New Hadron Facility at J-PARC

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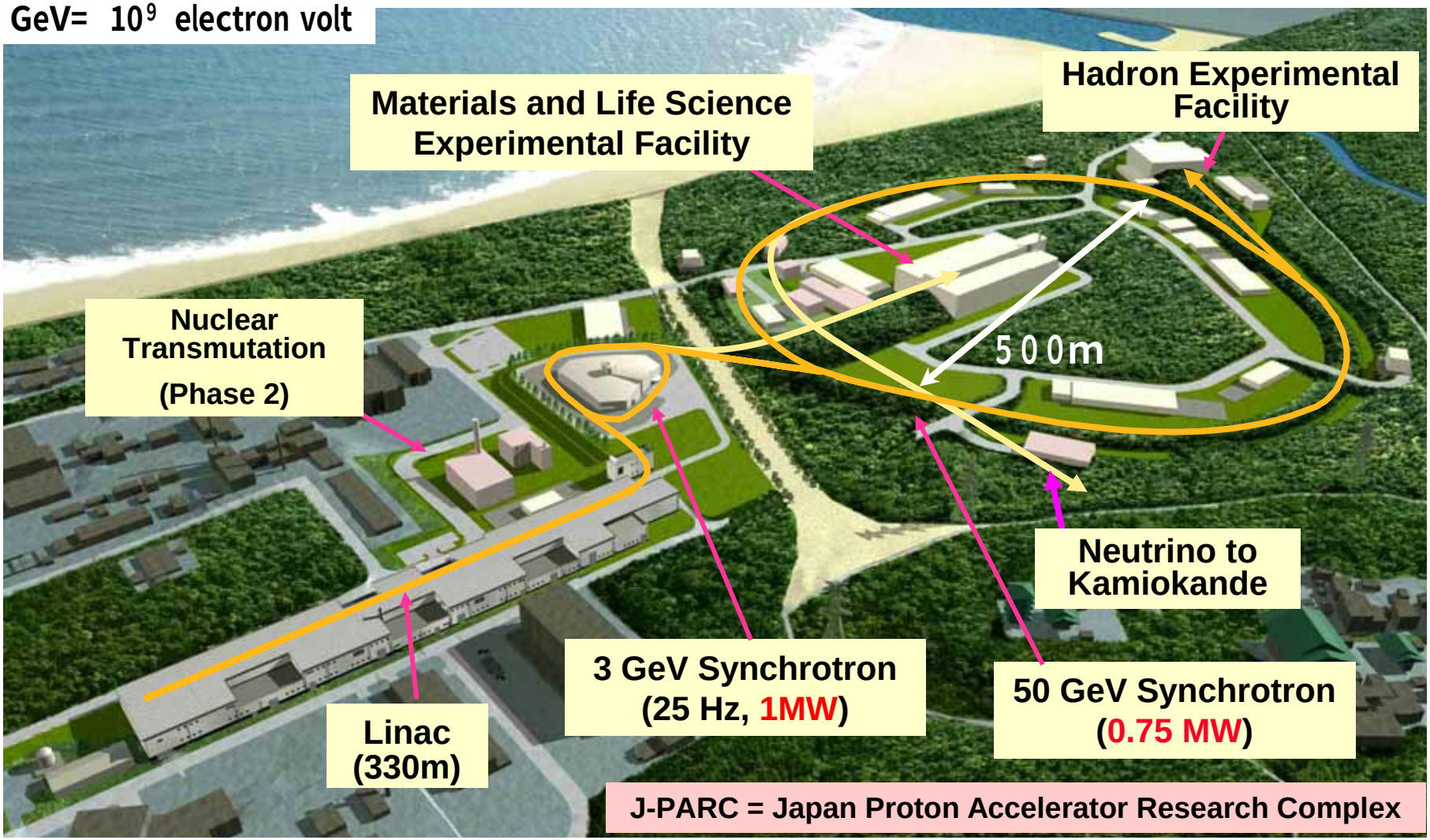
Contents

- Overview of J-PARC
- Hadron Experimental Facility (Hadron Hall)
- Hadron Physics Examples
  - Hypernuclear Physics
  - Hadron mass?
  - Drell-Yan
- Sumnmary

