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Unlocking Rock Magnetic Signals in Thick Sections

How double-sided scanning will strengthen MMT

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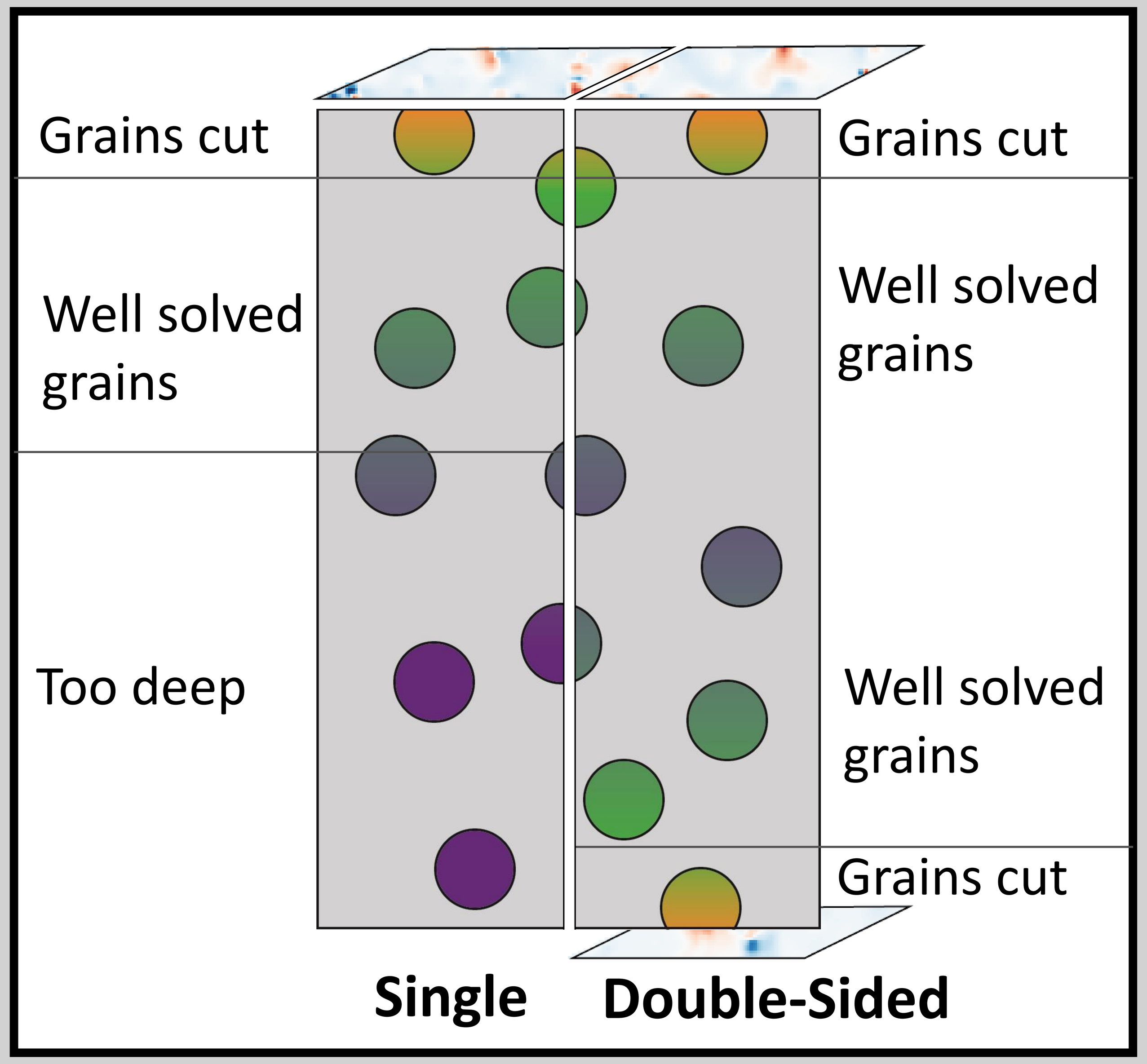
Introduction

Micromagnetic Tomography (MMT) is a paleomagnetic technique that solves magnetic moments per magnetic carrier, usually magnetite. To identify these magnetic moments, MMT requires a magnetic surface scan of the sample obtained by a quantum diamond microscope (QDM) and the locations of magnetic carriers obtained by micro/nanoCT .

