Current Status and Future Prospects of J-PARC

July 26th - 30th, 2018

10th Workshop on Hadron physics in China and Opportunities Worldwide”

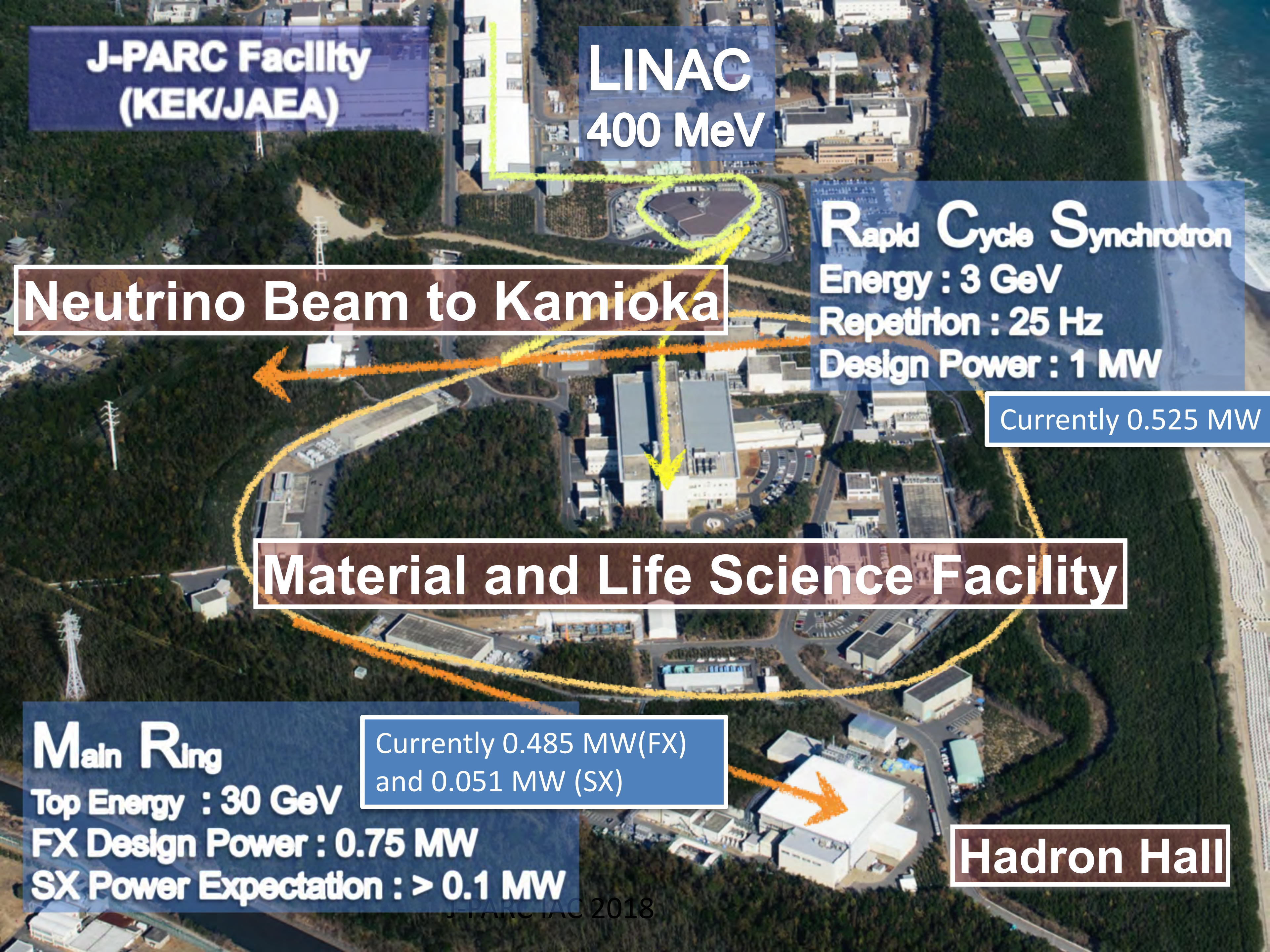
Shandong University, Weihai

Naohito SAITO (nsaito@post.j-parc.jp)

High Energy Accelerator Research Organization

Japan Atomic Energy Agency

J-PARC



J-PARC Facility (KEK/JAEA)

LINAC
400 MeV

Rapid Cycle Synchrotron
Energy : 3 GeV
Repetirion : 25 Hz
Design Power : 1 MW

Currently 0.525 MW

Neutrino Beam to Kamioka

Material and Life Science Facility

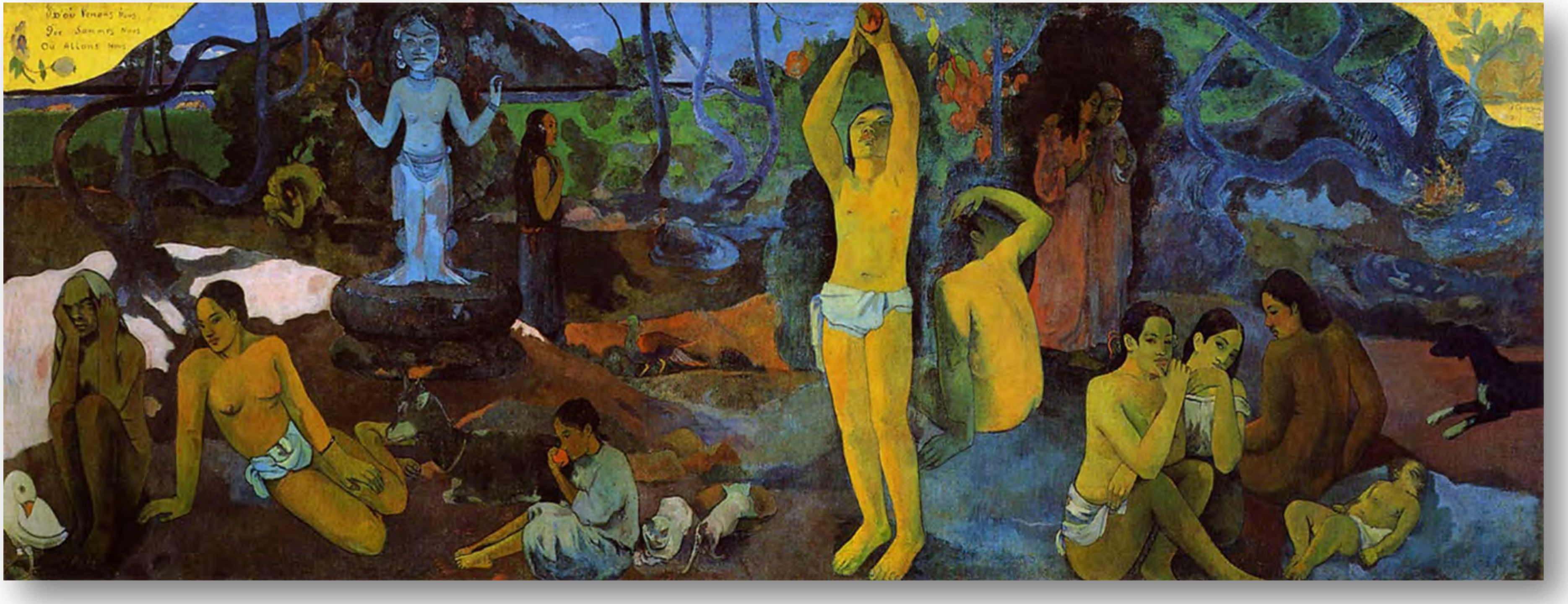
Main Ring
Top Energy : 30 GeV
FX Design Power : 0.75 MW
SX Power Expectation : > 0.1 MW

Currently 0.485 MW(FX) and 0.051 MW (SX)

Hadron Hall

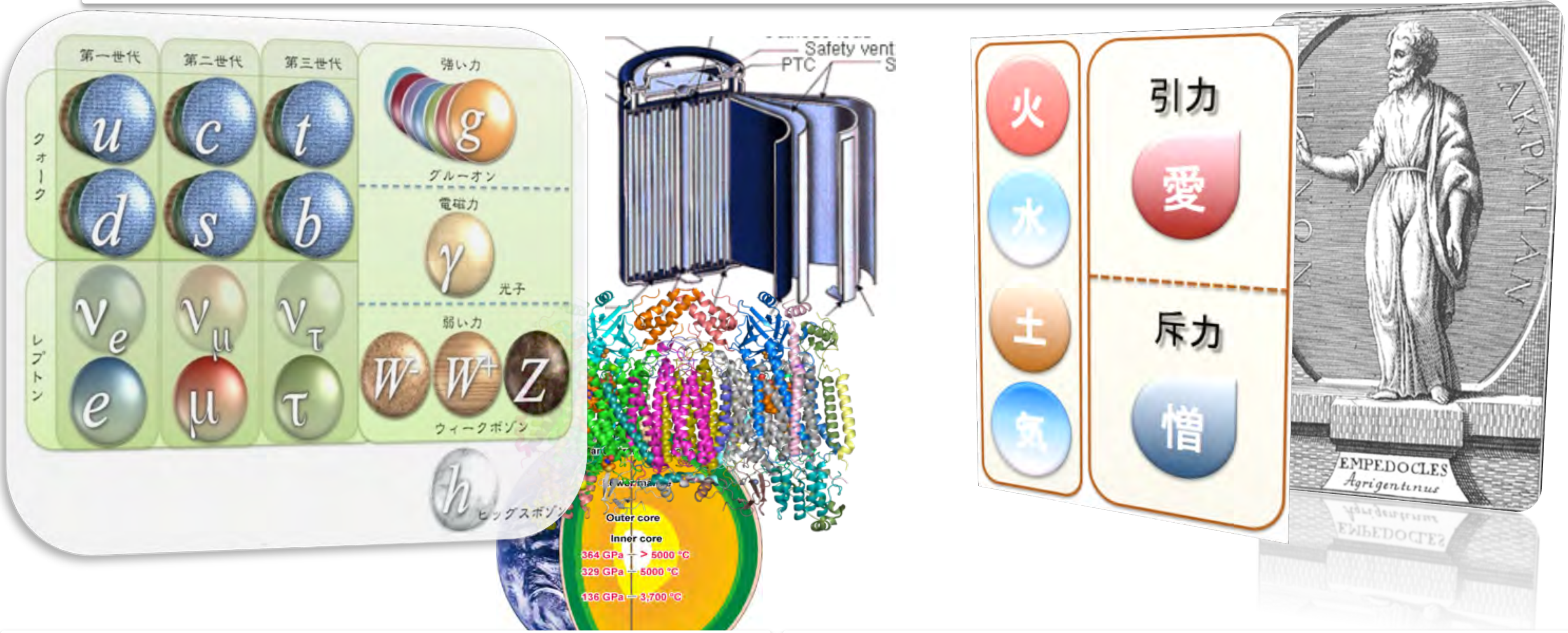
D'où venons-nous ? Que sommes-nous ? Où allons-nous ?

Where we came from? What are we? Where we go?



P. Gauguin 1897, Boston Museum

Hi-power Beams
for the Next Stage of Our Life



Why no anti-matter?
（matter and “anti-matter” are twin）
How a life emerged on the earth ?
（Anthropology）
How the diversity of the matter and life emerged?
（What a beautiful world!）

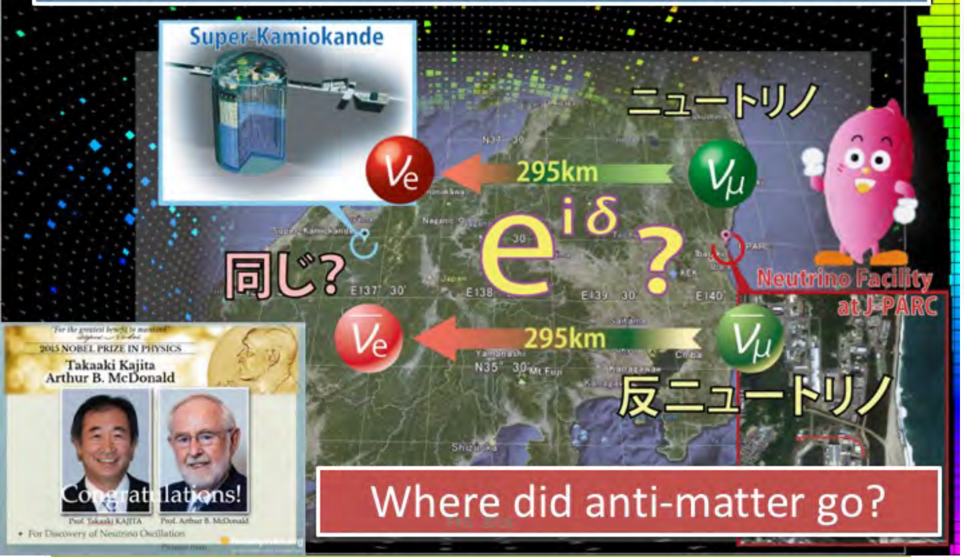
Our view is limited by
“what we can feel and touch”
To elucidate the truth in the nature, we need
”better eyes to investigate more fine structure
more precisely with more sensitivity”

Science at J-PARC

- **Elucidate Origin of Matter and Universe**
  - Neutrino Oscillation and its CPV search
  - Charged Lepton and Quark Flavor studies and CPV search
  - Strong Interaction studies
- **Explore Origin of Diversity in Matter and Life**
  - Neutron as penetrating and hydrogen sensitive probe
    - Energy materials (e.g.bettery), Life and soft matter (e.g. proteins, polymer), Hard matter (e.g. super conductor)
  - Muon as a micro magnetic probe
    - μSR, X-ray from muonic atom, muon microscope
    - Fundamental physics
  - Create core of innovation with multi-probe
  - Industrial Application
    - Synergetic use of SPring-8/PF and J-PARC, Super Computer “Kei”
- **R&D for Nuclear Transmutation**

Neutrino and Anti-neutrino for…

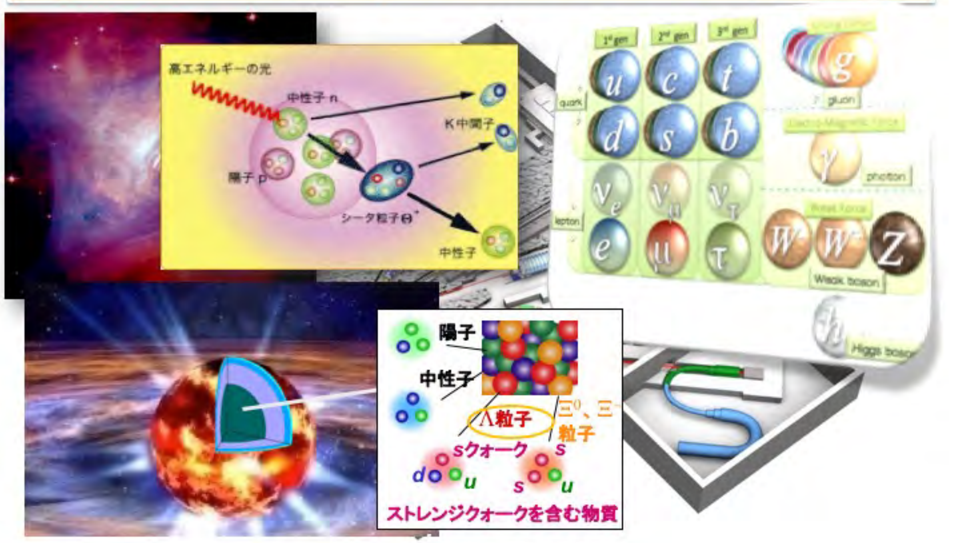
Elucidation of the origin of universe and matter!



Where did anti-matter go?

Hadron beams for…

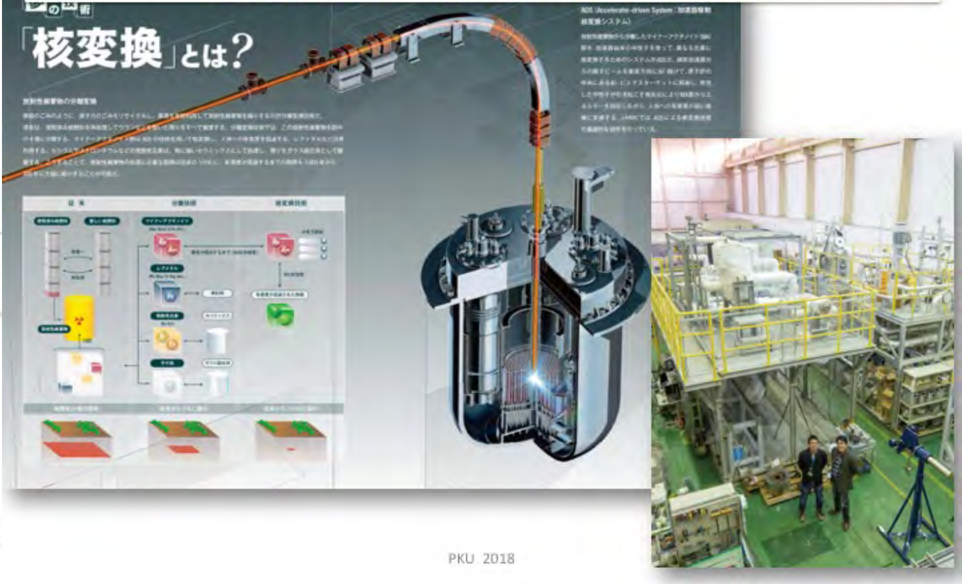
Exploration of the mysteries in formation of matter!



Neutron and Muon for…

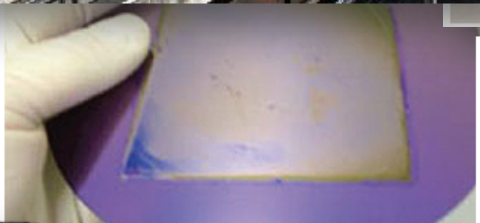
Investigation of the origins of variety of material and life！

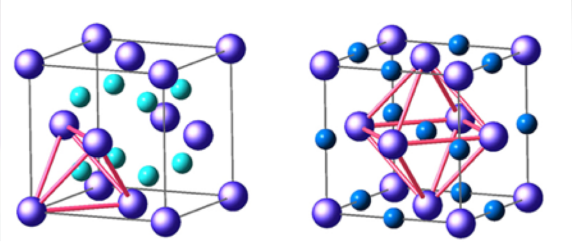
R&D of Accelerator Driven System for Nuclear Transmutation

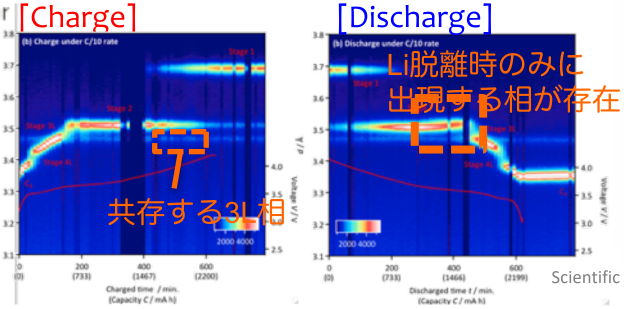


Industrial Applications for …

Acceleration of Future Technologies!



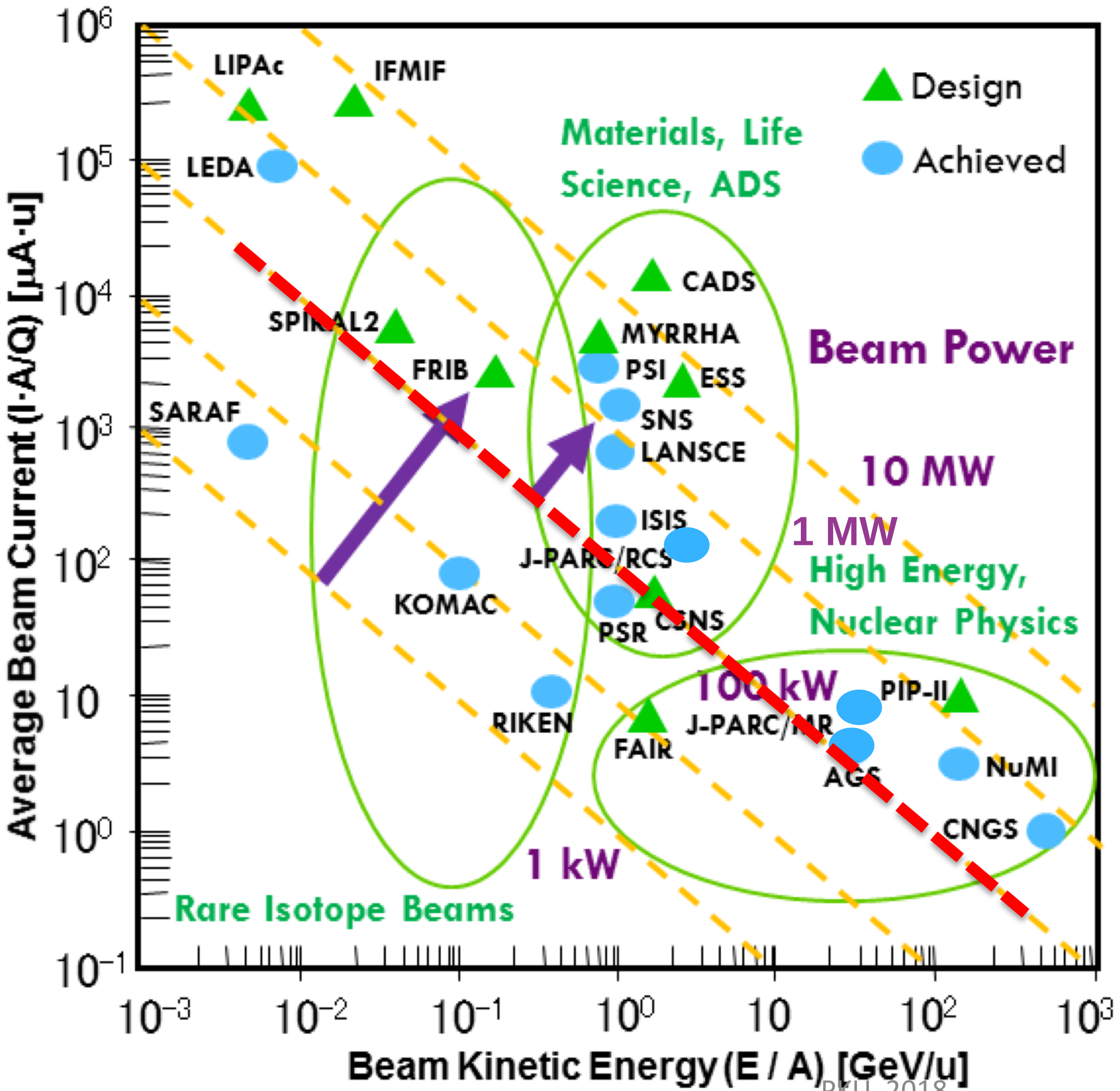




Scientific Reports (2016)

Industrial Application and Academic Research are Two important wheels to accelerate the society for future!

