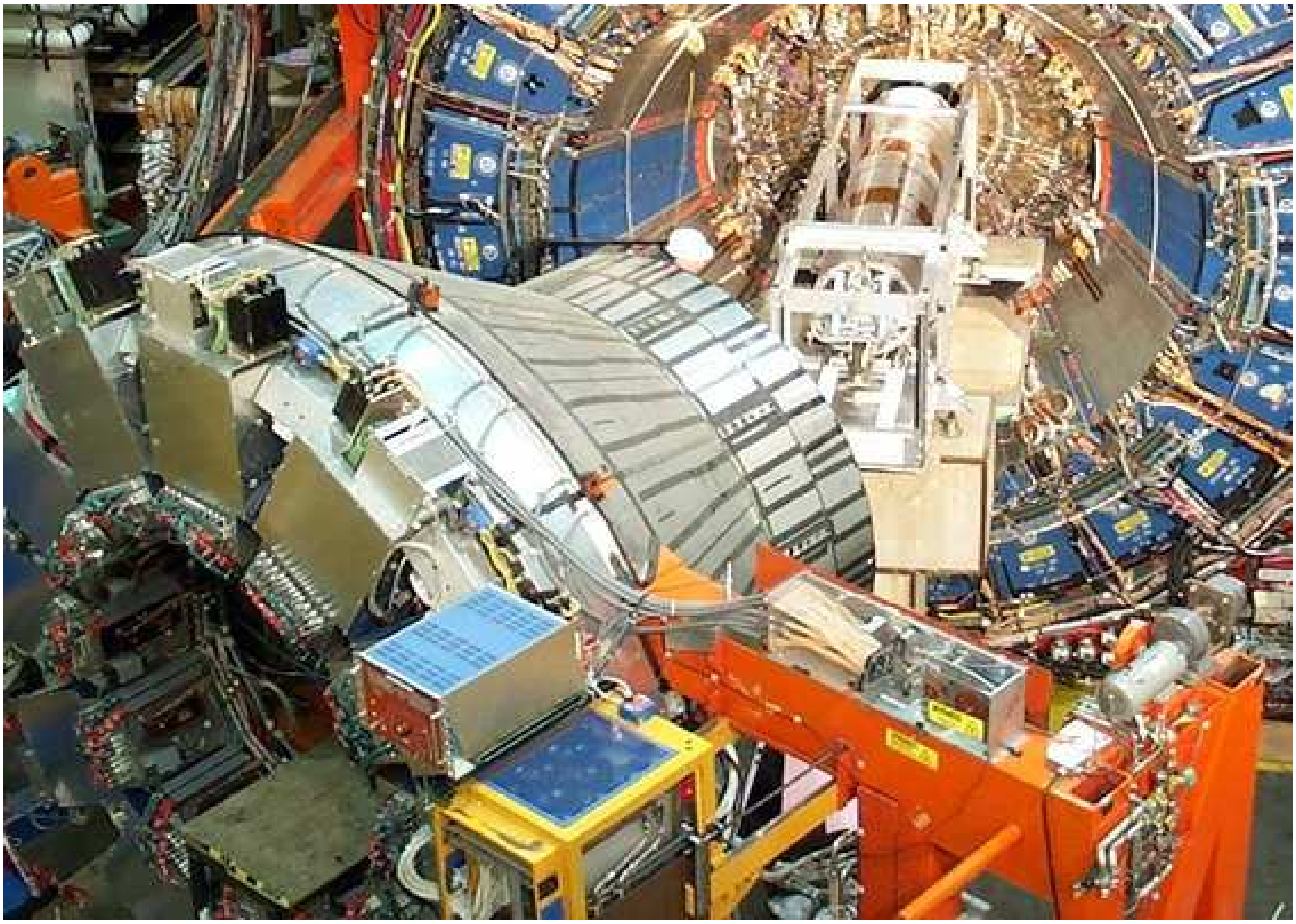
01Jul04

Plug Calorimetry



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1. The Run II plug calorimeter
   - Covers: $1.1 < |\eta_{\mathrm{det}}| < 3.64$
   - Has a projective tower geometry
   - Is a new, compact, more hermetic, sampling scintillator calorimeter
   - Is read out with plastic fibers and phototubes

