Radon-Induced Backgrounds: Introduction with Sources and Assay Overview

Juergen Reichenbacher

South Dakota School of Mines & Technology (SDSMT)

DUNE Backgrounds Mitigation Strategies Workshop

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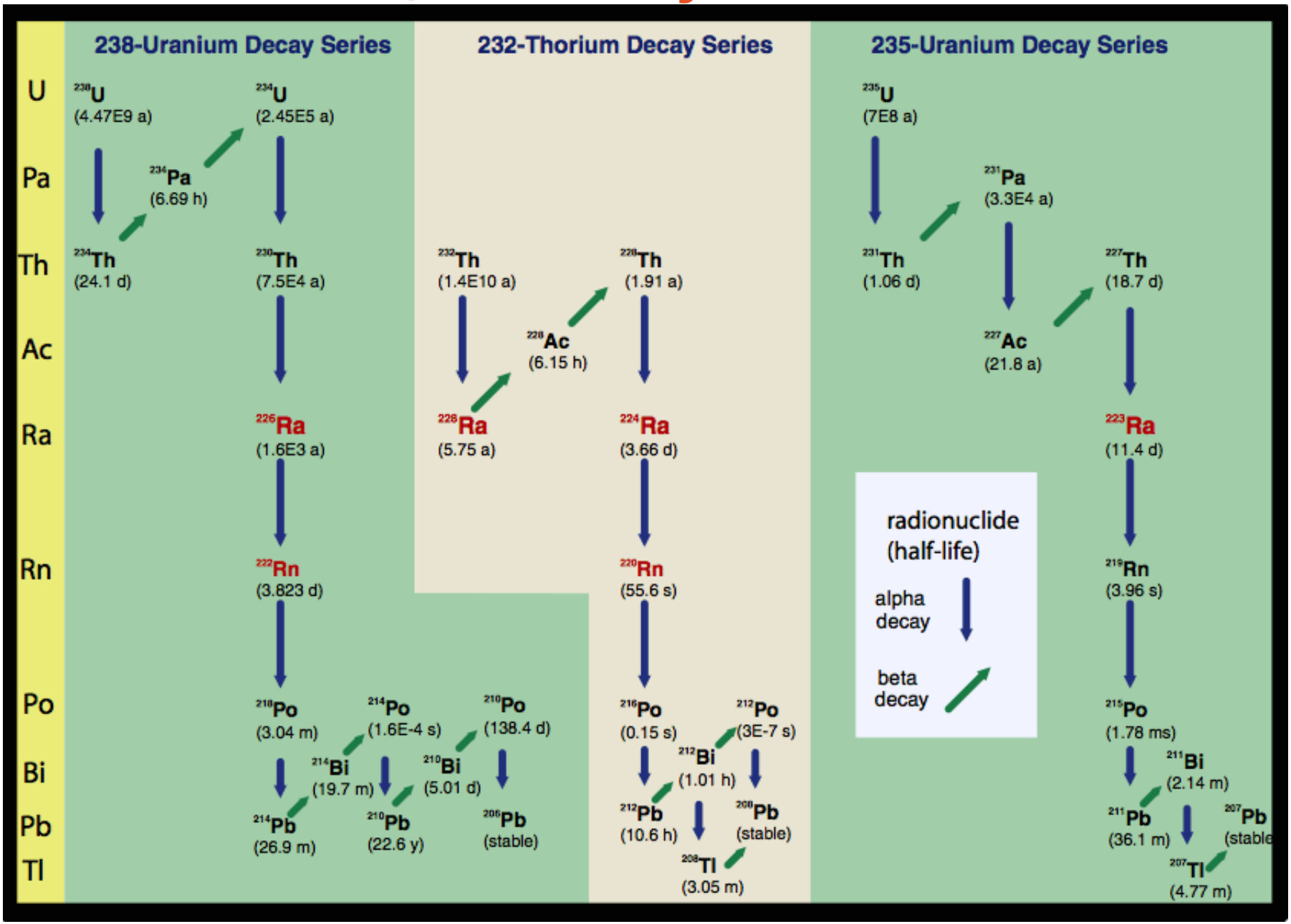
U, Th Decay Chains



Recommendation 3 (Previous Review Report)

