CURRICULUM VITAE
MARSICANO LUCA

Genova, 2/9/2020

Il sottoscritto Luca Marsicano, consapevole delle responsabilita penale prevista, dall'art. 76 del D.P.R. 445/2000, per le ipotesi di falsità in atti e dichiarazioni mendaci ivi indicate:

DICHIARA

che le informazioni sotto riportate sono veritiere.

Education:

November 2016/March 2020	PHD Course in Physics, University of Genoa Thesis: *"Test and development of the Beam-Dump Experiment at Jefferson Lab"* Advisor: Marco Battaglieri
March 2014/October 2016	Master Degree Course in Physics, University of Genoa Thesis: *"Characterization of a Prototype of the BDX Detector"* Advisors: Marco Battaglieri, Andrea Celentano, Raffaella De Vita Final Mark: 110/110 cum laude
September 2009/ March 2014	Undergraduate Degree in Physics, Universty of Genoa Final Mark: 110/110 cum laude
September 2004/ July 2009	High school graduation, Liceo Scientifico G.Marconi, Chiavari Final Mark: 100/100

Research statement summary:

My research activity is focused on the Beam Dump eXperiment (BDX), an experiment searching for light dark matter in the vector-mediated dark sector scenario. Dark Matter (DM) is one of the hottest topics in modern physics: from the second half of the last century, multiple proofs of its existence were obtained from astrophysical and cosmological observations. Stellar rotation curves in galaxies and dwarf-galaxies, the power spectrum of temperature fluctuations in the Cosmic Microwave Background (CMB), the power spectrum of matter density fluctuations, the ratios of light element yields from Big Bang Nucleosynthesis (BBN), the morphology of galaxy cluster collisions and astrophysical mass measurements based on gravitational lensing, all consistently indicate that 85% of the matter and 25% of the total energy of our universe comprises an electrically neutral, non relativistic population of DM.

However, no unequivocal DM signal have been detected to date by particle physics experiments. While most of "traditional" DM experiments are designed and optimized to prove the weak-force mass scale, O(100 GeV), the "light DM" (LDM) region, O(10 MeV - 1 GeV) is, so far, vastly unexplored. This new scenario can explain the existing gravitational measurements, if a new DM-SM interaction mechanism also exists. In the simplest model, this is provided by a light, kinetically mixed gauge boson (A', or "dark photon"), interacting with SM particles through the electric charge. Dedicated fixed-target experiments at accelerators working at the "intensity frontier", such as BDX, are a unique way to explore this scenario. BDX is a proposed experiment [4] making use of CEBAF (Continuous Electron Beam Accelerator Facility) 11 GeV electron beam impinging on the Jefferson Lab (Jlab) Hall-A beam-dump. The interaction of the energetic electrons in the beam-dump may lead to the production of dark photons through a bremsstrahlung-like radiative process. Subsequently, the A's decay to LDM particle-antiparticle pairs, which travel almost unaltered through the length of the dump. A ~ 1 m^3 detector made of CsI(Tl) (Thallium doped Cesium Iodide) crystals is located in the trajectory of the LDM beam, 20 m downstream of the beam-dump. A fraction of the LDM particles scatter off atomic electrons in the detector giving rise to a detectable electromagnetic shower of approximately 100 MeV. Thanks to the cosmic background suppression and the high intensity of the electron beam (up to 65 μA at 11 GeV), BDX will be able, with a 280 days run, to exceed by up to two orders of magnitude the sensitivity of current competitor experiments.

Master Thesis Work:

I graduated in May 2016, at Genoa University. The title of the thesis is "R&D of a prototype detector of the Beam Dump eXperiment" (advisors Marco Battaglieri, Andrea Celentano, Raffaella De Vita). The work was focused on the characterization of the components of the BDX prototype detector, which is made of a single scintillating crystal enclosed into two active veto layers (inner and outer veto) and a 5 cm thick lead shielding. In order to validate the choice of the prototype materials, I tested and characterized three different crystal samples: a Thallium doped CsI crystal from BaBar electromagnetic calorimeter, a BaF_3 and a BGO sample crystal. Using cosmic rays I measured the relevant characteristics of each sample (light yield, signal rise and decay time). SiPMs were used as light readout, as foreseen in final BDX detector design. Since the CsI(Tl) proved to be an optimal choice for BDX , I participated to a measurement campaign of the BaBar crystal at Laboratori Nazionali del Sud (LNS), Catania. The LNS proton beam was used to characterize the crystal response to low energy protons (2 -22 MeV kinetic energy) [11]. Together with the crystal tests, I performed measurements of the plastic scintillator paddles forming the prototype inner veto. I measured the efficiency of the single paddles for cosmic muons and I modeled their positional response. During the course of my master thesis, the prototype was fully assembled in Catania; I participated both to the assembly and testing of the detector. Part of the thesis work was included in the 2016 BDX Proposal, submitted to Jefferson Lab PAC 44.

