ISOLDE Workshop and Users meeting 2011

Nanostructured Calcium Oxide Targets for the Production of Argon Beams

João Pedro Ramos

7th of December 2011

Dr. Thierry Stora

Prof. Ana Senos

Overview

- CaO Targets at ISOLDE:
  - Overview and Issues
- Material Study
  - Characterization Techniques
  - Material Synthesis
  - Reactivity with Air
  - Sintering Kinetics
- ISOLDE Application
  - Target Production
  - Target Handling
  - Target Operation
- Online Tests: Yields
- Future Work

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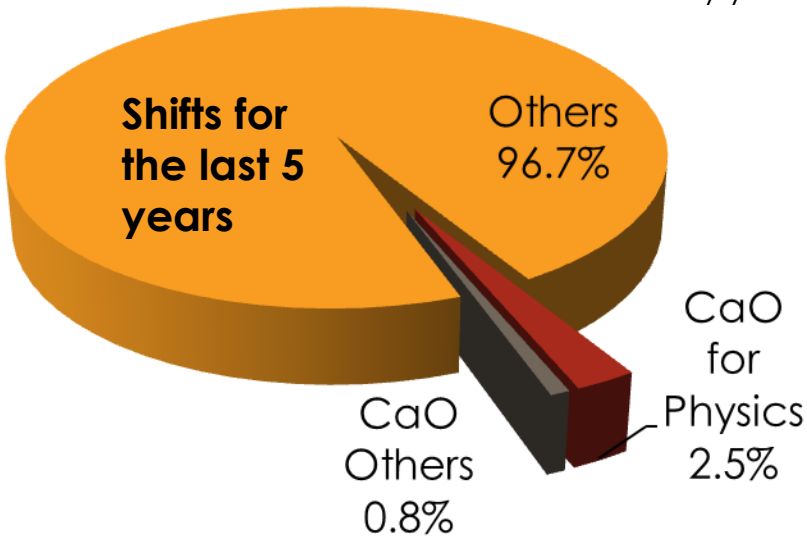
Overview

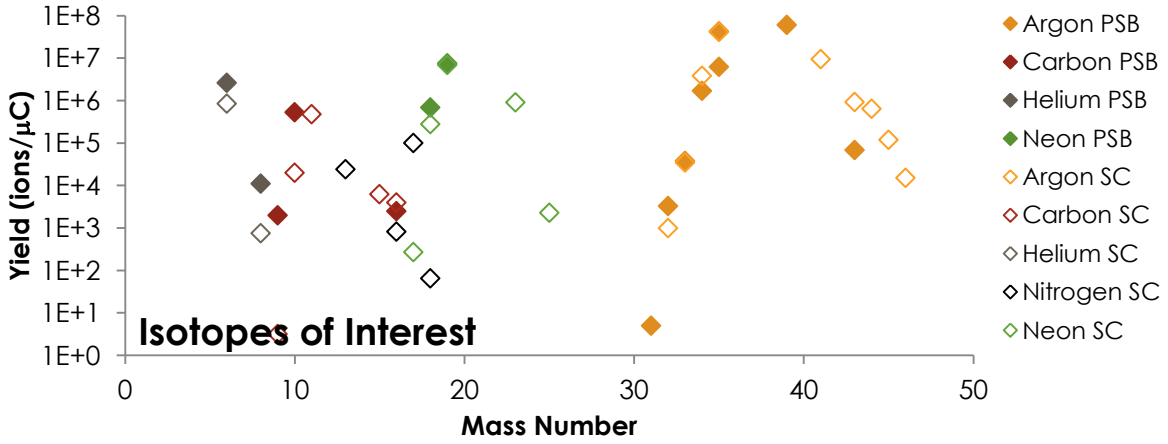
CaO Target

- Main Issues:
  - Unstable Yields
    - Low since the beggining
    - Drop over time