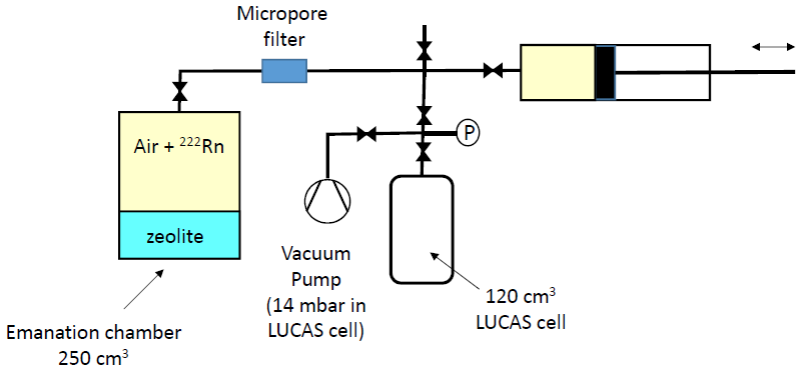
Radon in LAr (original requirement <10 mBq/kg):

“We recommend that radon level specifications be reduced to at least 1 mBq/kg in order to reduce this background to the level expected of external neutrons, and that a cost-benefit study of 0.1 mBq/kg be performed to determine if this is a goal that could be achieved without extraordinary measures.”

=> We already suggested requirement of 1 mBq/kg and assayed LAr filter materials and started cold emanation measurements (potential main driver of radon in LAr)

Internal Backgrounds: Radon Emanation into LAr from Filter Materials

Jose Busto (CPPM Marseille)



	Zeolite	Cu Getter
Mass	71.5 g (20Bq/kg)	76.5g (2Bq/kg)
Ra in emanation chamber	1.44 Bq	0.153 Bq
Rn in Lucas cell	40.1 Bq/m3	20 Bq/m3
Rn in emanation chamber	0.01 Bq/m3	0.0052 Bq/m3
Ration Rn in air chamber	0.7 %	3.4 %

=> 0.55 mHz/kg alpha-ray activity in our LAr corresponding to a Rn-222 level of only 0.14 mBq/kg

This would already meet our Recommendation!

=> 0.1 mBq/kg goal of Rn-222 in LAr seems feasible (especially with further cold suppression)!

Plans for unique cold emanation measurement into Ar

⇒ Asks for extensive emanation assays of "2nd order" components
(e.g. large cables @ Sheffield?)

Recommendation 4 (Previous Review Report)

(alpha, n) in LAr:

“Committee recommends measuring the cross-section in a dedicated small experiment in order to obtain reliable prediction of the background rate.”

=> We have green light received from Notre Dame to measure this xsection at accelerator (together with Frank Strieder/SDSMT of CASPAR),
but DUNE excavation forces CASPAR to move into new location (=> too busy 2020)

=> use Vitaly’s calculations for now

Recommendation 5 (Previous Review Report)

Pb-210 Plate-Out:

