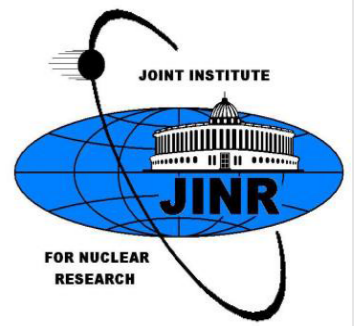




The **CO**herent **M**uon to **E**lectron Transition (**COMET**) experiment



Project

Search for new physics in the charged lepton sector

Project extension for the period 2022-2024

Experiment COMET at the J-PARC

JINR COMET team

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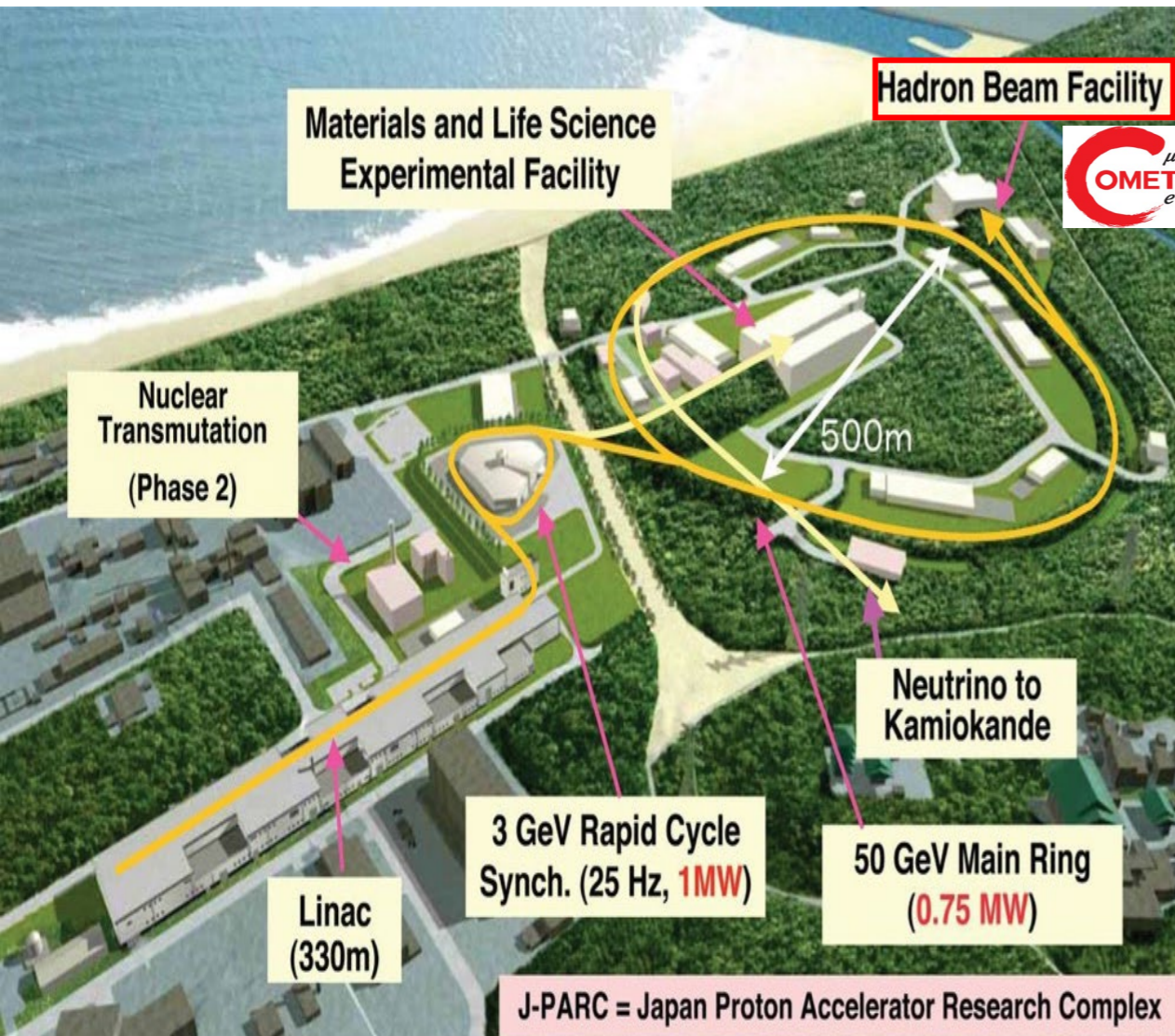
¹Dzhelepov Laboratory of Nuclear Problems (DLNP)

²Veksler and Baldin Laboratory of High Energy Physics (VBLHEP)

³Bogoliubov Laboratory of Theoretical Physics (BLTP)

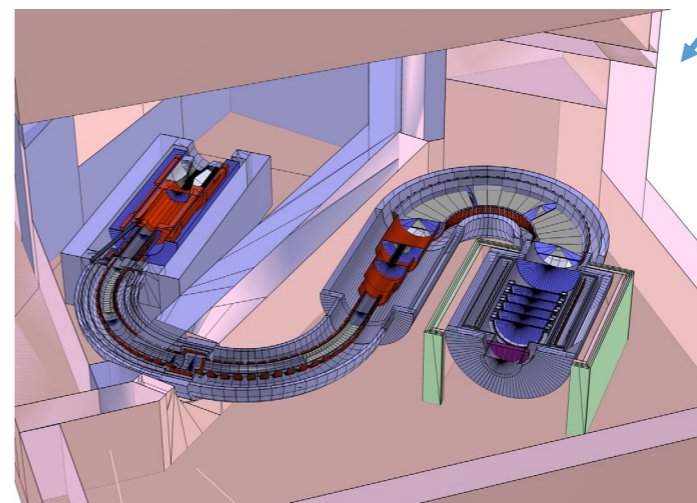
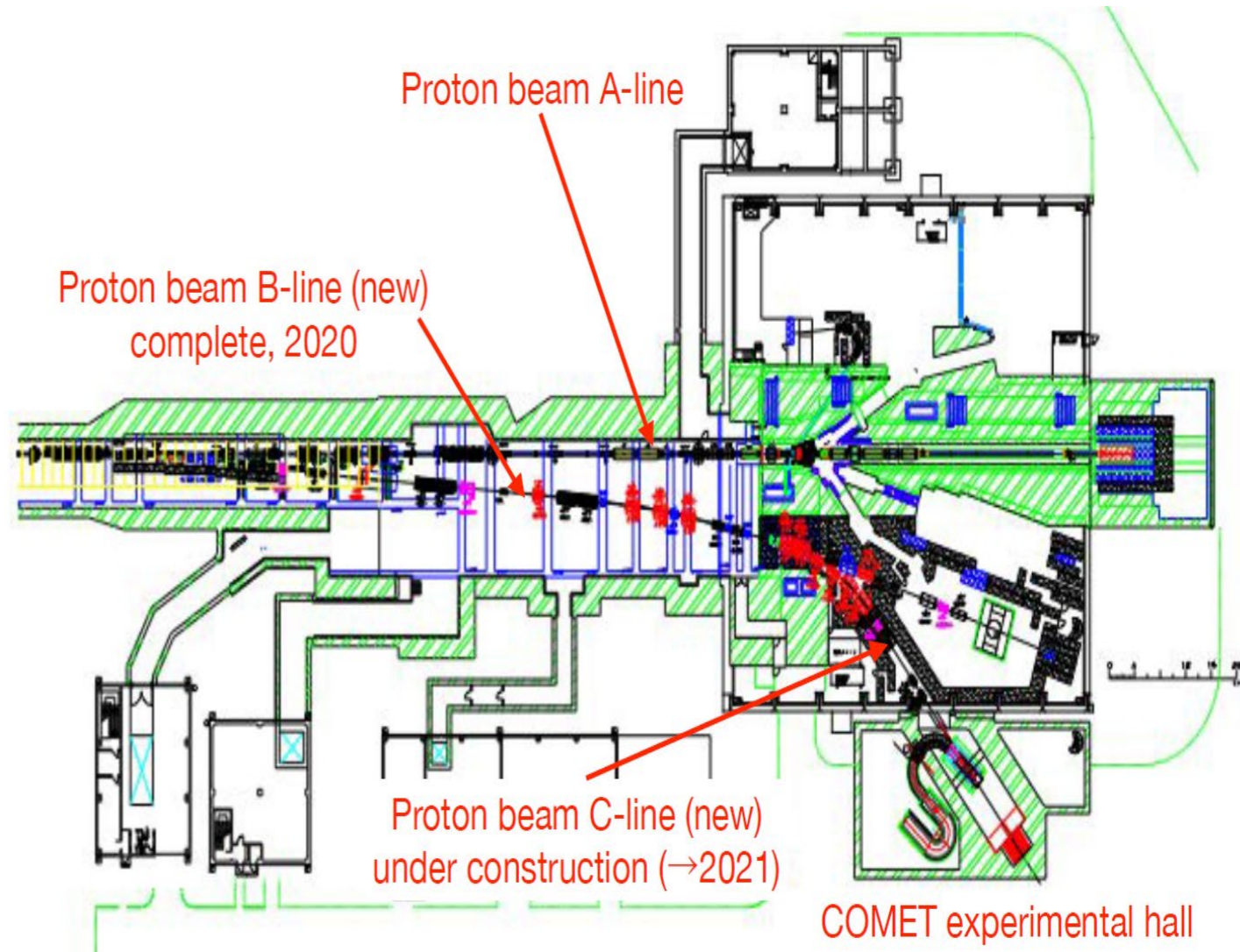
⁴Laboratory of Information Technologies (LIT)

COMET at J-PARC



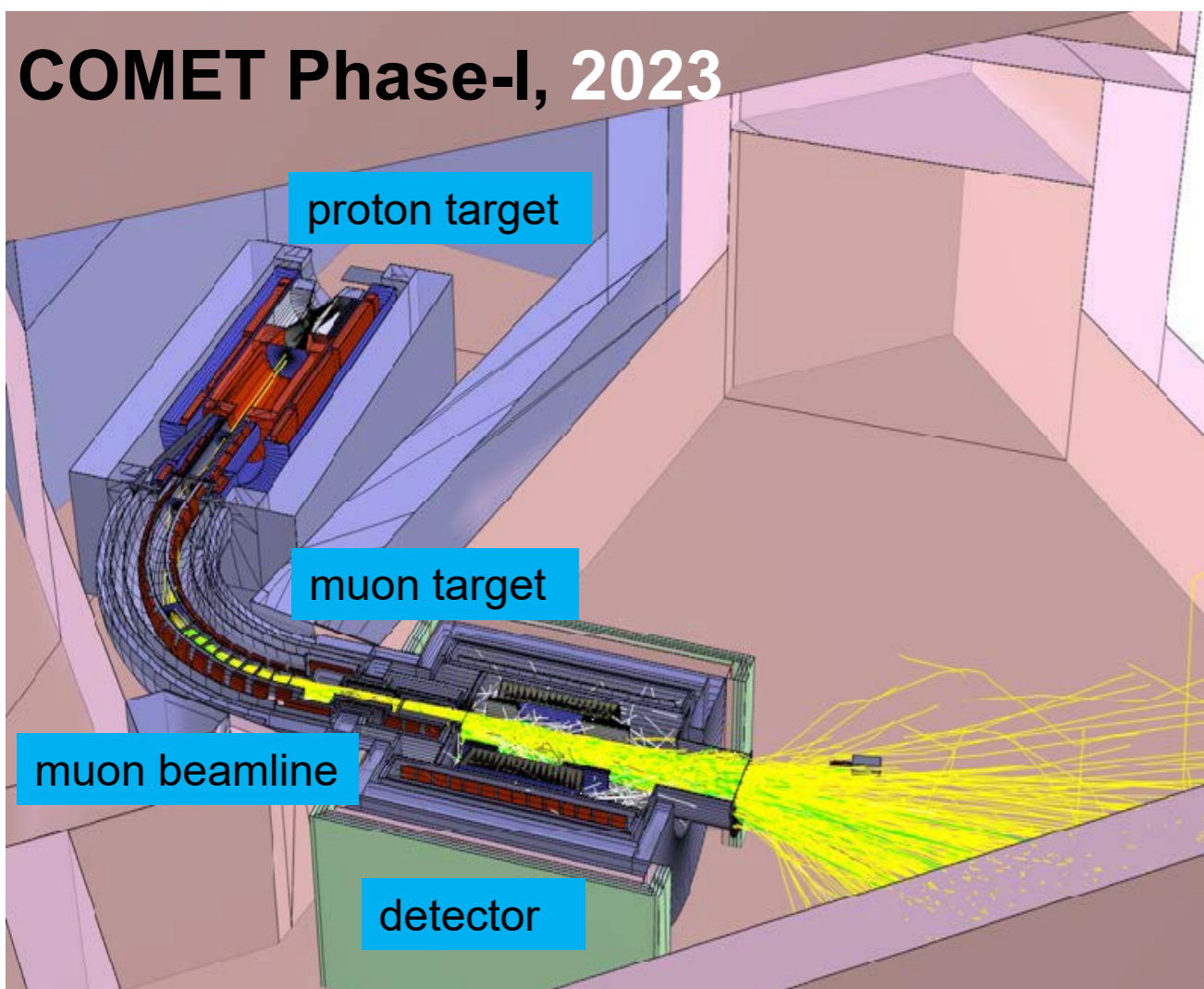
Joint Project between KEK and JAEA

Proton beam and power for COMET Phase – I and Phase - II	
8GeV	8 GeV
3.2kW	56kW

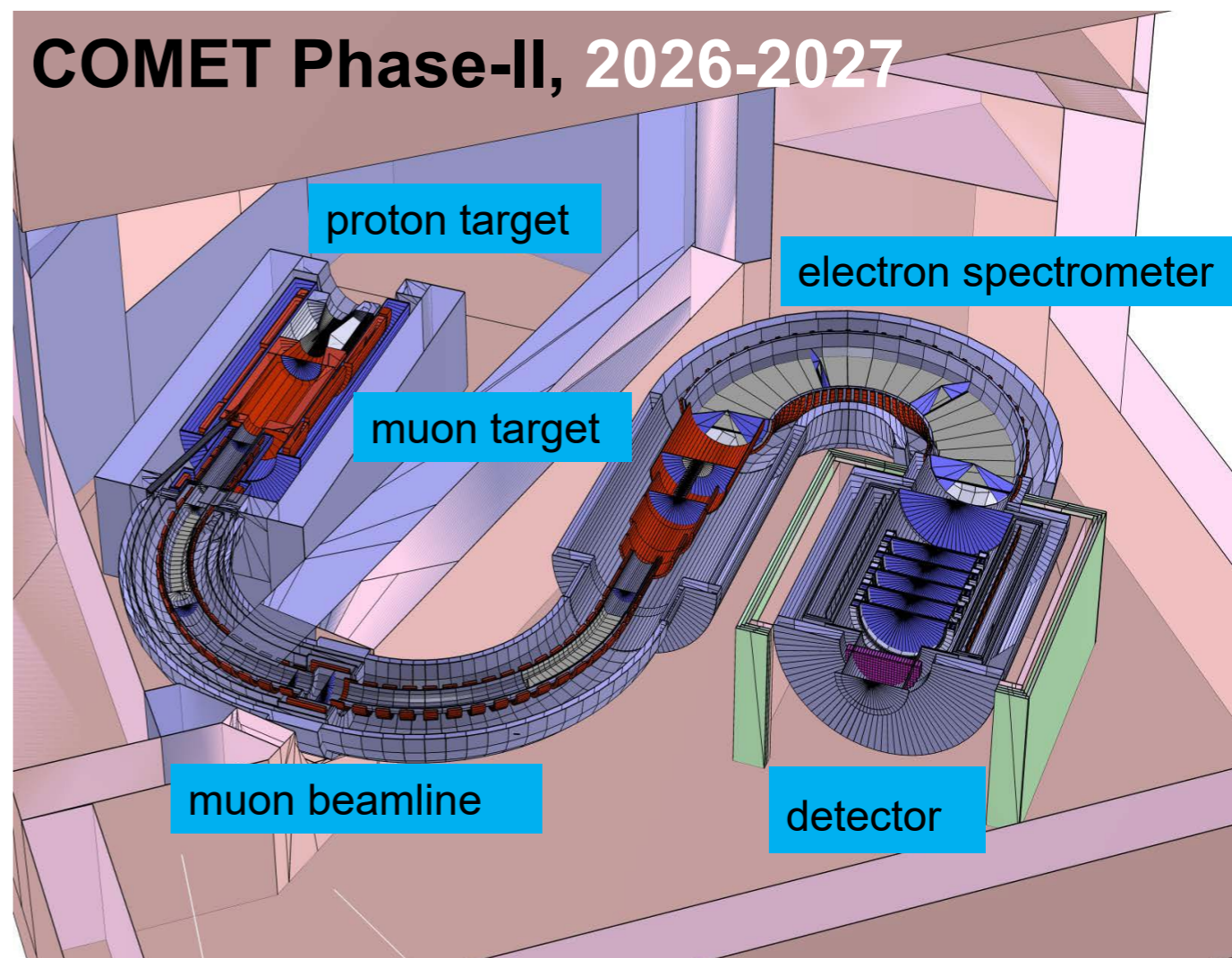


Two-phase realization

COMET Phase-I, 2023



COMET Phase-II, 2026-2027



Phase-I goal

1 Search for μ -e conversion

- A search for μ -e Conversion at the intermediate sensitivity with would be 100-times better than the present limit (SINDRUM-II) 3×10^{-15}

