

Isotopx



SIRIX IRMS for CO₂ & Clumped Isotopes

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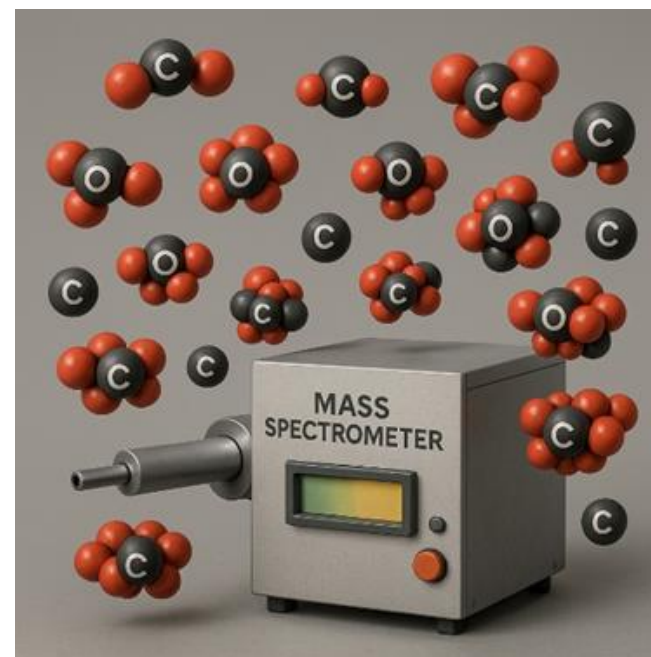
What's in this presentation?

The challenges with clumped CO₂: what are we up against?

Evolution of SIRIX: where did it come from?

SIRIX: Instrument & carbonate prep system

Data: our early data



The challenges with clumped CO₂

Carbonates: the *analytical* challenges



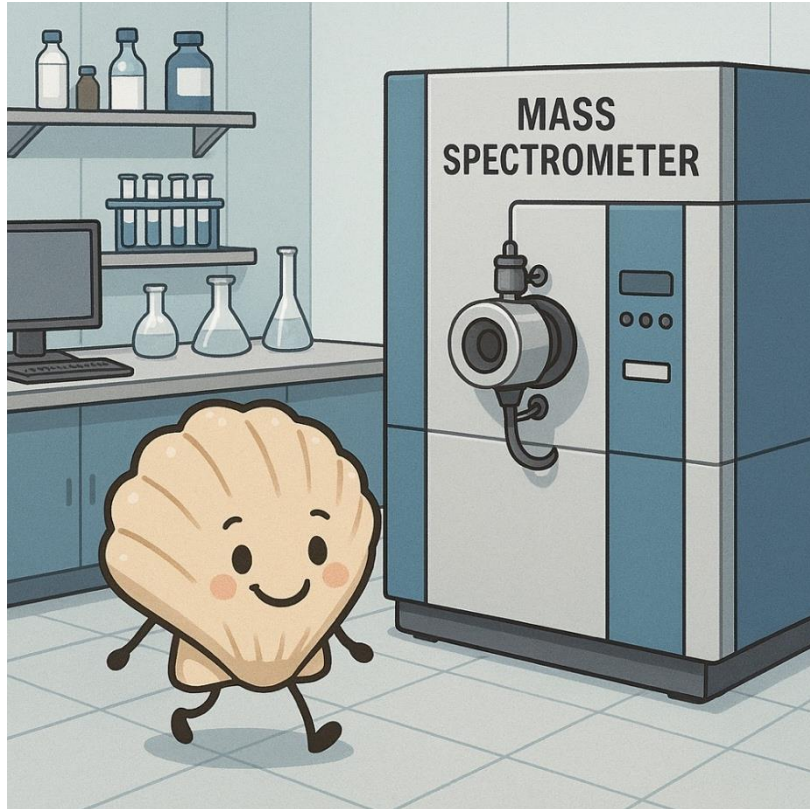
- **General carbonate analytical challenges include:**
- Small samples
- High precision required
- Small differences in isotope ratio

Specific clumped CO₂ challenges



- **Specific challenges include:**
- Variable sample size
- High precision required
- Some isotopologues very low abundance (m/z 47 is 0.005%)

The *instrumentation* challenges



- **Clumped CO2 challenges:**
- Variable sample sizes
- Abundance sensitivity issues
- ...Baselines hard to measure
- Multiple collectors required
- High precision required
- Wide dynamic range required

The evolution of SIRIX

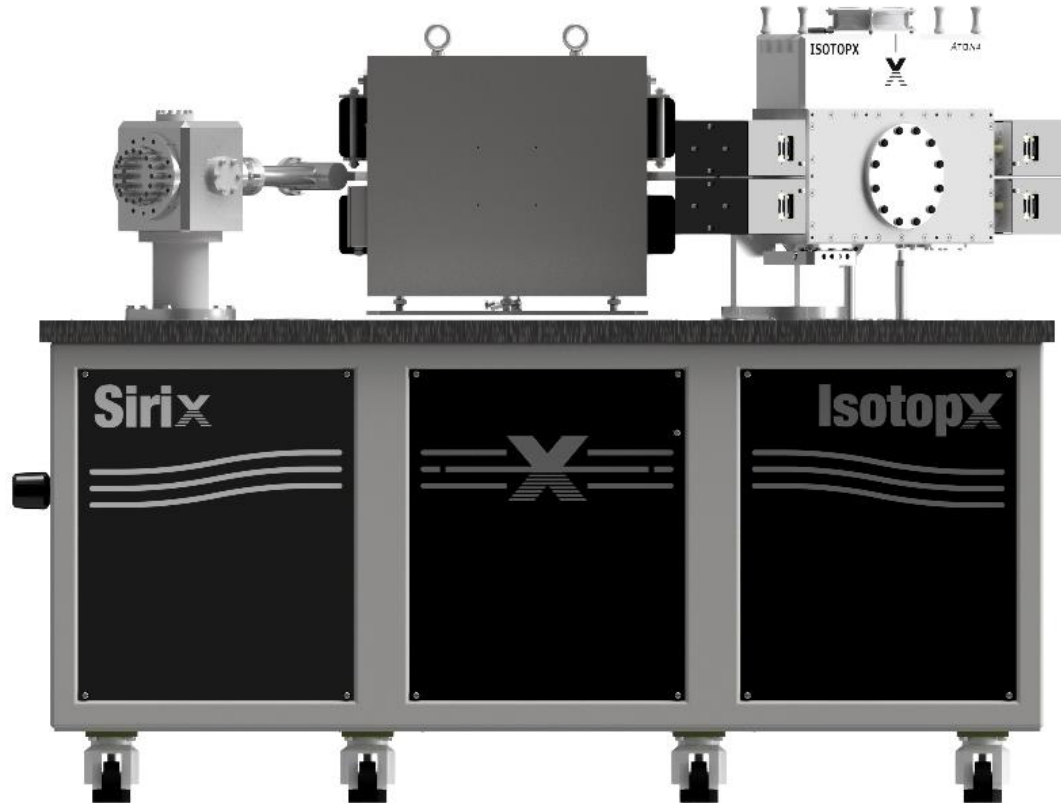
Why did Isotopx develop an IRMS?

Market demand: Some applications required the performance of a larger radius instrument

Platform: Isotopx has a great “large radius” platform

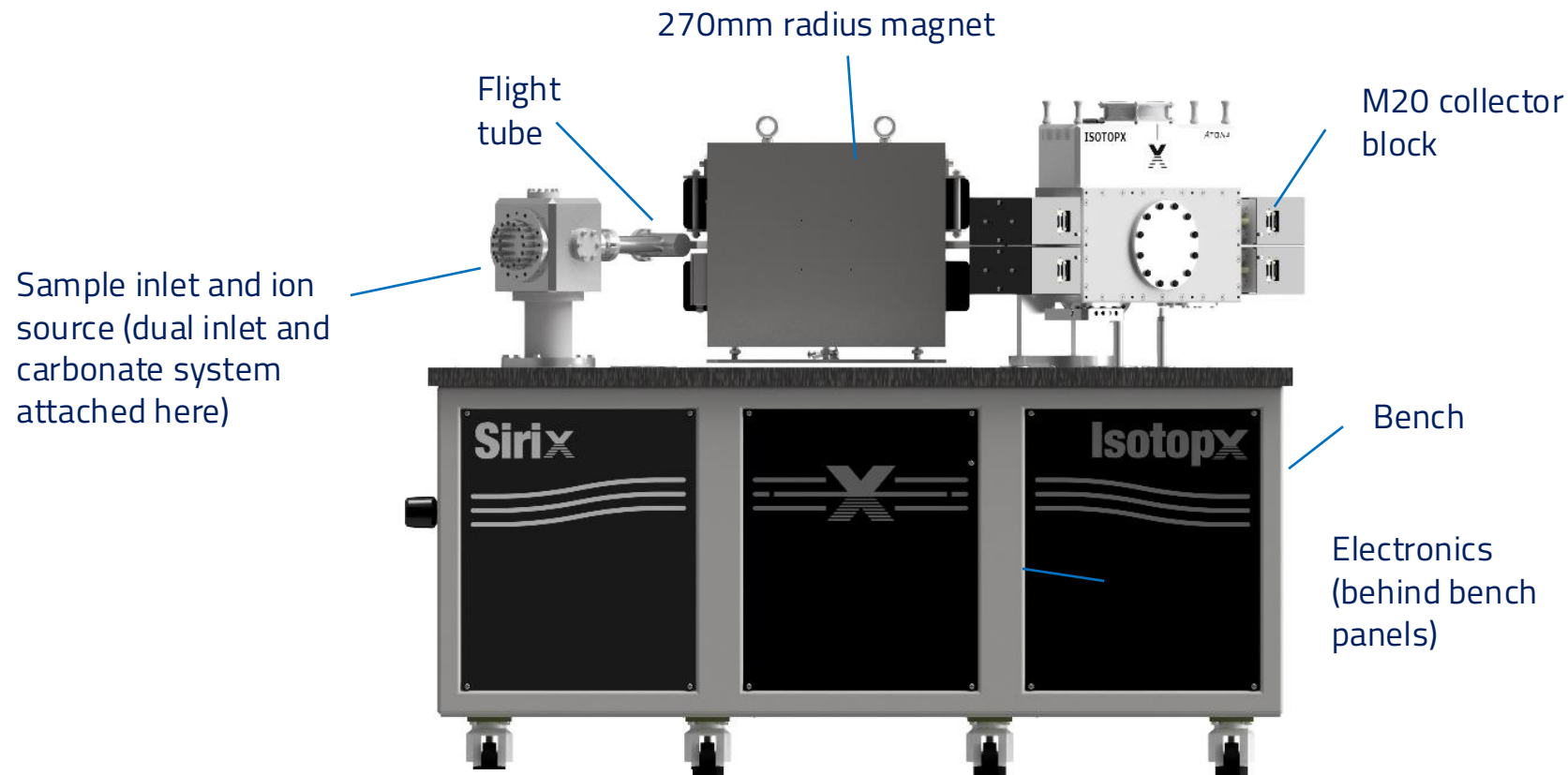
Technology: Our unique ATONA detector tech

