

Development of the StrECal System for COMET Phase-I

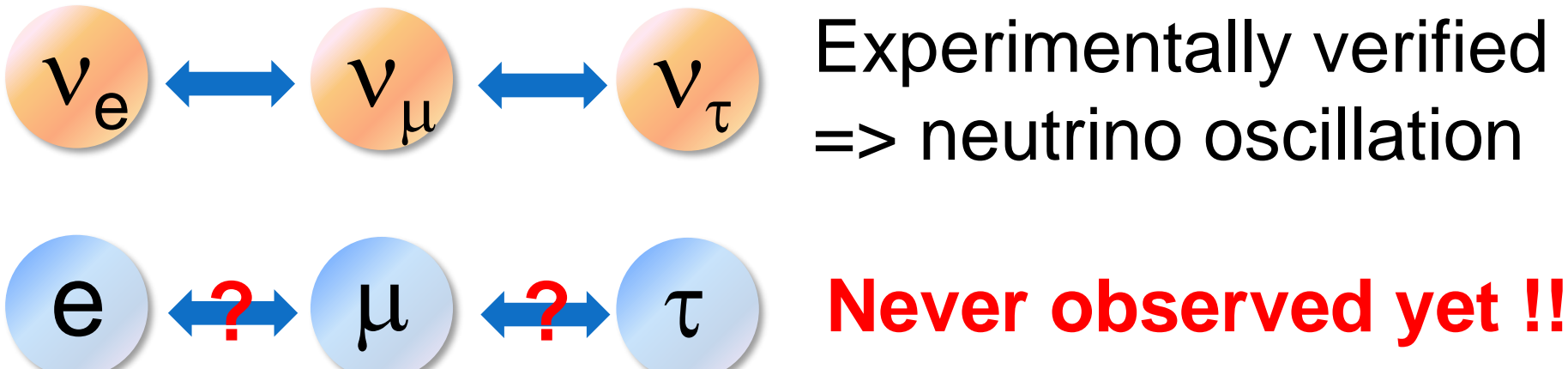


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Introduction

Lepton Flavor Violation (LFV)

