

LAr purification and LAr purity measurement

on behalf of A. DI Vacri

Technology developed by INFN groups in the framework of ICARUS project. ICARUS LNGS group (F. Arneodo, F. Cavanna, O. Palamara and coworkers (A. Ferella)) significantly improved the technology of purity monitor and prepared "quasi off-shell" devices.

This technique is at present used to monitor LAr/LXe purity in

ICARUS

WARP

XENON

Slides provided by N. Canci & F. Arneodo, ICARUS collaboration.

In noble liquid gas are present at level of ppms some electronegative species (O_2 , CO_2 , N_2O , etc.) that cause the reduction of the charge produced by ionization.

Electronegative atoms and molecules (S) capture free electrons:



The reaction constant :

$$k_S = \int \sigma(E) f(E) dE$$

- E electron energy
- $\sigma(E)$ cross section of the process
- $f(E)$ Maxwell-Boltzmann distribution

- N_e number of electrons generated by an ionizing particle (23.6 eV energy needed to produce an $e^- - Ar^+$ pair, i.e. 1 MeV electron produce $4 \times 10^4 e^- - Ar^+$). In presence of E field couples are separated and can be collected at respective electrodes provided they are not trapped along their path.
- N_S impurities concentration

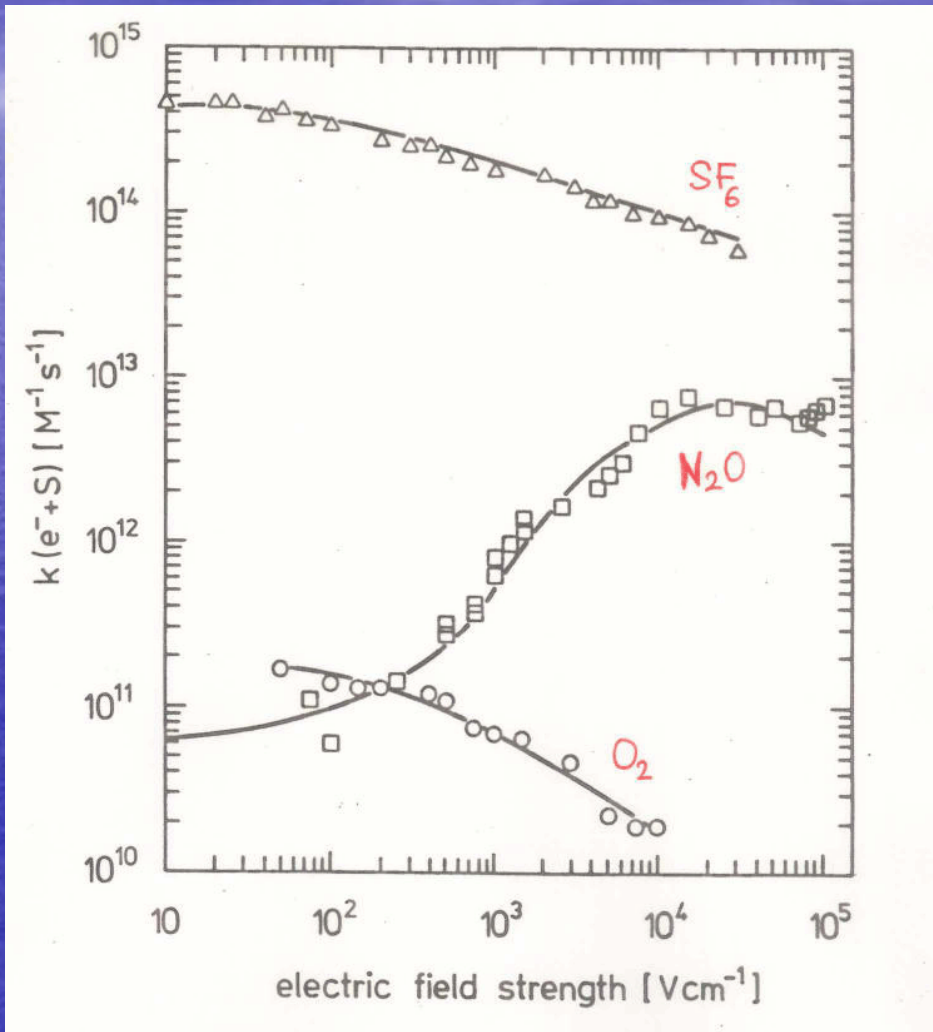
N_e time variation:

$$\frac{dN_e}{dt} = -k_S N_S N_e \quad \longrightarrow \quad N_e(t) = N_{e0} \cdot e^{-\frac{t}{\tau}}$$

$$\tau = \frac{1}{k_S N_S}$$

is the electron lifetime

Example: $N_S \sim 1$ ppm (LAr industrial grade) $\rightarrow \tau \sim 1 \mu\text{sec}$



Purification of noble liquid gases

Molecular sieves:

- Hydrosorb
- Oxisorb (Cr)
- Hopcalite (Mn, Cu)
- Trigon (Cu, Mn, Co, Ni)
[provato per la prima volta in ambiente criogenico]

