E21 COMET Report

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on behalf of the COMET collaboration

January 14th, 2012

Progress Report for COMET

Progress Report
of
Experimental Search for Lepton Flavor Violating $\mu^- - e^-$
Conversion at Sensitivity of 10^{-16}
with a Slow-Extracted Bunched Proton Beam
(COMET)

J-PARC E21

Jan 13, 2011

Abstract

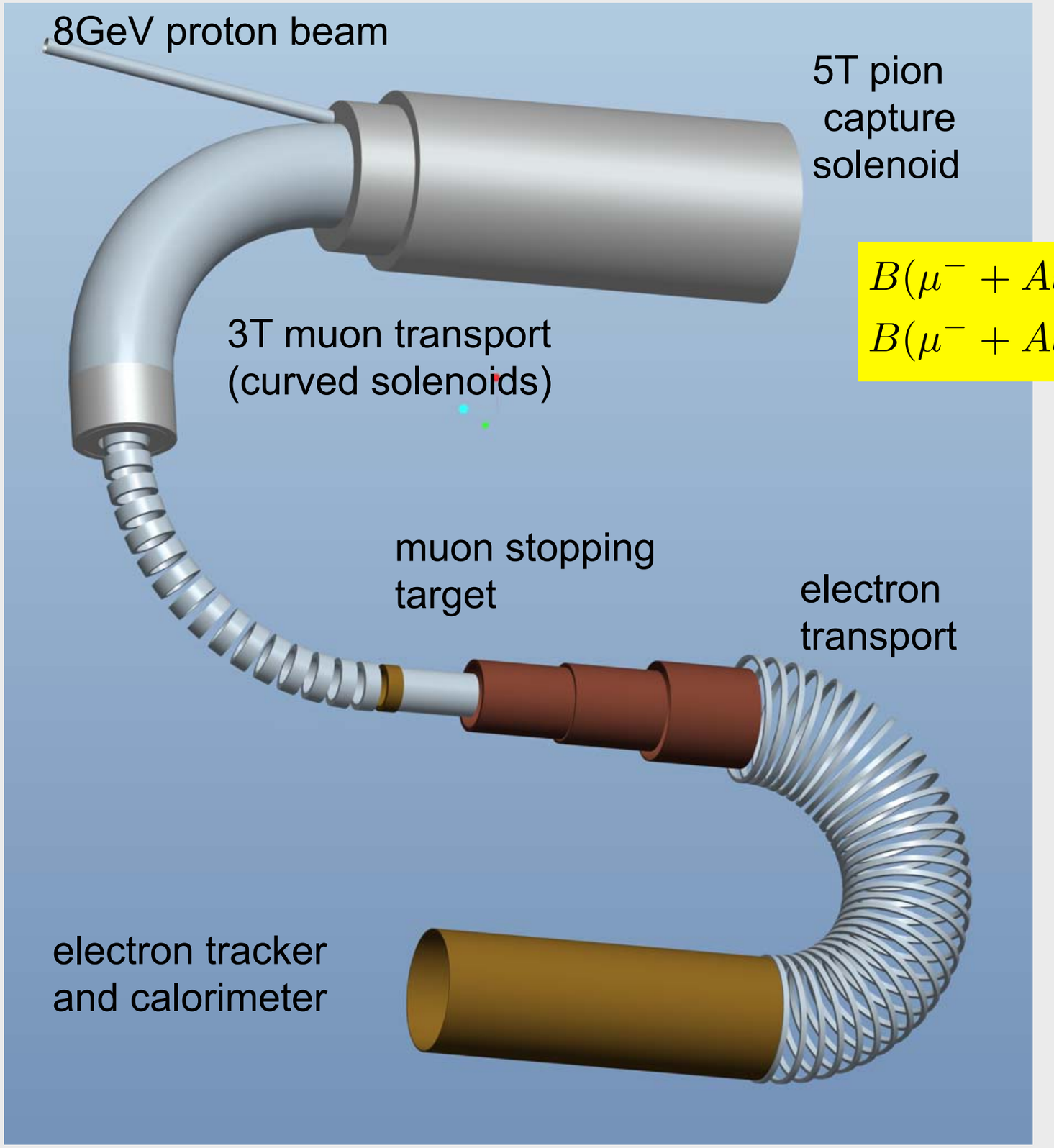
We describe the progress made since the last PAC presentation in realising the COMET experiment that is seeking to measure neutrinoless muon to electron conversions with a sensitivity of 10^{-16} using a slow-extracted bunched proton beam at J-PARC.

The progress report of January, 2012 has been distributed to the J-PARC PAC.

Outline

- What is COMET (J-PARC E21)?
- COMET TDR status
- Highlights of COMET R&D
  - Solenoid Magnet Design
  - Detector R&D
  - Others
  - COMET_g4
- COMET Collaboration
- Response to MTF/JPNC proposal (staging approach)
- Summary

What is COMET?



Experimental Goal of COMET
J-PARC E21

$$B(\mu^- + Al \rightarrow e^- + Al) = 2.6 \times 10^{-17}$$
$$B(\mu^- + Al \rightarrow e^- + Al) < 6 \times 10^{-17} \quad (90\% C.L.)$$

10,000 improvement over the previous

- 10^{11} muon stops/sec for 56 kW proton beam power.
- C-shape muon beam line and C-shape electron transport followed by electron detection system.
- Stage-1 approved from the J-PARC PAC in 2009.

COMET Technical Design Report (TDR)

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Technical Design Report
for
Experimental Search for Lepton Flavor Violating $\mu^- - e^-$
Conversion at Sensitivity of 10^{-16}
with a Slow-Extracted Bunched Proton Beam
(COMET)

J-PARC E21

January 13, 2012

COMET Technical Design Report (TDR) has been almost complete. It has already about 200 pages. Some highlights in TDR have been included in the progress report.

Contents

COMET Technical Design Report (TDR)

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January 13, 2012

COMET Technical Design Report (TDR) has been almost complete. It has already about 200 pages. Some highlights in TDR have been included in the progress report.

