SL_COMB

LABORATORI NAZIONALI DI FRASCATI
RESP. NAZ.: DR. ENRICA CHIADRONI (LNF)

LECCE (A. LORUSSO)
MILANO (L. SERAFINI)
NAPOLI (R. FEDELE)
ROMA I (A. MOSTACCI)
ROMA II (A. CIANCHI)

COMB= COHERENT (RESONANT) PLASMA OSCILLATIONS BY MULTIPLE ELECTRON BUNCHES

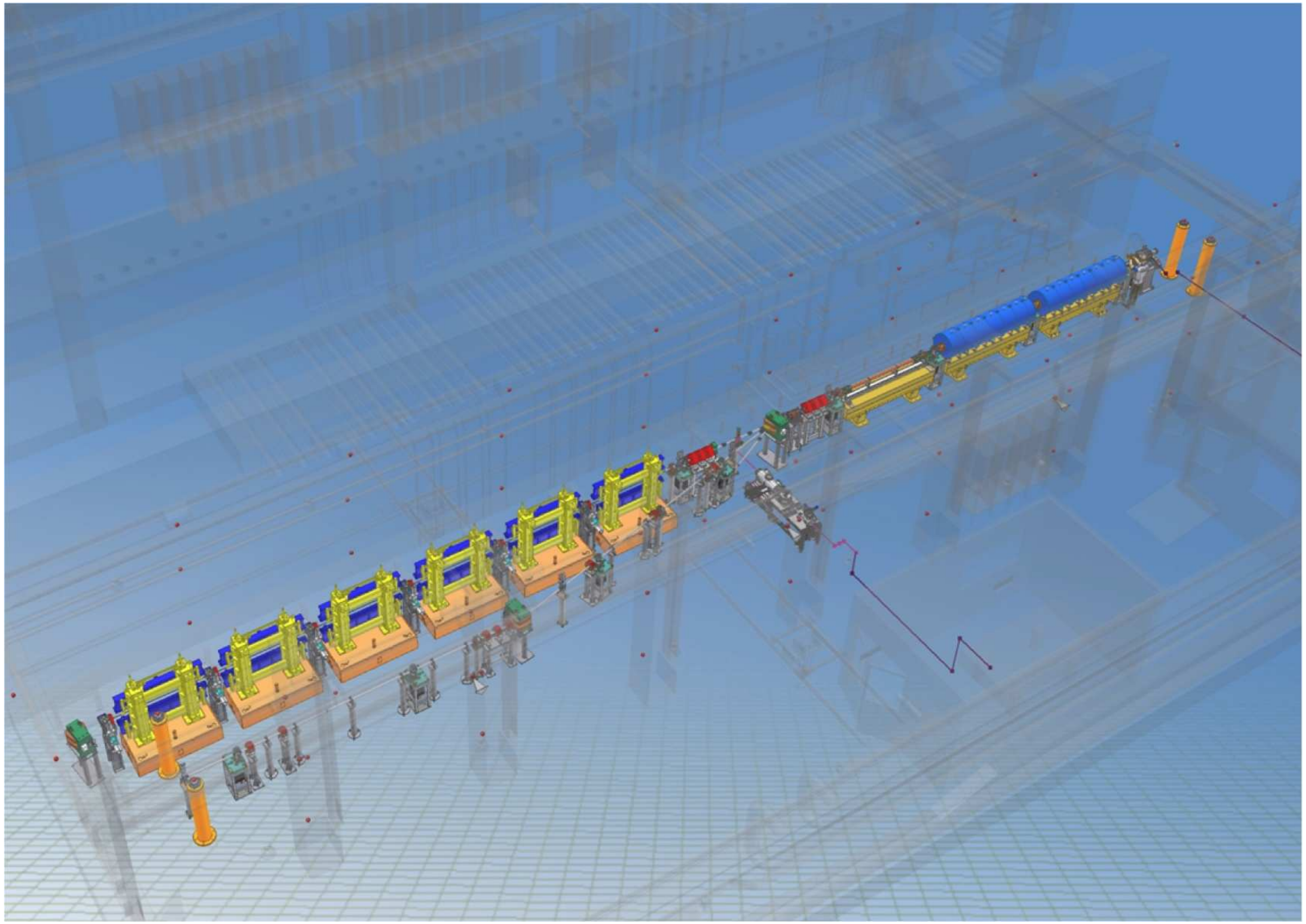
Scientific Interest

Plasma-based accelerators are of great interest because of their ability to:

•Sustain ultra-high accelerator gradients (~10 GV/m) enabling the development of compact accelerators.

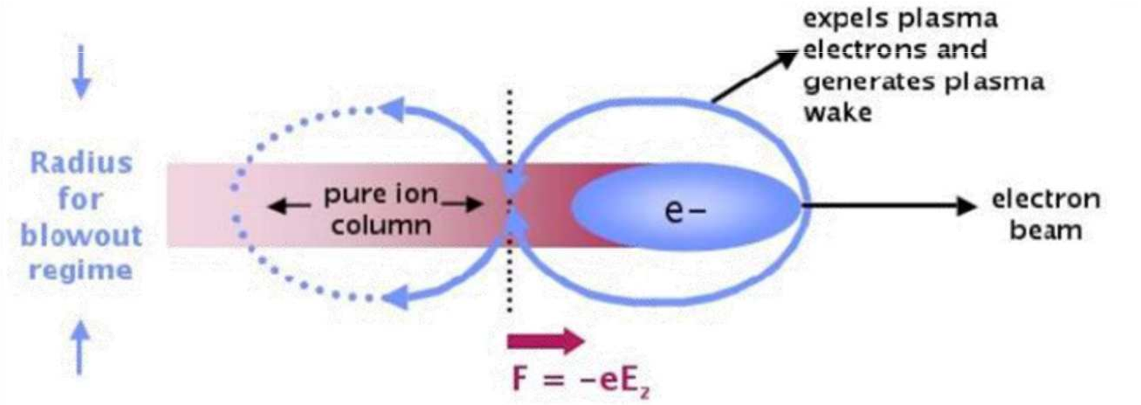
•Produce extremely short electron bunches, enabling the production of advanced radiation sources