2 Background Study for the full COMET Phase-II

- Direct measurement of potential background sources for the full COMET experiment by using the actual COMET beam line

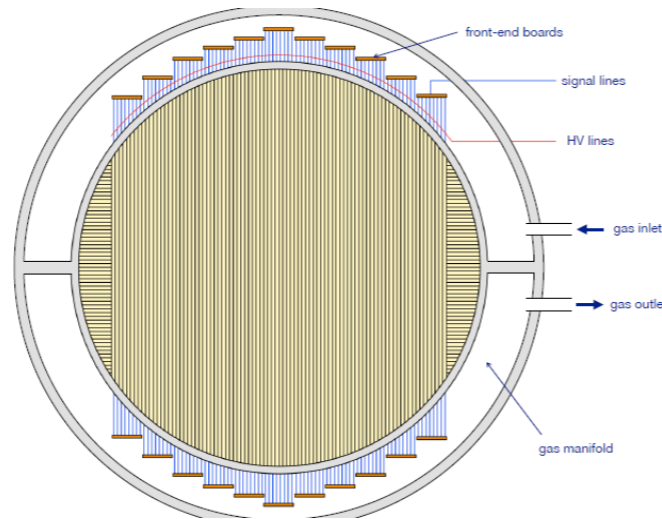
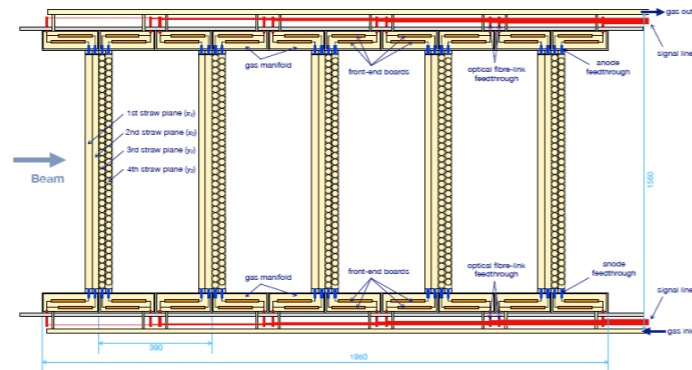
COMET Phase-I serves several roles that are highly complementary to the Phase-II experiment. It provides a working experience of many of the components to be used in Phase-II and enables a direct measurement of backgrounds. Significantly it will also produce competitive physics results for the μ -e conversion process.

COMET detector system

Straw Tracker: 5 station (Phase – I) ~ 2500 straw tubes, 9.75 mm diameter, 20 μm thickness, Ar:C₂H₆ = 50:50

Requirements:

- Momentum resolution $\leq 200 \text{ keV}/c$
- Space resolution $\leq 200 \mu\text{m}$
- Work in vacuum, magnetic field 1 Tesla



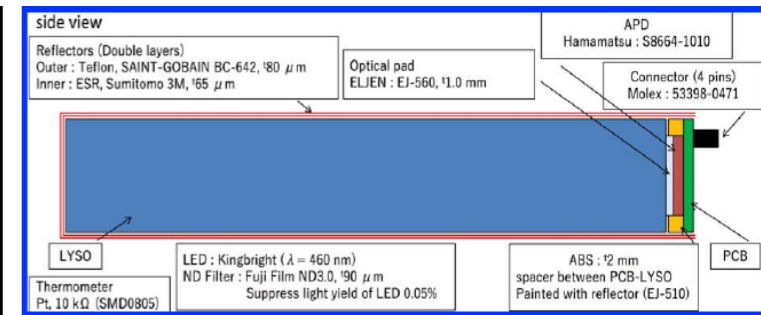
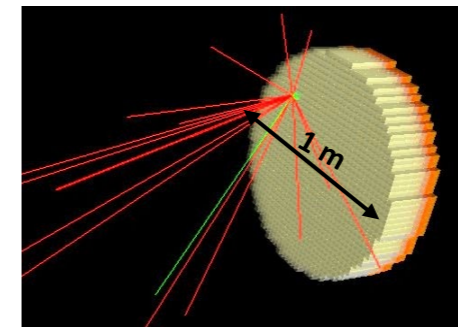
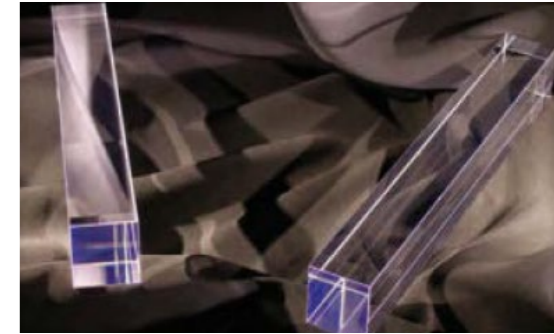
Electromagnetic calorimeter

ECAL (crystal type LYSO, Lu_{1.8}Y₂SiO₅Ce)

- Combination of around 600 (for Phase II 2272) LYSO crystals for Phase-I
- Total size: diameter ~ 1m
- Crystal size 20x20x120 mm³ (11 radiation length)
- Photon detector: APD

Requirements:

- < 5% ER at 105 MeV
- < 10 mm space resolution
- < 100 ns time resolution
- Work in vacuum and magnetic field of 1 Tesla



Cosmic Ray Veto (CRV)

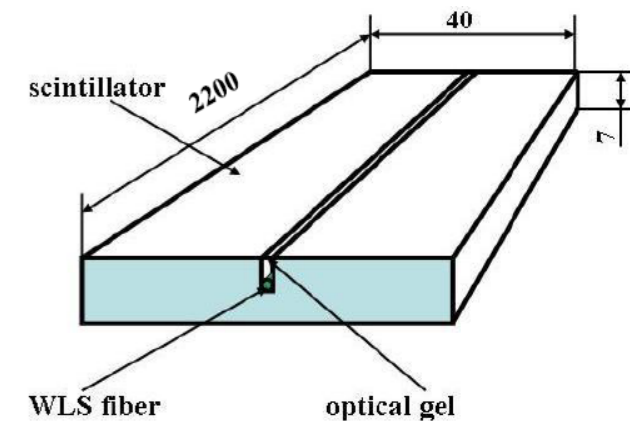
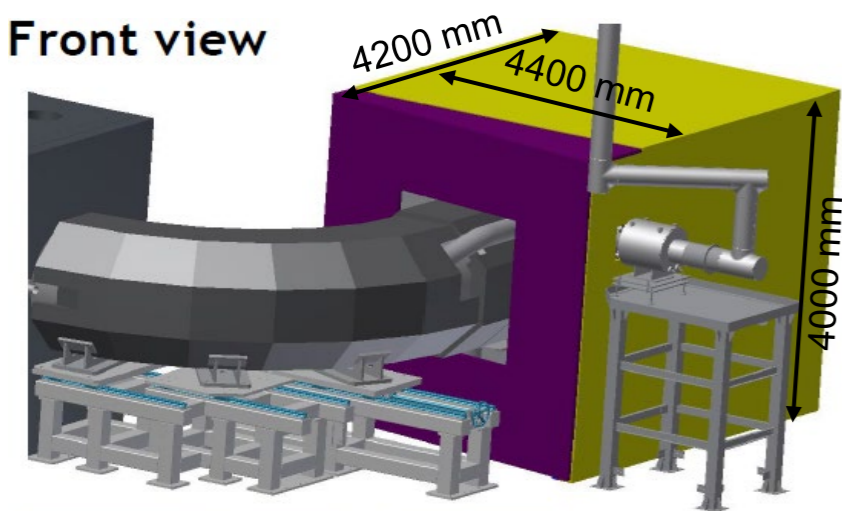
Requirement: Efficiency $\geq 99.99\%$.

CRV will be consist of two major parts:

- scintillator based (SCRV)
 - CRV consists of 8 supermodules
 - The modules are formed from four layers, 15 strips
 - Strip sizes: 0.7 x 4 x 220 cm³, 1.2 mm diameter WLS
- Glass Resistive Plate Chambers (GRPC).

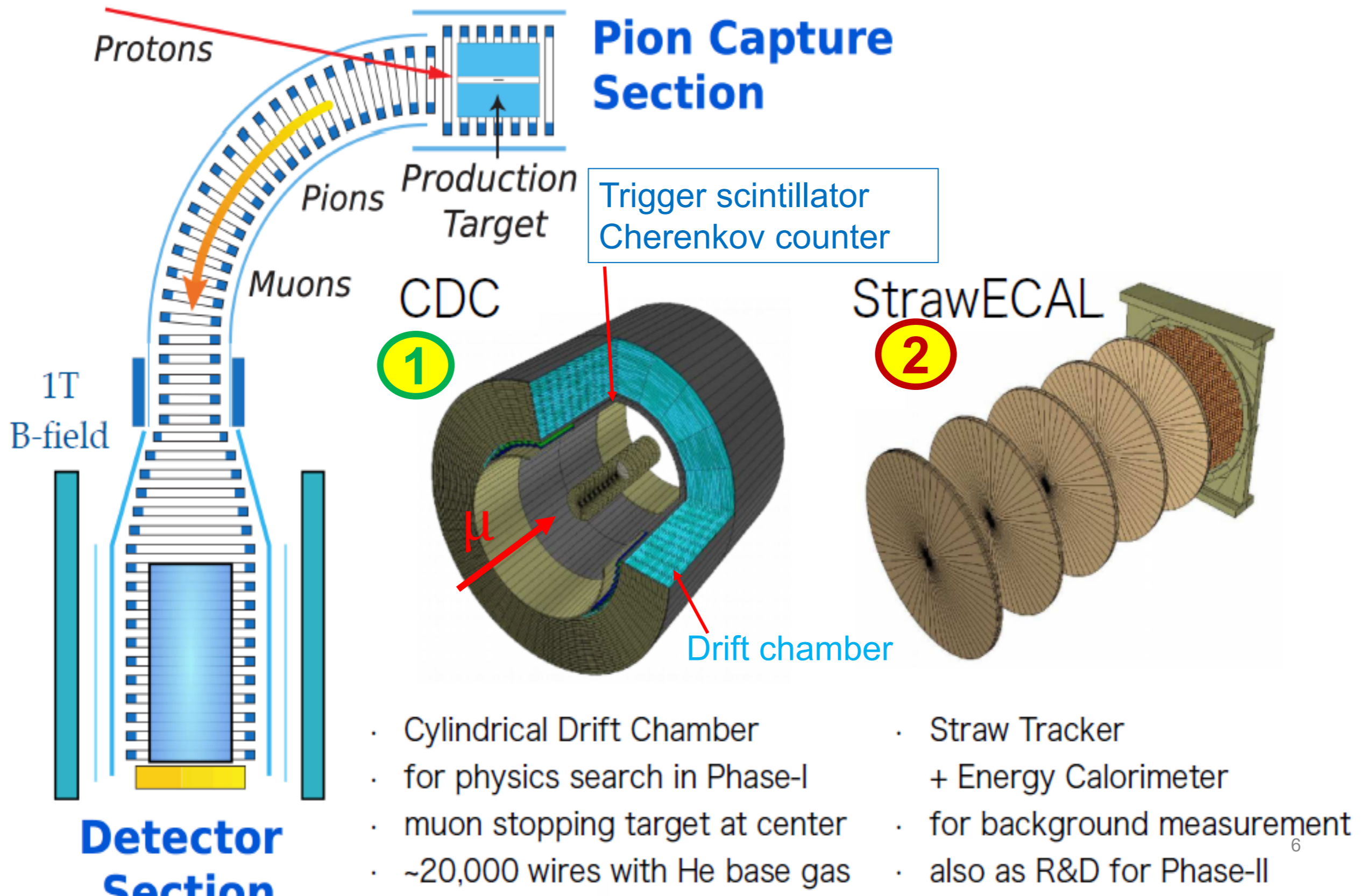
The SCRv subsystem placed on top and back sides of the COMET and based on extruded plastic scintillation strip with WLS fiber glued to the strip groove. The GRPC will be placed in hottest area at front of the COMET (active shield).

