# Analyzing Ca-41 sample at E-16 abundance level with cold atom trap techniques

Tian Xia, Tong-Yan Xia, Wei-Wei Sun, Sven Ebser, Hui-Min Zhu,
Yun-Chong Fu, Wei Jiang, Tian Xia, Zheng-Tian Lu

University of Science and Technology of China (USTC)

# Calcium-41

- **Widely distributed on the earth**
- **Natural abundance: 41Ca/Ca $10^{-17}$～$10^{-15}$**
- **Production: $^{40}_{20}\mathrm{Ca}(\mathrm{n},\gamma)^{41}_{21}\mathrm{Ca}$**
- **Decay: $^{41}\mathrm{Ca}(\mathrm{e},\nu)^{41}\mathrm{K}$, half-life 99.4kyr**
- **Dating range : 50 kyr to 1 Myr**

**Exposed Rock**

**Ancient Bones**

# Accelerator Mass Spectrometry (AMS)

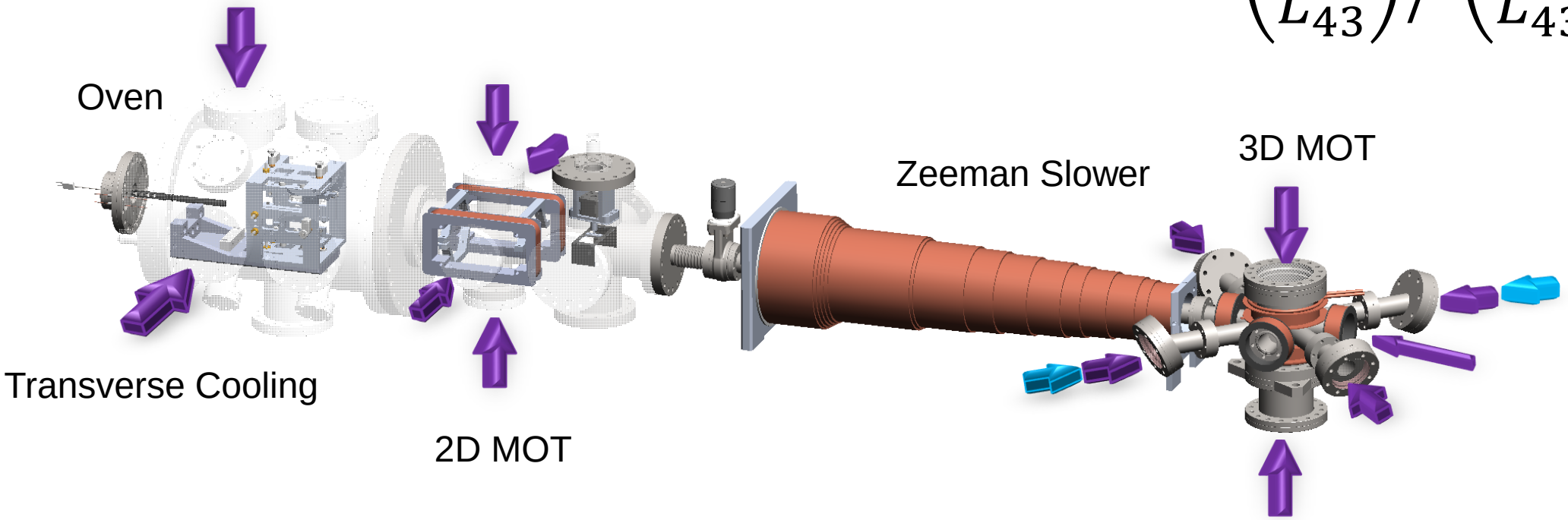
- **AMS has measured $^{41}$Ca in natural samples at $10^{-15}$**
- **Limited by isobar interference from $^{41}$K**
- **To fully explore natural sample ($10^{-17}$~$10^{-15}$) , AMS needs to suppress background**

| Facilities | $^{41}$Ca/Ca Abundance Measurement |
|---|---|
| GSI Helmholtz Center for Heavy Ion Research<br>A.Steinholf, et al.,1990 | Bones:<br>1E-14~1E-13 |
| University of Pennsylvania<br>D.Fink, et al.,1990 | Bones and rocks：<br>~E-15 level |
| ATLAS，Argonne National Laboratory<br>W.Kutschera, et al.,1989 | Bones and rocks:<br>~E-14 level |
| Vienna VERA<br>A.Wallner, et al., 2010 | Meteorite:<br>2E-13 |
| Technical University of Munich<br>T.Faestermann, et al., 2010 | Tooth enamel:<br>3E-15~2E-14 |

