# SPES DIRECT TARGET Study

Final Goal: development of a Direct Target for SPES

**protons/sec ~ 200 μA → UCx**
**$10^{13}$ fissions/sec**

Fission efficiency → 100p per 1.5 fissions
Beam power = 40 MeV protoni x 200 μA = 8 KW

Direct target→ **7 disks 6 cm ϕ** ~1 mm thick

Energy loss UCx (60gr) → 4.2 KW
(**600 W each disk, ~70 W/gr**)
Window energy loss → 400 W
beam-dump → 3.5 KW

# Project: development of a SPES DIRECT TARGET prototype

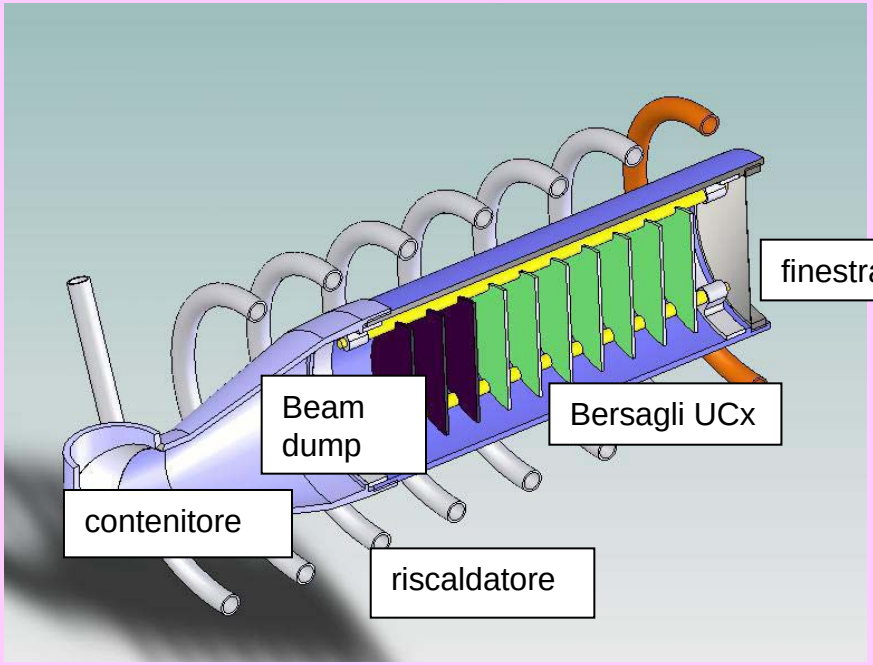



**Fig. 4**. schema del prototipo di bersaglio diretto per SPES

## 1:5 prototype

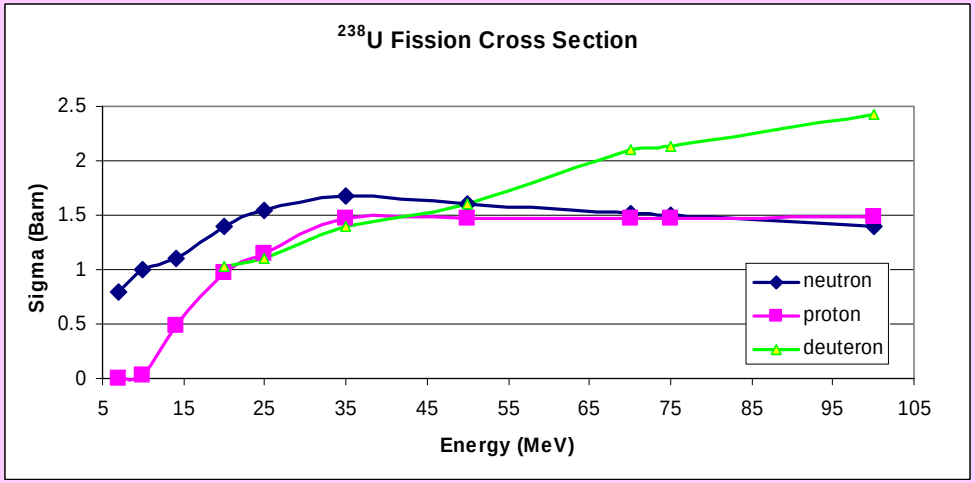
7 Disks 1.2 cm $\phi$ ~1 mm thick
Disk interspace 4 mm

