





Search for Charged Lepton Flavor Violation at J-PARC

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and Matter-Antimatter Asymmetry

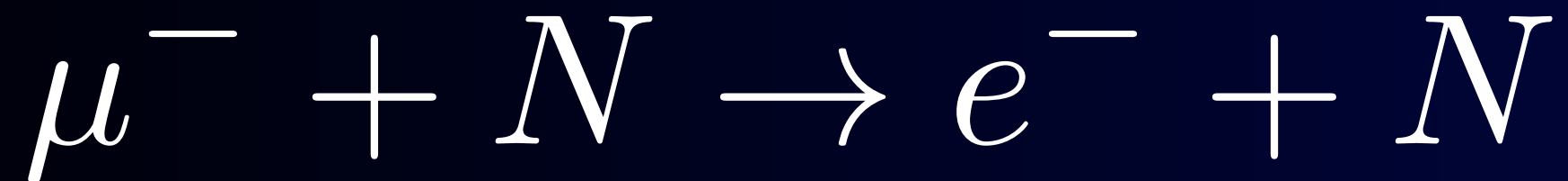
Muon to Electron Conversion



Muon to Electron Conversion



muon to electron conversion in a muonic atom

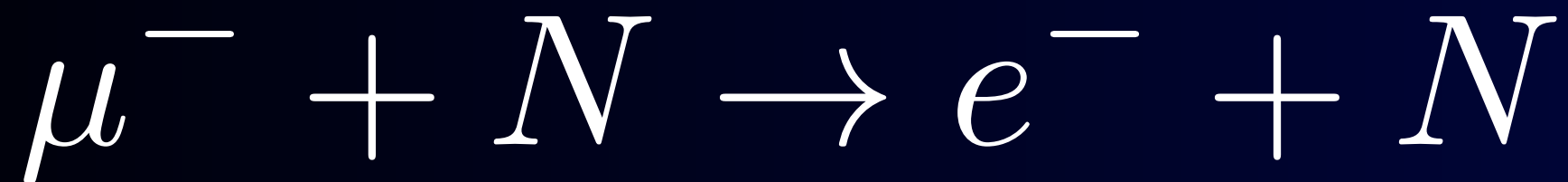


(charged lepton flavor violation)

Muon to Electron Conversion



muon to electron conversion in a muonic atom



(charged lepton flavor violation)

- Outline
- Muon to Electron Conversion
- COMET at J-PARC and Mu2e at FNAL
- COMET Phase-I (under construction)

Flavour Transitions



Flavour Transitions

Quarks



Quark
transition
observed

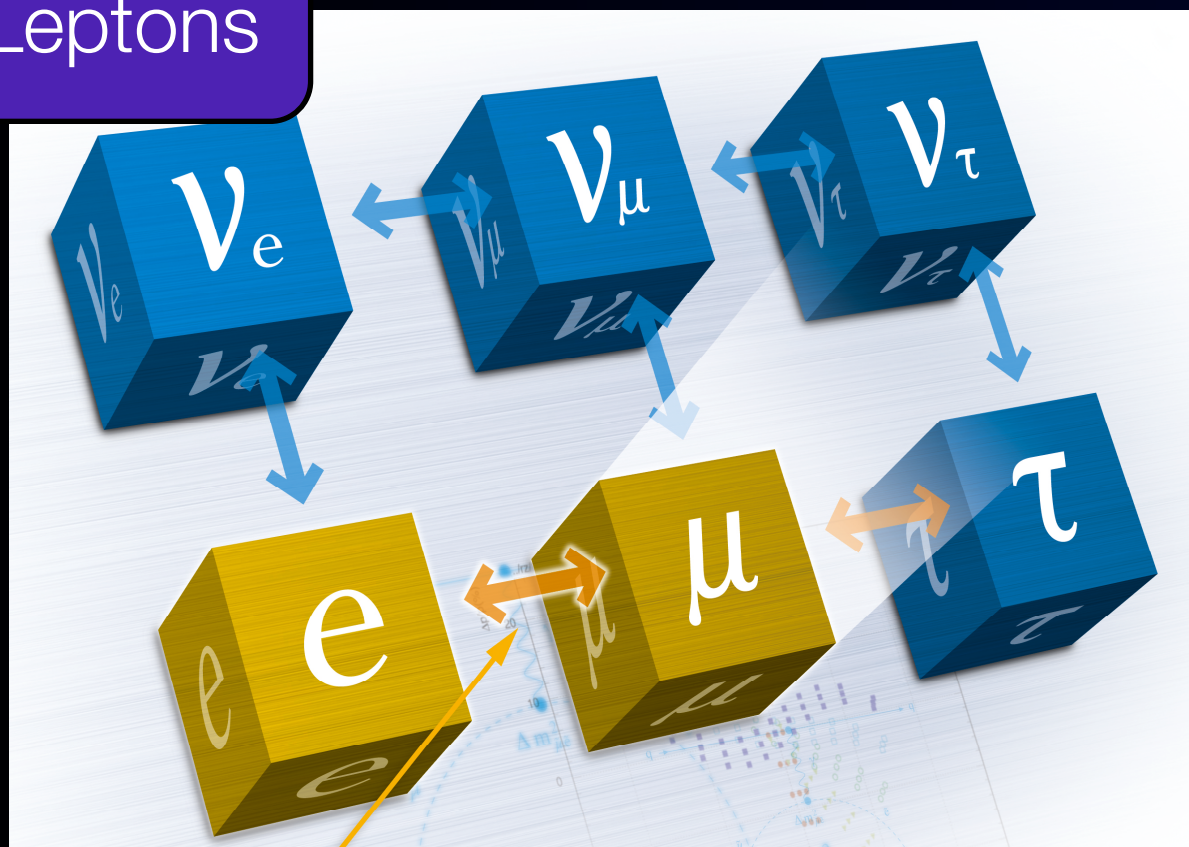
Flavour Transitions

Quarks



Quark
transition
observed

Leptons



Neutrino
transition
observed

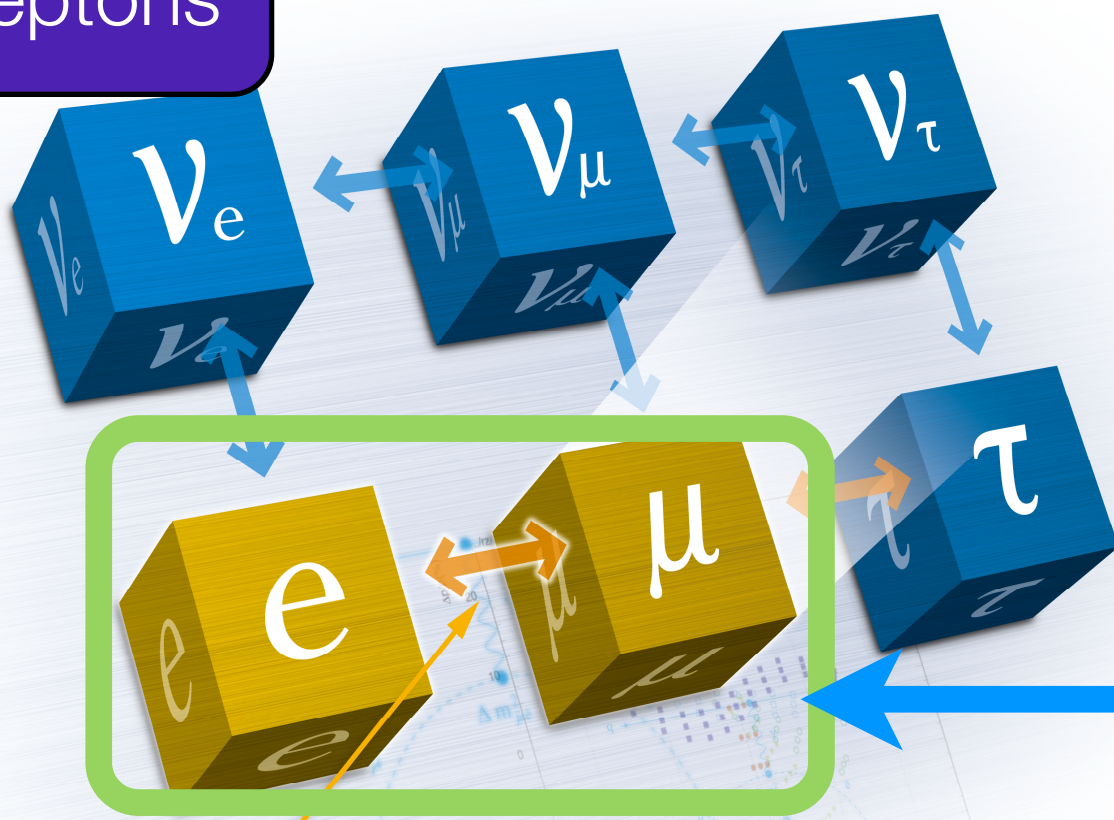
Flavour Transitions

Quarks



Quark
transition
observed

Leptons



Neutrino
transition
observed

Charged lepton
transition
not observed.



Muon to Electron Conversion

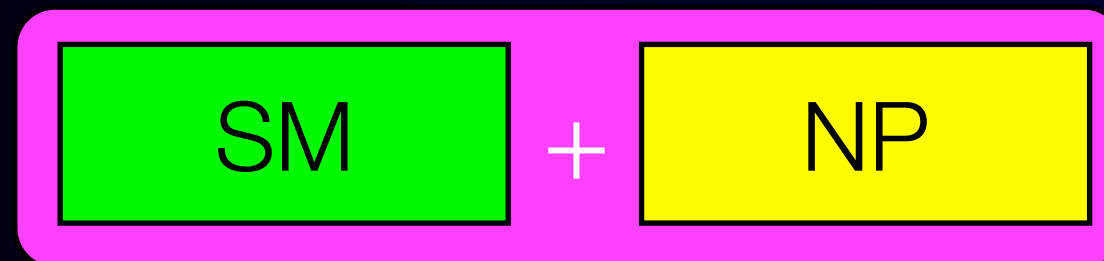
Rare Decays



Rare Decays



Quark Sector
(SM suppressed)



Uncertainty of
the SM prediction
limits the sensitivity.

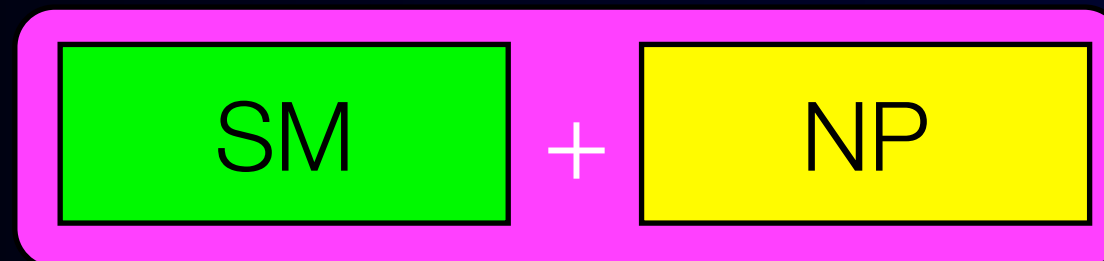
SM contribution has to be subtracted.

ex. $B \rightarrow s \gamma$

Rare Decays



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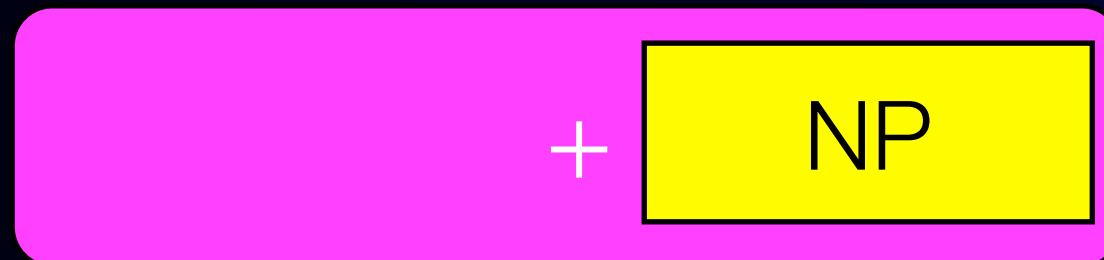


Uncertainty of
the SM prediction
limits the sensitivity.

SM contribution has to be subtracted.

ex. $B \rightarrow s \gamma$

Lepton Sector
(SM forbidden)



Clear signature
without any
subtractions

No SM contribution be subtracted.

ex. $\mu \rightarrow e \gamma$

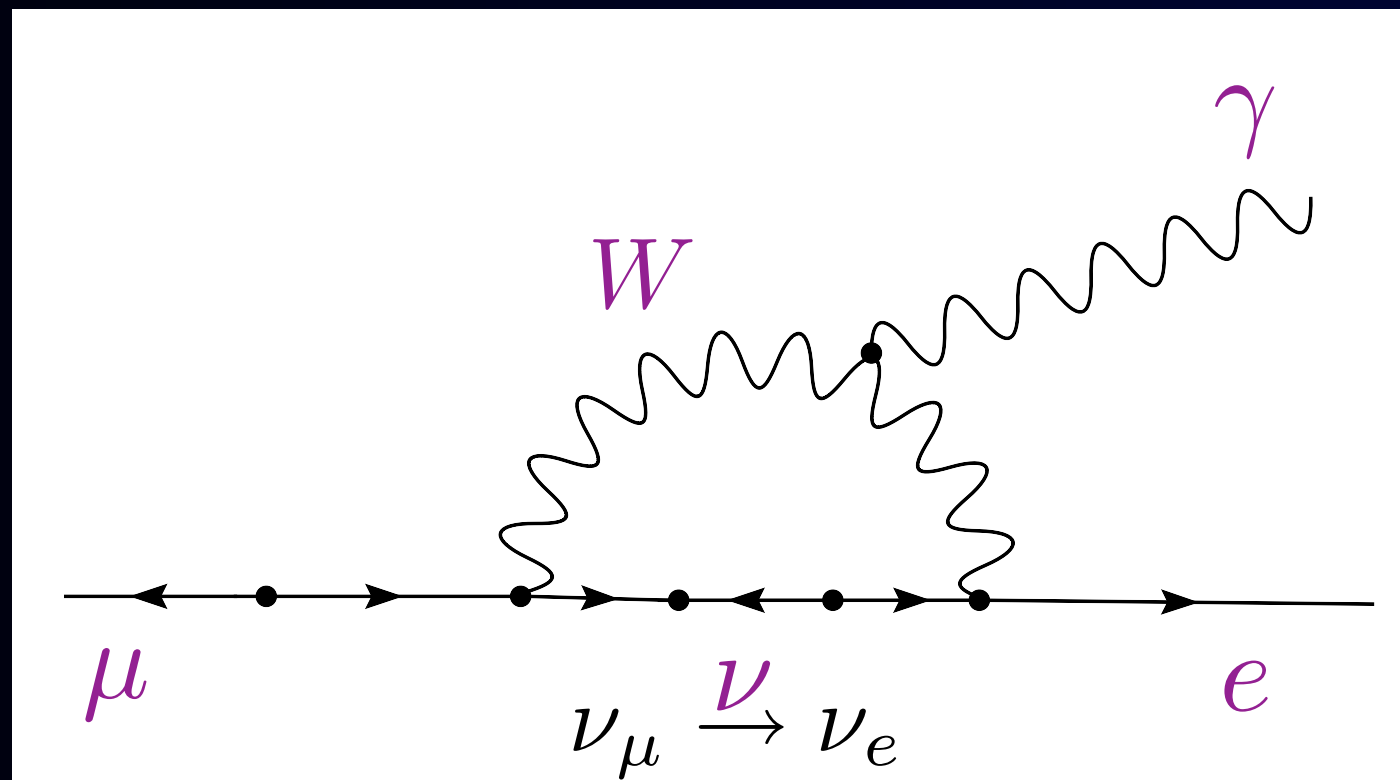
Rare Process

No SM Contribution to CLFV



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

GIM suppression



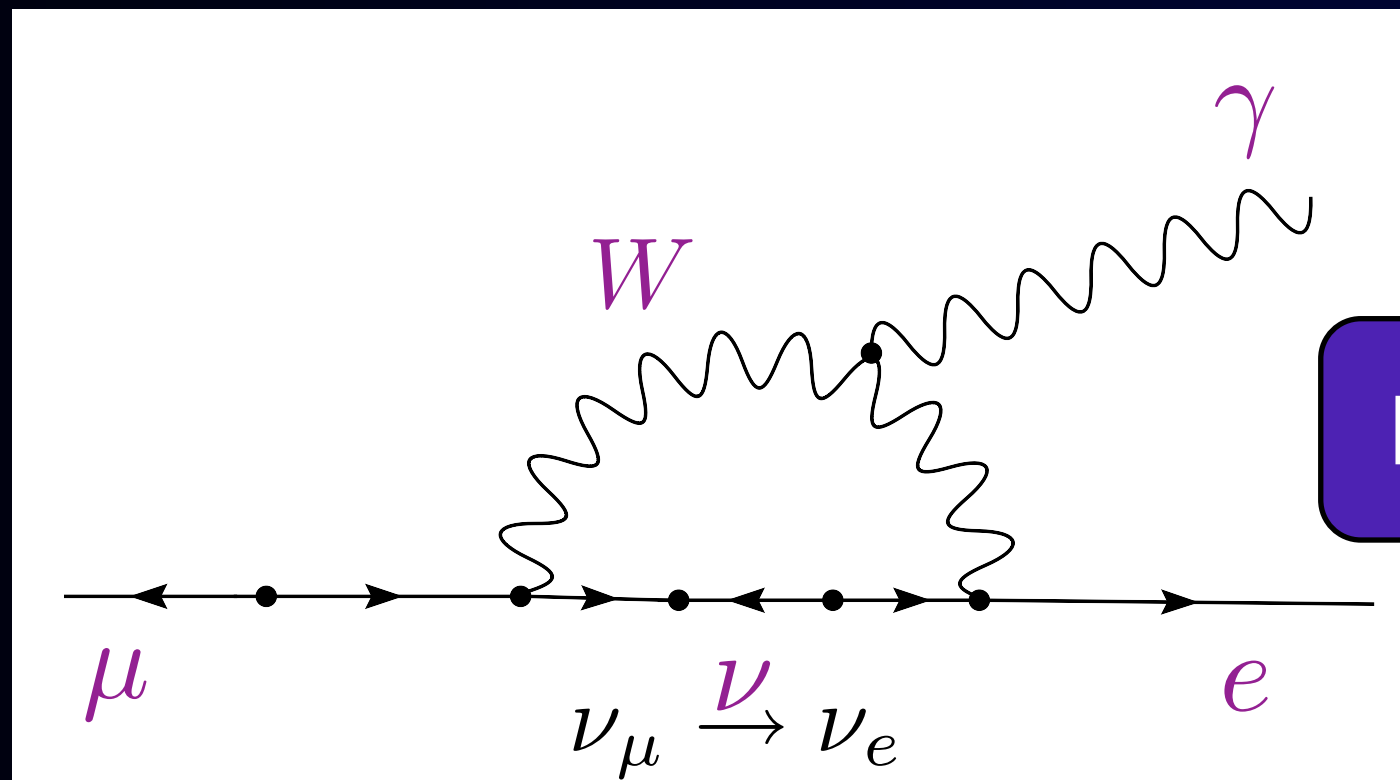
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GIM suppression



BR $\sim O(10^{-54})$

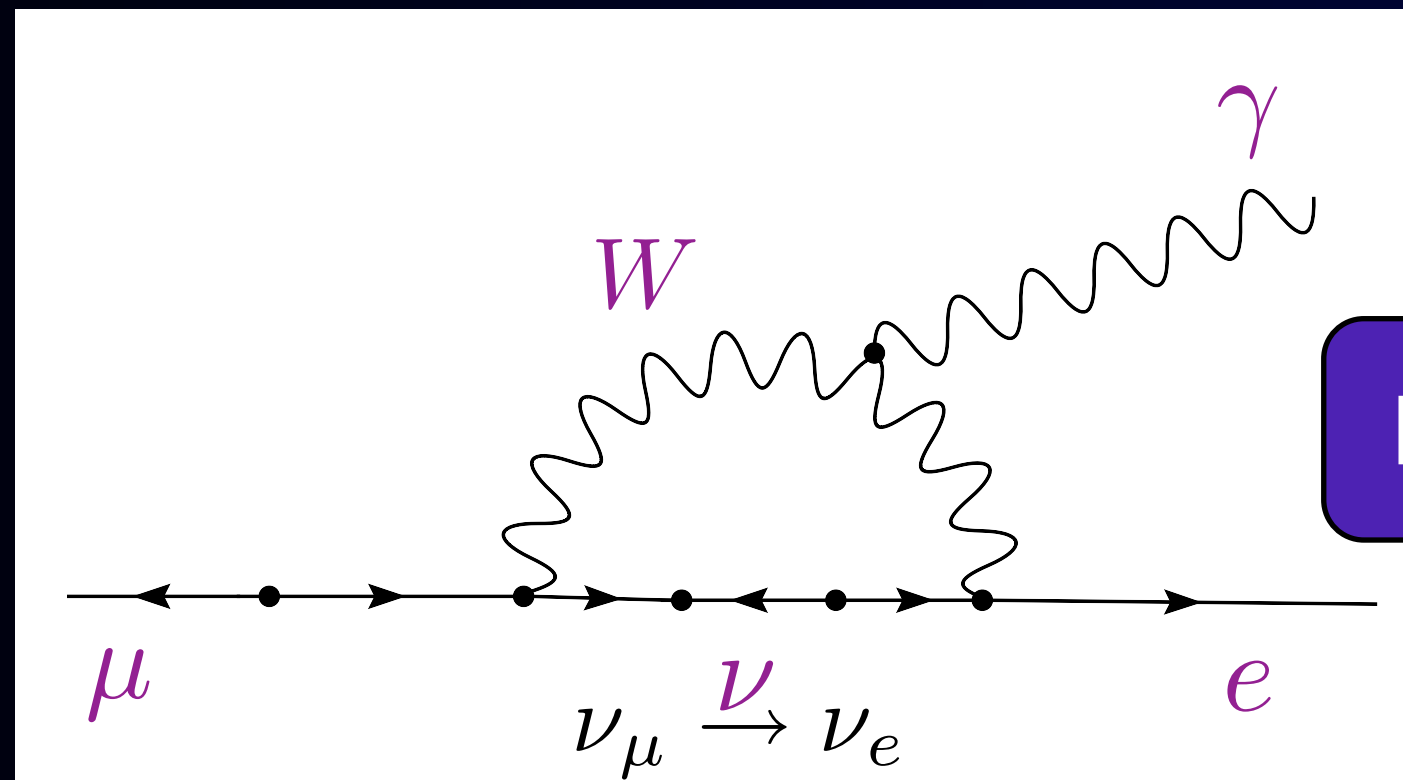
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GIM suppression



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

Effective Lagrangian with New Physics



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

dimension 6

Λ is the energy scale of new physics ($\sim m_{\text{NP}}$)

C_{NP} is the coupling constant.

Effective Lagrangian with New Physics



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C_{NP} is the coupling constant.

ex: Charged lepton flavor violation (CLFV),
 $\mu \rightarrow e \gamma$ ($B < 4.2 \times 10^{-13}$ from MEG(2016))

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

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

$$\Lambda > O(10^5) \text{ TeV with } C_{\mu e} \sim O(1)$$

or

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

Our Aimed Sensitivity



Our Aimed Sensitivity



$$R \propto \frac{1}{\Lambda^4}$$

Our Aimed Sensitivity



$$R \propto \frac{1}{\Lambda^4}$$

$$\Lambda \geq 10 \rightarrow R \leq 10^{-4}$$

Various Models Predict CLFV.....

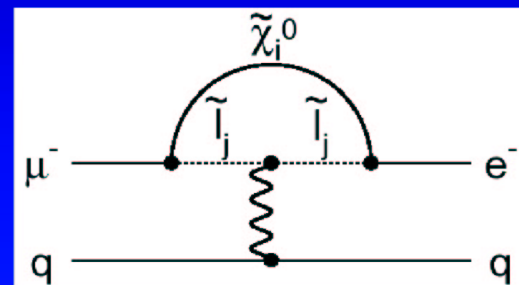


Various Models Predict CLFV.....

