U.S. ATLAS

3.5 ATLAS Muon Maintenance and Operations

Frank Taylor

MIT

DOE/NSF Review of U.S. ATLAS Research Program
April 9-11, 2002 - Fermilab

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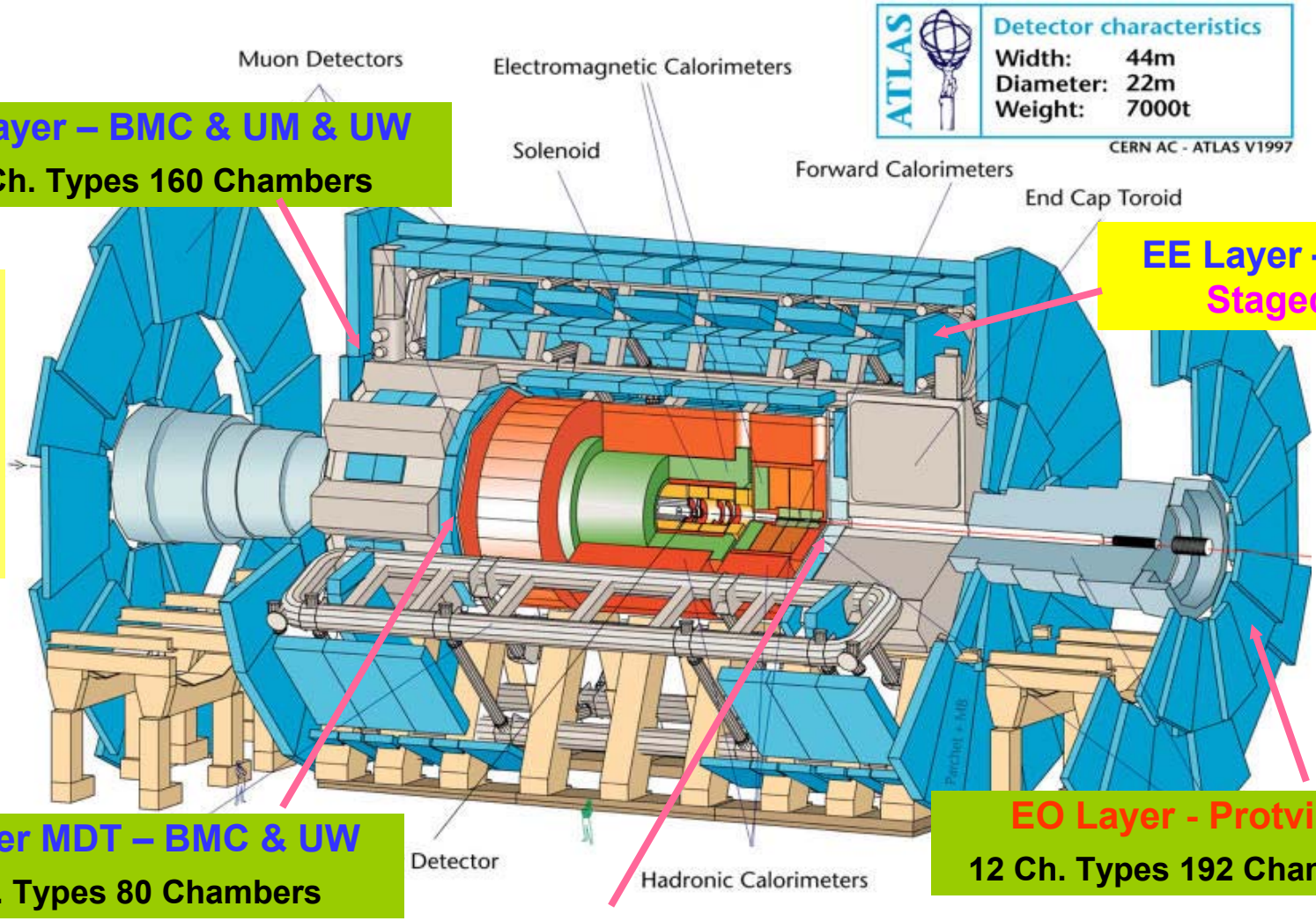
ATLAS Muon Endcap System