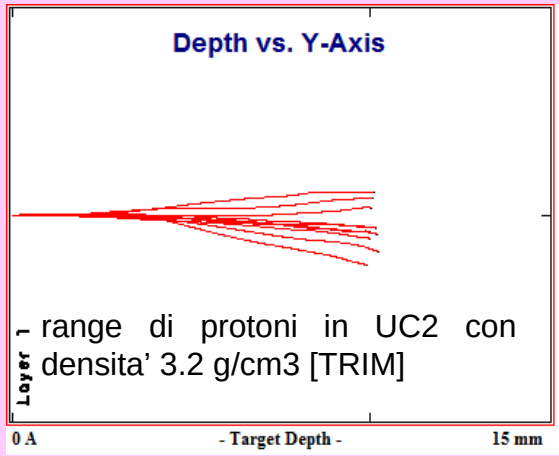
Same density power and geometry as final target

Total dimensions cylinder
2.0 cm $\phi$ x 6 cm length

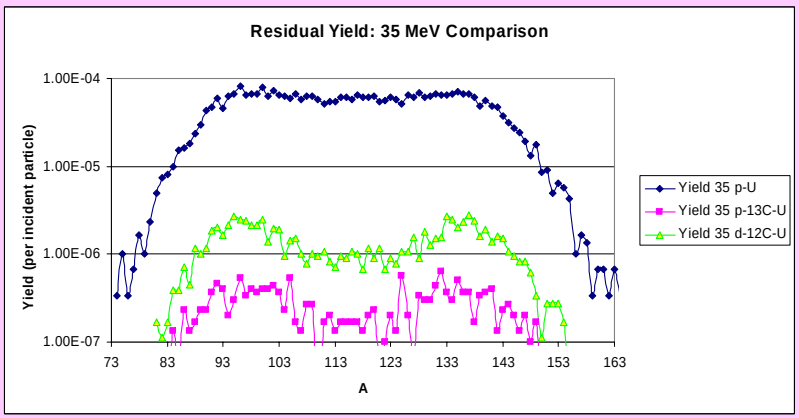
Easily adaptable to existing targets (LNS, ORNL, TRIUMF, ISOLDE)
Low current for final test: 10$\mu$A
Significant tests possible at LNL (2$\mu$A)

# Concepts




- range di protoni in UC2 con densita' 3.2 g/cm3 [TRIM]

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Window energy loss → 400 W

beam-dump → 3.5 KW

(ORNL target: 100 W/gr)

# Planning

**2 years project**:

**2006:** Study of materials not subjected to radioprotection limitations: SiC, LaC
Similar physical characteristics as U
(used as radioactive beam production target at ISOLDE and TRIUMF).
Definition of production and operation methodology.

**2007:** Development and test of UCx targets.
Study of nano-structured materials to reach $10^{13}$ Fission/sec
Possibly set-up of a test-bench for in-beam experiments with Tandem Accelerator

# Reserchers and Tasks

| | |
|---|---|
| **LNL Task#1-3** | A.Andrighetto, G.Prete, F.Gramegna, M.Cinausero, M.Barbui, V.Rizzi, Zafiroupolos, A.Dainelli |
| **Lab. Mat. LNL Task#3** | Sara Carturan, Michele Tonezzer |
| **Dip.Chim. Pd Task#2** | Prof. Plinio Di Bernardo<br>Prof. Pier Luigi Zanonato<br>Laureando Luigi Piga |
| **Dip.Ing. Pd Task#1-2** | Prof Paolo Colombo<br>Prof Giovanni Meneghetti<br>Laureando ?? |
| **ENEA Bo Task#1** | Ing. Carlo Maria Antonucci<br>Ing. Silvio Cevolani<br>Dott. Carlo Petrovich |
| ***LNS* Task#3** | *Cuttone .....* |