Sensitivity to Different Muon Conversion Mechanisms

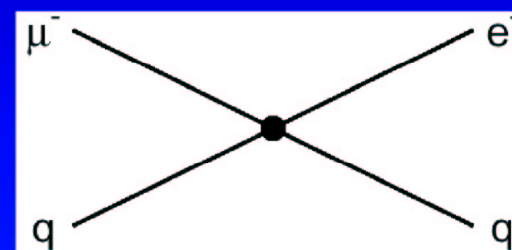


Supersymmetry
Predictions at 10^{-15}



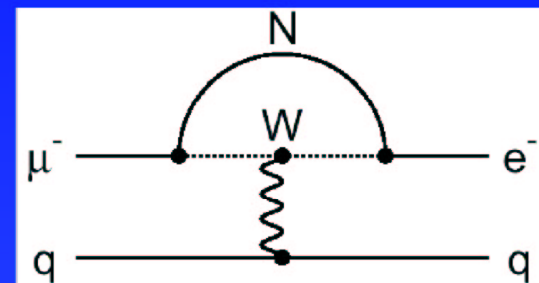
Compositeness

$$\Lambda_c = 3000 \text{ TeV}$$



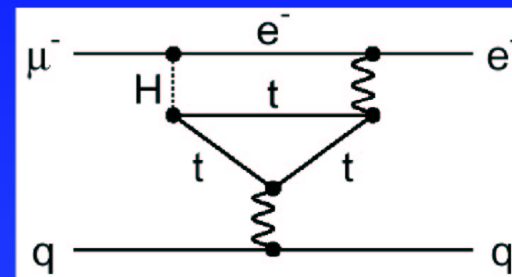
Heavy Neutrinos

$$|U_{\mu N}^* U_{eN}|^2 = 8 \times 10^{-13}$$



Second Higgs doublet

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

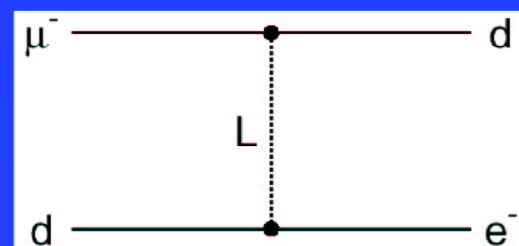


Leptoquarks

$$M_L =$$

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

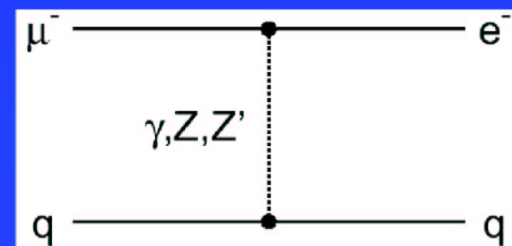
After W. Marciano



Heavy Z' ,
Anomalous Z
coupling

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

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



Experimental Limits at Present and in the Future



process	present limit	future	
$\mu \rightarrow e \gamma$	$< 4.2 \times 10^{-13}$	$< 10^{-14}$	MEG at PSI
$\mu \rightarrow e e e$	$< 1.0 \times 10^{-12}$	$< 10^{-16}$	Mu3e at PSI
$\mu N \rightarrow e N$ (in Al)	none	$< 10^{-16}$	Mu2e / COMET
$\mu N \rightarrow e N$ (in Ti)	$< 4.3 \times 10^{-12}$	$< 10^{-18}$	PRISM
$\tau \rightarrow e \gamma$	$< 1.1 \times 10^{-7}$	$< 10^{-9} - 10^{-10}$	superKEKB
$\tau \rightarrow e e e$	$< 3.6 \times 10^{-8}$	$< 10^{-9} - 10^{-10}$	superKEKB
$\tau \rightarrow \mu \gamma$	$< 4.5 \times 10^{-8}$	$< 10^{-9} - 10^{-10}$	superKEKB
$\tau \rightarrow \mu \mu \mu$	$< 3.2 \times 10^{-8}$	$< 10^{-9} - 10^{-10}$	superKEKB/LHCb

Experimental Limits at Present and in the Future

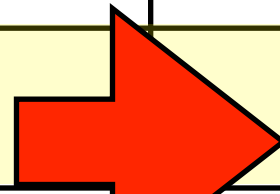


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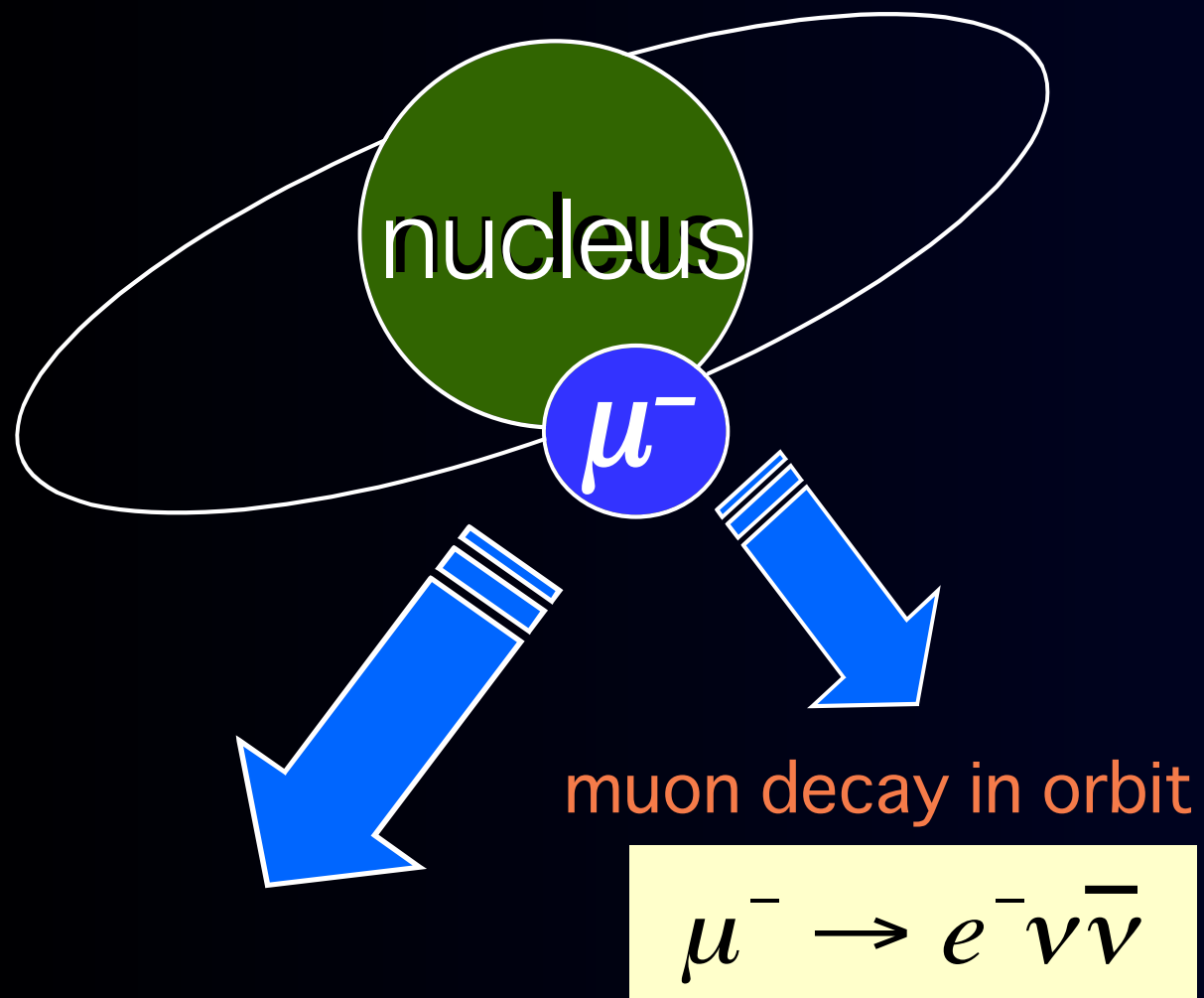
$\times 10^{-4}$

What is Muon to Electron Conversion?



What is Muon to Electron Conversion?

1s state in a muonic atom



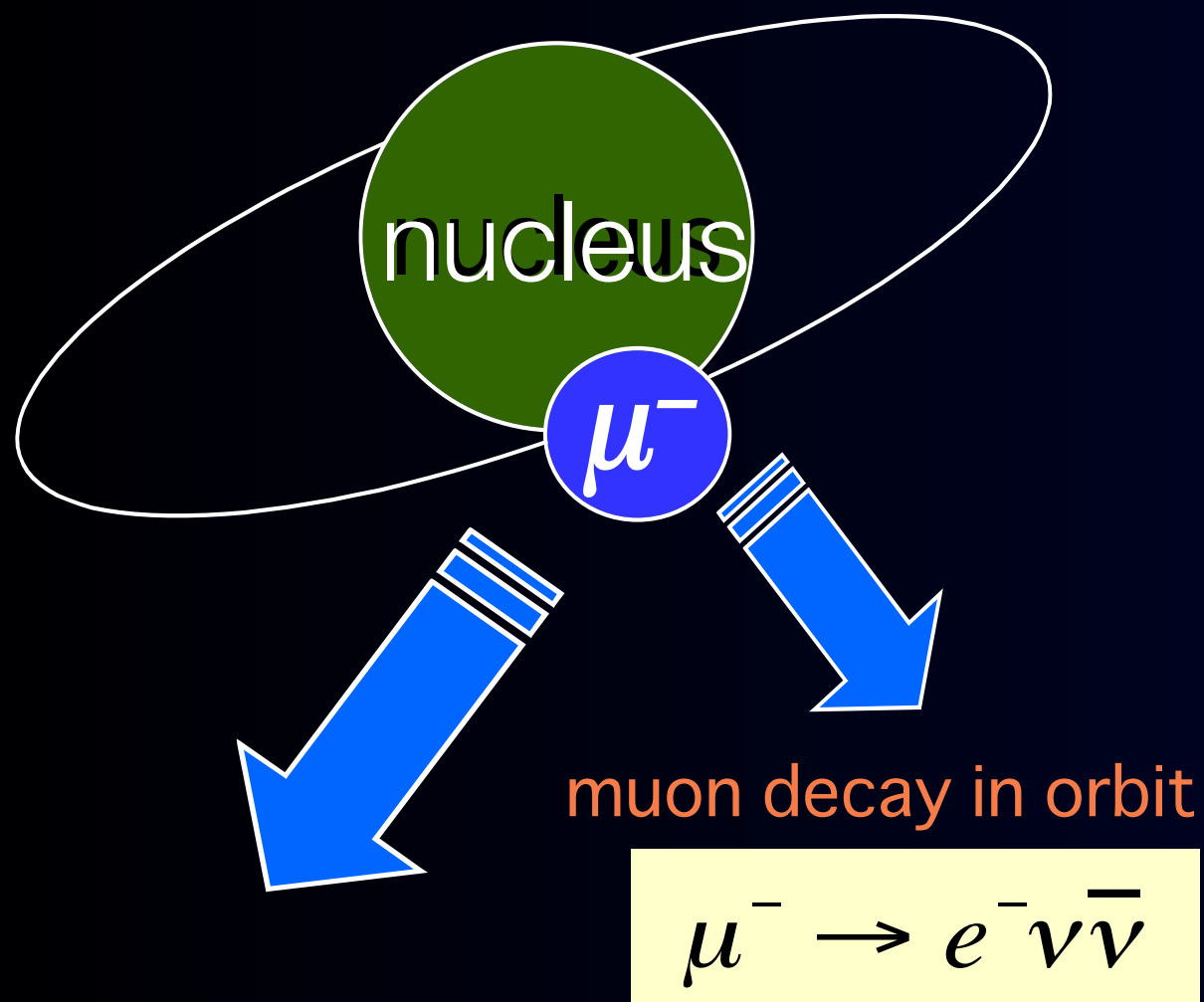
nuclear muon capture

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

What is Muon to Electron Conversion?



1s state in a muonic atom



nuclear muon capture

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

Neutrino-less muon
nuclear capture

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

coherent process

$$\propto Z^5$$

Event Signature :

a single mono-energetic
electron of 105 MeV

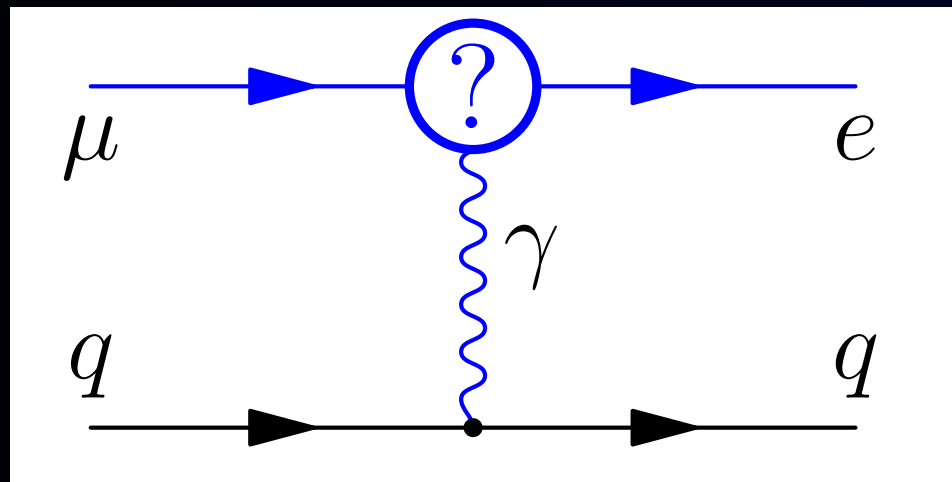
Backgrounds:

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

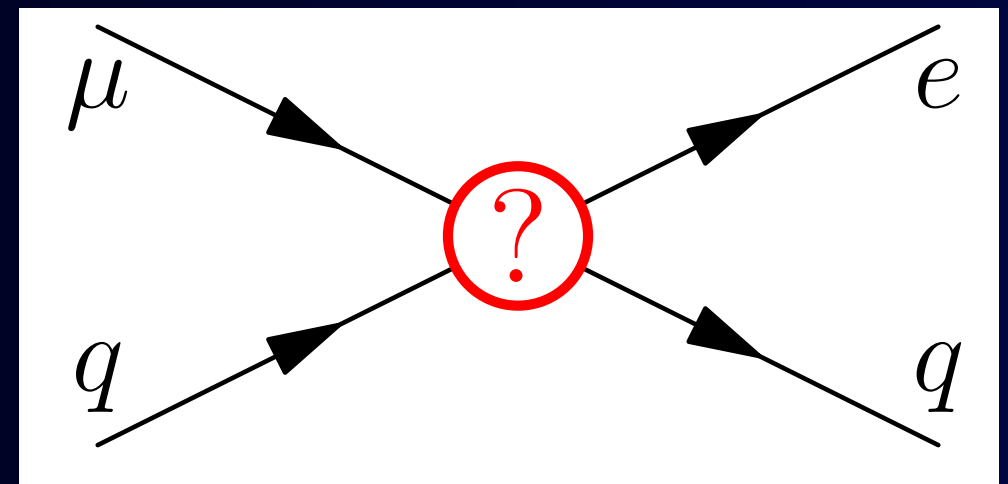
Physics Sensitivity Comparison : $\mu \rightarrow e\gamma$ vs. μ -e conversion



Photonic (dipole) interaction



Contact interaction

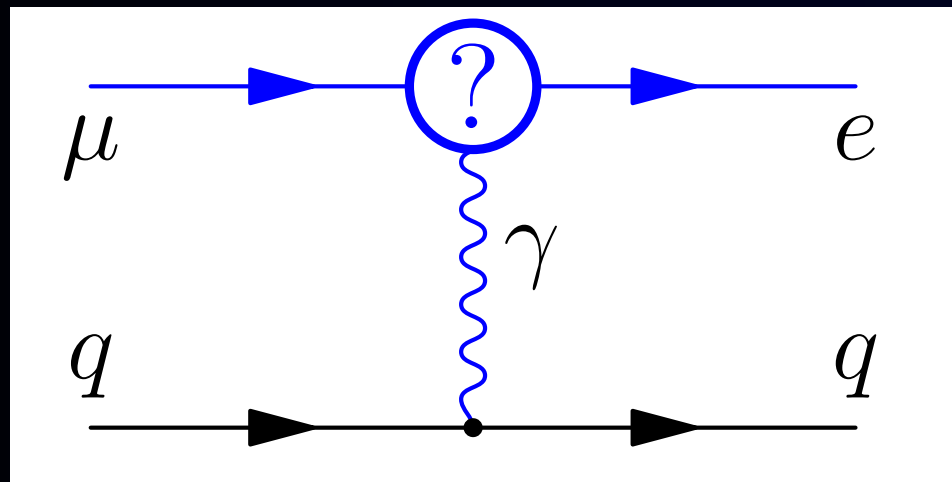


tree levels

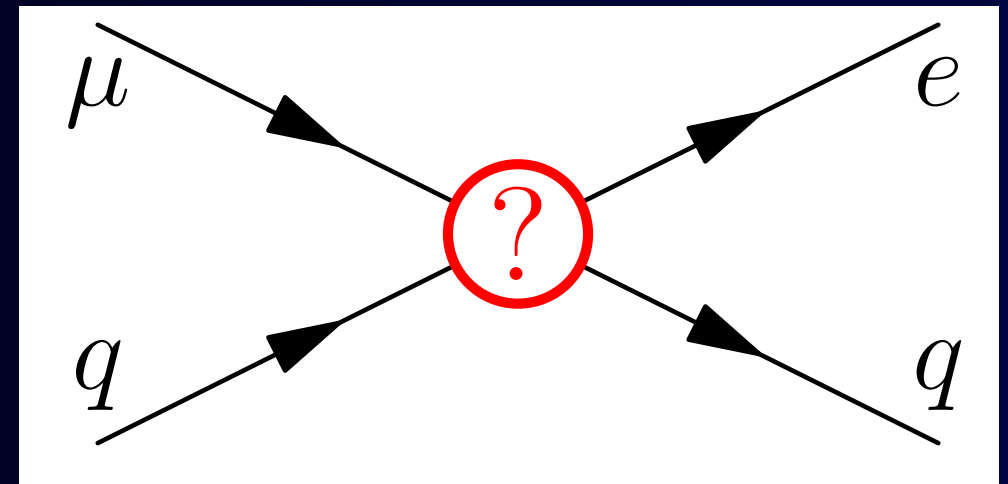
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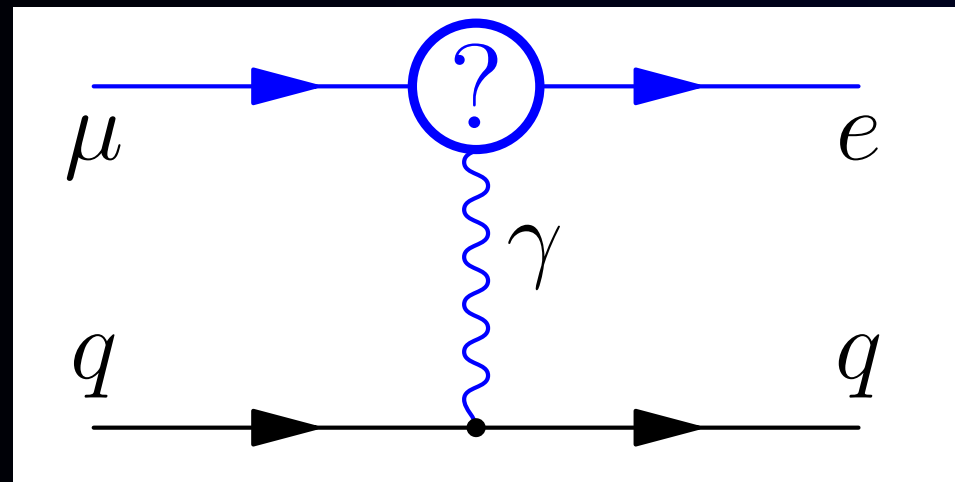
tree levels

$$L_{\mu \rightarrow e\gamma} = \frac{1}{1 + \kappa} \frac{m_\mu}{\Lambda^2} \bar{\mu}_R \sigma^{\mu\nu} e_L F_{\mu\nu}$$

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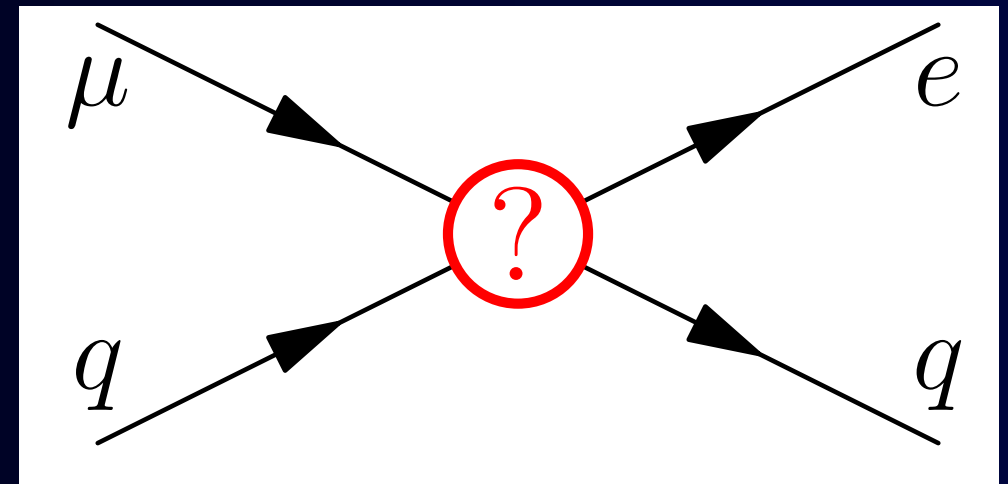
Photonic (dipole) interaction



$$L_{\mu N \rightarrow e N} = \frac{1}{1 + \kappa} \frac{m_\mu}{\Lambda^2} \bar{\mu}_R \sigma^{\mu\nu} e_L F_{\mu\nu} + \frac{\kappa}{1 + \kappa} \frac{1}{\Lambda^2} (\bar{\mu}_L \gamma^\mu e_L) (\bar{q}_L \gamma_\mu q_L)$$

$$L_{\mu \rightarrow e\gamma} = \frac{1}{1 + \kappa} \frac{m_\mu}{\Lambda^2} \bar{\mu}_R \sigma^{\mu\nu} e_L F_{\mu\nu}$$

Contact interaction

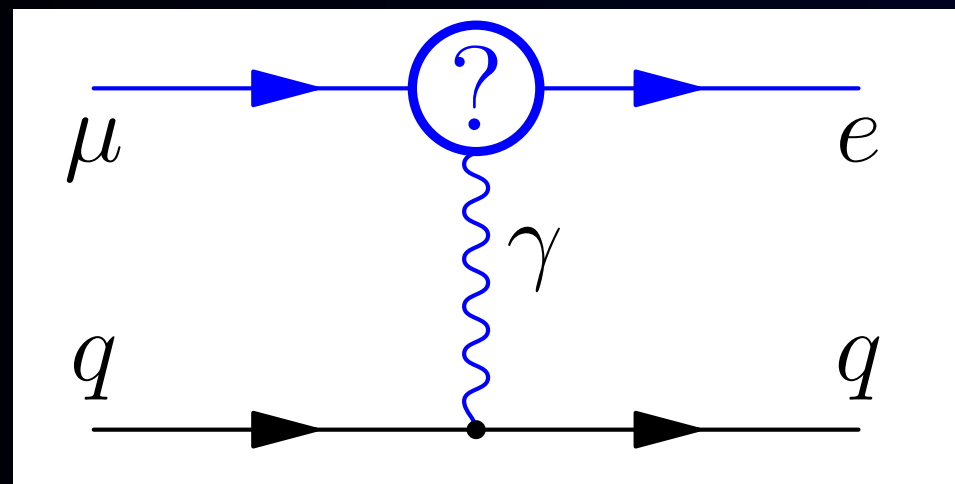


tree levels

Physics Sensitivity Comparison : $\mu \rightarrow e\gamma$ vs. μ -e conversion



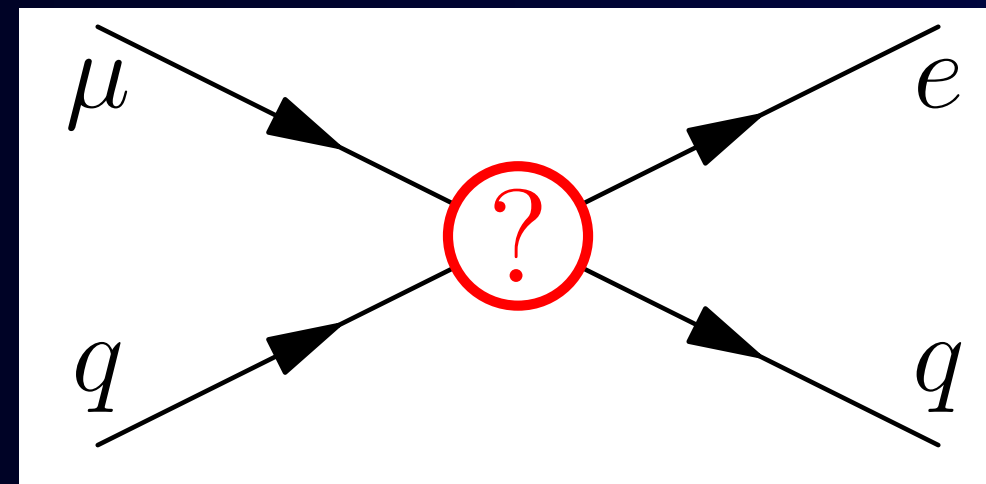
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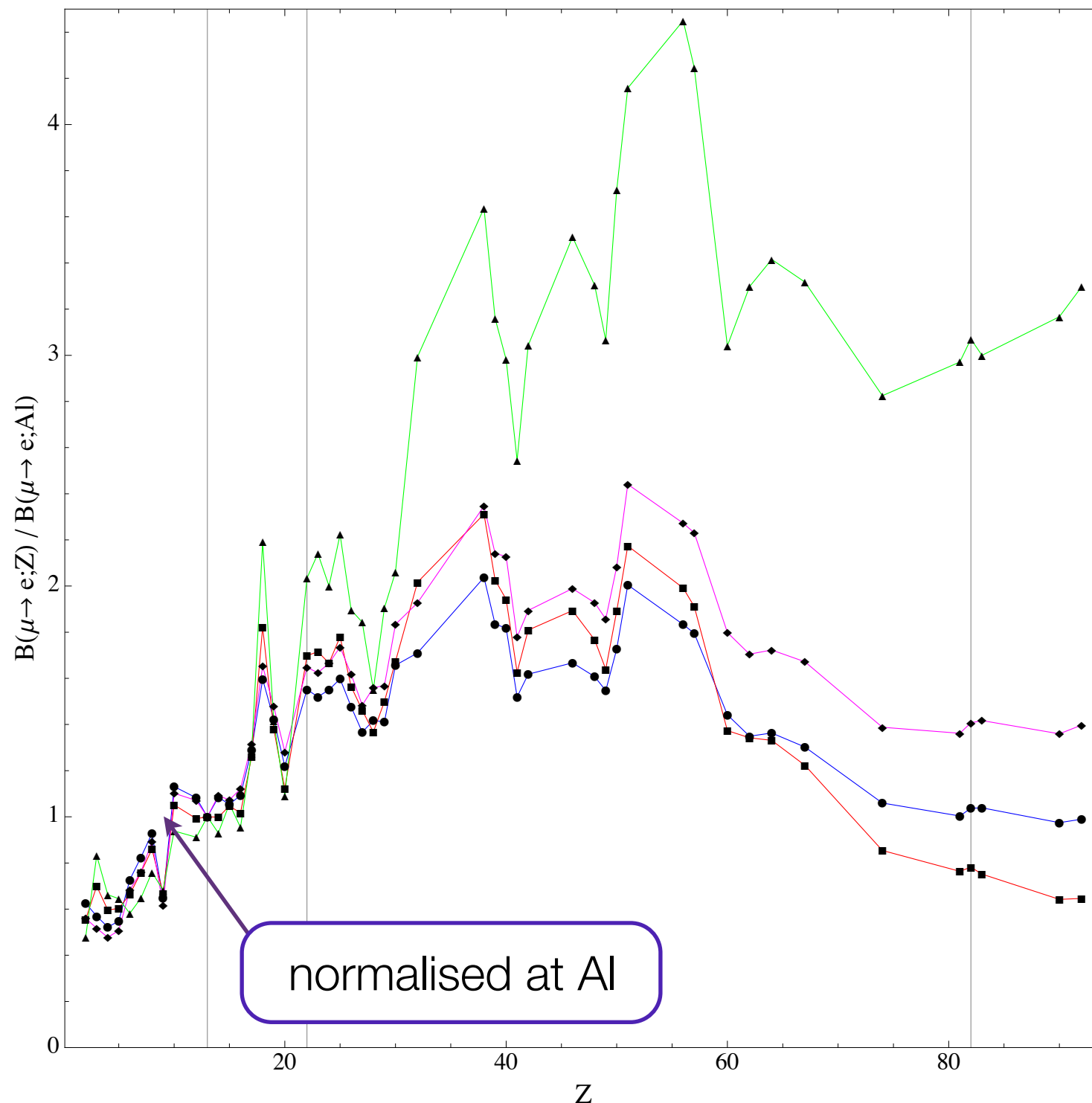
Contact interaction



tree levels

μ -e conversion sensitive to many new physics

μ -e Conversion : Target dependence (discriminating effective interaction)



