The FAARM

Requirements, Conceptual Layout

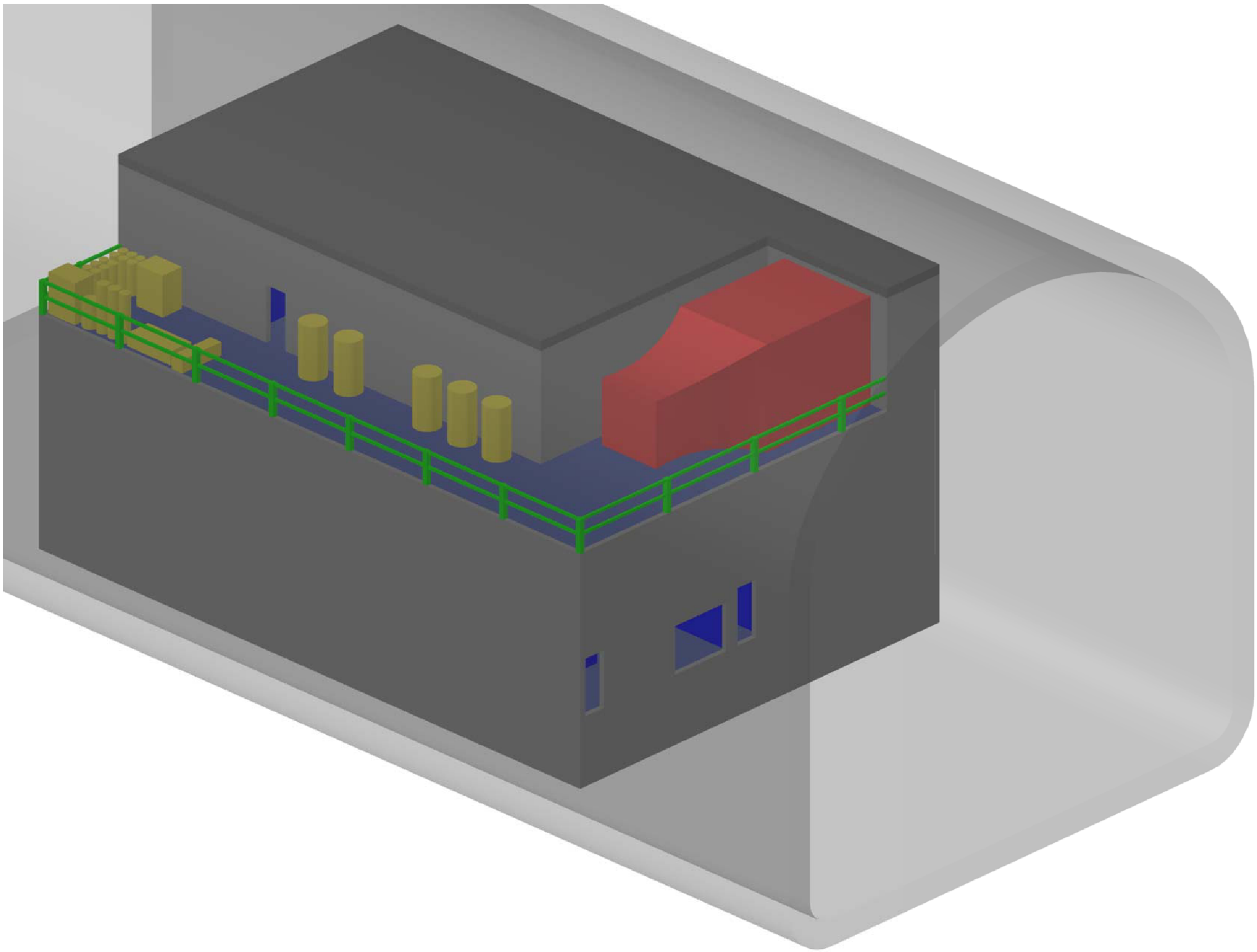
Lee Petersen, CNA Engineers

Purpose, Plans, and Early Screening

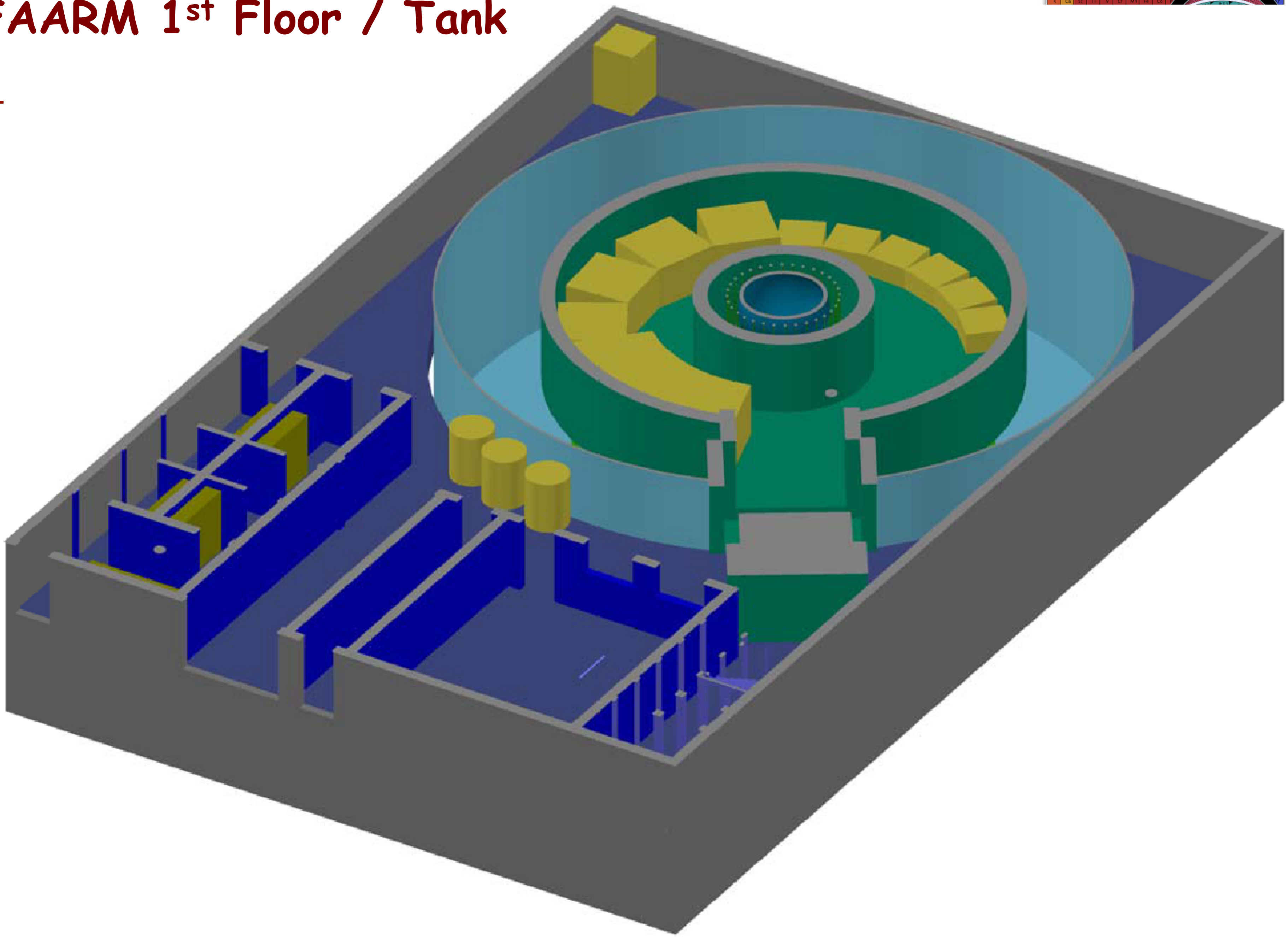
Prisca Cushman, University of Minnesota

AARM Collaboration Meeting
November 12, 2010

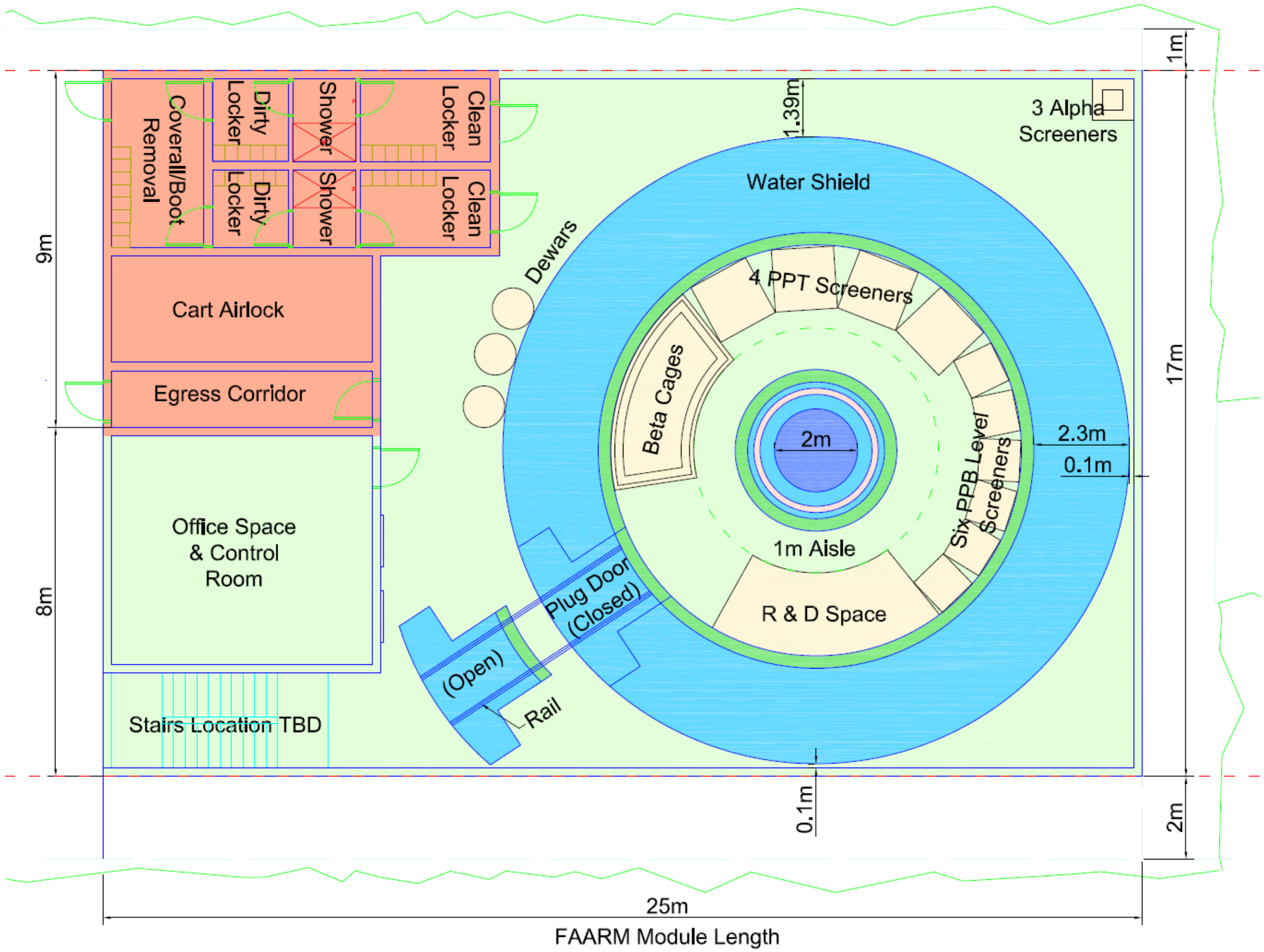
FAARM



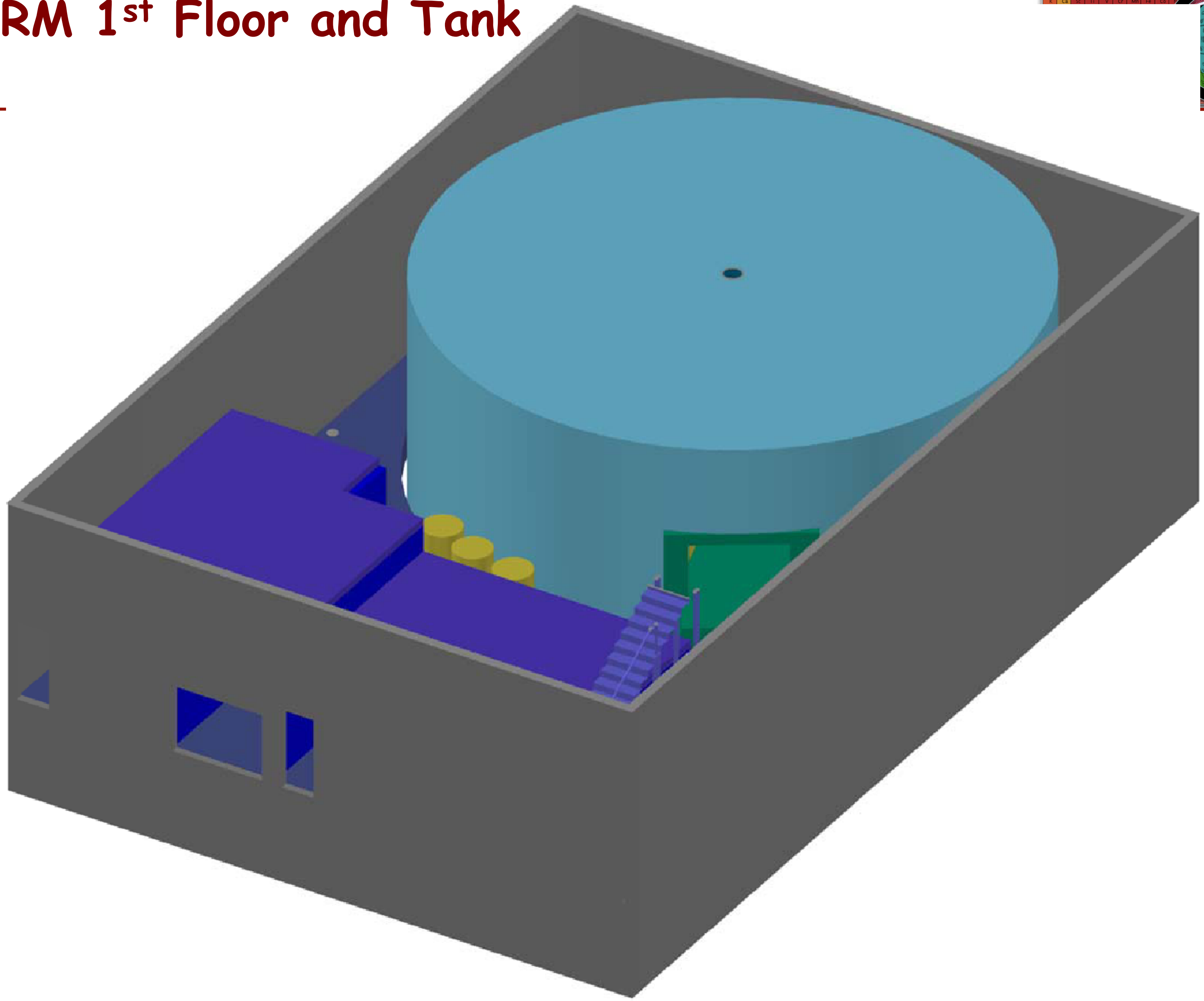
FAARM 1st Floor / Tank



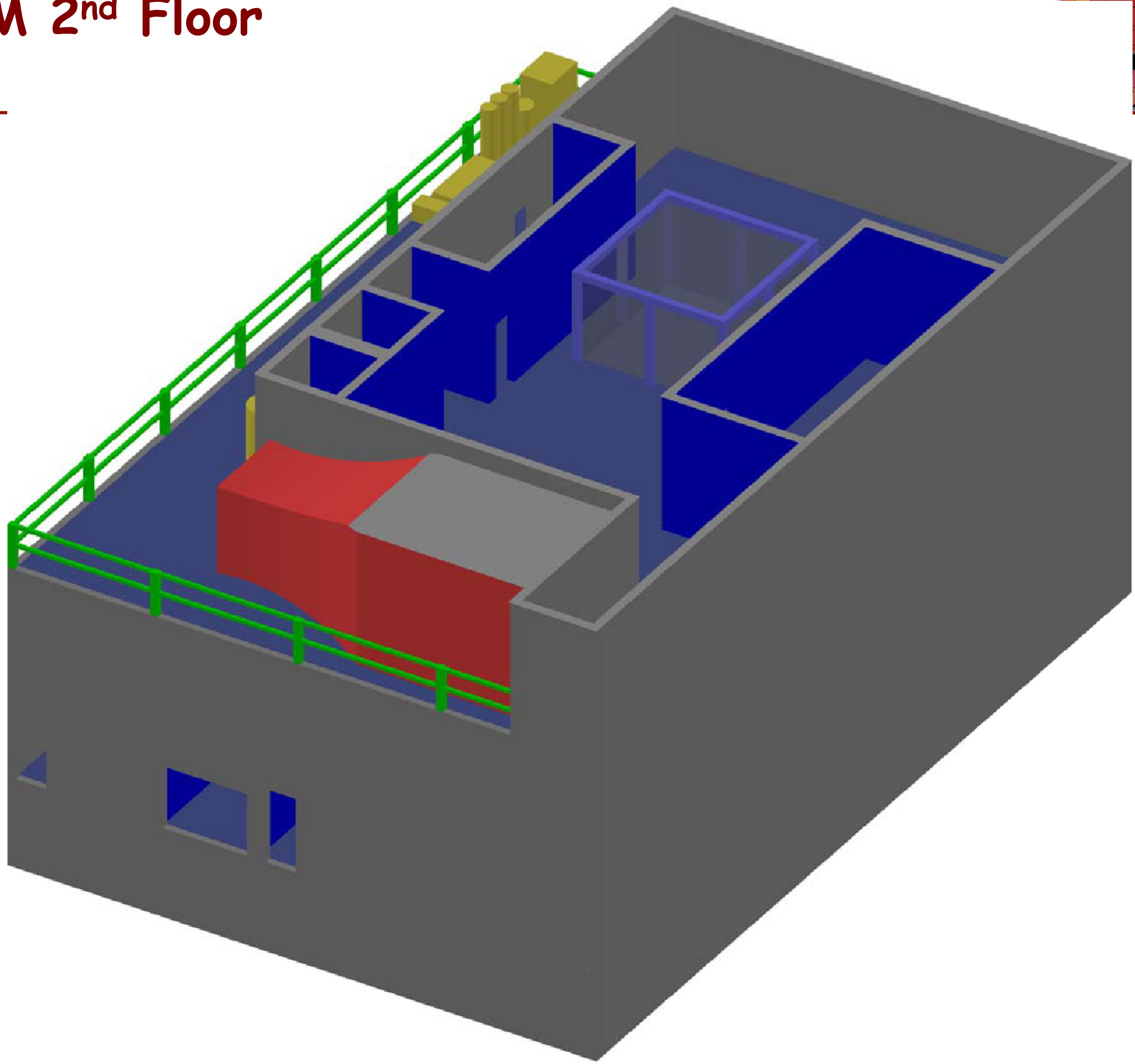
FAARM First Floor



FAARM 1st Floor and Tank

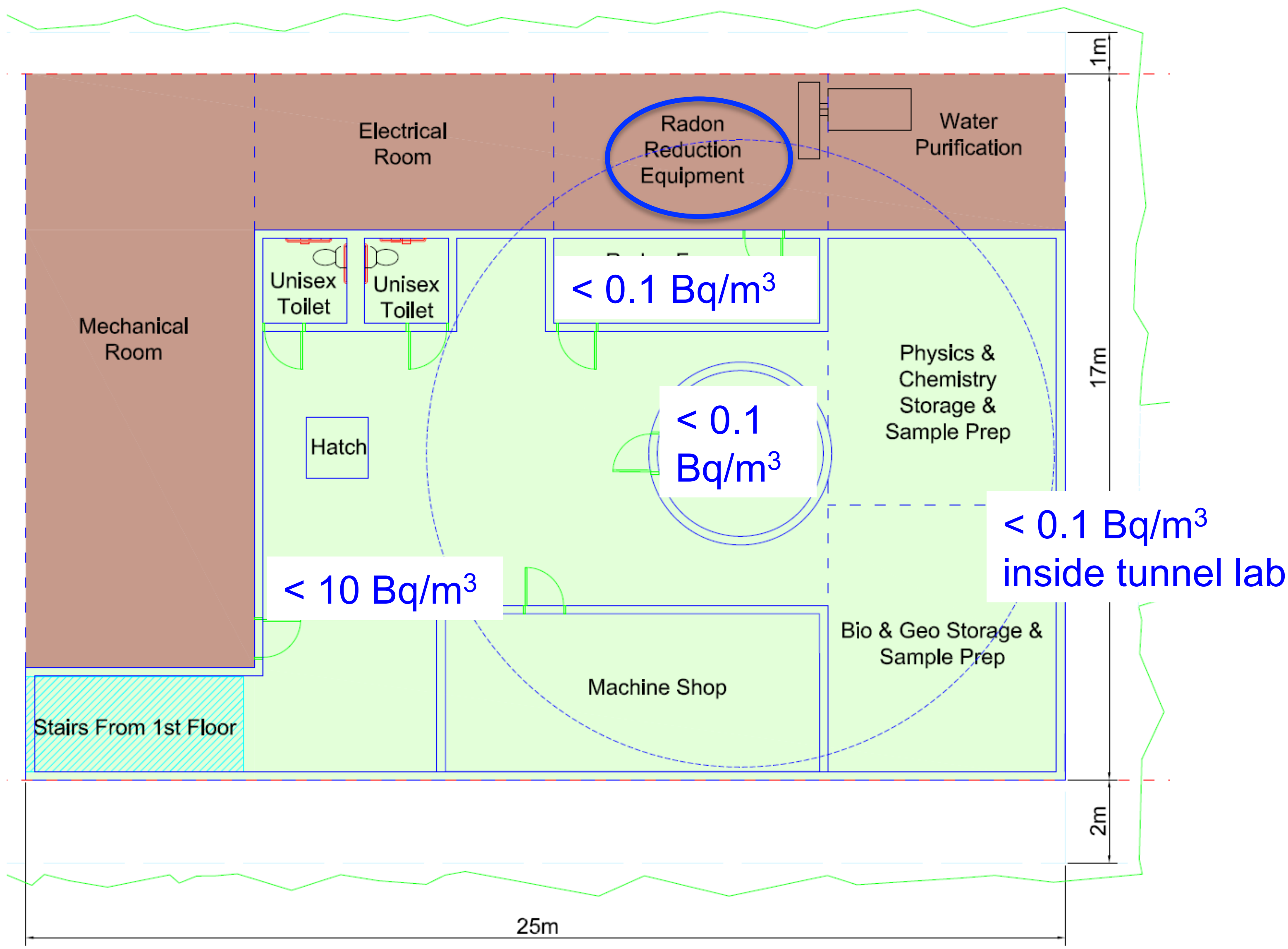


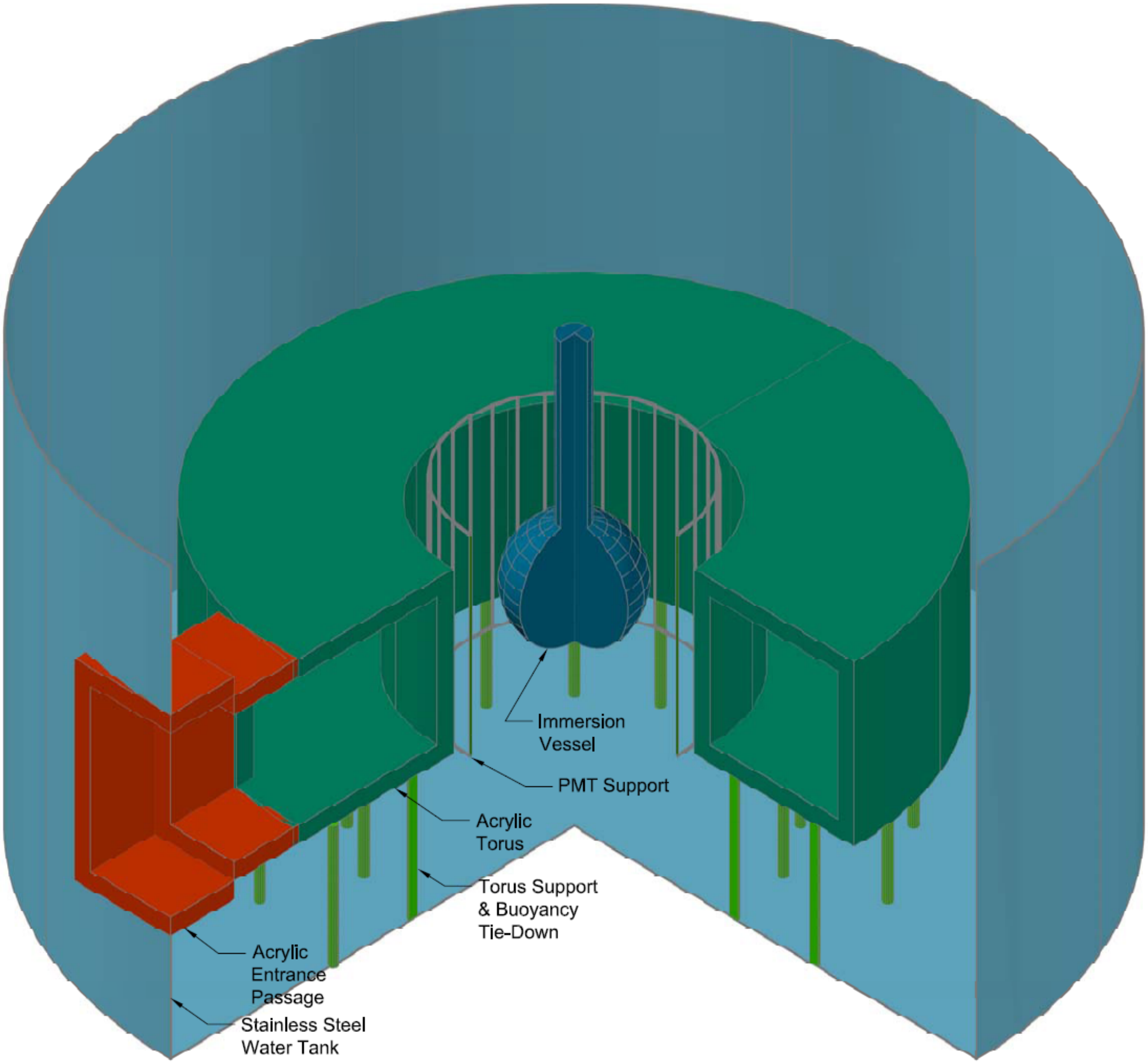
FAARM 2nd Floor

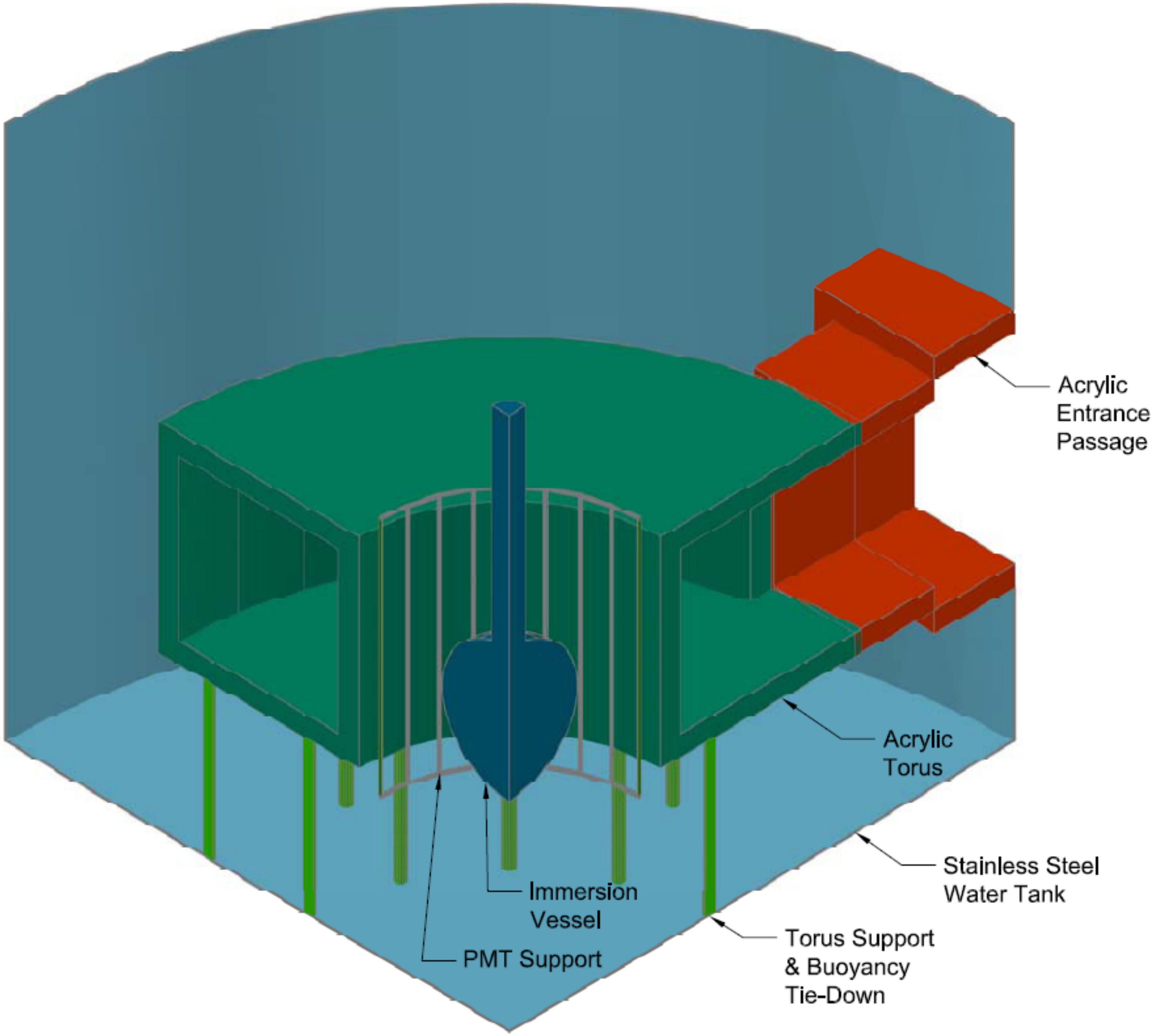


FAARM Second Floor

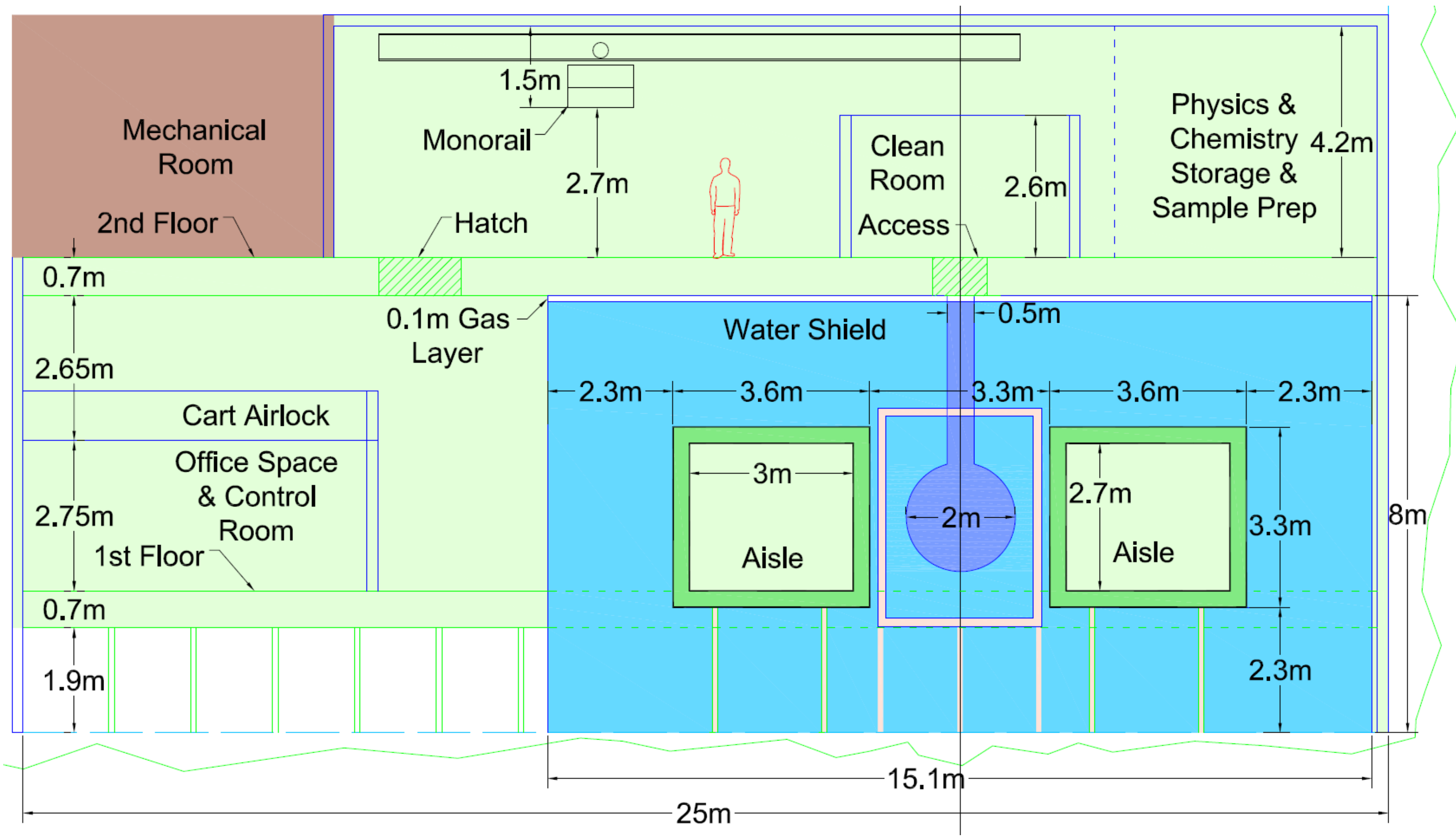
Staged Radon Mitigation
~ 200 Bq/m³ outside



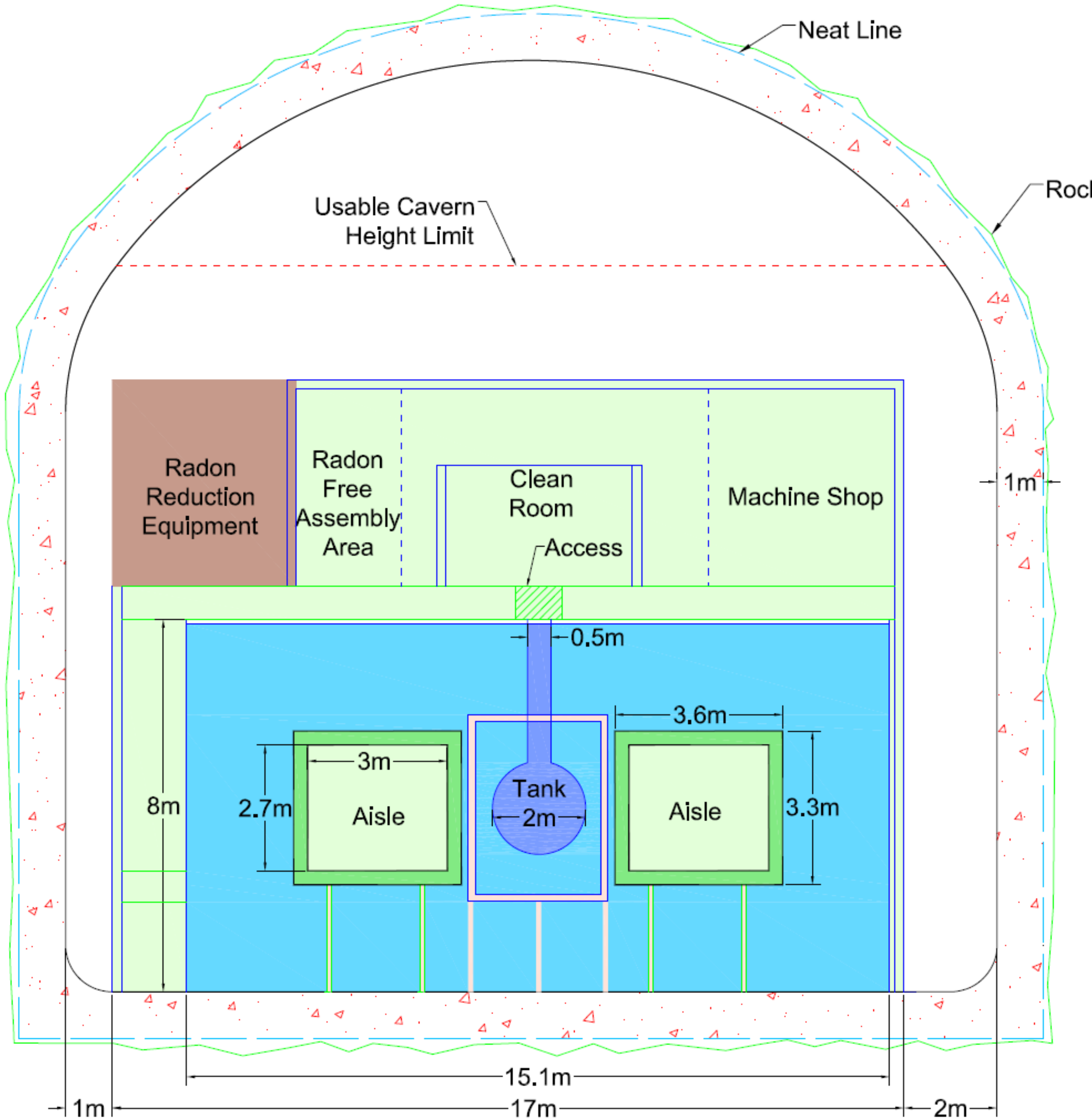

Immersion
Vessel
PMT Support
Acrylic
Torus
Torus Support
& Buoyancy
Tie-Down
Acrylic
Entrance
Passage
Stainless Steel
Water Tank


Acrylic
Entrance
Passage
Acrylic
Torus
Stainless Steel
Water Tank
Immersion
Vessel
PMT Support
Torus Support
& Buoyancy
Tie-Down

FAARM Elevation



FAARM Section At Tank



Ventilation: Clean room and Civil Engineering

- One approach:
  - Follow ASHRAE design codes (classified clean room)
  - Based on extensive experience
  - Produce designs with large mechanical systems
  - Many air changes per hour
  - Result is a very reliable system that will produce the desire cleanliness
