PAUL SCHERRER INSTITUT

UNIVERSITÄT BERN

ISOLDE CERN

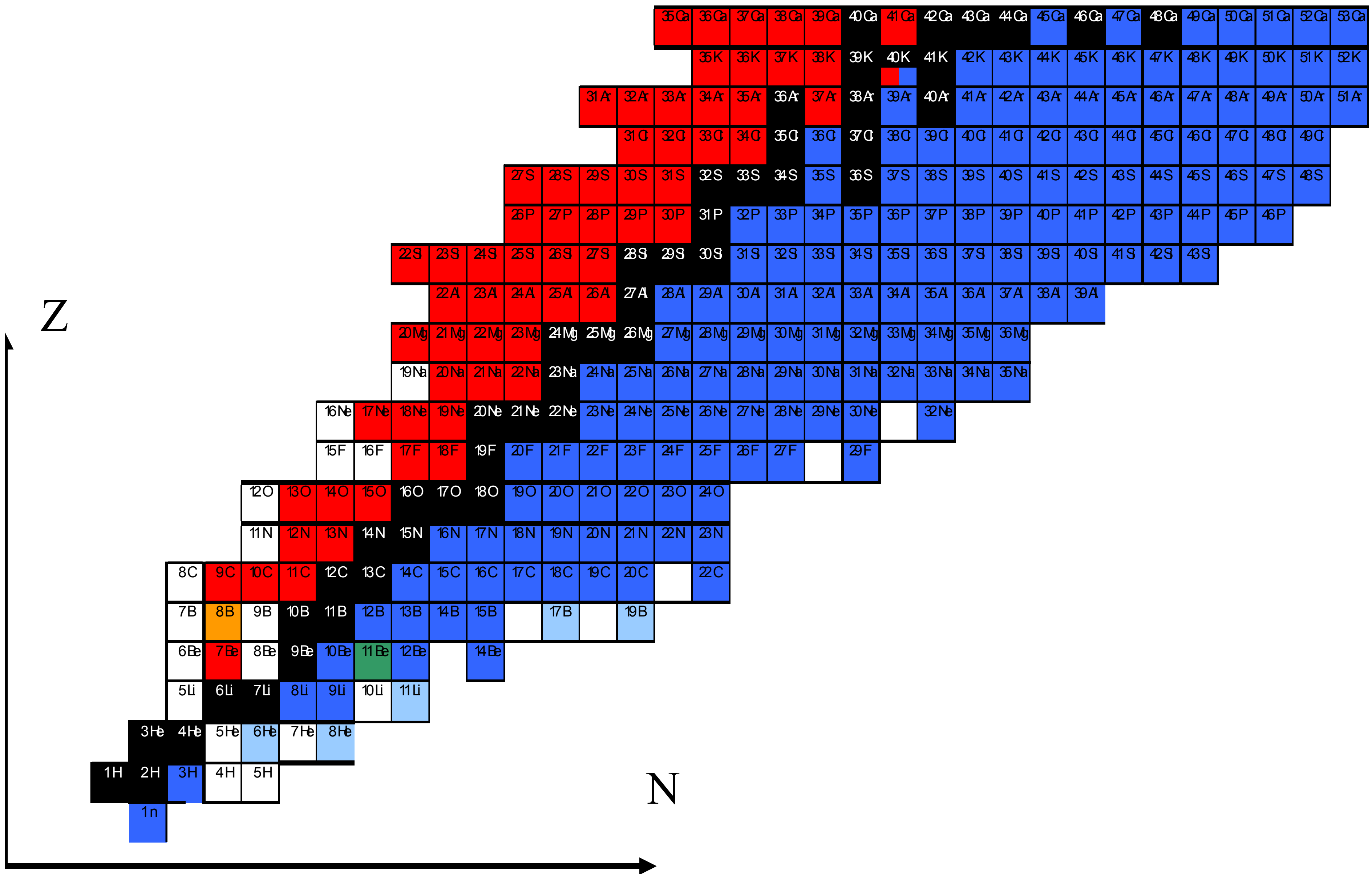
TARGISOL

Beam development at ISOLDE

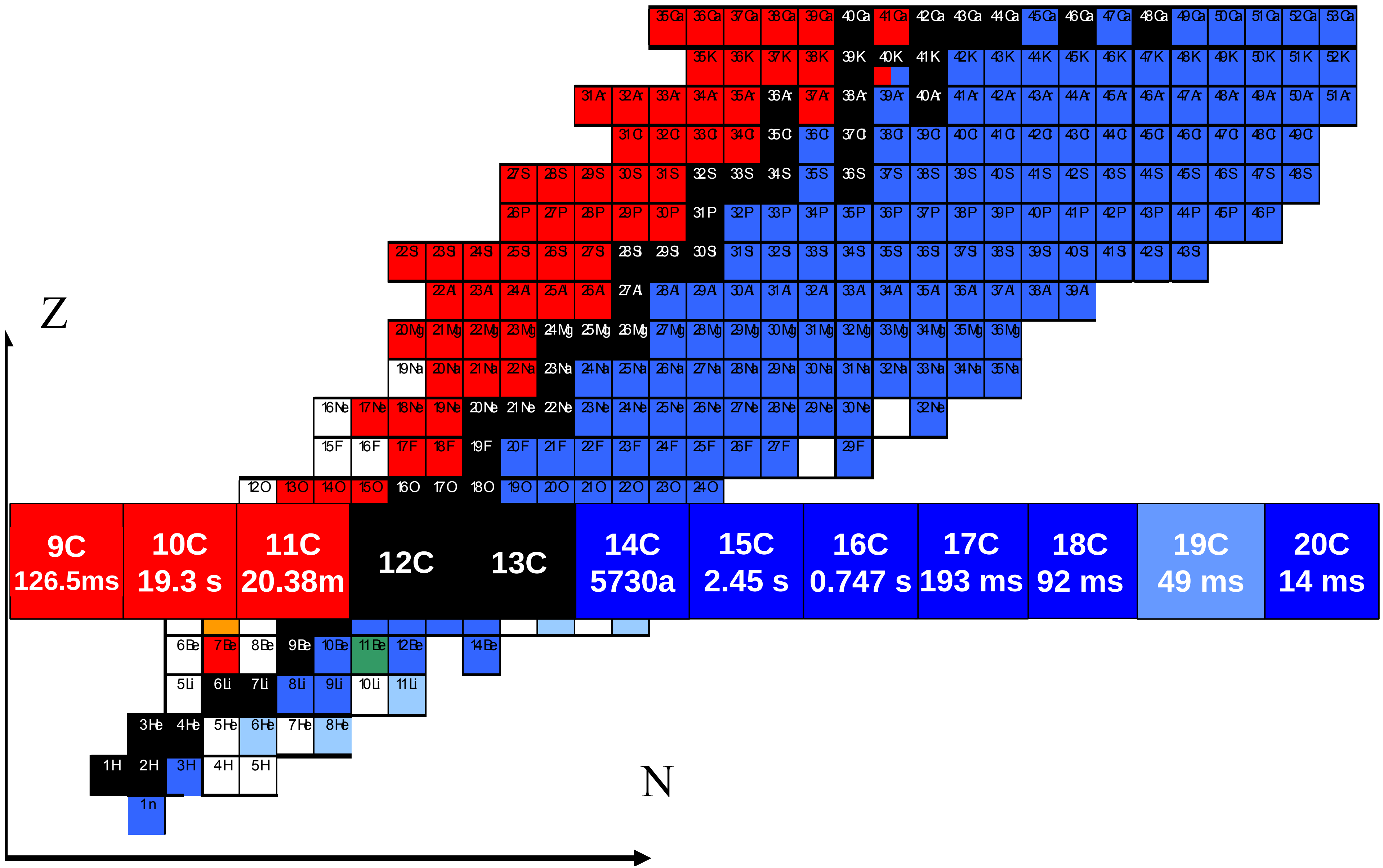
Overview

1. Problems with carbon
2. Target
3. What is the status of carbon and nitrogen beams today.

Carbon

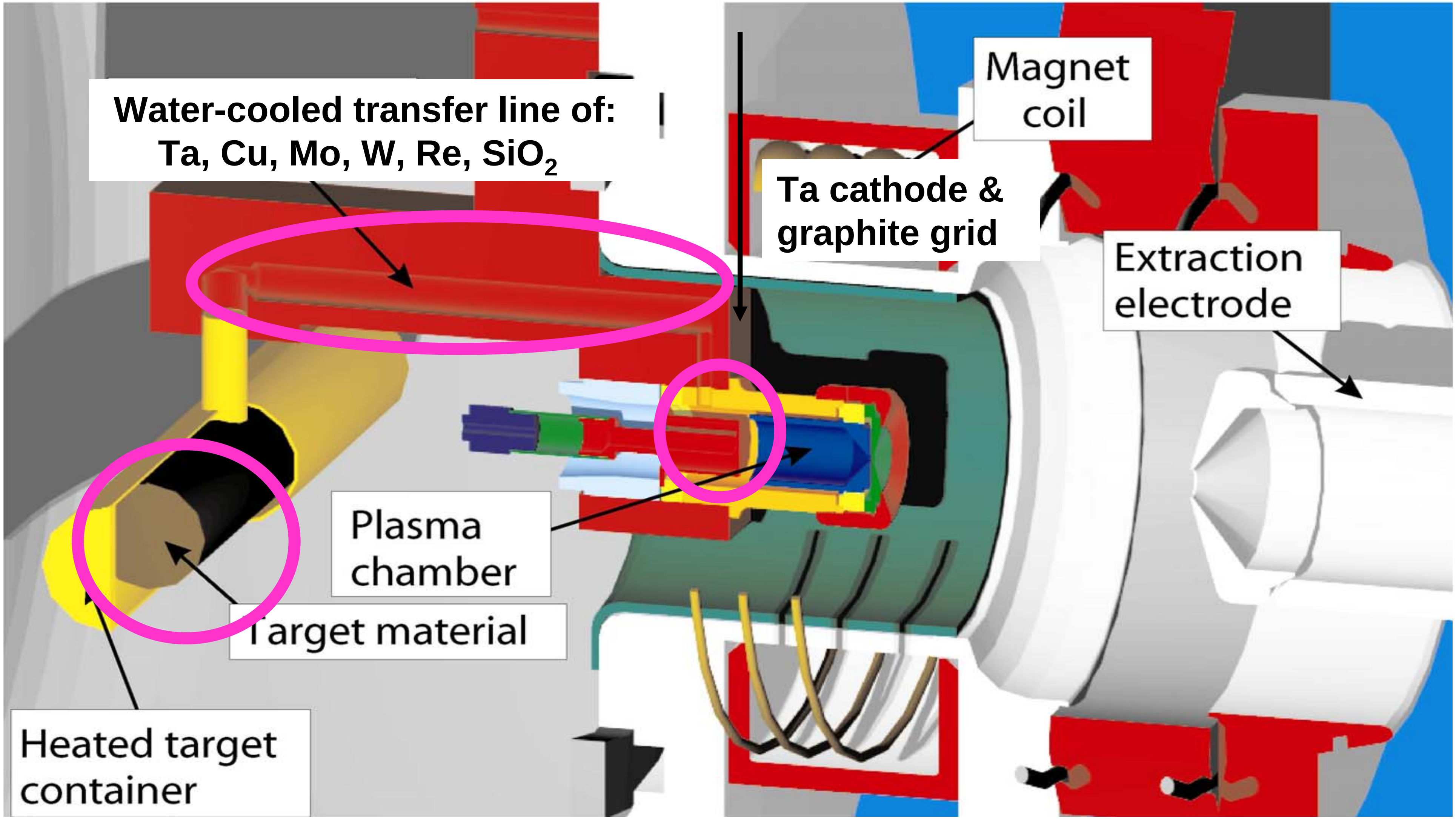


Carbon



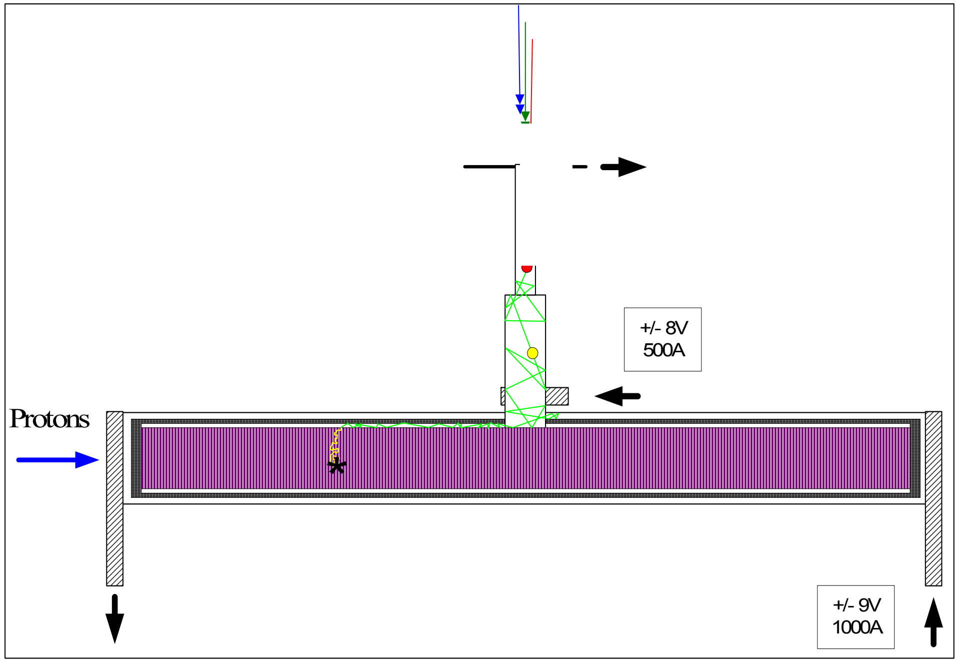
35Ca 36Ca 37Ca 38Ca 39Ca 40Ca 41Ca 42Ca 43Ca 44Ca 45Ca 46Ca 47Ca 48Ca 49Ca 50Ca 51Ca 52Ca 53Ca
35K 36K 37K 38K 39K 40K 41K 42K 43K 44K 45K 46K 47K 48K 49K 50K 51K 52K
31Ar 32Ar 33Ar 34Ar 35Ar 36Ar 37Ar 38Ar 39Ar 40Ar 41Ar 42Ar 43Ar 44Ar 45Ar 46Ar 47Ar 48Ar 49Ar 50Ar 51Ar
31Cl 32Cl 33Cl 34Cl 35Cl 36Cl 37Cl 38Cl 39Cl 40Cl 41Cl 42Cl 43Cl 44Cl 45Cl 46Cl 47Cl 48Cl 49Cl
27S 28S 29S 30S 31S 32S 33S 34S 35S 36S 37S 38S 39S 40S 41S 42S 43S 44S 45S 46S 47S 48S