R. Kitano, M. Koike and Y. Okada, Phys. Rev. D66, 096002 (2002)

vector interaction
(with z boson)

vector interaction
(with photon)

dipole interaction

scalar interaction

Experimental Comparison : $\mu \rightarrow e\gamma$ and μ -e Conversion



Experimental Comparison : $\mu \rightarrow e\gamma$ and μ -e Conversion



	Beam	background	challenge	beam intensity
$\mu \rightarrow e\gamma$	continuous beam	accidentals	detector resolution	limited
$\mu \rightarrow eee$	continuous beam	accidentals	detector resolution	limited
μ -e conversion	pulsed beam	beam-related	beam background	no limitation

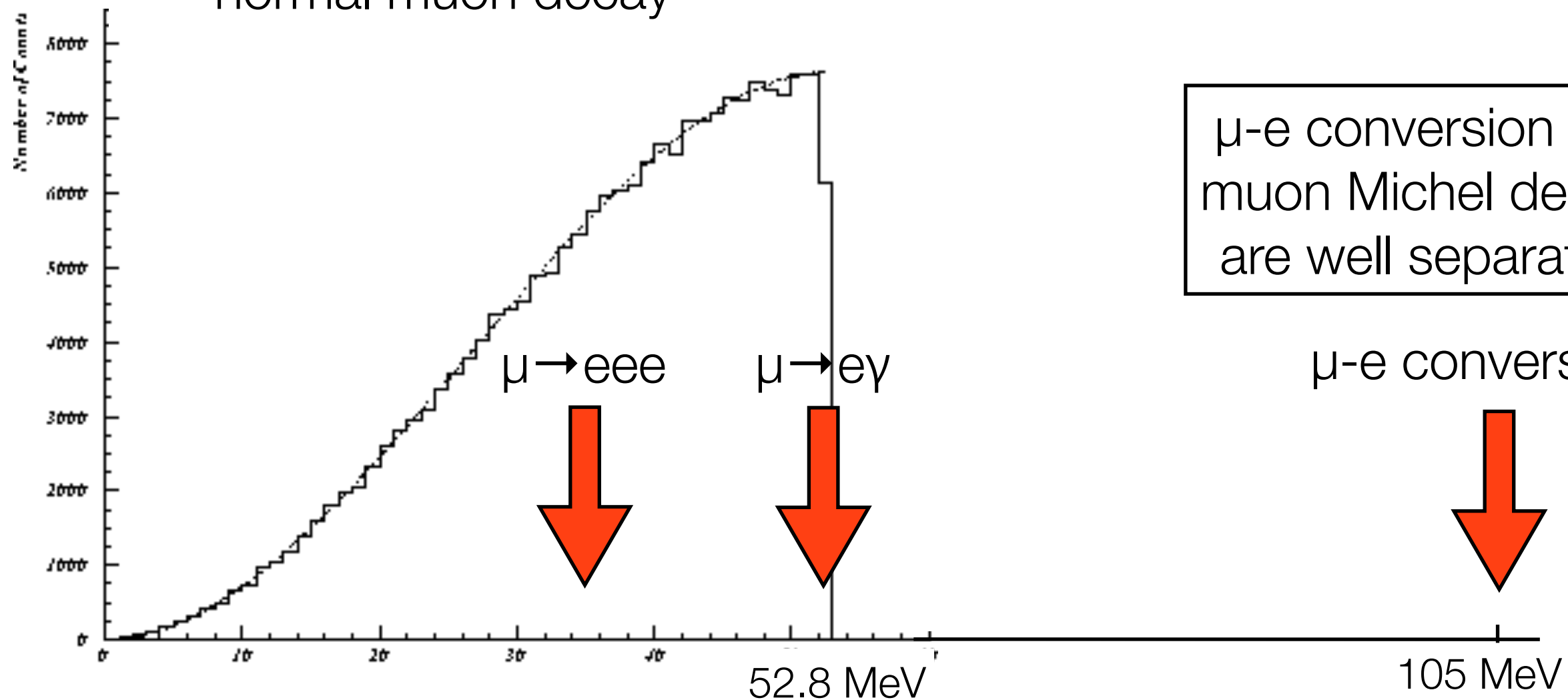
Signal of μ -e Conversion and Normal Muon Decays



Signal of μ -e Conversion and Normal Muon Decays



normal muon decay



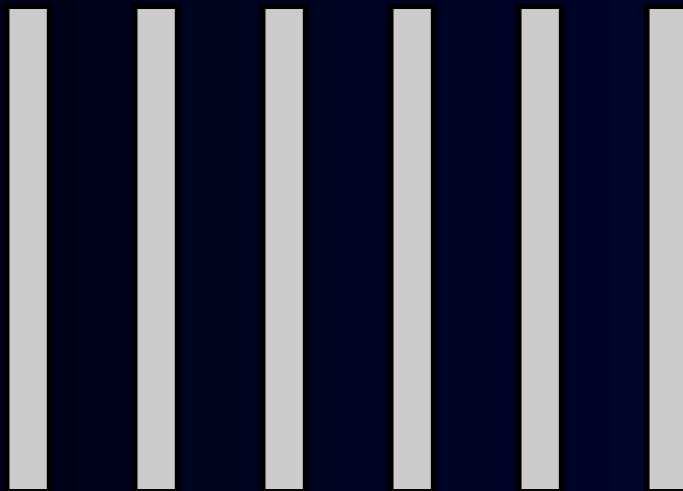
electron momentum spectrum





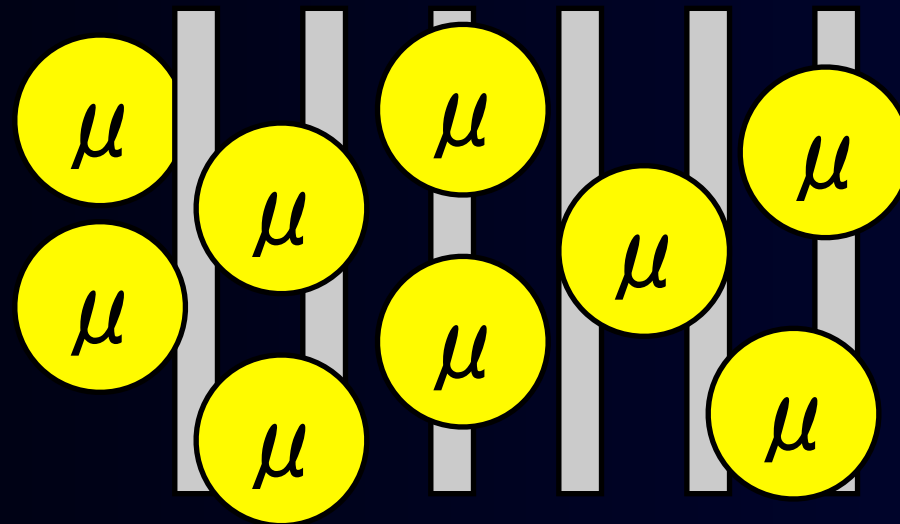
COMET and Mu2e

Principle of Measurement of μ -e Conversion



muon stopping target

Principle of Measurement of μ -e Conversion



muon stopping target

A total number of muons is the key for success.

COMET : 10^{18} muons (past exp. 10^{14} muons)

(note: 10^{10} sec = 1000 years needed at PSI.)

MuSIC at RCNP, Osaka University

- Highly Intense Muon Source -



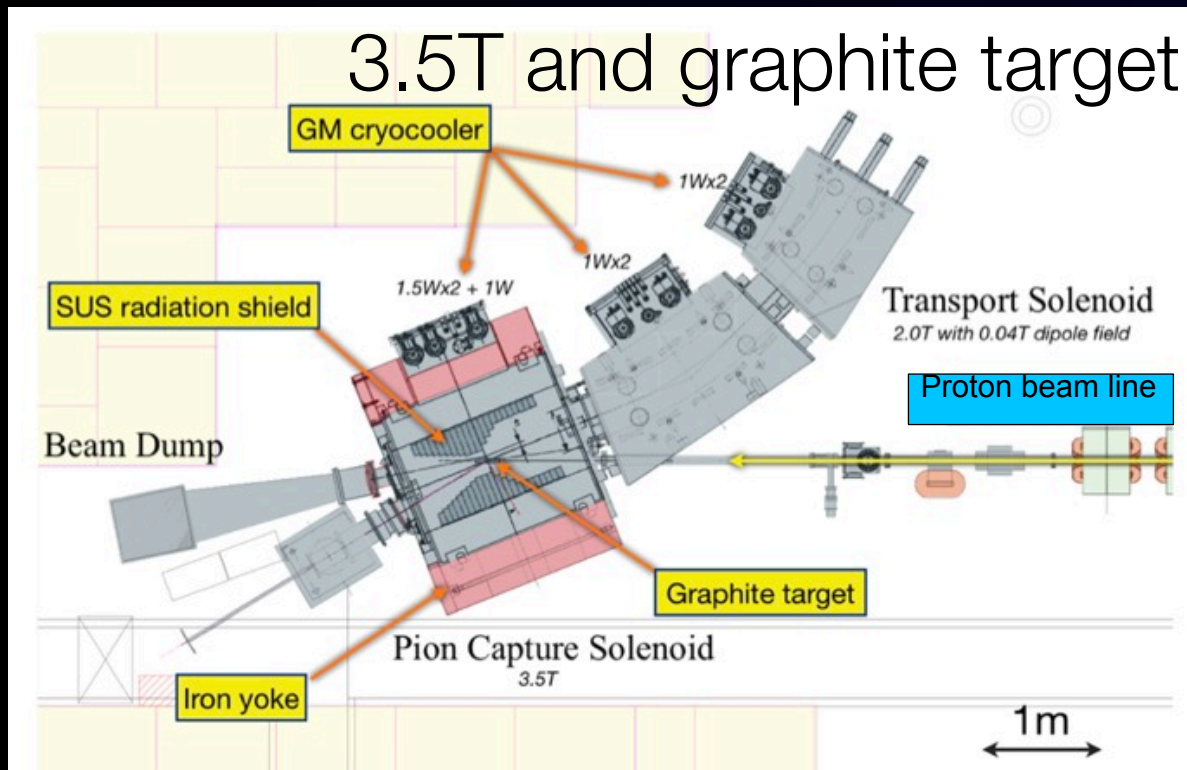
3.5T and graphite target

MuSIC at RCNP, Osaka University

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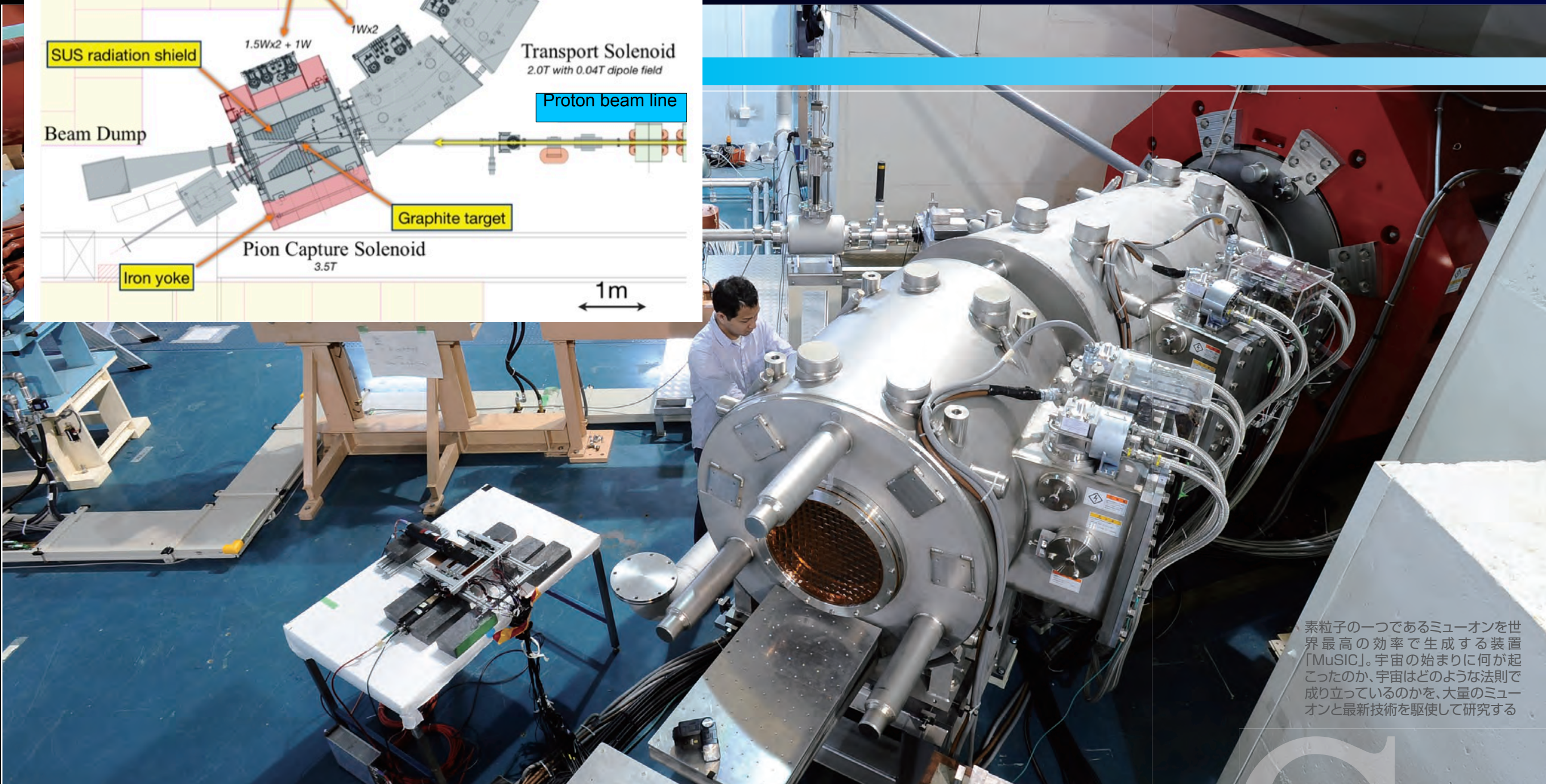
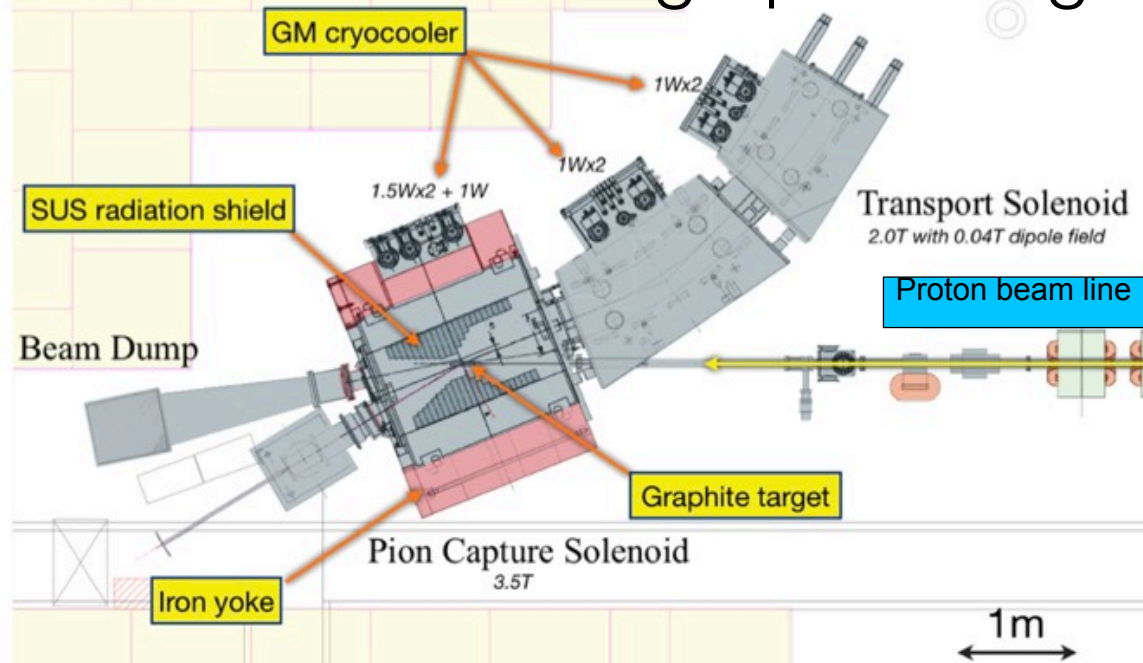


MuSIC at RCNP, Osaka University

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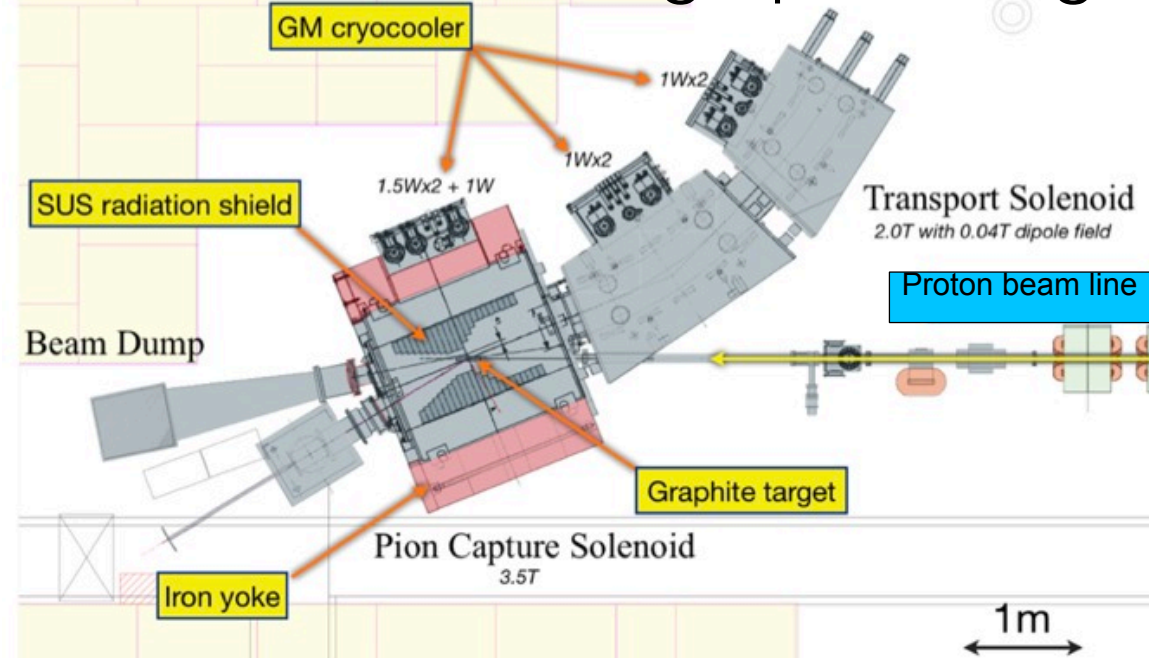
素粒子の一つであるミューオンを世界最高の効率で生成する装置「MuSIC」。宇宙の始まりに何が起きたのか、宇宙はどのような法則で成り立っているのかを、大量のミューオンと最新技術を駆使して研究する

MuSIC at RCNP, Osaka University

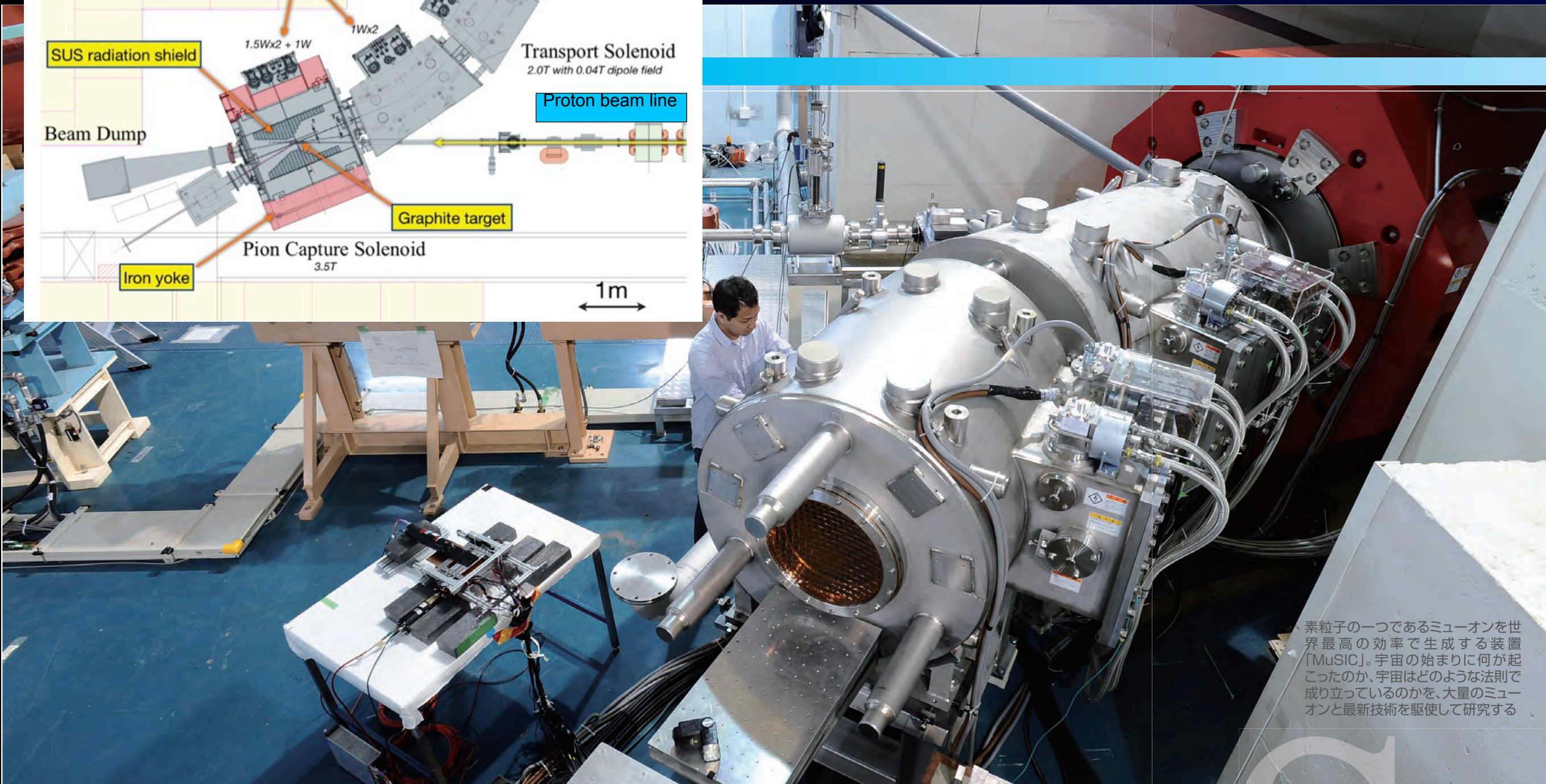
- Highly Intense Muon Source -



3.5T and graphite target



Muon Science Intense Channel (>2011)



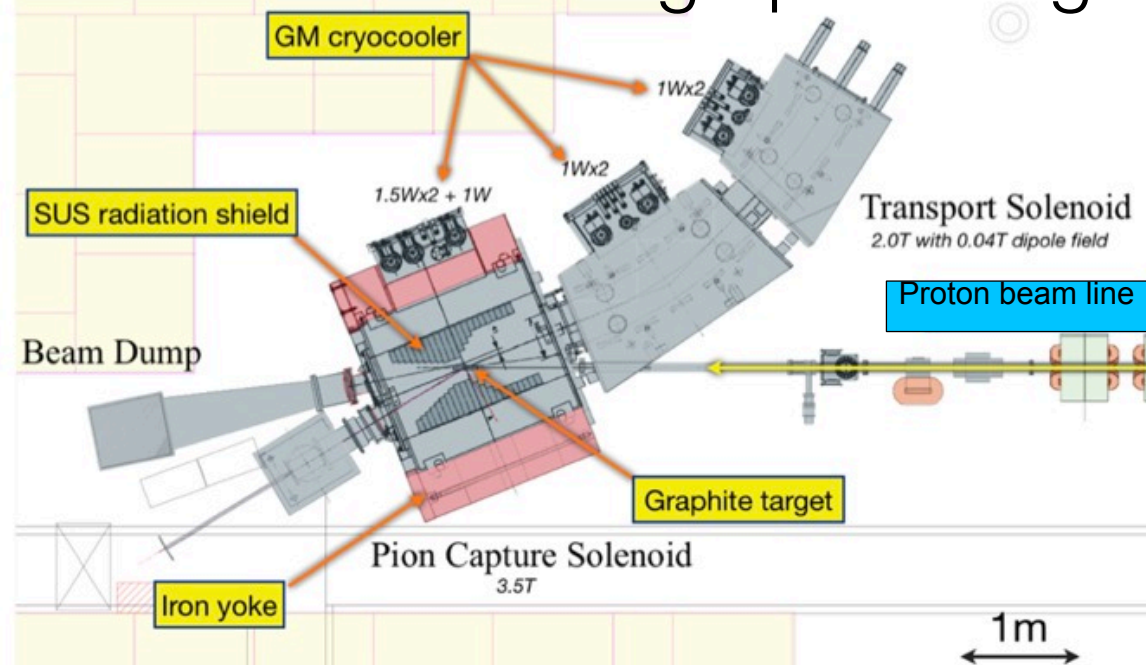
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MuSIC at RCNP, Osaka University