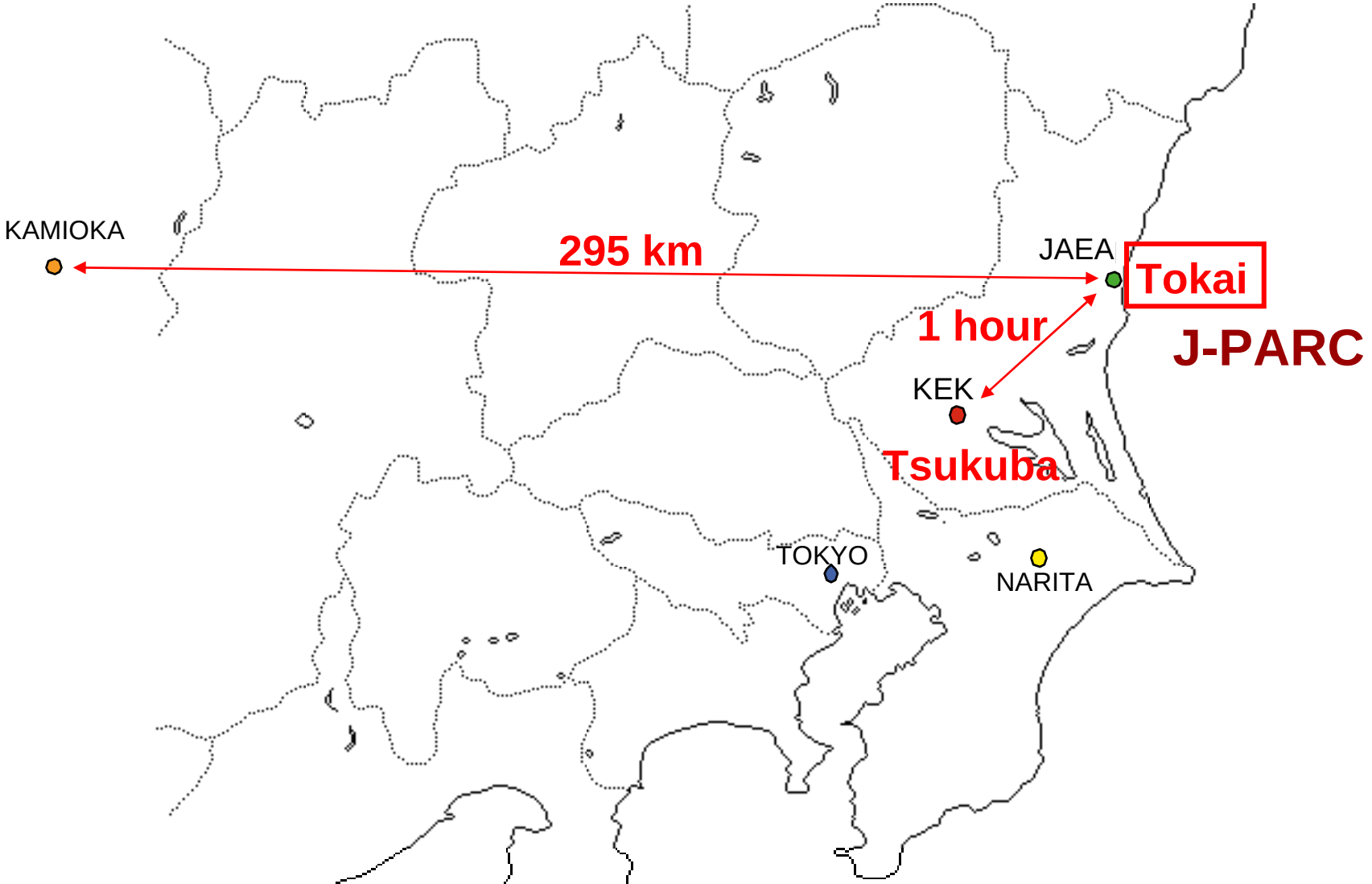
J-PARC Facility

GeV= 10^9 electron volt

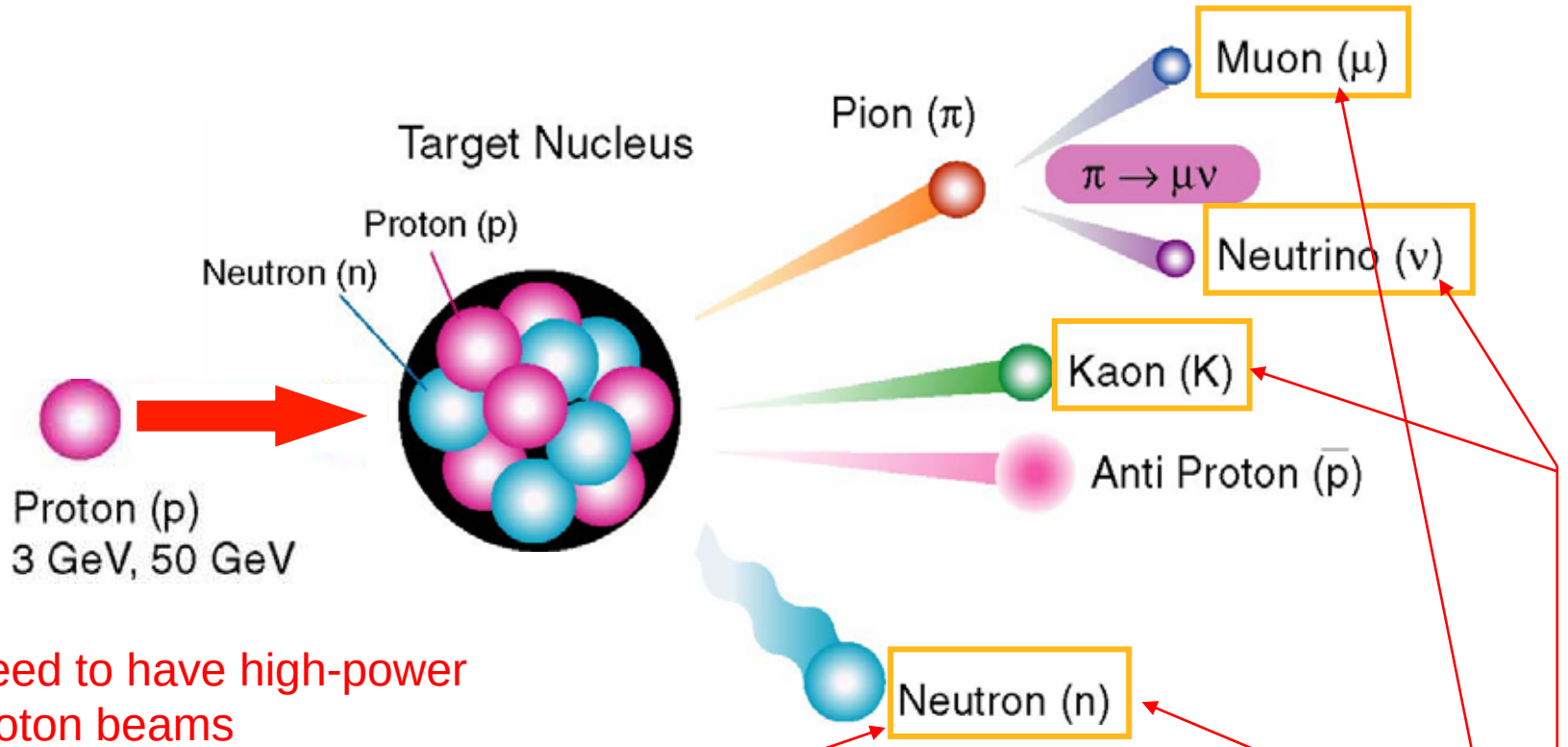


Joint Project between KEK and JAEA

Location of J-PARC at Tokai



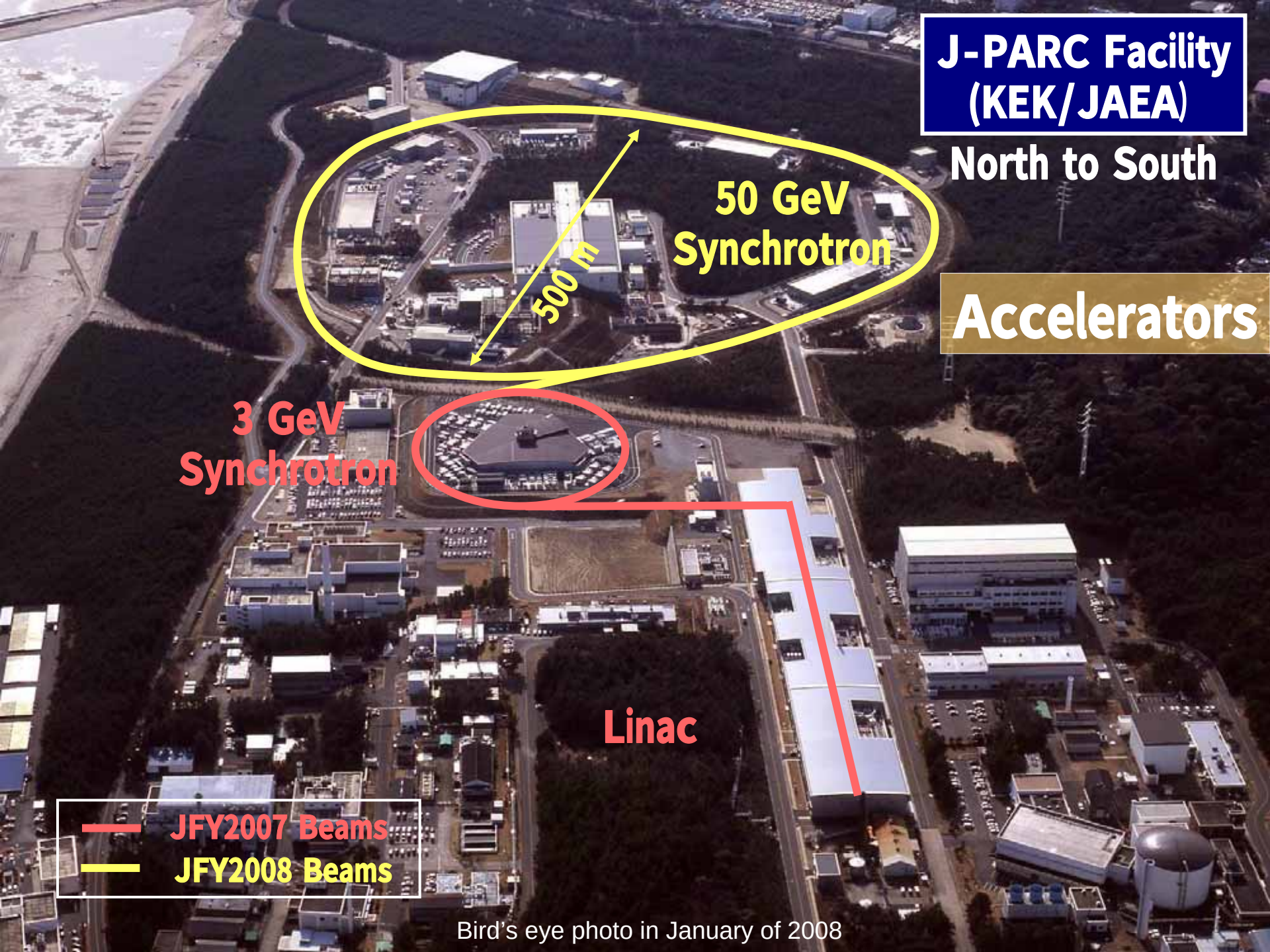
Goals at J-PARC



Need to have high-power proton beams

→ MW-class proton accelerator (current frontier is about 0.1 MW)

Materials & Life Sciences at 3 GeV
Nuclear & Particle Physics at 50 GeV
R&D toward Transmutation at 0.6 GeV



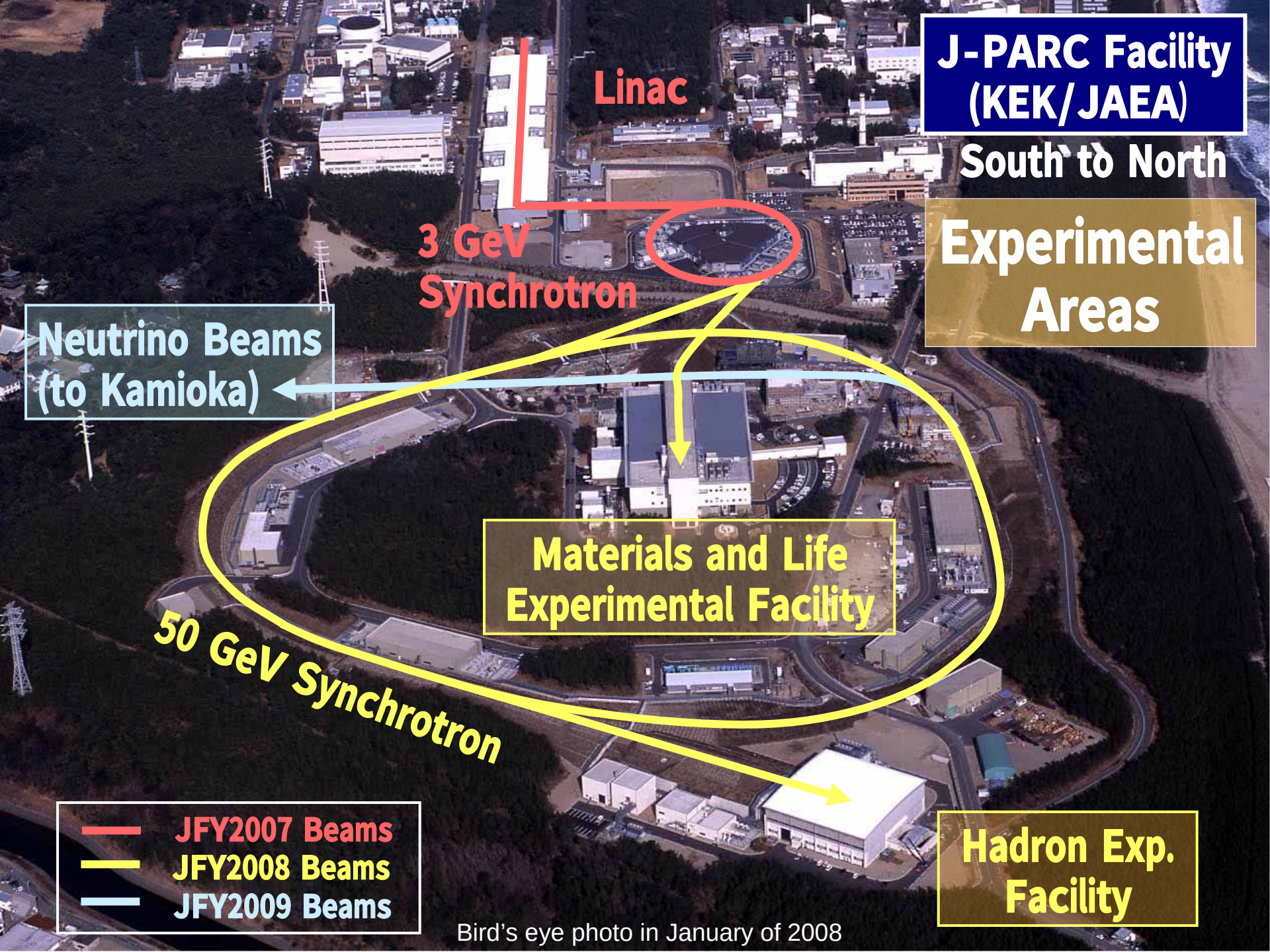
Bird's eye photo in January of 2008

Linac (330m)

3GeV Synchrotron (350m)

50GeV Synchrotron (1600 m)

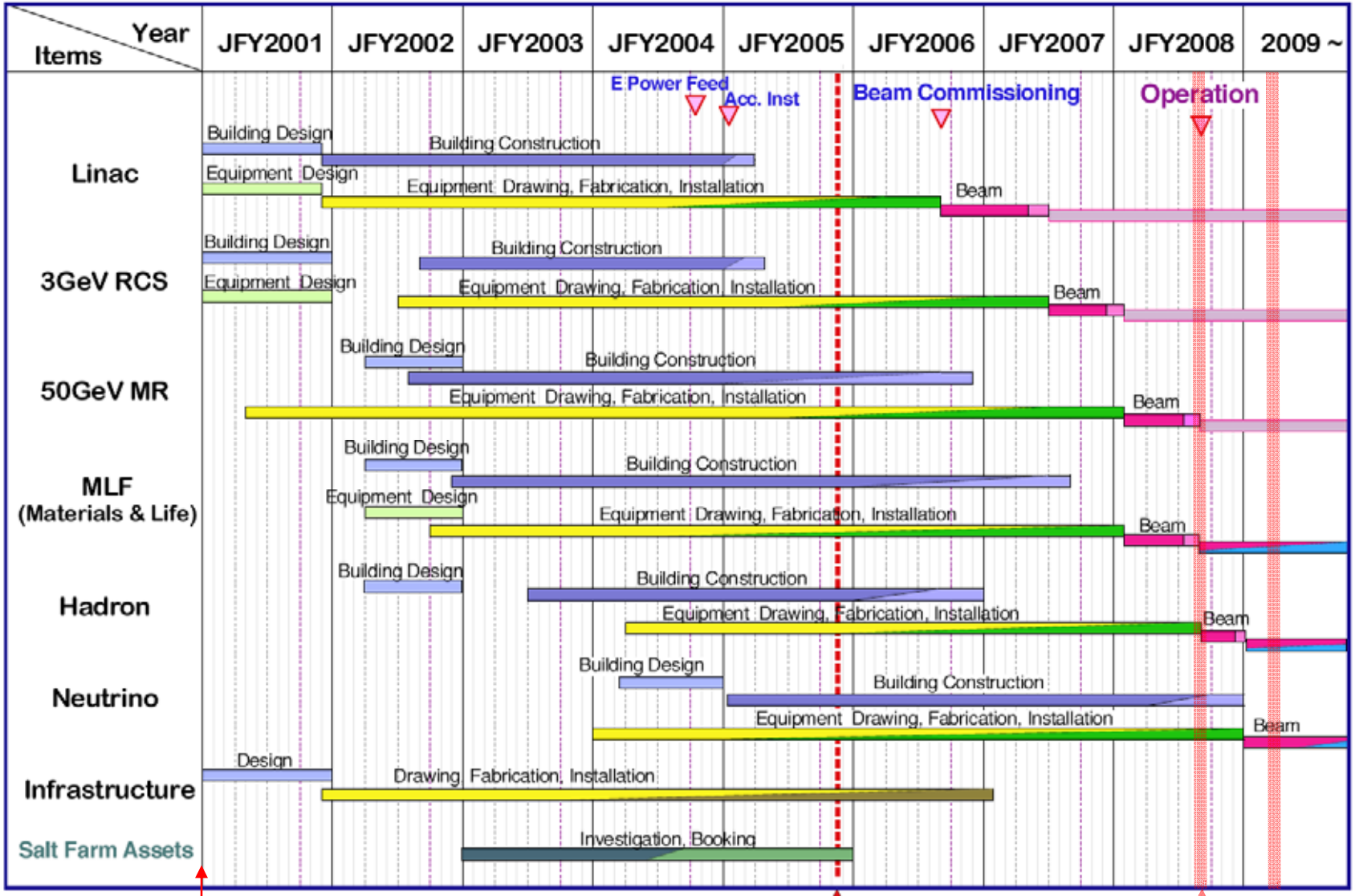
Superconducting magnets for the neutrino beamline



