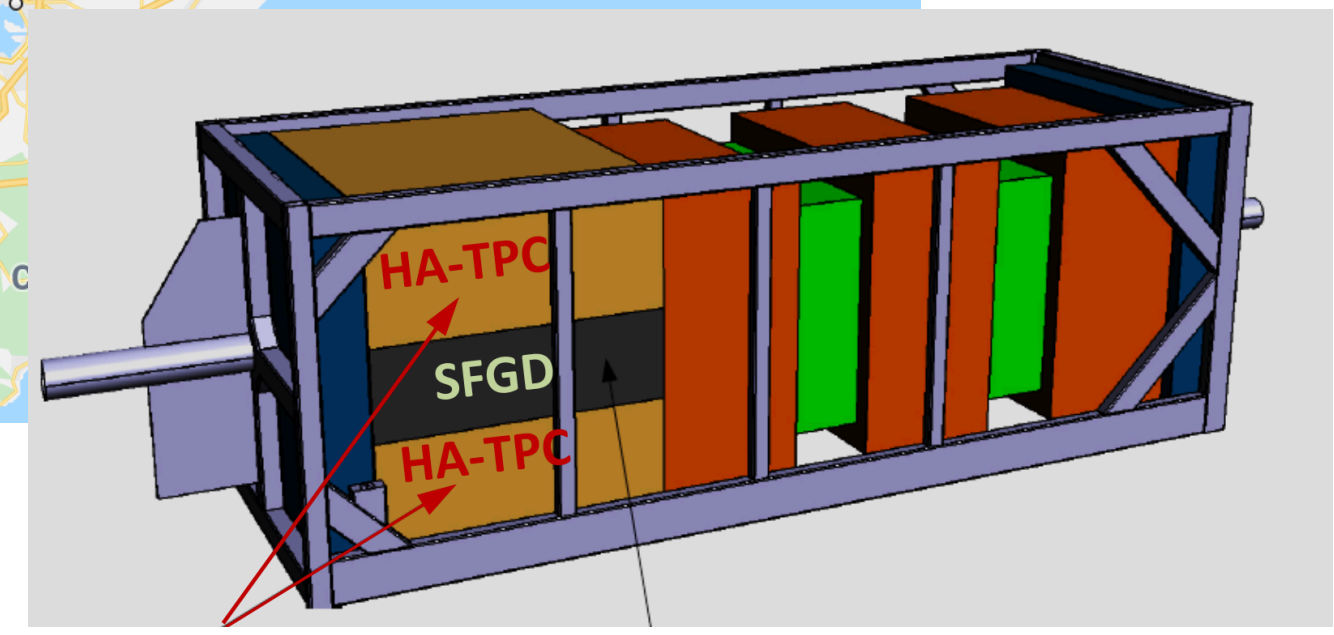
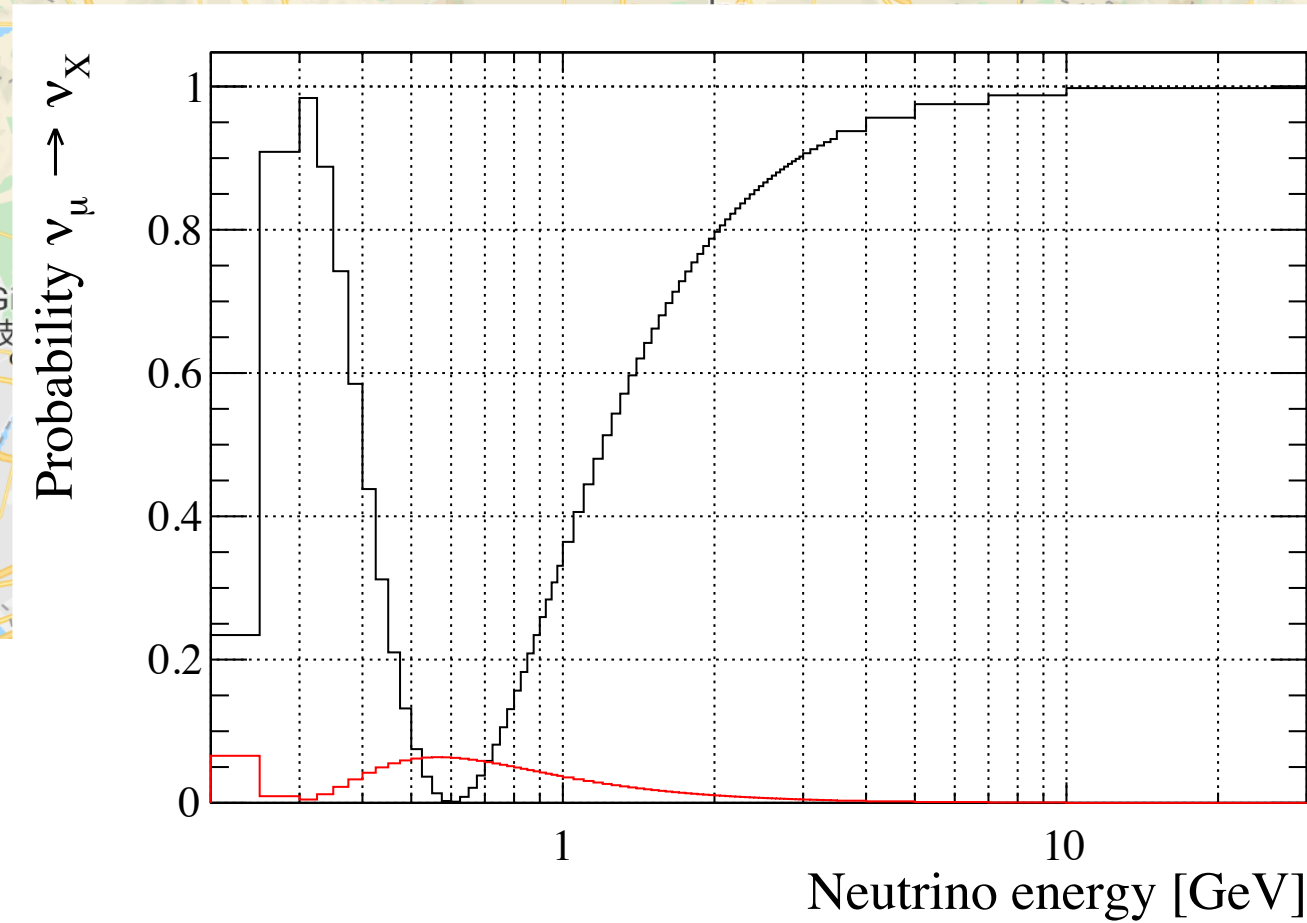
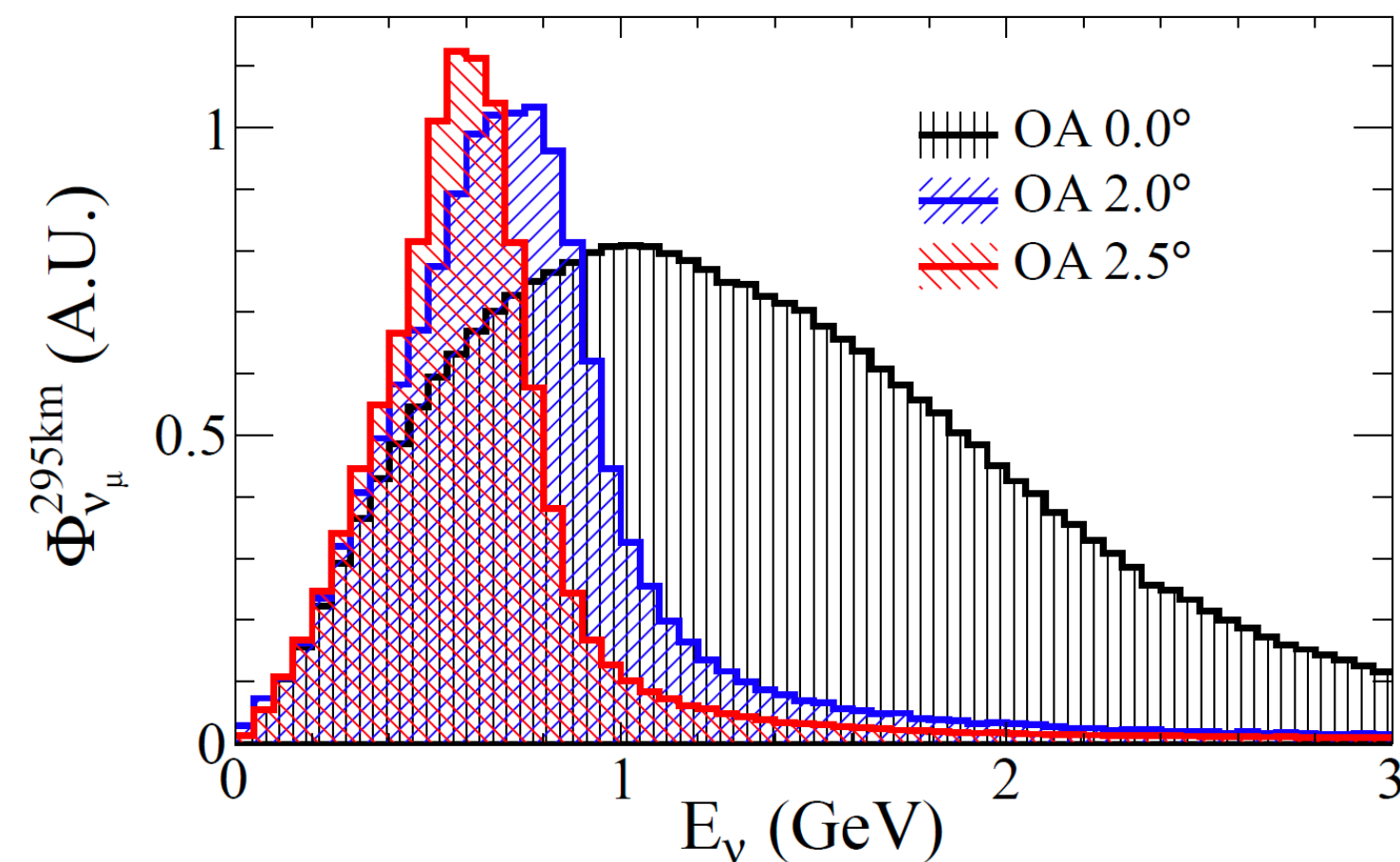
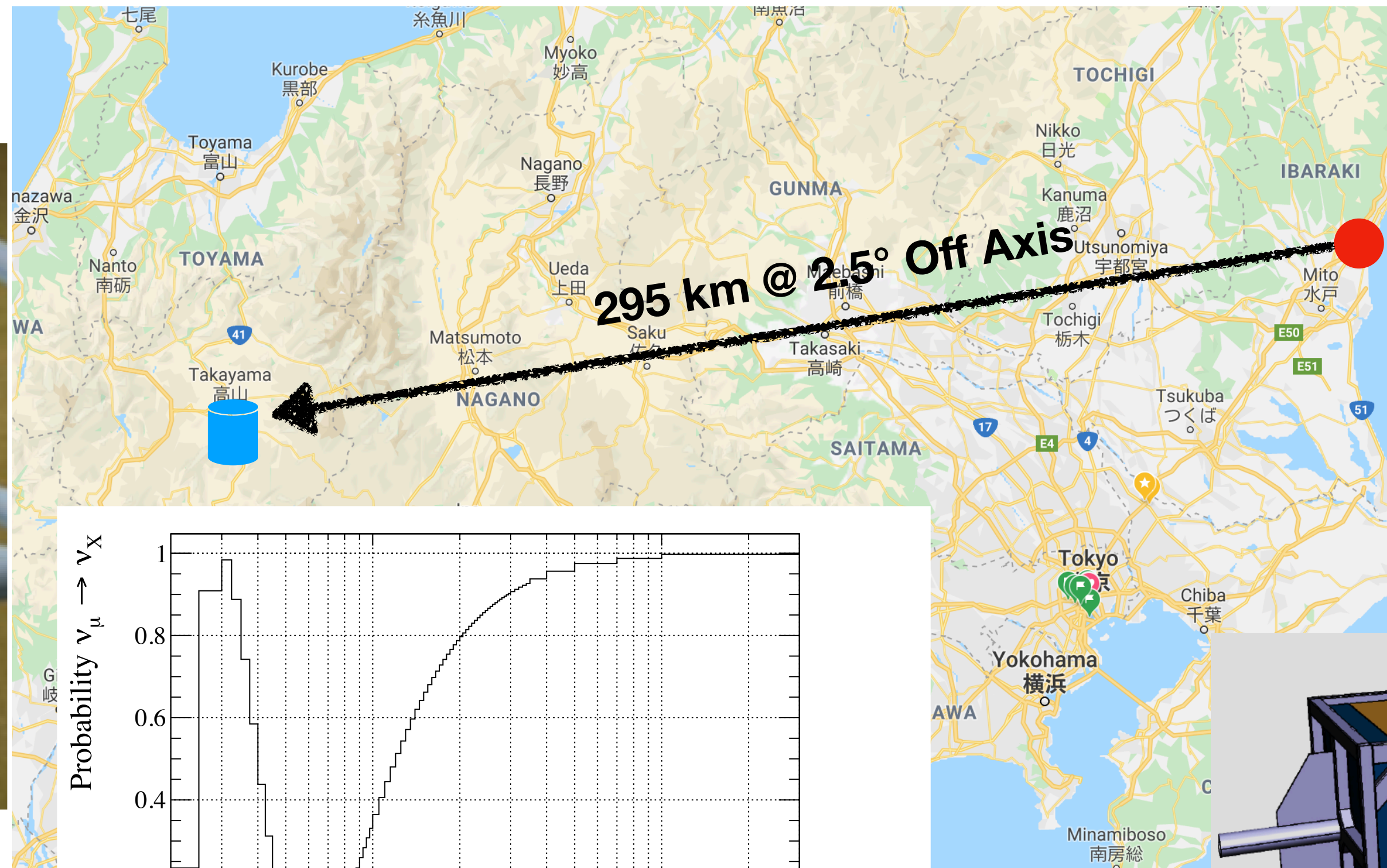
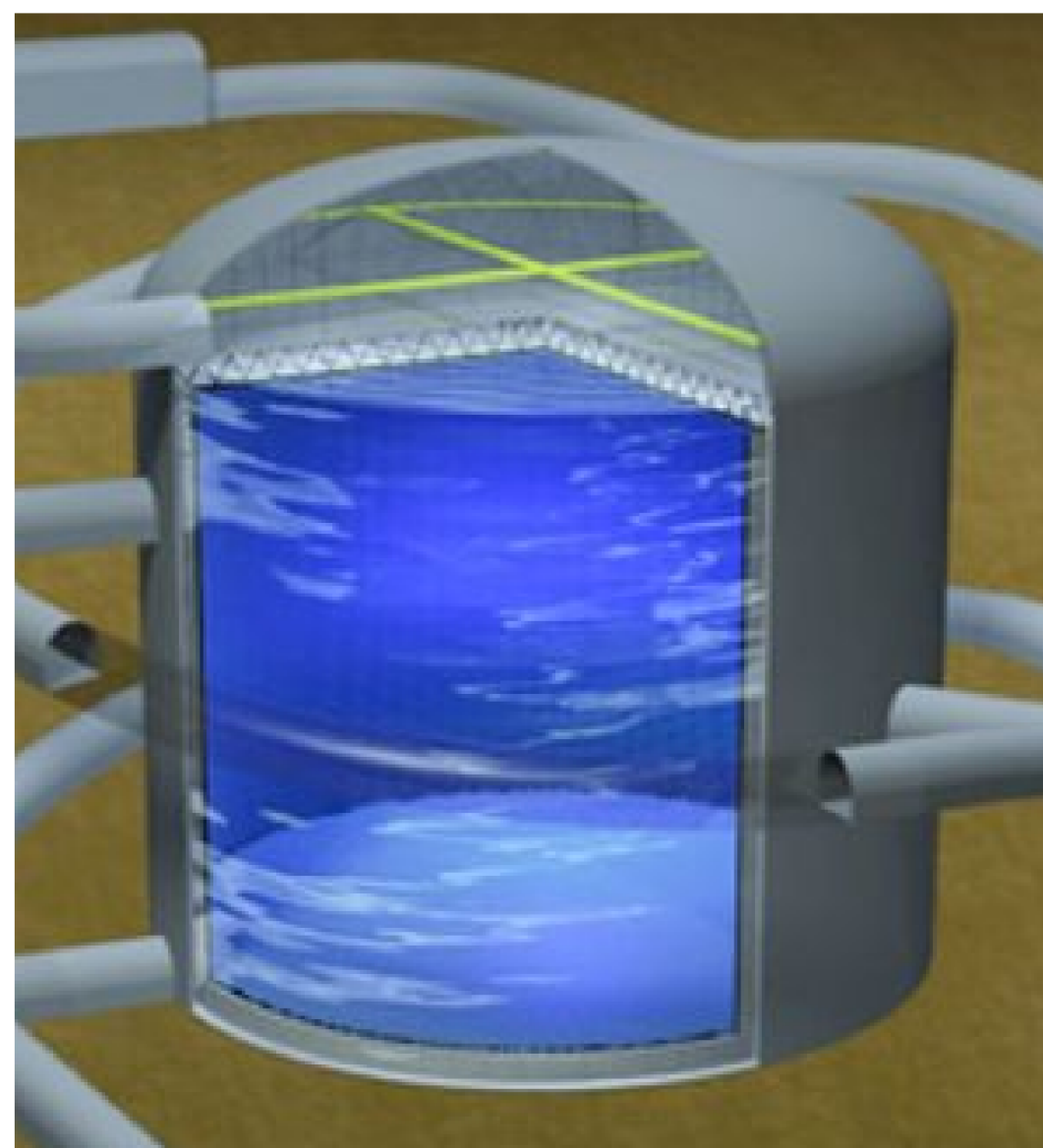


