UNIVERSITY OF ALBERTA

Background characterization and detector model after upgrades of the DEAP-3600 detector

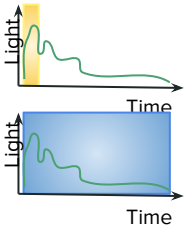
CAP Congress - June 10, 2021

Courtney Mielnichuk on behalf of the DEAP-3600 Collaboration

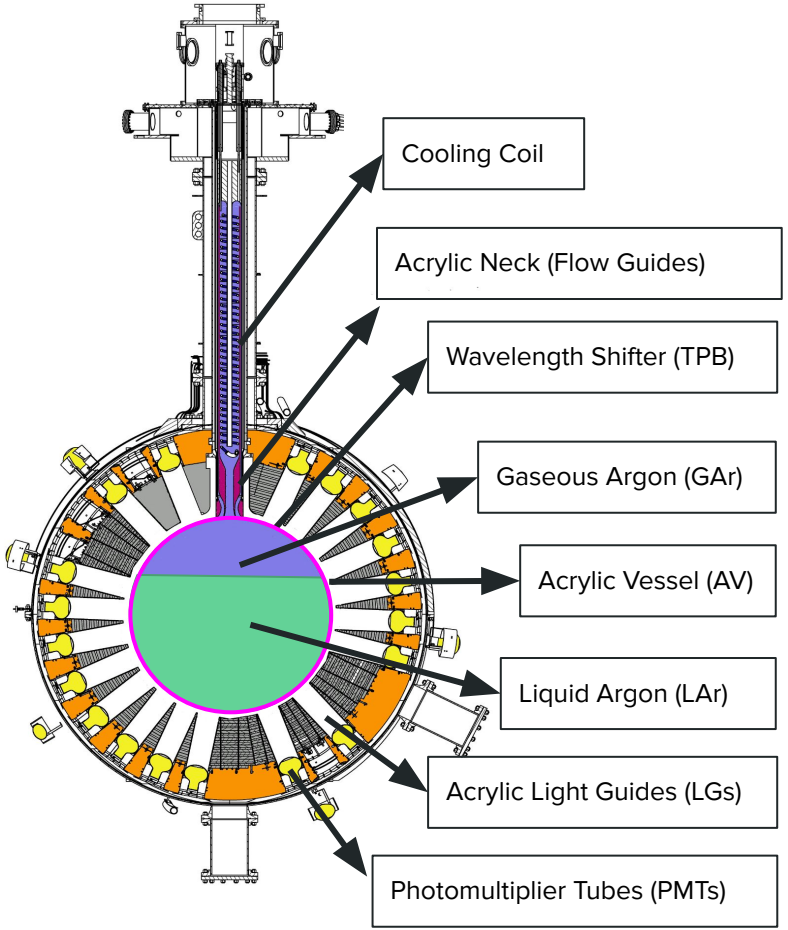
DEAP-3600 Detector

- Single phase dark matter experiment operating 2 km underground at SNOLAB
- 3300 kg liquid argon as target material contained in acrylic vessel
- Pulse Shape Discrimination (PSD):

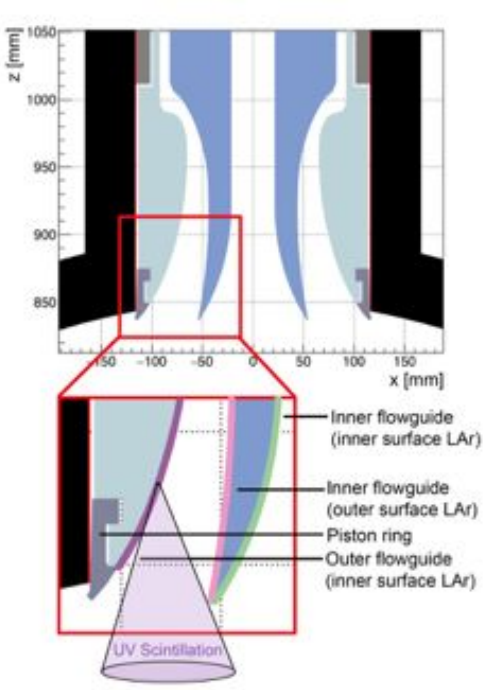
$$F_{prompt} = \frac{\text{Prompt PE}}{\text{Total PE}}$$



