Laser-ablation U-Pb geochronology in common-Pb rich minerals

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Introduction

Despite its popularity, laser ablation U-Pb dating is largely limited to minerals with negligible common-Pb (i.e., zircon) because:

- High ^{204}Hg backgrounds and low ^{204}Pb count rates make a ^{204}Pb-based common-Pb correction impractical
- Alternative corrections are compromised by the interplay between down-hole elemental fractionation and within-grain variability in common-Pb content
- Reference materials have variable proportions of common-Pb, making conventional standard normalisation impossible.

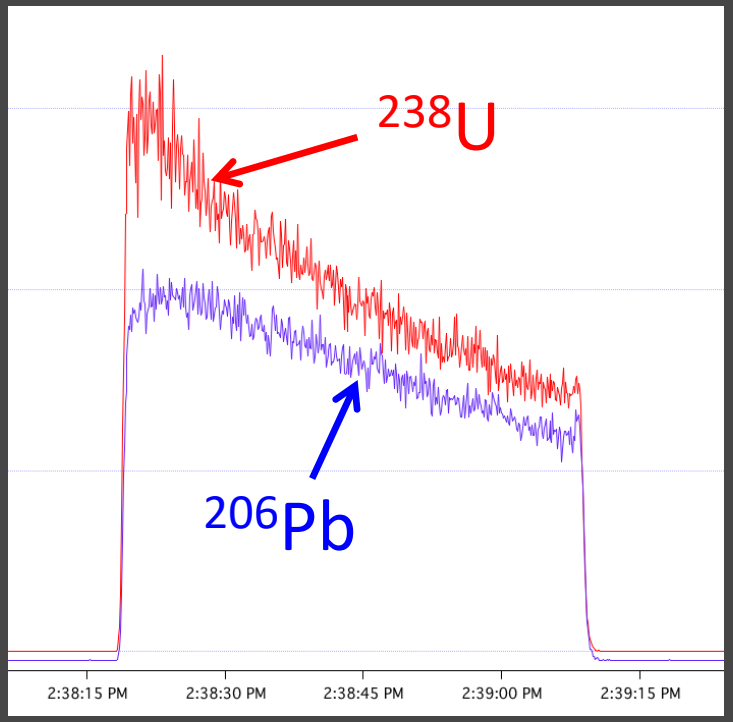
Here we present a 2-dimensional data treatment approach:

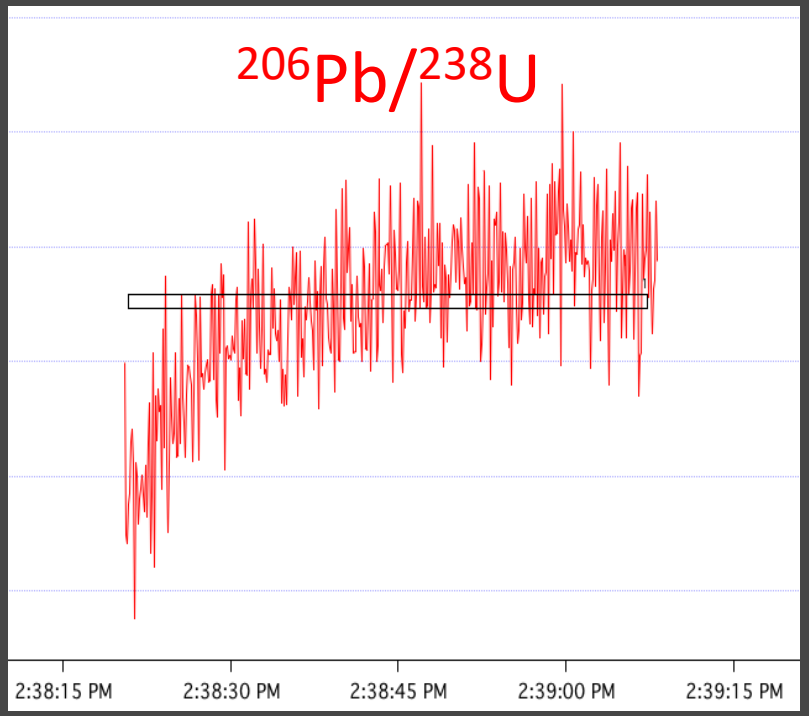
Can be used to correct for down-hole elemental fractionation without a common-Pb correction

Allows normalisation to reference materials that have variable common-Pb content

Quick outline of conventional approach

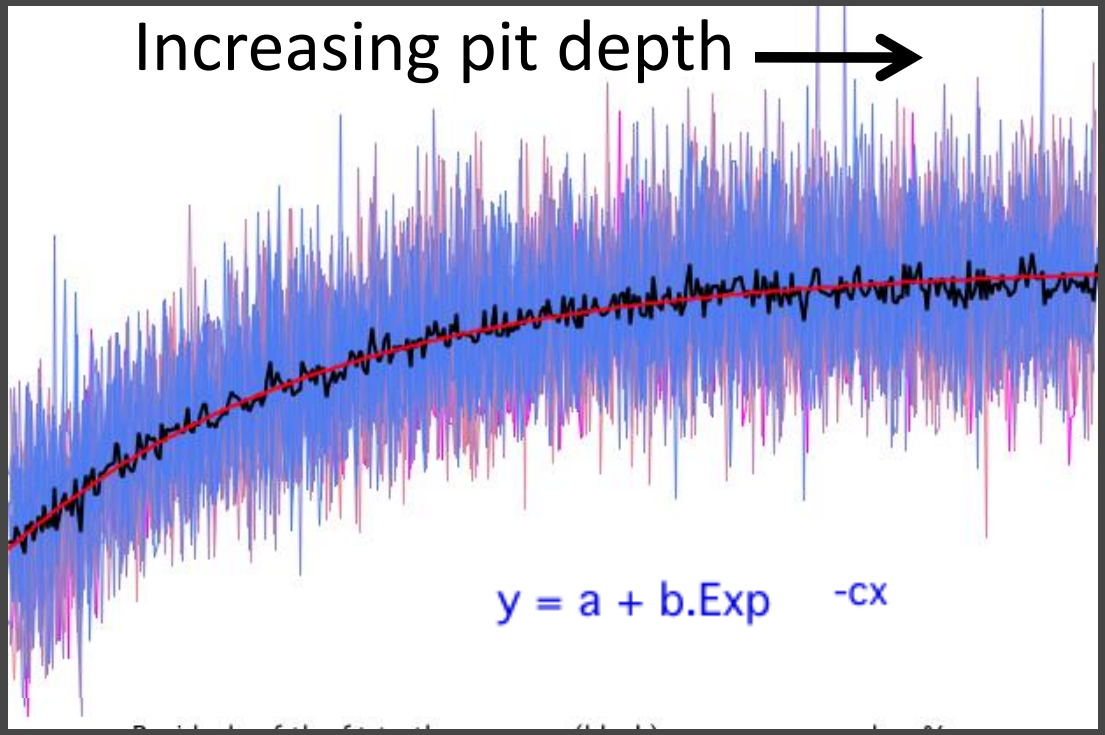
Calculate raw ratios from baseline-subtracted intensities





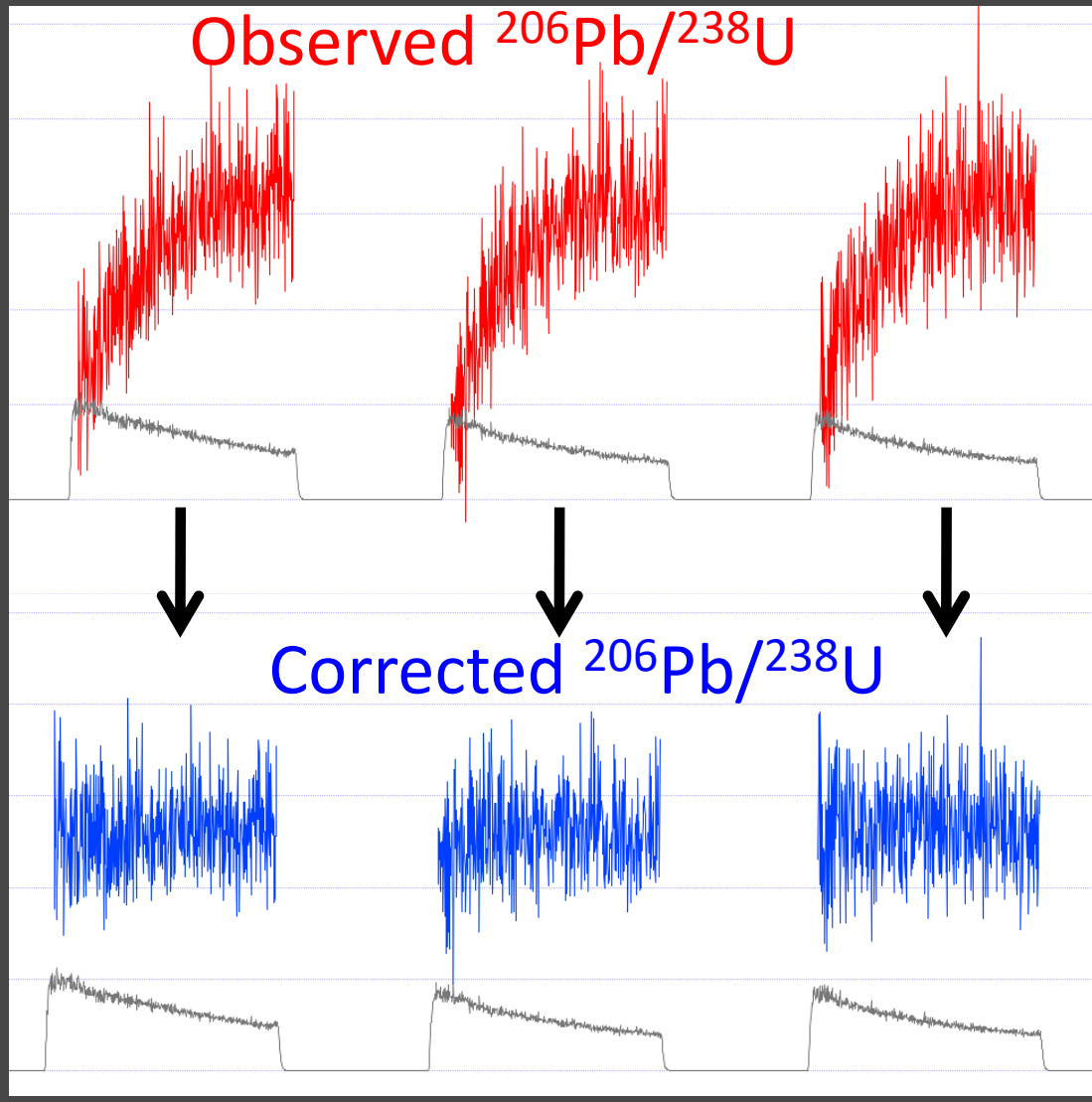
Quick outline of conventional approach

Model down-hole elemental fractionation using analyses of a matrix-matched reference material



