The Large Water Detector project for DUSEL

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Projext-X workshop
Nov. 25, 2007
Fermilab

Progress since last PrjX workshop

- Further calculations on sensitivity versus background and parameter systematics.
- PMT's of various kinds have been delivered and tests have started.
- Faster civil construction schedule has been created.
- Work in progress to include first module in initial suite in NSF project.

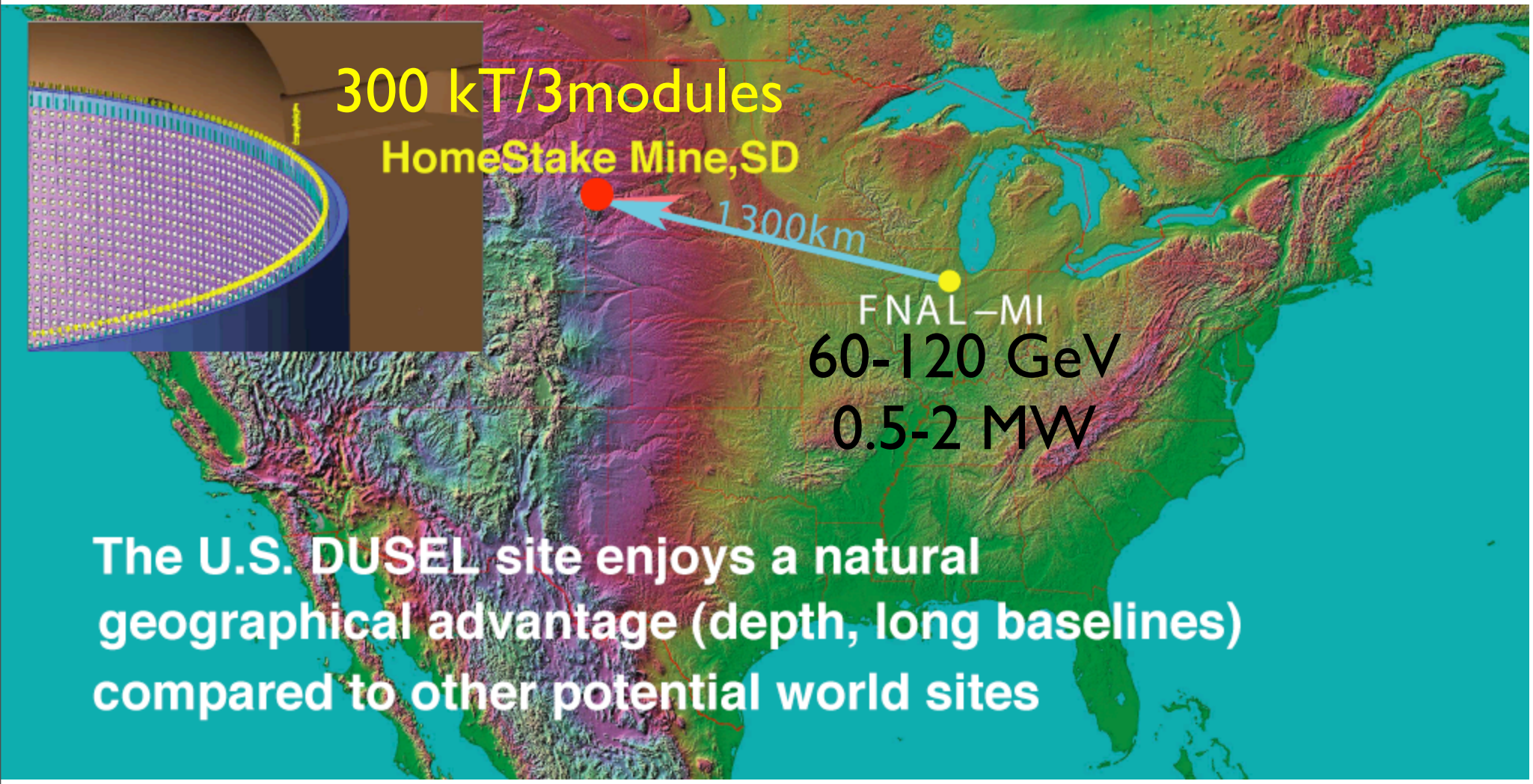
The Project

- Project plan is preliminary. It has not been reviewed.
- Many items need to be backed up or reconsidered.
- Please see my talk to the last Prjt-X workshop. This has details that I will skip over today.

The plan

- Build a >300 kTon fiducial volume water Cherenkov detector at ~5000 ft depth.
- The detector should have wide dynamic range (5 MeV to 50 GeV)
- Should have good particle identification capability and must lead to a facility with a long life (~30 yrs).

