QPS Engineering Progress and Plans

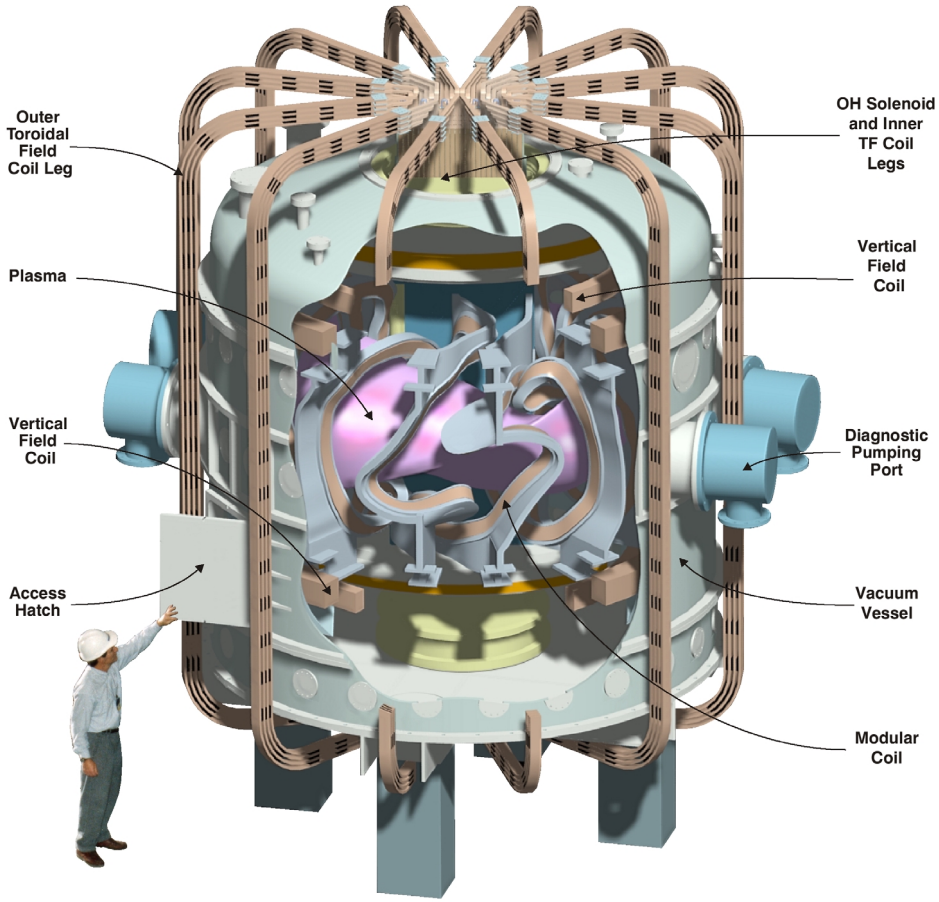
Presented by B. Nelson for the QPS design team

QPS Project Validation Review
June 5, 2002
DOE-Germantown

Presentation Outline

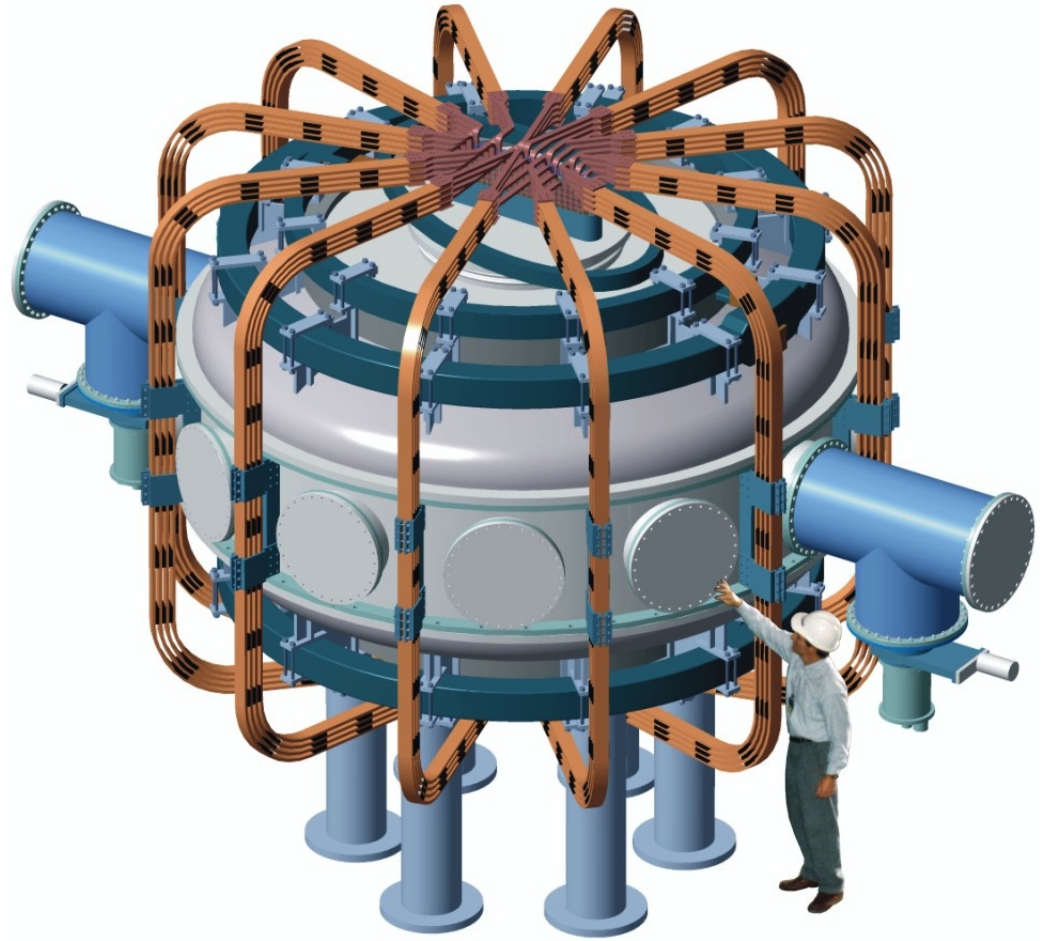
- Progress on QPS Engineering Development
  - New vacuum vessel configuration
  - New coil set
- Plans for conceptual design
  - Balance of FY 2002
  - FY 2003
- Plans for accomplishing the QPS project
  - QPS schedule by year
  - Design approach and benefits of NCSX work
  - Compatibility with NCSX commitments

