Muon flux at the MuSIC beamline

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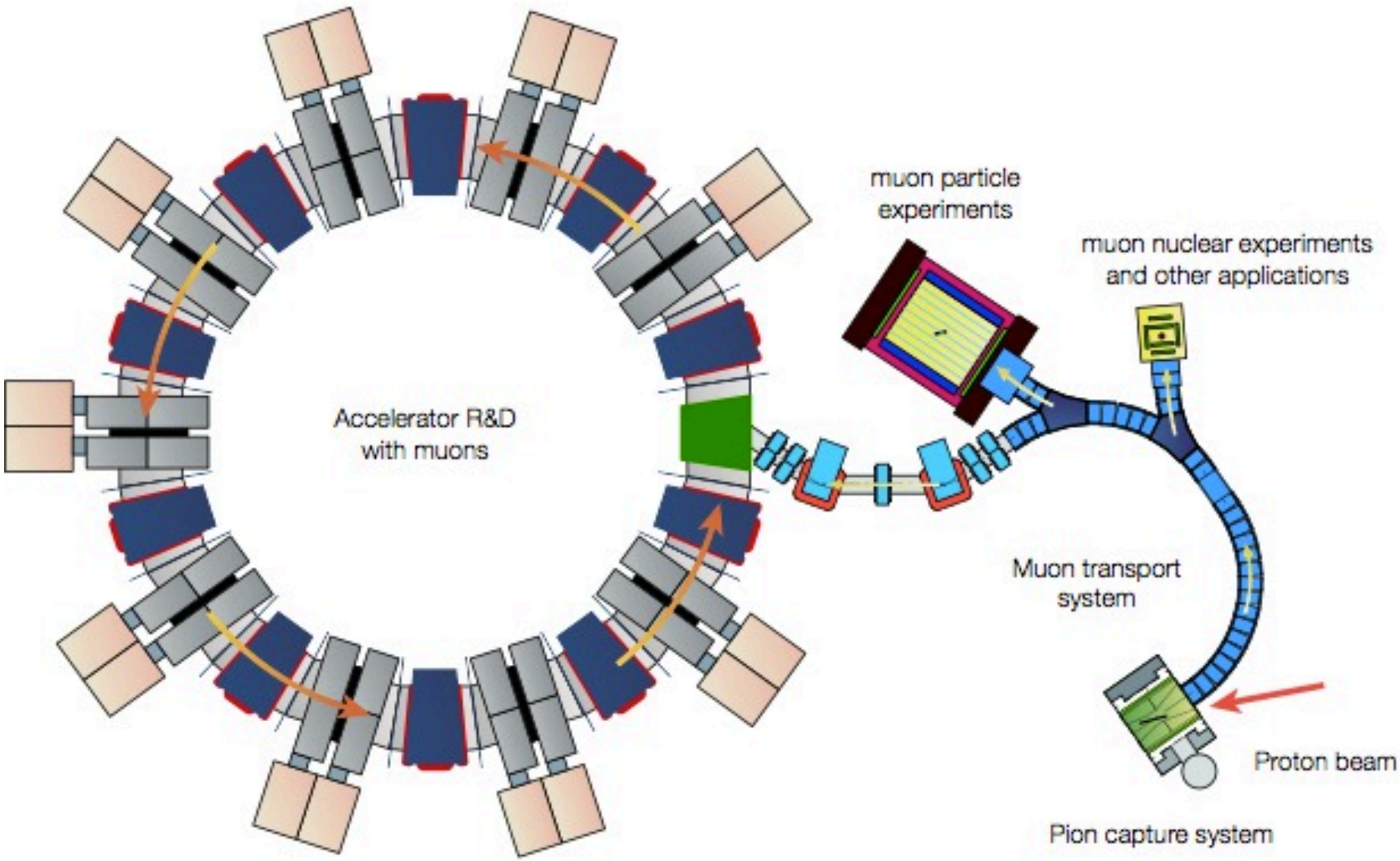
Outline

- What is MuSIC?
- Motivation
- Current status
- Initial measurements
- Simulation
- Conclusion

What is MuSIC?

- Muon Science Innovative Commission
- Aims to be the world's most efficient muon source
  - Target of producing >10^8 muon/sec using only 400W proton beam
- Currently under construction at the RCNP, Osaka, Japan
- Uses the 400W proton cyclotron and a novel system to maximise muon production

MuSIC


muon particle
experiments
muon nuclear experiments
and other applications
Accelerator R&D
with muons
Muon transport
system
Proton beam
Pion capture system

Why have an intense muon beam?

