Actilab Kick-off meeting

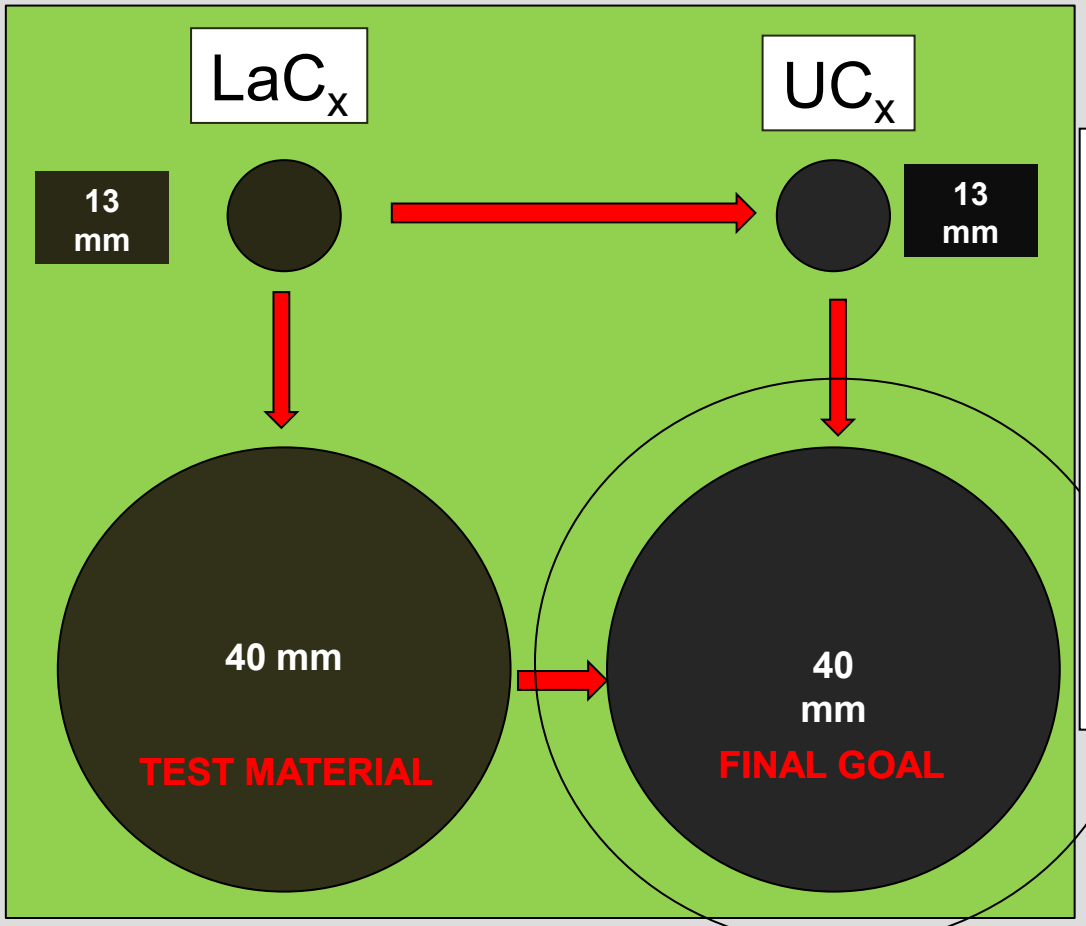
2010 SPES Target developments

Jacobo Montano

On behalf of the INFN-LNL

The Material R&D
(Two labs are involved!)

R&D Started on 2004 ; LaC_x test material ->UC_x



Good News (!) concerning:

- 40 mm dia UCx production
- UCx on line test @ HRIBF
- Data analysis almost completed
- Start production of B_4C

Proton-rich beams for SPES-α

1 H																2 He
3 Li	4 Be										5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg										13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba		72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra															

Alkaline - Alkaline earth metals

Post-transition elements

Halogens

Noble gases

Transition metals

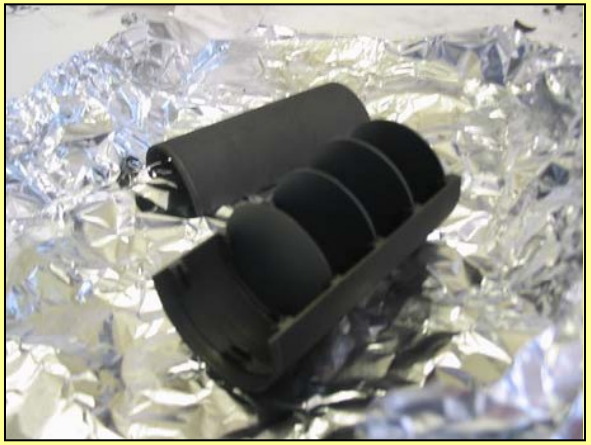
Lanthanides

57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Te	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

SiC Target

Elemento	A	Half Life	Target dedicati	Ionizzazione
Na	**21**	22.48 s	Al_2O_3 – SiC - CeS	SIS
Na	**22**	2.6 a	Al_2O_3 – SiC - CeS	SIS
Mg	**22**	3.86 s	Al_2O_3 – SiC - CeS	LIS-FEBIAD
Mg	**23**	11.3 s	Al_2O_3 – SiC - CeS	LIS-FEBIAD
Al	**24**	2.05 s	SiC - CeS	SIS-LIS
Al	**25**	7.18 s	SiC - CeS	SIS-LIS
Al	**26**	6.35 s	SiC - CeS	SIS-LIS
P	**29**	4.1 s	SiC - CeS	FEBIAD

