DUSEL AARM Collaboration Meeting at Sanford Lab – November 12-13

DIANA – Screening Requirements

Talk Outline:

- DIANA Goals (very very briefly).
- DIANA Shielding (LUNA at Gran Sasso Example) and Detectors.
- Screening Needs.
- Low Background Counting Needs.
- Screening Timeline and Storage Needs.
- Very Early Screening.
- Rn Pollution at DUSEL

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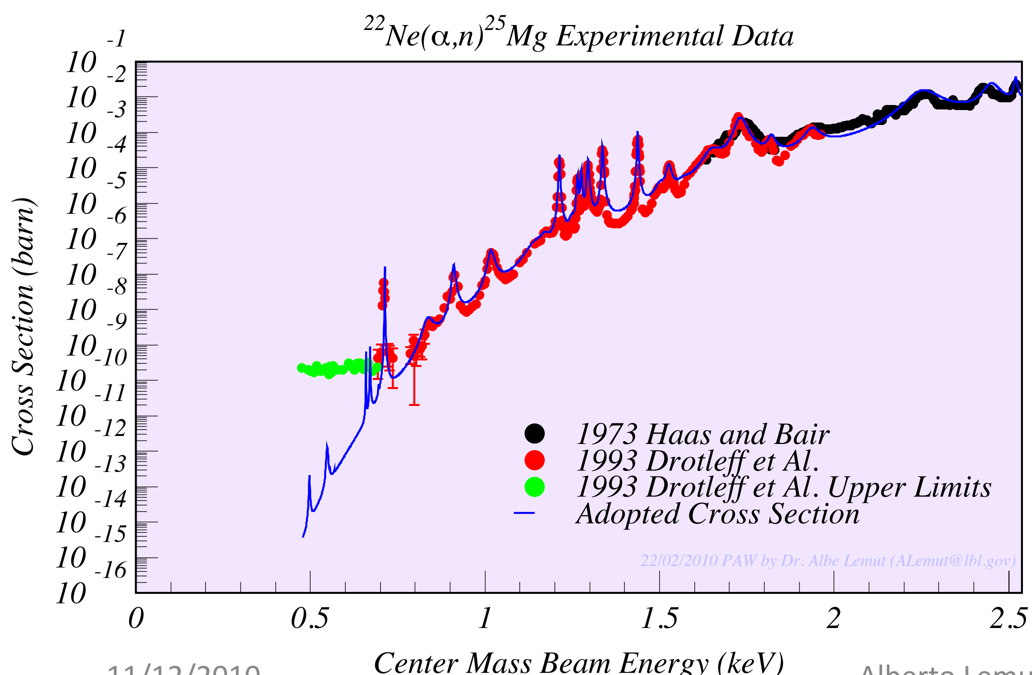
DIANA Goals

- Today it is well known that stars are powered by nuclear reactions.
- They determine the origin of elements in the cosmos, stellar evolution and dynamic, etc.
- Many reactions ask for High Precision data.

DIANA Goals:
Small Cross Section Measurements of Astrophysically Relevant Nuclear Reactions.



