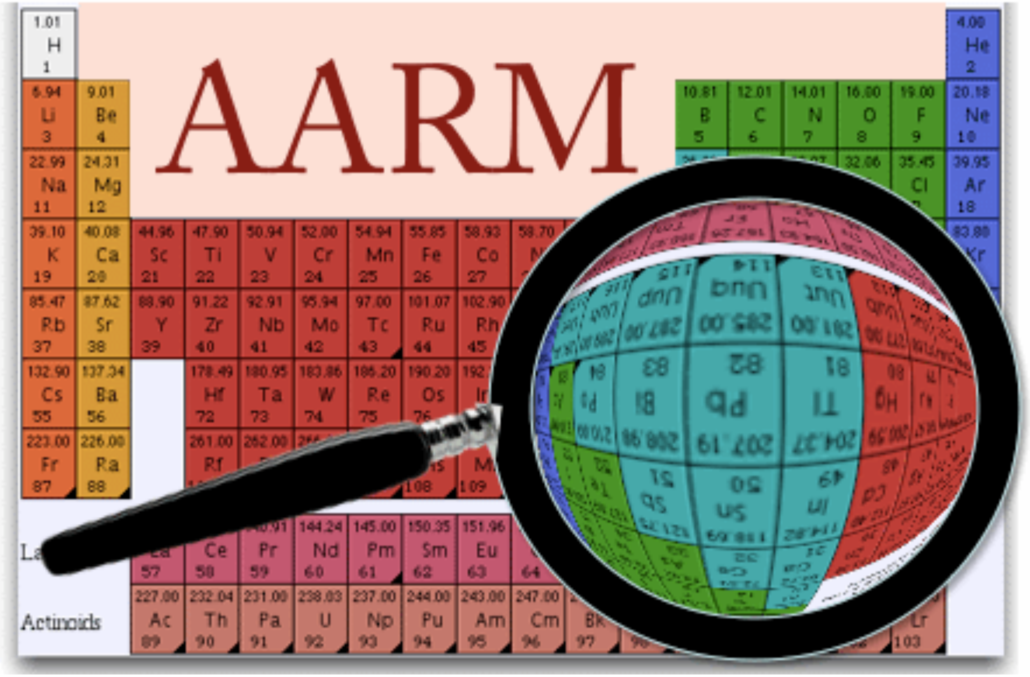
Assay and Acquisition of Radiopure Materials



Principle Investigators

Priscilla Cushman (University of Minnesota)
Dongming Mei (University of South Dakota)
Kara Keeter (Black Hills State University)
Richard Schnee (Syracuse University)

Engineering Consortium

CNA Consulting Engineers (Lee Petersen)
Dunham Associates
Miller Dunwiddie Architecture, Inc

- Characterize radon, neutron, gamma, and alpha/beta backgrounds at Homestake
- Develop a conceptual design for a common, dedicated facility for low background counting and other assay techniques.
- Assist where appropriate in the creation of common infrastructure required to perform low background experiments.
- Perform targeted R&D for ultra-sensitive screening and water shielding

Structure of AARM S4 Process

Conventional Design of the Facility for AARM by Engineering Consortium
Based on Information from the Users (YOU!)
Gleaned and organized by the Co-PIs

YOU are represented by the following “AARM Scientific Collaboration” who has already given feedback, but must continue to provide information as the process evolves.

Scientific Collaboration

Craig Aalseth
Henning Back
Tim Classen
Jodi Cooley-Sekula
Yuri Efremenko
Reyco Henning
Jeff Martoff
Robert McTaggart
Esther Mintzer
Tullis Onstott
Andreas Piepke
Andrew Sonnenshein
John Wilkerson

Integrate Effort with European Labs

The Synergy Workshops and Integrative Website were dropped: budget 1.3M → 1.0M

(linking research fields and linking multiple sites)

Same thing happened in ILIAS Next process via reviewer comments

**** Difficult to fund interdisciplinary projects ****

But, we will still draw heavily from expertise in existing Low Background Facilities via

