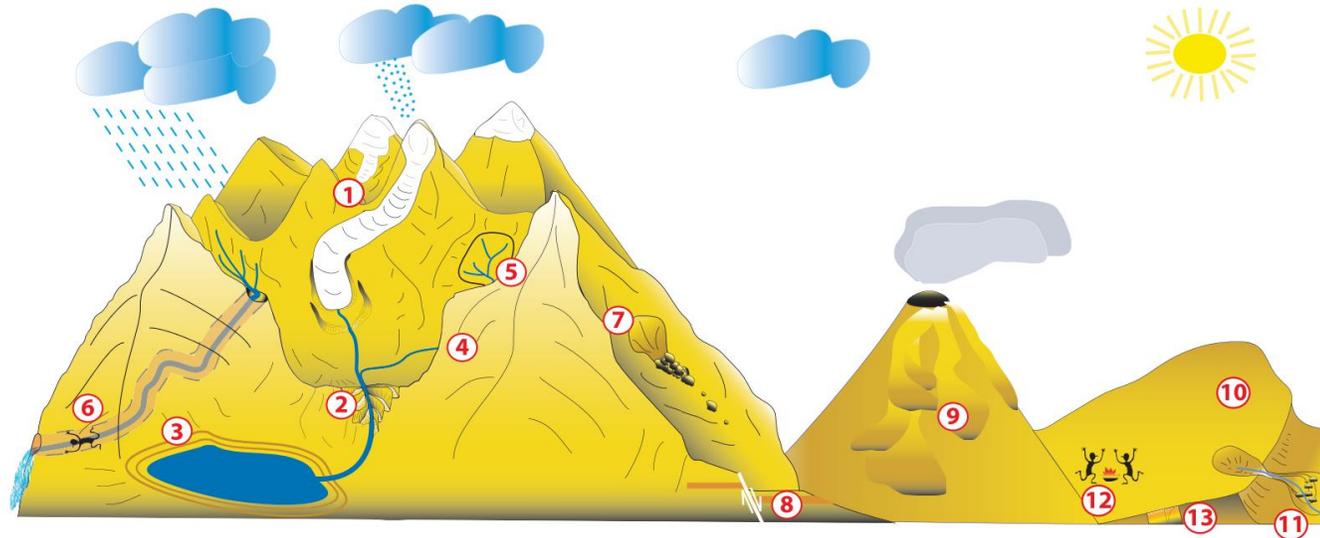# Analyzing ^{41}Ca Sample at 1E-15 abundance level with cold atom trap techniques

Tongyan Xia, Weiwei Sun, Sven Ebser, Wei Jiang, Tian Xia, Zheng-Tian Lu

University of Science and Technology of China, Hefei, China

Contact: txia1@ustc.edu.cn

How is ^{41}Ca of great importance ?
Surface exposure cosmogenic nuclide dating

① glacial chronologies (alpine, ice-sheets)
② fluvial chronologies (terraces, incision)
③ shoreline chronologies (terraces, lacustrine, marine)
④ hillslope rates
⑤ catchment wide denudation rates
⑥ burial chronologies (caves, terraces, paleosols)
⑦ landslide chronologies
⑧ fault scarp chronologies
⑨ volcanic eruption chronologies
⑩ desert chronologies
⑪ alluvial fan chronologies
⑫ archeology
⑬ pedogenic chronologies

Fig. various landforms that can be dated and approaches for using cosmogenic nuclides

Features of ^{41}Ca

- Alkaline-earth element

- Good tracer：half-life $\mathbf{9.94 * 10^4}$ yr, abundance ~ $\mathbf{10^{-15}}$

