

NUFACT WG4 – Muon Physics

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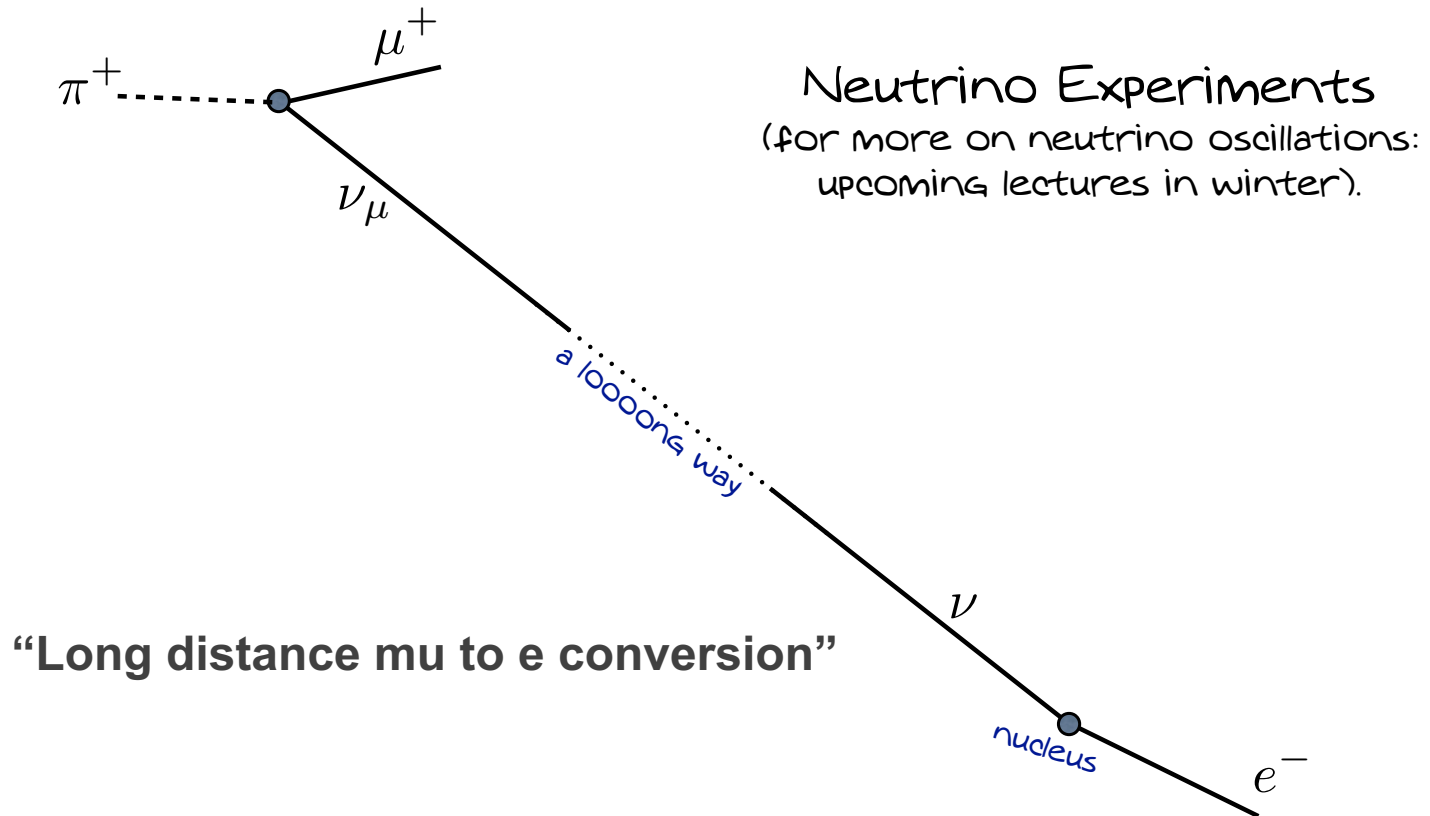
Yuri Oksuzian (ANL, USA)

NUFACT, Aug 26, 2019

Why Muon Physics in Neutrino Conference?

