Project

T2K-II / Hyper-Kamiokande

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Joint Institute for Nuclear Research, Dubna, Russia

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Institute for Nuclear Research of the Russian Academy of Sciences

PROJECT LEADERS V.V. Glagolev, Yu.I. Davydov

SCIENTIFIC PROJECT LEADER J.A. Budagov

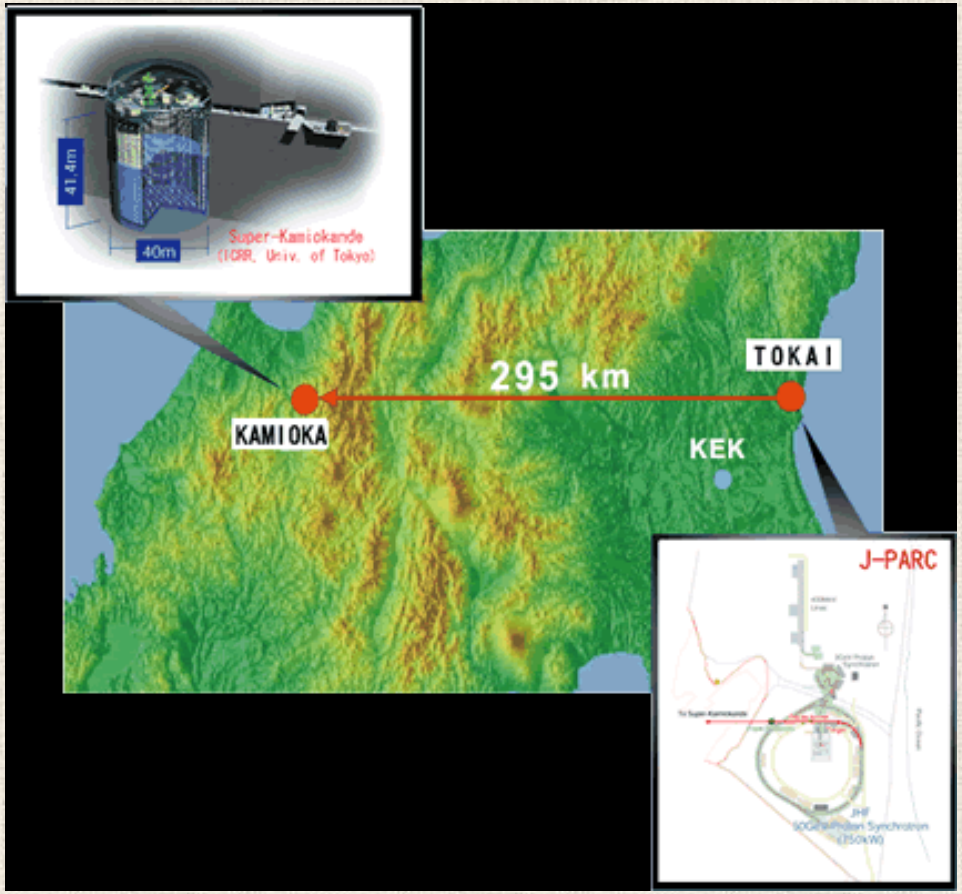
DATE OF SUBMISSION OF PROPOSAL OF PROJECT TO SOD _____

DATE OF THE LABORATORY STC 1.04.2021 DOCUMENT NUMBER _____

STARTING DATE OF PROJECT 2022

(FOR EXTENSION OF PROJECT — DATE OF ITS FIRST APPROVAL) _____

Date of the Lab seminars 17.03.2021, 30.03.2021



Vladimir Glagolev for the JINR group

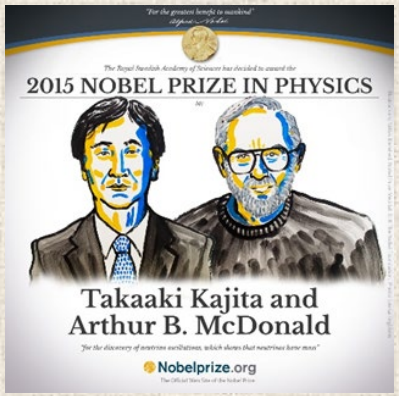
PAC JINR

June 21 2021

predecessor

Kamiokande

2002 first-ever detection of astrophysical neutrinos



Super-Kamiokande

For the discovery of neutrino oscillations, which shows that neutrinos have mass

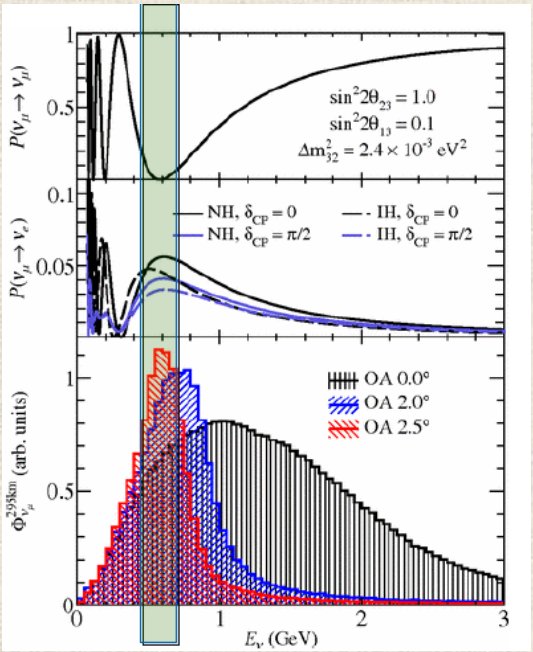
T2K / Hyper-Kamiokande world first class physics program

- Precision measurements of ν_e and $\overline{\nu_e}$ appearance -> determine θ_{13} and δ_{cp}
- Precision measurements of ν_μ and $\overline{\nu_\mu}$ disappearance -> θ_{23} and Δm^2_{32}

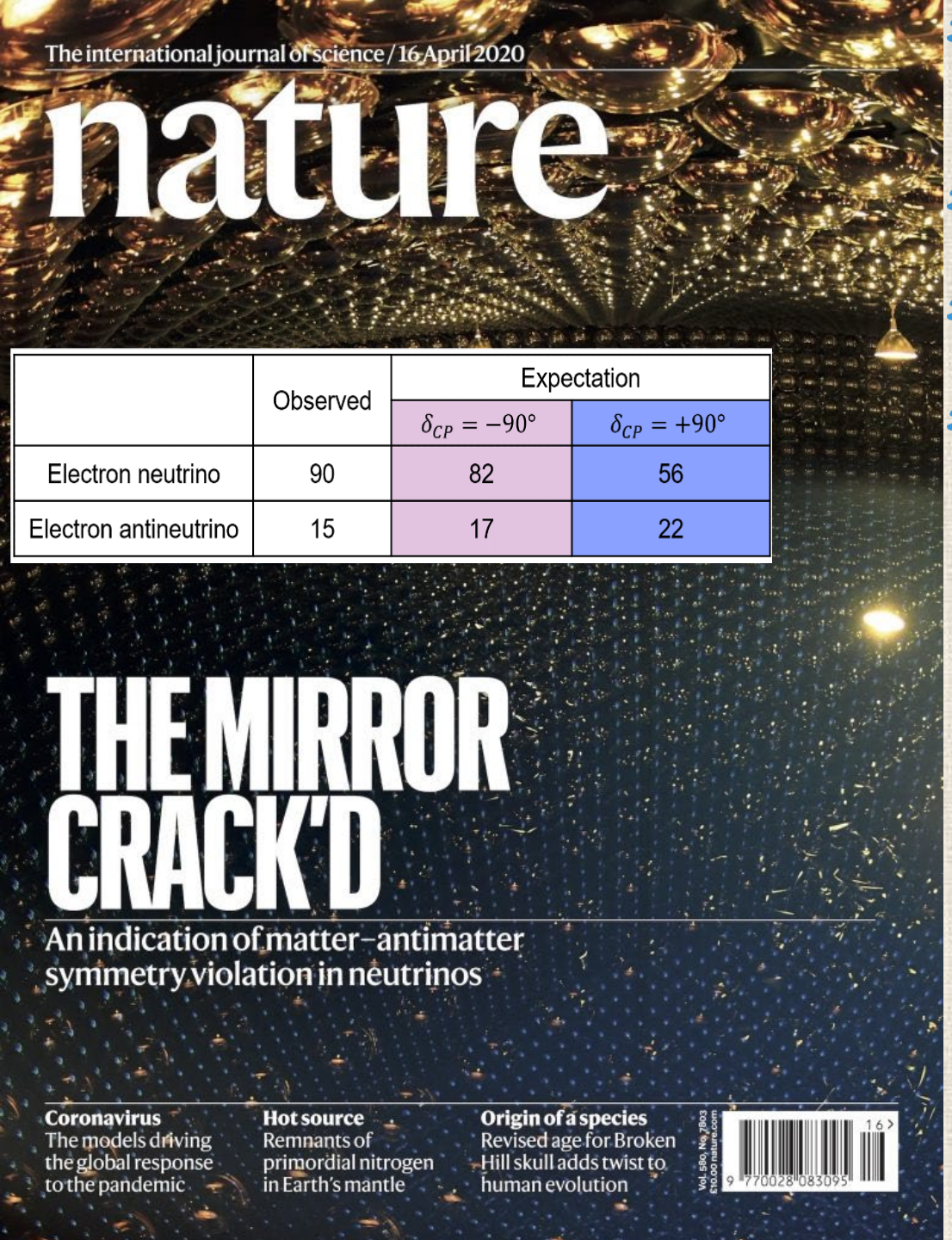
Having collected 1.5×10^{21} POT, T2K has produced the first single-experiment constraint on the value of δ_{CP}. Assuming the normal (inverted) neutrino mass hierarchy, T2K has measured:

- $\sin^2\theta_{23} = 0.55^{+0.05}_{-0.09}$ $(0.55^{+0.05}_{-0.08})$
- $|\Delta m^2_{23}| = 2.54 \pm 0.08$ $(2.51 \pm 0.08) \times 10^{-3} eV^2/c^4$
- $\sin^2\theta_{13} = 0.027^{+0.007}_{-0.006}$ $(0.030^{+0.008}_{-0.007})$
- $\delta_{CP} = -1.73^{+0.85}_{-0.81}$ $(-1.45^{+0.67}_{-0.72})$

Mark Scott and T2K Collaboration 2020 *J. Phys.: Conf. Ser.* **1342** 012043

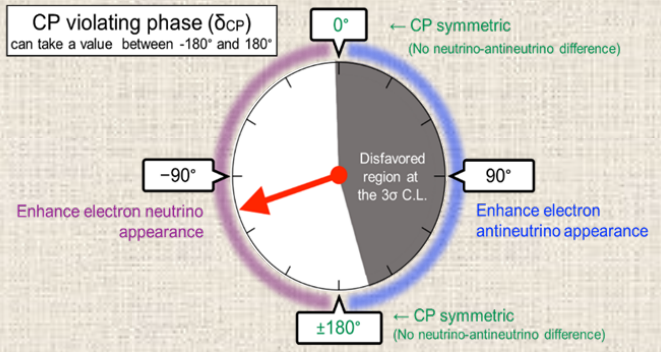


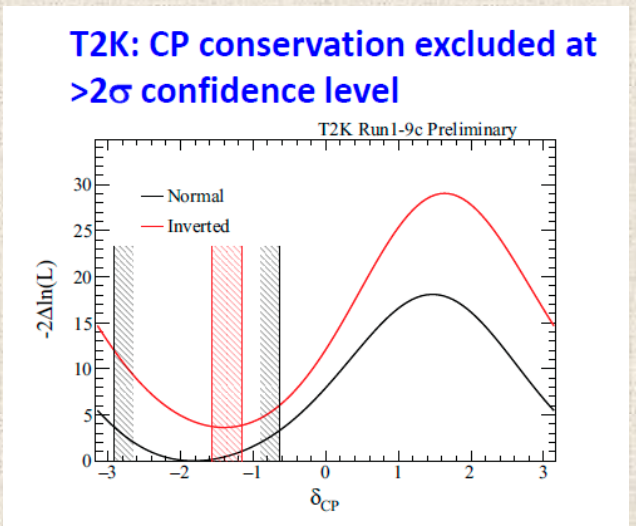
- Search for heavy neutrinos with the T2K near detector ND280
- Gadolinium doping to separate anti-neutrino interaction by neutron capture
- HK program
  - CP violation measurement
  - Determining the Ordering of the Neutrino Masses
  - Cosmic Neutrino Observation (Solar, Supernova, Relic), Dark Matter Search
  - Proton decay Searches

