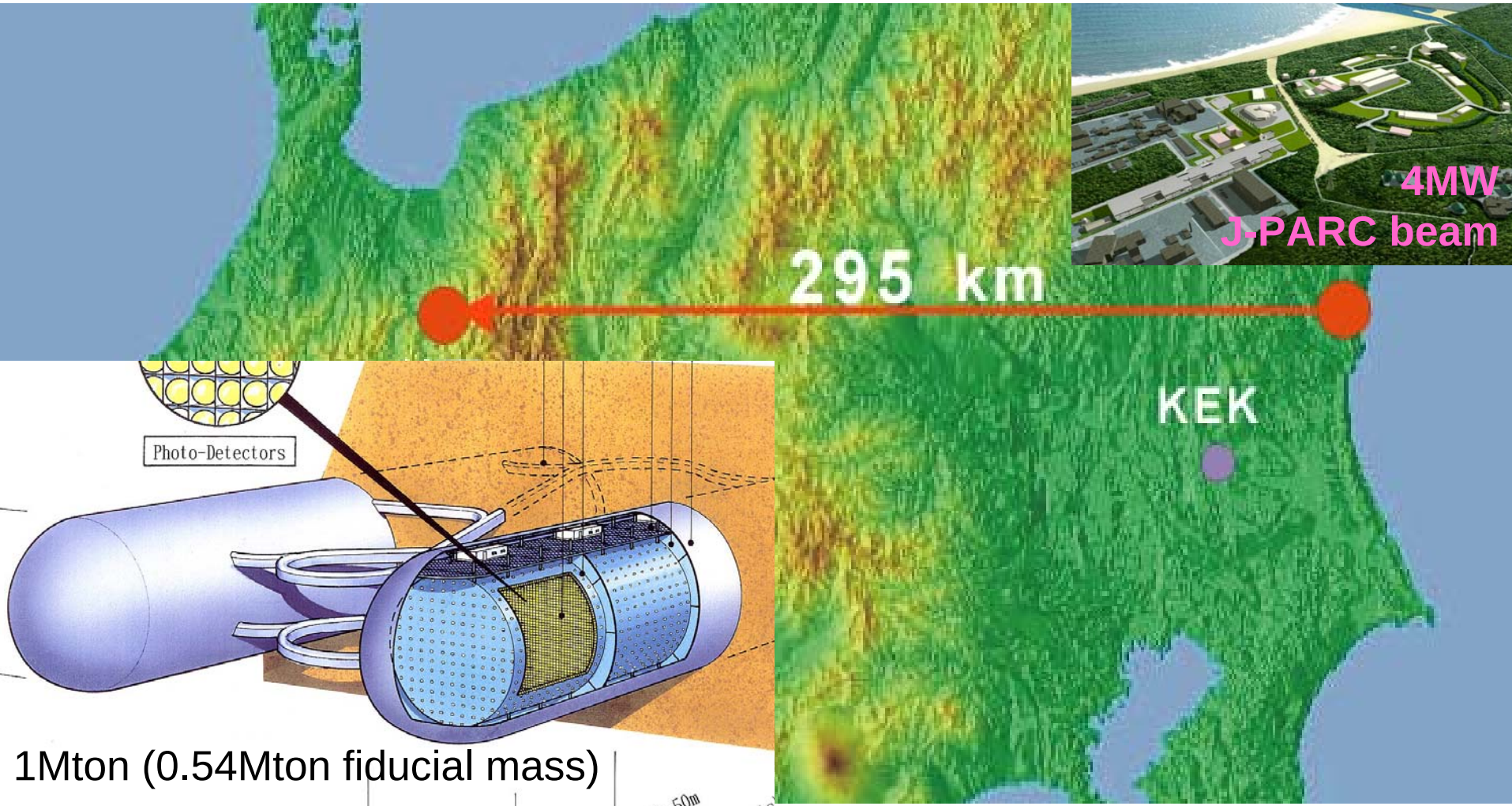
Deep Underground Large Water Cerenkov Detectors

- Two types have been proposed.

