INFN
Istituto Nazionale di Fisica Nucleare
Sezione di Lecce

Laboratorio di Elettronica Applicata e Strumentazione

Esperimento Nta_SL_....ELIMED….

extreme light infrastructure

ex NTA_LILIA
ex LEABI
ex LILIA
ex LEABI

Low Emittance Accelerated Beams of Ions
LILIA : Laser Induced Light Ions Acceleration
(2010-2013)

Accelerazione di protoni e ioni leggeri
Emissione di protoni da target sottili a seguito interazione laser FLAME
-Adroterapia
-Fusione inerziale (fast ignition indotta da fasci di protoni)
-Positron Emission Tomography, PET
-Ecc.

BO, LNS, MI, MI Bic, LE

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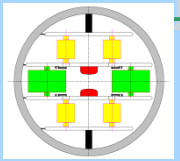


Laboratorio di Elettronica Applicata e Strumentazione

LEAS
Laboratorio di Elettronica
Applicata e Strumentazione
Lecce

L'esperimento è l'evoluzione di Plaia e Platone nella direzione dell'accelerazione per ottenere acceleratori compatti utili per applicazioni mediche e nucleari

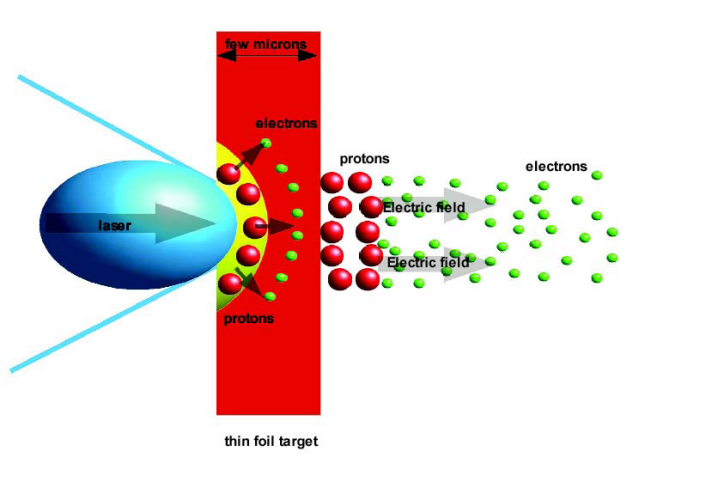
Sfocerà in: FLAME e HIPER.

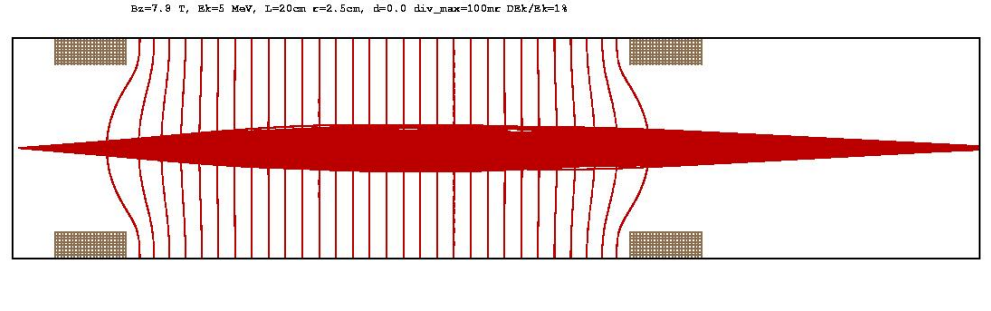
- COLLABORAZIONI:
- **Laboratorio Nazionale del Sud, Catania**
- **Dipartimento di Matematica e Fisica, Lecce**
- **Laboratorio LASA, Segrate Milano**
- -L. Laska, J. Krasa:
- **Institute of Physics of Prague (ASCR) Pals, Czech Rep.**
- *-M. Rosinki, J. Wolowski*:
- **Institute of Plasma Physics and Laser Microfusion (IPPLM), Varsaw, Poland**
- *-B. Foldes*: **Res. Inst. Nucl. Phy. HUNGARY**
- **Laboratorio di spettroscopia a fluorescenza EDXRF, ex Dipartimento di Scienza dei Materiali**

- -D. Bleiner
- **University of Antwerp, Dept. of Chemistry, Belgium:**

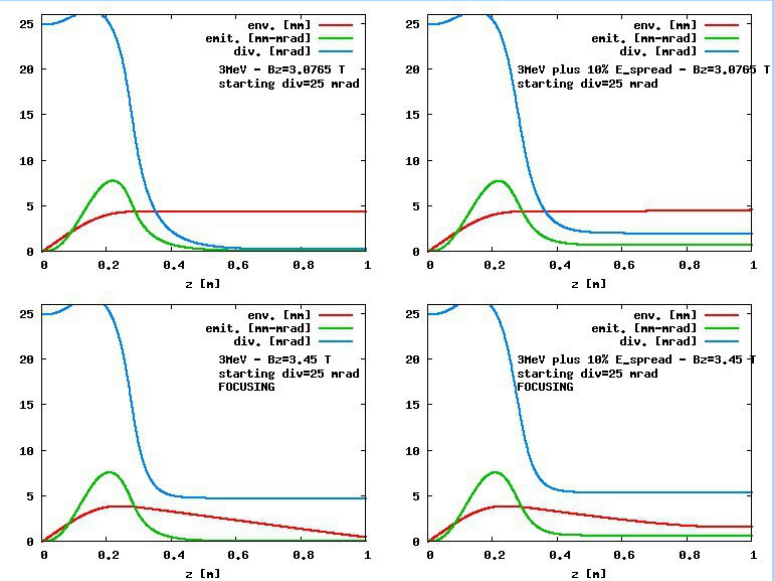
- -F. Belloni **Institute Transuranium Elements, Dept. SIMS, Karlsruhe, Germany**

LILIA
Laser Induced Light Ions Acceleration





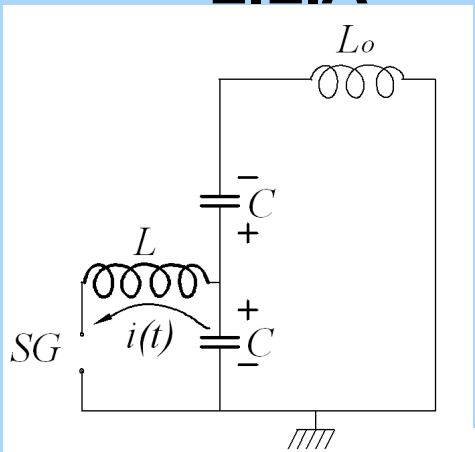
Simulazioni del trasporto:
-Aladyn
-Simion
-calcoli di massima

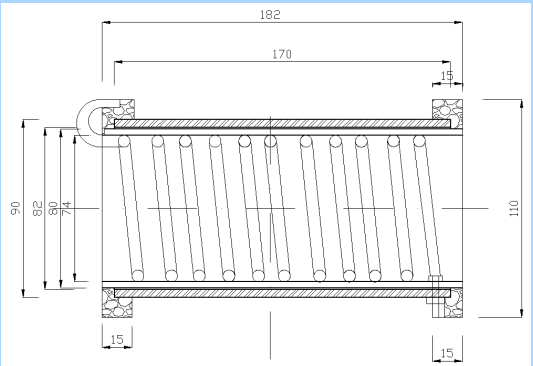


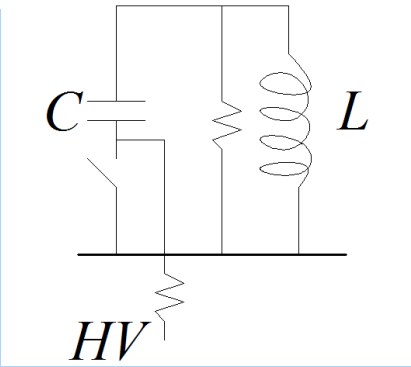
-.I° Il laser incidendo sulla superficie della targhetta , esercita una pressione che risulta in un campo elettrico FSA (Front Surface Acceleration).
-II° l'interazione alla superficie produce una popolazione di elettroni relativistici in grado di propagarsi all'interno del bersaglio ed espandersi nel vuoto oltre la seconda superficie. TNSA (Target Normal Sheath Acceleration)
-III° Per target bulk gli elettroni accelerati formano un campo accelerante per gli ioni (Larmor)