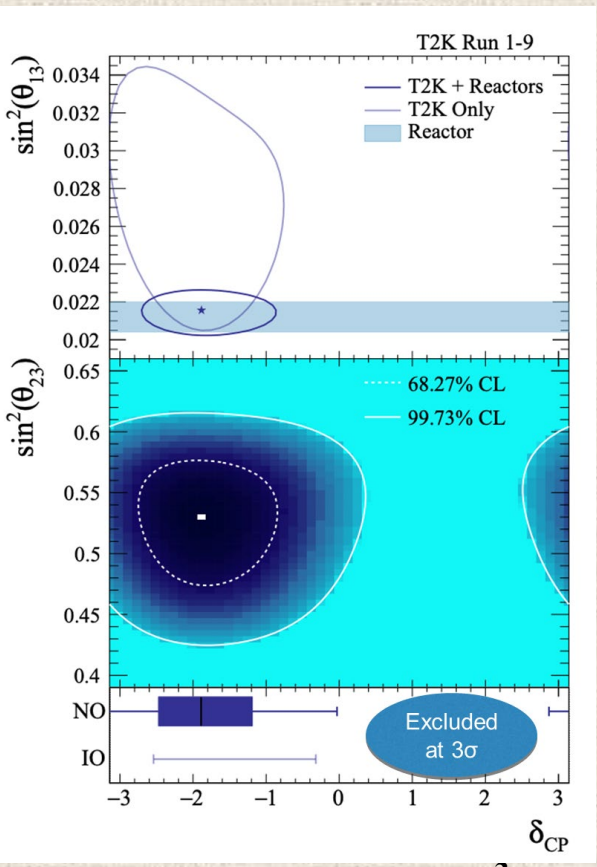


	Observed	Expectation	
		$\delta_{CP} = -90°$	$\delta_{CP} = +90°$
Electron neutrino	90	82	56
Electron antineutrino	15	17	22

* Paper published in Nature: **Constraint of the matter-antimatter symmetry violating phase in Neutrino oscillations**
* First 3σ exclusion for 46% (65%) for the δ_{CP} values in NO (IO)
* Both CP conserving points, $\delta_{CP} = 0$ and $\delta_{CP} = \pi$, are ruled out at the 95% confidence level.
* Need more data (and smaller systematics)!



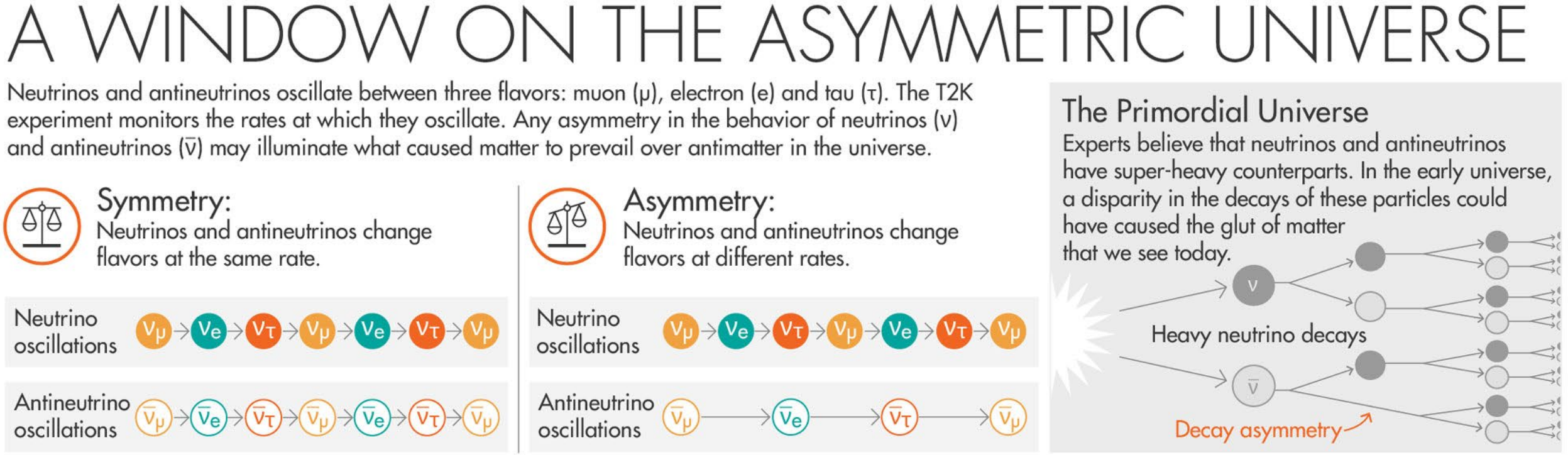




δ_{CP} importantce

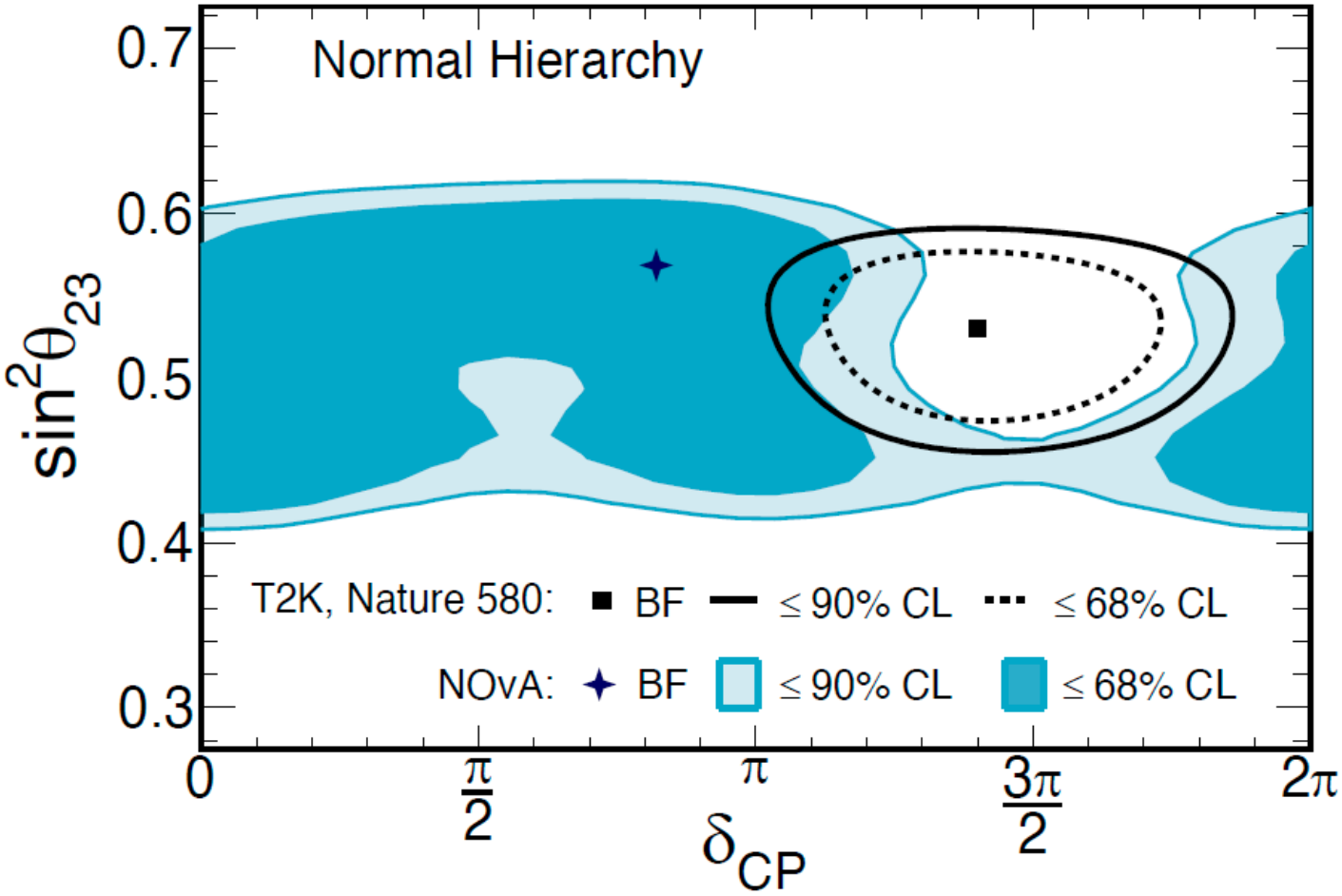
Baryon Asymmetry of Universe (BAU)

See-saw model satisfies Sakharov's conditions producing BAU by leptogenesis mechanism



https://www.quantamagazine.org/do-neutrinos-explain-matter-antimatter-asymmetry-20160728/

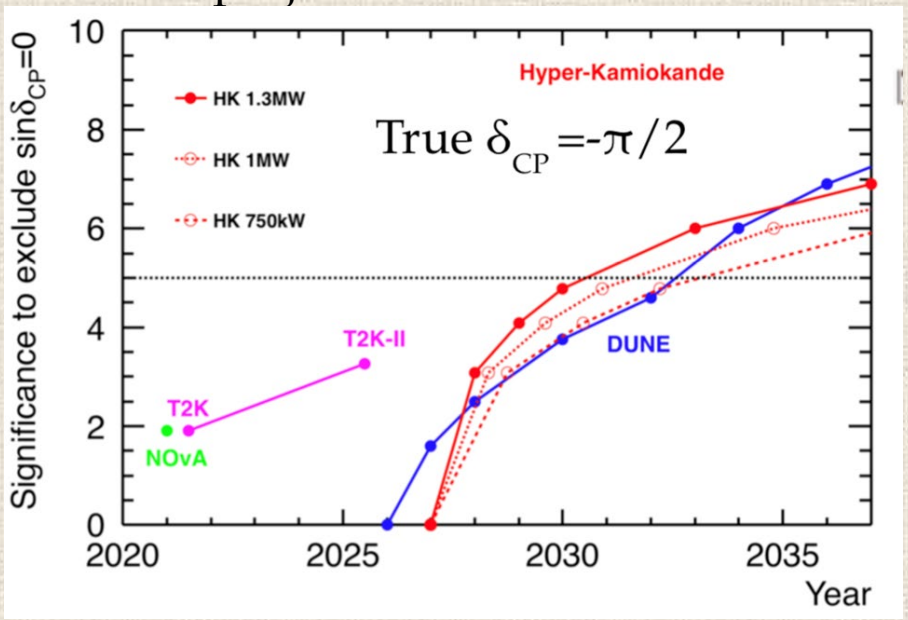
A mismatch in the determination of the standard CP-phase δCP extracted by the two experiments. NOvA prefers values close to δCP ~ 0.8π, T2K δCP ~ 1.4π. Existence of complex neutral-current non-standard interactions (NSI) ?



- Clear tension with T2K's preferred region.
- Quantifying consistency requires a joint fit of the data from the two experiments, which is already in the works.
  - Semi-annual workshops, regular joint group meetings, and a signed joint agreement.

