

Investigations With a Camera at the Cathode Position

Comparison of optical properties at cathode position with virtual cathode

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Camera at Cathode Position
PITZ Physics Seminar
Zeuthen, 4. April 2013

> Motivation

> Setup

> Results

- Lateral intensity distribution
- Size
- Laser pulse energy
- Edge effect of vacuum mirror
- Comparison with simulation

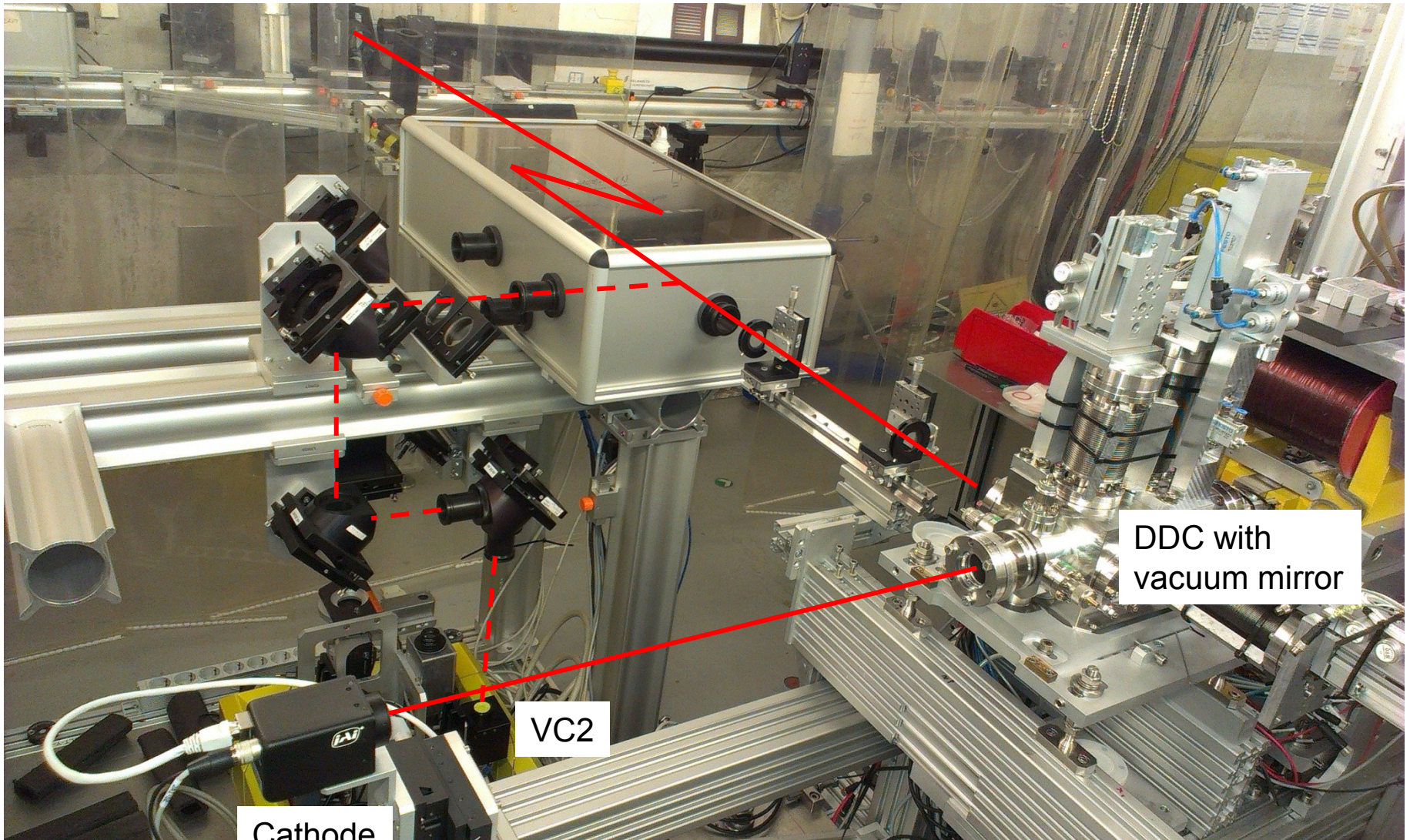


Motivation and Opportunity

- > Question: how does the laser beam look like at the photocathode compared to the virtual cathode position?
- > Opportunity: gun exchange
 - Place camera of same type as VC2 at position normally occupied by photocathode
 - Need: special holder for camera and double diagnostics cross (contains vacuum mirror)
- > Special holder was designed and constructed
- > Setup was integrated into PITZ beam line and experiments were conducted on 11. and 12. of March 2013



