Laser and Ion Experiments for WDM Studies at **UEC** and **LBNL**

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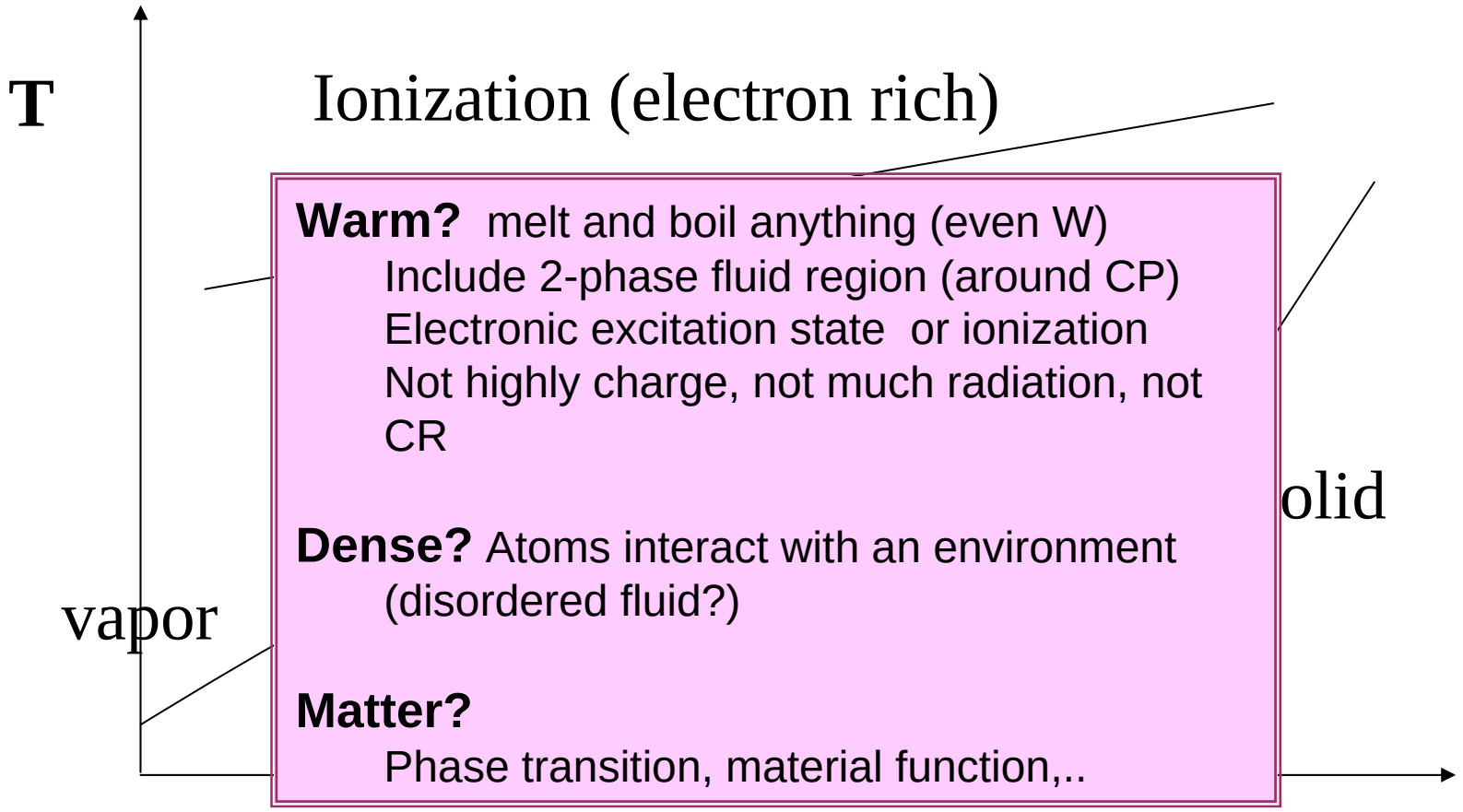
I would like to thank many people in LBNL.

Definition of WDM

Strong inter atomic interaction + electronic excitations



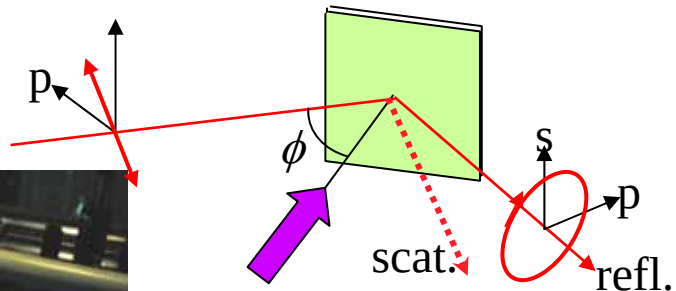
What relation form these details to real material problems?

Remarkable phenomena predicted in WDM

- Negative positive ion plasma
- Metal-nonmetal transition
- Fast black absorber
- Ultra-fast cluster formation
- Ionization distortion of 2ϕ boundary
- others

Measurements of ellipsometric parameters and diffuse scattering

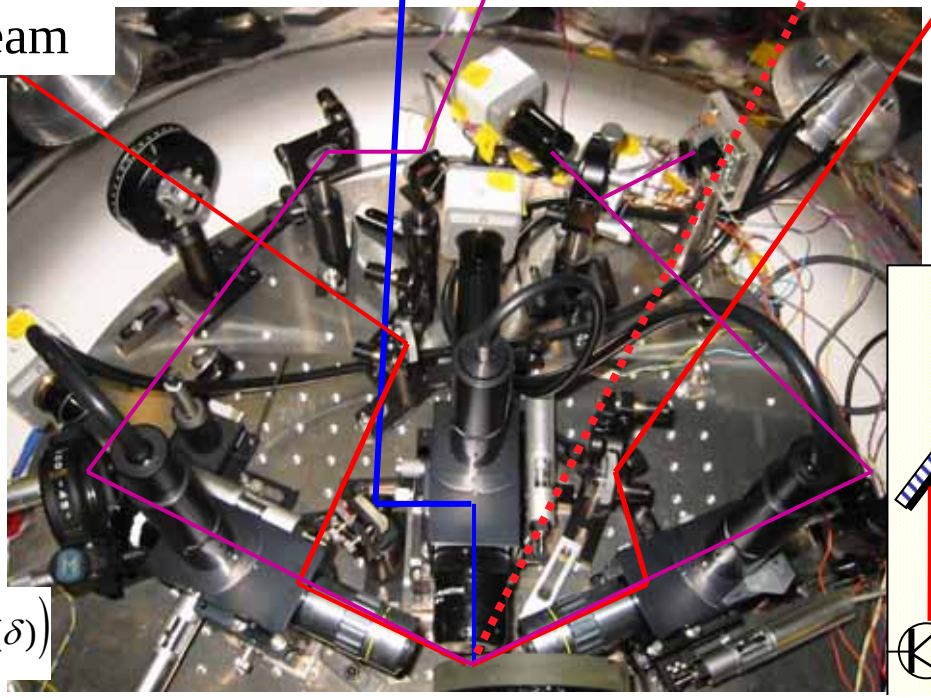
White-light probe beam



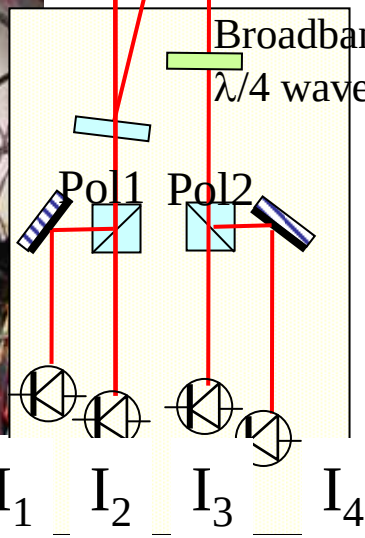
pump beam
λ=248nm

Alignment
beam

Detector for for scattering
(~45 forward scattering)



target



I_1 I_2 I_3 I_4

$$I_1 \approx |R_S|^2$$

$$I_2 \approx |R_p|^2$$

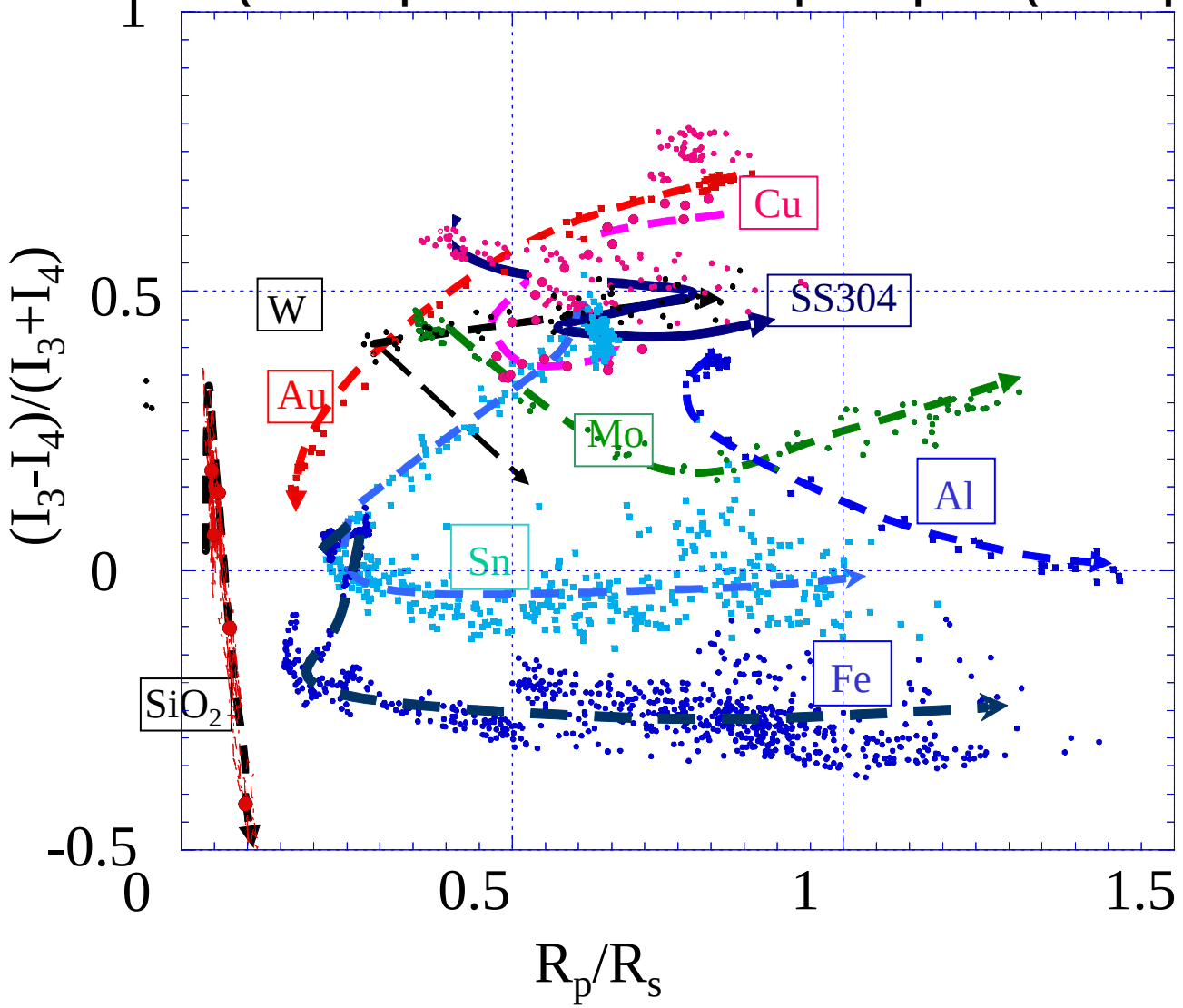
$$I_3 \approx \frac{1}{2}\left(|R_P|^2 + |R_S|^2 - 2|R_P||R_S|\sin(\delta)\right)$$

$$I_4 \approx \frac{1}{2}\left(|R_P|^2 + |R_S|^2 + 2|R_P||R_S|\sin(\delta)\right)$$

We have measured Au, Cu, Al, W, Mo, Sn, Fe, SS304, SiO_2.