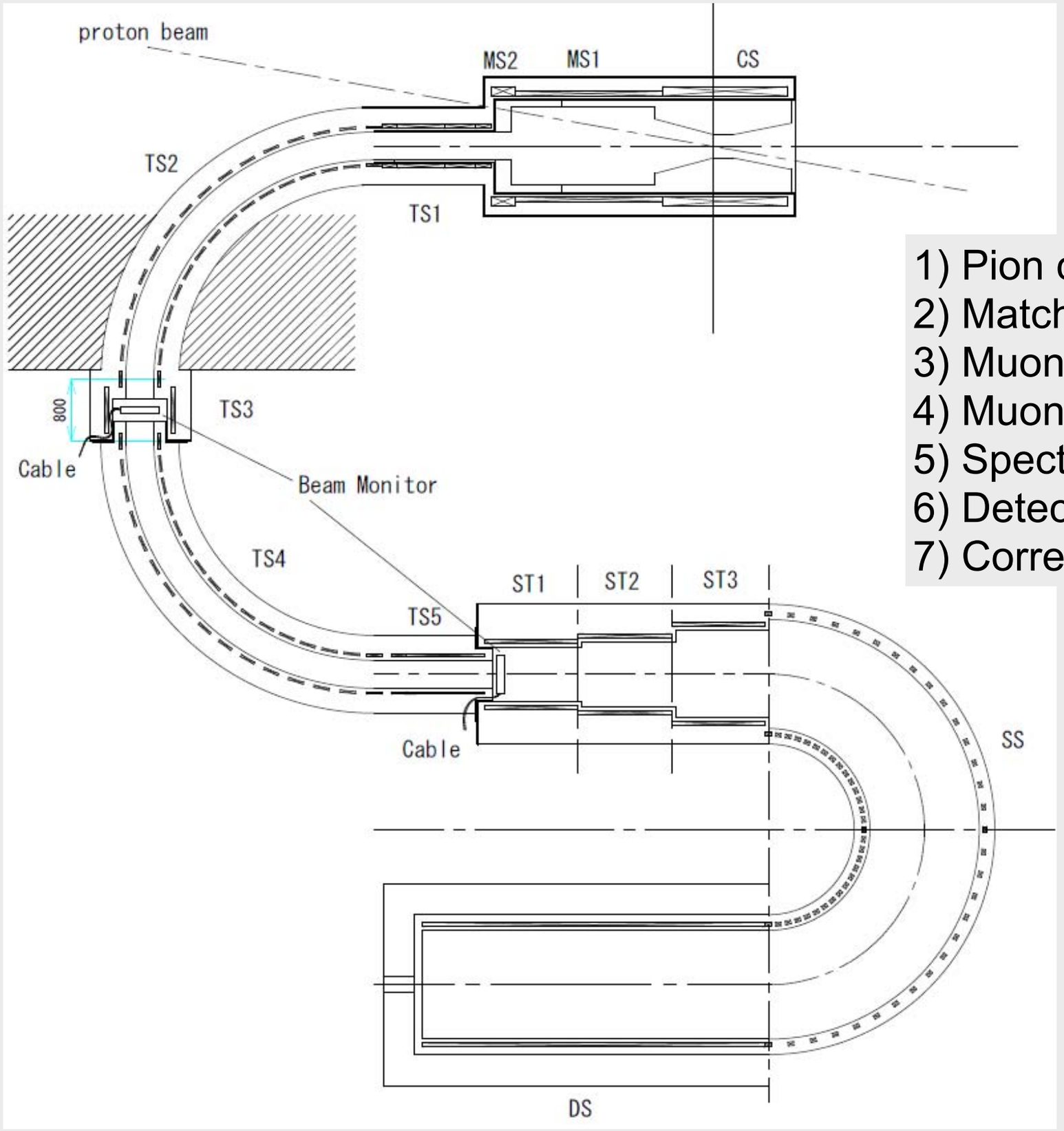
Submit by the March J-PARC PAC

Contents

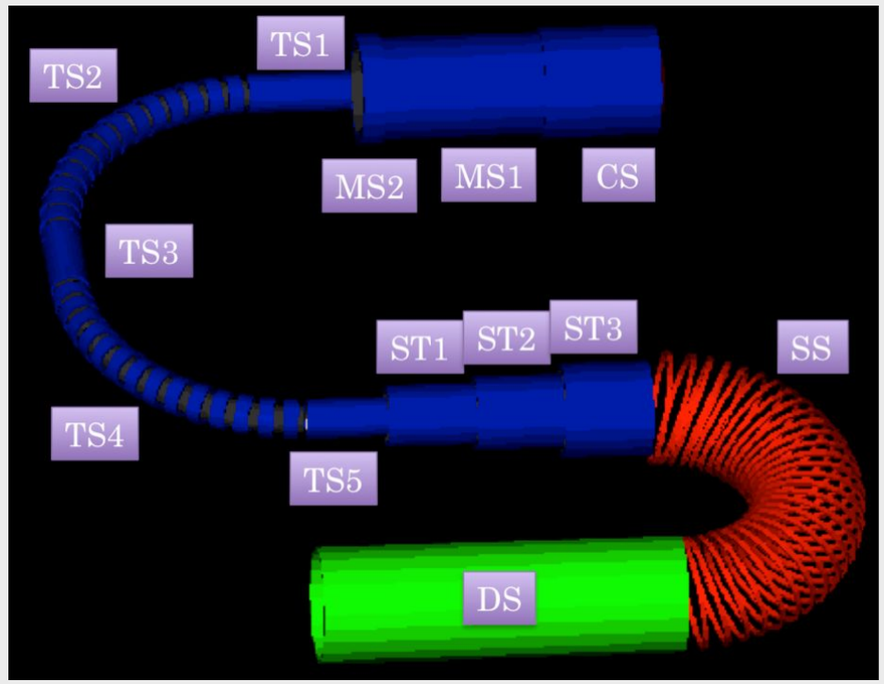
Highlights of COMET R&D

Superconducing Solenoid Magnets

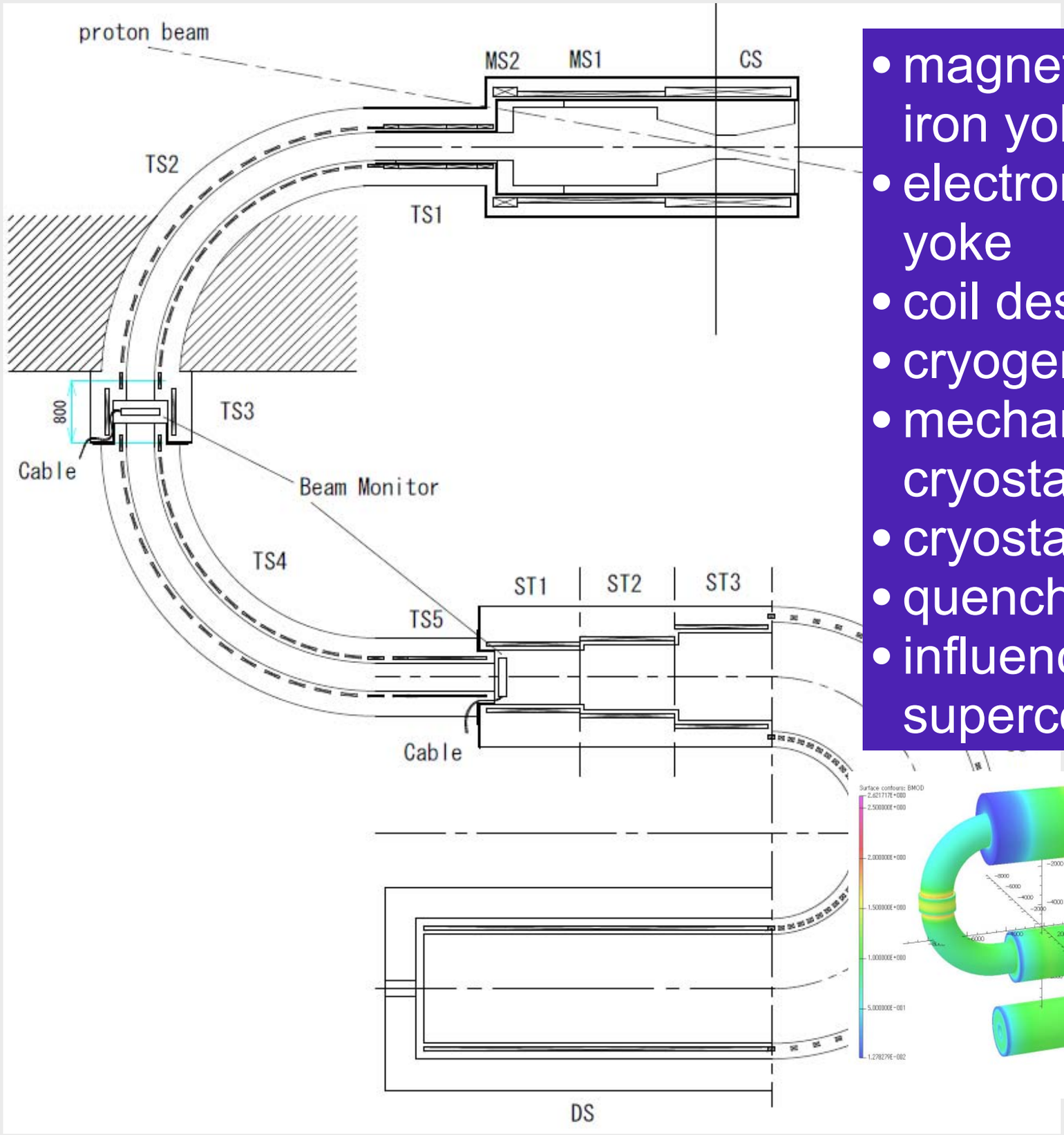
COMET Magnet System



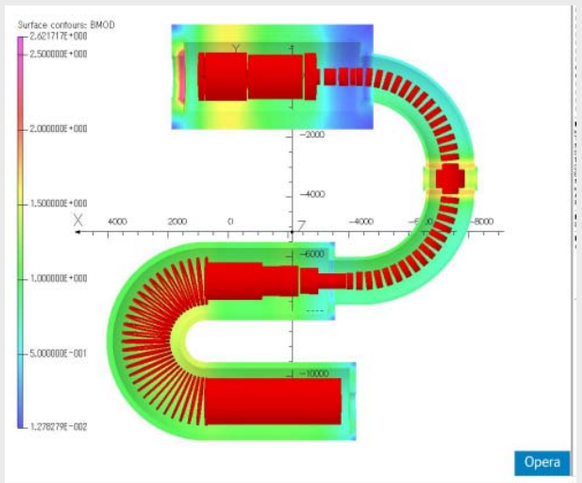
1) Pion capture solenoid (CS)
2) Matching solenoid (MS)
3) Muon transport solenoid (TS)
4) Muon stopping target solenoid (ST)
5) Spectrometer solenoid (SS)
6) Detector Solenoid (DS)
7) Correction dipole coils for TS and SS



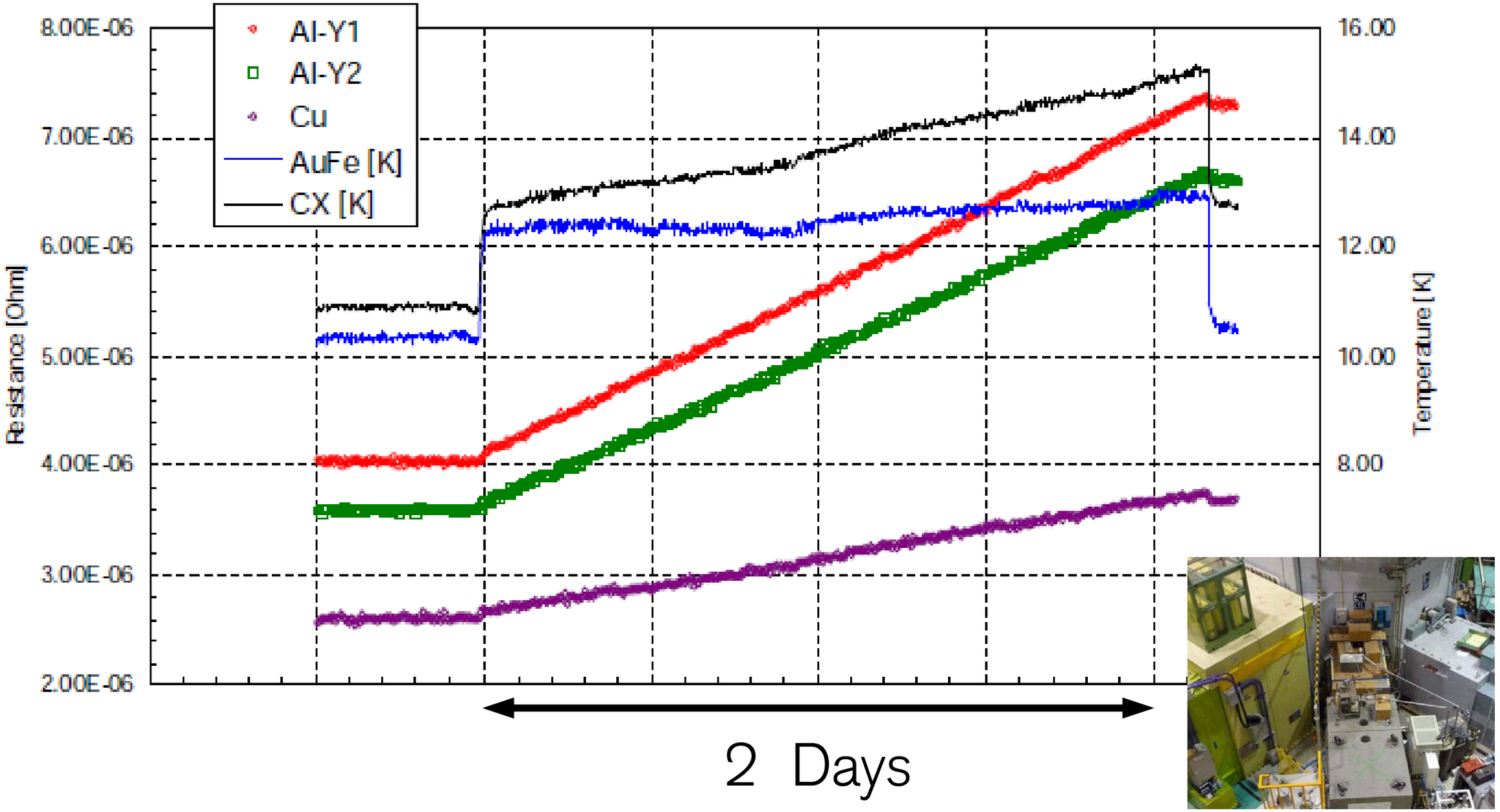
COMET Solenoid Magnet Study includes



- magnetic field distribution with iron yoke
- electromagnetic forces with iron yoke
- coil design
- cryogenic system
- mechanical analysis of cryostats and coil supports
- cryostat design
- quench protection system
- influence of radiation on superconductors



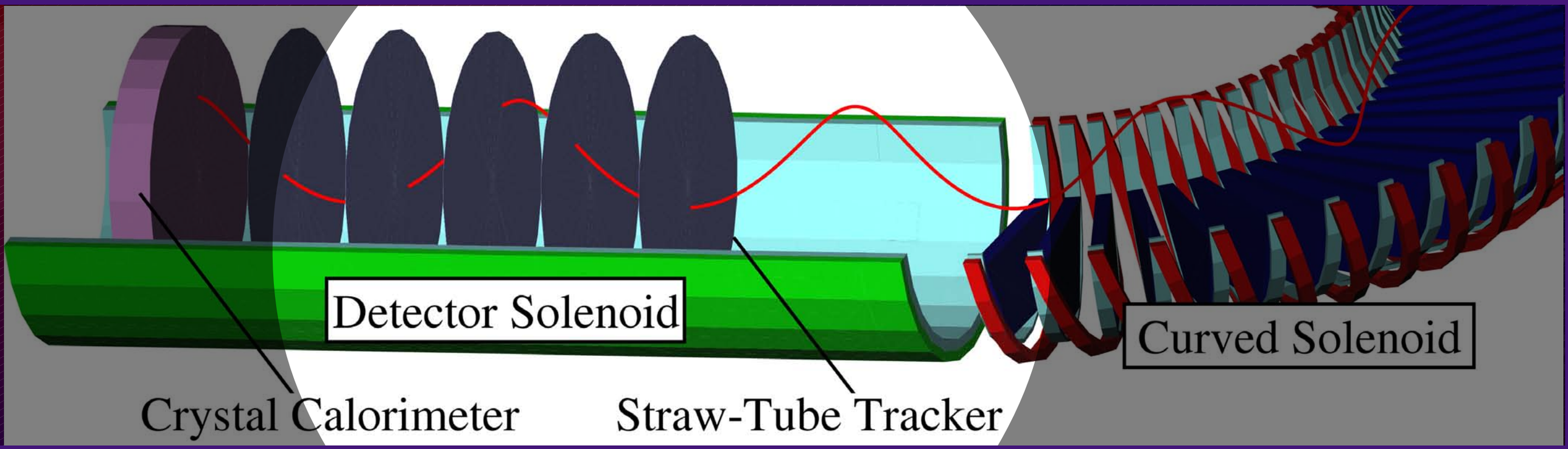
Irradiation Test at KURRI reactor



Demonstrated that Al stabilizer tolerates COMET radiation environment.