The plan at Homestake



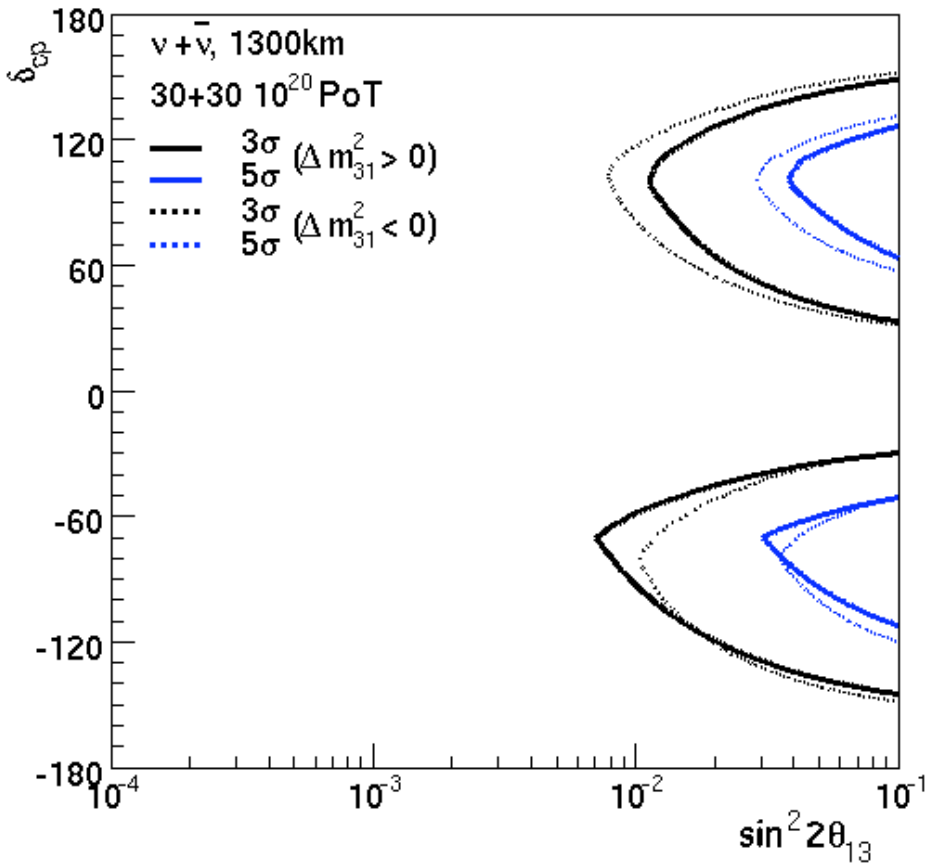
The physics (this talk is not on the Physics)

- Astrophysical sources of neutrinos. In particular, supernova, relic supernova, solar, atmospheric sources.
- Nucleon decay.
- Accelerator neutrino beam with emphasis on CP violation in neutrinos.
- The detector required for all the above has to be very large (~100kton of efficient fiducial mass)

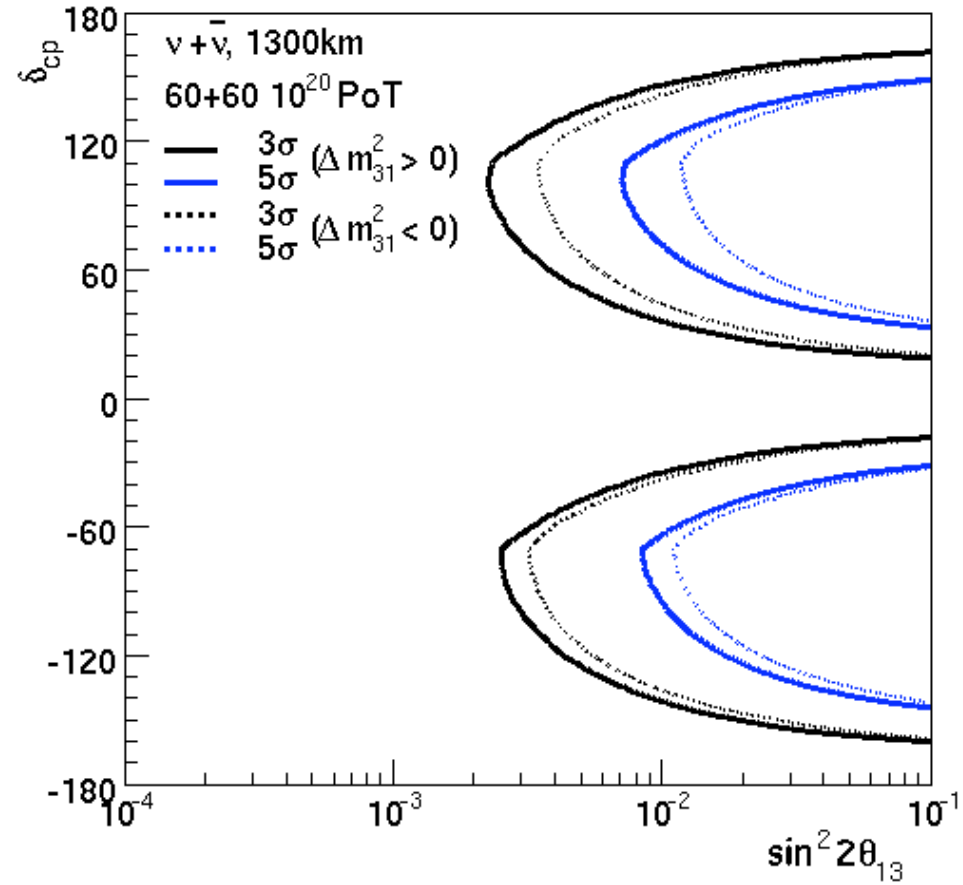
FOR CP VIOLATION DETECTOR SIZE CANNOT BE REDUCED FOR LARGE THETA_13

http://nwg.phy.bnl.gov/fnal-bnl

CP sensitivity



NUSAG pessimistic 10% bck, large errors on parameters with 120 GeV beam at 0.5 deg