- Charged Lepton Flavour Violation (cLFV)
  - > 10^8 muon/sec ($\mu \rightarrow eee$)
  - > 10^{11} muon/sec ($\mu N \rightarrow eN$)
  - > 10^{11} muon/sec ($\mu \rightarrow e\gamma$)
- Neutrino factories: 10^{12} muons/sec
- Muon collider: >10^{14} muons/sec

Physics at MuSIC

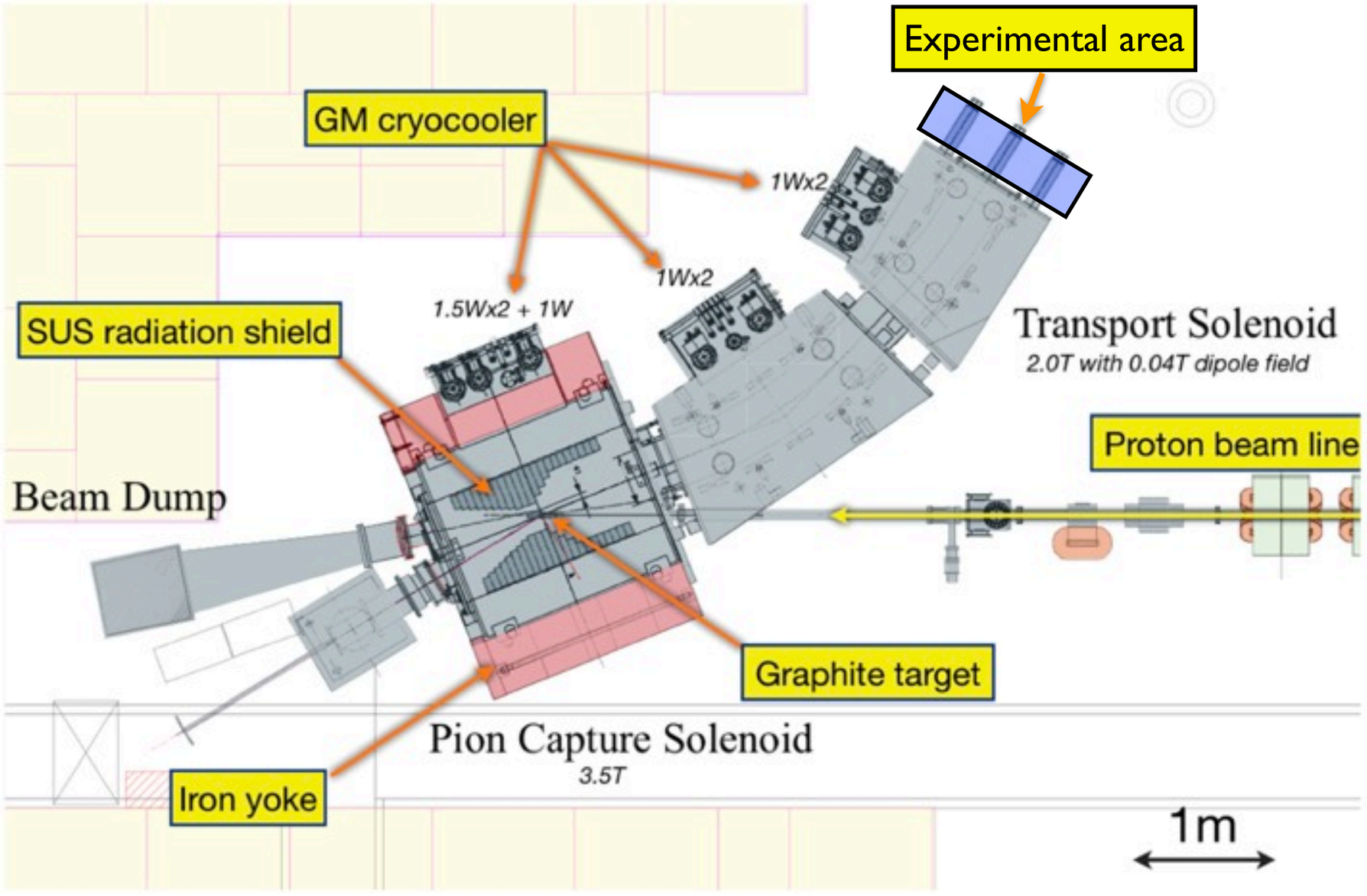
- cLFV searches ($\mu \rightarrow eee$)
- Muon storage/acceleration rings (Fixed Field Alternating Gradient systems)
- Feasibility studies for COMET/PRISM
  - Proof of proton to muon efficiency
  - Testing of the capture solenoid