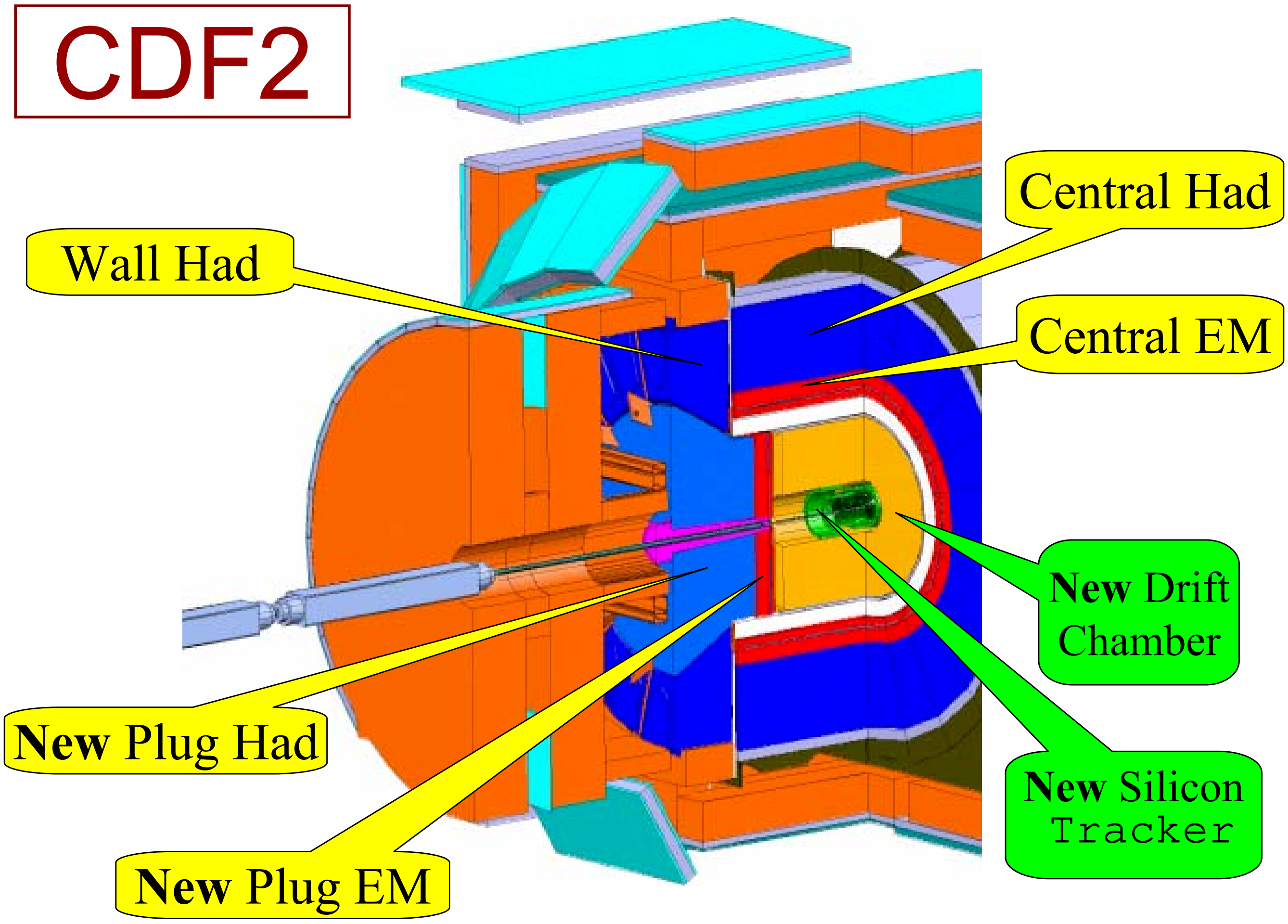
2. Components
   - Electromagnetic (EM) section
     - PEM: tile/fiber tower calorimeter
     - PPR: tile/fiber preshower detector
     - PES: strip/fiber shower–max detector
     - EMT: EM shower timing
   - Hadronic (HAD) section
     - PHA: tile/fiber tower calorimeter
     - HAT: HAD shower timing

3. The Run II plug upgrade began around 1992 and was completed in Summer 2003 with the installation of the plug EM timing system.

   The following groups contributed to this effort:

   - PEM: Tsukuba, KEK, Waseda
   - PPR: Tsukuba, KEK, Waseda
   - PES: Rockefeller, UCLA
   - PHA: Rochester
   - Fiber optics: MSU
   - Photomultiplier tube (PMT) systems
     - –PMTs: Fermilab and UCLA (MAPMT)
     - –PMT box cooling: Brandeis
     - –PMT HV system: Bologna
   - Calibration systems
     - – Laser: Udine
     - – Source: Purdue
   - Engineering: Fermilab
   - Shower timing: Frascati, CMU, Texas A&M