26P 27P 28P 29P 30P 31P 32P 33P 34P 35P 36P 37P 38P 39P 40P 41P 42P 43P 44P 45P 46P
22Si 23Si 24Si 25Si 26Si 27Si 28Si 29Si 30Si 31Si 32Si 33Si 34Si 35Si 36Si 37Si 38Si 39Si 40Si 41Si 42Si 43Si
22Al 23Al 24Al 25Al 26Al 27Al 28Al 29Al 30Al 31Al 32Al 33Al 34Al 35Al 36Al 37Al 38Al 39Al
20Mg 21Mg 22Mg 23Mg 24Mg 25Mg 26Mg 27Mg 28Mg 29Mg 30Mg 31Mg 32Mg 33Mg 34Mg 35Mg 36Mg
19Na 20Na 21Na 22Na 23Na 24Na 25Na 26Na 27Na 28Na 29Na 30Na 31Na 32Na 33Na 34Na 35Na
16Ne 17Ne 18Ne 19Ne 20Ne 21Ne 22Ne 23Ne 24Ne 25Ne 26Ne 27Ne 28Ne 29Ne 30Ne 32Ne
15F 16F 17F 18F 19F 20F 21F 22F 23F 24F 25F 26F 27F 29F
12O 13O 14O 15O 16O 17O 18O 19O 20O 21O 22O 23O 24O
9C 126.5ms
10C 19.3 s
11C 20.38m
12C
13C
14C 5730a
15C 2.45 s
16C 0.747 s
17C 193 ms
18C 92 ms
19C 49 ms
20C 14 ms
6Be 7Be 8Be 9Be 10Be 11Be 12Be 14Be
5Li 6Li 7Li 8Li 9Li 10Li 11Li
3He 4He 5He 6He 7He 8He
1H 2H 3H 4H 5H
1n
Z
N

