Longitudinal Beam Halo from Photocathodes*

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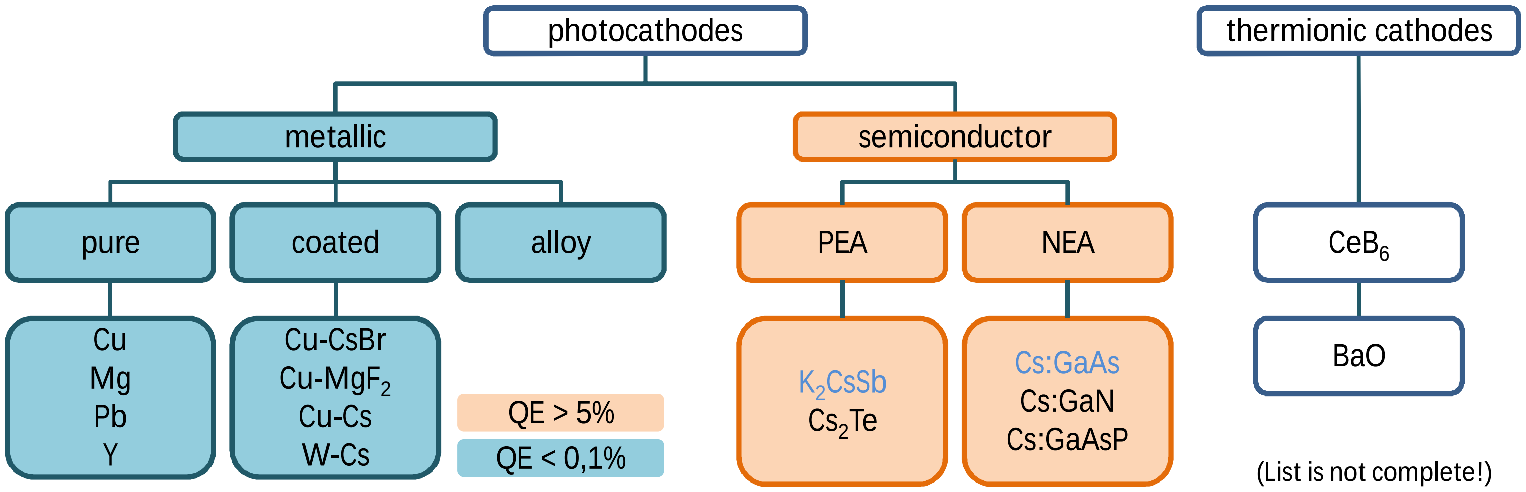
*Supported by BMBF through project

Outline

- Introduction
- Experimental setup
- Time response measurements
- Conclusion and Outlook

- Demand of high current injectors for future accelerator projects (e.g. MESA, BERLinPro) on
  - Beam current of 10-100mA (CW)
  - High quantum efficiency (QE)
  - Long cathode lifetime
  - Low emittance
  - Low unwanted beam
- Fundamental research of emission process of electrons out of photocathodes is necessary
  - Bunch length
  - Energy distribution
  - Longitudinal halo

- Different types of cathodes for electron sources



[D.H. Dowell, I. Bazarov, B. Dunham, K. Harkay, et.al: Cathode G&D for future light sources; NIM – 2010]

- Time response measurement
  - A TM_{110} deflector cavity transforms the longitudinal beam profile into a transversal beam profile
  - The electron bunches have to be synchronized to the RF to be observed
  - The beam profile is observable as an intensity distribution on a YAG-screen