MuSIC: comparison

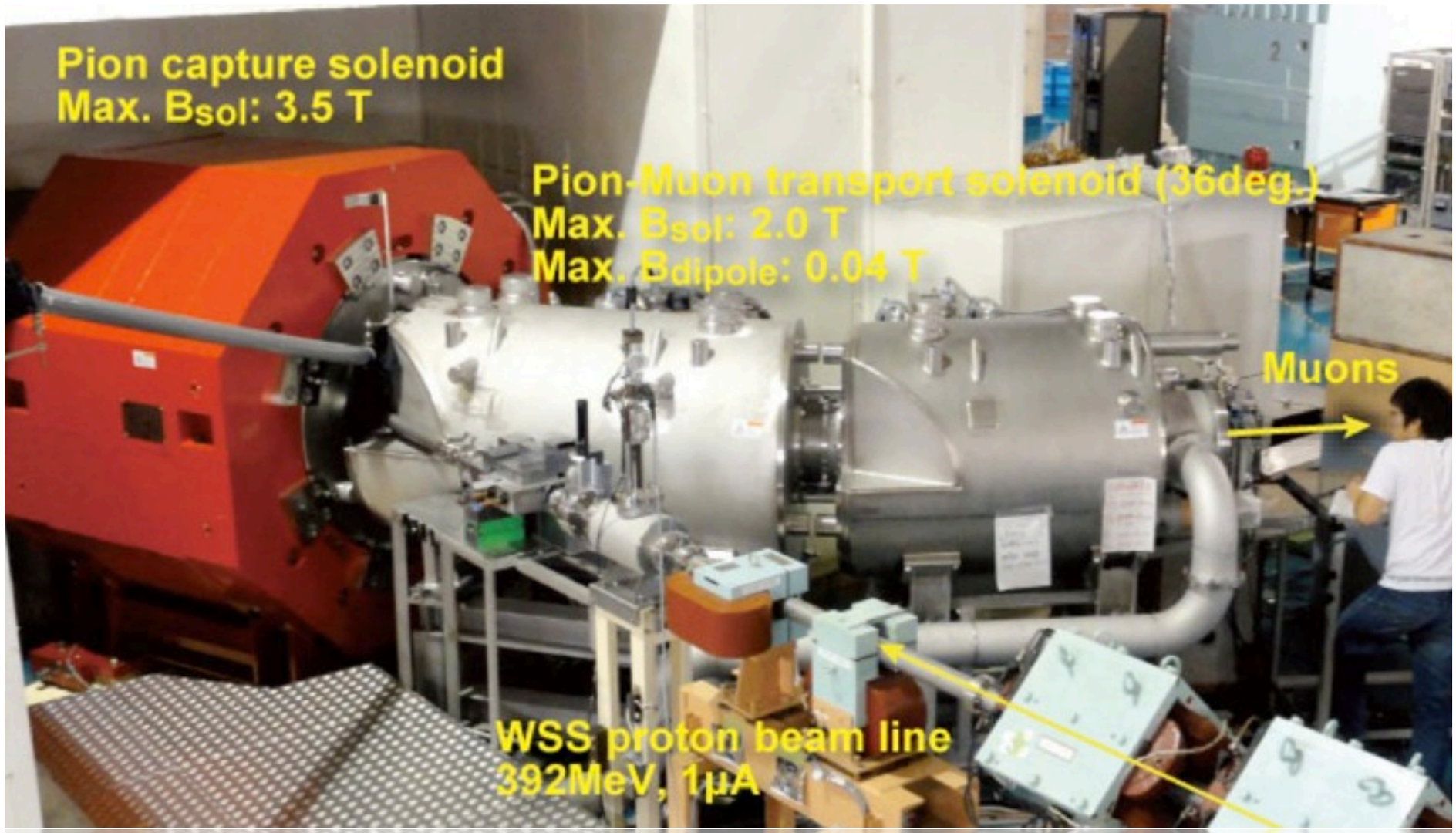
	PSI[1] (μE4)	MuSIC	COMET[2]	NuFACT[3]
Muon intensity (/sec)	3.5×10^{8}	$10^{8\text{-}9}$	10^{11}	$10^{12\text{-}13}$
Proton beam energy (GeV)	0.590	0.4	8	8
Proton beam power (W)	1.2M	400	56k	4M
Production efficiency (muon/W)	292	$2.5\times10^{5\text{-}6}$	1.7×10^{6}	$2.5\times10^{5\text{-}6}$
Time structure	Continuous	Continuous	Pulsed	Pulsed
Muon momentum (MeV/c)	85-125[4]	20-70	20-70	170-500
Beam current (μA)	1.8	1	7	Not given
Production target	Graphite	Graphite	Tungsten	Mercury jet
Max Solenoid Field Strength (T)	5.0	3.5	5.0	20

(1) *Based on: "A New High-intensity, Low-momentum Muon Beam for theGeneration of Low-energy Muons at PSI", Prokscha, T.; Morenzoni, E.et al. (Hyperfine Interactions, Vol.159, Issue 1-4, pp. 385-388)*
(2) *COMET CDR*
(3) *Based on The Muon Collider/Neutrino Factory Target System, H.Kirk and K.McDonald (Aug.14,2010) and Study-II report*
(4) *Range over all beamlines*