| | |
|---|---|
| **Task #1** | **Computing**<br>**ANSYS: thermomechanical calculations**<br>**GEANT4 & RIBO: diffusion-effusion**<br>**MCNPX: on-target productions & shielding.**<br>**FISPACT: activations** |
| **Task #2** | **Pellet Development**<br>**Production of LaC, SiC, UCx pellets**<br>**Research of binder materials**<br>**Research of Carbide Foam** |
| **Task #3** | **Prototype**<br>**Full engineering study of the Target Prototype (rescaled): 1.2 cm disk target diameter, using LaC or SiC pellets**<br>**Test of C Window System (~200 W on 200μm) using TRIPS (80 keV) SPES source Test of the power dissipation**<br>**Emissivity & Conducibility Measurements of the samples** |

# Collaborazione

| | | |
|---|---|---|
| **LNL** | **Sviluppo prototipo** | A.Andrighetto, G.Prete, F.Gramegna, M.Cinau<br>V.Rizzi, Zafiroupolos, A.Dainelli |
| **Lab. Mat. LNL** | **Forno, SEM** | Sara Carturan, Michele Tonezzer |
| **Dip.Chim. Pd** | **Lab chimica Nucleare** | Prof. Plinio Di Bernardo<br>Prof. Pier Luigi Zanonato<br>Laureando Luigi Piga |
| **Dip.Ing. Pd** | **Lab test materiali,**<br>**Calcolo ANSYS sviluppo materiali** | Prof Paolo Colombo<br>Prof Giovanni Meneghetti<br>Laureando ?? |
| **ENEA Bo** | **Calcolo termico e neutronica** | Ing. Carlo Maria Antonucci<br>Ing. Silvio Cevolani<br>Dott. Carlo Petrovich |
| ***LNS*** | ***Sorgenti,***<br>***target EXCITE*** | |

# LNL Logistic and Laboratory

- A laboratory has to be settled and instrumented for characterization and test of single parts and prototype.
- Area available at first floor “sala3” or LAE (60 $m^2$)
- Test-bench may be installed at Tandem accelerator exit*

* Compatibly with PAC scheduled experiments

## LNL Technical support

| | 2006-1/4 | 2006-2/4 | 2006-3/4 | 2006-4/4 | 2007-1/4 | 2007-2/4 | 2007-3/4 | 2007-4/4 |
|---|---|---|---|---|---|---|---|---|
| **PERSONALE tecnico LNL** | **3** | **2** | **2** | **2** | **3** | **3** | **2** | **2** |
| **FTE tecnico LNL** | **2** | **1.5** | **1.5** | **1.5** | **3** | **2** | **1.5** | **1.5** |

# Logistica LNL e Laboratorio

- Messa a punto di un laboratorio attrezzato per la caratterizzazione e il test di singole parti e del prototipo di bersaglio completo
- Area disponibile al primo piano “sala3” o al LAE (60 $m^2$)
- Un Test-bench puo’ essere installato all’uscita dell’acceleratore Tandem *

* Compatibly with PAC scheduled experiments

## Supporto tecnico LNL

| | 2006-1/4 | 2006-2/4 | 2006-3/4 | 2006-4/4 | 2007-1/4 | 2007-2/4 | 2007-3/4 | 2007-4/4 |
|---|---|---|---|---|---|---|---|---|
| **PERSONALE tecnico LNL** | **3** | **2** | **2** | **2** | **3** | **3** | **2** | **2** |
| **FTE tecnico LNL** | **2** | **1.5** | **1.5** | **1.5** | **3** | **2** | **1.5** | **1.5** |