Microstructure related → **Material study needed!**

1 to 2 Targets built every year





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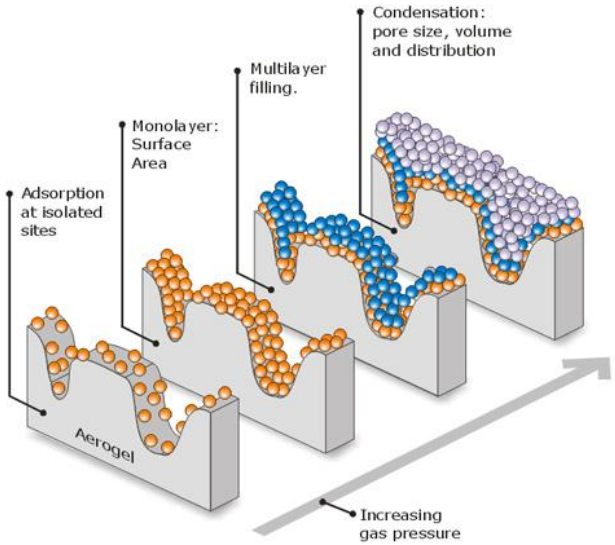
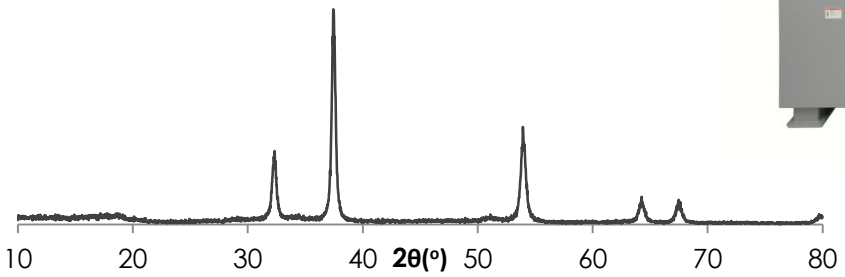
Turrion, M.; Urszula, H.-I. ISOLDE Yield Database. https://oraweb.cern.ch/pls/isolde/query_tgt (accessed December 1st, 2011)
Shift numbers by courtesy of Magdalena Kowalska, Physics Coordinator at ISOLDE, CERN.

Material Study

Material Characterization



- Best material for best release properties:
  - High porosity (>30%)
  - High pore size (>100nm)
  - Nanometric grain (<100nm)



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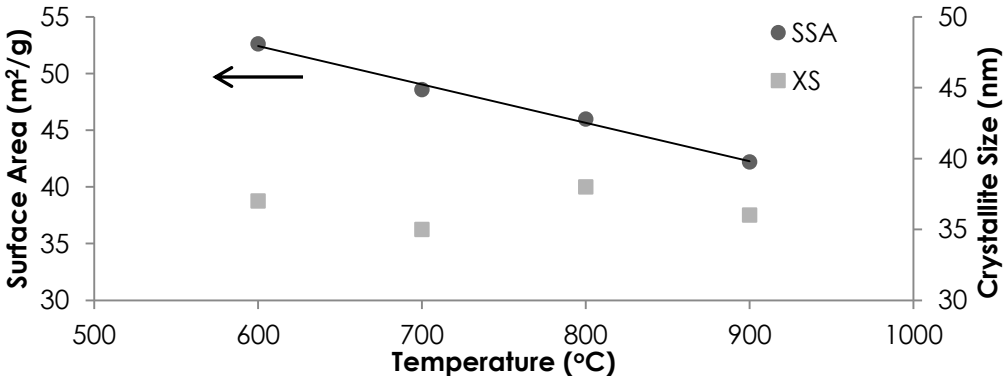
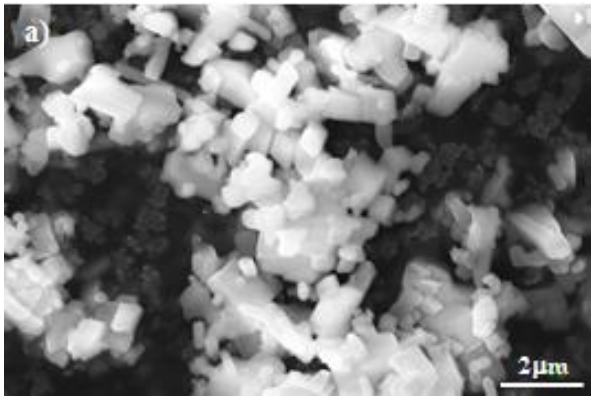
Stora, T. et al., Nanostructured Target for Isotope Production, WO 2010/034364 A1, 2010.