Introducing SIRIX



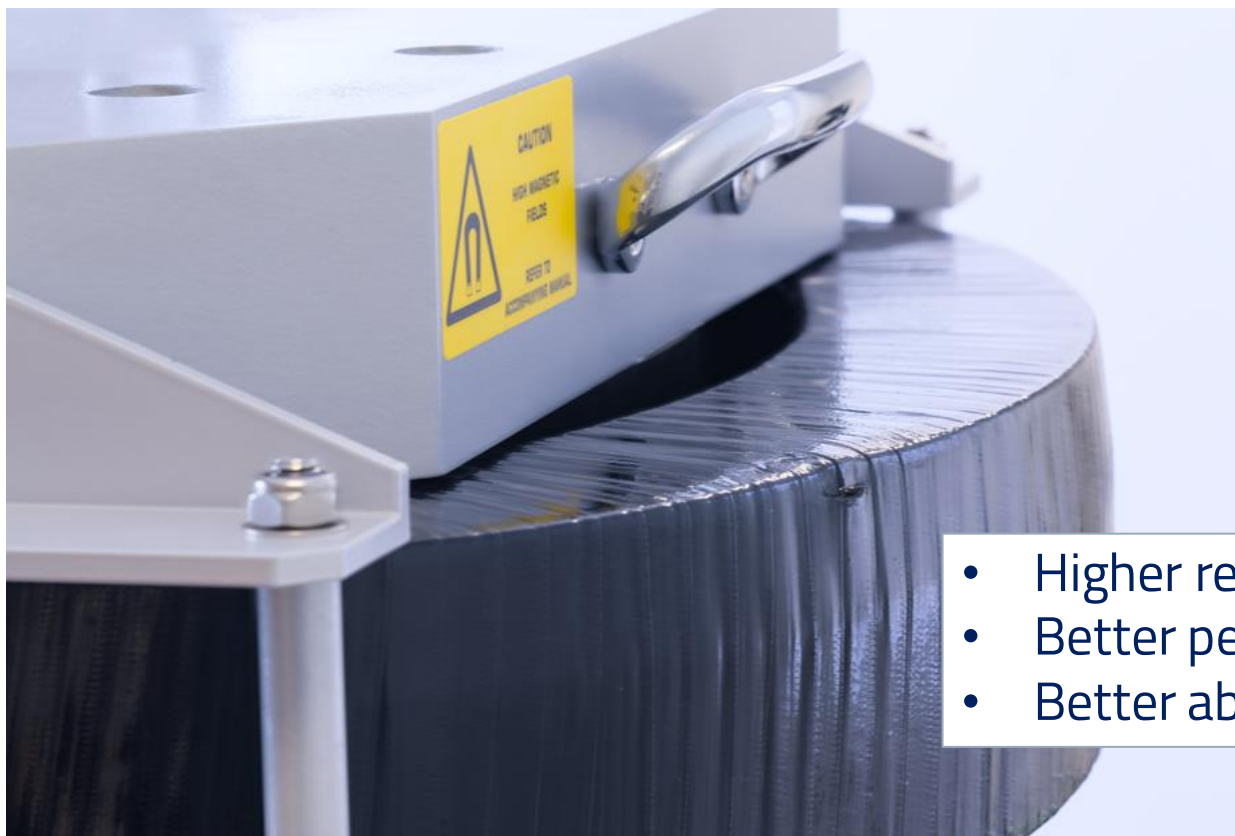
- Gas source IRMS
- Based on Phoenix TIMS
- Proven platform (>100 installations)
- Proven dual inlet and carbonate prep system

Introducing SIRIX



Dimensions: 1m x 2m x 1.5m (depth x width x height).
Weight: 1,300Kg
Power: single phase 32A supply

SIRIX: large magnet, all metal seals



- Higher resolution
- Better peak shape
- Better abundance sensitivity

SIRIX: M20 collector



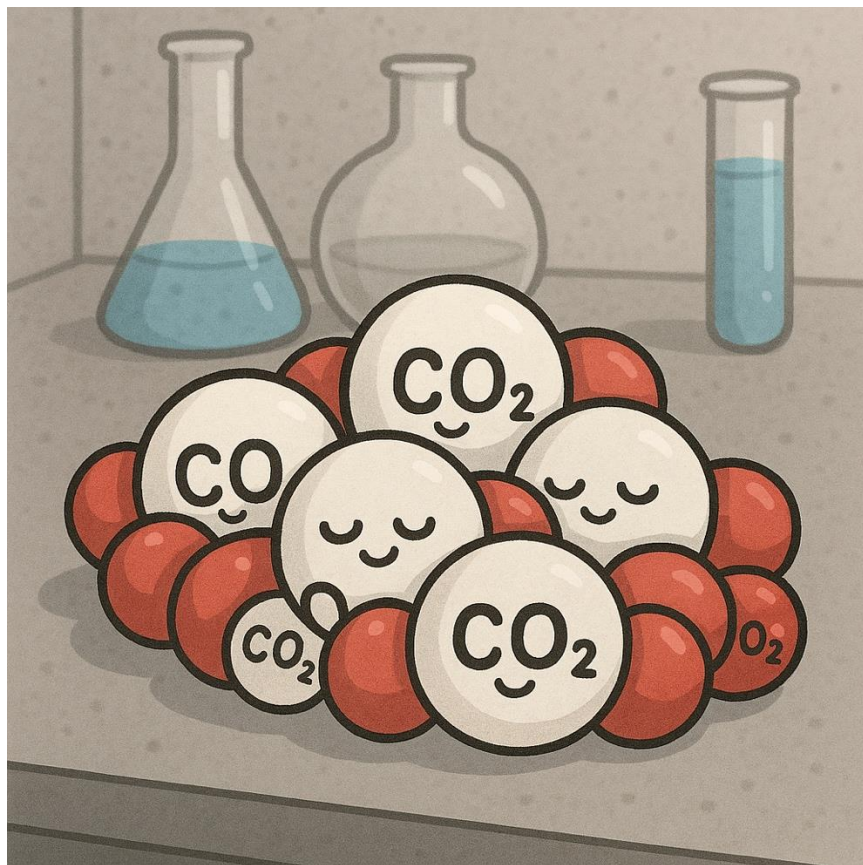
- Up to 20 collectors
- Mixture of ion counters & Faradays
- Fully motorised detectors
- Easy half mass baseline measurement

SIRIX: ATONA technology



- More sensitive than most Faraday systems
- Lower noise, wider dynamic range
- Extremely high gain stability
- Almost no Tau settle time

Benefits of SIRIX for clumped CO₂



- Massive Faraday dynamic range
- Even m/z 48 on Faradays!
- Clean baselines
- Excellent abundance sensitivity
- Fully flexible detector array
- Exceptional stability

Dual inlet and carbonate system

Benefits of uCarbs carbonate preparation system

In order to utilise the power of SIRX a sample inlet system is required.

- Firstly, sample is converted to gaseous phase compatible with the Neir type source
- Secondly the sample isotope measurement needs to be made relative to a known reference material

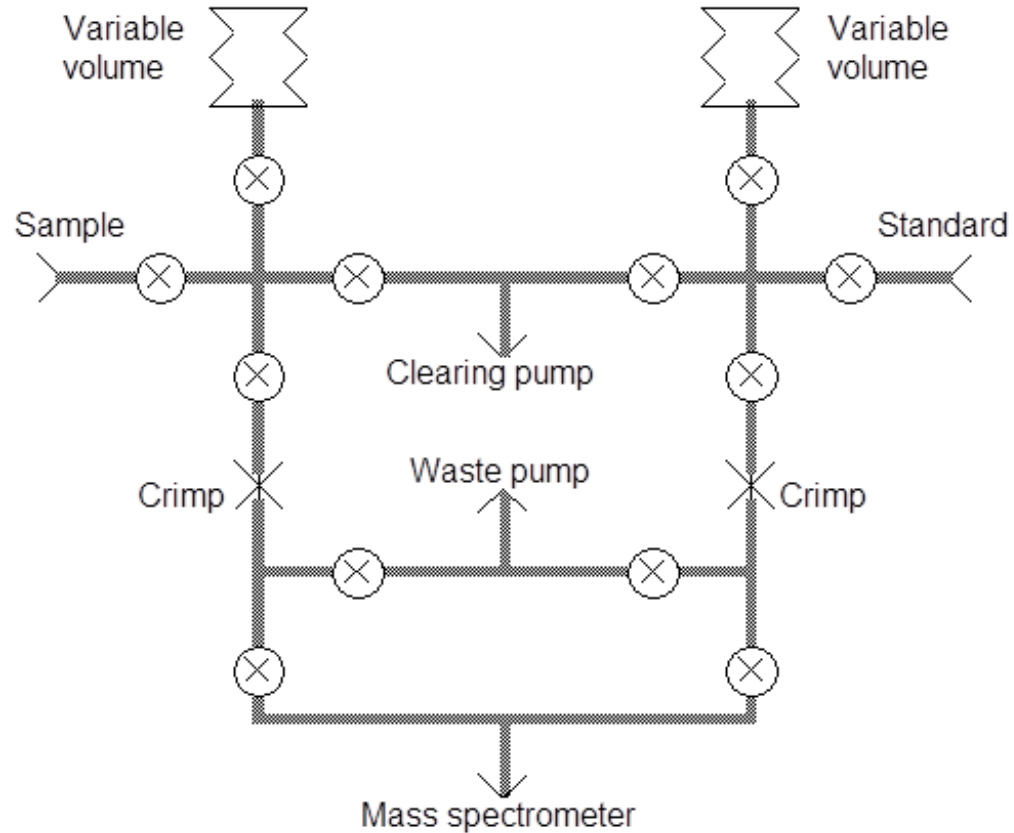
Typically, the highest precision measurements are made using a dual inlet arrangement to allow sample and reference gases to be directly measured and compared.