A Quest for High Intensity



Jie Wei / Y. Yamazaki

High Intensity

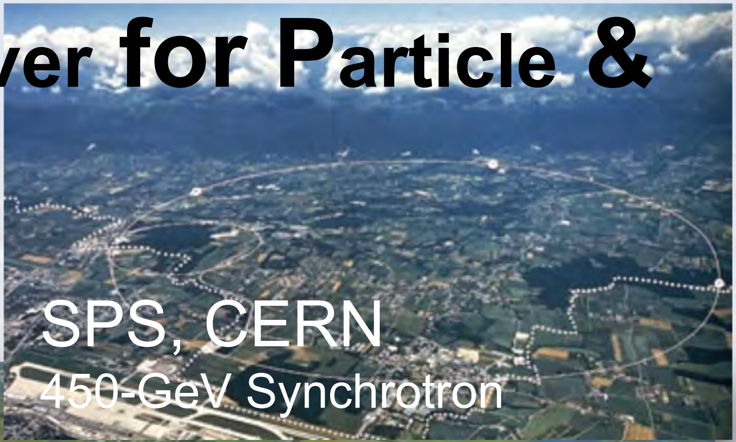
High Statistics

- More Precision
- More Rare Searches
- More Materials

Discovery!

World Hi-Intensity Proton Driver for Particle & Nuclear Physics

J-PARC, KEK&JAEA
3-GeV RCS, 1 MW
30-GeV MR , 750 kW



SPS, CERN
450-GeV Synchrotron

Main Injector, FNAL
120-GeV Synchrotron, 700 kW

FAIR@GSI
(under construction)

HIPA, PSI
590 MeV/u cyclotron, 1.4 MW

Accelerator Based Neutron Source in the World

5MW

ESS
(Sweden)
2019~

ISIS, RAL
(UK)

2nd target station
2008~

0.16MW → 0.3MW

CSNS
(China),500kW
2019~

MLF, J-PARC
(Japan)
2008~

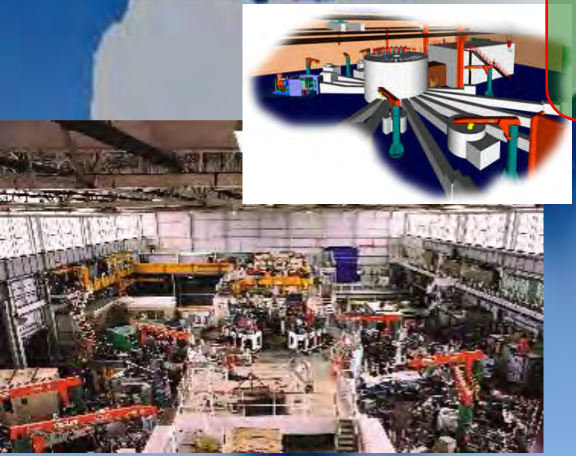
1MW

IPNS, ANL
@Illinois, USA
0.01MW

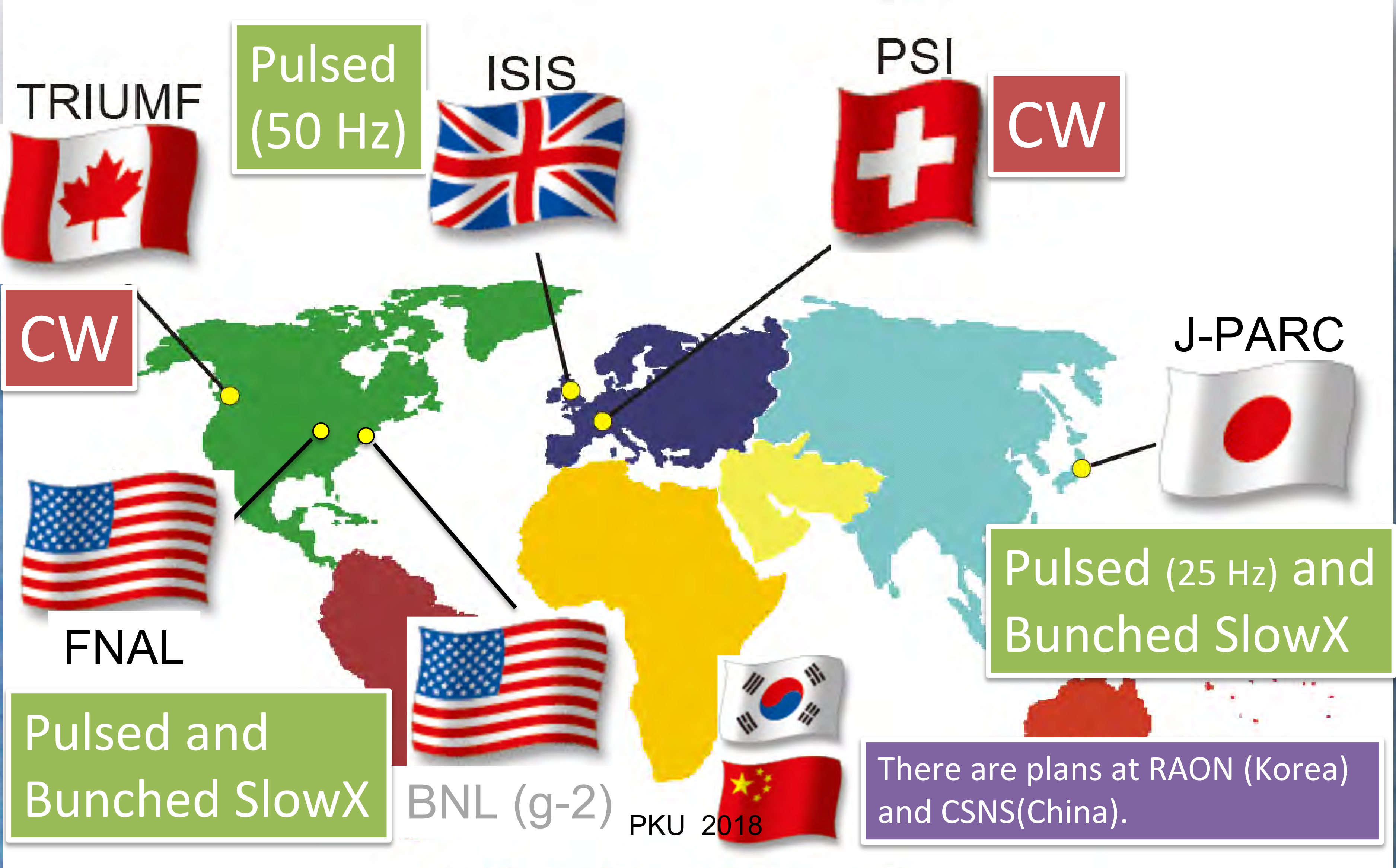
LANSCE, LANL
@Los Alamos, USA
0.06MW

SNS, ORNL
(USA)
2006~

1.4MW



Muon Facilities around the World



TRIUMF

CW

Pulsed
(50 Hz)

ISIS

PSI

CW

J-PARC

Pulsed (25 Hz) and
Bunched SlowX

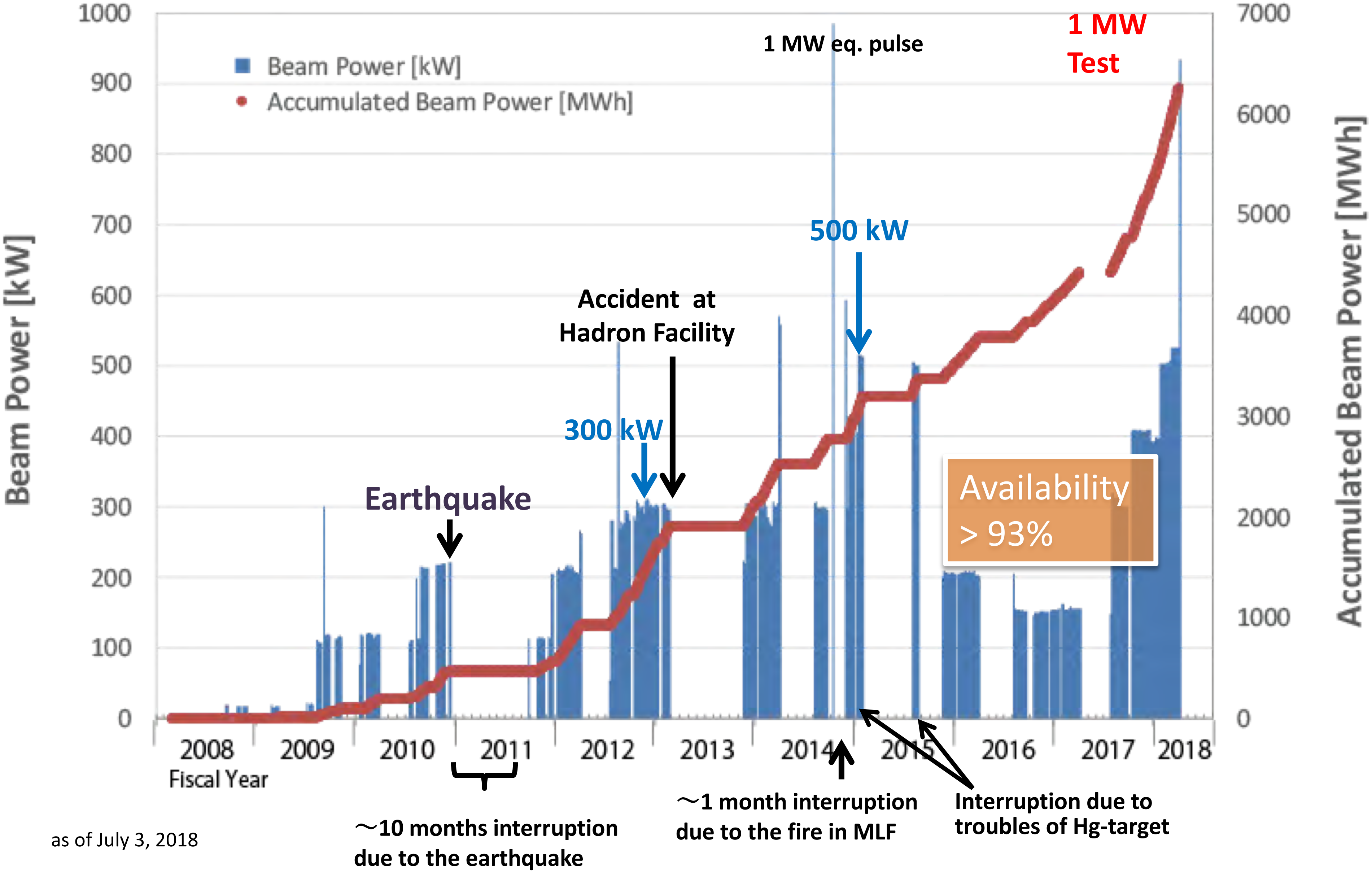
FNAL

Pulsed and
Bunched SlowX

BNL (g-2)

There are plans at RAON (Korea) and CSNS(China).

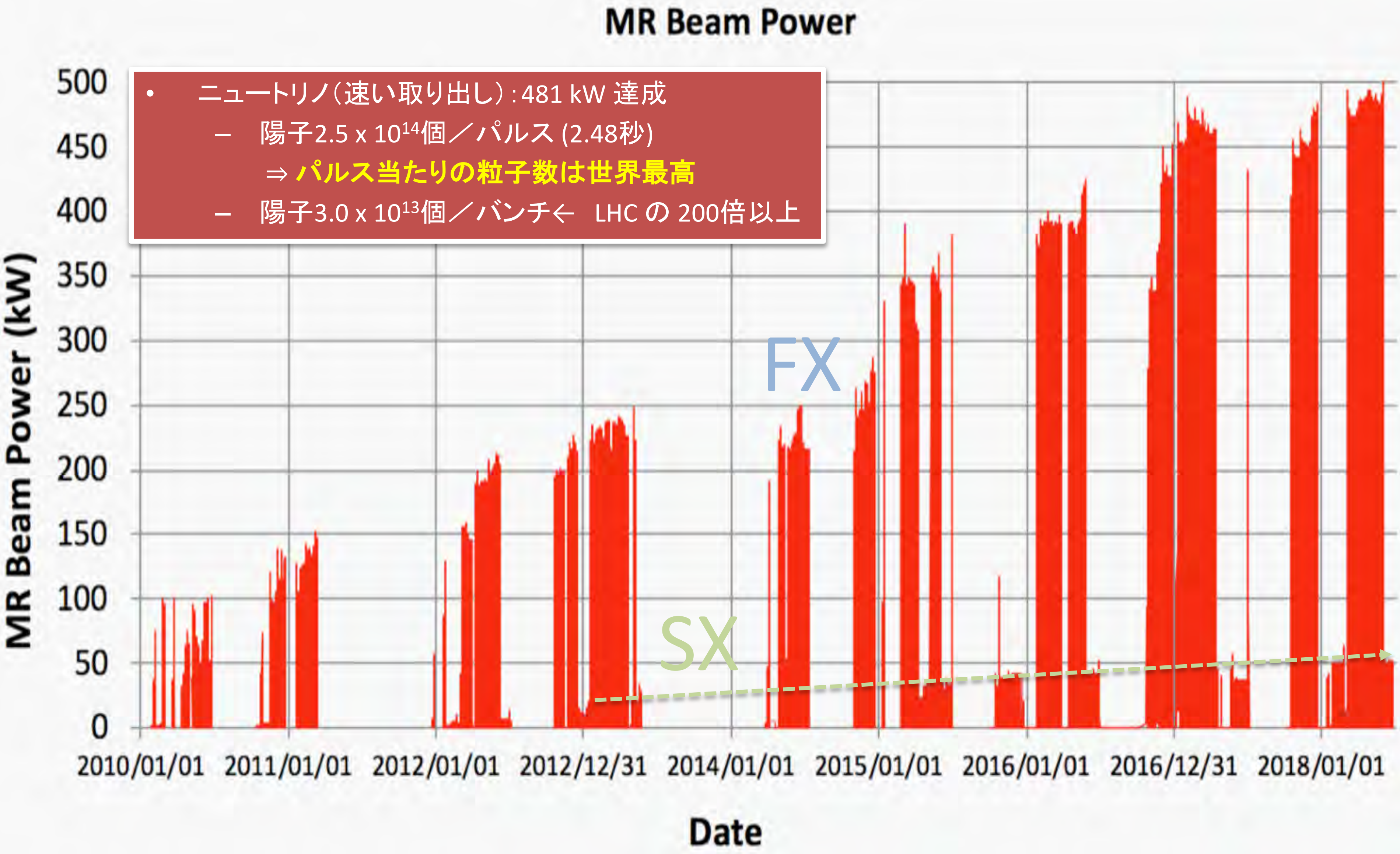
Beam Power History at MLF



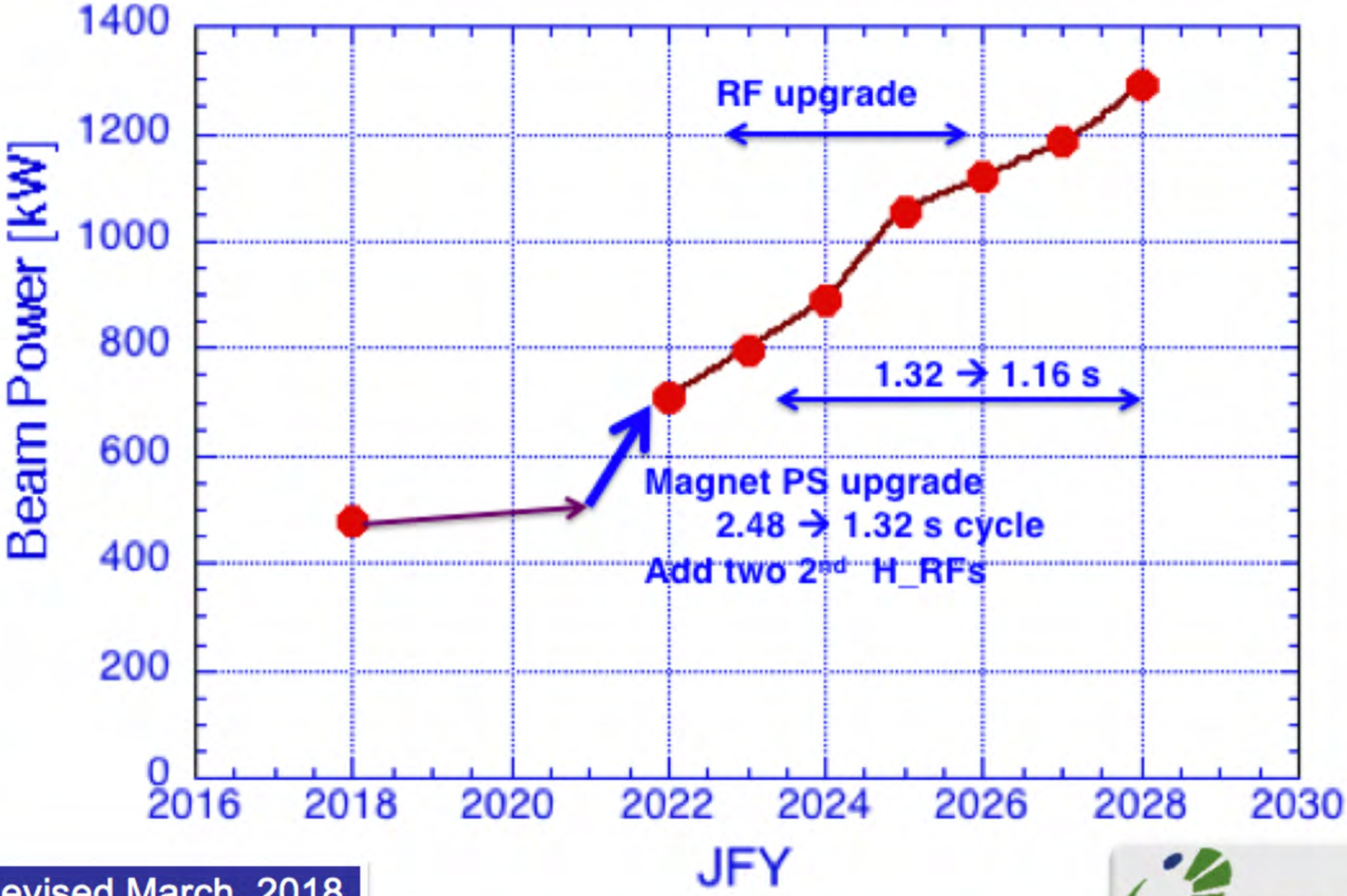
as of July 3, 2018

Beam Power History of Main Ring

- ニュートリノ（速い取り出し）：481 kW 達成
  - 陽子2.5 x 10^{14}個／パルス (2.48秒)
    ⇒ **パルス当たりの粒子数は世界最高**
  - 陽子3.0 x 10^{13}個／バンチ← LHC の 200倍以上

