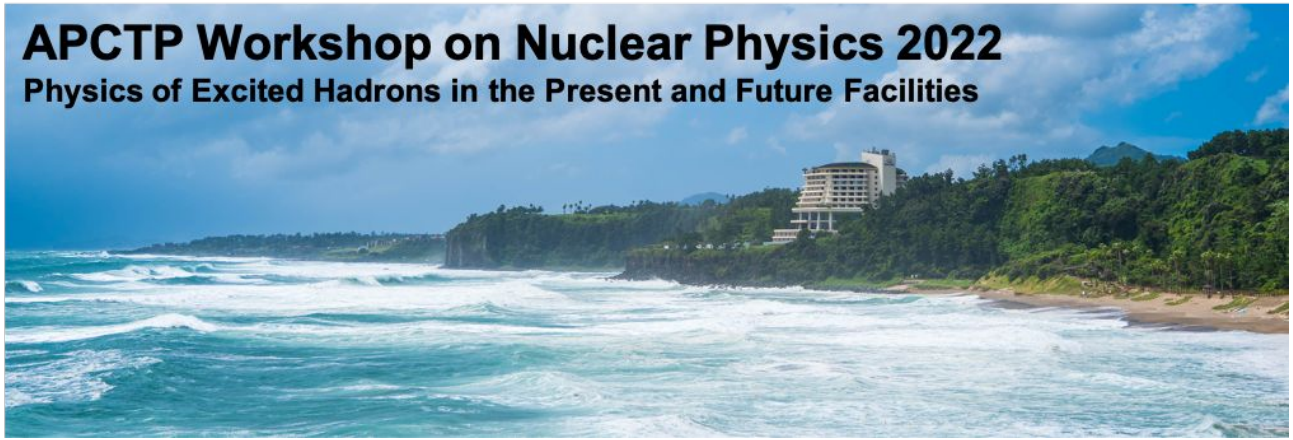
Report on Korea summer visit

June 17(Arrival) - August 2 (Departure)

Chueng-Ryong Ji

North Carolina State University



Group Meeting, August 5, 2022

Outline

- APCTP Seminar (July 6)
- Inha HTG workshop-Modern issues in Hadronic Physics (July 7-8)
- APCTP Workshop on Nuclear Physics 2022 (July 11-16)
- APCTP Focus Program in Nuclear Physics 2022 (July 18-23)
- KNUT Seminar (July 25)
- What did I learn?
- What do we need to work on?

Dynamical mass generation in ‘tHooft Model

Chueng-Ryong Ji
North Carolina State University

July 6, 2022, APCTP

APCTP JRG group leader Prof. Matti Jarvinen stopped by my office and we have discussed few points of linking between the light-front quark model (LFQM) with the holographic QCD.

String Theory and Quantum Chromodynamics

Leader Prof. Matti JARVINEN

279-1336

matti.jarvinen@apctp.org

515


Inha HTG Workshop: Modern issues in Hadronic Physics
• 일정 : 2022년 7월 7일(목) ~ 8일(금)
• 장소 : 인하대학교 60주년 기념관
주최 | 인하대학교 물리학과
후원 | 인하대학교
NRF 한국연구재단
CENuM 극한핵물질연구센터

Is the sub-eV active neutrino Dirac or Majorana particle? *Choong Sun Kim*

인하대학교 60주년기념관 107호 13:00 - 13:40

Photo- and electro-production of phi meson *Sangho Kim*

인하대학교 60주년기념관 107호 13:40 - 14:10

Transverse single-spin asymmetry of the very forward neutral pion production *Hee-Jin Kim*

인하대학교 60주년기념관 107호 14:10 - 14:40

Study of the radial excitation of hadron *Ahmad Jafar Arifi*

인하대학교 60주년기념관 107호 14:40 - 15:10

Analysis of virtual meson production in (1+1)-scalar field model *Yongwoo Choi*

인하대학교 60주년기념관 107호 15:30 - 16:00

Chiral anomaly and the pion properties in the light-front quark model *Ho-Meoyng Choi*

인하대학교 60주년기념관 107호 16:00 - 16:30

Light-Front Dynamics in Hadron Physics *Chueng-Ryong Ji*

인하대학교 60주년기념관 107호 09:30 - 10:30

Axial-vector transition form factors of singly heavy baryons in chiral quark-soliton model *Jung-Min Suh*

인하대학교 60주년기념관 107호 10:30 - 11:00

Deeply virtual Compton scattering with CLAS and CLAS12 *Hyon-Suk Jo*

인하대학교 60주년기념관 107호 11:00 - 11:30

Energy-momentum tensor form factors of of the baryon octet and their stability conditions with flavor SU(3) symmetry breaking
Ho-Yeon Won

Light quark distribution functions in a heavy baryon in the large Nc limit *Hyeondong Son*

인하대학교 60주년기념관 107호 13:30 - 14:00

Instanton effects on electromagnetic transitions of charmonia — *Kihoon Hong*

인하대학교 60주년기념관 107호 — 14:00 - 14:30

The mass-radius relations of neutron stars in an pion mean-field approach — *Nam-Yong Ghim*