SiC (Saint Gobain)



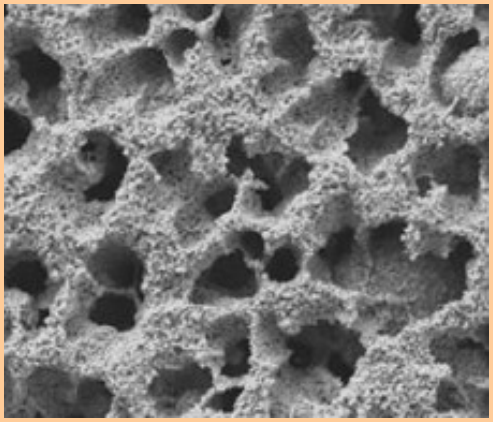
$^{28}Si(p,\alpha)^{25}Al$

$^{28}Si(p,2pn)^{26}Al$

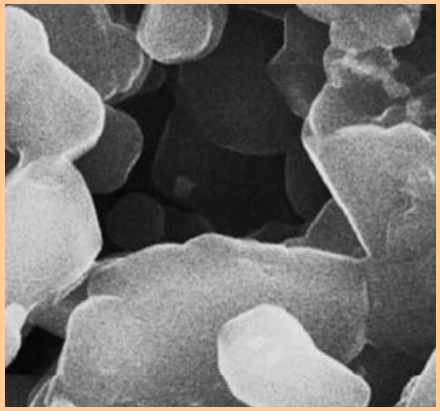
Oxide/Boron Carbide Target

Elemento	A	Half Life	Target dedicati	Ionizzazione
Be	**7**	53.29 d	B_4C - Ossidi	LIS-FEBIAD
F	**17**	64.8 s	ZrO_2 – HfO_2	FEBIAD
F	**18**	109.7 m	Al_2O_3	FEBIAD
Si	**26**	2.21 s	Al_2O_3 - CeS	FEBIAD
Si	**27**	4.16 s	Al_2O_3 - CeS	FEBIAD

Oxide foams



Boron Carbide

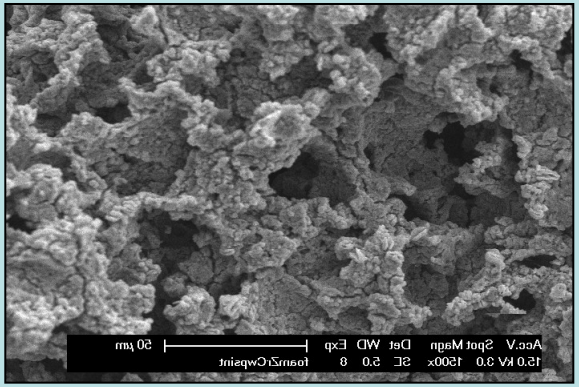


H_3BO_3 + C source → B_4C

Zr-based target

Elemento	A	Half Life	Target dedicati	Ionizzazione
As	**73**	80.3 d	$ZrC - ZrO_2$	FEBIAD
As	**74**	17.77 d	$ZrC - ZrO_2$	FEBIAD
Br	**77**	57 h	$ZrC - ZrO_2$	FEBIAD
Br	**78**	6.46 m	$ZrC - ZrO_2$	FEBIAD
Kr	**79**	34.9 h	$ZrC - ZrO_2$	FEBIAD
Rb	**80**	30 s	$ZrC - ZrO_2$	SIS
Rb	**81**	4.58 h	$ZrC - ZrO_2$	SIS
Rb	**82**	6.3 h	$ZrC - ZrO_2$	SIS
Rb	**83**	86.2 d	$ZrC - ZrO_2$	SIS
Rb	**84**	32.8 d	$ZrC - ZrO_2$	SIS
Sr	**82**	25.34 d	$ZrC - ZrO_2$	SIS
Sr	**83**	32.4 h	$ZrC - ZrO_2$	SIS
Sr	**85**	64.9 d	$ZrC - ZrO_2$	SIS

