



Interazione Radiazione - Materia: Plasmi, Nanomateriali ed Applicazioni

L. Silipigni & L. Torrisi

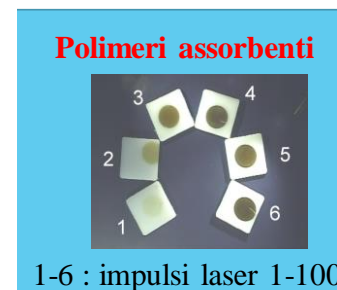
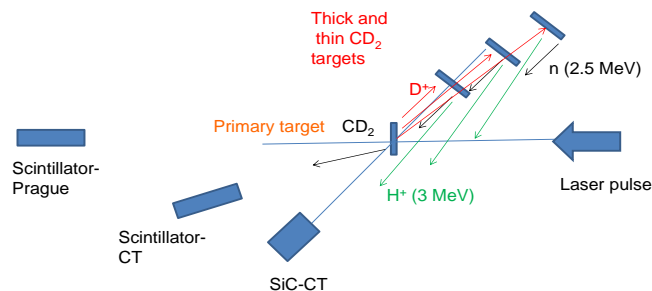
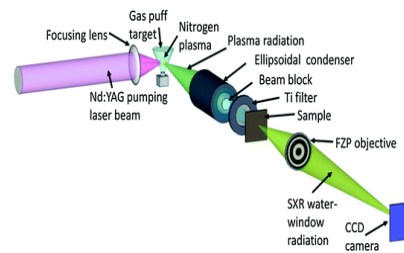
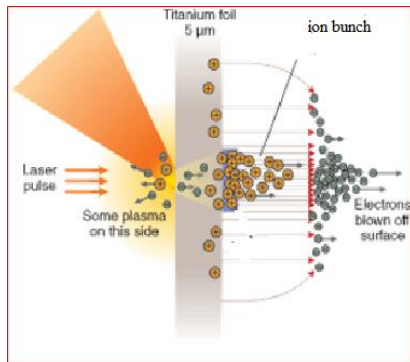
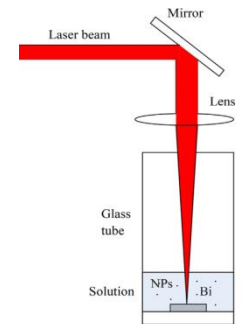
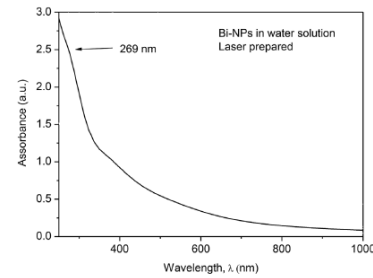
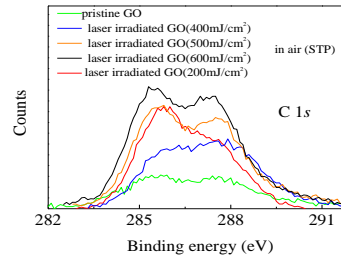
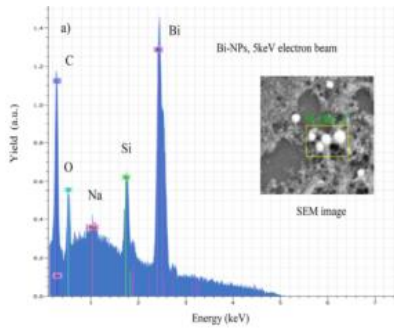
Dipartimento MIFT - Università degli Studi di Messina

