2nd Forward Physics Facility Meeting

Thursday, 27 May 2021 - Friday, 28 May 2021

Book of Abstracts

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LEvEL: Low-Energy Neutrino Experiment at the LHC

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The Large Hadron Collider Beam Dump, where an enormous number of 7 TeV protons are brought to rest twice a day, is an intense source of neutrinos. In this talk, I will discuss a proposed experimental program, LEvEL, the Low-Energy Neutrino Experiment at the LHC, which can measure several interesting neutrino-interaction cross sections near the LHC Beam Dump. These interaction processes may help us unlock even more understanding of coherent neutrino-nucleus interactions as well as enabling us to extract fundamental physics from the observation of supernova neutrinos in the coming decades. This setup is highly complementary to measurements of neutrinos in the Forward Physics Facility.

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Dark Sectors via Proton Bremsstrahlung

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In this talk, I discuss the production of dark vectors and scalars via proton bremsstrahlung, making use of a model that accurately captures the underlying nucleon scattering cross-section in the forward direction due to pomeron exchange.

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Hadronic structure at a Forward Physics Facility

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Inclusive as well as exclusive forward emissions are widely recognized as excellent channels to access the nucleon structure in the high-energy/small-x regime. Here, several phenomenological analyses have been proposed so far, this allowing us to probe kinematic ranges in the intersection corners of different approaches. At large transverse momenta, a high-energy factorization (HEF) formula is established within the Balitsky-Fadin-Kuraev-Lipatov (BKFL) formalism, where the so-called unintegrated gluon distribution (UGD) drives the gluon evolution at small-x. Recent analyses on the diffractive electroproduction of ρ mesons have corroborated the underlying assumption that the small-size dipole scattering mechanism is at work, thus validating the use of the HEF formalism. Nonetheless, a significant sensitivity of polarized cross sections to intermediate values of the meson transverse momenta, where, in the case of inclusive emissions, a description at the hand of the transverse-momentum dependent (TMD) factorization starts to be most appropriate framework, has been observed. Similar studies on emissions of quarkonium states, whose theoretical description at small-x is expected to rely also on quark dipoles of larger size, would certainly help us to shed light on the interplay between HEF and TMD formalisms. In this talk I propose to address all the considered points, showing how phenomenological analyses doable at a Forward Physics Facility can accelerate progress in our understanding of the hadronic structure at small-x. Ultimately, they trace the path toward the development of a unified formalism, where both the TMD and the BFKL evolution mechanisms are consistently integrated in the definition of small-x gluon TMD distributions.

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Neutrino fluxes at the FPF: the case of tau neutrinos

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Welcome and Introduction

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Semi-hard reactions at the Forward Physics Facility

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Forward emissions represent a unique opportunity to test perturbative QCD in new, and so far unexplored, kinematical regimes. In the semi-hard regime, where $s >> Q^2 >> \Lambda_{QCD}$, pure fixed-order predictions need to be supplemented by an all-order resummation which takes into account the effect of large energy-type logarithms. The Balistky-Fadin-Kuraev-Lipatov (BFKL) approach is established as a powerful tool for performing such a resummation. The definition and the study of observables sensitive to high-energy dynamics has the double advantage of (i) allowing to clearly discern the BFKL dynamics from the fixed-order one and (ii) providing us with an auxiliary tool to extend studies in wider sectors of physics (heavy flavor, Higgs and jet physics for instance).
In this talk, I will summarize the main efforts of the Community in this direction, showing how experimental analyses at a Forward Physics Facility could significantly advance our knowledge of the high-energy regime of QCD.

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Crunching dilaton, hidden naturalness

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We introduce a new approach to the Higgs naturalness problem, where the value of the Higgs mass is tied to cosmic stability and the possibility of a large observable Universe. The Higgs mixes with the dilaton of a CFT sector whose true ground state has a large negative vacuum energy. If the Higgs VEV is non-zero and below ~TeV, the CFT also admits a second metastable vacuum, where the expansion history of the Universe is conventional. As a result, only Hubble patches with unnaturally small values of the Higgs mass support inflation and post-inflationary expansion, while all other patches rapidly crunch. The elementary Higgs VEV driving the dilaton potential is the essence of our new solution to the hierarchy problem. The main experimental prediction is a light dilaton field in the 0.1-10 GeV range that mixes with the Higgs. Part of the viable parameter space has already been probed by measurements of rare B-meson decays; we emphasize the possibility for probing the rest of the parameter space at the Forward Physics Facility.

