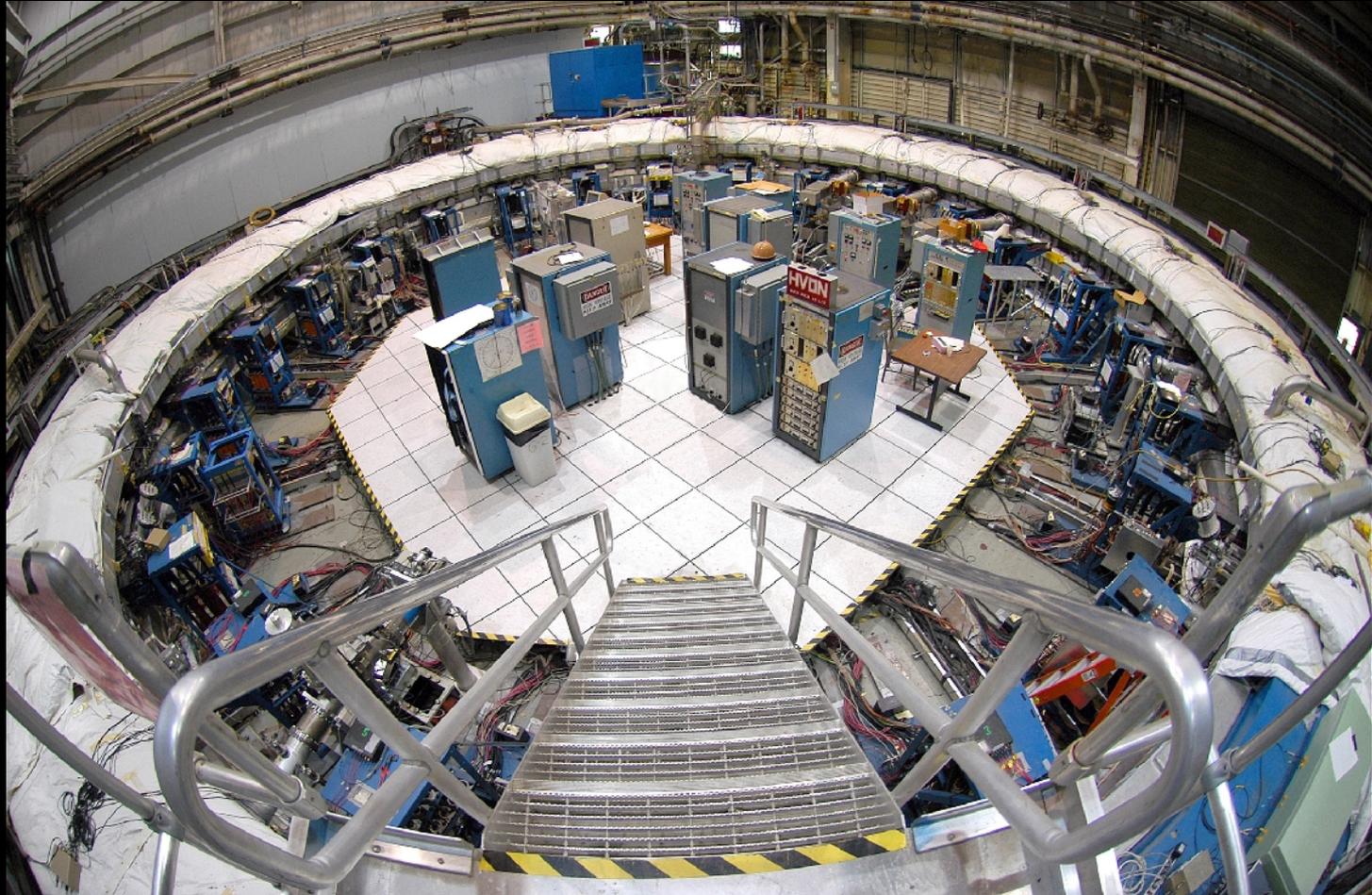


Installation of g-2 at Fermilab

Chris Polly, Fermilab



Included in this talk

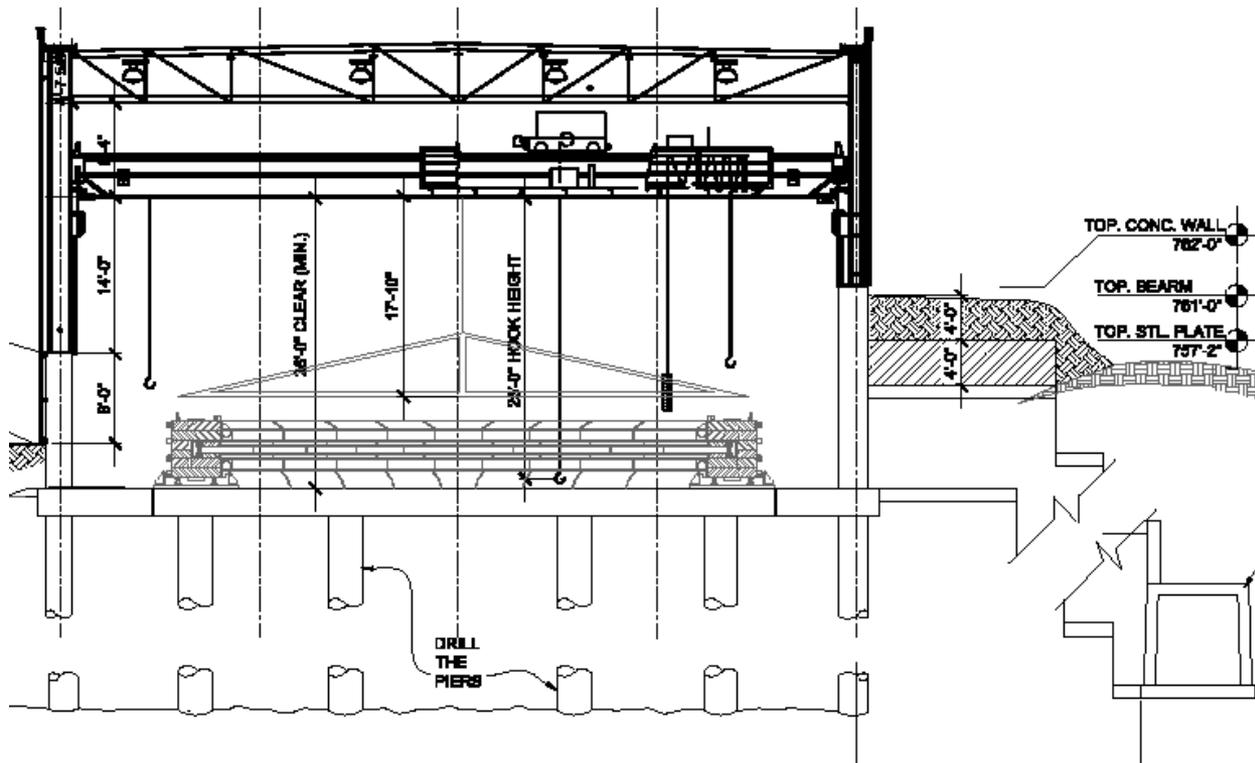
- Critical path items
- Costing and schedule