EM Layer – BMC & UM & UW
10 Ch. Types 160 Chambers

BMC
Boston
Brandeis
Harvard
MIT
Tufts

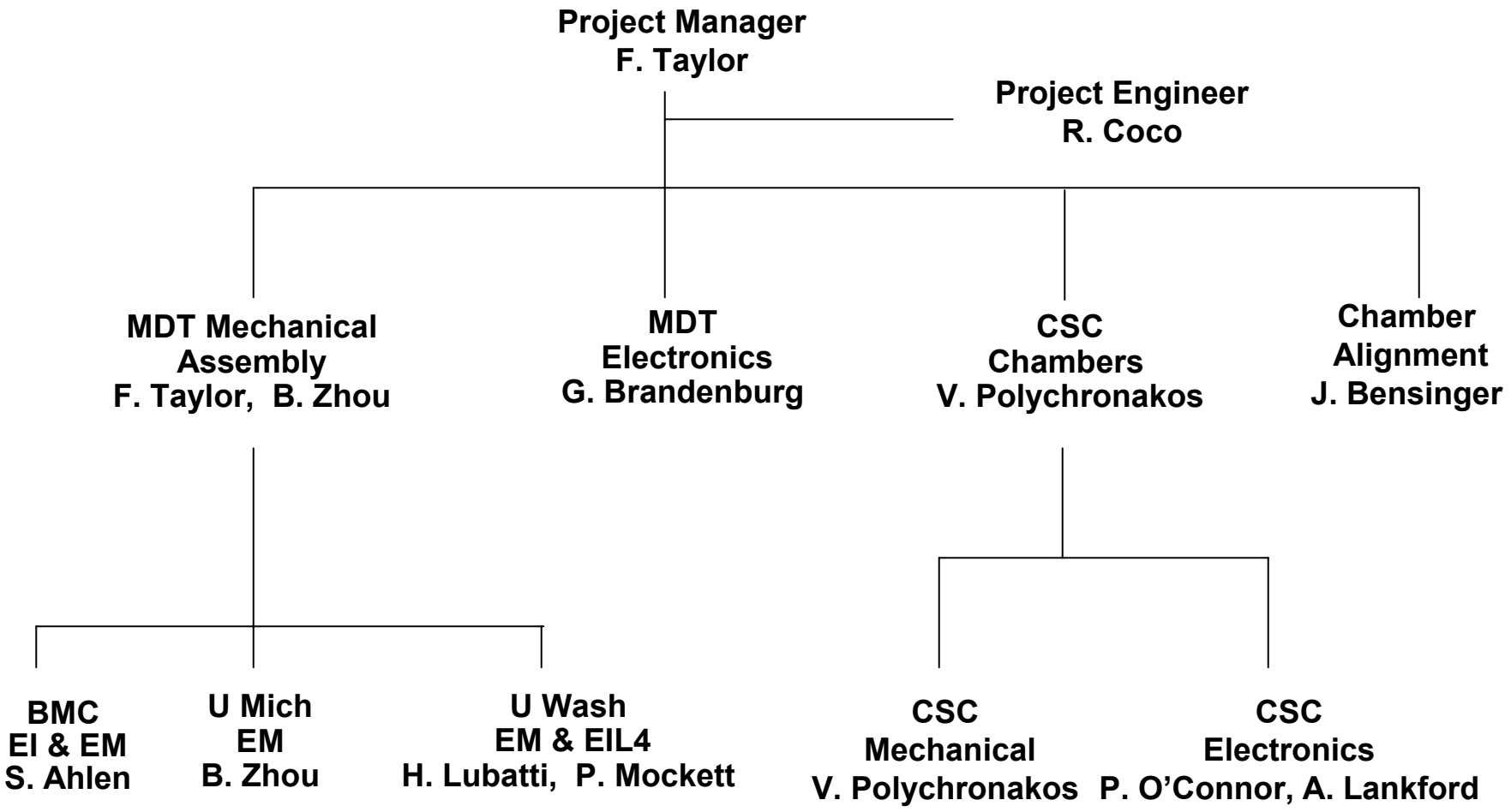
EE Layer – US
Staged

EI Layer MDT – BMC & UW
5 Ch. Types 80 Chambers

EO Layer - Protvino
12 Ch. Types 192 Chambers

EI Layer CSC – BNL & UCI
2 Ch. Types 32 Chambers

Organization of US ATLAS Muon



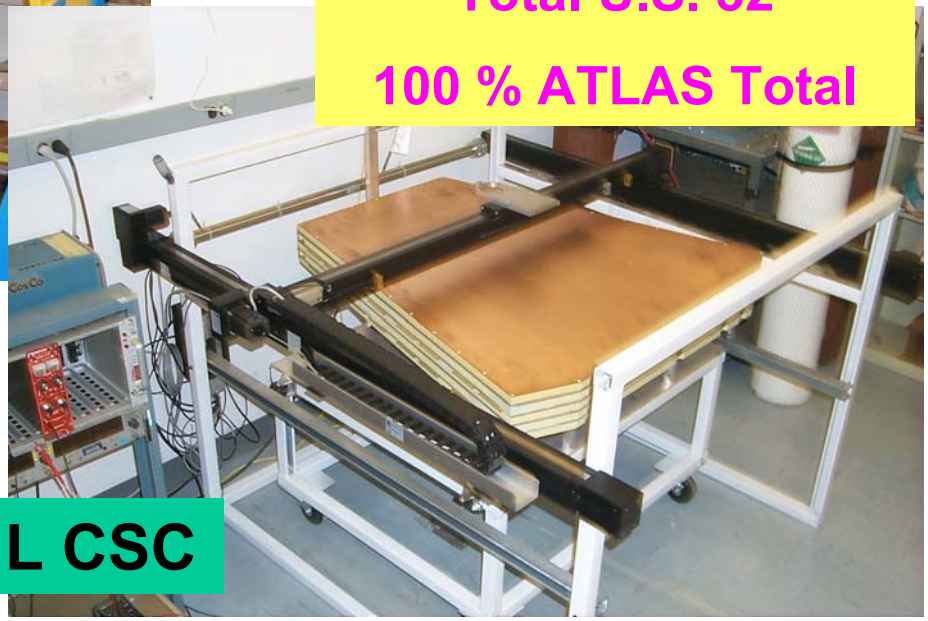
Chamber Deliverables

Seattle MDT EML2

CSC Production

Total U.S. 32

100 % ATLAS Total



BNL CSC

MDT Production

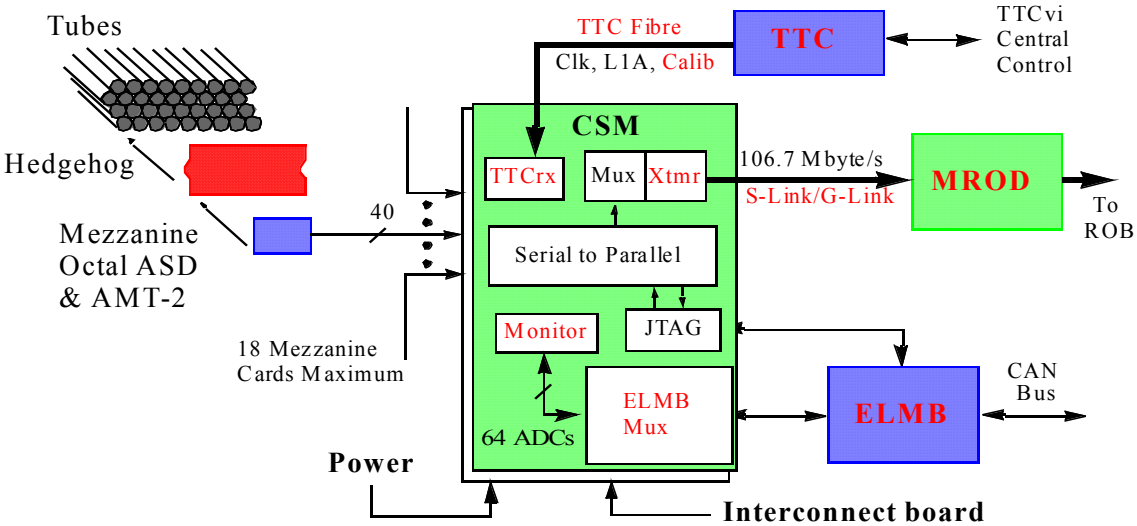
Total U.S. 240

15 Chamber Sizes

23.6 % ATLAS Total

100 % EI & EM Layers

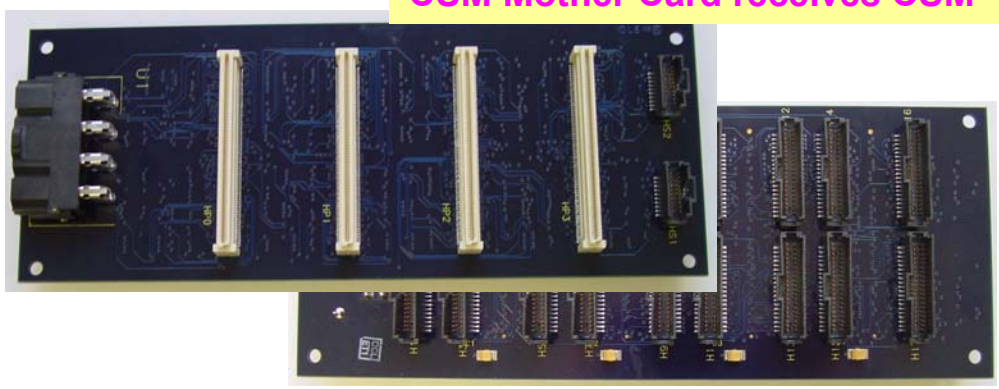
MDT Electronics Deliverables



Note: All connections to the CSM are through a passive interconnect except the TTC & MROD systems

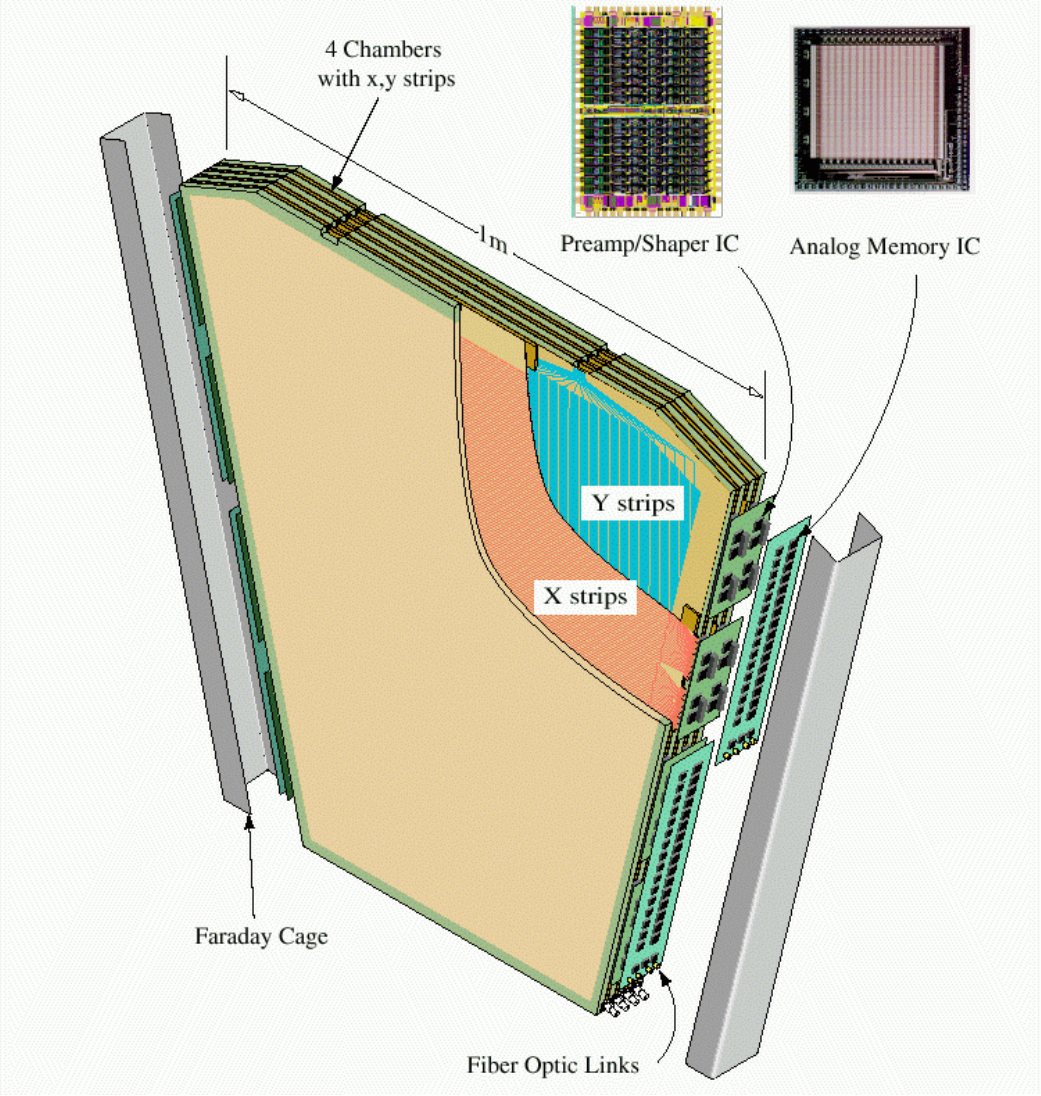
Design	Production
Signal HH Card	100 % US
Endcap HV HH Card	(Italy)
Mezzanine Card	100 % ATLAS
CSM	100 % US