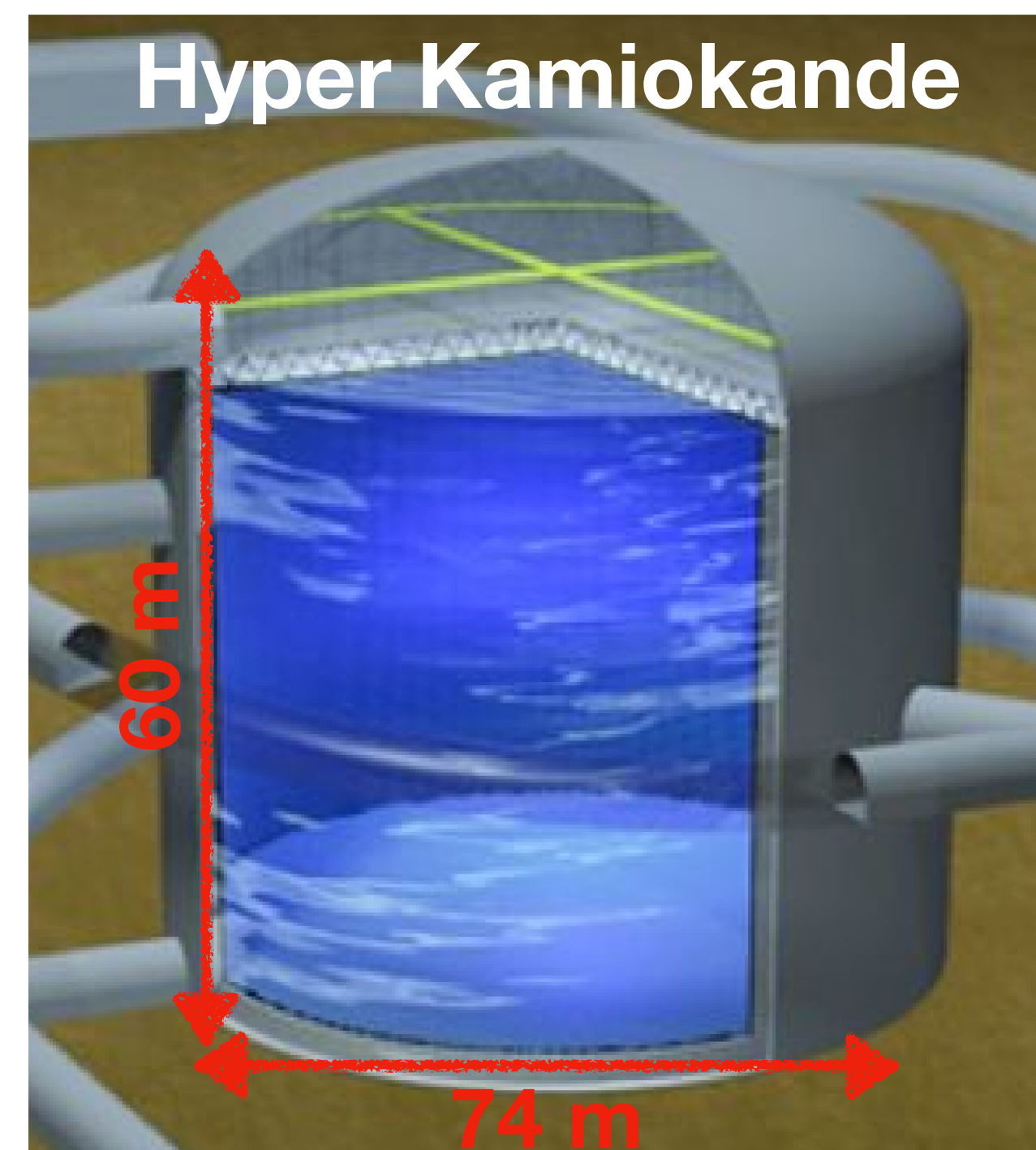
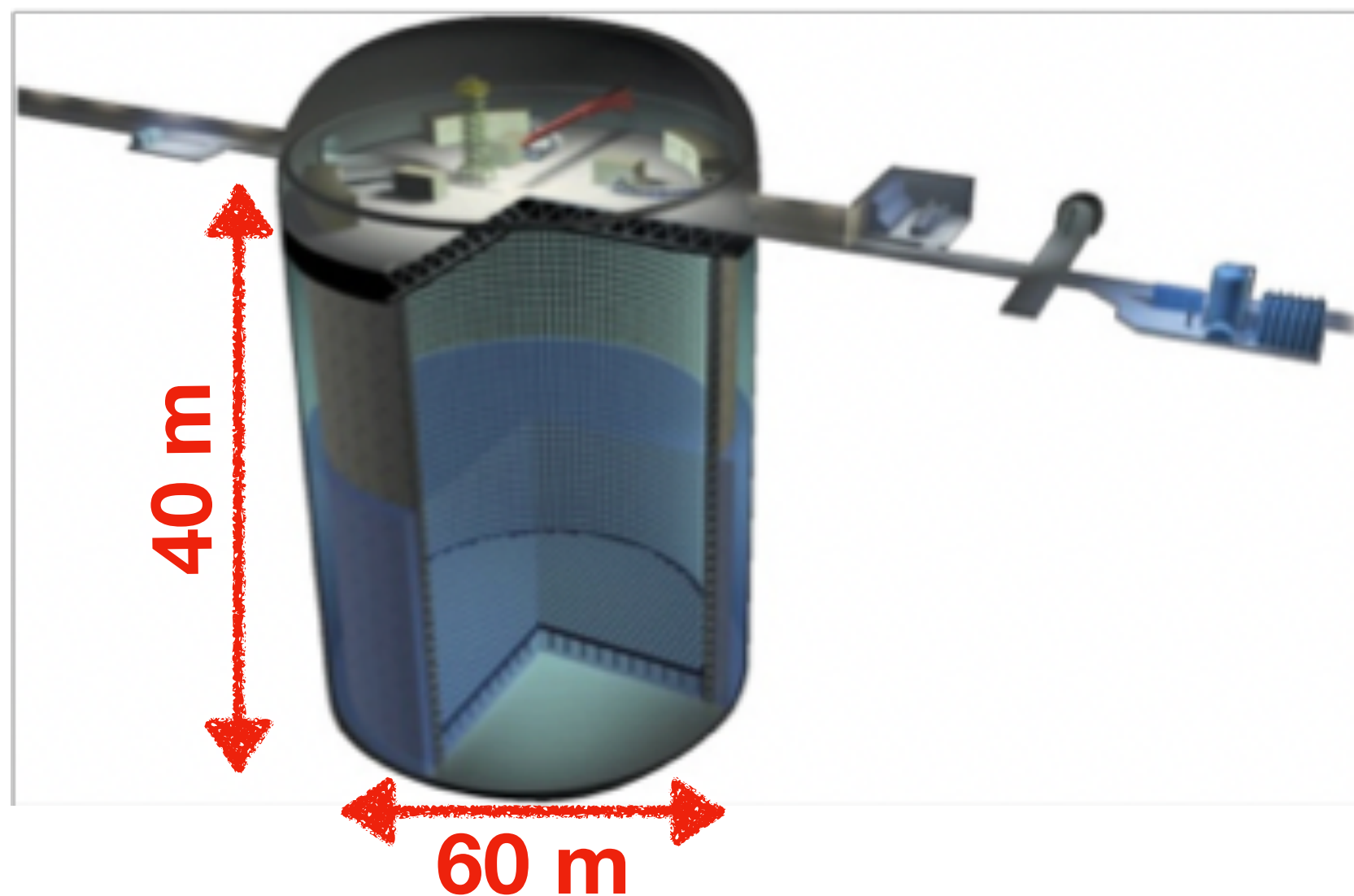
Groupe Neutrino: Perspectives à 5 ans

