COMET μe

Osaka University

Search for Charged Lepton Flavor Violation with Muons

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Outline

- Muon LFV for BSM search
- Muon LFV processes
  - μ→eγ
  - μ→eee
  - μ→e conversion
- Other muon LFV processes
- Muon sources in the world
- COMET@J-PARC
  - COMET Phase-II
  - COMET Phase-I
- Timeline
- Summary

COMET official Logo

Muon LFV for BSM Search

EFT with LFV

$$\mathcal{L}_{\rm eff} = \mathcal{L}_{\rm SM} + \frac{C_{\rm NP}}{\Lambda^2} O_{ij}^{(6)}$$

dimension 6

Λ is the energy scale of new physics

C_{NP} is the coupling constant.

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ex : $\mu \to e\gamma$ $B<4.2\times10^{-13}$ from MEG(2016)

$$\frac{C_{\rm NP}}{\Lambda^2} O_{ij}^{(6)} \to \frac{C_{\mu e}}{\Lambda^2} \overline{e}_L \sigma^{\rho\nu} \mu_R \Phi F_{\rho\nu}$$

$$\Lambda > 2 \times 10^5 \,{\rm TeV} \times (C_{\mu e})^{\frac{1}{2}} \ .$$

$\Lambda > O(10^3)$ TeV with $C_{\mu e} \sim O(1)$

or

$C_{\mu e} \sim O(10^{-9})$ with $\Lambda < O(1)$ TeV

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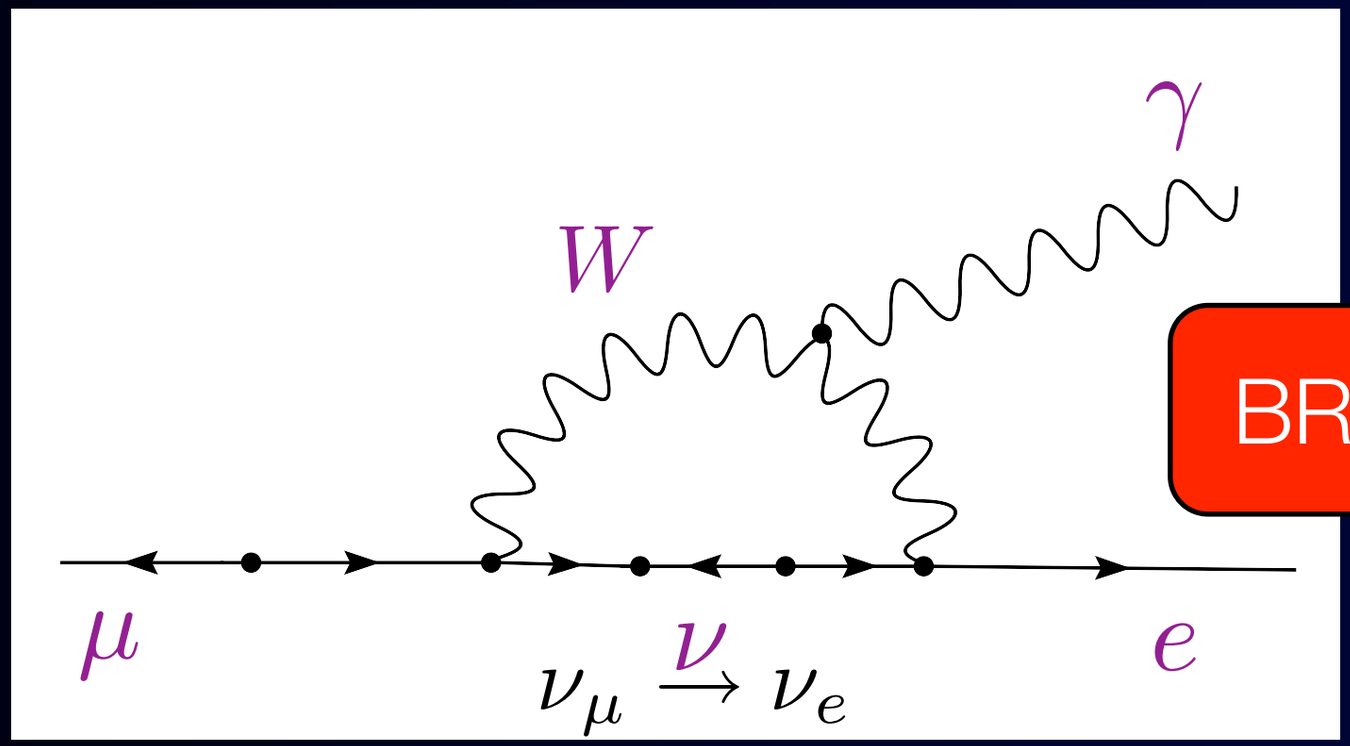
or

$C_{\mu e} \sim O(10^{-9})$ with $\Lambda < O(1)$ TeV

can explore very high energy scale that accelerators cannot directly reach.

SM Contribution to CLFV

SM Contribution with neutrino mixing



BR~O(10^{-54})

$$B(\mu \to e\gamma) = \frac{3\alpha}{32\pi}\left|\sum_l (V_{MNS})^*_{\mu l}(V_{MNS})_{el}\frac{m^2_{\nu_l}}{M^2_W}\right|^2$$

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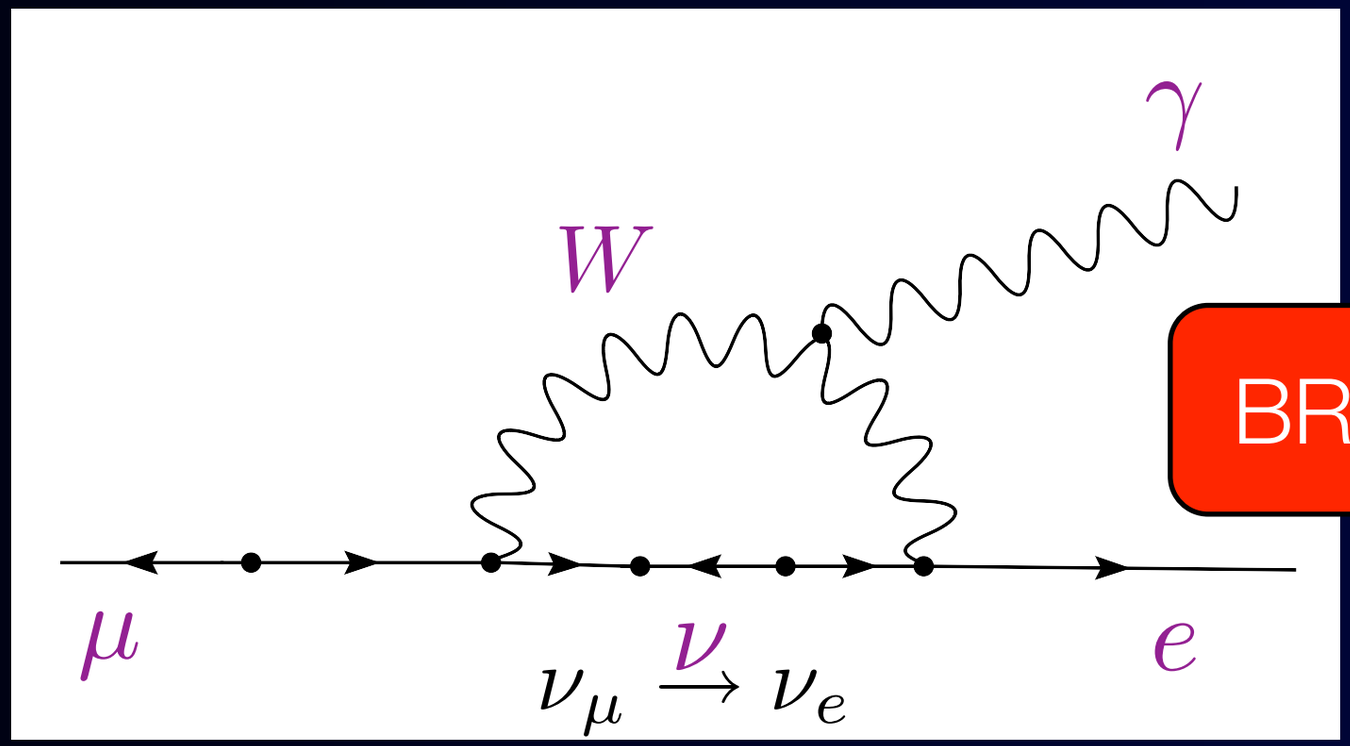

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Observation of CLFV would indicate a clear signal of physics beyond the SM with massive neutrinos.

Model Dependent CLFV

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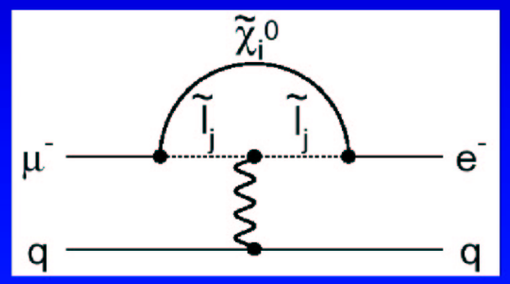
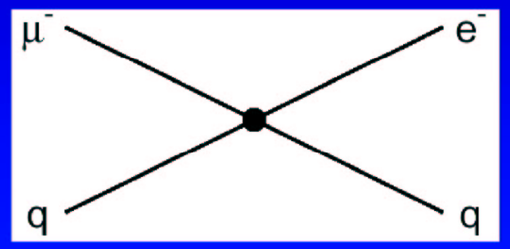
Sensitivity to Different Muon Conversion Mechanisms

Supersymmetry

Predictions at 10^{-15}





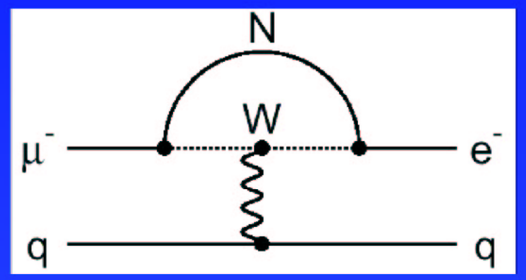
Compositeness

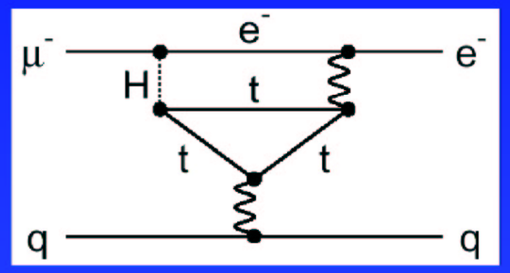
Λ_c = 3000 TeV

Heavy Neutrinos

$|U^*_{\mu N} U_{eN}|^2 =$

8×10^{-13}

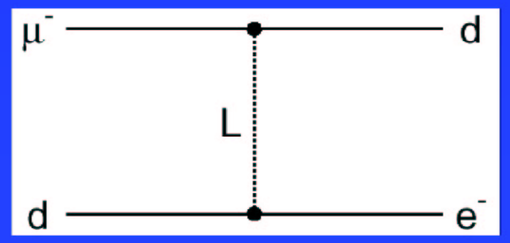


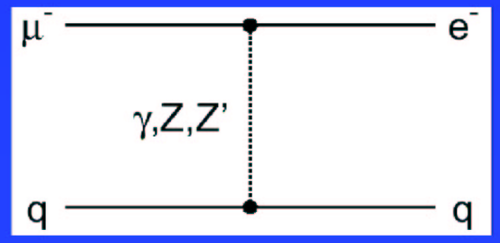


Second Higgs doublet

$g_{H\mu e} = 10^{-4} \times g_{H\mu\mu}$

Leptoquarks





Heavy Z', Anomalous Z coupling

$M_L =$

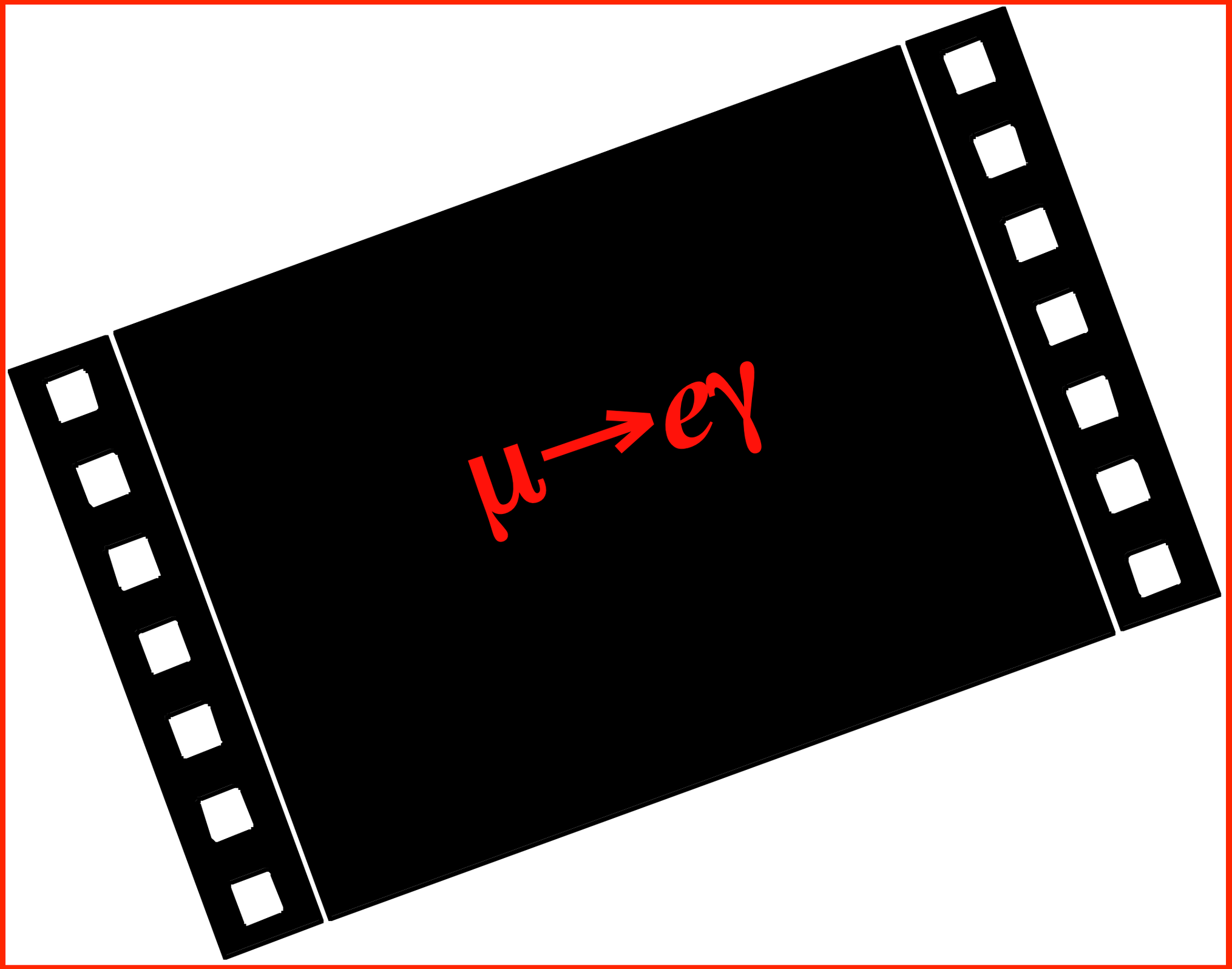
$3000\ (\lambda_{\mu d}\lambda_{ed})^{1/2}$ TeV/c^2

After W. Marciano

$M_{Z'}$ = 3000 TeV/c^2

$B(Z \rightarrow \mu e) < 10^{-17}$

Muon CLFV Processes


μ→eγ

$\mu \rightarrow e\gamma$

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- Event Signature
  - $E_e = E_\gamma = m_\mu/2$ (=52.8 MeV)
  - angle $\theta_{\mu e}$=180 (back-to-back)
  - time coincidence
- Backgrounds
  - prompt physics backgrounds
    - radiative muon decay
      $\mu \rightarrow e\nu\nu\gamma$
  - accidental backgrounds

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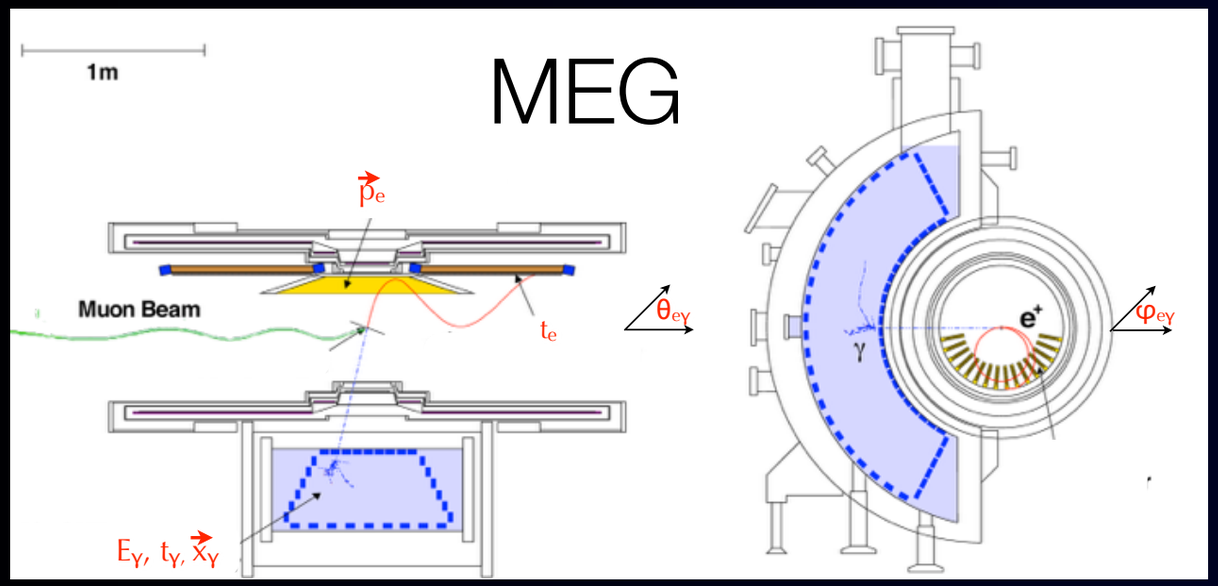


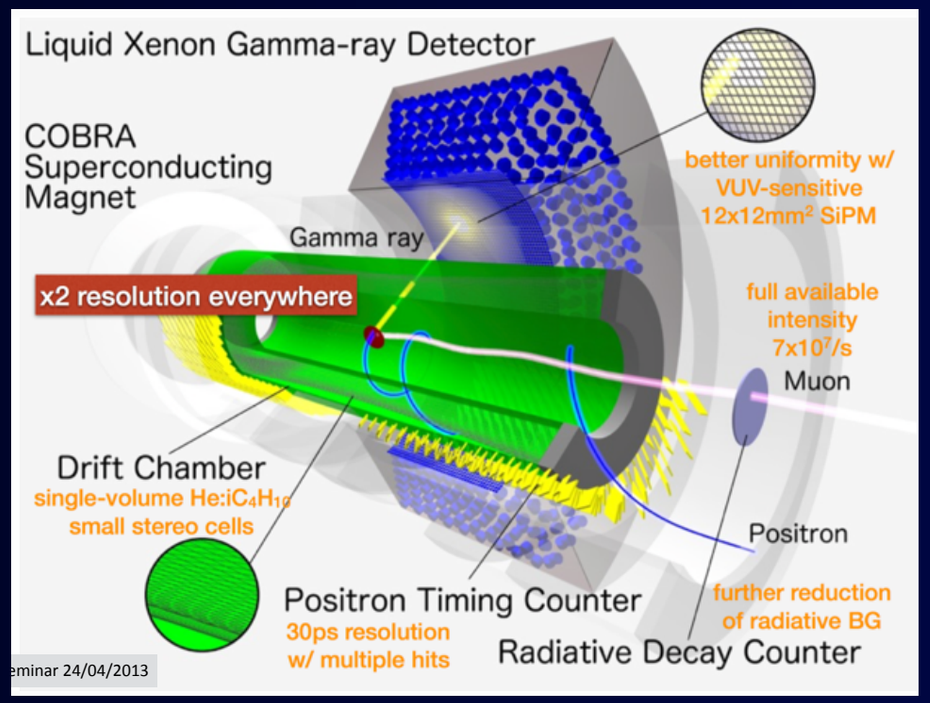
Final MEG result (2016)

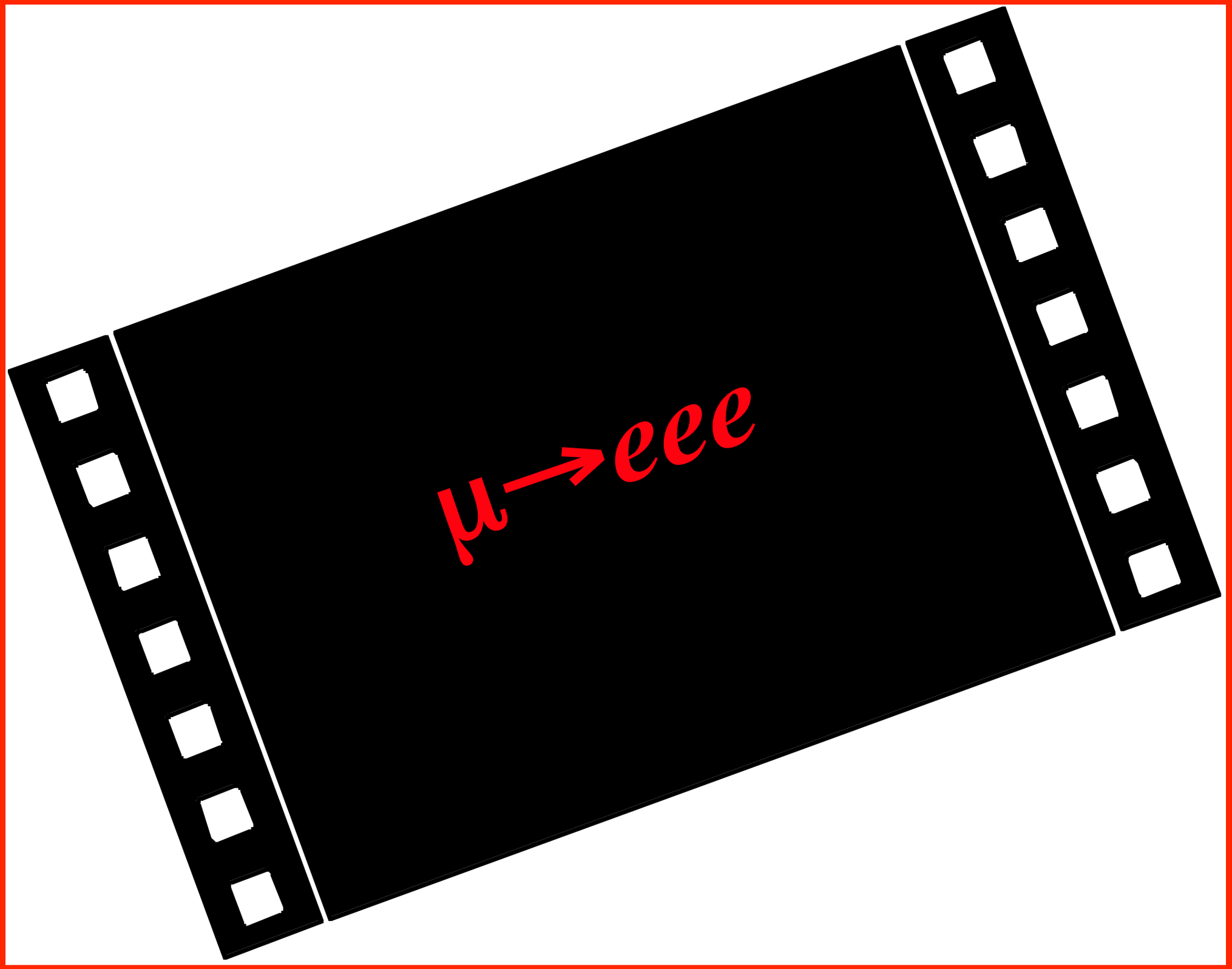
$$B(\mu^+ \to e^+\gamma) < 4.2 \times 10^{-13}$$

MEG II

goal ~ 4×10^{-14}

2018-2020




$\mu \to eee$

μ→eee

$\mu \rightarrow eee$

- Event Signature
  - $\Sigma E_e = m_\mu$
  - $\Sigma P_e = 0$ (vector sum)
  - common vertex
  - time coincidence
- Backgrounds
  - physics backgrounds
    - $\mu \rightarrow e\nu\nu ee$ decay
  - accidental backgrounds