인하대학교 60주년기념관 107호 — 14:30 - 15:00

The axial-vector meson in the coupled-channel approach — *Samson Clymton*

인하대학교 60주년기념관 107호 — 15:30 - 16:00

Studies of baryonic states in Belle — *Youngjoon Kwon*

인하대학교 60주년기념관 107호 — 16:00 - 16:40

Double Higgs Production at the LHC — *KC Kong*

인하대학교 60주년기념관 107호 — 16:40 - 17:20

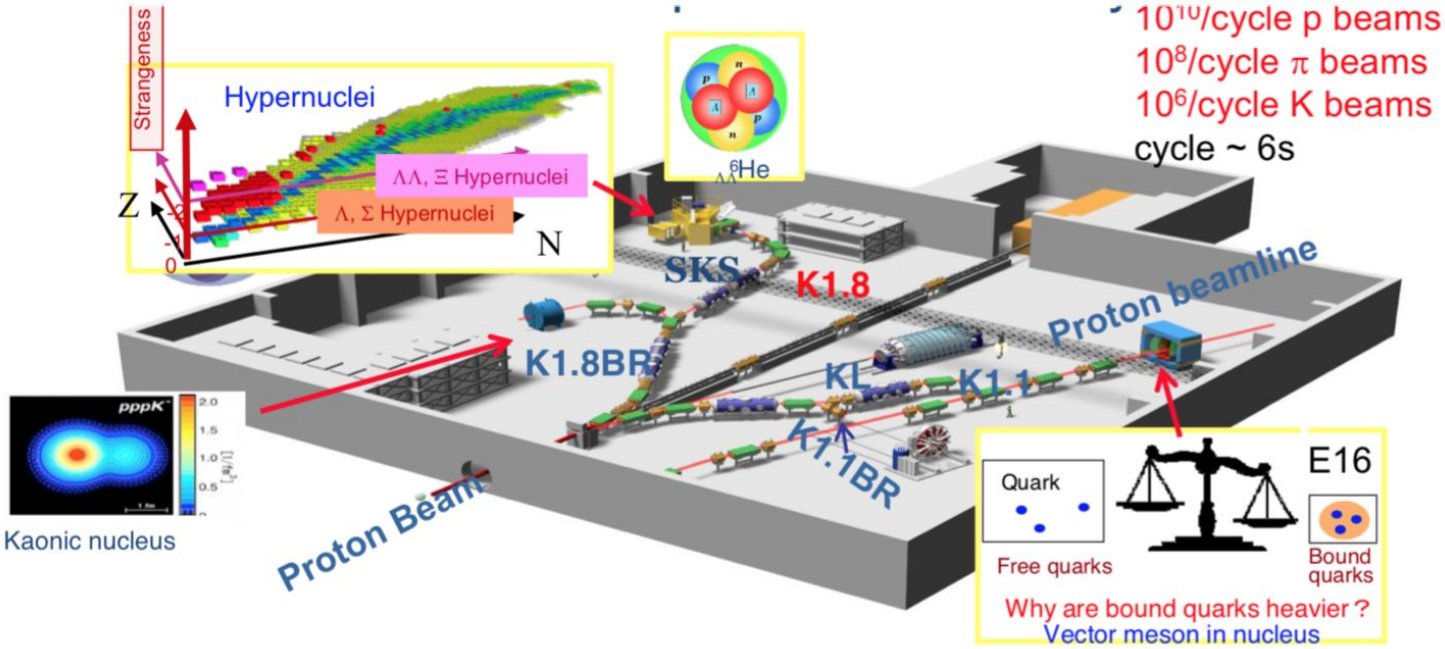

APCTP Workshop on Nuclear Physics 2022
Physics of Excited Hadrons in the Present and Future Facilities
July 11 - 16 / Jeju Suites Hotel / Sponsors: apctp , CHEP@KNU
The APCTP is supported by the Korean Government through the Science and Technology Promotion Fund and Lottery Fund and strives to maximise social value through its various activities.
아시아태평양 이론물리센터는 정부의 과학기술진흥기금 및 복권기금 지원으로 사회적 가치 제고에 힘쓰고 있습니다.

Overview & Topics

The study of electromagnetic transitions opens a window into the very nature of the strong interaction. And, indeed, such a study of how a ground-state nucleon transitions to an excited state, over a broad range of q^2, will provide keen insight into the evolution of how dynamically generated masses emerge from the asymptotically-free, nearly massless quarks of perturbative QCD as well as provide information on the ancillary effects from the meson-baryon cloud. The discussions will include electro- and photo-production measurements (for example, at ELSA, JLab, LEPS, and MAMI), as well as meson-beam data (for example, at GSI, FAIR, and J-PARC), which amply complement the requisite information for baryon spectroscopy. Research topics to be performed in future facilities will also be discussed. Finally, studies of in-medium vector meson spectral function modifications, which are related to the electromagnetic transitions will be addressed as well. A variety of theoretical developments in this field will be discussed in depth. The motivation of this workshop is to share and exchange ideas and research plans for excited hadron among theorists and experimentalists.

J-PARC Hadron Experimental Facility

Hiroyuki Sako Baryon Spectroscopy – search for new N* and Δ* states,

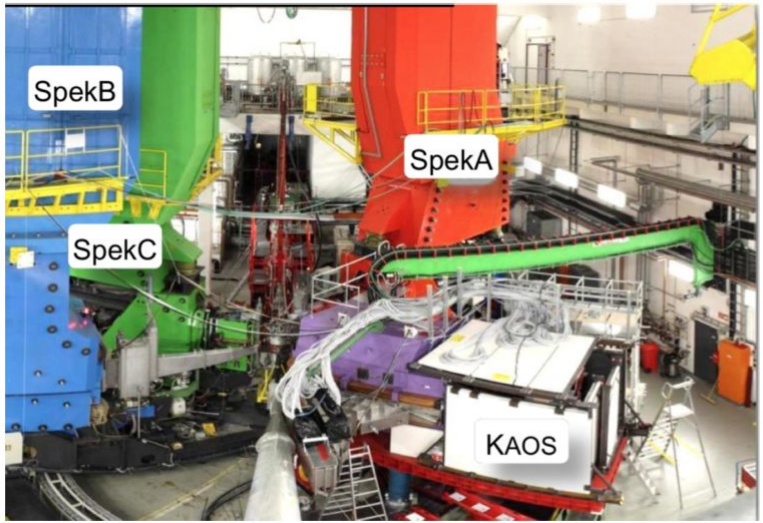


Hiroyuki Noumi Extension plan to study excited baryons with heavy flavor

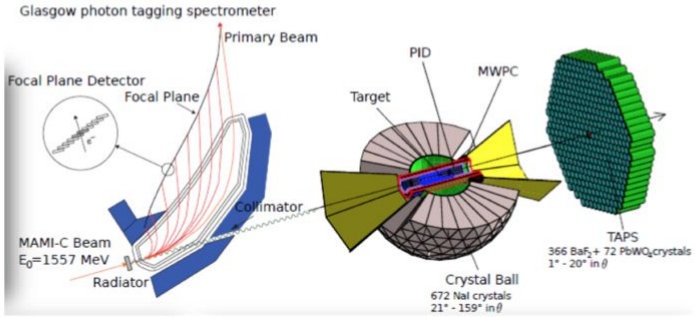
Physics Highlights and Perspectives with Electron Beams at Mainz

P. Achenbach

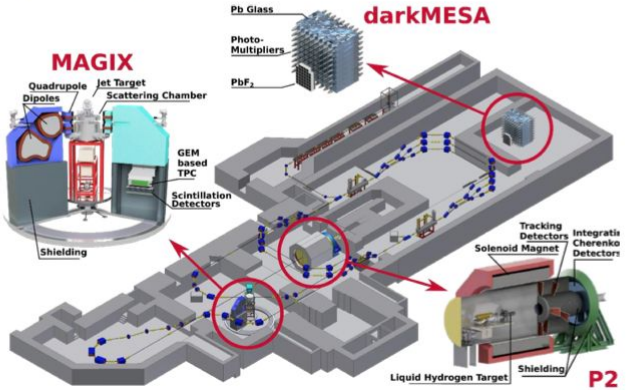
Precision electron scattering with **high resolution** focusing spectrometers. Many exciting high impact results at energy < 1.6 GeV in various stages of microtron



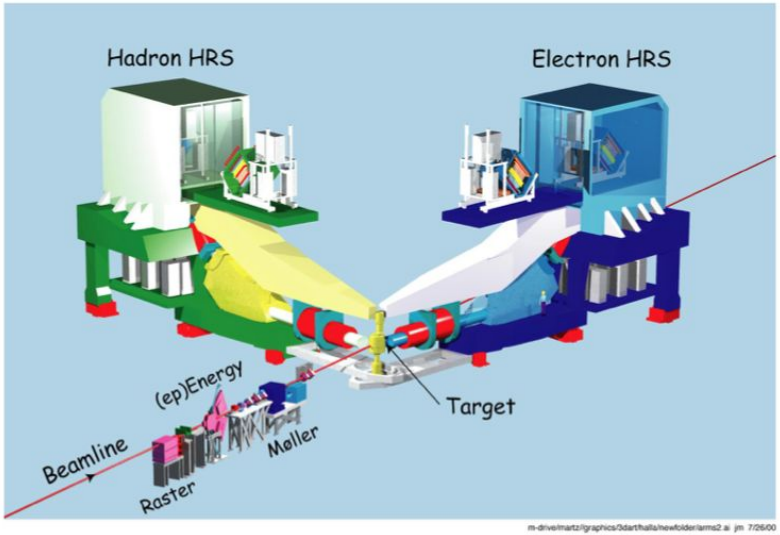
Physics with energy-tagged photon beam and crystal detectors

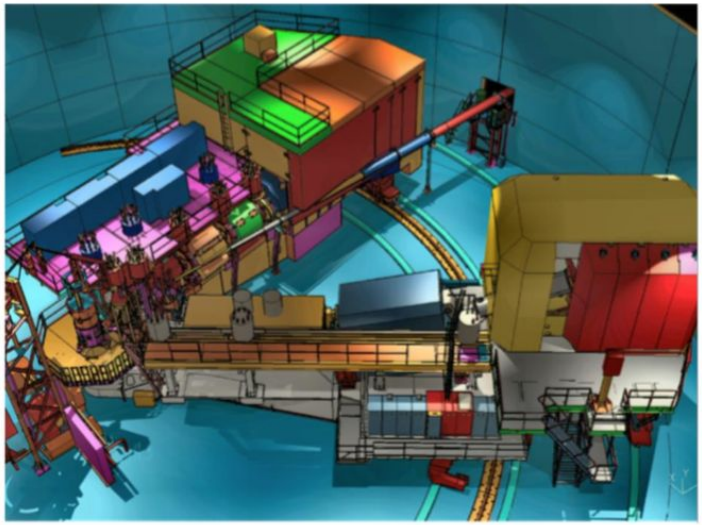


New project: **MESA** – Ultra-high current e-beam 15mA luminosity, energy below pion threshold < 155 MeV