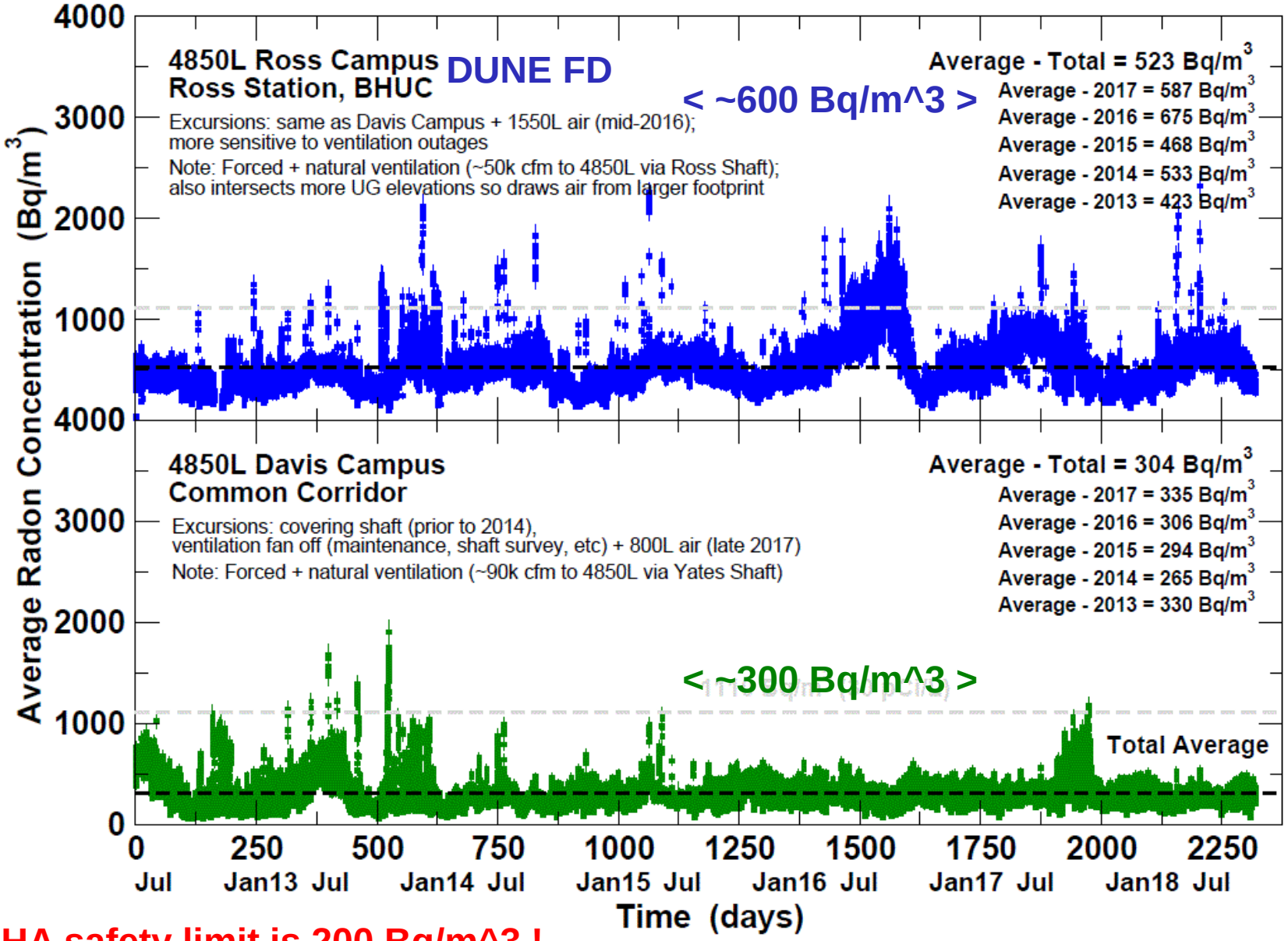
“The committee recommends that the collaboration compile any available data on 210-Pb plate out to make an estimate of the potential impact.”

=> Note in Oct 2018 at the DUNE Installation workshop at Sanford Lab, I presented my radon daughter plate-out and dust deposition modeling for cleanliness requirements (https://indico.fnal.gov/event/18435/other-view?view=standard)

=> Further, we suggest using simple protection means on detector components such as cover foils that also block radon (and possibly backfill those with boil-off nitrogen during installation)

SURF Underground Radon Concentration

Using Saphymo Alphaguard detectors since July 2012



OSHA safety limit is 200 Bq/m^3 !

Updated November 9, 2018

How much Radon Daughter Plate-Out to expect: Jacobi Model

High radon levels underground!

Selected model is the Jacobi model

Total Pb-210 activity allowed on component (mBq/m^2)	200.0
Radon Concentration (Bq/m^3)	300.0
Clean Room Volume (m^3)	11760.0
Clean Room Surface Area (m^2)	3360.0
Radon Daughter Diffusion Velocity (m/hr)	10.0
Air Recirculation Rate (cfm)	10000.0

Quantity	Units	Value
Exposure Limit for 200.0 mBq/m^2	**day**	**3.36990643221**
Radon Activity	Bq/m^3	300.0
Room Volume	m^3	11760.0
Room Surface Area	m^2	3360.0
Deposition Rate	hr^{-1}	2.85714285714
Ventilation Rate	hr^{-1}	1.44474489796
Plate-out Activity Deposition Rate	$mBq/m^2/day$	59.3488288246
Exposure Limit for 1 mBq/m^2	day	0.0168495321611

⇒ ***Recommend to protect PDs / APAs with foil (and ideally fill bags with nitrogen) to limit exposure during a one year long installation***

