LENA specification document

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Specification Document

Table of Contents

- Detector technology
- Detector dimensions and volume
- Tank materials and purity
- Tank instrumentation
- Scintillator properties
- Liquid and gas handling systems
- Detector installation and filling
- Detector operation

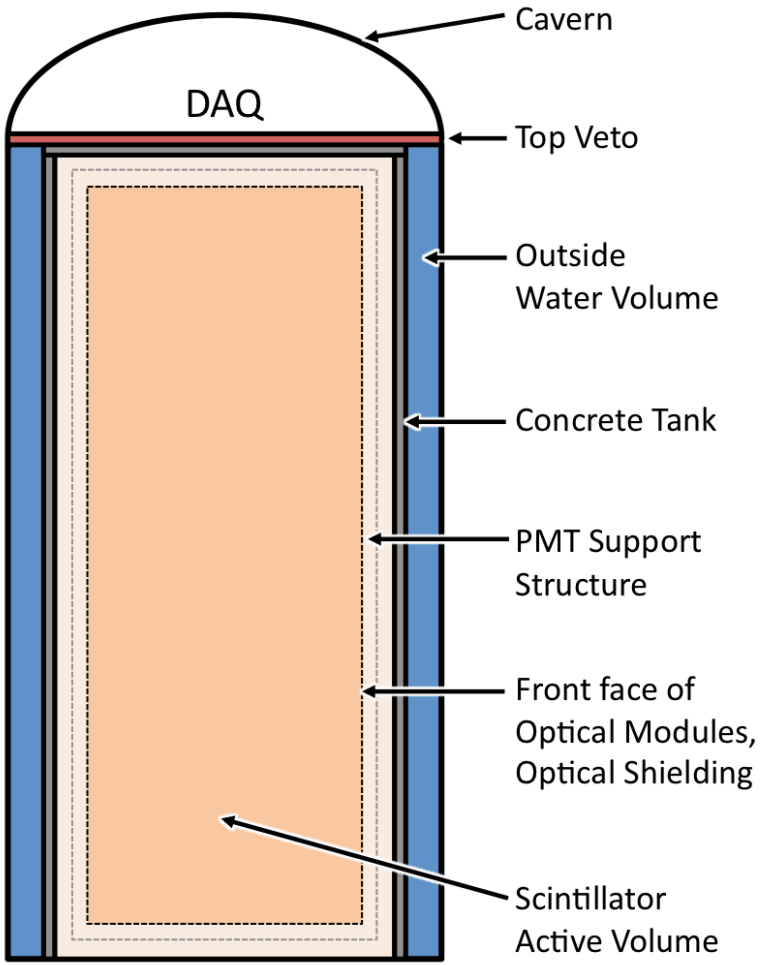
Aim: *A document serving as a reference, e.g. for technical partners.*

New features of the detector design

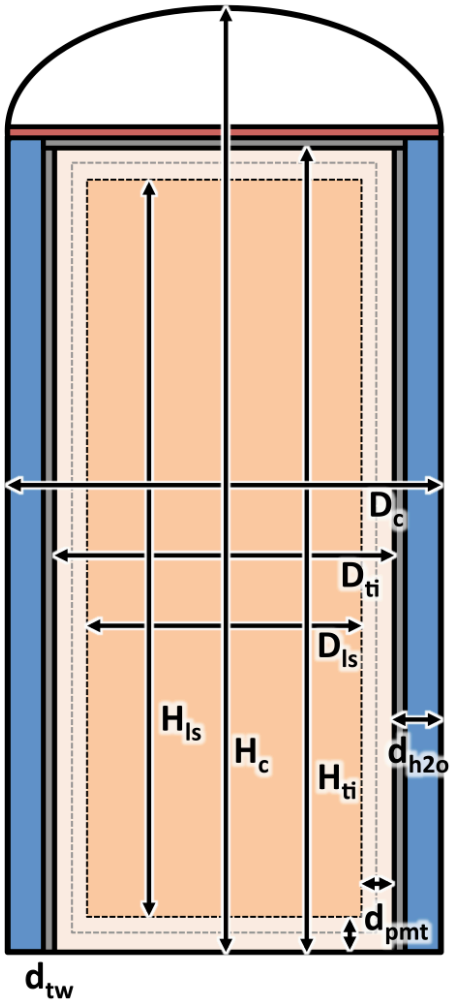
- Concrete tank
- No buffer:
  Scintillator touches tank walls
- PMTs mounted to scaffolding
  2m from the detector walls
- Optical separation of active volume (center) and volume behind the PMTs

