FB20

20-25 August, 2012

Hadron Experimental Facility at J-PARC

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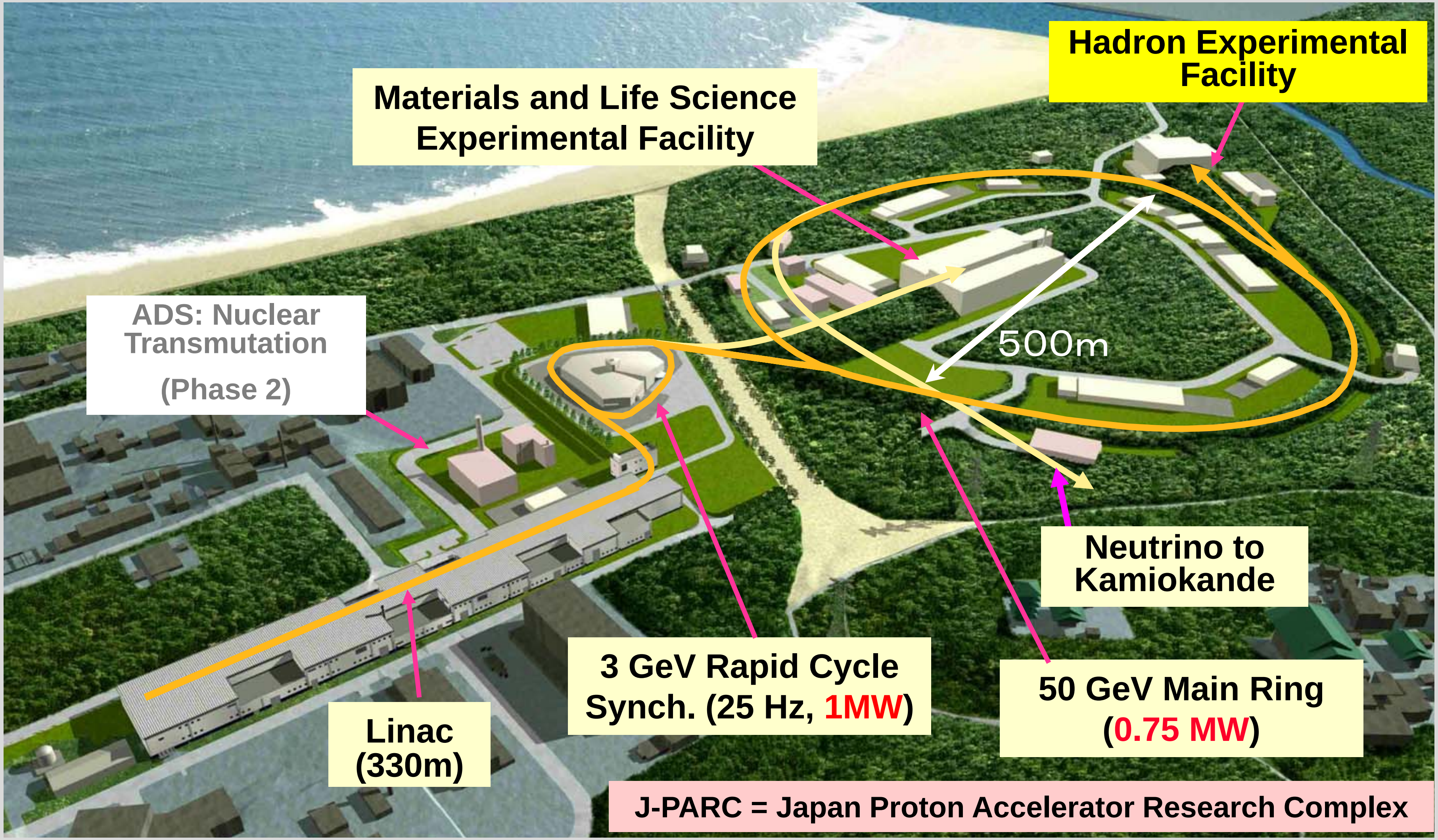
Hadron Experimental Facility at J-PARC

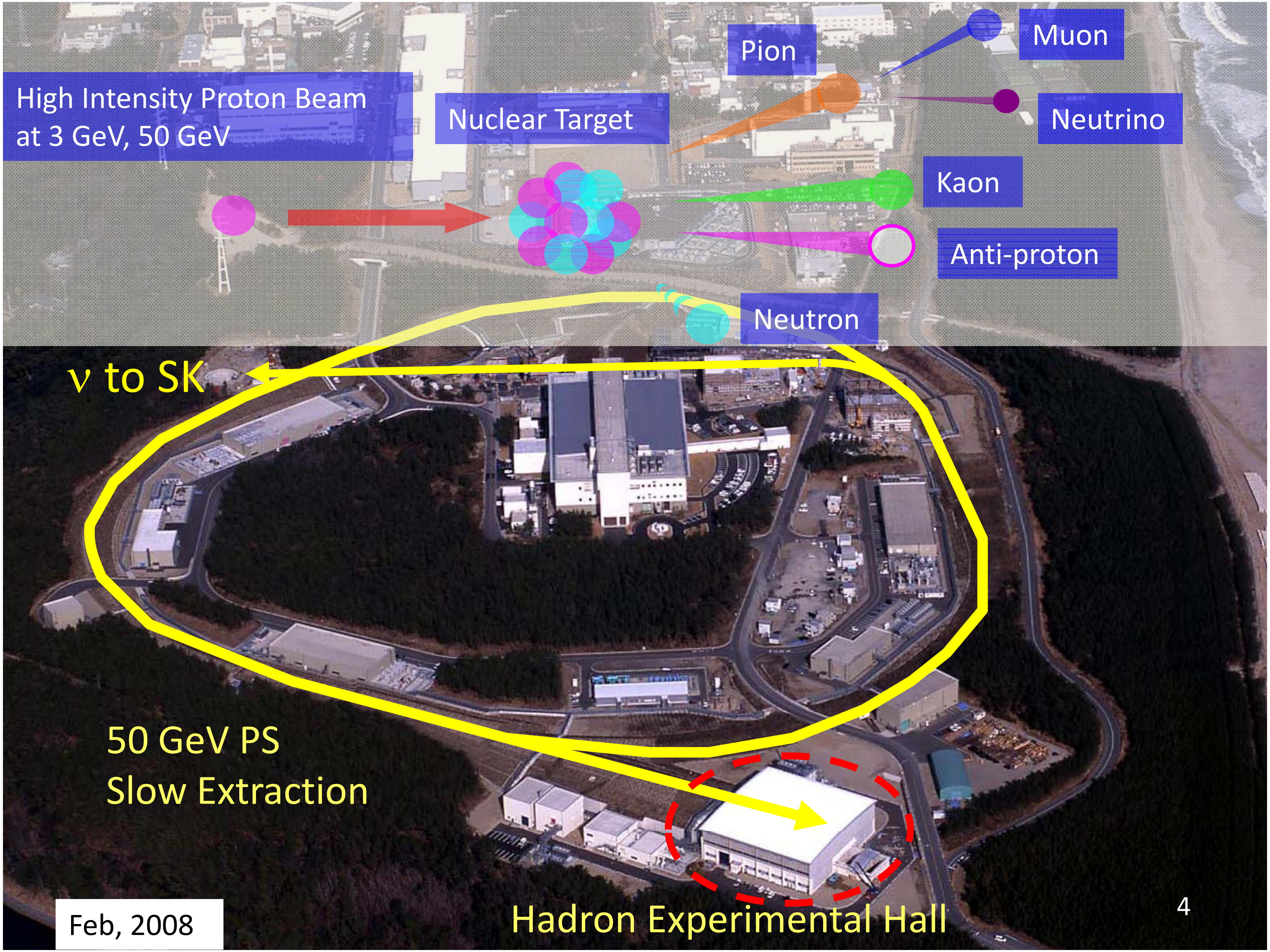
Contents:

1. Present
   - Hyperon resonance below KbarN threshold
2. Near Term
   - A research project in the High-momentum Beam Line
3. Future Extension

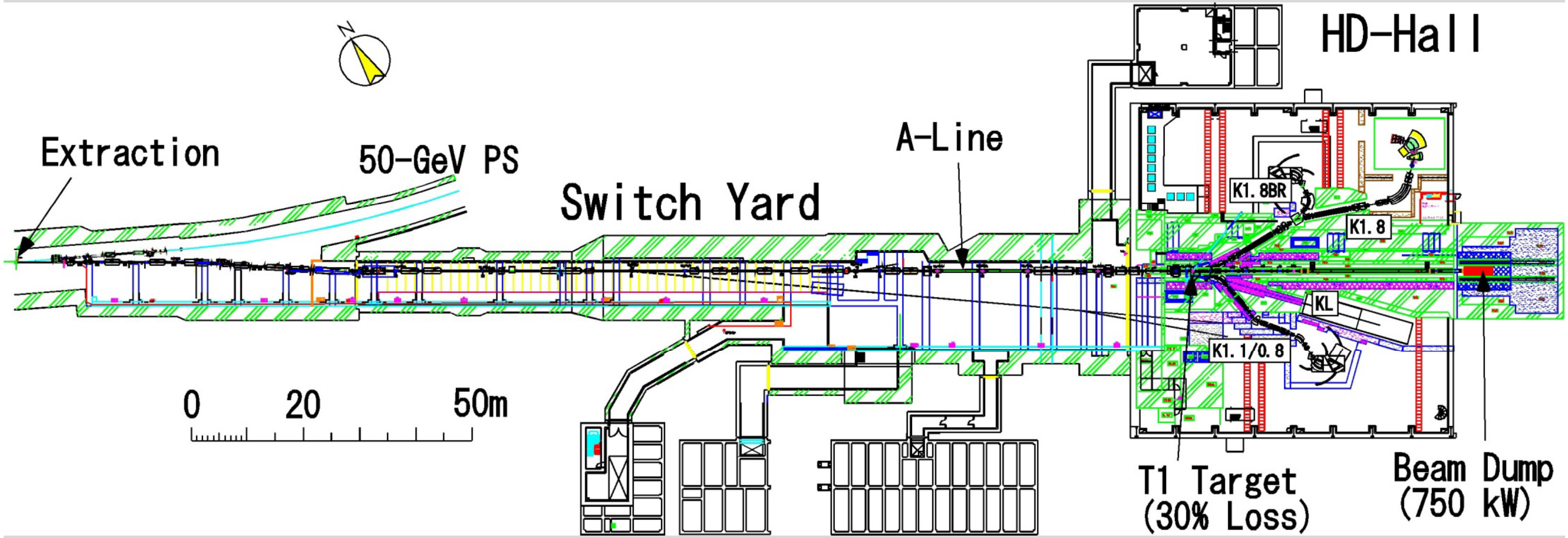
J-PARC Facility



Joint Project between KEK and JAEA since 2001


High Intensity Proton Beam
at 3 GeV, 50 GeV
Nuclear Target
Pion
Muon
Neutrino
Kaon
Anti-proton
Neutron
ν to SK
50 GeV PS
Slow Extraction
Hadron Experimental Hall
Feb, 2008

HADRON BEAM LINE FACILITY



- Slow Extraction (SX) Beam :
  - Currently, the accelerator is operated at 30 GeV.
  - 1st phase: A design goal is 9μA (270 kW, 3.4×10^{14} /6s spill)

    SX Beam: step by step operation to increase extracted power.