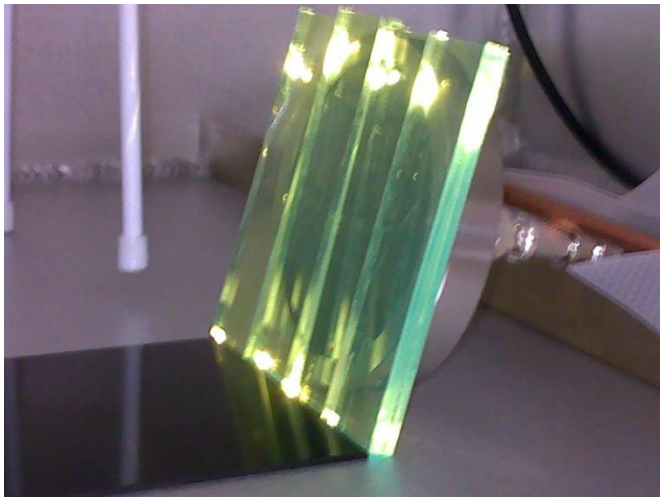
⇒ ***Surface alpha-activity on PDs from dust deposition in one year: 20 Bq / m^2 (>> 0.2 Bq / m^2 requirement from earlier slide) -> limit dust exposure on PDs***

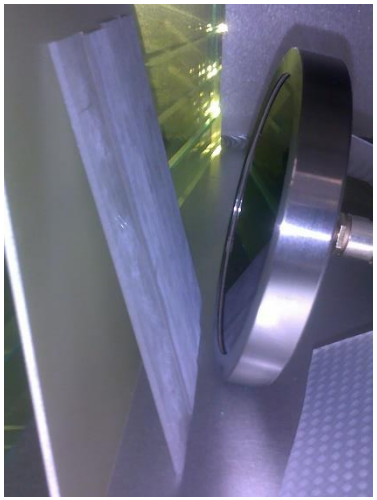
⇒ ***Several mBq/kg if all Pb-210->Bi-210->Po-210 gets dissolved!***

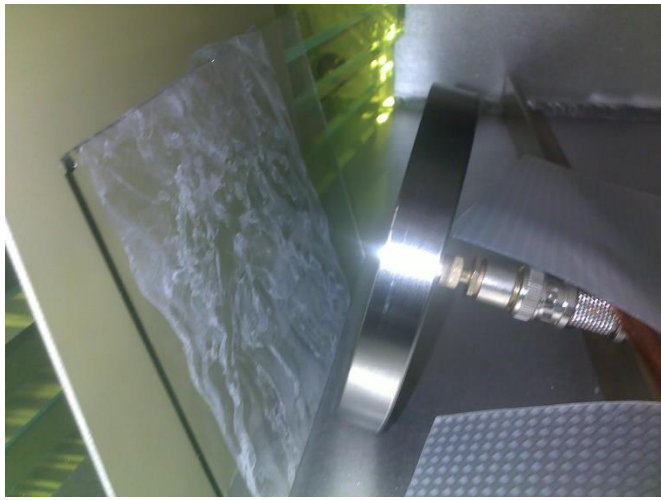
Surface α-Activity on Photon Detectors Could be Critical

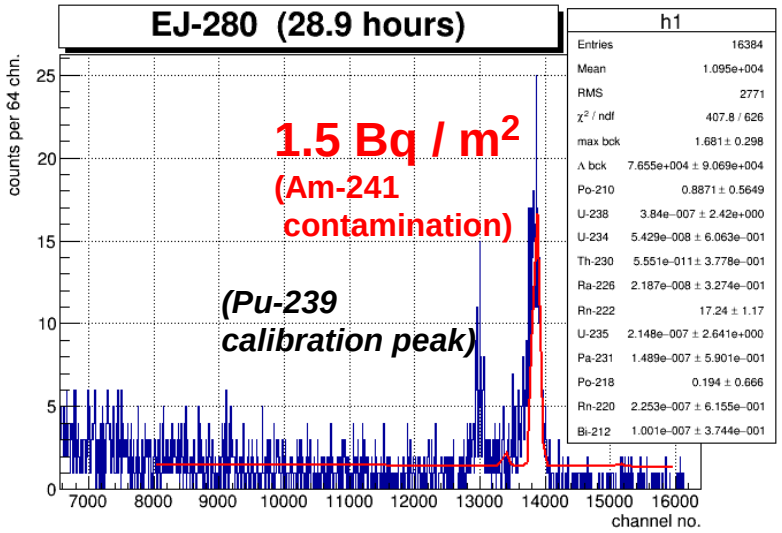
<200 mBq / m^2 α-activity uniformly distributed across surfaces

α/β–screening with AlphaBACH at Mines:





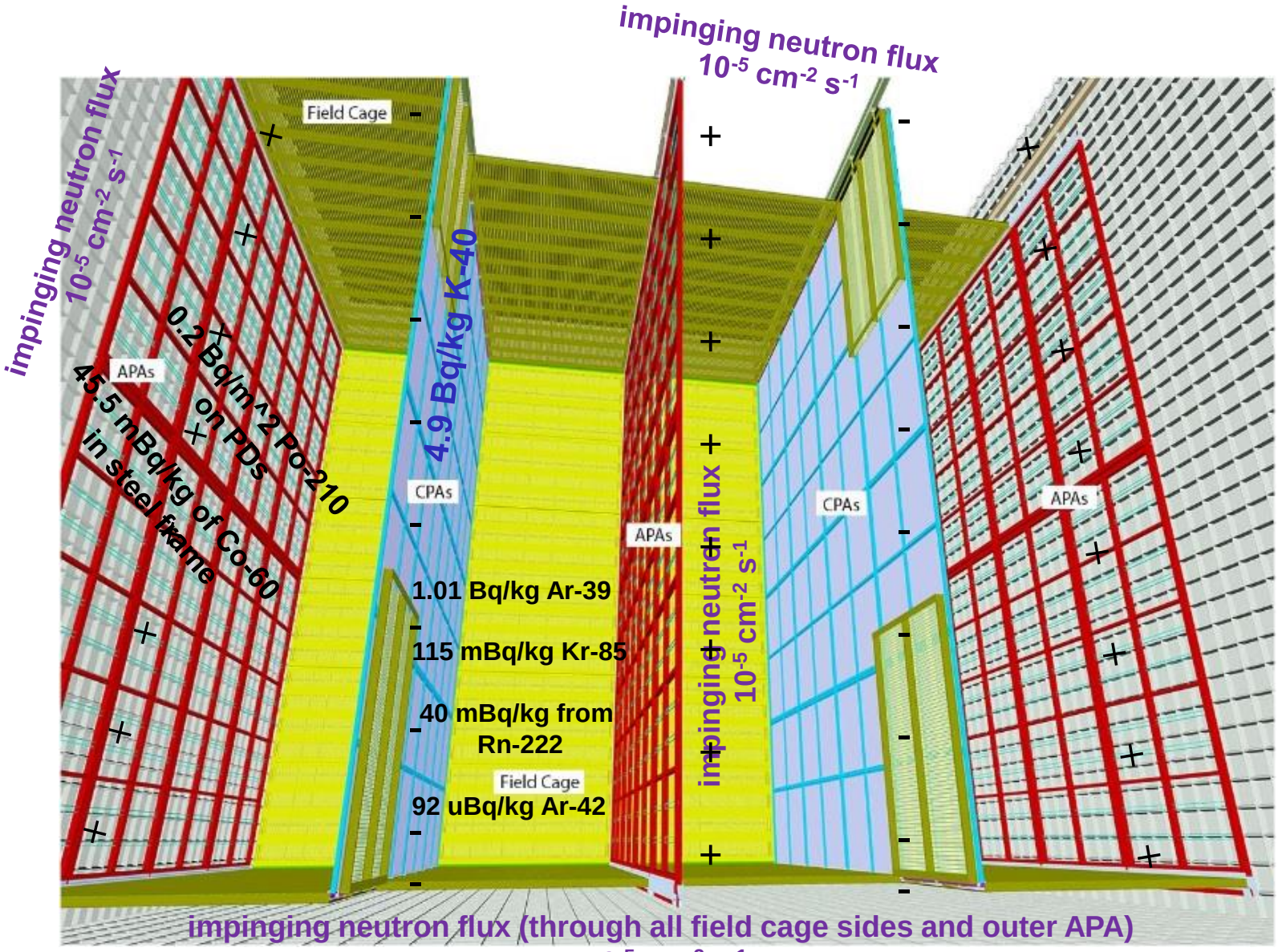




Eljen-280 WLS strips, coated TallBo plates & heat shrink contaminated during handling at IU, although 1000x below NRC swipe sample sensitivity
(but 1000x above AlphaBACH sensitivity)

In addition heat shrink shows excessive triboelectric effect,
prolifically attracting radon daughters from air!

Model Migration of Radon Daughter Ions in LAr



Outlook

- Already meet our recommendation on radon content in LAr of 1 mBq/kg
- 0.1 mBq/kg goal of Rn-222 in LAr seems feasible (especially with further cold suppression)!
- Unique cold emanation measurement into Ar is ongoing
- Results encourage extensive emanation assays of “2nd order” components (e.g. large cables @ Sheffield)
- Mitigate radon daughter plate-out (clean air ventilation?, radon reduction system?, protective coverings? remedial cleaning?)
- (alpha, n) cross section measurements and n-yield calculations are crucial
- Implement a model for migration of radon daughter ions in LAr