

Hardware R&D Towards DARWIN: Construction of a Radon Emanation Chamber

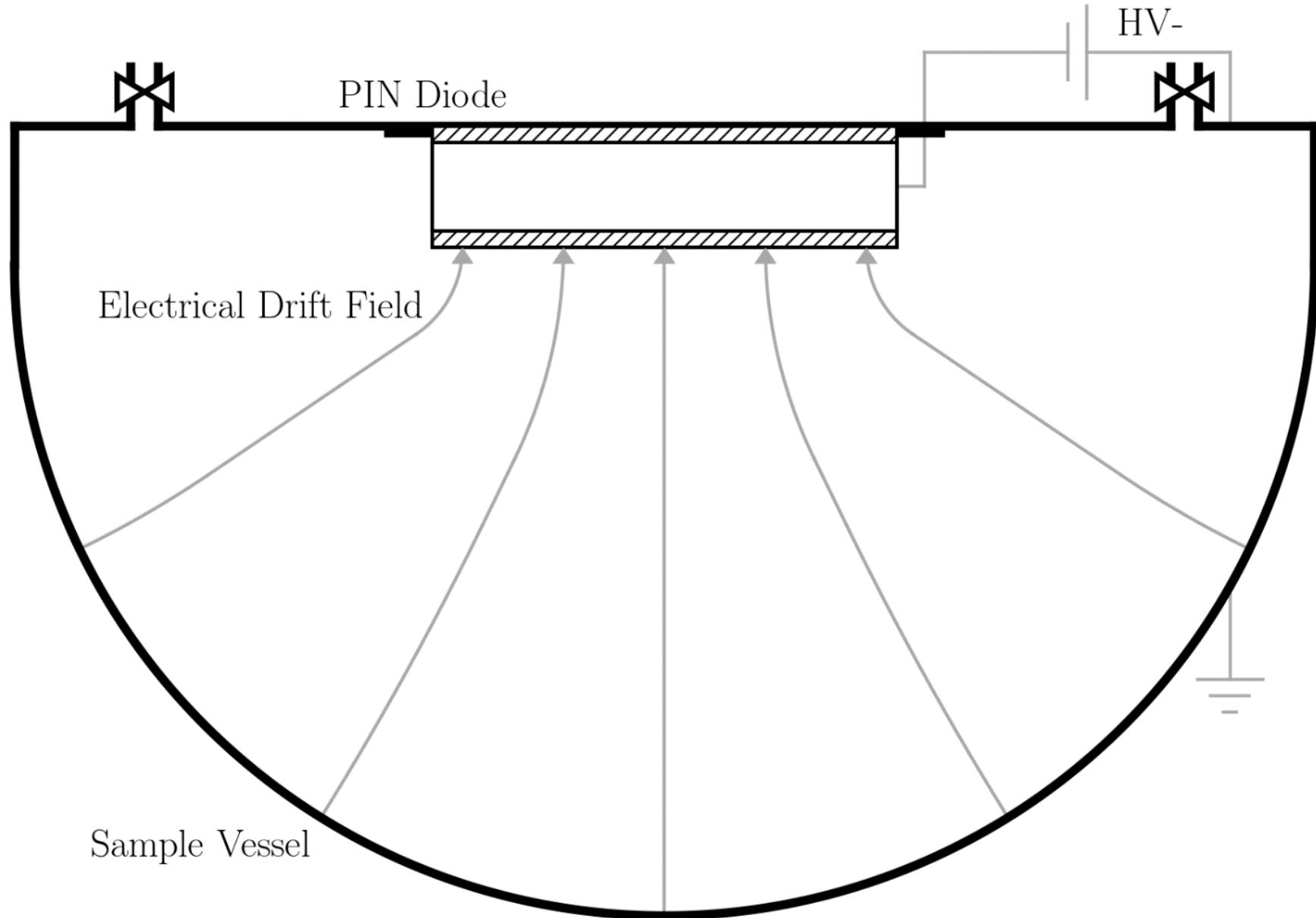
Daniel Baur

DARWIN Collaboration Meeting 2019
10th December 2019



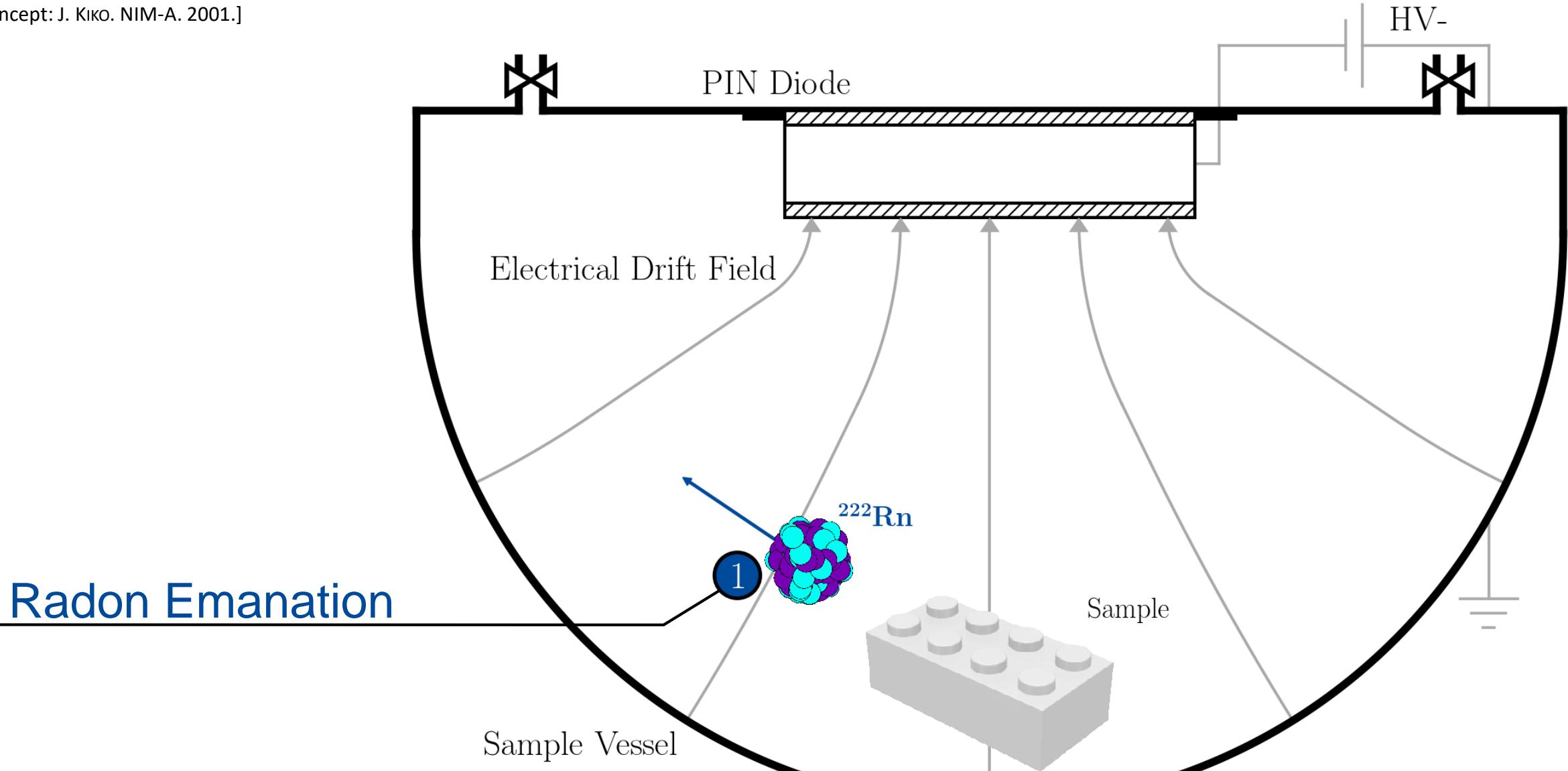
Radon Emanation Chamber

[Concept: J. Kiko, NIM-A. 2001.]