Experimental Setup
Laser

Verdi 10G
- Pump laser
- $\lambda_{laser} = 532nm$
- P_{out}~10W CW

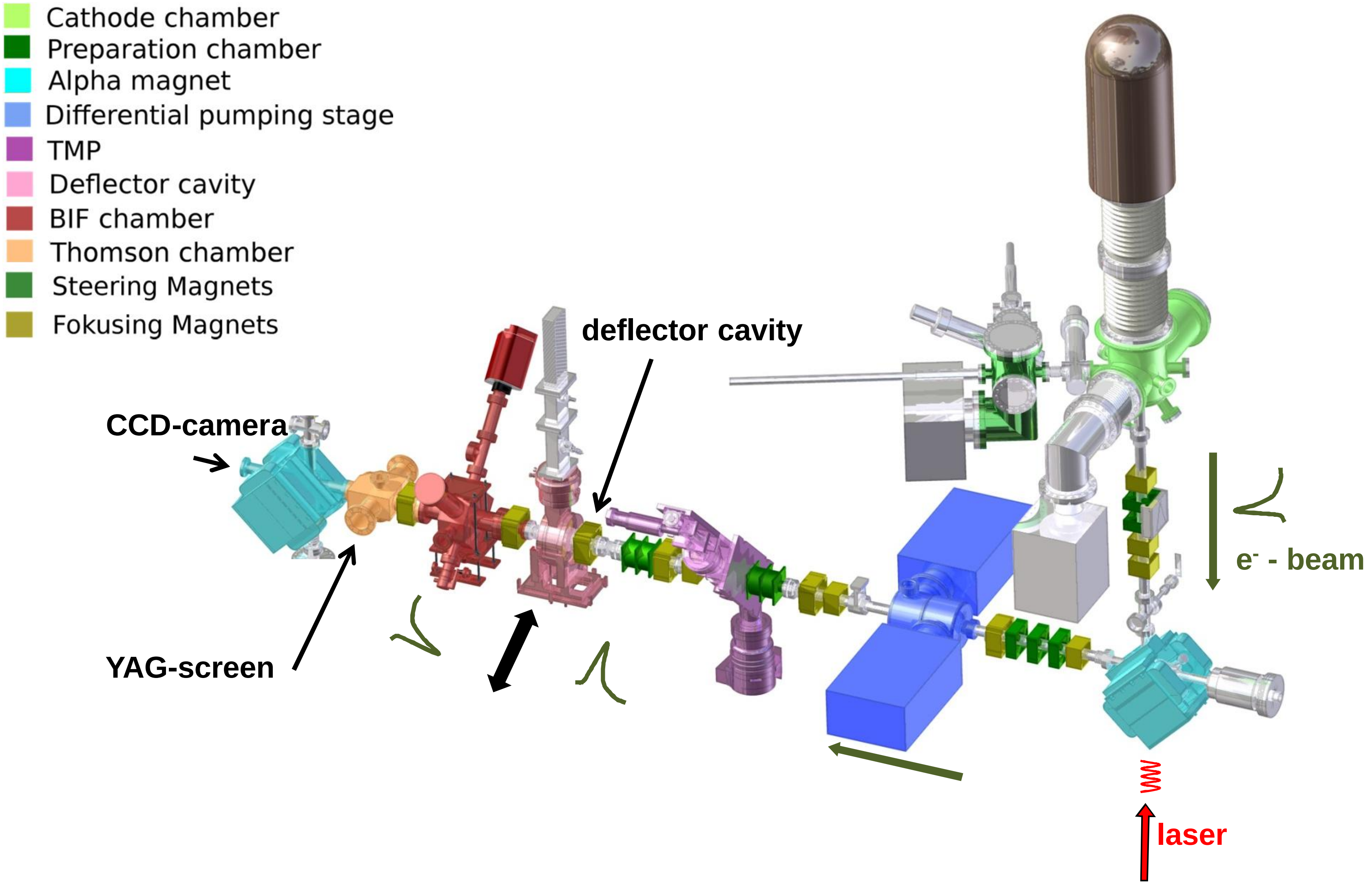
Modelocked Ti:Sapphire Laser (MIRA 900)
- Pulsed (~150fs) or CW
- $\lambda_{laser} = 755 - 800nm$ tunable
- Repetition rate 76MHz
- P_{out}~1,6W at $\lambda_{laser} = 800nm$ pulsed

HarmoniXX SHG
- Frequency doubler (Second Harmonic Generation)
- $\lambda_{laser} = 400nm$
- $P_{out} \sim 500mW$

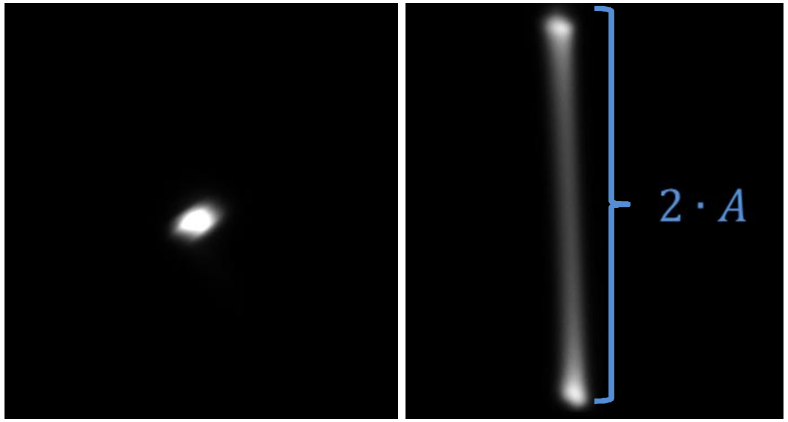
PKAT laboratory

There is a possibility to bypass the HarmoniXX SHG to measure at $\lambda_{laser} = 800nm$.