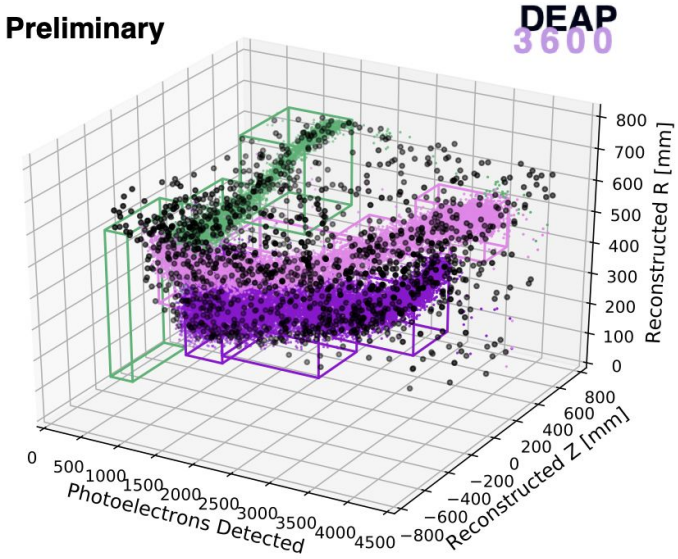
Particle Type	F_{prompt}
Nuclear Recoil	0.7
Beta/Gamma	0.3
LAr Alpha	0.75
GAr Alpha	0.12