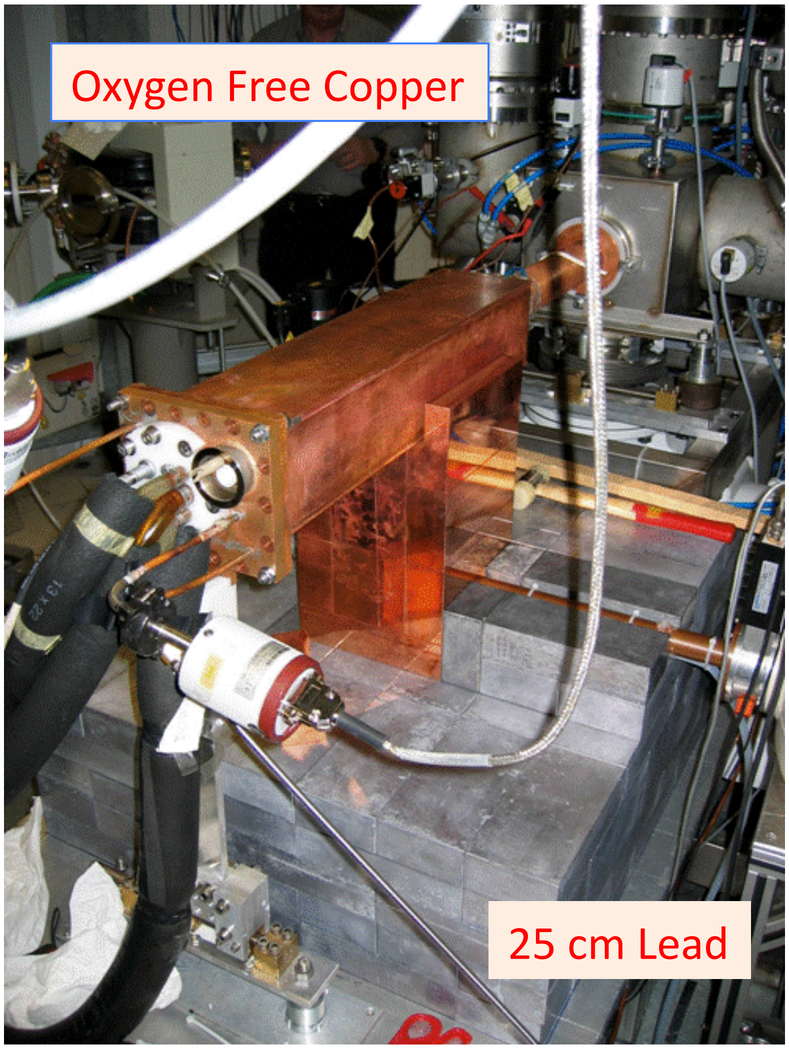
Very Small Cross Sections:

$$\sigma(E) = \frac{1}{E} e^{-\left(2\pi \frac{Z_T Z_p e^2}{\hbar} \sqrt{\frac{\mu}{2E}}\right)} S(E)$$

Low Counting Rates:
1 counts/month – 1 counts/day.

DIANA Is a Low Counting Facility for Nuclear Reactions Experiments!