Experimental Setup
PKAT Laboratory (100keV beam facility)



Measurement
Calibration of YAG-Screen



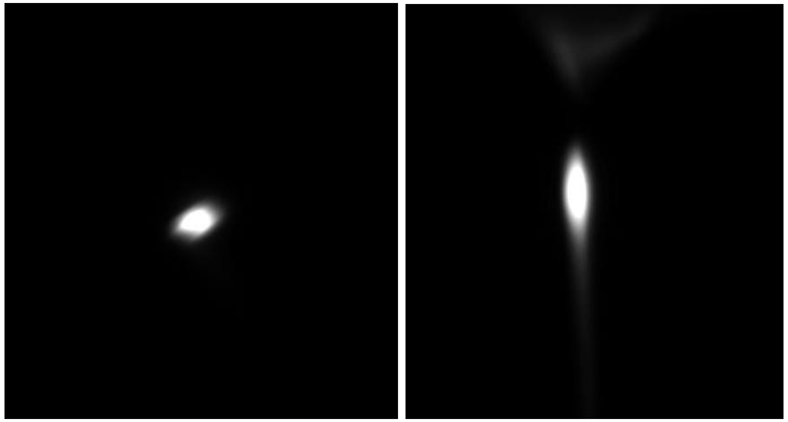
[E. Kirsch: Diploma Thesis, will be finished 2014]

- Picture of beam spot on YAG-screen
  - CW beam and no single shot
  - RF and Laser are not synchronized
  - P_{RF} = 45W and λ_{laser} = 800nm

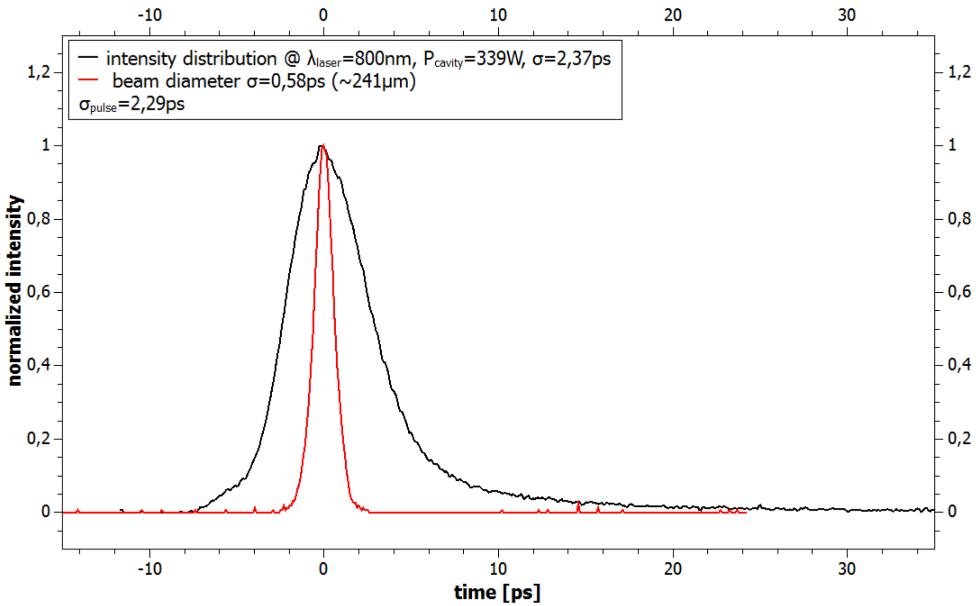
- Position on the screen
  - $x(t) = A \cdot \sin(\varphi_{RF}) = A \cdot \sin(\omega t)$
  - $\dot{x}(t) = A \cdot \omega \cdot \cos(\omega t)$
  - $A \sim \sqrt{P_{RF}}$

- RF dependency of deflection
  - λ_{laser} = 800nm
  - P_{RF} = 45W → 1mm ≙ 6,6ps
  - P_{RF} = 339W → 1mm ≙ 2,4ps