- Another approach:
  - Follow the experience of SNO, etc.
  - Far fewer air changes per hour
  - Achieve cleanliness with protocols and cleaning
  - Reduces capital cost, increases operating costs (labor)
  - Increases risk
  - LUX/Majorana for Davis Campus is 15 ach

Power Requirements

Description	Base Power Consumption (kW)	Diversity Factor	Power with Diversity Factor (kW)	Heat Sink	Comment
Clean Facility Requirements					N.A.
Water Shield	5	1	5	Air to chiller	Estimated by dlp, possible shared with others
Veto Shield		1	0	Air to chiller	Eliminated
Ultra-Sensitive Immersion Tank		1	0	Air to chiller	Eliminated
Gamma Counting Stations	15	1	15	Air to chiller	From FAARM documentation
Commercially available sub-ppb screeners	12	1	12	Air to chiller	Used "other alpha/beta counters"
Customized sub ppt screeners	2	1	2	Air to chiller	Used "other alpha/beta counters"
Ultrasensitive screeners	10	1	10	Air to chiller	Used "beta/alpha sensitive screeners"
Alpha screeners	0.6	1	0.6	Air to chiller	from Richard Schnee
Beta cages	5	1	5	Air to chiller	from Richard Schnee
Radon emanation chamber	1	1	1	Air to chiller	from below
Clean Machine Shop	10	0.25	2.5	Air to chiller	Estimate based on Majorana
Physics & chemistry storage & sample prep	0.93	1	0.93	Air to chiller	17 kWh/sf/yr
Physics & chemistry storage & sample prep	5.00	0.5	2.50	Air to chiller	From FAARM documentation, 20 amps at 220 v