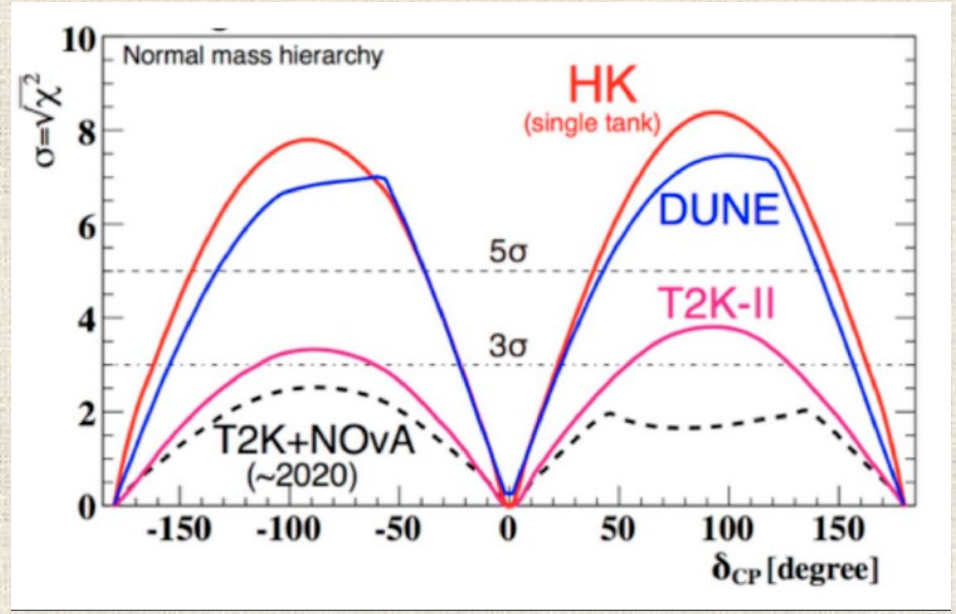
T2K-II

- Upgrade of J-PARC Main Ring (1.3 MW beam)
  - Approved and funded, will be done by 2022
- Goal: collect >10×10^{21} POT by 2026 → 3σ measurement of CP violation if $\delta_{CP}\sim-\pi/2$
- Near Detector upgrade to reduce systematics from ~7% to ~4%
  - Installation the new detectors in 2022
  - Use the ND280 Upgrade detector also as initial Near Detector for Hyper-Kamiokande
  - Strong involvement of the JINR group
- Improvements of the Far Detector thanks to the SK-Gd project

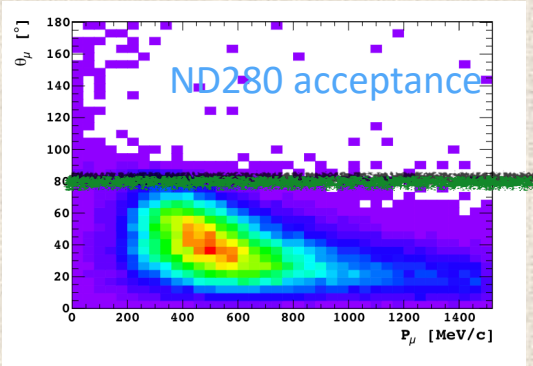


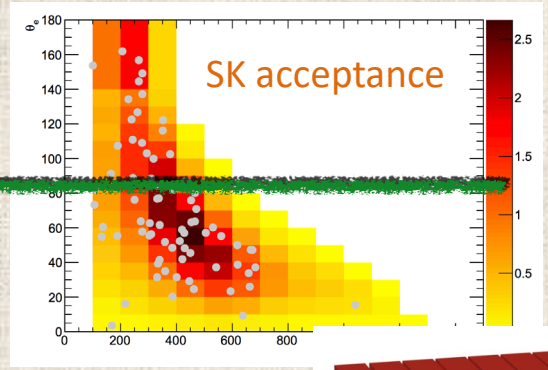
Hyper-Kamiokande

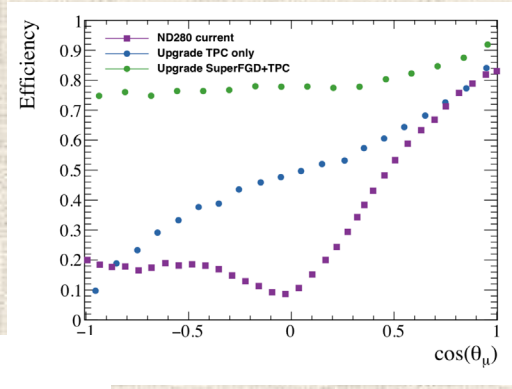
- Exclusion of $\delta_{CP}=0$
  - 8σ for $\delta_{CP}\sim\pm\pi/2$
  - >3σ (5σ) significance for 76% (57%) of δ_{CP} space
- Sensitivity will be further enhanced by combination with atmospheric neutrino measurements
- Assume systematics uncertainties of ~4% (currently 7% for T2K)



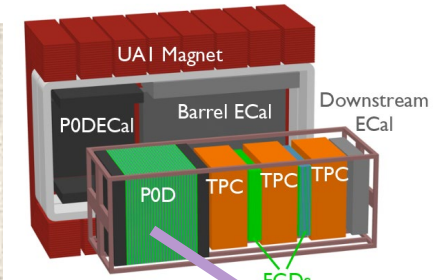
ND280 upgrade

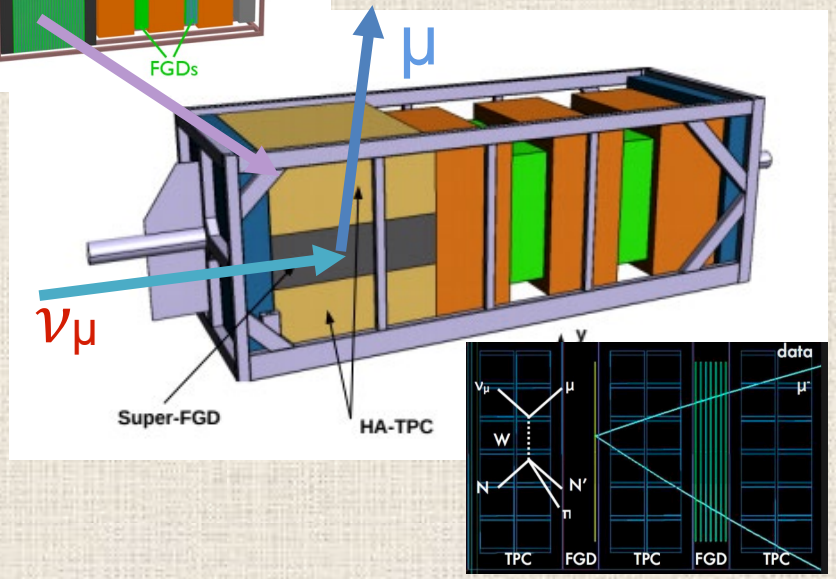






- Main strength of ND280 : magnetized detector → separate ν from $\bar{\nu}$ (cannot be done in SK or HK)
- Main limitation of ND280 : reduced angular acceptance → only forward going tracks are reconstructed with high efficiency
- An analysis dedicated to select tracks with high polar angles → 20% efficiency
- We can do better with an upgrade → Horizontal target and horizontal TPCs
- + Efficiently detect charged particles at any angle
- + The reduction of the protons threshold
- + Measure neutrons in antineutrino interactions
- + As a result, reduce the systematic error from 6 to 4% when counting electronic antineutrinos



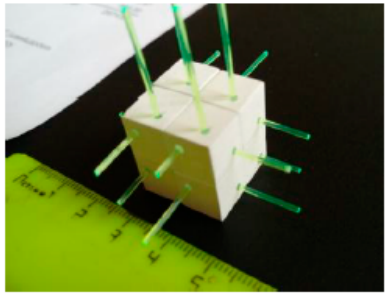


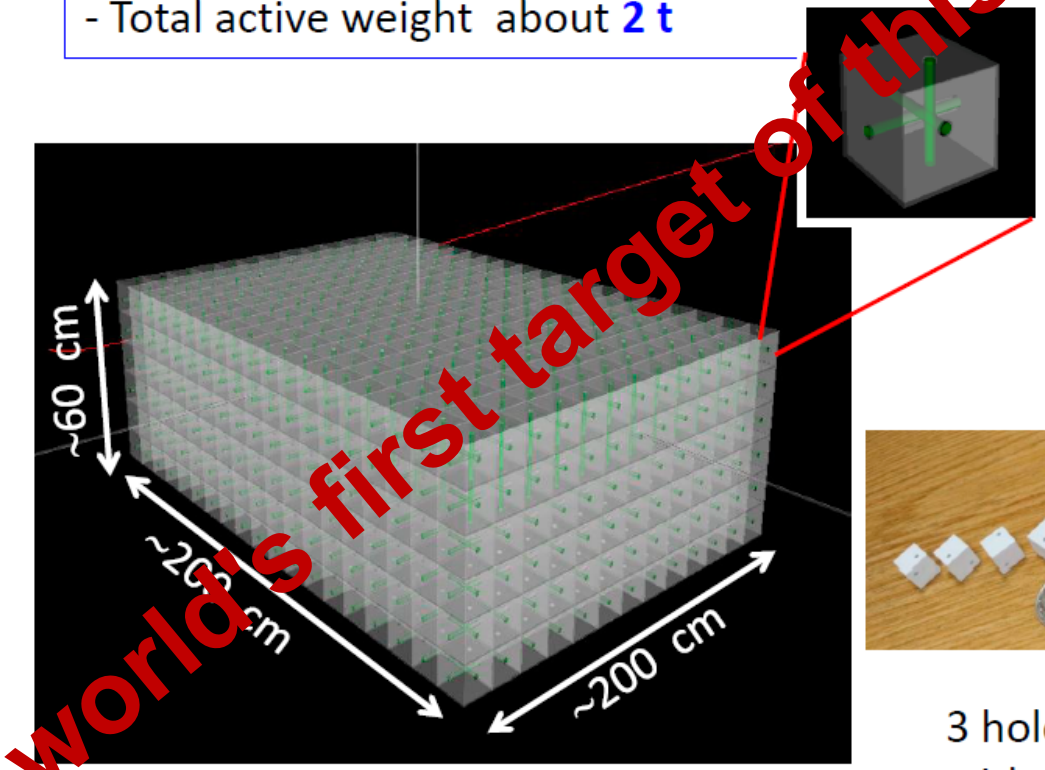
SuperFGD

JINST 13 (2018) 02006

- Volume ~200 x 200 x 60 cm^3
- **~2 x 10^6** scintillator cubes , each 1 x 1 x 1 cm^3
- Each cube has orthogonal 3 holes, diameter 1.5 mm
- 3D (x,y,z) WLS readout
- About **60000** readout WLS/MPPC channels
- Total active weight about **2 t**

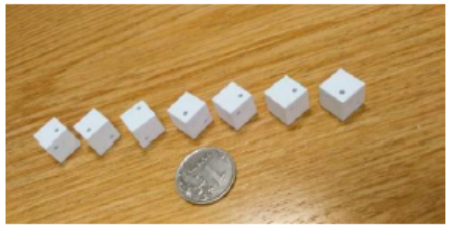
Fully active, highly granular, 4π scintillator neutrino detector with 3D WLS/MPPC readout

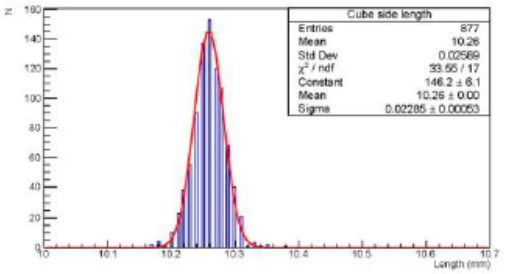




the world's first target of this type

Cubes produced by injection molding
Covered by chemical reflector
Tolerance (each side) about 30 microns

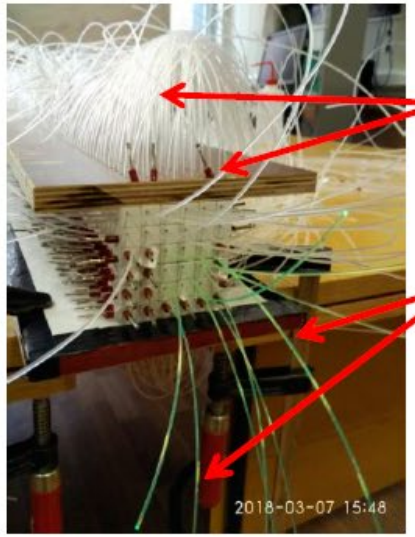




3 holes in each cube drilled
with the tolerance of 50-70 microns

Assembly procedure

Baseline method: 1- assembly of planes and whole detector using fishing lines
2 - replacement of fishing lines by WLS fibers