Laboratorio di Fisica dei Plasmi Laser

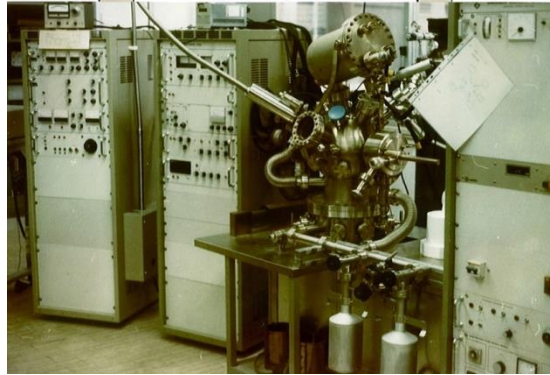
&

Laboratorio di Analisi Spettroscopiche

Interazione radiazione – materia: per compiere studi in vari settori di ricerca



Laboratorio di Analisi spettroscopiche - MIFT



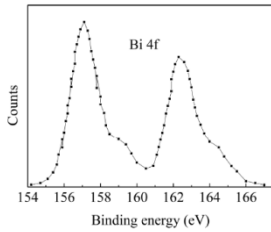
XPS

ma anche

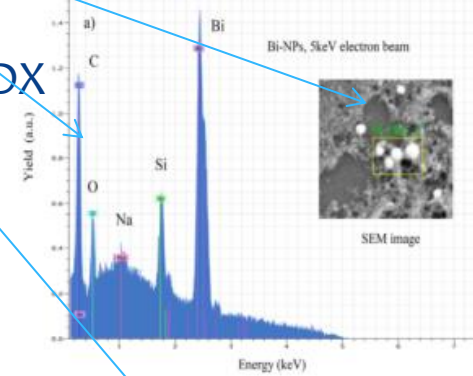
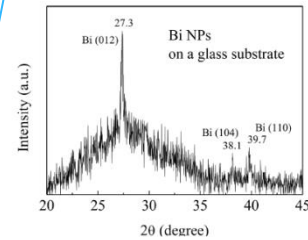
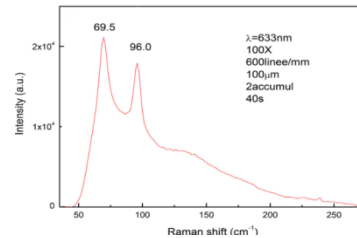
SEM

XRD

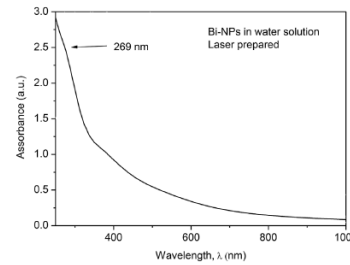
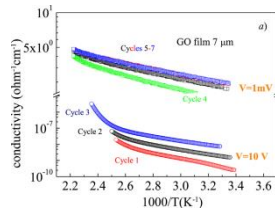
EDX



