

Search for cLFV with



experiment at J-PARC

XIII International Conference on Kaon Physics

8 – 12 September 2025

Mainz, Germany

kaon25

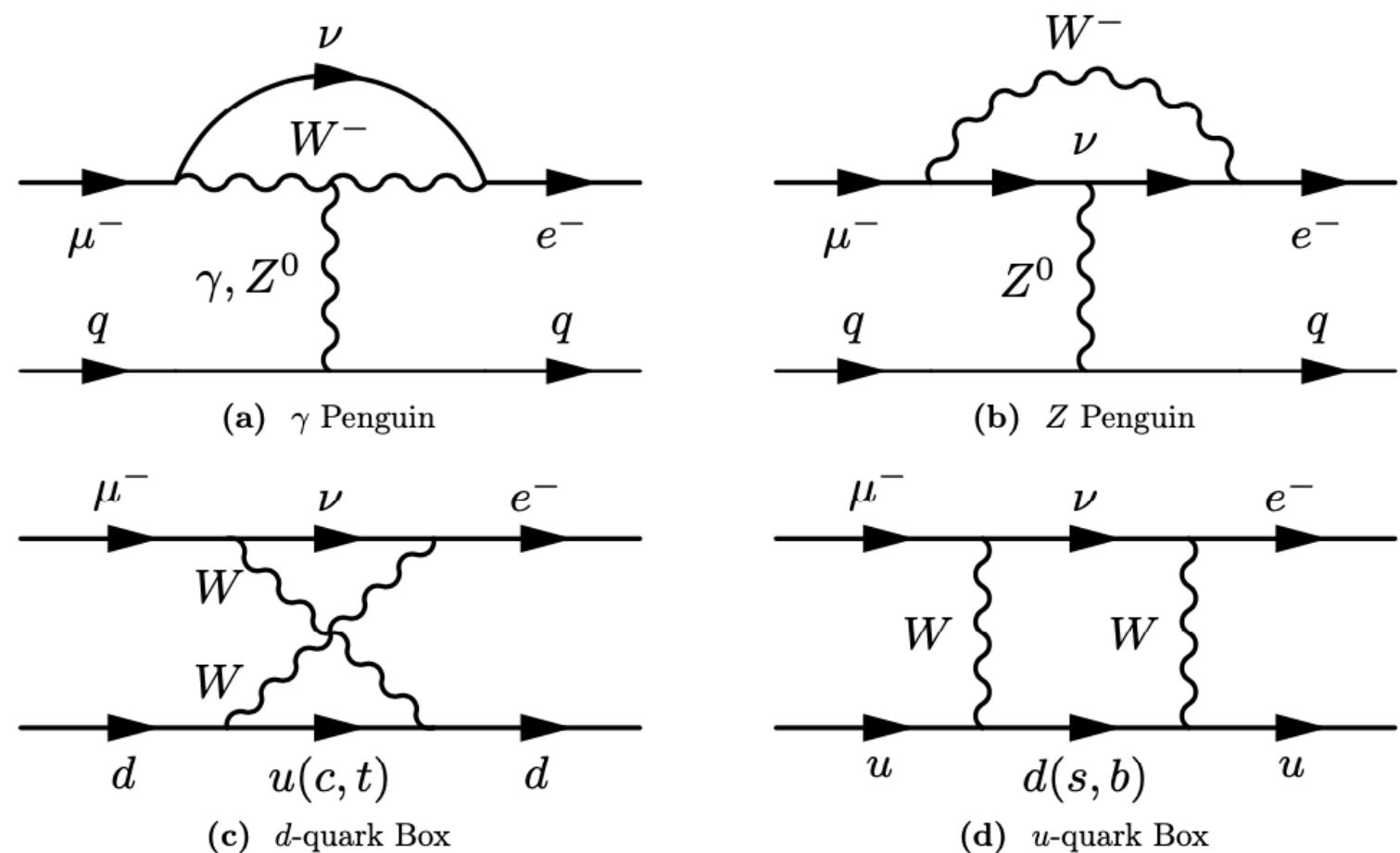


C Cârloganu, LPCA/IN2P3/CNRS
10.09.2025

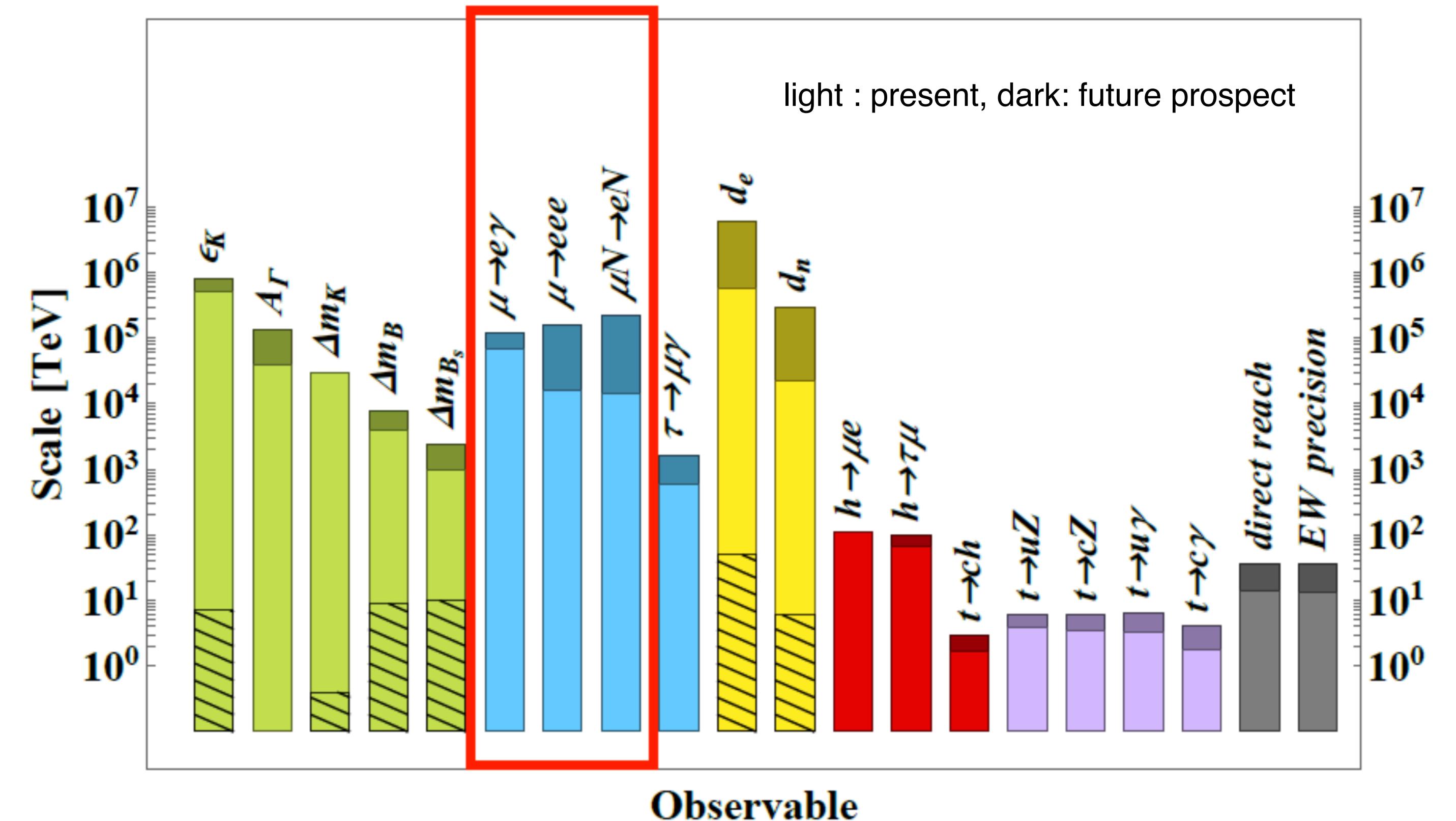
on behalf of COMET collaboration

cLFV observed \Rightarrow New Physics in the lepton sector beyond minimally extended SM

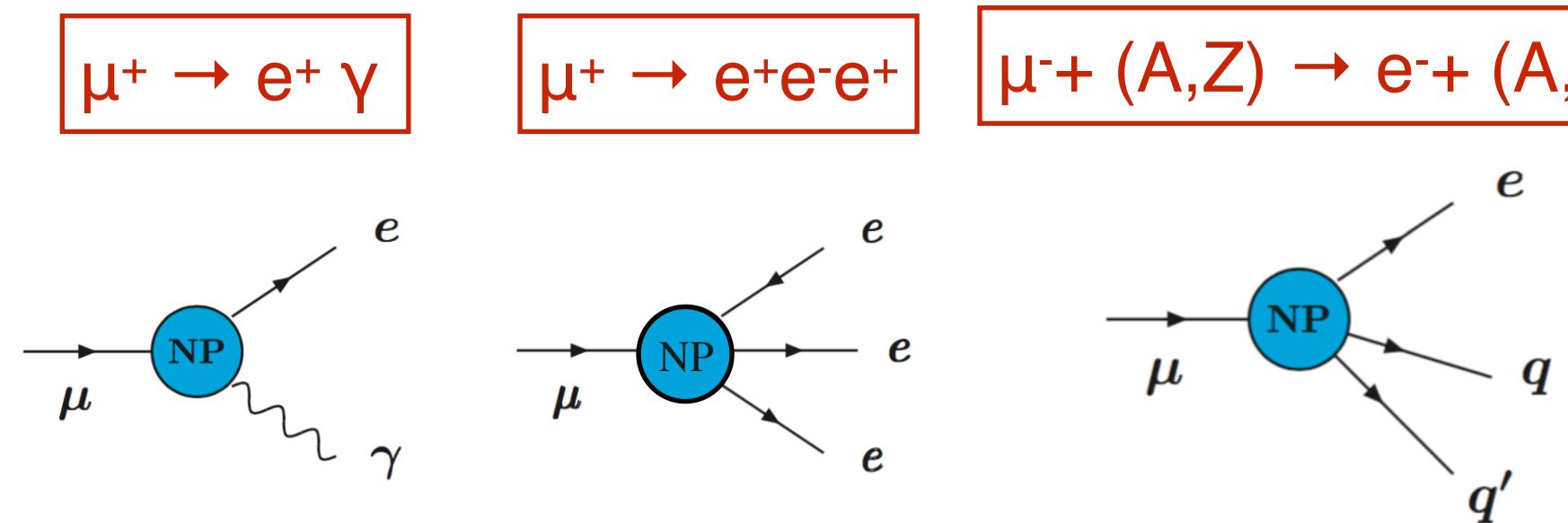
$$\text{BR}(\mu \rightarrow e\gamma) \propto \left| \sum U_{\mu i}^* U_{ei} \frac{m_{\nu i}^2}{M_W^2} \right|^2 \sim 10^{-54}$$



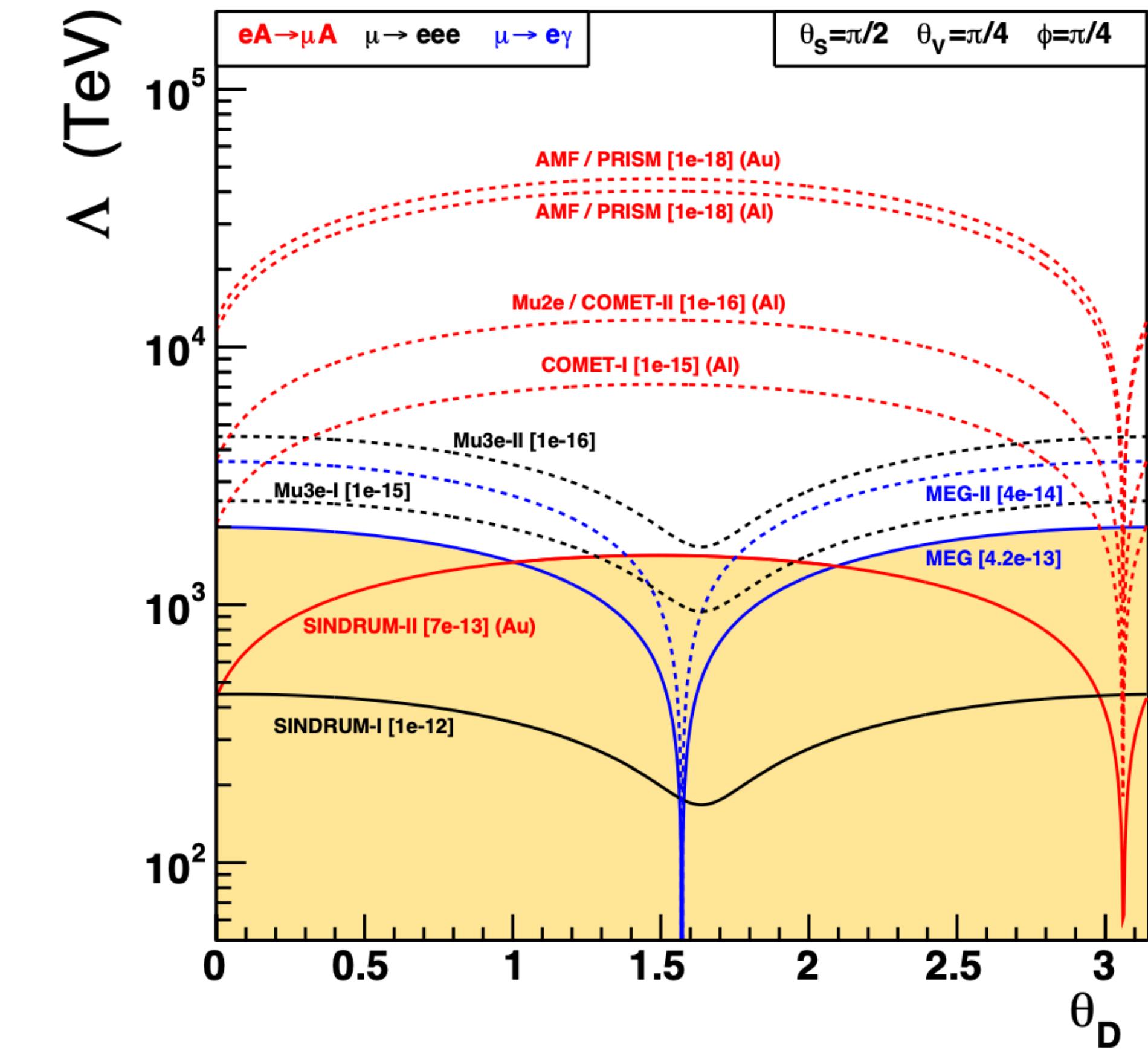
muon observables among the most sensitive to high scale new physics