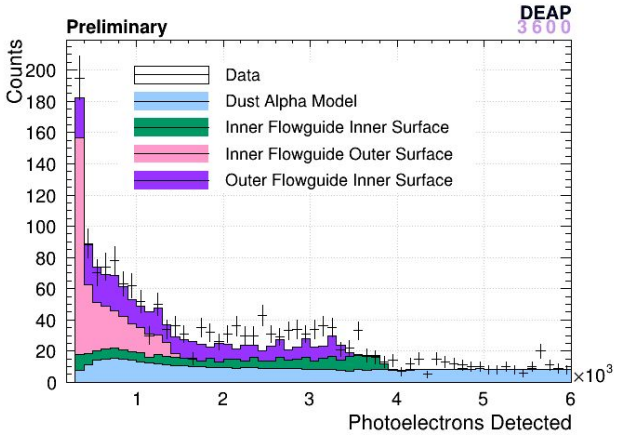


Neck Alpha Backgrounds



Condensing 4.9 g/s LAr in neck region
→ model as 50 micron LAr film



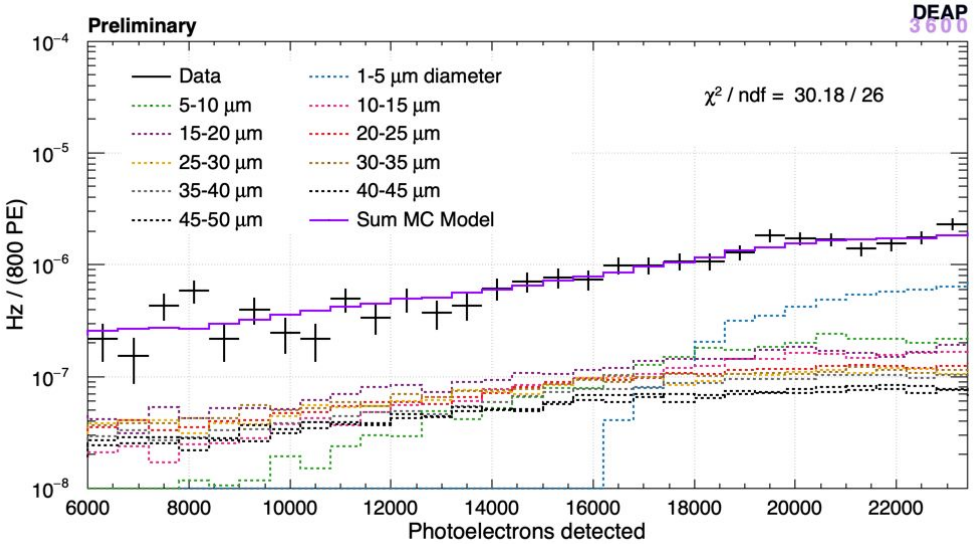


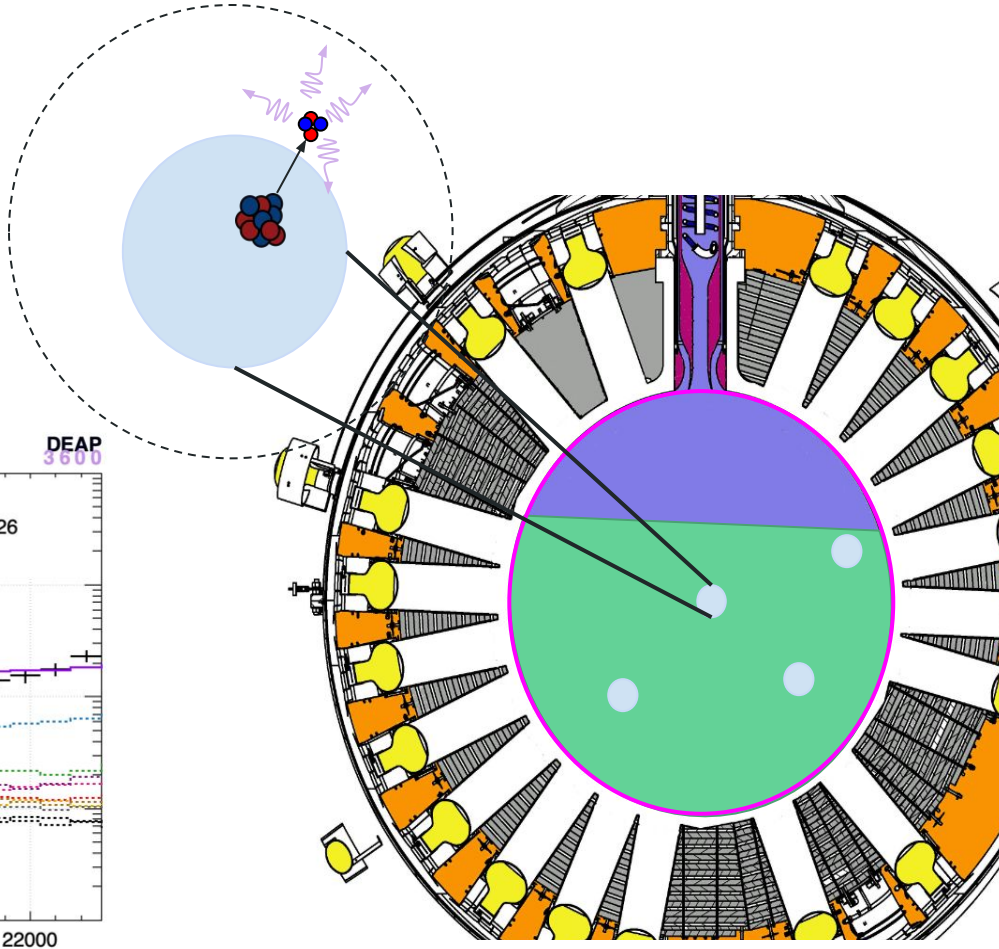
Long lived α decays

Component	Activity/Rate
^{210}Po inner FG, IS	(12.5 ± 1.1) μHz
^{210}Po, inner FG, OS	(18.9 ± 1.2) μHz
^{210}Po, outer FG, IS	(22.1 ± 1.3) μHz

Dust Alpha Backgrounds

- Alpha decay embedded in dust particulate will have reduced energy deposition in LAr and isotropic photon emission





Hardware Upgrades Summary

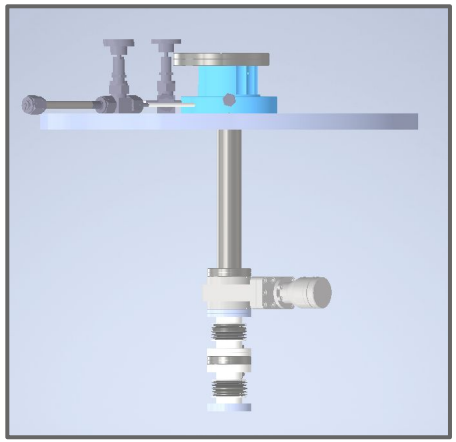
Objectives:

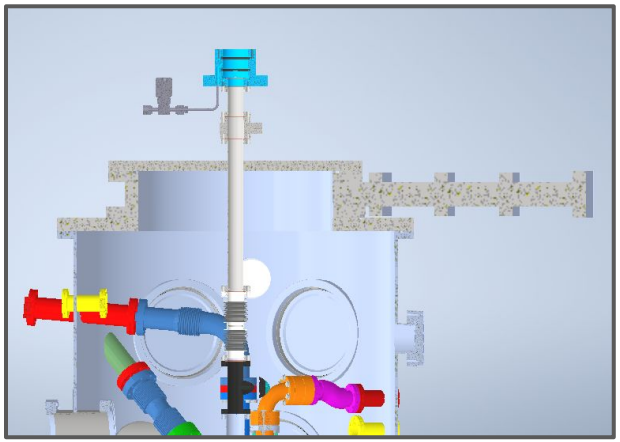
1. **Modify the detector characteristics in the neck region**
   a. Warming the neck region to remove possibility of liquid film or droplets forming
   b. Coat the flow guide surfaces with a “slow” WLS
      ↳See S. Garg’s talk for more information
2. **Remove & filter argon in a liquid state**