For carbonate type materials acid digestion is the proven and established technique

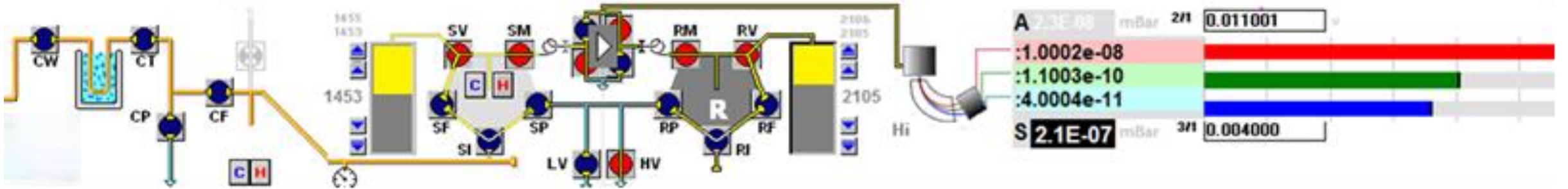


Dual Inlet Principle

The dual inlet was devised in the late 1940s as a means of ensuring that sample and standard gases could be presented to the mass spectrometer at the same pressure and handled (from the point of view of depletion), in the same way.



Sercon Geo Dual Inlet



μ Carbs carbonate preparation system



- Acid digestion coupled with Dual Inlet
- Fully automated under software control
- Fully integrated into SIRIX
- Established installation base
- Very reliable, low running cost

μ Carbs: Controlled Carbonate & DIC Preparation for High-Precision IRMS



- Acid delivery equilibration system for $\delta^{13}\text{C}$ / $\delta^{18}\text{O}$ analysis
- Purpose-built for **carbonate and dissolved inorganic carbon (DIC) workflows** with direct integration to IRMS
- Controlled phosphoric acid digestion generates CO_2 under **stable, reproducible equilibration conditions**
- Supports multi-matrix isotope analysis:
 - Carbonates: $\delta^{13}\text{C}$, $\delta^{18}\text{O}$
 - DIC: $\delta^{13}\text{C}$
 - Water equilibration: $\delta^{18}\text{O}$, $\delta^2\text{H}$
 - Gases (CO_2): atmospheric and breath

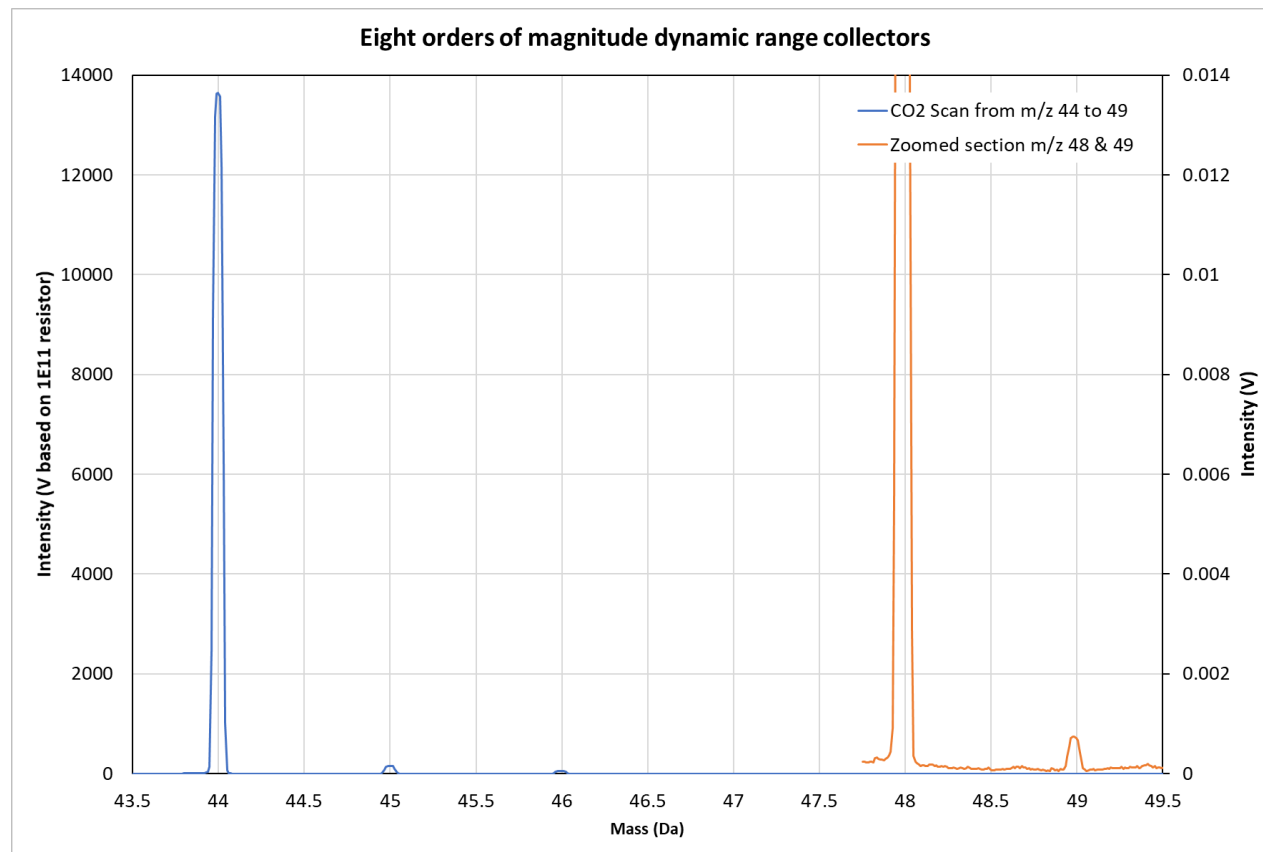
System Architecture: Reproducibility, Throughput, and Stability



- **Designed to remove preparation-induced variability**
- **Dual-needle system**
Independent acid delivery and headspace handling
→ Stable flow control, reduced cross-contamination, fewer blockages
- **Temperature-controlled reaction environment ($\pm 0.1^\circ\text{C}$)**
→ Consistent acid-carbonate reaction kinetics and equilibration efficiency
- **High-throughput autosampler (up to ~200 vials)**
→ Long unattended sequences with consistent analytical conditions
- **Integrated heated acid reservoir**
→ Prevents phosphoric acid crystallisation, ensuring **uniform acid strength and delivery**
- **Chemically resistant wetted components**
→ Reduced corrosion, improved long-term reproducibility and uptime

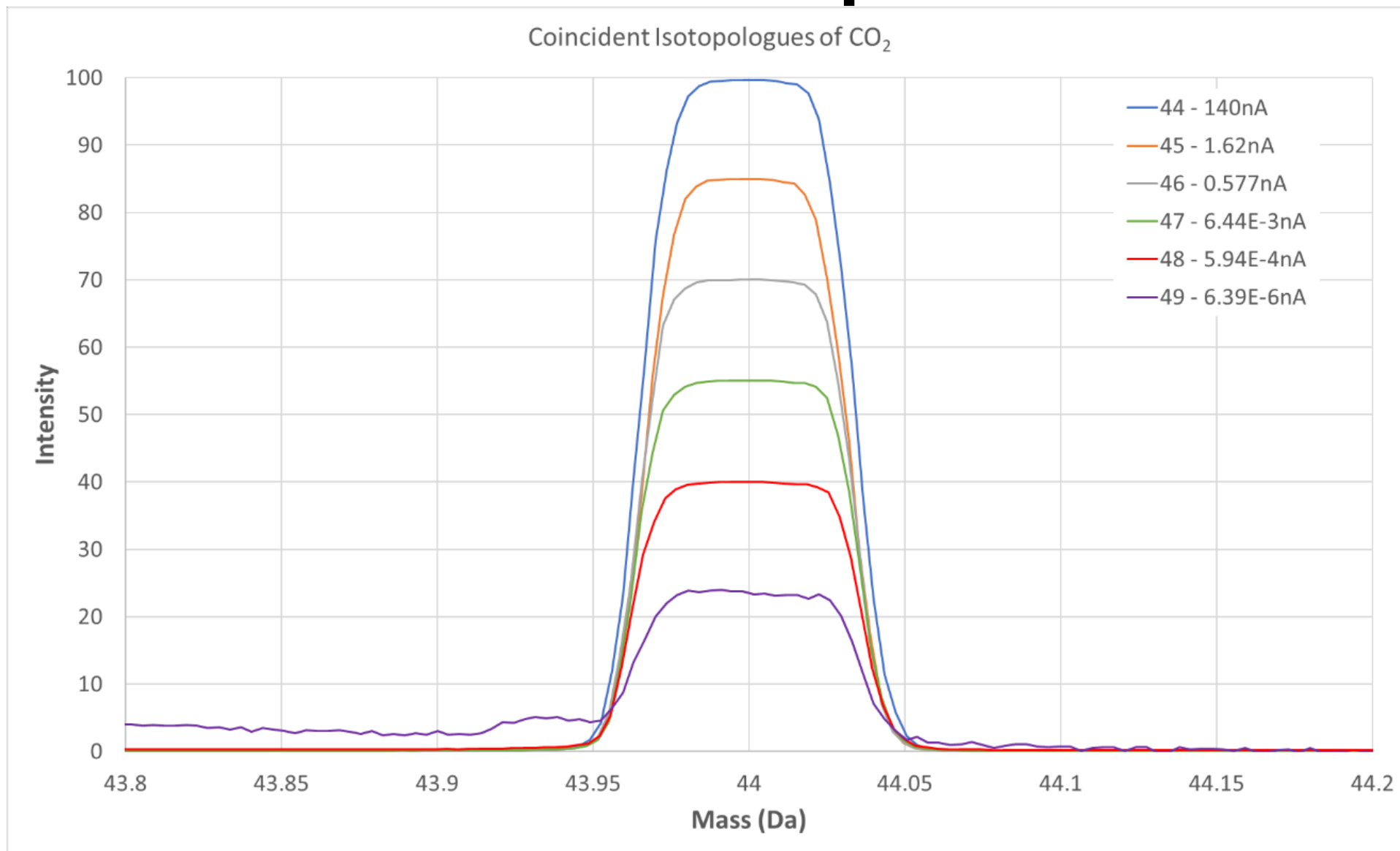
SIRIX Data

Dynamic range



- Relative abundance of the smaller isotopes is a huge challenge
- Zoomed-in section on right is x1,000,000
- ATONA is the **only** solution for this!