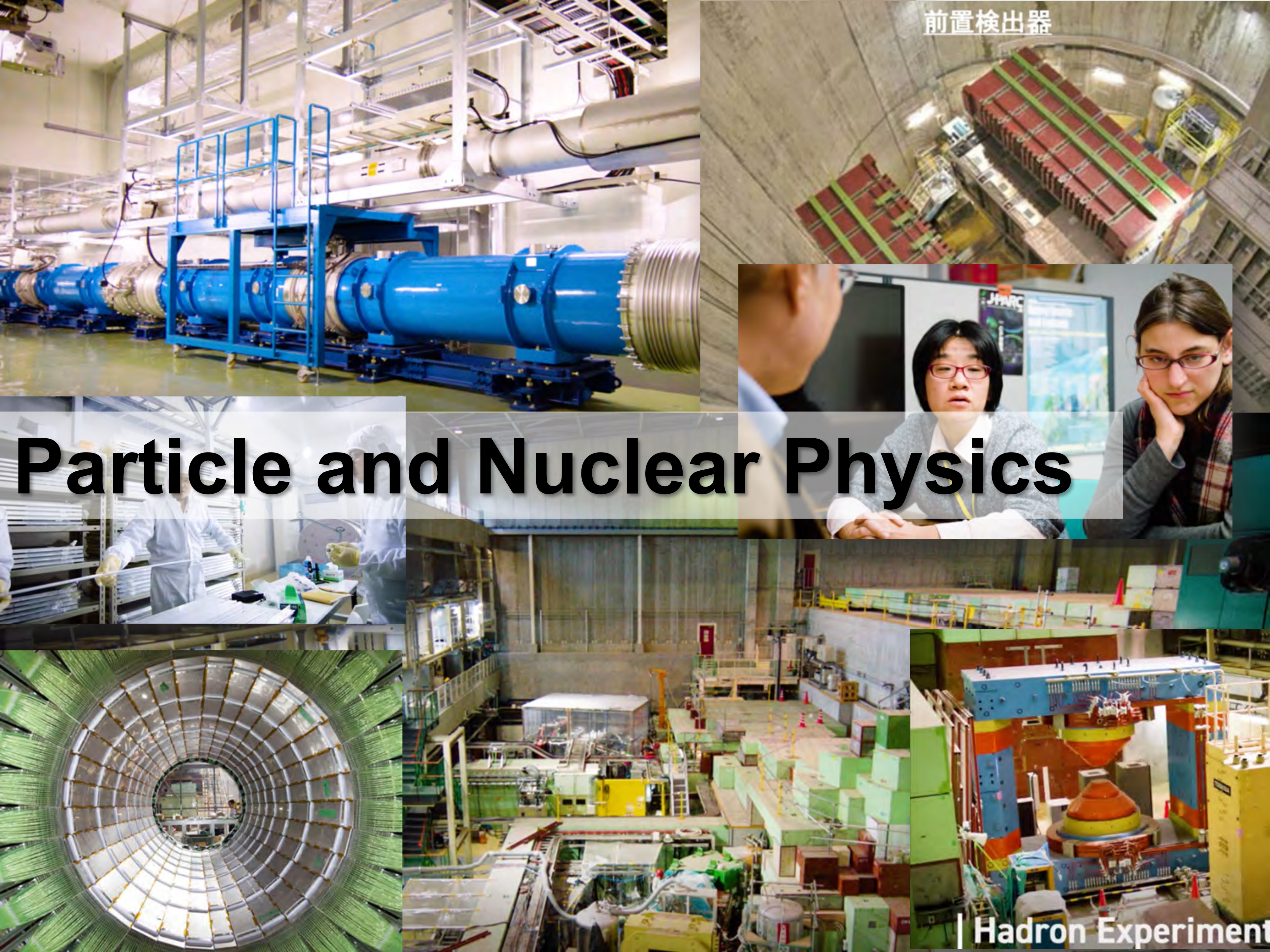


J-PARC Main Ring (30 GeV) operates beyond 1 MW



Revised March, 2018

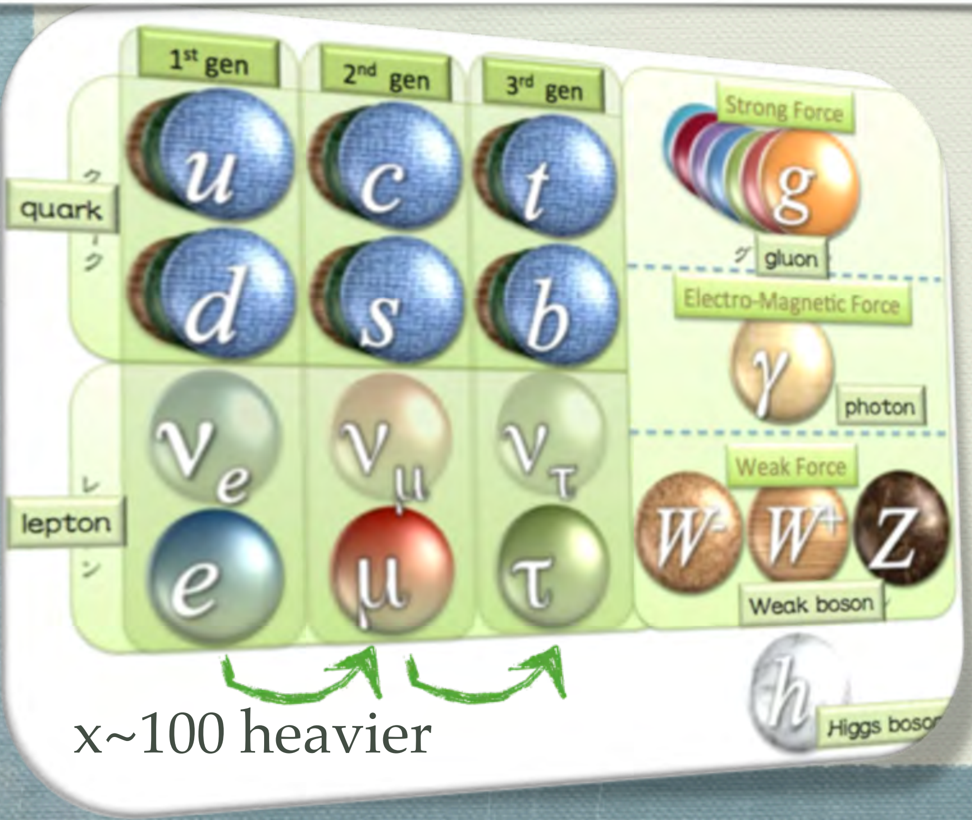
Particle and Nuclear Physics



Higgs Particle Discovery

- Completion of the Standard Model

Beginning of New Physics Era



x~100 heavier

Why 3 generations?
Why CP violates? (particle-anti-particle asymmetry)
Why
Bary n
flav
Wha
Wha
How y?
Why ?
Is su

Hi-Energy Frontier

New phenomena may exist in the unprecedented energy region

→LHC, ILC and future colliders

Astrophysics

Energy Frontier

Higgs
SUSY,
Extra-dimensions…

Uncover SUSY
Grand Unification
New Physics to solve
many mysteries in the SM

Quark Flavor

CP violation
New mixing
LR symmetry
Charged Higgs?.
. . .

Lepton Physics

Neutrino mass
Flavor violation
CP violation
Seesaw mechanism

Quark-Lepton
Symmetry

Hi-Intensity Frontier

Ultra-precision measurements may provide a hint for New Physics!

→Hi-Luminosity lepton colliders, Hi-Intensity Proton Drivers

Matter = Remnant of 1/10^9 Asymmetry

Origin of Matter =

Enigma of Missing Anti-Particle : CP Violation

CP Violation beyond CKM・Role of Muon

Particle 10^9+1 + Anti-Particle 10^9+1

Exact symmetry btw Particle and Anti-P

CPV !

Particle 10^9+2 + Anti-Particle 10^9

→ 2×10^9 photons + ●●

Origin of Matter

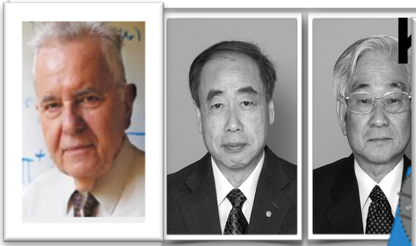
+ Formation of Matter by Strong Interaction

Can be created at J-PARC for Precision Meas.

Our Stable World

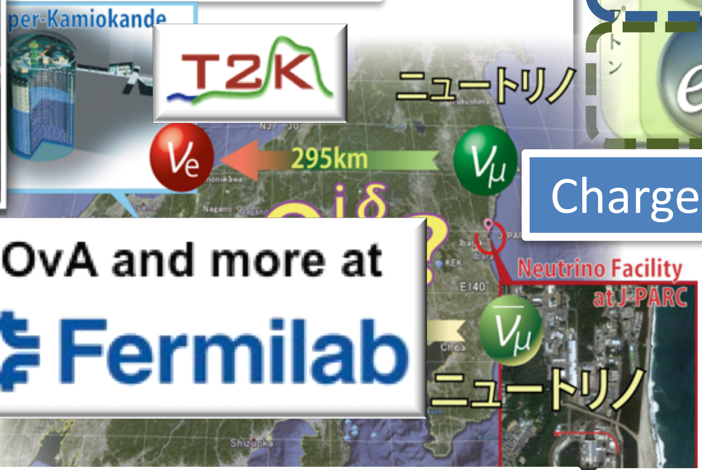
Particle-Nuclear Physics explored at J-PARC

Search for CPV beyond CKM theory



NA62, LHCb at CERN

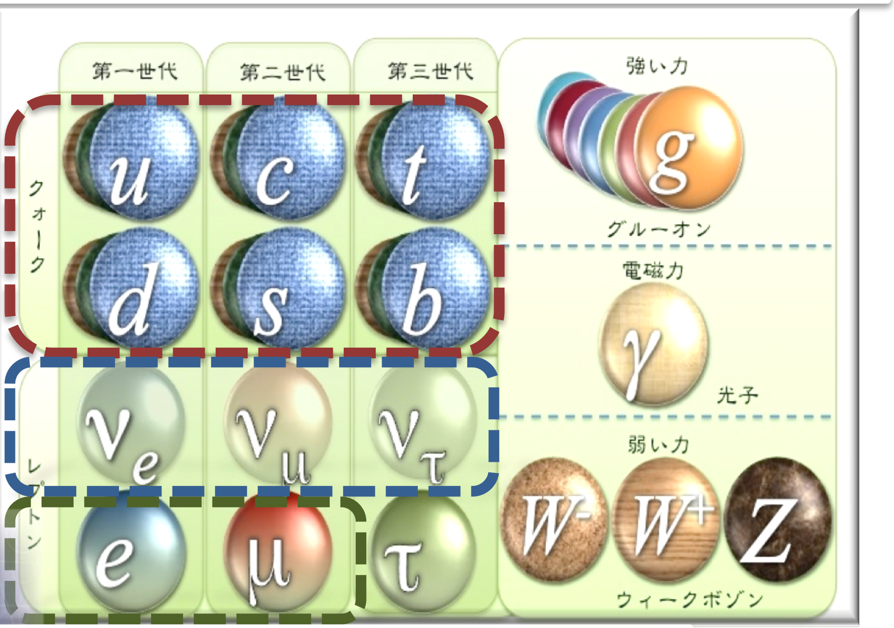
Neutrino Mixing thru PMNS matrix



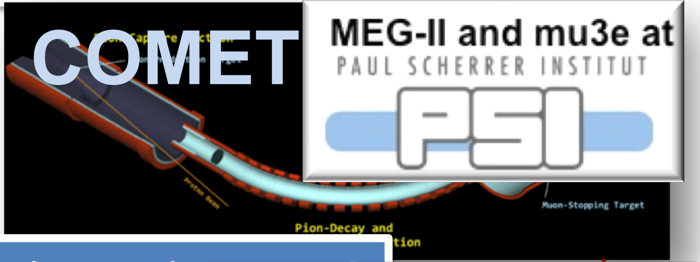
T2K Exp.

CPV in neutrin
sector?

NOvA and more at Fermilab



Charged Lepton Flavor violated?



COMET

MEG-II and mu3e at PAUL SCHERRER INSTITUT PSI

Explore role of strangeness in neutron stars

Hadron Physics at GSI FAIR

y play an
an extreme high
a neutron star.

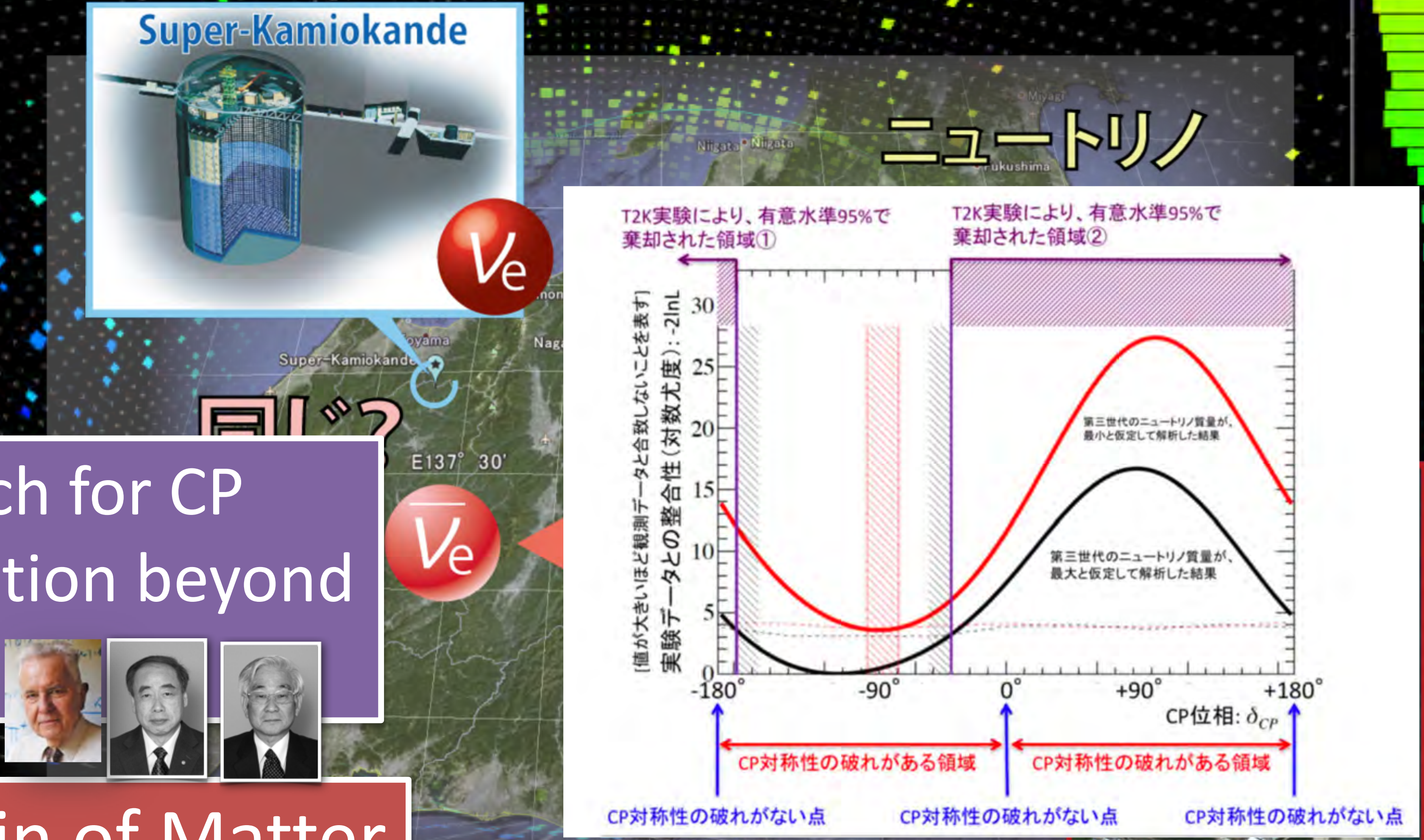
CPV in Charged L

mu2e and g-2 at Fermilab

g_μ-2/μEDM

Goal of T2K

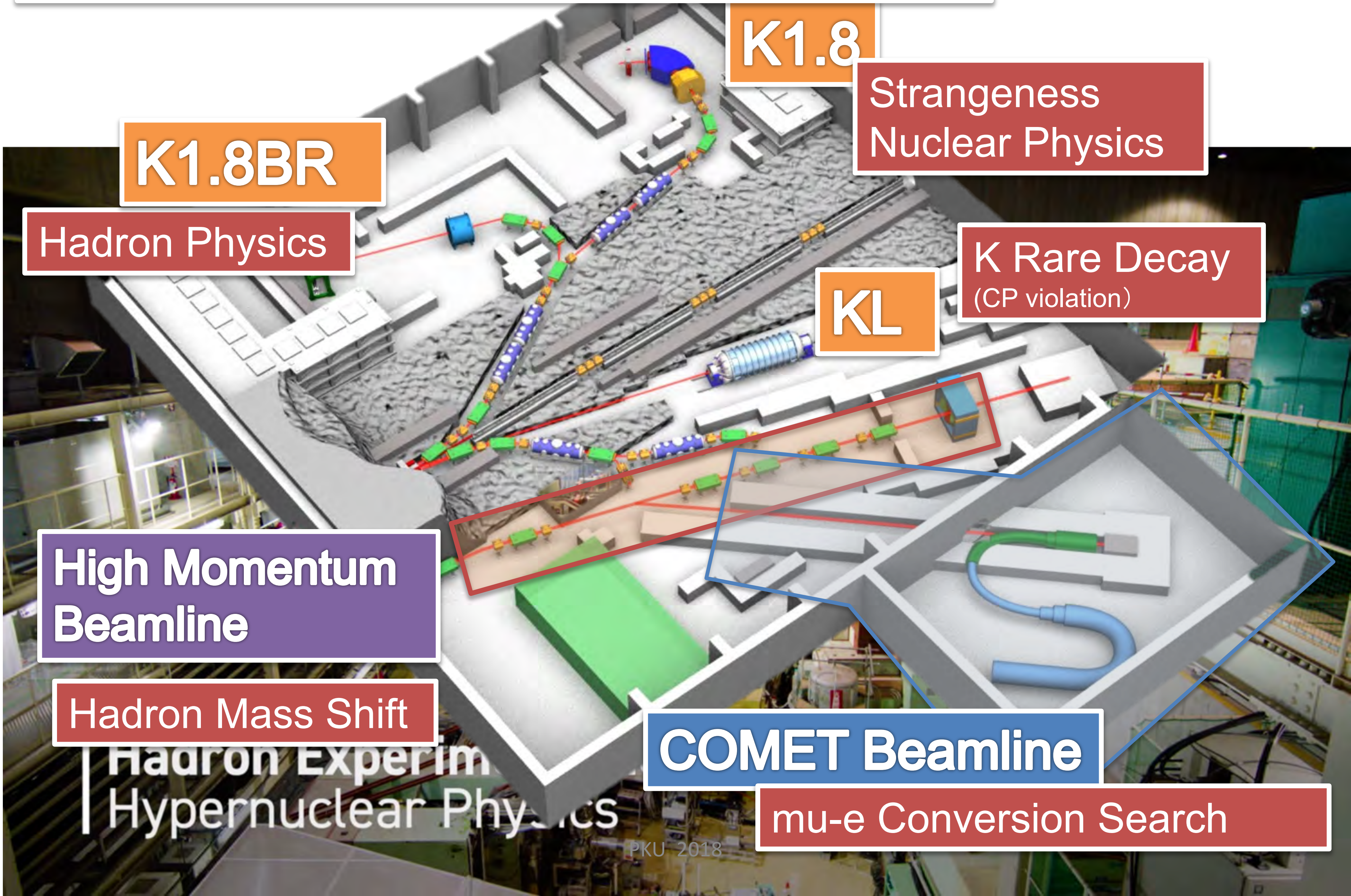
Neutrino and anti-neutrino behave same?



Search for CP Violation beyond CKM

Origin of Matter

Hadron Experiment Facility



K1.8

Strangeness Nuclear Physics

K1.8BR

Hadron Physics

KL

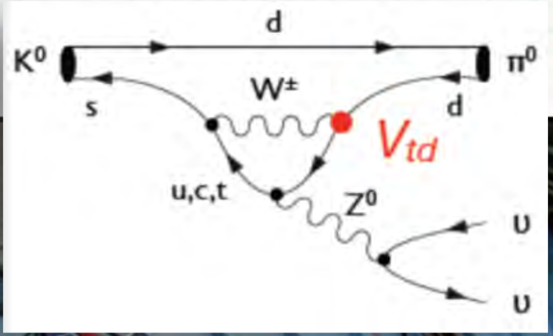
K Rare Decay
(CP violation)

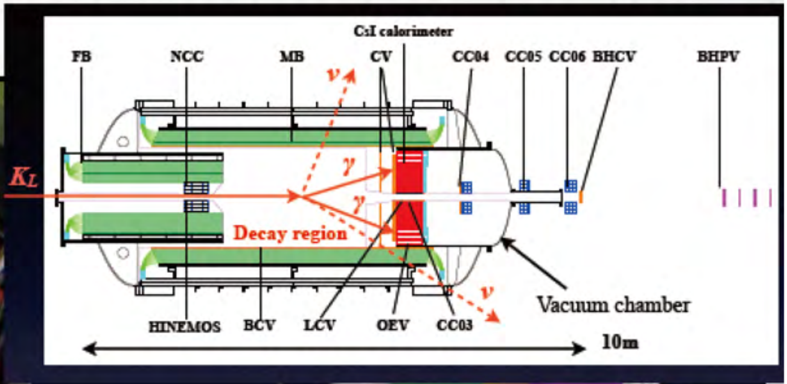
High Momentum Beamline

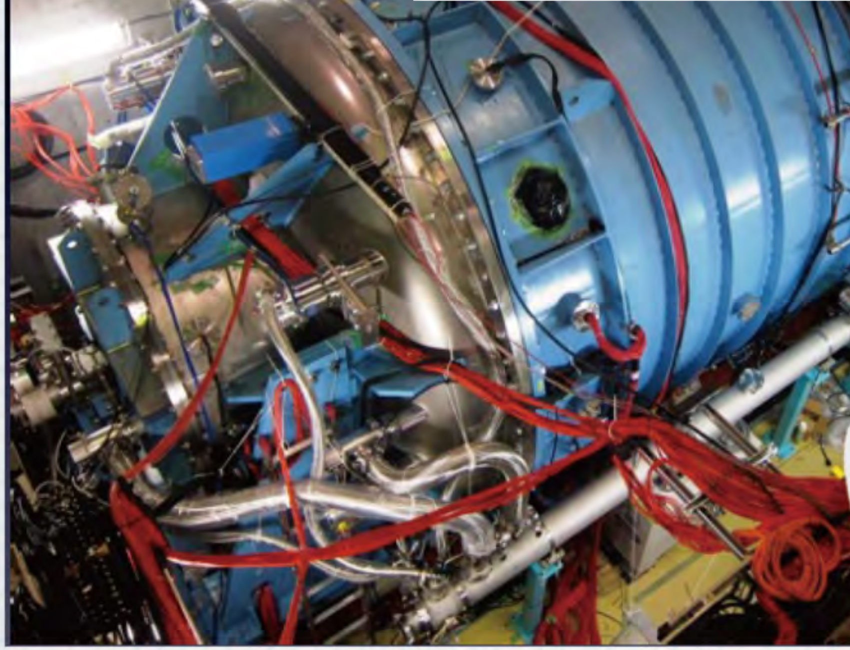
Hadron Mass Shift

COMET Beamline

mu-e Conversion Search







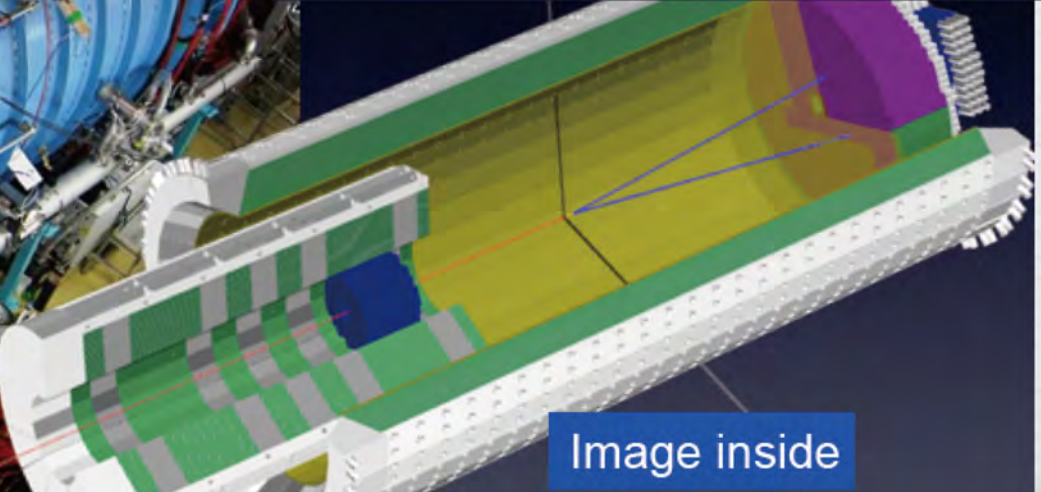
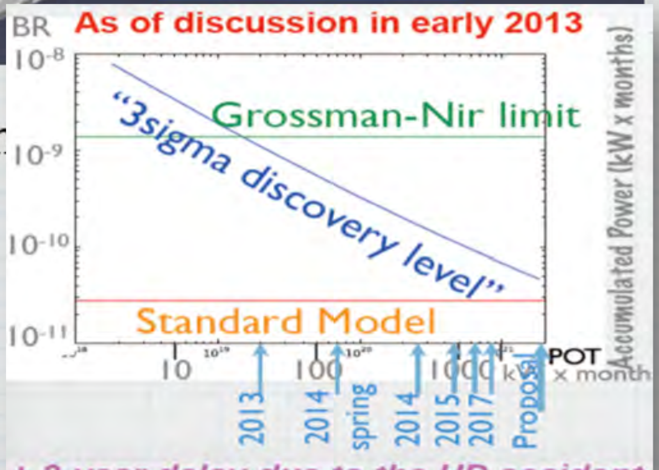


