



Ion drift in the DUNE LArTPC

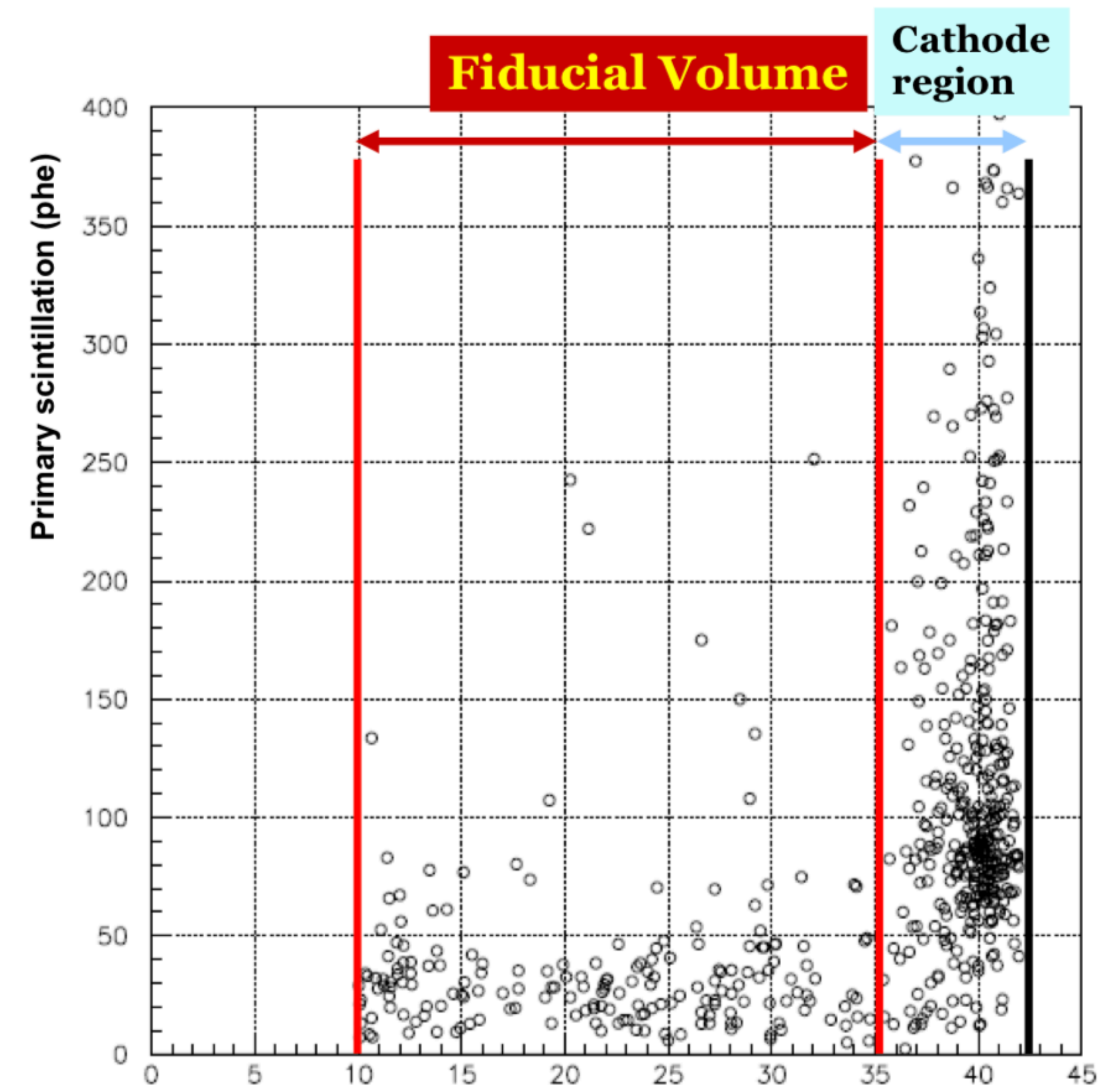
DUNE Background mitigation strategies workshop

July 20, 2020

Anyssa Navrer-Agasson

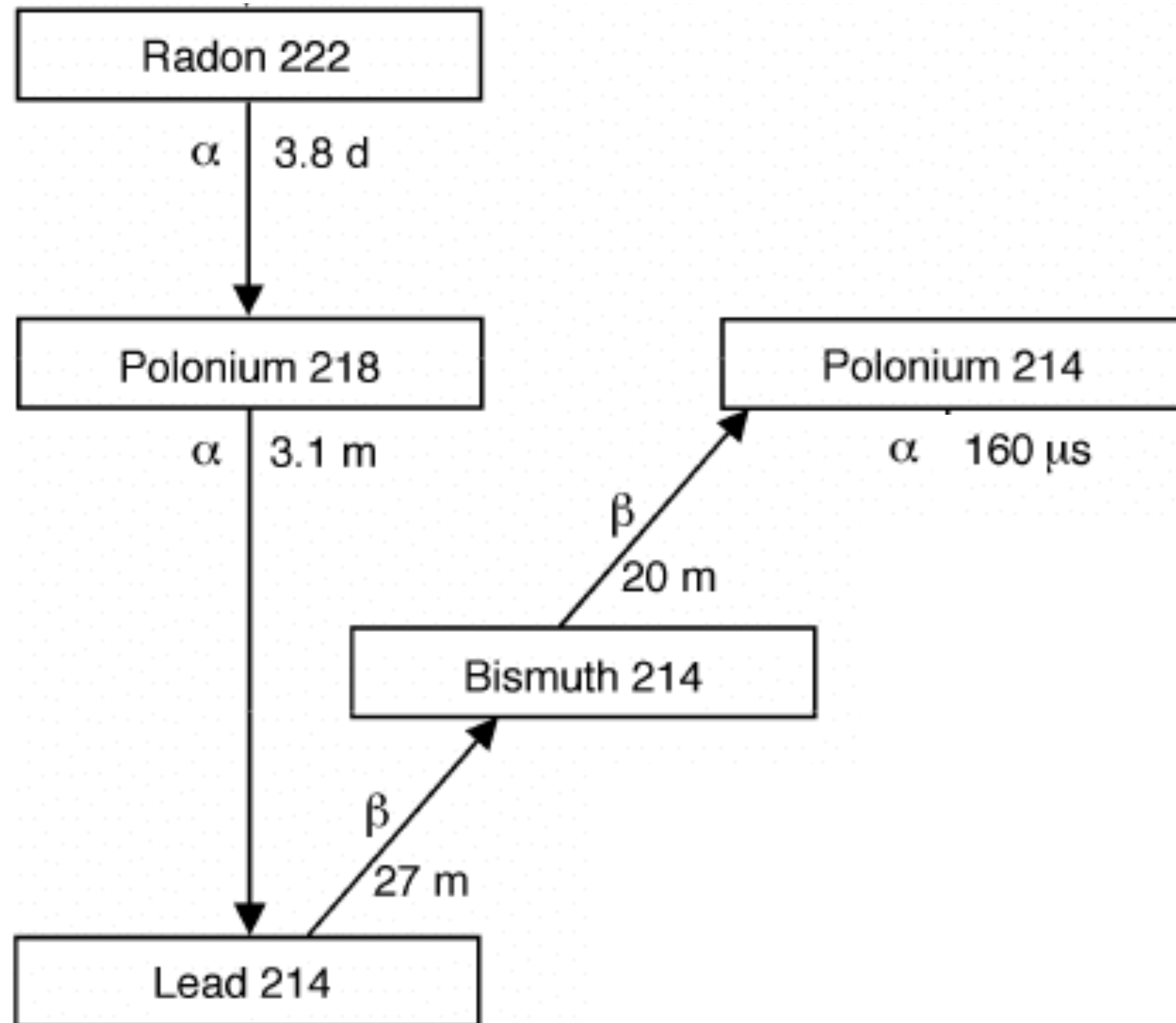
Context

- Some dual phase TPC experiments observed an accumulation of ^{222}Rn daughters events near the cathode
 - Due to some radon daughters being produced as positive ions
- Can provide a way to discriminate against background if we are able tag events near the cathode
 - Useful for alpha/gamma events (dangerous for solar neutrinos studies for example)
- Need to know the fraction of alpha decays happening at the cathode



Observation by WArP

Method



- Simulate the decay position of the different elements of the chain
 - The two key parameters are the ionisation fraction and drift velocity
 - Lack of measurements in LAr so some values are extrapolated from LXe
- ^{222}Rn distributed uniformly along x-position with no drift
- ^{214}Po drift neglected due to its short half-life
- Extract the x distribution of alpha decays

Ion mobility measurements in LAr and LXe

Measurements of the ion fraction and mobility of alpha and beta decay products in liquid xenon using EXO-200

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T.N. Johnson,⁵ K.S. Kumar,^{10,§} D. Moore,⁶ A. Robinson,¹⁷ T. Tost,⁷ L. ...

