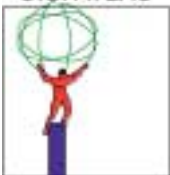


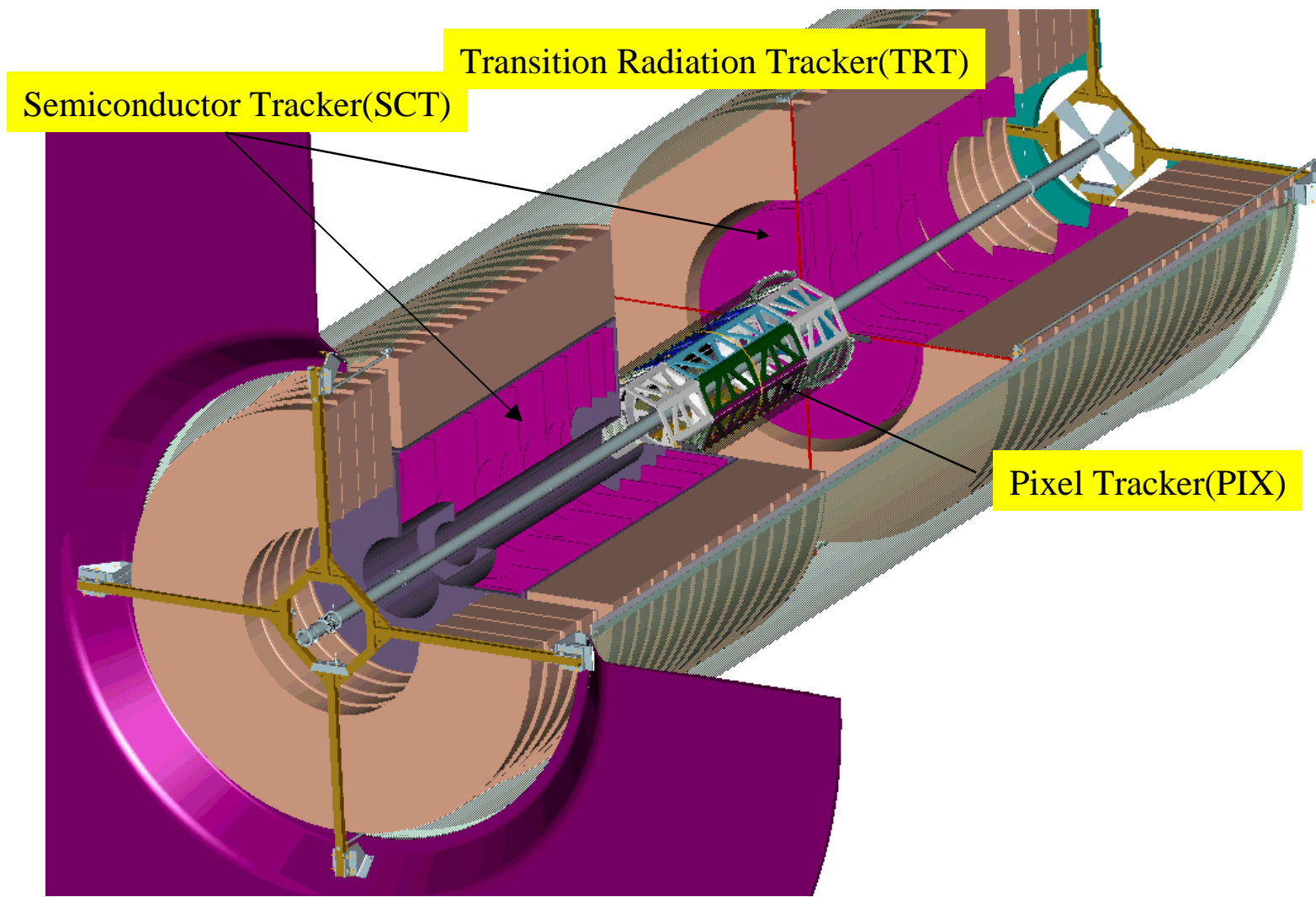
# **WBS 1.1.1 Pixel Overview and WBS 1.1.1.1 Pixel Mechanics**

**M. G. D. Gilchriese**

**Lawrence Berkeley Laboratory**



# ATLAS Pixel System



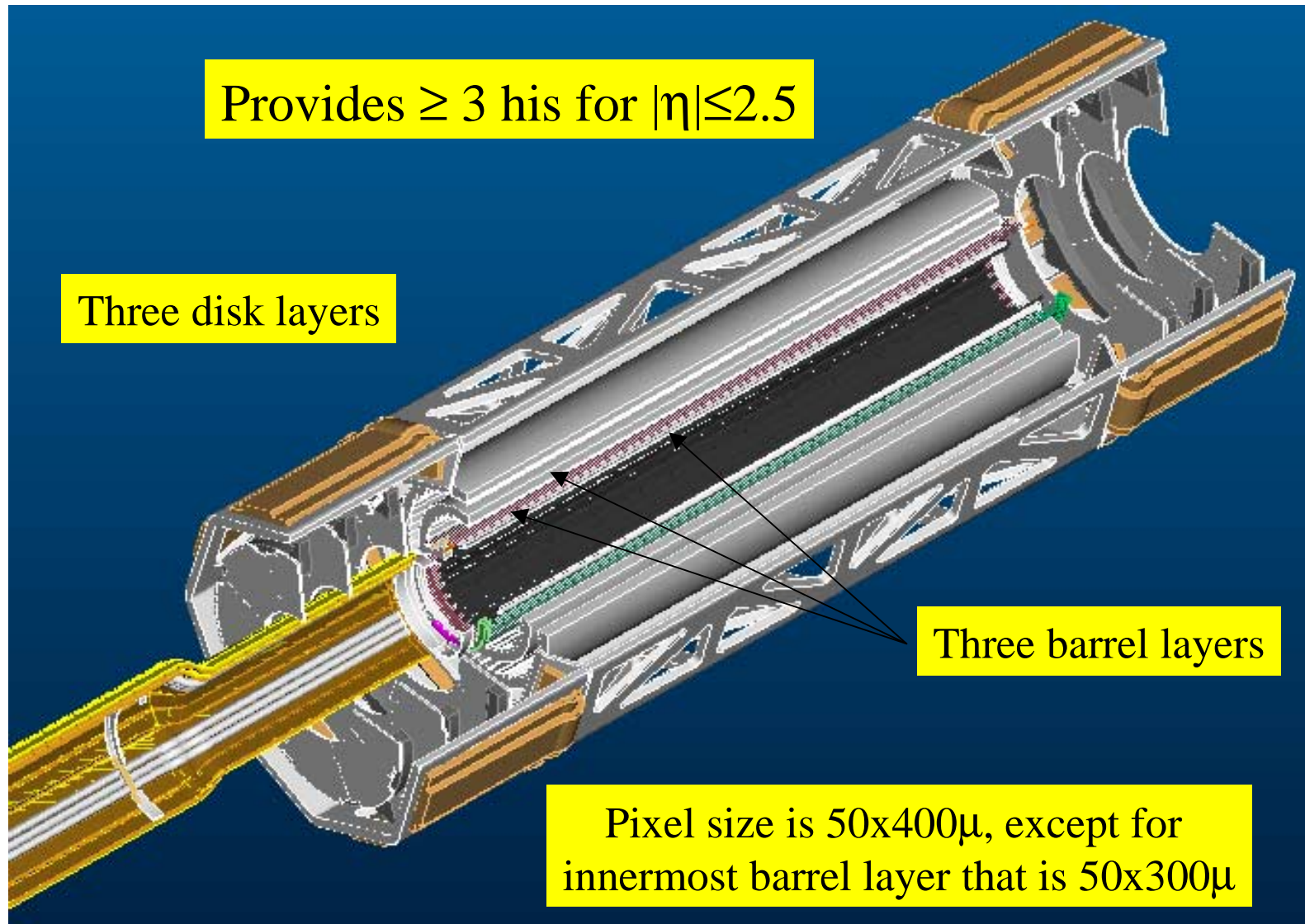


# Overview

- **Pixel system in ATLAS**
  - ◆ Provides critical pattern recognition
  - ◆ Determines ability to find secondary vertices eg. for identifying b-quarks
  - ◆ Part of Level 2 trigger
- **Countries involved are Canada, Czech Republic, France, Germany, Italy and US.**
- **The US is roughly 20% of the project.**



# ATLAS Pixel Baseline





# US Pixel Baseline Scope

- The US baseline scope corresponds to a 2-hit system.
- The innermost(B-layer) and outermost barrel layers are retained.
- 2x2 disks are retained.
- This corresponds to the current concept for the ATLAS initial detector
- Upgrade path to full 3-hit system



