Calibration of Dynamic Vacuum Meter

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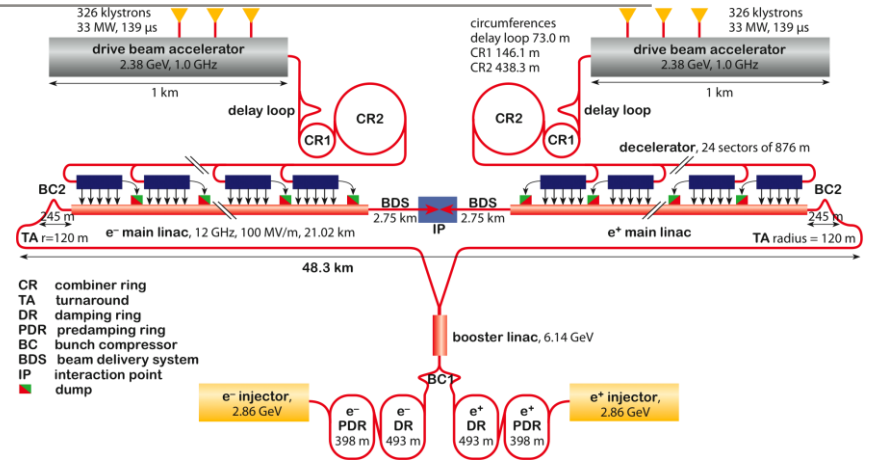
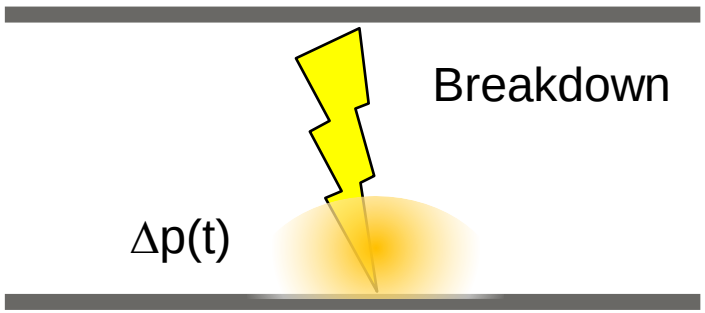
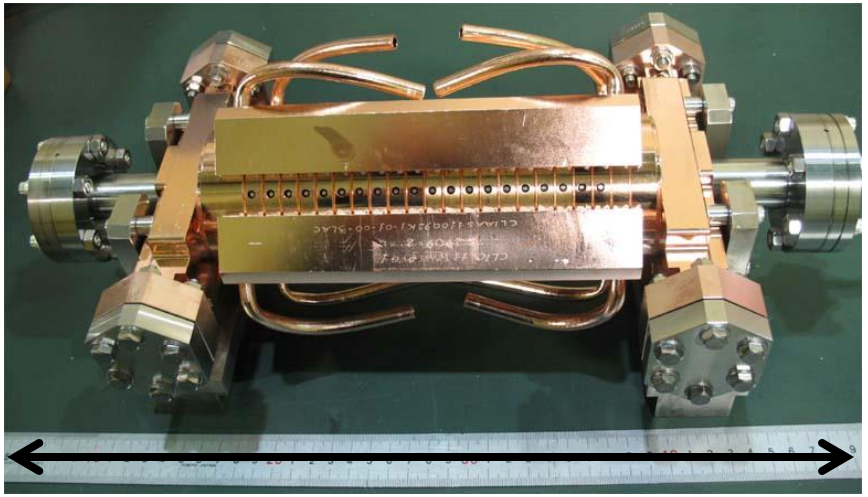
Dynamic Vacuum Meter