Bird's eye photo in January of 2008

J-PARC Construction Schedule

Feb. 27 2006



September 25, 2009
Construction Start

Shin'ya

Time when this schedule was created (J-PARC Center started)

Now
Open to Users

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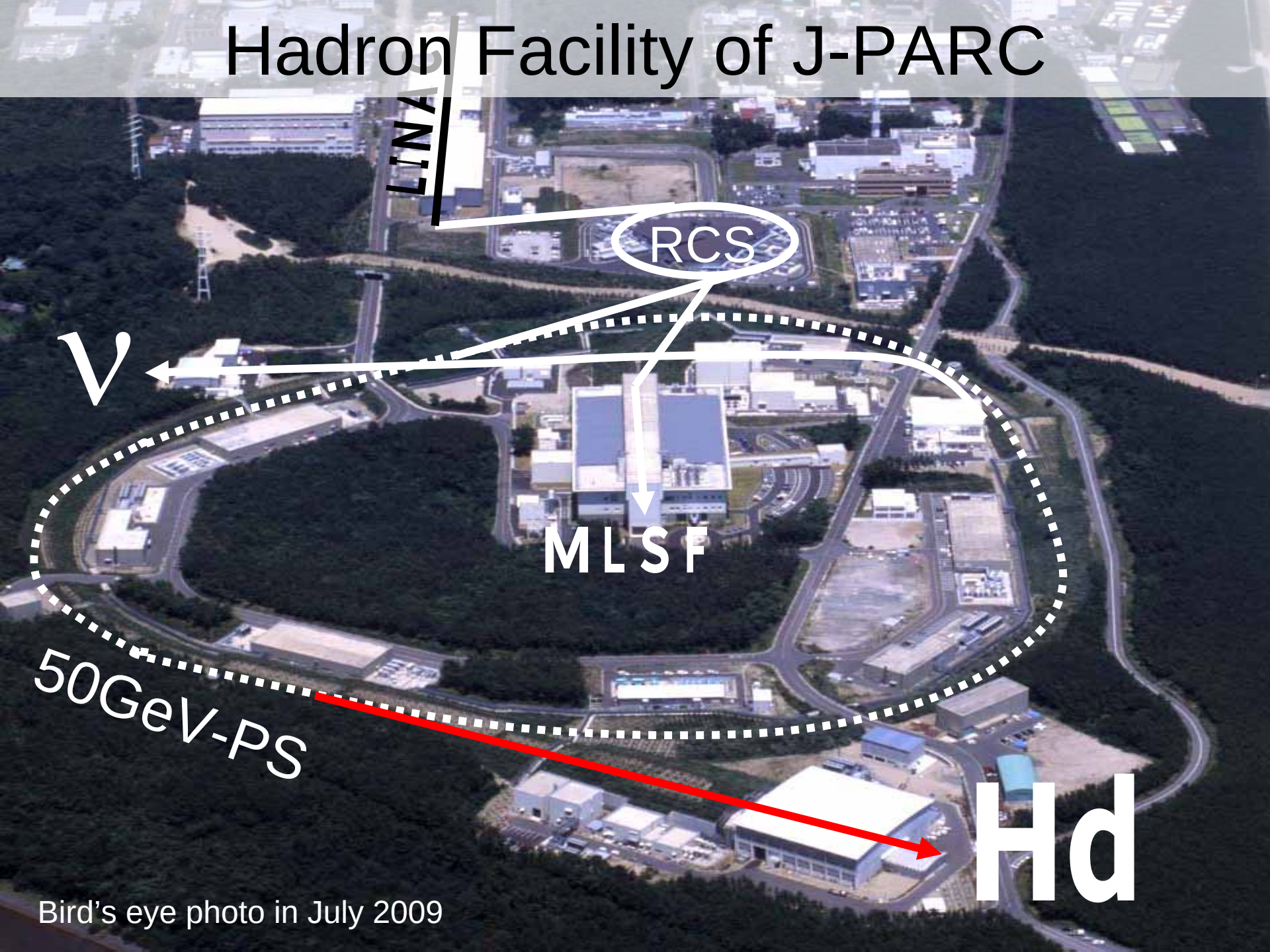
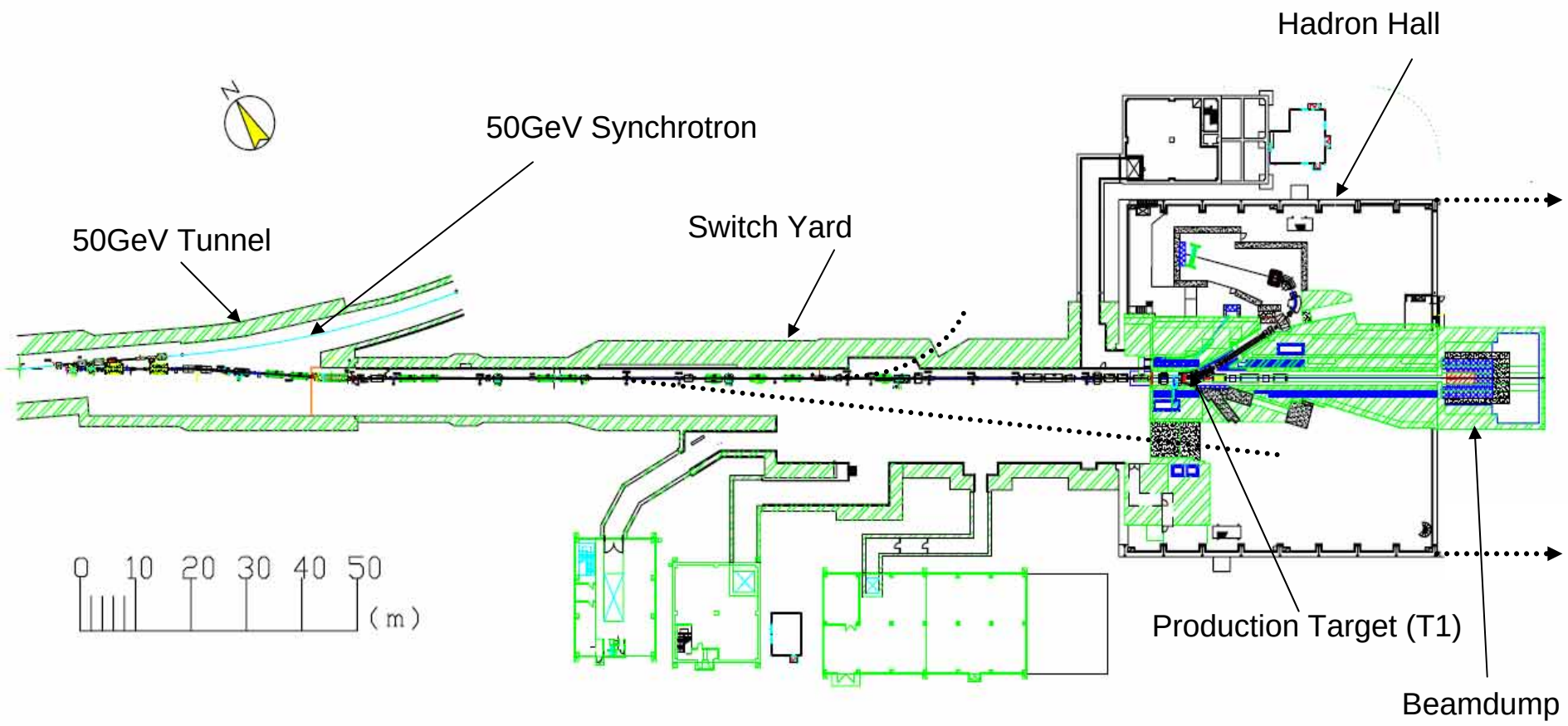
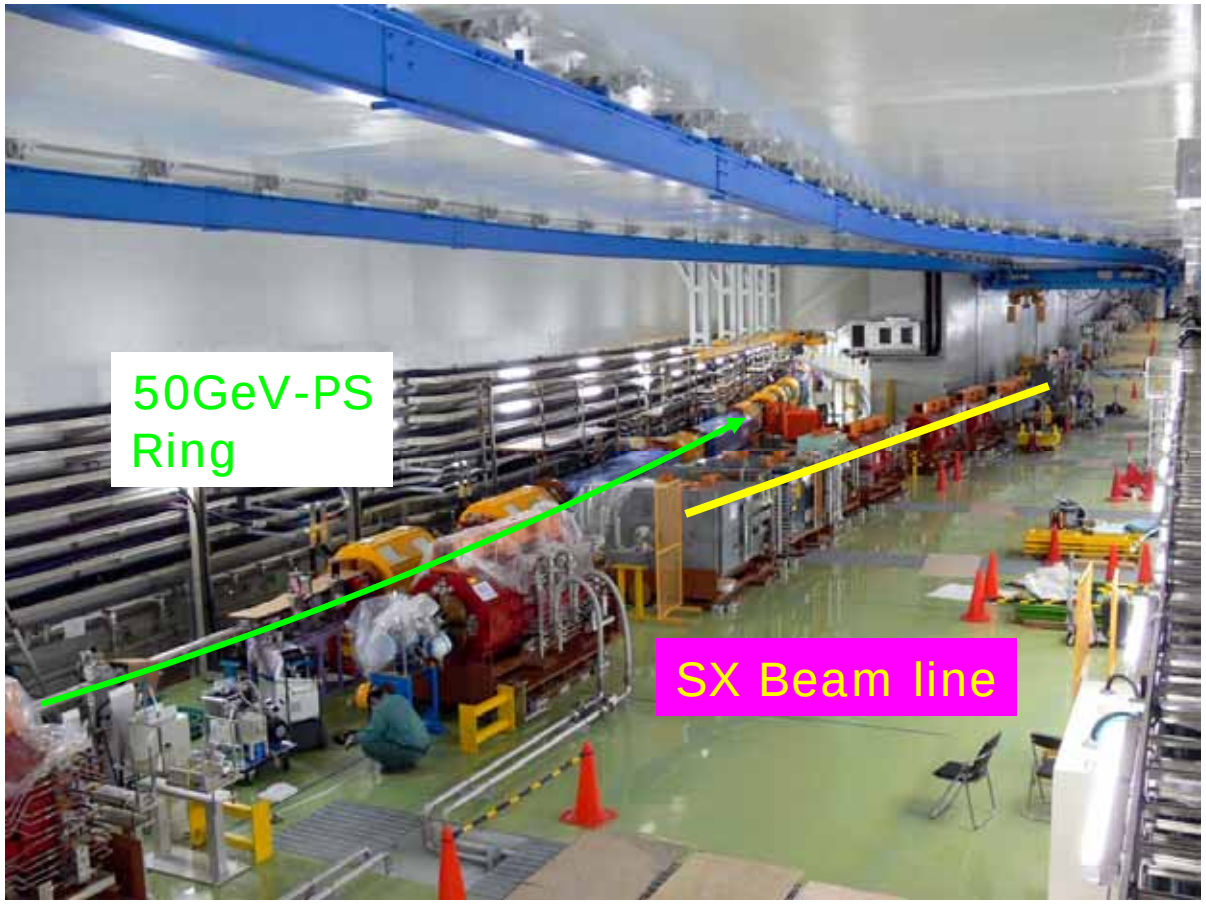
Hadron Facility of J-PARC



Hadron Experimental Facility (December, 2008)