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Charming ALPs

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Axion-like particles (ALPs) are ubiquitous in models of new physics explaining some of the most pressing puzzles of the Standard Model. However, until relatively recently, little attention has been paid to its interplay with flavour. In this work, we study in detail the phenomenology of ALPs that

exclusively interact with up-type quarks at the tree-level, which arise in some well-motivated ultraviolet completions such as QCD-like dark sectors or Froggatt-Nielsen type models of flavour. Our study is performed in the low-energy effective theory to highlight the key features of these scenarios in a model independent way. We derive all the existing constraints on these models and demonstrate how upcoming experiments at fixed-target facilities and fast forward physics facilities at the LHC can probe regions of the parameter space which are currently not excluded by cosmological and astrophysical bounds. We also emphasize how a future measurement of the currently unavailable meson decay $D \to \pi + \text{invisible}$ could complement these upcoming searches.

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Searching for anomaly-free gauge bosons at forward physics experiments

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A popular choice for a new mediator between the Standard Model (SM) and a dark sector are kinetically mixed hidden photons. However, beyond a minimal kinetic mixing coupling such a new vector boson can also have gauge interactions with SM particles. In general, these gauge interactions are constrained by anomaly cancellation, fermion mass terms and the CKM and PMNS matrix. In this talk I will demonstrate that these constraints only allow for a limited number of Abelian gauge extensions of the SM without the introduction of new chiral fermions. I will furthermore argue that of these gauge groups only $U(1)_{B-L}$ can allow for Dirac neutrino masses, while for all other choices neutrinos must have Majorana masses. For this whole class of new vector bosons there is ample parameter space with rich forward physics phenomenology. I will show that FASER and FASERν as representative forward physics experiments will play a crucial role in the future search for these bosons.

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Update from millliQan

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We report an update on plans for milliQan in Run 3 (https://arxiv.org/abs/2104.07151). Having secured the necessary funding, we plan to construct two detectors, including a novel slab detector configuration, for the LHC Run 3. The dataset provided by a prototype scintillator-based detector has been used to characterise the performance of these detectors and provide an accurate background projection. We are also exploring the possibility to move the Run 2 milliQan prototype to the FASER location to test the feasibility of a forward millicharged detector. If successful, a larger scintillator detector can be placed in the FPF (FORMOSA).

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Addressing the cosmic ray muon excess by probing a ”fireball” state at the Forward Physics Facility

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The muon excess in cosmic ray data can be traced back to uncertainties on the hadronic energy fraction after forward interactions. These uncertainties could be addressed by the Forward Physics Facility (FPF) if neutrino measurements will be able to constrain the charged pion to kaon ratio and the charm production in very forward interactions.
I will discuss a "fireball" model which increases the effective hadronic energy fraction in an attempt to resolve the muon excess, and how its physical nature could be probed by measurements at the FPF.

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Probing PDFs via Neutrino Scattering with FASERν

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We study the impact that FASER\(\nu\) will have on the determination of nuclear and nucleon PDFs using neutrino/anti-neutrino deep inelastic scattering $\nu_\mu q \to \mu^- q'$. FASERν will be able to probe a broader range of the x, y, and Q^2 parameter space with the access to the high energy neutrinos generated from interactions at ATLAS. For the nucleon PDFs focus on the strange PDF, which suffers from large uncertainties particularly at low x. The strange PDF can be probed via the charm exclusive final state. The charm hadronizes into a D meson, which can be identified via a displaced decay, leading to a kink signature. We use the `ePump` package to forecast how these events will update the PDFs and their uncertainties.

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Search for Lepton Flavour Violating Decay at FASER

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FASER is one of the promising experiments which search for long-lived particles in beyond standard models.
We study the sensitivity to the charged lepton flavor violating (cLFV) decays of the long-lived particles by FASER experiment.
We find that FASER can search the cLFV decays of these particles in the parameter region which survives the current severe experimental constraints on cLFV coupling.

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Updated projections for FASER2 at the FPF

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Abstract: First studies of the projected physics reach of FASER2 have been available for some time [arXiv:1811.12522], and possible detector technologies for FASER2 have previously been presented at the FPF kick-off meeting. We will show updated studies of the expected FASER2 reach taking into account recent developments in planning for the FPF, notably the possible layouts of the underground facility, and more detailed analysis of possible magnet and detector technologies.

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