μ→eee

- Event Signature
  - $\Sigma E_e = m_\mu$
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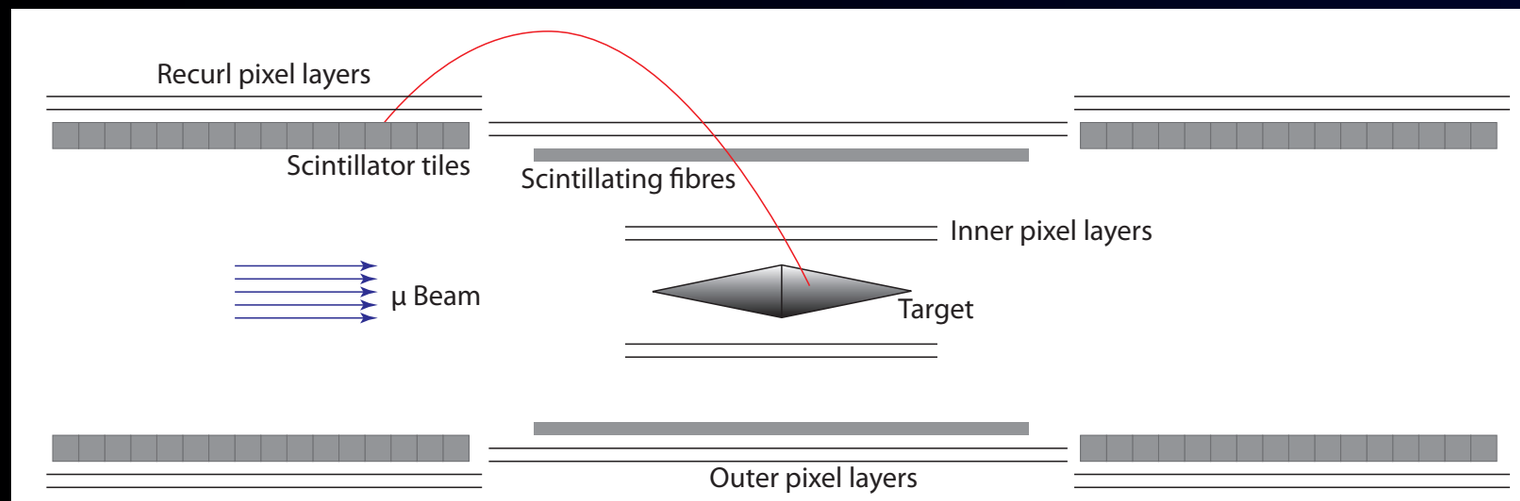
  - time coincidence
- Backgrounds
  - physics backgrounds
    - μ→eννee decay
  - accidental backgrounds

Mu3e (@PSI)

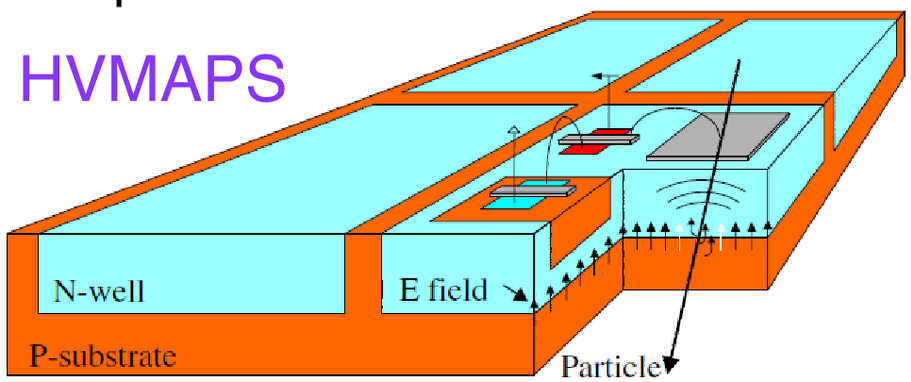
- current limit : 1×10^{-12}
- Stage-I (2020 -)
  - $B\sim10^{-15}$ at πE5
- Stage-2
  - $B<10^{-16}$ at new muon source

Mu3e



50μm thickness

HVMAPS



$\mu \rightarrow e$ conversion in a muonic atom

What is μ→e Conversion ?

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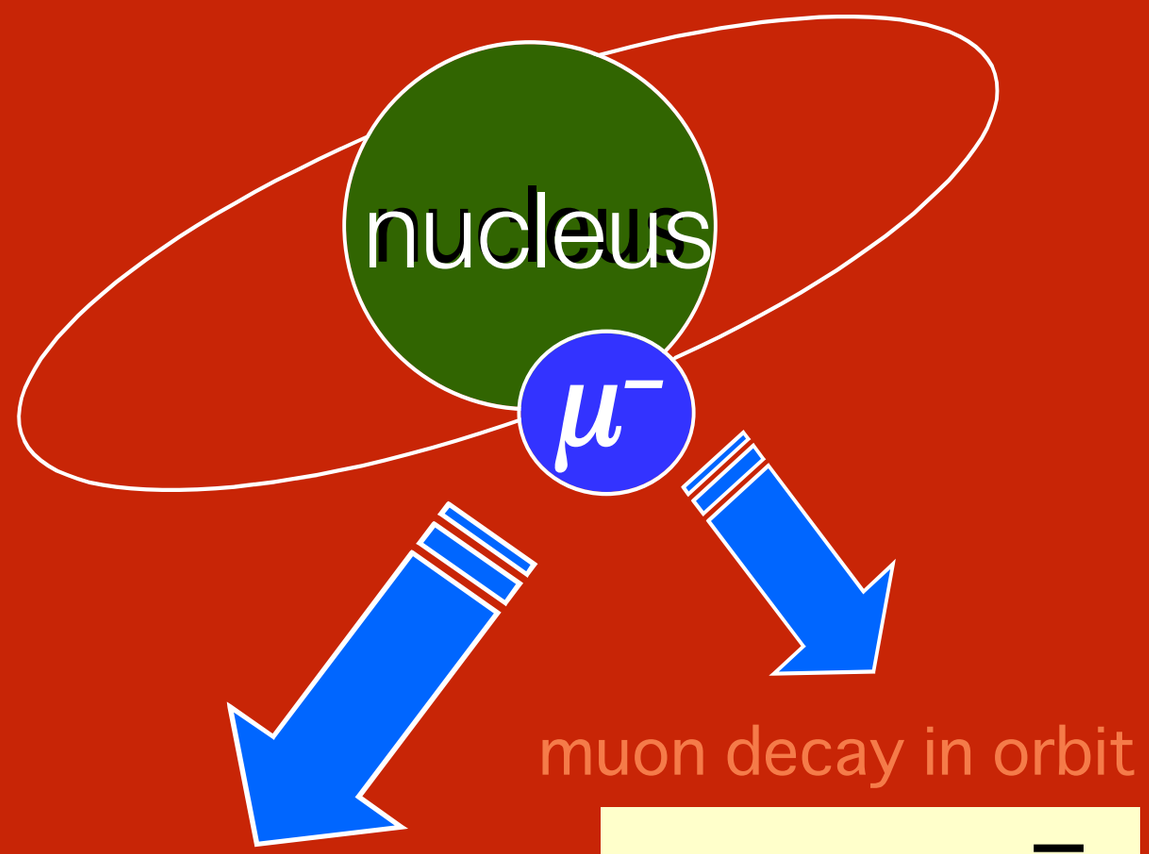
1s state in a muonic atom



muon decay in orbit

$$\mu^- \rightarrow e^- \nu \bar{\nu}$$

nuclear muon capture

$$\mu^- + (A, Z) \rightarrow \nu_\mu + (A, Z-1)$$

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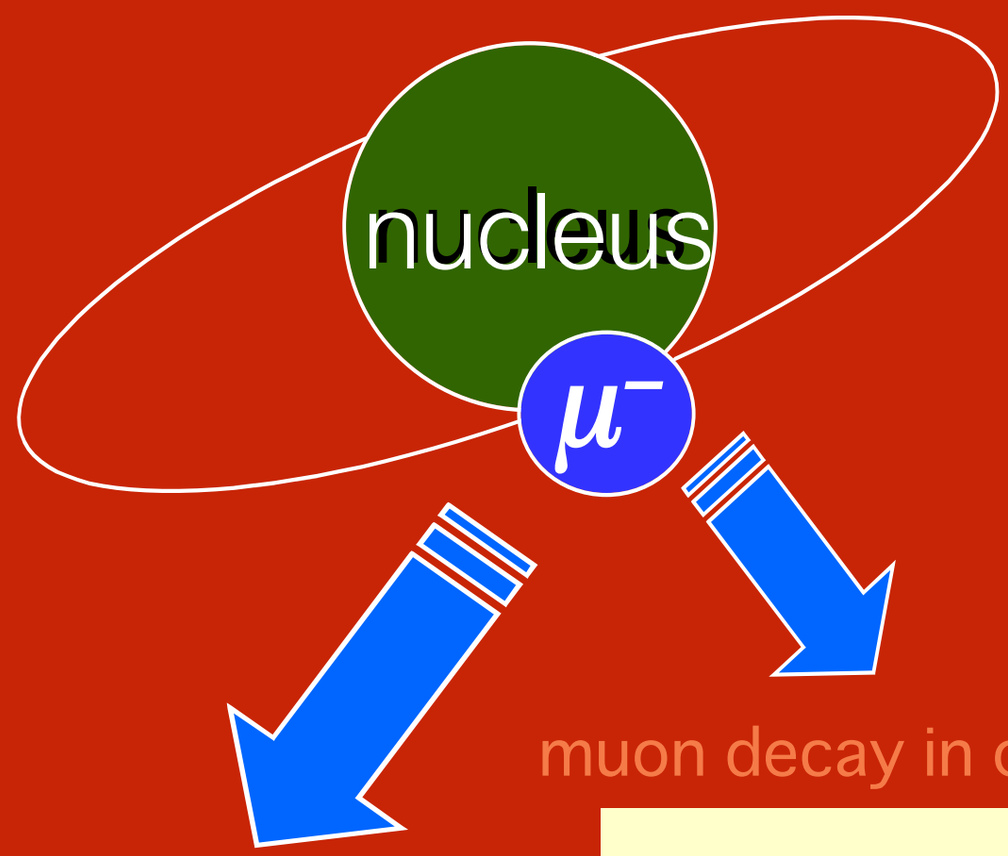

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Neutrino-less muon nuclear capture

$$\mu^- + (A,Z) \rightarrow e^- + (A,Z)$$

Event Signature :

a single mono-energetic electron of 105 MeV

Backgrounds:

(1) physics backgrounds
(2) beam-related backgrounds
(3) cosmic rays, false tracking

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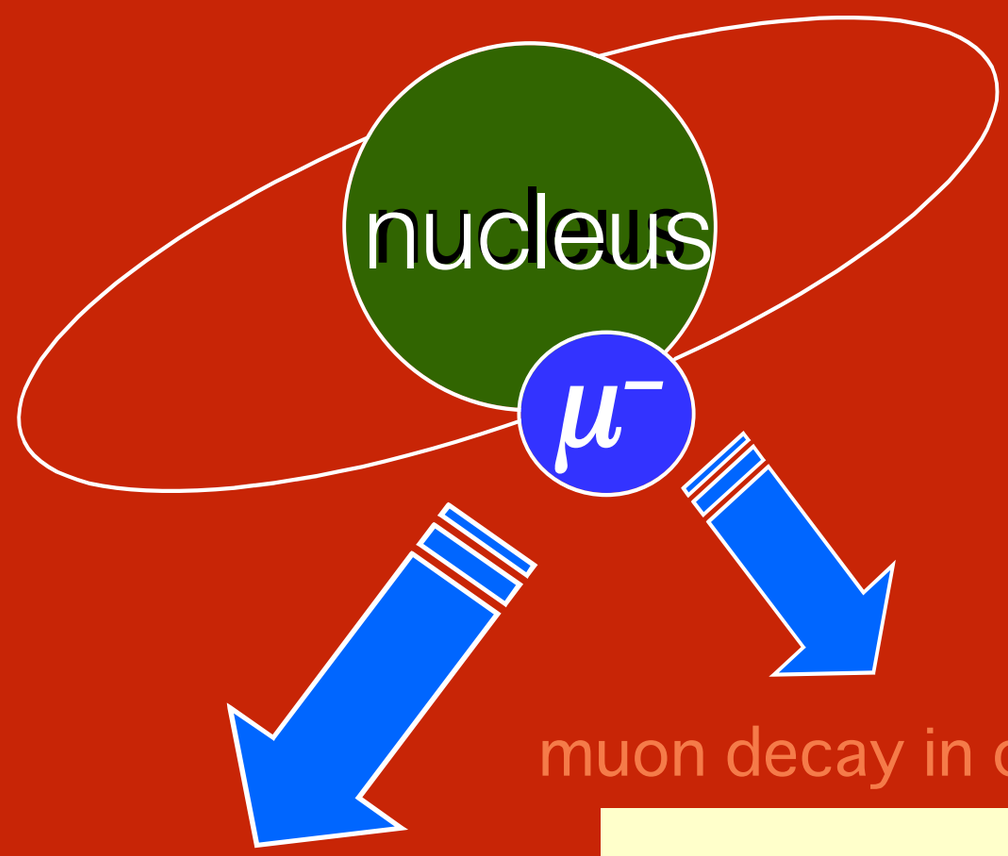

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COMET explained later

Experimental Comparison

	Beam	background	challenge	beam intensity
μ→eγ	continuous beam	accidentals	detector resolution	limited
μ→eee	continuos beam	accidentals	detector resolution	limited
μ-e conversion	pulsed beam	beam-related	beam background	no limitation

if found,

Effective Field Theory for μ→e Conversion

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$$\mathcal{L}_{\mu A\to eA}(\Lambda_{expt}) = -\frac{4G_F}{\sqrt{2}}\sum_{N=p,n}\Big[m_\mu\left(C_{DL}\overline{e_R}\sigma^{\alpha\beta}\mu_L F_{\alpha\beta}+C_{DR}\overline{e_L}\sigma^{\alpha\beta}\mu_R F_{\alpha\beta}\right)$$

dipole

scalar $$+\left(\widetilde{C}_{SL}^{(NN)}\overline{e}P_L\mu+\widetilde{C}_{SR}^{(NN)}\overline{e}P_R\mu\right)\overline{N}N$$

pseudo-scalar $$+\left(\widetilde{C}_{P,L}^{(NN)}\overline{e}P_L\mu+\widetilde{C}_{P,R}^{(NN)}\overline{e}P_R\mu\right)\overline{N}\gamma_5 N$$

vector $$+\left(\widetilde{C}_{VL}^{(NN)}\overline{e}\gamma^\alpha P_L\mu+\widetilde{C}_{VR}^{(NN)}\overline{e}\gamma^\alpha P_R\mu\right)\overline{N}\gamma_\alpha N$$

axial-vector $$+\left(\widetilde{C}_{A,L}^{(NN)}\overline{e}\gamma^\alpha P_L\mu+\widetilde{C}_{A,R}^{(NN)}\overline{e}\gamma^\alpha P_R\mu\right)\overline{N}\gamma_\alpha\gamma_5 N$$

tensor $$+\left(\widetilde{C}_{T,L}^{(NN)}\overline{e}\sigma^{\alpha\beta}P_L\mu+\widetilde{C}_{T,R}^{(NN)}\overline{e}\sigma^{\alpha\beta}P_R\mu\right)\overline{N}\sigma_{\alpha\beta}N+h.c.\Big] \quad .$$

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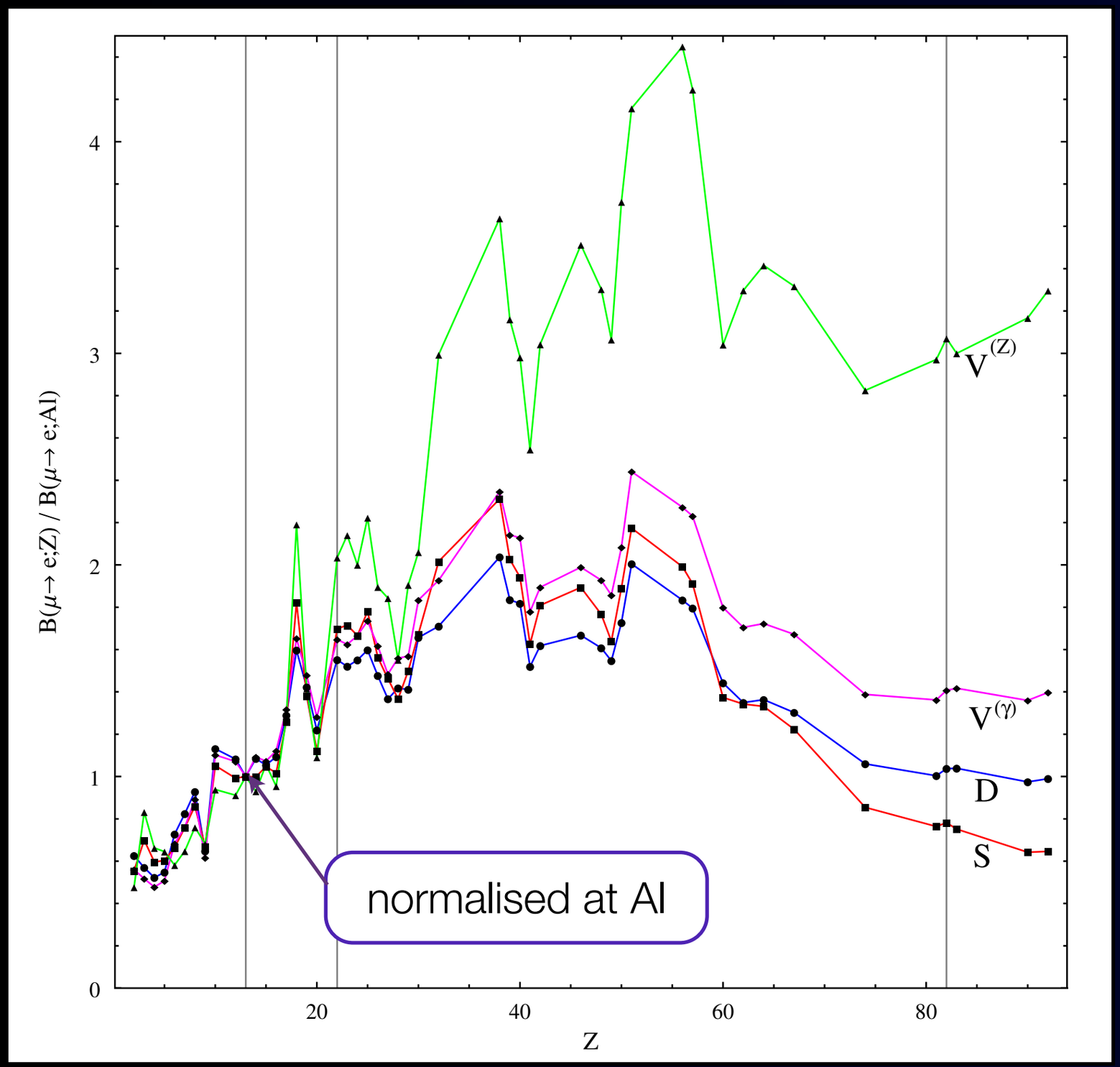
axial-vector $$+\left(\widetilde{C}^{(NN)}_{A,L}\overline{e}\gamma^\alpha P_L\mu+\widetilde{C}^{(NN)}_{A,R}\overline{e}\gamma^\alpha P_R\mu\right)\overline{N}\gamma_\alpha\gamma_5 N$$

tensor $$+\left(\widetilde{C}^{(NN)}_{T,L}\overline{e}\sigma^{\alpha\beta}P_L\mu+\widetilde{C}^{(NN)}_{T,R}\overline{e}\sigma^{\alpha\beta}P_R\mu\right)\overline{N}\sigma_{\alpha\beta}N+h.c.\Big] \quad .$$

22 coeff. = 2 (dipole) + 2 (left/right) x 2 (proton/neutron) x 5 (interaction)

μ-e Conversion : Target dependence



V. Cirigliano, R. Kitano, Y. Okada, and P. Tuzon, Phys. Rev. D80, 013002 (2009)

vector interaction (with Z boson)	with Z penguin
vector interaction (with photon - charge radius)	left-right models
dipole interaction	SUSY-GUT
scalar interaction	SUSY seesaw

Spin Dependent μ-e conversion

Spin Dependent μ-e conversion

dipole interaction

vector interaction

scalar interaction

Coherent
μ-e Conversion
(spin independent)

Spin Dependent μ-e conversion

dipole interaction

vector interaction

scalar interaction

Coherent
μ-e Conversion
(spin independent)

axial vector interaction

tensor interaction

Incoherent
μ-e Conversion
(spin dependent)

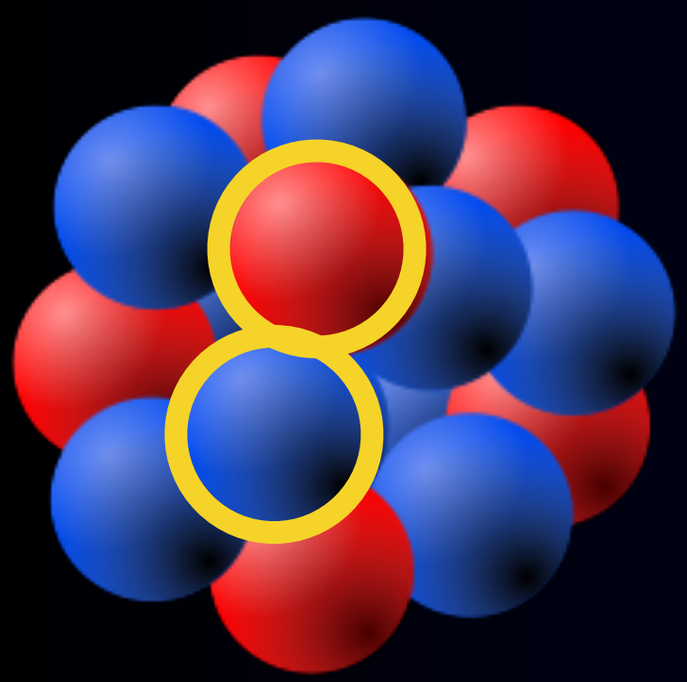
compare zero-spin and non-zero-spin nuclear targets

V. Cirigliano, S. Davidson, YK, Phys. Lett. B 771 (2017) 242

S. Davidson, YK, A. Saporta, Eur. Phys. J. C78 (2018) 109

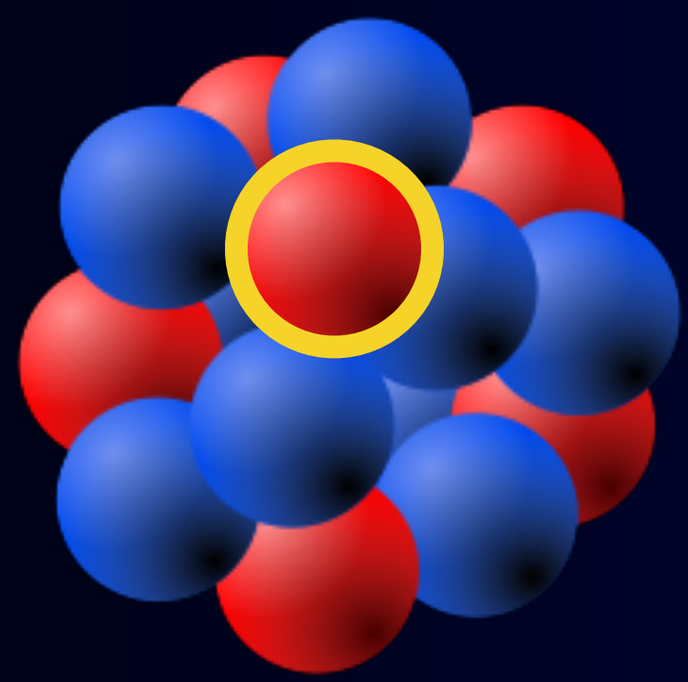
Coherent and Incoherent : Pros and Cons

Coherent
μ-e Conversion
(spin independent)



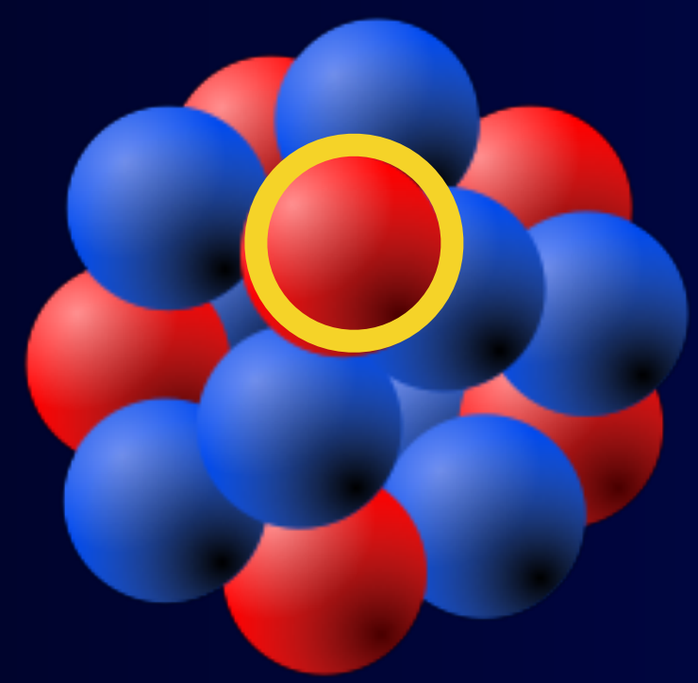
$$|\Sigma_i N_i|^2 \propto A^2$$

nuclear muon
capture



$$\Sigma_i |N_i|^2 \propto Z$$

Incoherent
μ-e Conversion
(spin dependent)



$$|N_i|^2 \propto 1$$

Other Muon LFV Processes

μ^- to e^+ conversion in muonic atom

$$\mu^- + N(A,Z) \rightarrow e^+ + N(A,Z-2)$$

Lepton number violation (LNV) and
Lepton flavour violation (LFV)

Final can be the ground or excited states.

signal signature

$$E_{\mu e^+} = m_\mu - B_\mu - E_{rec} - (M(A,Z-2) - M(A,Z))$$

backgrounds

- radiative muon nuclear capture (RMC)

$$\mu^- + N(A,Z) \rightarrow N(A,Z-1) + \nu + \gamma$$

$$E_{RMC} = m_\mu - B_\mu - E_{rec} - (M(A,Z-1) - M(A,Z))$$

μ^- to e^+ conversion in muonic atom

$$\mu^- + N(A,Z) \rightarrow e^+ + N(A,Z-2)$$

Lepton number violation (LNV) and
Lepton flavour violation (LFV)

$\mu^- + \mathrm{Ti} \rightarrow e^+ + \mathrm{Ca(gs)}$	1.7×10^{-12}
$\mu^- + \mathrm{Ti} \rightarrow e^+ + \mathrm{Ca(ex)}$	3.6×10^{-11}

Final can be the ground or excited states.