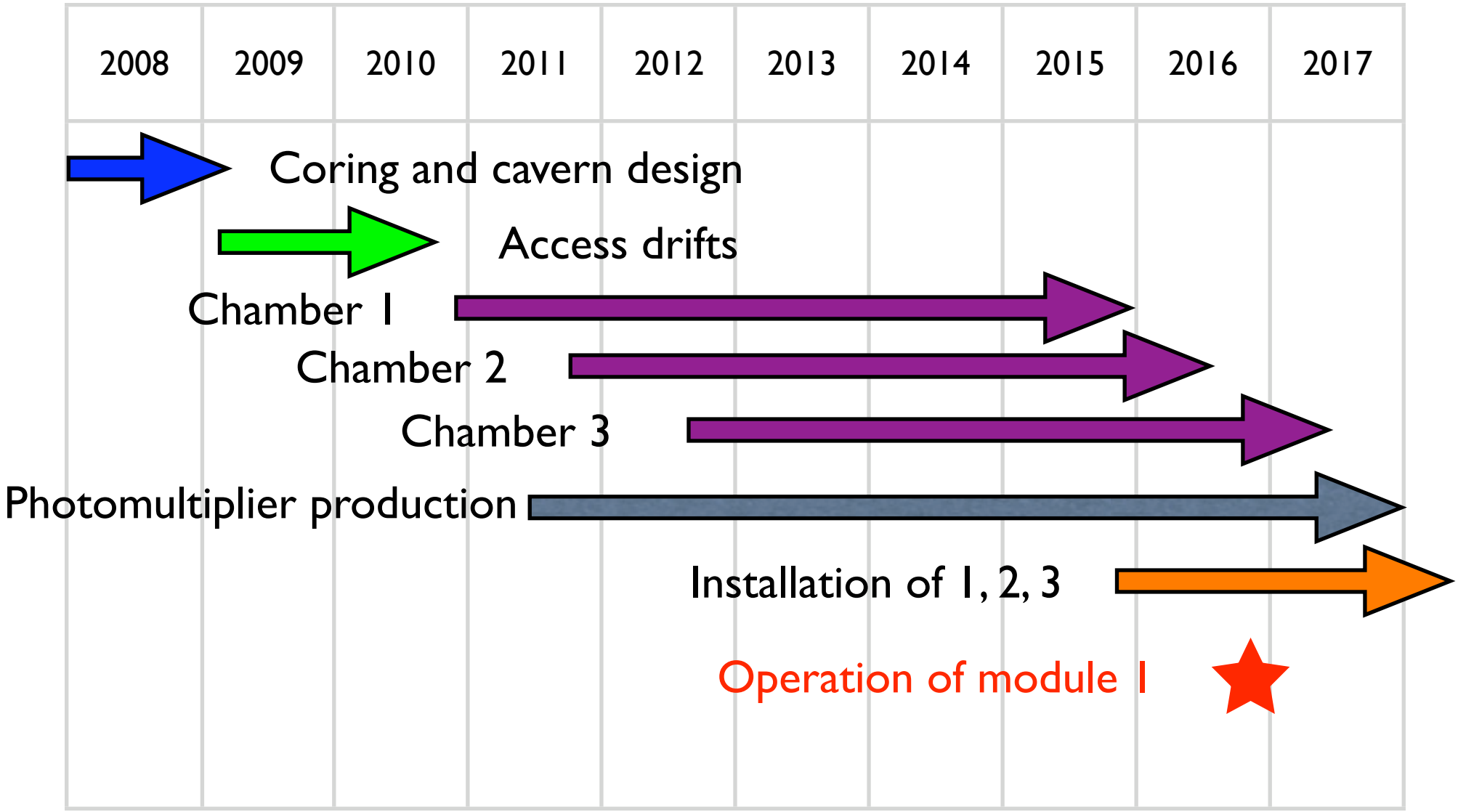
5% errors on bck. no errors on parameters. 60 GeV Project X.