International Scientific Advisory Panel

Laura Baudis (Zurich University)
Richard Ford (Queen's University, SNOLab)
Gilles Gerbier (CEA Saclay)
Gerd Heusser (Max Planck Institute, Heidelberg)
Andrea Giuliani (University of Insubria (Como), Coordinator of ILIAS Continuation)
Mikael Hult (European Commission: JRC Inst. for Reference materials and Measurements)
Vitaly Kudryavtsev (University of Sheffield)
Pia Loaiza (Laboratoire Souterrain de Modane)
Matthias Laubenstein (INFN, Gran Sasso Laboratory)
Neil Spooner (University of Sheffield)

Why do we need a common Low Background Facility?

- Cost effective sharing of resources, close to experiments
- Unified scheduling tools and infrastructure will streamline counting and match users to the sensitivity and modality needed.
- Common materials database and shared experience
- Electronics pool, code repository, unified analysis system
- Expert Technicians and Training center
  can become a center for new R&D in screening and assay
  develops new field of low background techniques
- Large enough to include on site clean machine shop, chemical services, radon-free storage and assembly areas, common shielding and shielding elements available

Why do we need other sites as well?

Urgency of screening: DUSEL experiments need to begin screening NOW

Design parameters are determined in part by material selection
Prototypes are being built now
Sanford is not yet up to speed, Multiple sites can help

Economy of scale only goes so far

Experiments are designed and built at local institutions
Local on-site analysis/screening
inexpensive access, quick turn-around, student training

Cooperative agreements with local industry, accelerators, commercial labs
can generate user fees and foster synergies with other fields

Some specialty users may prefer a different site
e.g. high security, different rock or bugs, different bkgds

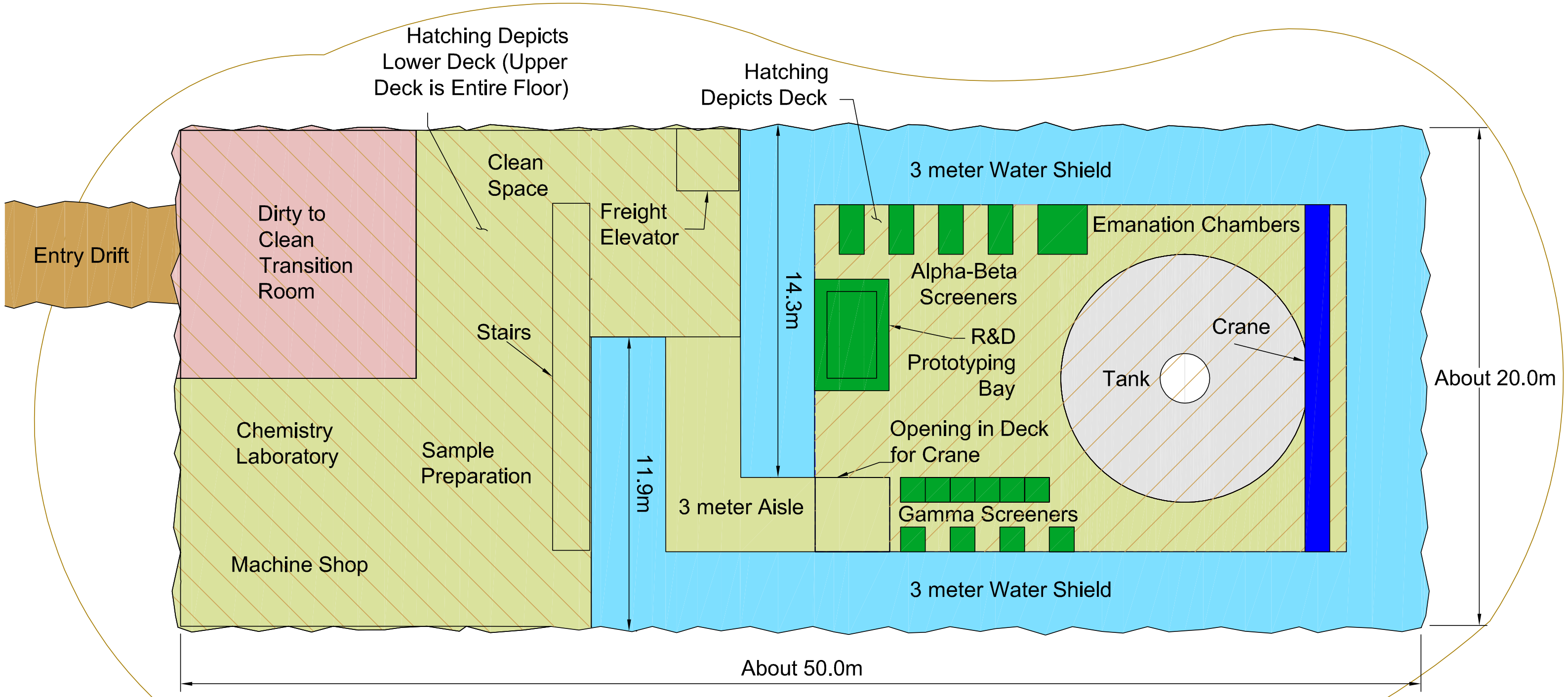
There are no resources in the S4 to unify and facilitate multiple sites