Facility SPARC_LAB
Laboratori Nazionali di Frascati

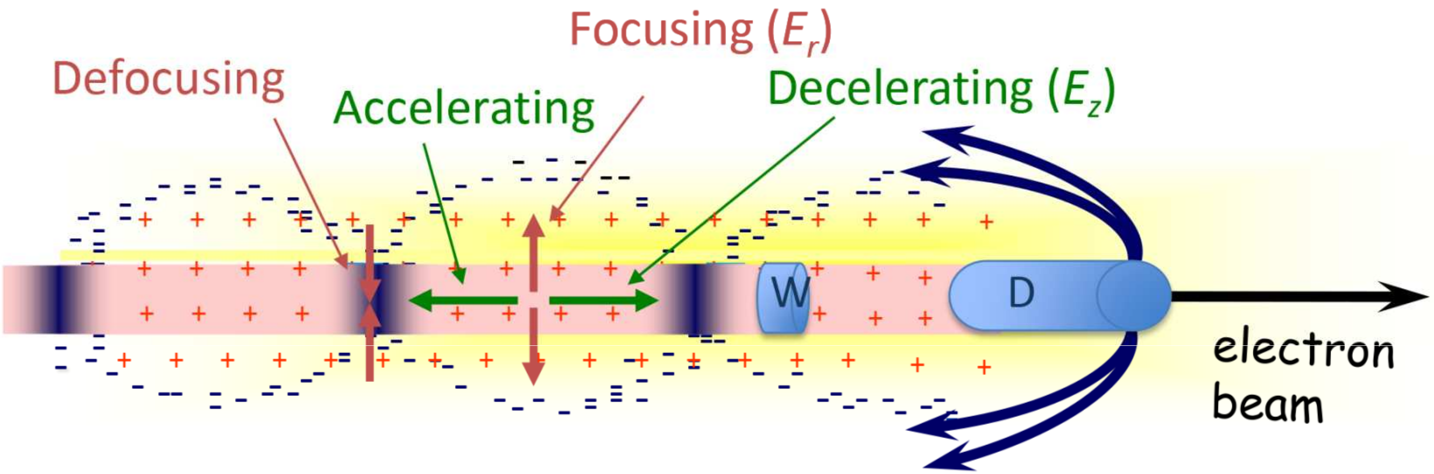


Particle-driven plasma-based Wakefield Accelerator (PWFA)

The high-gradient wakefield is driven by an intense, high-energy charged particle beam as it passes through the plasma.
The space-charge of the electron bunch blows out the plasma electrons which rush back in and overshoot setting up a plasma oscillation.



2-bunch Train PWFA



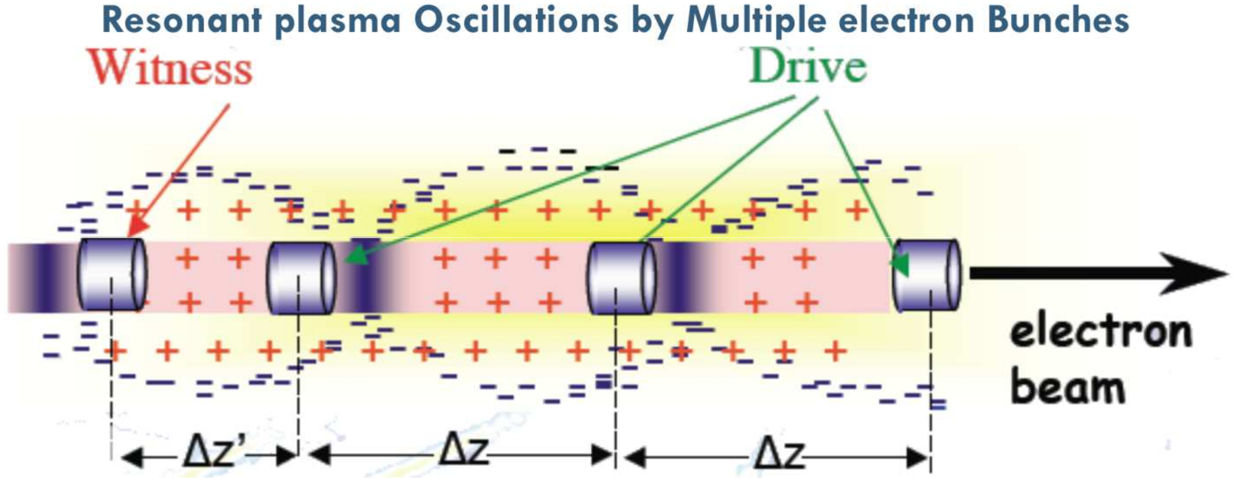
A second, appropriately phased accelerating beam (**witness beam**), containing fewer particles than the **drive beam**, is then accelerated by the wake.

Bunch train (D+W) for bunch acceleration

(ΔE/E<<1)

Particle-driven plasma-based Wakefield Accelerator (PWFA)

