

Long-range plan of nuclear physics in Japan

Workshop on “Future vision of the
nucleon structure study” at RIKEN

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Future vision of nuclear physics in Japan

- We are making a “Long-Range Plan” of nuclear physics in Japan
 - at a major turning point
 - with two new worldwide facilities
 - RIBF at RIKEN Nishina Center, Wako
 - J-PARC at Tokai
 - aiming at a dramatic progress
- Mainly young physicists are discussing how to develop and expand the nuclear physics
 - making common knowledge of all the nuclear-physics research theme and field
 - discussing future direction
- Internal report will be made in 2011 summer

Working groups

- Unstable nucleus (incl. super-heavy element)
 - RIBF/TRIAC
- Hyper nucleus & strangeness
 - J-PARC/JLab
- Hadron
 - J-PARC/RCNP-LEPS/ELPH
- High-energy heavy ion
 - PHENIX/ALICE
- Precision nuclear physics
 - RCNP/RIBF
- Fundamental physics
 - Universities/CERN/RCNP/J-PARC
- Nucleon structure
 - RHIC/COMPASS/Fermilab/J-PARC
- Computational nuclear physics
 - Super-computer

Two time ranges

- 10 years
 - What did we achieve in past 10 years?
 - What will we achieve in future 10 years?
 - fundamental questions
 - development/expansion/construction/achievement???
 - necessary resources (budget/manpower)
- 20-30 years
 - With no boundary condition...

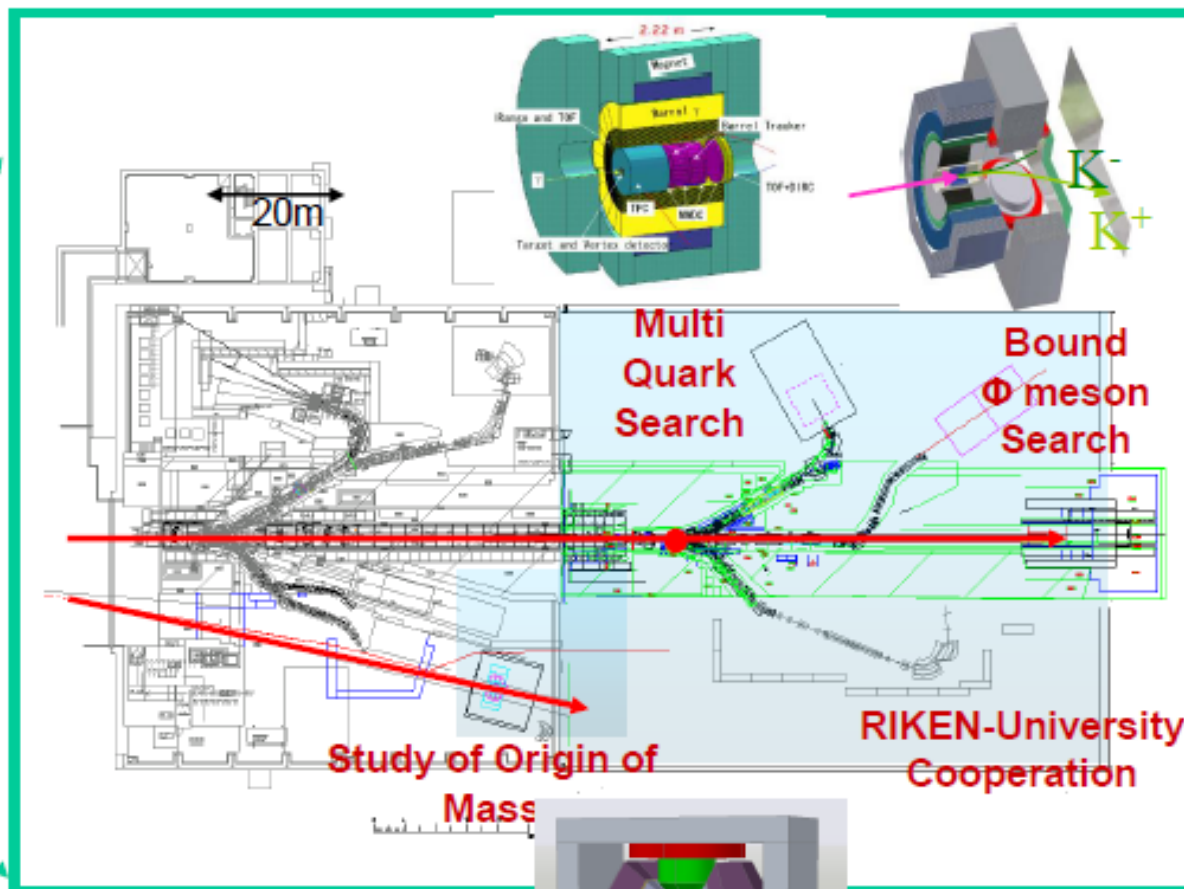
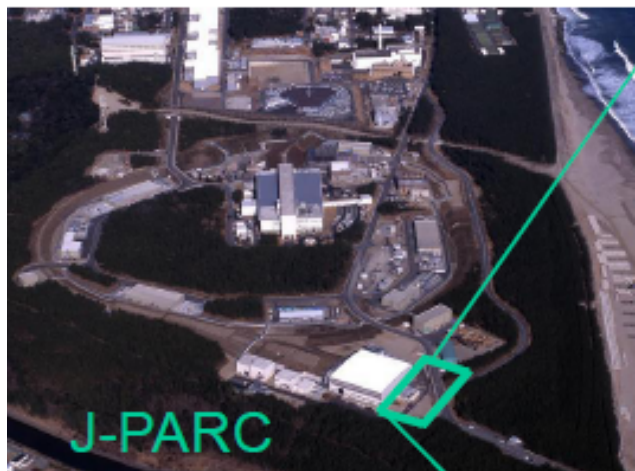
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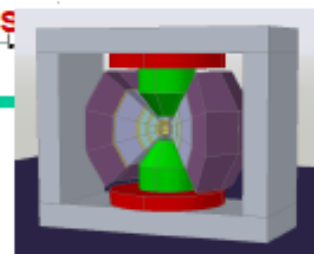
Big future projects