ZrC foam

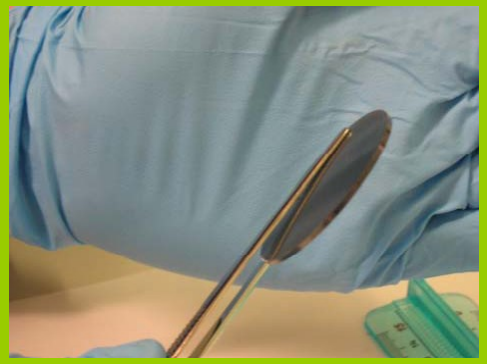


$ZrO_2 + 3C \rightarrow ZrC + 2CO$

Lanthanide-based target

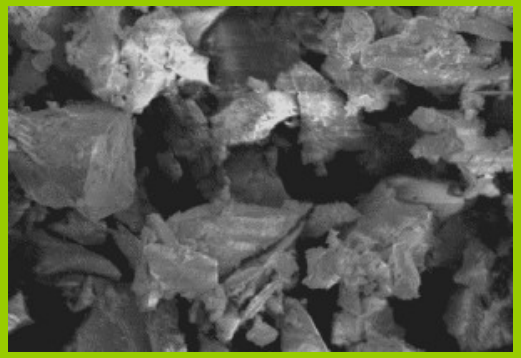
Elemento	A	Half Life	Target dedicati	Ionizzazione
I	126	13.11d	LaCx - CeS	FEBIAD
Xe	127	36.4 d	CeS	FEBIAD
Cs	129	32 h	CeS	SIS
Cs	130	29.2 m	LaCx - CeS	SIS
Cs	131	9.69 d	LaCx - CeS	SIS
Cs	132	6.47 d	LaCx - CeS	SIS
Ba	131	11.5 d	LaCx - CeS	SIS
La	133	3.91 h	CeS	SIS
La	134	6.67 m	CeS	SIS
La	135	19.4 h	CeS	SIS
La	136	9.9 m	CeS	SIS
Ce	135	17.76 h	LaCx	SIS
Pr	137	76.6 m	CeS	SIS
Pr	138	2 h	CeS	SIS
Pr	139	4.5 h	CeS	SIS
Pr	140	3.4 m	CeS	SIS

LaCx



$La_2O_3 + 11C \rightarrow 2LaC_2 + 4C + 3CO$

CeS

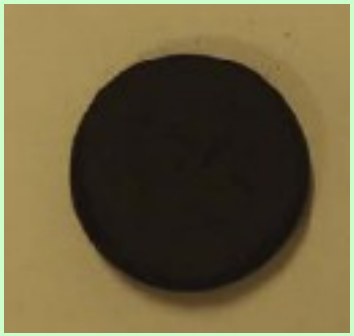


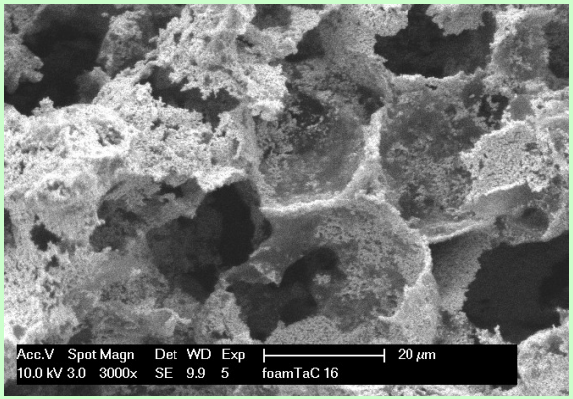
$Ce_2S_3 + CeO_2 + 2C \rightarrow 3CeS + 2CO$

TaC target

Elemento	A	Half Life	Target dedicati	Ionizzazione
Ho	**164**	29 m	TaC	SIS
Tm	**168**	93.1 d	TaC	SIS
Yb	**169**	32 d	TaC	SIS
Lu	**172**	6.7 d	TaC	SIS
Lu	**173**	1.37 a	TaC	SIS
Lu	**174**	3.31 a	TaC	SIS
Hf	**173**	23.6 h	TaC	FEBIAD

TaC foam





$Ta_2O_5 + 7C \rightarrow 2TaC + 5CO$

Boron carbide (B_4C)

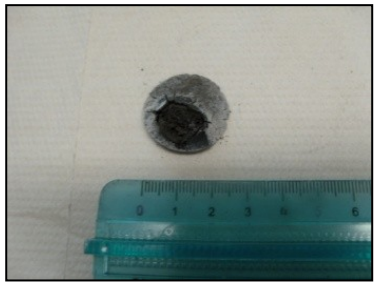
Sol-gel synthesis: boric acid $B(OH)_3$ + citric acid $C_6H_8O_7$

Solution of the acid

Gel formation

Dried gel

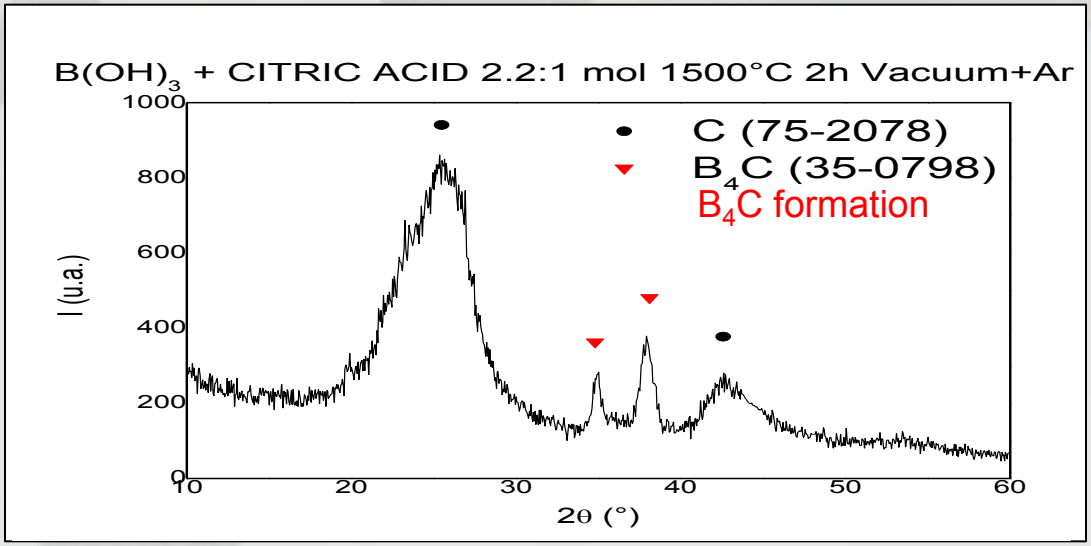
Grounding and cold pressing



Thermal treated sample

Thermal treatment :