    ~6 kW (June, 2012)

    >10 kW in 2012

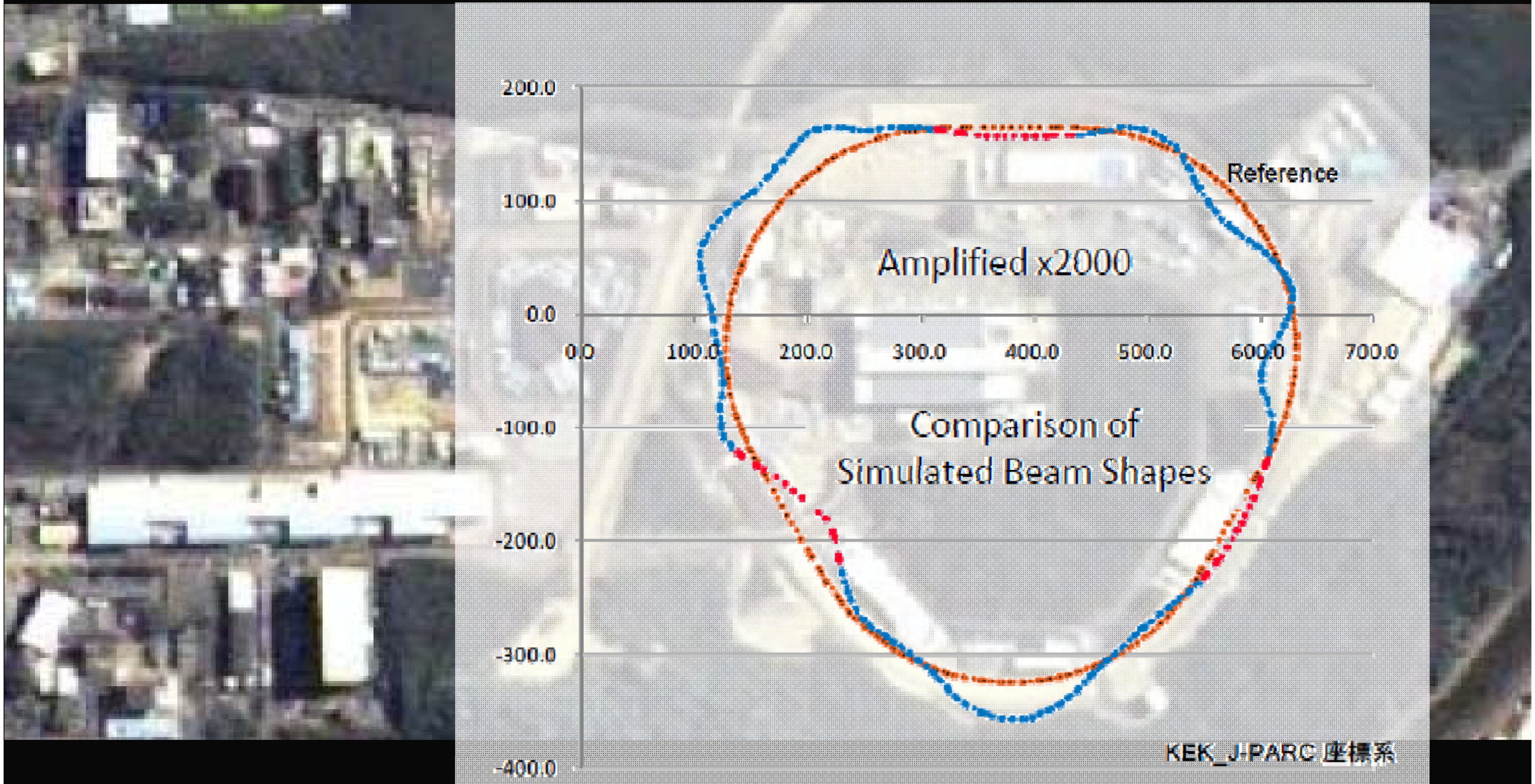
    ~50 kW in 2013

    ~100 kW

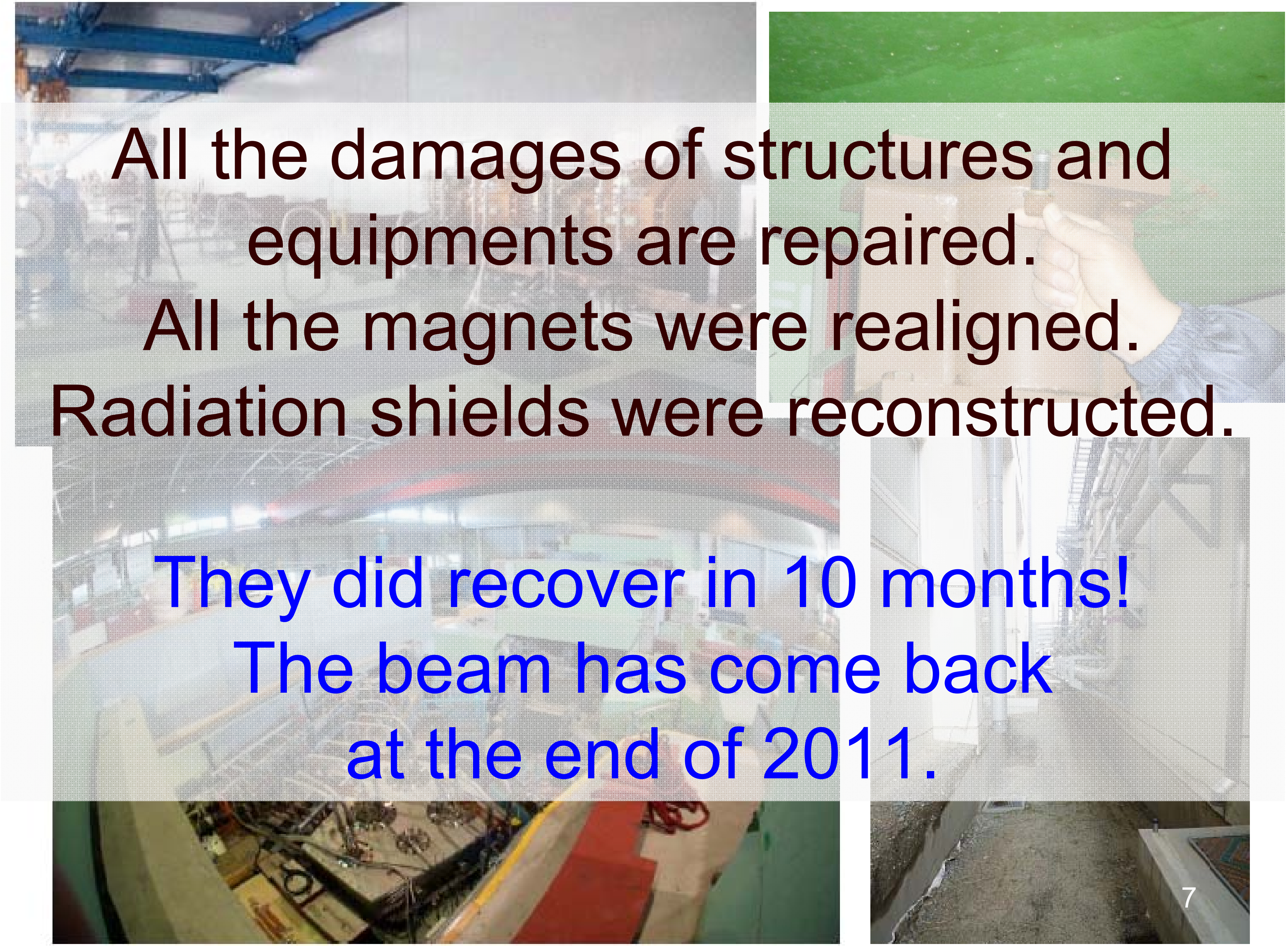
99.6% Extraction efficiency is achieved!
- The World Highest Score -

For FX: >180kW has been achieved.

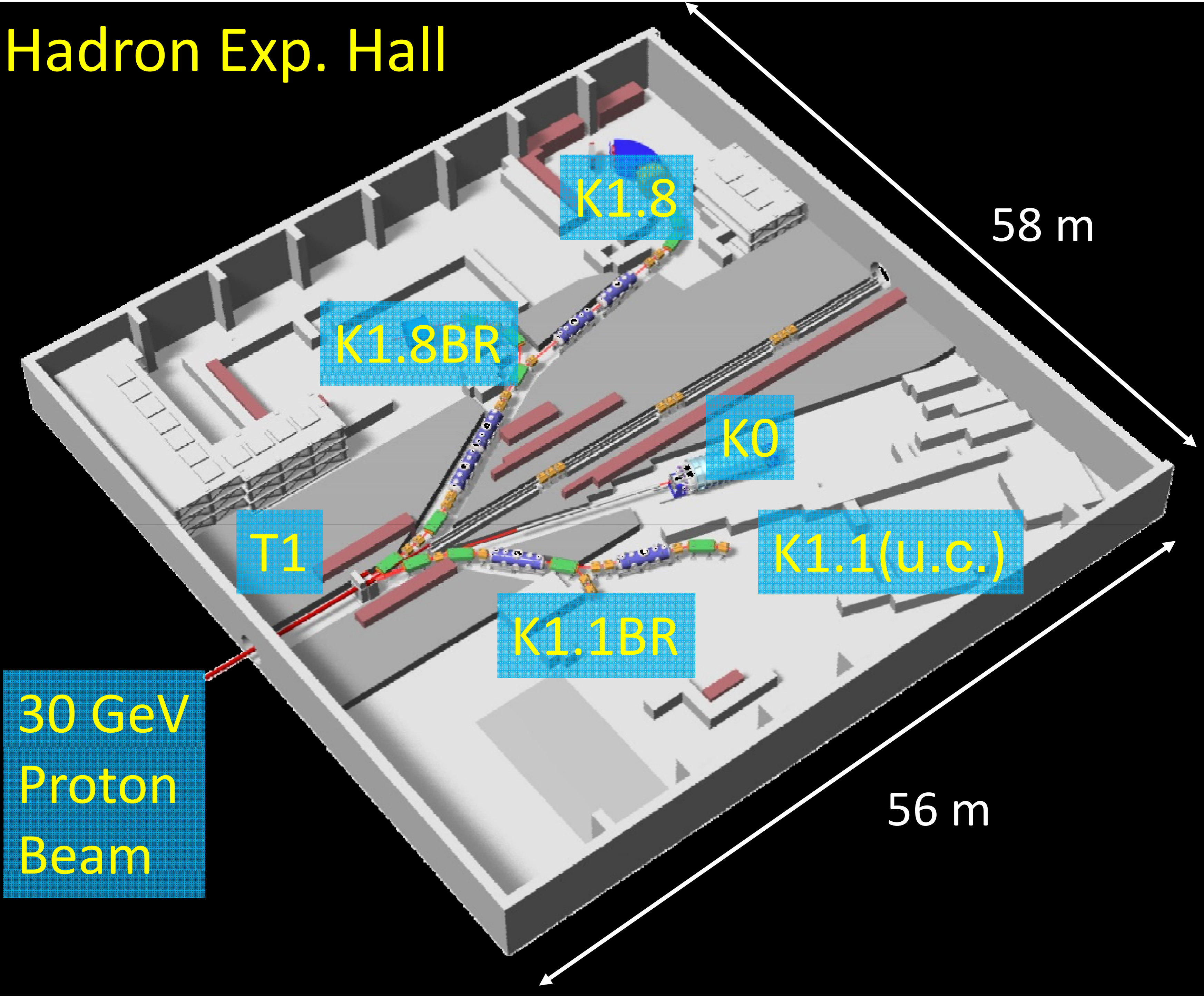
March 11, 2011



Horizontal Position Variation of Magnets
(red: before; blue: after the earthquake)


All the damages of structures and equipments are repaired.
All the magnets were realigned.
Radiation shields were reconstructed.
They did recover in 10 months!
The beam has come back at the end of 2011.

