Hyper-K Liner and PMT support

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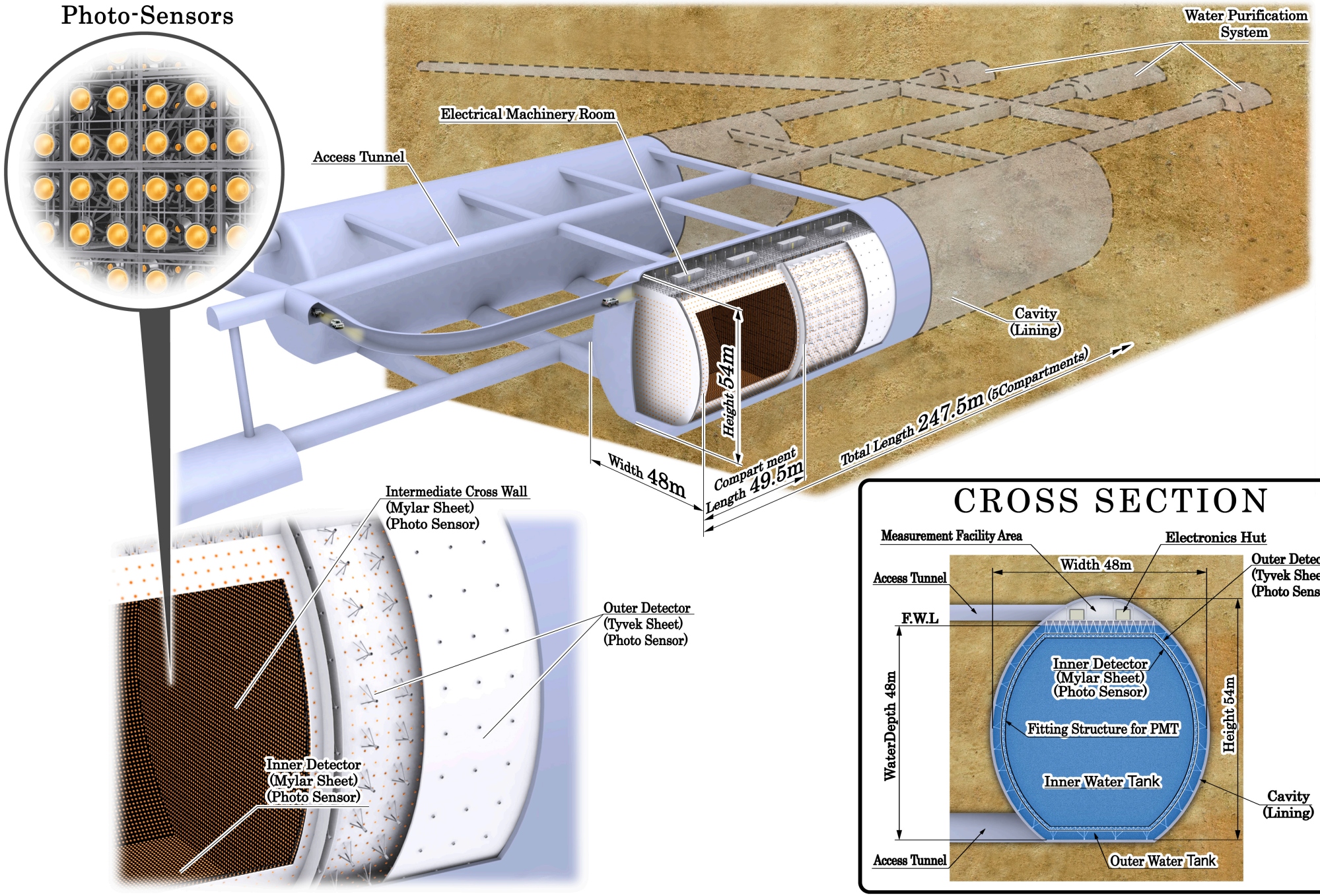
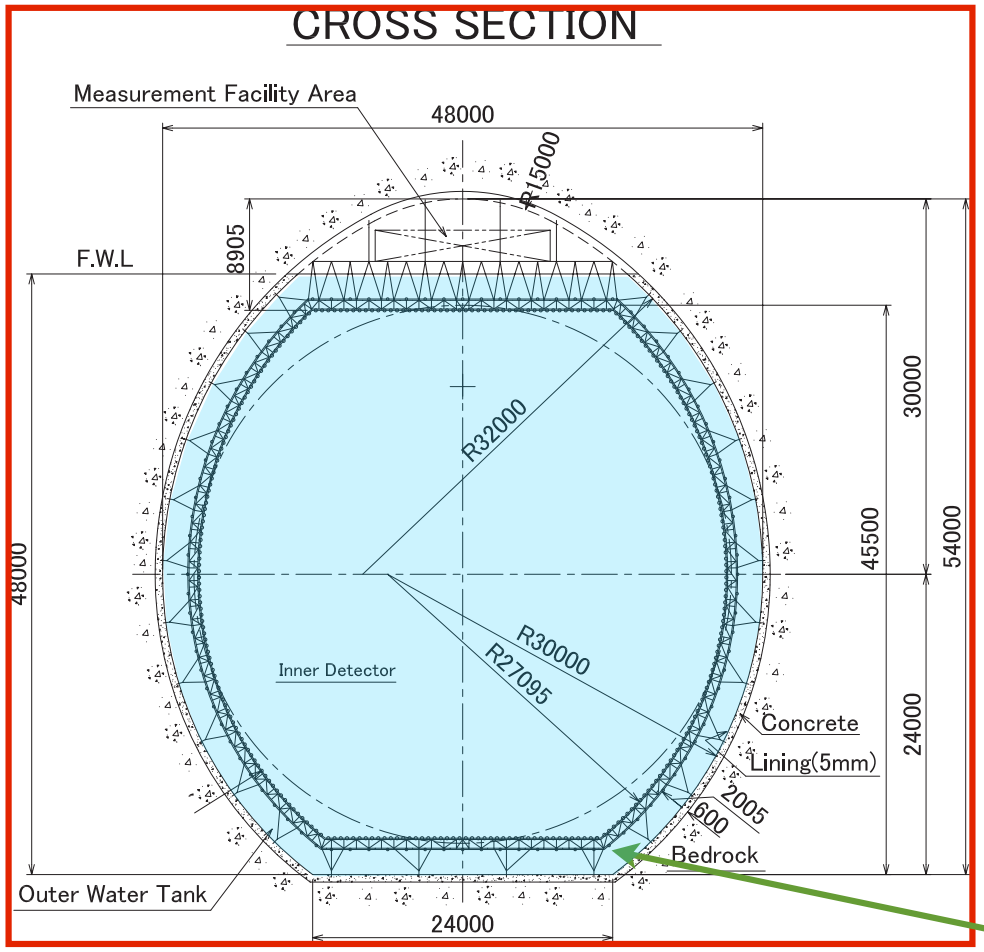
Contents

- Baseline design of the water tank
  - Geometry
  - Liner design
  - PMT support structure, PMT installation, PMT cover
- What's next