Vacuum tube or AS-element

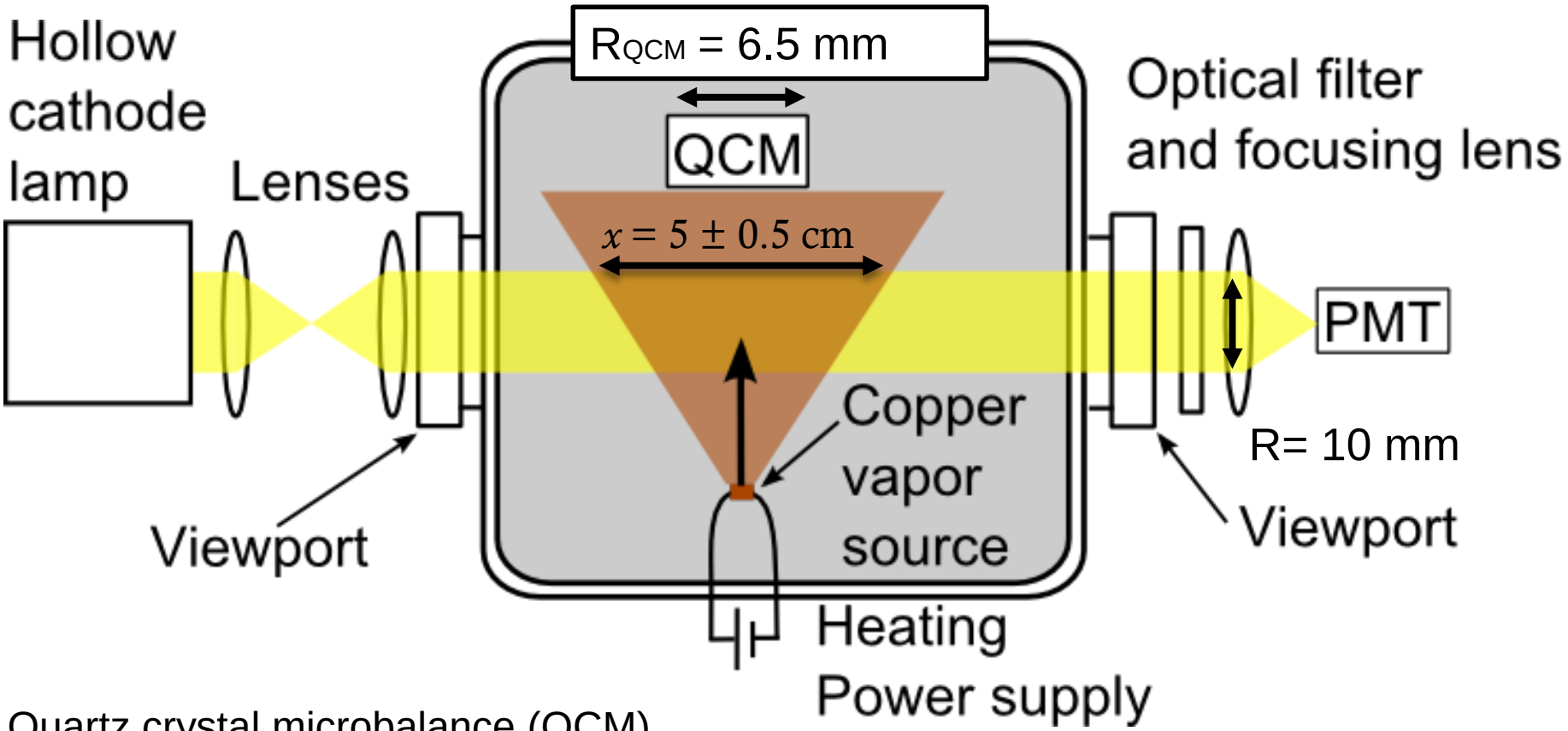




50 cm

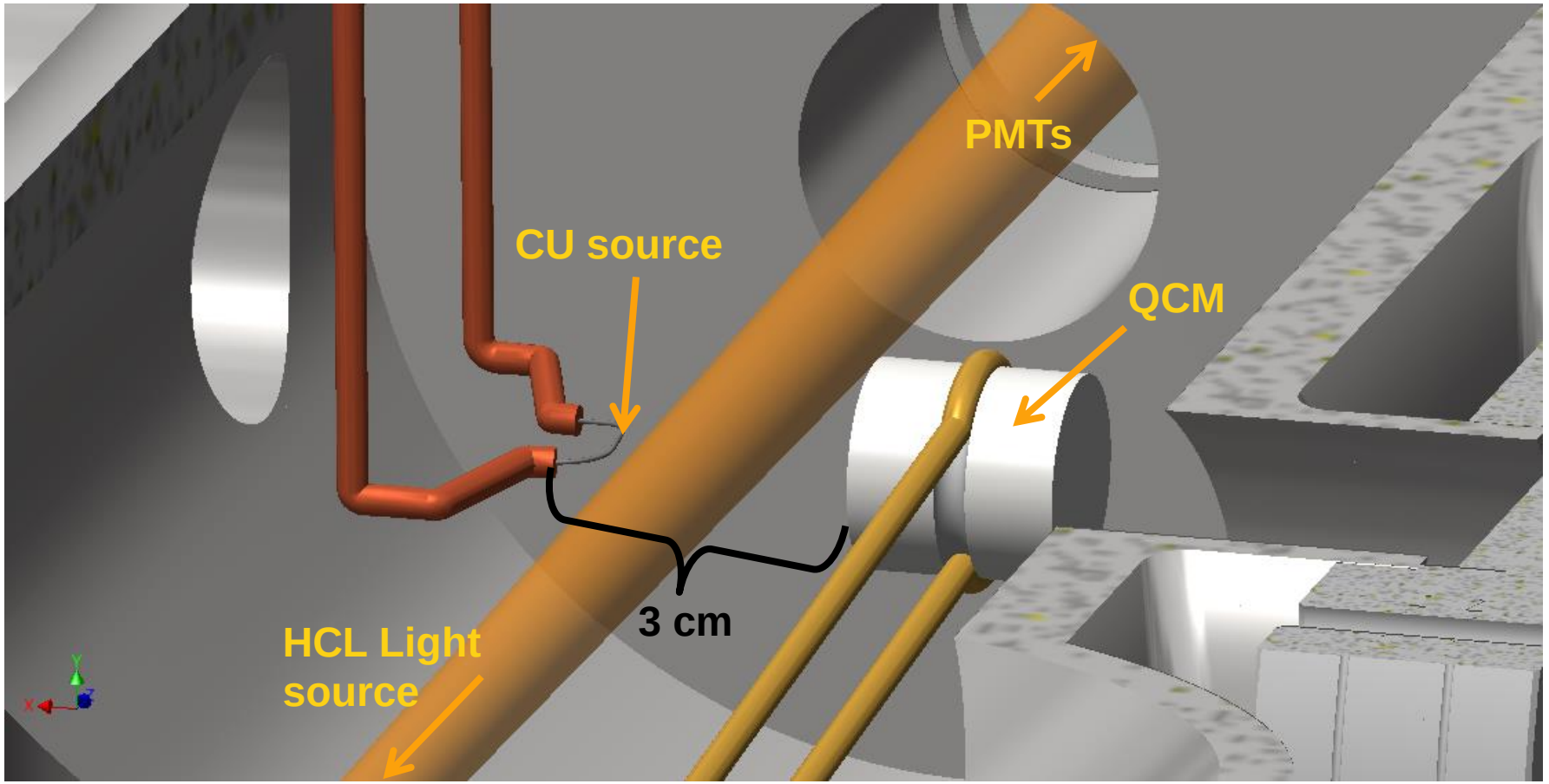
Dr. Walter Wuensch, Introduction to CLIC, Collaboration meeting at HIP 19.10.2010

Setup

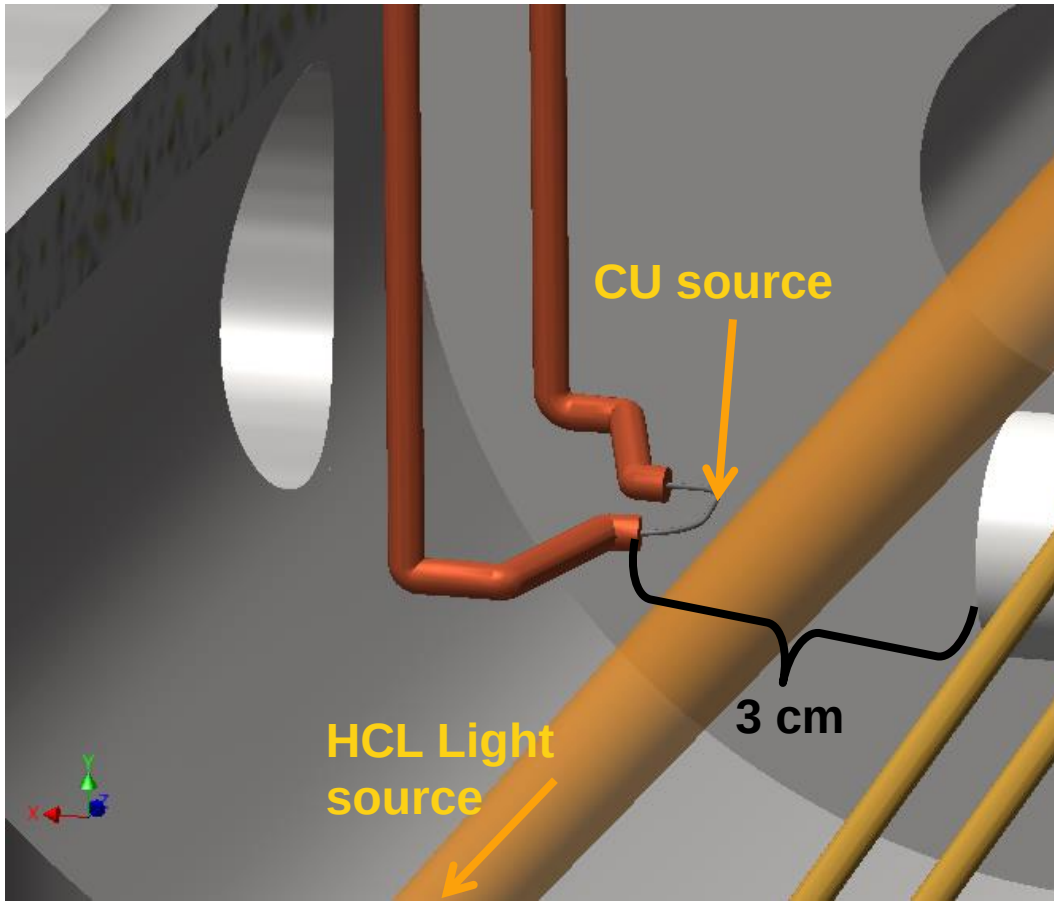


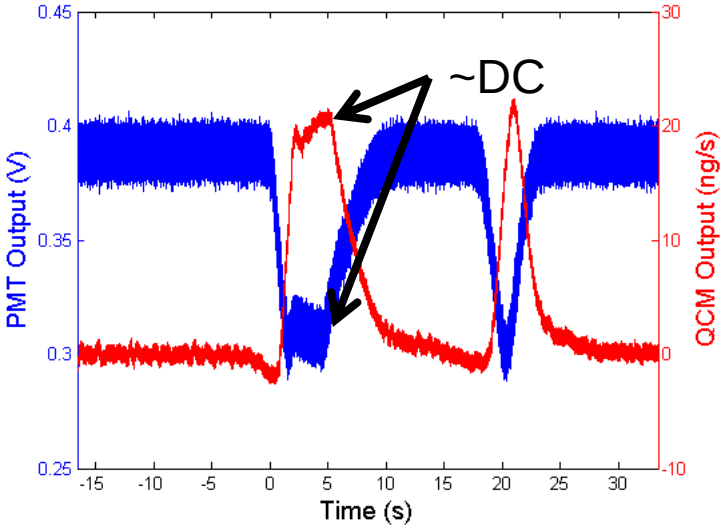
Quartz crystal microbalance (QCM) as reference