Setup



Cathode
Camera

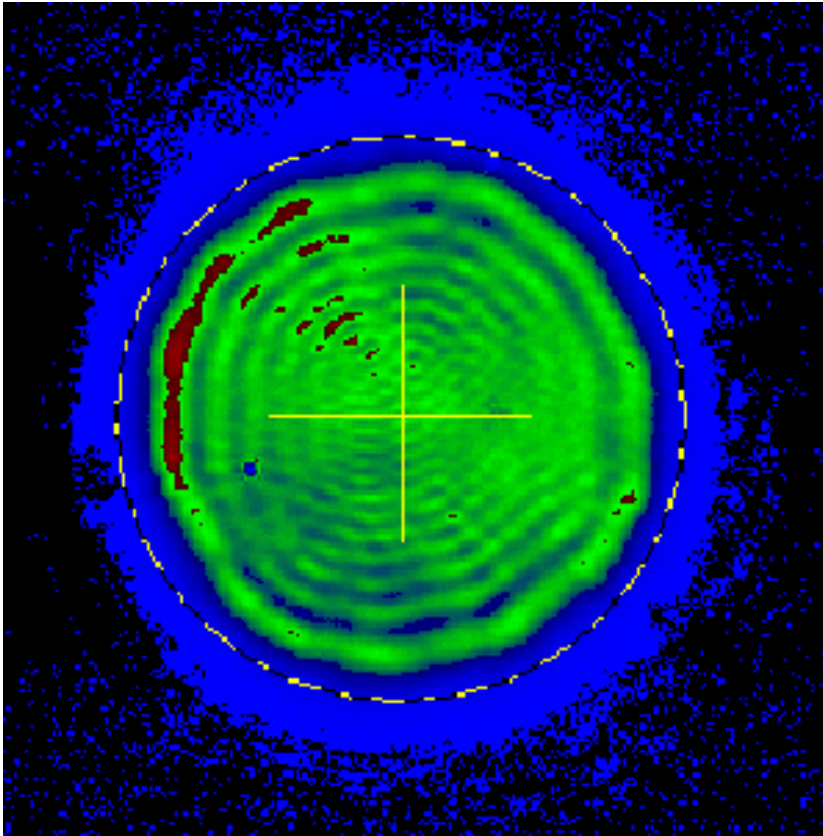
VC2

DDC with
vacuum mirror

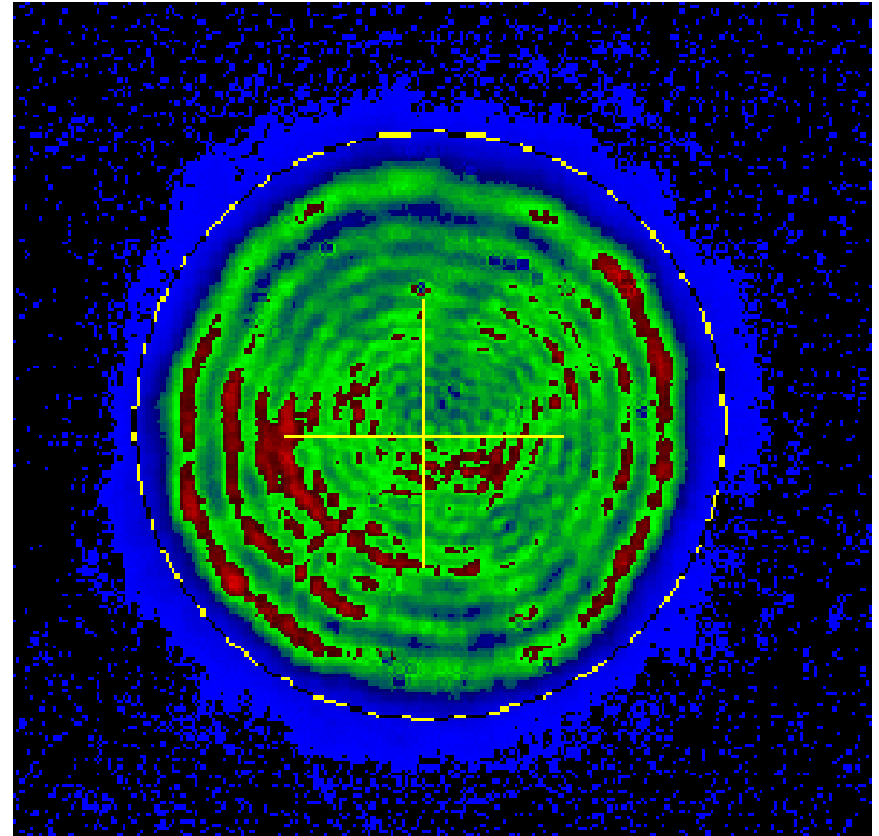


Comparison

Photocathode



Virtual cathode



- Quality similar, a little better on the photocathode (only one mirror in the path)