	Ion fraction [%]	Ion mobility [cm ² /V s]
²¹⁸ Po	50.3 ± 3.0	(0.219 ± 0.004) × 10 ⁻³
²¹⁴ Pb	50.3 ± 3.0	—
²¹⁴ Bi	76.3 ± 6.2	—

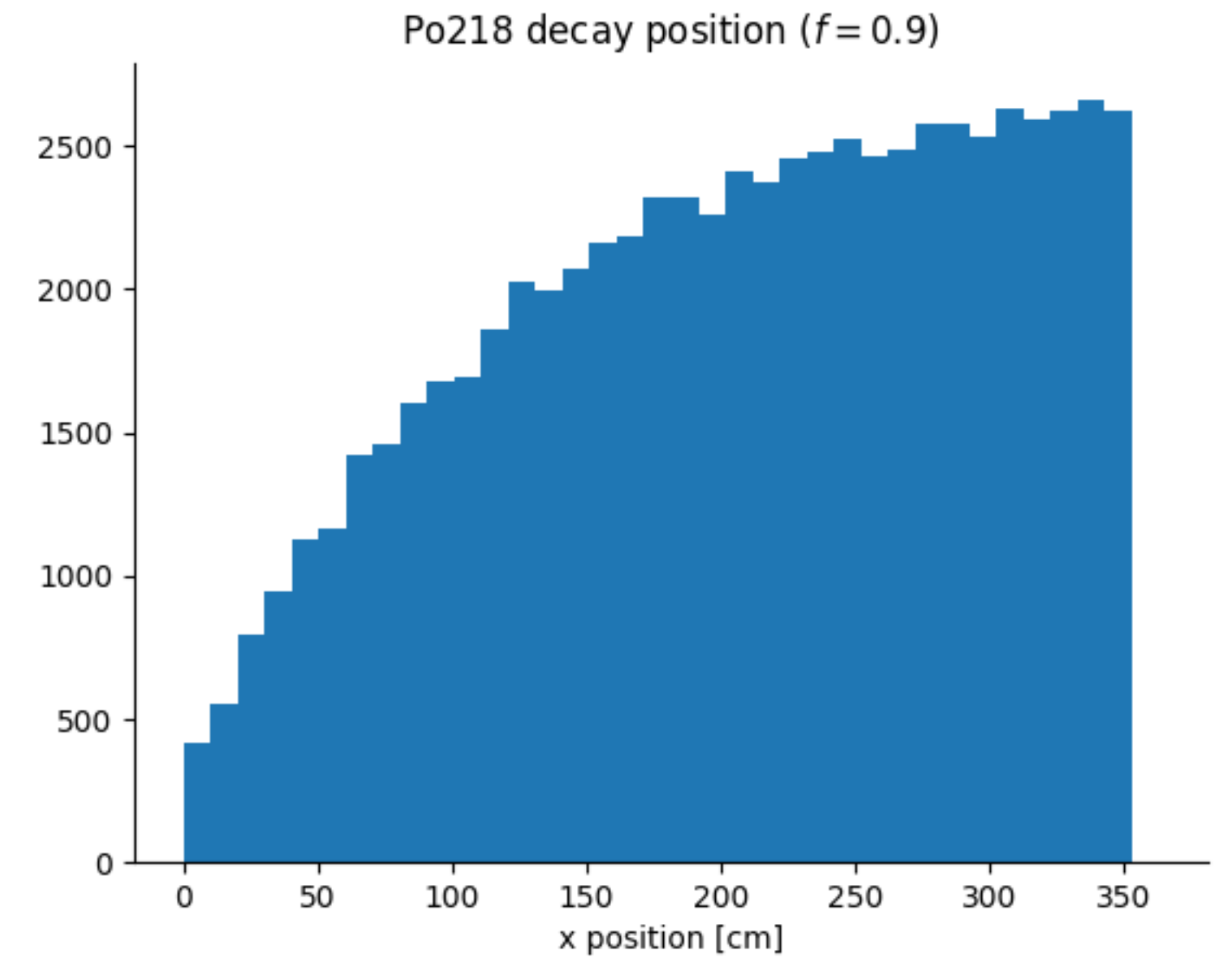
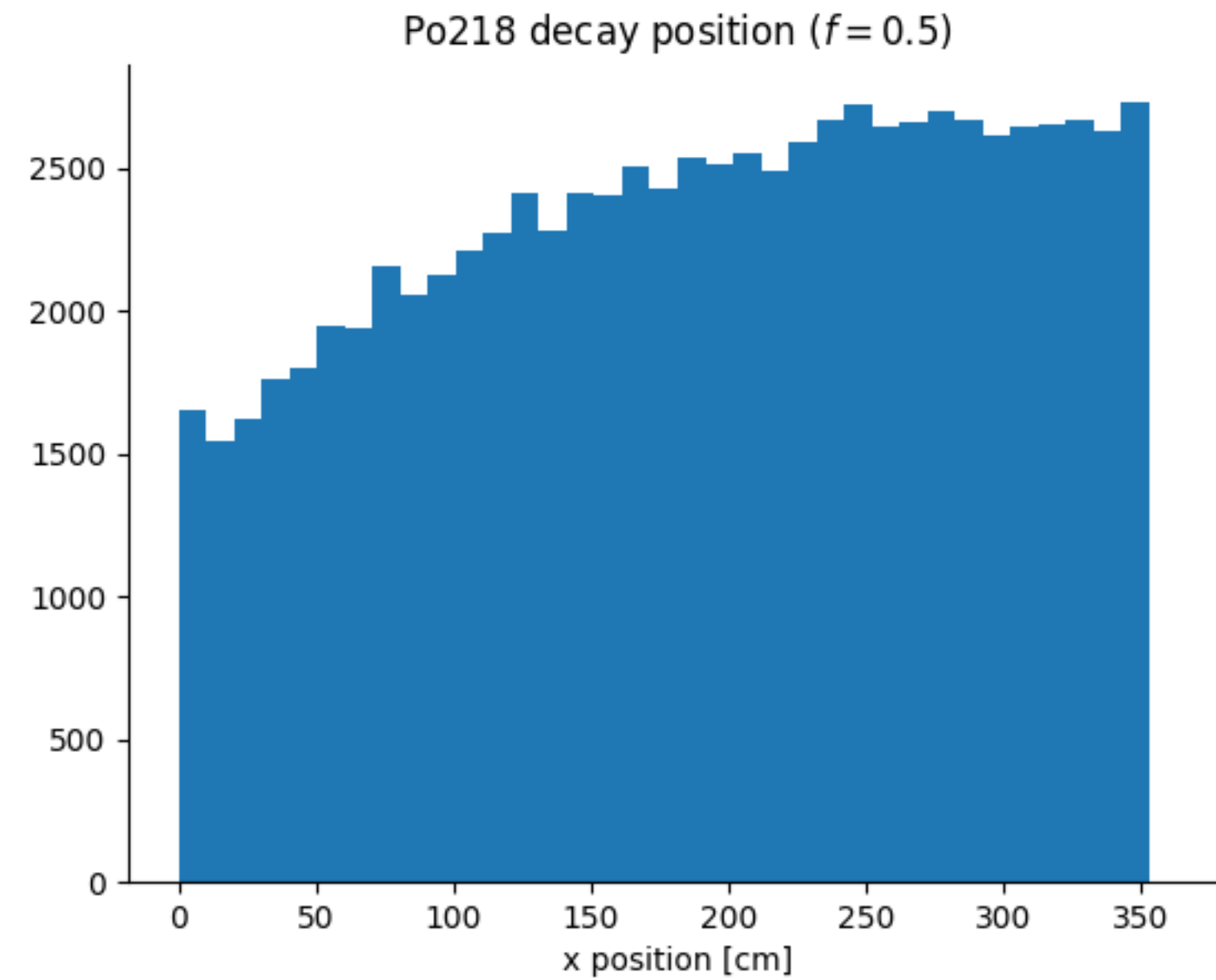
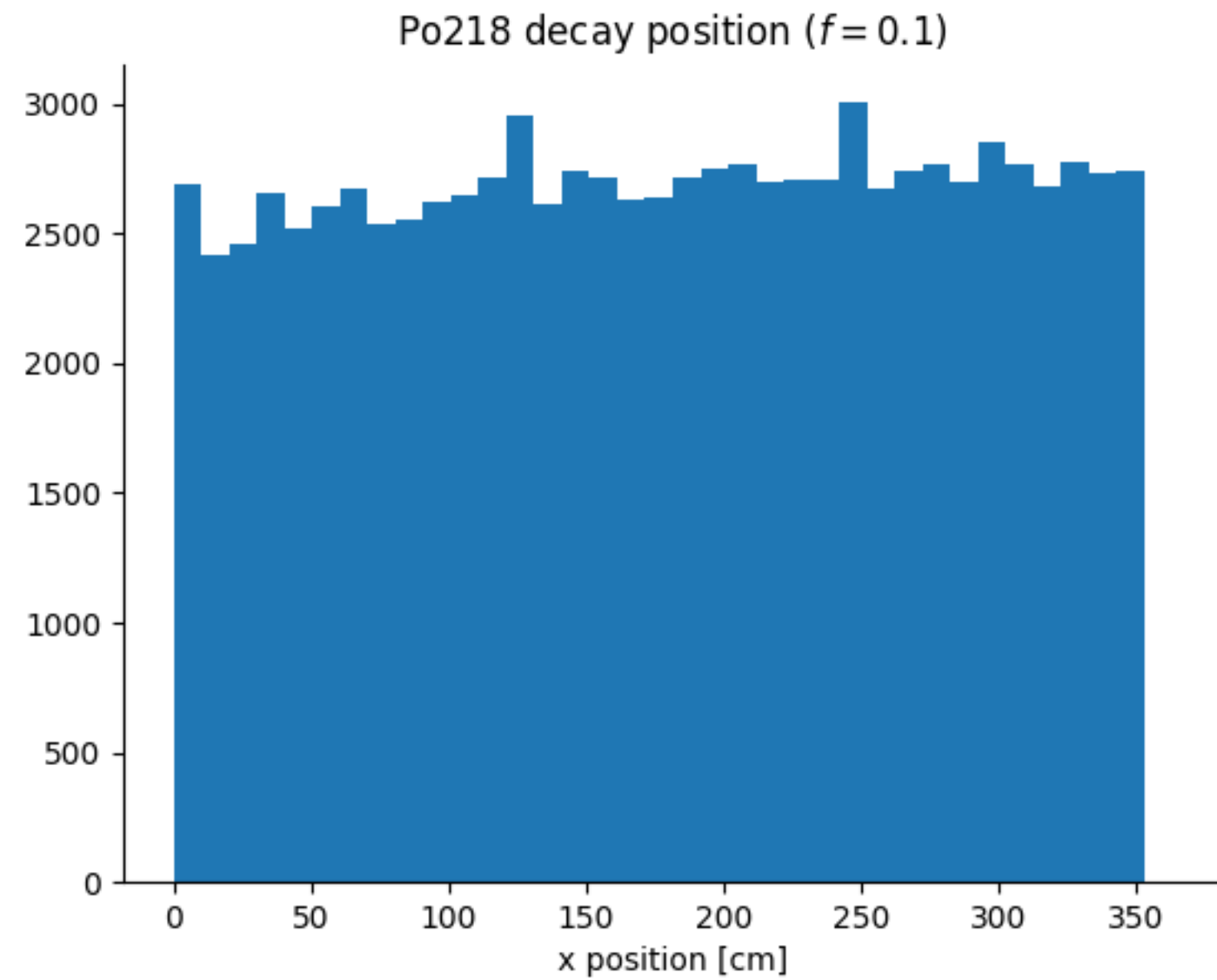
Measurement of the ion fraction and mobility of ²¹⁸Po produced in ²²²Rn decays in liquid argon