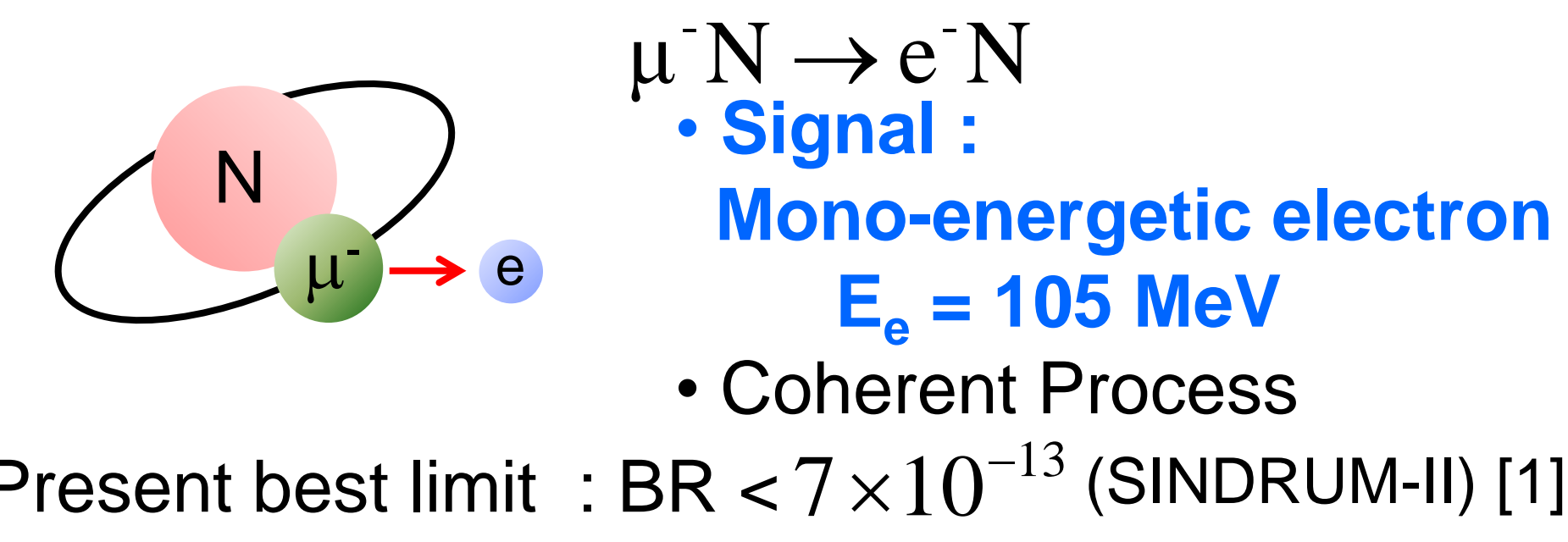


Standard Model (SM) + ν mass:
Branching ratio (BR) $\sim O(-54)$
Impossible to observe...

Discovery of charged LFV indicates beyond SM

Beyond SM:
BR $\sim O(-13) - O(-16)$ Possible to observe

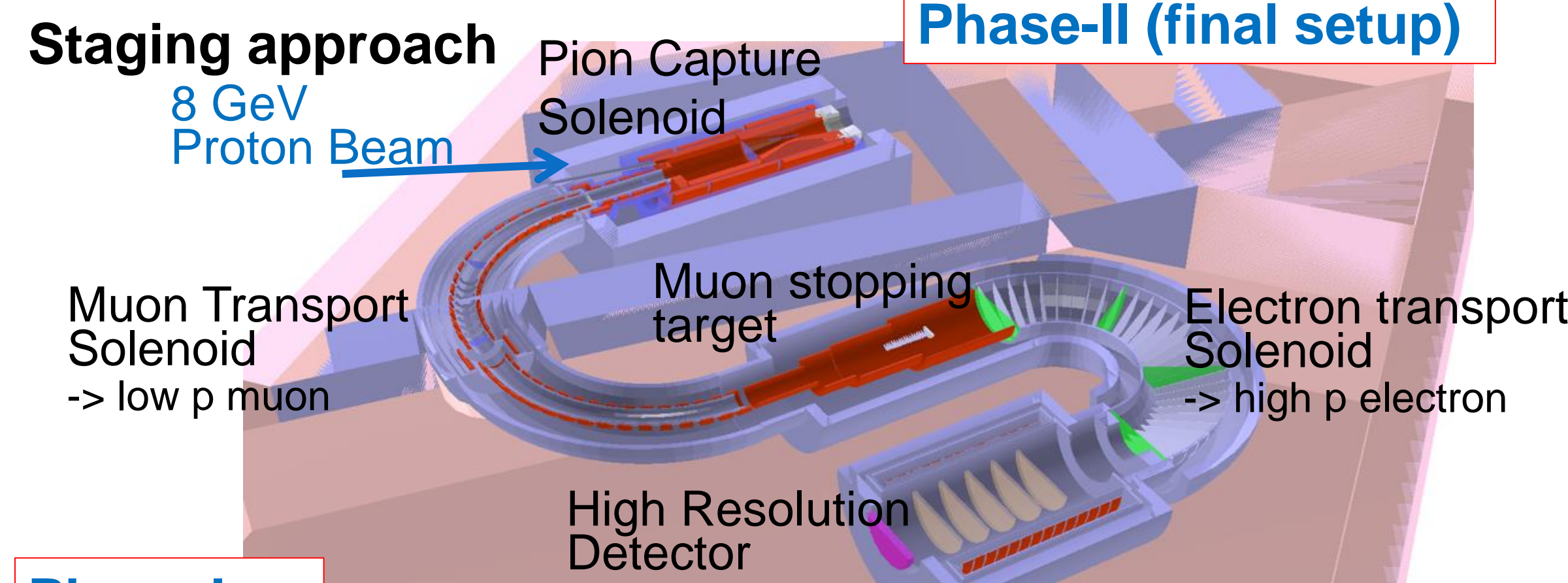
μ -e conversion



COMET experiment

(COherent Muon to Electron Transition) [2]

Search for μ -e conversion @ J-PARC



Phase-I
1st 90 deg.

- High-intensity pulsed beam at J-PARC
- Special muon transport with long line using super conducting magnet
- High momentum resolution detectors

Goal sensitivity : $\sim 10^{-17}$

improve by a factor of 10000 to current limit!

Phase-I goal

- Background study for the full COMET (Phase-II)
- Search for μ -e conversion (sensitivity of 10^{-15})

StrECal system

Requirements

Detector should be operational in vacuum and B-field of 1 T.