# Pixel Parameters

Barrel						Active	Tilt
	<u>Radius(mm)</u>	<u>Staves</u>	<u>Modules</u>	<u>Chips</u>	<u>Channels</u>	<u>Area(m<sup>2</sup>)</u>	<u>Angle(°)</u>
B-layer	50.5	22	286	4576	1.76E+07	0.28	-20
Layer 1	88.5	38	494	7904	3.04E+07	0.48	-20
Layer 2	122.5	52	676	10816	4.15E+07	0.65	-20
Subtotal(3 hits)		112	1456	23296	8.95E+07	1.41	
Subtotal(2 hits)		74	962	15392	5.91E+07	0.93	
Disks							
	Inner	Outer				Active	
<u>Z(m)</u>	<u>Radius(mm)</u>	<u>Radius(mm)</u>	<u>Modules</u>	<u>Chips</u>	<u>Channels</u>	<u>Area(m<sup>2</sup>)</u>	<u>Sectors</u>
495	88.1	148.9	48	768	2.21E+06	0.04	8
580	88.1	148.9	48	768	2.21E+06	0.04	8
650	88.1	148.9	48	768	2.21E+06	0.04	8
Subtotal(Both Sides - 3 hits)			288	4608	1.33E+07	0.27	48
Subtotal(Both Sides - 2 hits)			192	3072	8.85E+06	0.18	32
GRAND TOTALS(3 hits)			1744	27904	1.0E+08	1.68	
GRAND TOTALS(2 hits)			1154	18464	6.8E+07	1.11	



# US Institutions and Management

	<u>ALB</u>	<u>LBL</u>	<u>UNM</u>	<u>UOK</u>	<u>OSU</u>
<b>1.1.1 Pixels(Gilchriese)</b>					
<b>1.1.1.1 Mechanics(Gilchriese, Anderssen)</b>		X	X		
<b>1.1.1.2 Sensors(Seidel, Hoferkamp)</b>			X	X	
<b>1.1.1.3 Electronics(Einsweiler, Denes)</b>		X			X
<b>1.1.1.4 Hybrids(Skubic, Boyd, Gan)</b>	X	X		X	X
<b>1.1.1.5 Modules(Garcia-Sciveres, Goozen)</b>		X	X	X	X
<b>1.1.1.6 Test Support(Gilchriese)</b>		X			

(Physicist, Engineer)

SUNY Albany, LBL, New Mexico, Oklahoma, Ohio State

In addition, off-detector electronics(ReadOut Drivers for both pixels and SCT) are separate project(Wisconsin, Iowa State and LBL).

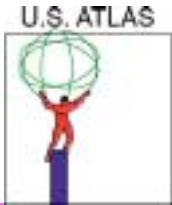


# 2-Hit System - US Deliverables<sup>1</sup>

- **Mechanics(1.1.1.1)**
  - ◆ Support tube and plugs at end of support tube
  - ◆ Overall pixel support structure(frame)
  - ◆ Disks
  - ◆ Coolant pipes(shared with Europe)
  - ◆ Power and other cables(shared with Europe)
  - ◆ Tooling for final assembly of system(shared with Europe)
- **Sensors(1.1.1.2)**
  - ◆ About 20% of production procurement and testing
- **Electronics(1.1.1.3)**
  - ◆ About 20% production procurement, 50% of testing of front-end ICs
  - ◆ About 50% production procurement and testing of optical ICs
  - ◆ Common test systems for all collaboration for front-end ICs, modules
- **Hybrids(1.1.1.4)**
  - ◆ All flex hybrids
  - ◆ Optical components and hybrids for disk region
- **Modules(1.1.1.5)**
  - ◆ Thinning, dicing of FE and die sort
  - ◆ Assemble and test about 25% of modules
- **Test Support(1.1.1.6)**
  - ◆ About 20% of support for system tests and beam tests at CERN

<sup>1</sup>Assumes release of 600K of management contingency





# US Baseline Cost

WBS Number	Description	FY 96 (k\$)	FY 97 (k\$)	FY 98 (k\$)	FY 99 (k\$)	FY 00 (k\$)	FY 01 (k\$)	FY 02 (k\$)	FY 03 (k\$)	FY 04 (k\$)	FY 05 (k\$)	Total (k\$)
1.1.1	<b>Pixels</b>	0	0	0	0	0	1932	1989	2023	408	30	6382
1.1.1.1	<b>Mechanics and Final Assembly</b>	0	0	0	0	0	923	917	1032	177	19	3067
1.1.1.1.1	Design	0	0	0	0	0	571	447	262	83	12	1375
1.1.1.1.2	Development and Prototypes	0	0	0	0	0	152	105	0	0	0	257
1.1.1.1.3	Production	0	0	0	0	0	199	365	770	94	7	1435
1.1.1.2	<b>Sensors</b>	0	0	0	0	0	97	35	0	0	0	133
1.1.1.2.1	Design/Engineering	0	0	0	0	0	35	35	0	0	0	70
1.1.1.2.3	Production	0	0	0	0	0	62	0	0	0	0	62
1.1.1.3	<b>Electronics</b>	0	0	0	0	0	615	621	354	26	0	1616
1.1.1.3.1	Design/Engineering	0	0	0	0	0	381	446	161	0	0	989
1.1.1.3.2	Development and Prototypes	0	0	0	0	0	234	133	0	0	0	367
1.1.1.3.3	Production	0	0	0	0	0	0	42	193	26	0	261
1.1.1.4	<b>Flex Hybrids/Optical Hybrids</b>	0	0	0	0	0	110	138	273	4	0	525
1.1.1.4.1	Design/Engineering	0	0	0	0	0	18	50	9	0	0	77
1.1.1.4.2	Development and Prototypes	0	0	0	0	0	92	62	0	0	0	154
1.1.1.4.3	Production	0	0	0	0	0	0	26	264	4	0	294
1.1.1.5	<b>Module Assembly/Test</b>	0	0	0	0	0	159	244	330	190	0	924
1.1.1.5.1	Design/Engineering	0	0	0	0	0	79	47	0	0	0	126
1.1.1.5.2	Development and Prototypes	0	0	0	0	0	80	135	46	0	0	261
1.1.1.5.3	Production	0	0	0	0	0	0	61	285	190	0	536
1.1.1.6	<b>Beam/System Test Support</b>	0	0	0	0	0	28	33	33	11	11	117
1.1.1.6.1	Test Beam Support	0	0	0	0	0	11	17	17	0	0	45
1.1.1.6.2	System test support	0	0	0	0	0	17	17	17	11	11	72

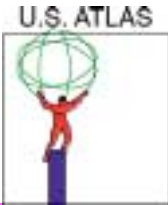


# Management Contingency

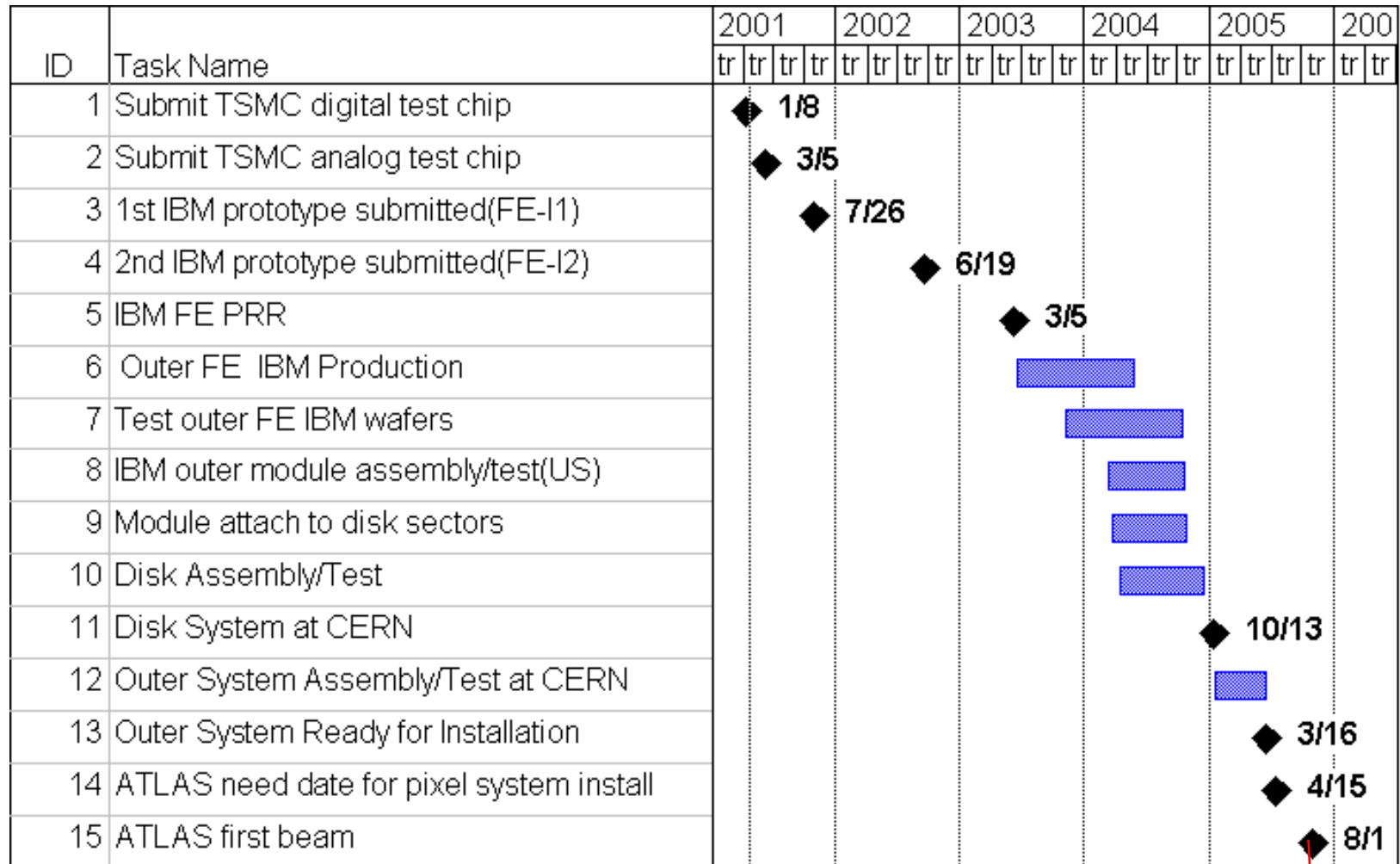
- Management contingency for pixels in two parts.
- High priority(600K)to complete 2-hit system. See below.