P. Agnes^a I.F.M. Albuquerque^b T. Alexander^c A.K. Alton^d M. Ave^b H.O. Back^c G. Batignani^{e,f} K. Biery^g V. Bocci^h G. Bonfiniⁱ W.M. Bonivento^j B. Bottino^{k,l} S. Bussino^{m,n} M. Cadeddu^{o,j} M. Cadoni^{o,j} F. Calaprice^p A. Caminata^l N. Canci^{a,i} A. Candelaⁱ M. Caravati^{o,j} M. Cariello^l M. Carlini^{i,q} M. Carpinelli^{r,s} S. Catalanotti^{t,u} V. Cataudella^{t,u} P. Cavalcante^{v,i} S. Cavuoti^{t,u} A. Chepurnov^w C. Cicalò^j A.G. Cocco^u G. Covone^{t,u} D. D'Angelo^{x,y} S. Davini^l

	Ion fraction [%]	Ion mobility [cm ² /V s]
²¹⁸ Po	37 ± 3.0	(8.6 ± 0.1) × 10 ⁻⁴

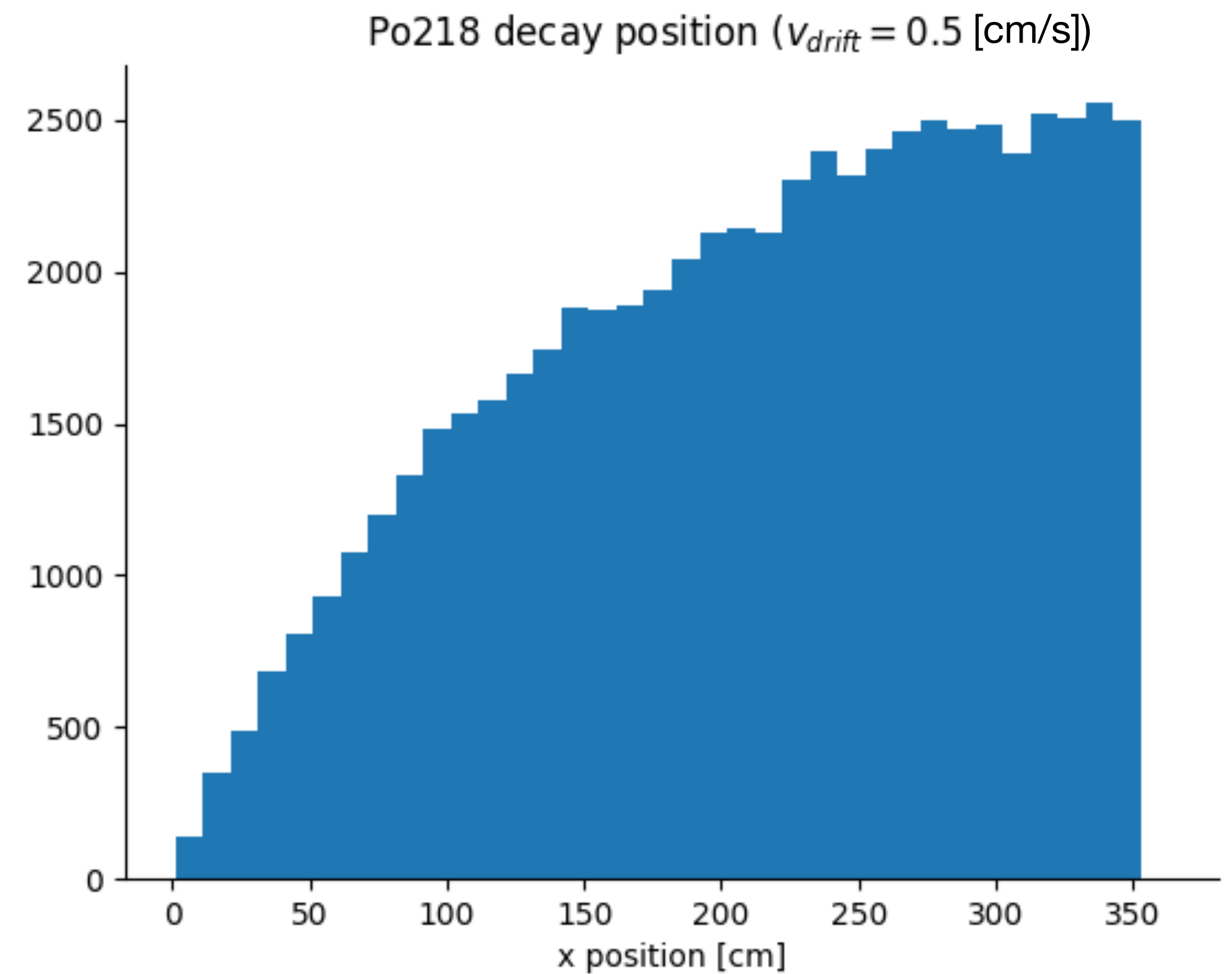
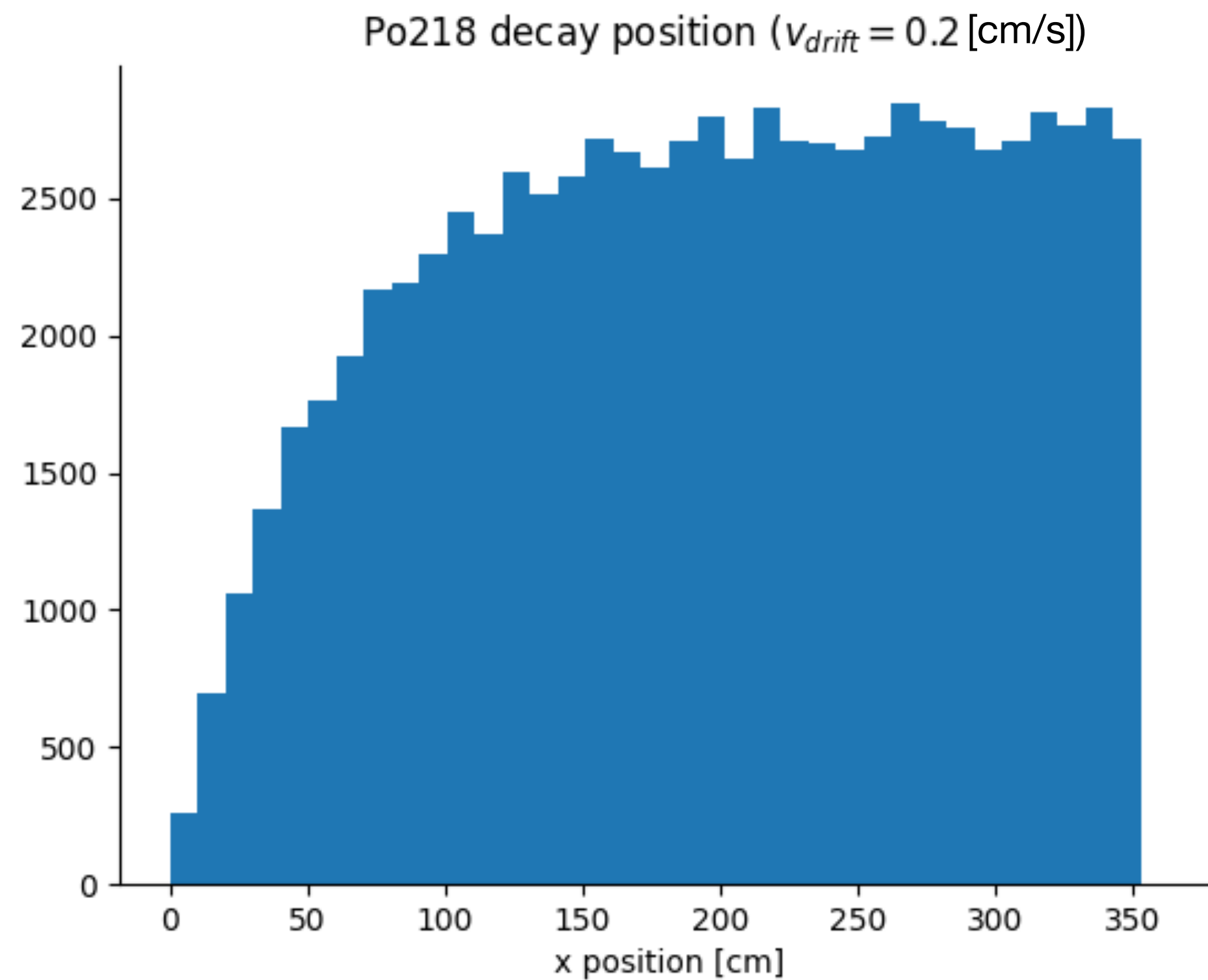
Lack of measurements in LAr, so ion fractions values are extrapolated from LXe