	Year			
	1	2	3	4
Building Engineering	■			
Building Construction		■		
Ring Disassemble/Move		■		
Ring Assembly			■	
Field Shimming/Subsystems				■

Muon's idea of 'critical path'

Some technical aspects of the building

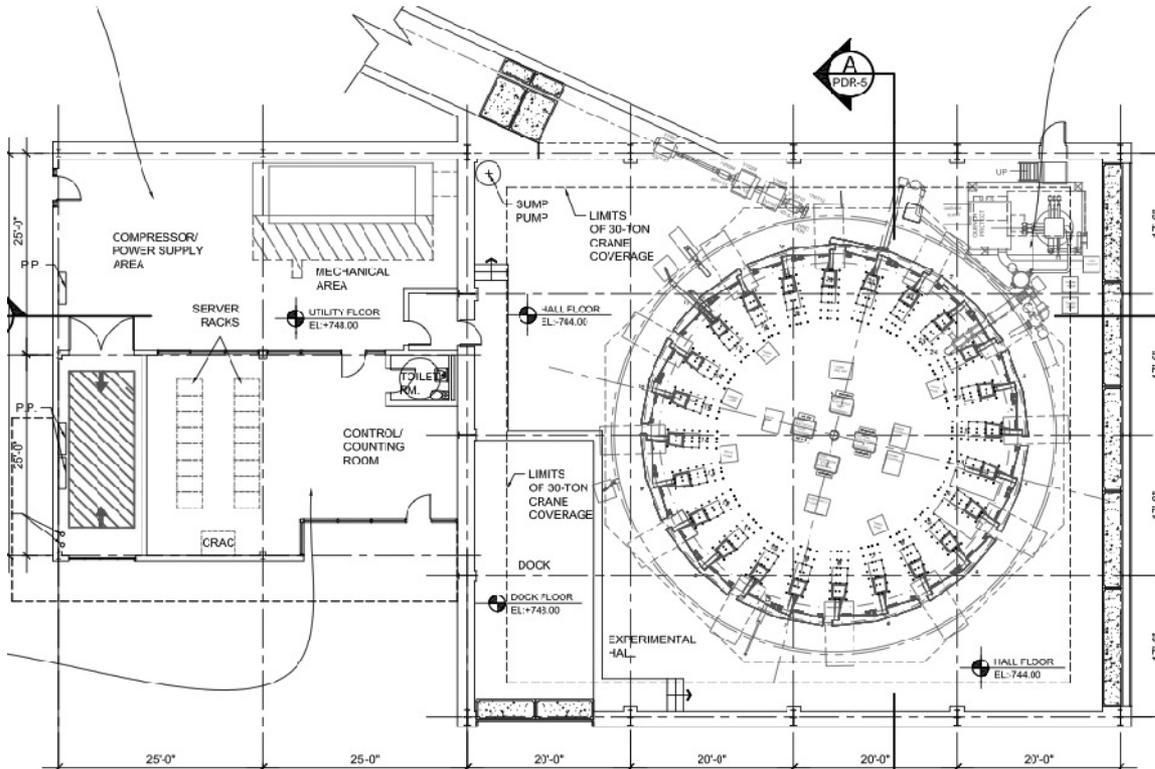
Elevation view of new building design



- 70' x 80' high bay
- ➔ 30 ton crane
- 50' x 50' low bay
- ➔ control room, mechs, power supplies, & WC
- Shielded tunnel connect
- Floor supports 650 ton ring via caissons down to bedrock
- 4' below grade with 2'x8' shielding wall
- Temp. stable to +/- 2 F

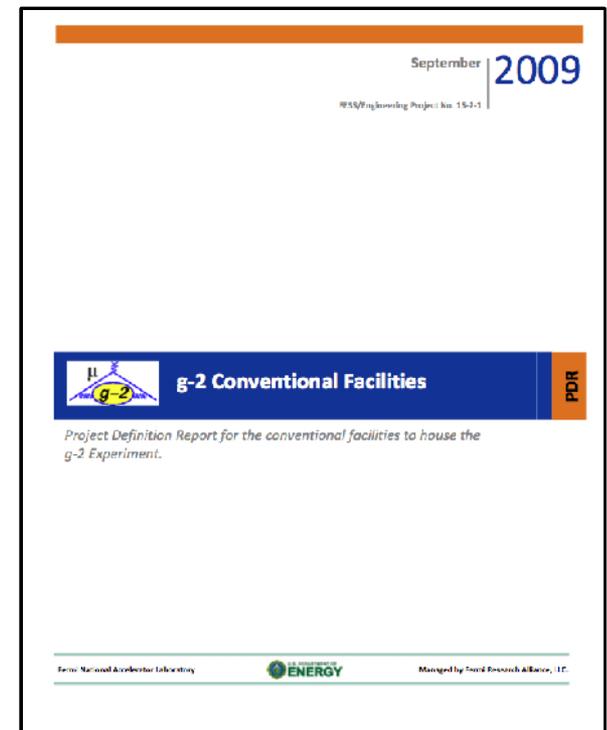
Muon beam delivered to new building

Overhead view of new building design



● Fermilab engineers (FESS) have developed an initial Project Definition Report (PDR)