Electron tracker

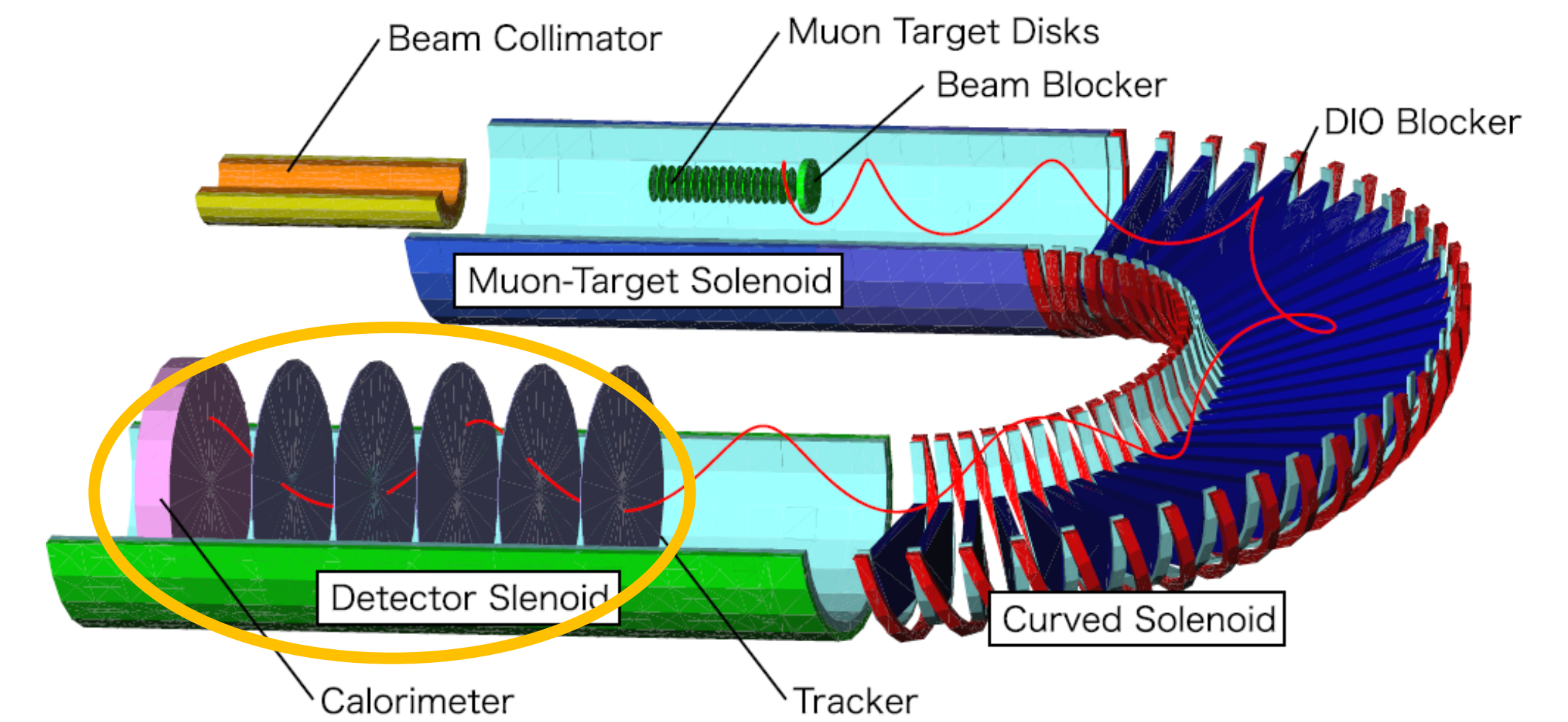
- Detection of particle track in B-field \rightarrow momentum
- Momen resolution:
 $\sigma_p < 200 \text{ keV/c}$ for $105 \text{ MeV/c } e^-$
- Spatial resolution : $< 200 \mu\text{m}$
- Rate : $< 100 \text{ kHz}$

Calorimeter

- Detection of timing, position, and energy of particles \rightarrow trigger, energy, and particle identification with tracker
- Energy resolution : $\sigma_E < 5\%$ for $105 \text{ MeV/c } e^-$
- Position resolution : $< 1 \text{ cm}$
- Time response : $< 100 \text{ ns}$