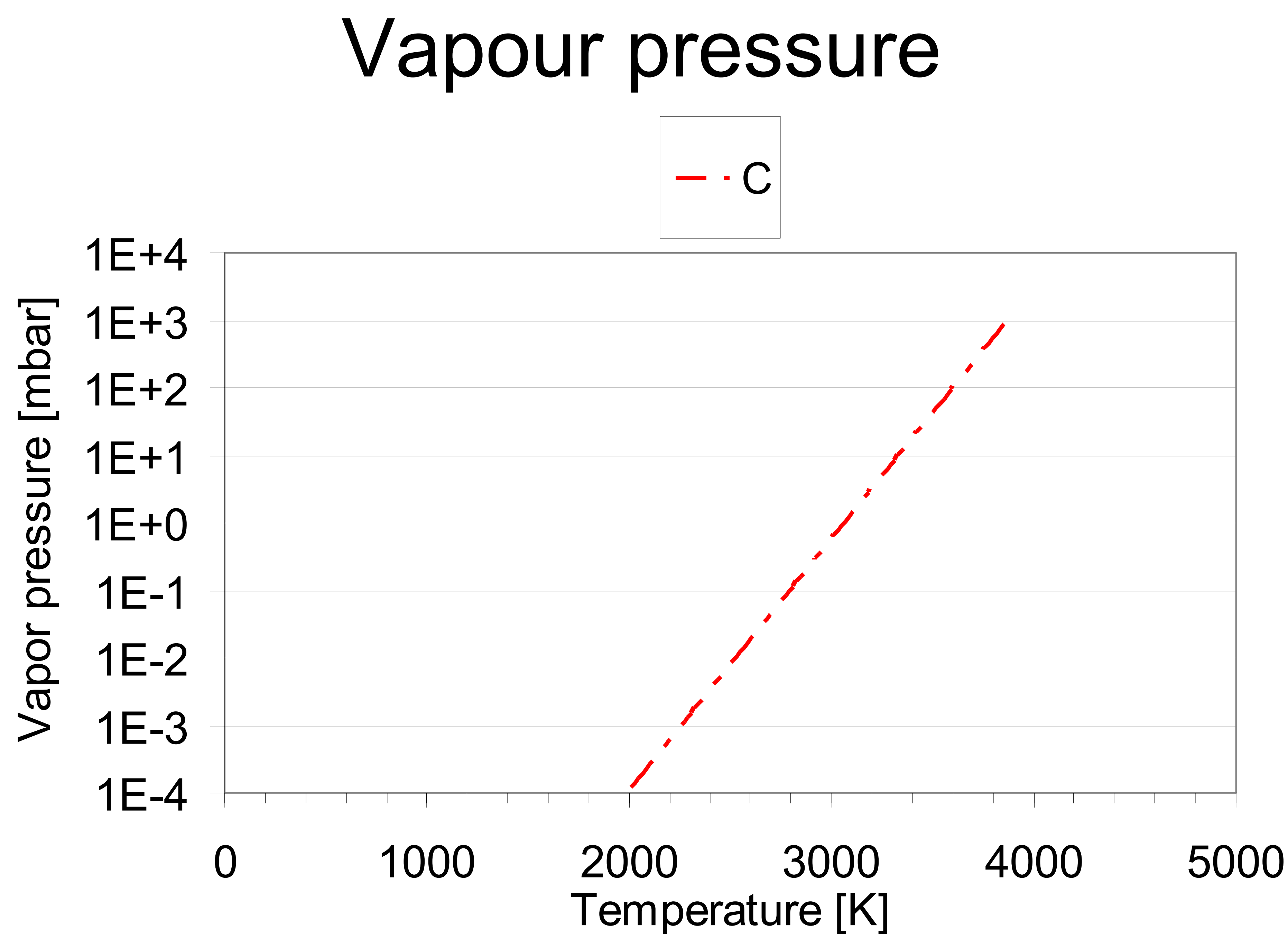
MK7 target + ion source



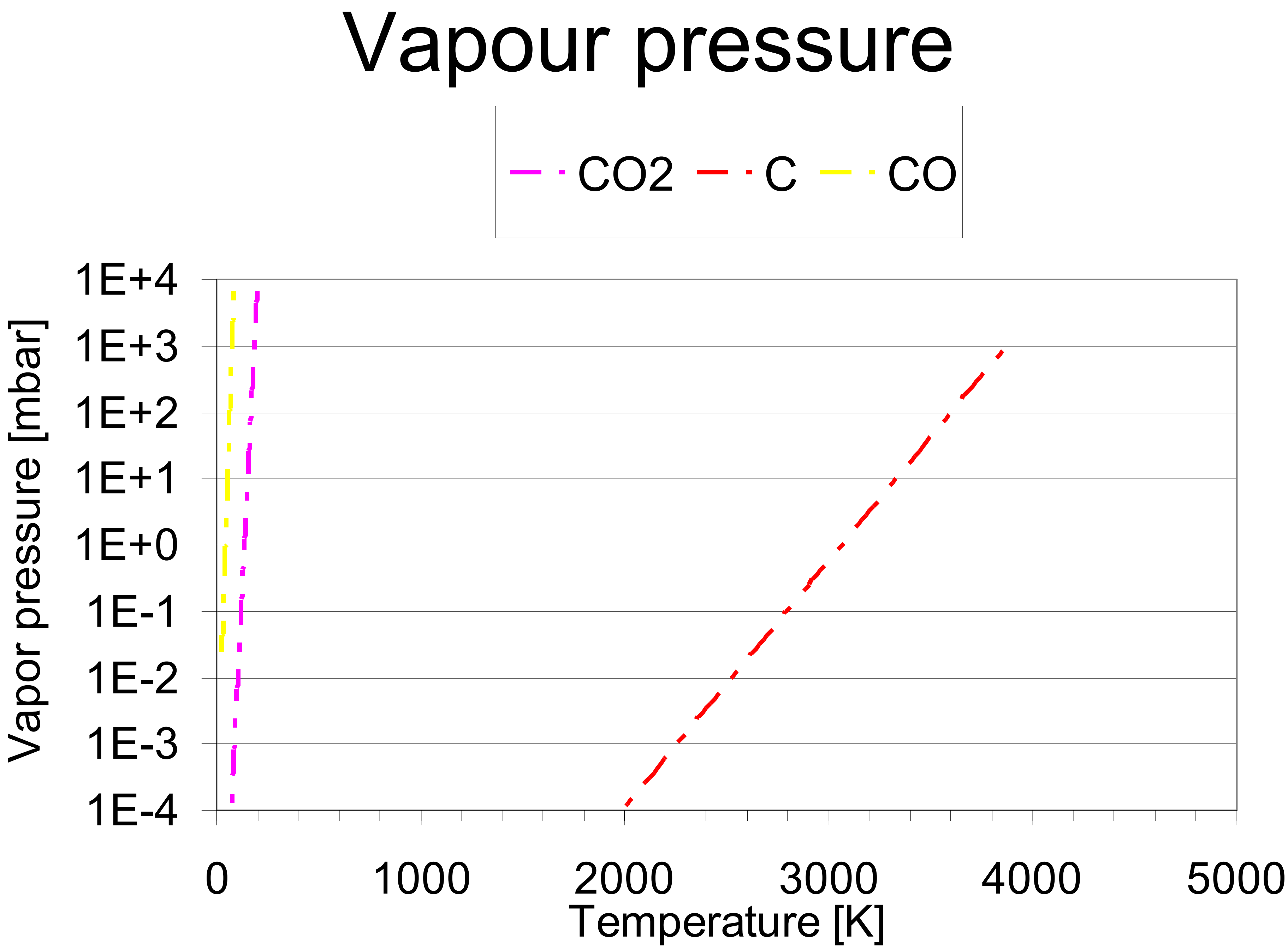
What are the problems?