Image inside

Collaboration photo at KEK, October 2014



As of discussion in early 2013

+ 2-year delay due to the HD accident

Slide by T. Nomura

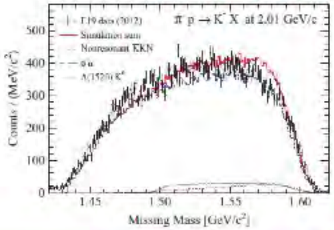
Results (1)

- E19:Search for Θ^+ by π^-+p→K⁻X

2010, Jan.2012

  - No peak was observed
  - U.L. of cross section : 0.28μb/sr
  - U.L. of Θ^+ width: 0.36 (1.9) MeV for ½ ⁺ (½⁻)

PRL **109**, 132002(2012)
PRC **90**, 035205(2014)



- E10:Neutron-rich $^6_\Lambda$H via the ^{6}Li(π^-,K⁺)

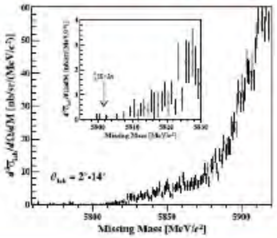
Dec.2012-Jan.2013

  - No peak was observed
  - U.L. of cross section :1.2nb/sr

  ⇔ Observation of 3 candidates

  by FINUDA (PRL **108**,04251(2012))

PLB **729**, 39 (2014)

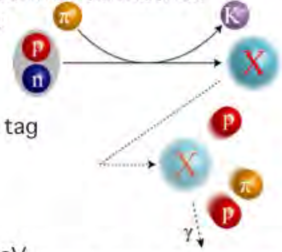


Results (2)

- E27: Search for K⁻pp bound states by the d(π^+,K⁺) at P$_\pi$=1.7GeV/c

Jun. 2012

Experimental Method



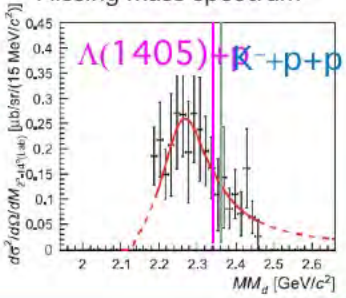
Missing mass spectrum is obtained with two protons tag
Observation of "K⁻pp" -like structure
PTEP **2015**, 021D01 (2015)

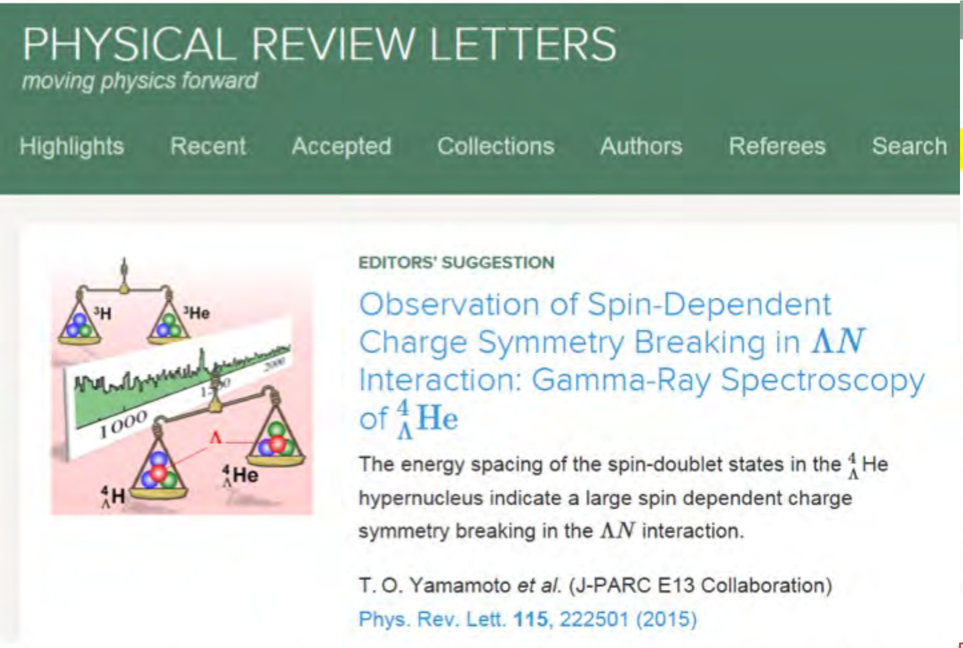
Binding Energy 95$^{+18}_{-17}$ (stat.)$^{+30}_{-21}$ (syst.) MeV
Width $^{+87}_{-45}$162 $^{+66}_{-78}$(stat.) (syst.) MeV

A positive signature of K⁻pp bound state was obtained. Comparison with other experiments and theoretical studies are necessary and important to establish K⁻pp bound state.

Analysis of inclusive spectrum was also published.
PTEP **2014**, 101D03(2014)
- ΣN-ΛN cusp
- Shift of Y* bump

Missing mass spectrum





PHYSICAL REVIEW LETTERS
moving physics forward

Highlights Recent Accepted Collections Authors Referees Search

EDITORS' SUGGESTION

Observation of Spin-Dependent Charge Symmetry Breaking in ΛN Interaction: Gamma-Ray Spectroscopy of $^4_\Lambda$He

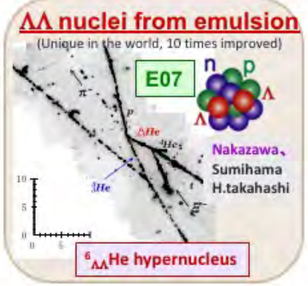
The energy spacing of the spin-doublet states in the $^4_\Lambda$He hypernucleus indicate a large spin dependent charge symmetry breaking in the ΛN interaction.

T. O. Yamamoto *et al.* (J-PARC E13 Collaboration)
Phys. Rev. Lett. **115**, 222501 (2015)

Press-released from Tohoku U., KEK, JAEA, J-PARC

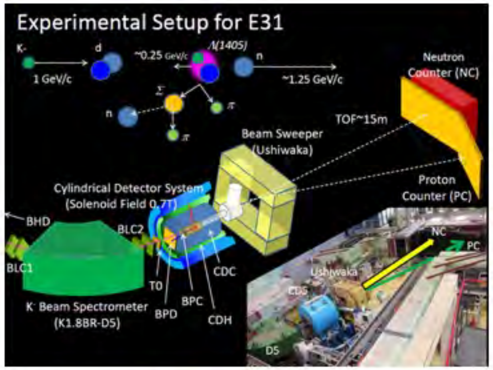
Experiments just completed and to come soon

ΞN→ΛΛ int.



Just completed irradiation of 100 emulsion stacks

Lambda(1405) **E31**

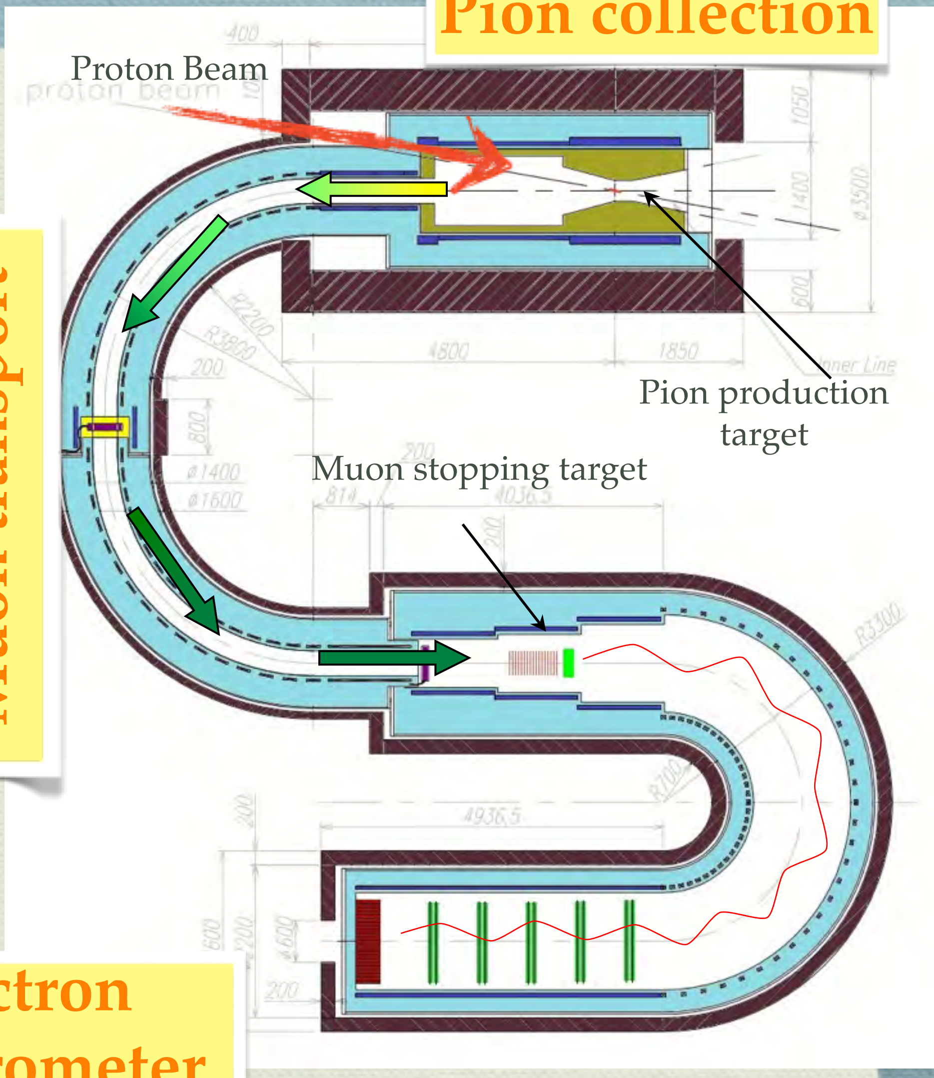


measuring an S-wave $\bar{K}N \rightarrow \pi\Sigma$ scattering below the $\bar{K}N$ threshold in the $d(K^-,n)\pi\Sigma$ reactions at a forward angle of n.

Slides by S. Sawada

COMET J-PARC E21

- Search for LFV process, μ-e conversion with a sensitivity of 10^{-16}
- Utilize J-PARC Hi- Intensity proton beam
  - 8GeV, 7μA
- Innovative apparatus
  - Pion collection
  - Muon Transport
  - Electron Spectrometer



Pion collection

Proton Beam

Pion production target

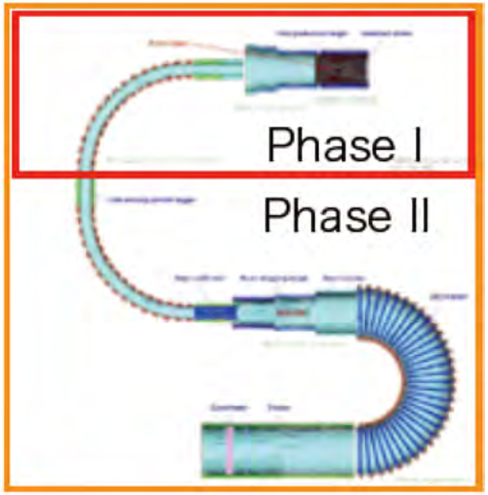
Muon transport

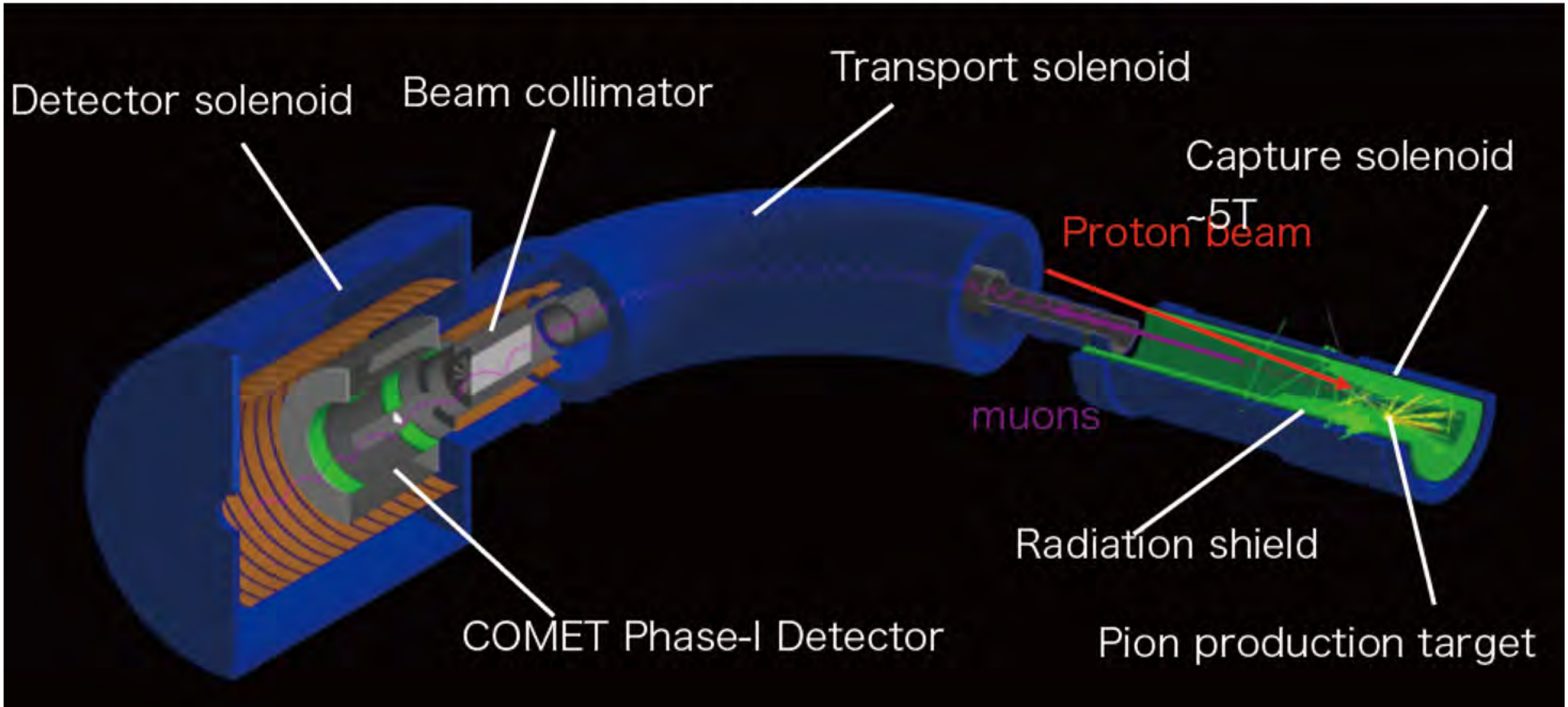
Muon stopping target

Electron Spectrometer

COMET Phase I

- Phase I
  - Beam background study and achieving an intermediate sensitivity of $<10^{-14}$
    - 8GeV, ~3.2kW, ~90 days of DAQ
- Phase II
  - 8GeV, ~56 kW, 1 year DAQ to achieve the COMET final goal of $< 10^{-16}$ sensitivity





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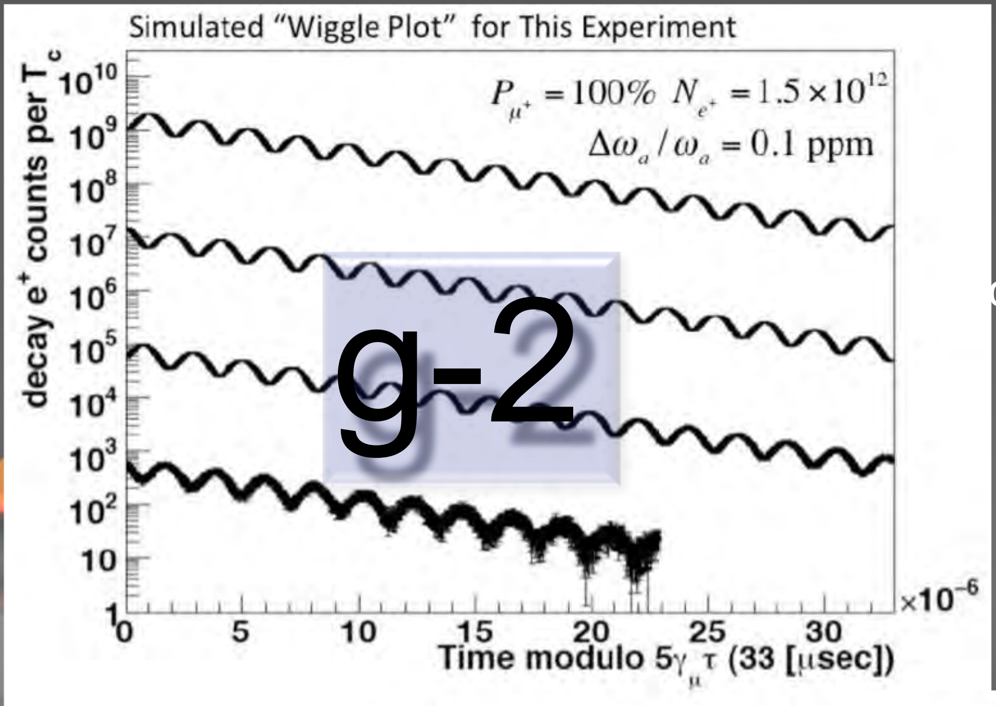
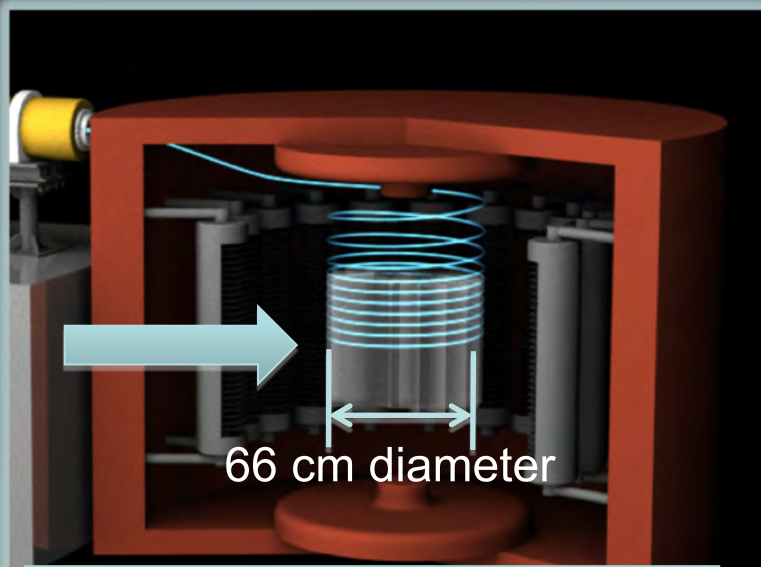