- up to 800°C in low vacuum ($5*10^{-2}$mbar), 0.5 °C/min
- up to 1500°C in vacuum with Ar flow ($5*10^{-1}$ mbar), 3°C/min
- 2 hours at 1500°C

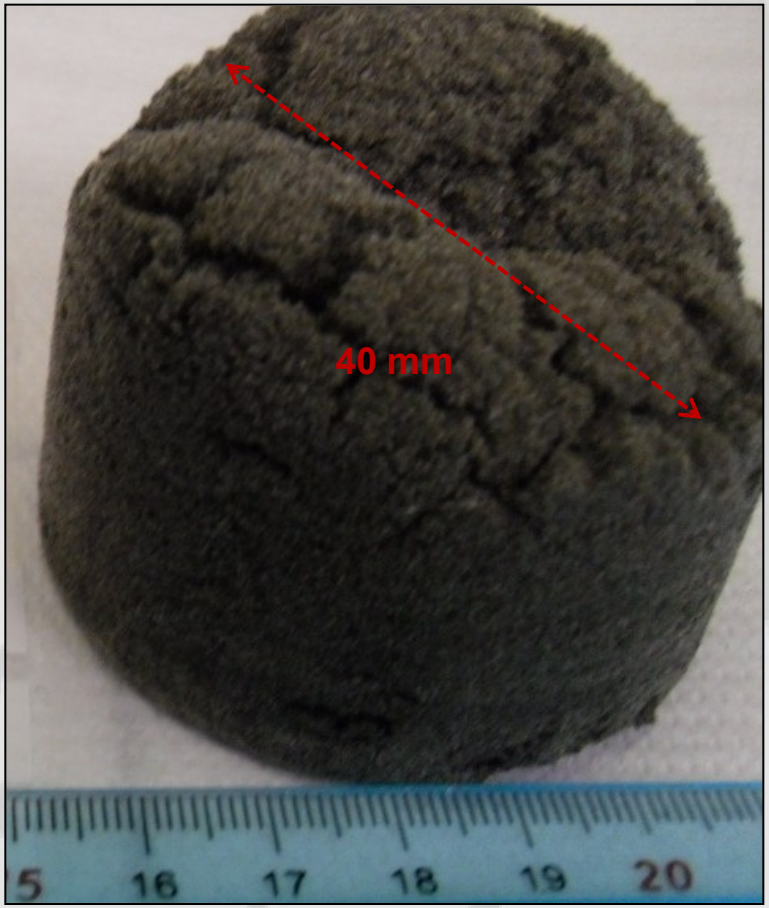


Further treatments:

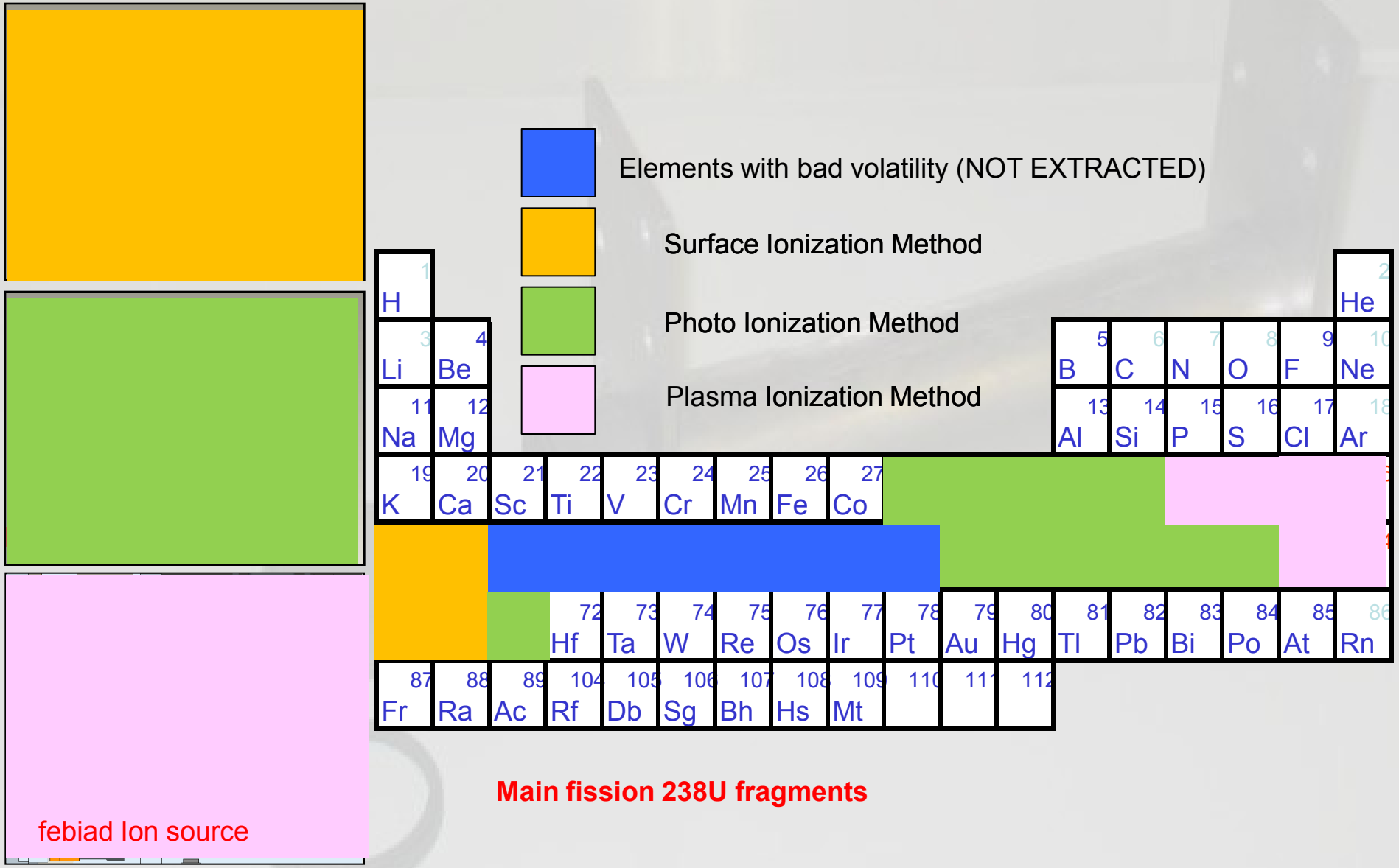
- Different boric acid/citric acid ratios
- Different time/temperatures
- Different pressures during treatment
- Use of binders