Can we identify funding source(s) to create

Training Centers at existing sites (Kimballton, WIPP, Soudan, Oroville)
Establish loan programs and jump start purchases of detectors the will eventually be part of the DUSEL AARM system?

4850 level = Facility for AARM (FAARM)
γ,β,α screening and support infrastructure

- Fits in a Standard Lab Module (20m x 30m x 50m)
- Water shield is inexpensive reduction of rock radioactivity with few contaminants
- Active Muon Veto covers shielded room (or instrument the water shield)
- Additional shielding will be screener-dependent (sensitivity requirements)
- 4850-ft level (deep enough for screening, close to experiments, one unified location for economy of scale, may share water shield infrastructure)



4850 level = Facility for AARM (FAARM)
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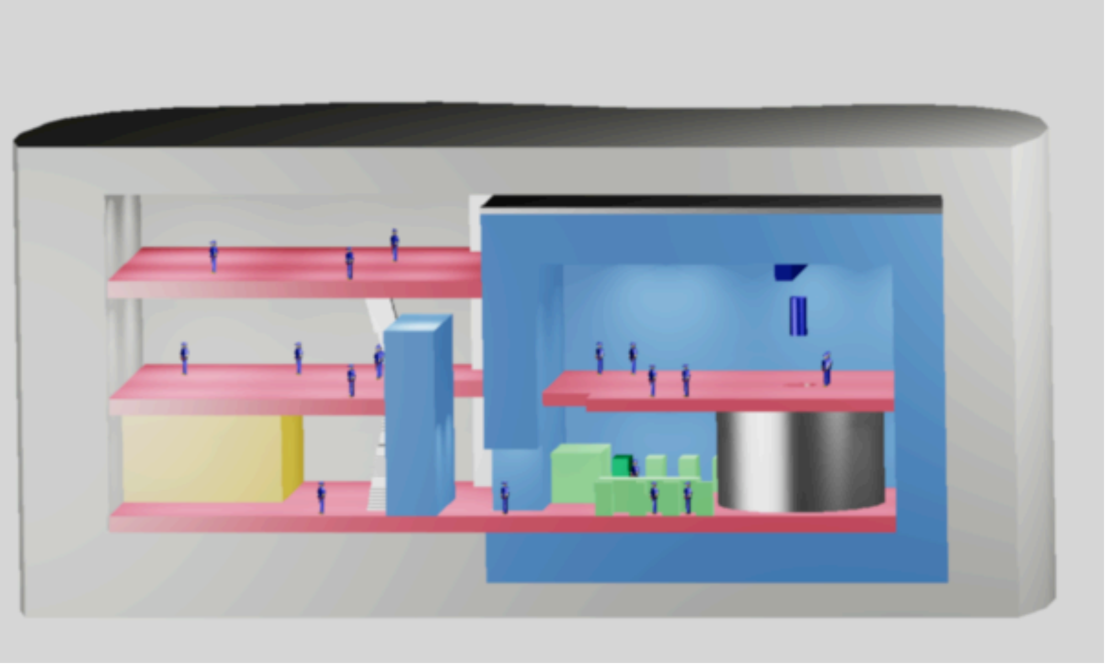
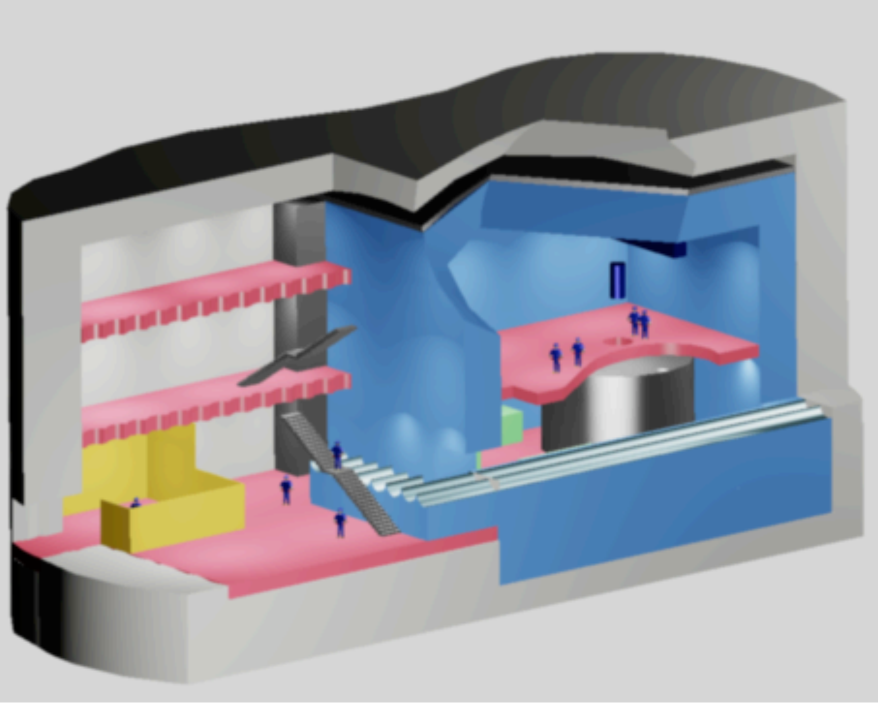




rendered images from CNA Engineering

Other levels are also part of AARM

800’ level

Storage of Materials (overburden and radon-free)

copper, lead, small components

Pre-screeners and NAA gamma counters

Radiochemistry labs for NAA

Chemical Assay and/or Cu Electroforming

