UNIONE EUROPEA
Fondo Europeo di Sviluppo Regionale

Ministero dell'Università e della Ricerca

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INFN
Istituto Nazionale di Fisica Nucleare

Water diffusion in KM3Net equipment

Claudio Santonastaso

PACK
Potenziamento Appulo-Campano di KM3NeT

KM3NeT

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Goals

- Develop new methodologies to predict penetration of water in Km3NET equipments and test new materials. *(Ion Beam Analysis [IBA])*

- Quality Check during production phase *(Isotope Ratio Mass Spectrometry [IRMS])*

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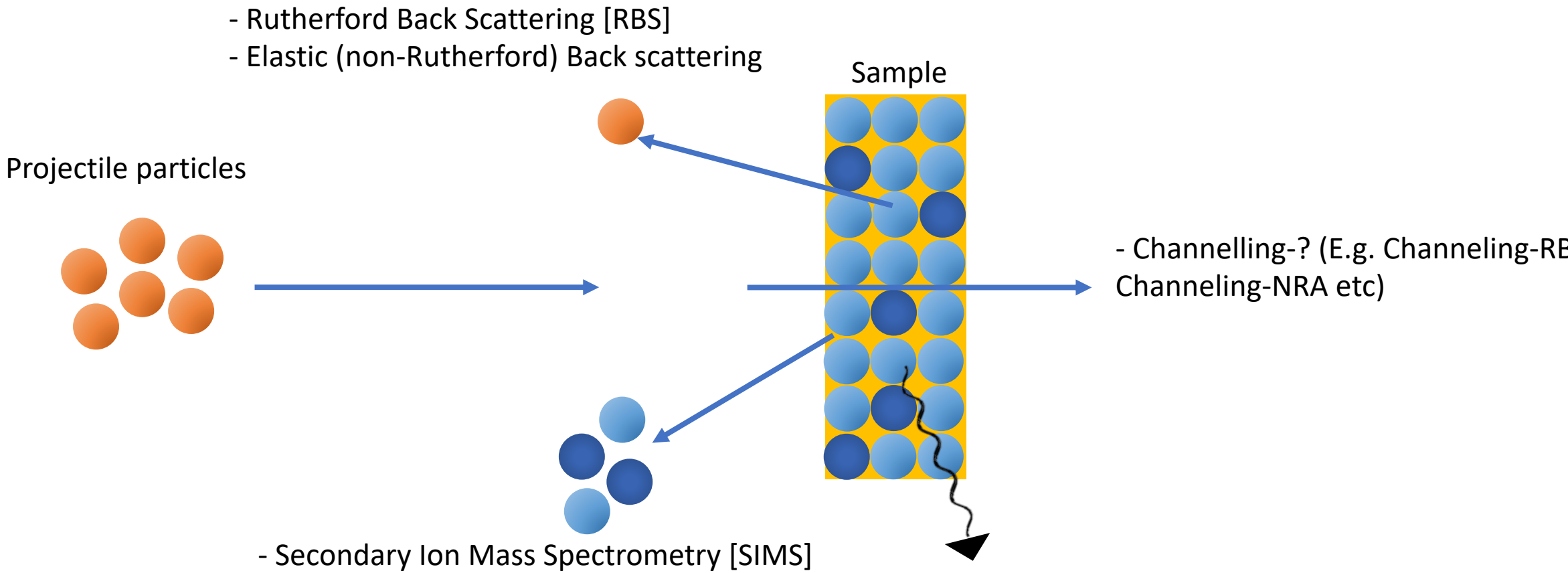
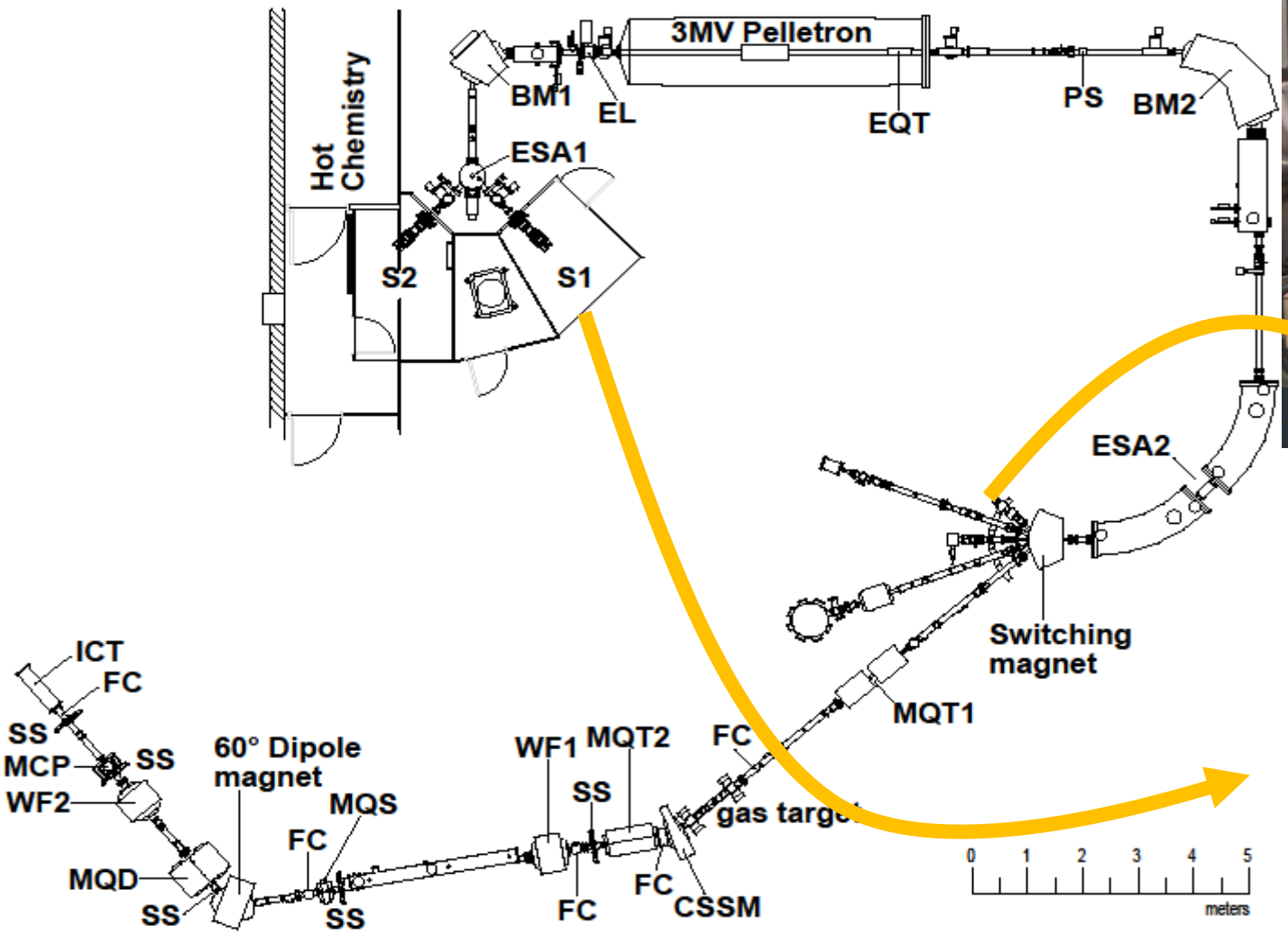
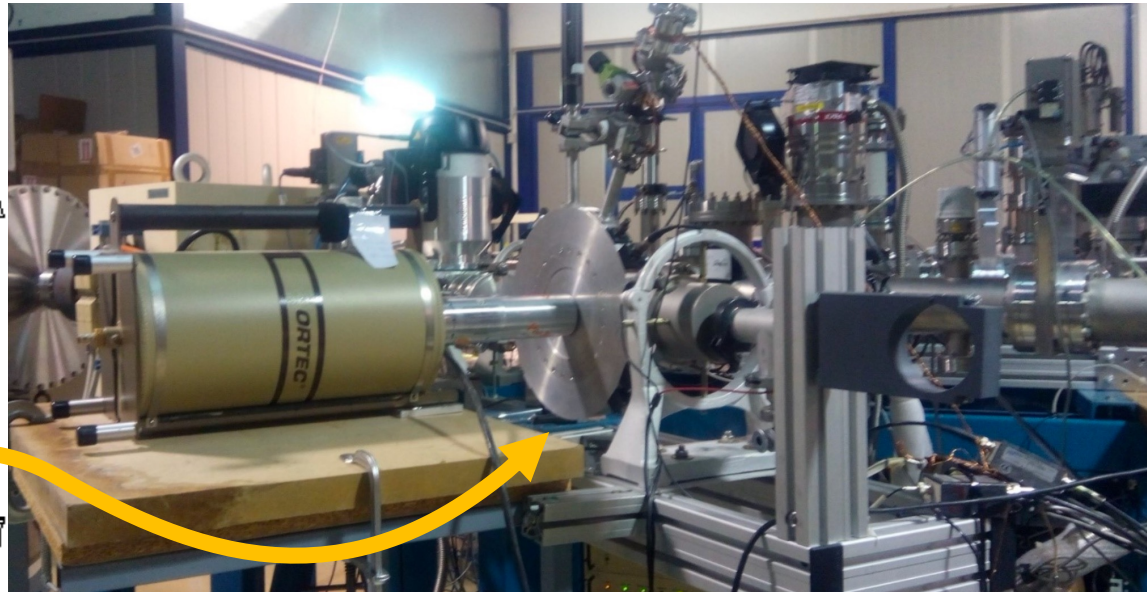
Ion beam analysis

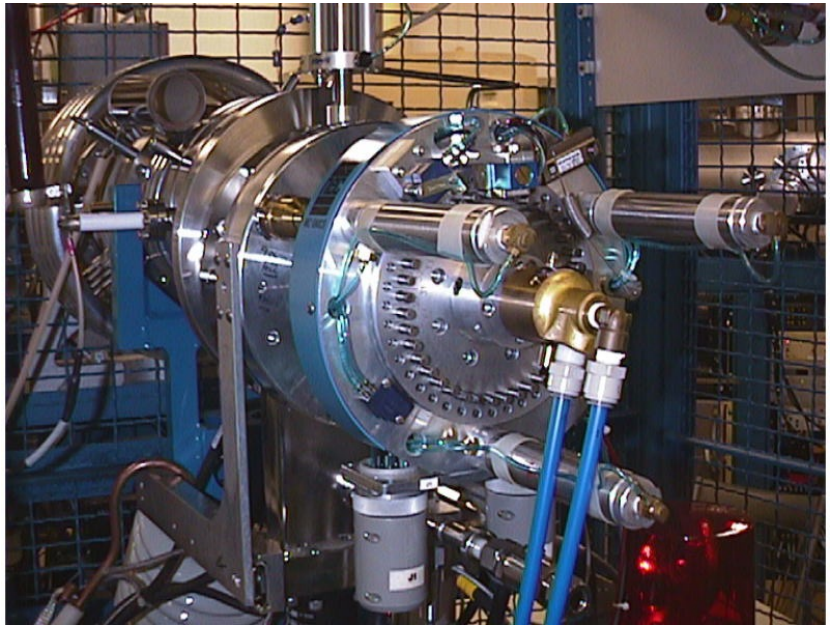


Beam production

Tandem Accelerator Laboratory







IBA analysis

H_2O in:

- Low Density PolyEthylene (LDPE)
- Glass
- Other plastics

IBA analysis

$$-\frac{dE}{dx} = Kz^2\frac{Z}{A}\frac{1}{\beta^2}\left(\frac{1}{2}ln\frac{2m_ec^2\beta^2\gamma^2T_{max}}{I^2} - \beta^2 - \frac{\delta(\beta\gamma)}{2}\right) \propto \frac{mz^2}{E}$$

$$\frac{d\sigma}{d\Omega} = (\frac{Z_1Z_2e^2}{4\pi\epsilon_o}\frac{1}{4E})^2\frac{1}{sin^4(\theta/2)}$$

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Beam choice

- Availability (obvious)

- Low Z beams (1H, 3He, 4He) for high penetration [RBS]

- Depending on nuclear reactions possible, eventual background and available cross sections in literature [NRA]

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Possible beams

RBS:

Protons -> ^{16}O

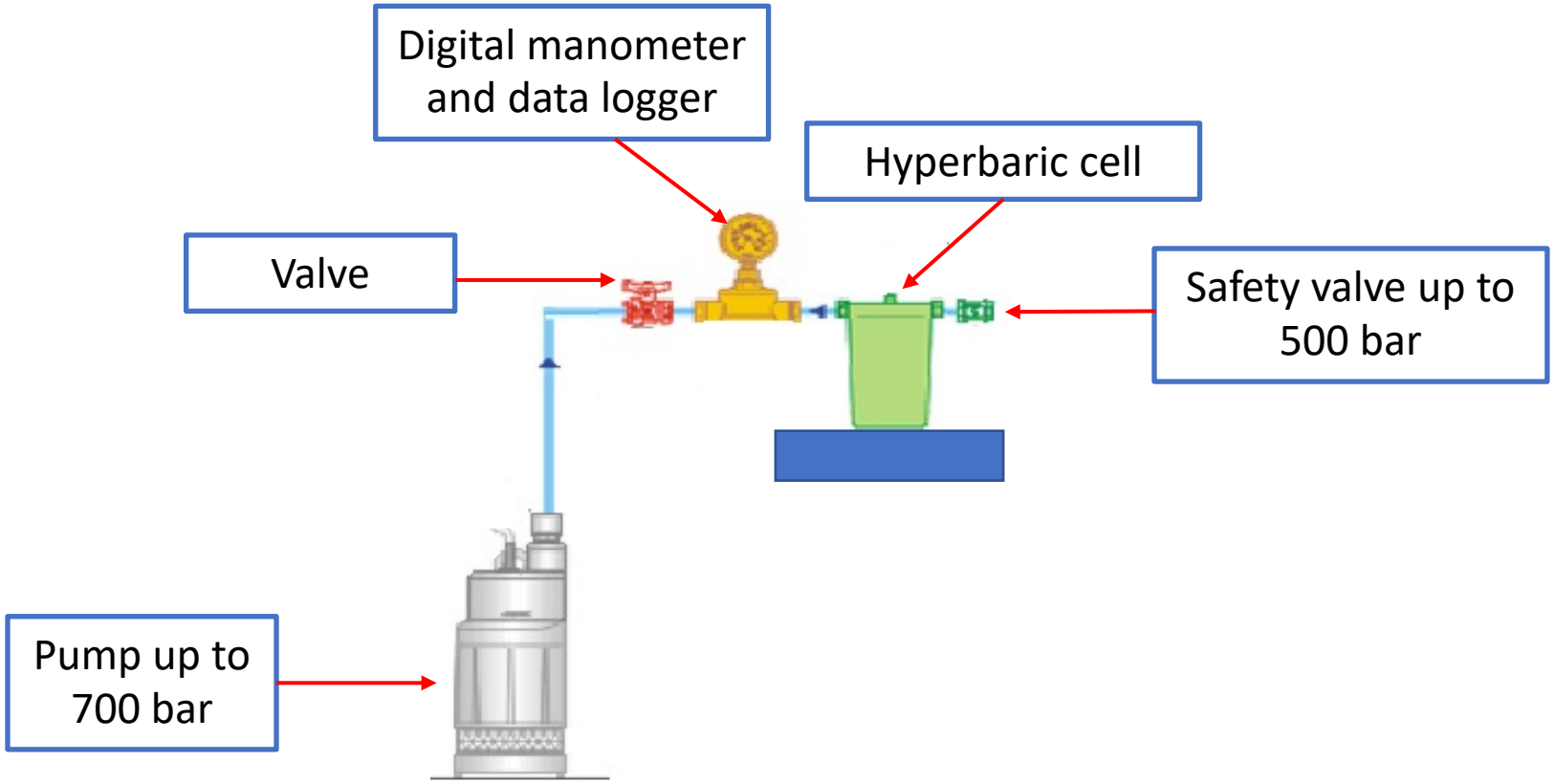
NRA:

$^{15}N(p,\alpha\gamma)^{12}C$ (1)

$^{15}N(d,p)^{16}N$ -(β)-> 16O* -(γ)-> 16O

(1) Not suitable for plastics

Sample production



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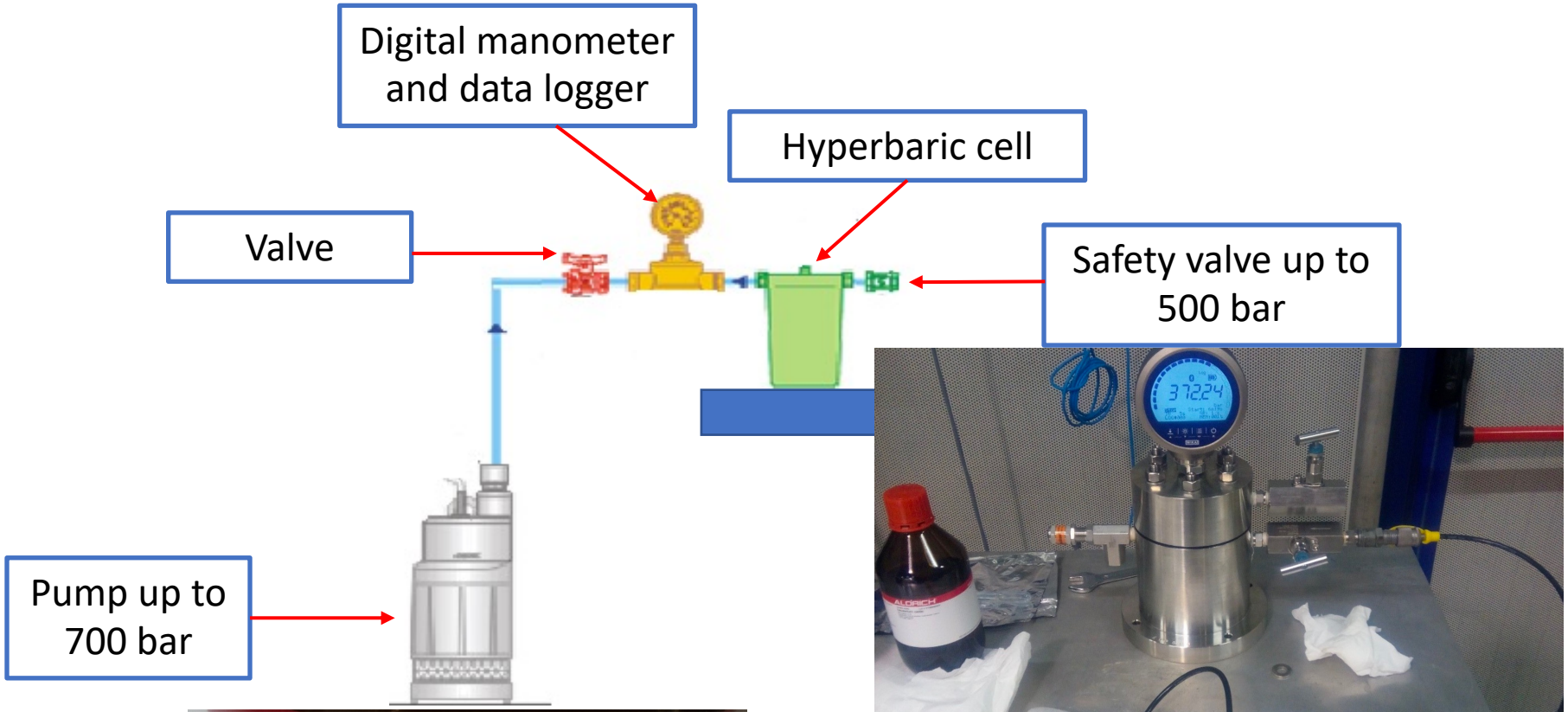