COMB Principle

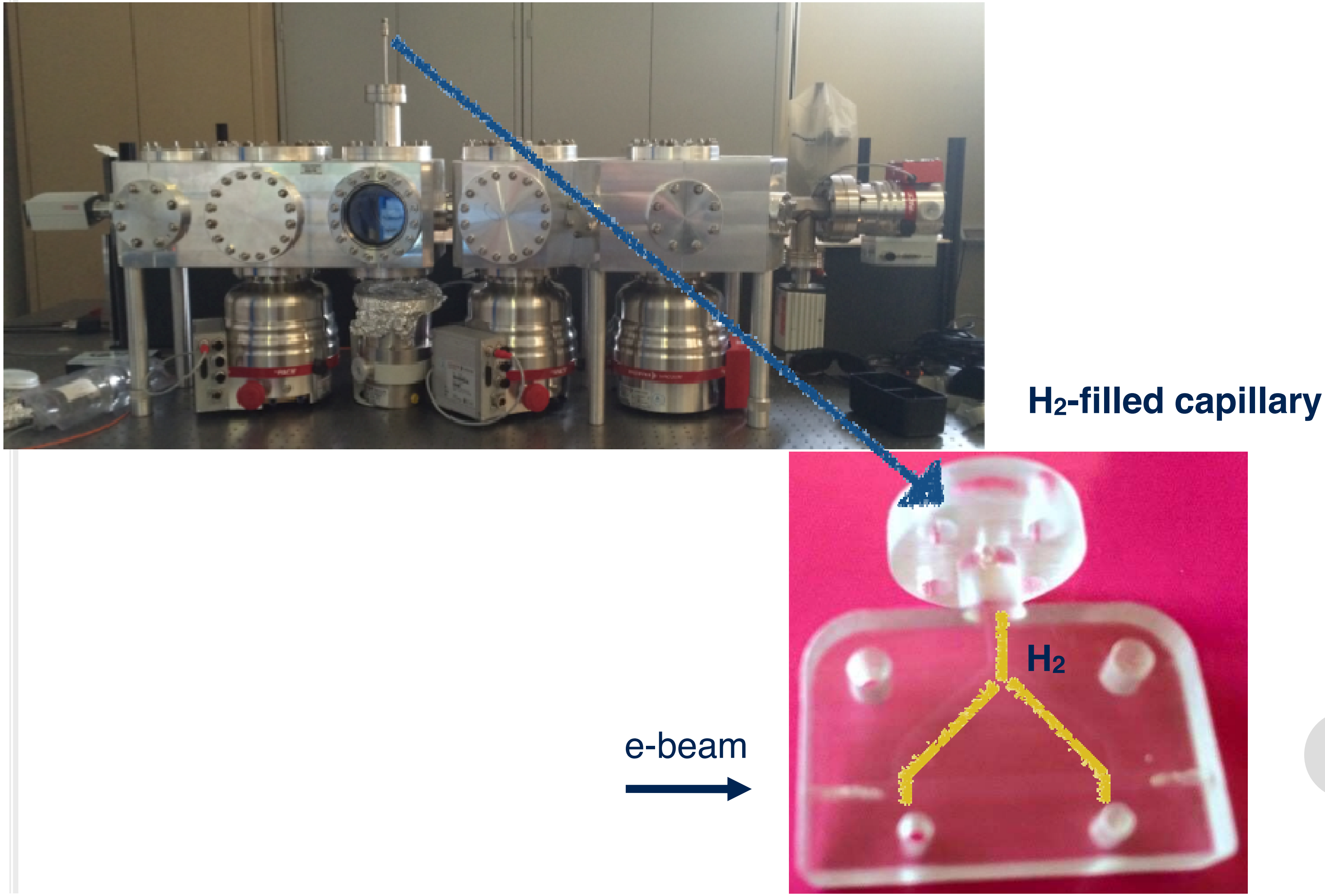


$\Delta z = \lambda_p$ (resonance) $\sigma_z \leq \lambda_p/2$

$\Delta z' \approx (m+1/2)\lambda_p$

❖ **Weak blowout regime** with resonant amplification of plasma wave by a train of high brightness electron bunches produced by **Laser Comb** technique ➔ **5 GV/m** with a train of 3 bunches, 100 pC/bunch, 50 μm long, 20 μm spot size, in a plasma of density 10^{22} e^-/m^3 at λ_p=300 μm ?

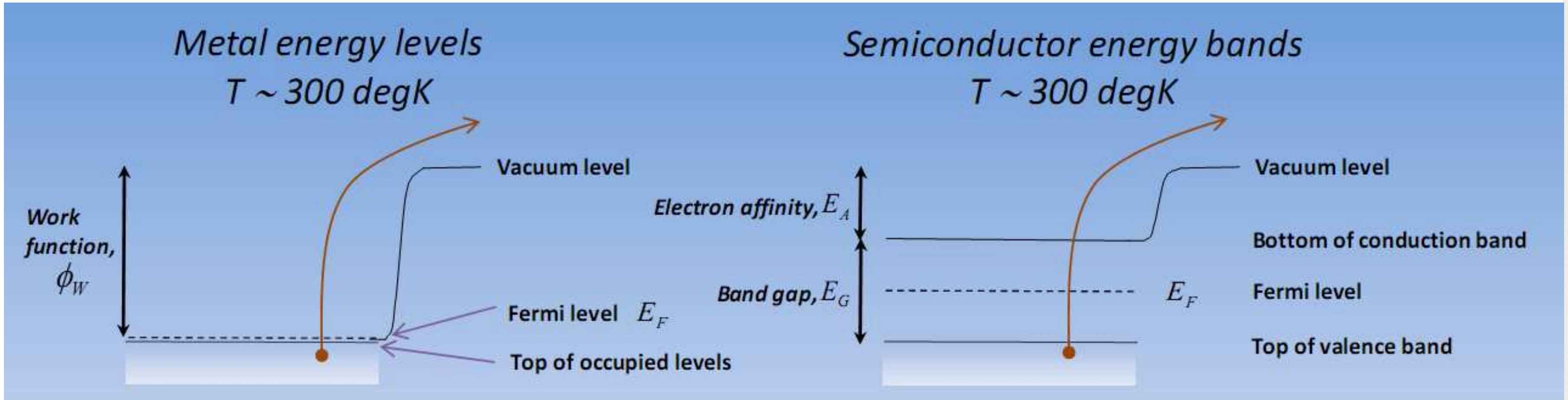
Experimental activities



SL_COMB- Lecce

R&D of photocathodes with higher performances

PHOTOCATHODES



Metals

- Low thermal emittance;
- Fast response time;
- Better tolerance to vacuum contaminations.

Low QE

Semiconductors

- High QE,
- Low dark current

- Long response time,
- High thermal emittance,
- Very sensitive to the vacuum contaminations.

DESIRED PHOTOCATHODE PROPERTIES

➢Quantum efficiency

- High QE at the longest possible wavelength;
- Fast response time : <100 ps;
- Uniform emission;
- Easy to fabricate;
- Low dark current.

➢Intrinsic emittance $\varepsilon_{\text{intrinsic}} \propto \sqrt{\hbar\omega - \phi_{eff}}$

- As low as possible;
- Smooth surface (few nm) to minimize emittance grown due to surface roughness;
- Tunable, controllable with photon wavelength and with the work function.

