A Bunched Proton Beam Facility Plan at J-PARC

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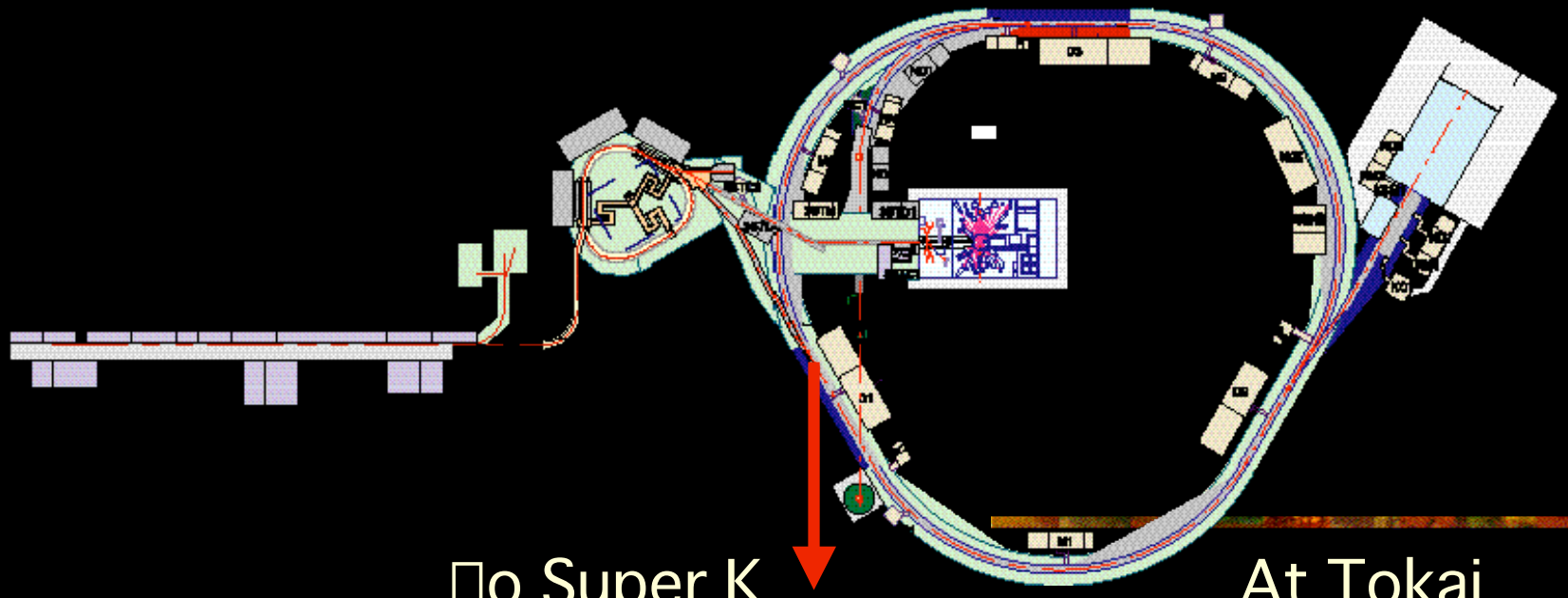
Muon EDM meeting at BNL
November 19th, 2002

KEK/JAERI Joint Project

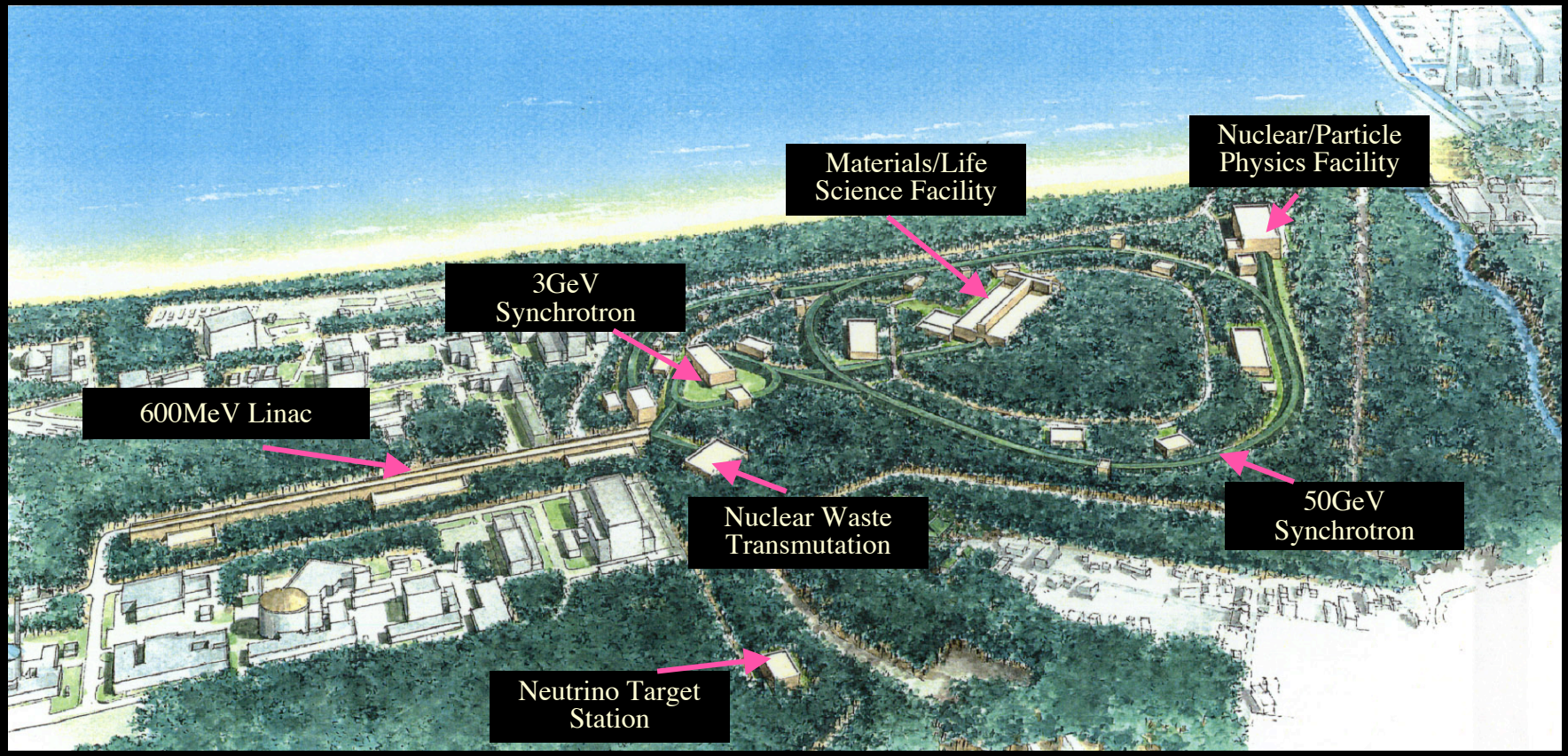
Finally named!

