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Canada's national laboratory for particle and nuclear physics and accelerator-based science

Canadian plan on HyperK

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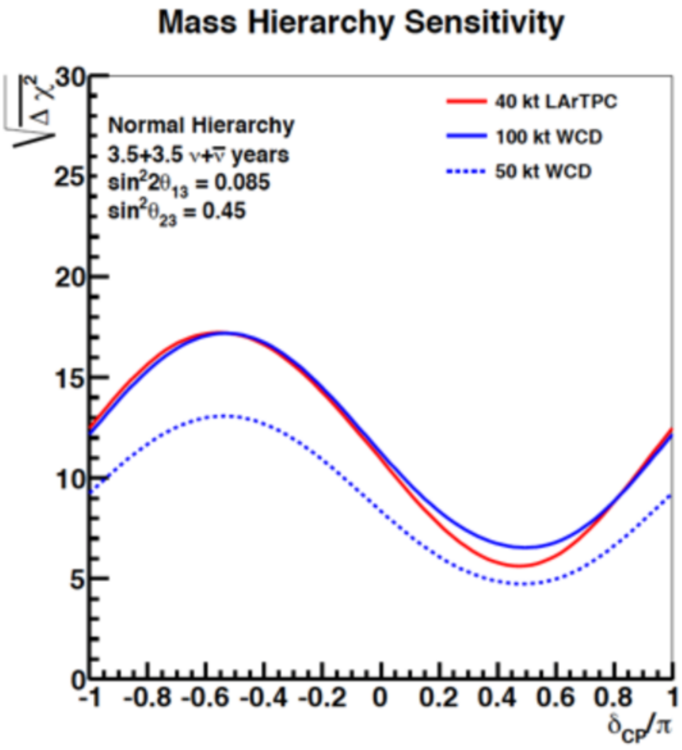
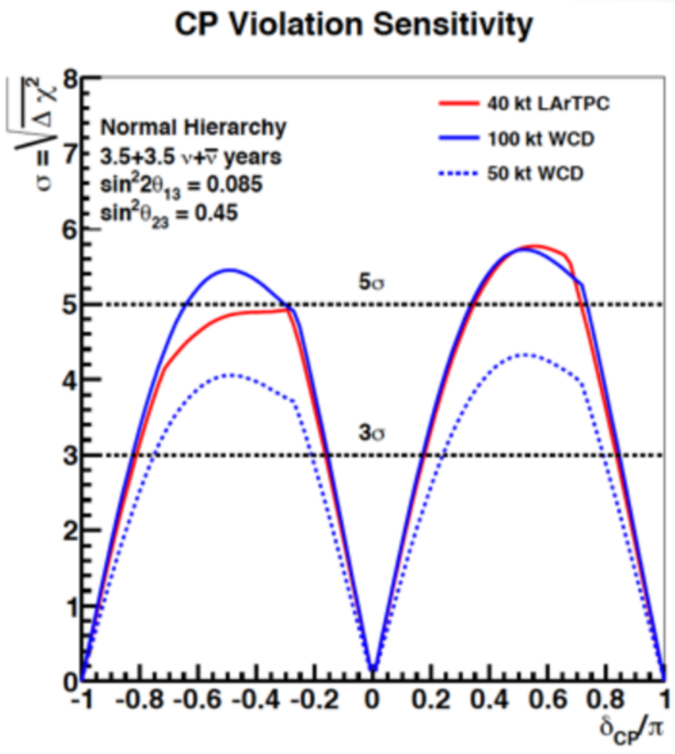
Dec.14, 2017

- Competitiveness
  - 1/3 of cost compared to DUNE/LBNF with "better/competitive" physics reach
    - The 2nd detector in Korea (T2HKK) would make the case even stronger
  - Well established technologies
  - Solid first class scientific output (CP) with new physics capability
- Decision to be made in 1-2 years based on progress on the following:
  - HK funding (187kton fiducial mass) [prospect?]
  - Sufficient beam operation (~3×10^{21} POT/year) [commitment?]
  - Intermediate Water Cherenkov to control systematics [approval process?]
- Challenges (pointed out in the MEXT roadmap)
  - Expand and deepen international cooperation
  - Clarify relationship with the existing projects at the implementing institutions