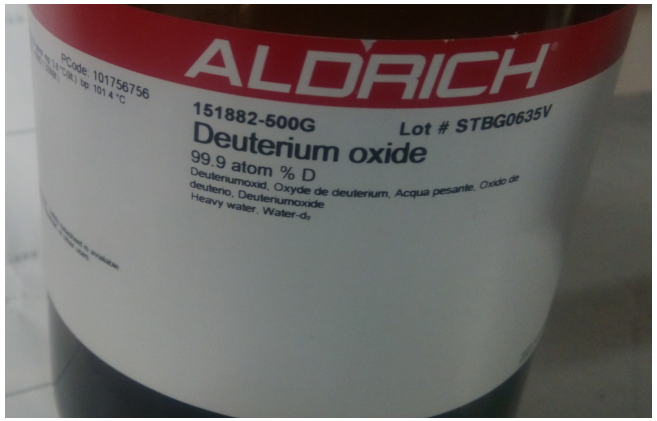

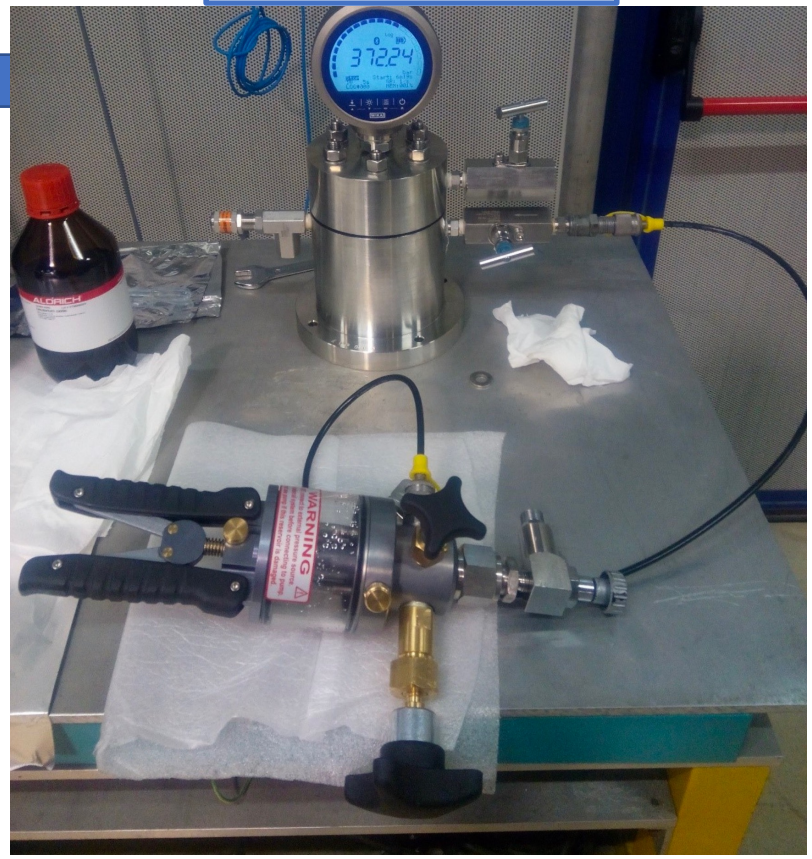

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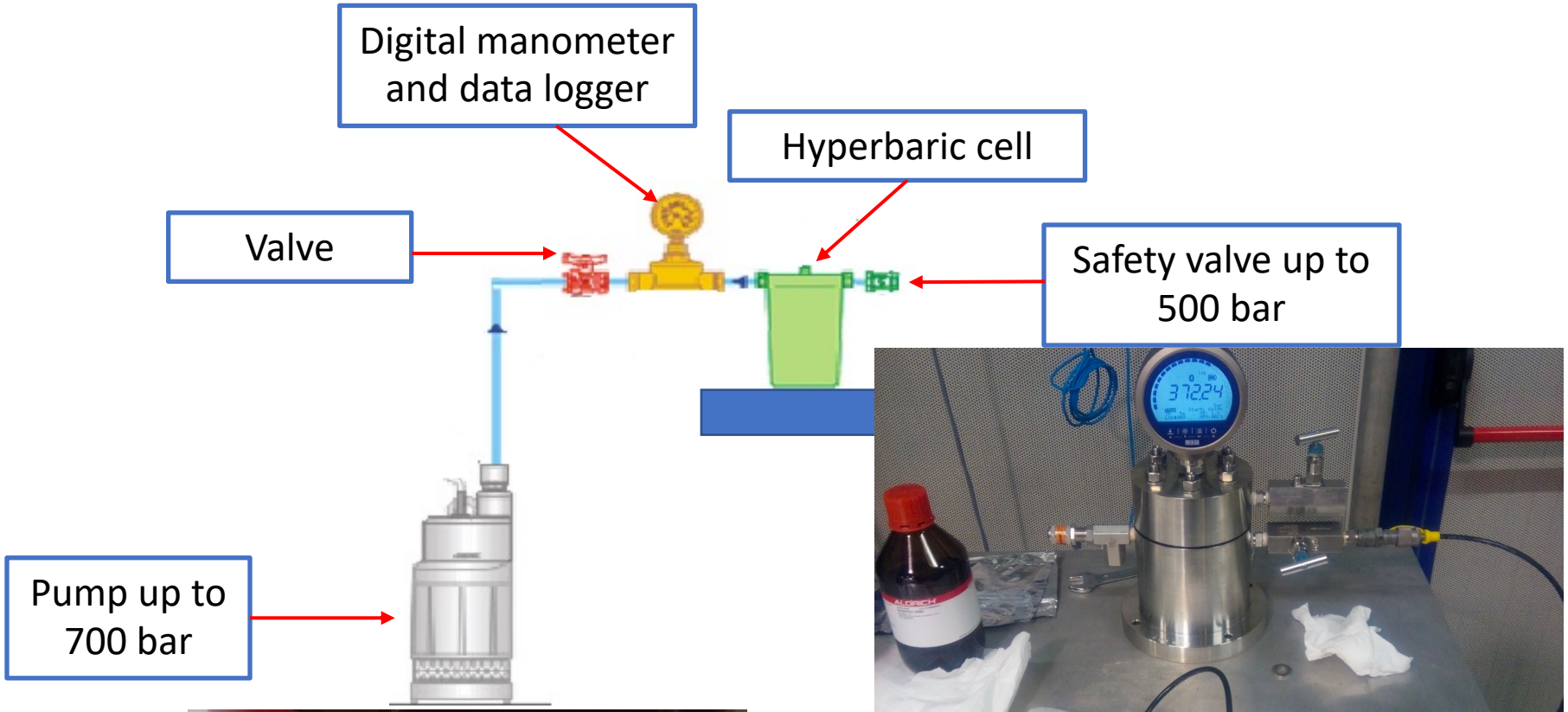
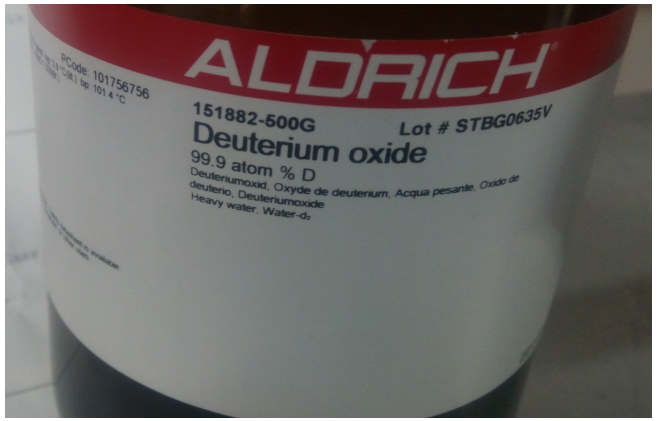
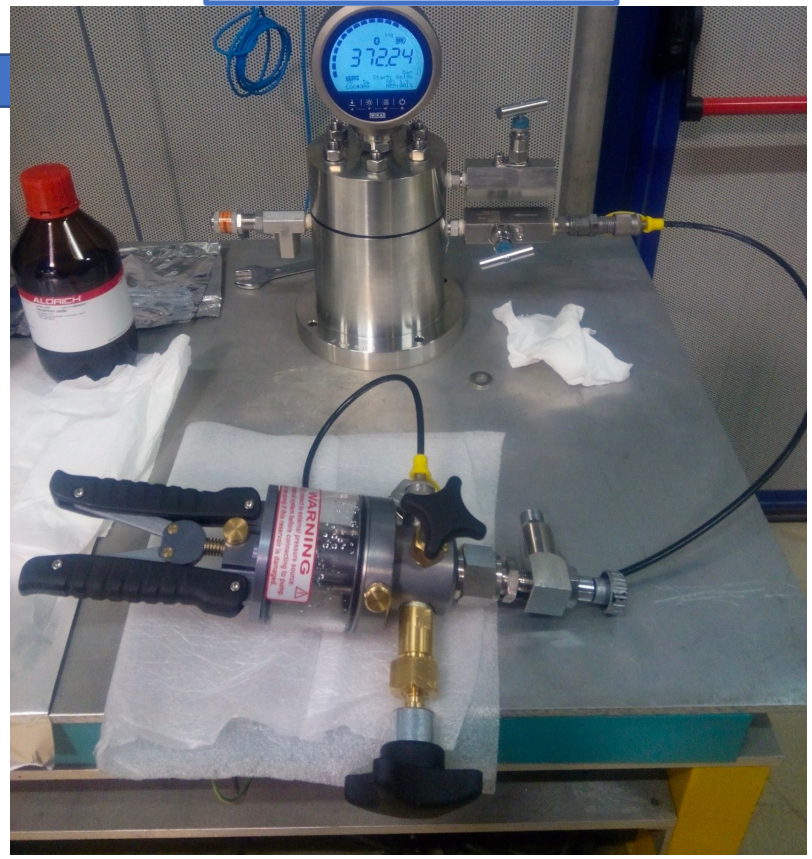
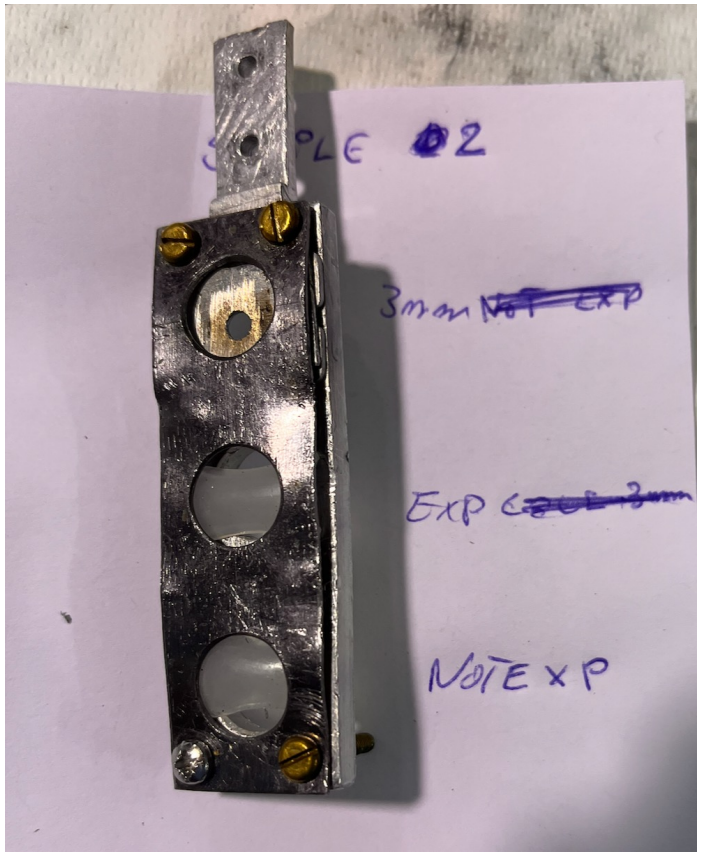
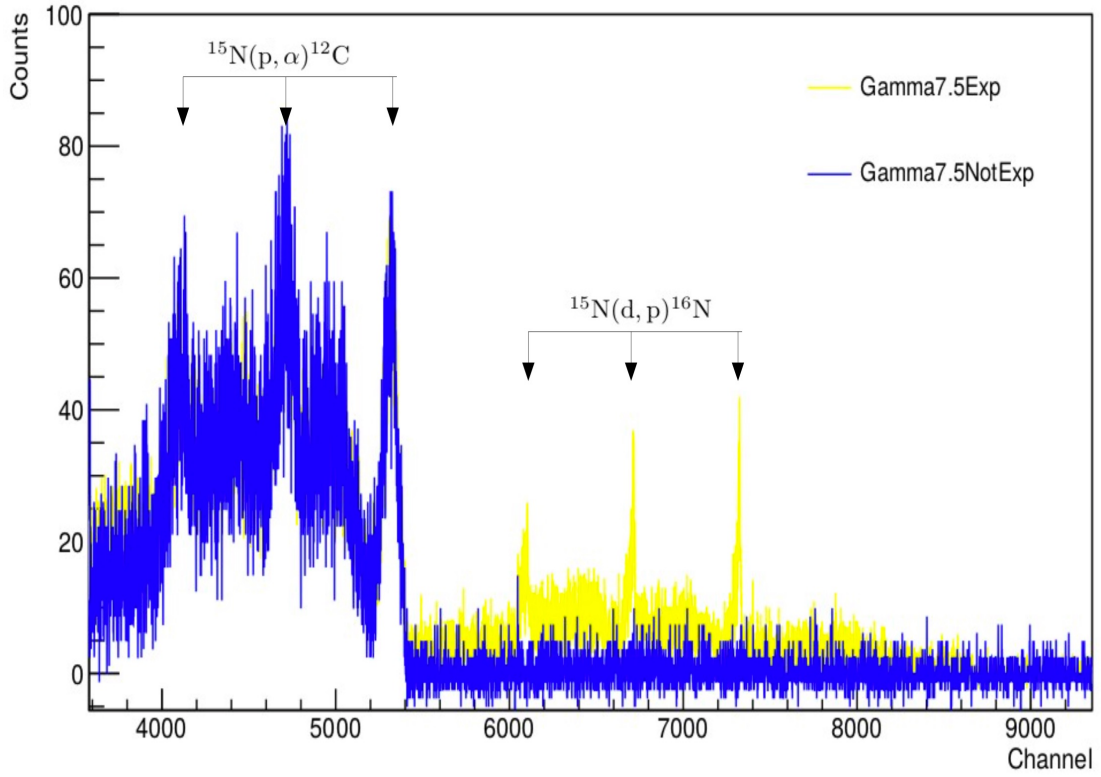




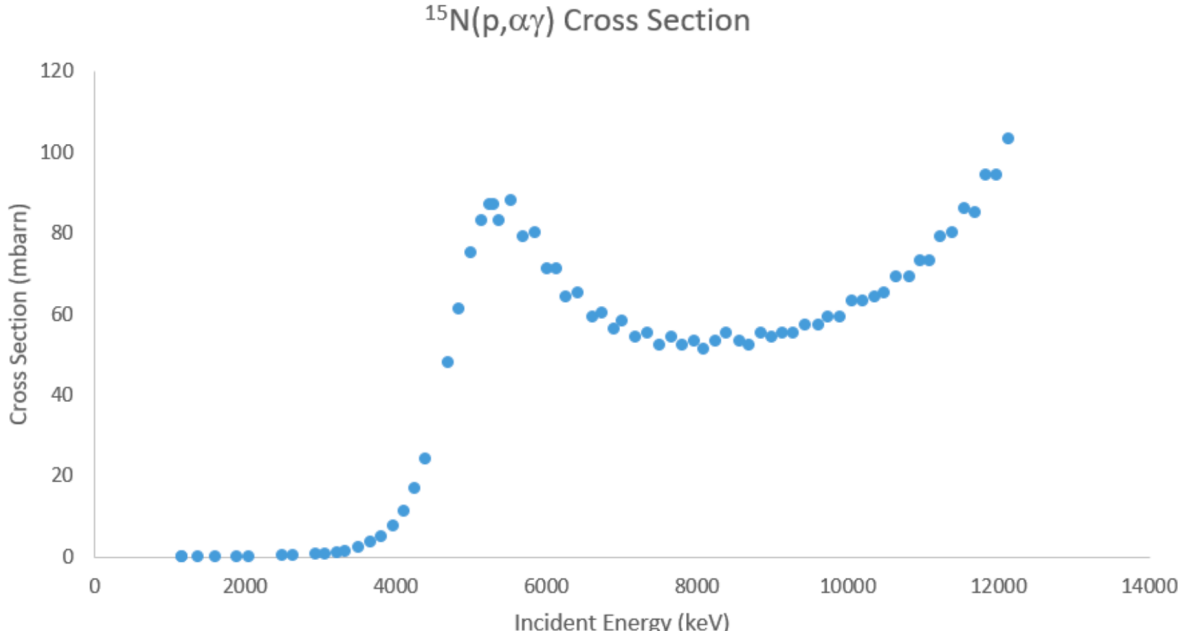


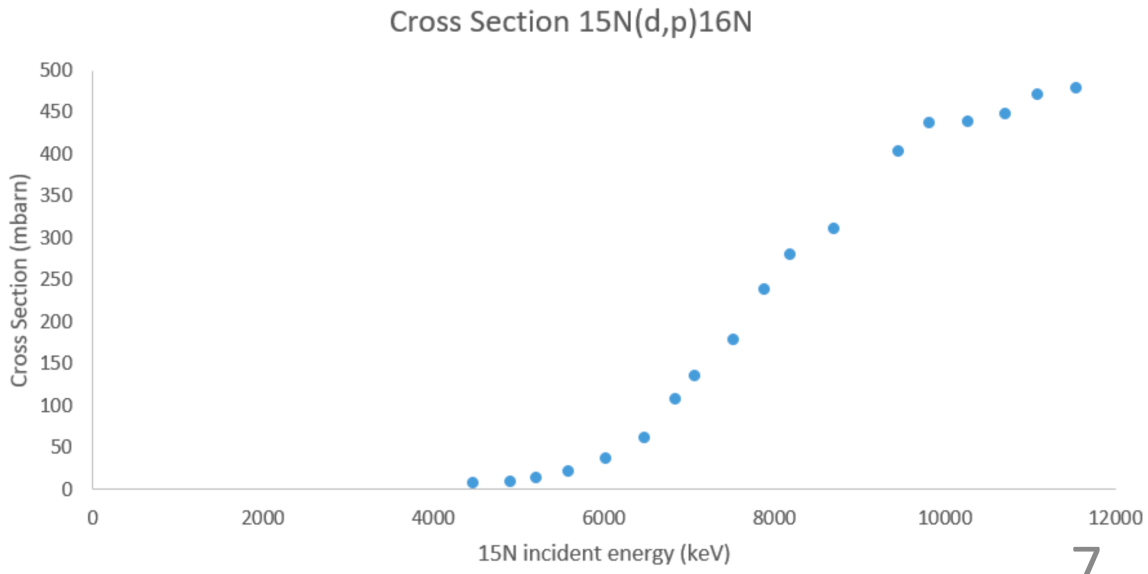


NRA measurements



VEOC measurement with Ge Detector





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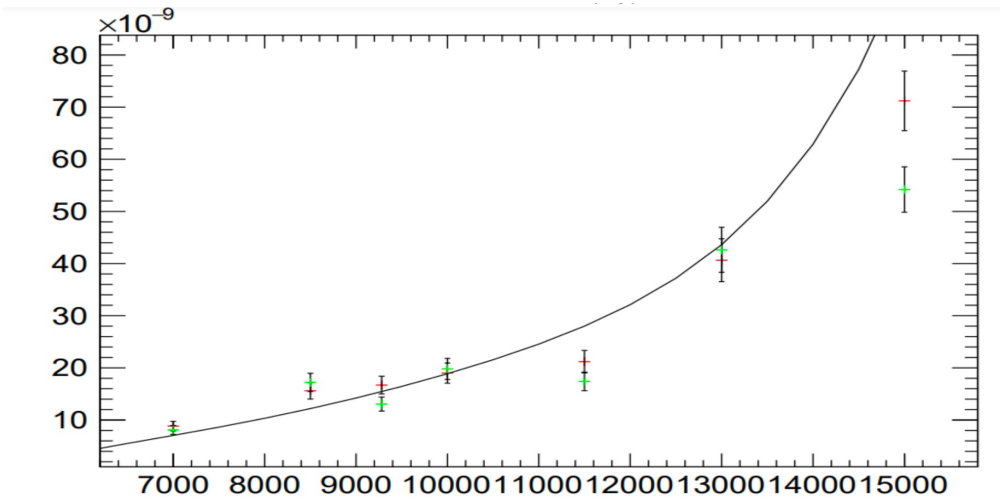
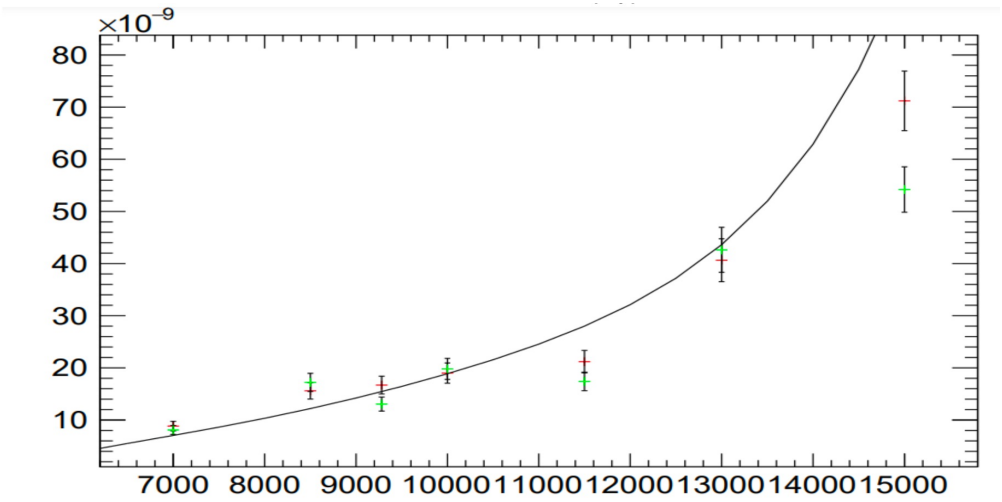


Figure 1. Hydrogen yield from **15N(p,a)** used for normalization pourpose.