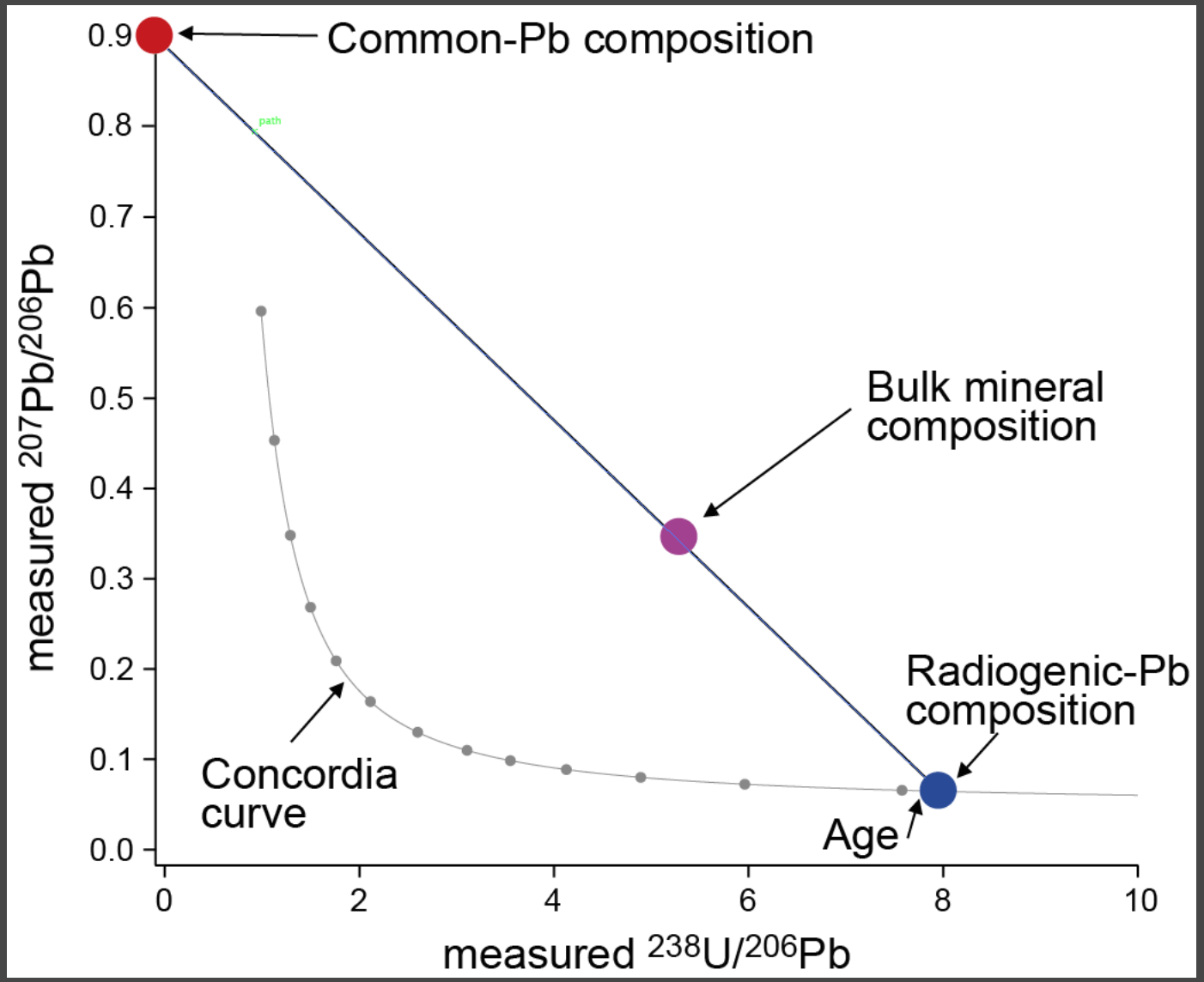
Quick outline of conventional approach

Generate down-hole corrected ratios for each timeslice



Problem of common-Pb variability

Easy to visualise using a Tera-Wasserburg diagram



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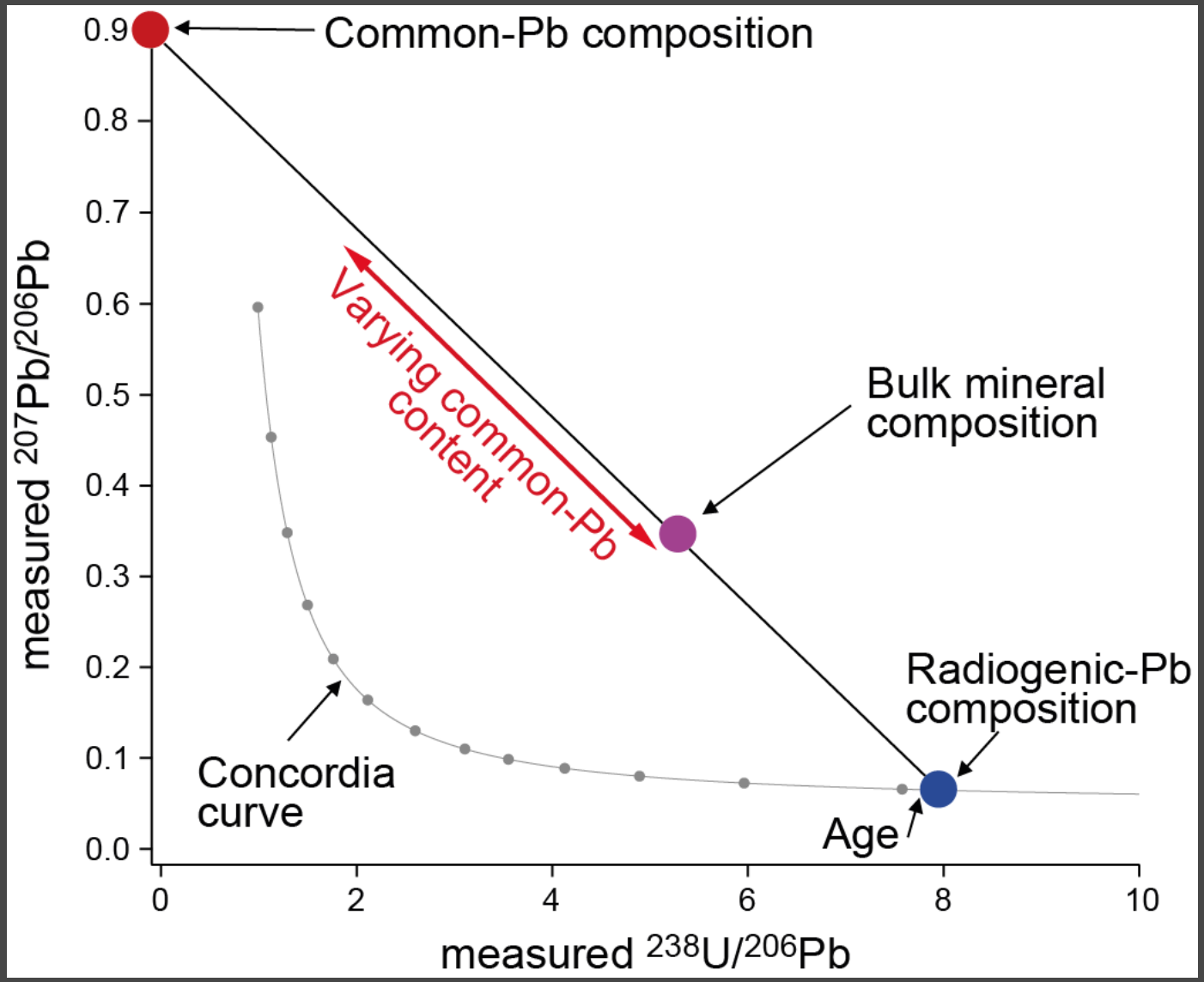

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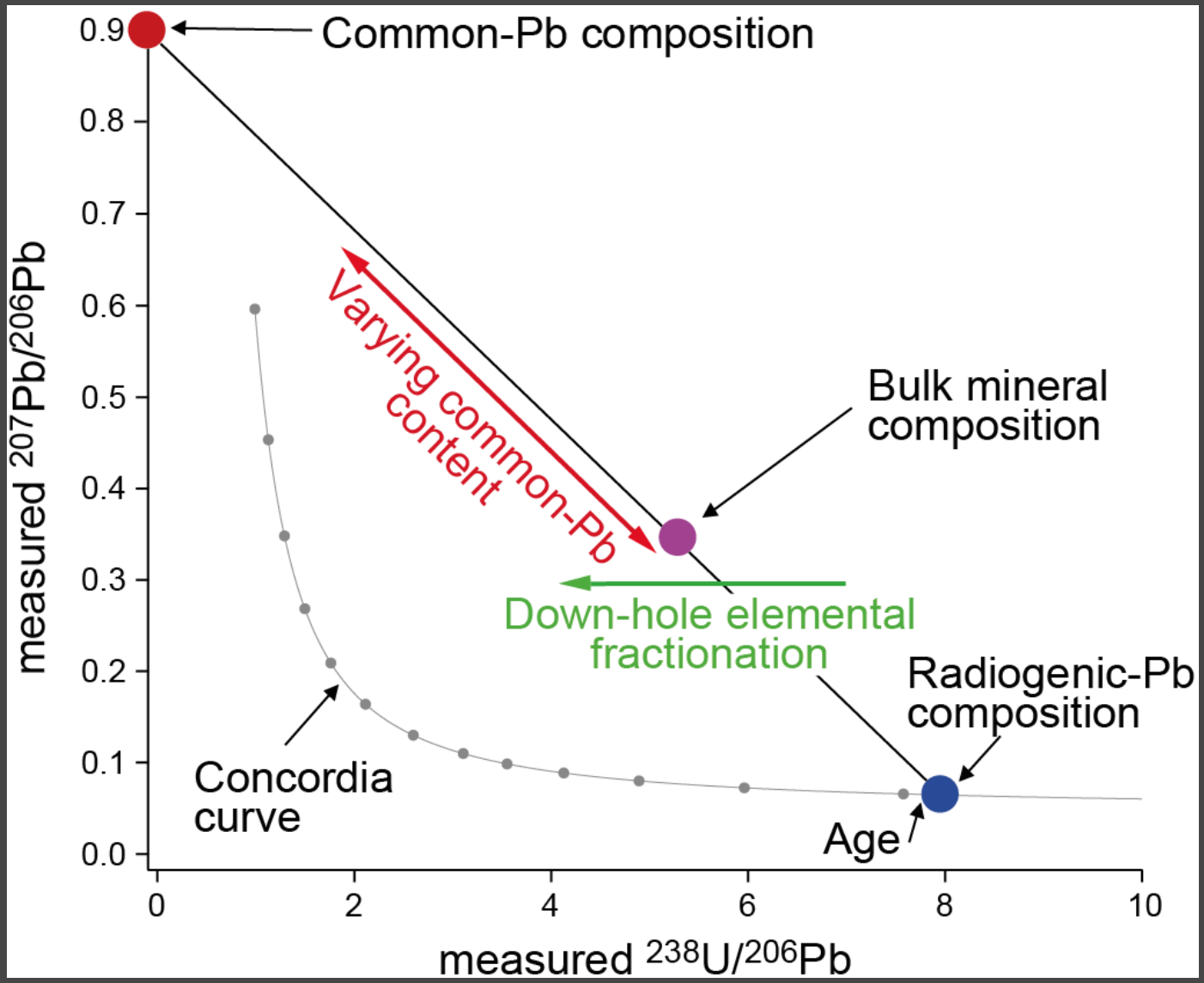