Material Study

Material Synthesis

$$CaCO_3 \leftrightarrow CaO + CO_2$$



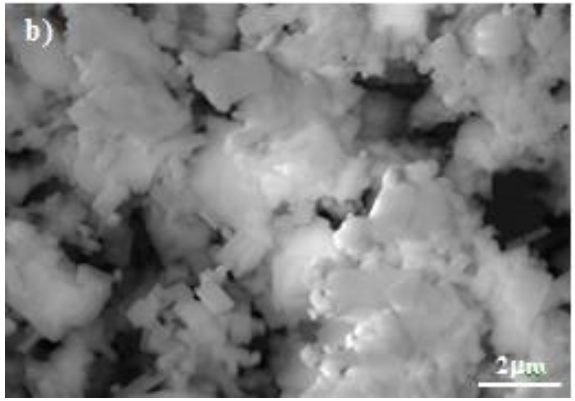


$CaCO_3$

Nanostructured material

35 – 40nm

High Open Porosities (~47%)
Pore Size ~20nm



CaO

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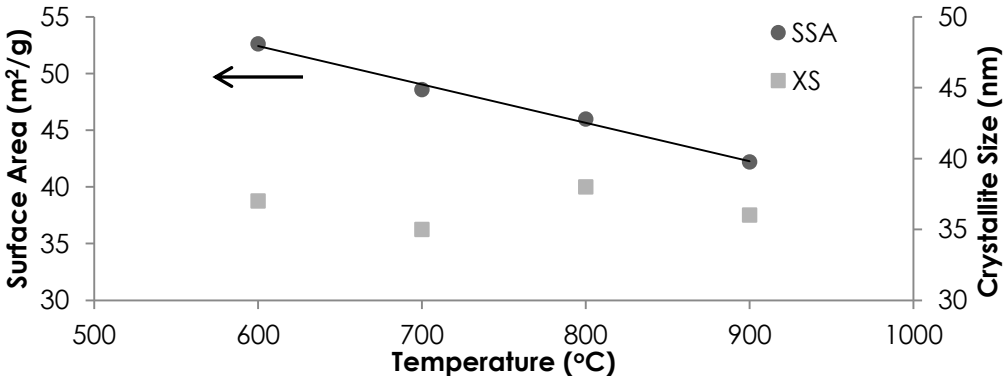
Material Study

Material Synthesis



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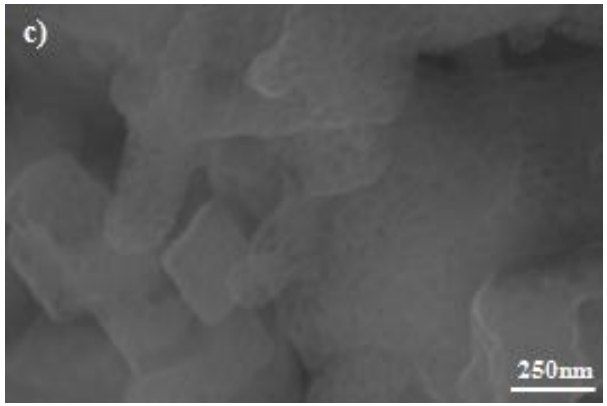

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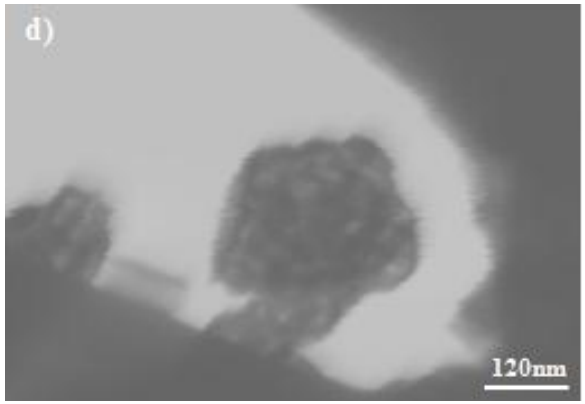

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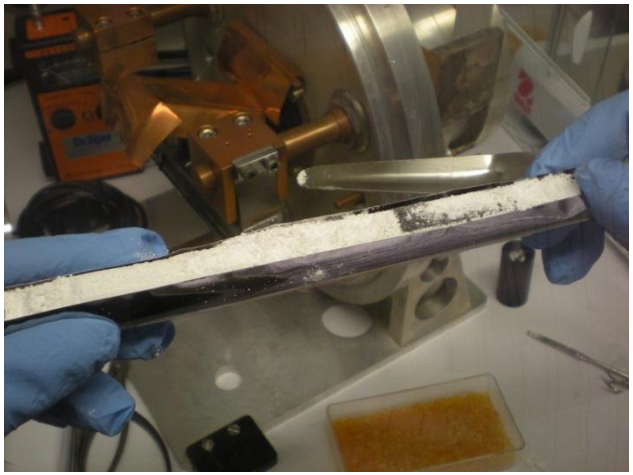
Target Production