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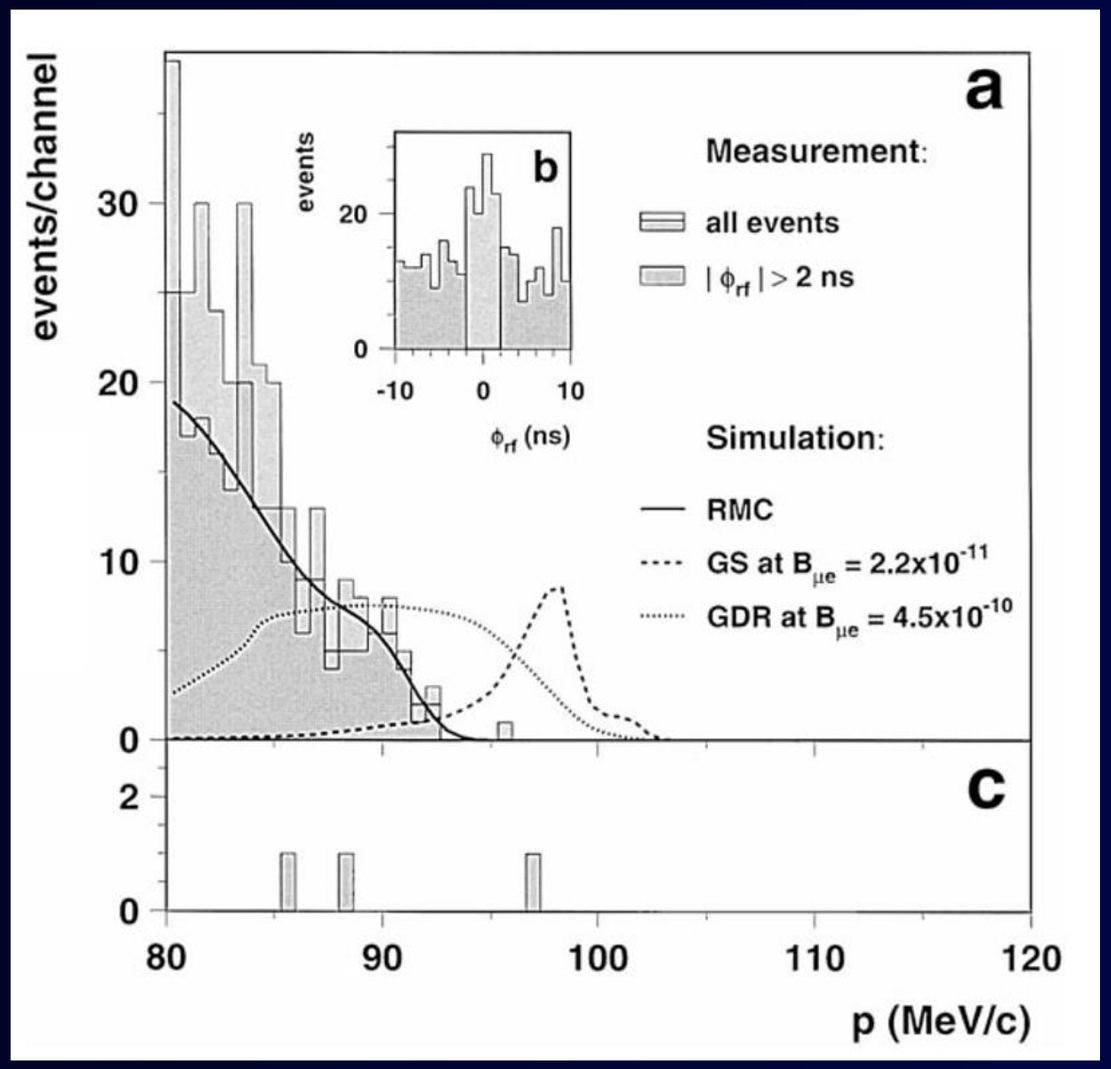


μ^- to e^+ conversion in the future

$$\mu^- + N(A,Z) \rightarrow e^+ + N(A,Z-2)$$

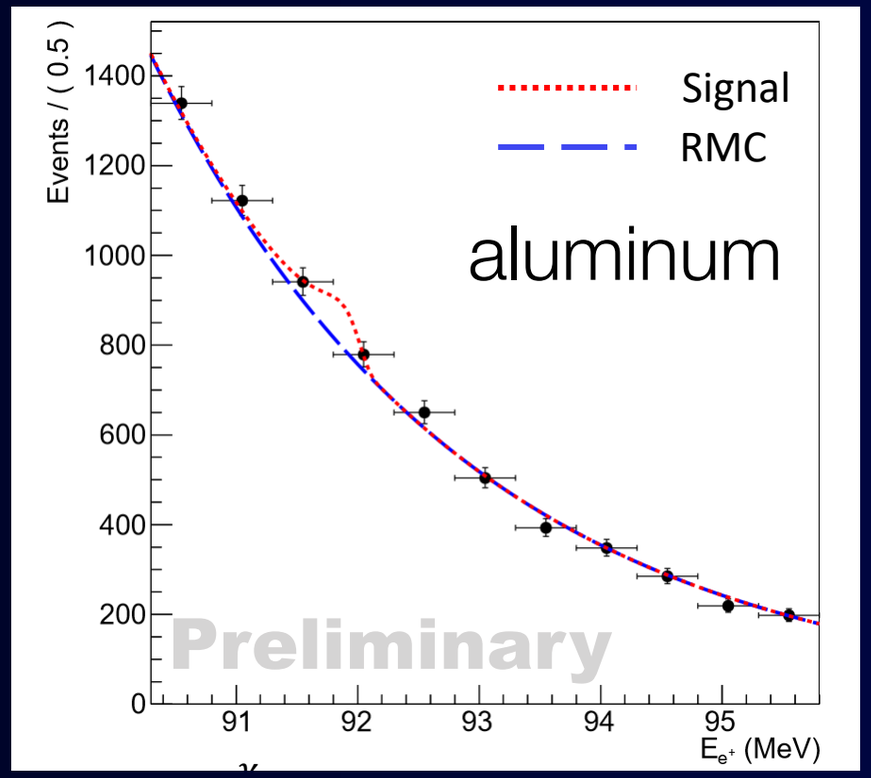
μ^- to e^+ conversion in the future

$$\mu^- + N(A,Z) \rightarrow e^+ + N(A,Z-2)$$

Requirement on targets $E_{\mu e^+} > E_{RMC} \longrightarrow M(A,Z-1) < M(A,Z-2)$

Atom	$E_{\mu^- e^+}$ (MeV)	$E_{\mu^- e^-}$ (MeV)	E_{RMC}^{end} (MeV)	N.A. (%)	f_{cap} (%)	τ_{μ^-} (ns)	A_T
^{27}Al	92.30	104.97	101.34	100	61.0	864	0.191
^{32}S	101.80	104.76	102.03	95.0	75.0	555	0.142
^{40}Ca	103.55	104.39	102.06	96.9	85.1	333	0.078
^{48}Ti	98.89	104.18	99.17	73.7	85.3	329	0.076
^{50}Cr	104.06	103.92	101.86	4.4	89.4	234	0.038
^{54}Fe	103.30	103.65	101.93	5.9	90.9	206	0.027
^{58}Ni	104.25	103.36	101.95	68.1	93.1	152	0.009
^{64}Zn	103.10	103.04	101.43	48.3	93.0	159	0.011
^{70}Ge	100.67	102.70	100.02	20.8	92.7	167	0.013

simulation for 10^{18} muons
signal ~ 1×10^{-12}



Aluminum (for COMET & Mu2e) is not good.

B. Yeo, YK, M. Lee and K. Zuber, Phys. Rev. D96 (2017) 075027

μ^- to e^+ conversion in the future

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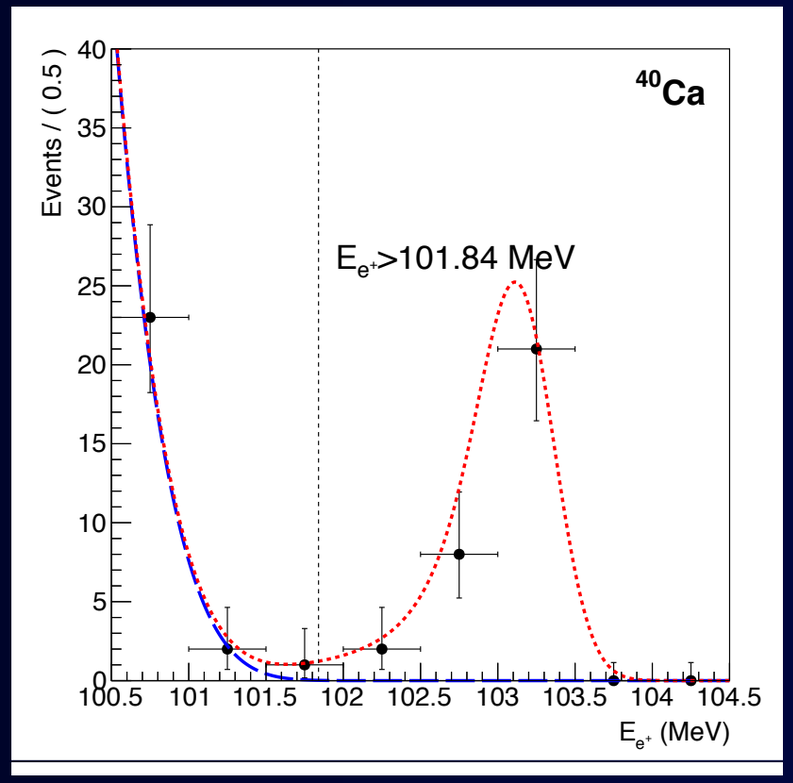


B. Yeo, YK, M. Lee and K. Zuber, Phys. Rev. D96 (2017) 075027

Muonium to Antimuonium Conversion
Mu (μ^+e^-) →Mu (μ^-e^+)

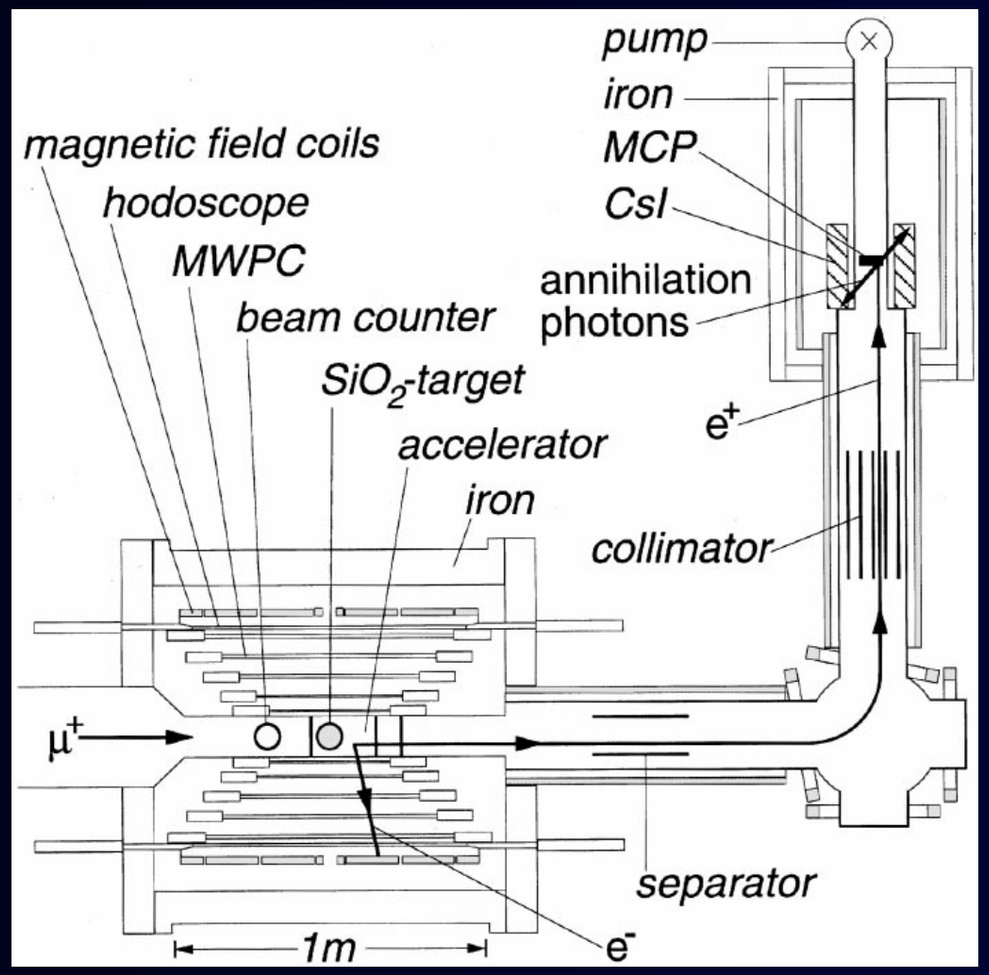
$$\mu^+ + e^- \rightarrow \mu^- + e^+$$

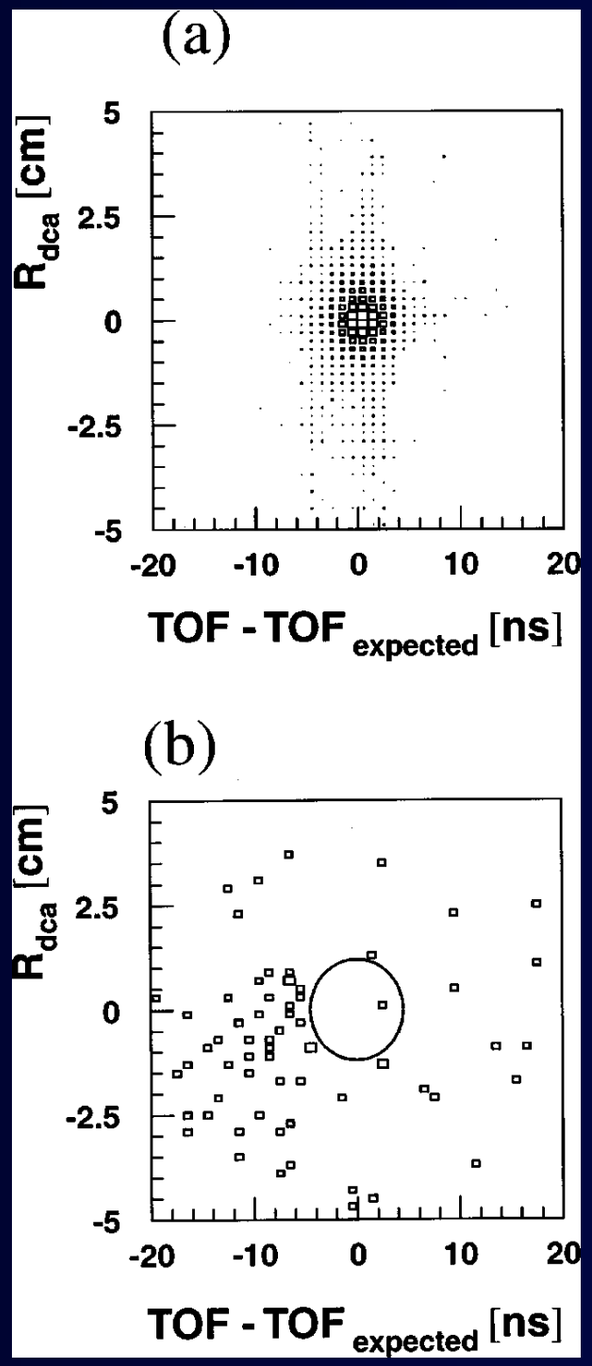
muonium to anti-muonium conversion

$$|\Delta L_{\mu/e}| = 2$$

- doubly-charged Higgs model etc.
- muonium production in vacuum
- previous experiment at PSI (1999)

$$G_{Mu\overline{Mu}} < 3 \times 10^{-3} G_F$$





Muonium to Antimuonium Conversion
Mu (μ^+e^-) →Mu (μ^-e^+)

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

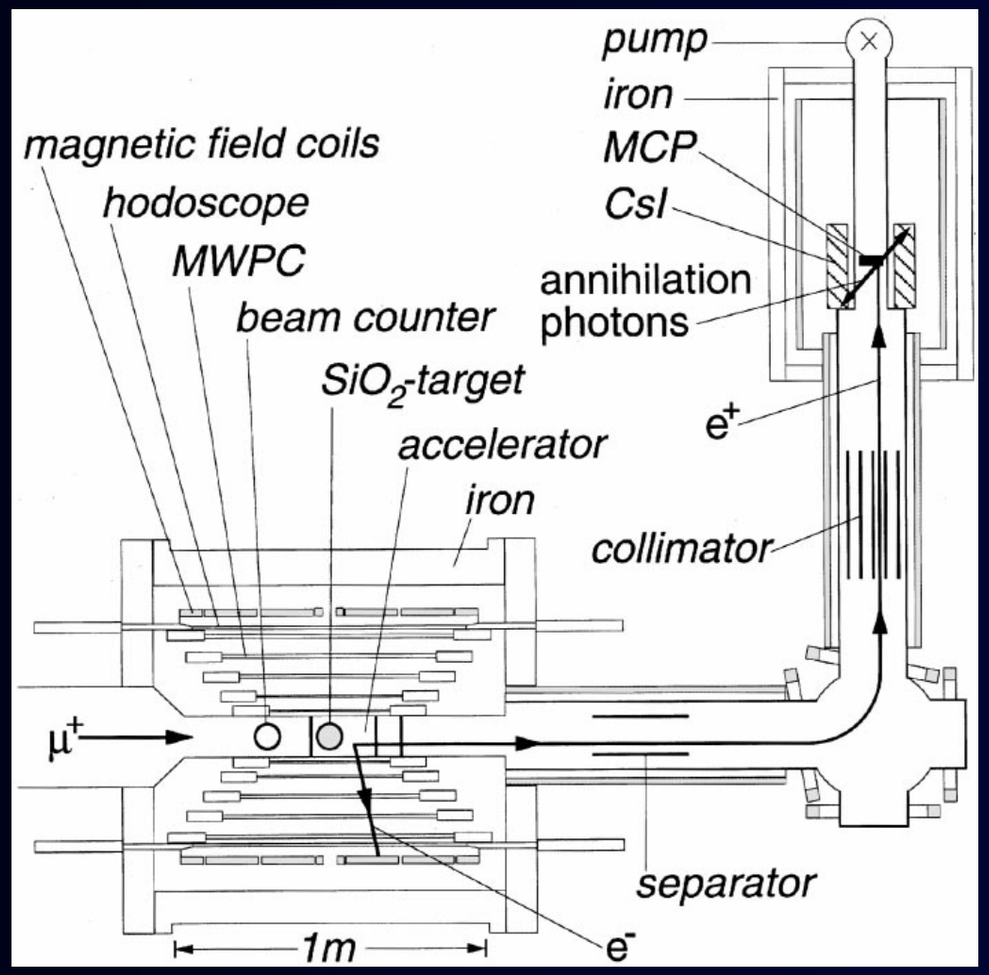
muonium to anti-muonium conversion

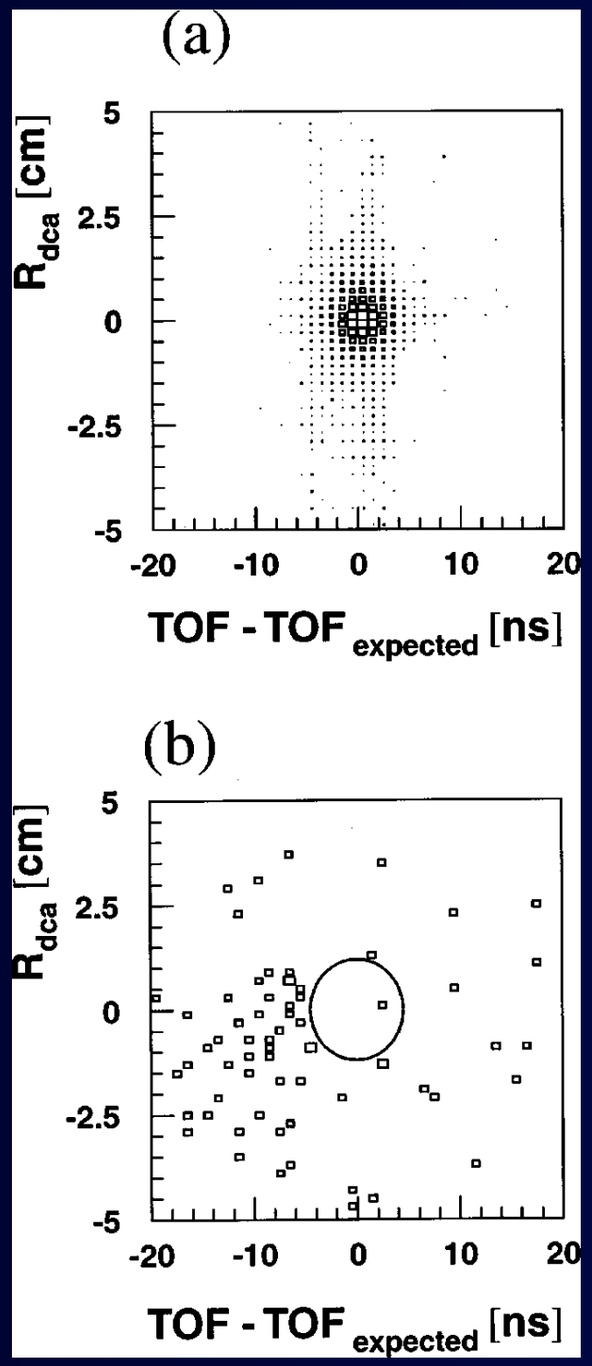
$$|\Delta L_{\mu/e}| = 2$$

- doubly-charged Higgs model etc.
- muonium production in vacuum
- previous experiment at PSI (1999)

$$G_{Mu\overline{Mu}} < 3 \times 10^{-3} G_F$$

new attempt at J-PARC?