For λ=745nm

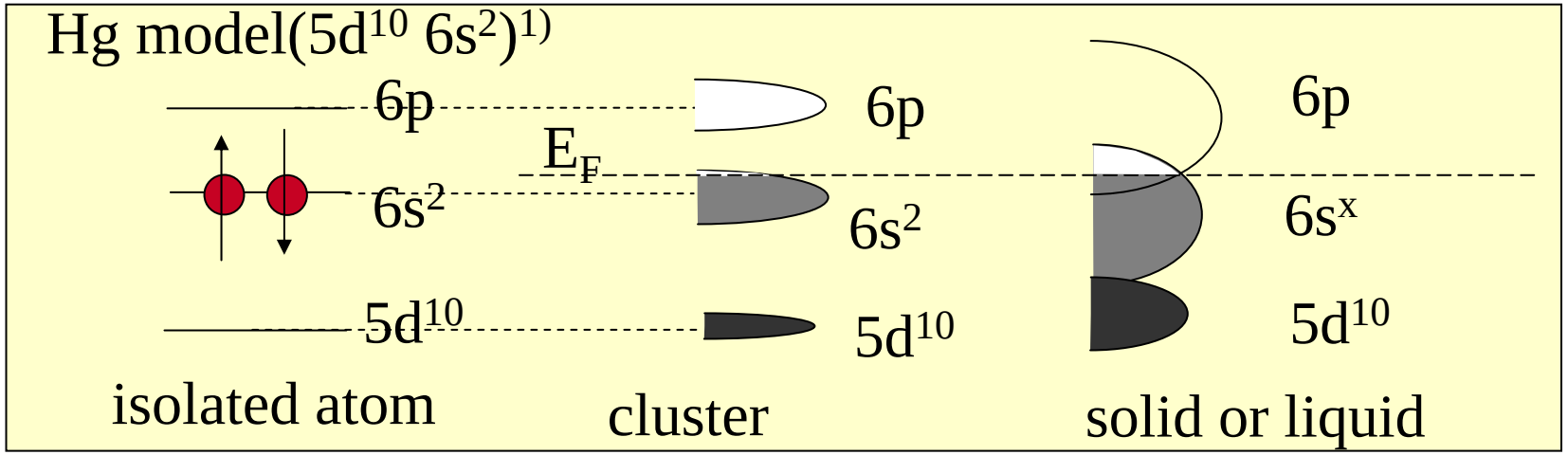
various trajectory
(time-dependent reflection of probe pulse (t~ -0~3ps))



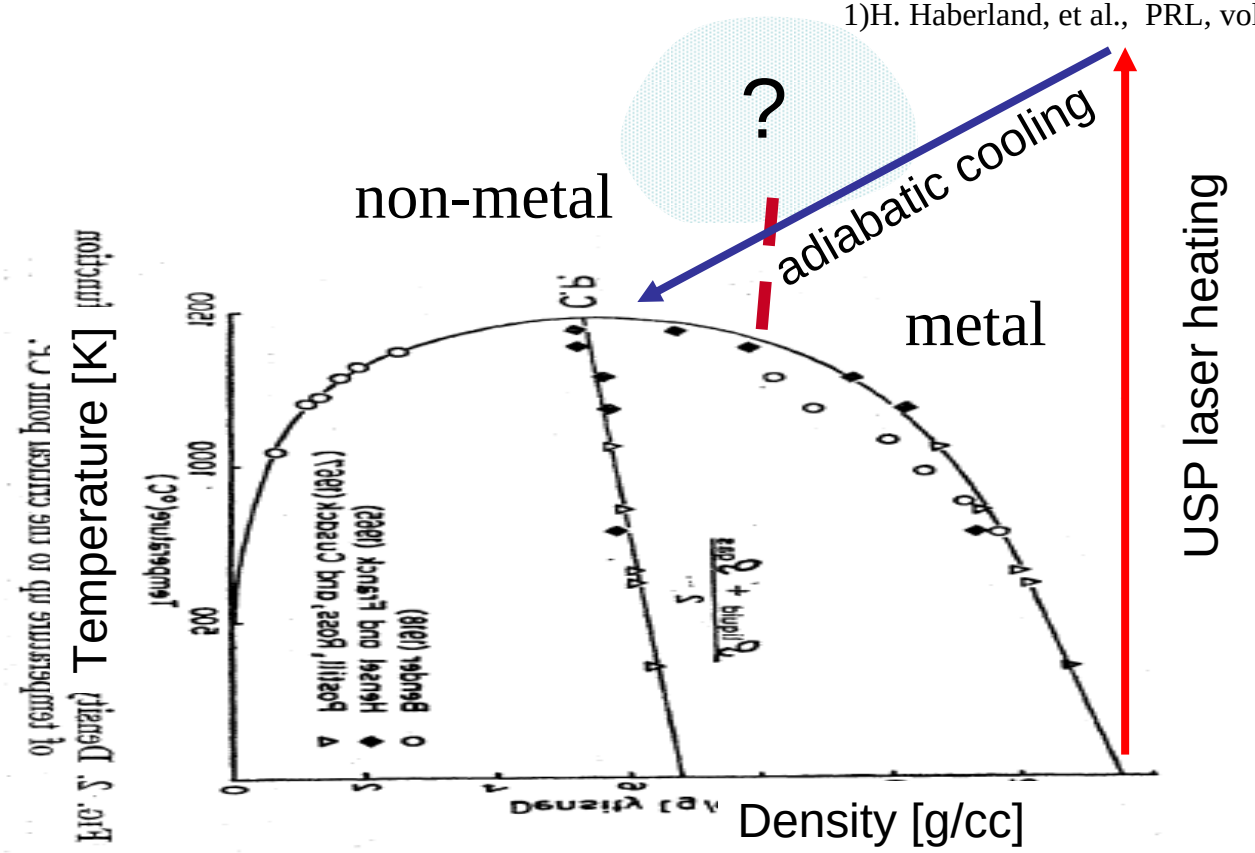
+Zn..

to be continued

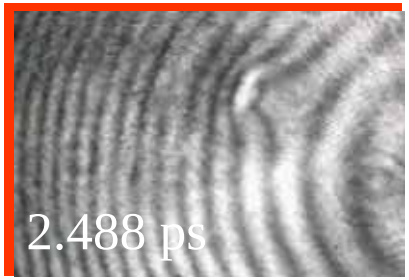
Metal-Nonmetal transition in Hg



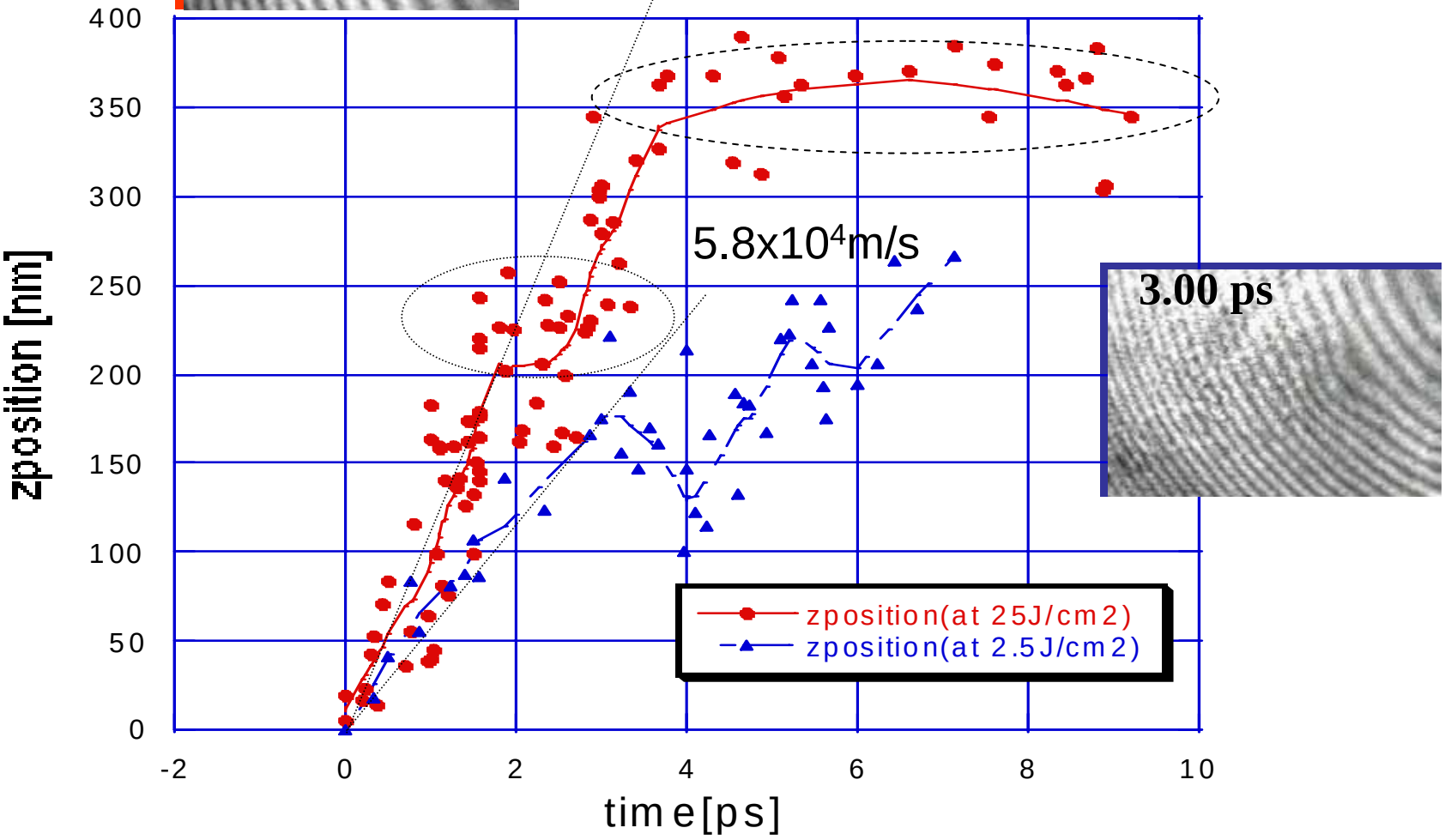
1)H. Haberland, et al., PRL, vol.69, p.3212