➢Lifetime, robustness, survivability

- Require long operating lifetime > 1 year;
- Easy, reliable cathode cleaning or rejuvenation.

WHICH METAL?

Metallic photocathodes	Φ_W (eV)	λ(nm), $\hbar w$ (eV)	*QE*
Cu	4.5	266, 4.66	1.4×10^{-5}
Mg	3.7	266, 4.66	1.8×10^{-3} 1.3×10^{-3}
Y	3.0	266, 4.66 406, 3.01	3.3×10^{-4} 1.1×10^{-5}
Pb	4.0	250, 4.96 193, 6.42	6.9×10^{-4} 1.5×10^{-3}

IS YTTRIUM MORE INTERESTING AND SUITED THAN MAGNESIUM?

- 2° HARMONIC (400 nm~3.1 eV) OF Ti:Sa LASER INSTEAD OF 3° HARMONIC (266 nm~4.66 eV) CAN BE USED;
- IT MEANS MORE AVAILABLE AND STABLE ENERGY OF THE PHOTOCATHODE DRIVE LASER;
- REDUCED THERMAL EMITTANCE ($\varepsilon_{\text{intrinsic}} \propto \sqrt{\hbar\omega - \phi_{eff}}$)

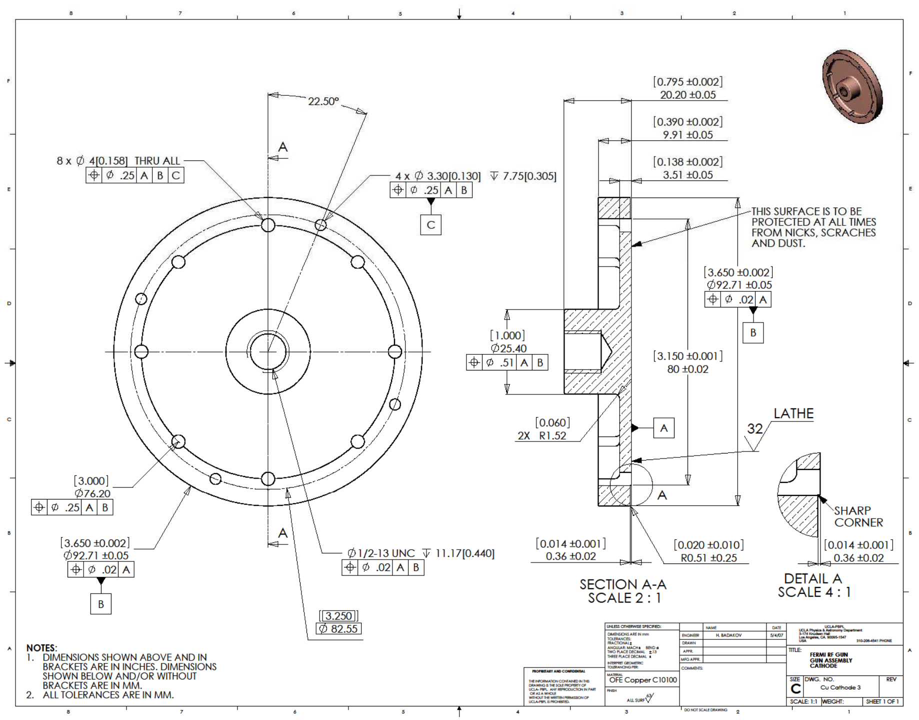
WHY PULSED LASER ABLATION DEPOSITION TECHNIQUE FOR PRODUCING METALLIC PHOTOCATHODES?

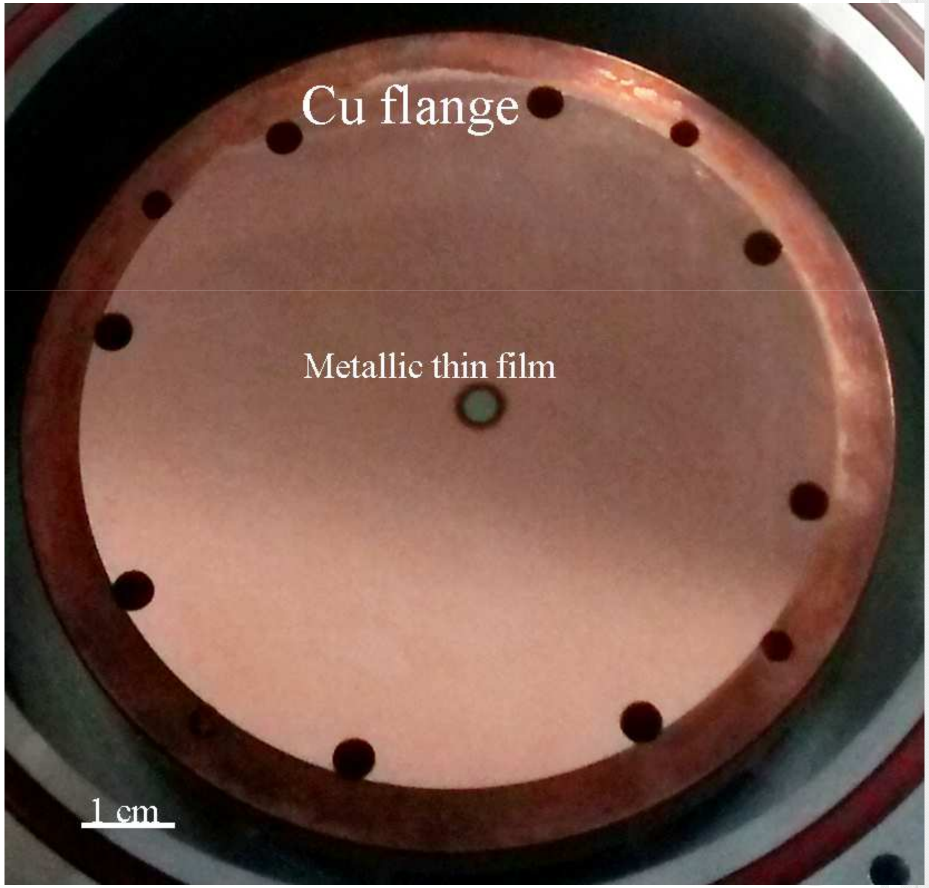
- FILMS HIGHLY ADHERENT TO THE SUBSTRATE;
- HIGH QUALITY FILMS;
- VERSATILE TECHNIQUE.