Baseline design for PVR



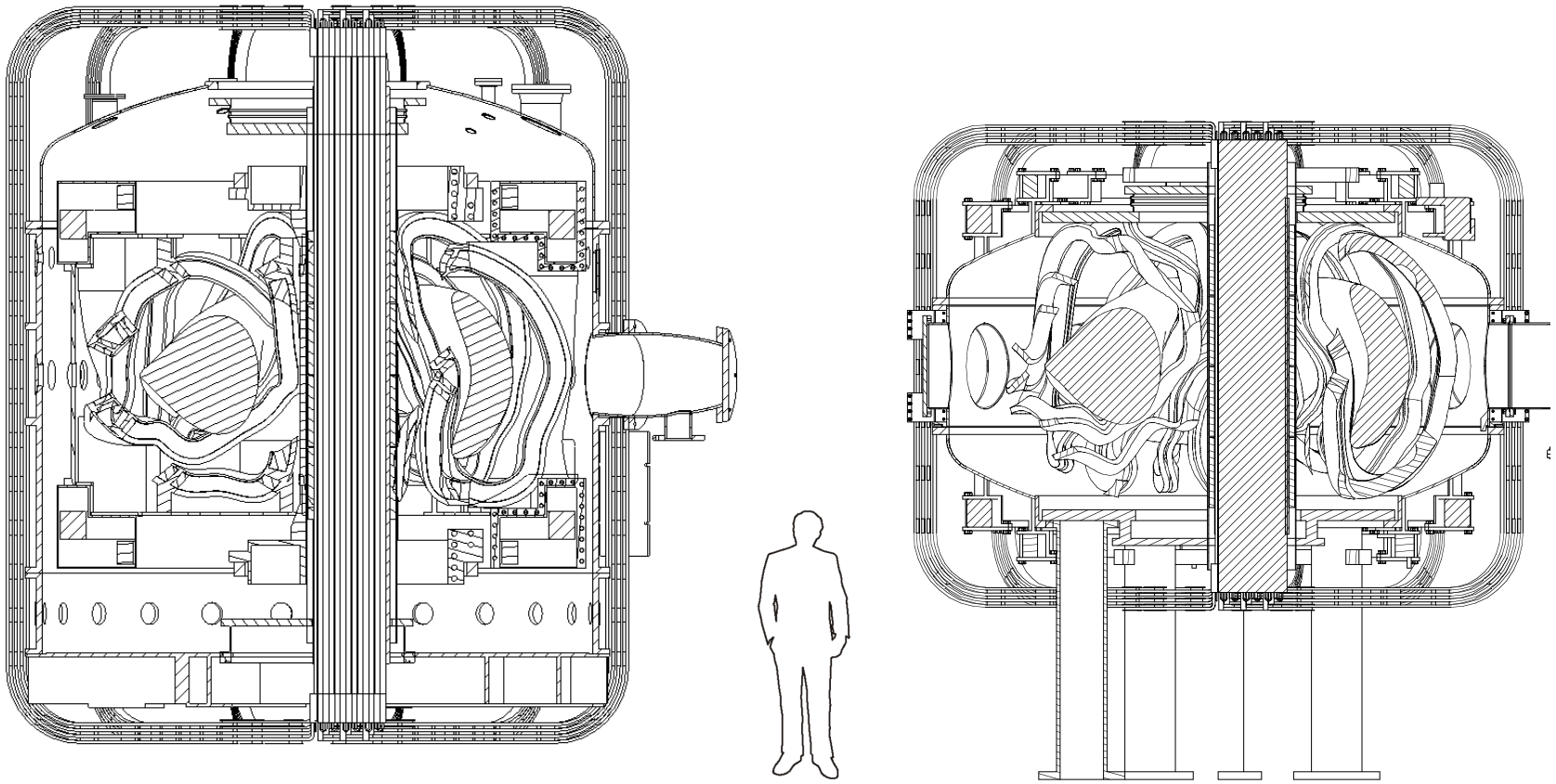
- ORMAK vacuum tank with Al sections
- Canned PF coils inside vacuum tank
- Large Ti gettering surface inside tank
- GB4 modular coil set

Current design basis for CDR

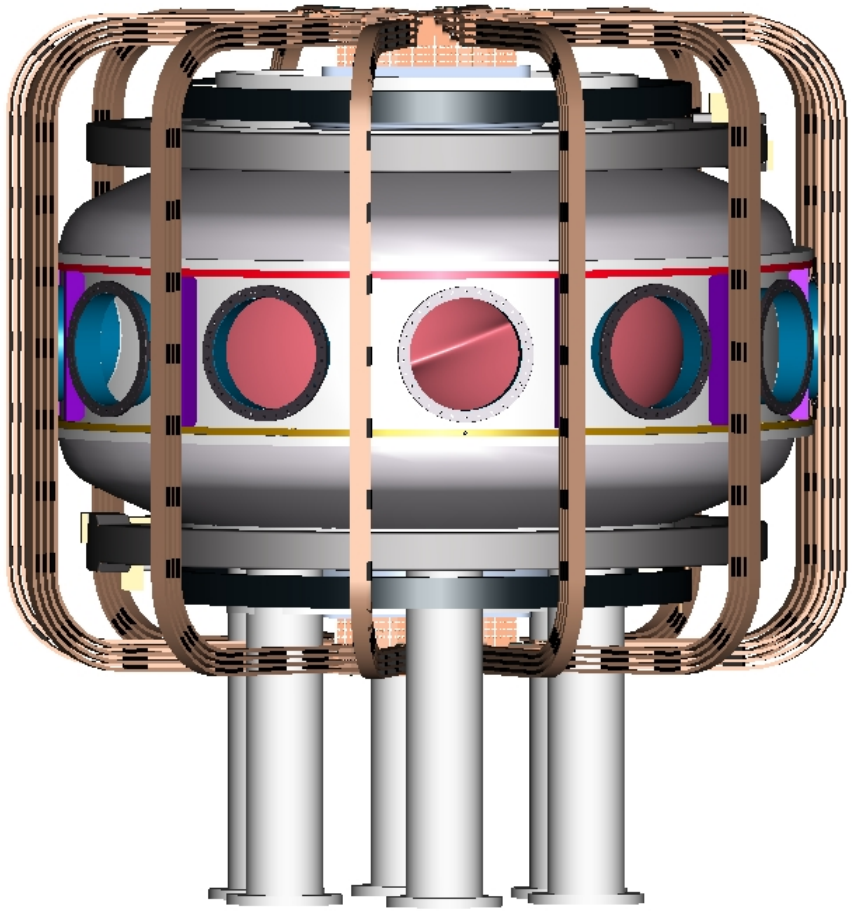


- New, smaller, stainless steel vacuum tank
- PF coils outside vacuum
- External getter pumps
- 041102 modular coil set with split coils