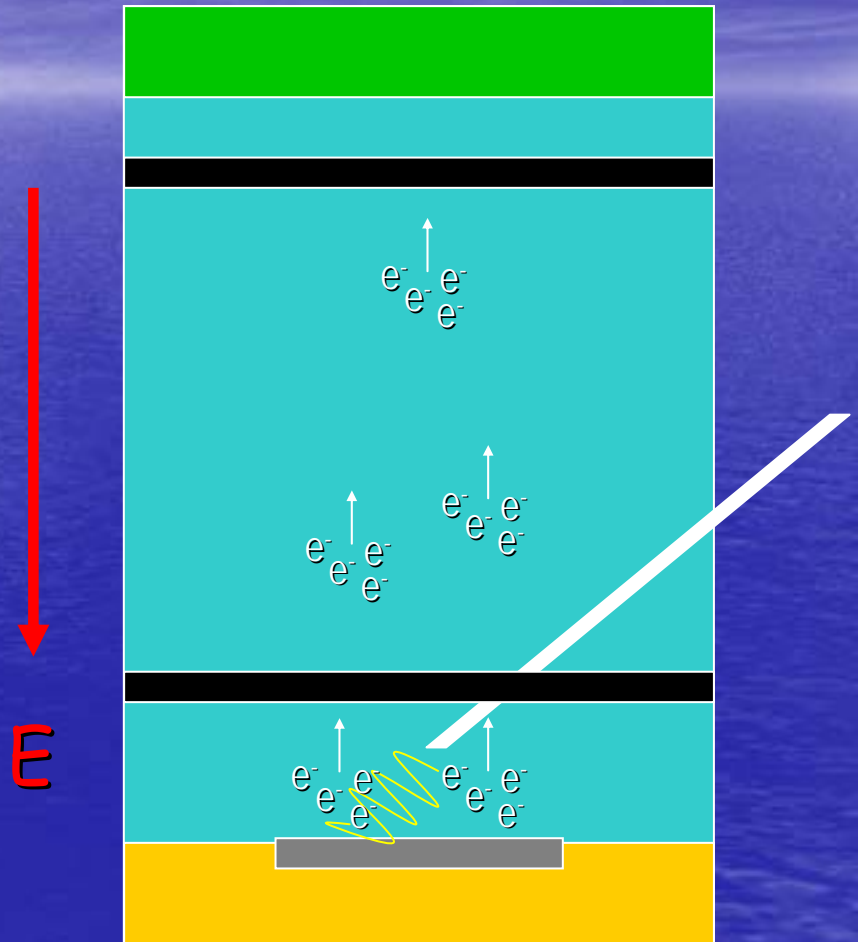


Filtration by these sieves reduces the O₂ concentration
at level < 0.1 ppb

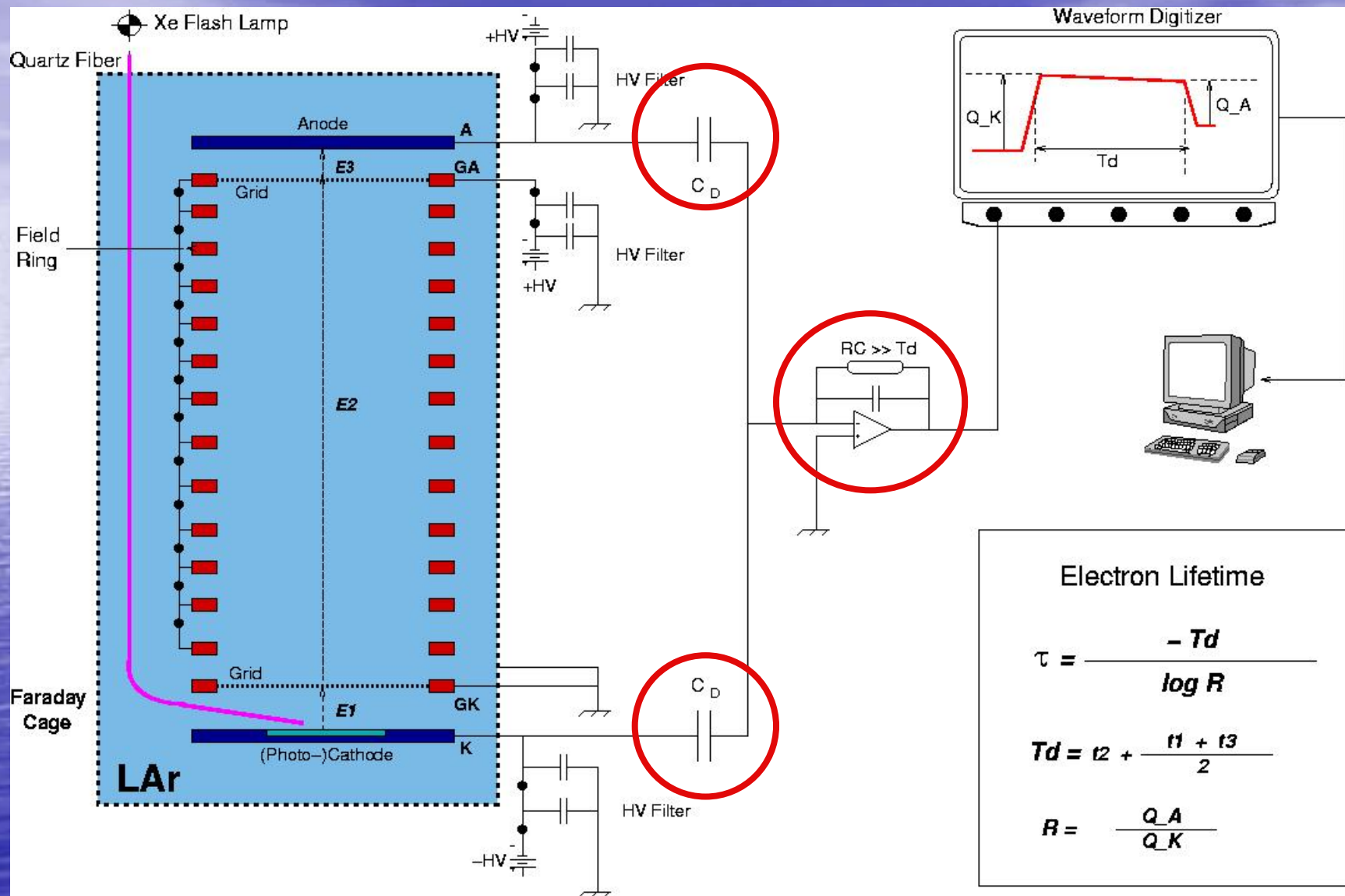
Il monitor di purezza

Piccola camera a deriva

- Anode
- Cathode
- Grids
- Optical fiber to illuminate photocathode by UV light
- Photocathode



The purity monitor: principle of operation



Electron Lifetime

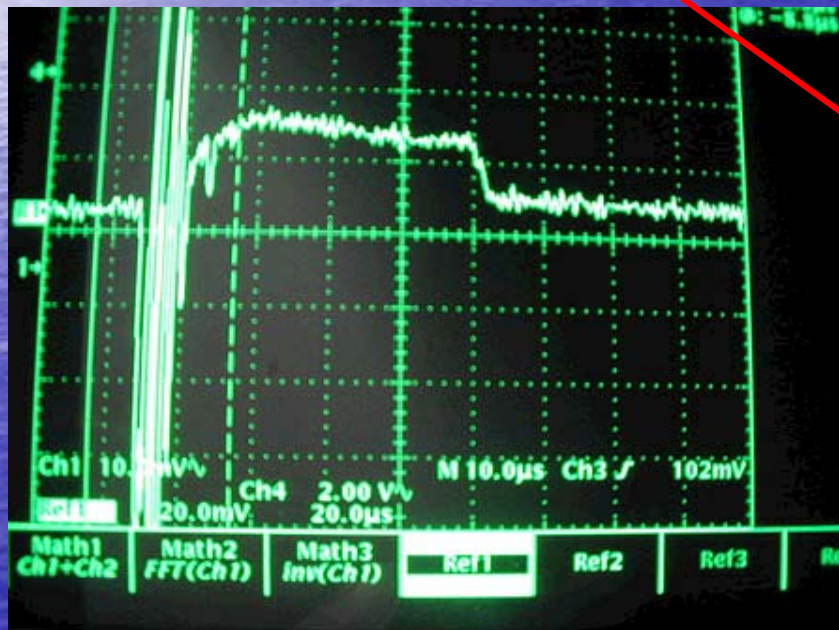
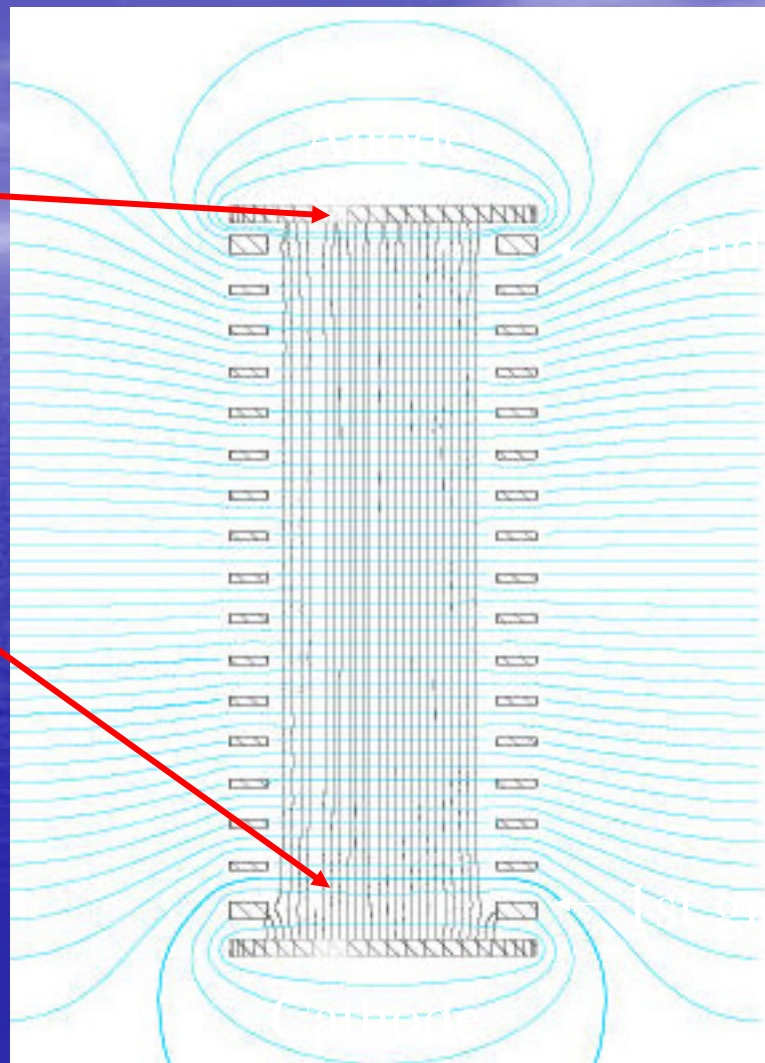
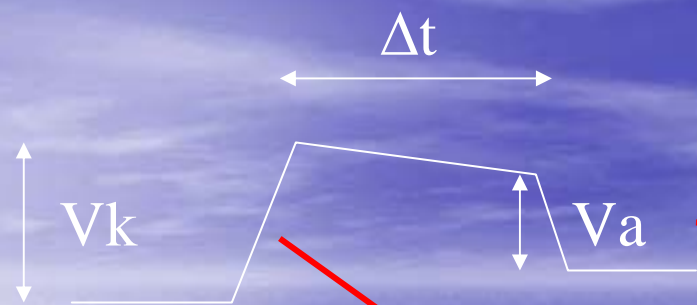
$$\tau = \frac{-T_d}{\log R}$$