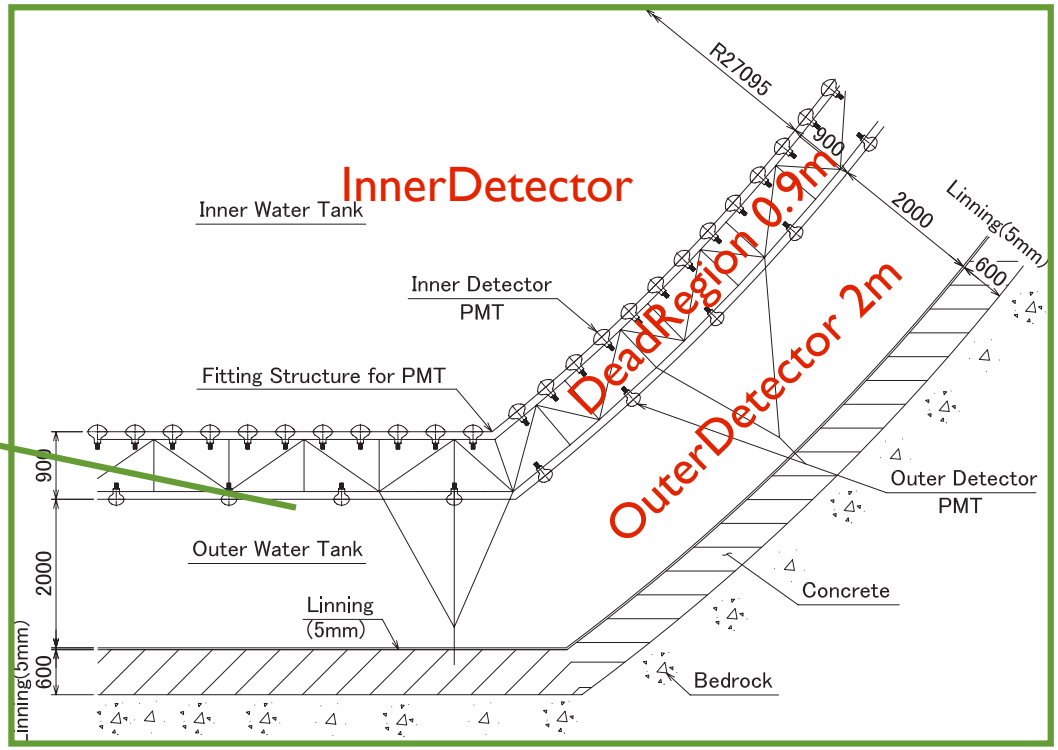
Schematic View of the Hyper-Kamiokande



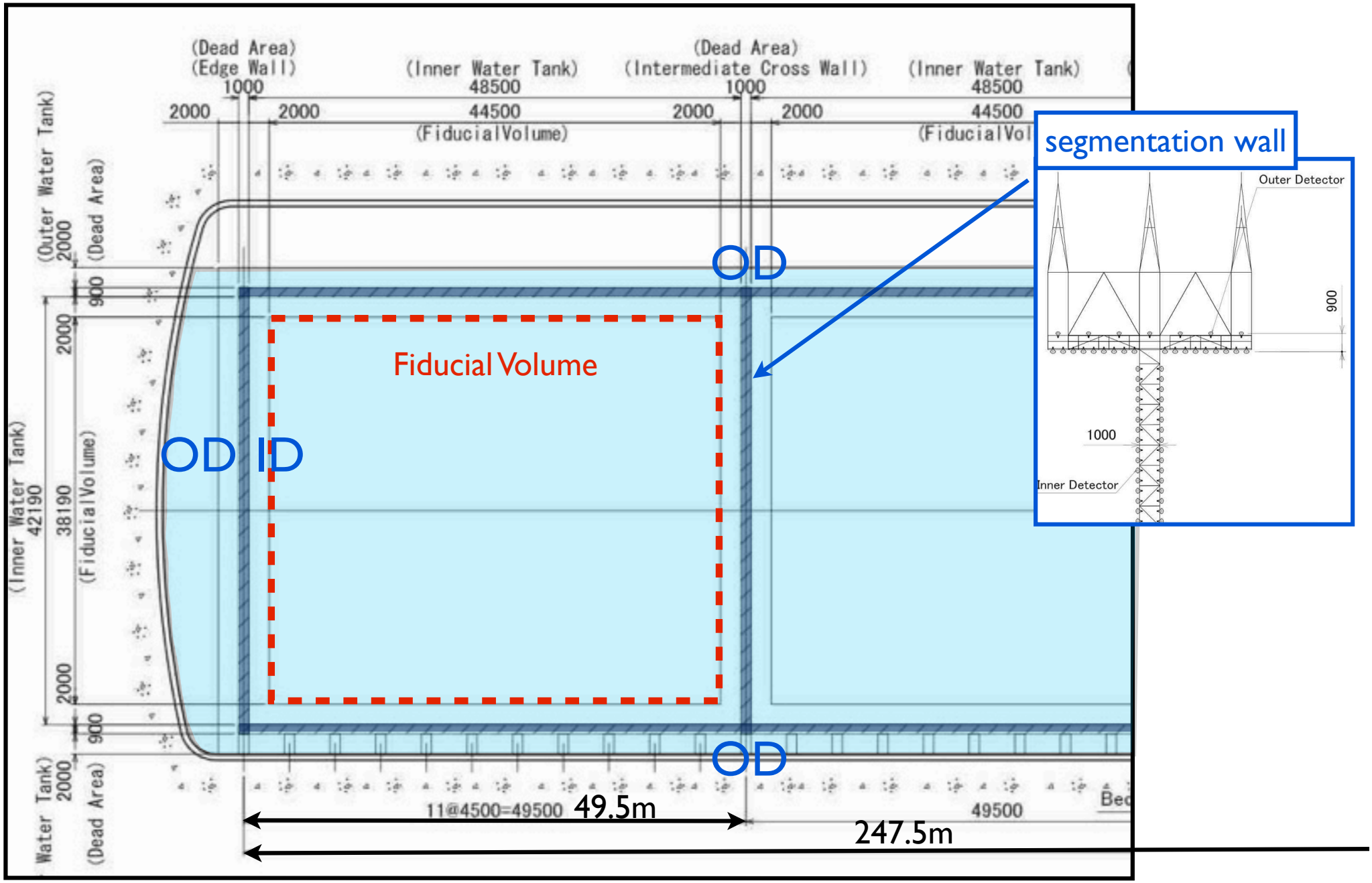
Cross section view



- The cavern with egg-shape optimized for stability
  - avoiding sharp edges



Side view

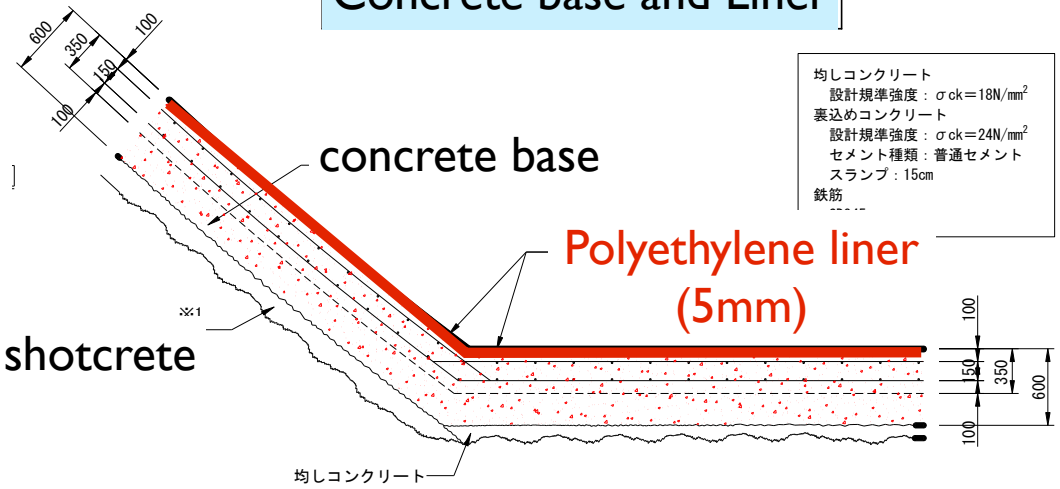

(Dead Area)
(Edge Wall)
1000
(Inner Water Tank)
48500
(Dead Area)
(Intermediate Cross Wall)
1000
(Inner Water Tank)
48500
2000
2000
44500
(FiducialVolume)
2000
2000
44500
(FiducialVol
segmentation wall
Outer Detector
900
1000
Inner Detector
(Outer Water Tank)
(Dead Area)
2000
900
OD
Fiducial Volume
OD
ID
(Inner Water Tank)
42190
38190
(FiducialVolume)
2000
2000
900
OD
Water Tank)
2000
(Dead Area)
11@4500=49500
49.5m
49500
247.5m