Front view



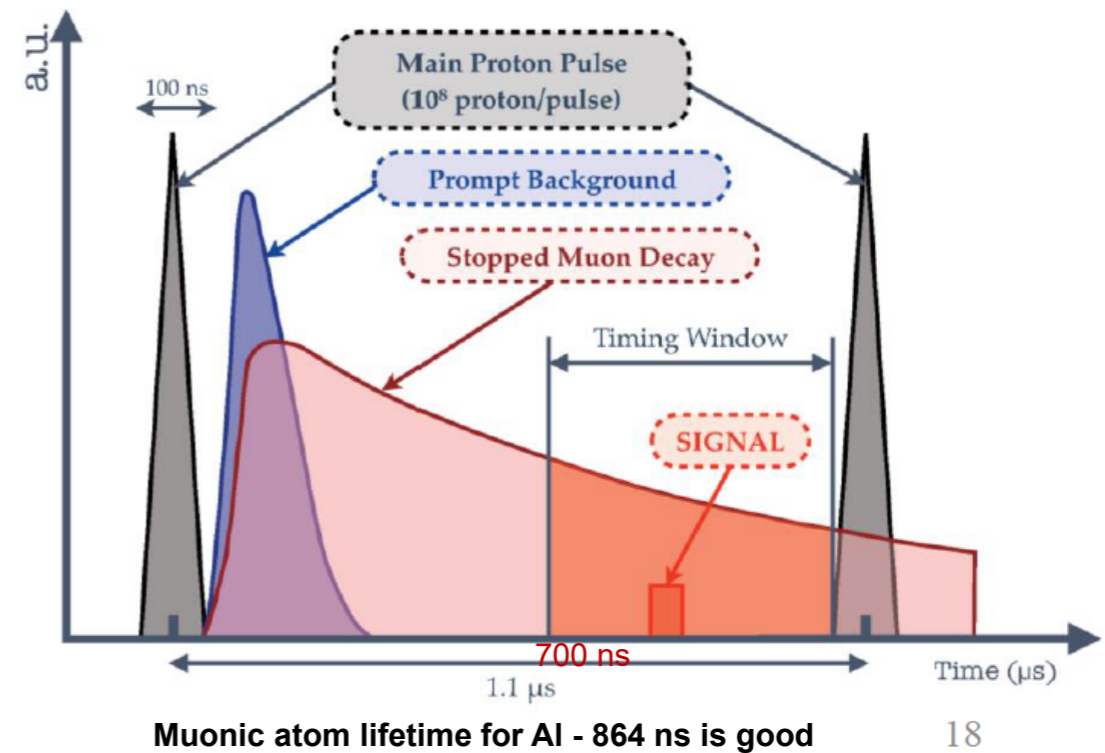
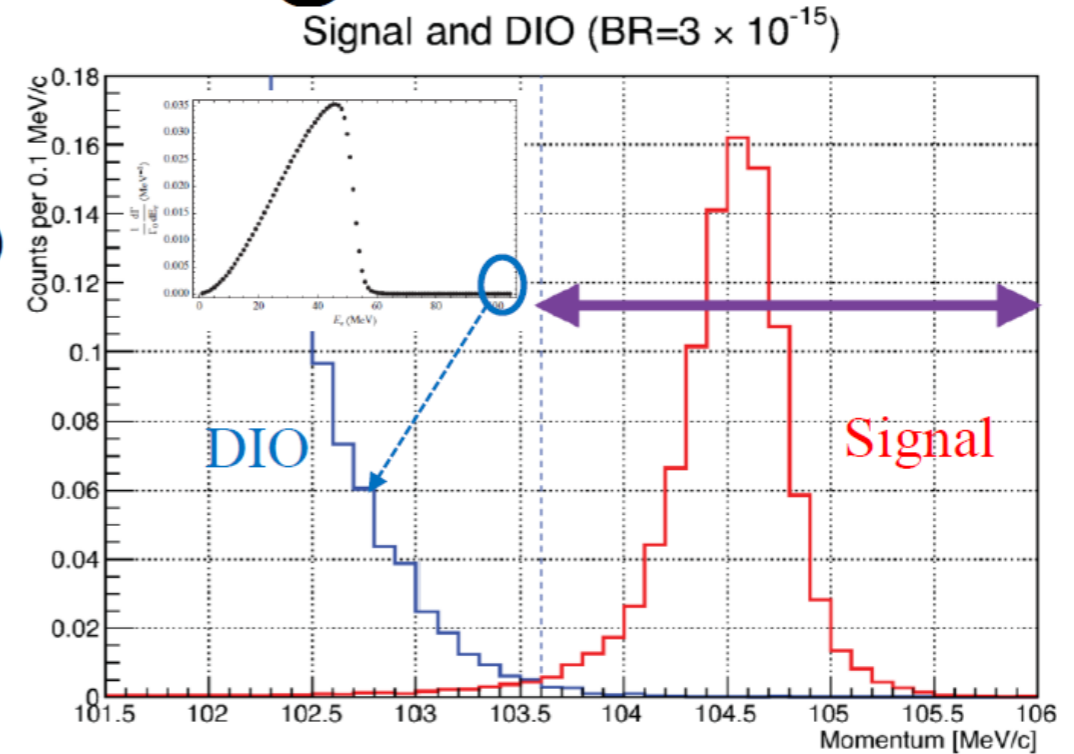
Also used passive CRV, concrete and lead.

COMET Phase-I Detectors



To control the background

- **Intrinsic physics background**
 - Mostly from muon decay in orbit (DIO)
 - Calculated by Czarnecki with radiative correction. Branching ratio drops with order-5 function near end point.
 - Momentum resolution required to be better than 200 keV/c
- **Beam related background**
 - Energetic particles in beam with $E > 100 \text{ MeV}$
 - Mostly prompt. Can be suppressed by a delayed measurement window ($\sim 700 \text{ ns}$)
 - Some due to leaked proton. Proton extinction factor required to be $< 10^{-10}$.
actually achieved $\sim 10^{-11}$!
- **Cosmic ray background**
 - Cosmic ray: cover the system with cosmic ray veto detectors.
Required Inefficiency $< 10^{-4}$



The estimated background events for a single-event sensitivity of 3×10^{-15} in COMET Phase – I with a proton extinction factor 3×10^{-11} is, DIO: **0.01**, RPC: **0.01**, anti-protons: **0.01**, Total: **0.032 events**

COMET Phase-I Sensitivity

Event selection	Value
Online event selection efficiency	0.9
DAQ efficiency	0.9
Track finding efficiency	0.99
Geometrical acceptance + Track quality cuts	0.18
Momentum window (ϵ_{mom}) (a signal acceptance)	0.93 $103.6 < p_e < 106.0 \text{ MeV}/c$
Timing window (ϵ_{time})	0.3 $700 \text{ ns} < t_e < 1170 \text{ ns}$
Total (Signal Acceptance for the μ-e conversion)	0.041

$$B(\mu^- + \text{Al} \rightarrow e^- + \text{Al}) = \frac{1}{N_\mu \cdot f_{\text{cap}} \cdot f_{\text{gnd}} \cdot A_{\mu-e}}$$

Number of muons stopped inside targets
 $N_\mu = 1.5 \times 10^{16}$

Fraction of μ -e conversion to the ground state = 0.9

Fraction of muons to be captured by Al target = 0.61

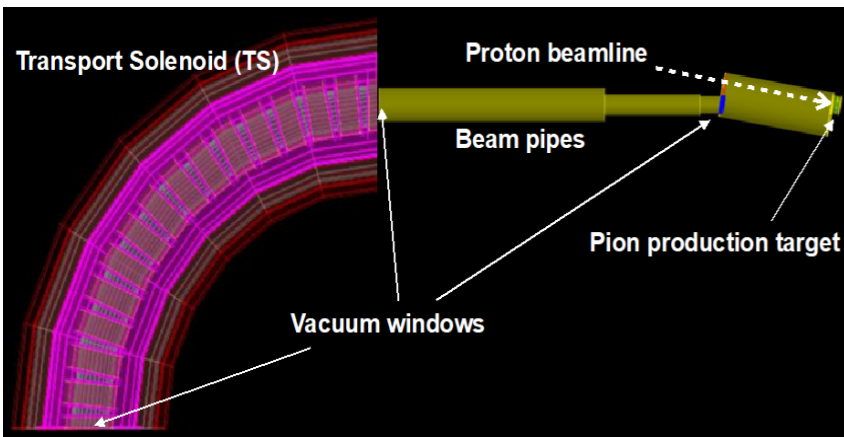
3×10^{-15} (as SES) achievable in ~ 150 days, or $< 7 \times 10^{-15}$ (as 90% C. L/ upper limit)

Phase- α (2022)

A low beam intensity run, 15-20 days in November 2022, without Pion Capture Solenoid (PCS).
A thin ($1 \times 20 \times 20 \text{ mm}^3$) graphite plate as a pion production target. Simulation Study (GEANT4)

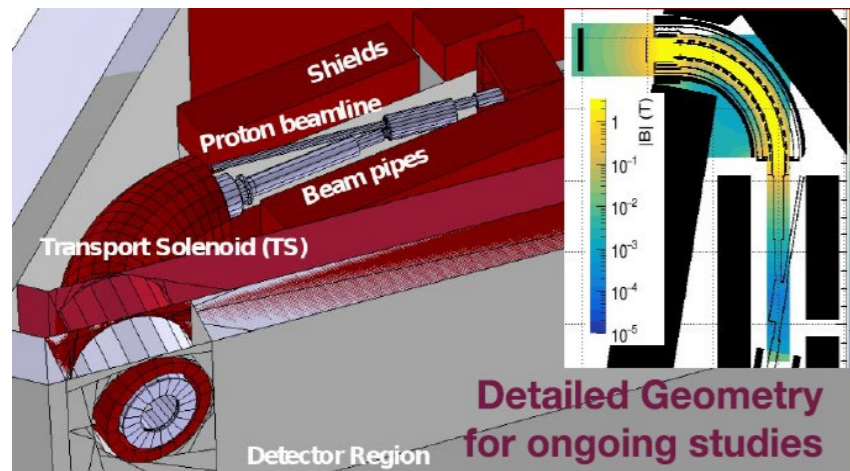
1. Secondary beam yield measurement with simplified geometry & magnetic field at both TS ends

- Detectors
 - Proton-beam diagnostic detectors around the target area
 - Secondary-beam measuring detectors in the exp. area.
- 10^{11} proton-on-target (POT) events.
- $10^5 - 10^6$ magnitude smaller yields than Phase-I



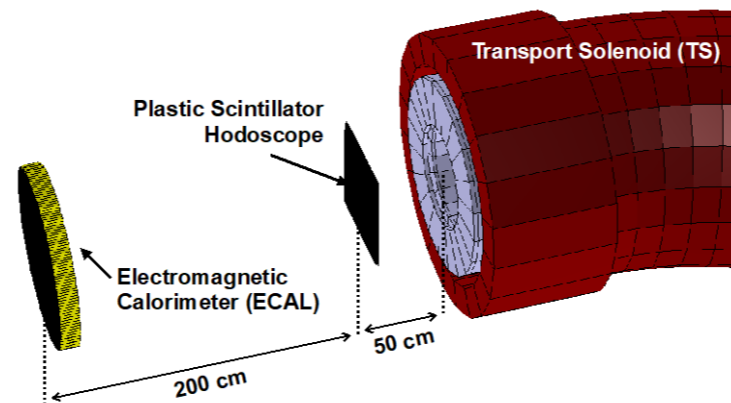
Particle	TS entrance	TS exit
e^-	8.3×10^{-8}	4.6×10^{-8}
e^+	3.2×10^{-8}	3.3×10^{-8}
μ^-	2.0×10^{-8}	6.9×10^{-9}
μ^+	2.8×10^{-8}	1.1×10^{-8}
π^-	5.2×10^{-8}	1.7×10^{-9}
π^+	7.3×10^{-8}	2.8×10^{-9}
ρ	1.6×10^{-7}	4.0×10^{-10}

Particle Yields per POT at both TS ends



2. Measurement w/ PID

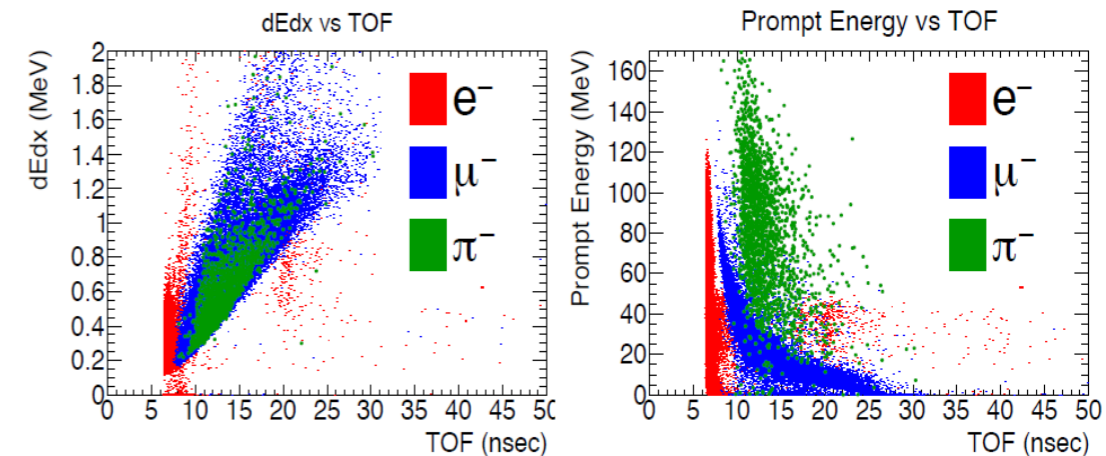
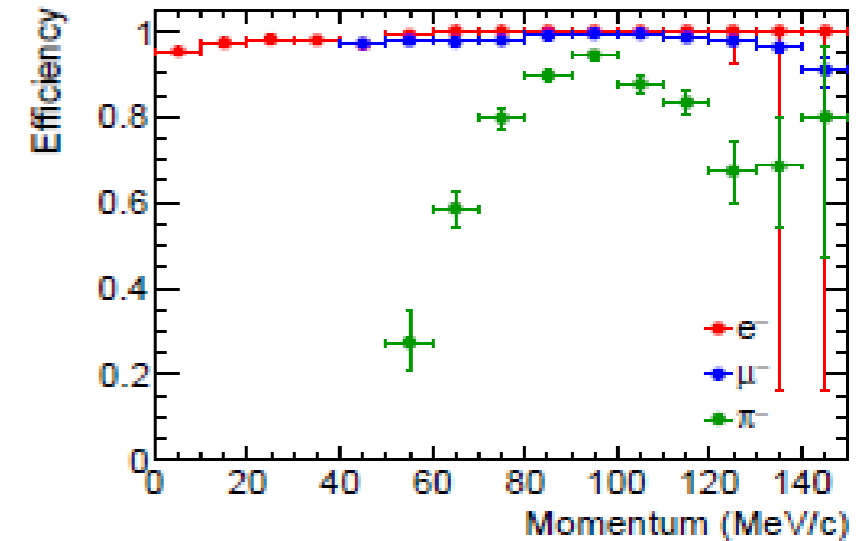
- Detectors
 - Combination of fibre plastic scintillator hodoscope and COMET ECAL
- Particle Identification (PID) method and performance
 - Multi-variate analysis (MVA) with three observable parameters
 - dE/dx in the hodoscope
 - ECAL prompt energy deposit ($< 10 \text{ ns}$ after hit)
 - Time-of-flight (TOF) between both detectors
- The results: PID efficiency for e^- , μ^- , and π^- .
 - e^- : Good $\sim 100\%$.
 - μ^- : Good $> 90\%$ but drops at high momentum.
 - π^- : Still low over the range, need improvement



Baseline Detector Layout

	Phase- α	Phase-1
Energy (GeV)	8	
Beam Power (kW)	0.26	3.2
Spill Cycle (sec)	9.2	2.48
Extraction Period (sec)	0.5	
# of Bunches / sec	7.6e+5	
# of Protons / Bunch	4.9e+6	1.6e+7
# of Protons / Spill	1.9e+12	6.2e+12

The proton beam characteristics such as the bunch length, extinction, time structure of $1.17 - 1.75 \mu\text{sec}$ bunch-to-bunch are identical to COMET Phase-I.



Next steps and Prospects

- Large-scale MC production
- Exploration of different detector configurations
- Optimization of geometries, measurement schemes
- Antiproton measurements
- "Beam blocker" studies for Phase-I beam measurement programme.