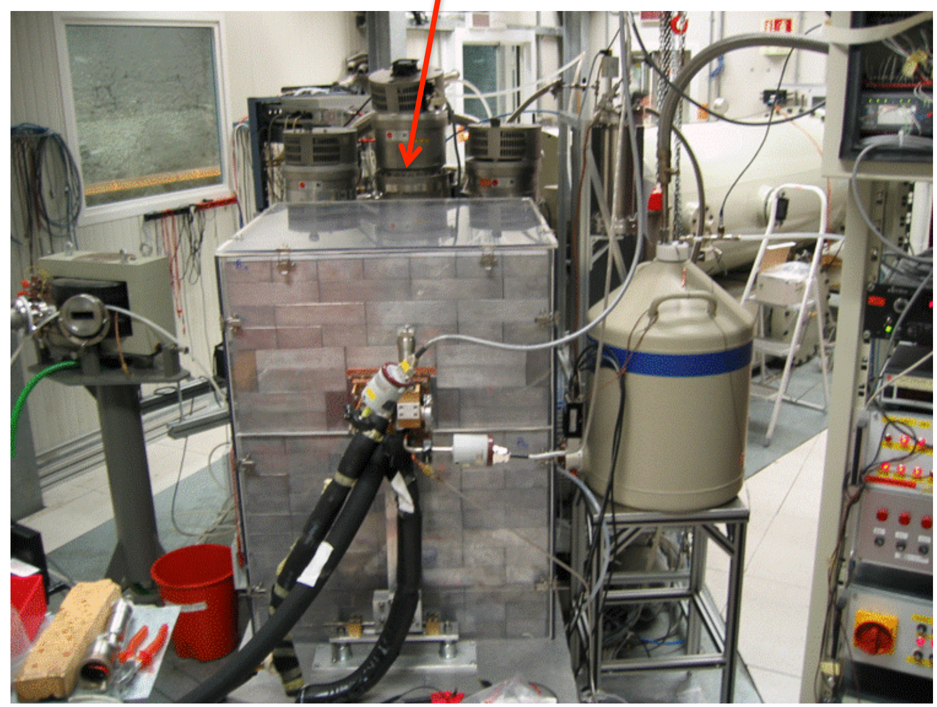
DIANA Shielding



Pictures from LUNA $^{3}He(\alpha,\gamma)^{7}Be$ Setup at LNGS

High Purity, Ultra Low Activity Materials

Radon Box Flushed with High Purity Nitrogen



5 t of lead, each brick surface cleaned with high purity chemical treatment

DIANA Detector Stations

- DIANA will have 4 γ-detector stations:
  - For each, high radio-purity lead and copper (with some additional materials) must be selected.
  - Each brick must be chemically treated for removing surface contaminations and stored in a "safe place", before installation. LNGS has high purity chemical lab: does anybody need a similar thing? If yes we may share it!
  - γ-Detectors must be selected for intrinsic low background capabilities from vendors.
- DIANA will have also a neutron detector (^{3}He counter and/or liquid scintillator, R&D project): high radio-purity materials must be selected:
  - Polyethylene, and ^{3}He or scintillator chambers (and some other materials/pieces of equipment).

Screening

- During the construction phase of the DIANA project various samples of material (lead, copper, polyethylene and some others), to be used as passive detector shield, will need to be screened for high radio-purity.
- The goal of this process is to choose the lowest contaminated sample provided by different vendors. The screening-needs are essentially low gamma radioactivity searches (tolerable activities will be defined during project development).
- Some additional alpha screening may be required for the neutron detector material selection.
- The quantity will be limited to few samples (lets say 10-20), and the counting time will depend on radio-purity (usually few days to a week or a little bit more).

Low Background Counting

- Some of the experiments performed at DIANA may additionally require a post irradiation target “activity measurement”.
- The counting rate of the samples could be very small and challenging, requiring long counting times (let’s say of the order of a month to a few months).
- Additional support by the FAARM staff could be required for the development of such challenging measurement (β^+, β^-, α counting, eventually with secondary γ’s).

Screening Timeline and Storage

- Screening Timeline:
  - DIANA will need to start high radio-purity materials selection and machining, 1-1.5 year before operations begin (2018-2019). Similar timeline for detector selection.
- Storage Needs:
  - After materials acceptance and machining, surface cleaning processing, to avoid contaminations, will be performed.
  - Then DIANA will most likely need to store the selected materials and detectors in a "safe place" while waiting for installation.
  - Quantities to be stored (and storage time), will be determined during project development, and are expected 1-10 t range for lead (less of other materials).

Very Early Screening

- University of Notre Dame (IN), Regis University (CO), South Dakota School of Mines (SD) are involved in a DUSEL early neutron background characterization project .
- At the current status they are developing a new low intrinsic background detector for this task.
- This detector consists of ^{3}He counters embedded in a polyethylene matrix.
- The selection of tube/moderator material that minimize the internal background is needed.
- What are the current (very early) screening capabilities?