LILIA

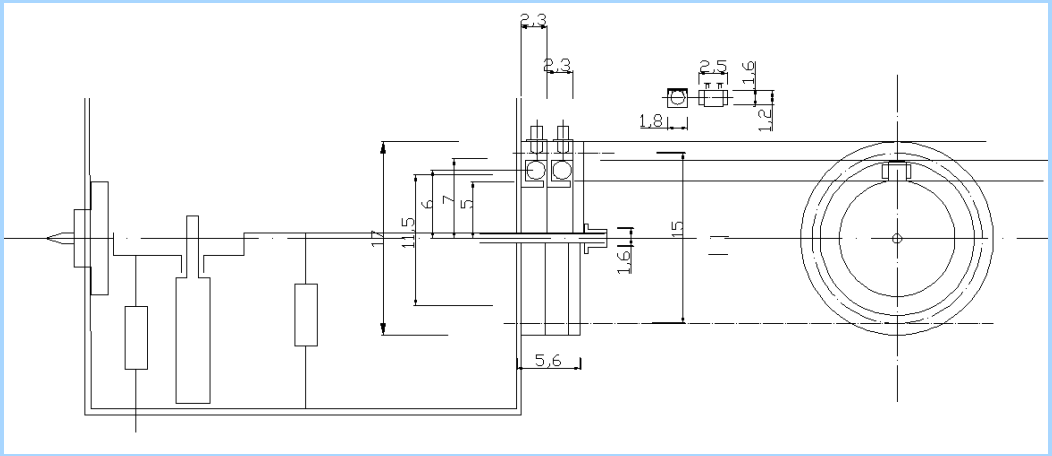
- Io= Vo/Z
- Z= RAD(L/C)
- Vo= 5000-10000V
- B= 2-5 T







- Io= Vo/Z
- Z= RAD(L/C)
- Vo= 10000 - 40000V
- I= 2300 - 9300 A
- B= 0.2-1 T
- T= 4 10^-6 s



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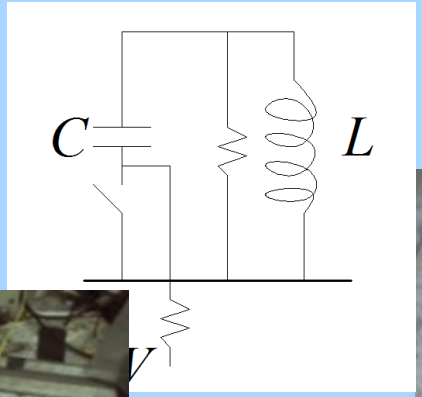

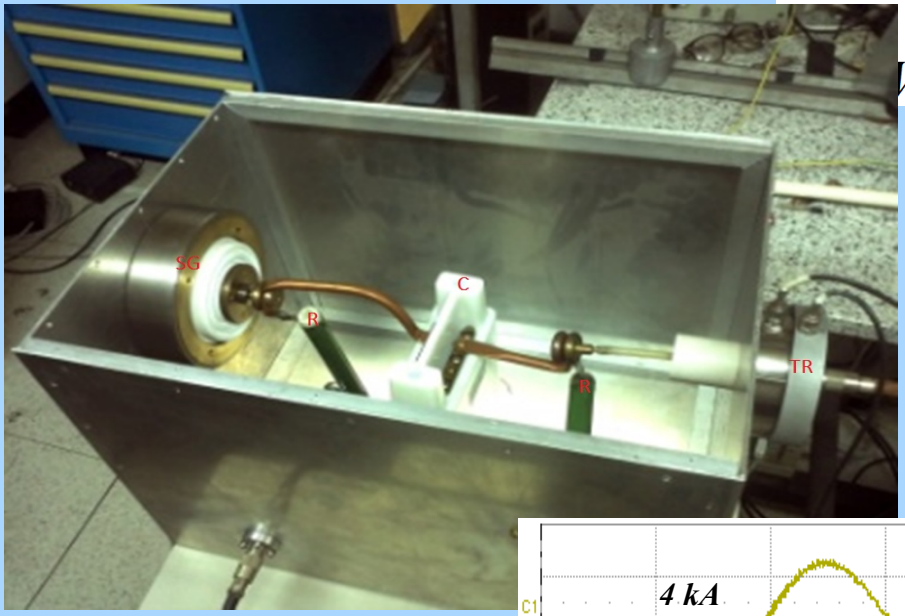

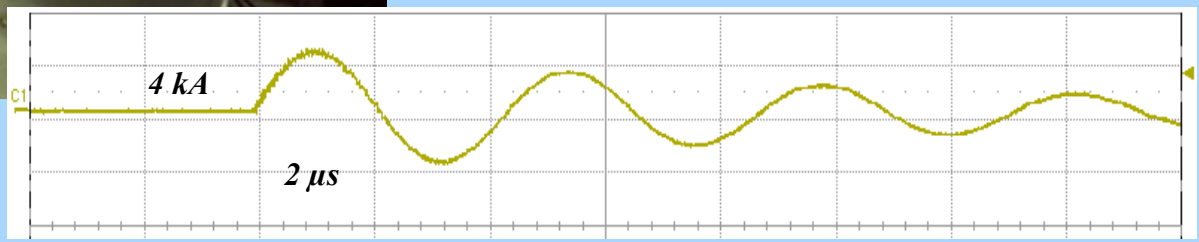

LILIA

Dipartimento di Fisica

Laboratorio di Elettronica Applicata e Strumentazione

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NTA
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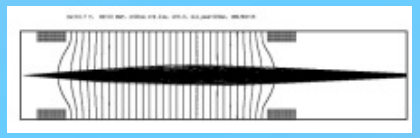
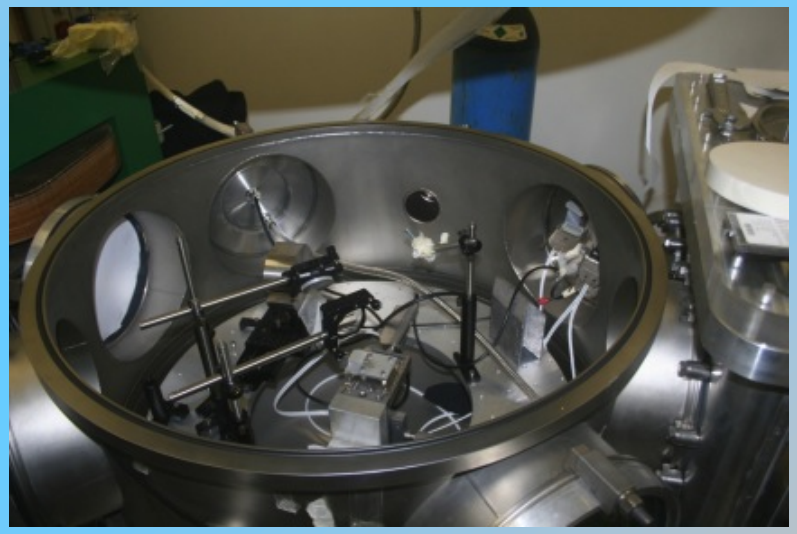
Solenoide di focalizzazione