PVR configuration and new configuration



New Vacuum Tank has advantages



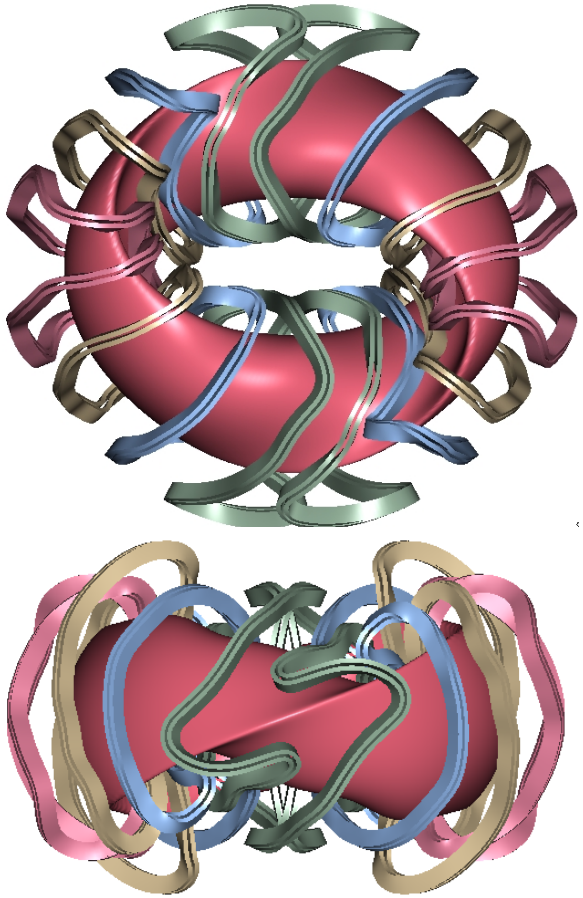
- PF coils outside vacuum (cheaper)
- Smaller (cheaper)
- All stainless steel (better vacuum, reduced eddy currents)
- Allows top and bottom diagnostic access
- *However*, maintenance access to interior requires disassembly of TF coils

Alternate option with extended TF coils

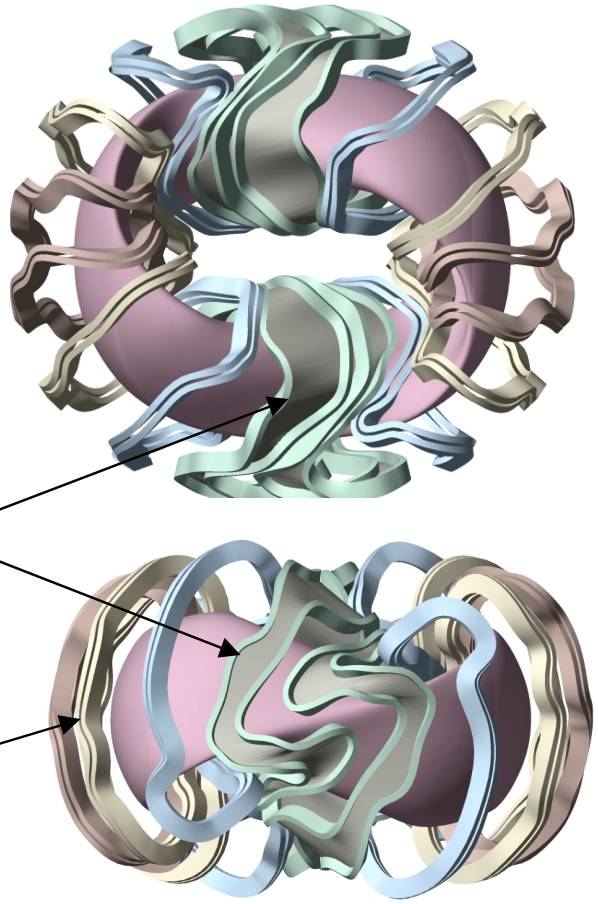
- Allows improved maintenance access to interior without disassembly of TF coils
- TF coils are slightly more expensive, higher voltage
- Centerstack casing is longer

Old and new modular coil configurations

April 2001



May 2002

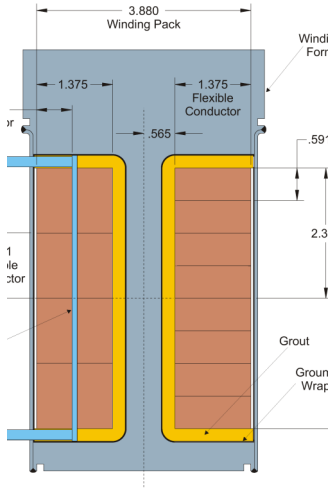


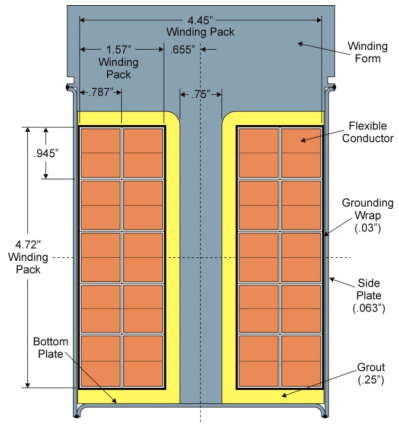
Coil improvements

- Changed from I-beam to tee section after NCSX: easier to wind, more available space