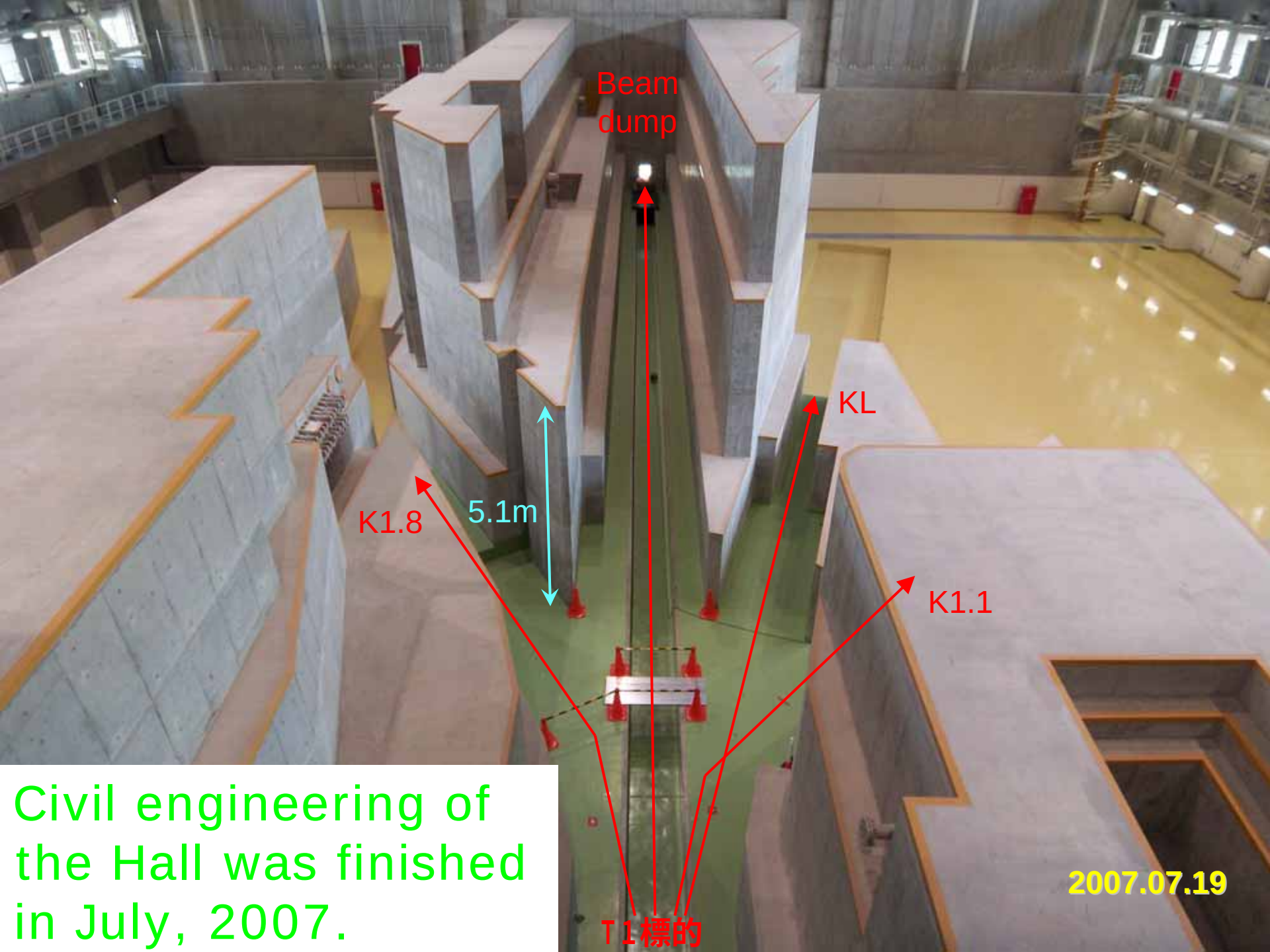
Slow Extraction Section and Switch Yard



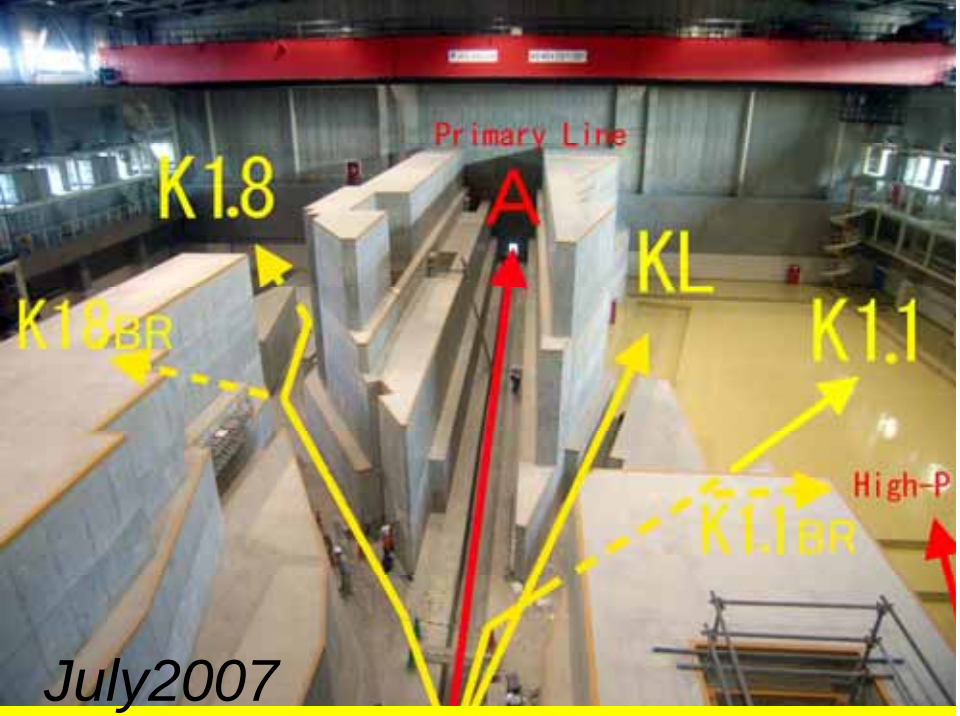
- Length: 250m
- Magnets: 36
  - MIC: 7
  - PI: 29
  - All these are “second hand” from the KEK-PS facility.
- Semi-remote-handling system against high rad and heat deposit
  - Electricity
  - Water
  - Vacuum
  - Beam monitors

Hadron Hall

Hadron Hall
Photo was taken in Oct. 2008

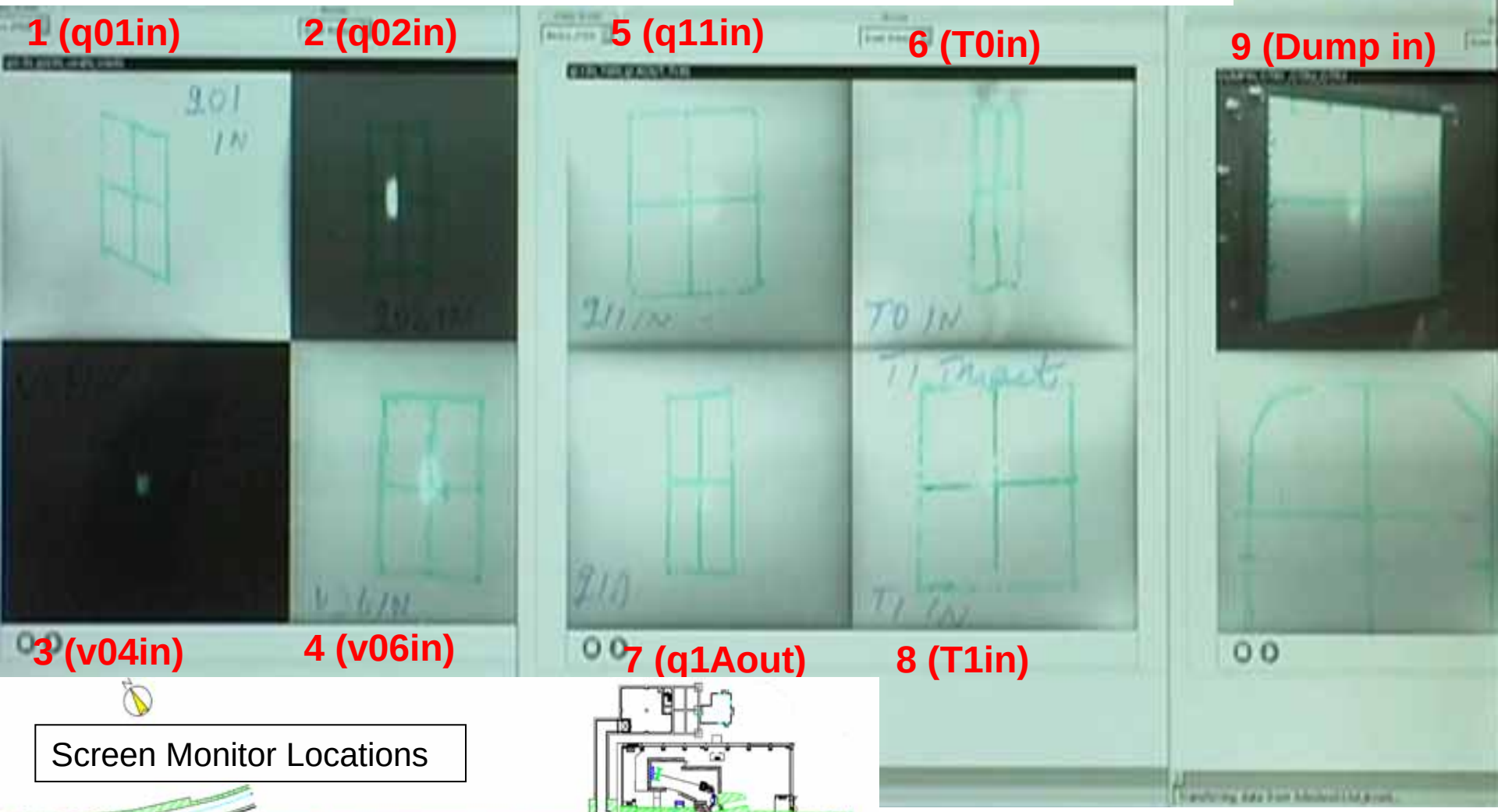


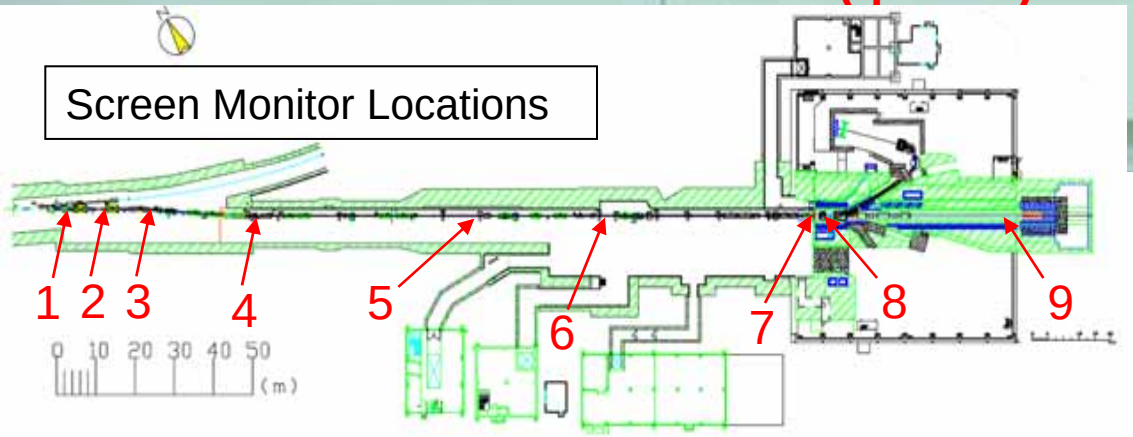
Civil engineering of the Hall was finished in July, 2007.



