

Annual Report (XXXVII cycle)

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Name and surname: *Marco Spreadico*

Supervisor: *Prof. Marco Battaglieri*

Ph.D. cycle: *XXXVII*

Year: *First*

Research activity

My research activity is focused on Physics Beyond Standard Model at Jefferson Lab (Newport News, Virginia, USA).

It was split between two main topics: data analysis of BDX-MINI experiment and studies to evaluate the feasibility of a neutrino coherent scattering experiment at Jefferson Lab.

During the first months of my PhD I studied different statistical tools to consolidate and improve the results presented in my thesis. I evaluated how exclusion limits change if we fully exploit the information given by the Dark Matter model considered to further constrain data. In particular, I included constraints on Dark Matter energy spectrum provided by the model to analyze data binned according to energy deposited. I considered two different models of Dark Matter: fermionic, used to evaluate a preliminary exclusion limit in my thesis, and scalar. I have performed the energy-dependent data analysis, evaluating a more stringent exclusion limit for Light Dark Matter.

During the last part of the year and in parallel with BDX-MINI analysis, I also performed different studies for a possible neutrino coherent scattering measurement at JLab.

I studied possibility of a Dark Matter measurement using the same experimental setup characterizing the BDX Caesium Iodide (CsI) crystals response to low energy deposition.

In addition I worked on the simulation framework. In particular, I introduced in GEMC (a user-friendly interface to Geant4 used at JLab) Dark Matter production and interaction. Both processes were implemented by adding custom libraries containing the predominant LDM production and interaction processes. I then studied the Dark Matter flux produced in the beam dump and the expected signal in the detector.

To characterize the CsI crystals, I performed different measurements on spare BaBar endcap calorimeter crystals, meant to be used in the BDX experiment. We used different radioactive sources (mainly ^{139}Cs , but also ^{60}Co , ^{22}Na and AmBe) to evaluate the crystal light yield and test different readout technologies for sub-MeV energy deposition. In particular I tested photomultiplier tubes (PMT), Silicon Photomultipliers (SiPM) and SiPM tiles. I also studied the effect of temperature on the readout: in particular, I studied the dark current noise of SiPM for different temperatures.

1 Courses and exams

I attended the following courses:

- Electronics and Data acquisition (F. Fontanelli, S. Minutoli, P. Musico)
- Particle Physics and Multimessenger Astroparticles (M. Pallavicini, M. Sanguineti)
- Machine learning and Data Analysis (L. Oneto from Computer Science study course)
- INFN School of Statistics

I gave the exams for the following courses:

- Electronics and Data acquisition
- On September 19th I will give the exam for the Particle Physics and Multimessenger Astroparticles course

2 Publications

I was coauthor of the following publications:

- M. Battaglieri et al., "Dark matter search with the BDX-MINI experiment" (<https://arxiv.org/abs/2208.01387>, submitted to PRD)
- P. Ilten et al., "Experiments and Facilities for Accelerator-Based Dark Sector Searches", (<https://arxiv.org/pdf/2206.04220.pdf>)
- S. J. Paul et al., "Alignment of the CLAS12 central hybrid tracker with a Kalman Filter", (<https://arxiv.org/abs/2208.05054>)

I'm corresponding author of the following publications:

- M. Spreafico, "Light Dark Matter searches with the BDX-MINI experiment" (<https://www.sif.it/riviste/sif/ncc/econtents/2022/045/05/article/40>)
- M. Spreafico, "Performance of BDX-MINI veto systems" (submitted and expected to be published on NIM A)

3 Conferences

I attended the following conference:

- INFN School of Statistics (<https://agenda.infn.it/event/28039/>)

and I participated to the following contribution

- M. Battaglieri, M. Spreafico, "Update on BDX" - talk at the HPS Collaboration meeting (<https://indico.jlab.org/event/496>), presented by M. Battaglieri and me
- M. Spreafico, "The BDX-MINI detector for Light Dark Matter search at JLAB" - poster at the 15th Pisa Meeting on Advanced Detectos (<https://www.pi.infn.it/pm/>), presented by me
- M. Spreafico, "The BDX experiment" - talk at the Physics Beyond the Standard Model workshop (<https://indico.jlab.org/event/540/>), presented by me

4 Comments and notes

Between April 3rd and April 13th 2022 I travelled to JLab to perform BDX-MINI detector decommissioning. During this period I took part in the detector disassembling and performed the necessary training to enter JLab.

In addition to my research activity, I also became part of the CLAS-12 collaboration. In the next months I will perform service work for the CLAS-12 experiment, mainly consisting in simulation of electromagnetic background in the detector.

I also became part of the EIC collaboration. I tested new scintillator technologies and streaming readout systems. In the next months I will travel to JLab to test the streaming readout system in preparation of on-beam measurements next year.