PVR

"I-beam" section





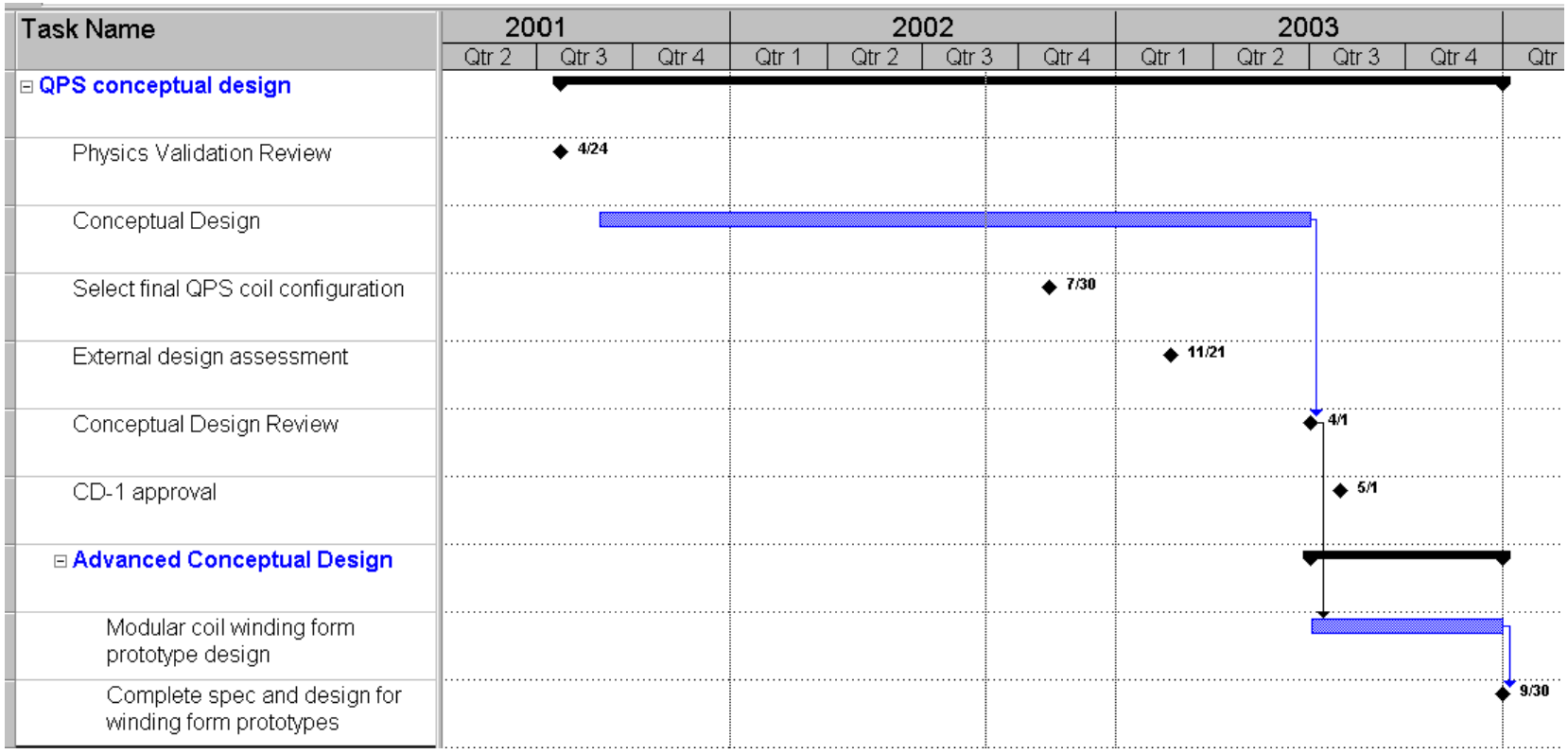
current

"Tee" section

- New cross section may allow use of conductor identical to NCSX
- Lower current density allows longer pulse length and /or higher operating temperature (better vacuum)

What do we plan for the rest of FY02 and FY03?

- Update design and hold external design assessment
- Update cost estimate and schedule, hold CDR
- Prepare for modular coil R&D



Update design for external assessment

- "Engineer" new modular coil set :
  - Optimize winding cross section, twist
  - Configure integrated coil structure
  - Perform field/force/stress analysis

- Develop balance of design
  - Select vacuum vessel / TF coil configuration
  - Develop vacuum pumping, bakeout, and wall conditioning scheme
  - Create integrated Pro-E models of all components
  - Perform integrated stress/deflection analysis

Prepare for needed R&D

- Determine minimum amount of R&D required

  Only modular coils will need R&D, to verify casting patterns

- Integrate R&D with NCSX project
  - Modular coil winding forms will be very similar, although smaller
  - Modular coil conductor and windings will be very similar
  - Coil can welding may be transferred to NCSX to simplify vacuum impregnation process
  - Continue involvement of University of Tennessee and potential vendors for coil winding forms

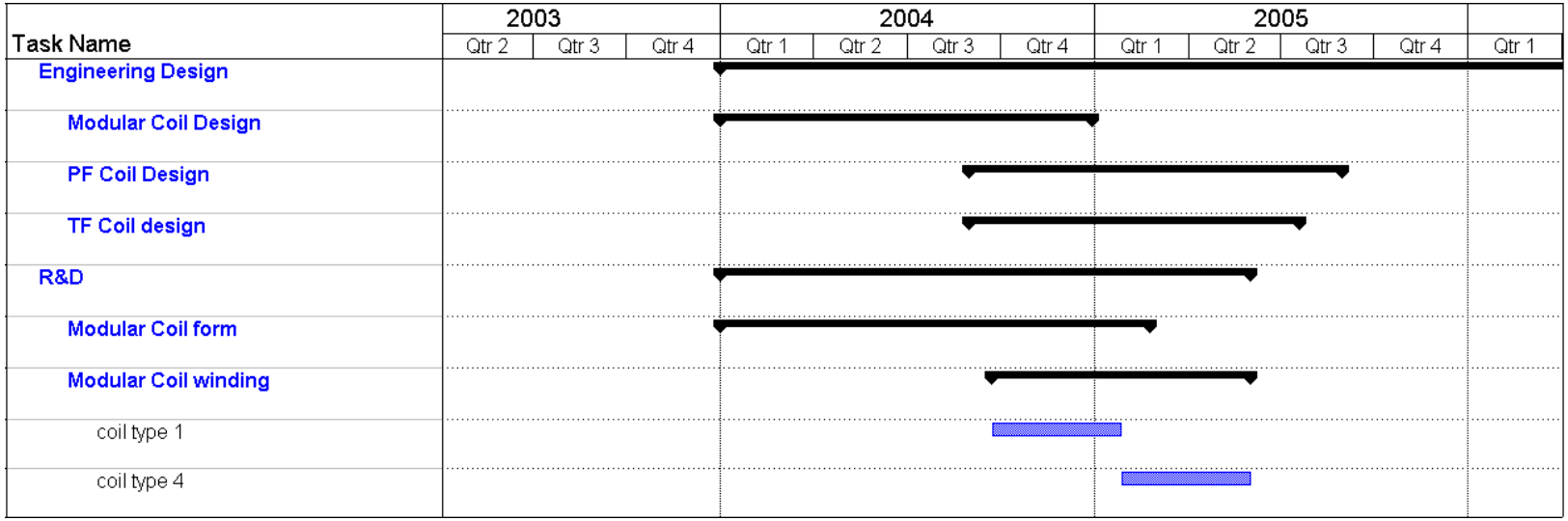
- Develop complete spec and models for prototype coil winding forms

Develop new cost estimate and schedule

- Cost estimate will take advantage of NCSX experience, but with modifications
  - components are smaller, lower performance
  - Winding will be performed in University facilities with University labor, supervised by UT, ORNL engineers and technicians
  - Infrastructure separately funded
- Resource loaded schedule will dovetail with NCSX project

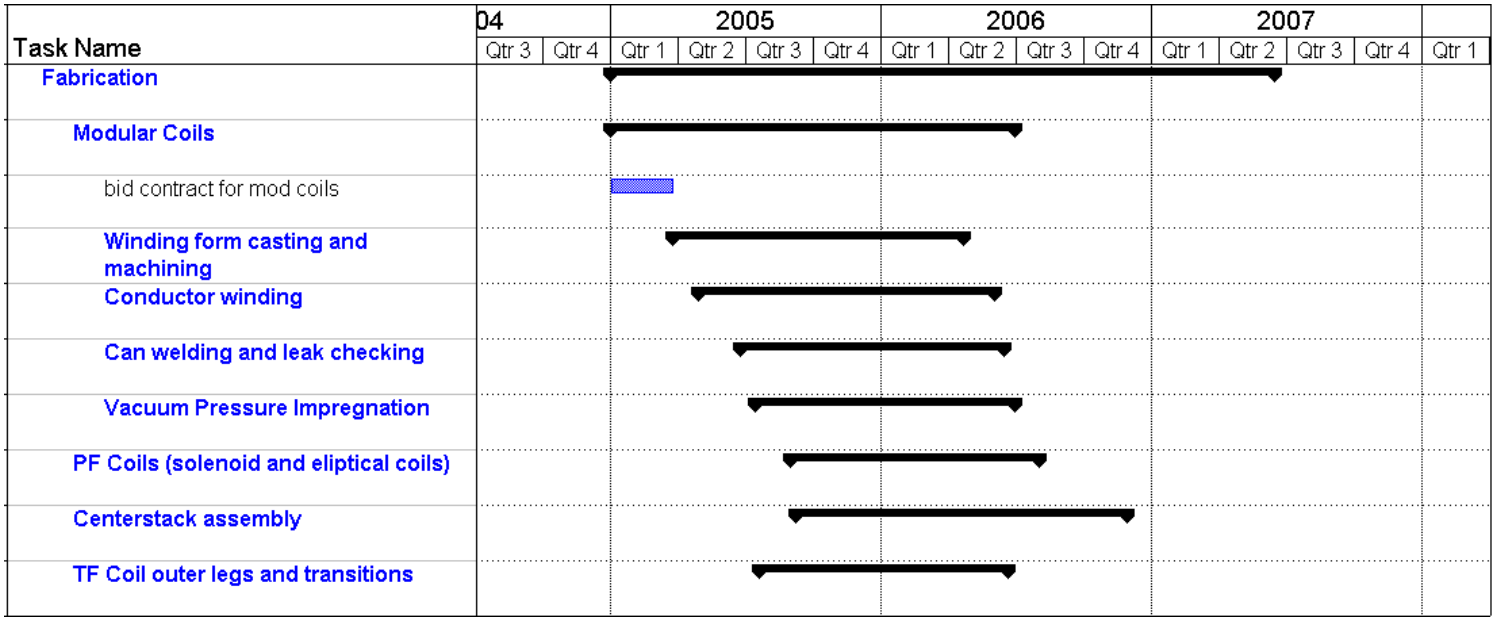
What will we do in FY 2004?