Neutrino Physics approach in Japan is excellent





- 100 kT WČ @ Homestake in LBNF has comparable/greater sensitivity than 40 kt LAr
  - important role of fiTQun (or at least sensible performance assumptions) in new sensitivity estimates
  - Previous assumption was that a LAr detector achieved equivalent sensitivity to a WČ detector 6 times in mass
    - now it is more like ~2 , and even this assumes LAr performance assumptions that have not been demonstrated

MEXT roadmap 2017 report

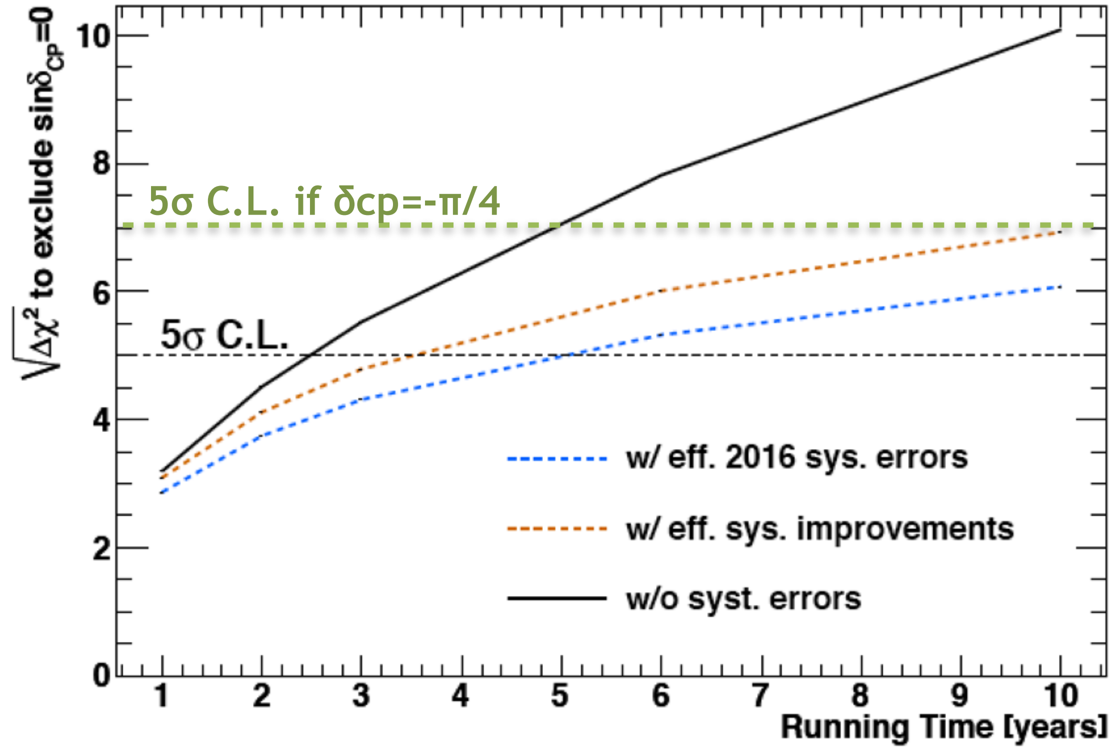
Financial requirement (JPY 100 millions) ~$1M	Evaluation ①	Evaluation ②	Main outstanding points, etc.	Main tasks, points to keep in mind, etc.
Total 1547 (Japan's share: 1393) Hyper-Kamiokande: Construction 675 (551), Operation 400 over 20 years J-PARC: Operation 400 over 10 years Other: Accelerator upgrades etc. 72 (42)	a	a	● Originating from Japan's creative innovation, Hyper-Kamiokande is a flagship experiment that will not only maintain, but expand Japan's world-leading and internationally renown neutrino and nucleon decay physics research program. ● Preparations for the start of the project are already underway, including the formation of a framework in which more than 300 researchers from both within and outside of the implementing institutions will participate in the realization of the experiment.	● Due to its expansive scale and cost, the formation of a system of broad international cooperation to expand and deepen collaboration on the project is necessary. ● It is necessary to clarify the relationship between the project and existing large-scale projects at the implementing institutions and to develop more comprehensive and actionable plans to handle budgetary and personnel issues. (In particular, clarification of the project's relationship to Super-Kamiokande is desired.)