Construction of Hadron Experimental Hall

Typical Beam Profiles measured with Screen Monitors

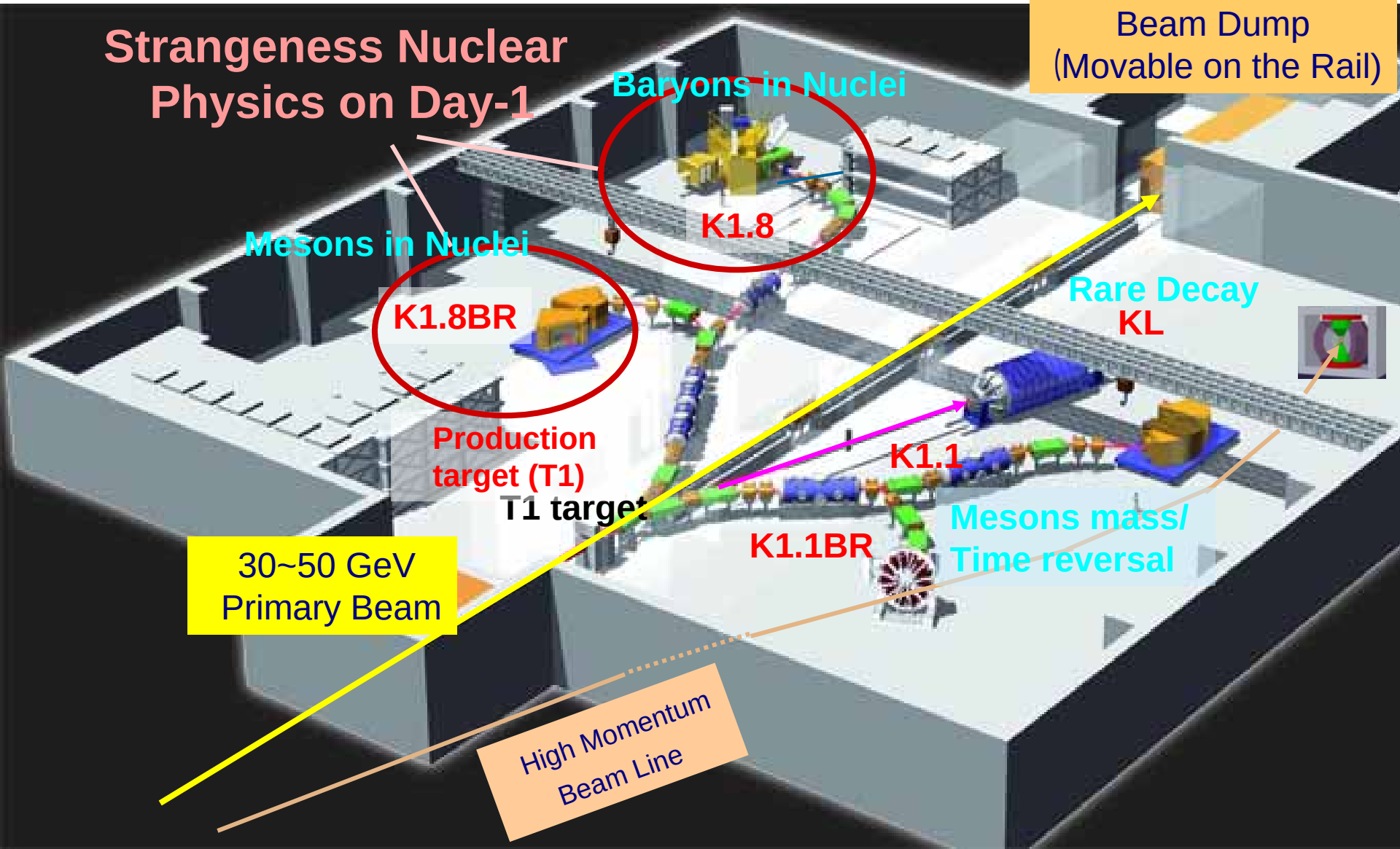




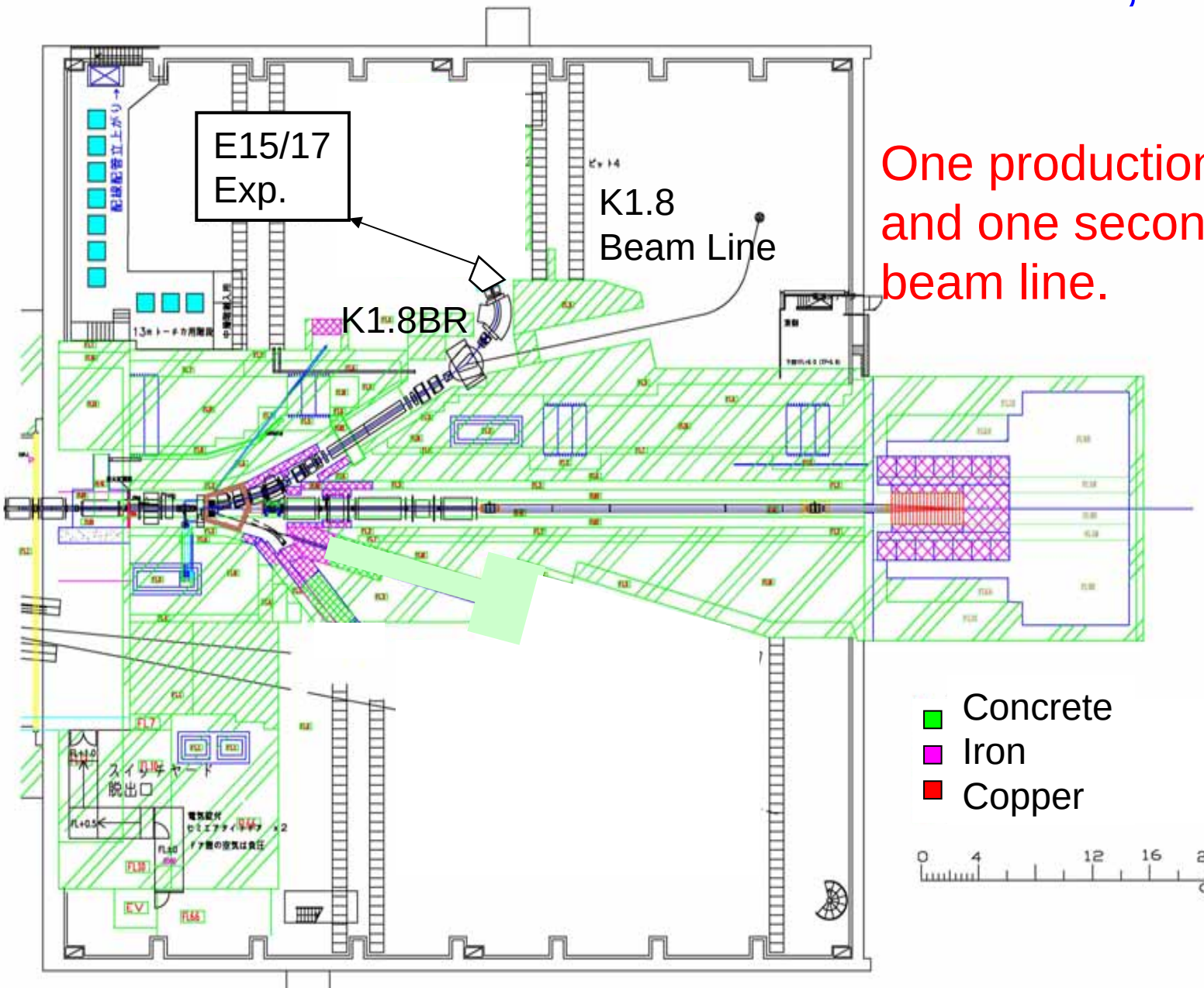
January 27th, 2009

Hadron Beamline Control Room

Plan View: Hadron Experimental Hall

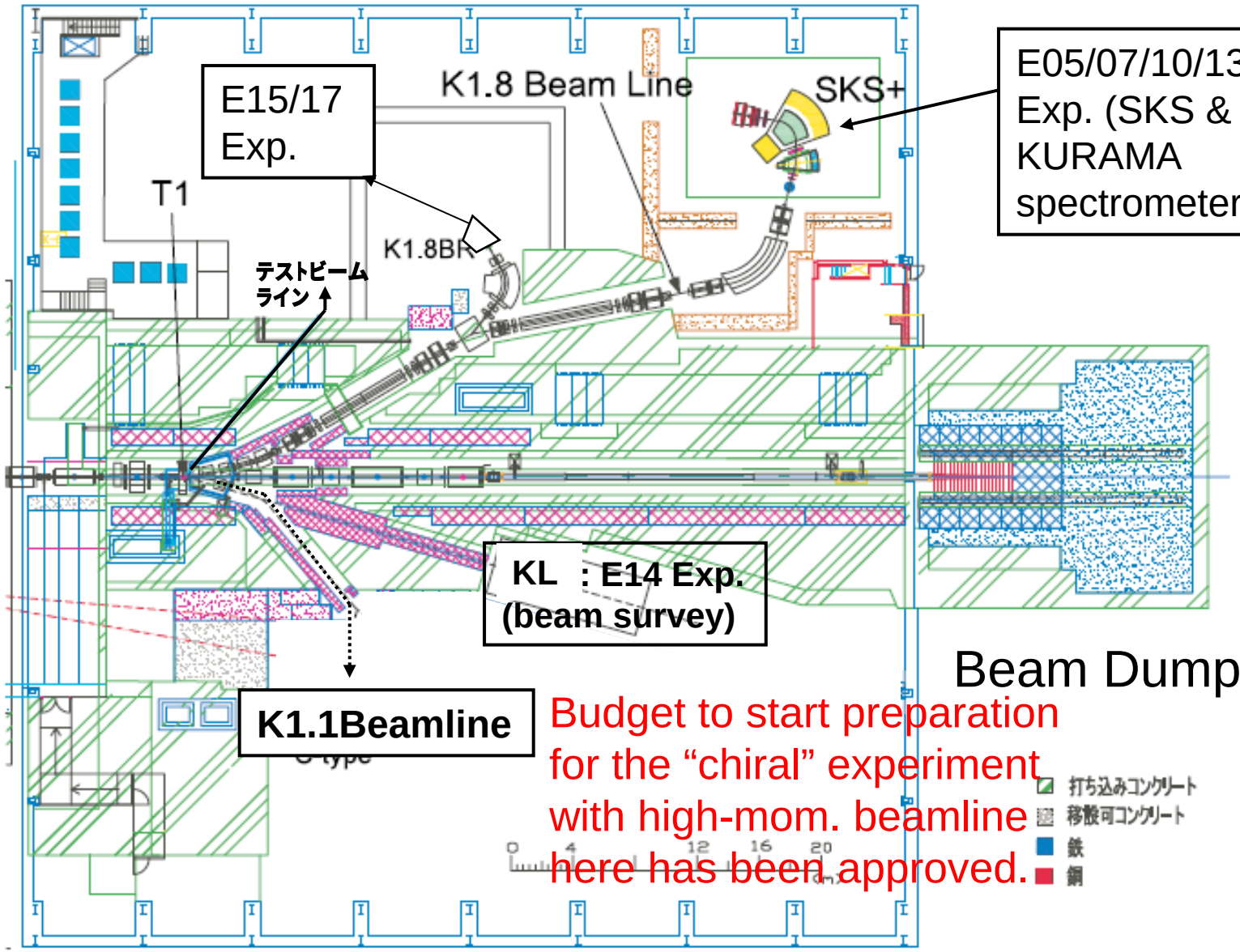


Hadron Hall in March, 2009

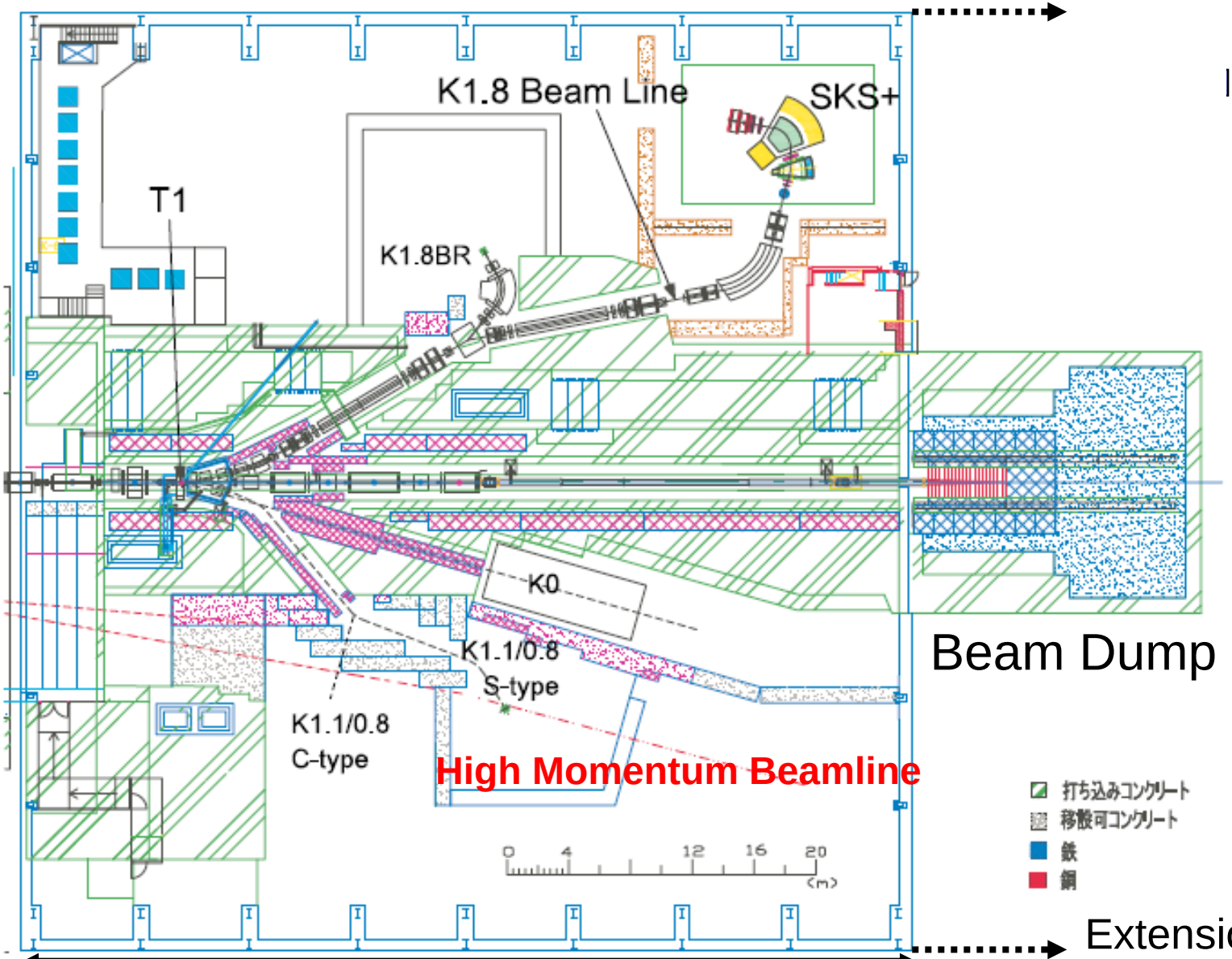


One production target and one secondary beam line.

Hadron Hall in March, 2010



Hadron Hall in ? Years



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Three Dimensional Nuclear Chart

Nu ~ Nd ~ Ns

"Stable"

p,n,Λ,Ξ⁰,Ξ⁻

Strangeness in neutron stars ($\rho > 3 - 4\ \rho_0$)

Strange hadronic matter (A → ∞)

Higher density

Strangeness

ΛΛ, Ξ Hypernuclei

Λ, Σ Hypernuclei

Z

N

-2

-1

0

Λ

p

n

S=-2 System: Ξ Hypernuclei (Ξ bound states)

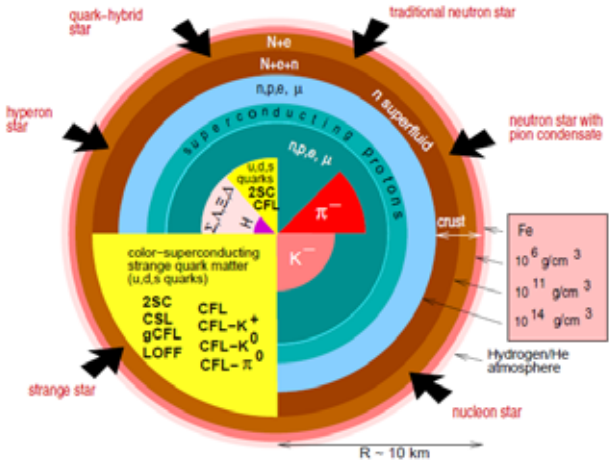
- Existense of the Ξ hypernuclei?
  - Potential of the Ξ ?
    - → EOS in high density nuclear matter, say in a neutron star