WBS	Description	Scope-\$s (FY00 \$s)	Decision Date	FY01	FY02	FY03	FY04
1.1.1.2.3.1.2	Pixels Sensor	92,873	9/30/01		92,873		
1.1.1.2.3.1.3	Pixel Sensor testing (FY02 on)	78,000	7/1/01		39,000	39,000	
1.1.1.4.3.1.1	Bare Flex Hybrid Production	144,075	7/1/02		144,075		
1.1.1.4.3.1.2	Flex Components & Assembly	67,487	7/1/02			67,487	
1.1.1.3.3.1.1.2	FE IBM Production	60,549	3/1/03			60,549	
1.1.1.4.3.3.2	Optical Hybrids	32,621	3/1/03			32,621	
1.1.1.4.3.3.1	Optical Package & Component	13,538	3/1/03			13,538	
1.1.1.3.3.2.1	Optoelectronics Production	26,460	3/1/03			26,460	
1.1.1.3.3.1.2	B-Layer Production	28,345	11/1/03			28,345	
1.1.1.5.3.3	FE IC die sort	58,080	6/1/03			54,000	4,080

- Lower priority - to complete 3 hit system.
- Note all structural mechanics in baseline, so if more money found(even from outside US) chance to complete 3-hit system.



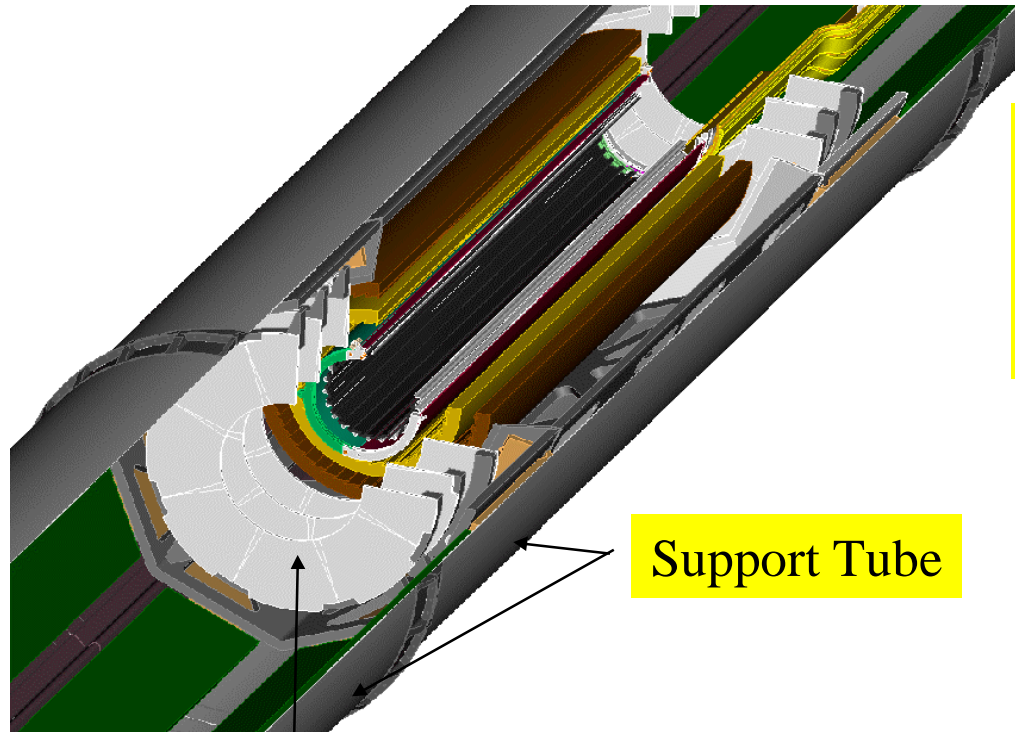
# US Baseline - Critical Path



US Baseline schedule established before recent change to LHC/ATLAS schedule. More float? → 4/06



# Mechanics(1.1.1.1)



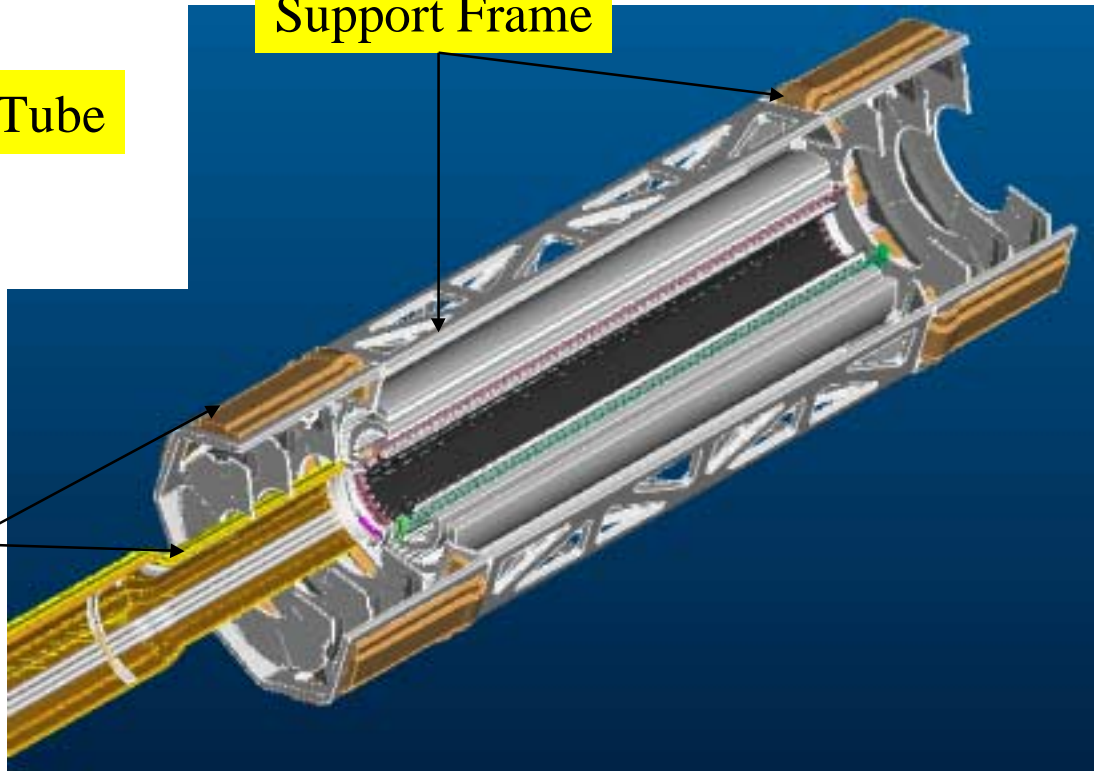
Barrel supporting./cooling structures are European responsibilities. Services and final assembly/installation are shared with US.

Disks

Support Tube

Support Frame

Services



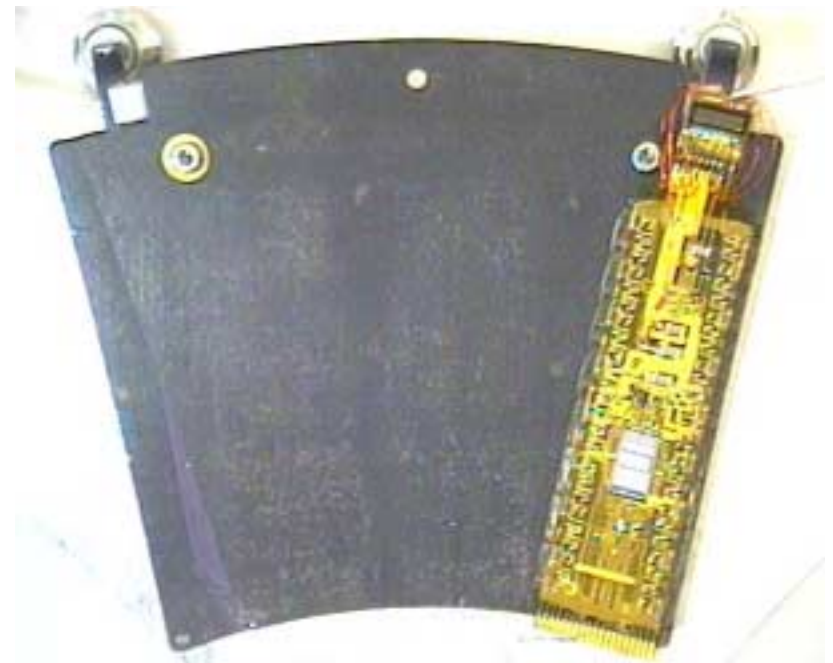


# Disk Structures

- Disks are composed of sectors(8 per disk) that provide mechanical support and cooling and support rings.
- Six modules are mounted on each sector.
- Sectors are attached to disk support ring at outer radius.
- Disk support ring is mounted in support frame.