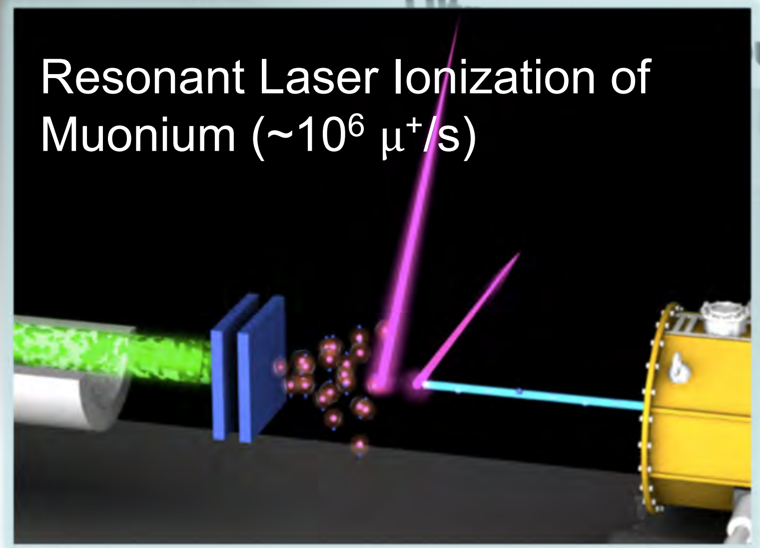
g-2



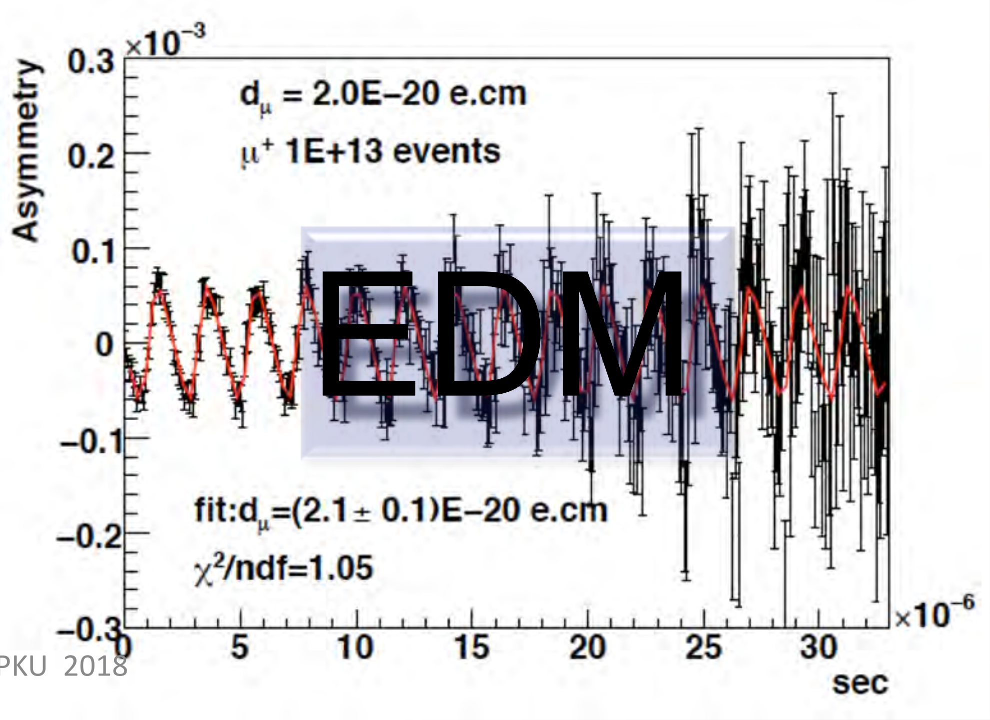
Super Precision Magnetic Field
(3T, ~1ppm local precision)

face muon

urce



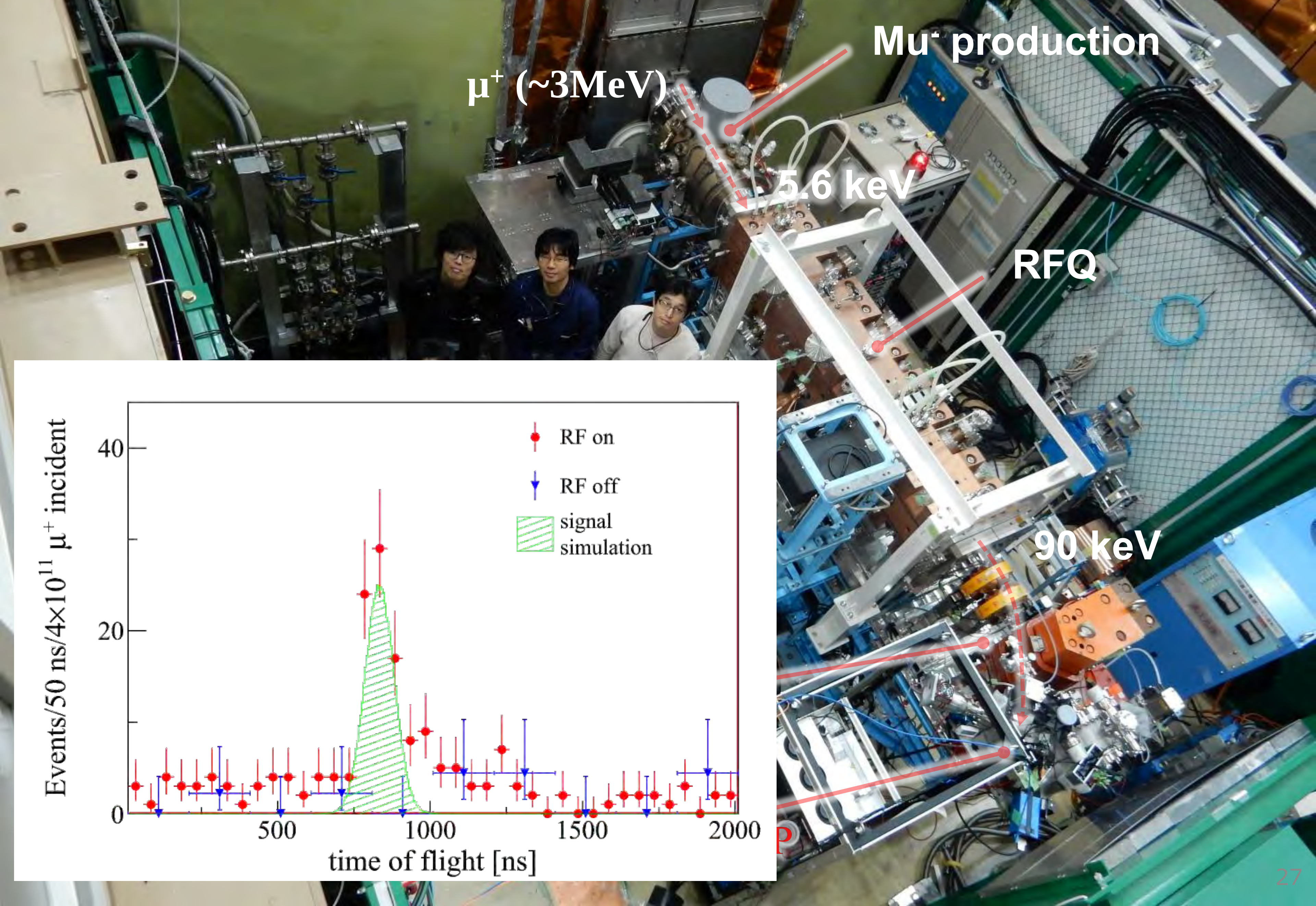
Resonant Laser Ionization of Muonium (~10^6 μ^+/s)



EDM

talk by G. Marshall

World First Muon Acceleration



Material and Life Science

Material and Life Science with
The Synergetic Use of Neutron, Muon, Photon, and Positron

Neutron
Interact with Nuclei

Muon
Sensitive to Magnetism

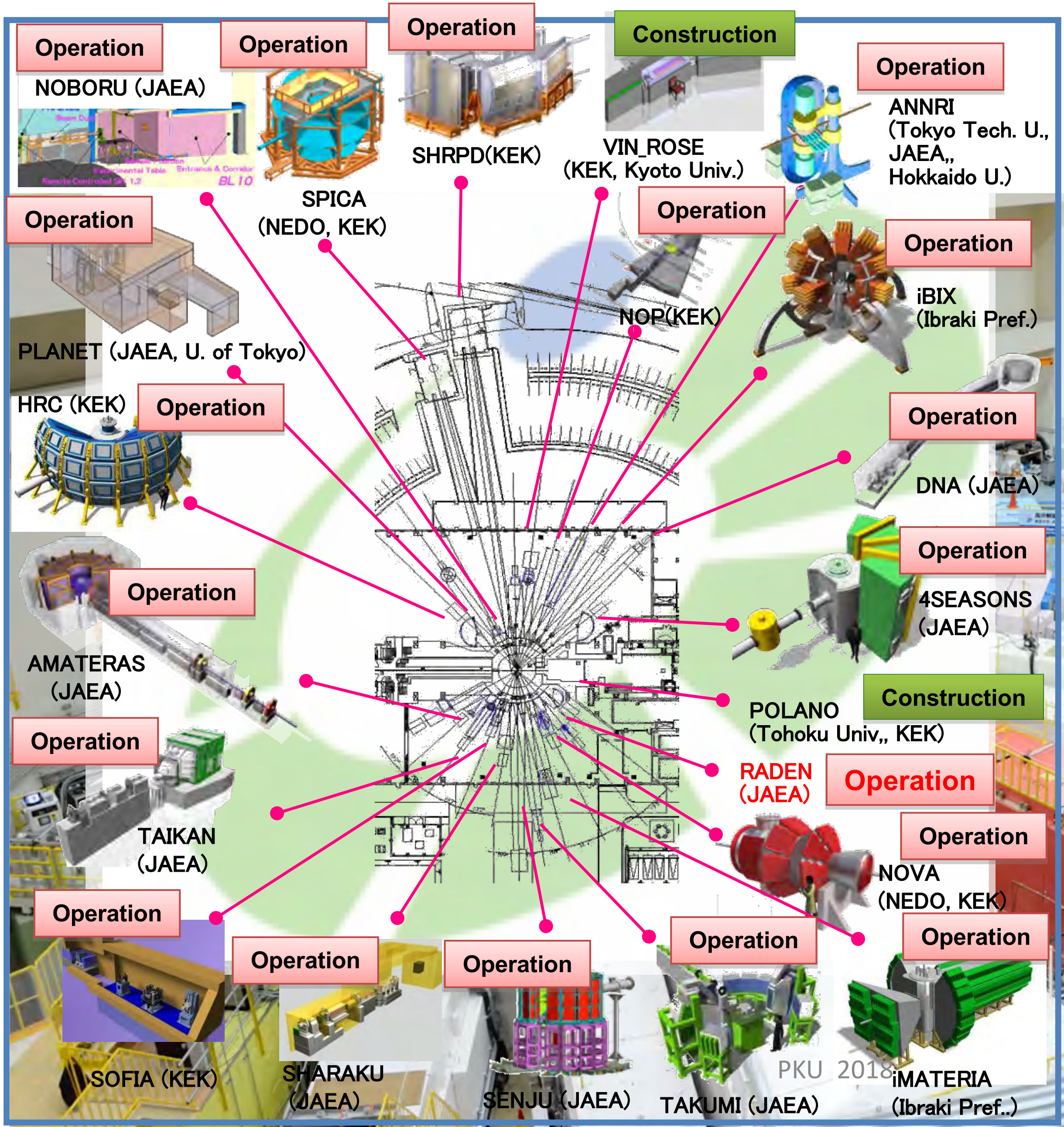
Photon
Sensitive to electrons

Positron
Sensitive to surface

Neutron • Mjuon
(J-PARC)

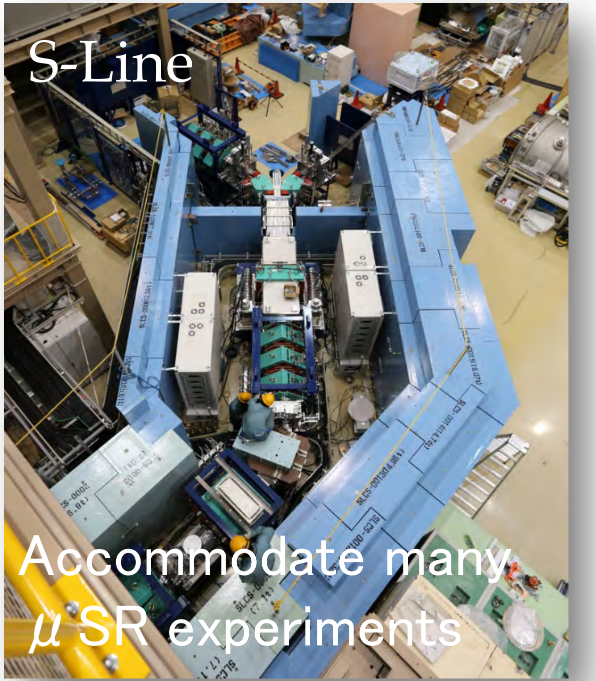
Photon • Positron
(KEK • SPring-8)

Neutron Instruments at MLF



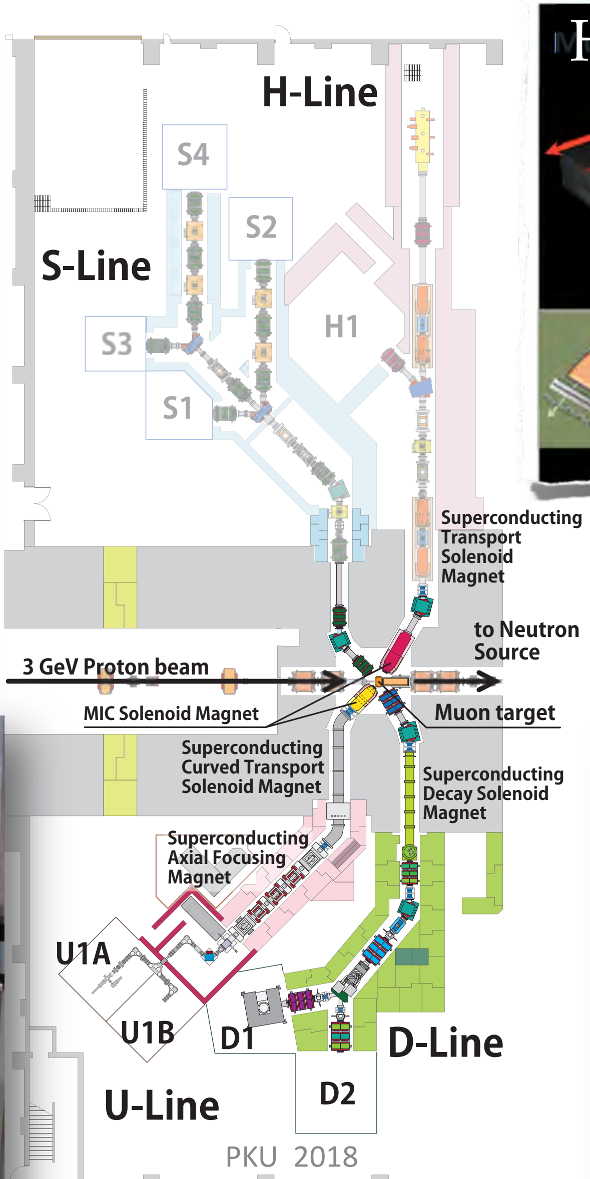
- The first neutron in May, 2008
- 23 Neutron Beam Ports
- From Fundamental Physics to Industrial Uses
- Operation: 20
  Construction/Commissioning:1
- Constructed by
  - ▪KEK
  - ▪JAEA
  - ▪Ibaraki Prefecture
  - ▪Universities, Institutes & Government organizations...
- Yearly Operation Days
  - ▪~180
- Yearly Guest Number
  - ▪~1,000

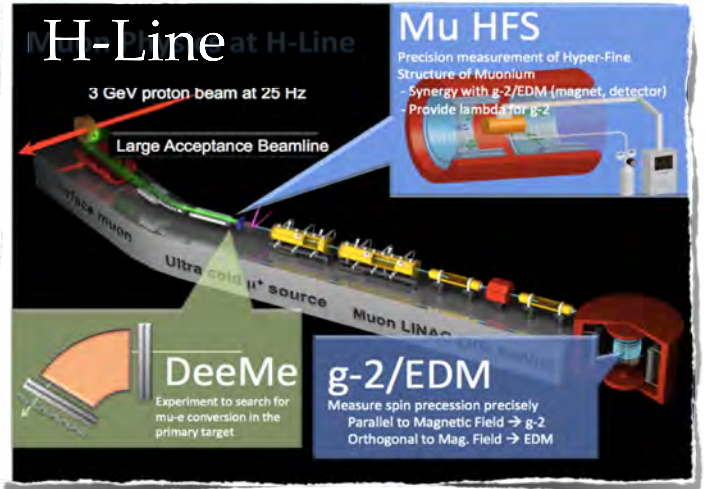
Muon Facility MUSE @ MLF



S-Line

Accommodate many μSR experiments





H-Line

Fundamental Science with a large scale international coll.

U-Line

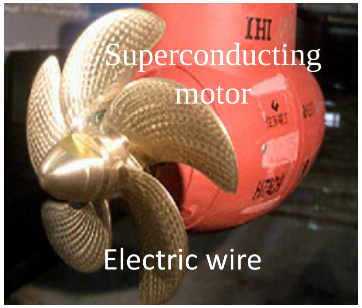
Very unique Ultra-Slow Muon Beam

D-Line

Mid-intensity beam line
For general use

Magnetism, Strongly-correlated electron systems (S=1/2）

Applications



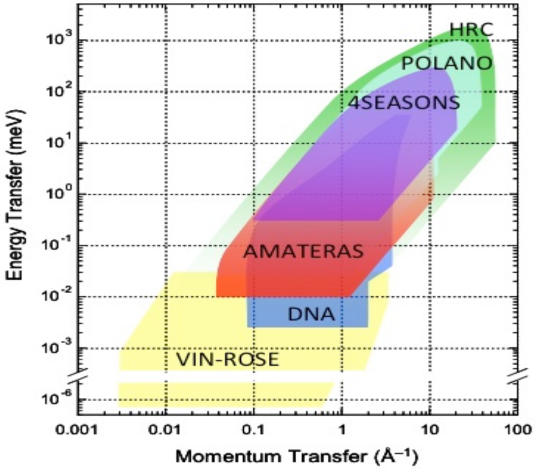
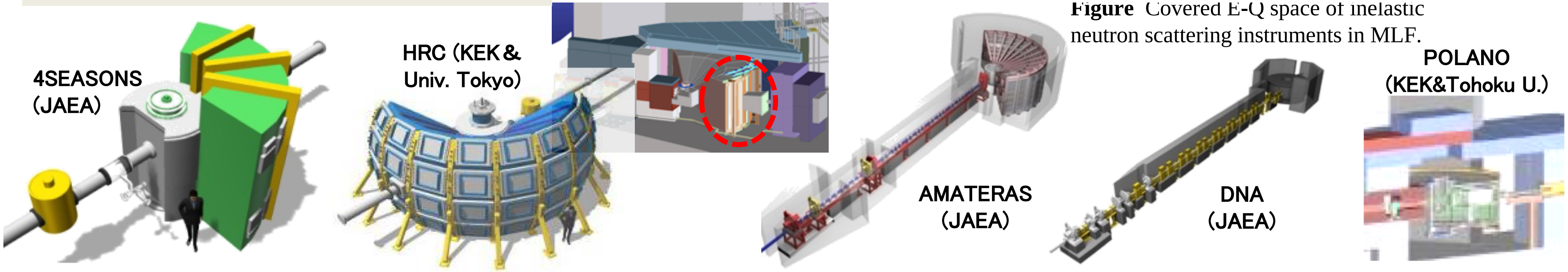


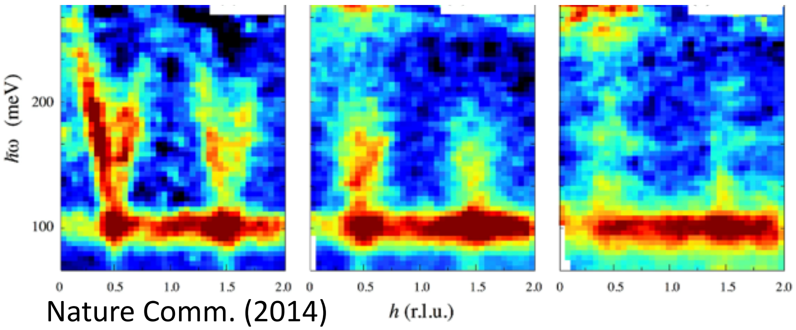
Figure Covered E-Q space of inelastic neutron scattering instruments in MLF.

Instruments in MLF

（high intensity and wide dynamics range）

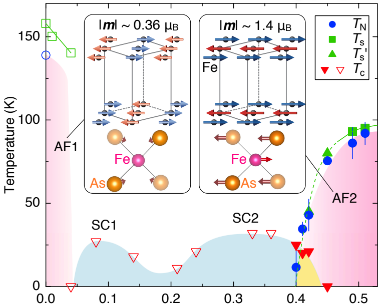


Electron doping effect on high-energy magnetic excitations in high-T_c cupurate



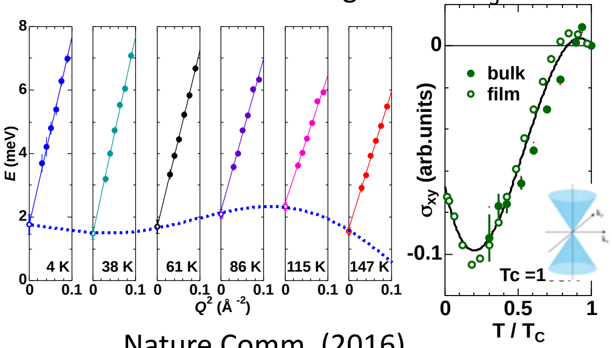
Nature Comm. (2014)

Fe-based superconducting material $LaFeAsO_{1-x}H_x$



Nature Physics,(2014)

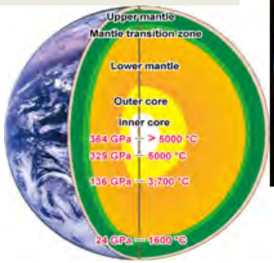
Weyl Fermions and Spin Dynamics of Metallic Ferromagnet $SrRuO_3$



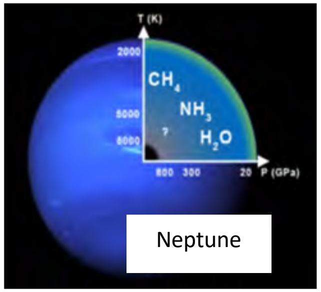
Nature Comm. (2016)

High Pressure Science

Applications

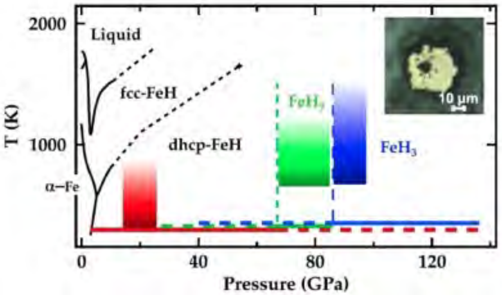


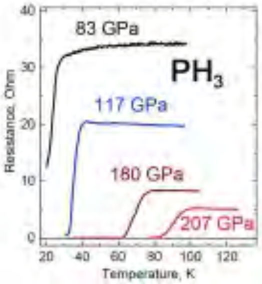
Earth science



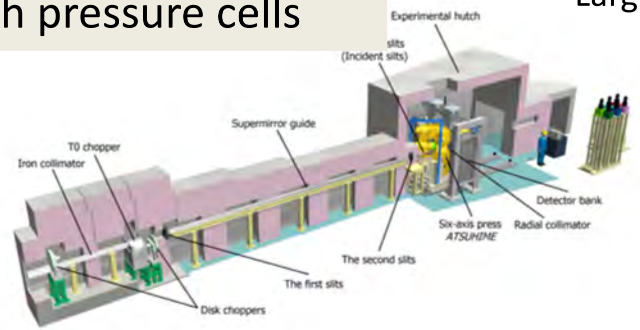
Neptune

High Tc superconductors under high pressure



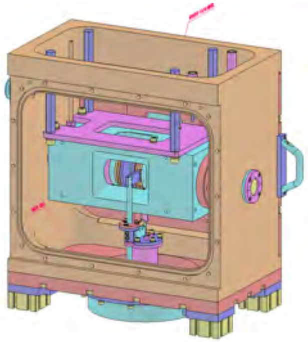


PLANET (BL11) in MLF, and high pressure cells



Large press “ATSUHIME”

Low-T cell, MITO System

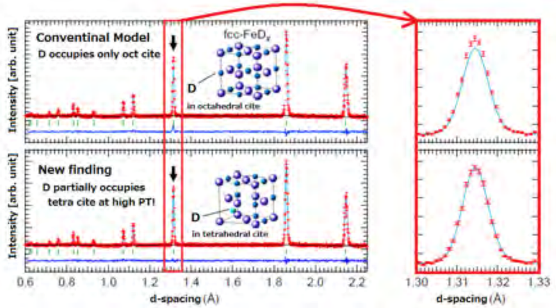


Character
- Cooling only around the sample
- 30K, 5GPa

Merit
- P is changeable even at low-T.
- Quick cooling at 20 K /min

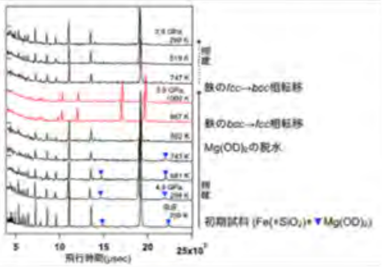
outcomes

Hydrogen in Fe lattice under high pressure and high temperature condition



Nature Comm (2014).