- Widely distributed

A.stone

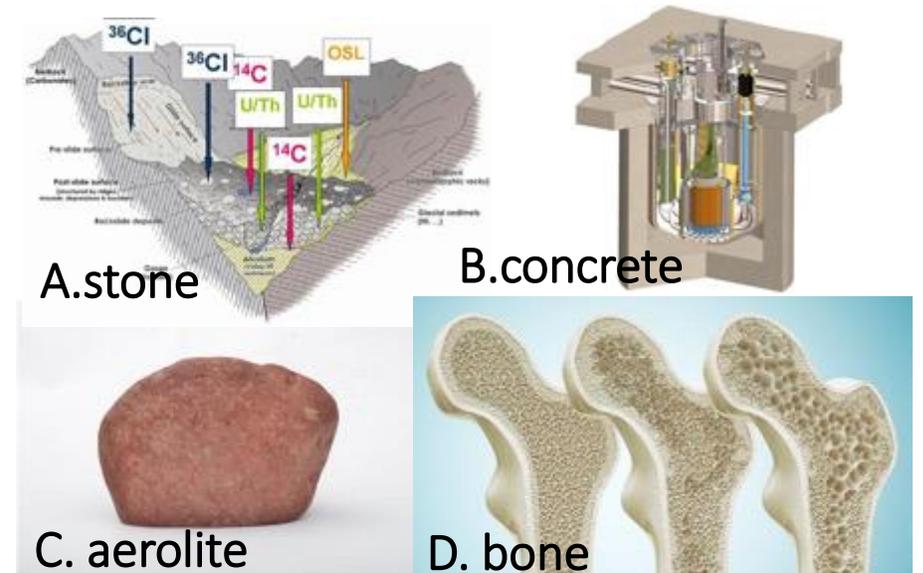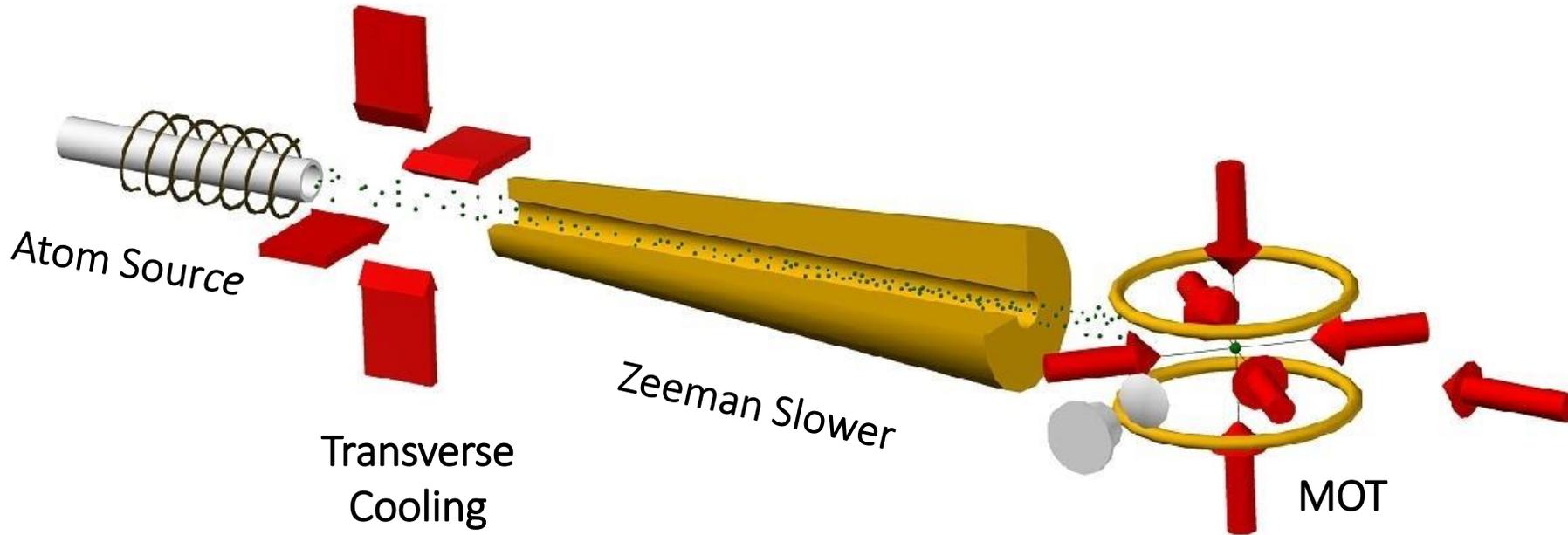B.concrete

C. aerolite

D. bone

Fig.1 Distribution of calcium（from baidu.com）

Pre-existing method: AMS, but interfering isobar ^{41}K

Our method: atom trap trace analysis (ATTA)

