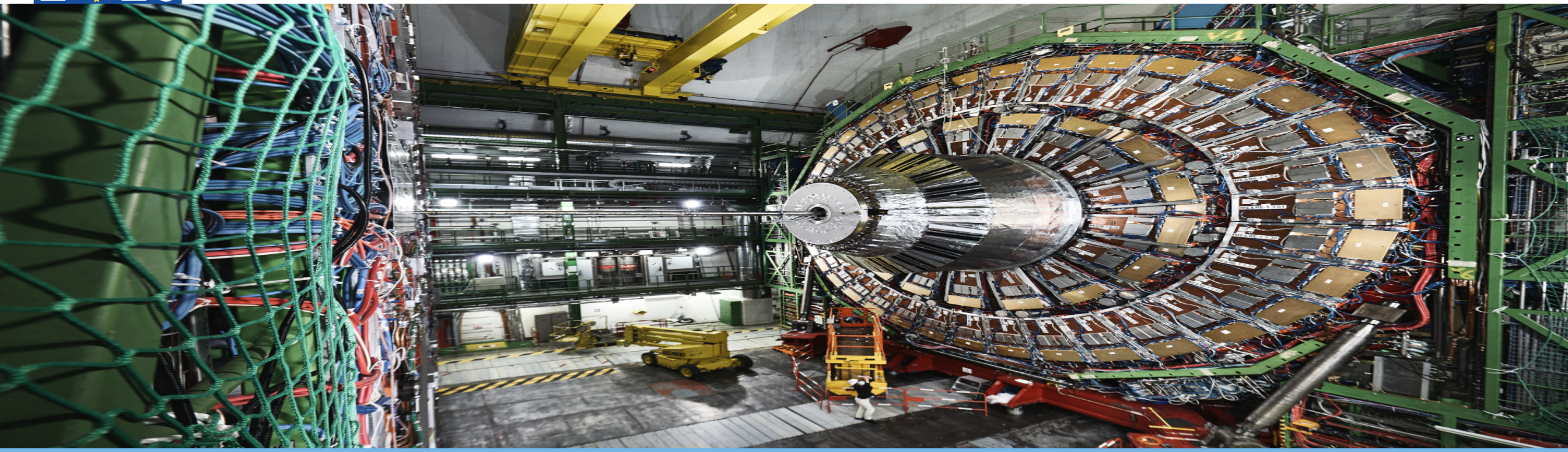


WP25-JR7
Light-and heavy-quark hadron spectroscopy (HaSP)

M.Battaglieri (Jlab/INFN) & J.Nieves (IFIC, UV & CSIC)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 824093

Light and heavy-quark hadron spectroscopy (HaSP)

Study the spectrum of the hadrons

- New generation of experiments are running or are in preparation at CERN, Mainz, Bonn GSI, JLab, BESIII and Belle
- Precise and abundant data requires an adequate analysis
- Collaborative effort between experimental and theory: observables need to be interpreted using robust methods that rely only on the basic theoretical principles, and compared to the best solutions provided by the fundamental theory of the strong interaction via LQCD or systematic effective field theory expansions

HaSP aims to coordinate the leading European institutions active in hadron spectroscopy to make progress in

- Developing a theoretical, phenomenological and computational foundations for amplitudes
- establishment of best practices for accessing systematic uncertainties in analysis of hadron reaction data and interpretation of physics results

Light and heavy-quark hadron spectroscopy (HaSp)

Task 1: Precision calculations in non-perturbative QCD (I)

- QCD Effective Field Theories: description of low energy hadronic phenomenology and properties of excited states **(C.Hanhart - FZJ)**
- Heavy hadrons Decay: Dalitz-plot, EFT, exotic resonances nature, isospin or CP violations **(D.Rodriguez-Entem - USAL)**

Task 2: Precision calculations in non-perturbative QCD (II)

- EFTs control extrapolations to physical kinematics covering regions not yet reachable in the lattice **(A.Parreño – UB – A.Lovato - ANL)**
- Precision spectroscopy of exotic and excited states in quarkonia using EFT combined with significant advancements in LQCD **(A.Vairo - TUM)**
- Heavy quarkonia in heavy-ion experiments and their suppressed production **(A.Vairo - TUM)**

Task 3: Meson Spectroscopy analysis of new and exotic states

- Search for and study of light exotic mesons, charmonium and strangeonium **(V.Mathieu -UB)**
- Spectroscopy of low-lying scalars, strange mesons and strangeonia **(S.Schadmand - FZJ)**

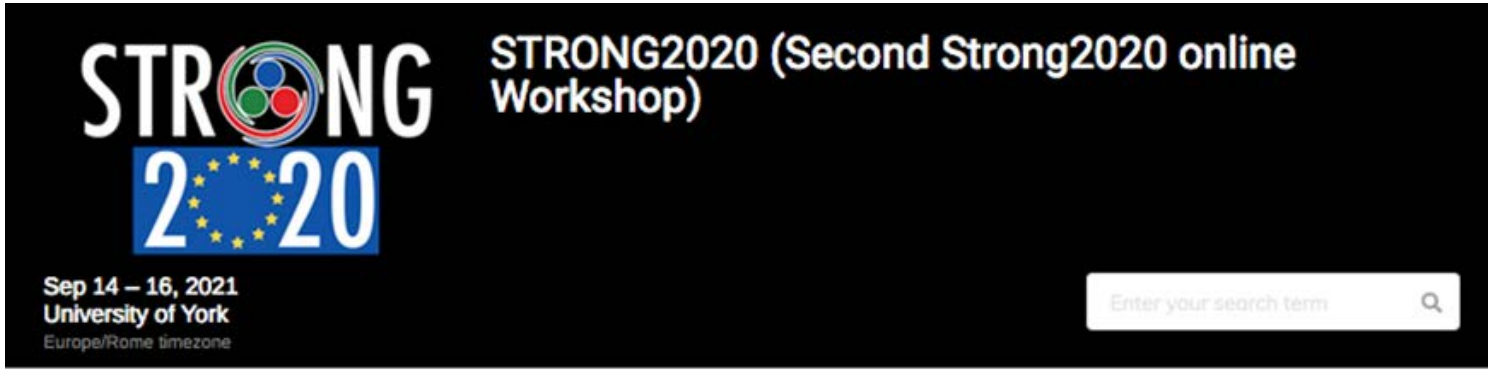
Task 4: Baryon and multi-baryon spectroscopy

- Resonance parameter determination **(M.Ostrick – Mainz)**
- Diffractive and annihilation production and exotic baryon **(A.D'Angelo – URM-TV)**
- Dibaryon structure and parameter determination **(D. Watts – U. York)**

Light and heavy-quark hadron spectroscopy (HaSp)