Detector Schedule

CyDet will be ready at COMET site by 30 September 2022

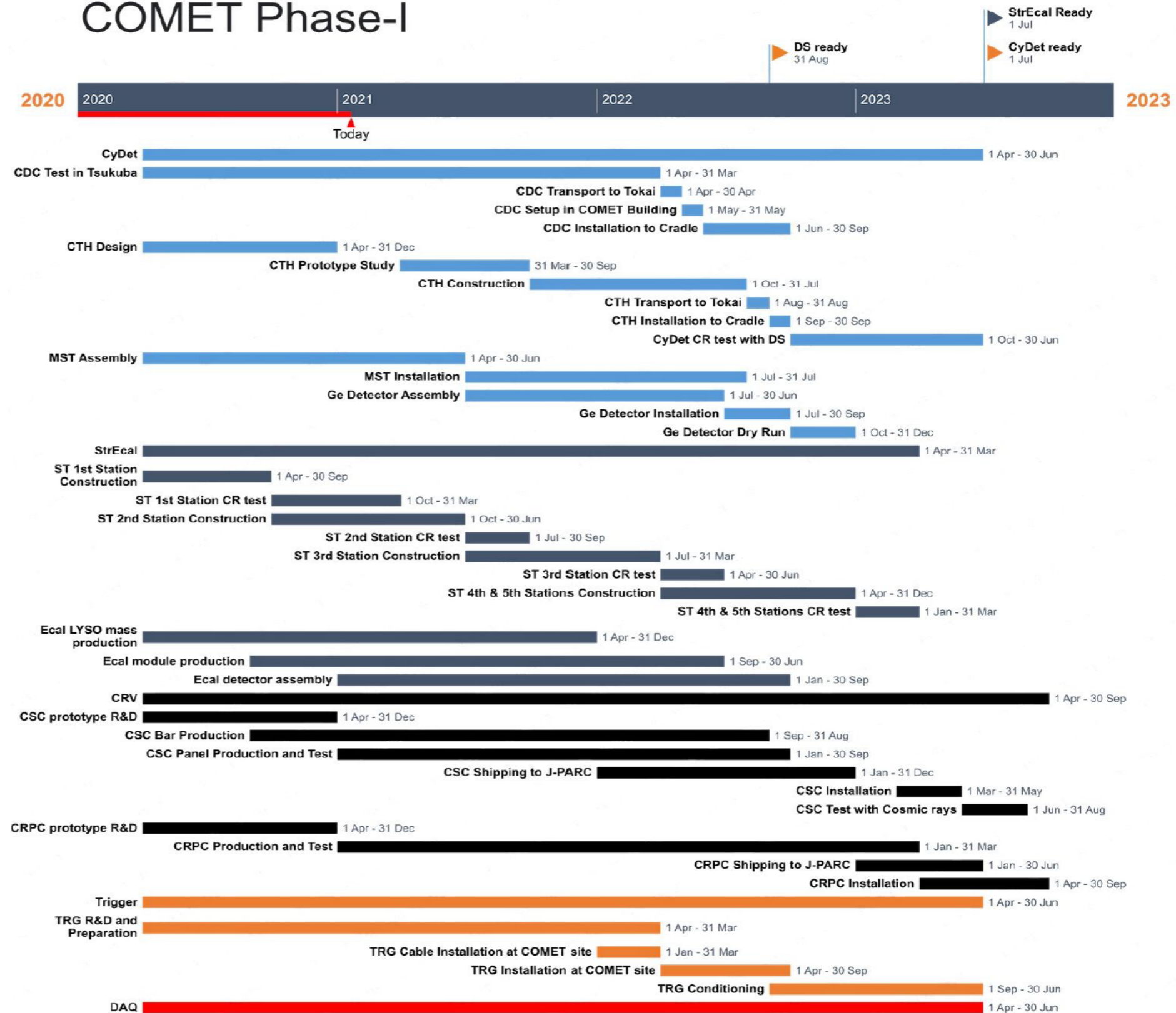
- On-site long-term CR test

StrECAL will be ready at COMET site by 31 March 2023

- ECAL and part of the Straw-Tracker will be ready earlier

The **Cosmic Ray Veto** comes in at the very end after all other installation is complete

COMET Phase-I



Summary

- The COMET is a search experiment for μ -e conversion at J-PARC
 - aiming improvement the sensitivity x 10,000 better than the past limit, 1.0×10^{-17}
 - staging approach called Phase-I (under construction) / Phase-II
 - Before Phase-I we need Phase- α – a low beam intensity run in 2022

➤ Phase- α Goal

- The beam and secondary beam yield estimation, measurement w/ PID

➤ COMET Phase-I is now under construction

- aiming improvement the sensitivity x 100 better than the past

$$B(\mu^- + Al \rightarrow e^- + Al) = 3.0 \times 10^{-15} \text{ (S.E.S)}$$

$$\text{Phase-I Goal: } B(\mu^- + Al \rightarrow e^- + Al) < 7 \times 10^{-15} \text{ (90\%C.L.)}$$

(in 150 days operation)

Up to 10^{-15} → sensitive to “new physics”

- The creation of CDC detector for physics search is already finished
 - The other system is under construction
 - We plan to be ready in 2023.
- In parallel preparation and carrying out Phase-I, will go work on creation of a full muon bunch, R&D for COMET Phase-II is underway. After completion of Phase-I, will immediately begin installation and assembly for Phase-II. Expecting to start in 2026-2027
 - JINR plays a **leading role** in preparation of this experiment of fundamental importance.

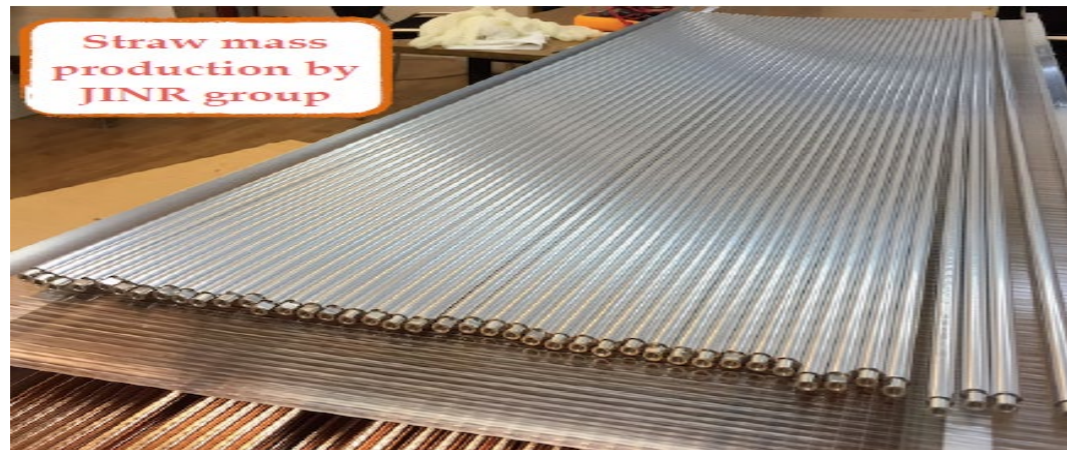
JINR group's contributions and responsibilities

1. Straw tracker
2. Electromagnetic calorimeter (ECAL)
3. Cosmic Ray Veto (CRV)
4. Software studies (simulations) for straw tracker, ECAL and CRV

Straw tubes production for Phase-I

The complete set tubes for Phase-I has been produced and tested:

- 2700 tubes of 20 μ wall thickness, \varnothing 9.8 mm 120 and 160 cm length have been produced
- These tubes passed all the tests and have been sent to Japan



The study of the properties of straws

The following mechanical properties of the 9.8 mm straws have been measured:

- the range of elastic deformation of the straw
 - **Results: The limit value of the straw tension is obtained 1.85kg (in COMET up to 1 kg)**
- the influence of temperature and the dependence of the elastic properties of the straw on its thickness
 - **Results: The maximum tension of the straw is provided at temperature from 10 to 20°C**
- The tubes aging
 - **Results: The service life of straw detector is 9 years.**

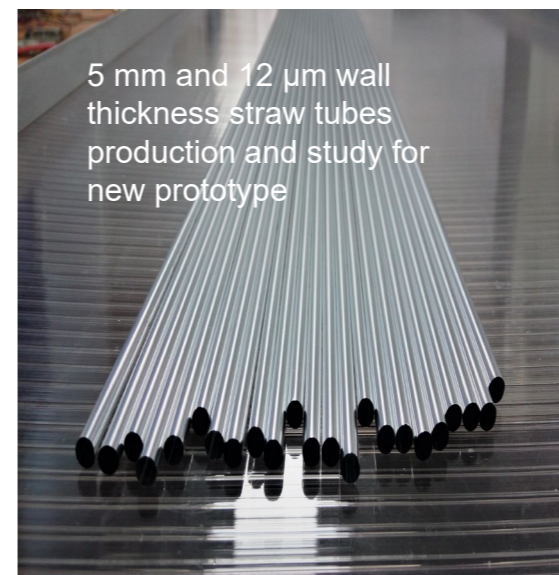
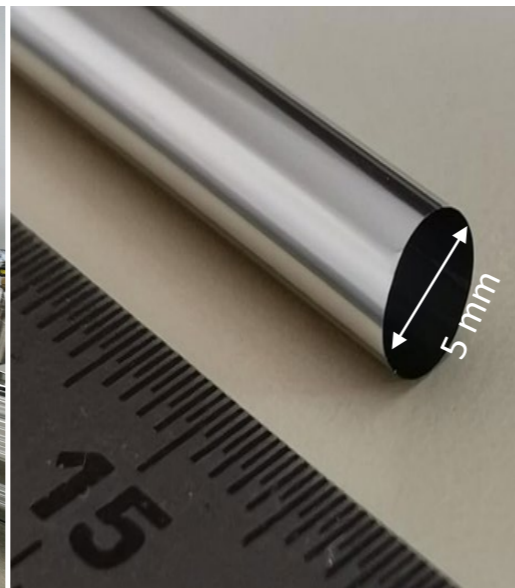


For Phase-II we need even thinner and less diameter tubes: 5 mm diameter and 12 μ m wall thickness.

For this purpose we prepared a new straw production line in our laboratory.

The manufacturing area for straw-tube R&D at DLNP

Completed real working machine for full dimension 12 μm thickness and 5 mm diameter straw tube production with controllable parameters

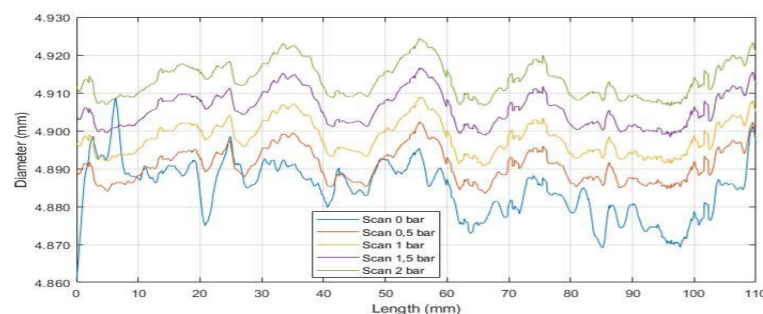


Produced straw parameters for prototype

- 100 pieces
- 70 cm in Length
- 5 mm Diameter
- 12 μm Mylar tape thickness
- Aluminum layer 70 nm
- Prototype working pressure 1 bar
- Long term testing pressure 2 bar
- Max safe pressure 3 bar
- Max load pressure 4 bar

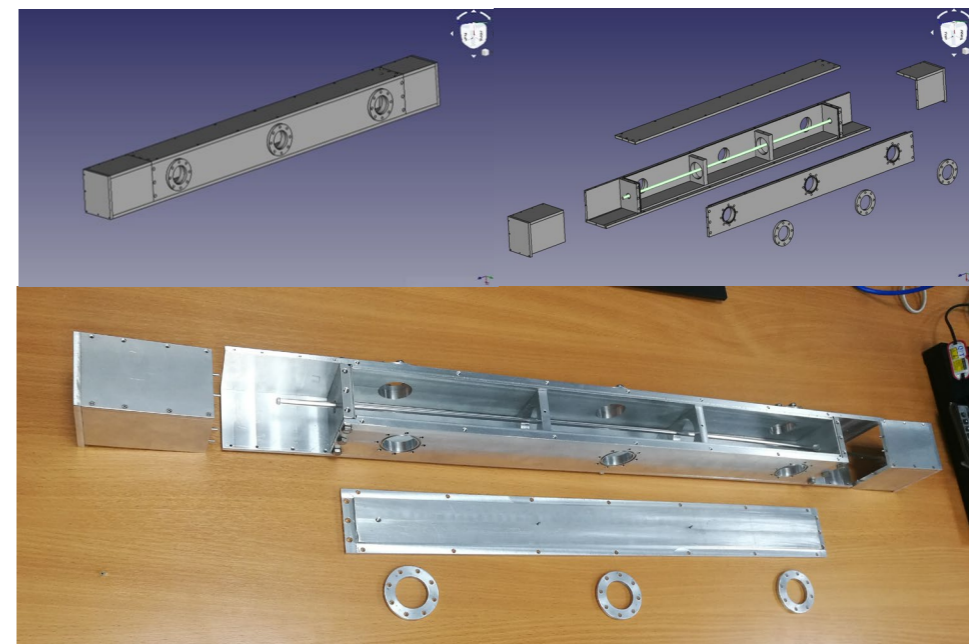
Capability of the new straw tubes production facility

- 1) New welding machine design and 5-th class clean room with temperature and humidity control
- 2) 5 mm diameter and 12 μm wall thickness straw tube production
- 3) Examination of straw quality control of tubes
- 4) Study straw tube properties
- 5) Precise measurements and monitoring of straw diameter with optical methods, accuracy of 0.1 μm



- Diameter scan along straw tube length with different inner pressures
- Diameter deviation along the tubes is less than 20 μm ,
- Shape stays consistent under different pressures

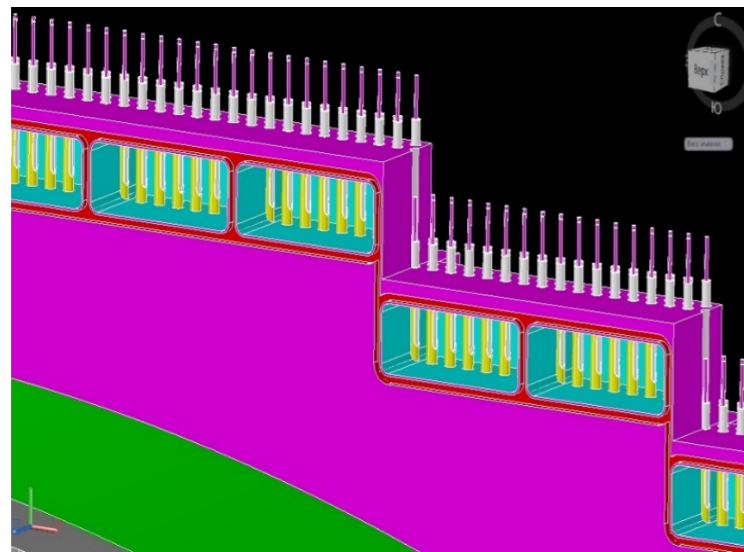
Single channel prototype, 64 channel prototype in progress



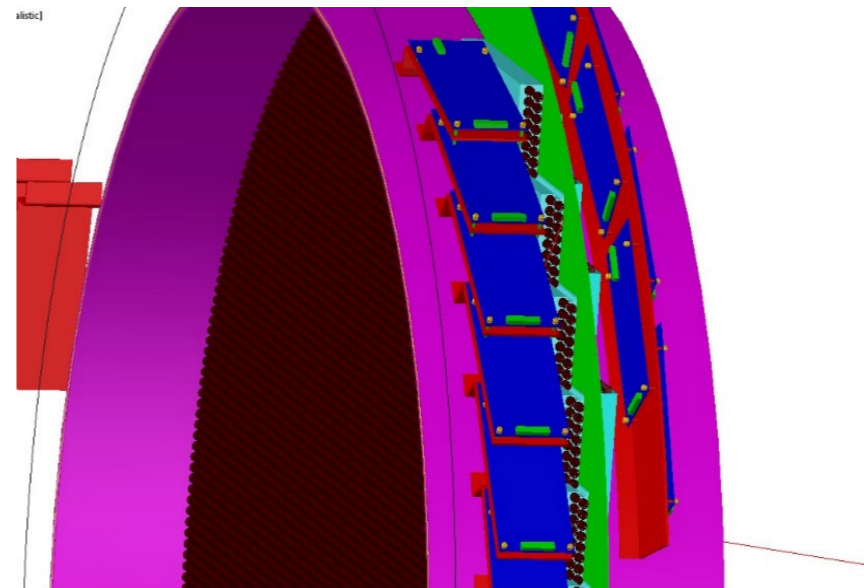
Great success in R&D, in the production of 5 mm diameter and 12 μm thick tubes