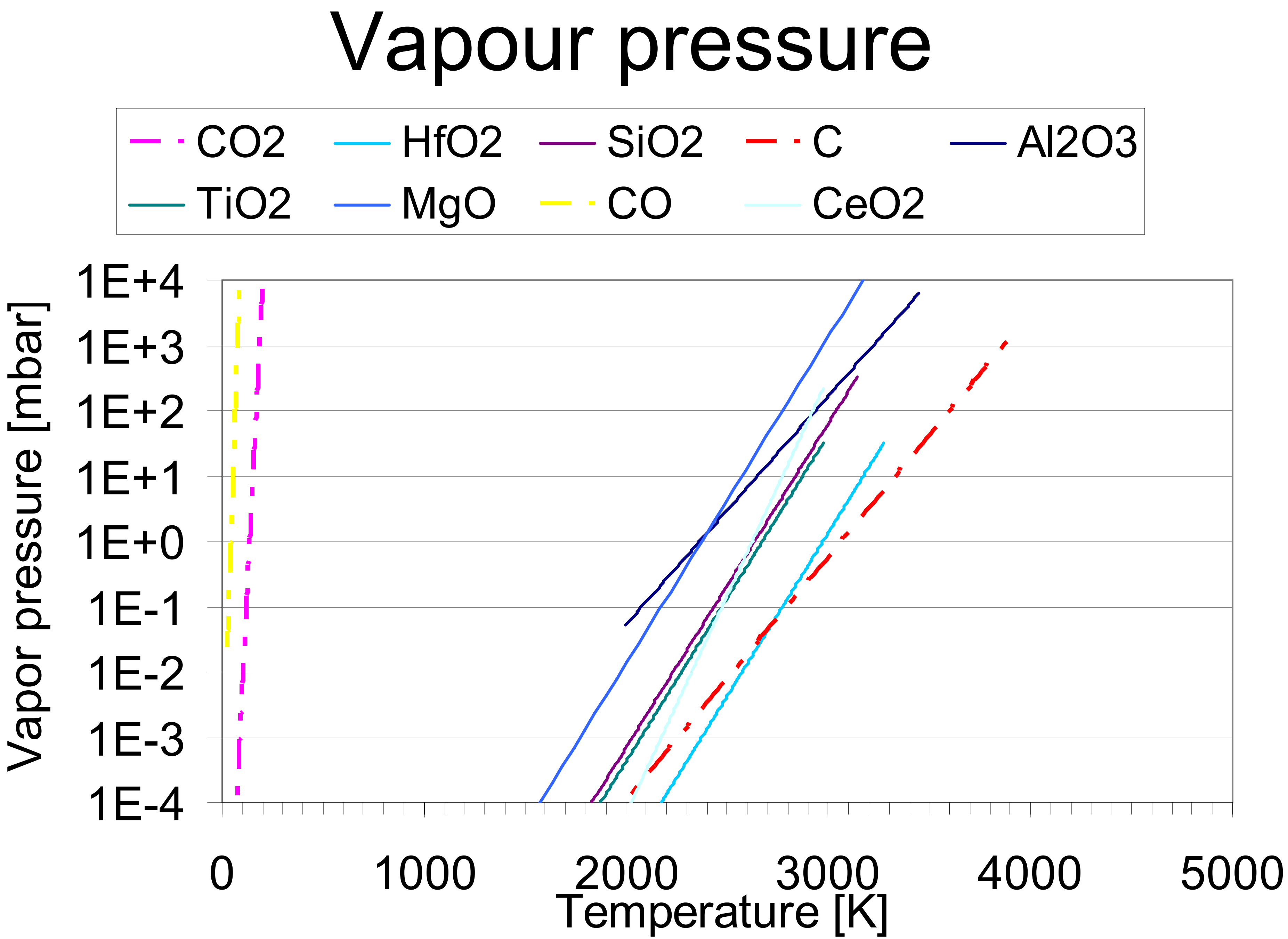
- Diffusion out of the target.
- Reaction with target material, transport lines and materials in the ion source.
- Ionization efficiencies.





Vapour pressure
C
1E+4
1E+3
1E+2
1E+1
1E+0
1E-1
1E-2
1E-3
1E-4
Vapor pressure [mbar]
0
1000
2000
3000
4000
5000
Temperature [K]


Vapour pressure
CO2
C
CO
1E+4
1E+3
1E+2
1E+1
1E+0
1E-1
1E-2
1E-3
1E-4
Vapor pressure [mbar]
0
1000
2000
3000
4000
5000
Temperature [K]

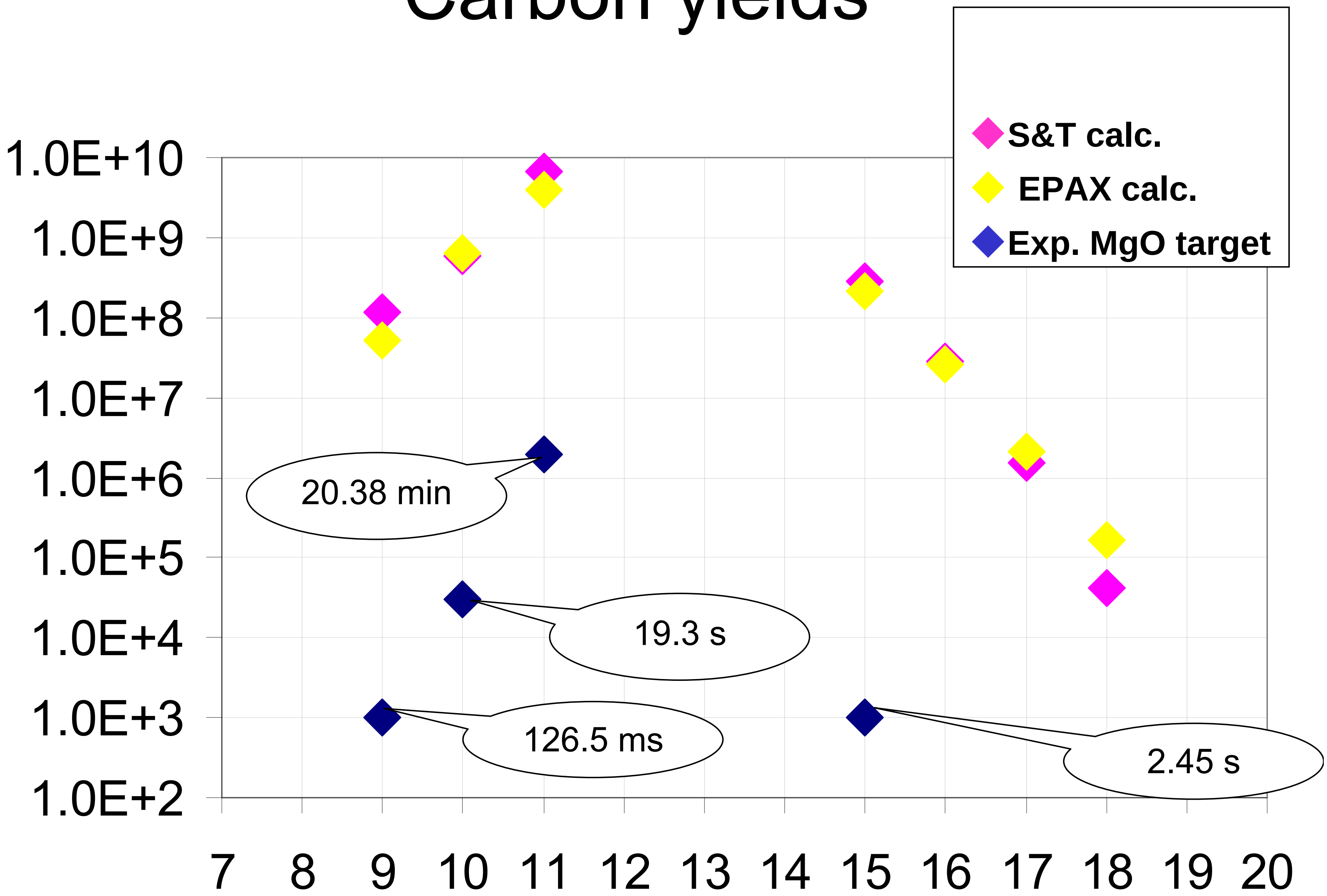


Vapour pressure
CO2
HfO2
SiO2
C
Al2O3
TiO2
MgO
CO
CeO2
1E+4
1E+3
1E+2
1E+1
1E+0
1E-1
1E-2
1E-3
1E-4
Vapor pressure [mbar]
0
1000
2000
3000
4000
5000
Temperature [K]