Old Process

- Temperature up to 1200°C
- Pyrometer to control T
- No defined heating and cooling rates

New Process

- Temperature up to 800°C
- Thermocouple to control T
- ~10°C/min (Heating and Cooling rates)



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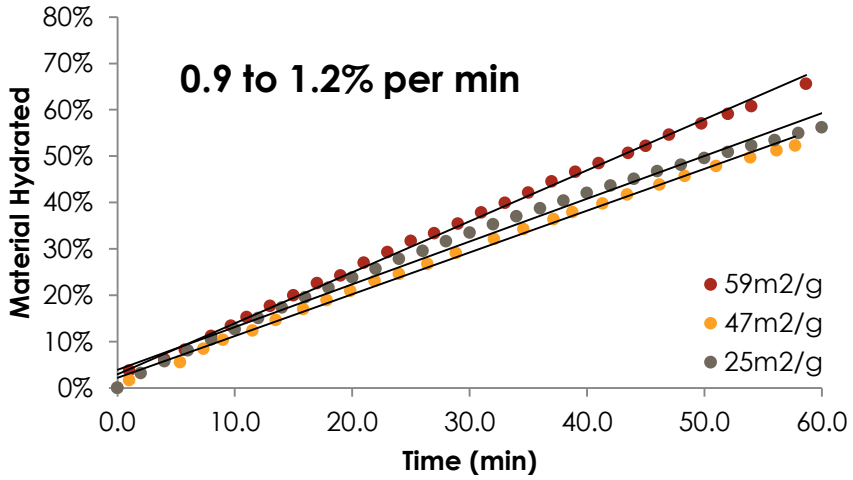
Material Study

Reactivity to Air

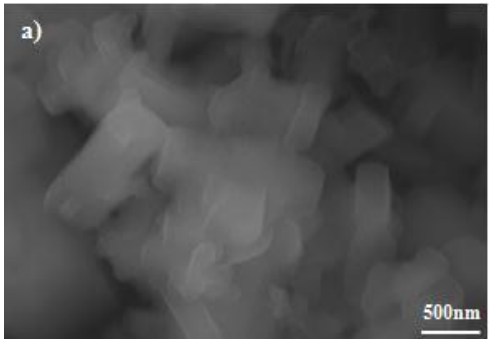


$$CaO + H_2O \leftrightarrow Ca(OH)_2$$

$$CaO + CO_2 \leftrightarrow CaCO_3$$

$$Ca(OH)_2 + CO_2 \leftrightarrow CaCO_3 + H_2O$$

- Higher Sintering of CaO produced from $Ca(OH)_2$
- Irreversibility in terms of microstructure



As produced: 59m²/g

Left at Air for 2 days: 9m²/g
TT at 800°C for 20 min: 28m²/g

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Target Handling

No care with respect to hydration was taken before.

- Glove Box (Argon atm)
- Single Batch Preparation

  - Prevents Hydration
  - Enhances safety (nanomaterial)

No traces of $Ca(OH)_2$ on XRD were detected!

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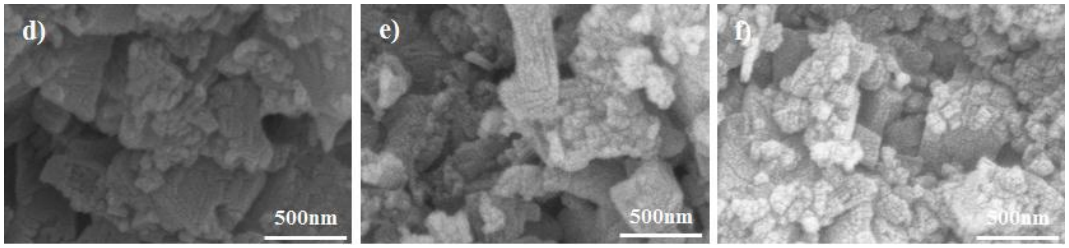
Material Study

