Prospects for neutrino physics with the Hyper-Kamiokande experiment

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The Hyper-Kamiokande Experiment

🌊 **Water Cherenkov experiment** based in **Japan**

🌎 **International Collaboration:**

- **22 countries**
- **106 institutes**
- **~650 members**

✅ Builds on the successful strategies of **Super-K** and **T2K**

- **Larger detector → ~8.4× Super-K volume (187 kT)**
- **Improved PMT + new mPMTs** → higher detection efficiency
- **More powerful beam → 1.3 MW vs. 0.8 at present**
- **Upgraded near detectors + new intermediate detector (IWCD)**

🎯 **Broad Physics Program**

Neutrino oscillations with accelerator and atmospheric ν:

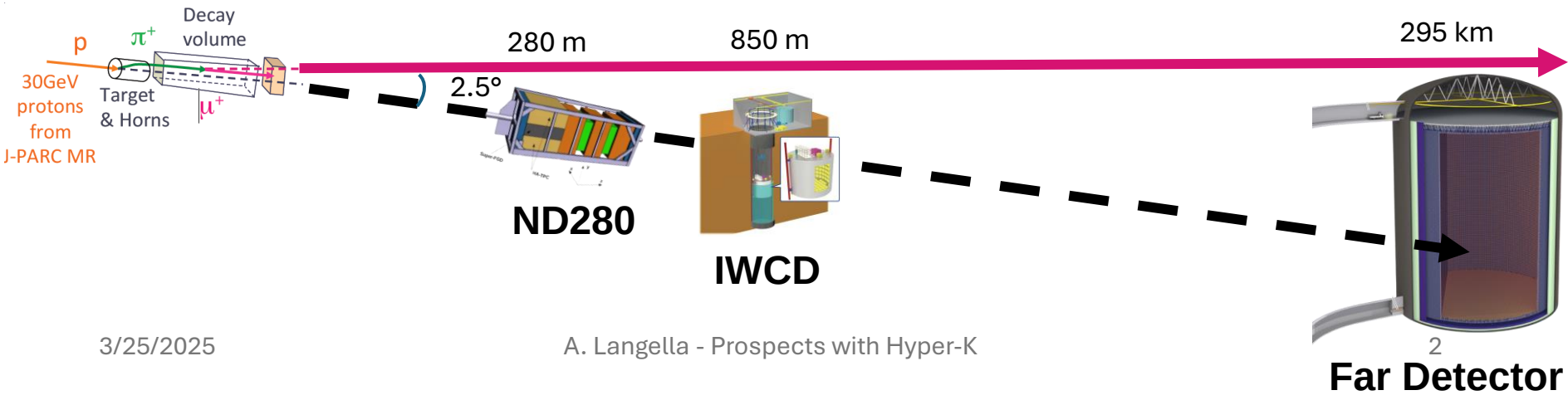
- **CP violation**
- **Neutrino mass ordering (MO)**
- **θ_{23} octant determination**

Astrophysical neutrinos:

- Solar neutrinos
- **Supernova burst neutrinos**
- **Diffuse Supernova Neutrino Background (DSNB)**

Beyond Standard Model searches:

- **Proton decay**
- Dark matter indirect detection



Oscillations w/ accelerator and atmospheric ν

Sensitive to CP violation phase by measuring $P(\nu_\mu \rightarrow \nu_e)$ vs $P(\bar{\nu}_\mu \rightarrow \bar{\nu}_e)$

→ **LBL** CP sensitivity expectations:

- **Known MO: 5σ sensitivity** for **62%** of true δ_{CP} values after 10 years.
- **For NO and δ_{CP} = -π/2: CP conservation excluded** in **3-5 years** depending on systematics.

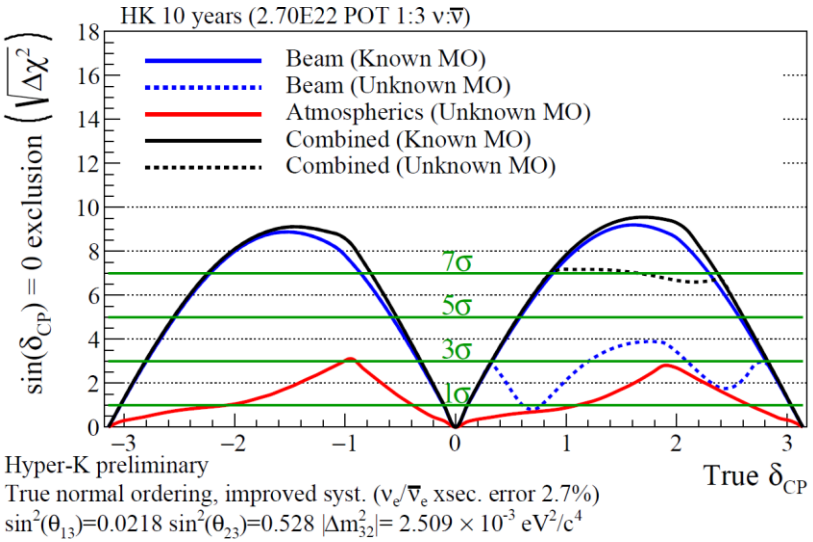
→ **Atmospheric ν** can **solve degeneracy** between δ_{CP}, MO, and octant.