Size

BSA size [mm]*	Cathode camera			VC2			Size ratios Cathode/VC2			BSA/VC2 xyRMS
	xRMS	yRMS	xyRMS	xRMS	yRMS	xyRMS	x	y	xy	
0.08	0.066	0.065	0.065	0.064	0.063	0.063	1.03	1.03	1.03	1.26
0.16	0.056	0.068	0.062	0.055	0.062	0.058	1.02	1.10	1.06	2.74
0.22	0.072	0.085	0.078	0.067	0.078	0.072	1.07	1.09	1.08	3.04
0.33	0.095	0.107	0.101	0.091	0.106	0.098	1.04	1.01	1.03	3.36
0.75	0.202	0.21	0.206	0.203	0.205	0.204	1.00	1.02	1.01	3.68
1.13	0.3	0.301	0.300	0.306	0.294	0.300	0.98	1.02	1.00	3.77
1.52	0.413	0.402	0.407	0.409	0.4	0.404	1.01	1.01	1.01	3.76
1.98	0.511	0.499	0.505	0.504	0.493	0.498	1.01	1.01	1.01	3.97
2.37	0.624	0.604	0.614	0.618	0.588	0.603	1.01	1.03	1.02	3.93
3.5	0.843	0.817	0.830	0.836	0.791	0.813	1.01	1.03	1.02	4.30

Average: 1.02 1.04 1.03

- > Laser beam a little bit bigger on photocathode (1 to 3%)
- > *BSA (calibration?) – Ratio BSA size to xyRMS about 4 for flat tops, reduced for smaller sizes
 - No flat top for small BSA



Energy

BSA size [μm]*	Pulse energy [pJ]			Pulse energy ratio			B/A ² (density)
	laser trolley	before DDC	at cathode***	DDC/trolley	cathode/DDC	cathode/trolley	
30	1.8	31.6	4.7	17.78	0.15	2.64	1.98
40	2.9	90.3	40.1	31.27	0.44	13.90	1.81
50	5.3	154.8	64.7	29.34	0.42	12.27	2.11
60	6.9	209.7	88.6	30.19	0.42	12.76	1.93
70	9.6	261.3	116.8	27.19	0.45	12.15	1.96
80	13.4	412.9	159.1	30.84	0.39	11.88	2.09
160	16.1	1619.4	640.1	100.51	0.40	39.73	0.63
220	101.1	3000.0	1301.9	29.67	0.43	12.88	2.09
330	212.8	5935.5	2694.2	27.90	0.45	12.66	1.95

> Constant fluence except red marked measurement (error)

- *BSA (calibration?) – density constant → intercept calibration ok

> Ratios are constant except for 30 μm BSA (real effect?)

> Only 40 to 45% reflection of vacuum mirror

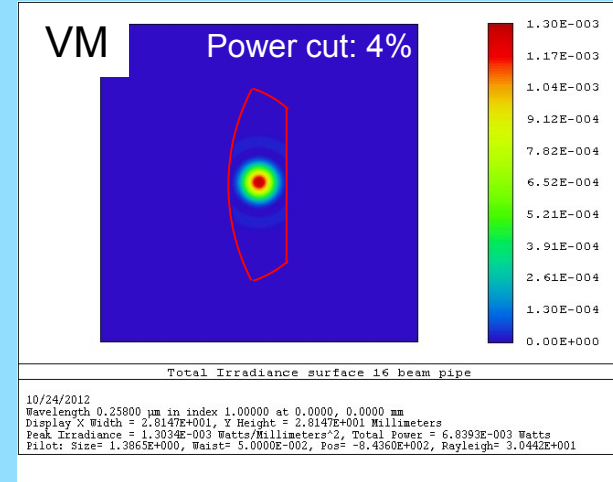
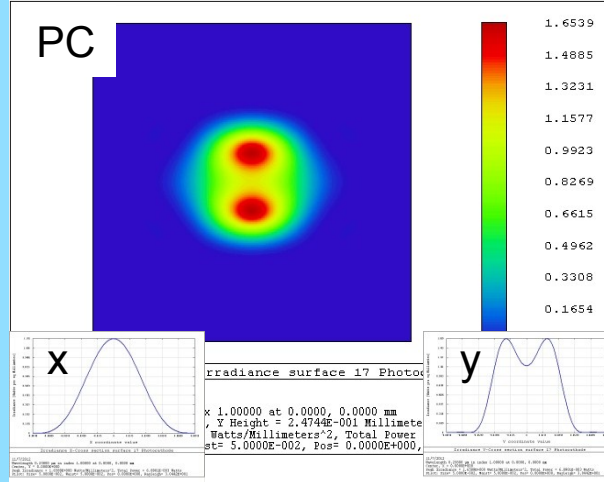
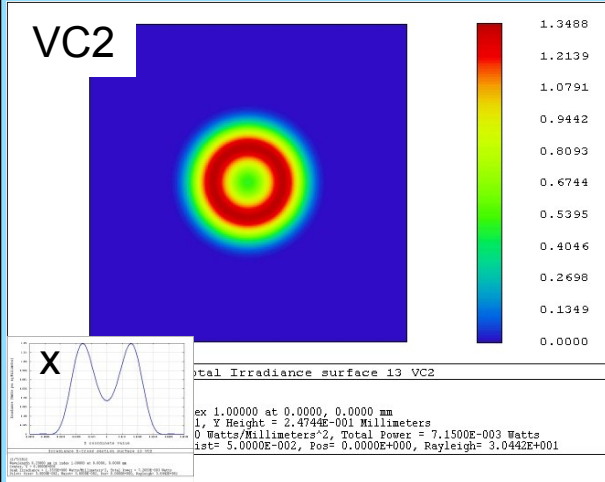
- Mirror damage? R=70% measured in lab before mounting into beam line