What has been tested

- Production -- ISOLDE and GANIL
  - Yield measurements
  - Release measurements
- Diffusion from different materials
  - Implantations of ^{11}C in different oxide materials.
- Transport trough TIS unit – TC exp. at PSI
- Ionization efficiency
  - Off-line tests with MiniMono

Carbon yields



Enthalpies: retrieved through TC experiments at PSI

- MgO,
  - CO_2 $\Delta H = -154$ kJ/mol
  - CO $\Delta H = -127$ kJ/mol
- CaO
  - CO $\Delta H \leq -200$ kJ/mol
  - CO_2 $\Delta H \leq -200$ kJ/mol
- TiO_2
  - CO_2 $\Delta H = -146$ kJ/mol
  - CO $\Delta H = -123$ kJ/mol
- SiO_2
  - CO $\Delta H = -16$ kJ/mol
  - CO_2 $\Delta H = -27$ kJ/mol
- Al_2O_3 , coating
  - CO $\Delta H = -68$ kJ/mol
  - CO_2 $\Delta H = -70$ kJ/mol
- Al_2O_3 , felt
  - CO $\Delta H = -77$ kJ/mol
  - CO_2 $\Delta H = -69$ kJ/mol
- HfO_2
  - CO_2 $\Delta H = -66$ kJ/mol
  - CO $\Delta H = \geq -8$ kJ/mol
  - NO_2 $\Delta H = \geq -8$ kJ/mol
  - NO $\Delta H = \geq -8$ kJ/mol
- CeO_2
  - CO $\Delta H = -154$ kJ/mol
  - CO_2 $\Delta H = -156$ kJ/mol

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  - CO ΔH = $\geq$ -8 kJ/mol
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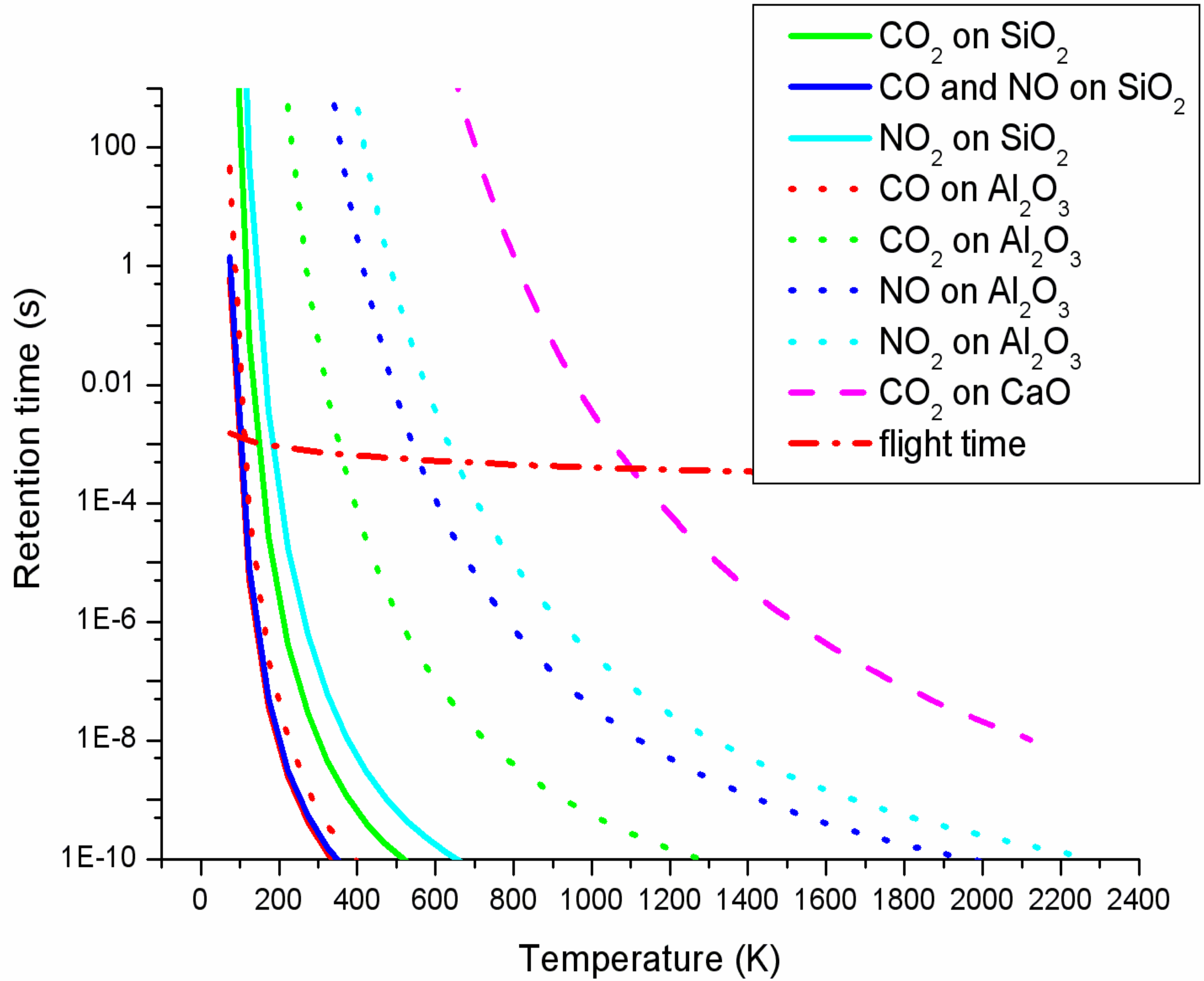
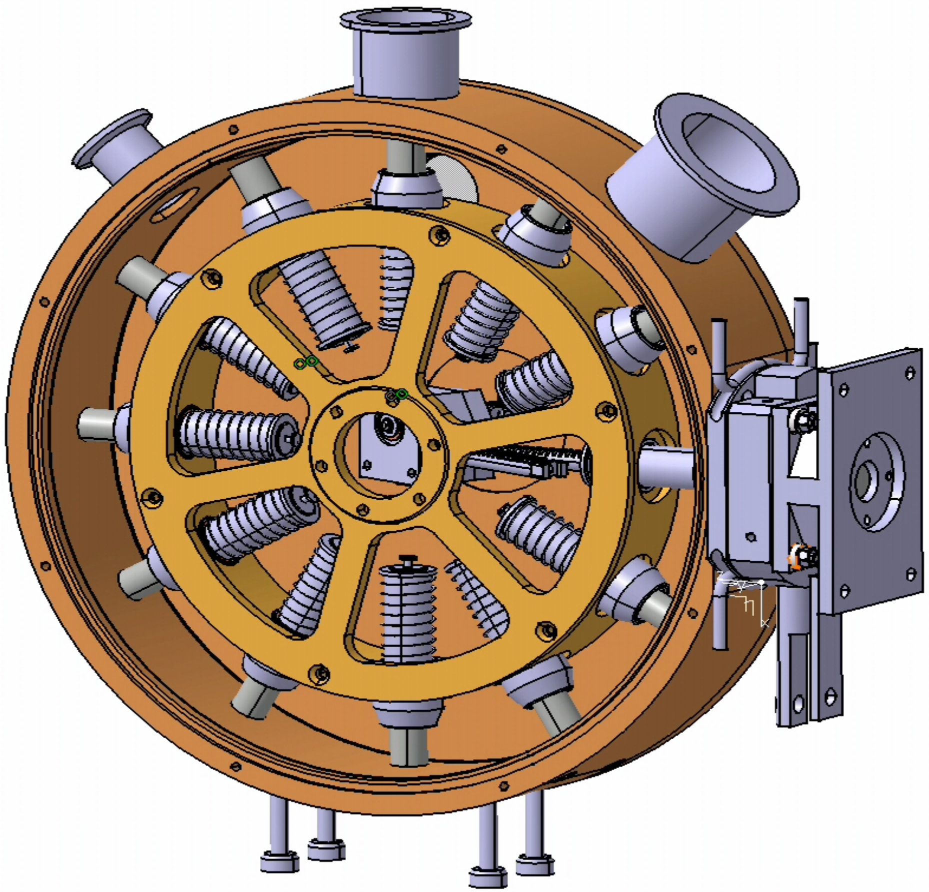
  - NO_2 ΔH = ≥ -8 kJ/mol
  - NO ΔH = ≥ -8 kJ/mol
- CeO_2
  - CO ΔH = -154 kJ/mol
  - CO_2 ΔH =-156 kJ/mol

Retention times.