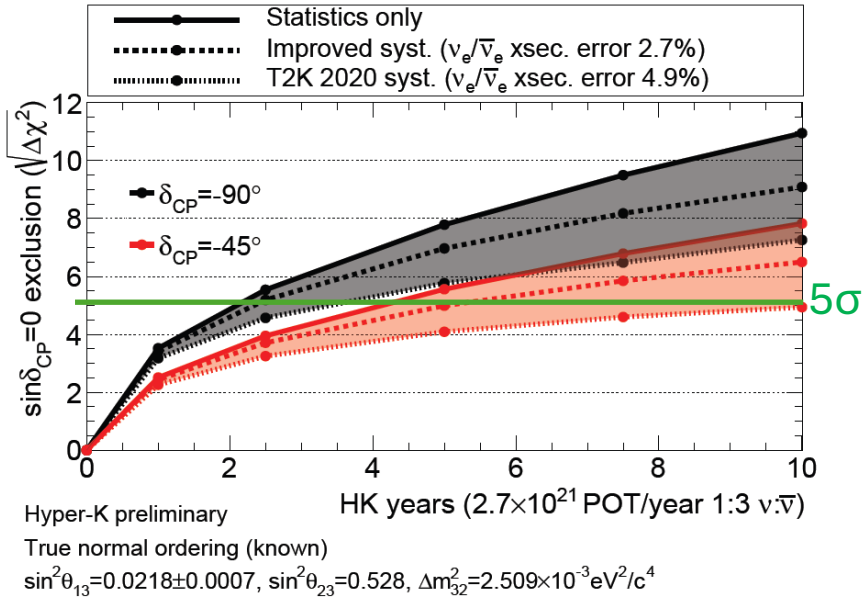
- **Reject CP-conserving hypothesis** independently from the true MO, combining atm+beam data.

Mass ordering and θ_{23} octant determination with ~ 3 - 6 σ significance after 10 years of data, depending on $\sin^2\theta_{23}$

	$\sin^2\theta_{23}$	Atmospheric neutrino	Atm + Beam
Mass ordering	0.40	2.2 σ	→ 3.8 σ
	0.60	4.9 σ	→ 6.2 σ
θ_{23} octant	0.45	2.2 σ	→ 6.2 σ
	0.55	1.6 σ	→ 3.6 σ

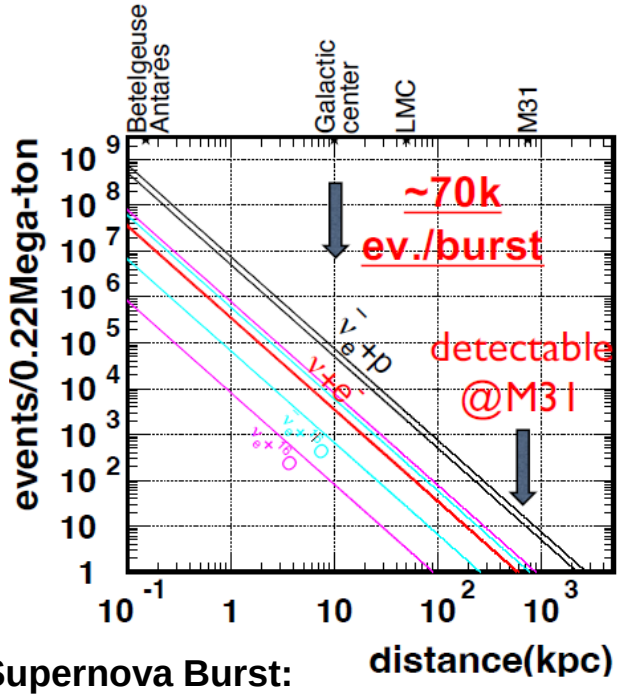
10 years with 1.3MW, normal mass ordering is assumed