Bio storage and sample prep	0.81	1	0.81	Air to chiller	17 kWh/sf/yr
Cryogen infrastructure					N.A.
Water purification infrastructure	10	1	10	Air to DUSEL	Estimate based on LUX
Radon reduction equipment				Air to DUSEL	Not included at this time
Electroforming					Located in another space
Intermediate Overburden Level					N.A.
Surface					N.A.
Lighting	22.7	0.7	15.9	Air to chiller	Space by space summary
Miscellaneous receptacle loads	22.7	0.2	4.5	Air to chiller	Same as lighting
Storage	0.60	1	0.6	Air to chiller	17 kWh/sf/yr
Control room and office	1.08	1	1.08	Air to chiller	17 kWh/sf/yr
Air handlers	75	1	75	Air to DUSEL	Extrapolated from LUX/MJ
Subtotal			164.4		
Chillers					By DUSEL
Total (all on)	**199.3**	**Total w/ Diversity**	**164.4**	**kW**	
		Heat loss to module	**85.0**	**kW**	
		Heat to chillers	**79.4**	**kW**	
		Heat to exhaust	**???**	**kW**	

Depth and Location
Questions to be discussed

Key layout comments:

1st experiment is built towards module center to allow both entry drifts to remain unobstructed

Each experiment ≤25m length

3m at each end of module reserved for future entry clearance

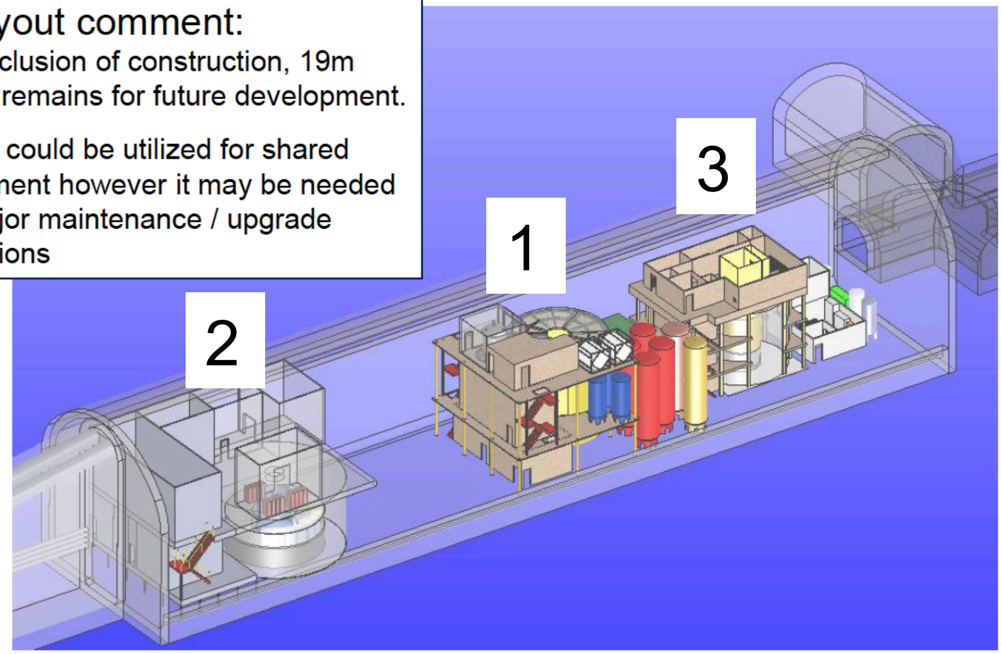
Key layout comment:

2nd experiment is built towards module west end to allow two lay-down areas for ongoing construction / assembly

Key layout comment:

At conclusion of construction, 19m space remains for future development.