- 1) **Horizontal cylinders ~60 m diameter by 180 m long** – **UNO & HyperKamiokande**

- 2) **Vertical cylinders – diameters 40 – 57 m, height constrained by PMT pressure limit** – **SuperKamiokande, Homestake and Frejus**

2. Hyper-Kamiokande and T2K-II



2years of ν run + 6 years of anti-ν run ➔
O(0.5 10^6) events for both runs

UNO Detector Conceptual (Baseline) Design

A Water Cherenkov Detector

optimized for:

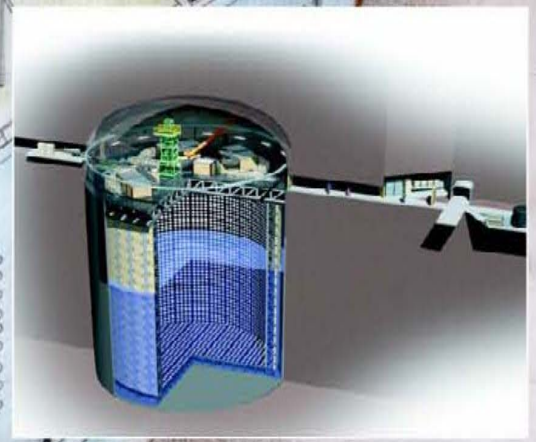
- Light attenuation length limit
- PMT pressure limit
- Cost (built-in staging)