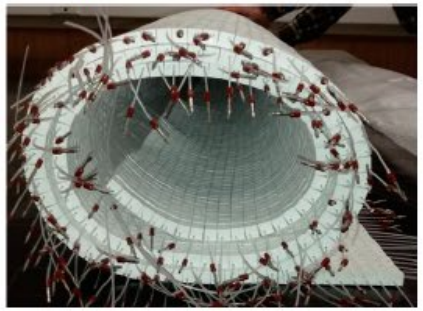


Fishing lines

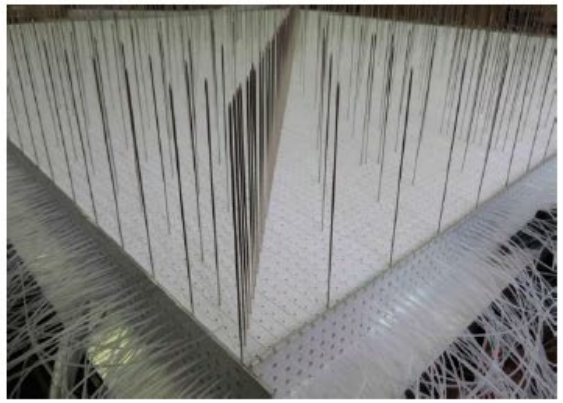
Y11 WLS fibers

Method was tested with small prototypes

Swiss roll made of a plane of cubes



Four panes assembled with fishing lines and stainless steel needles



Strong JINR participation in T2K

- Study of the secondary particle yields from graphite target (replica target at CERN) Improving neutrino flux uncertainty down to to ~5% and further
- Participation in the simulation and data analysis to reduce systematic uncertainties for T2K-II data down to to ~4%. Taking part in oscillation analysis and heavy neutrinos searches.
- SFGD box design (alternative variant) Special NOTE uploaded
- Design of the SFGD assembly platform and tooling for assembling, seismic study. Special NOTEs uploaded
- Development of the electronics for LED calibration system
- Study of the cubes parameters

JAPAN PROTON ACCELERATOR RESEARCH COMPLEX
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March 2021

Prof. Grigory V. Trubnikov
Director of JINR
6 Joliot-Curie St.
141980 Dubna, Moscow Region
Russia

Dear Prof. Grigory Trubnikov,

I am writing to express our deep respects for the achievements of the group from JINR, led by Dr. V. Glagolev and Dr. Yu. Davydov, in the upgrade of the near detector ND280 of the T2K experiment. We acknowlege the members of the group have great experience in renowned experiments such as CDF, ATLAS. Thanks to their efforts, together with colleagues from INR (Moscow), the creation of a unique SuperFGD target of a new type becomes a reality. The JINR colleagues make a significant contribution to the development of engineering tools and procedures for target assembly, calibration and testing of properties of target elements.

We hope that you and JINR PAC will strongly support the further participation of the JINR group in T2K-II and in the approved Japanese and worldwide leadership Hyper-Kamiokande experiment. We expect that JINR scientists will make a great contribution to data analysis, electronics, DAQ and the construction of the Hyper-Kamiokande detector.

We are looking forward to fruitful scientific results and strengthening scientific cooperation between J-PARC and JINR.

Sincerely Yours,
Director of J-PARC Center
Naohito SAITO

CC:
Dr. Viktor Matveev
Dr. Vadim Bednyakov
Dr. Vladimir Glagolev

Strong contribution of the JINR engineers

- **The SuperFGD assemble platform is developed**
- **Reliability calculations of the assembly platform for the static load and seismic stresses demonstrate that the structure has a good safety margin.**
- **SuperFGD assemble procedure is under development**

1. Platform for the SFGD assembly. Manual
2. Note to the technical project
3. Calculations. Statics (Reliability calculation. Part I)
4. Calculations. Seismic (Reliability calculation. Part II)
5. SFGD Detector Assembly Procedure

T2K UPGRADE

Platform for assembling and maintaining of the SFGD detector

24.04.2021

A. Shaikovskiy

Platform SFGD

Manual

Joint Institute for Nuclear Research

T2K UPGRADE

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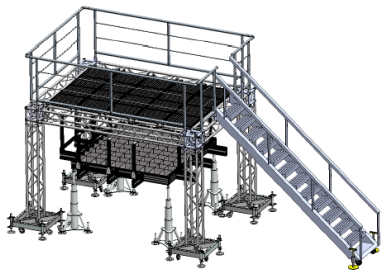
04.2021

Shaikovskiy, A. Sinitsa, A. Brazhnikov

Note to the technical project



«Platform SFGD»

Joint Institute for Nuclear Research

T2K UPGRADE

Platform for assembling and maintaining of the SFGD detector

24.04.2021

A. Shaikovskiy, N. Kirichkov

Calculations. Statics

Reliability calculation

part I

«Platform SFGD»

Joint Institute for Nuclear Research

T2K UPGRADE

Platform for assembling and maintaining of the SFGD detector

28.04.2021

A. Shaikovskiy, N. Kirichkov

Calculations. Seismic

Reliability calculation

part II

«Platform SFGD»

Joint Institute for Nuclear Research

T2K UPGRADE

Platform for assembling and maintaining of the SFGD detector

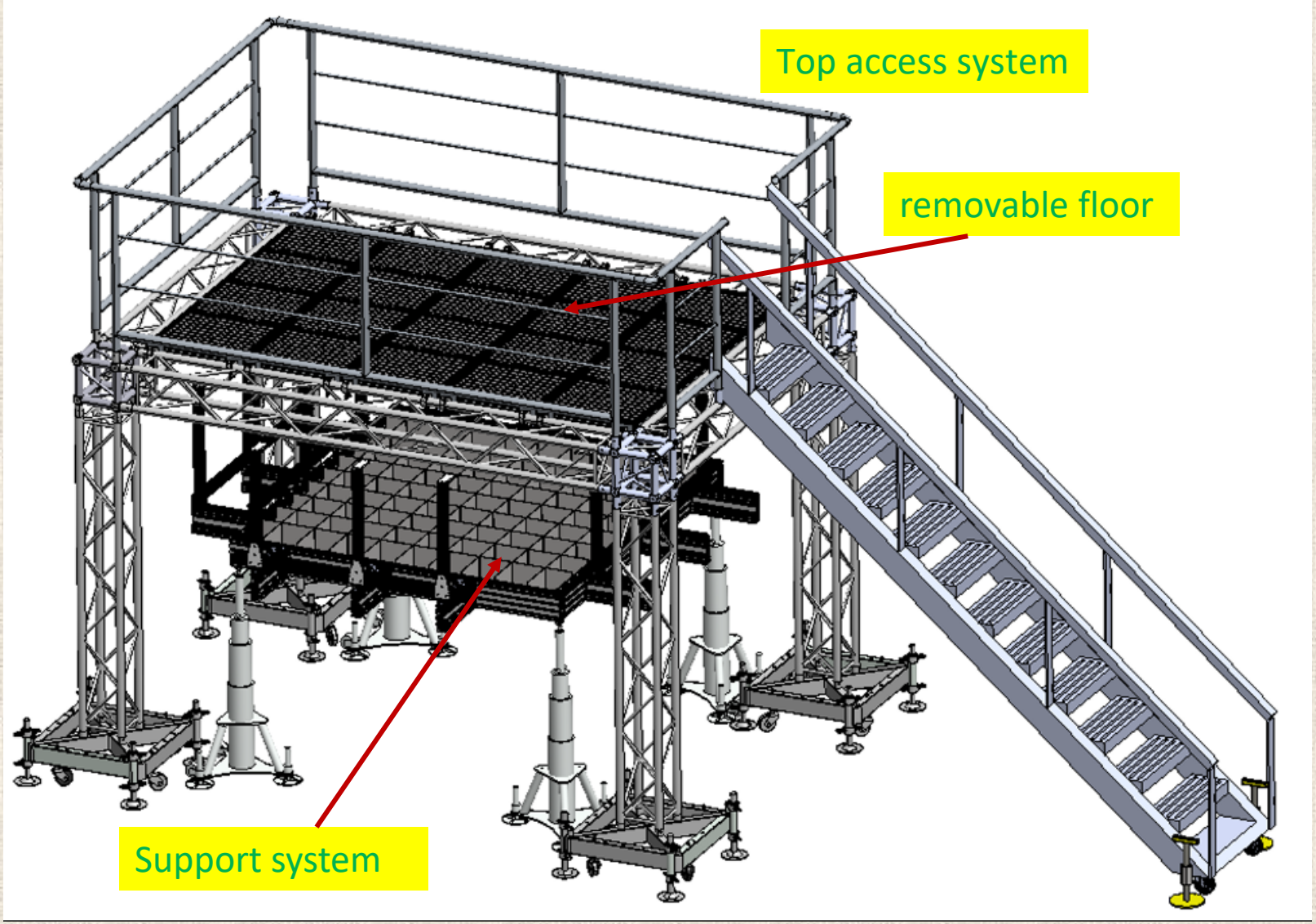
SFGD Detector

Assembly Procedure

Joint Institute for Nuclear Research

The assembly platform

consists of two parts: the top access system and the support system



The height of the top access system for the detector assembly is (**2.3** ± 0.1) m or (**2.6** ± 0.1) m, depending on the installation level of the removable floor frames -> "**Heavy works** " @J-PARC.
It can be reduced to (1.3 ± 0.1) m or (1.6 ± 0.1) m.
Only **two people** can work at the top access system.
|
The support system is used as a base for installing the cube layers inside the mechanical box. The lifting height of the detector is from (1.20 ± 0.05) m to (1.40 ± 0.05) m. It can be set from (0.50 ± 0.05) m to (0.60 ± 0.05) m.

Reliability calculations

Static seismic cases

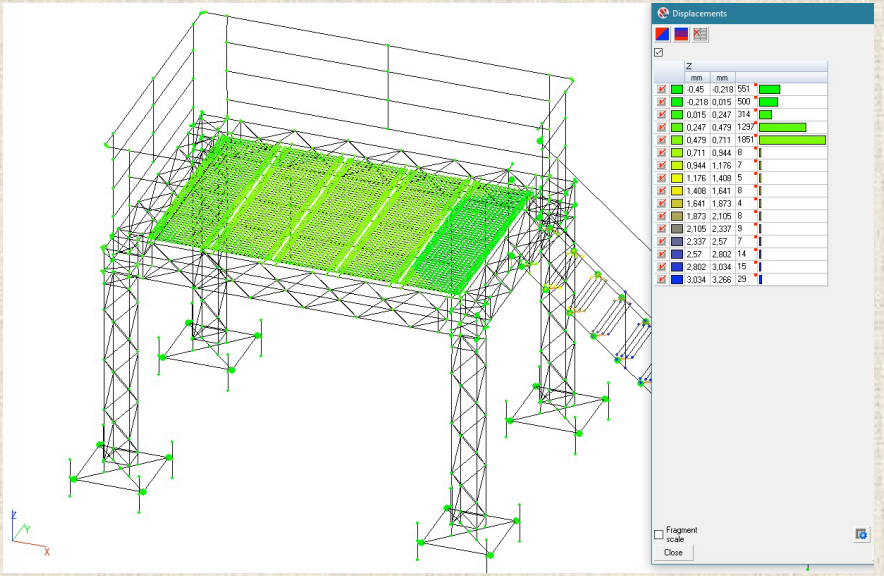
- Top access system: 4627 nodes; 8659 elements; own weight (650 kg) + 2 people (200 kg)
- Support system: 1298 nodes; 2368 elements; own weight (600 kg) + detector&box (3000 kg)

- A measure of the deformation criticality:

KMAX = current stresses/maximal allowable stress for the material

0.50 - 0.79 – optimal value;👍

1.00 or higher – unacceptable stress level, potential failure



Max deformations along the Z axis (vertical)

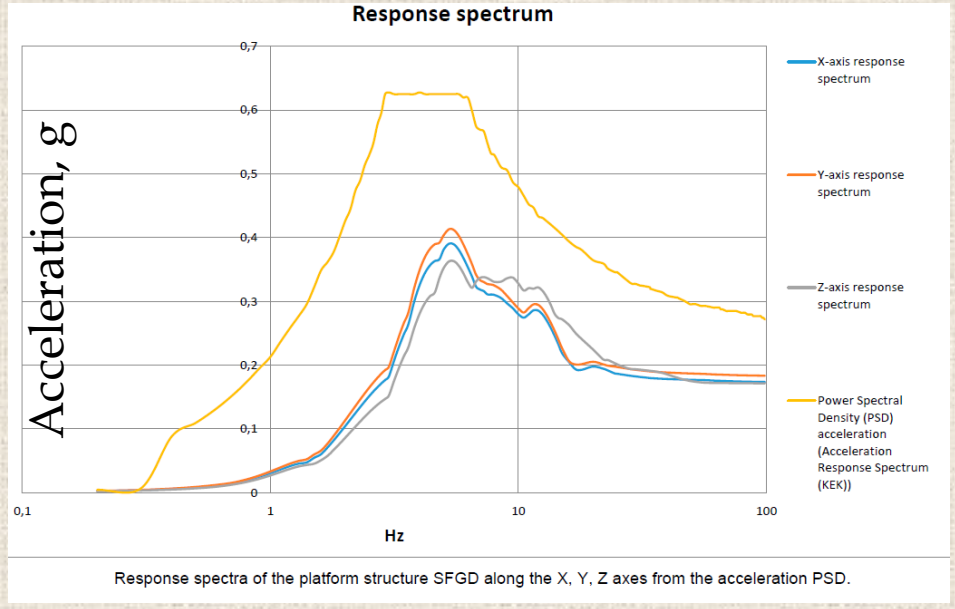
top access system

KMAX = 0.53 – **optimal**👍

support system

Kmax = 0.617 – **optimal**👍

The acceleration spectrum caused by earthquakes was provided by KEK/J-PARC



Response spectra of the platform structure SFGD along the X, Y, Z axes from the acceleration PSD.

Reliability calculations of the assembly platform for the static load and seismic stresses demonstrate that **the structure has a good safety margin**.

SuperFGD assembly procedure

Cube production and assembly" subgroup is created
Conveners Yu. Dadydov (JINR), M. Khabibullin (INR)
Unique target assembly procedure is under developing

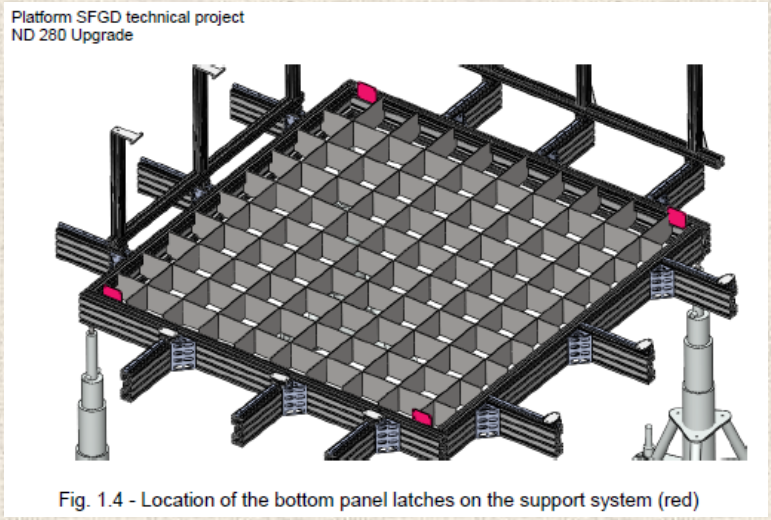


Fig. 1.4 - Location of the bottom panel latches on the support system (red)

Support system (grid)

The procedure in general:
1.Installing the bottom & first two side panels of the box
2.Installing the cube layers
3.Installing two other side & top panels

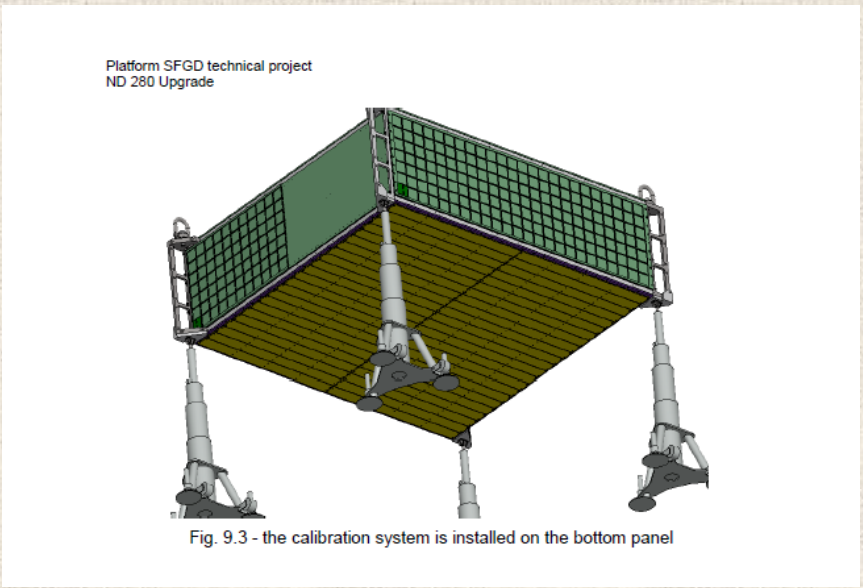


Fig. 9.3 - the calibration system is installed on the bottom panel

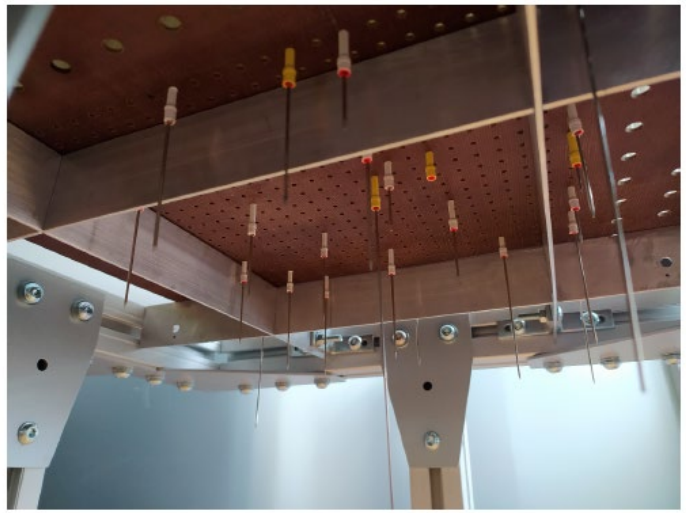
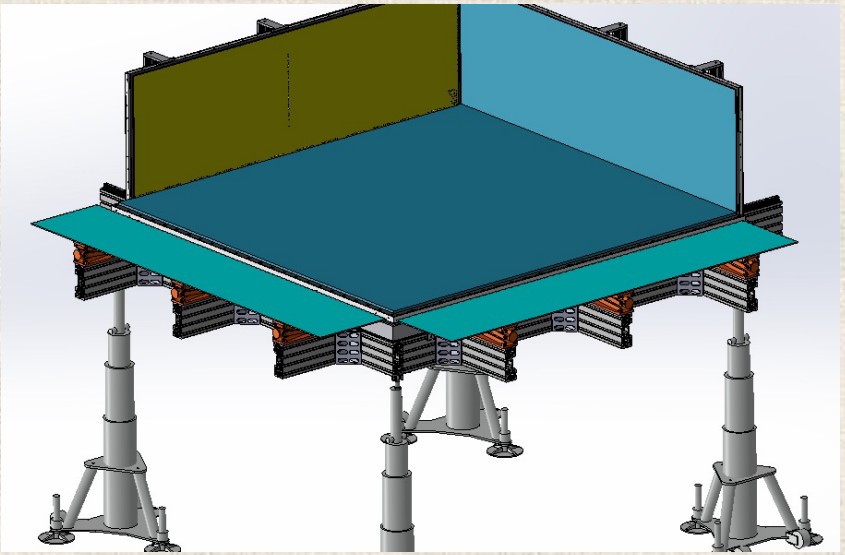