NRA measurements



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$$Y(E) = \int_{E_{lab}-\Delta E_{lab}}^{E_{lab}} \frac{\sigma(E_{lab})}{-\frac{1}{N_d \cdot \rho(x(E))} \frac{dE_{lab}}{dx}(E)} dE$$

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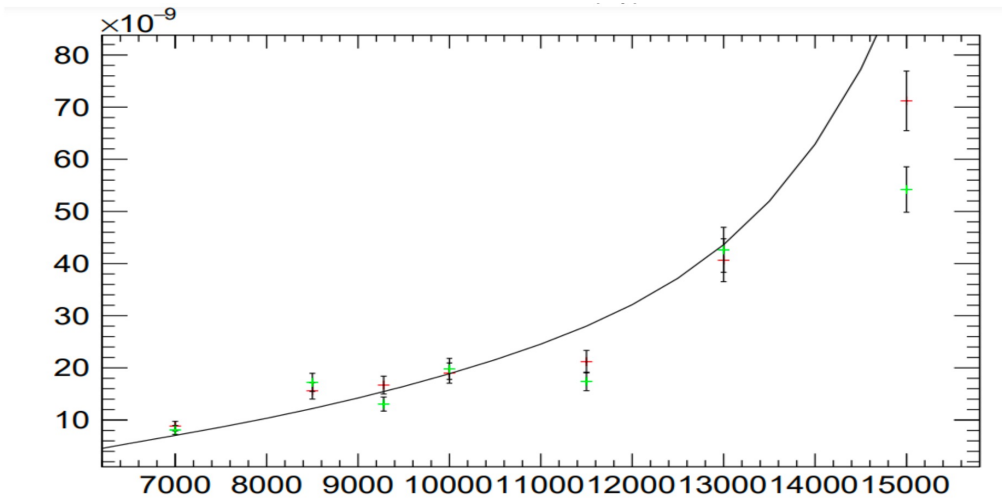

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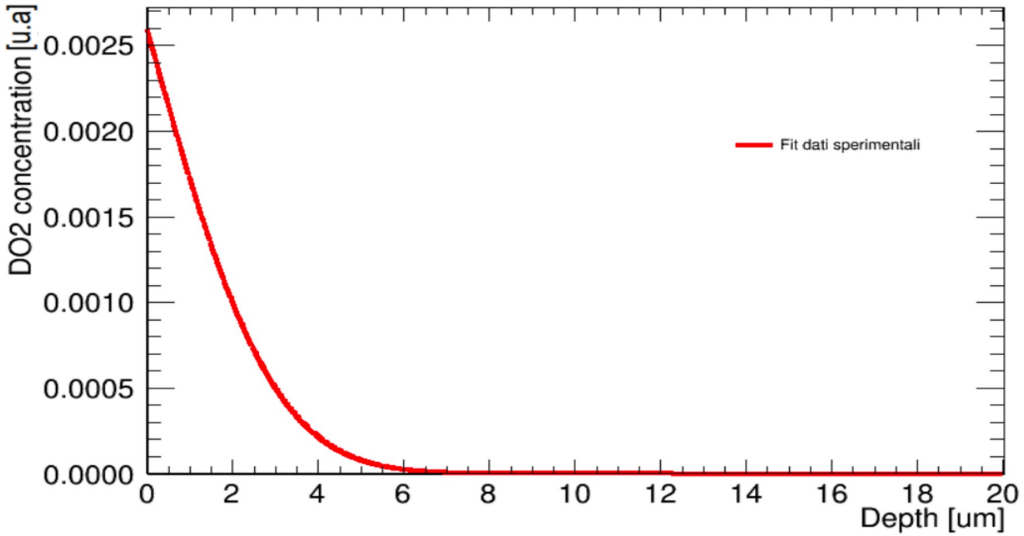

Figure 3. D2O Simulated penetration profile in the LDPE sample.

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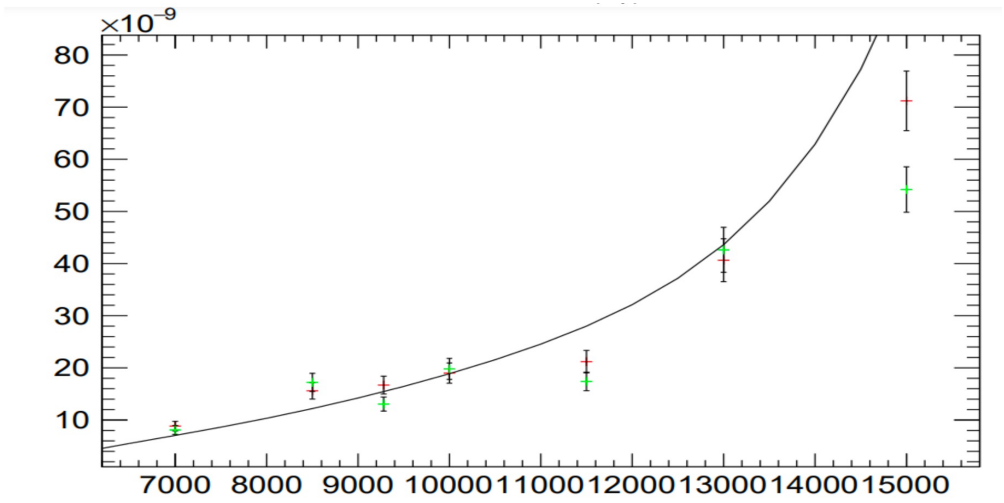

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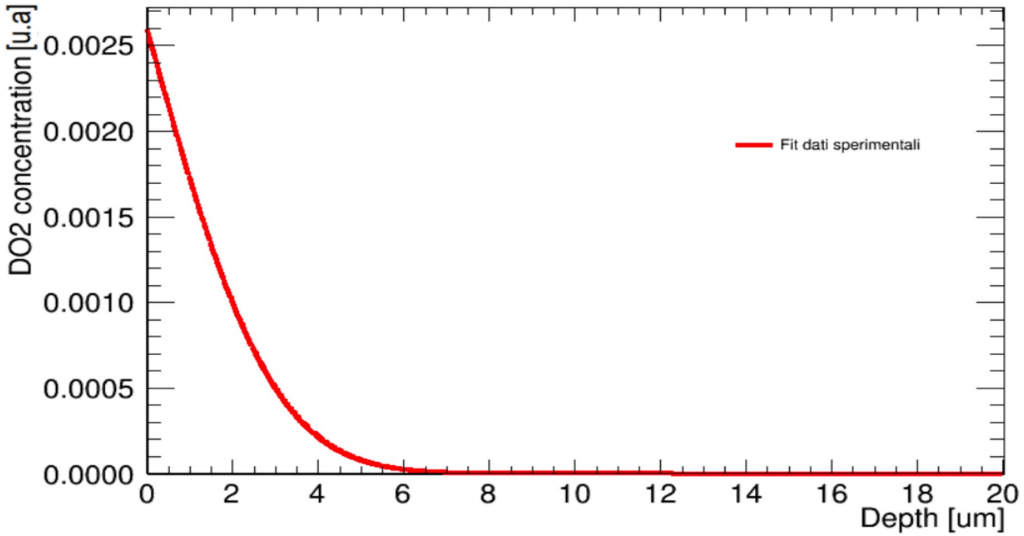

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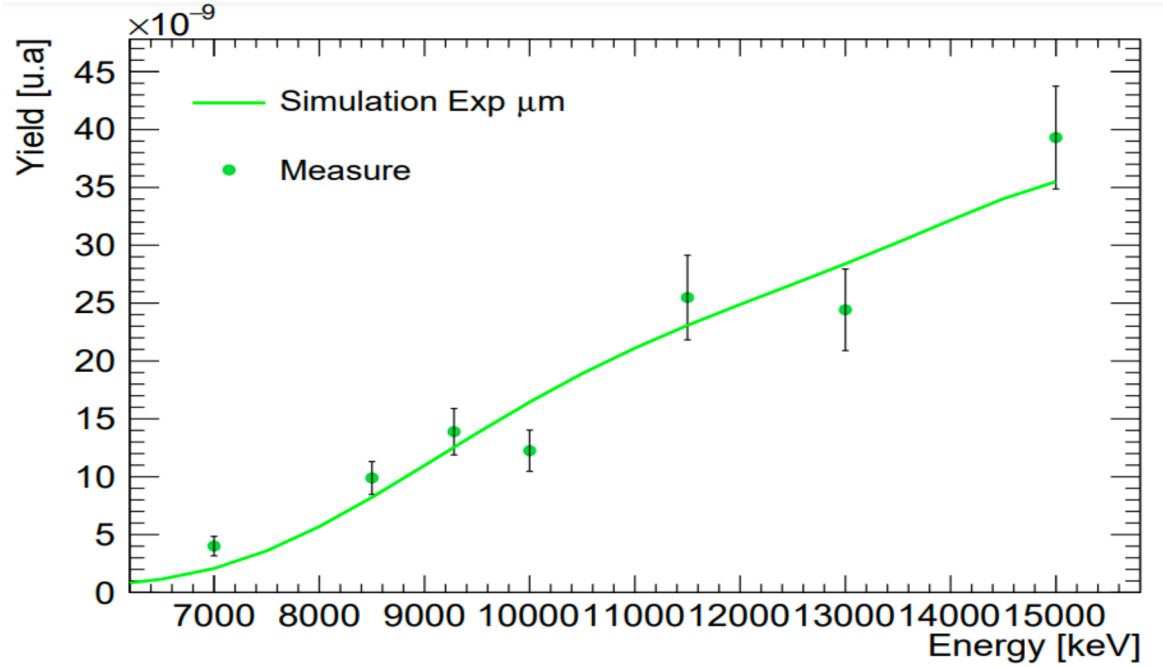
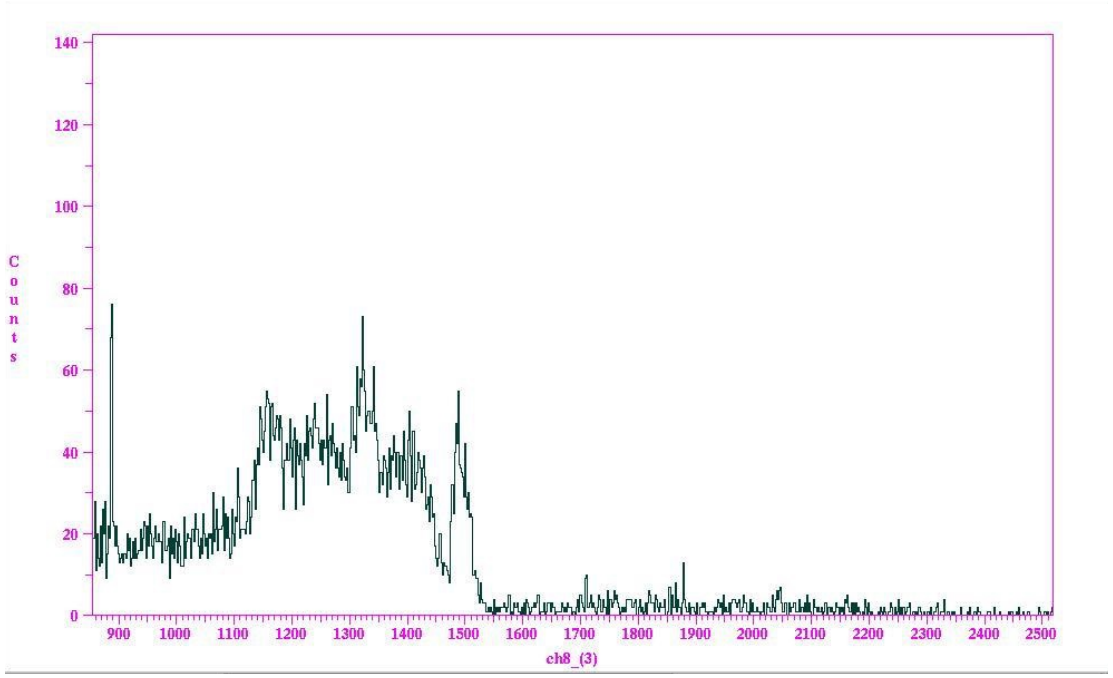