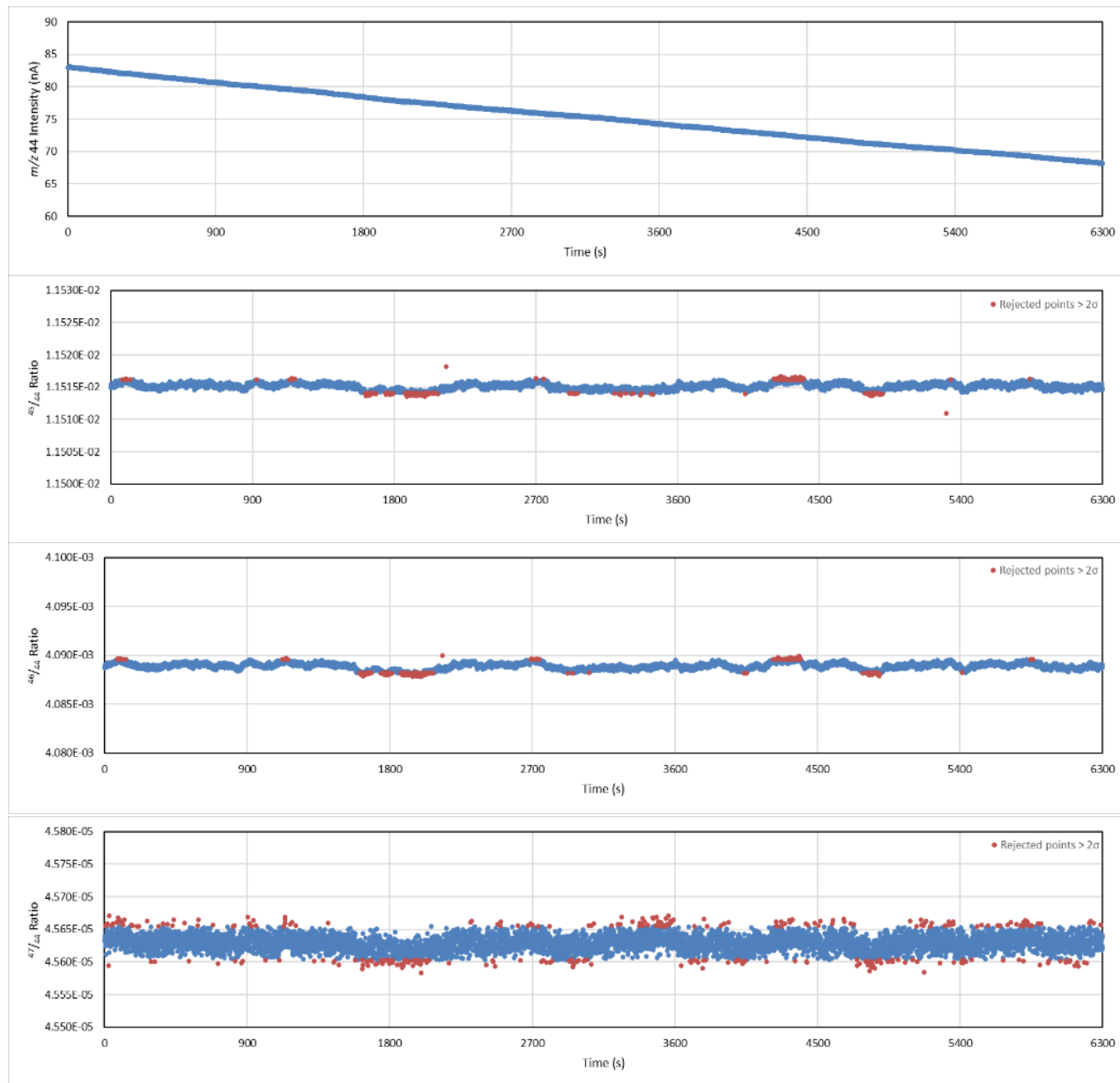
Peak shapes



Excellent peak shapes, even for m/z 48 and 49

SIRIX data

- Isotope ratio stability
- Excellent over 6,000 measurements



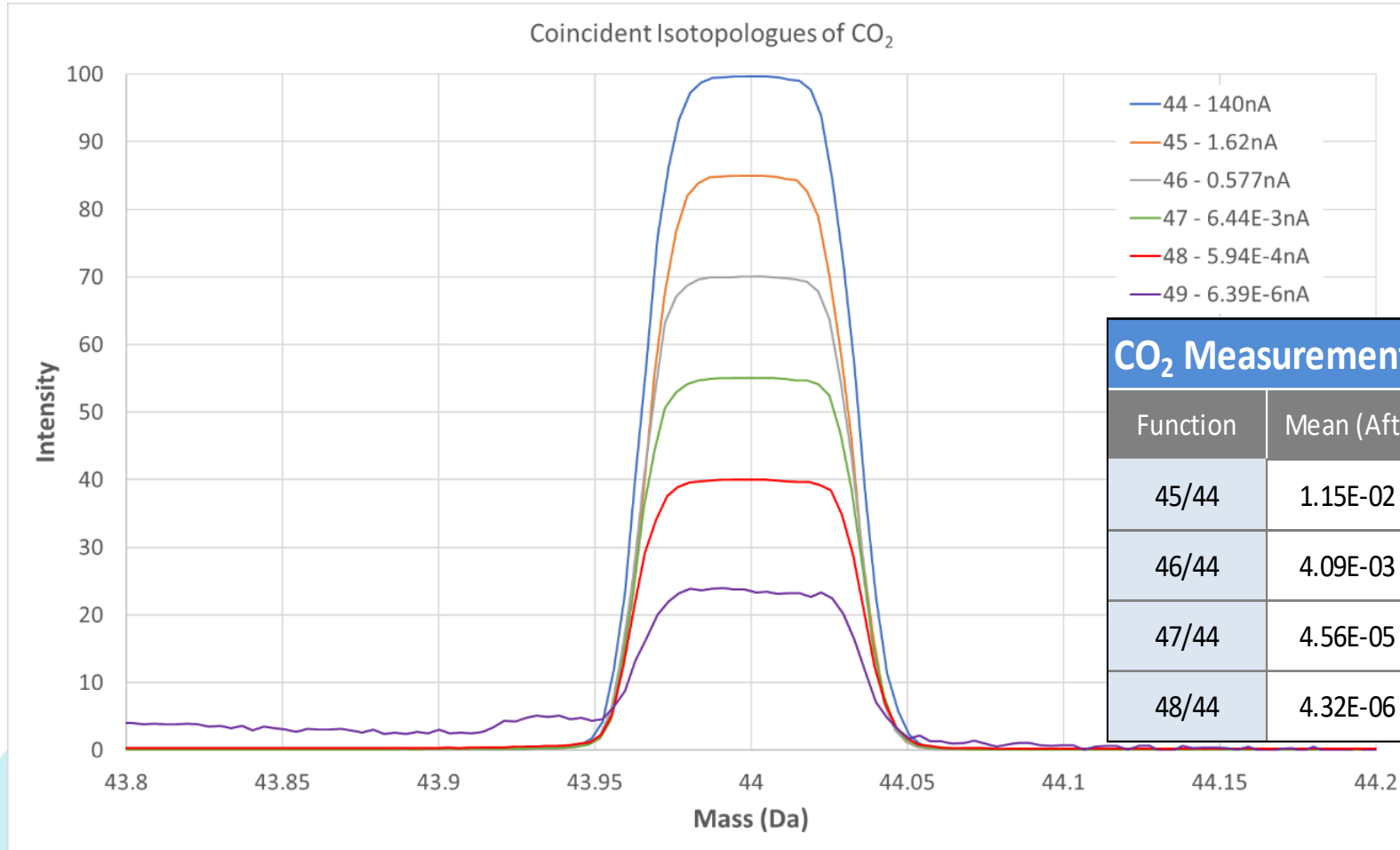
m/z 44 raw intensity

45/44 ratio

46/44 ratio

47/44 ratio

SIRIX data

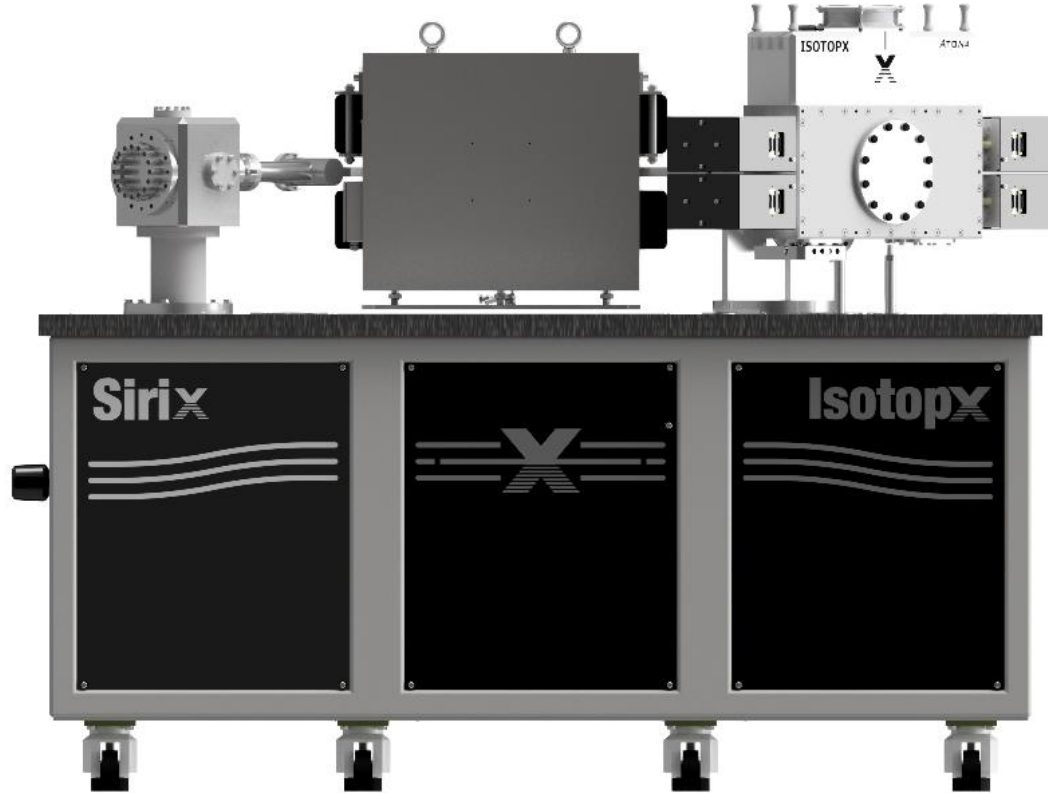


- Raw data
- Excellent precision even for 48/44 ratio

CO₂ Measurement, 6300 1s Integrations

Function	Mean (Aft)	Std Dev% (Aft)	Std Err ppm (Aft)	Included	Total
45/44	1.15E-02	0.0040	0.51	6044	6300
46/44	4.09E-03	0.0071	0.91	5971	6300
47/44	4.56E-05	0.0243	3.15	5982	6300
48/44	4.32E-06	0.1121	14.45	6022	6300

SIRIX in summary



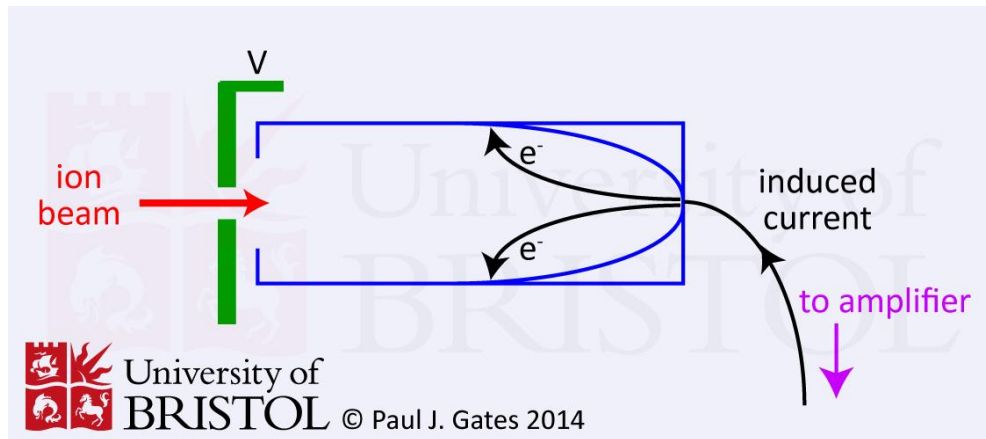
- Large radius IMRS based on TIMS
- Fully flexible collector array