Raman

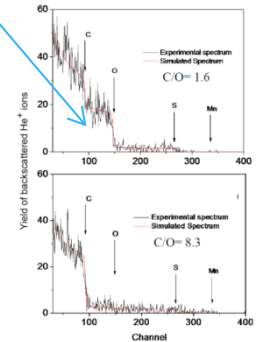


Trasporto elettrico

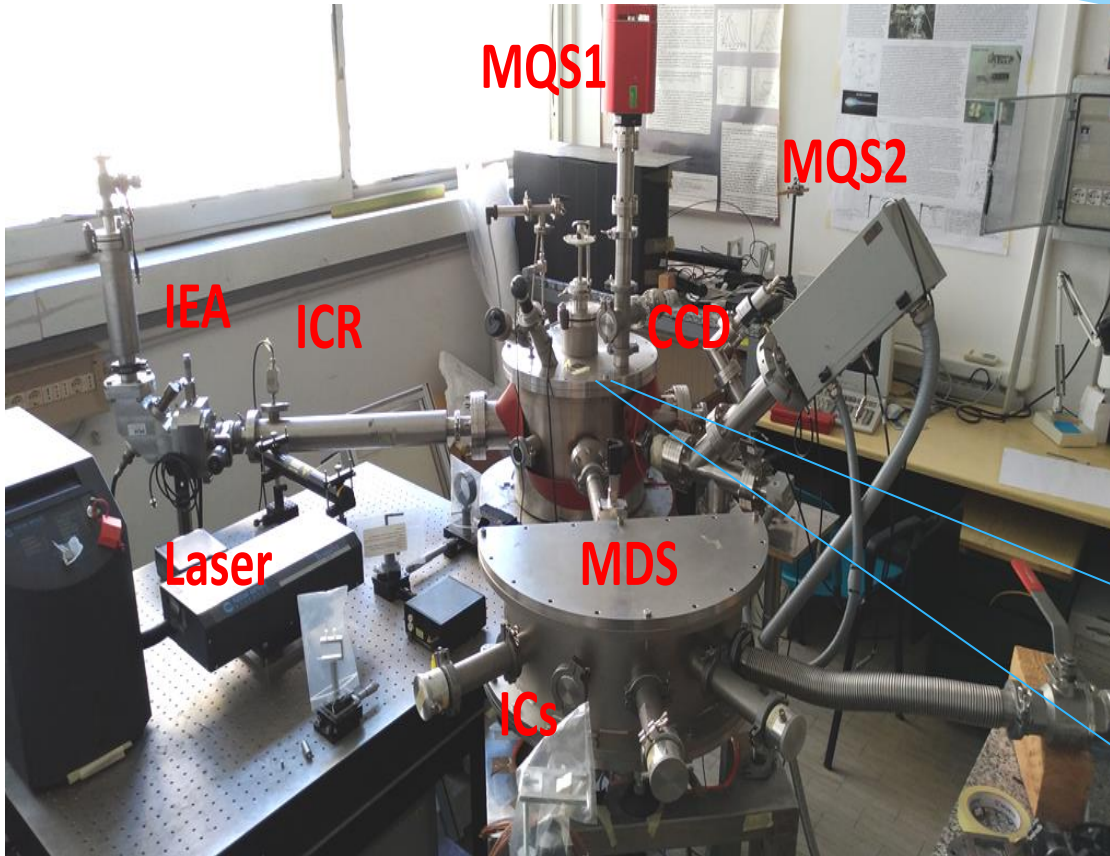


UV-Vis-NIR

RBS



Laboratorio di Fisica dei Plasmi Laser - MIFT



Nd:YAG, 1064 nm , 6 ns , 600 mJ, $I=10^{11}$ W/cm²

Nd:YAG, 1064 nm , 32nm, 355nm 3ns , 850 mJ, $I=10^{12}$ W/cm²

Impulso singolo o ripetitivo (1-10 Hz).

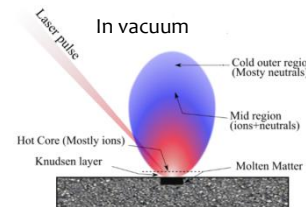
Irraggiamenti focalizzati su target solidi (metalli, polimeri, semiconduttori)



Tecniche diagnostiche di plasmi laser a media T:

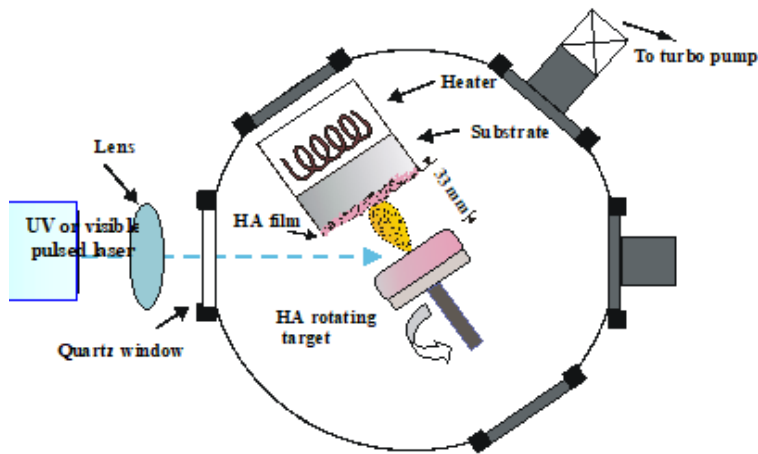
- distribuzioni in E
- abbondanza specie ionica
- rivelazione specie chimiche
- rivelazione isotopi
- T_{plasma}
- monitoraggio stati di carica degli ioni

$$n_{\text{elettroni, ioni}}, kT_{\text{plasma}}, E_{\text{max ion}}, Z_{\text{max ioni}} \propto I_{\text{laser}} \lambda_{\text{laser}}$$



Deposizione di film sottili da laser pulsati PLD

In lab

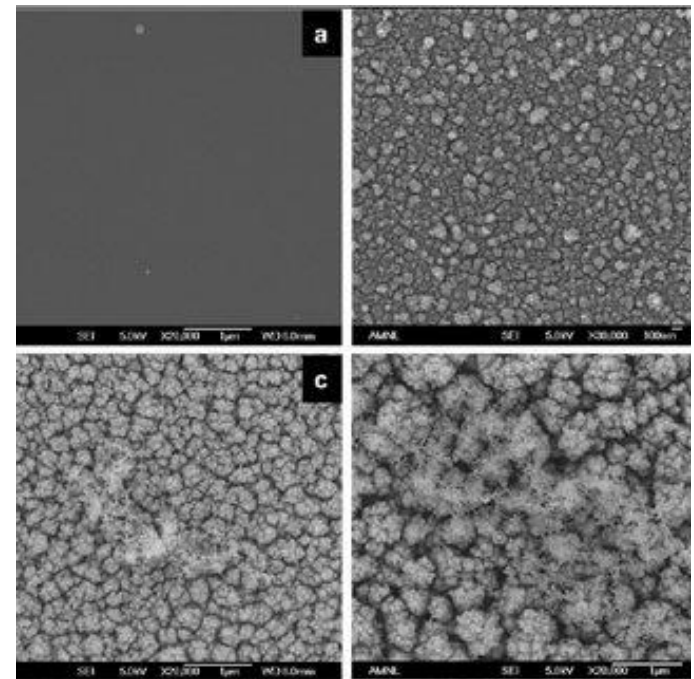


Deposition method: Pulsed Laser ablation in high vacuum chamber (pressure lower than 1×10^{-6} torr)