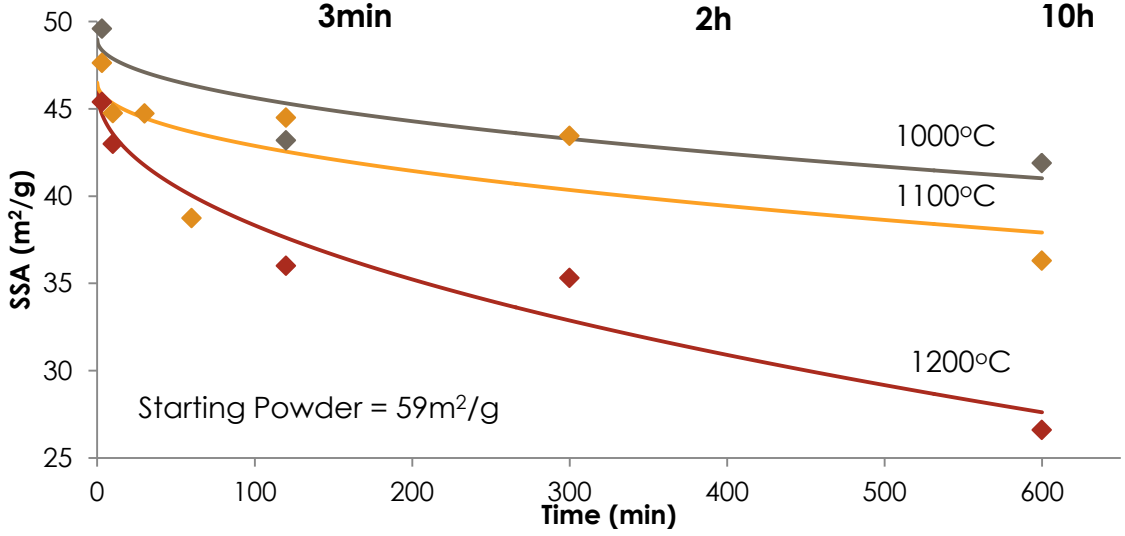
Sintering Kinetics

- CaO Pellets with 60% porosity were pressed

1200ºC



3min **2h** **10h**



$$\left(\frac{\Delta S}{S_0}\right)^{\gamma} = kt$$

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Target Operation

Old Settings

- T up to 1200ºC
- 3x10^{13}ppp

New (Safe) Settings

- T up to 800ºC
- 8x10^{12}ppp

Avoid Nanostructure degradation.

Temperature effect only!
Effect of Protons is unknown!

- 25 to 40 m^2/g
- 40 to 70nm
- 33% Porosity (~11nm)

↓

- ~4 m^2/g
- 0.3 to 0.5µm
- 9% Porosity (~9nm)

→

- >40 m^2/g
- <45nm
- 47% Porosity (~20nm)

↓

- >38m^2/g
- <45nm
- 47% Porosity (~20nm)

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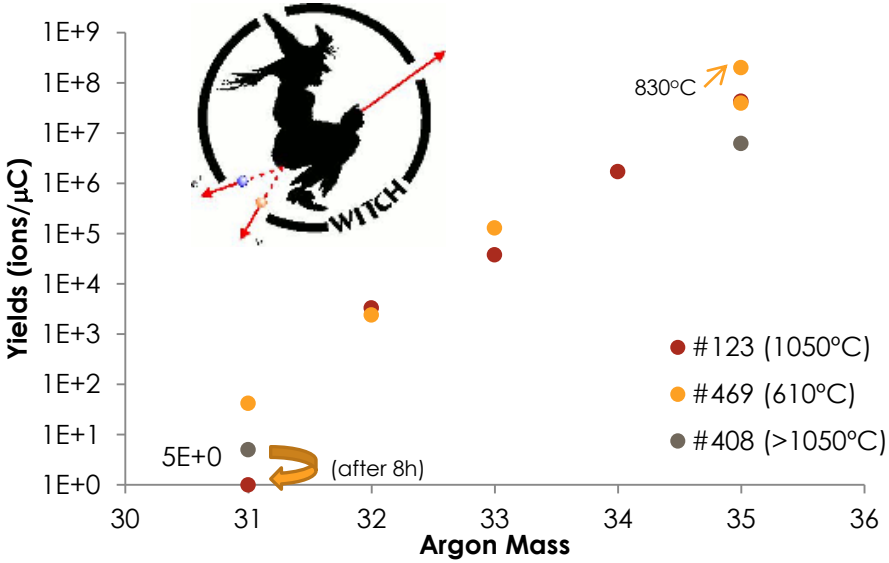
Online Tests

Target CaO #469 (VADIS)

Isotope	T(°C)	Yield (ions/μC)	Database (ions/μC)
^{6}He	610	2.3E+6	2.6E+6
^{10}C (CO)	705	6.1E+5	5.3E+5
^{15}C (CO)	705	7.0E+3	6.2E+3
^{19}Ne	610	9.6E+6	7.6E+6