Idea:

Get rid of the nylon vessel and shield PMTs from scintillation light of external radiation.



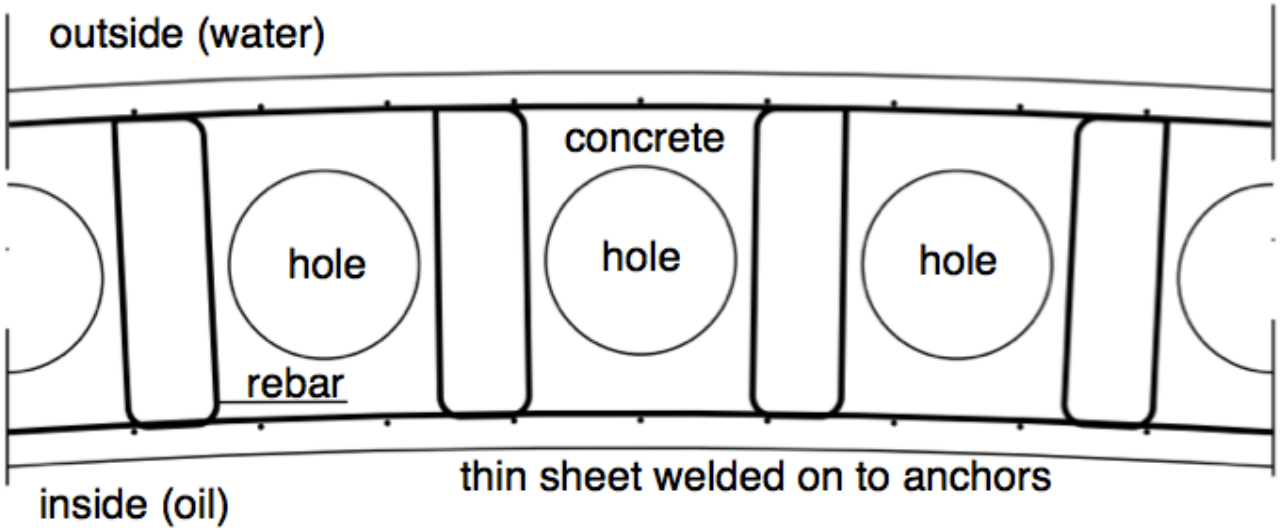
Detector dimensions



Item			25 kt	50 kt
cavern: minimum diameter	D_c	mm	40000	36000
cavern: estimated height	H_c	mm	50000	115000
concrete tank: inner diameter	D_{ti}	mm	36000	32000
concrete tank: inner height	H_{ti}	mm	40000	100000
concrete tank: wall thickness	d_{tw}	mm	600	600
scintillator: total volume		10^3 m^3	40.7	80.3
scintillator: total mass		kt	35.0	69.1
active volume: diameter	D_{ls}	mm	32000	28000
active volume: height	H_{ls}	mm	36000	96000
scintillator: active volume		10^3 m^3	28.9	59.1
scintillator: active mass		kt	24.9	50.8
ratio: active/total			71%	74%
outer water volume: width	d_{h2o}	mm	2000	2000

→ Tank radius increased (by 1m) to 16m to shield additional radioactivity of the concrete tank.