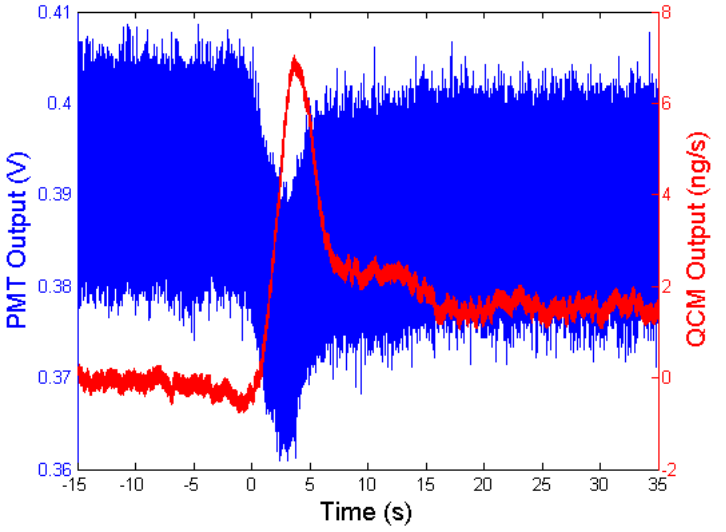
Setup



Early Results



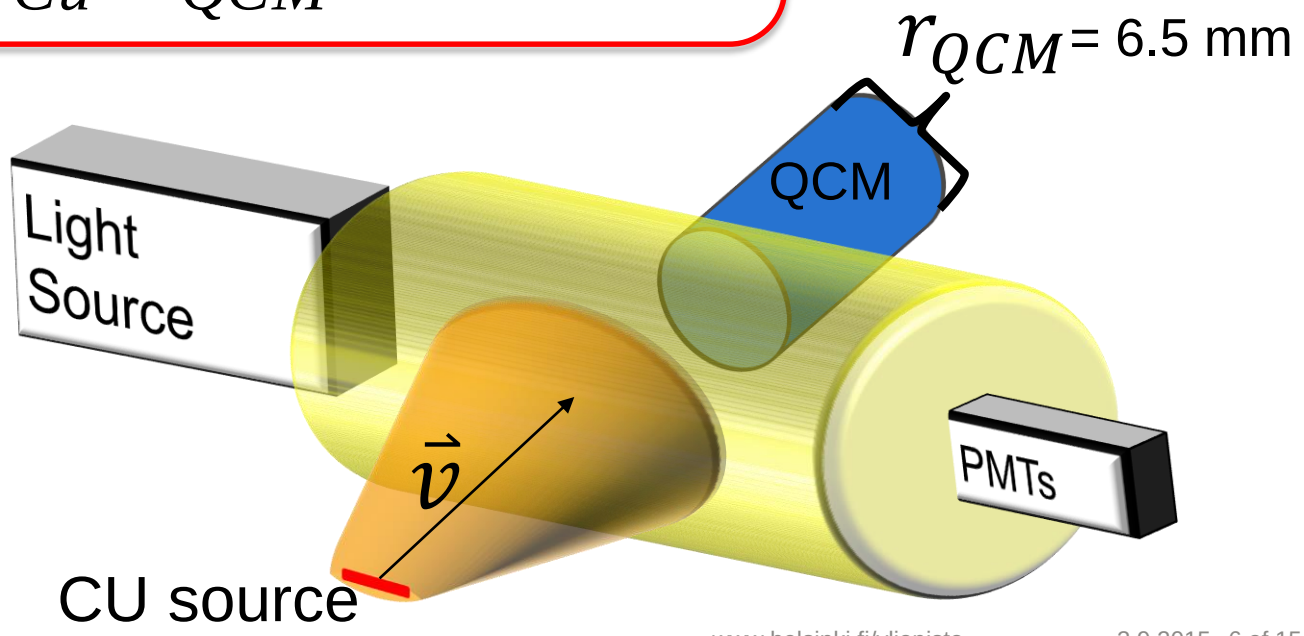




Estimation of Atom Density

For constant (DC) QCM signal:

$$N_{QCM} = \frac{3}{m_{Cu}\pi r_{QCM}{}^{2} v} \frac{dm_{QCM}}{dt}$$

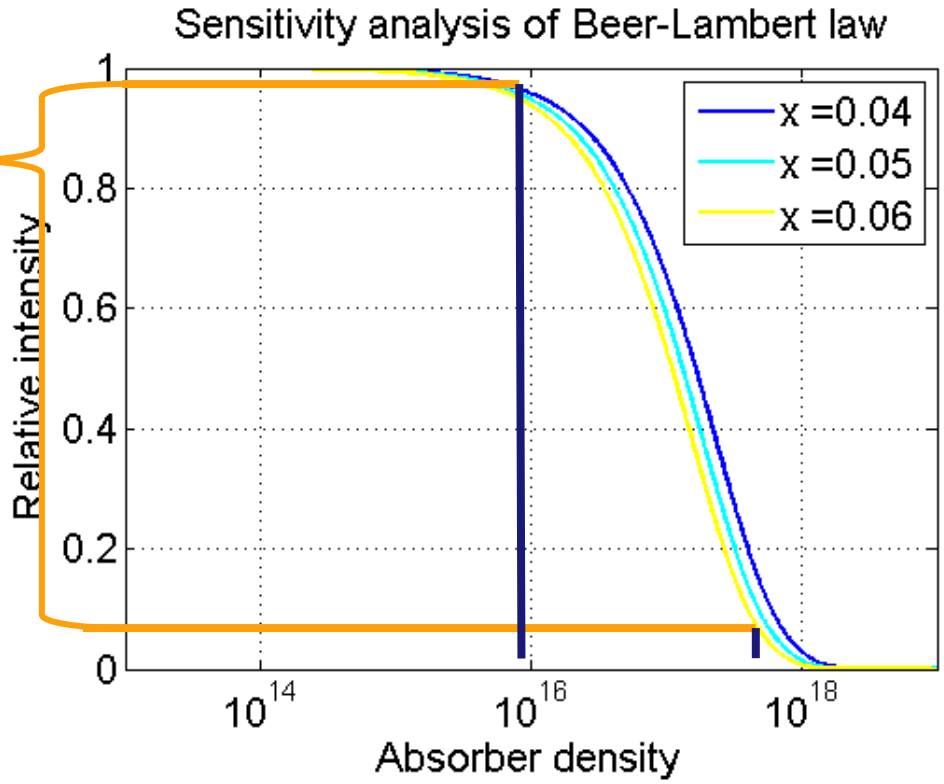


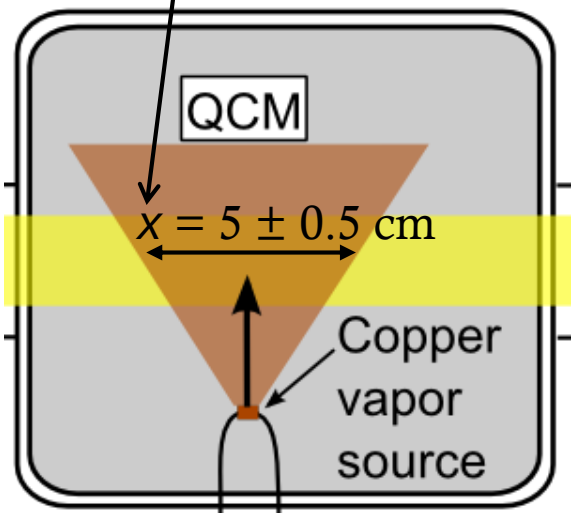
Absorption density

Beer-Lambert's law (PMT):

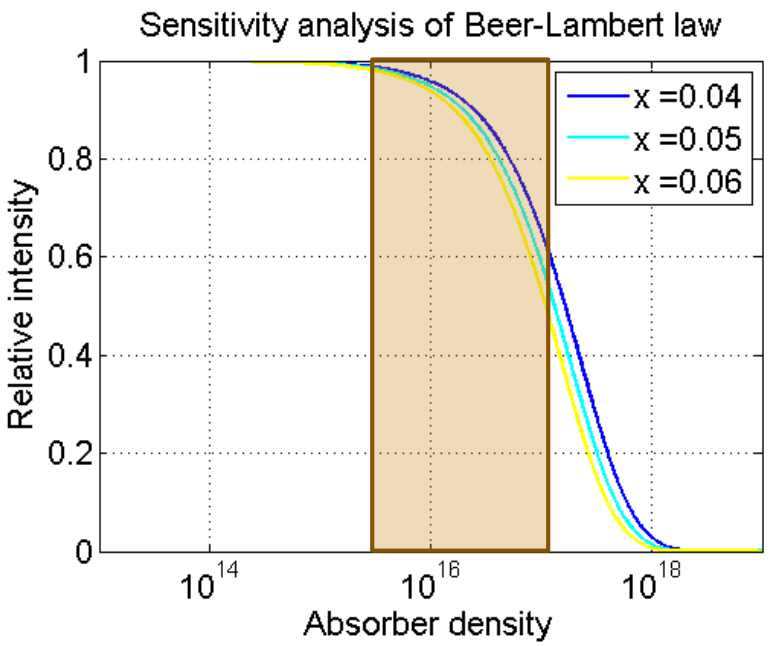
$$I(N_{PMT}) = I_{0,325nm} e^{-x\sigma_{325nm} N_{PMT}(\tau)} + I_{0,327nm} e^{-x\sigma_{327nm} N_{PMT}(\tau)}$$