Lasers :
excimer KrF (248 nm),
excimer XeCl (308 nm)
ruby laser (694 nm)
pulse width ~20 ns, rate 15 Hz,
Energy for pulse 100-500 mJ,
Fluency 2-20 Jcm⁻², spot area 1-20 mm²

Target: rotating HA pellets

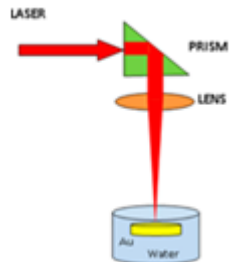
Substrates: c-Si and Ti held at 500°C



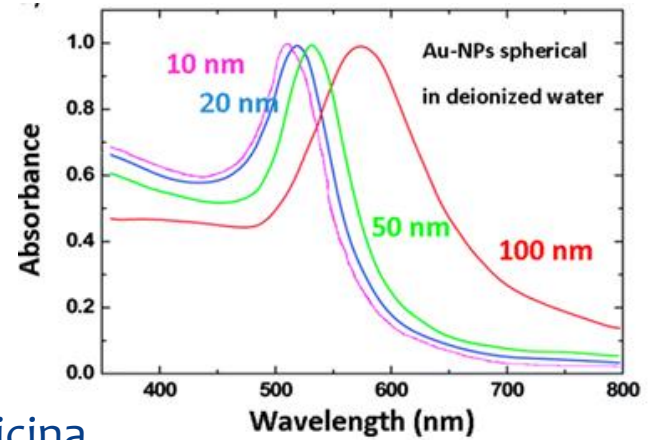
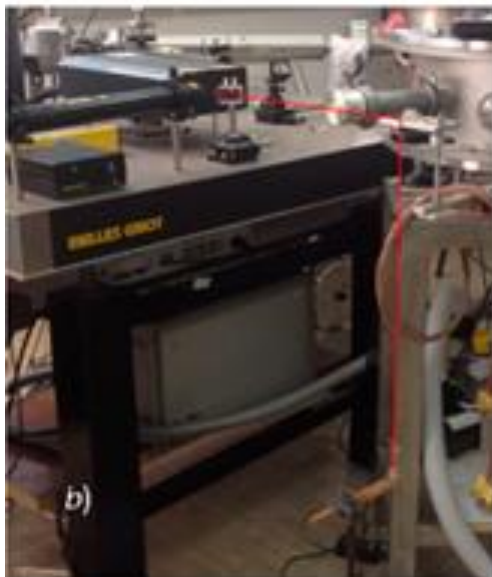
HydroxyApatite ($\text{Ca}_{10}(\text{PO}_4)_6(\text{OH})_2$)

In lab

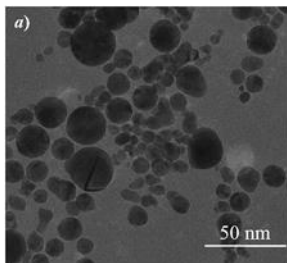
Pulsed laser ablation in liquid PLAL



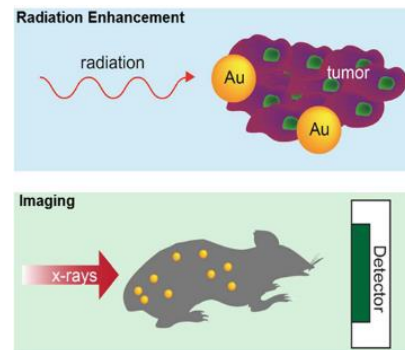
Nanoparticelle di Au in acqua
a varie concentrazioni