UNO Collaboration

101 Physicists

43 Institutions

9 Countries

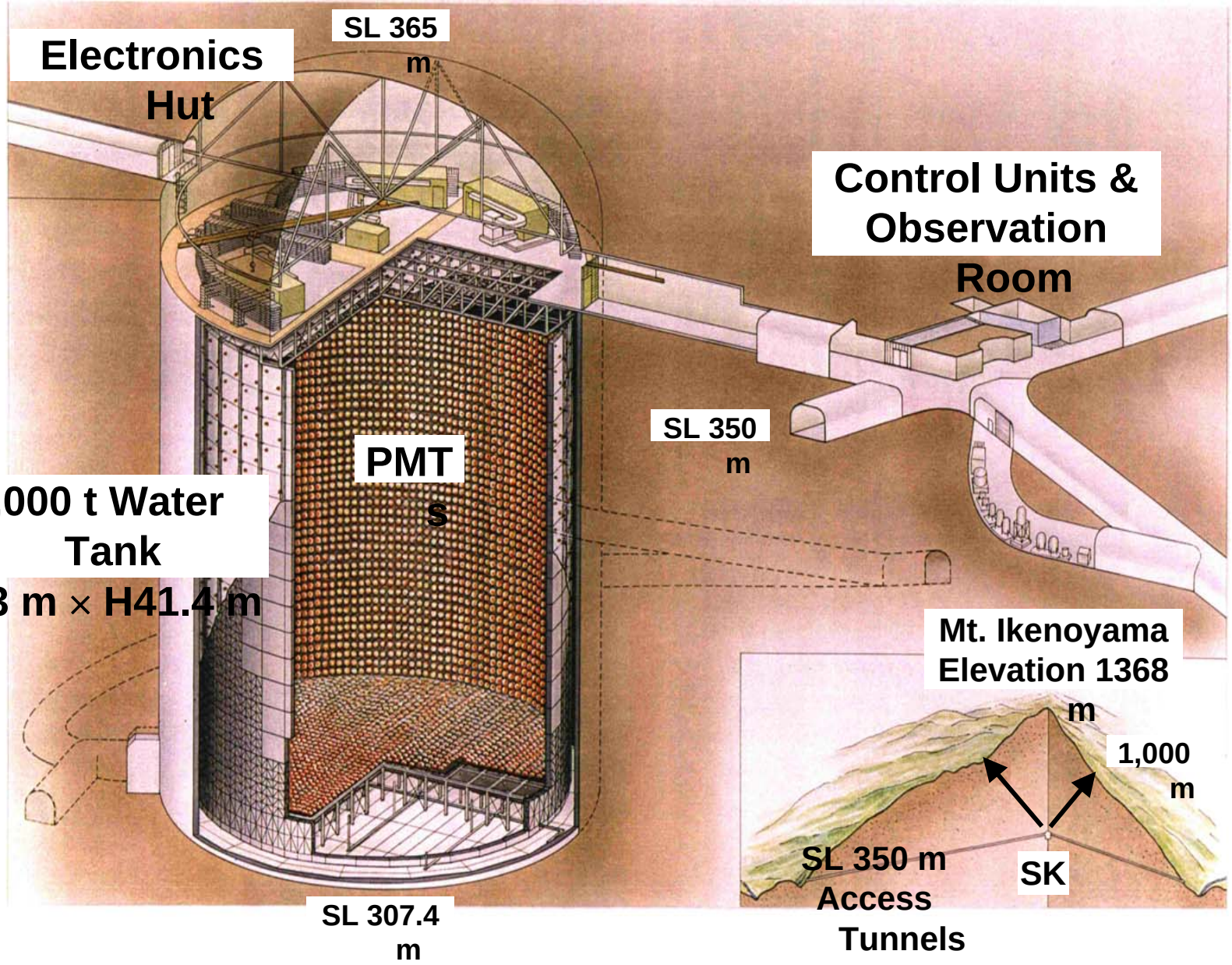


$60x60x60m^3x3$

Total Vol: 650 kton

Fid. Vol: 440 kton (20xSuperK

# of 20" PMTs: 56,000


Electronics Hut
SL 365 m
Control Units & Observation Room
SL 350 m
PMTs
50,000 t Water Tank
ϕ39.3 m × H41.4 m
Mt. Ikenoyama
Elevation 1368 m
1,000 m
SL 350 m Access Tunnels
SK
SL 307.4 m
SUPERKAMIOKANDE
INSTITUTE FOR COSMIC RAY RESEARCH UNIVERSITY OF TOKYO
NIKKEN SEKKEI

DESIGN AND CONSTRUCTION OF A MODULAR MASSIVE DETECTOR AT THE HOMESTAKE LAB

Modular Mass – 100 Kilotons - fiducial

Modular Shape –Cylinder –53m dia x 53m high

Depth – 4200 mwe (cosmic ray rate = 0.1Hz)

