



The MoEDAL Experiment

A Progress Report

CERN - LHC

MoEDAL / LHCb

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University of Alberta

LHCC Open Session, June 2015



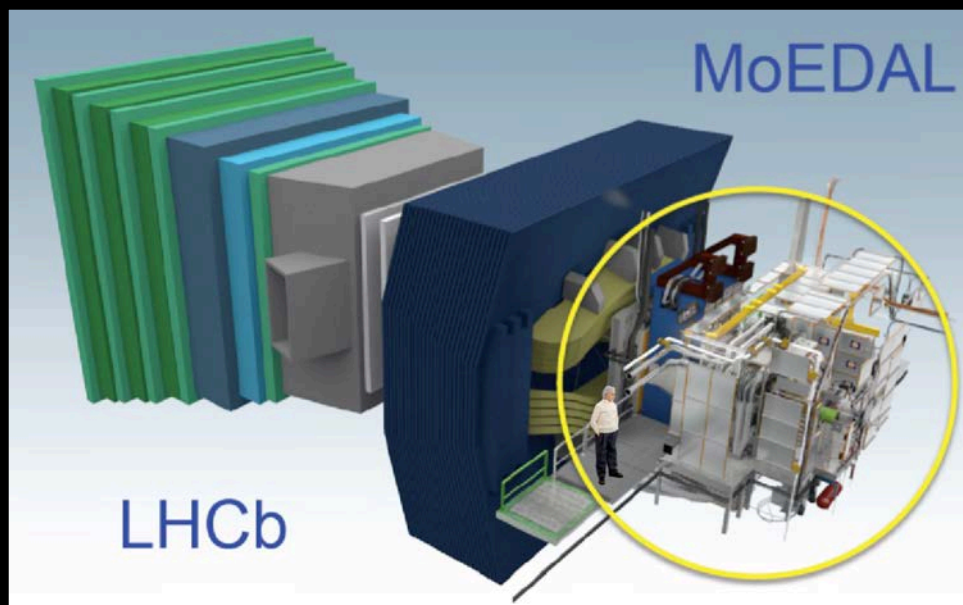
Menu

- *The MoEDAL Experiment Intro*
 - *The MoEDAL Detector*
 - *The Physics Program*
- *Progress since last report*
 - *Publications and Presentations*
 - *MoEDAL Collaboration – new faces*
 - *MoEDAL Installation winter 2014*
- *Closing words*



MoEDAL - Very Different from Other LHC Expts

**Permanent
Physical
record
of new
physics**



**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

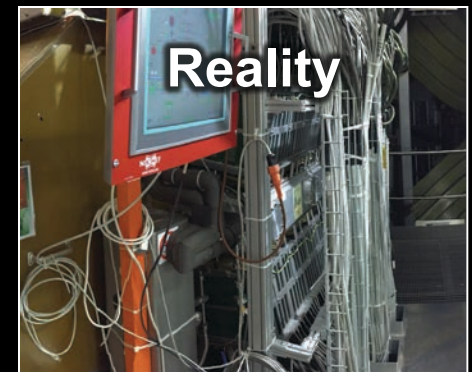
TRAPPING DETECTOR ARRAY
A tonne of Al to trap Highly
Ionizing Particles for analysis

TIMEPIX Array a digital
Camera for real time
radiation monitoring



The Analysis Effort & MoEDAL Software

The MoEDAL Software Group: J. Chwastowski, D. Derendarz, M. King, P. Malecki, P. Mermod, V. Mitsou, J. Pinfold, R. Staszewski, R. Soluk, M. Trzebiński, T. Whyntie. LHCb CONTACT: Gloria Corti



- 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_{loss} etc) in the LHCb framework for $\beta \geq 10^{-4}$

Publications June 2014 – June 2015

● PUBLISHED (By the collaboration or its members)