$10M for the IWCD facility

Essential to control systematic uncertainties

- CP sensitivity is limited by systematics
  - Improving systematics has big impact on sensitivity
  - Systematic error does not behave like gaussian
    - 5σ tail in systematic uncertainty assuming gaussian tail is not correct

HK Sensitivity for δcp=-π/2 (maximal CP viol.)



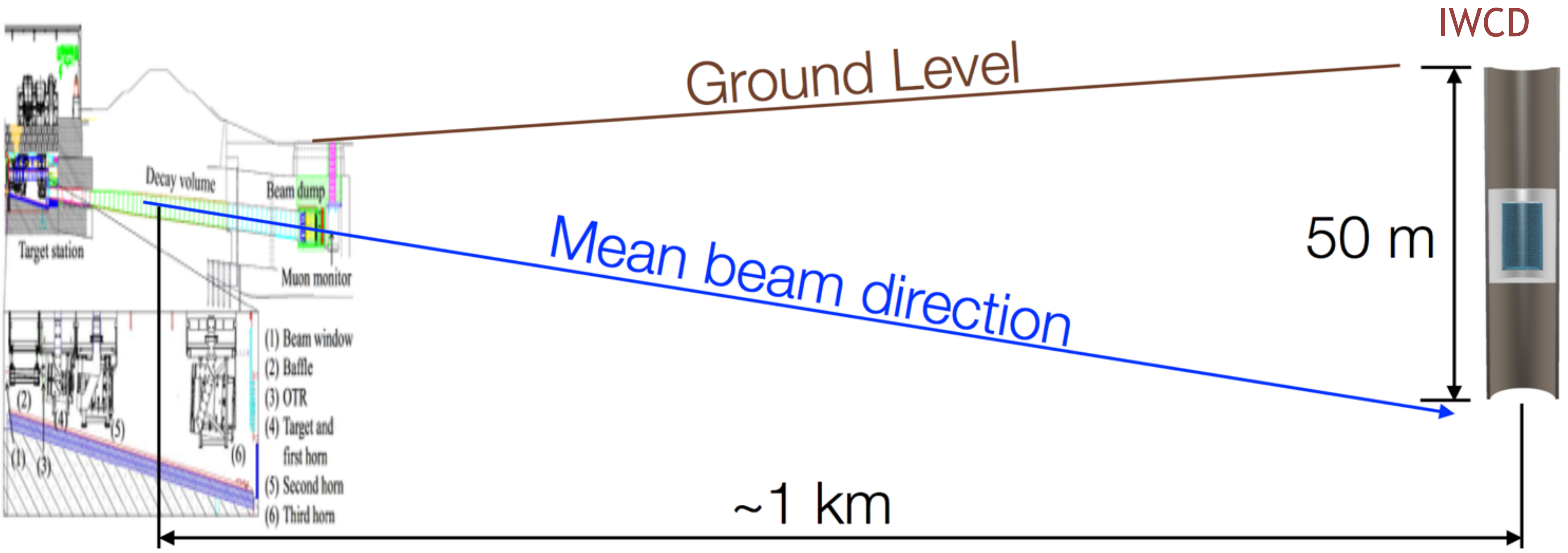
Canadian initiatives on systematic uncertainties

	% Errors on Predicted Event Rates, Osc. Parameter Set A					
	1R μ-Like		1R e-Like			
Error Source	FHC	RHC	FHC	RHC	FHC CC1π	FHC/RHC
SK Detector	1.86	1.51	3.03	4.22	16.69	1.60
SK FSI+SI+PN	2.20	1.98	3.01	2.31	11.43	1.57
ND280 const. flux & xsec	3.22	2.72	3.22	2.88	4.05	2.50
$\sigma(\nu_e)/\sigma(\nu_\mu)$, $\sigma(\bar{\nu}_e)/\sigma(\bar{\nu}_\mu)$	0.00	0.00	2.63	1.46	2.62	3.03
NC1γ	0.00	0.00	1.08	2.59	0.33	1.49
NC Other	0.25	0.25	0.14	0.33	0.98	0.18
Total Systematic Error	**4.40**	**3.76**	**6.10**	**6.51**	**20.94**	**4.77**

- Neutrino cross sections
  - IWCD (E61/NuPRISM)
    - ν_e cross section
    - NC and beam ν_e
    - Nuclear effect
    - Neutron tagging

- Detection efficiency (calibration)
  - E61 beam test @ Fermilab
    - Bottom-up calibration
- Neutrino flux
  - Hadron production experiment @ Fermilab
    - hybrid emulsion spectrometer