WCC 300kT fiducial mass

M. Dierckxsens/U.Chicago

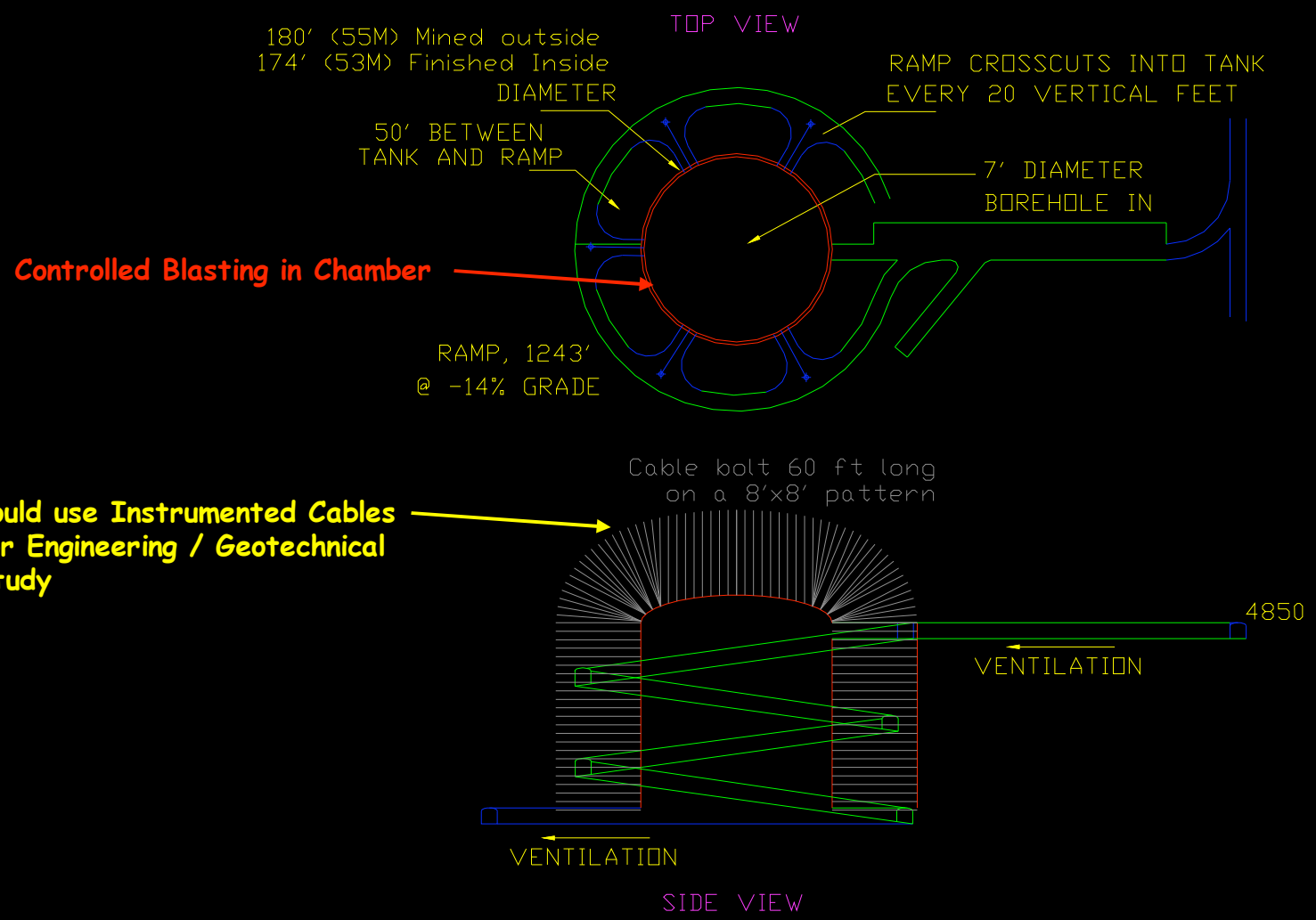
3 elements of detector project

- Cavern excavation
  - Critical for determining size and feasibility
- Photo-multiplier tube production
  - Should match excavation schedule.
- Photo-multiplier installation
  - Drives the technical manpower need.


2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
Coring and cavern design
Access drifts
Chamber 1
Chamber 2
Chamber 3
Photomultiplier production
Installation of 1, 2, 3
Operation of module 1

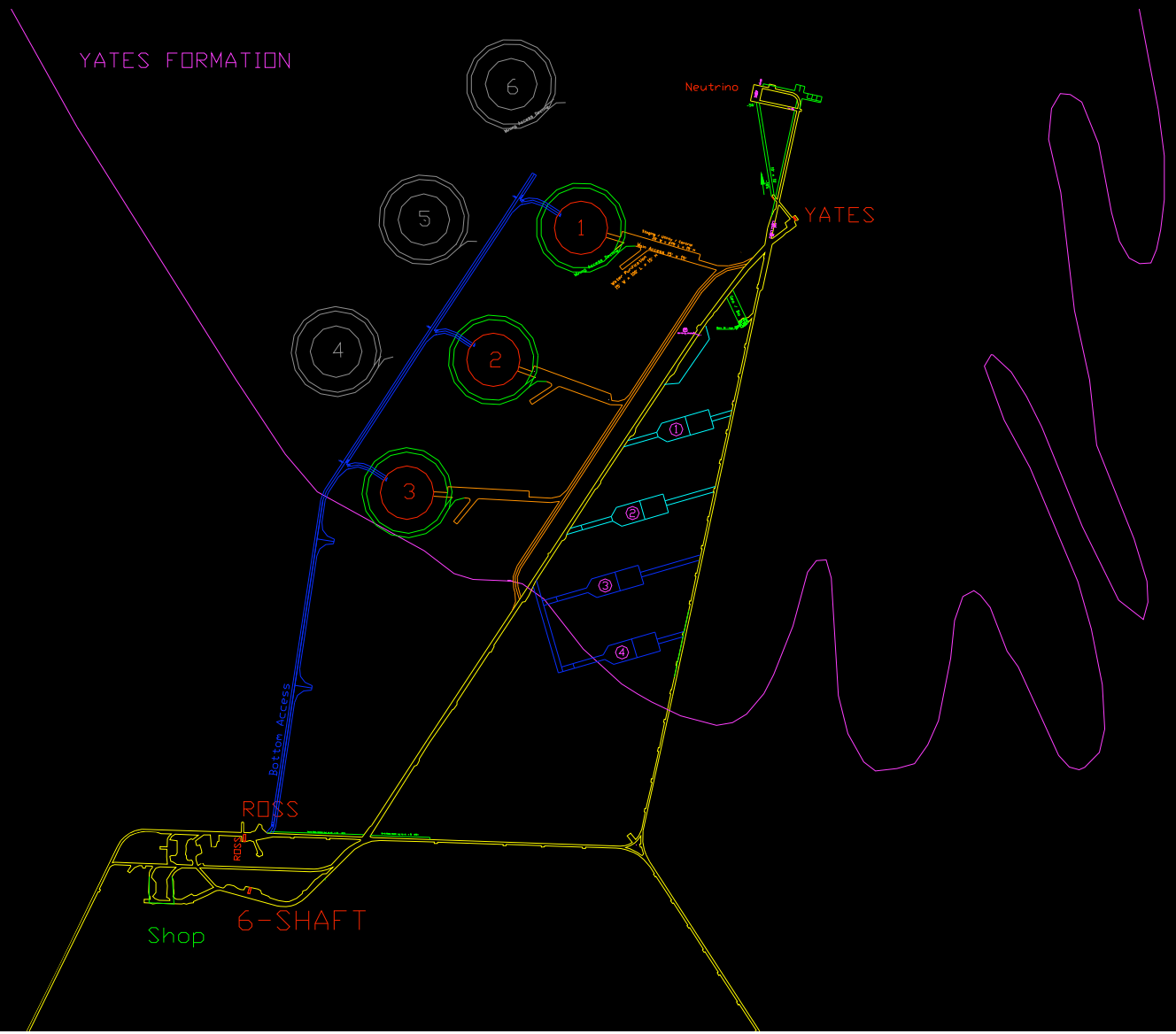
Megaton Modular Multi-Purpose Neutrino Detector