Hadron Exp. Hall

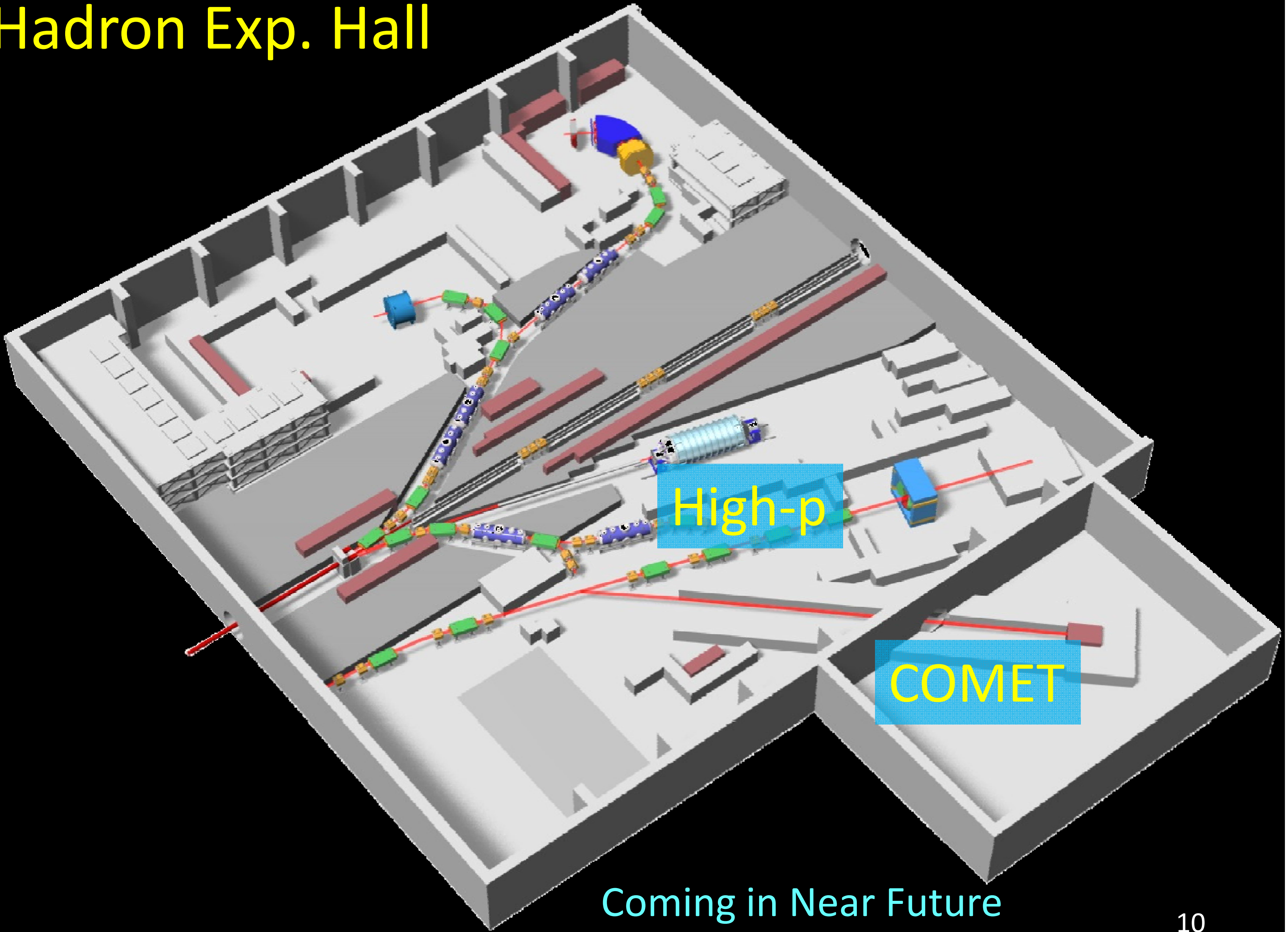


Hadron Exp. Hall

	K1.8	K1.8BR	K1.1	K1.1BR	KL
Design					
Max. p (GeV/c)	2.0	1.1	1.1	1.1	~2 (#) (0~5)
Prod. angle	-6 deg.	-6 deg.	+6 deg.	+6 deg.	+16 deg.
Length	45.8 m	31.4 m	27.9 m	21.5 m	20.6 m
Acceptance	1.5 msr･%	2.0 msr･%	1 msr*%	5.0 msr･%	7.8 μsr
Separator Max. Field	6 m x 2 80 kV/cm	6m x 1 80 kV/cm	2 m x 2 50 kV/cm	2 m x 1 50 kV/cm	-
Measured performance	ES1:50kV/cm ES2:40kV/cm	ES1:50kV/cm	Under Const'n	ES1:40kV/cm	
Kaon Intensity /10^{14} proton on Pt 6cm	K- (1.8GeV/c) 1.3E+6 ($)	K- (1GeV/c) 8.1E+5	-	K+ (1 GeV/c) 1.6E+6	KL: 2.1E+7
K/all	0.15	0.23	-	0.47	

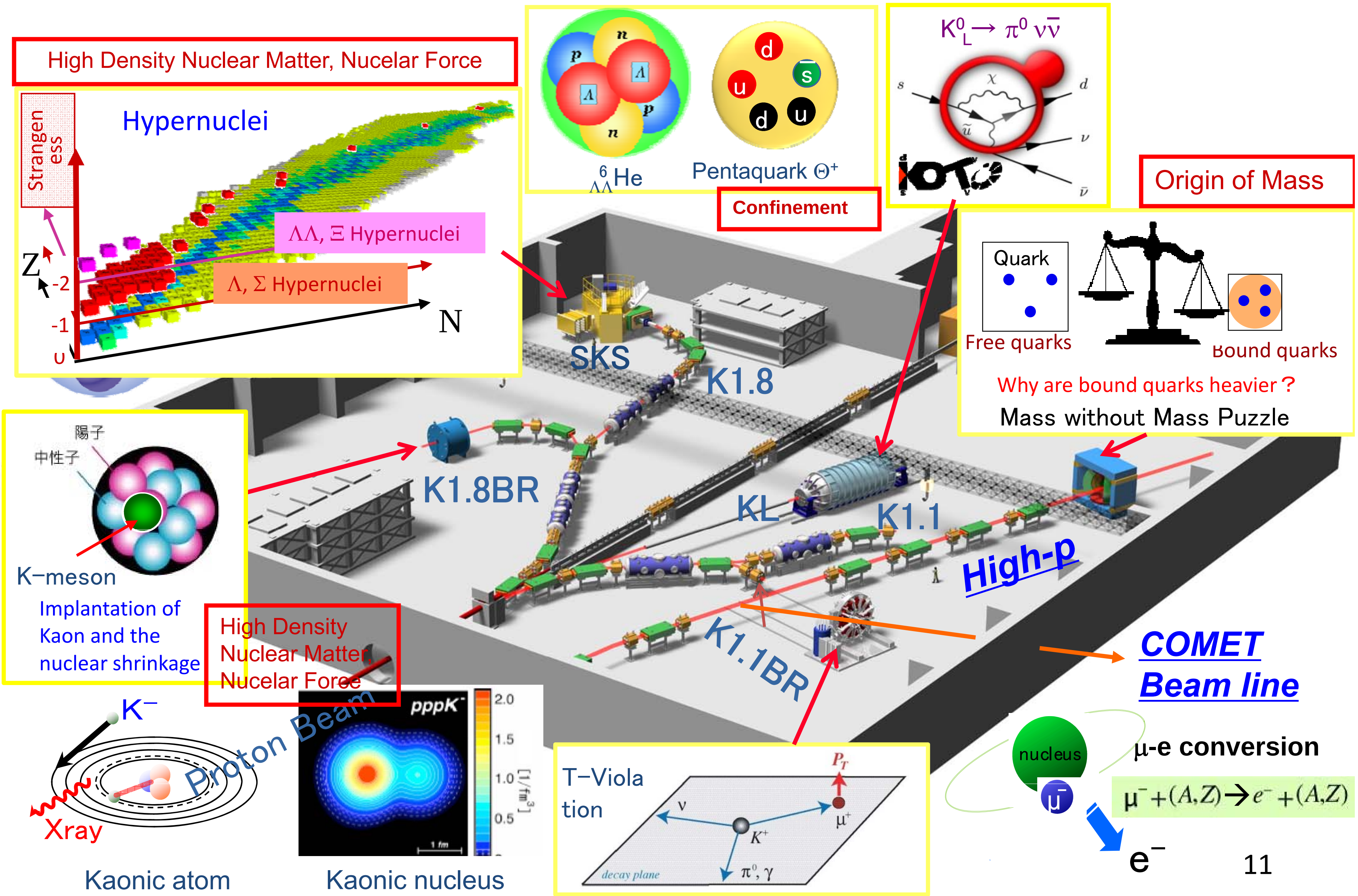
($) Mass Slits was closed about half of designed. (#) typical mean value

Hadron Exp. Hall



Coming in Near Future

Nuclear & Hadron Physics at J-PARC



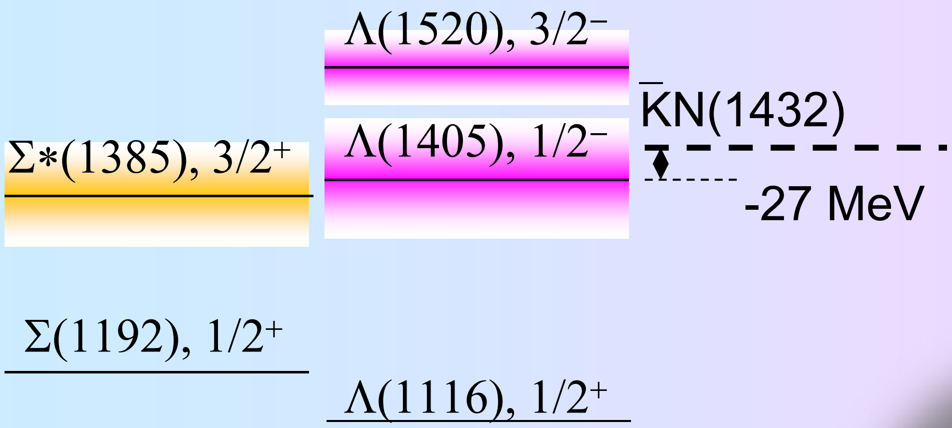
Hadron/Nuclear Physics

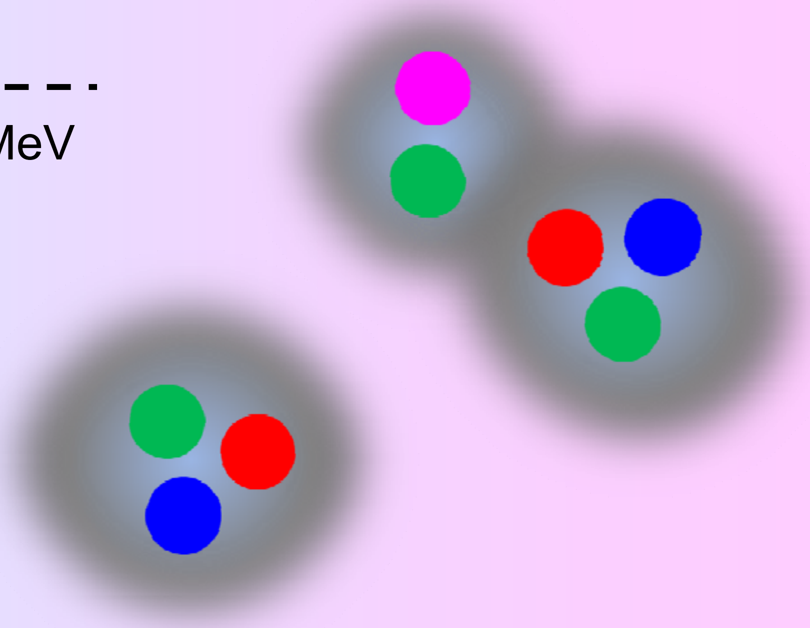
- Strangeness Nuclear Physics
  - Precision Spectroscopy of S=-1, -2 Hypernuclei
    - Ξ hypernuclei, $\Lambda\Lambda$ hypernuclei
    - Hypernuclear γ-ray spectroscopy, Ξ-Atomic X ray
    - Neutron-rich Λ hypernuclei, ΣN scattering
  - Deeply Bound Kaonic Nuclear System
    - ^{3}He(K-,n)"K-pp", K-He X ray, d(π^+,K^+)"Λ^*p"
- Hadron Physics
  - Hadron Spectroscopy, including "Exotics"
    - Penta-quark baryon
    - Λ(1405) via d(K^-,n)
    - H-dibaryon via (K^-,K^+)
  - Mass modification of Vector Meson in Medium
    - ϕ->e+e- in A, $_\phi$A via (p^{bar},ϕ), ω->$\pi^0\gamma$ in A

Λ(1405) :

$J^P = \frac{1}{2}^-$, $I = 0$, $M_{\Lambda(1405)} < M_{\bar{K}N}$,

lightest in neg. parity baryons: one cannot easily explain its light mass…





3q or not? A long standing argument

A part of recent arguments on Λ(1405)