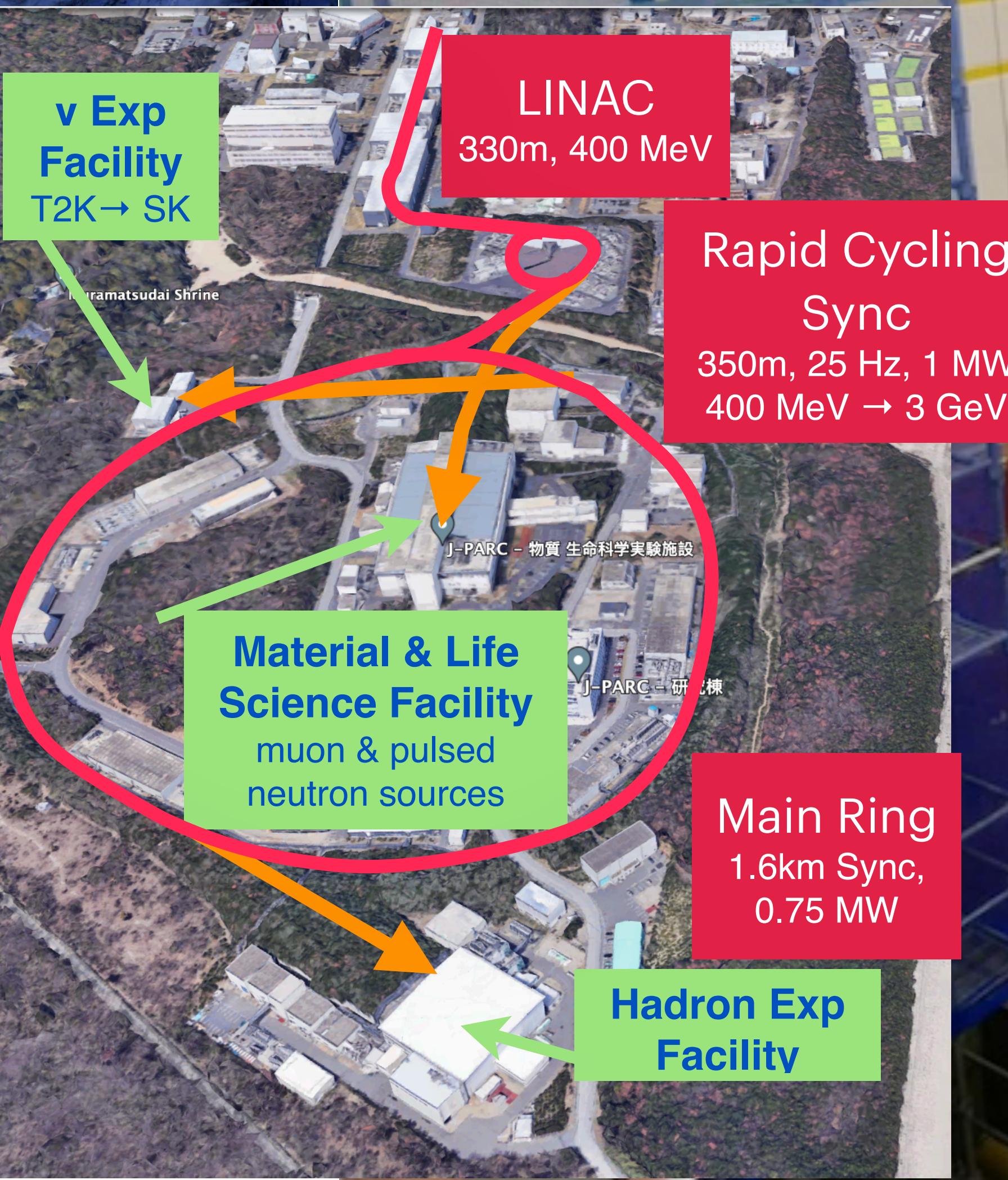
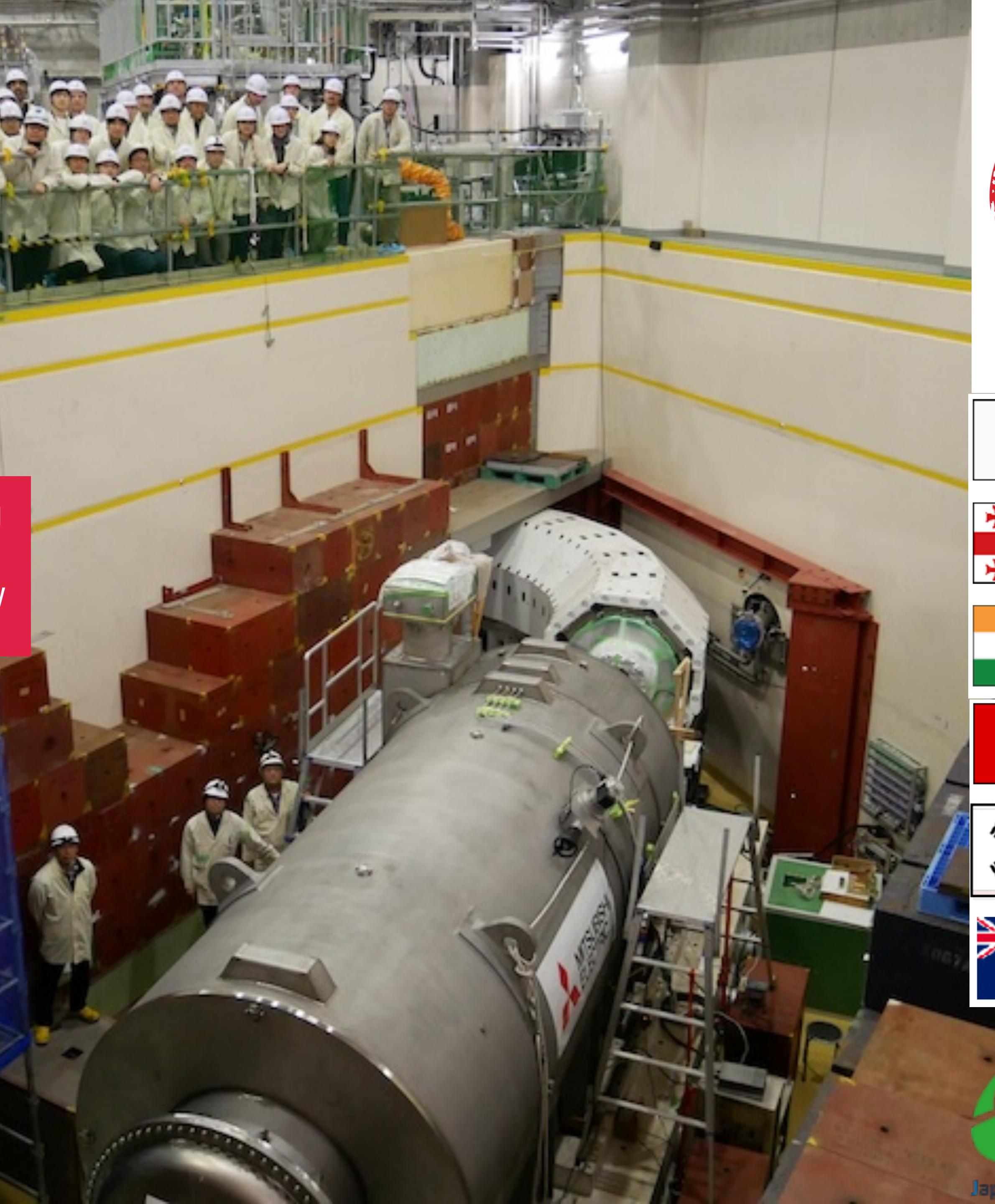
$$\delta\mathcal{L} = \frac{1}{\Lambda_{LFV}^2} \left[m_\mu C_D (\bar{e} \sigma^{\alpha\beta} P_R \mu) F_{\alpha\beta} + C_S (\bar{e} P_R \mu) (\bar{e} P_R e) + C_{VR} (\bar{e} \gamma^\alpha P_L \mu) (\bar{e} \gamma_\alpha P_R e) + C_{VL} (\bar{e} \gamma^\alpha P_L \mu) (\bar{e} \gamma_\alpha P_L e) + C_{Alight} \mathcal{O}_{Alight} + C_{Aheavy\perp} \mathcal{O}_{Aheavy\perp} \right]$$

S. Davidson, B. Echenard, Eur. Phys. J. C **82** (2022) no.9, 836


	Collaboration	year	BR 90% C.L.
$\mu \rightarrow e\gamma$	PSI/MEG+MEG2	2025	1.5×10^{-13}
$\mu \rightarrow eee$	PSI/SINDRUM	1988	1×10^{-12}
$\mu N \rightarrow eN(A,Z)$	PSI/SINDRUM	2006	7×10^{-13}



Rate $\sim \frac{[]^2}{\Lambda^4}$ Need to improve the SES by 10000 to reach 10 times higher in energy scale!



Rapid Cycling Sync
350m, 25 Hz, 1 MW
400 MeV → 3 GeV

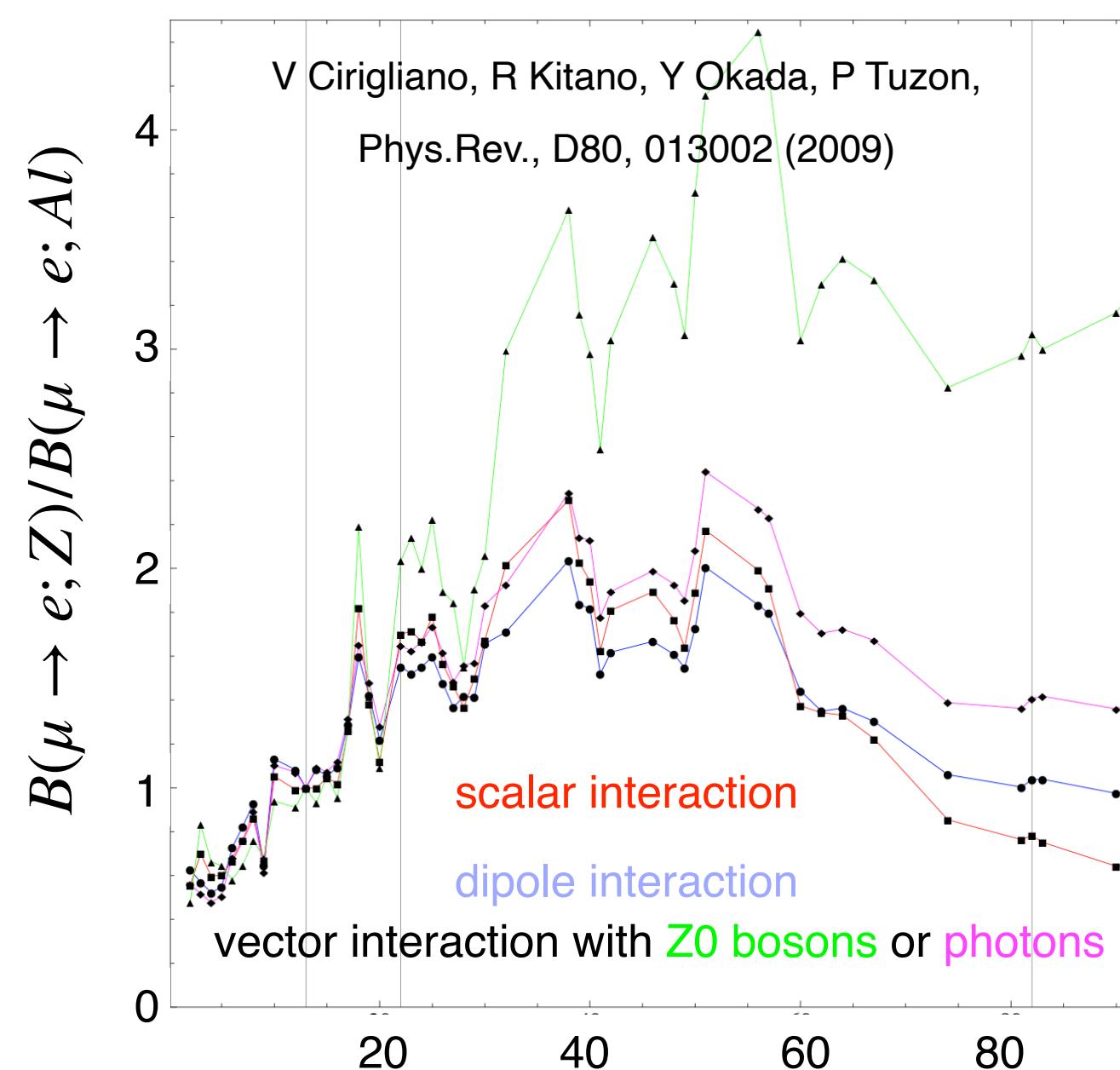
Main Ring
1.6km Sync,
0.75 MW

Hadron Exp Facility

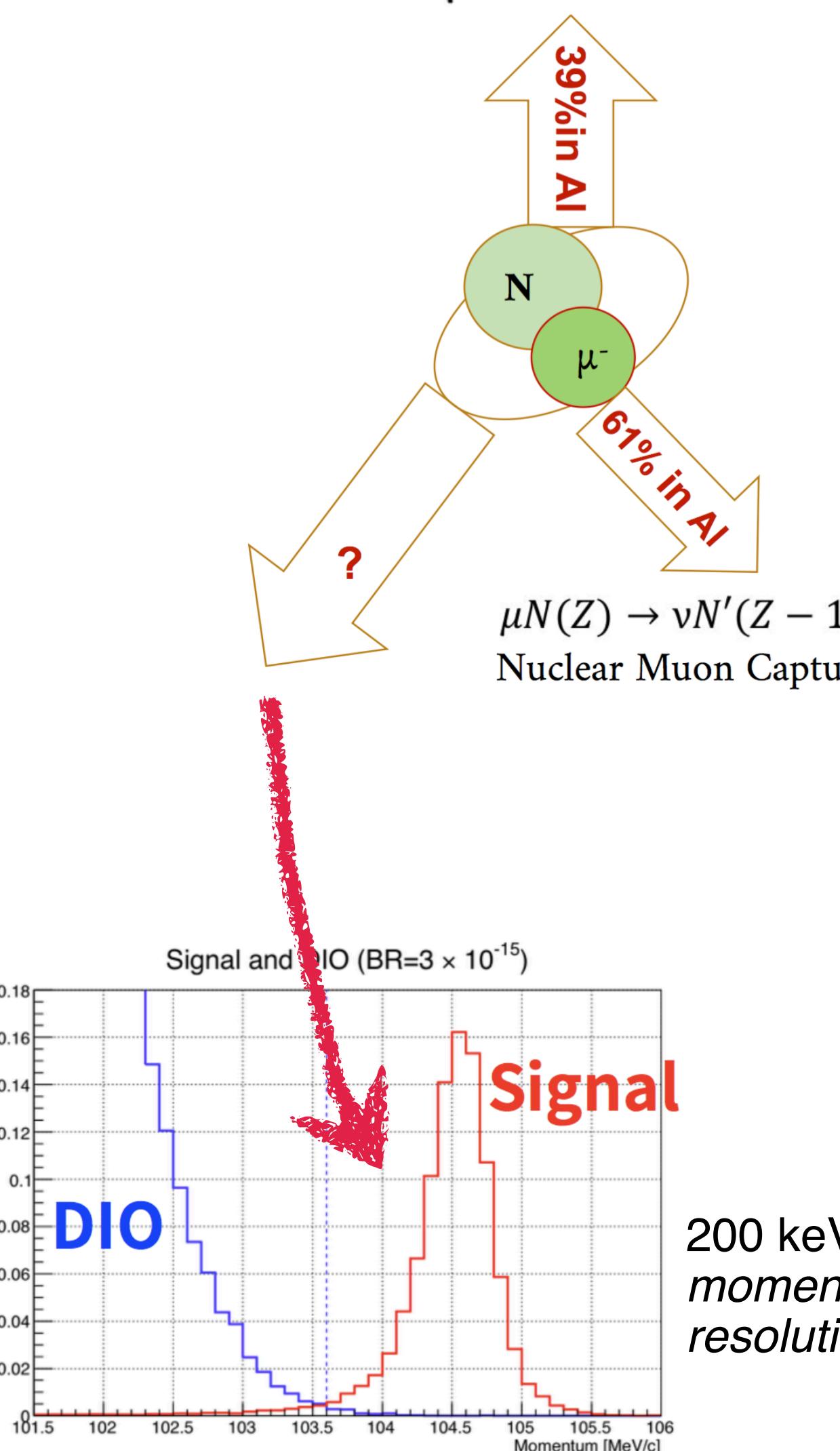


Japan Proton Accelerator Research Complex

Muonic Atom Choice : Al



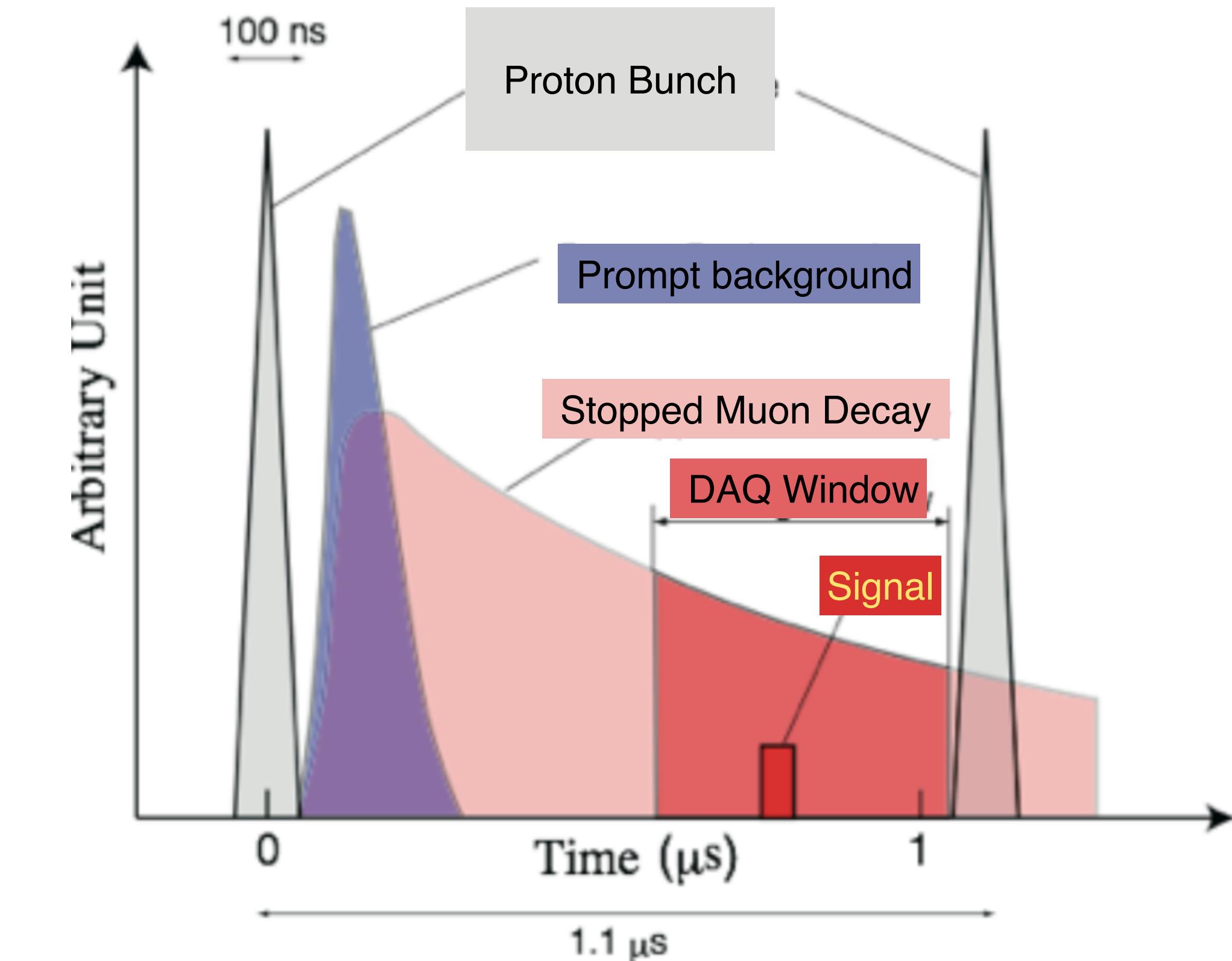
Decay In Orbit
 $\mu N \rightarrow e \nu \bar{\nu} N$



good momentum resolution @ 105 MeV/c

Pulsed beam

Material target	Atomic number (Z)	Muonium lifetime (ns)
Aluminum	13	864
Titanium	22	330
Lead	82	74



Delayed DAQ gate (700ns-1,17 μ s)
Narrow proton pulses



PHYSICAL REVIEW ACCELERATORS AND BEAMS

[Highlights](#) [Recent](#) [Accepted](#) [Special Editions](#) [Authors](#) [Referees](#) [Sponsors](#) [Search](#)[Editors' Suggestion](#)[Open Access](#)

Delivering the world's most intense muon beam

S. Cook, R. D'Arcy, A. Edmonds, M. Fukuda, K. Hatanaka, Y. Hino, Y. Kuno, M. Lancaster, Y. Mori, T. Ogitsu, H. Sakamoto, A. Sato, N. H. Tran, N. M. Truong, M. Wing, A. Yamamoto, and M. Yoshida
Phys. Rev. Accel. Beams **20**, 030101 – Published 15 March 2017

$$(9 \pm 1) \times 10^4 \mu^-/s/W \text{ at } \sim 400\text{W}$$

素粒子の一つであるミューオンを世界最高の効率で生成する装置「MuSIC」。宇宙の始まりに何が起ったのか、宇宙はどのような法則で成り立っているのかを、大量のミューオンと最新技術を駆使して研究する