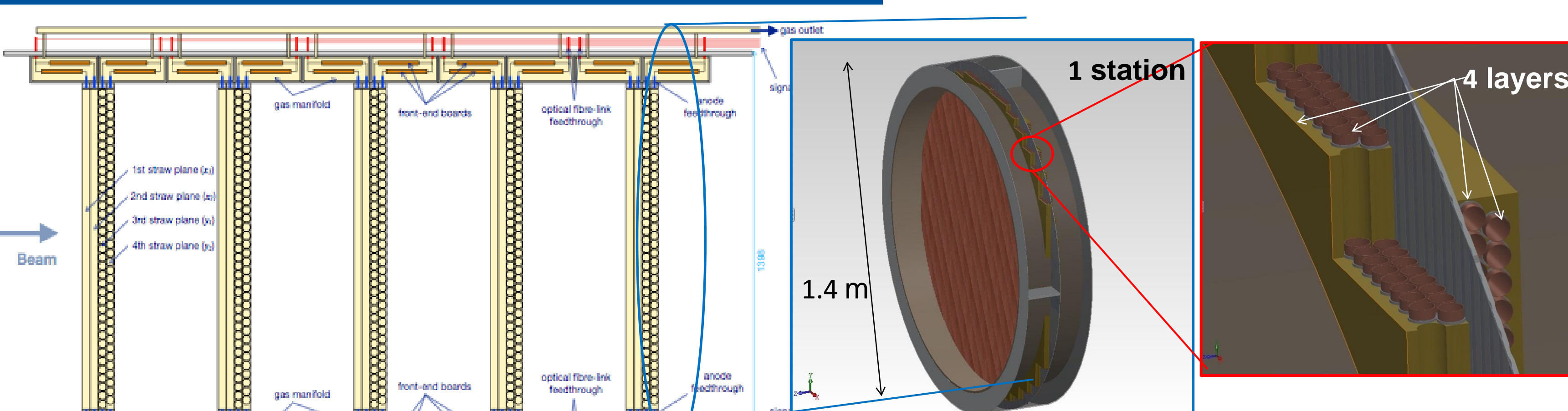
On the basis of the requirements, we adopted "StrECal" system for detection and identification of charged particles.

StrECal = Straw tube tracker + Electro-magnetic Calorimeter



Straw tube tracker

Concept

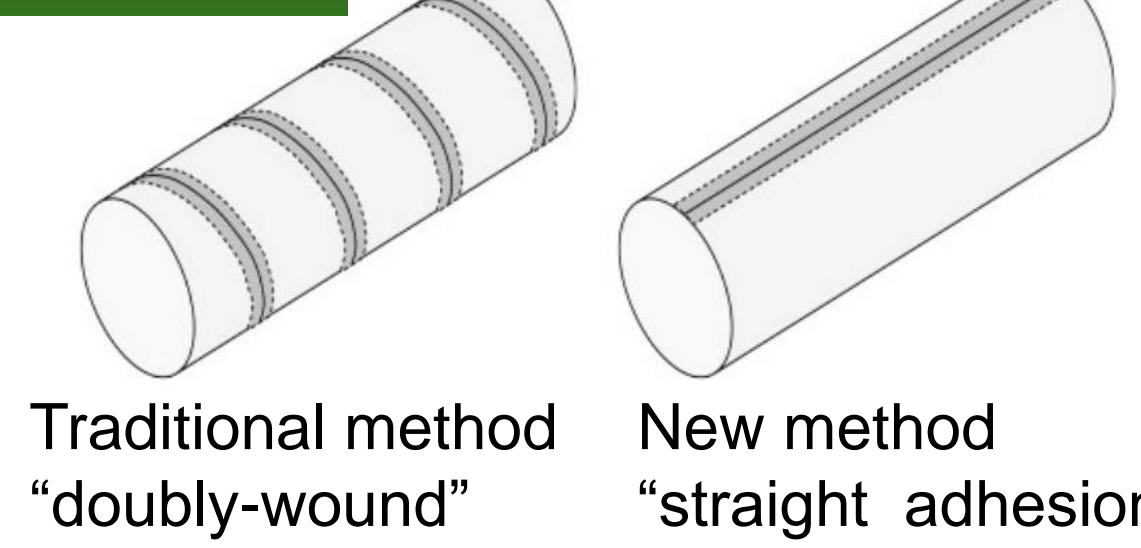


Parameter	Specifications
Straw tube diameter	9.75 mm
Straw tube length	0.6 - 1.2 m
Straw tube thickness	20 μm
Cathode	Al 70 nm
Number of channels	24000 ch
Position resolution	$\sim 100 \mu\text{m}$
Drift velocity (Ar:C ₂ H ₆ =50:50)	4.8 cm/ μs