New Graphite disks

Graphite foams with different porosity (for effusion tests)



Main n-rich SPES beams



Main fission 238U fragments

SPES Expected neutron rich beams

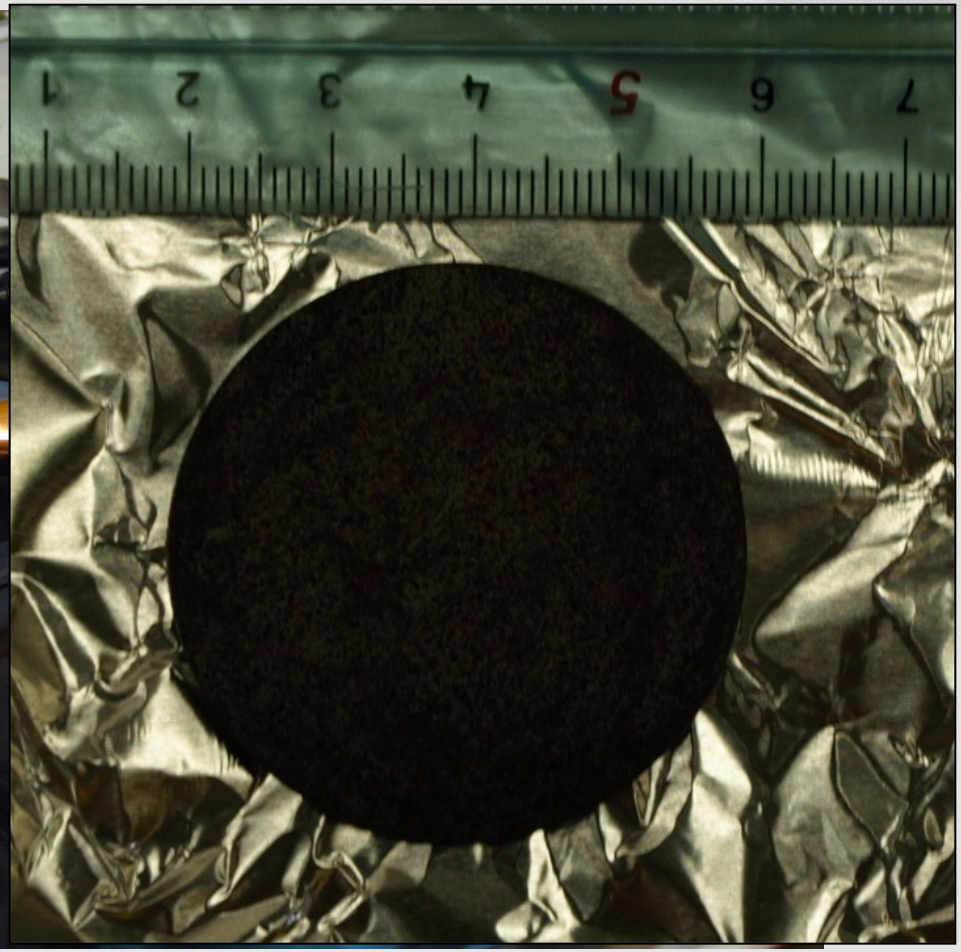
Element	Mass	Most Intense isotope (1/s)	Ioniz. Eff (%)	Target	Ionization method	R&D (difficulty)
Ni	65-69	10^{+6}	6	UCx	LIS	**
Cu	66-76	10^{+6}	7	UCx	LIS	**
Zn	72-79	10^{+6}	5	UCx	LIS	**
Ga	72-84	10^{+6}	20	UCx	LIS	**
Ge	75-84	10^{+7}	3	UCx	LIS	***
Kr	85-93	10^{+7}	30	UCx	FEBIAD	***
Rb	86-94	10^{+9}	65	UCx	SIS	*
Sr	89-96	10^{+8}		UCx	SIS+LIS	***
Y	90-97	10^{+7}		UCx	LIS	****
Pd	111-118	10^{+7}		UCx	LIS	****
Ag	110-120	10^{+8}	14	UCx	LIS	**
Cd	115-124	10^{+8}	10	UCx	LIS	**
In	116-128	10^{+8}	15	UCx	SIS+LIS	**
Sn	123-134	10^{+9}	15	UCx	LIS	**
Sb	124-135	10^{+8}	3	UCx	LIS	***
Te	129-138	10^{+7}		UCx	LIS	****
Xe	137-142	10^{+7}	30	UCx	FEBIAD	***
Cs	134-144	10^{+9}	85	UCx	SIS	*
Ba	139-146	10^{+8}		UCx	SIS+LIS	***
La	141-145	10^{+6}		UCx	SIS+LIS	***