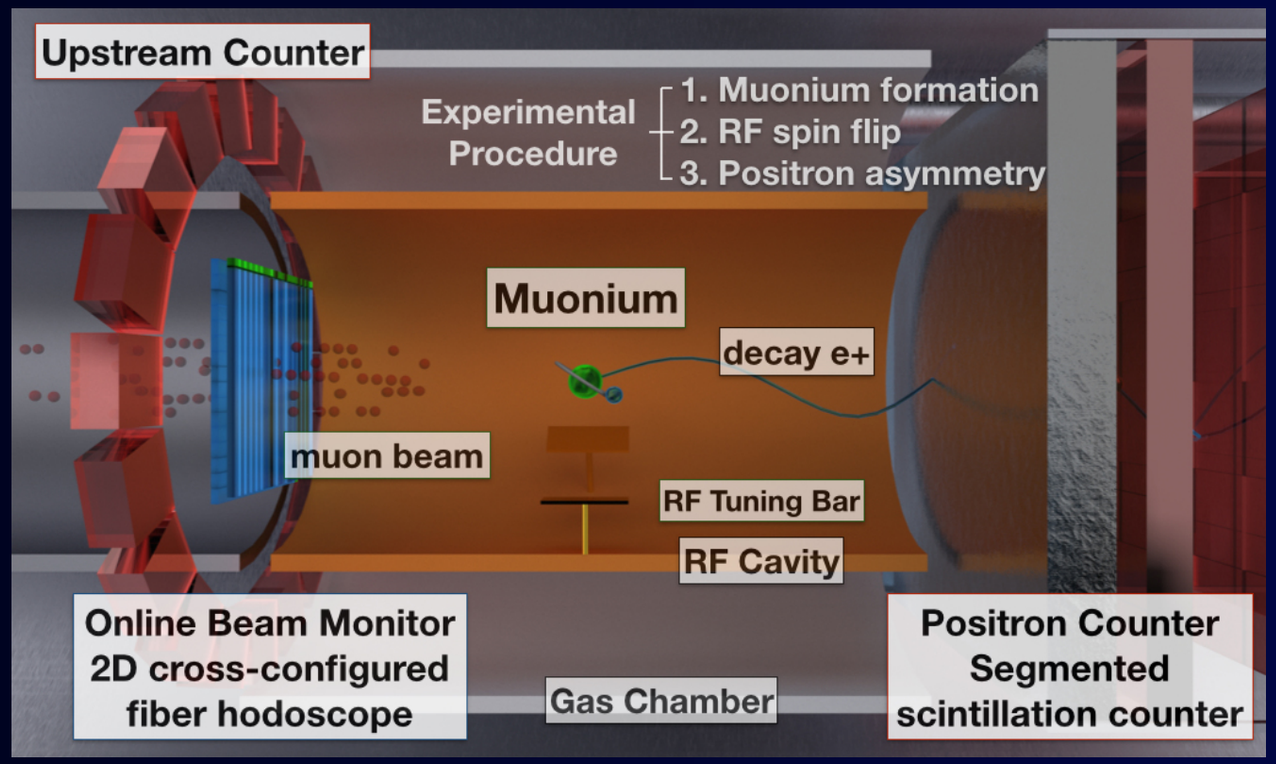
Muonium :
$\mu^- + e^- \rightarrow e^- + e^-$

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

- similar to μ→eee
  - may be useful to distinguish different couplings
  - 2 body final state
- disadvantage
  - poor wave function overlap between μ and e
    - Coulomb bound state

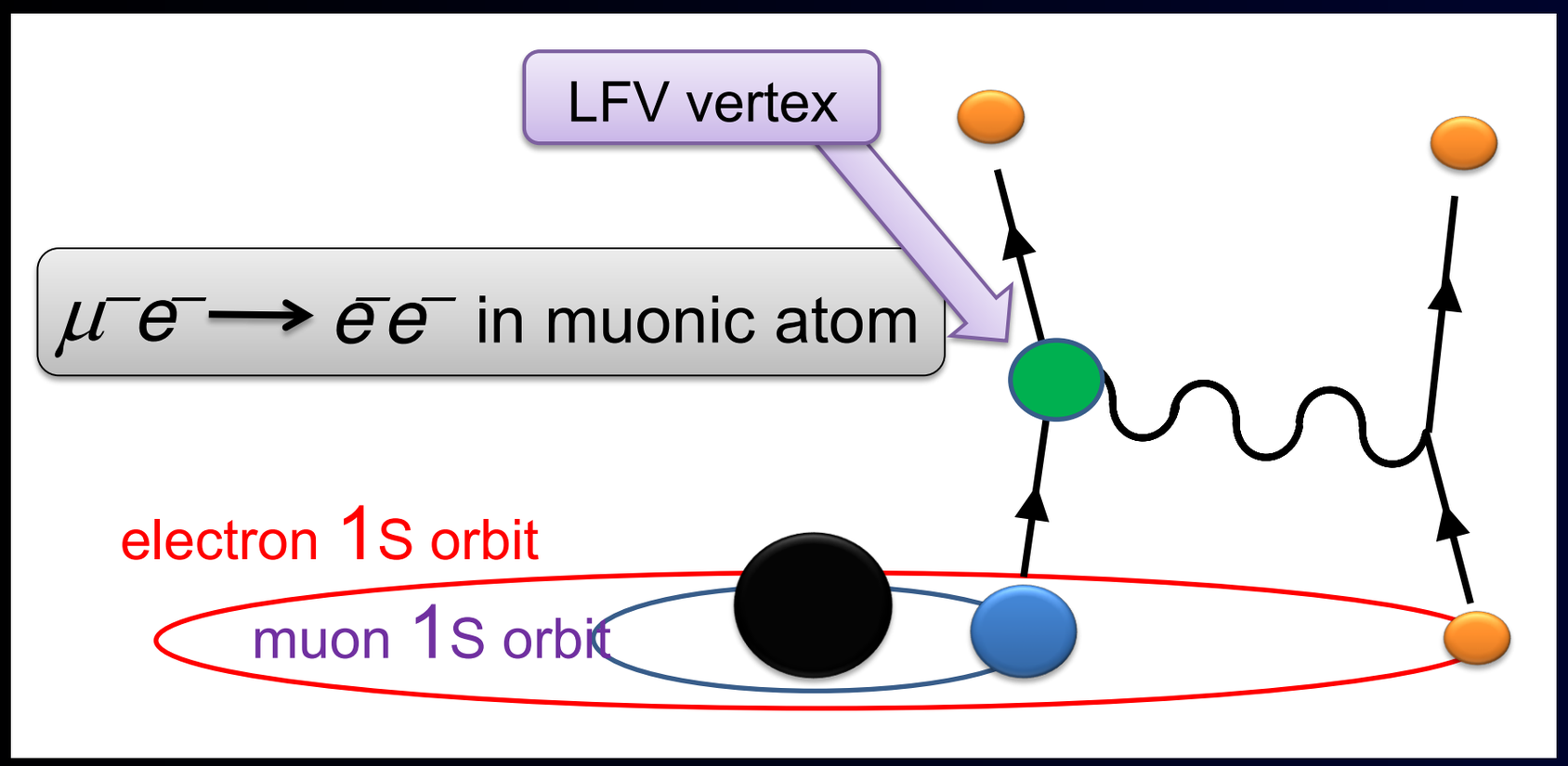
- no experiments so far
- muonium production in vacuum at Muse @ J-PARC
  - 10^{15} for 2×10^{7} sec
  - $< 10^{-13}$ might be possible in the near future.

Museum detector @J-PARC



$\mu^- + e^- \to e^- + e^-$ in a muonic atom

$$\mu^- + e^- \to e^- + e^-$$



$\mu^- e^- \to e^- e^-$ has the overwrap of μ^- and e^- which is proportional to Z^3. (almost compatible to $\mu^+ \to e^+ e^+ e^-$)

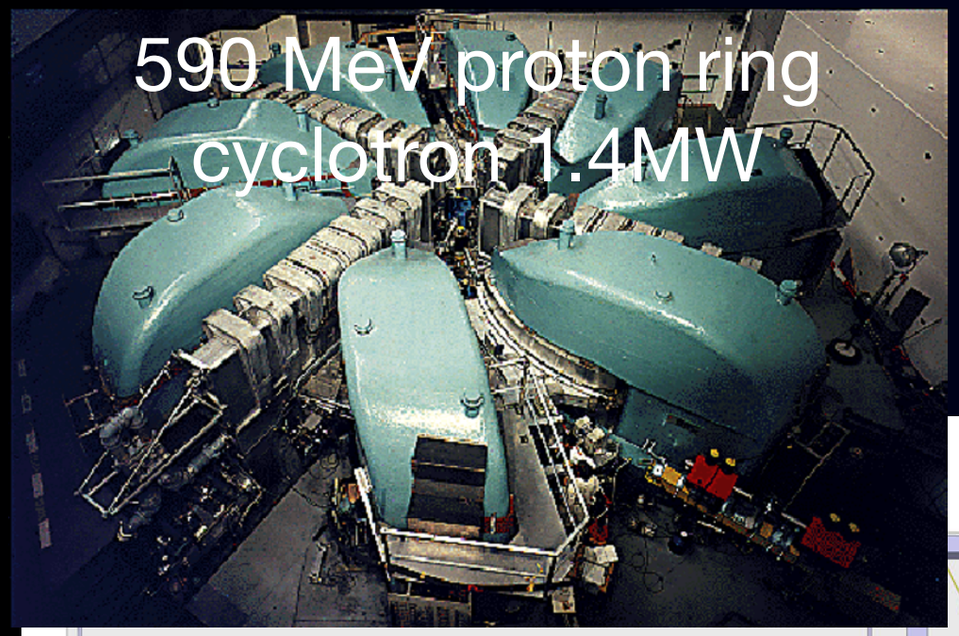
Experimentally a pair of e^- and e^- in the final state is measured.

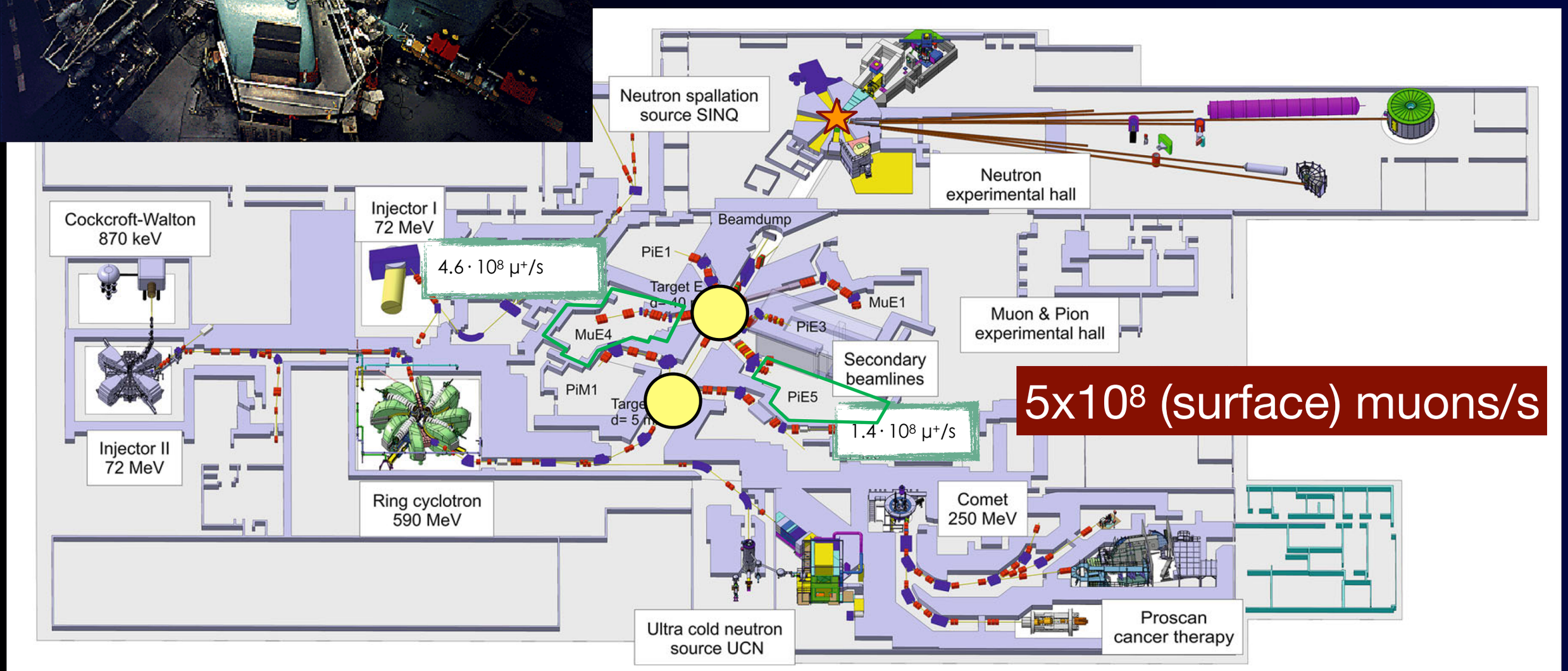
Z dependence discriminate dipole and contact contributions.

M. Koike, YK, J. Sato and M. Yamanaka, Phys. Rev. Lett. 105 (2010)
Y. Uesaka, YK, J. Sato, T. Sato and M. Yamanaka, Phys. Rev. D93 (2016) 076006
Y. Uesaka, YK, J. Sato, T. Sato and M. Yamanaka, Phys. Rev. D97 (2018) 015017

Muon Facilities for CLFV

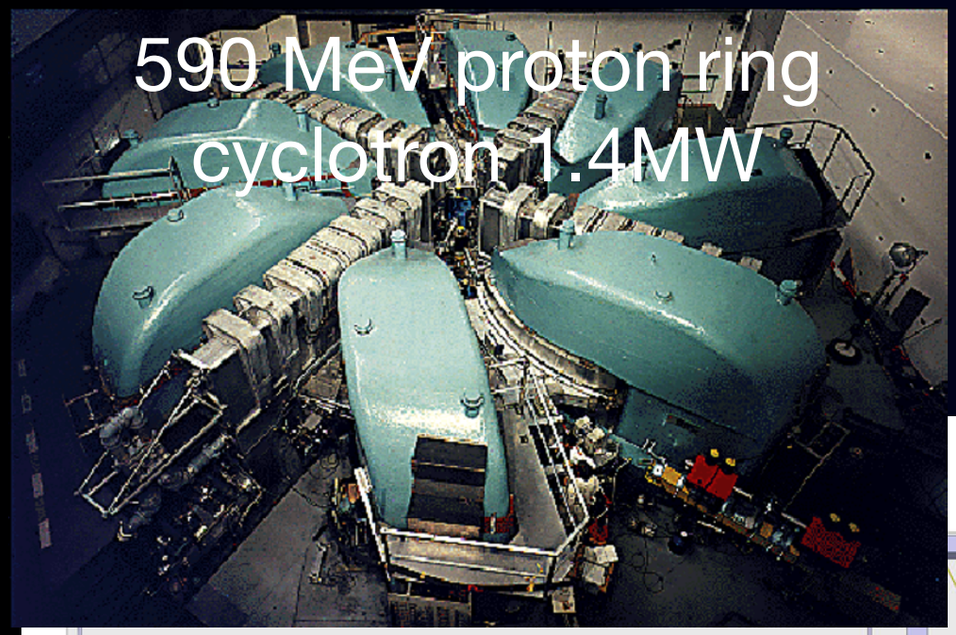
Paul Sherrer Institute (PSI)

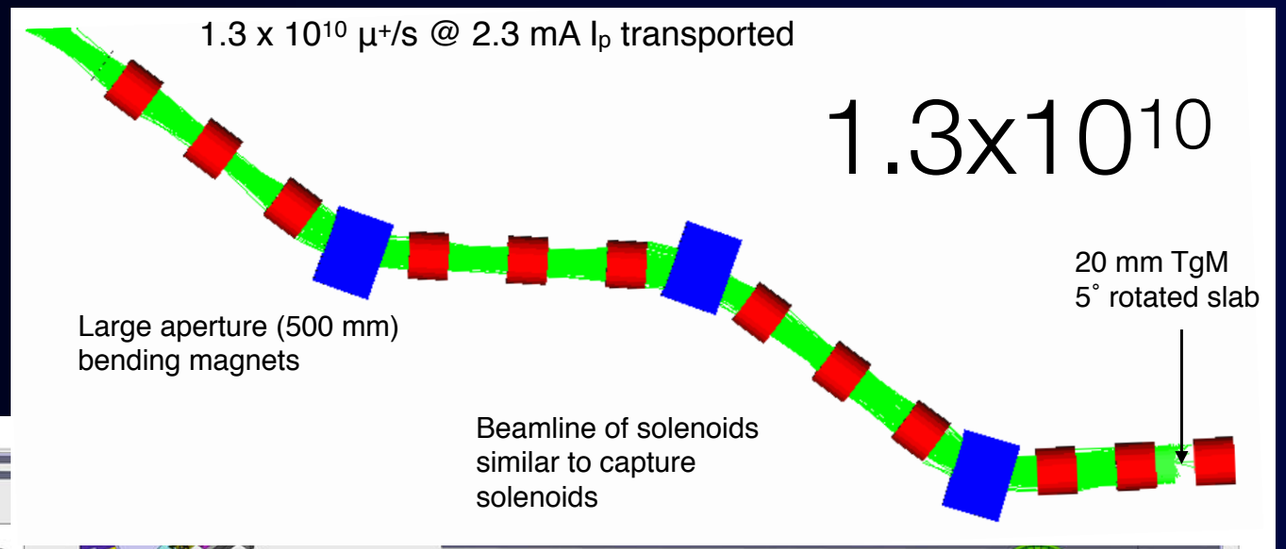


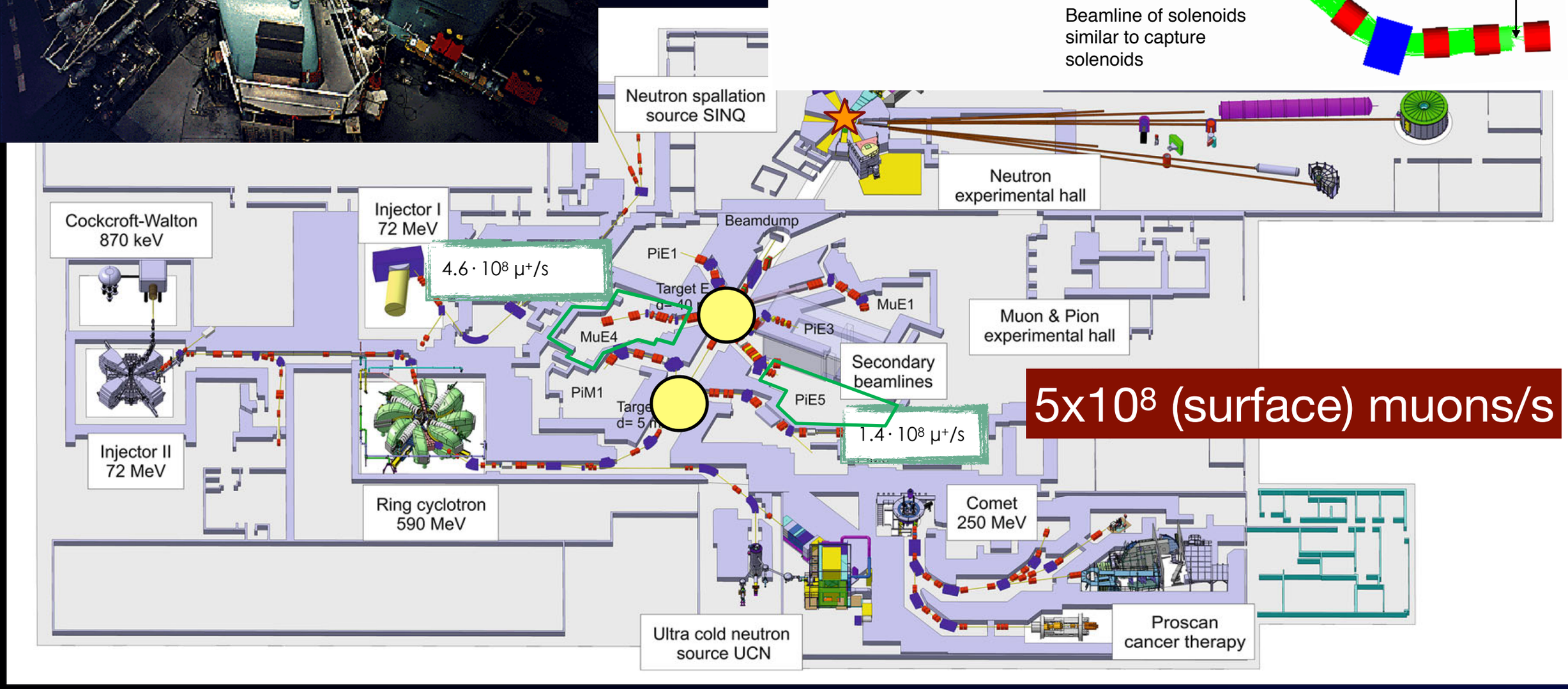


5x10⁸ (surface) muons/s

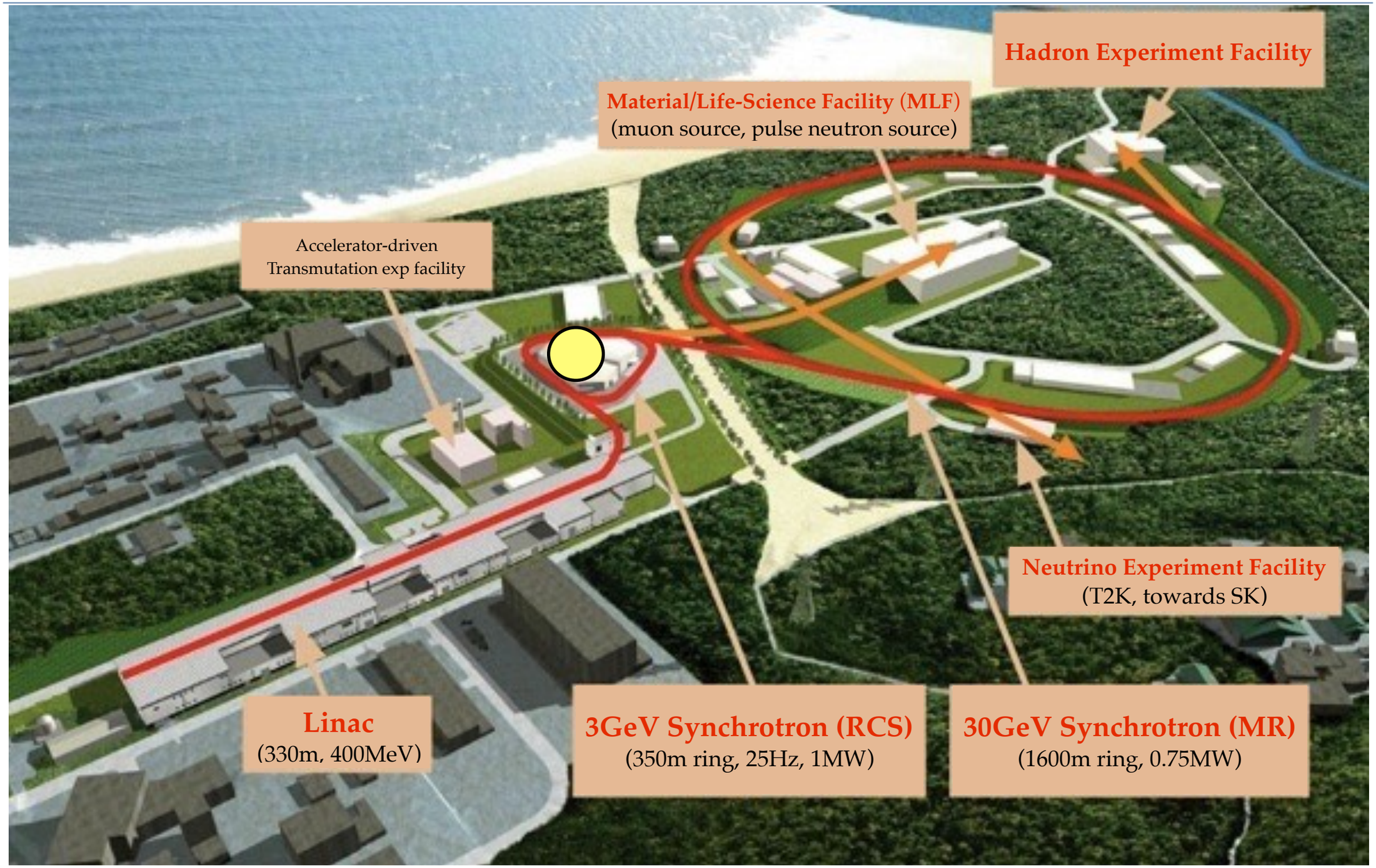
Paul Sherrer Institute (PSI)







J-PARC (Muse@MLF)