Hyper Kamiokande: overview



Long-baseline neutrino oscillation experiment
 Muon (anti)neutrinos off-axis beam between Tokai and Cherenkov detector
 Measurement of changes in the energy spectrum induced by neutrino oscillation

Super Kamiokande

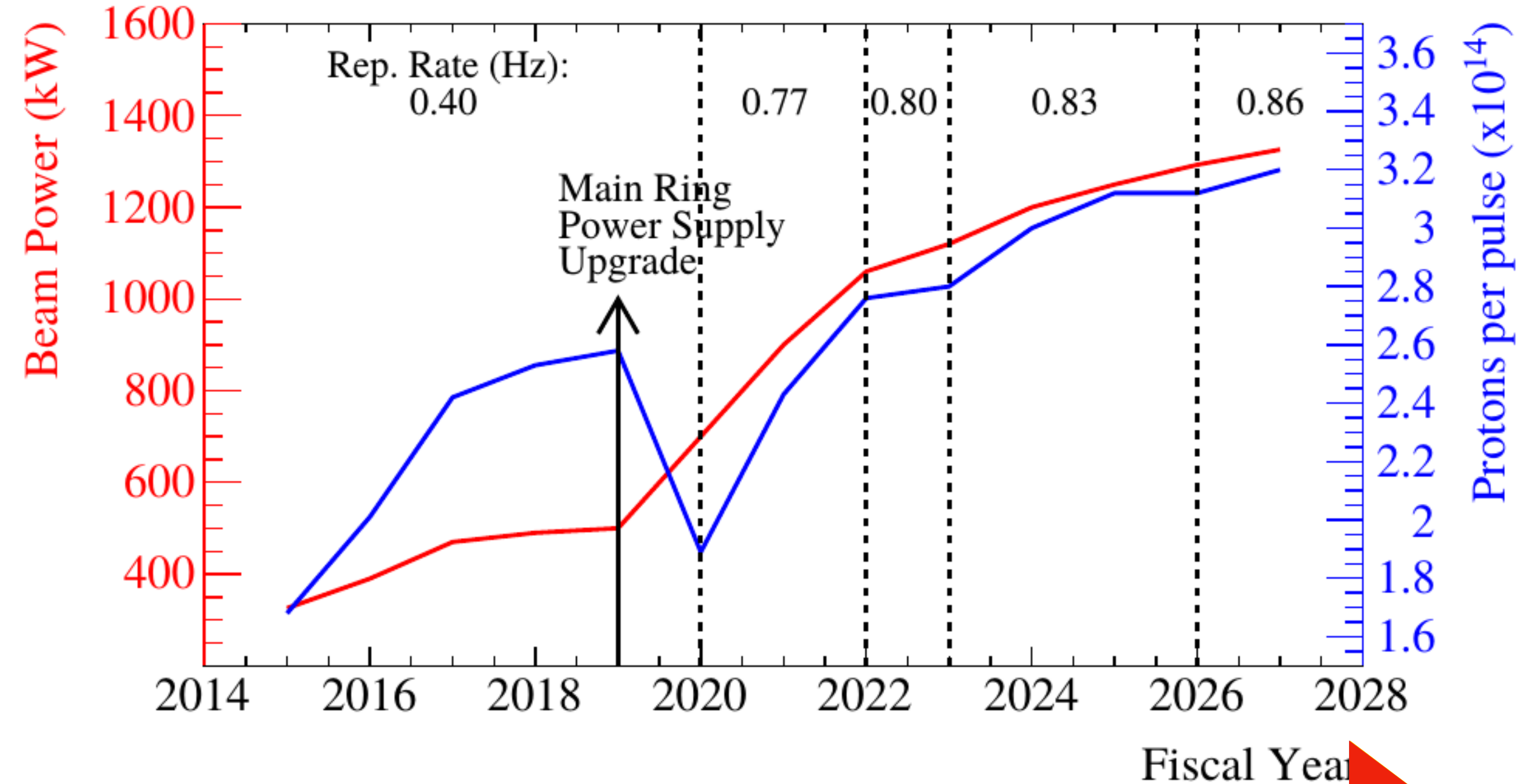


	Super-K	Hyper-K (1st tank)
Site	Mozumi	Tochibora
Number of ID PMTs	11,129	40,000
Photo-coverage	40%	40% (x2 sensitivity)
Mass / Fiducial Mass	50 kton / 22.5 kton	260 kton / 187 kton

T2HK: what will be new?

Accelerator upgrade
 Power increase (1.3 MW)
 Cycle change (1.16 sec cycle)

J-PARC Main Ring Fast Extraction Power Projection



T2HK: what will be new?