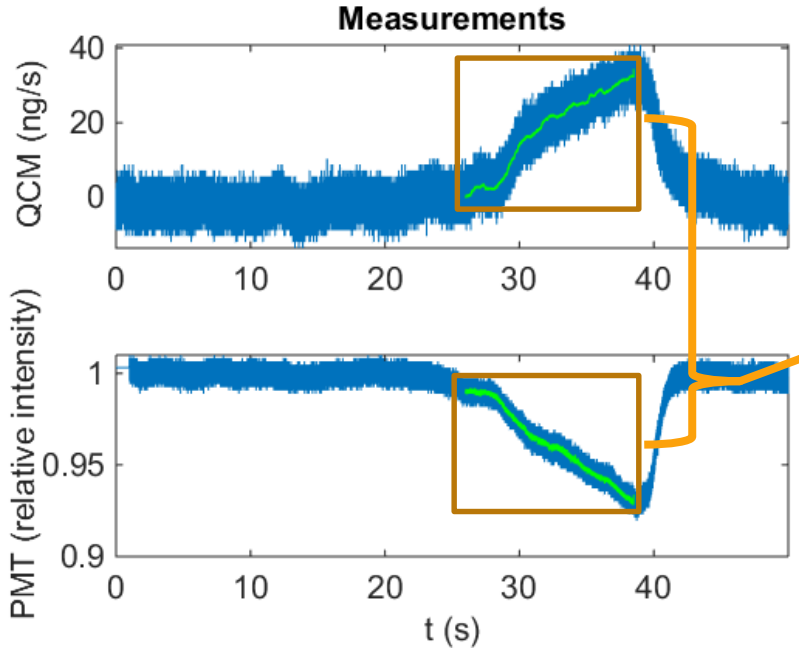
Operational range

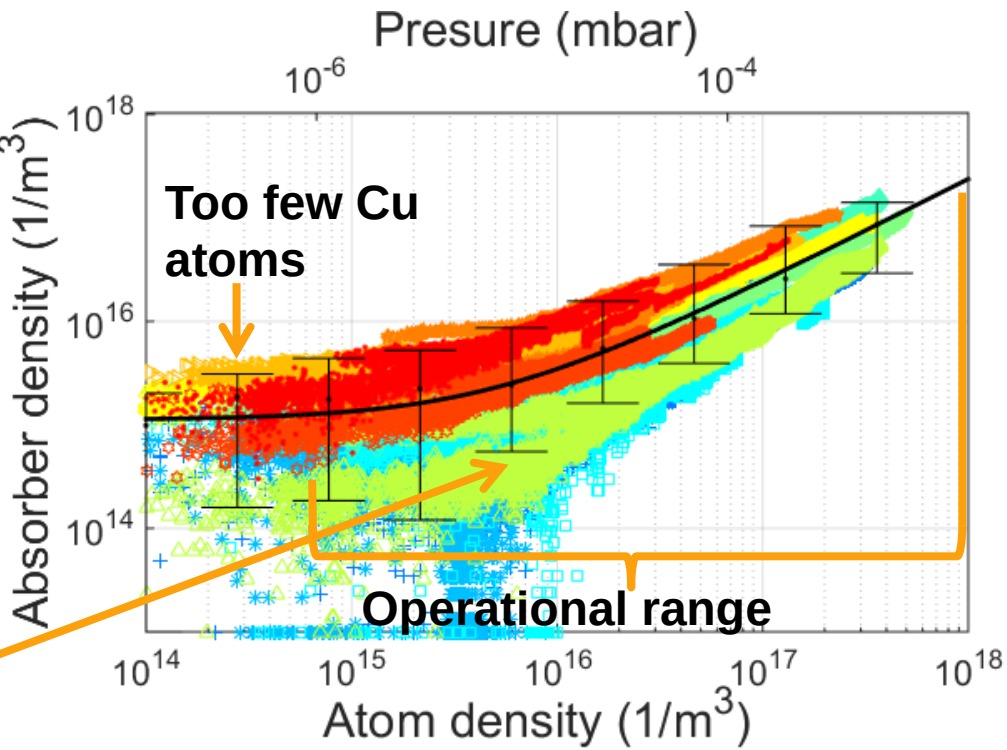




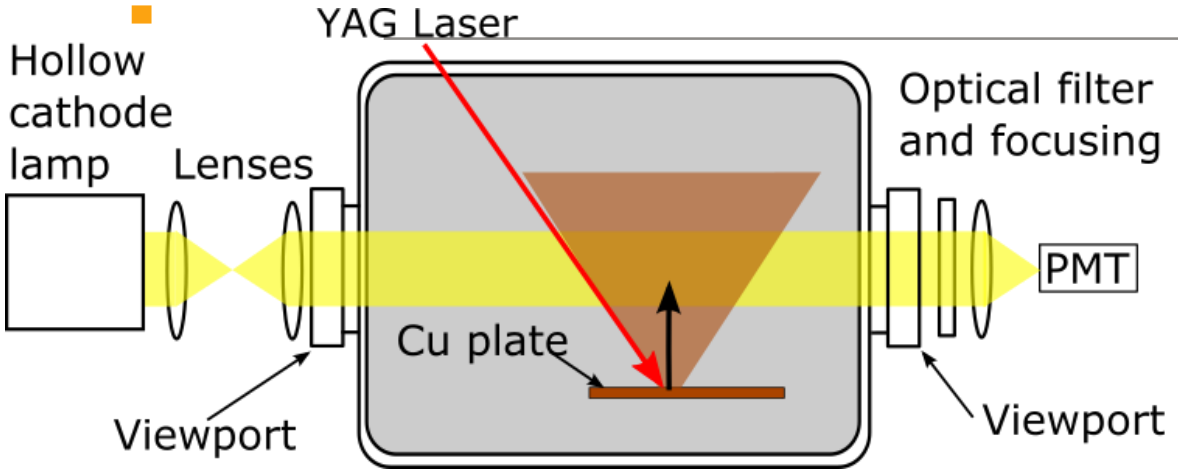
Calibration