Coordinate with Majorana (e.g. might be at 4850’)

Define Surface Facilities

NAA receiving

Later additions may include ICPMS, Surface Characterization Lab (PIXE, SIMS, RBS, Auger …)

WBS for AARM S4 Proposal

1. Develop FAARM science requirements (Cushman)

- 1.1 Water-shielded room (Martoff, Mei)
- 1.2 Ultra-sensitive immersion tank (Keeter)
- 1.3 Design throughput, sensitivity, type, and number of screeners (Schnee)
  - 1.3.1 Gamma counting (incl. NAA) (Piepke, Mei)
  - 1.3.2 Beta counting (Schnee)
  - 1.3.3 Alpha counting (Cooley, Sonnenshein)
- 1.4 Materials acquisition and storage (Henning)
  - 1.4.1 Solid (Cu stockpiling, lead, common shielding material) (Henning)
  - 1.4.2 Liquid (storage of cryogens, water, liquification plant) (Efremenko)
- 1.5 Materials purification and assay (Hoppe)
  - 1.5.1 Cu electroforming (Mintzer)
  - 1.5.2 ICPMS and other chemically assisted processes (Mintzer)
  - 1.5.3 Cryogen purification (Keeter)
  - 1.5.4 Laser isotope separation (Mei)
- 1.6 Common and support spaces
  - 1.6.1 Physics sample prep, wet chemistry lab (Hoppe)
  - 1.6.2 Clean machine shop and specialized assembly (Hoppe, Petersen)
  - 1.6.3 Bio, geo, micro sample prep and clean rooms (McTaggart, Onstott)