Space could be utilized for shared equipment however it may be needed for major maintenance / upgrade operations



Major Changes

East end is a real entry
All Module-2 experiments have water tank needs
3 ISE must share space, no 3rd module.

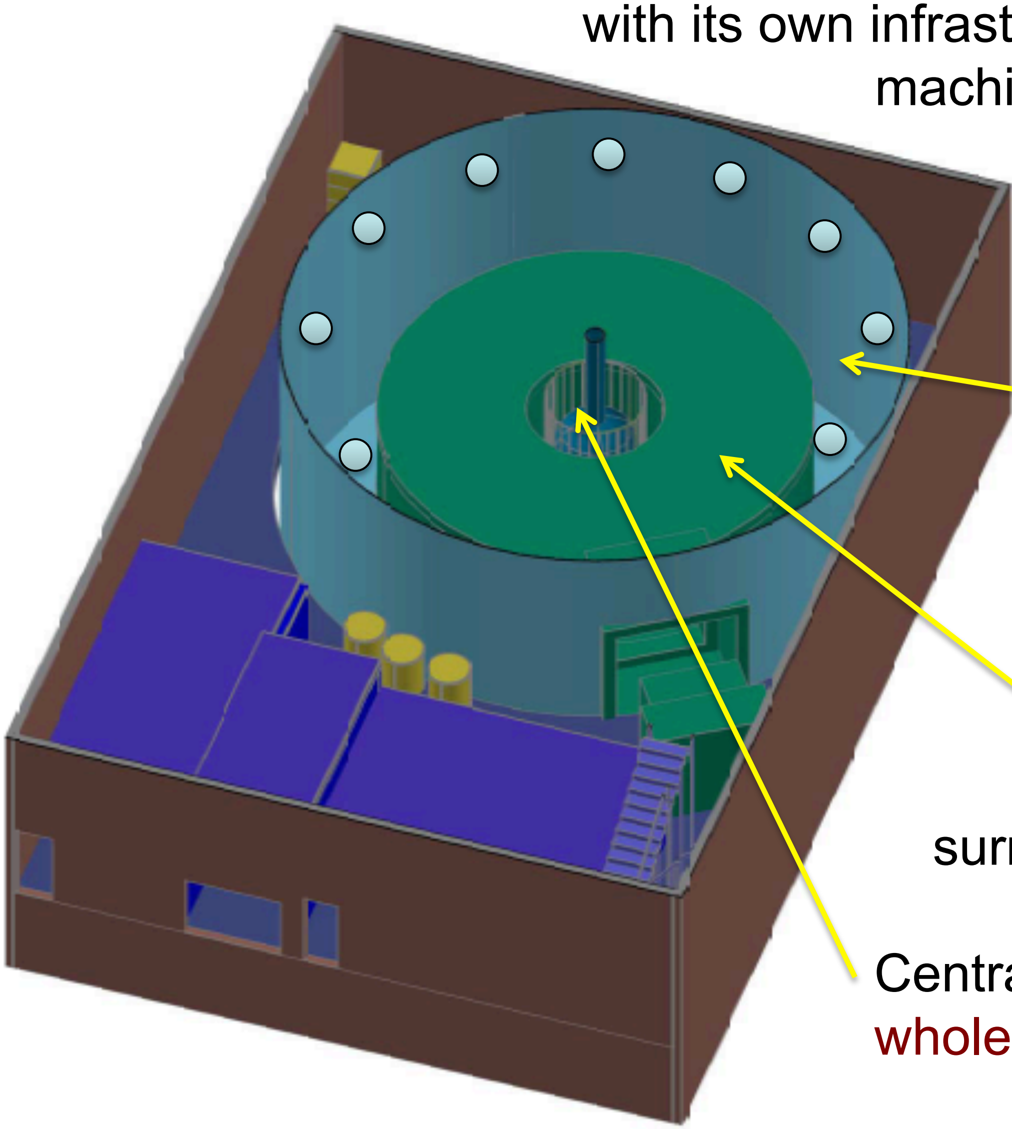
FY2011 Engineering Work Plan

- Update conceptual design
  - Input from this meeting
  - DUSEL input
- Occupancy and FLS review
- Select means for torus access
- Tank-torus design
- Ventilation conceptual design
- Resolve elevation issues
  - Sunken vs. raised compared to module
- WBS update

FAARM is located on the 4850 level

Entire facility is a self-contained class 10,000 clean room with its own infrastructure, incl. safety, showers, offices, machine shop, plus clean rooms for assembly, sample storage, etc…

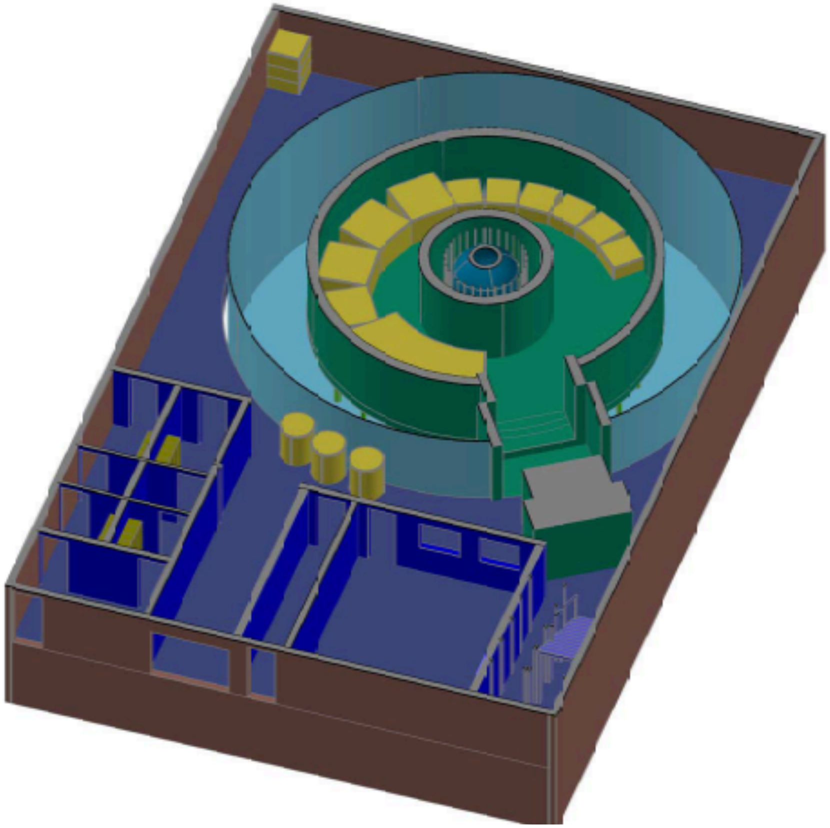
Designed to accommodate all users: physics/bio/geo

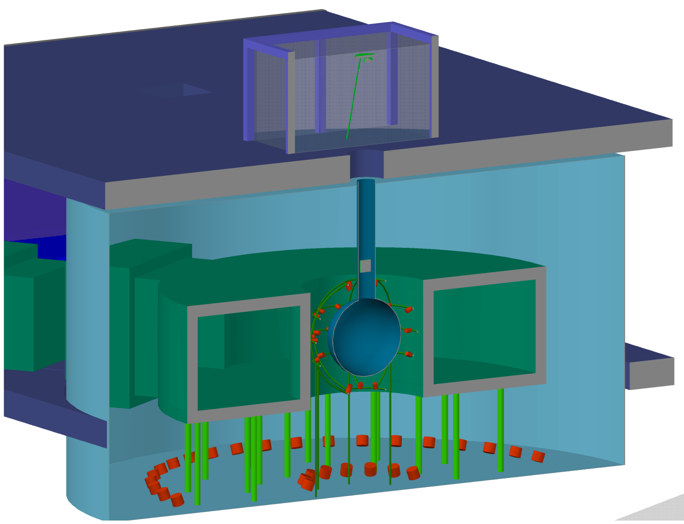


15m diam x 8m high stainless tank
(standard tank construction)
pure water with PMT muon veto
(upgrades: LS or B-loading)

Acrylic Tunnel Lab with screeners
(standard aquarium construction)
surrounded by a 2.3 m thick water shield

Central slot reserved for ultra-sensitive whole body counter or germanium array





Inner Tunnel Lab

γ-flux	7.974×10^{-5}	$cm^{-2}\ s^{-1}$
n-flux	4.817×10^{-10}	$cm^{-2}\ s^{-1}$

4 < ppt (GeMPI, arrays)
6 < ppb (well, clover, coax)
2 Beta Cages
Prototyping Space
(DM or $0\nu\beta\beta$ or novel assay)

Radon Mitigation
Common cryogen plumbing and
LN boil-off for screeners

Central Pool

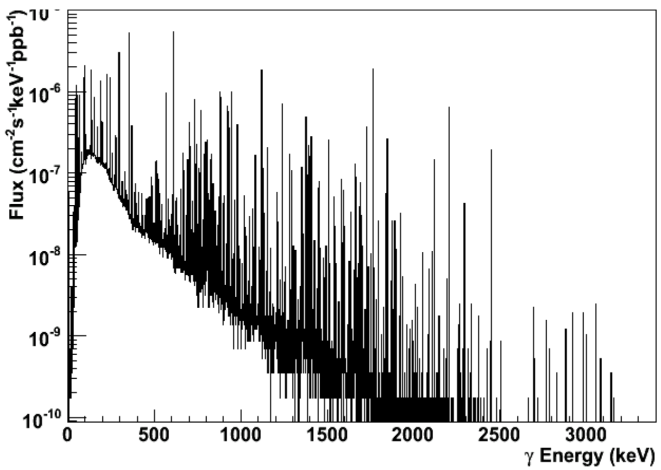
0.1 counts/day, E > 250 keV
sensitivity of 10^{-14} g/g U/Th 10^{-12} g/g K
modeled on Borexino CTF
2m diam nylon vessel filled with LS
Observed by low rad QUPIDs
Top-loading from dedicated Clean Room

Water Shield Simulations

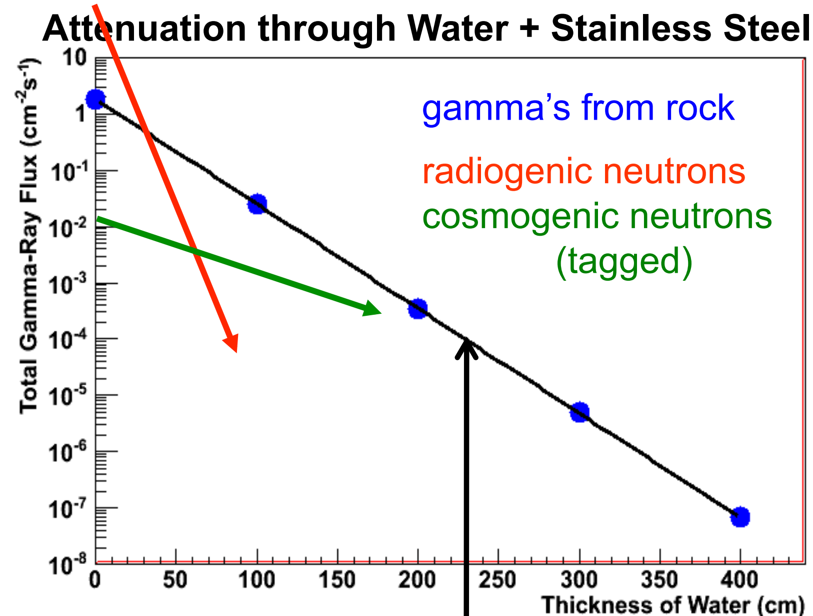
Optimize shield thickness

Rock (Homestake 4850')

^{238}U 0.55 ppm ^{232}Th 0.3 ppm ^{40}K 2.21%



X



Contam	Stainless Steel		Acrylic
^{238}U	0.1 ppb	9.5×10^{-6}	24 ppt
^{232}Th	0.1 ppb	2.3×10^{-6}	14 ppt
^{40}K	0.028 ppb	1.2×10^{-6}	2.4×10^{-4} ppb
^{60}Co	4.6×10^{-10} ppb	6.4×10^{-5}	
	Total:	7.7×10^{-5}	Total: ~10^{-5}