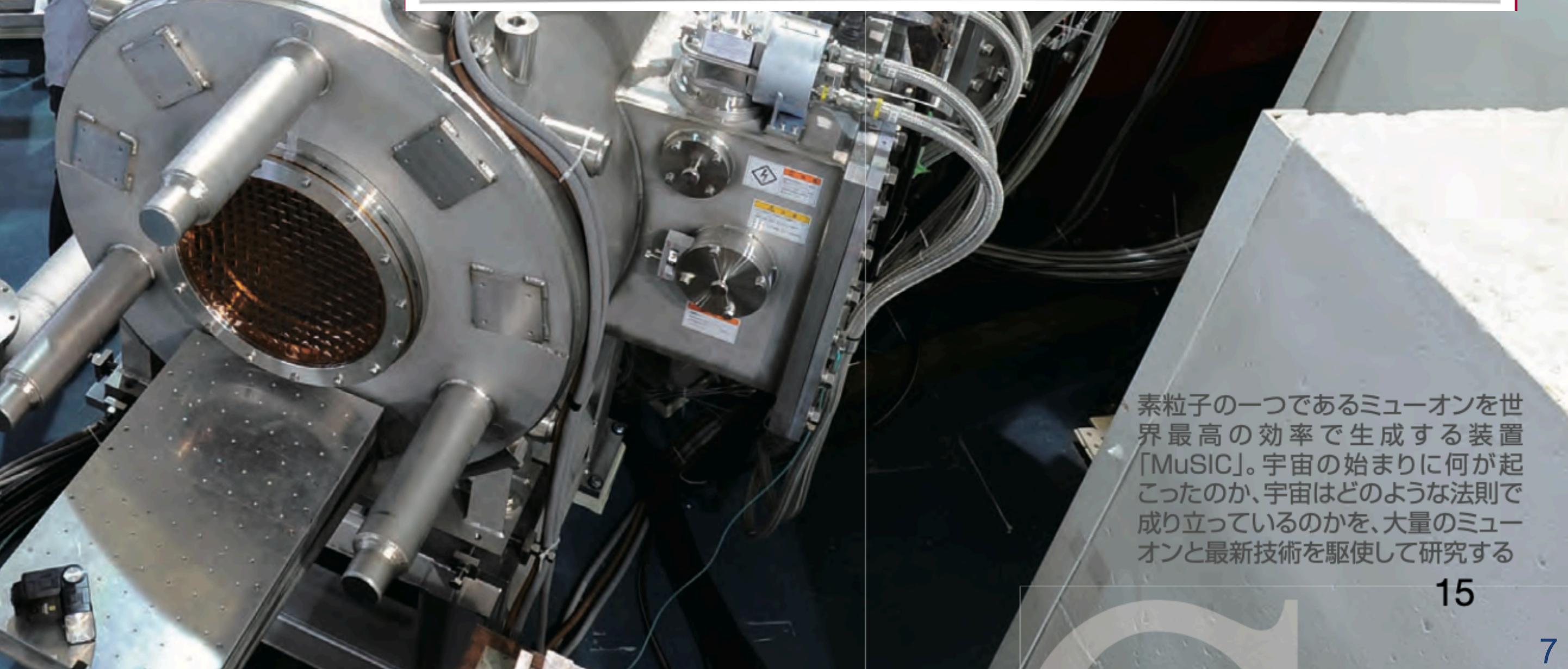
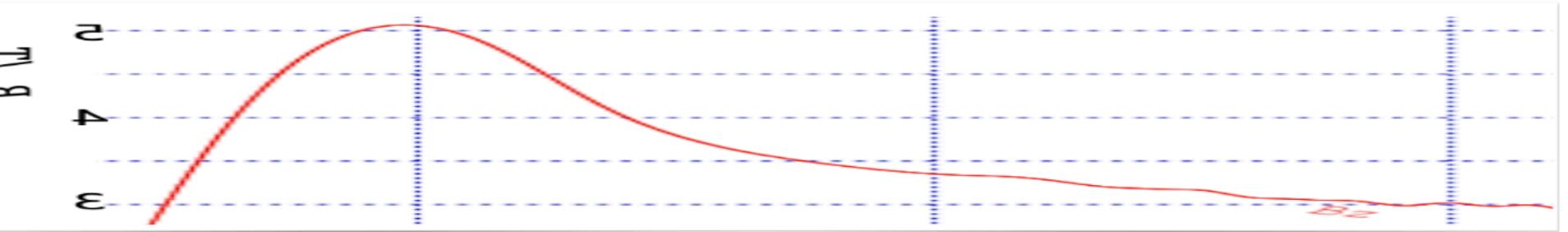


© Lobashev and Djilkibaev MELC experiment [Sov.J.Nucl.Phys. 49, 384 (1989)]

proton beam

proton beam

© S.Giovannella



PHYSICAL REVIEW ACCELERATORS AND BEAMS

Highlights Recent Accepted Special Editions Authors Referees Sponsors Search

Editors' Suggestion

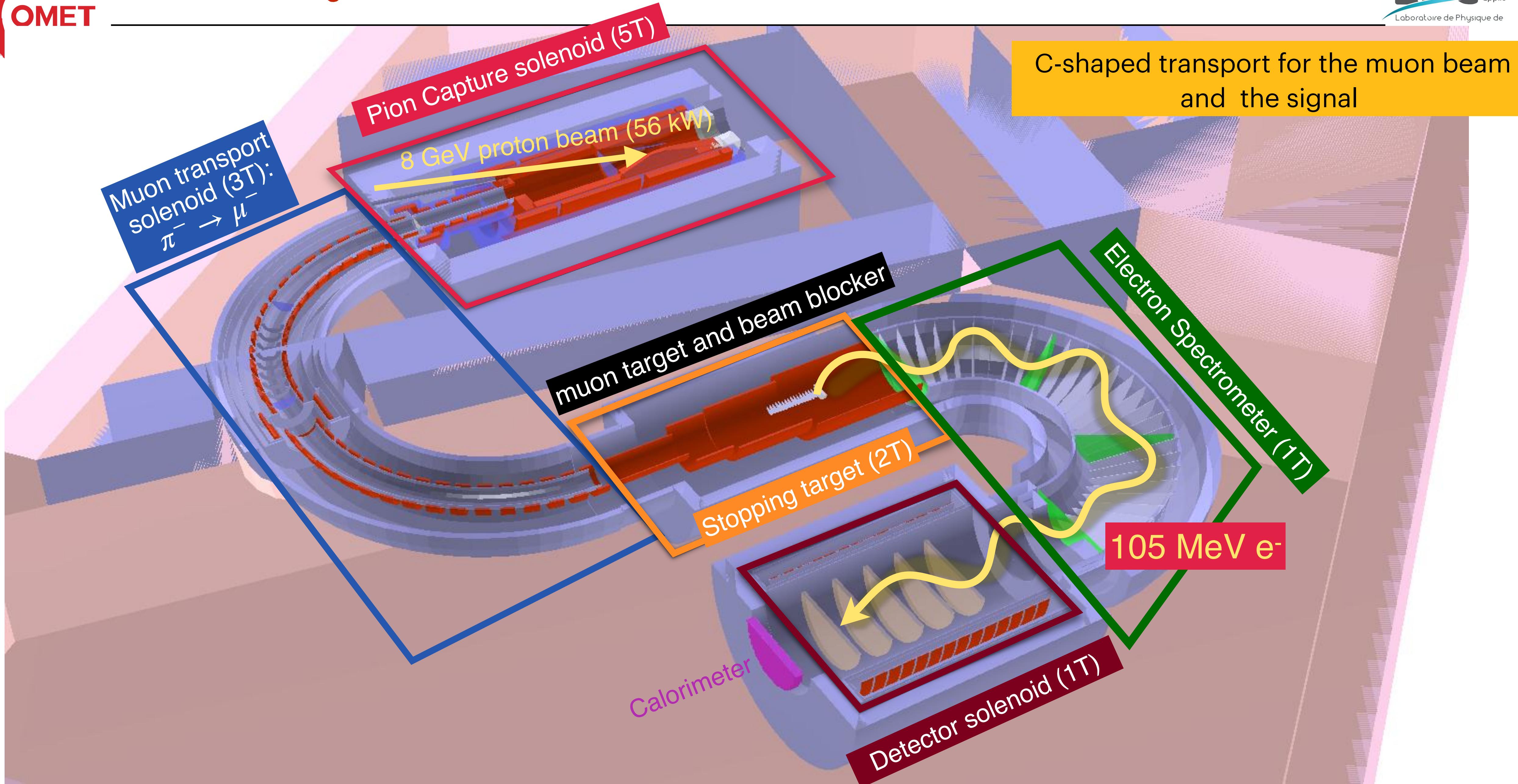
Open Access

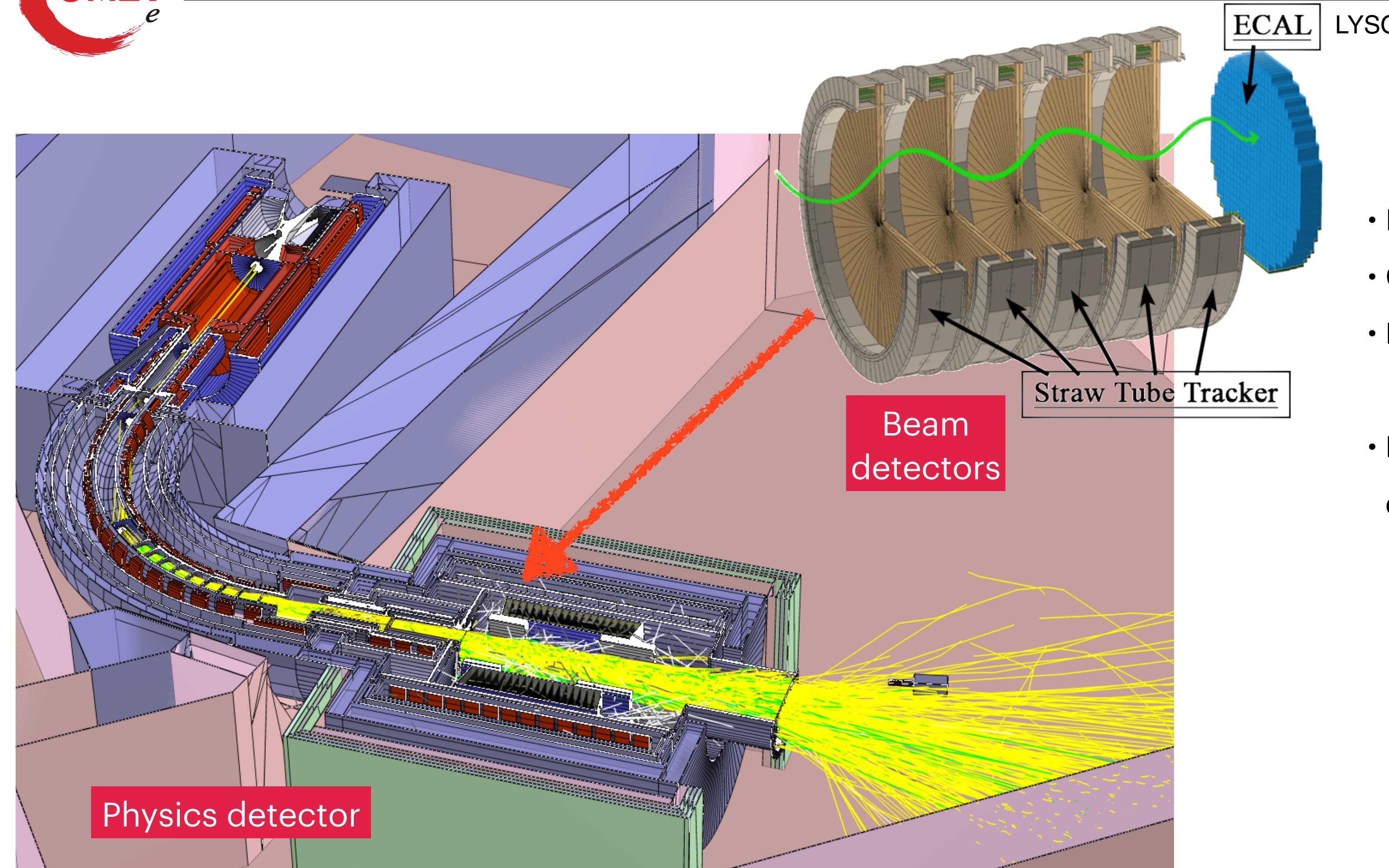
Delivering the world's most intense muon beam

S. Cook, R. D'Arcy, A. Edmonds, M. Fukuda, K. Hatanaka, Y. Hino, Y. Kuno, M. Lancaster, Y. Mori, T. Ogitsu, H. Sakamoto, A. Sato, N. H. Tran, N. M. Truong, M. Wing, A. Yamamoto, and M. Yoshida
Phys. Rev. Accel. Beams **20**, 030101 – Published 15 March 2017

$(9 \pm 1) \times 10^4 \mu^-/s/W$ at $\sim 400W$

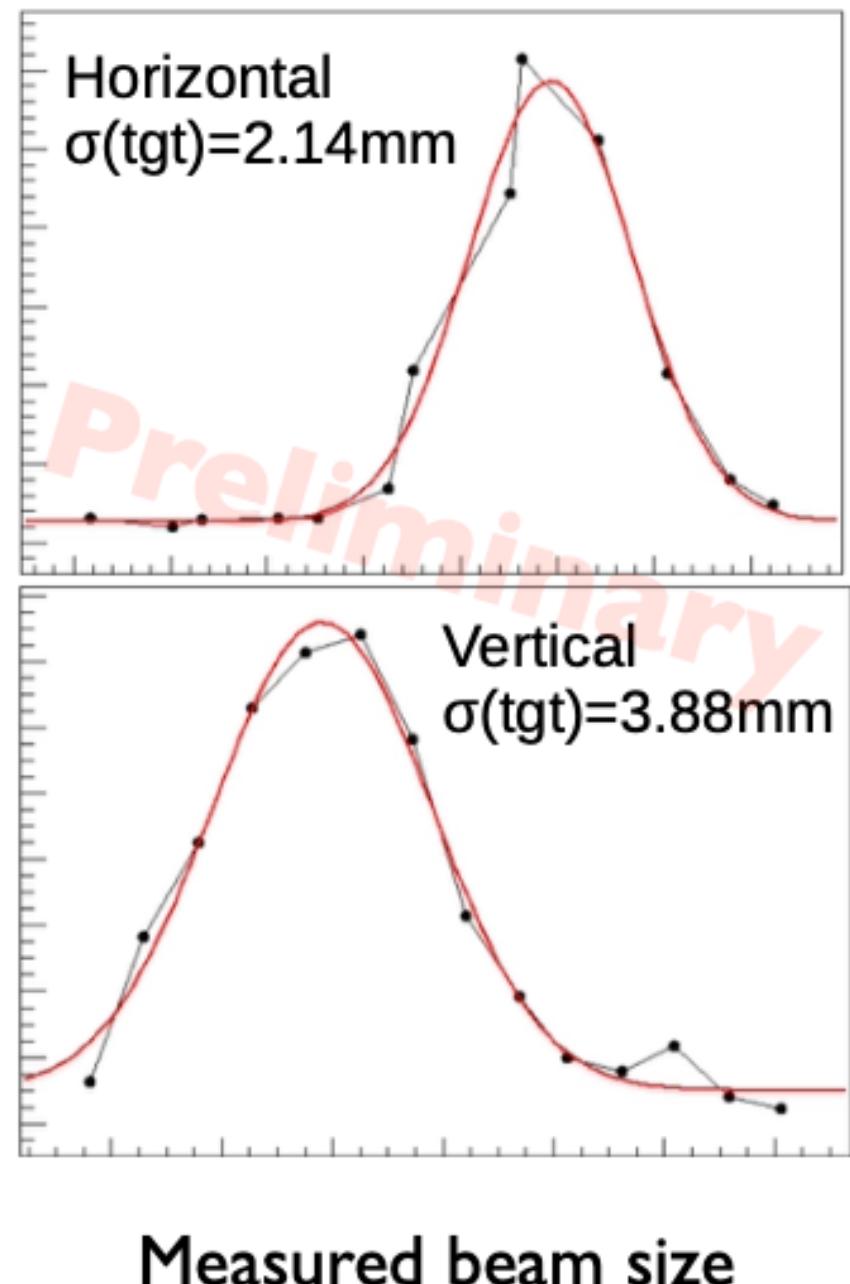
素粒子の一つであるミューオンを世界最高の効率で生成する装置「MuSIC」。宇宙の始まりに何が起ったのか、宇宙はどのような法則で成り立っているのかを、大量のミューオンと最新技術を駆使して研究する