Current Status

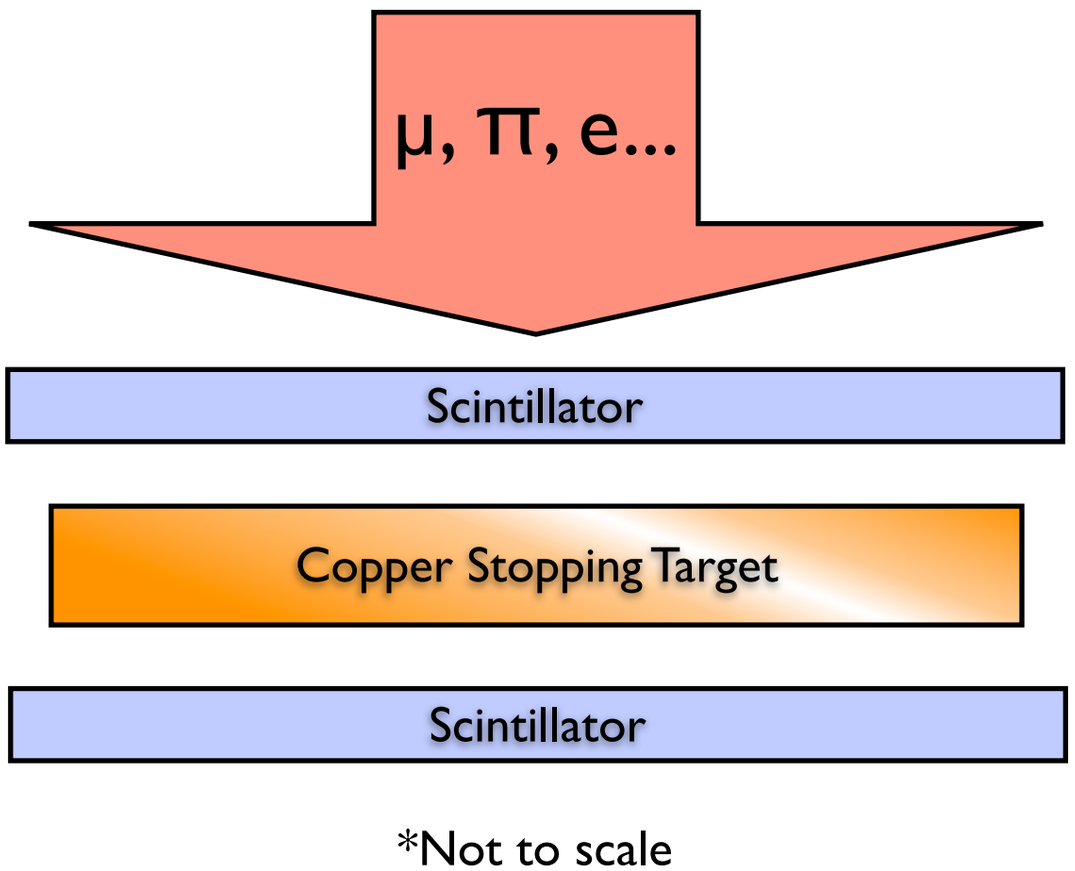


Current Status



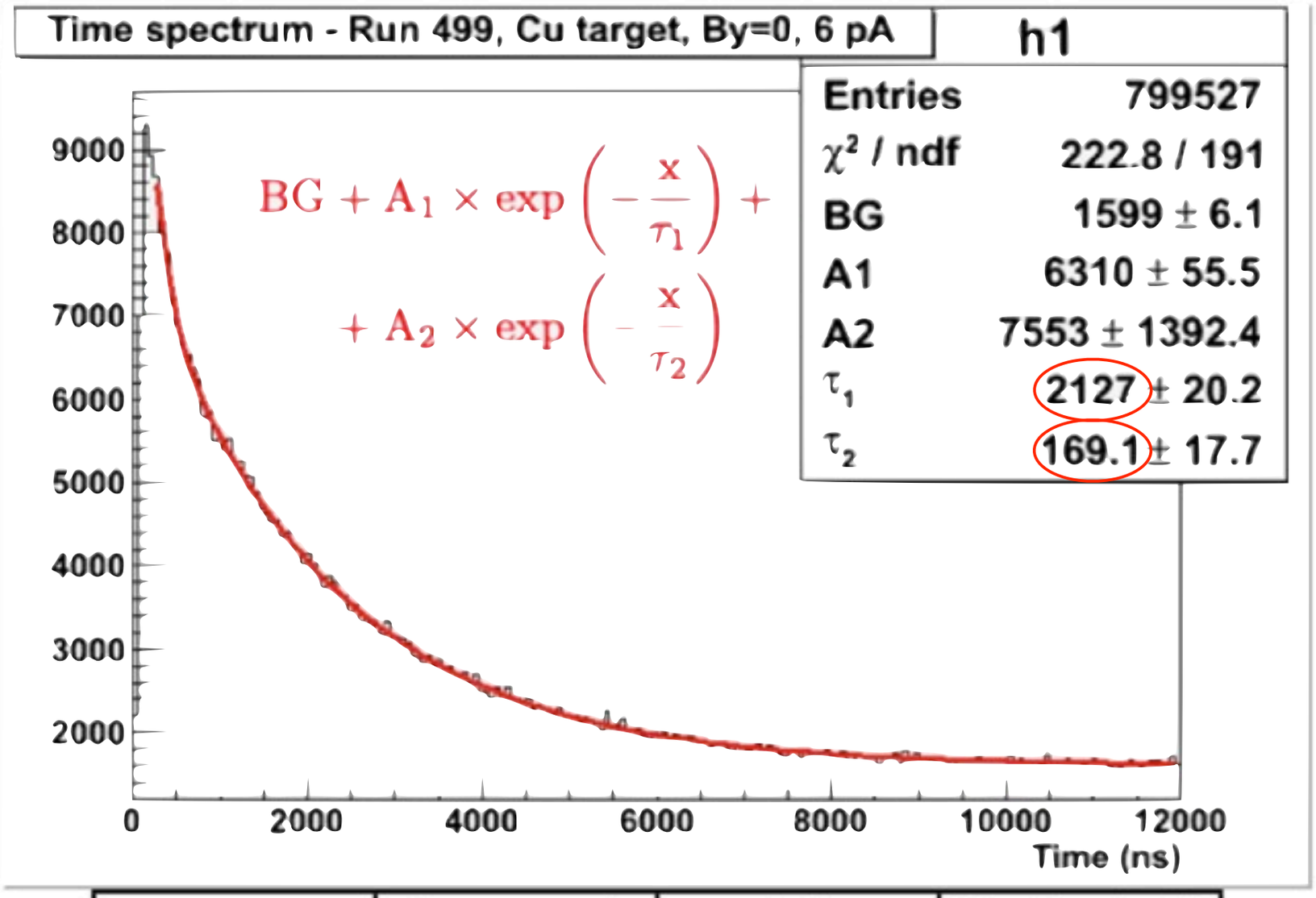
Initial measurements of the muon flux

- Measurement made by counting muon decays
- Only a 2.4mW proton beam was used
  - 400MeV at 6pA
- 1.3×10^3 muons/sec flux measured
  - 5.4×10^5 muons/W
- At 1μA the flux should be 2.2×10^8 muons/sec