TASKS/Subtasks	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1. Precision calculations in non-perturbative QCD (I)																
1.1 Development and application of EFTs			**M1**							**M3**			**M4**			
1.2 Hadron decays			**M1**							**M3**			**M4**			
2. Precision calculations in non-perturbative QCD (II)																
2.1 Study of hadron resonances, form factors, LECs, etc			**M1**							**M3**			**M4**			
2.2 Computation of heavy-quark, hybrid and tetraquark potentials			**M1**							**M3**			**M4**			
2.3 Computation of m.e. for in medium quarkonium evolution			**M1**							**M3**			**M4**			
3. Meson Spectroscopy analysis of new and exotic states																
3.1 Search for and study of light exotic mesons, charmonium and strangeonium						**M2**				**M3**			**M4**			
3.2 Spectroscopy of low-lying scalars, strange mesons and strangeonia						**M2**				**M3**			**M4**			
4. Baryon and multi-baryon Spectroscopy																
4.1 Resonance parameter determination						**M2**				**M3**			**M4**			
4.2 Diffractive and annihilation production and exotic baryons						**M2**				**M3**			**M4**			
4.3 Dibaryon structure and parameter determination						**M2**				**M3**			**M4**			

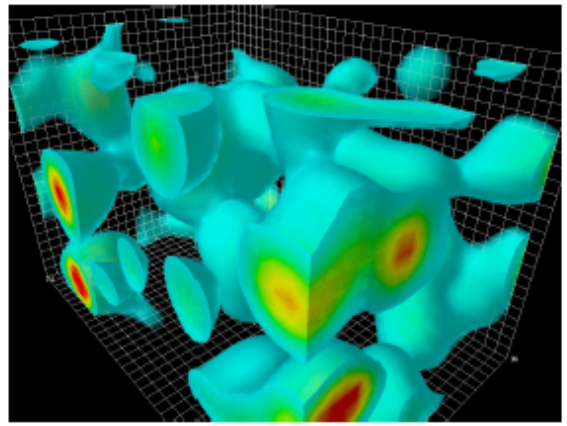
Progress: more details and references in
https://agenda.infn.it/event/27658/timetable/#20210914



This workshop is included in the activities of the working package WP25 (Light-and heavy-quark hadron spectroscopy) of the project STRONG-2020. It has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 824093.

QCD allows much richer hadron spectrum than **conventional** $q\bar{q}$ mesons and qqq baryons.

Exotic hadrons	
glueballs	GG, GGG
multiquark states	$q\,q\,\bar{q}\,\bar{q}$, $q\,q\,q\,q\,\bar{q}$
hybrids	$q\,\bar{q}$ G, $\boldsymbol{q\,q\,q}$ **G**, $q\,q\,\bar{q}\,\bar{q}$ G
molecular hadrons	$[D\bar{D}^*]$, $[\bar{D}^*\,\Sigma_c]$



Derek B. Leinweber – University of Adelaide

Annalisa D'Angelo (2nd STRONG2020 Workshop, U. York)

Discovery Exotic Mesons

Vincent Mathieu (2nd STRONG2020 Workshop, U. York)

Design and build detectors
Collect data
Build observables
Fit data
Extract pole position,
…

Experiments Tools

Interpretation

Lattice QCD,
Constituent Models,
Effective Field Theories,
…

Theory

QCD allows much richer hadron spectrum than **conventional** $q\bar{q}$ mesons and qqq baryons.

Exotic hadrons	
glueballs	GG, GGG
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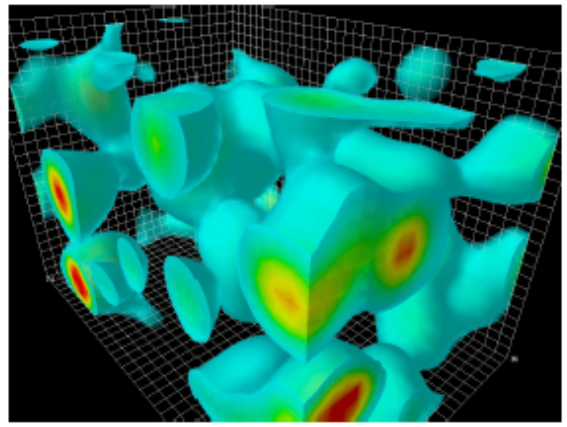
hybrids	$q\,\bar{q}$ G, **$q\,q\,q$ G**, $q\,q\,\bar{q}\,\bar{q}$ G
molecular hadrons	$[D\bar{D}^*]$, $[\bar{D}^*\,\Sigma_c]$

and temperature & density QCD phase-diagram



Derek B. Leinweber – University of Adelaide

Annalisa D'Angelo (2nd STRONG2020 Workshop, U. York)

Discovery Exotic Mesons and/or Baryons

Vincent Mathieu (2nd STRONG2020 Workshop, U. York)

Design and build detectors
Collect data
Build observables
Fit data
Extract pole position,
…

Experiments Tools

Interpretation

Lattice QCD,
Constituent Models,
Effective Field Theories,
…

Theory

dispersive & analyticity techniques…

Progress in Tasks 1.1 and 1.2: development and application of EFTs and Hadron Decays

ChPT, HQET or Quarkonium Non Relativistic EFTs & unitarization methods and dispersive techniques, we have made significant progress in *establishing a robust framework for studying QCD in the non-perturbative regime*. Looking for interacting hadron pairs that might produce **resonances**

- ❑ spectrum and phenomenology of (exotic) hadrons: $Z_{b,c}^{(*)}, \Lambda_c^*, \Xi_{c,b}^*, \Xi_{cc}^{(*)}$, pentaquarks,tetraquars (T_{cc}^+, J/ψJ/ψ) …
- ❑ scalar πK FF beyond the elastic region
- ❑ Weinberg's compositeness rule
- ❑ phenomenology of (exotic) hadrons in hot environments: $D, D^*, D_s, D_0^*, ..$

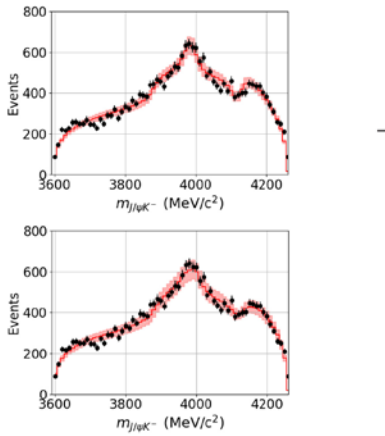


Fig. 3. Theoretical description (solid) of the experimental $J/\psi K^-$ invariant mass spectrum (black dots) measured by LHCb [21]. Same legend as in Fig. 2.