- ΞN interaction
  - Attractive or repulsive? How strong?
  - Spin, isospin dependence?
- Width of the bound state?
  - ΞN–>ΛΛ Conversion.

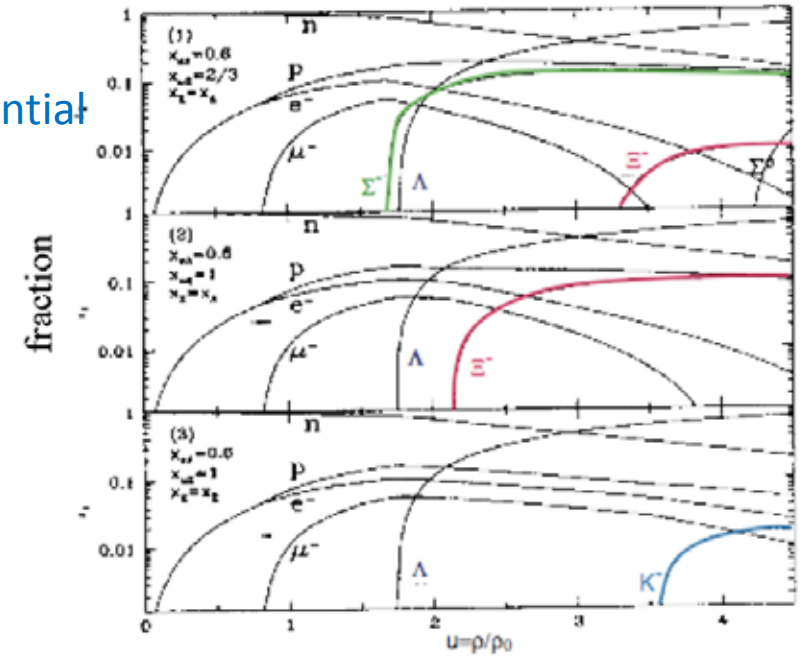
Ξ Potential & High Density Nuclear Matter

Λ, Σ^-, Ξ^-, K^- in the core of Neutron-Star

$$\mu_B = m_B + \frac{k_F^{\,2}}{2m_B} + U(k_F)$$

depends on Mass, Charge, and Potential





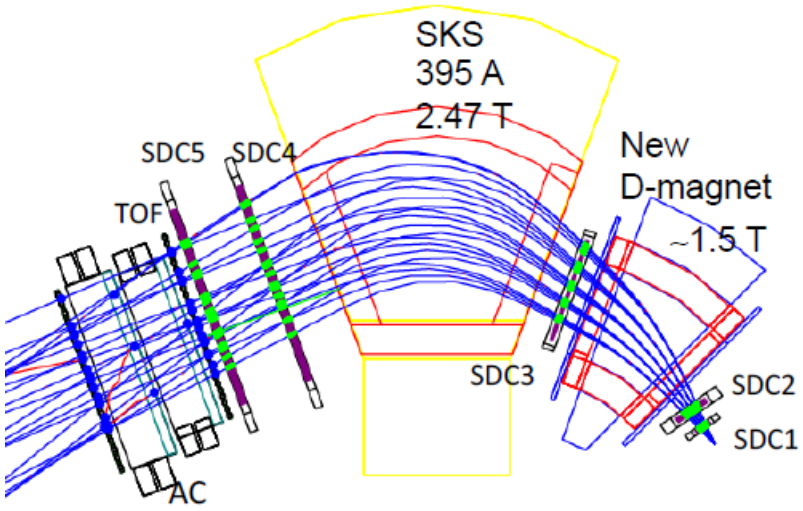
U_Σ <0, U_Ξ <0

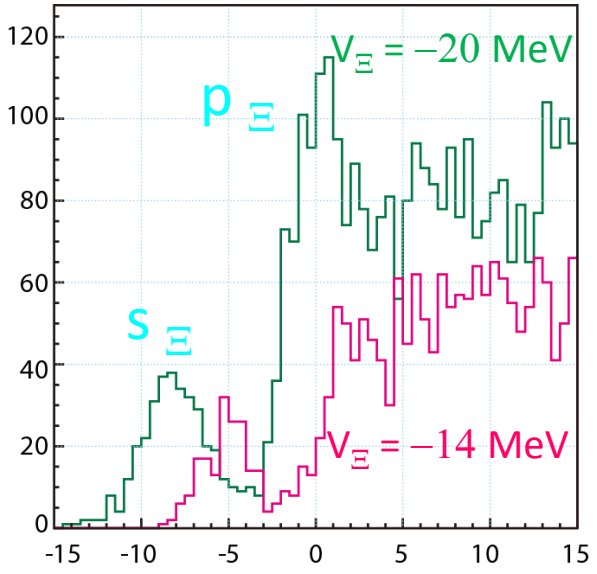
U_Σ >0, U_Ξ <0

U_Σ >0, U_Ξ >0

E05: Spectroscopic Study of Ξ-Hypernucleus, $^{12}_{\Xi}$Be, via the ^{12}C(K^-,K^+) Reaction

- Missing mass spectroscopy via the (K^-,K^+) reaction
  - K1.8 Beam Analyzer
  - $\Delta p/p = 3.3\times10^{-4}$
  - SksPlus Spectrometer
    - 30msr
    - $\Delta p/p = 0.17\%$
  - ΔM=3MeV(FWHM)
- The first observation of Ξ hypernuclear states
  - Ξ-Nucleus Potential
  - Ξ-N Interaction
  - Ξ-N –> ΛΛ Conversion





Recent K1.8/K1.8BR Beamlines

- Students, postdocs, and professors working hard!