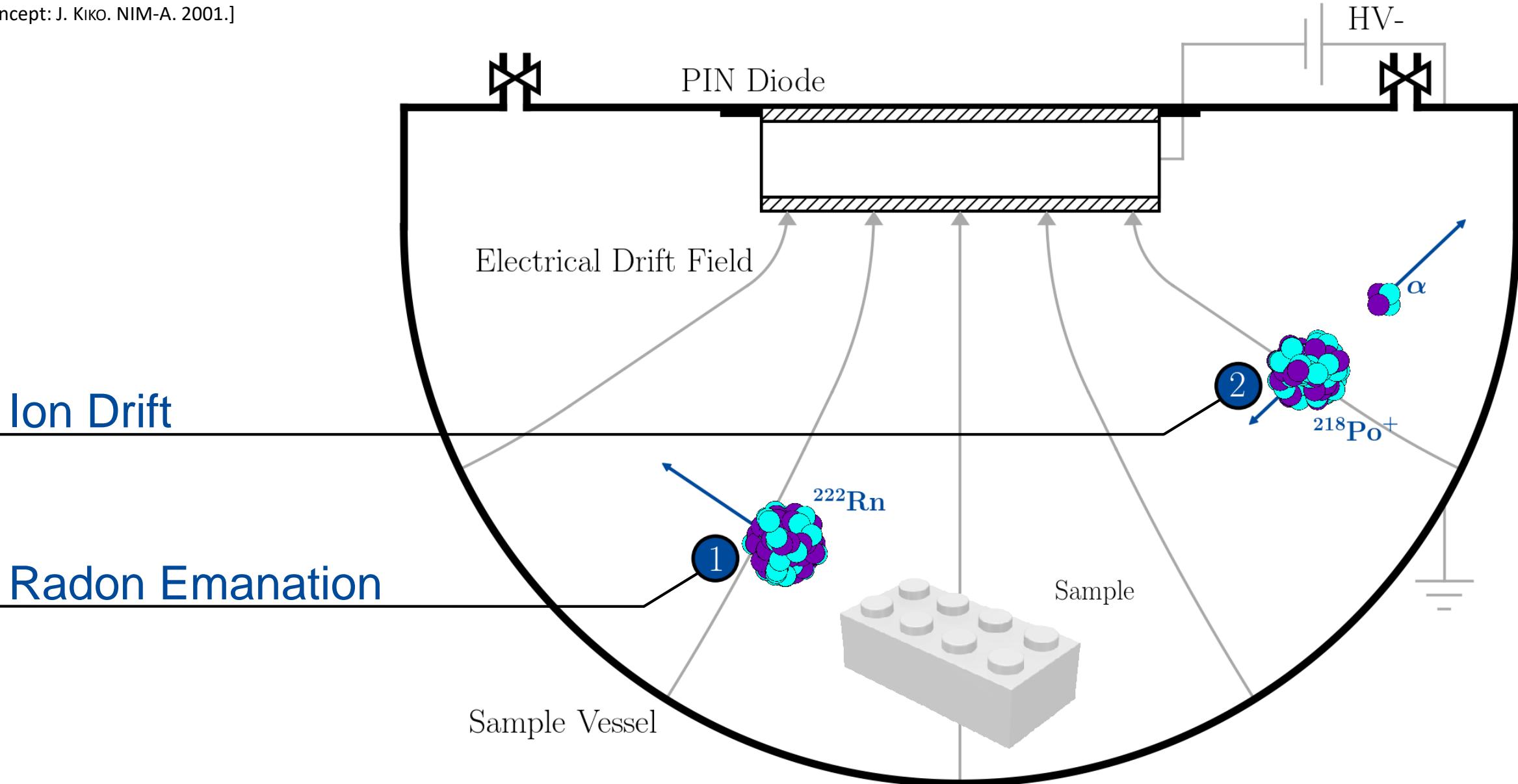
Radon Emanation Chamber

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Signal Formation

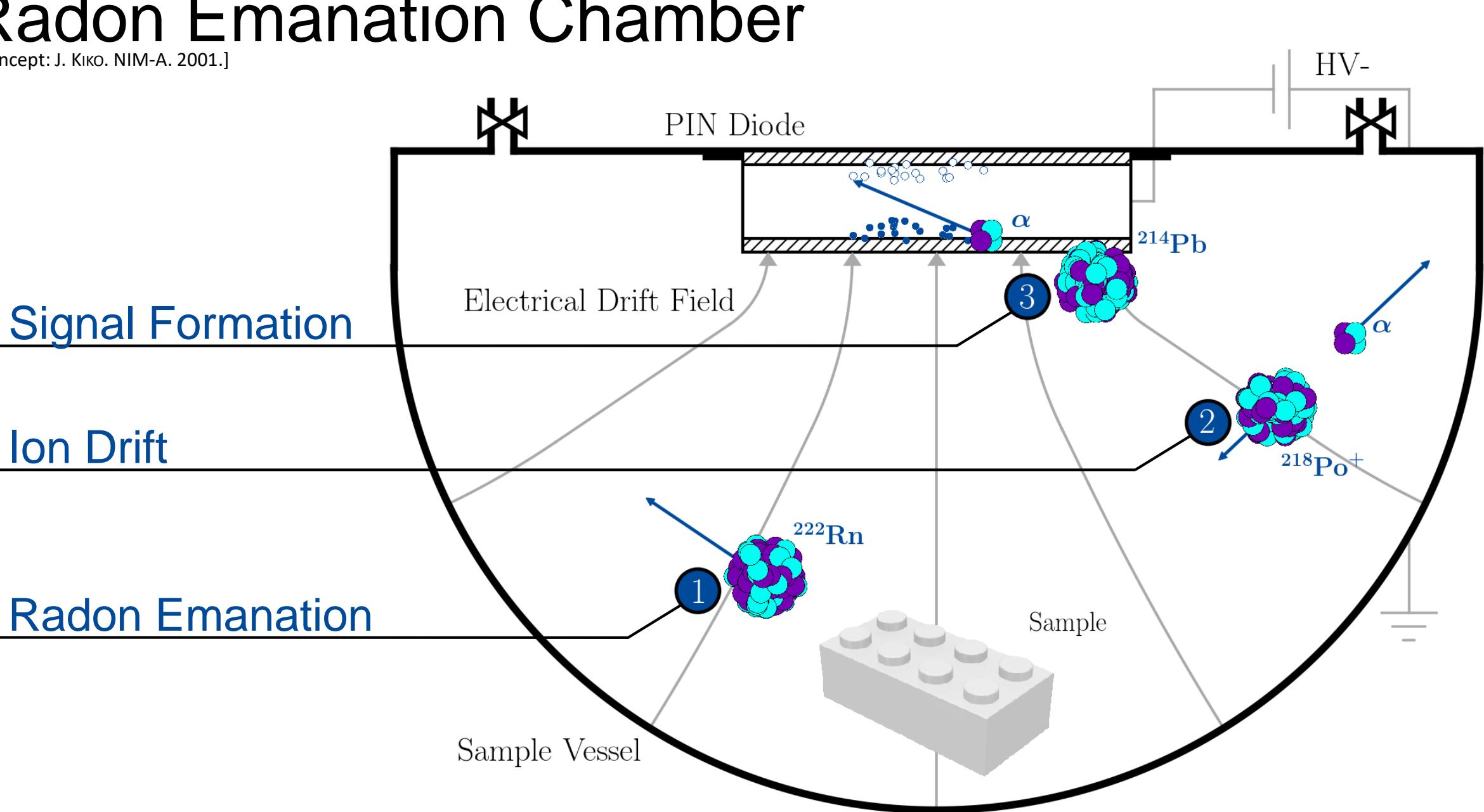
Ion Drift

Radon Emanation

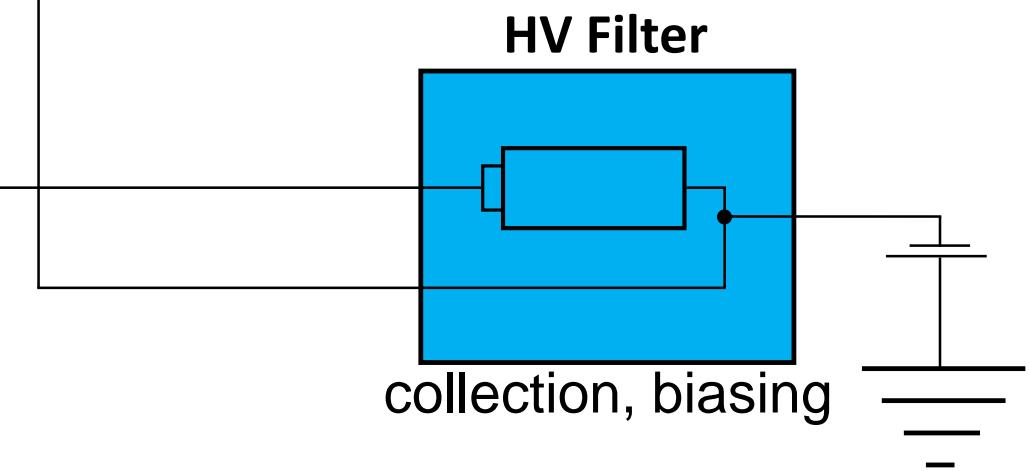
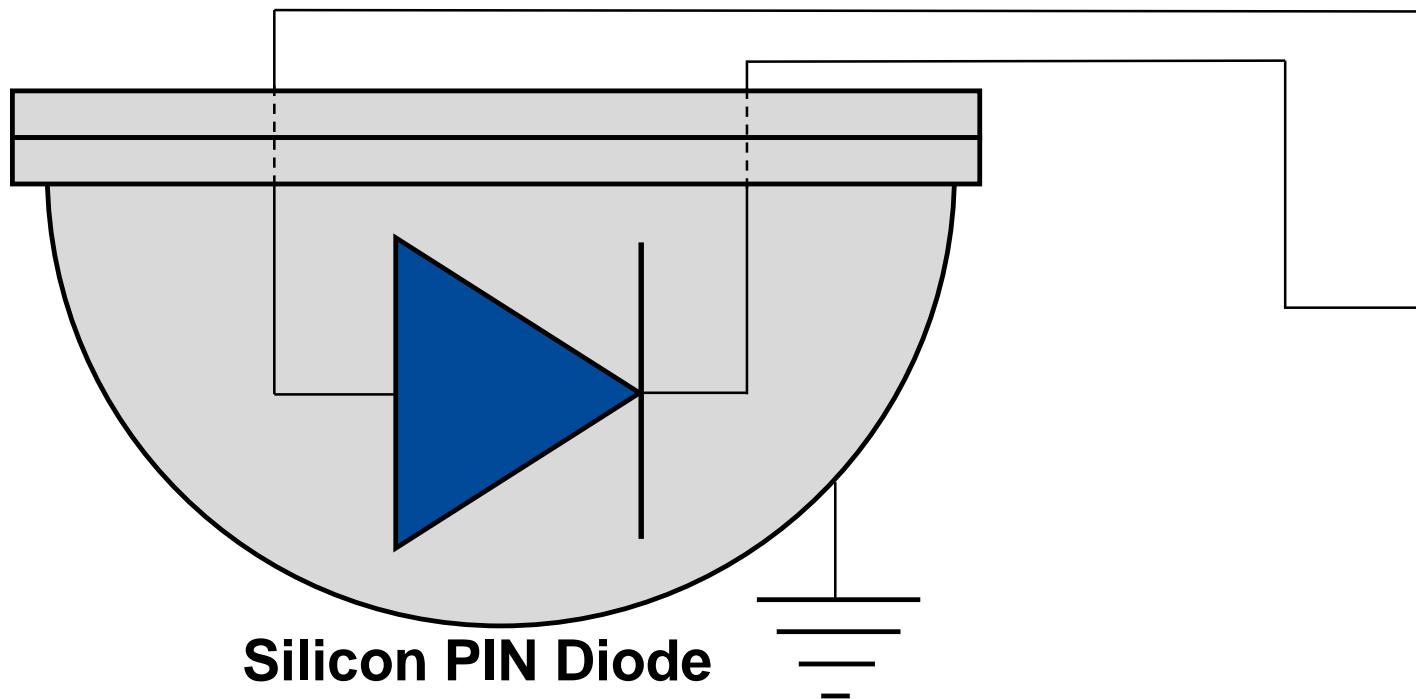
Sample Vessel

PIN Diode

HV-

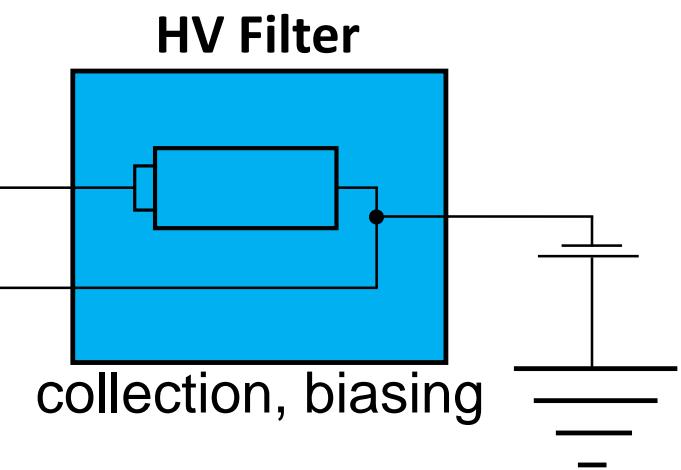
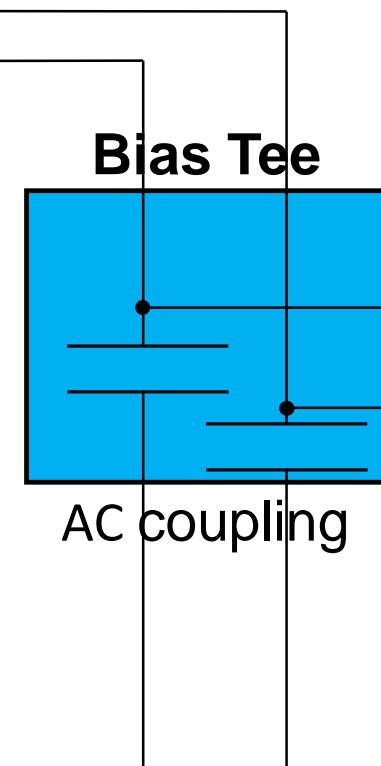
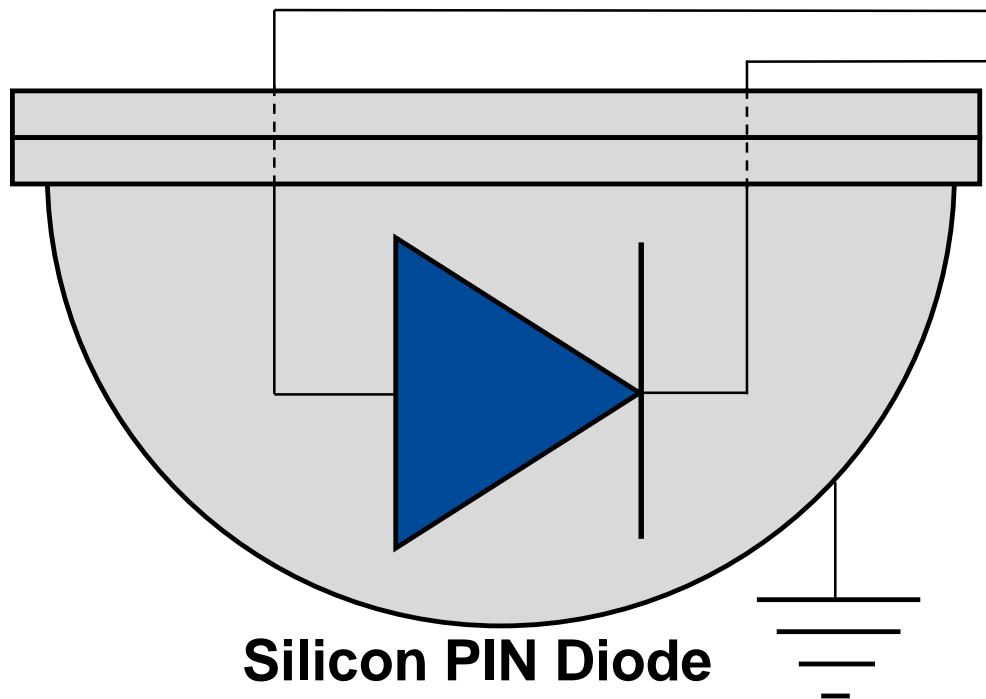


Electronics Chain



optimization:
▪ diode biasing

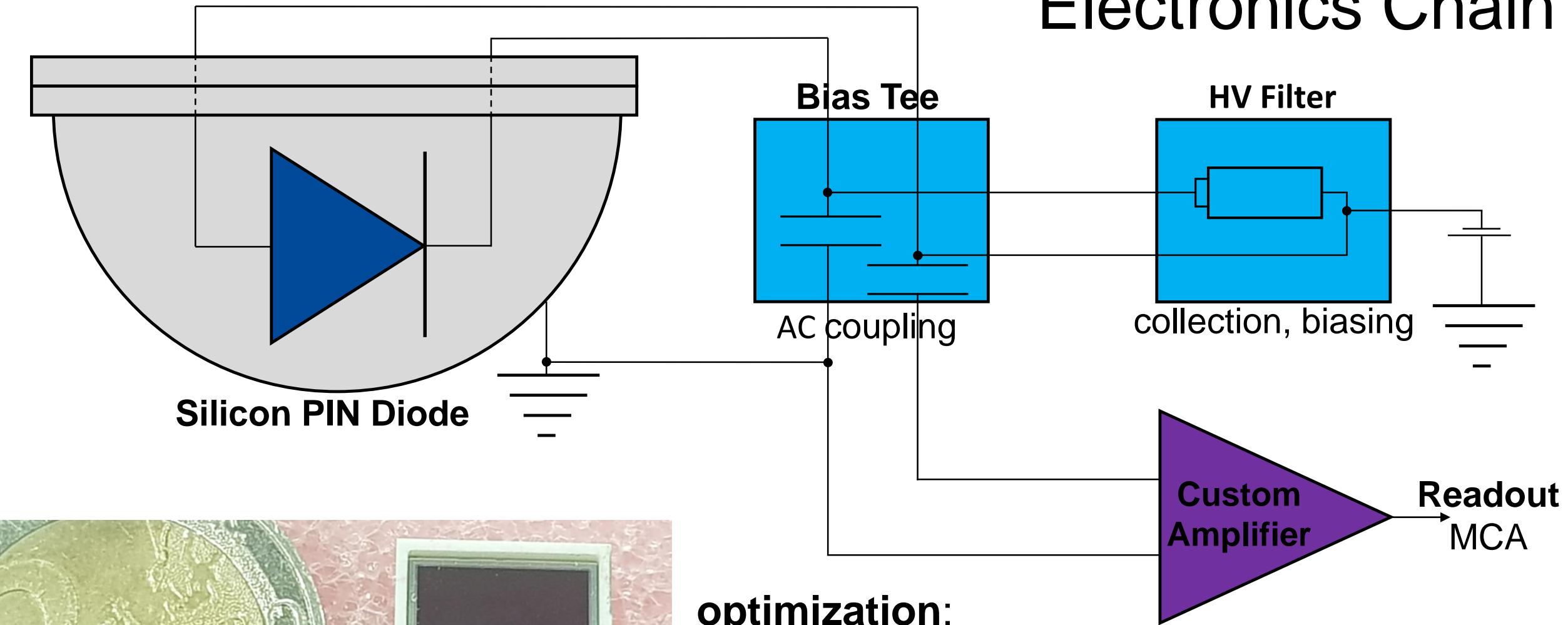
Electronics Chain



optimization:

- diode biasing
- capacitive decoupling: signal \leftrightarrow HV

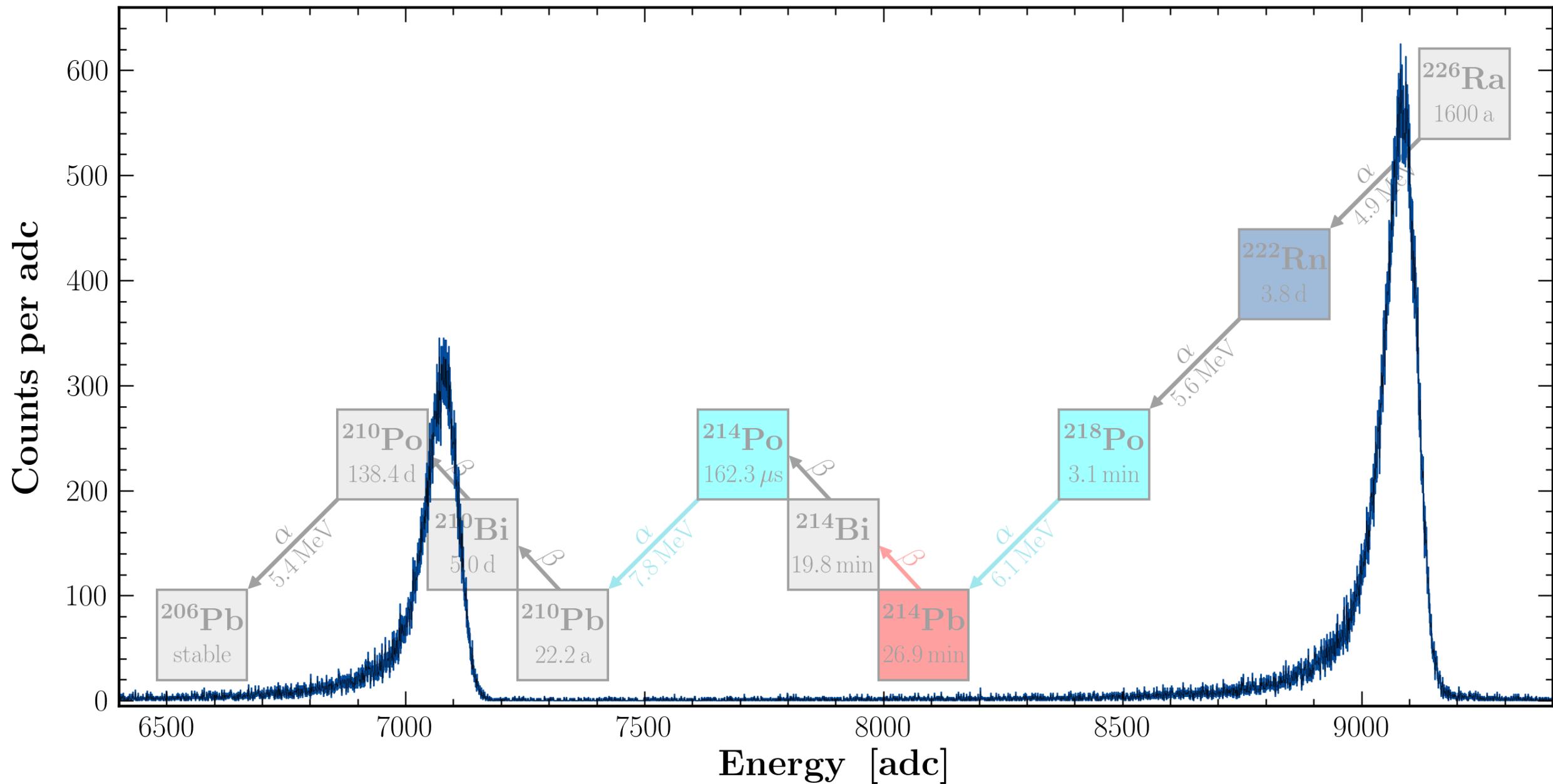
Electronics Chain



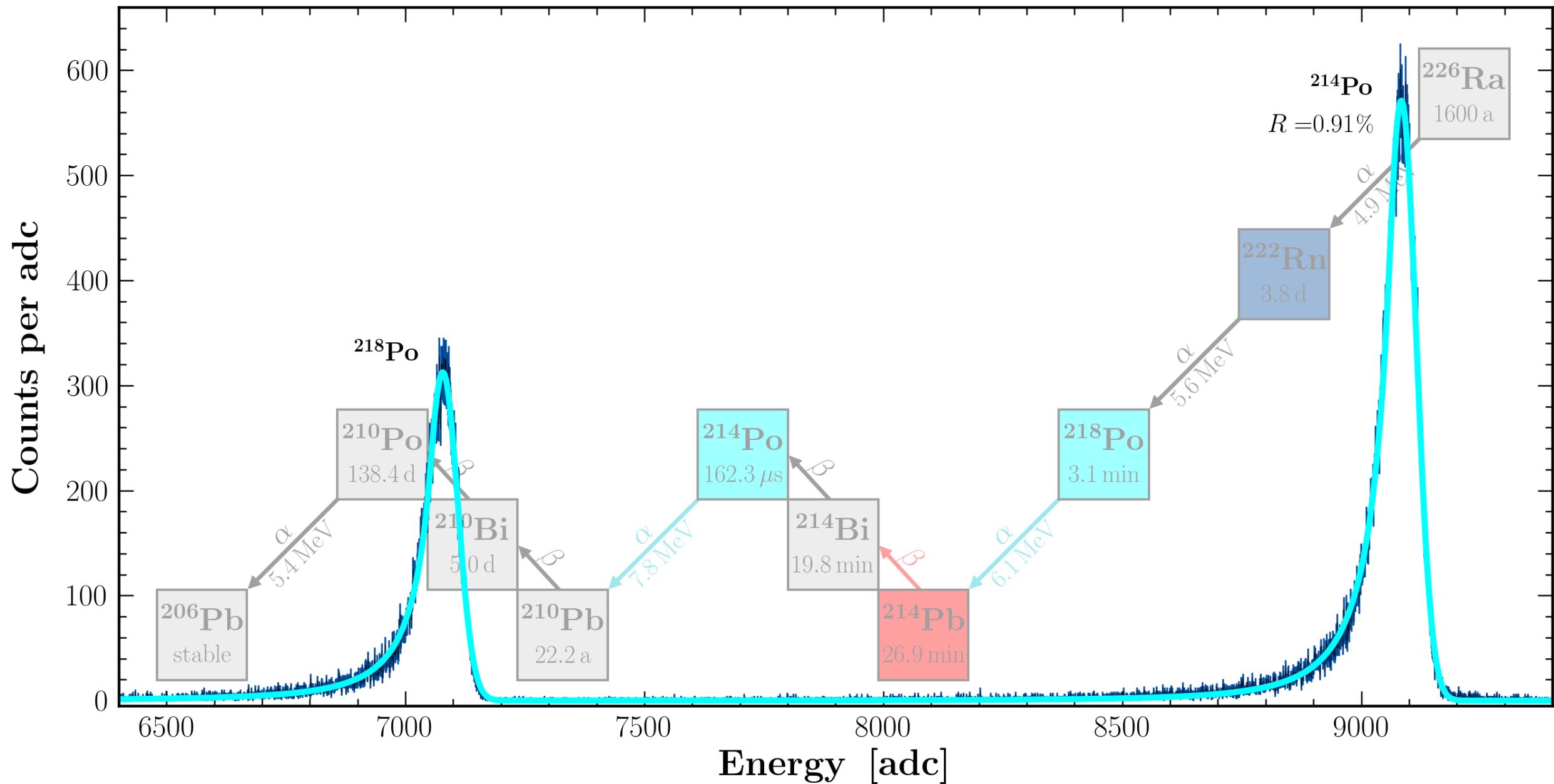
optimization:

- diode biasing
- capacitive decoupling: signal \leftrightarrow HV
- custom amplifier: low noise, high gain

^{222}Rn in Ambient Air



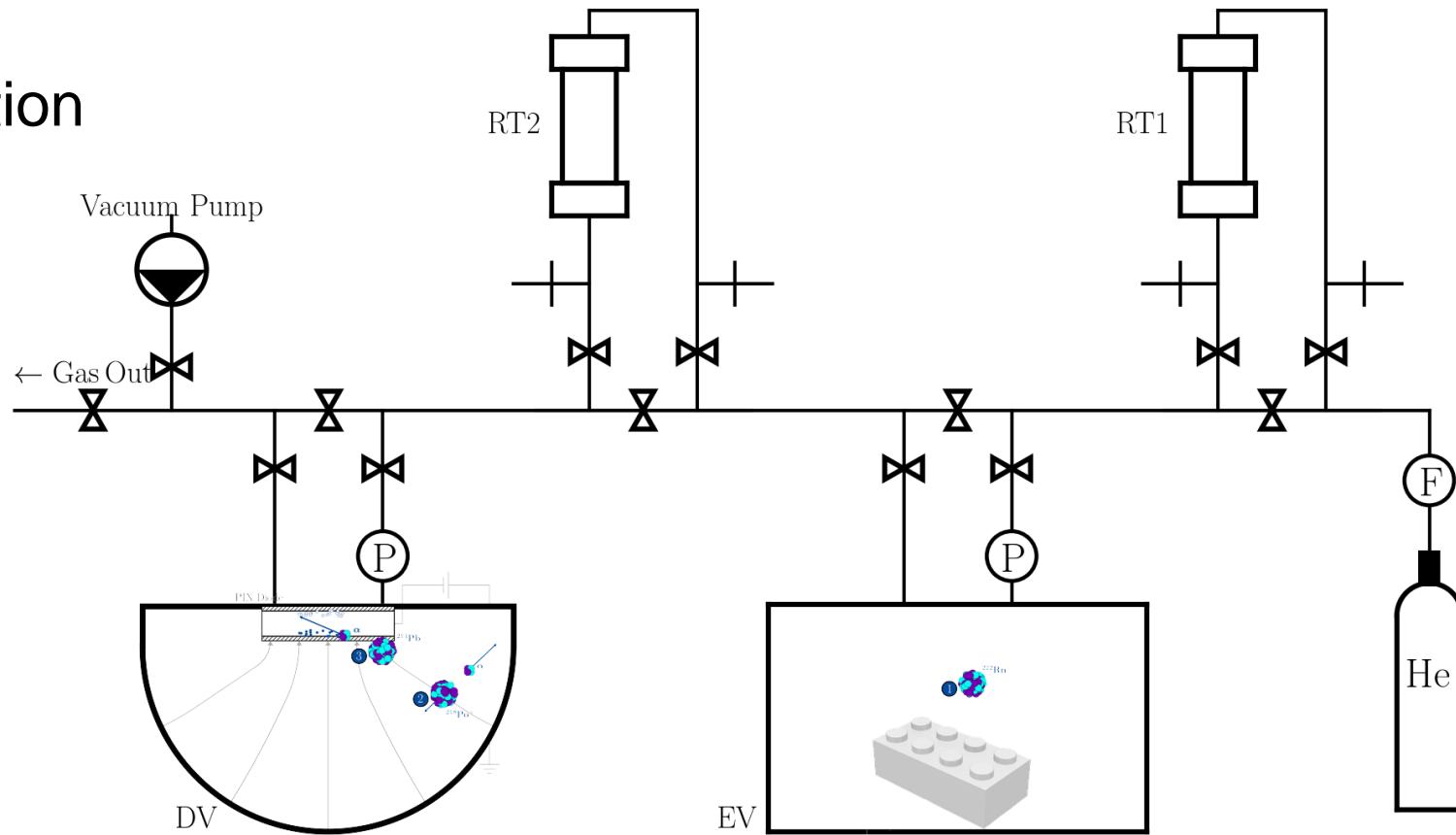
^{222}Rn in Ambient Air



Upgrade Efforts

gas system:

- decoupled: emanation \leftrightarrow detection
- carrier gas: helium
- activated charcoal filters



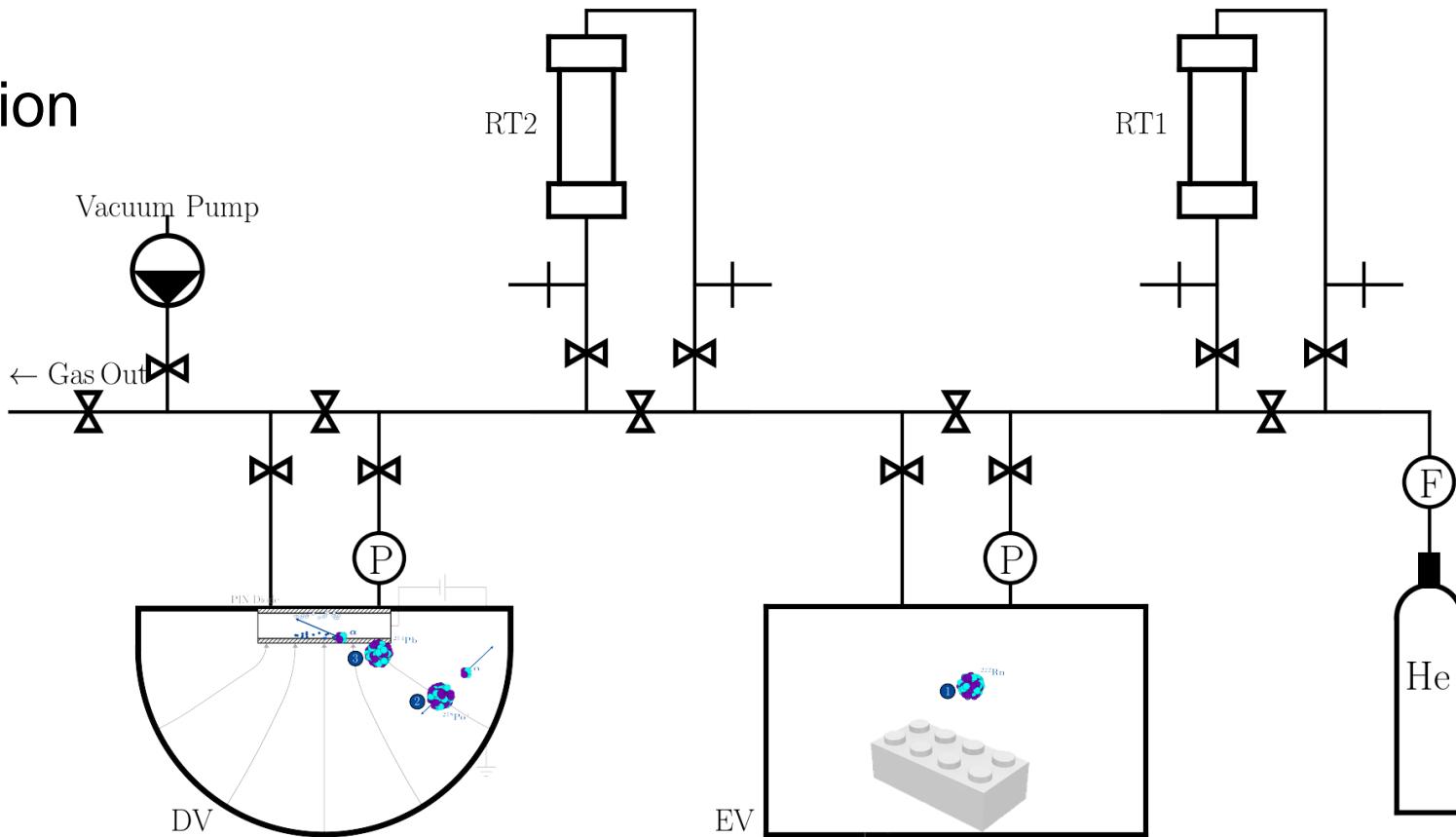
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data acquisition:

- custom electronics + MCA
- database storage



Upgrade Efforts

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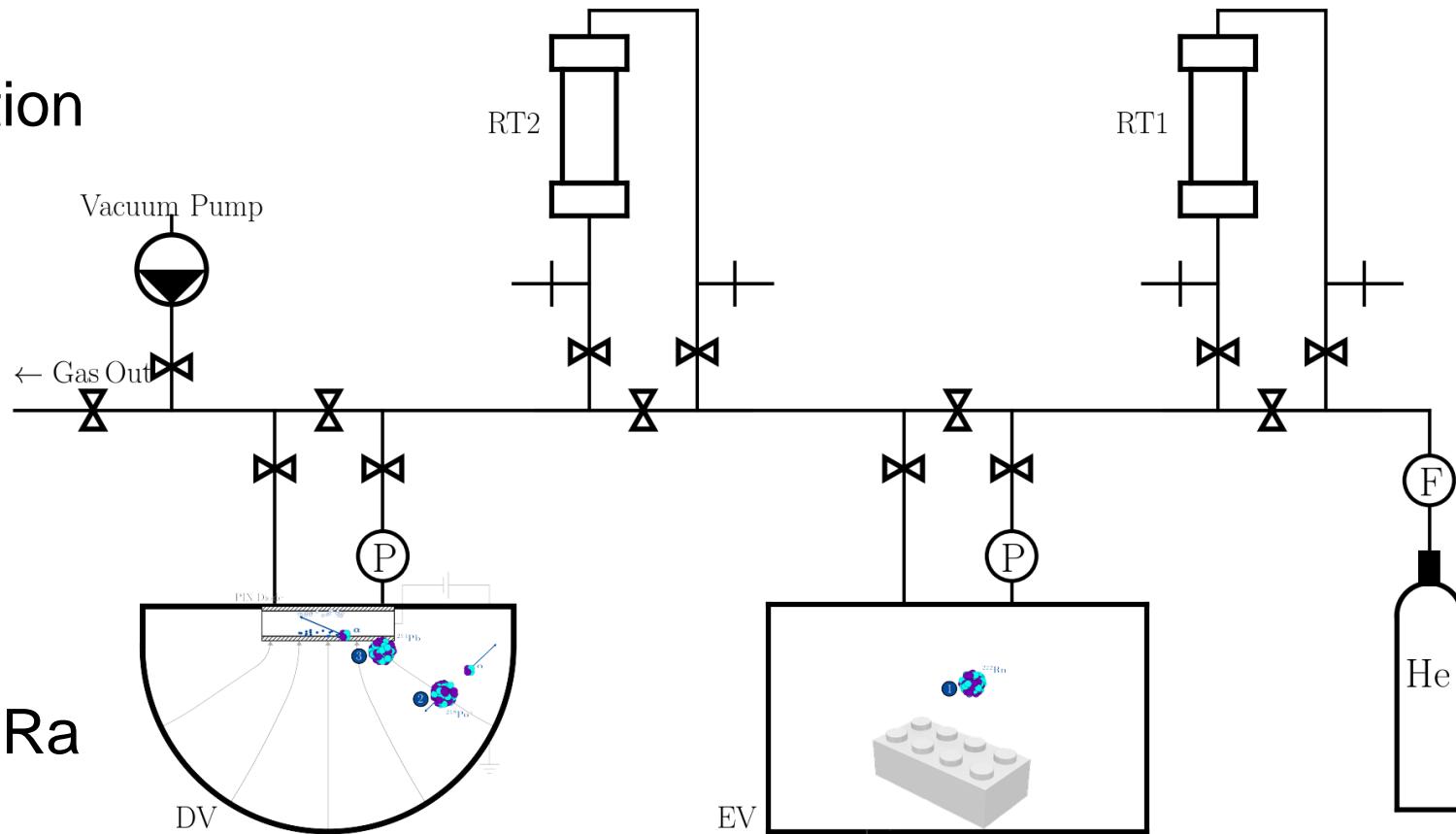
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first measurements:

- calibration: electrodeposited ^{226}Ra
- screening: PTFE samples



Thank You for Your Attention

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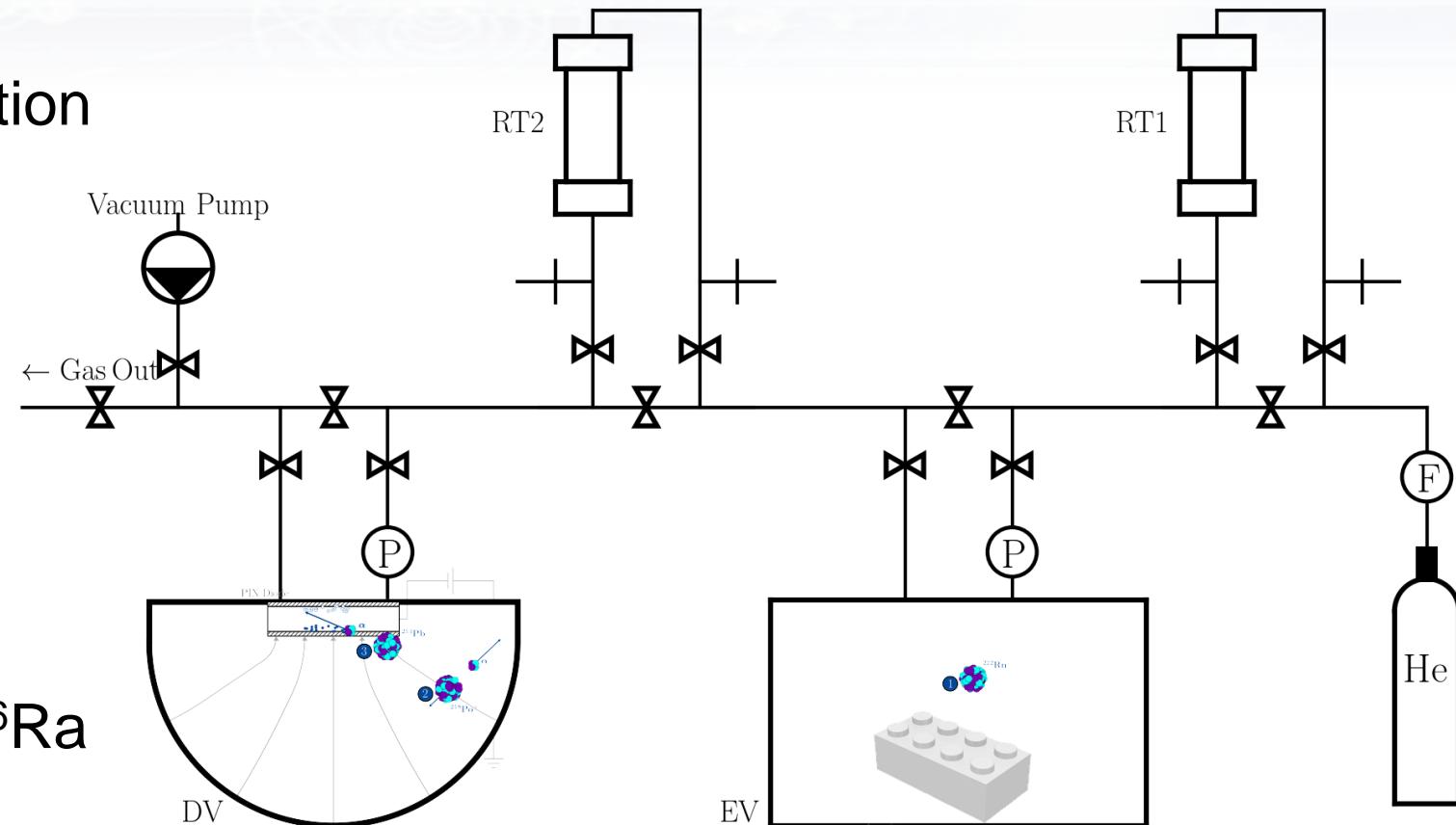
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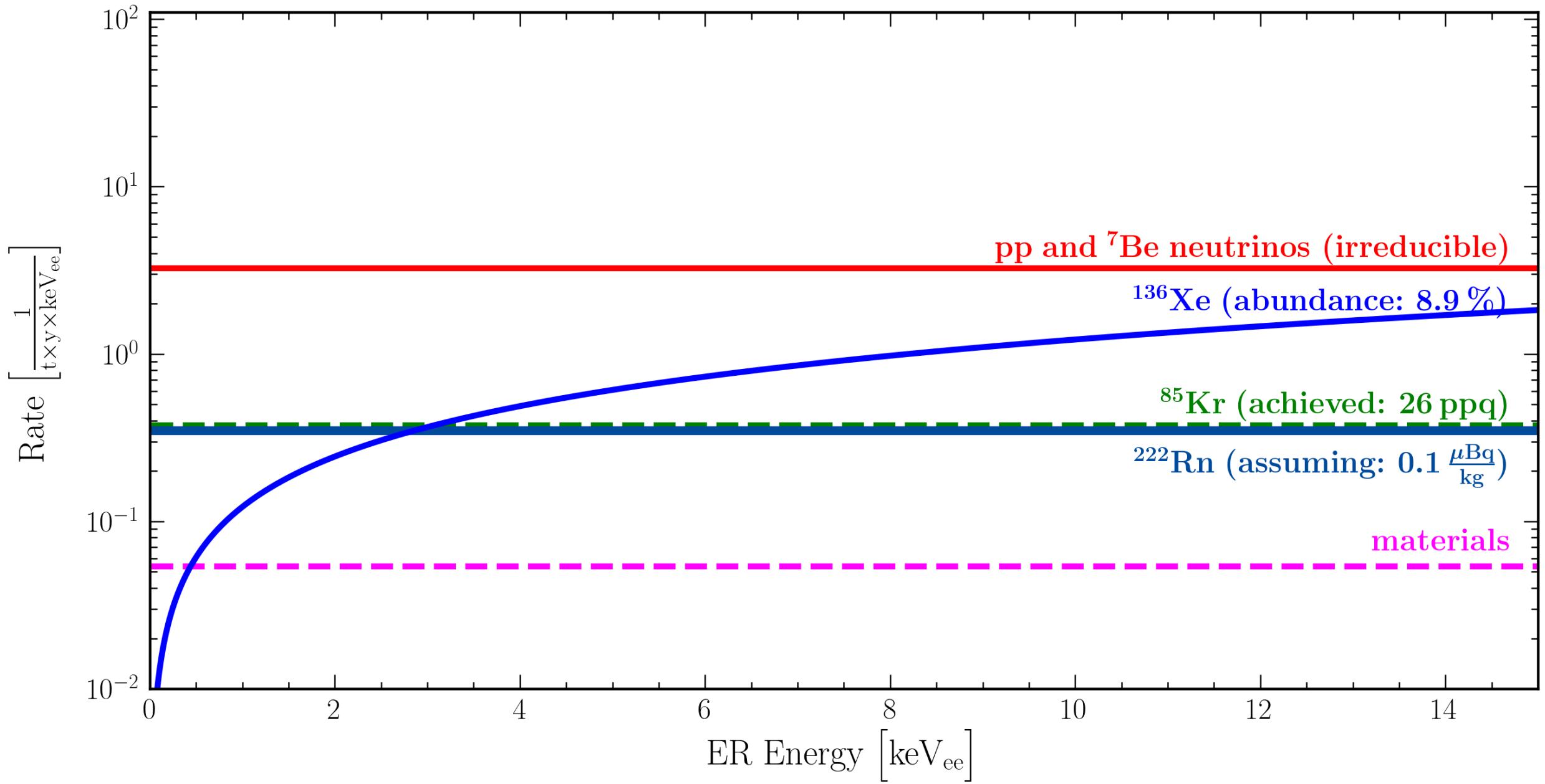