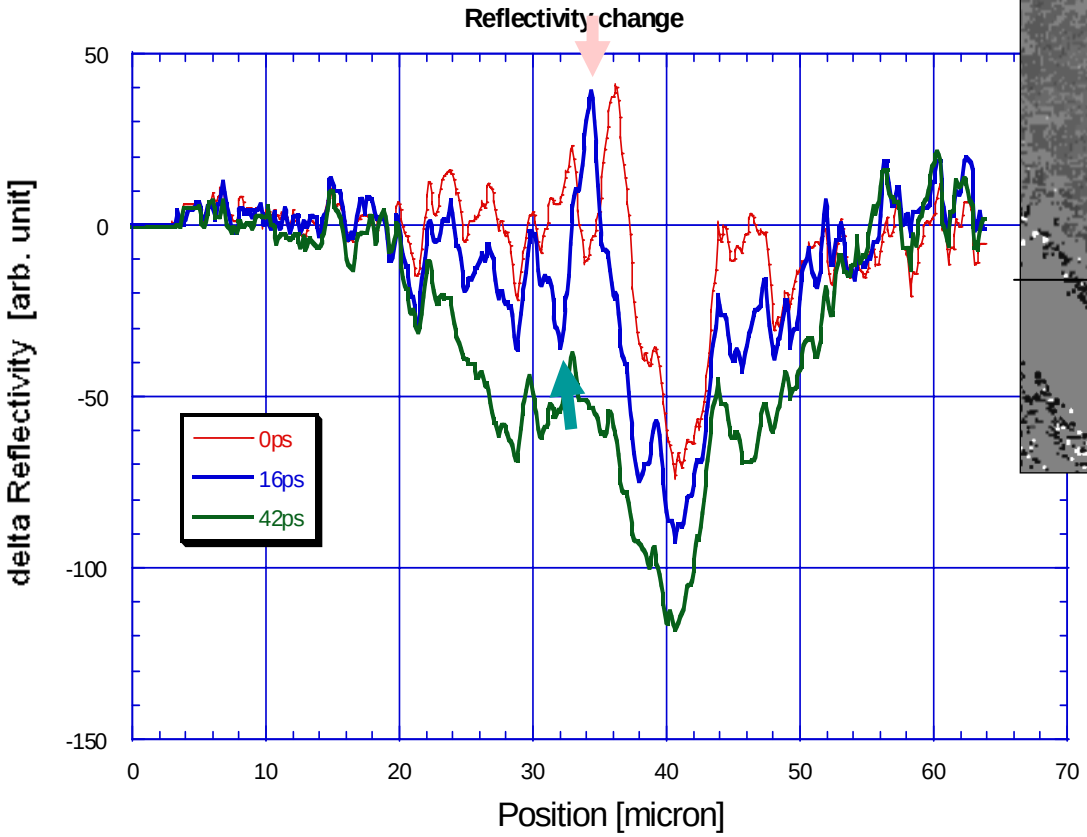


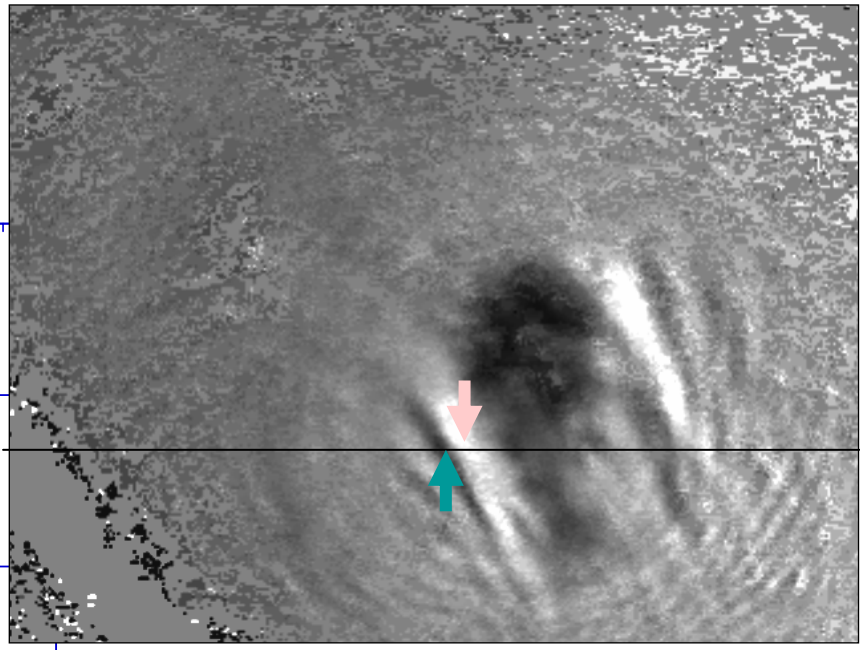
Apparent speed: 350nm/3ps~1.2x10^{5}m/s

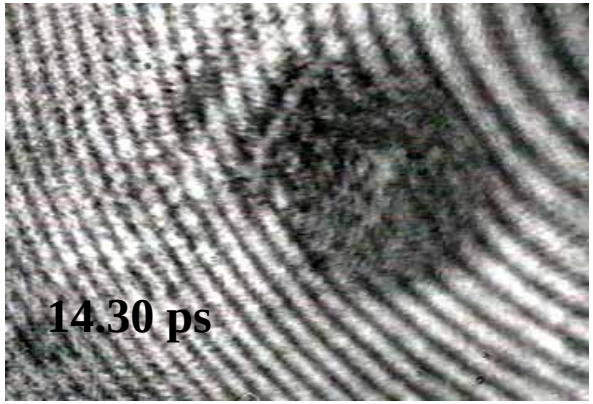


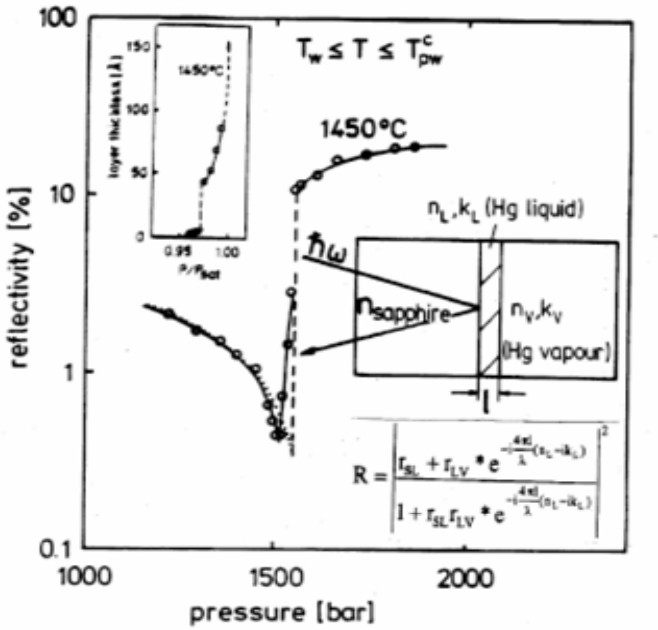
Hg expansion





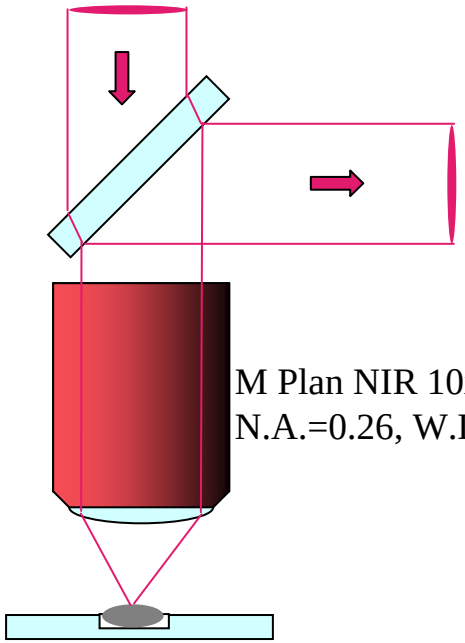




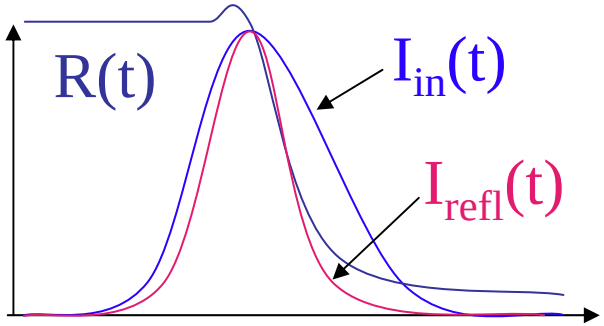


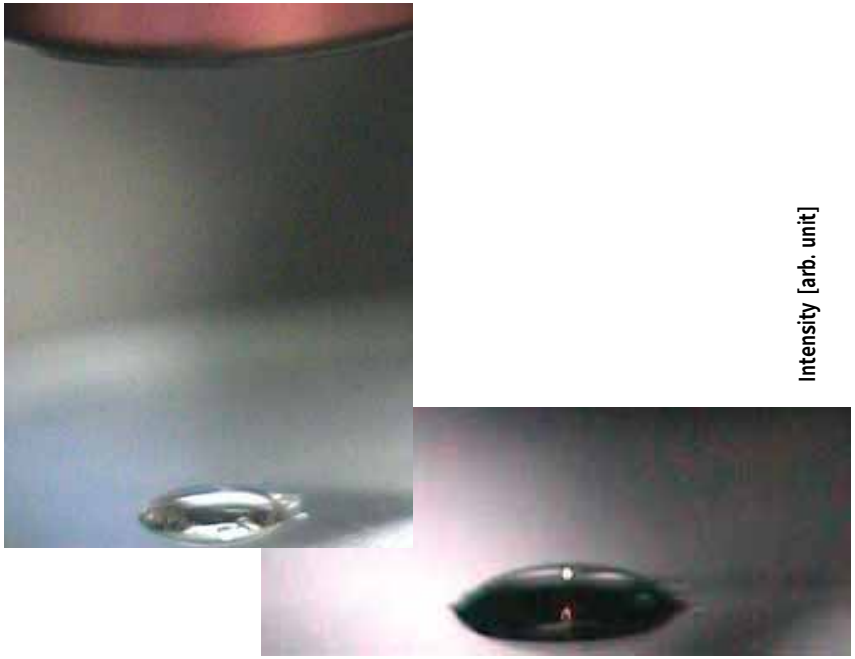
from F. Hansel

Plasma photonic device: Liquid metal M-NM transition switch

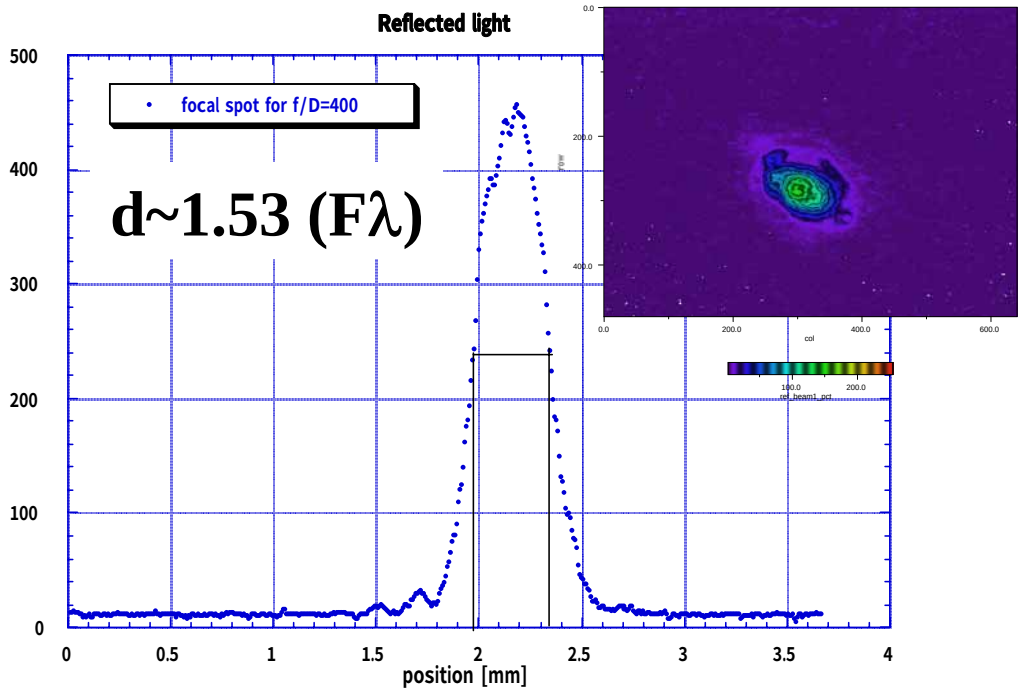


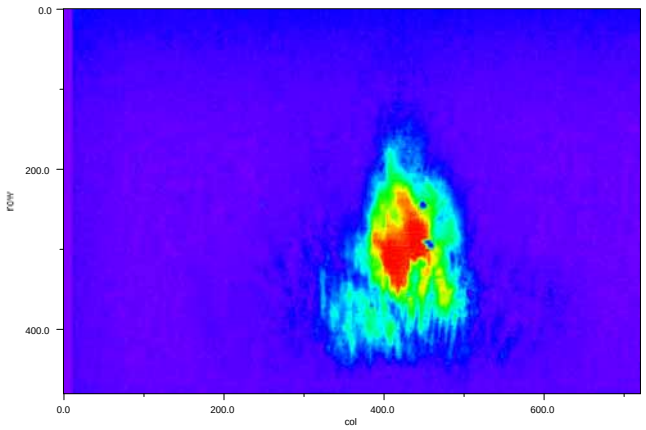
M Plan NIR 10x
N.A.=0.26, W.D.=30.5mm

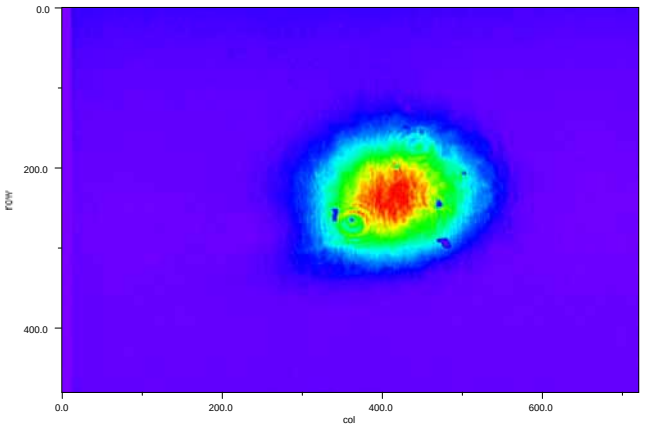




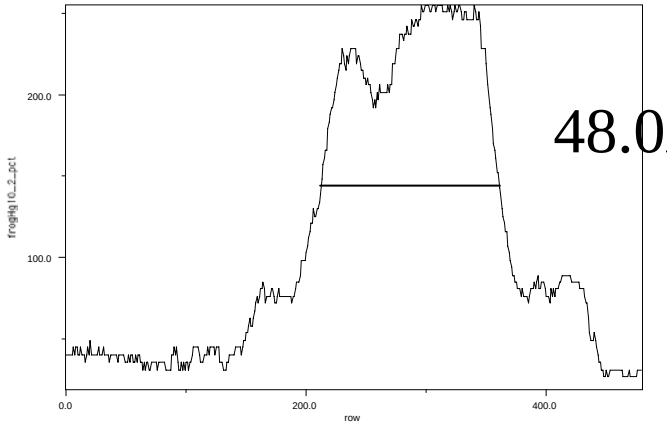
Far-field pattern of reflected laser



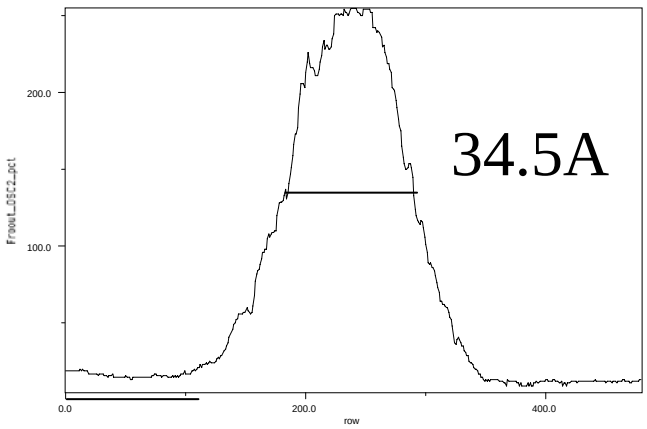




154A

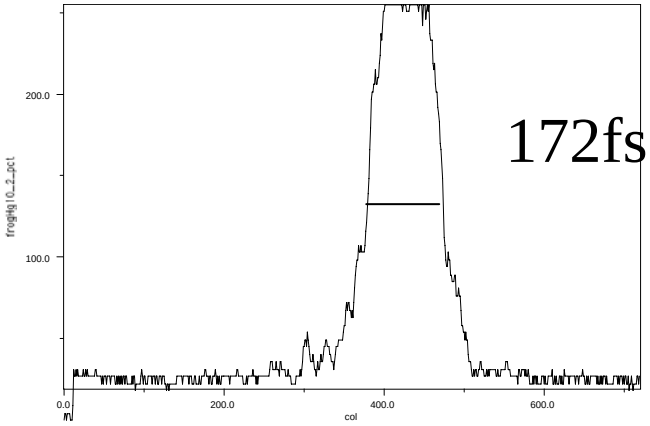


48.0A

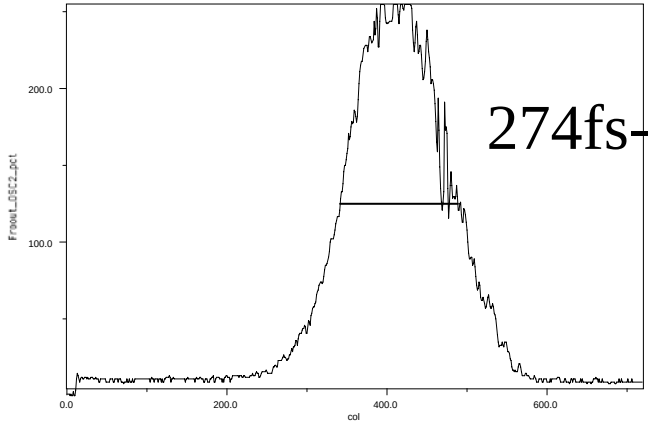


34.5A

1308fs



172fs->103fs

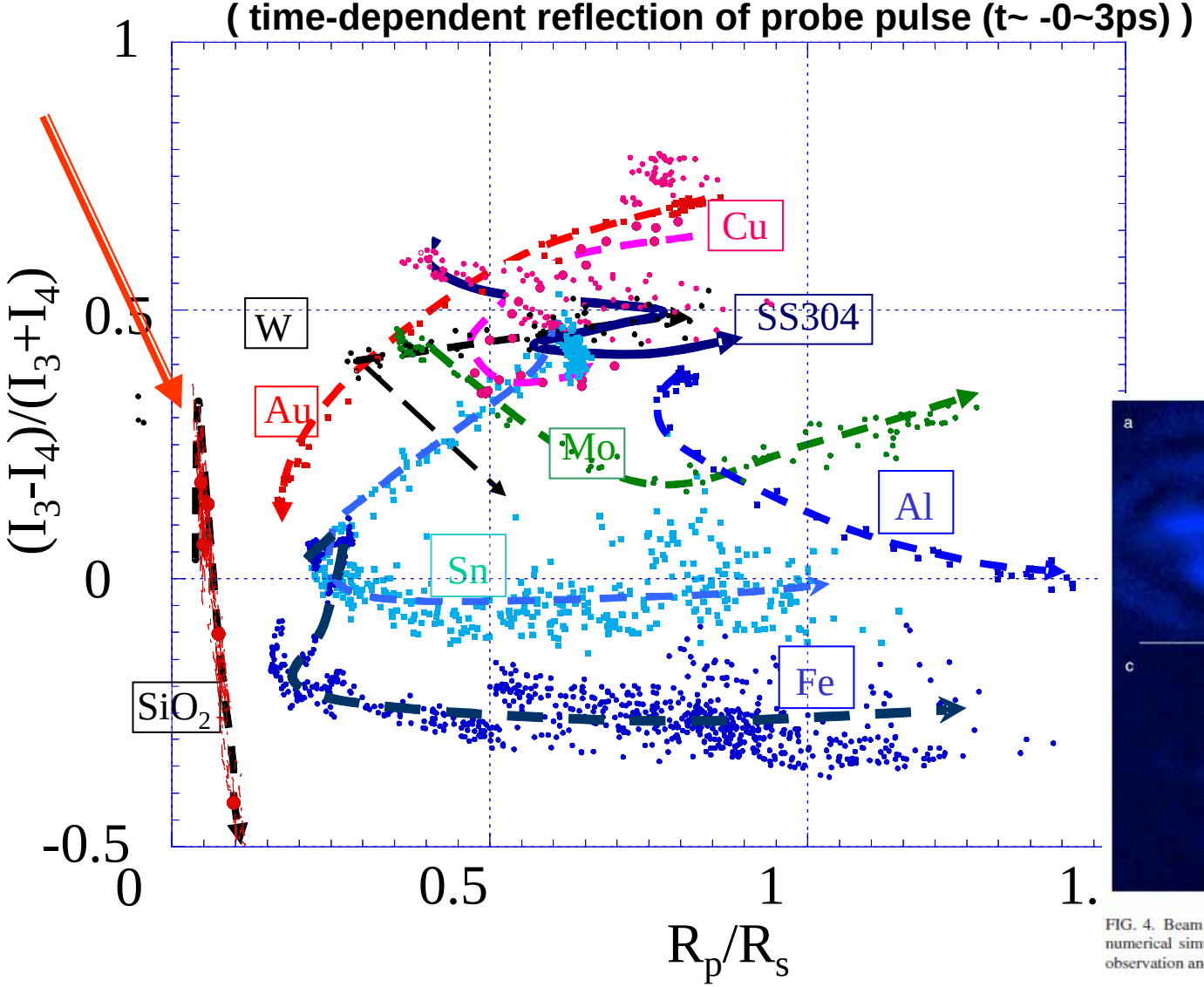


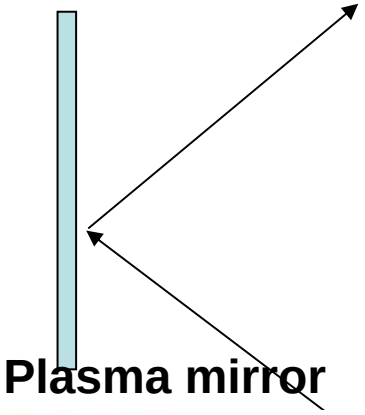
274fs->164fs

Black glass

For λ=745nm

various trajectory
