# LASA $Cs_2Te$ Photocathodes: the electron source for the XFELs

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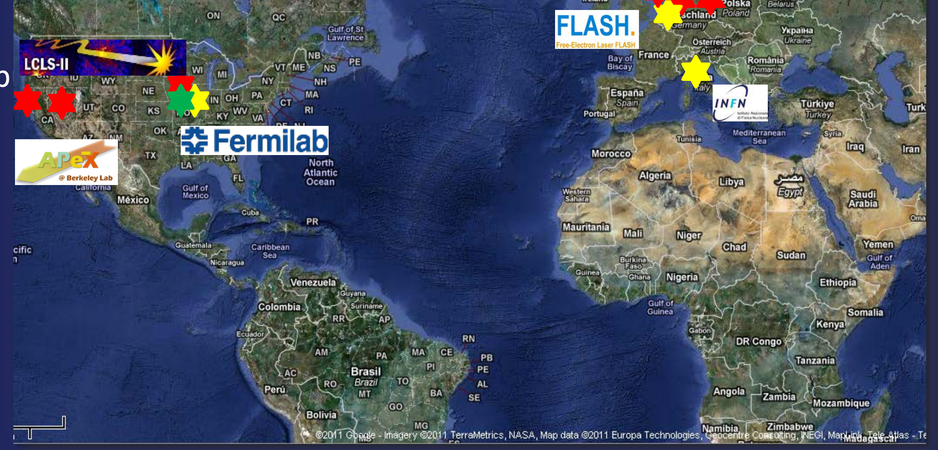
Laser triggered photocathodes are key components of the electron sources for the XFELs. Research on semiconductor photocathodes started in the 1990s at INFN LASA Milano by studying multialkali antimonied compounds ($Cs_2Sb$, $K_3Sb$, and $K_2CsSb$), showing that the high QE was coupled with very high sensitivity to vacuum pollution. To avoid these deterioration issues, we focused our activity on $Cs_2Te$ which, while sensitive to UV light, has better resistance to gas contamination. Since then, we have a dedicated R&D program aimed at developing a always more reliable photocathode and its associated transport systems. Today our photocathodes are used at FLASH and at European XFEL at DESY Hamburg, PITZ at DESY Zeuthen, APEX in LBNL, FAST at FNAL and at LCLS-II at SLAC.

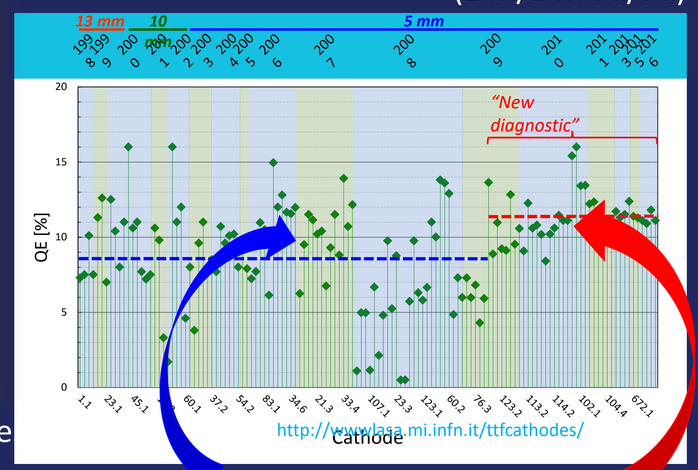
## LASA Photocathodes in the World

In 90's we developed a split system to detach the production system from the RF gun. The first system of this kind has been installed at the Tesla Test Facility (TTF) now FLASH at DESY Hamb

Due to the sensitivity of the photocathode to gas exposition, the photocathode have to be kept under UHV condition all the time. A key element is the transport system and its associated components (carrier, suitcase, etc.). In the last years, we have upgraded our transport suitcase with a new pumping systems based on Non Evaporable Getter (NEG) to guarantee always pumping speed to the system.




The Cs2Te photocathodes produced up to now are more then 140 with lifetime that now exceed 180 days of continuous operation (24h/24h 7d/7d).