Weak points:

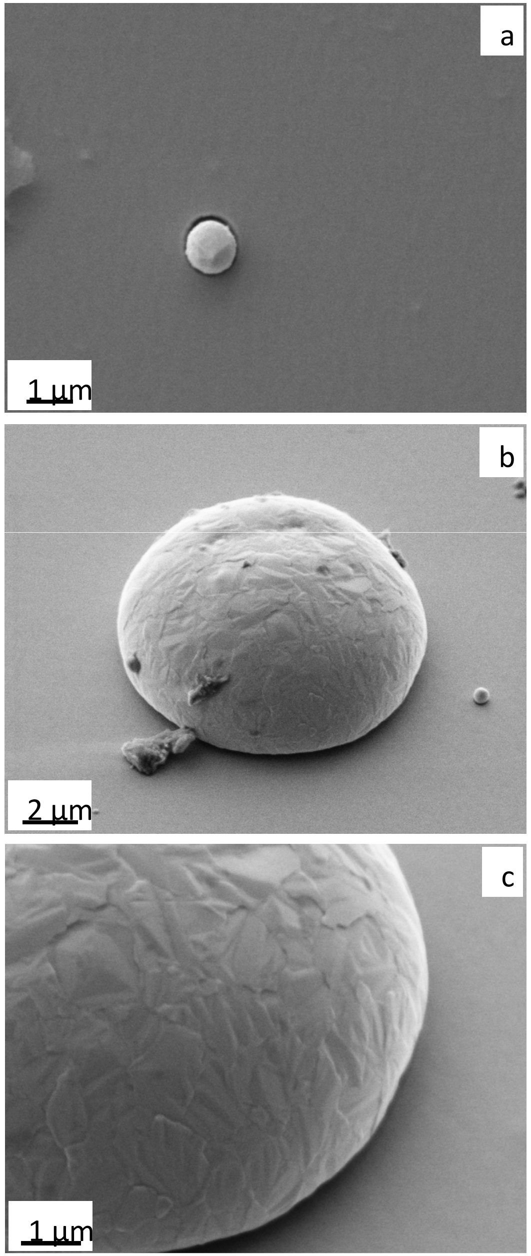
- Inhomogenity of the deposited thin films due to the narrow angular distribution of the plasma plume and to the plume deflection effect;
- Presence of particulates and droplets on the film surface.

Y-BASED PHOTOCATHODES

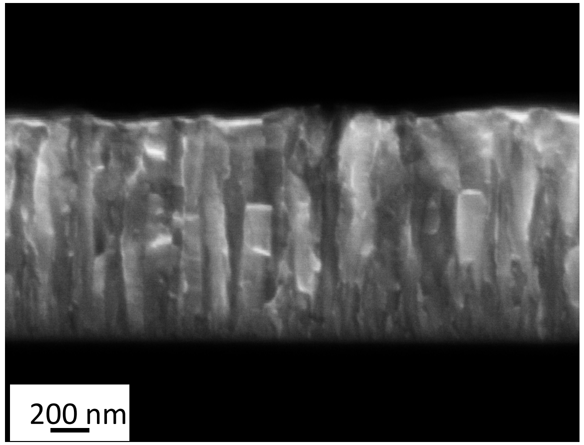




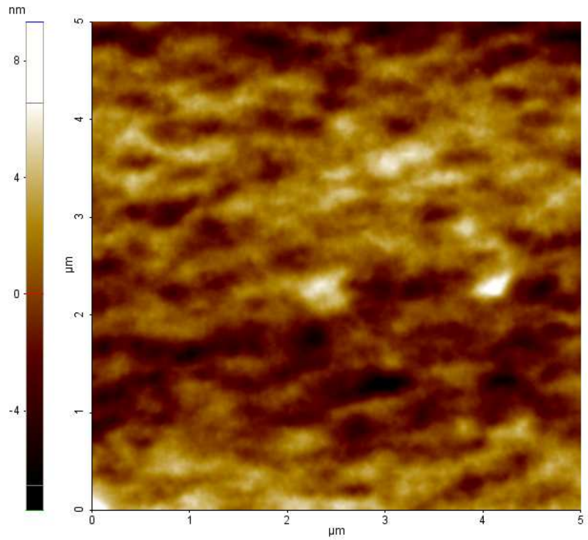
Morphological and Topographical analysis of Y thin Film