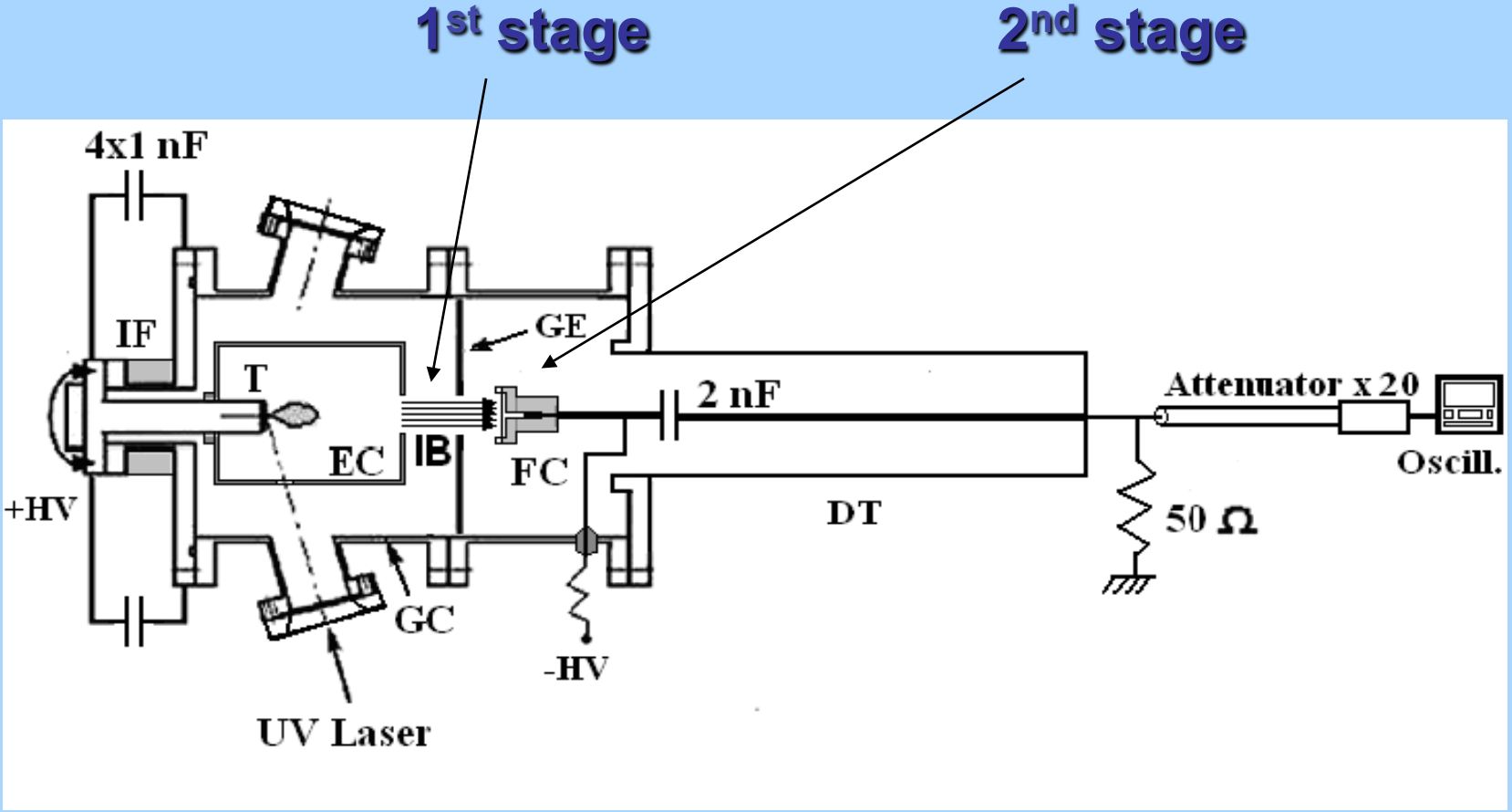
Bz=3.5 T, E= 1 MeV



Bz=10.7 T, E=10MeV

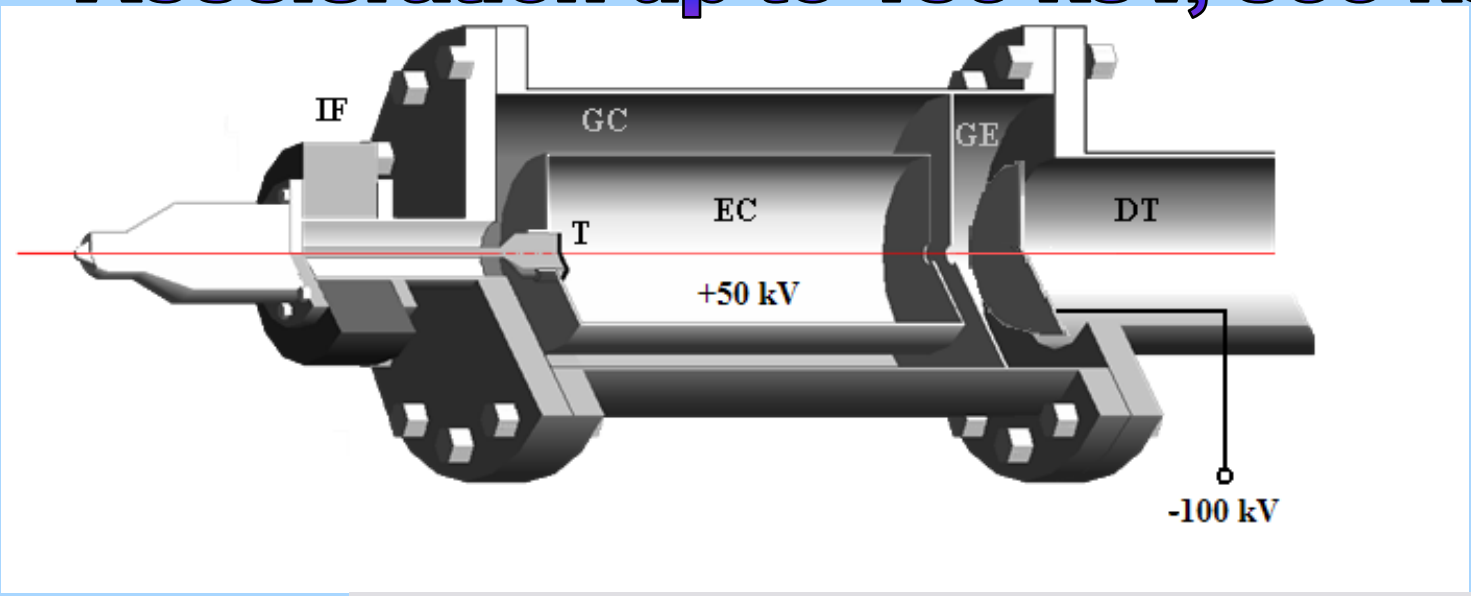


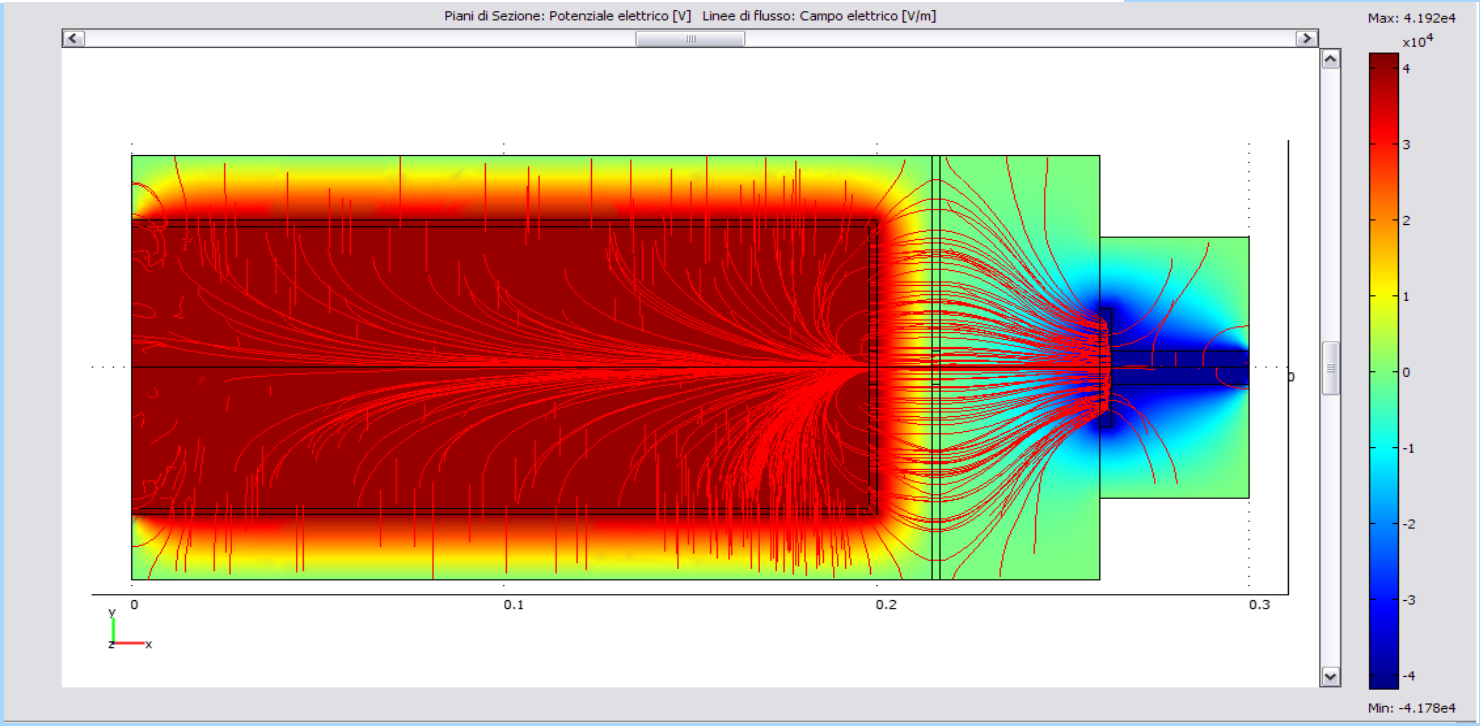
DOUBLE ACCELERATION



Accelerating voltage up to 150 kV

Acceleration up to 150 keV, 300 keV ecc.