CSM Mother Card receives CSM



Signal HH and Mezz cards w/o FC

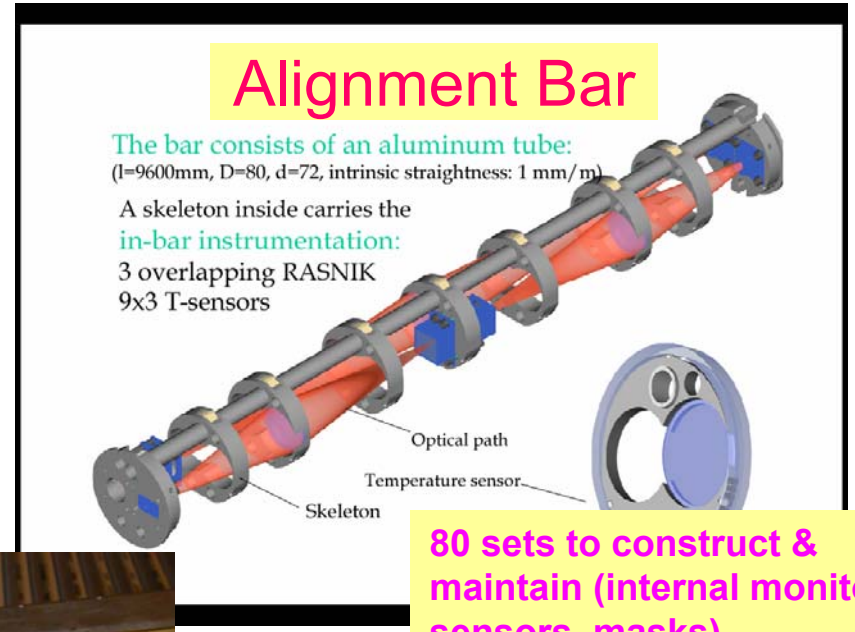
CSC Electronics Deliverables



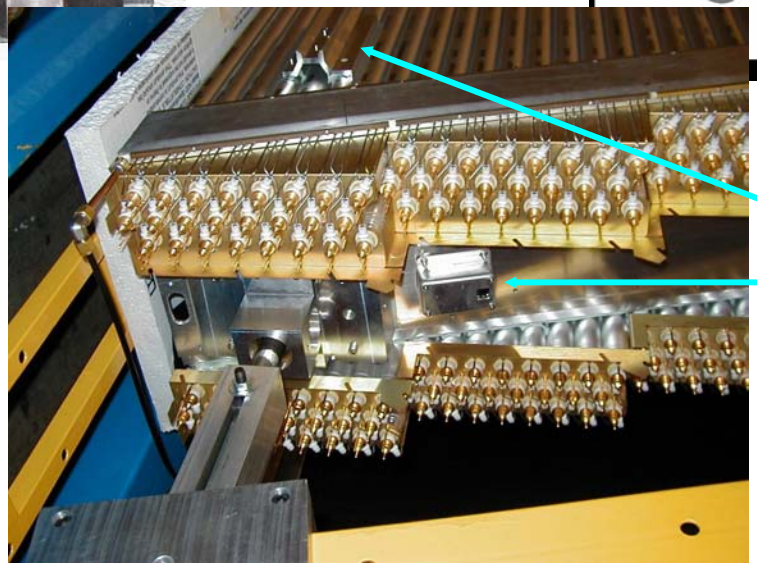
Design	Production
Front-End	100 % ATLAS
RoD	100 % ATLAS
32 Chambers	
30k Channels (X and Y strips)	

Alignment System Deliverables

800 elements to construct & maintain



80 sets to construct & maintain (internal monitors, sensors, masks)



On-chamber components

Global alignment telescopes

In-plane RASNIKs

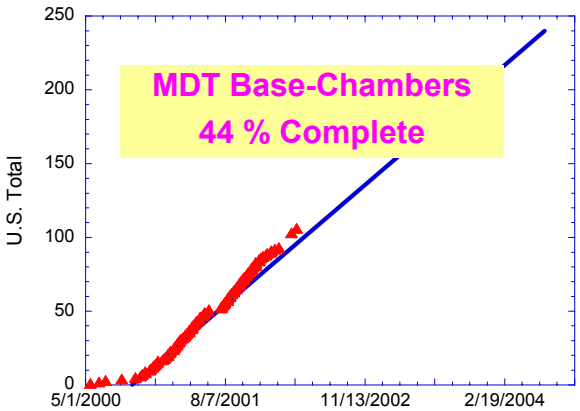
US Responsibilities (Brandeis)

100 % EI & EM Components

Design of complete EC System

Chamber Technical Status

- **Chamber Production:**
  - MDT base-chamber on schedule
    - Series 1, 2 completed at all sites
    - Series 3 in production @ UoM & UoW & BMC
    - Critical parts delivered ahead of need
  - CSC 4 / 32 ~ 12.5 % complete
    - Delivery of production parts expected 1-Apr-02
    - Internal button needed to improve cathode planarity



- **MDT Electronics Common European Procurement:**
  - HV & Signal Hedgehogs expected April '02
    - HH will allow Step II Service Installation to start (HV dark current)
  - Mezzanine cards still in development but with working prototypes
- **On-chamber alignment components ahead of critical path:**
  - Drawings and parts supplied by Brandeis

Details of MDT Production

				Boston Muon Consortium					
Sequence	Chamber Type	Tubes	Tubes Built	Tube Percentage	Chambers	Chambers Built	Chambers Percentage	Chambers FC & Gas	Chambers @ CERN
1	EIL1	4608	4608	100.0%	16	16	100.0%		
2	EIS1	5376	5376	100.0%	16	16	100.0%	10	1
3	EIS2	4608	1586	34.4%	16				
4	EMS1	6144			16				
5	EIL2-3	6144			16				
Totals		26880	11570	43.0%	80	32	40.0%	10	1
				University of Michigan					
Sequence	Chamber Type	Tubes	Tubes Built	Tube Percentage	Chambers	Chambers Built	Chambers Percentage	Chambers FC & Gas	Chambers @ CERN
1	EMS5	6144	6144	100.0%	16	16	100.0%	1	15
2	EMS4	6144	6144	100.0%	16	16	100.0%	16	11
3	EML3	6144	3606	58.7%	16	5	31.3%	5	1
4	EML4	6144			16				
5	EML5	6144			16				
Totals		30720	15894	51.7%	80	37	46.3%	22	27
				University of Washington					
Sequence	Chamber Type	Tubes	Tubes Built	Tube Percentage	Chambers	Chambers Built	Chambers Percentage	Chambers FC & Gas	Chambers @ CERN
1	EML2	6144	6144	100.0%	16	16	100.0%	16	3
2	EMS2	6144	6144	100.0%	16	16	100.0%	13	6
3	EMS3	6144	2429	39.5%	16	5	31.3%	1	
4	EML1	5376			16				
5	EIL4	5376			16				
Totals		29184	14717	50.4%	80	37	46.3%	30	9
US Totals	15	86784	42181	48.6%	240	106	44.2%	62	37

M&O Plan Follows US Deliverables

- MDT Chambers $1<|\eta|<2$
  - 240 chambers – EI and EM series
  - Electronics for 240 chambers
  - Kinematic mounts and support struts for 240 chambers
- Cathode Strip Chambers $2<|\eta|<2.7$
  - 32 CSCs deployed in both endcaps
  - Electronics for CSC readout
  - Kinematic mounts for 32 CSCs
- Alignment for Endcap Chambers $1<|\eta|<2.7$
  - Alignment bar instrumentation (image sensors, thermistors)
  - Proximity & Multipoint systems (cameras, masks, BCAMs)
  - Inplane alignment kits (installed on MDT chambers)

Organization of Muon M&O

- WBS 3.5.1 – MDT
- WBS 3.5.2 – CSC
- WBS 3.5.3 – Alignment
- WBS 3.5.4 – Common Costs
- WBS 3.5.5 – Monitoring & Calibration