- Atom Trap Trace Analysis, a laser-based neutral atom counting method

- High selectivity：Different laser frequency for different isotopes

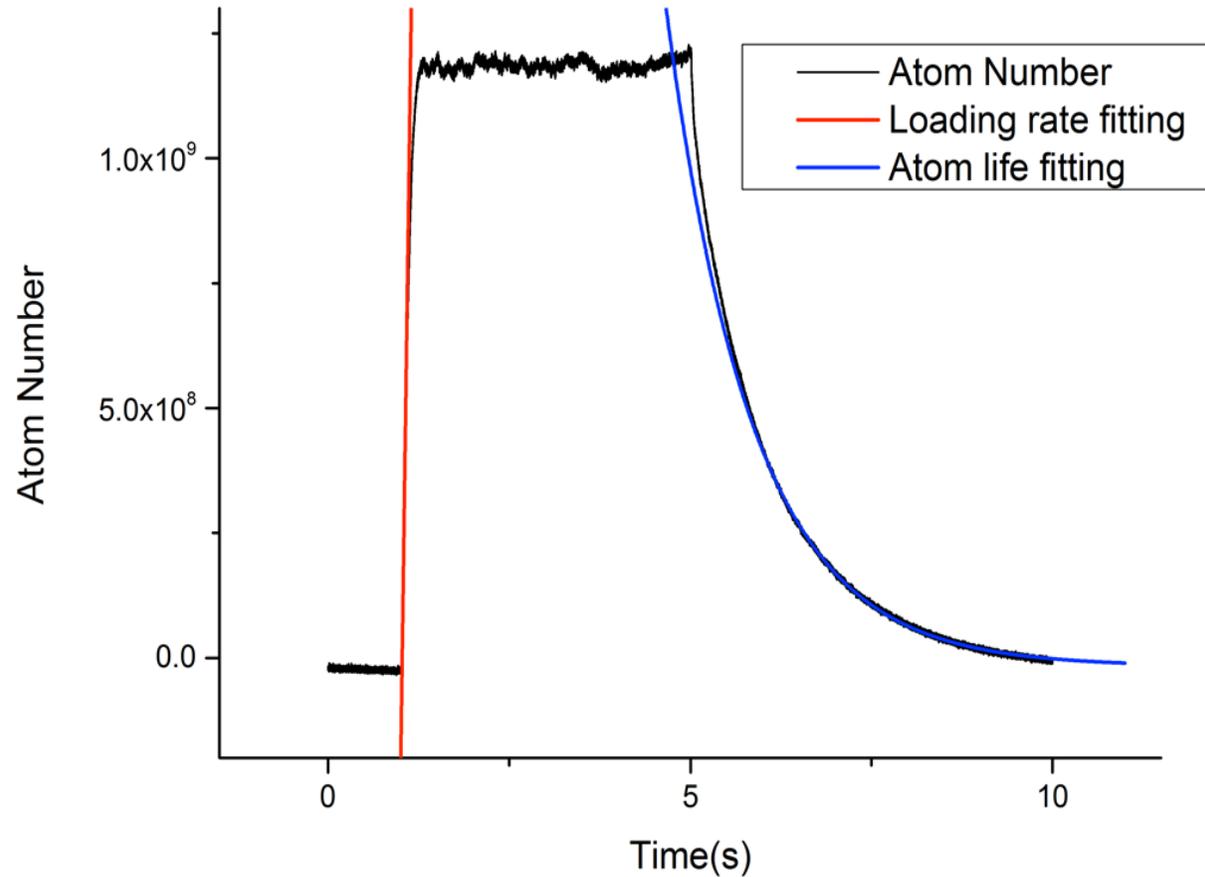- High sensitivity：Count atom one-by-one

- Low-cost，Small-size

Atom Loading

Fig.3 Loading rate = $1.03 \times 10^{10}\ atom/s$,   Atom life = $1.2\ s$

Isotope	Relative Abundance	Isotope Shift(MHz)
40	1	0
41	$\sim 10^{-15}$	174
42	0.0065	395
43	0.0014	578
44	0.022	777
46	4E-05	1184
48	0.0019	1518