Emittance measurement

The area in the PP is

$$A_x^o = \iint_{f_2^o \neq 0} dx dp_x = p_z A_x$$

where p_z is invariable and A_x is the area in the trace plane

The emittance is

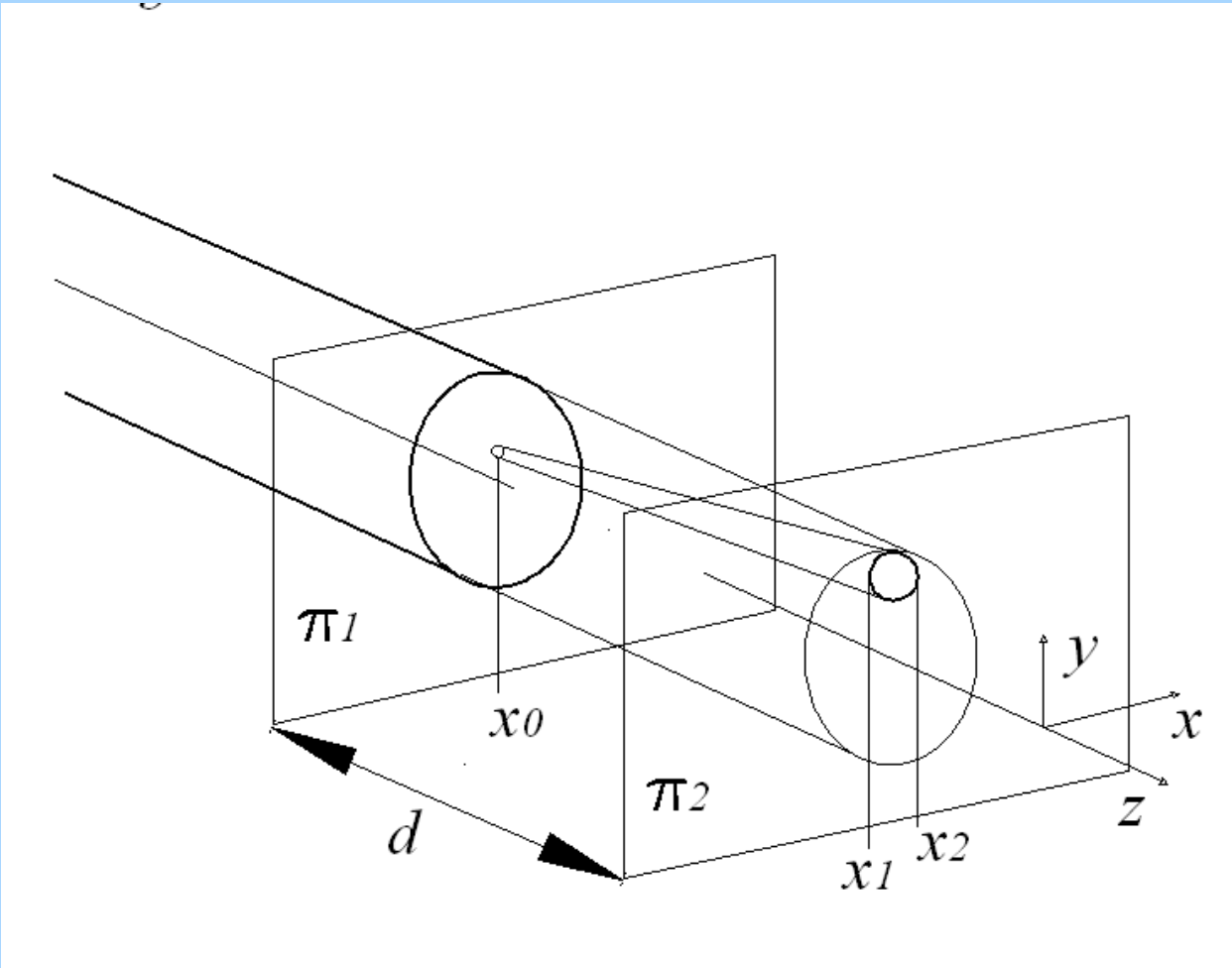
$$\varepsilon_x = \frac{A_x}{\pi}$$

With A_x the area in the trace plane: $\left(x,\ x'(z) = \frac{dx}{dz}\right)$

$$A_x^o = m_o c \beta \gamma A_x$$

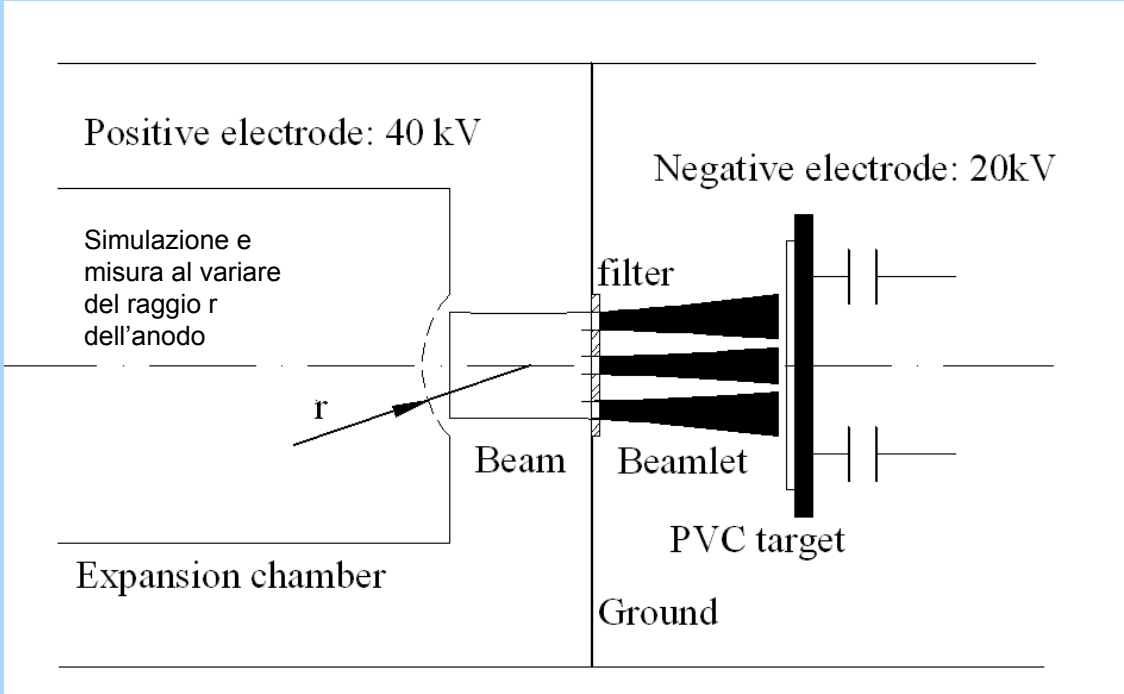
And A^o_x is the area in the phase space

Emittance measurement by pepper pot method



Emittance measurement

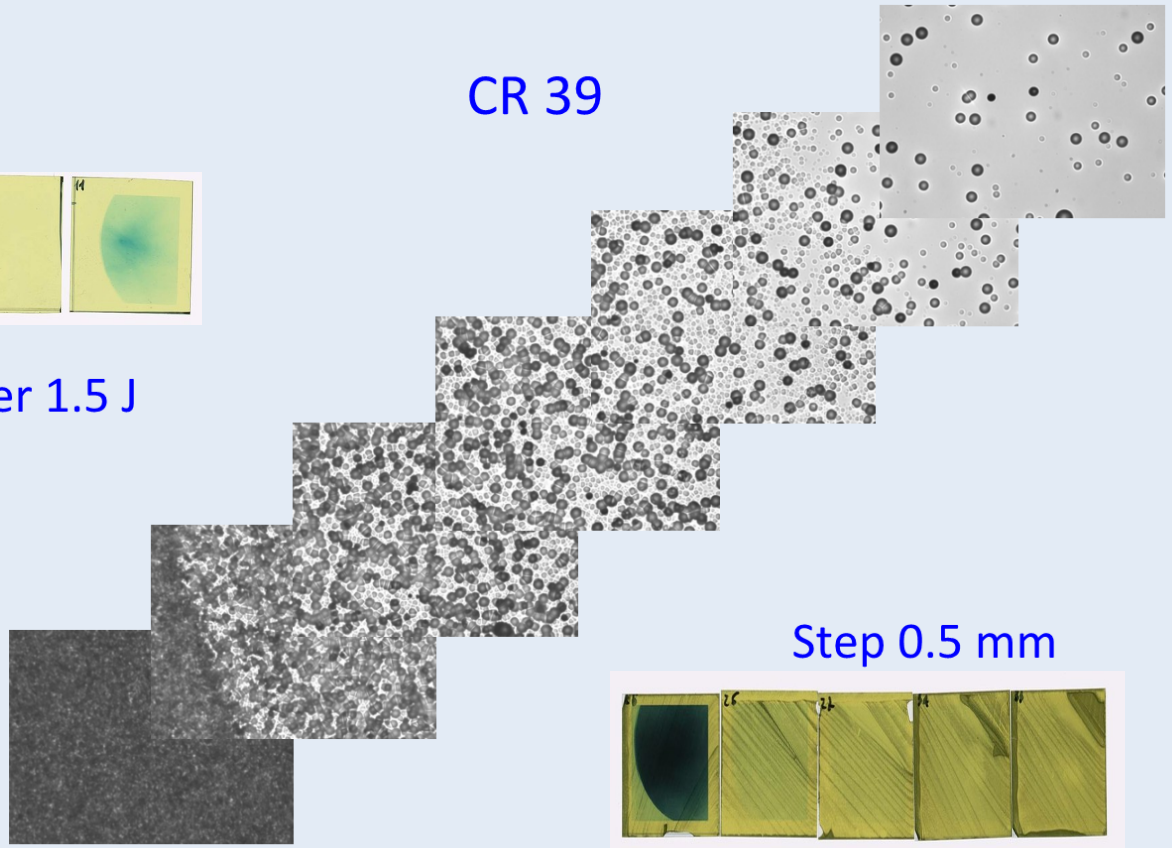
$$\varepsilon_{nx} = \beta\gamma\varepsilon_x$$