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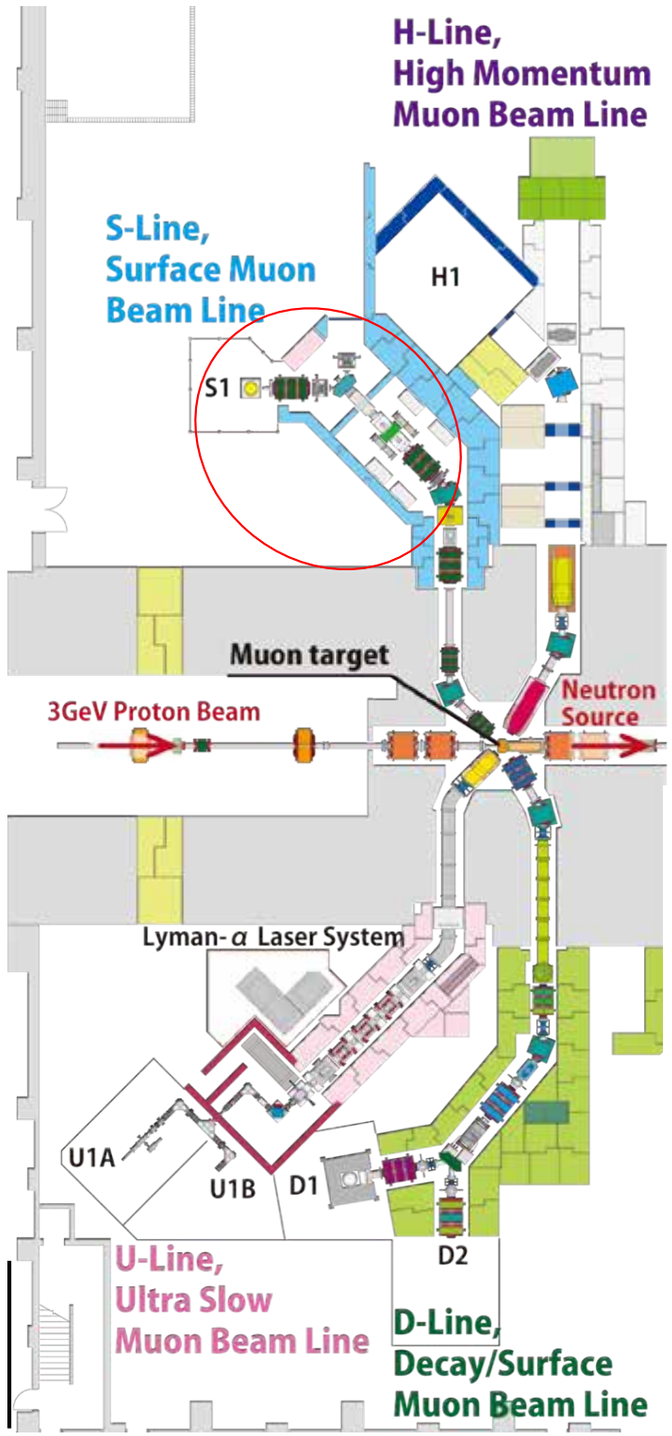
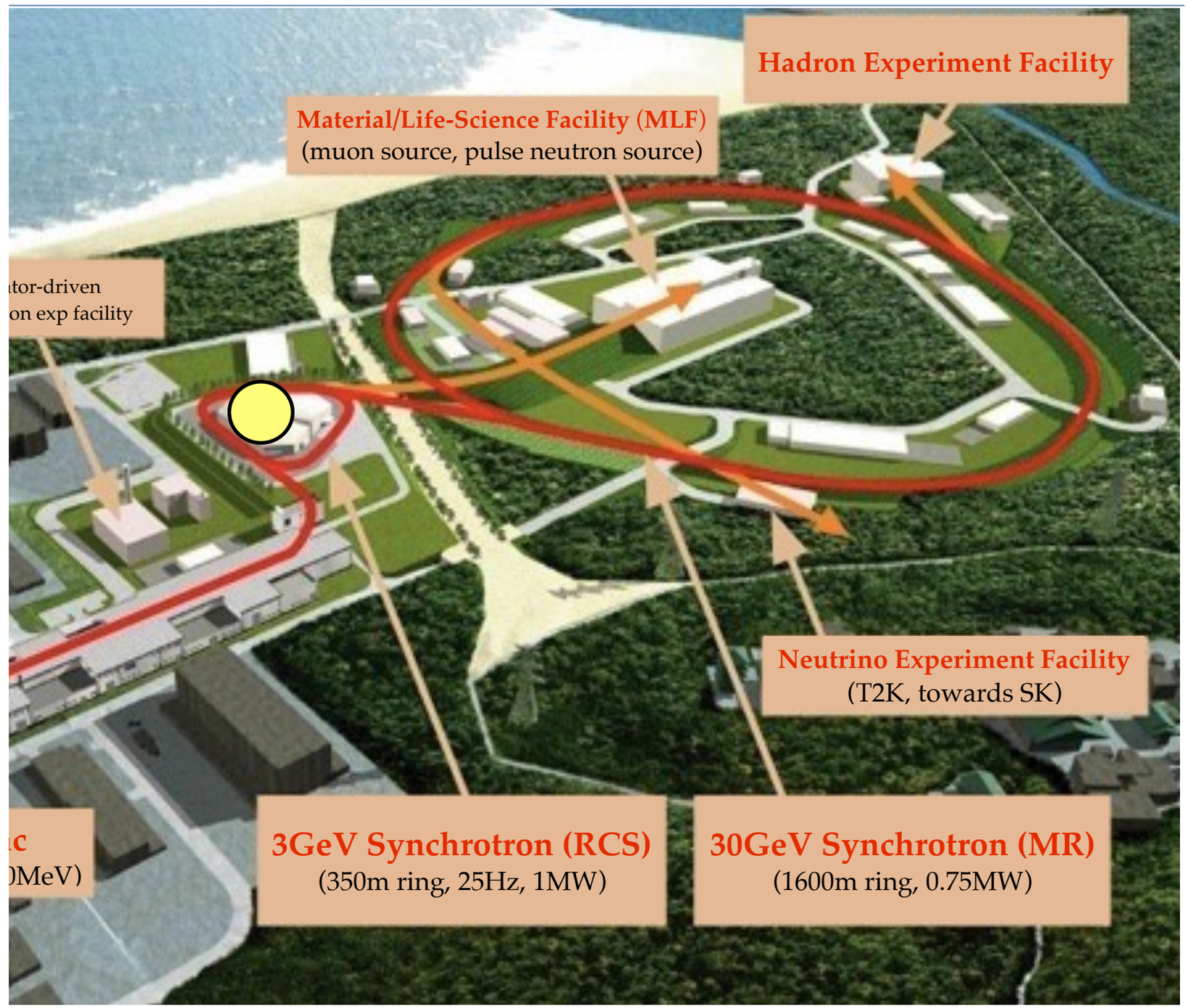
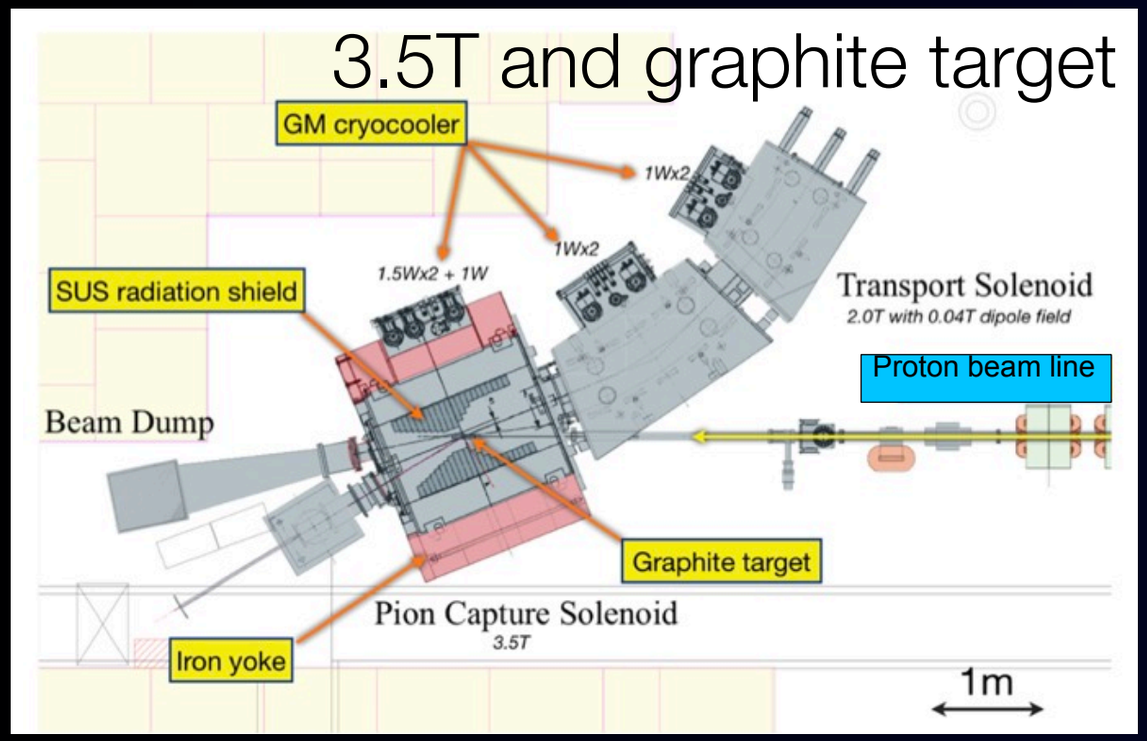




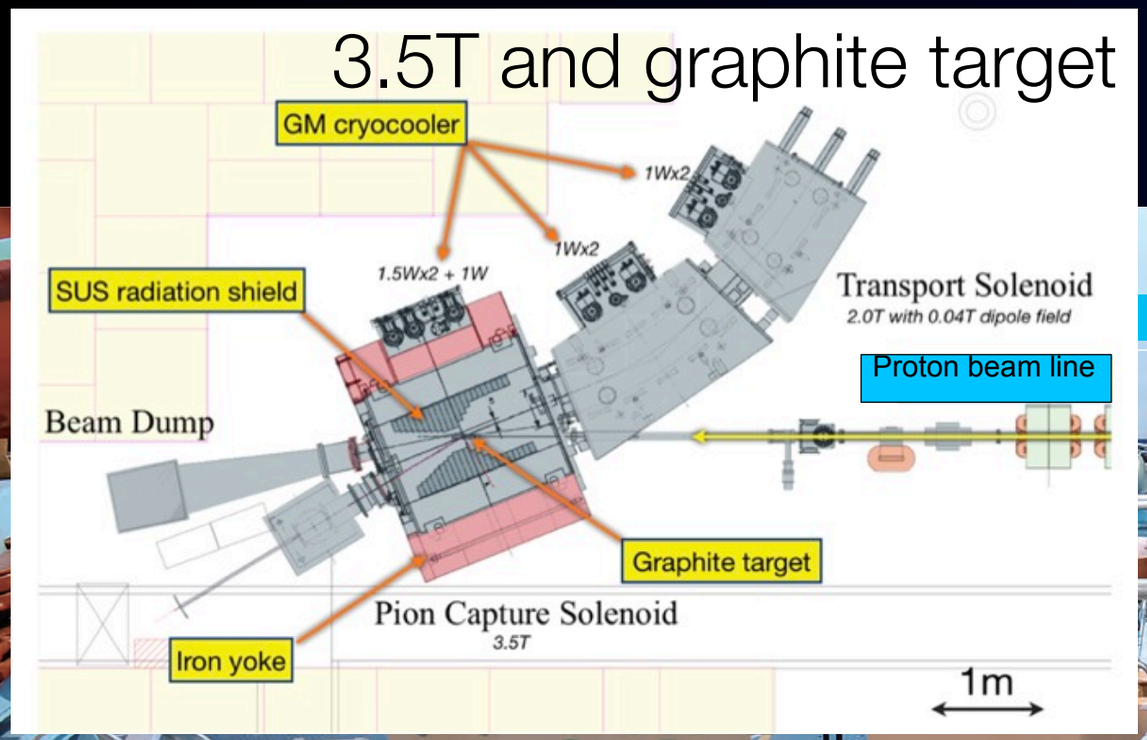
MuSIC at RCNP, Osaka University

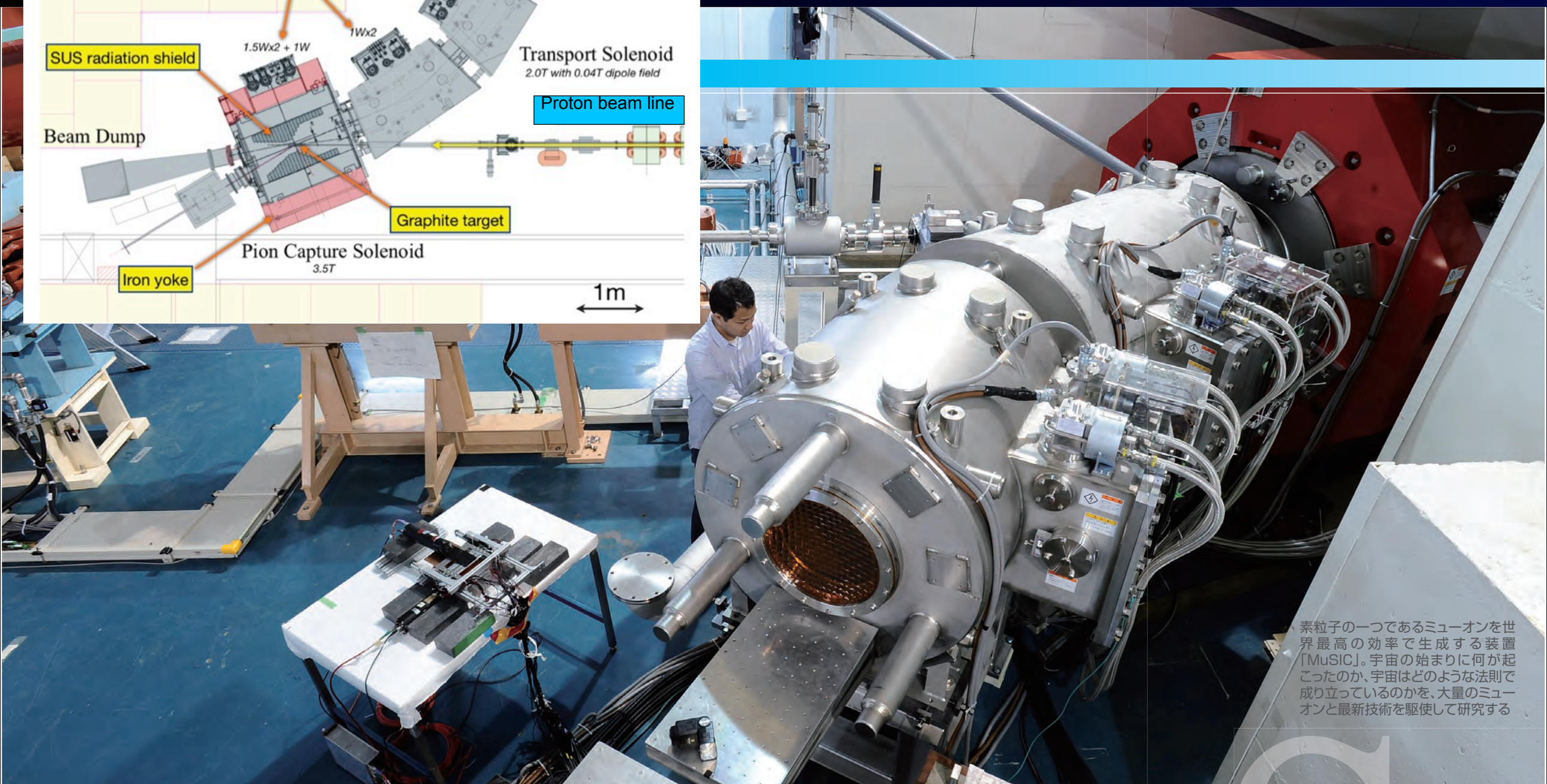
3.5T and graphite target

MuSIC at RCNP, Osaka University



MuSIC at RCNP, Osaka University

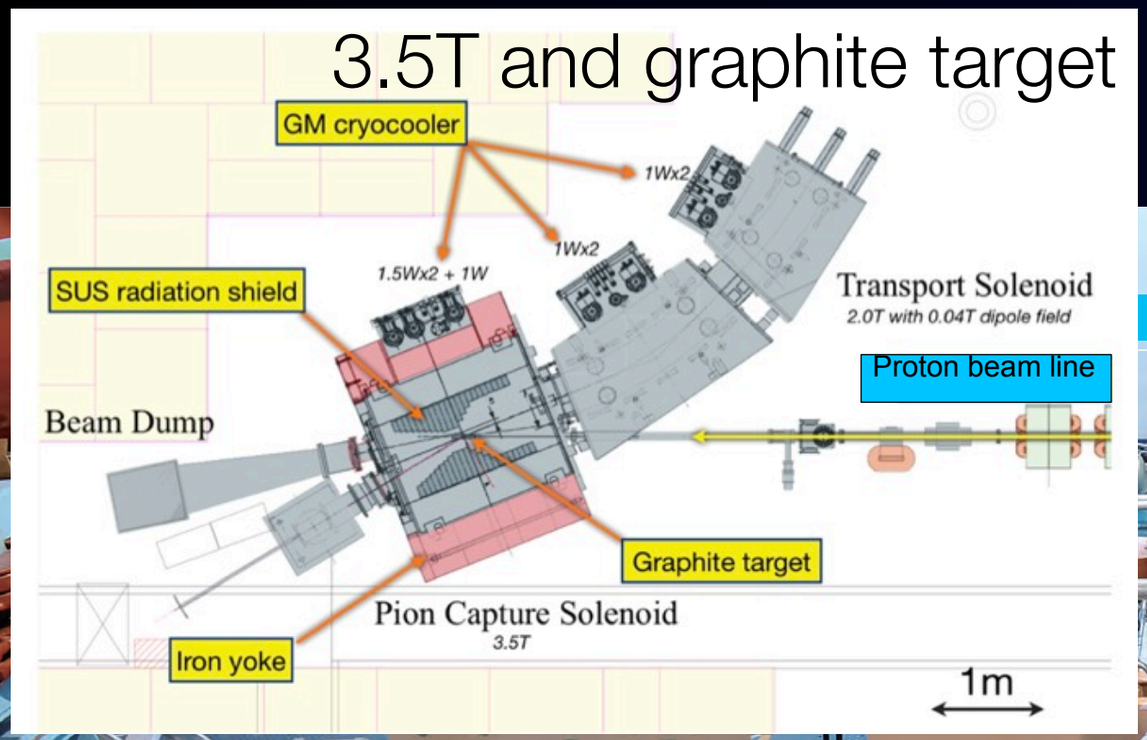


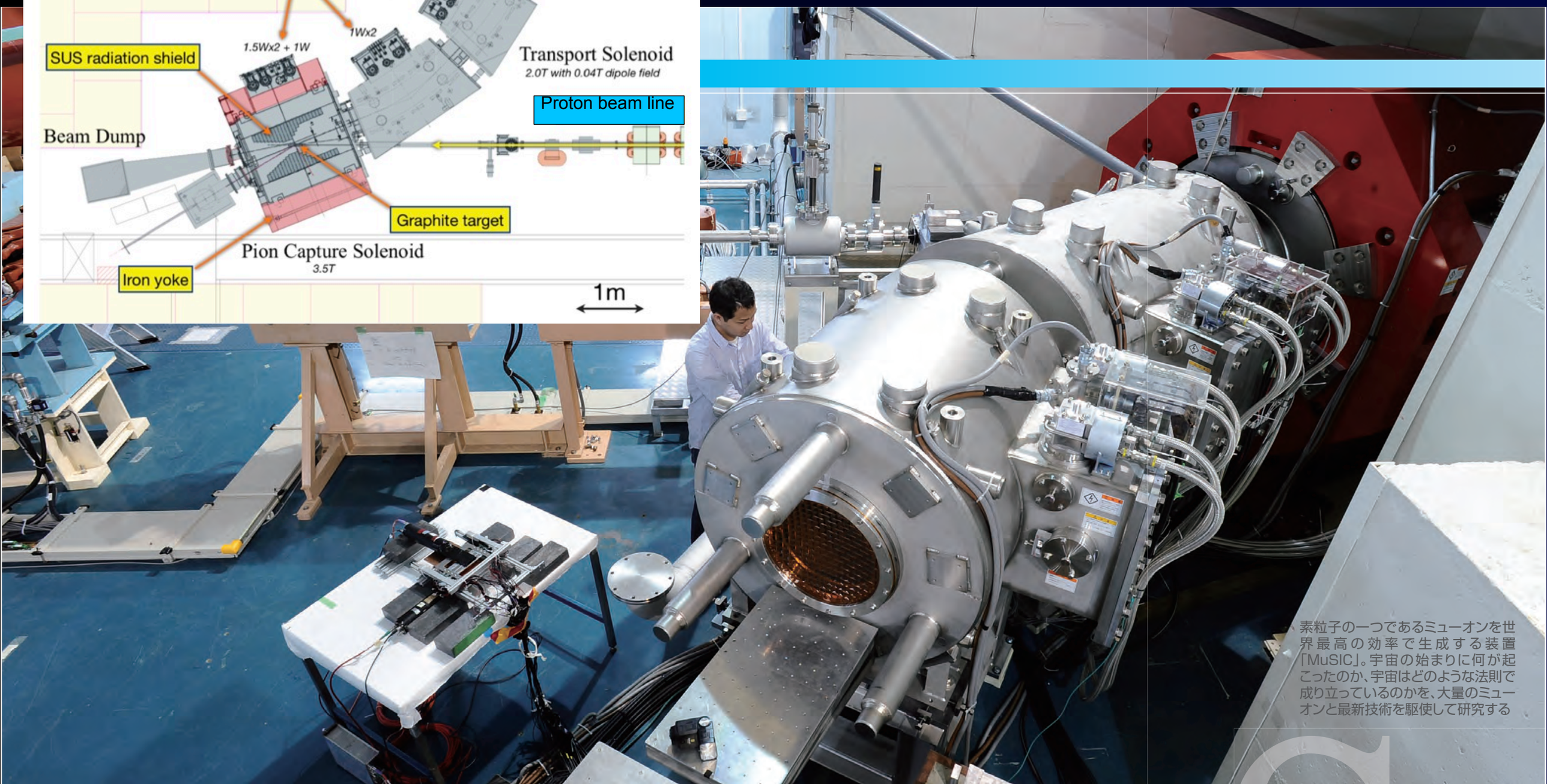


素粒子の一つであるミューオンを世界最高の効率で生成する装置「MuSIC」。宇宙の始まりに何が起こったのか、宇宙はどのような法則で成り立っているのかを、大量のミューオンと最新技術を駆使して研究する

MuSIC at RCNP, Osaka University

Muon Science Intense Channel (>2011)





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MuSIC at RCNP, Osaka University