# MILESTONES

| | |
|---|---|
| Gennaio 2006: | Definizione del personale coinvolto<br>Definizione dell'area per il Laboratorio<br>Acquisto strumentazione<br>Calcoli termici preliminari<br>Produzione pastiglie in LaC |
| Marzo 2006: | installazione laboratorio<br>inizio misure di caratterizzazione<br>carburizzazione e sinterizzazione pastiglie SiC, LaC<br>progetto meccanico<br>Produzione |
| Giugno 2006 | completamento laboratorio<br>completamento caratterizzazione materiali (LaC, SiC)<br>fornitura camere di test<br>inizio costruzione prototipo |
| Dicembre 2006 | Completamento prototipo<br>Inizio produzione pastiglie UCx |
| Gennaio 2007 | Inizio installazione test bench al Tandem |

| Planning | 2006-1/4 | 2006-2/4 | 2006-3/4 | 2006-4/4 | 2007-1/4 | 2007-2/4 | 2007-3/4 | 2007-4/4 |
|---|---|---|---|---|---|---|---|---|
| Studio preliminare temperature | EneaBo IngPd | | | | | | | |
| Acquisiz. materiale | LNL | | | | | | | |
| Studio materiali | IngPd ChPd | IngPd ChPd | | | IngPd ChPd | IngPd ChPd | IngPd ChPd | IngPd ChPd |
| Produzione pastiglie + chimica | ChPd | ChPd | | | | ChPd IngPd | ChPd IngPd | |
| Produzione finestre e misure | LNL | LNL | | | | | | |
| Installazione laboratorio | LNL | LNL | LNL | | | | | |
| Realizzazione camere test misure termiche | LNL ext | ext | ext | | | | | |
| Misure caratterizzazione materiali | | LNL (LNS) IngPd | LNL (LNS) IngPd | | | | LNL (LNS) IngPd | LNL (LNS) IngPd |
| Progetto meccanico prototipo | LNL EneaBo | | | | | | | |
| Progetto camera a vuoto e riscaldatore | (LNS) EneaBo IngPd | (LNS) EneaBo IngPd | | | | | | |

| Planning | 2006-1/4 | 2006-2/4 | 2006-3/4 | 2006-4/4 | 2007-1/4 | 2007-2/4 | 2007-3/4 | 2007/4 |
|---|---|---|---|---|---|---|---|---|
| Progetto sistema estrazione | | (LNS) LNL | | | | | | |
| Costruzione prototipo con sistema estrazione | | | LNL ext | (LNS) ext | ext | | | |
| Misure fisica nucleare su bersagli sottili | | LNL (LNS) | | | LNL (LNS) | | | |
| Misure termiche sul prototipo | | | | LNL IngP EneaBo | LNLIng Pd EneaBo | | | |
| Installazione test bench TANDEM | | | | | LNL | LNL | | |
| Misure su test bench | | | | | | LNL (LNS) | LNL (LNS) | LNL (LNS) |
| PERSONALE tecnico LNL | 3 | 2 | 2 | 2 | 3 | 3 | 2 | 2 |
| FTE tecnico LNL | 2 | 1.5 | 1.5 | 1.5 | 3 | 2 | 1.5 | 1.5 |

# Lavoro Preliminare

- Calcoli termici
- Analisi ANSYS
- Produzione pastiglie (LaC)
- Acquisto strumentazione (Pirometri, power supply) e messa in funzione forno sotto vuoto

# Preliminary work

- ENEA thermal calculations
- ANSYS analysis
- Pils production (LaC)
- Instrumentation restored (evaporator) and new parts ordered (Pirometers, high power supply)