- Ideal for clumped isotopes
- ATONA: low noise, wide dynamic range, low backgrounds
- Clean baselines
- Half mass baseline measurement
- 10ppm reproducibility 48/44

Any questions?

Appendix: ATONA technology

ATONA amplification

Faraday detectors have a large dynamic range, are linear, have stable gain and a long lifetime



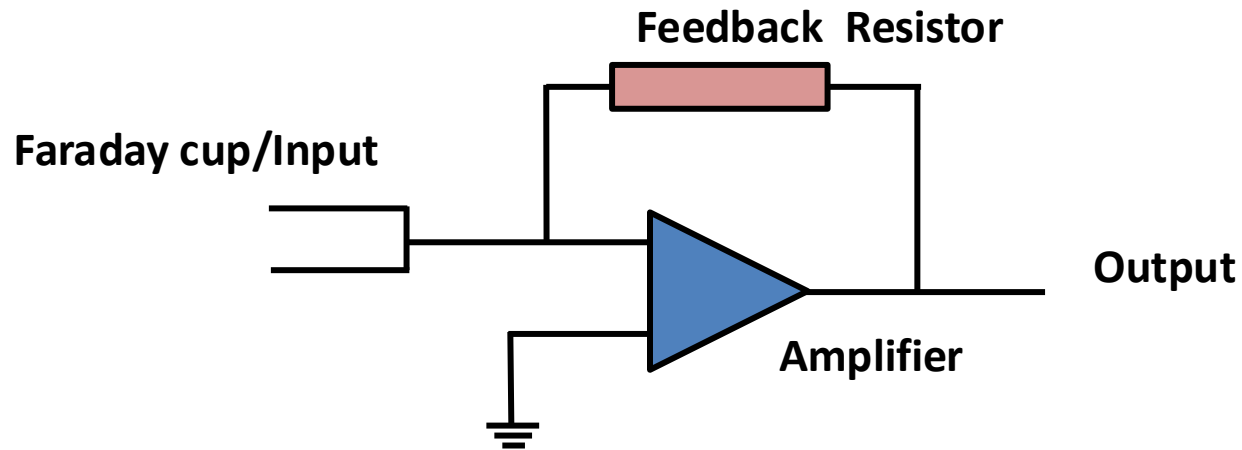
So what's the problem?

Amplification of ion beam current introduces **noise** which limits measurement of small signals

ATONA amplification

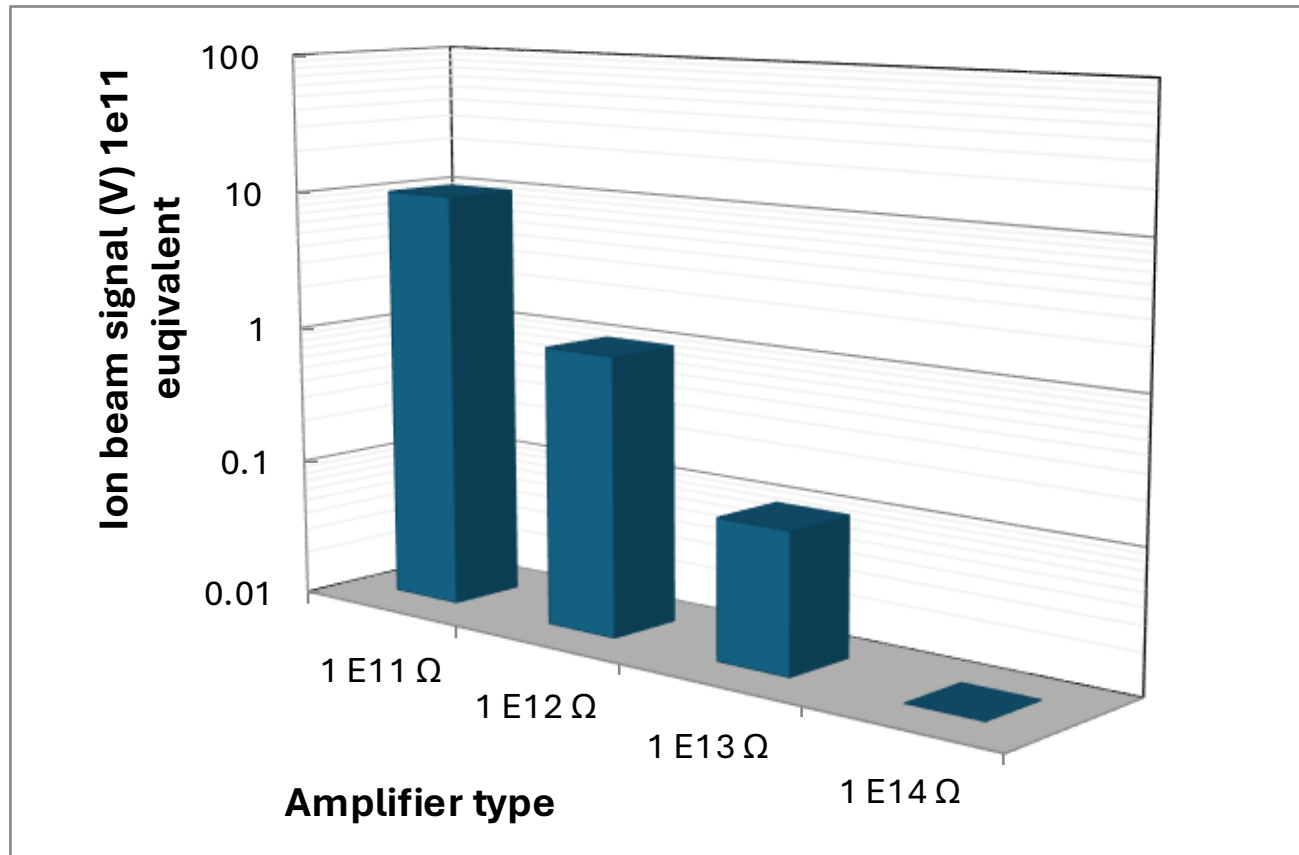
Existing technology – high gain resistor amplifiers

- Temperature instability
- Resistance depends on voltage across resistor
- Parasitic capacitance slows response (Tau decay)
- Noise!