Intermediate Water Cherenkov Detector (E61/NUPRISM)



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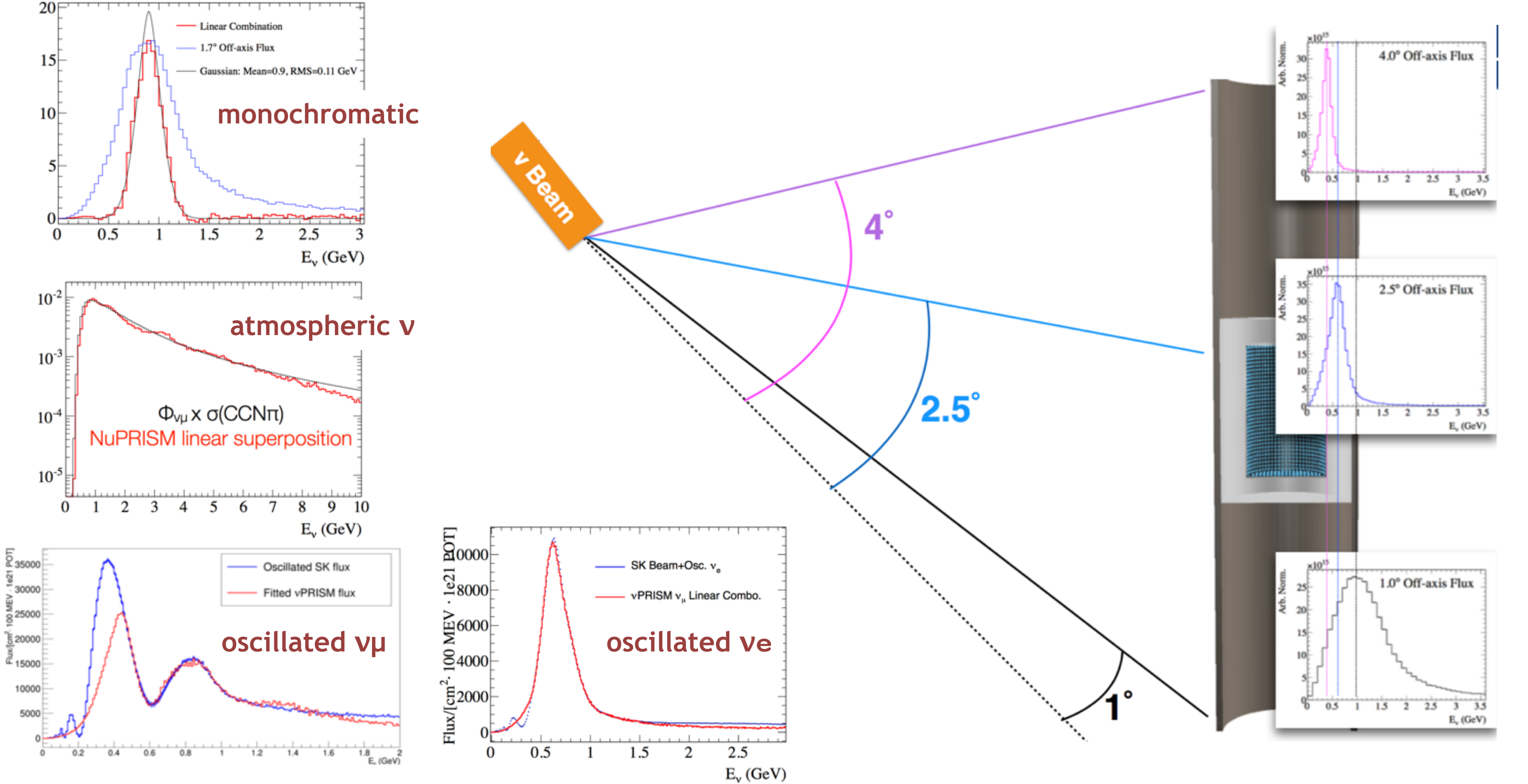
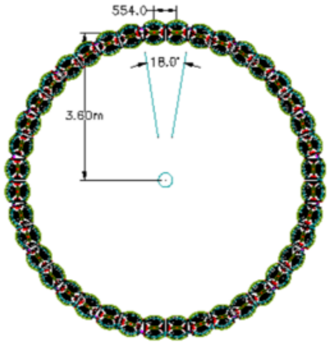
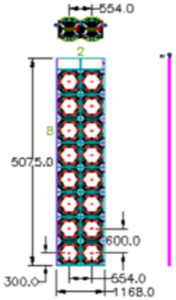
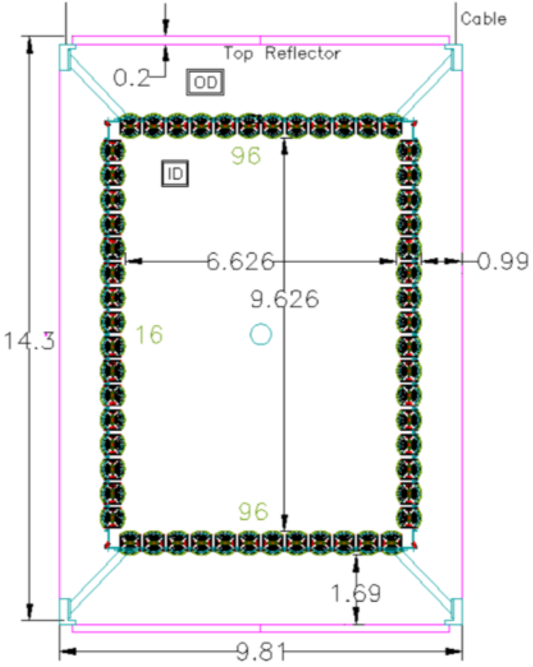
NUPRISM linear combination