Measurement
First Results with Bulk-GaAs Photocathodes



- Picture of beam spot on YAG-screen
  - CW beam and no single shot
  - RF and Laser are synchronized
  - P_{RF} = 339W and λ_{Laser} = 800nm



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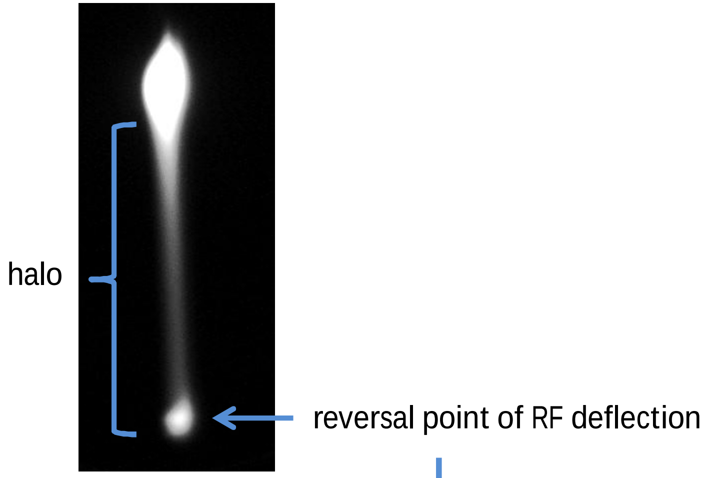
- First approximation
  - Pulse profiles are gaussians
- Deconvolution of two gaussians
  - σ_{pulse} = 2,29ps

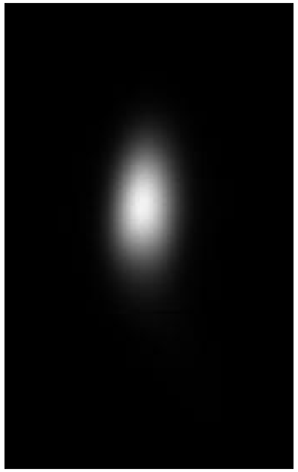
Comparison of Beam Profiles at Different λ_{laser} (I)