Detector R&D

COMET Detector Section
Straw-Tube Tracker

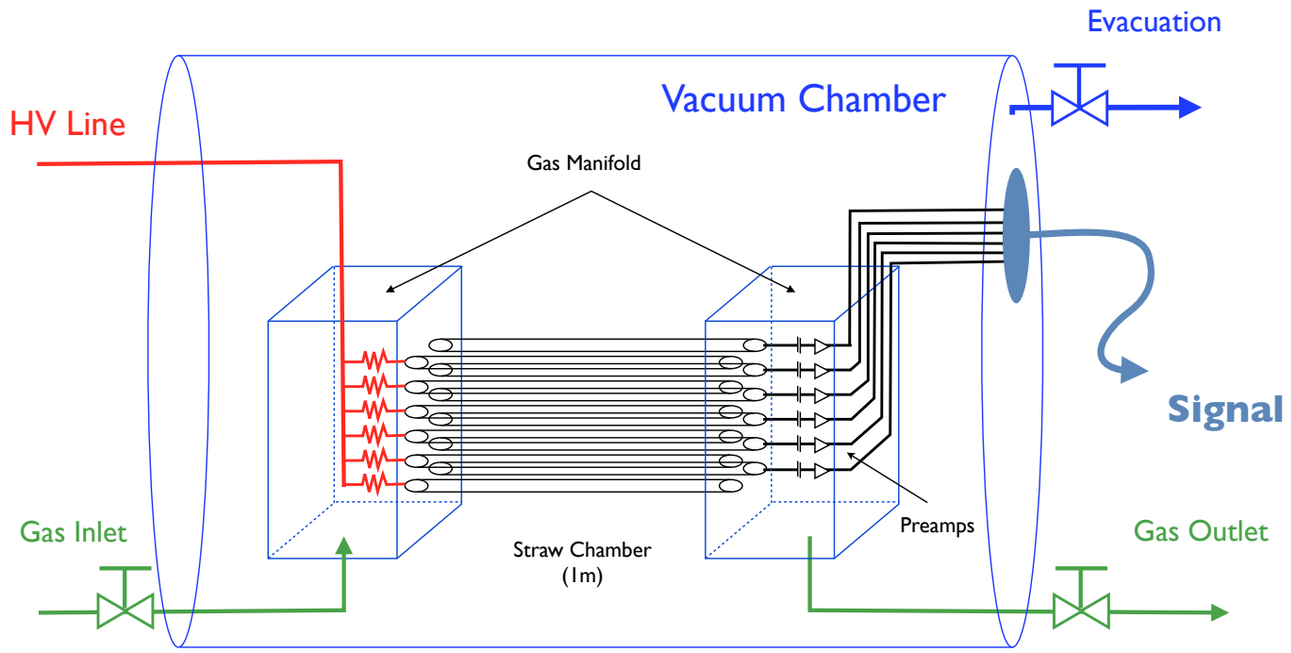


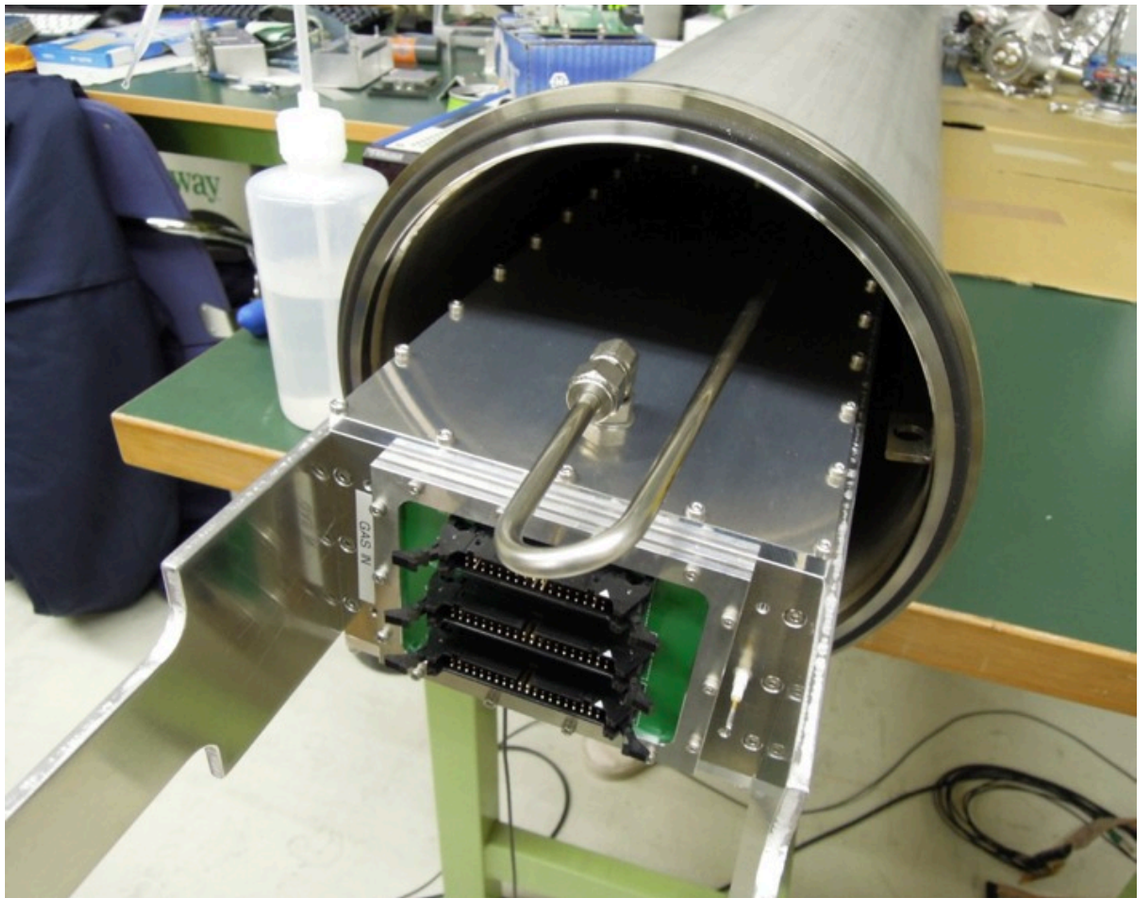
- Straw-tube electron tracker in vaccum under 1 T magnetic field
- 800 kHz charged particles and 8 MHz gamma rate per plane
- 0.4 % momentum resolution and 700 micron spacial resolution

Straw Gas Chamber R&D (1)

Tests of Straw chambers in vacuum

- Prototyping of straw chambers
- Construction of a vacuum chamber
- Gas manifold and front-end electronics in place.



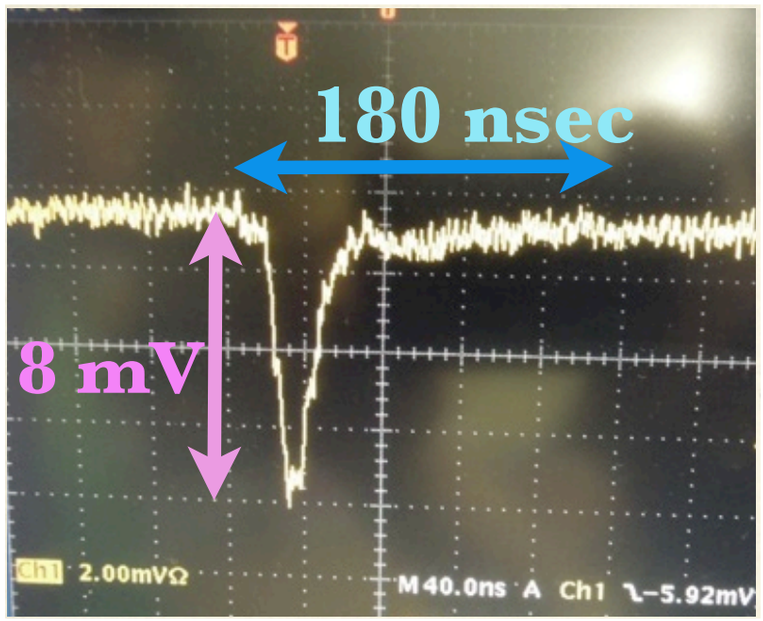


Straw Gas Chamber R&D (2)

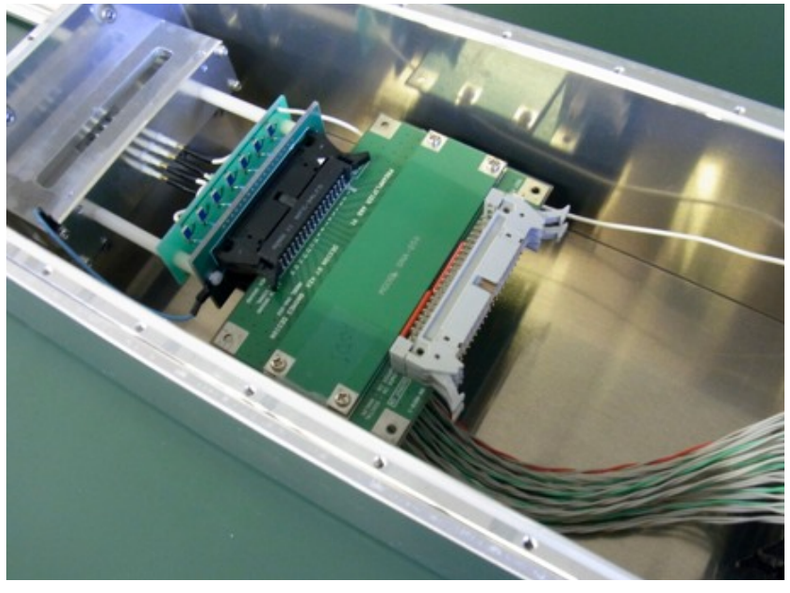
Tests of Straw chambers in vacuum

- Normal operation in air
  - X-t relation and spatial resolution
- Gas leak study
- Over-pressurized study
  - 2 atom.
- Deformation study
  - capacitive sensor
- Operation in vacuum
  - just started...