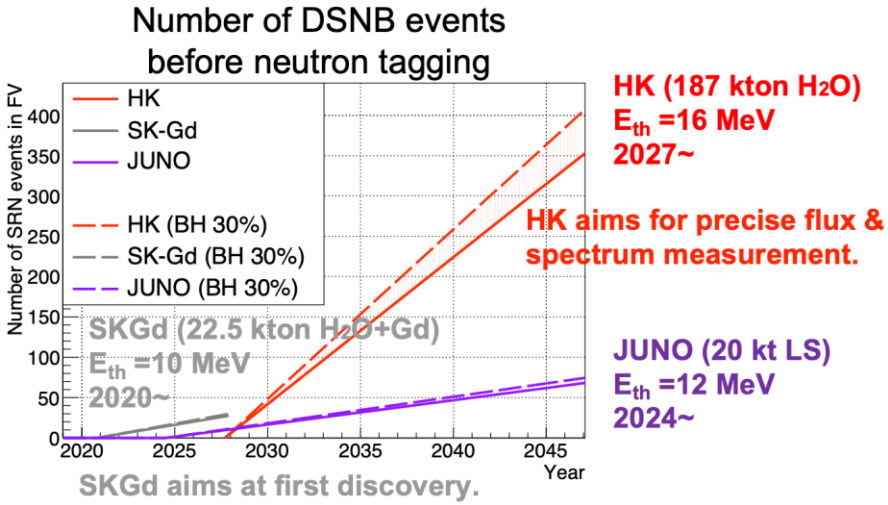
Astrophysical neutrinos

Hyper-Kamiokande will be a key tool for astrophysical discoveries, particularly in advancing our understanding of supernovae.



Supernova Burst:

- Expected ~70,000 events per burst at 10 kpc.
- Insight into:
  - Core-collapse explosion mechanisms
  - Black hole / neutron star formation
  - Early alert system with ~1° pointing accuracy

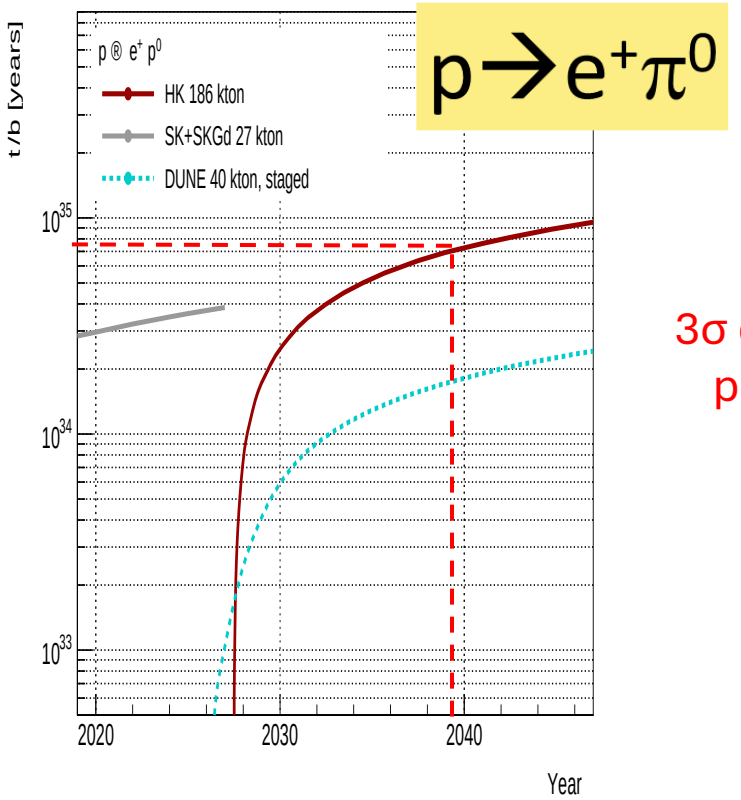


DSNB search:

- Expected ~4 events per year (with neutron tagging in water).
- Probes:
  - History of stellar collapses
  - Cosmic star formation rate
  - Heavy element (metal) synthesis in the Universe