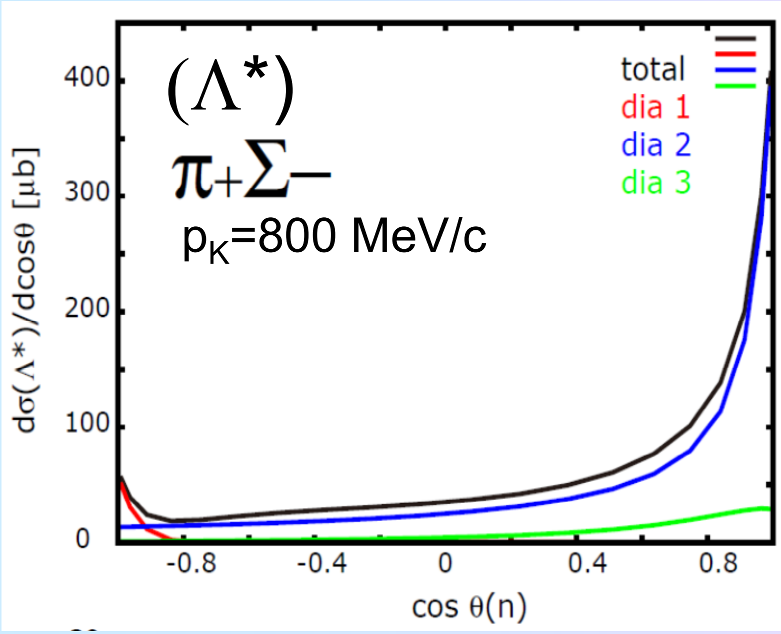
- PDG 2012 gives the mass of $1405.1^{+1.3}_{-1.0}$ MeV, adopting two theoretical analyses by:
  - Dalitz et al: $\pi\Sigma$ IM Spec. in $K^-p \to \pi\pi\Sigma$, w/ M-matrix
  - Esmaili et al: $\pi\Sigma$ IM Spec. of Stopped K^- on ^{4}He
- Two-pole structure
  - Chiral Unitary Model: D. Jido et al., NPA725(03)181
  - Evidence in K-p-> $\pi^0\pi^0\Sigma^0$, Magas et al, PRL95(05)052301
- New Experimental data are coming:
  - pp->p$K^+\pi^0\Sigma^0$, $\pi\Sigma$ MM spec., Zychor et al, PLB660(08)167
    -> disputed by Geng et al,
  - γp->$K^+\pi\Sigma$, $\pi\Sigma$ MM spec., M. Niiyama et al, PRC78(08)035202
    Y. Nakatsugawa, [parallel-Ia, 20th]
  - γp->$K^+\pi\Sigma$, $\pi\Sigma$ IM spec., K. Moriya et al, PTPS186(10)234

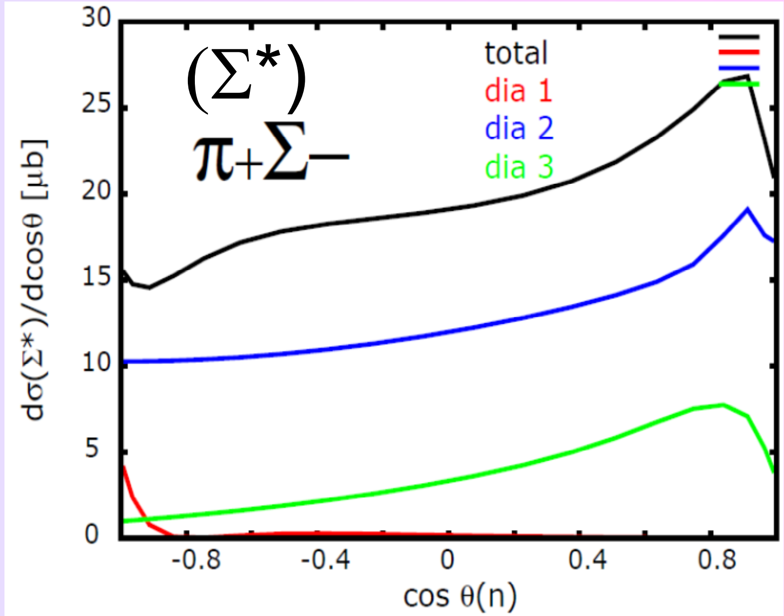
✓ Data of different reactions are necessary to understand the dynamically generated state.

$\Lambda(1405)$: S-wave $K^{bar}N \rightarrow \pi\Sigma$ scattering below $K^{bar}N$ threshold

d(K^-,n) may enhance the S-wave scattering at θ_n = 0 degree.

J. Yamagata-Sekihara, T. Sekihara, and D. Jido

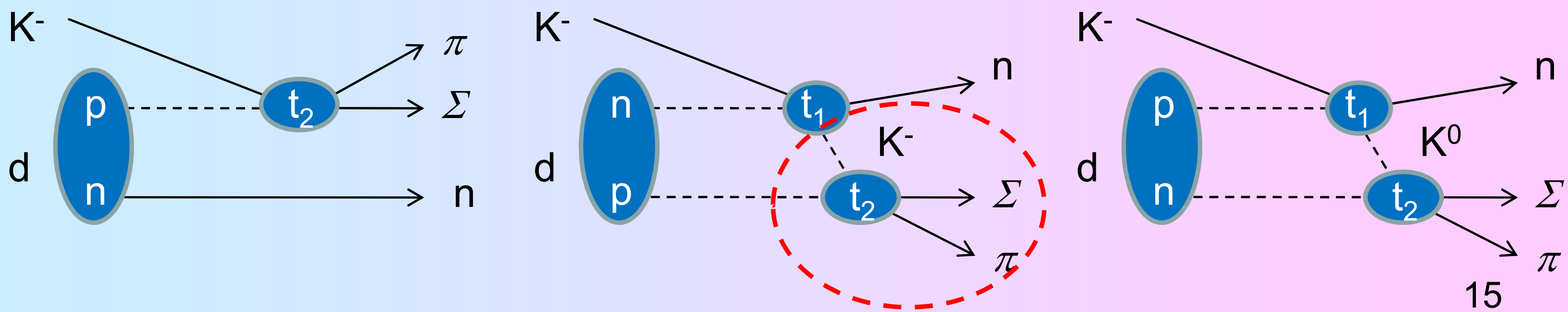




dia.1:small

dia.2:dominant

dia.3:Interference



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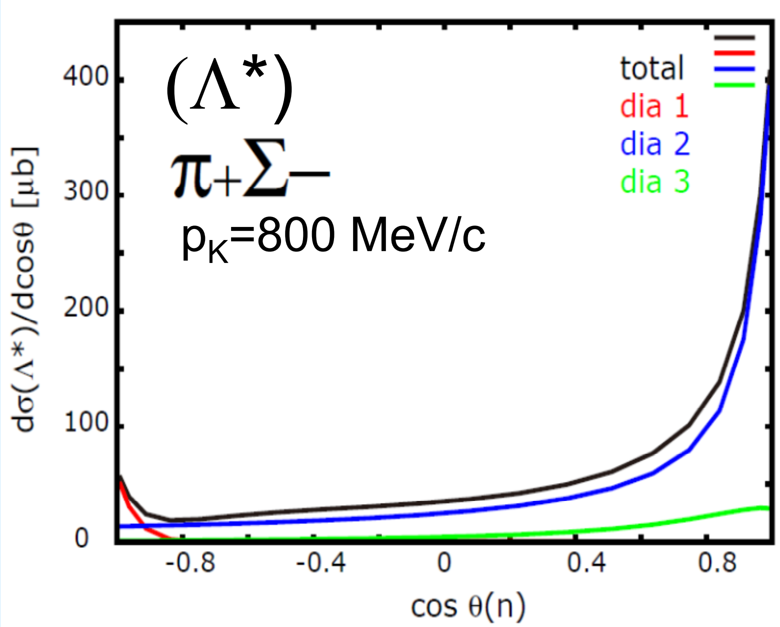
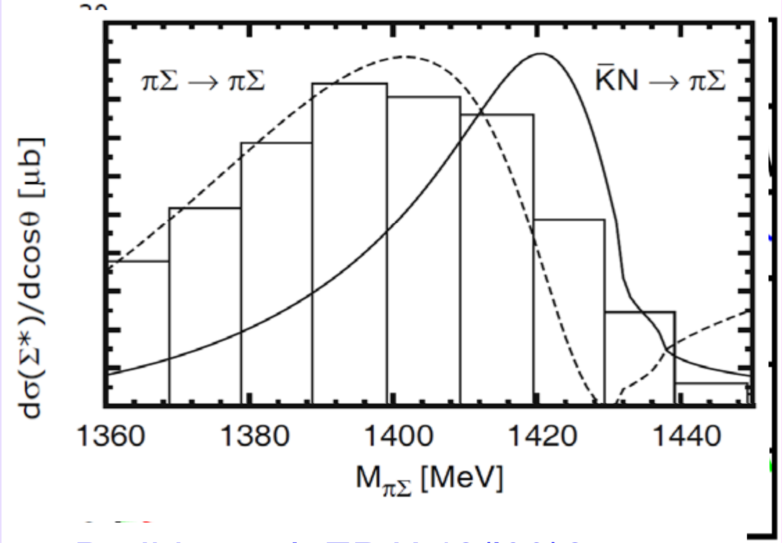