Concrete tank



- Sandwich tank: concrete between stainless steel sheet
- Option: holes for instrumentation/active leak prevention
- Increased stability against outside pressure, cheap material
- Increased radioactivity level: about 10^3 compared to steel
  → dominates PMT activity

PMT support structure

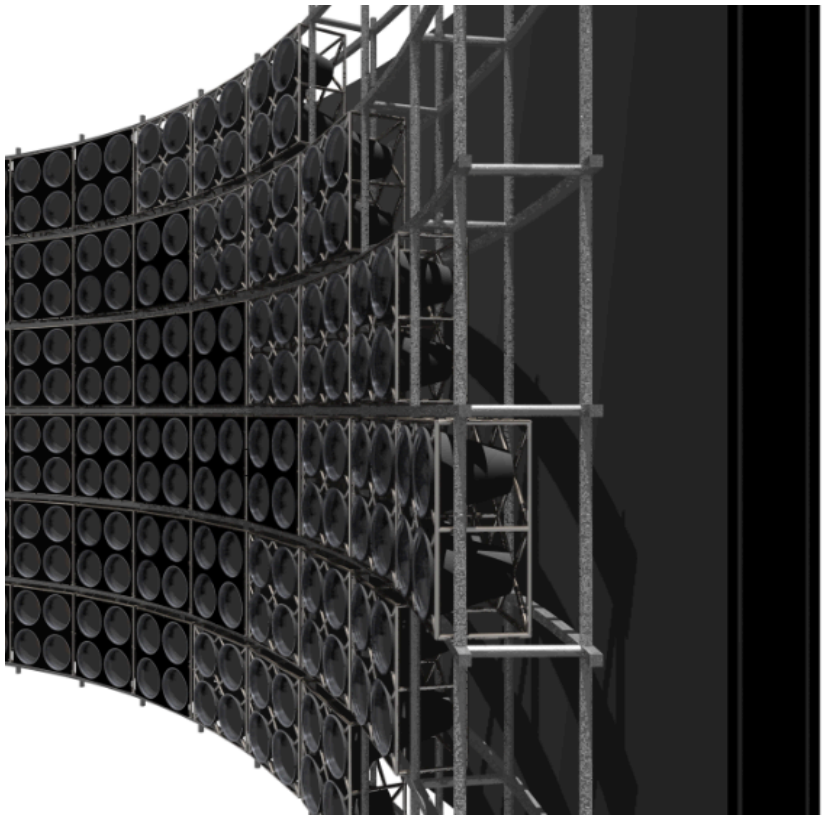
- PMTs are mounted to a steel scaffolding 2m from tank walls

→ attenuates γ-rays (^{208}Tl) by ~10^2

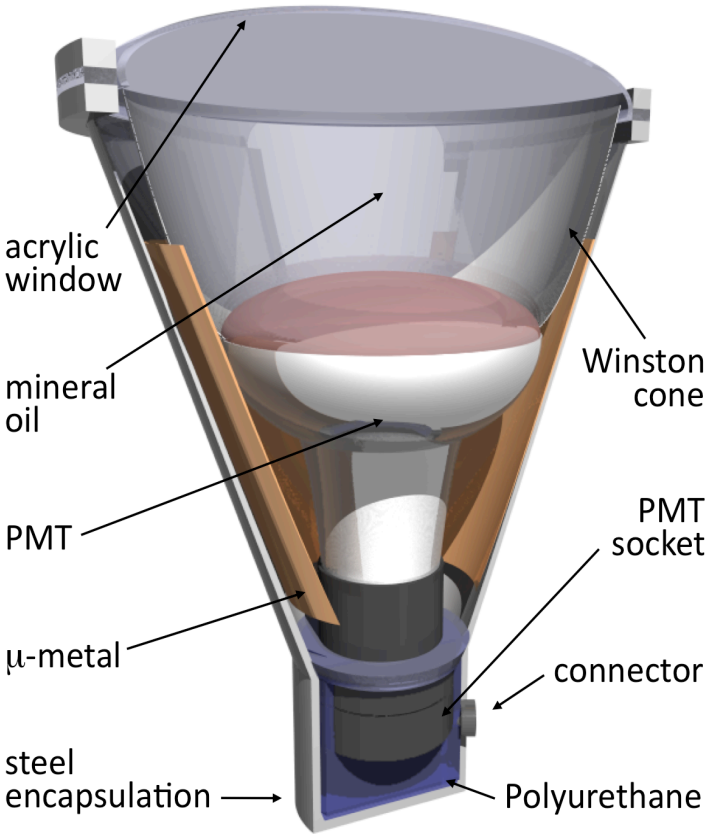
- optical separation of outside volume and inside active volume by opaque, non-reflective plastic sheets

→ OS mitigates Rn-convection (?)