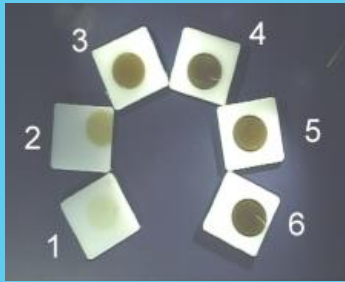
In medicina



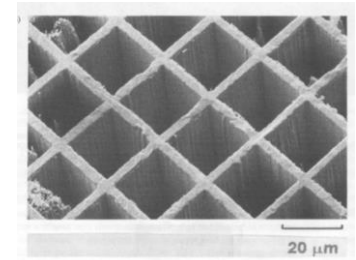
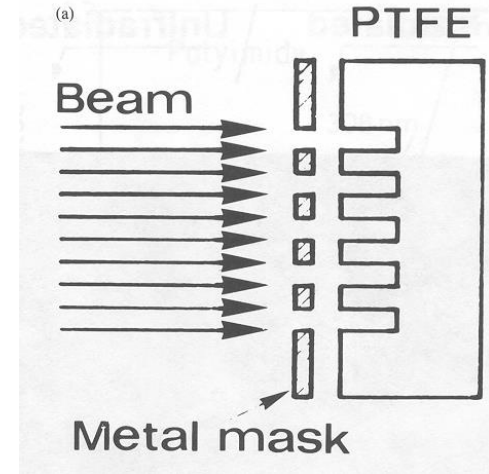
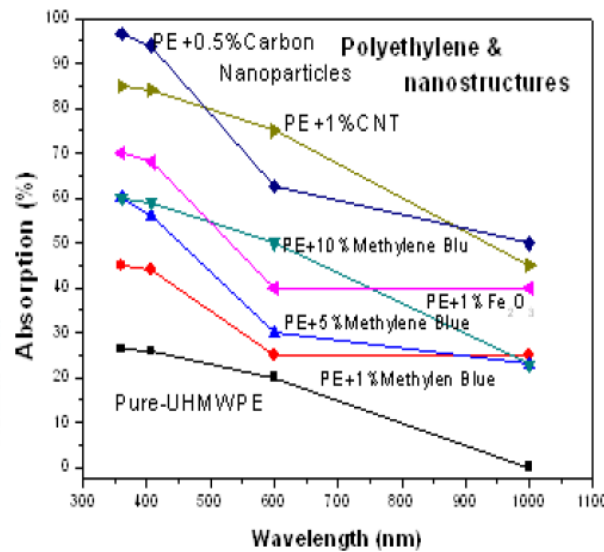
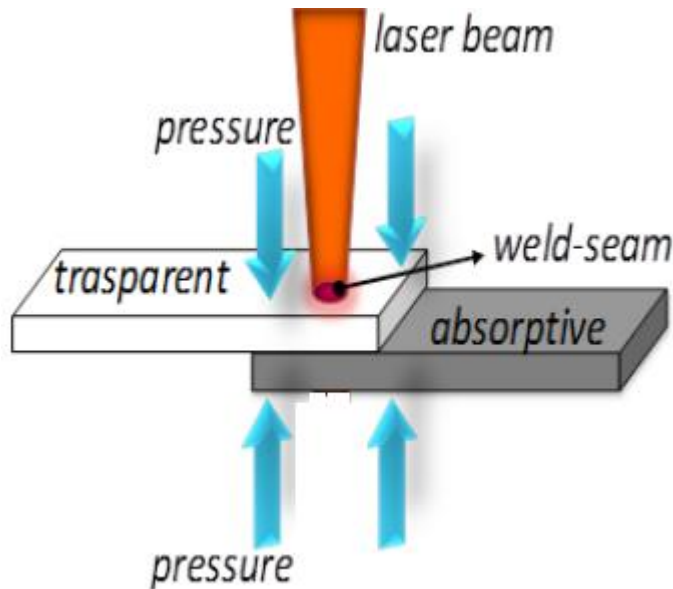
NPs di Au



Polimeri assorbenti



1-6 : impulsi laser 1-100

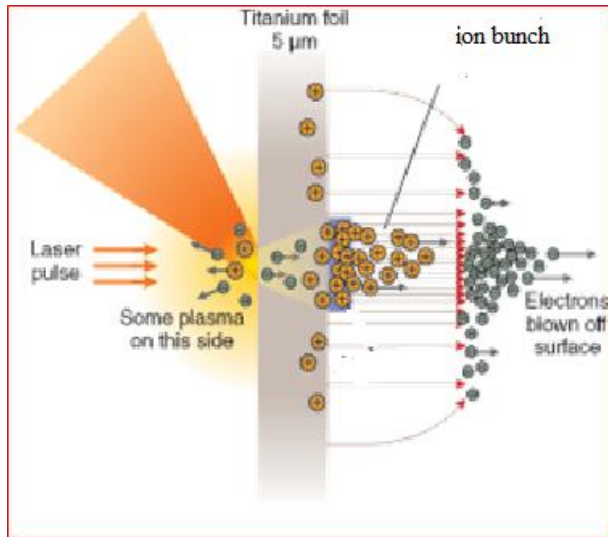


Abroad:

Sorgenti di ioni, elettroni, raggi X,...

fascio laser
ad alta intensità

(10^{16} W/cm² - 10^{19} W/cm²) TNSA (target-normal-sheath-acceleration)



Target sottili : subμm-20μm

Plasma in non equilibrio ad alta T (10^7 K) e alta densità (10^{18} atomi/cm³)