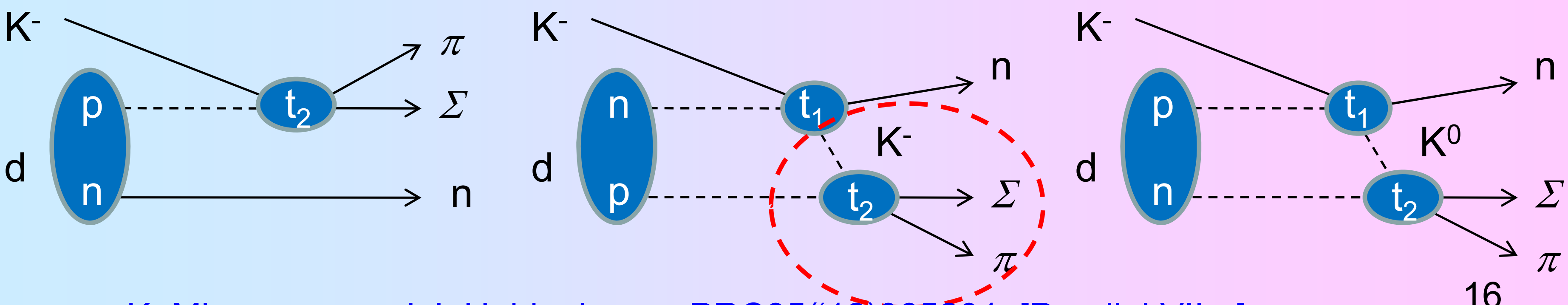


D. Jido et al, EPJA42('09)257

dia.1:small

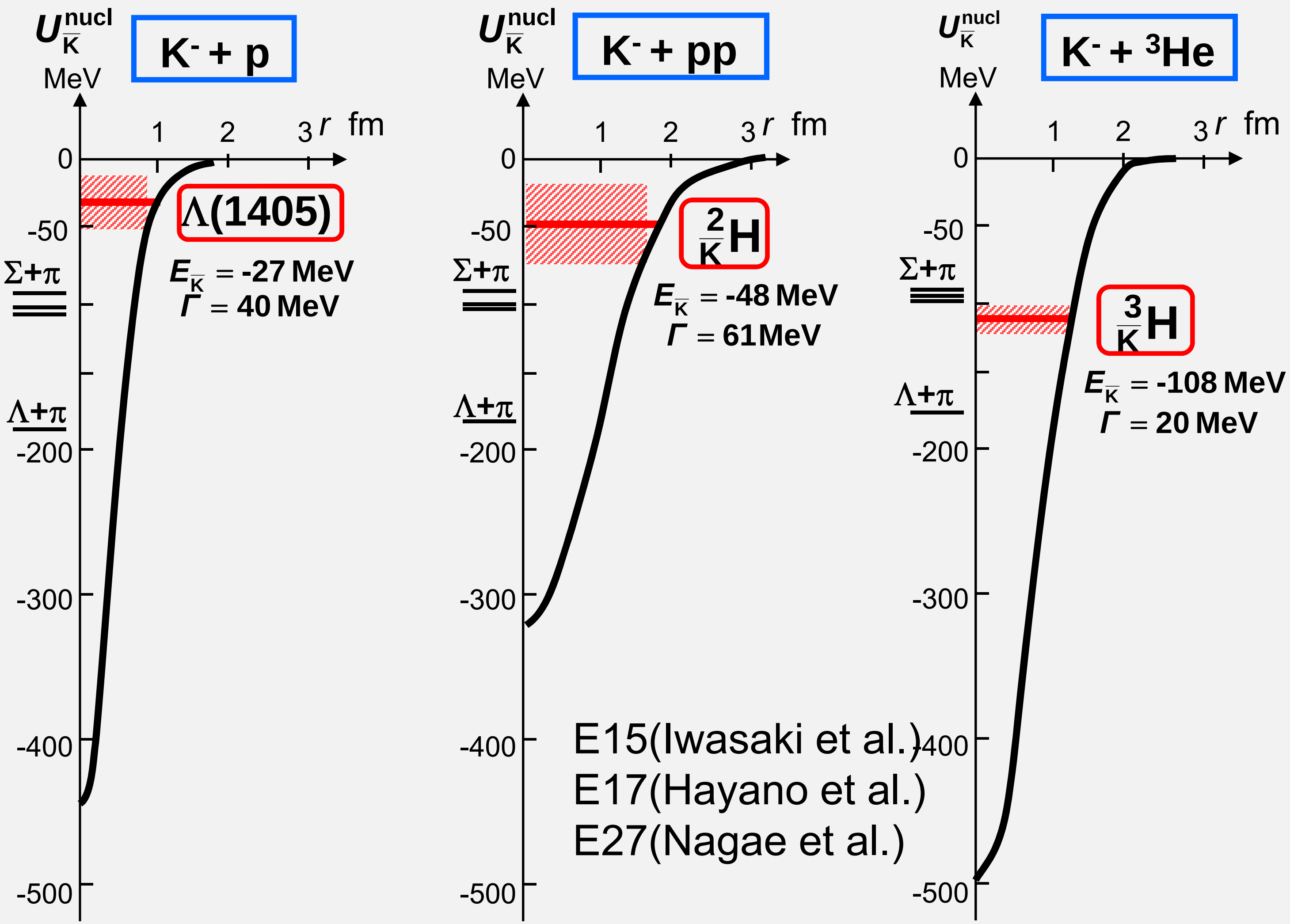
dia.2:dominant

dia.3:Interference



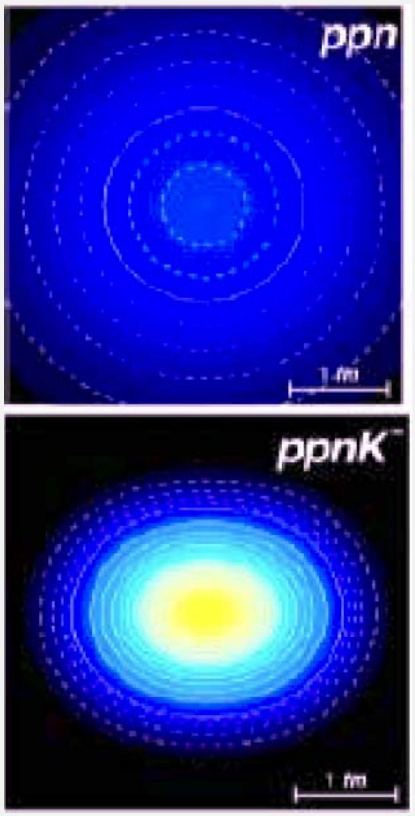
<=> K. Miyagawa, and J. Haidenbauer, PRC85('12)065201, [Parallel VII-a]

Deeply Bound K⁻-Nucleus System ?



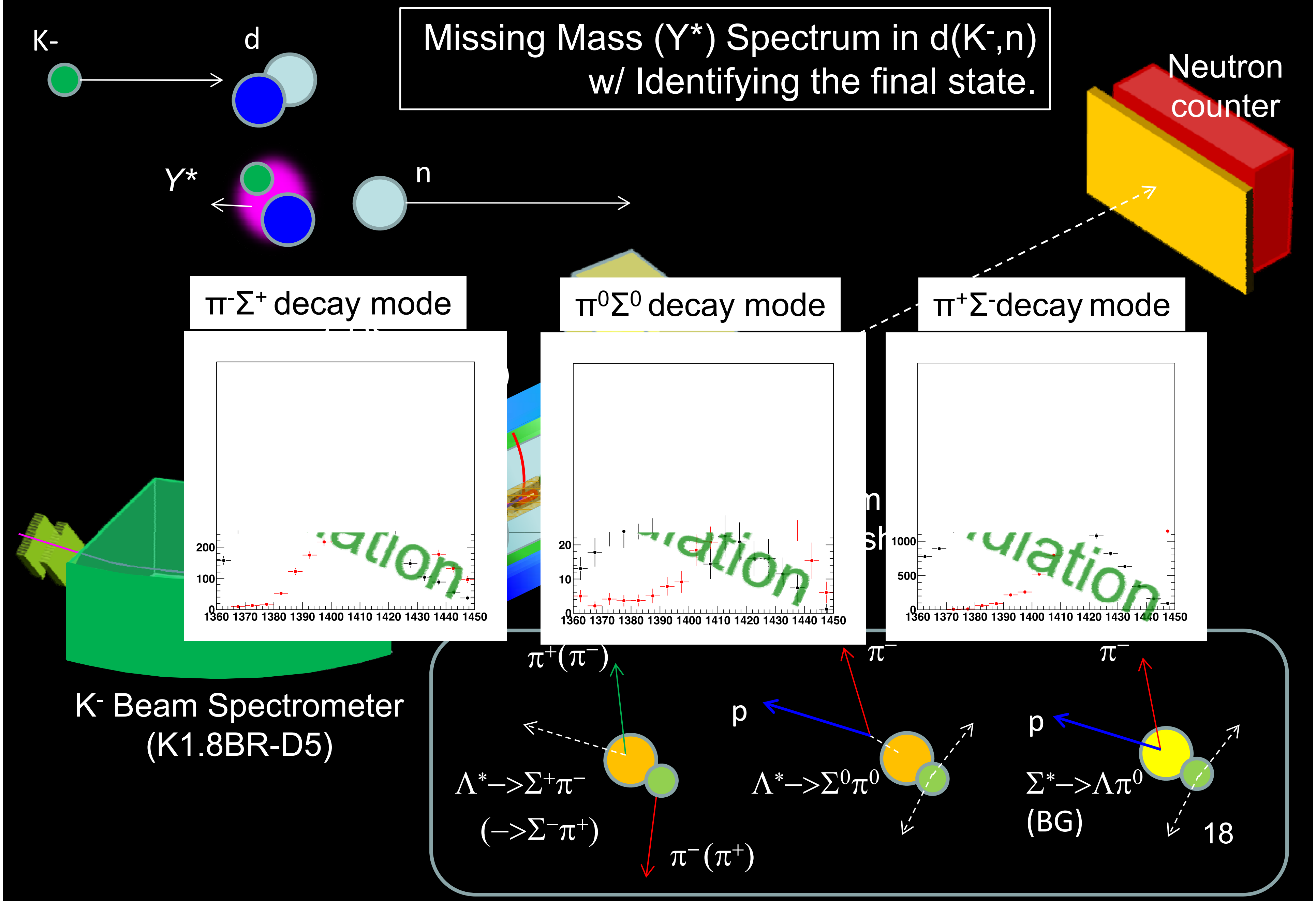
E15(Iwasaki et al.)
E17(Hayano et al.)
E27(Nagae et al.)

Dote et al.



Y. Akaishi & T. Yamazaki, Phys. Rev. C65 (2002) 044005.
Y. Akaishi & T. Yamazaki, Phys. Lett. B535 (2002) 70.

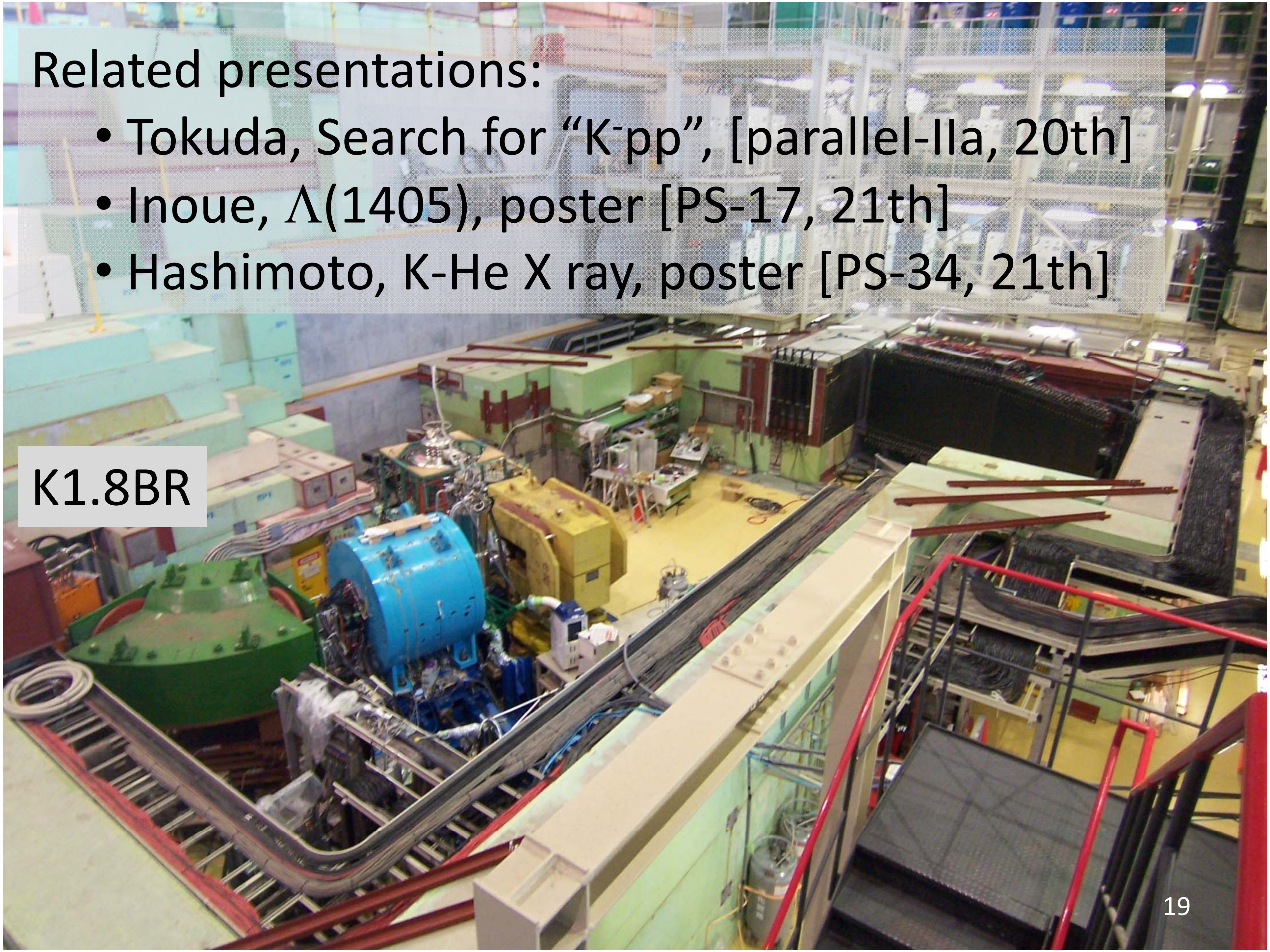
Λ(1405) Spectroscopy via the (K⁻,n) reaction on Deuteron



Related presentations:

- Tokuda, Search for “K^{-}pp”, [parallel-IIa, 20th]
- Inoue, Λ(1405), poster [PS-17, 21th]
- Hashimoto, K-He X ray, poster [PS-34, 21th]