*Not to scale

Muon half life measurement



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

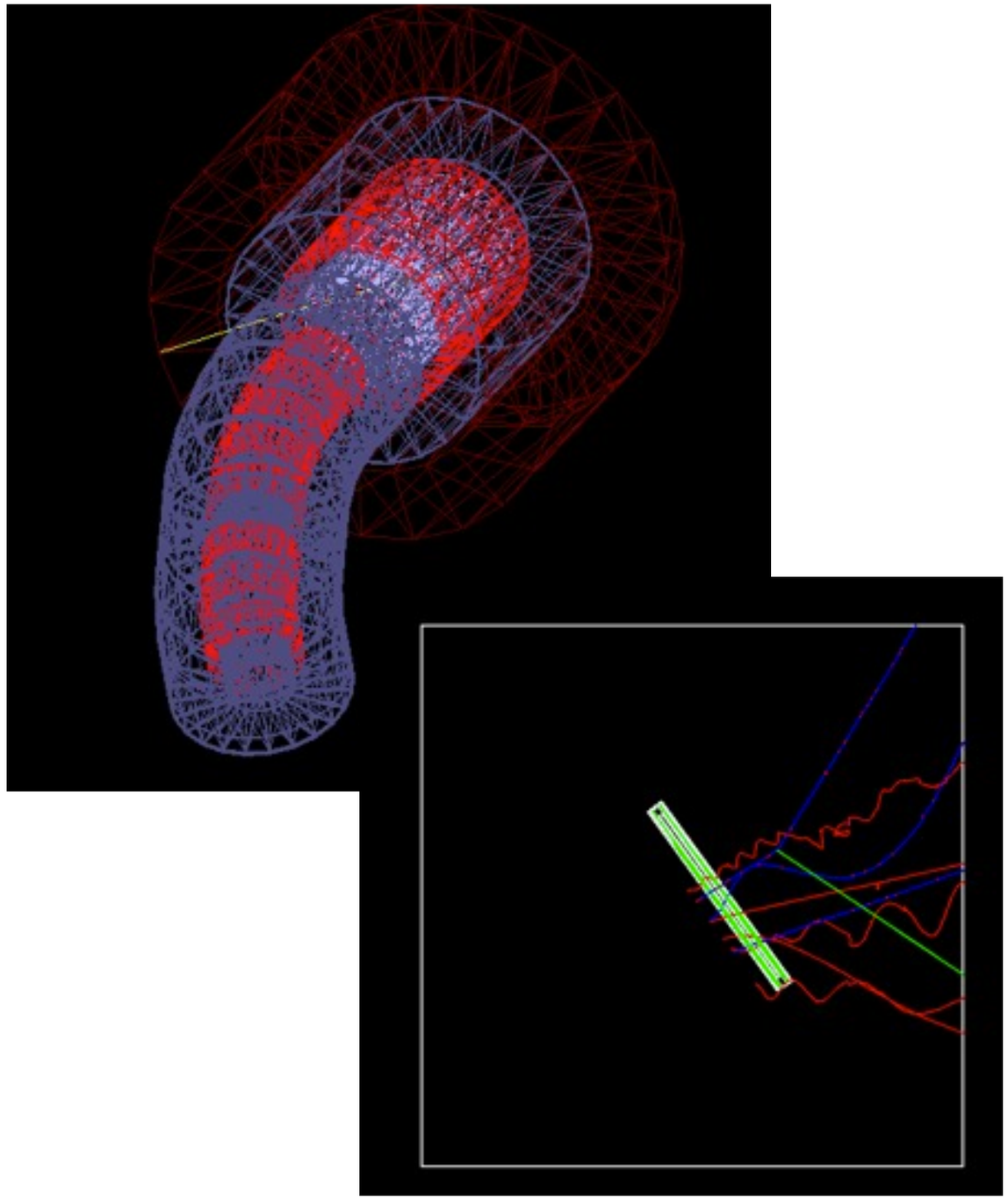
*http://pdg.lbl.gov

**DOI: 10.1103/PhysRevC.35.2212

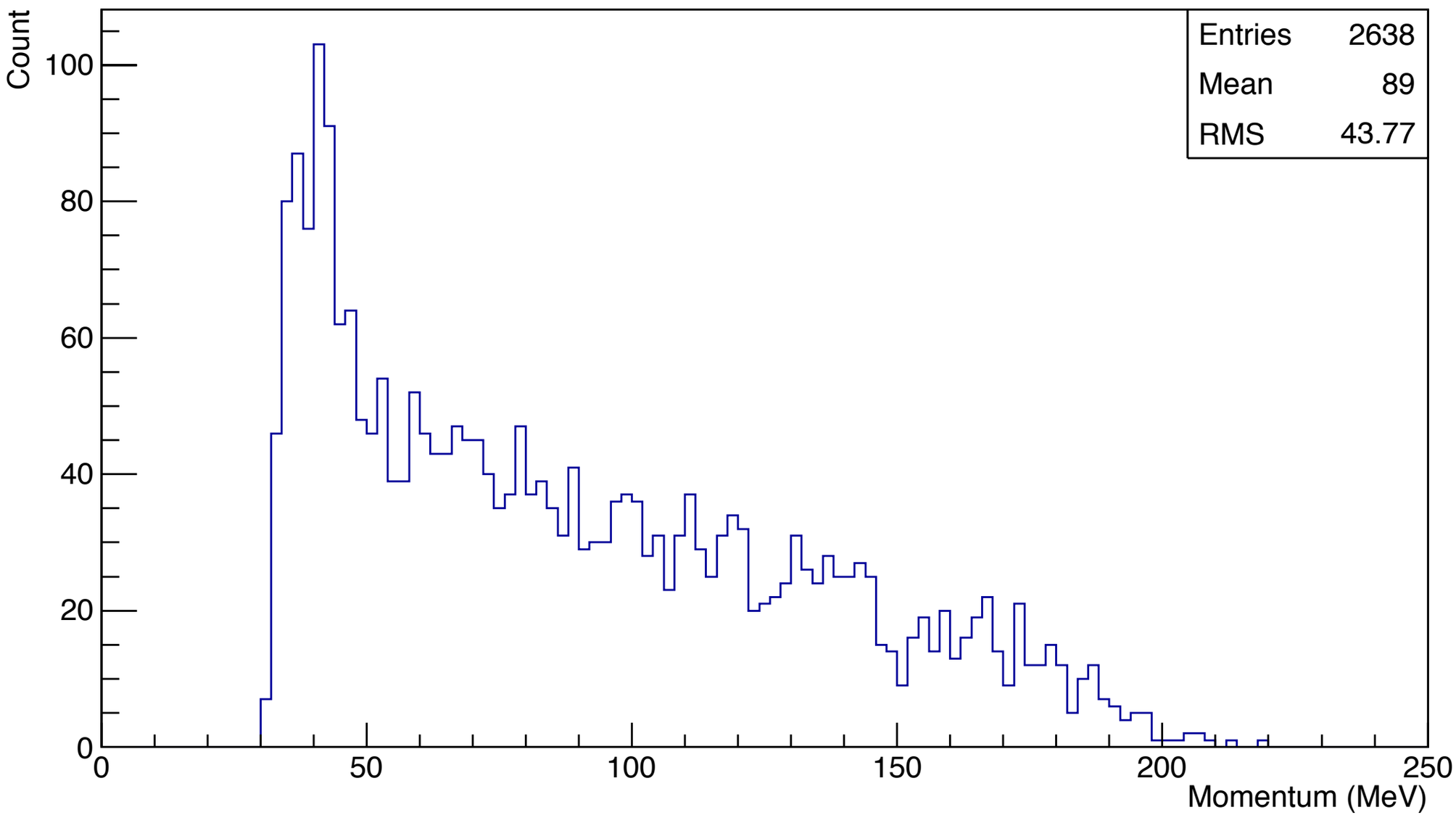
Plot courtesy of Tran Hoai Nam, Osaka University

Simulation of MuSIC

- System developed using G4beamline and geant4
- Currently analysing the initial simulation results to verify it against the muon flux measurements
- Hope to make strong predictions of the momentum distribution for future beamtime



