



# **The MoEDAL-MAPP Report to LHCC Referees**

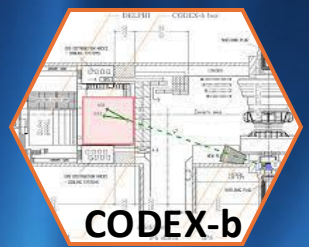
**Takeaways from presentations  
and some physics aims.**

**James L Pinfold  
for the MoEDAL-MAPP Collaboration**





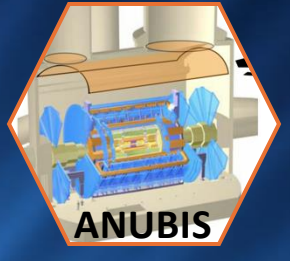
# MAPP – Covering Intermediate $\eta$



CODEX-b



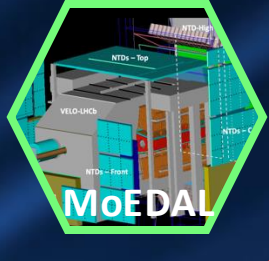
MATHUSLA



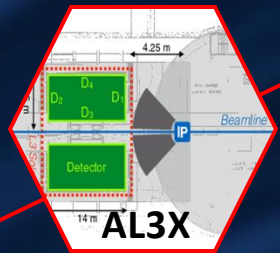
ANUBIS



MilliQan



MoEDAL



AL3X

$\eta=0$

**Transverse**  
 $0 < \eta < 1.5$

$\eta=0.5$

$\eta=1$

$\eta=1.5$

**Intermediate**  
 $1.5 < \eta < 4$

$\eta=2$

$\eta=2.5$

$\eta=3$

$\eta=4$



MAPP-2



MAPP-1

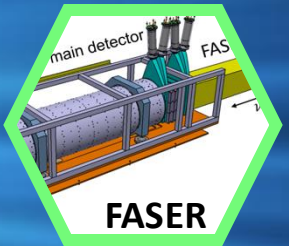
**Forward**  
 $\eta > 4$



FASER- 2, FASERnu2,  
adVSND, FORMOSA, FLARE



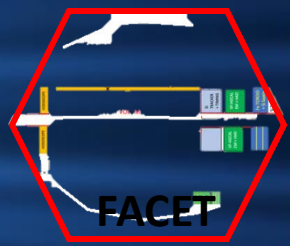
FORMOSA



FASER



SND

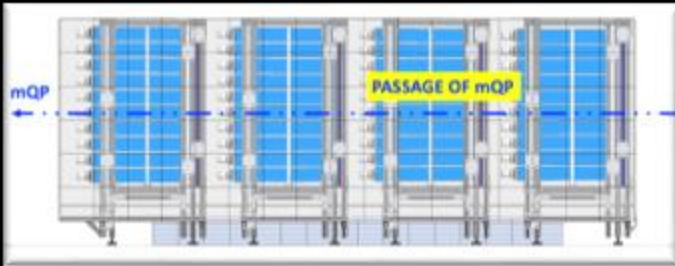


FACET

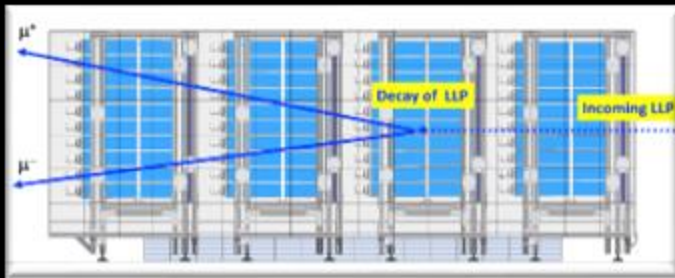