J-PARC(Japan Proton Accelerator Research Center)

600 (400) MeV proton linac
3 GeV Proton synchrotron (330□A)
50 GeV Proton synchrotron (15□A, 20□A)



Artist View of J-PARC Layout



J-PARC Plan and Schedule

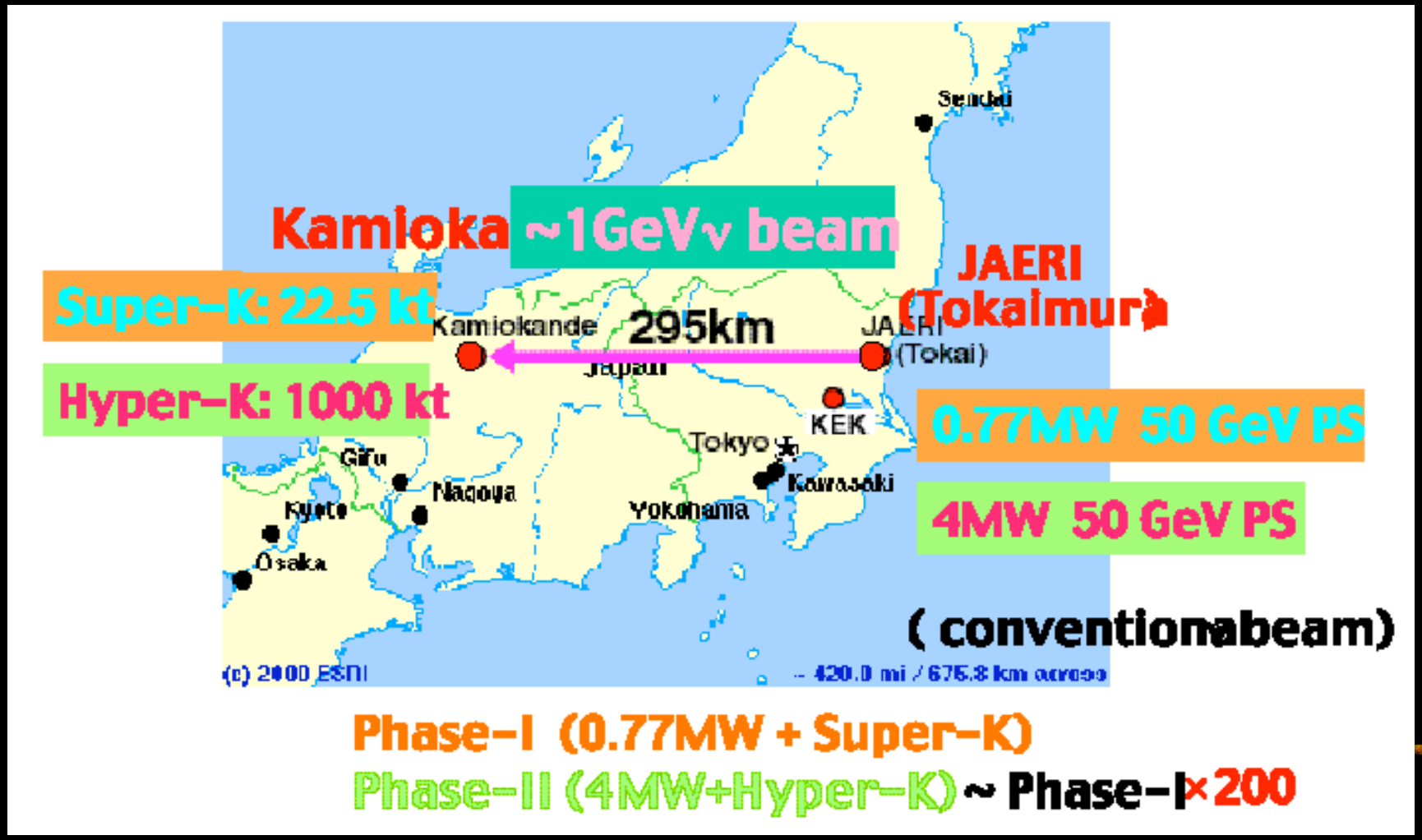
- Initial
  - 1 MW spallation neutron + 0.75 MW50 GeV PS 15mA
  - A total requested cost = 1.8B$
  - phase-I (mainly accelerators)
    - 2001 - 2006 1.3B$ (approved)
  - phase-II (mainly experiments)
    - 2007?- 0.5B$
  - phase-III ???
- Upgrade
  - 5 MW spallation neutron + 4.4 MW 50 GeV beam
  - Cost : not known
  - Schedule: not known