- Physics
 - Looking for BSM in Leptonic sector
 - BSM in neutrino may yield BSM effect in Muon
 - Good example : muon charged lepton flavor violation
 - Standard model estimation : $O(10^{-50})$ via neutrino oscillation
 - Sterile neutrino may increase this rate

CLFV was Observed!

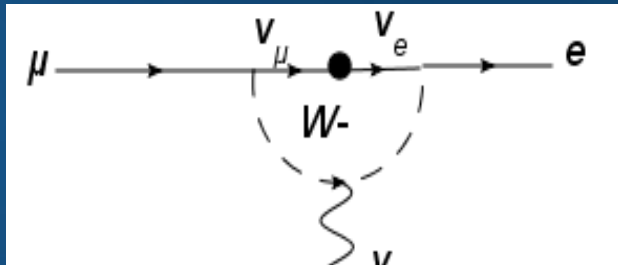


R.Harnik (FNAL), “CLFV theory”, The Allure of Ultrasensitive Experiments (2014)

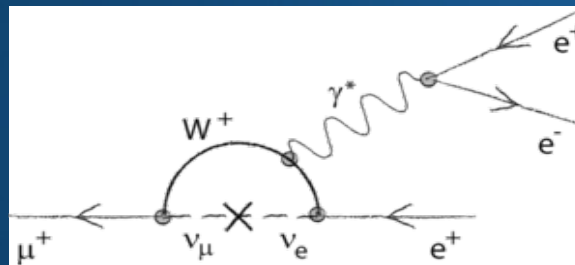
Muon CLFV

$$\mu \rightarrow e \gamma$$

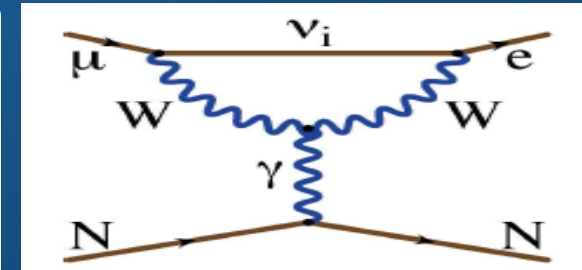
In SM



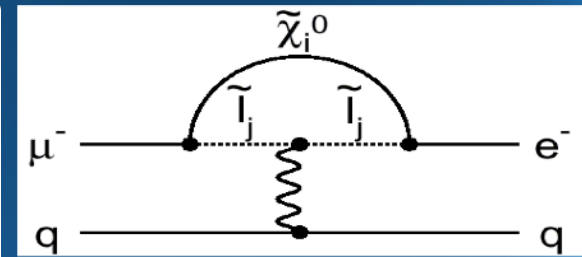
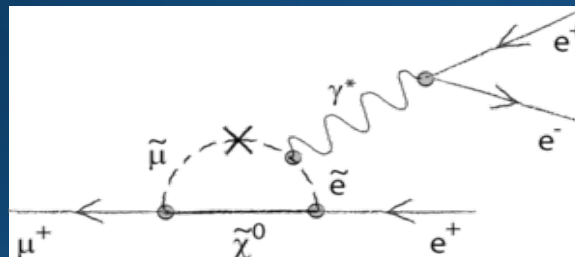
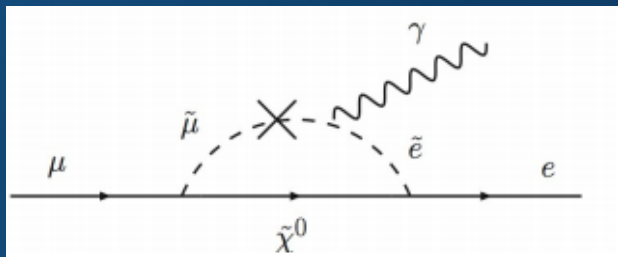
$$\mu \rightarrow 3e$$



$$\mu N \rightarrow e N$$



In BSM (SUSY)



Why Muon Physics in Neutrino Conference?