# MAPP-1 – Modes of Detection



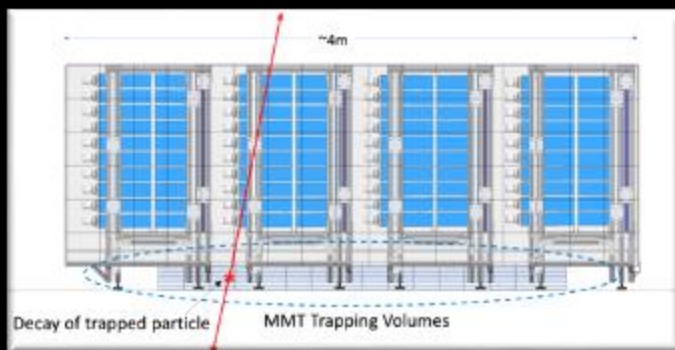
*Muons from IP (Calibration)*



*Millicharged particle detection*

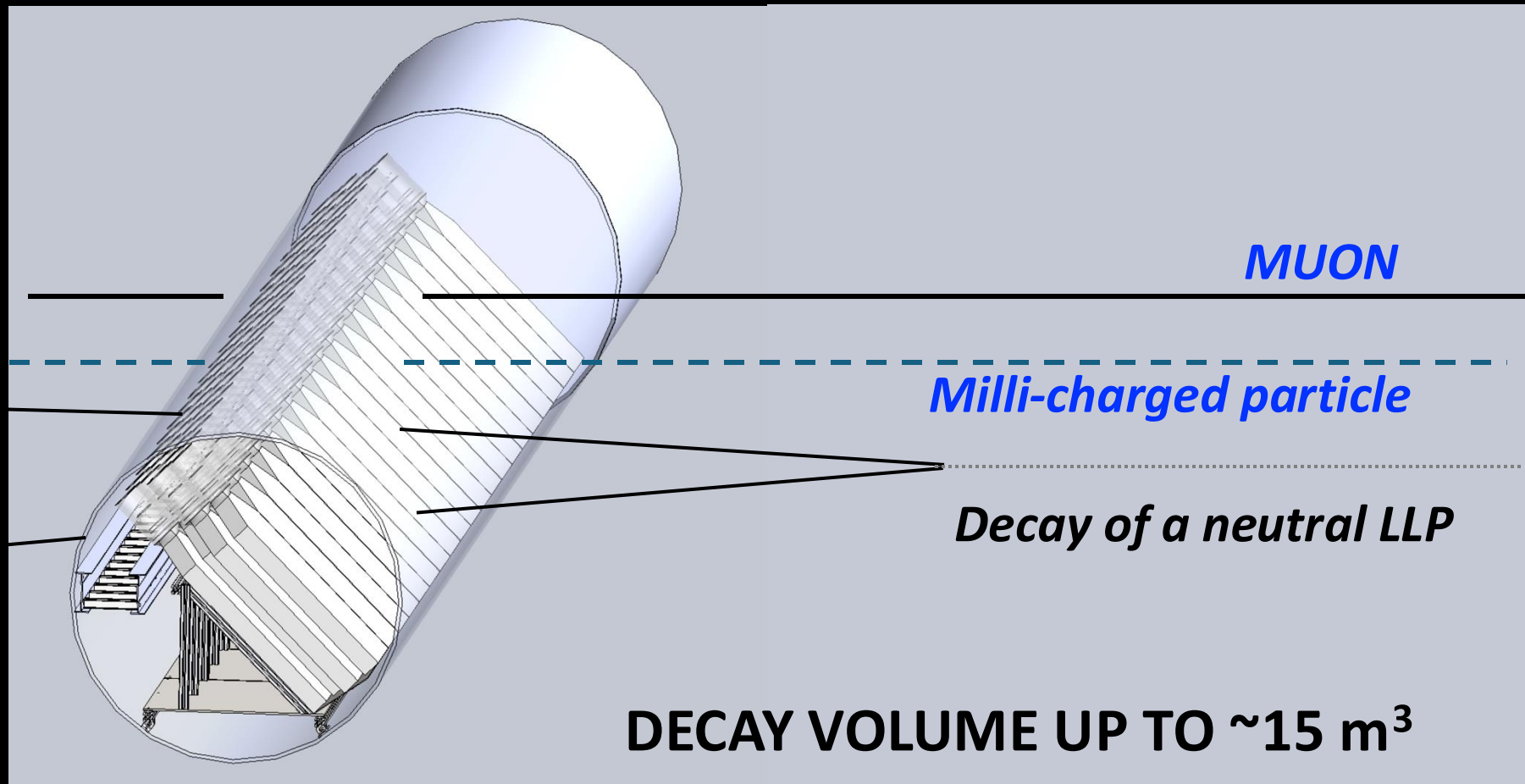


*Neutral LLP Detection*



*Charged LLP Detection  
(In conjunction with MoEDAL)*

# OUTRIGGER – Modes of Detection



**OUTRIGGER** (embedded in 8m thick concrete wall between UA83 and the beam tunnel).



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# Outrigger Status



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## The MAPP-1 Outrigger Technical Proposal

Version 1.31, November 19, 2024

M. Baker<sup>1</sup> S. Behera<sup>2</sup> P. Davis<sup>1</sup> M. Kalliokoski<sup>3</sup> I. Ostrovskiy<sup>2</sup> J. L. Pinfold<sup>1,1</sup> R. Soluk<sup>1</sup> M. Staelens<sup>4</sup> for the MoEDAL Collaboration

<sup>1</sup>Physics Dept., University of Alberta, Edmonton, Alberta, Canada.

