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Argonne Mechanical Design Proposal For the ATLAS Hadron Calorimeter

Presented by

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High Energy Physics Division
Argonne National Laboratory

In Collaboration with

Brandeis University, University of Chicago, Harvard University,
University of Illinois, and Michigan State University

ATLAS Engineering Meeting

CERN Laboratory
Geneva, Switzerland

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MASTER *Se*

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Argonne Proposal

What is unique about the Argonne proposal?

- By overlapping the spacer plates the compression load is carried through the module without affecting the scintillator slots.
- Flat thin straps are used in place of tie rods.
- A supermodule is constructed of six 1 meter modules.
- It is not necessary to drill holes through the scintillator.
- Absorber structure can be assembled independent of scintillator.
- Straps provide better load distribution across the plates.
- This design, as currently drawn, does not include internal sourcing, but does not preclude it being used.

One Meter Module Split to Show Strap Positions

Schematic Assembly of 6 Meter Module

MODULE-1

MODULE-6

TYP. SPACERS

HALF-PERIOD-1

TYP. SPACER

HALF-PERIOD-2

ATLAS
MODULE ASSY.
PLATE-SPACER
AT 10-1-1 THRU 11

ITEM NO.	NO. REQ'D.	DIM.-A	DIM.-B	DIM.-C	DIM.-D	DIM.-E	DIM.-F	DIM.-G	DIM.-H	DIM.-J	DIM.-K
1	326										
2	325	237.64	187.22	92.32	24.02	22.89	87.26	178.84	227.53	103.00	5.05
3	326	247.46	195.44	97.23	25.62	23.88	92.18	187.07	237.35	103.00	5.05
4	325	280.22	206.14	103.61	27.68	25.47	97.08	195.29	247.16	133.00	6.53
5	326	272.99	216.83	110.00	29.76	27.54	103.46	205.99	259.93	133.00	6.53
6	325	285.75	227.53	116.38	31.82	29.61	109.84	216.68	272.69	133.00	6.53
7	326	300.48	239.87	123.74	34.21	31.67	116.22	227.38	285.45	153.00	7.51
8	325	315.20	252.20	131.10	36.60	34.06	123.59	239.72	300.18	153.00	7.51
9	326	329.93	264.54	138.46	38.98	36.45	130.96	252.06	314.91	153.00	7.51
10	325	348.59	280.18	147.80	42.01	38.84	138.32	264.40	329.64	193.00	9.47
11	326

DIMENSIONS ARE IN mm.
FOR CONVERSION 1.0mm = .03937".

CENTER SLOT
2-REQ'D PER SPACER
FOR ITEMS-2 THRU 10
1-REQ'D. PER SPACER
FOR ITEMS-1 AND 11

END SLOT
4-REQ'D PER SPACER
FOR ITEMS-2 THRU 10
2-REQ'D. PER SPACER
FOR ITEMS-1 AND 11

CERN Tile-Cal Questions to be Answered

1. What are the rod and strap stresses in both designs?
2. How would the spacers and tiles be located in both designs?
3. How precise could the slots for the straps be manufactured and located?
4. Provide a preliminary design and costing of the assembly tooling for both designs.
5. What is the welding procedure and possible weld distortions in both designs?
6. If the spacers are tack welded to the master plates, will there be damage to the surface that will interfere with the tile?
7. How will sub-modules be assembled together into a full module, and what are the tolerances that can be achieved in the final assembly?
8. How would the straps be tensioned and welded?

Question # 1

What are the rod and strap stresses in both designs (1 meter submodules and 6 meter modules)?

The strap and rod stresses have been calculated in three different ways:

- Assuming .5 MPa, as specified in the Alstom feasibility study.
- Assuming single node out of plane surfaces on plates.
- Assuming multinode out of plane surfaces for plates.

Single Node

Multinode

Summary of Rod/Strap Stress and Deformation

Module	Structure Compressive Load	Rod		Straps	
		Stress	Elongation	Stress	Elongation
6 m module	.5 MPa	277.3 MPa (40,220 psi)	2.1 mm .081"	39.2 MPa (5,686 psi)	1.14 mm .045"
	.3 MPa Single node	154 MPa (22,370 psi)	1.1 mm .045"	21.8 MPa (3,167 psi)	.63 mm .025"
	5.2 MPa Multi-node	2,860 MPa* (414,800 psi)	21.3 mm .83"	405 MPa* (58,730 psi)	11.4 mm .45"
1 m module	.5 MPa	277.3 MPa (40,220 psi)	2.1 mm .081"	39.2 MPa (5,686 psi)	1.14 mm .045"
	.06 MPa Single node	32.9 MPa (4,672 psi)	.24 mm .009"	4.4 MPa 633 psi)	3×10^{-4} mm 1.3×10^{-5} "
	1.1 MPa Multi-node	619 MPa (87,924 psi)	4.5 mm .178"	82.8 MPa (11,750 psi)	.6 mm .024"

* Material will yield.

Question # 2

How would the spacers and tiles be located in both designs?

- The spacers and tiles would be located using the same methods in both the 6 meter and 1 meter submodule design.
- The spacers are located using fixturing.
- The tiles are located by the straps radially and by clips in ϕ .

RADIAL TILE POSITION

FIBER ARRANGEMENT
(IN UPPER TILES)

Question # 3

How precise could the slots for the straps be manufactured and located?

- The slots can be located in Z and in ϕ to ± 0.25 millimeters.

DIMENSIONS ARE IN MM.
FOR CONVERSION 1MM = .03937"

NO. REQ'D: 643
MATERIAL: C.R. STEEL

ARAS
MODULE ASSY.
PLATE-MASTER

AT-10-1-12

Master Plate Slot Position Tolerances

Question # 4

Provide a preliminary design and costing of the assembly tooling for both designs.