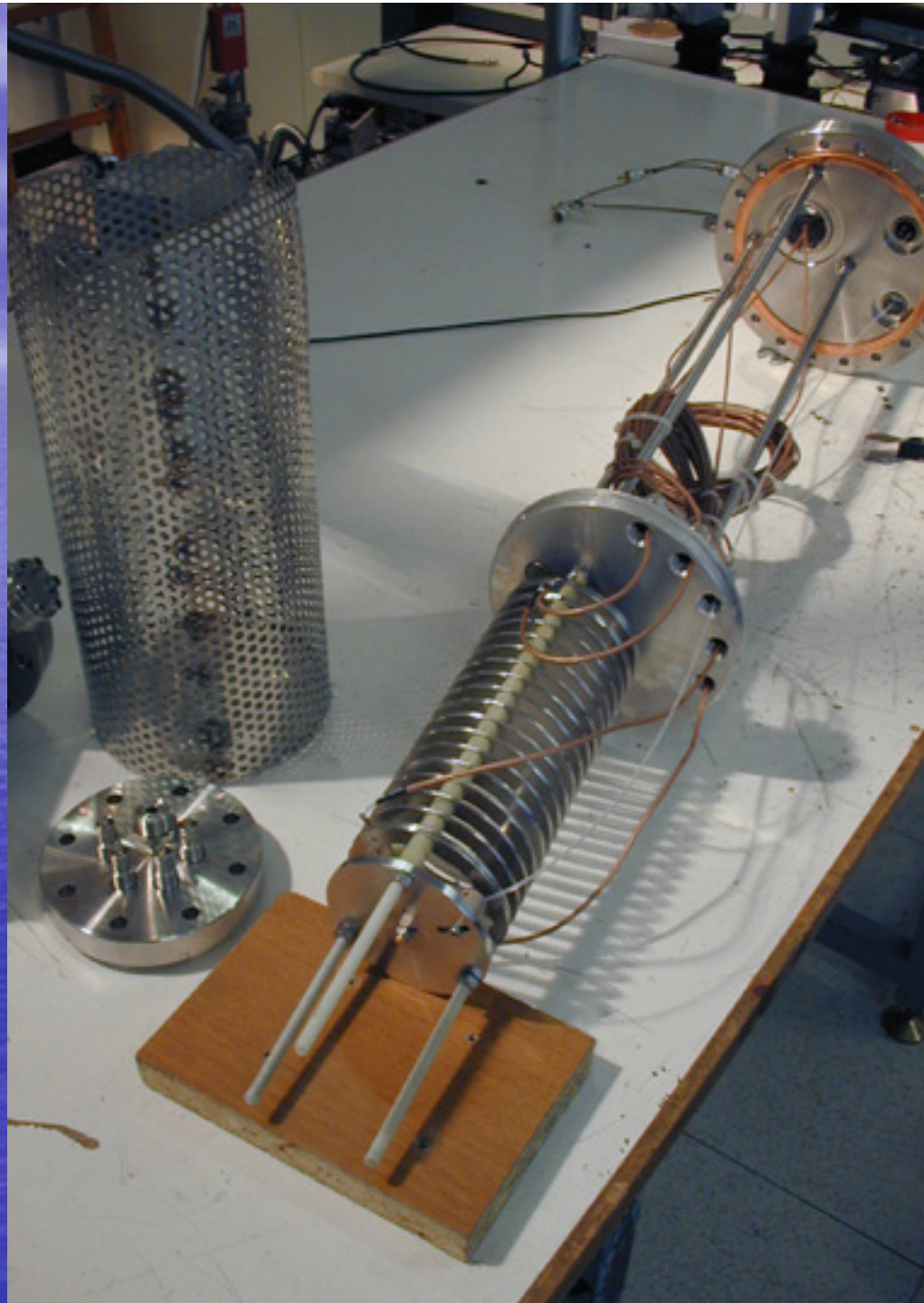
$$T_d = t_2 + \frac{t_1 + t_3}{2}$$

$$R = \frac{Q_A}{Q_K}$$

How do we measure electron lifetime in LAr?