vs

Cavern radioactivity
after 2.3 m thick wall

γ 7.974×10^{-5} /cm^2/s
n 4.817×10^{-10} /cm^2/s

Detailed Geant4 studies will determine

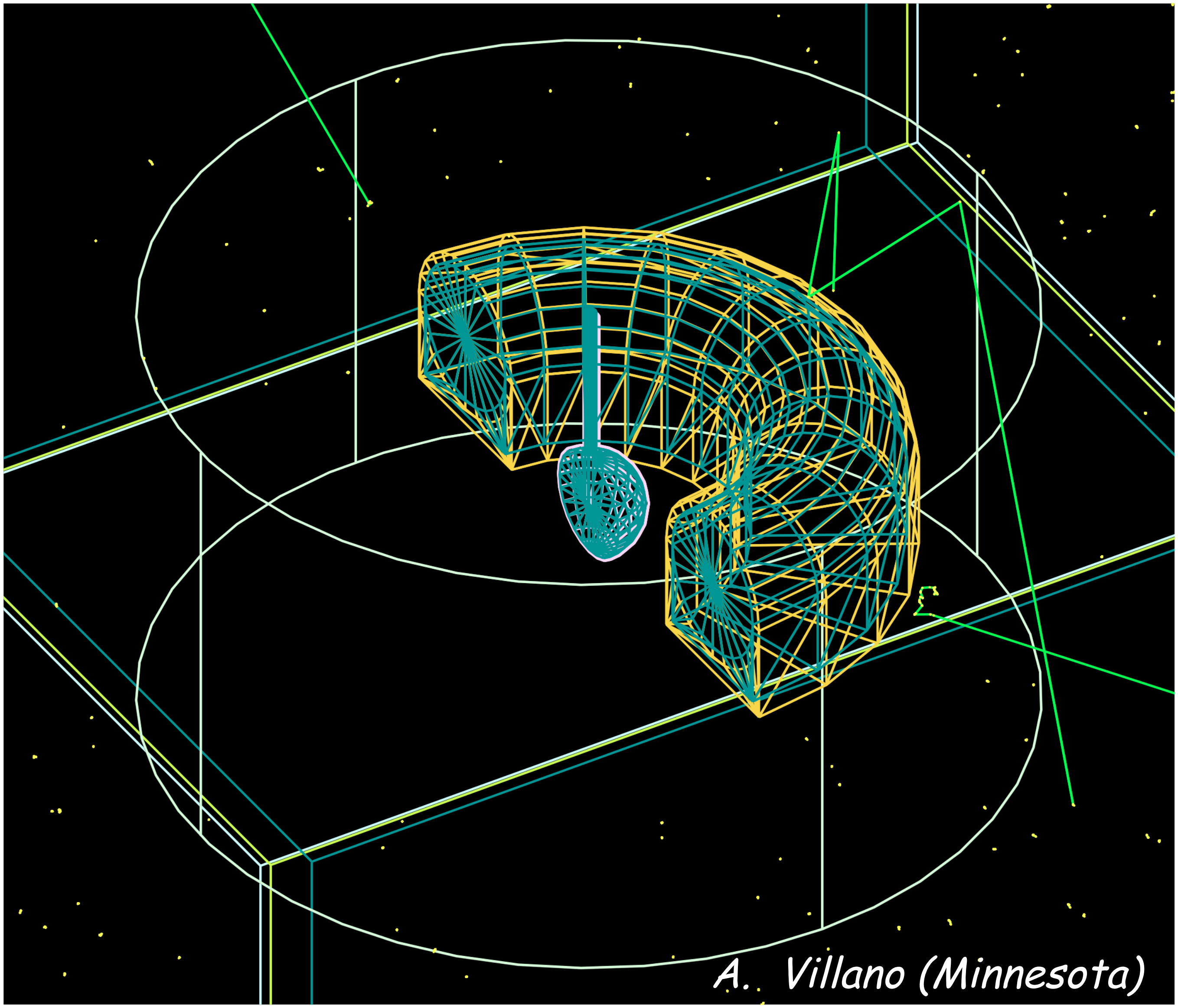
background levels

design optimization

materials choice
  support structures
  water purity

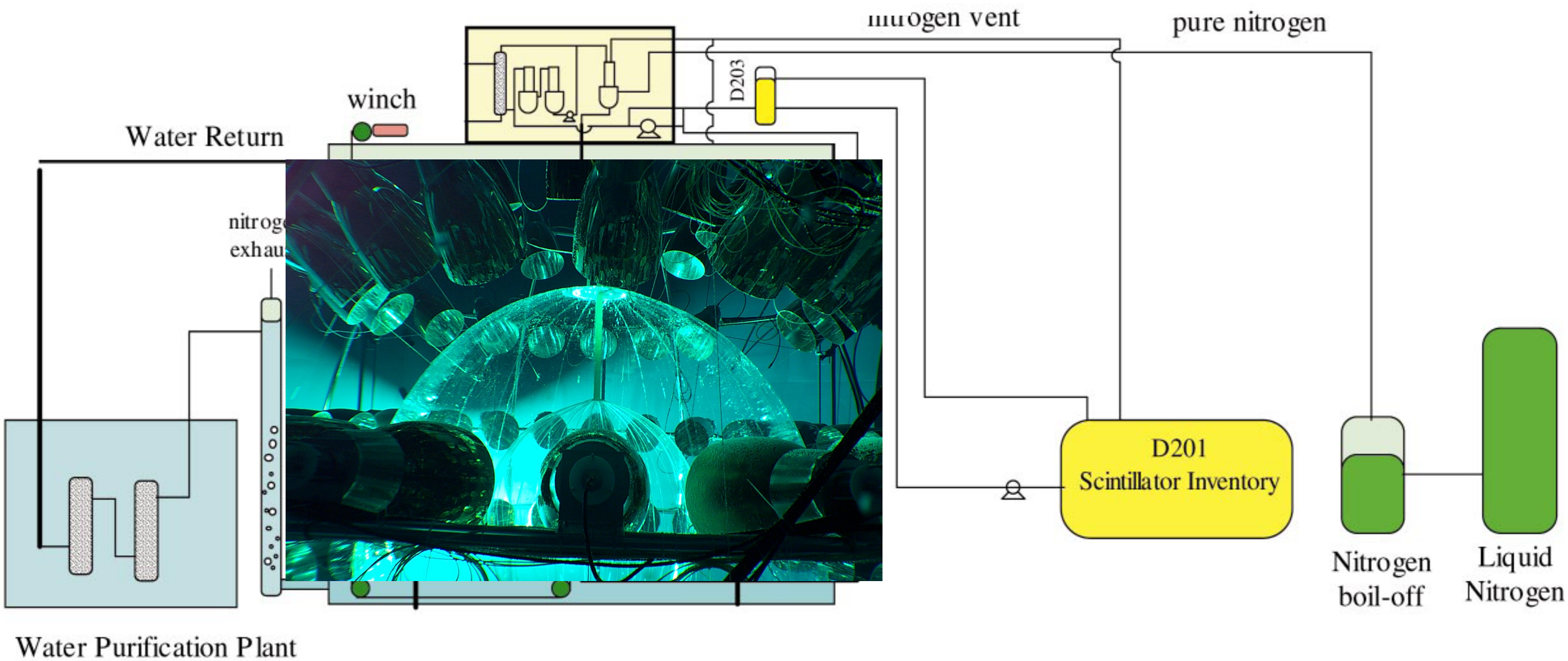
PMT and QUPID
  placement
  active rejection
  light yield
  rejection efficiency

Upgrade options:
  Gd-loading or
  LS shield



Borexino Counting Test Facility

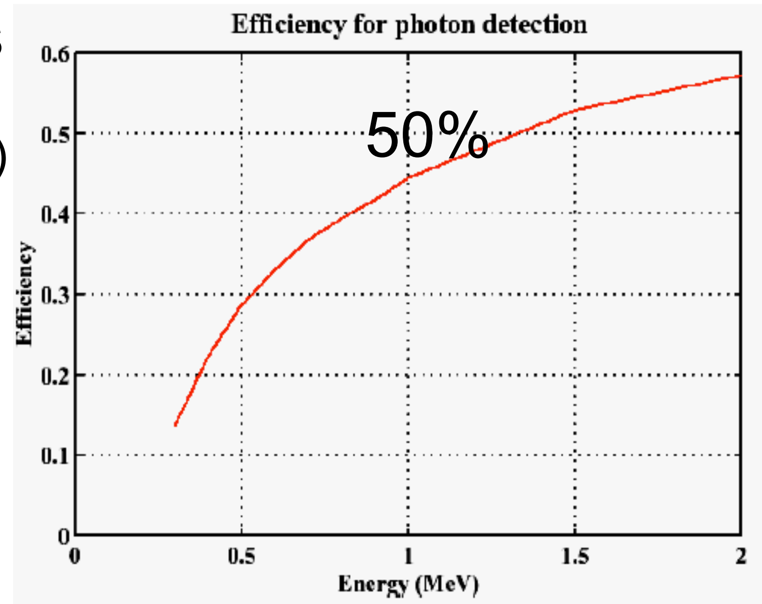
- 4 tonnes of scintillator (PC + 1.5 g/L PPO)
- 1m radius 500μm Nylon vessel for scintillator
- 2 m radius “shroud” vessel to shield Rn
- 3.6 p.e./PMT for 1 MeV electron
- Muon veto PMTs on floor
- 100 PMTs (Optical coverage: 21%)
- Buffer of water – 2.3m vessel to PMT
- Energy saturation: 6 MeV



CTF-like Immersion Tank for Screening

Instrumented water shield becomes outer shroud and veto
Low radioactivity QUPIDs can be placed closer to LS
Nylon bag filled with LS (LAB proposed)
Purification methods (10^{-16} g/g U/Th andd 10^{-14} g/g K)

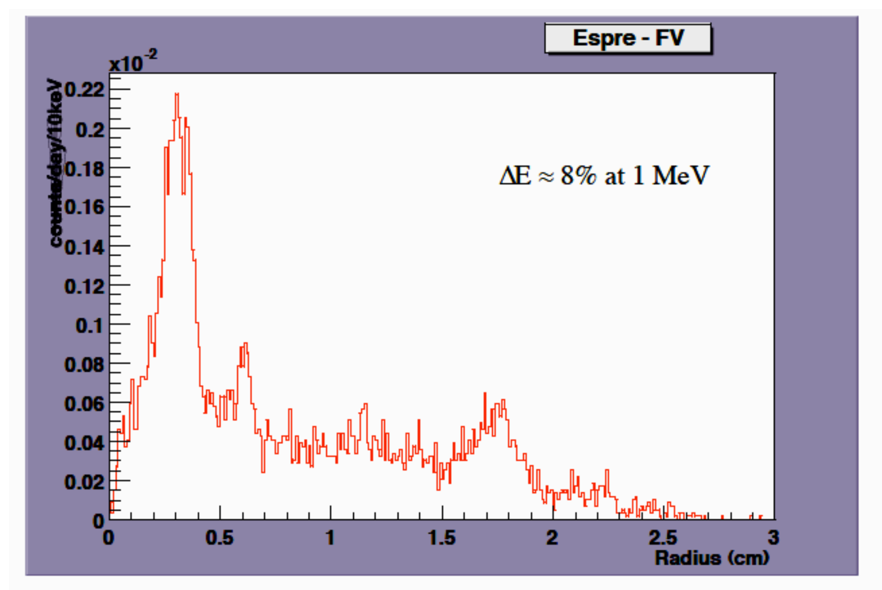
- *Distillation (also removes Rn)*
- *Water extraction*
- *N_2 stripping*
- *Solid-column adsorption*



Sensitive to

- *bulk gammas*
- *betas and alphas from surface*
- *betas inside 50 μm nylon sample bag*

Moderate energy resolution & Efficiency



Distinguish

- β:γ via event reconstruction
- α via pulse shape

Bottoms-up cost estimate

part of a complete Resource-loaded Schedule

7.2 M in equipment, M&S, contracted structures
1.6 M in labor: *0.7M scientific staff (mostly base funding)*
0.9M engineering

3 M: Shield + Inner Lab **2.5 M**: Immersion Screener **3 M**: Arch. Structure

this does NOT include the screeners themselves

Most important aspect of FAARM is the active SHIELD

Shield transforms sensitive screeners into ultra-sensitive
Central pool can house a 3rd generation screener
Shield has been optimized for COST:
~ $200k per Screener + free shield for prototype R&D

Schedule for FAARM Procurement and Assembly

Before Module is ready, but money is allocated

- Detailed engineering-level design
- Obtain bids, contracts and permits and hire contractor
- Assemble and test water purification system
- Procure radon system from Ateko (year lead time)
- Choose photodetectors, screening and testing, bids
- Purchase photodetectors, calibration and QA, electronics
- Procure nylon and build dedicated clean room
- Build nylon vessel in clean room

Once module is ready (Jan 2017) and radon < 100 Bq/m^3 (ventilation, rock coating)

- Install Ateko in module, operate temporary radon-free room for sensitive materials
- Water tank assembly incl torus + civil + radon under direction of contractor
- Ateko moved to final location inside FAARM
- Beneficial occupancy one year later.

Schedule for FAARM Installation and Commissioning

After Beneficial Occupancy

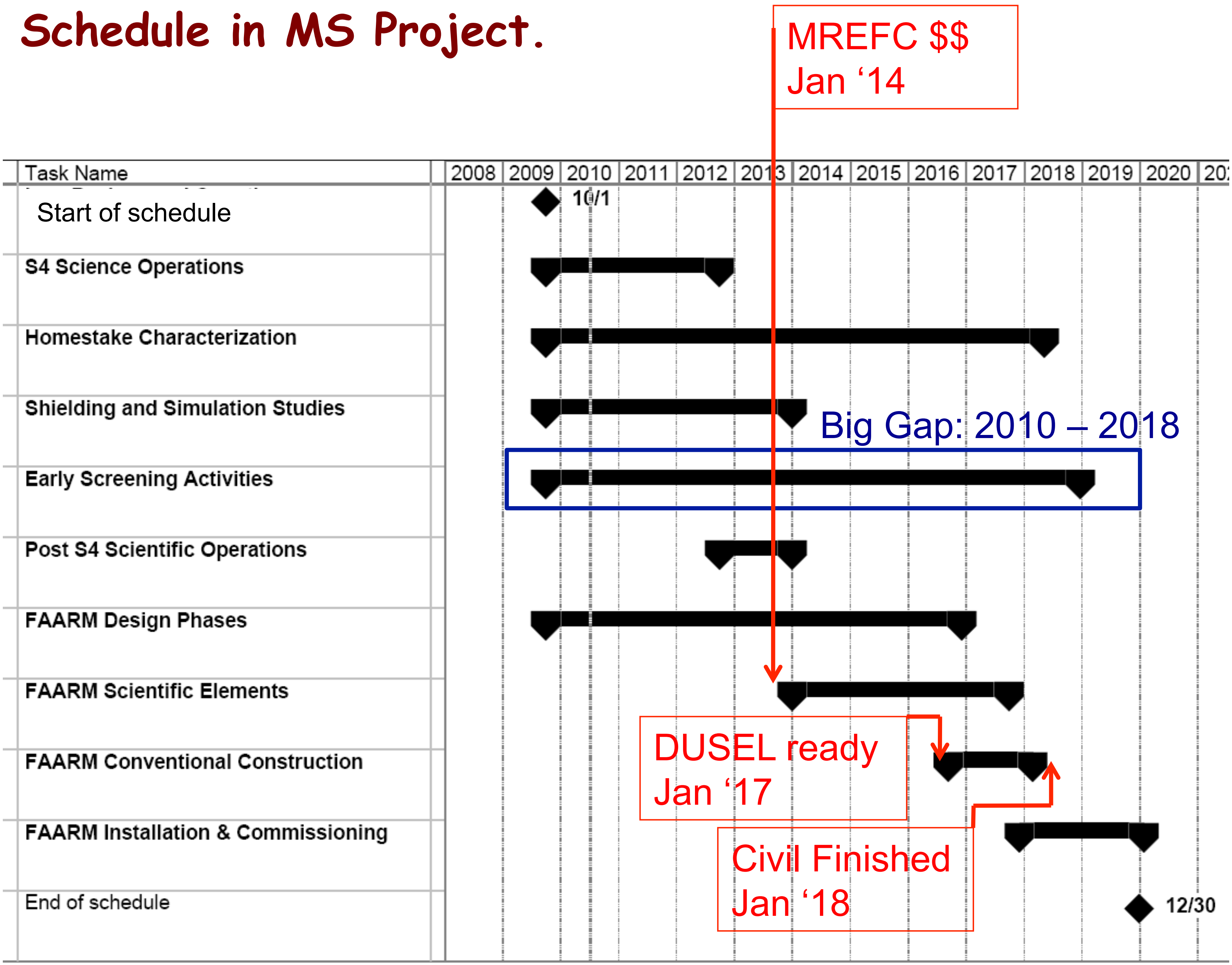
Establish moderate cleanliness protocols immediately after heavy construction

Clean entire lab as soon as possible
Clean and coat interior of shield, Install cables, plumbing, air, cryogen system
Initial water fill and test plumbing – drain and clean
Install Water Shield PMTs – fill shield, operate and calibrate PMTs
Comission DAQ and shield – long muon run - drain

Establish tight cleanliness protocol, including showers and radon mitigation

Measure particulate level and radon to confirm – commission monitoring
At least one sensitive HPGe moved to FAARM as bkgd monitor
Install nylon vessel and QUPIDs (test and calibrate)
Fill Immersion Tank with LS
Install nitrogen blanket, clean room – Purity studies with QUIPIDs
Fill shield – Combined Water + LS test and bkgd run
Move other screeners in parallel with Immersion Tank commissioning

Schedule in MS Project.