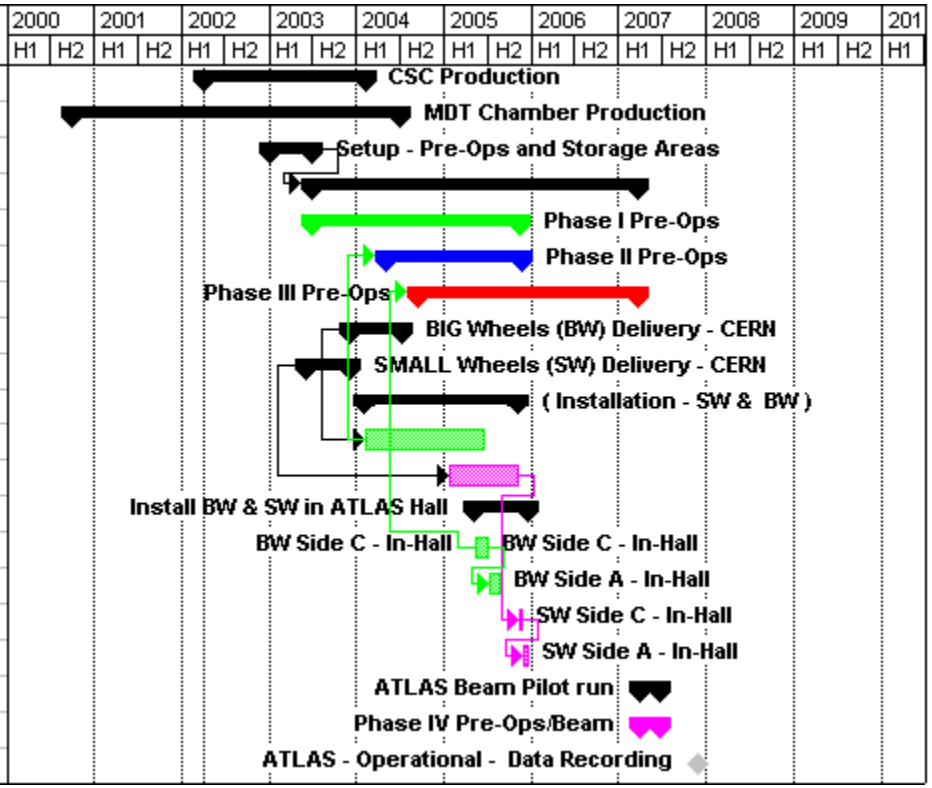
Includes:

Pre-operations, maintenance & operations

U.S. ATLAS

Schedule of Muon Pre-Operations

ID	Task Name	Start
1	CSC Production	Mon 4/1/02
2	MDT Chamber Production	Mon 10/2/00
3	Setup - Pre-Ops and Storage Areas	Thu 1/2/03
4	Chamber Pre-operations at CERN	**Fri 6/27/03**
5	Phase I Pre-Ops	**Fri 6/27/03**
37	Phase II Pre-Ops	Mon 5/3/04
38	Phase III Pre-Ops	Mon 9/13/04
39	BIG Wheels (BW) Delivery - CERN	Mon 12/1/03
40	SMALL Wheels (SW) Delivery - CERN	Mon 6/2/03
41	(Installation - SW & BW)	**Thu 2/5/04**
42	[Install on BW (EML/EMS) - Surface]	Thu 2/5/04
43	[Install on SW (EIS/EIL) - Surface]	Thu 1/20/05
44	Install BW & SW in ATLAS Hall	**Wed 5/4/05**
45	BW Side C - In-Hall	Wed 5/4/05
46	BW Side A - In-Hall	Thu 6/30/05
47	SW Side C - In-Hall	Mon 11/7/05
48	SW Side A - In-Hall	Fri 11/25/05
49	ATLAS Beam Pilot run	**Mon 4/2/07**
50	Phase IV Pre-Ops/Beam	Mon 4/2/07
51	ATLAS - Operational - Data Recording	Sat 12/1/07



Phases of Pre-operations

- **Phase – I**
  - Work performed on chambers & global alignment @ CERN prior to installation on support structures

Installation of Chambers & Alignment on SW and BW sectors

- **Phase – II**
  - Pre-operations of chambers and alignment DAQ on support structures above pit

Support Structures lowered to pit and installed

- **Phase – III**
  - Pre-operation of chambers and alignment elements in pit

Beam (2006)

- **Phase – IV**
  - Pre-operation of muon system with first beam

Method of Estimate

- Estimated Labor & Materials for Each Phase
  - Setup staging and pre-operations areas
    - Chambers & Alignment Components Test Stations
      - Setup work benches, gas distribution, electronics
        - CSCs 1 T-Stations, MDT 2 T-Stations, Alignment T-Station
        - Technical and Engineering (ME & EE) Support
  - Phase I Certify chambers & alignment ready to install
    - Technical Support + M&S to operate 4 tests stations
  - Phase II Chambers operational on support structures
    - Technical Support to work on SSs above pit
      - Pre-Ops Chambers & alignment components on 18 structures
  - Phase III System operational in pit
    - Technical Support to work on BW-(A,C), SW-(A,C) in pit
  - Phase IV
    - Technical Support for pre-operations first beam
- Travel: $2.5 k/1wk @ CERN, $30k/FTE/yr living

Muon Staging Areas @ CERN

- **ISR-3 tunnel - EI/BI MDTs**
  - Space: 700 m^2; crane hook 4.5m, availability limited (shared with CMS)
  - All EI/BI chambers are delivered and stored there until their installation
- **Hall 188-2 or 182* - CSCs** (* not yet allocated to muons)
  - Space required: 100 m^2 storage + 50 m^2 work
  - Close to building 191 (assembly on Small Wheels)
- **Hall 191* - Small Wheel (SW)** (* not yet allocated to muons)
  - Assembly of SW structure: 300 m^2
  - Installation of MDTs on SW: 200 m^2
  - Installation of TGCs on JD (shield disk)
  - Integration of JD + SW

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NOTE Hall Assignments are not FINAL

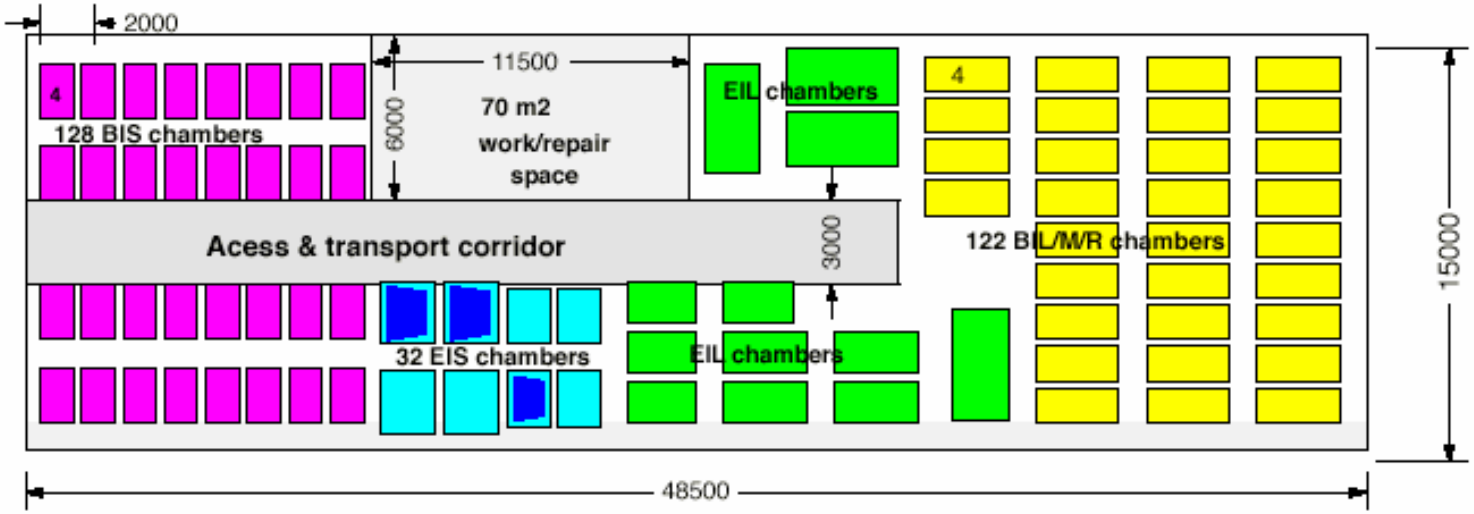
- **180* (West Hall) - BW + MDTs** (* not yet allocated to muons)
  - 400 m^2 for assembly of sectors 300 m^2 for storage of sectors 1–16
  - 300 m^2 for storage of sectors 16–32
  - Storage of assembled TGC BWs: 600 m^2