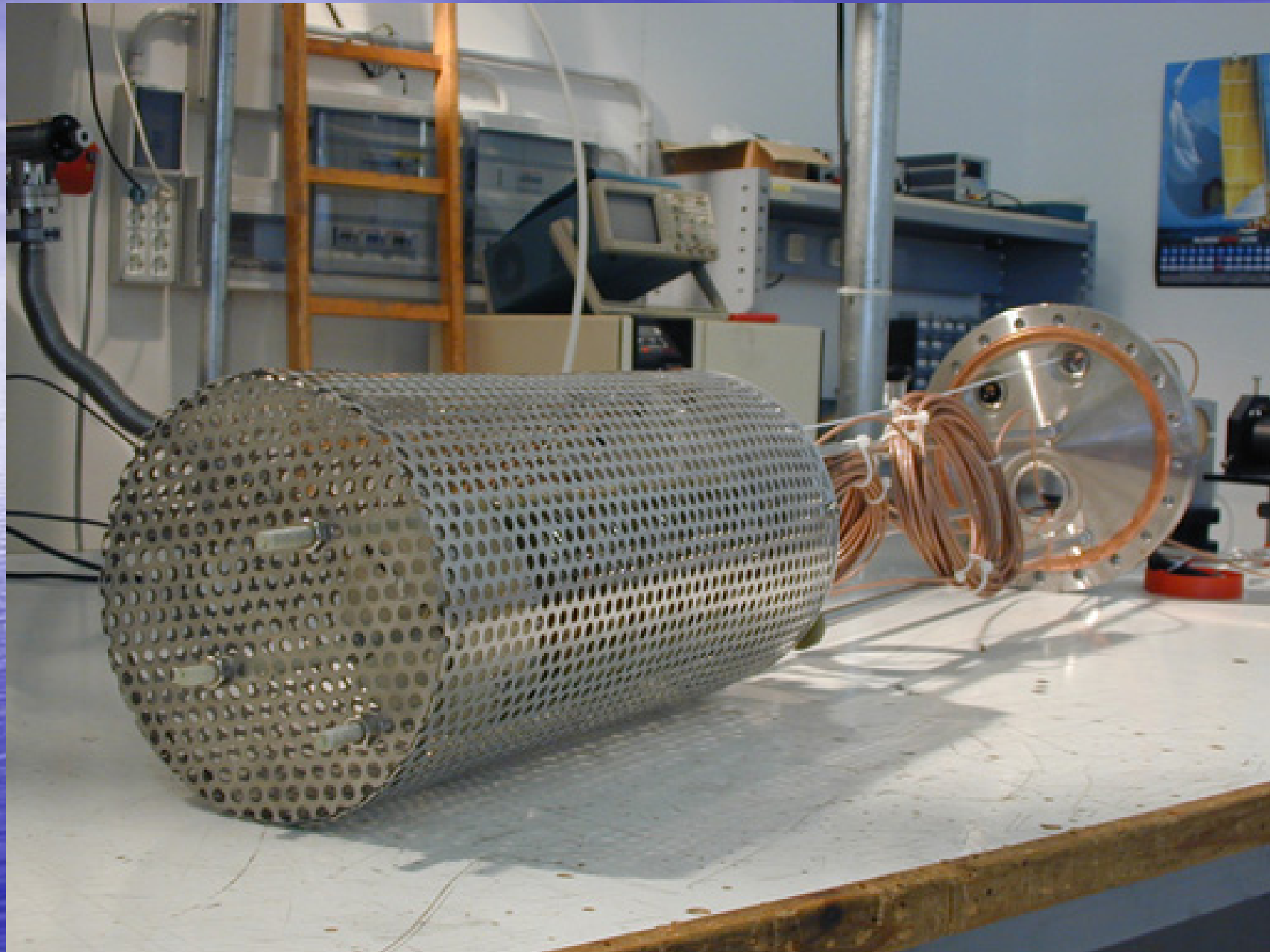






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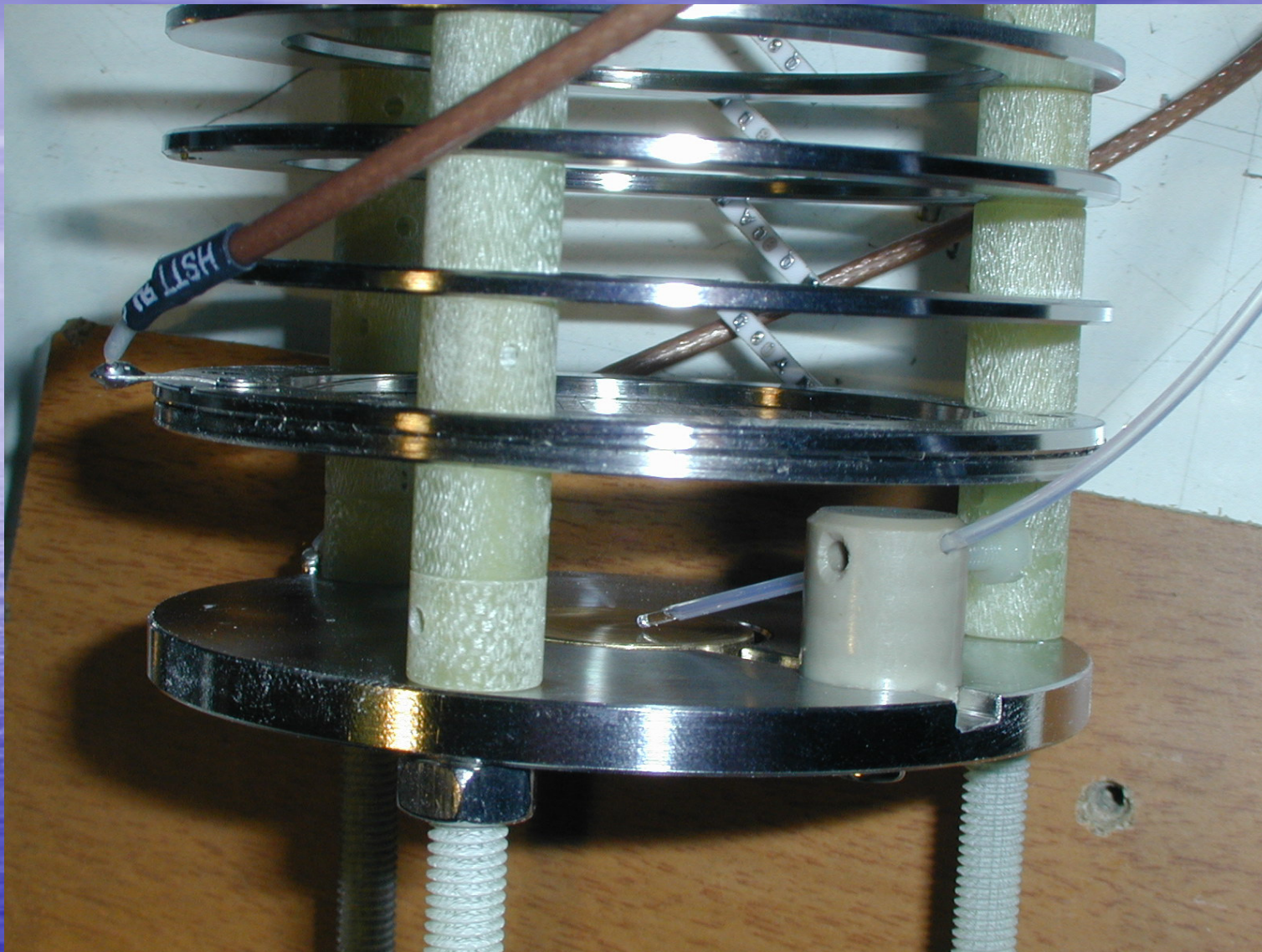
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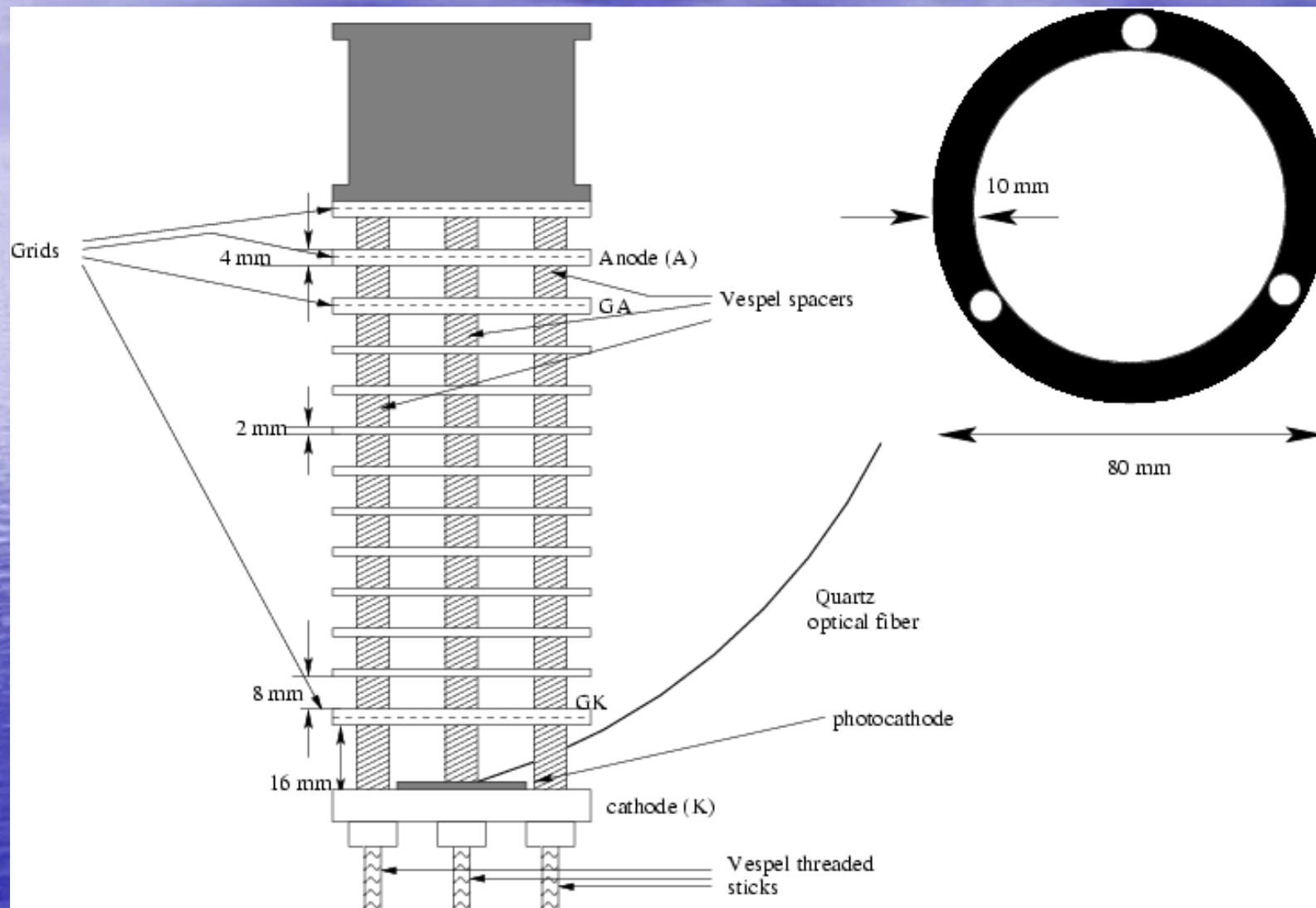
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C.Cattadori- Geel GERDA meeting

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Il nuovo prototipo di Monitor