- Straw tube tracker consists of 5 stations.
- 5 stations consist of 4 layers of straw tube.
2 layers for x-coordinate and 2 layers for y-coordinate, each layer is staggered by half a cell to solve the left-right ambiguity.
- All tracker modules are installed in vacuum.
- Trigger is provided by the ECal.

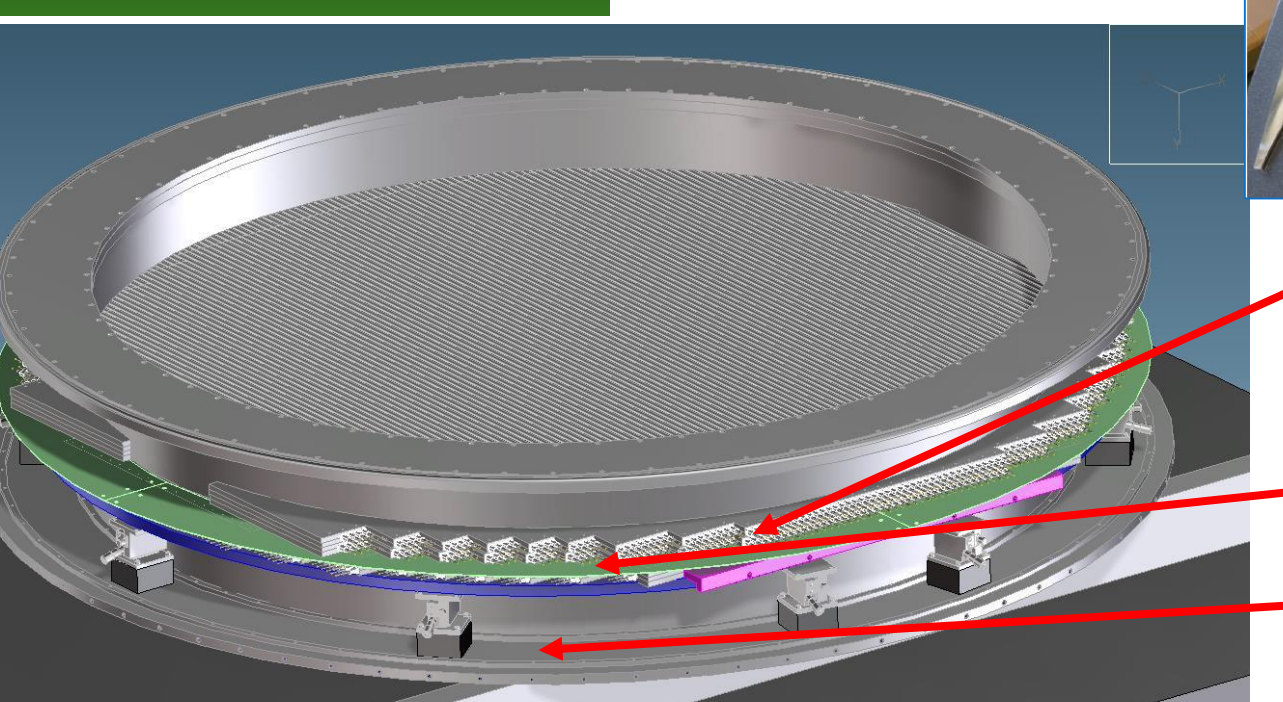
Status on tracker construction

Straw tube



- New adhesion style developed by JINR group for NA62 exp. at CERN, which was enabled by ultrasonic welding method, was adopted for COMET.
- Optimization of Phase-I Straw (20 μm thickness + 70 nm Al deposition) was successfully done.
- All the straws for Phase-I (>2400) were already constructed.

Straw station



- Inner structure
 - All parts were prepared.
 - Outer structure
 - Final design is ongoing.
 - Straw end-plugs
 - All parts were prepared.
 - Glueing test is ongoing.
- Assembly work will start soon!