J-PARC Beams for Users

- Slow-extracted proton beam experiments
- Neutrino experiments
- Fast-extracted (bunched) proton beam experiments

This is not in the original budget line items.
Therefore, it will not come out automatically.
We should work hard to make it happen.

JHF-SK (superbeam) Project

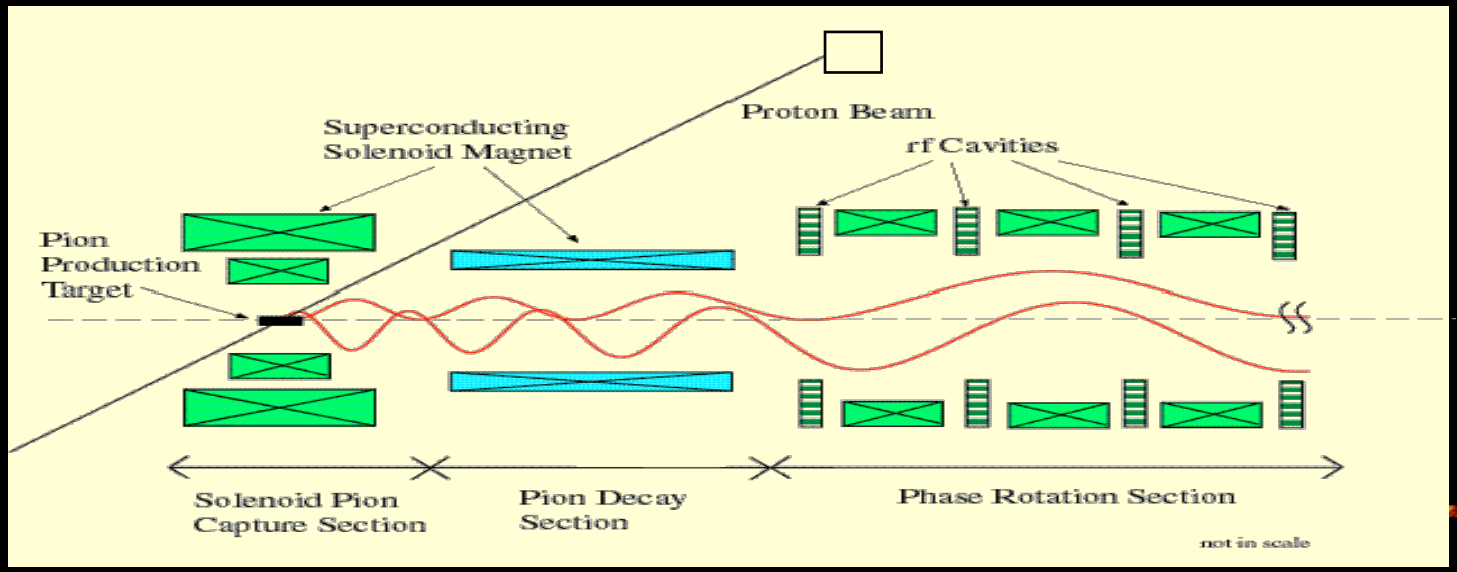


Potential Physics with Bunched Proton Beams

- Muon Physics
  - PRISM (=Phase Rotated Intense Slow Muon source)
    - low energy (or stopped) muon experiments
    - e.g. muon-electron conversion process, etc.
  - muon electric dipole moment
  - muon (g-2) precision measurement
- Anti-proton Physics

PRISM Scheme

- pulsed proton beam
- pion capture by high solenoid field
- pion decay section
- phase rotation section