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DOE/NSF Review of U.S. ATLAS /March 2001



# Baseline Sector Concept

- Combined structural support with cooling.
- Carbon-carbon faceplates. Front and back faceplates offset in phi to provide full coverage (minimal gaps).
- Aluminum coolant tube between faceplates.
- Three precision support points to disk ring.
- Modules mounted on both sides.



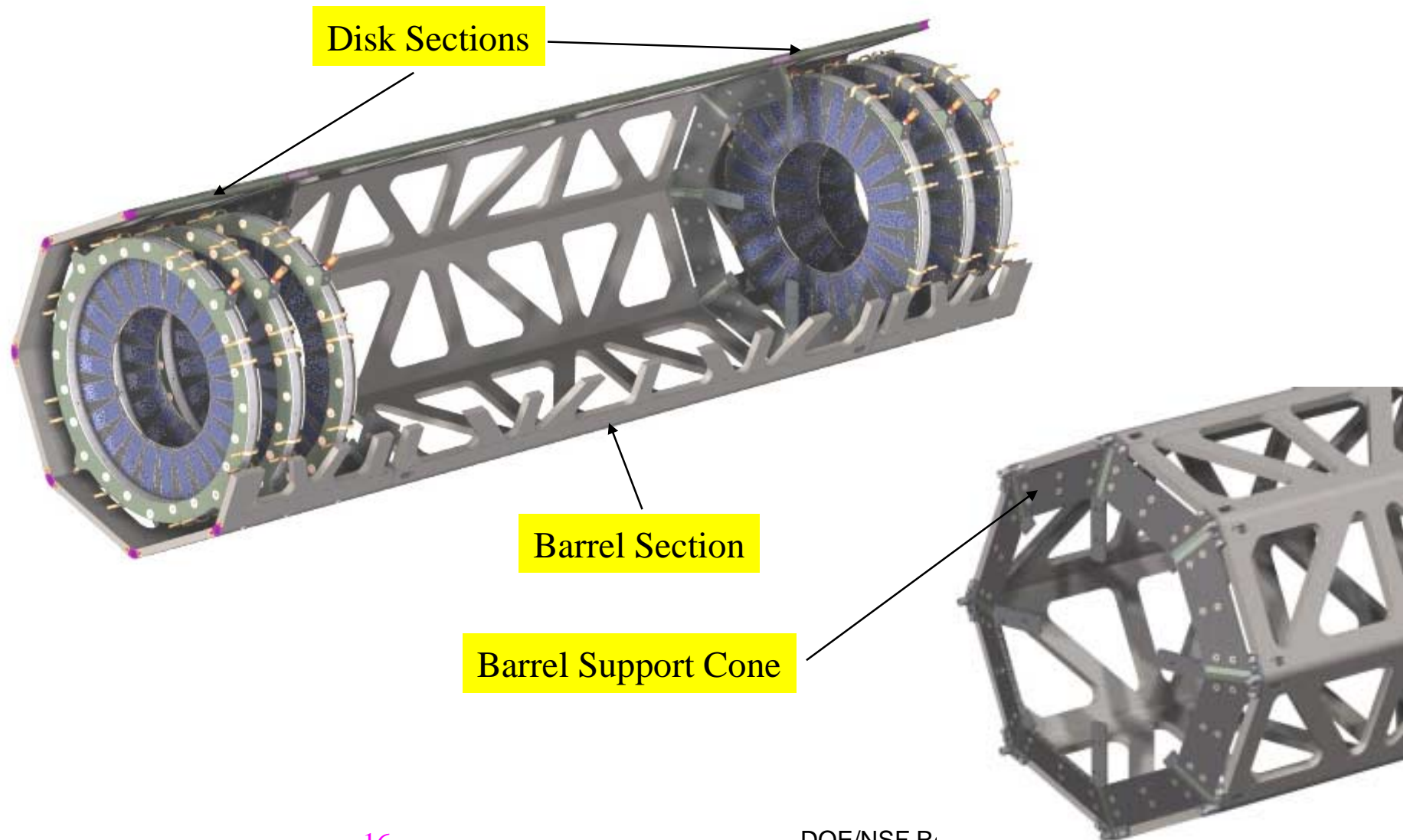


# Disks - Status

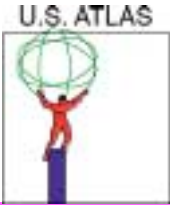
- Two complete mechanical/thermal disks have been made and tested.
- In addition, about one dozen prototypes of sectors along baseline design have been made and tested.
- Baseline design of sectors is under configuration control.
- Final design of support rings is almost complete, but not yet under configuration control. Need to verify mount concept to frame - see next pages.
- Requirements and interface documents for sectors exist and Final Design Review completed.
- Production Readiness Review for sectors(and corresponding barrel element - staves) scheduled for June 19.
- On track to make a preproduction disk(8 sectors + 1 ring) starting in July.
- On or ahead of schedule, costs OK so far but still very early - production ahead.



# Support Frame







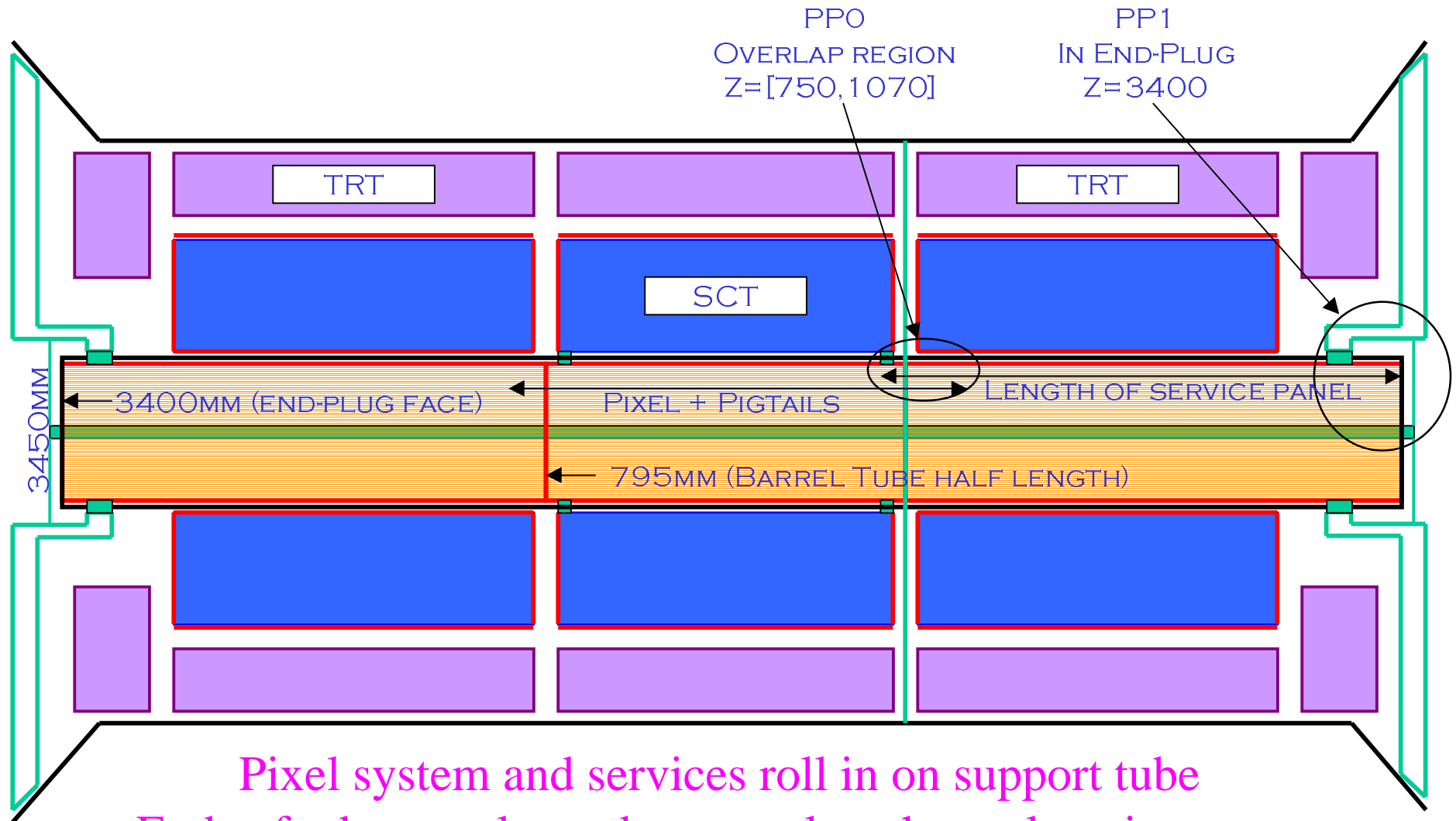
# Support Frame Status

- Full-size disk portion of frame made and tested. Looks good.
- Prototype endcone under construction. Tests complete by July.
- Prototype disk ring mounts made, preliminary tests complete.
- Final location of disks made by drilling in frame. Fixture to do this under fabrication, prototype ring modified to accept prototype mounts, procedure, including insertion, will be tested by Sept.
- Interfaces(to barrel region, services and support tube) now design drivers.