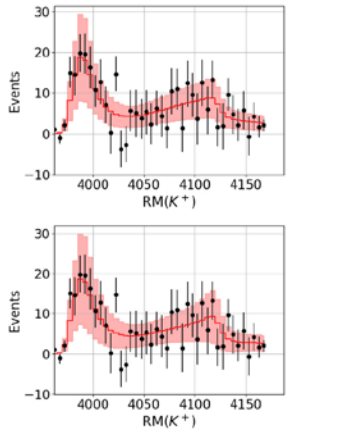


Fig. 2. Theoretical description (solid lines) of the experimental K^+ recoil-mass spectra (black dots) measured by BESIII [6]. The red shadowed-area around the line represents the 68% CL of the fit. The upper panel shows the calculation for *model a* and the lower panel for *model b*. We remark here that the fit only affects the production part from the e^+e^- vertex, with no fine-tuning of the CQM parameters in the description of the coupled-channels S-matrix.

The strange partners of Z_c states

PHYSICAL REVIEW D **103,** 074029 (2021)

Strange molecular partners of the $Z_c(3900)$ and $Z_c(4020)$

Zhi Yang,[1,*] Xu Cao,[2,3,†] Feng-Kun Guo,[4,3,‡] Juan Nieves,[5,§] and Manuel Pavon Valderrama[6,¶]

- *EFT framework using SU(3) flavor symmetry*
- *The mass does not necessarily coincide with BW*
- *Z_{cs} could be a virtual state or a resonance*
- *Z_{cs} is probably the SU(3) flavor partner of $Z_c(3900)$*
- *Z_{cs}^* should exist as its spin partner*

Physics Letters B 818 (2021) 136382

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ELSEVIER

The strange partner of the Z_c structures in a coupled-channels model

Pablo G. Ortega[a,*], David R. Entem[b], Francisco Fernández[b]

- *Similar conclusions in a Chiral Quark Model*

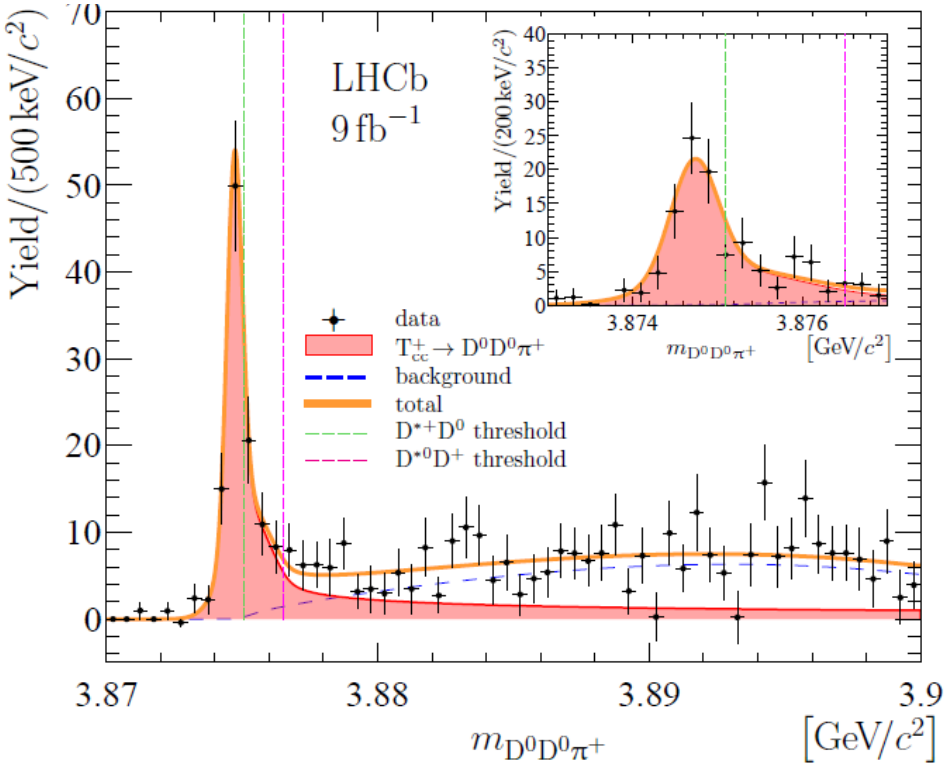
other works: 2110.00398 (Bochum & Jülich), PLB 814, 136120 (IFIC) …

Progress in Tasks 1.1 and 1.2: development and application of EFTs and Hadron Decays

Doubly charmed tetraquark T_{cc}^{+}

$\delta m_{\rm BW} = -273 \pm 61 \pm 5^{+11}_{-14}$ keV,
$\Gamma_{\rm BW} = 410 \pm 165 \pm 43^{+18}_{-38}$ keV,

relative $D^{*+}D^{0}$ threshold



Narrow near-threshold structures are observed in the D^0D^0 and D^+D^0 mass spectra, that supports the conjecture that the T_{cc}^+ decays through a formation of the D^* meson at the intermediate stage of the reaction with its subsequent decays to the $D\pi$ and $D\gamma$ final states,

$$T_{cc}^+ \to D^0D^{*+} \to D^0D^0\pi^+ / D^0D^+\pi^0,$$
$$T_{cc}^+ \to D^+D^{*0} \to D^+D^0\pi^0 / D^+D^0\gamma.$$

To produce a visible near-threshold signal in the line shape, the D^*D pair in the T_{cc}^+ has to be in S-wave. This hints at the quantum numbers of the T_{cc}^+ to be $J^P = 1^+$.

- molecular interpretation: A. Feijoo, W. H. Liang, and E. Oset, arXiv:2108.02730; M.-J. Yan and M. P. Valderrama, arXiv:2108.04785, M. Albaladejo, arXiv:2110.02944,..., IFIC + Bochum + Moscow + Beijing+ Guangzhou+ Jülich, arXiv: 2110.13765 (full consistent treatment including OPE and three body effects)
- Isoscalar bound state in the DD^* system using quark cluster model: T. F. Carames, A. Valcarce, and J. Vijande, PLB699 **(2011)** 291, or with potential modelled by meson exchanges X.-K. Dong, F.-K. Guo, and B.-S. Zou, Commun. Theor. Phys. 73 (2021) 125201…
- compact double-charm tetraquarks: J. P. Ader, J. M. Richard, and P. Taxil, PRD25 (1982) 2370 (1982),..., M. Karliner and S. Nussinov, JHEP 07 (2013)153 ….