4. The Run II plug calorimeters are very close to the beam:

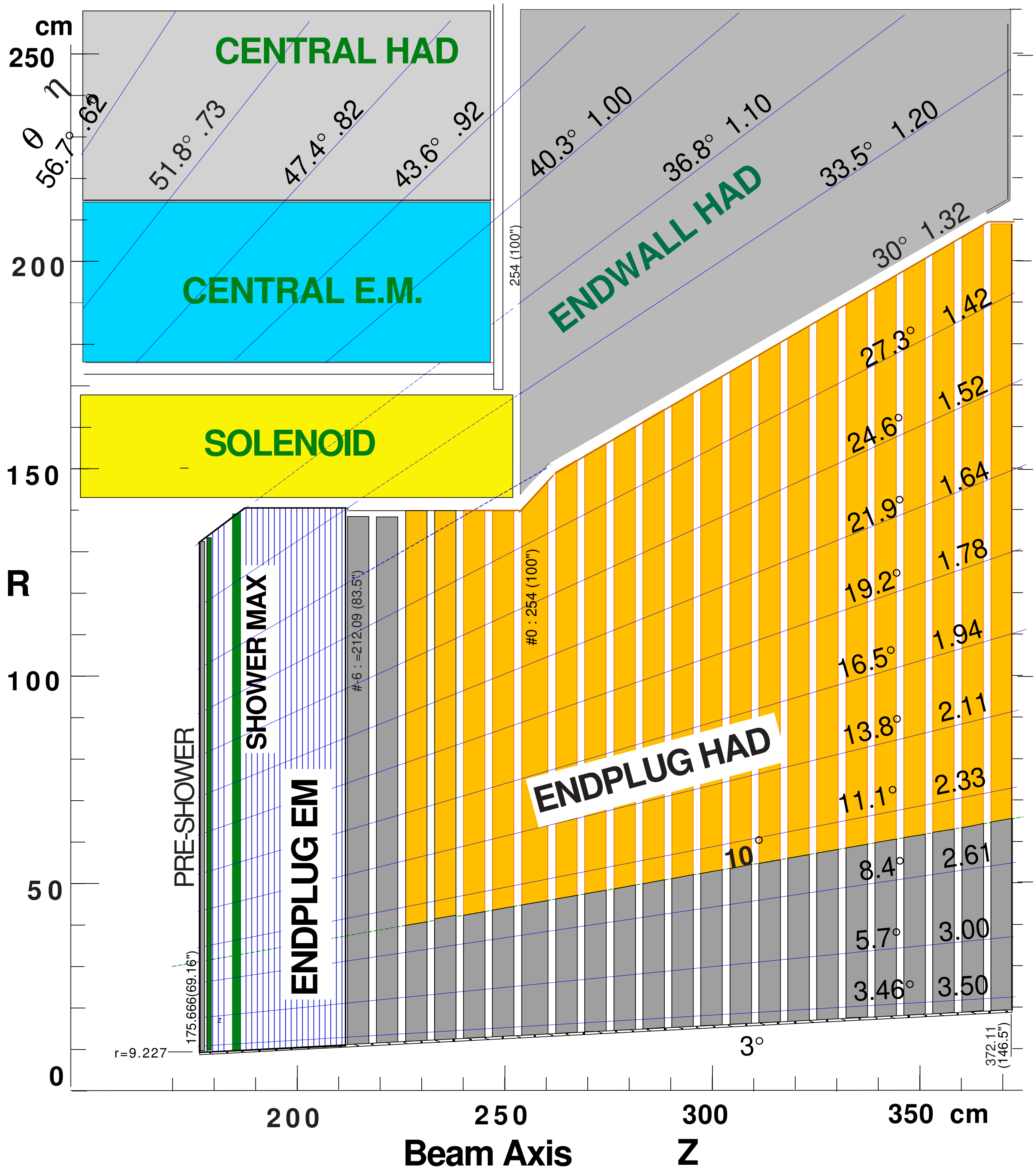


The inner front edge of the PEM is only 9.2 cm away from the beam line. Near the beam line,