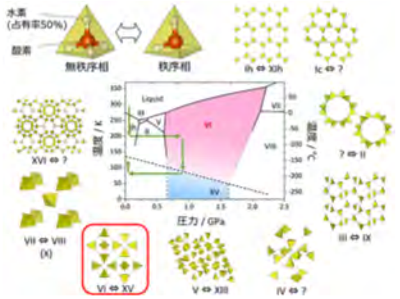
Hydrogenation of iron in the early stage of Earth’s evolution



PKU 2018

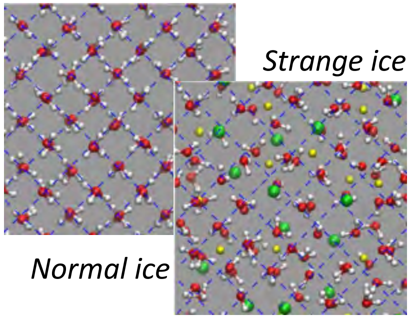
Nature Comm 8 (2017)

Partially ordered state of ice XV



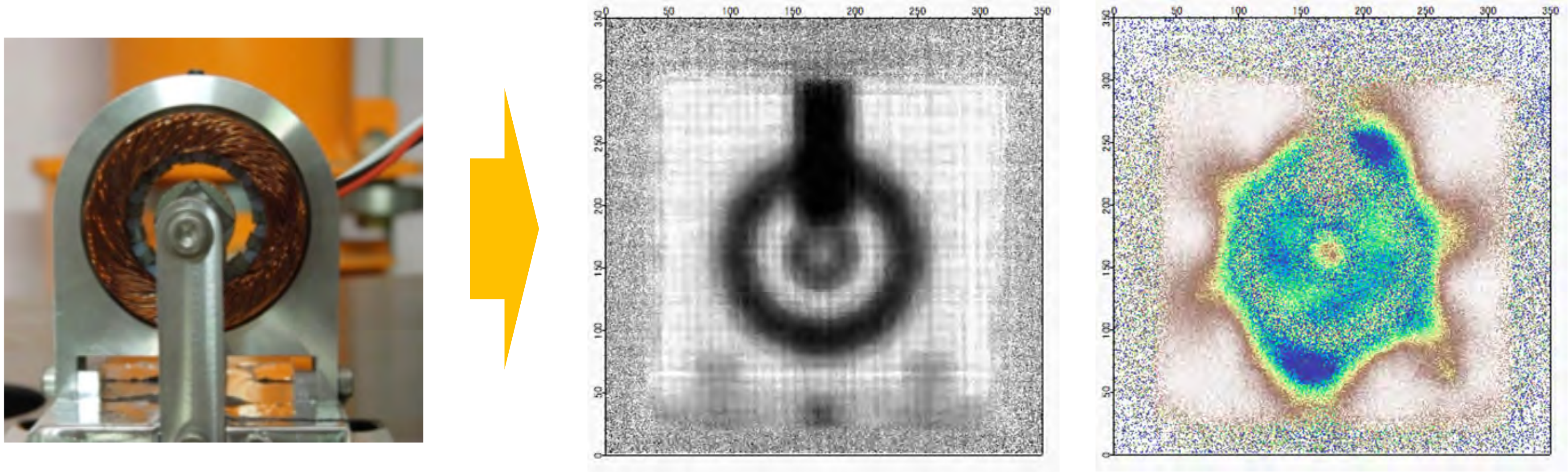
Scientific Reports (2016)

Ice VII from aqueous salt solutions



Scientific Reports (2016)

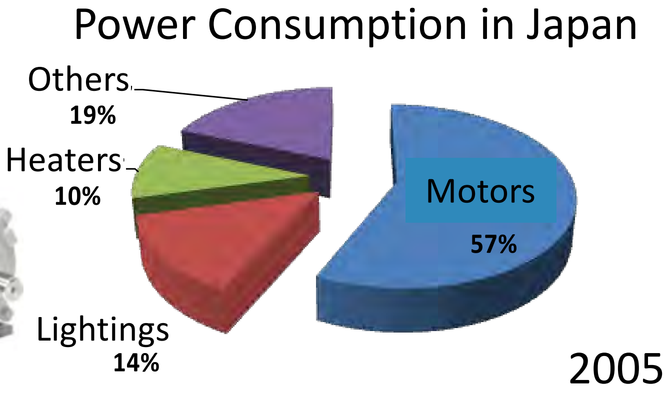
Magnetic Imaging @ RADEN



The world's 1st demonstration of visualizing magnetic field of a working motor.

Collaboration with Hitachi Ltd. HITACHI Inspire the Next

RADEN results are used to improve simulation technology to design higher performance motors.

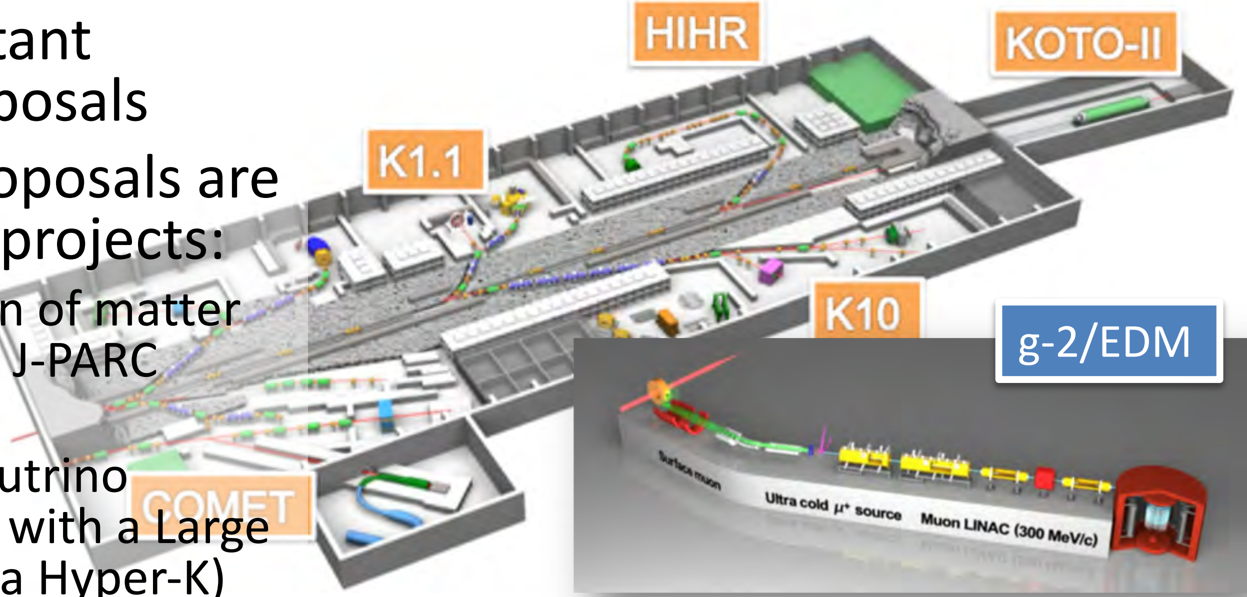


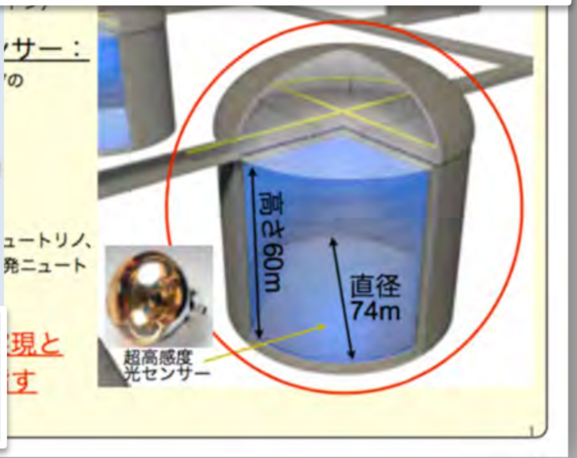
Motors consume more than 50% of total electric power in Japan

Supported by Photon and Quantum Basic Research Coordinated Development Program by MEXT (2013-2018)

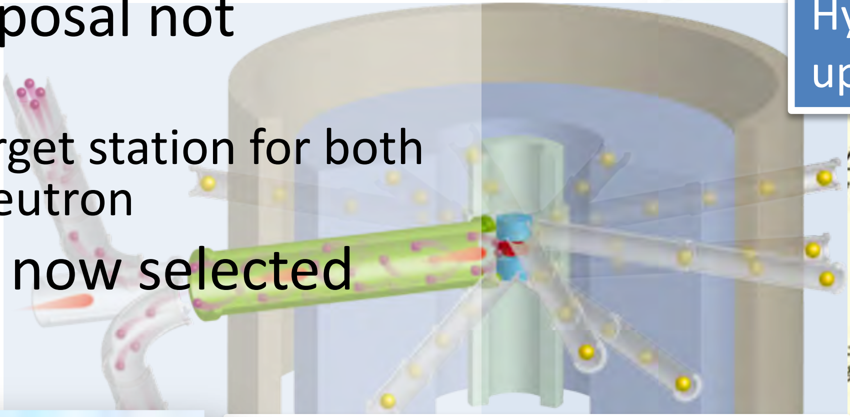
Japan Science Council Master Plan 2017

- JSC selected 28 important projects from 166 proposals
- Two J-PARC related proposals are selected as important projects:
  - Elucidation of the origin of matter with an upgrade of the J-PARC experimental facility
  - Nucleon Decay and Neutrino Oscillation Experiment with a Large Advanced Detector (aka Hyper-K)
- One J-PARC proposal not selected
  - MLF the 2nd target station for both neutron and neutron
- MEXT roadmap now selected Hyper-K





Hyper-K and relevant J-PARC upgrade



MLF the 2nd target station for neutron x 10+muon x 50

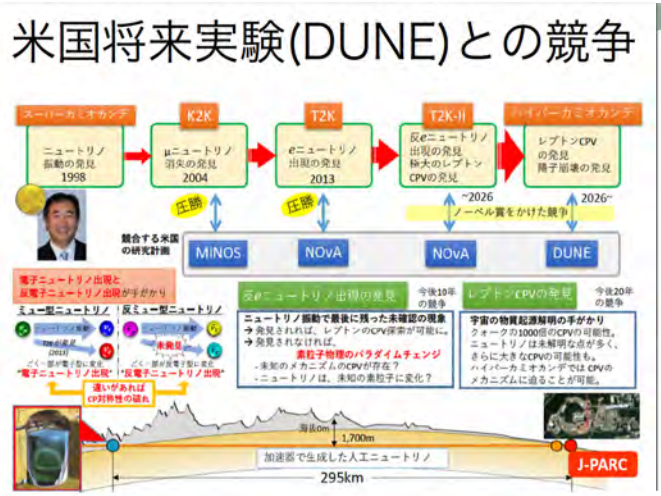
Science Council of Japan

J-PARC near Future Projects

- Neutrino future plan
- Hadron Hall extension
- COMET phase-2
- Muon g-2/EDM@J-PARC
- The 2nd target station at MLF
- Nuclear Transmutation Project
- Irradiation and Examination facility
- Heavy Ion Acceleration
- Muon microscope
- Stretcher ring for Slow EX.

Monday, 23 April 2018

13:30 - 13:50	はじめに *20'* Speaker: Naohito SAITO (J-PARC)
13:50 - 14:10	ニュートリノ将来計画 *20'* Speaker: Takeshi NAKADAIRA (KEK IPNS) Material: **Slides**
14:10 - 14:30	ハドロン拡張計画 *20'* Speaker: Shinya SAWADA (KEK) Material: **Slides**
14:30 - 14:50	COMET Phase-2 *20'* Speaker: Hajime NISHIGUCHI (KEK IPNS) Material: **Slides**
14:50 - 15:10	Muon g-2/EDM@J-PARC *20'* Speaker: Tsutomu MIBE (KEK IPNS) Material: **Slides**
15:10 - 15:30	tea / coffee break
15:30 - 15:50	MLF 第二標的ステーション *20'*
15:50 - 16:10	核変換開発プロジェクト *20'* Speaker: Fujio Maekawa (J-PARC) Material: **Slides**
16:10 - 16:30	材料照射施設計画 *20'* Speaker: Eiichi Wakai (J-PARC) Material: **Slides**
16:30 - 16:50	重イオン加速計画 *20'* Speaker: Hiroyuki HARADA (J-PARC) Material: **Slides**
16:50 - 17:10	tea / coffee break
17:10 - 17:30	ミュオン顕微鏡計画 *20'* Speaker: Yukinori NAGATANI (IMSS) Material: **Slides**
17:30 - 17:50	遅い取り出しストレッチャーリング *20'* Speaker: Masahito TOMIZAWA (KEK ACCL) Material: **Slides**
17:50 - 18:10	discussion *20'*



米国将来実験(DUNE)との競争

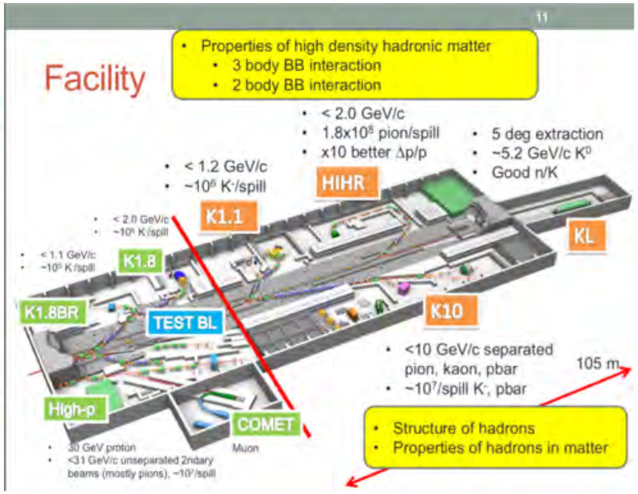
電子ニュートリノ出現と反電子ニュートリノ出現が手がかり

反eニュートリノ出現の発見　今後10年の競争

ニュートリノ振動で最後に残った未確認の現象
→ 発見されれば、レプトンのCPV探索が可能に。
→ 発見されなければ、
素粒子物理のパラダイムチェンジ
- 未知のメカニズムのCPVが存在？
- ニュートリノは、未知の素粒子に変化？

レプトンCPVの発見　今後20年の競争

宇宙の物質起源解明の手がかり
クォークの1000倍のCPVの可能性。
ニュートリノは未解明な点が多く、さらに大きなCPVの可能性も。
ハイパーカミオカンデではCPVのメカニズムに迫ることが可能。



Facility

- Properties of high density hadronic matter
  - 3 body BB interaction
  - 2 body BB interaction

- < 2.0 GeV/c
- 1.8x10^8 pion/spill
- x10 better Δp/p

- 5 deg extraction
- ~5.2 GeV/c K^0
- Good n/K

- < 1.2 GeV/c
- ~10^6 K$^-$/spill

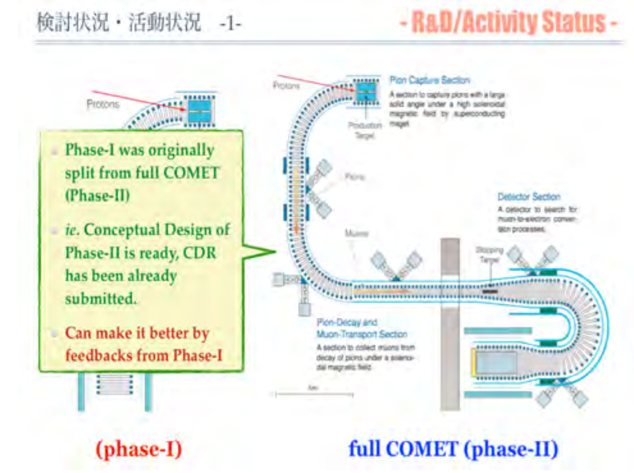
- < 2.0 GeV/c
- ~10^6 K$^-$/spill

- < 1.1 GeV/c
- ~10^5 K$^-$/spill

- <10 GeV/c separated pion, kaon, pbar
- ~10^7/spill K$^-$, pbar

- 30 GeV proton
- <31 GeV/c unseparated 2ndary beams (mostly pions), ~10^7/spill

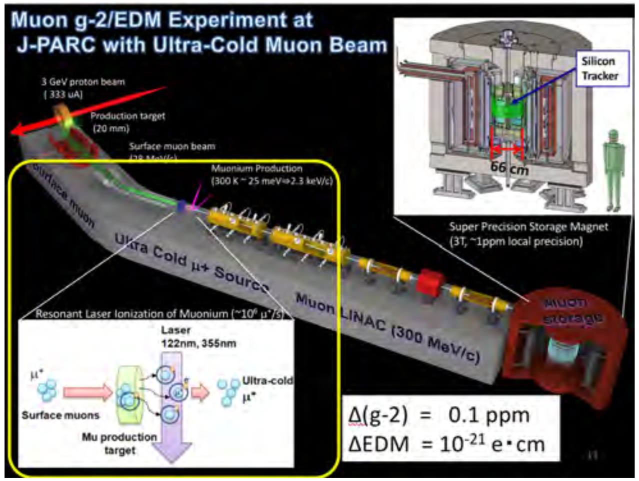
- Structure of hadrons
- Properties of hadrons in matter



検討状況・活動状況　-1-　- R&D/Activity Status -

- Phase-I was originally split from full COMET (Phase-II)
- *ie*. Conceptual Design of Phase-II is ready, CDR has been already submitted.
- Can make it better by feedbacks from Phase-I

(phase-I)　　full COMET (phase-II)

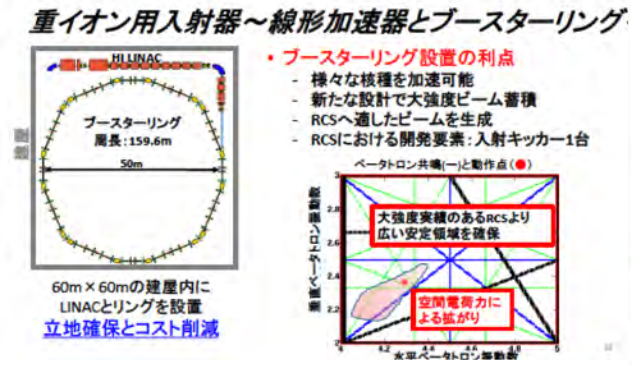


Muon g-2/EDM Experiment at J-PARC with Ultra-Cold Muon Beam

Super Precision Storage Magnet (3T, ~1ppm local precision)

$$\Delta(g\text{-}2) = 0.1\ \mathrm{ppm}$$

$$\Delta EDM = 10^{-21}\ e\cdot cm$$



重イオン用入射器～線形加速器とブースターリング

60m × 60mの建屋内にLINACとリングを設置

立地確保とコスト削減

- ブースターリング設置の利点
  - 様々な核種を加速可能
  - 新たな設計で大強度ビーム蓄積
  - RCSへ適したビームを生成
  - RCSにおける開発要素：入射キッカー1台

大強度実績のあるRCSより広い安定領域を確保

空間電荷力による拡がり

ADS 研究計画 見直しの概要

実用規模ADS
30MW-beam、800MW$_{th}$
・LWR10基分のMA核変換

PSi 計画の解析システム（①）により仮想ADSを構築し、実用規模ADS実現のための技術要件を緩和

実証試験施設

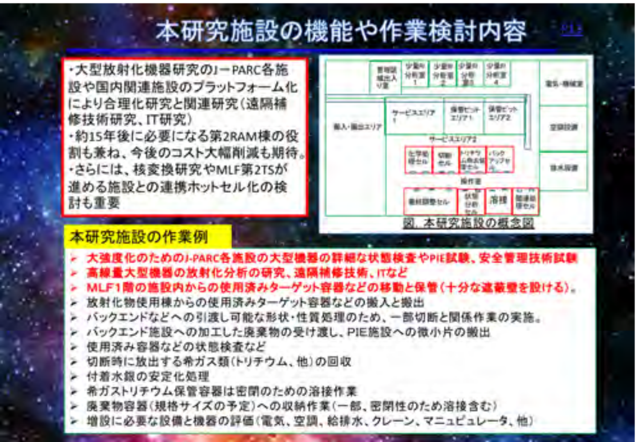
PSi計画の解析モデル（②）・実験データ取得（③）により施設に求められる機能・仕様を重点化し、実証試験施設を合理化

J-PARC照射施設

PSi 計画

PSi 計画　【計算科学的アプローチ】
① ADSプラント設計システムの詳細化・大規模化
② 燃料材料の照射損傷・腐食解析モデル開発
③ V&V のための既存施設を活用した実験データ取得

ループ実験、KUCA実験などの基礎試験



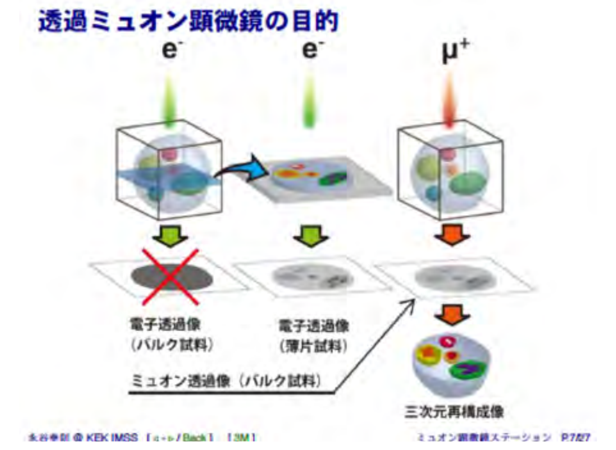
本研究施設の機能や作業検討内容

・大型放射化機器研究のJ－PARC各施設や国内関連施設のプラットフォーム化により合理化研究と関連研究（遠隔補修技術研究、IT研究）
・約15年後に必要になる第2RAM棟の役割も兼ね、今後のコスト大幅削減も期待。
・さらには、核変換研究やMLF第2TSが進める施設との連携ホットセル化の検討も重要

図. 本研究施設の概念図

本研究施設の作業例

- ➢ 大強度化のためのJ-PARC各施設の大型機器の詳細な状態検査やPIE試験、安全管理技術試験
- ➢ 高線量大型機器の放射化分析の研究、遠隔補修技術、ITなど
- ➢ MLF1階の施設内からの使用済みターゲット容器などの移動と保管（十分な遮蔽壁を設ける）。
- ➢ 放射化物使用棟からの使用済みターゲット容器などの搬入と搬出
- ➢ バックエンドなどへの引渡し可能な形状・性質処理のため、一部切断と関係作業の実施。
- ➢ バックエンド施設への加工した廃棄物の受け渡し、PIE施設への微小片の搬出
- ➢ 使用済み容器などの状態検査など
- ➢ 切断時に放出する希ガス類（トリチウム、他）の回収
- ➢ 付着水銀の安定化処理
- ➢ 希ガストリチウム保管容器は密閉のための溶接作業
- ➢ 廃棄物容器（規格サイズの予定）への収納作業（一部、密閉性のため溶接含む）
- ➢ 増設に必要な設備と機器の評価（電気、空調、給排水、クレーン、マニュピュレータ、他）



透過ミュオン顕微鏡の目的

Installation and Tunnel Civil Engineering

宮原正信氏 (KEK Acc.)、日建設計による検討

・トンネル杭強度　MR磁石の荷重までOK
・トンネル躯体強度　問題なし
・トンネル表面ひび割れ　設計応力裕度にばらつきがあるため詳細検討が必要
（対策　繊維シート）

Collaboration with Academia & Industry

Domestic University

2016
茨城大学大学院・理工学研究科
博士前期(修士)課程
Graduate School of Science and Engineering
2016年４月量子線科学専攻を新設します

New Graduate Course Established to include J-PARC science

Oversea Institutions

Collaboration with ANSTO

For improving user environment, sample environment, e.g. deuterization lab, and exchange program for researchers.