Numbers

- Depth of tank water 48m
- Cavern size 48m(W) x 54m(H) x 250m(L) x 2 caverns
- optically separated compartments 5x2 = 10
- Water Volume
  - Total: 0.496x2=0.992 Megaton
  - ID volume: 0.74 Mton
  - Fiducial Volume: 0.056x10 = 0.56 Mton (25 x Super-K)
- PMT
  - ID: 99,000 20" PMTs (20% photo-coverage)
  - OD: 25,000 8" PMTs (same coverage as SK)

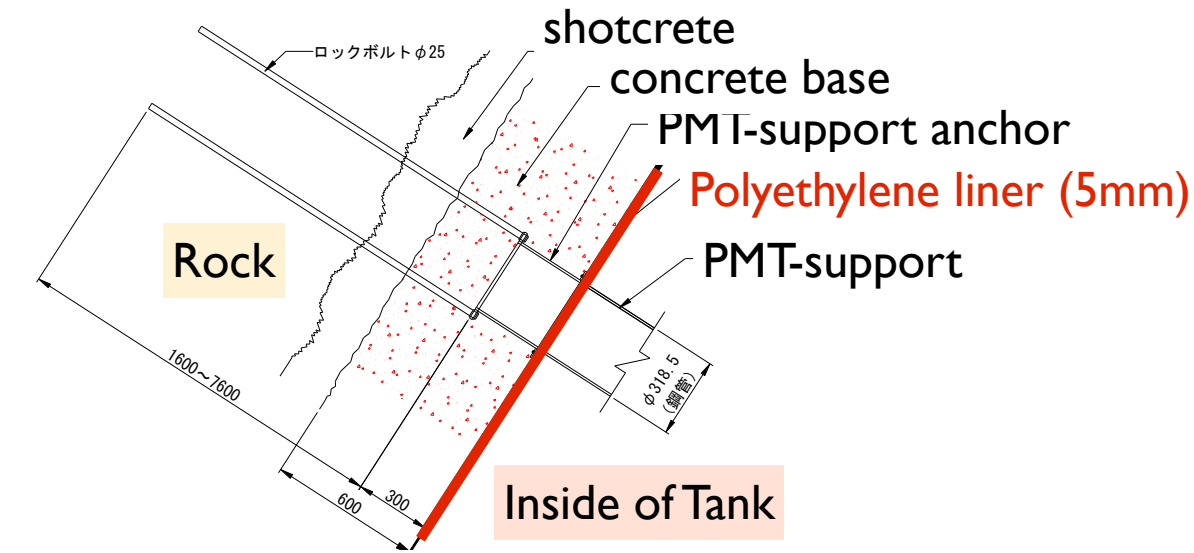
Concrete base and PE liner

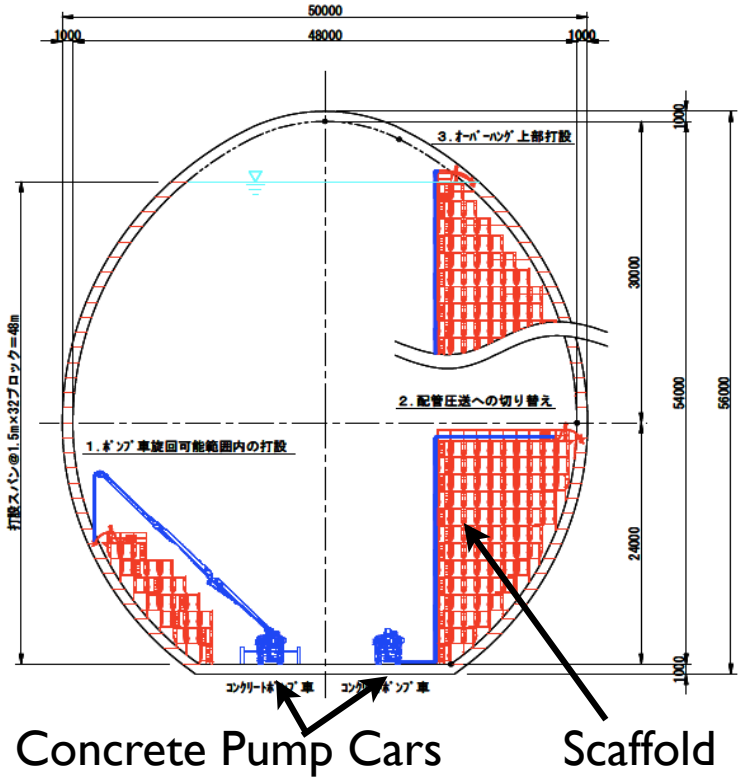
Concrete base and Liner



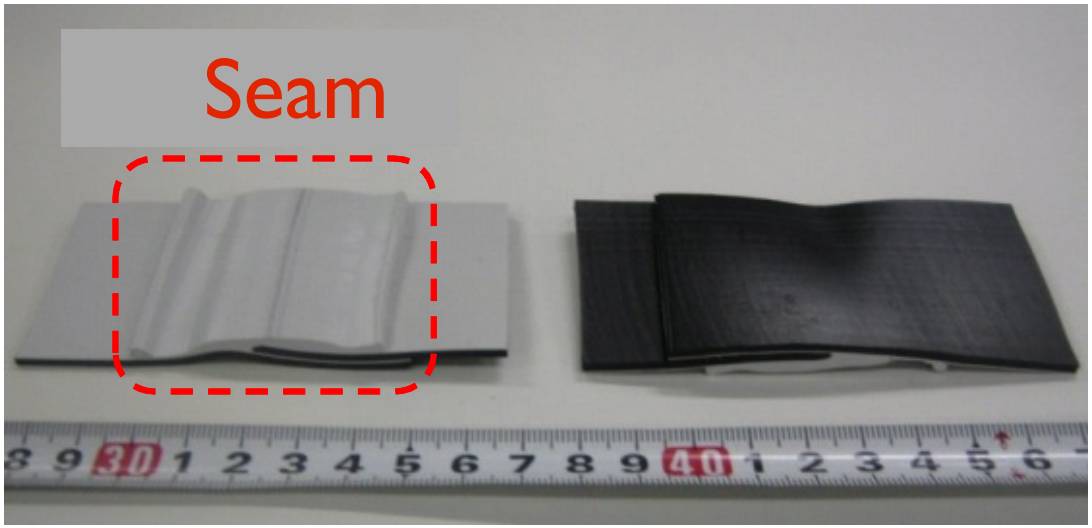
Detailed design of the structure of the concrete layer, connection with the lining sheet is yet to be made.