JLab Hall A & C spectrometers + large acceptance



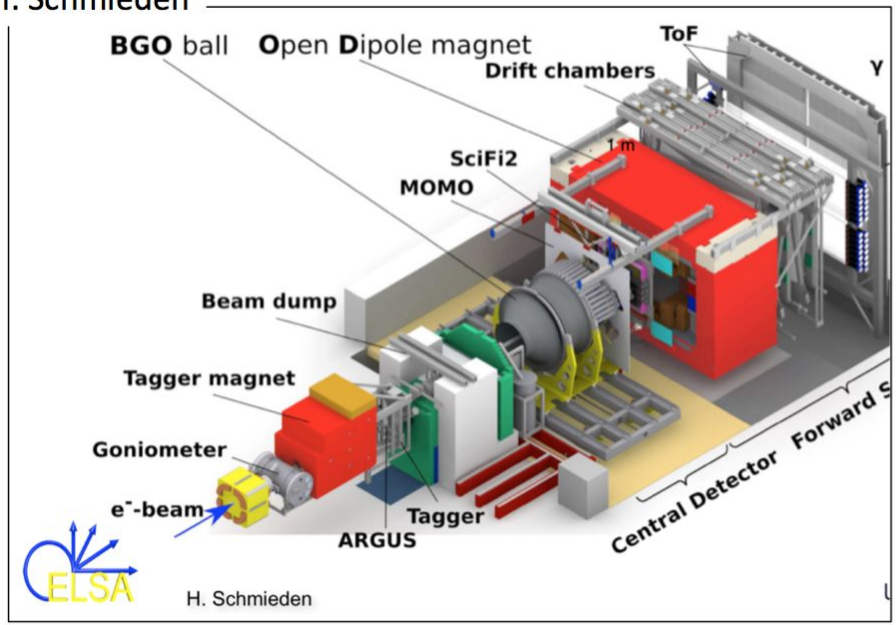


A. Cansomme

- Hall A and C high luminosity halls luminosity ranging from 10^{36} up to 5.10^{38} cm-2s-1
- Few simple measurements using small acceptance spectrometers
- Larger acceptance detectors available such as Super Big Bite
- Large acceptance detector like SoLID striving to keep running at highest luminosity
  - Approved experiments SIDIS and J/Psi
  - Future possible experiment DDVCS
- Focus on deep inelastic but could have dedicated experiment in resonance region

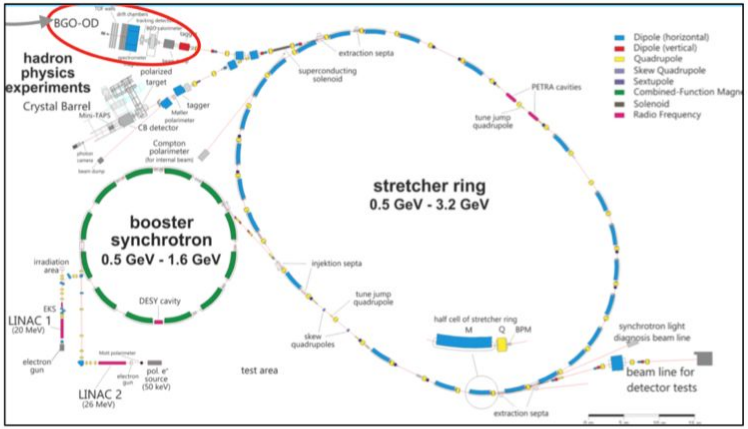
ELSA – BGOOD Experiment

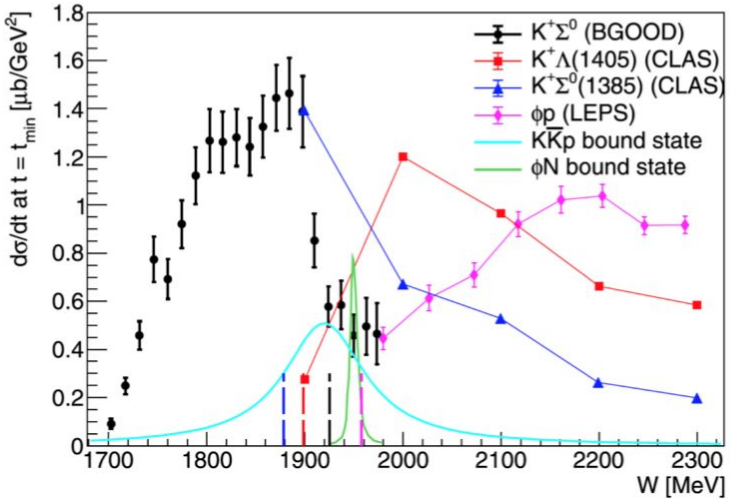
H. Schmieden



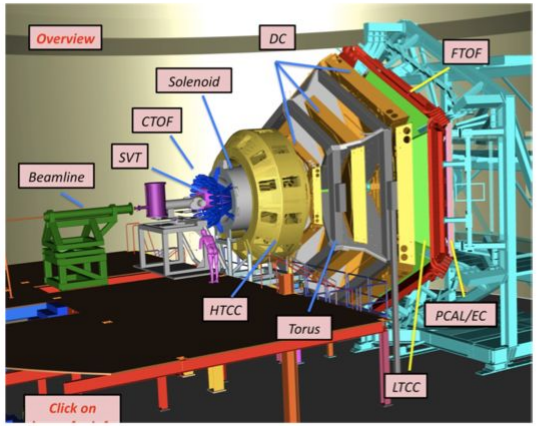
BGOOD tuned for threshold physics in uds sector

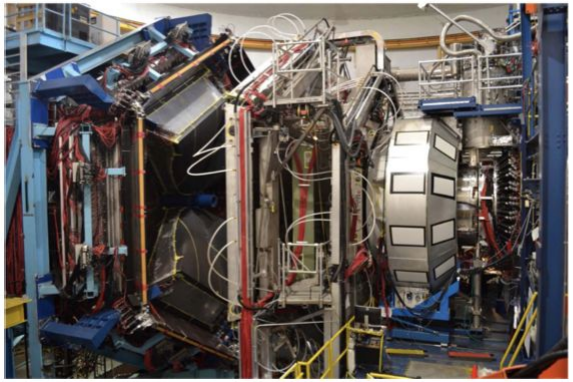
Current focus on missing strange baryons