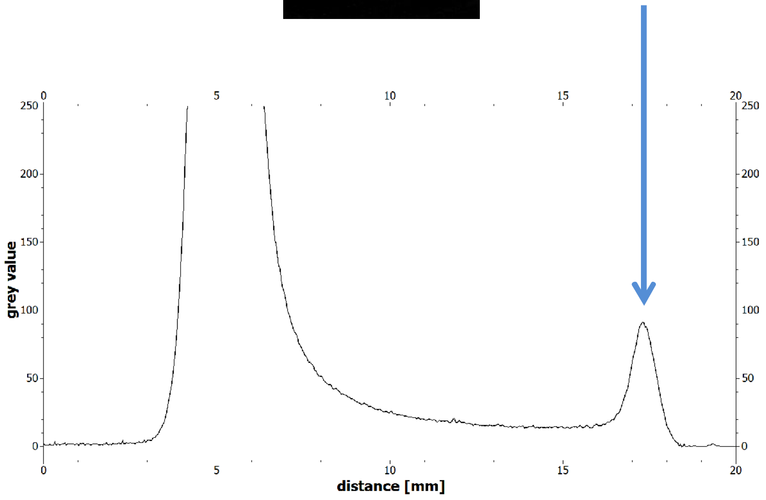
- Picture of beam spot on YAG-screen

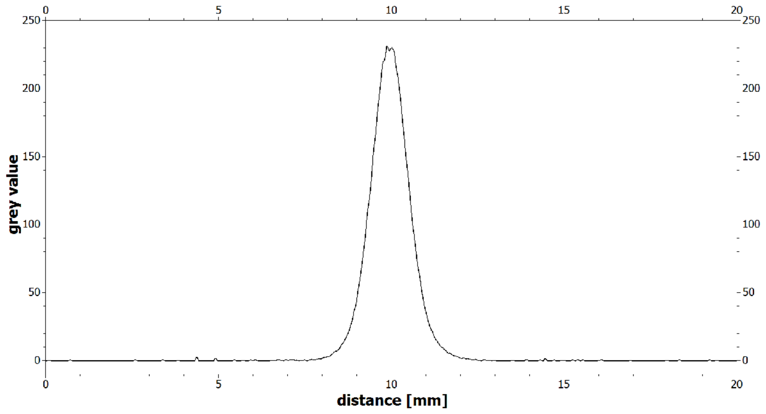
λ_{laser} = 800nm



λ_{laser} = 400nm







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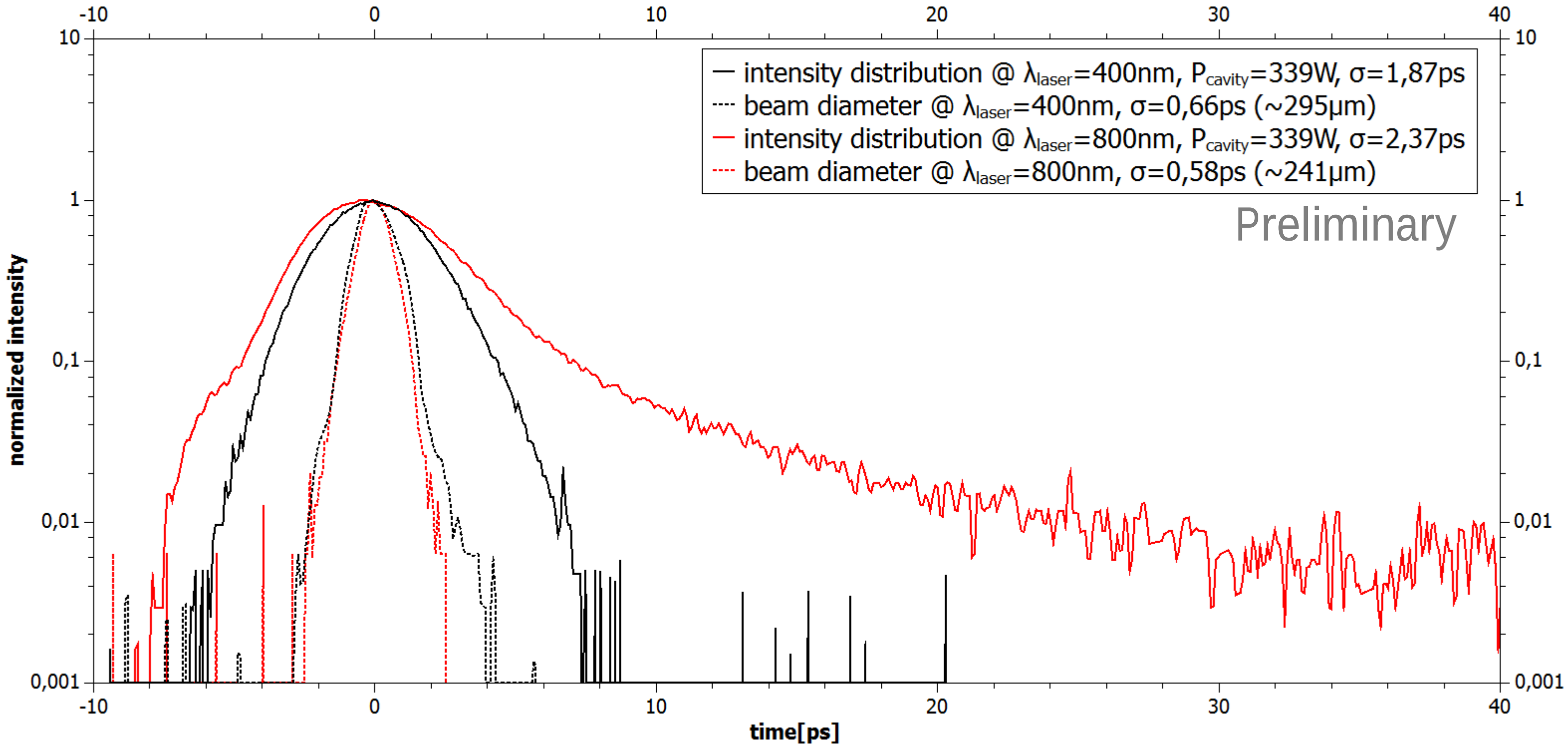
Measurement
Comparison of Beam Profiles at Different λ_{laser} (II)