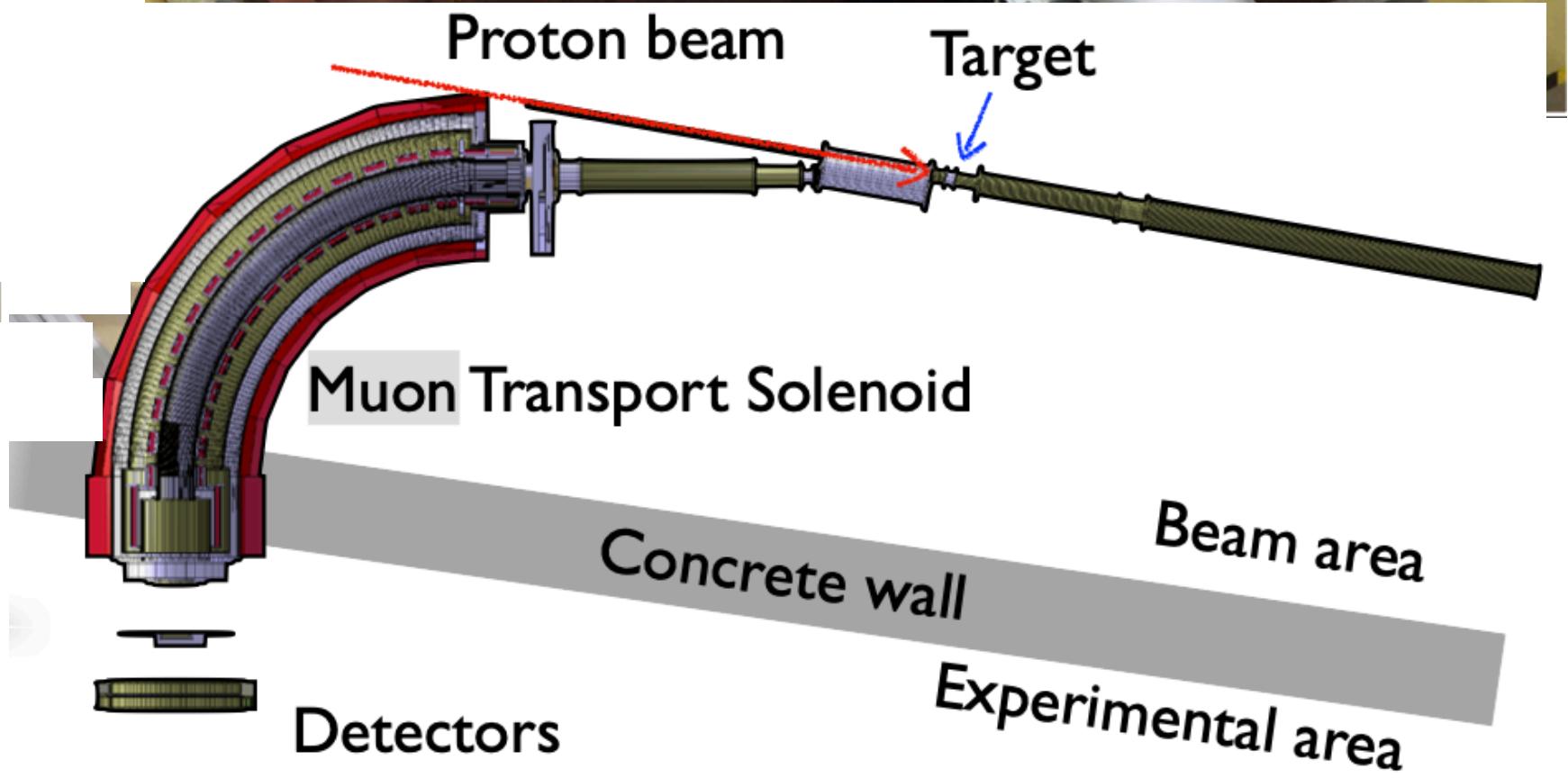
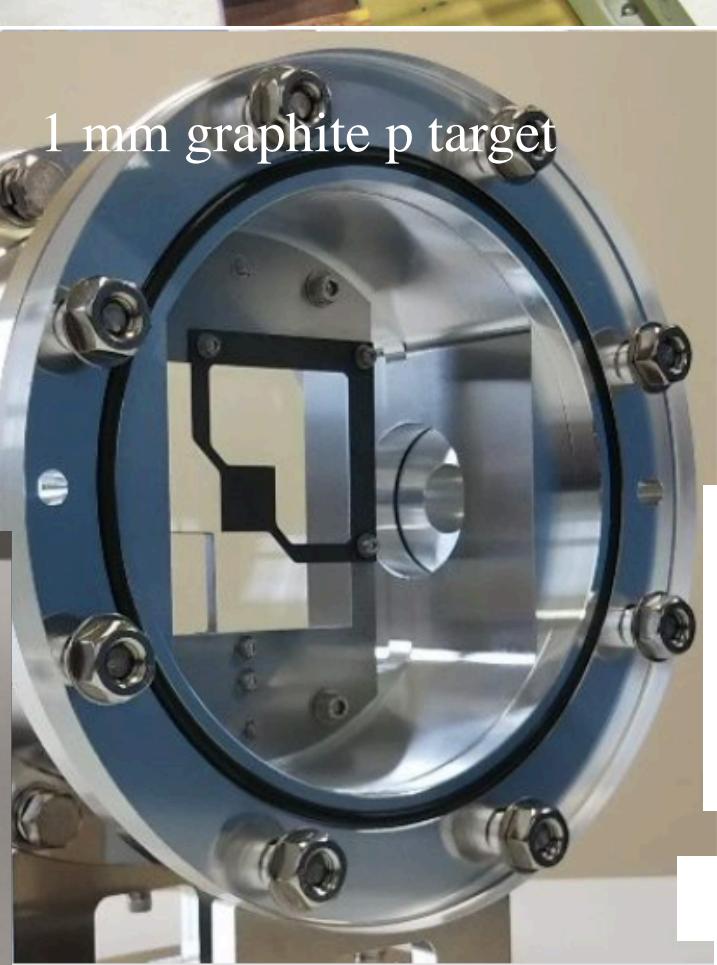
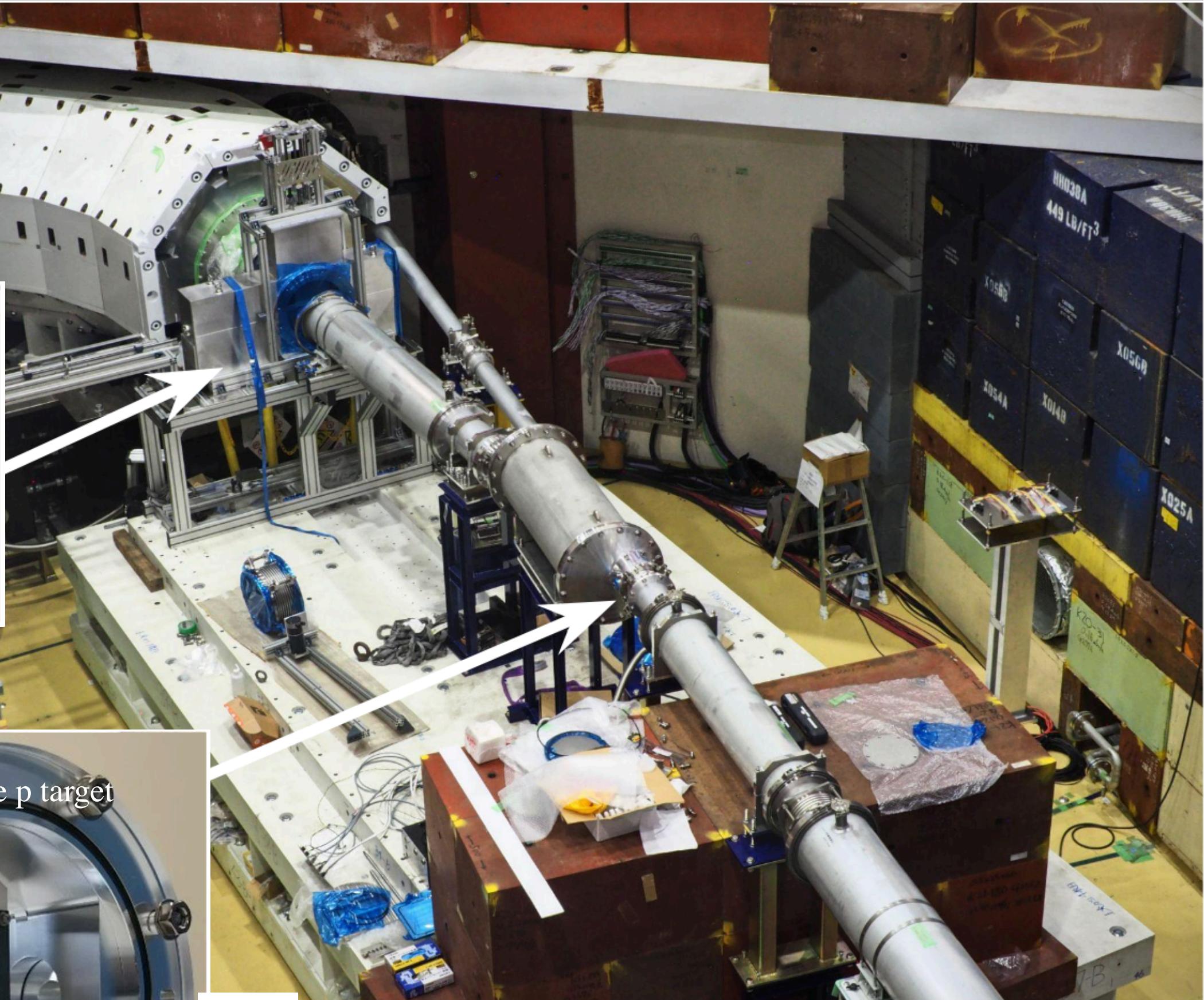
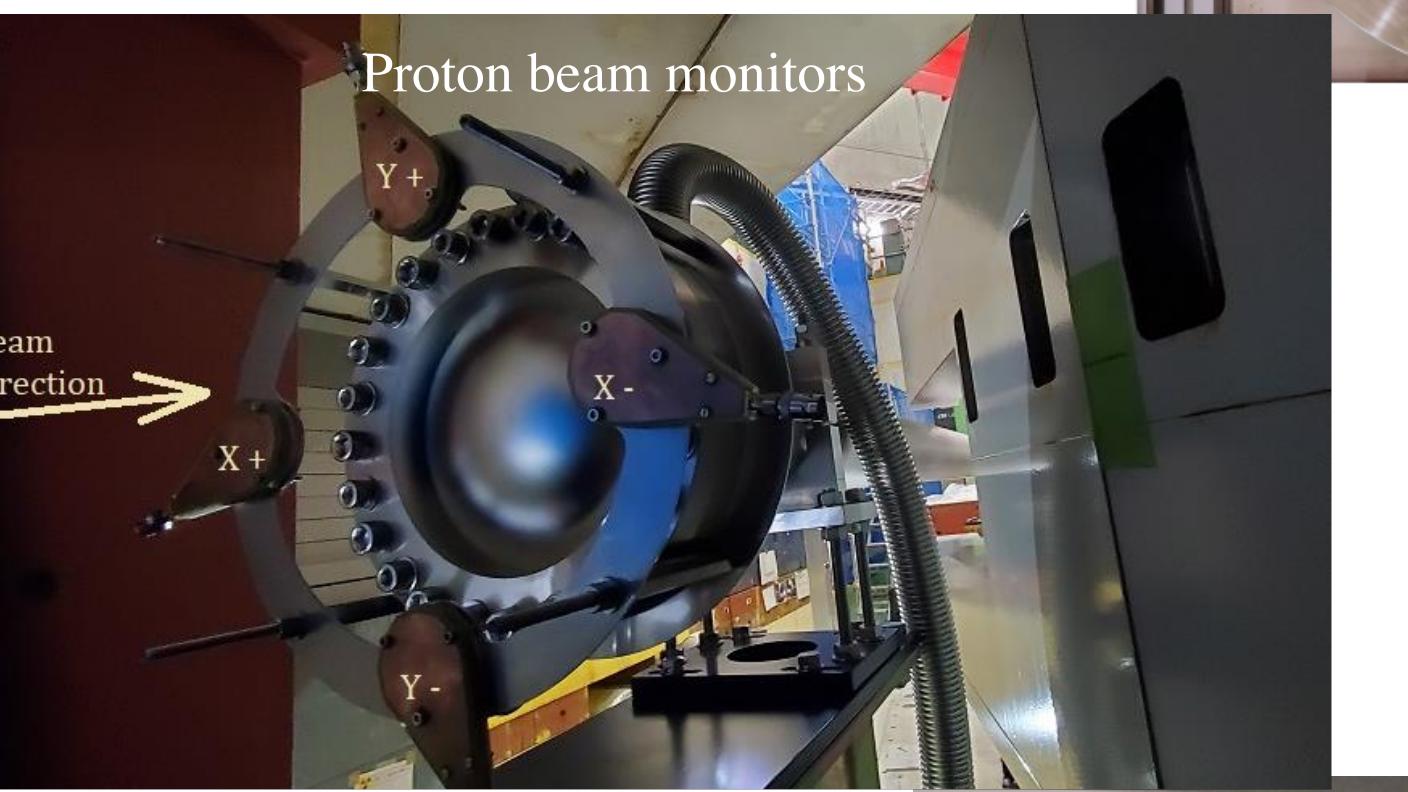


- Demonstrate the basic concept
- Characterise the muon beam
- Measure the backgrounds
- Make a first physics measurement in a cheaper configuration
 - ✓ only half of the Muon Transport Solenoid
 - ✓ no signal transport
 - ✓ lower intensity proton beam (1/10)
 - ✓ graphite target instead of tungsten
 - ✓ a dedicated Physics Detector

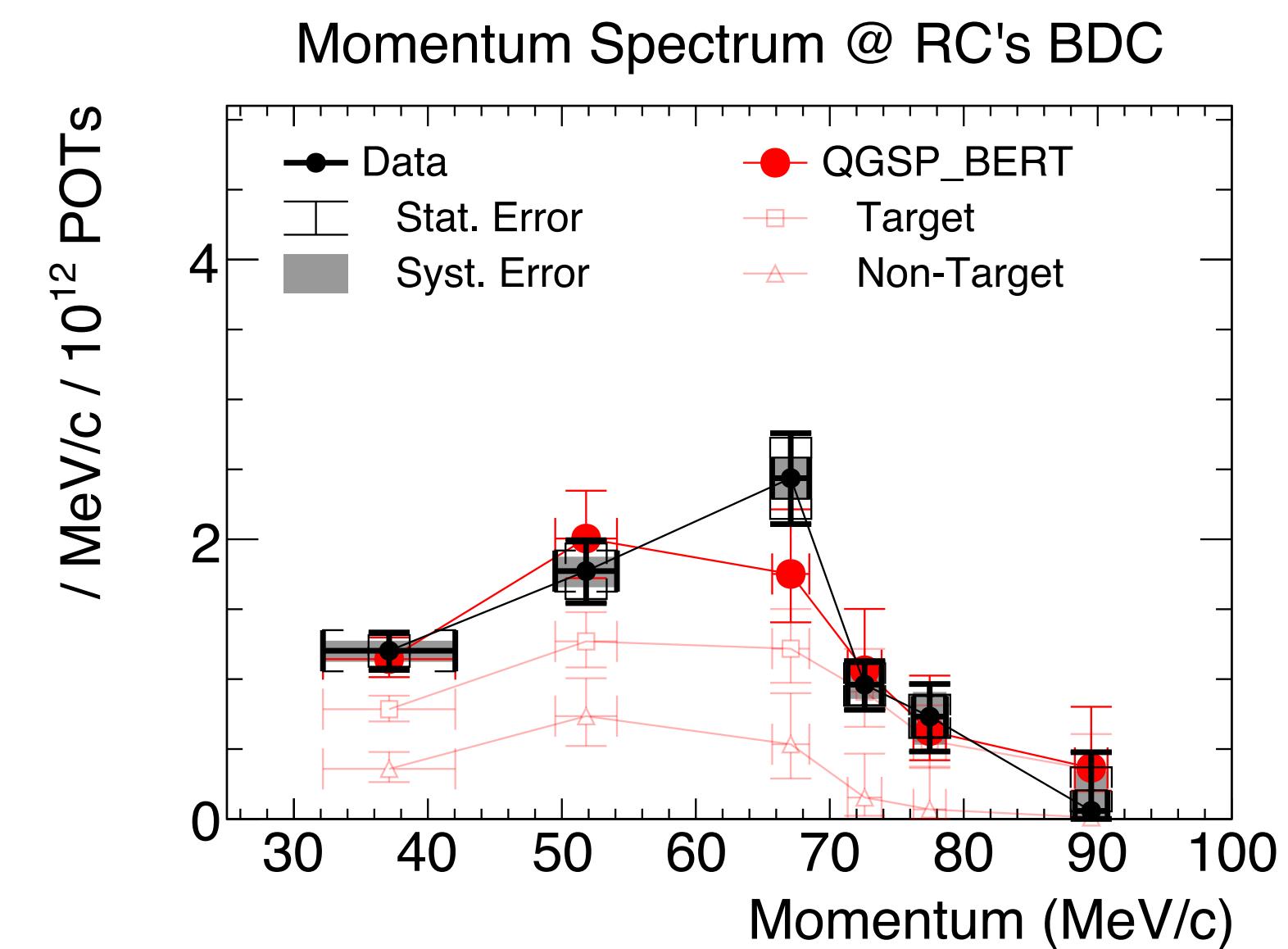
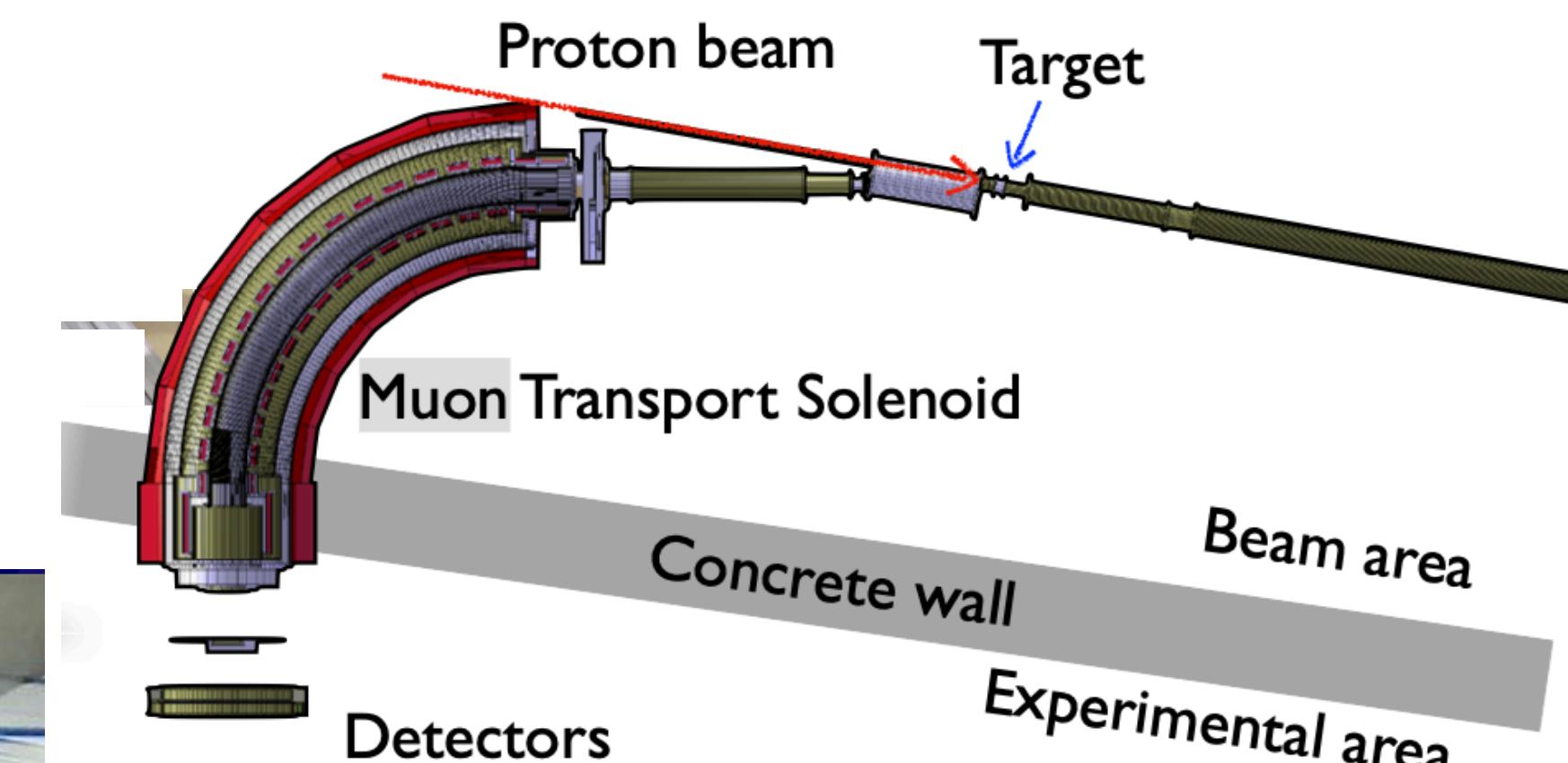
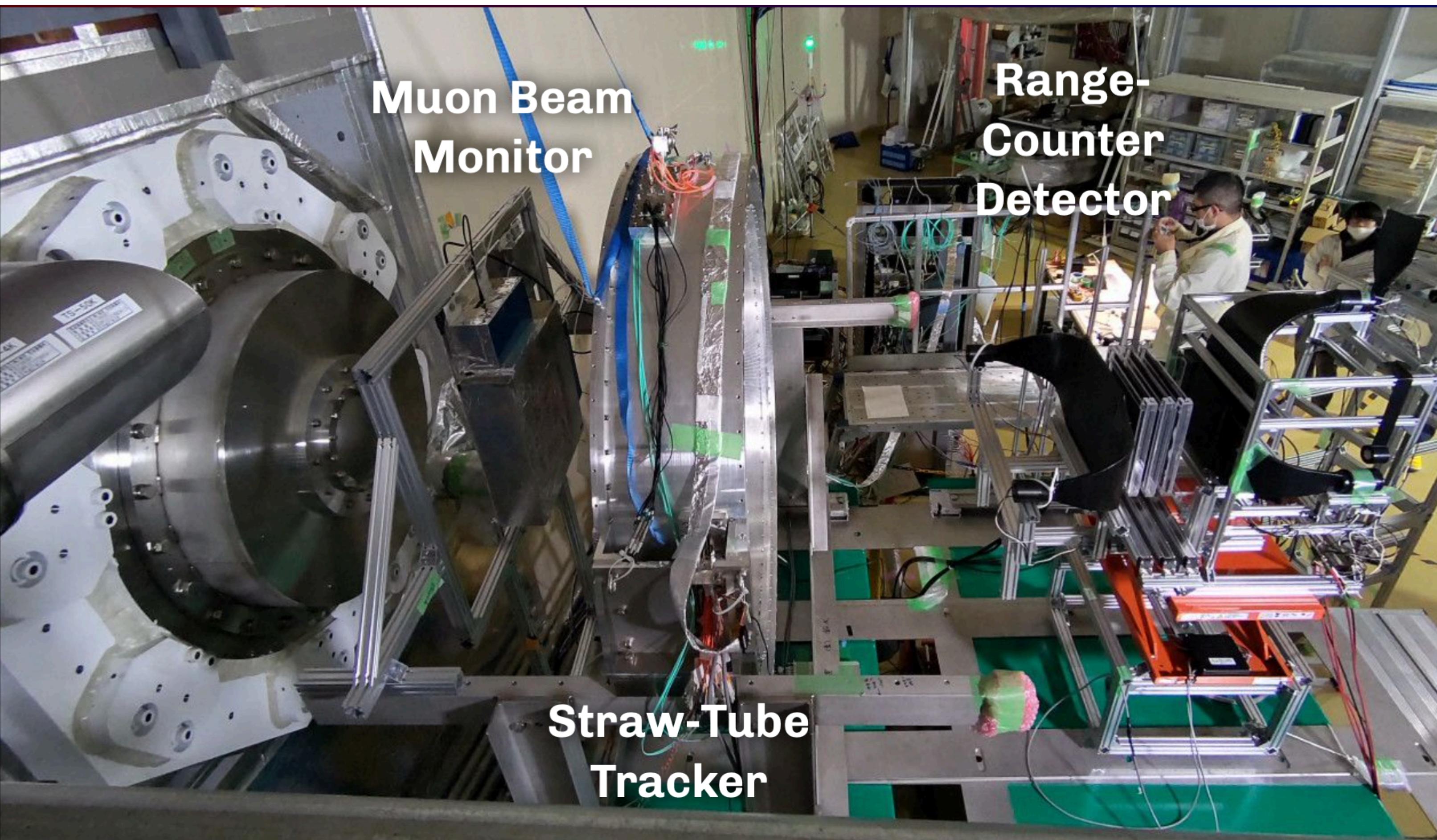
- Slowly-extracted pulsed 8 GeV proton beam at 260 W (~1/10 of Phase-I)
- Thin graphite pion-production target
- Proton beam diagnostic detectors (time, intensity & xy distribution)
- Secondary particle detectors → muon range distribution