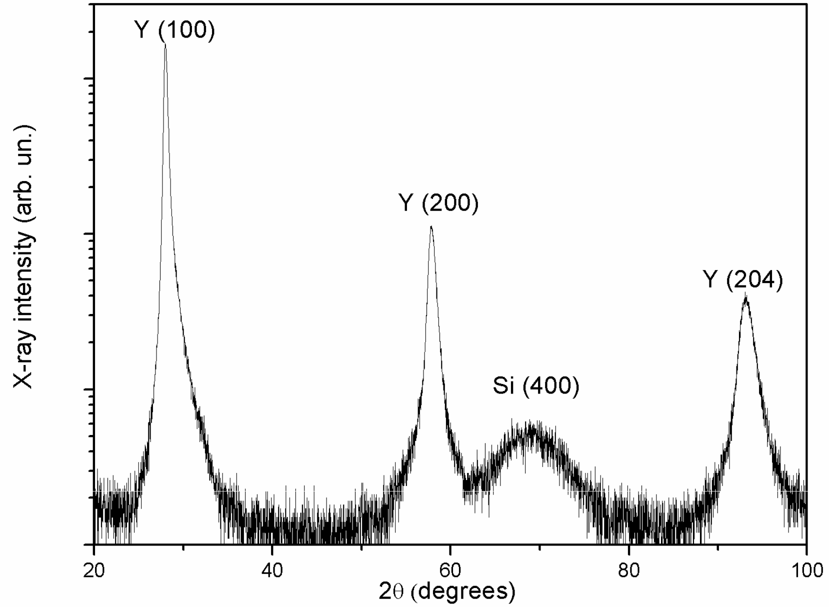
Film Thickness ~ 1µm



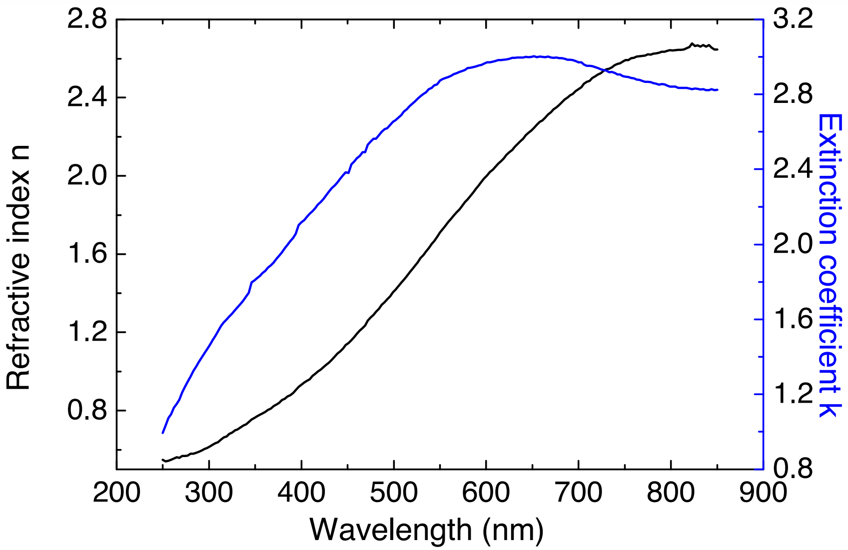
Film RMS Roughness ~2nm



Structural and Optical analysis of Y thin Film



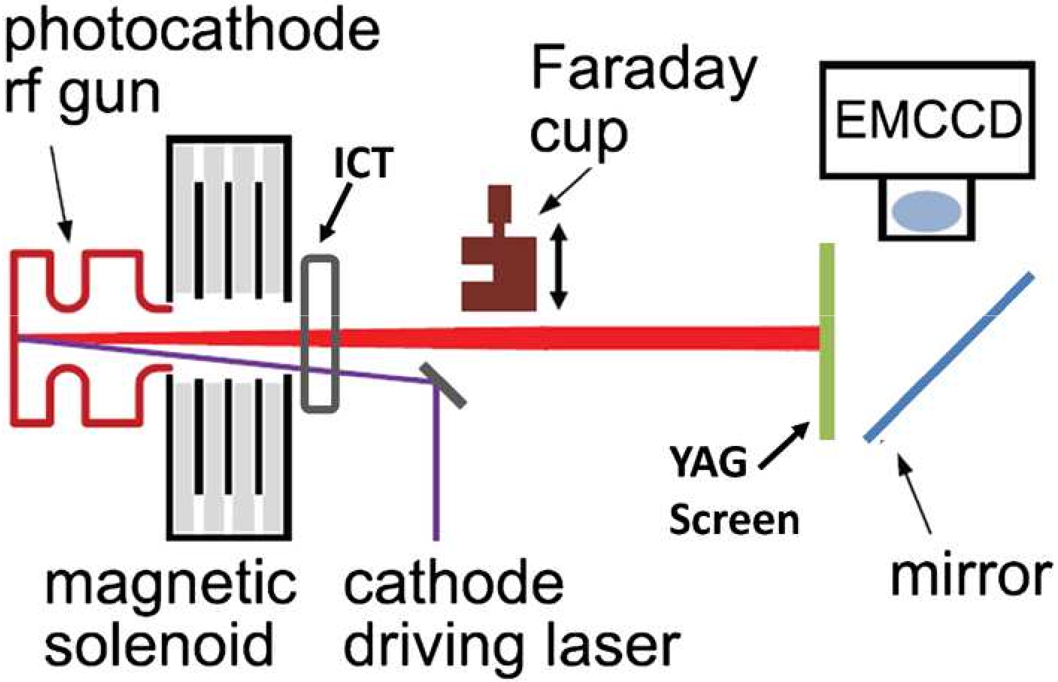
Polycrystalline Y Thin Film

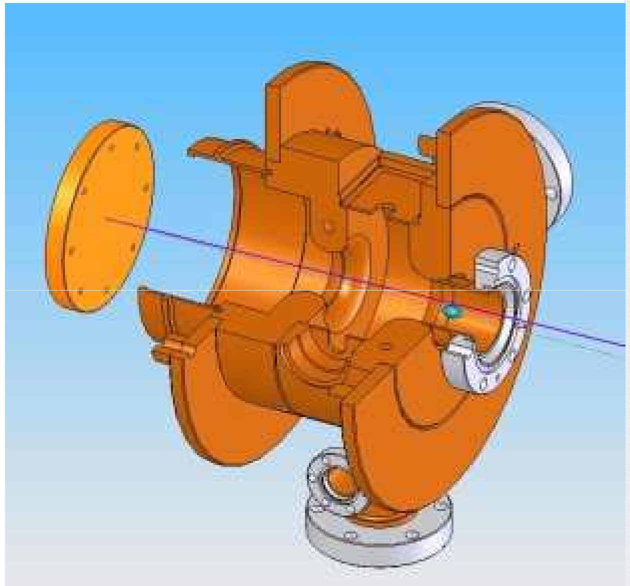


Reflectivity of Y film ~55% at 400 nm

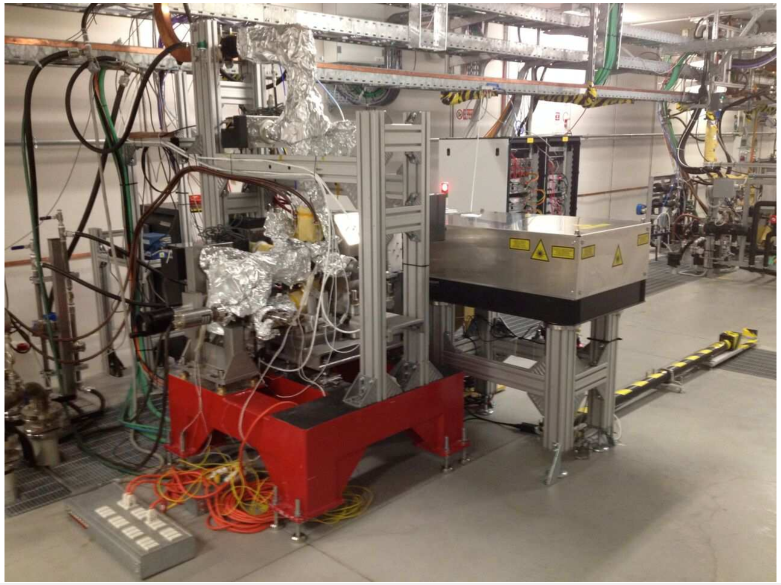
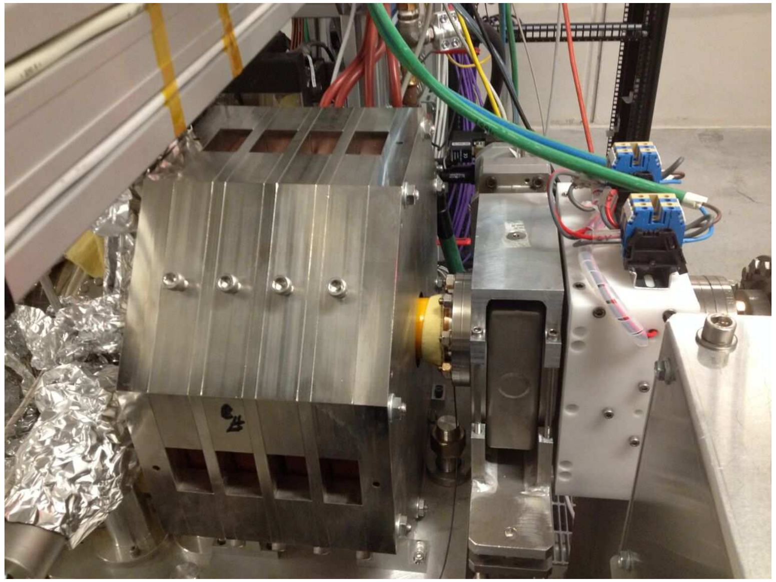
Elettra Sincrotrone Trieste