# Support Tube

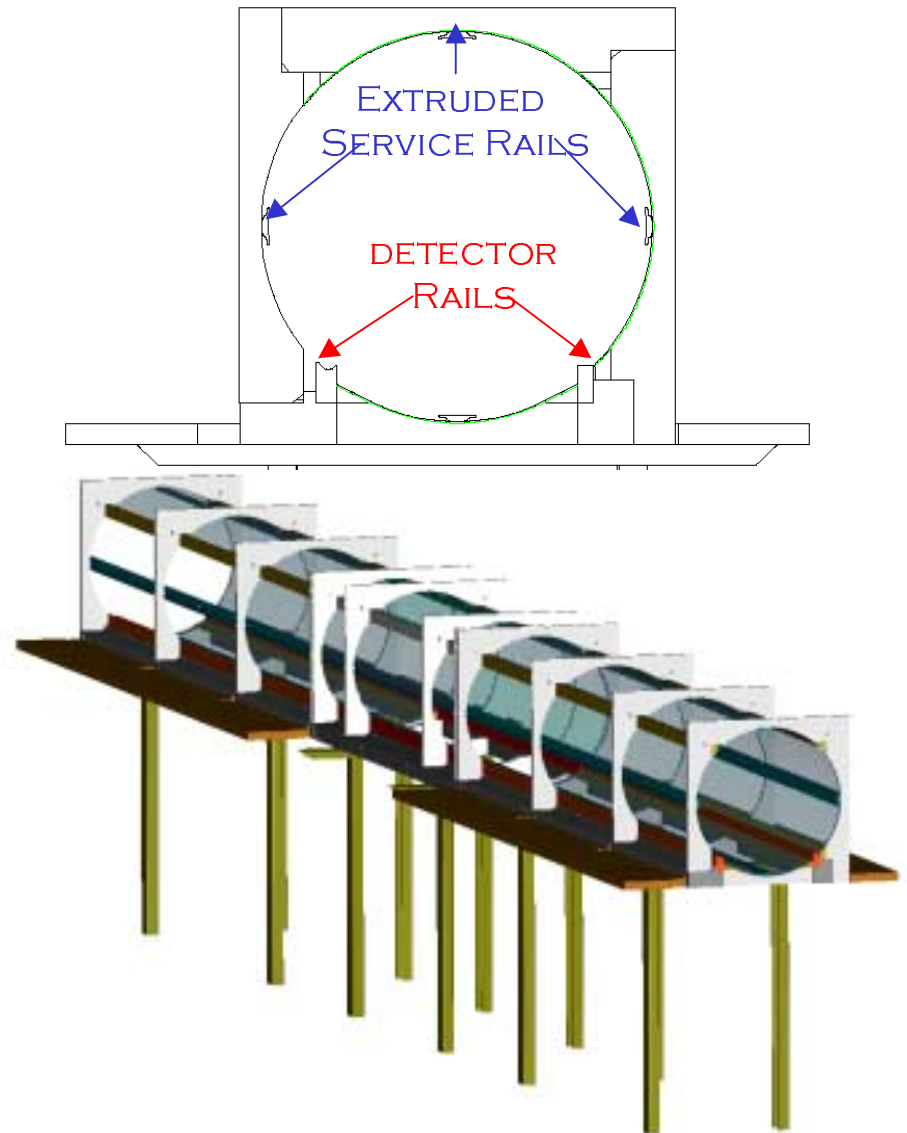


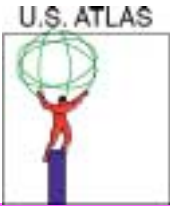
Pixel system and services roll in on support tube  
 Ends of tube are plugged to complete thermal environment



# Support Tube Status

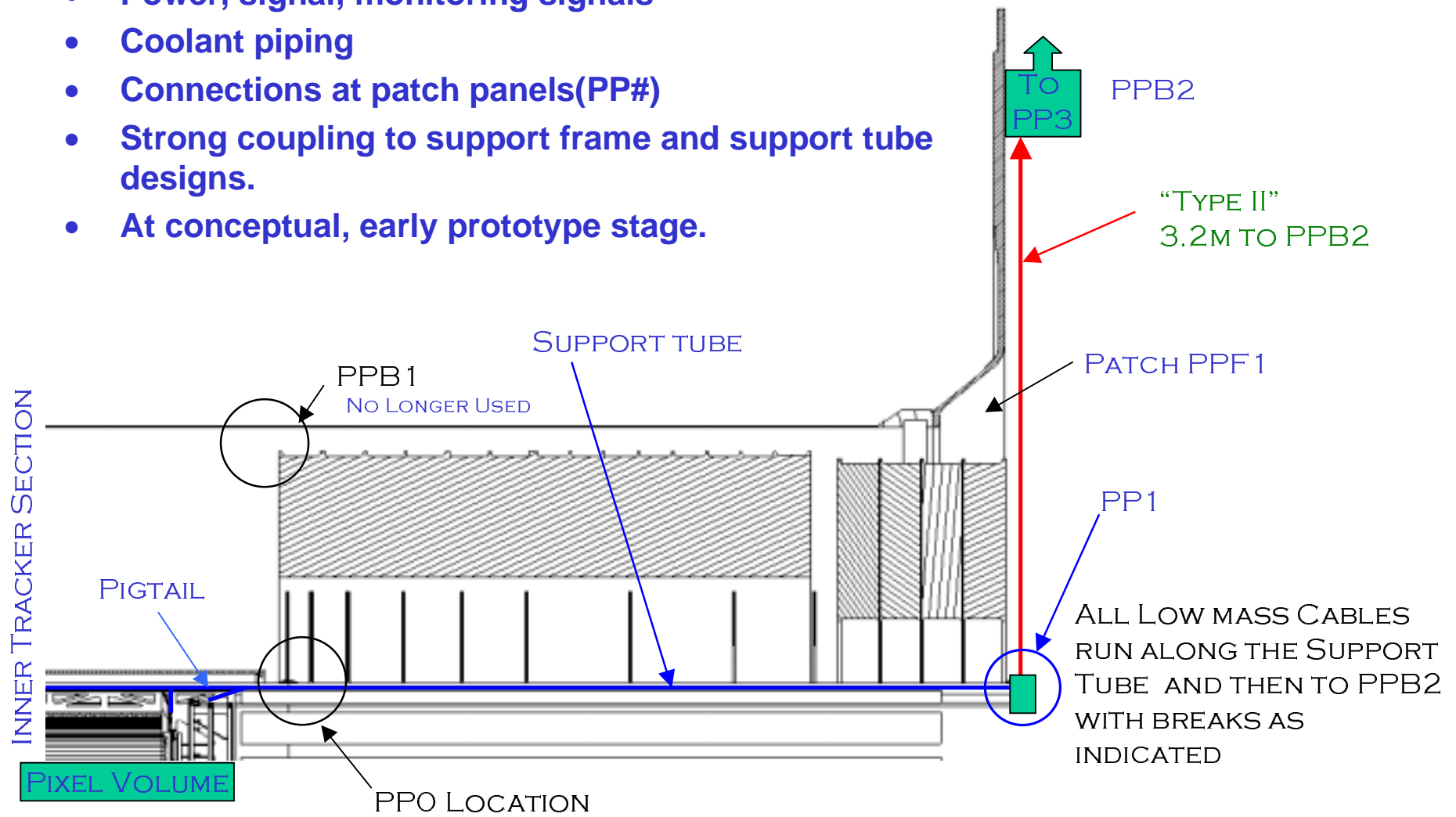
- Conceptual design phase
- Full-scale mockup under construction at LBL
- Test insertion and services support schemes
- Will fabricate prototype of center section by next year.