Collaboration with TRIUMF

Experimental Collaboration and exchange program of researchers; share the know-how on facility and safety management

Collaboration with ESS

Contribute to the newly constructed major facility based on the experience of J-PARC construction.

Osaka U@J-PARC

Kyoto U@J-PARC

Kyushu U@J-PARC

University branches at J-PARC

Education and training of students and young researchers at the very front of J-PARC operation, especially to raise the next generation who can create a future cutting edge facilities

Industrial Sector

J-PARC／住友ゴム フェローシ

先端研究施設
(学術)

スパイラルアップが必要

潜在的課題

産業界

学術・産業成果の
両方が求められる

ブラックボックスのまま商品開発も可能
一旦　解明されればそれで成功、満足
継続的に将来ニーズ・シーズが提言できな

基盤技術からモノ作り連携を理解した
研究員の育成課題

企業内における先端特殊研究の人材育成・
終身雇用体制の課題

従来の
共同研究
(大学)

ポスドク

大学

最終商品に貢献するのニーズが不明。データ・技術のみ。

企業

制度案

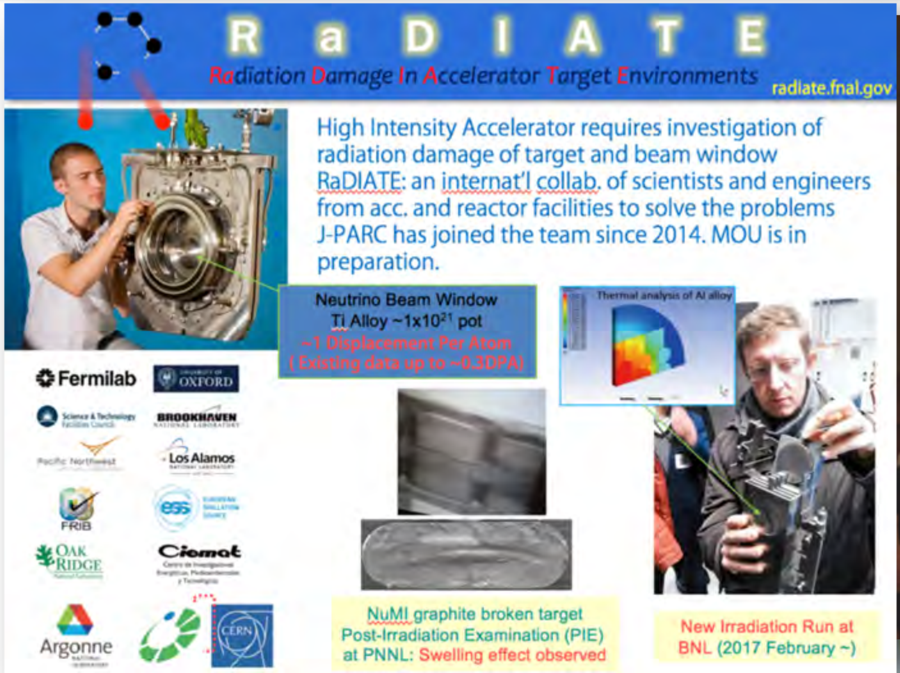
先端施設

出向

ポスドク

J-PARC/Sumitomo rubber Inc. Fellowship is been enlarged

Now a member of RaDIATE September, 2017



R a D I A T E

Radiation Damage In Accelerator Target Environments

radiate.fnal.gov

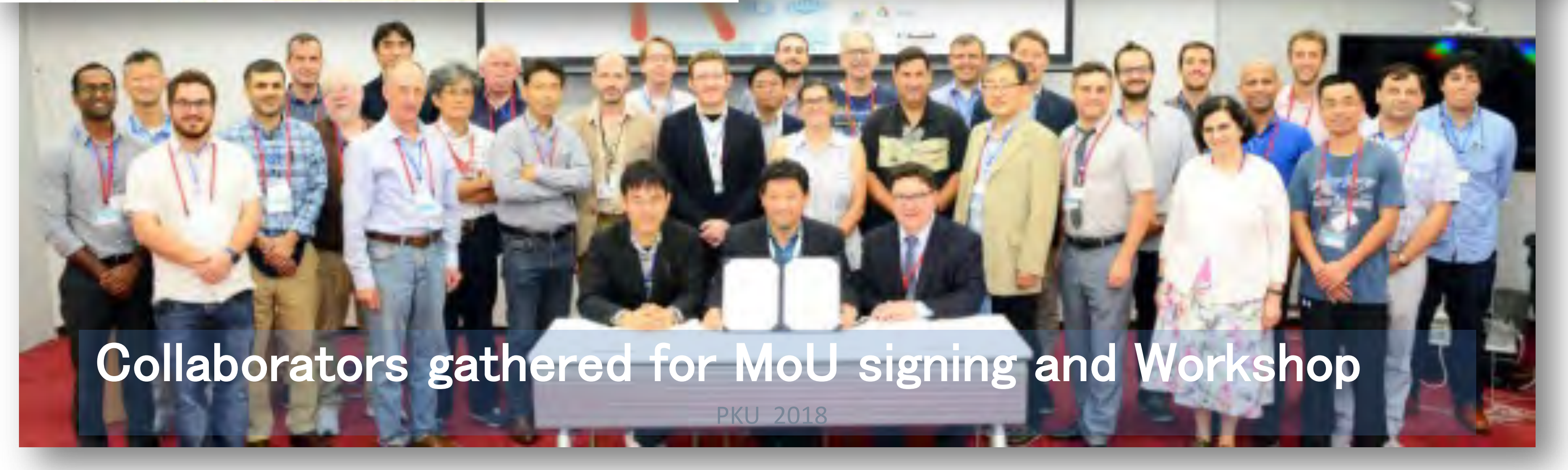
High Intensity Accelerator requires investigation of radiation damage of target and beam window
RaDIATE: an internat'l collab. of scientists and engineers from acc. and reactor facilities to solve the problems
J-PARC has joined the team since 2014. MOU is in preparation.

Neutrino Beam Window
Ti Alloy ~1x10^{21} pot
~1 Displacement Per Atom
(Existing data up to ~0.3DPA)

Thermal analysis of Al alloy

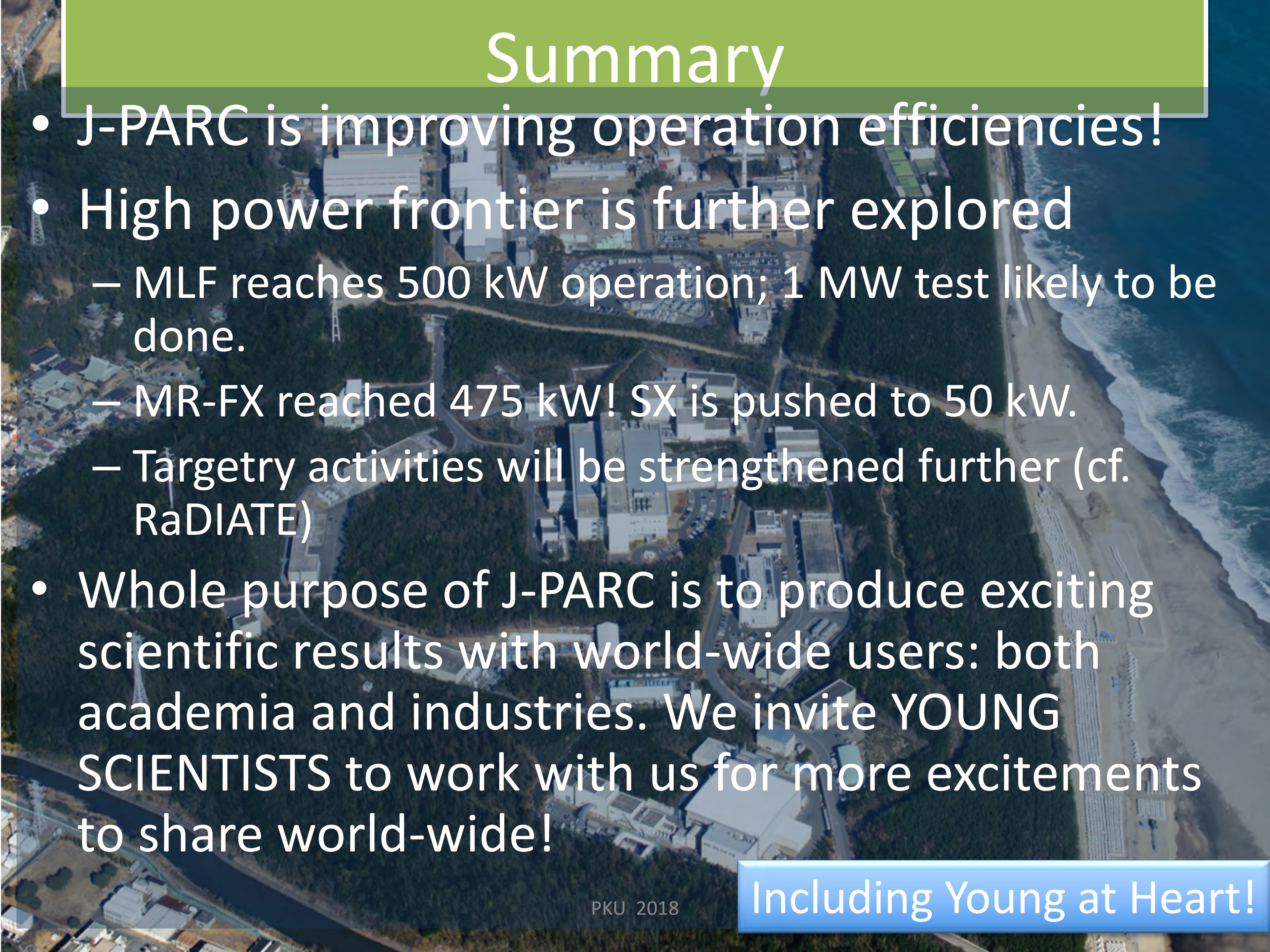
NuMI graphite broken target
Post-Irradiation Examination (PIE)
at PNNL: Swelling effect observed

New Irradiation Run at
BNL (2017 February ~)



Collaborators gathered for MoU signing and Workshop

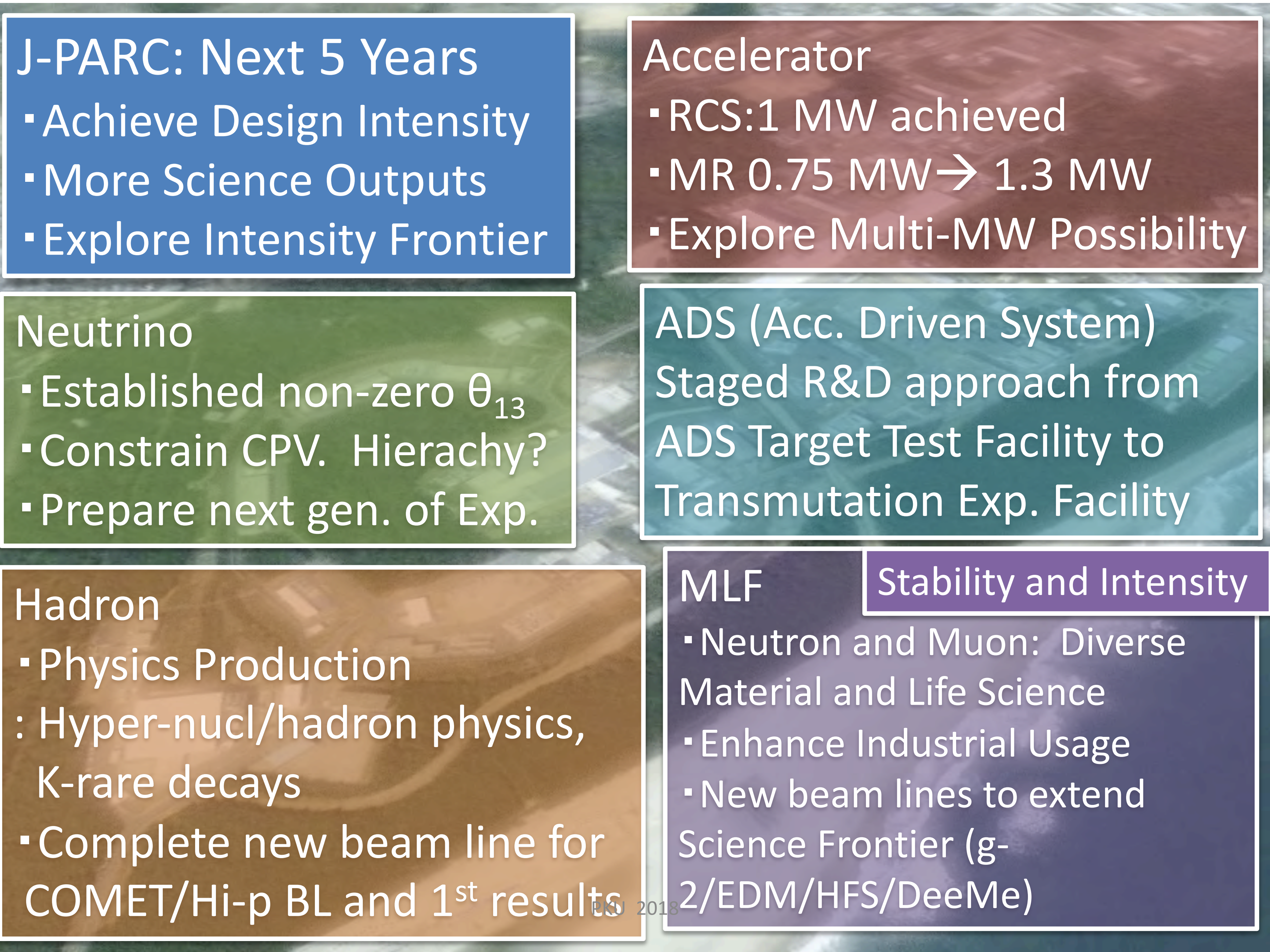
Summary



- J-PARC is improving operation efficiencies!
- High power frontier is further explored
  - MLF reaches 500 kW operation; 1 MW test likely to be done.
  - MR-FX reached 475 kW! SX is pushed to 50 kW.
  - Targetry activities will be strengthened further (cf. RaDIATE)
- Whole purpose of J-PARC is to produce exciting scientific results with world-wide users: both academia and industries. We invite YOUNG SCIENTISTS to work with us for more excitements to share world-wide!

Including Young at Heart!

J-PARC



J-PARC: Next 5 Years

- Achieve Design Intensity
- More Science Outputs
- Explore Intensity Frontier

Accelerator

- RCS:1 MW achieved
- MR 0.75 MW→ 1.3 MW
- Explore Multi-MW Possibility

Neutrino

- Established non-zero θ_{13}
- Constrain CPV. Hierachy?
- Prepare next gen. of Exp.

ADS (Acc. Driven System)

Staged R&D approach from ADS Target Test Facility to Transmutation Exp. Facility

Hadron

- Physics Production
: Hyper-nucl/hadron physics, K-rare decays
- Complete new beam line for COMET/Hi-p BL and 1st results

MLF

Stability and Intensity

- Neutron and Muon: Diverse Material and Life Science
- Enhance Industrial Usage
- New beam lines to extend Science Frontier (g-2/EDM/HFS/DeeMe)

Characteristic Features of Neutron

- Neutrons can investigate structure and dynamics of atoms and molecules

- Neutron has spin=1/2

→ Magnetism, Electric properties

- Neutron can distinguish isotopes (H, D)

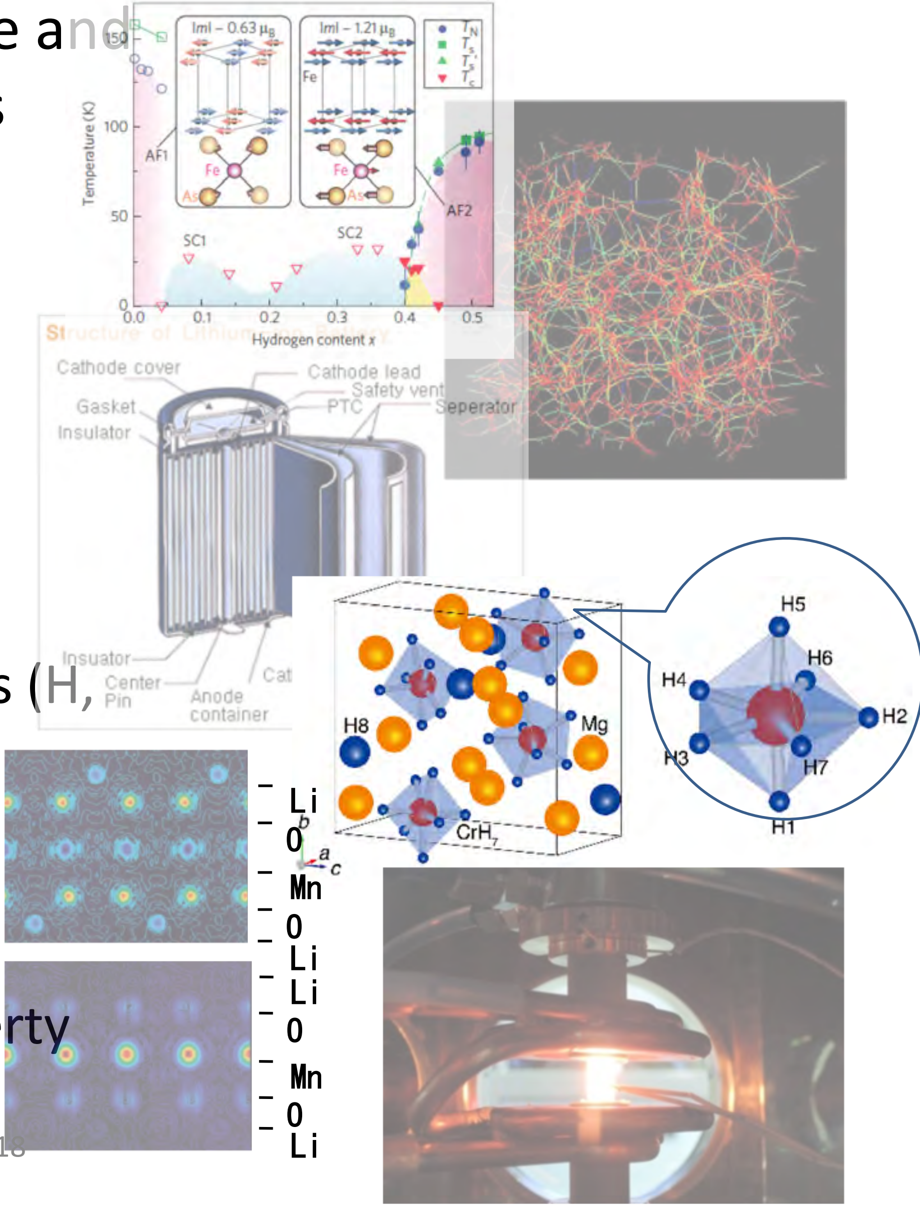
→ Soft Matter Researches

- Neutron is sensitive to light elements (H, Li, ,,,)

→ Energy Material (battery, hydrogen absorbing materials)

- Neutron has deep penetration property

→ Engineering Material



Accelerator and Targetry

Join Us!