(time-dependent reflection of probe pulse (t~ -0~3ps))





Plasma mirror

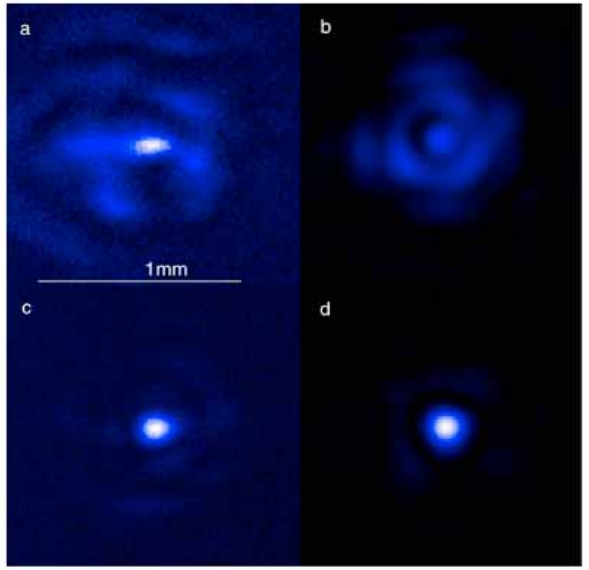


FIG. 4. Beam profiles on PM plates: (a) experimental observation and (b) numerical simulation of the fluence distribution on PM1; (c) experimental observation and (d) numerical simulation of the fluence distribution on PM2.

Wittmann et al. Rev. Sci. Instrum. **77**, 083109 2006

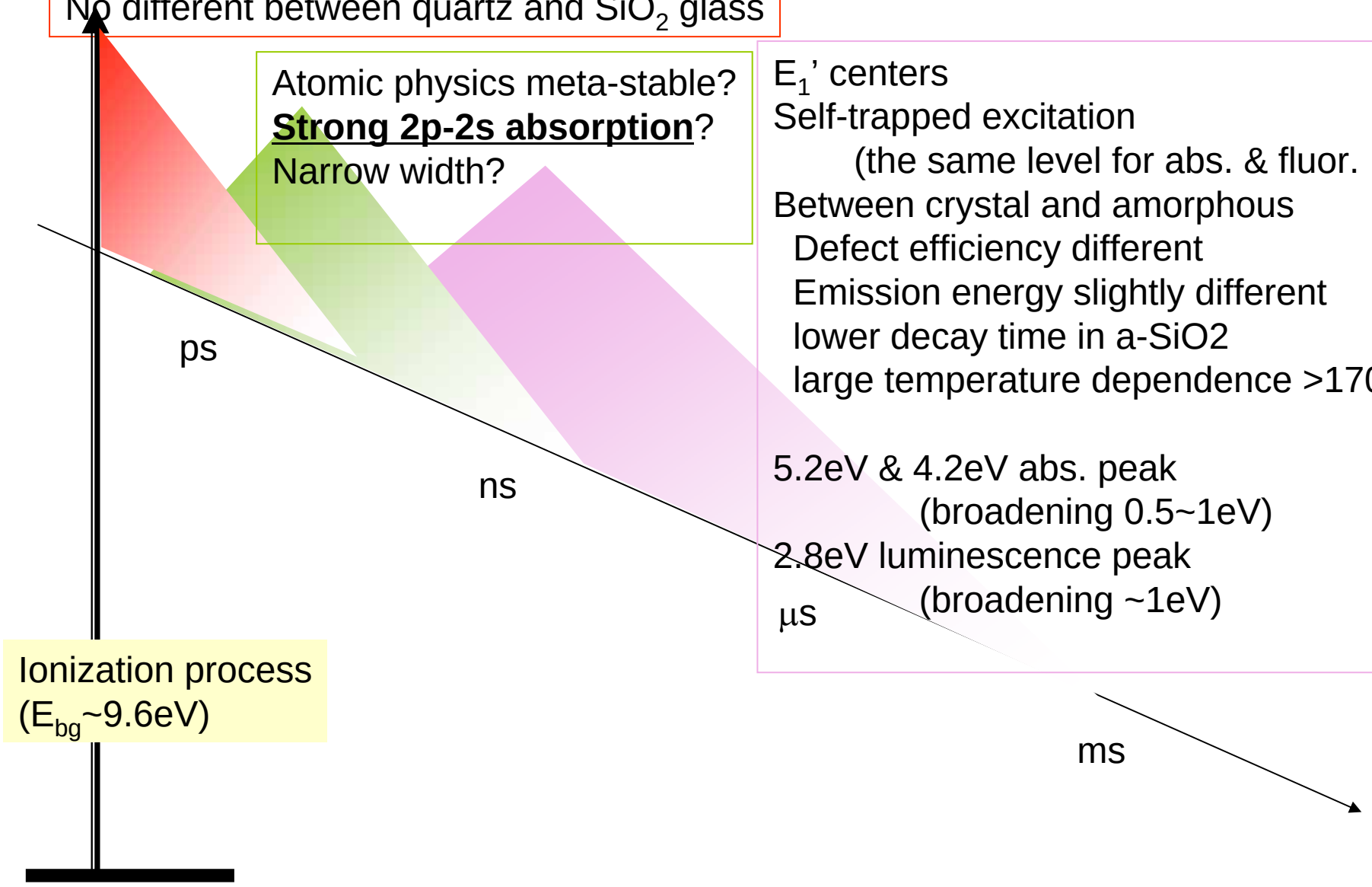
What's happen in Glass

Electron-phonon coupling
Life time (electron trapping time)~150fs
No temperature dependence
No different between quartz and SiO_2 glass

Atomic physics meta-stable?
Strong 2p-2s absorption?
Narrow width?

E_1' centers
Self-trapped excitation
(the same level for abs. & fluor.)
Between crystal and amorphous
Defect efficiency different
Emission energy slightly different
lower decay time in a-SiO2
large temperature dependence >170K

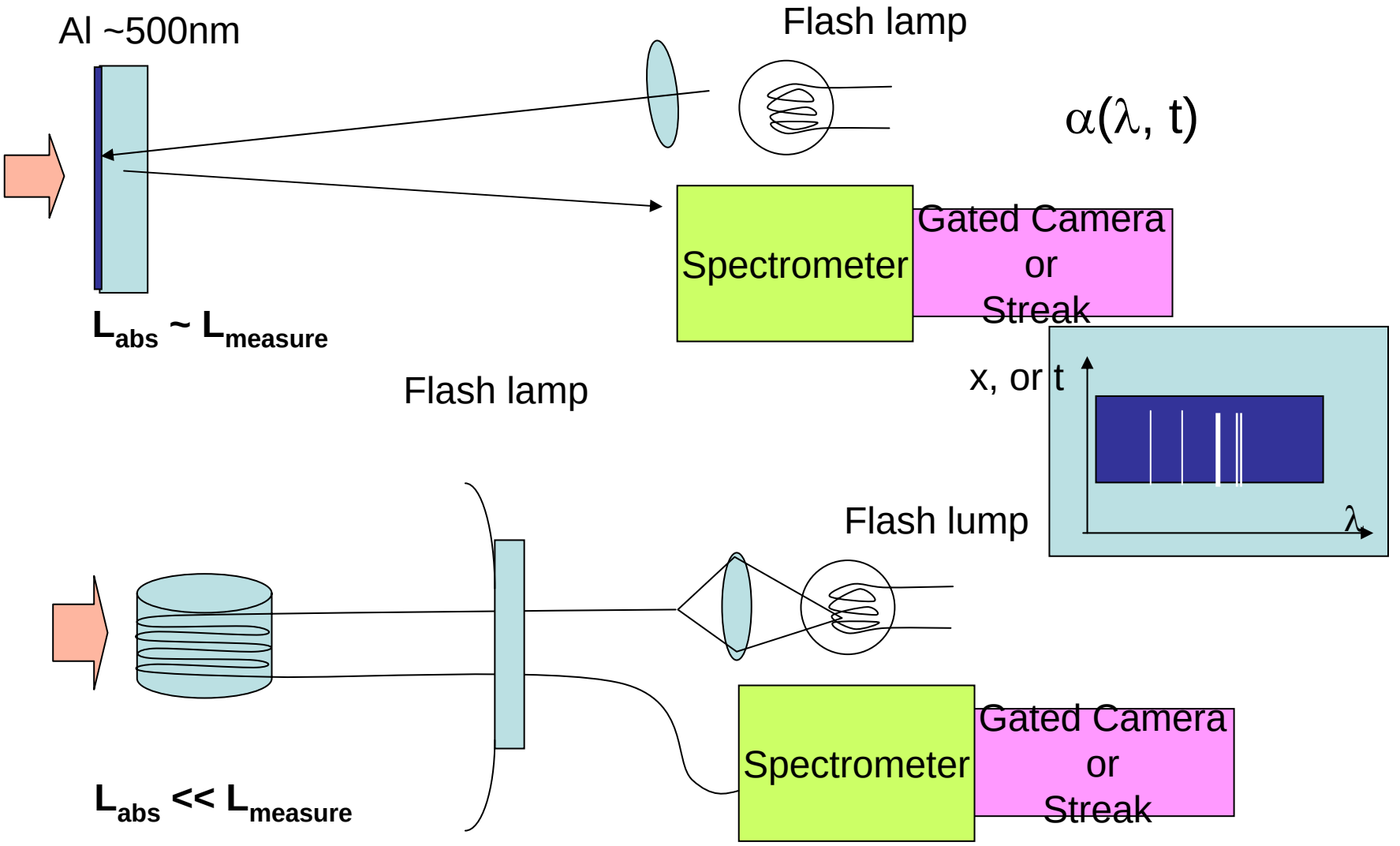
5.2eV & 4.2eV abs. peak
(broadening 0.5~1eV)
2.8eV luminescence peak
(broadening ~1eV)