- ➔ Site considerations
- ➔ Tunnel connection to bldg
- ➔ Muon experimental hall

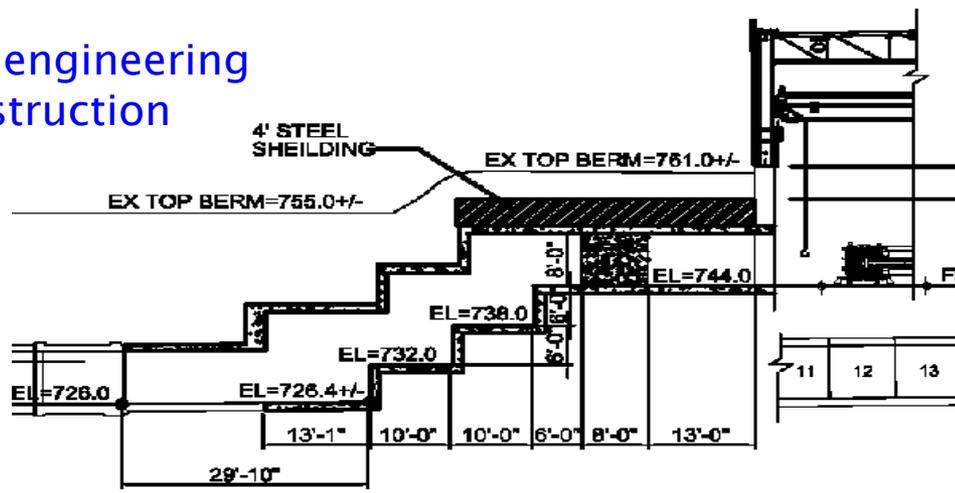


*included on USB stick

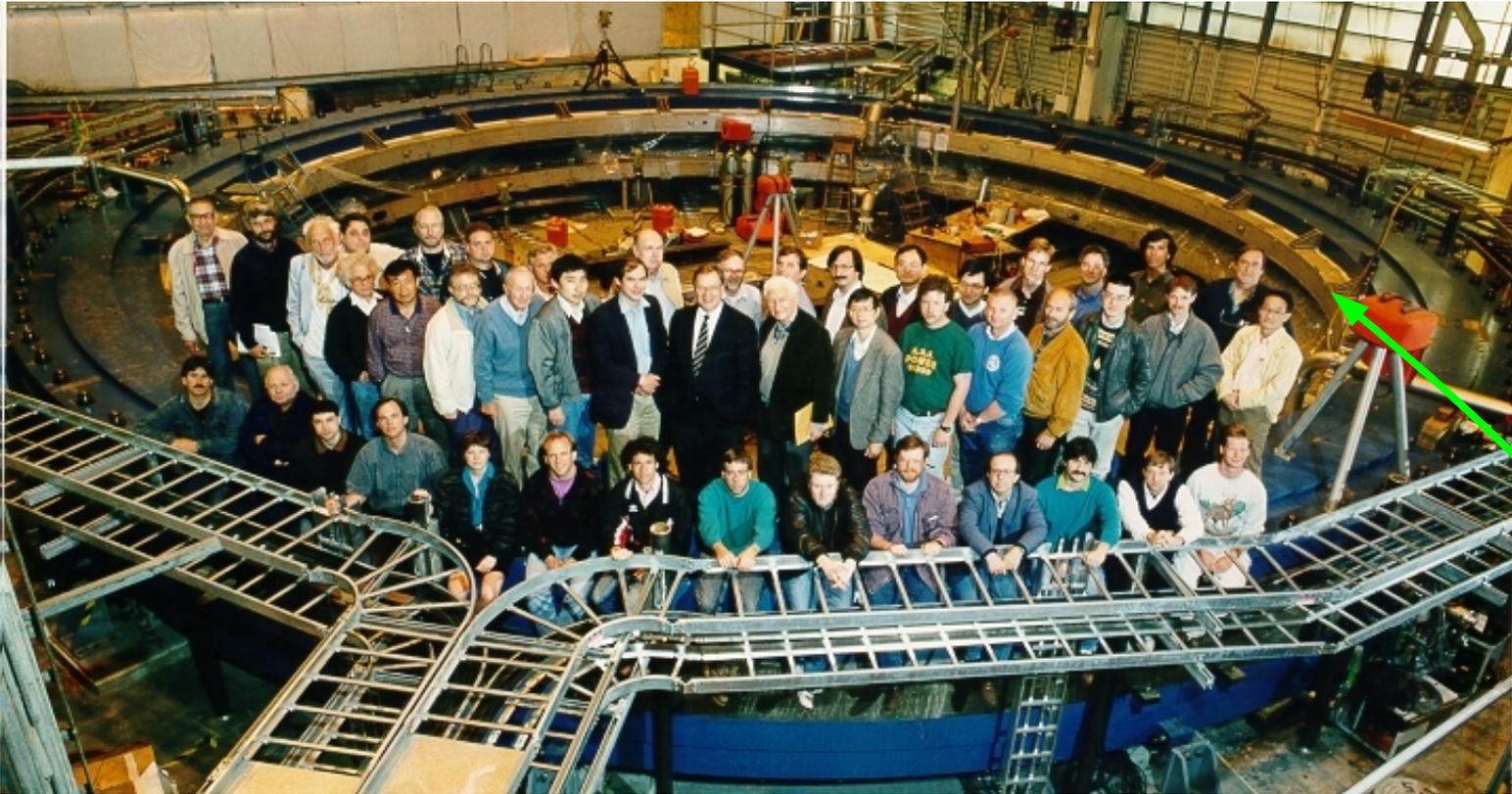
How it might look on-site at FNAL



9 months finalize engineering
+ 9 months for construction



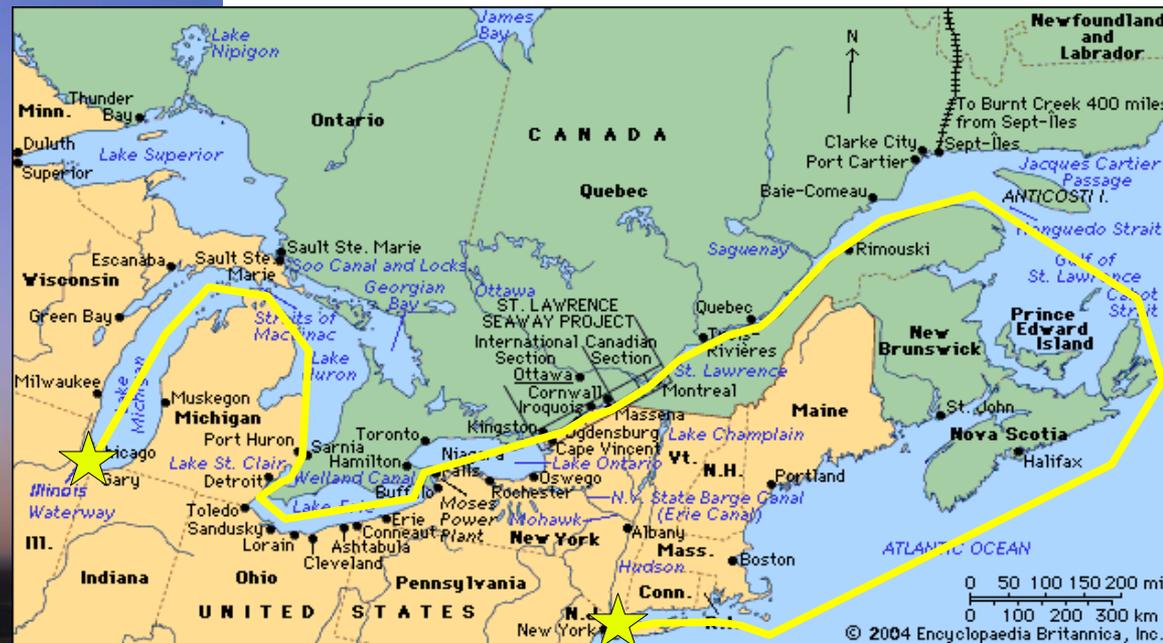
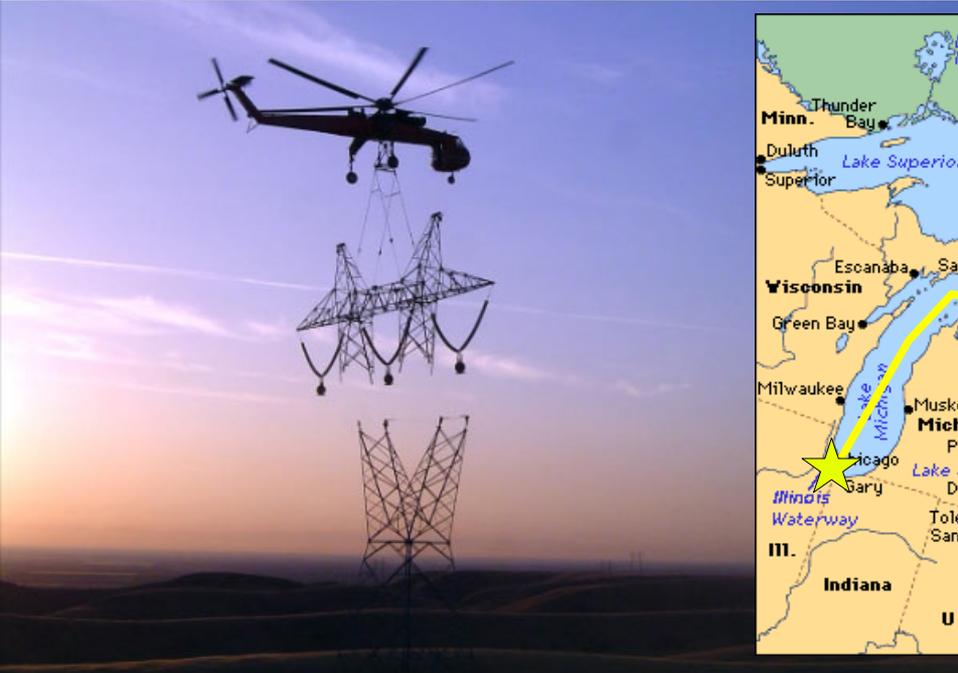
Moving the ring to Fermilab