Straw module design

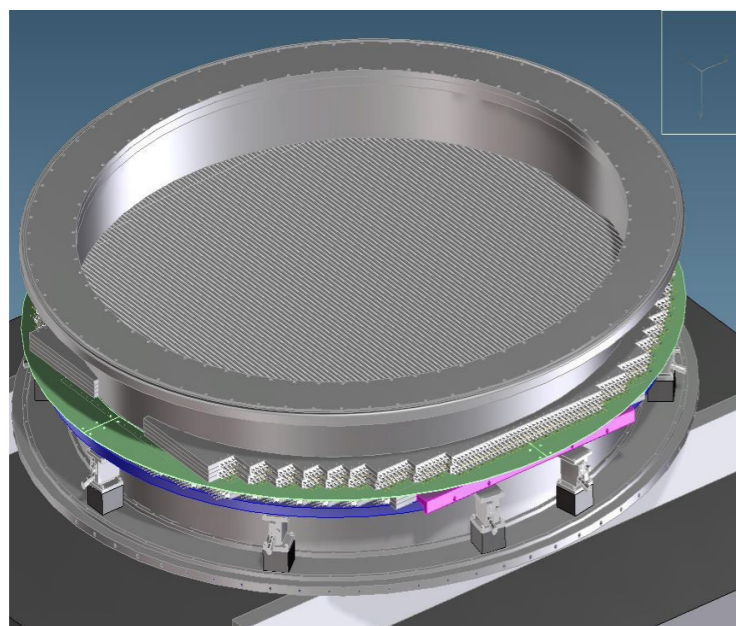
Taking into account the success of JINR, DLNP COMET group in R&D and production of thin-wall tubes with 5 mm diameters, and development of straw station design, **the COMET TB and CB approved the idea of JINR group to use an additional station with new tubes at Phase-1**



Design of support structure



Schematic view of the ROESTI boards



Design of a complete module

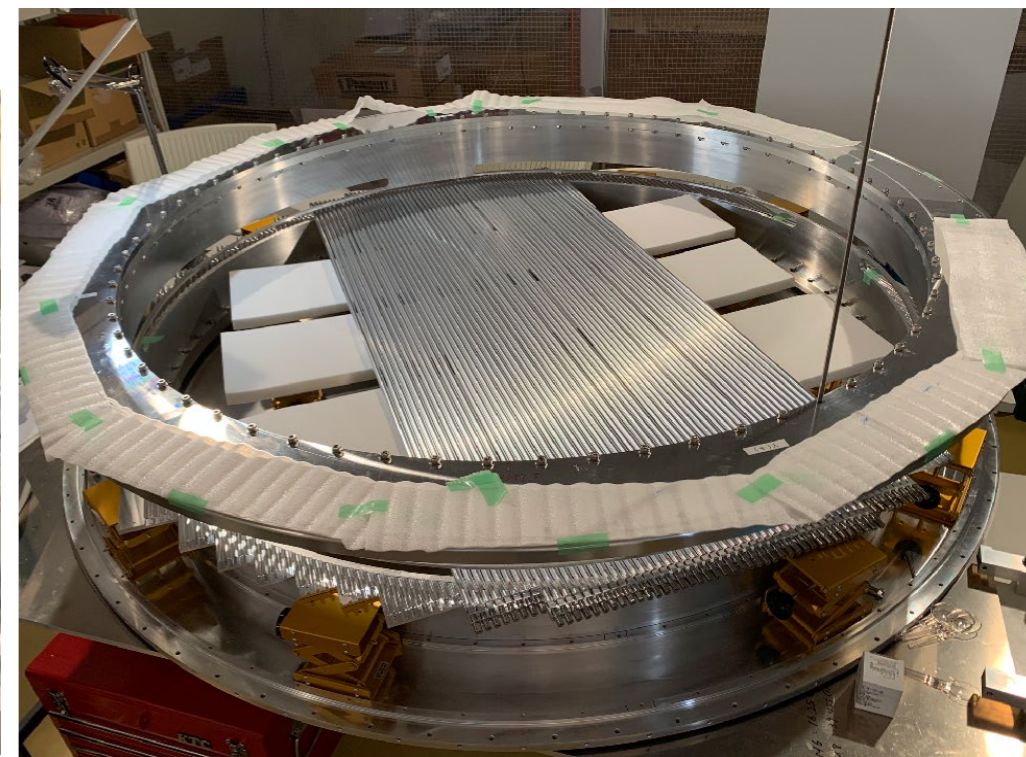
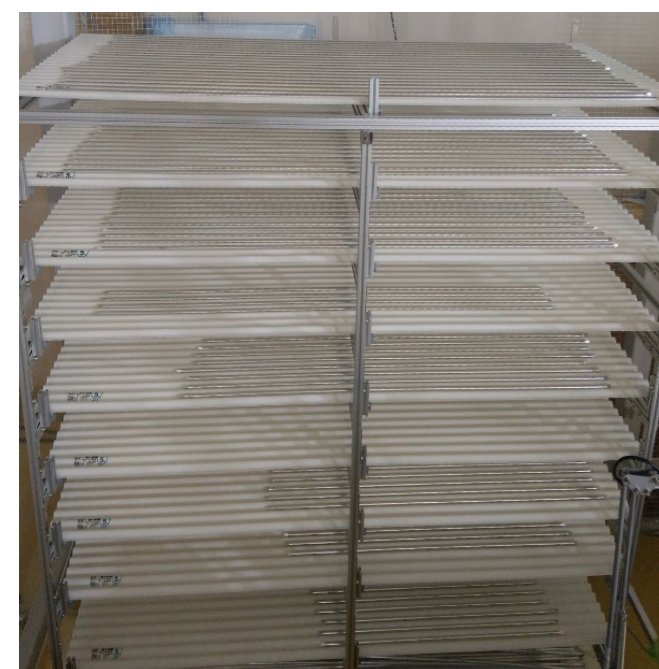
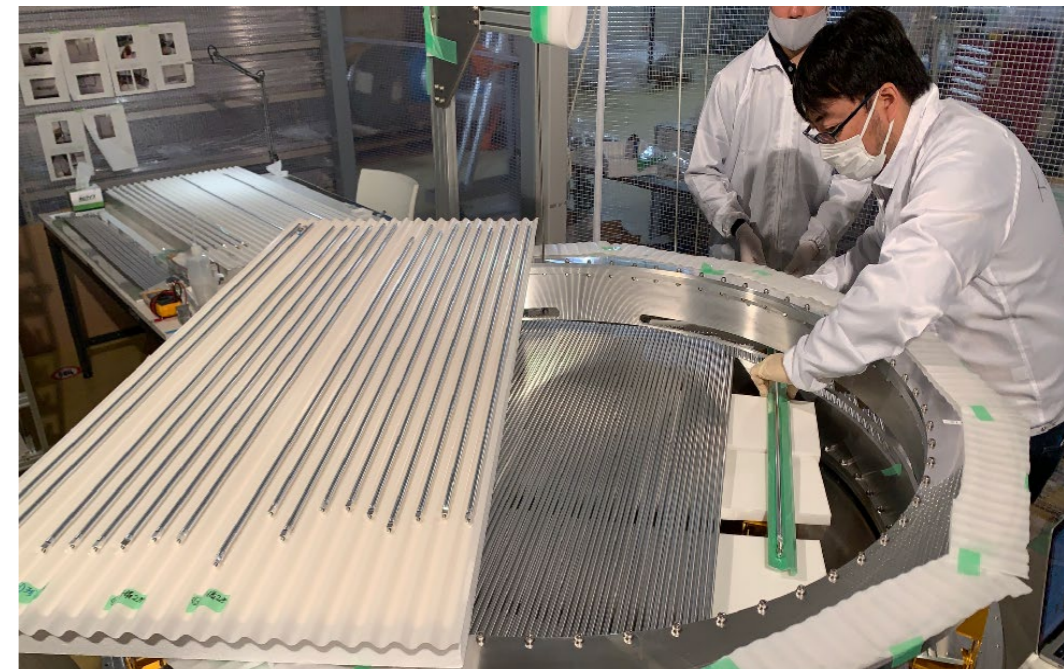
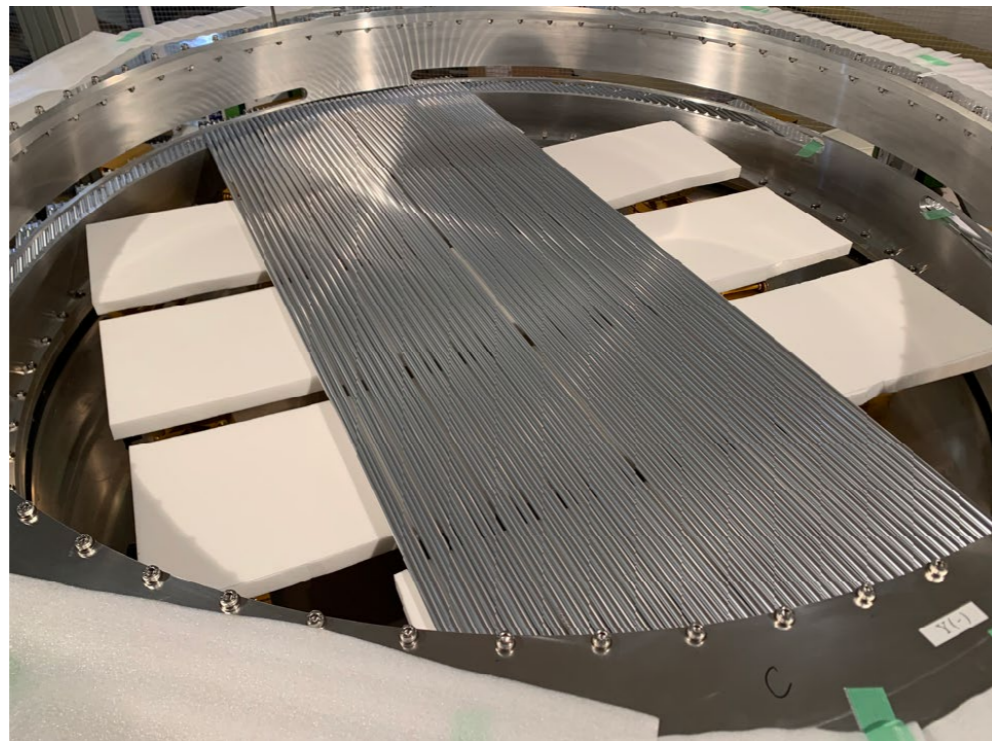
Module contains about 1000 straws with the diameter of 5mm (500 in horizontal direction + 500 in vertical direction) which in its turn means 60 ROESTI boards for both direction have to be allocated along the circular surface which are cooled down by cooling gas.

- Next to final design of the straw module for the 5mm diameter straws is developed
- Complete construction documentation for production is in progress
- Also full documentation on the ROESTI board, we will try to produce in RUSSIA, 60pcs.
- If we are lucky to produce the module in time, it can be used for Phase-I measurements