Progress in Task 2.1 : Resonances, FFs, LECs, fundamental parameters of QCD, light nuclei spectroscopy

DETERMINATION OF THE STRONG COUPLING CONSTANT α_S

1. **LQCD, EFTs and data** (TUM, PRD100 114511, PRD102 074503…)

- From static energy of a $q\bar{q}$ pair (2+1), $\alpha_s(M_Z) = 0.11660^{+0.00110}_{-0.00056}$
- Singlet free energy at finite temperature, $\alpha_s(M_Z) = 0.11638^{+0.00095}_{-0.00087}$

2. **Sum-rules** $\alpha_s(M_Z) = 0.1170 \pm 0.0014$ (USAL, JHEP 03 (2020) 094)

MESON INTERACTIONS, FSI AND DISPERSIVE METHODS

Dispersive study of π K and $\pi\,\pi \rightarrow K\bar{K}$ scattering: threshold parameters and κ/K*(700) resonance determination (UCM, *2010.11222 , to appear in Phys.Rept.)*

MATCHING LQCD TO EFT IN THE BARYON SECTOR

- Study of baryon-baryon strong interactions in the strangeness 0 → -4 sectors
- Axial charge of the triton
- Calculation of nuclear effects in the parton distribution functions
- Variational method to extract the energy spectrum for NN systems

NPLQCD (UB): PRD103 054508, PRD103 074511, PRL126 202001

NUCLEAR STRUCTURE WITH CHIRAL FORCES

- Study of neutron matter with chiral-EFT potentials: benchmark calculations of the energy per particle of pure neutron matter as a function of the baryon density
- Nuclear energy density functional from ab initio calculations
- Nuclei with up to A=6 nucleons with artificial neural network wave functions (**quantum computing and machine-learning techniques)**
- Ab initio calculation of medium-mass and heavy nuclei based on chiral EFT NN+3N forces

INFN, ARGONNE, FERMILAB, JLAB,UB,DARMSTADT: PRC101 045801, PRC104 024315, arXiv:2108.06836, arXiv:2108.11805

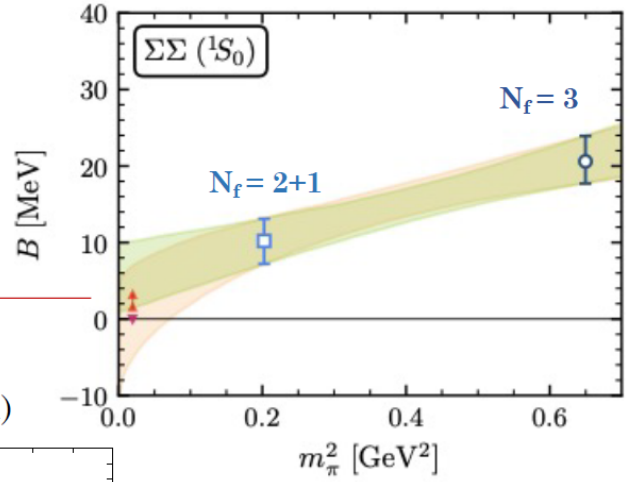
INCLUSIVE, EXCLUSIVE NEUTRINO-NUCLEUS CROSS SECTIONS AND THE RECONSTRUCTION OF THE INTERACTION KINEMATICS [IFIC, JHEP (2021) 004]

PROPERTIES OF *X(3872)* IN NUCLEAR MATTER [IFIC & ICE-Barcelona, PRC104 035203]

NEW PHYSICS: TEST OF LEPTON FLAVOR UNIVERSALITY IN $b \rightarrow c\ell\bar{\nu}_\ell$ DECAYS [USAL & IFIC, JHEP 10 (2021) 122, JHEP 06 (2021) 118]

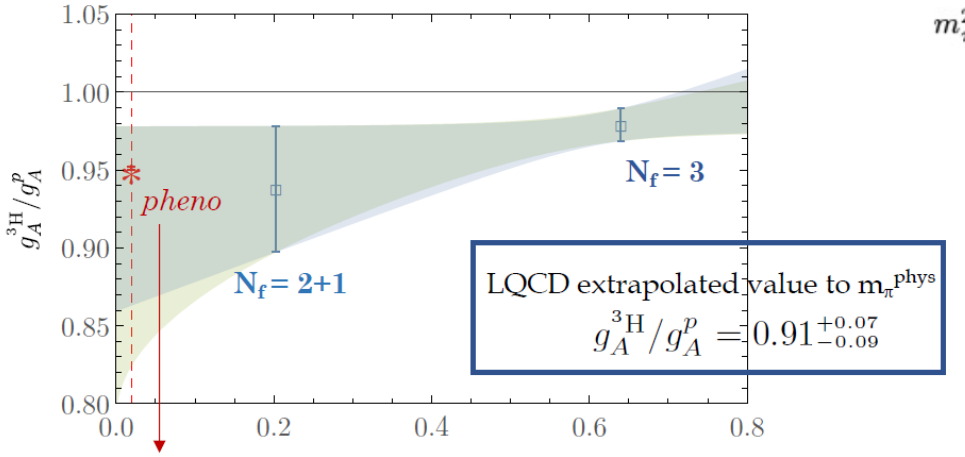
Recent work

Baryon-Baryon interactions, strangeness from 0 to -4
Phys. Rev. D 103, 054508 (2021) @ m_π ~450 MeV



NSC97, χEFT @ NLO

^{3}H axial charge
Phys. Rev. D 103, 074511 (2021)



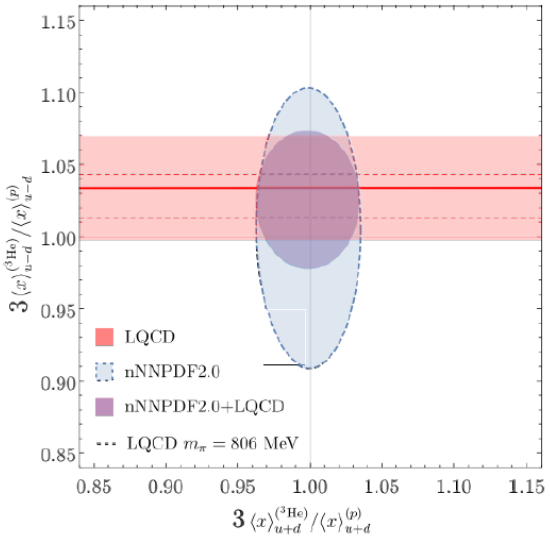
LQCD extrapolated value to m_π^{phys}
$g_A^{^3\mathrm{H}}/g_A^p = 0.91^{+0.07}_{-0.09}$

Baroni et al,
PRC 94, 024003 (2016); PRC95 059902 (2017)

$g_A^{^3\mathrm{H}}/g_A^p = 0.9511(13)$

Nuclear matrix elements
from LQCD
Phys. Rept. **900**, 1 (2020)