$$\bar{\mathrm{E}} \sim 100 \text{ MeV/tower}$$

in both the PEM and PHA

5. Side view of the east end plug, the WHA, and portions of the solenoid, CEM, and CHA



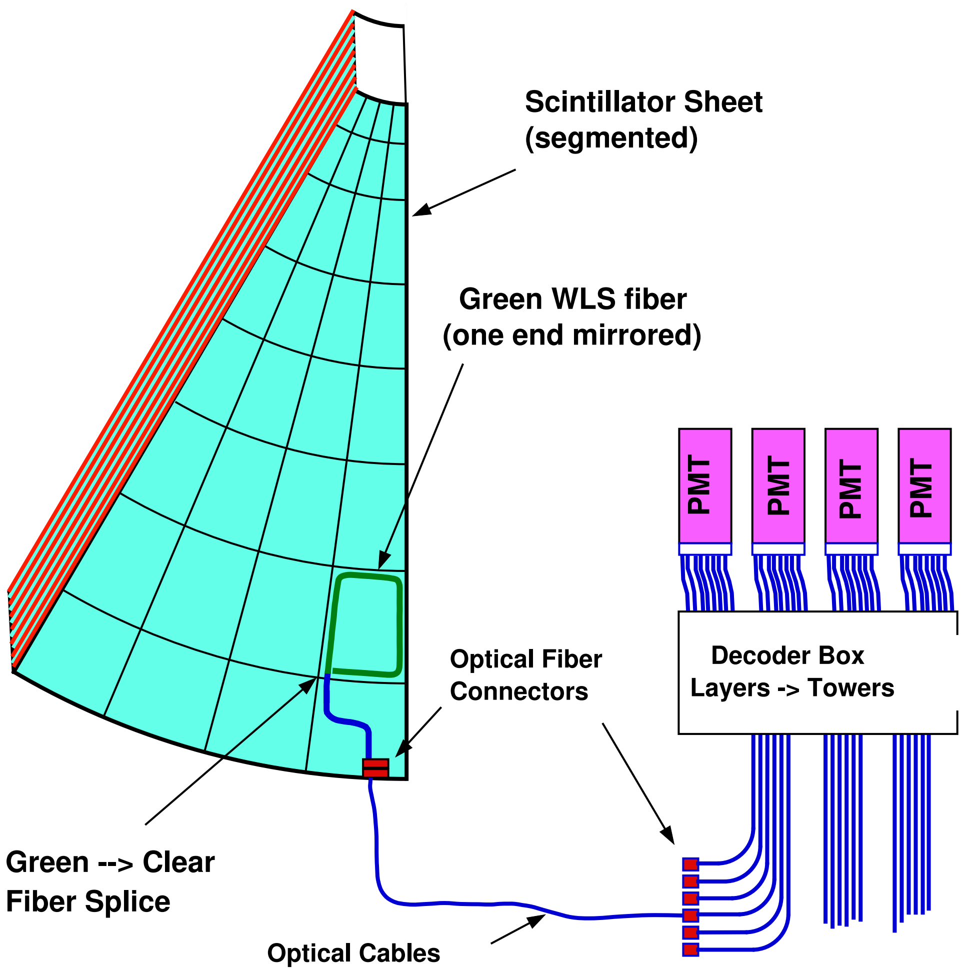
6. PEM and PHA detail summary

	PEM	PHA
Coverage	$1.1 < \lvert\eta\rvert < 3.64$	$1.2 < \lvert\eta\rvert < 3.64$
Towers	20 per wedge	18 per wedge
Thickness	$21\ X_0$, $1\ \lambda_I$	$7\ \lambda_I$
Density	$0.36\ \rho_{\mathrm{Pb}}$	$0.75\ \rho_{\mathrm{Fe}}$
Sampling Layers	22 + PPR PPR = Layer 1	22
Scintillator	4mm SCSN38	6mm SCSN38
Absorber	4.5mm Pb with 0.5mm SS covers	5.08cm Fe
Light	5 pe/mip/tile 400 pe/GeV	5 pe/mip/tile 40 pe/GeV
Light x-talk	0.5% per side	1.0% per side
σ/E	$0.16/\sqrt{E} \oplus 0.01$	$0.74/\sqrt{E} \oplus 0.04$
PMTs	Hamamatsu R4125	Hamamatsu R4125

- SCSN38: Kuraray polystyrene scintillator
- R4125: 0.75" green extended version of R580
- σ/E from 1996–97 test beam run

7. PPR detail summary: 20 tiles per wedge
   - Tile segmentation matches that of the PEM
   - Scintillator tile: 10mm thick Bicron BC-408 (50% brighter than SCSN38)
   - Light yield: 10 pe/mip/tile
   - Phototubes: Hamamatsu R5900-M16
8. PES detail summary: 400 strips per octant
   - Coverage: $1.15 < |\eta_{\mathrm{det}}| < 3.5$
   - Location: layer 5 of PEM – $6X_0$ depth
   - Geometry: U–V strips, 45° crossing angle
   - Strip width: 5mm nominal
   - Scintillator: 6mm thick Bicron BC-404
   - Light yield: 2 pe/mip/strip
   - Phototubes: Hamamatsu R5900-M16
   - A separate PEM layer 5 scintillator plane is downstream of the PES

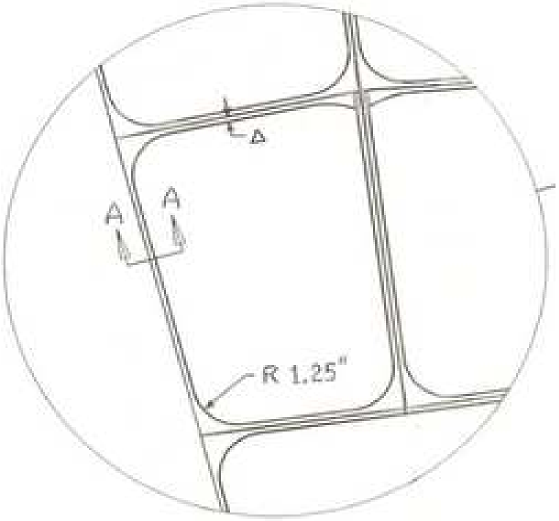
9. The PEM, PPR, and PHA consist of "megatiles" with tile/fiber readout



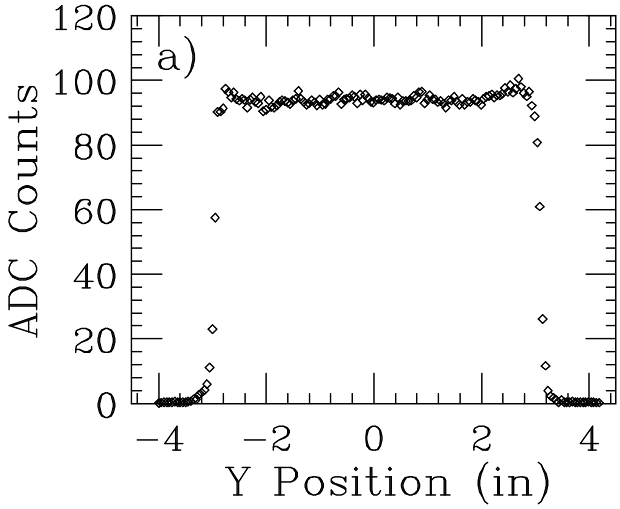
- Megatiles: 15° (PEM, PPR) or 30° (PHA) ϕ sector mechanical units that securely hold and protect scintillator tiles and its fragile fibers
- The Run II plug pioneered the megatile
- Fiber optics with mass termination connectors for ease of construction and assembly

10. Tile/fiber basics

- σ groove pattern developed by CDF



- Relatively flat transverse response



—Depth of fiber groove must be tuned
—Fiber groove close to tile edge
—Light yield $\sim$ Length/Area
—PEM uniformity: $\sim 5\%$
—PHA uniformity: $\sim 2\%$

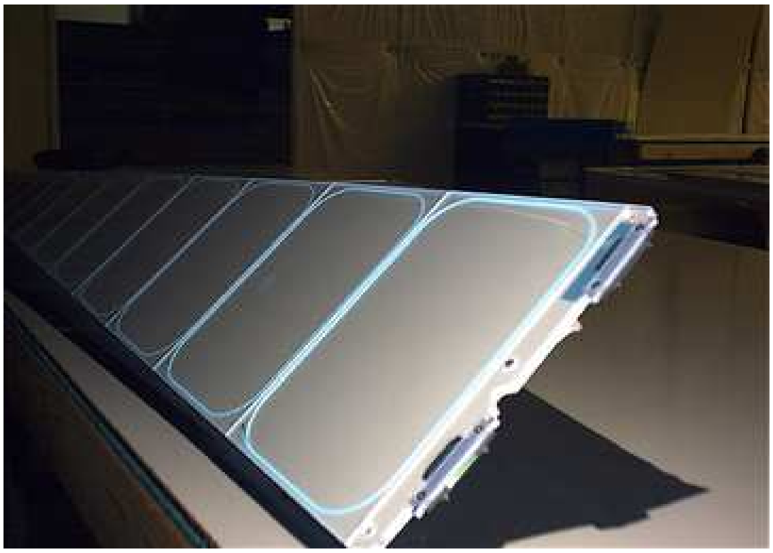
11. Section view of megatiles:

Top cover

Fiber routing
Plate

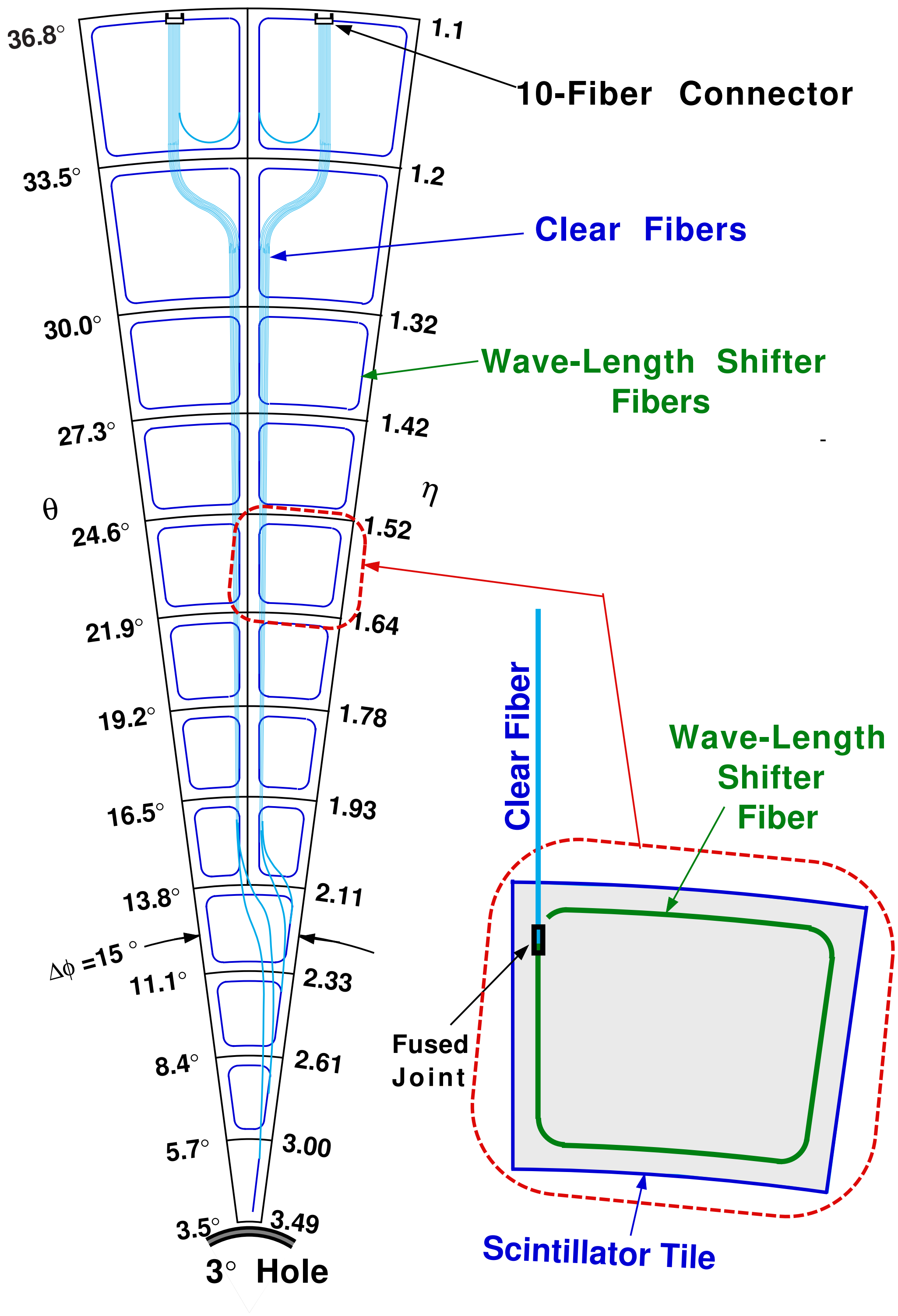
Scint. tiles
Bottom cover

A close up of the scintillator tile plane:

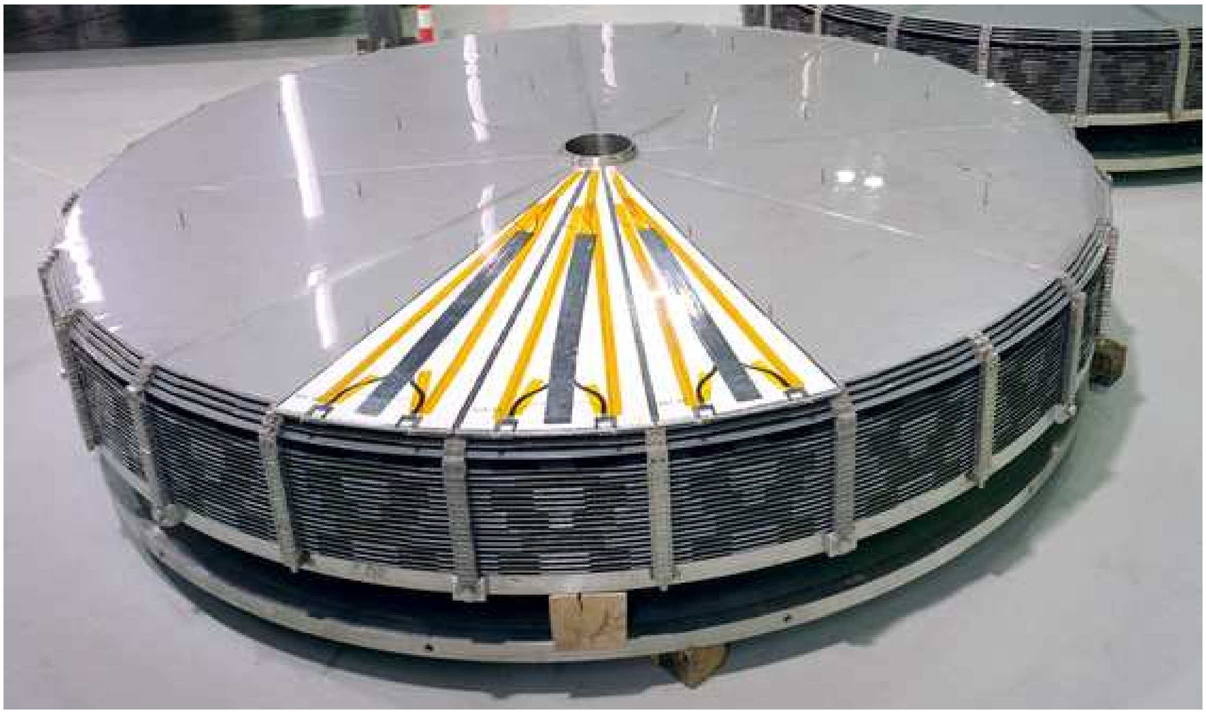


This is a Star EM megatile plucked off the web

12. PEM megatile and plug segmentation



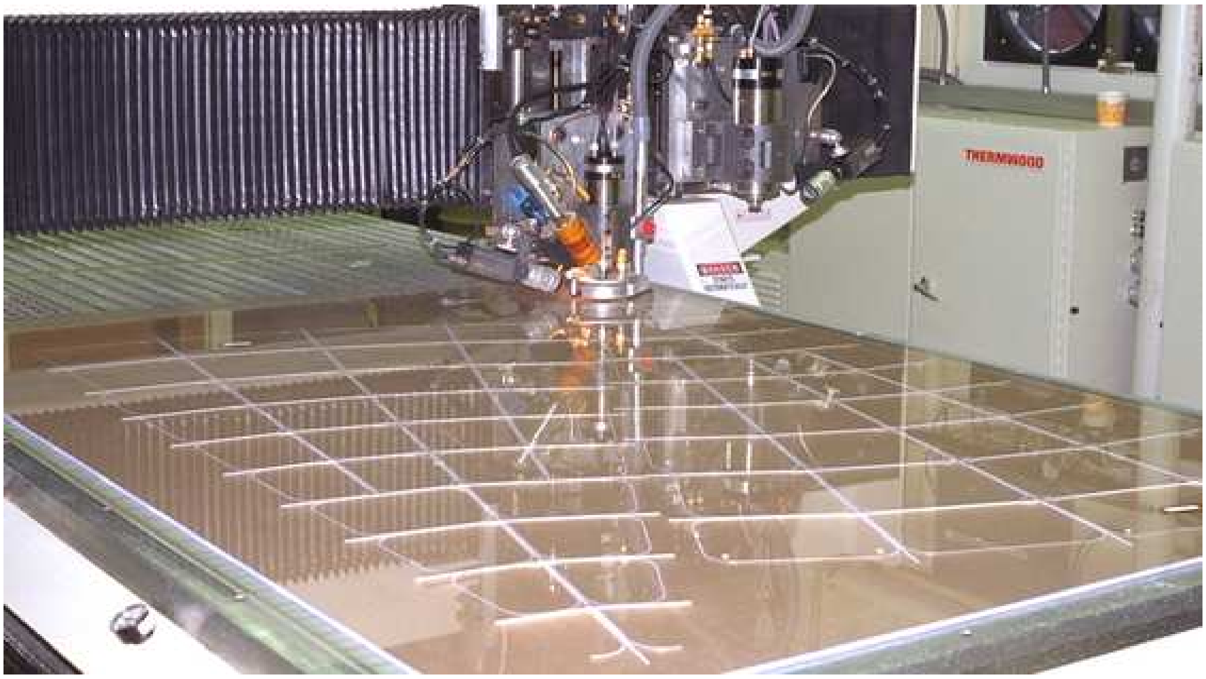
PEM assembly at ICB:

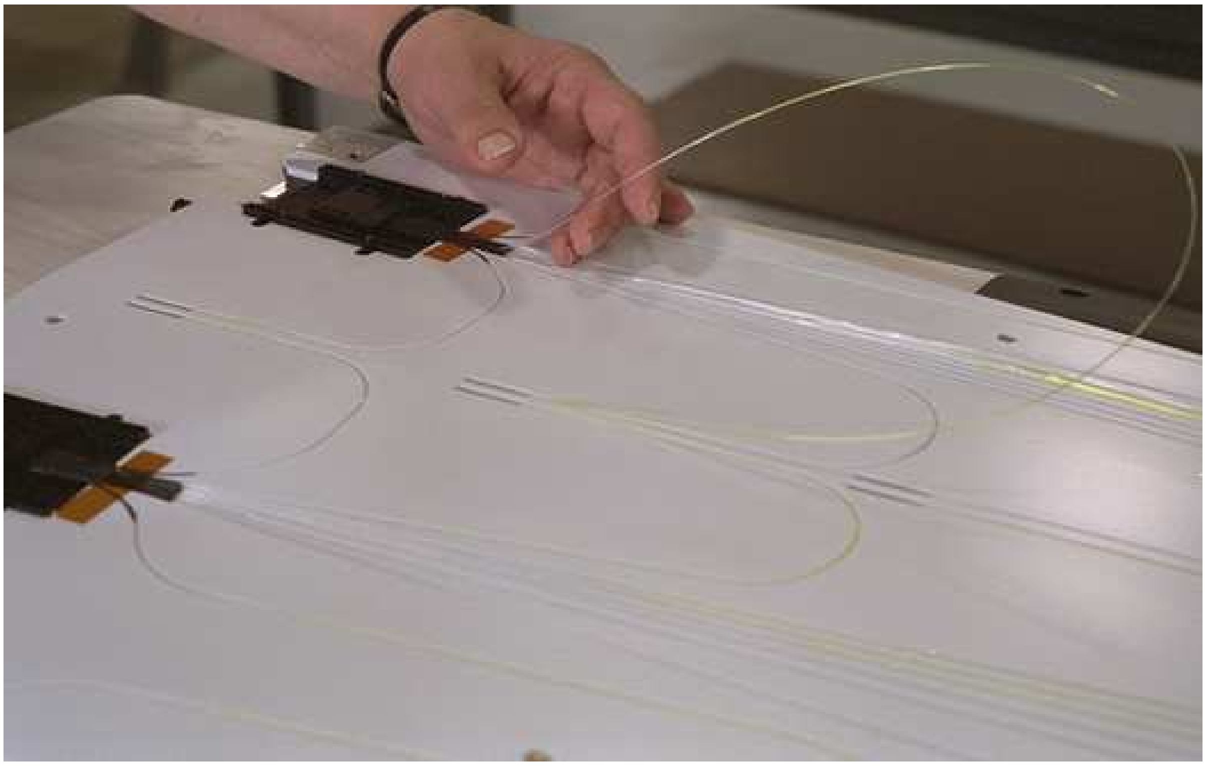


- PPR / Layer 1 is exposed at the top
- Shiny skin is the SS cover over the Pb
- The pins are the megatile alignment pegs
- No sizeable gaps between megatiles

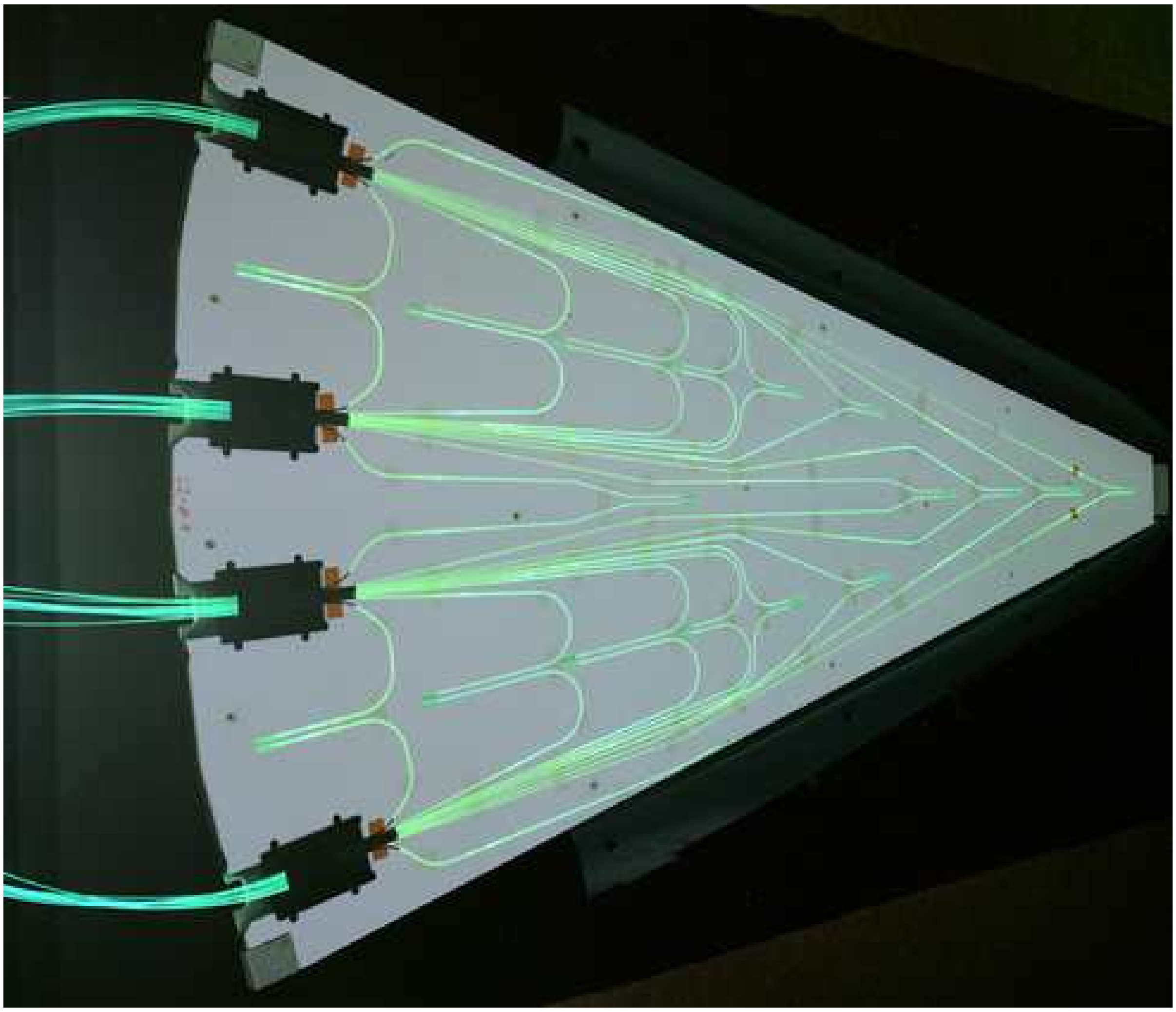
- PHA inter-megatile gap tolerances looser.
  L0–5: 0.125", L6-22: 0.375"