Photocathode coverage – 25%

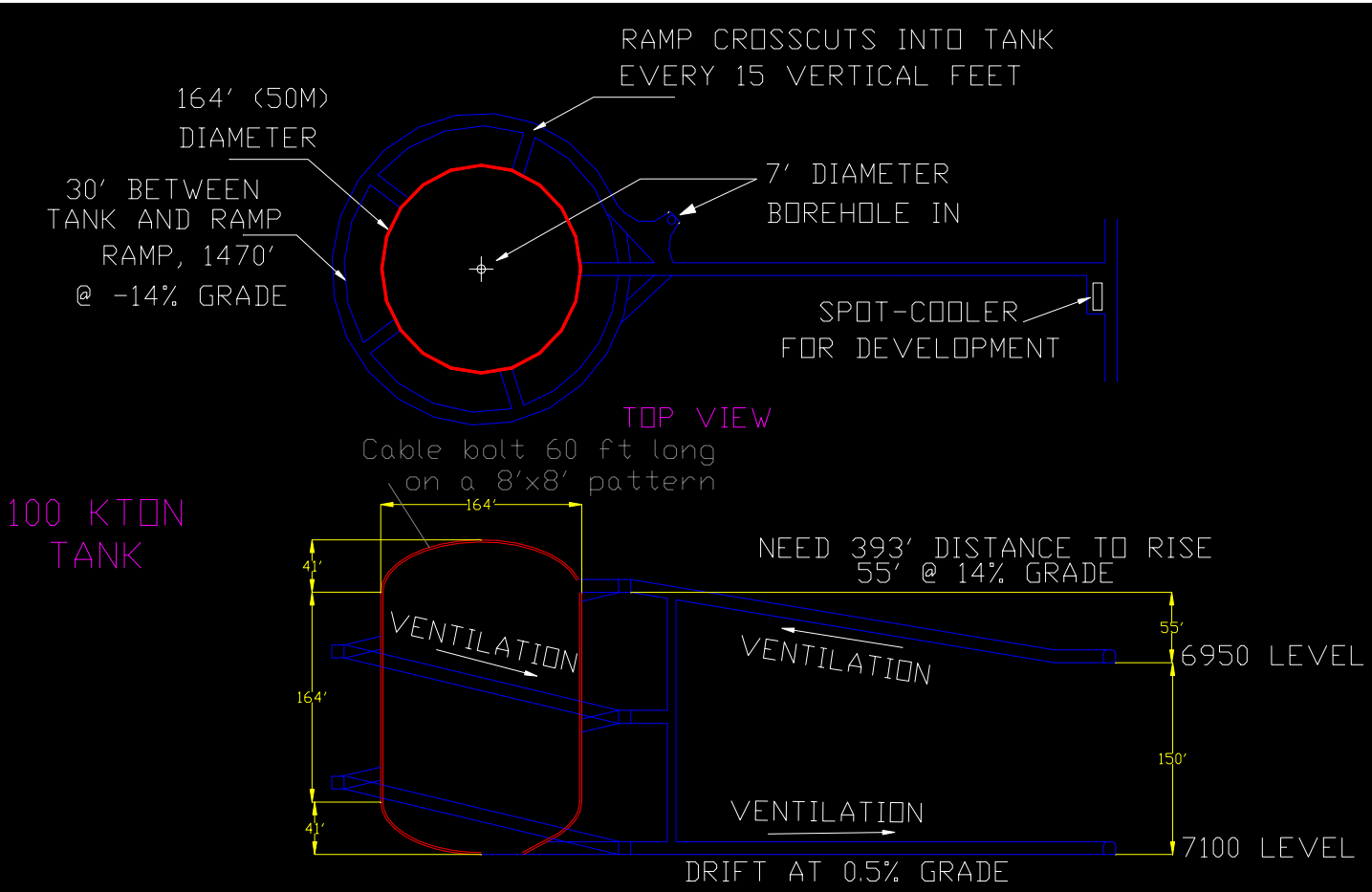
Initial Detector – 3 modules (300 kilotons)

Construction time - 5 years for 3 modules

Cost - ~ $100 M / module

Ultimate detector – 10 modules (1 Megaton)