- Passante elettrico per alta tensione di nuova concezione



Barre lavorate in Vespel

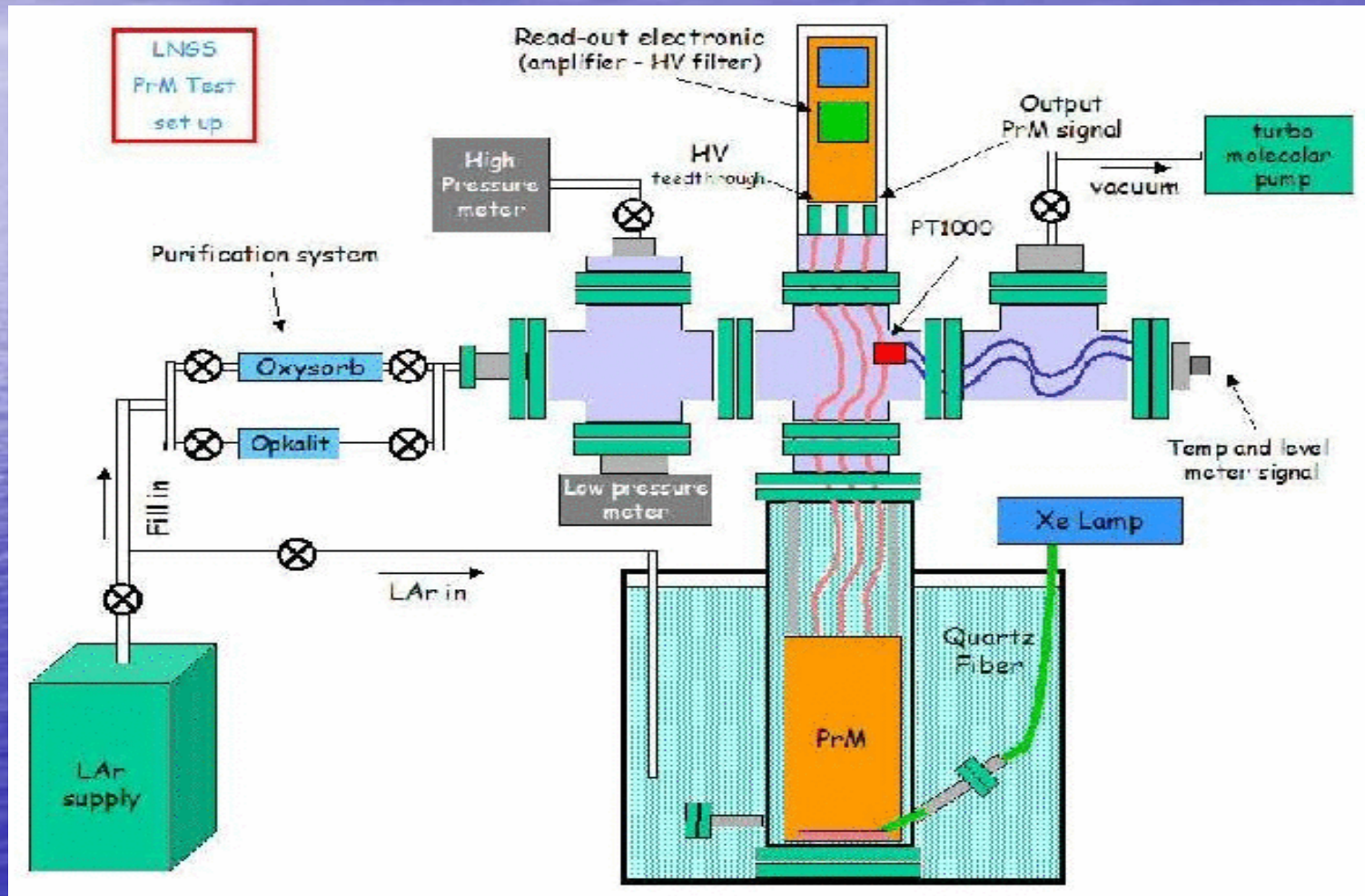


- Passanti ottici Caburn

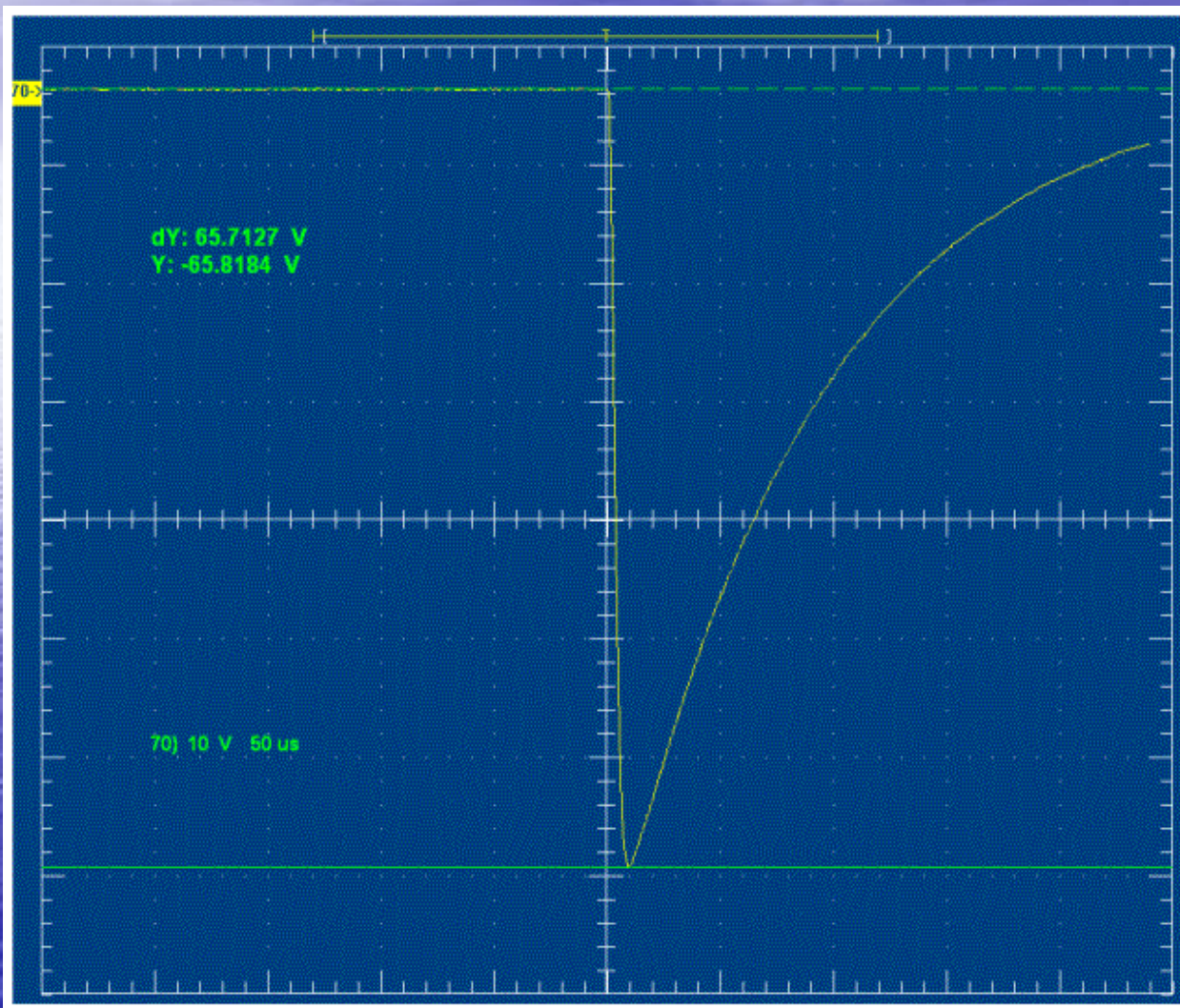


Realizzazione

apparato per la misura in liquidi nobili della carica fotoestratta e della purezza