Search for proton decay

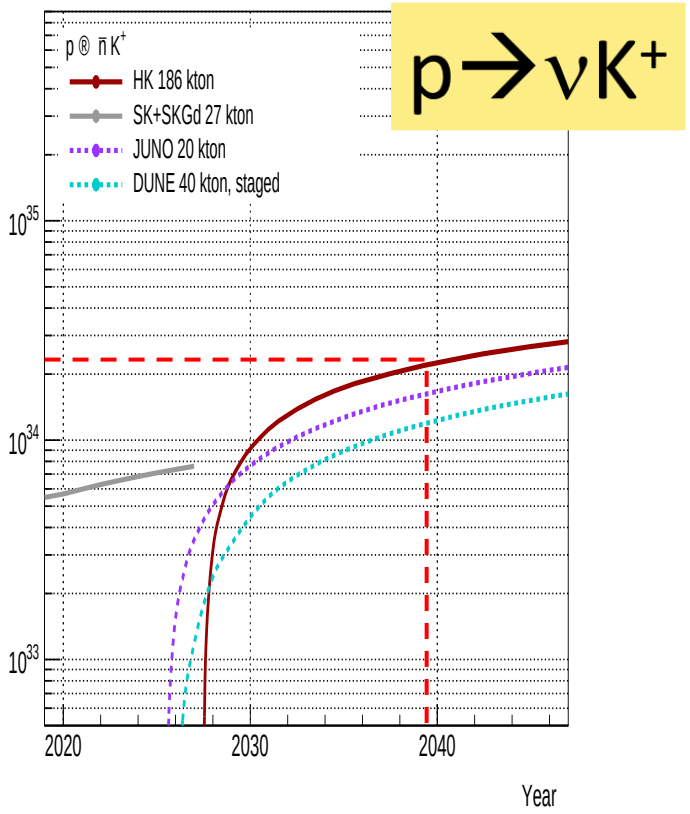
Hyper-K will be characterized by an unprecedented sensitivity to proton decay, enabled by the detector's large mass.



3σ sensitivity after 10 years:

~6x10^{34} for $p \rightarrow e^{+}\pi_{0}$

3σ discovery potential



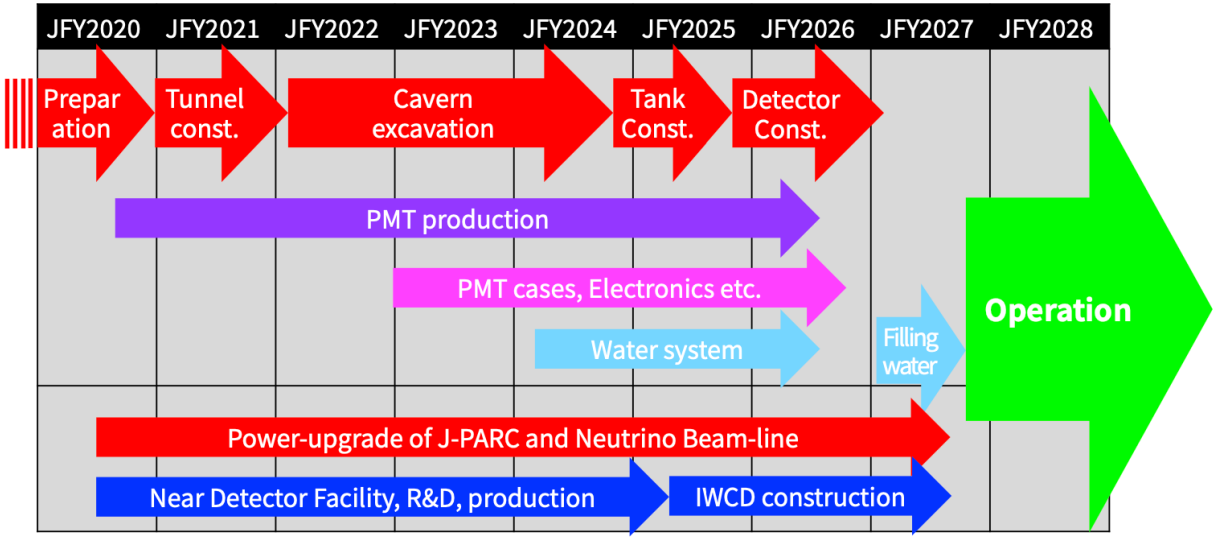
3σ sensitivity after 10 years:

~2x10^{34} yrs for $p \rightarrow \nu^{+} K^{+}$

Hyper-K current status and outlook

- Construction phase started in 2021.
- **Detector construction completion** and **start of water filling** scheduled for **May 2027.**
- **Operations expected to begin in December 2027.**

*JFY=Japanese Fiscal Year (starts in April)



Stay tuned for first data and new discoveries in neutrino physics and astrophysics!


Thank you!