✓ Chamber Design



Megaton Modular Multi-Purpose Neutrino Detector

✓ **Modular Configuration**



Megaton Modular Multi-Purpose Neutrino Detector

Summary Of Chamber Excavation

	TOTAL	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
TOTAL COSTS	**$ 33,886,224**	**$ 4,129,694**	**$ 6,715,723**	**$ 5,575,330**	**$ 5,535,670**	**$ 5,528,100**	**$ 5,444,946**	**$ 956,762**
Design (3 Chambers)								
Cost / Chamber	**$ 253,867**							
	$ 761,600	**$ 761,600**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
Months	**7**	7	-	-	-	-	-	-
Diamond Drilling ft	**10,932 ft**	10,932 ft	0	0	0	0	0	0
Diamond Drill Costs	**$ 546,600**	$ 546,600	$ -	$ -	$ -	$ -	$ -	$ -
Geotechnical Over site	**$ 90,000**	$ 90,000	$ -	$ -	$ -	$ -	$ -	$ -
Geotechnical Modeling & Recommendations	**$ 125,000**	$ 125,000	$ -	$ -	$ -	$ -	$ -	$ -
Site Set Up (6 Chamber Access)								
Cost / Chamber	**$ 721,842**							
	$ 4,331,054	**$ 3,368,094**	**$ 962,961**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
Drift Footage	4,667 ft	3,704 ft	963 ft	0 ft	0 ft	0 ft	0 ft	0 ft
Months	**9**	7	2	-	-	-	-	-
Labor	**$ 2,058,596**	$ 1,637,468	$ 421,128	$ -	$ -	-	$ -	0
Equipment Operating	**$ 1,073,520**	$ 793,800	$ 279,720	$ -	$ -	-	$ -	0
Supplies	**$ 1,198,938**	$ 936,826	$ 262,113	$ -	$ -	-	$ -	0
Other	**$ -**	$ -	$ -	$ -	$ -	-	$ -	0
Chamber (1)								
Cost / Chamber	**$ 28,793,569**							
	$ 28,793,569	**$ -**	**$ 5,752,762**	**$ 5,575,330**	**$ 5,535,670**	**$ 5,528,100**	**$ 5,444,946**	**$ 956,762**
Top Cut (40 ft high)	**84,820 Tons**	-	65,020	19,800	-	-	-	-
Ramp Top to Bottom	**1,737 ft**	-	1,737	-	-	-	-	-
Bench Tons	**381,510 Tons**	-	-	63,780	105,780	85,170	126,780	-
Cable Bolt Feet	**233,280 ft**	-	36,080	26,960	62,160	44,240	49,560	14,280
Shot Crete	**1,800cuYd**	-	-	1,800	-	-	-	-
Concrete Panels	**1,944**	-	-	216	459	621	432	216
Bore Hole Feet	**174 ft**	-	-	174	-	-	-	-
Months	**61**	-	11	12	12	12	12	2
Labor	**$ 14,002,126**	$ -	$ 2,423,660	$ 2,807,088	$ 2,807,088	$ 2,807,088	$ 2,807,088	$ 350,114
Equipment Operating	**$ 7,064,820**	$ -	$ 1,701,000	$ 1,401,540	$ 1,262,100	$ 1,243,200	$ 1,298,220	$ 158,760
Supplies	**$ 7,639,624**	$ -	$ 1,628,102	$ 1,279,702	$ 1,466,482	$ 1,477,812	$ 1,339,638	$ 447,888
Other	**$ 87,000**	$ -	$ -	$ 87,000	$ -	$ -	$ -	$ -

One time expense

One time expense

additional 7.1M for capital equipment

Summary Of Chamber Excavation

This has already been proposed by a collaboration to be funded from the DUSEL R&D and S4 money