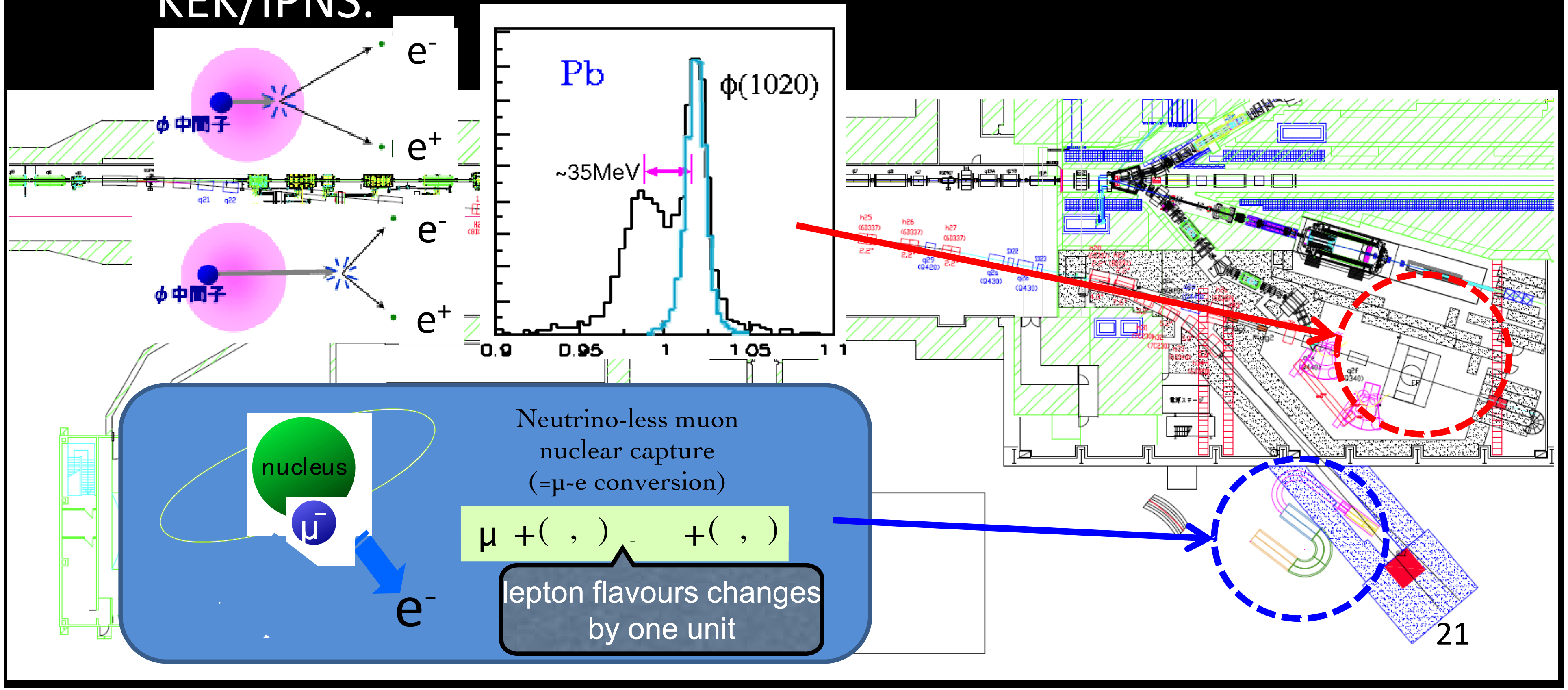
K1.8BR



A New Research Project at the High-p Beam Line

High-p/COMET Beam Line

- High-p BL will be constructed as a primary beam line for E16(ϕ mass modification in medium) by 2015.
- A branch line for 8 GeV primary beam (1kz pulsed) are also to be built for COMET (E21:μ-e conversion).
- Budget request will be done at the highest priority from KEK/IPNS.

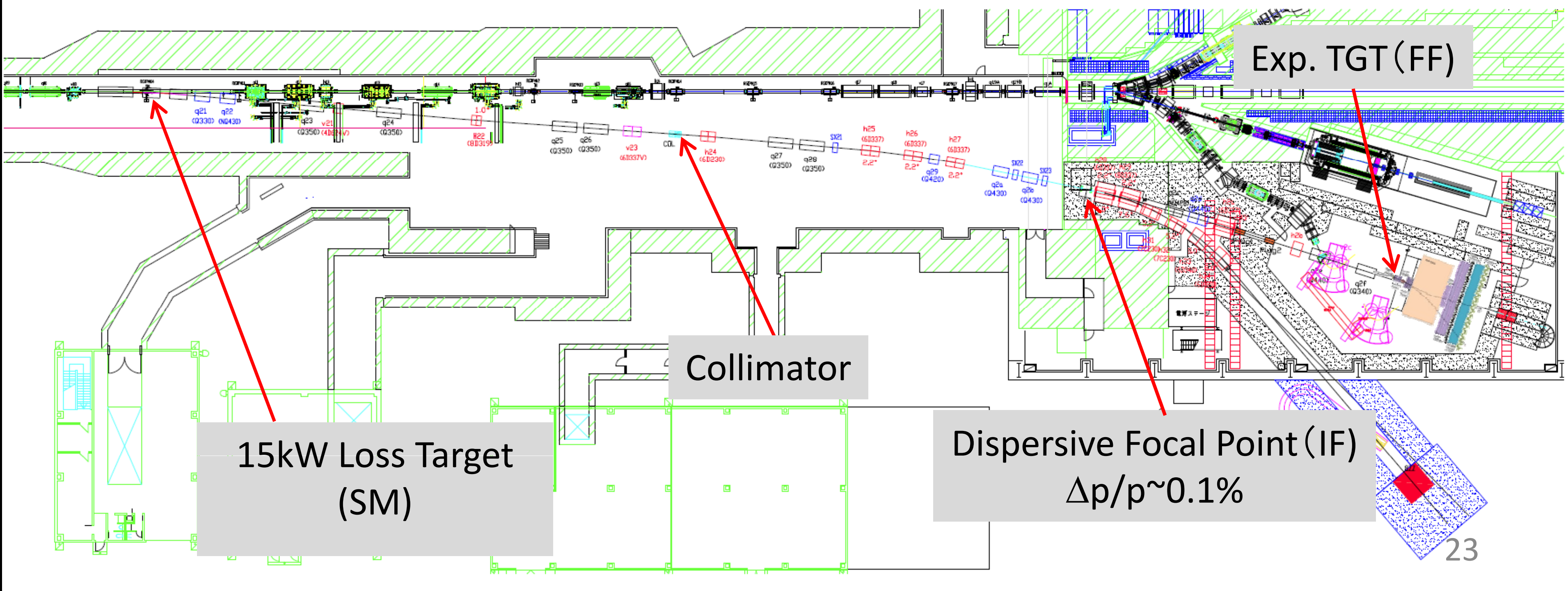


A new research project in High-res., High-p Beam Line at J-PARC

- Proposed by RCNP, Osaka U. under the MOU on research cooperation between RCNP, IPNS/KEK, and the J-PARC Center
- Role of RCNP
  - Collect research ideas and collaborators
  - Introduce new methods/techniques
    - High-resolution, high-p Secondary Beam Line
    - Multi-particle Spectrometer

High-p Line for 2^{ndary} Beam

- To be constructed for a 30 GeV primary beam line (by FY2015)
- High-intensity secondary beam（unseparated）can be delivered.
  - 2 msr・%、1.0×10^{7} Hz @ 15GeV/c π
- High-resolution beam: $\Delta p/p$~0.1%
  - Momentum dispersion and eliminate 2^{nd} order aberrations
- Charmed particles can be produced.



Possible Subjects

- Charmed Baryon Spectroscopy
- N*, Y* resonances via (π,ρ), (π,K^*)
- η', ω, ϕ, J/ψ productions off N/A
- "K^-K^-pp" strongly interacting hadronic system
- S=-2, -3 baryon spectroscopy
- others

Hadron Spectroscopy w/ "charm"

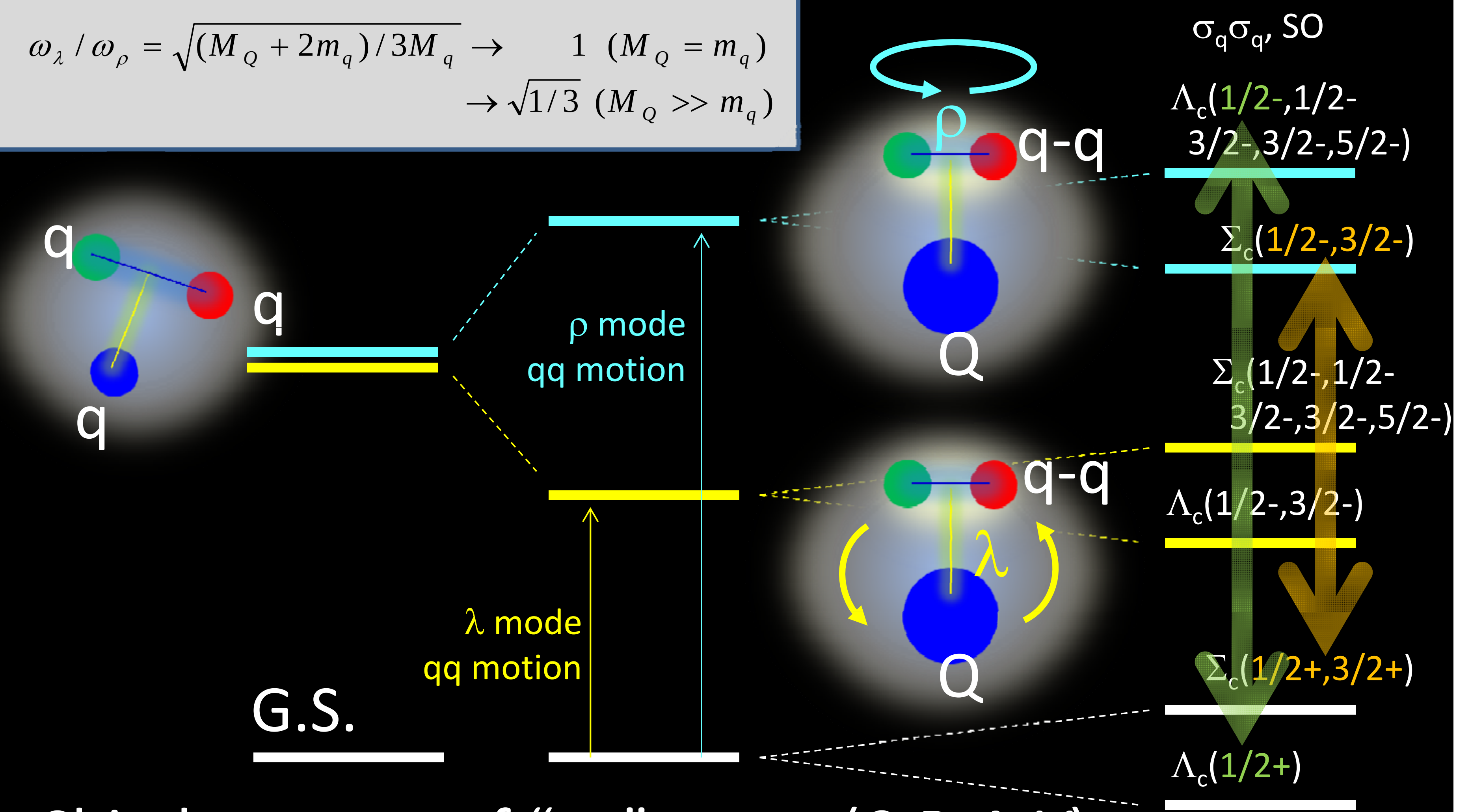
- In Heavy Quark (Q) sector,
  - "Bare Q" is already good "constituent".
    - Q is expected to weakly couple to NG boson
  - Non-Relativistic treatment is valid.
  - Color magnetic interaction be weaken by $1/m_Q$

    →Expects Simpler Spectra
- Charmed baryon would provide good and unique opportunity to study dynamics of hadron constituents

"Q" may make "qq" correlation stand out in Qqq.