Penetration



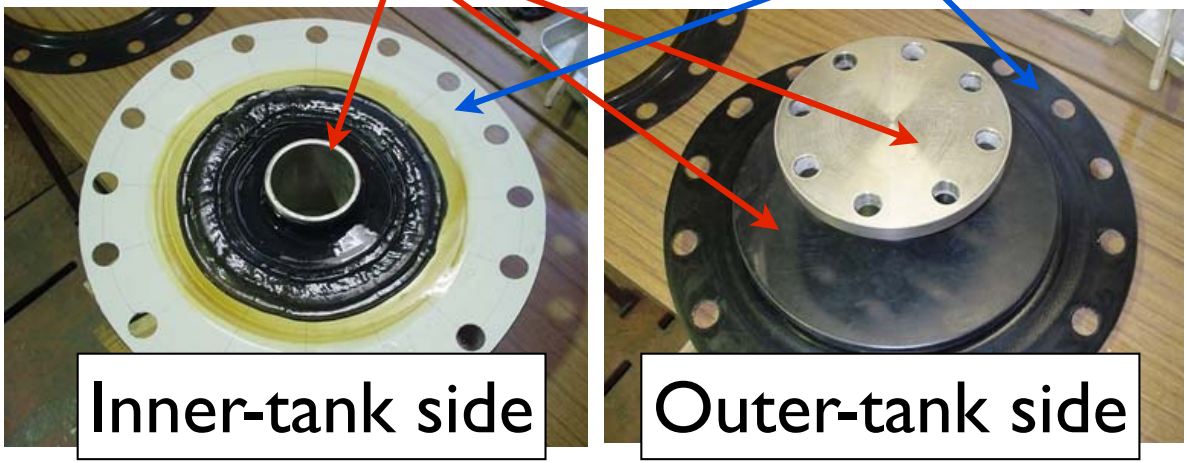


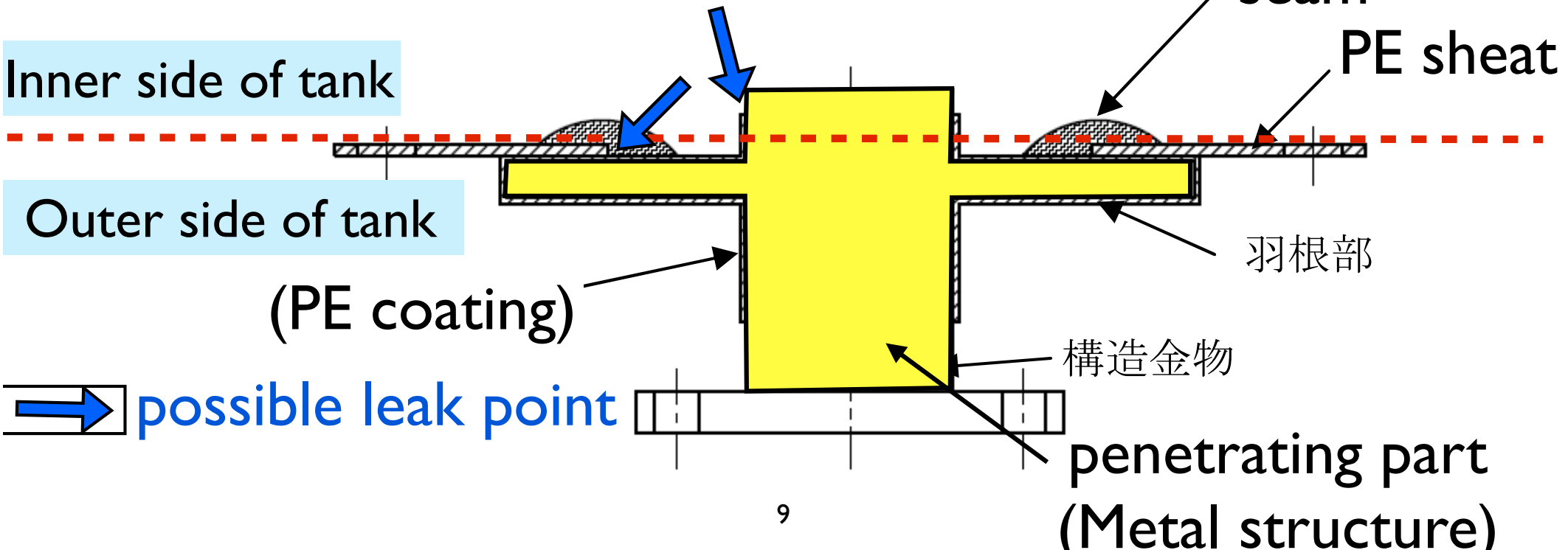
Tank liner sheet



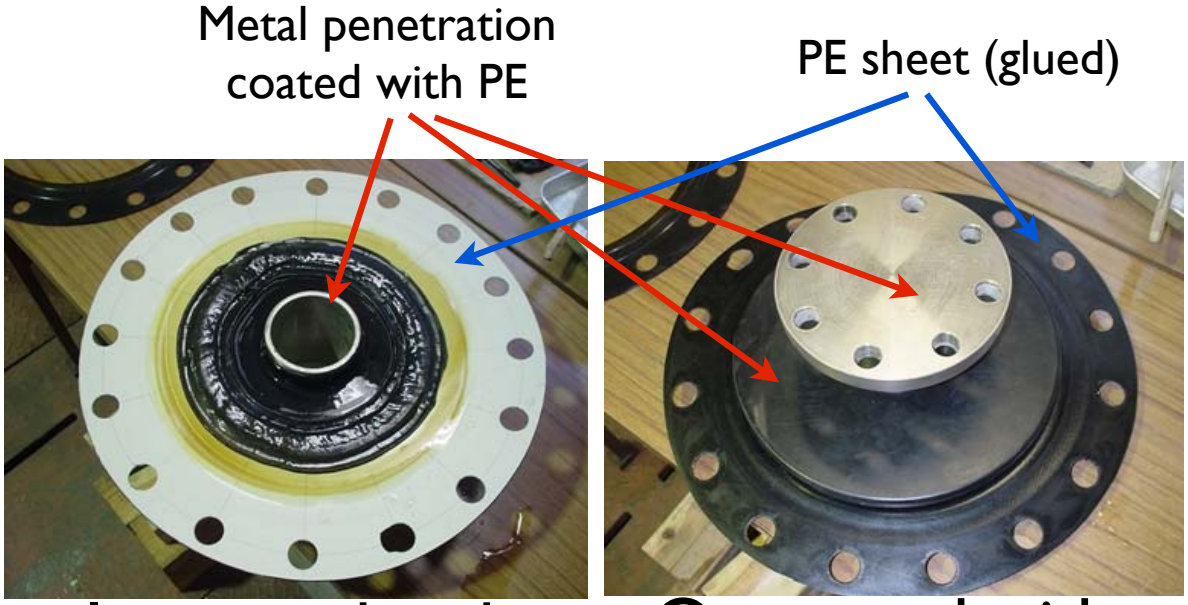
- Plan to use 5mm Polyethylene (HDPE) sheets as tank liner.
  - will be placed on a concrete base to achieve water tight structure.
  - The PE sheets will be welded to each other at on-site.
  - established spark test for holes & seam defects test which will be conducted after installation. Holes/defects will be fixed if found.

Tank liner (penetration)





Tank liner (penetration)

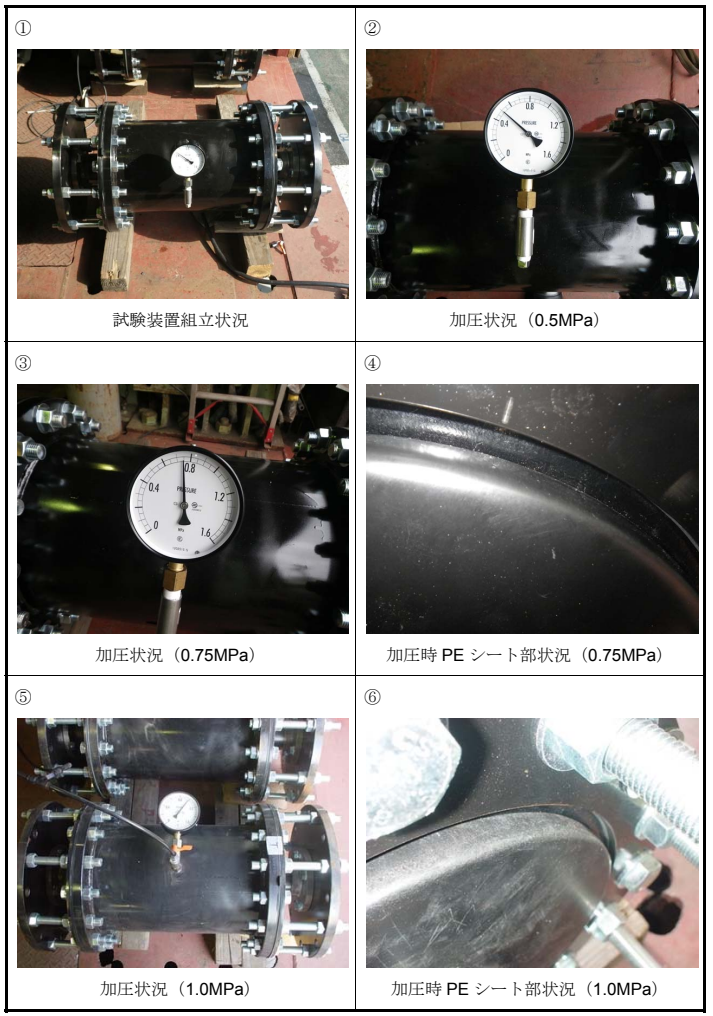


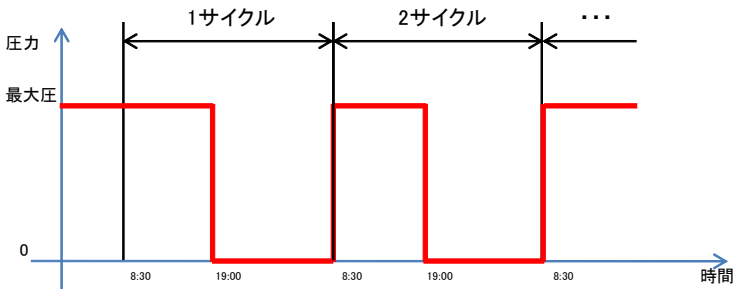
- Plan to produce the penetrating parts in factory (for Quality Control)
  - PE coated metal structure welded with a small piece of PE sheet
  - Large PE sheets and the parts will be welded at on-site
- Pressure test for (0.5MPa, 3 months) was successfully completed. No water leak observed.