1. “The Physics Programme of the MoEDAL experiment at the LHC”, *Int. J. Mod. A Phys. Vol. 29* 1430050 91pp (2014).
2. “The Physics Case for the MoEDAL Experiment at the LHC”, *arXiv: 1411.7651 [hep-ph]*
3. “The MoEDAL experiment at the LHC — a new light on the high energy frontier”, *Mod. Phys. Lett. A29* 1430003 (2014)

● 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*



MoEDAL 10 Talks June 2014 – June 2015



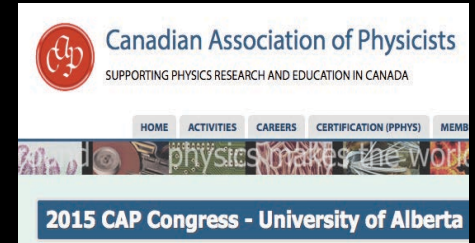
(2014)



*“LHCC Public Session”
(2014) CERN*



*“CERN Scientific Policy
Committee meeting”
(2014), CERN*



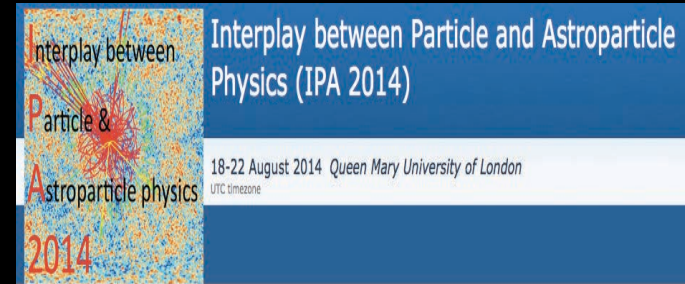
*“CAP Congress”
Alberta, (2015)*



(2014)