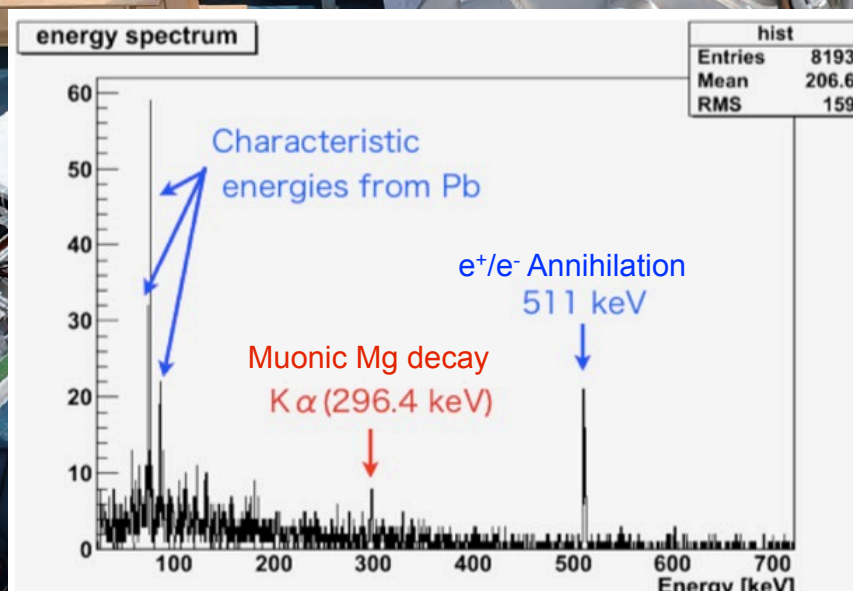
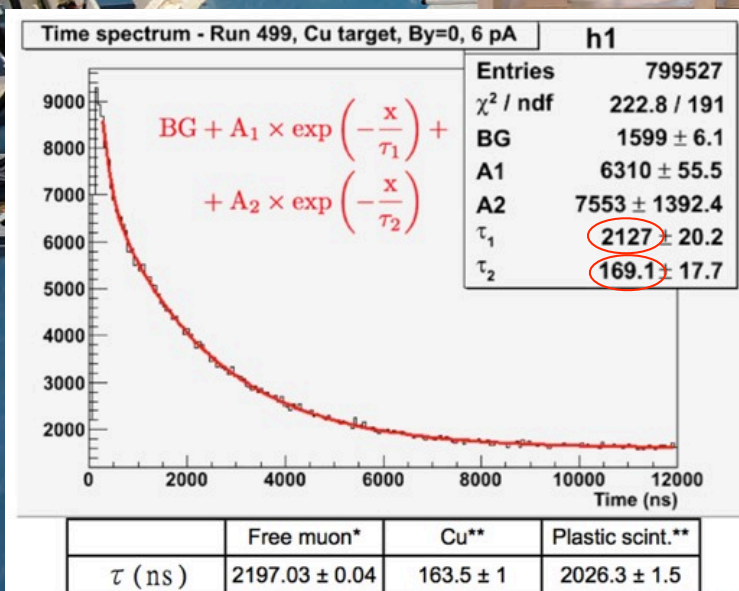
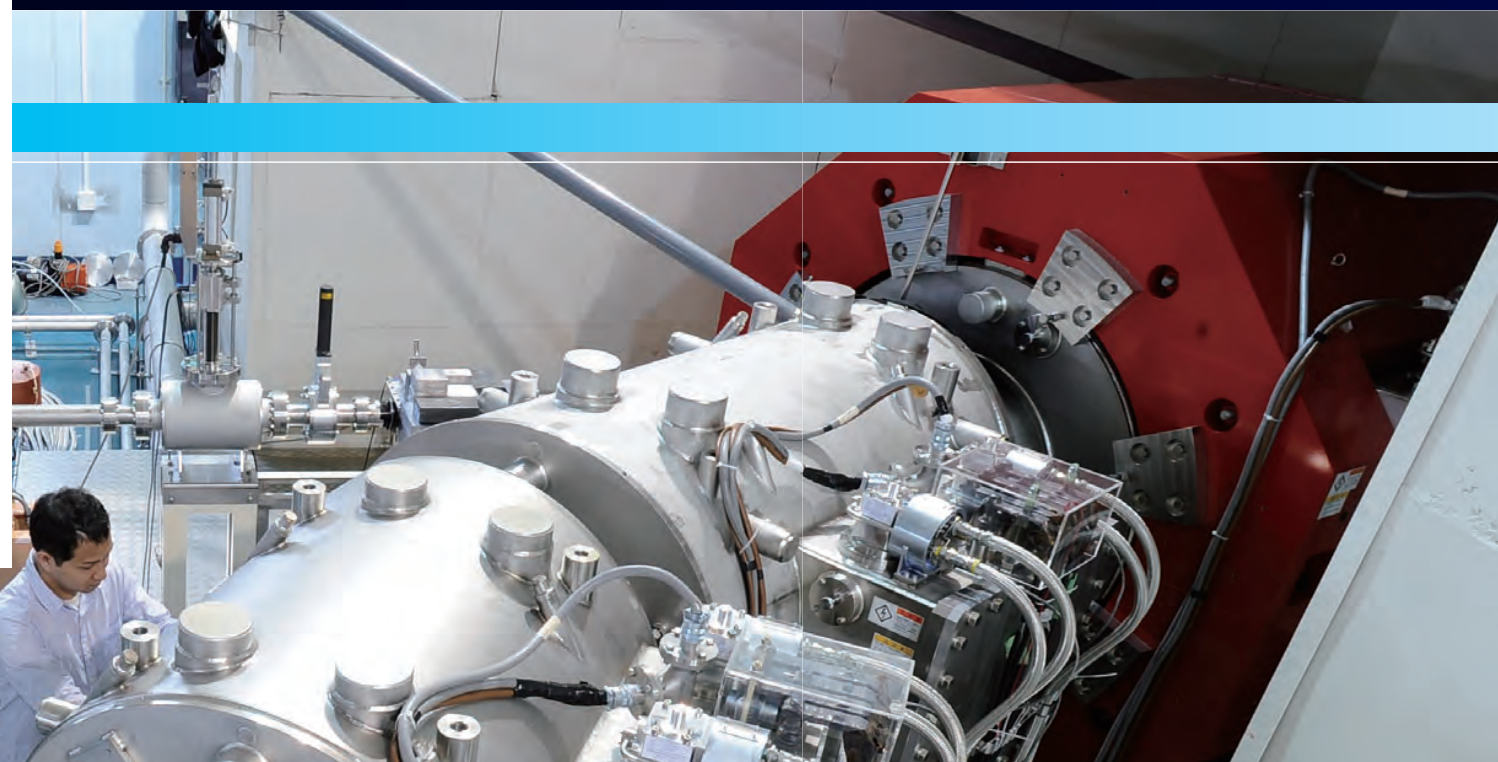
- Highly Intense Muon Source -



3.5T and graphite target



Muon Science Intense Channel (>2011)



MuSIC muon yields

μ^+ : $3 \times 10^8/\text{s}$ for 400W

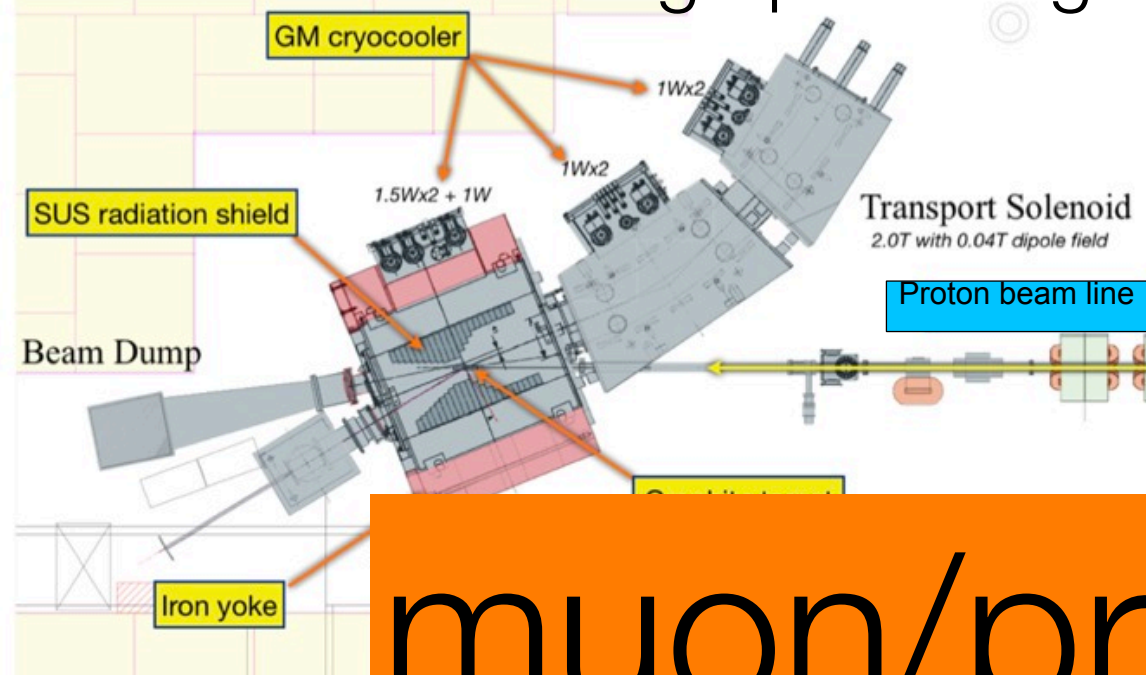
μ^- : $1 \times 10^8/\text{s}$ for 400W

MuSIC at RCNP, Osaka University

- Highly Intense Muon Source -

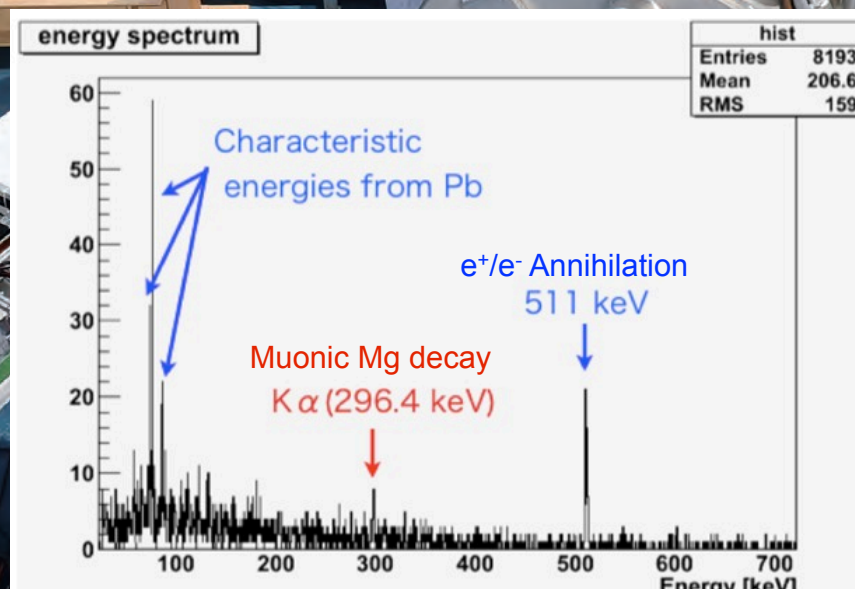
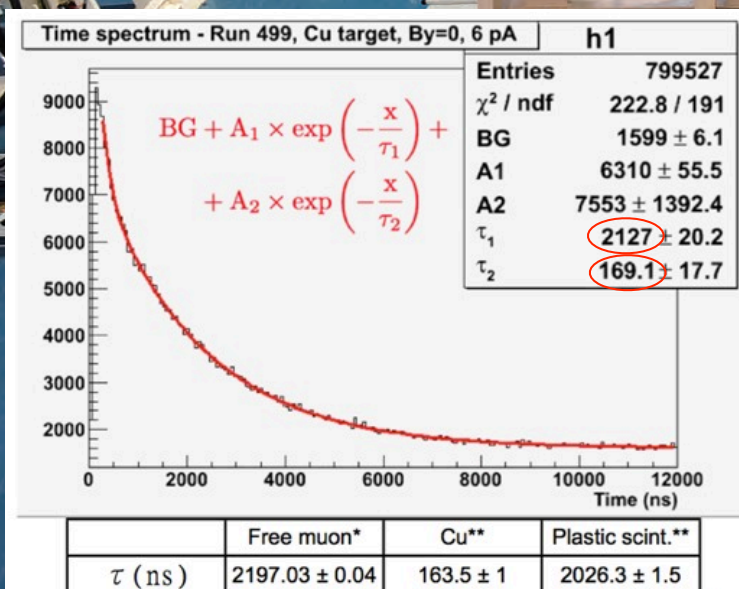


3.5T and graphite target



Muon Science Intense Channel (>2011)

muon/proton ~ x1000



MuSIC muon yields

μ^+ : $3 \times 10^8/\text{s}$ for 400W

μ^- : $1 \times 10^8/\text{s}$ for 400W

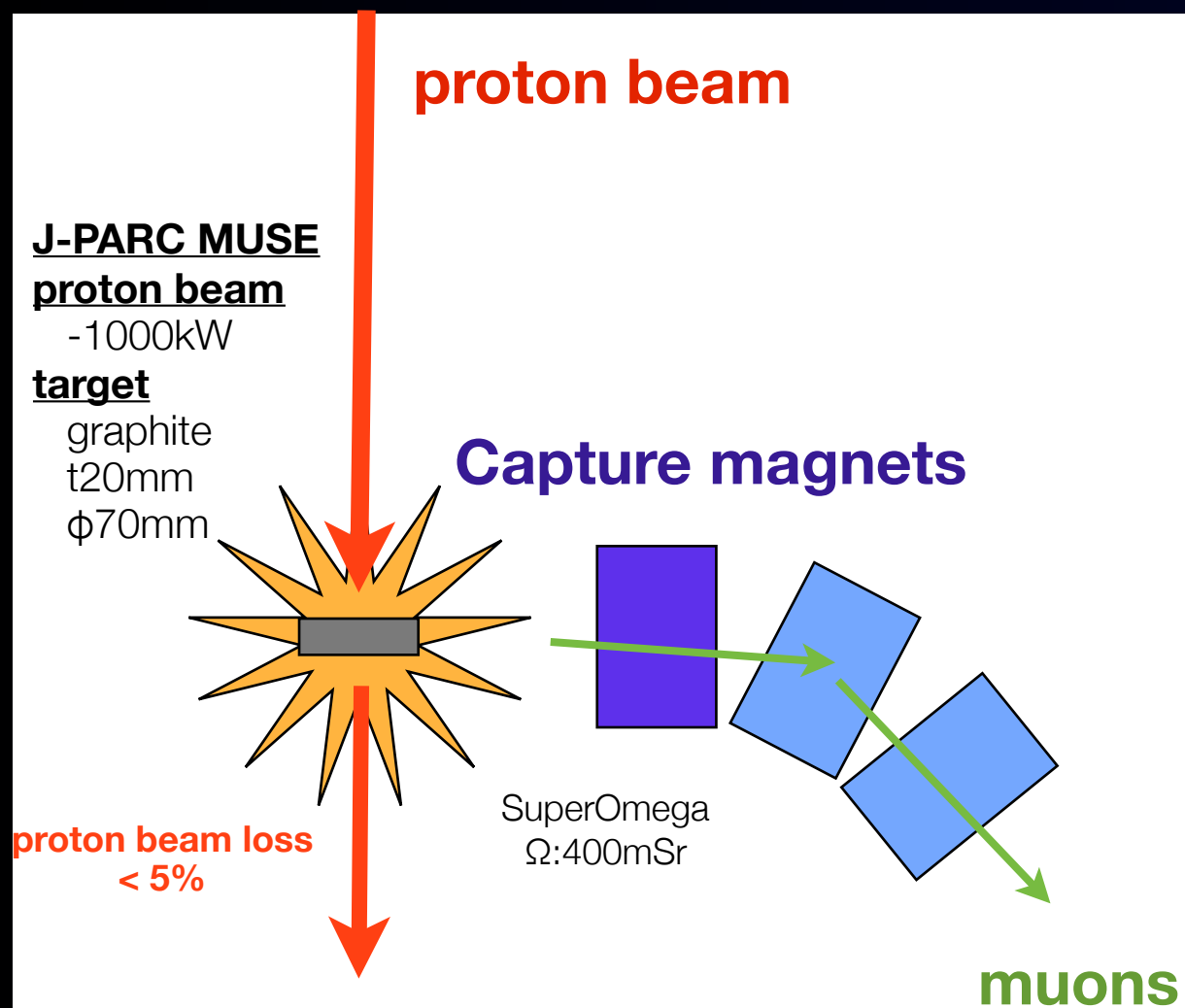
Production and Collection of Pions and Muons



Production and Collection of Pions and Muons



Conventional muon beam line



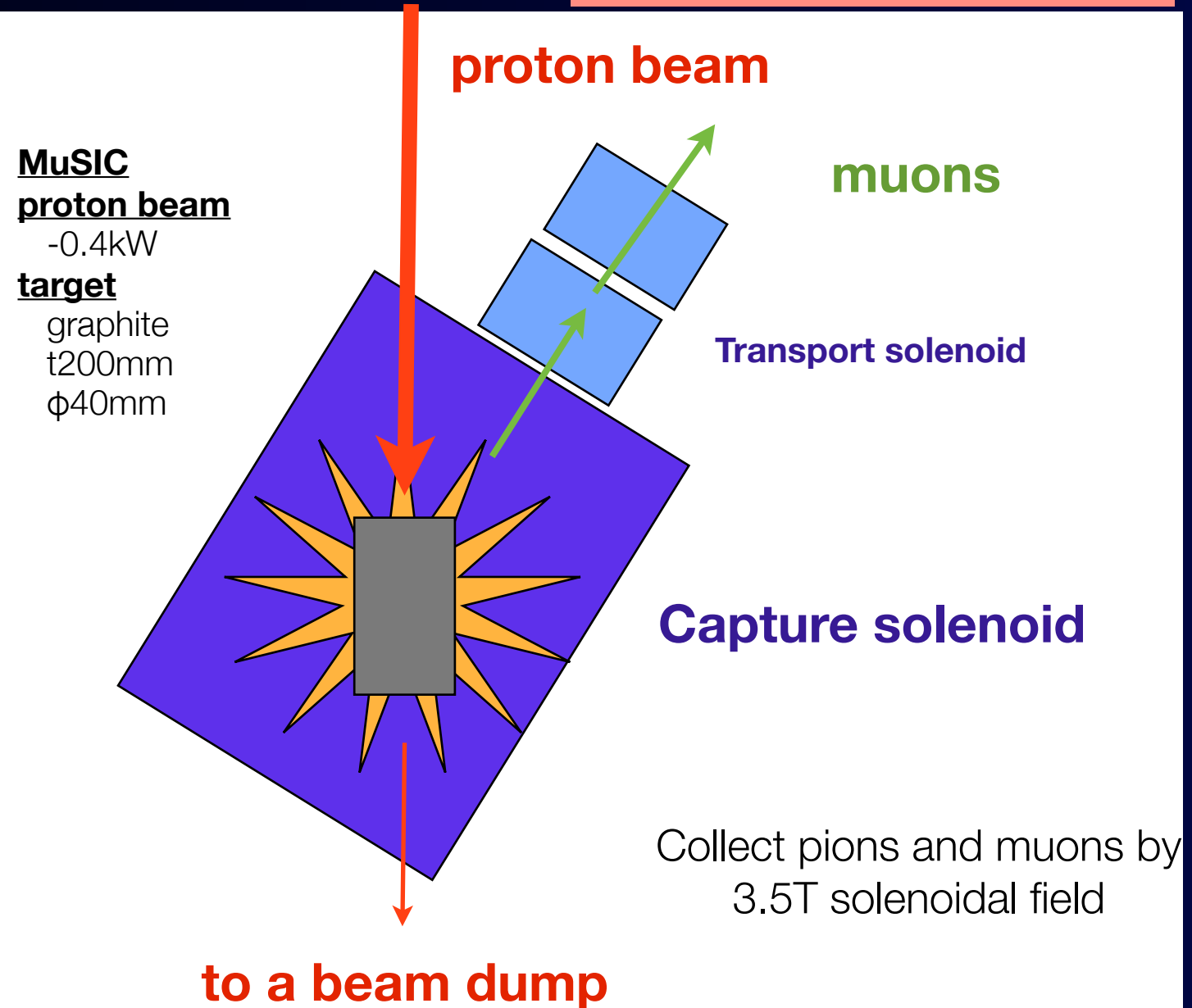
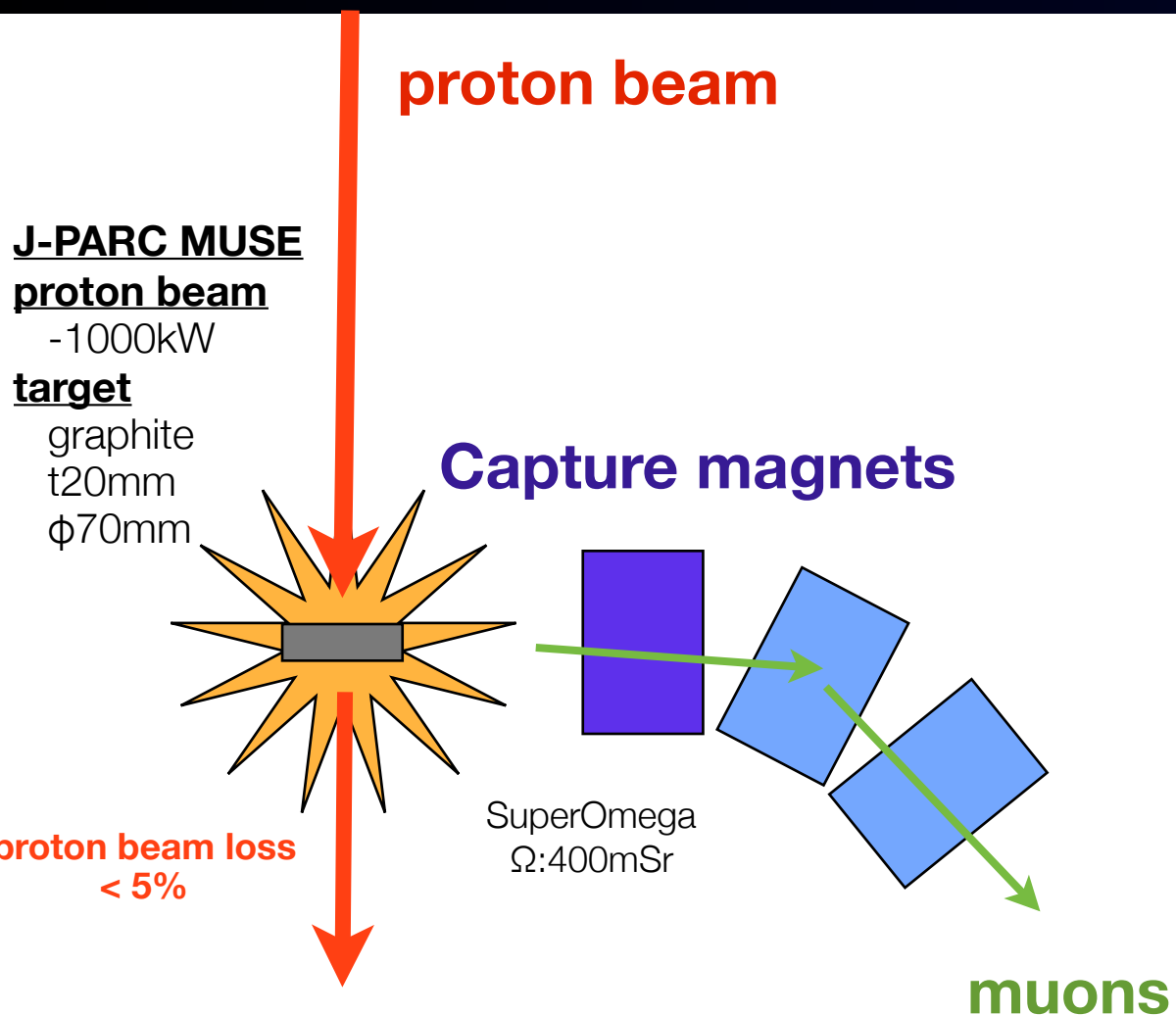
Production and Collection of Pions and Muons



Conventional muon beam line

More efficient

MuSIC, COMET, PRISM,
Neutrino factory,
Muon collider



Large solid angle & thick target

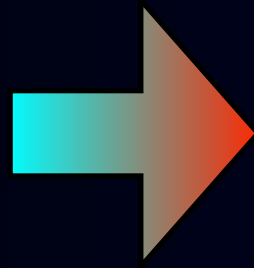
Improvements for Background Rejection



Improvements for Background Rejection



Beam-related
backgrounds



Beam pulsing with
separation of 1 μsec

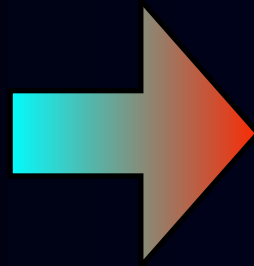
measured
between beam
pulses

proton extinction = #protons between pulses/#protons in a pulse $< 10^{-9}$

Improvements for Background Rejection



Beam-related
backgrounds

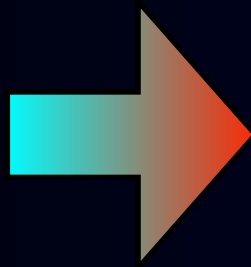


Beam pulsing with
separation of 1 μsec

measured
between beam
pulses

proton extinction = #protons between pulses/#protons in a pulse $< 10^{-9}$

Muon DIO
background



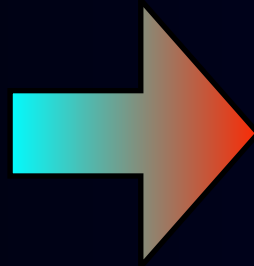
low-mass trackers in
vacuum & thin target

improve
electron energy
resolution

Improvements for Background Rejection



Beam-related
backgrounds

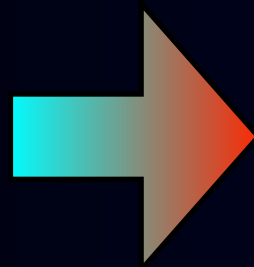


Beam pulsing with
separation of 1 μsec

measured
between beam
pulses

proton extinction = #protons between pulses/#protons in a pulse $< 10^{-9}$

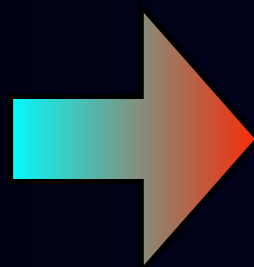
Muon DIO
background



low-mass trackers in
vacuum & thin target

improve
electron energy
resolution

Muon DIF
background



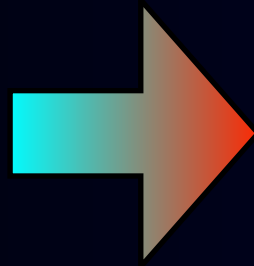
curved solenoids for
momentum selection

eliminate
energetic muons
(>75 MeV/c)