The signals of large or close-to-the-sensor magnetic carriers are stronger than small and deep grains. Therefore, these small/deep grains are badly resolved by inverse modelling if the QDM measures one side of the sample. **Double-Sided (DS) scanning might provide a major improvement for correctly resolving magnetic moments!**

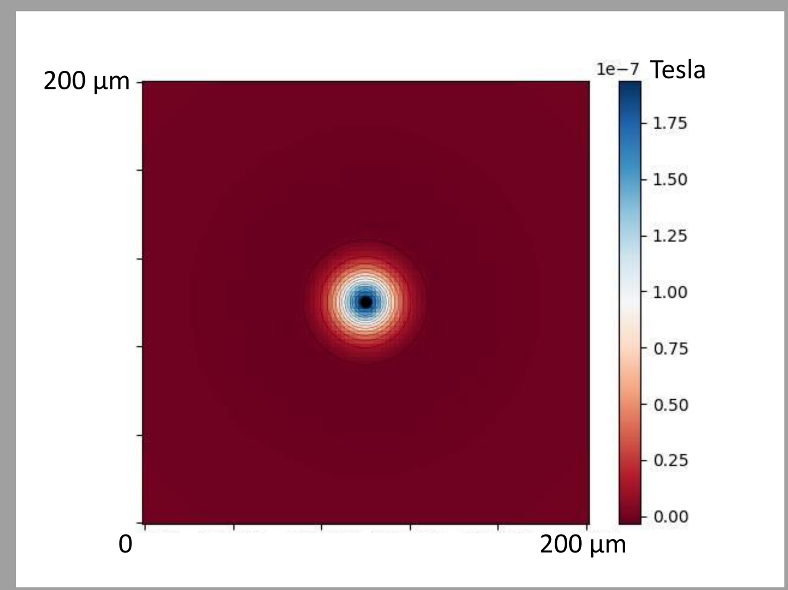


Methods

We modeled **a single magnetic grain** ($V=1\ \mu m^3$ & $m_z \approx 10^{-15}\ Am^2$) to test:

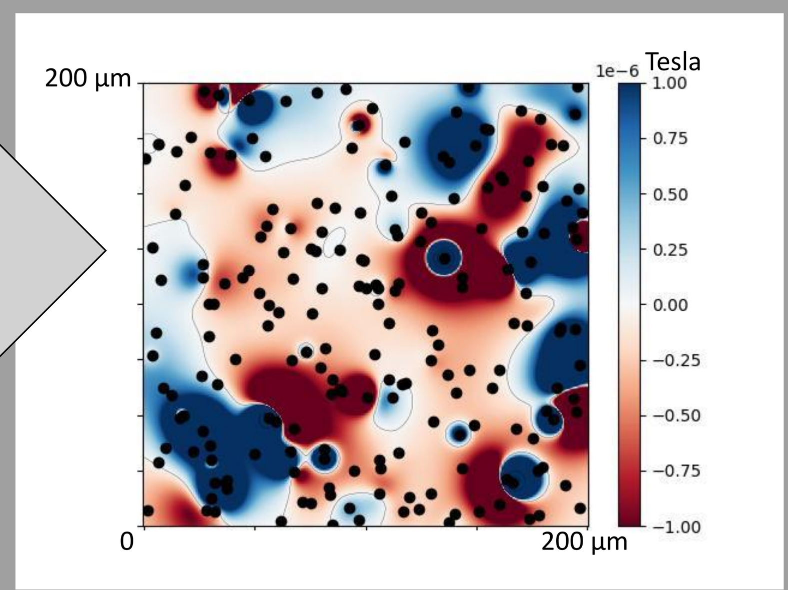
1. Sensitivity of DS scanning
2. Effect of measurement errors