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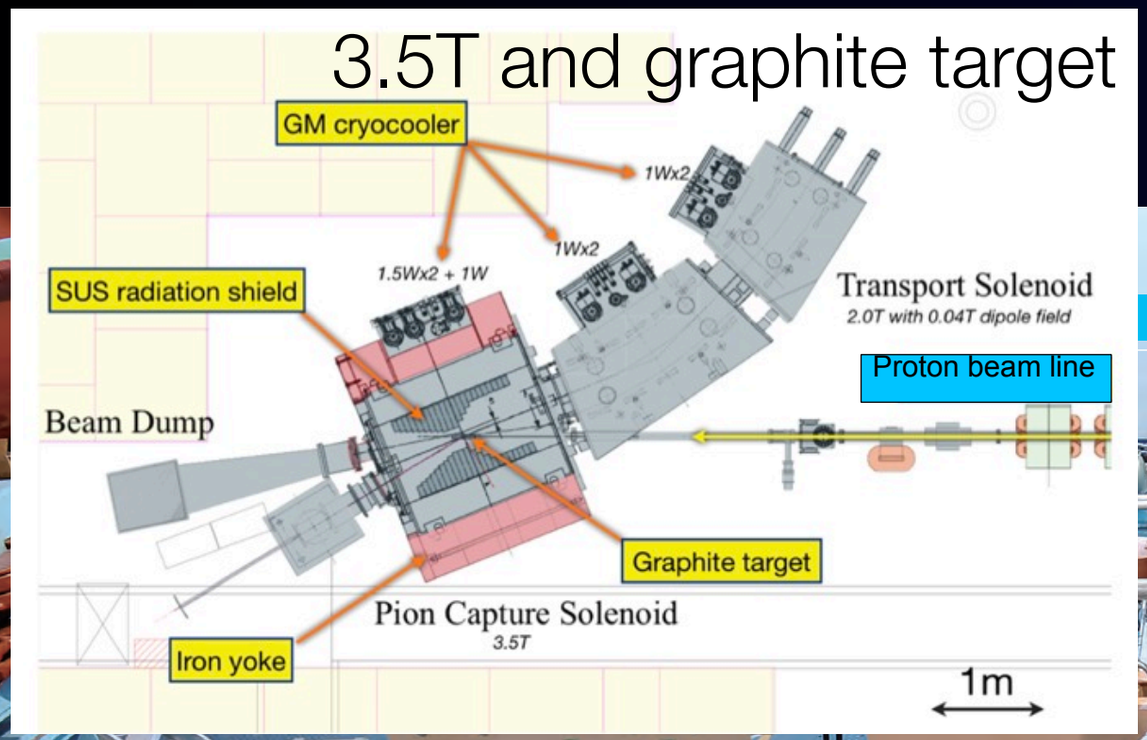
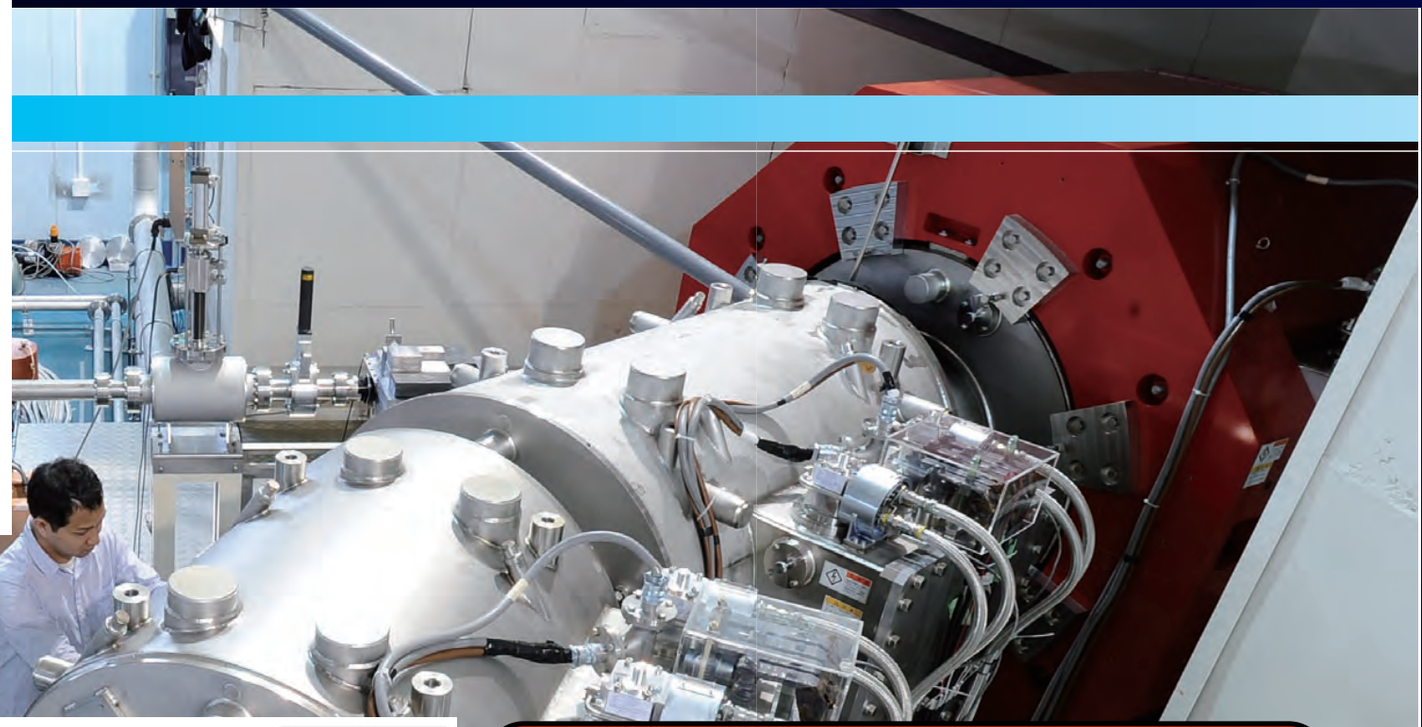
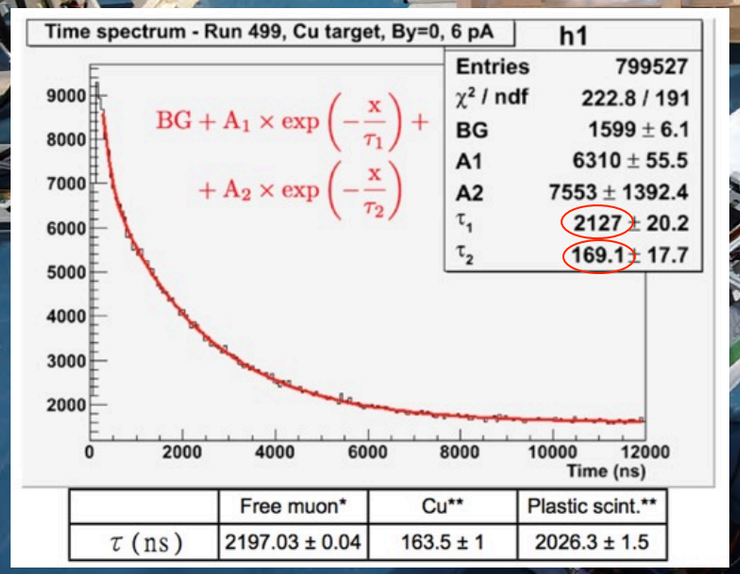
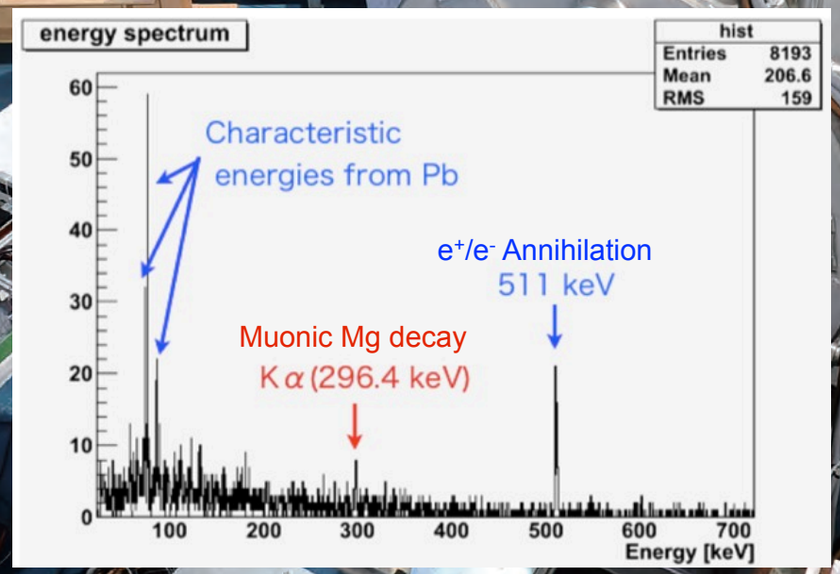






	Free muon*	Cu**	Plastic scint.**
τ (ns)	2197.03 ± 0.04	163.5 ± 1	2026.3 ± 1.5



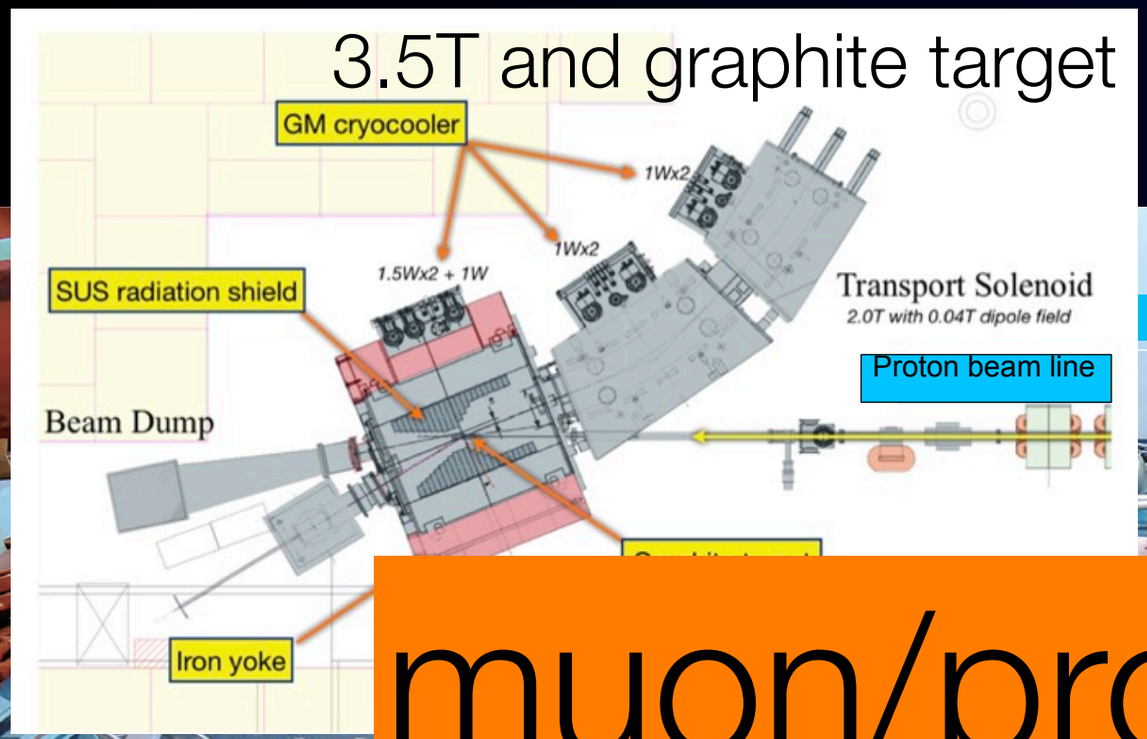
MuSIC muon yields

μ^+ : 3×10^8/s for 400W

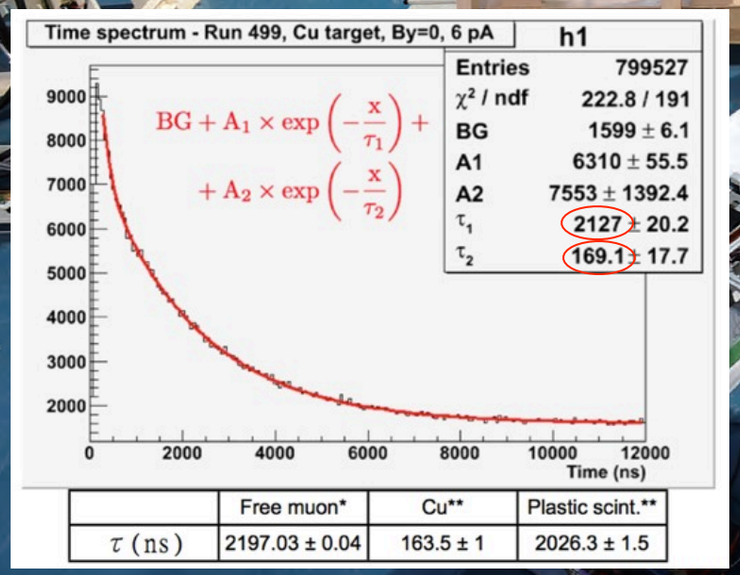
μ^- : 1×10^8/s for 400W

MuSIC at RCNP, Osaka University

Muon Science Intense Channel (>2011)



muon/proton~x1000



	Free muon*	Cu**	Plastic scint.**
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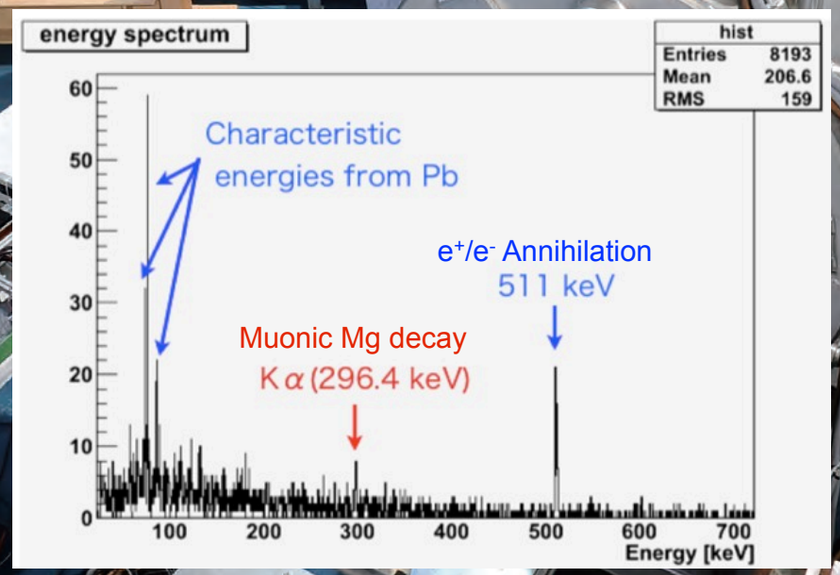

MuSIC muon yields

μ^+ : 3×10^8/s for 400W

μ^- : 1×10^8/s for 400W

MuSIC Paper

Editors Suggestions

March, 2017, Editors Suggestions

PHYSICAL REVIEW ACCELERATORS AND BEAMS **20,** 030101 (2017)

Delivering the world's most intense muon beam

S. Cook,[1] R. D'Arcy,[1] A. Edmonds,[1] M. Fukuda,[2] K. Hatanaka,[2] Y. Hino,[3] Y. Kuno,[3] M. Lancaster,[1] Y. Mori,[4] T. Ogitsu,[5] H. Sakamoto,[3] A. Sato,[3] N. H. Tran,[3] N. M. Truong,[3] M. Wing,[1,*] A. Yamamoto,[5] and M. Yoshida[5]

[1]*Department of Physics and Astronomy, UCL, Gower Street, London WC1E 6BT, United Kingdom*
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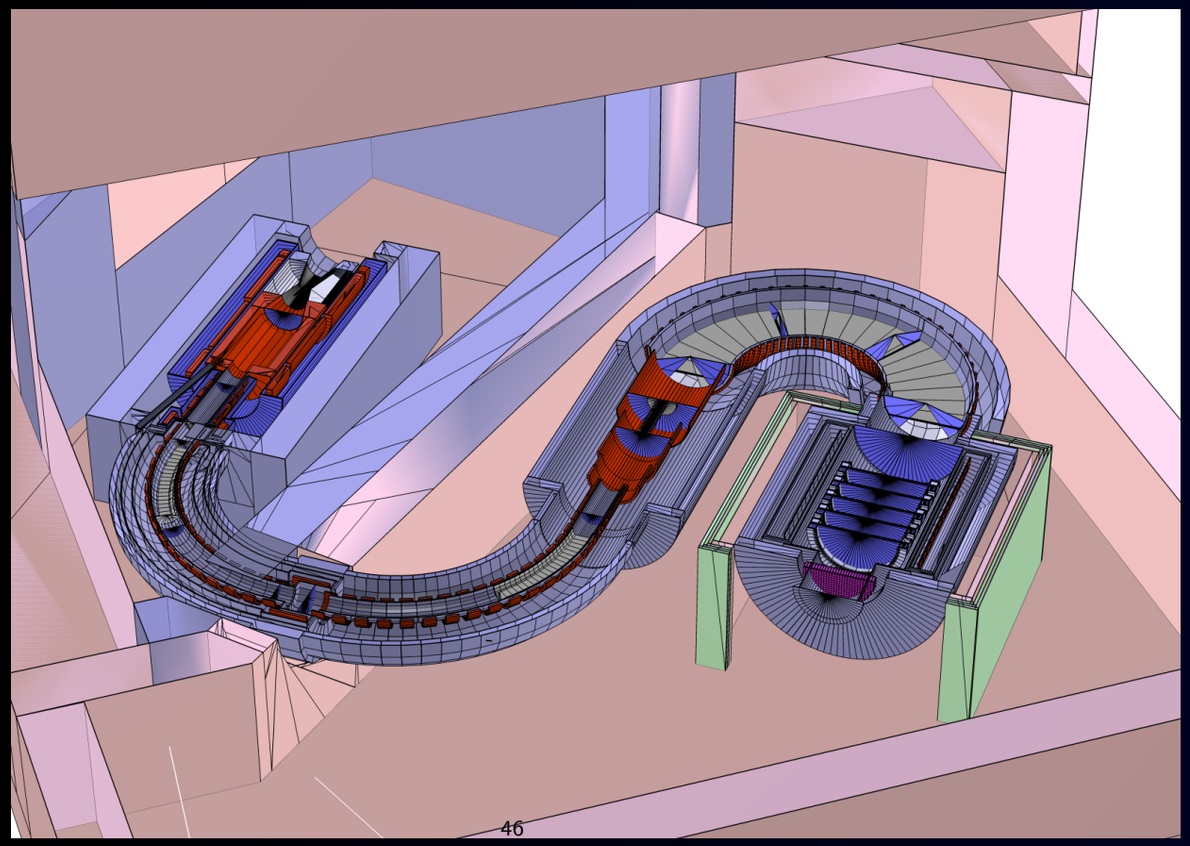
[3]*Department of Physics, Graduate School of Science, Osaka University, Osaka 569-0043, Japan*
[4]*Kyoto University Reactor Research Institute (KURRI), Kyoto 590-0494, Japan*
[5]*High Energy Accelerator Research Organization (KEK), Tsukuba 305-0801, Japan*
(Received 25 October 2016; published 15 March 2017)

A new muon beam line, the muon science innovative channel, was set up at the Research Center for Nuclear Physics, Osaka University, in Osaka, Japan, using the 392 MeV proton beam impinging on a target. The production of an intense muon beam relies on the efficient capture of pions, which subsequently decay to muons, using a novel superconducting solenoid magnet system. After the pion-capture solenoid, the first 36° of the curved muon transport line was commissioned and the muon flux was measured. In order to detect muons, a target of either copper or magnesium was placed to stop muons at the end of the muon

COMET Phase-I

COMET Phase-I

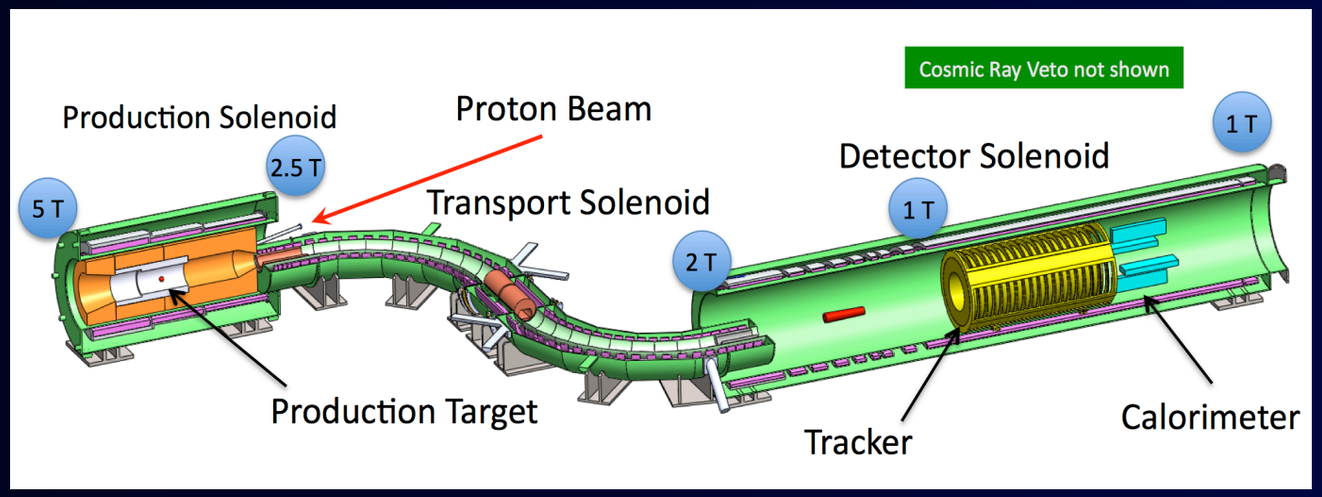


proton beam power=56 kW

~2.0×10^{11} stopped muon/s

(0.004 stopped muon/proton)