Simulation results



- Prediction of the muon momentum for the next beamtime
- The simulation will also be used to verify the flux measurement

Conclusion and future plans

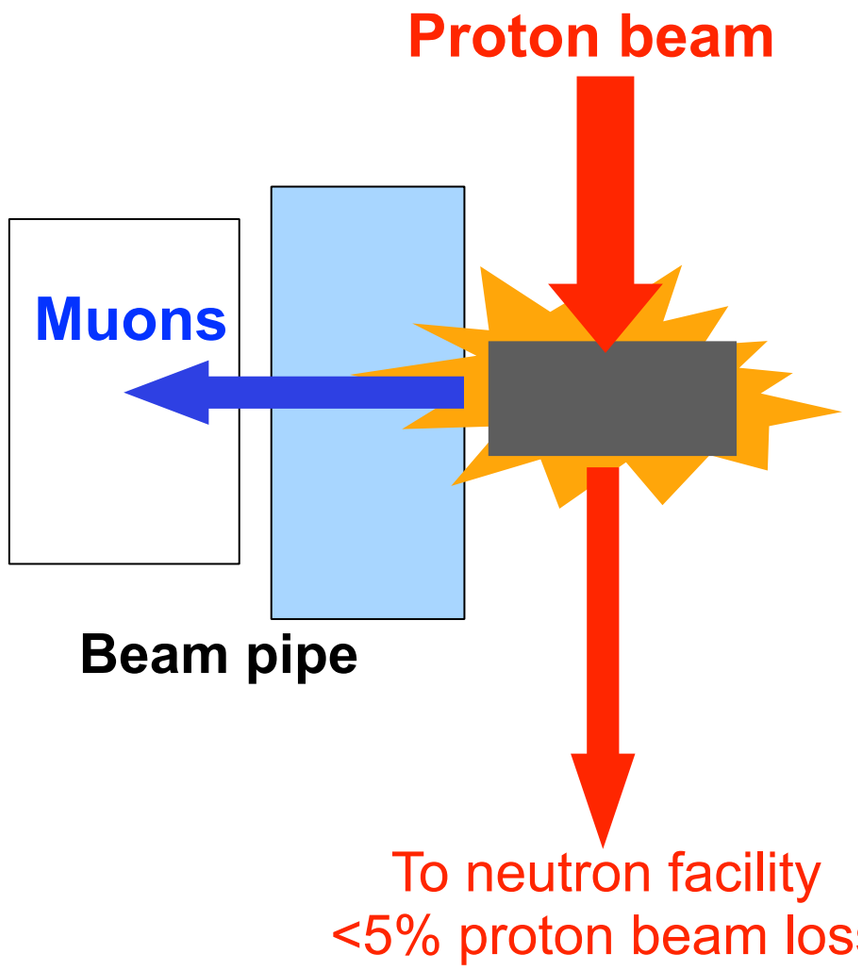
- MuSIC has world beating muon production
- Will hopefully soon be the most intense muon beam in the world
- I hope to finish the analysis of simulation data
- Confirm the 2011 muon flux measurement
- Make a definitive measurement of the muon momentum distribution during the next beam time (June)

Thank you

Any Questions?

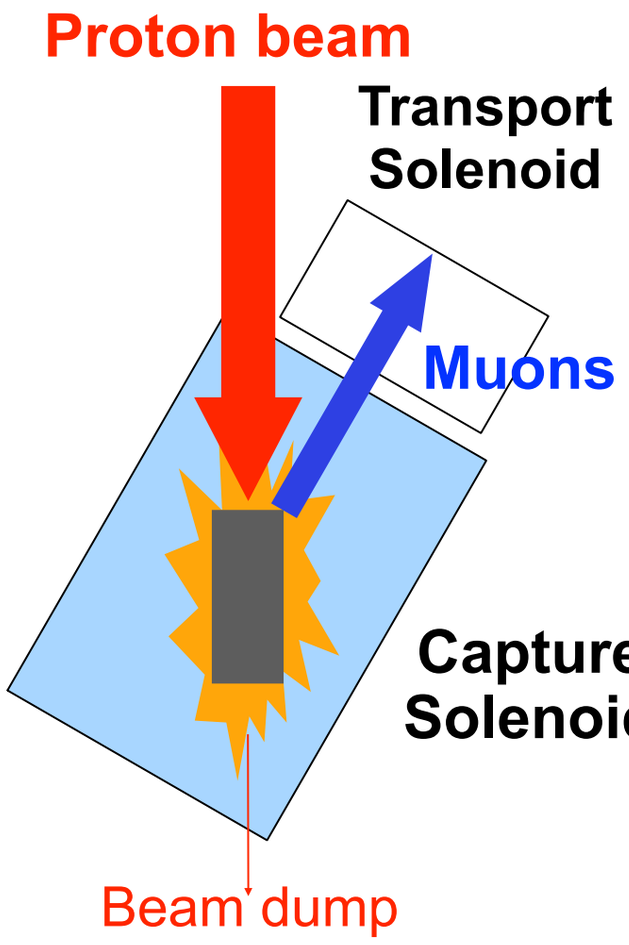
MuSIC: what's so novel?