Ionization process
(E_{bg}~9.6eV)

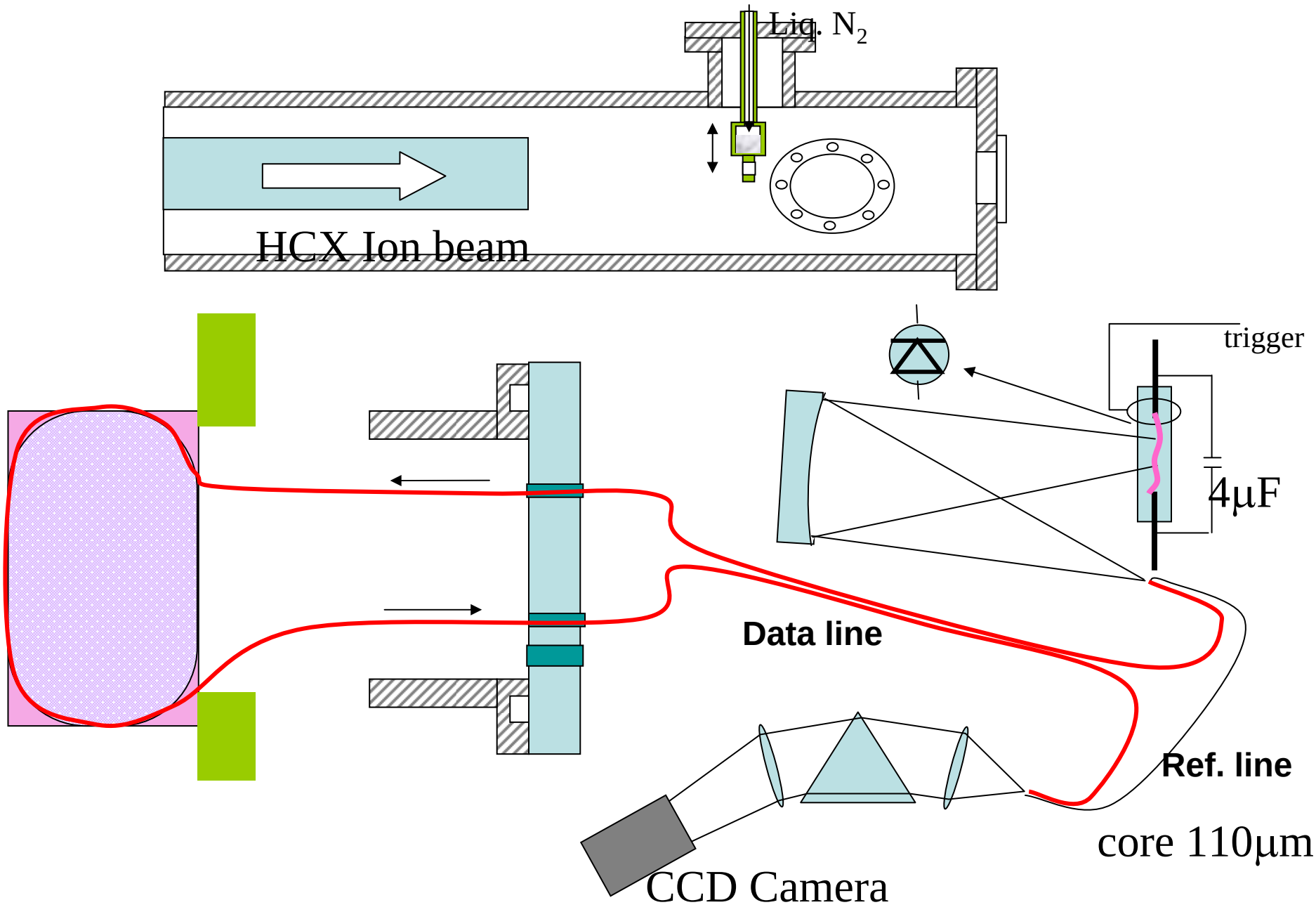
Absorption measurements for black glass in LBNL

Δt~ns, $\Delta\lambda$~10nm

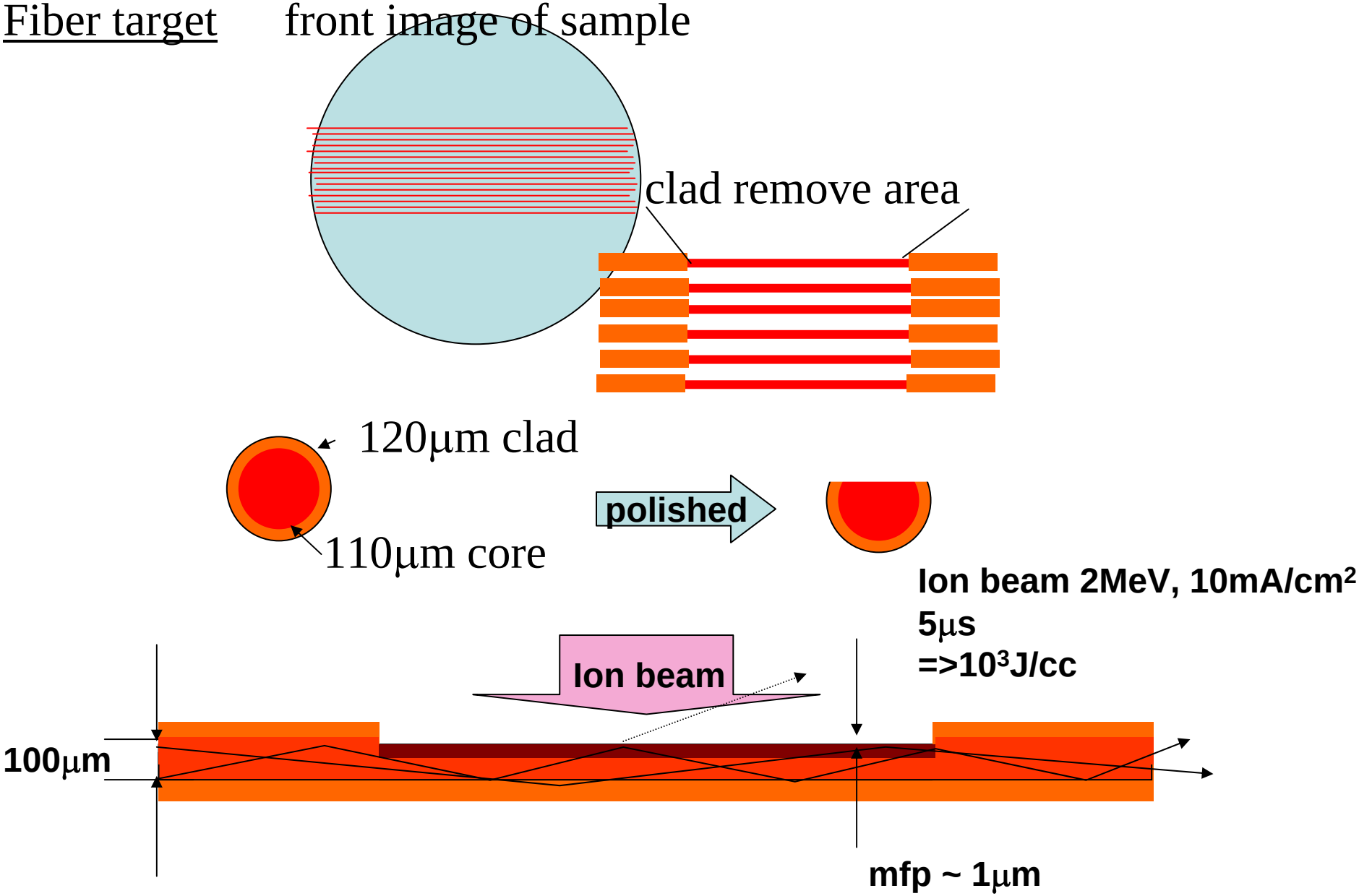


α(λ, t), emission(λ, t)

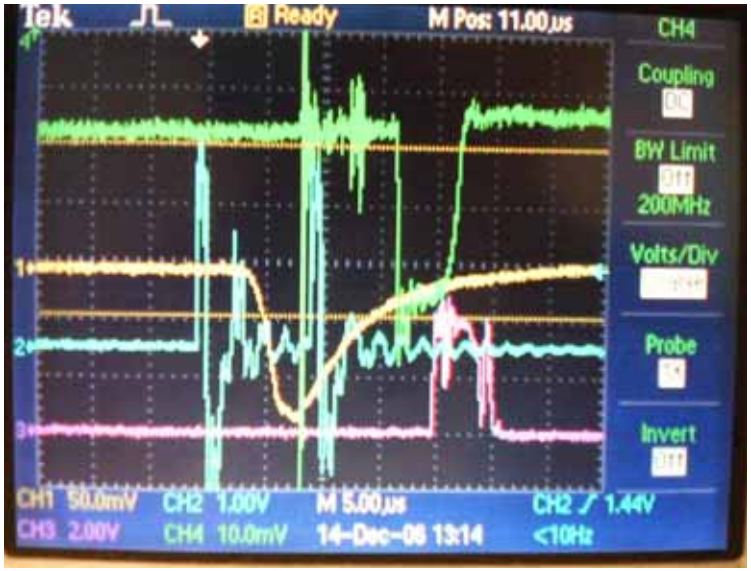
White light probe for the LBNL fiber experiments