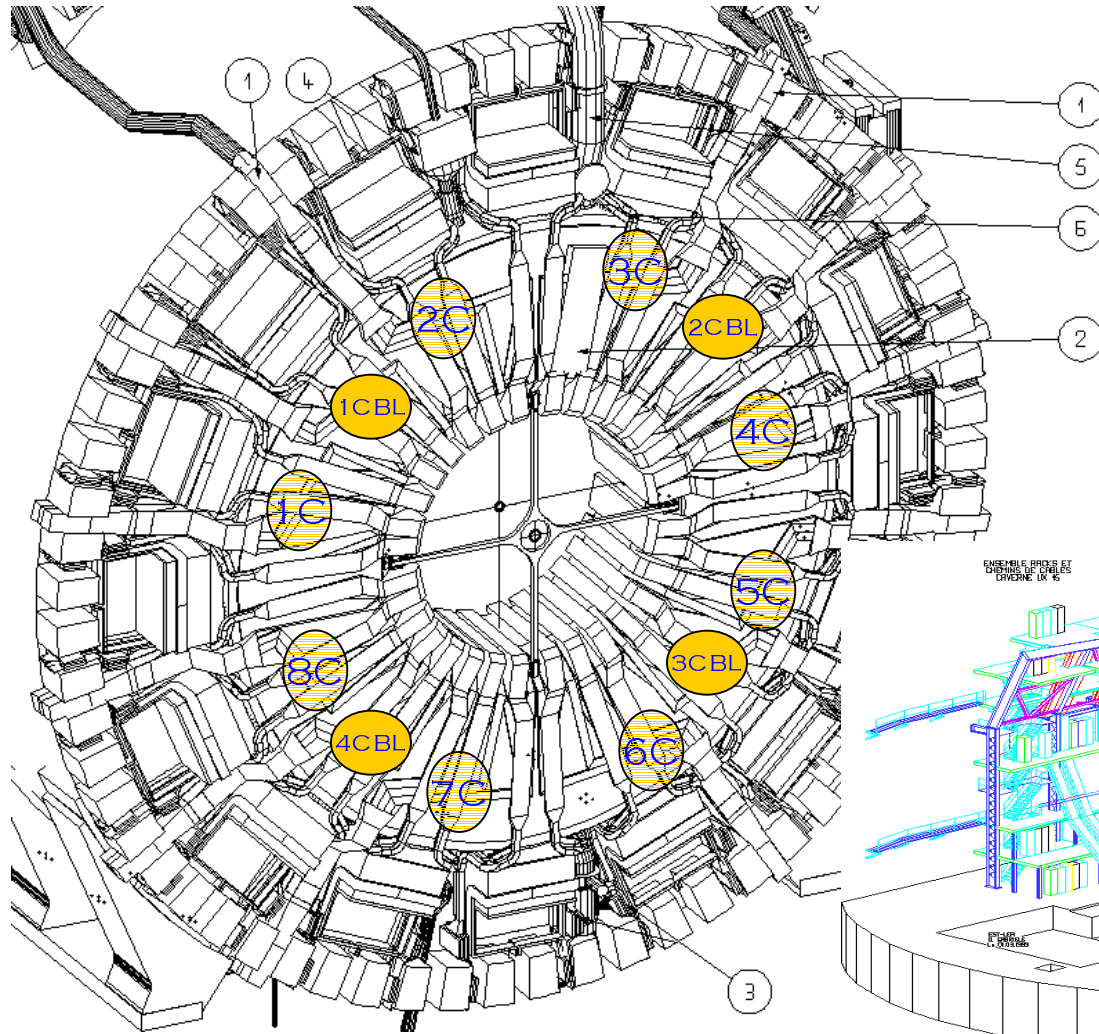
# Services - Inner Detector Region

- Power, signal, monitoring signals
- Coolant piping
- Connections at patch panels(PP#)
- Strong coupling to support frame and support tube designs.
- At conceptual, early prototype stage.



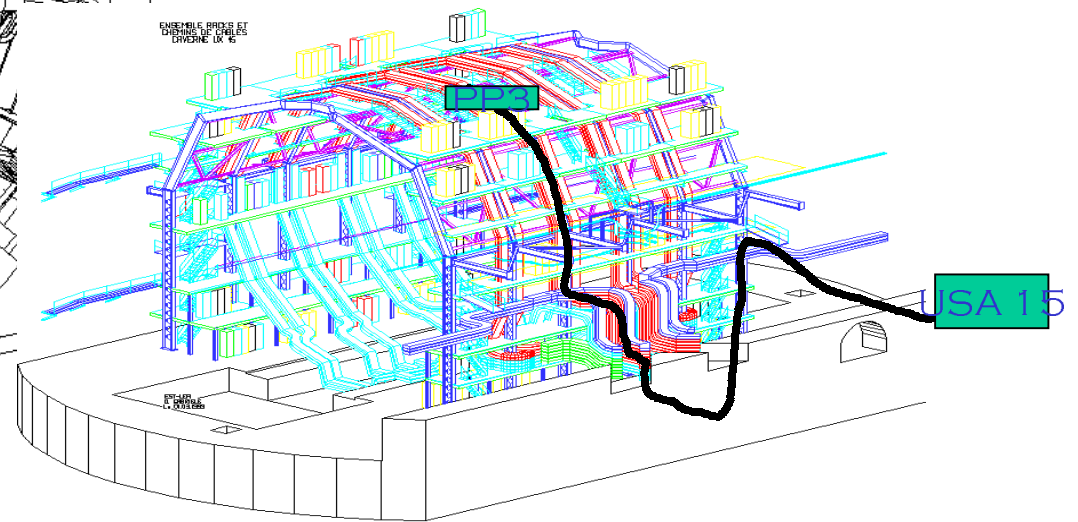


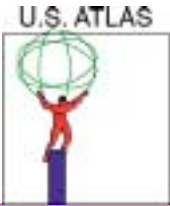
# Services - Outside Inner Detector



PP2 region

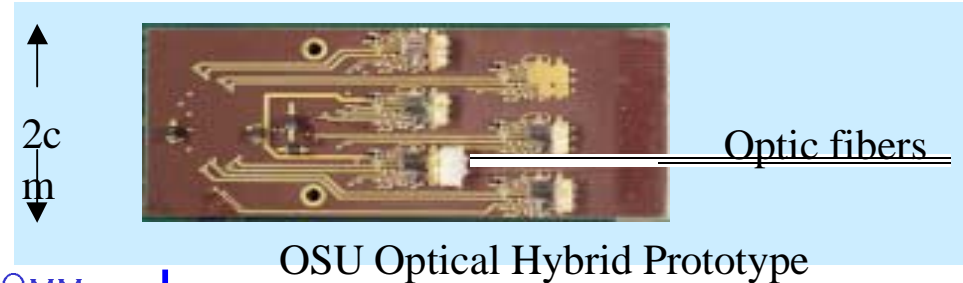
- PP2
- PP2 -> PP3
- PP3 -> underground caverns
- Also conceptual, early prototype phase.



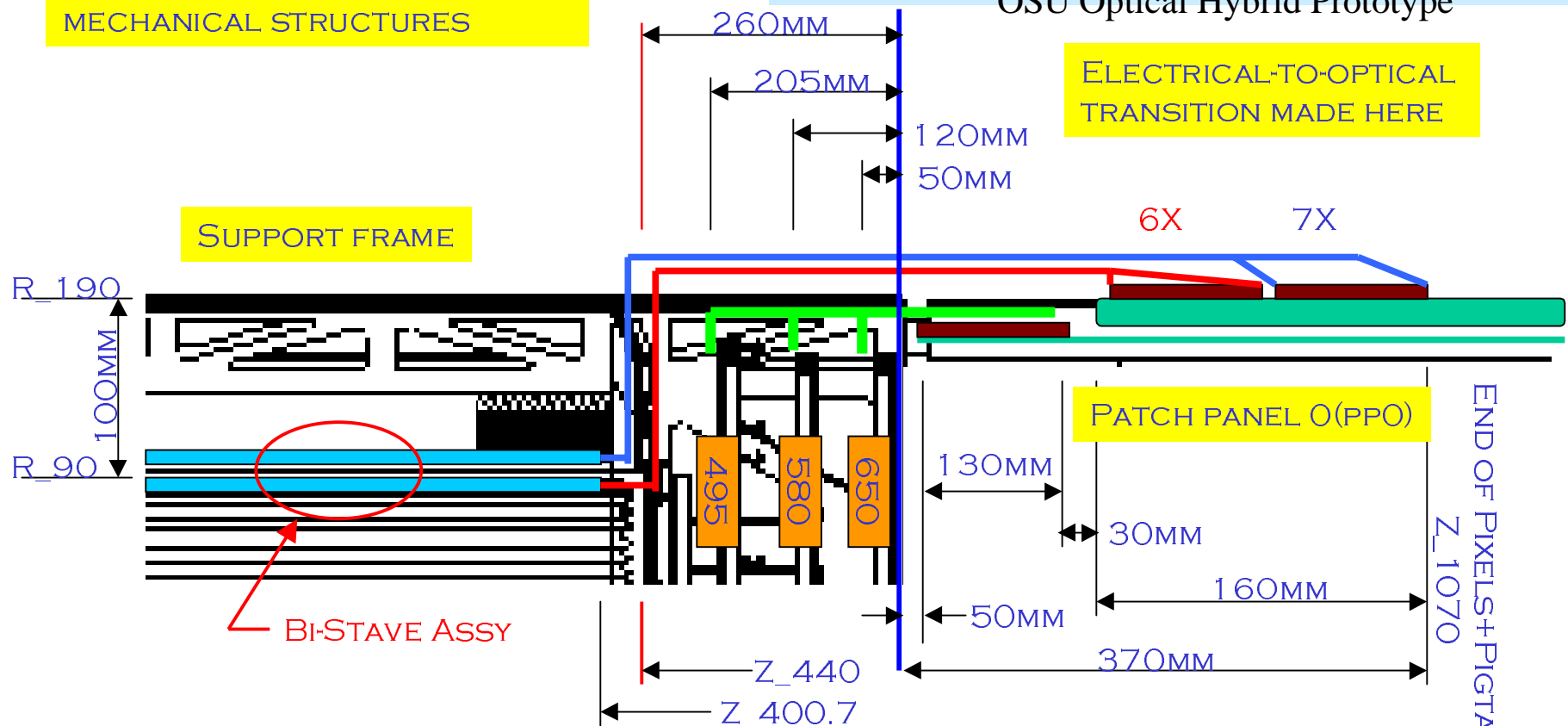


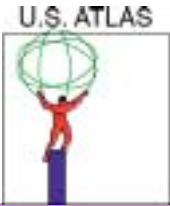
# Services I

INTEGRATION OF SERVICES  
-COOLING, POWER, SIGNAL-  
IS NOW MAJOR DESIGN DRIVER  
FOR SUPPORT FRAME AND OTHER  
MECHANICAL STRUCTURES