Proton beam monitors

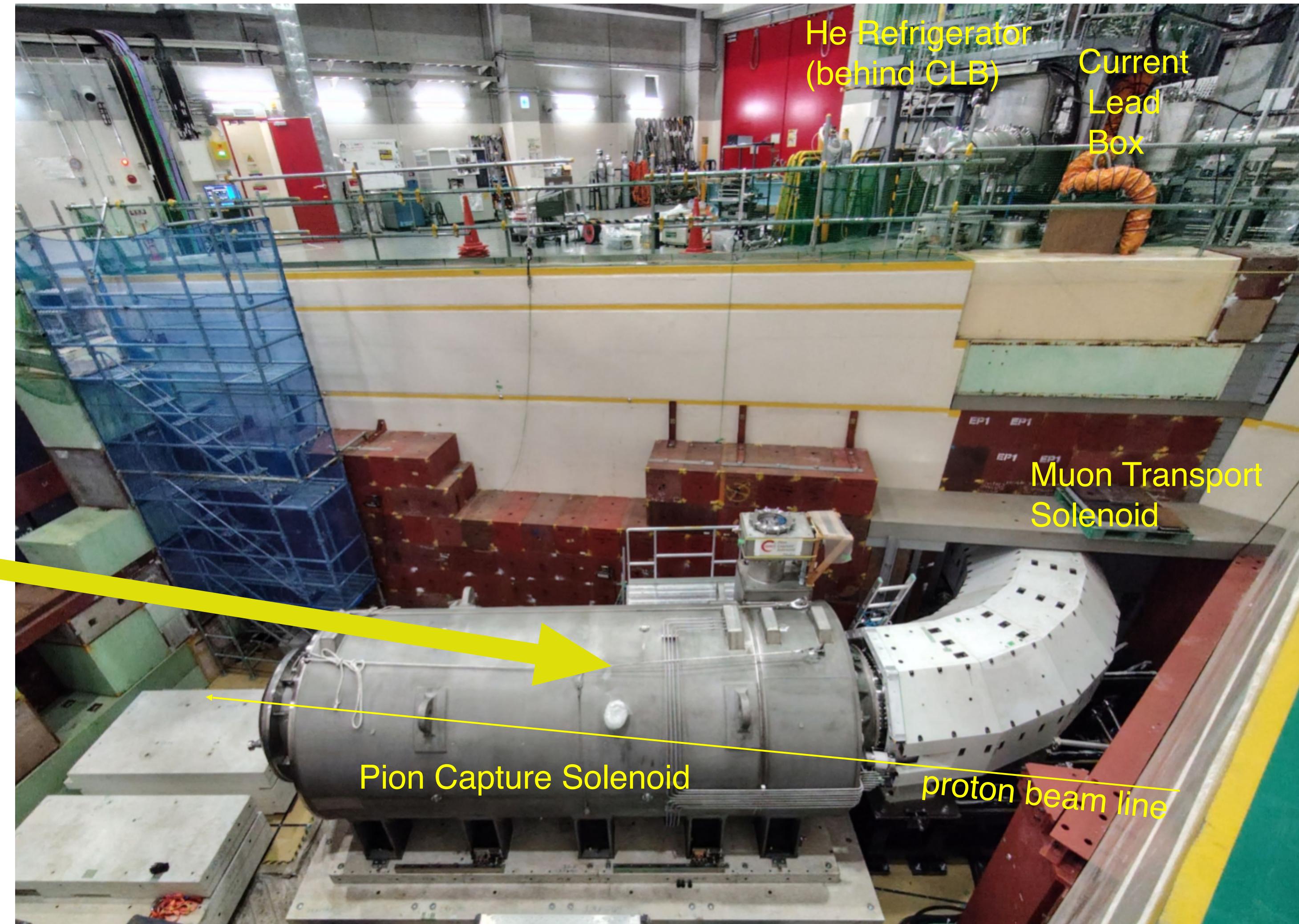
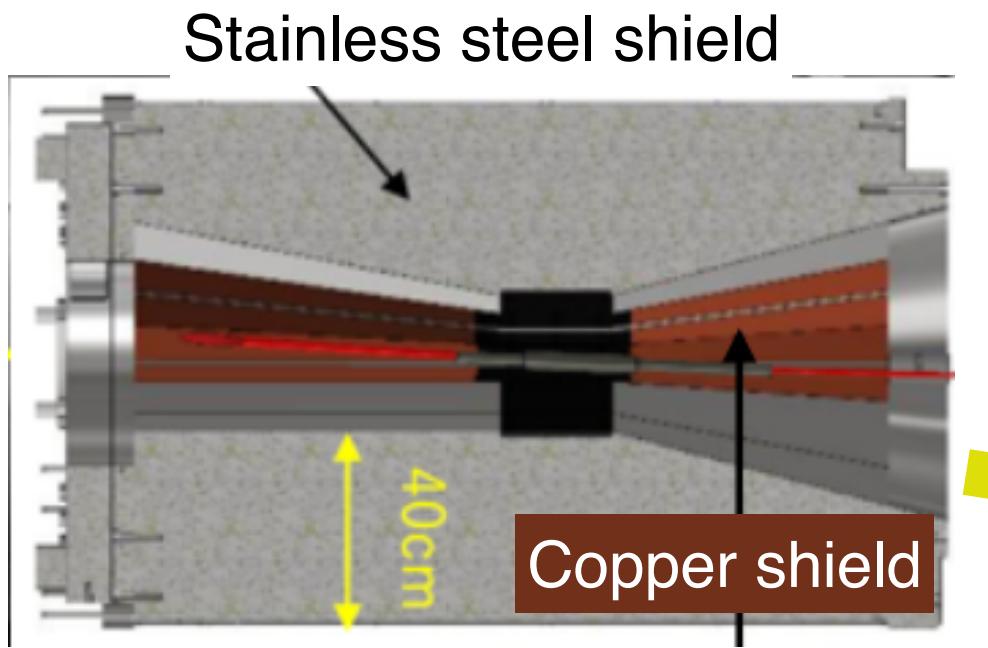


- Slowly-extracted pulsed 8 GeV proton beam at 260 W (~1/10 of Phase-I)
- Thin graphite pion-production target
- Proton beam diagnostic detectors (time, intensity & xy distribution)
- Secondary particle detectors → muon range distribution



Needs to stand hard conditions in Phase I:

- Heat deposition: $\sim 2 \text{ mW/kg} \rightarrow \sim 26 \text{ kGy} / 150 \text{ days}$
- Neutron flux: $3 \times 10^{13} \text{ n/m}^2/\text{s} \rightarrow 4 \times 10^{20} \text{ n/m}^2 / 150 \text{ days}$
- Thick stainless shielding ($\sim 40 \text{ cm}$) protects coil



Installed and connected with MTS in Dec. 2024

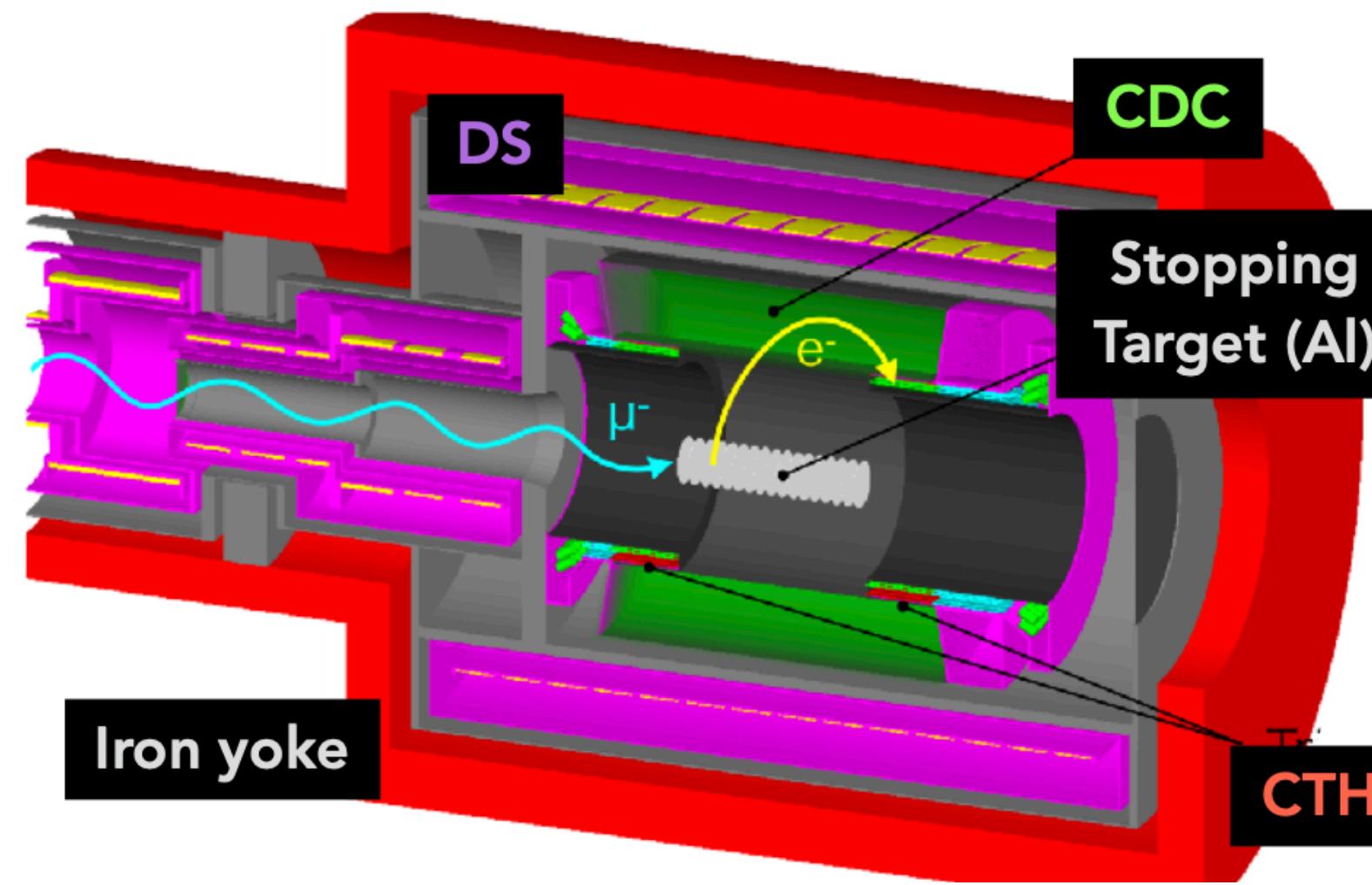
- Coil resistance & voltage withstand up to 500 V
- Leak tests of LHe- & water-cooling pipes successful



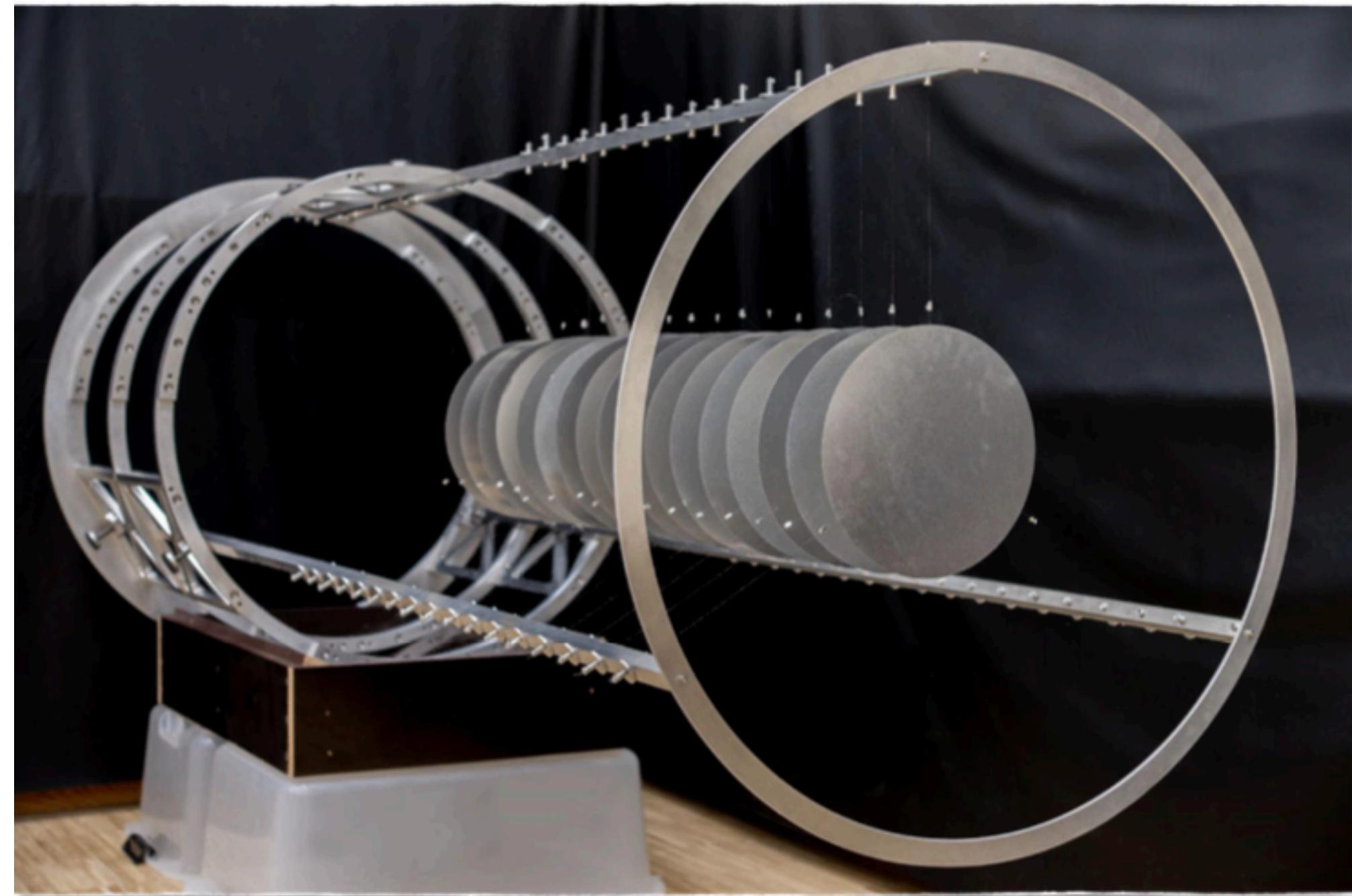
BS magnet is at NU1 in J-PARC, stand-alone commissioning has been completed