- Complete modular coil detailed design
- Modular coil R&D
  - Procure prototype winding forms for all coil types
  - Machine winding forms for coil types 1 and 4
  - Set up winding line, wind prototype coil 1
  - Set up second winding line, begin winding coil 4
- Begin TF and PF coil design



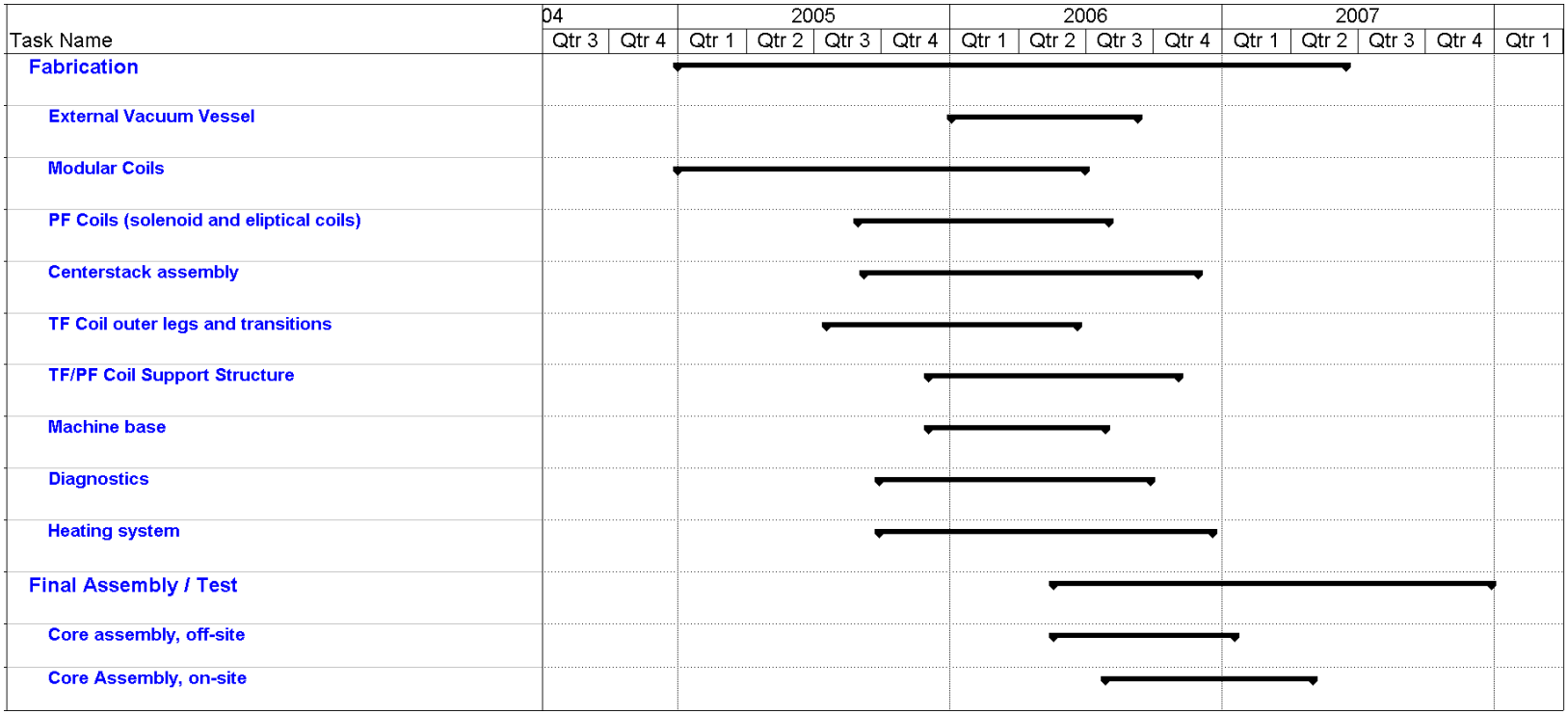
What will we do in FY 2005?

- Procure full set of modular coil winding forms and begin winding modular coils
  - First forms arrive end of Jan 05
  - First coil completed in April 05
- Begin detailed design of vessel, structures, and ancillary systems
- Begin fabrication of PF, TF and Centerstack assembly