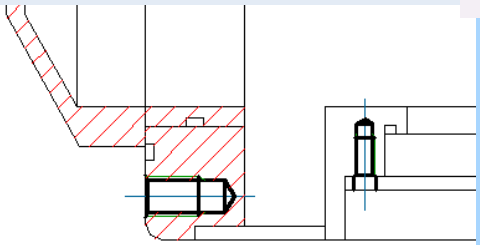
LILIA 2012

laser 1.5 J

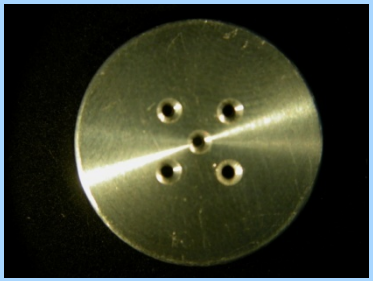
CR 39



Step 0.5 mm

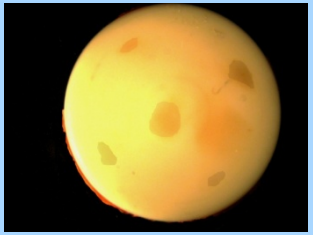


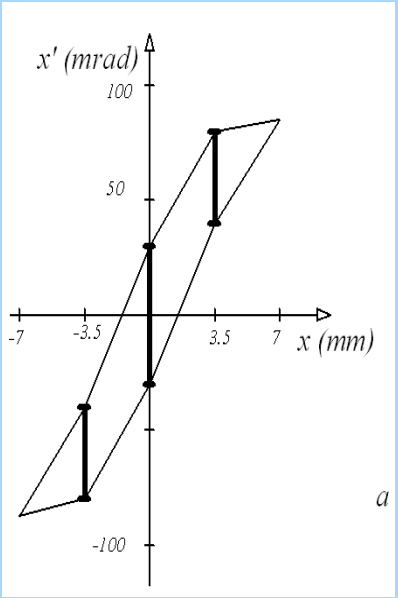
Emittance measurement



Cu

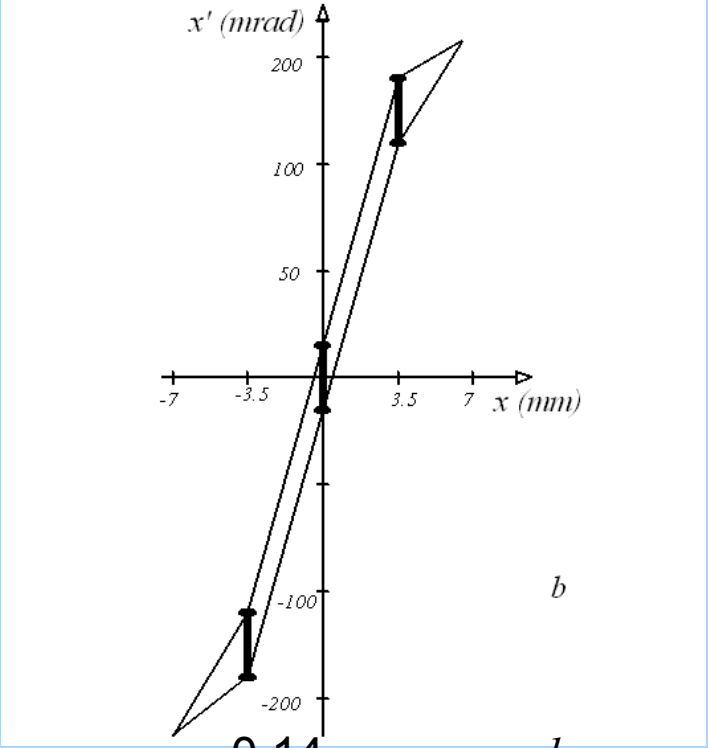
Y





$\varepsilon n = 0.22\ \pi\ mm\ mrad$
for 15 mm, 60 kV

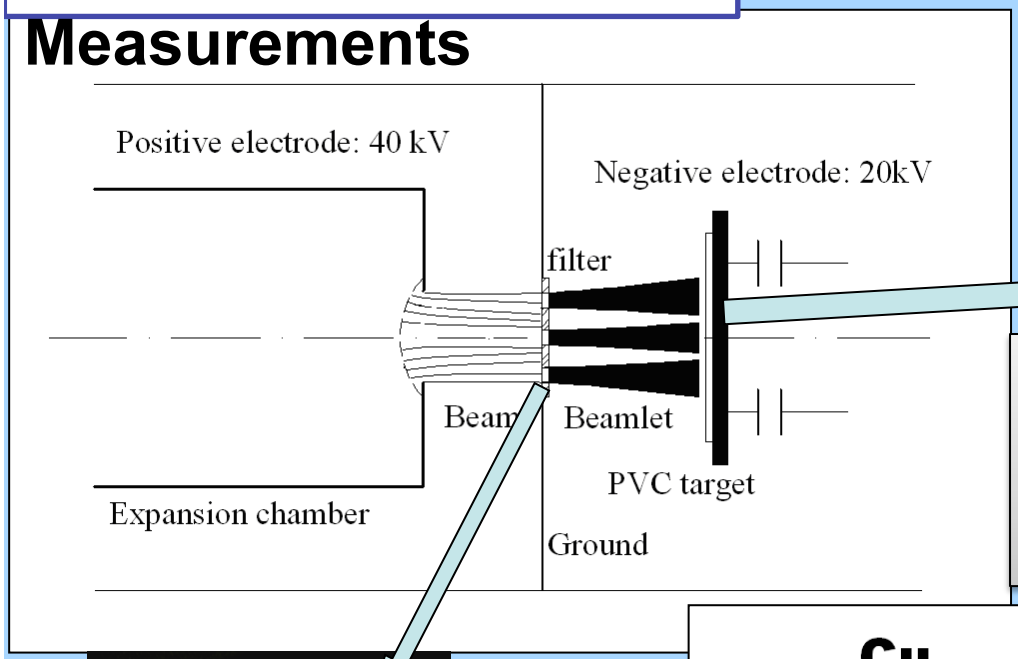
I=5.5 mA



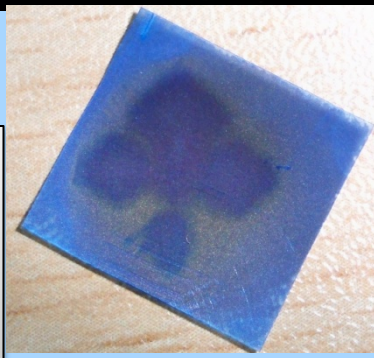
$\varepsilon n = 0.14\ \pi\ mm\ mrad$
for 15 mm, 60 kV