Emissione direzionata

Elevati campi elettrici ($E \geq 10^{12}$ V/M) tra le nuvole di elettroni e di ioni

$$E = \sqrt{n_e kT / \epsilon_0}$$

Intensità: 10^{16} W/cm² , ps,
 10^{19} W/cm² , 10 fs,

~ 1 MeV/z (PALS-Czech Republic)
~ 10 MeV/z (IPPLM-Poland)

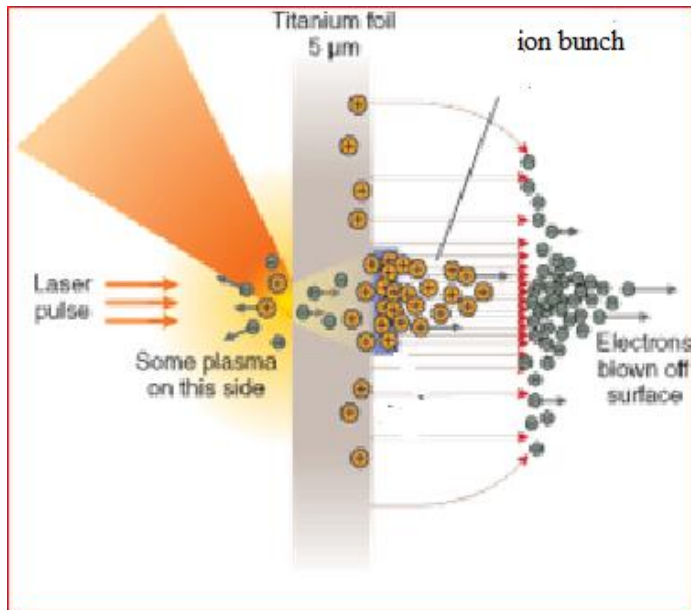
Progetto Europeo ELI (Extreme Light Infrastructure)-Praga: (10^{23} – 10^{24})W/cm², fs e campi elettrici di 10^{15} V/m su un 'area di alcuni μm²- advanced targets, protoni~100 MeV .

Sorgenti di ioni, elettroni, raggi X,...

Abroad:

fascio laser
ad alta intensità
($10^{16} \text{ W/cm}^2 - 10^{19} \text{ W/cm}^2$)

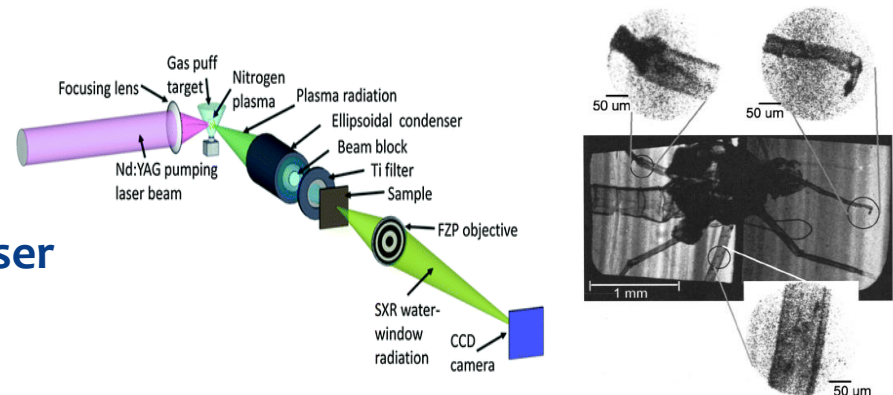
impulsi dal ps al fs
Au H, C



Applicazioni:

- Sorgenti di ioni di vari elementi ed ad elevato stato di carica (i.e.: $\text{C}^+ \dots \text{C}^{6+}$)
- Nuove tecniche di accelerazione di ioni (protoni fino a 100 MeV)
- Sorgenti di elettroni (da 1 keV fino a 100 MeV dipende dal tipo di laser ns,..) e di raggi X di alta intensità con piccole dimensioni (sotto il mm^3)