- C-shaped return yoke built in 12 sections. Requires transporting 650 tons of steel, but can be disassembled (heaviest pieces ~20 tons)
- Three monolithic 14 m diameter cryostats with superconducting coils inside do not come apart...too big for overland shipping

Barge around St. Lawrence

- Airlift coils to barge off Long Island
- Estimated barge cost \$1M to transport yoke steel and coils
- Ship through St Lawrence -> Great Lakes -> Calumet SAG
- Airlift from somewhere around Romeoville, IL to Fermilab



Cryostats airlifted to barge for transport



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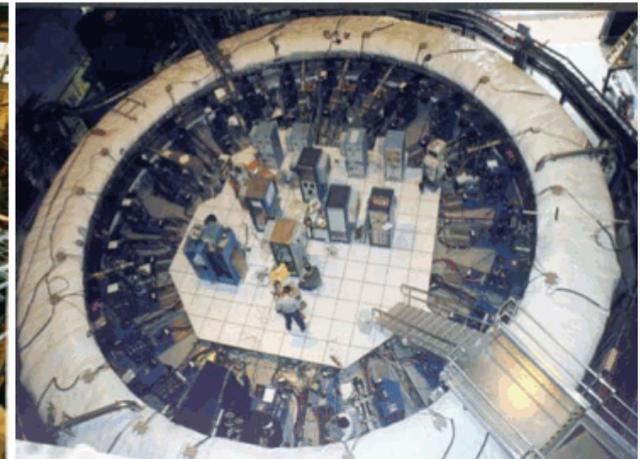
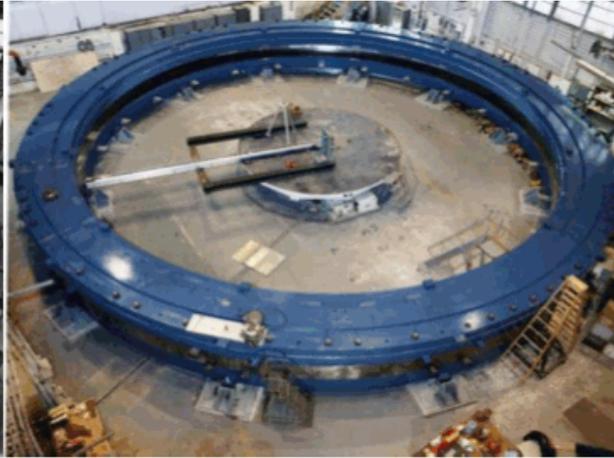
TRAINING SERVICES
Flight Crew Training | Maintenance Training | Contract Crew Services

11/30/2009 "Elvis" and "Isabelle" Arrive a Month Early to Help Australians...

<http://www.ericksonaircrane.com/>

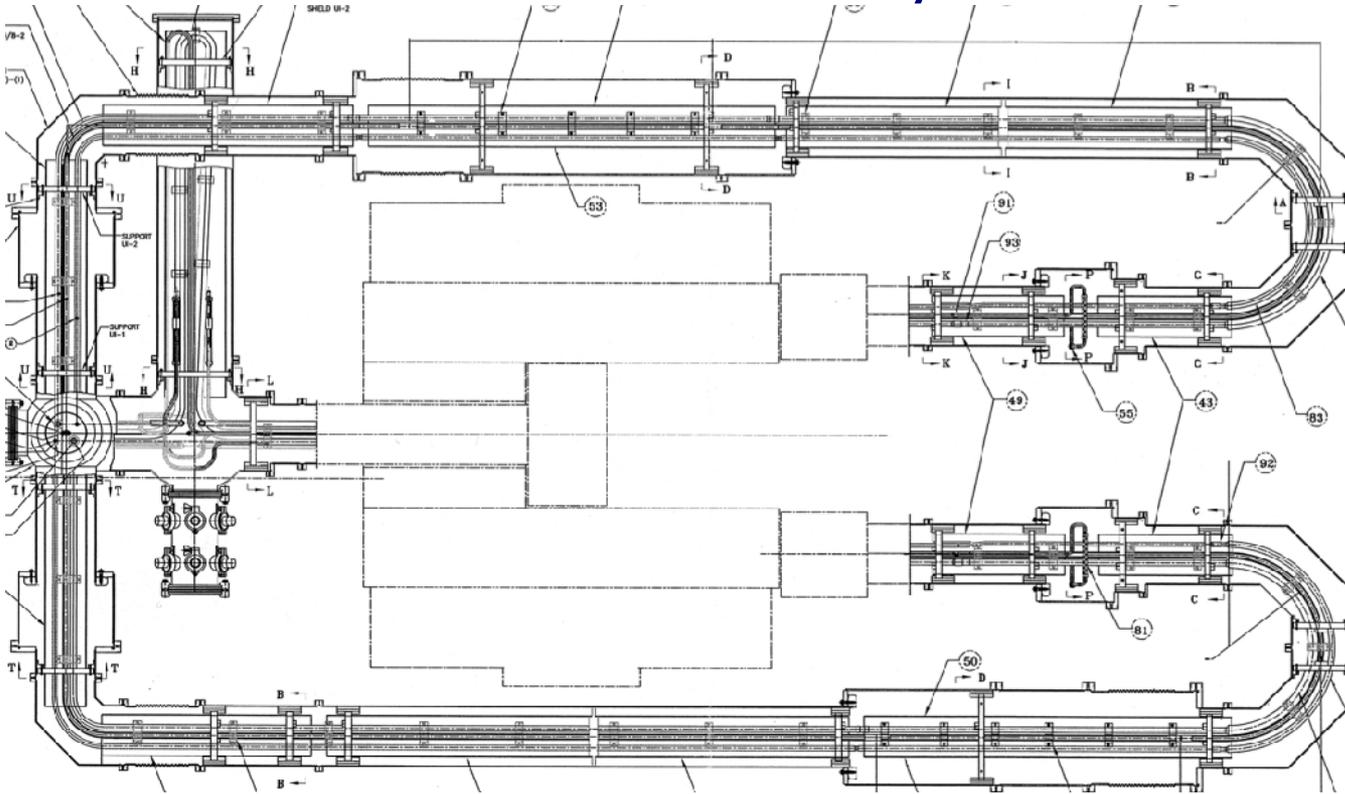
- Several discussions with Erickson Air-Crane for handling lift operations
- Cost per lift <\$100k (additional 75% contingency added in proposal)