<sup>2</sup>Physics Dept., University of Alabama, Tuscaloosa, Alabama, USA.

<sup>3</sup>Helsinki Institute of Physics, Helsinki, Finland.

<sup>4</sup>IFIC, Universitat de València - CSIC, València, Spain.

<sup>a</sup>Communicating Author, E-mail: jpinfoldualberta.ca.

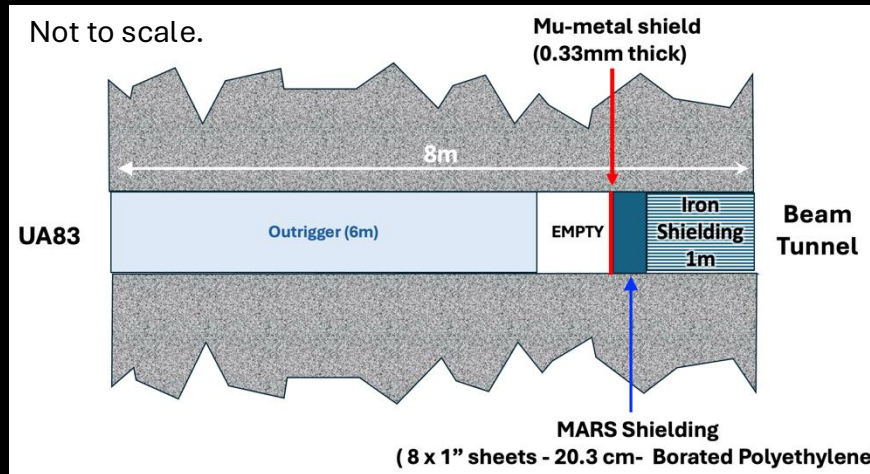
- ***The Outrigger Technical Proposal is now complete and in place***
  - *Three rows of 20 Outrigger slabs with PMTs have been completed*
  - *The machine tool needed to complete the remaining row of 20 scintillator slabs is in place and working. The work is scheduled to start Nov./Dec. All necessary materials and PMTs have been acquired.*
  - *Readout, power and calibration electronics identical to MAPP-2's*
- ***The completion of the Outrigger is on schedule for completion ready for installation in February 2025***
  - *The design of the PMTs bases still needs to be completed but is on track*





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# Outrigger + Shielding Installation



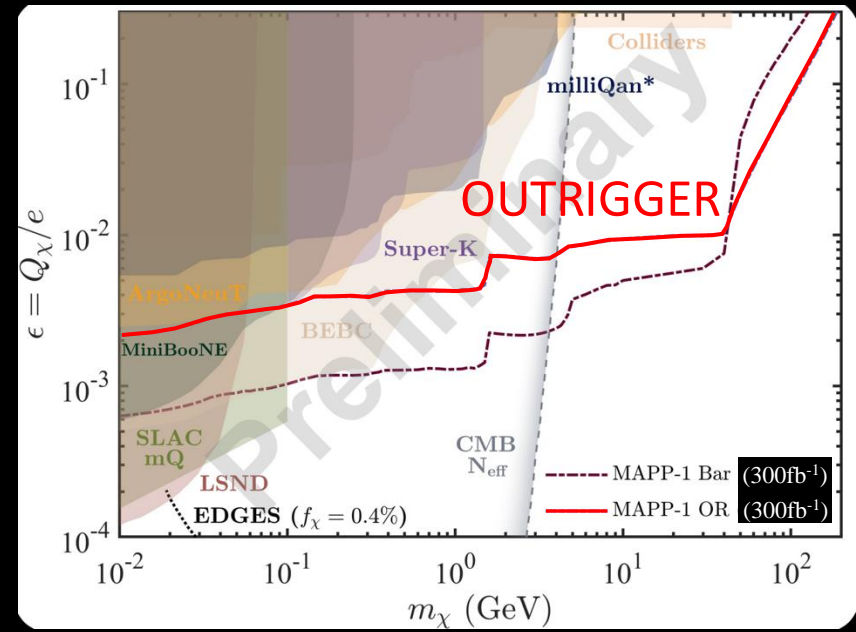
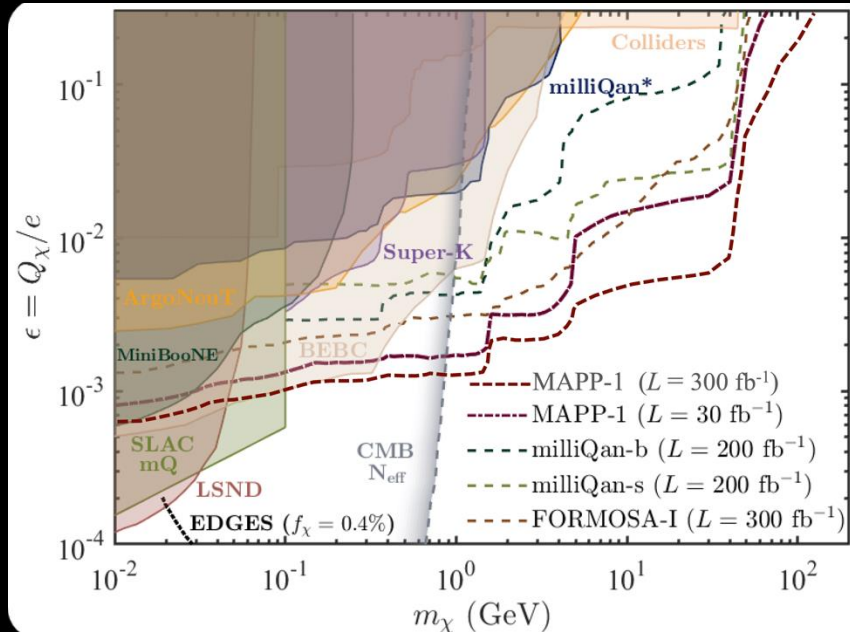
*A sketch of the design for the shielding for the Outrigger is shown above*