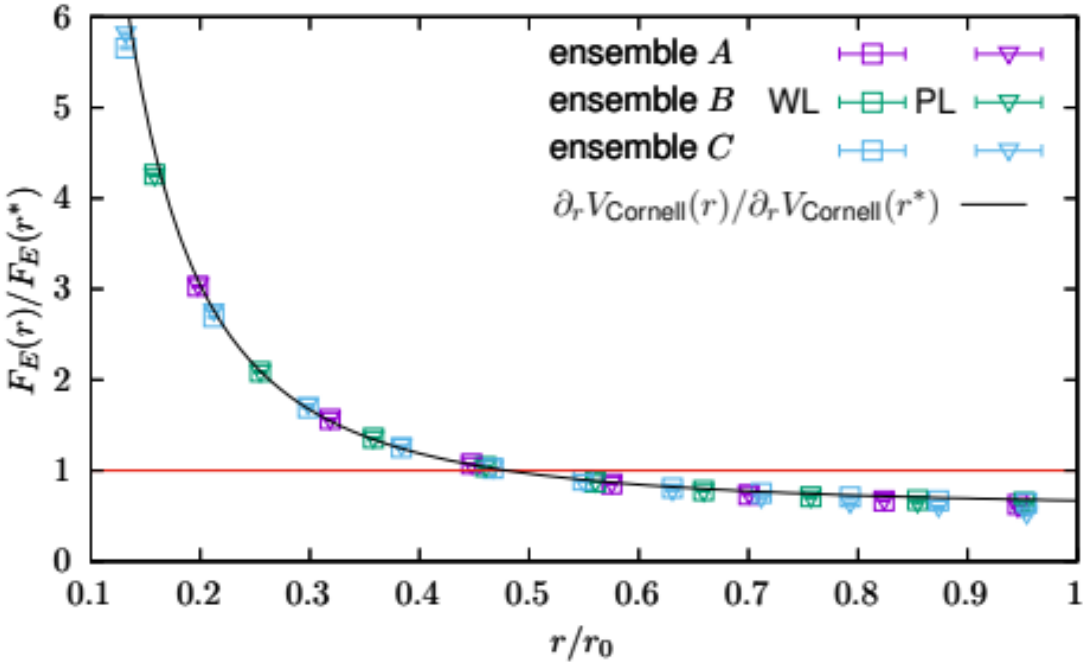
Momentum fraction of ^{3}He
Phys. Rev. Lett. 126, 202001 (2021)



Progress in Task 2.2: heavy-quark, hybrid and tetraquark potentials

- The derivative of the static energy, the static force, offers a way to extract the running of the strong coupling
- Instead of taking a numerical derivative of the potential, it can be shown that the static force can be measured directly from the lattice by measuring an operator that is a chromoelectric field inserted in a Wilson loop
- Proof of concept arXiv:2106.01794 that the method works
- Further work is going on measuring this operator with gradient flow to ease the renormalization of the operator

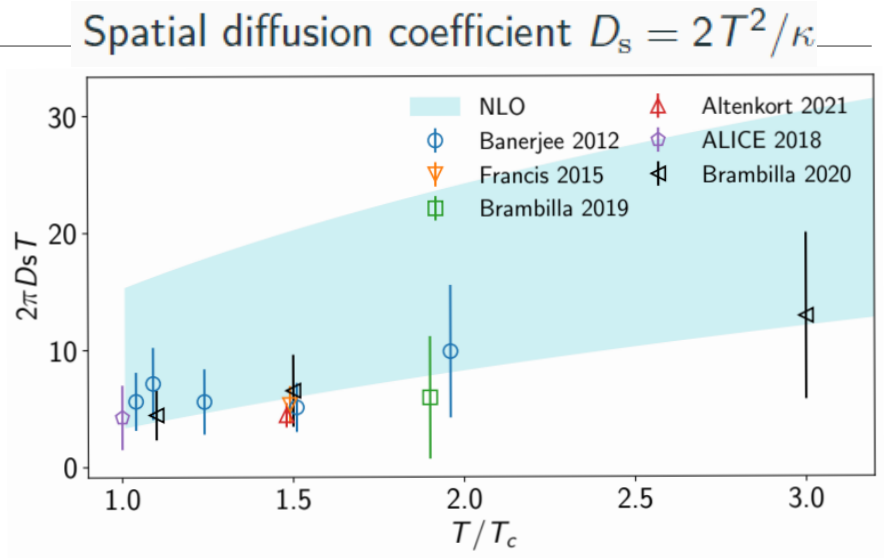
Brambilla, Leino, Philipsen, Reisinger, Vairo, Wagner arXiv:2106.01794

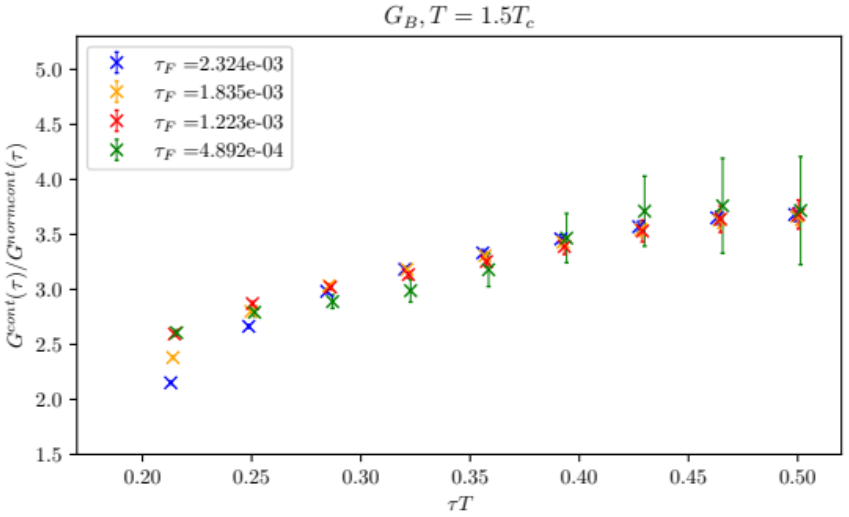


Lattice gauge theory computation of the static force

Progress in Task 2.3: matrix elements for in medium quarkonium evolution

- The heavy quark and quarkonium behavior in a quark gluon plasma is governed by transport coefficients that can be computed non-perturbatively on lattice QCD
- The heavy quark **diffusion coefficient** was computed in a wide temperature range in Brambilla et al. PRD 102 (2020). The fitted temperature dependence is found to be compatible with the NLO perturbative result
- Currently we are running measurements of the 1/M corrections to the diffusion coefficient on the lattice. These come from the chromomagnetic correlators G_B





Progress in Task 3.1: Search for and study of light exotic mesons, $c\bar{c}$ and $s\bar{s}$

Experimental efforts

- Measurement of pT- distributions for K*(892)+ @LHCb
- Study of $X(3872)$ line shape @LHCb
- Inclusive measurement of $h_c(1s)$ and $\psi(2S)$@BESIII
- Search for $Z_c(4430)$ and $X(1835)$ @BESIII
- Search for partners of $Z_c(3900)$ and $Z_c(4020)$ @BESIII
- Study of Deck effect in $\eta\pi$ @COMPASS
- Ongoing analyses on $\eta\pi$ and 3π @CLAS and GlueX
- Publication of EIC Yellow Report