- PMT encapsulation contains an individual buffer volume to reduce activity by >10



New design for optical module



- 12‘‘ PMT favored
- Light concentrator: increases light-collecting area by x1.8
- Due to cylindrical geometry, effective increase only x1.5
- new baseline design: 29,600 PMTs of 20% QE

Properties	12" PMT
OM front diameter	560 mm
OM length	700 mm
PMT length	330 mm
Light cone length	320 mm
Weight	30 kg
Maximum current	0.125 mA
HV requirement	2.0 kV
Power per OM	2.5 W

Radiopurity requirements

Isotope	Concrete	PSS Steel	OM-PMTs	OS Sheets	Scintillator
^{232}Th	14 Bq/kg	0.2 Bq/kg	0.3 Bq/OM	150 Bq/kg	10^{-8} Bq/kg
^{238}U	62 Bq/kg	0.5 Bq/kg	3.2 Bq/OM	600 Bq/kg	10^{-8} Bq/kg
^{40}K	17 Bq/kg	0.03 Bq/kg	0.2 Bq/OM	200 Bq/kg	10^{-8} Bq/kg
^{60}Co	--	0.03 Bq/kg	--	--	--

- Concrete: corresponds to the situation at LNGS, selection required
- PMT support structure: stainless steel for chemical compatibility
- Optical modules and shielding: no special requirements
- Scintillator: Borexino level

→ **Estimated trigger rate: 13 kHz**
PMTs: 8.5 kHz, tank concrete 4.5 kHz

Liquids and gases

Materials

- 80,000 m^3 of LAB
- 240 tons of PPO (3g/l)
- 1.6 tons of bis-MSB (20mg/l)
- >100,000 m^3 pure water
- Nitrogen