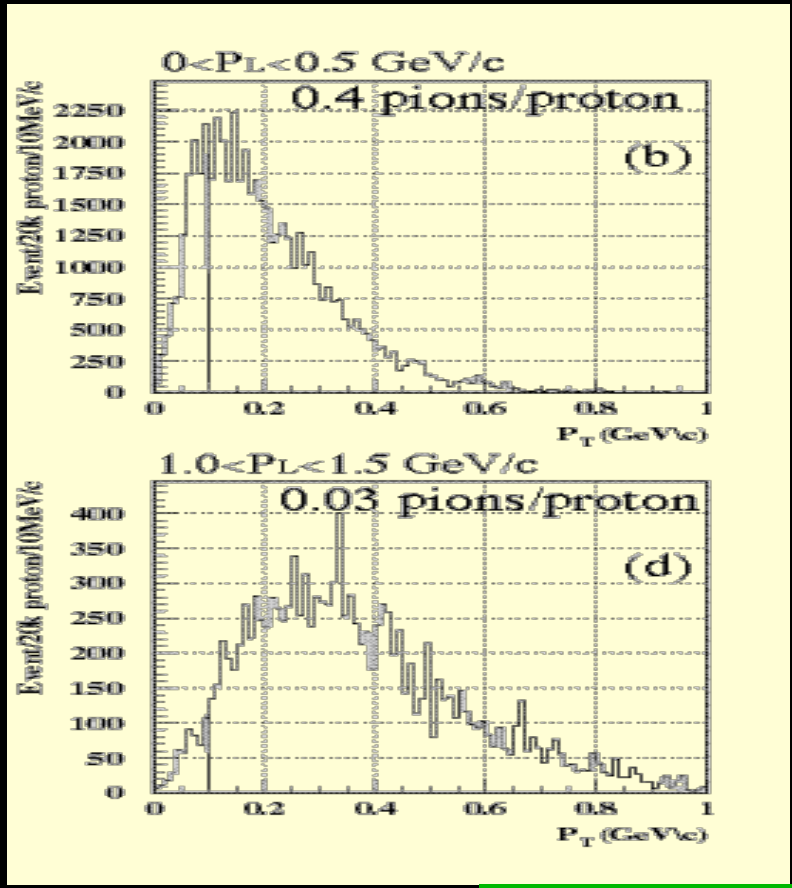


Pion Capture in SC magnet

- maximum transverse momentum

$$P_T(MeV/c) = 0.3 \times H(kG) \times \left(\frac{R}{2}\right)(cm)$$

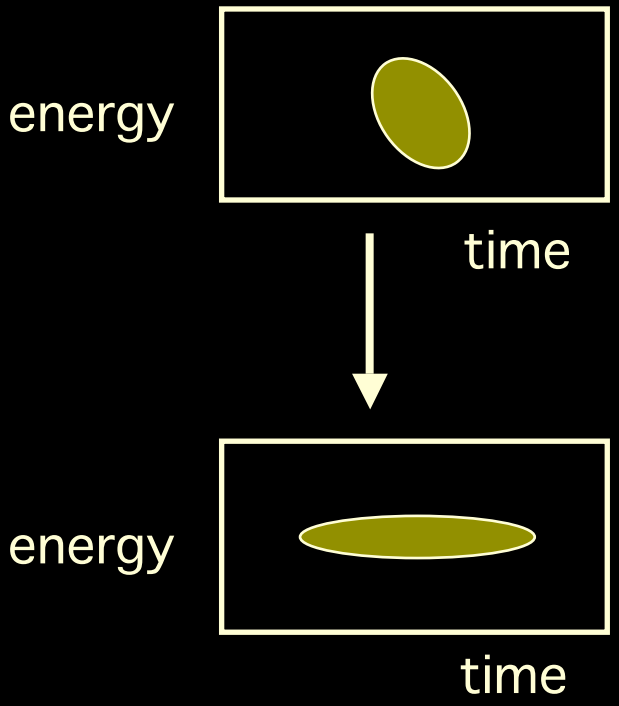
  - *R* : radius of magnet
  - *ex: H*=120kG(=12T), *R*=5cm
    - P_T < ??? *MeV/c*
- capture yields



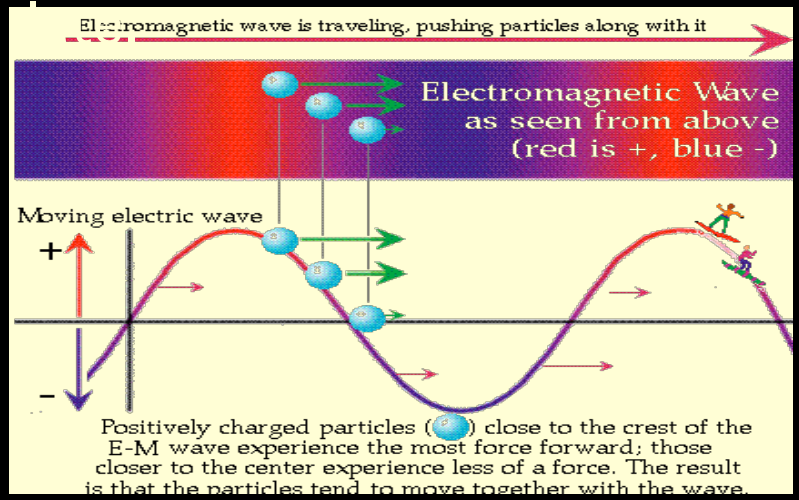
for 50GeV protons

Phase Rotation

- Phase Rotation = decelerate particles with high energy and accelerate particle with low energy by high-field RF