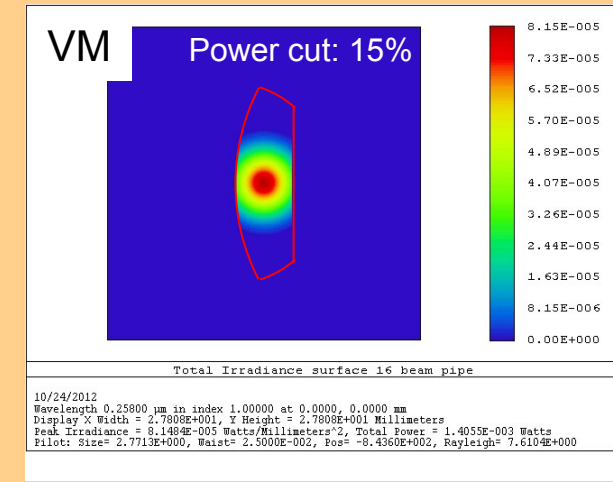
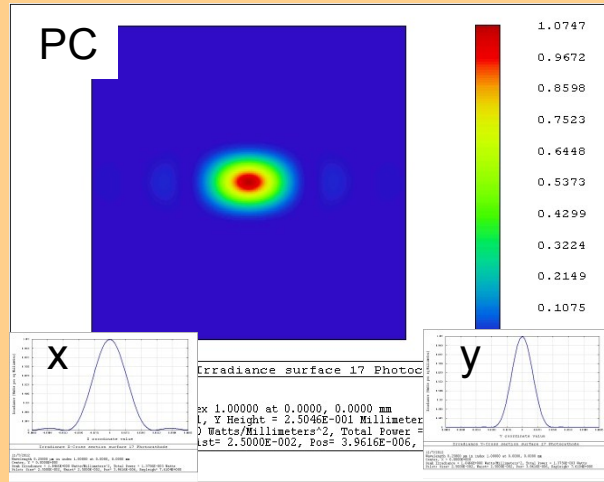
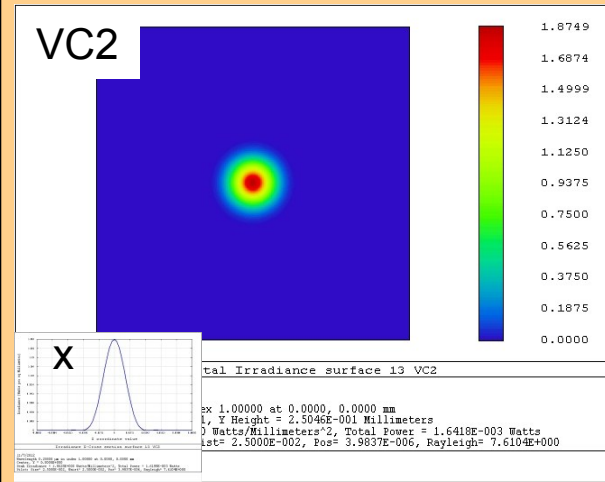
Diffraction Effects at Photocathode (PC) Laser Beam Line Simulation with ZEMAX Physical Optics Propagation Tool