Accelerator upgrade

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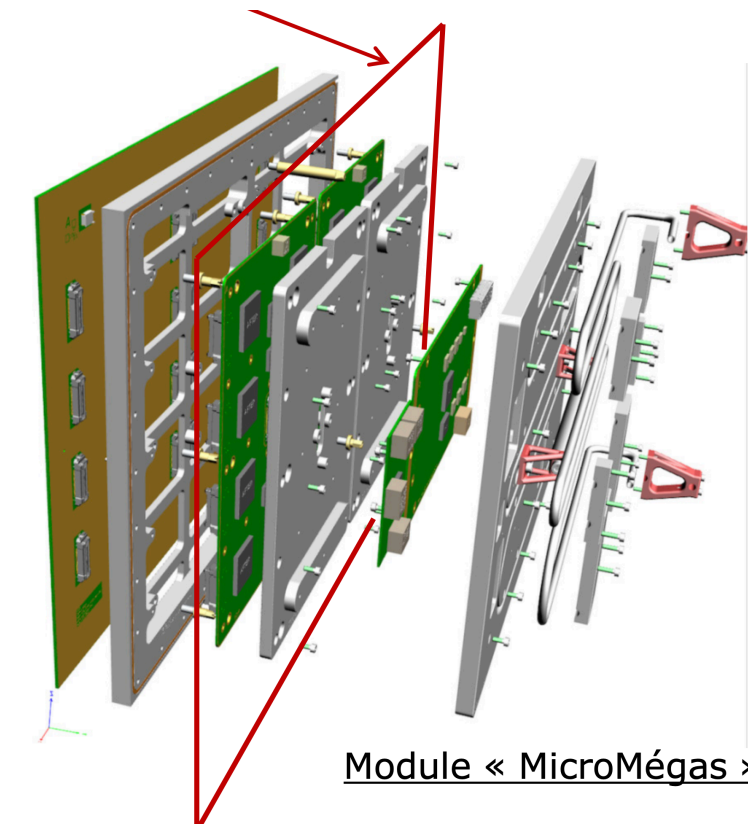
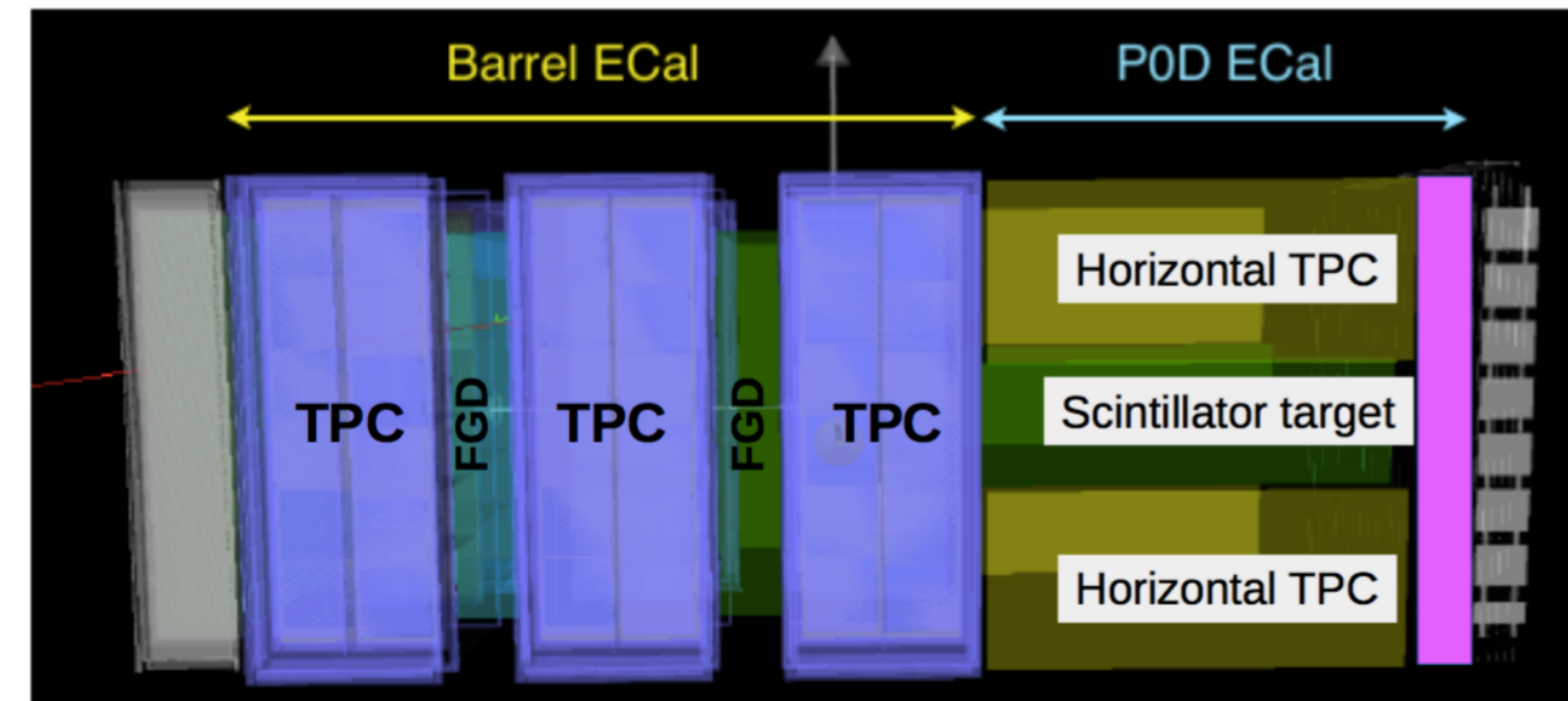
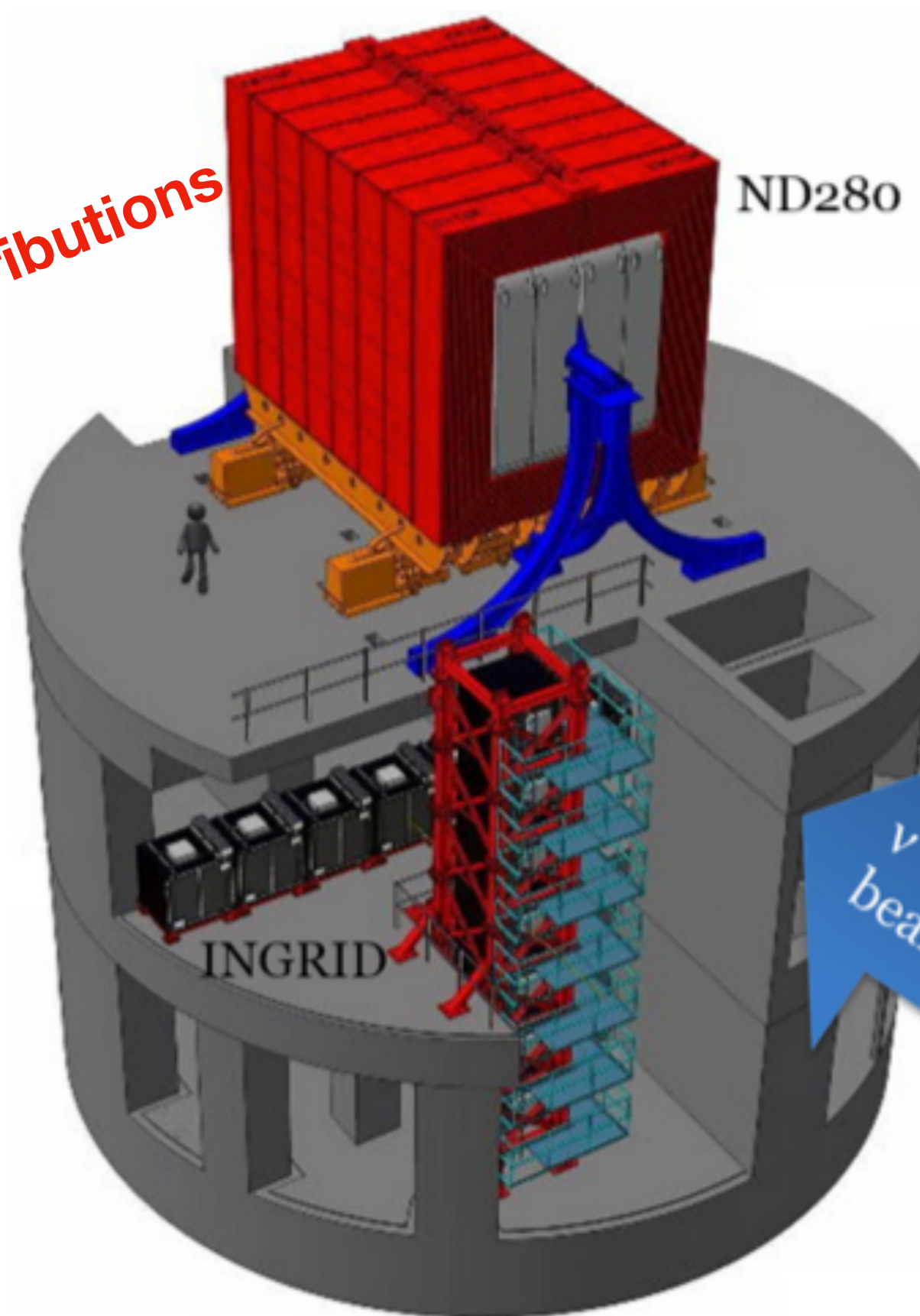
Upgraded near detector @280 m

Reduce uncertainties 5% to 3%

ND280 is being upgraded now

Considering Ingrid update

LPNHE contributions



LPNHE contributing ITs

- Jean-Marc PARRAUD
- François TOUSSENEL
- Eric PIERRE
- Yann ORAIN
- Julien PHILIPPE
- Diego TERRONT

T2HK: what will be new?

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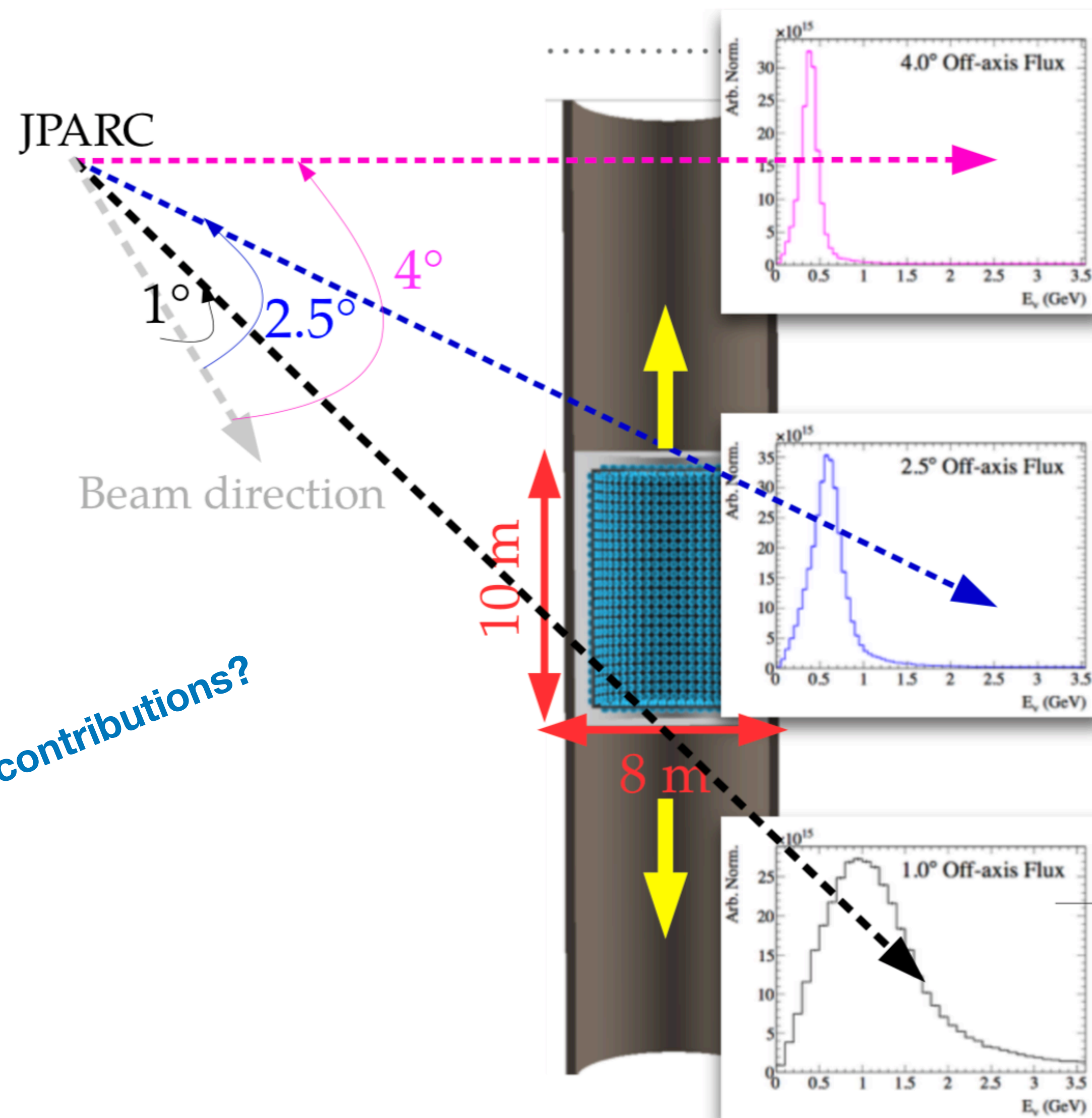
Intermediate water Cherenkov detector (E61)