Influence of the ion fraction



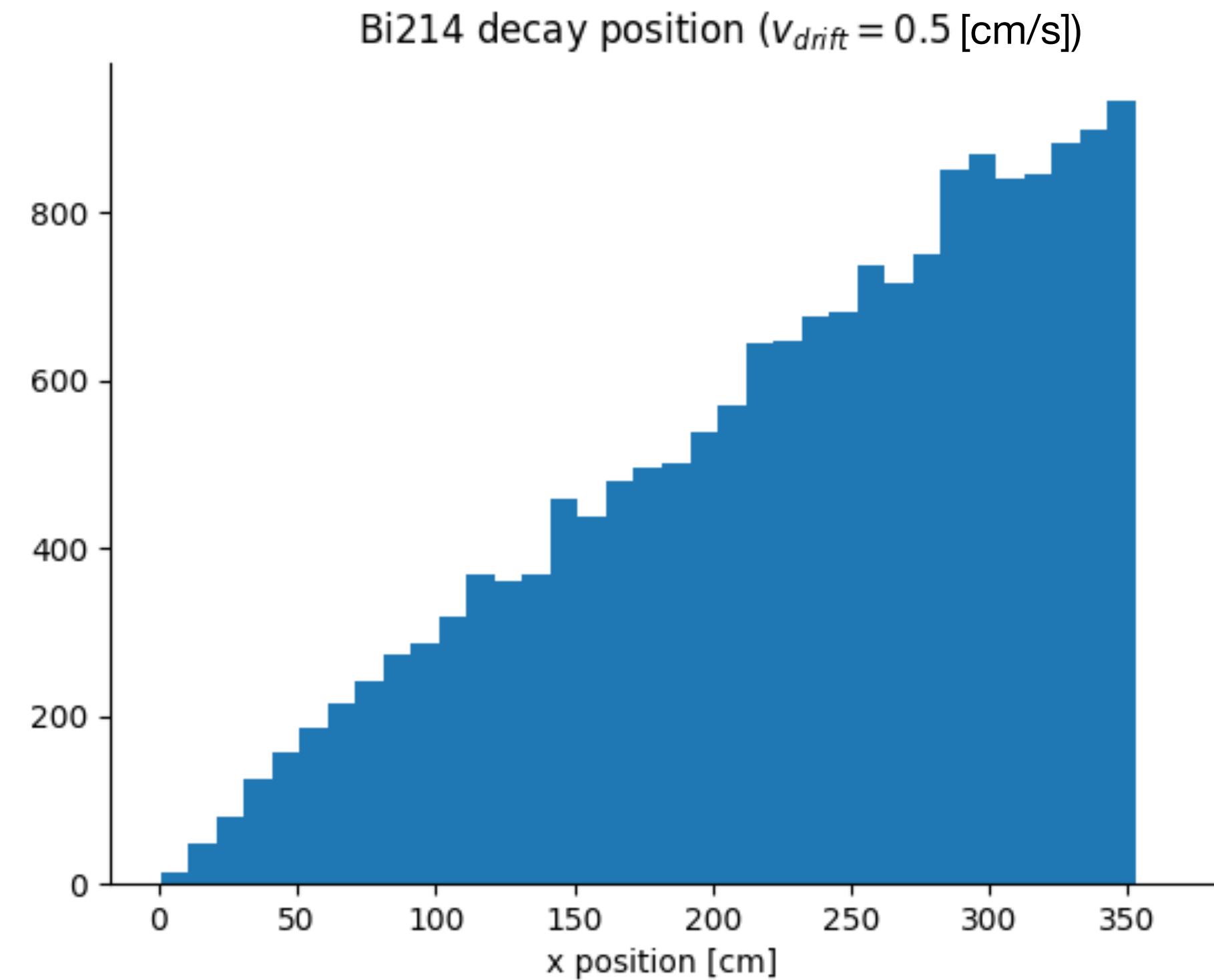
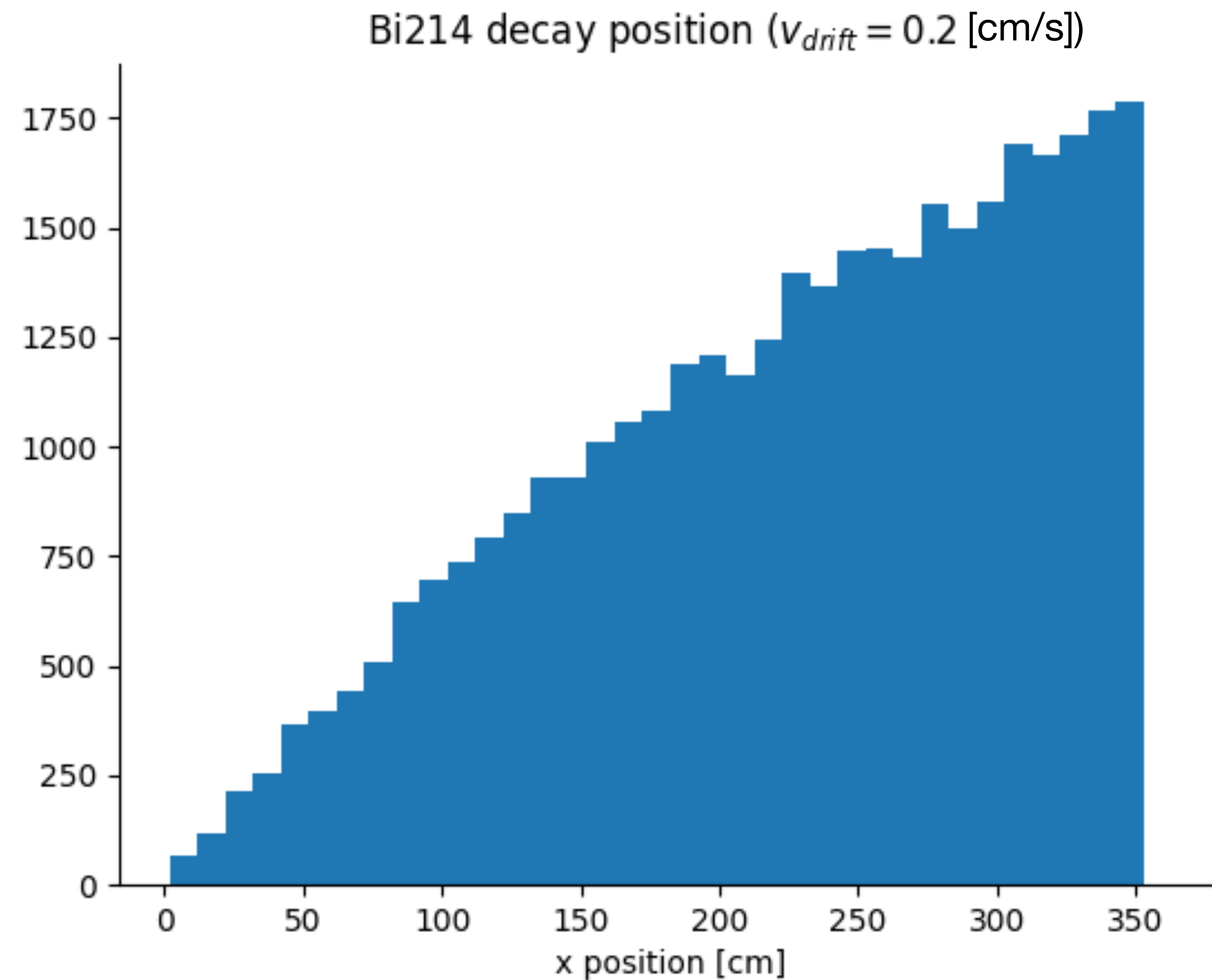
Ionisation fraction will be a key parameter in the simulation

Influence of the drift velocity (^{218}Po)



Changing the drift velocity changes the shape of the distribution

Influence of drift velocity (^{214}Bi)