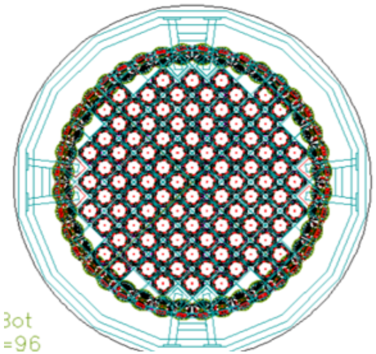


OVERALL LAYOUT



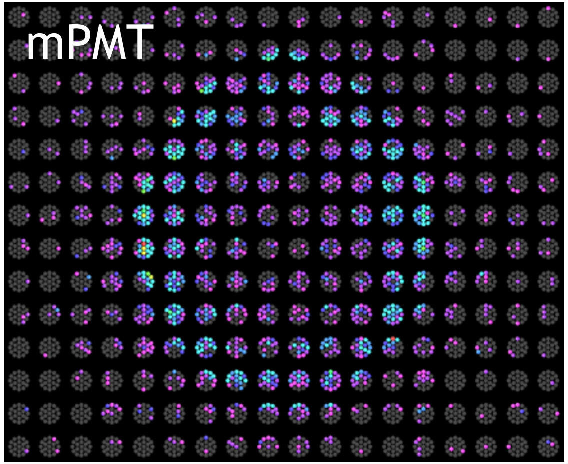


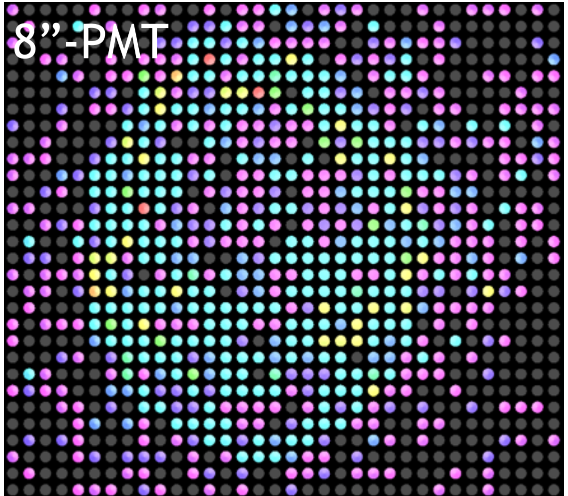




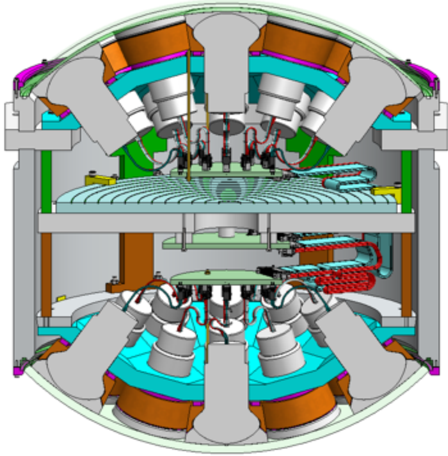
Total	Top	4x24= 96
	Bot	4x24= 96
Side Walls		20x2x16=640
		832