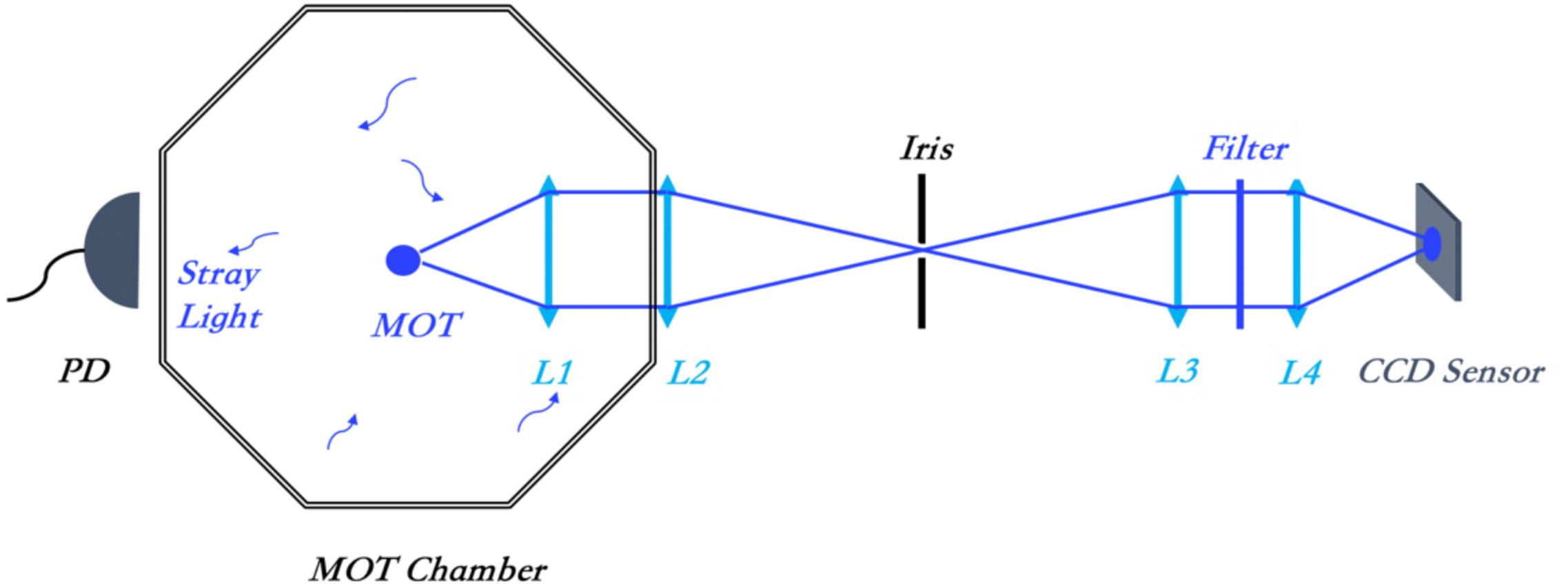Table.1 Main isotopes of Calcium

Single Atom Detection

Fig.4 Single atom detection system
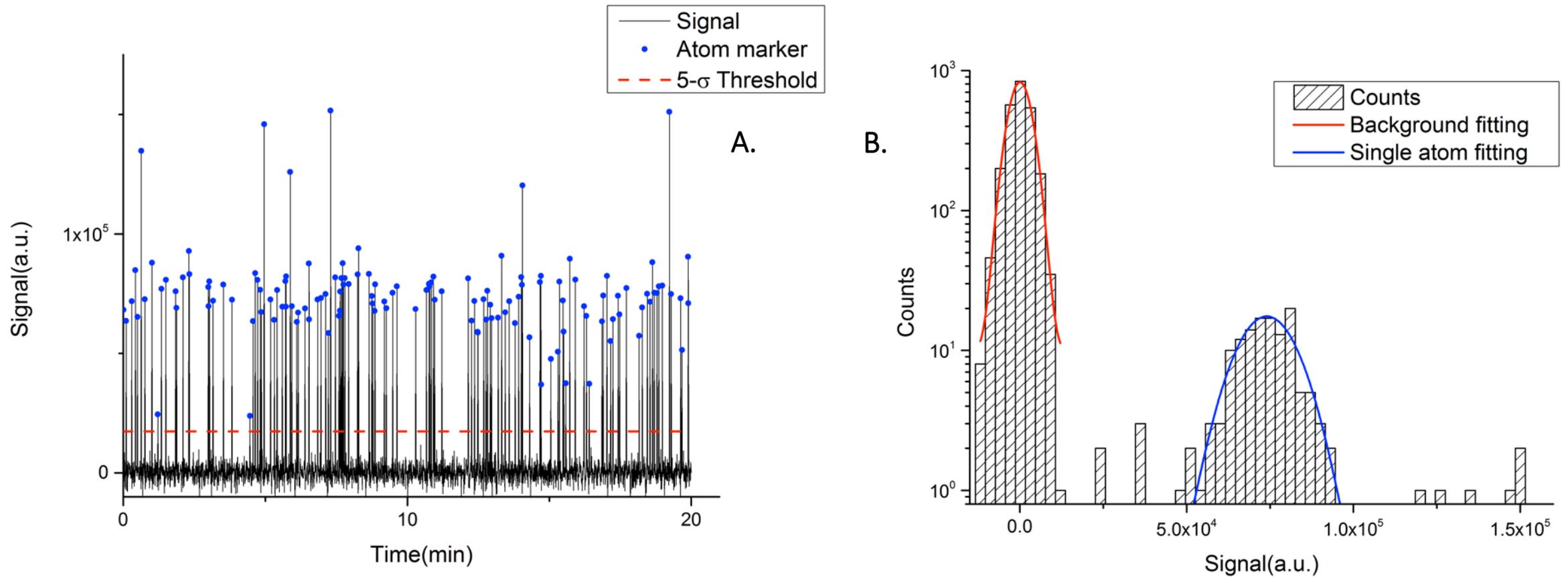
^{41}Ca Abundance Measurement