DIFFUSION

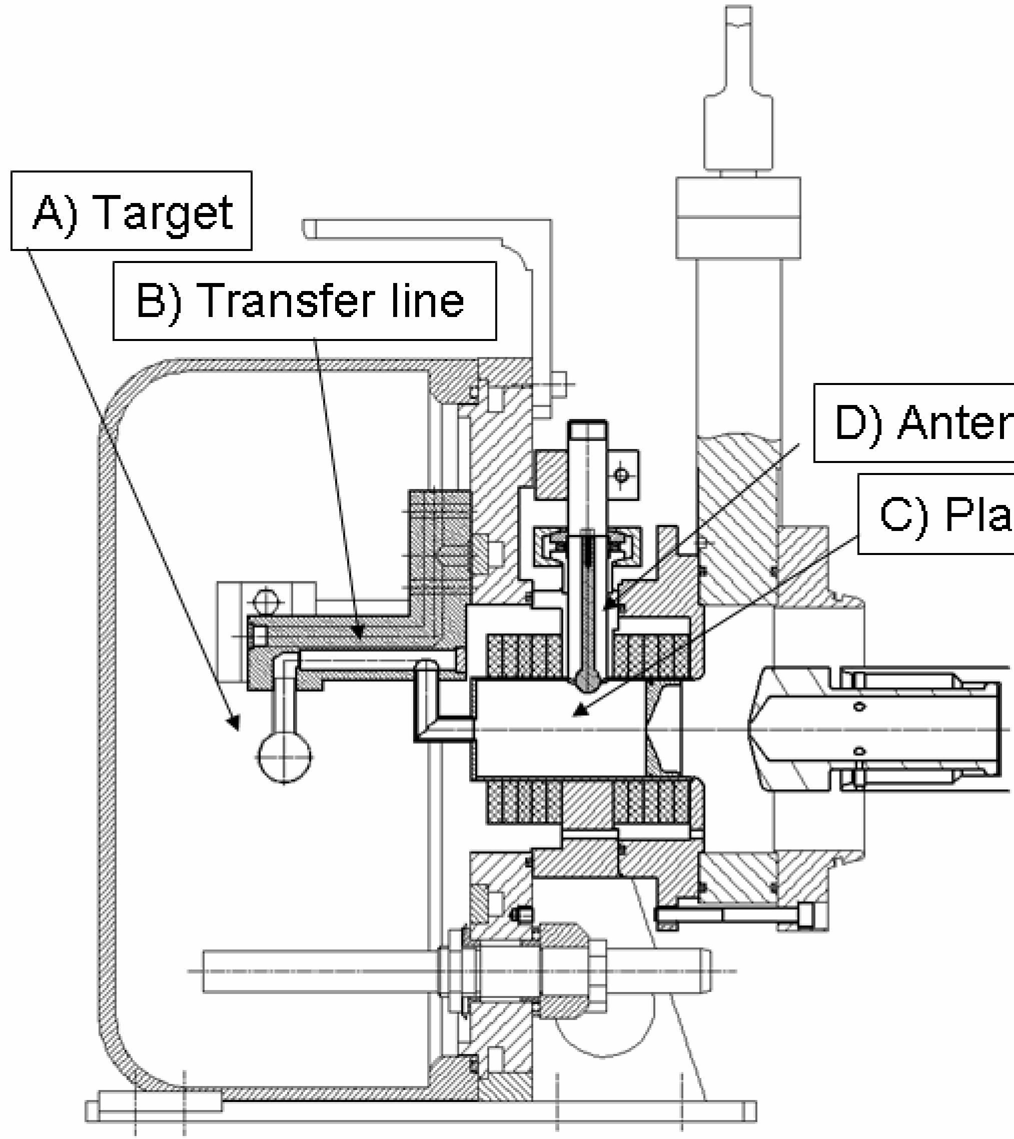
- GANIL
  - Release from targets, 12 targets to be tested one after the other →similar conditions give better comparisons!



- ISOLDE
  - Implantation of ^{11}C for comparison of diffusion times.

Pressed pills/ powder vs. Fibre targets

Mini Mono ECR ion source



Ion	Effic.
He^+	6%
CO_2^+	7%
NO^+	5.6% (low transmission during exp.)

Summary

Problem ☹	**Solution ☺**
Losses in target	☺ diffusion/effusion ☺ retention times vs. lifetime of target!
Losses in transfer line.	☺ Minimize the retention time through coating
Release properties	☺ Material optimization
Ion source	☺ with 15 x more efficiency than FEBIAD (offline)

Summary

Problem ☹	**Solution ☺**
Losses in target	☺ diffusion/effusion
Lo	n
R	
Ion source	☺ with 15 x more efficiency than FEBIAD (offline)

Ion source efficiency: x 10

Release: diffusion and effusion > 100

>1000 higher yields ☺ for carbon and nitrogen beam!

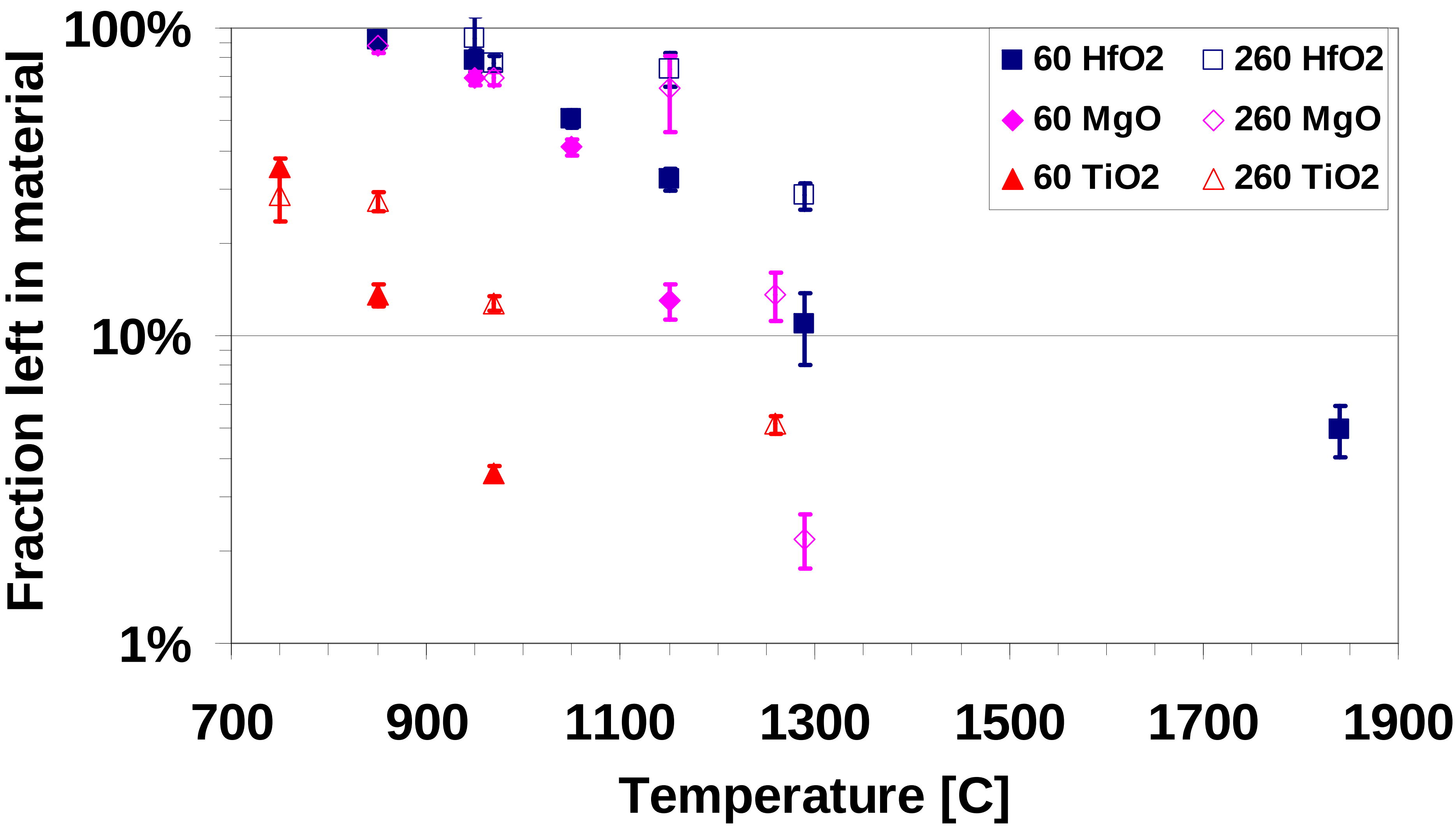
Thank you for your attention!