- Facility
 - Neutrino beam from accelerator = Muon beam
 - (Roughly) vice versa

Worldwide Muon Sources

TRIUMF (Canada)

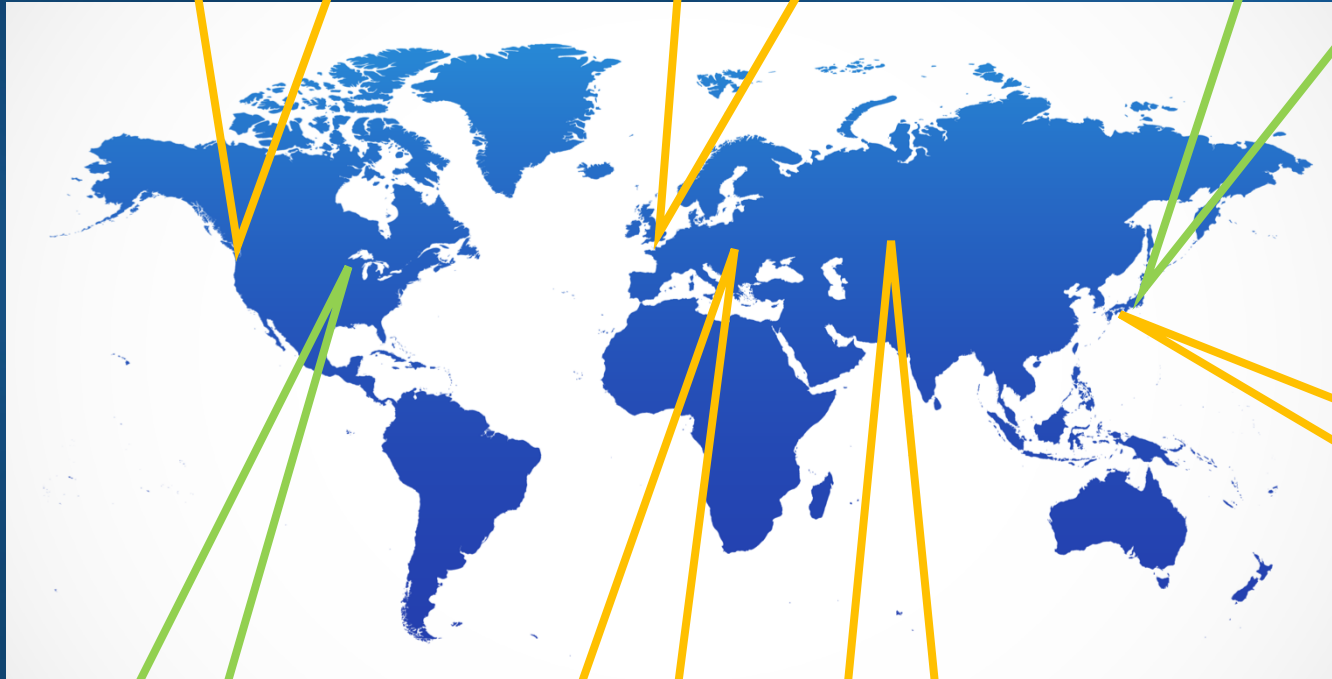
$2 \times 10^6 \mu^+/\text{s}$

RAL (UK)

$6 \times 10^5 \mu^+/\text{s}$, $7 \times 10^4 \mu^-/\text{s}$

J-PARC (Japan)

$6.4 \times 10^7 \mu^+/\text{s}$, $1 \times 10^{11} \mu^-/\text{s}$



RCNP (Japan)

$7 \times 10^5 \mu^+/\text{s}$,
 $10^5 \mu^-/\text{s}$

Fermilab (USA)

$5 \times 10^{10} \mu^-/\text{s}$

PSI (Switzerland)

$4 \times 10^8 \mu^+/\text{s}$,
 $10^8 \mu^-/\text{s}$

JINR (Russia)