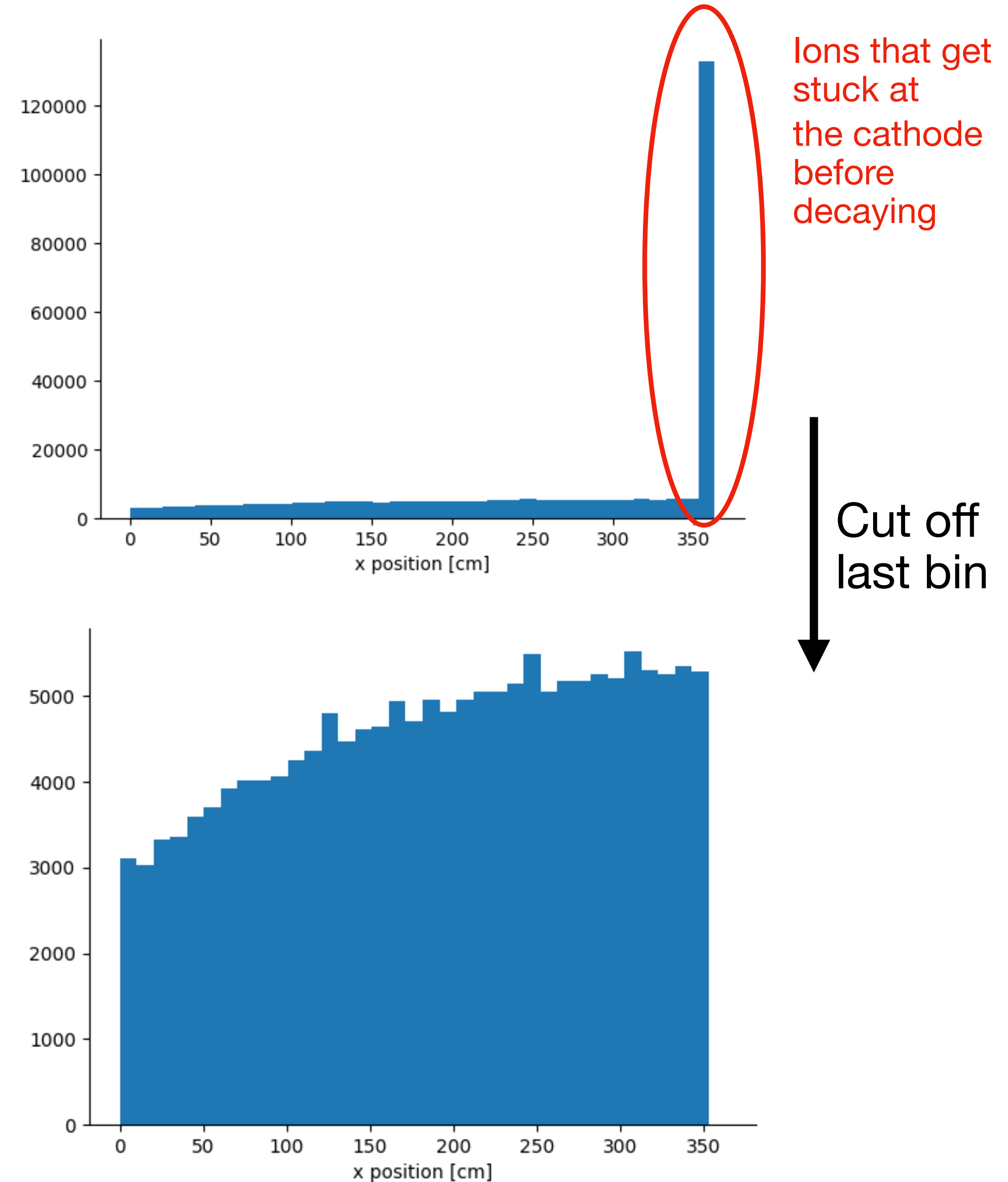
- Less influence for ^{214}Bi (half-life \simeq time to travel to the cathode)
 - Similar behaviour for ^{214}Pb
- Drift velocity for ^{214}Po and ^{214}Bi fixed at 0.4

Ideal scenario

Total ionisation and high drift velocity

Isotope	Drift velocity [cm/s]	Ion fraction
Po218	0.4	1.
Pb214	0.4	1.
Bi214	0.4	1.