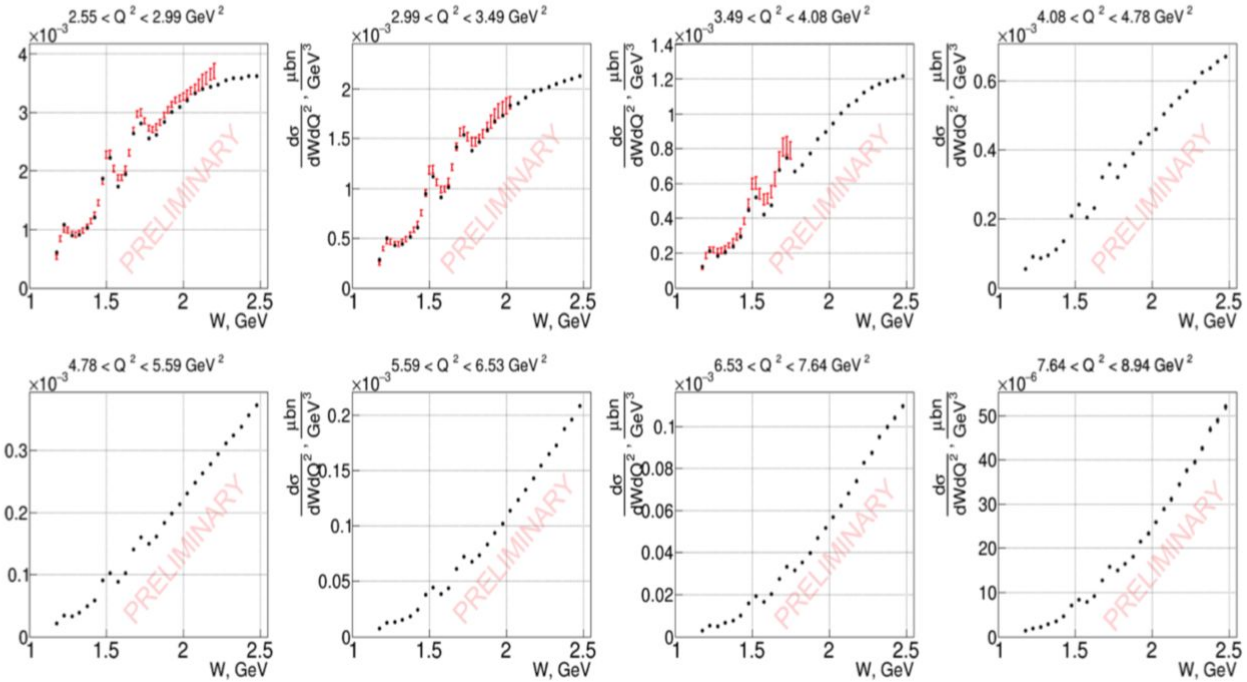
JLab CLAS12 spectrometer





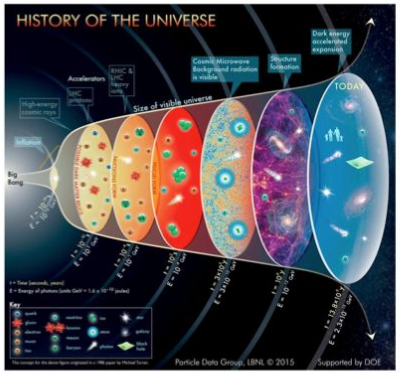
Timothy Hayward, Valerii Klimenko

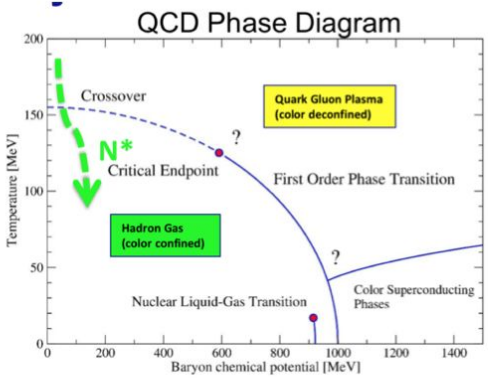
The first absolute inclusive cross section to reconstruction efficiencies.



Experiment – phenomenology- and theory - together

Hiroyuki Sako



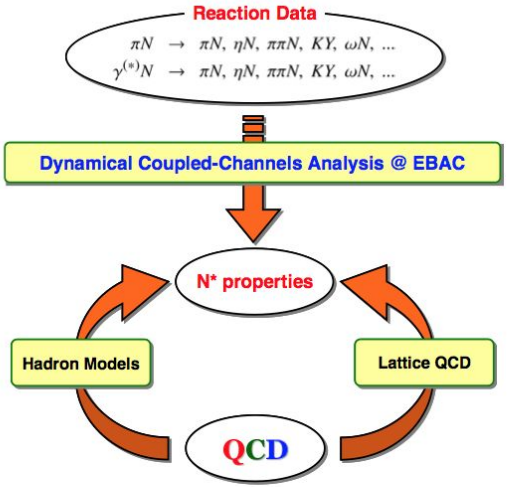


The history of the universe tells us how mass was generated in the transition from quark-gluon plasma of non-interaction quarks and gluons to confinement of hadrons. It involves all excited baryon resonances.

We are trying to reconstruct from todays data what happened in the process that took place 14 x 10^9 years ago at temperatures above 10^{12}K (100 MeV). Experiments at GeV levels are perfectly matched to probing resonances generated in during this transition in “isolation”.

T.S. Harry Lee

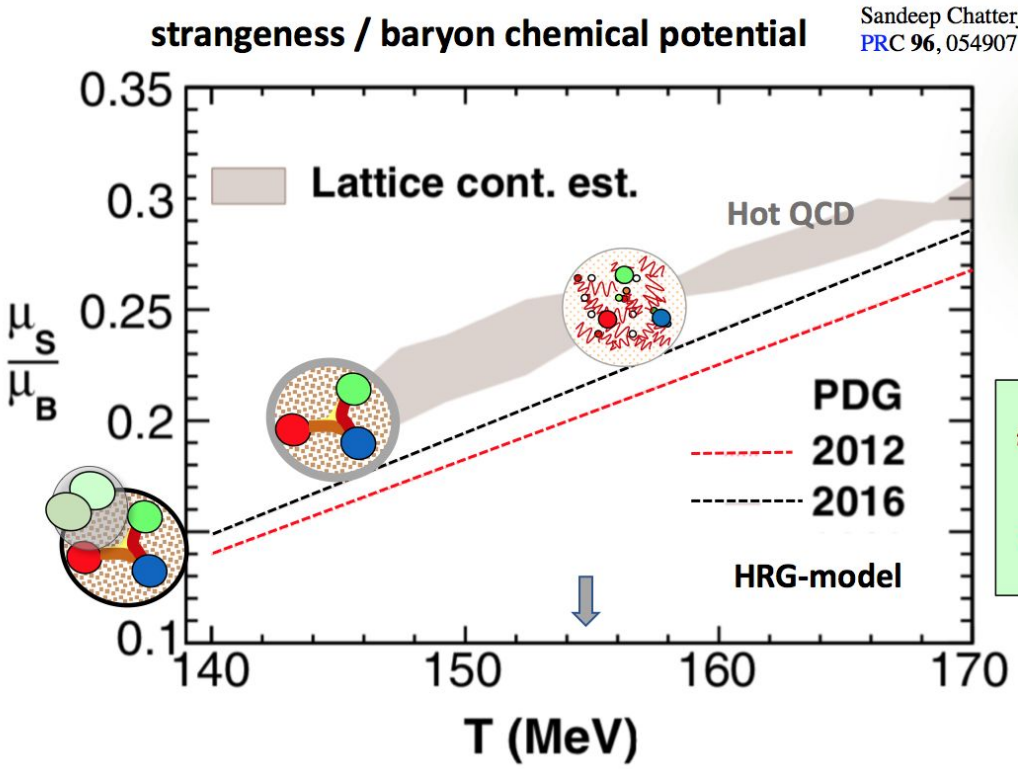
Study of N → N* over a broad range of Q^2 will reveal how the **nucleon mass is dynamically generated from massless quarks of PQCD** and provide information on the effects of the meson-baryon cloud.

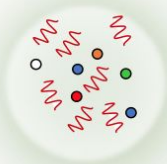


1. Need extensive data of meson production reactions
2. Need theoretical models to extract the N* from the data
3. Need to understand the structure of N*

The ultimate case for the missing excited baryons

Understanding the history of our universe





We do not describe the transition near the cross over temperature without accounting for the full complement of quark model baryon resonances.