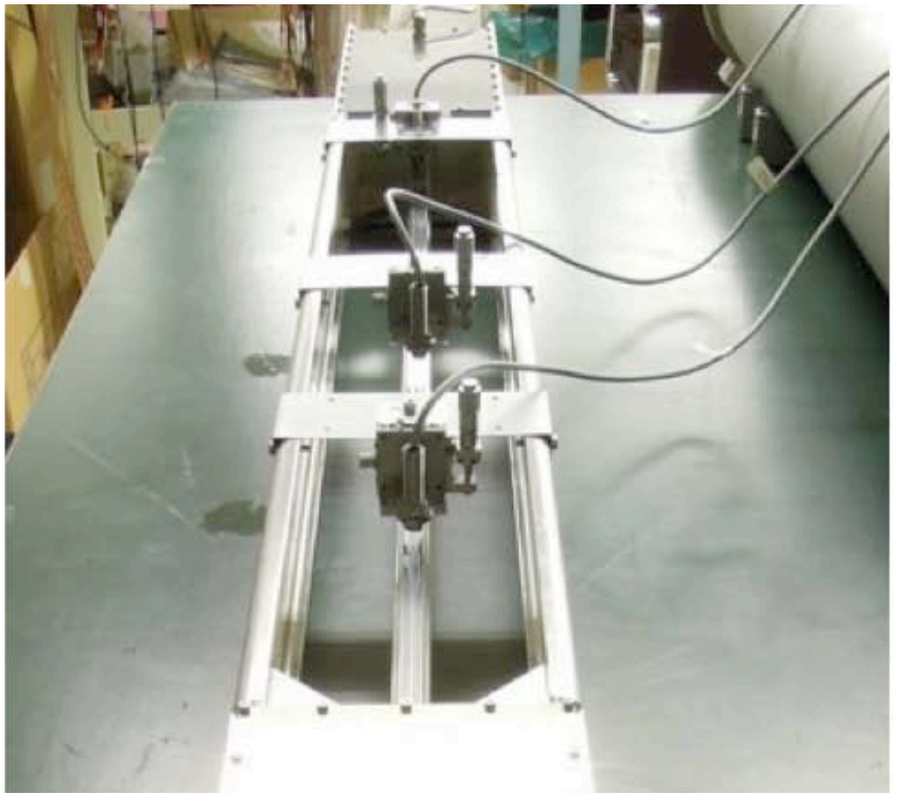
Raw signal without amp.



front-end electronics in a manifold

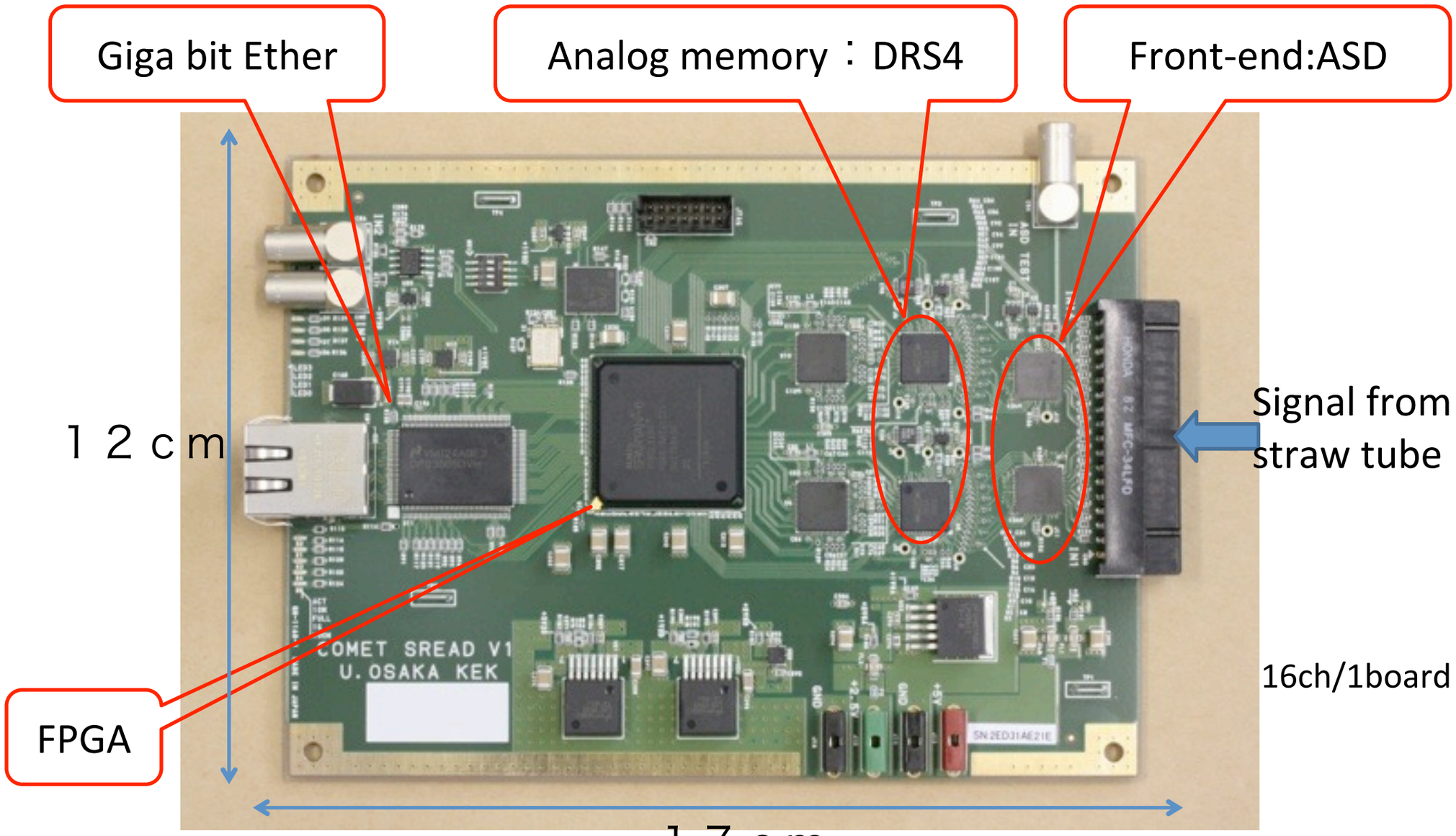


Deformation study by capacitive sensor

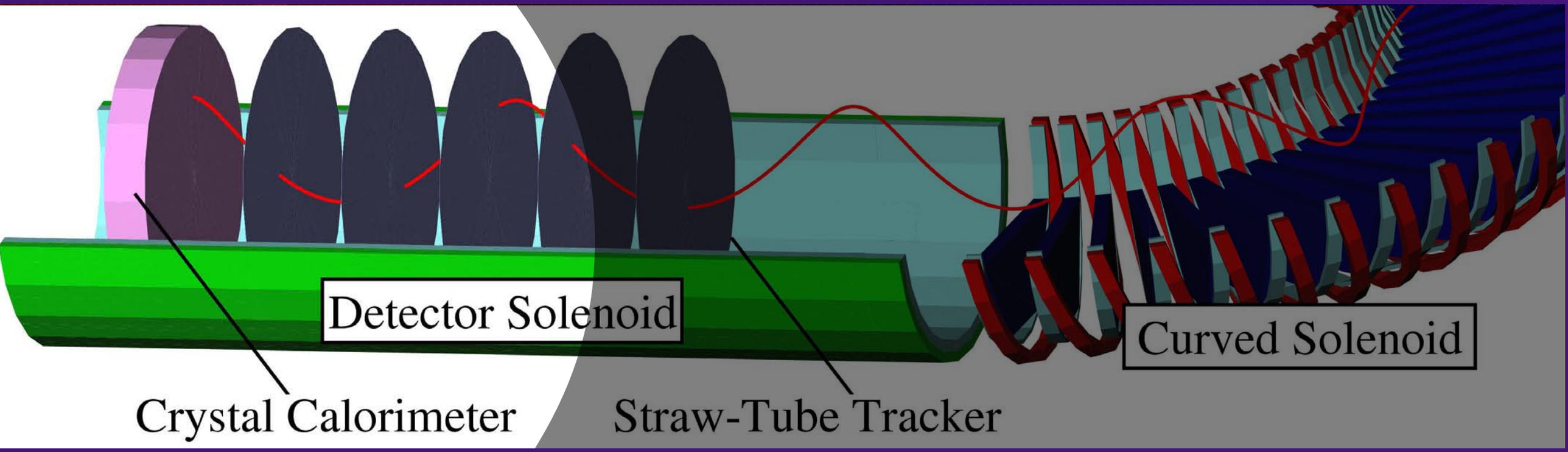


Frontend Electronics R&D

- Front-end electronics for straw trackers and crystal calorimeter.
- wave-form sampling based on switched capacitor array (DRS4)
- a prototype board is constructed and tested with the KEK electronics group.



COMET Detector Section
Crystal Calorimeter

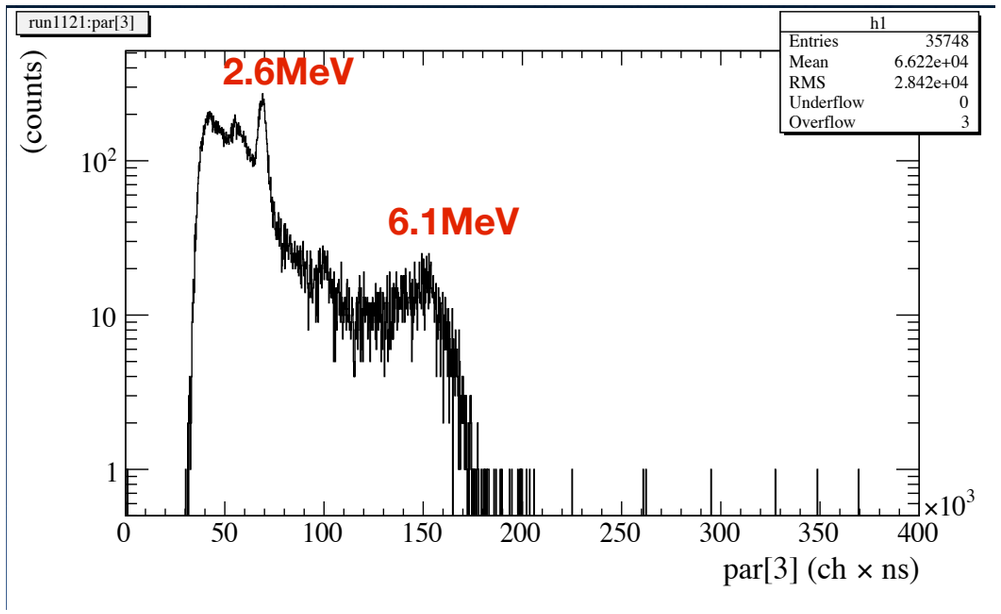


- Energy and position measurements, PID, trigger signal
- 5% energy and 1 cm spatial resolution at 100 MeV