Straw Tracker Status — COMET Phase-I

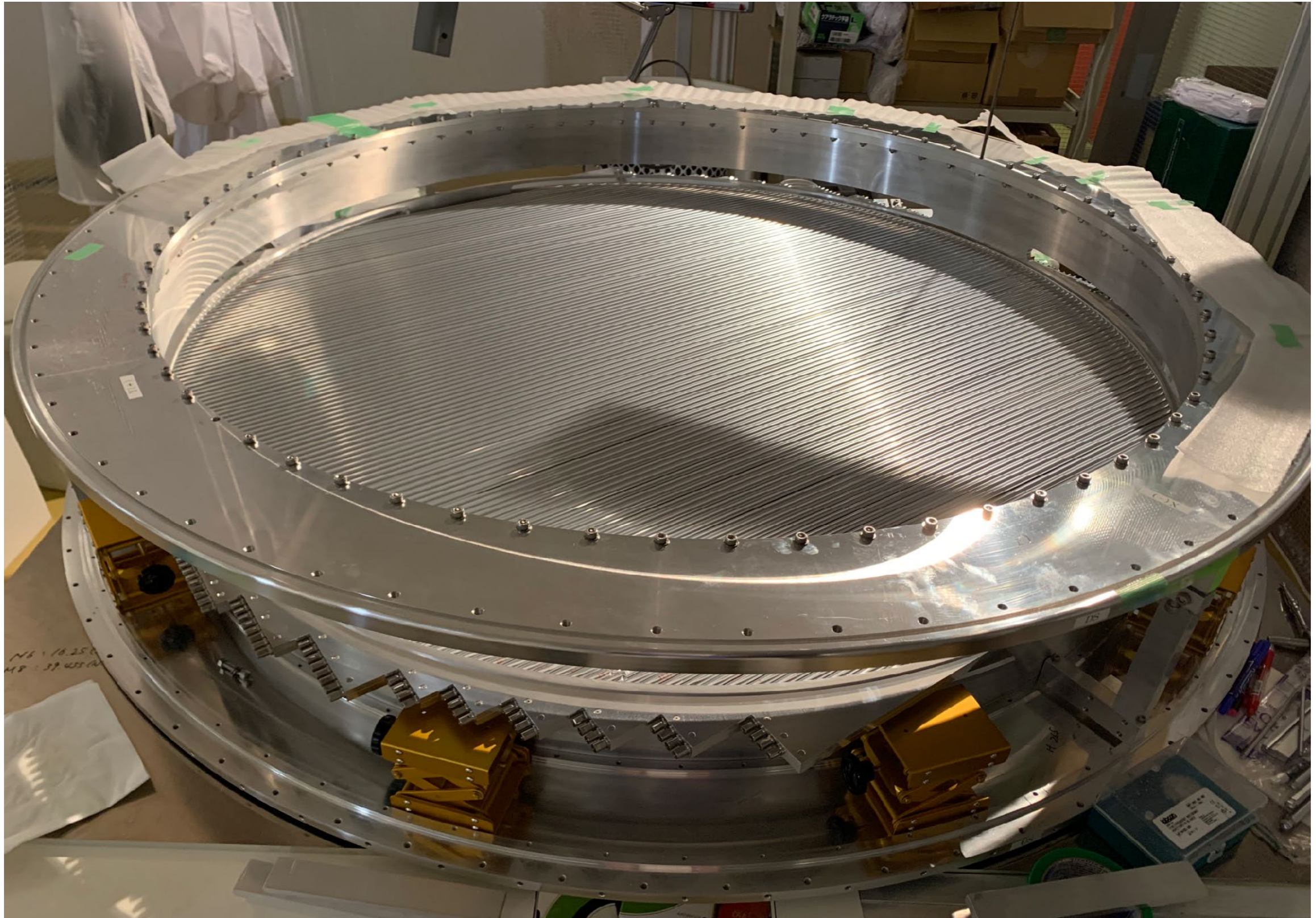
Straw-Tracker Assembly

Assembly for 1st Station is ongoing

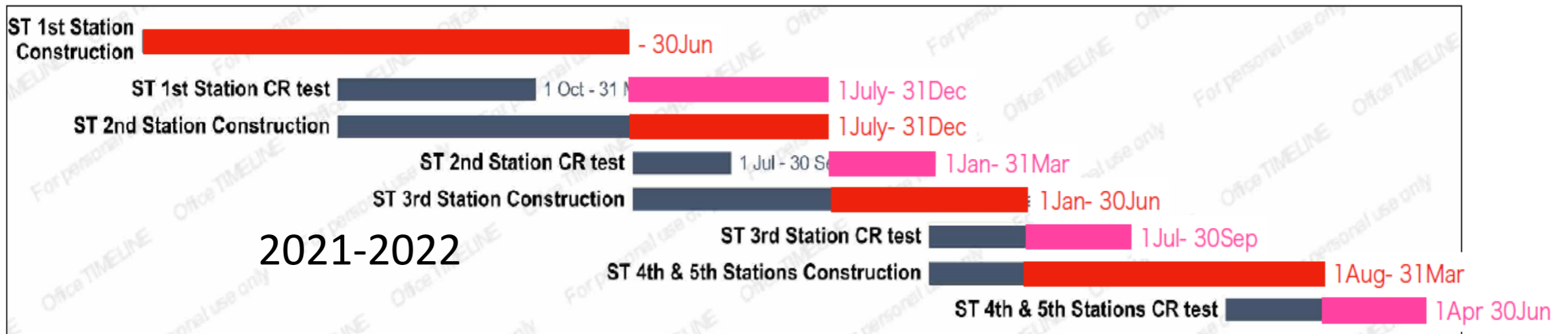
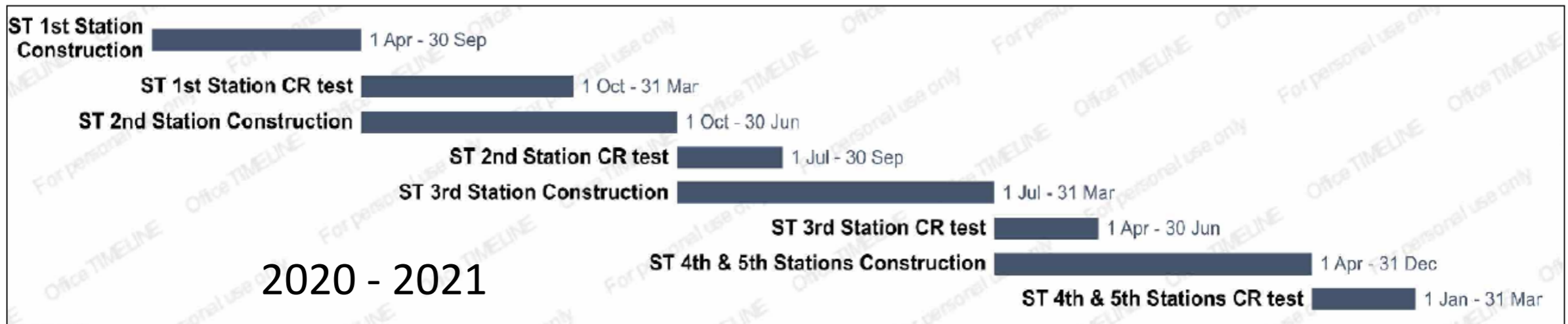


Straw-Tracker Assembly

1st layer, completed !!!



Assembly Schedule update

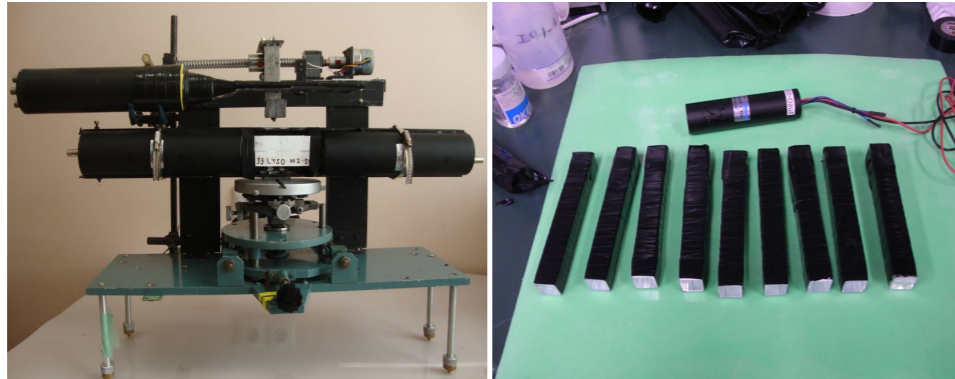


- Unclear schedule, depends on the “man power” and “budget”.
 - Current manpower @ KEK (2 physicists, 2 technicians, 1 students),
 - For the next FY 2nd-5th station, **JINR people is supposed to join, and the collaboration is very much looking forward to this (depends on COVID situation...)**

Electromagnetic calorimeter

R&D of LYSO crystals, LYSO crystal parameters investigation

The test bench has been prepared in DLNP



Three candidates vendors

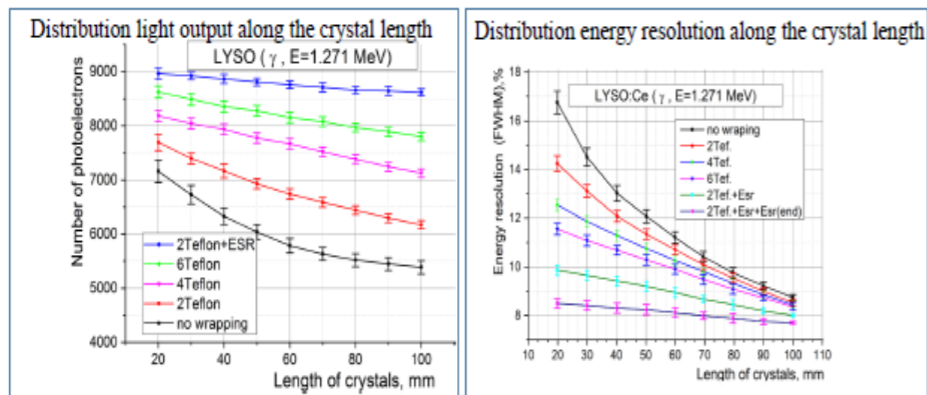
- **Saint-Gobain (SG), Baseline**
- OXIDE (OX), Japan
- Suzhou JT Crystal Technology (JTC)

Saint-Gobain has introduced an engineered version of LYSO which, compared to standard LYSO, offers up to:

- 6% improvement in energy resolution
- 20% higher light yield
- 20% faster decay time

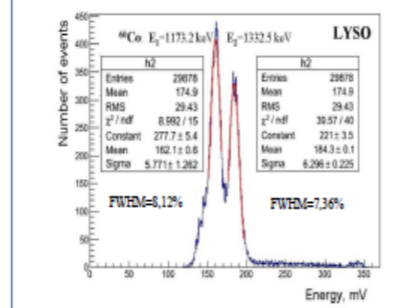
Properties	Standard LYSO	Engineered LYSO
Density [g/cm ³]	7.1	
Hygroscopic		no
Attenuation length for 511keV (cm)	1.2	
Energy resolution [%] @ 662 keV*	8.5	8
Wavelength of emission max [nm]	420	
Refractive index @ emission max.	1.81	
Decay time [ns]	45	36
Light yield [photons/MeV]*	27600	33200
Average temperature coefficient from 25 to 50° C (%/°C)		-0.28

Optimal wrapping of LYSO:Ce crystal



Wrapping	Length (mm)	Energy resolution (L= 60 mm), [%]
1 Without wrapping	60	11.37
2 2Teflon	74	11.44
3 4Teflon	79	10.59
4 6Teflon	83	9.5
5 2Teflon+ESR	~98,5	8.1

Energy resolution on the center of crystal

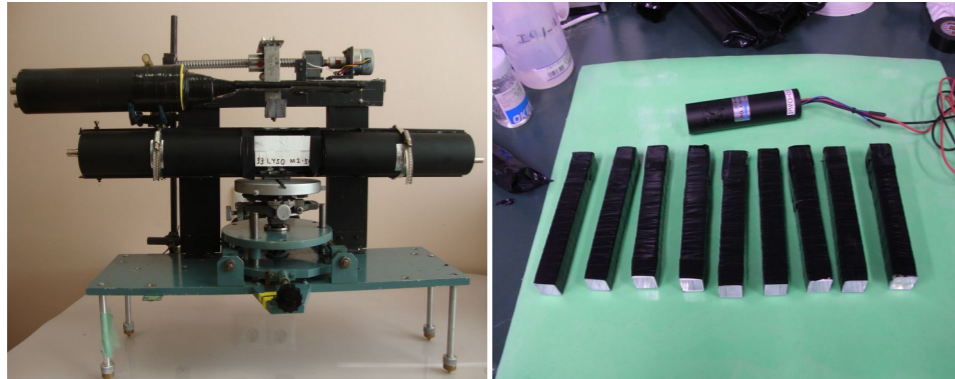


- Simulation of processes in crystals, **ongoing**
- Comparison of the crystal types, **finished**
- Simulation of optimal structure of the calorimeter, **ongoing**
- Simulation of the calorimeter geometry in framework ICEDUST, **ongoing**
- Experimental study of the main parameters (uniformity, light output) LYSO crystals on a precision JINR stand, **ongoing**
- Calibration of 64 crystals of LYSO at the JINR stand for Beam Test (Tohoku), **finished**
- Participation in a calorimeter design, **ongoing**
- Quality control (certification) of all crystals in JINR (**full responsibility**), **ongoing**
- Calorimeter assembling, testing, calibration and installation at setup, **in the near future**

Electromagnetic calorimeter

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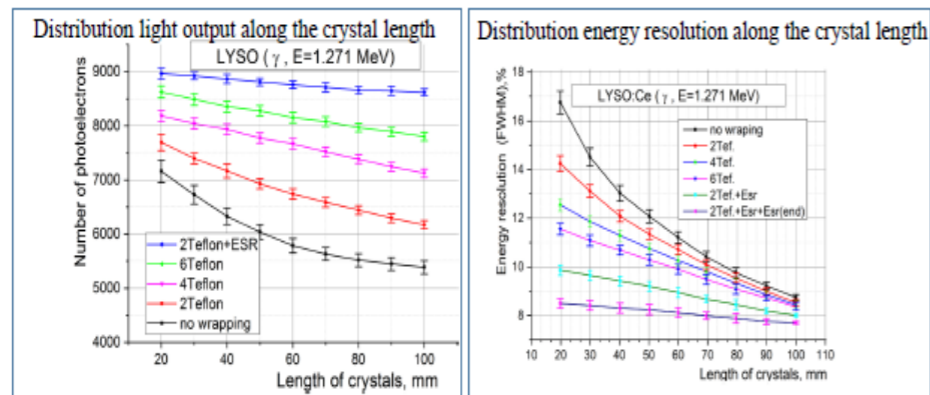
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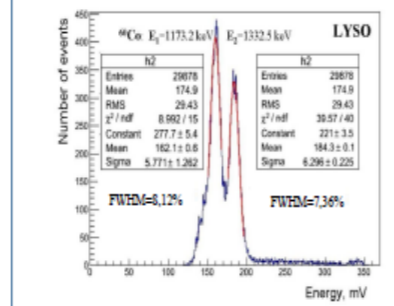
Properties	Standard LYSO	Engineered LYSO
Density [g/cm ³]	7.1	7.1
Hygroscopic	no	no
Attenuation length for 511keV (cm)	1.2	1.2
Energy resolution [%] @ 662 keV*	8.5	8
Wavelength of emission max [nm]	420	420
Refractive index @ emission max.	1.81	1.81
Decay time [ns]	45	36
Light yield [photons/MeV]*	27600	33200
Average temperature coefficient from 25 to 50° C (%/°C)	-0.28	-0.28

Optimal wrapping of LYSO:Ce crystal



Wrapping	Energy resolution (L= 60 mm), [%]
1 Without wrapping	60
2 2Teflon	74
3 4Teflon	79
4 6Teflon	83
5 2Teflon+ESR	~98,5

Energy resolution on the center of crystal



- Simulation of processes in crystals, **ongoing**
- Comparison of the crystal types, **finished**
- Simulation of optimal structure of the calorimeter, **ongoing**
- Simulation of the calorimeter geometry in framework ICEDUST, **ongoing**
- Experimental study of the main parameters (uniformity, light output) LYSO crystals on a precision JINR stand, **ongoing**
- Calibration of 64 crystals of LYSO at the JINR stand for Beam Test (Tohoku), **finished**
- Participation in a calorimeter design, **ongoing**
- Quality control (certification) of all crystals in JINR (**full responsibility**), **ongoing**
- Calorimeter assembling, testing, calibration and installation at setup, **in the near future**

Measurement of the electromagnetic calorimeter prototype parameters of the COMET experiment on cosmic muons



Crystals: LYSO - 4

Wrapper

Two layers of TEFLON
 - Thickness = 65 μm
 - Absorbance 28 %/cm

One layer of ESR film

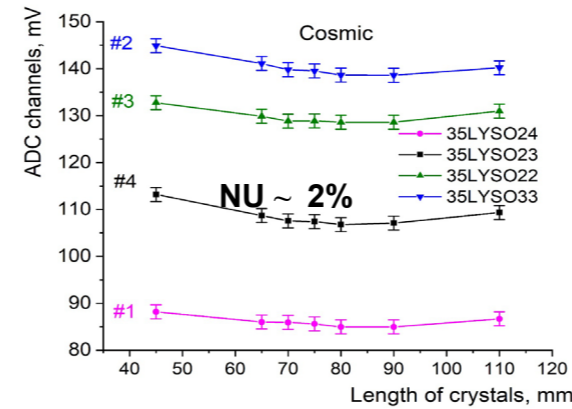
Thickness = 65 μm
 Refl. Coeff. = 0,99/0,1

One layer of paper

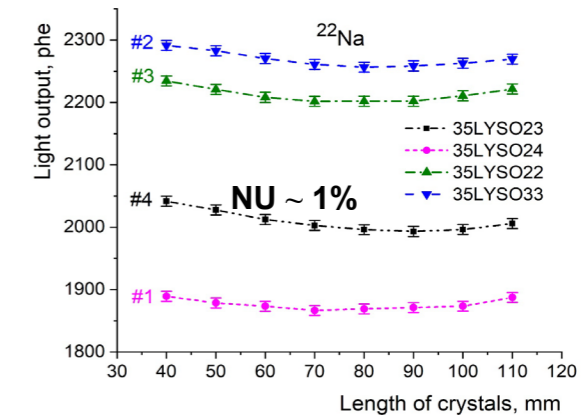
Thickness = 200 μm

Photomultipliers: 6

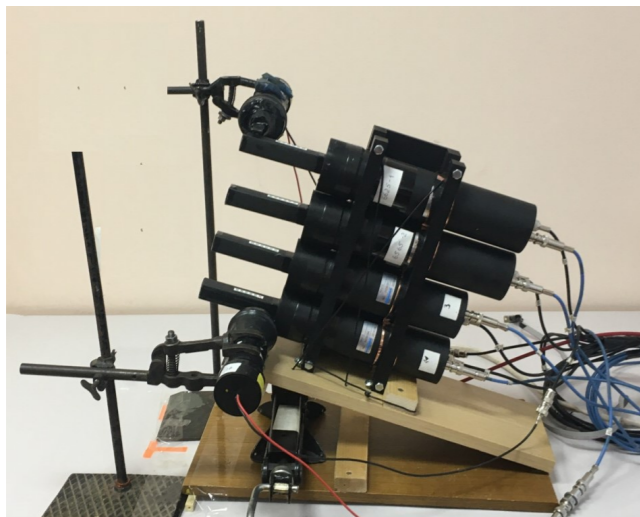
For Crystals (4) and coincidence (2)