Improvements for Background Rejection



Beam-related
backgrounds

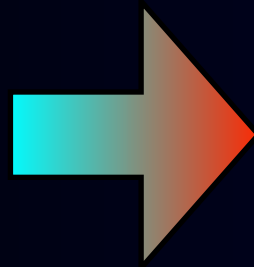


Beam pulsing with
separation of 1 μsec

measured
between beam
pulses

proton extinction = #protons between pulses/#protons in a pulse $< 10^{-9}$

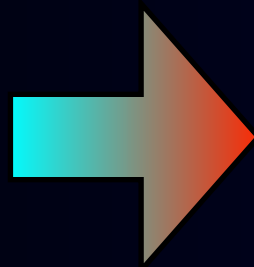
Muon DIO
background



low-mass trackers in
vacuum & thin target

improve
electron energy
resolution

Muon DIF
background



curved solenoids for
momentum selection

eliminate
energetic muons
(>75 MeV/c)

based on the MELC proposal at Moscow Meson Factory

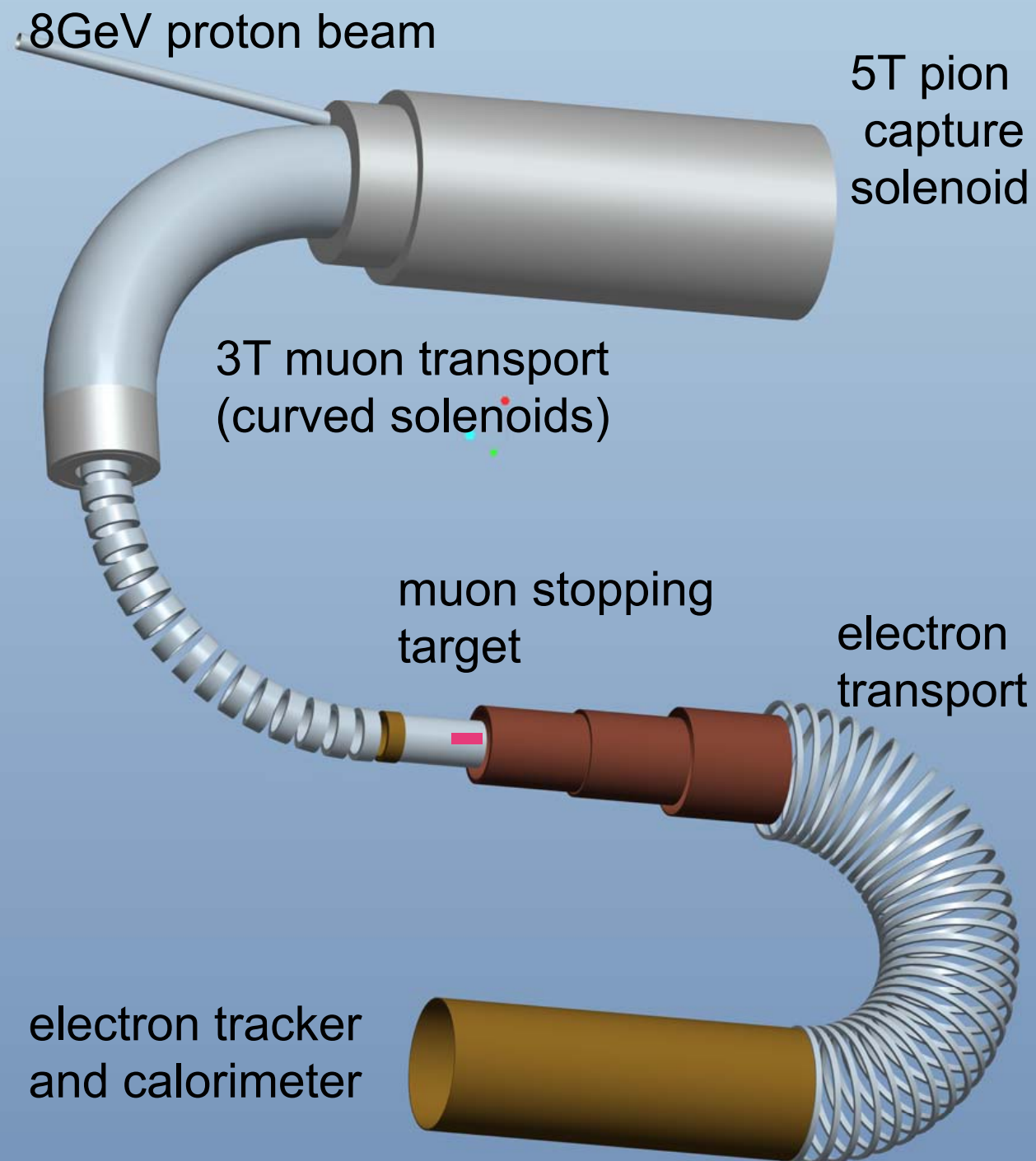
COMET=COherent Muon to Electron Transition

COMET at J-PARC



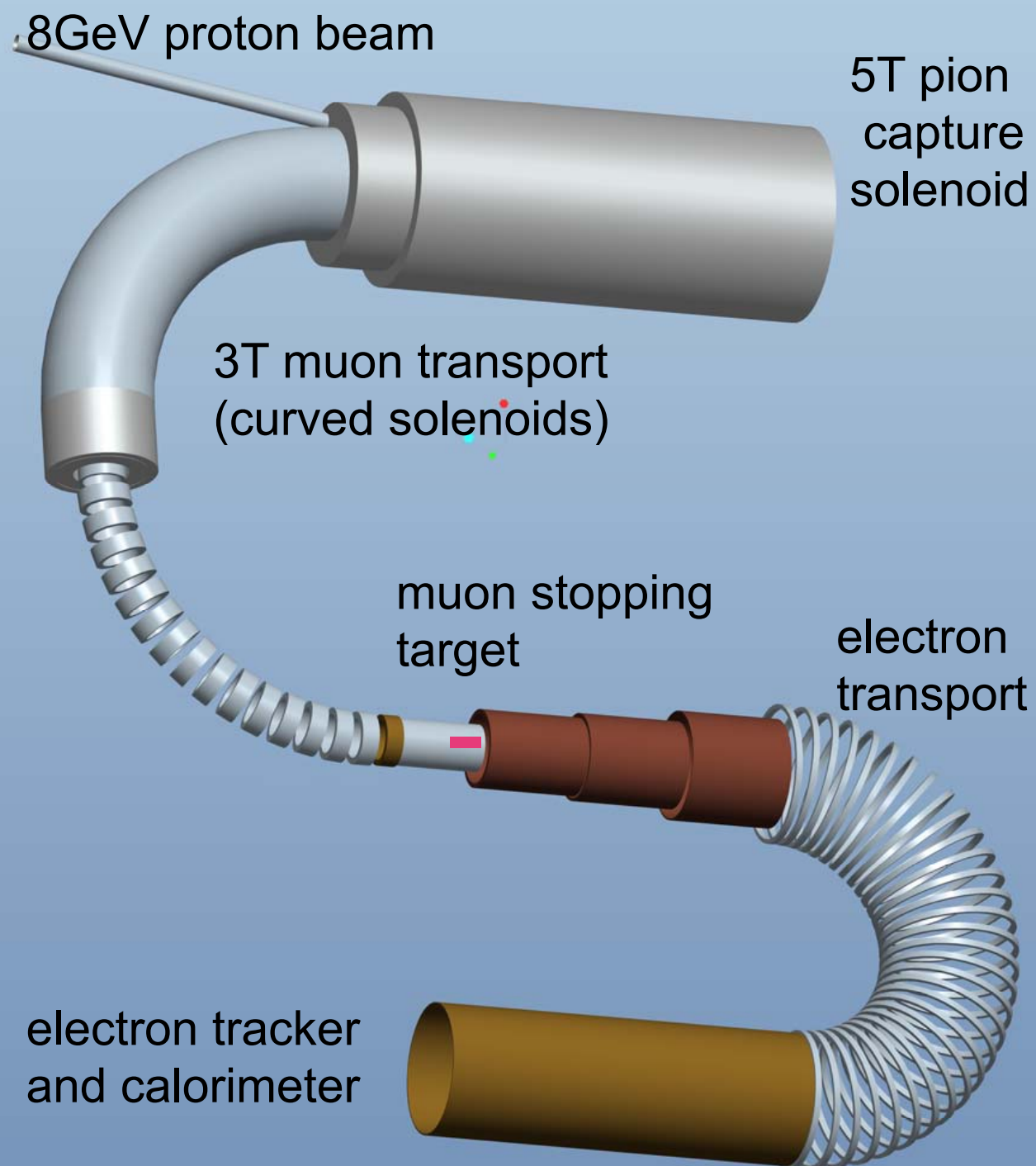
COMET=COherent Muon to Electron Transition

COMET at J-PARC



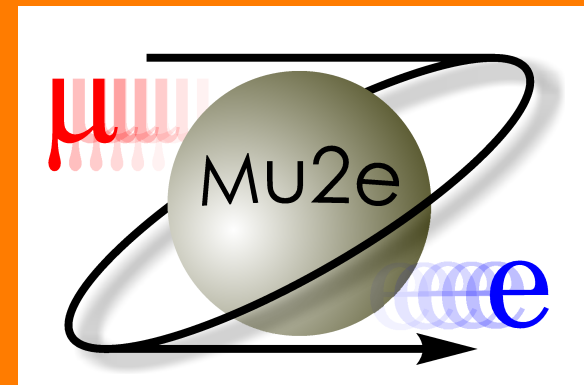
COMET=COherent Muon to Electron Transition

COMET at J-PARC

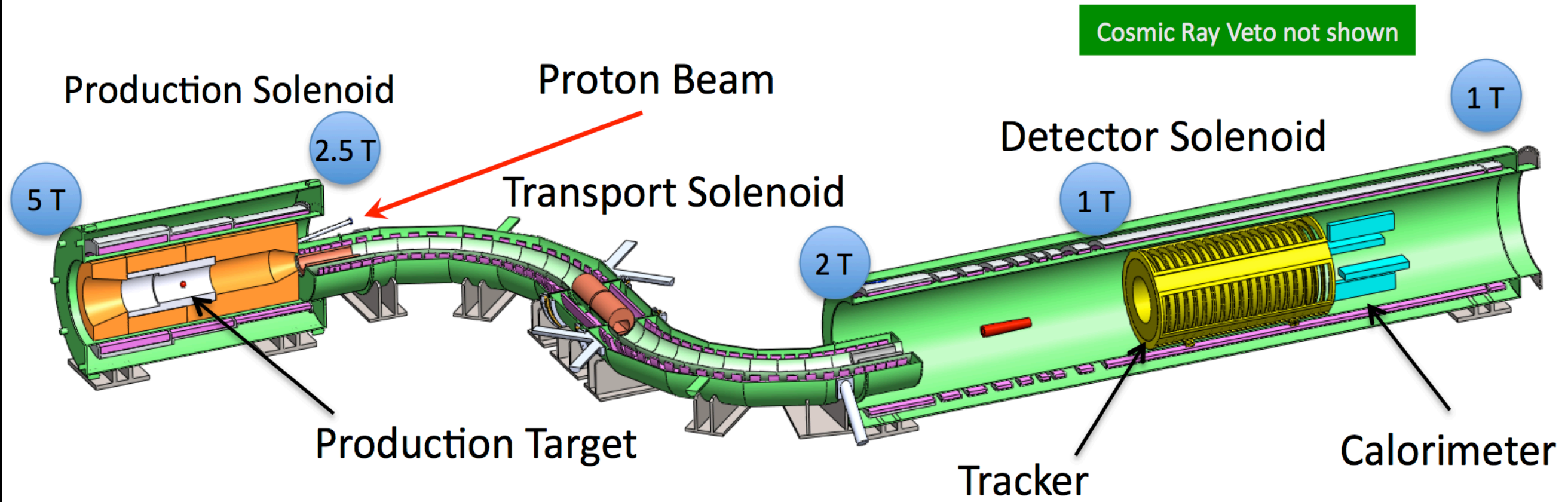
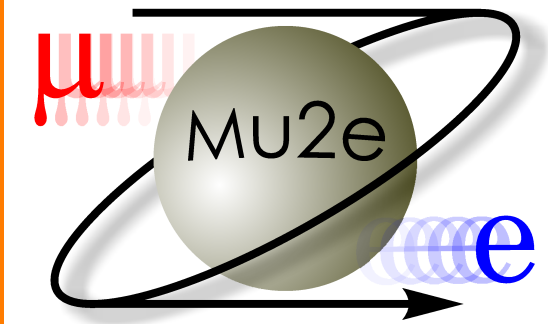


Physics sensitivity : $(1.0-2.6) \times 10^{-17}$
Total background : 0.32 events
Expected limits : $< 6 \times 10^{-17} @ 90\% \text{CL}$
Running time: 1 years ($2 \times 10^7 \text{sec}$)

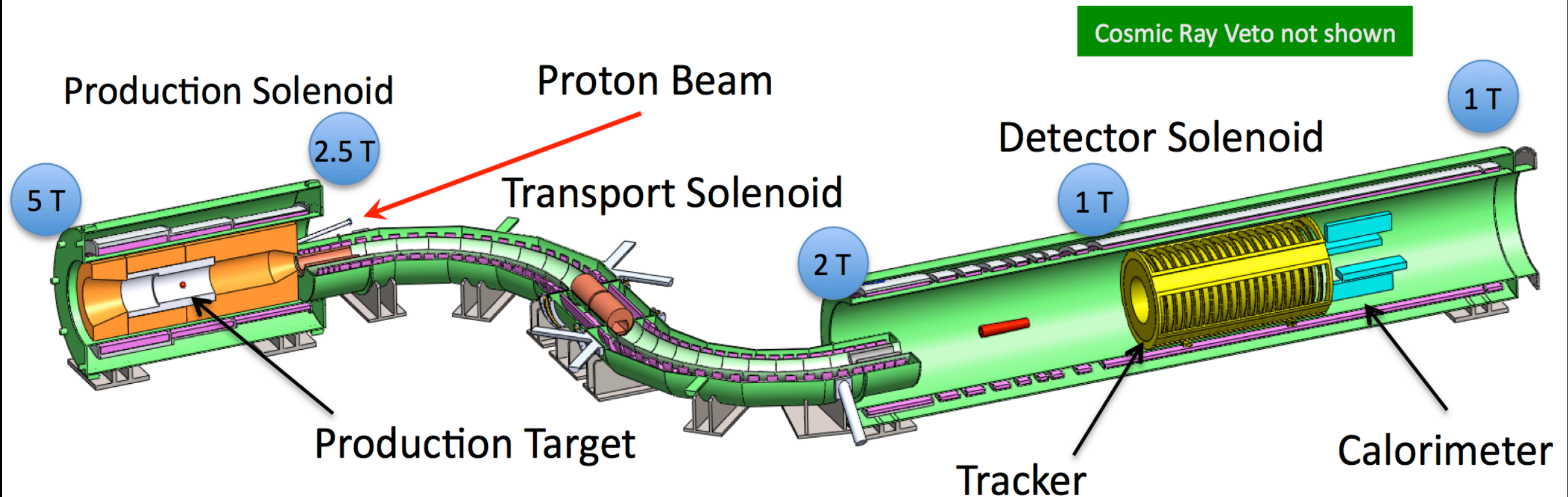
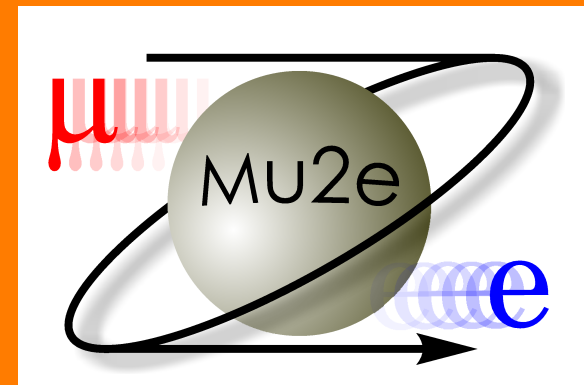
Mu2e at Fermilab



Mu2e at Fermilab



Mu2e at Fermilab



Single-event sensitivity : $(2.5 \pm 0.3) \times 10^{-17}$

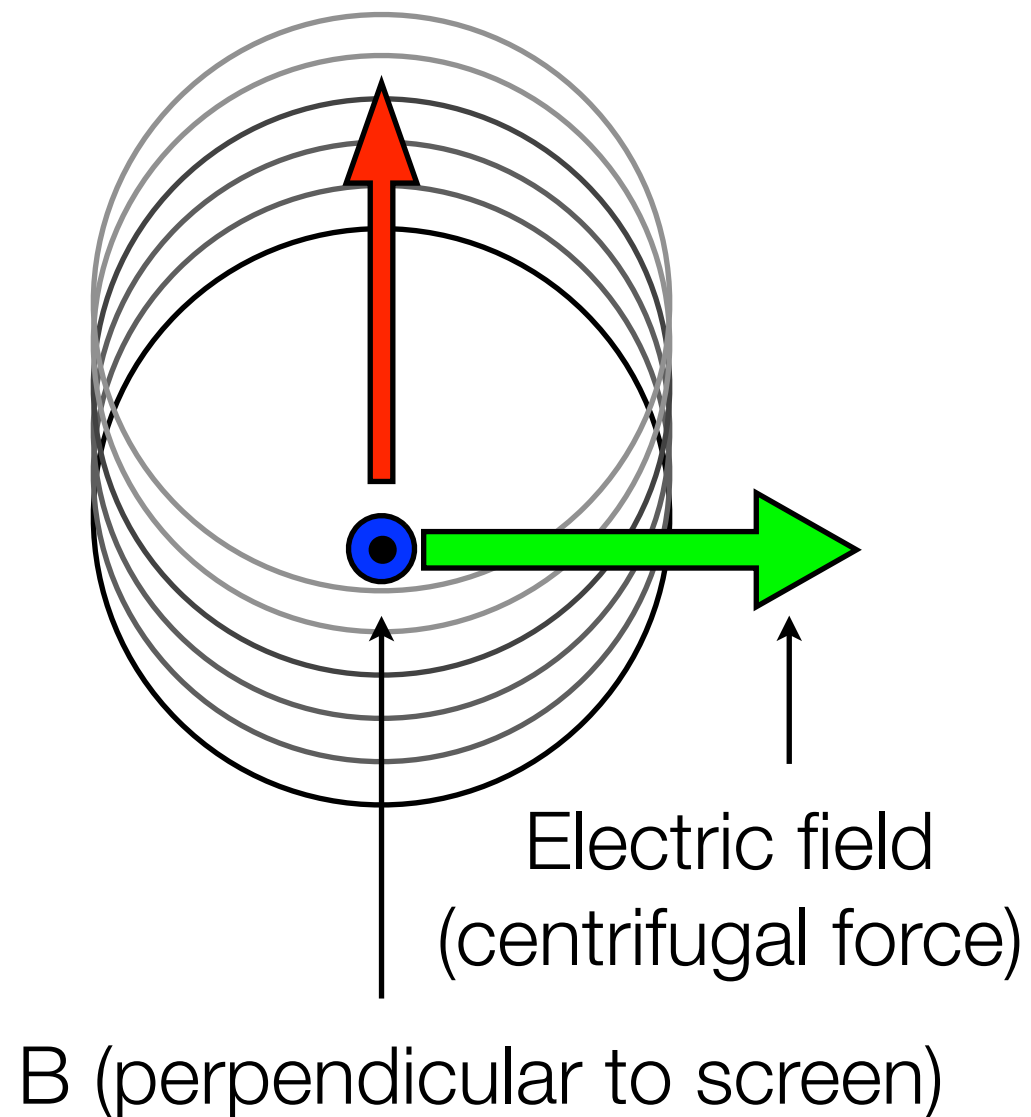
Running time: 3 years (2×10^7 sec/year)

Total background : (0.36 ± 0.10) events

Expected limits : $< 6 \times 10^{-17}$ @90%C.L.

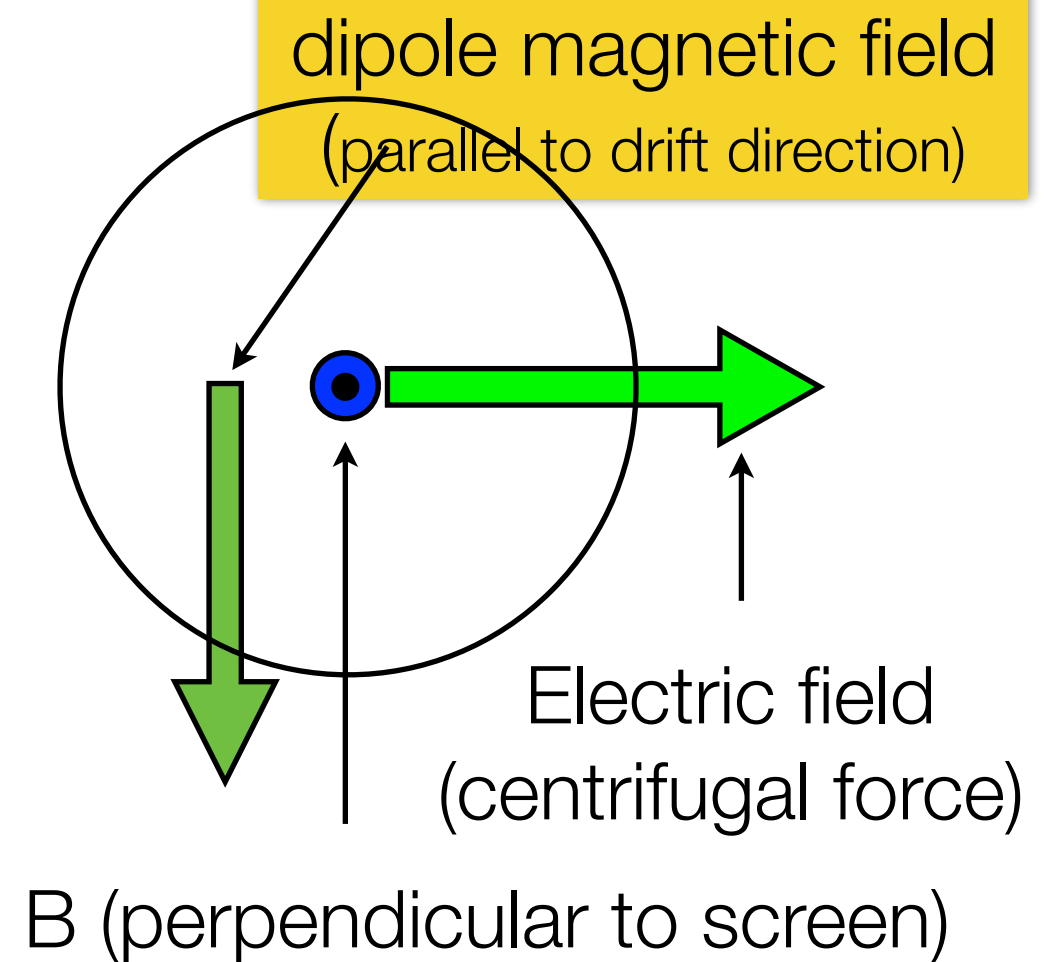
Particle Trajectories in Curved Solenoid

vertical shifting



$$D = \frac{p}{qB} \theta_{bend} \frac{1}{2} \left(\cos \theta + \frac{1}{\cos \theta} \right)$$

keep particular momentum
on bending plane

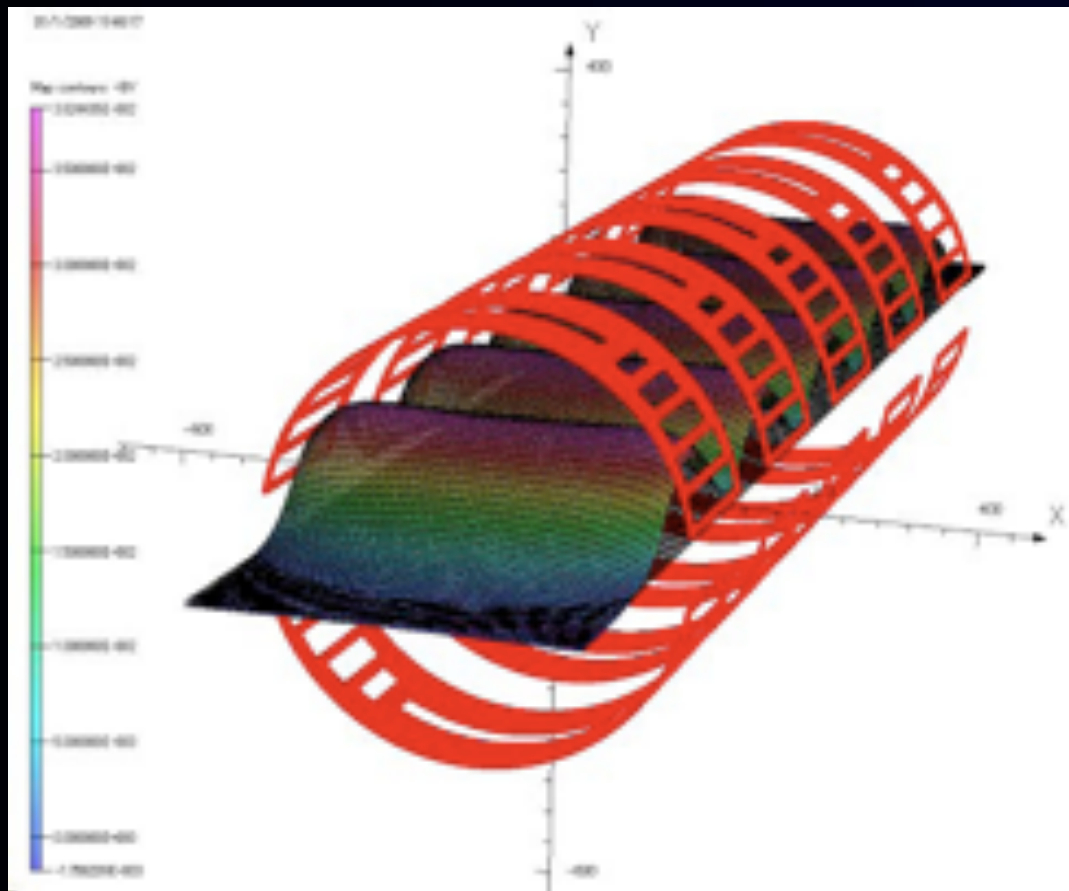


$$B_{comp} = \frac{p}{qr} \frac{1}{2} \left(\cos \theta + \frac{1}{\cos \theta} \right)$$

COMET Curved Solenoids



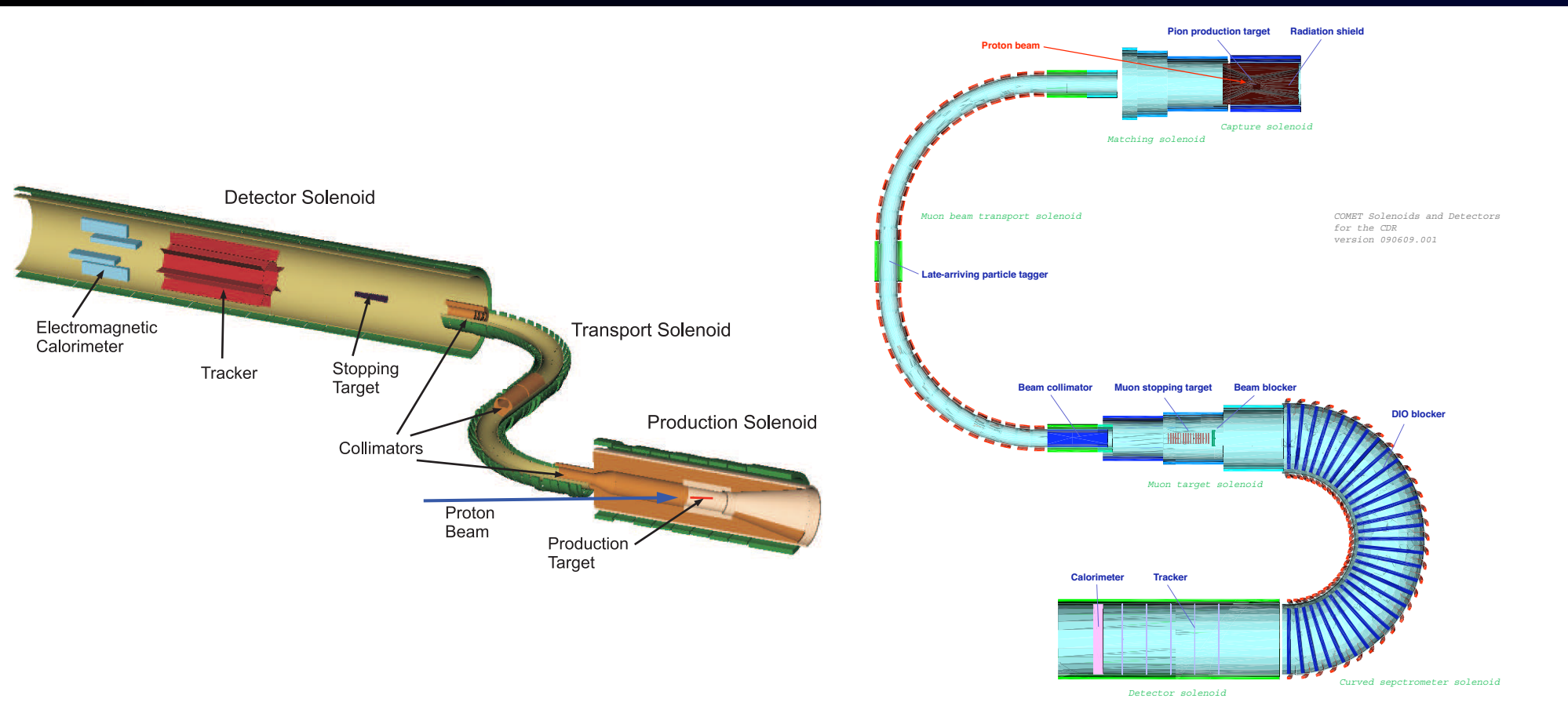
To keep particles of interest in momentum at the center transverse magnetic field is needed.