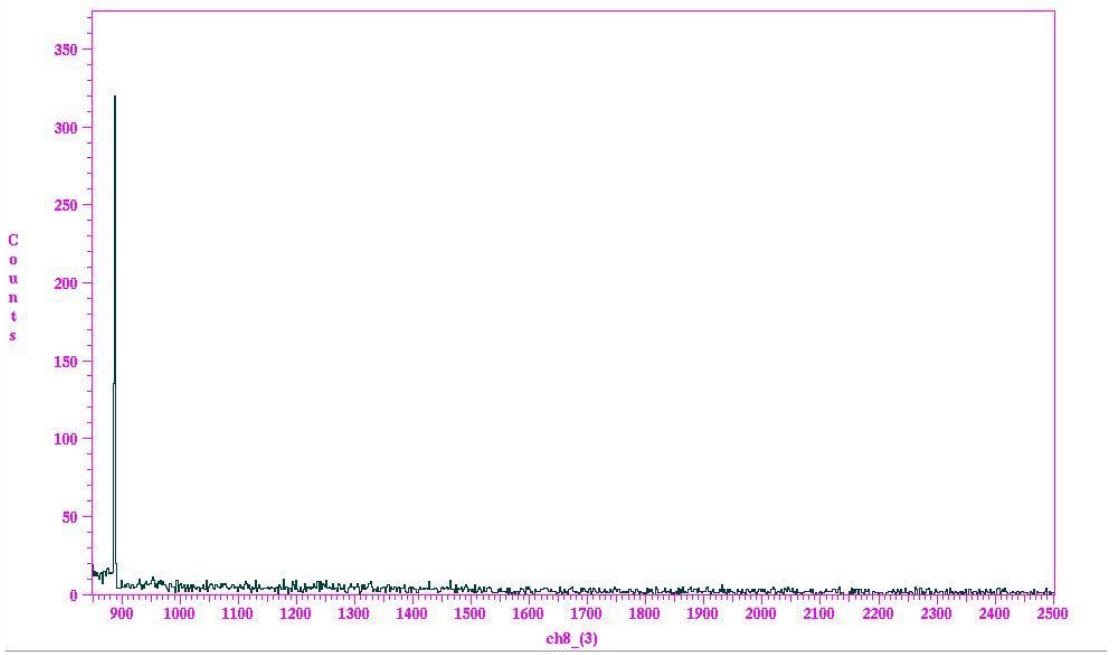
Figure 2. Normalized data and simulated yield curve obtained considering the profile of D2O showed in the figure 3.

NRA measurements

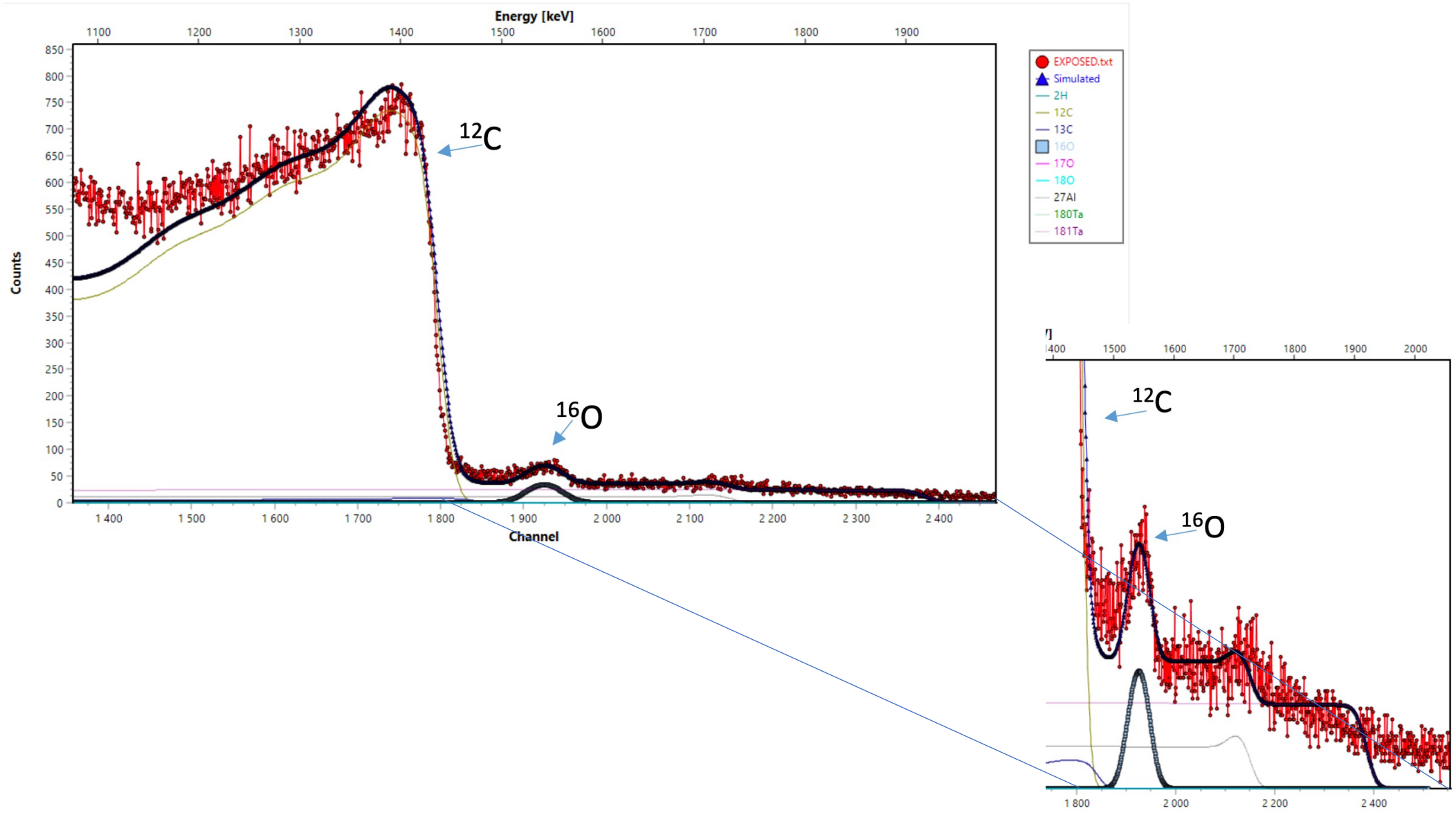
Bob plastic (KM3Net)
Run time 900 s



Glass (KM3Net)
Runtime 4320 s



RBS measurements



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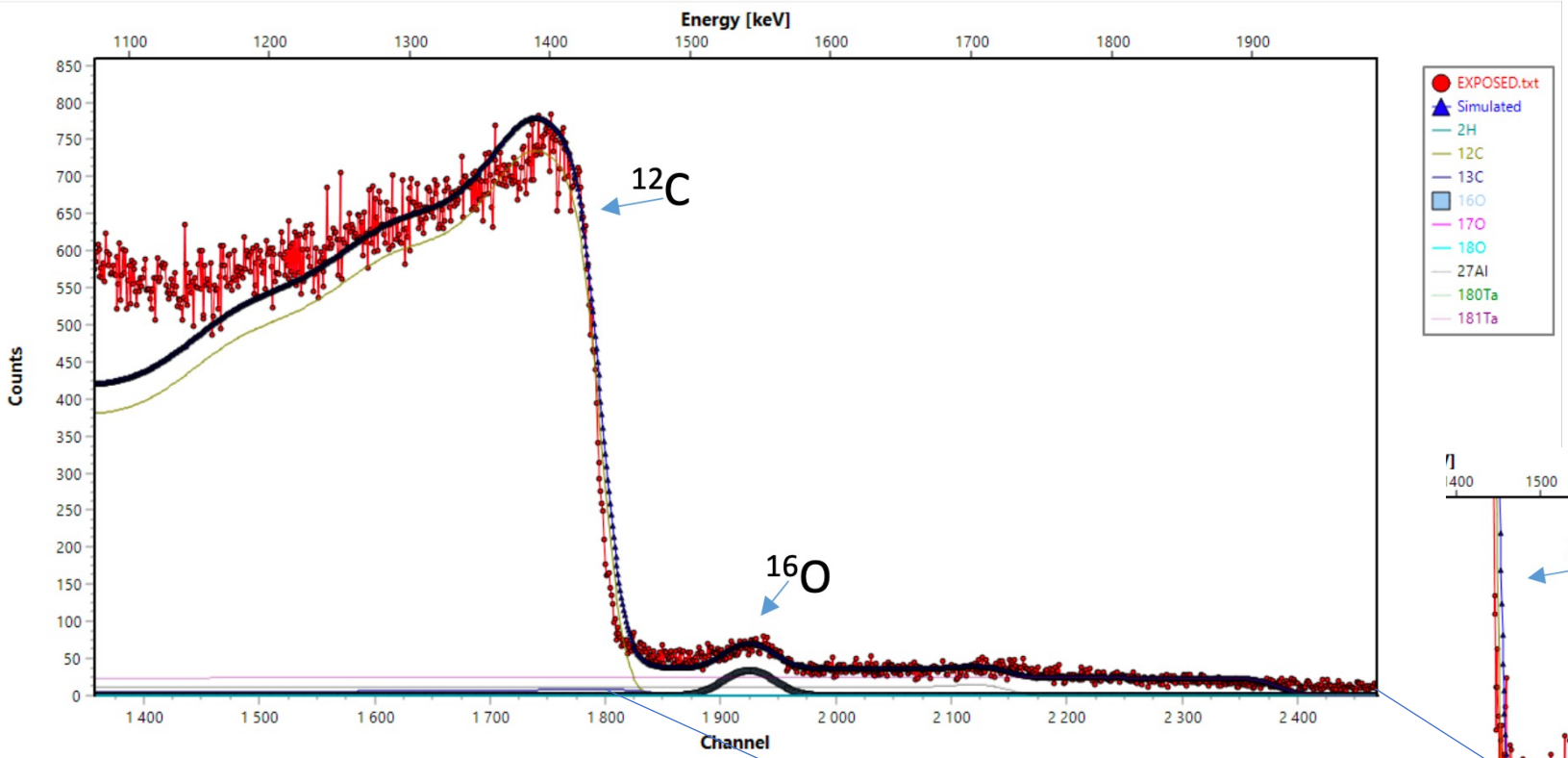

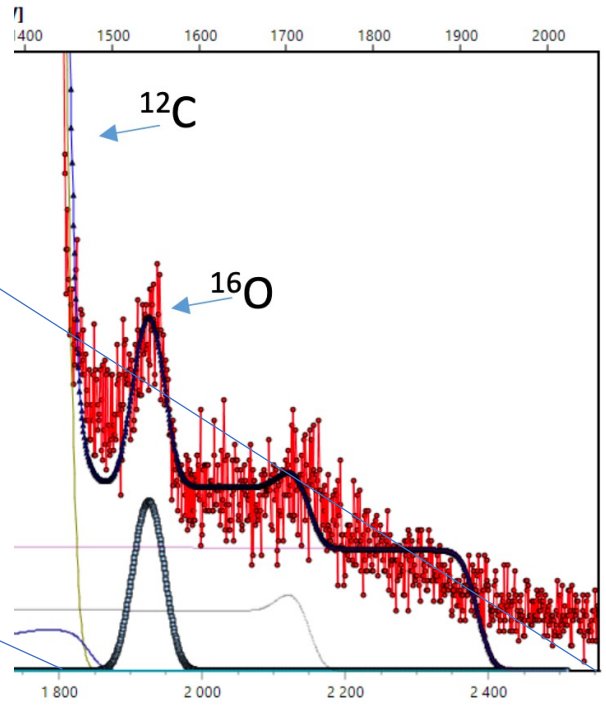

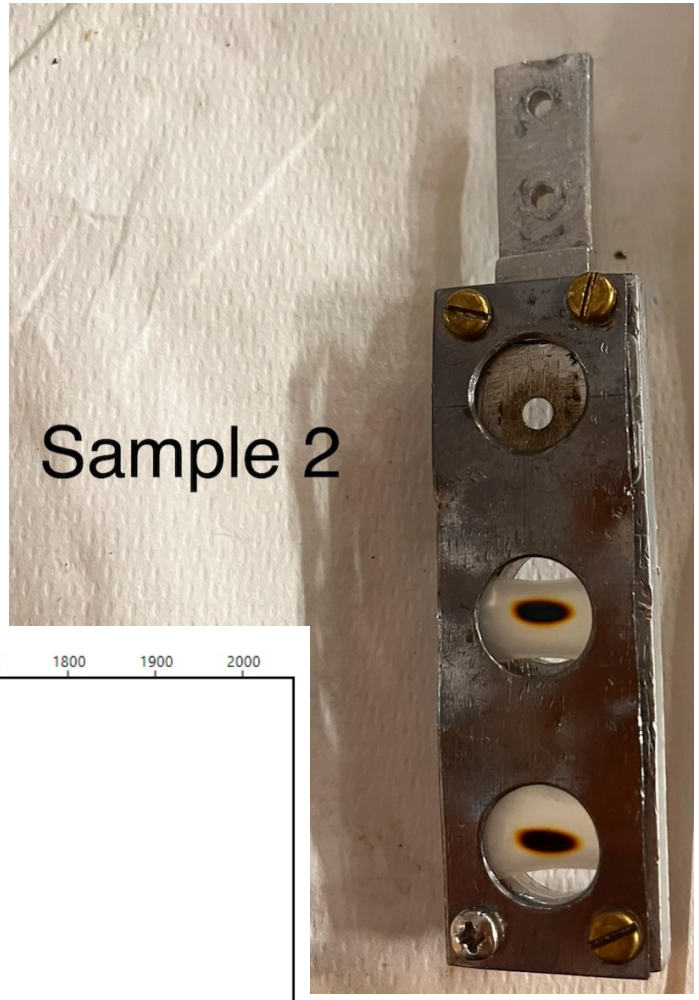

IBA conclusions and outlooks

- ✓ Preliminary results show time to reach the VEOC inner wall >> 20 years

- Investigate on outgassing rate when under vacuum
- Investigate dependence on exposure time, pressure and temperature