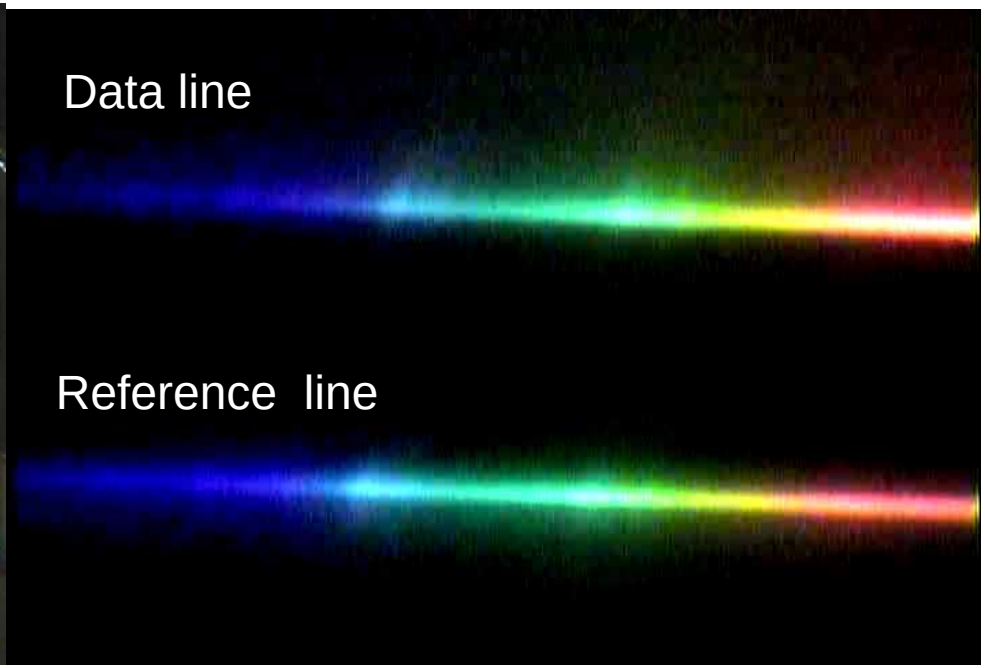
Fiber target

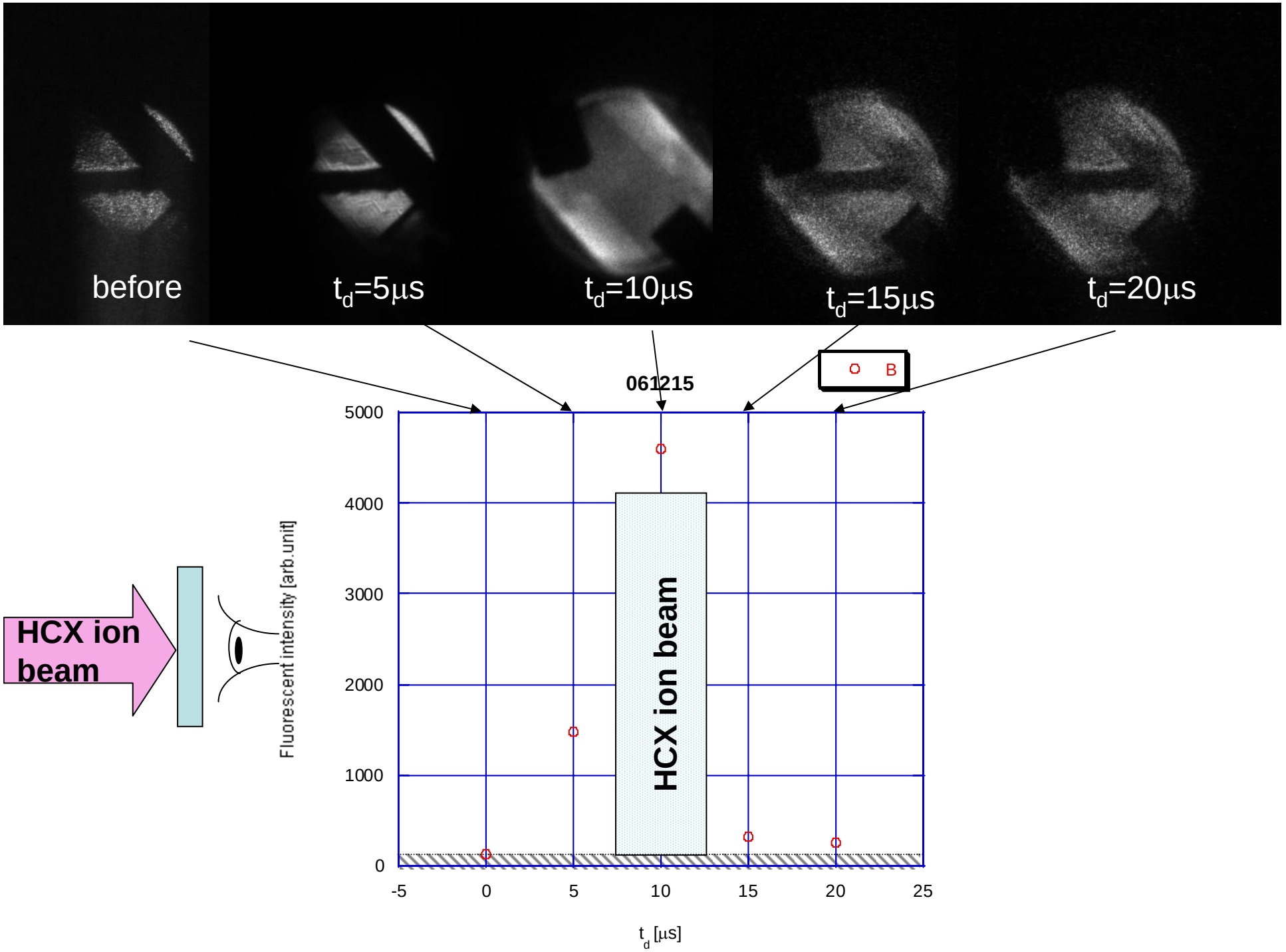


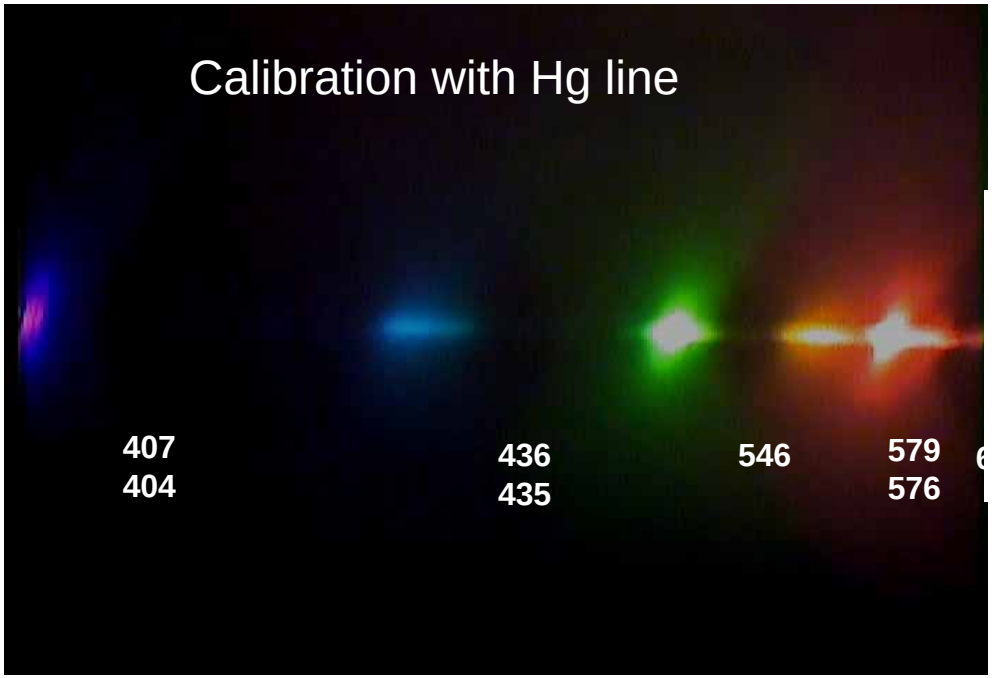
Transmission mode?
After absorption, how much decreasing occurs?

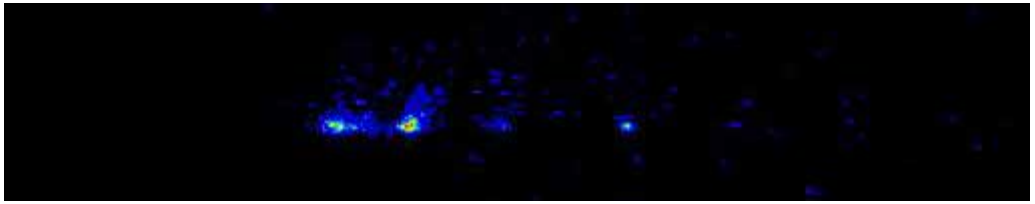


t_r=2µs t_f=~10µs

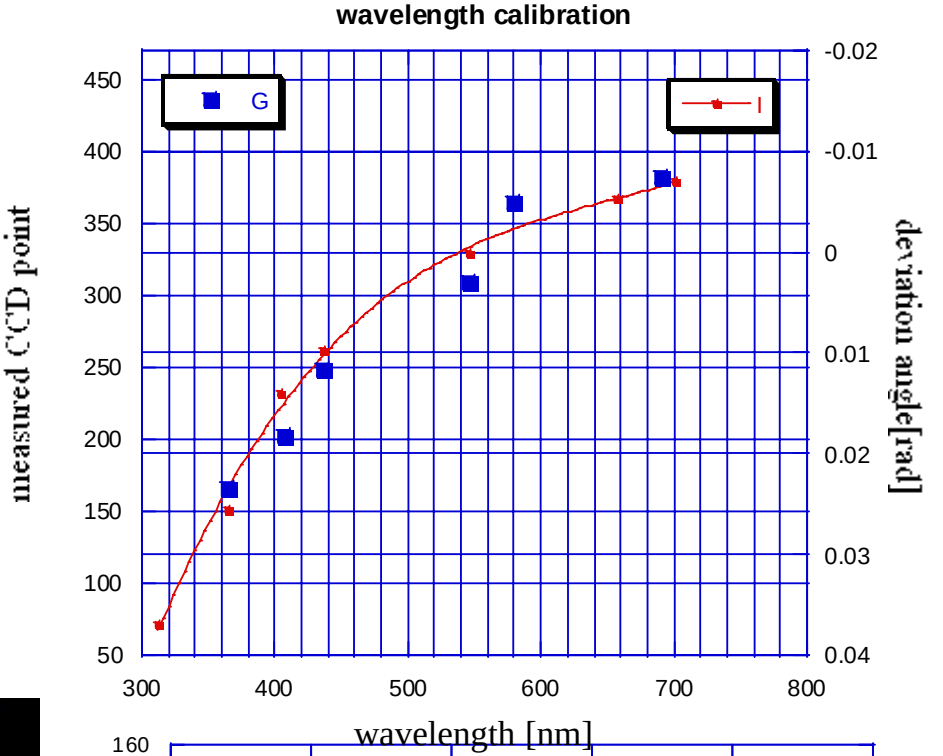


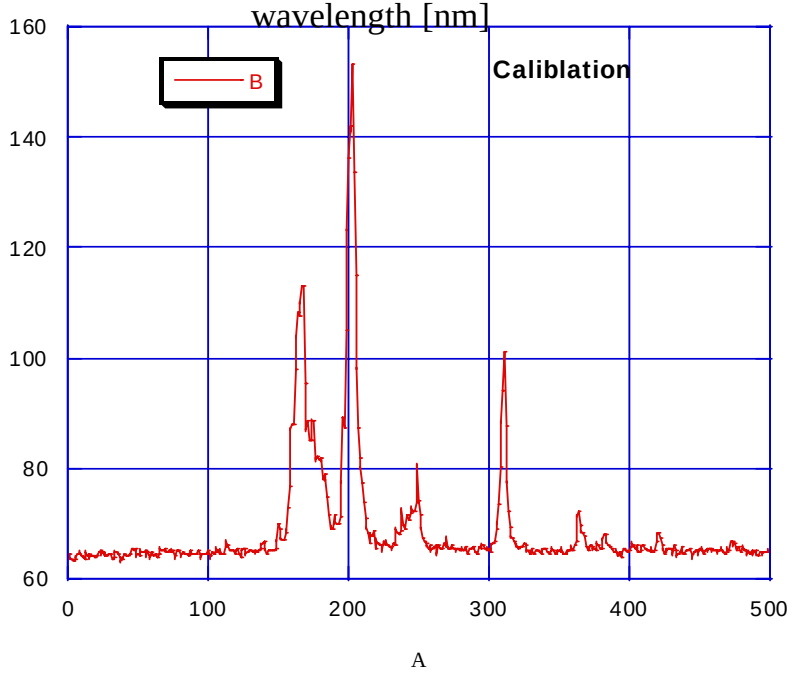

before
t_d=5μs
t_d=10μs
t_d=15μs
t_d=20μs
061215
B
HCX ion beam
Fluorescent intensity [arb.unit]
HCX ion beam
5000
4000
3000
2000
1000
0
-5
0
5
10
15
20
25
t_d [μs]