Only COMET has the transverse field coils.

Mu2e vs. COMET (1)

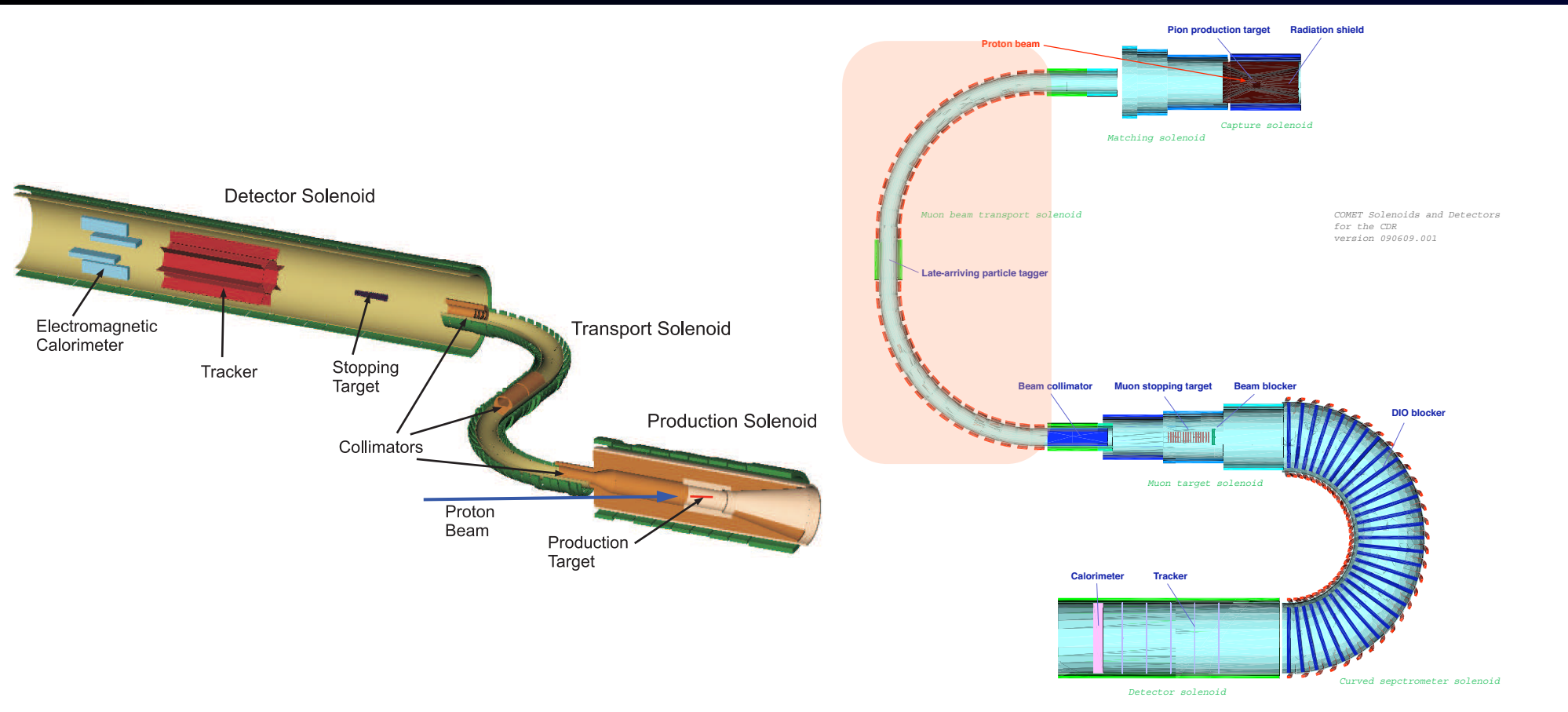
- Muon and Electron transports -



	Mu2e	COMET
muon beam line	2x 90° bends (opposite direction)	2x 90° bend (same direction)
electron spectrometer	straight solenoid	curved solenoid

Mu2e vs. COMET (1)

- Muon and Electron transports -



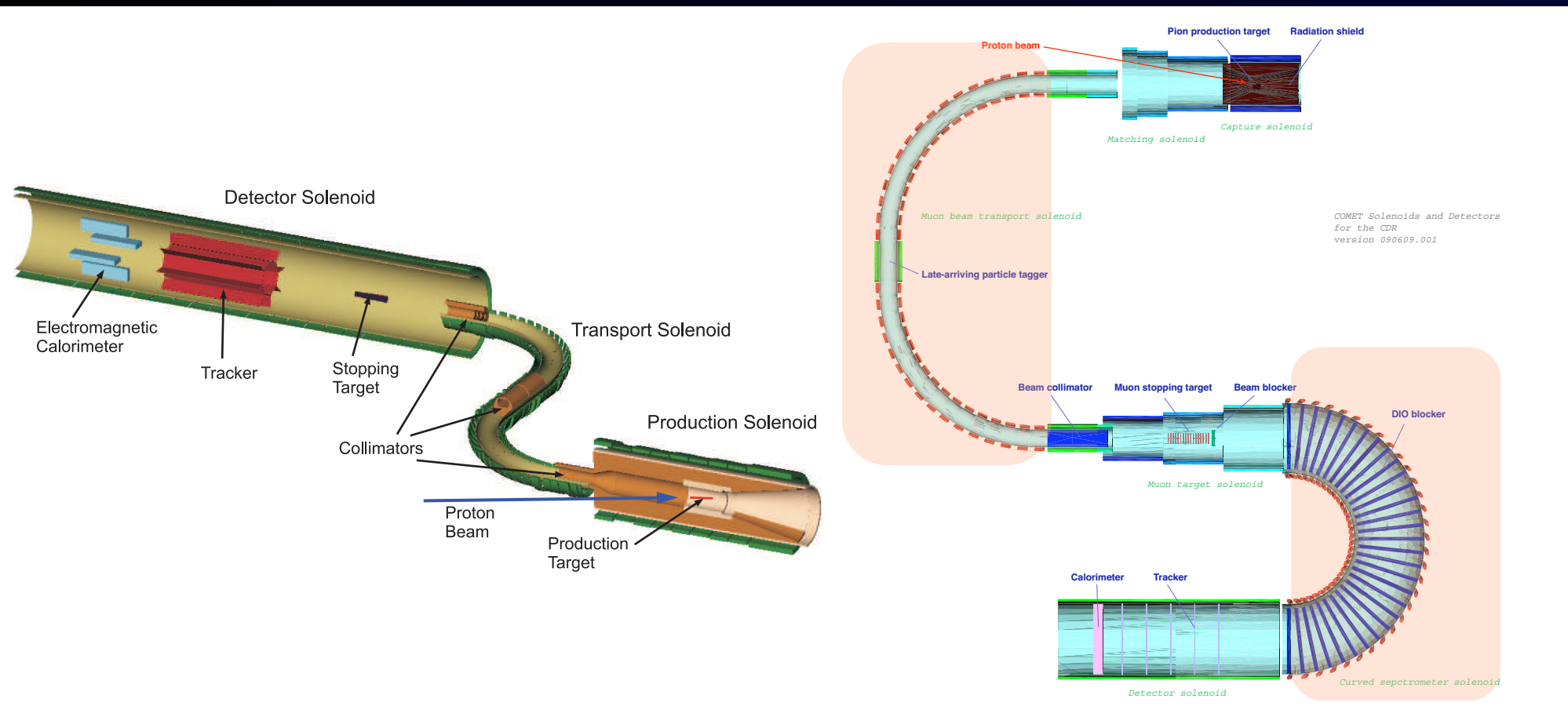
Select low
momentum
muons

eliminate
muon decay
in flight

	Mu2e	COMET
muon beam line	2x 90° bends (opposite direction)	2x 90° bend (same direction)
electron spectrometer	straight solenoid	curved solenoid

Mu2e vs. COMET (1)

- Muon and Electron transports -



	Mu2e	COMET
muon beam line	2x 90° bends (opposite direction)	2x 90° bend (same direction)
electron spectrometer	straight solenoid	curved solenoid

Select low momentum muons

eliminate muon decay in flight

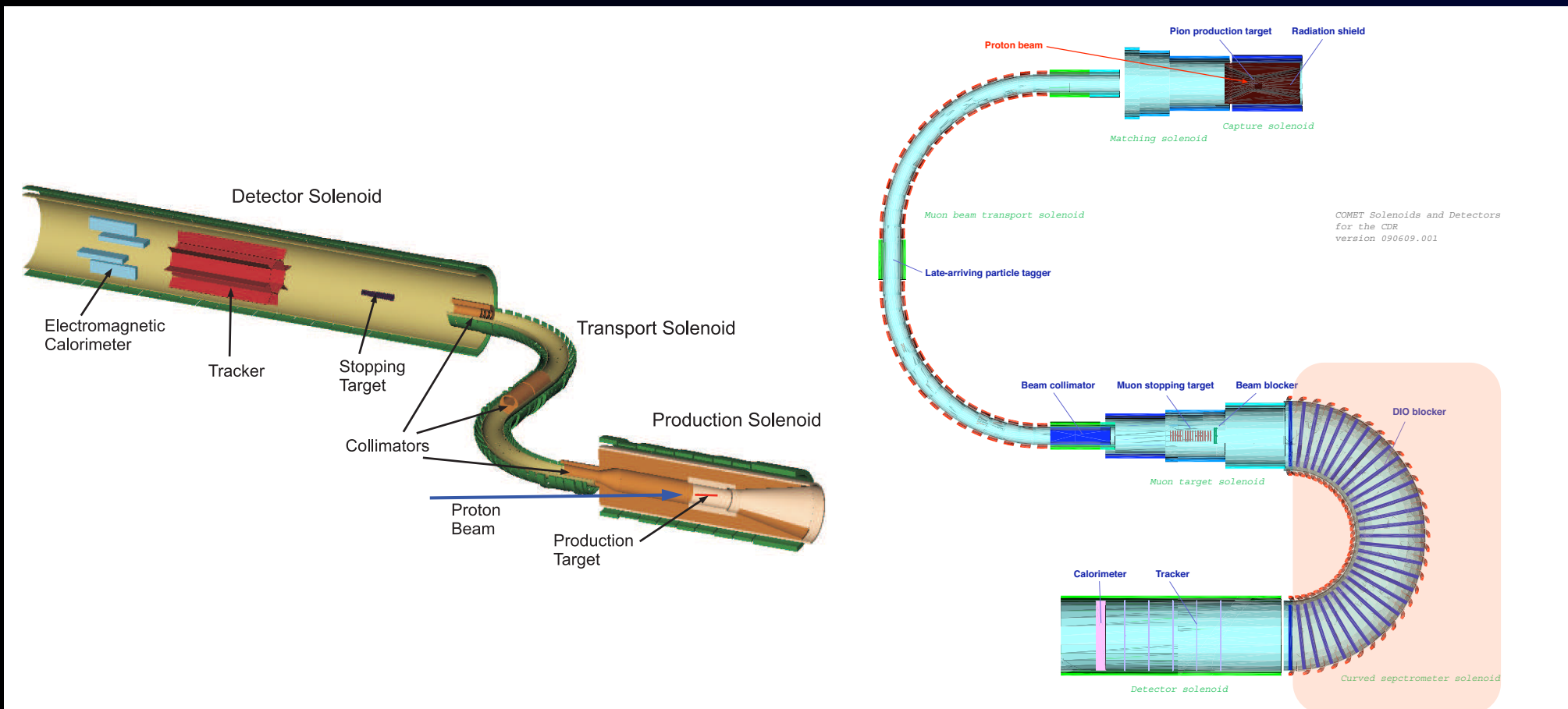
Selection of 100 MeV electrons

eliminate protons from nuclear muon capture.

eliminate low energy events to make the detector quiet.

Mu2e vs. COMET (2)

- Number of Total Muons -



Selection of
100 MeV
electrons

Higher muon
intensity can be
handled.

$$\text{Sensitivity} / 2 \times 10^7 \text{ sec} \\ = 7.5 \times 10^{-17}$$

$$\text{Sensitivity} / 2 \times 10^7 \text{ sec} \\ = 1.0 \times 10^{-17}$$

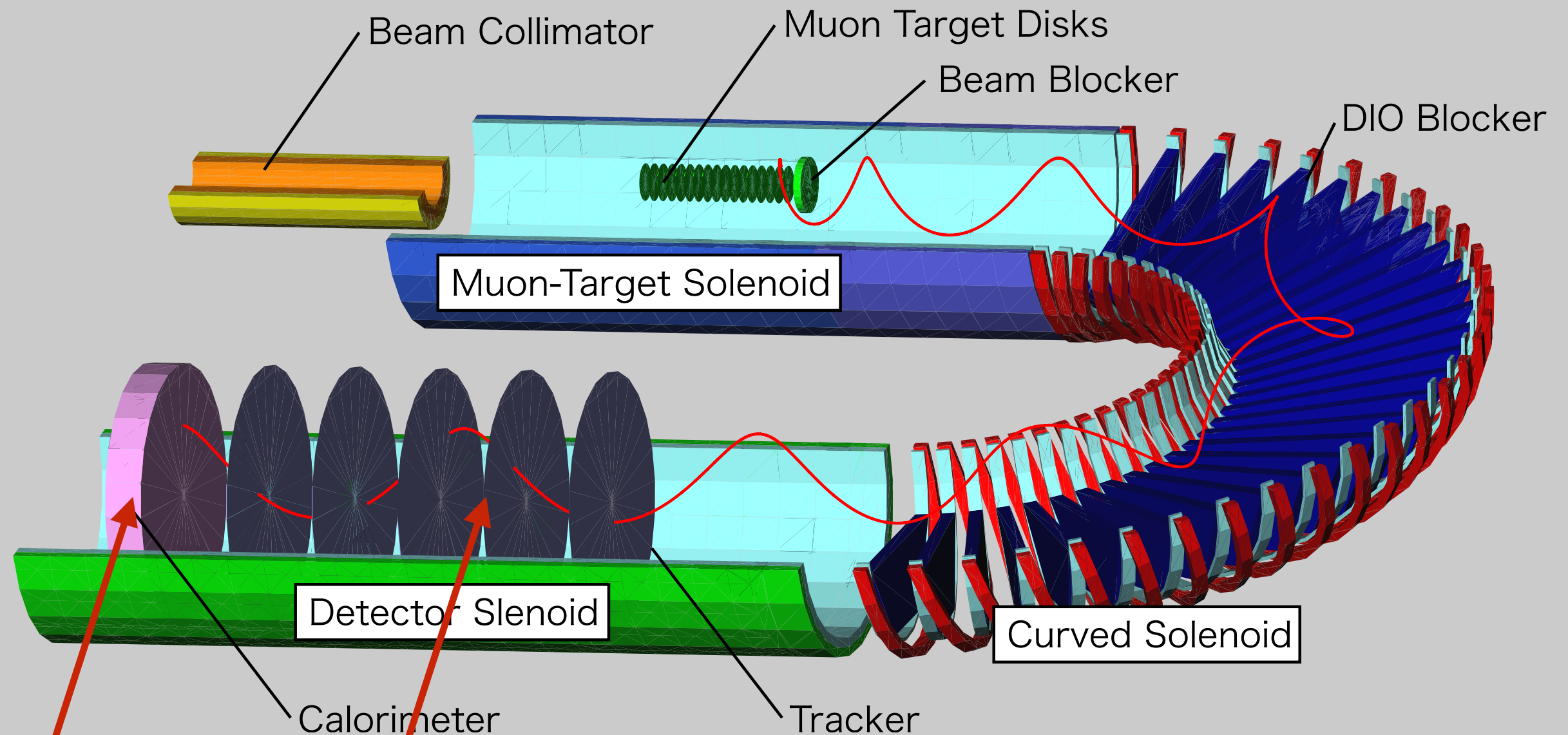
proton beam ~ 8kW
14 years

proton beam ~ 56kW
2 years
(down to 0.5×10^{-17})

COMET Detectors



COMET Detectors



ECAL

Straw Tracker

(# of straw stations
is not determined)

in vacuum under
1T magnetic field





COMET Phase-I

COMET Collaboration



182 collaborators
37 institutes, 15 countries

PI: Y. Kuno

The COMET Collaboration

R. Abramishvili¹¹, G. Adamov¹¹, R. Akhmetshin^{6,31}, V. Anishchik⁴, M. Aoki³², Y. Arimoto¹⁸, I. Bagaturia¹¹, Y. Ban³, A. Bondar^{6,31}, Y. Calas⁷, S. Canfer³³, Y. Cardenas⁷, S. Chen²⁸, Y. E. Cheung²⁸, B. Chiladze³⁵, D. Clarke³³, M. Danilov^{15,26}, P. D. Dauncey¹⁴, J. David²³, W. Da Silva²³, C. Densham³³, G. Devidze³⁵, P. Dornan¹⁴, A. Drutskoy^{15,26}, V. Duginov¹⁶, L. Epshteyn^{6,30}, P. Evtoukhovich¹⁶, G. Fedotov^{6,31}, M. Finger⁸, M. Finger Jr⁸, Y. Fujii¹⁸, Y. Fukao¹⁸, J-F. Genat²³, E. Gillies¹⁴, D. Grigoriev^{6,30,31}, K. Gritsay¹⁶, E. Hamada¹⁸, R. Han¹, K. Hasegawa¹⁸, I. H. Hasim³², O. Hayashi³², Z. A. Ibrahim²⁴, Y. Igarashi¹⁸, F. Ignatov^{6,31}, M. Iio¹⁸, M. Ikeno¹⁸, K. Ishibashi²², S. Ishimoto¹⁸, T. Itahashi³², S. Ito³², T. Iwami³², X. S. Jiang², P. Jonsson¹⁴, V. Kalinnikov¹⁶, F. Kapusta²³, H. Katayama³², K. Kawagoe²², N. Kazak⁵, V. Kazanin^{6,31}, B. Khazin^{6,31}, A. Khvedelidze^{16,11}, T. K. Ki¹⁸, M. Koike³⁹, G. A. Kozlov¹⁶, B. Krikler¹⁴, A. Kulikov¹⁶, E. Kulish¹⁶, Y. Kuno³², Y. Kuriyama²¹, Y. Kurochkin⁵, A. Kurup¹⁴, B. Lagrange^{14,21}, M. Lancaster³⁸, M. J. Lee¹², H. B. Li², W. G. Li², R. P. Litchfield³⁸, T. Loan²⁹, D. Lomidze¹¹, I. Lomidze¹¹, P. Loveridge³³, G. Macharashvili³⁵, Y. Makida¹⁸, Y. Mao³, O. Markin¹⁵, Y. Matsumoto³², T. Mibe¹⁸, S. Mihara¹⁸, F. Mohamad Idris²⁴, K. A. Mohamed Kamal Azmi²⁴, A. Moiseenko¹⁶, Y. Mori²¹, M. Moritsu³², E. Motuk³⁸, Y. Nakai²², T. Nakamoto¹⁸, Y. Nakazawa³², J. Nash¹⁴, J. -Y. Nief⁷, M. Nioradze³⁵, H. Nishiguchi¹⁸, T. Numao³⁶, J. O'Dell³³, T. Ogitsu¹⁸, K. Oishi²², K. Okamoto³², C. Omori¹⁸, T. Ota³⁴, J. Pasternak¹⁴, C. Plostinar³³, V. Ponariadov⁴⁵, A. Popov^{6,31}, V. Rusinov^{15,26}, A. Ryzhenenkov^{6,31}, B. Sabirov¹⁶, N. Saito¹⁸, H. Sakamoto³², P. Sarin¹³, K. Sasaki¹⁸, A. Sato³², J. Sato³⁴, Y. K. Semertzidis^{12,17}, D. Shemyakin^{6,31}, N. Shigyo²², D. Shoukavy⁵, M. Slunicka⁸, A. Straessner³⁷, D. Stöckinger³⁷, M. Sugano¹⁸, Y. Takubo¹⁸, M. Tanaka¹⁸, S. Tanaka²², C. V. Tao²⁹, E. Tarkovsky^{15,26}, Y. Tevzadze³⁵, T. Thanh²⁹, N. D. Thong³², J. Tojo²², M. Tomasek¹⁰, M. Tomizawa¹⁸, N. H. Tran³², H. Trang²⁹, I. Trekov³⁵, N. M. Truong³², Z. Tsamalaidze^{16,11}, N. Tsverava^{16,35}, T. Uchida¹⁸, Y. Uchida¹⁴, K. Ueno¹⁸, E. Velicheva¹⁶, A. Volkov¹⁶, V. Vrba¹⁰, W. A. T. Wan Abdullah²⁴, M. Warren³⁸, M. Wing³⁸, T. S. Wong³², C. Wu^{2,28}, H. Yamaguchi²², A. Yamamoto¹⁸, Y. Yang²², W. Yao², Y. Yao², H. Yoshida³², M. Yoshida¹⁸, Y. Yoshii¹⁸, T. Yoshioka²², Y. Yuan², Y. Yudin^{6,31}, J. Zhang², Y. Zhang², K. Zuber³⁷

COMET Staged Approach (2012~)