commission in April 2020

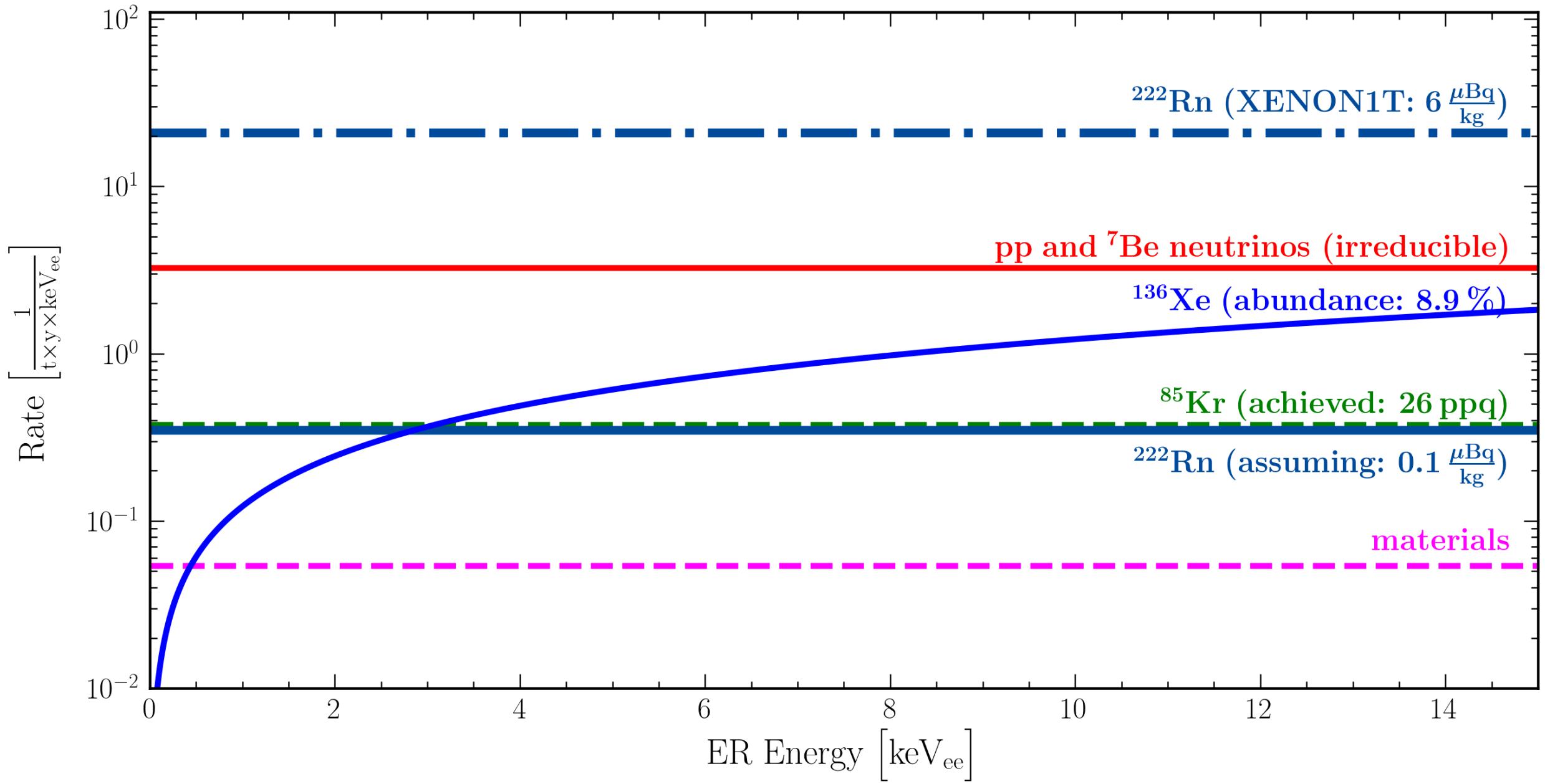


Backup

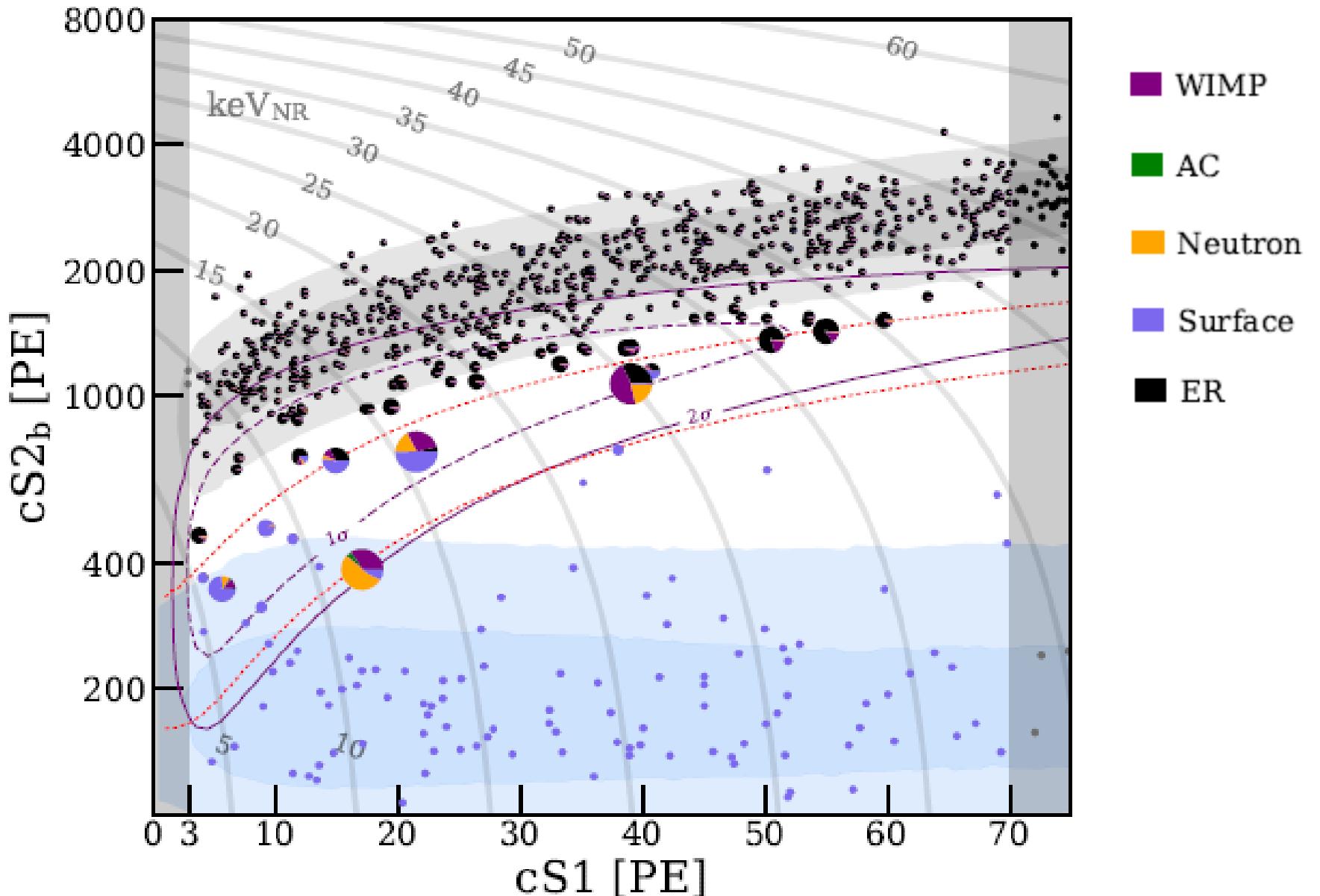
ER Background in DARWIN



ER Background in DARWIN



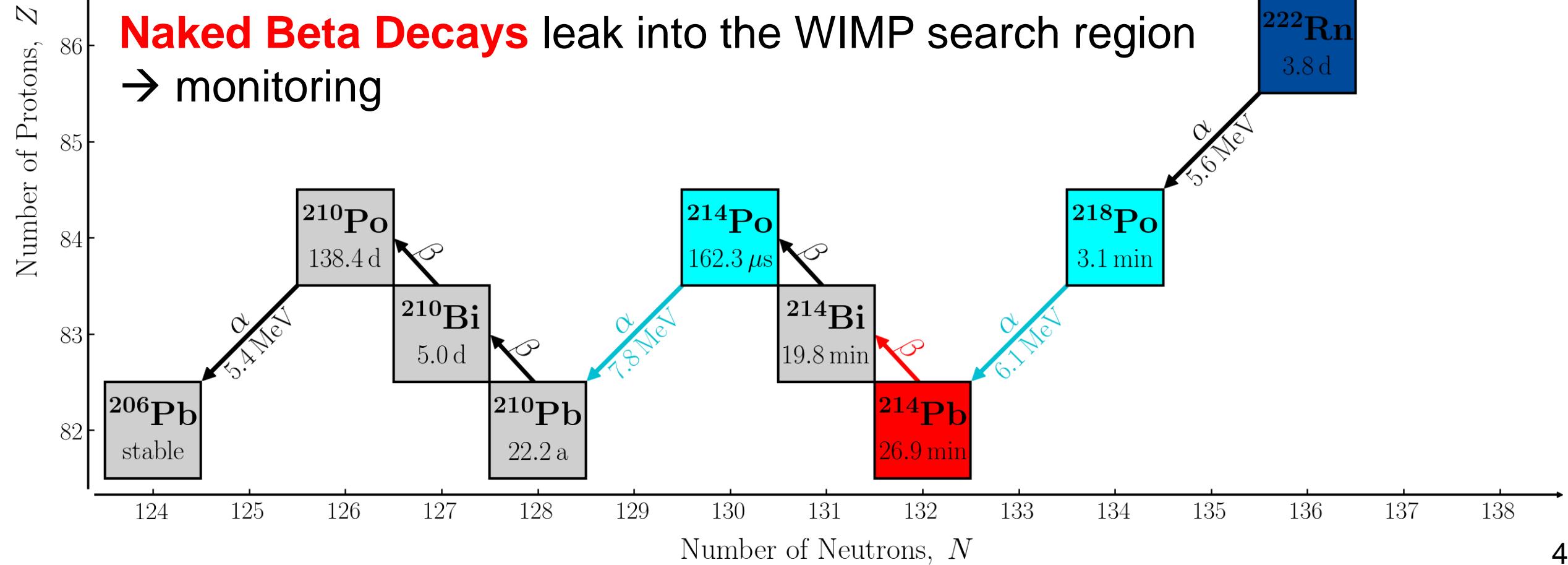
Relevance of Radon Induced Background



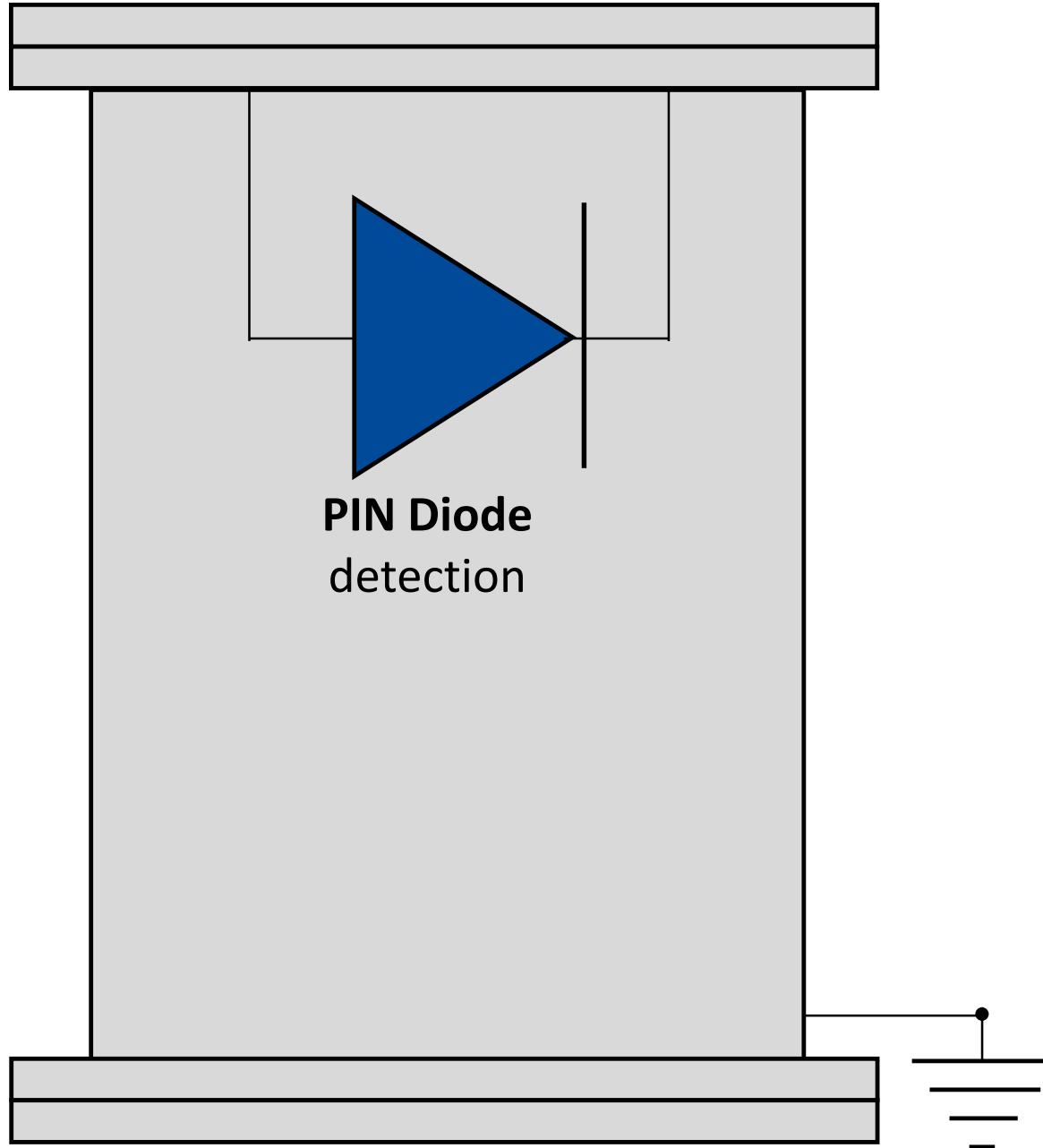
Radon Emanation

^{222}Rn Emanation from the surface of the detector components
→ homogeneous distribution within the TPC