Electron Calorimeter R&D

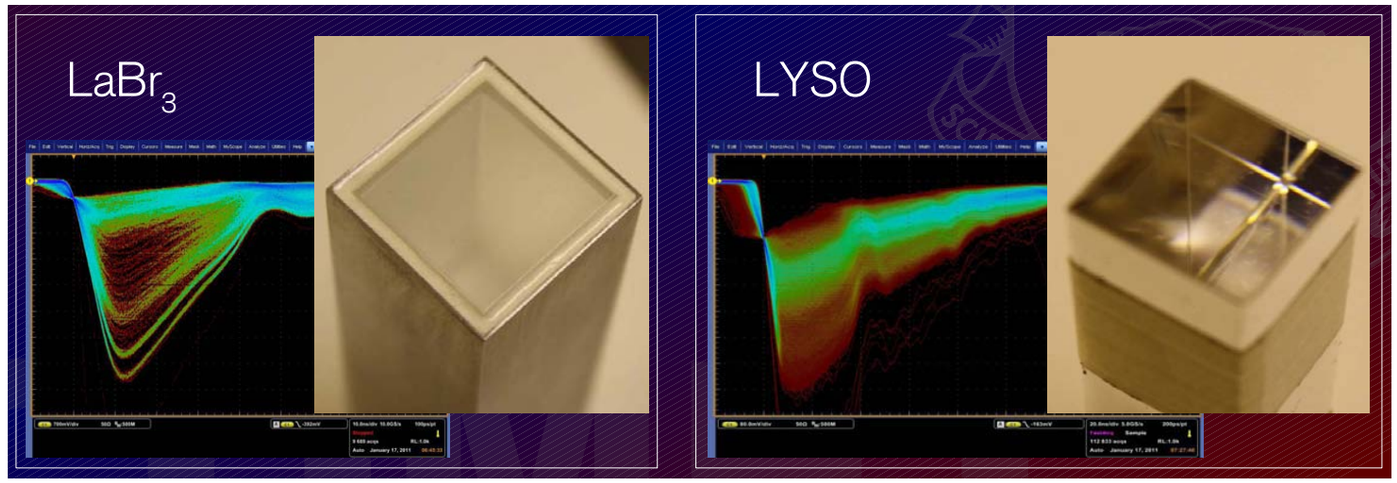
Calorimeter Prototyping R&D

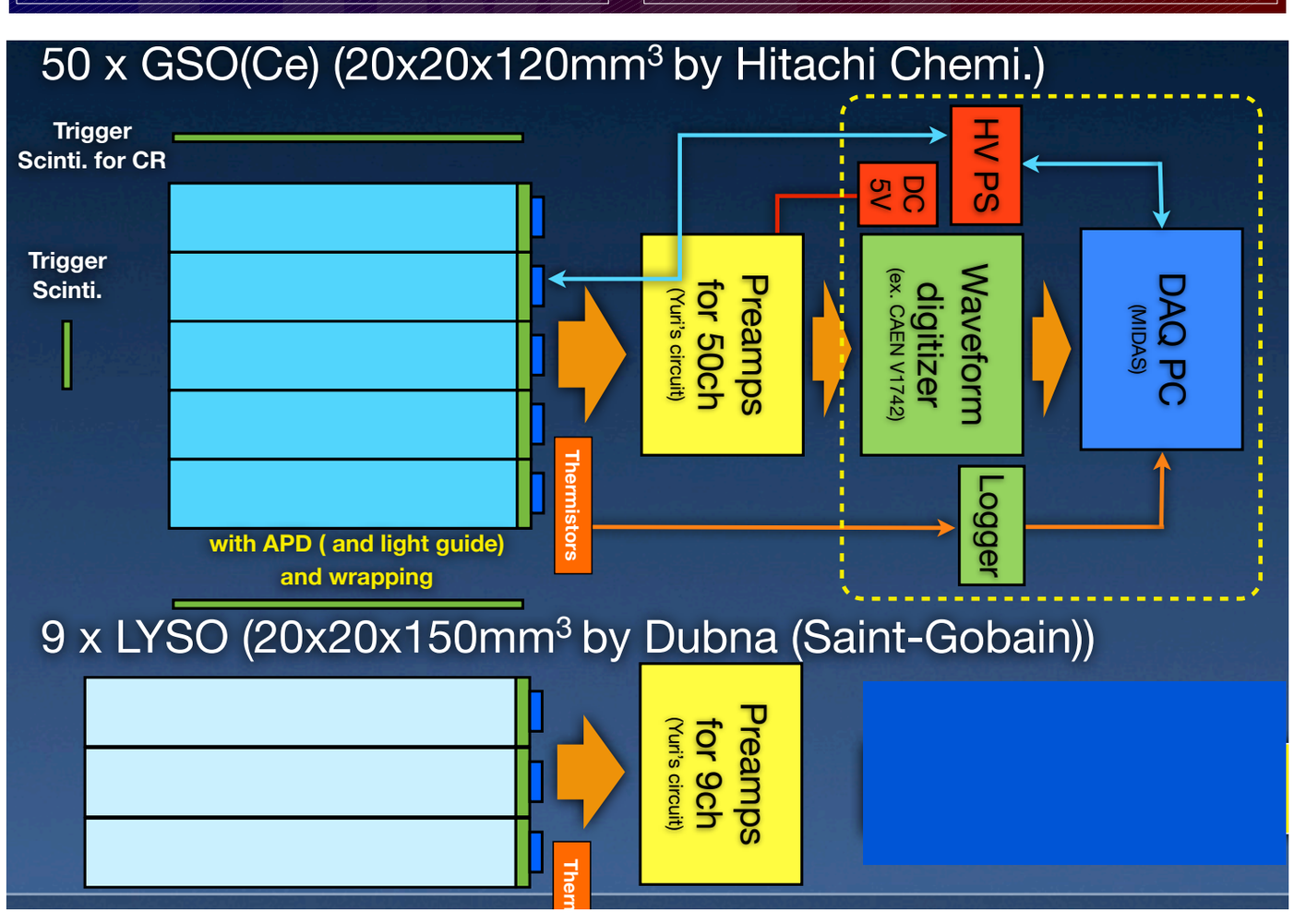
- Single crystal test has been done at BINP.



typical spectrum for LYSO and APD (10×10 mm^2)

- Prototypes for GSO and LYSO crystal array are planned.
- Beam tests at BINP in summer and winter, 2012.

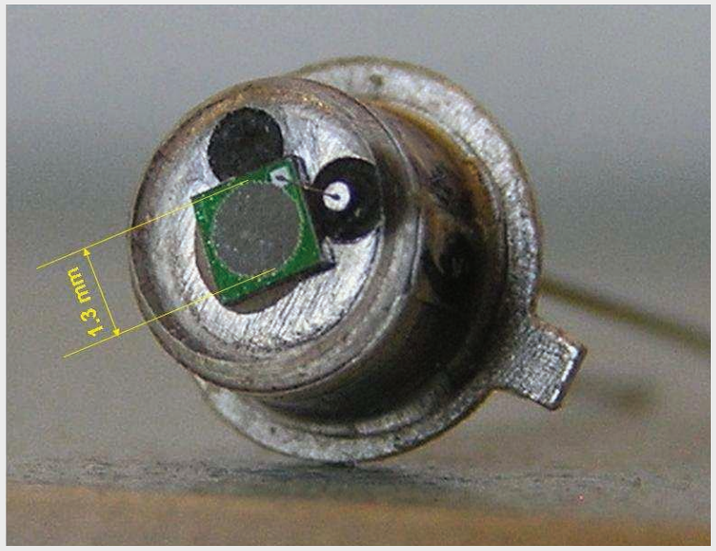




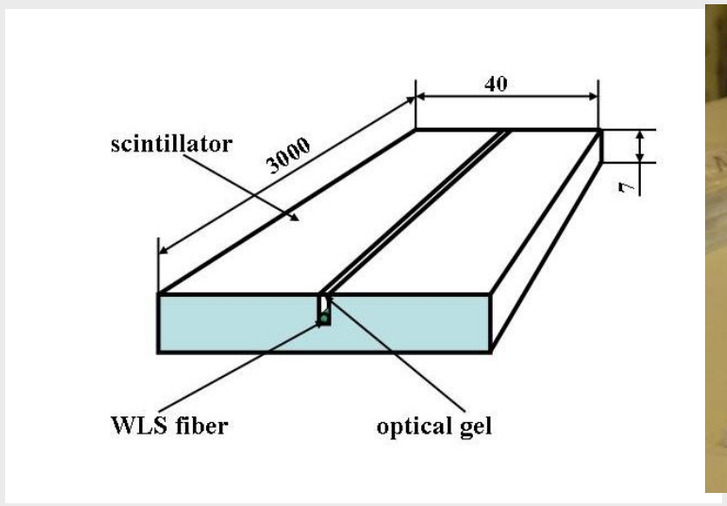
Other R&D

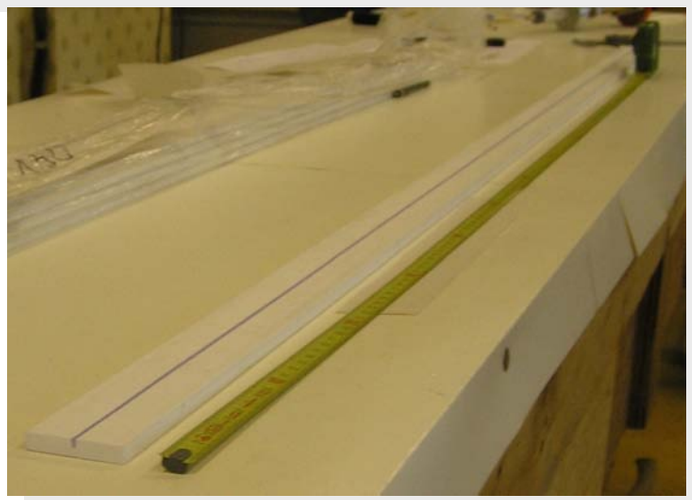
R&D on Cosmic Ray Veto System

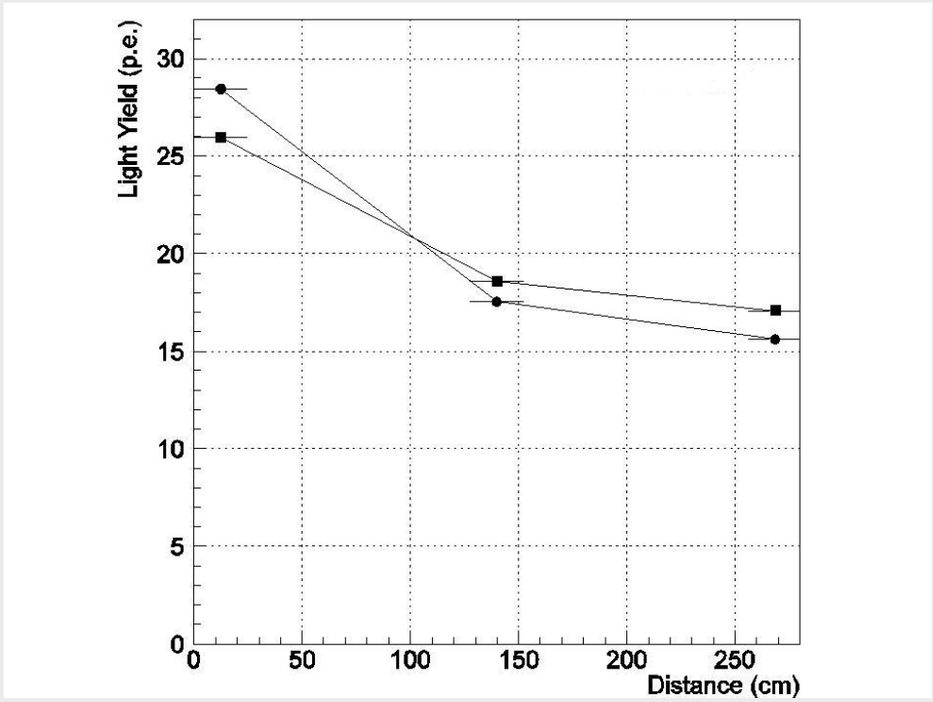
- The active cosmic ray veto system is based on plastic scintillator with fiber readout.
- Photosensors are MRS APD or MPPC.
- Designed by the BINP (Novosibirsk) and ITEP (Moscow) groups.
- Strip 0.7x4x300 cm^3 scintillator made by Uniplast (Russia).
- The light yield at a far end is even 15 pe. The counter efficiency for MIP is 99.7% with 55 pixel threshold.



796 pixel MRS APD fiber (CPTA, Russia).







R&D on Muon Monitor System

- To monitor a number of stopping muons, muonic X-rays from the muon stopping target (made of aluminum) is to be measured.