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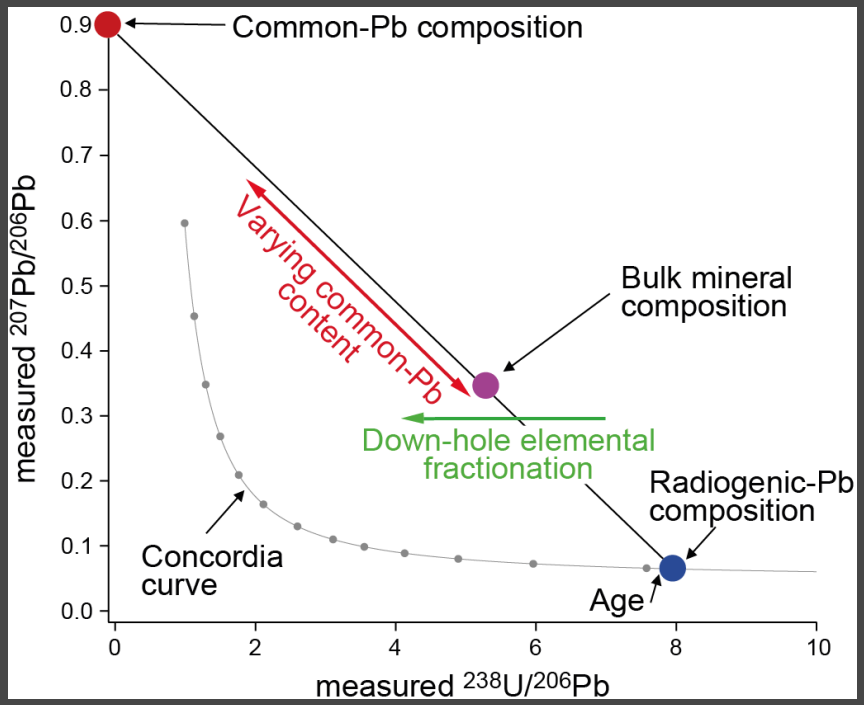
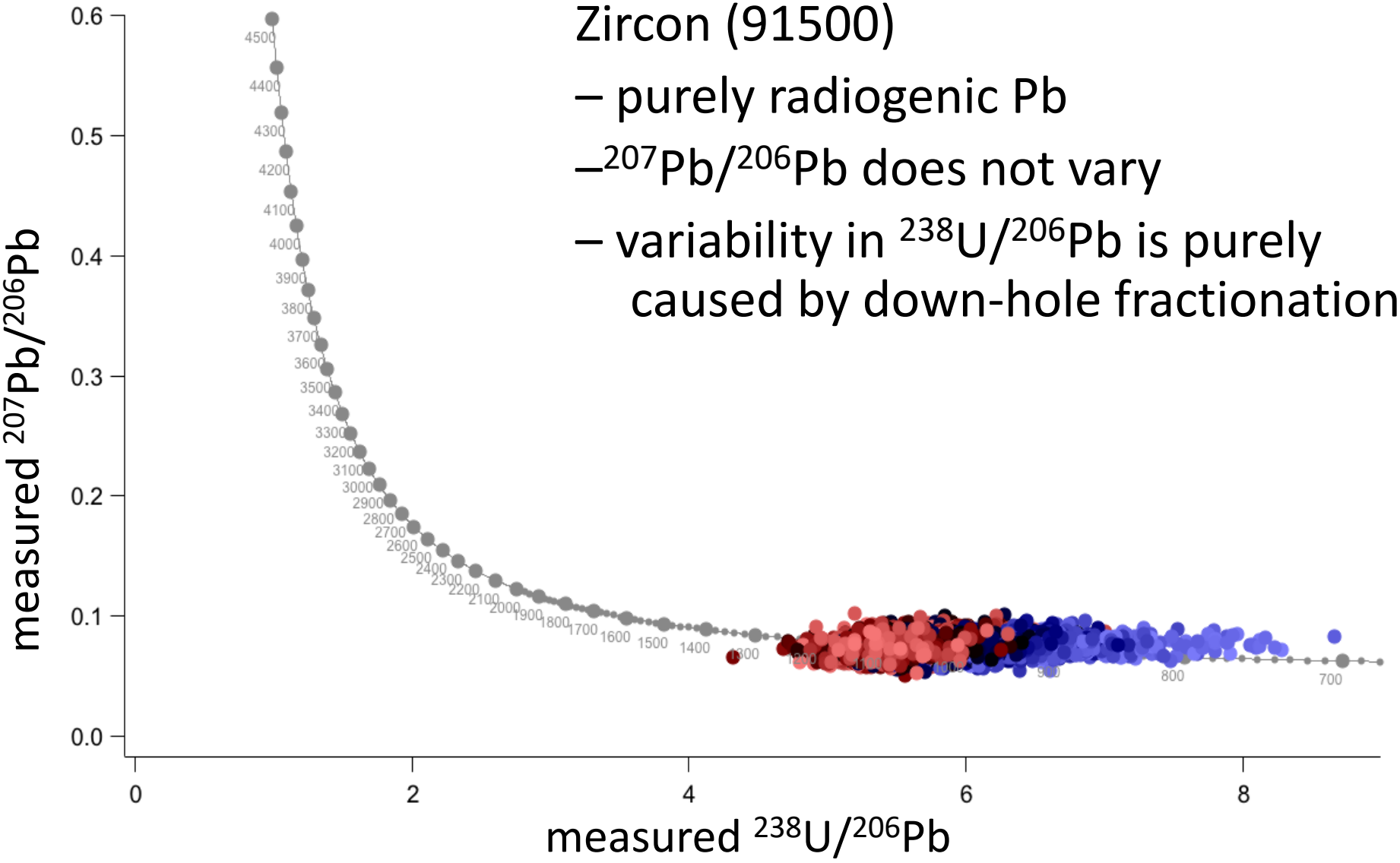


- Both processes generate variability in U/Pb ratios
- Conventional approach will falsely assign common-Pb variability to down-hole fractionation

Some examples



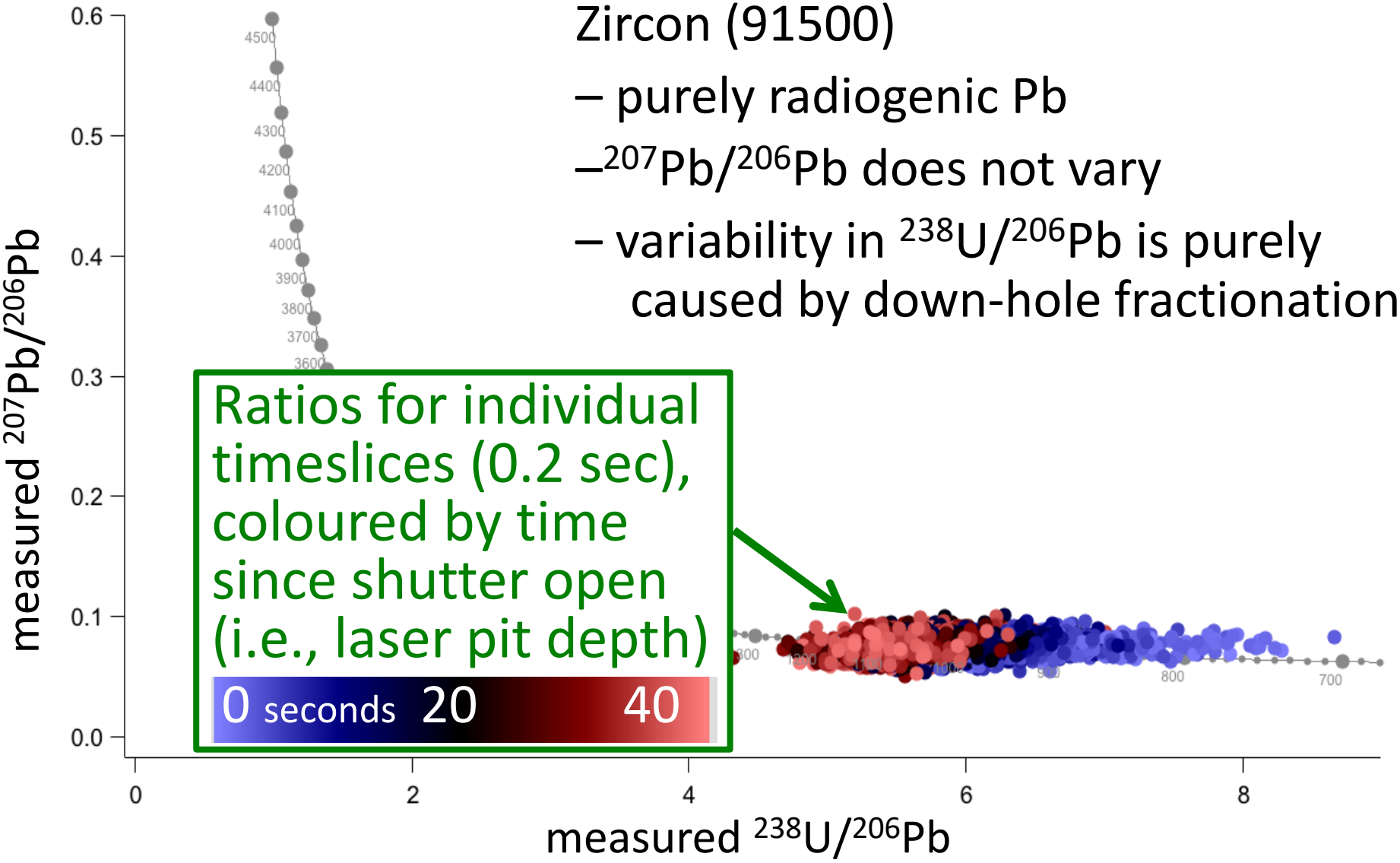
Zircon (91500)