$10^5 \mu^+/\text{s}$

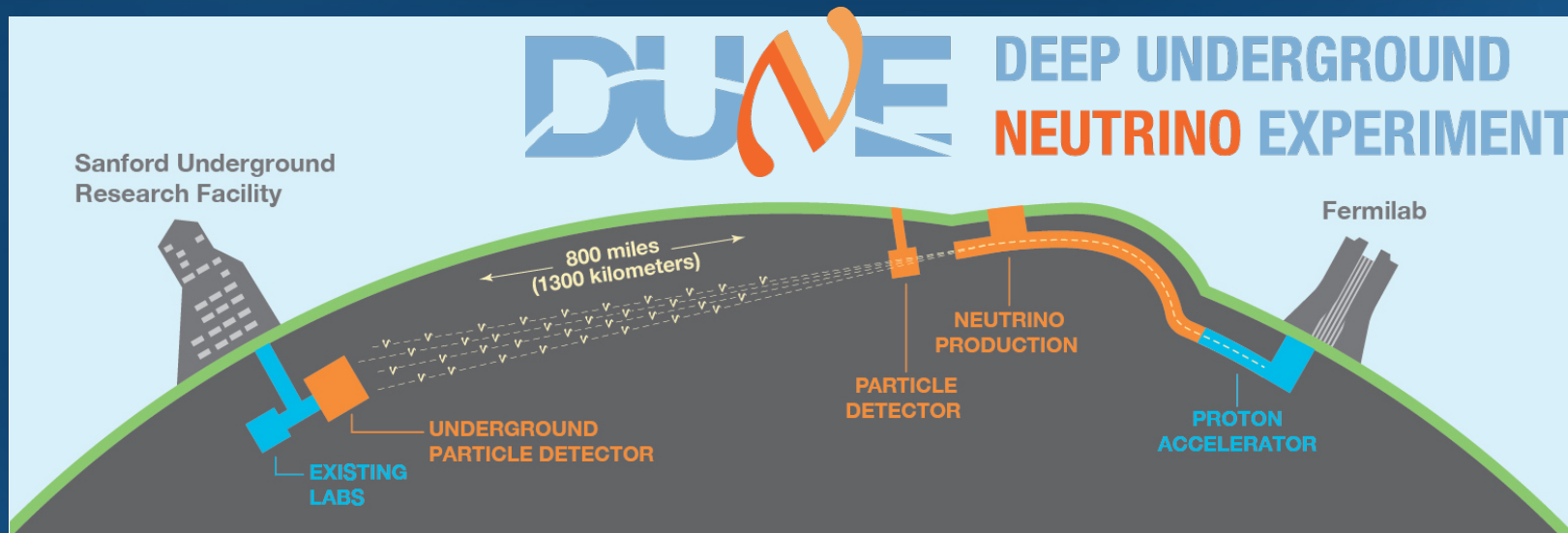
DC Muon beam

Pulsed Muon beam

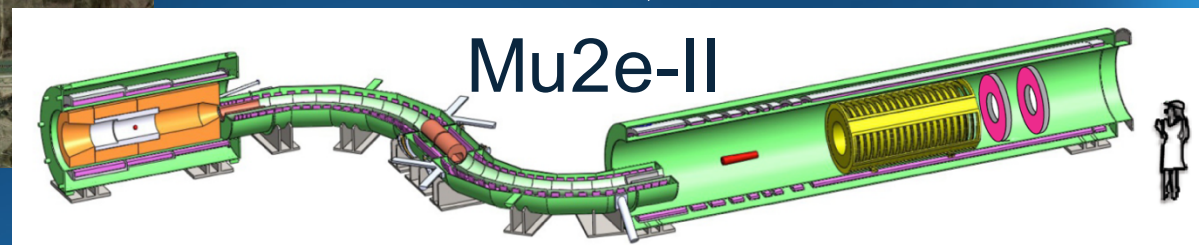