Disassembly and reassembly



- Pictures showing a few stages of the assembly at BNL..note coils have been lifted and craned before, still have lifting fixture available

Disassembly



- Most delicate part of disassembly is disconnecting superconducting interconnects
 - ➔ Interconnects for main ring shown above, separate inflector interconnect
 - ➔ BNL master tech responsible for original assembly, Don von Lintig, still at BNL. Available for leading BNL disassembly effort/consulting on FNAL reassembly
- Consultation with original BNL engineers/technicians -> 6-9 months to take apart

Reassembly

Main Ring Assembly	Techs	Time
Prepare floor	2	2
Install plates & bookends	4	2
Bottom steel & survey	4	5
Back steel & survey	4	2
Outer coils survey, leak check	5	2
Top steel & survey & bolt	6	5
Upper/lower coils survey, check	5	3
Total Labor (techs*weeks)		95

Prep Work	Techs	Time
Steel	2	2
Pole pieces	2	2
Quadrupoles	2	24
Kickers	2	12
Vacuum chambers	2	4
Total Labor (techs*weeks)		88

Subsystem Assembly	Techs	Time
Interconnects	3	12
Pole tips	4	12
Correction coils	2	2
Install inflector	4	2
Quad chambers & ceramics trolley rails, leak check	4	12
Vacuum connections	2	4
Kickers	2	8
Trolley devices	2	4
Beam devices	2	4
Detectors	4	2
Cables	4	3
Power supplies	4	3
Cryo outside ring	4	6
Vacuum outside ring	2	4
Total Labor (techs*weeks)		252



- Timeline developed by consultation with original WBS & meeting with original engineers, technicians, physicists, and project manager
- 18 months to assemble

“Think of it as constructing a 650 ton Swiss watch” Don von Lintig

Shimming the magnetic field/install final subsystems

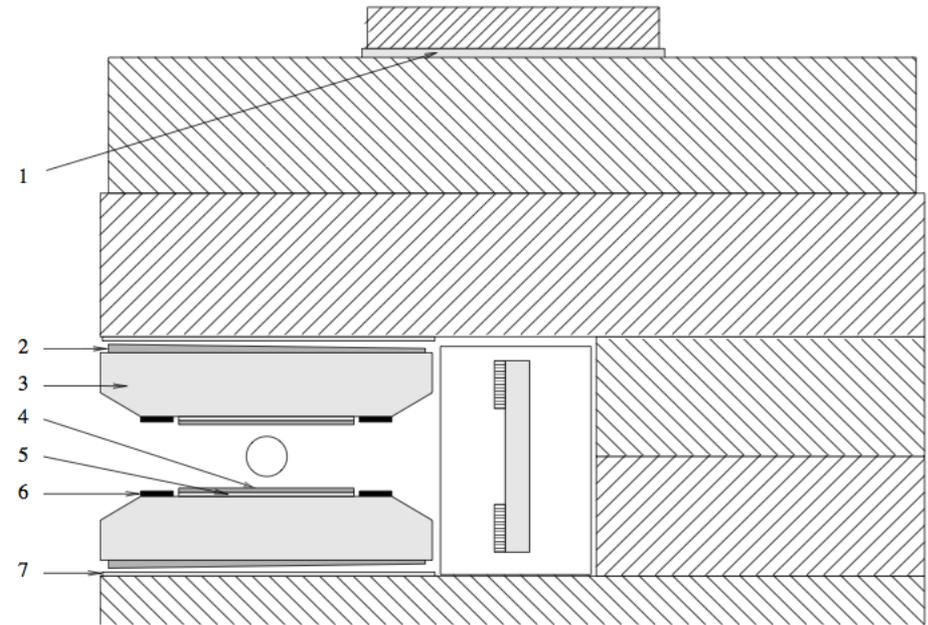
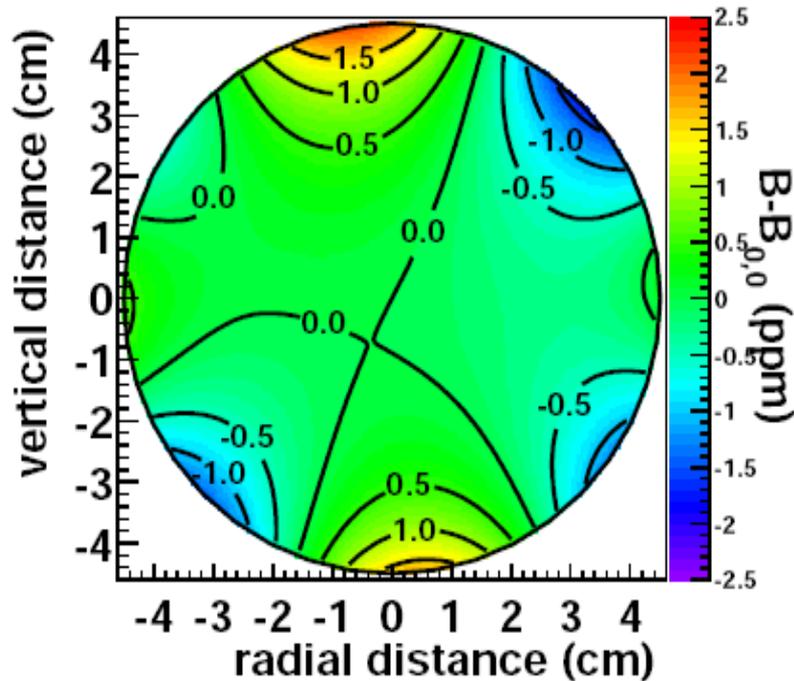


Figure 2: Shimming techniques: 1 – aluminum or iron shims between top and/or bottom iron plate and the rest of the yoke; 2 – iron wedges; 3 – tilting of poles; 4 – aluminum/iron sandwiches; 5 – surface correction coils; 6 – Rose (edge) shims; 7 – dipole correction coils

- Sub-ppm B precision is challenging
- Requires functional NMR systems
- Iterative process of making measurements and adjusting via 7 techniques
- Estimate 9 months to shim
- ➔ Use the time to also commission many other subsystems

- That's it for the critical path for timeline drivers
- Many other experimental subsystems coming from BNL, and worked into the schedule...montage of photos from recent trip to BNL