Staging Area for EI Chambers

Total area ISR-2/3: 730 m2

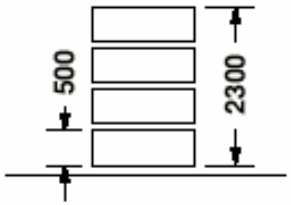
J. W. ASSO Review
CERN 12/01

BIS/L/R:
BIS: 128 x (2000 x 2000 mm2); stored in 4 layers => 150 m2
BIL/M/R: 122 x (3200 x 2000 mm2); stored in 4 layers => 200 m2



EIS (MDTs)
32 x (2000 x 3000 mm2); stored in 4 layers => 50 m2

EIL (MDTs)
16 x (1800 x 3500 mm2); stored in 4 layers => 25 m2
16 x (1800 x 4000 mm2); stored in 4 layers => 30 m2
22 x (2000 x 5000 mm2); stored in 4 layers => 60 m2



Assembly of BW Sectors

LEP/LHC point 4 (SX-4)

Or Hall 180 for MDT

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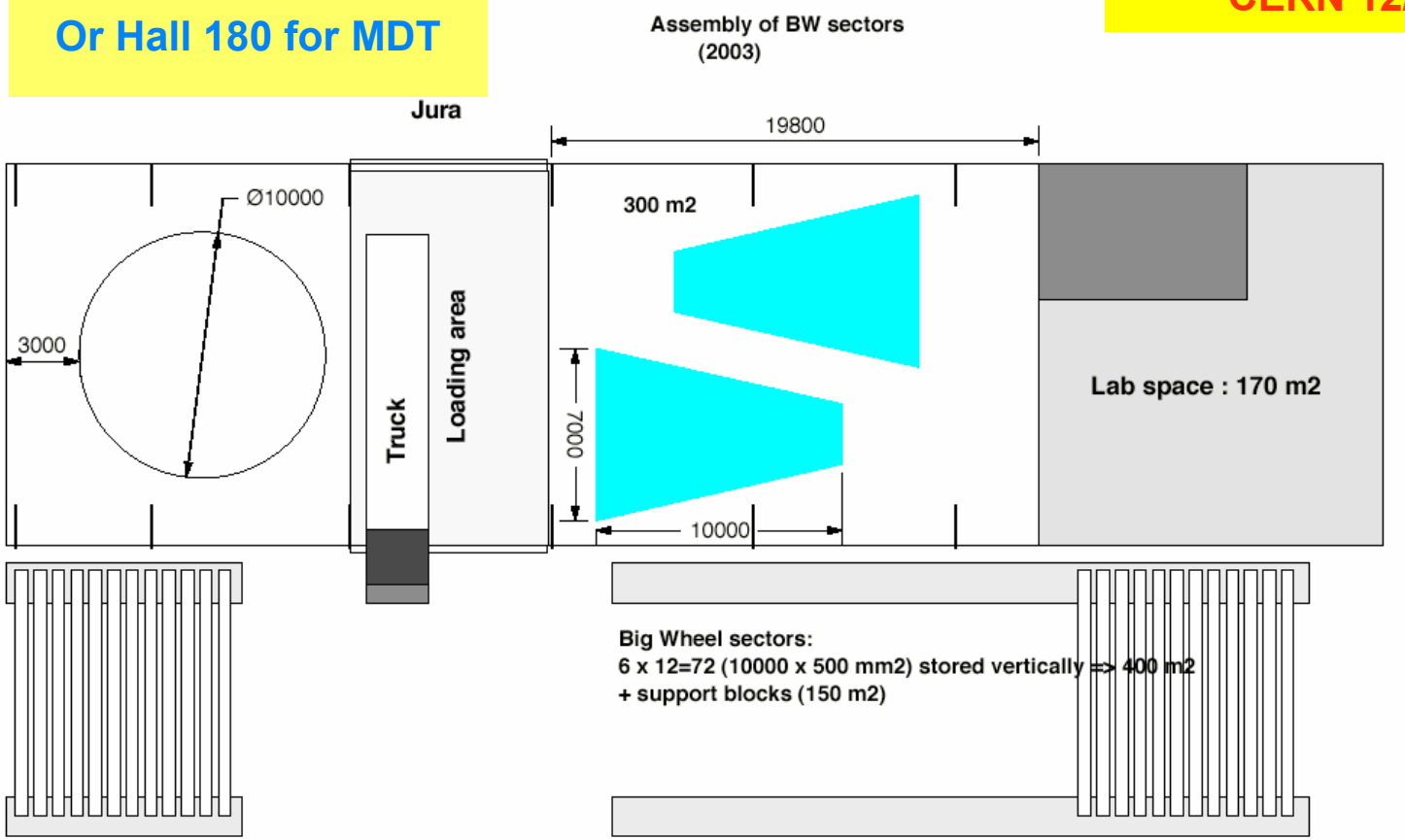
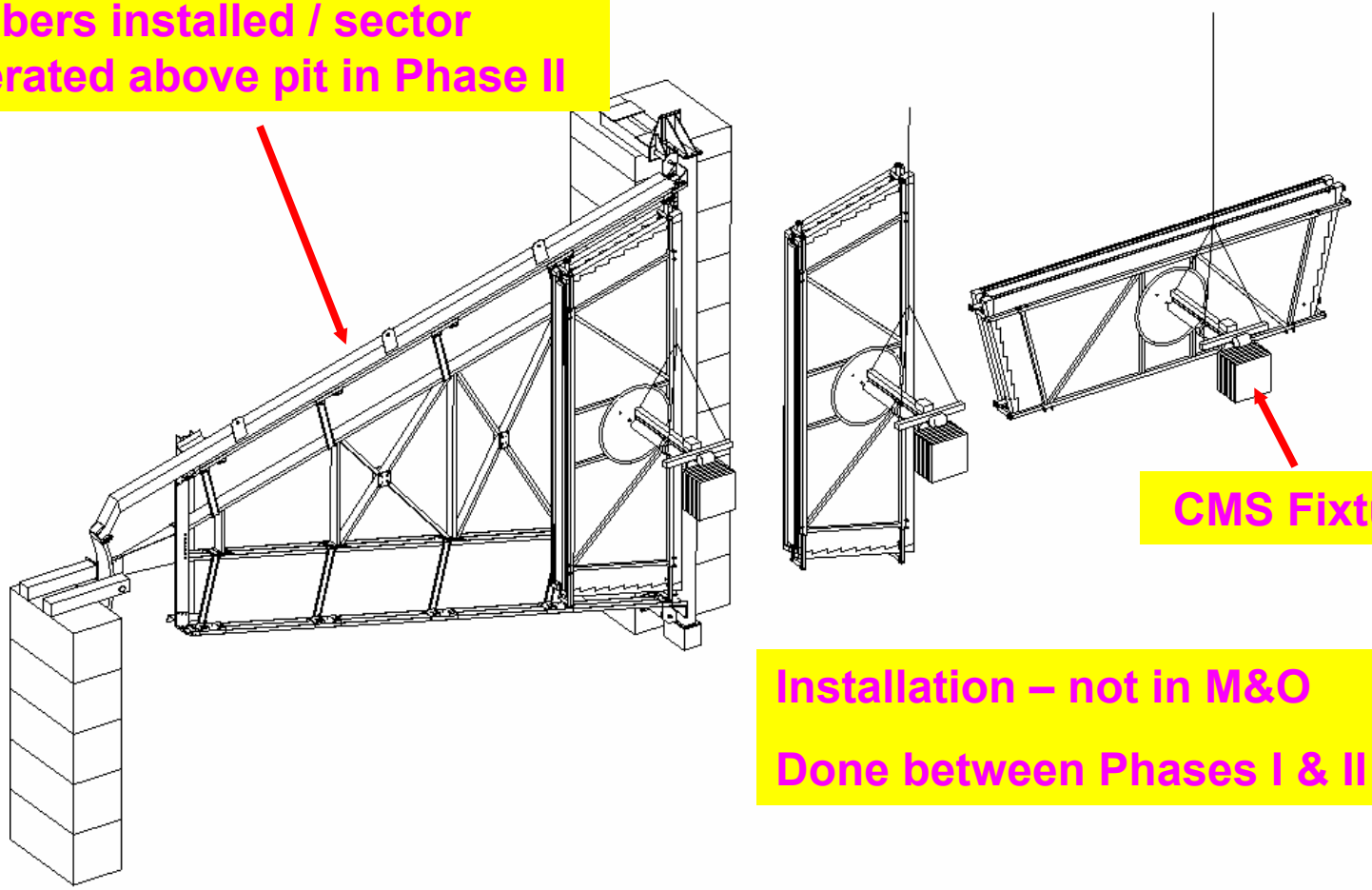