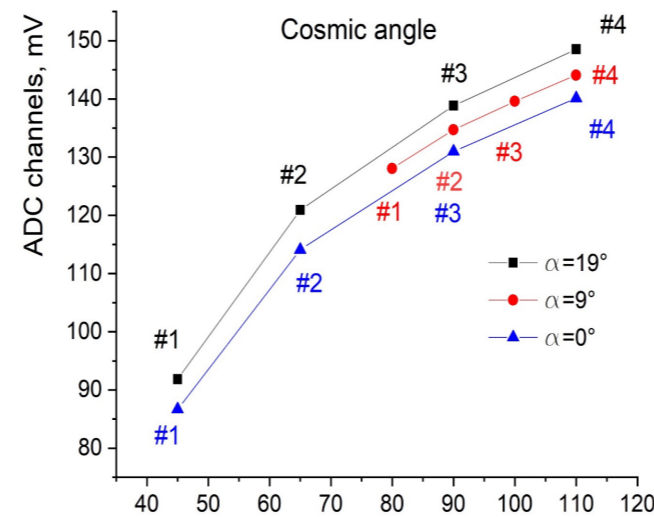
Non-uniformity of the prototype response along the crystals measured using cosmic muons



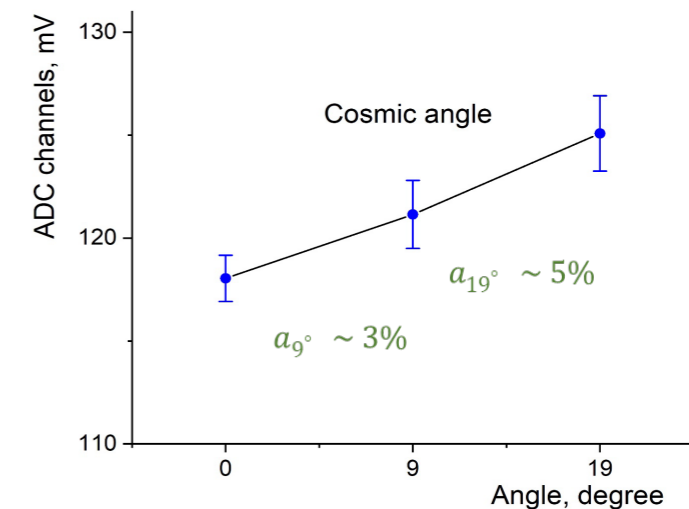
Non-uniformity of the LY along the crystals length, measured at an energy of 511 keV



Measuring setup: measurements under the angels



Prototype response non-uniformity, using cosmic muons for angles of 19 and 9 degrees relative to the end plane of crystals



Deviations of the non-uniformity response of crystals from their average values for angles of 9 and 19 degrees (non-uniformity of the response depending on the angle)

Сравнение кристаллов SG и JTC

- Образцы двух фирм SG и JTC имеют сравнимые сцинтилляционные параметры: высокий световыход, короткое время высвечивания и подходящее энергетическое разрешение.
- Распределение люминесцентных центров более однородно у кристаллов фирмы Saint-Gobain.
- Несмотря на то, что оптические свойства кристаллов фирмы SG немного лучше, чем фирмы JTC, при определенных условиях оба кристалла могут быть использованы в калориметре COMET эксперимента.

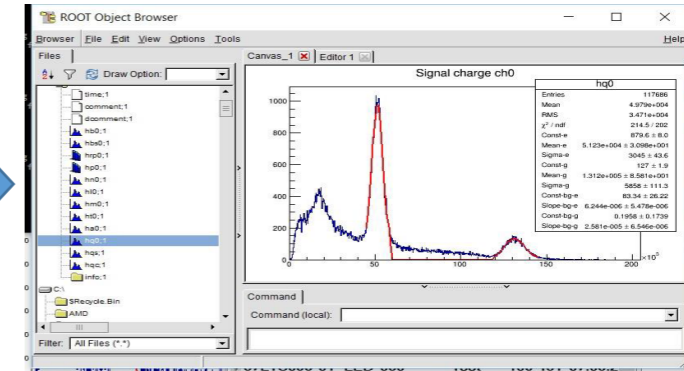
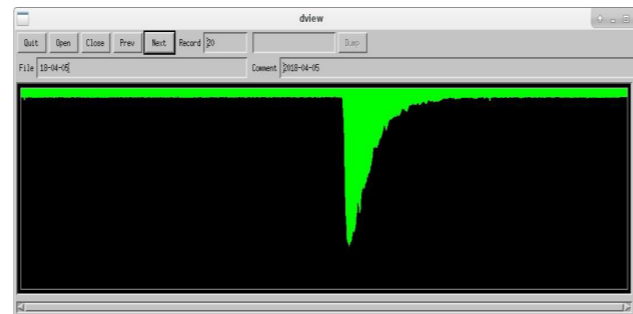
The LYSO crystal certification

A stand was created for certification of the crystals for the COMET calorimeter Passport for every crystal

The light output and the losses of the light along the crystal length for each crystal are measured.



The measuring setup

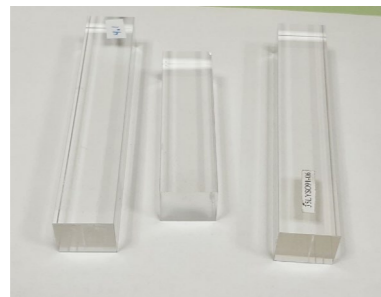


The spectrum of Na-22



Passport for every crystal

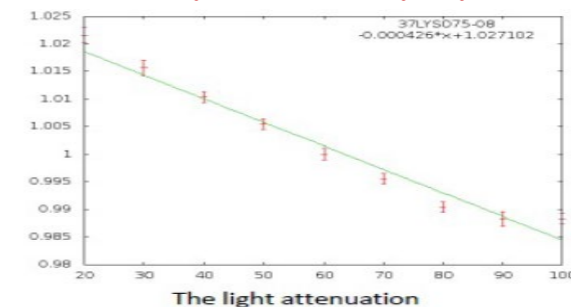
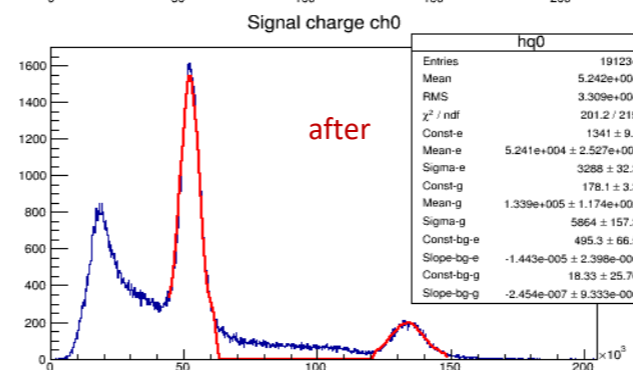
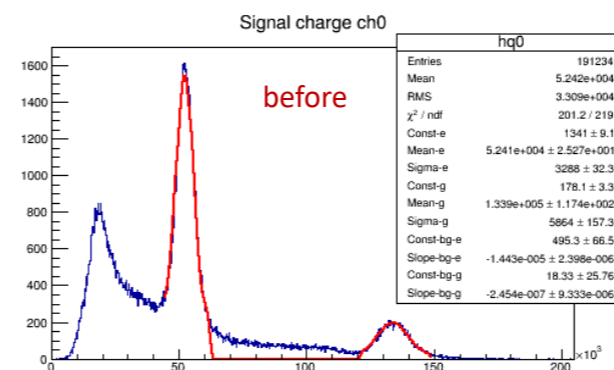
3 crystals
 $6 \cdot 10^{11}$ n/cm²
 (~50 Gy/cm²)



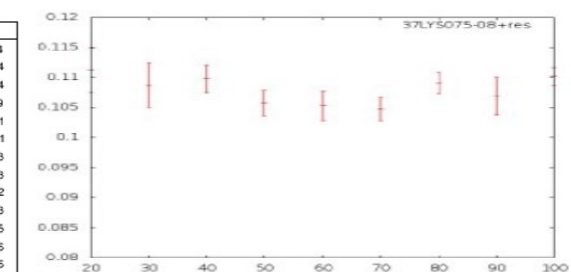
The middle crystal was cut because it had a defect in the form of the bubbles.

Radiation test

- Light output increased by about 1.1-1.2 times, but after 3 months returned to almost the initial value.
- Own radioactivity increased from 12 kHz to 30 kHz, but after 3 months fell to 15 kHz.



The light attenuation



The energy resolution

Light attenuation $\sim 0.426 \pm 0.08$ %/cm, 0.6 %/cm with good linearity.

More than 200 crystals have already been certified

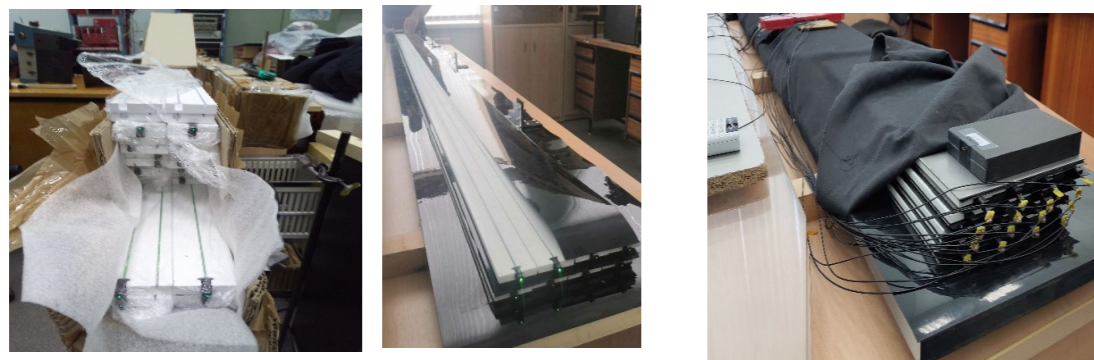
Cosmic Ray Veto (CRV) system

JINR participates in R&D, in design and in development of the CRV subsystem. This activity includes two parts:

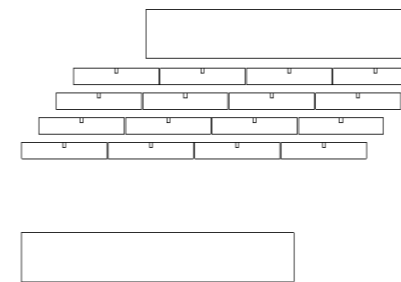
- to finalize design of the CRV with providing scintillation strips production, testing, CRV modules creation schedule and
- to design/create/test the electronics embedded to the scintillators.

Testing the efficiency for CRV module based on 7x40 mm² in cross section strip with one 1.2-mm WLS fiber

- In 2020, we did some R&D searches with such design (including the simulation and experimental results for 4x4 module) and was found that the design of CRV was based on 4-layers array of plastic scintillator strips 7x40 mm² (produced in “UNIPLAST”, Vladimir, Russia) in cross section and with one 1.2-mm in diameter WLS fiber glued in the groove along the strip will not be able to provide necessary 99.99% efficiency for muon registration.
- At the next stage we will use 56 3-m-long strips with different geometry and thickness.
- Also, we simulated using Geant 4 the muon registration probability of the CRV module with different pattern of shifts layers to each other and created the map of its distributions of transversal distance and of muon entrances angles with average light yield of 21 ph.e.



Assembly of the CRV prototype module for cosmic tests.

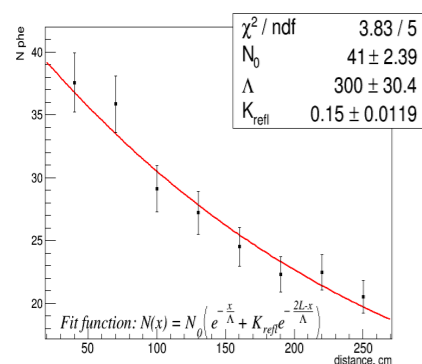


4x4 CRV module geometry for simulation with muons

Shift pattern	Overall efficiency
20-20-20 mm	0.99902
10-10-10 mm	0.99976
8-8-8 mm	0.99988
-----	-----
8-10-6 mm	0.99983
8-10-8 mm	0.99985
8-10-10 mm	0.99981
8-10-12 mm	0.99976
8-10-14 mm	0.99968
8-10-16 mm	0.99963
8-10-18 mm	0.99958

Simulation of the muon registration probability for modules with different pattern (21ph.e)

- Average light yield at 250 cm distance is 21 ph.e.
- **The overall module efficiency with real cosmic muons and “5 ph.e.” threshold is 99.69%**
- **Simulation**, for the overall module efficiency “5 ph.e.” threshold with this geometry, gave us (an **angle distribution of muon intensities is included**):
 99.74% for average light yield of 20 ph.e.
 99.93% for average light yield of 25 ph.e.



Attenuation Length:
Average Light Yield & strip length fitted with modified exponential function

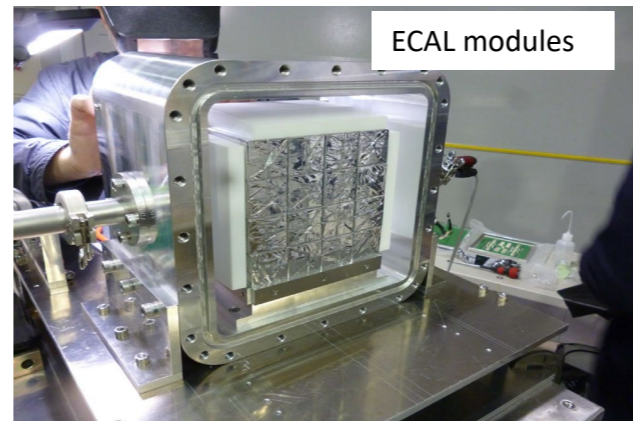
Our research showed that it is quite difficult to achieve 99.99% overall efficiency for CRV module based on 300x40x7 mm strips with 1 1.2-mm WLS fiber. Work on R&D +simulation to achieve the required efficiency (0.9999) of the experiment continues.

StrECAL system integration tests at ELPH in Tohoku

Energy range: 65 -145 MeV



Straw prototype

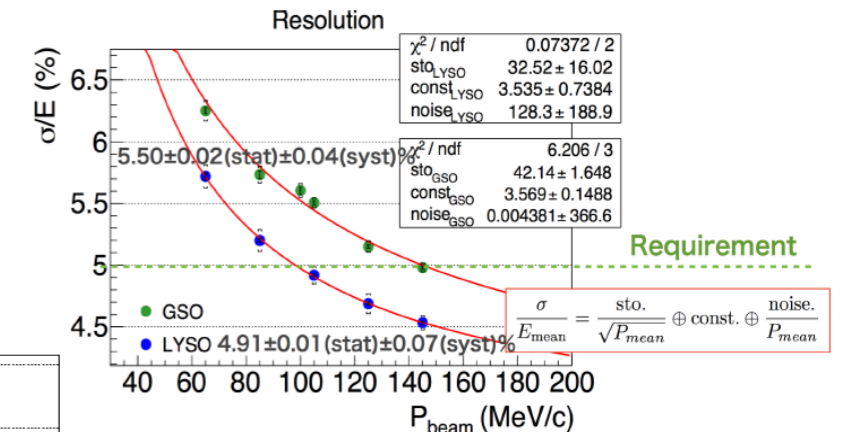


ECAL modules

ECAL prototype 64 (8x8) JINR cryst.