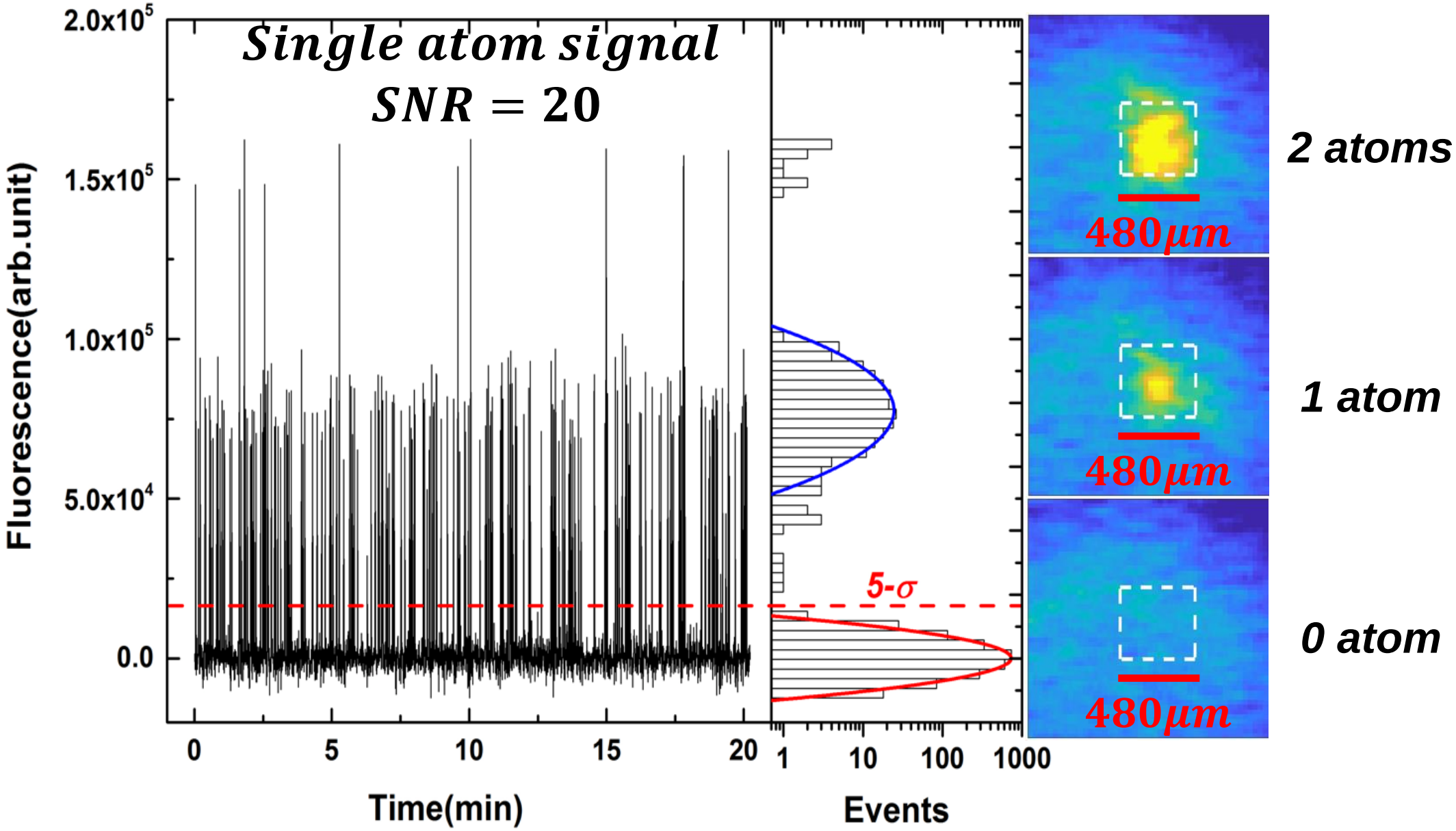
# Calcium Atom Trap Trace Analysis (ATTA)

- Reference: $^{43}$Ca loading rate 2E10 atoms/s (0.13% abundance)
- $^{41}$Ca counting rate 2 atoms/h (3E-16 abundance)
- Loading Efficiency ~ 0.5%