– purely radiogenic Pb

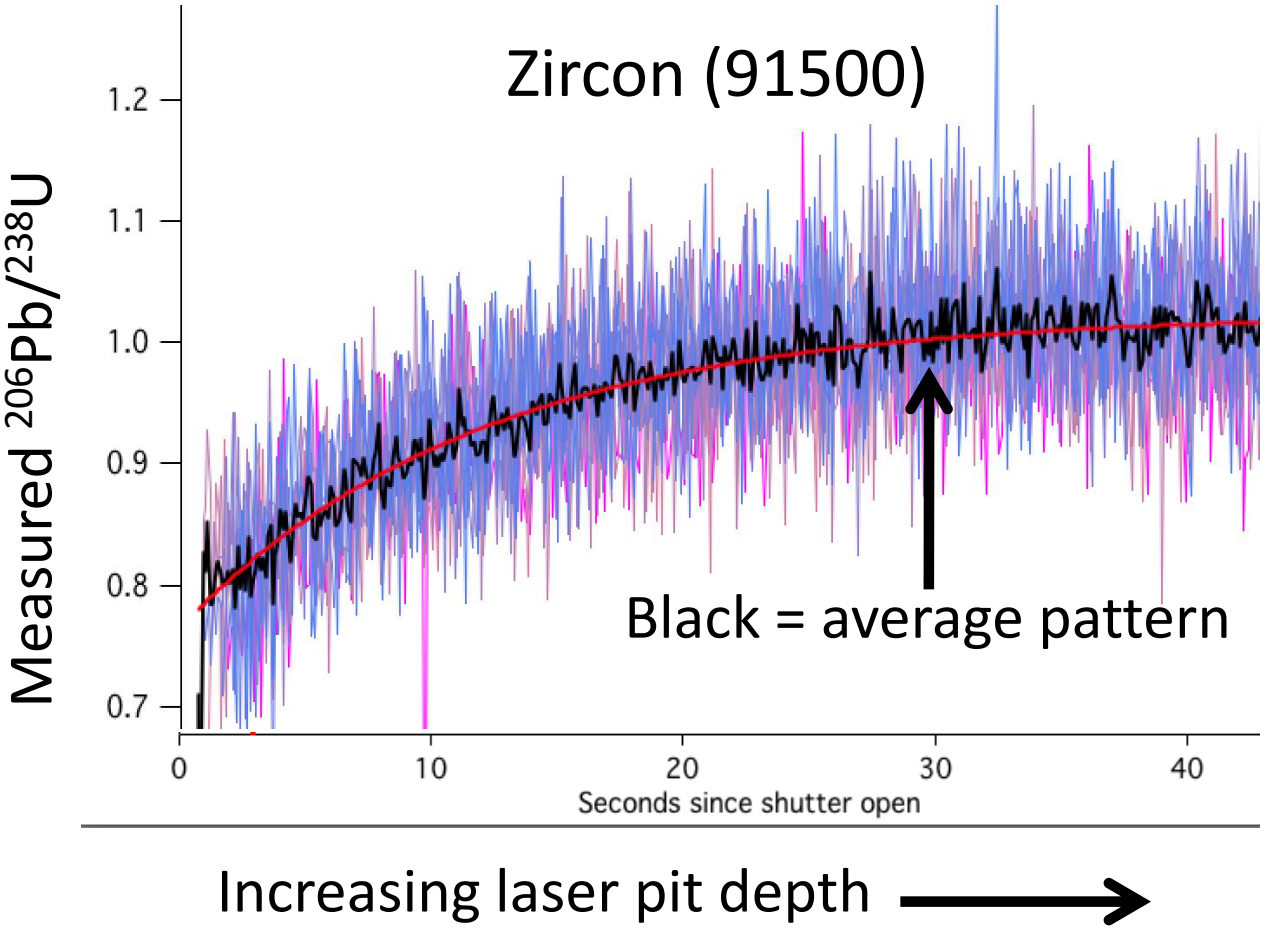
– $^{207}Pb/^{206}Pb$ does not vary

– variability in $^{238}U/^{206}Pb$ is purely caused by down-hole fractionation

Some examples



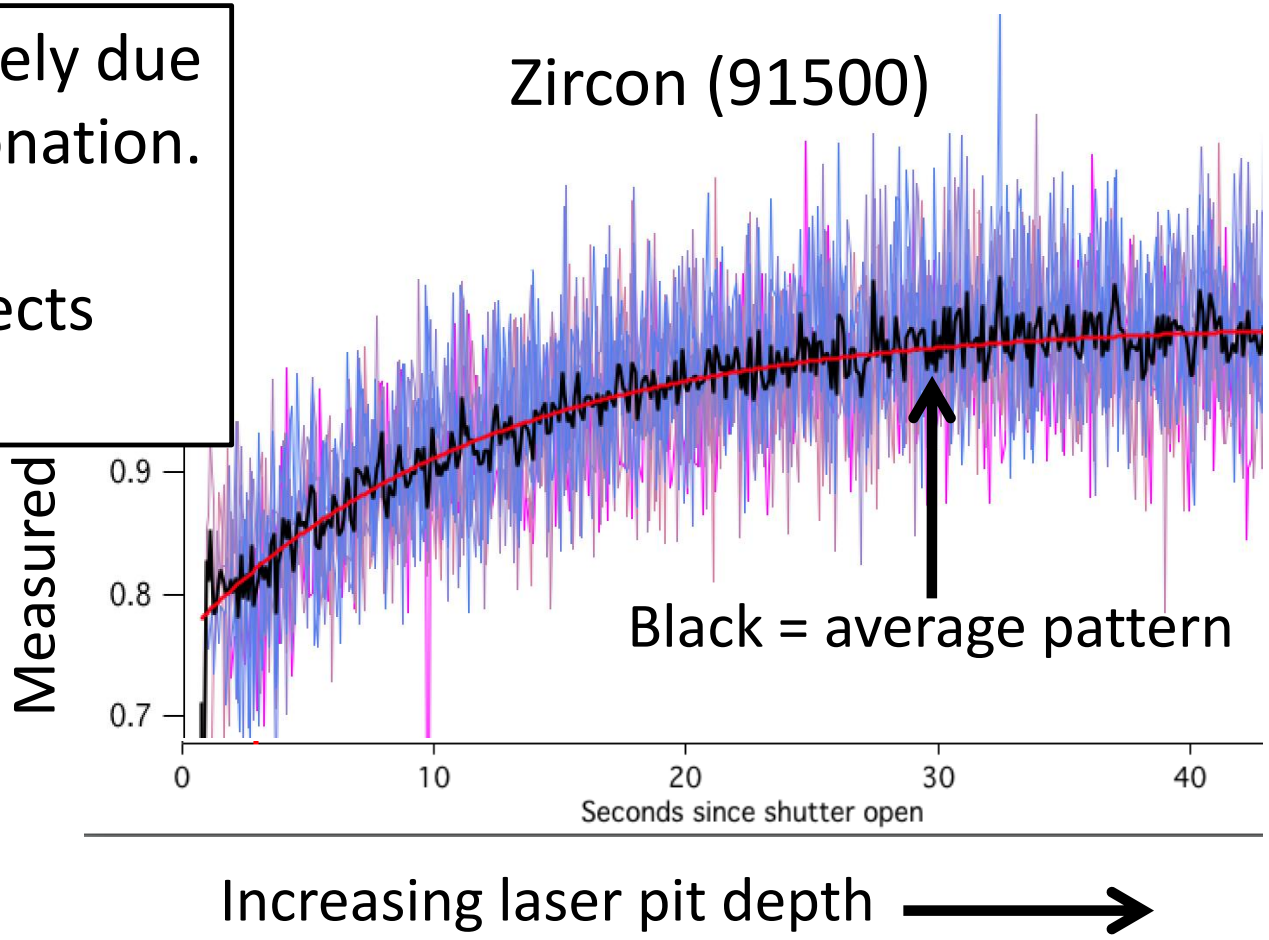
Apparent downhole fractionation



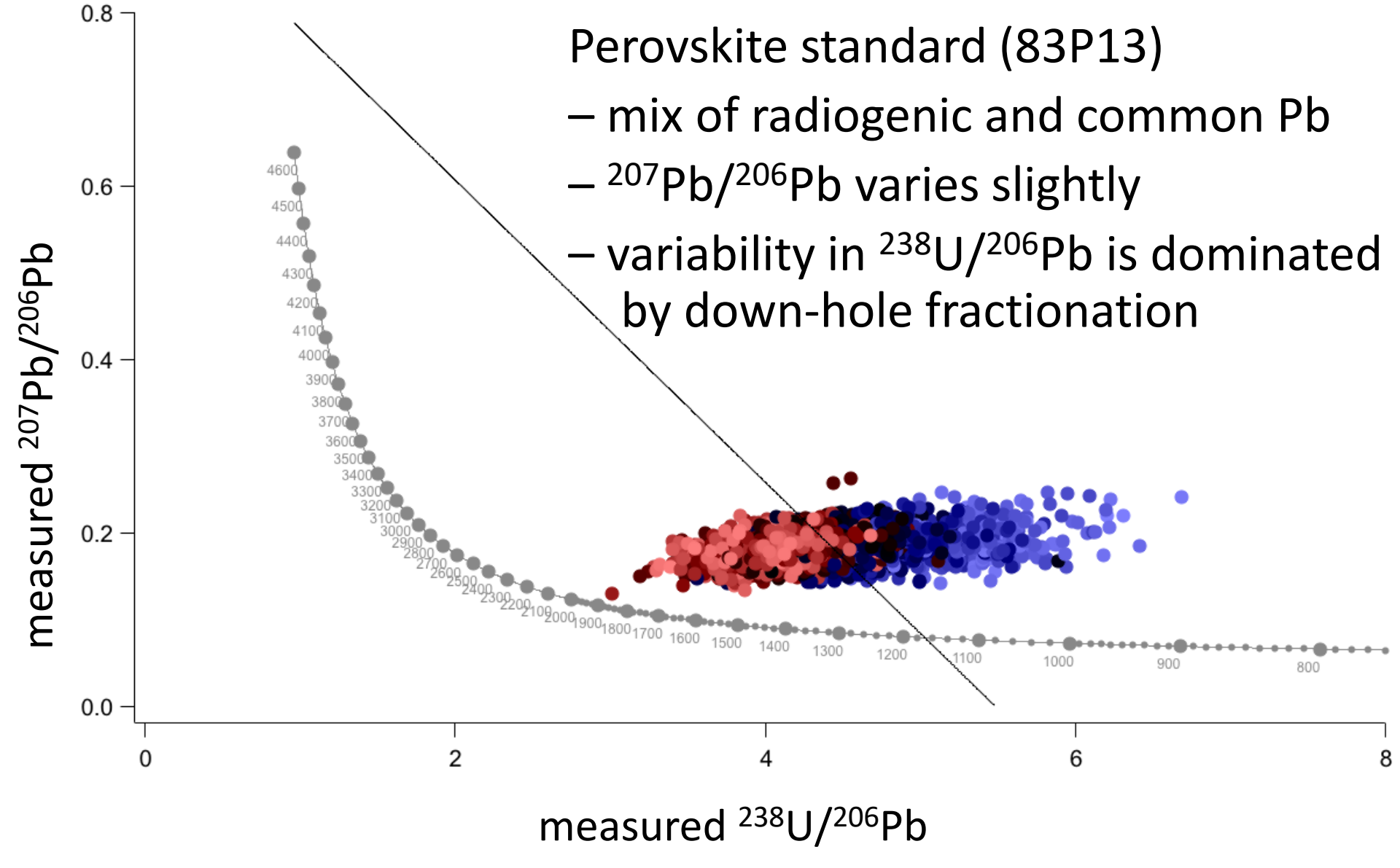
Apparent downhole fractionation

– The pattern is purely due to downhole fractionation.

– Easy to model effects and correct ratios



Some examples



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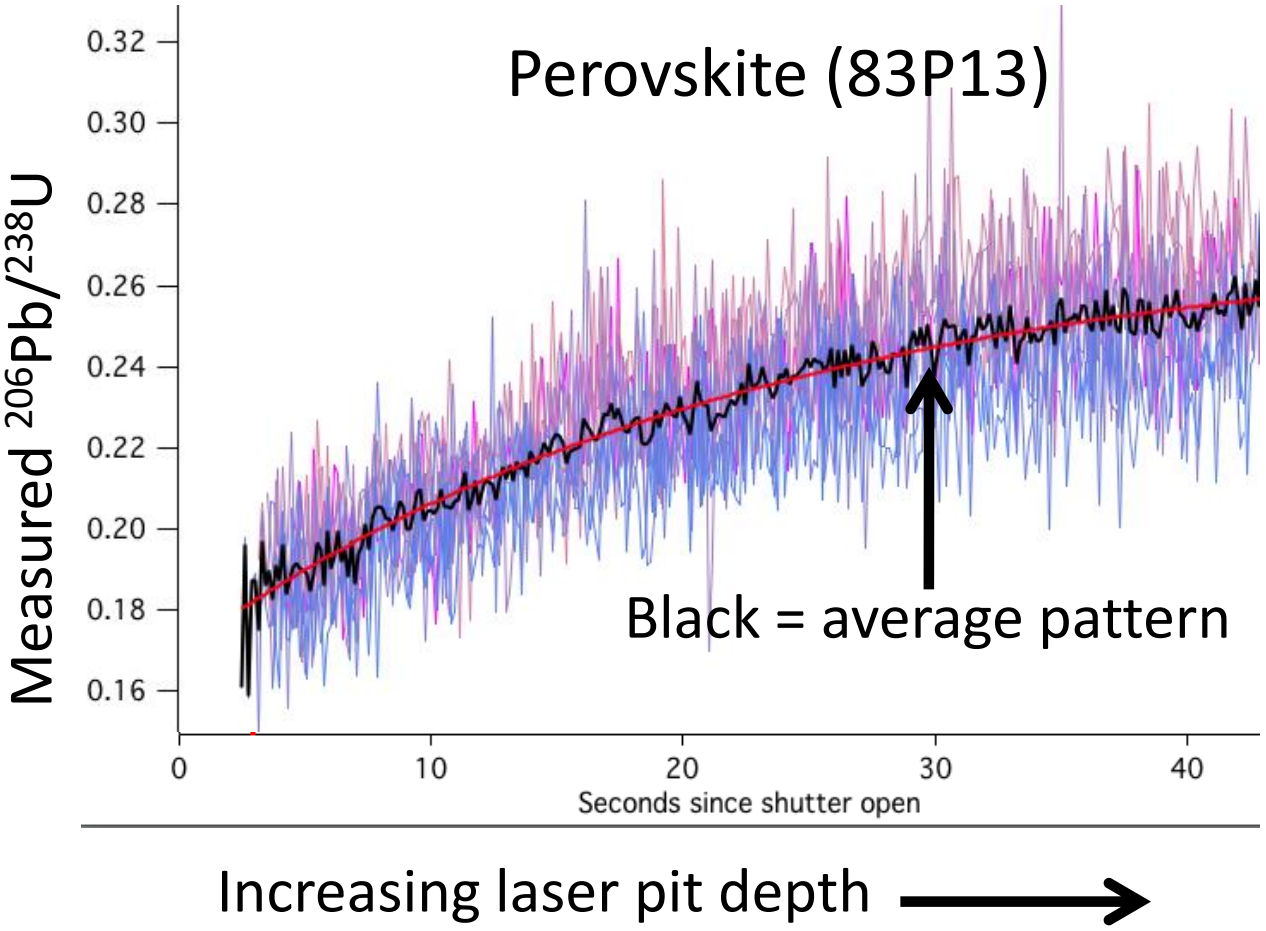
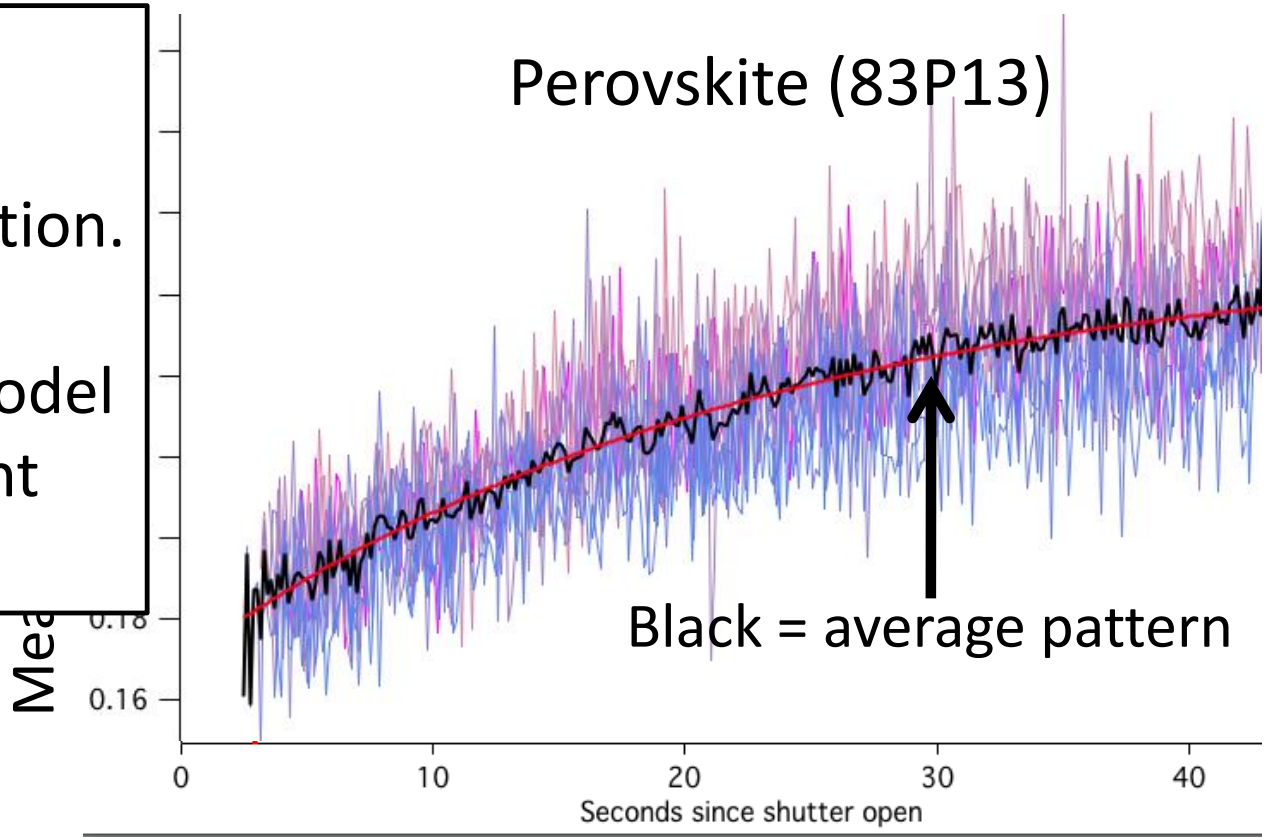