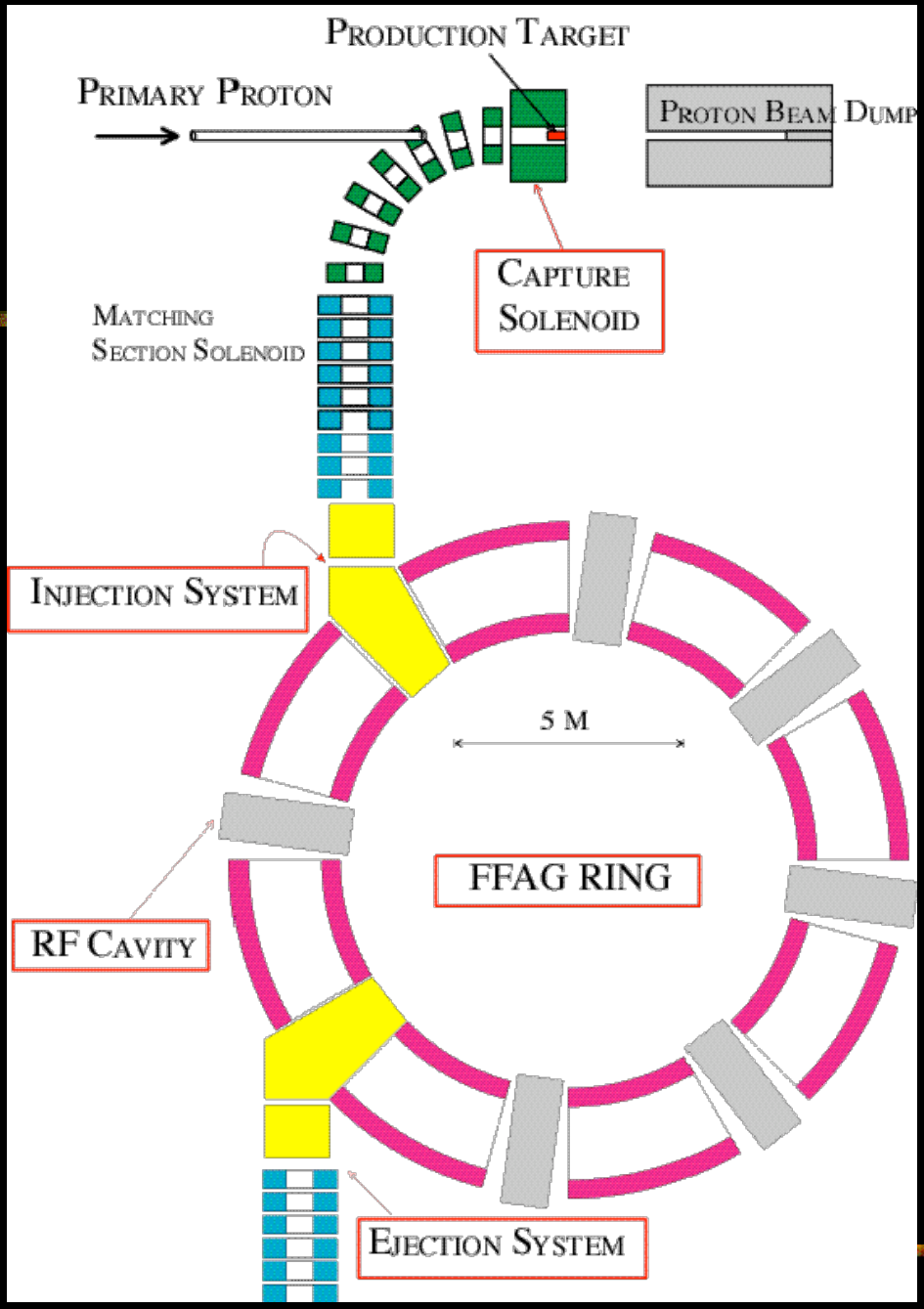


- A narrow pulse structure (<1 nsec) of proton beam is needed to ensure that high-energy particles come early and low-energy one come



PRISM

- Backward Pion Extraction
- 10-m pion decay section
- PRISM beam
  - 10^{11}-10^{12} muons/sec
  - centran momentum = 68 MeV/c
  - energy width : 2-3 % after phase rotation
- PRISM FFAG
  - 10 m diameter
  - 5 MHz RF frequency
  - Kicker injection and extraction
- for □-e conversion experiment.