➢ Compared to single sided scanning



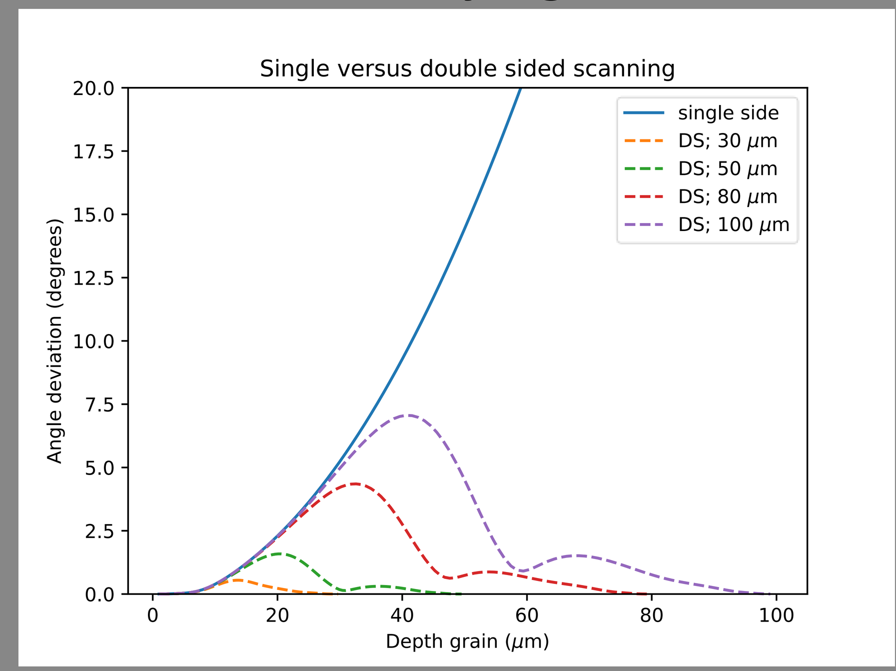
We also modeled **a realistic (volcanic) sample** to find:

1. Optimal sample thickness
2. Which grains are solved correctly
3. Percentage solvable grains



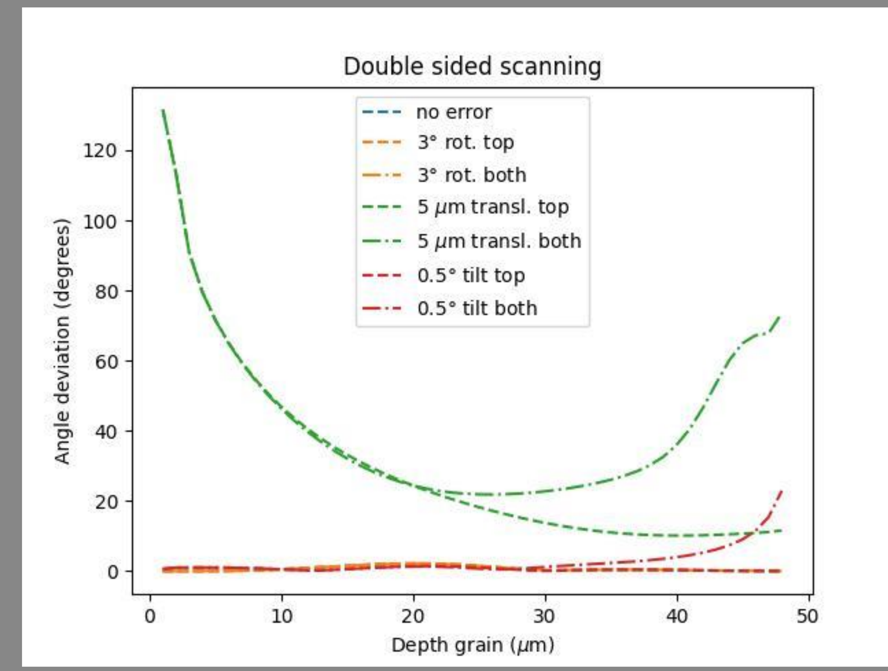
Results

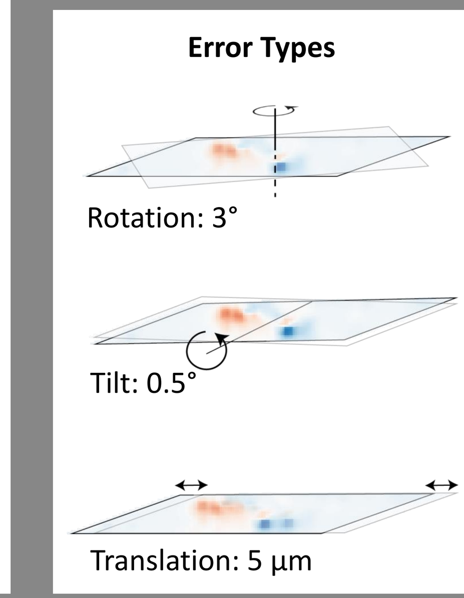
Sensitivity 1 grain



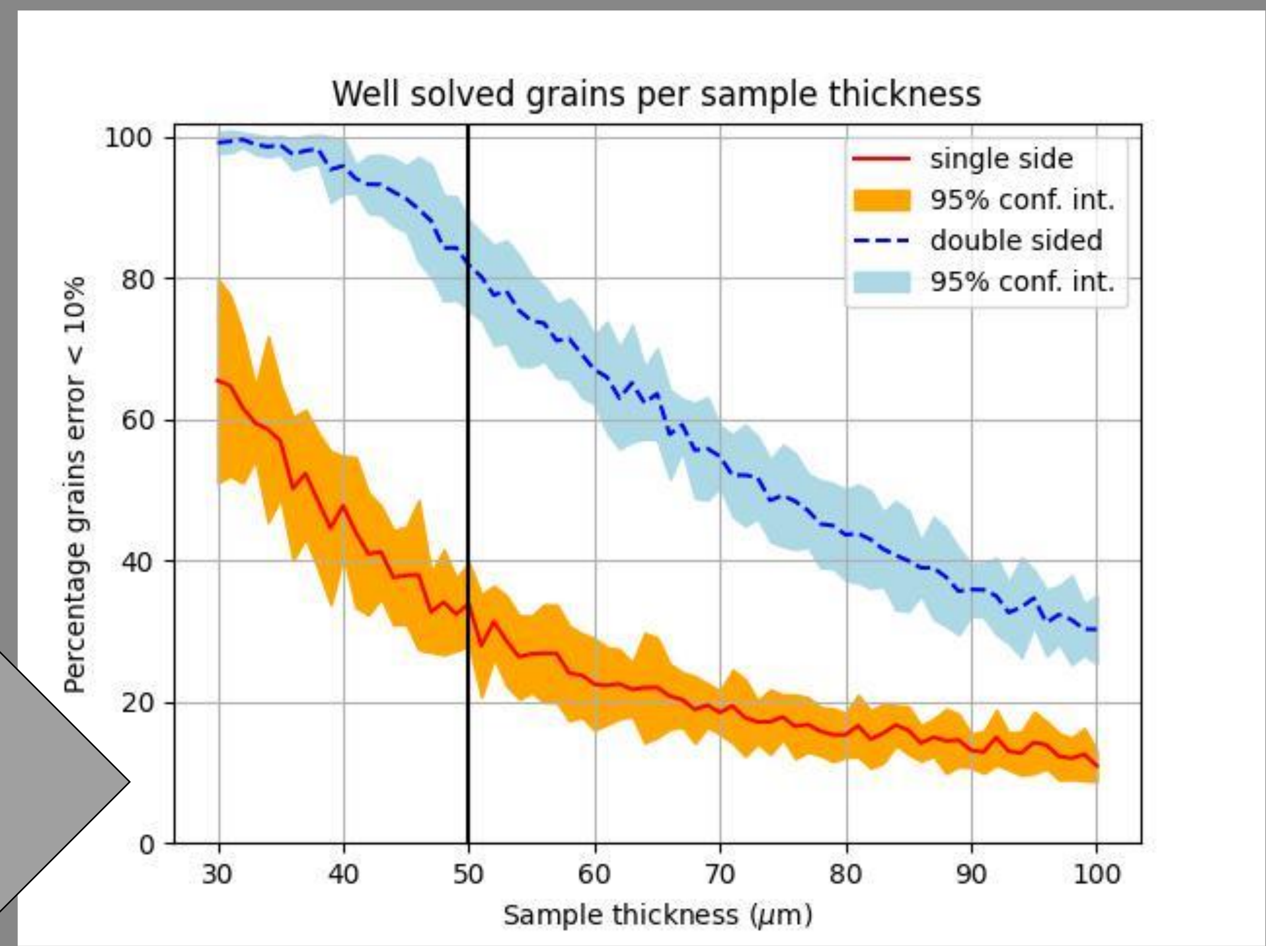
Angle between original and calculated magnetic moment vector for single sided and DS scanning for increasing grain depths. For DS scanning the sensor planes have either 30, 50, 80, or 100 µm distance in between. Note how **DS scanning is less sensitive to errors than single sided scanning**