Model for Deployment

We have 8 years to move from a model of

dedicated screeners ➔ centrally managed system

Sanford Lab does NOT have enough room in Davis, nor funds to purchase enough screeners. Therefore, this will require the entire community to

- Determine needs for next decade
- Form a coherent community with official reps to each experiment
  - *through AARM S4 (Nov 12-13 collab meeting)*
  - *through Low Radioactivity Techniques (Aug 28-29, and new wiki)*
- Build up capacity (in multiple sites)
- Seek out new funding sources and proposals for shared equipment

Tie this to DUSEL via

- lease arrangements, matching funds, MOUs (?)
- Fund a dedicated effort to design the ultra-sensitive central pool assay

2018: Move the most sensitive screeners into FAARM shield
Collect less sensitive screeners as needed under one roof.
Install the central pool assay

AARMing DUSEL for Success: DUSEL Early Screening Plan

Possible ADS Plan – Let's discuss!!

Surface site at USD becomes main campus
(equidistant to both deep sites)
Hire a director (+students, etc)
Keenan Thomas (USD masters student)
Build scheduling tool for multiple sites
Tightest coordination between
LBNL + CUBED (USD + Sanford) + Soudan
Integrate database sharing through this new ADS entity,
coordinated with CUBED or maybe it is an expanded CUBED

Davis Cavern + Soudan can provide enough new deep real estate until 2019 FAARM
Conventional HPGe bought and installed at Davis
GeMPI developed over the next several years by USD,
but deployed at Soudan (Cu electroforming…Reeves&Sons??)
Beta cages & Alpha counter at Soudan become slated for DUSEL
Neutron detectors built by USD and UCSB deployed at multiple sites and
multiple depths
and Integrated into a cosmogenic simulations working group

ADS to FAARM Transition Timeline

- All screeners already bought, tested, and in operation from Early Screening era
- Screening must continue with as few interruptions as possible
- Staff is already in charge of all screeners, regardless of location
- Each sensitive screener is commissioned at FAARM before the next one dismantled
- Decommissioning effort (FTE) is flat over the year long transition

MILESTONE

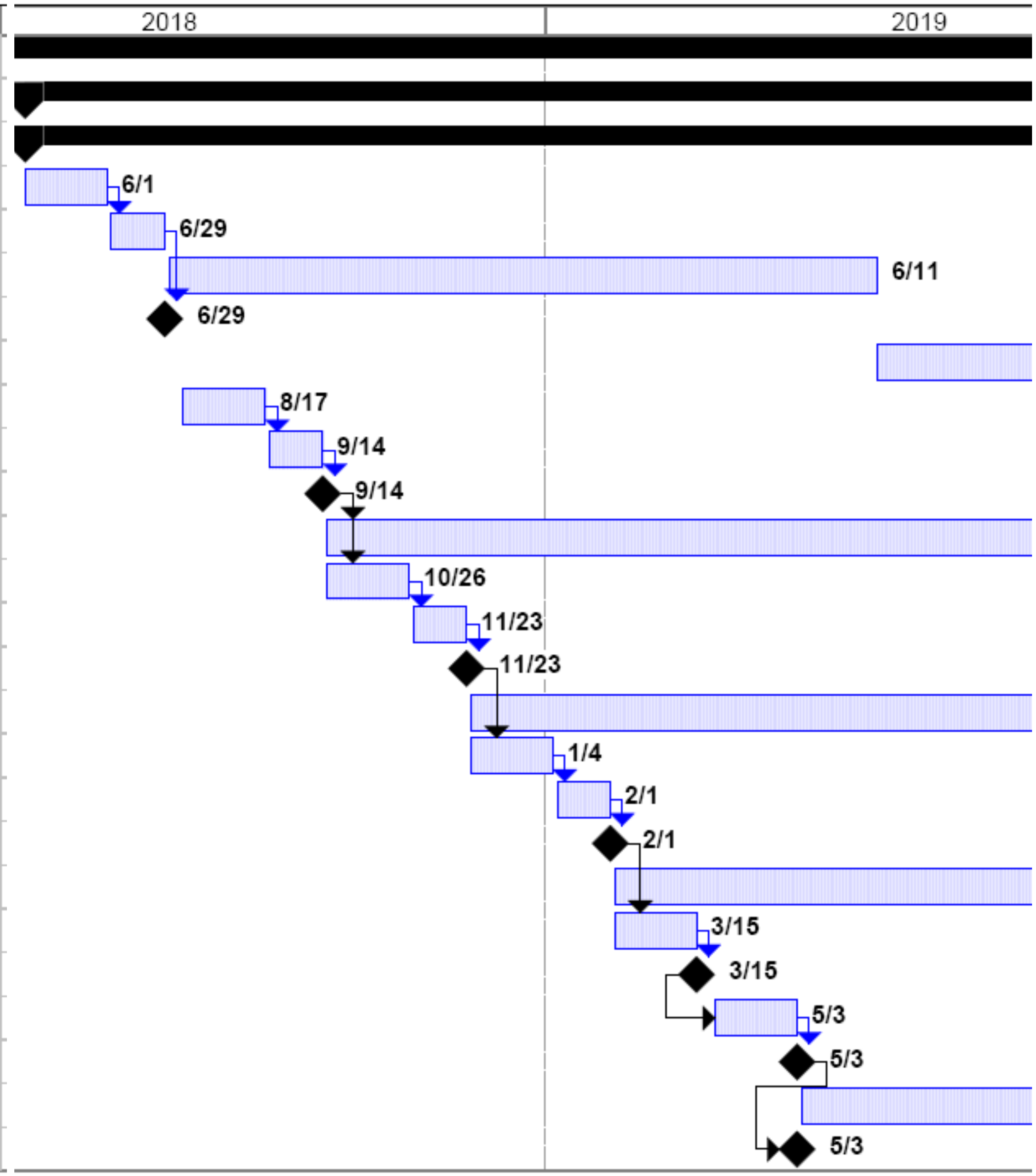
1/18 Beneficial Occupancy
7/18 First GeMPI operational (Background Monitor)
10/18 First Beta cage is screening at FAARM

Interleaved transfer schedule continues through the year

1/19 All XIA alpha screening now at FAARM
2/19 All GeMPIs, BetaCages now at FAARM *** Decommission Soudan LBCF
3/19 All gamma screening at FAARM *** Release Davis cavern
6/19 Whole body screening in Immersion Tank *** Fully operational FAARM

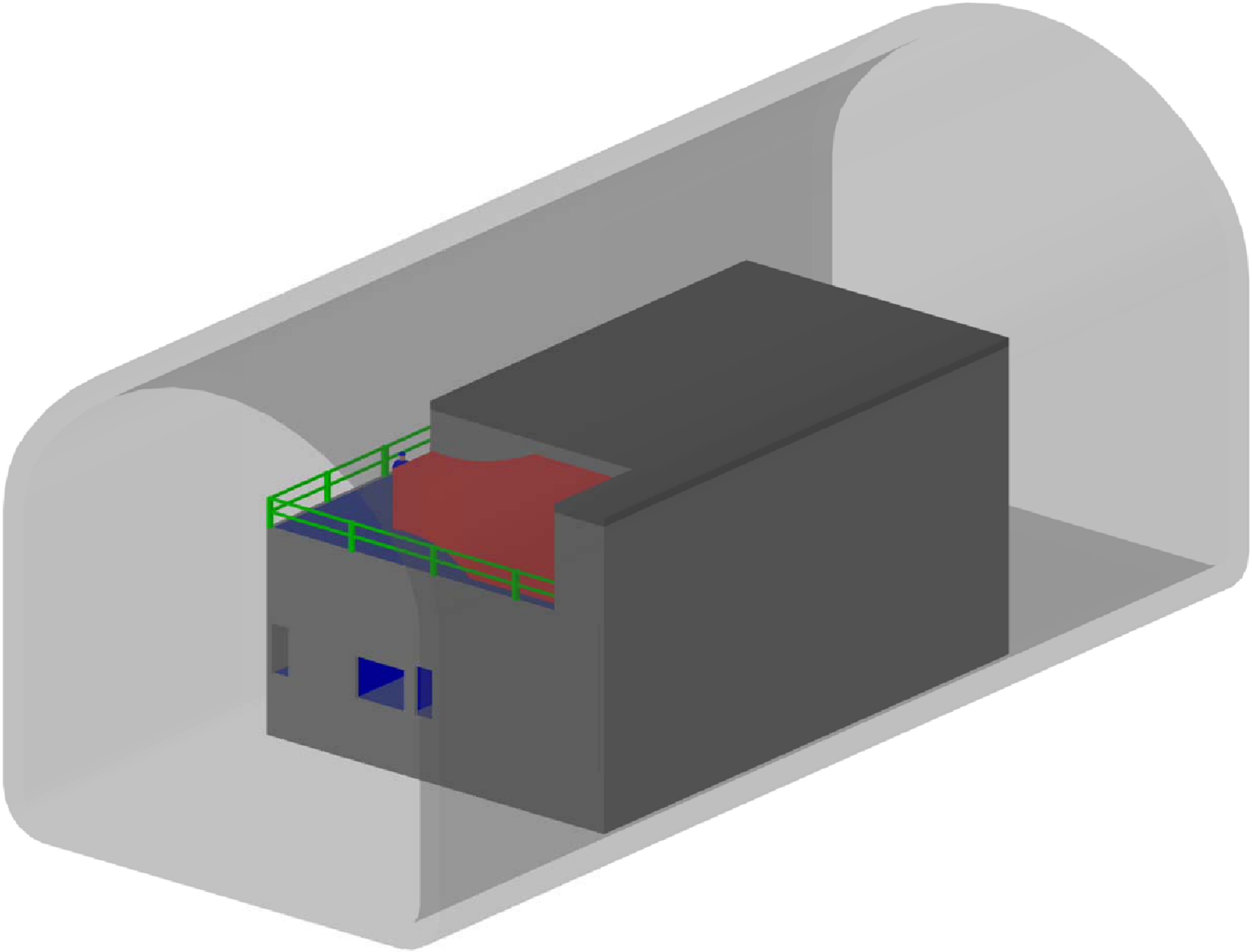
Transitioning of Screening from multiple sites to FAARM Commissioning (detail)

WBS	Task Name
10	**FAARM Installation & Commissioning**
10.3	**Phase 2: Tight Cleanliness**
10.3.4	**Gamma screener installation and commissionin**
10.3.4.1	Move GeMPI-1 from Soudan to FAARM
10.3.4.2	Commission GeMPI-1
10.3.4.3	Run GeMPI-1 as Monitor
10.3.4.4	GeMPI-1 Screening begins at FAARM
10.3.4.5	GeMPI-1 Screening
10.3.4.6	Move GeMPI-2 from Soudan to FAARM
10.3.4.7	Commission GeMPI-2
10.3.4.8	GeMPI-2 Screening begins at FAARM
10.3.4.9	GeMPI-2 Screening
10.3.4.10	Move GeMPI-3 from Soudan to FAARM
10.3.4.11	Commission GeMPI-3
10.3.4.12	GeMPI-3 Screening begins at FAARM
10.3.4.13	GeMPI-3 Screening
10.3.4.14	Move GeMPI-4 from Soudan to FAARM
10.3.4.15	Commission GeMPI-4
10.3.4.16	GeMPI-4 Screening begins at FAARM
10.3.4.17	GeMPI-4 Screening
10.3.4.18	Move conventional HPGe's from Davis to FAAF
10.3.4.19	Davis LBCF available for other exper.
10.3.4.20	Commission HPGe's
10.3.4.21	HPGe screening begins at FAARM
10.3.4.22	HPGe Screening
10.3.4.23	All gamma screening at FAARM