I=7.4 mA

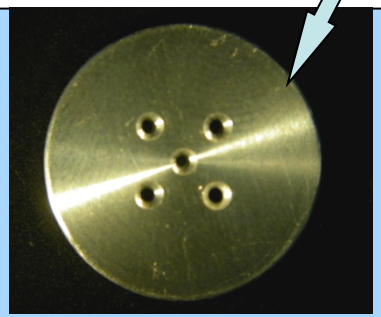
Emittance Measurements

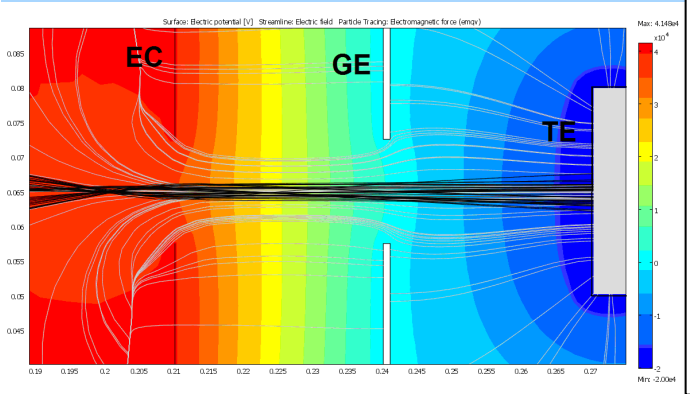


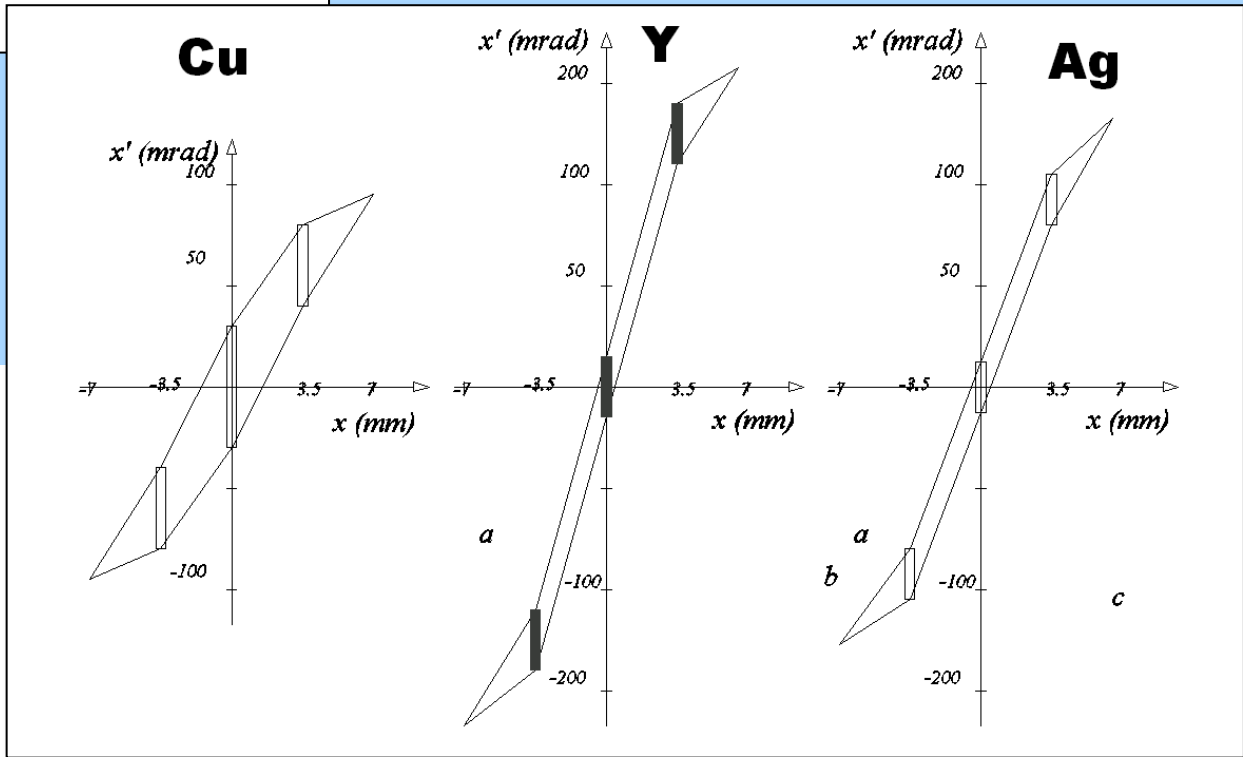
$$\varepsilon = \frac{1}{\pi}\int_{\Gamma} dr\,dp$$



ε = 0.22 π *mm mrad* (Cu)
ε = 0.12 π *mm mrad* (Y)
ε = 0.09 π *mm mrad* (Ag)



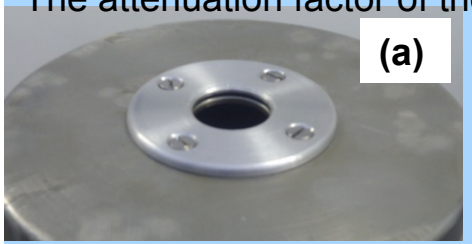


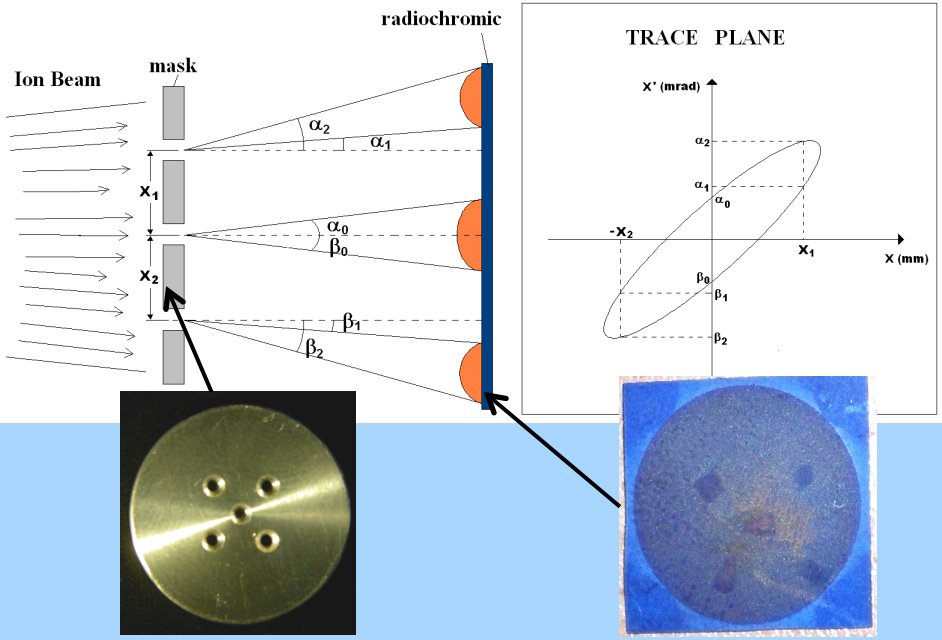


Modification of the hole of the extraction electrode (EC):

- extraction hole without grid (a),
- extraction hole with a plane grid (b),
- extraction hole with a curved grid, radius 0.8 cm (c).

The attenuation factor of the grid is 20%. a)





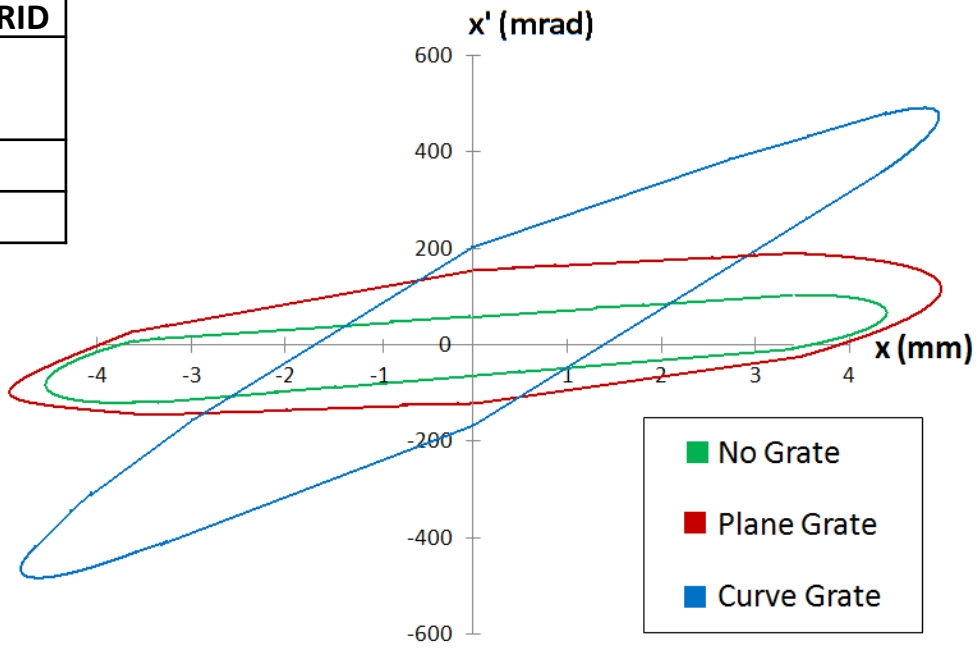
	NO GRID	PLANE GRID	CURVED GRID
Acceler. Voltage (kV)	40+20	40+20	40+20
ε_x (mm mrad)	435	795	1316
ε_{nx} (π mm mrad)	**0.20**	**0.36**	**0.60**