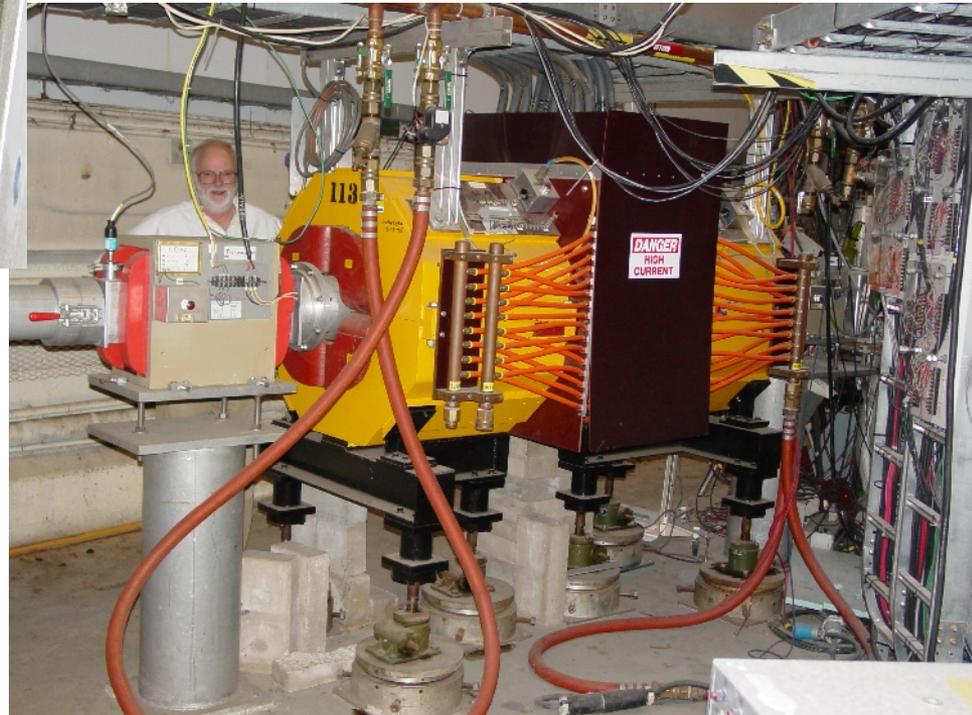
	Year			
	1	2	3	4
Building Engineering	■			
Building Construction		■		
Ring Disassemble/Move		■		
Ring Assembly			■	
Field Shimming/Subsystems				■