Fig. 3.2 - installing the spoke locks

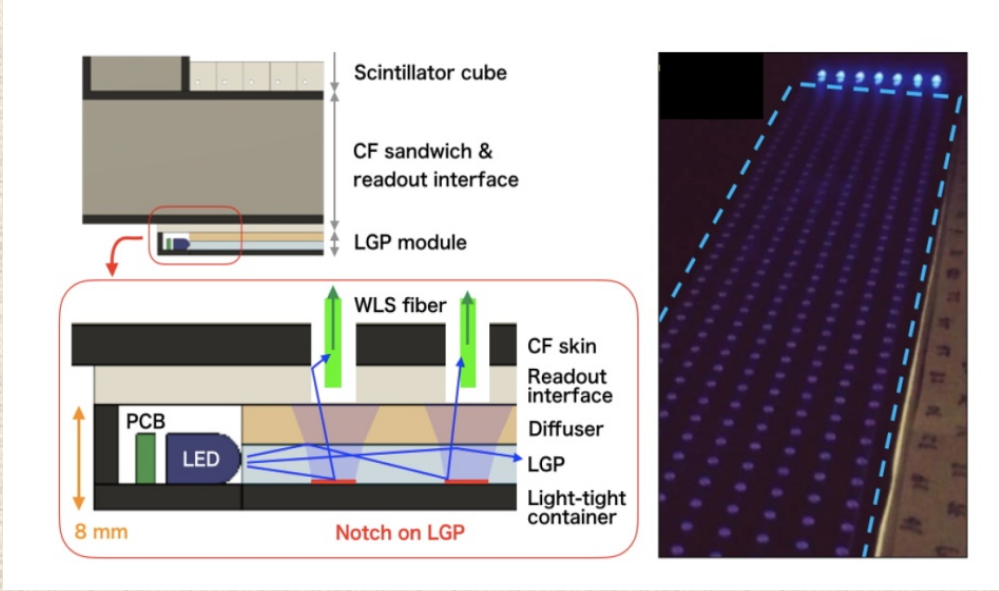
Spokes locks at the Dubna moskup

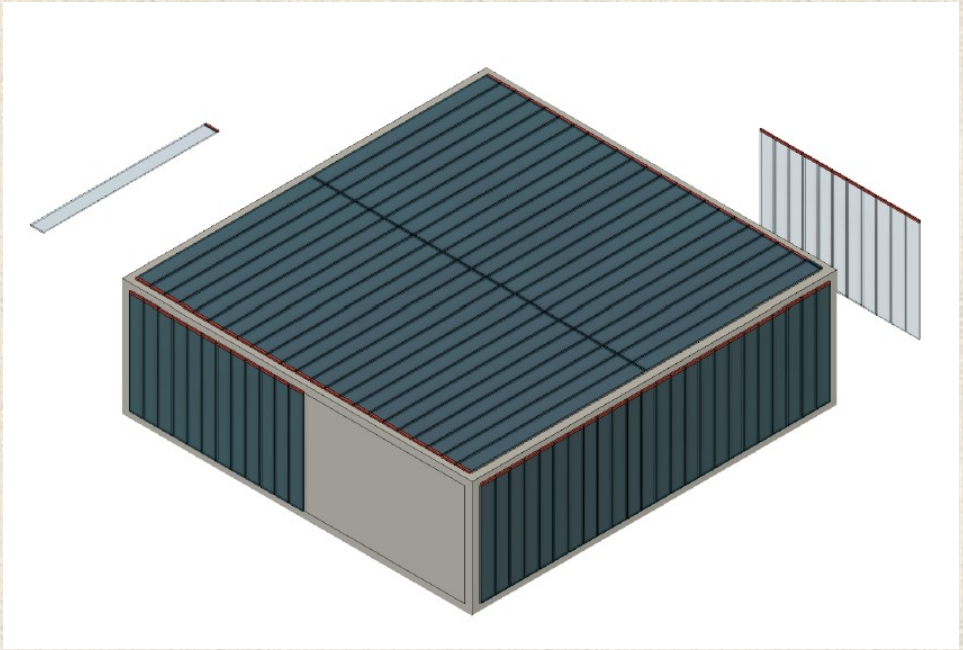


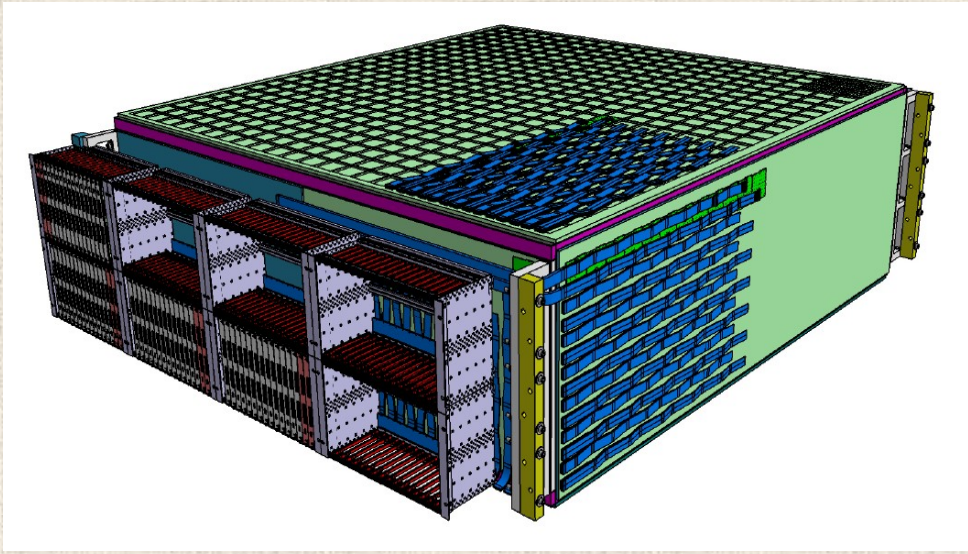
Install two *additional* panels to extend the area (for cube layers)

JINR contribution to the calibration system of SFGD

LNP develops electronics for the SFGD calibration system. The Figures show the concept of the calibration system. 93 LGP modules are located around the detector and allow us calibrate all 56k MPPC. Intensity of calibration LED radiation is controlled down to single photons.







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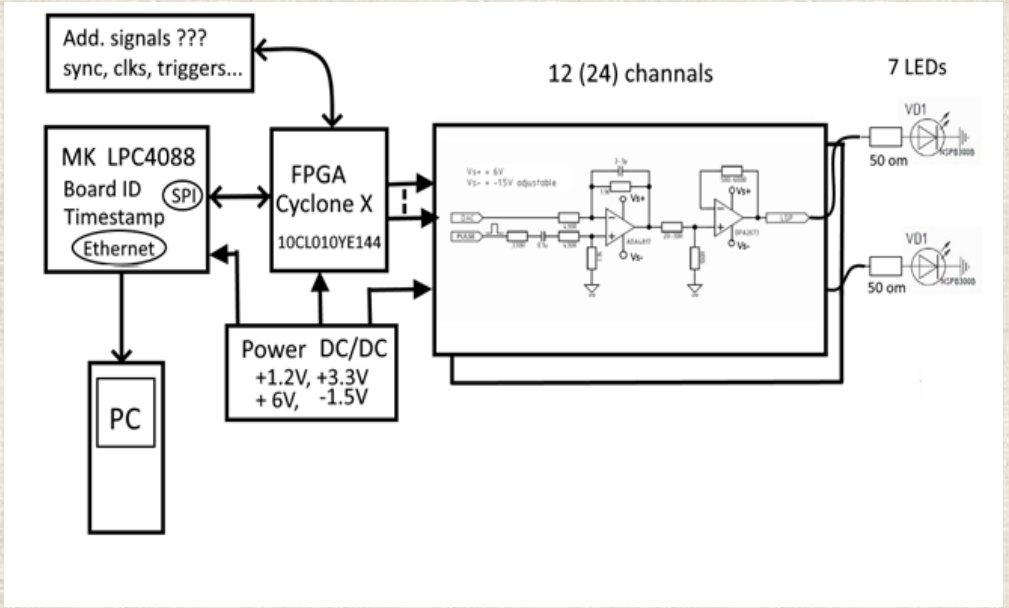
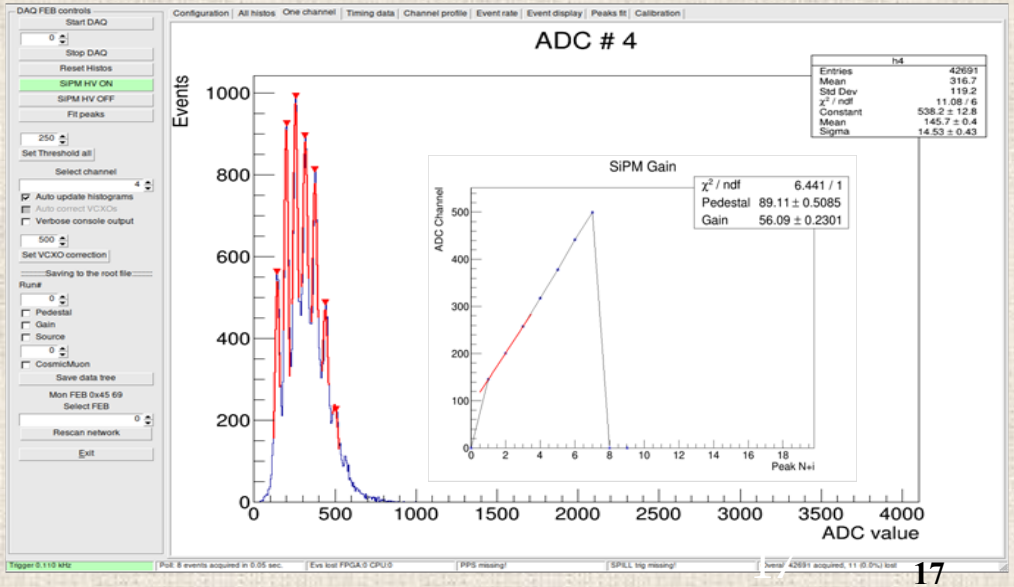
JINR contribution to the calibration system of SFGD

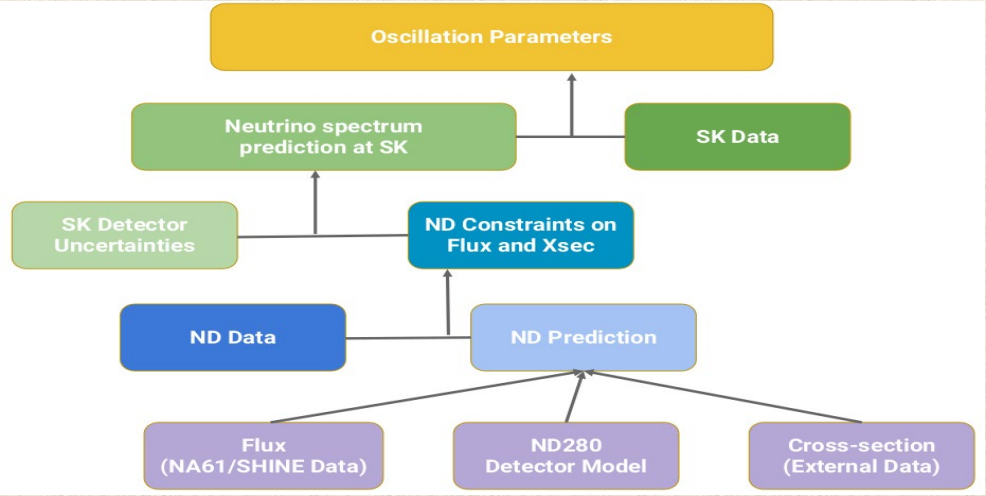
Photo on the left shows a module developed and manufactured in DNLP, which contains 12 channels of SFGD electronics. JINR group is obliged to manufacture 8 such modules up to June 2022.

Upper right picture shows the module's scheme. Lower right picture demonstrates calibration of a single LGP channel with single photons.





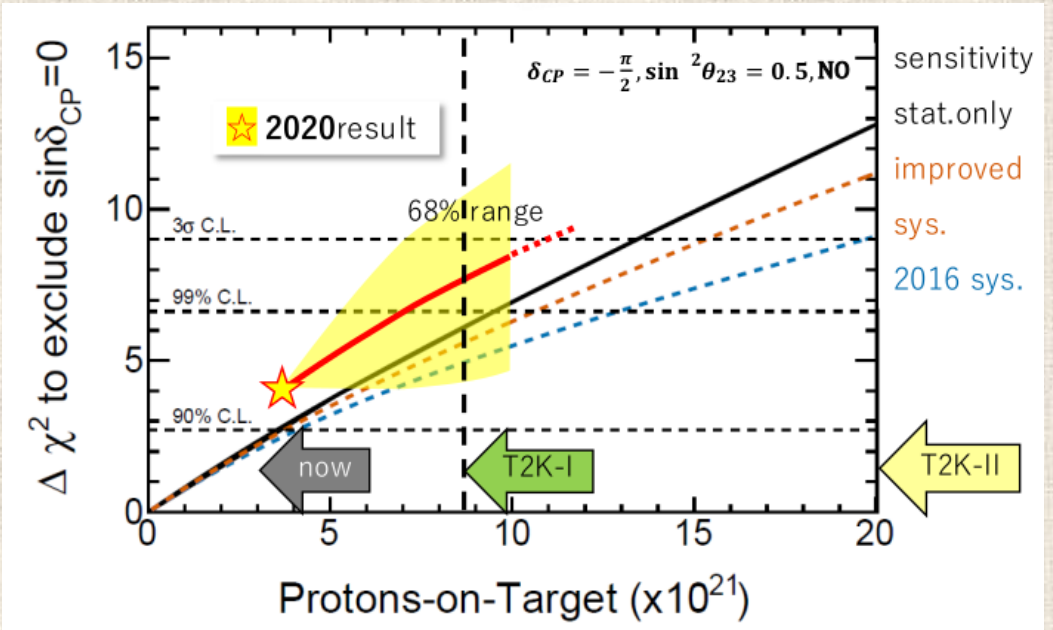
T2K oscillation analysis



- Parameters of interest: δ_{CP}, $sin^2\theta_{23}$, Δm^2_{32} and $sin^2\theta_{13}$
- Neutrino mass hierarchy
- Probing of the consistency of the PMNS framework

OA development in coming years with respect to J-PARC/T2K upgrades

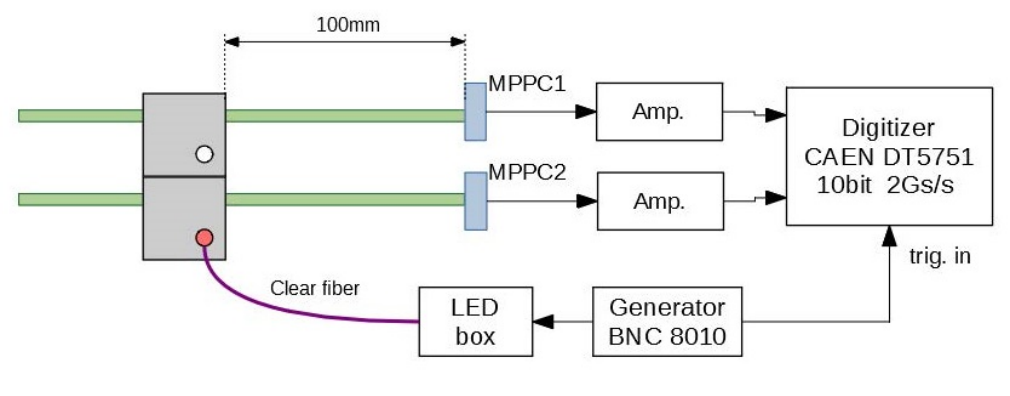
Upgrade	Upgrade property	Effect on OA
J-PARC	Large POT statistics	- Increased statistics - Crucial for moving to analyze the exclusive final states with pions, protons, neutrons; - Multidimensional analysis
SFGD + ToF + HA TPCs	Increased target mass; Improved reconstruction at high and backward angles; 3D tracking, lower proton detection threshold; Neutron kinetic energy measurement	- Sensitivity to larger portion of phase space - Better constraints on cross-sections - Improving systematic uncertainties on nuclear model - Adding new info into analysis
SK-Gd	Neutrons tagging	Adding samples/info at the far detector