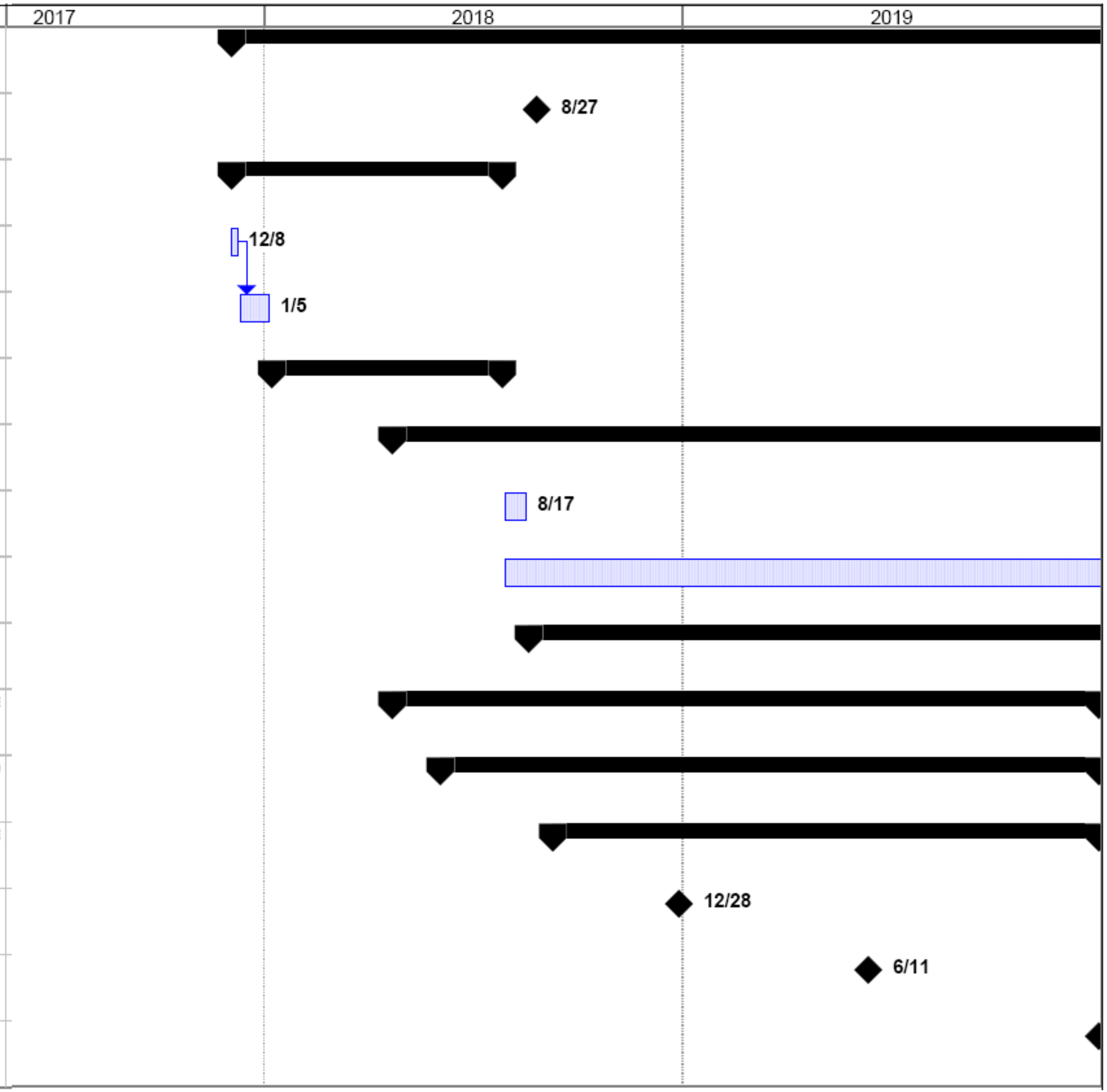
Additional slides for reference

FAARM Perspective



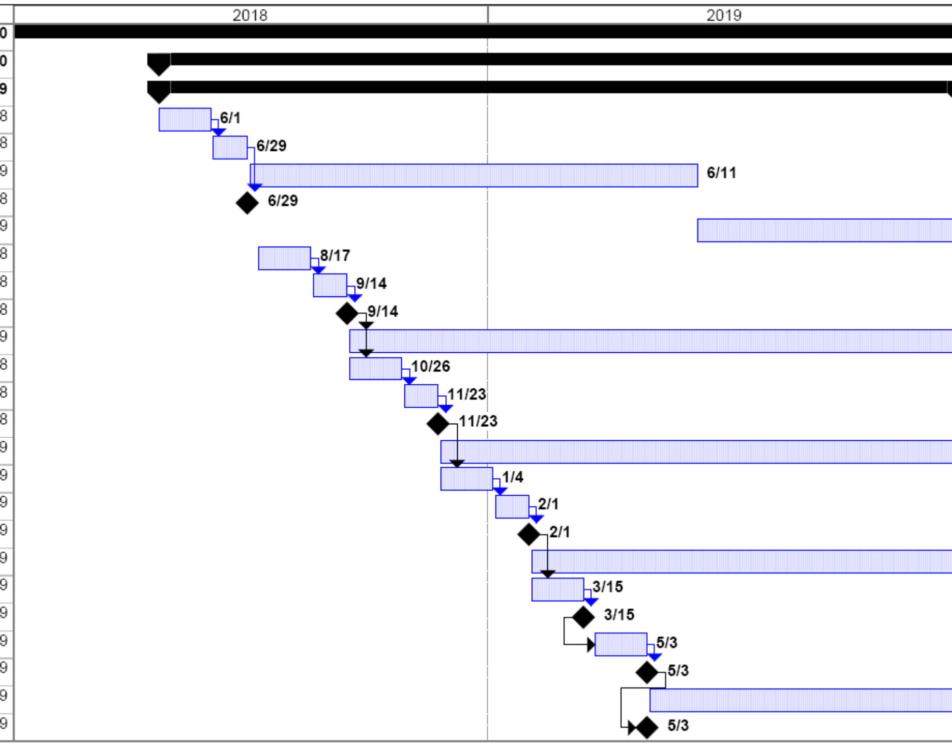
FAARM Installation & Commissioning

ID	WBS	Task Name
302	**10**	**FAARM Installation & Commissioning**
303	10.1	FAARM screening starts 1
304	**10.2**	**Phase 1: Moderate Cleanliness**
305	10.2.1	Establish moderate cleanliness protocols
306	10.2.2	Clean entire FAARM
307	**10.2.3**	**Water Shield Commissioning**
317	**10.3**	**Phase 2: Tight Cleanliness**
318	10.3.1	Establish tight cleanliness protocols
319	10.3.2	Monitor particulate level and radon
320	**10.3.3**	**Immersion Tank Commissioning**
333	**10.3.4**	**Gamma screener installation and commis**
357	**10.3.5**	**Beta Screener Installation and Commissi**
371	**10.3.6**	**Alpha Screener Installation and Commiss**
376	10.4	Decommission Soudan LBCF
377	10.5	FAARM Fully Operational
378	11	End of schedule

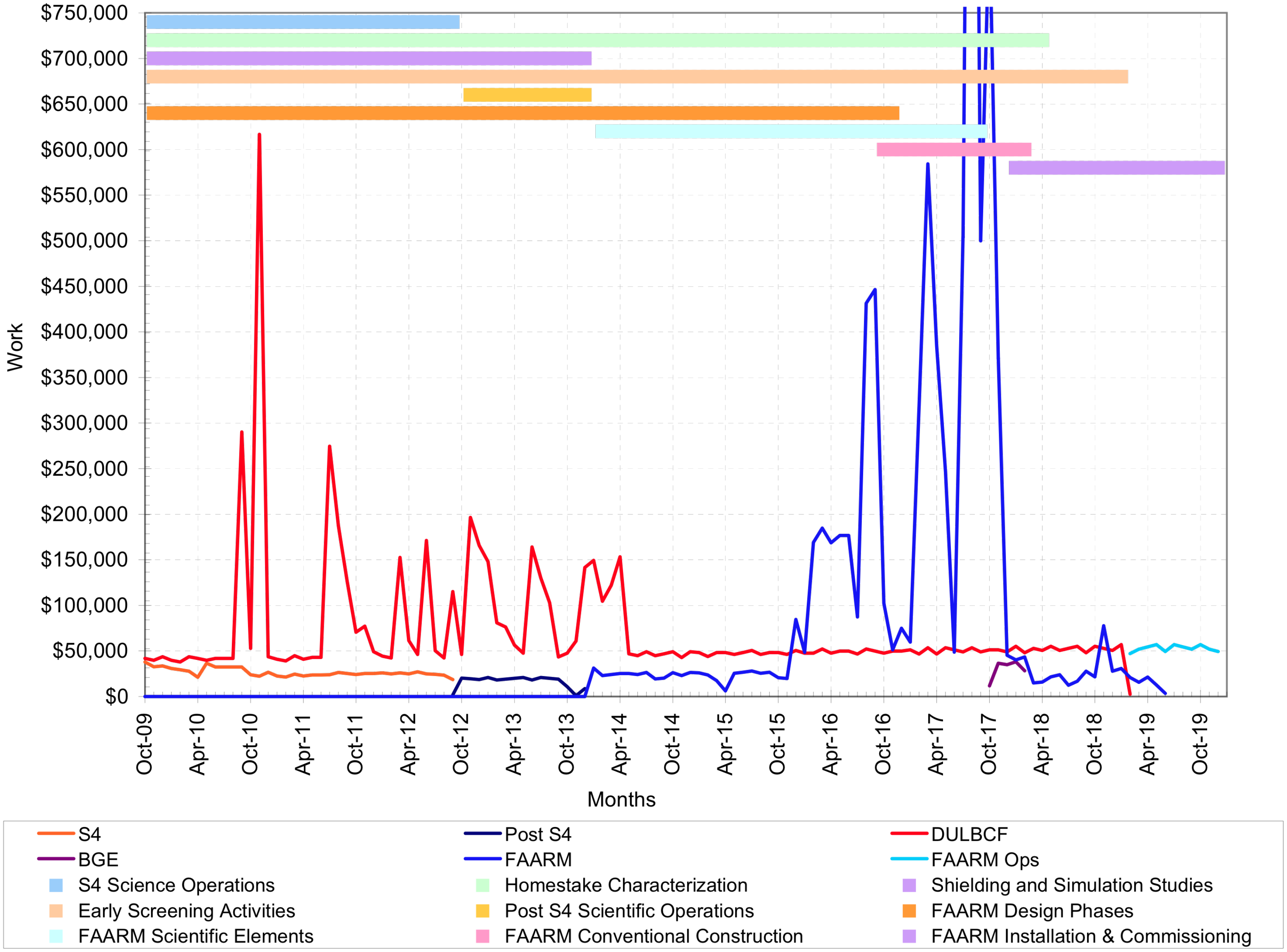


FAARM Installation & Commissioning (detail)

ID	WBS	Task Name	Duration	Start	Finish
302	**10**	**FAARM Installation & Commissioning**	**561 d**	**Mon 12/4/17**	**Mon 1/27/20**
317	**10.3**	**Phase 2: Tight Cleanliness**	**461 d**	**Mon 4/23/18**	**Mon 1/27/20**
333	**10.3.4**	**Gamma screener installation and commissioning**	**440 d**	**Mon 4/23/18**	**Mon 12/30/19**
334	10.3.4.1	Move GeMPI-1 from Soudan to FAARM	30 d	Mon 4/23/18	Fri 6/1/18
335	10.3.4.2	Commission GeMPI-1	20 d	Mon 6/4/18	Fri 6/29/18
336	10.3.4.3	Run GeMPI-1 as Monitor	247 d	Mon 7/2/18	Tue 6/11/19
337	10.3.4.4	GeMPI-1 Screening begins at FAARM	0 d	Fri 6/29/18	Fri 6/29/18
338	10.3.4.5	GeMPI-1 Screening	143 d	Wed 6/12/19	Fri 12/27/19
339	10.3.4.6	Move GeMPI-2 from Soudan to FAARM	30 d	Mon 7/9/18	Fri 8/17/18
340	10.3.4.7	Commission GeMPI-2	20 d	Mon 8/20/18	Fri 9/14/18
341	10.3.4.8	GeMPI-2 Screening begins at FAARM	0 d	Fri 9/14/18	Fri 9/14/18
342	10.3.4.9	GeMPI-2 Screening	335 d	Mon 9/17/18	Mon 12/30/19
343	10.3.4.10	Move GeMPI-3 from Soudan to FAARM	30 d	Mon 9/17/18	Fri 10/26/18
344	10.3.4.11	Commission GeMPI-3	20 d	Mon 10/29/18	Fri 11/23/18
345	10.3.4.12	GeMPI-3 Screening begins at FAARM	0 d	Fri 11/23/18	Fri 11/23/18
346	10.3.4.13	GeMPI-3 Screening	285 d	Mon 11/26/18	Mon 12/30/19
347	10.3.4.14	Move GeMPI-4 from Soudan to FAARM	30 d	Mon 11/26/18	Fri 1/4/19
348	10.3.4.15	Commission GeMPI-4	20 d	Mon 1/7/19	Fri 2/1/19
349	10.3.4.16	GeMPI-4 Screening begins at FAARM	0 d	Fri 2/1/19	Fri 2/1/19
350	10.3.4.17	GeMPI-4 Screening	235 d	Mon 2/4/19	Mon 12/30/19
351	10.3.4.18	Move conventional HPGe's from Davis to FAAF	30 d	Mon 2/4/19	Fri 3/15/19
352	10.3.4.19	Davis LBCF available for other exper.	0 d	Fri 3/15/19	Fri 3/15/19
353	10.3.4.20	Commission HPGe's	30 d	Mon 3/25/19	Fri 5/3/19
354	10.3.4.21	HPGe screening begins at FAARM	0 d	Fri 5/3/19	Fri 5/3/19
355	10.3.4.22	HPGe Screening	170 d	Mon 5/6/19	Mon 12/30/19
356	10.3.4.23	All gamma screening at FAARM	0 d	Fri 5/3/19	Fri 5/3/19



Cost Profile from the Project File



Resource Loaded Schedule

- We used MS Project, 356 tasks, 150 resources
- WBS task identification
- Capital costs are MS Project “materials”
- Labor costs are MS Project “work”
- Conventional construction tasks/costs are “materials”
- Costs distinguish ten “color of money” categories
  - S4
  - Post S4
  - Other
  - CDMS
  - DULBCF
  - DUSEL
  - DUSEL R&D
  - FAARM
  - FAARM Ops
  - BGE