Mu2e



proton beam power=8 kW

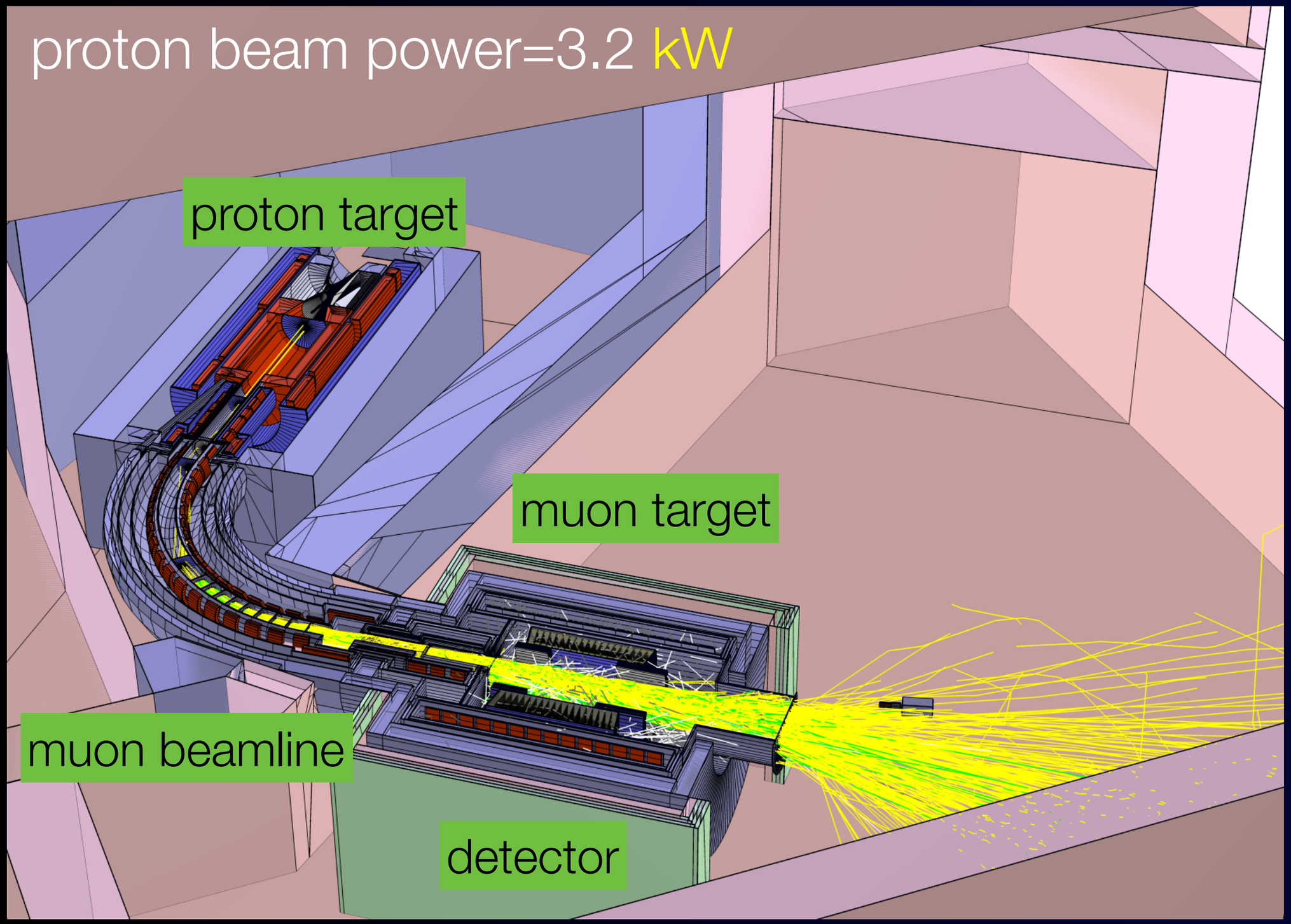
~1.2×10^{10} stopped muon/s

stopped muons
~$O(4 \times 10^{18})$/year

$\mu - e$ conversion

COMET@J-PARC

COMET Phase-I

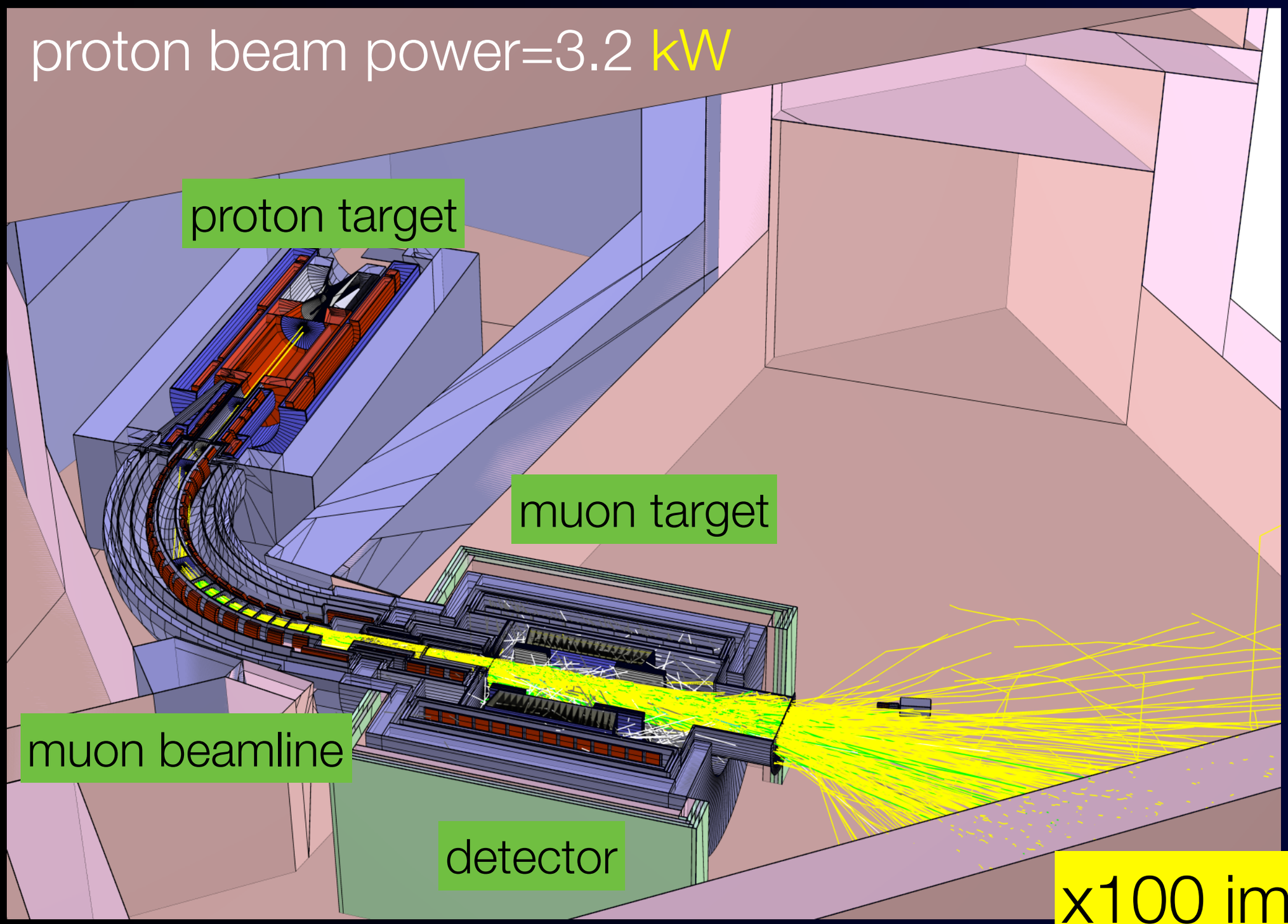


current limit: $< 6\times10^{-13}$

aimed sensitivity: $< 6\times10^{-15}$

$\mathcal{O}(10^{-15})$

COMET Phase-I



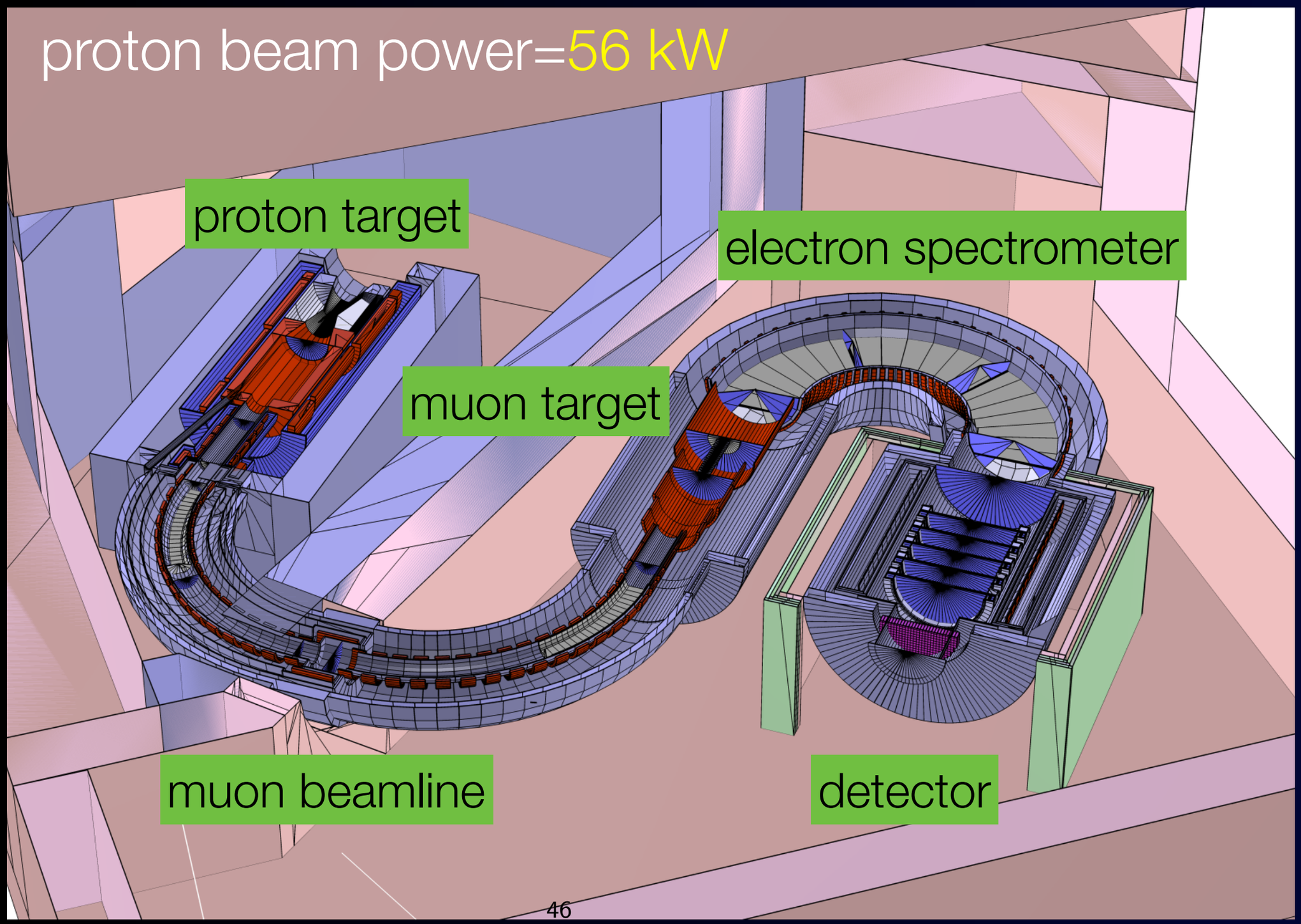
current limit: $< 6\times10^{-13}$

aimed sensitivity: $< 6\times10^{-15}$

$\mathcal{O}(10^{-15})$

x100 improvement

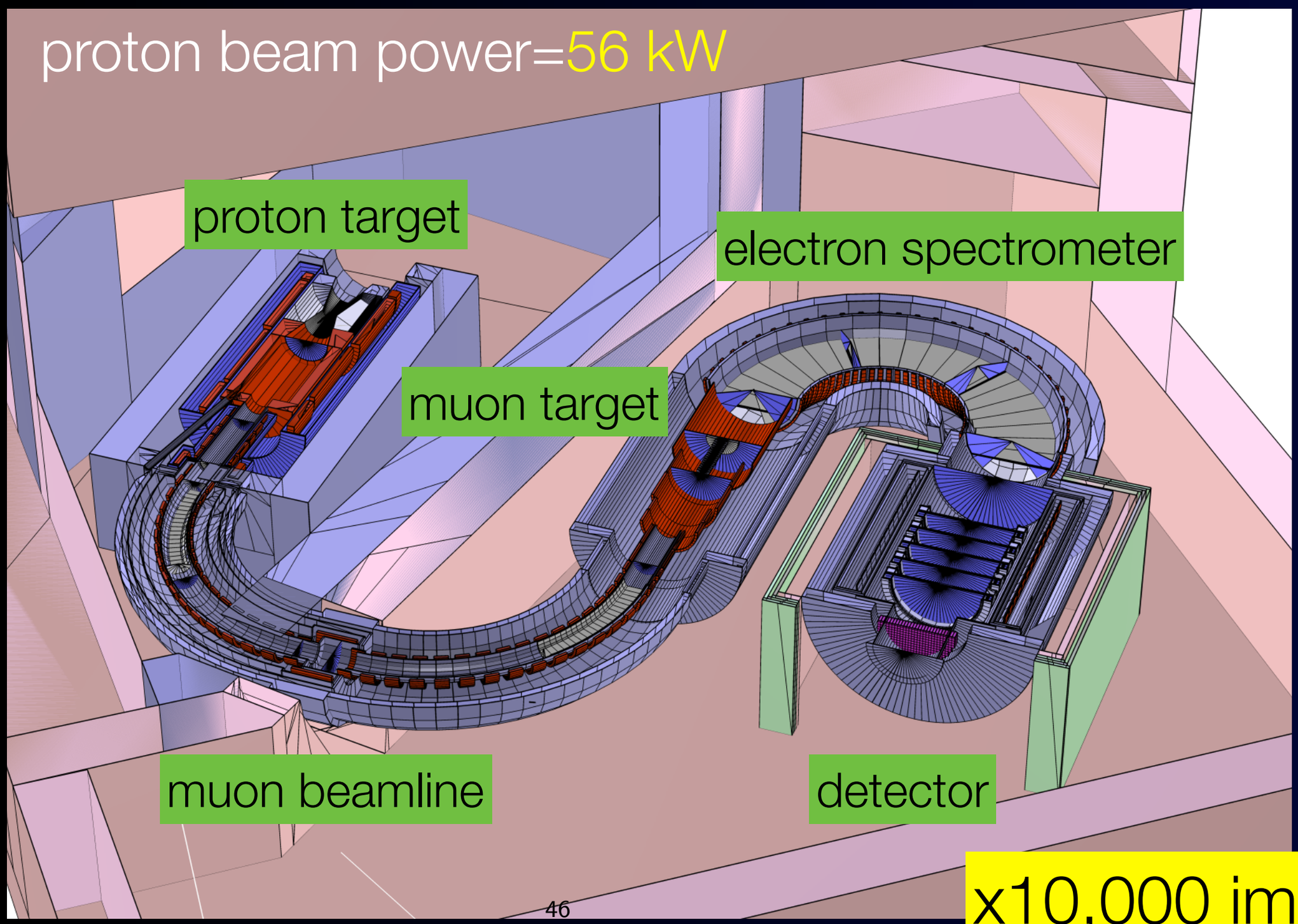
COMET Phase-II



original sensitivity: 2.6×10^{-17}

$\mathcal{O}(10^{-17})$

COMET Phase-II



original sensitivity: 2.6×10^{-17}

$\mathcal{O}(10^{-17})$

x10,000 improvement

COMET Collaboration

PI: Y. Kuno

The COMET Collaboration

R. Abramishvili[11], G. Adamov[11], R. Akhmetshin[6,31], V. Anishchik[4], M. Aoki[32], Y. Arimoto[18], I. Bagaturia[11], Y. Ban[3], A. Bondar[6,31], Y. Calas[7], S. Canfer[33], Y. Cardenas[7], S. Chen[28], Y. E. Cheung[28], B. Chiladze[35], D. Clarke[33], M. Danilov[15,26], P. D. Dauncey[14], J. David[23], W. Da Silva[23], C. Densham[33], G. Devidze[35], P. Dornan[14], A. Drutskoy[15,26], V. Duginov[16], L. Epshteyn[6,30], P. Evtoukhovich[16], G. Fedotovich[6,31], M. Finger[8], M. Finger Jr[8], Y. Fujii[18], Y. Fukao[18], J-F. Genat[23], E. Gillies[14], D. Grigoriev[6,30,31], K. Gritsay[16], E. Hamada[18], R. Han[1], K. Hasegawa[18], I. H. Hasim[32], O. Hayashi[32], Z. A. Ibrahim[24], Y. Igarashi[18], F. Ignatov[6,31], M. Iio[18], M. Ikeno[18], K. Ishibashi[22], S. Ishimoto[18], T. Itahashi[32], S. Ito[32], T. Iwami[32], X. S. Jiang[2], P. Jonsson[14], V. Kalinnikov[16], F. Kapusta[23], H. Katayama[32], K. Kawagoe[22], N. Kazak[5], V. Kazanin[6,31], B. Khazin[6,31], A. Khvedelidze[16,11], T. K. Ki[18], M. Koike[39], G. A. Kozlov[16], B. Krikler[14], A. Kulikov[16], E. Kulish[16], Y. Kuno[32], Y. Kuriyama[21], Y. Kurochkin[5], A. Kurup[14], B. Lagrange[14,21], M. Lancaster[38], M. J. Lee[12], H. B. Li[2], W. G. Li[2], R. P. Litchfield[38], T. Loan[29], D. Lomidze[11], I. Lomidze[11], P. Loveridge[33], G. Macharashvili[35], Y. Makida[18], Y. Mao[3], O. Markin[15], Y. Matsumoto[32], T. Mibe[18], S. Mihara[18], F. Mohamad Idris[24], K. A. Mohamed Kamal Azmi[24], A. Moiseenko[16], Y. Mori[21], M. Moritsu[32], E. Motuk[38], Y. Nakai[22], T. Nakamoto[18], Y. Nakazawa[32], J. Nash[14], J. -Y. Nief[7], M. Nioradze[35], H. Nishiguchi[18], T. Numao[36], J. O'Dell[33], T. Ogitsu[18], K. Oishi[22], K. Okamoto[32], C. Omori[18], T. Ota[34], J. Pasternak[14], C. Plostinar[33], V. Ponariadov[45], A. Popov[6,31], V. Rusinov[15,26], A. Ryzhenenkov[6,31], B. Sabirov[16], N. Saito[18], H. Sakamoto[32], P. Sarin[13], K. Sasaki[18], A. Sato[32], J. Sato[34], Y. K. Semertzidis[12,17], D. Shemyakin[6,31], N. Shigyo[22], D. Shoukavy[5], M. Slunecka[8], A. Straessner[37], D. Stöckinger[37], M. Sugano[18], Y. Takubo[18], M. Tanaka[18], S. Tanaka[22], C. V. Tao[29], E. Tarkovsky[15,26], Y. Tevzadze[35], T. Thanh[29], N. D. Thong[32], J. Tojo[22], M. Tomasek[10], M. Tomizawa[18], N. H. Tran[32], H. Trang[29], I. Trekov[35], N. M. Truong[32], Z. Tsamalaidze[16,11], N. Tsverava[16,35], T. Uchida[18], Y. Uchida[14], K. Ueno[18], E. Velicheva[16], A. Volkov[16], V. Vrba[10], W. A. T. Wan Abdullah[24], M. Warren[38], M. Wing[38], T. S. Wong[32], C. Wu[2,28], H. Yamaguchi[22], A. Yamamoto[18], Y. Yang[22], W. Yao[2], Y. Yao[2], H. Yoshida[32], M. Yoshida[18], Y. Yoshii[18], T. Yoshioka[22], Y. Yuan[2], Y. Yudin[6,31], J. Zhang[2], Y. Zhang[2], K. Zuber[37]

COMET Collaboration

PI: Y. Kuno

The COMET Collaboration

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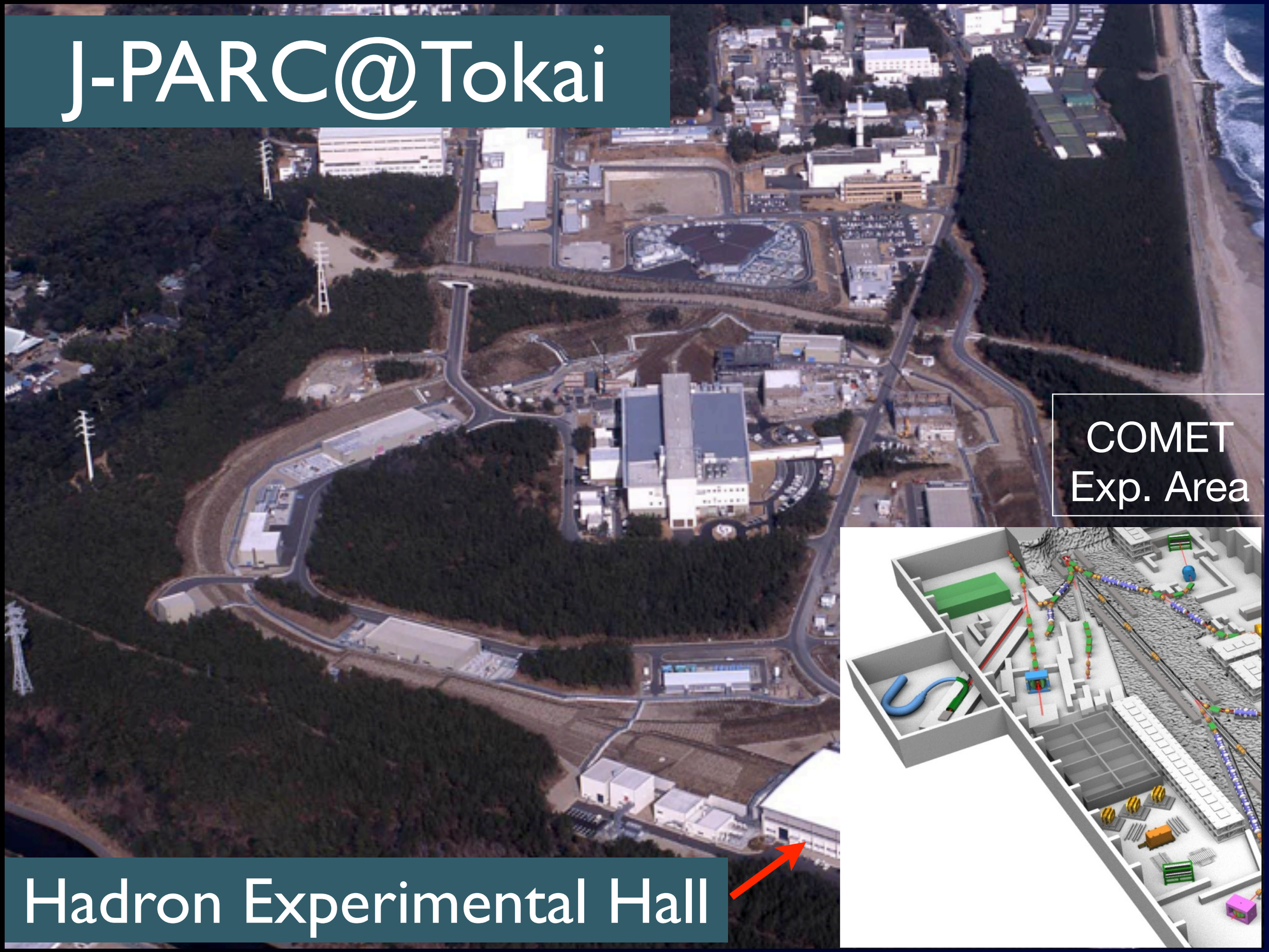
about 200 collaborators
40 institutes, 17 countries

J-PARC@Tokai



COMET
White Paper

The 2020 Update of the European Strategy for Particle Physics

16 December 2018

Further improvements by one order of magnitude

$\mathcal{O}(10^{-18})$

COMET

J.-C. Angélique, C. Cârloganu, W. da Silva, A. Drutskoy, M. Finger, D. N. Grigoriev, T. Kachelhoffer, F. Kapusta, Y. Kuno[1], P. Lebrun, R. P. Litchfield, D. Lomidze, D. Shoukavy, A. M. Teixeira, I. Tevzadze, Z. B. Tsamalaidze, Y. Uchida, V. Vrba, K. Zuber

A submission to the 2020 update of the European Strategy for Particle Physics on behalf of the COMET collaboration.

Abstract

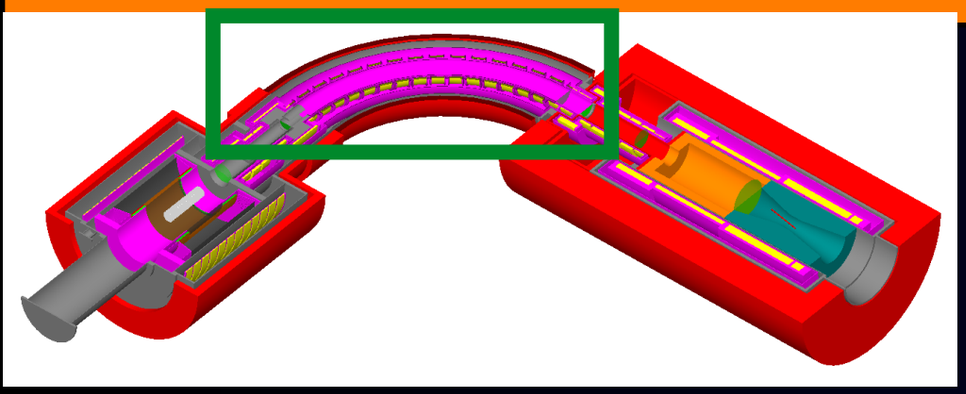
The search for charged lepton flavour violation (CLFV) has enormous discovery potential in probing new physics Beyond the Standard Model (BSM). The observation of a CLFV transition would be an undeniable sign of the presence of BSM physics which goes beyond non-zero masses for neutrinos. Furthermore, CLFV measurements can provide a way to distinguish between different BSM models, which may not be possible through other means. So far muonic CLFV processes have the best experimental sensitivity because of the huge number of muons which can be produced at several facilities world-wide, and in the near future, new muon beam-lines will be built, leading to increases in beam intensity by several orders of magnitude. Among the muonic CLFV processes, $\mu \to e$ conversion is one of the most important processes, having several advantages compared to other such processes.

We describe the COMET experiment, which is searching for $\mu \to e$ conversion in a muonic atom at the J-PARC proton accelerator laboratory in Japan. The COMET experiment has taken a staged approach; the first stage, COMET Phase-I, is currently under construction at J-PARC, and is aiming at a factor 100 improvement over the current limit. The second stage, COMET Phase-II is seeking another 100 improvement (a total of 10,000), allowing a single event sensitivity (SES) of 2.6×10^{-17} with 2×10^7 seconds of data-taking. Further improvements by one order of magnitude, which arise from refinements to the experimental design and operation, are being considered whilst staying within the originally-assumed beam power and beam time. Such a sensitivity could be translated into probing many new physics constructions up to $\mathcal{O}(10^4)$ TeV energy scales, which would go far beyond the level that can be reached directly by collider experiments. The search for CLFV $\mu \to e$ conversion is thus highly complementary to BSM searches at the LHC.