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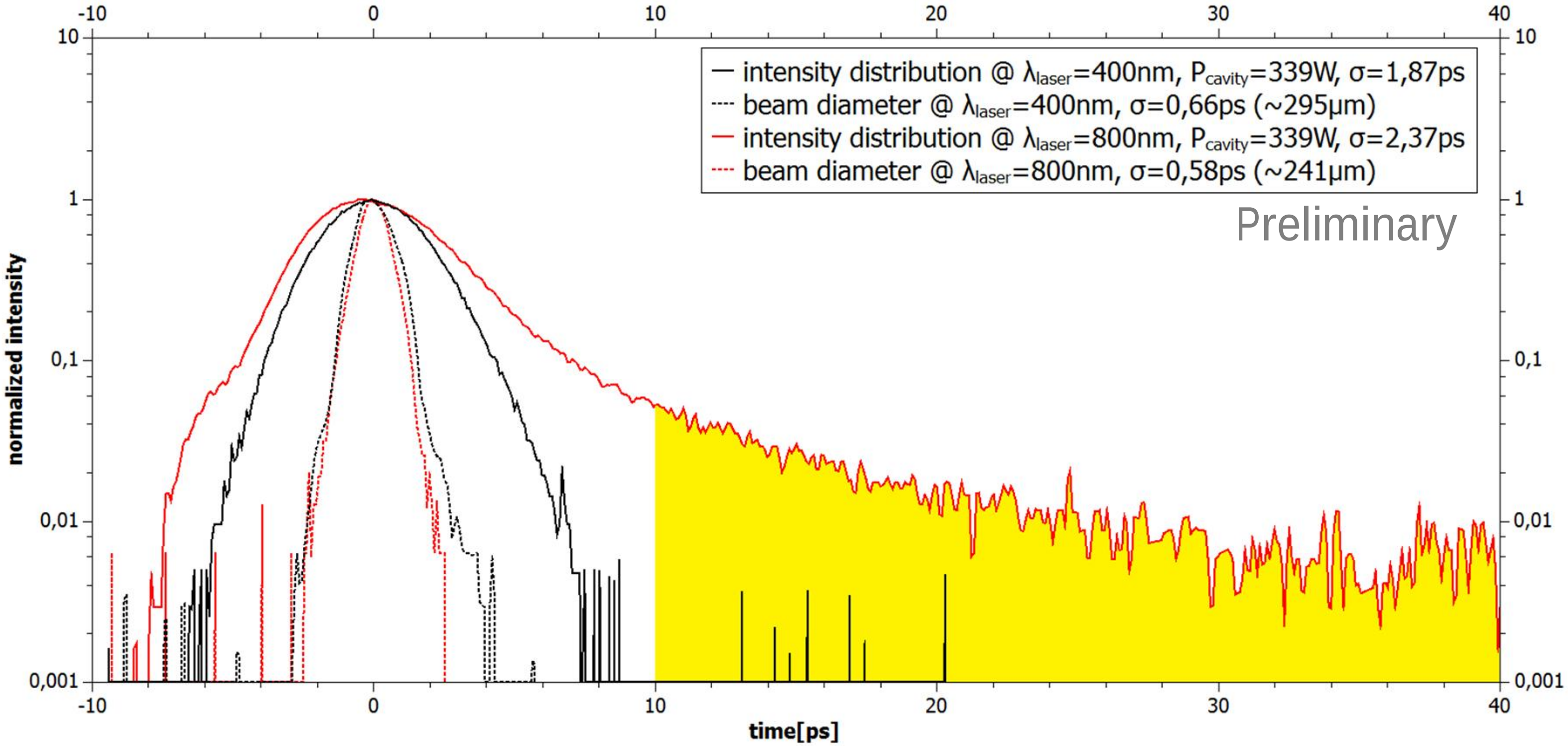
- Results at small beam current and bunch charge
  - $I_{\text{e-beam}} < 10\text{nA}$, bunch charge ~0,1fC
- Same range of transversal $\boldsymbol{\sigma}$
- Exposure time (shutter) of 4ms
  - Corresponds to $3 \cdot 10^5$ bunches

Measurement
Comparison of Beam Profiles at Different λ_{laser} (III)