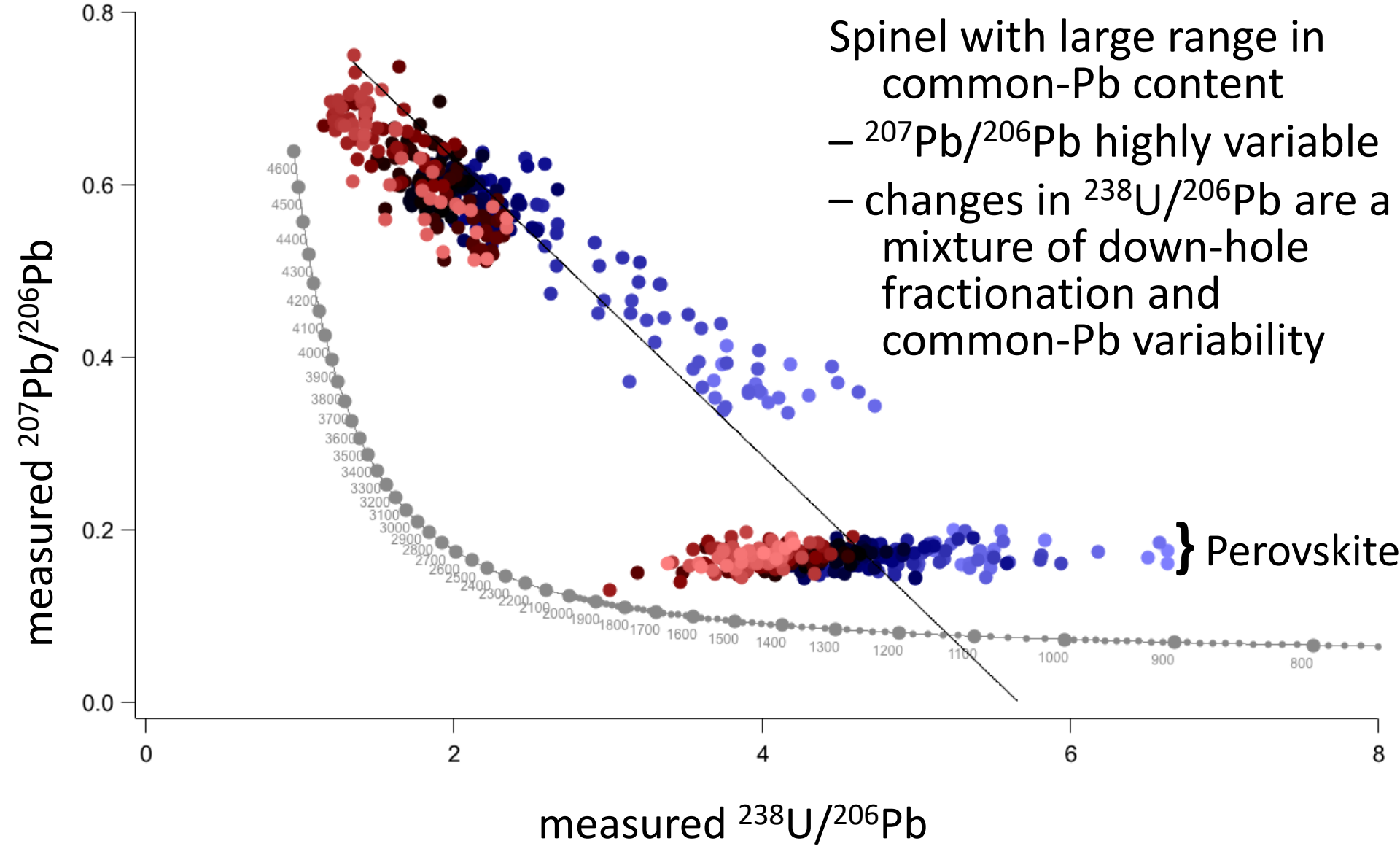
Apparent downhole fractionation

– The pattern is dominated by downhole fractionation.

– Still possible to model relative to a constant value



Some examples



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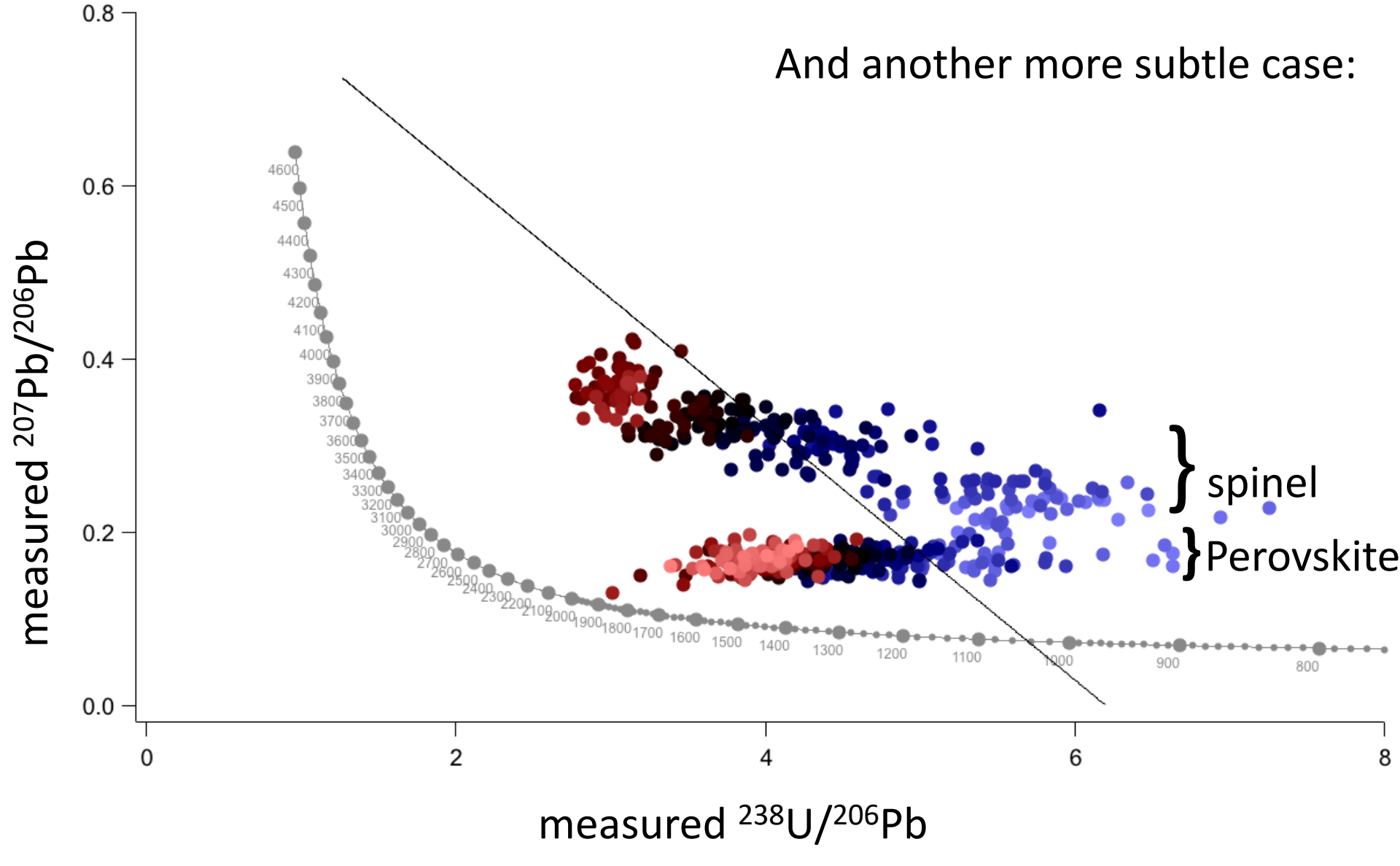
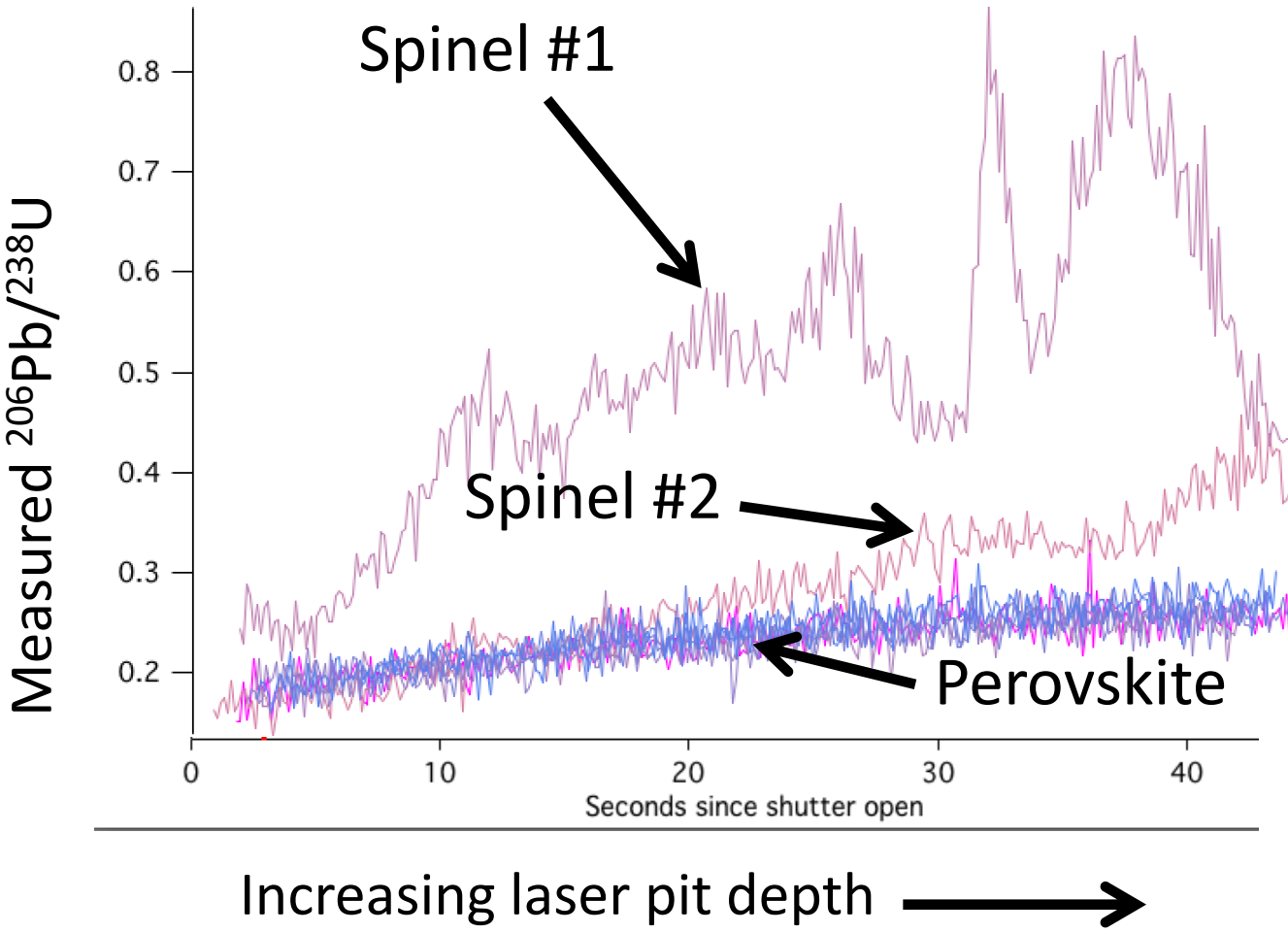