FIRST UCx 40mm. Pellet

Made at Padova UCx Lab (Feb '10)

Before thermal treatment

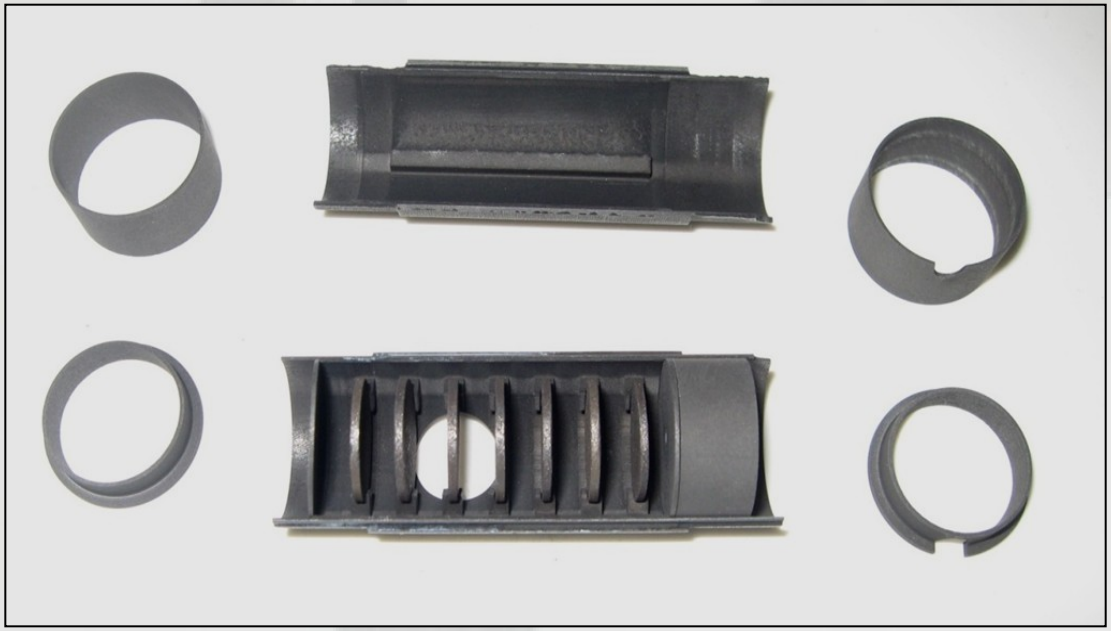
After thermal treatment

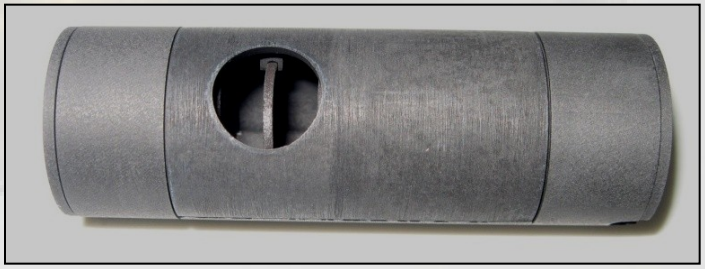


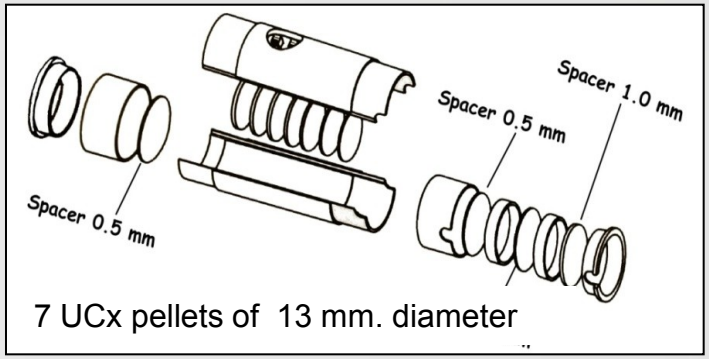
On line UCx test at HRIBF

Thanks to Dan Stracener and ORNL-TIS group

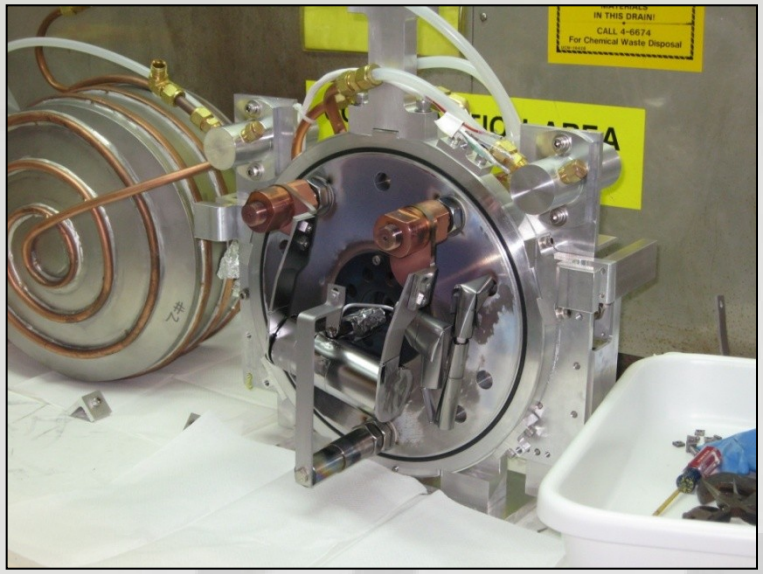
- Seven UC_2 samples SPES Target Group (in collaboration with HRIBF)
- Densities in the range of 4.2 g/cm^3
- Used the SPES design where the targets are spaced out to allow for enhanced radiation to the walls of the container
- Heated to 2000° C for about two weeks without any out-gassing or obvious change in structure (samples observed after the on-line test)