Resource Table

- 3 percent escalation on labor

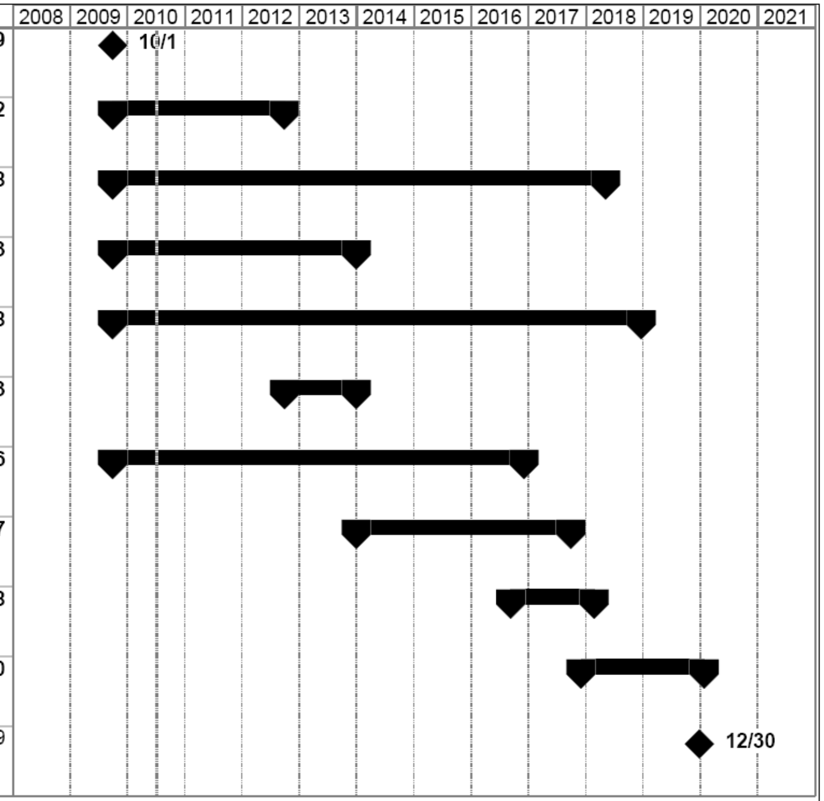
ID		Resource Name	Type	Mate Labe	Initial	Group	Max. Units	Std. Rate	Ovt. Rate
155		Architect (FAARM)	Work			FAARM	100%	$154.50/h	$0.00/h
84		Architect (post S4)	Work			Post S4	100%	$154.50/h	$0.00/h
83		Architect (S4)	Work			S4	100%	$154.50/h	$0.00/h
85		Beta cage-gas handling (DULBCF)	Material			DULBCF		$10,000.00	
110		Beta cage-gas handling (DUSEL R&D)	Material			DUSEL R&D		$10,000.00	
86		Beta cage-high voltage (DULBCF)	Material			DULBCF		$5,000.00	
111		Beta cage-high voltage (DUSEL R&D)	Material			DUSEL R&D		$5,000.00	
90		Beta cage-load/lock hardware (DULBCF)	Material			DULBCF		$7,000.00	
112		Beta cage-load/lock hardware (DUSEL R&D)	Material			DUSEL R&D		$7,000.00	
82		Beta cage-MWPC grids/frames/shapers (DULBCF)	Material			DULBCF		$25,000.00	
113		Beta cage-MWPC grids/frames/shapers (DUSEL R&D)	Material			DUSEL R&D		$25,000.00	
91		Beta cage-radon purge (DULBCF)	Material			DULBCF		$3,000.00	
114		Beta cage-radon purge (DUSEL R&D)	Material			DUSEL R&D		$3,000.00	
87		Beta cage-readout electronics (DULBCF)	Material			DULBCF		$50,000.00	
115		Beta cage-readout electronics (DUSEL R&D)	Material			DUSEL R&D		$50,000.00	
88		Beta cage-shielding (DULBCF)	Material			DULBCF		$15,000.00	
116		Beta cage-shielding (DUSEL R&D)	Material			DUSEL R&D		$15,000.00	
81		Beta cage-vacuum chamber with HV feed-throughs (DULBCF)	Material			DULBCF		$20,000.00	
117		Beta cage-vacuum chamber with HV feed-throughs (DUSEL R&D)	Material			DUSEL R&D		$20,000.00	
118		BGE-cabinet storage with lead shielding – 1 m^3	Material			BGE		$95,276.00	
109		BGE-HEPA filtered laminar flow through hood	Material			BGE		$15,000.00	
65		BGE-wet bench for nucleic acid extraction	Material			BGE		$39,000.00	
134		CDMS staff	Work			CDMS	200%	$50.00/h	$0.00/h
120		Civil-Concrete	Material		C	FAARM		$0.00	
126		Civil-Doors and Windows	Material			FAARM		$29,000.00	
129		Civil-Equipment including material handling	Material		C	FAARM		$20,000.00	
127		Civil-Finishes	Material			FAARM		$159,000.00	
130		Civil-Furnishings	Material		C	FAARM		$0.00	
122		Civil-General metals	Material			FAARM		$26,000.00	
121		Civil-Masonry	Material			FAARM		$303,900.00	
119		Civil-Site Preparation	Material		C	FAARM		$0.00	
131		Civil-Special Construction	Material		C	FAARM		$0.00	
128		Civil-Specialties	Material			FAARM		$26,000.00	
123		Civil-Structural steel decks	Material			FAARM		$1,073,000.00	
125		Civil-Thermal and Moisture	Material			FAARM		$32,000.00	
124		Civil-Wood and Plastics	Material			FAARM		$9,000.00	
76		CLOVER-deployment system	Material			DULBCF		$10,000.00	
75		CLOVER-with electroformed copper cryostat	Material			DULBCF		$350,000.00	
66		Computer systems	Material			FAARM		$10,000.00	

WBS Level 1 Items

1 Low Background Counting (start)
2 S4 Science Operations
3 Homestake Characterization
4 Shielding and Simulation Studies
5 Early Screening Activities
6 Post S4 Scientific Operations
7 FAARM Design Phases
8 FAARM Scientific Elements
9 FAARM Conventional Construction
10 FAARM Installation & Commissioning
11 End of schedule

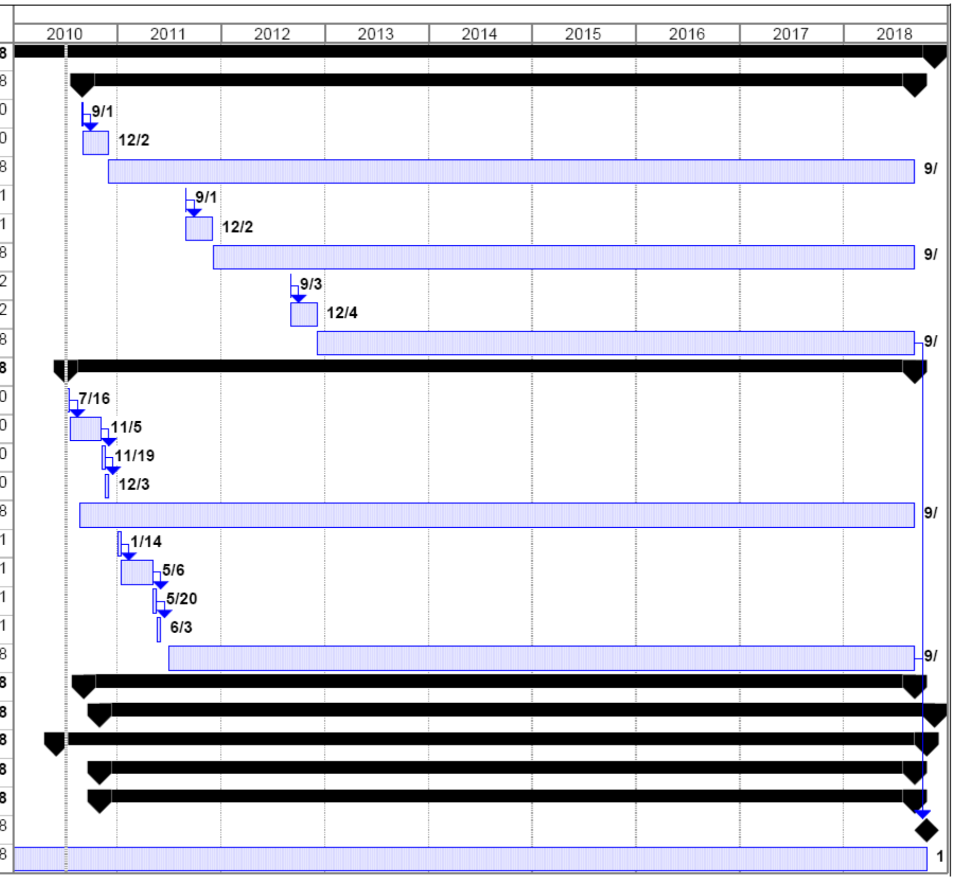
All Tasks Rolled Up

ID	WBS	Task Name	Duration	Start	Finish
1	**1**	**Low Background Counting**	**0 d**	**Thu 10/1/09**	**Thu 10/1/09**
3	**2**	**S4 Science Operations**	**782 d?**	**Thu 10/1/09**	**Fri 9/28/12**
5	**3**	**Homestake Characterization**	**2245 d**	**Thu 10/1/09**	**Wed 5/9/18**
31	**4**	**Shielding and Simulation Studies**	**1109 d**	**Thu 10/1/09**	**Tue 12/31/13**
47	**5**	**Early Screening Activities**	**2407 d?**	**Thu 10/1/09**	**Fri 12/21/18**
181	**6**	**Post S4 Scientific Operations**	**327 d**	**Mon 10/1/12**	**Tue 12/31/13**
183	**7**	**FAARM Design Phases**	**1872 d**	**Thu 10/1/09**	**Mon 12/5/16**
210	**8**	**FAARM Scientific Elements**	**978 d**	**Wed 1/1/14**	**Fri 9/29/17**
239	**9**	**FAARM Conventional Construction**	**381 d?**	**Mon 9/12/16**	**Mon 2/26/18**
302	**10**	**FAARM Installation & Commissioning**	**561 d**	**Mon 12/4/17**	**Mon 1/27/20**
378	11	End of schedule	0 d	Mon 12/30/19	Mon 12/30/19



Early Screening Activities

ID	WBS	Task Name	Duration	Start	Finish
47	**5**	**Early Screening Activities**	**2382 d?**	**Thu 10/1/09**	**Mon 11/19/18**
48	5.1	Alpha screening	2093 d	Wed 9/1/10	Mon 9/10/18
49	5.1.1	Procure first XIA screener	1 d	Wed 9/1/10	Wed 9/1/10
50	5.1.2	Install and commission first XIA screener at Soudan	66 d	Thu 9/2/10	Thu 12/2/10
51	5.1.3	Conduct CDMS screening at Soudan	2026 d	Fri 12/3/10	Mon 9/10/18
52	5.1.4	Procure second XIA screener	1 d	Thu 9/1/11	Thu 9/1/11
53	5.1.5	Install and commission second XIA screener at Souc	66 d	Fri 9/2/11	Fri 12/2/11
54	5.1.6	Conduct CDMS screening at Soudan	1765 d	Mon 12/5/11	Mon 9/10/18
55	5.1.7	Procure third XIA screener	1 d	Mon 9/3/12	Mon 9/3/12
56	5.1.8	Install and commission third XIA screener at Soudan	66 d	Tue 9/4/12	Tue 12/4/12
57	5.1.9	Conduct screening at Soudan	1503 d	Wed 12/5/12	Mon 9/10/18
58	**5.2**	**Neutron detectors**	**2135 d**	**Mon 7/5/10**	**Mon 9/10/18**
59	5.2.1	Purchase components for neutron detectors	10 d	Mon 7/5/10	Fri 7/16/10
60	5.2.2	Fabricate neutron detectors	80 d	Mon 7/19/10	Fri 11/5/10
61	5.2.3	Install neutron detectors at Soudan	10 d	Mon 11/8/10	Fri 11/19/10
62	5.2.4	Integrate neutron detectors with shield	10 d	Mon 11/22/10	Fri 12/3/10
63	5.2.5	Run detectors	2100 d	Mon 8/23/10	Mon 9/10/18
64	5.2.6	Purchase components for neutron detectors	10 d	Mon 1/3/11	Fri 1/14/11
65	5.2.7	Fabricate neutron detectors	80 d	Mon 1/17/11	Fri 5/6/11
66	5.2.8	Install neutron detectors at Davis	10 d	Mon 5/9/11	Fri 5/20/11
67	5.2.9	Integrate neutron detectors with shield	10 d	Mon 5/23/11	Fri 6/3/11
68	5.2.10	Run detectors	1875 d	Mon 7/4/11	Mon 9/10/18
69	**5.3**	**GeMPI screeners**	**2090 d**	**Mon 9/6/10**	**Mon 9/10/18**
104	**5.4**	**HPGe screeners**	**2100 d**	**Mon 11/1/10**	**Mon 11/19/18**
147	**5.5**	**Beta screeners**	**2189 d**	**Tue 6/1/10**	**Mon 10/22/18**
163	**5.6**	**Other Gamma Screeners**	**2050 d**	**Mon 11/1/10**	**Mon 9/10/18**
171	**5.7**	**Radon Emanation Chamber**	**2050 d**	**Mon 11/1/10**	**Mon 9/10/18**
179	5.8	End of early screening tasks	0 d	Mon 10/22/18	Mon 10/22/18
180	5.9	DULBCF Activities (hammock task)	2362 d?	Thu 10/1/09	Mon 10/22/18



Design Phases

ID	WBS	Task Name	Duration	Start	Finish
183	**7**	**FAARM Design Phases**	**1872 d**	**Thu 10/1/09**	**Mon 12/5/16**
184	**7.1**	**FAARM Conceptual Design**	**310 d**	**Thu 10/1/09**	**Wed 12/8/10**
185	7.1.1	Conceptual design phase 1	120 d	Thu 10/1/09	Wed 3/17/10
186	7.1.2	Design review	30 d	Thu 3/18/10	Wed 4/28/10
187	7.1.3	Conceptual design phase 2	120 d	Thu 4/29/10	Wed 10/13/10
188	7.1.4	Design review	30 d	Thu 10/14/10	Wed 11/24/10
189	7.1.5	Conceptual design updates from design revi	10 d	Thu 11/25/10	Wed 12/8/10
190	7.1.6	Conceptual design complete	0 d	Wed 12/8/10	Wed 12/8/10
191	**7.2**	**FAARM Preliminary Design**	**795 d**	**Thu 12/9/10**	**Wed 12/25/13**
192	7.2.1	Preliminary design phase 1	440 d	Thu 12/9/10	Wed 8/15/12
193	7.2.2	Design review	30 d	Thu 8/16/12	Wed 9/26/12
194	7.2.3	Completion of preliminary design with S4 fur	0 d	Wed 9/26/12	Wed 9/26/12
195	7.2.4	Preliminary design phase 2	275 d	Thu 9/27/12	Wed 10/16/13
196	7.2.5	Design review	30 d	Thu 10/17/13	Wed 11/27/13
197	7.2.6	Preliminary design updates from design revi	20 d	Thu 11/28/13	Wed 12/25/13
198	7.2.7	Preliminary design complete	0 d	Wed 12/25/13	Wed 12/25/13
199	**7.3**	**FAARM Final Design**	**763 d**	**Wed 1/1/14**	**Mon 12/5/16**
200	7.3.1	Final design phase 1	316 d	Wed 1/1/14	Thu 3/19/15
201	7.3.2	Design review	30 d	Thu 3/19/15	Thu 4/30/15
202	7.3.3	Final design phase 2	317 d	Thu 4/30/15	Mon 7/18/16
203	7.3.4	Design review	30 d	Mon 7/18/16	Mon 8/29/16
204	7.3.5	Final design updates from design review	10 d	Mon 8/29/16	Mon 9/12/16
205	7.3.6	Documents ready for procurement	0 d	Mon 9/12/16	Mon 9/12/16
206	7.3.7	Procurement approved, funding authorized	0 d	Mon 9/12/16	Mon 9/12/16
207	7.3.8	Bidding phase	30 d	Mon 9/12/16	Mon 10/24/16
208	7.3.9	Contracting phase	30 d	Mon 10/24/16	Mon 12/5/16
209	7.3.10	FAARM Notice to Proceed	0 d	Mon 12/5/16	Mon 12/5/16