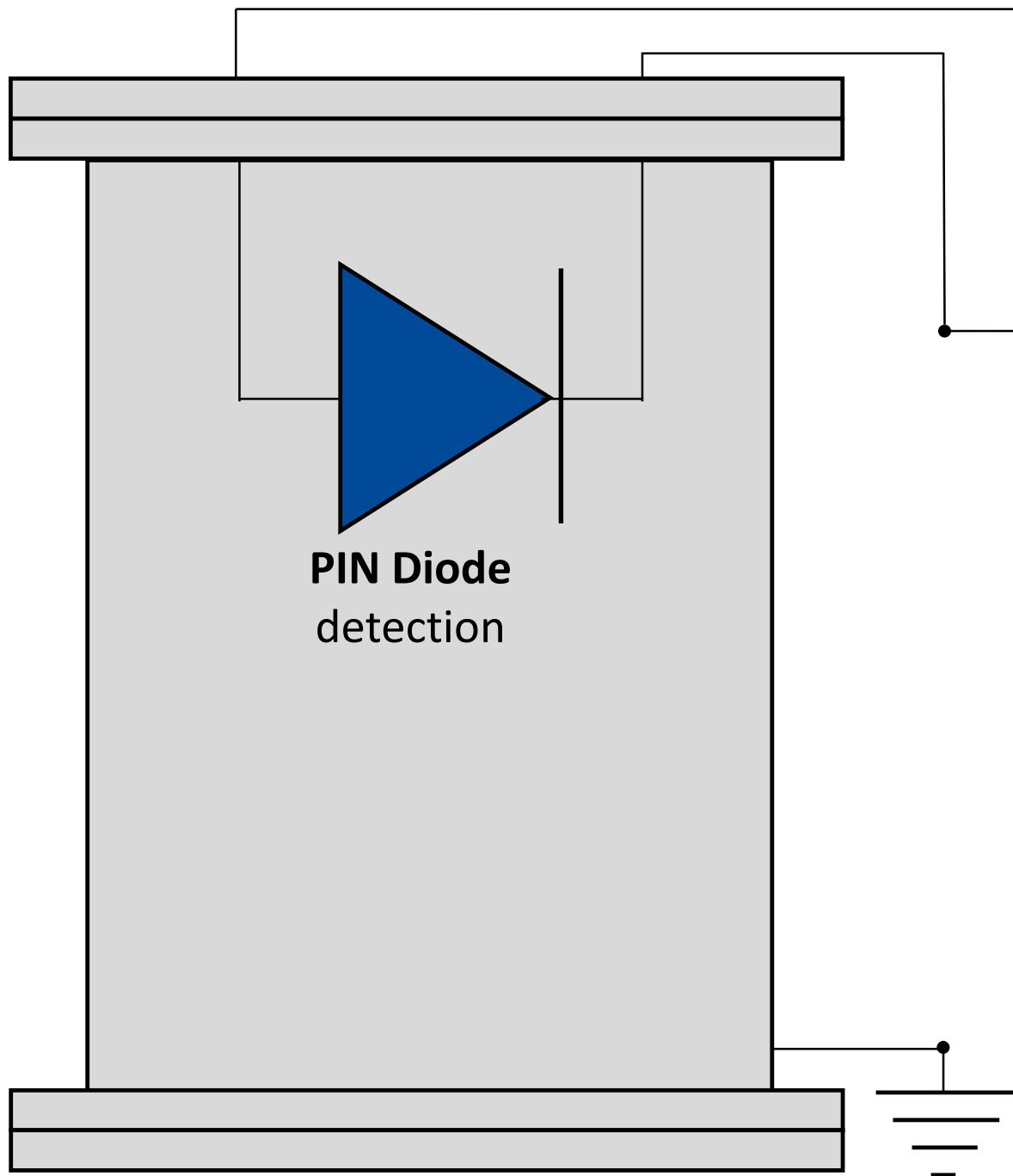
Naked Beta Decays leak into the WIMP search region
→ monitoring