Fig.5 ^{41}Ca signal measurement,140 ^{41}Ca in 20min. A, Raw data; B, Histogram. SNR = 22
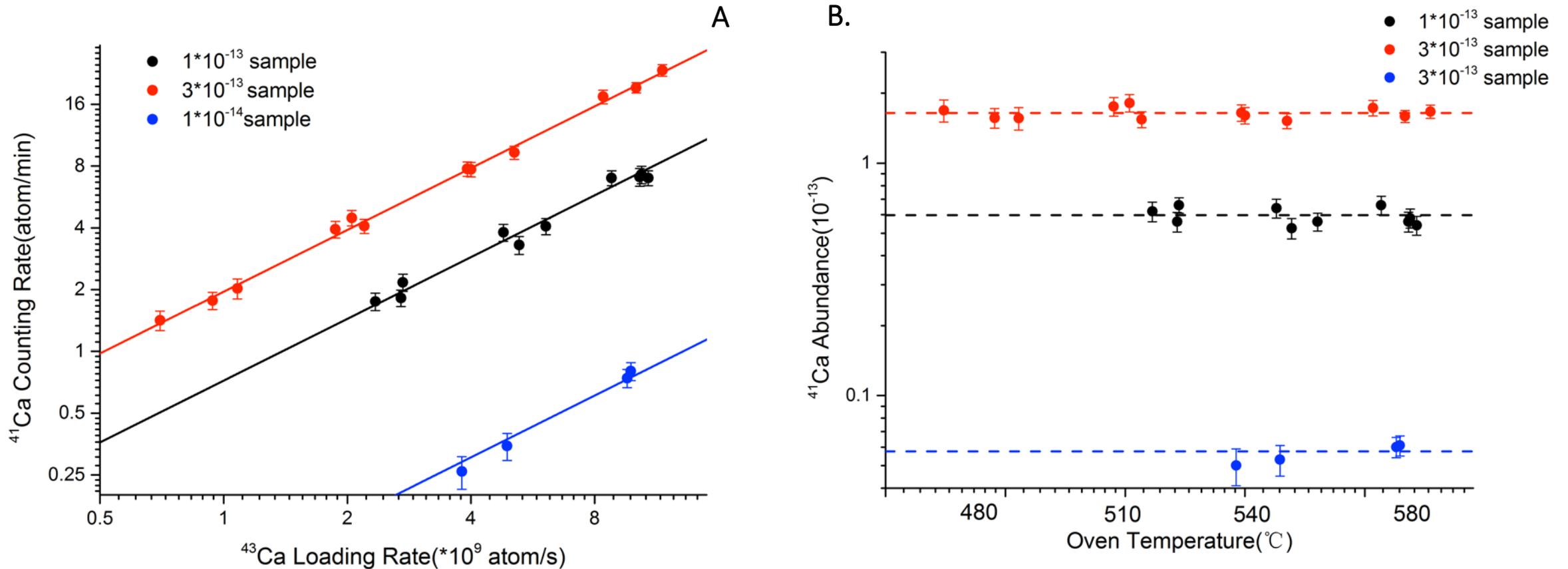
Measurement consistency for different samples

Fig.6 Repeability test. A:^{41}Ca counting rate vs ^{43}Ca loading rate; B: ^{41}Ca abundance

Prospect

- More ^{41}Ca counts at higher oven temperature；
- For sample with ^{41}Ca abundance of $\mathbf{1 \times 10^{-15}}$,

  10 hour measurement

  10% accuracy

  200 mg consumption