Upgrade Deployment System

- Designed to deploy stainless steel tubes through the neck of the existing detector
- Deployment will be done under vacuum and through the existing DEAP glovebox to prevent radon from entering the detector

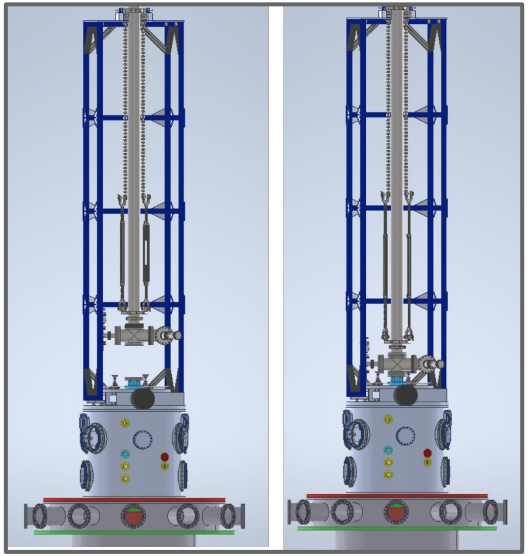
1. Install lower SDDD onto glovebox





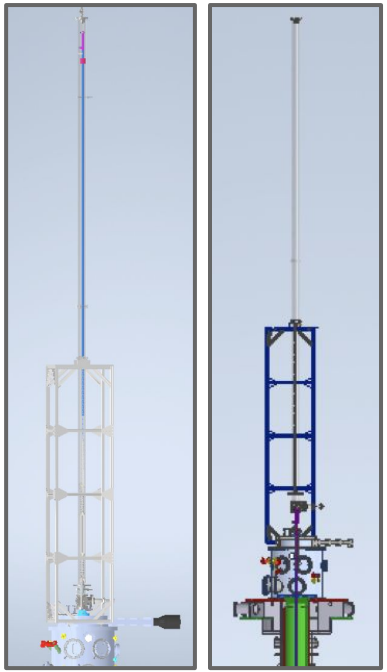
Upgrade Deployment System

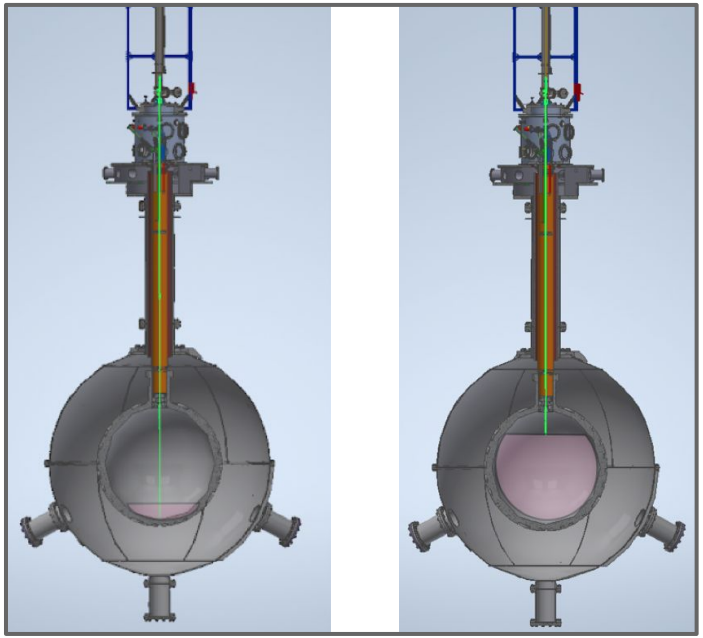
2. Install upper SDDD onto lower SDDD (contains LAr-fill or dust pipe)