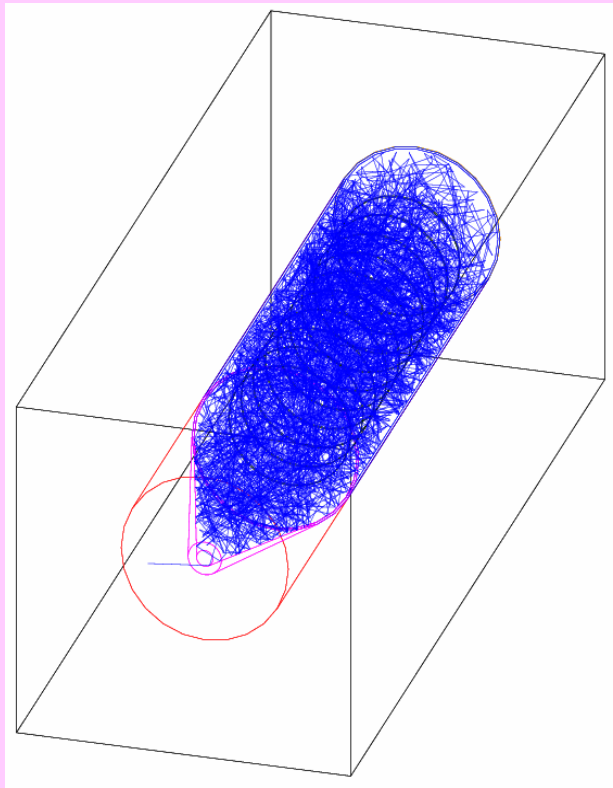
# Effusion time

## Preliminary Calculation with RIBO (M. Santana Leitner (Cern))

- Isotope considered: $^{132}Sn$
- Effusion time without sticking: 0.25 *s*

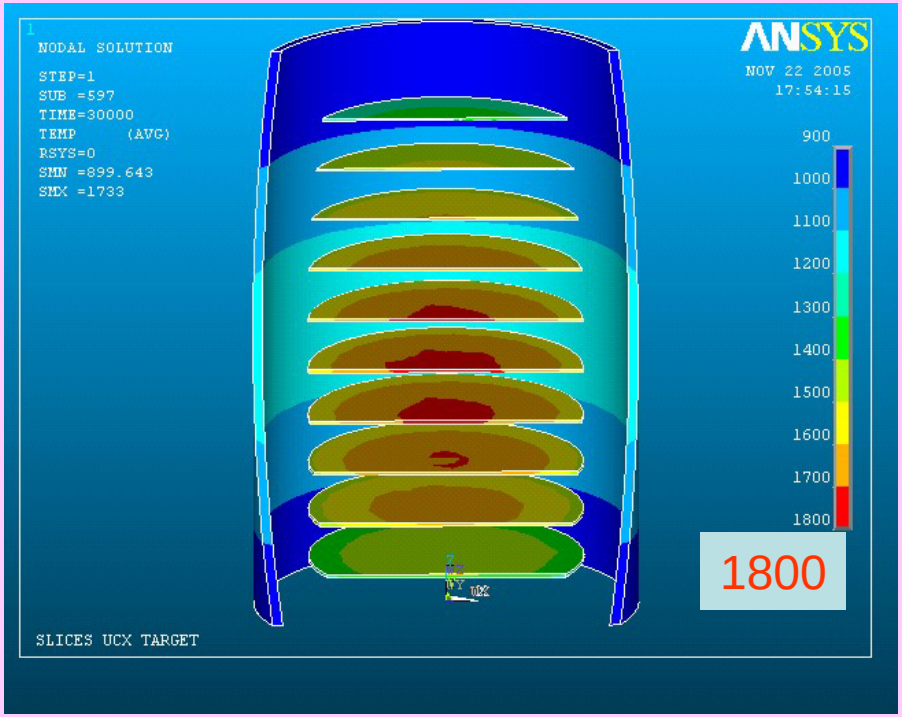
## Preliminary Calculation with Geant4 (Marina)