Beam Requirement (PRISM)

- short bunched proton beam
  - a few nano second width
- 100-1000 Hz repetition
  - reduce muon intensity/bunch
- Backward extraction
- stopped muons (~68 MeV/c)

Beam Requirement (EDM)

- High intensity with high polarization
  - $NP^2=10^{16}$/year for 10^{-24} ecm
- Muon energy = about 500 MeV/c
- Length of pion decay section
  - about 30 m (flight)

Beam Requirement (g-2)

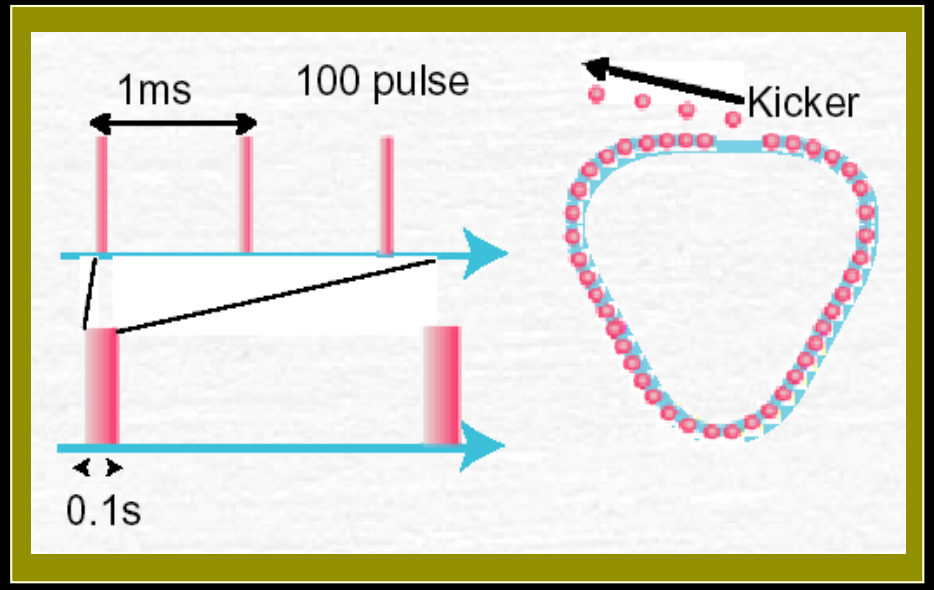
- Muon momentum = 3.1 GeV/c
- High polarization (~100%)
- Reduction of instantaneous rates
  - large number of proton bunches
- Preferably backward-decay muons
  - reduction of pion contamination
- Length of pion decay section
  - about 100 m (in flight)
- Single bunch kicking

Beam Requirement (Antiproton)

- 50-GeV preferable
- 1 proton bunch (out of 8) enough
- bring the CERN AD ring ?
  - depends on future antiproton programs at CERN or GSI ?
  - Japanese community has not decided.