Experimental Setup



Experimental Setup



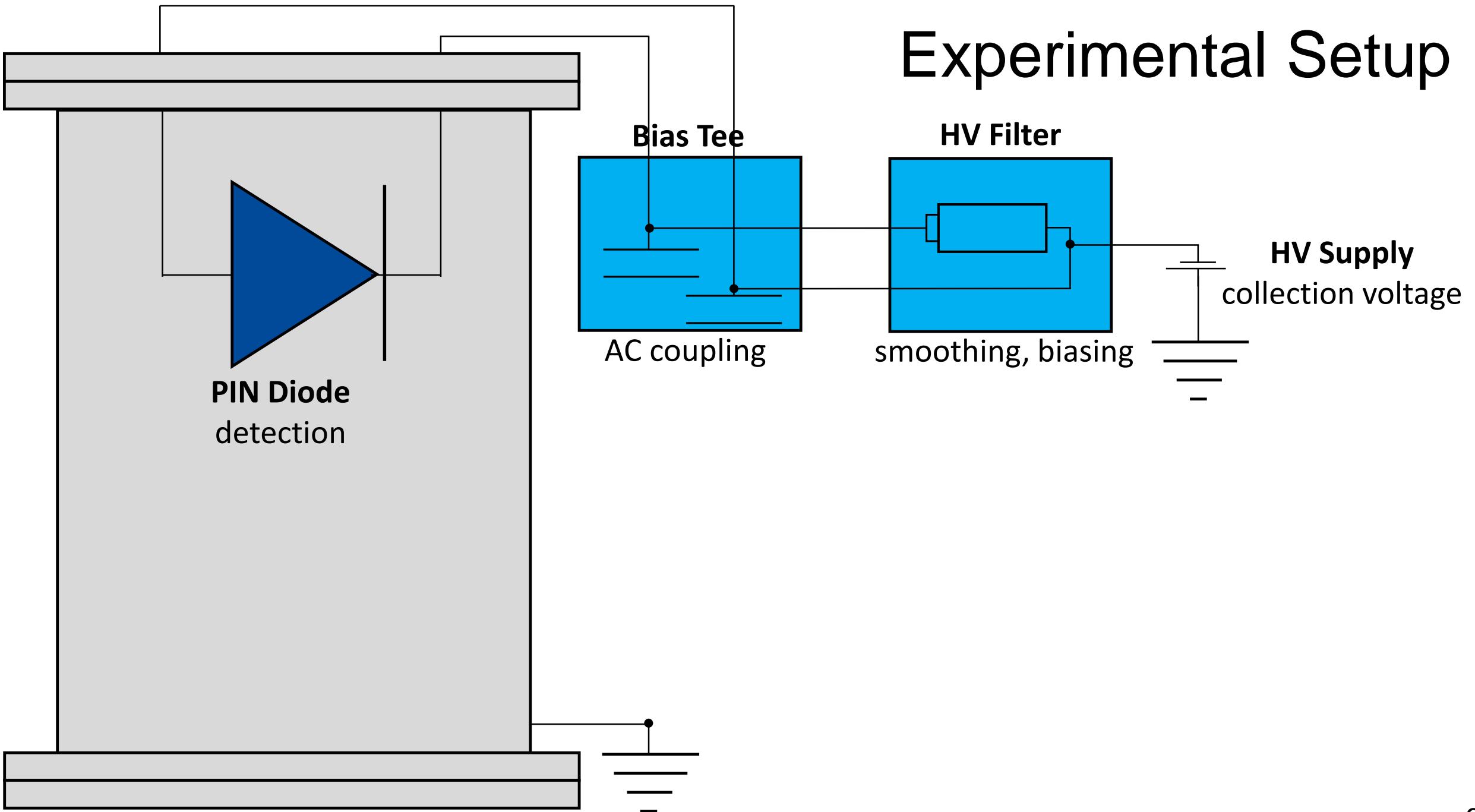
HV Filter

smoothing, biasing

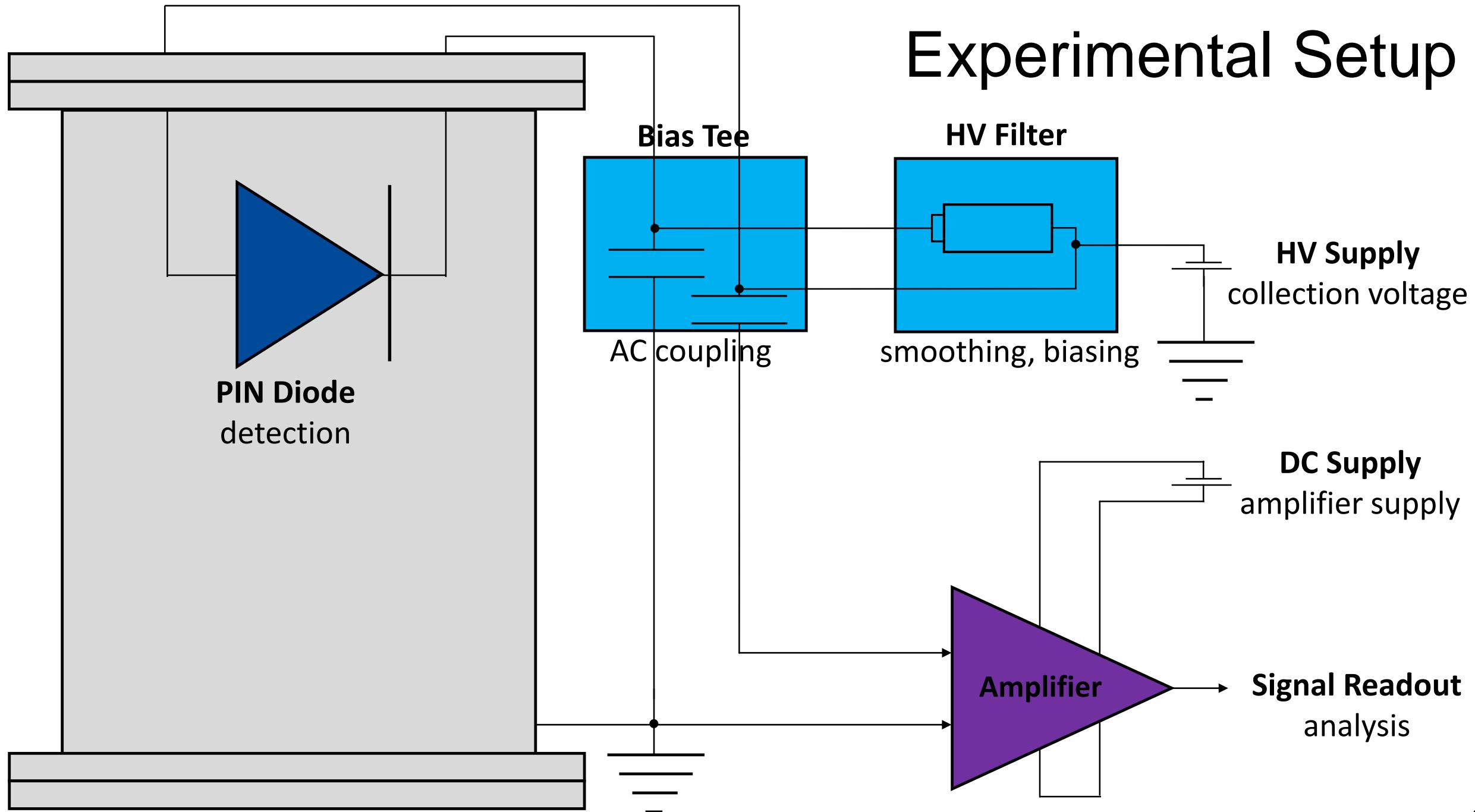
HV Supply

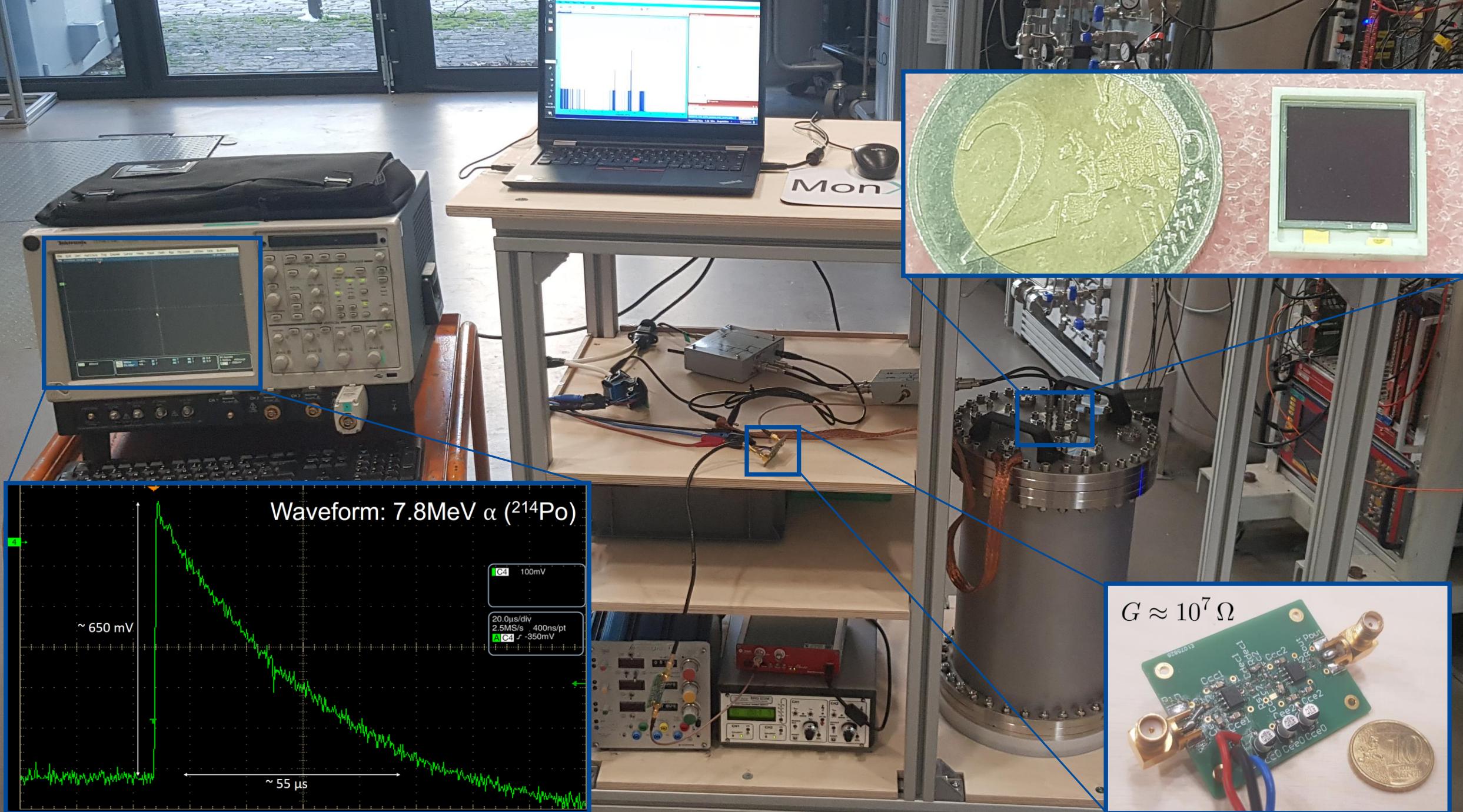
collection voltage

Experimental Setup



Experimental Setup



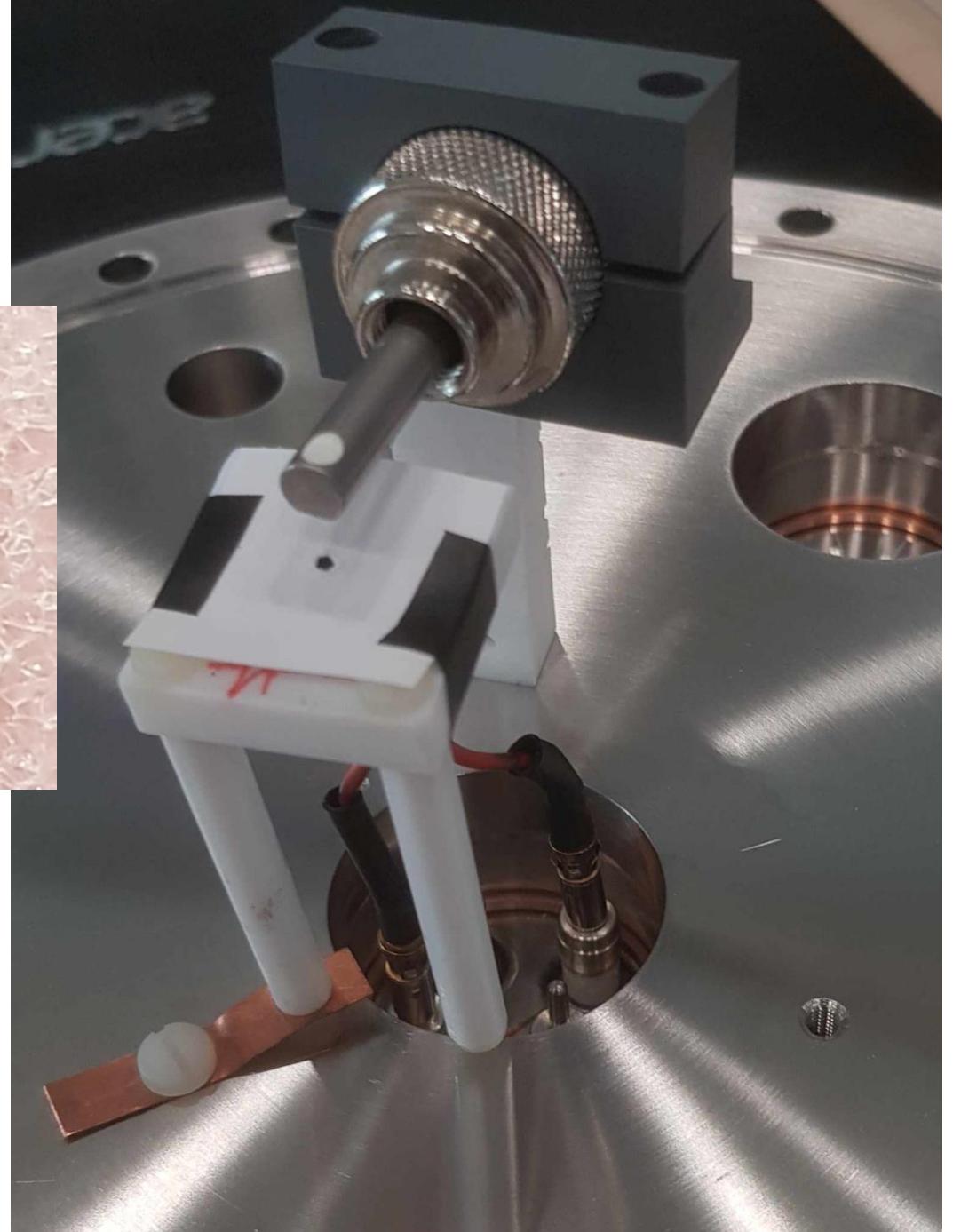


Experimental Setup: Diode

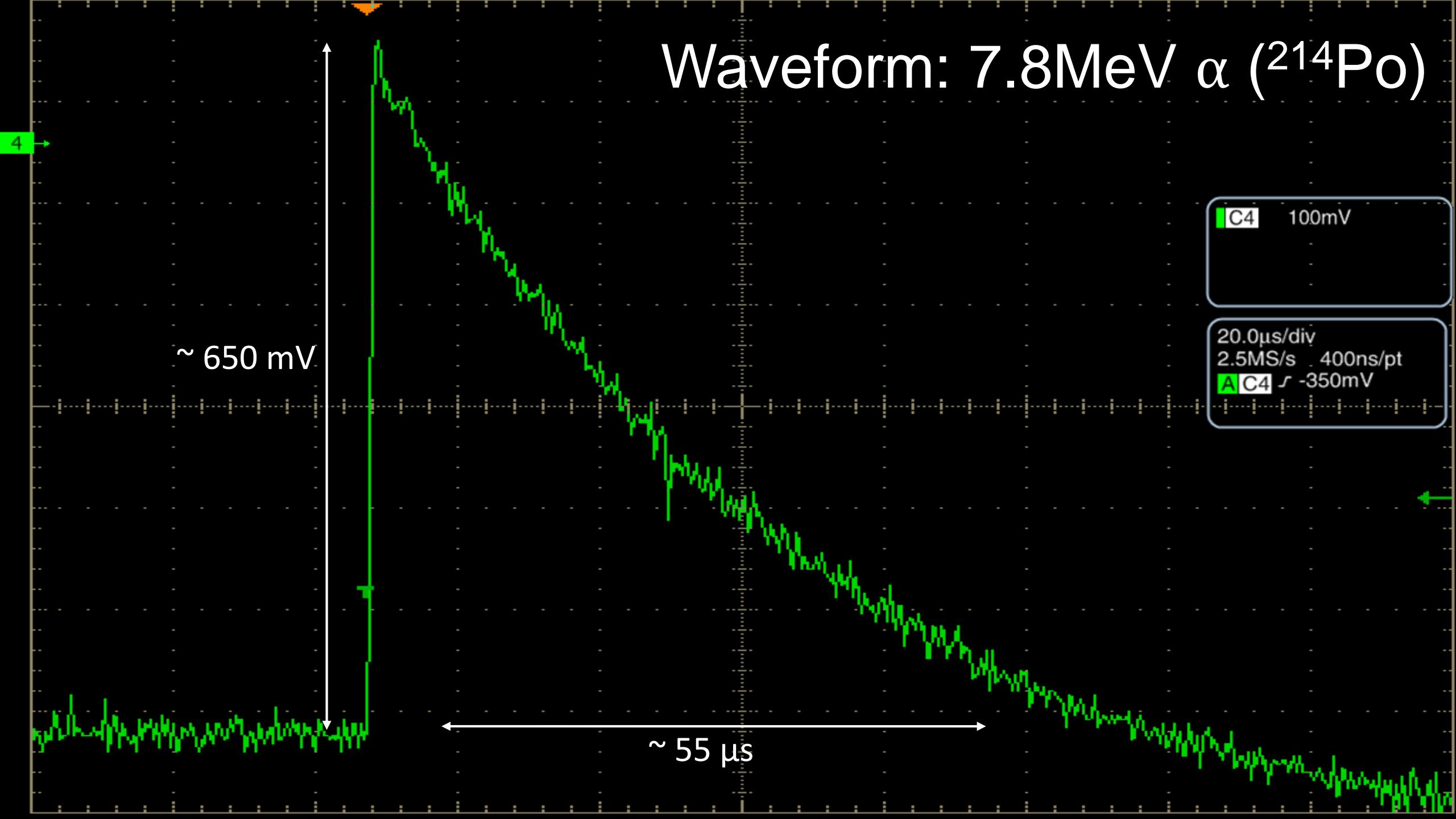
model: **Hamamatsu S3590-09**



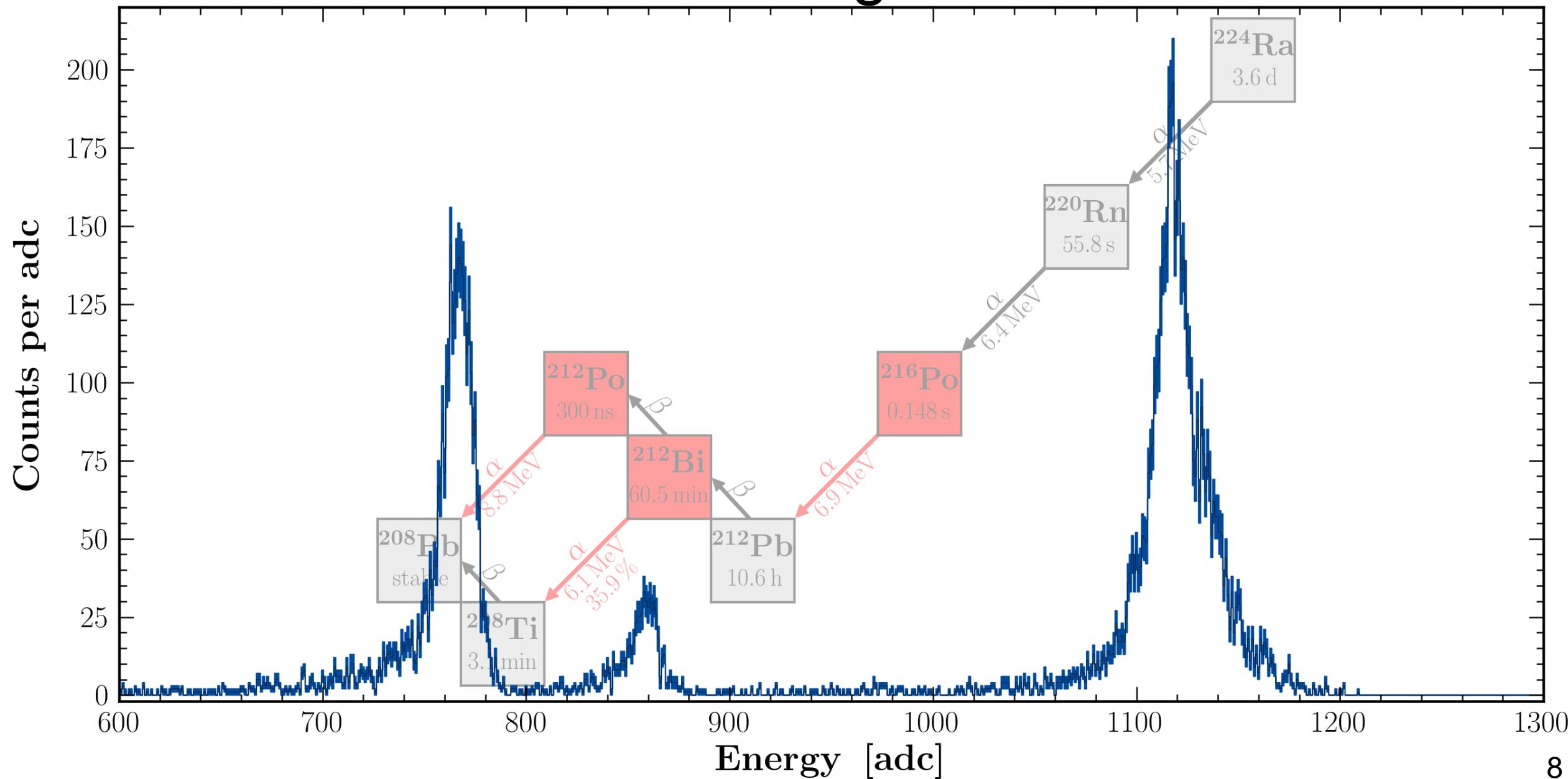
- intrinsic layer: $d_i = 300 \mu\text{m}$
- collection voltage: $U_{\text{coll}} = -1000 \text{ V}$
- bias voltage: $U_{\text{bias}} = 9 \text{ V}$



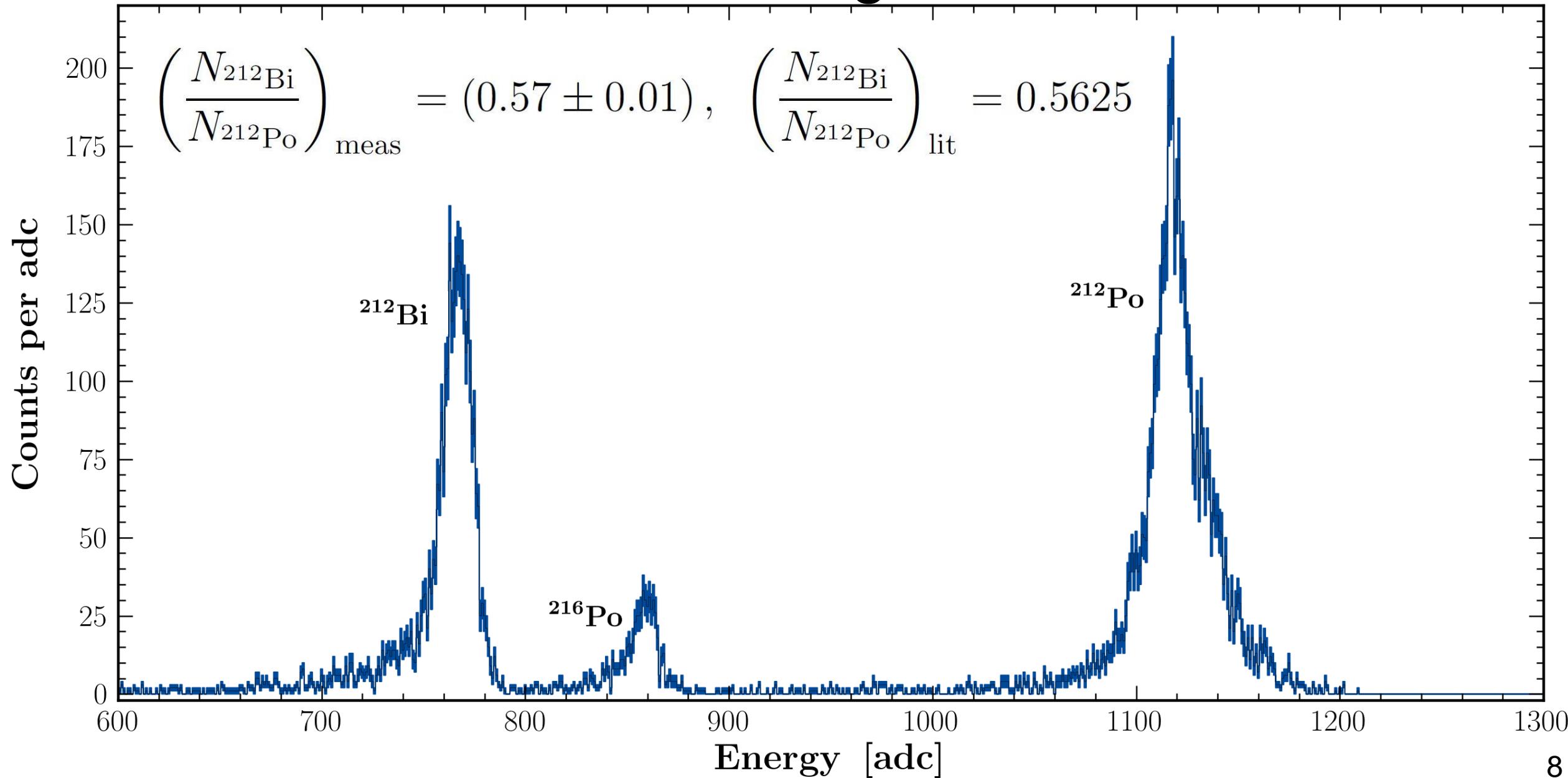
Waveform: 7.8MeV α (^{214}Po)