- Relative and CM motions of "qq" in excited states

$$\omega_\lambda / \omega_\rho = \sqrt{(M_Q + 2m_q)/3M_q} \rightarrow 1 \quad (M_Q = m_q)$$
$$\rightarrow \sqrt{1/3} \quad (M_Q >> m_q)$$



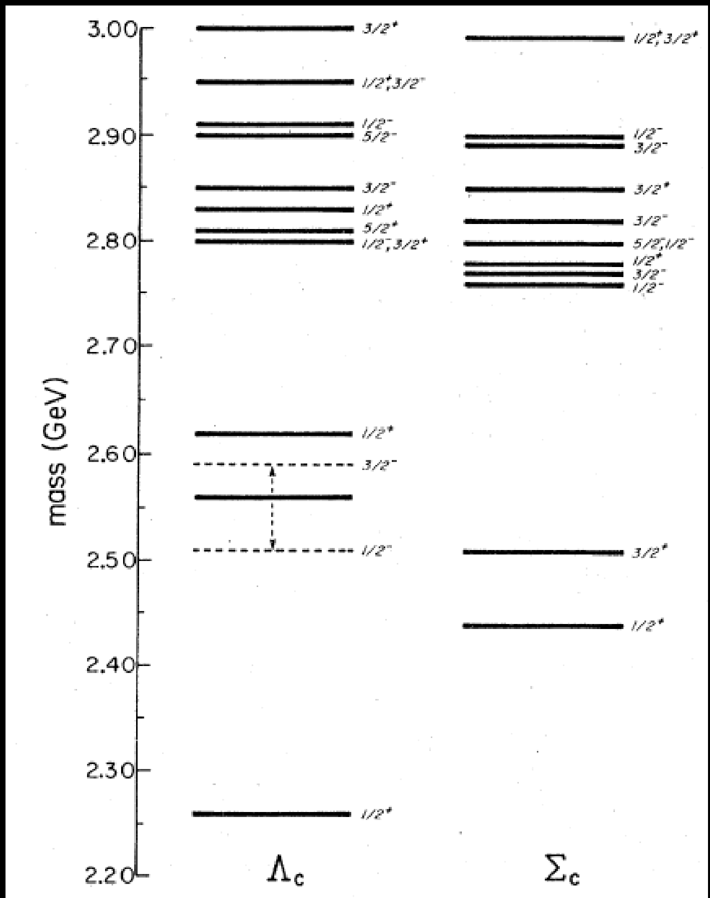
- Chiral partners of "qq" states (*S-P, A-V*)

C=1 Baryon Spectra

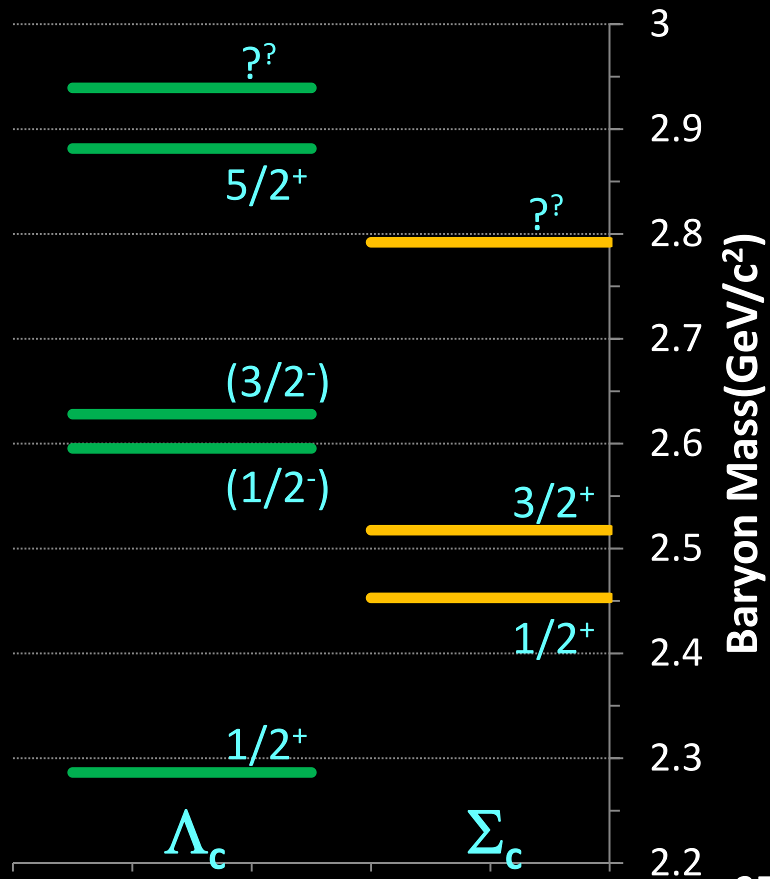
QM prediction and Observed States

- Many States have yet to be observed.

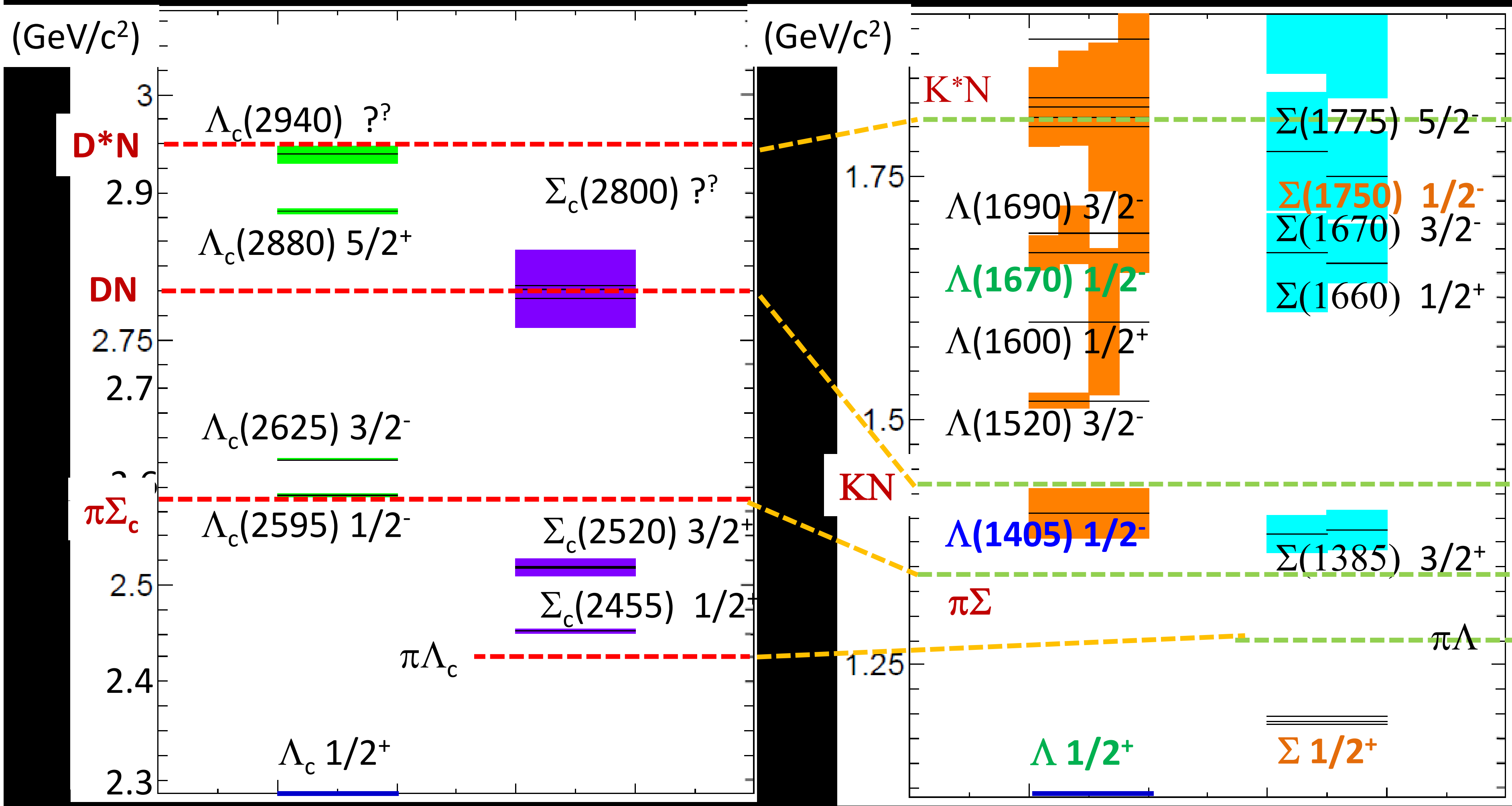
QM prediction
(L.A. Copley et. al, PRD20 (1979) 768)



Measured states
(PDG, 2012 online)



Baryon Spectra upto ~1 GeV Excitation Energy



- Difference and Similarity in s- and c-sector are of interest

Hadron Cluster States near threshold

Y. Yamaguchi, S. Ohkoda, S. Yasui, and A. Hosaka, PRD85, 054003(2012)

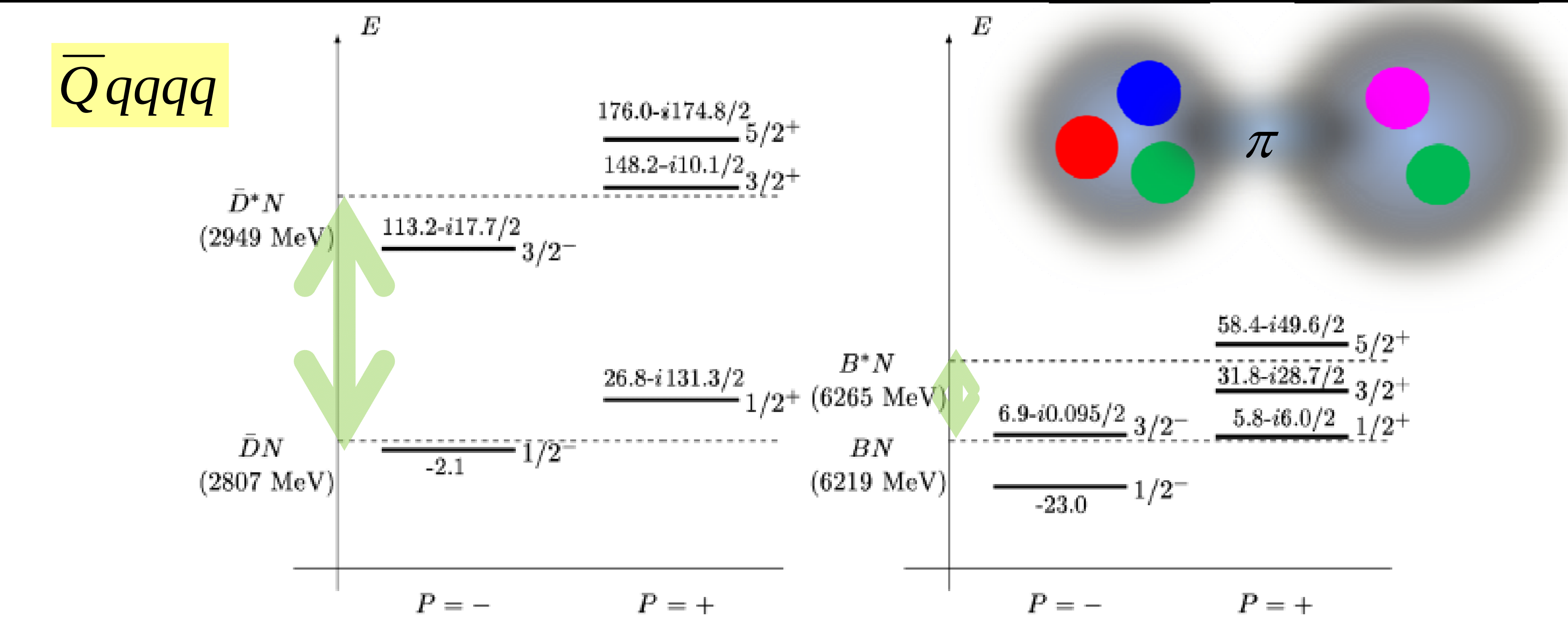


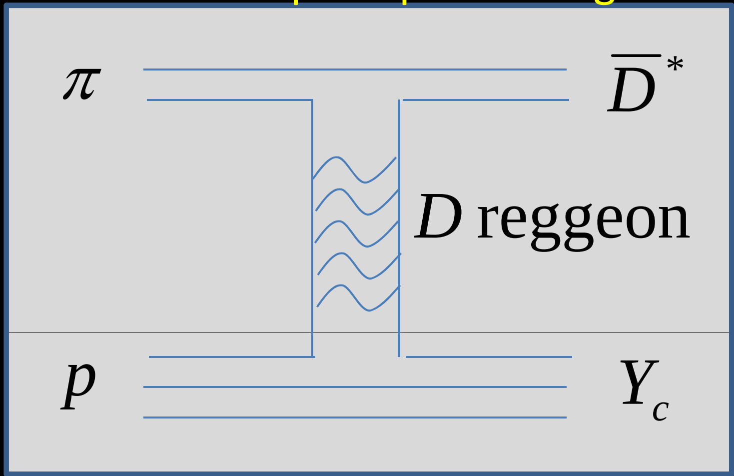
FIG. 10. Exotic states with positive parity ($P = +$) and negative parity ($P = -$). The energies are measured from the lowest thresholds ($\bar{D}N$ and BN). The binding energy is given as a real negative value, and the resonance energy E_{re} and decay width Γ are given as $E_{re} - i\Gamma/2$, in units of MeV. The values are given when the $\pi\rho\omega$ potential is used.