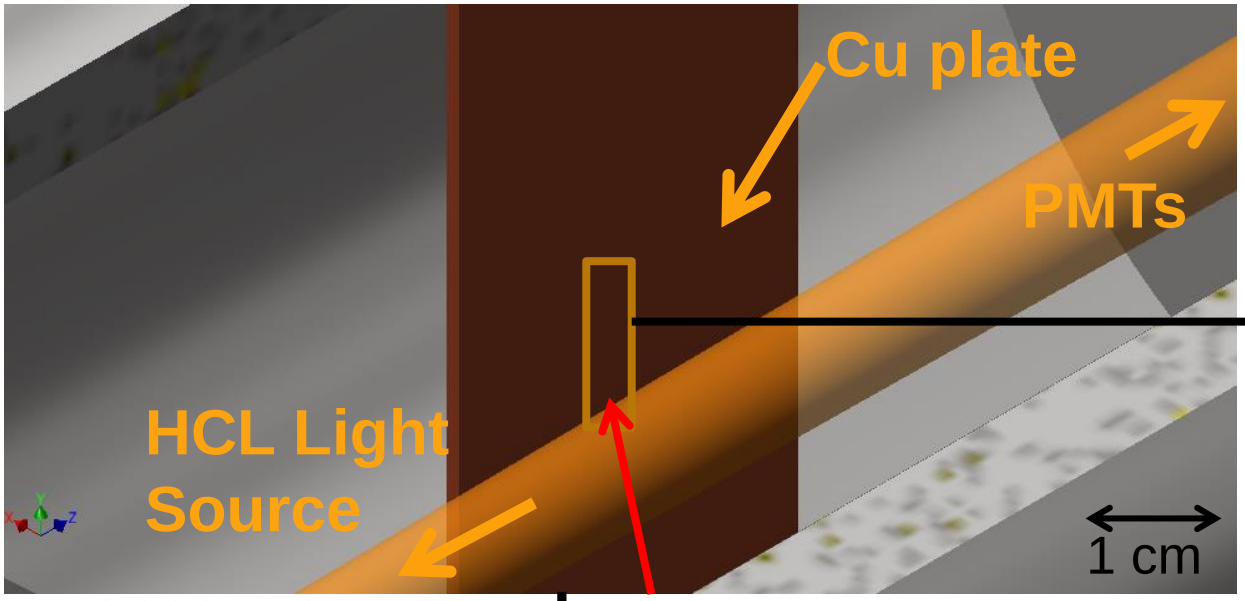


Laser Ablation

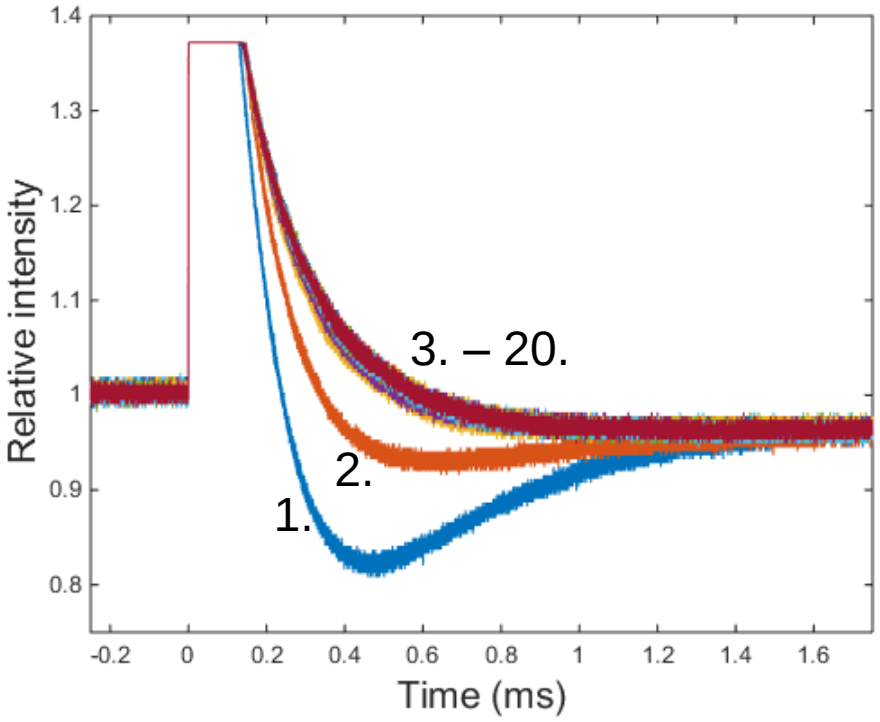


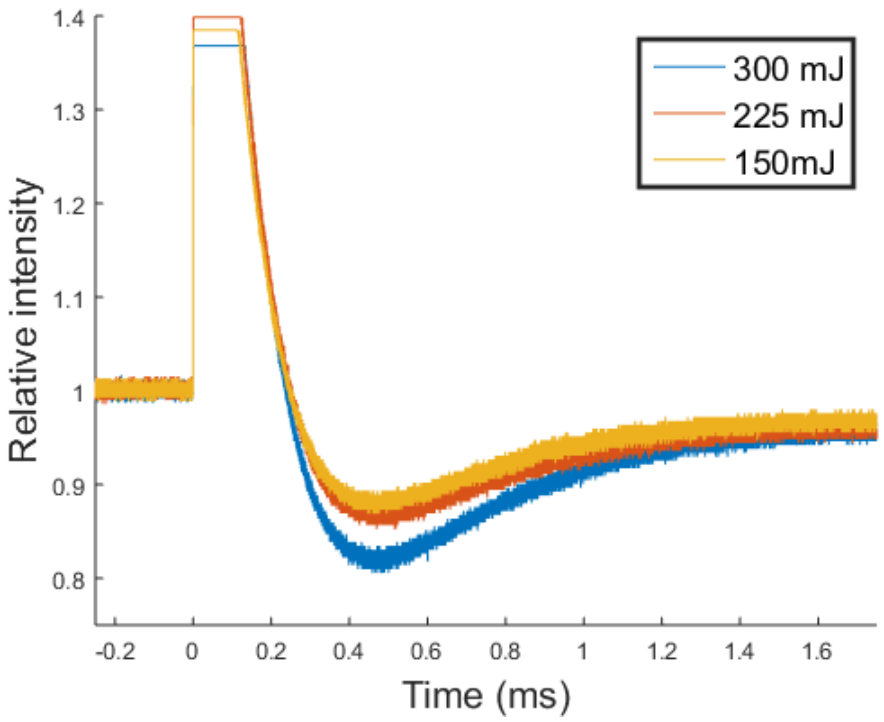
YAG- Laser:

- λ = 1064 nm
- Pulse Width: 9ns
- Pulse Energy: 150 – 300 mJ

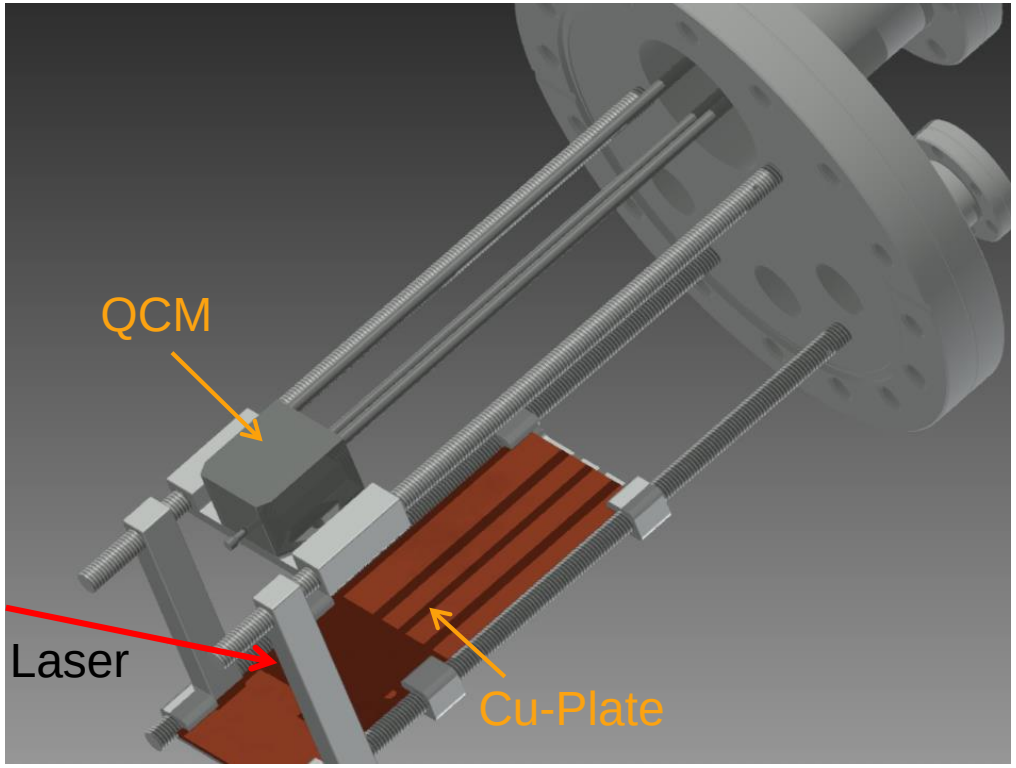


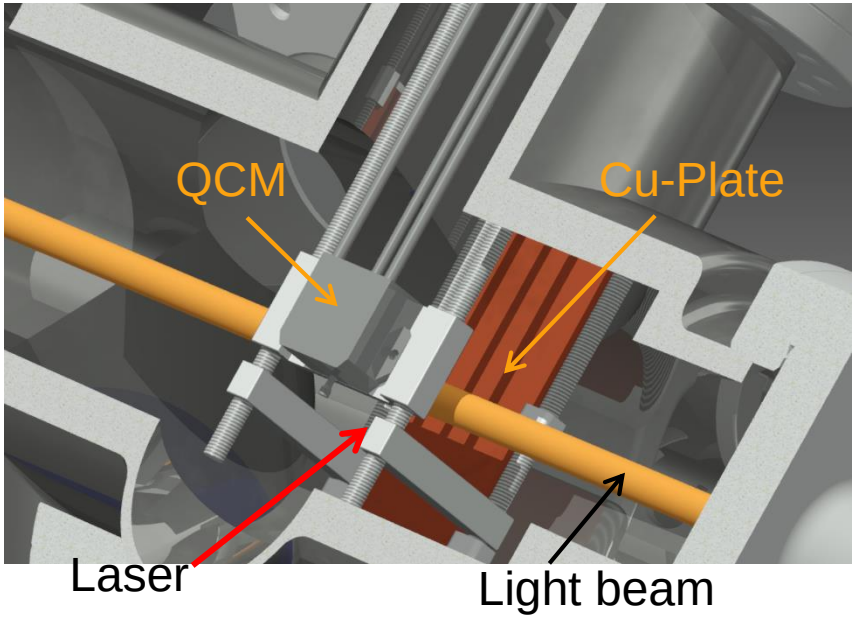
Results of Laser Ablation



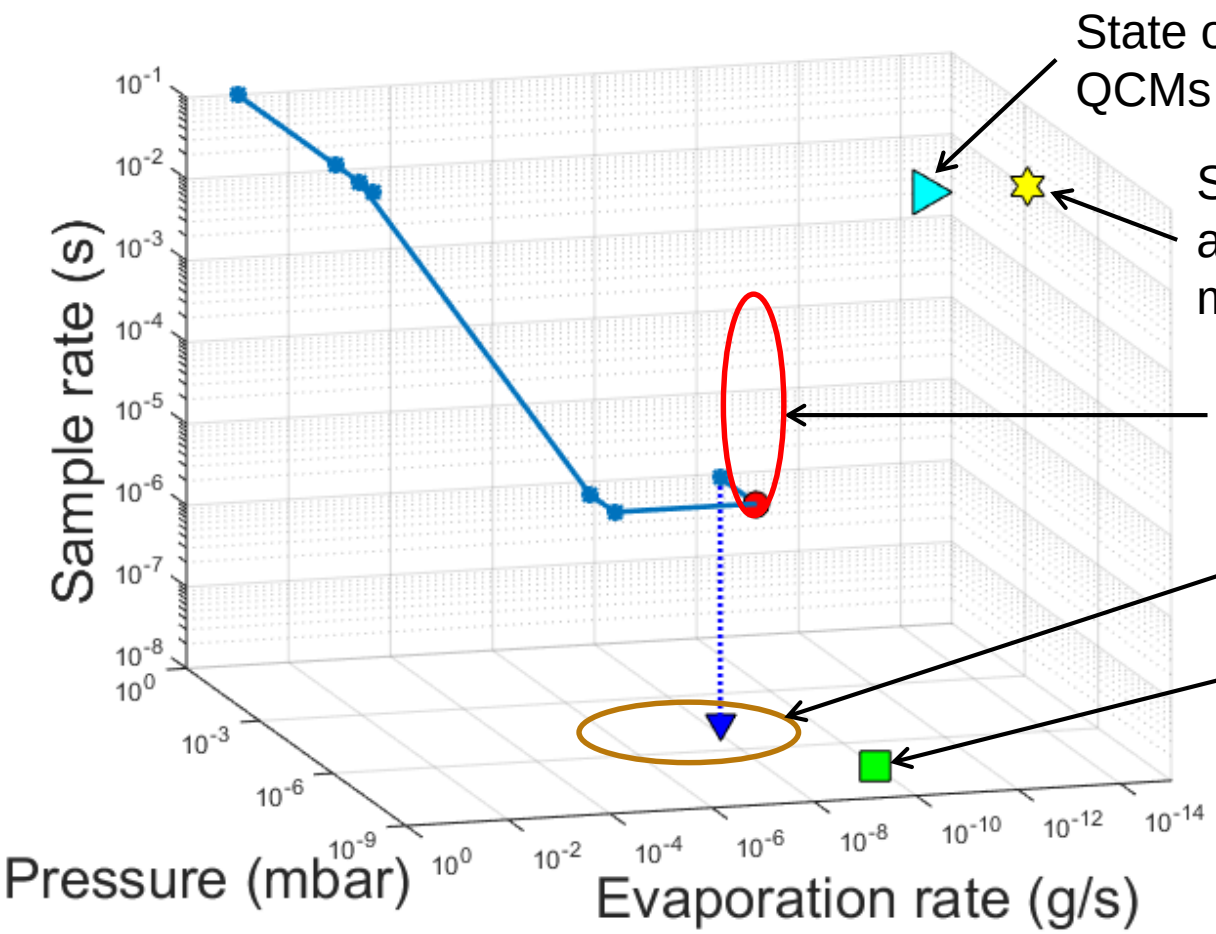


Laser Ablation Calibration





Progress
t – dP – P Diagram



State of the art of commercial QCMs

State of the art of commercial absorption-based thin film monitors

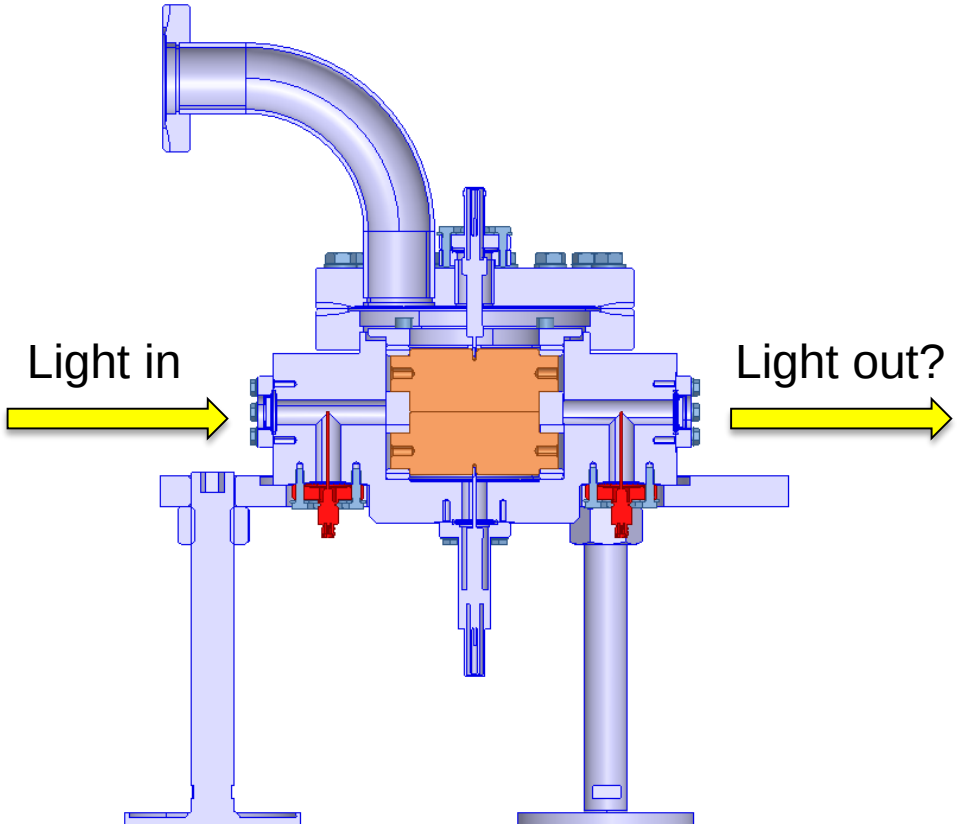
Calibration measurement

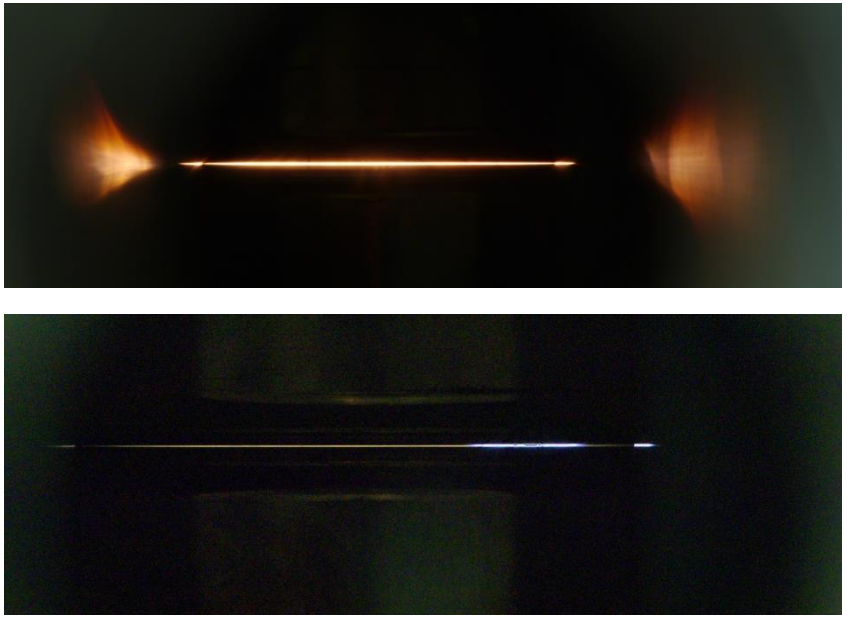
Speed upgrade

Target

$1\ \mathrm{ng/s} = 10^{13}\ \mathrm{Cu\ atoms/s} \approx 5 \cdot 10^{-5}\ \mathrm{mbar}$

DVM and DC-Spark





Upper: Shining a LED through the gap. Lower: Breakdown. Pictures taken by K.N. Sjobak.