Al	**347keV** (0.811)	413keV (0.058)	436keV (0.019)	**66keV** (0.422)	89keV (0.072)	100keV (0.031)

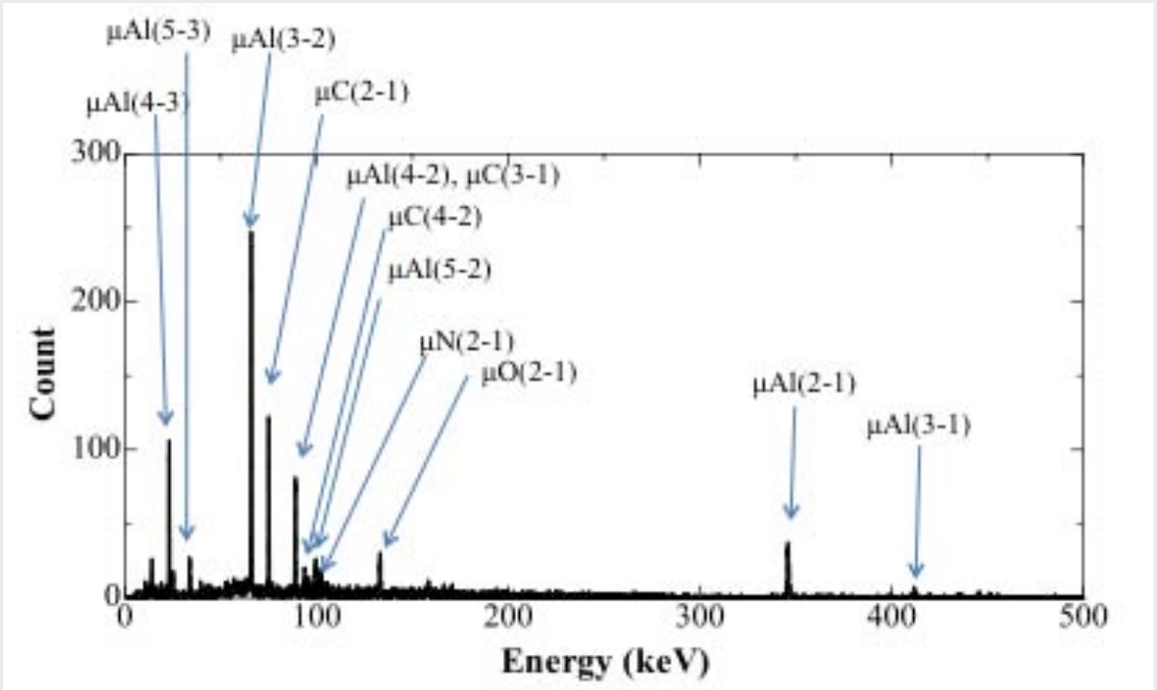
- Two different detectors, Ge and CdTe were tested.
- Detector efficiencies and transition rates are studied.
- R&D on Multi-pixel detectors is being done.

CdTe detector

EURORAD,Ohmic type
10mm×10mm×3mm

Ge detector

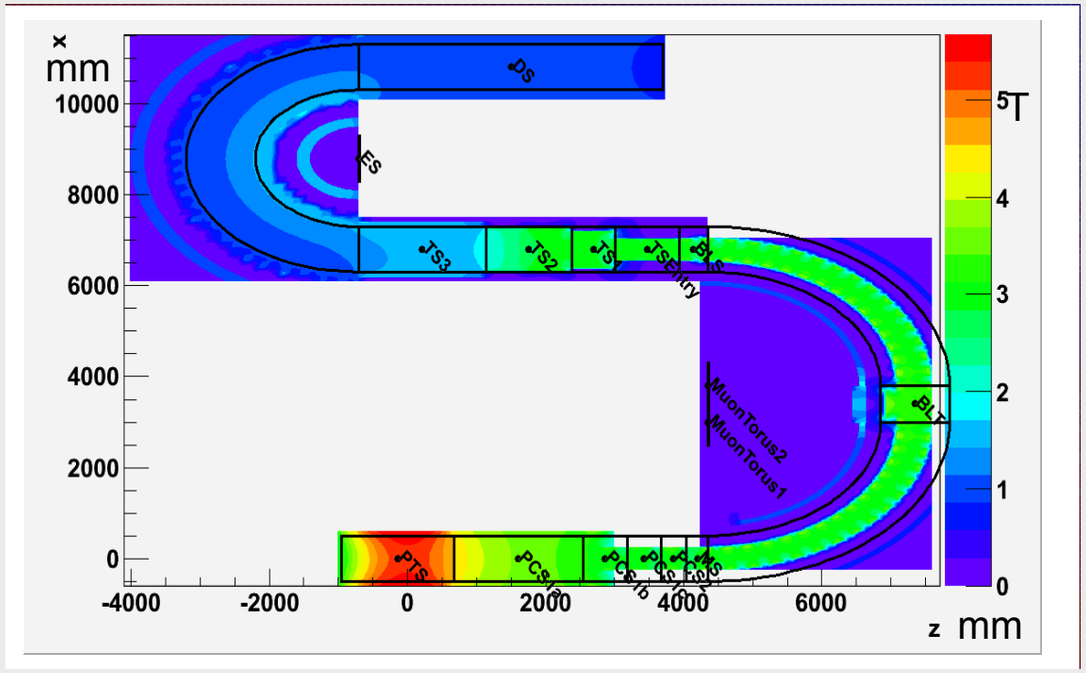
Ortec,POPTOPtype,GMX
ϕ=50mm,length=50mm



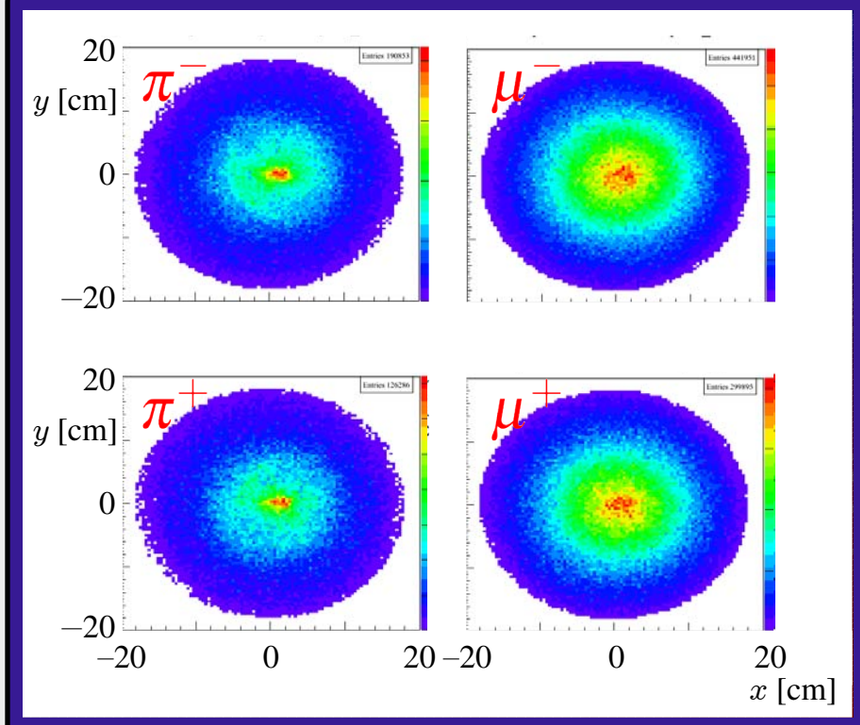
Measured muonic X-rays from aluminum

COMET G4

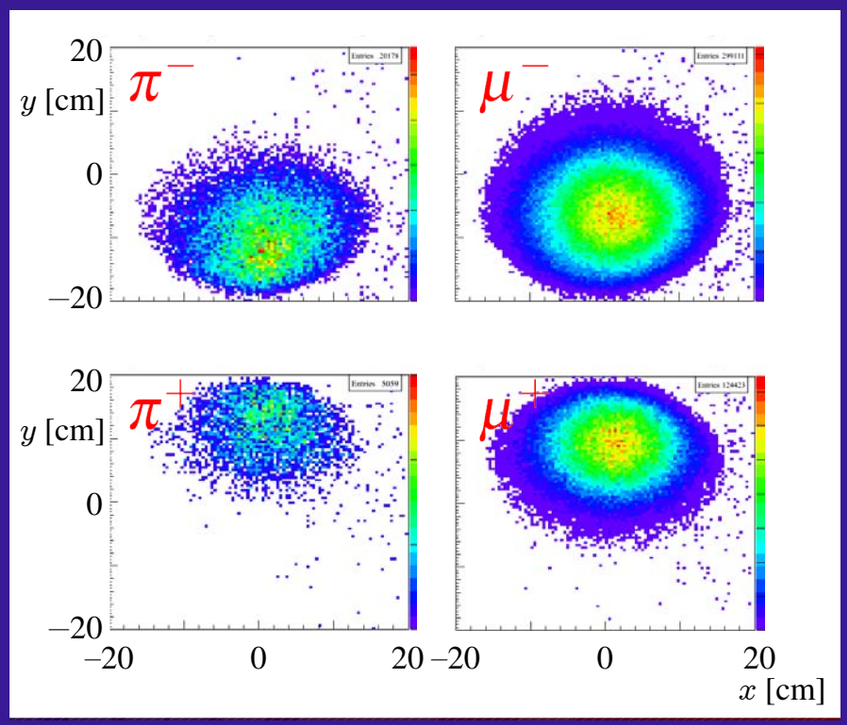
COMET_G4 (Geant Simulation)



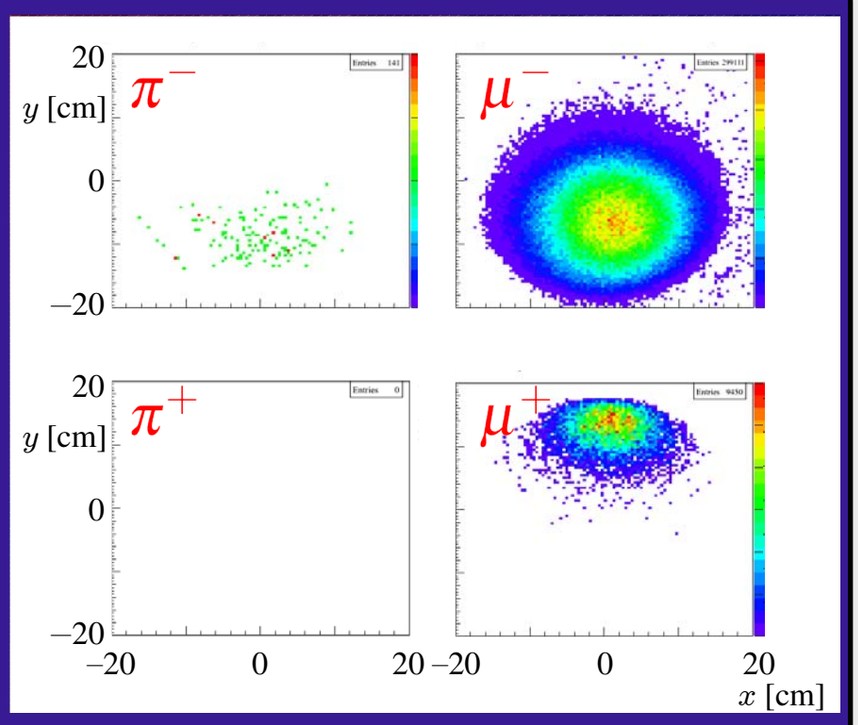
- Full 3D field mapping (from Toshiba) is introduced.
- Mass data production has been made.