And thanks to:

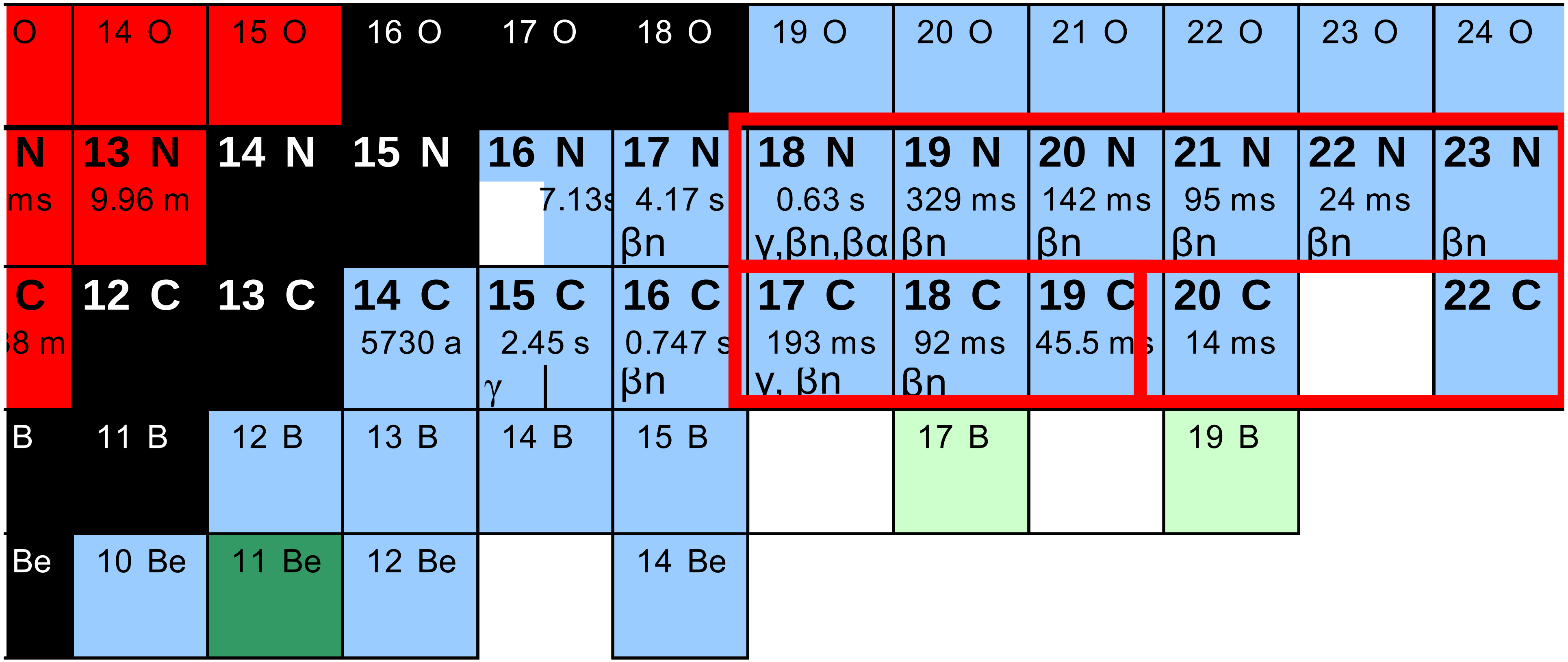
Ulli Köster, Markus Ammann, Heinz W. Gäggeler, Fredrik Wenander, Henrik Jeppessen, Liviu Penescu

R. AlvèsCondé, V. Dubois, F. Durantel, C. Eleon, G. Gaubert, B. Jacquot, P. Jardin, R. Leroy, N. Orr, J.-Y. Pacquet, M.-G. Saint-Laurent, C. Stodel, J.-C. Thomas, A. C. C. Villari and the ISOLDE collaboration

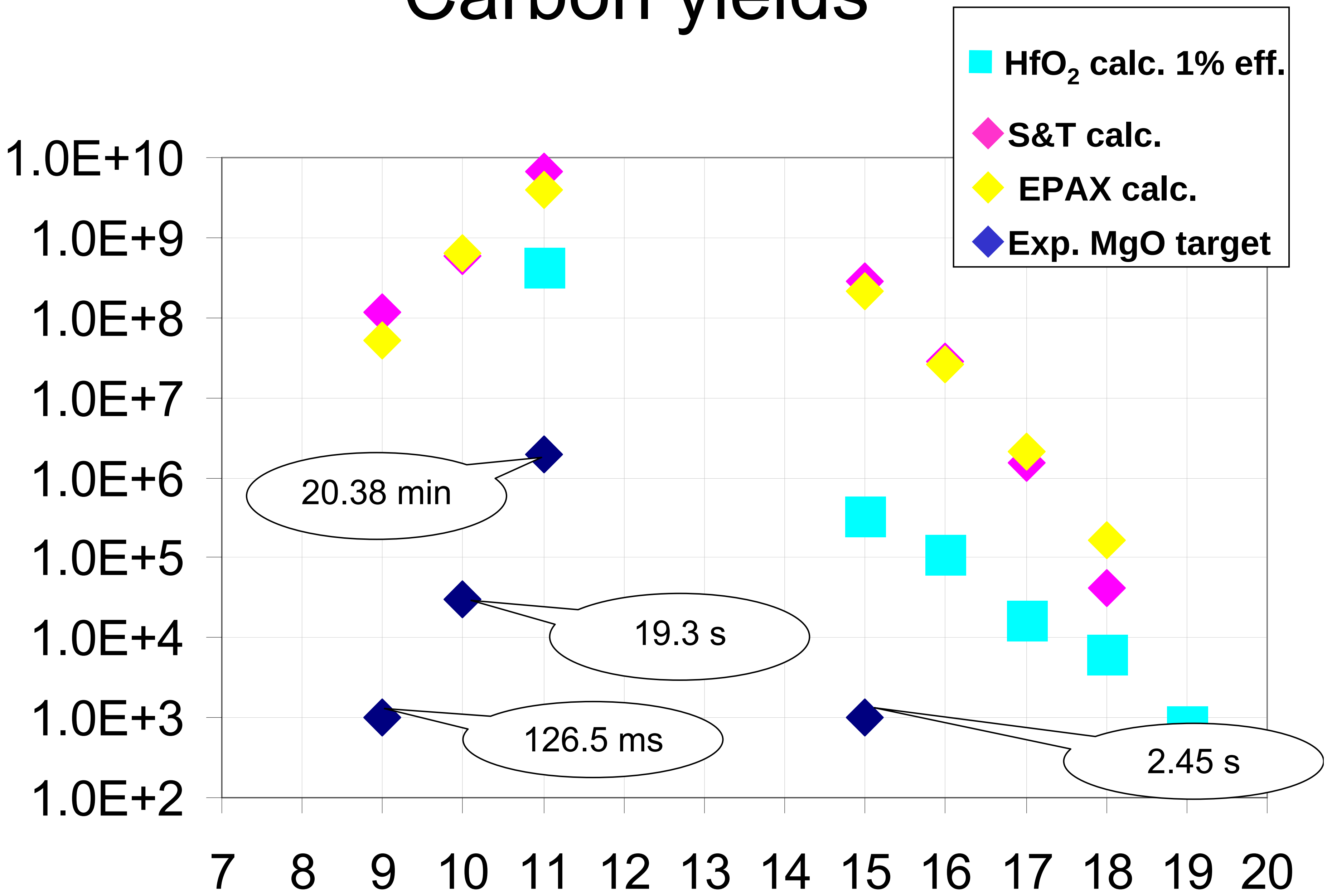
Diffusion


100%
10%
1%
Fraction left in material
700
900
1100
1300
1500
1700
1900
Temperature [C]
60 HfO2
260 HfO2
60 MgO
260 MgO
60 TiO2
260 TiO2