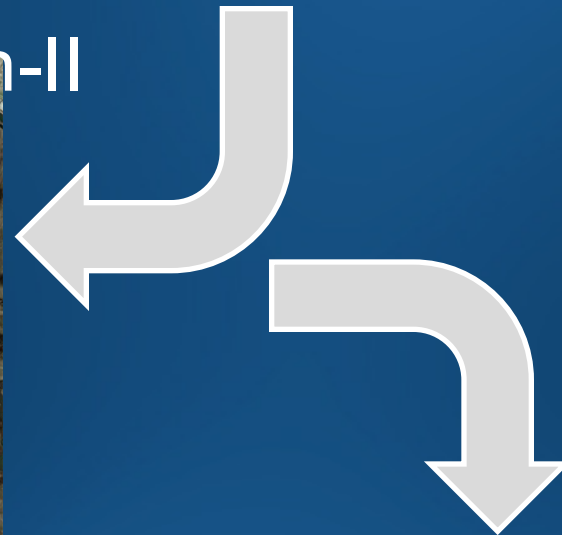
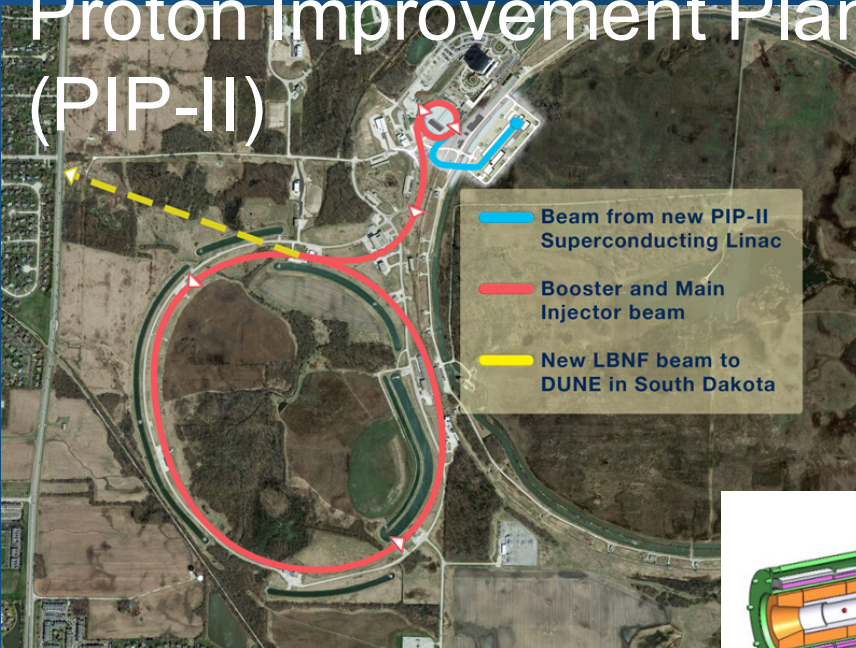
(= **Neutrino factory**)

Why Muon Physics in Neutrino Conference?