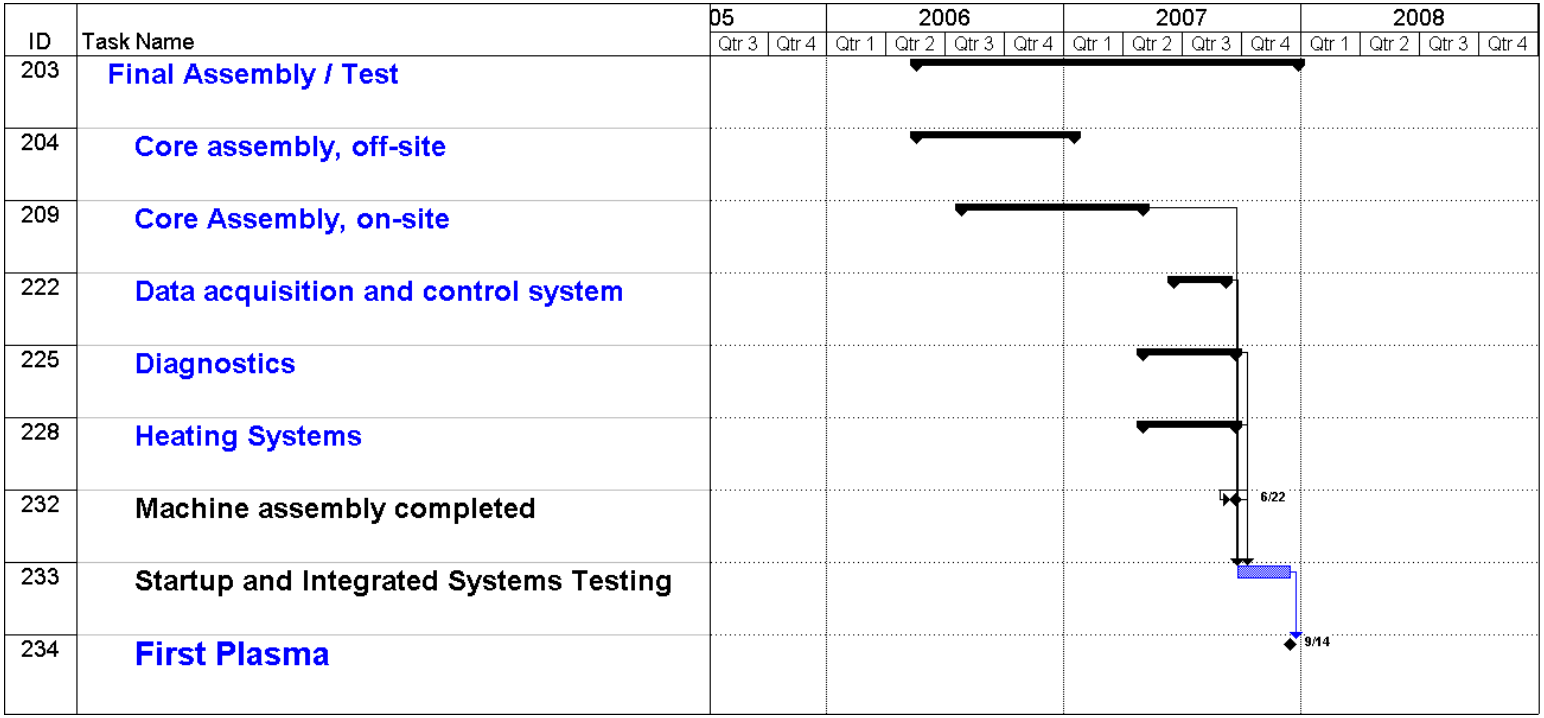
What will we do in FY 2006?

- Complete fabrication of modular coil set and vacuum vessel
- Complete fabrication of OH coils, elliptical PF coils, TF coils, center-stack assembly, diagnostics, heating system hardware
- Begin pre-assembly of stellarator core field periods, set base

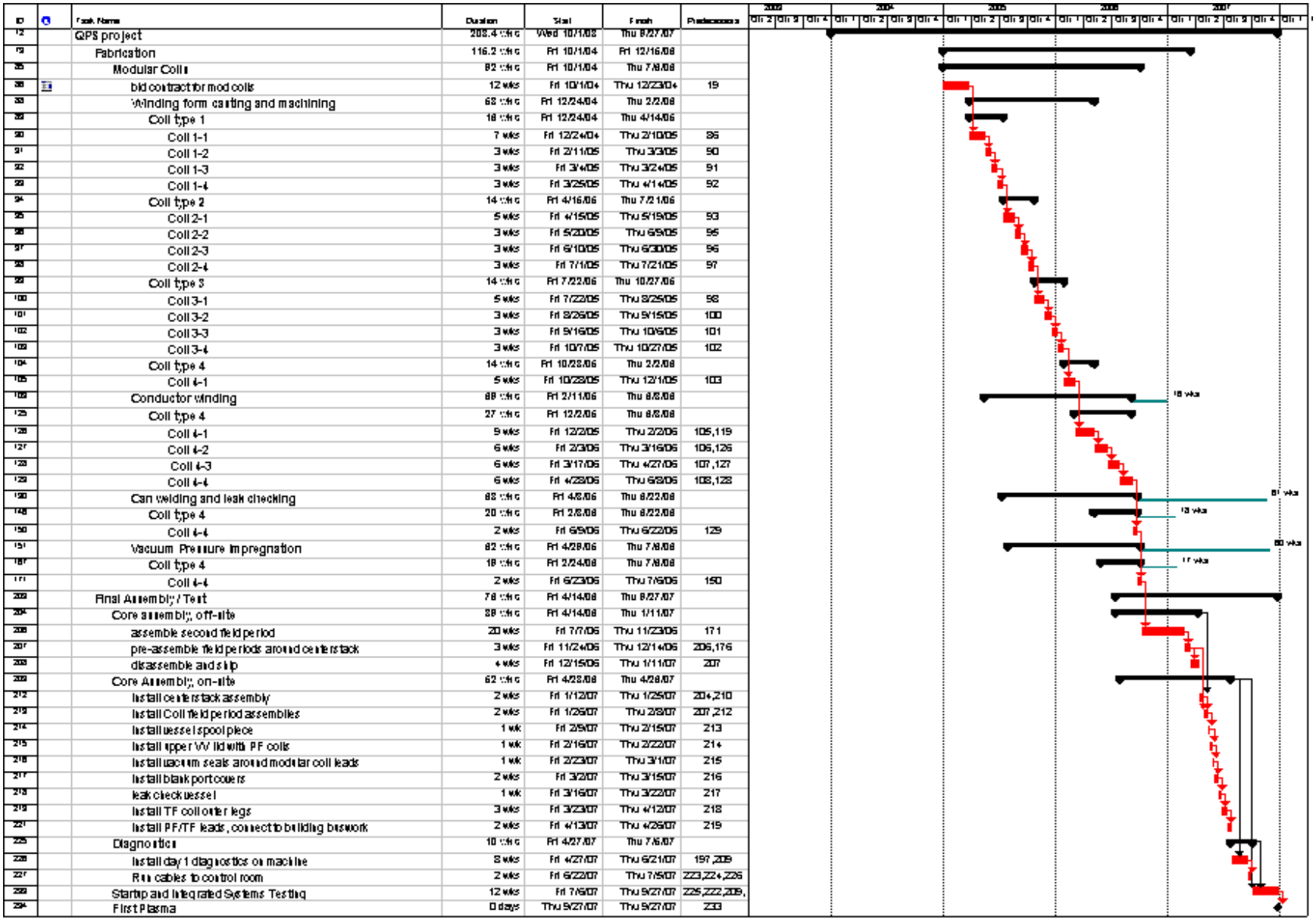


What will we do in FY 2007?