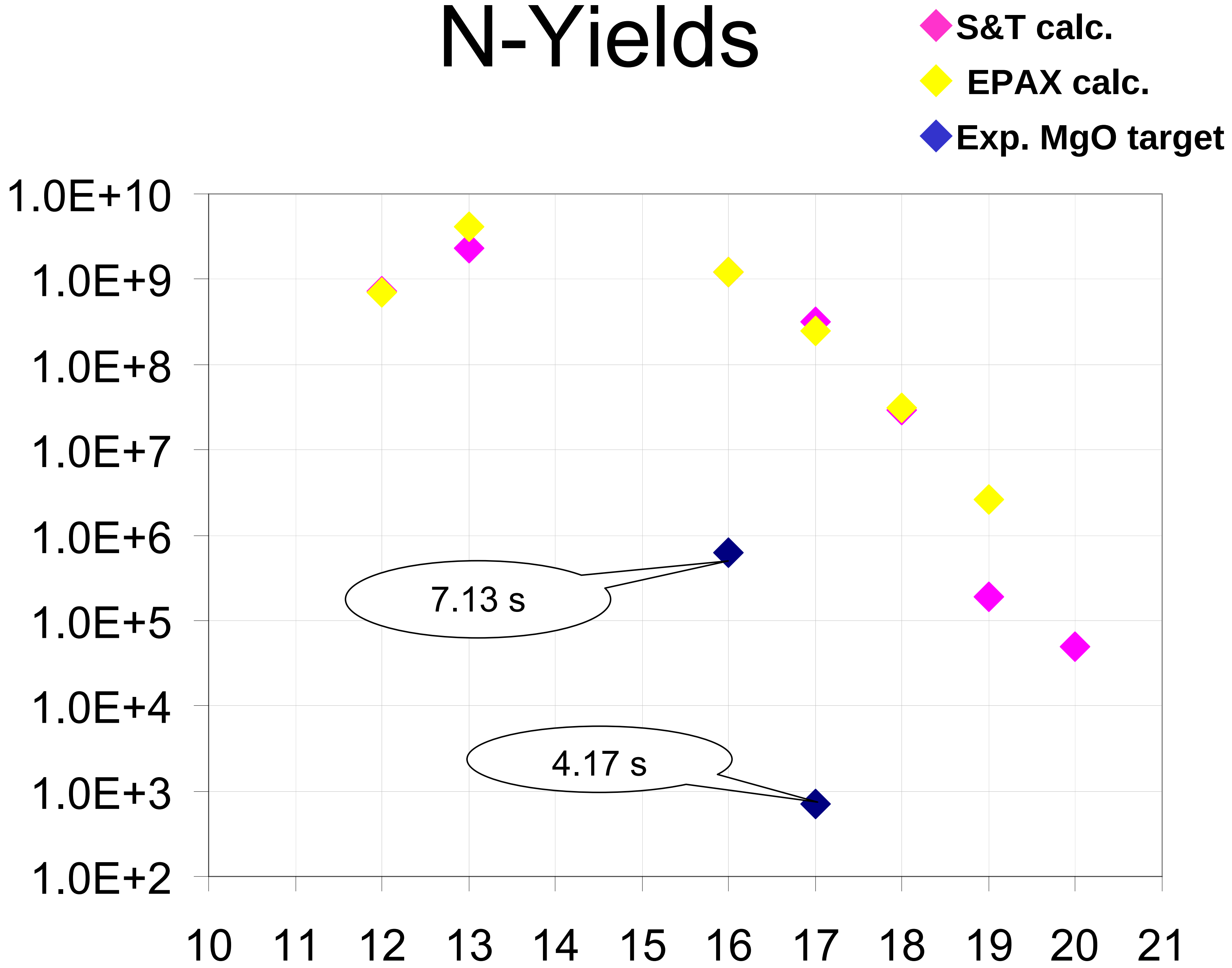
B-decay experiments



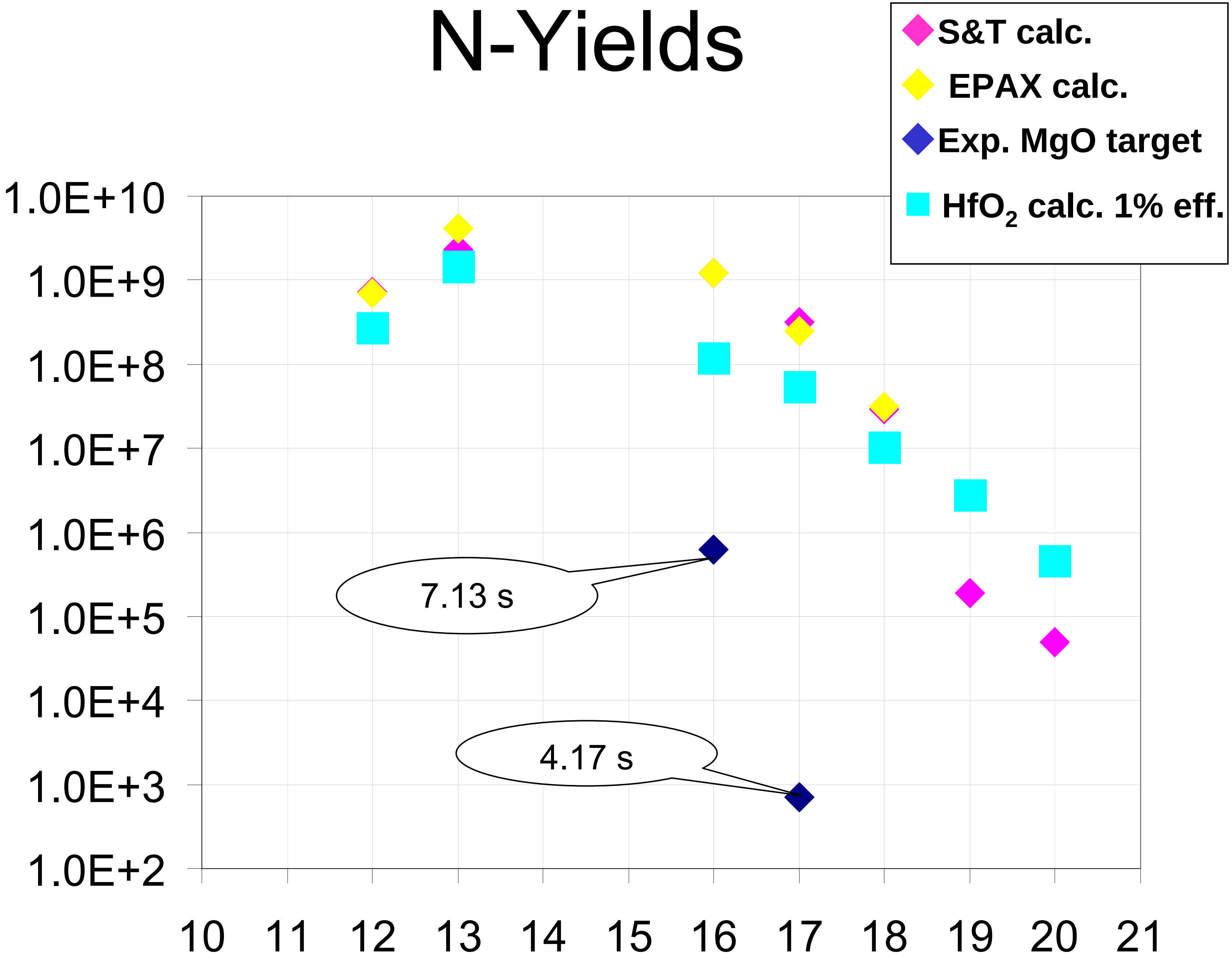
Carbon yields



N-Yields


S&T calc.
EPAX calc.
Exp. MgO target
1.0E+10
1.0E+9
1.0E+8
1.0E+7
1.0E+6
1.0E+5
1.0E+4
1.0E+3
1.0E+2
7.13 s
4.17 s
10
11
12
13
14
15
16
17
18
19
20
21

N-Yields



S&T calc.
EPAX calc.
Exp. MgO target
HfO2 calc. 1% eff.
1.0E+10
1.0E+9
1.0E+8
1.0E+7
1.0E+6
1.0E+5
1.0E+4
1.0E+3
1.0E+2
7.13 s
4.17 s
10
11
12
13
14
15
16
17
18
19
20
21