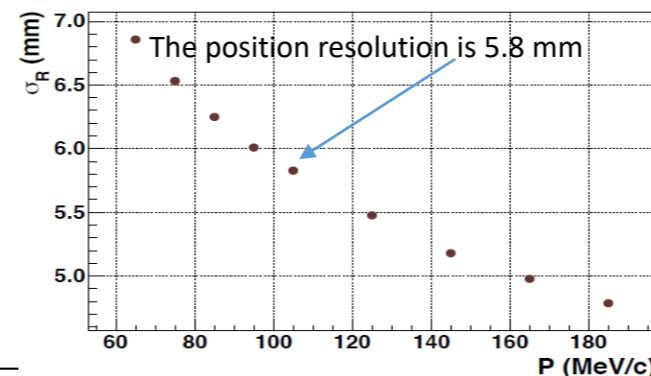
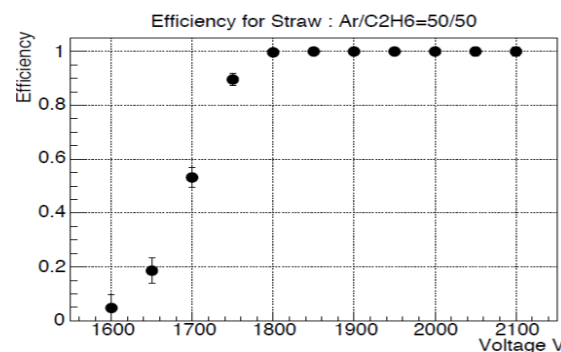
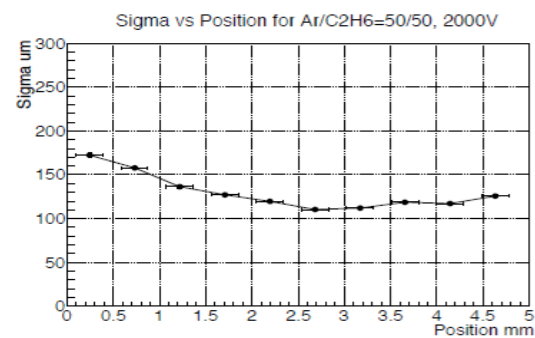
The energy resolution at 105 MeV for

- GSO - 5.5 ± 0.02 (stat) ± 0.04 (syst) %
- LYSO - 4.91 ± 0.01 (stat) ± 0.07 (syst) %



At 105 MeV/c, the energy resolution varying from 3.8% to 4.8%, depends on where the electron hits (center, border, corner) on the ECAL

- The results of ECAL prototype test**
- Energy Resolution 4.8% @105MeV
 - Position resolution < 10 mm @105 MeV
 - Timing resolution < 1.0 nsec



The position resolution varying from 5.3 mm to 8.5 mm, depends on where electron hits (center, border, corner)

The results of straw efficiency and spatial resolution HV 1800- 2000) for Argon/Ethan

- $\epsilon > 96\%$
- $\sigma \sim 119 \mu\text{m}$
- Momentum resolution $\sim 180\text{-}200 \text{ keV/c}$

The results of StrECAL system integration beam tests meet all the requirements of the experiment

Current Status

Straw tube Tracker

- the straw tubes were already mass-produced and checked.
- the 1st station of the straw tracker system is ongoing

ECAL

- in the process to purchase ~500-600 LYSO crystal for Phase-I
- the design work for the real detector is completed, and in the near future the assembly of calorimeter will start

Schedule of works on the project in 2022-2024

- Participation in the preparation, engineering and physics run, the data acquisition and analysis of Phase- α , 2022-2023
- Finalization assembling, testing, calibration, installation, cosmic test and maintenance of the straw detector for Phase-I, 2022-2023
- R&D program for production of the straw tubes of 12 μm wall thickness and 5 mm diameter. Measuring of all mechanical properties and development of standards for quality control of manufactured of the 5 mm brand-new straw tubes, 2022 -2023
- Creating a straw prototype (64 channels) with new tubes (12 μm , 5 mm) and measurement on the beam, 2022 - 2023
- Production of straw tubes (about 1000 pcs) for full-scale prototype, 2022
- Production of a full-scale straw station for Phase-I, with new tubes (12 μm , 5 mm), and measurements on the beam, 2022-2024
- Preparation for mass-production and testing of straw tubes for Phase-II, 2024
- Test (certification) of the LYSO crystals, to be used in the calorimeter, 2022-2023
- Development and optimization of a crystal calibration method for a COMET calorimeter, given the features of the experiment: the presence of a magnetic field and high resolution calorimeter, 2022-2023
- Participation in the calorimeter designing, assembling, installation, cosmic test and maintenance, 2022-2023
- Participation in the assemble and maintenance of the CRV for Phase-I, 2022-2023
- Participation in assembling, testing, installation and maintenance of whole detector system for Phase-I, 2022-2023
- Complex detector system (tracker, calorimeter, etc.) simulation, 2022-2024
- Participation in the engineering and physics run, 2023-2024
- Participation in the data acquisition and analysis, 2023-2024
- Participation in the beam tests of the detector components for Phase II, 2023-2024

The responsibility of the JINR in the COMET

- The JINR group is a single one in the COMET collaboration, which is capable to produce thin-wall straw tubes. Therefore, we are **fully responsible** for manufacturing of all straw tubes. Different procedures of the tube tests on pressure, gas leakage and elongation have been also updated in accordance with the COMET requirements and new test standards have been established.
- JINR takes **full responsibility** for the next step to this direction, carrying out of R&D works of straw tubes for the COMET Phase-II, with the tubes of 5 mm diameter and 12 μ wall thickness. For this purpose, we are preparing a new straw line in DLNP.
- JINR physicists **together with the KEK colleagues take full responsibility** in assembling, tests and installation of the full-scale straw tracker for Phase-I. Appreciating the crucial contribution of the JINR to the creation of the straw tracker, a member of JINR-COMET team was elected as one of the **coordinator for the straw tracker system**.
- JINR takes **full responsibility** in production of a full-scale straw station for Phase-I, with new type of straw tubes.
- JINR takes **full responsibility** for development and optimization of a crystal calibration method for the calorimeter to be used in COMET Phase I and Phase-II.
- Physicists from JINR take **full responsibility** for the certification of crystals, and are **the leaders** in the R&D work.
- **JINR together with KEK and Kyushu University takes full responsibility** for assembling, testing, installation and operation of the calorimeter.
- JINR physicists have implemented a full-scale R&D program to create a cosmic veto system. The program was completed successfully, and the results were reported at the collaboration meetings. Based on these results, all the parameters and methods for creating the CRV are determined. Also, the **main responsibility** in the assembly, testing and installation of the CRV for Phase-I will be on scientists from JINR. Based on these, a member of JINR-COMET group was elected as the CRV **team leader**.

10. Estimation of human resources

COMET JINR group members (bold – new members)

#	Name	FTE	Position	Work (apart common duties like shifts)
1	G. Adamov	0.7	Junior researcher PhD student	Hardware and Software tools development, data quality control, analysis
2	A.M.Artikov	0.5	Senior scientist	Hardware development and support of CRV
3	D. Aznabayev	0.3	Junior researcher	Theoretical issues, physics analysis
4	D. Baygarashev	0.4	Junior researcher	Data quality control, calibration, physics analysis
5	A. Boikov	0.3	Junior researcher PhD student	CRV electronics, R&D COMET
6	D. Chokheli	1.0	Senior scientist	CRV construction, Leader of COMET-CRV detector system
7	V.N. Duginov	0.8	Deputy head of department	Calorimeter development, analysis
8	T.L. Enik	0.3	Senior scientist	Hardware development and support
9	I.L. Evtoukhovitch	0.9	Senior engineer	Hardware development and support
10	D. Goderidze	0.5	Junior researcher PhD student	Software/analysis
11	P.G. Evtoukhovitch	1.0	Senior scientist	Coordinator of Straw Tracker detector system
12	A. Issadykov	0.3	Senior scientist	Theoretical issues, physics analysis
13	V.A. Kalinnikov	1.0	Leading scientist	Calorimeter development, MC, analysis
14	E.S. Kaneva	1.0	Engineer	Hardware/software
15	X. Khubashvili	0.9	Engineer	Hardware development and support
16	A. Khvedelidze	0.4	Leading scientist	Theoretical issues, models development
17	A. Kobey	0.5	Master student	Calorimeter development, MC, analysis
18	G.A. Kozlov	0.3	Leading scientist	Theoretical issues, models development
19	A.S. Moiseenko	1.0	Scientist	Hardware development and support
20	A.V. Pavlov	1.0	Junior researcher PhD student	MC, Data quality control, physics analysis
21	B.M. Sabirov	1.0	Scientist	Hardware development and support
22	A.G. Samartsev	0.4	Senior engineer	Hardware development, detector design
23	A.V. Simonenko	1.0	Senior scientist	CRV creation and maintenance
24	V.V. Tereschenko	0.3	Head of group	CRV electronics, R&D COMET
25	S.V. Tereschenko	0.5	Engineer	CRV electronics, R&D COMET
26	Z. Tsamalaidze	0.8	Head of sector	Leader of COMET-JINR group, IB represent.
27	N. Tsverava	1.0	Junior researcher PhD student	Hardware development, calibration, analysis
28	I.I. Vasilyev	0.3	Junior researcher	Calorimeter R&D and tests
29	E.P. Velicheva	1.0	Senior scientist	Calorimeter development, MC, analysis
30	A.D. Volkov	1.0	Scientist	Hardware development
31	I. Zimin	0.5	Junior scientist PhD student	Software, simulation, analysis
	Total FTE	20.9		

The average age of the JINR COMET team is ~ 44 years, including 1 master and 9 junior researchers.

15. Estimation of costs and resources

Schedule proposal and resources required for the implementation of the **Project COMET**

Expenditures, resources, financing sources		Costs (k\$) Resource requirements	Proposals of the Laboratory on the distribution of finances and resources			
			2022	2023	2024	
Expenditures	Computers (Simulation, data analysis)	30	10	10	10	
	Laboratory electronic devices	110	30	30	50	
	Materials and Equipment for: - The R&D and construction of CRV modules (scintillation strips, SiPM, fibers and other components), - The straw tubes R&D, straw tubes production and prototype creation (equipment for straw tube stand, optical sensors, pressure sensors, printing plastic for the 3D, other components). - The R&D and construction of ECAL.	190	70	70	50	
Required resources	Standard hour	Resources of:				
		- Laboratory design bureau; - JINR Experimental Workshop;	600 h 900 h	200 h 300 h	200 h 300 h	200 h 300 h
		- Laboratory experimental facilities division; - electron accelerator; reactor	1050h	350 h	350 h	350 h
Financing sources	Budgetary Resources	Budget expenditures including foreign-currency resources.	690	230	230	230
	External resources	- Grant of the Plenipotentiary of Georgia	30	10	10	10
		- Program of the JINR-Belarus Cooperation	15	5	5	5
		- Grant of the Plenipotentiary of Kazakhstan	15	5	5	5

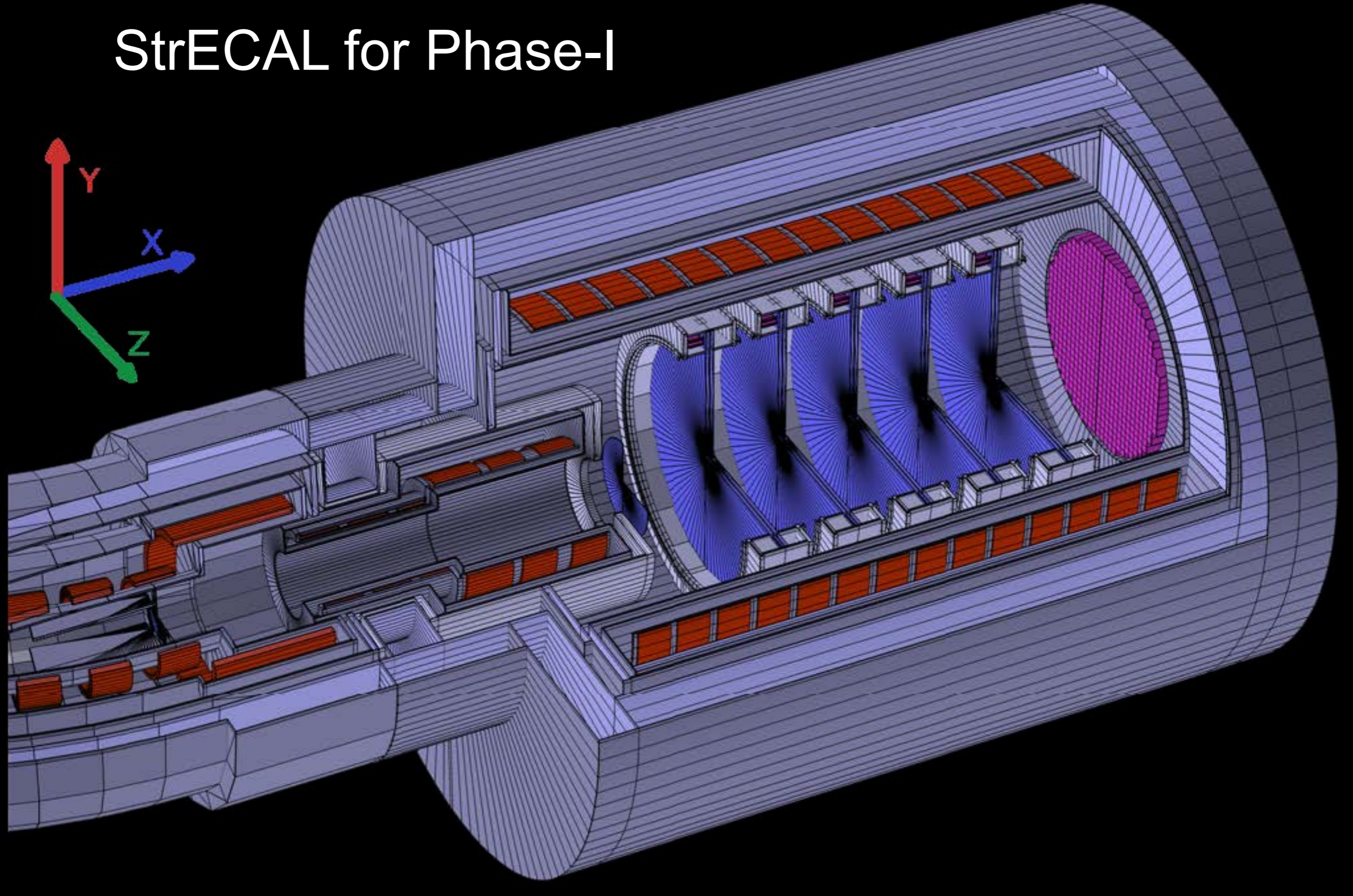
Estimated expenditures for the **Project COMET**

	Expenditure items	Full cost	2022	2023	2024
	Direct expenses for the Project				
1	Accelerator, reactor	1050 h	350h	350h	350h
2	Computers	-	-	-	-
3	Computer connection	-	-	-	-
4	Design bureau	600 h	200 h	200 h	200 h
5	Experimental Workshop	900 h	300 h	300 h	300 h
6	Materials (k\$)	190	70	70	50
7	Equipment (k\$)	140	40	40	60
8	Construction/repair of premises	-	-	-	-
9	Research operation fee (k\$)	60	20	20	20
10	Travel allowance (k\$)	300	100	100	100
	Total direct expenses (k\$)	690	230	230	230

Thank you for attention!

BACKUP

StrECAL for Phase-I



CyDet for Phase-I