Measurement errors 1 grain

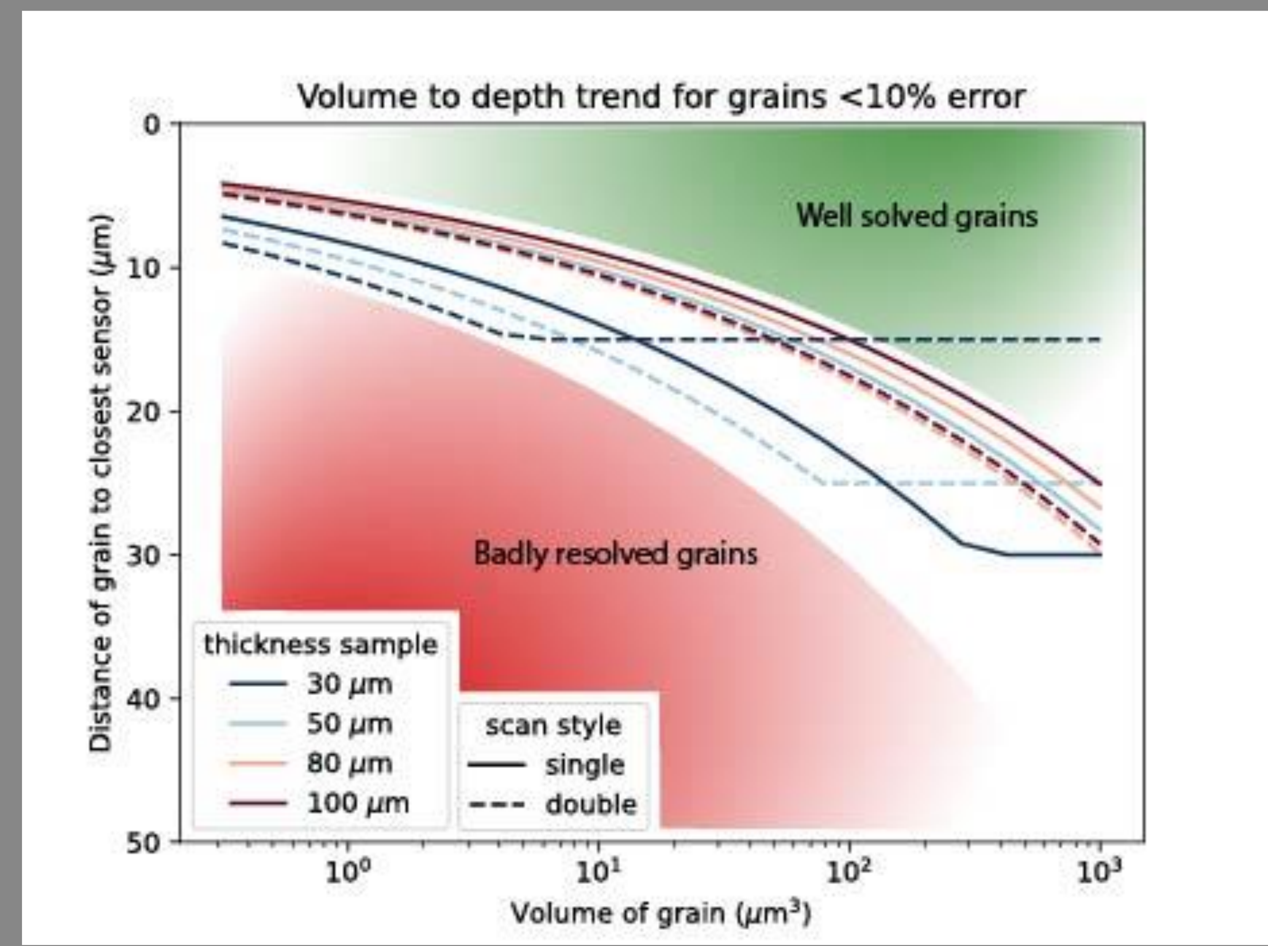




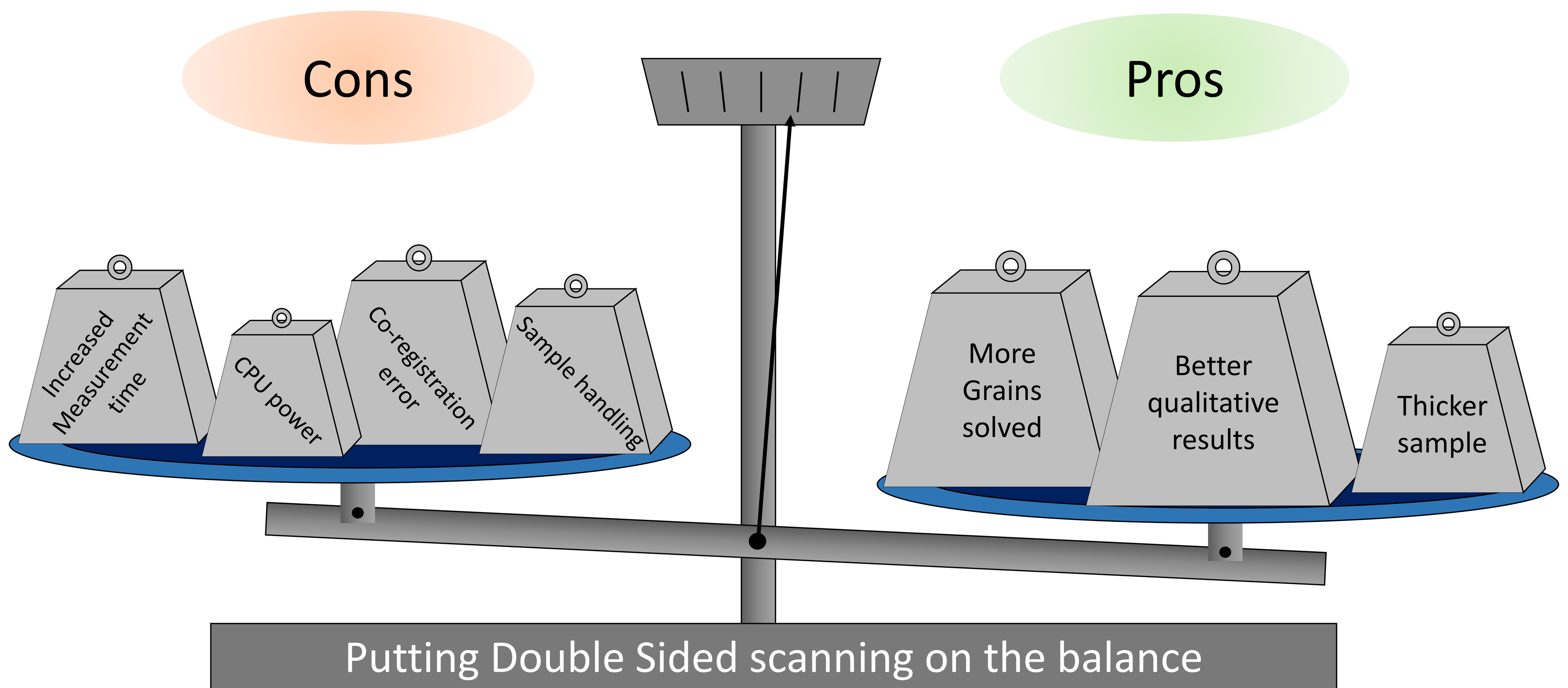
DS scanning exposed to rotation, translation, and tilt errors of the measurement planes. Most errors are restricted to 2 degrees or less. However, **translation of the measurement planes can induce very large errors**, so attention should be paid to reduce translational errors as much as possible when matching the datasets. **Errors between DS and single sided scanning are of similar ranges.**



Percentage well resolved grains (max 10% error) for a sample of variable thickness. At 50 µm sample thickness, 30% of the grains in single sided scanning, but 80% of the grains in DS scanning method are resolved. **DS scanning produces more than twice as much usable grains**!



Critical grain volume versus grain distance-to-sensor trend to resolve grains with 10% error. **The resolution of DS scanning goes deeper into the sample than single side scanning**, although the advantage of DS scanning decreases for thicker samples.



Should we use DS scanning?

DS scanning allows for calculating more reliable magnetic moments compared to single sided scanning. On one hand, DS scanning involves **more measurement time, more CPU power** to solve magnetic moments, and **delicate sample handling**. On the other hand, errors remain small and **DS scanning more than doubles the amount of usable particles**. We should therefore proceed to test and use this technique in practice!

Keypoints

1. Double Sided (DS) scanning uses the magnetic field of individual magnetic carriers at both sides of a sample

2. DS scanning produces **more correctly resolved magnetic moments of iron-oxides, also at greater depths**

3. DS scanning can provide more grains for estimating paleodirections and intensities