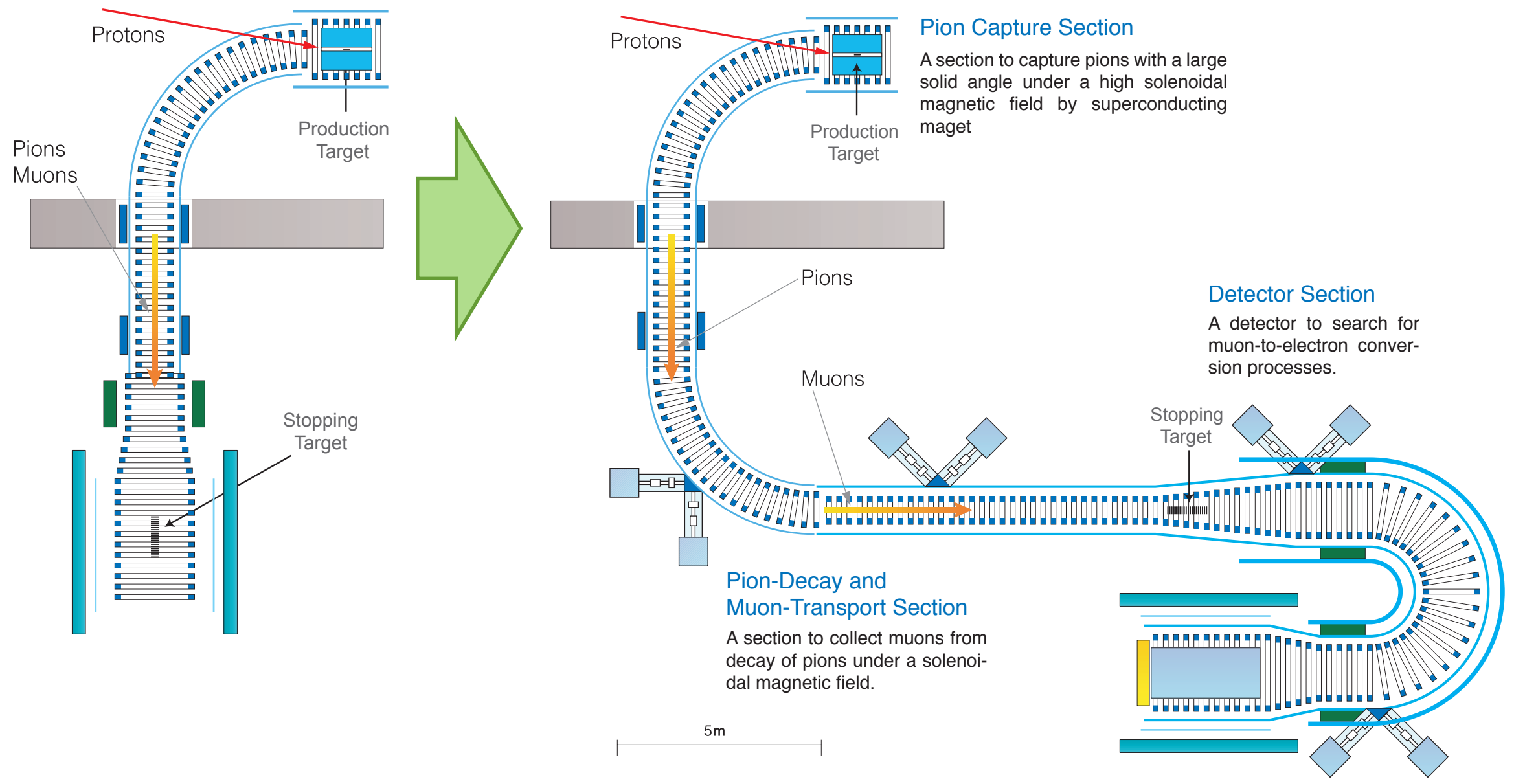


COMET Staged Approach (2012~)



COMET Phase-I

COMET Phase-II

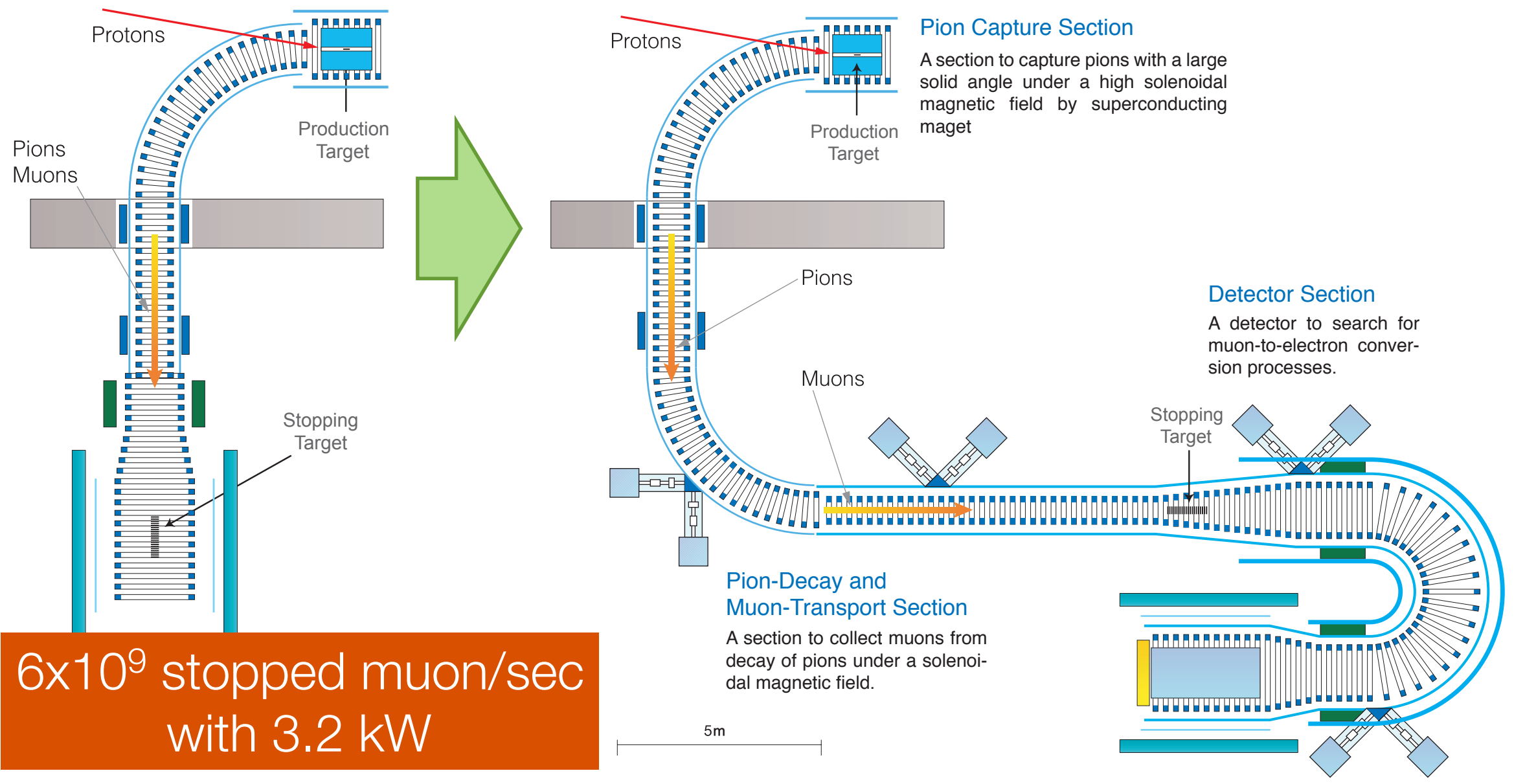


COMET Staged Approach (2012~)



COMET Phase-I

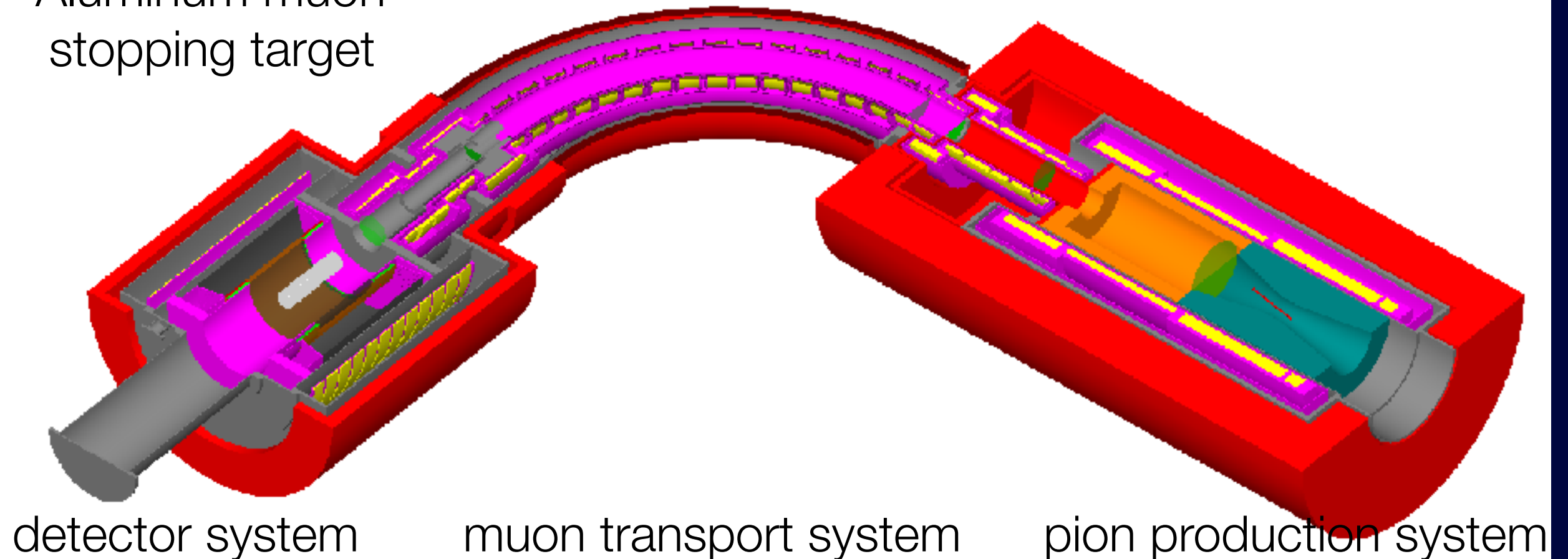
COMET Phase-II



COMET Phase-I



Aluminum muon
stopping target



Single-event sensitivity : 3×10^{-15}
Total background : 0.2 events
Expected limits : $< 6 \times 10^{-15}$ @90%CL
Running time: 150 days

J-PARC@Tokai

COMET
Exp. Area

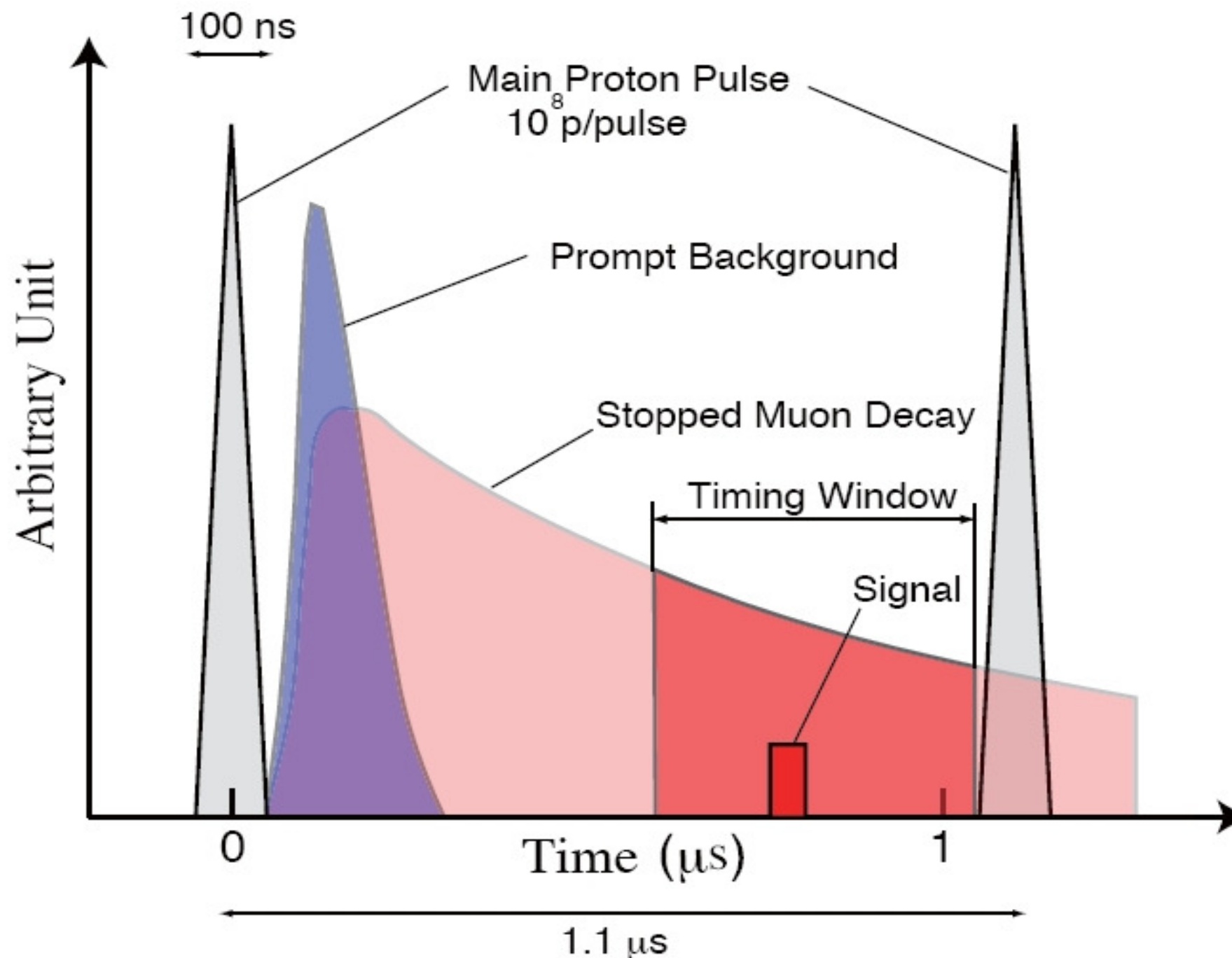
Hadron Experimental Hall



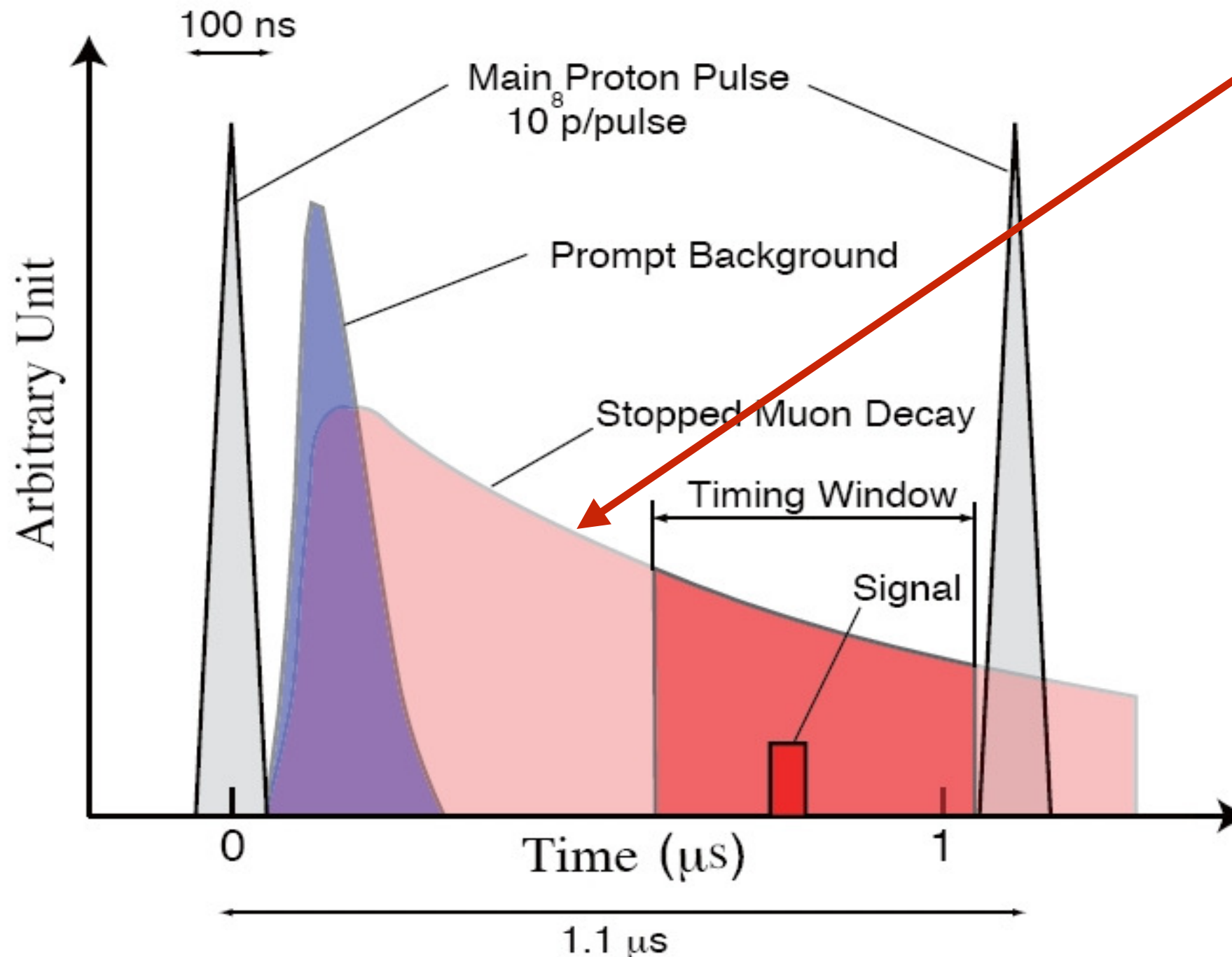
Time Structure of Measurement in COMET



Time Structure of Measurement in COMET

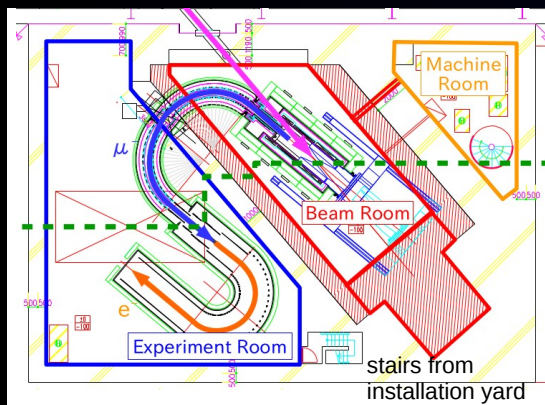


Time Structure of Measurement in COMET

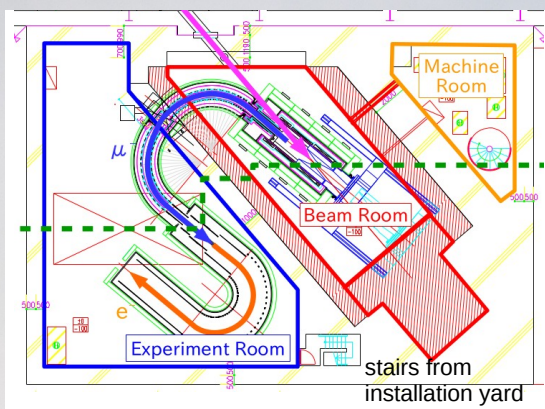


A lifetime of a
muonic atom in
aluminium
 ~ 880 sec

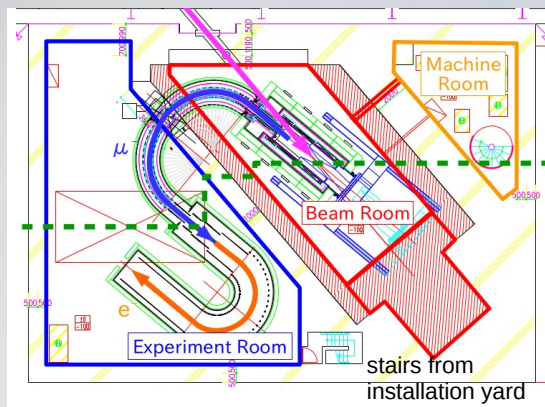
COMET Building at J-PARC



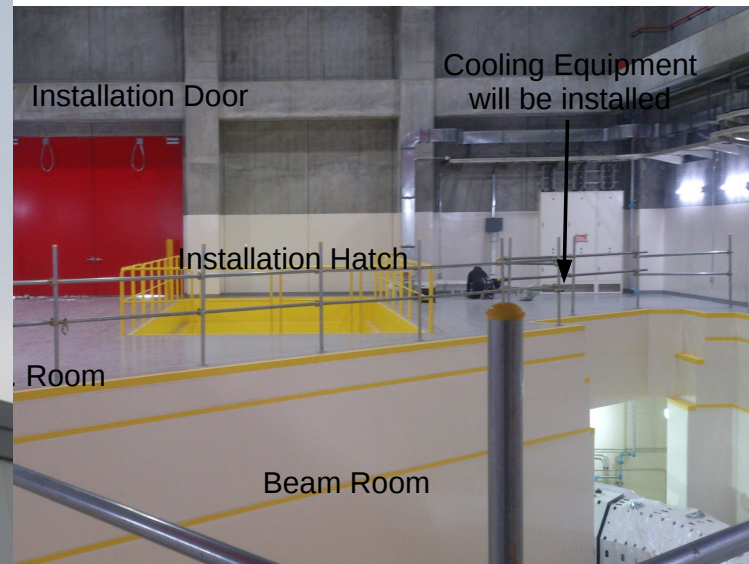
COMET Building at J-PARC



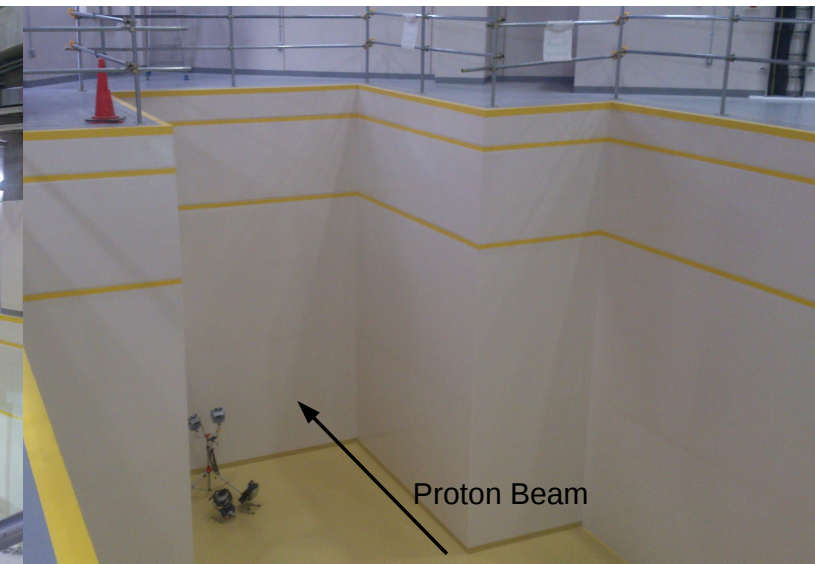
COMET Building at J-PARC



Installation Yard



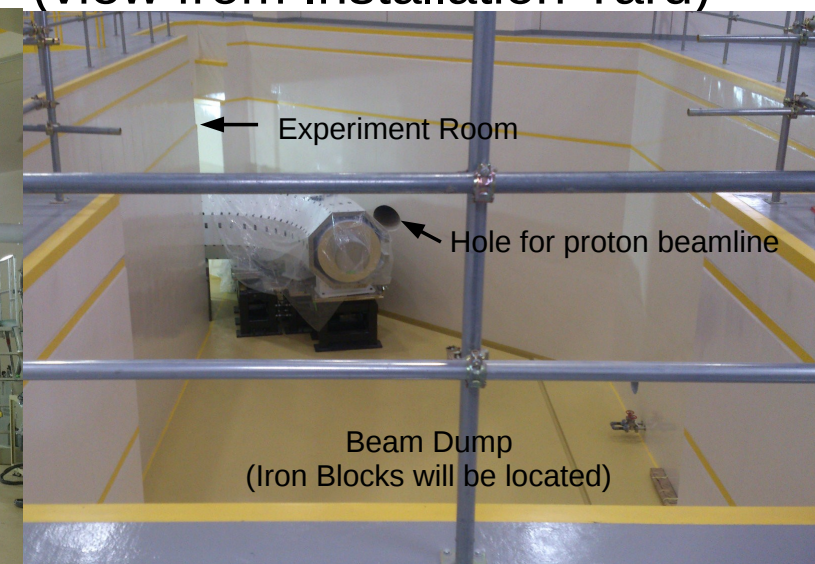
Beam Room



Experiment Room (View from Door)



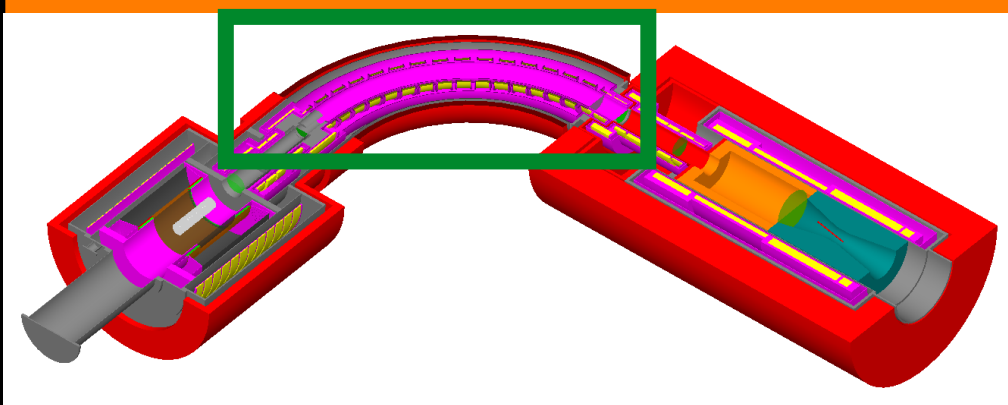
Beam Room (view from Installation Yard)



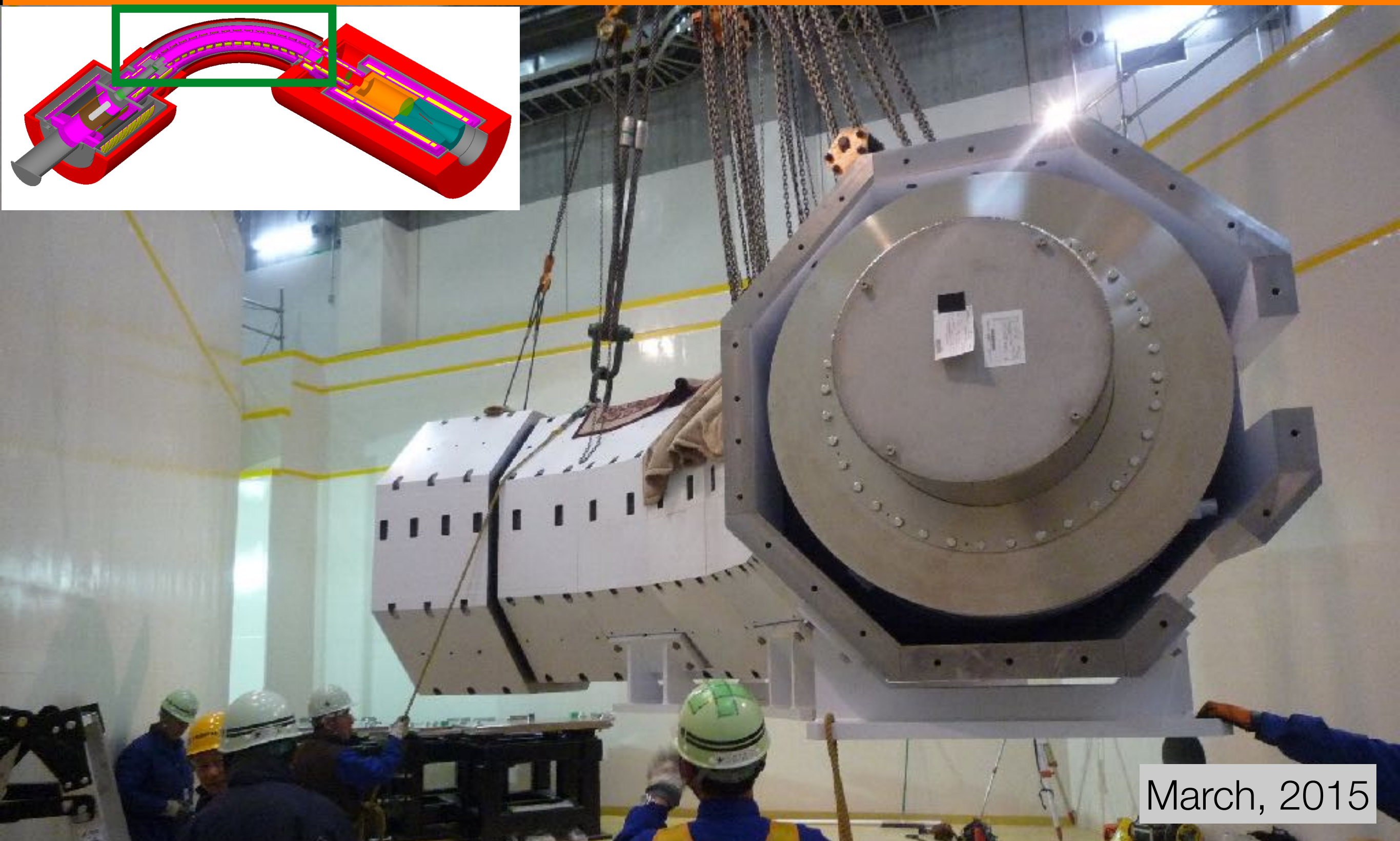
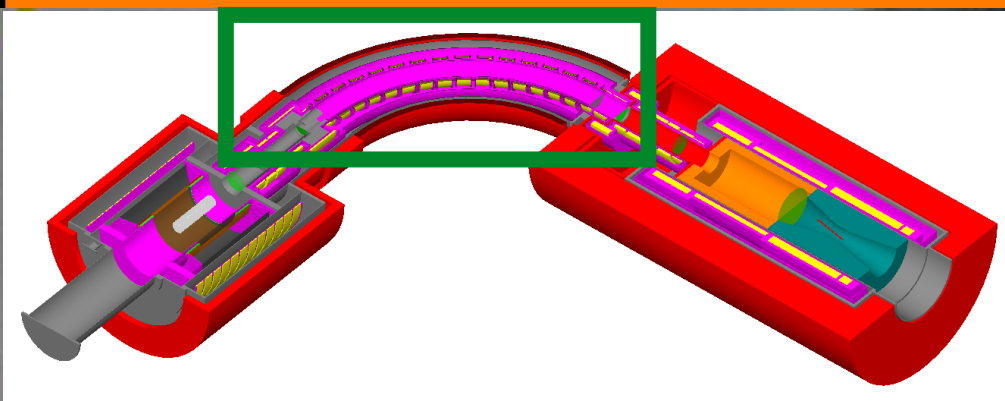
Curved Solenoids for Muon Transport Completed and Delivered!