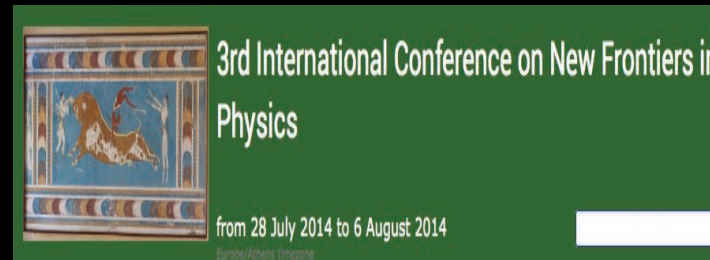
“Discrete” UCL London



*“Interplay Between Particle and
Astroparticle Physics”, QMC, London*



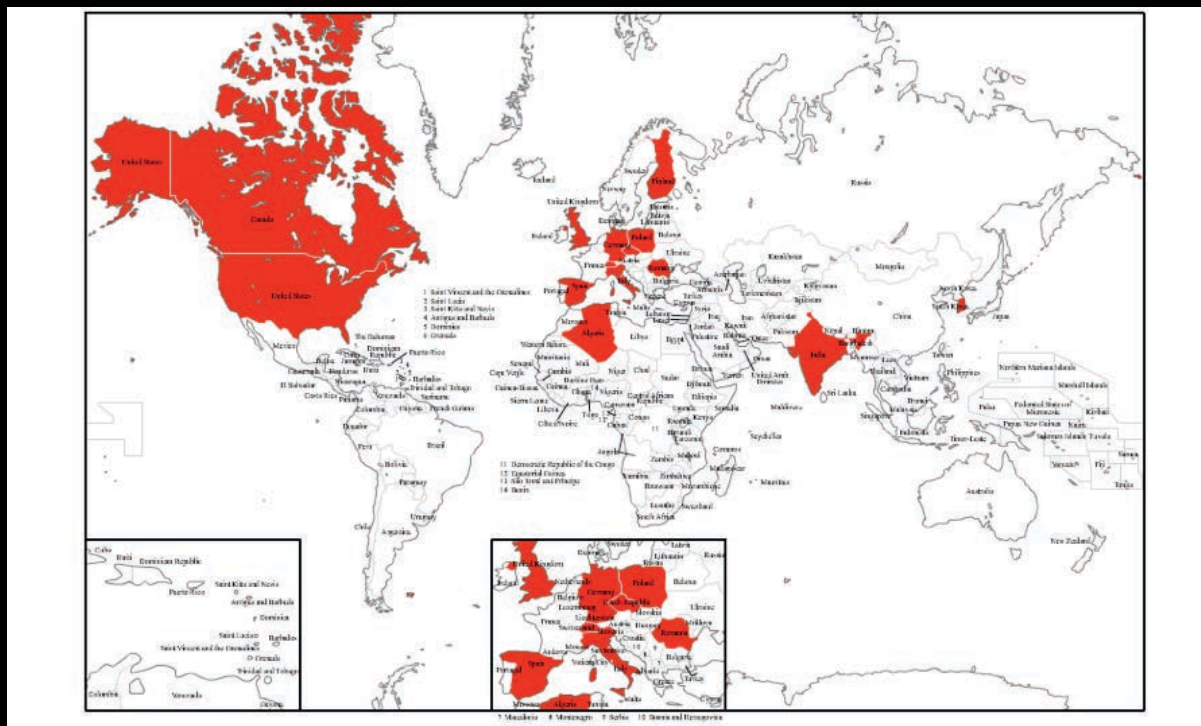
*“LHCb Collaboration”
at CERN (2014)*



*“3rd Int. Conf. on New Frontiers
In Physics” (Two talks), Crete*



The MoEDAL Collaboration



66 physicists from 14 countries & 23 institutions on 4 continents:

U. Alberta, UBC, INFN Bologna, U. Bologna, CAAG (Algeria), Algeria U. Cincinatti, Concordia U., CSIC Valencia, DESY, Gangneung-Wonju Nat. U., U. Geneva, U. Helsinki, ICTP Trieste, IEAP/CTU Prague, IFIC Valencia, Imperial College London, INP/PAS Cracow, ISS Bucharest, King's College London, Konkuk U., Muenster U., National Inst. Tec. (India), Northeastern U., Simon Langton School UK, Stanford (associate), Tuft's.



Four New MoEDAL Groups



*University of Constantine,
Algeria (with INFN Bologna)*



*University of Helsinki,
Helsinki, Finland*



*National Inst. of
Tech., India*



*Stanford University
(Assoc. Mem.) USA*

10 New MoEDAL Collaborators Since June 2014

G. Melo (Alberta), S. C. Lee (Gangnung), A. Chatterjee (Geneva) A. Dubreuil (Geneva), A. Lioni (Geneva), M. Mieskolainen (Helsinki) R. Orava (Helsinki), A. Kumar (NIT, Kurukshetra), Igor Ostrovskiy (Stanford), M. King (Valencia)



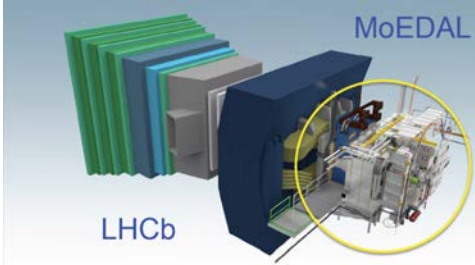
Four New MoEDAL Groups

● 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

MoEDAL Collaboration

MOEDAL INSTALLATION PLAN



RICHARD SOLUK, JAMES PINFOLD
THE UNIVERSITY OF ALBERTA
15th May 2014

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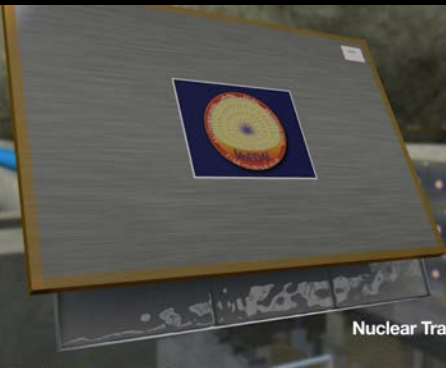
Richard Soluk rsoluk@gmail.com +1 780 907 4516 James Pinfold jpinfold@ualberta.ca +1 780 492 2498