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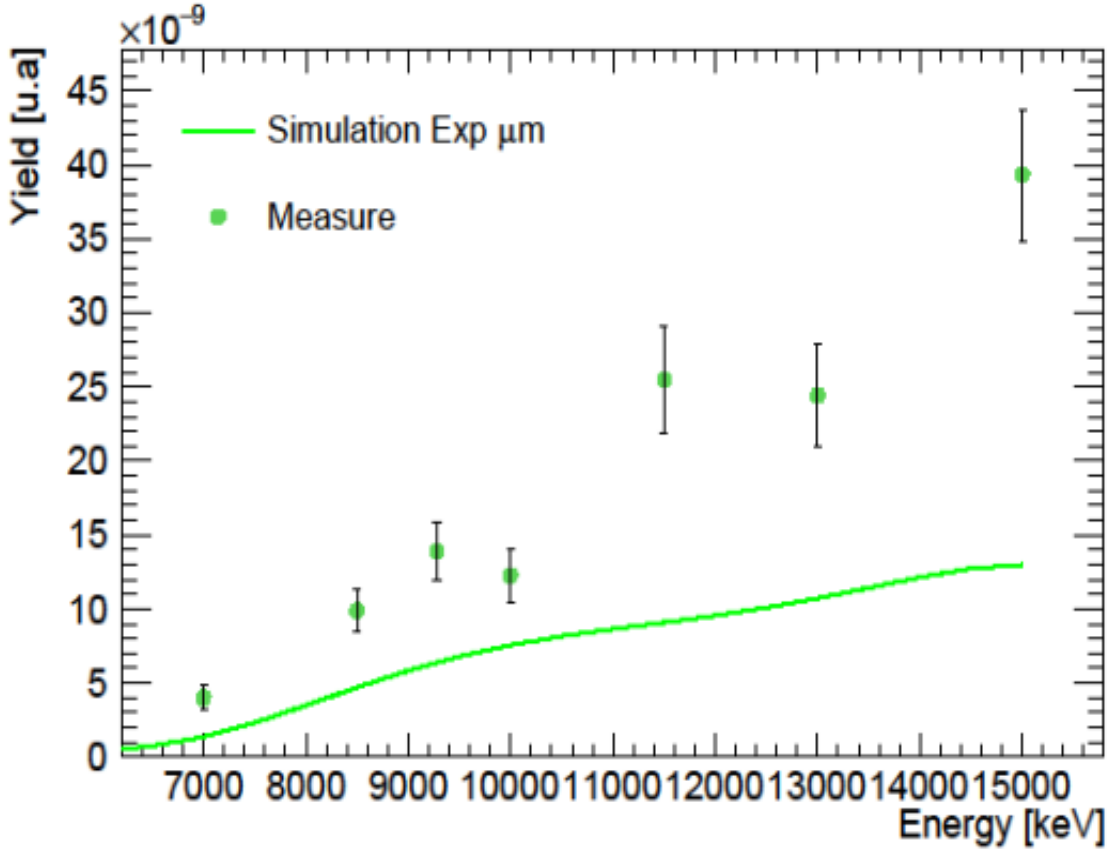
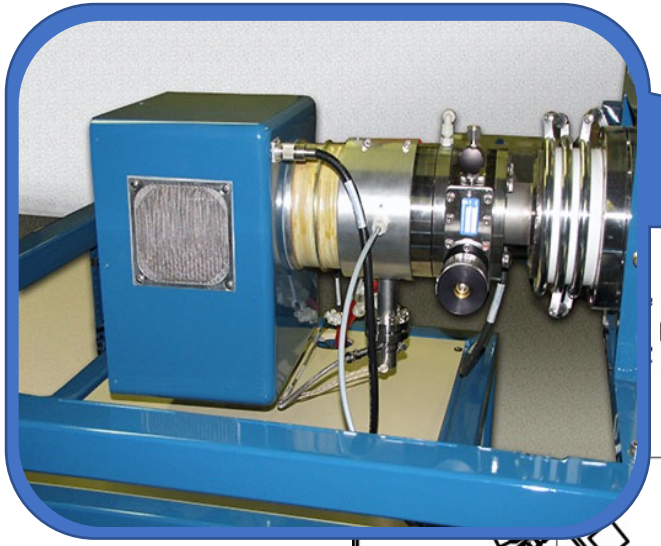
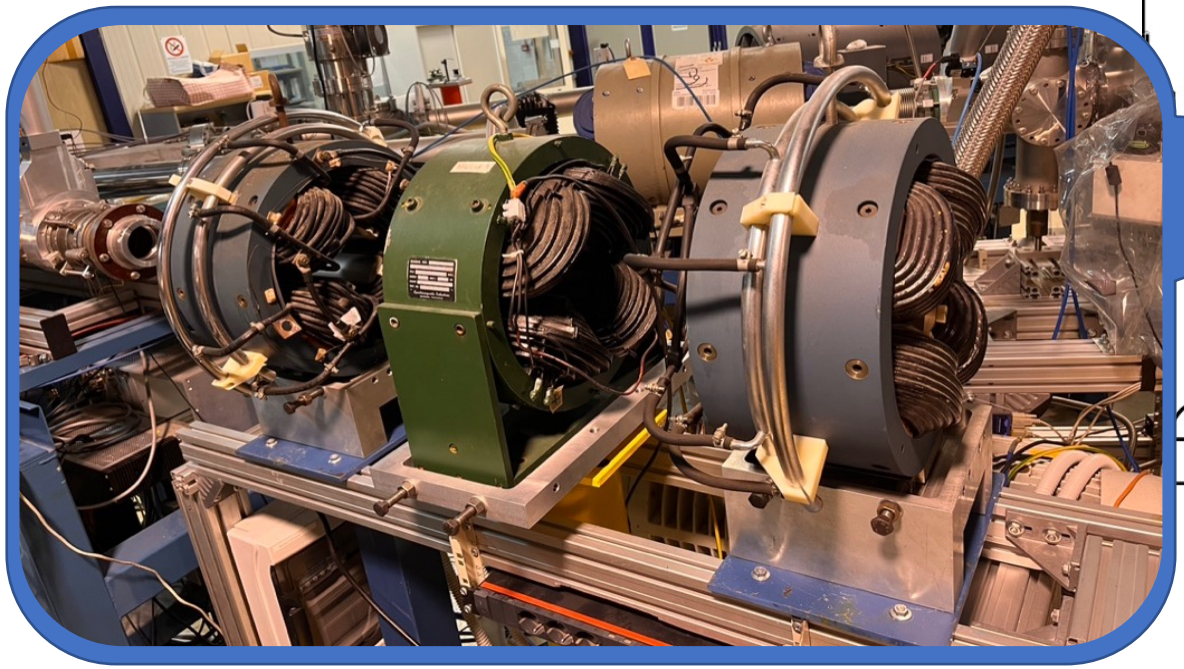
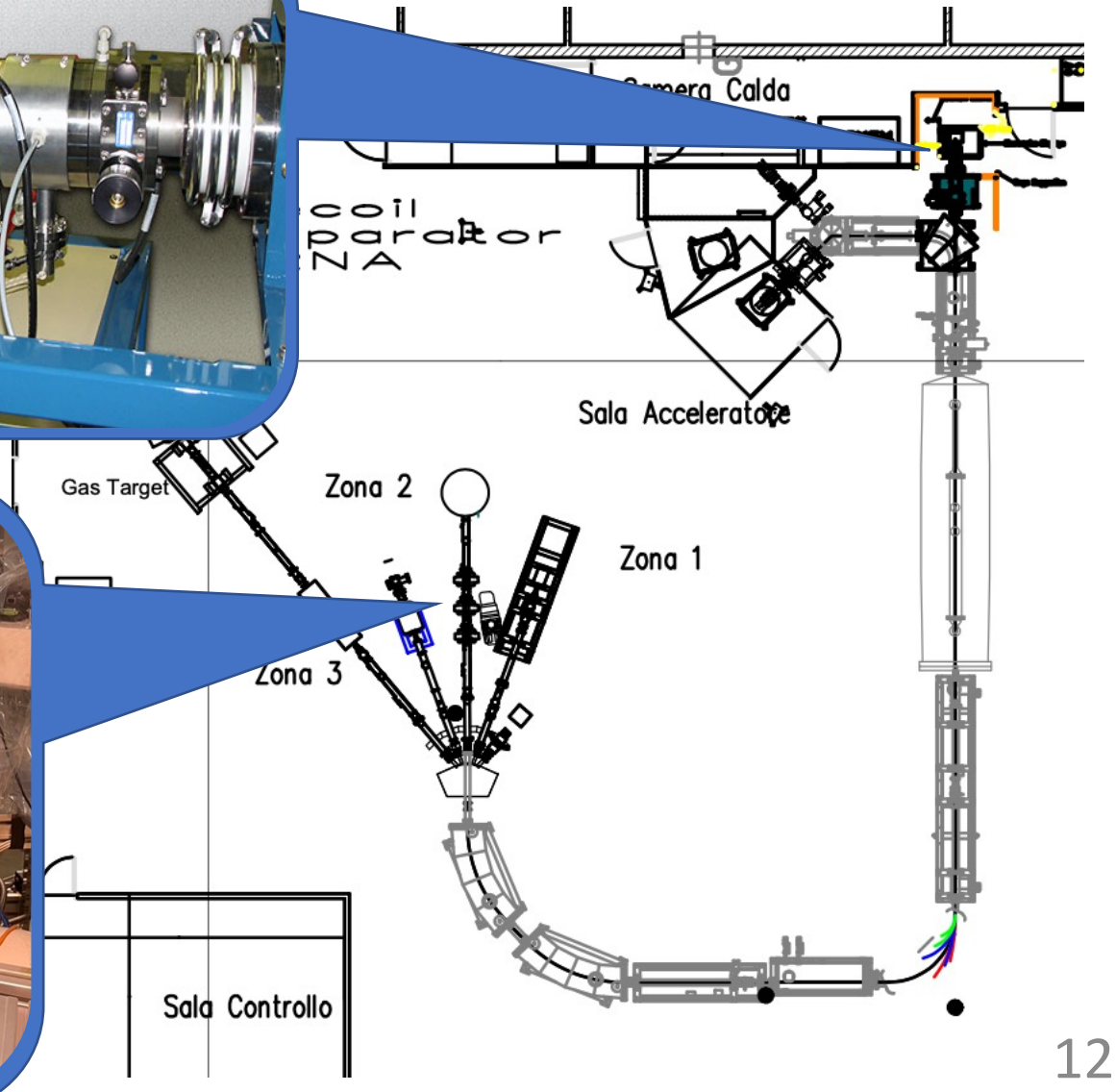


IBA conclusions and outlooks

- Damaging due to beam energy loss
- Background reduction
- $^{3}He(d,p)^{4}He$ cross section is a factor 10 higher than $^{15}N(d,p)^{16}N$





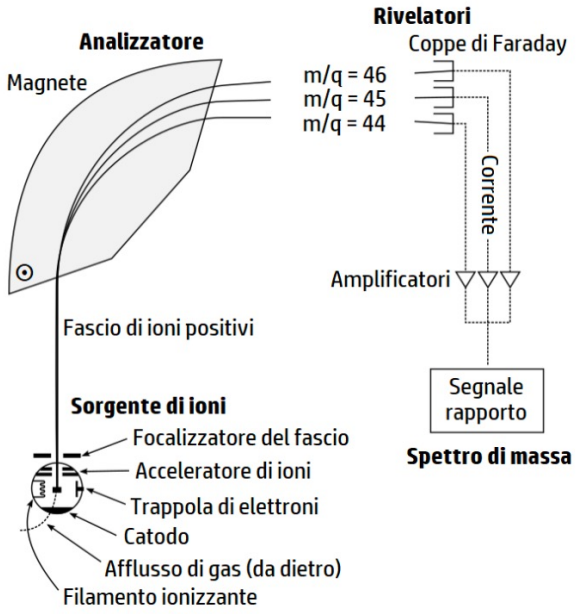


Goals

- Develop new methodologies to predict penetration of water in Km3NET equipments and test new materials. *(Ion Beam Analysis [IBA])*

- Quality Check during production phase *(Isotope Ratio Mass Spectrometry [IRMS])*