Constraining beam alignment

Better constraints on cross-section models

Measurement of ν_e background

Possible contributions?



T2HK: what will be new?

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Possible contributions?

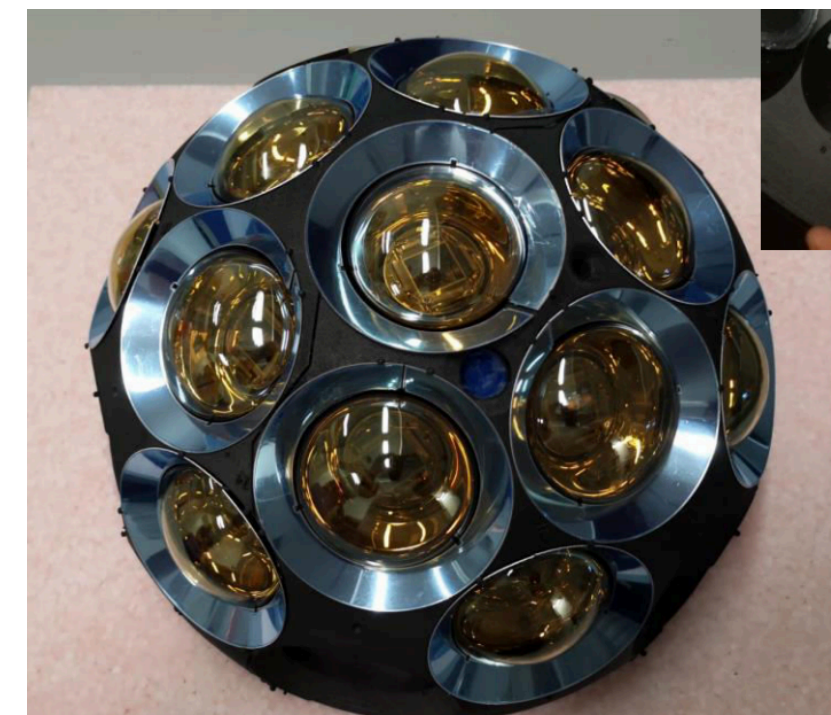
Use additional 5k+ mPMTs to enhance physics

Increase fiducial volume

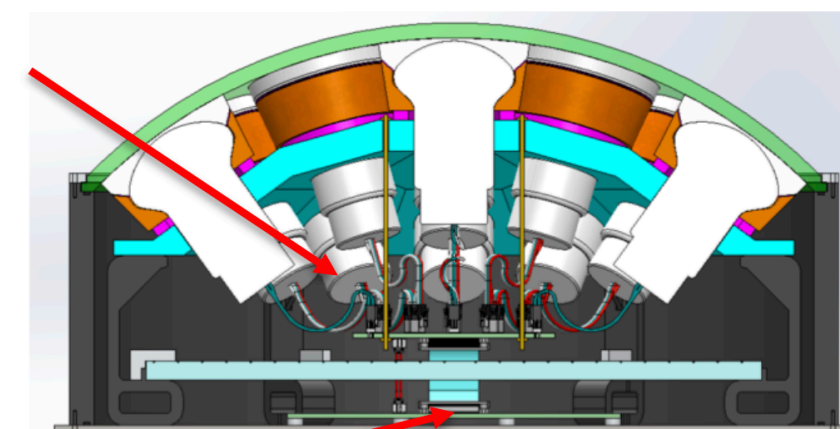
Better momentum resolution, SNR

LPNHE contributions

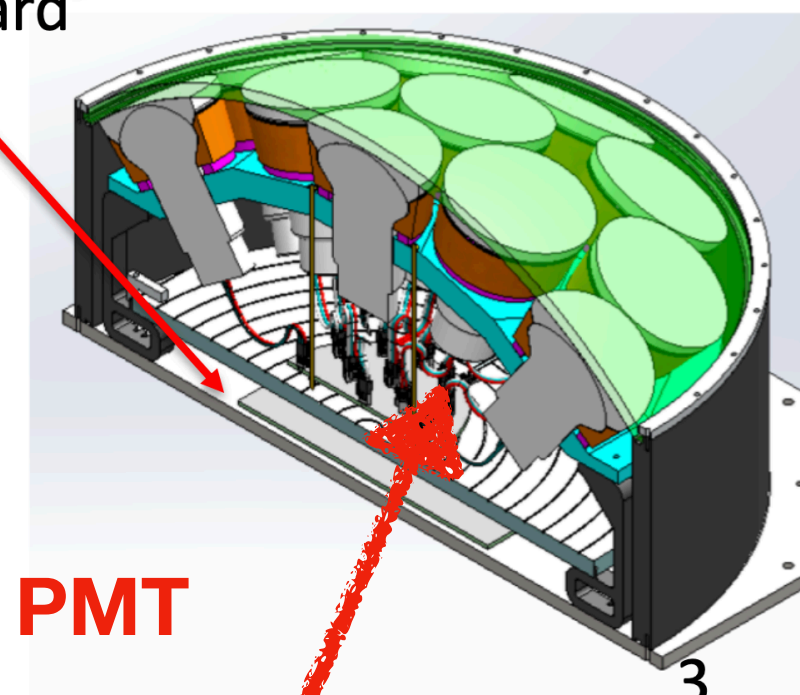
...



PMT Bases



mPMT
mainboard



19 x 3" PMT



CP-violation

60% @ 5σ of δ_{CP} phase-space after 10 y

Atmospheric parameters

Resolution of $\sin^2 \theta_{23}$
0.6% precision on Δm_{32}^2

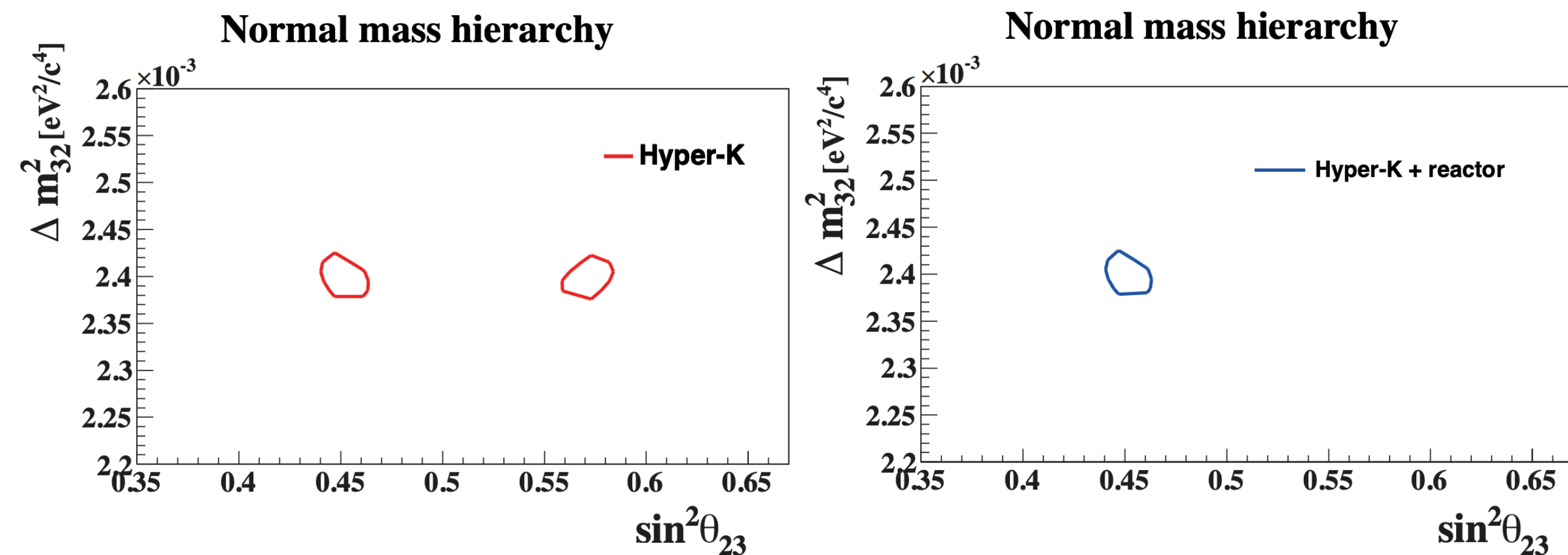
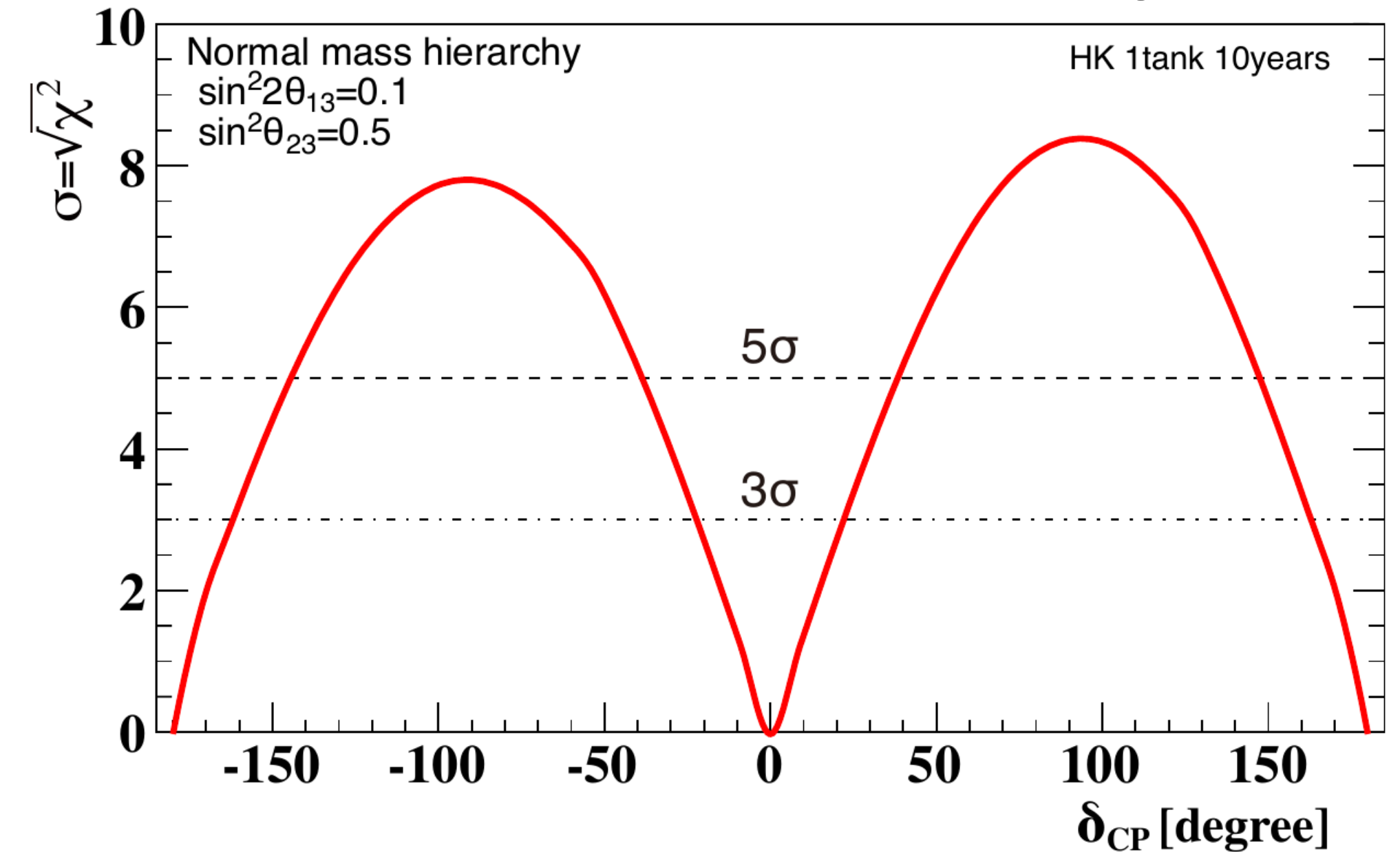
Mass hierarchy: 5σ after 10 years