Installation of MDT on BW Sectors

Big Wheel Sector:

5 Chambers installed / sector
pre-operated above pit in Phase II



Installation – not in M&O

Done between Phases I & II

Installation of TGC & EM Chambers on BW Sectors

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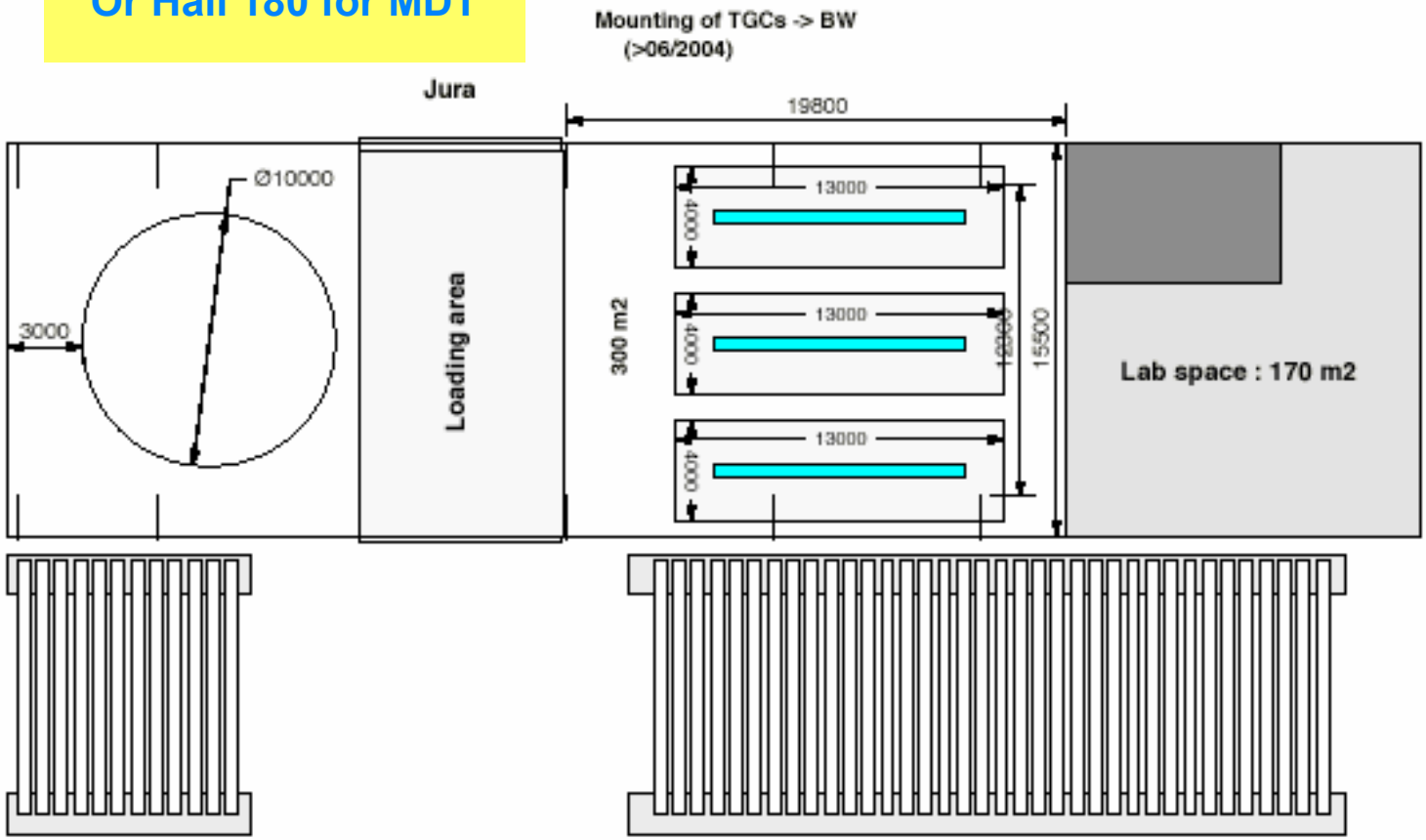
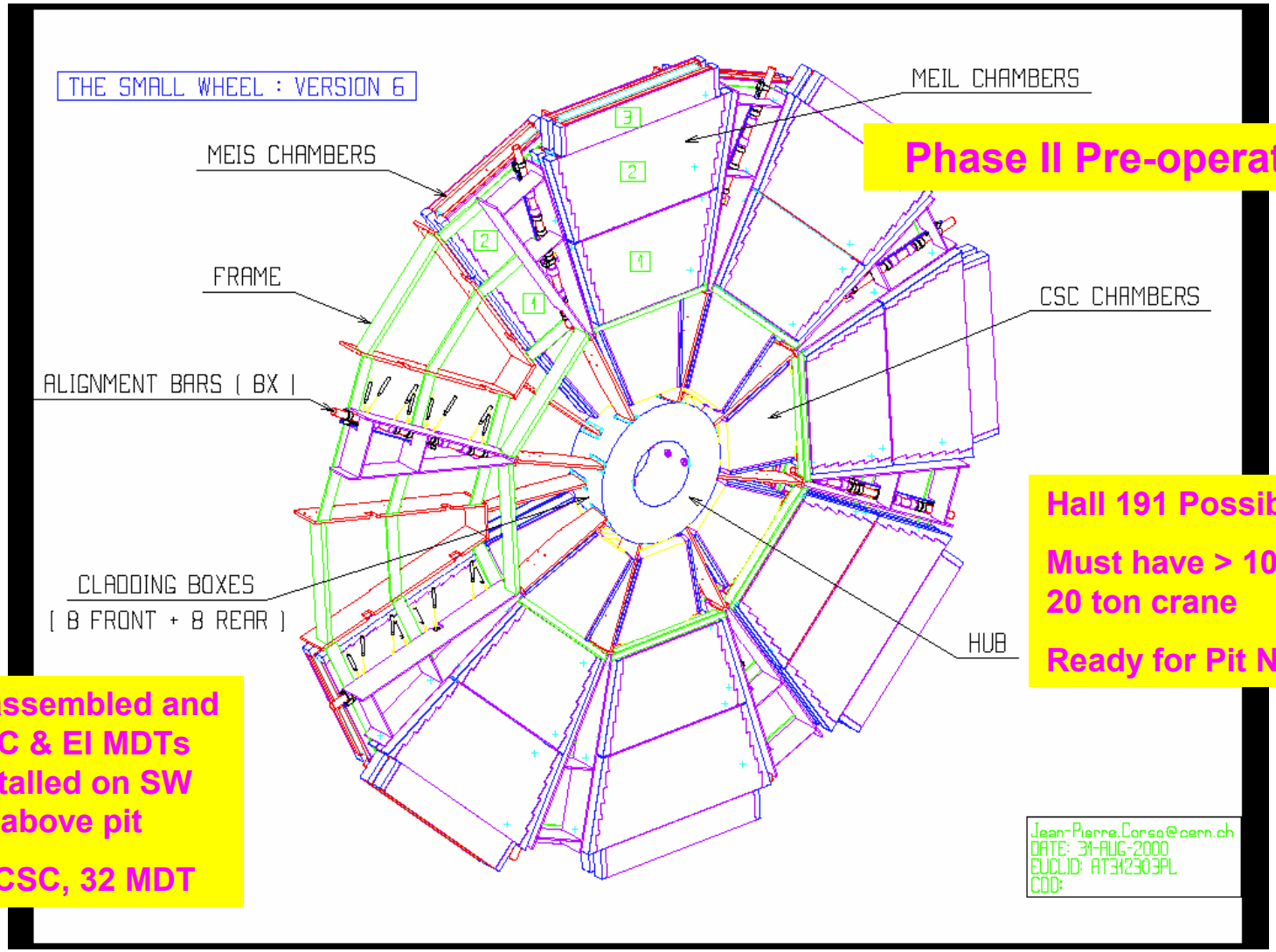
CERN 12/01

LEP/LHC point 4 (SX-4)