Distance to the cathode	Fraction of alpha decays [%]
< 30cm	52.14
< 20cm	50.38
< 10cm	48.56

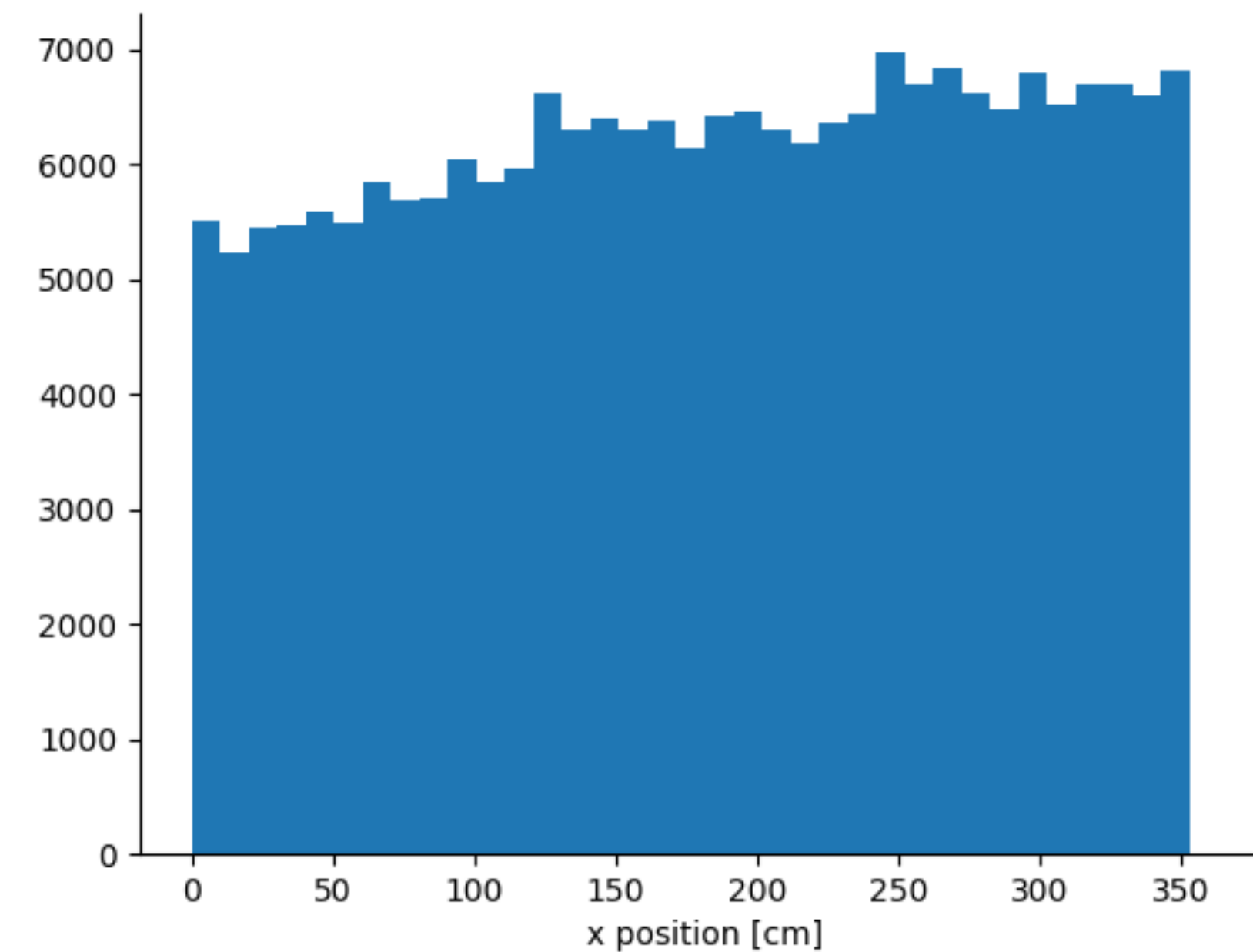
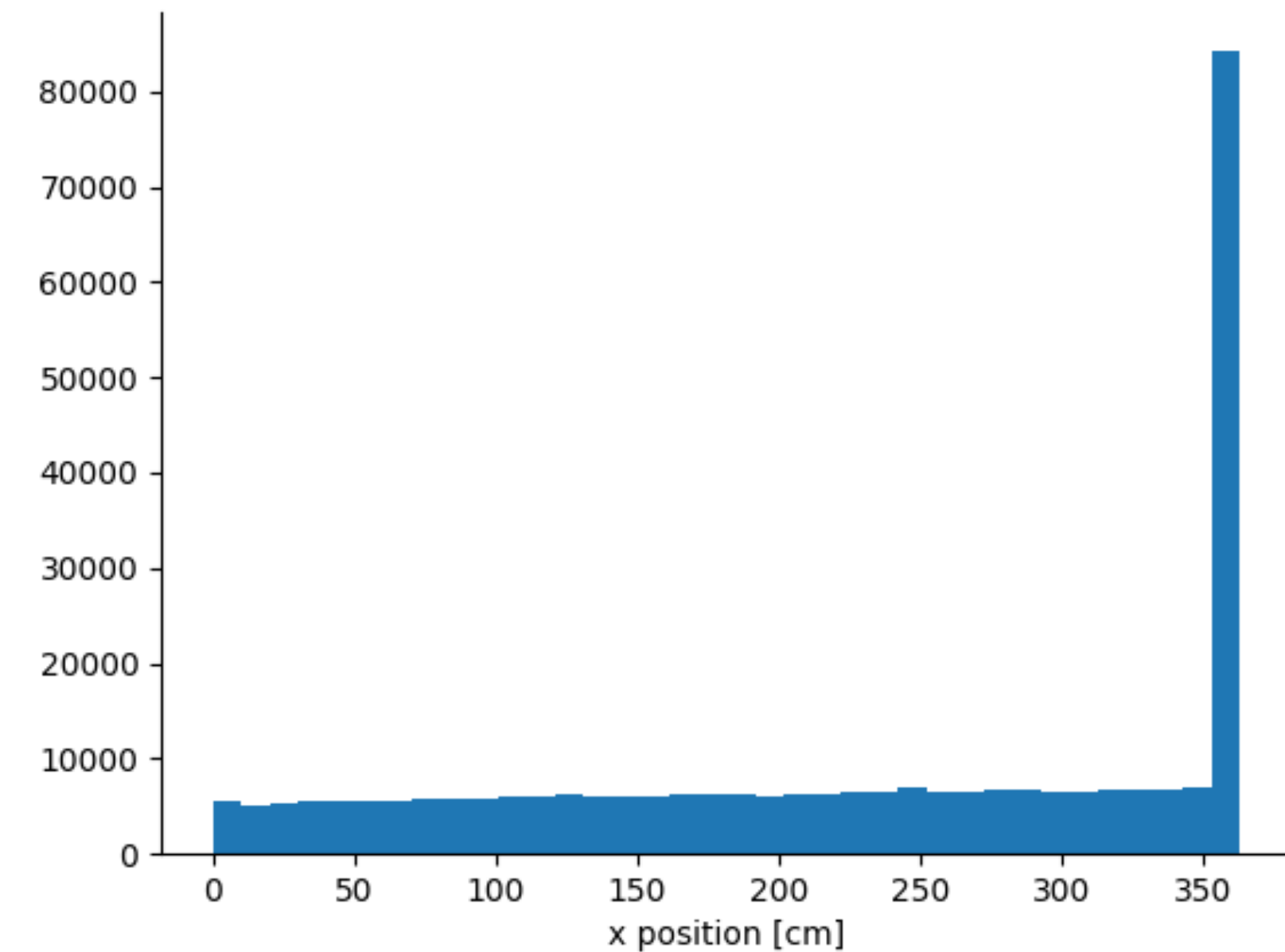


Realistic scenario

Values extrapolated from literature

Isotope	Drift velocity [cm/s]	Ion fraction
Po218	0.43	0.37
Pb214	0.4	0.37
Bi214	0.4	0.56