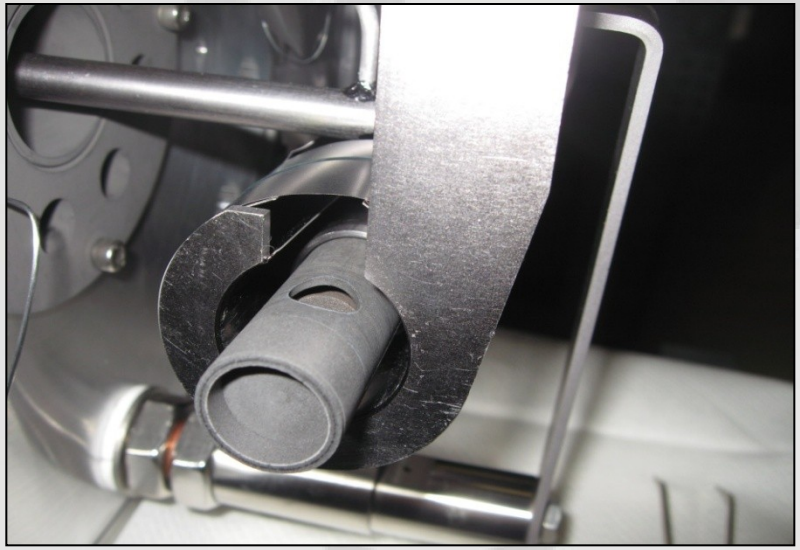




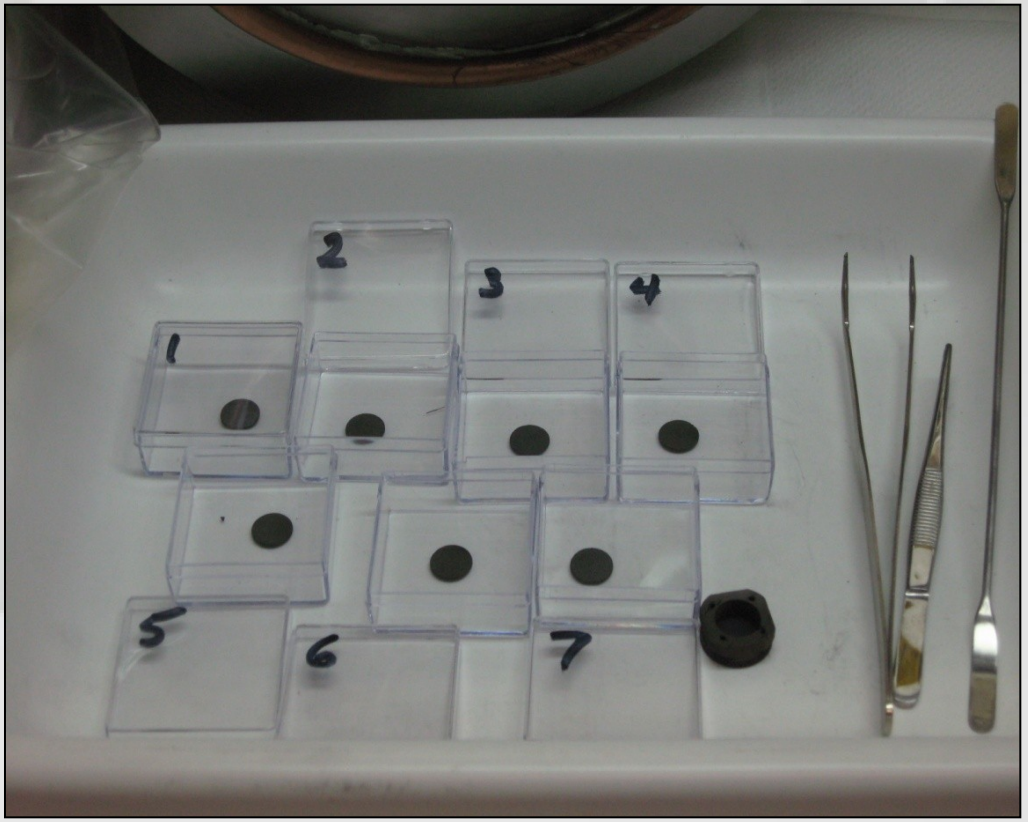


On line UCx test at HRIBF





Target discs status after (6 days) 40 MeV irradiation

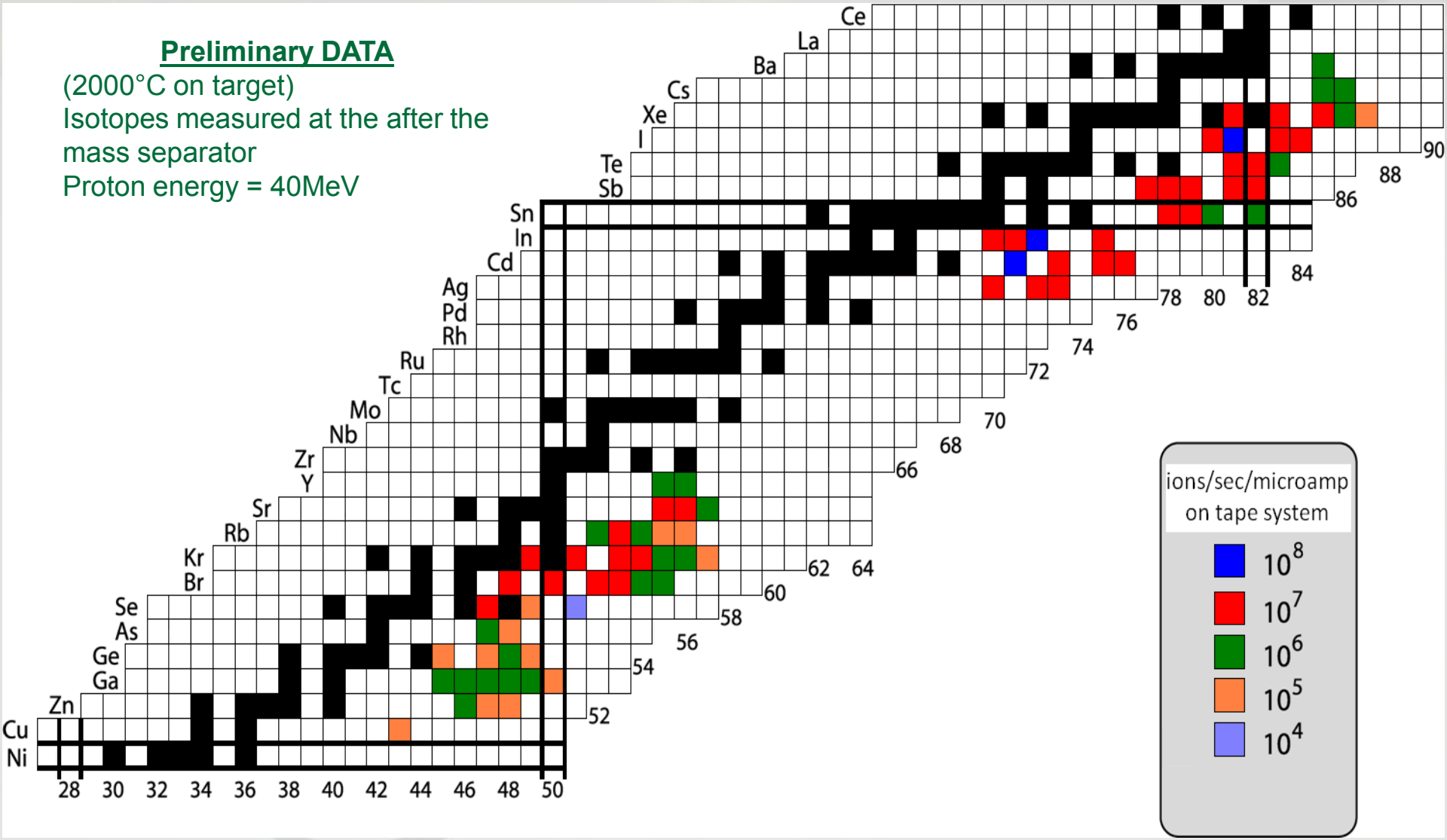


On line UCx test at HRIBF

N-Rich Isotopes yields

Preliminary DATA

(2000°C on target)
Isotopes measured at the after the mass separator
Proton energy = 40MeV



Conclusions

ENSAR – ACTILAB: European contract signed but up to now we do not have green light to go on for fellowship application.

INFN involved in two sub-tasks:

1) Production
2) Characterization

INFN contribution to ACTILAB:

1) development of UCx with CNT in collaboration with CERN
   two complete targets already available at ISOLDE.

2) we have new materials to be characterized and we are interested to collaborate at porosimetry measurements with Orsay.

2011 is a critical year for us about the material development. The Padova Laboratory is closing and we started the developing of a class A laboratory at LNL devoted to UCx development