➤ Big difference between VC2 and PC for small BSAs

■ BSA: 0.1mm

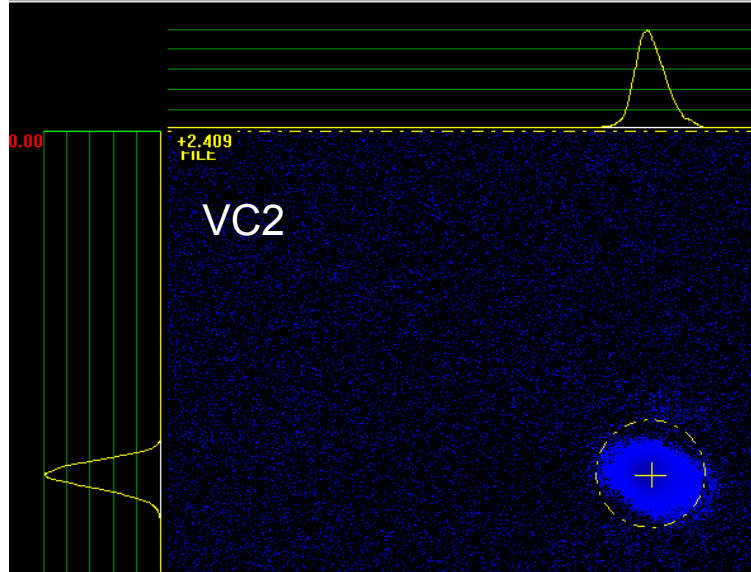
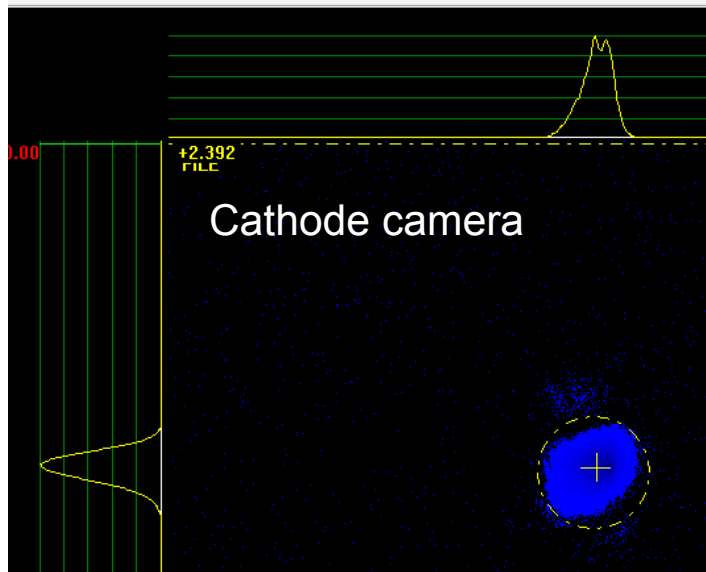
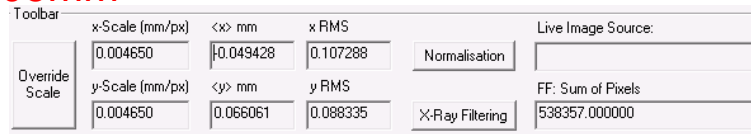
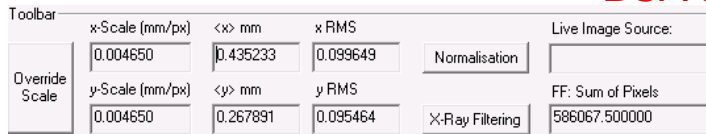