Isotope Ratio Mass Spectrometry

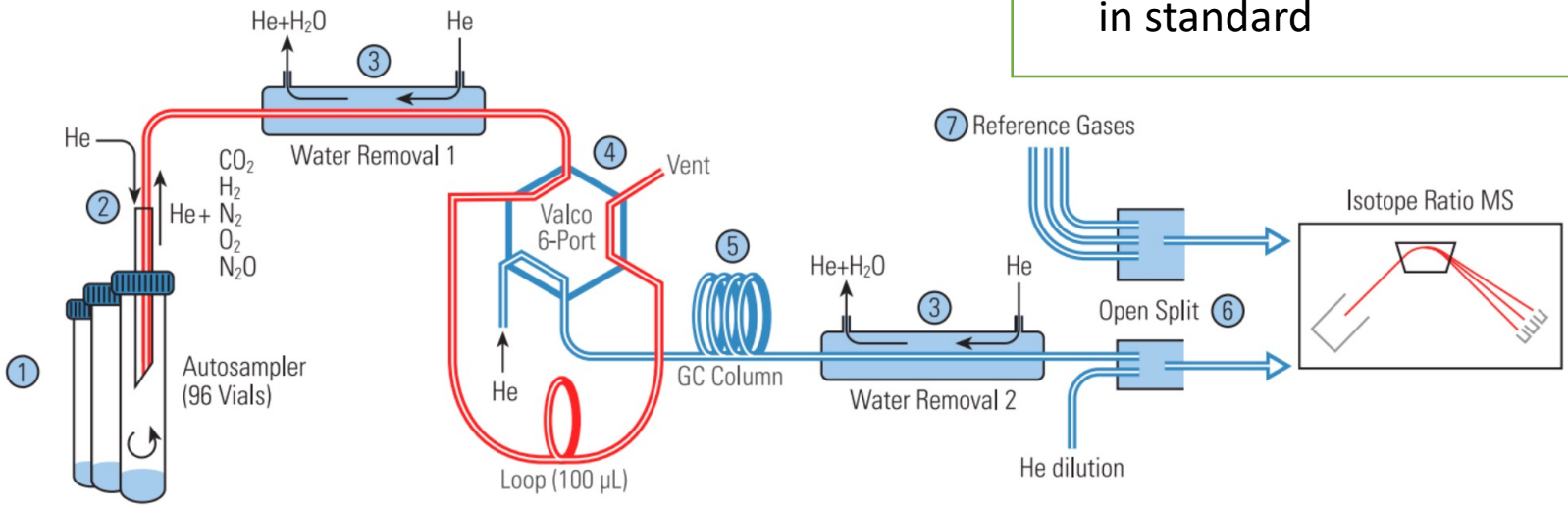


Nomenclature

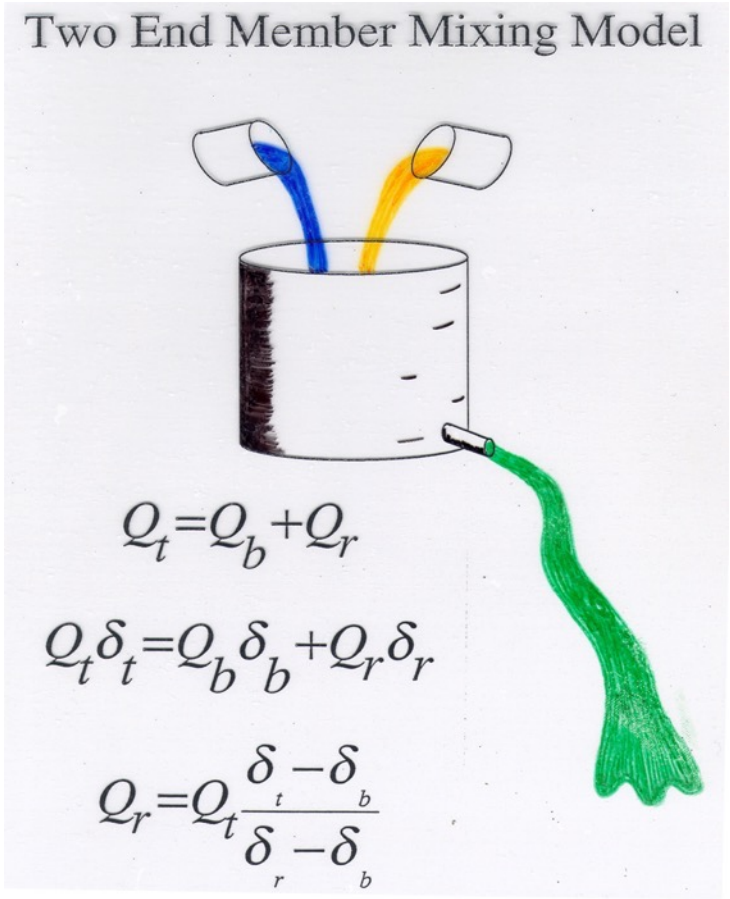
Isotopic Ratio $${}^{13}R = \frac{[{}^{13}C]}{[{}^{12}C]}$$

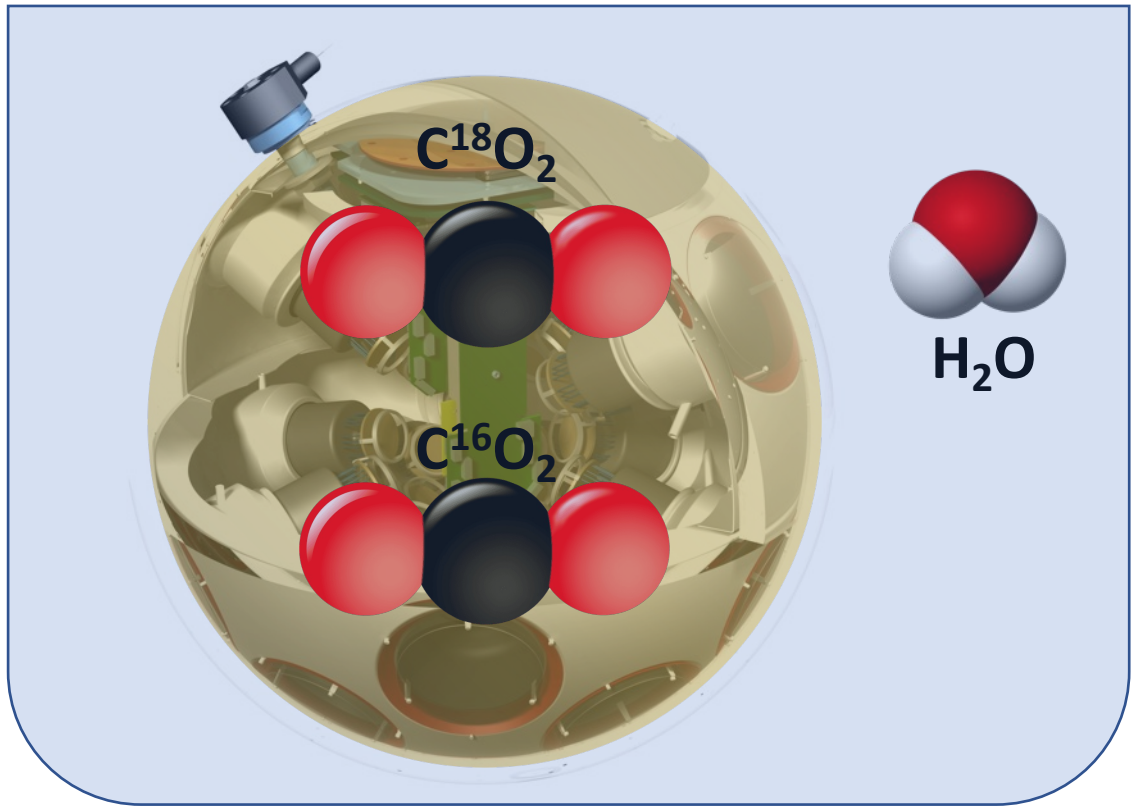
Isotopic delta $$\delta = \left(\frac{R_x}{R_{std}} - 1 \right) \times 1000$$