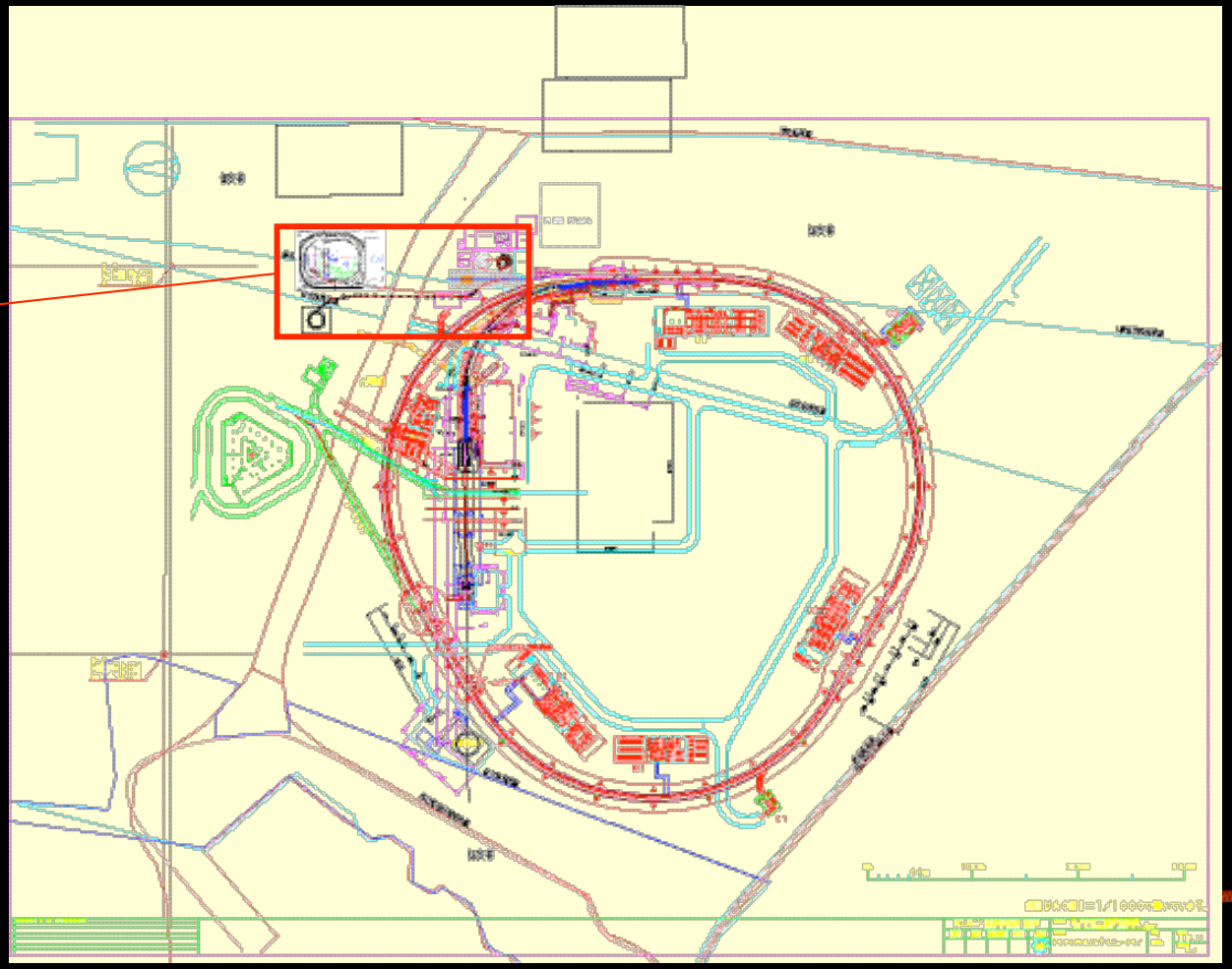
Short-bunched Proton Beam for PRISM

- 100 harmonics in PS ring
- Fast Extraction of bunched proton beam
  - Pulse width< 10ns
  - repetition
    - 100-1000 Hz
    - single-bunch kicking



Potential Location of Fast Extracted proton Beam Line

A potential area for a bunched proton beam facility



Possible Layout of Muon Factory

- see pdf files……

Options for muon EDM beam

- Option 1:
  - a conventional muon beam line
  - intensity ?
    polarization ?
- Options 2:
  - accelerate the PRISM beam (= 80 MeV/c) in the PRISM ring
- Option 3:
  - construct another FFAG ring (PRISM-II) dedicated for muon EDM beam.
  - 500 MeV/c
  - phase rotation (cooling ?)

NP^2 Requirement

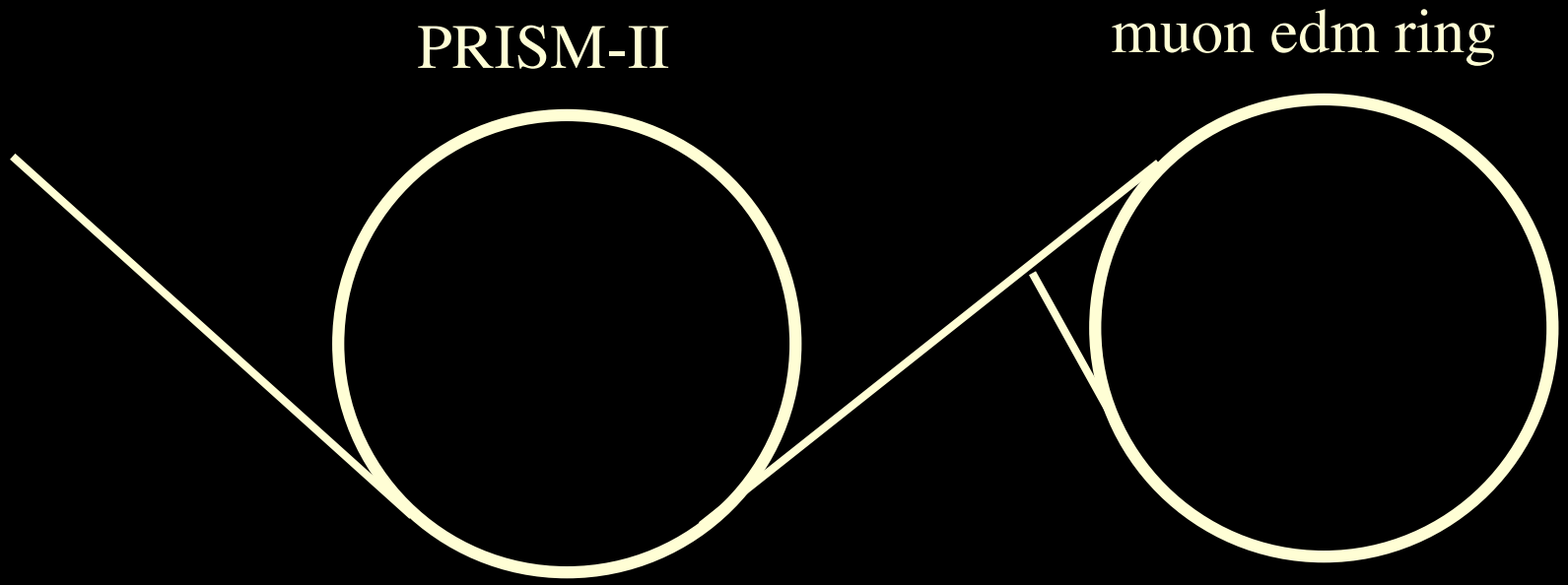
- at PRISM,
  - $N = 10^{11}$-10^{12} muons/sec, P~0.3
    - $NP^2 = 10^{17}$-10^{18} /year (some safe margin)
- at PRISM-II
  - needs estimation of N and P
  - improve P with cost of N (iteration)

- considerations
  - momentum selection of initial pions
  - emittance cut to match the edm ring
  - clockwise and counterclockwise injection to edm ring