WBS for AARM S4 Proposal

2. Design conventional facilities (Petersen, Hulne, Holland)

- 2.1 Develop conventional facilities WBS (and integrate with overall WBS)
- 2.2 Develop facility program and design criteria
- 2.3 Develop conceptual design of surface and underground facilities
- 2.4 Address critical requirements
- 2.5 Develop design and construction schedules
- 2.6 Develop cost estimates for WBS items
- 2.7 Prepare Conceptual Design Report

3. Characterize backgrounds (Mei)

- 3.1 Radon monitoring and design of radon mitigation (Schnee, Cooley)
- 3.2 Cosmogenic backgrounds (Cushman, Mei)
- 3.3 Gamma, (α,n) and fission backgrounds (Cushman, Mei)
- 3.4 Screener-specific shielding requirements (Schnee, Mei)

4. AARM Integration and Collaboration Building (Cushman)

- 4.1 Coordination between FAARM collaboration and design team (Cushman)
- 4.2 Coordination between design team and DUSEL engineers (Petersen)
- 4.3 Screening, training, staffing (Integrate with Sanford) (Cushman, Henning)
- 4.4 Synergies development (McTaggart, Onstott)
- 4.5 Nuclear database and counted materials (Mei)
- 4.6 E&O (Keller)

Outstanding Questions
Water Shield Design

Modular, stackable containers vs monolithic steel frame vs custom wall

Simulation of thickness and sensitivity requirements

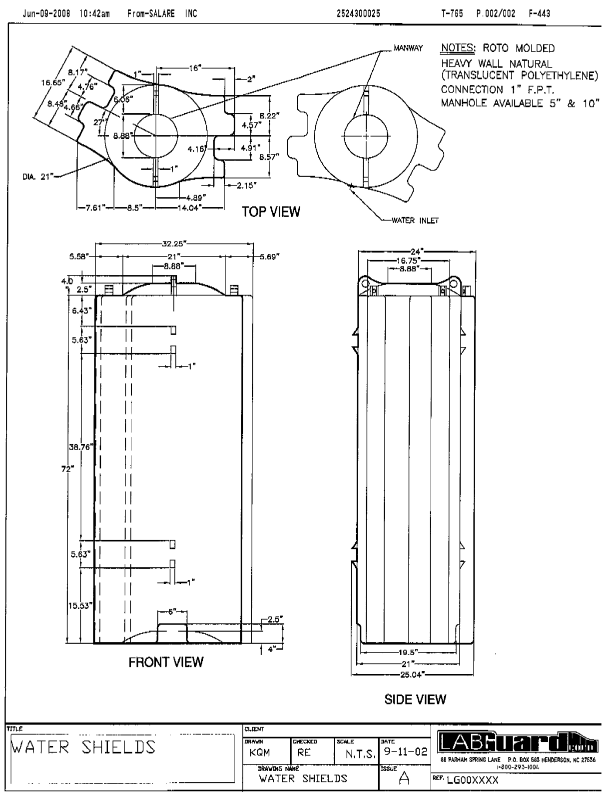
- Muon flux, spectrum
- Cosmogenic neutrons
- radioisotope n,γ reduction

In situ characterization

- gamma bkgd and isotope identification
- radon bkgd
- rock composition
- cosmogenic neutron measurements
- linked to overburden and rock

Choice of muon veto:

- Instrument water shield - or -
- Separate cheap technology umbrella veto.