	TOTAL	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
TOTAL COSTS	**$ 33,335,098**	**$ 4,720,252**	**$ 7,536,262**	**$ 6,547,486**	**$ 6,815,666**	**$ 6,816,318**	**$ 899,113**	**$ -**
Design (3 Chambers)								
Cost / Chamber	**$ 253,867**							
	$ 761,600	**$ 761,600**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
Months	**7**	7	-	-	-	-	-	-
Diamond Drilling ft	**10,932 ft**	10,932 ft	0	0	0	0	0	0
Diamond Drill Costs	**$ 546,600**	$ 546,600	$ -	$ -	$ -	$ -	$ -	$ -
Geotechnical Over site	**$ 90,000**	$ 90,000	$ -	$ -	$ -	$ -	$ -	$ -
Geotechnical Modeling & Recommendations	**$ 125,000**	$ 125,000	$ -	$ -	$ -	$ -	$ -	$ -
Site Set Up (6 Chamber Access)								
Cost / Chamber	**$ 752,361**							
	$ 4,514,164	**$ 3,958,652**	**$ 555,511**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
Drift Footage	4,667 ft	4,459 ft	208 ft	0 ft	0 ft	0 ft	0 ft	0 ft
Months	**8**	7	1	-	-	-	-	-
Labor	**$ 2,153,632**	$ 1,879,388	$ 274,244	$ -	$ -	-	$ -	0
Equipment Operating	**$ 1,143,072**	$ 952,560	$ 190,512	$ -	$ -	-	$ -	0
Supplies	**$ 1,217,460**	$ 1,126,704	$ 90,755	$ -	$ -	-	$ -	0
Other	**$ -**	$ -	$ -	$ -	$ -	-	$ -	0
Chamber (1)								
Cost / Chamber	**$ 28,059,334**							
	$ 28,059,334	**$ -**	**$ 6,980,751**	**$ 6,547,486**	**$ 6,815,666**	**$ 6,816,318**	**$ 899,113**	**$ -**
Top Cut (40 ft high)	**84,820 Tons**	-	84,820	-	-	-	-	-
Ramp Top to Bottom	**1,737 ft**	-	1,737	-	-	-	-	-
Bench Tons	**356,310 Tons**	-	-	127,170	101,970	127,170	-	-
Cable Bolt Feet	**275,840 ft**	-	41,760	64,480	69,360	85,240	15,000	-
Shot Crete	**1,800cuYd**	-	1,800	-	-	-	-	-
Concrete Panels	**2,376**	-	-	486	950	670	270	-
Bore Hole Feet	**174 ft**	-	-	174	-	-	-	-
Months	**49**	-	12	12	12	12	1	-
Labor	**$ 12,983,488**	$ -	$ 2,836,460	$ 3,290,928	$ 3,290,928	$ 3,290,928	$ 274,244	$ -
Equipment Operating	**$ 6,454,728**	$ -	$ 1,964,088	$ 1,601,208	$ 1,302,336	$ 1,491,840	$ 95,256	$ -
Supplies	**$ 8,534,118**	$ -	$ 2,180,203	$ 1,568,350	$ 2,222,402	$ 2,033,550	$ 529,613	$ -
Other	**$ 87,000**	$ -	$ -	$ 87,000	$ -	$ -	$ -	$ -

Chamber excavation (2006) needs to be updated from new work (previous slide)

Labor/Benefits	$19.3M
Mining equipment operations	$4.55M
Supplies	$15.8M
Precast concrete liner	$11.4M
Outside contractor (bore holes)	$0.42M
Plastic liner	$0.79M
Rock removal	$3.18M
Mining equiment	$5.30M
Contingency	$18.2M
Total for 3 chambers	$78.9M

Does not include

- General operations of the mine, shaft, pumping, and ventilation.
- Overhead functions: office, property maintenance, water consumption, power consumption.
- EDIA is partially there
- Mobilization
- Waste handling needs further scrutiny.

Sanity check: estimate based on previous estimate. Cost comes out to be $63/ton, well above to historical costs at Homestake.

PMT considerations

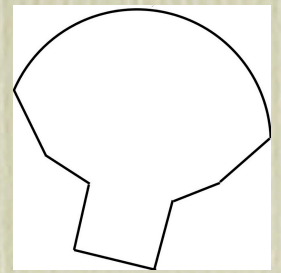
	10 inch R7081	20 inch R3600
Number (25% cov)	~50000	~14000
QE	25%	20%
CE	~80%	~70%
rise time	4 ns	10 ns
Tube length	30 cm	68 cm
Weight	1150 gm	8000 gm
Vol.	~5 lt	~50 lt
pressure rating	0.7Mpa	0.6Mpa
∢ coverage/pmt	0.6 deg	1.1 deg
∢ granularity	1.0 deg	2.1 deg