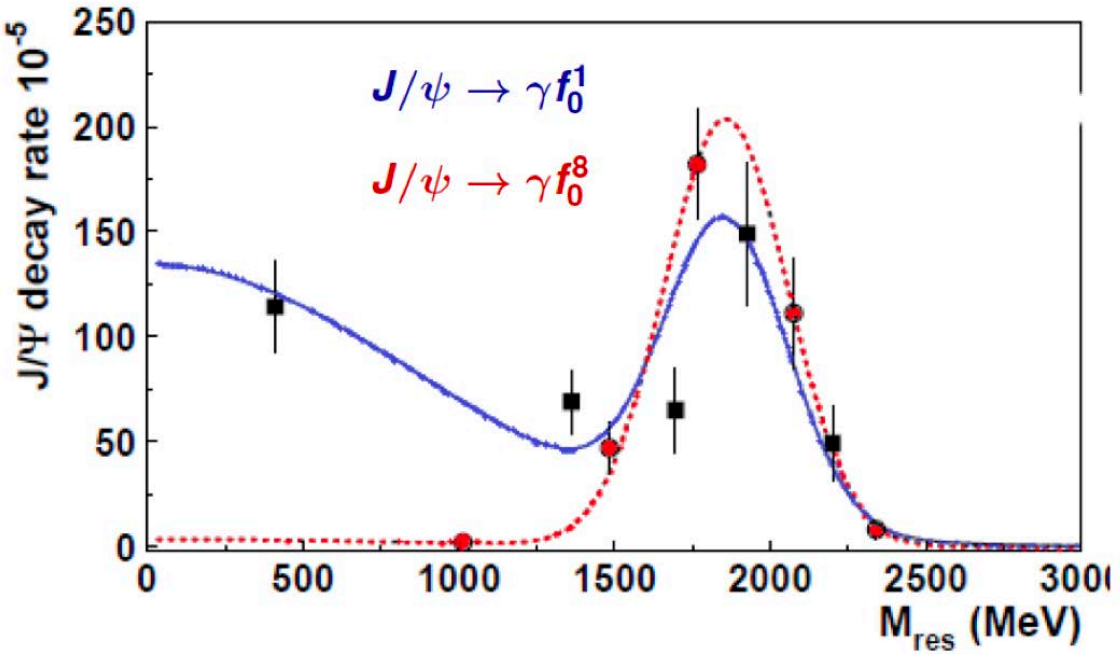
Theoretical efforts / phenomenology

- Study of open charm D meson in the medium (UB)
- Study of triangle singularities in the medium (UCM)
- Analysis of $\eta\pi$@COMPASS by JPAC
- Analysis of scalar mesons in J/ψ decays by JPAC
- Study of S- and P-wave quarkonium wave function at origin in effective field theories (TUM)
- Inclusive heavy quarkonia production in EFT (TUM)
- Publication of a review on glueballs (UCM)

More details and references in
https://agenda.infn.it/event/27658/contributions/142423/

Progress in Task 3.2: Spectroscopy of low-lying scalars, s – and c –mesons

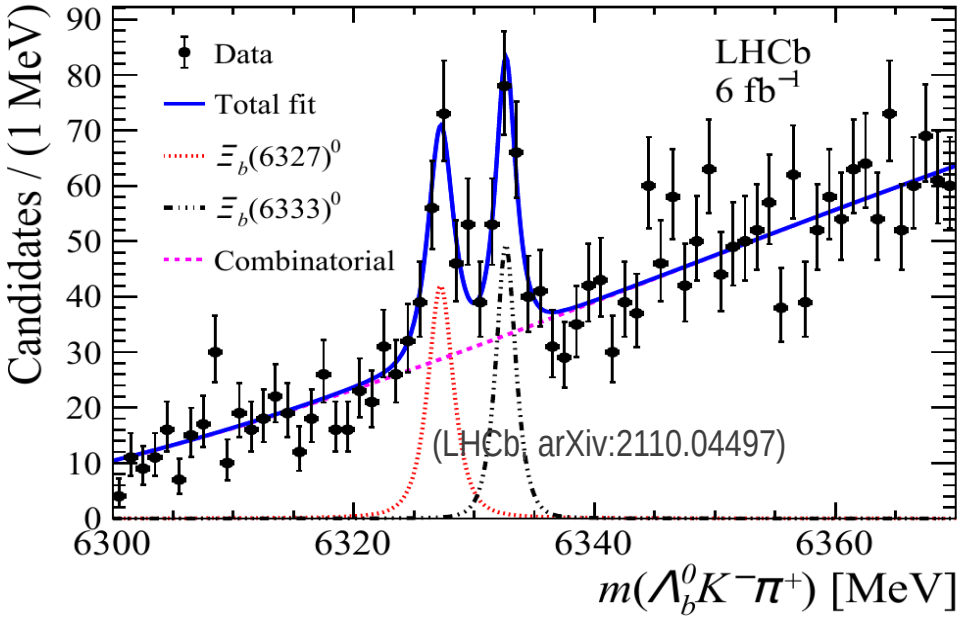
- Data-driven dispersive analysis of the $\pi\pi$ and πK scattering
  - application to a vast experimental or lattice data with a broad (or coupled-channel) resonance of non-genuine QCD nature
- On the scalar πK form factor beyond the elastic region
  - formalism combining low energy elastic description with high energy resonance exchange
- Exotic meson program at JLab - unique data sets with unprecedented statistical precision
  - CLAS12/MesonEx: light-quark mesons and search for exotics
  - GlueX: hybrid search in double meson production
  - studying production mechanisms and moments, developing PWA in parallel



Scalar isoscalar mesons and the **scalar glueball** from radiative J/ψ decays (PLB 816, 136227)

Progress in Task 4.1: Resonance parameters determination

- Heavy Baryons
  - Observation of two new excited Ξ_b^0 states
  - Observation of the excited Ω_c^0 baryons (LHCb, arXiv:2107.03419)
  - Evidence for a new structure in the $J/\psi p$ (LHCb, arXiv:2108.04720)
  - Lifetimes of Ω_c^0 and Ξ_c^0 (LHCb, arXiv:2109.01334)

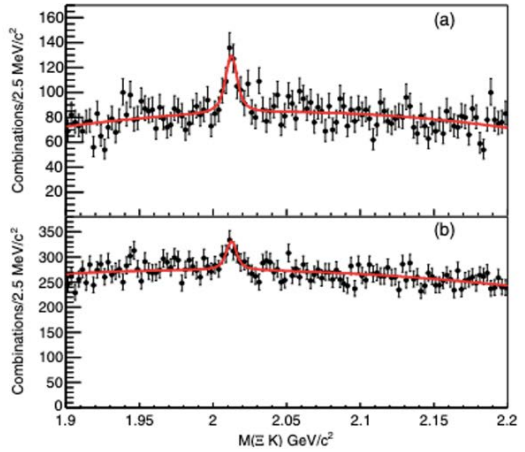


- Light Baryons
  - New ELSA results on $\gamma p \longrightarrow \eta p$ (Phys. Lett.B803 (2020) 135323)
  - First simultaneous measurement of G and E with elliptically polarized photon beam at MAMI
  - Observation of ηp cusp in the helicity dependence of πp
  - New single-energy partial-wave analyses (Phys. Rev .C 104 (2021) 3, 034605; Phys. Rev. C 104 (2021) 1, 014605)