Test results for the penetration

1. spark test: no pin hall was found.
2. Pressure test
   1. 0.5MPa, 30min.: no water leak
   2. 0.75MPa, 30min.: no water leak
3. Pressure cycle test
   1. 0→0.5MPa→0→0.5MPa,
   5cycles: no water leak
4. Long term pressure test
   1. 0.5MPa, 3months: no water leak
5. overload test
   1. 1.0MPa, 30min.: no water leak

表-2　試験写真②





water leak at PE sheet

- leaning literature...
- water leak could be dominated by
  - manufacturing deficiencies, improper handling of installation, seaming inadequacies, and puncture incurred during operation.
  - top three is expected to be solved by established spark test, but unpredictable?? need more data.
- leak by diffusion (water vapor transmission)
  - permeation coefficient $k=2.05\times10^{-11}$[cm/s] (measured)

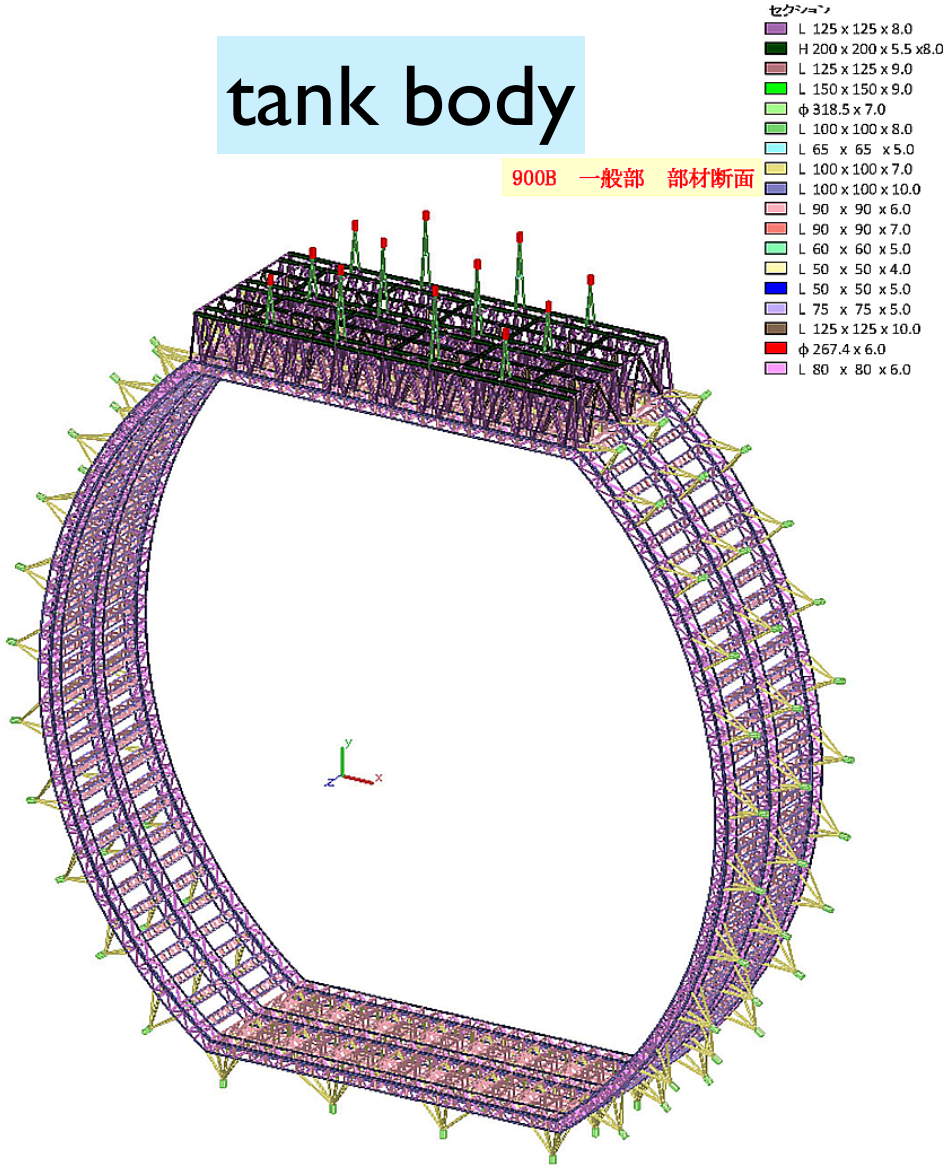
    →740yrs to start leaking, 0.14[m^3/day]
  - $k<1\times10^{-9}$[cm/s](Japan guideline for sheets used at waste disposal place)

    →16yrs to start leaking, 6.7[m^3/day]

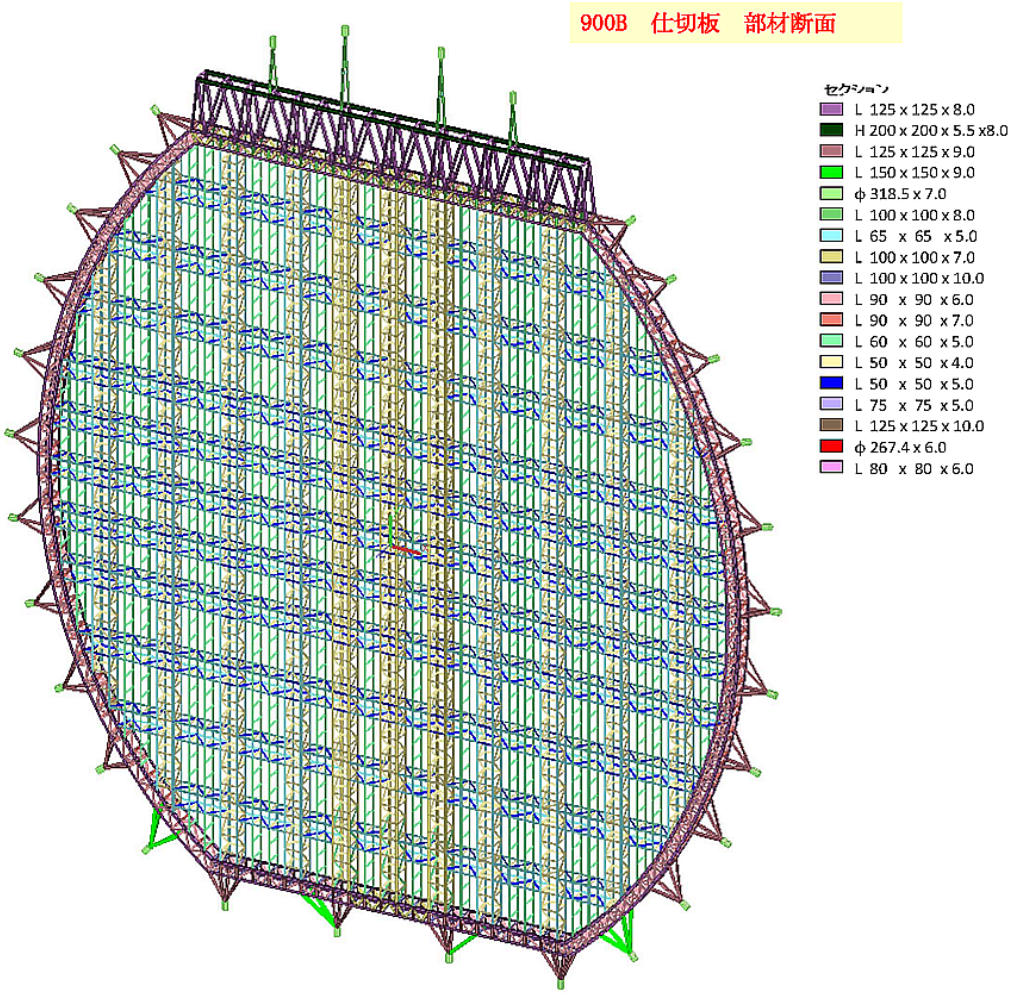
PMT support structure

SUS structure (Super-K style)