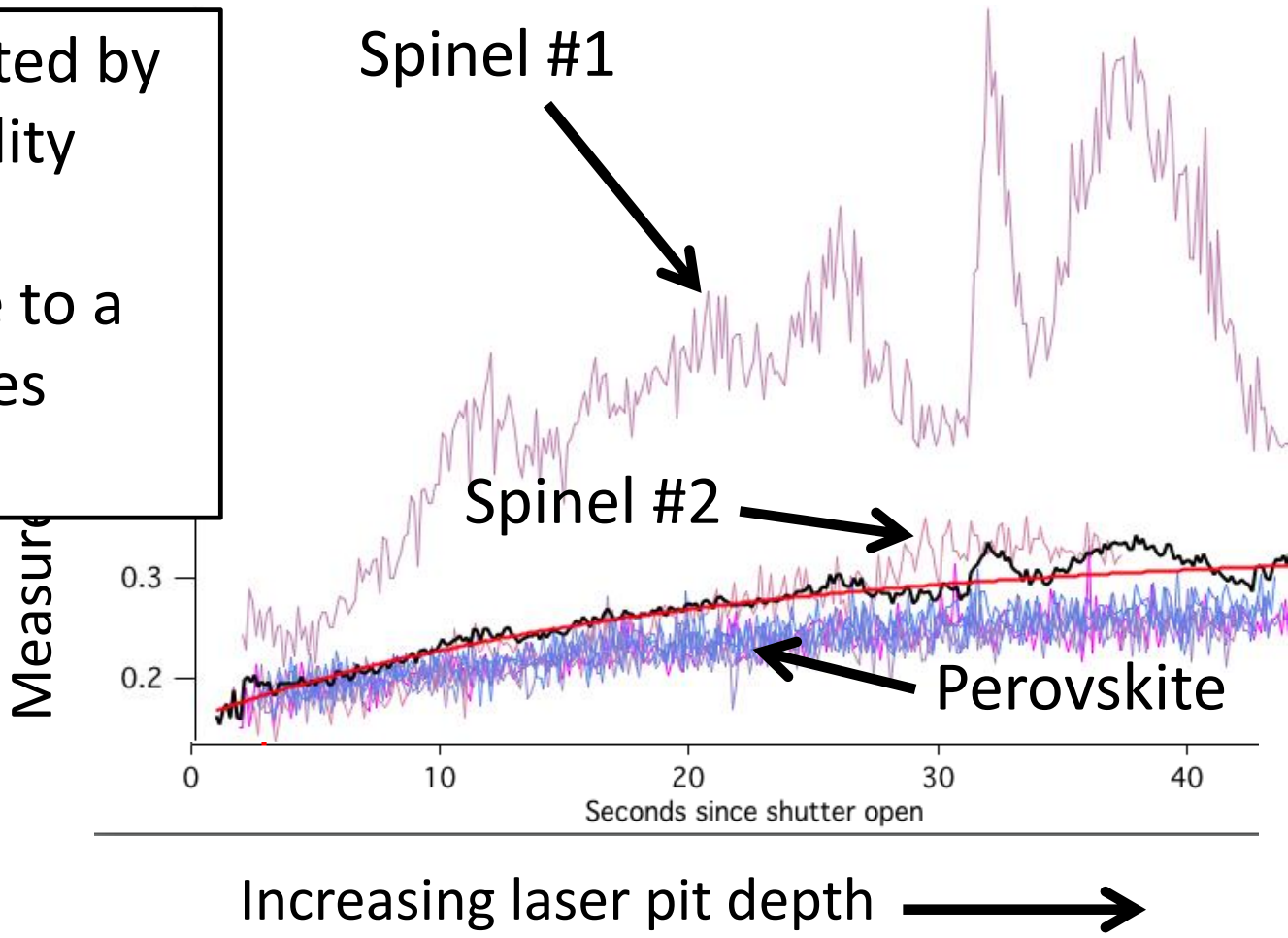
Apparent downhole fractionation



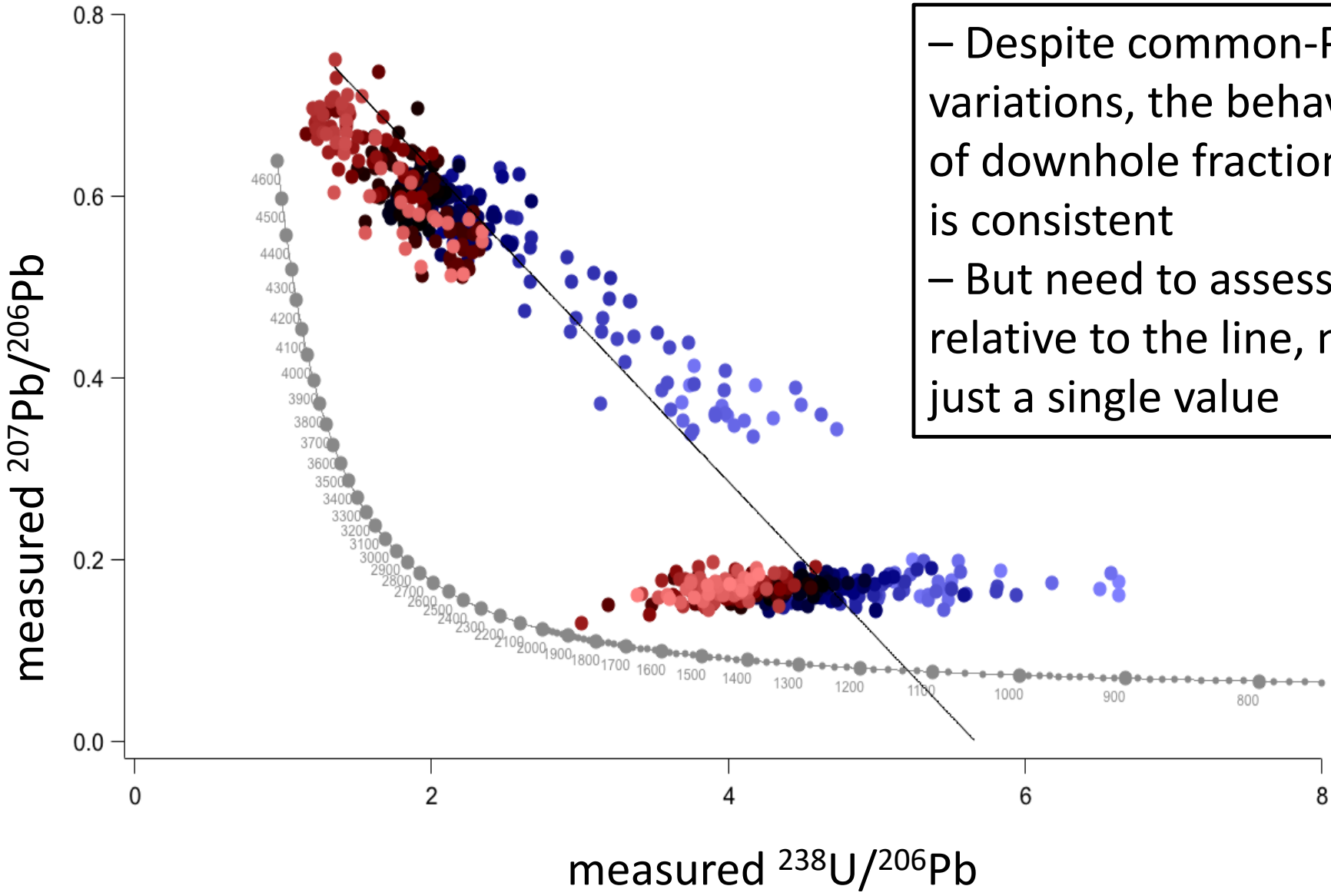
Apparent downhole fractionation

– Pattern is dominated by common-Pb variability

– Modelling relative to a single value produces meaningless results



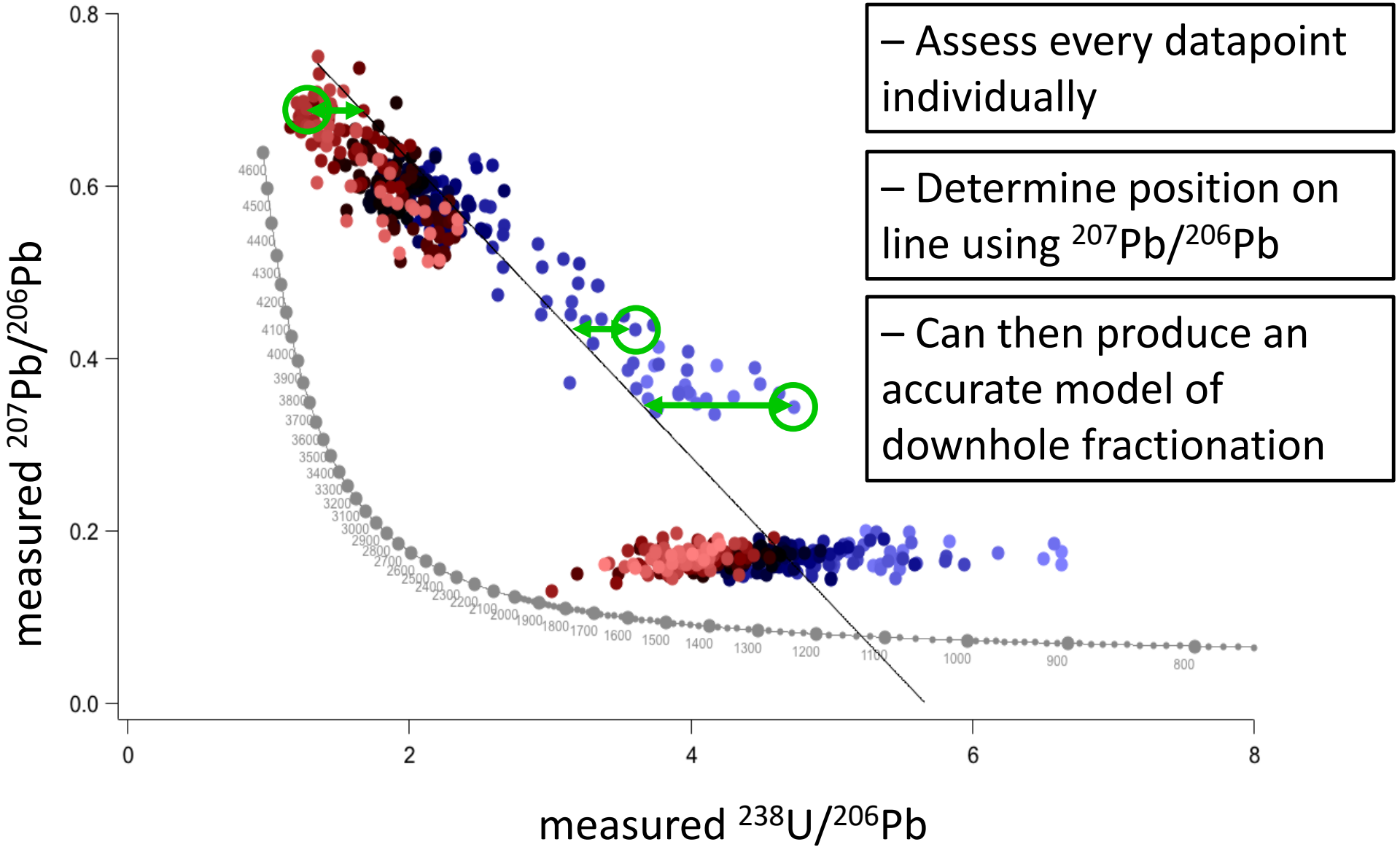
2-dimensional approach



– Despite common-Pb variations, the behaviour of downhole fractionation is consistent