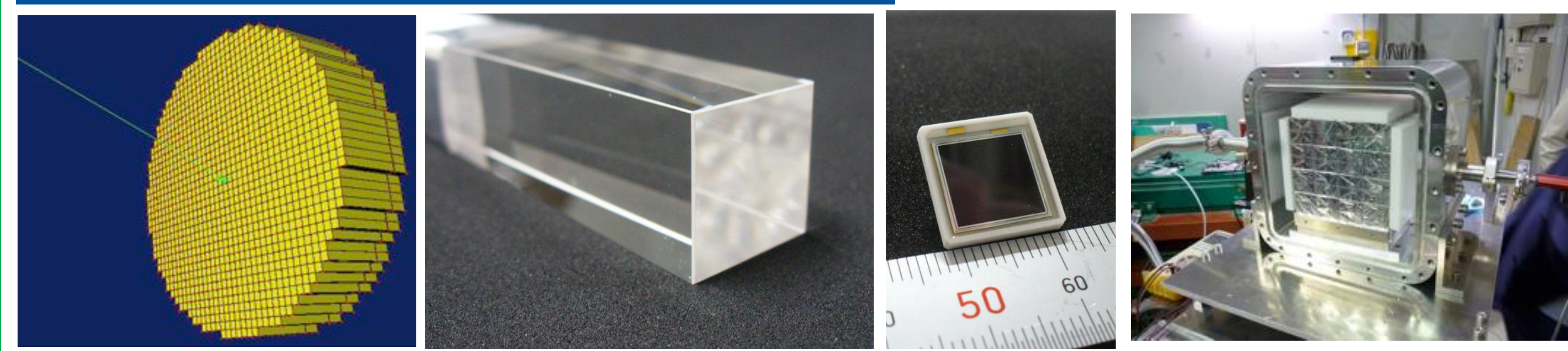
Frontend electronics



- ROESTI : Read Out Electronics for Straw Tube Instrument
- Pileup identification \rightarrow WD
 - Timing resolution $\rightarrow < 1 \text{ ns}$
 - Gain $\rightarrow 1 \text{ V/pC}$
 - # of feedthrough \rightarrow Daisy chain
 - Radiation hardness $\rightarrow n:10^{12} \text{ n/cm}^2 \text{ gamma:1kGy}$
 - Semi-final version was developed and evaluated, which satisfied our requirements [3,4].
 - Design of final version is ongoing.