1MW安定運転に成功！
平成30年7月3日
J-PARC
J-PARC MLF
消火器

祝 ニュートリノPOT達成
&MR 500 kW 越え

平成29年4月13日

More Power at MR

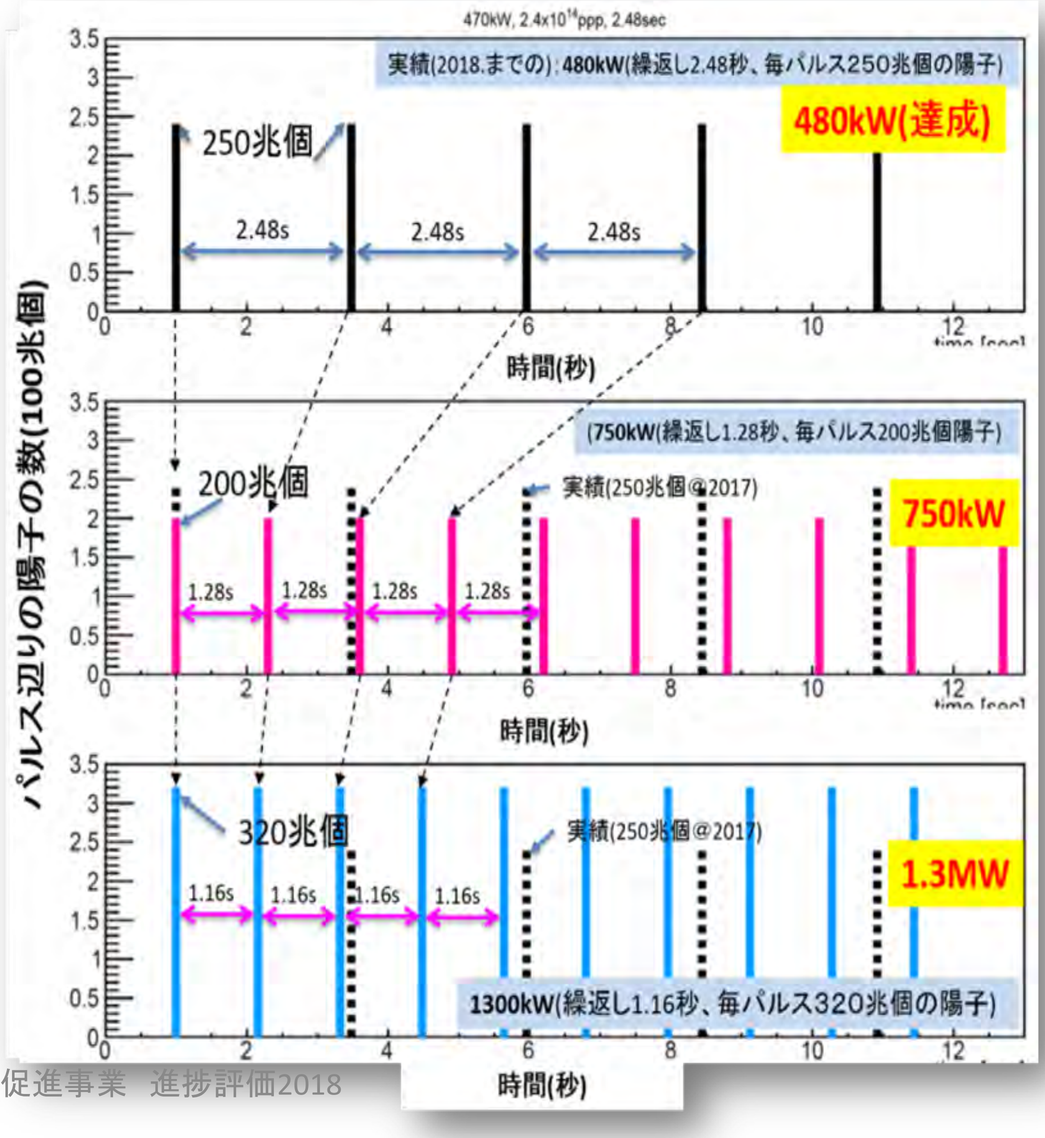
More Rapid Cycle:

2.48 s → 1.28 s → 1.16 s

- Main Power Supply to be re-newed
- High gradient RF Cavity
- Improve Collimator
- Rapid cycle pulse magnet for injection/extraction

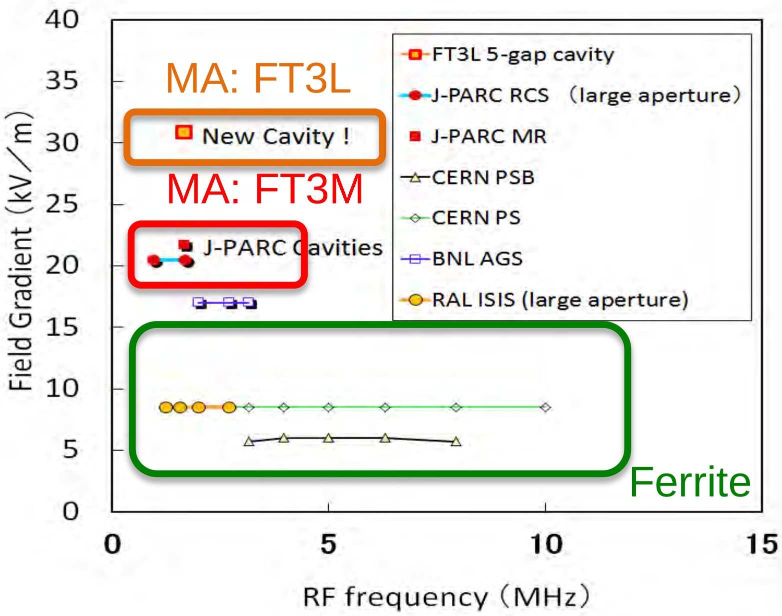
More Protons / Pulse :

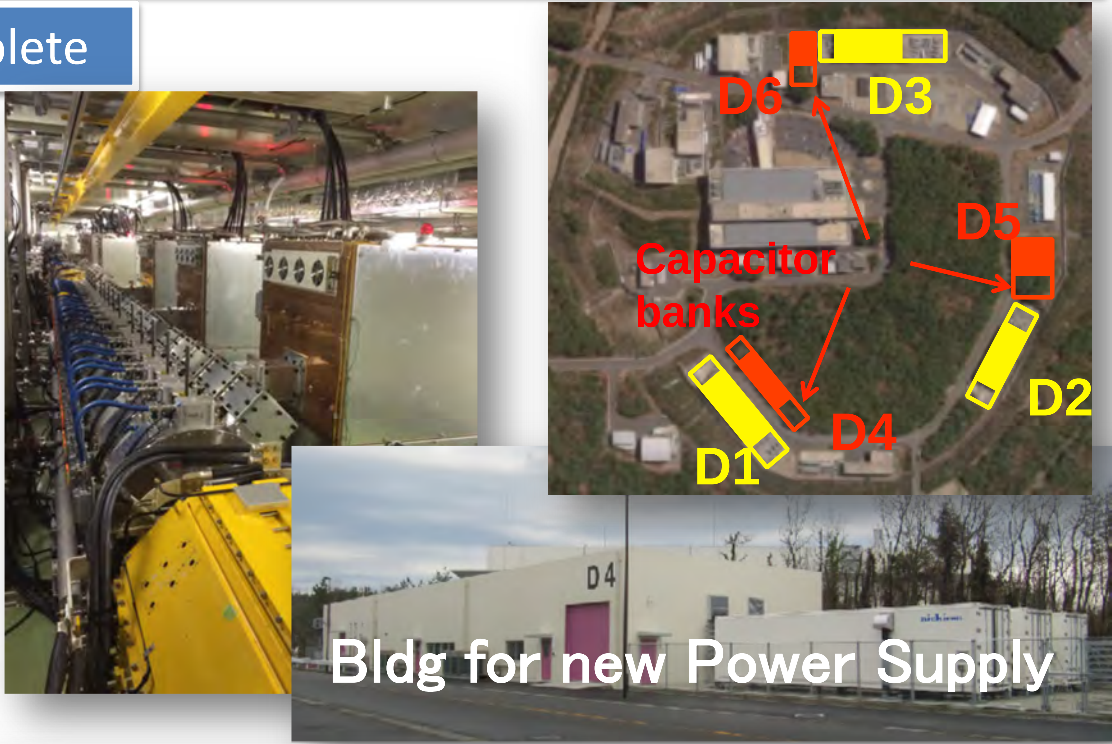
- Improve RF Power
- More RF Systems
- Stabilize the beam with feedback



Readiness for the new Power Supply at MR

R&D of Hi-Gradient RF Core is Complete





Bldg for new Power Supply

New Septum for Injection

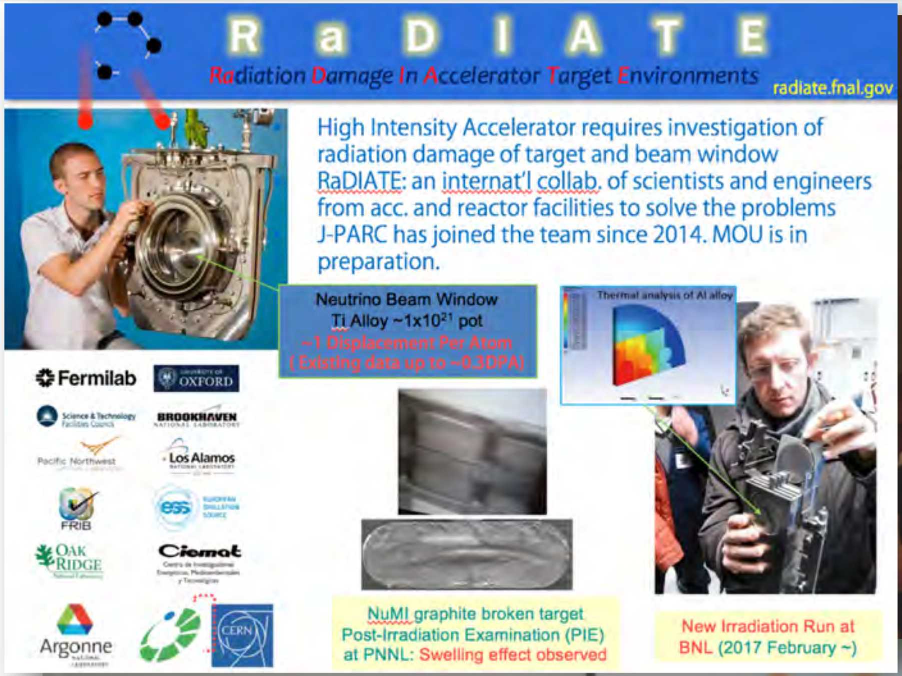
New Power Supply for Rapid Cycle

Projected Schedule of MR new Power Supply

JFY	2017	2018	2019	2020	2021	2022	2023	2024
Event →	New buildings →		HD target		Long shutdown			
FX power [kW]	475	>480	>480	>480		>700	800	900
SX power [kW]	50	50	50	70		> 80	> 80	> 80
Cycle time of main magnet PS	2.48 s	2.48 s	2.48s	2.48s		1.32 s	<1.32s	<1.32s
New magnet PS	→	Mass production installation/test →	→	→	→			
High gradient rf system						→	→	→
2nd harmonic rf system	→	Manufacture, installation/test →	→	→	→	→	→	→
Ring collimators	Add.collimators (2 kW)				Add.colli. (3.5kW)			
Injection system	Kicker PS improvement, Septa manufacture /test →	→	→	→	→			
FX system	Kicker PS improvement, FX septa manufacture /test →	→	→	→	→			
SX collimator / Local shields						Local shields →	→	→
Ti ducts and SX devices with Ti chamber	Ti-ESS-1	(Ti-ESS-2)						

利用者協議会
20180320

Now a member of RaDIATE September, 2017



RaDIATE

Radiation Damage In Accelerator Target Environments

radiate.fnal.gov

High Intensity Accelerator requires investigation of radiation damage of target and beam window

RaDIATE: an internat'l collab. of scientists and engineers from acc. and reactor facilities to solve the problems

J-PARC has joined the team since 2014. MOU is in preparation.

Neutrino Beam Window
Ti Alloy ~1x10^{21} pot
~1 Displacement Per Atom
(Existing data up to ~0.3DPA)

Thermal analysis of Al alloy

NuMI graphite broken target
Post-Irradiation Examination (PIE)
at PNNL: Swelling effect observed

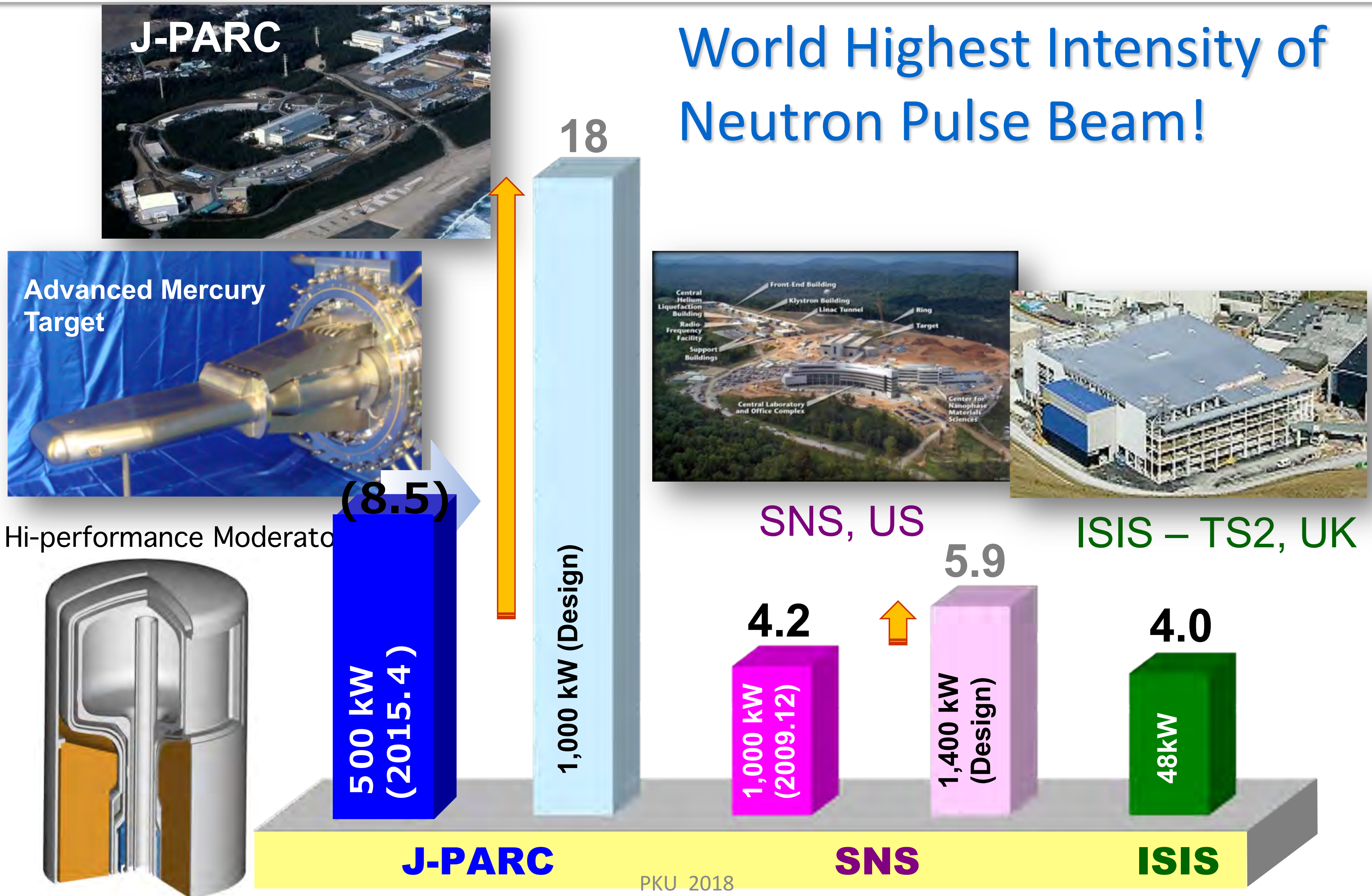
New Irradiation Run at
BNL (2017 February ~)

Fermilab
Oxford
Science & Technology Facilities Council
Brookhaven National Laboratory
Pacific Northwest
Los Alamos
FRIB
ESS European Spallation Source
Oak Ridge
Ciemat
Argonne
CERN

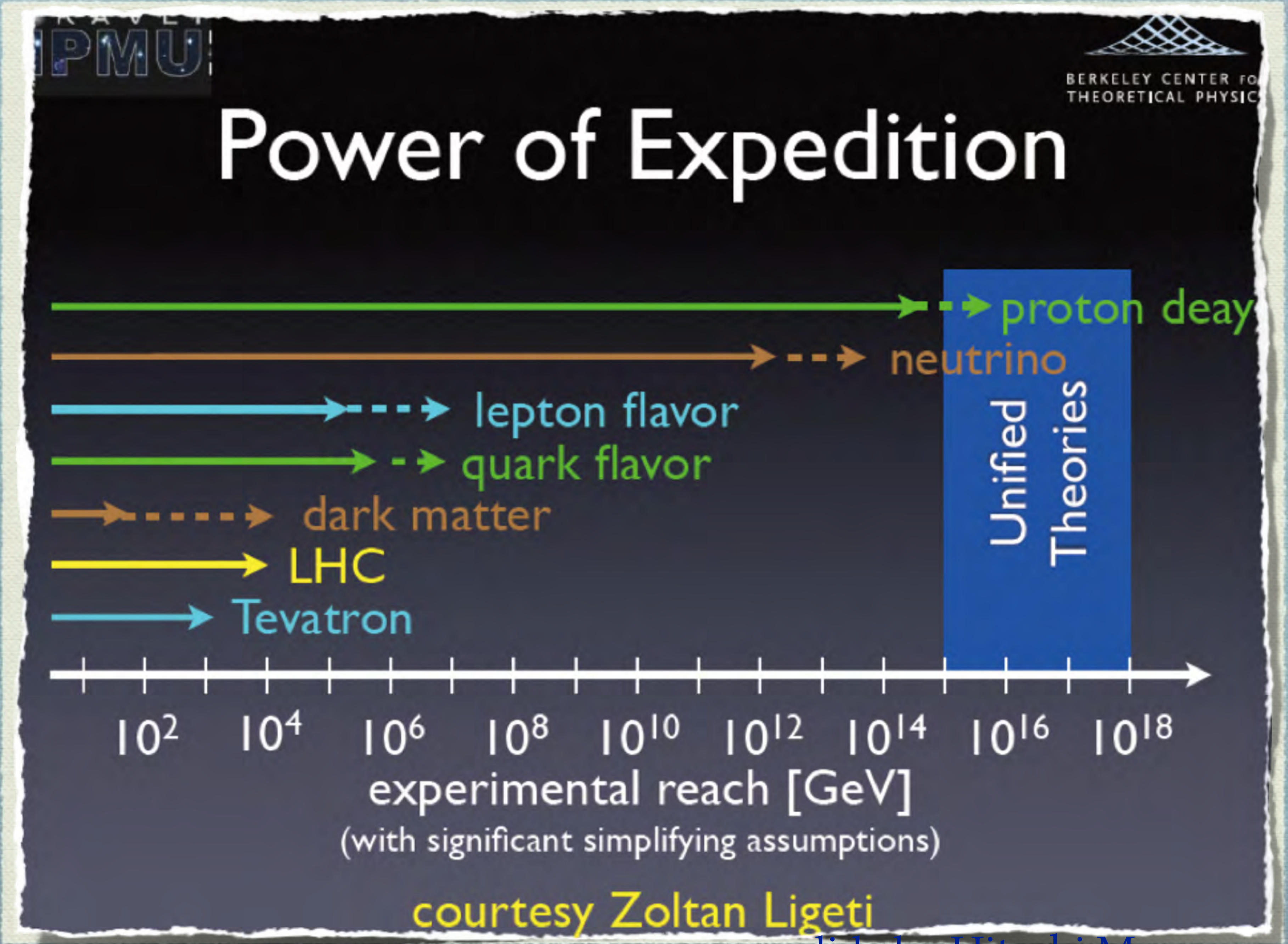
Collaborators gathered for MoU signing and Workshop

Material and Life Science Facility（MLF）

World Highest Intensity of Neutron Pulse Beam!



Unit: 10^{12} n/(sr・pulse)



IPMU

BERKELEY CENTER FO
THEORETICAL PHYSIC

Power of Expedition

experimental reach [GeV]
(with significant simplifying assumptions)

courtesy Zoltan Ligeti

a slide by Hitoshi Murayama

Uncertainty Principle

- Position and Momentum cannot be determined simultaneously
  - Measurement of position would disturb the quantum state so that momentum measurement would become inaccurate
- Time and Energy cannot be determined simultaneously
  - Energy conservation can be violated if in a short time interval

$$\Delta x \cdot \Delta p \geq \frac{\hbar}{2}$$

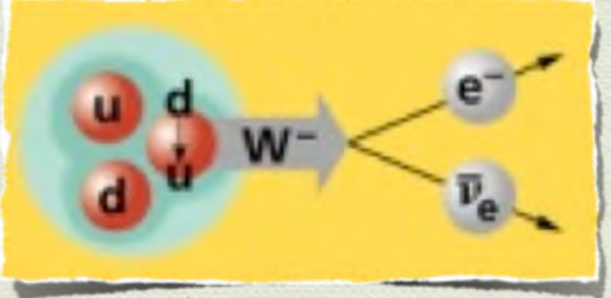
$$\Delta t \cdot \Delta E \geq \frac{\hbar}{2}$$

Examples

- Beta decay of neutron to proton
  - mediated by W boson

neutron mass ~ 1 GeV/c^2

W boson mass ~ 80 GeV/c^2

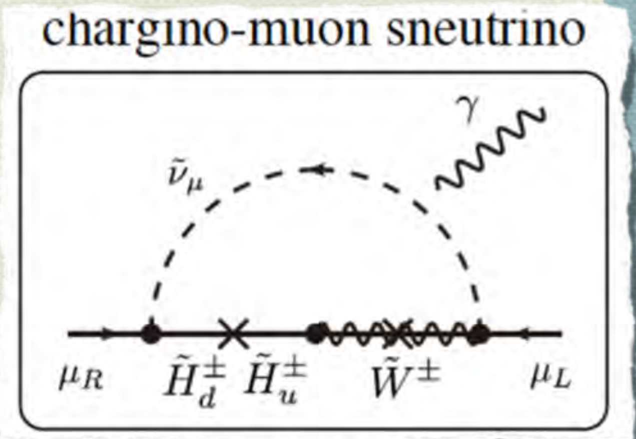


- Muon g-2 (anomalous magnetic moment)

- measured value > the SM theory by 3 standard deviation --> possible explanation is NEW PHYSICS

muon mass ~ 0.1 GeV/c^2

possible new physics scale ~ 1 TeV/c^2


chargino-muon sneutrino