Conventional design



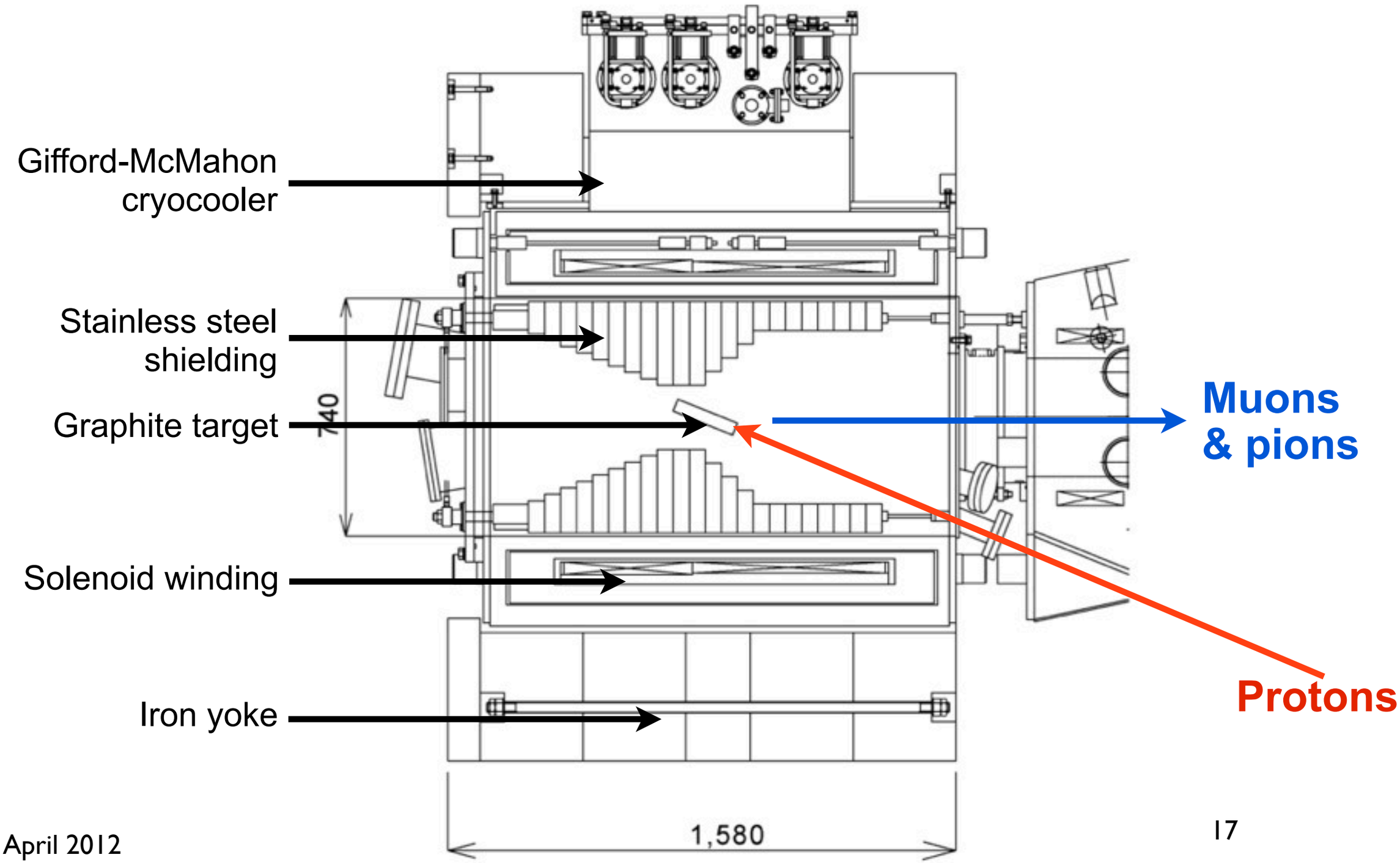
- Graphite target t=20mm φ=70mm
- Use only a fraction of the beam
- Small solid angle (400mSr for the Super Omega beamline)
  (values based on J-PARC MUSE)

MuSIC's design



- Graphite target t=200mm φ=40mm
- Use all of the beam
- 2πSr solid angle (only backwards particles collected)

Pion capture solenoid design (3.5T field)



Best limits for cLFV

Process	Limit	Collaboration
$\mu^- \rightarrow e^- e^+ e^-$	$<1.0 \times 10^{-12}$	SINDRUM
$\mu^- \rightarrow e^- \gamma$	$<1.2 \times 10^{-11}$	MEGA
$\mu^- Au \rightarrow e^- Au$	$<7 \times 10^{-13}$	SINDRUM II

Values from: : K. Nakamura et al. (Particle Data Group), JP G 37, 075021 (2010) and 2011 partial update for the 2012 edition (URL: http://pdg.lbl.gov)