ECal

Concept

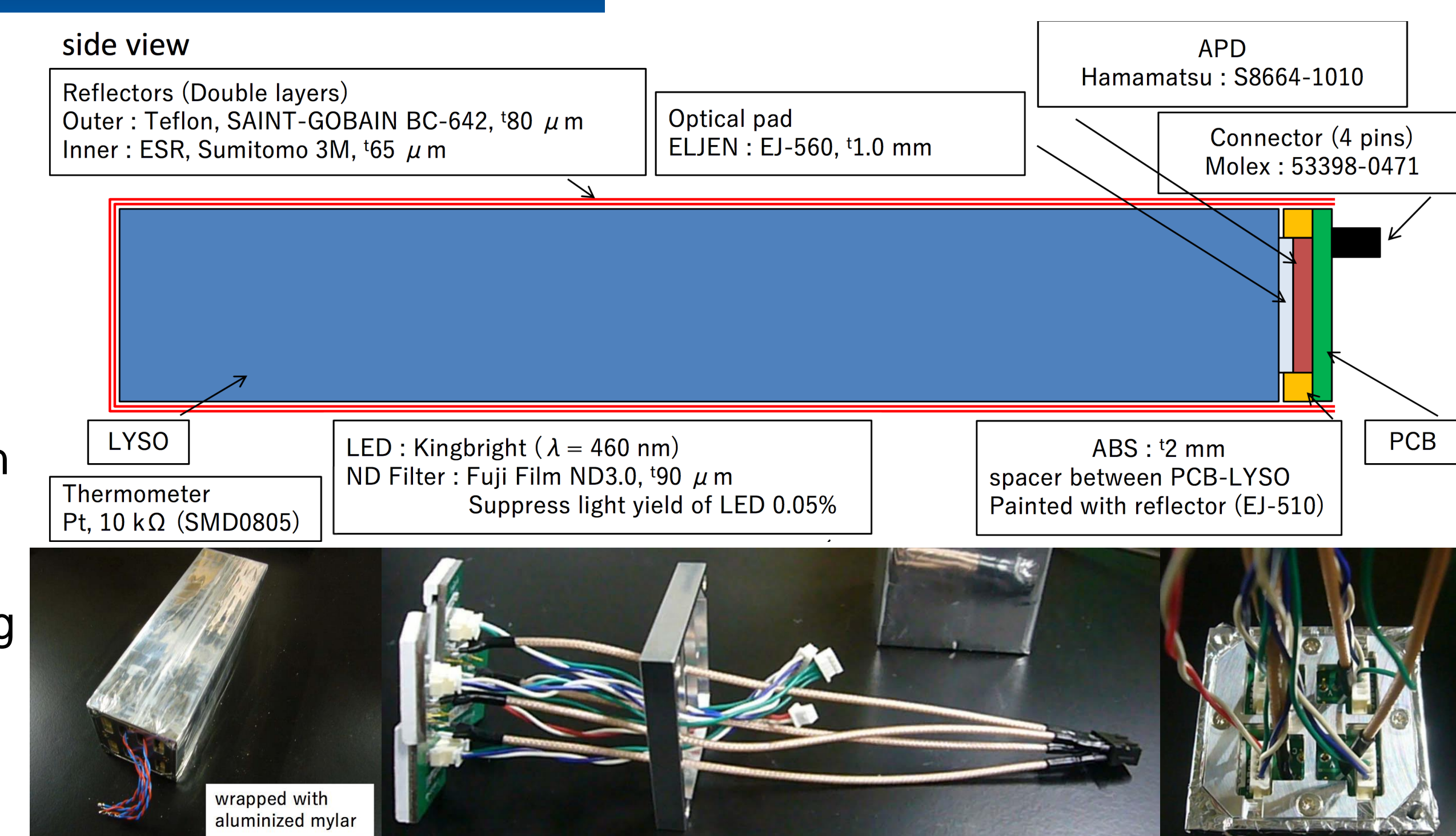


- ECal is installed in vacuum at downstream side of straw tracker.
- Crystal calorimeter, LYSO, is adopted, which has high density and high light yield.
- Crystal size is $2 \times 2 \times 12 \text{ cm}^3$.
- APD (10 x 10 mm², Hamamatsu S8664-1010) is used for photon-readout, which is operational in B-field.
- Prototypes with 7 x 7 crystals of LYSO were developed and evaluation was almost done.