Neutrino cross-sections

Sterile neutrinos w/ ND and ID

...

Assuming 1.3 MW



Proton decay

Sensitivity to GUT predictions

x10 on “golden channel” $p \rightarrow e^+ \pi^0$

Supernova neutrinos

Increase by 200 in stats sensitivity

SN1987A type ~2500 events

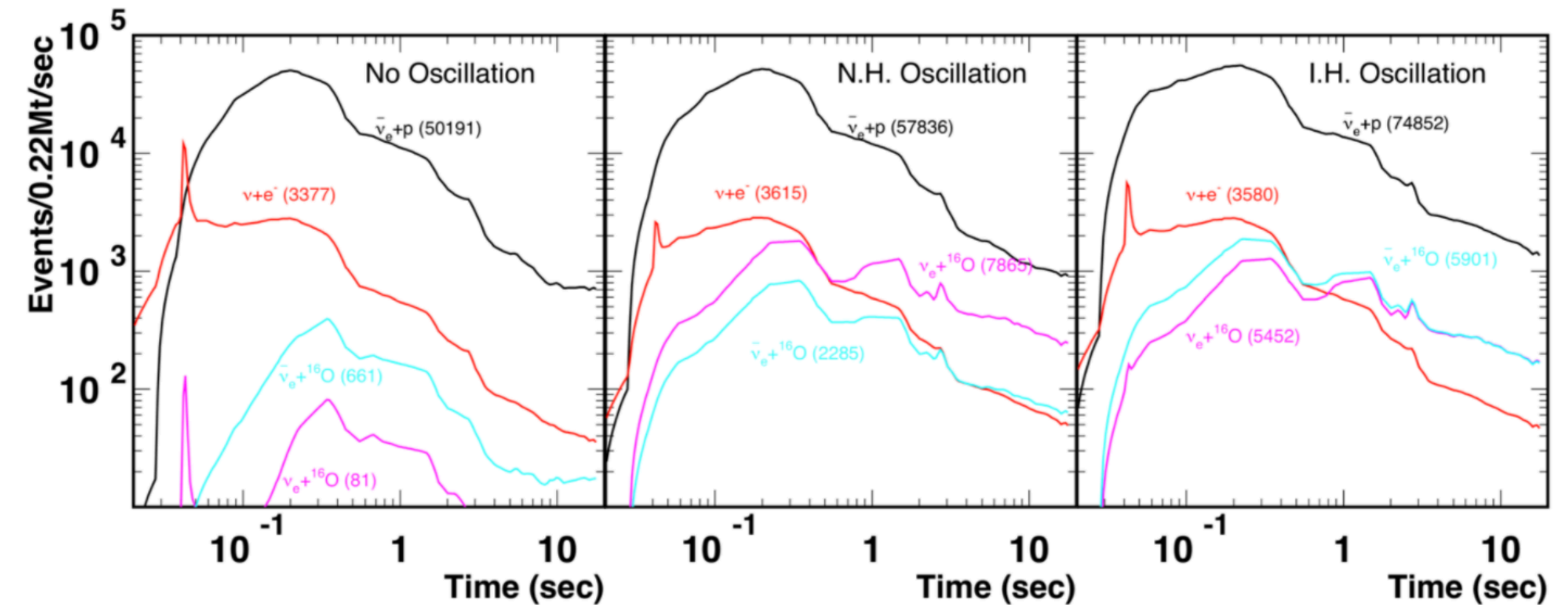
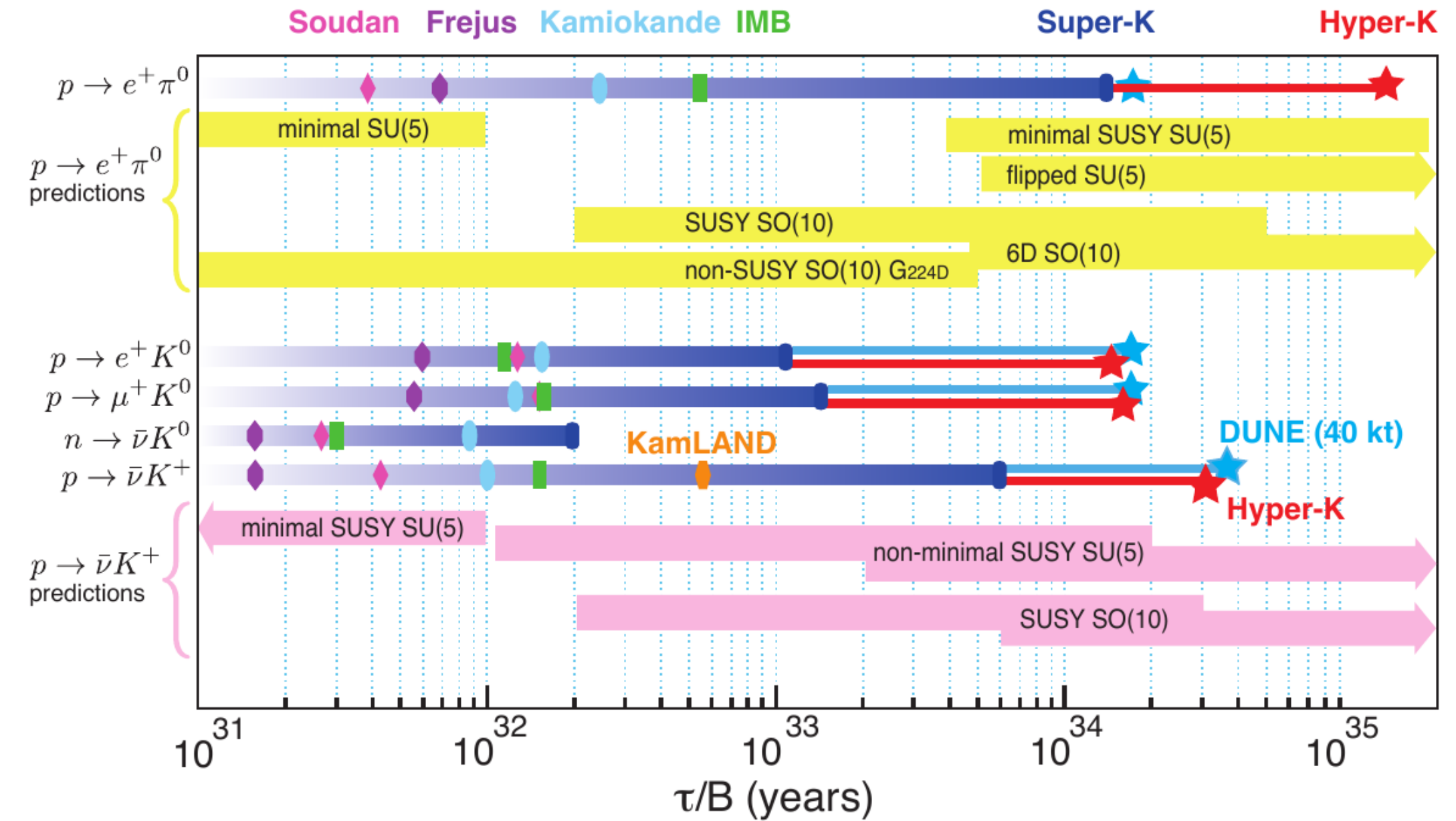
Galactic center: ~50000+ events

Time profile: collapse models

Gravitational waves sources

Nearby (10Mpc) neutron star mergers

→ Multi-messengers observations



Upcoming milestones

Project received seed funding from MEXT for this FY

Very good sign! Finalise international contribution before MEXT approval

Happening now: definition of LPNHE contributions (w/ LLR & CEA-Saclay)

Eol: PMTs/mPMTs electronics and clock sync.; software and computing...