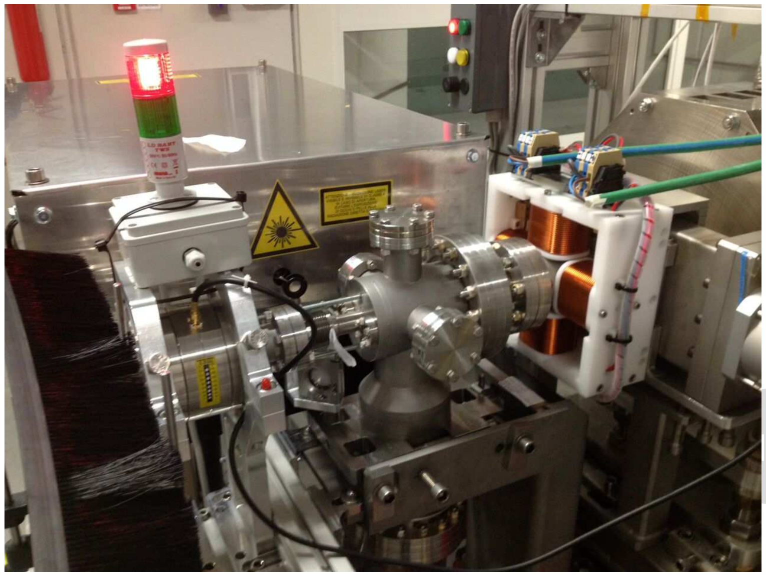
PHOTOINJECTOR FOR CATHODE TESTING AT FERMI OF ELETTRA SINCROTRONE



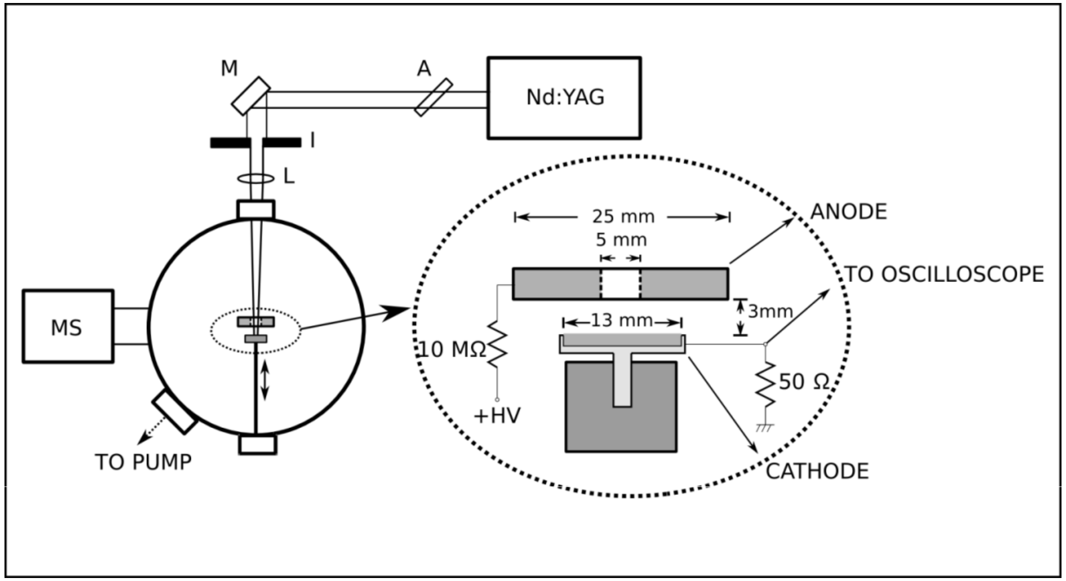


Photoinjector for cathode testing at FERMI of ELETTRA Sincrotrone

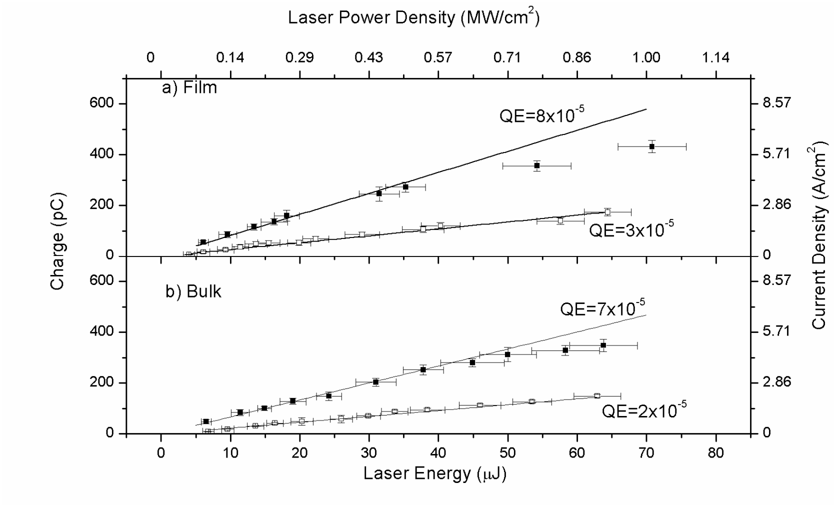





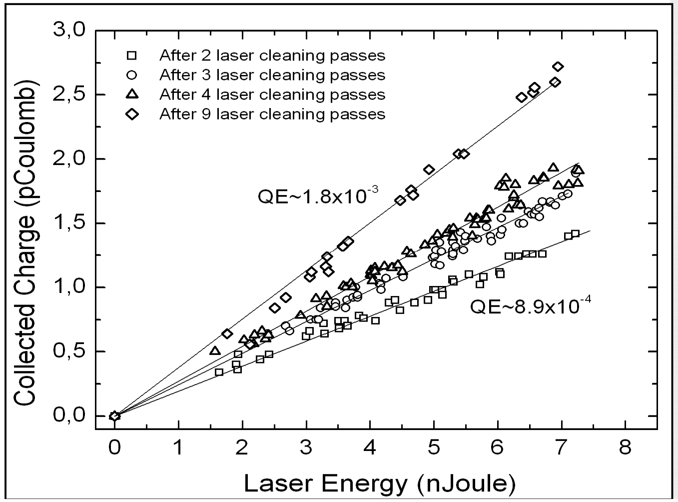
PHOTODIODE CELL FOR TESTING THE QUANTUM EFFICIENCY OF PHOTOCATHODES-LECCE



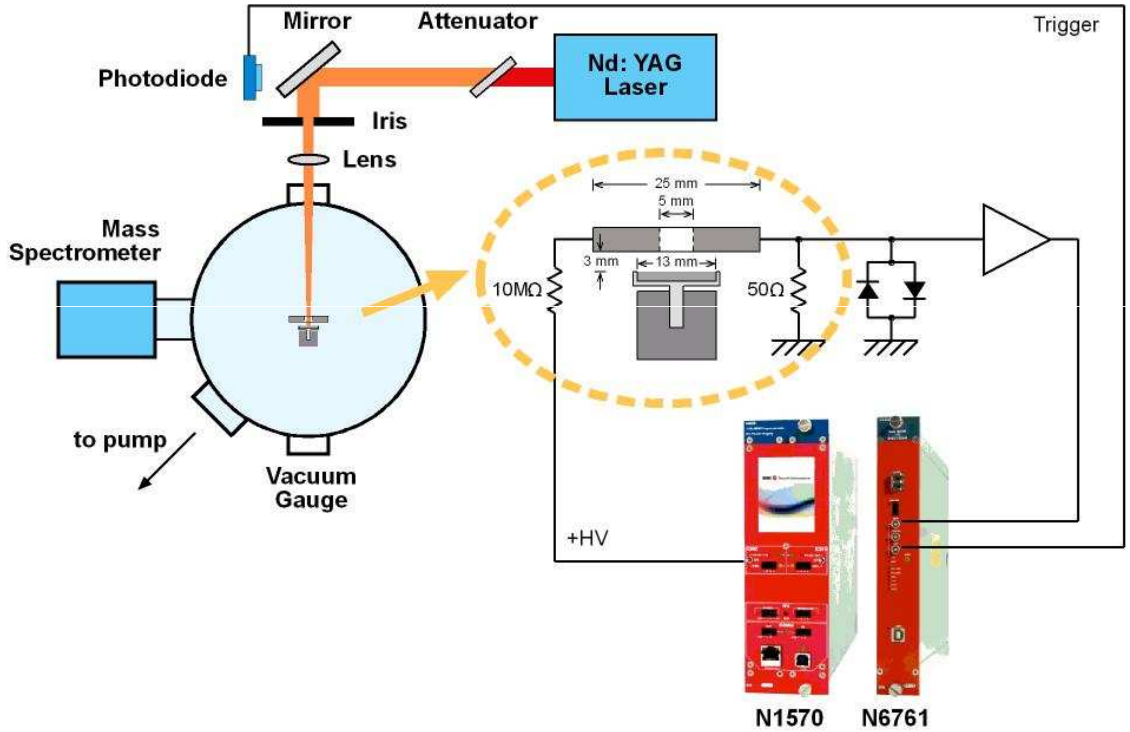
Pb photocathode



Mg photocathode



PHOTODIODE CELL FOR TESTING THE QUANTUM EFFICIENCY OF PHOTOCATHODES-LECCE



Richieste finanziarie

Crate NIM8301/30
12 slot

Alimentatore N1570
15kV/1mA

Digitalizzatore
N6761
10bit 4 GS/s

Anagrafica
SL_COMB-Lecce 2016

Nome	**Qualifica**	**%**
Caricato Anna Paola	Ricercatore Universitario	10
De Giorgi Maria Luisa	Ricercatore Universitario	40
Di Giulio Massimo	Professore Associato	20
Lorusso Antonella	Ricercatore Universitario	70
Perrone Alessio	Professore Ordinario	80
Solombrino Luigi	Professore Associato	100

Richieste Finanziarie SL_COMB-Lecce 2016

Missioni	3 k€
Materiale di consumo	2 k€
Strumentazione	15 k€