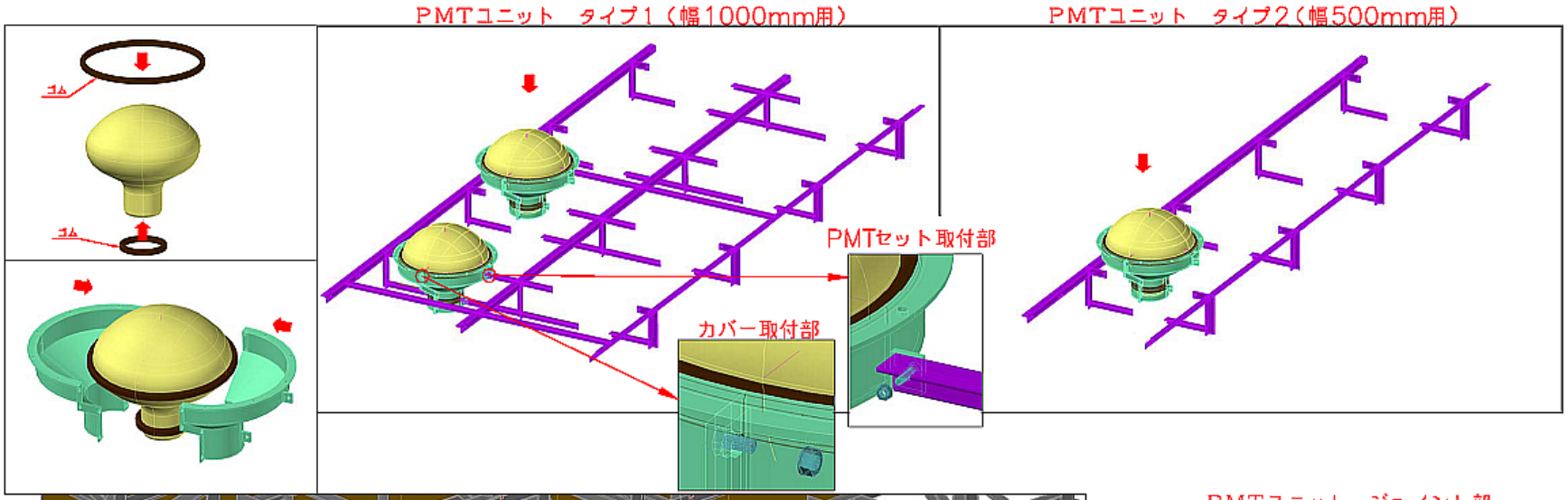
tank body

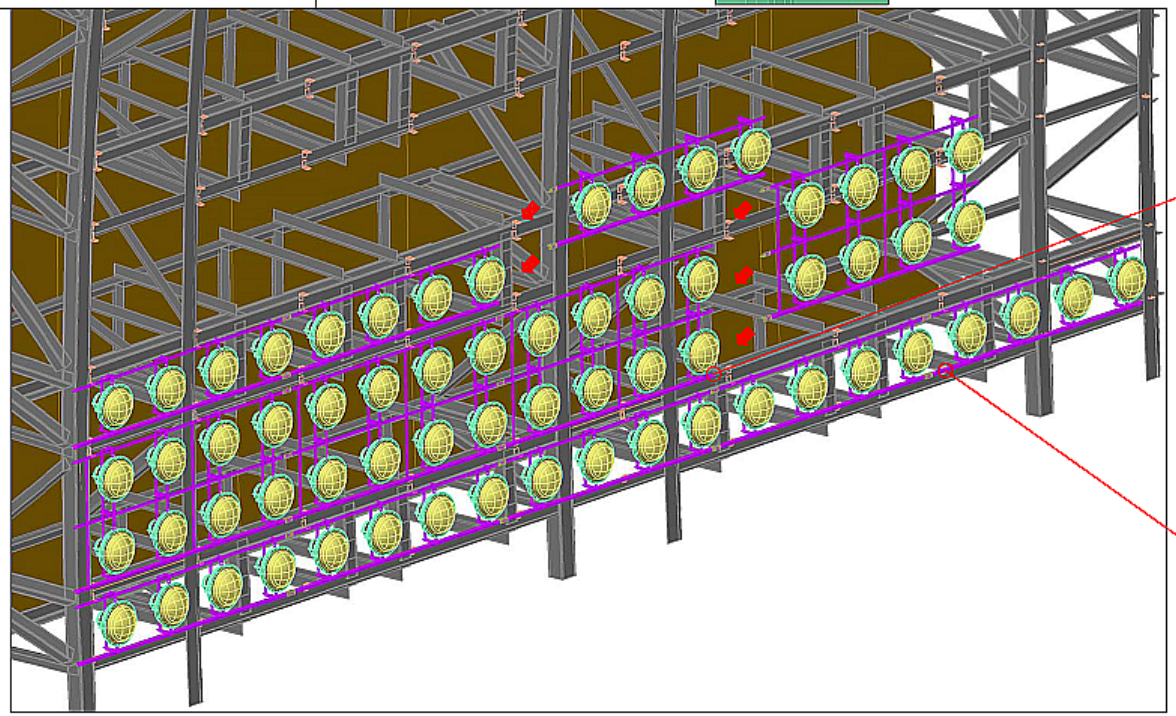


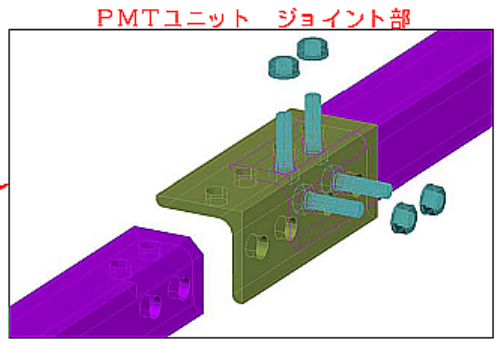
segmentation wall

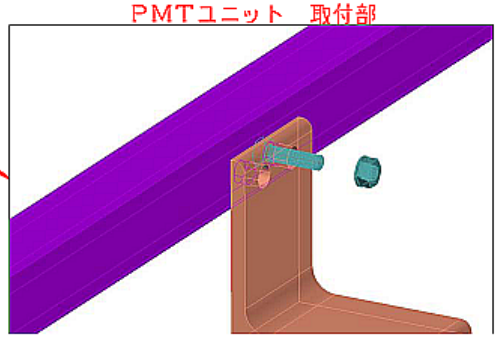


PMT installation