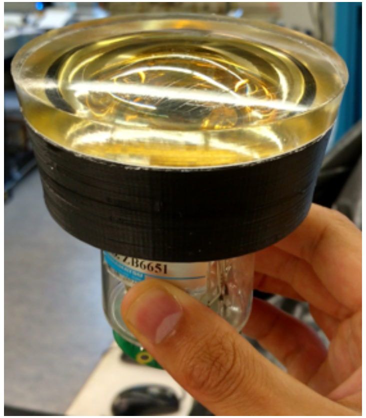
- Will need to interface closely with facility design and "local" civil construction requirements

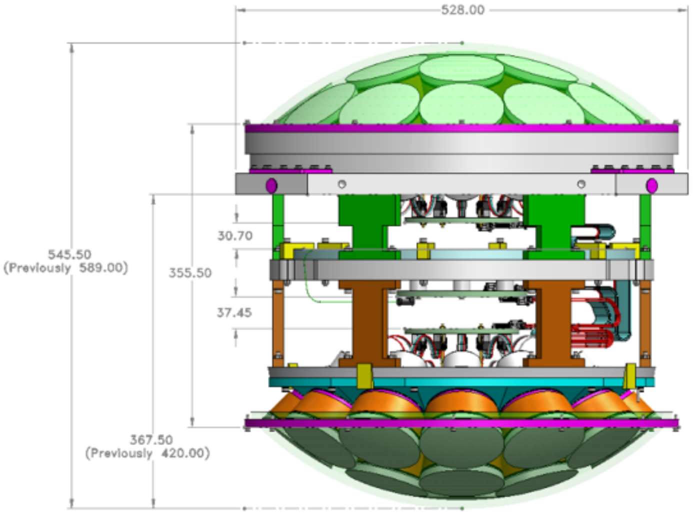


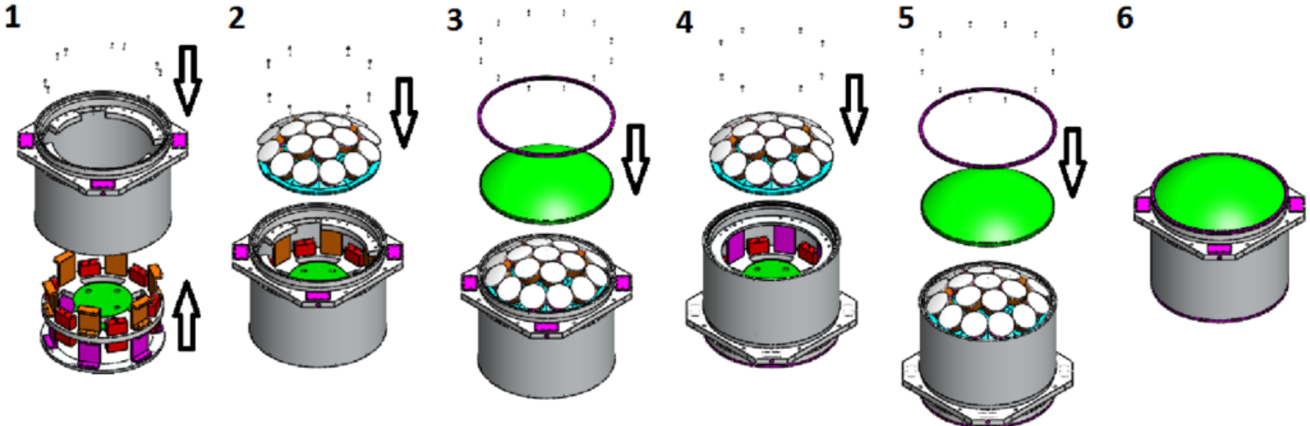


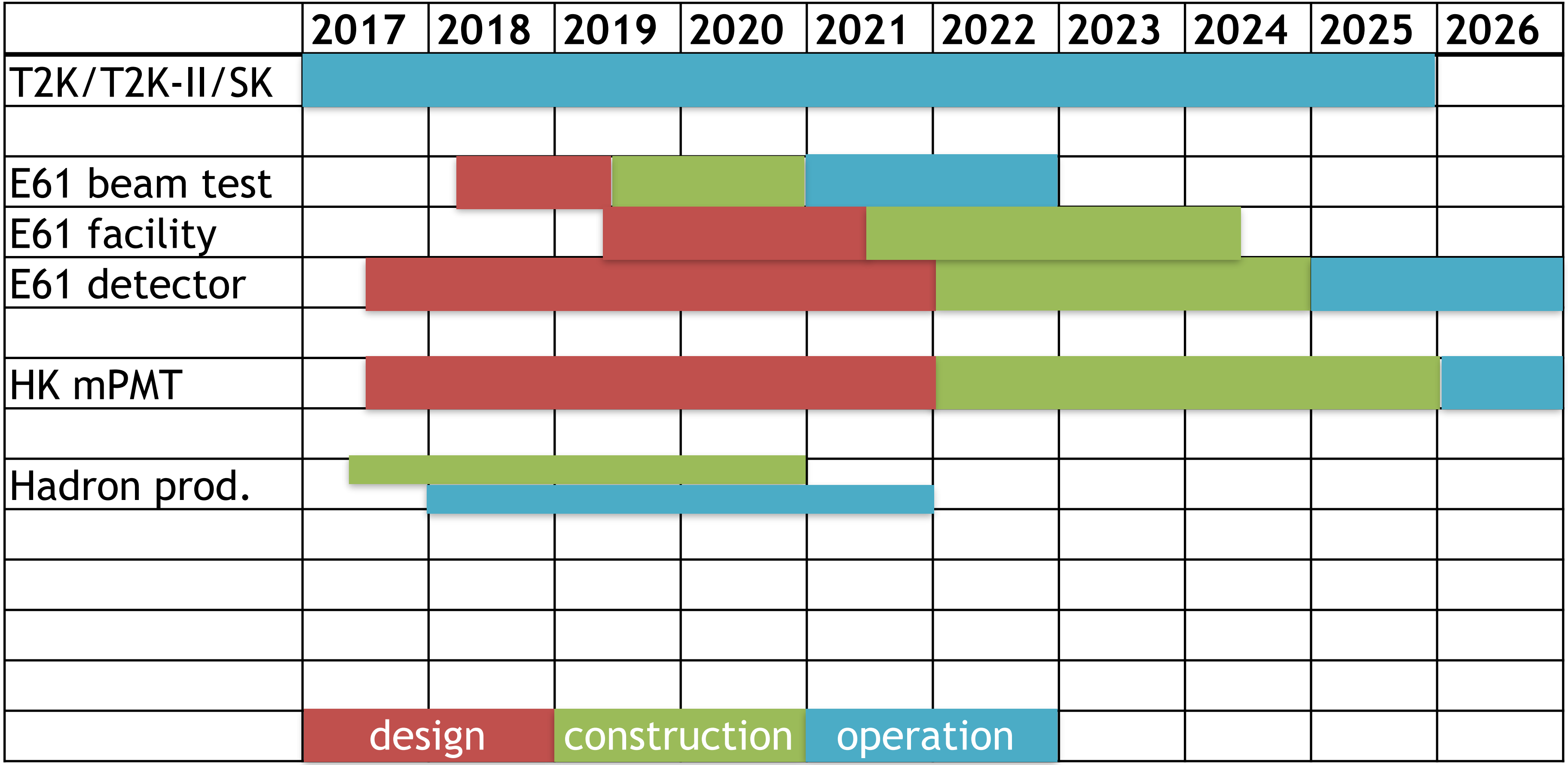
- multi-PMT (mPMT)
  - 19 of 3” PMT’s in a vessel
    - economical 3” PMT’s
- mPMT for IWCD(NuPRISM)
  - finer granularity for small WC
    - better than 8”
- mPMT for HyperK
  - multi-ring reconstruction
    - CC1π, mass hierarchy
  - angular sensitivity
    - accidental reduction for low E?
  - provide calibration standard






528.00
545.50
(Previously 589.00)
355.50
30.70
37.45
367.50
(Previously 420.00)


1
2
3
4
5
6


2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
T2K/T2K-II/SK
E61 beam test
E61 facility
E61 detector
HK mPMT
Hadron prod.
design
construction
operation