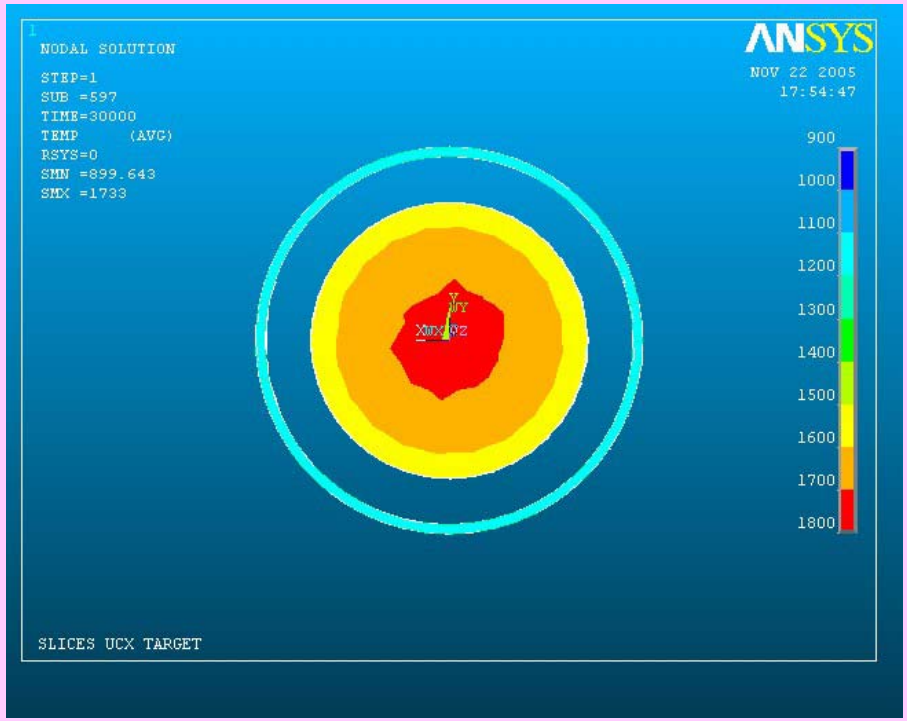
- Isotope considered: $^{132}Sn$
- Effusion time without sticking: 0.2 *s*



# Thermal Calculation :

(Similar results obtained with ENEA and Ansys codes)




Preliminary calculation: starting Box Temperature 30 °C

# Pellets production (Dip.Chimica Pd)

$$La_2(C_2O_4)_3 + 14C$$

Carburization with excess of graphyte:

$$La_2(C_2O_4)_3 + 14C \rightarrow 2LaC_2 + 4C + 12CO$$

Just to obtain $LaC_2$

- 76,3% of $La_2(C_2O_4)_3$ & 23,7% of C.



Idraulic Presses *Maassen Spektroskopie*. Max 25 tons.

# $La_2(C_2O_4)_3$+ 14C pellet with Binder


← binder

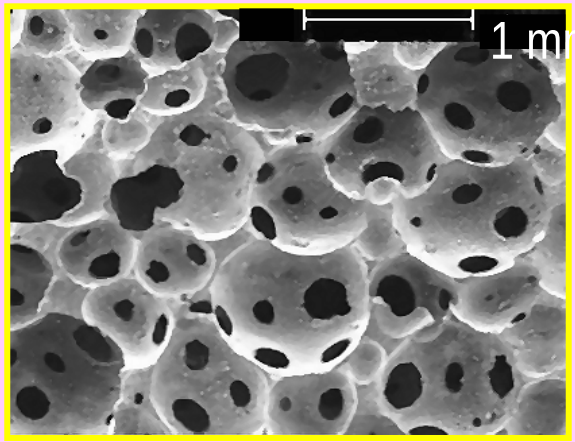
(5% in acetone)

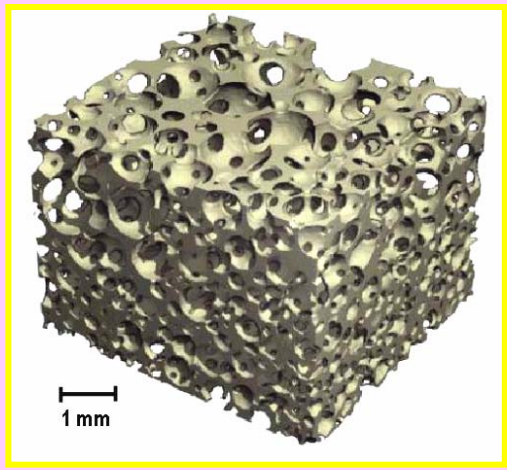

$La_2(C_2O_4)_3$+ 14C

With binder

(only 2 drops ! )

# Padova Foam Lab (P.Colombo Dip. Ingegneria)




Macro-cellular Ceramic Foams