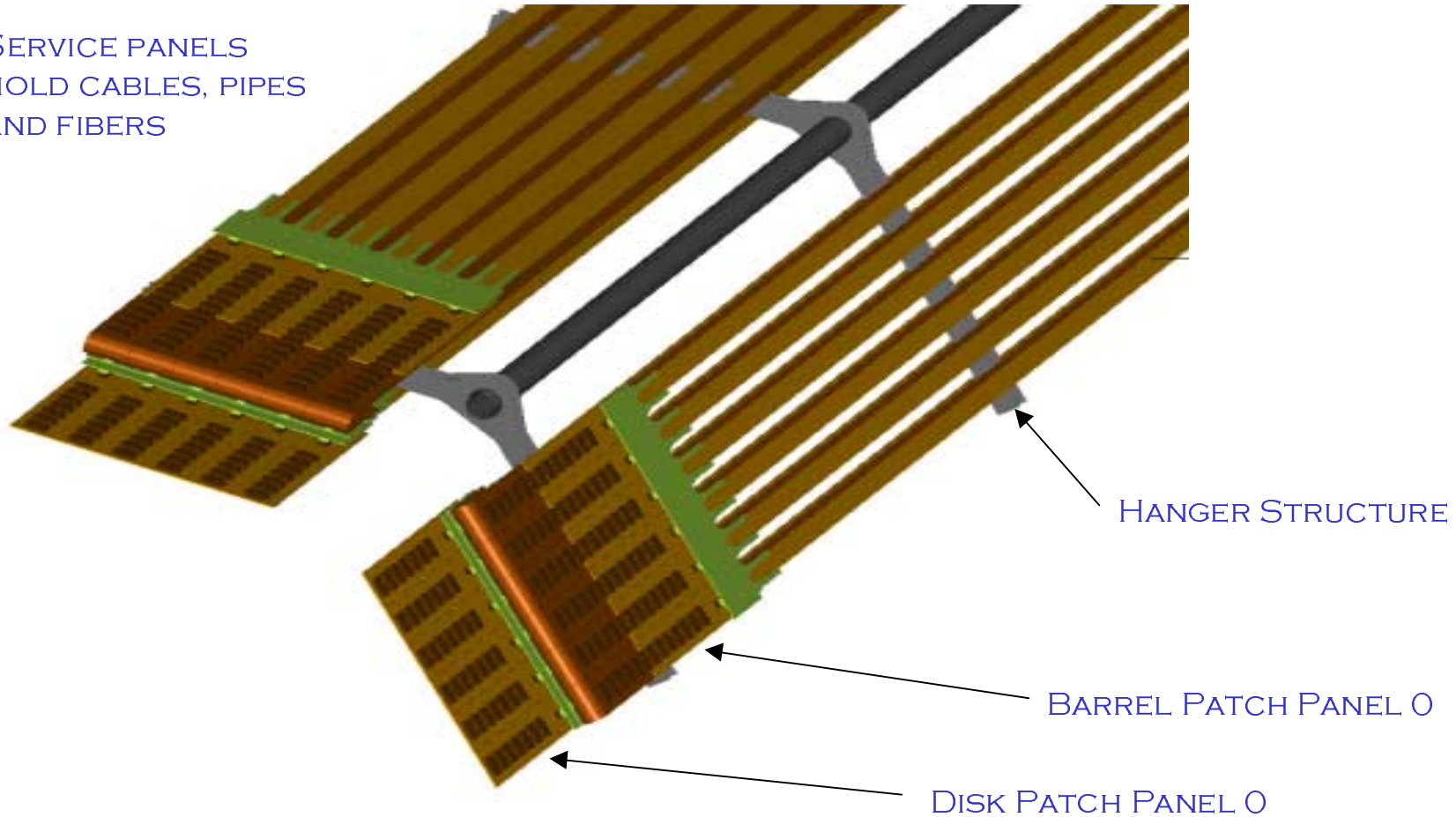
ELECTRICAL-TO-OPTICAL  
TRANSITION MADE HERE





# Services - II

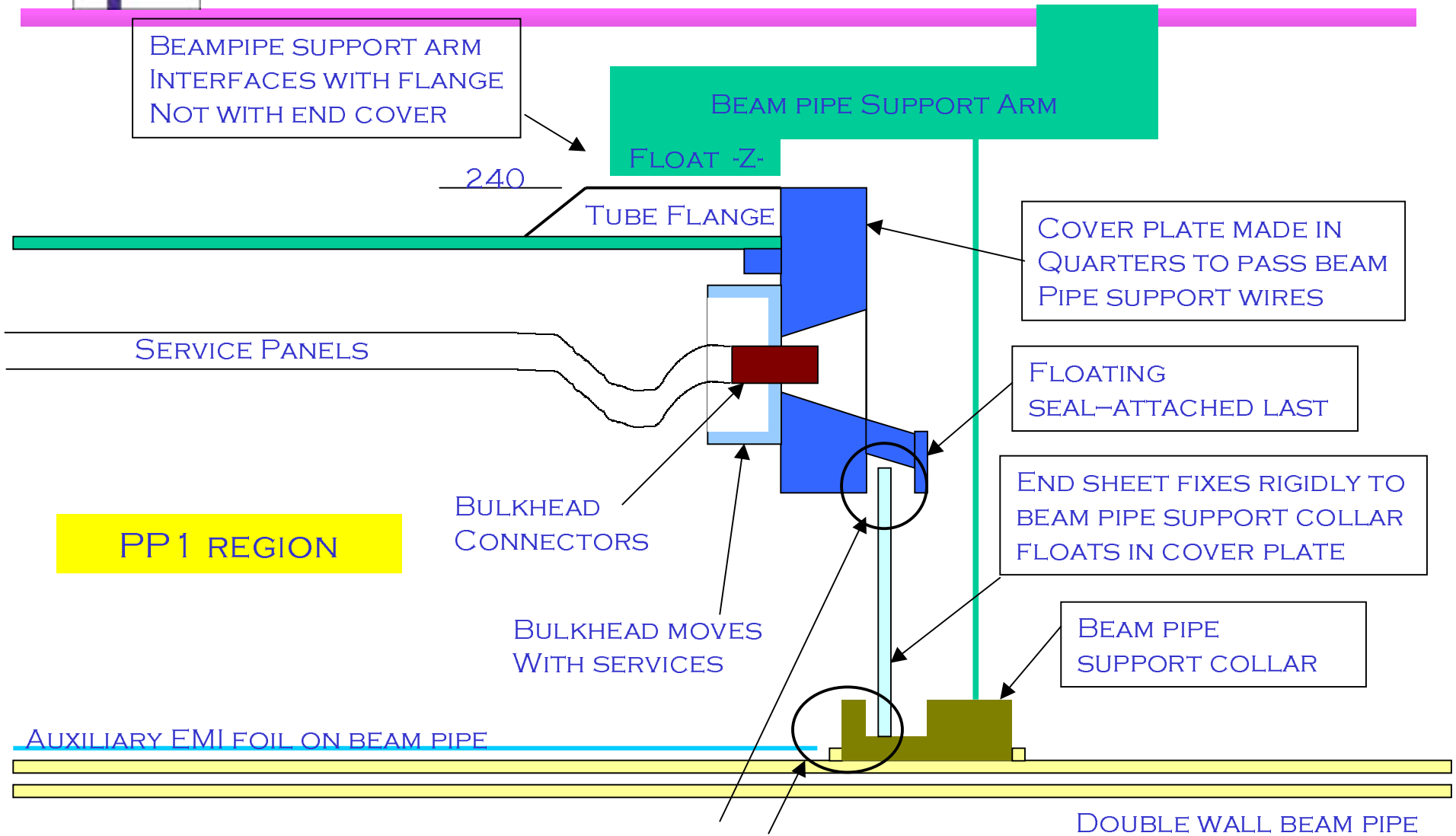
SERVICE PANELS  
HOLD CABLES, PIPES  
AND FIBERS



STRUCTURE NECESSARY TO SUPPORT SERVICES DURING  
INSTALLATION. THESE SLIDE ALONG RAILS IN SUPPORT TUBE

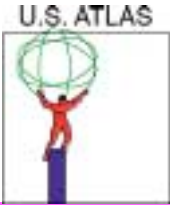


# Services - III



NEED TO AFFECT BOTH GAS AND EMI SEAL



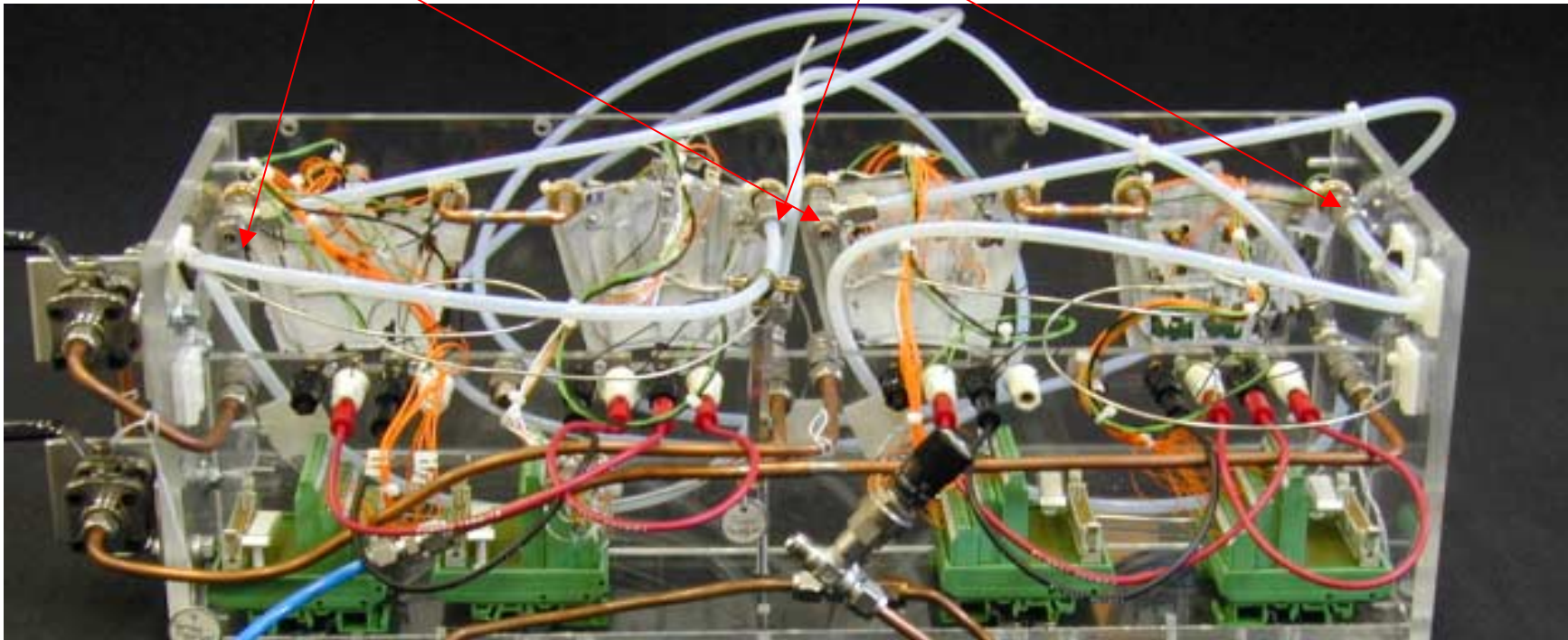


# Cooling

- Evaporative  $C_3F_8$  is baseline.
- Sectors tested - test setup below. Substantial headroom to maintain temperature of silicon at or below  $0^\circ C$ .

Capillary(0.030" ID  
1.2 m long)

Exhaust lines





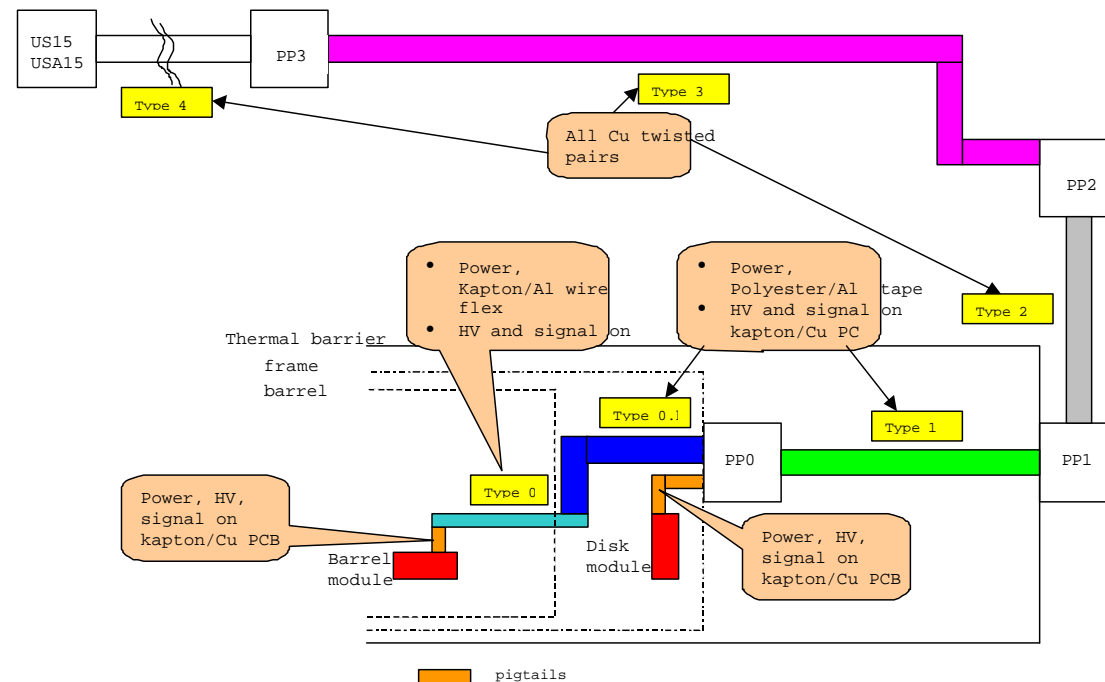
# Cooling Connections

- **Advanced prototype stage.**
- **Joint US/Europe program with multiple options for joining tubes and connectors.**
- **Brazing, gluing and e-beam welding under study.**
- **Connector types under study and test.**
- **Corrosion of aluminum under radiation in  $C_3F_8$  studied - not a problem.**
- **Baseline choice for connection to sector(or stave) in time for June PRR.**



# Cables and Connections

- Conceptual framework documented(eg. for ATLAS-wide power supply review this month).
- Prototypes built for
  - ◆ module -> PP0 ->PP1
  - ◆ evaluating prototype power supplies(simulate full length)





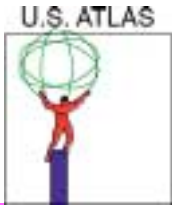
# Final Assembly/Installation

- Full “trial assembly” of structures in schedule.
- Disk regions assembled at LBNL.
- Shipped(as units or pieces) to CERN for integration with barrel. Barrel assembly will be done at CERN.
- Conceptual installation sequence in support tube exists.
- Still in conceptual design phase but mockup will allow test of some concepts(not all).
- Close integration with ongoing overall re-baselining of ATLAS installation plan and access scenarios.



# US Mechanics/Services Team

- Almost all at LBL or under contract to LBL(Hytec, Inc).