Il segnale di fotoestrazione

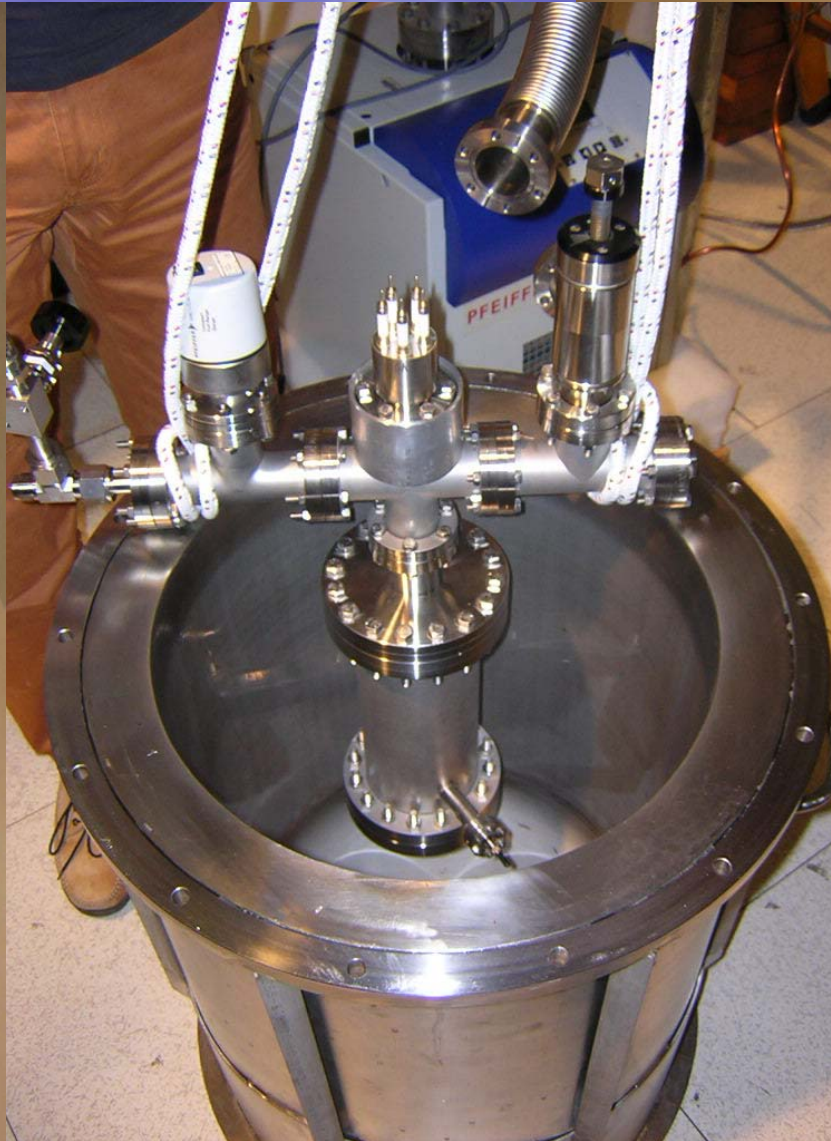


$$Q_e = \frac{\Delta V}{a_q}$$

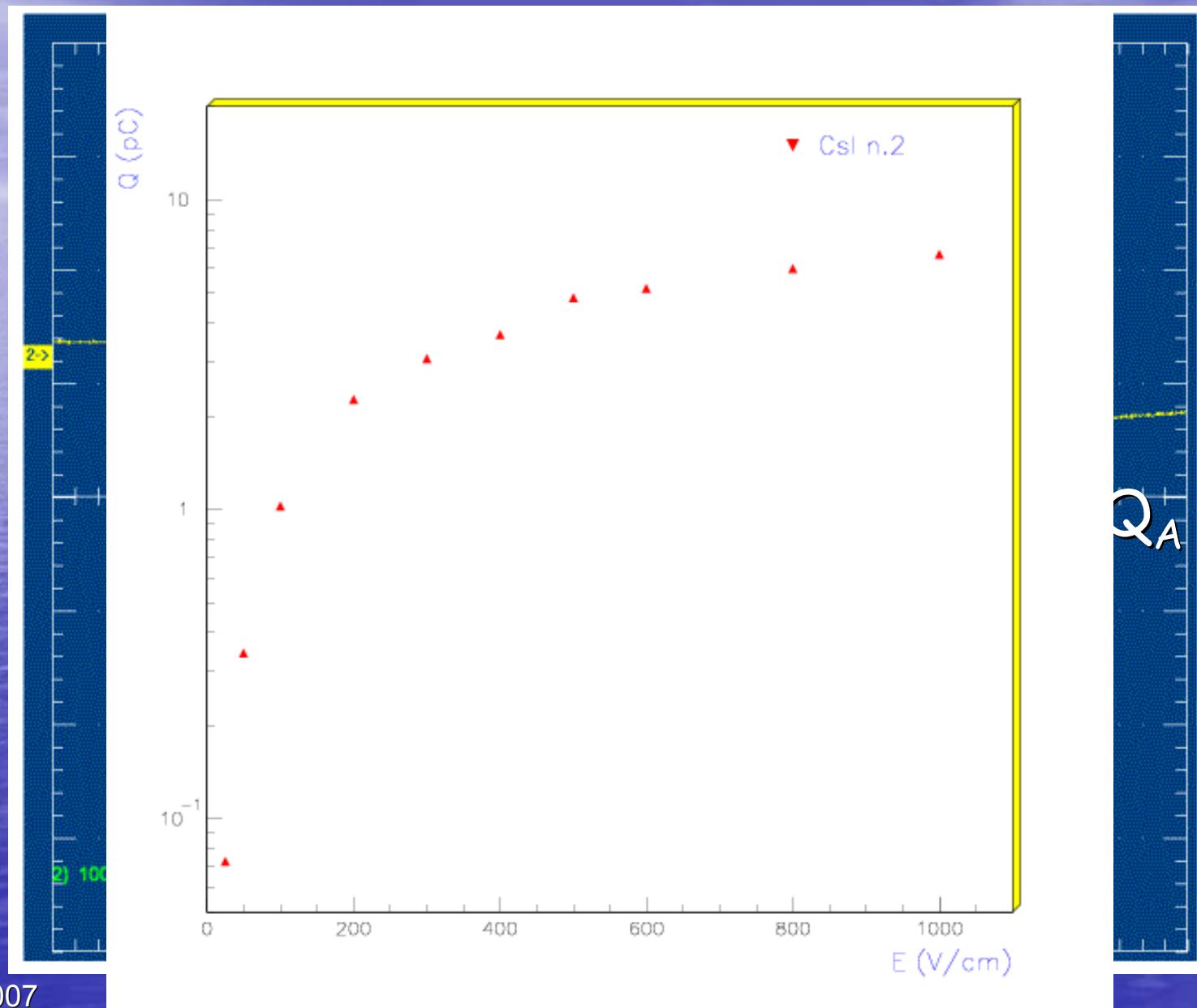
$$Z_e = \frac{Q_e}{e}$$

$$Q.E. = \frac{Z_e}{Z_y}$$

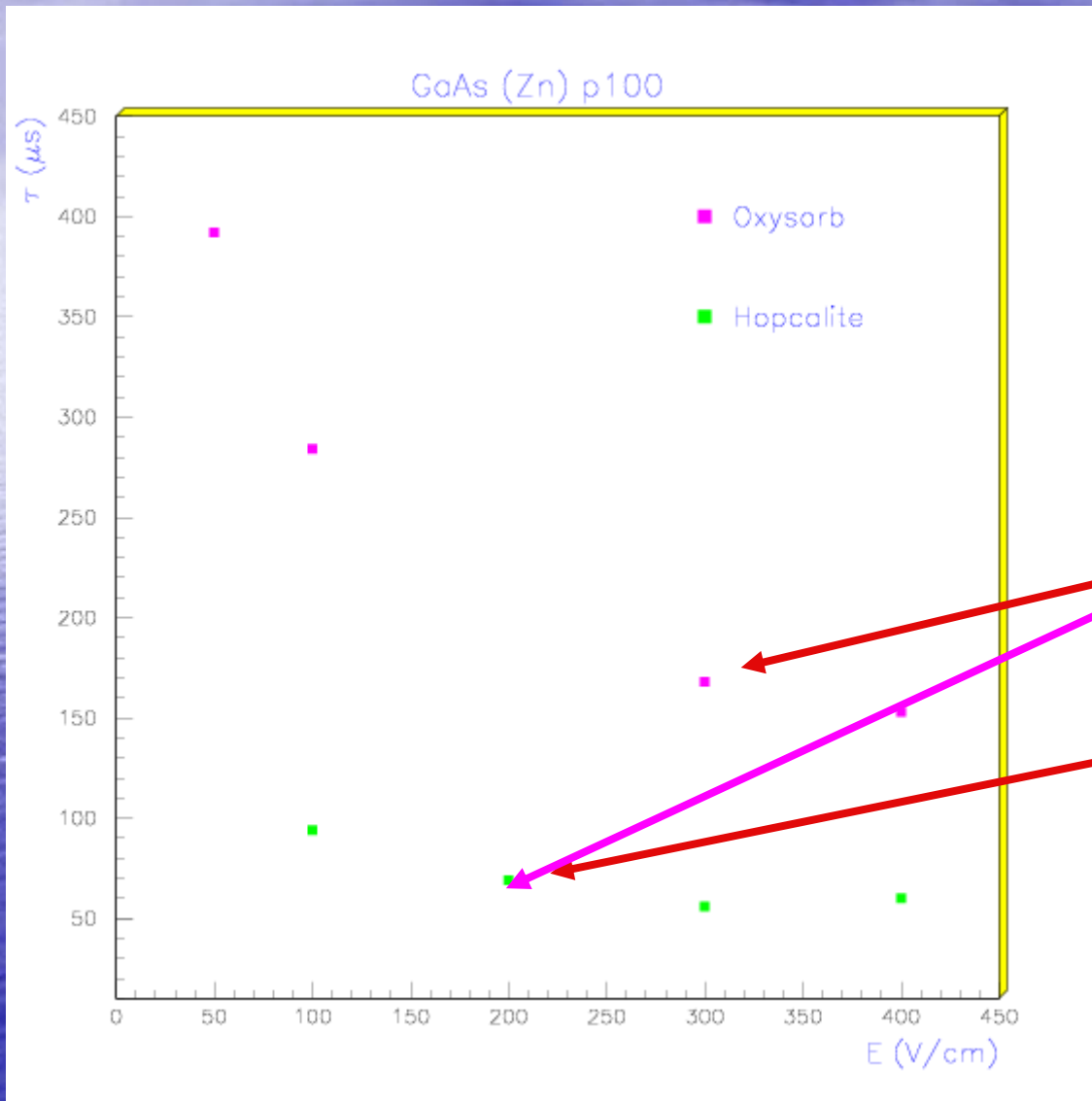
Struttura dell'apparato con il nuovo Monitor