■ BSA: 0.05mm



Measurements with Cathode Camera for Small BSAs

BSA 0.05mm

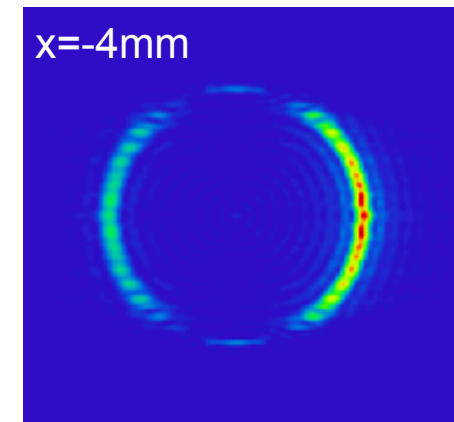
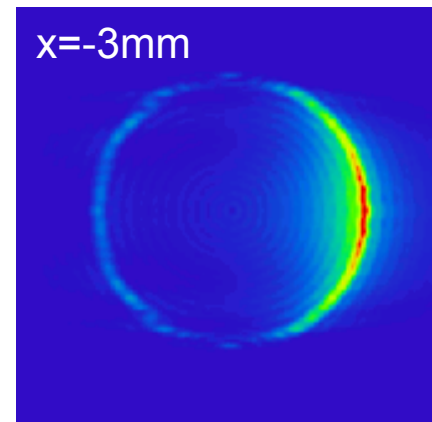
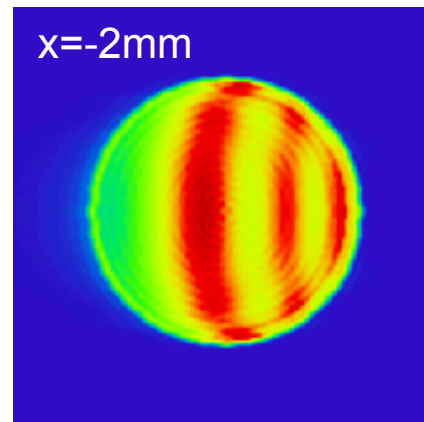
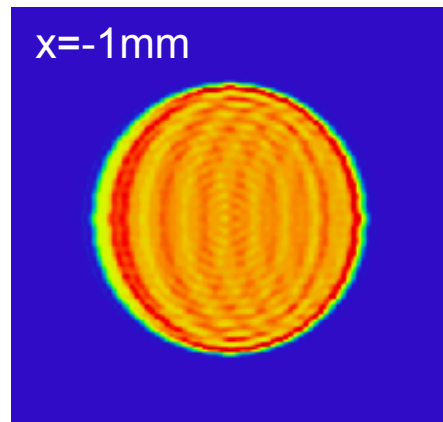
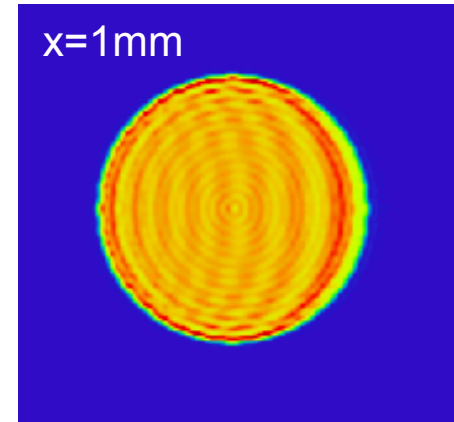
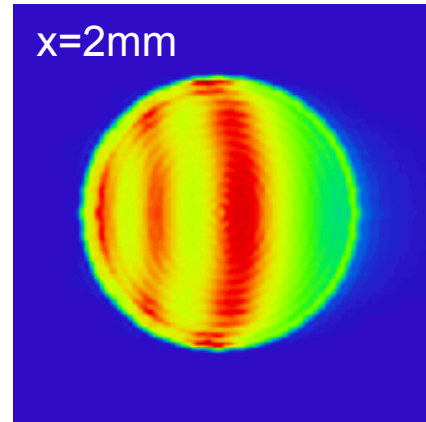
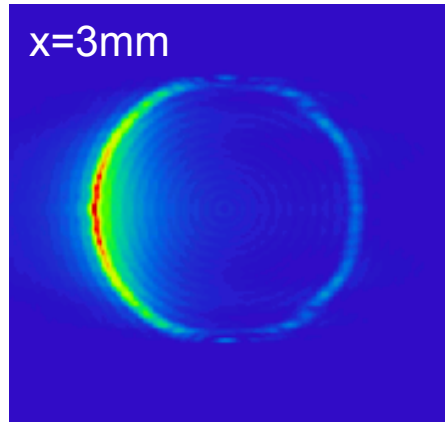
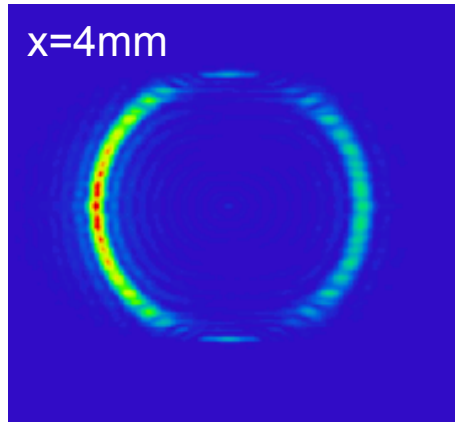


BSA size [mm]	Pulse energy ratio	Cathode camera
	cathode /trolley	xyRMS [mm]
0.03	2.64	
0.04	13.90	0.102
0.05	12.27	0.094
0.06	12.76	0.090
0.07	12.15	0.082
0.08	11.88	0.065
0.22	12.88	0.078
0.33	12.66	0.101

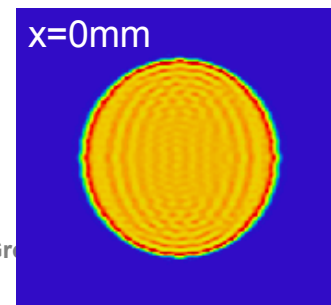
- > Cathode camera shows double maximum as in simulation but in x-direction and for different BSA sizes (<0.07mm)
 - Possible reason: ?
- > No energy loss visible until BSA of 0.03mm
- > rms size increasing for small BSAs