Mass modification of vector meson

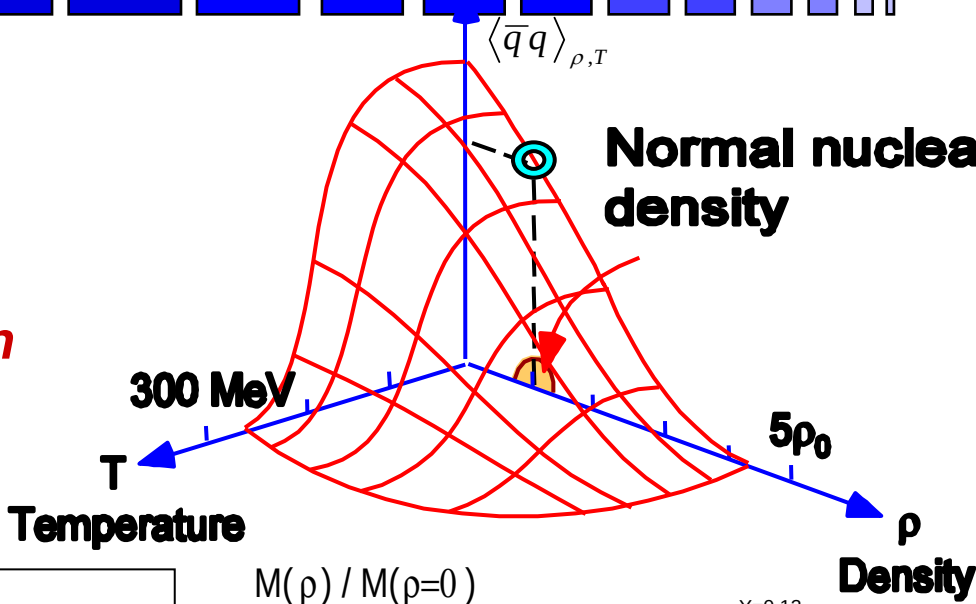
QCD Vaccum

Spontaneous Breaking of

Chiral Symmetry

Restoration

Hot/Dense Matter



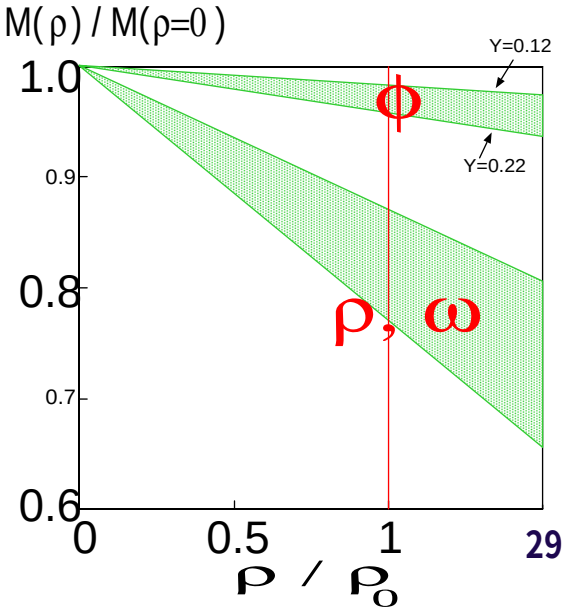
Vector meson mass at normal nuclear density

$m^*/m=1-k\rho/\rho_0$

(Hatsuda&Lee PRC46(92)R34)

ρ/ω : Δm = 130 MeV at ρ_0

ϕ : Δm = 20~40 MeV at ρ_0

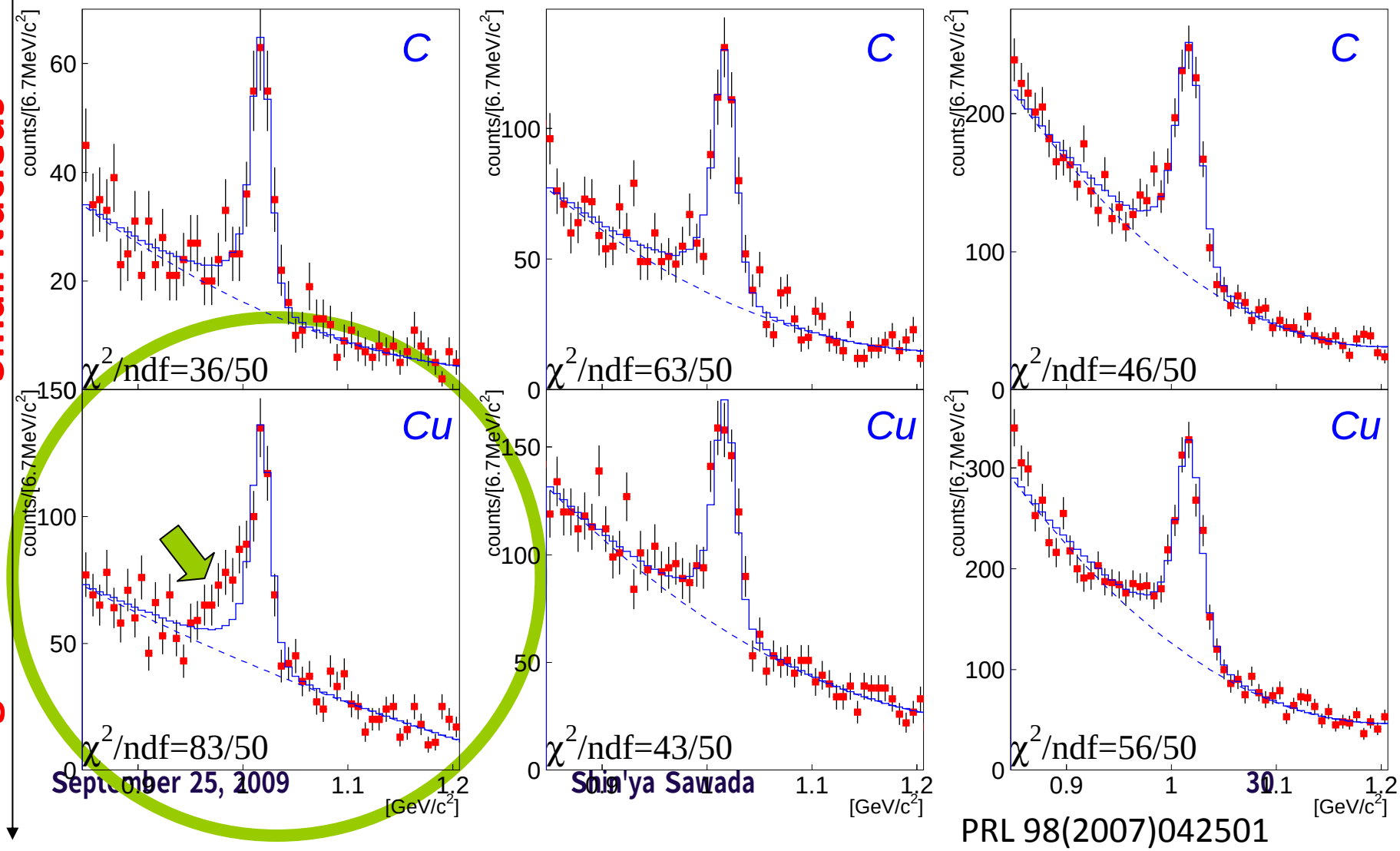


Results of a previous experiment (KEK-PS E325): Invariant mass spectra of $\phi \rightarrow e^+e^-$

$\beta\gamma<1.25$ (Slow) | $1.25<\beta\gamma<1.75$ | $1.75<\beta\gamma$ (Fast)

Small Nucleus

Large Nucleus

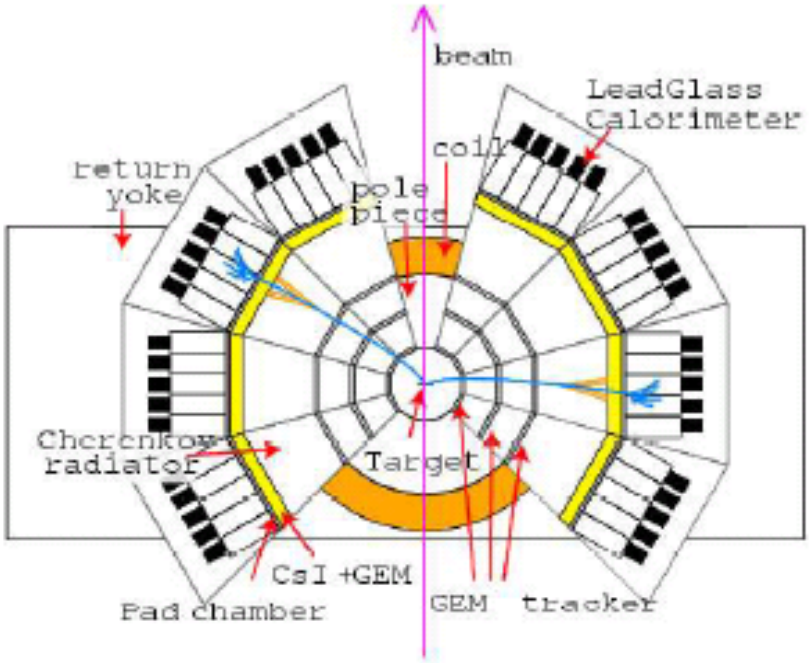


PRL 98(2007)042501

J-PARC E16: Electron pair spectrometer to explore the chiral symmetry in QCD

primary proton beam at high momentum beam line
+ large acceptance electron spectrometer

10^7 interaction (10 X E325)
10^{10} protons/spill
with 0.1% interaction length target
→ **GEM Tracker**
eID : **Gas Cherenkov**
+ Lead Glass
Large Acceptance (5 X E325)

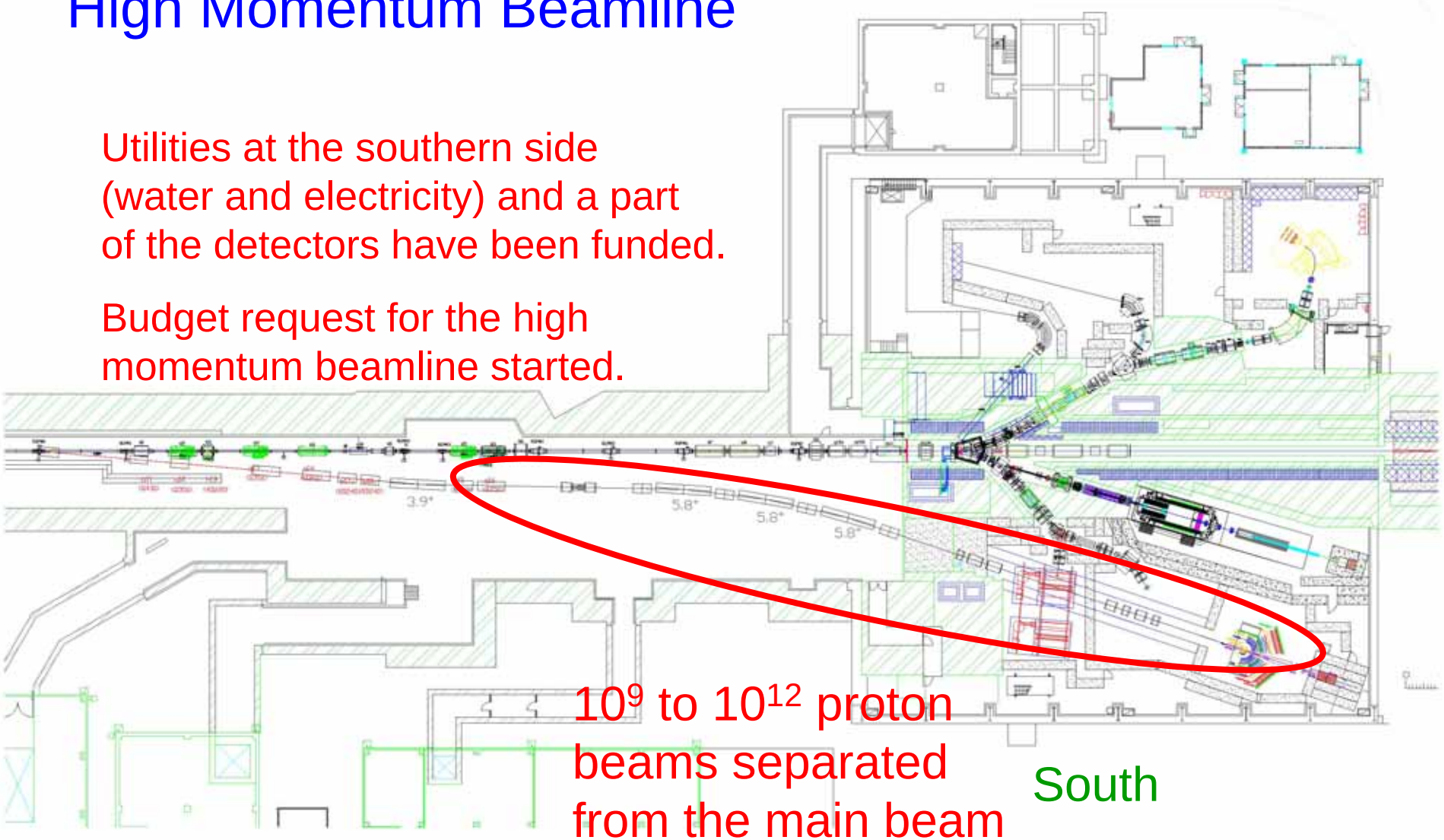


velocity dependence
nuclear number dependence (p → Pb)
centrality dependence
→systematic study of mass modification

High Momentum Beamline

Utilities at the southern side (water and electricity) and a part of the detectors have been funded.