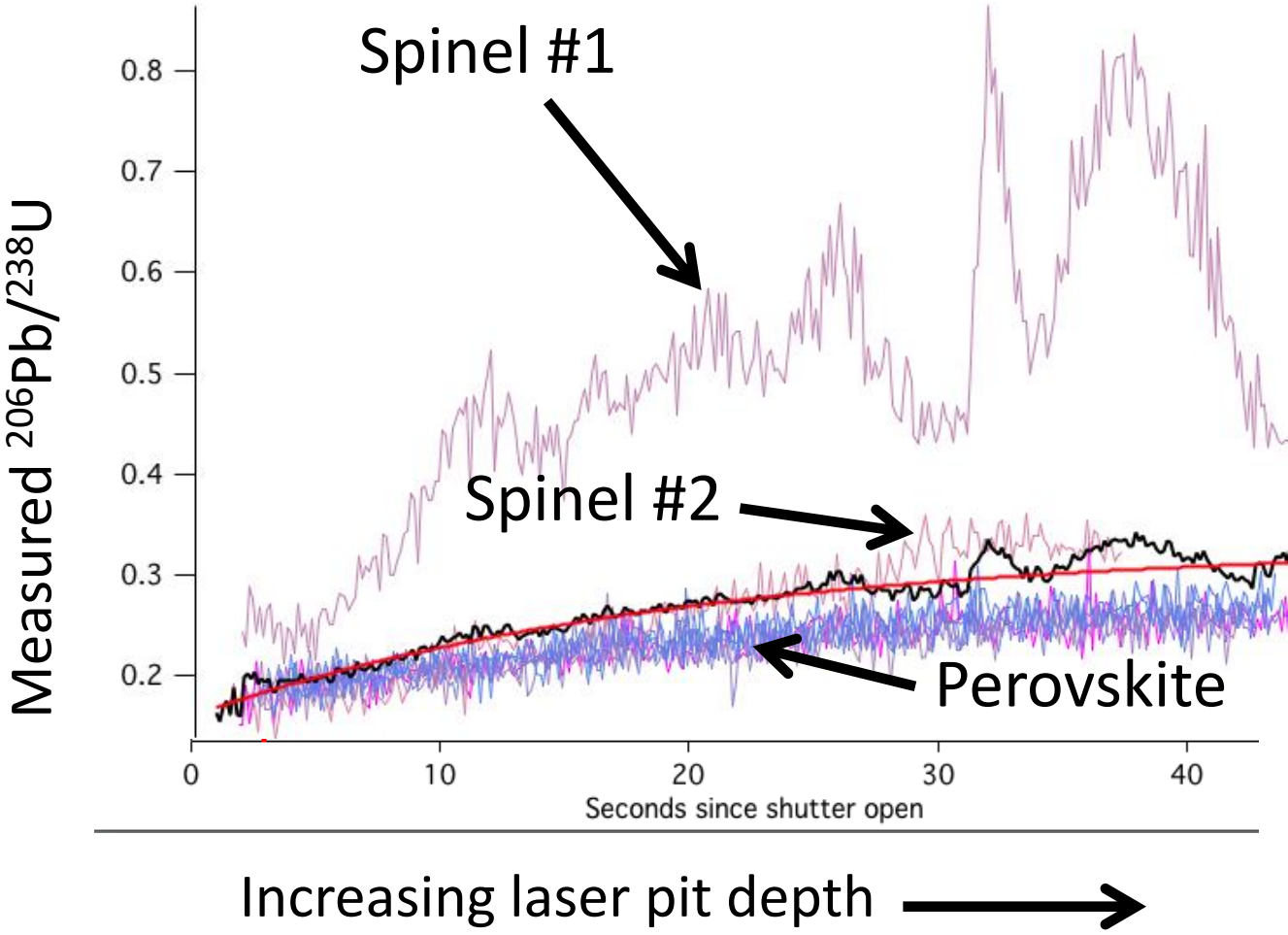
– But need to assess relative to the line, not just a single value

2-dimensional approach



2-dimensional approach

Move from seeing combined effects of common-Pb and downhole fractionation



2-dimensional approach

Move from seeing combined effects of common-Pb and downhole fractionation

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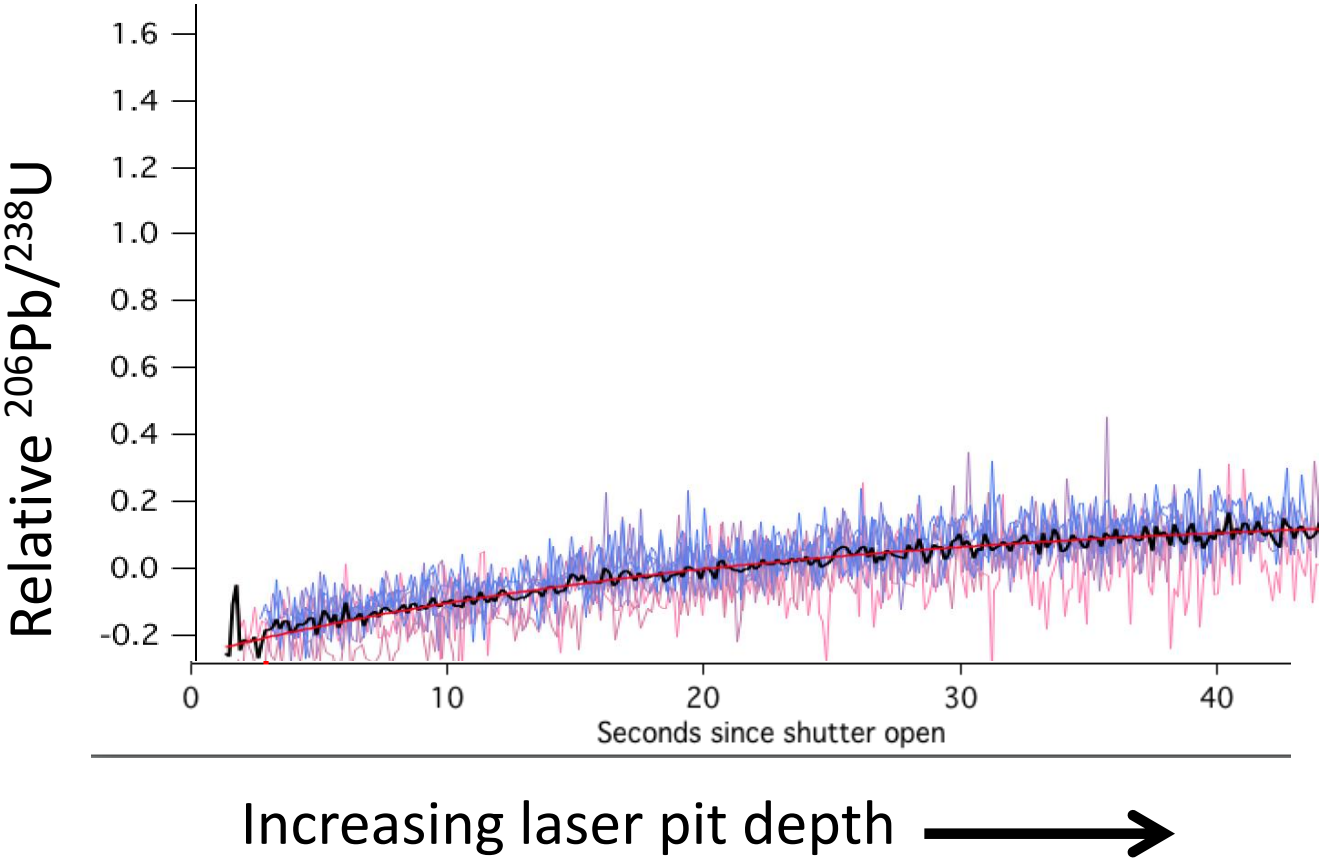
To being able to isolate downhole fractionation so that it can be quantified



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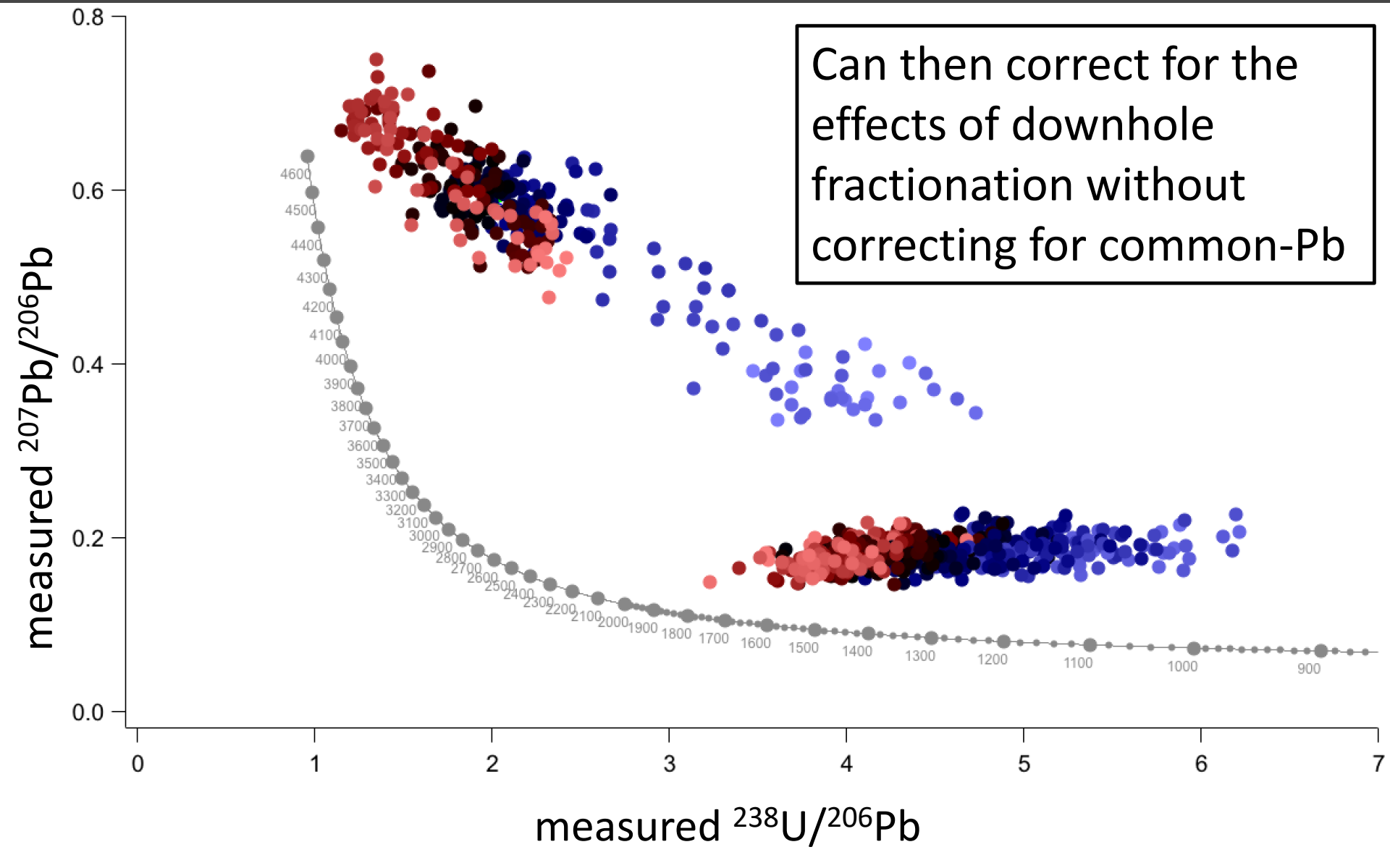