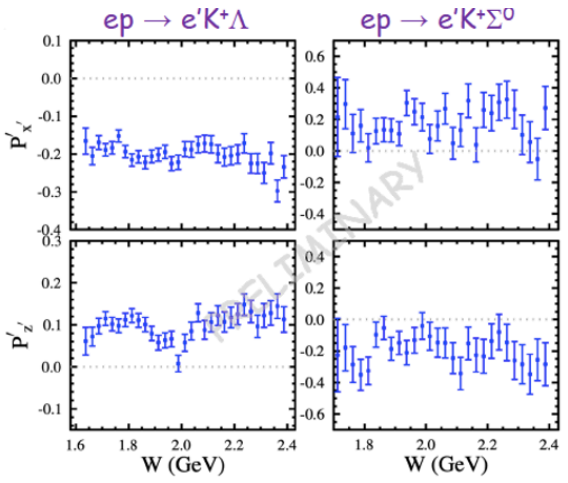
Progress in Task 4.2: Diffractive and annihilation production and exotic baryons and $P_{\odot}^{z}$ (Polarization Observables: Complete Experiment)

1. Measurement of double polarization observable E for $K^+\Sigma^-$ photoproduction on the neutron using CLAS-JLab data
   Status: Published *N. Zachariou et al Phys lett B 808 (2020) 135662*
2. Measurement of double polarization observable *G* for $\pi^0 p$ photoproduction using CLAS-JLab data
   Status: Published *N. Zachariou et al Phys. Lett. B 817, 136304 (2021)*
3. Measurement of single polarization observable Σ for $K^+\Sigma^-$ photoproduction on the neutron using CLAS-JLab data
   Status: Submitted for publication N. Zachariou et al arXiv:2106.13957v2 submitted to Phys. Lett. B (2021)
4. Measurement of transferred polarization asymmetry in KY electro-production using CLAS12-JLab data at 7.5 GeV and 6.5 GeV
   Status: Under collaboration Review
5. Measurement of polarization observables $I_{\odot}$ P_z and $P_{\odot}^{z}$ in $\pi^+\pi^-$ photoproduction on the proton and the neutron using CLAS-JLab data
   Status: Preliminary results available
6. Interpretation of SDME in Λ(1520) Photoproduction at 8.2 - 8.8 GeV in terms of dominating natural parity meson exchange contribution (GLUEX)
   Status: Theoretical curves published
7. Study of $\pi^0 p$ electroproduction using JLAB-CLAS12 data at 10.4 GeV – feasibility study for $\eta\pi^-$ channel to investigate exotic mesons production
   Status: Feasibility study underway
8. Search for hidden-strangeness pentaquark in Λ_c decay at BESIII
   Status: new data collected between 4.6 to 4.9 GeV in 2020/2021 to be analyzed
9. Ω (2012) production al LHC energies
   Status: machine learning techniques to improve $\Omega(2012)^{\pm}$ reconstruction efficiency and signal significance from $K^0\Xi^{\pm}$ decay.

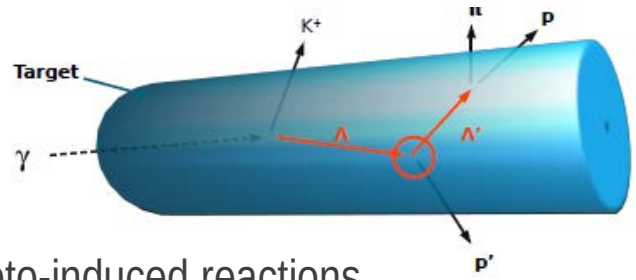
Ω (2012) production at BELLE



Exotic Baryon Search: Measured Transferred polarization in KY electro-production



Progress in Task 4.3: Dibaryon structure and parameter determination



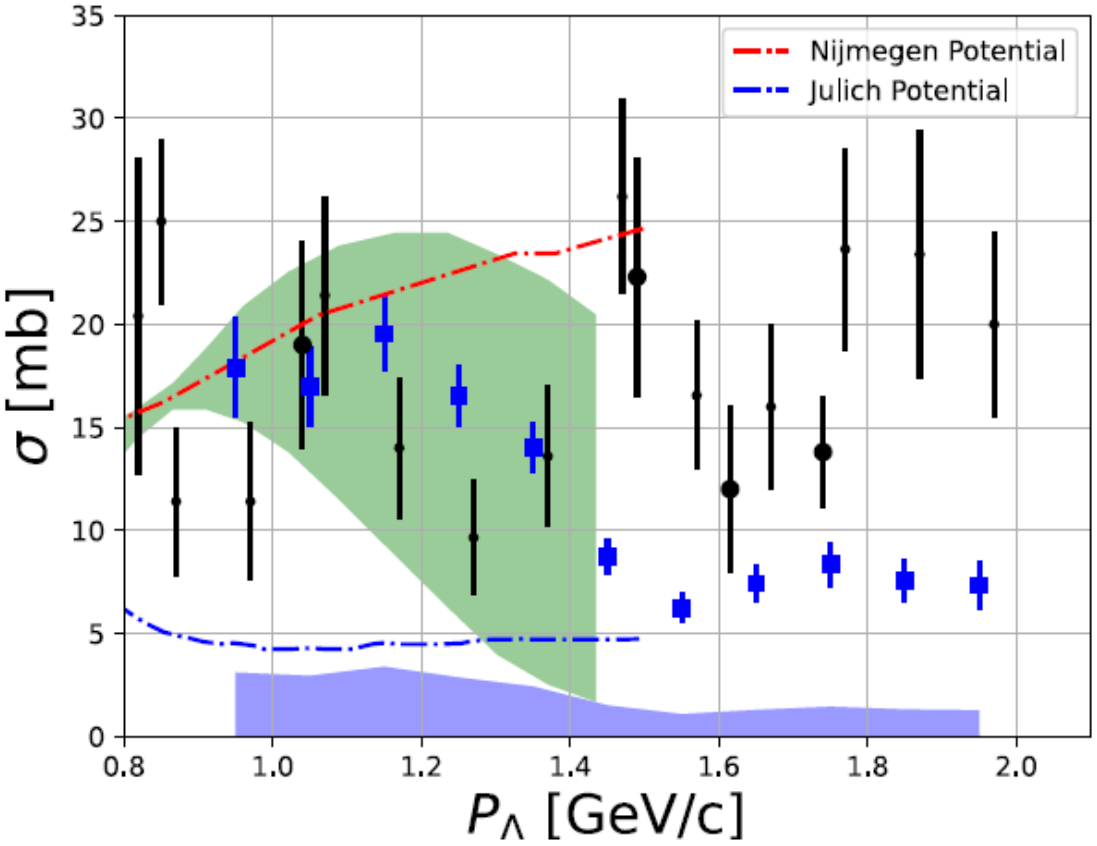
New Methods
- Secondary hyperon beams in photo-induced reactions

New Approved measurements
- MAMI 1000h double polarised measurement on deuteron target (2022)