PhD work:

After the graduation, I continued to work on BDX as a graduate student at Genoa University. The PhD defense was held on March 16th 2020. During the PhD period, I worked on different aspects of the Beam Dump eXperiment, focusing on MonteCarlo (MC) simulations and reach estimates. At the same time, I studied new dark photon production mechanisms which have proved to be particularly interesting for lepton beam-dump and missing energy experiments searching for LDM particles.

My contribution to BDX is mainly focused on three topics: the muon flux measurement behind Jlab Hall A beam-dump, the evaluation of the experiment reach, including an optimization study for the detector, and the construction and commissioning of a small-scale detector (called BDX-mini) for a

preliminary BDX measurement at Jlab.
-*Muon Flux Measurement*: in order to validate the MC simulations used to estimate background for the experiment, the BDX collaboration measured the muon flux behind Hall-A beam-dump. A hodoscope detector, composed of a CsI(Tl) crystal surrounded by plastic scintillators was lowered in a pipe and installed at the nominal beam-line height. I performed the simulations of the muon flux, starting from the interaction of the primary electron beam in the beam-dump to evaluate the yield and distribution of the produced muons. These were then propagated through the subsequent materials (concrete and dirt). Finally, their interaction with the hodoscope detector was simulated. This work, performed using both FLUKA ad GEANT4 tools, allowed to validate BDX simulation framework: measured data were compared with simulations, resulting in a good agreement for both absolute rates and flux profile [3].
-*BDX detector optimization:* I performed the optimization of the BDX detector, studying the optimal configuration and the best background rejection algorithms to maximize the sensitivity of the experiment. I based my work on the MC simulation of signal (Dark Matter scattering off detector electrons), the simulation of beam-related background (neutrino events) and the cosmic background measurement from Catania prototype. I studied the response of the detector to signal and background, varying systematically cuts to determine the optimal analysis strategy. I also studied different detector geometries, varying the arrangement of the crystals and of the veto layers. This work allowed to maximize the experiment sensitivity and correct flaws in the original detector design [4].
-*BDX mini:* I participated to the BDX-mini detector construction and commissioning at Jlab (early 2019). Currently I am working on the BDX-mini sensitivity evaluation. The goal of this work, in addition to the selection of the cuts providing the best signal-background ratio and the best reach for BDX mini, is to build a consistent framework including Dark Photon generation, scattering and detector response, suitable for the full scale BDX experiment.
In addition to this experimental work on BDX, I carried out a phenomenological study focused on the LDM production mechanisms in fixed-target electron experiments. I collaborated with Dr. E. Nardi (INFN – Laboratori di Frascati) to evaluate the sensitivity enhancement of electron beam-dump experiments (EBDEs) induced by secondary positrons. This study is based on the fact that electron beam dumps are positron-rich environments, so that the contribution of the resonant ($e^+e^- \rightarrow A'$) and non-resonant ($e^+e^- \rightarrow A'\gamma$) annihilation processes, usually neglected, can be sizable. Using a custom code, I evaluated this effect for various existing and past beam-dump and missing energy experiments: E137, NA64, BDX and LDMX [7],[8].
Other than positrons, EBDEs produce a large number of secondary muons. This secondary flux makes EBDEs sensitive to a specific Dark Sector scenario, foreseeing a new mediator coupled predominantly to muons. I worked in collaboration with Dr. Y. Zhong, (Boston University) to evaluate the sensitivity of BDX and E137 to this scenario [5].

Scientific Collaborations:

I am member of the following scientific collaborations: BDX (2016-present), HPS (2017-present), CLAS (2019-present).