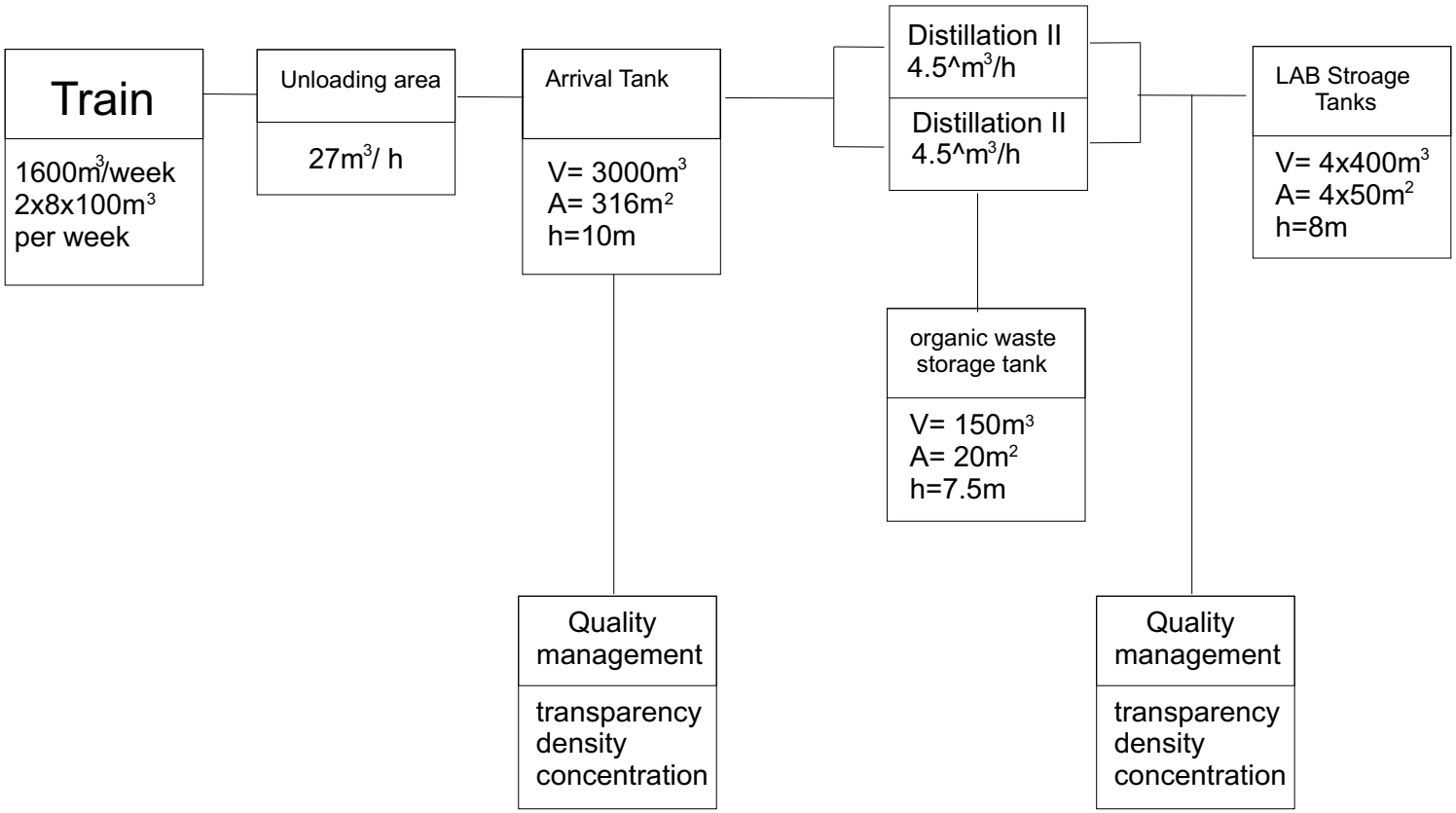
Properties of LAB	
Chemical data	
Chemical formula	$C_{18}H_{30}$
Molecular weight	241
Density	0.863 kg/l
Viscosity	4.2 cps
Flash Point	140 °C
HMIS ratings	
Health	1
Flammability	1
Reactivity	0
Optical parameters	
Index of refraction	1.49
Attenuation length	~15 m
Absorption length	40 m
Abs.-reemission length	60 m
Rayleigh scattering length	40 m

Liquid and gas handling surface systems

Tasks

- Unloading of the arriving scintillator raw materials
- Fabrication of a master solution:
  LAB + 60g/l PPO + 0.4g/l bisMSB
- Purification of pure LAB and master solution
- Dilution of master solution in LAB
- Feeding into the trunk line
- Storage of unprocessed and processed liquids

Example: LAB processing line



Detector installation and filling

One possible Scenario: Prefilling with water

- Bottom PMT support structure (PSS) and optical modules (OM) are installed first.
- Tank bottom is flooded until PSS+OM are covered.
- Floating platform is lowered into the tank.
- Store by store, PSS and OMs are added.
- OMs are grouped in arrays (at least 2x2) assembled off-site.

Year 1

- After reaching the top, water is drained from the tank while scintillator is added at the top.

Year 2

Conclusions

- New design simplifies the detector construction.
- Gamma rates are scaled from earlier calculations by Randolph. Calculations should be confirmed by MC.
- New dimensions and design have to be implemented in MC. In my opinion, new standard should be LAB and FADC read-out.
- Specification document is a good start and was well received within LAGUNA-LBNO and by the technical partners.
- However, it is far from finished – important items missing are e.g. clear concepts for wall anchorings, cabling and electronics, installation of the instrumentation ...