Distance to the cathode	Fraction of alpha decays [%]
< 30cm	34.72
< 20cm	32.5
< 10cm	30.31



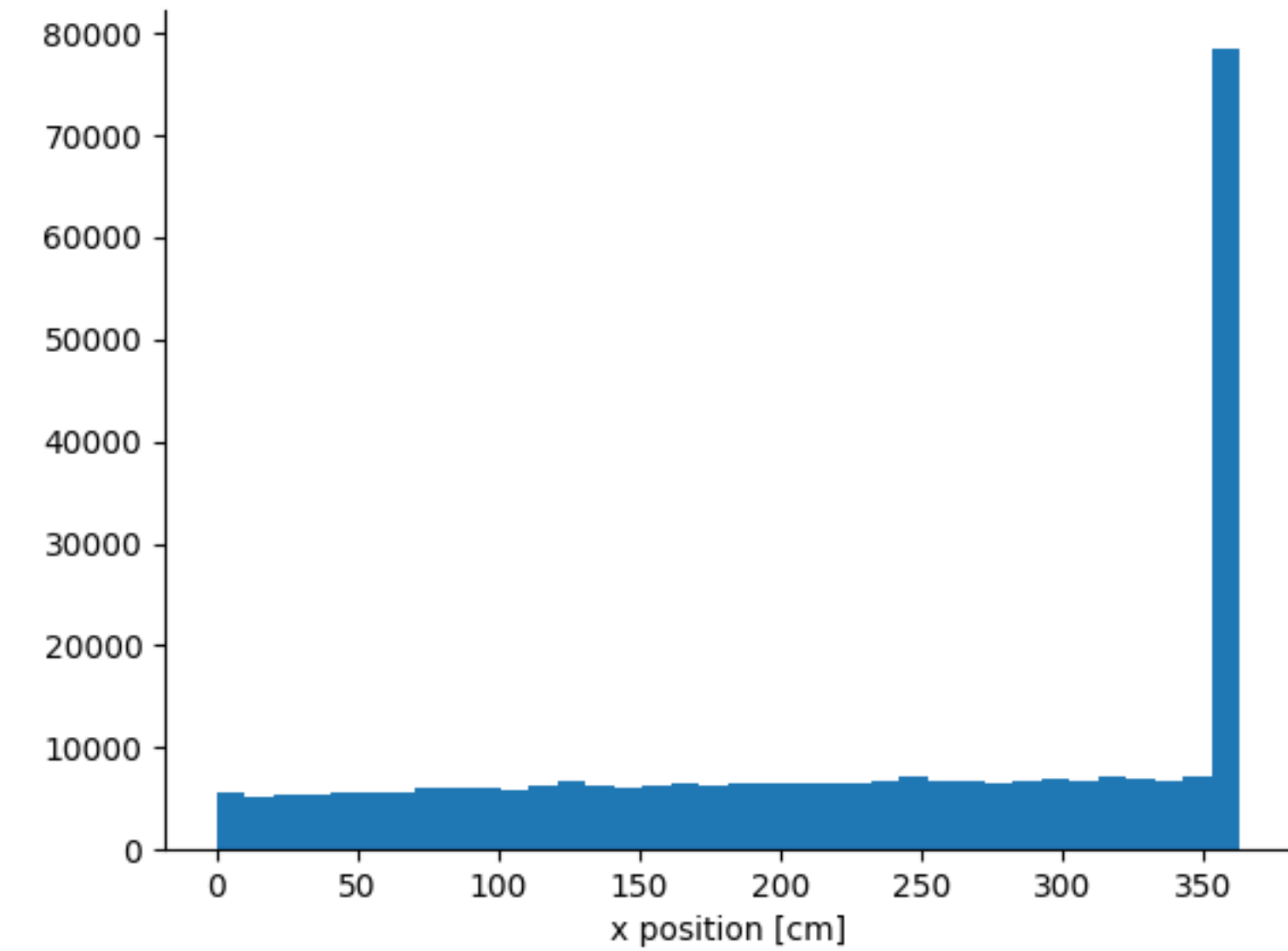
Cut off
last bin

Alternative scenario

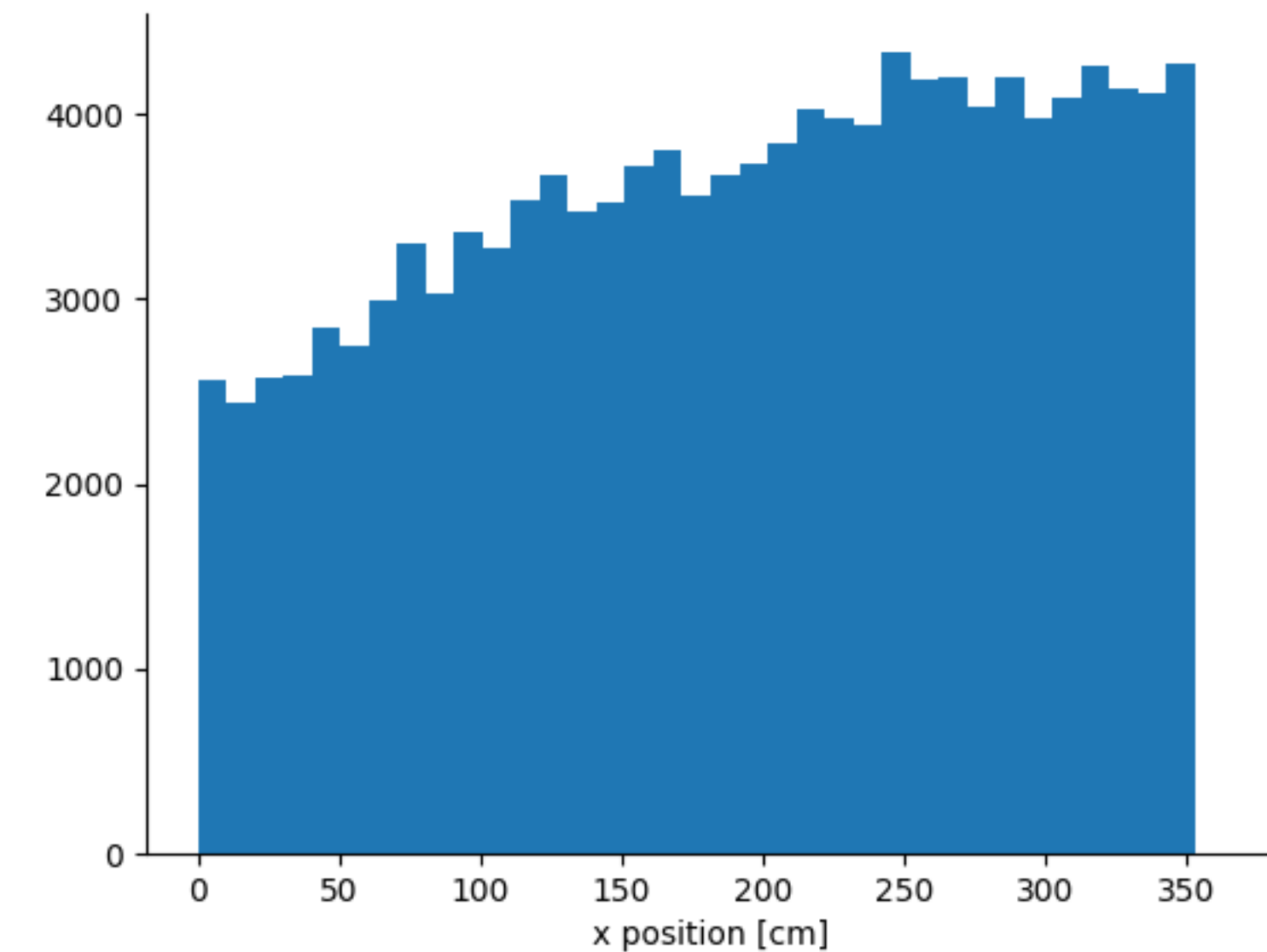
Previous scenario if ^{214}Pb isn't ionised

Isotope	Drift velocity	Ion fraction
Po218	0.43	0.37
Pb214	0.4	0.
Bi214	0.4	0.7

Distance to the cathode	Fraction of alpha decays [%]
< 30cm	33.15
< 20cm	30.88
< 10cm	28.61