PDG 2016 with *, **	
$N(1860)$	$N(1880)$
$N(1895)$	$N(1895)$
$N(2000)$	$N(2040)$
$N(2060)$	$N(2100)$
$N(2120)$	$N(2300)$
$N(2570)$	$N(2700)$
$\Delta(1750)$	$\Delta(1900)$
$\Delta(1940)$	$\Delta(2000)$
$\Delta(2150)$	$\Delta(2200)$
$\Delta(2300)$	$\Delta(2350)$
$\Delta(2390)$	$\Delta(2400)$
$\Delta(2750)$	$\Delta(2950)$
$N(1875)$	

PDG 2018 with ***, ****

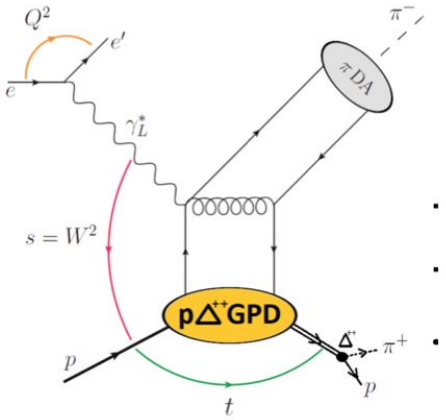
Resonance transition GPD (CFF)

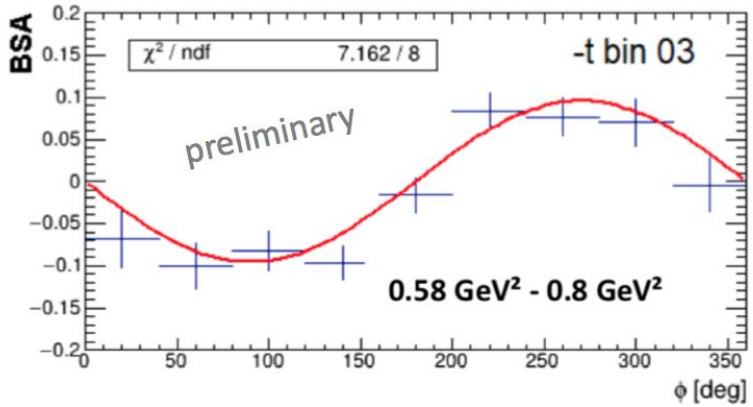
- The GPD program on the proton now well established and gravitational form factor was found to $d^q_1(t)$ make large contribution to the GPD (CFF) $\mathcal{H}(\xi,t)$ determined from DVCS data and confirmed by TCS data.

  $d_1(0)$ = -2.04 +/- 0.35 (DVCS data)

  $d_1(0)$ = -2.16 (χQSM), *H.Y. Won, et al*. (Friday cont. talk)

- Today we saw first preliminary data related to resonance transition GPD in **ep→ e$\Delta^{++}\pi^-$**



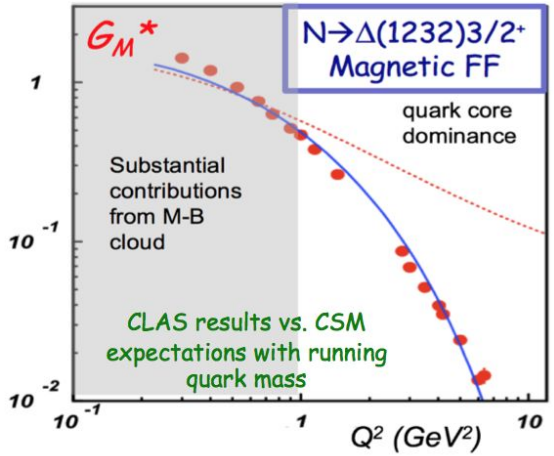


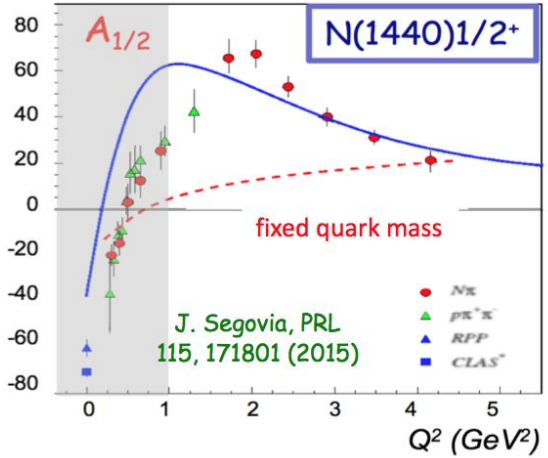
Kyungseon Joo

Electroexcitation of N* key to learn about EHM?

Measurements of transition form factors on N* states need to be extended to higher Q^2 to probe the transition where quarks have lost most of the dressing Q^2 >

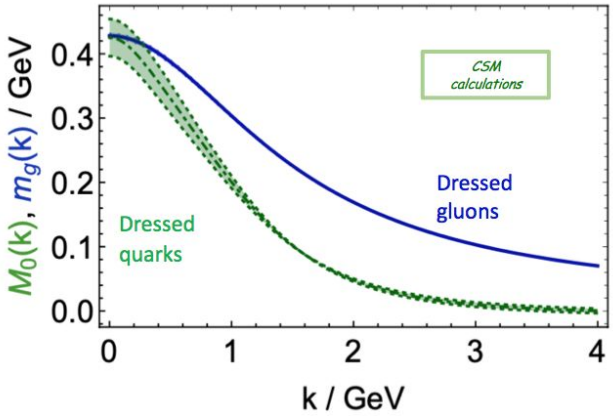
Importance of the pion cloud at small Q, not included in computation.





Victor Mokeev

Continuous QCD calculation



Defining the “complete experiment” problem

Finale: the 'coupled-channels complete experiment'

Consider *channel-space* $\{|\pi N\rangle, |\gamma N\rangle, |\pi\pi N\rangle\}$, i.e.:

$$(\mathcal{T}_{fi}) = \begin{bmatrix} \mathcal{T}_{\pi N,\pi N} & \mathcal{T}_{\pi N,\gamma N} & \mathcal{T}_{\pi N,\pi\pi N} \\ \mathcal{T}_{\gamma N,\pi N} & \mathcal{T}_{\gamma N,\gamma N} \simeq 0 & \mathcal{T}_{\gamma N,\pi\pi N} \\ \mathcal{T}_{\pi\pi N,\pi N} & \mathcal{T}_{\pi\pi N,\gamma N} & \mathcal{T}_{\pi\pi N,\pi\pi N} \end{bmatrix}.$$

↪ Measure individual complete experiments with perfect *phase-space coverage and overlap* among individual reactions (complete exp.'s determinable using *graphs*):

Reaction	Example complete experiment (yields $\lvert b_i\rvert$ & ϕ_{ij})
$\pi N \to \pi N$ $(N_{\mathcal{A}} = 2)$	$\sigma_0, \hat{P}, \hat{R}, \hat{A}$
$\pi N \to \pi\pi N$ $(N_{\mathcal{A}} = 4)$	$\sigma_0, \check{P}_y, \check{P}_z, \check{P}_{x'}, \check{P}_{y'}, \check{O}_{yy'}, \check{O}_{zy'}, \check{O}_{yz'}$
$\gamma N \to \pi N$ $(N_{\mathcal{A}} = 4)$	$\sigma_0, \check{\Sigma}, \check{T}, \check{P}, \check{E}, \check{H}, \check{L}_{x'}, \check{T}_{x'}$
$\gamma N \to \pi\pi N$ $(N_{\mathcal{A}} = 8)$	$\sigma_0, \check{P}_y, \check{P}_{y'}, \check{O}^{\odot}_{yy'}, \check{O}_{yy'}, \check{P}^{\odot}_{y'}, \check{P}^{\odot}_{y}, I^{\odot}, \check{P}_x, \check{P}_z, \check{P}_{x'}, \check{P}^{s}_{x}, \check{P}^{\odot}_{x}, \check{P}^{c}_{z}, \check{P}^{\odot}_{z}, \check{P}^{\odot}_{x'}$

⇒ For these 4 reactions, we have $\mathcal{T}_{fi} = e^{i\phi_{fi}}\tilde{\mathcal{T}}_{fi}$, with $\tilde{\mathcal{T}}_{fi}$ fixed.