13. PHA megatile construction



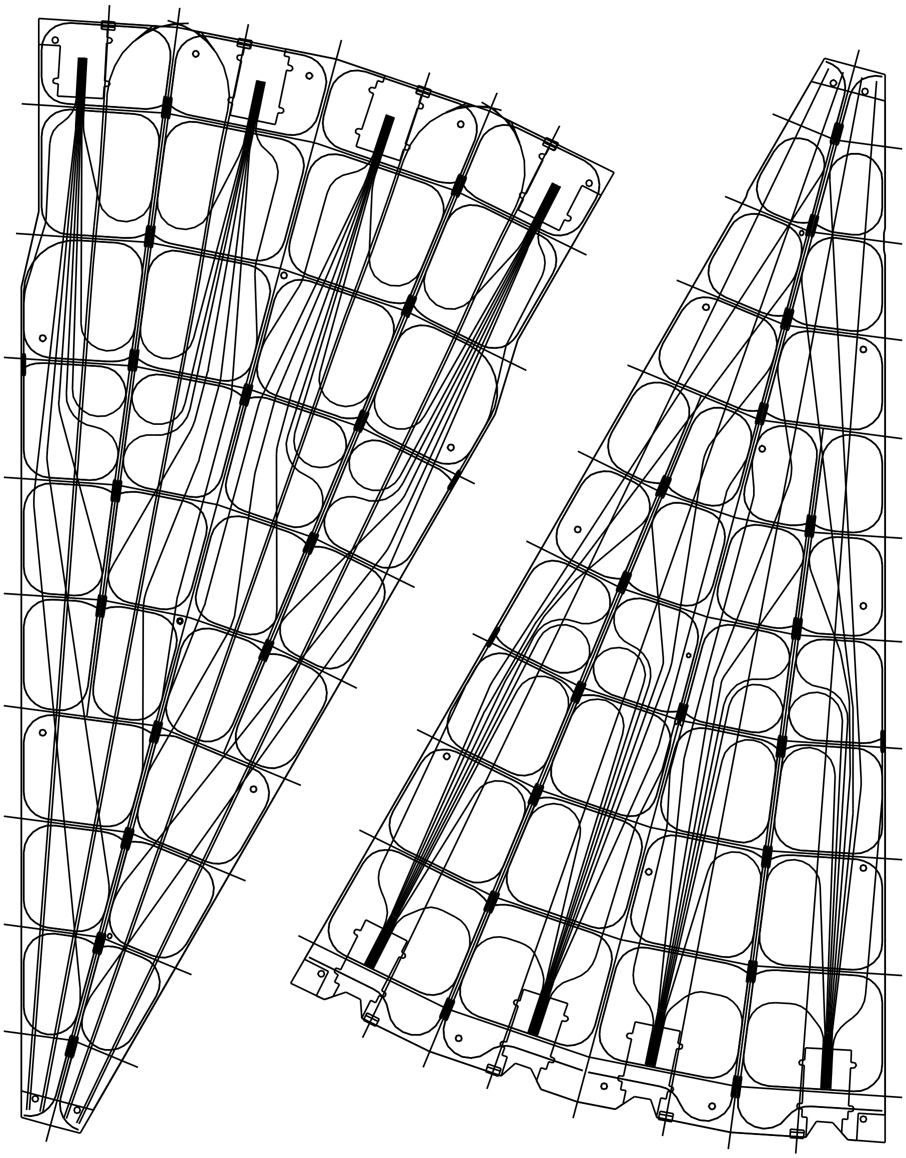


Layer 2 PHA megatile before light tightening and without its top Al cover:



- Fibers are secured and protected in grooves on the white polystyrene cover
- Mass-terminated fiber bundles called *pigtails*

14. PHA megatile: multi-layer CAD view for those who like details (L6 and L2)



- PHA megatiles have protective Al covers
- The first layer is Layer 0
- Layer 6 (left) and beyond: “steel fin” notches

15. Plug Fiber Optics

- Kuraray multi-clad polystyrene fibers used
  −0.83mm: Pigtails
  −0.90mm: 10-fiber transmission cable
  −1.00mm: PMT decoder box
- 0.83 → 0.90 → 1.00 steps: for fiber centering tolerance at the mass terminations
- WLS fibers: Y11 dye (guess ≡ CEM Y7)
- PPR, PEM: S-type pigtail fibers
- PES, PHA: non S-type pigtail fibers
- Cables, decoder box: S-type fibers
- Individual fibers are *very fragile*, but wrapped 10-fiber cable bundles are actually robust