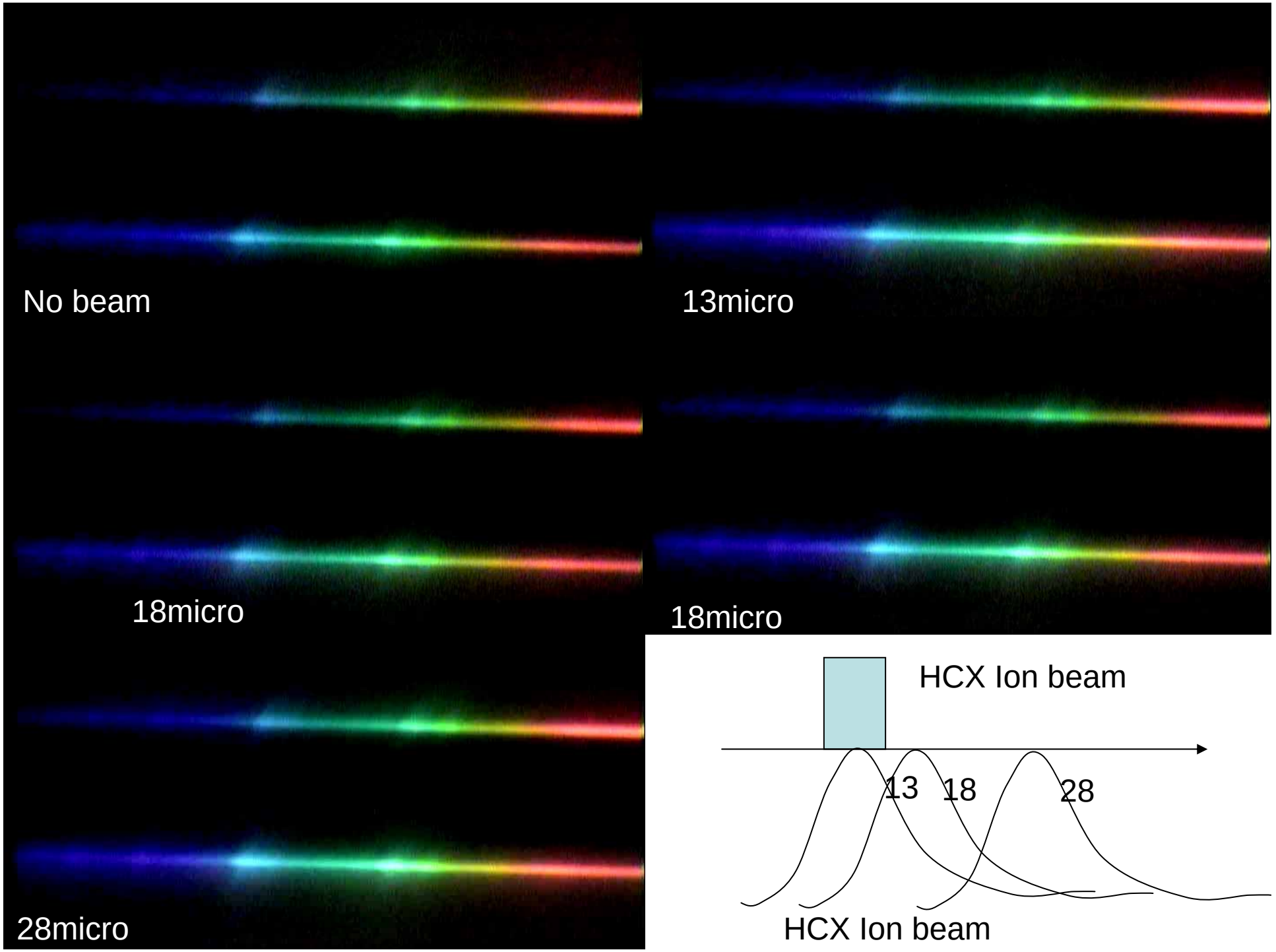

Calibration with Hg line
407
404
436
435
546
579
576

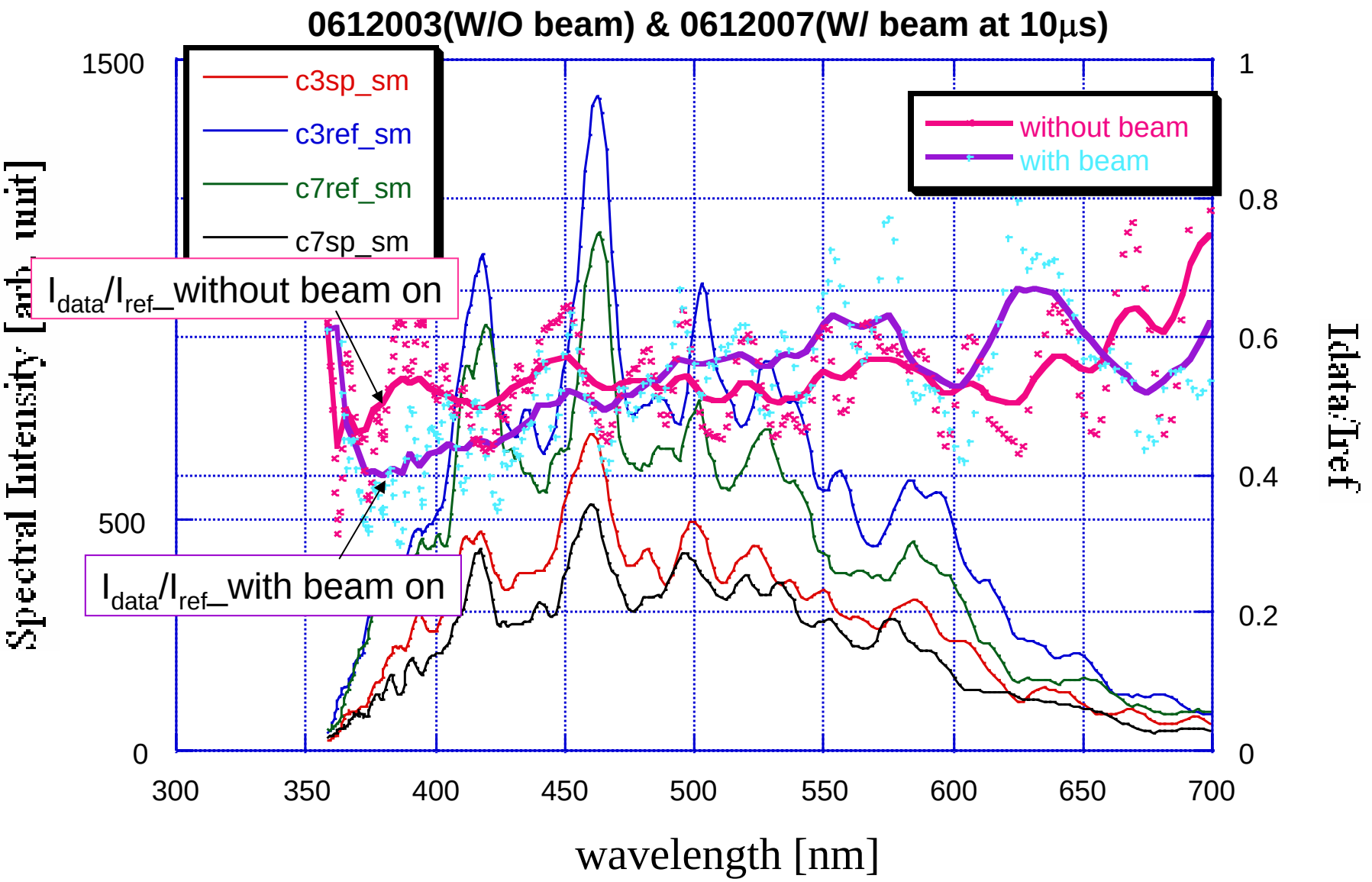


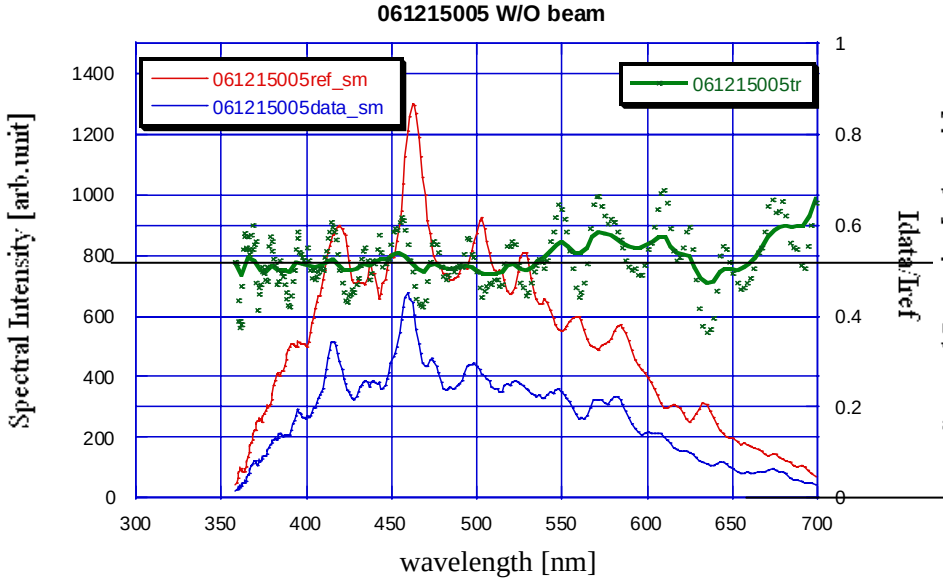
B


wavelength calibration
G
I
450
400
350
300
250
200
150
100
50
-0.02
-0.01
0
0.01
0.02
0.03
0.04
300
400
500
600
700
800
measured CCD point
deviation angle[rad]
wavelength [nm]

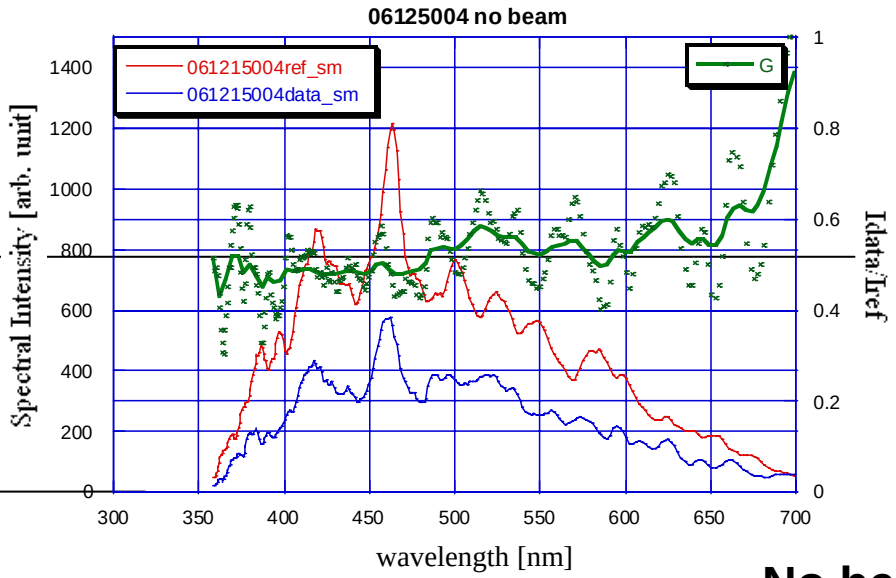

B
Caliblation
160
140
120
100
80
60
0
100
200
300
400
500
A


No beam
13micro
18micro
18micro
28micro
HCX Ion beam
13
18
28
HCX Ion beam

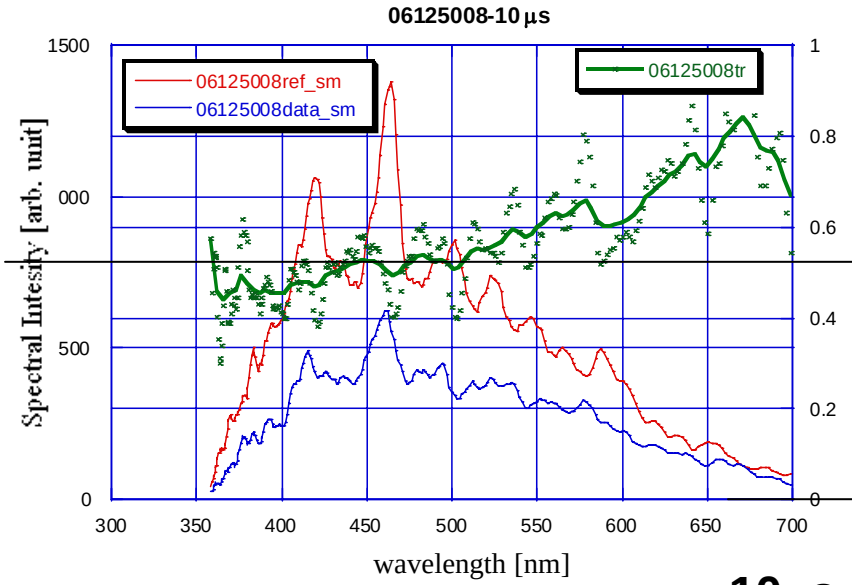

0612003(W/O beam) & 0612007(W/ beam at 10μs)
c3sp_sm
c3ref_sm
c7ref_sm
c7sp_sm
without beam
with beam
I_data/I_ref_without beam on
I_data/I_ref_with beam on
Spectral Intensity [arb. unit]
Idata/Iref
wavelength [nm]
1500
500
0
1
0.8
0.6
0.4
0.2
0
300
350
400
450
500
550
600
650
700