Forma d'onda e rampa in tensione

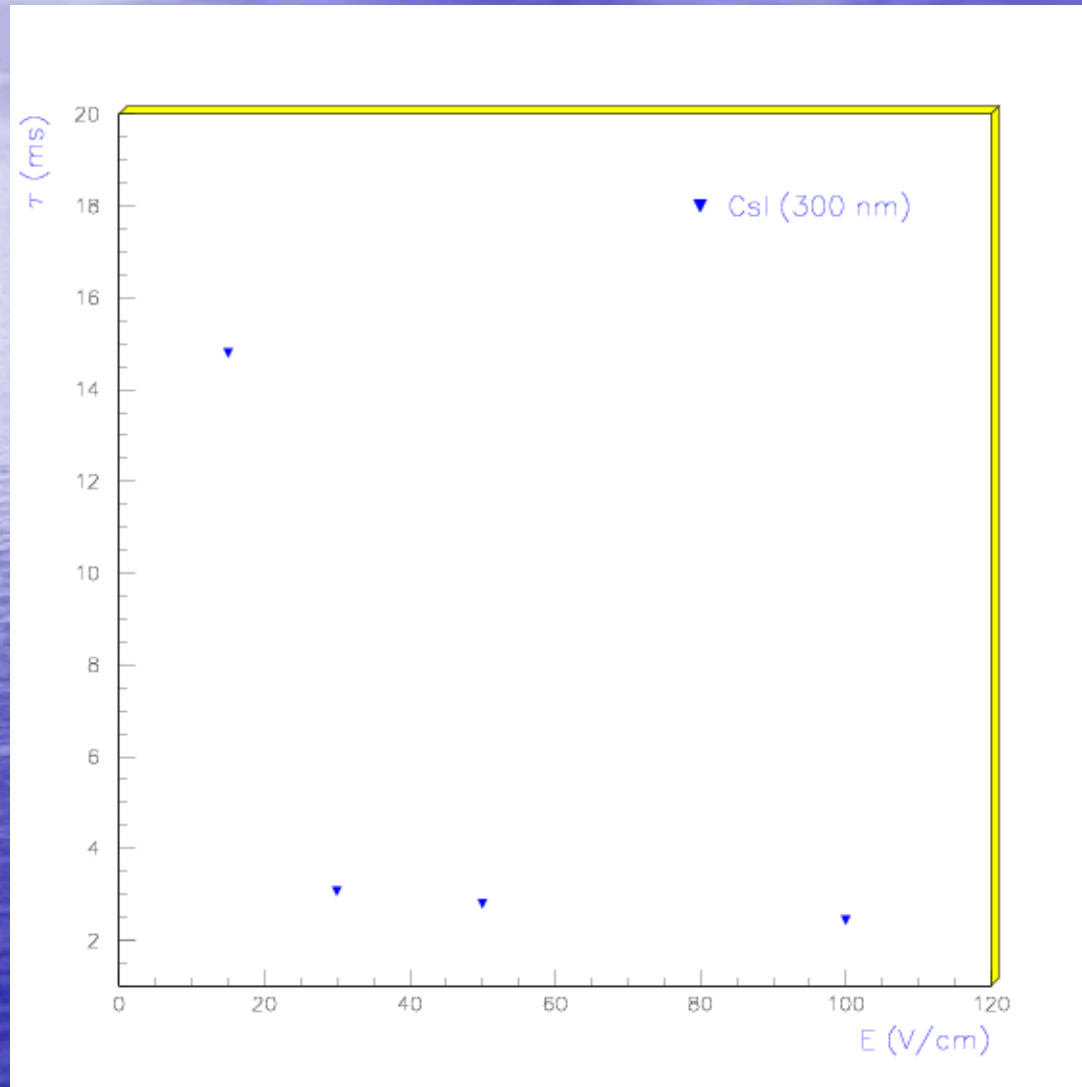


Some results on measurements of τ_{e^-} as a function of drift E field for GaAs photocathode



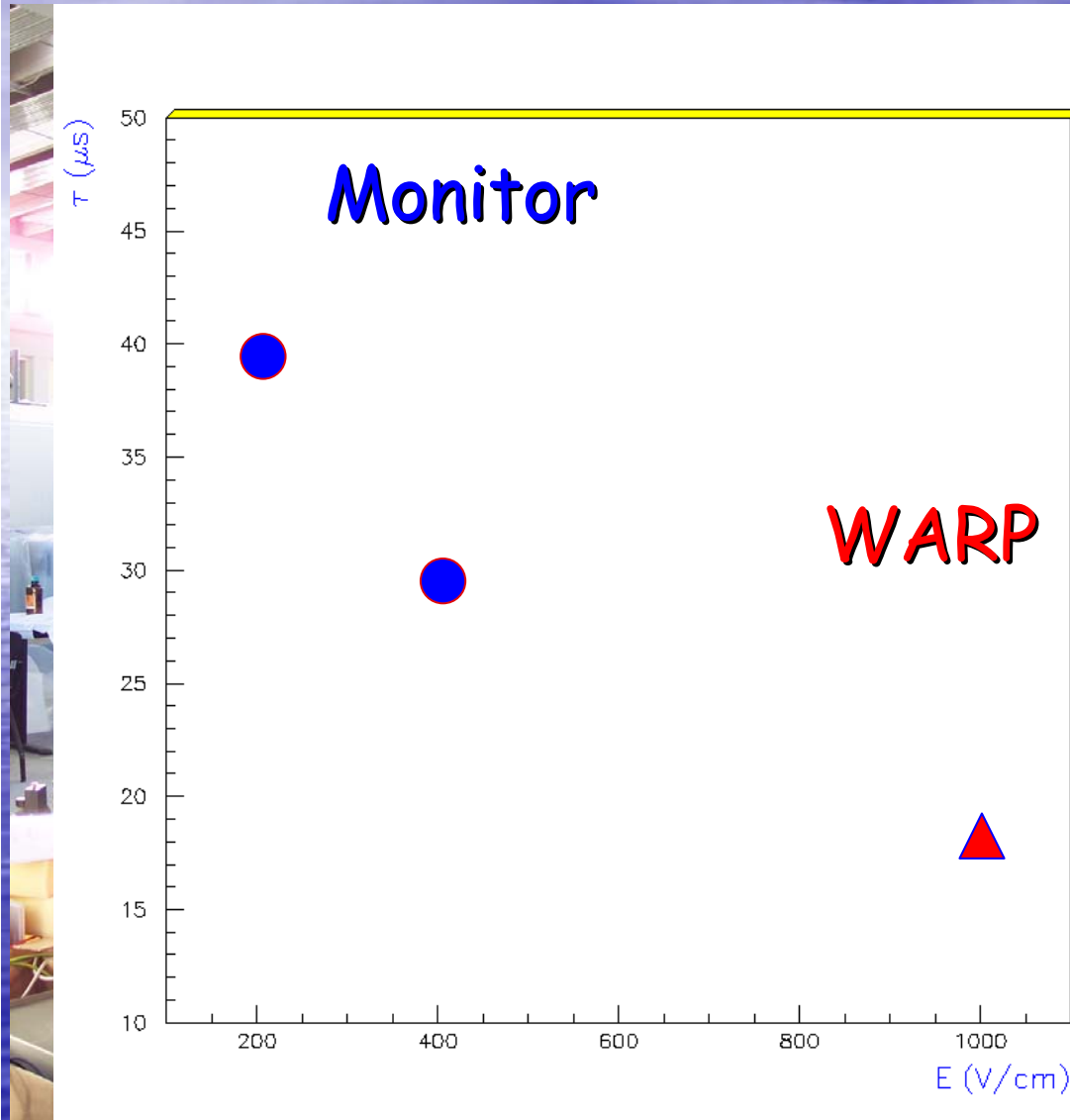
GaAs
con filtri
Oxisorb
&
Hopcalite

Some results on measurements of τ_{e^-} as a function of drift E field for CsI photocathode