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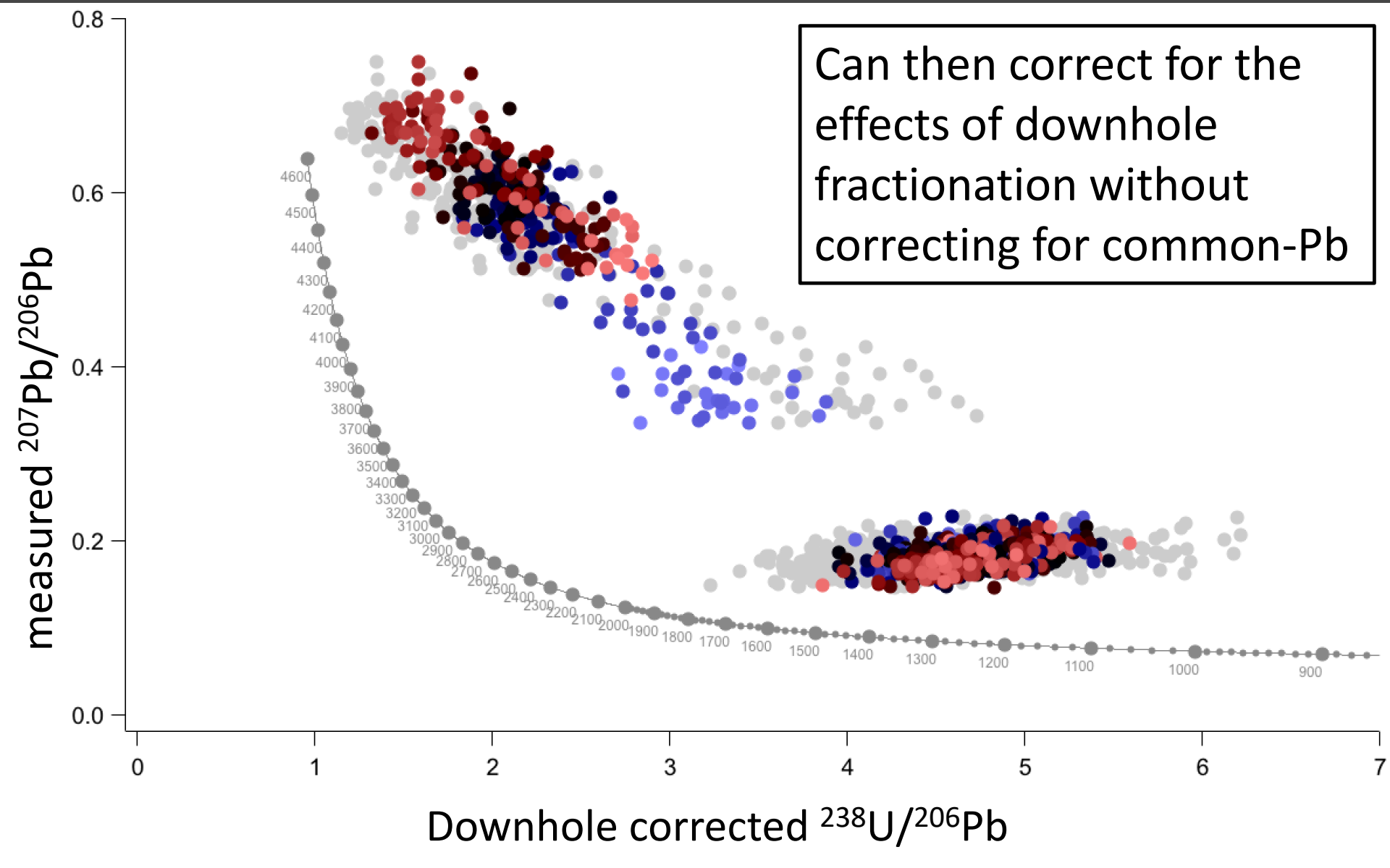

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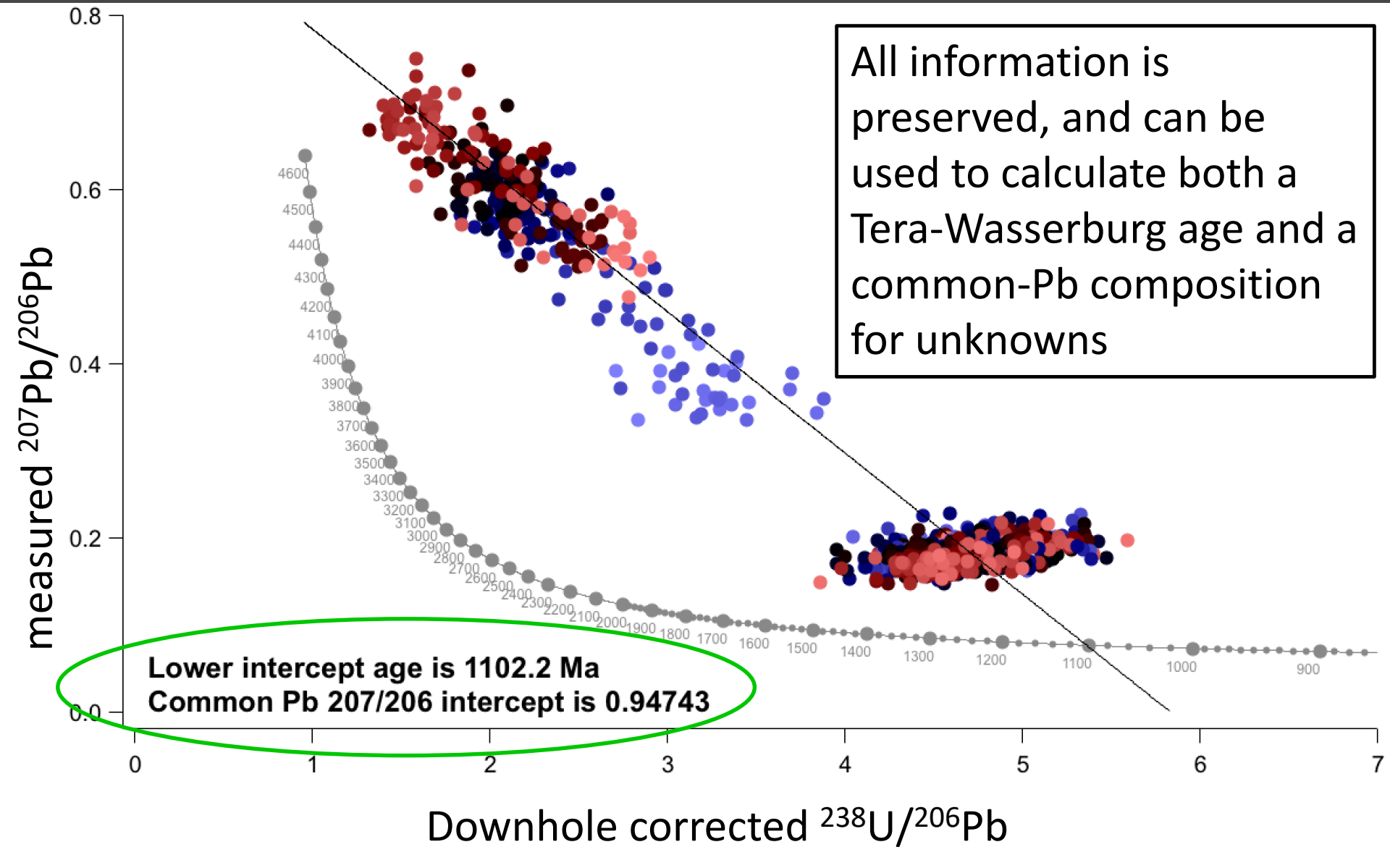

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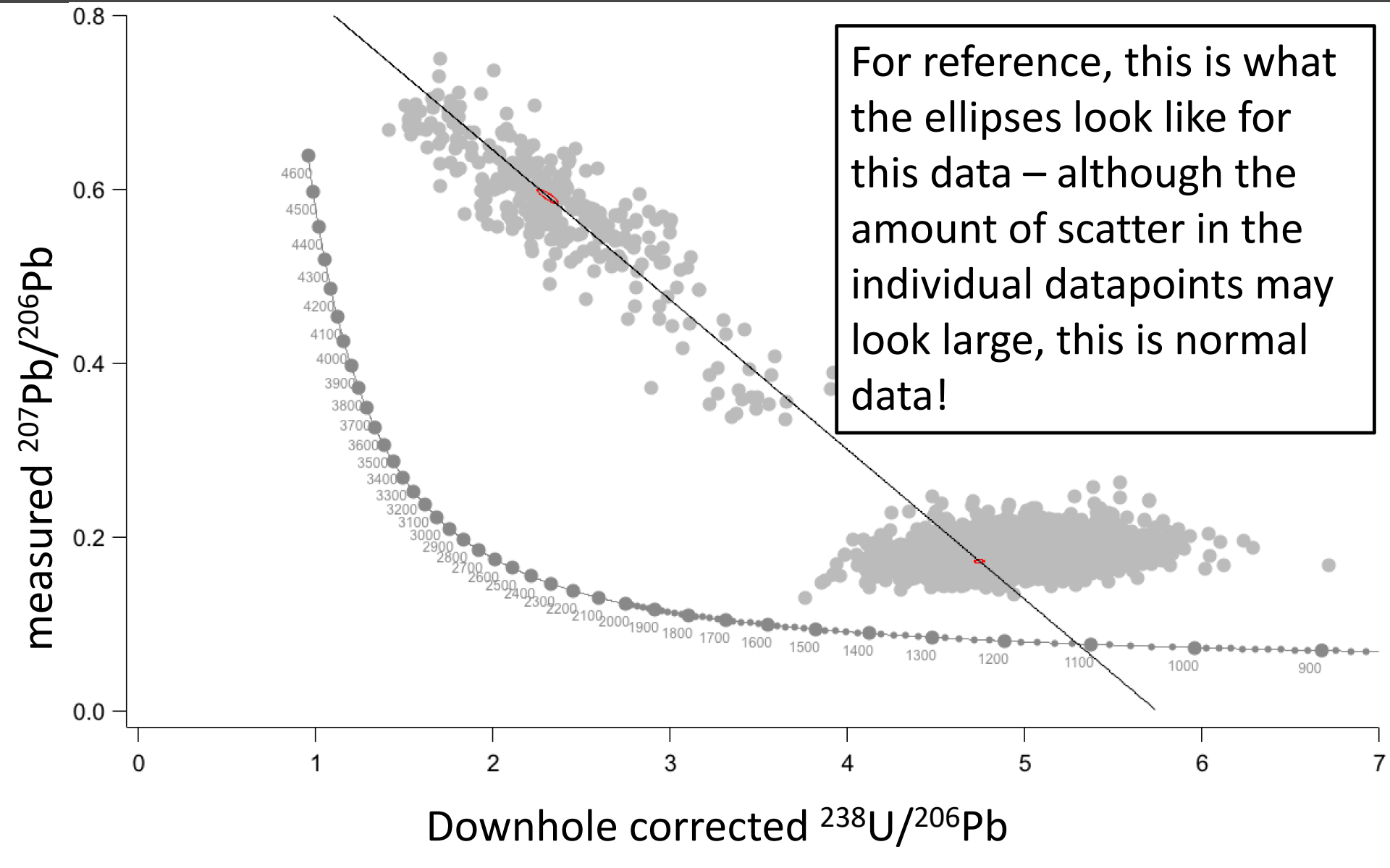

Conclusions

- 2-dimensional correction extends the laser ablation U-Pb method to common-Pb rich minerals
- A reference standard with variable common-Pb content can be used
- No loss of data – variations in common-Pb content are preserved
- Relies on the assumption that unknowns have same behaviour as reference standard
- As with the conventional approach, it is possible to check whether the above assumption is correct