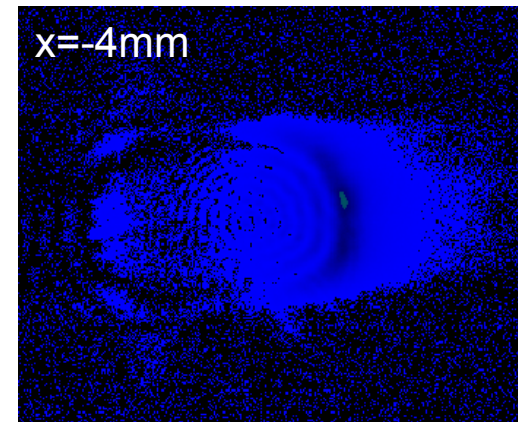
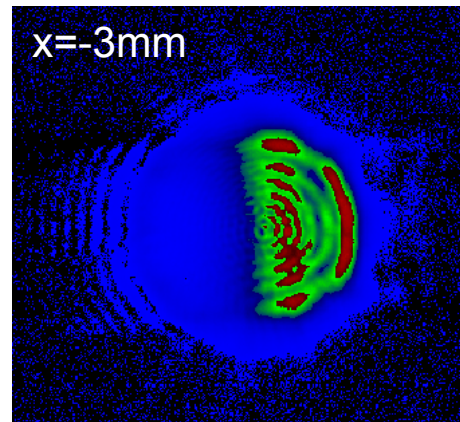
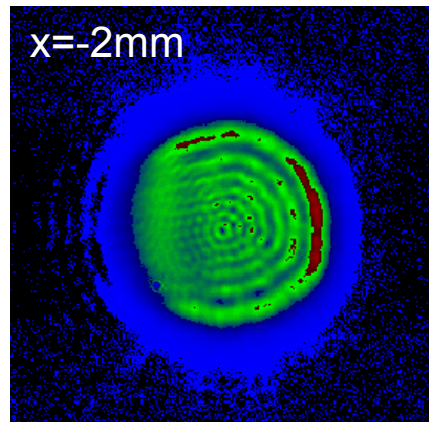
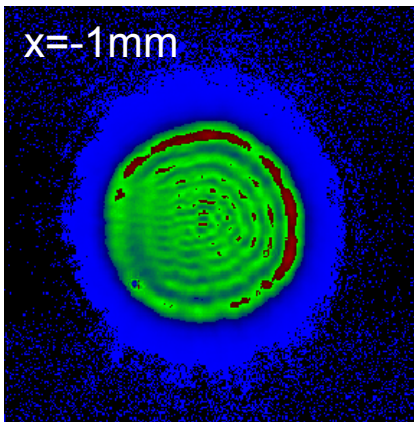
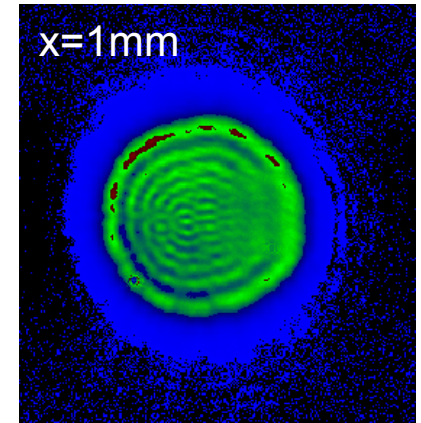
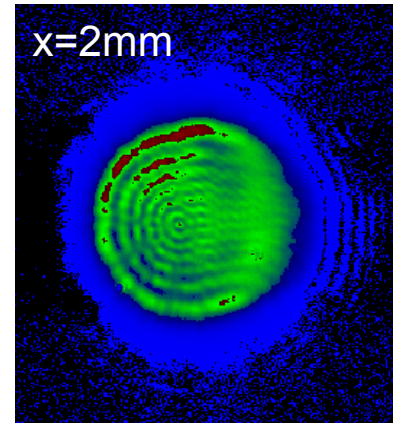
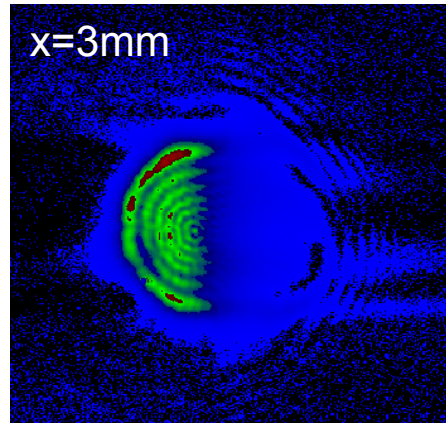
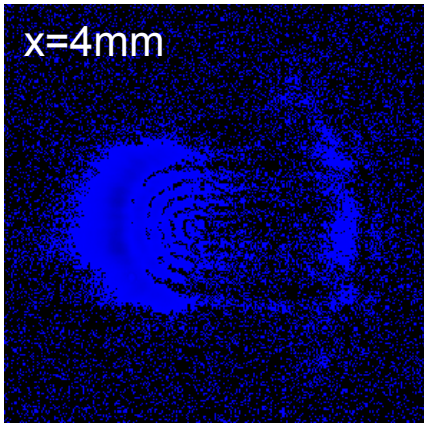
Simulated Scan over Vacuum Mirror (BSA 1.2mm)



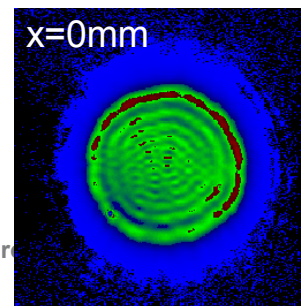
- > Influence on pattern already for 1mm displacement
- > Cut for displacement $>2\text{mm}$



Scan over Vacuum Mirror (BSA 1.2mm)