SINGLE 100 KILOTON MODULE - HOMESTAKE



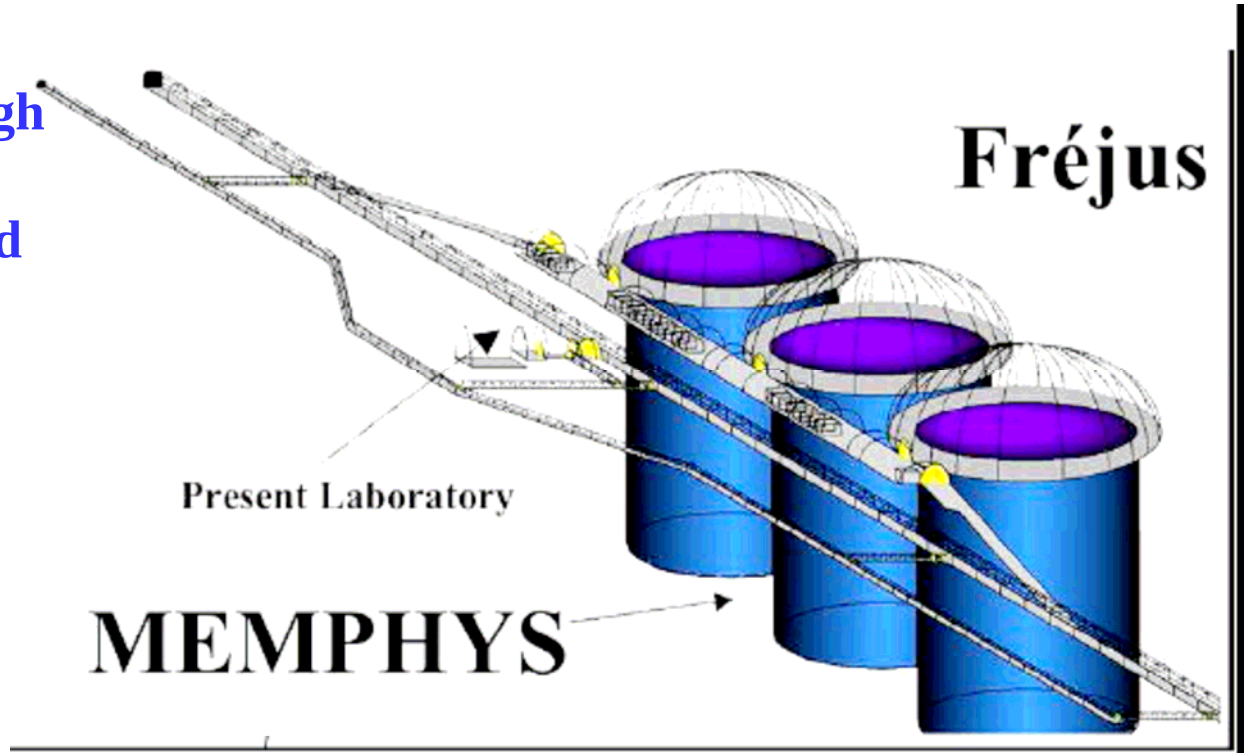

Mega Ton Dector
Xenon
Phase 1
Phase 2

MEMPHYS at Fréjus

Up to 5 shafts possible
Each 57m diam., 57m high

For most studies assumed
3 x 145 ktons.
Water Cerenkov

Depth: 4800 m.w.e



FOR 100 ktons)

Per shaft: 81,000 12" PMT's → 80 M€ including electronics (65M$ KL 62M$)
+80 M€ for civil engineering. (65M$ KL 29M$)

Rock Mechanics and Excavation

- **Rock characteristics will be measured & evaluated by Bill Pariseau (Utah) & NIOSH–**

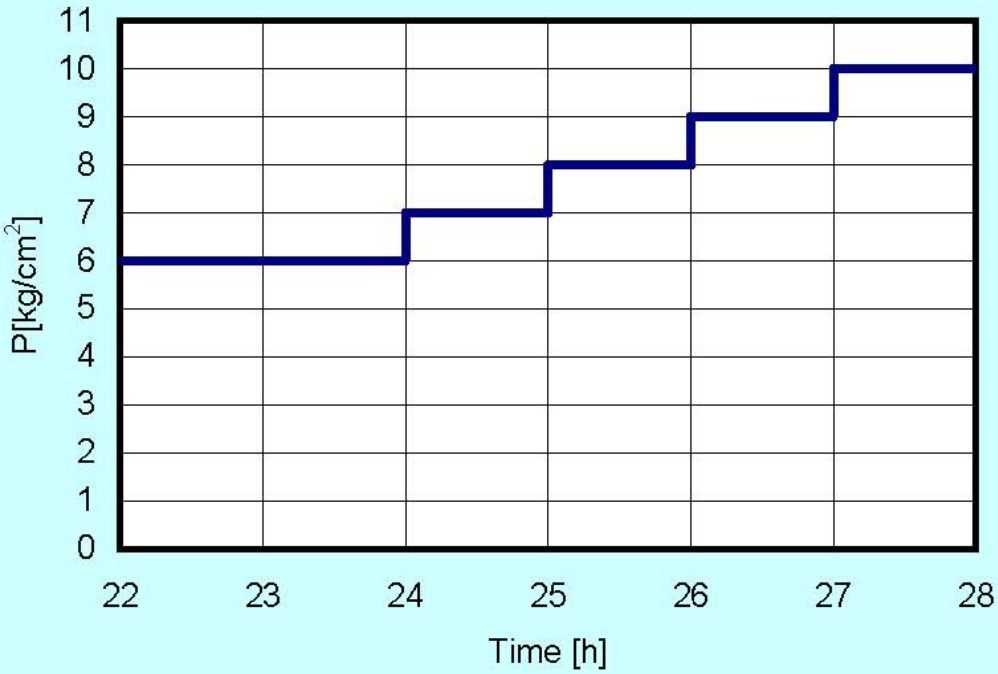
  Now an official NIOSH project (NIOSH is new name for U.S. Bureau of Mines)