Task Name	Dura	Start	Finish	Text1	February	March	April
16	MoEDAL Outrigger UA83	24 days	Mon 03.02.25	Thu 06.03.25			
17	Scaffolding installation RA side	1 day	Mon 03.02.25	Mon 03.02.25			
18	Opening of insulation	1 day	Tue 04.02.25	Tue 04.02.25			
19	Removal of cable tray	2 days	Wed 05.02.25	Thu 06.02.25			
20	Scan	1 day	Fri 07.02.25	Fri 07.02.25			
21	Outrigger supports installation	1 wk	Mon 10.02.25	Fri 14.02.25			
22	Shielding transport	1 day	Mon 17.02.25	Mon 17.02.25			
23	Shielding installation	2 days	Tue 18.02.25	Wed 19.02.25			
24	Closing insulation	1 day	Thu 20.02.25	Thu 20.02.25			
25	Scaffolding removal RA side	1 day	Fri 21.02.25	Fri 21.02.25			
26	Outrigger scintillators installation	2 wks	Fri 21.02.25	Thu 06.03.25			

- *The schedule provided by the LHC machine (Francois Butin) is shown above*
- *Our plan to install rails + cable trays for Outrigger installation in-duct prior to installation is deemed compatible with the above schedule*

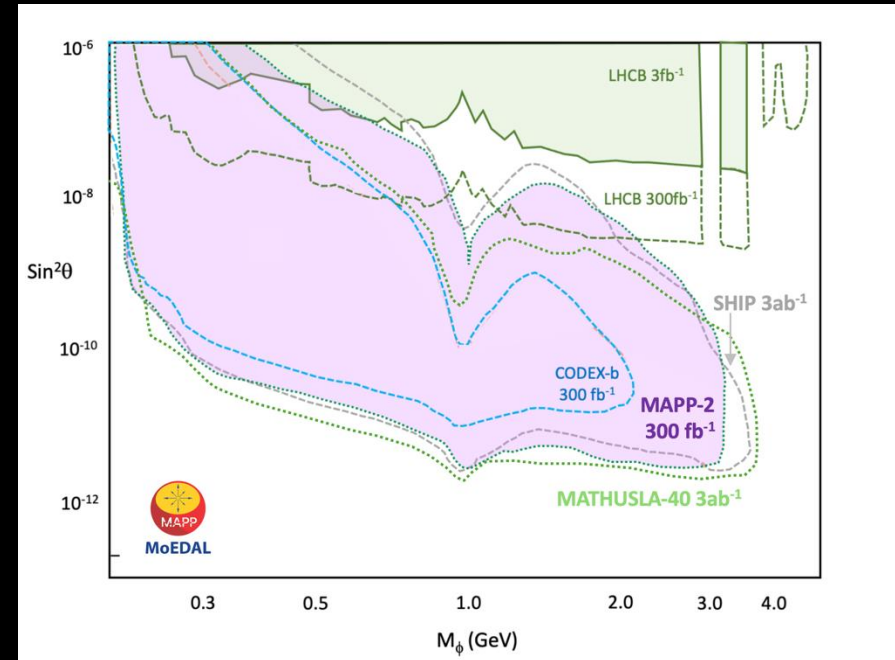
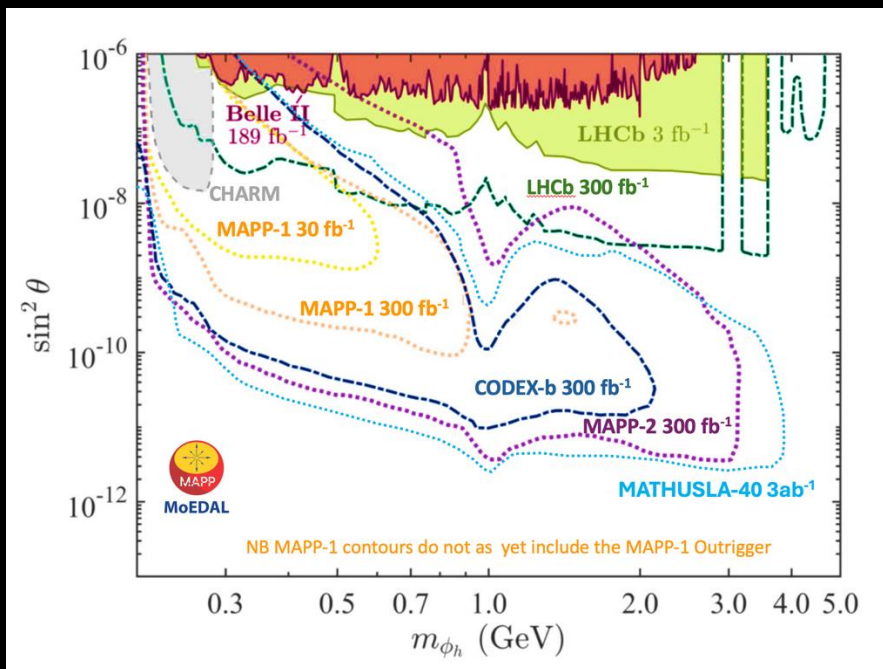
# MAPP-1 Sensitivity to Millicharged Matter

milliQan results—Phys. Rev. D 104, 032002 (2021); FORMOSA results—Phys. Rev. D 104, 035014 (2021)



- The 95% CL exclusion Limits for MAPP-1 for *mCPs produced by DY mech.* + direct decays of heavy quarkonia, light vector mesons, and single Dalitz decays of PS mesons.
  - Signal efficiency estimates included
- The OUTRIGGER improve the mass reach 130 GeV → 200 GeV

# Using MAPP-1 to Search for LLPs



The Higgs mixing portal admits inclusive  $B \rightarrow X_s \phi$  decays, where  $\phi$  is a light CP-even scalar that mixes with the Higgs, with mixing angle  $\vartheta \ll 1$ . See PRD97 (1) (2018) 15023.