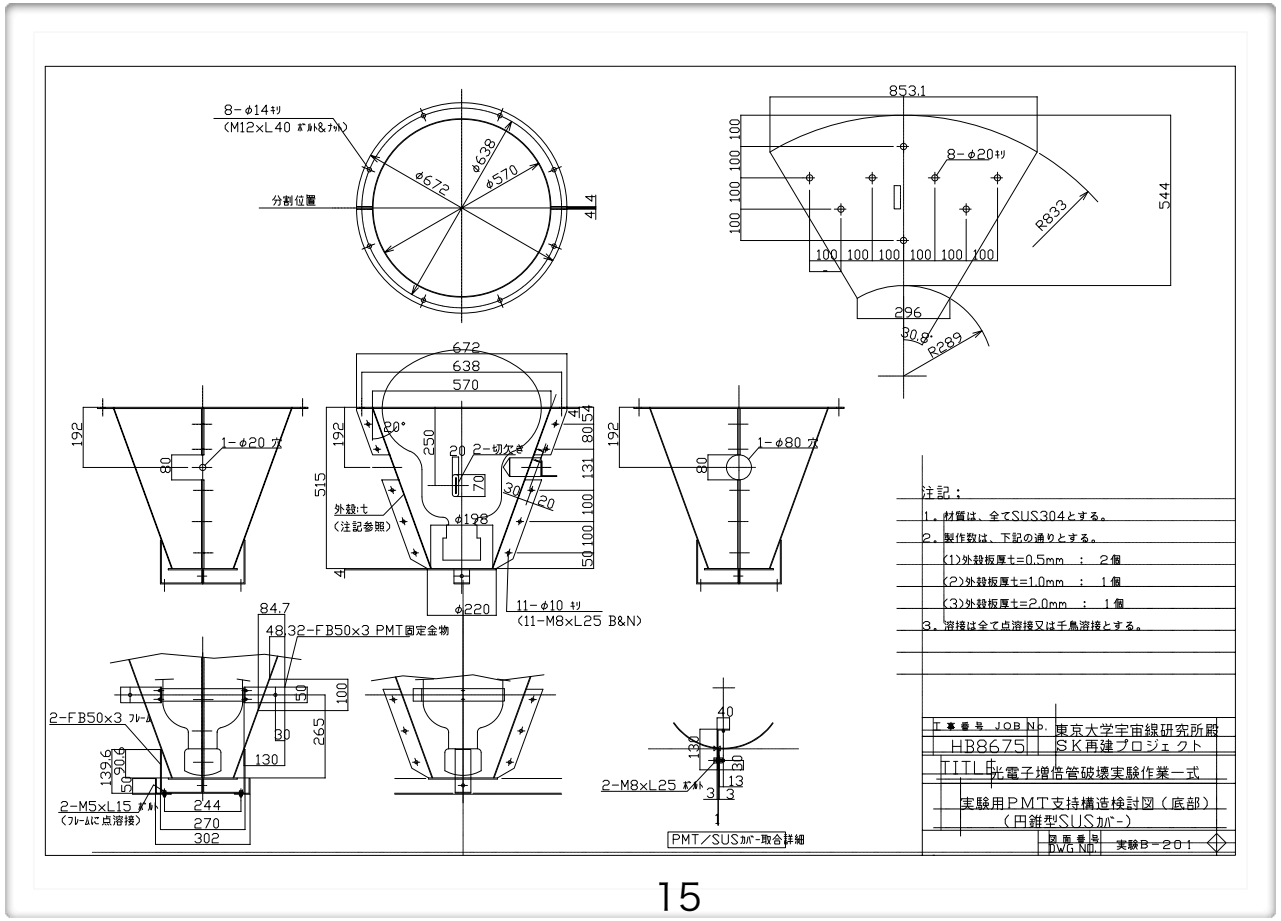






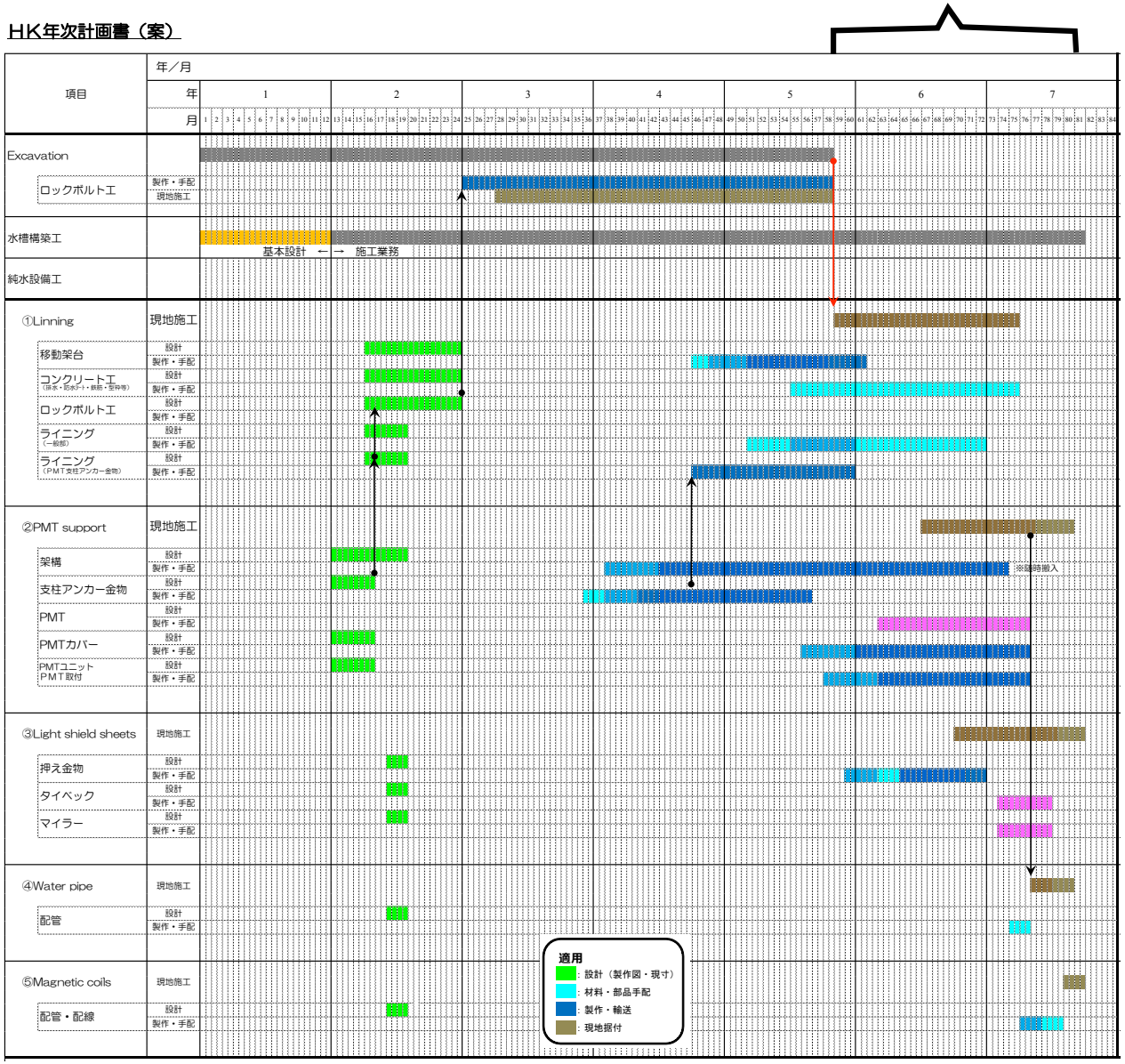
PMT cover

- SUS + acrylic based design
- plan to make prototype
  - feasibility, cost estimation to be made



construction schedule (rough estimation)