- **Chamber design by Mark Laurenti – former Homestake chief mine engineer and Underground Superintendent**

Photomultipliers

- Plan to use 11 –12 inch diameter hemispherical PMT (Frejus plans to use 12 inch dia PMTs)
- Smaller diameter PMTs reduces the danger of chain implosion – (SuperK accident)
- Gives improved angular resolution ~PMTdia/Detector radius
- Multiple manufacturer option
- Must determine hydrostatic pressure tolerance of PMTs -

Hydraulic Test Time Chart



HAMAMATSU
HAMAMATSU PHOTONICS K.K. Electron Tube Division

PMT Hydrostatic Tests

- **Will use 32 Hamamatsu 10 1/2 inch dia.hemispherical PMTs for ultimate pressure tests and for long term (multi-year) static pressure tests – insure no long term fatigue effects**

- **Will also measure effect of pressure shocks**

PMT Installation & Maintenance

- **Side PMTs will be mounted on a 52 meter dia. cylinder – leaving a ½ m thick veto region – light divider part of PMT mount**

- **Fiducial region is 50 m diameter & 50 m high (may be increased if PMT hydrostatic tests indicate greater depth possible)**

- **PMTs installed or removed without draining water fill -**

Water Fill

- **Have estimates for a commercial, “turn key” system, fill one detector in < 2 months.**

- **Plan to purify inflowing underground water – thus avoid removing water from the surface water system -**

	One Module	Three Modules
Construction (including 30% contingency)	$29.1M	$66.1M
Photomultipliers and Electronics	$62.1M	$186.3M
Other	$7.9M	$7.9M
Contingency (Other + PM)	$17.5M	$48.6M
TOTAL	**$116.6M**	**$308.9M**

Chamber Excavation

	One Chamber	Three Chambers
Labor & benefits	$6.060M	$12.030M
Mining Equipment Operation	1.430M	4.279M
Supplies	4.961M	14.685M
Precast concrete liner	3.575M	10.725M
Outside contractor	0.132M	0.396M
Plastic liner	0.250M	0.750M
Rock removal	1.000M	3.000M
Mining Equipment-Purchase	5.000M	5.000M
Contingency-30%	6.722M	15.260M
TOTAL	**29.130M**	**66.125M**

Photomultipliers & Electronics

	Cost for one PM
28 cm dia PM tube	$880
Installation/PM	$165
Electronics/PM	$120
Cable/PM	$77
Total per photomultiplier tube	**$1242**

One 100 kiloton Detector	**$62.1M**
Three 100 kiloton Detectors	**186.3M**

Other items

Development Labor	$3.000M
Water Purification System* (for 10 modules)	4.500M
Calibration equipment	0.400M
TOTAL	**$7.900M**