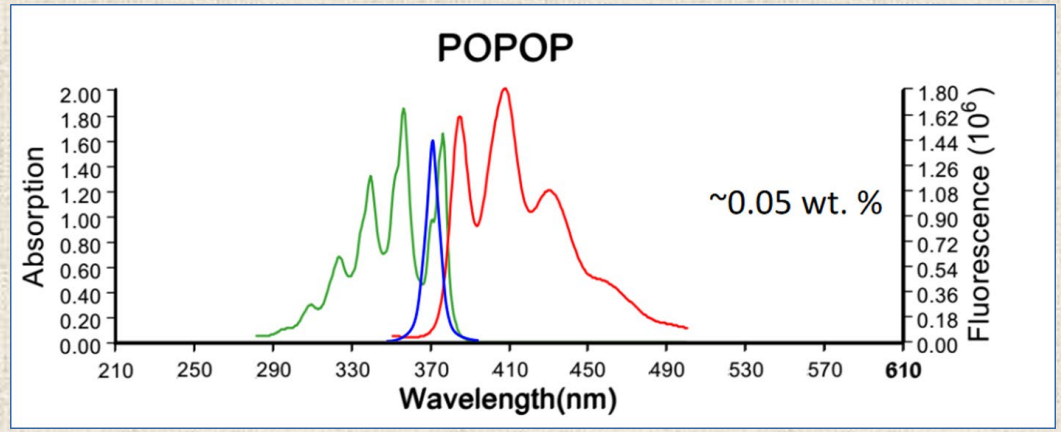
DLNP group participation in T2K analysis

- Started activity in analysis
  - collaborate with INR group
  - do studies on the “momentum by range” systematics in ECAL and SMRD
- Plan to participate in:
  - developing software tools for analysis for the upgraded ND280 detector
  - analyzing new data obtained with the upgraded ND280 detector;
  - developing event selection methods;
  - performing studies on various types of systematic uncertainties;
- In addition to our activity in oscillation analysis we plan to search for heavy neutrinos with the near detector ND280 of the T2K experiment. Heavy Neutral Leptons (HNLs, heavy neutrinos) with masses below the electroweak scale are considered in some extensions of the Standard Model (e.g. vMSM) in order to address the open questions: neutrino oscillations, dark matter and baryon asymmetry. T2K analysis searches for heavy neutrinos in the mass range of 140<M_HNL<493 MeV/c^2 and limits obtained are competitive with those of previous experiments such as PS191, E949 and CHARM, especially in the high-mass region (above 300 MeV/c2). As the analysis is still statistically limited, T2K results are expected to further improve by a factor of 2-3 with T2K data up to 2026.

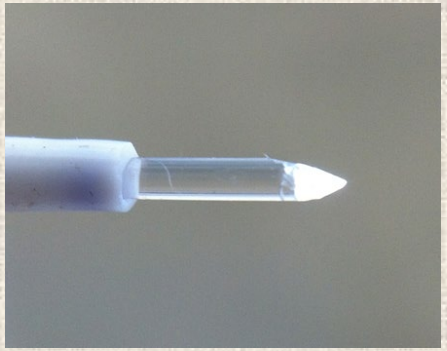
SFGD cubes optical cross talk study using a LED excitation

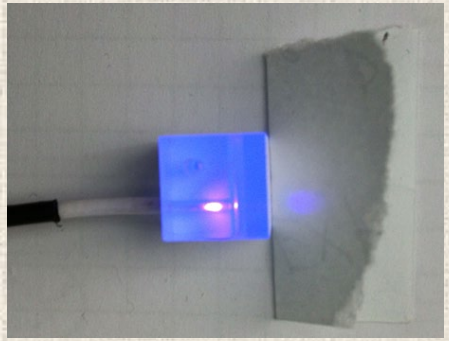


LED370E wavelength spectrum is peaked around of 375 nm



We have developed a way to study optical light leakage between cubes using LEDs, which provides a fast and reliable way to control light leakage through the surfaces of the cubes.

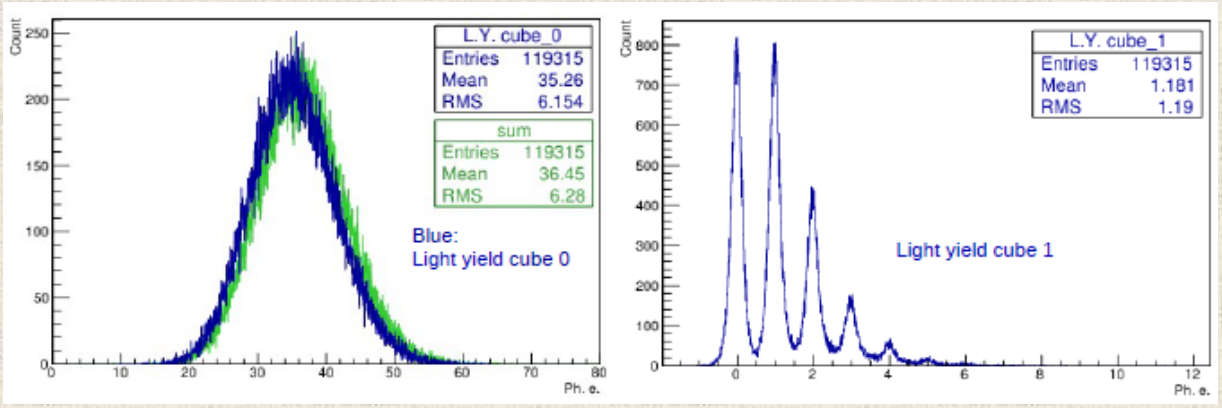




Fiber to illuminate the cubes with a LED light

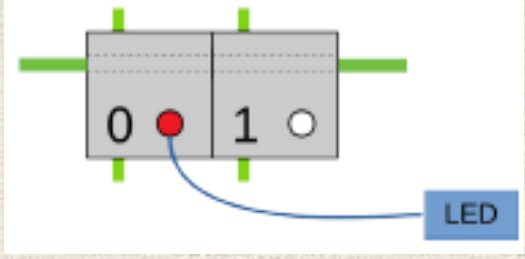
WLS fibers: 1 mm diameter, open far end
SiPM: Hamamatsu S13360-1350CS 1.3x1.3 mm^2

Cubes optical cross talk measurements

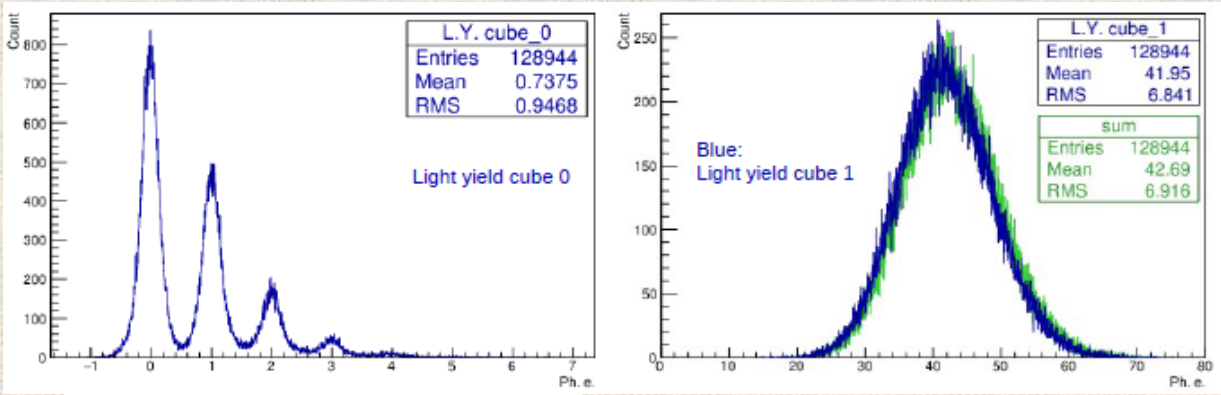


Spectra of signals from cubes, obtained when the cube "0" is illuminated. The left spectrum shows the signal from the illuminated cube "0", and the right one - the signal from the cube "1" due to the light leak from the cube "0".

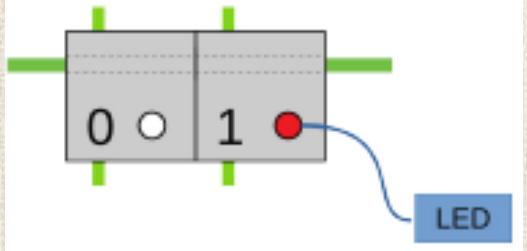
Light leak through one side wall is about 3.3%, it coincides with the data obtained by our colleagues in measurements on accelerators.



$$\frac{\overline{L.Y.}\,cube\,1}{\overline{L.Y.}\,cube\,0}=0.0335$$



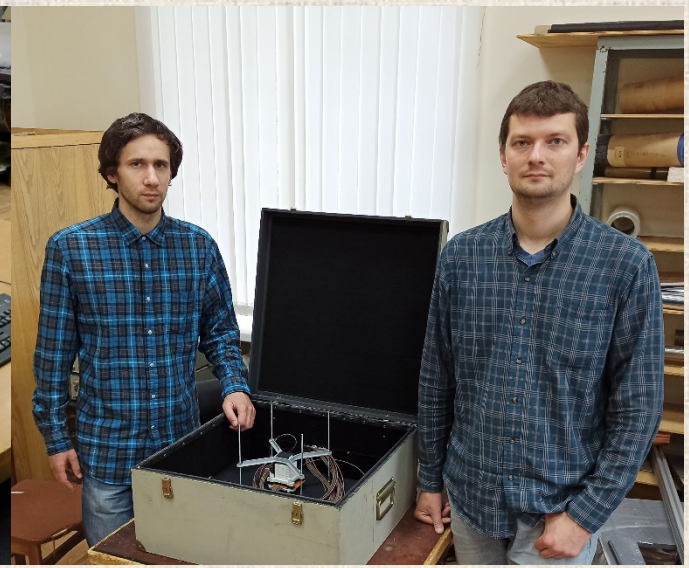
In the case of illumination of cube "1" light leakage into cube "0" is noticeably less and the ratio of the signal in the cube "0" to the signal in the cube "1" is 1.8 % . This is due to the different distance from the illumination spot to the cubes boundary walls.