- DS magnet tested successfully in 2024 in North Counter Hall in Tsukuba
- Currently is being installed in the COMET Hall
- The field measurement will follow shortly

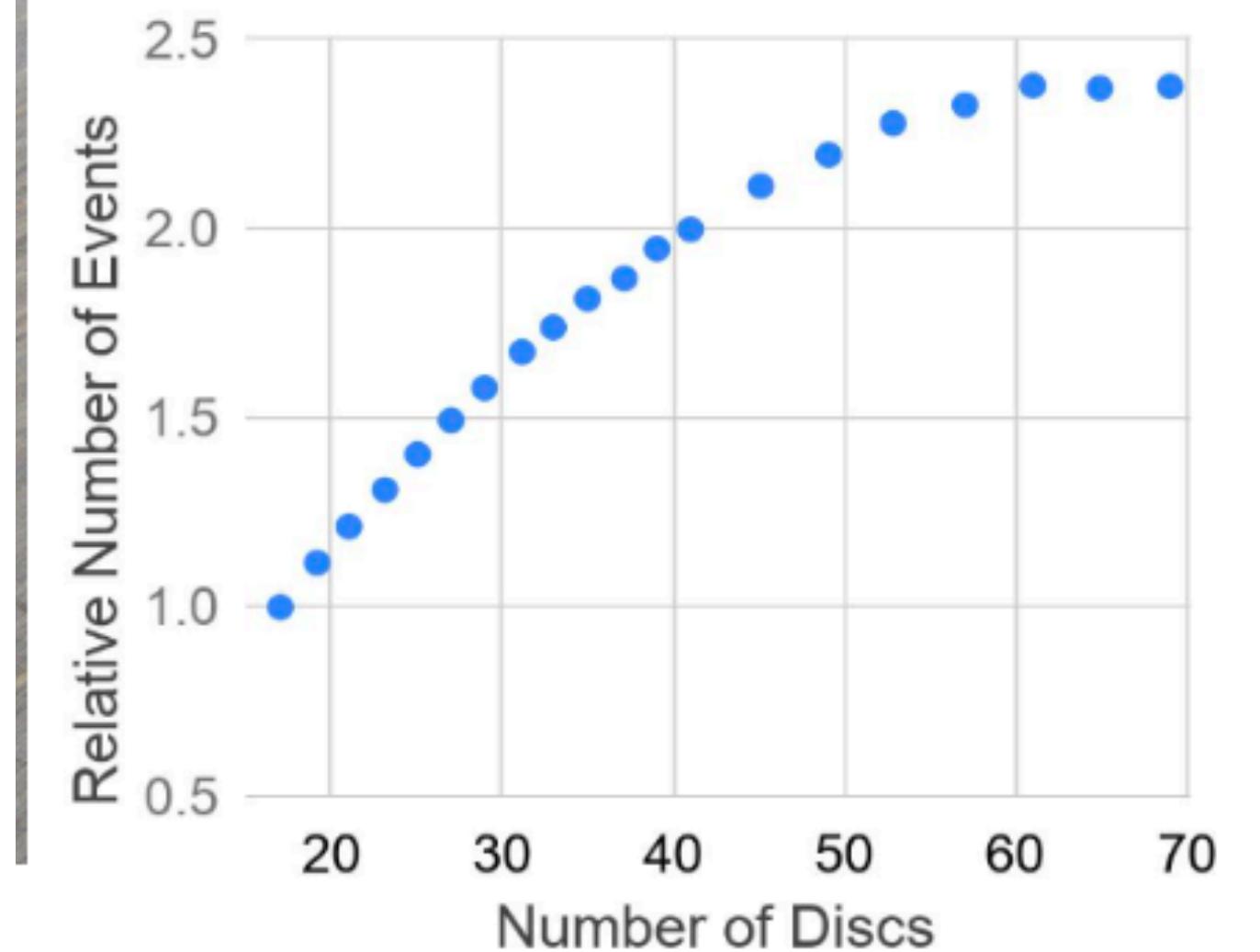


- 17 aluminium discs
- 10 cm radius, 200 μm thickness, and 50 mm spacing.
- Stability and performance tests of various aluminium alloys concluded.

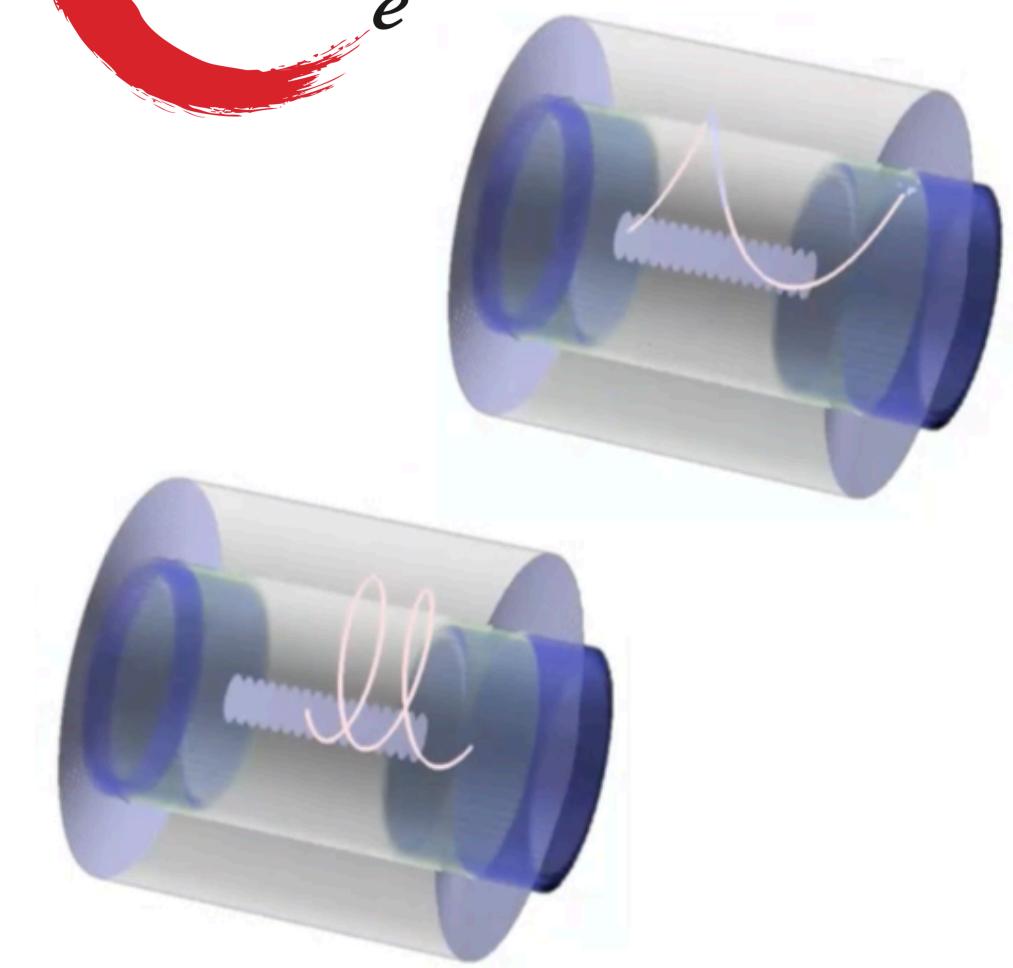


17 Al disks
100 mm radius, 200 μm thick

Number of Signal Events



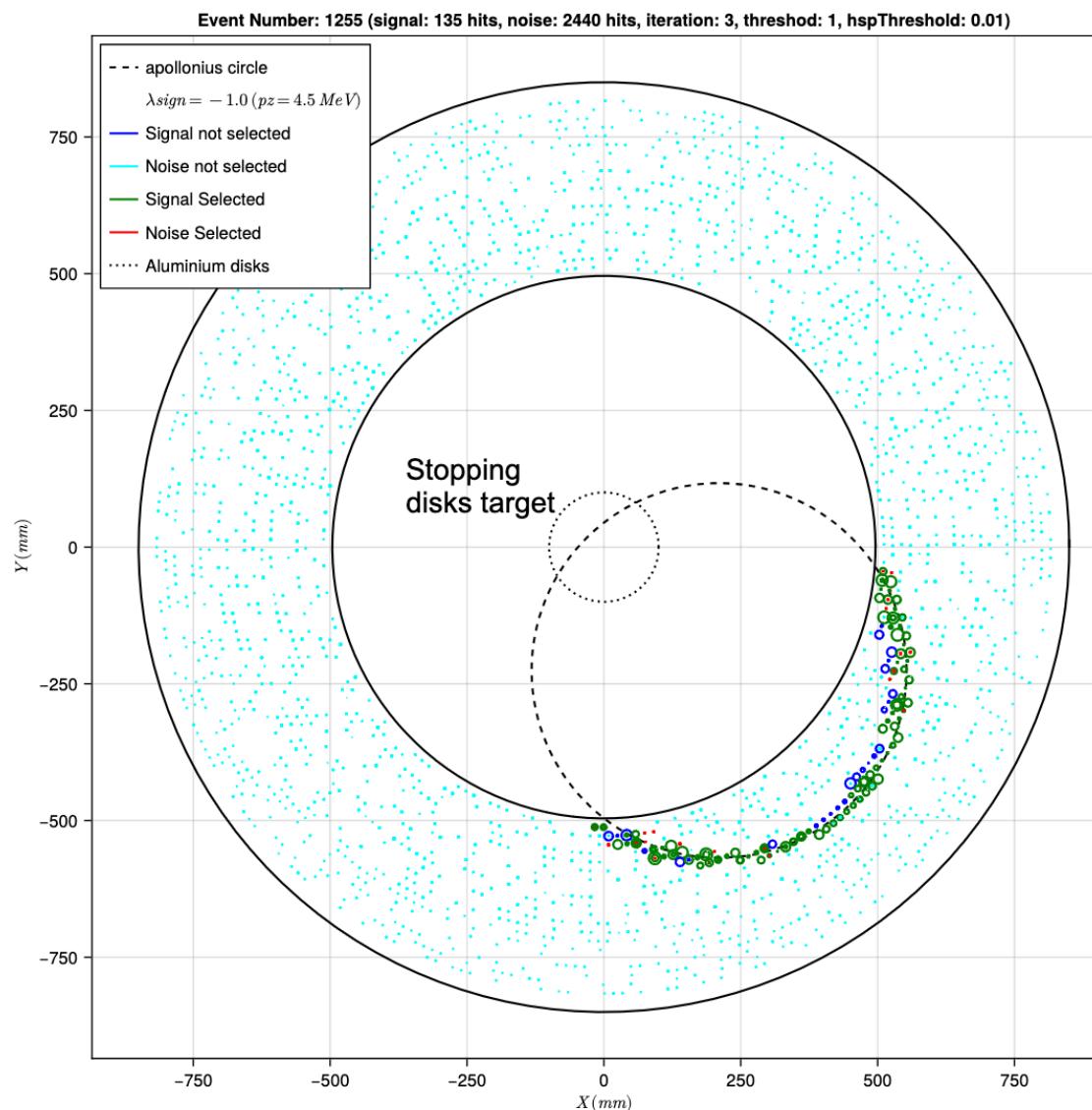
cylindrical Drift Chamber



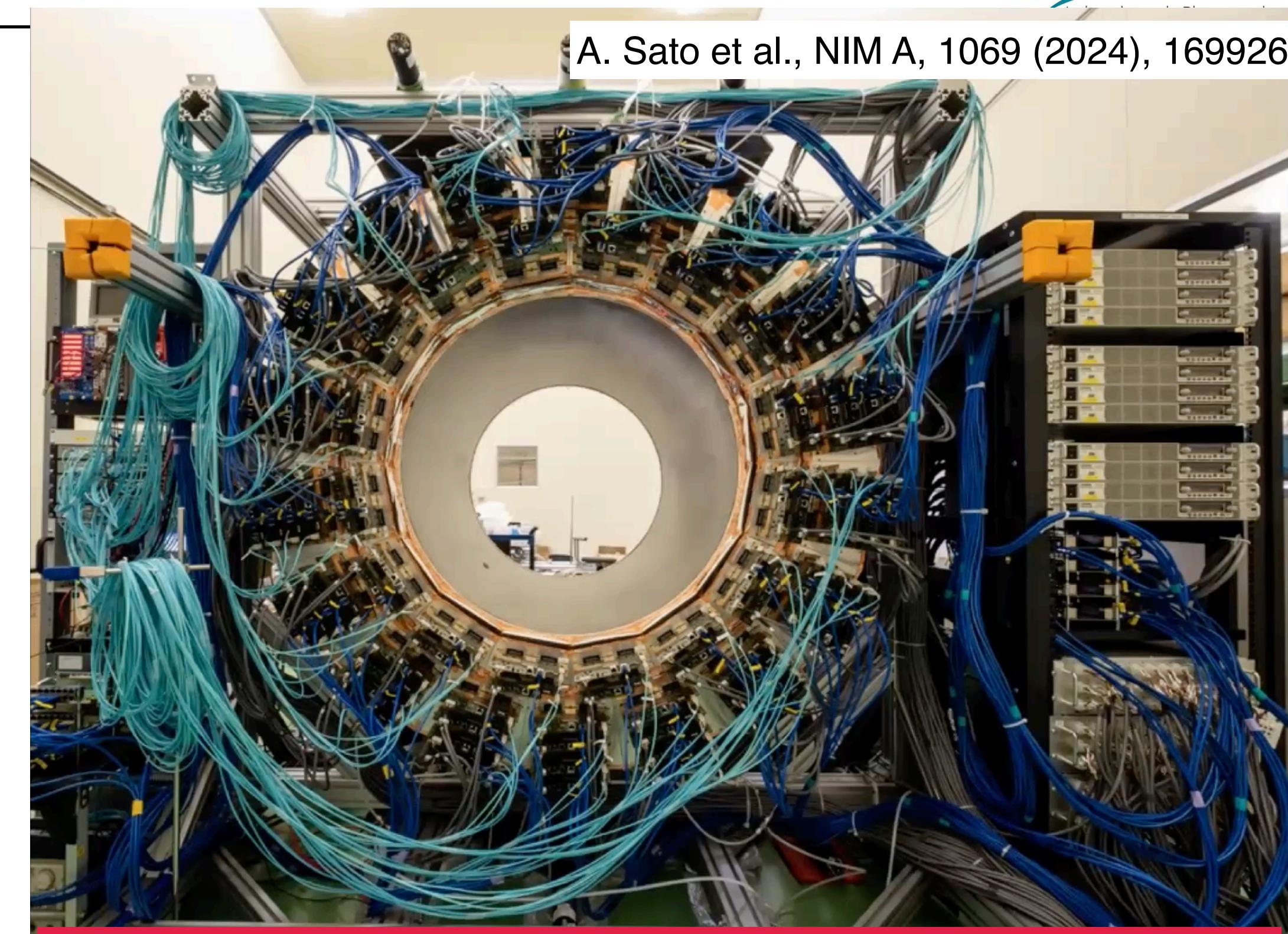
- 20 concentric sense layers (~5000 gold plated sense wires)
- mechanical design based on Belle II CDC
- all stereo layers ± 70 mrad (alternate)
- Helium based gas (He:iC4H10=90:10) to minimise multiple scattering
- large inner bore (~500 mm) to avoid beam flash and DIO

Momentum resolution: better than 200 keV/c @ 105 MeV/c

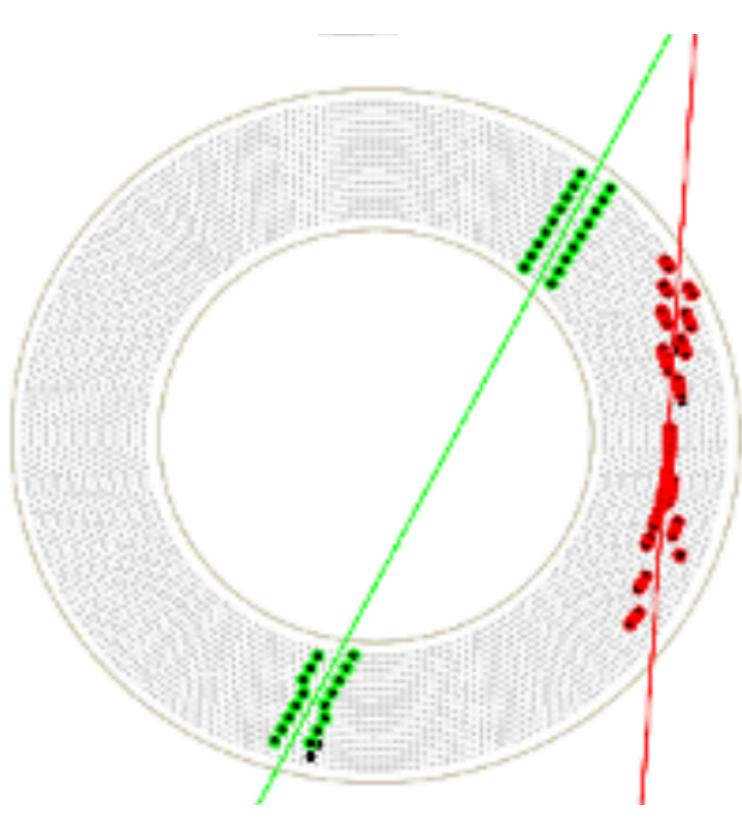
Studies of the track reconstruction with a high hit occupancy are ongoing



