The MoEDAL Experiment

A Progress Report

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University of Alberta
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MoEDAL - Very Different from Other LHC Expts

Permanent Physical record of new physics

LHCb

MoEDAL

No Standard Model Physics Backgrnds

MoEDAL is largely passive made up of three detector system.

NUCLEAR TRACK DETECTOR
Plastic array (~100 sqm) – Like a Giant Camera

TRAPPING DETECTOR ARRAY
A tonne of Al to trap Highly Ionizing Particles for analysis

TIMEPIX Array a digital Camera for real time radiation monitoring
MoEDAL is using the LHCb software framework (GAUSS, etc.)

Active priority for all MoEDAL analyses- define the material & detector map in the VELO cavern:
- Current LHCb map only accurate enough for our needs in LHCb accept.

Active priority for all MoEDAL analyses - implement monopole physics ($E_{\text{loss}}$, etc) in the LHCb framework for $\beta \geq 10^{-4}$
The search for the highly ionizing particle avatars of new physics
PUBLISHED (By the collaboration or its members)


PUBLICATIONS IN PREP. (By the collaboration or its members)

1. “Search for magnetic monopoles with the MoEDAL NTD detectors at the LHC with 7 TeV & 8 TeV Ecm”, in prep., to be submitted to Phys.Rev. D
2. “Search for magnetic monopoles with the MoEDAL Trapping detectors at the LHC with 7 TeV & 8 TeV Ecm”, in prep., to be submitted to Phys. Rev.D
3. “The MoEDAL Detector at the LHC” in prep., to be submitted to NIMA.
4. “The Mass of the Electroweak Monopole”, in prep., to be submitted to PLB
5. “The MoEDAL Experiment at the LHC”, commissioned by Contemporary Physics Journal
6. “Qballs and the Gallilean Complex Sine-Gordon Equation, to be submitted to PLB
66 physicists from 14 countries & 23 institutions on 4 continents:

10 New MoEDAL Collaborators Since June 2014

G. Melo (Alberta), S. C. Lee (Gangenung), A. Chaterjee (Geneva) A, Dubreuil (Geneva), A. Lioni (Geneva), M. Mieskolainen (Helsinki) R. Orava (Helsinki), A. Kumar (NIT, Kurukshetra), Igor Ostrovskiy (Stanford), M. King (Valencia)
Installation of MoEDAL

- Document detailing installation plan was supplied to LHCb in Spring 2014
- Presentation to LHCb technical coordination on 17th June
- Installation for 2015 started in June 2014 and ended in December 2014
- All elements of the MoEDAL detector planned for installation were installed
- MoEDAL would like to thank the LHCb collaboration particularly the technical coordination for its invaluable help in meeting our installation goals for 2015
Over 120m² of plastic Nuclear Track Detectors were deployed

- The LT-TDR detector consists of 3 sheets of CR39 and 3 sheets of Makrofol – the threshold for the CR39 is ~5 MIPs
- NTDS will be etched and then scanned using ultrafast “intelligent” optical scanning microscopes
- Response of NTDs monitored with alpha particles & heavy ions
- Plan is to change the LT–NTD array once a year.
THE HCC NTD array – threshold \( \sim 50 \) MIPs consists of \( \sim 4 \ m^2 \) (2 x 2m\(^2\)) deployed between the RICH & TT detectors (Z=2.2m)

- The HCC detector consists of 2 Makrofol foils in an Al foil envelope.
- The HCC detectors are low mass (0.3% RL) and flexible – deployed in two strips either side of the beampipe via a rail – like a shower curtain.
Analysis of MoEDAL NTDs by “Intelligent” High Rate Optical Scanning microscopes – developed by the:

- Muenster-MoEDAL group: INFN Bologna Group; and Helsinki Group
- 3D scan capable for signal pits
- Very high scan rate $\geq 60$-100 frames /sec $\rightarrow \geq 100 \text{ cm}^2$ in 40 min.
- Specialized image enhancement/pattern recognition software

Candidate events will also be studied with electron microscope.
Roughly 1 tonne of Al bar trapping detectors were deployed in three stacks (supported from concrete floor)

Bars are replaced once a year and the exposed volumes monitored by:

- A remote SQUID magnetometer at ETH Zurich for magnetic charge
- By an UG particle detector at SNOLab to detect slow decays of trapped massive charged particles.
5 TimePix devices were placed at various points around the MoEDAL cavern to monitor HIP radiation background.

- Used to monitor the low energy highly ionizing particle background.
- TimPix devices will be readout/monitored via the web.
MoEDAL Collaboration Meeting
CERN: 18th-19th June 2015

For all information regarding the meeting please check the link below
https://indico.cern.ch/event/389924/

Questions and/or problems please contact: jpinfold@ualberta.ca
Summary and Conclusion

- The size of the collaboration increased again by ~20%
- Thee publications defining the physics program of MoEDAL experiment have been published since the last report
  - Papers detailing: results of test deployments at Ecm of 7 & 8 TeV running; the detector; and, various physics studies are in preparation
- The MoEDAL detector was successfully installed for the 1st time between June & December 2014
  - But the detector needs to be renewed each year
- Prototypes for analysis of MoEDAL NTDs by “Intelligent” High Rate Optical Scanning Microscopes being refined at Muenster, INFN Bologna and Helsinki
- Plan to run until we have ~10 fb⁻¹ and/or a discovery!
- NB Thanks again to LHCb’s Technical & Software coordination
ADDITIONAL SLIDES
MoEDAL’s Complementarity

- Optimized for highly ionizing particles
- Insensitive to SM particles
- Can directly detect & trap magnetic charge
- Calibrated by heavy-ions

- Optimized for SM relativistic MIPs & photons
- Cannot directly detect magnetic charge
- Cannot be directly calibrated for highly ionizing particles

The totally different systematics of the MoEDAL and the ATLAS/CMS experiments will yield important validation of and insights into a joint observation of new physics
Cross-section limits for magnetic (LEFT) and electric charge (RIGHT) (from arXiv:1112.2999V2 [hep-ph]) assuming:

- Only one MoEDAL event is required for discovery and 10 (left) – 100 (right) events in the other (active) LHC detector.