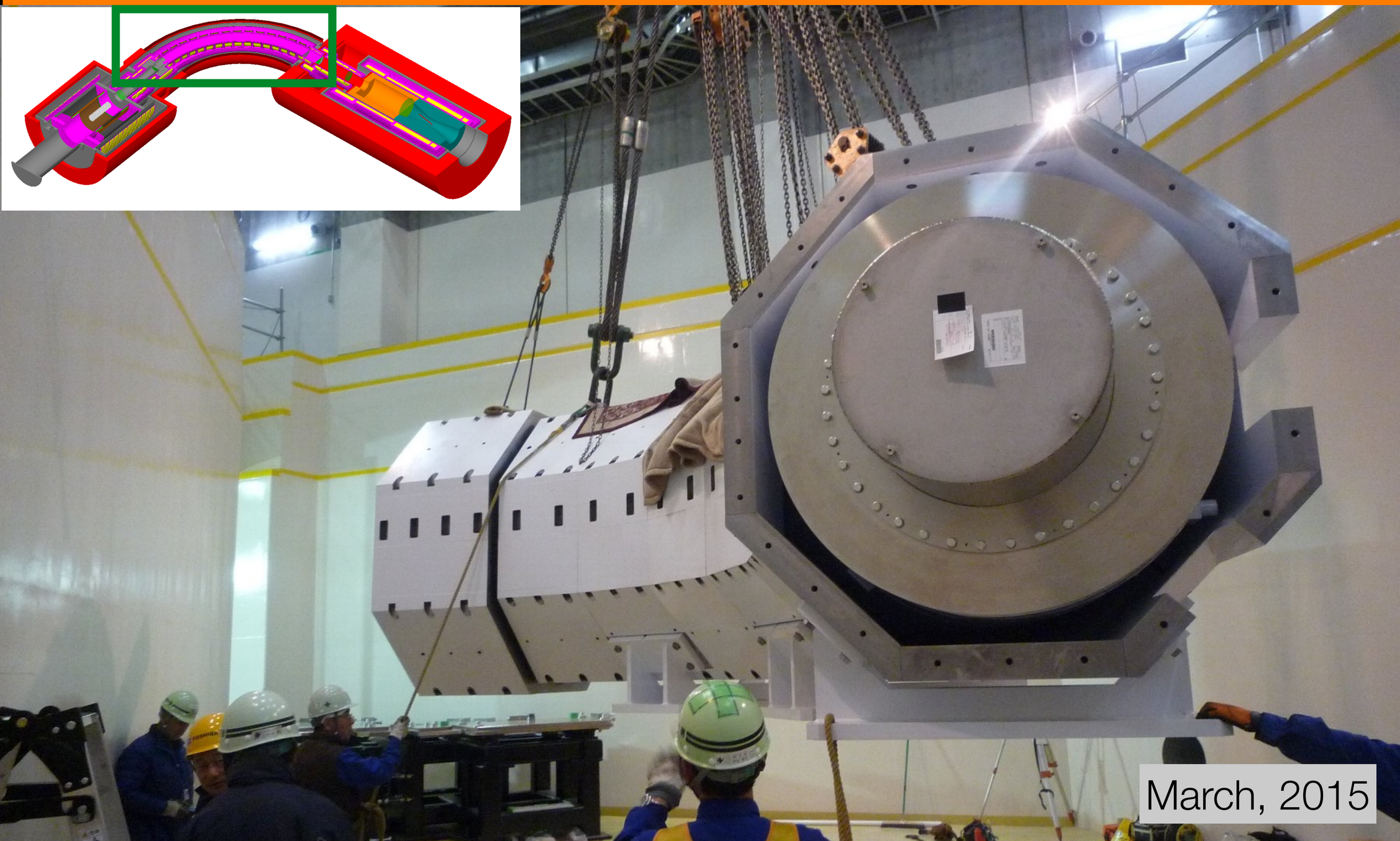
[1]contact person: kuno@phys.sci.osala-u.ac.jp.

Curved Solenoids for Muon Transport Completed and Delivered!

Curved Solenoids for Muon Transport Completed and Delivered!

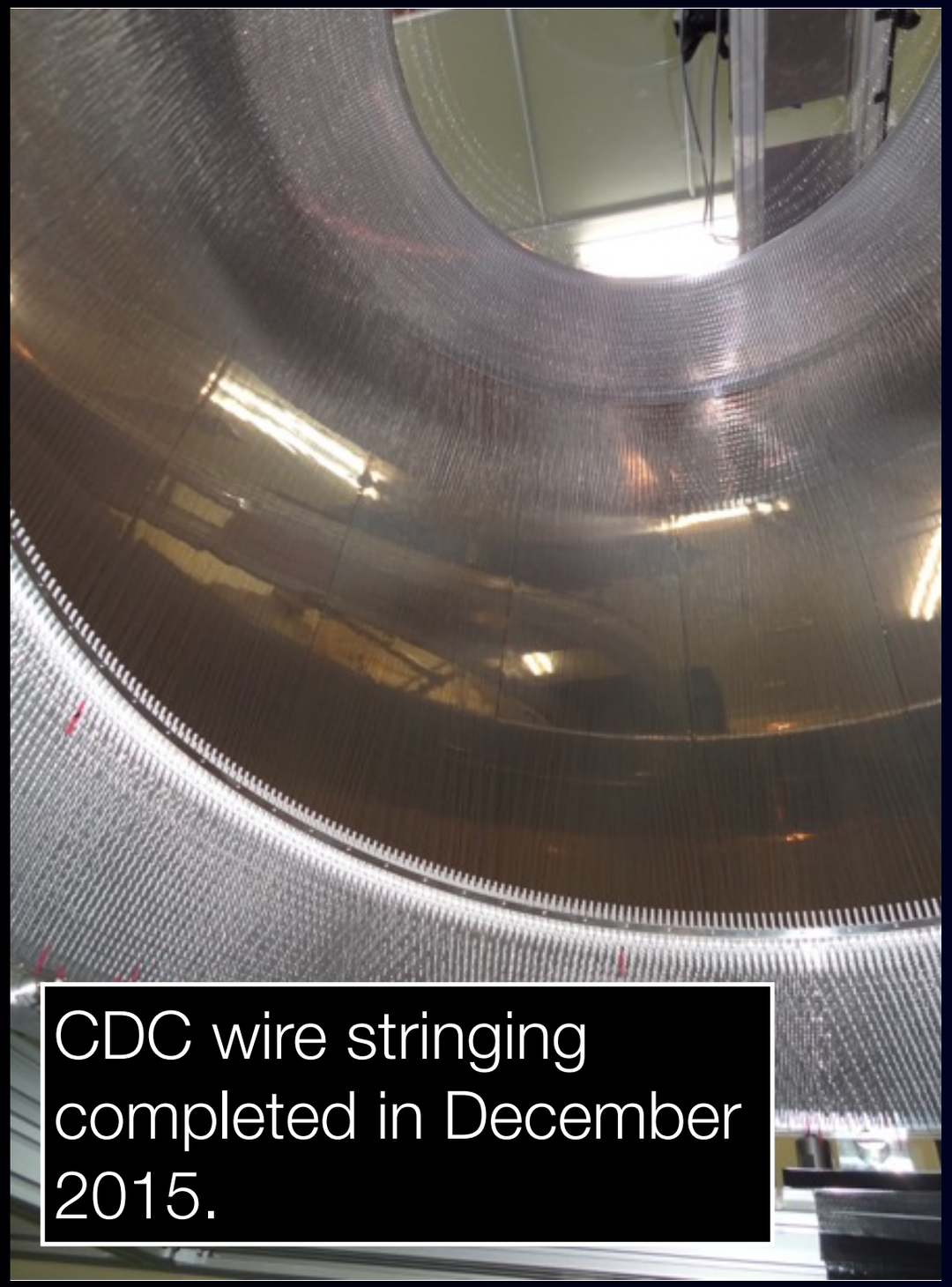


Curved Solenoids for Muon Transport Completed and Delivered!



March, 2015

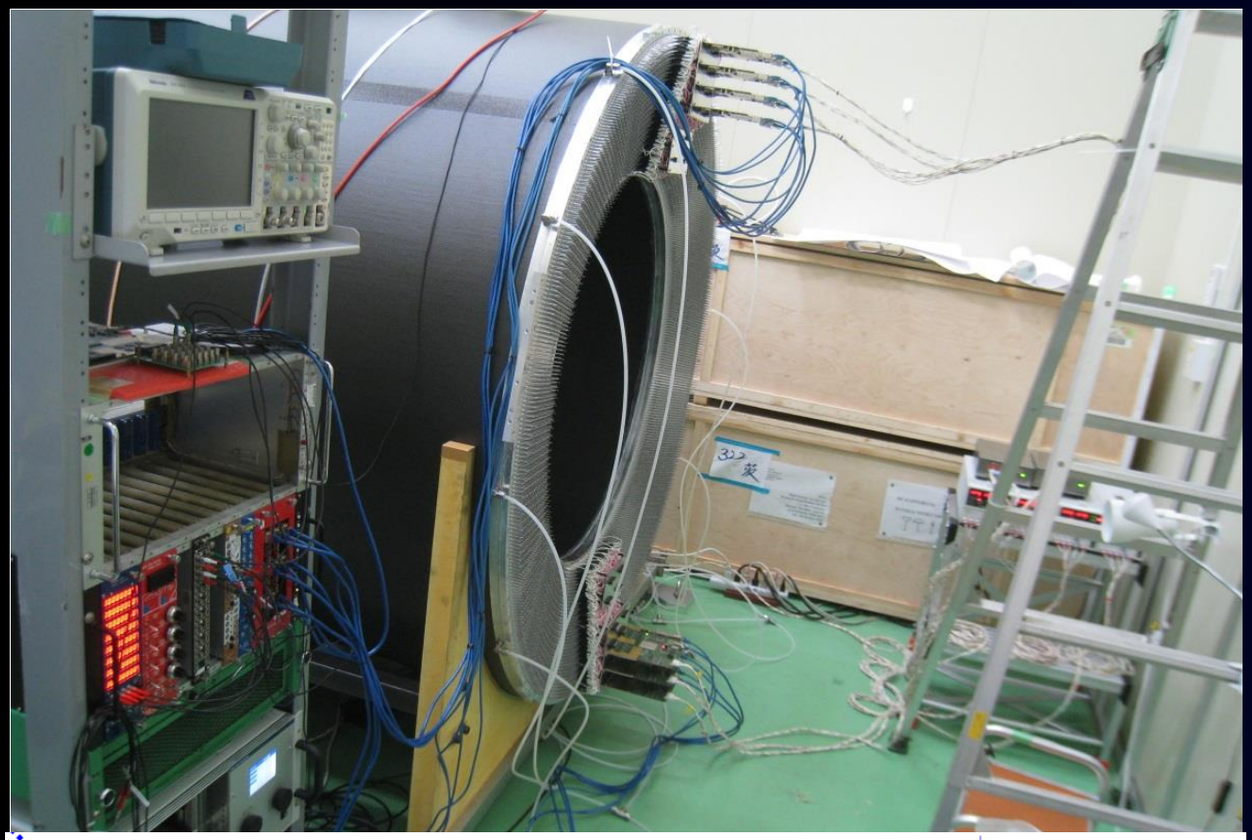
CDC Construction completed!

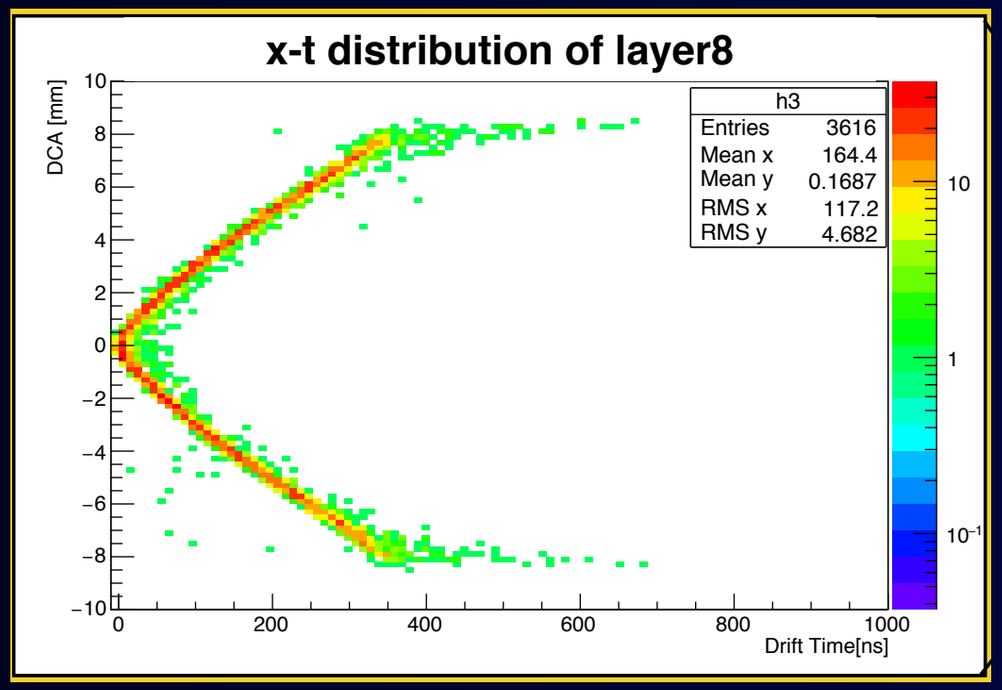


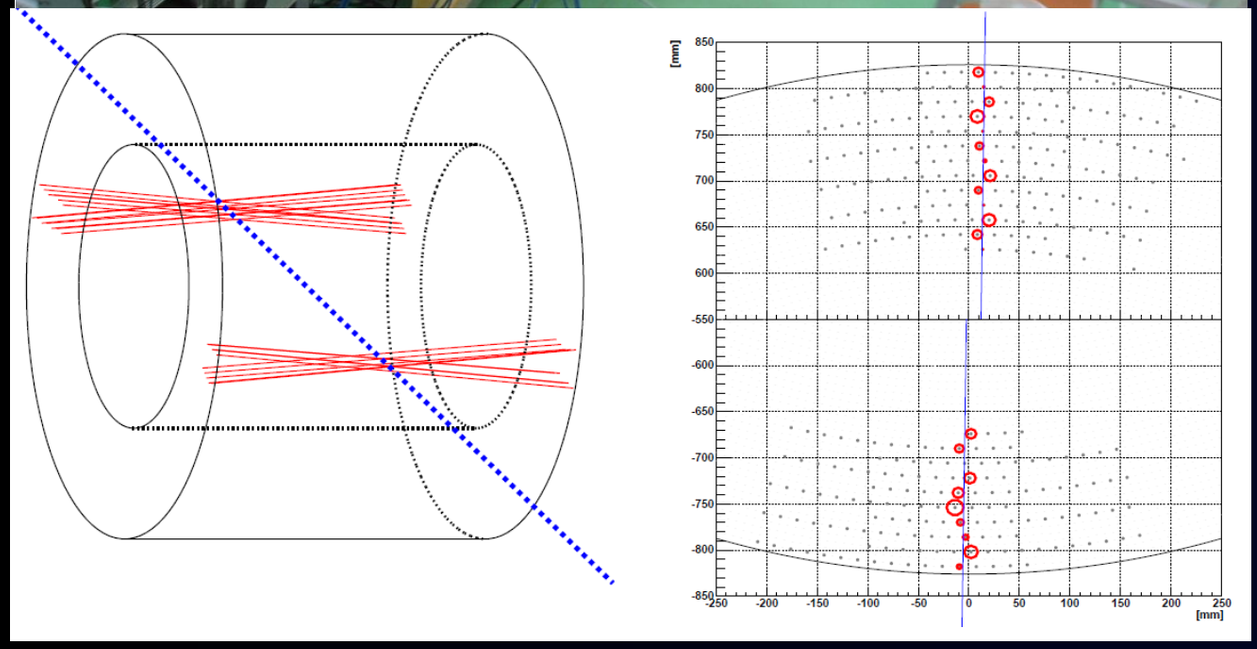
CDC wire stringing completed in December 2015.

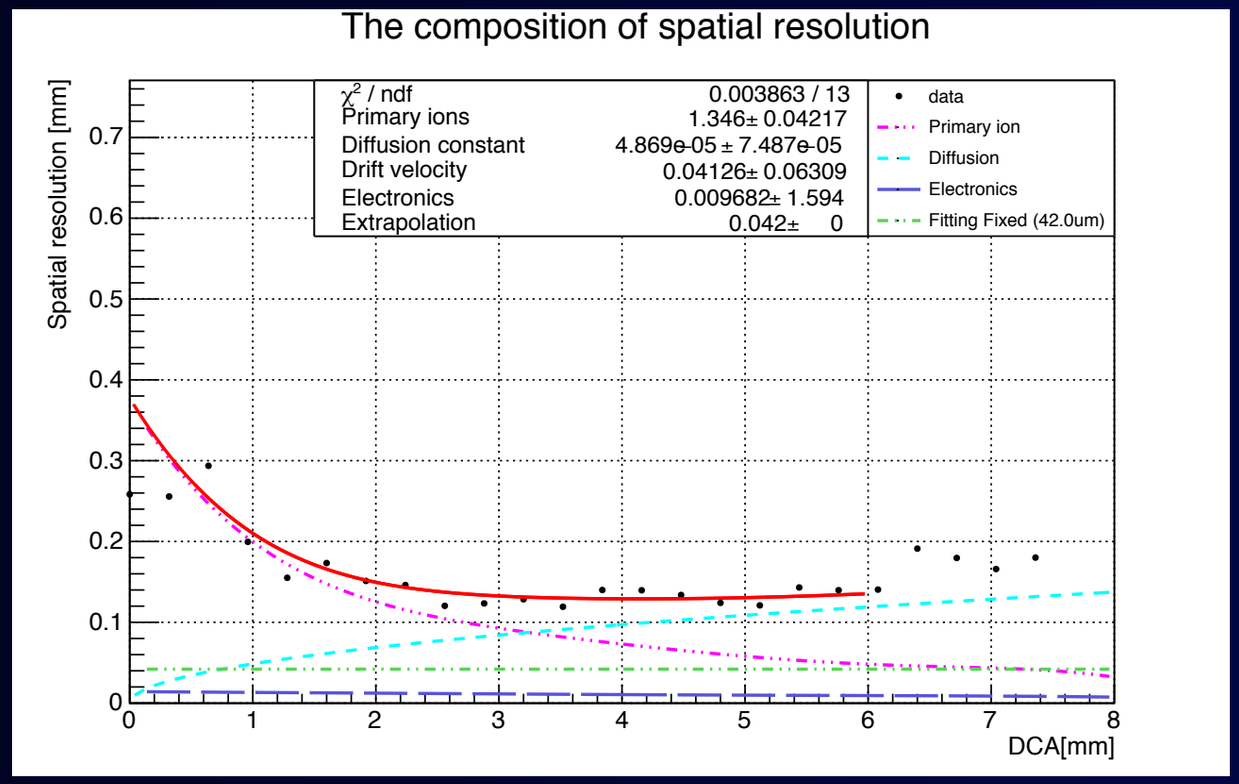
CDC readout electronics completed in August 2015.

CDC Cosmic Ray Test







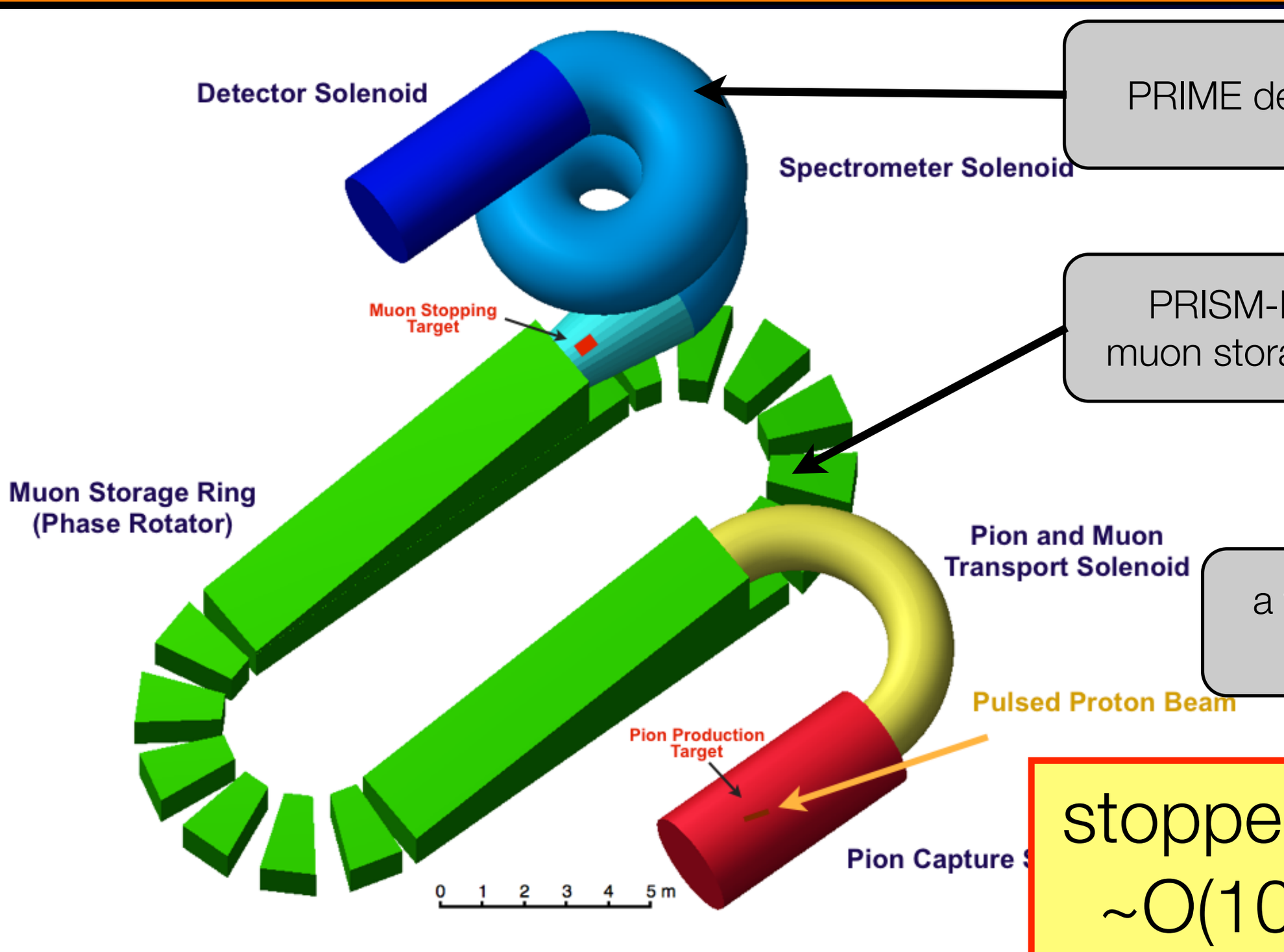


$\mu - e$ conversion

PRISM-PRIME@J-PARC

PRISM (=Phase Rotated Intense Slow Muon source)

PRISM/PRIME



PRIME detector

PRISM-FFAG muon storage ring

a few MW proton beam

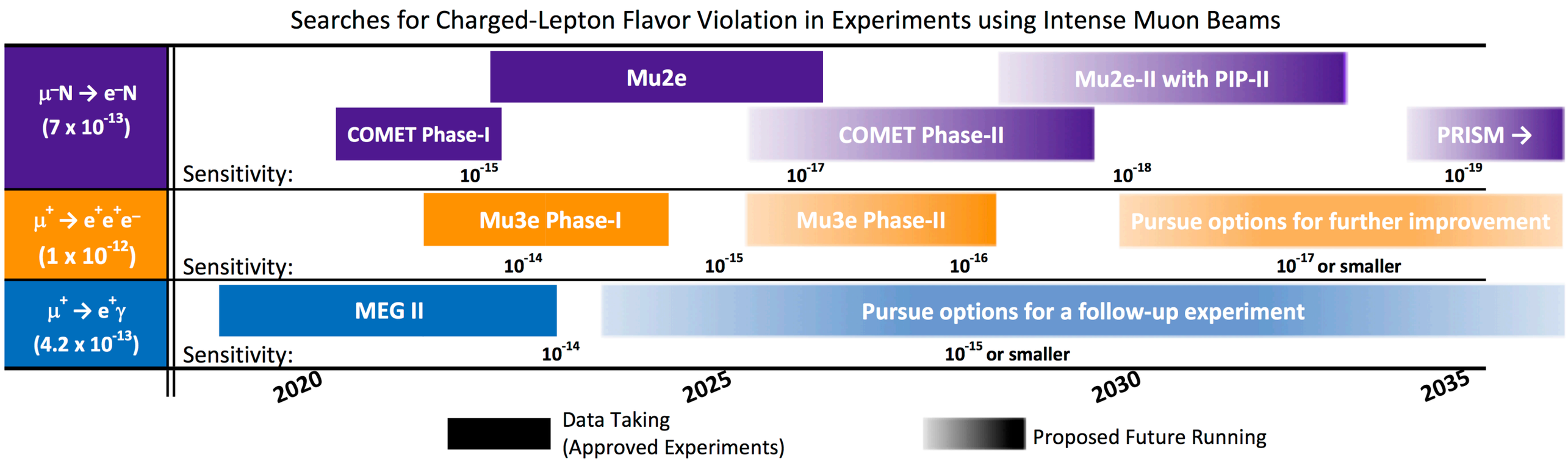
stopped muons ~O(10^{20})/year

R&D on the PRISM-FFAG Muon Ring at Osaka University

demonstration of phase rotation has been made.

Global Timeline of Muon CLFV

from the muon CLFV white paper for the 2020 update of European Strategy of Particle Physics



COMET Phase-I $\mathcal{O}(10^{-15})$

COMET Phase-II $\mathcal{O}(10^{-18})$

PRISM $\mathcal{O}(10^{-19})$

Summary

Summary

- Muon CLFV search would provide one of the best opportunity to search for BSM.
- The muon sources will be improved from 10^{18}/year (1000 more)
- Major muon CLFV processes are $\mu \to e\gamma$, $\mu \to eee$, $\mu \to e$ conversion, whilst there are other interesting muon CLFV processes.
- COMET @ J-PARC is seeking for $\mu \to e$ conversion with sensitivity of $O(10^{-18})$ with staged approach, 100,000 improvement.
- COMET Phase-I with 100 improvement is under preparation, starting soon.

Summary

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Thank you for your attention!