ATONA amplification

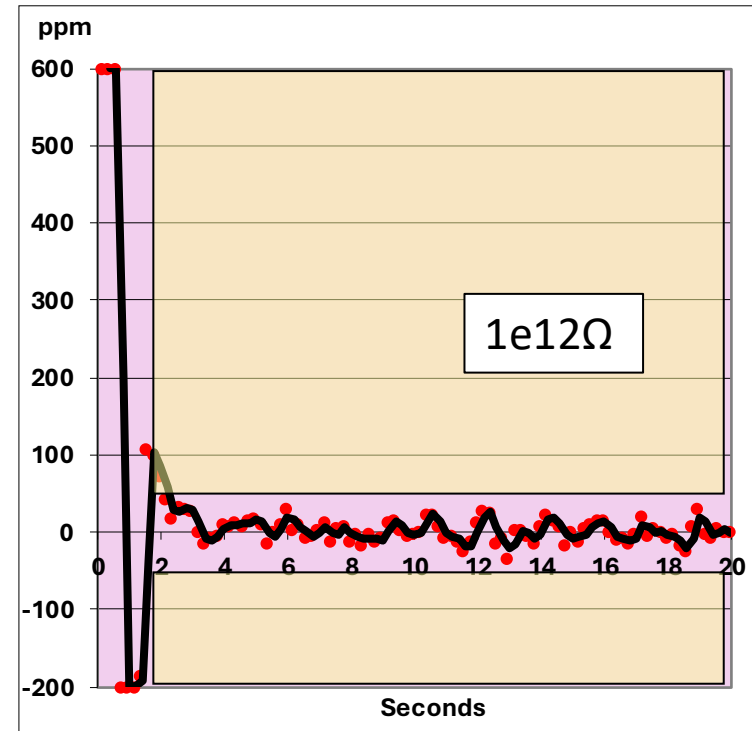
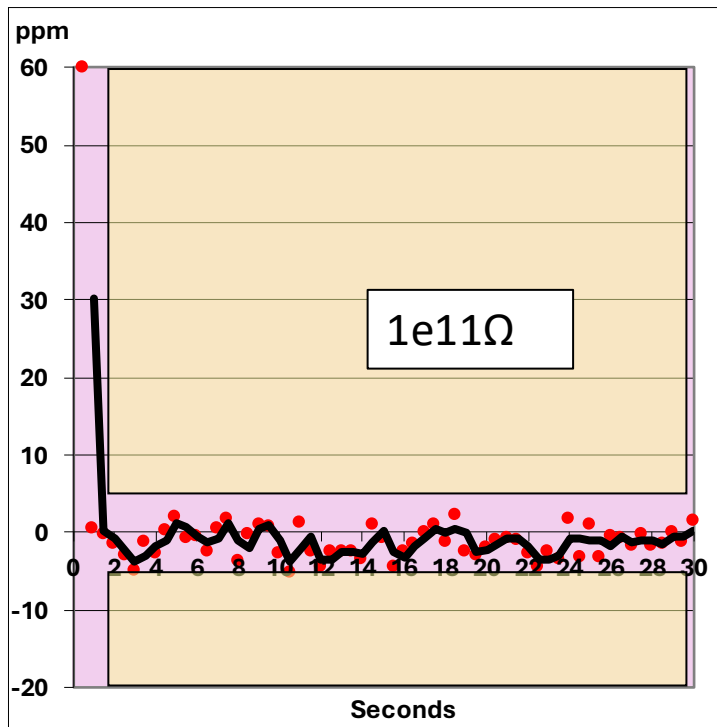
Higher gain resistor amplifiers have reduced dynamic range



ATONA amplification

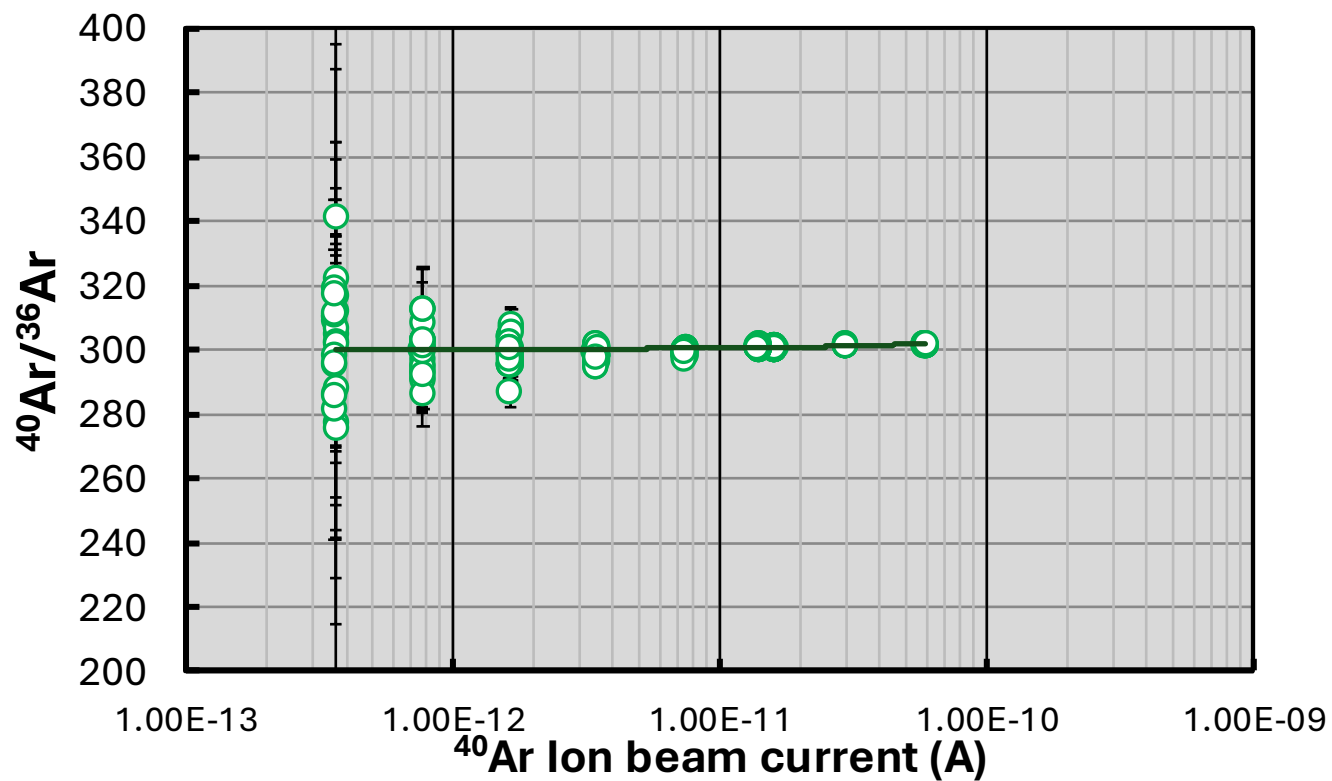
The higher the gain, the worse the issues

- Example shown is Tau response

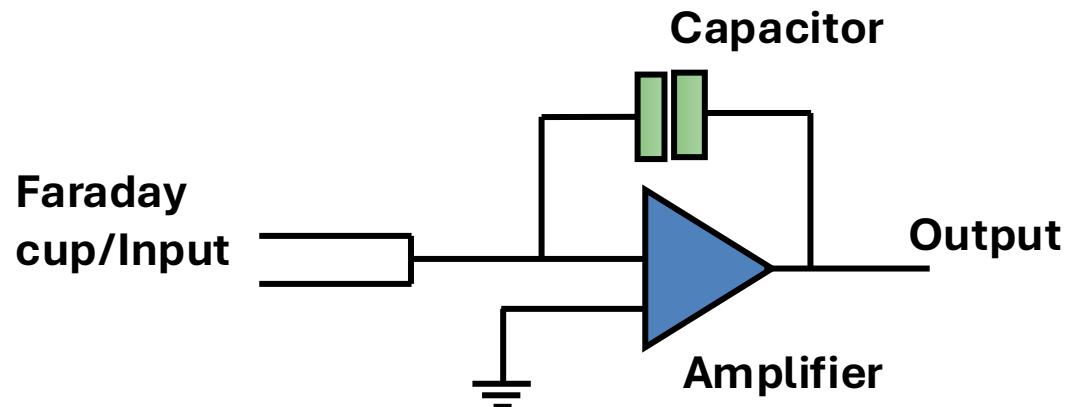
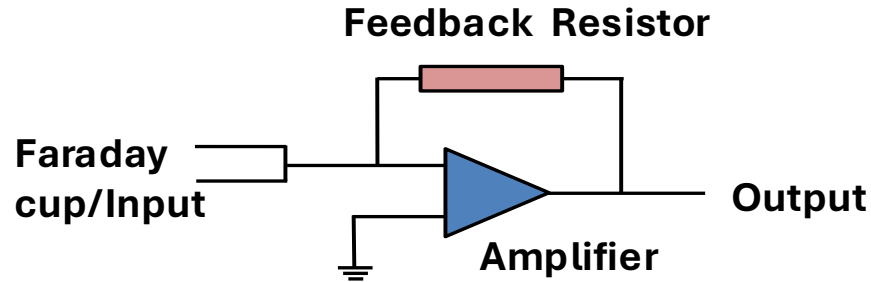