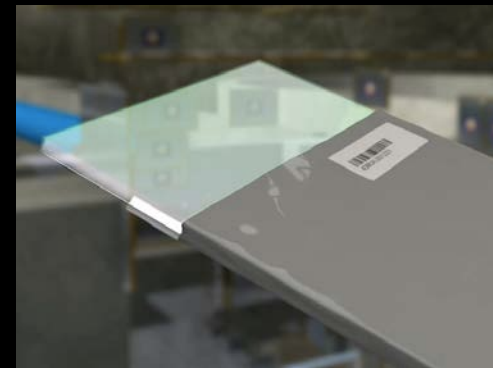
Installation of LT-NTD Array



LT-NTDs – on VELO and in Cavern



LT-NTD AI Housing



NTD stacks

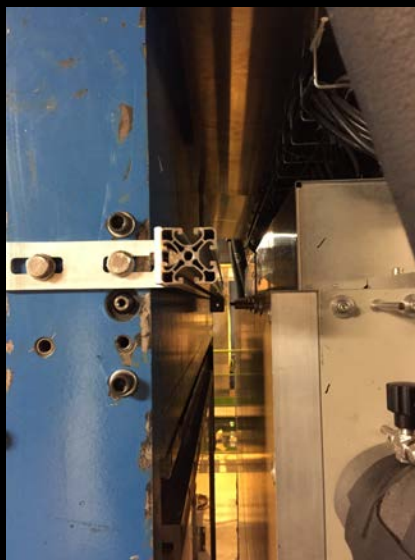
- *Over 120m² of plastic Nuclear Track Detectors were deployed*
 - *The LT-TDR detector consists of 3 sheets of CR39 and 3 sheets of Makrofol – the threshold for the CR39 is ~5 MIPs*
 - *NTDS will be etched and then scanned using ultrafast “intelligent” optical scanning microscopes*
 - *Response of NTDs monitored with alpha particles & heavy ions*
 - *Plan is to change the LT –NTD array once a year.*



Installation of HCC-NTD Array



The HCC “shower curtain” detector



Support Rail for HCC detector



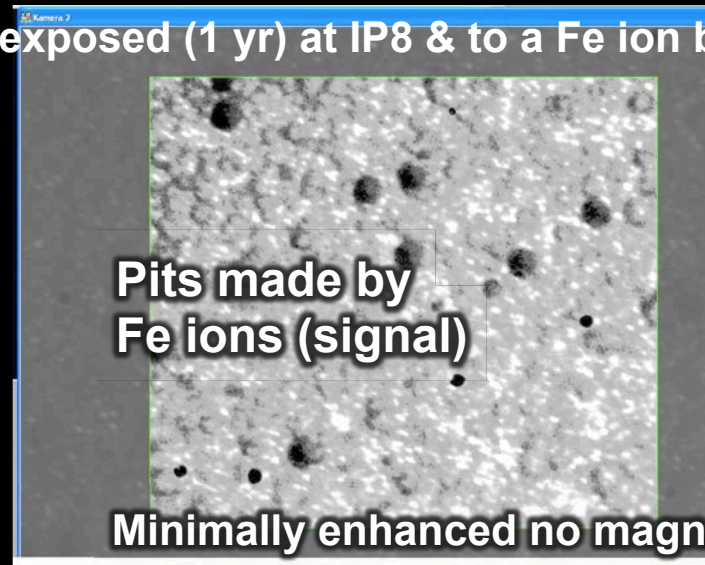
HCC detector in place next to LHCb's RICH & TT1 detectors

- *THE HCC NTD array – threshold ~ 50 MIPs consists of ~ 4 m² (2 x 2m²) 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 NTD Plastic



CR39 exposed (1 yr) at IP8 & to a Fe ion beam at BNL



- **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 ≥ 60 -100 frames /sec $\rightarrow \geq 100$ cm² in 40 min.
 - Specialized image enhancement/pattern recognition software
- **Candidate events will also be studied with electron microscope**



MMT Installation



Al bar absorbers



MMT stack 1 of 3.