Generally the beam is accelerated and p_z is not constant, then it is necessary to define an invariant quantity called *normalized emittance,* which not depends on the accelerati icles:

$$\varepsilon_{nx} = \beta\,\gamma\,\varepsilon_x$$

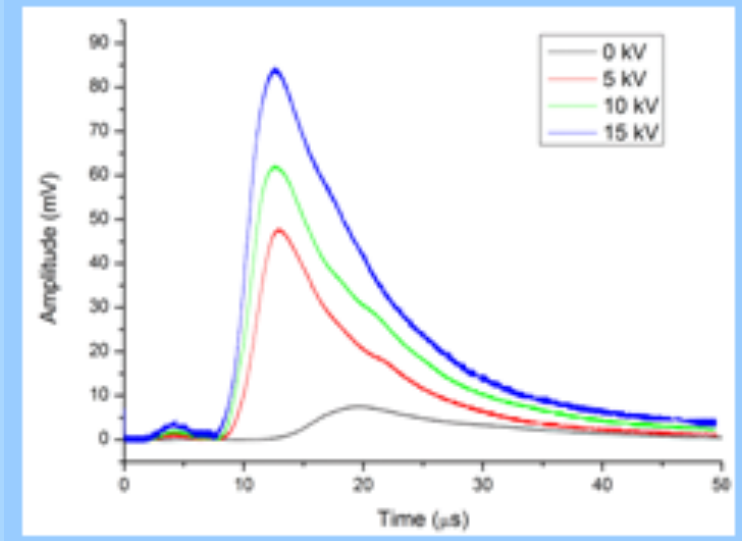
	NO GRID			
Acceler. Voltage (kV)	40+20	30+20	20+20	10+20
ε_x (mm mrad)	435	525	545	612
ε_{nx} (π mm mrad)	**0.20**	**0.20**	**0.20**	**0.20**

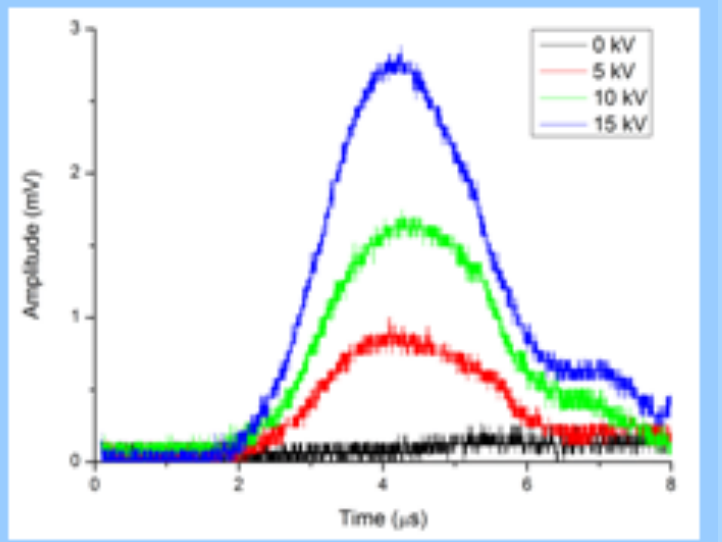
Trace Plane - Emittance



Produzione di protoni

- Target in atmosfera di H_2
- Target idrogenati (TiH_2, CaH_2)

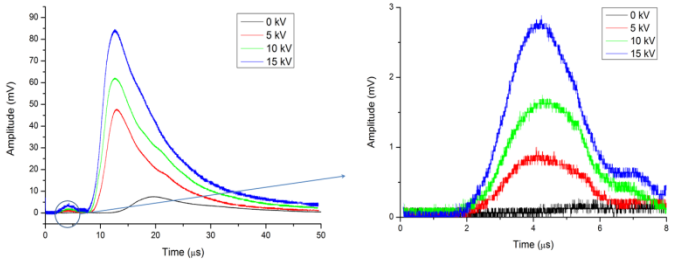


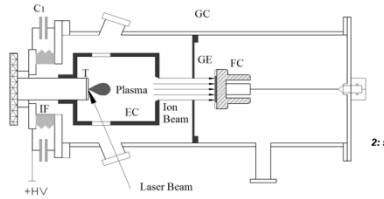


Production and acceleration of protons by TiH_2 targets via excimer laser ablation

D. Delle Side, L. Velardi and V. Nassisi
domenico.delleside@le.infn.it

Department of Mathematics and Physics and I.N.F.N., University of Salento, LEAS Laboratory, Via Provinciale, Lecce-Monteroni, 73100 Lecce, Italy





2: sketch of the accelerator device

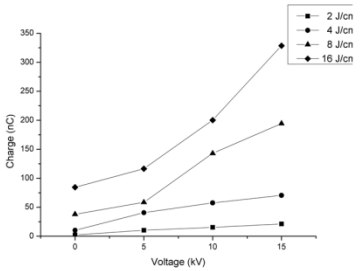


Fig. 4: total extracted charge

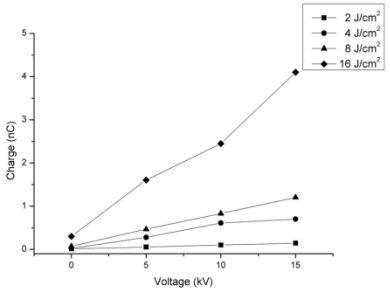


Fig. 5: extracted proton charge

CONCLUSIONS

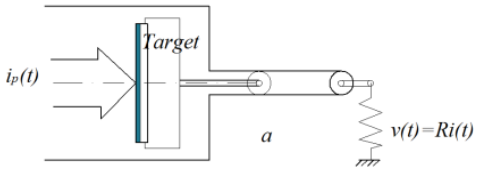
TiH_2 targets are a promising source of ions via laser ablation.

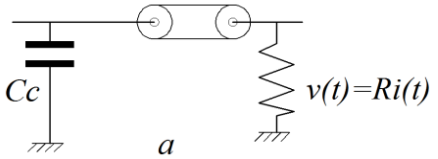
Their use is very interesting since it very easy to obtain them via compression of the TiH_2 powder.

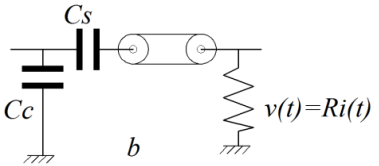
The study of the products of the laser ablation deserve more attention, since the spectra obtained from FC reveal peaks of difficult intepretation.

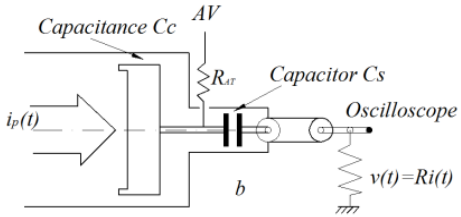
The use of mass spectrometry could shed light on the signals collected by FC.