Status on ECal construction

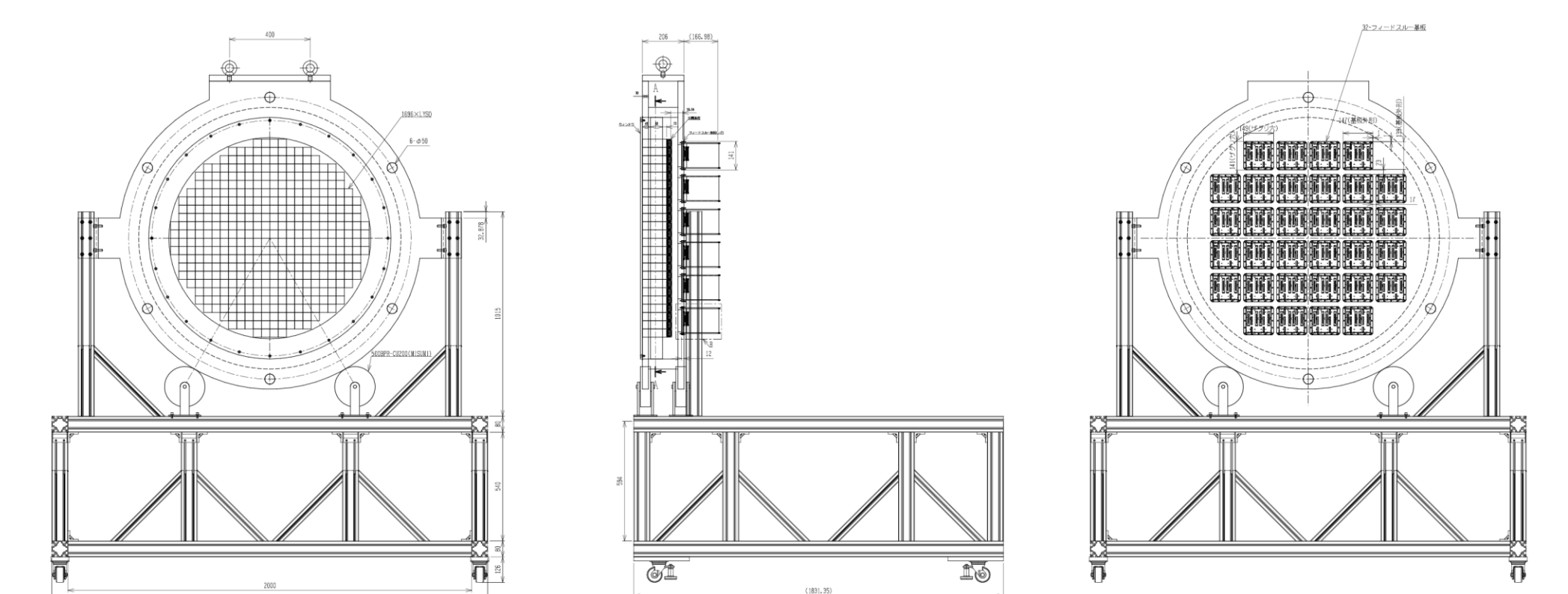
ECal module

- 2x2 crystals are put together into 1 module.
- Design of the module were completed except for minor part.
- Performance evaluation of the module was almost done.
- QA system is now being constructed.
- Mass production is ongoing.

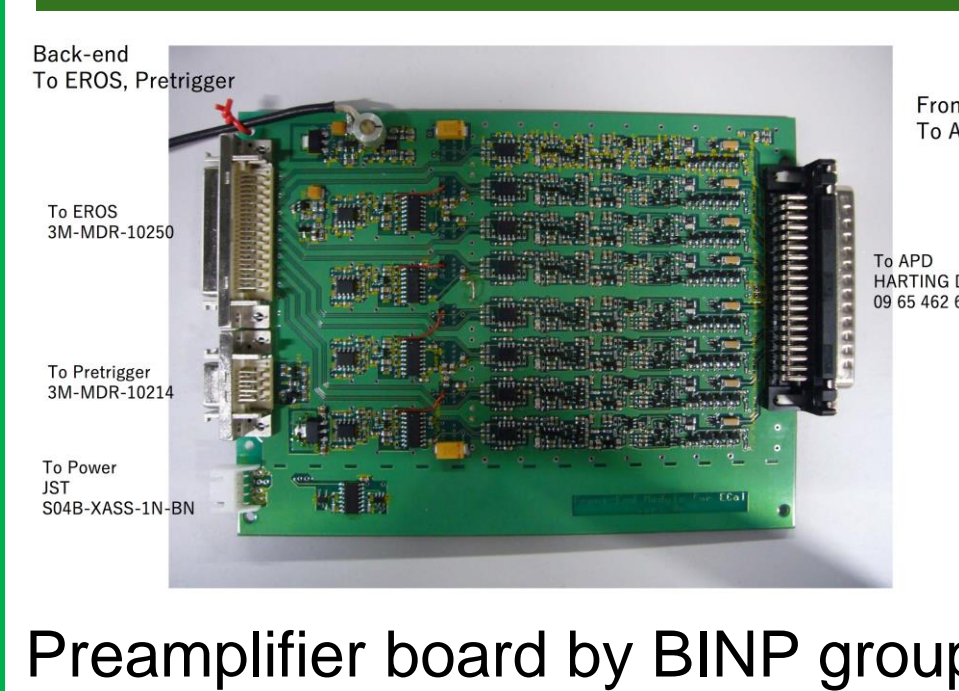


Support structure

- Design of support structure for ECal is ongoing.
- Construction for installation and integration scheme is also ongoing.



Frontend electronics



EROS : Ecal Read Out System



- EROS has the same function as ROESTI except for preamplification.
- It was confirmed using prototypes that performance satisfied our requirements.
- Design of final versions are ongoing.

Summary & Future work

Summary

- New charged LFV search at J-PARC, COMET, is planned.
- COMET has staging approach, phase-I and II.
- Developments and constructions of StrECal system for COMET phase-I is ongoing.

Future work

- Assembly work for straw tracker will start soon.
- Construction of ECal will start soon.
- Integration will be done.

Acknowledgment

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[References]

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