Conclusion

Achieved:

Preliminary calibration for dynamic vacuum meter

- Range: 10^{16} - $10^{17}\ \frac{Atoms}{m^3}$, pressure $2 \cdot 10^{-5}$ - $2 \cdot 10^{-4}$ mbar (Target: 10^{-9} mBar)
- Laser ablation release Cu-atoms in 10^{-4} s timescale (Target: 10^{-7} s)

Challenges:

Absolute calibration for full range

Interpretation of measurement:

Will the calibration hold when the E-field is added in acc. -structure

Future plans

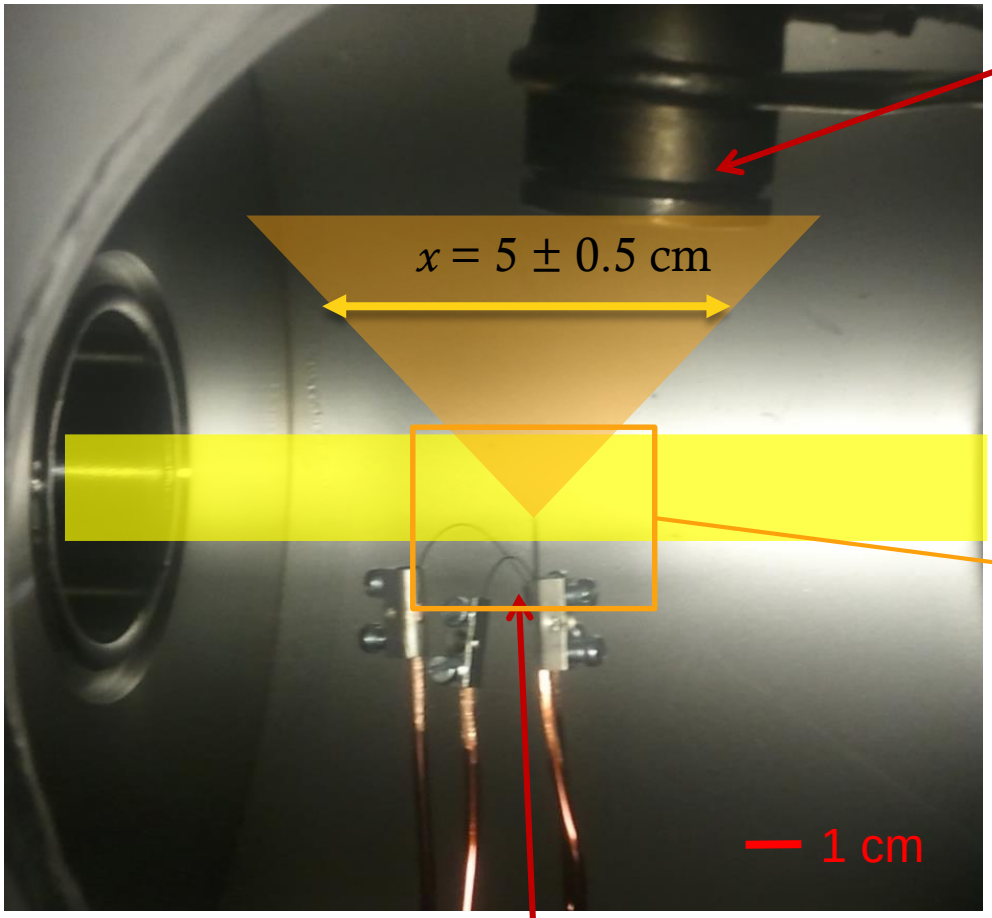
Add the DVM to DC spark setup

Extend calibration towards lower P's by increasing path length of light

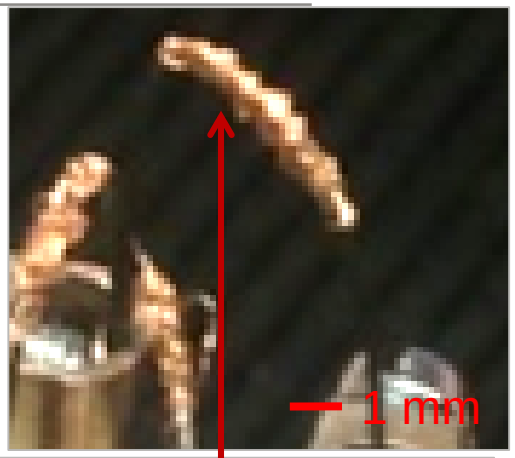
Questions and Comments

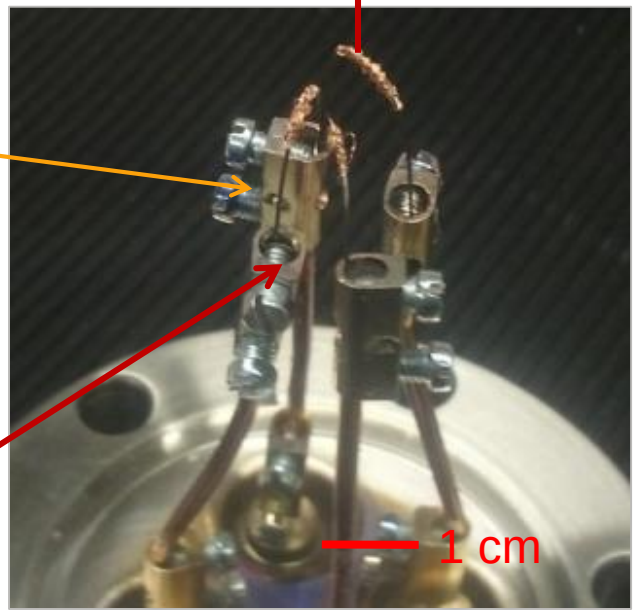
Thank You!