e.g. $\delta^{18}O$=19.7‰ --> $^{18}O/^{16}O$ is 1.97 % higher than in standard



Infiltration rate by delta ^{18}O measurements



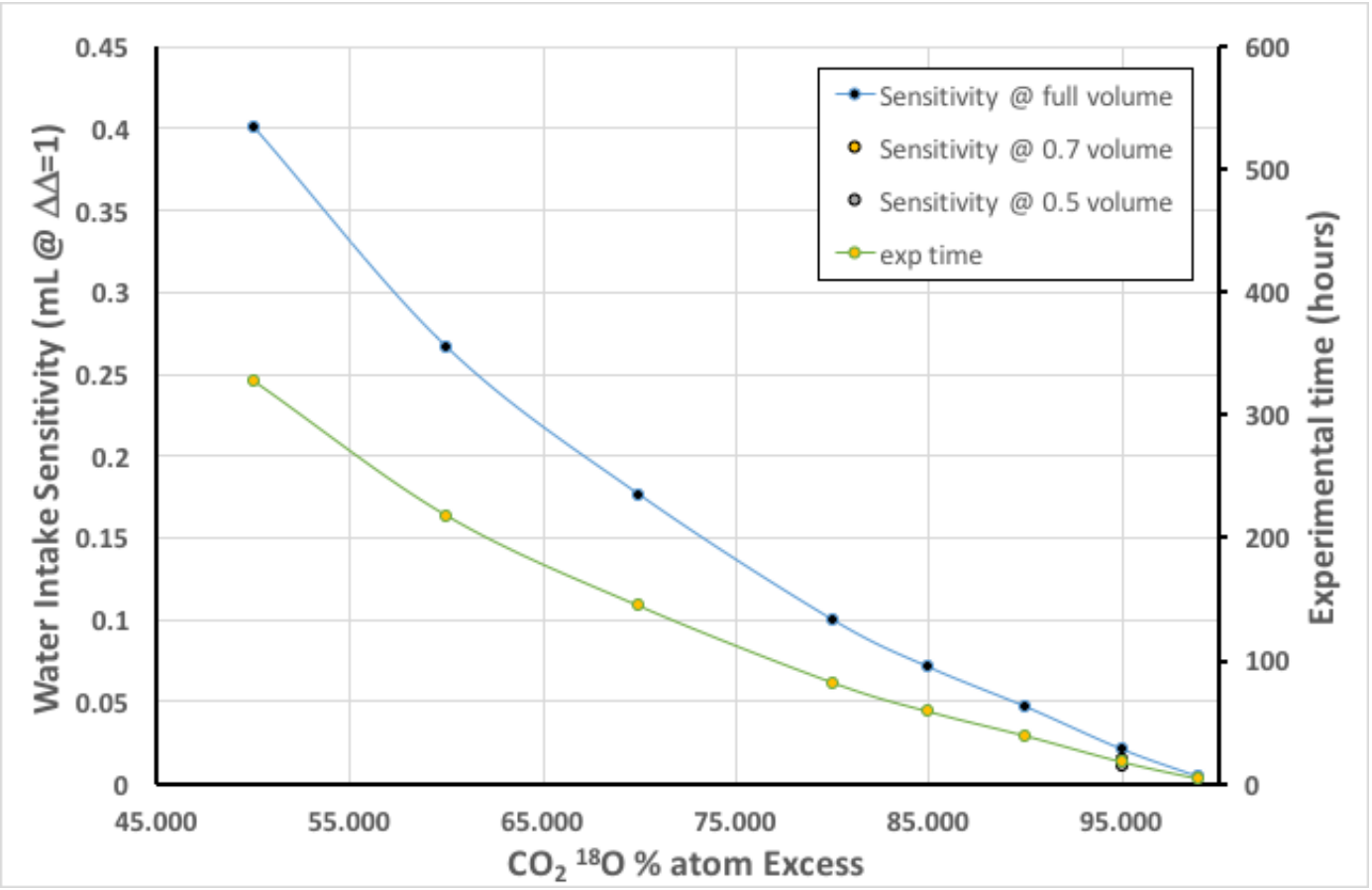


$$H_2O + CO_2 \leftrightarrows H_2CO_3$$

Isotopic Exchange Reaction

$$H_2^{16}O + C^{18}O_2 \leftrightarrows H_2^{18}O + C^{18}O_2$$

Infiltration rate by delta ^{18}O measurements

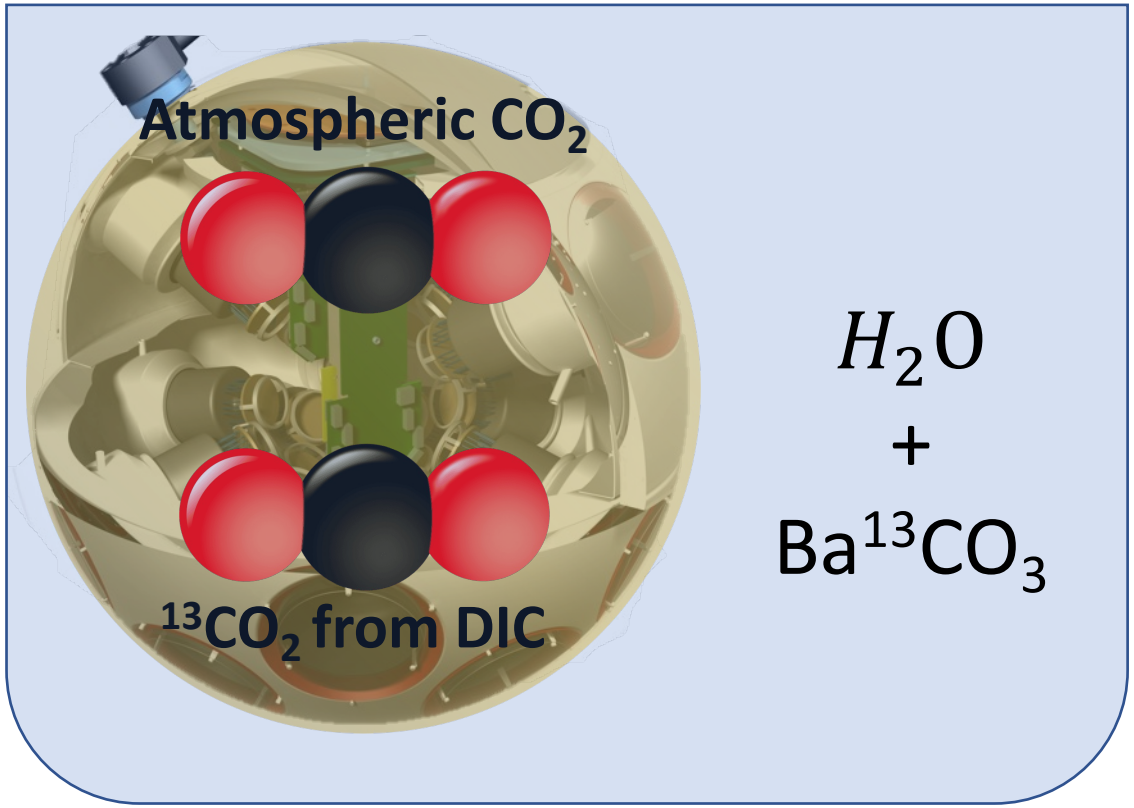


Sensitivity is enough but

- Need for specific DOM preparation
- Expensive spiked $C^{18}O_2$

Isotope Ratio Mass Spectrometry

Dissolved Inorganic Carbon



What we measure: ^{45}R

$$CO_2(g) + H_2O \rightleftarrows CO_2(aq) + H_2O$$

$$CO_2(aq) + H_2O \rightleftarrows H_2CO_3$$

$$H_2CO_3 \rightleftarrows H^+ + HCO_3^-$$

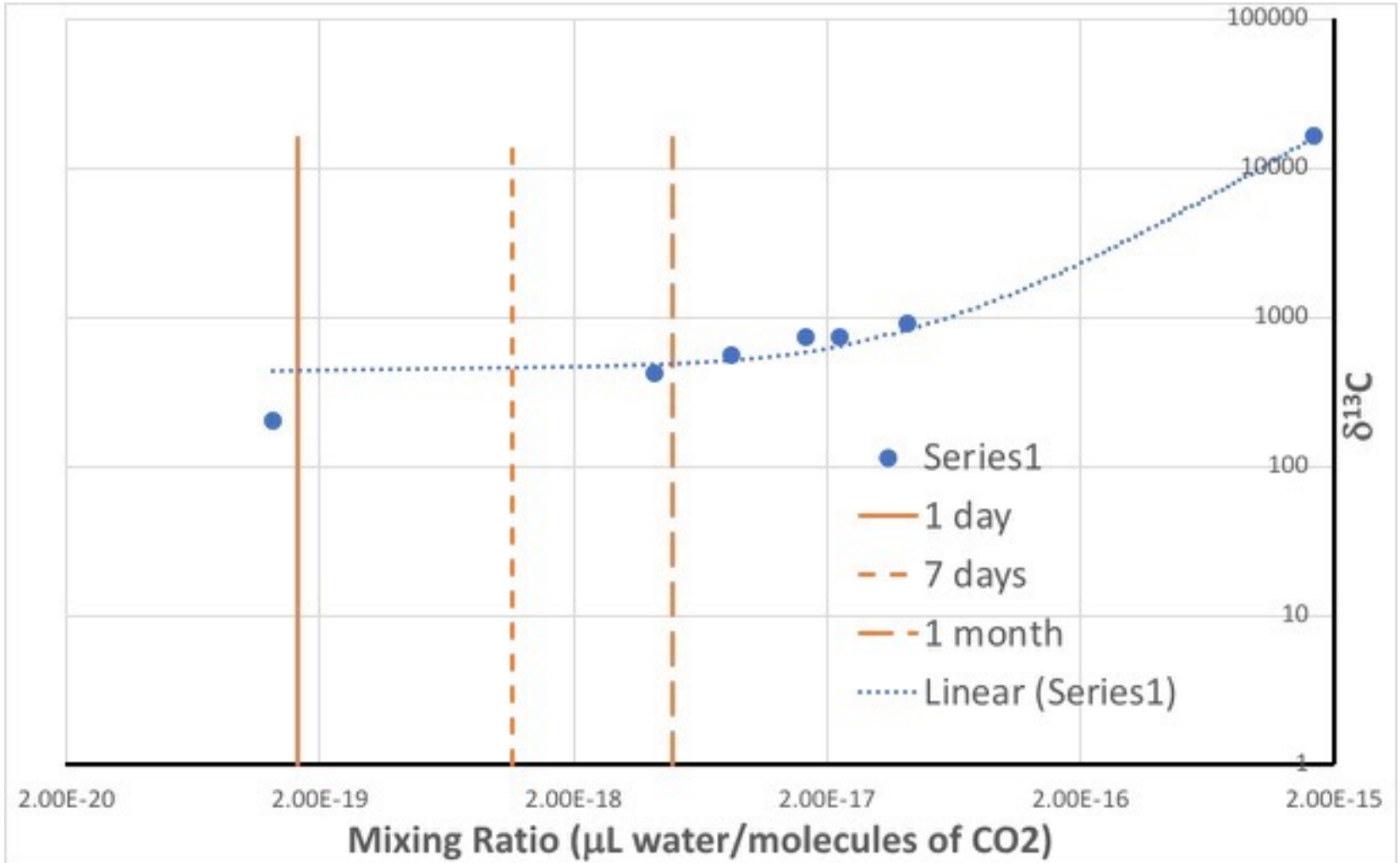
$$HCO_3^- \rightleftarrows H^+ + CO_3^{-2}$$

$$CO_3^{-2} + Ba^{+2} \rightleftarrows BaCO_3$$

Spiked with ^{13}C

Isotope Ratio Mass Spectrometry

Produced a solution of MILLIQ WATER 50 mL with 56 mg of $Ba^{13}CO_3$ ^{13}C 99%.



Isotope Ratio Mass Spectrometry

$$\frac{\delta_X(t) - \delta_X^{eq}}{\delta_X^i - \delta_X^{eq}} = e^{-kt}$$

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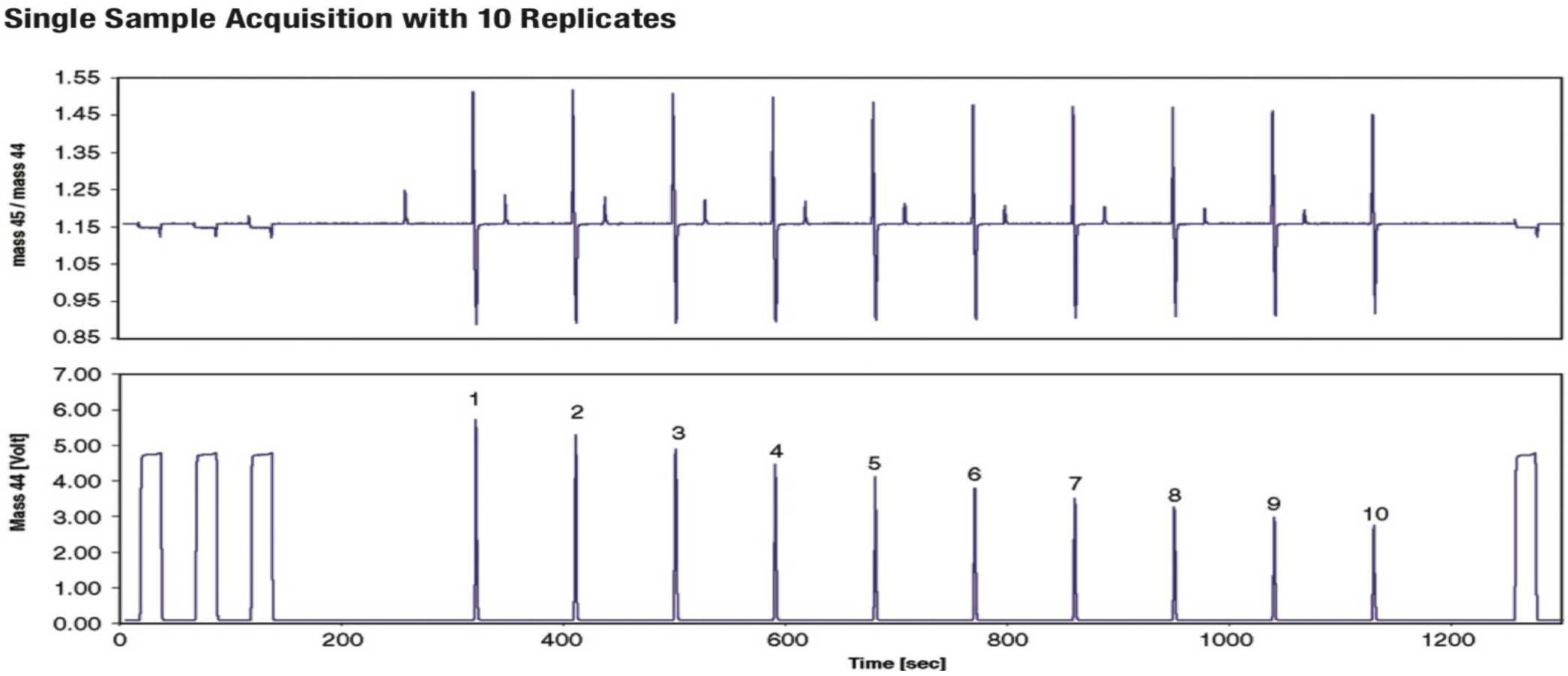

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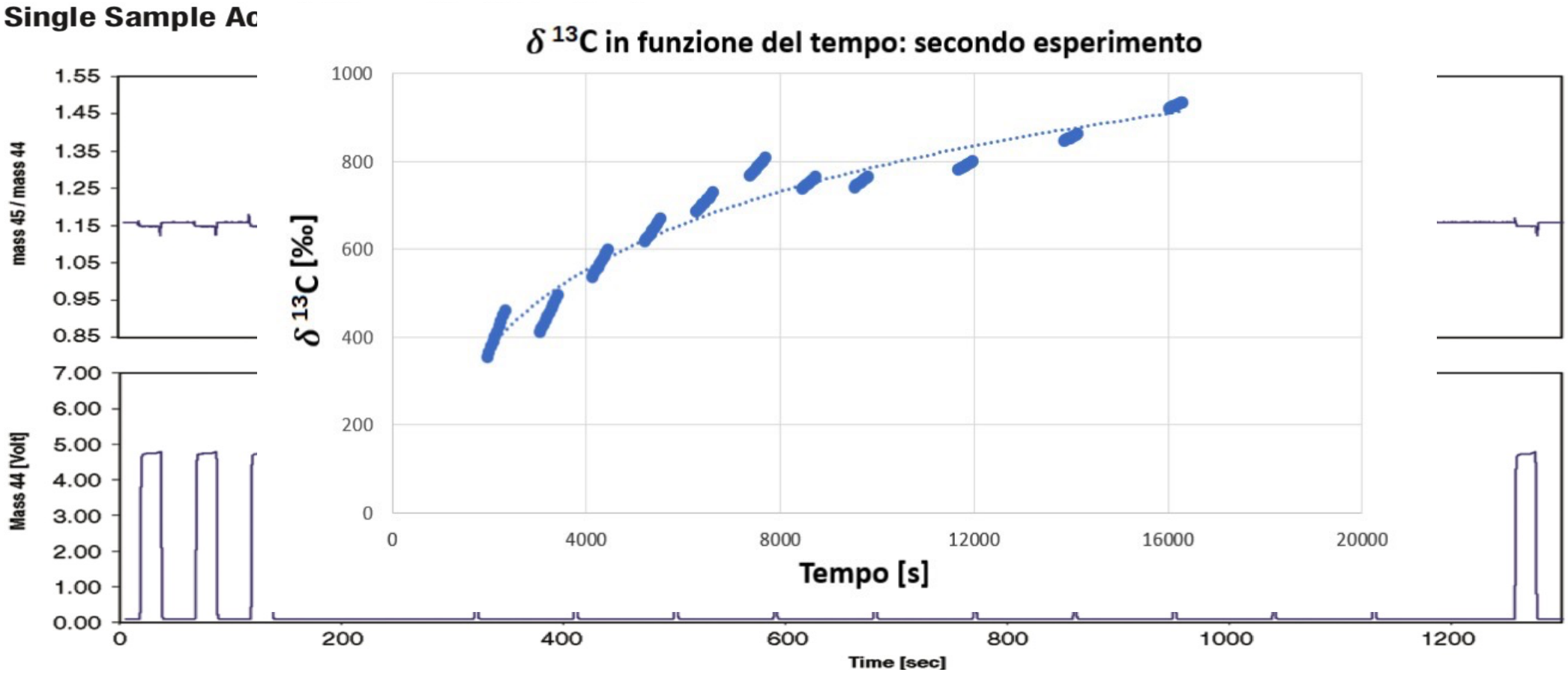

Isotope Ratio Mass Spectrometry

Is it feasible with MIDEL 7131 Oil too?

	$\delta^{13}C$ (per mil)	unc (per mil)
Oil (15 mL)	29.3	0.6
Air	17.01	0.09
Water Spiked	2562	6
Oil (15 mL) + 10 microL water spiked	43.1	0.4

IRMS conclusions and outlooks

- ✓ The sensitivity achieved in normal laboratory operating conditions is able to go as far as detecting the infiltration of water inside a DOM that had remained under operating conditions (i.e., Relative humidity < 50%) for a period equal to 10 years submerged under the sea with an experimental time of 1 to 7 days.

- Chamber to work on actual DOM will be completed soon
- To obtain sensitivity to detect operating conditions for 20 years we will work in clean room for sapling to prevent influence by atmospheric carbonatic dust (PM10)

Thanks for the attention