↪ Fit at least two (or more) complementary ED models (BnGa, JüBo, ...), which have to have *as good unitarity-constraints as possible*, to this database

⇒ Missing phase-information $e^{i\phi_{fi}}$ fixed and resonance-spectrum (hopefully) unique!

Issues: - Can we assume perfect time-reversal inv., to relate $3 \to 2$ to $2 \to 3$ processes?

- $3 \to 3$-process $\pi\pi N \to \pi\pi N$ unmeasurable. Does this hurt the proposal?

Y. Wunderlich

News from the Quark Model – it is still needed!

Detailed update on **covariant spectator quark model** (CSQM) calculations of the nucleon resonance transition form factors of the lower mass states.

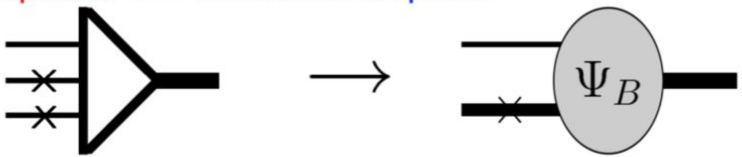
G. Ramalho

Calculations of N^* transition form factors at large Q^2

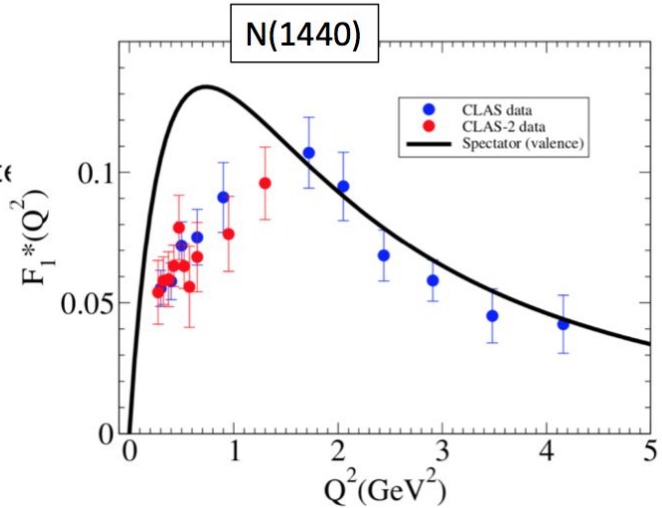
$\Delta(1232)\frac{3}{2}^+$, $N(1440)\frac{1}{2}^+$, $N(1535)\frac{1}{2}^-$, $N(1520)\frac{3}{2}^-$, $\Delta(1600)\frac{3}{2}^+$
$N(1650)\frac{1}{2}^-$, $N(1700)\frac{3}{2}^-$, $\Delta(1620)\frac{1}{2}^-$, $\Delta(1700)\frac{3}{2}^-$ **[SQTM]**

... some results at low-Q^2

Covariant Spectator Theory: wf Ψ_B defined in terms of a 3-quark verte
system with 2 on-shell quarks and an off-shell quark

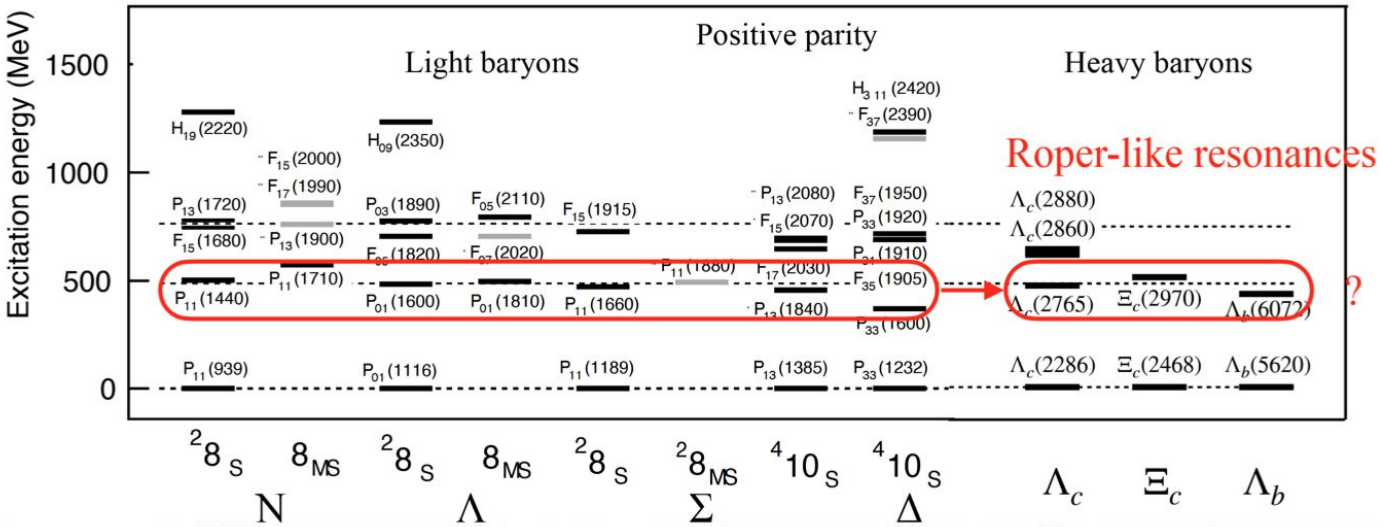


$\Rightarrow$ qq pair replaced by an *effective* diquark with mass m_D



Roper like resonances — why interesting?

Atsushi Hosaka, RCNP, Osaka and ASRC, JAEA



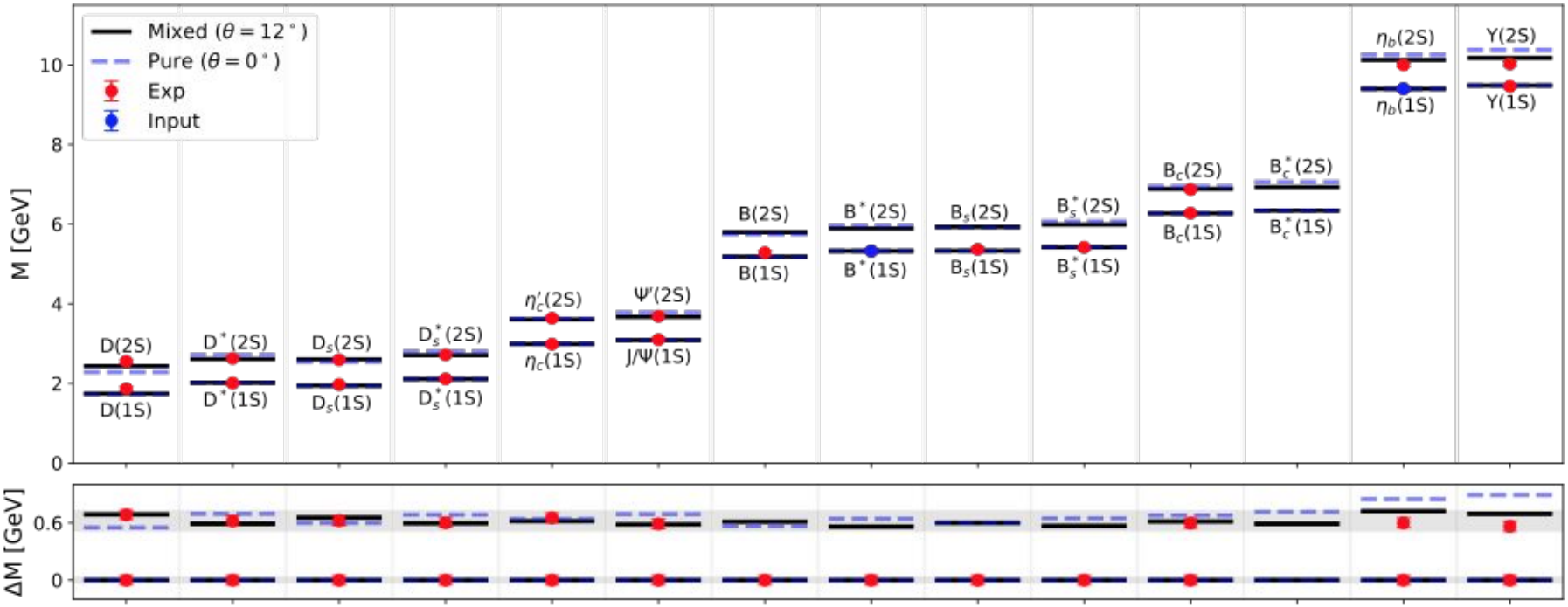
Takayama et al, PTP. 101 (1999) 1271; Arifi et al, PRD 101 (2020) 11, 111502; 103 (2021) 9, 094003