Teaching Experiencs:

Teaching assistant:

AY 2018/2019: *"General Physics 1 - module A"* course teaching assistant (Università degli Studi di

Genova, Corso di Laurea in Ingegneria Meccanica, Prof. A. Celentano)

AY 2019/2020: *"General Physics 1 - module A"* course teaching assistant (Università degli Studi di Genova, Corso di Laurea in Ingegneria Meccanica, Prof. A. Celentano)

Workshops/conferences talks and posters:

INVISIBLES17: School, Centre Loewenberg, Murten (Fribourg), Switzerland, 6-10 June 2017 - Poster: "The Beam Dump eXperiment"

JPOS17: *"International Workshop on Physics with Positrons at Jefferson Lab"*, Thomas Jefferson National Accelerator Facility Newport News, VA (USA) 12-15 September 2017- Contributed talk: "Searching for dark photon with positrons at Jefferson Lab"

ICHEP2018: *"International Conference on High Energy Physics"*, COEX, Seoul, Republic of Korea, 04-11 July 2018 – Contributed talk: "The Beam-Dump eXperiment"

SIF 2018: *"104° Congresso della Società Italiana di Fisica"* Arcavacata Di Rende (CS), Italy 17-21 September 2018 – Contributed talk: "The Beam-Dump eXperiment"

NuInt 18: "*12th International Workshop on Neutrino-Nucleus Interactions in the Few-GeV Region"*, Gran Sasso Science Institute (GSSI), L'aquila, Italy, 15-19 October 2018 - Poster: "The Beam-Dump eXperiment"

EIC Streaming Readout IV: *"Streaming Readout at Electron Ion Collider"* Camogli (GE), Italy 22-24 May 2019 – Contributed talk - "Validation of BDX Streaming Readout"

Schools:

"Invisibles17" School, Centre Loewenberg, Murten (Fribourg), Switzerland, 6-10 June 2017

"Machine Learning" INFN School, Camogli (GE), Italy, 20-22 May 2019

"Next Frontiers in Dark Matter", Galileo Galilei Institute, Firenze, Italy, 16-27 September 2019

Awards:

2018: *"Premio per la prima migliore comunicazione nella sezione fisica nucleare e subnucleare al 104° Congresso Nazionale della Società Italiana di Fisica"*

Expertise:

Good knowledge of scintillator-based particle detectors. In particular, my expertise focus on the following points:

- Plastic and inorganic scintillator characterization techniques: light yield measurements, light emission dynamics, optical transmission efficiency.
- Optical read-out sensors characterization techniques (SiPM, photomultipliers): gain, dark current, linearity measurements.

Computing/Programming skills:

Knowledge of programming languages:

- C++ : good
- Java : basic
- Python : basic

Analysis/simulations frameworks:

- Good knowledge of ROOT data-analysis framework
- Good knowledge of GEANT4 MonteCarlo Framework

Publications:

[1] N. Zachariou et al. (CLAS Collaboration), *"Beam-Target Helicity Asymmetry E in $K^+\Sigma^+$ Photoproduction on the Neutron"*, *Phys. Lett. B* 808, 135662 (2020).

[2] A. Schmidt et al. (CLAS Collaboration), *"Probing the Core of the Strong Nuclear Interaction"*, *Nature* 578, 540 (2020).

[3] M. Battaglieri, L. Marsicano et al. *"Measurements of the muon flux produced by 10.6 GeV electrons in a beam dump"*, *Nucl. Instum. Meth*, **A925**, (2019)

[4] L. Marsicano "*The Beam Dump eXperiment"* PoS(ICHEP18)075. 10.22323/1.340.0075. (2019)

[5] L. Marsicano et al. *"Probing leptophilic dark sectors at electron beam-dump facilities"*, *Phys. Rev. D* **98**, 115022 (2018)

[6] F. Ameli, L. Marsicano et al. "*A low cost, high speed, multichannel analog to digital converter*

board", Nucl. Instum. Meth, **A936**, (2018)

[7] L. Marsicano et al. *"Dark photon production through positron annihilation in beam-dump experiments", Phys. Rev. D* **98**, 015031 (2018)

[8] L. Marsicano et al. *"Novel Way to Search for Light Dark Matter in Lepton Beam-Dump Experiments", Phys. Rev. Lett.* 121 (2018) 041802

[9] L. Marsicano *"Searching for dark photon with positrons at Jefferson Lab"* AIP Conference Proceeding 1970. 020008. 10.1063/1.5040202 (2018)

[10] B. Wojtsekhowski, L. Marsicano et al. *"Searching for a dark photon: project of the experiment at VEPP-3", Journal of Instrumentation,* Vol. 13 (2018)

[11] M. Bondì, L. Marsicano et al. *"Large-size CsI(Tl) crystal read-out by SiPM for low-energy charged-particles detection", Nucl. Instum. Meth,* **A867**, (2017)

Languages:

Italian:	Mother tongue
English:	Good knowledge of spoken and written English
French:	Basic Knowledge