Setup inside vacuum



QCM





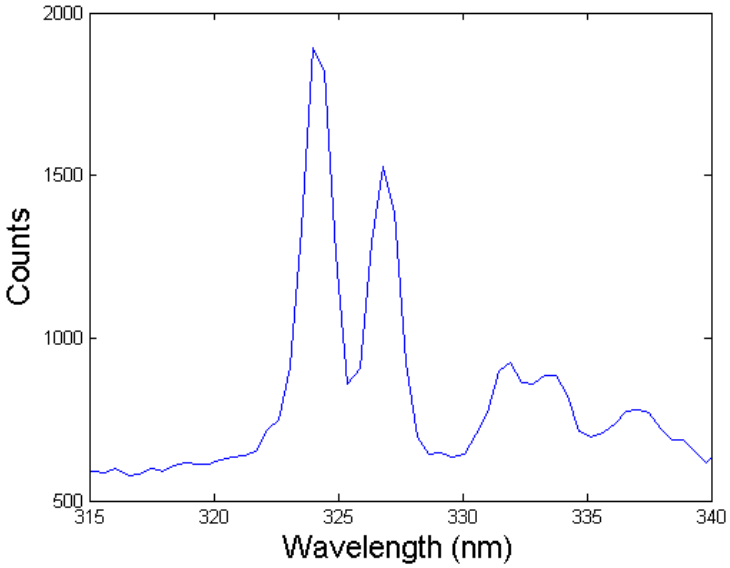
Cu vapour source:
Cu wire around W wire

Absorption spectroscopy

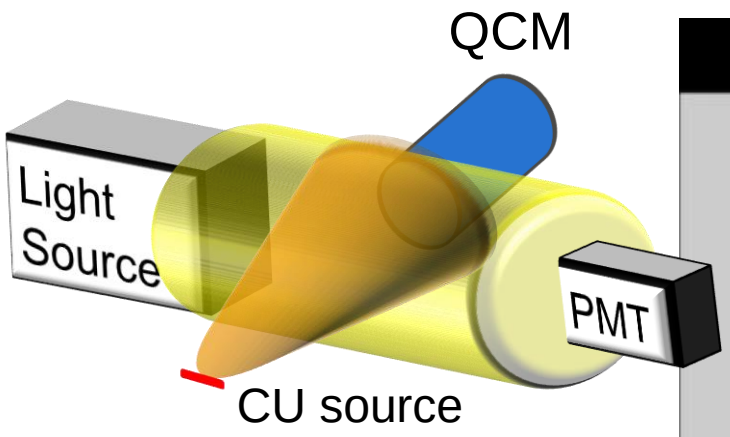
- 324.8 nm and 327.4 nm wavelengths are strongly absorbed in copper vapor

- Light source must be stable
  - Copper hollow cathode lamp is suitable low cost light source

- Light intensity changes is measured with Photomultiplier tube (PMT), bandwidth 20 kHz

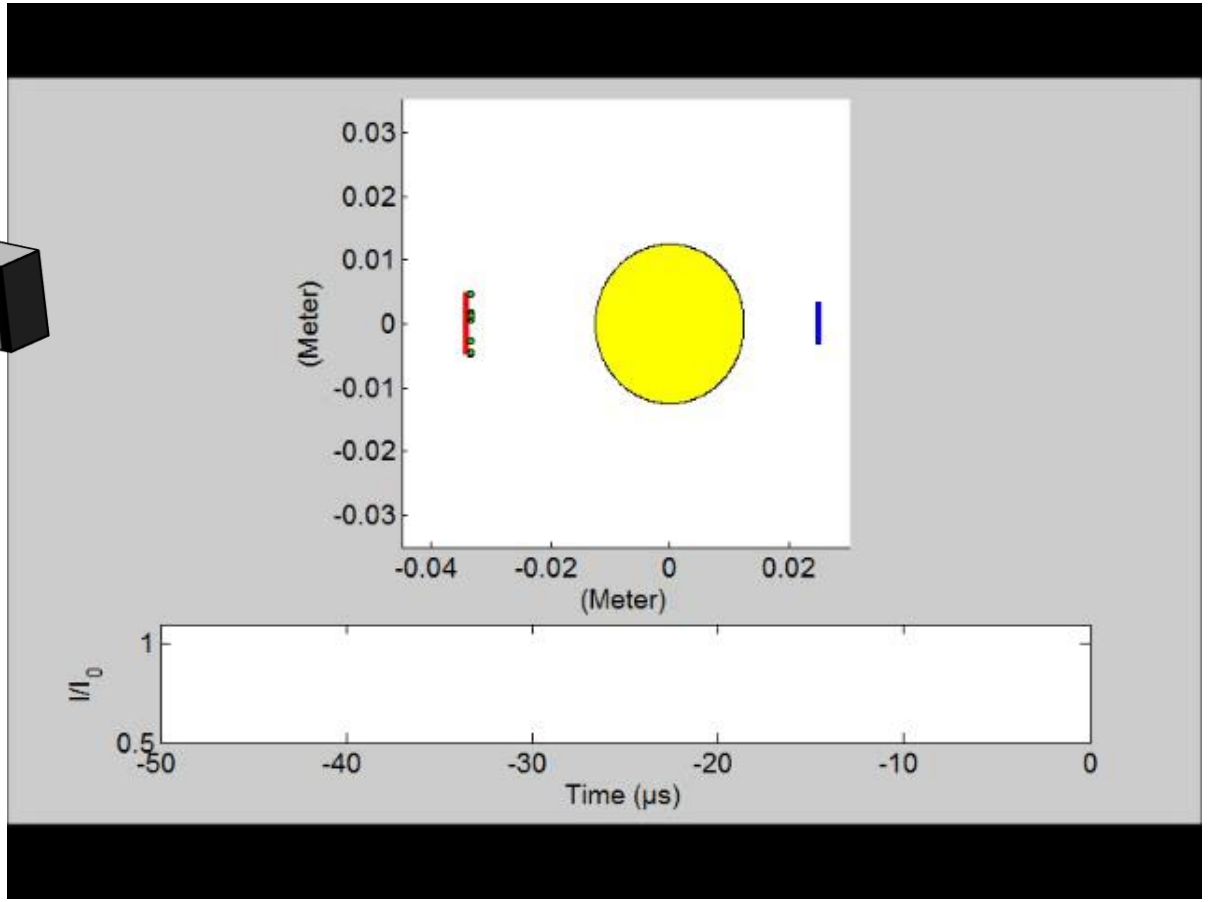


Simulated Visualization



$$p = \frac{N_{Cu} k_B T}{V}$$

$$dp \propto N_{Cu} \propto \frac{I}{I_0}$$

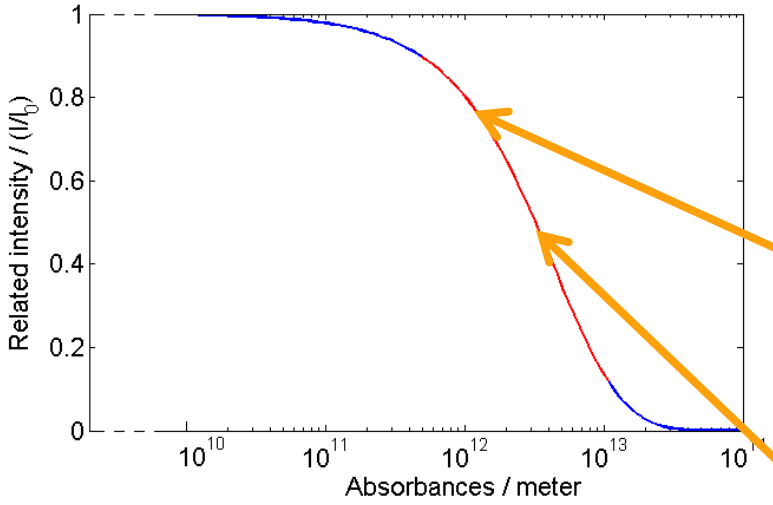


Beer-Lamberts law (Light absorbtion in copper vapour)

$$I = I_{0\,325} e^{-\sigma_{325} lN} + I_{0\,327} e^{-\sigma_{327} lN}$$

$\sigma_{325}, \sigma_{327}$ Cross section for 324.8 nm and 327.4 nm wavelengths

$I_{0\,325}, I_{0\,327}$ Emitted intensity of 324.8 nm and 327.4 nm wavelengths



l length of light beam in Cu vapor

N number of absorbing Cu atoms

Current operation area (Signal > |Noise|)

I = 90% - 10%

lN = 4.9 * 10^{11} - 1.2 * 10^{13} Absorbances/meter

Operation point sensitivity:

9 * 10^{11} Absorbances/meter