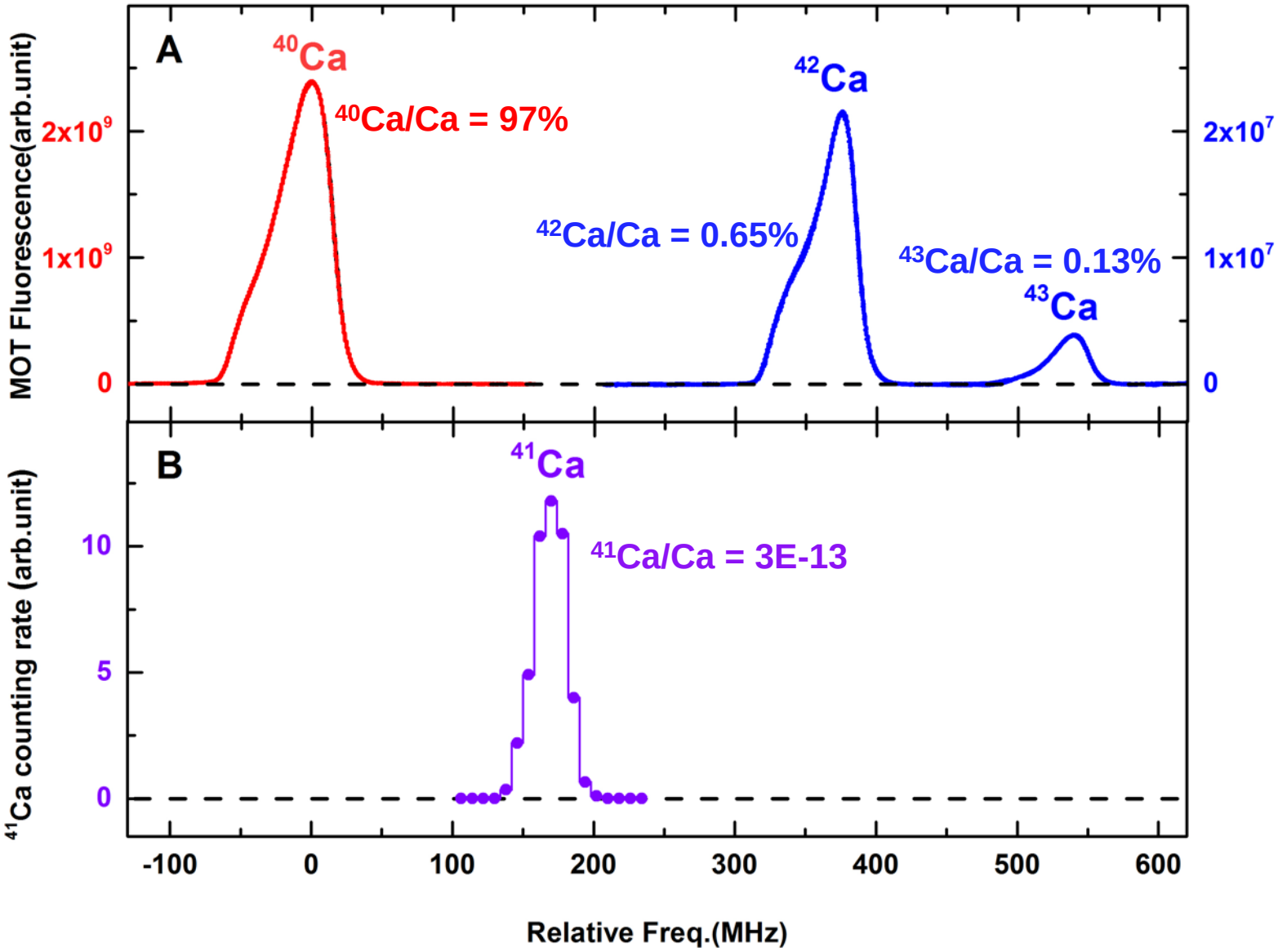
$$A_{41} = A_{41,std}\left(\frac{L_{41}}{L_{43}}\right)\Big/\left(\frac{L_{41}}{L_{43}}\right)_{std}$$