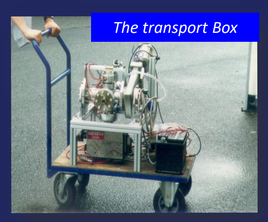


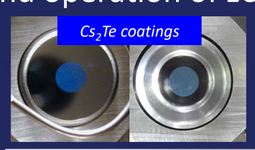

*Transfer system connected to the RF Gun at FLASH*


$Cs_2Te$ in the LASA system

Since then, similar systems have been installed in different laboratories around the world: *XFEL, PITZ, REGAE, APEX, FAST* and for the commissioning and operation of *LCLS II*.

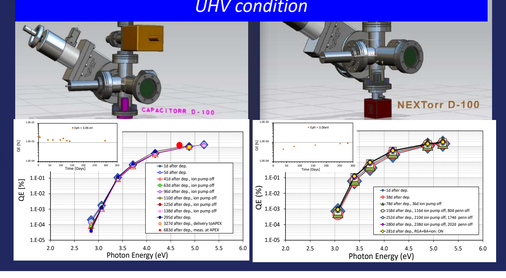
*The transport Box*

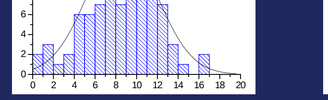


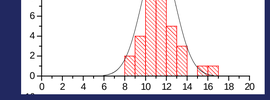




*Different transport boxes configuration guaranteeing the UHV condition*



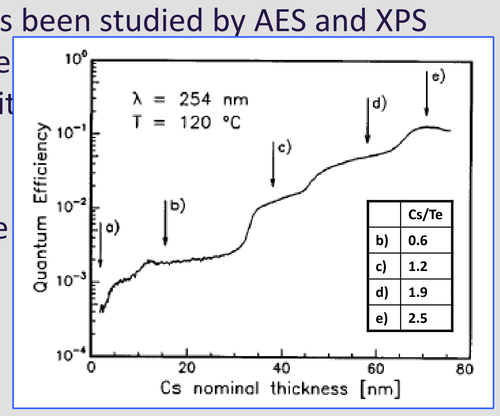



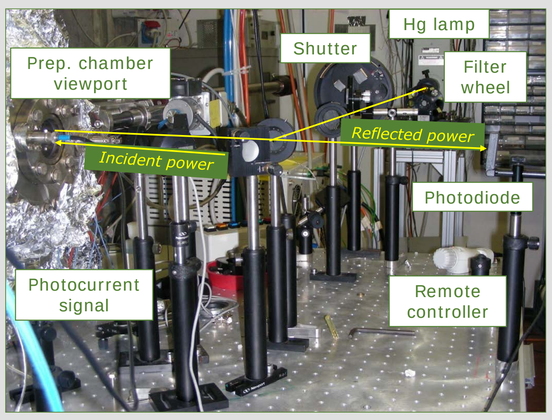

*The last cathode at FLASH is in operation since Feb. 2015 (prepared at LASA in Jul. 2013):* ***860 days!!***

## $Cs_2Te$ Production

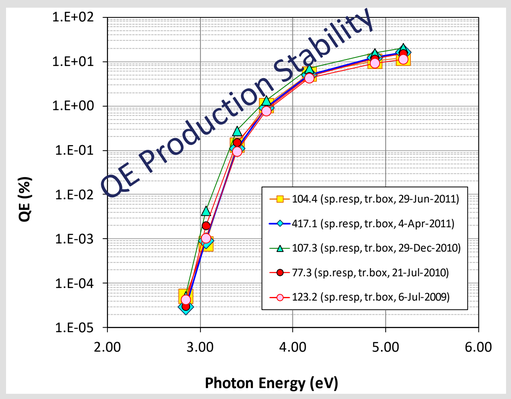
The $Cs_2Te$ production process has been studied by AES and XPS techniques for understanding the growth mechanism and the sensit of the photocathode to gases exposition.
We applied this know-how to the production process that has evolved till the actual one that allows very high reproducibility of the photocathode process.