Subsystems--beamline, final focus

80m Beamline Elements + Spares



Final Focussing Into Ring Elements



Beamline Magnet PS



Subsystems--magnet power, controls, quench



Subsystems--vacuum chambers, pumps, controls

Gauges and Controls



Scalloped Vacuum Vessels



Cryo Pumps



Roughing Pumps

Other Subsystems--by no means complete list

Fiber Harp Monitor



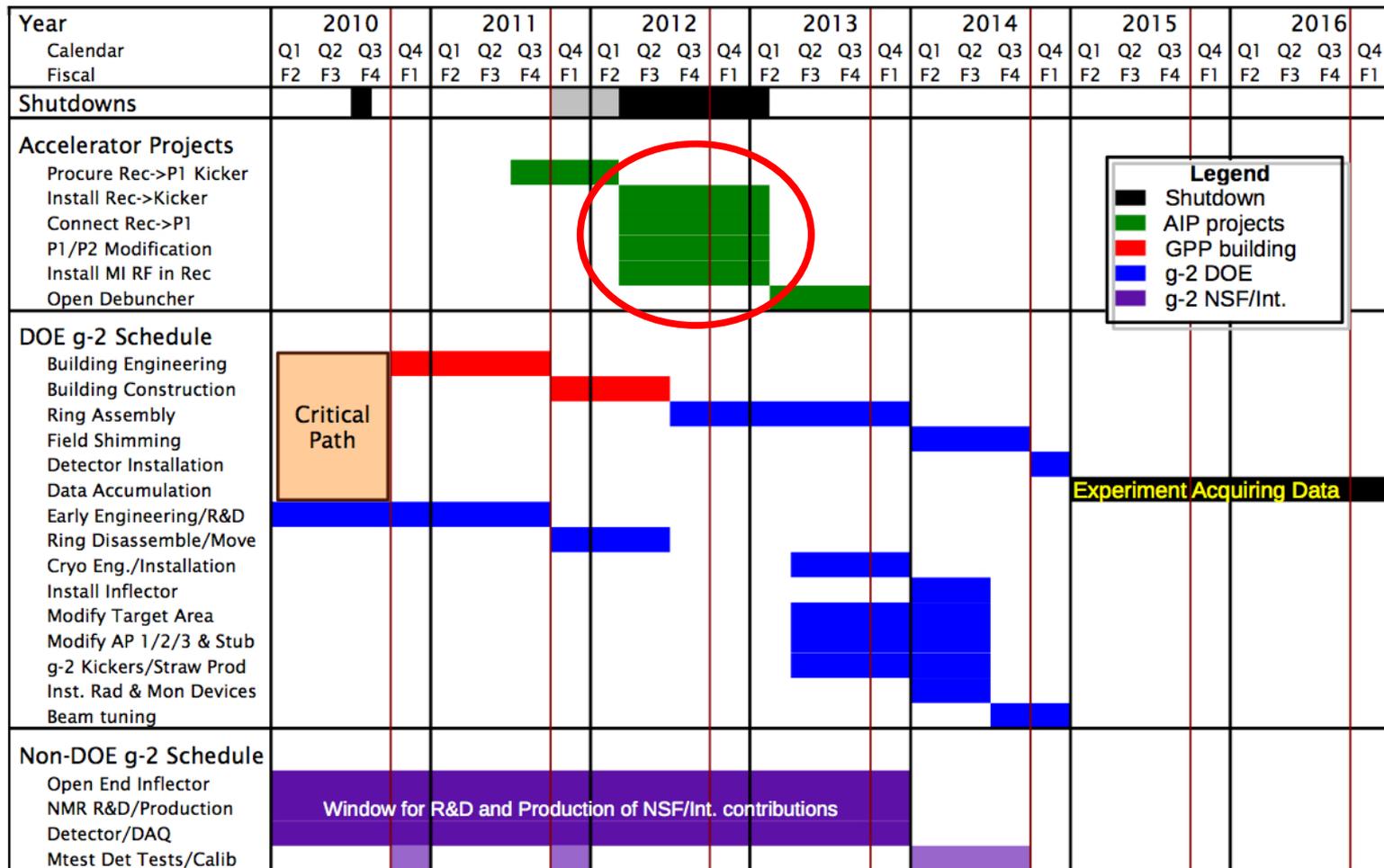
Cryo Infrastructure



NMR Trolley Systems

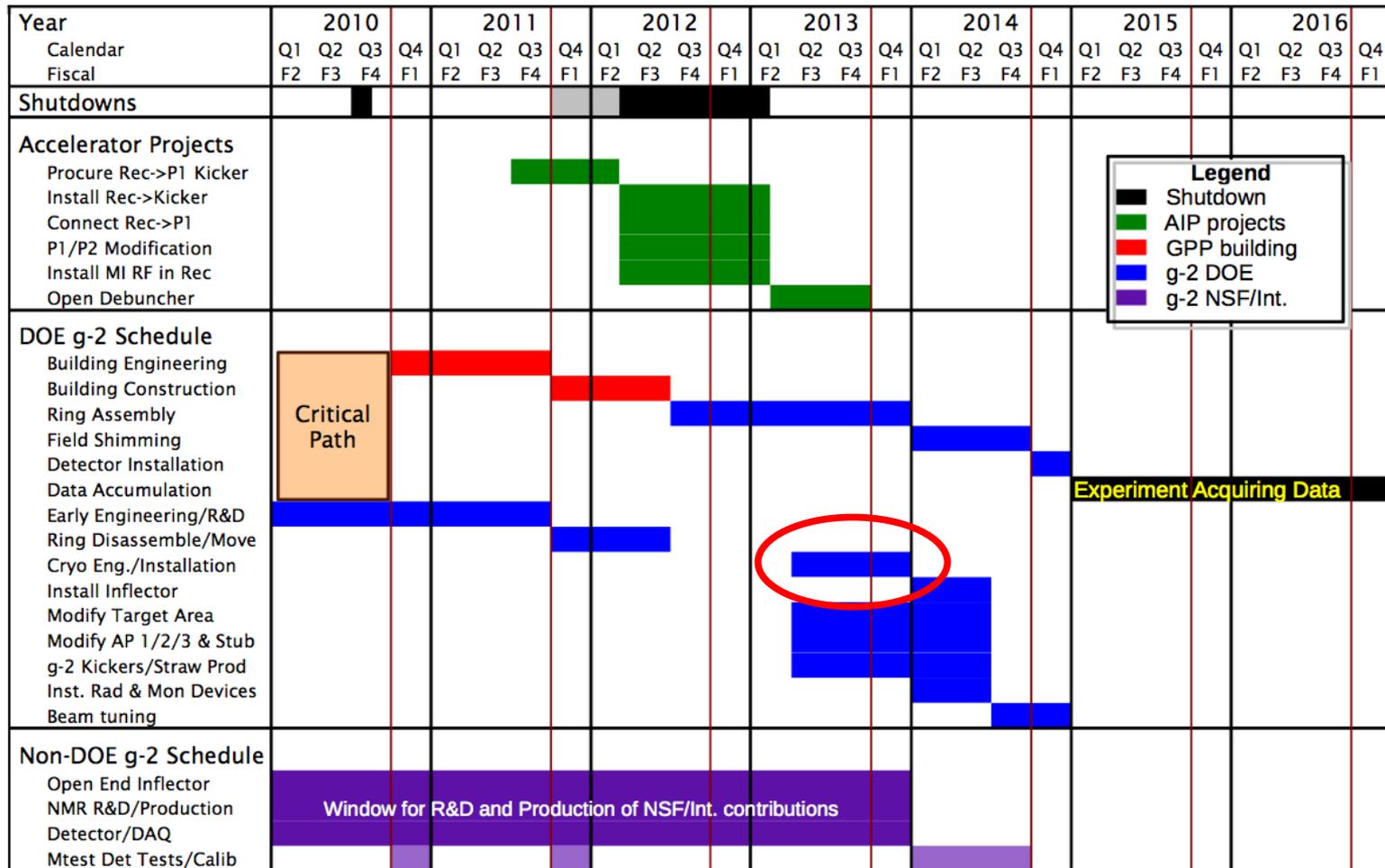


Expanded Project Timeline



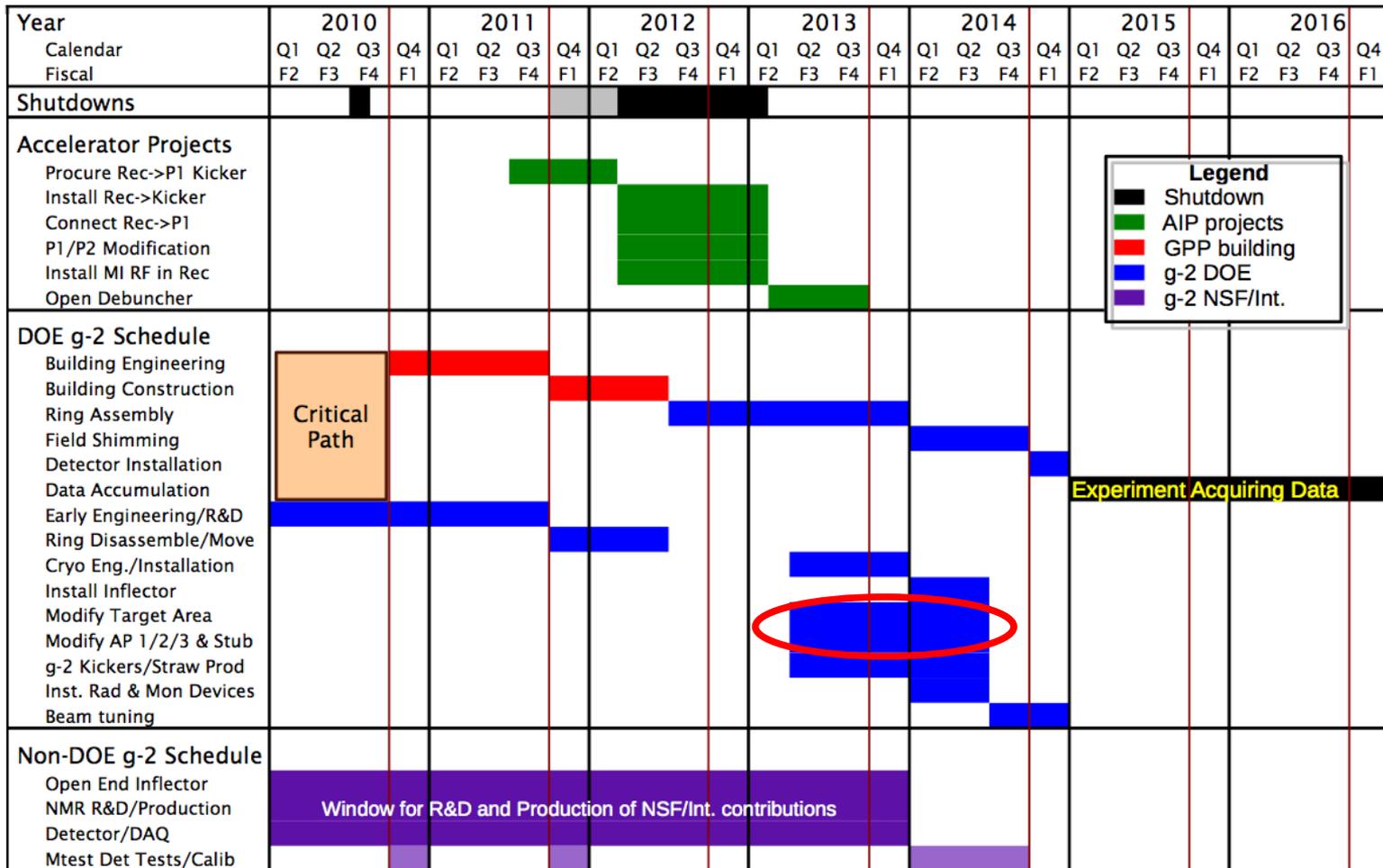
- Upgrades in Recycler most conveniently done in 2012 shutdown
- ➔ ~60% of upgrades also needed for Mu2e