- Complete fabrication of all systems
- Complete on-site assembly
- Complete integrated systems testing
- First plasma in Sept. 07



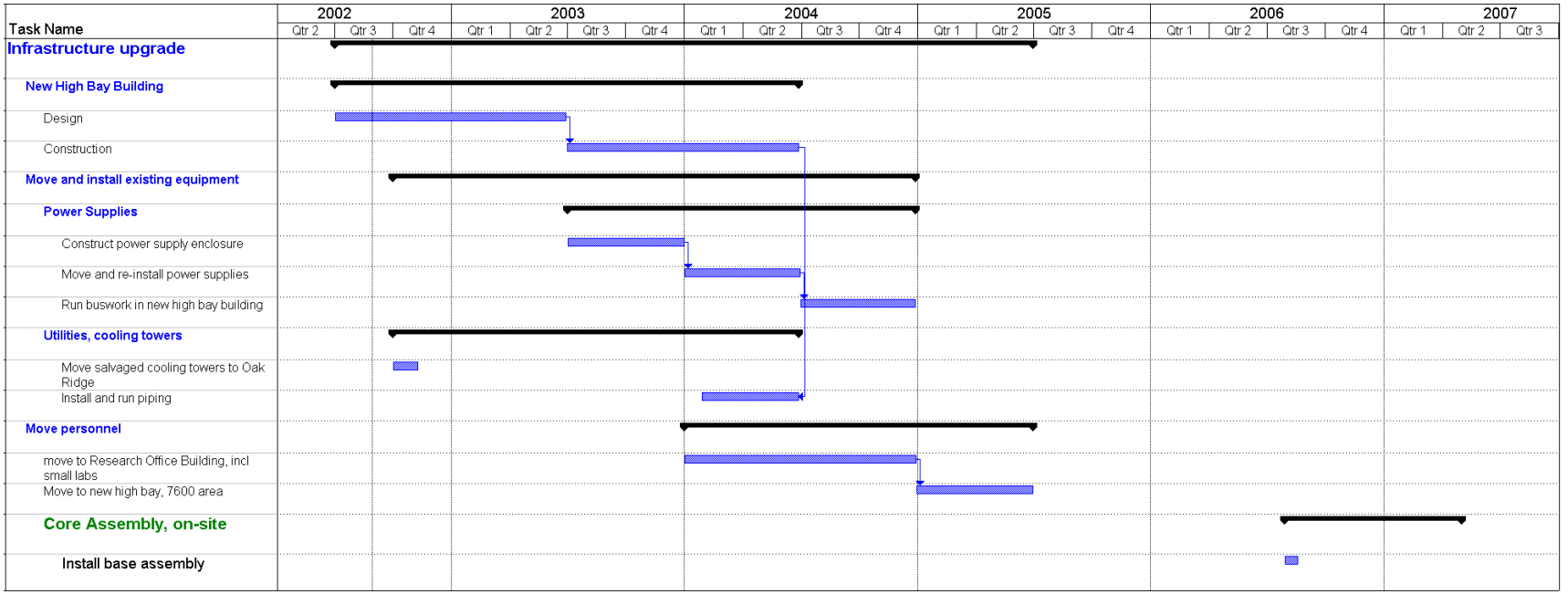
QPS Critical Path Schedule, Draft, 4 June 2002



ID	Task Name	Duration	Start	Finish	Predecessors
12	QPS project	208.4 wks	Wed 10/1/03	Thu 9/27/07	
13	Fabrication	116.2 wks	Fri 10/1/04	Fri 12/16/06	
35	Modular Coils	82 wks	Fri 10/1/04	Thu 7/5/06	
36	bid contract for mod coils	12 wks	Fri 10/1/04	Thu 12/23/04	19
53	Winding form casting and machining	68 wks	Fri 12/24/04	Thu 2/2/06	
89	Coil type 1	18 wks	Fri 12/24/04	Thu 4/14/06	
90	Coil 1-1	7 wks	Fri 12/24/04	Thu 2/10/05	86
91	Coil 1-2	3 wks	Fri 2/11/05	Thu 3/3/05	90
92	Coil 1-3	3 wks	Fri 3/4/05	Thu 3/24/05	91
93	Coil 1-4	3 wks	Fri 3/25/05	Thu 4/14/05	92
94	Coil type 2	14 wks	Fri 4/15/05	Thu 7/21/06	
95	Coil 2-1	5 wks	Fri 4/15/05	Thu 5/19/05	93
96	Coil 2-2	3 wks	Fri 5/20/05	Thu 6/9/05	95
97	Coil 2-3	3 wks	Fri 6/10/05	Thu 6/30/05	96
98	Coil 2-4	3 wks	Fri 7/1/05	Thu 7/21/05	97
99	Coil type 3	14 wks	Fri 7/22/05	Thu 10/27/06	
100	Coil 3-1	5 wks	Fri 7/22/05	Thu 8/25/05	98
101	Coil 3-2	3 wks	Fri 8/26/05	Thu 9/15/05	100
102	Coil 3-3	3 wks	Fri 9/16/05	Thu 10/6/05	101
103	Coil 3-4	3 wks	Fri 10/7/05	Thu 10/27/05	102
104	Coil type 4	14 wks	Fri 10/28/05	Thu 2/2/06	
105	Coil 4-1	5 wks	Fri 10/28/05	Thu 12/1/05	103
106	Conductor winding	88 wks	Fri 2/11/05	Thu 6/8/06	
125	Coil type 4	27 wks	Fri 12/2/05	Thu 6/8/06	
126	Coil 4-1	9 wks	Fri 12/2/05	Thu 2/2/06	105,119
127	Coil 4-2	6 wks	Fri 2/3/06	Thu 3/16/06	106,126
128	Coil 4-3	6 wks	Fri 3/17/06	Thu 4/27/06	107,127
129	Coil 4-4	6 wks	Fri 4/28/06	Thu 6/8/06	108,128
130	Can welding and leak checking	83 wks	Fri 4/8/05	Thu 8/2/06	
148	Coil type 4	20 wks	Fri 2/3/06	Thu 6/22/06	
150	Coil 4-4	2 wks	Fri 6/9/06	Thu 6/22/06	129
151	Vacuum Pressure Impregnation	82 wks	Fri 4/28/06	Thu 7/6/06	
167	Coil type 4	19 wks	Fri 2/24/06	Thu 7/6/06	
171	Coil 4-4	2 wks	Fri 6/23/06	Thu 7/6/06	150
202	Final Assembly / Test	78 wks	Fri 4/14/06	Thu 9/27/07	
204	Core assembly, off-site	39 wks	Fri 4/14/06	Thu 1/11/07	
208	assemble second field period	20 wks	Fri 7/7/06	Thu 11/23/06	171
207	pre-assemble field periods around centerstack	3 wks	Fri 11/24/06	Thu 12/14/06	206,176
209	disassemble and ship	4 wks	Fri 12/15/06	Thu 1/11/07	207
209	Core Assembly, on-site	62 wks	Fri 4/28/06	Thu 4/26/07	
212	Install centerstack assembly	2 wks	Fri 1/12/07	Thu 1/25/07	204,210
213	Install Coil field period assemblies	2 wks	Fri 1/26/07	Thu 2/8/07	207,212
214	Install vessel spool piece	1 wk	Fri 2/9/07	Thu 2/15/07	213
215	Install upper VV lid with PF coils	1 wk	Fri 2/16/07	Thu 2/22/07	214
216	Install vacuum seals around modular coil leads	1 wk	Fri 2/23/07	Thu 3/1/07	215
217	Install blank port covers	2 wks	Fri 3/2/07	Thu 3/15/07	216
218	leak check vessel	1 wk	Fri 3/16/07	Thu 3/22/07	217
219	Install TF coil outer legs	3 wks	Fri 3/23/07	Thu 4/12/07	218
221	Install PF/TF leads, connect to building buswork	2 wks	Fri 4/13/07	Thu 4/26/07	219
225	Diagnostics	10 wks	Fri 4/27/07	Thu 7/5/07	
226	Install day 1 diagnostics on machine	8 wks	Fri 4/27/07	Thu 6/21/07	197,209
227	Run cables to control room	2 wks	Fri 6/22/07	Thu 7/5/07	223,224,226
269	Startup and Integrated Systems Testing	12 wks	Fri 7/6/07	Thu 9/27/07	225,222,209,
294	First Plasma	0 days	Thu 9/27/07	Thu 9/27/07	233

How do Infrastructure improvements fit in?