A. di Bona et al., JAP80(1996)3024

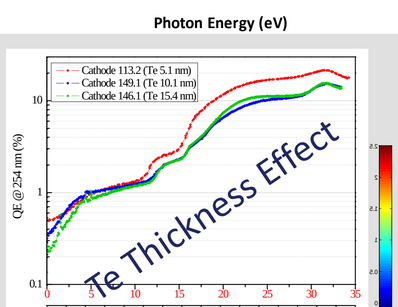


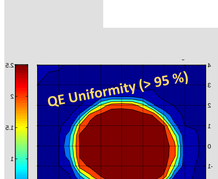

A multi-wavelength system is used to monitor the cathode QE during production. The system allows detecting the proper cathode formation based on a maximum at longer wavelengths. This has been an important step in improving the reproducibility of the cathode performances.

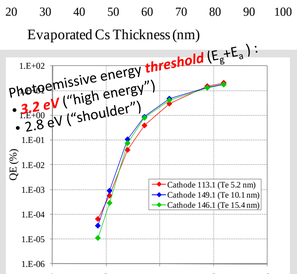








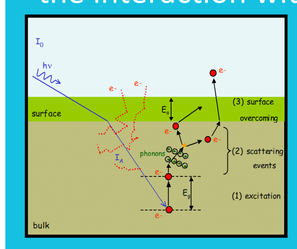



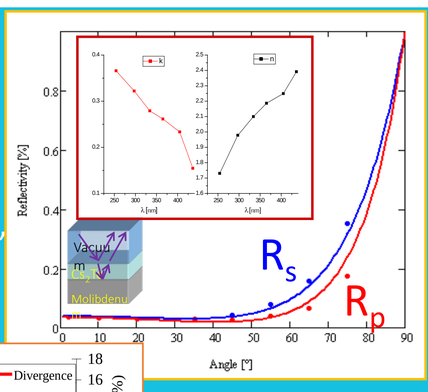

## R&D Activities on Photocathodes

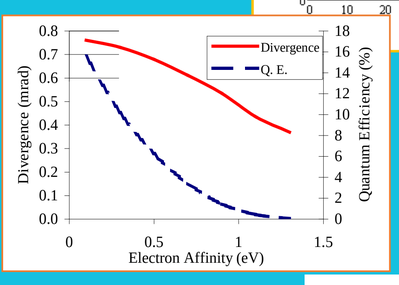
### • Optical Properties

We study the optical properties of $Cs_2Te$ by measuring the reflectivity at different angles. Given the thickness of the photoemissive material (10s of nm), the interaction with the substrate play an important role.

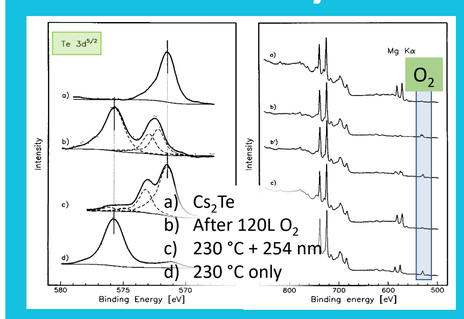



The optical parameters have been used to develop a simple Monte Carlo model of the photoemission process based on the "three steps" model approach of Spicer.

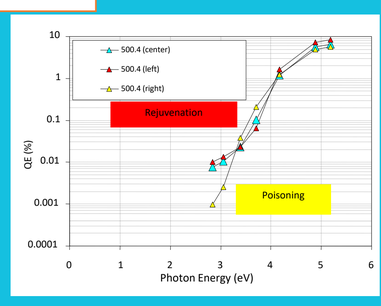



## Gas Sensitivity and Rejuvenation




$Cs_2Te$ can be rejuvenated after gas pollution by a combination of heating and UV irradiation.
This effect is studied measuring the photocurrent during the pollution also varying the wavelengths.
The QE spatial QE uniformity complete the diagnostic.




## Thermal Emittance

We developed a Time of Flight to measure the angle resolved photoelectron emission spectrum and reconstruct from it the $Cs_2Te$ thermal emittance.