"Hadrons from quarks and chiral symmetry", To appear in Handbook of Nuclear Physics (Springer)

- Mass excesses are ~ 500 MeV independent of flavors
- Decay widths are large as compare to the naive NR predictions
- $A_{1/2}(N^*)$, Q^2 dependence with the sign at the photon point

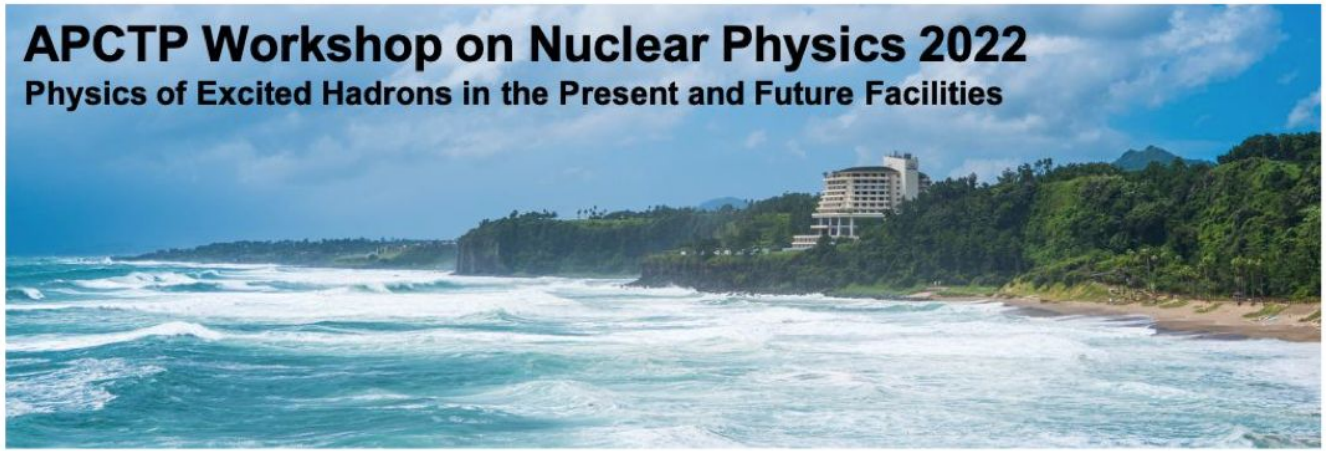
Mixing effects on 1*S* and 2*S* state heavy mesons in the light-front quark model

Ahmad Jafar Arifi,[1,*] Ho-Meoyng Choi,[2,†] Chueng-Ryong Ji,[3,‡] and Yongseok Oh[4,1,§]

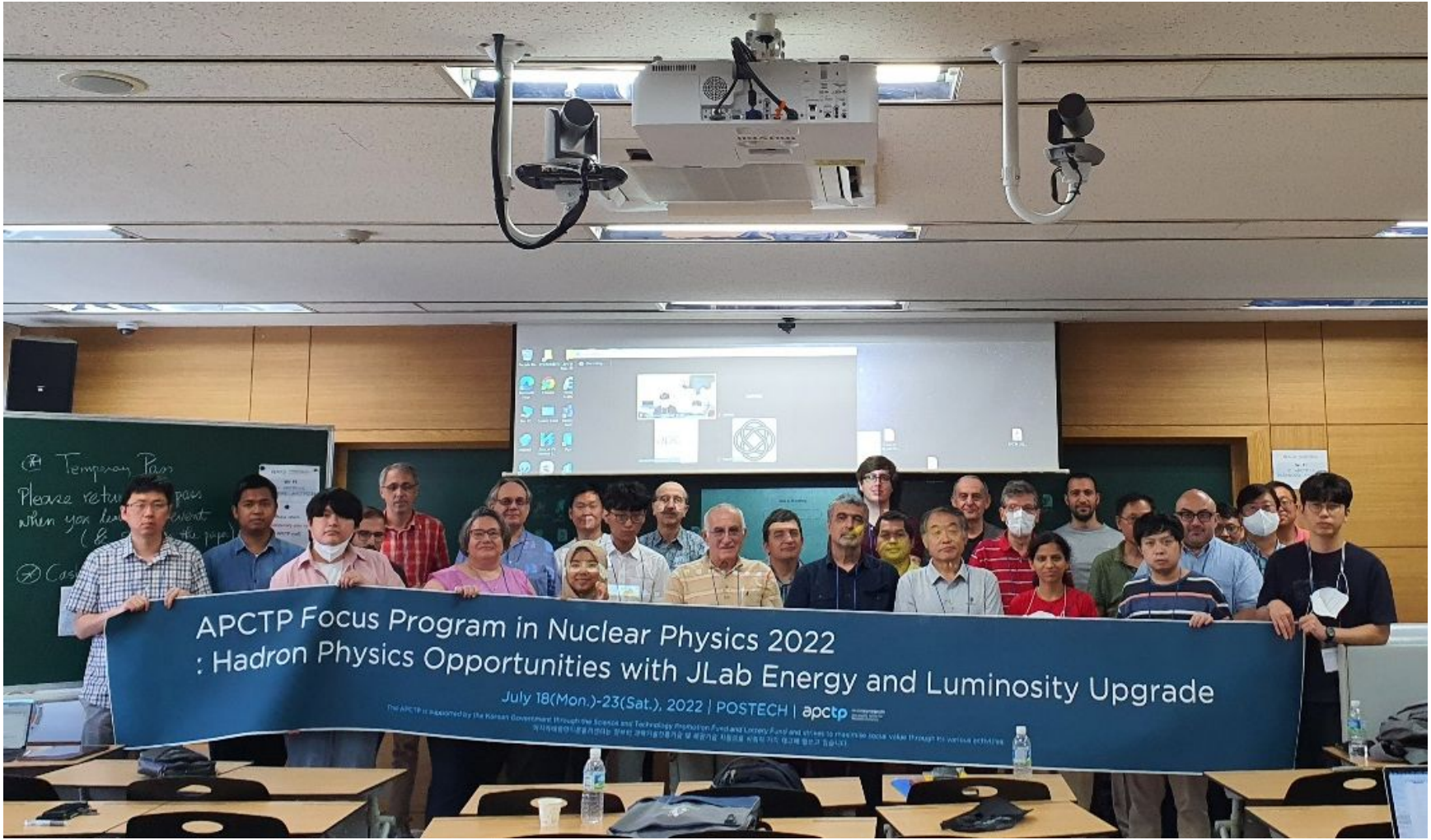


Light-Front Quark Model Analysis of Radially Excited Pseudo-scalar and Vector Mesons