Upcoming milestones:

May-June: Technical report

May: First “stab” at international contribution distribution (Work Package distribution)

June: 2nd HKFF in Japan w/ fundings agencies (IN2P3 invited)

Fall '19: response from MEXT

Fall '19: obtain IN2P3 directorate's approval to request money

'20: start construction (cave excavation)

Next-years milestones:

R&D on mPMT and electronics

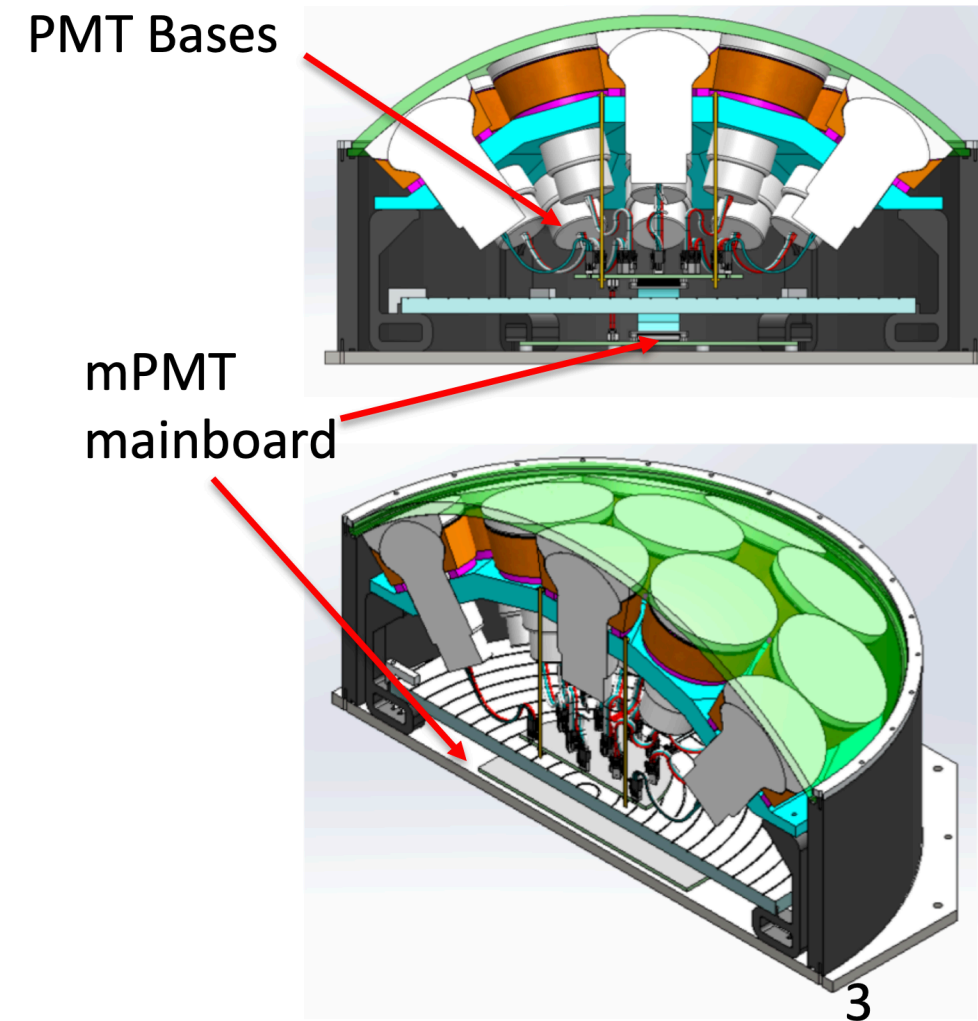
Start PMTs/mPMTs production in '22

'27: start data taking

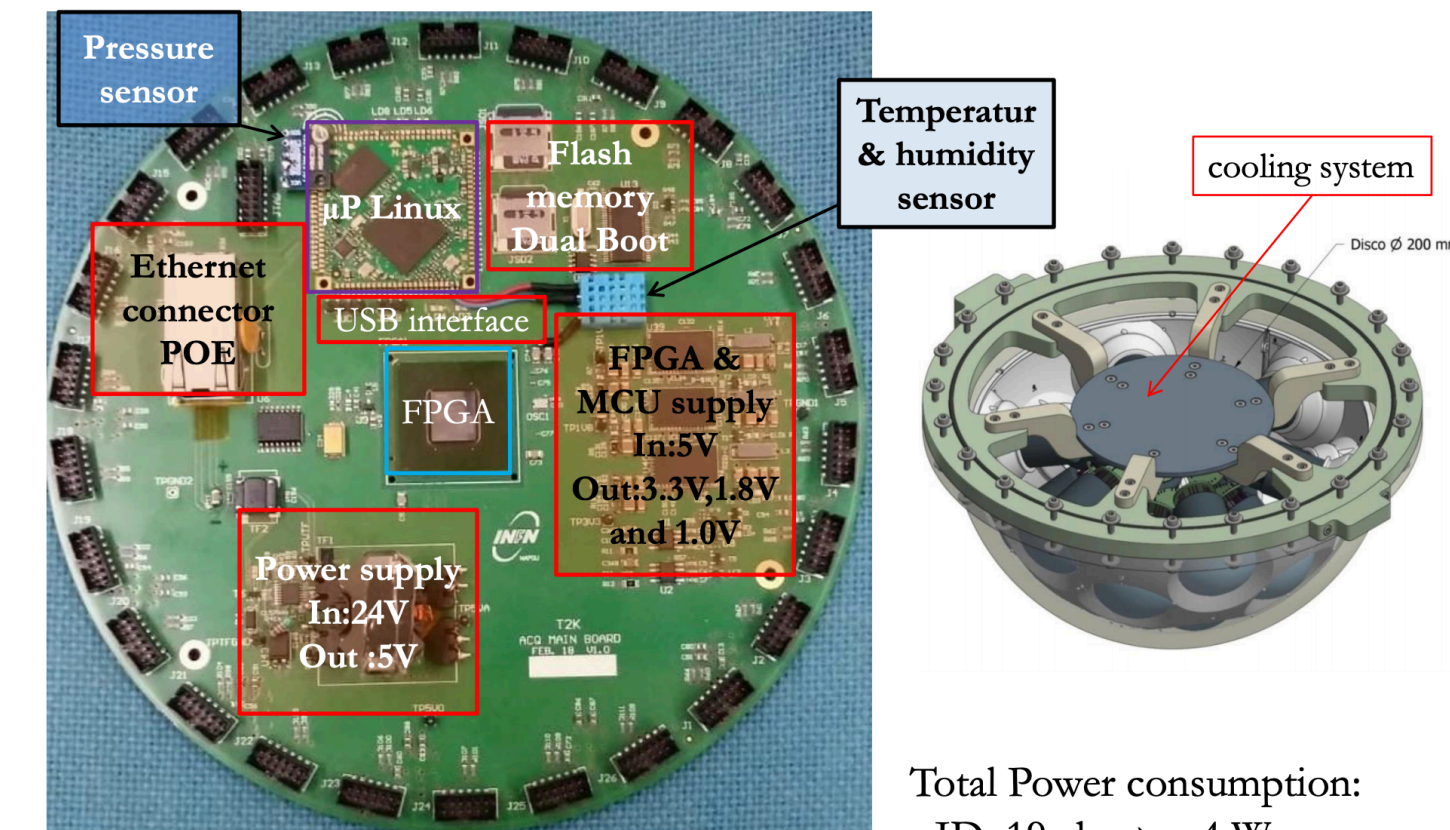
Collaboration with APC to use
Memphyno Cherenkov water tank
2 scintillator plans for comics trigger

In-water tests of mPMTs Canadian
and Italian (KM3Net) designs
(w/ electronics)

LPNHE contributions/goals
Leading data taking
Develop tools and expertise
DAQ, computing, storage



INFN mPMT electronics: main board



Total Power consumption:
- ID: 19 ch → ~ 4 W

Test critical components for full IWCD
 Detector energy calibration
 Cherenkov production light at low momentum

Build small WC detector on CERN charged
 particle test beam (140 MeV/c - 1200 MeV/c)
 Start data taking mid-2021