Remote SQUID det.



UG monitoring fac.

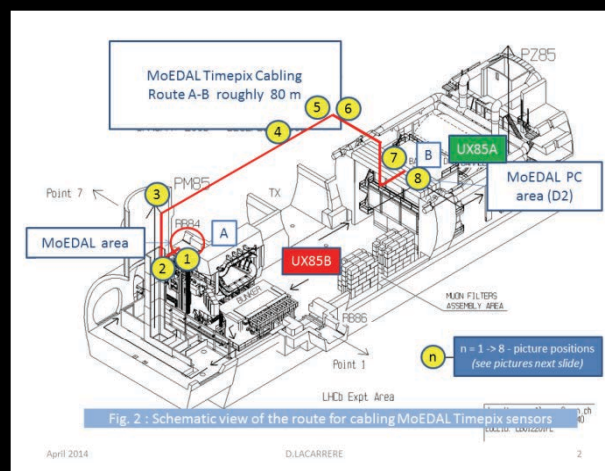
- *Roughly 1 tonne of Al bar trapping detectors were deployed in three stacks (supported from concrete floor)*
- *Bars are replaced once a year and the exposed volumes monitored by:*
 - *A remote SQUID magnetometer at ETH Zurich for magnetic charge*
 - *By an UG particle detector at SNOlab to detect slow decays of trapped massive charged particles.*



TMPX Installation



TimePix installation



Cable Routing



Readout/DAQ in D2 Barrack

- *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*
- *TimePix devices will be readout/monitored via the web.*

MoEDAL Collaboration Meeting

MoEDAL Collaboration Meeting

CERN: 18th-19th June 2015

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%*
- *Three 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 $\sim 10 \text{ fb}^{-1}$ and/or a discovery!*
- ***NB Thanks again to LHCB’s Technical & Software coordination***