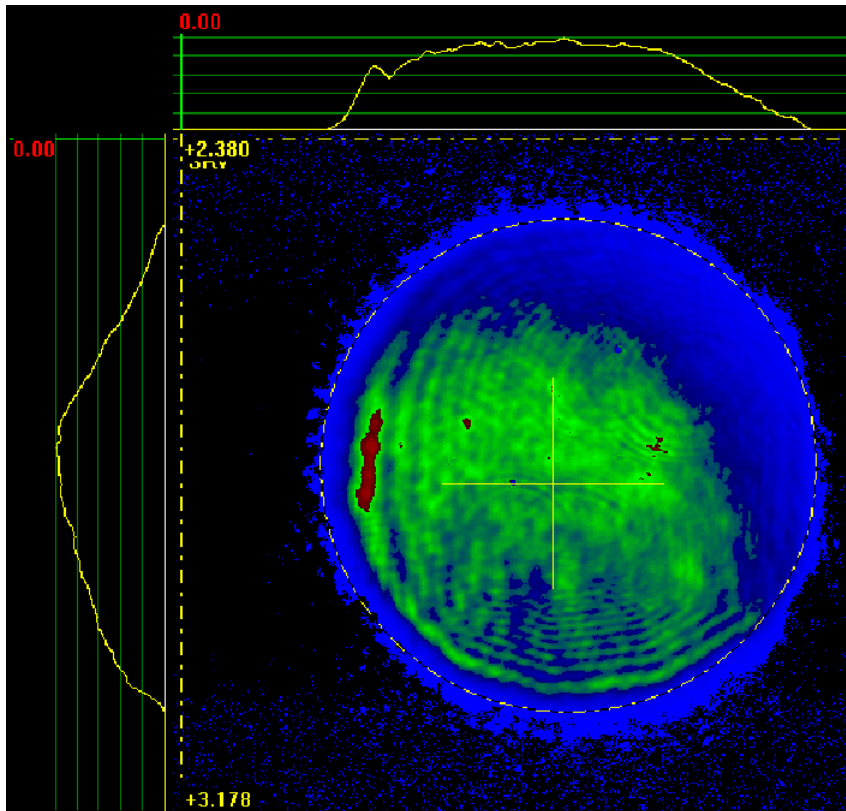


- It is important to stay in the middle of the vacuum mirror!
- Results comparable to simulation

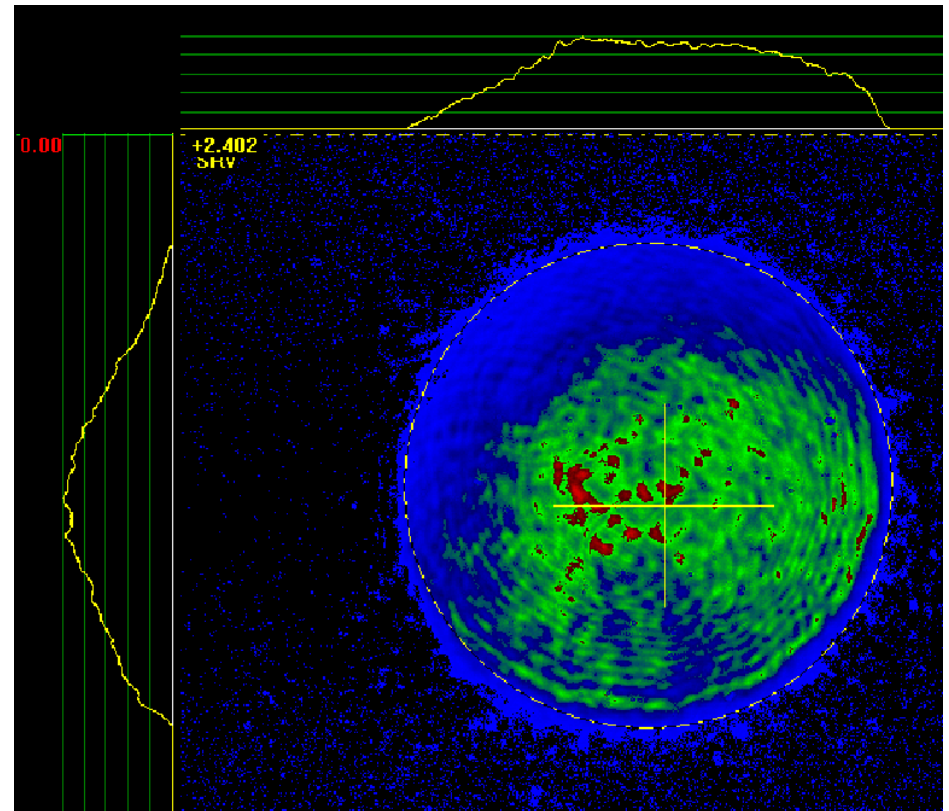


A Side Note

- Left and Right are exchanged for PC and VC2
 - 1 mirror to the cathode, 4 mirrors to VC2



Cathode camera



VC2