ATONA amplification

Higher gain resistor amplifiers have worse linearity



ATONA amplification



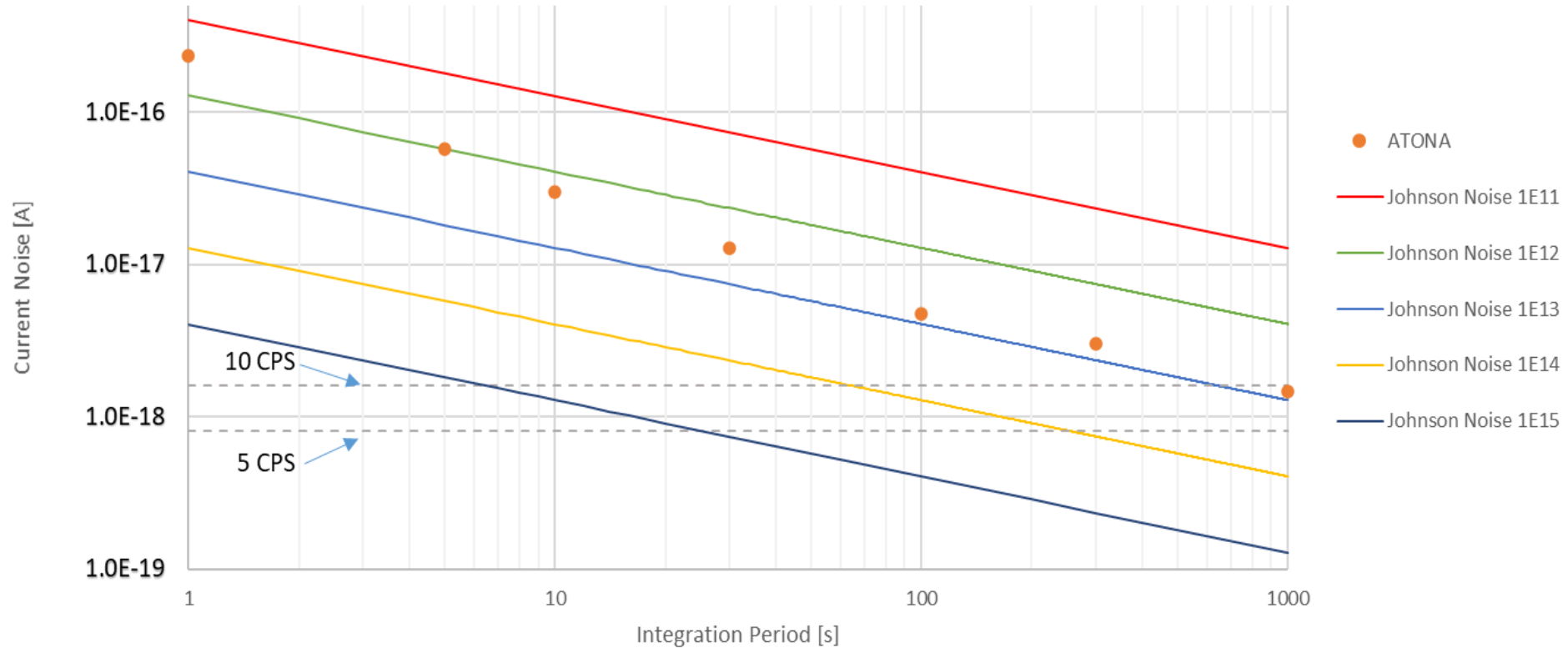
ATONA:

- Low noise
- Stable amplifier gains
- Fast Tau response
- Linear
- Large dynamic range

ATONA amplification

Log-Log plot of measured and theoretical (Johnson-Nyquist) current noise

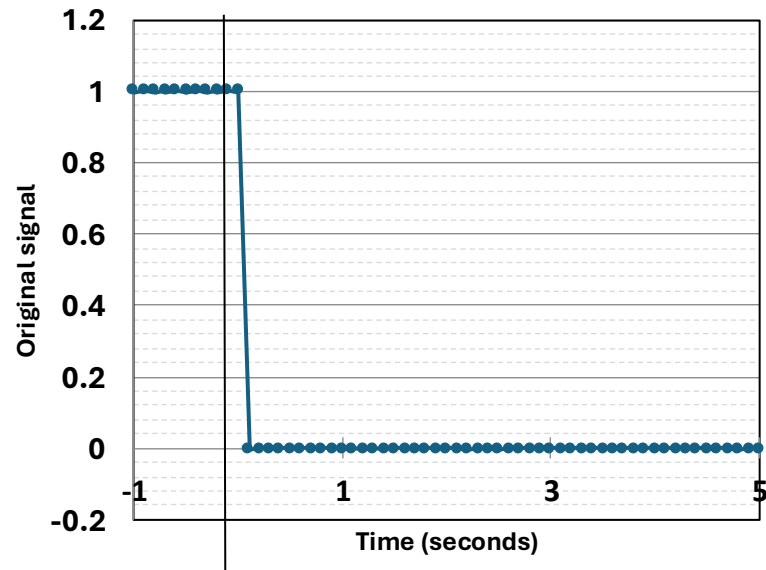
ATONA shows very competitive noise levels