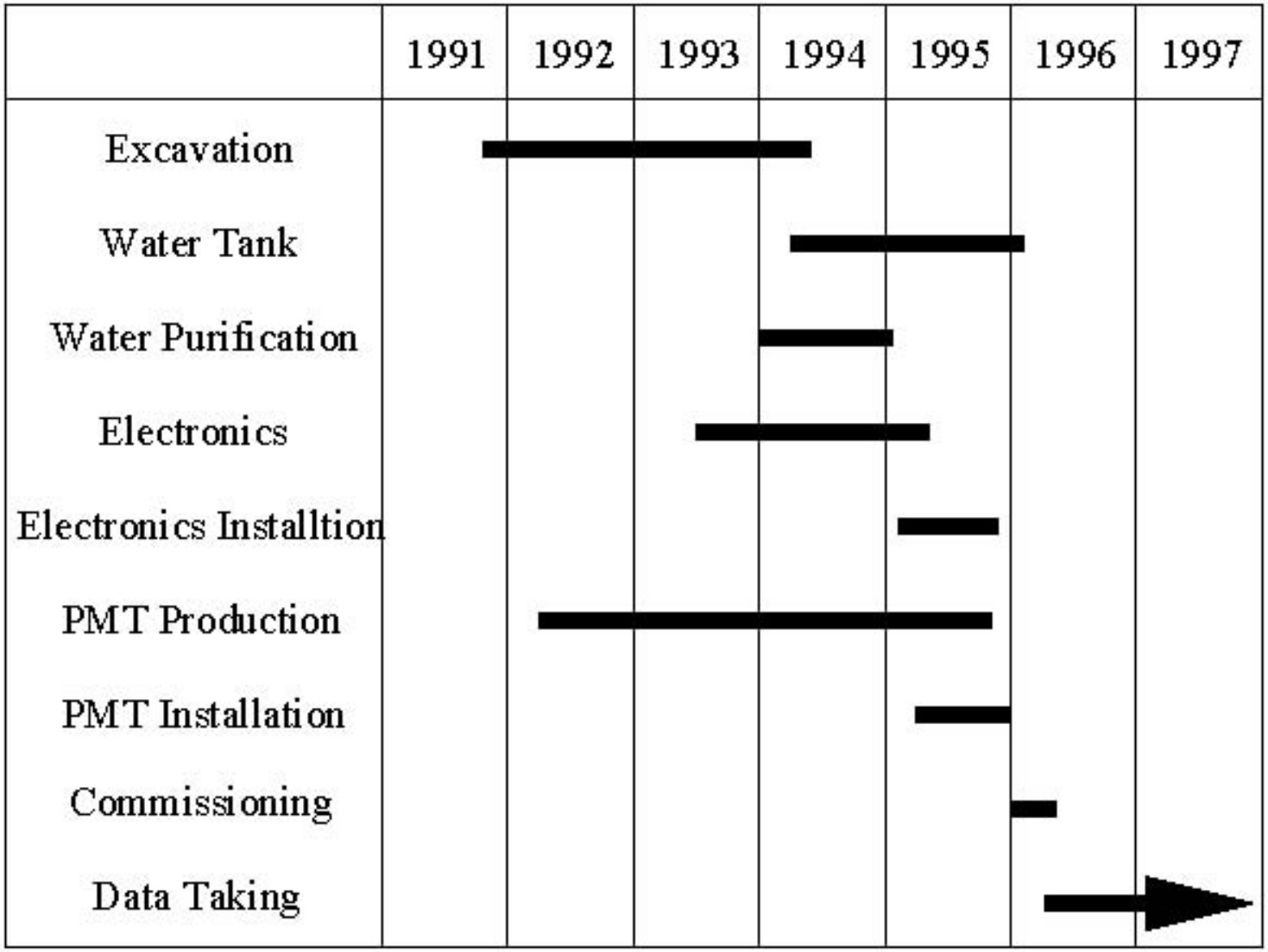
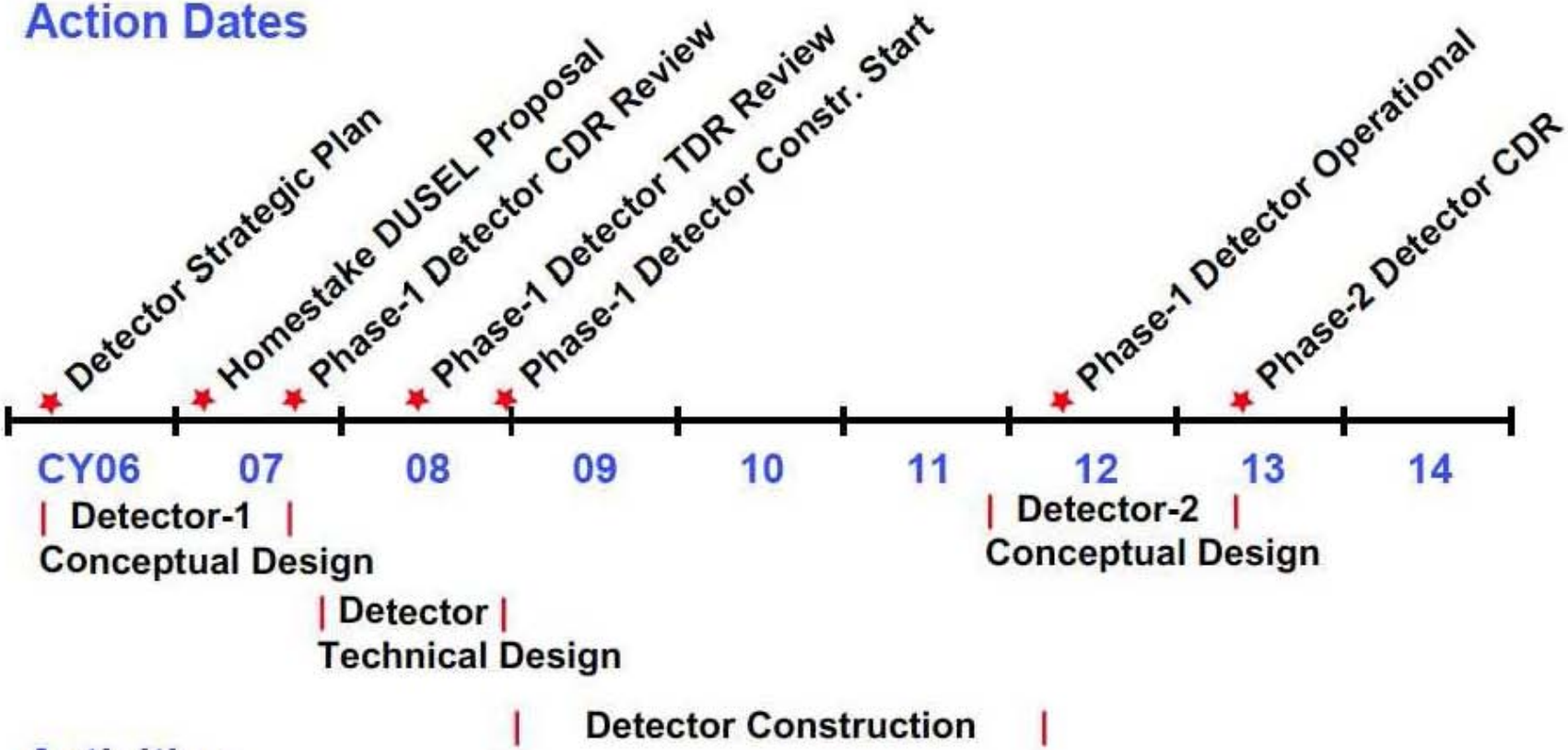


Fig. 3. Super-Kamiokande construction schedule.

Action Dates



Activities

SUMMARY

- 1) Initial Detector – Three 100 kiloton modules
- 2) Total cost - $308M.
- 3) Construction time – 5 years

Questions for Hamamatsu

- 1) What is the quantum efficiency of your 10 ½ inch diameter PMTs?
- 2) What is the electron collection efficiency?
- 3) What is the PMT rise time and jitter?
- 4) Do you have any plans for a 12 inch dia. Hemispherical PMT?
- 5) Any other PMT developments of interest to us?