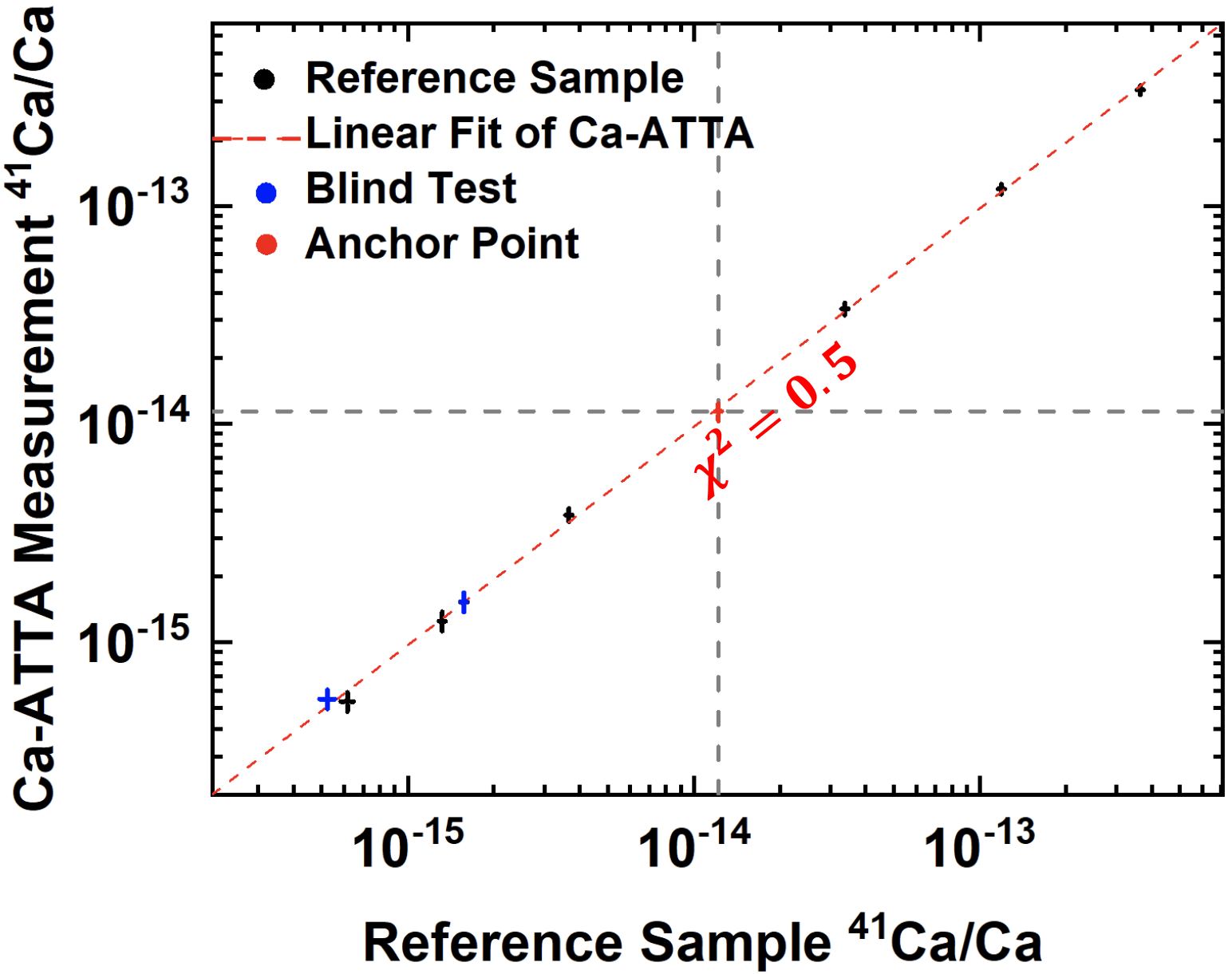
# Single $^{41}$Ca atom detection



# Ultra-high isotopic selectivity



# Calibration in reference samples



# Measurement for some environmental samples

| ***Environmental sample*** | ***Location*** | ***$^{41}$Ca/Ca ($10^{-16}$)*** |
|---|---|---|
| Granite | Tibetan Plateau | 32 ± 3 |
| Seawater | Indian Ocean | 4.1 ± 0.4 |
| Goat bone | East China | 6.7 ± 0.7 |
| Cod bone | North Atlantic | 3.6 ± 0.5 |
| Ancient bone | Yunnan, China | 7.5 ± 0.8 |

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**Group webpage: atta.ustc.edu.cn**

**Corresponding author: txia1@ustc.edu.cn**