ADDITIONAL SLIDES



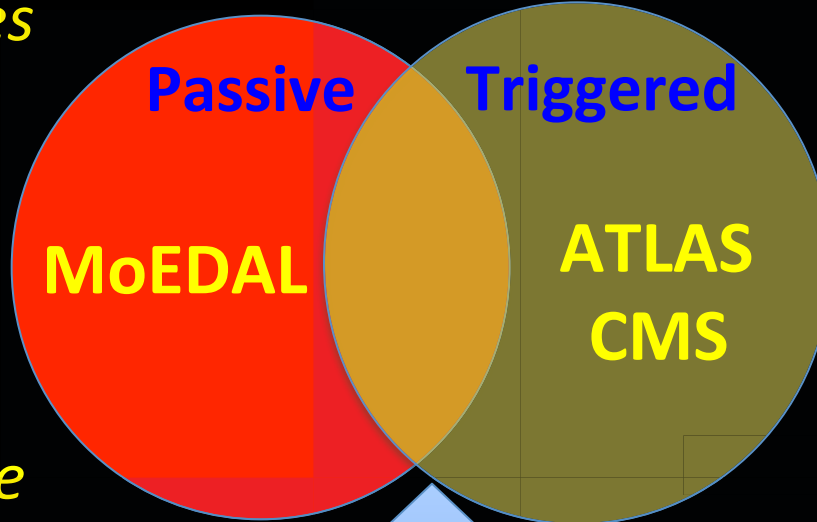
MoEDAL's Complementarity

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

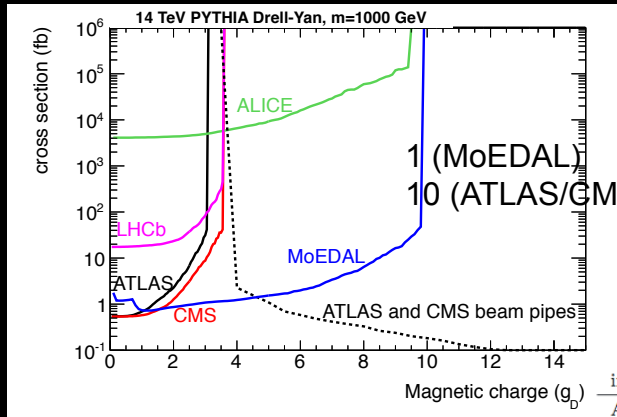
Cannot directly detect magnetic charge

Cannot be directly calibrated for highly ionizing particles

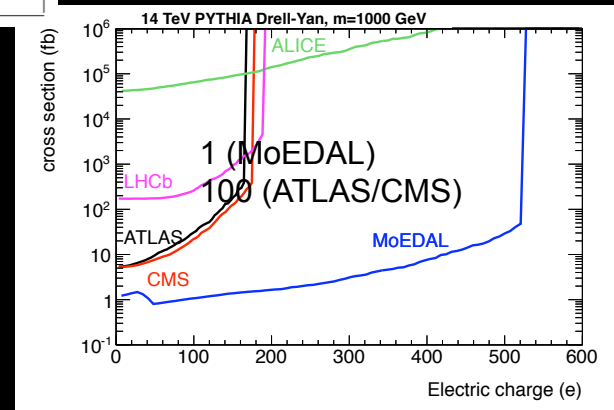
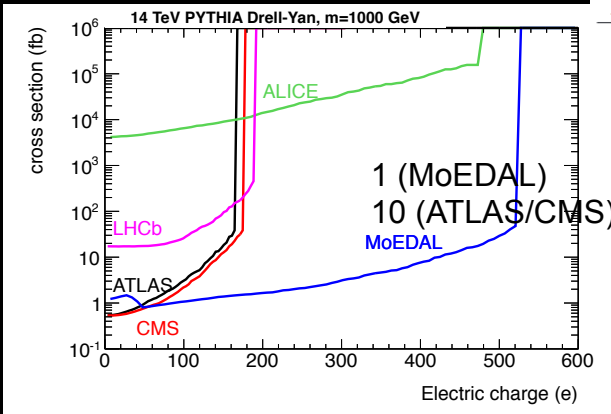
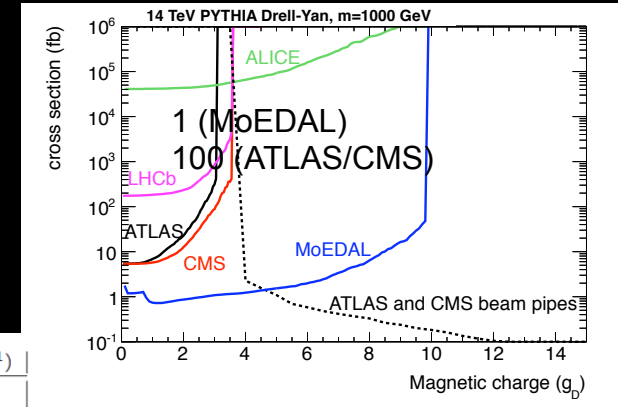
The totally different systematics of the MoEDAL and the ATLAS/CMS experiments will yield important validation of and insights into a joint observation of new physics



Sensitivity to Highly Ionizing Particles



interaction point	L ($\text{cm}^{-2}\text{s}^{-1}$)	$\int L dt$ (fb^{-1})
ATLAS	$5 \cdot 10^{33}$	20
CMS	$5 \cdot 10^{33}$	20
LHCb/MoEDAL	$5 \cdot 10^{32}$	2
ALICE	10^{30}	0.004



● Cross-section limits for magnetic (LEFT) and electric charge (RIGHT) (from [arXiv:1112.2999V2 \[hep-ph\]](https://arxiv.org/abs/1112.2999v2)) assuming:

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