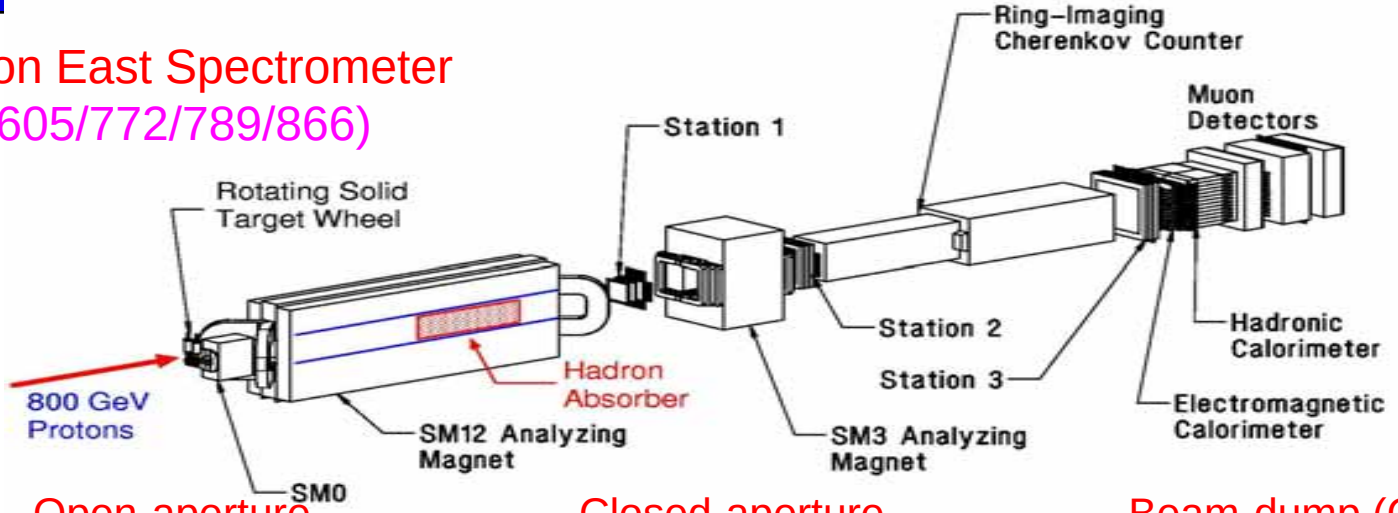
Budget request for the high momentum beamline started.



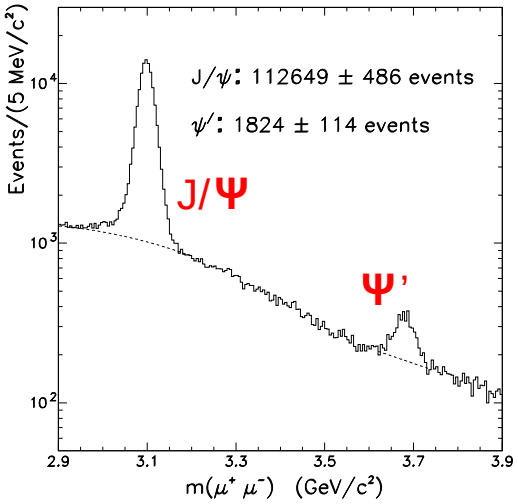
10^9 to 10^{12} proton beams separated from the main beam

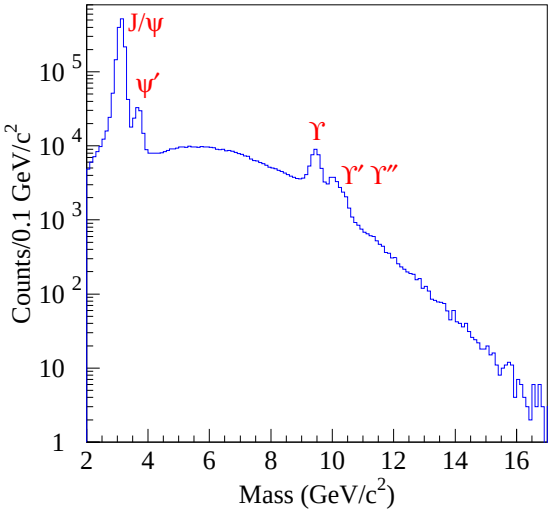
Dimuon from p+p, p+d, and p+A

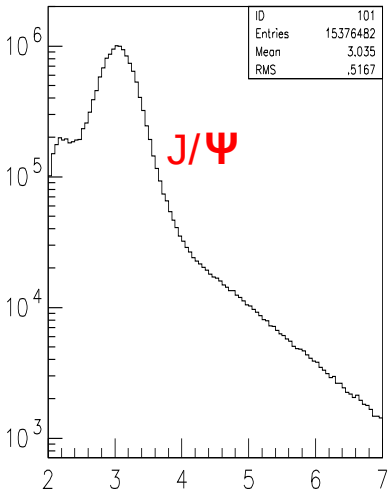
Meson East Spectrometer (E605/772/789/866)

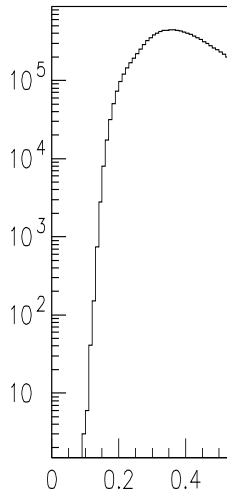


Open-aperture | Closed-aperture | Beam-dump (Cu)









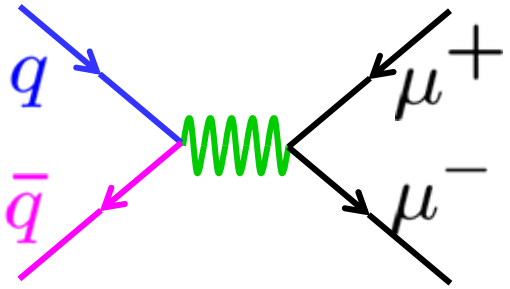
σ(Jhψ) ~ 150 MeV

σ (Jhψ) ~ 150 MeV

σ (J/ψ) ~ 300 MeV

Physics with High-Mass Dimuons with unpol beam/target

- Drell-Yan process
  - Antiquarks in nuclei and nucleons
  - Quark energy loss in nuclear medium
  - Drell-Yan angular distributions
    - Toward spin related structure such as Bohr-Molders



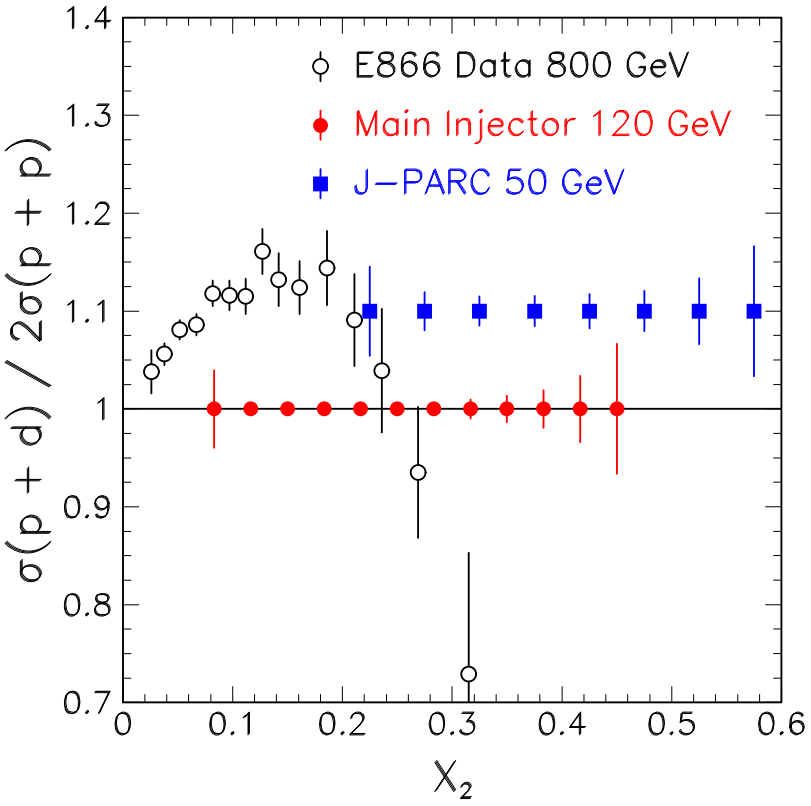
- Quarkonium production
  - Pronounced nuclear dependence
  - Production mechanism and polarization
  - Parton distribution in the nucleon
- Heavy quark production
  - Open charm production
  - B-meson production

dbar/ubar at Large x using 50 GeV Protons

- DY cross section is ~16 times larger at 50 GeV than at 800 GeV.

$$\frac{d\sigma_{DY}}{dx_1 dx_2} \approx \frac{1}{s} \text{ at fixed } x_1, x_2$$

- J-PARC can measure d-bar/u-bar at larger x.



Fermilab E906 and J-PARC P04

- Fermilab E906: Main Injector with 120-GeV protons
  - 2010-2012
  - Mid x region, really d-bar/u-bar < 1??
- J-PARC P04: Experiment with 30 and 50-GeV protons
  - 2013-?
  - Experimental apparatus mainly from E906
  - Ep = 30 GeV at the beginning
    - J/Psi physics
  - Ep = 50 GeV at the next stage with unpol beams for higher x
  - Polarized target and / or polarized beams
    - Pol. beams need further study.

Fermilab E906/Drell-Yan Collaboration

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John Arrington, Don Geesaman*, Kawtar Hafidi, Roy Holt, Harold Jackson, David Potterveld, Paul E. Reimer*, Patricia Solvignon

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Texas A & M University
Carl Gagliardi, RobertTribble

Thomas Jefferson National Accelerator Facility
Dave Gaskell

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Don Koetke, Jason Webb

*Co-Spokespersons

People with underline are included also in P04 and/or P24 at J-PARC.

Summary

- J-PARC is a world-class, high-intensity proton accelerator facility.
- The construction of the Phase 1 was completed in Japanese Fiscal Year 2008.
- First beams have been delivered to all the experimental facilities. From October, the beams are resumed, and we expect the beam quality/intensity would be very much improved.
- Hadron Experimental Facility is a main ground for nuclear physicist to play. The first experiment started, and many to begin.