Microscopia 3D a raggi X da plasm laser



Reazioni nucleari

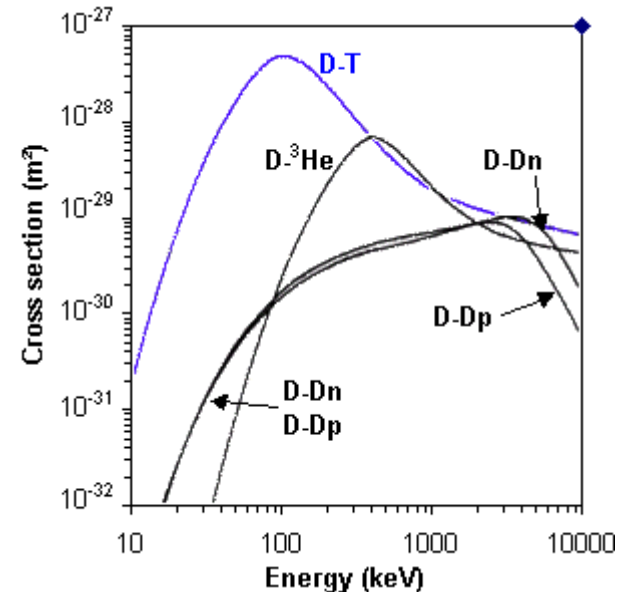
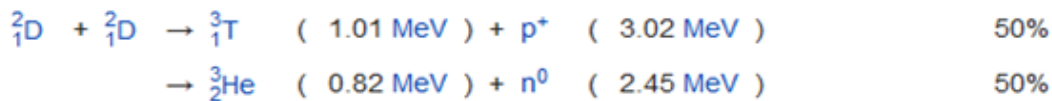
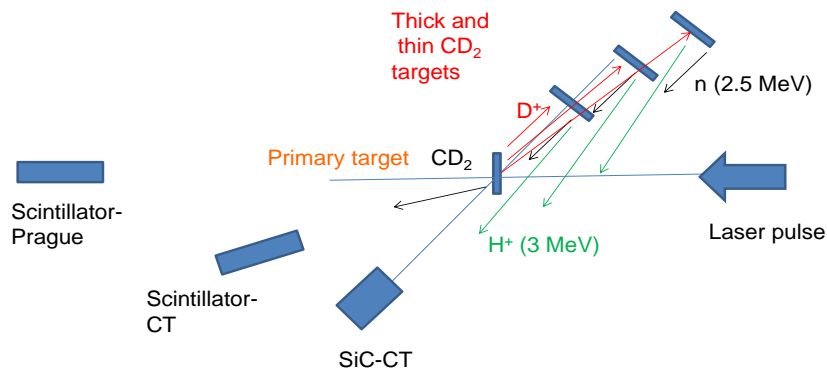
PALS laboratory
of Prague

Abroad:

fascio laser
ad alta intensità
(10^{16} W/cm²)

impulsi da 300ps

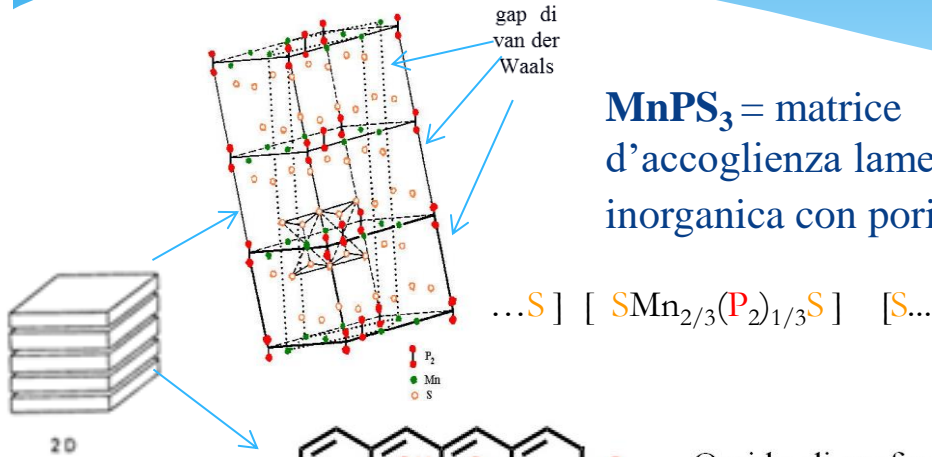
- Le temperature molte elevate raggiunte dal plasma creano le condizioni necessarie per generare reazioni nucleari (D-D, D-T) senza far uso di acceleratori



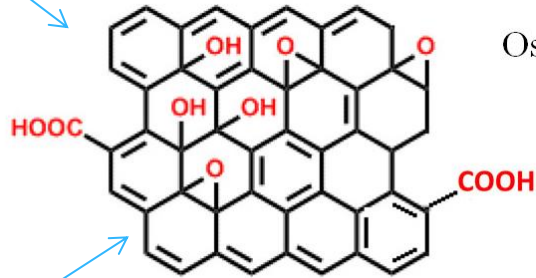
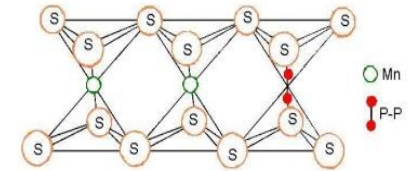
Tokamak