- ORNL Fusion Energy Division is moving from “Y-12” site to “X-10” site
- New buildings are planned and infrastructure will be moved
- Everything will be ready for QPS project



How does QPS fit with NCSX?

- ORNL and PPPL personnel will have similar design responsibilities for stellarator core on both projects for maximum leverage
  - Tools and methodologies developed for one project will be used for both
  - Modular coil design (and necessary R&D) very similar
  - WBS managers for stellarator core components are basically the same

WBS	System	WBS Mgr	
		QPS	NCSX
1	**Stellarator Core Systems**	**Nelson**	**Nelson**
11	VV and In-Vessel Components (incl PFCs, internal trim coils)	Goranson	Goranson
12	Conventional Coils (includes TF, PF, and external trim coils)	Heitzenroeder	Heitzenroeder
13	Modular Coils (includes winding and VPI)	Williamson	Williamson
14	Structures	Brown	Brown
15	Cryostat	not used	Brown
16	Coil Services	Cole	Cole
17	Stellarator Core Assembly	Cole	Chrzanowski
18	Stellarator Core Integration	Cole	Cole

- PPPL will procure modular coil winding forms,PF coils,TF coils for both projects to avoid duplicated effort

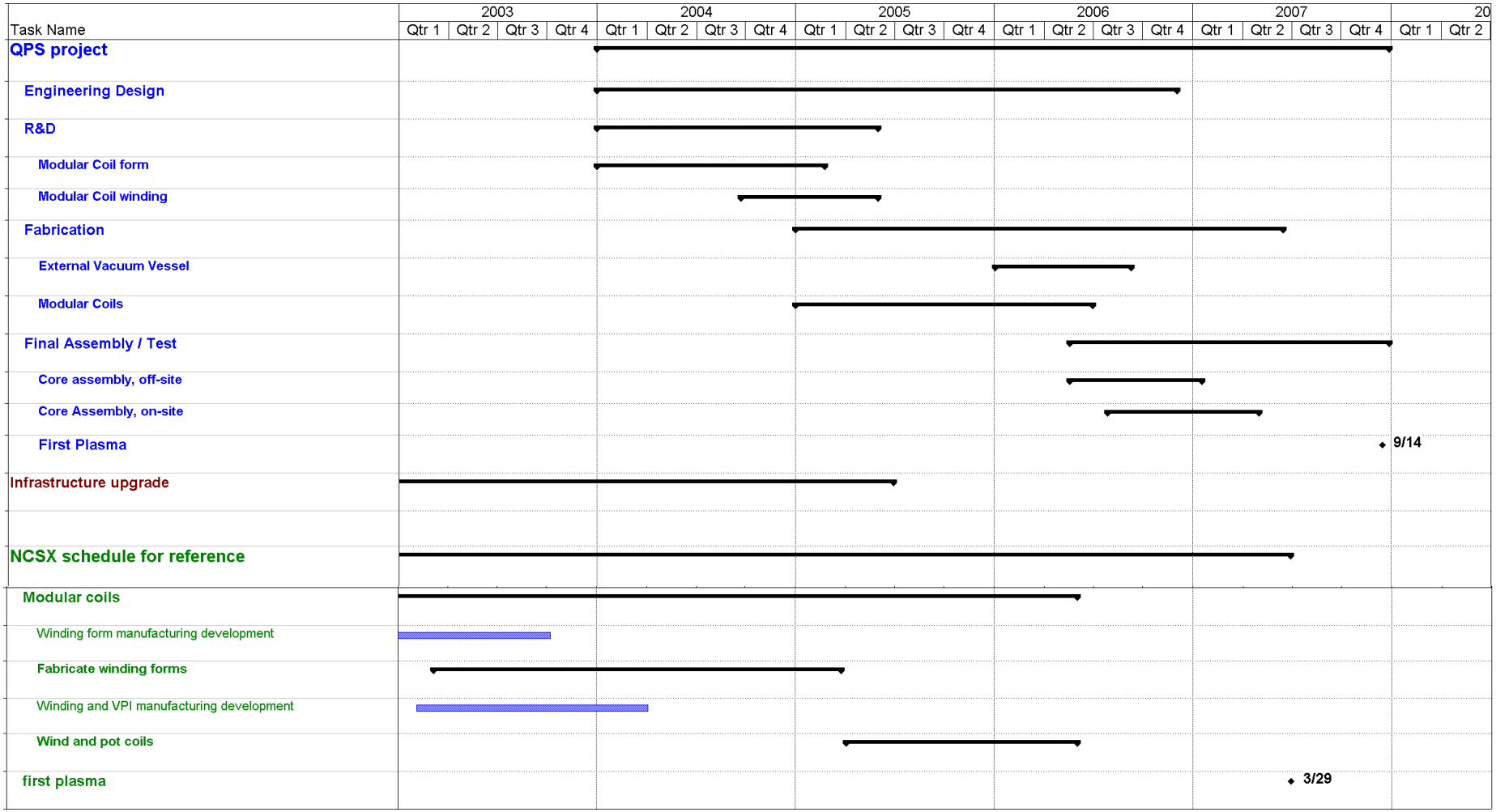
Note: PFCs and external trim coils are upgrades and not part or QPS project, but facility will accommodate them as upgrades

What about engineering staffing?

- NCSX and QPS will both ramp up next year
- Estimated engineering staff totaled for both project
- Staff will be augmented with contract workers leaving SNS project

WBS	System	Estimated engr hours			
		NCSX *		QPS	
		PPPL	ORNL	PPPL	ORNL
	Conceptual and Advanced Conc design	**6000**	**6000**	**1900**	**7600**
1	**Fusion Core Systems**	31050	37950	7420	13781
2	**Auxiliary Systems**			226	2030
3	**Diagnostic Systems Modifications**			245	573
4	**Power Systems Modifications**			136	545
5	**Central I&C and Data Acquisition System Mods**			395	923
6	**Site and Facilities**			0	219
7	**Machine Assembly**			215	1931
8	**Project Oversight & Support**			560	5040
9	**Preparations for Operations**			0	2507
	Aggregate sharing of time, after CDR*	**31050**	**37950**	**9198**	**27549**

Summary Schedule



Summary

- Progress on QPS Engineering Development
  - New vacuum vessel configuration addresses PVR concerns, simplifies design, lowers cost, provides better access,
  - New coil set features split coils for better plasma configuration and more access in center for TF legs and OH solenoid
- Plans for conceptual design
  - Rest of 2002, update design of coils and vacuum vessel and plan R&D
  - FY 2003 – External review, CDR, and prototype coil design for R&D in 2004
- Plans for accomplishing the QPS project
  - Developed preliminary schedule consistent with 2007 operation
  - The design approach takes advantage of NCSX developments
  - The schedule is compatible with NCSX commitments