e.g. commercial vendor
Dufrane Nucear Shieding

Outstanding Questions: Ultra-sensitive Immersion Tank

It is there because it needs to be!   Goal: 10^{-13} – 10^{-14} g/g U/Th
Ideas, but no existence proof yet – we will include only a footprint for April '10

R&D Includes
- Purified Water – how pure? water-soluble scintillators?
- Common stage 1 purification plant with other water shields
- Identify the additional stages

OR
- Liquid Scintillator – type, purification techniques?
- Instrumentation and readout

Tank design, frame? number of layers? radio-pure structural members
Types of immersed screeners, number of ports, location

Determine degree and type of instrumentation
- monitoring level of purity
- monitoring cosmogenics and other bkgds

Milestones for the AARM Cooperative Agreement

Site Characterization and Simulation Studies

12 month Milestones	24 month Milestones	36 month Milestones
Collate previous measurements, (radon variations, neutron and gamma fluxes and rock radioisotope information) Prepare site characterization database and begin targeted measurements. Setup site-specific n,γ GEANT4 MC of water shield and rock (SD and UM) Study immersion tank parameters Optical properties, H2O and LS purity (BHSU)	Characterize site: Measure radon, n,γ at all accessible levels Host ILIAS measurement team and cross correlate with their measurements Determine minimum acceptable radon levels for screening, storage, and experiments. Optimize external water shield thickness, radiopurity of structural members (SD and UM) Define immersion tank properties decide between H2O and LS, active vs passive, size and number of ports	Finish site characterization Establish joint backgrounds working group with new European infrastructures organization. Conceptual plan for radon mitigation Conceptual design of the surrounding water shield Conceptual design of the ultra-sensitive immersion tank

Milestones for the AARM Cooperative Agreement
Determining the parameters of the FAARM

12 month Milestones	24 month Milestones	36 month Milestones
Determine experimental needs and sensitivities of S4 groups as well as possible synergies from outside physics	Decide on number, type and sensitivity of screeners to be located inside the FAARM Preliminary simulations of backgrounds for beta screening. Define type and amount of additional shielding needed for individual screeners based on simulations and requirements Determine footprint of auxiliary services, such as a clean machine shop, material storage, the water purification plant, sample preparation and wet chemistry labs	Determine placement of the alpha, beta, and gamma screeners within the FAARM Finish simulations of backgrounds for beta screening Design of additional shielding configurations for screeners based on the sensitivities required for each screener. Conceptual design of the FAARM infrastructure

Milestones for the AARM Cooperative Agreement

Translating this into a Conceptual Design

WBS	Task	3 months	6 months	12 months	24 months	30 months	36 months
2.1	Develop conventional facilities WBS						
	2.1.1 Draft WBS	X					
	2.1.2 Updated WBS			X			
	2.1.3 Updated WBS				X		
	2.1.4 CDR WBS						X
2.2	Develop facility program and design criteria						
	2.2.1 Initial Program and Design Criteria		X				
	2.2.2 Revised Program & Design Criteria			X			
2.3	Develop conceptual design of surface and underground facilities						
	2.3.1 Develop floor plans, sections, profiles		X				
	2.3.2 Develop excavation requirements and systems concepts			X			
	2.3.3 Update layouts and systems concepts				X		
	2.3.4 Update layouts and systems concepts					X	
	2.3.5 Prepare final layouts and system conceptual designs						X
2.4	Address critical requirements						
	2.4.1 Identify critical requirements		X	X			
	2.4.2 Develop solutions for critical requirements				X		
	2.4.3 Develop final solutions for critical requirements					X	
2.5	Develop design and construction schedules						
	2.5.1 Initial Schedule			X			
	2.5.2 Updated Schedule				X		
	2.5.3 CDR Schedule						X
2.6	Develop cost estimates for WBS items						
	2.6.1 Initial Cost Estimate			X			
	2.6.2 Updated Cost Estimate				X		
	2.6.3 CDR Cost Estimate						X
2.7	Prepare Conceptual Design Report						
	2.7.1 Draft CDR					X	
	2.7.2 Final CDR						X

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