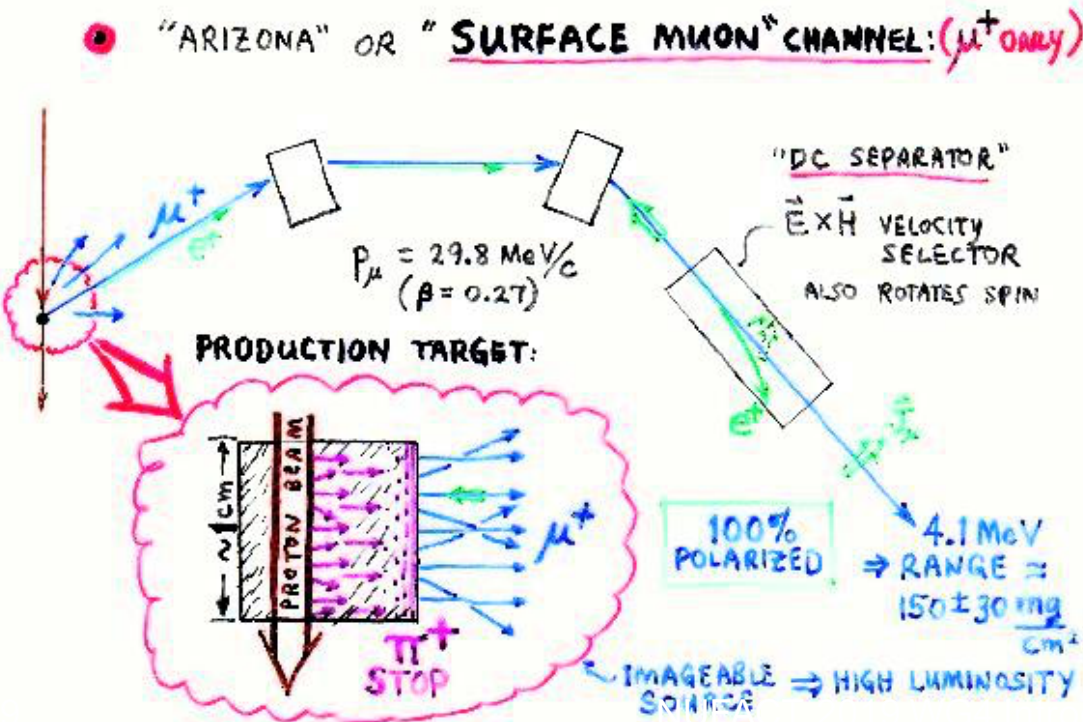
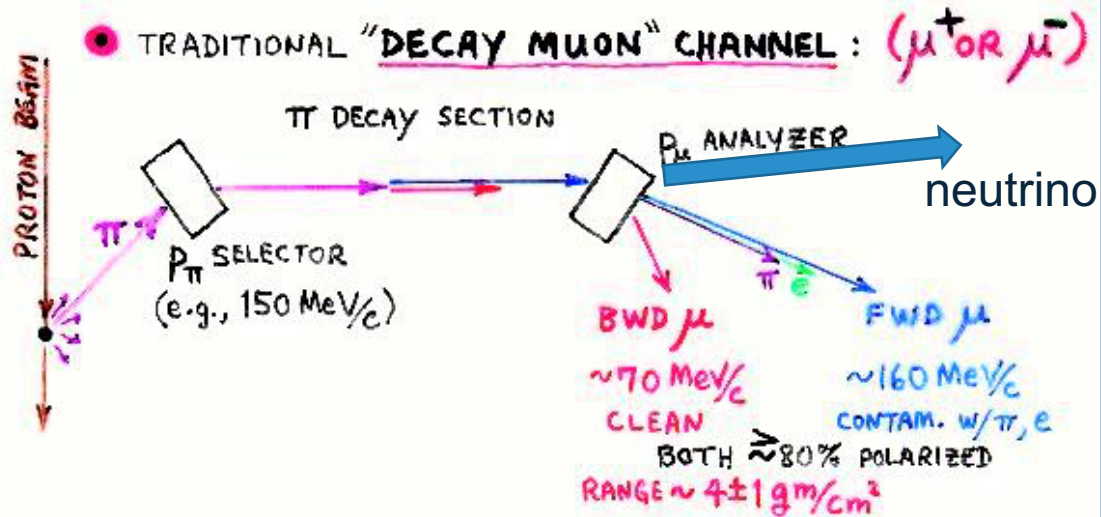
- Facility
 - Neutrino beam from accelerator = Muon beam
 - (Roughly) vice versa
 - Higher intensity neutrino experiments with accelerator
 - ⇒ Proton power increase
 - ⇒ Higher intensity muon experiment



Proton Improvement Plan-II (PIP-II)



BEAMLINES for POLARIZED MUONS:



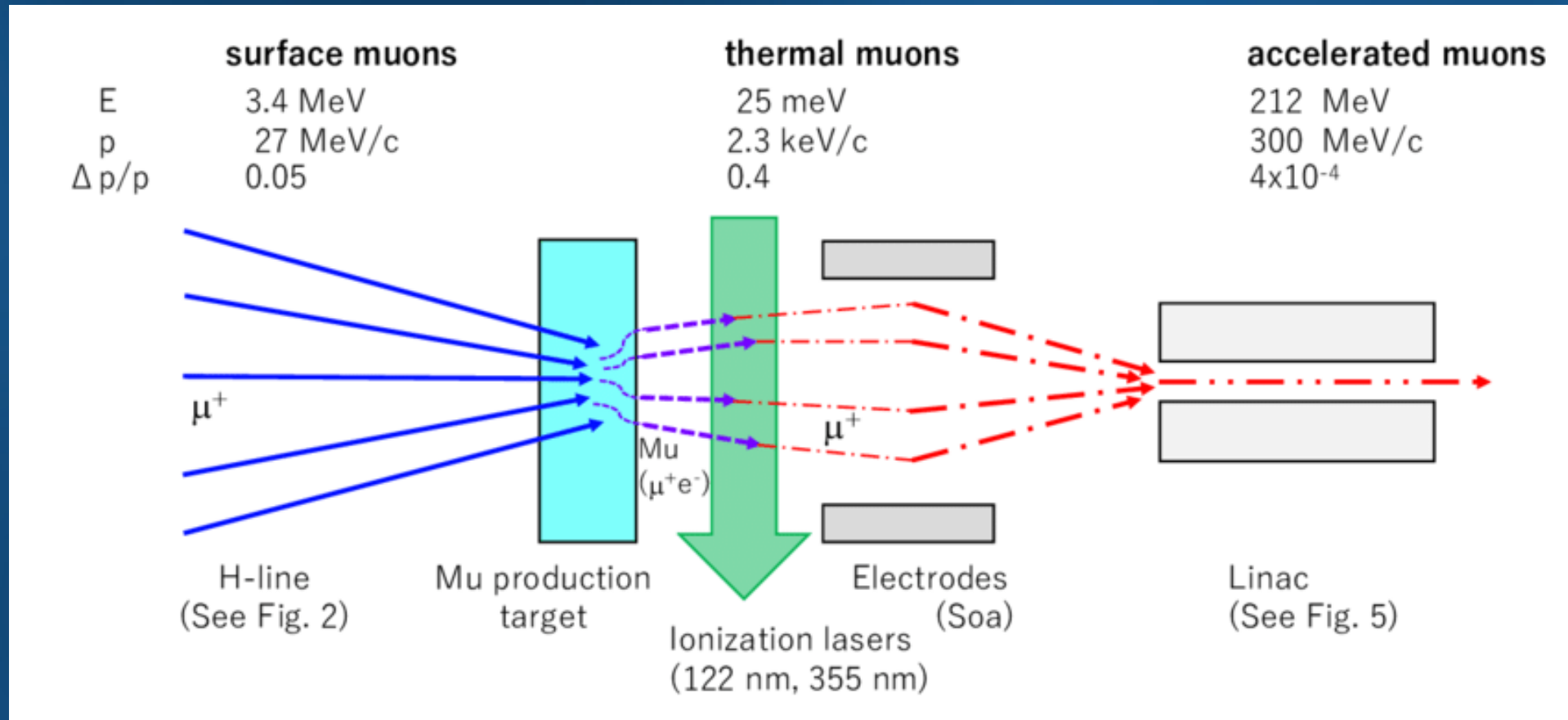
Note:
Not always
neutrinos are
generated
from muon

Slide by Jess H. Brewer (1977)
See <http://musr.net>

Decoupling between muon / neutrino physics

- CLFV involves neutrino oscillation within “Standard Model”
 - What if the contact interaction is the source CLFV?
- Not always neutrino beam are generated when generating muon in accelerator
 - Surface muon, which is more popular
- New trend of muon beam is “cold muon beam”
 - From surface muon
- Muon experiment may not get benefit from the higher power proton beam
 - Limited by detector technology - disfavoring higher intensity
 - Limited by the production rate of muonic atom ($N-\mu^-$) or muonium (μ^+-e^-) – favoring higher intensity

Cold Muon : No Neutrino



Ultra cold muon beam generation in J-PARC g-2/EDM

Current Muon Experiments Trend

- g-2 experiment
 - Past (BNL), Current (FNAL), Future (J-PARC)
- CLFV experiment
 - $\mu \rightarrow e\gamma$, muon conversion, $\mu \rightarrow eee$
 - LFV with muon (or tau) , from LHC, Belle-II, BESIII
- Other (various) DC beam or muonium experiments
- New idea??