Diagnostica elettromagnetica







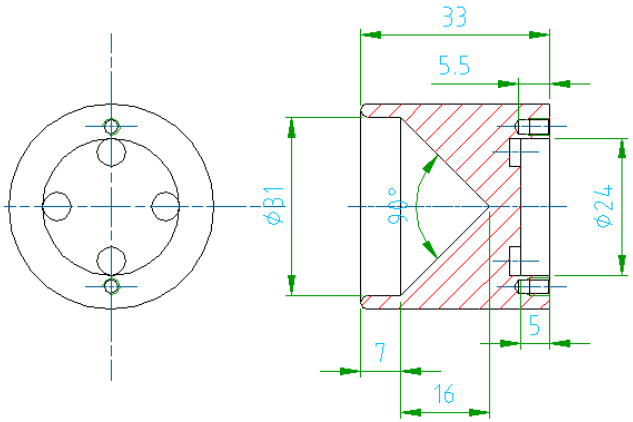


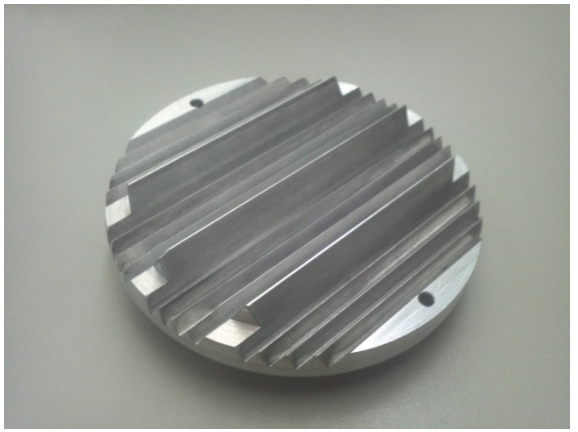
$$i_p(t) = \frac{i(t)}{\beta(1-\gamma)} \qquad per \qquad elettroni$$

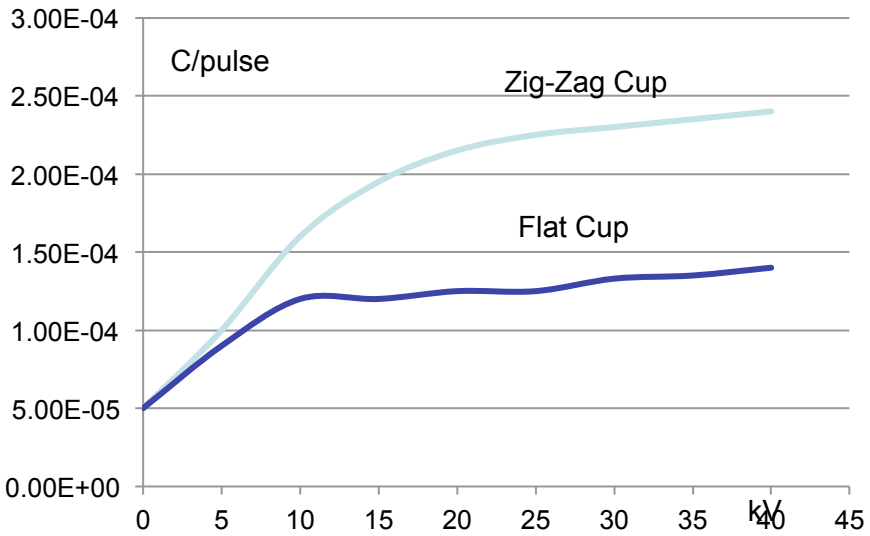
$$i_p(t) = \frac{i(t)}{\beta(1+\gamma)} \qquad per \qquad ioni$$

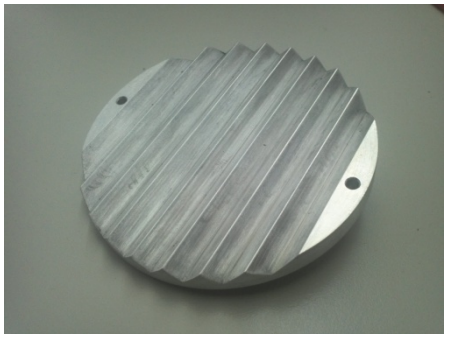
Where β is the optical transmission of the grid (if absent it is equal to 1) and γ is SEE parameter.

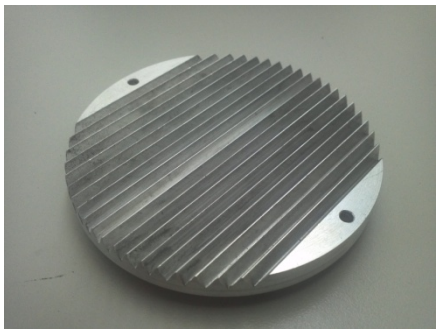
Diagnostica elettromagnetica





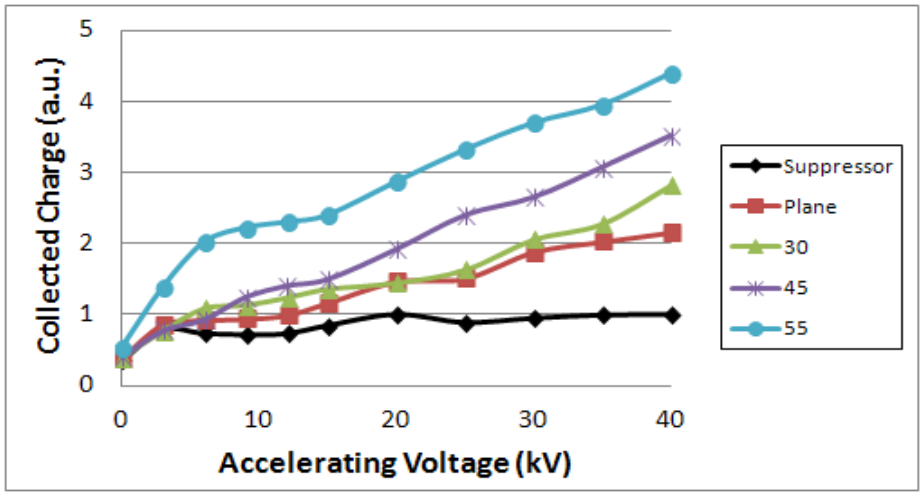






Diagnostica elettromagnetica

E. J. Sternglass, Phys. Rev., 108, p. 1-12 (1957).



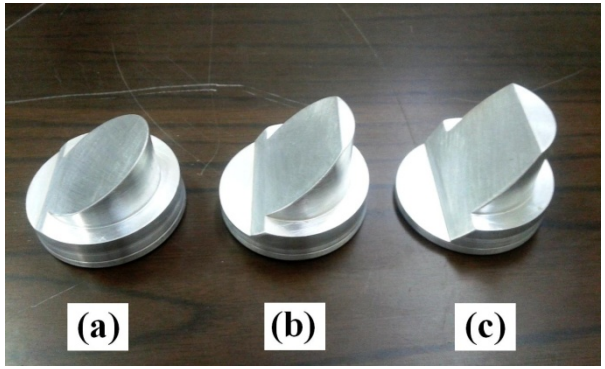


Fig. 8: Photos of cup collectors.

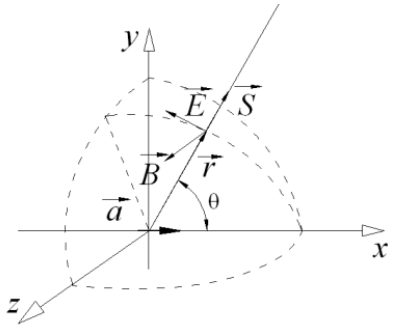
a) collector tilted at 30°;

b) collector tilted at 45°;

c) collector tilted at 55°.

Diagnostica elettromagnetica

Produzione di radiazione di THz



$$\vec{E}(\vec{r},t) = -\frac{q\vec{a}_{\perp}(t')}{4\pi\varepsilon_o rc^2} \qquad V/m \qquad\qquad \vec{B}(\vec{r},t) = \frac{\hat{r}\times\vec{E}(\vec{r},t)}{c} \qquad Weber/m^2$$

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Proposta Lecce 2013:

-Studio dellla configurazione delle coppe, morfologia e materiale
-Realizzazione e test at 100 kV a lecce
-Test presso il Flame di Frasacati
- Studio dell'antenna

Proposta Lecce 2014:

-Test di misure al PALS di Praga at energie di 1 MV
-Confronto dei dati delle coppe con i dati dei film radicromici
-Misure con l'antenna del campo responsabile.

Proposta Lecce 2015:

-Test di misure al PALS di Praga at energie di 1 MV
-Misure dei segnali al Pals per fasci da impulsati da 10 MV

.

Partecipanti:

Vincenzo	Nassisi	P.O	100	% Responsabile Nazionale
Alfredo	Castellano	P.O.	100	% S. dei materiali
Massimo	Di Giulio	P. A.	70	% S. dei materiali
Giovanni	Buccolieri	Ric	100	% S. dei materiali
Domenico	Delle Side	Dott	100	% Dottorando
Totale			4.70 unità	

Fabio	Paladini	Tecn. Laureat.	40%
Tecnici:			
Romualdo Gerardi	T. Universit. Elettr.		20%
Giorgio Accoto	T. Universit. Mecc.		30%

Totale tecnici: 0.90 unità

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- MI 6 k€ Contatti con Laboratori Nazionali Università, Congressi nazionali
- ME 6 k€ Presentazione dei risultati a conferenze internazionali e contatti con CERN e PALS e IPPM Warsav.
- CONS. 12 k€: Materiale meccanico, per l'adattabilità della strumentazione esistente. Materiale elettrico per la diagnostica. Materiale di consumo per laser. Software (licenza mathematica per analisi immagini)
- INV: 5k€ *Flat bed scanner per film radiocromici*
- *Richiesta da progetto* ***29.00 k€****:*