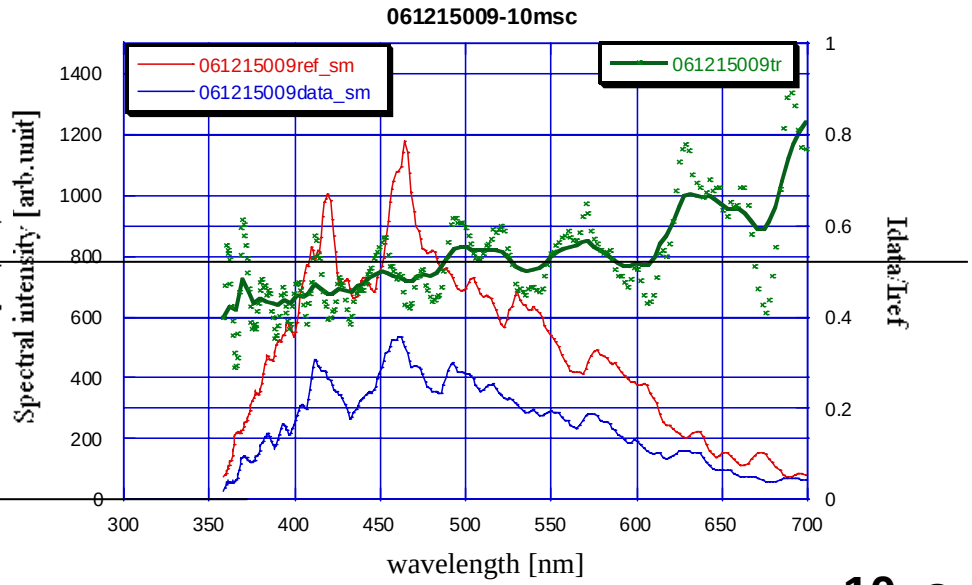
No beam



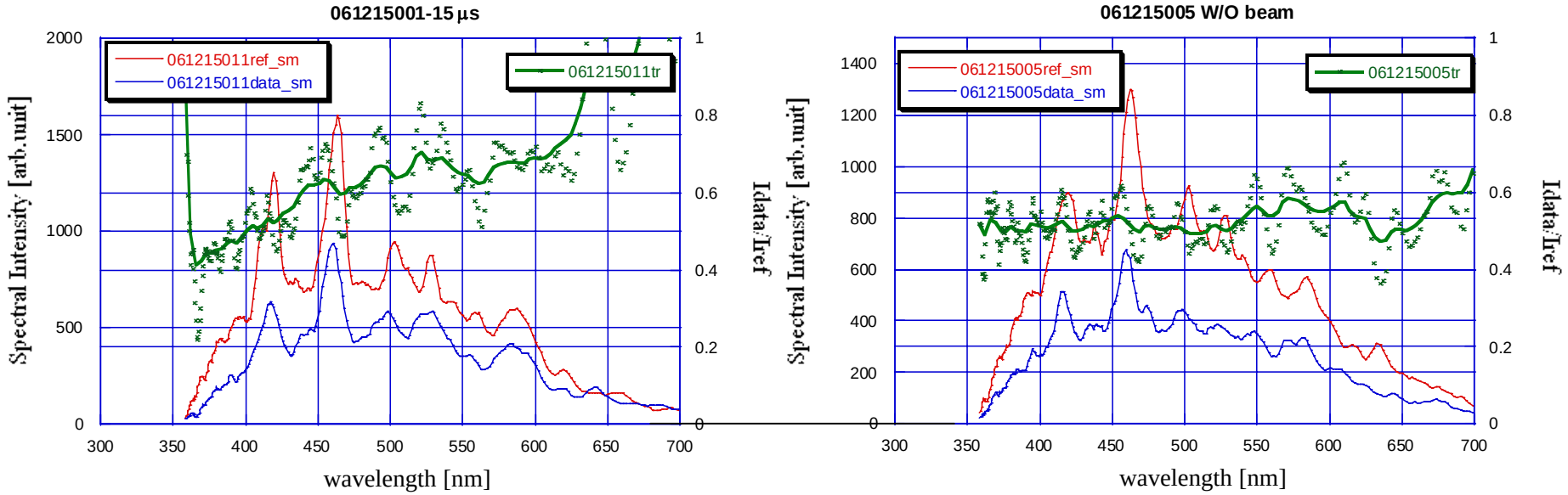
No beam

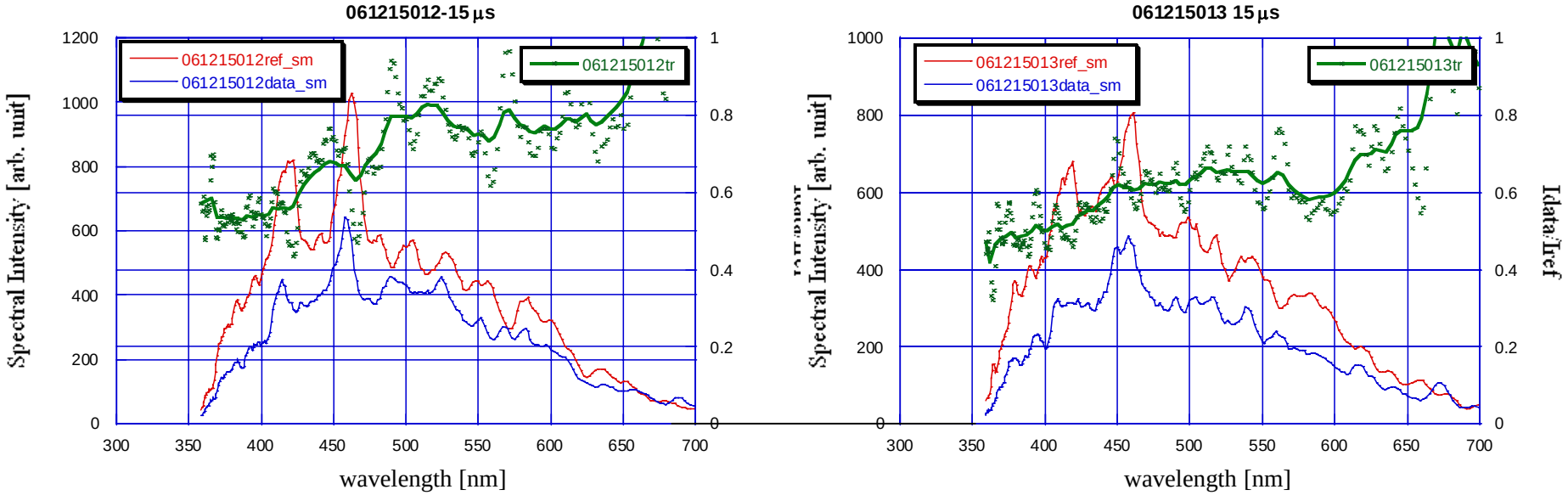


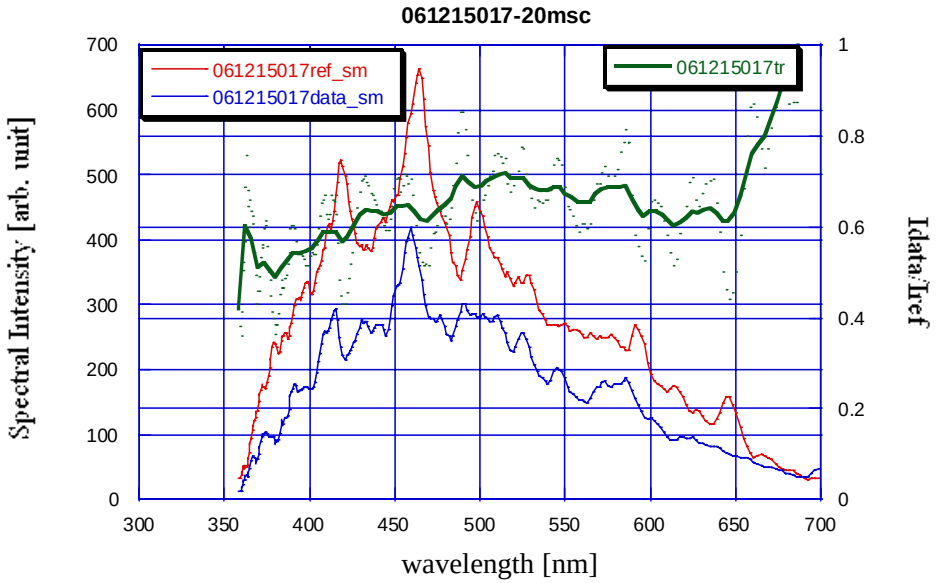
10µs



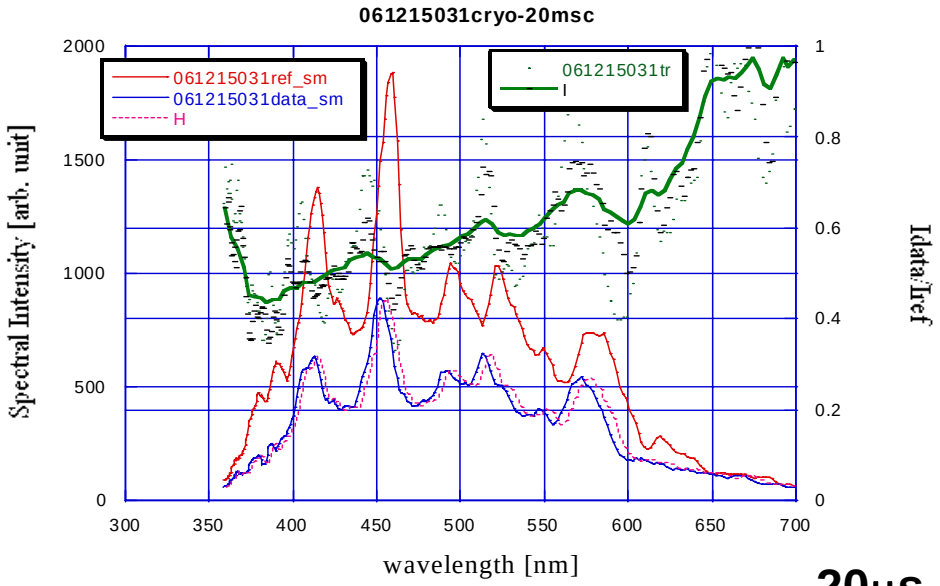
10µs


061215001-15 µs
061215011ref_sm
061215011data_sm
061215011tr
Spectral Intensity [arb.unit]
Idata/Iref
wavelength [nm]
061215005 W/O beam
061215005ref_sm
061215005data_sm
061215005tr
Spectral Intensity [arb.unit]
Idata/Iref
wavelength [nm]

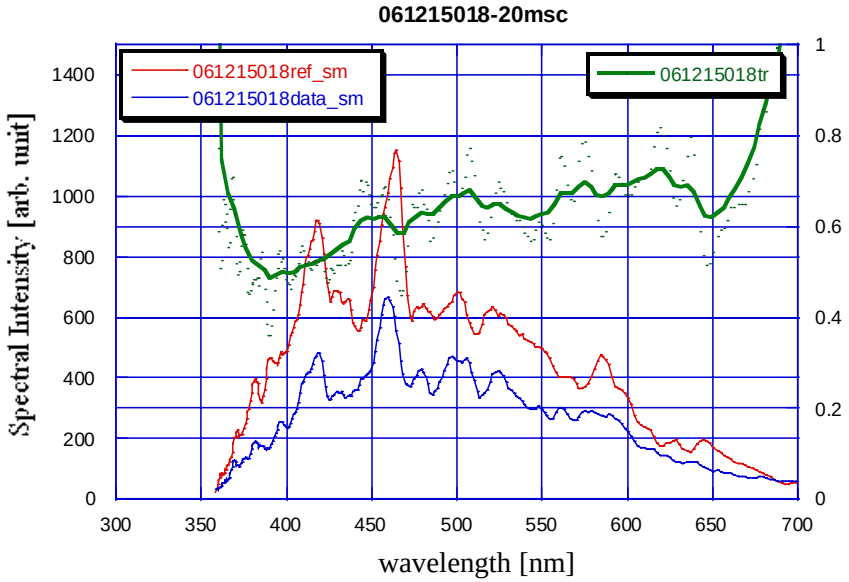

061215012-15 µs
061215012ref_sm
061215012data_sm
061215012tr
Spectral Intensity [arb. unit]
wavelength [nm]
061215013 15 µs
061215013ref_sm
061215013data_sm
061215013tr
Spectral Intensity [arb. unit]
Idata/Iref
wavelength [nm]



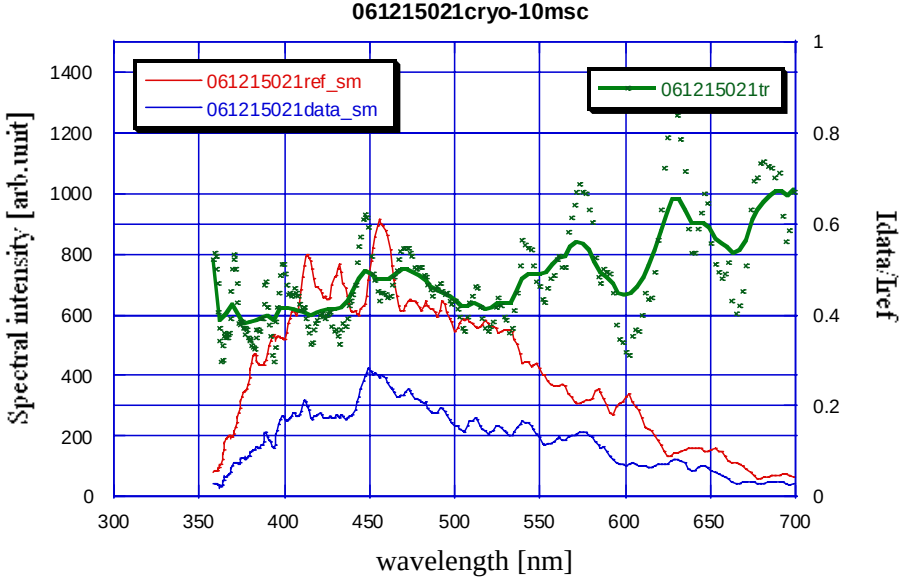
20μs



20μs



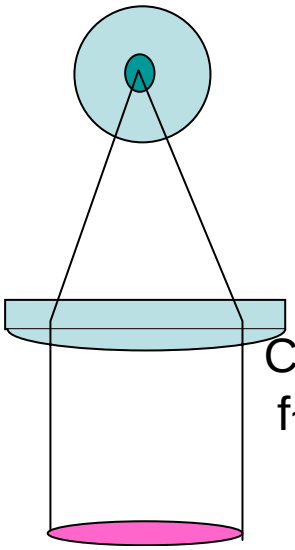
20μs



10μs

248nm USP laser experiment for SiO_2

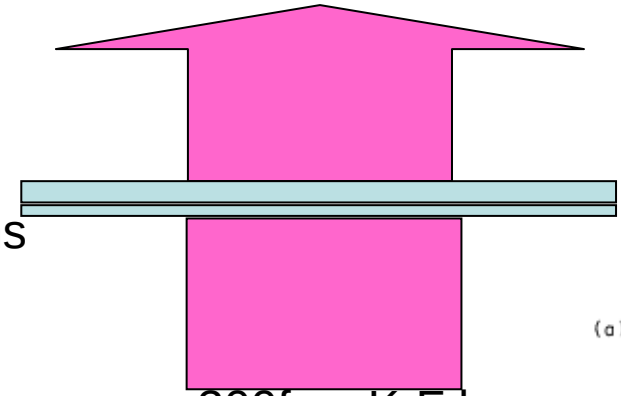
2 photon abs.



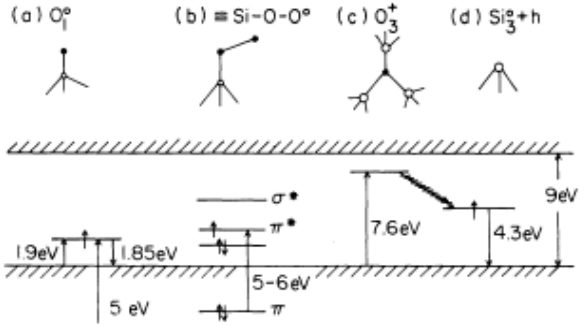
Cylindrical lens
f~50

I~5x10^{10}W/cm^2
E~3J/cm^3

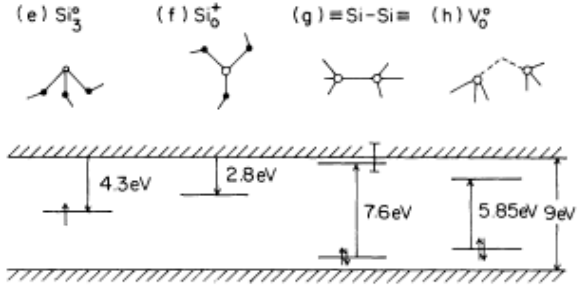
Multi-mode fiber



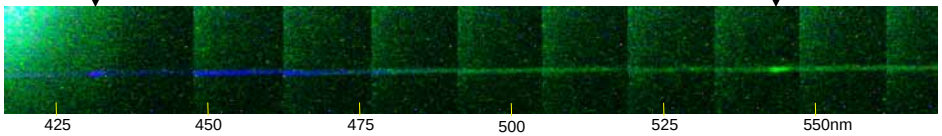
300fs – KrF laser



Spectrome



2.9eV
2.3eV
time integrated spectrum



425nm
550nm

1.9eV

600nm
725nm

K. Takahashi, ILS/UEC, 2006

Conclusion

- Ultra-fast transient absorption or reflection change will be used for real optical device in high power laser systems.
- New type of hydro-test and evaporation test are now ready to check by EOS model.
- We have got the direct evidence for (broadband) transient black in SiO_2 for the first time.
- We also have some evidence of changing optical properties in SiO_2 under illumination of HCX ion beam.