Curved Solenoids for Muon Transport Completed and Delivered!

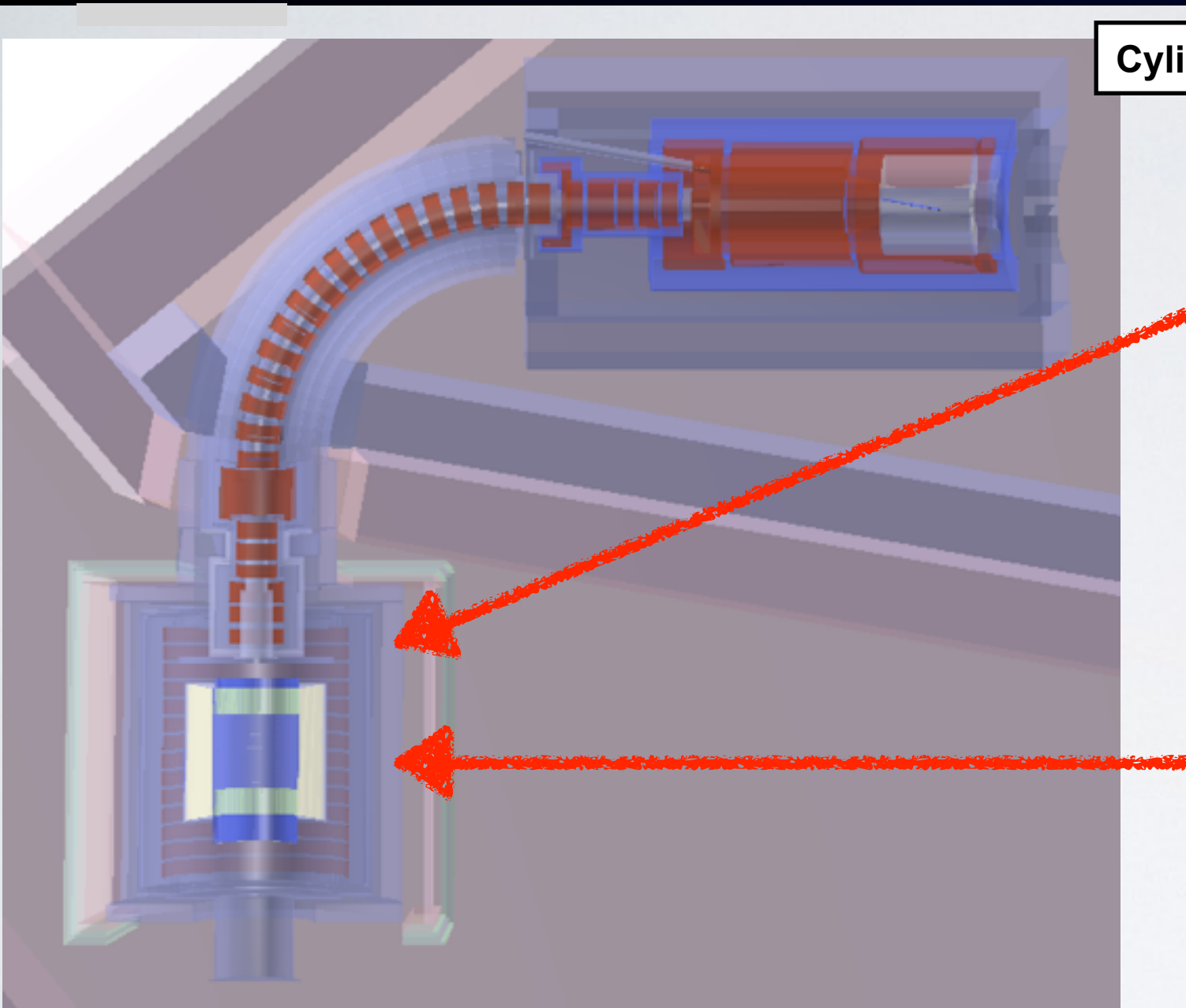


Curved Solenoids for Muon Transport Completed and Delivered!



March, 2015

Two Detectors for COMET Phase-I



Cylindrical Drift Chamber

Muon Stopping Target

Trigger Hodoscope

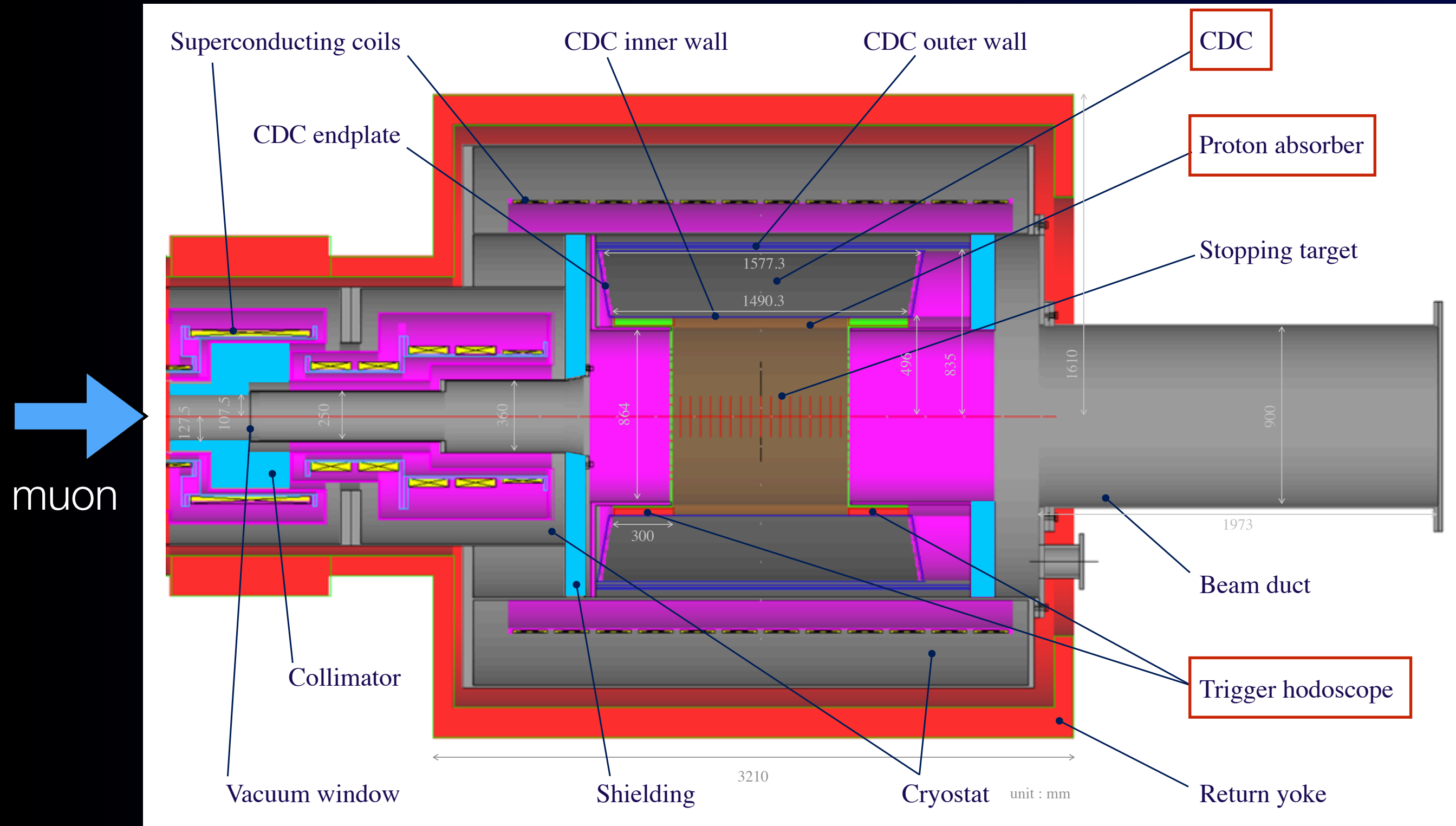
CyDet

Straw Tube Tracker

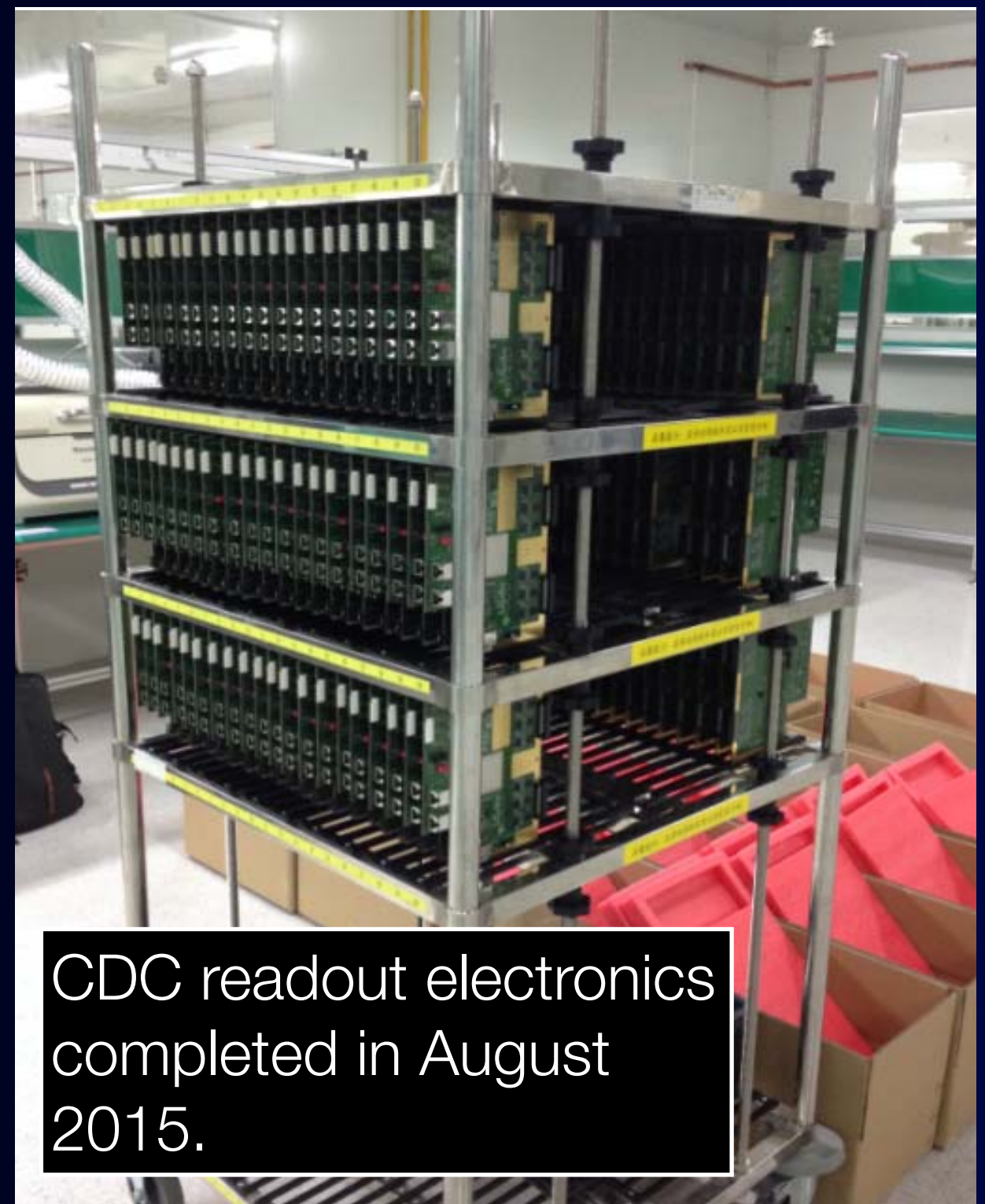
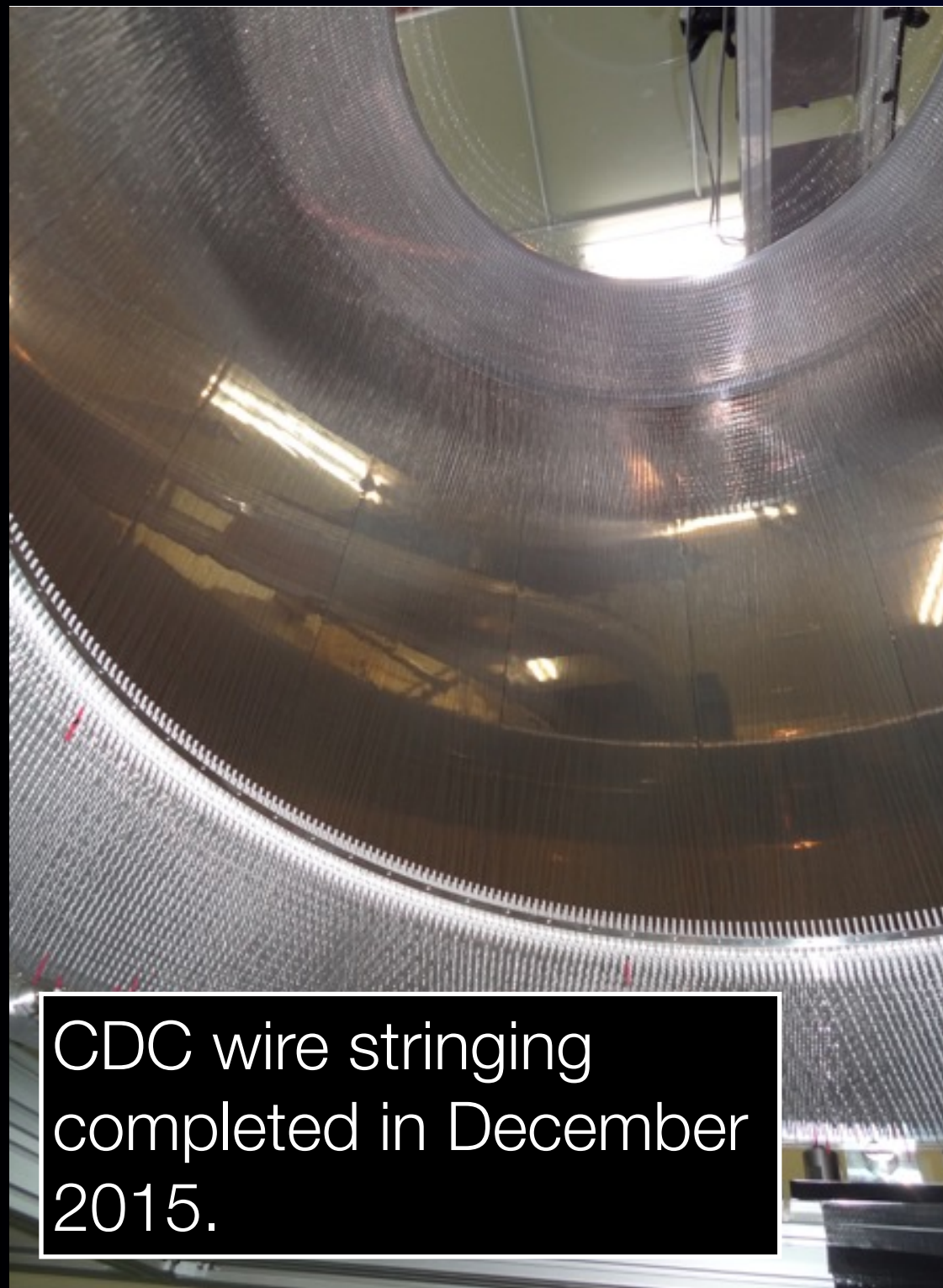
ECAL

StrECAL

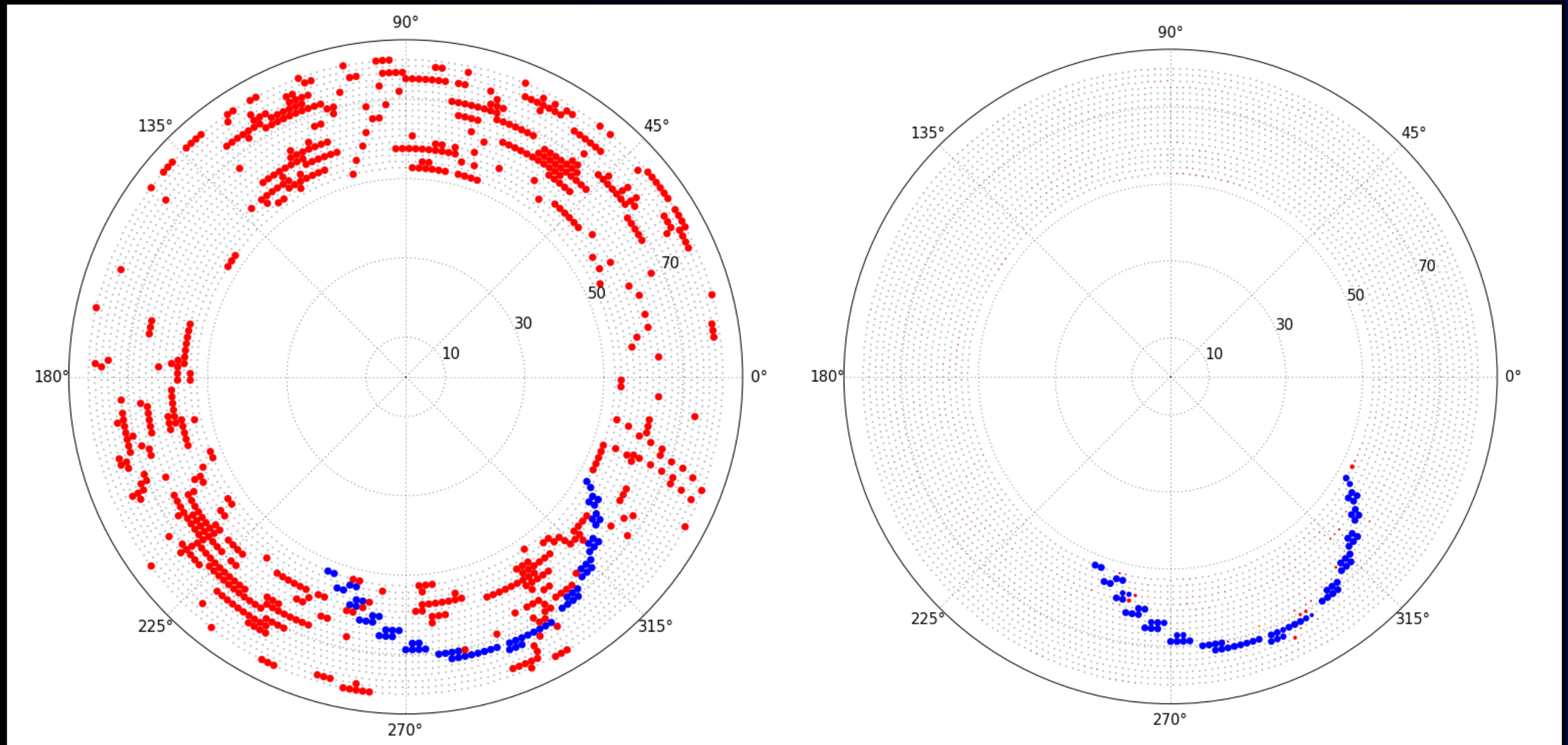
CyDet (Cylindrical Detector)



CDC Construction completed!



Tracking in COMET Phase-I Drift Chamber



based on Boosted Decision Tree Method and Hough transformation

COMET Phase-I Sensitivity



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})	0.93 $103.6 < p_e < 106.0 \text{ MeV/c}$
Timing window (ϵ_{time})	0.3 $700 < t_e < 1170 \text{ ns}$
Total	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

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} S.E.S. achievable in ~ 150 days of DAQ time corresponds to $N_\mu = 1.5 \times 10^{16}$

COMET Phase-I Backgrounds



Type	Background	Estimated events
Physics	Muon decay in orbit	0.01
	Radiative muon capture	0.0019
	Neutron emission after muon capture	< 0.001
	Charged particle emission after muon capture	< 0.001
Prompt Beam	* Beam electrons	
	* Muon decay in flight	
	* Pion decay in flight	
	* Other beam particles	
	All (*) Combined	≤ 0.0038
	Radiative pion capture	0.0028
	Neutrons	$\sim 10^{-9}$
Delayed Beam	Beam electrons	~ 0
	Muon decay in flight	~ 0
	Pion decay in flight	~ 0
	Radiative pion capture	~ 0
	Anti-proton induced backgrounds	0.0012
Others	Cosmic rays [†]	< 0.01
Total		0.032

[†] This estimate is currently limited by computing resources.

Physics Programs



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

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

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

Majoron emission in muon DIO

QED corrections in muon DIO

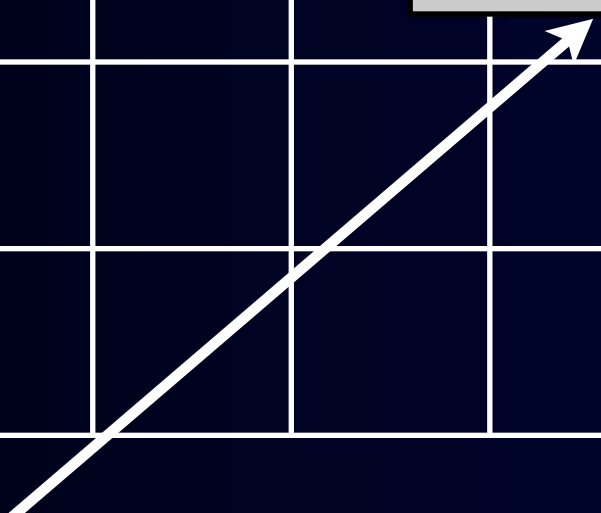
Schedule of COMET Phase-I and Phase-II

[illegible]

Schedule of COMET Phase-I and Phase-II



	JFY	2015	2016	2017	2018	2019	2020	2021	2022	2023
COMET Phase-I	construction									
	data taking									
COMET Phase-II	construction									
	data taking									



COMET Phase-I :
2018 ~
S.E.S. $\sim 3 \times 10^{-15}$
(for 150 days
with 3.2 kW proton beam)

Schedule of COMET Phase-I and Phase-II



	JFY	2015	2016	2017	2018	2019	2020	2021	2022	2023
COMET Phase-I	construction									
	data taking									
COMET Phase-II	construction									
	data taking									

COMET Phase-I :
 2018 ~
 S.E.S. $\sim 3 \times 10^{-15}$
 (for 150 days
 with 3.2 kW proton beam)

COMET Phase-II :
 2022 ~
 S.E.S. $\sim (1.0-2.6) \times 10^{-17}$
 (for 2×10^7 sec
 with 56 kW proton beam)

Summary



- Flavor Physics at Intensity Frontier, in particular CLFV, would give the best opportunity to search for BSM.
- Muon to electron conversion could be one of the important CLFV processes.
- COMET Phase-I is aiming at S.E. sensitivity of 3×10^{-15} (**10,000 improvement**)
 - The measurement will start in early 2018-2019.
- COMET (Phase-II) at J-PARC is aiming at S.E. sensitivity of $(1.0-2.6) \times 10^{-17}$. (**100 improvement**) after Phase-I.

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my dog, IKU



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my dog, IKU



New collaborators are welcome.



Thank you!



Thank you!



COMET character