Suggested WG4 2019 Focus questions

(And long lasting questions)

- Q1: Neutrino/Muon Physics: (Overlaps with WG1 and WG5)
 - What overlaps exist to BSM neutrino interactions?
 - How would BSM physics manifest in the muon/precision measurements sector and in the neutrino sector?
 - (Are they related each other? How?)
- Q2: Beam/Machine/Detector Design: (Overlaps with WG3)
 - What sensitivity can be reached with current or future facilities? Improved detectors? Increased beam power? What are the implications?
- Q3: Program Planning: (Overlaps with WG3)
 - How do you support the physics needs for both DC and pulsed beam experiments in the planning of new facilities?

More questions...

- What should be prepared to get benefit from super beam ?
- What will be the next generation experiment using pulsed muon beam ?
- How can we utilize cold or DC muon beam in BSM search ?

WG4 session: Aug 27

Aug 27 2pm: g-2 experiments

Status of Standard Model prediction for muon g-2	Daisuke Nomura
Status and Future Plans of the g-2 Experiment at Fermilab	Simon Corrodi
Muon g-2/EDM Experiment at J-PARC	Soohyung Lee
Spectroscopy of the Muonium Hyperfine Structure at J-PARC	Yasuhiro Ueno

Aug 27 4pm: European experiments

The MUSE experiment at PSI: Status and Plans	Wolfgang Lorenzon
Searches for lepton flavor and lepton number violation in K^+ decays (NA62)	Aigul Baeva
B-flavor anomalies in $b \rightarrow s \ell \ell$ and $b \rightarrow c \ell \nu$ transitions at LHCb	Adlene Hicheur
Search for BSM physics related to lepton universality and flavor anomalies with the ATLAS detector	Chunhui Chen

WG4 session: Aug 29

Aug 29 11am: muon cLFV

The hunt for lepton flavor violation with the Mu3e experiment	Sebastian Dittmeier
MEG II Status and Plan	Satoshi Mihara
Status of the DeeMe Experiment, an Experimental Search for μ -e Conversion at J-PARC MLF	Natsuki Teshima

Aug 29 2pm: muon cLFV

Status of COMET Phase-I muon conversion experiment in J-PARC	Tinanyu Xing
Searching for Muon to electron conversion : The Mu2e experiment at Fermilab	Richard Bonventre
Mu2e-II : next generation muon conversion experiment	Yuri Oksuzian

WG4 session: Aug 30

Aug 30 2pm

Muon decay with light boson emission in muon atoms	Yuichi UESAKA
Status of the AICap experiment	Mark Wong
The Belle II Experiment: Status and Prospects	Kunxian Huang
Searches for LFV and LNV at Belle II	Tomoyuki Konno

Aug 30 4pm: New experimental concepts

Development of very slow negative muon beam	Hiroaki Natori
A search for Majoranality of neutrinos in muon decay using a positron polarimeter	Sohtaro Kanda
Non-standard interactions at a decay-at-rest experiment (MuDAR)	Sushant Raut
Invisible neutrino decays at the MOMENT experiment	Jian Tang

WG4 session: WG3 Joint session

Aug 29 4pm : WG3 + WG4 Joint session

Progress and scientific activities of the Japanese DC muon facility	Akira Sato
Status and Future Prospect of Muon Target at J-PARC MLF	Shunsuke Makimura
Development of next generation muon beams at Paul Scherrer Institute	Ryoto Iwai
Design and development of a tungsten pion production target for the Mu2e experiment	Christopher Densham
Mu2e Muon Beam Optimization	Helenka Casler

Aug 26 6pm : Poster session

A search for parity violation in muonic atoms using a segmented calorimeter	Sohtaro Kanda
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Summary

- We prepared >20 talks on the current Muon experiments and theories,
wishing to get some idea on the future experiments.
- Please Enjoy