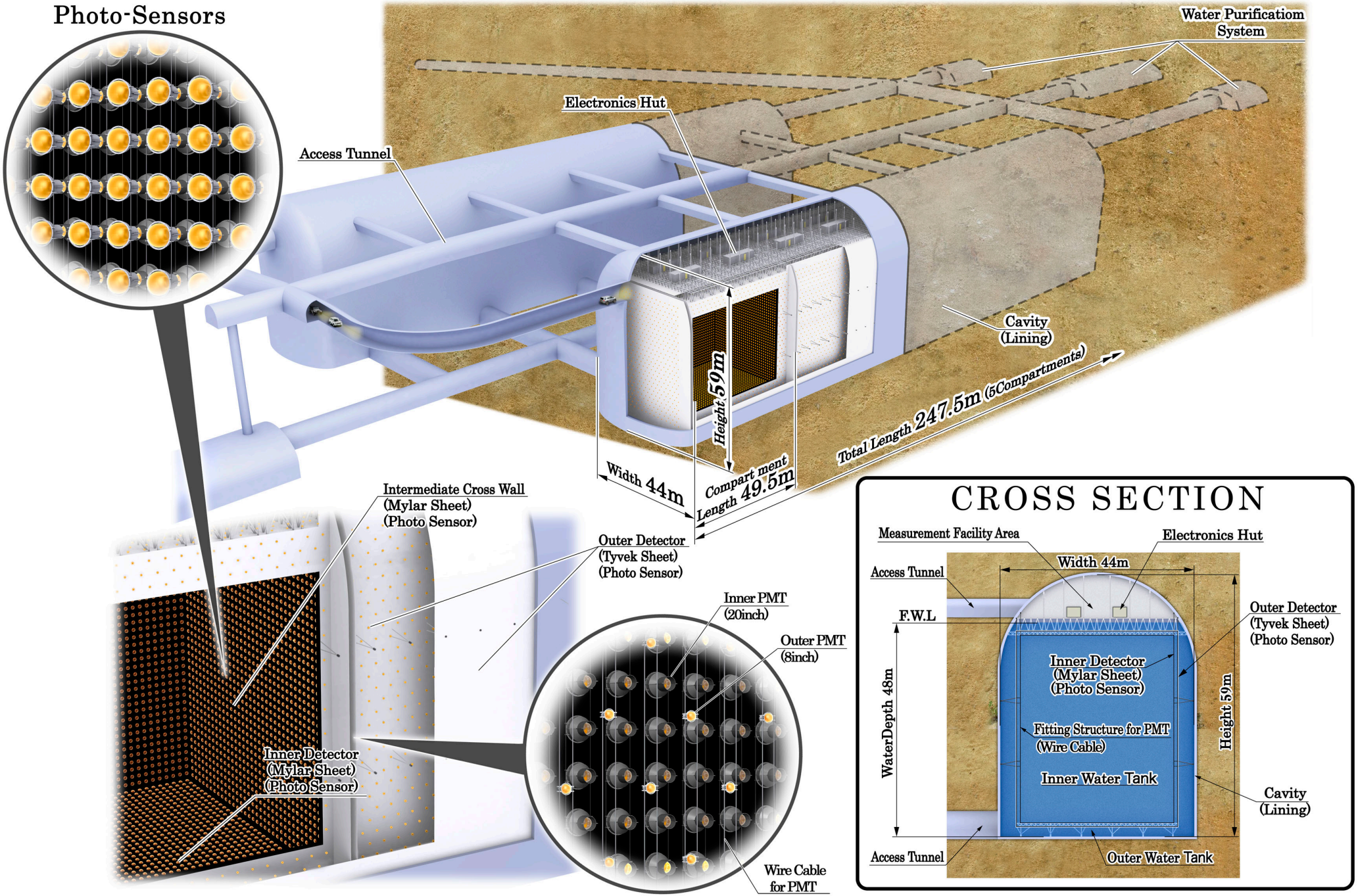
~2years for Tank construction



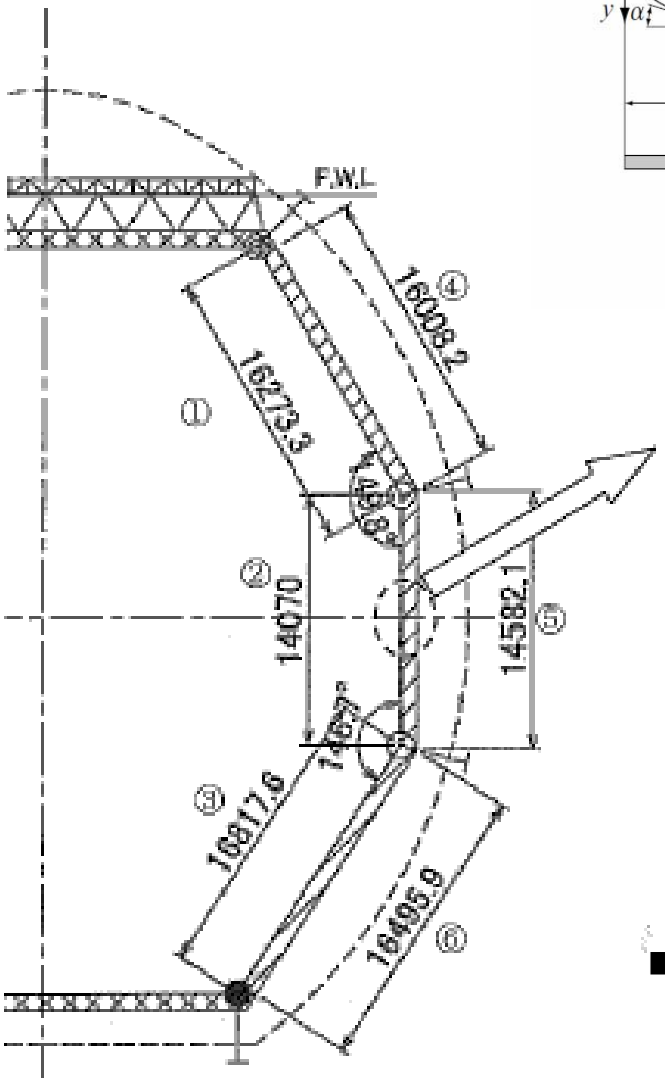
What's next

1. Optimization (design, cost, construction period)
   - Minimization of the SUS structure
     - Can we reduce the load capacity of the deck? 100kg/m^2 (300kg/m^2 for baseline design, 100kg/m^2 for SK)
     - Can we reduce the segmentation walls? ex "5x50m compartments" to "2x125m" (need sensitivity study)
   - Hang PMTs by wire? looks feasible (LBNE)
   - Change of the tank shape? (straight vertical wall)
   - Detailed structure for the concrete and liner
   - Design of manholes, calibration holes, cable holes, water pipes, magnetic coils...
2. Development works, proof test etc.
   - Further study on PE water leak
   - PMT cover prototype and implosion test

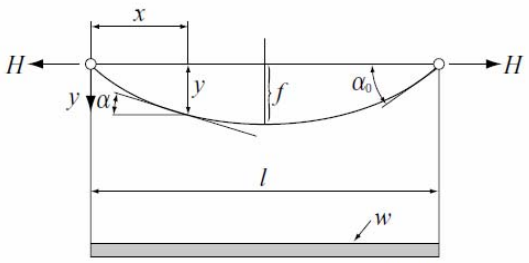
Schematic View of the Hyper-Kamiokande



supplements



①対称形



w=ケーブルの単位質量

$$y=\frac{4f}{l^2}x(l-x)$$

勾　配　$\tan\alpha=\frac{4f}{l^2}(l-2x)$

最大勾配　$\tan\alpha_0=\frac{4f}{l}$

水平張力　$H=\frac{wl^2}{8f}$

最大張力　$Tmax=H\sec\alpha_0=H\sqrt{1+16n^2}\left(n=\frac{f}{l}\right)$

ケーブル長　$L=l\left(1+\frac{8}{3}n^2\right)$

require f < 0.1meter

ロープにかかる張力

area	ω (kg/m)	l (m)	f (m)	H (tf)	T (tf)	T (kN)	必要RBS (kN)
繊維	29.300	16.900	0.1	10.5	11.0	107.9	323.7
CFCC	29.003	16.900	0.1	10.4	10.9	106.9	320.7
鋼ロープ①	30.764	16.900	0.1	11.0	11.5	112.8	338.4
鋼ロープ②	30.690	16.900	0.1	11.0	11.5	112.8	338.4

必要RBS:安全率を　3　とする。

■ロープの選定

	径	構成	破断荷重 kN	単位重量 kg/m	被覆厚 mm	被覆後重量 kg/m	断面積 mm^2	弾性係数 $x10^5$ N/mm^2
繊維ロープ	24	–	353		3.0		705	–
CFCC	17.2	1x7	350	0.289	2.0	0.114	151.1	1.55
鋼ロープ①	22.4	7x7	345	2.02	2.0	0.144	244	1.37
鋼ロープ②	20.0	1x19	350	1.96	2.0	0.130	239	1.57