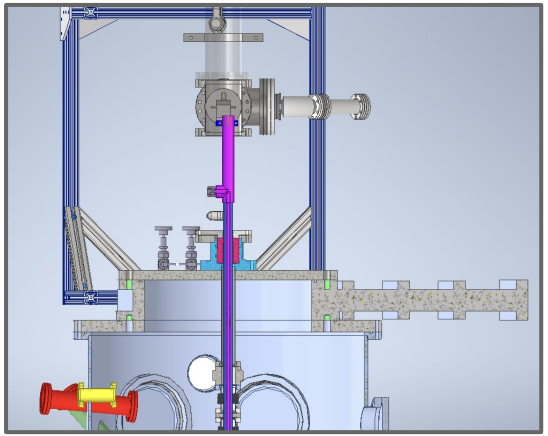


Upgrade Deployment System

3. Lower LAr-fill or dust pipe into the detector

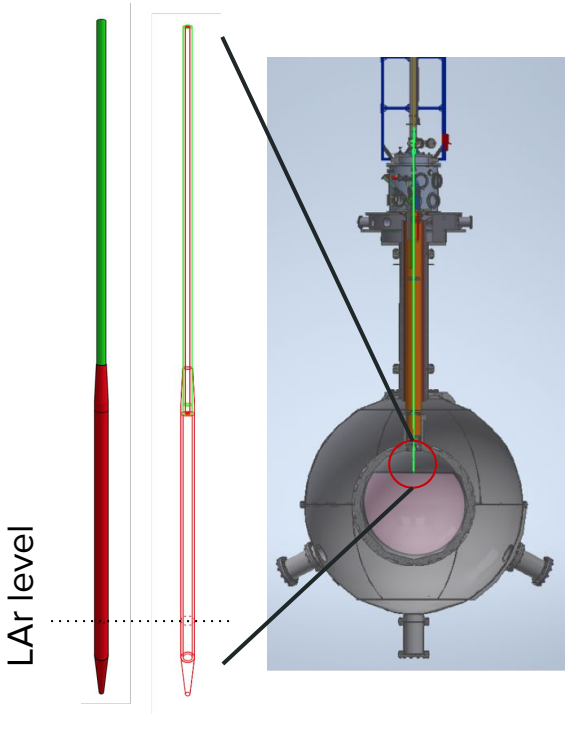






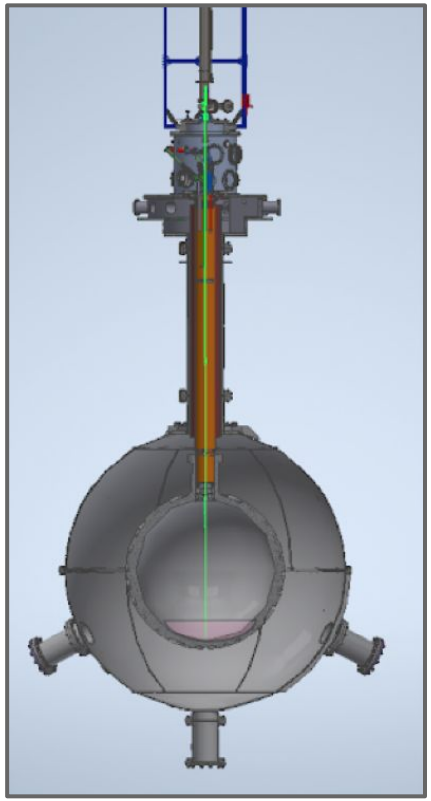
LAr Fill Tube

- Stainless steel vacuum jacketed pipe deployed through the neck to deliver LAr to the detector
- Acrylic cone attached at end of pipe to minimize high radioactive material in contact with liquid argon
- Simulation Results:
  - Surface ^{210}Po: < 0.017 events/yr (0.6 mBq/m^2)
  - Bulk ^{210}Po: < 0.00082 events/yr (0.2825 mBq/kg)



Removal of LAr Dust

1. Deployment of stainless steel pipe through the neck of the detector
    - syphon liquid argon into external storage dewar
2. Removal of dust using high purity filter installed in existing gas purification system
3. Refill AV with clean LAr



Conclusions

- Two different alpha backgrounds have been identified in the current DEAP-3600 configuration
- **Extensive upgrades to DEAP-3600 have been developed to address both backgrounds types**
- Neck alpha decays have been constrained and modelled in simulation and will be identifiable in the upgraded configuration
- Dust alpha decays have been investigated in simulation and will be mitigated by LAr removal and particulate filtration
- **Hardware upgrades are progressing well and are scheduled to be installed at SNOLAB this summer**

INFN Istituto Nazionale di Fisica Nucleare

Queen's University

Canadian Nuclear Laboratories
Laboratoires Nucléaires Canadiens

Instituto de Física

National Research Center "Kurchatov Institute"

TRIUMF

Princeton University

University of Alberta

Carleton University

Particle Physics
Rutherford Appleton Laboratory

AstroCeNT
Nicolaus Copernicus Astronomical Center of the Polish Academy of Sciences

University of Sussex

Technical University of Munich

Royal Holloway University of London

Gobierno de España · Ministerio de Ciencia, Innovación y Universidades · Ciemat Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

Johannes Gutenberg Universität Mainz

Laurentian University / Université Laurentienne

SNOLAB