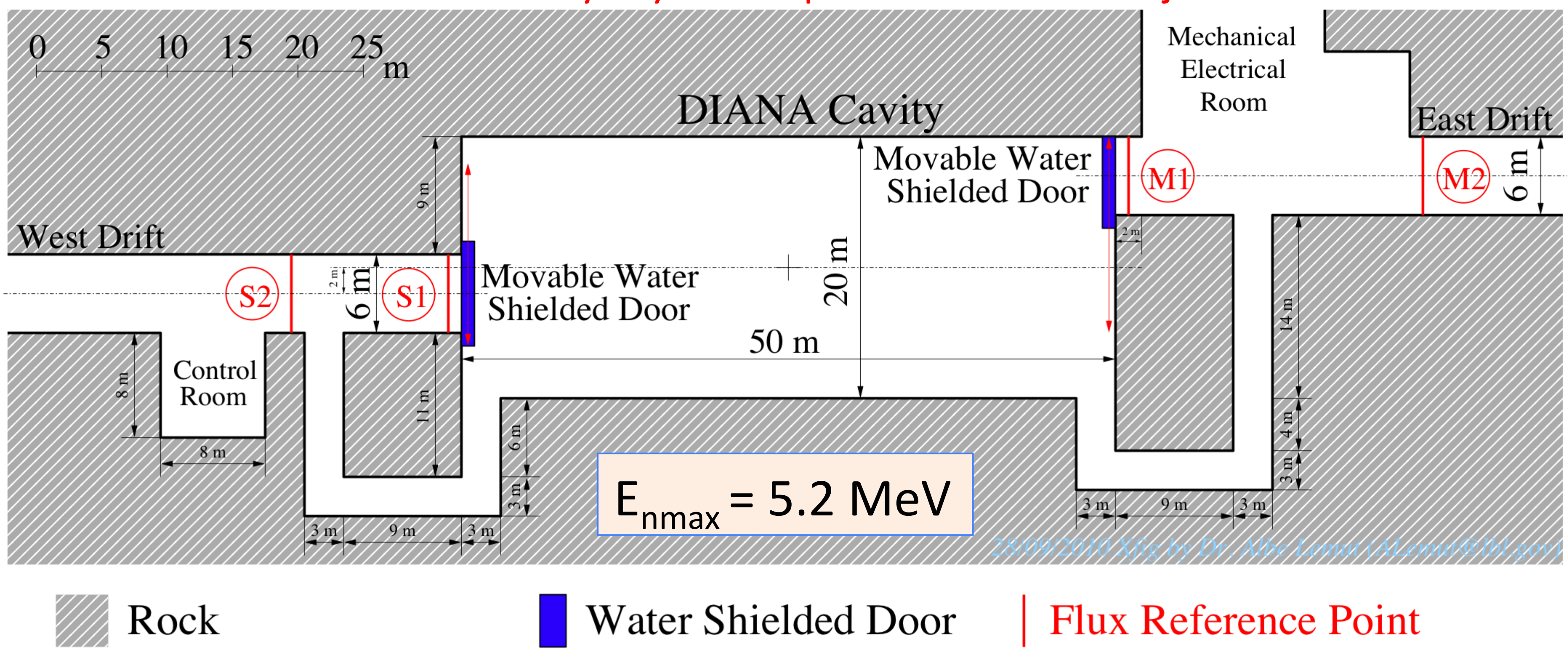
Rn Pollution at DUSEL

- The current DIANA Rn requirements provided to DUSEL projects are 30-100 Bq/m^3 (Min-Max). These numbers are derived from LUNA operations at Gran Sasso.
- In this scenario a simple LN_2 flushed Rn-box was pretty effective. However LUNA setup was sensitive to Rn concentration changes due to Gran Sasso Laboratory venting changes (i.e. shutdown due to maintenance).
- If the Rn levels are as high as Homestake mine operations (≈ 500-800 Bq/m^3), which could be expected since there is no Rn mitigation plan in the DUSEL plans, the DIANA facility should study additional Rn mitigation actions.
- At the present DIANA design level, this scenario hasn't been analyzed, and further study will be required. In particular how to make sure the Rn activity level will stay low enough in the detector area.

Thank You!

Backup Material

Modified Cavity Layout Proposed to DUSEL Project



The LM1 entrances shielding has been designed such that any beam induced radiation outside (at M2 at S2) will be **BELOW THE NATURAL RADIATION LEVELS** of DUSEL (Φ_n = (2.3 ± 0.8) × 10^{-6} n/(cm^2 s), Φ_γ = (0.32 ± 0.10) γ/(cm^2 s), after D. Mei *et Al.*, Astropart. Phys, Vol. 34 (2010) 33 - 39).