Tube production

Glass

Stamped metal and wire parts

First assembly
vacuum deposition of metal platings
Graded seal

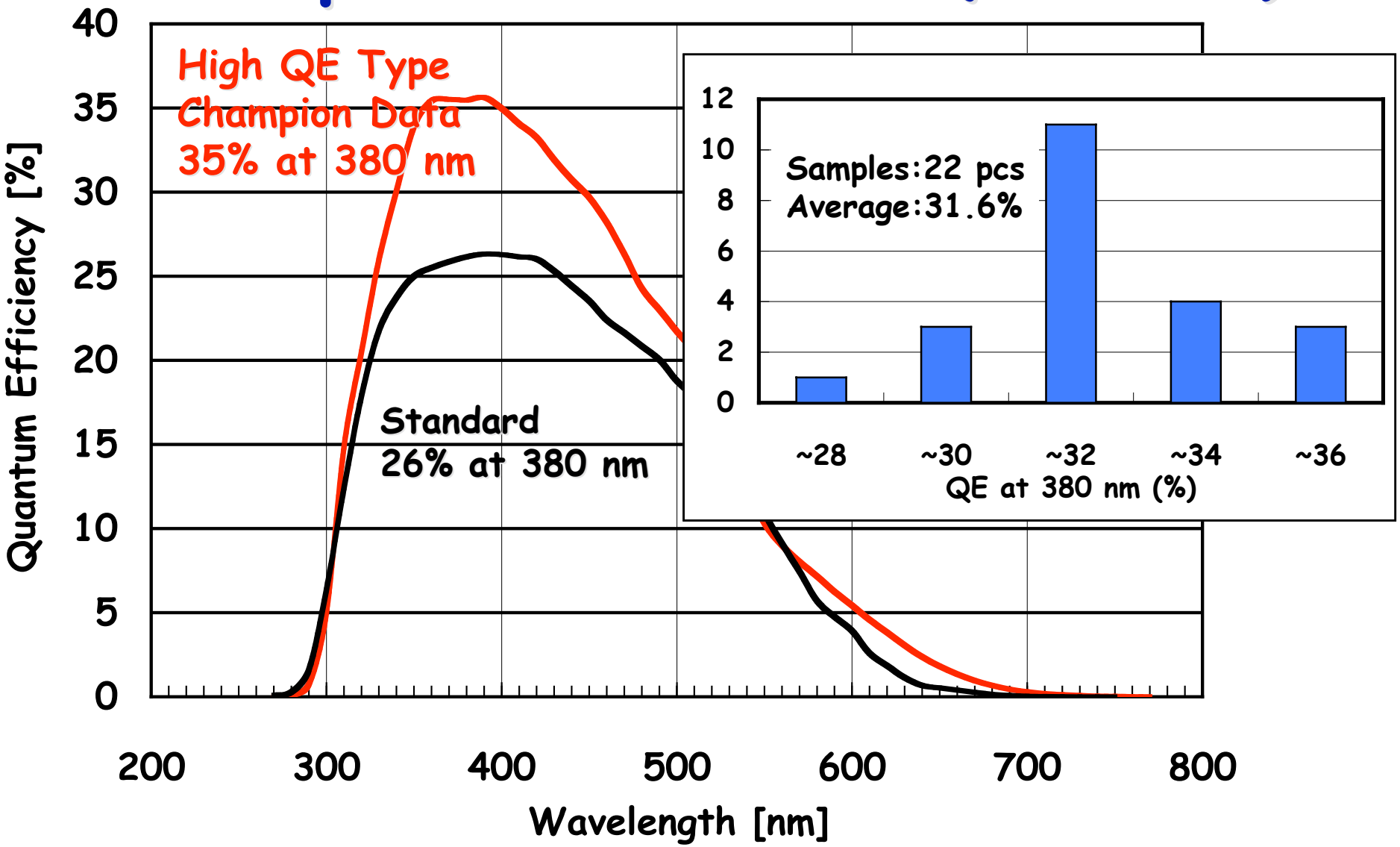


Final vacuum
Cathode deposition

Final assembly of 10 inch tubes needs lab space of 30'x30'; six stations with 6 pmts/station; 1 full day => 36tubes/day = icecube production. tripling this rate is not difficult

HPK and Photonis are NOT concerned about their ability to manufacture at this rate

Example data R7081 (10 inch)



Goal of development is 43%

M.Diwan

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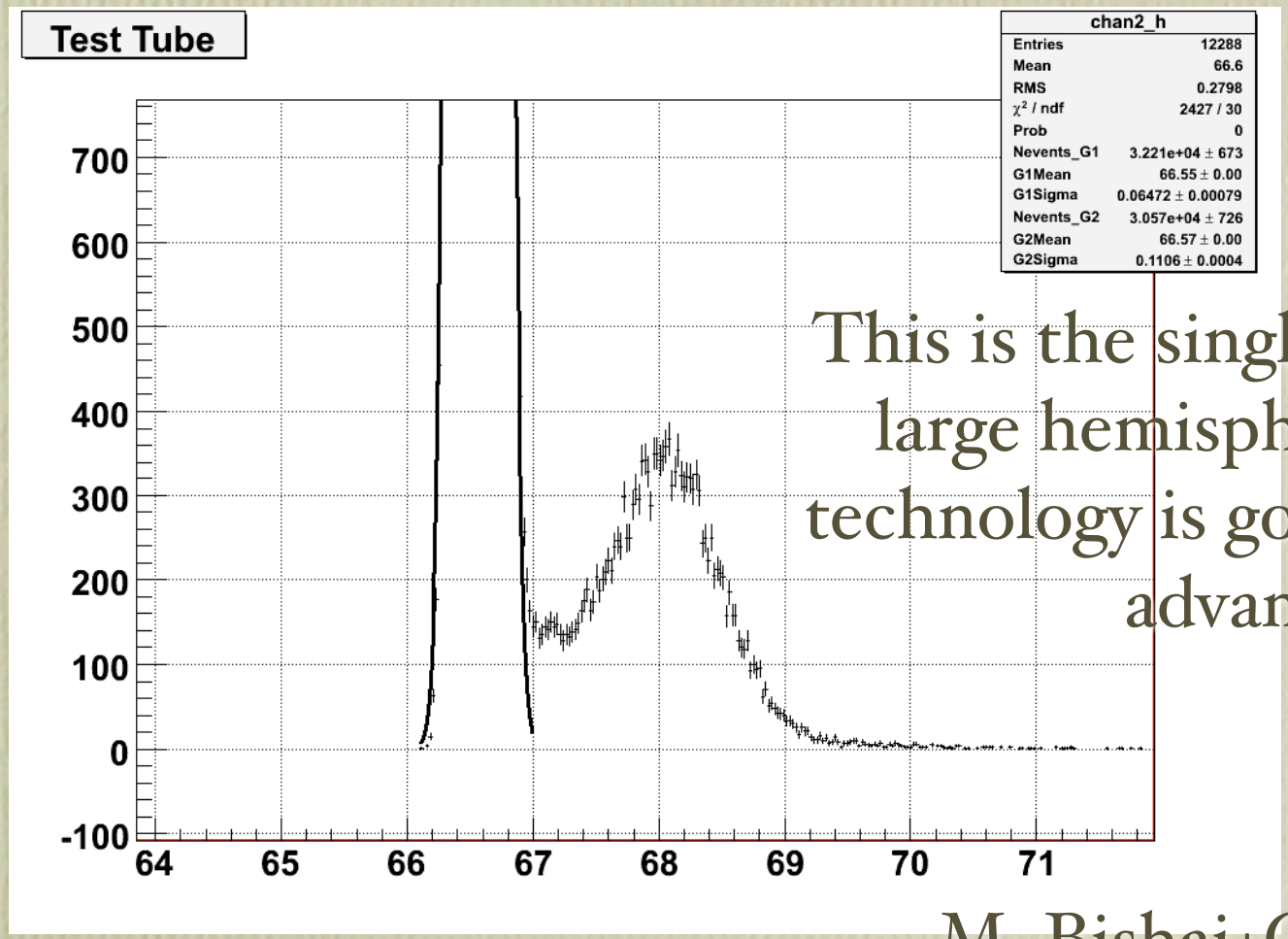
Photonis XP1806 (8 inch)



This is the single PE response of a large hemispherical tube. This technology is going through steady advancement.