Chueng-Ryong Ji
North Carolina State University



July 15, 2022


APCTP Focus Program in Nuclear Physics 2022
: Hadron Physics Opportunities with JLab Energy and Luminosity Upgrade
July 18(Mon.)-23(Sat.), 2022 | POSTECH | apctp

Opening — *Harut Avagy*

Classroom 512, APCTP — 08:50 - 09:00

Hadron physics with CLAS12 at energies up to 24 GeV. — *Volker Burkert*

Classroom 512, APCTP — 09:00 - 09:30

Applications of the gauge/gravity duality to hadron physics — *Matti Jarvinen*

Classroom 512, APCTP — 09:40 - 10:10

Probing Nuclear Structure at Extreme Conditions — *Misak Sargsian*

Classroom 512, APCTP — 10:40 - 11:10

Photo- and electro-production of ϕ meson on the nucleon and 4He — *Sangho Kim*

Classroom 512, APCTP — 11:20 - 11:40

Overview of transverse momentum dependent parton distributions * — *Feng Yuan*

Classroom 512, APCTP — 09:00 - 09:30

Transverse-Momentum-Dependent Proton Structures from Lattice QCD * — *Yong Zhao*

Classroom 512, APCTP — 09:40 - 10:10

Nucleon spin structure studies at COMPASS: recent results and prospects — *Bakur Parsamyan*

Classroom 512, APCTP — 10:40 - 11:10

The SoLID Science Program at 12 GeV and Beyond — *Zein-Eddine Meziani*

Classroom 512, APCTP — 11:20 - 11:50

JLab Upgrade Opportunities for SIDIS Dihadrons at CLAS * — *Christopher Dilks*

Classroom 512, APCTP — 14:00 - 14:30

Nuclear hadronization studies JLab: present and future — *Hayk Hakobyan*

Classroom 512, APCTP — 14:40 - 15:10

Fixed targets at LHC * — *Pasquale Di Nezza*

Classroom 512, APCTP — 15:20 - 15:50

Fracture functions formalism for hadron production from the target remnant in hard processes — *Aram Kotzinian*

Classroom 512, APCTP — 09:00 - 09:30

Accessing Target Fragmentation: Prospects and Results from CLAS — *Timothy Hayward*

Classroom 512, APCTP — 09:40 - 10:10

Confinement, Color Vortices and Nonperturbative Structures in QCD — *Dennis Sivers*

Classroom 512, APCTP — 10:40 - 11:10

Matching of fracture functions for SIDIS in target fragmentation region * — *Xuanbo Tong*

Classroom 512, APCTP — 11:20 - 11:50

Theoretical simulation of the virtual meson production in the forward direction — *Chueng-Ryong Ji*

Classroom 512, APCTP — 09:00 - 09:30

Radiative effects in polarized SiDIS — *Alexander Ilyichev*

Classroom 512, APCTP — 09:40 - 10:10

Light quark distribution functions in the heavy baryon within a chiral quark-soliton approach — *Hyeon-Dong Son*

Classroom 512, APCTP — 10:40 - 11:00

Analysis of the virtual meson production in a (1+1)-dimensional scalar field model — *Yongwoo Choi*

Classroom 512, APCTP — 11:10 - 11:30

Generalized parton distributions for the Goldstone boson — *Parada Tobel Paraduan Hutauruk*

Classroom 512, APCTP — 11:40 - 12:00

Polarized vector meson production in semi-inclusive DIS * — *Kai-bao Chen*

Classroom 512, APCTP — 14:00 - 14:30

Vector meson production in polarized string fragmentation in Pythia * — *Albi Kerbizi*

Classroom 512, APCTP — 14:40 - 15:10

Extractions of TMD distributions from the SIDIS data * — *Alexey Vladimirov*

Classroom 512, APCTP — 15:40 - 16:10

Hard exclusive reactions with baryon number transfer: status and perspectives. — *Kirill Semenov-Tyan-Shanskiy*

Classroom 512, APCTP — 09:00 - 09:30

Studies of exclusive processes at JLab Hall-A/C — *Julie Roche*

Classroom 512, APCTP — 09:40 - 10:10

What can we learn on GPDs from Lattice QCD * — *Martha Constantinou*

Classroom 512, APCTP — 10:40 - 11:10

Deeply Virtual Meson Electroproduction at Jefferson Lab with CLAS12 — *Andrey Kim*

Classroom 512, APCTP — 11:20 - 11:50

Recent GPD developments obtained with PARTONS framework * *Paweł Sznajder*

Classroom 512, APCTP 14:00 - 14:30

Deeply Virtual Compton Scattering with CLAS12 at Jefferson Lab *Adam Hobart*

Classroom 512, APCTP 14:40 - 15:10

3D Structure of the Nucleon: from JLab12 to JLab24 *Harut Avagyan*

Classroom 512, APCTP 15:40 - 16:10

Insight into Emergence of Hadron Mass in the Exploration of N* Structure at JLab after Energy and Luminosity Increase
Victor Mokeev

Exclusive Processes and GPDs *Kyungseon Joo*

Classroom 512, APCTP 09:40 - 10:10

Concluding Remarks *Kyungseon Joo*

Classroom 512, APCTP 10:20 - 10:30

Theoretical Simulation of the Virtual Meson Production in the Forward Direction

Chueng-Ryong Ji
North Carolina State University

July 21, 2022

Conclusion and Outlook

- Unless small $|t|/Q^2$, "Cat's ears" contribution should not be neglected.
- Sum rule correspondence between DGLAP/ERBL GPDs and Valence/Nonvalence contributions to the form factor works only for a certain current component.
- Form factor decomposition depends on the current component although the form factor itself is independent of the choice of the current component.(Democracy in current components)
- 3+1 D extension with BSA investigation is underway.
- Application to the energy-momentum tensor decomposition appears feasible.

Mass generation in QCD_{1+1} Theory

Chueng-Ryong Ji
North Carolina State University

July 25, 2022, KNUT, Chungju

Heat conduction in General Relativity

Korea National University of Transportation, Hyeong-Chan Kim

``Heat conduction in general relativity", arXiv:2206.09555, (HK, Youngone Lee)

``Local temperature in general relativity", arXiv2110.00209, PRD 2022, (HK, Youngone Lee)

Matter equation of state in general relativity

Hyeong-Chan Kim and Chueng-Ryong Ji
Phys. Rev. D **95**, 084045 – Published 24 April 2017

What did I learn from these meetings?

- Degrees of freedom matter in physics of excited hadrons: nucleus, nucleon, quarks and gluons…
  Lagrangian vs. Hamiltonian and IFD vs. LFD
  Energy scales for NJL, CQS, LFQM and PQCD
- Roper resonance and radial excitations:
  QCD confining potential provides 500~600 MeV difference
- Three-body extension of LFQM is necessary
- Timelike region vs. dynamical mass generation
- SIDIS (TMDs, GPDs, TDAs) focused 20+ GeV Upgrade
- Experiments, Lattice, PARTON vs. Theoretical Simulation
- Data analyses and Impact studies called more extensively

What do we need to work on?

- Timelike region study with transition form factor
- Three-body extension and higher Fock-states in LFQM
- 3+1D electroproduction of mesons
- Theoretical simulations of GPDs vs. TDAs
- Impact studies for JLab 20+ GeV upgrade and EIC
- Scaled interpolating variables and covariance
- Isometry of SO(4,2) and conformal symmetry
- Energy-Momentum Tensor in LFD
- Physical observable universality and decomposition issue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