^{220}Rn from Thoriated Welding Rods in Helium



^{220}Rn from Thoriated Welding Rods in Helium

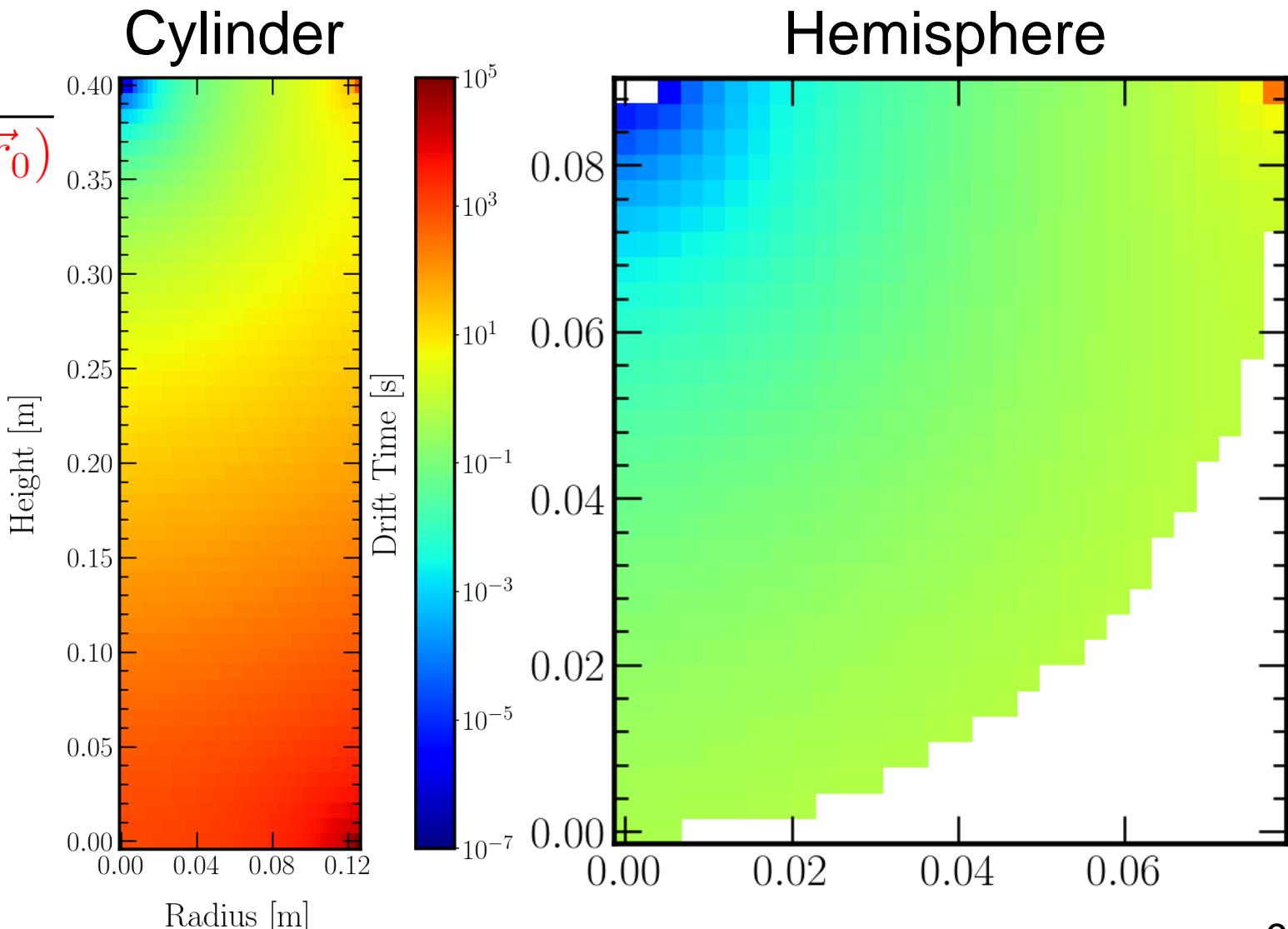


Drift Time Estimation

[L. GOD: *Efficiency Studies for the MonXe Radon Emanation Chamber*. B.Sc. Thesis. Aug 2019. Freiburg.]

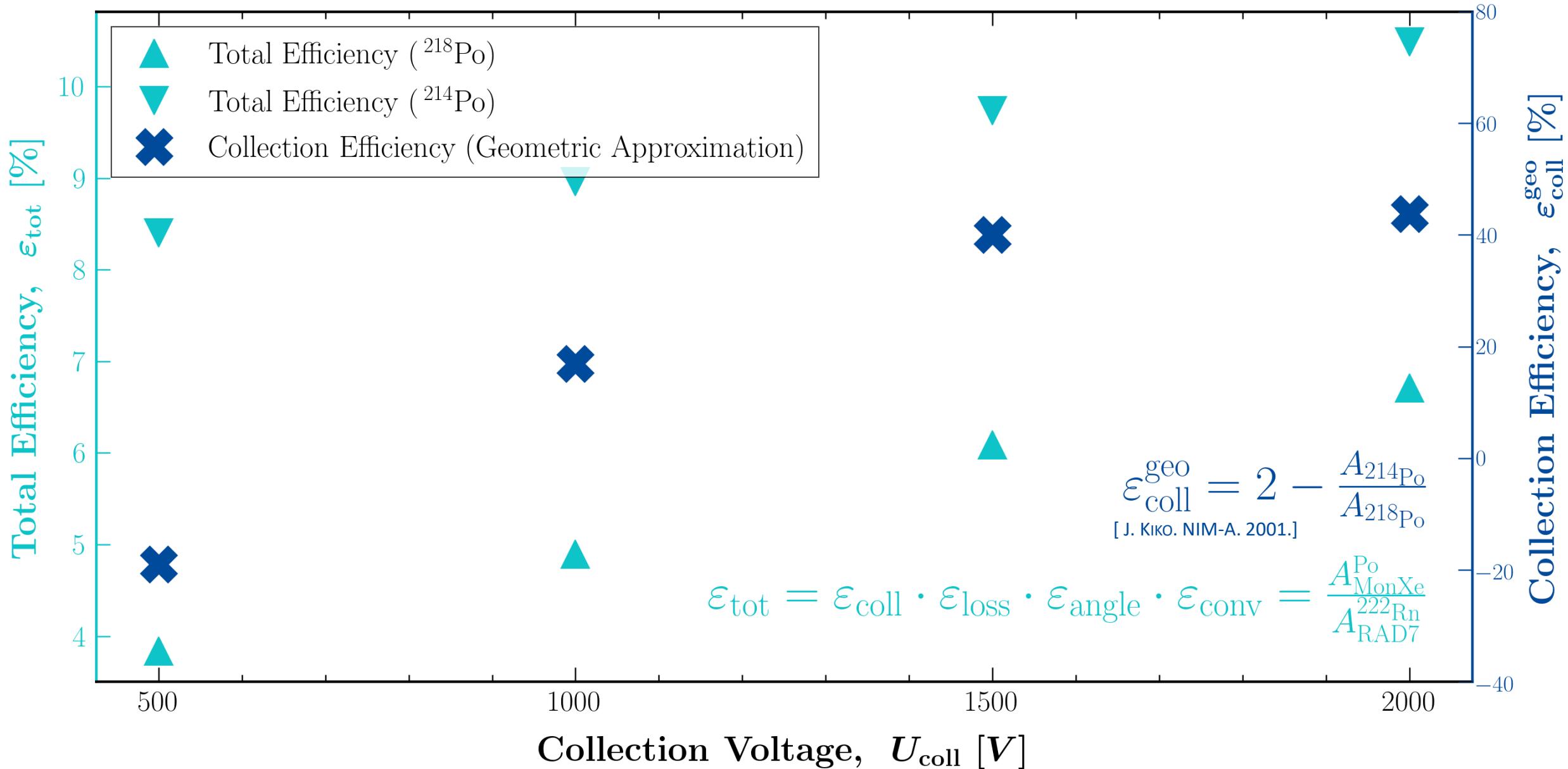
$$\tilde{t}_{\text{drift}} = \frac{\tilde{d}}{\tilde{v}_{\text{drift}}} = \frac{h(\vec{r}_0) + r(\vec{r}_0)}{\mu(E_{\text{eff}}, p, T) \cdot E_{\text{eff}}(\vec{r}_0)}$$

- **drift path**
geometric approximation
- **ion mobility**
LXcat database
- **electrical drift field**
Comsol simulation

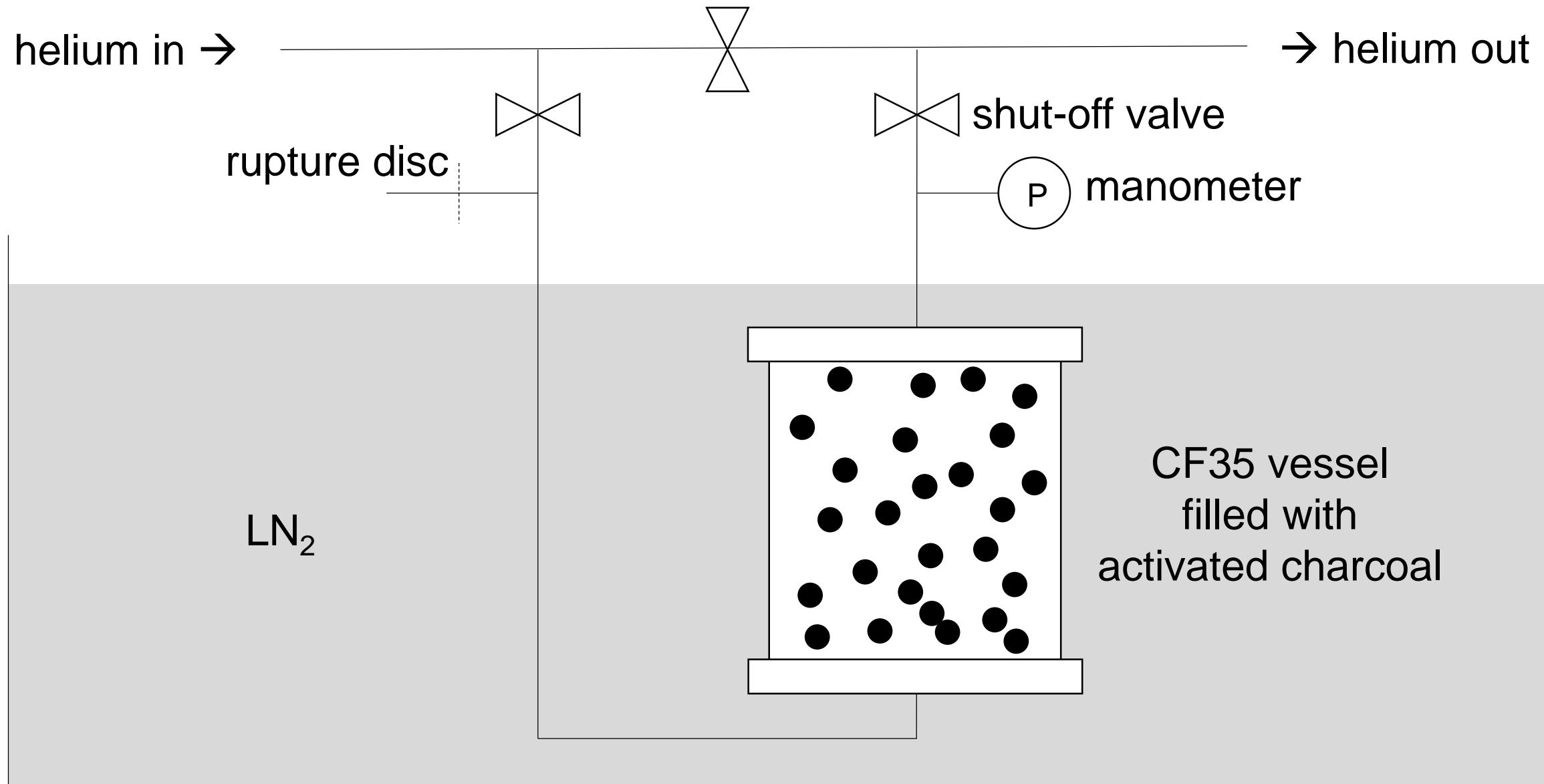


Efficiency Studies

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Activated Charcoal Filter



MonXe