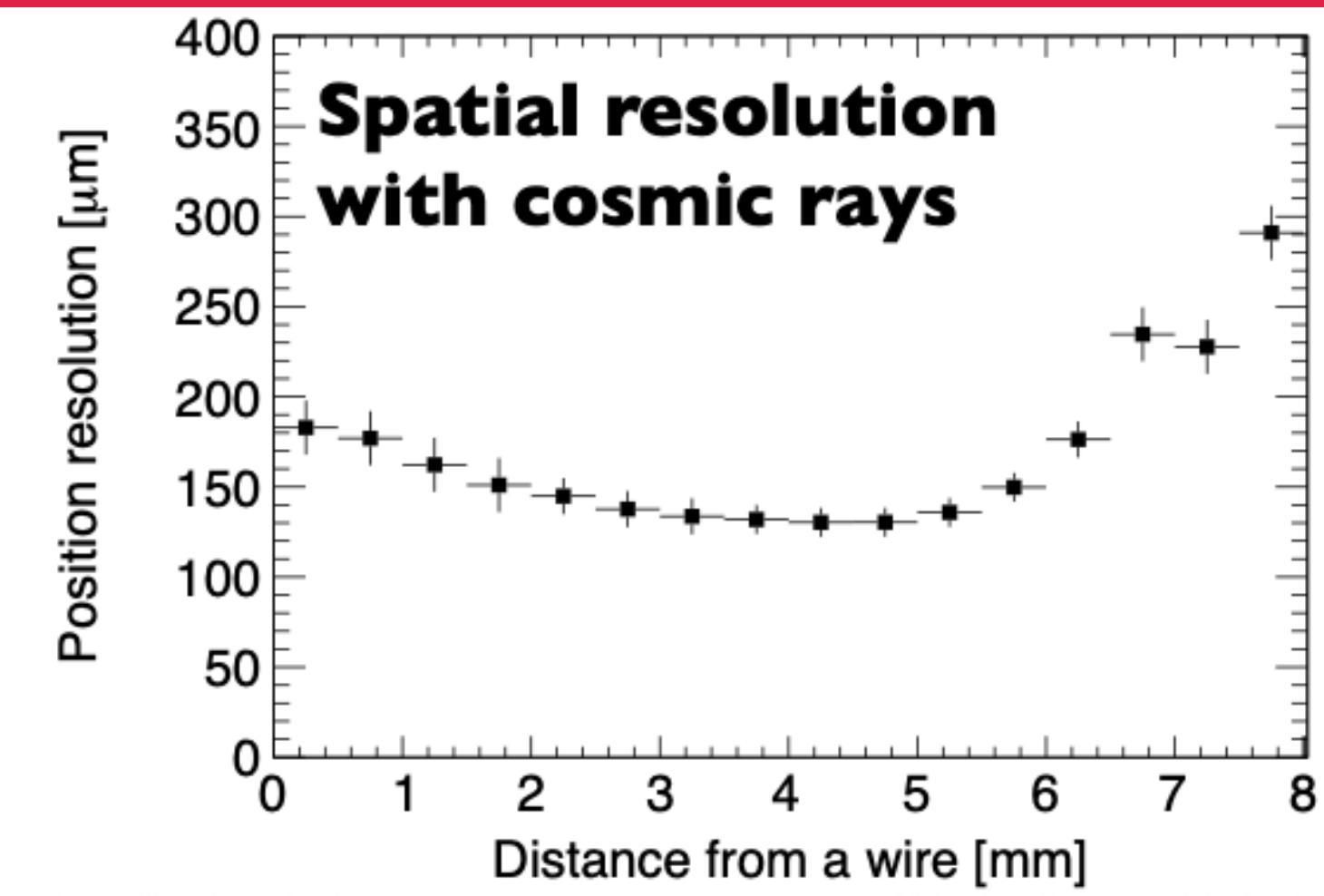
C. Cârloganu, KAON2025, Mainz

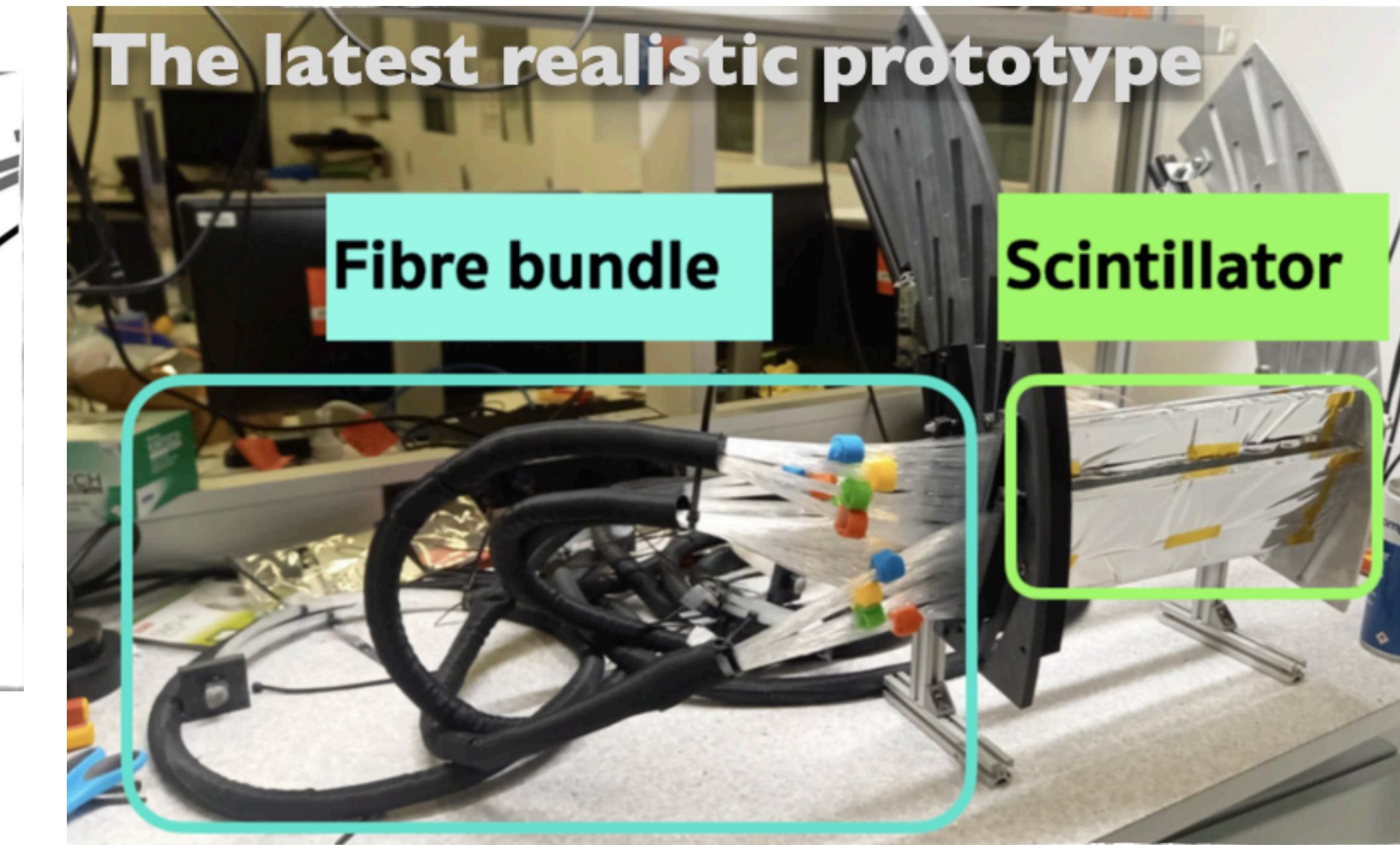
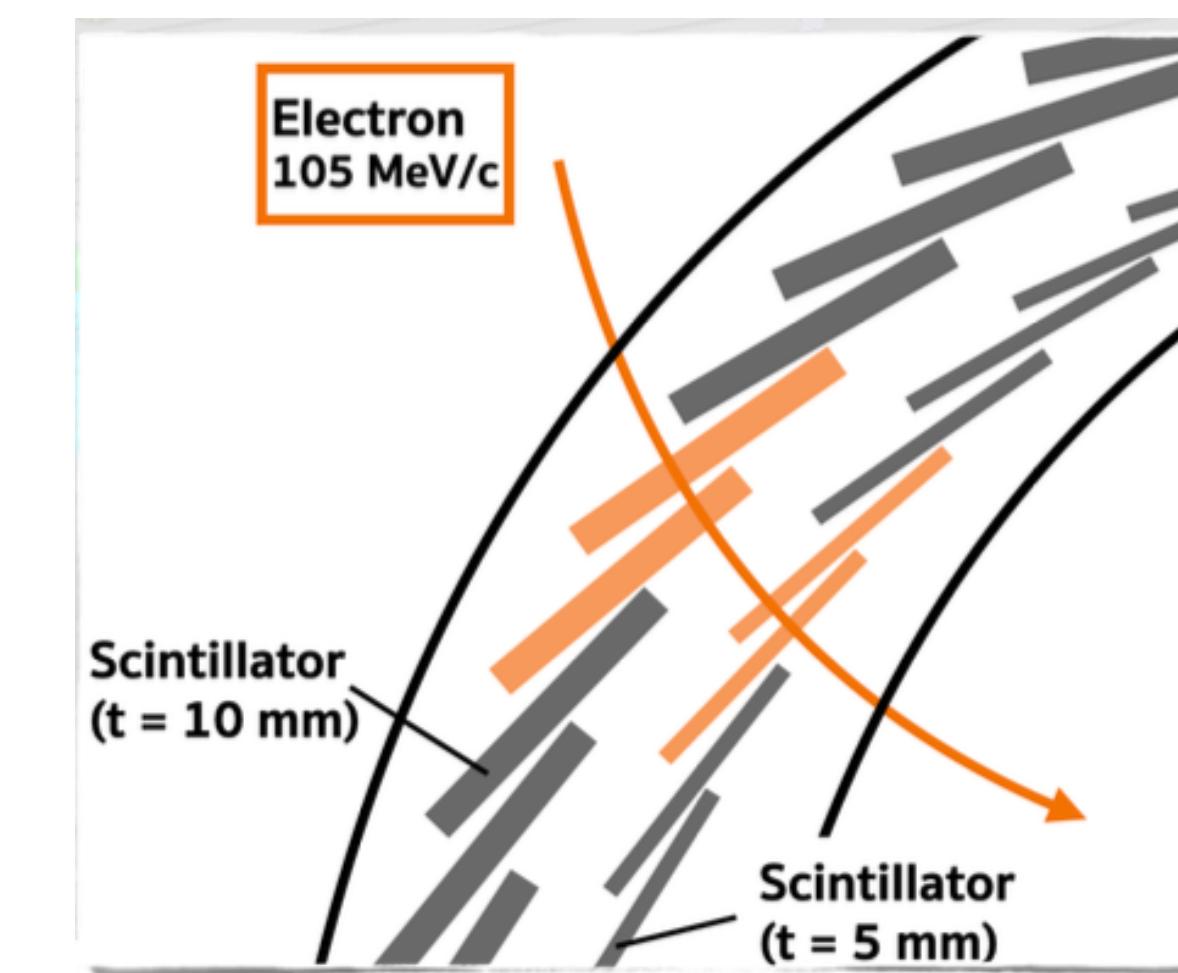
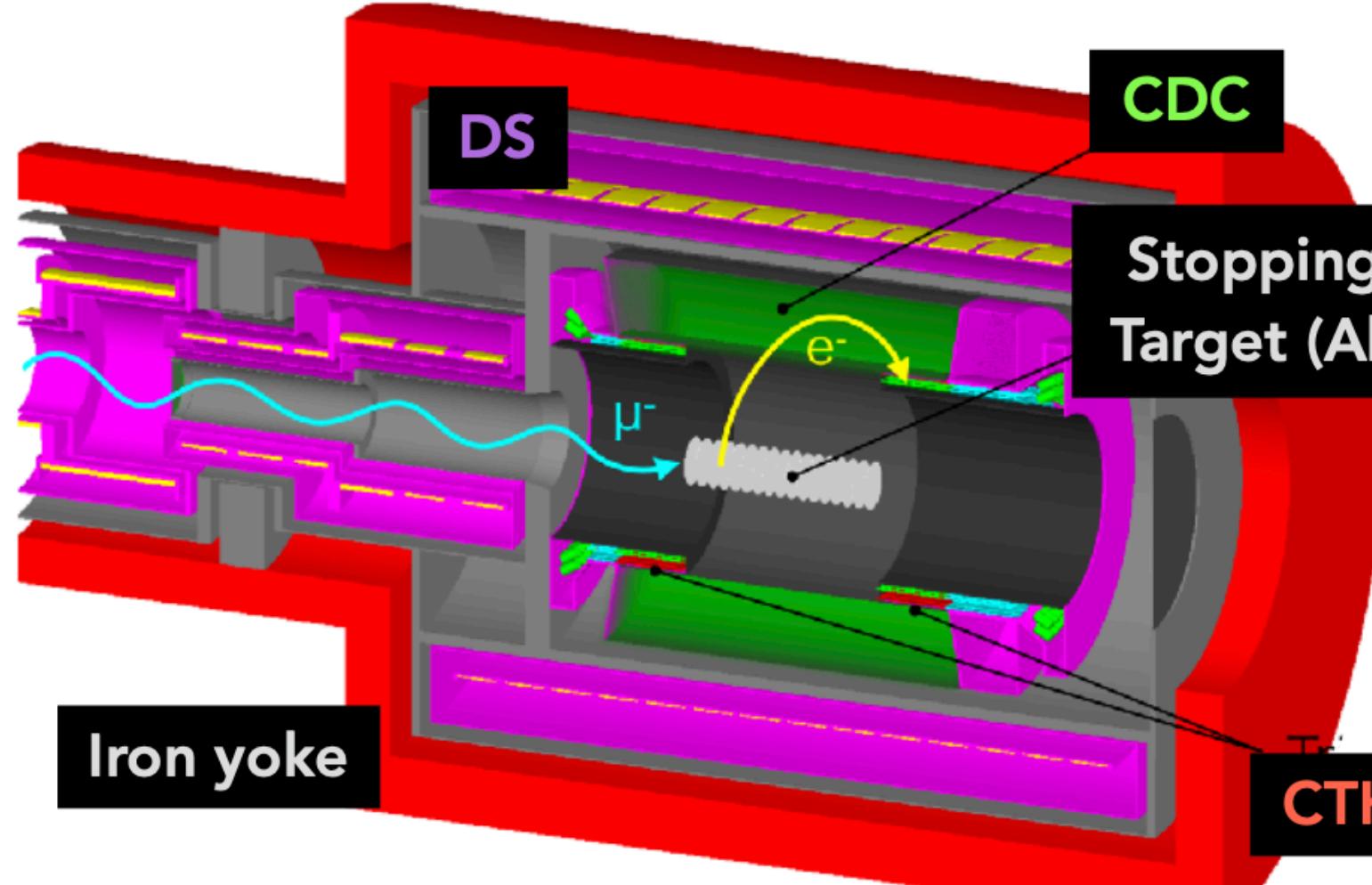