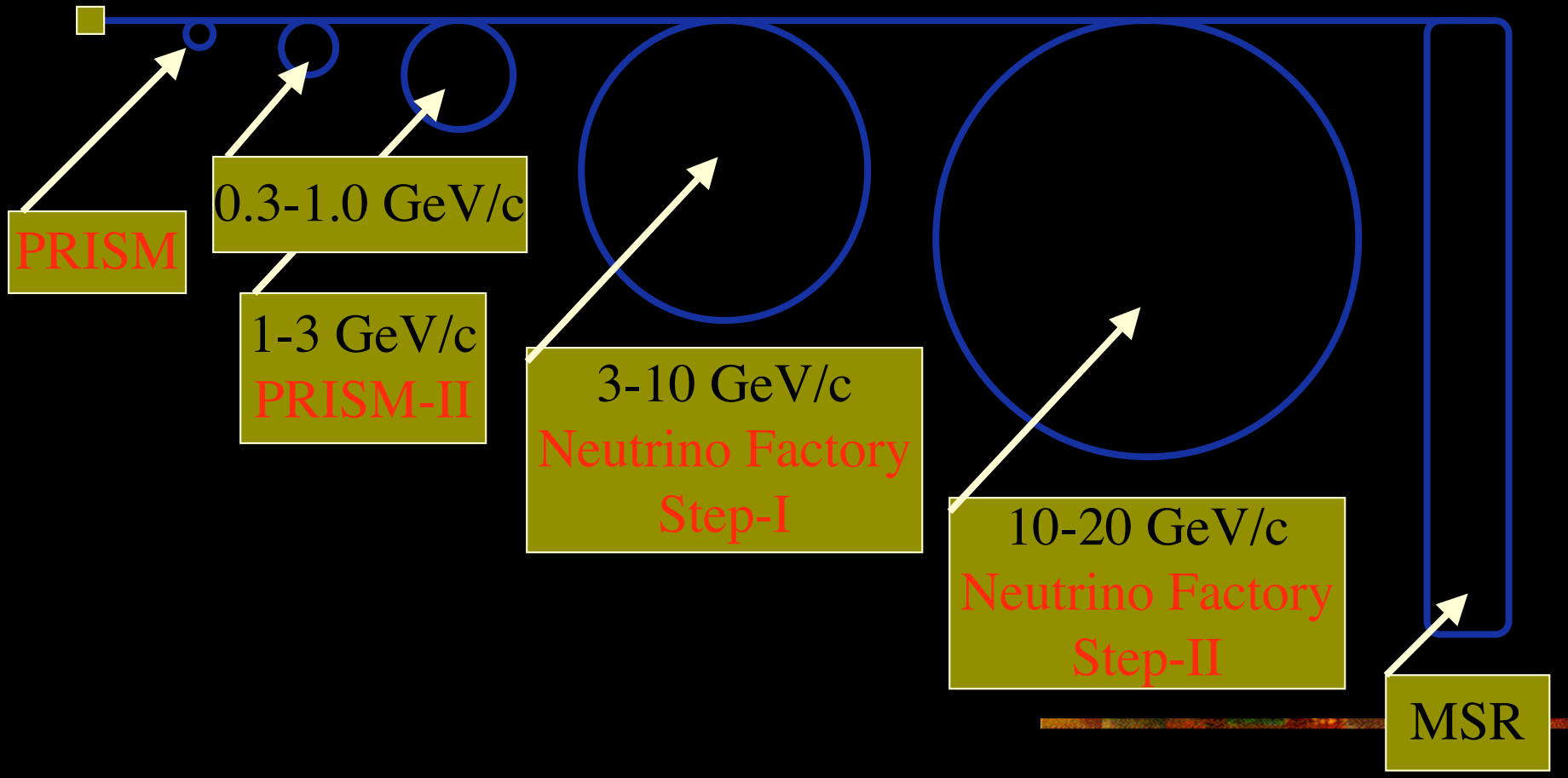
PRISM-II RING

- Phase rotation needed ?
  - a factor of 10 times intensity
- dedicate lattice design is not done yet.
  - ask FFAG lattice design to KEK accelerator group (Y. Mori group)
  - ask Masa Aoki to do MC simulation
- Another good reason to consider PRISM-II
  - refer to 0.3-1.0 GeV ring in the Nufact-J project

Schematic Layout ?



FFAG-based Staging Scenario



Possible Layout of NufactJ

- see PDF files…

  (edm ring is not in)

Technical Issues

- The area is tight.
- A public road near by.
- The area is assigned to be a first-class wind-break forest. Need permission to cut trees. (probably underground ?)

Necessary Current Treatment

- Avoid soil activation to keep future tunnel making possible.
  - place some heavy concrete shielding at the location.
  - It is to some extent agreed.

Political Issues

- Get approval of a bunched proton beam facility at JPARC
  - a letter
  - LOIs
- Budget (when ?)

LOIs

- LOI for a bunched proton beam facility
- LOI for PRISM
- LOI for mu-e conversion experiment
- LOI for muon EDM

- deadline is January 1st, 2003

Requests from JPARC project director on LOI

- (1) what kind of foreign contribution is anticipated to commit ?
  - manpower, budget, etc.
- (2) What kind of contribution from the JPARC project is expected at the Phase-1 construction ?