- MAPP-1 + Outrigger has a combined fiducial decay volume of  $4 \text{ m}^3$  (MAPP-1) + up to  $15 \text{ m}^3$  (Outrigger).
  - CODEX-b ( $10^3 \text{ m}^3$ )  $\rightarrow$  CODEX- $\beta$  ( $8 \text{ m}^3$ ) for Run-3 a  $>100$  reduction in decay volume, without proposed CODEX-b shielding
- Thus, MAPP-1 + Outrigger is competitive as an LLP search detector until Run-4!
  - We envisage MAPP-2 takes over the LLP search starting Run-4 and is competitive with all LLP detectors actual (FASER and SHIP) and planned (CODEX-b and MATUSLA)





# Take Aways

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- *Despite the 3 days → 2 days reduction in TS2*
  - *The exposed MoEDAL NTD plastic was removed and fresh NTD detectors were installed.*
  - *The readout crate was installed along with 2 x 64 channel RO cards.*
    - *A longitudinal detector section was cabled ( 4 x (4x4) bars) and connected to the readout cards for tests.*
  - *The MAPP-1 detector was prepared for a safety inspection, which it passed – now we can run the detector with the beam on.*
  - *The MAPP-1 + Outrigger detector gives us a competitive sensitivity for LLPs (eg CODEX- $\beta$ ) as well as milli-charged particles in an intermediate pseudo-rapidity region – until LHC's RUN-4*
  - *The MAPP-1 detector, in conjunction with the MoEDAL's trapping detector, is uniquely sensitive to hyper-long-lived charged LLPs.*
  - *MAPP-2 is designed to continue the search for LLPs into Run-4 & beyond*