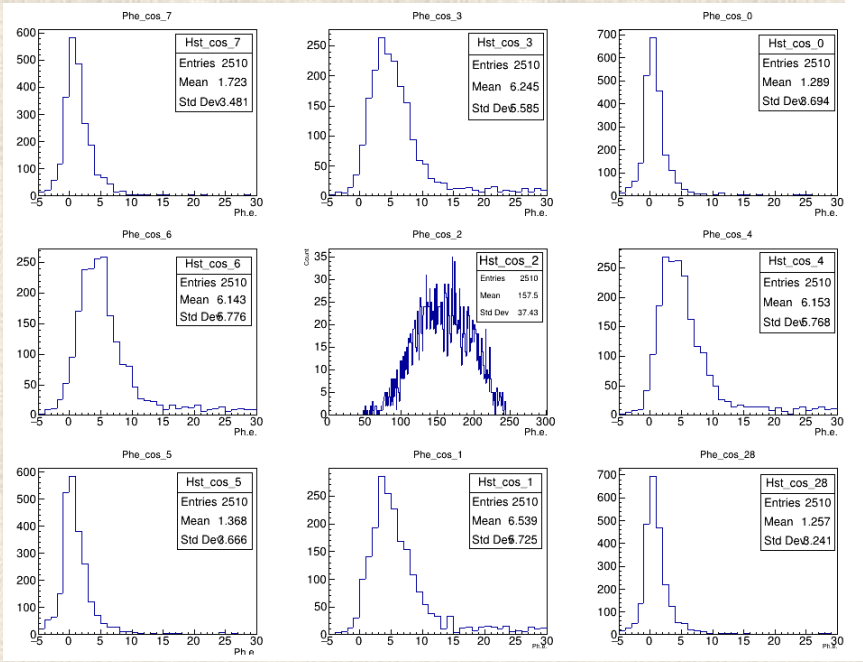


$$\frac{\overline{L.Y.}\,cube\,0}{\overline{L.Y.}\,cube\,1}=0.0176$$

This effect can be used to increase the "spatial" sensitivity when reconstructing tracks of charged particles.

3x3x3 cubes prototype measurements





3x3x3 cubes matrix tests on cosmic muons

Signals from cubes from the central column and cross talk on adjacent columns when cosmic muons pass vertically through the central column

We plan to study the possibility of improving the accuracy of reconstructing the tracks of charged particles in the SFGD taking into account the optical cross talk in adjacent channels. To do this, it is necessary to develop an algorithm to take into account cross talk in cubes.

To test this technique on cosmic muons and on accelerator beams, it is planned to create a prototype detector with a size of about 5x5x10 cubes.

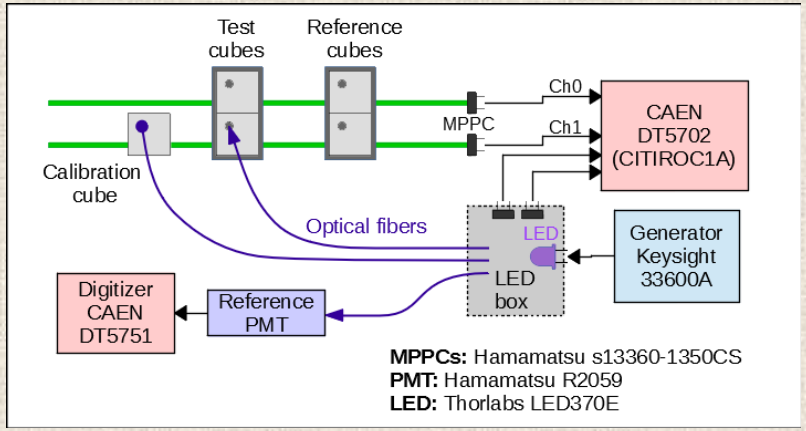
Heating influence on the light yield and crosstalk of the cubes

We want to check how temperature treatment, for example, heating of the transportation container during the transportation of the detector from INR to J-PARC could affect on the scintillating properties of the cubes and on the reflecting coating and consequently crosstalk.

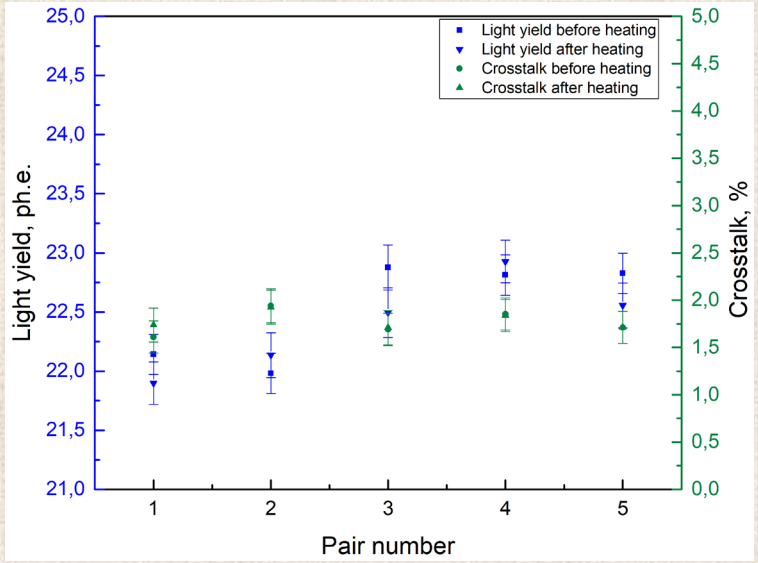
Using the UV LED (λ≈375 nm) light injection into the cubes we can measure the light yield and crosstalk of the cubes before and after heating and compare the results.

Heating of the cubes we are going to do using the industrial thermostabilized chamber.

We have tested 5 pairs of cubes, measured their light yield and crosstalk before and after heating. We put it to the thermostabilized chamber and kept under 60 °C for 24 hours, and then allowed them cool to room temperature for 20 hours before measuring.



The light yield and crosstalk did not change significantly after heating



Plans of the JINR group

- Finalize design of the SFGD assembly platform (2021)
- Participation in the assembling of the SFGD (2022-2023)
- Participation in the creation of the LED calibration system for SFGD (2021-2022)
- Possible participation in the DAQ of the SFGD (2022-2023)
- Participation in the start-up and maintenance of the SFGD during data taking (2022-2024…)
- Participation in the simulation and data analysis SFGD and T2K in perspective (2022-2024…)
- Participation in the HYPER-KAMIOKANDE in the perspective (HK outer detector, data analysis)

Estimation of human resources

Name	FTE	Positon	Work (apart common duties like shifts)
V.Yu. Baranov	1.0	Junior researcher	SuperFGD cube tests
A.V. Boikov	1.0	engineer	SuperFGD calibration system
A.O. Brazhnikov	0.3	design engineer	platform and tooling for SFGD assembly
J.A. Budagov	0.2	Chief researcher	SuperFGD
Yu.I. Davydov	0.9	Head of department	SuperFGD assemble group leader
D.L. Demin	0.3	Head of sector	Tests at DLNP Linak-200
V.V. Glagolev	0.6	DLNP Deputy director	SuperFGD
N.V. Khomutov	0.3	scientist	Firmware development
N.V. Kirichkov	0.3	head of the design department	platform and tooling for SFGD assembly
V.I. Kiseeva	1.0	Young researcher	Monte Carlo, data analyses
A.O. Kolesnikov	0.8	Senior engineer	SuperFGD tests
A.V. Krasnoperov	0.3	scientist	Software support
K.K. Limarev	1.0	PhD student	Monte Carlo, data analyses
V.L. Malyshev	0.5	scientist	SuperFGD tests
B.A. Popov	1.0	Senior scientist	Data analyses
A.V. Shaikovskiy	0.7	design engineer category 1	platform and tooling for SFGD assembly
A.A. Sinitsa	0.4	design engineer category 2	platform and tooling for SFGD assembly
I.A. Suslov	1.0	Senior scientist	Monte Carlo, data analyses
V.V. Tereschenko	0.8	Head of group	SuperFGD calibration system
S.V. Tereschenko	0.6	Engineer	SuperFGD calibration system
I.I. Vasilyev	1.0	Junior researcher	SuperFGD cube tests
Total FTE	**14.0**		

Young JINR colleagues

49% FTE

SWOT ANALYSIS

STRENGTHS	WEAKNESS
Hyper-Kamiokande is successor of the Super-Kamiokande with the same near detectors and well tested technologies. Possible to be first in CP violation measurement or CP-parity violation detection	The mass hierarchy could be determined not at the T2K alone but combining the future data coming from the ongoing experiments such as NOvA, T2K and reactor experiments.
OPPORTUNITIES	THREATS
Cosmic Neutrino Observation (Solar, Supernova, Relic), Dark Matter Search Proton decay Searches Search for heavy neutrinos with the T2K near detector ND280	Possible delay in implementation due to the pandemic.

Tasks and resources

	2022	2023	2024
Simulation and data analysis	Improvement of T2K (anti) neutrino flux uncertainty down to 3-4%. Adapting and developing T2K analysis method with respect of upgraded ND280 detector. $ 8 k	T2K data analysis $ 10 k	T2K data analysis $ 10k
SuperFGD mechanics. Finalize design of the SuperFGD assembly platform.	Assembling of the SuperFGD	Hyper-Kamiokande Outer detector PMT support system design	Hyper-Kamiokande Outer detector PMT support system design
RnD for detector subsystems. SuperFGD properties investigations.	Assembling and start-up of the SuperFGD at near detector facility. Study of the SuperFGD properties. RnD with PMT samples and shifters for Hyper-Kamiokande Outer detector. Materials $ 20 k (scintillators, fibers) Equipment $ 32 k (PMT's, elect. blocks, stand computer)	RnD with PMT samples and shifters for Hyper-Kamiokande Outer detector. Materials $ 20 k (shifters, mech. parts) Equipment $ 30 k (PMT's, elect. blocks)	RnD with PMT samples and shifters for Hyper-Kamiokande Outer detector. Finalize design of the shifters. Materials $ 15 k (shifters, mech. parts) Equipment $ 30 k (PMT's, elect. blocks)
Electronic for SuperFGD LED calibration design and DAQ	Creation, assembly and start-up of the calibration system. DAQ support of the SuperFGD. Equipment $ 20 k	Development of electronics and DAQ for further upgrade of the ND280 and Hyper-Kamiokande (Outer detector) Equipment $ 15k	Development of electronics and DAQ for further upgrade of the ND280 and Hyper-Kamiokande Equipment $ 10 k
SuperFGD/ND280 maintenance, T2K data taking shifts, meetings, conferences	Participation in the SuperFGD start-up, data taking shifts, meetings $ 85 k	SuperFGD/ND280 maintenance, T2K data taking shifts, meetings, conferences $ 85 k	SuperFGD/ND280 maintenance, T2K data taking shifts, meetings, conferences $ 85 k
Operation fee	$ 25 k	$ 35 k	$ 35 k

Form No. 26

Schedule proposal and resources required for the implementation of the Project

T2K
(Project title)

Expenditures, resources, financing sources			Costs (k$) Resource requirements	Proposals of the Laboratory on the distribution of finances and resources		
				1st year	2nd year	3rd year
Expenditures		Main units of equipment, work towards its upgrade, adjustment etc.	165	60	55	50
		Construction/repair of premises				
		Materials	55	20	20	15
Required resources	Standard hour	Resources of – Laboratory design bureau; – JINR Experimental Workshop; – Laboratory experimental facilities division; – accelerator; – computer. Operating costs.	7000h 600h 420h	3000h 200h 140h	2000h 200h 140h	2000h 200h 140h
Financing sources	Budgetary resources	Budget expenditures including foreign-currency resources.	600 k$	200	205	195
	External resources	Contributions by collaborators. Grants. Contributions by sponsors. Contracts. Other financial resources, etc.	30 10	10 5	10 5	10

PROJECT LEADERS V.V.Glagolev Yu.I.Davydov

Form No. 29

Estimated expenditures for the Project T2K
(full title of Project)

	Expenditure items	Full cost	1st year	2nd year	3rd year…
	Direct expenses for the Project				
1.	Accelerator, reactor	420 h	140	140	140
2.	Computers	h			
3.	Computer connection	k$			
4.	Design bureau	standard	3000	2000	2000
		7000 hour			
5.	Experimental Workshop	standard	200	200	200
		600 hour			
6.	Materials	55 k$	20	20	15
7.	Equipment	165 k$	60	55	50
8.	Construction/repair of premises	k$			
9.	Payments for agreement-based research (operation fee)	95 k$	25	35	35
10.	Travel allowance, including:	k$			
	a) non-rouble zone countries	255	85	85	85
	b) rouble zone countries	30	10	10	10
	c) protocol-based				
	Total direct expenses	600	200	205	195

Thank you for attention