Or Hall 180 for MDT



Small Wheel above Pit



Phase II Pre-operations

Hall 191 Possible

Must have > 10 m under 20 ton crane

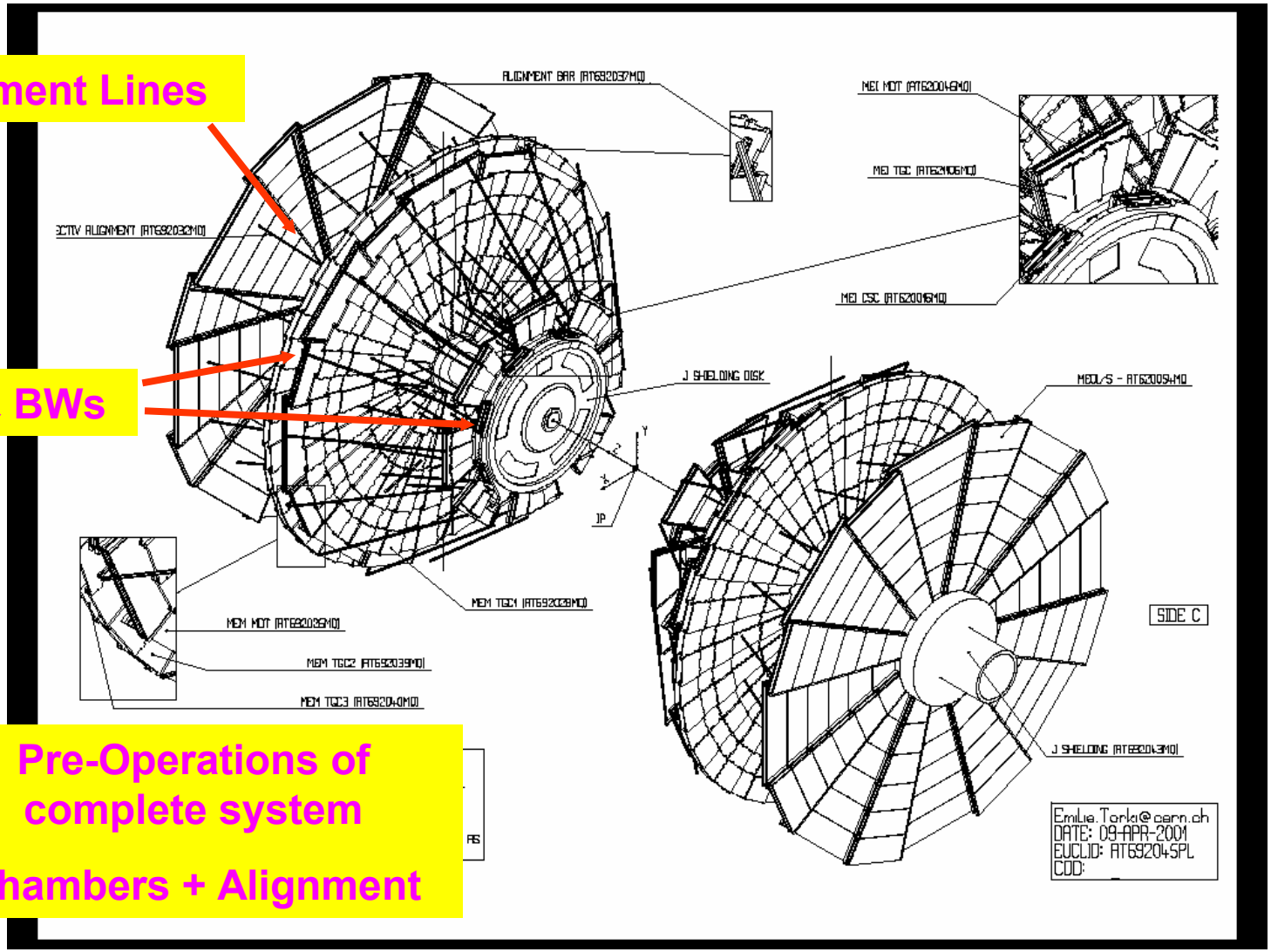
Ready for Pit Nov-05

SW assembled and CSC & EI MDTs installed on SW above pit

16 CSC, 32 MDT

Endcap Chamber Support Structure
H8 - CERN Mockup

Phase III in Cavern



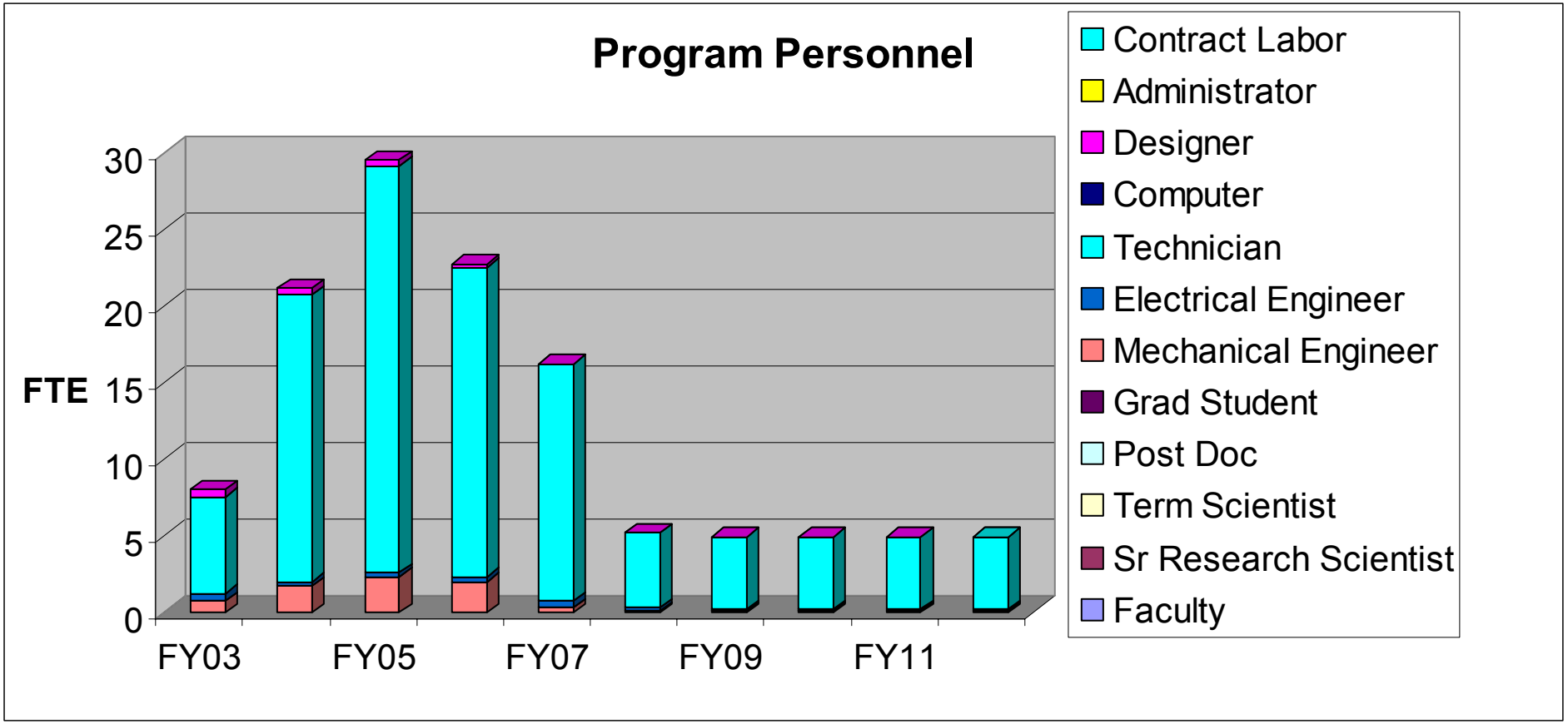
Alignment Lines

SW & BWs

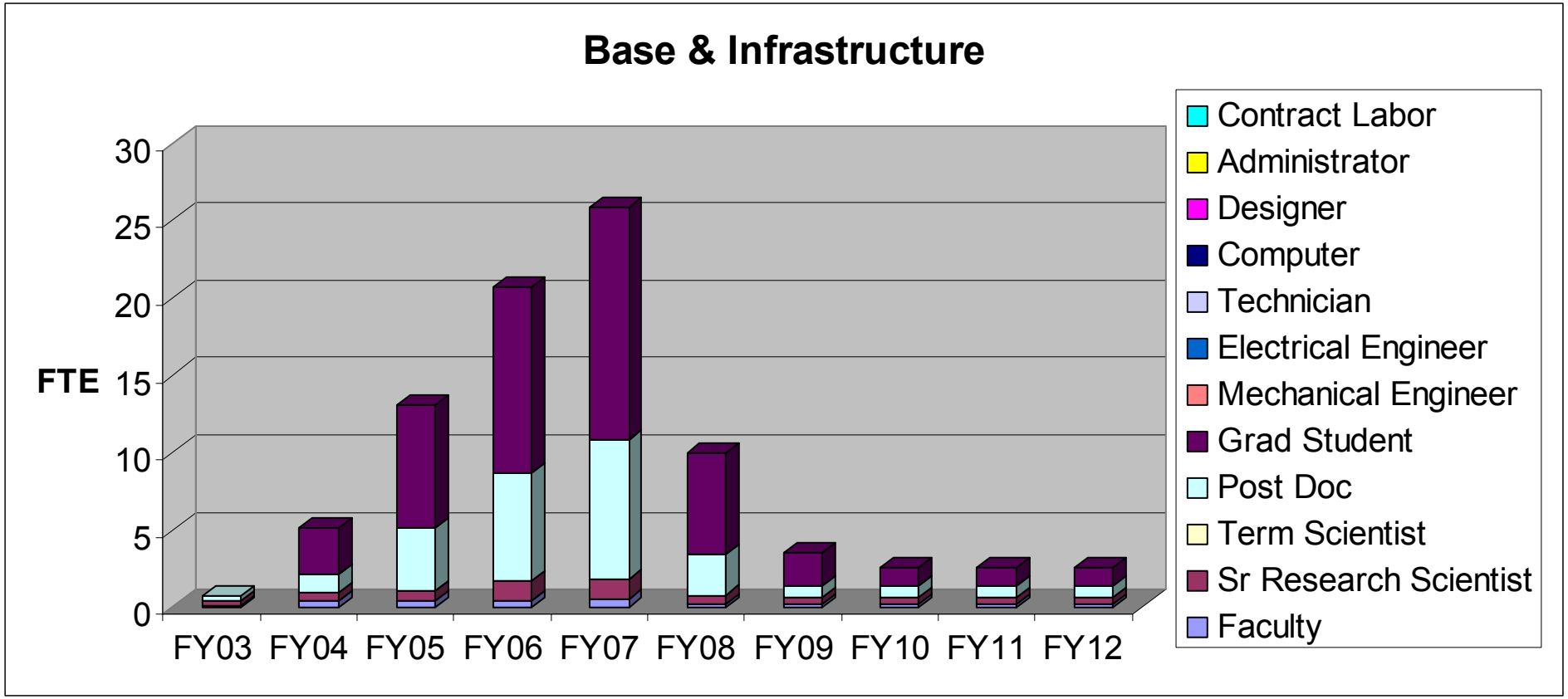
Pre-Operations of complete system

Chambers + Alignment

Program Labor Summary



Research Program Labor Summary



SPARES

- Electronic spares purchased on project funds
  - HV and Signal HH cards – European purchase 5 % & 10%
  - Mezzanine cards – US procurement for B&EC ATLAS 5%
  - CSC on-chamber electronics 10 % spare boards
  - Funds in program for further spares if needed
- MDT Chambers – if chamber destroyed
  - Tubes for the largest US MDT chamber (EML5) are being purchased (0.42 % spare on the chamber level). In addition 2.5% spares of all lengths were purchased for the build cycle. Not all will be used.
  - Endplug spares will come out of 'MPI' stock ~ 1.7 %. We also purchased 2.5% spares for the build cycle – not all will be used.

U.S. ATLAS M&O Estimate
Endcap MUON WBS Level 4 Profile

Funding Source: All | Funding Type: Program | 4/3/02 8:25:20 AM

Institutions: All | Labor/Material: Both

WBS Number	Description	FY 03 (k$)	FY 04 (k$)	FY 05 (k$)	FY 06 (k$)	FY 07 (k$)	FY 08 (k$)	FY 09 (k$)	FY 10 (k$)	FY 11 (k$)	FY 12 (k$)
3	U.S. ATLAS M&O Estimate	809	1823	2495	2124	1657	610	595	595	595	595
3.5	ATLAS Endcap Muon M&O	809	1823	2495	2124	1657	610	595	595	595	595
3.5.1	MDT Operations and Maintenance	519	1208	1701	989	981	277	277	277	277	277
3.5.1.1	MDT Pre-operations, Operations an	519	1208	1701	982	974	270	270	270	270	270
3.5.1.2	MDT Spares - Mechanical and Elect	0	0	0	7	7	7	7	7	7	7
3.5.2	CSC Operations and Maintenance	80	181	197	346	329	64	49	49	49	49
3.5.2.1	CSC Pre-operations, Operations an	80	181	197	346	329	58	43	43	43	43
3.5.2.2	CSC Spares - Electrical and Mecha	0	0	0	0	0	6	6	6	6	6
3.5.3	Alignment System	29	116	248	233	62	46	46	46	46	46
3.5.3.1	Alignment System Pre-operations	29	116	248	233	62	0	0	0	0	0
3.5.3.2	Alignment System Operation (Bea	0	0	0	0	0	9	9	9	9	9
3.5.3.3	Alignment System Maintenance (Be	0	0	0	0	0	37	37	37	37	37
3.5.4	Muon Endcap Common Costs	128	266	332	506	240	166	166	166	166	166
3.5.4.1	Pre-Operation Engineering of Endc	92	167	200	189	0	0	0	0	0	0
3.5.4.2	Muon Endcap Common Cost Opera	36	36	69	236	240	166	166	166	166	166
3.5.4.3	Access to Muon Endcap System	0	63	63	81	0	0	0	0	0	0
3.5.5	Monitoring & Calibration	52	52	18	50	45	57	57	57	57	57
3.5.5.1	Pre-operations of Monitoring and	52	52	18	50	41	0	0	0	0	0
3.5.5.2	Operation of M&C Systems (Beam	0	0	0	0	0	25	25	25	25	25
3.5.5.3	Maintenance of M&C (Beam Off)	0	0	0	0	4	33	32	32	32	32

WBS M&O Dictionary
Endcap MUON Level 2 Summary