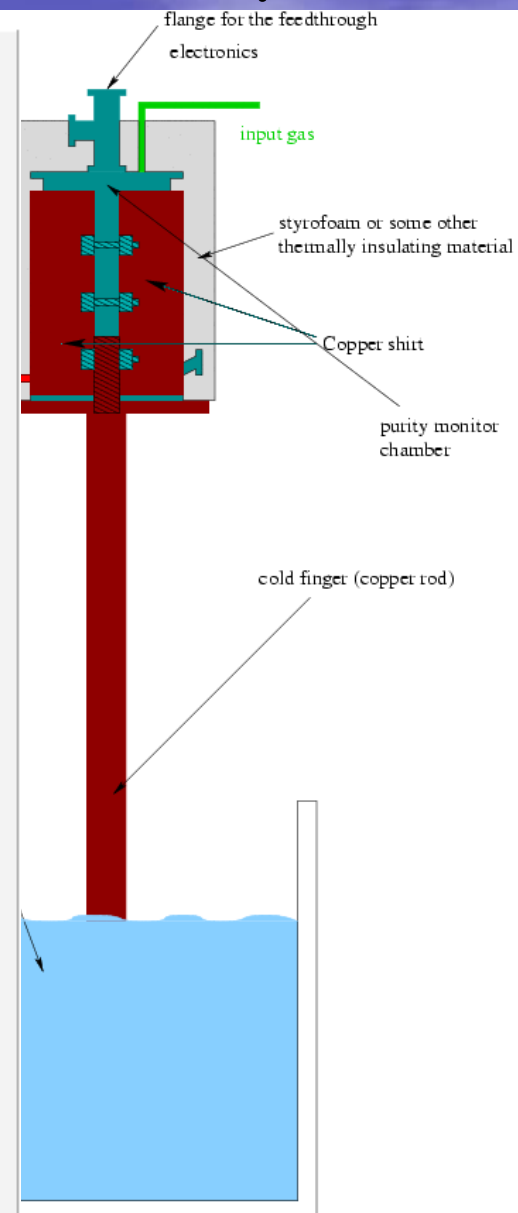
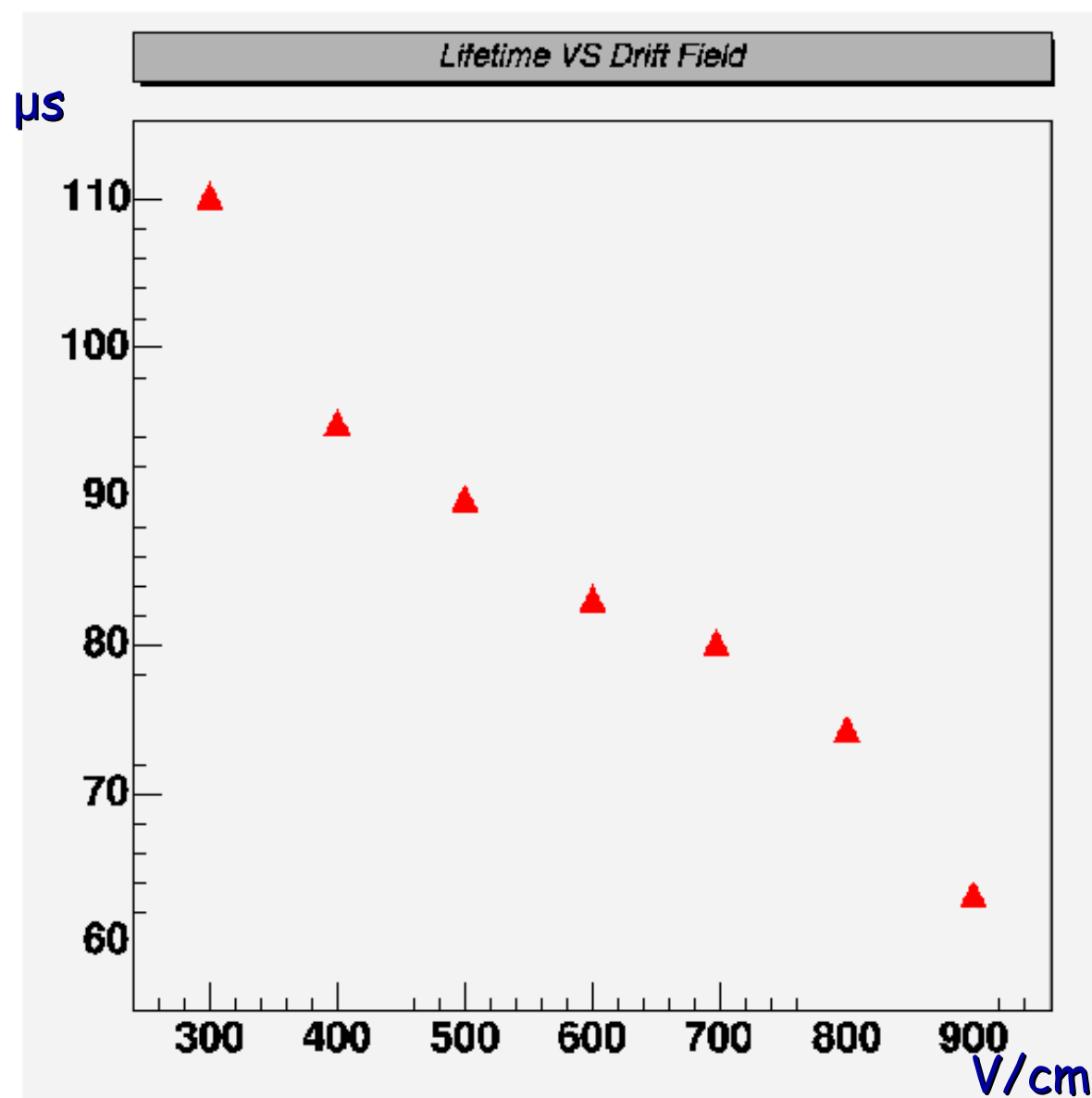


CsI
con filtro
Trigon

Misura di τ nella camera bifasica da 2.3 l dell'esperimento WARP



Misura della purezza dello Xe liquido



Technology transfer to GERDA

- ICARUS is ready to provide (meeting on 16th may)
 - a LAr purity monitor (a spare device) to associate measurement of electronegative impurities concentration to crystal LC value once crystal & surrounding LAr are irradiated by γ -source
 - to borrow a TRIGON cartridge to test effect of LAr purification on crystal LC.
- Another LAr purity monitor for LARGE should be built.
- Possible at LNGS mechanical workshop where all the exiting LAr purity monitor have been built up to now. All mechanical drawings and raw material and mainly know how is there.

Dipendenza di τ dal campo elettrico di deriva

- Nei test effettuati con i filtri Oxisorb ed Hopcalite con fotocatodo di GaAs
- Nei test condotti con il filtro Trigon con fotocatodo di CsI
- Nella misura del tempo di vita medio in WARP
- Nella misura della vita media in XENON

$$\tau = 1/k_S N_S$$

Conclusioni

- Realizzazione di un apparato per la rapida caratterizzazione in vuoto di materiali fotoemissivi
- Caratterizzazione di vari fotocatodi
- Realizzazione di monitor di purezza "quasi portatile" con soluzioni innovative
- Test di diversi purificatori
- Misure di vita media in Ar e Xe liquidi e osservazione di effetto di dipendenza dal campo elettrico

Sviluppi Futuri

- Effettuare ulteriori misure con differenti purificatori, anche a lungo termine, in grado di eliminare CO_2 e N_2O per comprendere quale molecola sia effettivamente responsabile degli andamenti osservati
- Test a lungo termine dell'efficienza del fotocatodo di CsI