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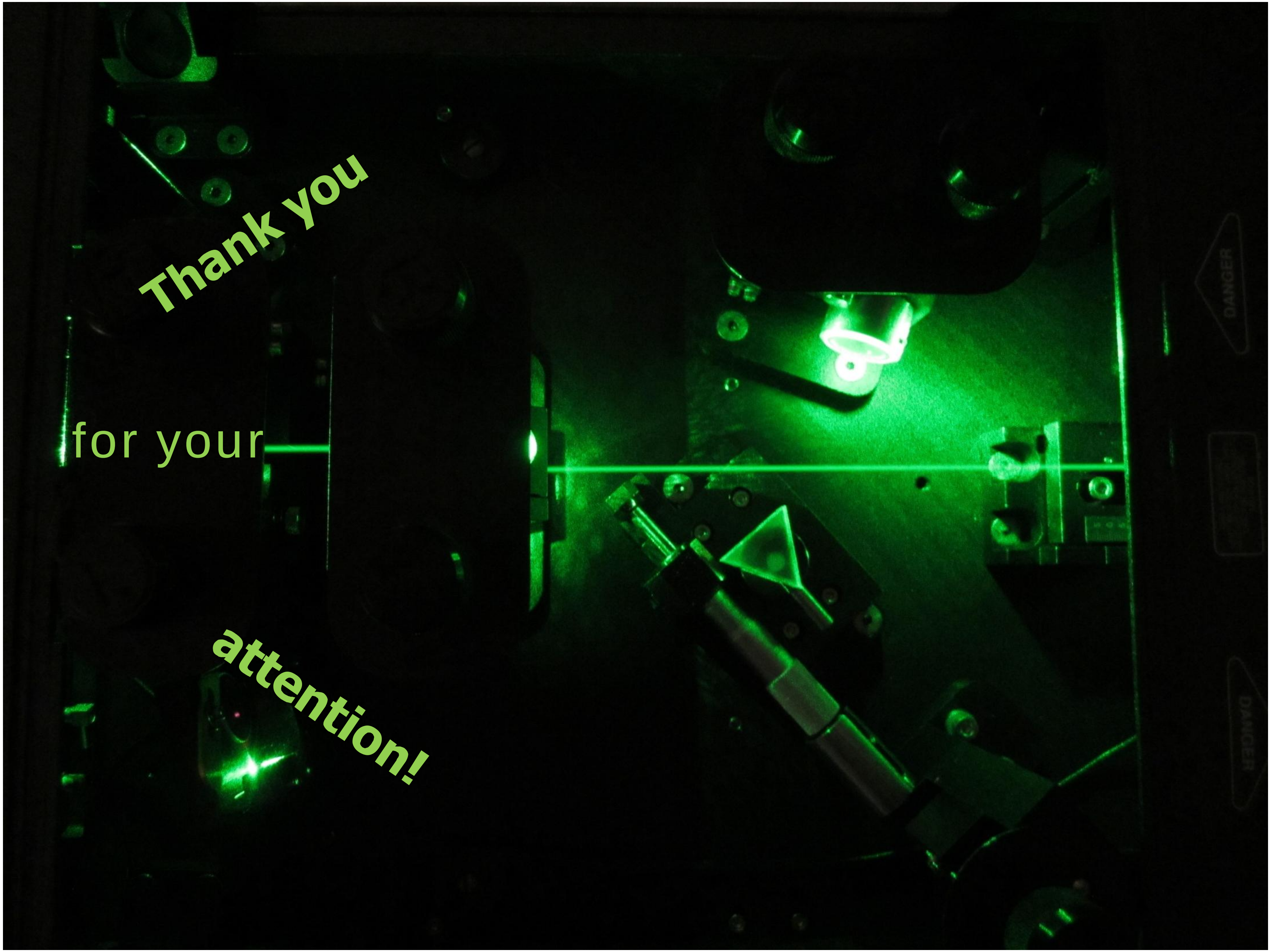
- Longitudinal halo depends on $\boldsymbol{\lambda}_{\text{laser}}$
  - Higher absorption coefficient for $\lambda_{\text{laser}} = 400\text{nm}$
- Assuming an acceptance of $\boldsymbol{\sigma}_{\text{pulse}} = 10\text{ps}$
  - 10% of intensity is lost ($\lambda_{\text{laser}} = 800\text{nm}$)
  - $I_{\text{e-beam}} = 10\text{mA} \Rightarrow 1\text{mA}$ is lost

Conclusion and Outlook

- Conclusion
  - Cs:GaAs photo cathodes have been analyzed
  - Longitudinal halo is observable
  - The halo seems to depend on laser wavelength
    - ⇨ For λ_{laser} = 400nm orders of magnitude lower than for λ_{laser} = 800nm
- Outlook
  - Installation of an alternative method for improved time response measurement for higher dynamic range
  - Measurements with K_2CsSb (PCA) photocathodes


Thank you
for your
attention!