U.S. ATLAS M&O Estimate
WBS Dictionary

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3.5

WBS Number	Description
3.5	**ATLAS Endcap Muon M&O**

Cost of labor and materials needed to operate and maintain the US deliverables of the ATLAS Muon system. The work is broken down into each technology - Monitored Drift Tube and Cathode Strip Chambers - Electrical and Mechanical, Alignment System and Common Costs.

There are several phases of pre-operations in the WBS that apply to MDT, CSC Mechanical and Electrical Work as well as the Alignment System Work. The prefix 'pre' corresponds to 'before beam'.

Phase - I of pre-operations covers work to first operate the chambers and alignment components after shipment to CERN but prior to their installation on the support structures.

Phase - II of pre-operations is the work performed on the chambers and alignment components following their installation on the support structures (small wheels and big wheel octant sectors) before the support structures are lowered in the pit.

Phase - III is pre-operations work performed on chambers and alignment systems following the wheel installations in the ATLAS cavern. It is assumed that there will have to be at least 4 crews working - one for each wheel for the MDT pre-operations. Further, some estimate was made for the innate difficulty of working in the pit from competition for space and access. It is during Phase III that the alignment system finally comes together. Phase III includes surface pre-work prior to wheel installations in cavern.

Phase - IV is pre-operation of the systems with the first beam but prior to the steady operations of data collection.

Common Costs cover the costs of services. Included are costs of U.S. contribution to pre-operation engineering as well as consumables (gas and electrical power). Also included in the Common Costs is a contribution to funds needed access to chambers and alignment components.

Monitoring & Calibration includes cost to maintain the M&C systems - such as B and T sensors. This WBS includes muon test beam costs.

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M&O Funding Crisis FY03-04

- Consequence of no Funding FY03-04
  - FY03 – no funds
    - Would not be able to set up staging area at CERN
    - Increases risk to commissioning in FY04
  - FY04 – no funds
    - Would not be able to meet chamber commissioning schedule

Conclusions - Muon System

- Chamber production:
  - MDT 106 complete & 62 with gas & FC
  - CSC 4 / 32 ~ 12.5 % complete
- MDT production on schedule
  - 3 (4) layer chambers in 7 (9) working days
  - Retooling between series takes ~ 1 month
- MDT electronics working prototypes
  - Another design iteration needed for Mezzanine card
  - Hedgehogs expected April ’02
- ATLAS Endcap Large & Complex System
  - M&O Resources loaded for pre-operations Phases I-III
  - Geography @ CERN needs further definition