at entrance



at 90 degree bending



at muon stopping target

COMET Collaboration

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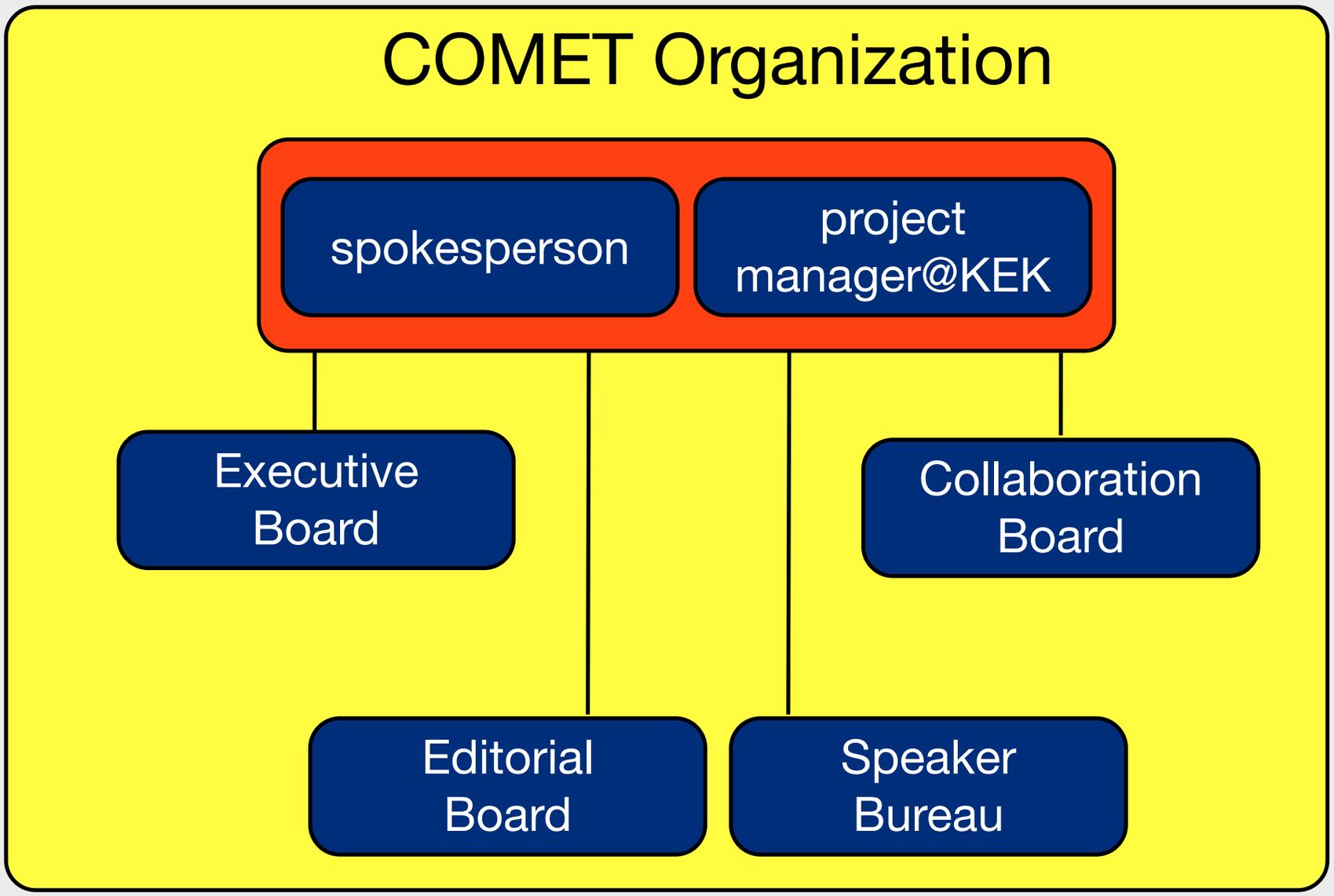
COMET was approved as a project at JINR in 2011.

COMET Organization

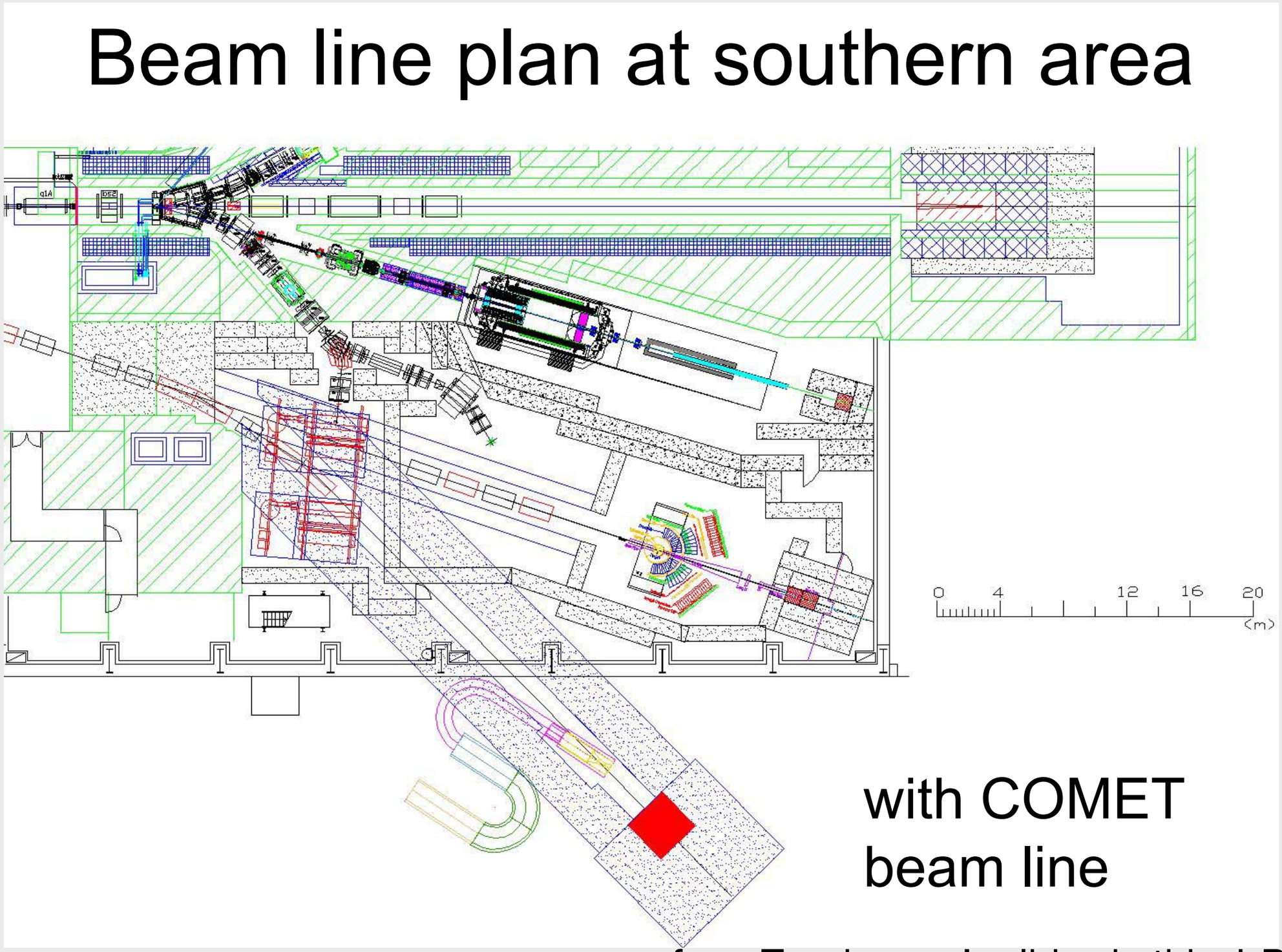
- The “COMET Constitution” has been written and agreed.
- The COMET organization is defined.
- The COMET organization will be formed and started in the next collaboration meeting.



On MTF Proposal (COMET Staging Plan)

MTF Proposal on COMET Beam Line

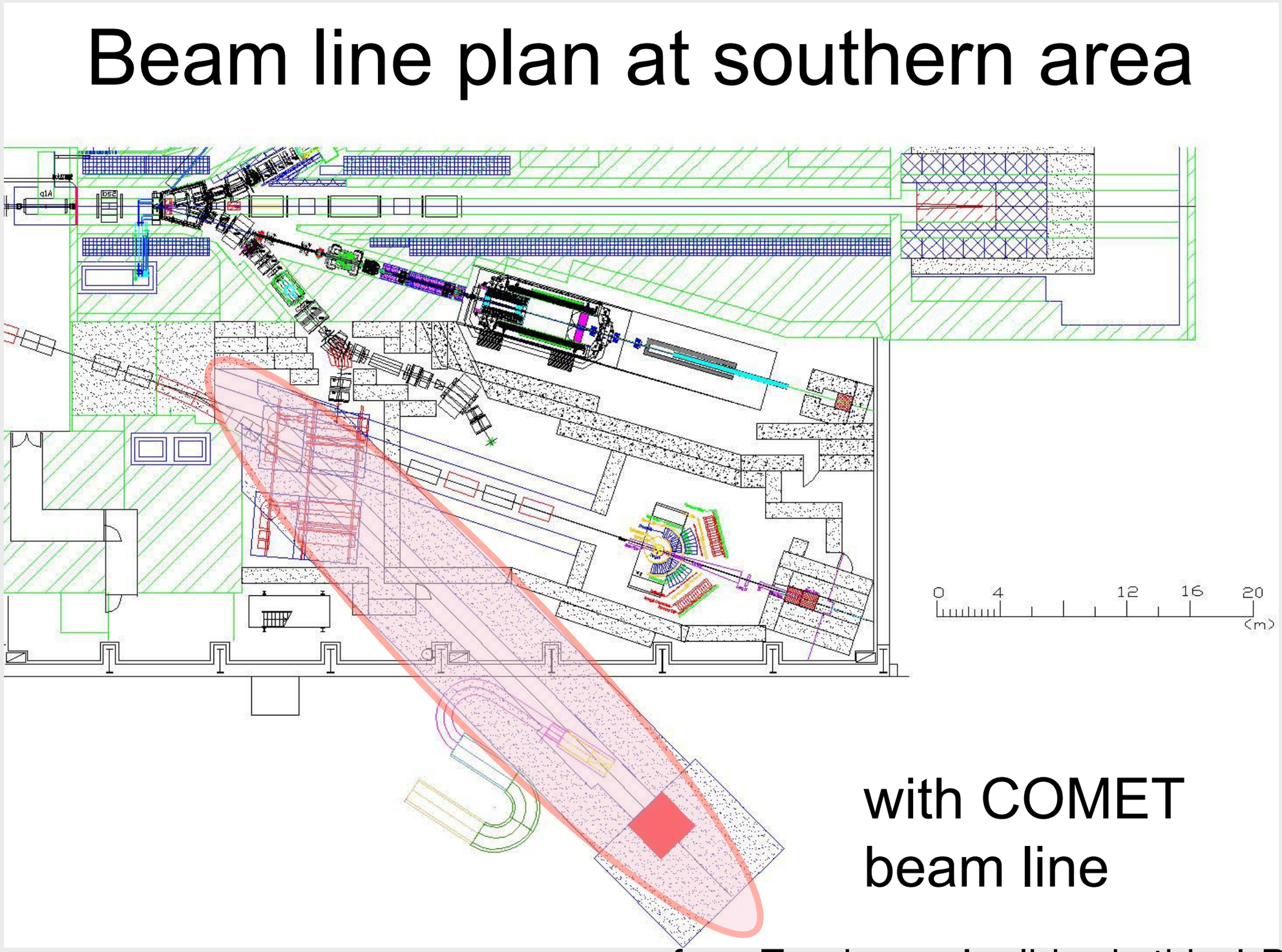
- MTF and JPNC's proposal on the beam lines at the south area.



from Tanaka-san's slides in this J-PARC PAC.