- The assembly fixturing consists of two parts:
 - Fixturing for 1/2 period subassembly.
 - Fixture for stacking and welding the submodule.

- The estimated cost for tooling:
 - \$15,000.00 USD for 1/2 period fixture.
 - \$150,000.00 USD for stacking and welding fixture.

Stacking Fixture Precompression Mode

STACKING FIXTURE

Question # 5

What is the welding procedure and possible weld distortions in both designs?

- The procedures and expected distortions are the same for both designs.
- Procedures vary only slightly based on end plate configuration of different submodules as shown in weld samples.
- Welding tests to confirm need for prestress and straps.
- Module is completely stacked and compressed when straps are inserted and welded.

Question # 6

If the spacers are tack welded to the master plates, will there be damage to the surface that will interfere with the tile?

- No surface damage expected if TIG welds are used and contained within the weld slots.
- Local effects of welding can be seen in weld samples.
- Weld procedures will be refined to prevent tile interference.

Question # 7

How will sub-modules be assembled together into a full module, and what are the tolerances that can be achieved in the final assembly?

- Pin location to be match drilled to back beam structure at time of assembly.
- Gaps provide for Z dimension tolerances of submodule when assembled into full module.
- Front plate to be attached across the submodule boundaries by welding or bolting.

$\pm .004" / \text{SPACER} = \pm .10 \text{ mm}$

$\pm .004" / \text{MASTER} = \pm .10 \text{ mm}$

Module Length Control

5 Cell

Module Length Control

10 Cell

MODULES-1 AND 6

Module-to-Module Radial Gap

SUPERMODULE

LENGTH OF MODULES:

MODULE-1: 974mm (INCLUDES 20 mm END PLATE)

MODULES-2 THRU 5: 990 mm

MODULE-6: 960 mm (INCLUDES 20 mm END PLATE)

GAP BETWEEN MODULES: .5 mm

PIN HOLES TO BE MATCH DRILLED
FROM BACK BEAM TO MODULES

Question # 8

How would the straps be tensioned and welded?

- Prestress is considered to not be required, but tests will be conducted.
- Straps only need to be held straight.
- If tests show that prestress is required, we are concerned with possible annealing of heat effected zone.

Strap Tests

- Tests to determine if strap preload is necessary and if preload is affected by welding.
- Tests assuming different compression loads.
- Tests will vary from no preload to load 1.5 times expected strap load due to stack compression.
- Strain gauge measurements to determine stress on strap during preload and welding.

TENSIONING FIXTURE

Summary of Rod/Strap Stress and Deformation

Module	Structure Compressive Load	Rod		Straps	
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	1.1 MPa Multi-node	619 MPa (87,924 psi)	4.5 mm .178"	82.8 MPa (11,750 psi)	.6 mm .024"

* Material will yield.

Strap Test Sequence

Test #	Disk Spring Compressive Load	Strap Preload	Strap Stress at Preload
1	.5 MPa	2,487 lbs. 1,128 Kg	5,686 psi 39.2 MPa
2	.5 MPa	3,731 lbs. 1,692 Kg	8,529 psi 60 MPa
3	.3 MPa	1,385 lbs. 628 Kg	3,167 psi 22.3 MPa
4	.3 MPa	2,078 lbs. 942 Kg	4,750 psi 33.5 MPa
5	5.2 MPa	25,694 lbs. 11,654 Kg	58,730 psi 414 MPa
6	.06 MPa	277 lbs. 125 Kg	633 psi 4.4 MPa
7	.06 MPa	415 lbs. 188 Kg	950 psi 6.7 MPa
8	1.1 MPa	5,140 lbs. 2,331 Kg	11,750 psi 82.8 MPa
9	1.1 MPa	7,711 lbs. 3497 Kg	17,625 psi 124 MPa
10	5.2 MPa	0	0

Strap Test Status

- Basic frame components completed by the University of Chicago.
- Estimates received by Argonne for balance of parts.
- Technicians will complete parts in 3 weeks.
- Expect to complete tests by next Atlas meeting.

Cost in U.S. Dollars for Absorber Plates and Tooling

Plates

Spacers	\$234,766.00*
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Masters	\$732,720.00*
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(Note - plate costs include material estimated at \$.55/kg)

Production Tooling

Spacers	\$42,000.00*
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Masters	\$40,472.00*
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Assembly Fixtures

Stacking and welding	est. \$150,000.00
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1/2 period assembly	est. \$15,000.00
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* Supported by vendor quotations.

1m PROTOTYPE MODULE COMPRESSION FIXTURE

ATLAS One Meter Prototype Cost

Mechanical

Norman F. Hill

10 June 1994

		Material	Labor	TOTAL
1	Master Plates	\$1078.00	\$18,920.00	\$19,998.00
1a	Adjustment Plates	\$786.00	\$6,000.00	\$6,786.00
2	Spacer Plates	\$539.00	\$49,375.00	\$49,914.00
3	Straps	\$50.00	\$2,200.00	\$2,250.00
4	Inner Radius Plate	\$1500.00	\$2000.00	\$3,500.00
5	Outer Radius Plate	\$1500.00	\$2000.00	\$3,500.00
6	1/2 Period Subassembly Tooling Welding	\$20,000.00	\$40,000.00	\$20,000.00 \$40,000.00
7	Stacking Press (assuming ZEUS fixture model)	\$35,000.00		\$35,000.00
8	Inner and Outer Plate Welding		\$8000.00	\$8000.00
9	Strap Welding		\$2,000.00	\$2,000.00
	GRAND TOTAL	\$60,453.00	\$130,495.00	\$190,948.00

**DATE
FILMED**

9 / 30 / 94

END