- Hadron Cluster?: X, Y, Z, Z_b tetra-quark candidates, $\Lambda(1405)$, and Hoyle states in ^{12}C.

Missing Mass Spectroscopy by $p(\pi^-,D^{*-})$

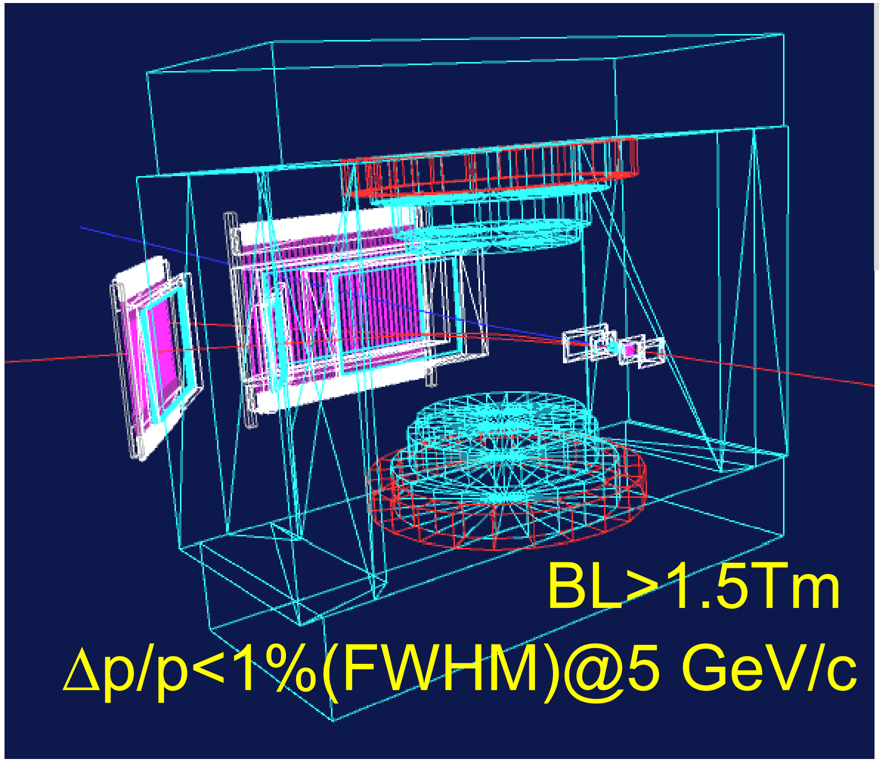
- Production Rate, as well as Mass and Width, gives valuable information on the states
  - Coupling of NDY_c
    Coupling constant
    Form Factor (transition)
- Cross Section:
  - σ<7nb@13 GeV/c (PRL55, 154(1985))
  - $10^{-4\sim-5}$ of $\pi^- p \to K\Lambda$, $K\Sigma$
- Intense Beam at J-PARC is indispensable.
  - 10^7 Hz at 15 GeV/c pions

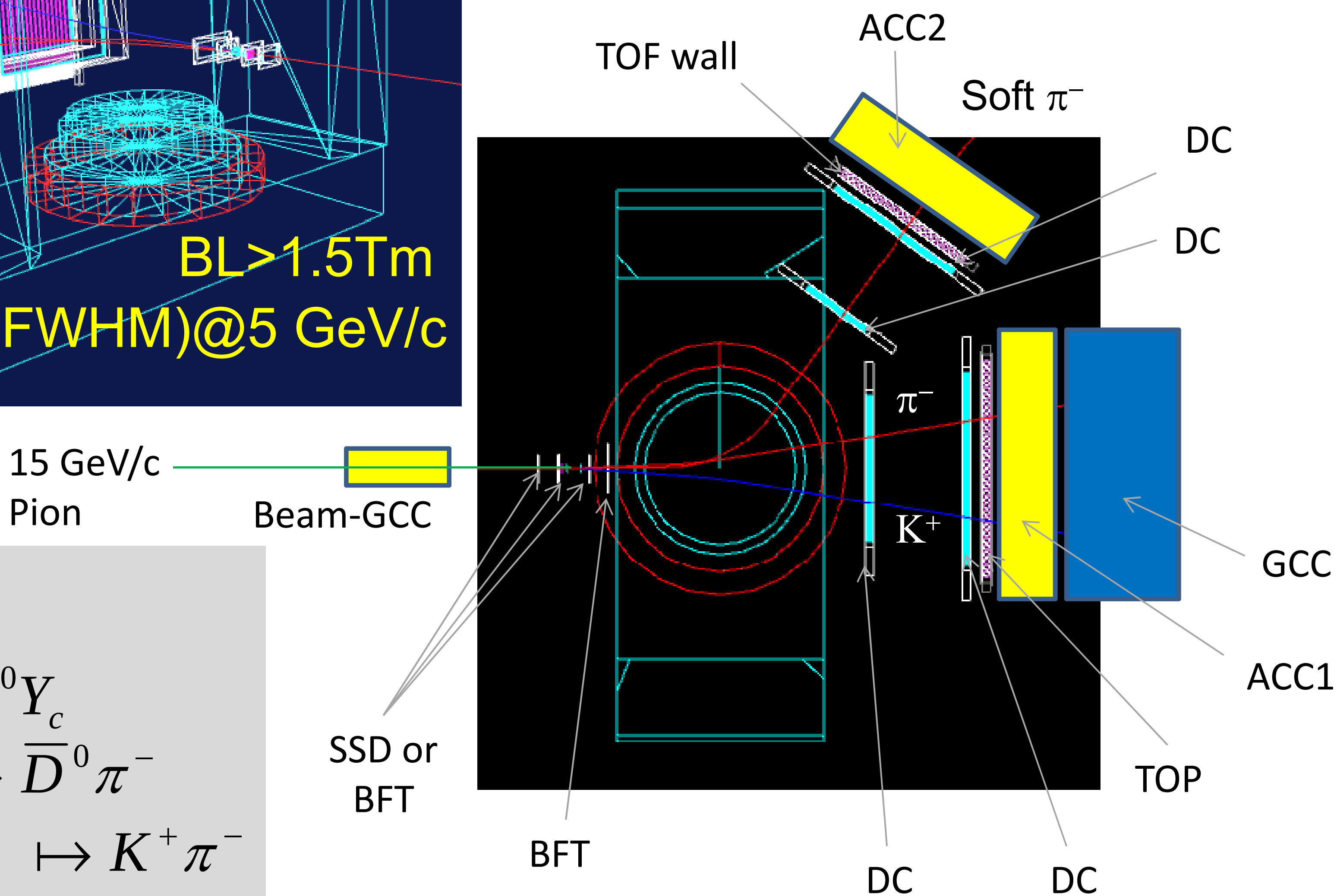
Binary Reaction at High E is well described as quark planar diagram.



A.B. Kaidalov, ZPC12, 63(1982)

Conceptual Layout of Multi-particle Spectrometer

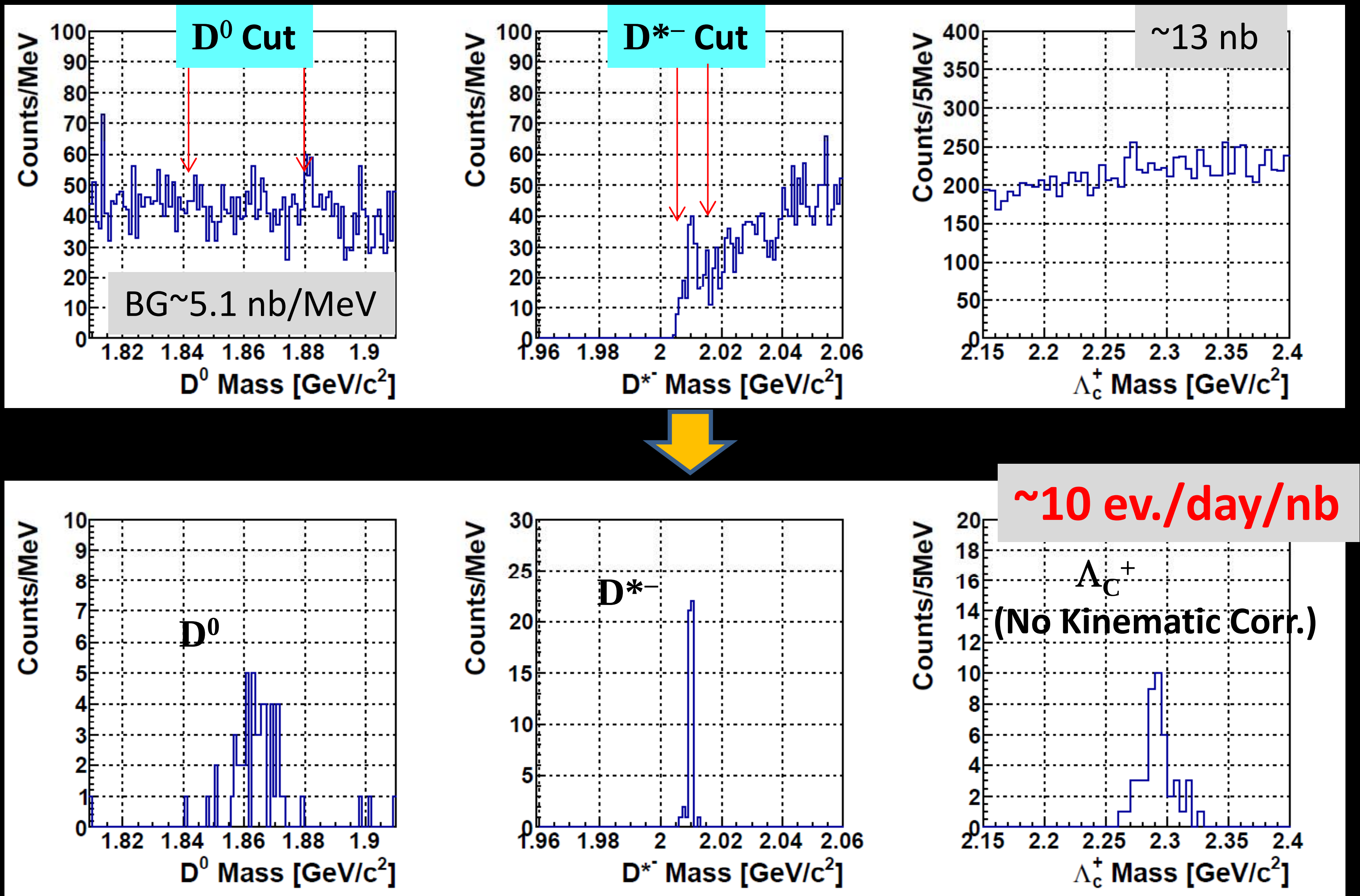




$$\pi^- p \rightarrow \overline{D}^{*0} Y_c$$
$$\mapsto \overline{D}^0 \pi^-$$
$$\mapsto K^+ \pi^-$$

Missing Mass Resolution ~ a few MeV (Kinematic correction)

Simulation



- Sensitivity Improvement of x100 than previous exp.

Future Extension of Hadron Facility

Extension of Hadron Exp. Hall (in planning)

increase of new physics opportunities w/ unique beam lines

Baryon-Baryon interaction (γ-ray from Hyp.Nucl., YN scat., Σ-A)
Hadron Property in Nuclear Medium (Λ Mag. Moment in A)
Quark-Gluon Dynamics in Hadron/Medium (Ξ^*, Ω^*, Exotics, D off A)
Mechanism of Dynamical mass generation (σ, ϕ, η', J/ψ, multi-K in A)

Summary

- J-PARC Hadron Facility provides opportunities to study Nuclear/Hadron Physics
- A new research project at High-resolution, high-p BL is proposed under the MoU between RCNP, KEK/IPNS, and J-PARC.
  - It opens unique opportunities to study hadron physics. In particular,
    - C=1 baryon excited state via the (π, D^{*bar}) reaction
    - "Inert" Heavy quark may direct unique quark dynamics, *i.e.* "qq" correlation, in a baryon.
- Extension of the Hadron Exp. Hall is planning :
  - new physics opportunities w/ unique beam lines.

Thank you very much