L. Torrìsi et Al., "Monoenergetic proton emission from nuclear reaction induced by high intensity laser-generated plasma", *Review of Scientific Instruments* 83, 02B11,1-3 (2012)

Labs AS&FPL: sistemi bidimensionali

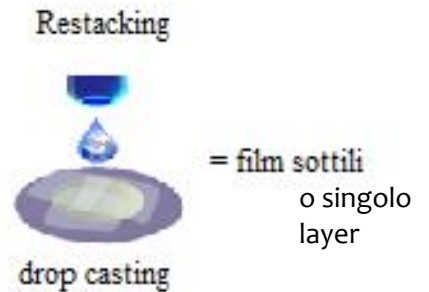
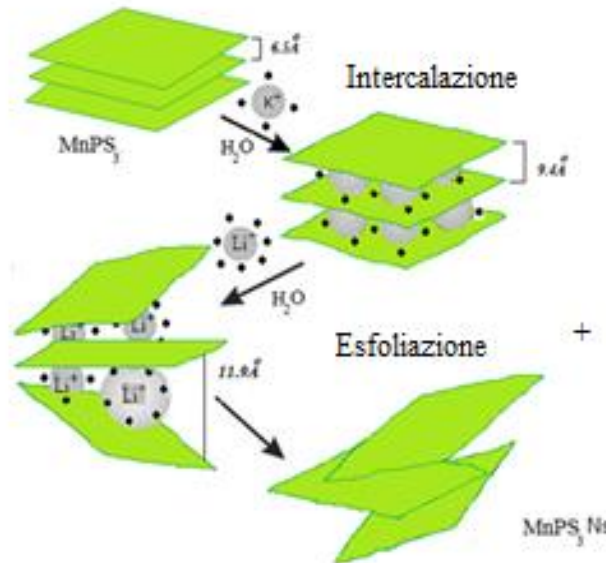


il singolo sandwich $[\text{SMn}_{2/3}(\text{P}_2)_{1/3}\text{S}]$ è il blocco elementare di base e consiste in:



Ossido di grafene (GO)

Tecnica intercalazione-esfoliazione-restacking



Un singolo foglio di GO ha uno spessore di circa 1 nm e dimensioni laterali che variano da alcuni nm a centinaia di μm .





Progetto INFN-Gr. V, Sezione di Catania

Carbon-Based Innovative Materials for Nuclear Physics Applications (CIMA)

Responsabile Nazionale: Prof. L. Torrisi

Collaborazioni (con protocolli di intesa):

- PALS, Prague, Czech Republic, Dr. K. Jungwirth, Dr. J. Krasa
- **NPI-Accademia delle Scienze-CANAM, Rez, Czech Republic, Dr. J. Vacik, M. Cutroneo, A. Makova**
- **IPPLM, Warsaw, Poland, Prof. J. Wolowski, Prof. J. Badziak, Dr. M. Rosinski**
- CLPU, Villamayor, Salamanca, Spain, Prof. L. Roso
- PPD, WRCP, HAS, Budapest, Hungary, Dr. I. Foldes
- ENEA, Frascati, Dr. De Angelis
- INFN-LNS, Catania, Dr. S. Gammino
- Università del Salento, Proff. V. Nassisi, D. Manno, A. Serra, L. Calcagnile, G. Buccolieri
- Università di Pisa, Prof. D. Giulietti
- Università di Catania, Prof. L. Calcagno,
- CNR-IPCF, Dr. B. Fazio, Dr. G. Di Marco, Dr. G. Salvato
- CNR-IMM, Dr. Sciuto

Possibili elaborati o tesi di ricerca :

- Generazione di UV, raggi X, fasci di elettroni e di ioni e loro utilizzo come tecniche di analisi di superficie
- Trattamento e modifica di materiali con fasci laser e di particelle
- Processi di accelerazione di ioni in plasmi e induzione di reazioni nucleari per radioterapia
- Deposizione e caratterizzazione di film sottili nanostrutturati (nanoparticelle, nanocristalli, strutture 2D,...)

Possibili stage:

n. 1

« Analisi di materiali con tecniche spettroscopiche di superficie» (primo semestre)

n. 1

« Trattamento di materiali con fasci laser » (secondo semestre)

con 1 studente a semestre

The background features a vibrant blue light flare effect. A bright, multi-colored beam of light (ranging from white to cyan) originates from the left edge and extends horizontally across the center. From this central beam, numerous thin, radiating lines of varying shades of blue fan out towards the right, creating a sense of depth and energy. The overall color palette is dominated by various tones of blue, from deep navy to bright cyan and white at the light source.

Grazie per l'attenzione!!!

L. Silipigni & L. Torrisi