- Large facilities planning
 - J-PARC upgrade
 - RIKEN J-PARC center for hadron physics
 - RIBF upgrade
- New large-scale research programs
 - RCNP (Osaka Univ.)
 - ELPH (Tohoku Univ.)
 - Antiproton (Univ. of Tokyo)

理研J-PARC連携センター構想



- ハドロンホールを拡張
- 第二生成標的を設置
- ビームラインを数本設置
- ハドロン研究用スペクトロメータ設置



2012年度予算要求を目指す

Nucleon structure WG

- WG members
 - 11 experimentalists
 - 10 theorists
- Physics of nucleon structure
 - Understanding with the first principle = QCD
 - Approach with high energy
 - To investigate dynamics of the confinement

Research theme and history

- Spin puzzle: origin of the nucleon spin
 - Quark-spin contribution
 - 1980's-1990's: CERN(EMC/SMC), SLAC
 - 1990's-2000's: DESY(HERMES), CERN(COMPASS), JLab
 - Gluon-spin contribution
 - 2000's: CERN(COMPASS), RHIC(PHENIX/STAR)
- Transverse-spin phenomena
 - 1990's: Fermilab(E704)
 - 1990's-2000's: DESY(HERMES), CERN(COMPASS), RHIC(PHENIX/STAR), JLab
- Flavor asymmetry of antiquark distributions
 - 1990's: CERN(NMC/NA51)
 - 1990's-2000's: Fermilab(E866/E906)
- Polarized fragmentation functions
 - 2000's: KEK(BELLE)
- Form factor (high-momentum transfer)
 - 1980's-1990's: SLAC
 - 2000's: JLab

Goals

- Understanding of the spin puzzle
 - What is the origin of the nucleon spin?
 - Quark-spin contribution
 - Precision measurements with lepton scatterings
 - Polarized DIS (deep-inelastic scattering) experiments
 - ~30% contribution
 - Gluon-spin contribution
 - Polarized SI (semi-inclusive) DIS experiments and polarized proton collision experiments
 - Large restrictions
 - More precision to be achieved
 - Orbital angular momentum contribution
 - GPD (Generalized parton distribution) function
 - Determination of the orbital angular momentum inside the nucleon with Ji's sum rule

Goals

- Transverse-spin phenomena
 - SSA (single-spin asymmetry) and angular distribution measurements
 - Incoherent scattering of partons cannot explain the large SSA
 - Dynamics different from longitudinal-spin or helicity structure
 - Understanding with QCD
 - TMD (transverse-momentum dependent) factorization, TMD distribution functions
 - Transversity distribution function + fragmentation function (as an analyzer)
 - Higher-twist effect

Goals

- Understanding of newly developed (polarized) nucleon structure
 - GPD functions
 - Including form factor and PDF
 - Determined by
 - DVCS (deeply virtual compton scattering)
 - HEMP (hard exclusive meson production)
 - Multiple-dimensional data necessary
 - Factorization is proved (process independent)
 - Relation to the orbital angular momentum inside the nucleon with Ji's theorem
 - TMD distribution functions
 - variety of measurements with lepton scatterings and proton collisions
 - SSA measurement, angular distribution measurement
 - NOT process independent
 - Final/initial state interaction effect
 - Unknown quantitative relation to orbital angular motion
 - Higher-twist effect
 - Quantum multi-body correlation

Goals

- Refinement of PDF (and pol-PDF)
 - Flavor asymmetry of antiquark distributions
 - Drell-Yan reaction
 - Weak boson production
 - Development of the QCD global analysis
 - Understanding of small-x and large-x
- (Polarized) fragmentation function measurement
 - Analyzer for the transversity distribution functions
 - Collins fragmentation function
 - Interference fragmentation function
- Form factor measurements
 - Expansion to high-momentum transfer region
 - 2 photon exchange?
 - Hybrid region between hadron and parton

Goals

- perturbative QCD
 - Higher-order calculation
 - Resummation of logarithmic divergence
- Non-perturbative QCD
 - Lattice QCD
 - Effective theory/model
 - Meson-cloud model
 - Chiral soliton
 - VMD (vector meson dominance)
 - Instanton picture
 - Approach from AdS/CFT

Goals

- 5 – 10 years
 - Measurement of the TMD distribution functions
 - Measurement with polarized SIDIS process and Drell-Yan process
 - show opposite sign
 - Establishment of theoretical basis
- 10 – 20 years
 - Measurement of the GPD functions
 - measurement with lepton scatterings
 - DVCS/HEMP
 - Determination of the orbital angular momentum inside the nucleon with Ji's sum rule
 - Multi-dimensional data necessary

Experimental projects

- CERN/COMPASS
- RHIC
- Drell-Yan experiments
- BELLE
- JLab-12GeV
- EIC/ENC/LHeC
- J-PARC
- GSI/FAIR
- LHC
- Neutrino scattering, Neutrino factory