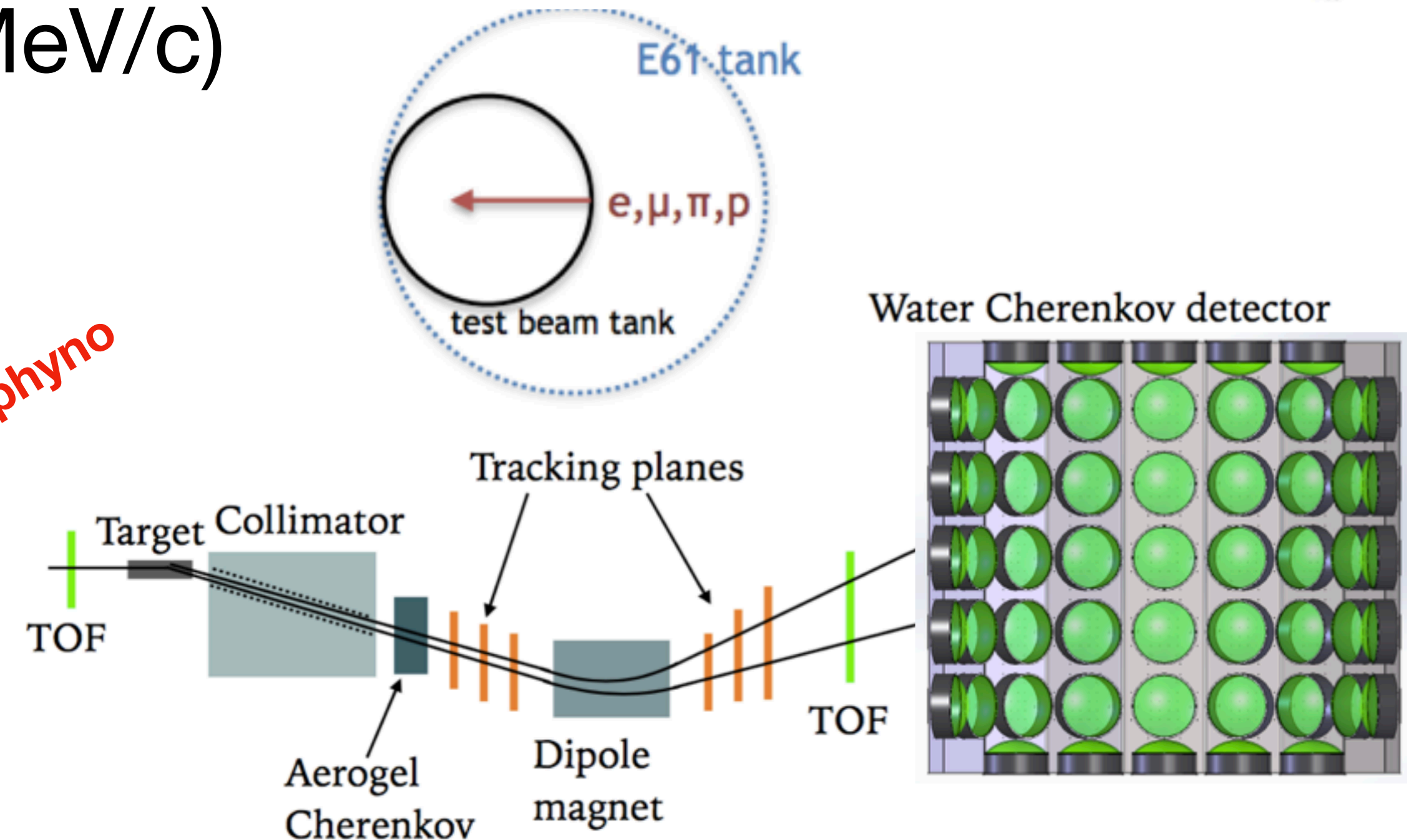
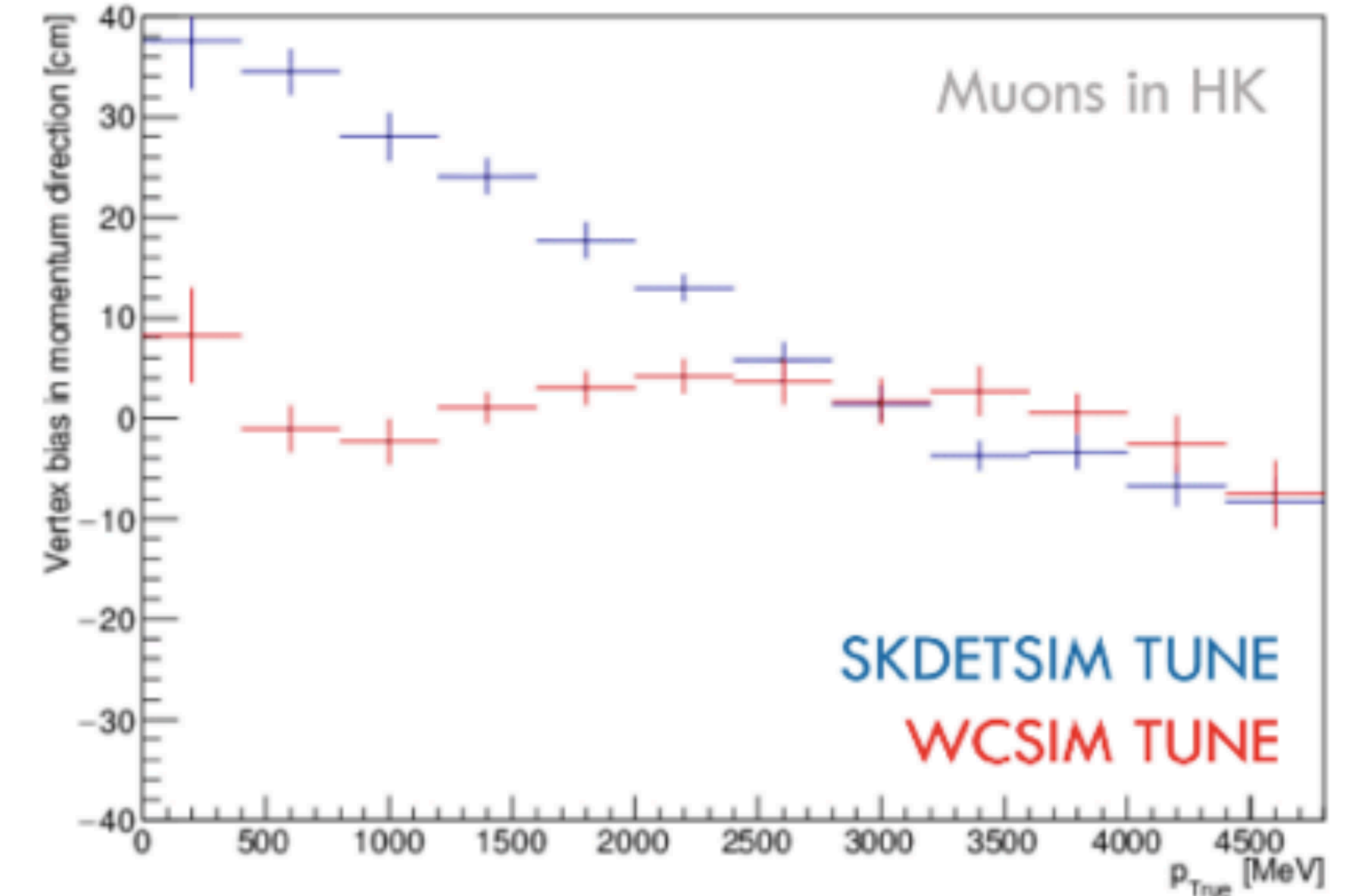
LPNHE possible contributions

DAQ software

mPMTs electronics

Computing @CC-IN2P3

Expertise built on Memphyno



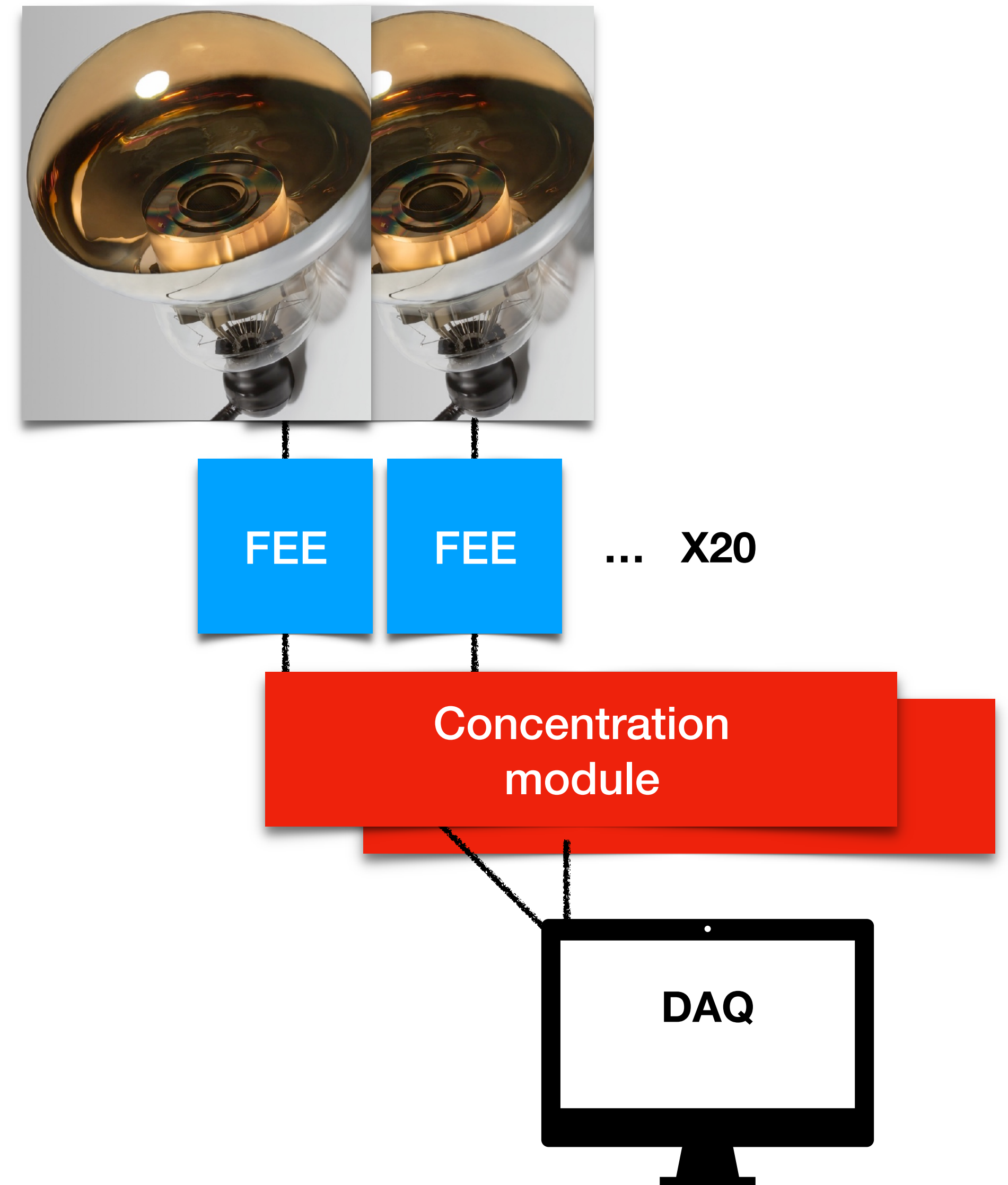
New 20" PMT model (better timing, Q-resolution)
****New**** Front-end electronic and concentration modules under water
****New**** Possibility to use Flash-ADC for better event discrimination

LPNHE possible contributions

- Expertise in FPGA**
- Digitisation**
- FE module control**
- Clock and counter**
- Mechanical support**

...

Will be defined in the coming months



Distribute 125 MHz clock to all FEE modules (~40k 20" & 5k+ mPMTs)

Reference clock from GPS receiver

Transmission using optical fibre

Jitter must be smaller than 0.1 ns

Handling both data and clock distribution

Available commercial technologies (White Rabbit), but expensive

Custom solution possible to accommodate electronic specificities

Stefano R. → LPNHE expertise in clock synchronisation

**LPNHE possible contribution:
clock distribution design**

Need to share data, software and computing resources across contributing clusters
Challenge: share unified/reproducible environment

Chosen technologies: DIRAC + Singularity
High synergy with Belle-II French groups

Currently led by QMUL, but few human resources
Possibility to **take over leadership**



Conclusions and outlook

HK relies on all past Water Cherenkov experience to achieve unprecedented precision on lepton CP-violation and in rare events

Tons of possible contributions combining hardware and software!

Electronics, software, computing...

Currently defining French contributions (w/ LLR & CEA-Saclay)

A lot of expertise useful for this project!

On the verge of being approved by MEXT

Important that IN2P3 directorate starts communications with MEXT!