Cut off last bin



Summary and next steps

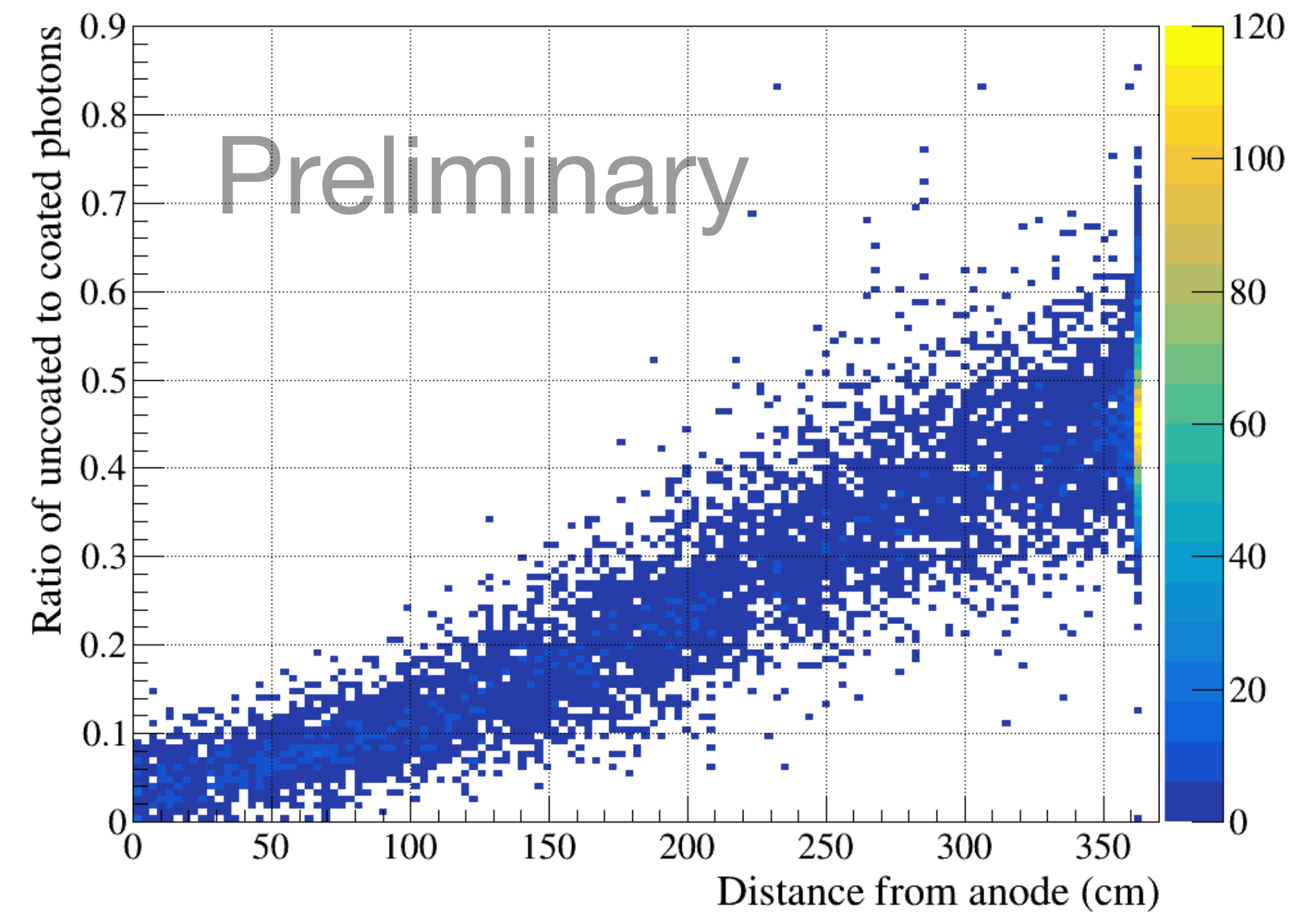
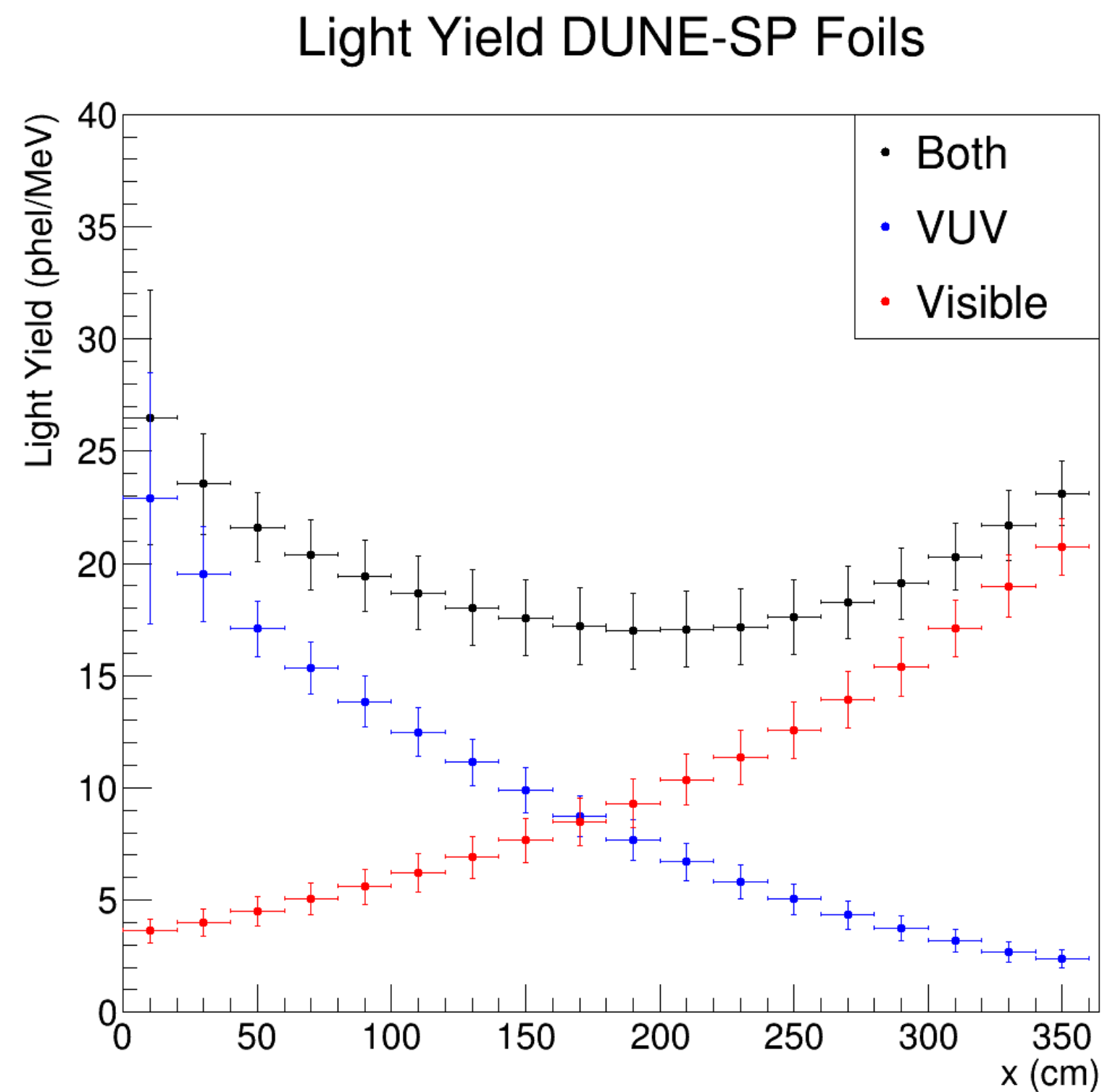
- Measurements from low energy experiments show that radon daughters tend to drift towards the cathode
 - This should mean that also in DUNE a fraction of these decays should be present closer to CPA
- Ion fraction is the key parameter influencing the position of the decays
- Current best estimate: $\sim 30\%$ of the alpha decays from the radon chain will happen within 30 cm of the cathode
- It should be possible to construct a variable using scintillation photons with dependence on the x-position to remove events happening at the cathode. (work in progress)

Backup slides

Teaser : tagging events near the cathode

Can we construct a variable to tag events near the cathode ?

Addition of reflective foils at the cathode



Visible dependence on the x-position