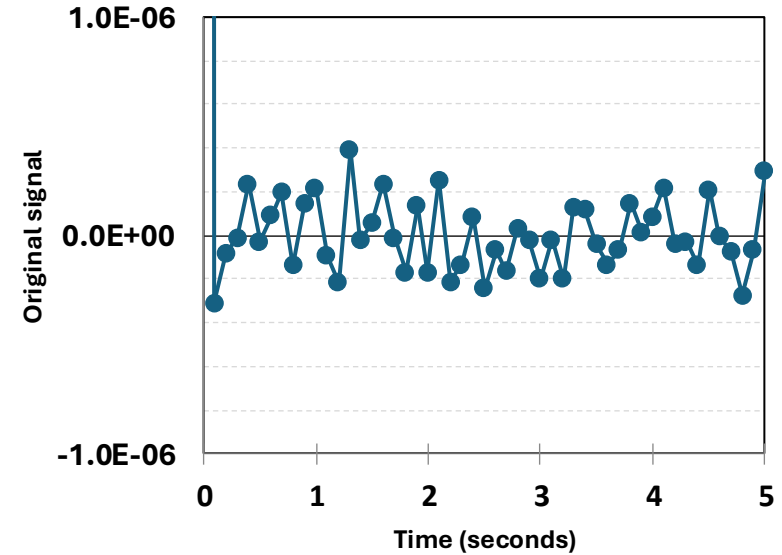
ATONA amplification

Amplifier returns to within 1 ppm within 100ms

ATONA® Tau response

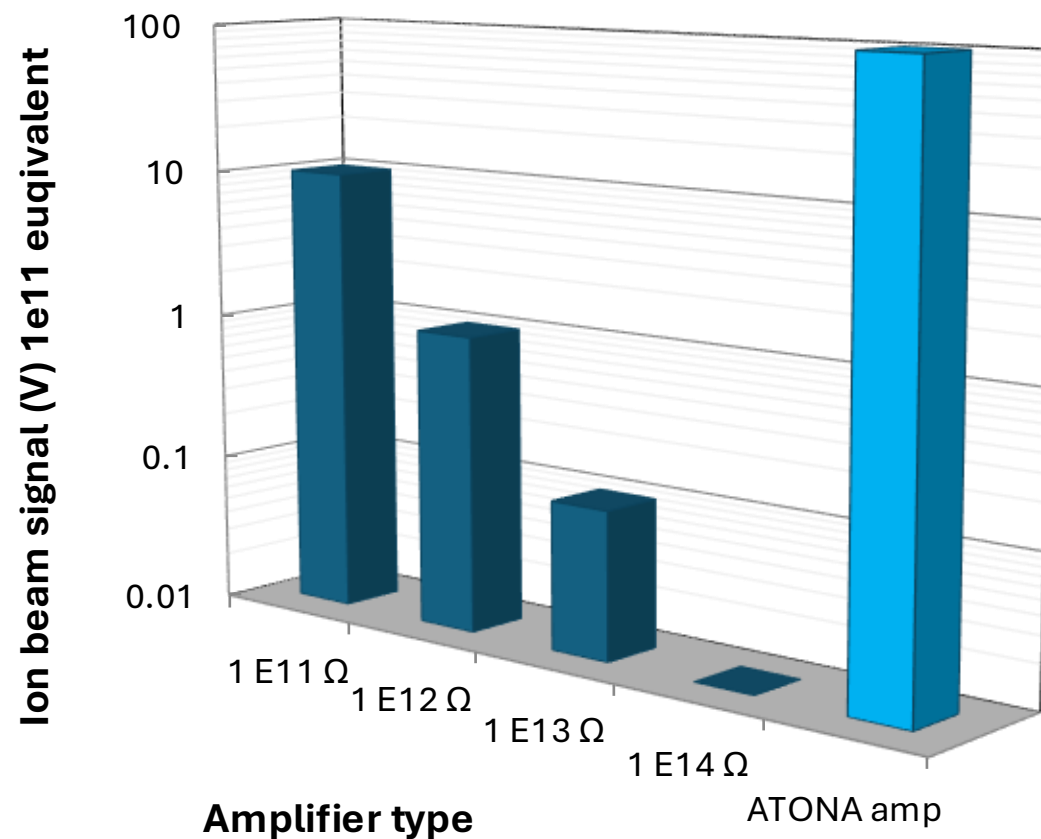


ATONA® Tau response

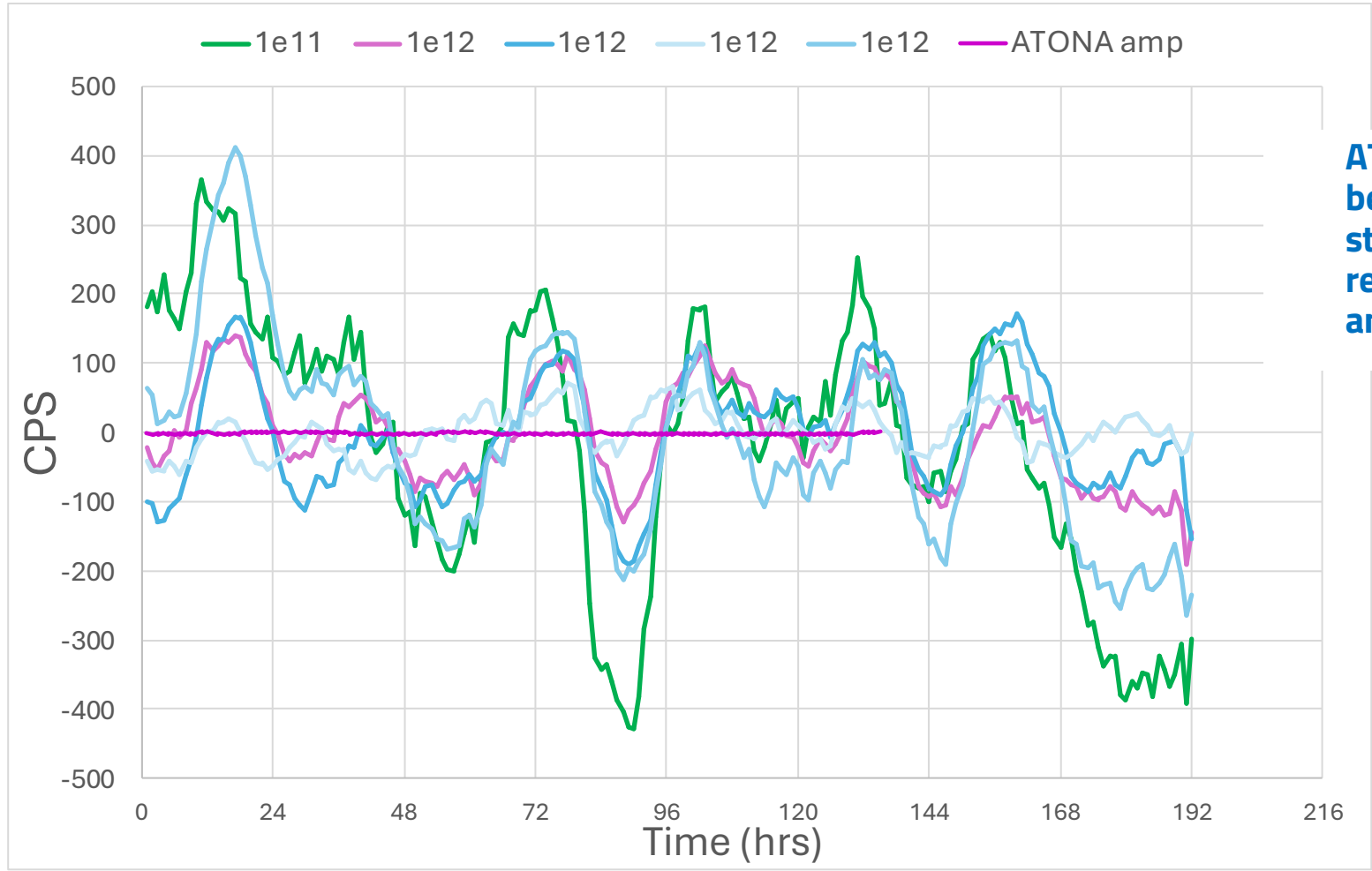


ATONA amplification

ATONA has huge dynamic range



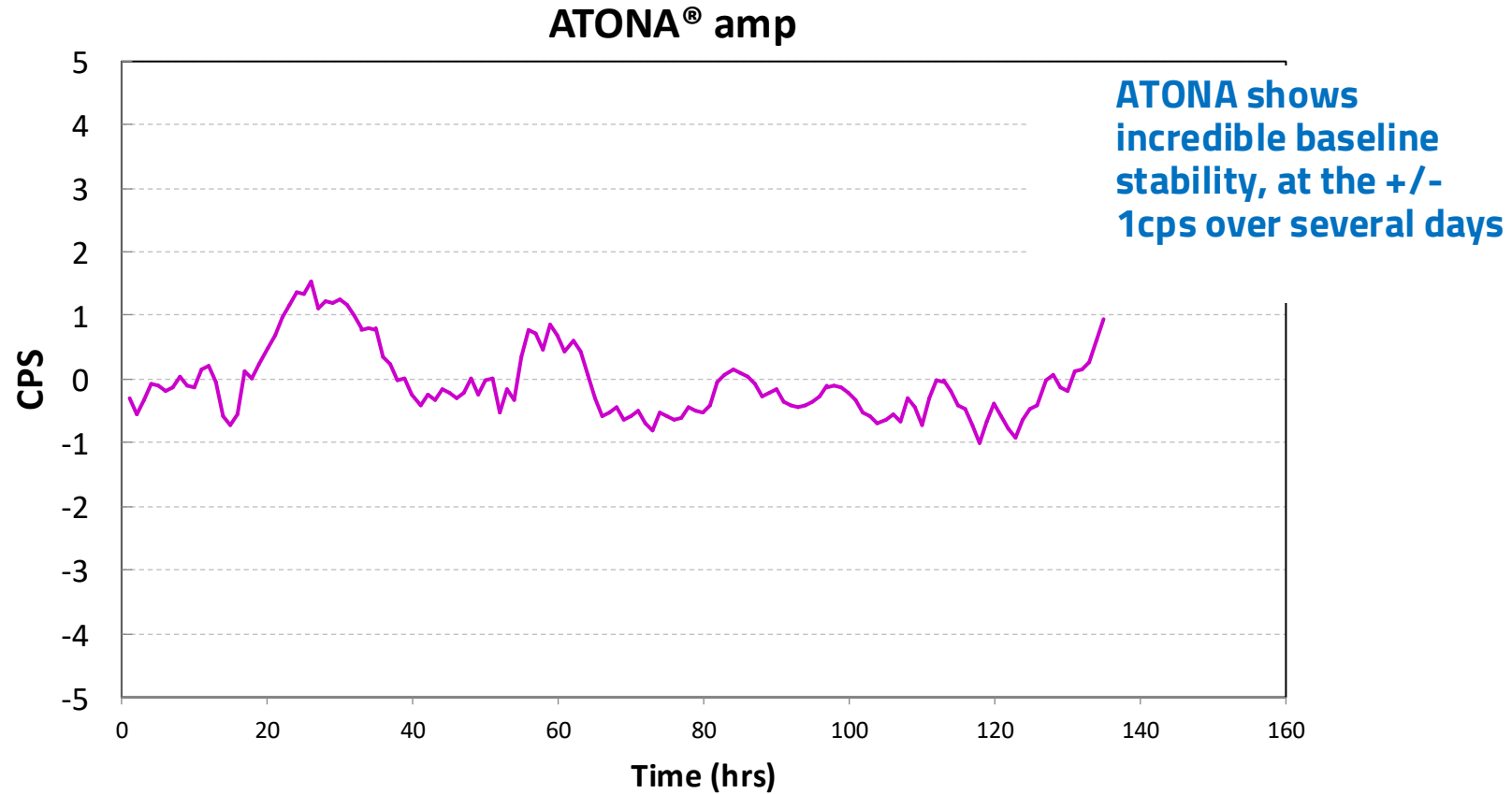
ATONA amplification



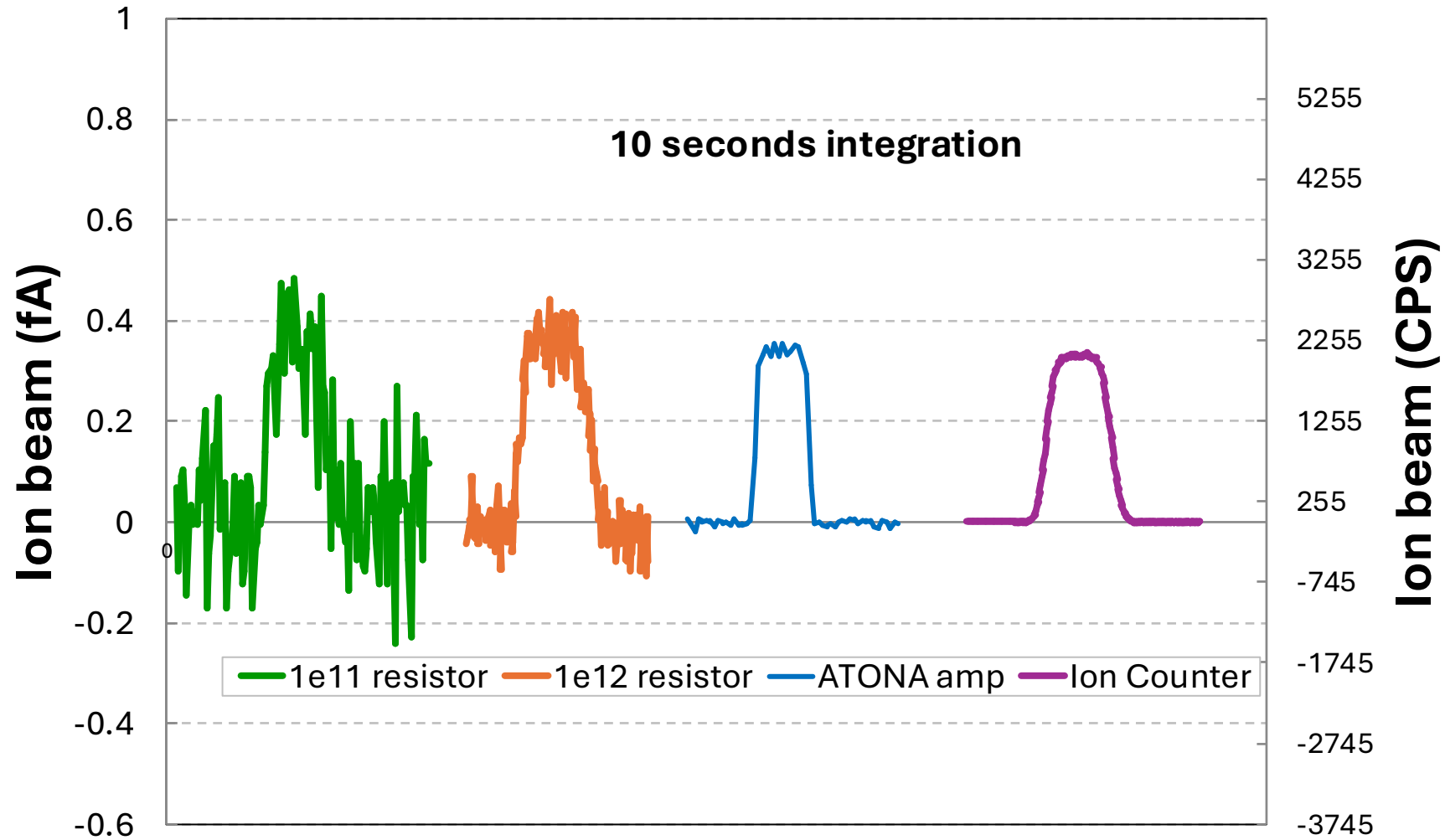
ATONA show far better baseline stability than resistor-based amplifiers



ATONA amplification



ATONA amplification



ion beam profiles with different detector technologies (10 second integration)

ATONA - summary



- Extremely low baseline noise
 - Ultra-fast Tau decay – no waiting
 - Can be used for 100 volt beams
 - ...but also down to 10,000 cps or lower
 - Almost no gain calibration required
-
- **Faster**
 - **Easier**
 - **More flexible**
 - **Better data confidence!**

Isotopx

 **sercon**
innovators in isotopes

5/20/26

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