More to report on C beams next year (C. Seiffert)



- Comparing ISOLDE Ar beams:

Protons per second	^{31}Ar (15.1ms)	^{32}Ar (98ms)	^{33}Ar (174.1ms)	^{34}Ar (844ms)	^{35}Ar (1.78s)
ISOLDE	6.3E+01	3.6E+03	2.0E+05	2.6E+06	3.0E+08
TRIUMF	-	-	7.0E+02	2.9E+04	6.5E+06
SPIRAL	4.4E+00	1.0E+03	9.1E+04	5.0E+06	3.5E+08

Yields on ^{31,32}Ar measured by ISOLDE experiment IS476 – H. Fynbo and B. Blank.

Turrion, M.; Urszula, H.-I. ISOLDE Yield Database. https://oraweb.cern.ch/pls/isolde/query_tgt (accessed December 1st, 2011)
TRIUMF. ISAC Yield Measurement. http://www.triumf.info/facility/research_fac/yield.php (accessed December 5th, 2011)
GANIL. SPIRAL Beams. http://pro.ganil-spiral2.eu/users-guide/accelerators/spiral-beams (accessed December 5th, 2011)

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Online Tests

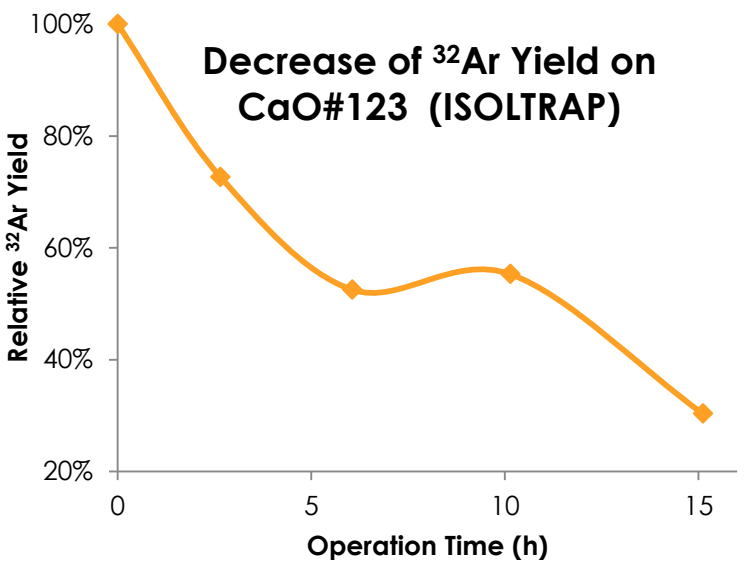
Yields Over time

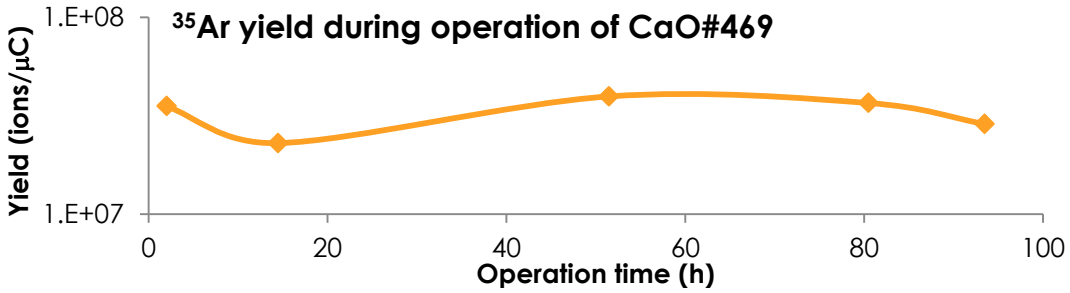
- ^{31}Ar drop on CaO#408

5 to 1 ion/μC in 8 hours

- ^{31}Ar measured CaO#469

to be 42 ions/μC after >80h of operation





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[32]Ar Yield drop, courtesy of Susanne Kreim – ISOLTRAP, ISOLDE, CERN

Future Work/Plans

- Further development of CaO target
  - Tunning the production process
  - Using higher operation temperatures/proton intensities
  - Study of the proton impact effect on CaO

- Possible PhD: Development of nanograined oxide target materials for ISOLDE
  - MgO
  - TiO_2 or TiC – Ca beams
  - HfO_2 – C beams
  - CeO_2 – Se beams
  - ThO_2 – gains on metalic beams

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Acknowledgments

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Thank you!

Comments and questions?

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