A. Sato et al., NIM A, 1069 (2024), 169926



Basic performance test using CRs has been completed





Trigger : 4-fold coincidences

T0 measurement for tracking

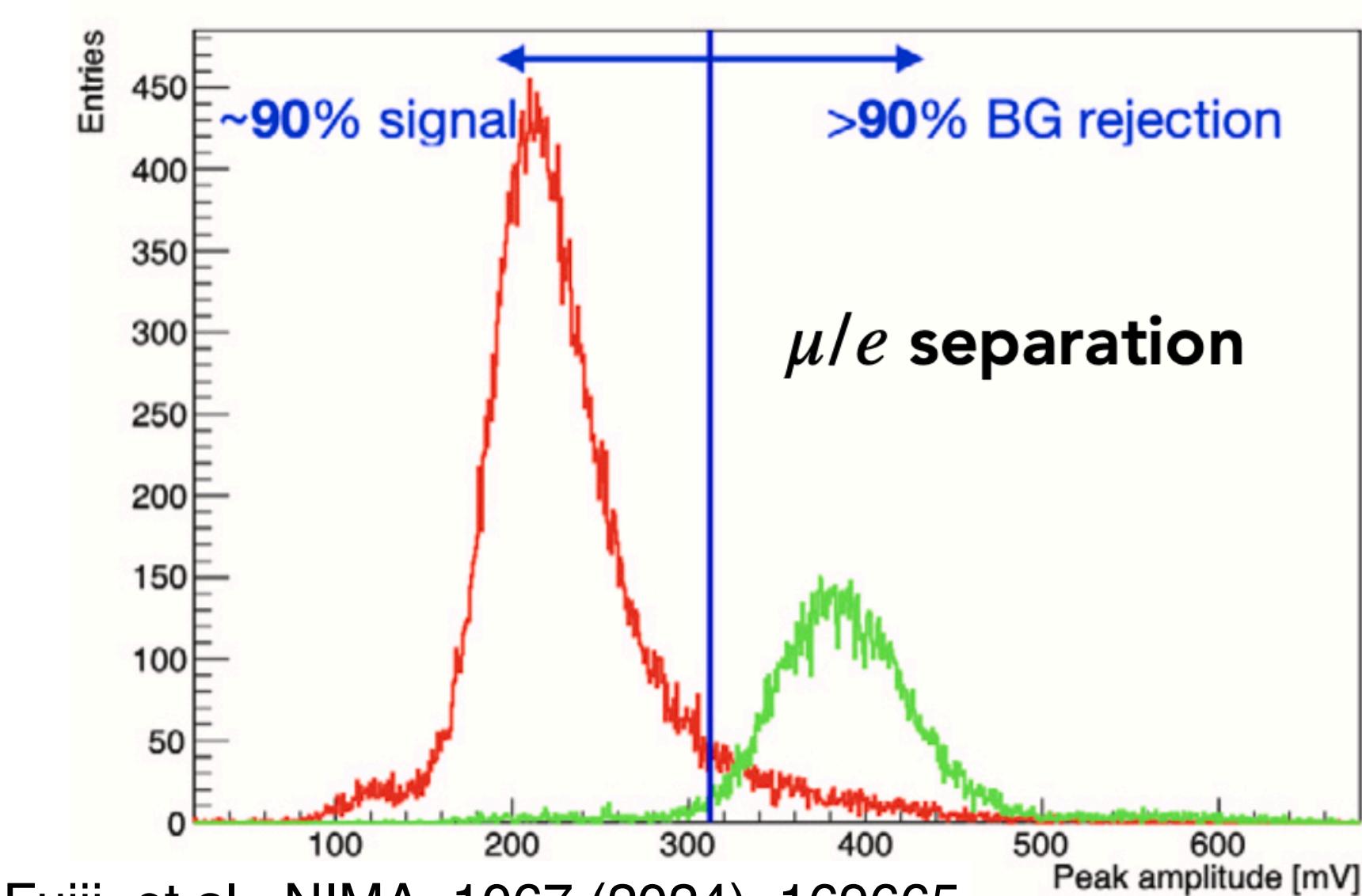
Muon / electron discrimination

2 wheels of 2×64 plastic scintillators

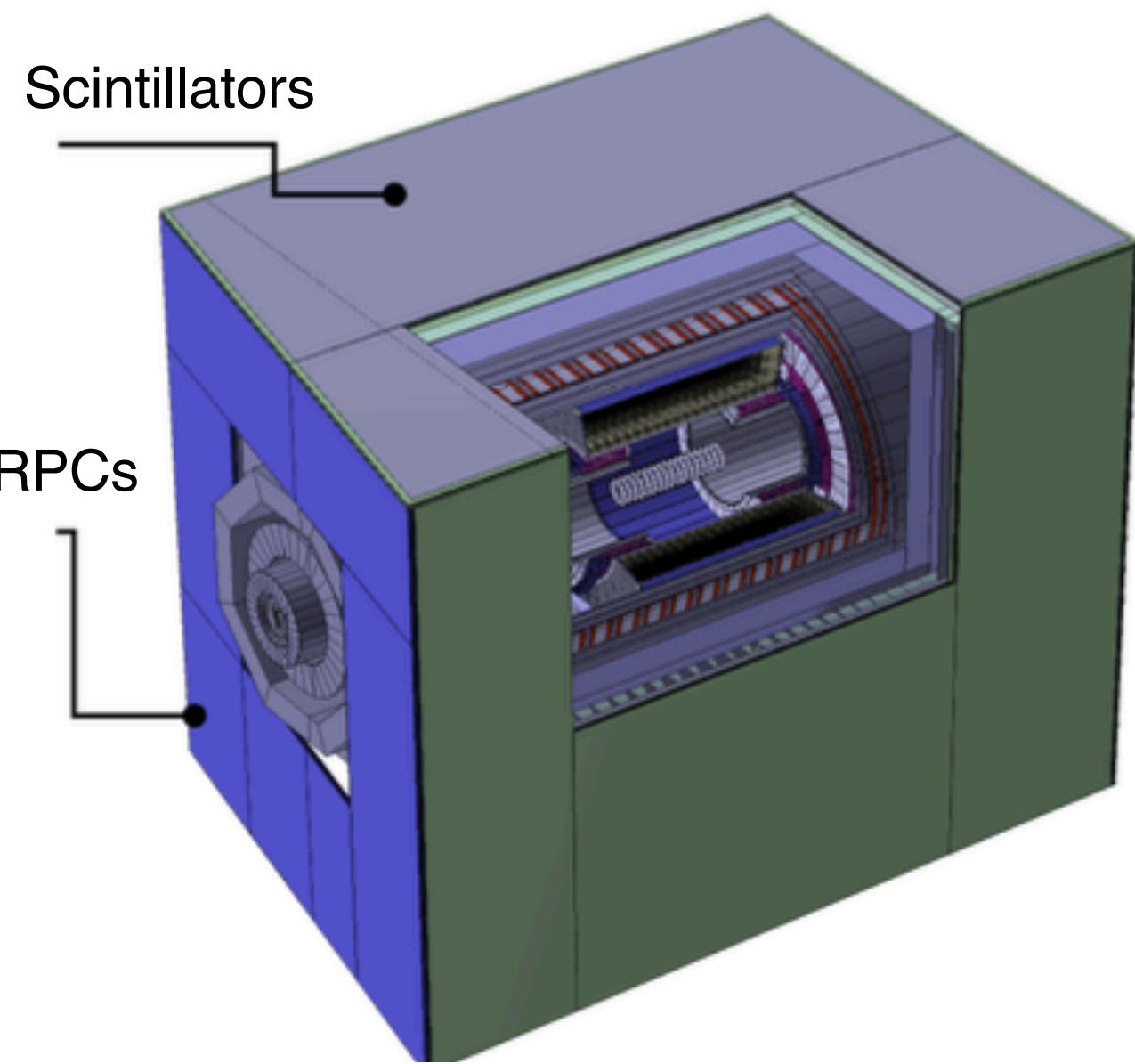
> 40 p.e. for a detection efficiency > 99%

MPPCs operated < -36°C (radiation damage).

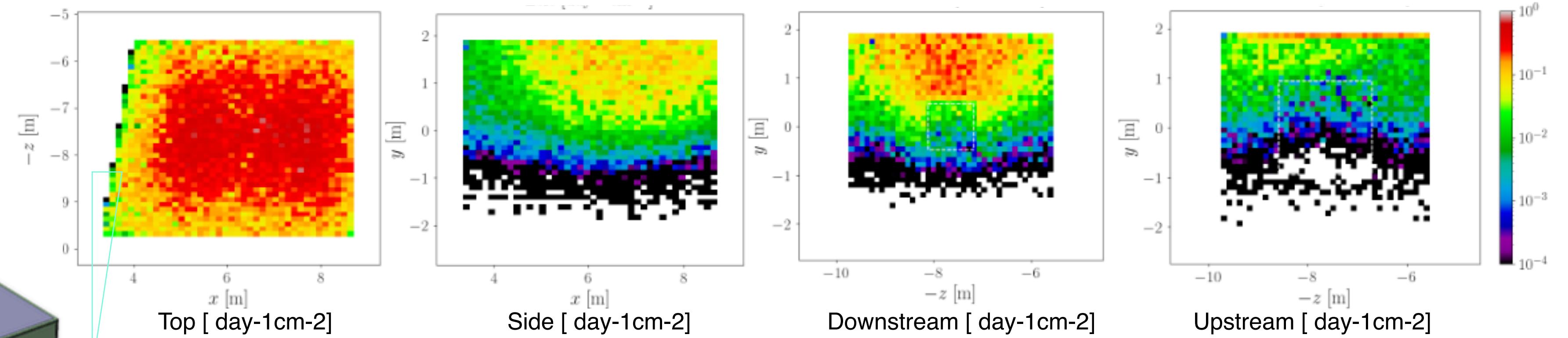
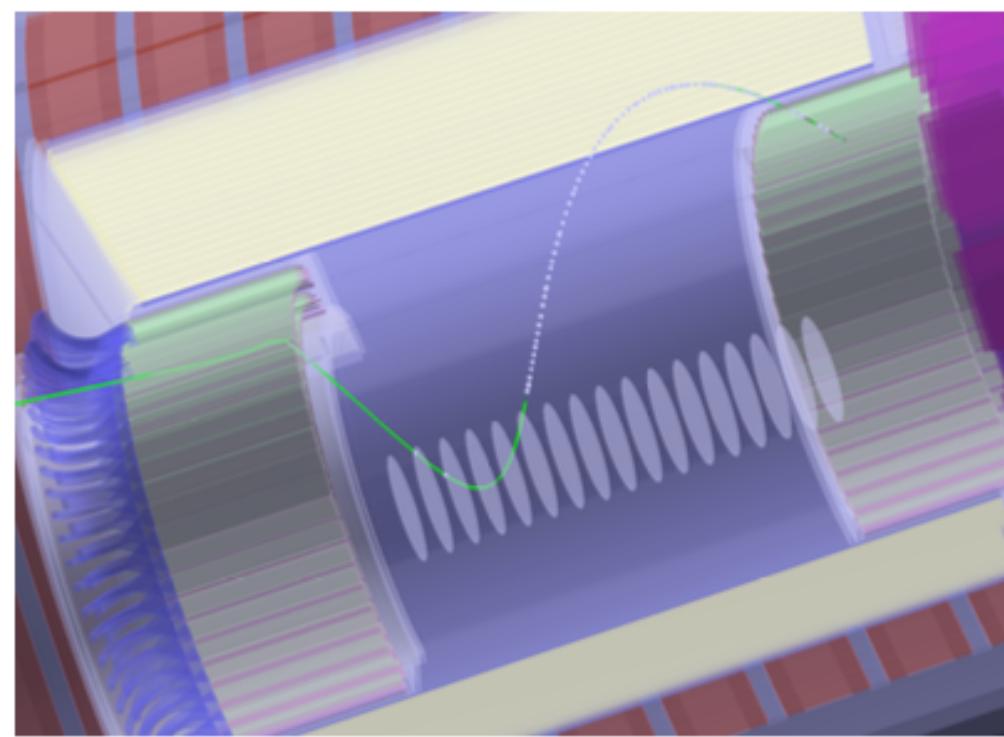
Front-end electronics is being produced
Mass production will start soon



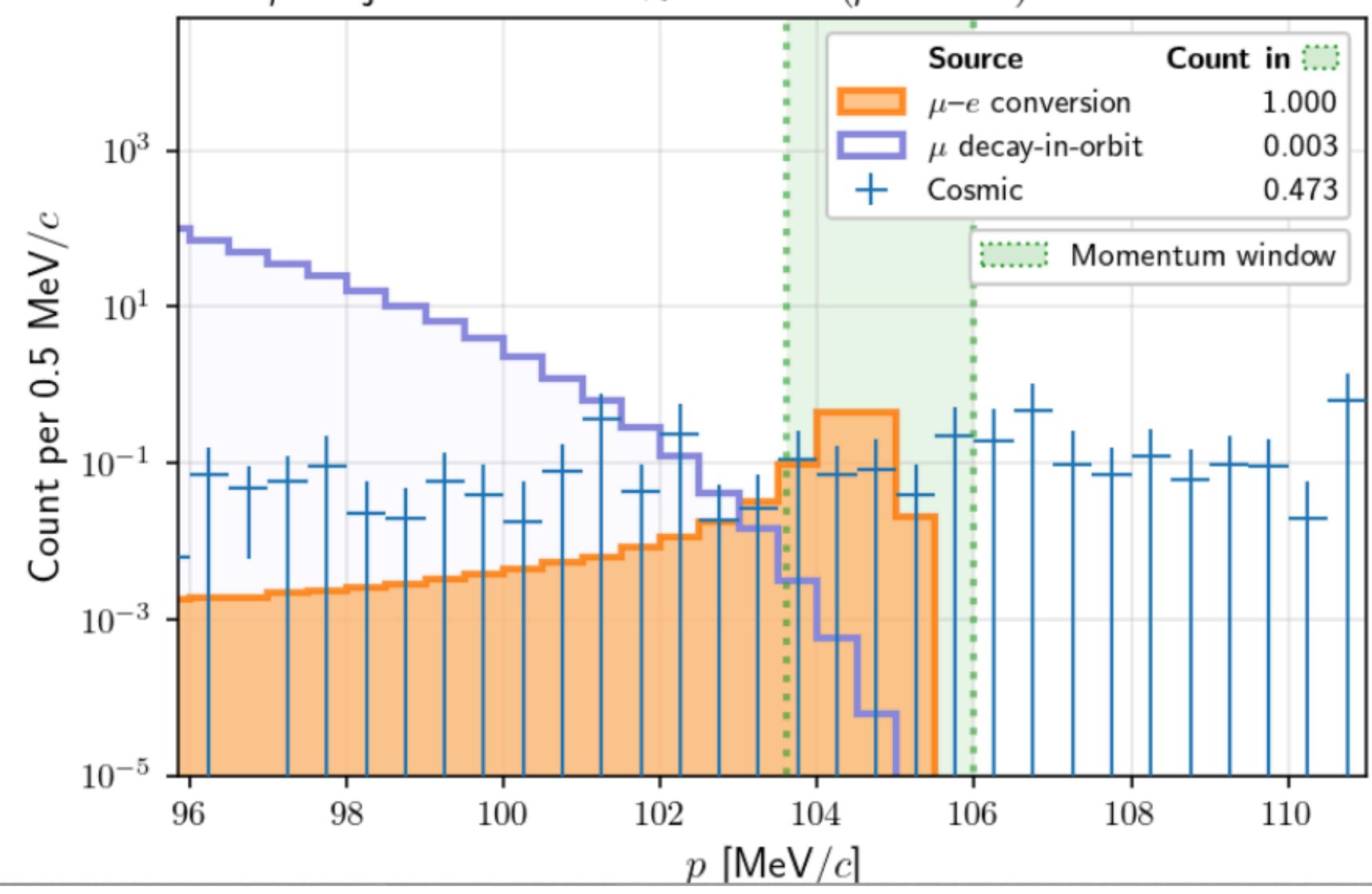
Non analog simulation using Importance Sampling and Backward Monte Carlo



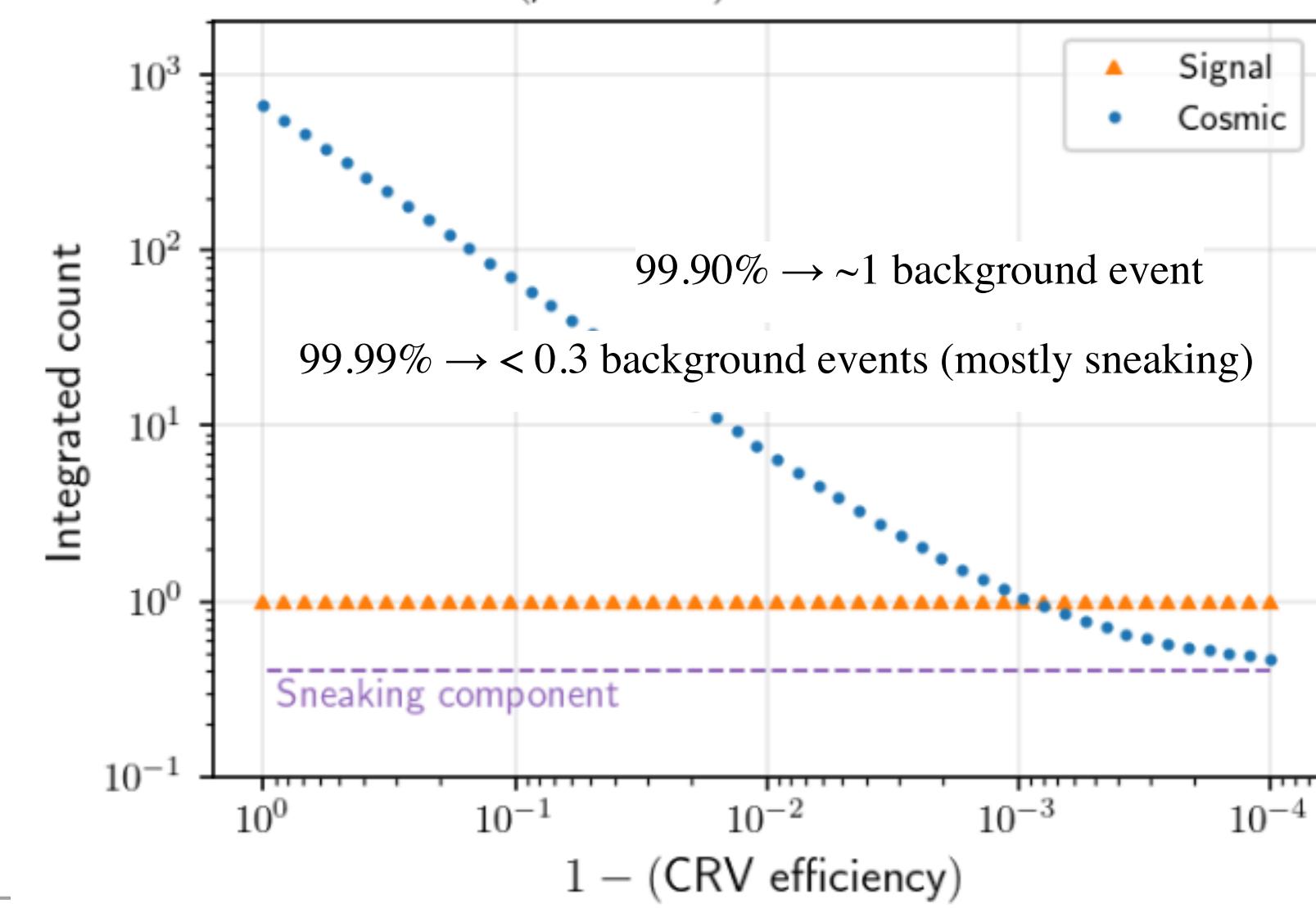
Sneaking μ^+ with $p_{\text{fit}} = 101 \text{ MeV}/c$



COMET Phase-I, 142 days at 3.2 kW
With cuts (timing, trigger, CRV, track)
 μ^+ rejection rate = 89% CRV efficiency = 99.99%
 μ^- rejection rate = 0% $\mathcal{B}(\mu^- \rightarrow e^-) = 4.4 \times 10^{-15}$



COMET Phase-I, 142 days at 3.2 kW
 μ^+ rejection rate = 89% μ^- rejection rate = 0%
 $\mathcal{B}(\mu^- \rightarrow e^-) = 4.4 \times 10^{-15}$



	2025						2026						2027																				
	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
DSBS installation / commissioning																																	
Refrigerator Overhaul / Compressor																																	
DSBS+MTS commissioning / field measurement																																	
CyDet off-site test (CDC & Cradle)																																	
beam window, CyDet installation																			CDC	CTH	★	CyDet dry run ready											
CyDet trigger test / cosmic-ray test																						CyDet DAQ											
CRV (RPC & Scintillator)																					★	CRV ready for CyDet dry run											
PCS power supply installation																																	
PCS yoke, TRT installation																																	
Refrigerator Overhaul / Oil separator																						Installation, test											
PCS cooldown / commissioning																																	
Magnet full integration test / field measurement																												★	Magnet ready				
Radiation Safety Approval																												proposal submission					

↓ When CS field measurement is completed

- COMET Phase-I will search for neutrinoless muon to electron conversion with a target sensitivity a factor of 100 better than the current limit.
- The experiment is expected to start with low intensity ($\sim 10\%$ power) runs in 2027 for commissioning the detector and the muon beam line before reaching the nominal beam intensity.
- In addition to the physics measurement, COMET Phase-I will fully characterise the muon beam and the backgrounds with prototypes of COMET Phase-II detectors.
- A sensitivity of $O(10^{-17})$ is expected to be reachable by COMET Phase-II thanks to improved muon beam intensity and backgrounds and systematics under control.