- Engineers[Anderssen, Goozen, Hartman, Hoferkamp(EE - UNM), Miller(Hytec), Miller(Hytec)]
- Designers(Taylor, Uken, Hytec team)
- Techs(Johnson, McCormack, Weber, Wirth, Witharm)
- Shops, special services + students.
- Physicists[Gilchriese + Einsweiler/Garcia-Sciveres on services]



# Funding Profile - Base Cost

WBS Number	Description	FY 96 (k\$)	FY 97 (k\$)	FY 98 (k\$)	FY 99 (k\$)	FY 00 (k\$)	FY 01 (k\$)	FY 02 (k\$)	FY 03 (k\$)	FY 04 (k\$)	FY 05 (k\$)	Total (k\$)
1.1.1.1	<b>Mechanics and Final Assembly</b>	0	0	0	0	0	923	917	1032	177	19	3067
1.1.1.1.1	<b>Design</b>	0	0	0	0	0	571	447	262	83	12	1375
1.1.1.1.1.1	Prototype Design	0	0	0	0	0	136	0	0	0	0	136
1.1.1.1.1.2	Production Design	0	0	0	0	0	435	447	262	83	12	1239
1.1.1.1.2	<b>Development and Prototypes</b>	0	0	0	0	0	152	105	0	0	0	257
1.1.1.1.2.1	Disk Sectors	0	0	0	0	0	17	0	0	0	0	17
1.1.1.1.2.2	Disk Support Rings	0	0	0	0	0	8	0	0	0	0	8
1.1.1.1.2.3	Support Frame	0	0	0	0	0	20	0	0	0	0	20
1.1.1.1.2.4	Support Tube	0	0	0	0	0	44	21	0	0	0	65
1.1.1.1.2.5	Services	0	0	0	0	0	64	84	0	0	0	148
1.1.1.1.2.6	Disk Assembly	0	0	0	0	0	0	0	0	0	0	0
1.1.1.1.2.7	Final Assembly and	0	0	0	0	0	0	0	0	0	0	0
1.1.1.1.2.8	Test Equipment	0	0	0	0	0	0	0	0	0	0	0
1.1.1.1.3	<b>Production</b>	0	0	0	0	0	199	365	770	94	7	1435
1.1.1.1.3.1	Disk Sectors	0	0	0	0	0	117	28	0	0	0	145
1.1.1.1.3.2	Disk Support Rings	0	0	0	0	0	0	126	0	0	0	126
1.1.1.1.3.3	Support Frame	0	0	0	0	0	0	122	122	0	0	243
1.1.1.1.3.4	B-layer Support	0	0	0	0	0	0	0	26	37	0	64
1.1.1.1.3.5	Support Tube	0	0	0	0	0	0	56	156	0	0	211
1.1.1.1.3.6	Endplug Thermal Barrier	0	0	0	0	0	0	0	41	0	0	41
1.1.1.1.3.7	Services	0	0	0	0	0	0	21	290	0	0	311
1.1.1.1.3.8	Disk Assembly	0	0	0	0	0	0	11	91	0	0	102
1.1.1.1.3.9	Disk Region Final Assembly	0	0	0	0	0	0	0	42	50	0	92
1.1.1.1.3.10	Test Equipment	0	0	0	0	0	82	2	2	7	7	100
1.1.1.1.3.11	Installation	0	0	0	0	0	0	0	0	0	0	0



# 1.1.1.1 Mechanics -Schedule Flow