Expanded Project Timeline



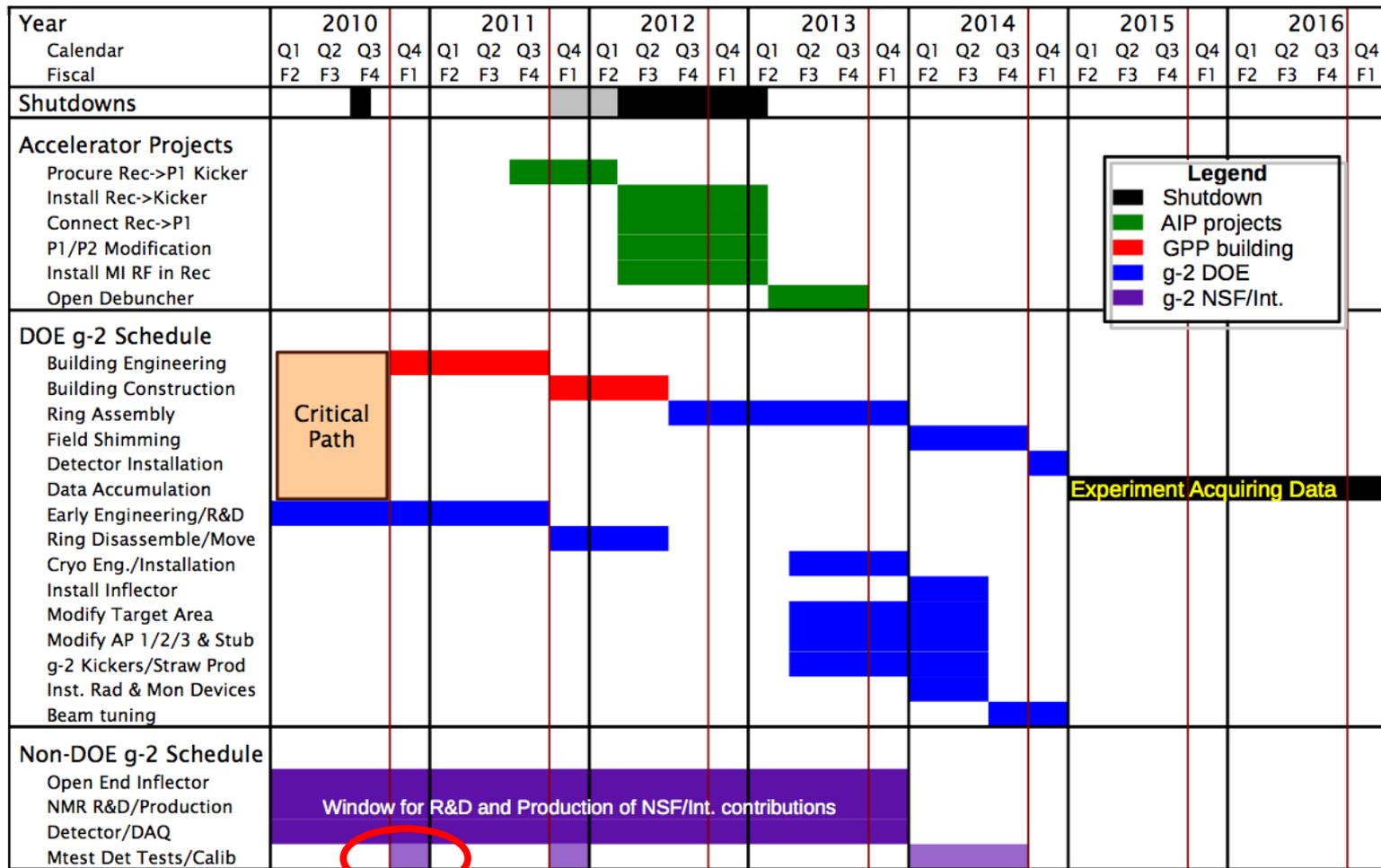
● Cryo and magnet power required to shim

Expanded Project Timeline



- Beamline/target work can proceed in parallel with assembly and shimming

Expanded Project Timeline



● Detector test at the FNAL Test Beam Facility planned

➔ First one completed this summer (ahead of schedule)

Cost summary

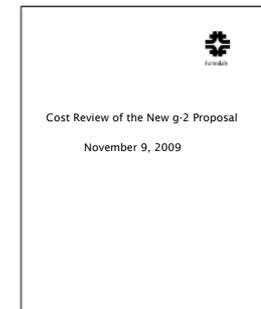
Building & Tunnel Connection	Cost	Cont.	Total
<i>g</i> -2 conventional facilities	5240	25%	6550
Total	5240	25%	6550

Accelerator Upgrades	Cost	Cont.	Total
Recycler RF	3022	17%	3536
Recycler extraction kicker	711	50%	1066
Recycler to P1 transfer*	2043	50%	3065
Prepare P1/P2/AP1 lines*	850	50%	1275
Open Debuncher aperture*	250	50%	375
Total	6876	36%	9317

<i>g</i> -2 Experiment (Other)	Cost	Cont.	Total
Detector/electronics/straws/DAQ	3066	30%	3986
Inflector	462	30%	600
Field probes	154	30%	200
Moving ring (BNL D&D)	571	75%	1000
Total	4253	36%	5786

<i>g</i> -2 Experiment (DOE-HEP)	Cost	Cont.	Total
New replacement target	43	50%	64
Li lens (costed) or 2 rad-hard quads	733	50%	1100
PMAG (pulsed or DC rad hard)	425	50%	638
Quads in AP2	400	75%	700
Debuncher, AP3 & Beamline stub	1050	75%	1838
Radiological issues	67	50%	100
Diagnostics	300	50%	450
Moving ring (\$1M also in D&D)	2209	75%	3865
Recon ring & maintenance	3000	50%	4500
Cryo for <i>g</i> -2 experiment	1270	50%	1905
Inflector installation	504	19%	600
Kicker modification	570	42%	809
Fermilab straw detectors	385	30%	500
Project management	2000	30%	2600
Total	12956	52%	19669

- Total project cost of \$41M (\$12M in cont & \$6M common to Mu2e)
- Independent cost review agrees with collaboration's to 5-10%



Conclusions

- Experiment can be ready ~3 yrs from building ground-breaking
- Establishing high intensity beam from Booster -> Recycler -> P1 Transfer and in Debuncher gives Mu2e a head start
- Costs are understood and include appropriate contingencies, independent review agrees to 5-10% in overall TPC
- The g-2 storage ring and subsystems represent a substantial DOE investment (\$25M in 1990 capital costs), coupling to the FNAL accelerator complex they will provide a 2nd (and possibly 3rd) generation experiment