MTF Proposal on COMET Beam Line

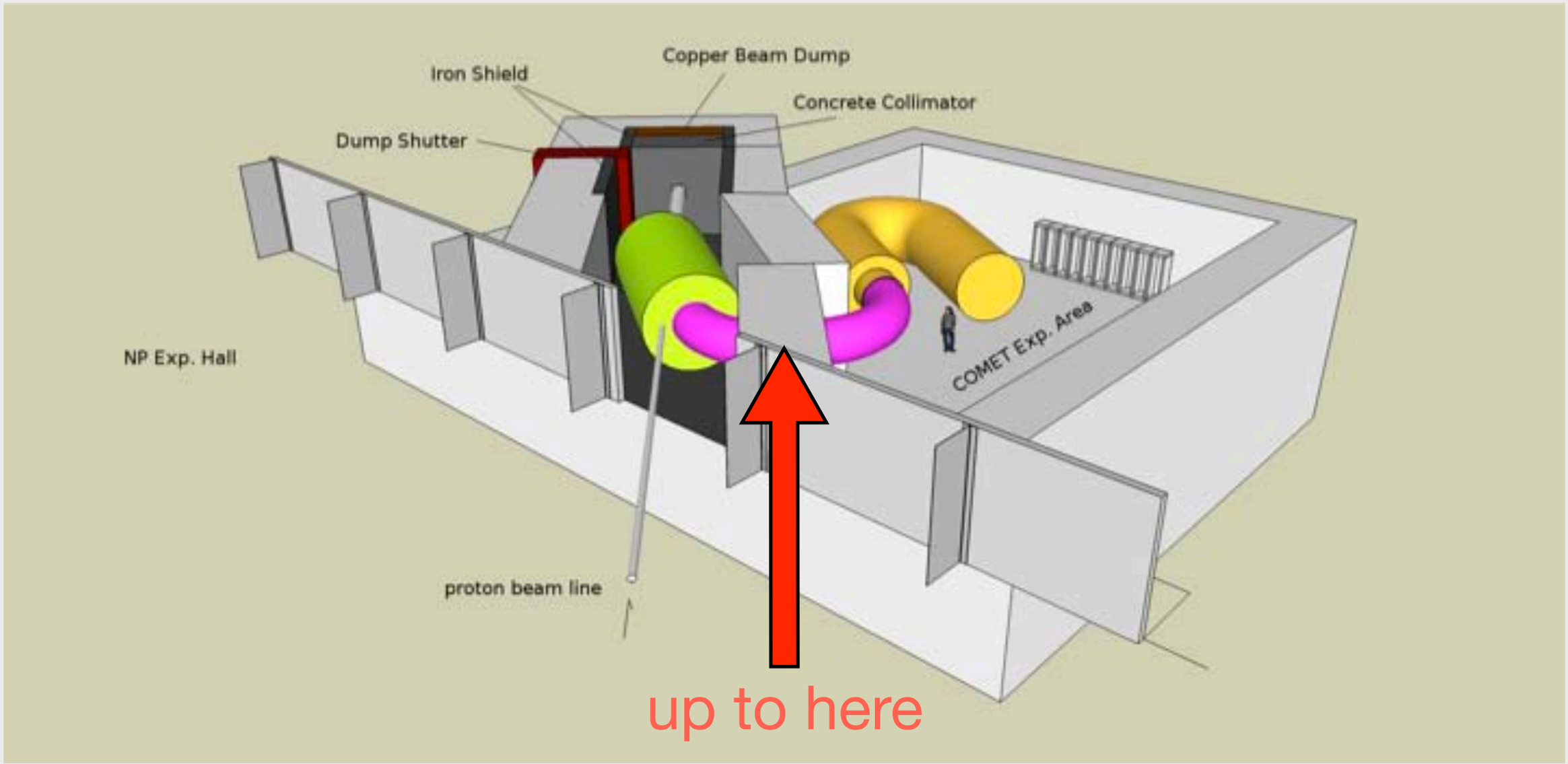
- MTF and JPNC's proposal on the beam lines at the south area.



from Tanaka-san's slides in this J-PARC PAC.

COMET Muon Beam Line

COMET wishes to have the first 90 degrees of the muon transport curved solenoids (which are located inside concrete shields) in this proposal, since the installation of these magnets would become difficult after activation by a proton beam.



COMET Staging Plan

COMET Phase-I

COMET Staging Plan

COMET Phase-I

(1) Study for the COMET full experiment

- Measurement of secondary particle production
- Measurements of muon yield,
- Measurements of backgrounds from pions, electrons, neutrons, kaons, and anti-protons.
- Muon beam tuning

Table 11.9: Summary of Estimated Backgrounds.

Radiative Pion Capture	0.05
Beam Electrons	$< 0.1^{\ddagger}$
Muon Decay in Flight	< 0.0002
Pion Decay in Flight	< 0.0001
Neutron Induced	0.024
Delayed-Pion Radiative Capture	0.002
Anti-proton Induced	0.007
Muon Decay in Orbit	0.15
Radiative Muon Capture	< 0.001
μ^- Capt. w/ n Emission	< 0.001
μ^- Capt. w/ Charged Part. Emission	< 0.001
Cosmic Ray Muons	0.002
Electrons from Cosmic Ray Muons	0.002
Total	0.34

‡ Monte Carlo statistics limited.

Background estimation in CDR

COMET Staging Plan

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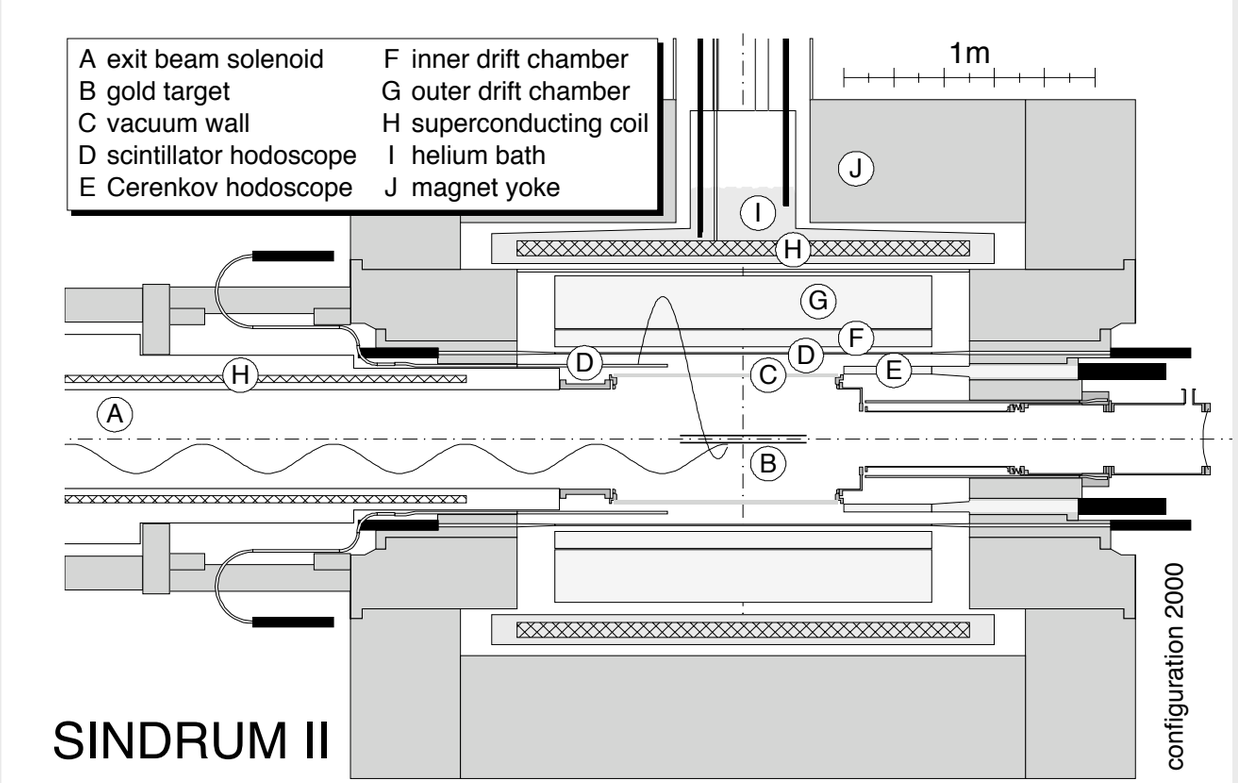
(2) Physics experiments

- $\mu^- + N \rightarrow e^- + N$ conversion
- $\mu^- + N \rightarrow e^+ + N$ conversion
- $\mu^- + e^- \rightarrow e^- + e^-$



Detector is being studied.
Its cost can mostly be covered by the COMET collaboration.

COMET Staging Plan

COMET Phase-I

(1) Study for the COMET full experiment

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- Muon beam tuning

(2) Physics experiments

- $\mu^- + N \rightarrow e^- + N$ conversion
- $\mu^- + N \rightarrow e^+ + N$ conversion
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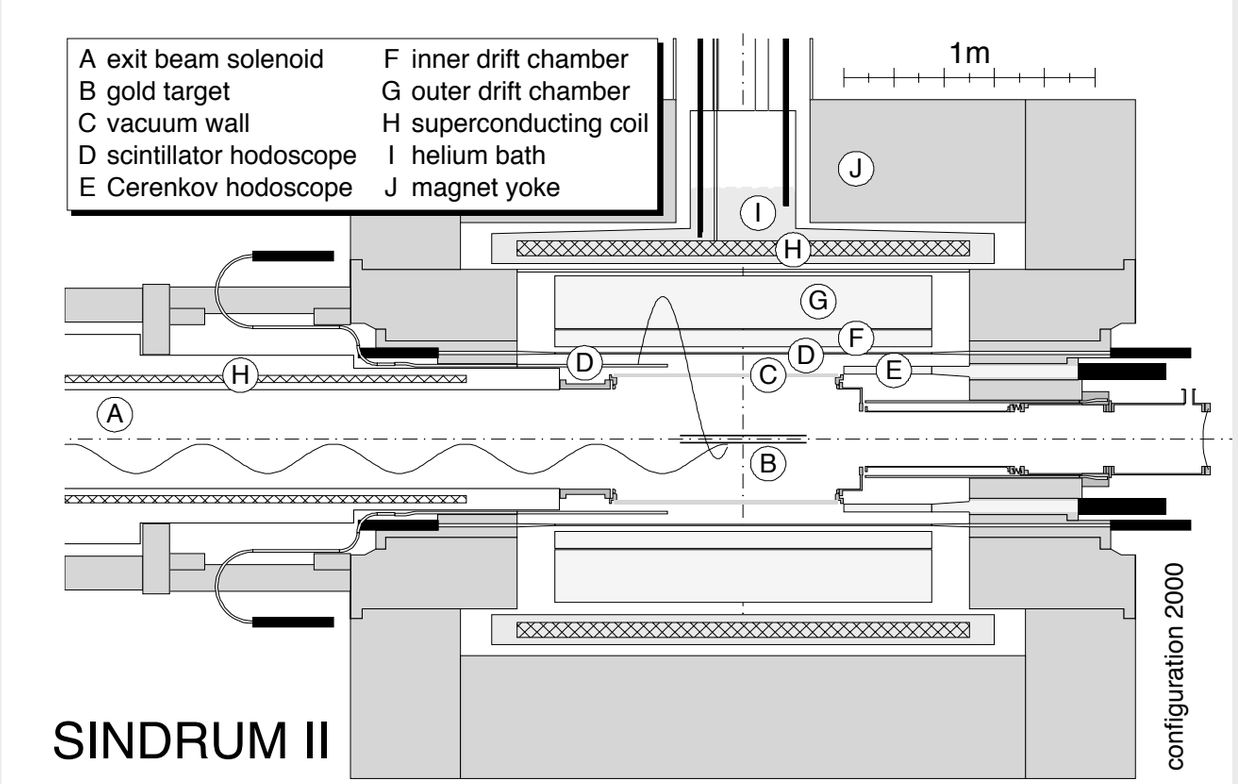
plan to submit a LOI for the July PAC.



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COMET Timeline and World Competitiveness

COMET Phase-I and Phase-II

year	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
mu2e	CD1	CD2/ 3a	CD3b	solenoid/ detector fabrication		solenoid/ detector installation		engi neer ing run	physics running		

COMET Timeline and World Competitiveness

COMET Phase-I and Phase-II

year	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
comet		Phase-I				physics run	Phase-II				physics run
mu2e	CD1	CD2/ 3a	CD3b	solenoid/ detector fabrication		solenoid/ detector installation	engi neer ing run	physics running			

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COMET collaboration asks J-PARC PAC to support the COMET staging approach.

COMET collaboration will submit a LOI of COMET Phase-I to the July J-PARC PAC.