M. Bishai+G. Wille (BNL)

PMTs

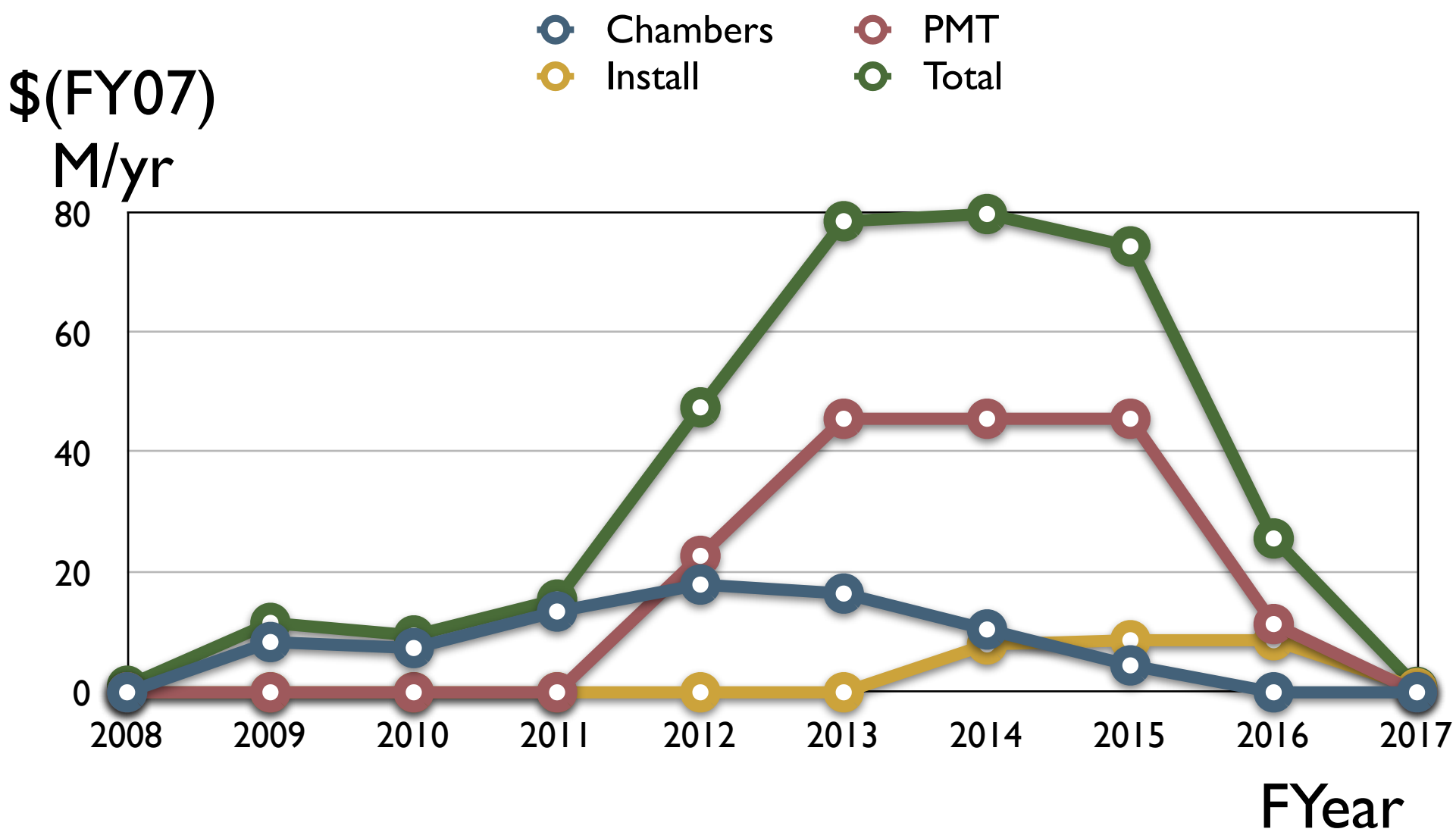
	Cost for one
28 cm dia PMT	$933
Installation/PM	$175
Electronics/PM	$127
Cable/PM	$86
Total per PMT	$1317

50000 PMTs per 100 kT tank => 25% coverage
Sanity checks: Auger PMT cost $629/each for 5000 units with 9 inch diameter. Base cost additional $175. Other costs have basis with SNO actual costs with adjustments for differences.

Summary cost ($FY07) for 300kT

Cavity construction (30% contingency)	$78.9M
PMT+electronics	$171.3M
Installation+testing	$35.7M
R&D, Water, DAQ, etc.	$8.2M
Contingency(non-civil)	$50.8M
Total	$344.9M

Profile


Chambers
PMT
Install
Total
$(FY07)
M/yr
80
60
40
20
0
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
FYear

Summary

- Baseline detector 3 modules each 100 kTon
- Total cost $FY2007: $345M
- First 100kT in FY2015, Full detector by FY2017.
- This is a preliminary plan. A lot of work is needed to turn it into a "real" plan.