New Approved facilities
- KLF (intense secondary hyperon beams)

New dibaryon Network members
- Khon Kaen University (D. Samart, C. Pongkitivanichkul)

CLAS Collab. 2108.03134, Improved Λp Elastic Scattering Cross Sections Between 0.9 and 2.0 GeV/c and Connections to the Neutron Star Equation of State



Deliverables and Milestones

Deliverable No.	Deliverable name	Lead Beneficiary	Nature	Dissemination level[1]	Delivery month from Annex I	Delivered (yes/no)	Actual delivery month	Comments
D25.1	HaSP Combined Analysis framework	30 - INFN	Websites, patents filling, etc.	PU	18	yes	15	HaSp web site link: http://web.ge.infn.it/jstrong2020/

✓ **Delivered on time**

HaSp web site

http://web.ge.infn.it/jstrong2020/

- Used routinely by the HaSP collaboration to exchange information
- Living tool updated with highlights, Tasks progress, Combined analysis
- Store documentation with link to papers, reports, docs
- Theory/experiments exchange

The HaSP Network

The spectrum of hadrons is composed of bound states of quarks and gluons. The distinctive property of confinement in strong interactions, which are described by Quantum Chromo-Dynamics (QCD), prevents quarks and gluons from appearing as free particles. A new generation of dedicated experiments in hadron physics has been proposed with the aim of uncovering properties of strong interactions and specifically the mysteries of confinement. Some of these experiments are already in operation and several more are planned for the near future in the main EU laboratories (CERN, Mainz, Bonn, GSI) and abroad (TJNAF/US, BESIII/China, J-PARC/Japan, Belle/Japan). These new experiments will produce an unprecedented amount of high-precision data that requires a level of sophistication in analysis never before achieved. The challenge for the hadron physics community is to synergize the theoretical and experimental efforts to develop best practices for analyzing and interpreting the complex experimental data, developing a sound analysis framework that incorporates latest advances in theory and phenomenology and a set of tools to manipulate, analyze, and preserve the data. Thus, the most advanced and innovative theoretical techniques (effective theories, analyticity constraints, unitarity re-summations and dispersion relations, Lattice-QCD (LQCD) simulations and analysis, etc.) need to be fully developed and applied for a solid interpretation of the experimental results. Observables need to be interpreted using robust methods that rely only on the basic theoretical principles, and compared to the best solutions provided by the fundamental theory of the strong interaction via LQCD or systematic effective field theory expansions. These goals can only be achieved through a large-scale collaborative effort that takes full advantage of the expertise in hadron physics communities in Europe and in the rest of the world. The HaSP network activity aims to coordinate the leading European institutions active in hadron spectroscopy with the objective of making progress in: development of theoretical, phenomenological and computational foundations for amplitude; establishment of best practices for accessing systematic uncertainties in analysis of hadron reaction data and interpretation of physics results.

Deliverables and Milestones

Milestone number	Milestone name	Lead beneficiary	Delivery month from Annex I	Delivered (yes/no)	Actual delivery month	Comments
MS52	Topical Workshop on Theoretical aspects of Hadron Spectroscopy and Phenomenology (IFIC). Tasks 1 and 2	30 - INFN	9	NO	December 2020	Given the serious public health problems related to Covid-19, which forced the closure of several countries inside and outside the EU, as well as the imposition of extreme travel limitations, the organizing committee decided to cancel the meeting expected to be held in Valencia (Spain) from April 21 to April 24, 2020 as part of the STRONG-2020 activity. Unfortunately, due to still strong travel constraints after the summer in many countries, we decided to hold it in remote mode http://ific.uv.es/nucth/TH-WP25-H2020/

✓ **Delivered**

Topical Workshop (Theory) web page
http://ific.uv.es/nucth/TH-WP25-H2020/

Theoretical aspects of Hadron Spectroscopy and Phenomenology

The workshop is organized as an online meeting with talks from 13.30h to 18h each day

Valencia, Valencian Community (Spain), ~~April 21-24, 2020~~ **December 15-17, 2020**

JRA7-HaSP: Light-and heavy-quark hadron spectroscopy

Horizon 2020 research and innovation programme grant agreement num. 824093 (STRONG-2020)

Valencia (Spain), December 15-17, 2020
Online meeting: https://ilab.bluejeans.com/688545587

Timetable (CET)

	Tuesday 15th	Wednesday 16th	Thursday 17th
13.30h-15.35h	Session 1	Session 3	Session 5
15.35h-15.55h			
15.55h-18.00h	Session 2	Session 4	Session 6

Distribution of talks in sessions **(25'= 20' talk +5' discussion)**

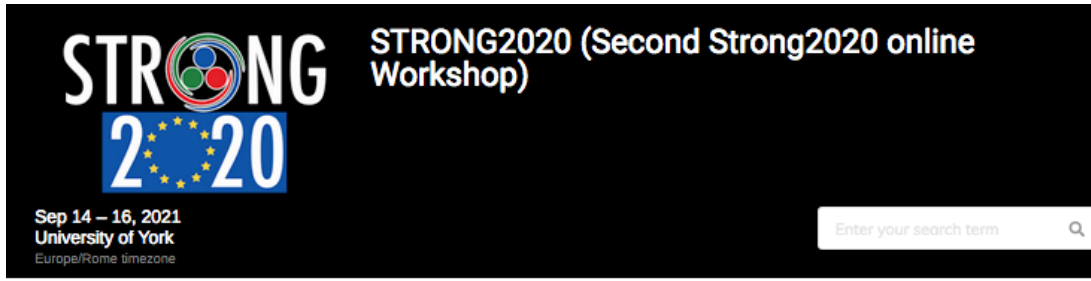
Deliverables and Milestones

MS53	Topical Workshop on Experimental Aspects of Hadron Spectroscopy and Phenomenology (UEdin). Tasks 3 and 4	30 - INFN	18			Pending the clarification about the funds-transfer between UEDI and the University of York (see Sec.3.1). In case funds will be available, due to COVID19 pandemic the workshop will be postponed to June-September 2021 (24-28). Depending on the medical condition in the first months of 2021, we will decide about 'in person' or 'remote only' attendance.

✓ **Delivered**

Topical Workshop (Experimental) web page https://agenda.infn.it/event/27658/

- **Both workshops had a large attendance (~60-90 participants)**
- **Detailed reports in STRONG2020 Newsletters (see DISCO activity)**



successful virtual poster session

Deliverables and Milestones (FUTURE)

Milestone number[18]	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS54	General Workshop on Hadron Spectroscopy and Phenomenology (TUM) Tasks 1, 2, 3 and 4	30 - INFN	28	Workshop proceedings
MS55	School on Hadron Spectroscopy and Phenomenology	30 - INFN	38	School proceedings

- Expected in September 2022 at TUM (Munich). Organization started
- Expected in May or September 2023 at Univ. Salamanca. Organization started

Thank you for the attention!