Performance of the 16-ID-B Bimorph Mirrors

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Thank you to:

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Riccardo Signorato
(ESRF - SPring-8 - ACCEL)

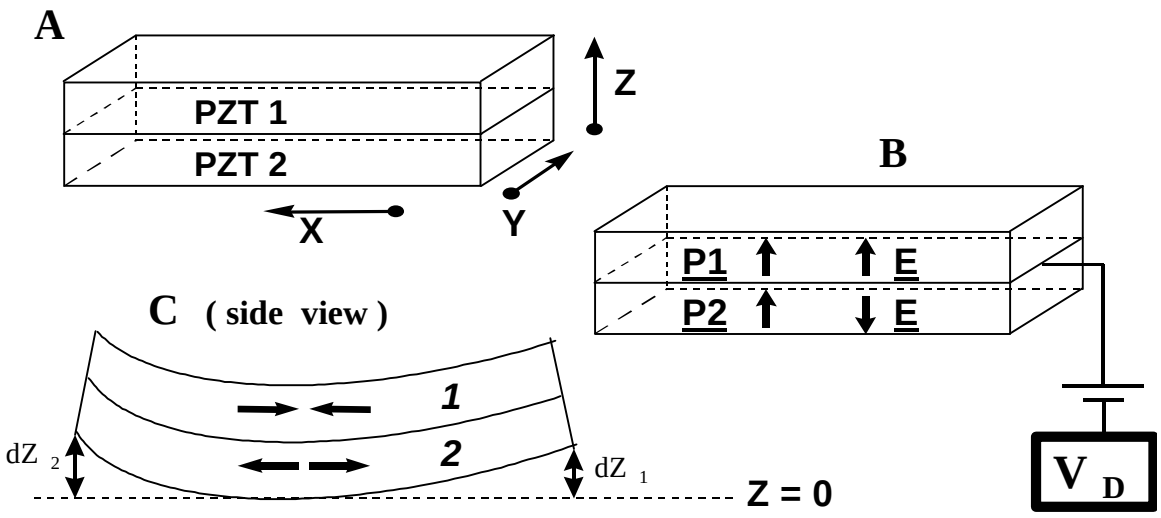
- Introduction: Focusing for High Pressure studies
- HPCAT facility: Brief overview
- Principle of bimorph mirrors and their history
- 16ID-B K-B bimorphs
    - Performance: Optical and X-ray
    - Control
    - Stability
- Conclusion and plans for the future

Modular Bimorph mirrors installed base

Mirror No.	*Facility*	*Mirror Length*	*Functionality*	*Status*	*Notes*
1	**ESRF**	**750 mm**	**HFM in a K-B setup**	**Operational. Routinely used at ID26 since 1997**	M / FS / MC
2	ESRF	450 mm	VFM in a K-B setup	Operational. Routinely used at ID26 since 1998	M / FS / MC
3	ESRF	450 mm	VFM in a double mirror system	Operational. Routinely used at ID 32 since 1997	M / FS / MC
4	SPring-8	300 mm	Movable, quick installation HFM/VFM for the RIKEN beamlines	Operational. Routine use since 2000 at three different beamlines	M / FS / MC
5	SPring-8	300 mm	R&D on chemical superpolishing; extra-wide dynamical range	To be polished by Osaka University	M / PI / B
6 **7**	**APS**	**300 mm** **300 mm**	**K-B microfocusing mirrors**	**Operational. Routinely used at HP-CAT since Nov. 2002** **Operational. Routinely used at HP-CAT since Nov. 2002**	M / FS / MC M / FS / MC
8	APS	600 mm	VFM in a K-B setup	Being manufactured	M / FS / MC
9		1050 mm	HFM in a K-B setup	Being manufactured	M / FS / MC
10		600 mm	VFM in a K-B setup	Being manufactured	M / FS / MC
11		1050 mm	HFM in a K-B setup	Being manufactured	M / FS / MC

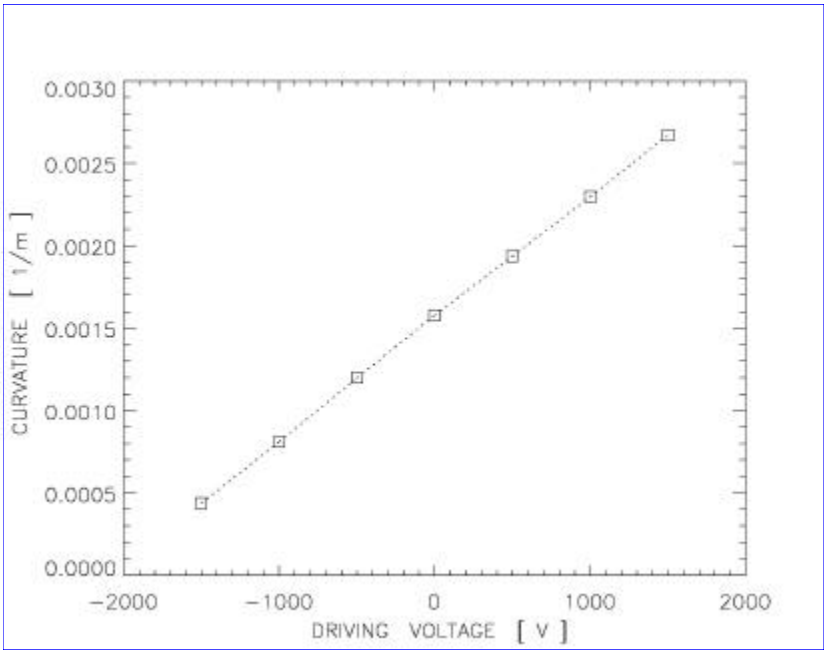
B = bare reflecting surface
C = cooled mirror
M = mirror exposed to monochromatic beam only
P = mirror exposed to pink beam
FS = reflecting plates material: fused silica
MC = metallic coating (Pt, Rh, Cr …)
PI = reflecting plates material: pirex glass
SI = reflecting plates material: silicon
HFM = horizontally focusing mirror
VFM = vertically focusing mirror

NOT IN TABLE:
Prototype 150mm K-B (single electrode) pair successfully used on High-Pressure Beamline (ID30) from 1996 to 1997 BUT not very stable and required frequent re-optimisation for best focal spot (~every few days for very best focal spot of ~ 15µm x 20µm, but asymmetric)



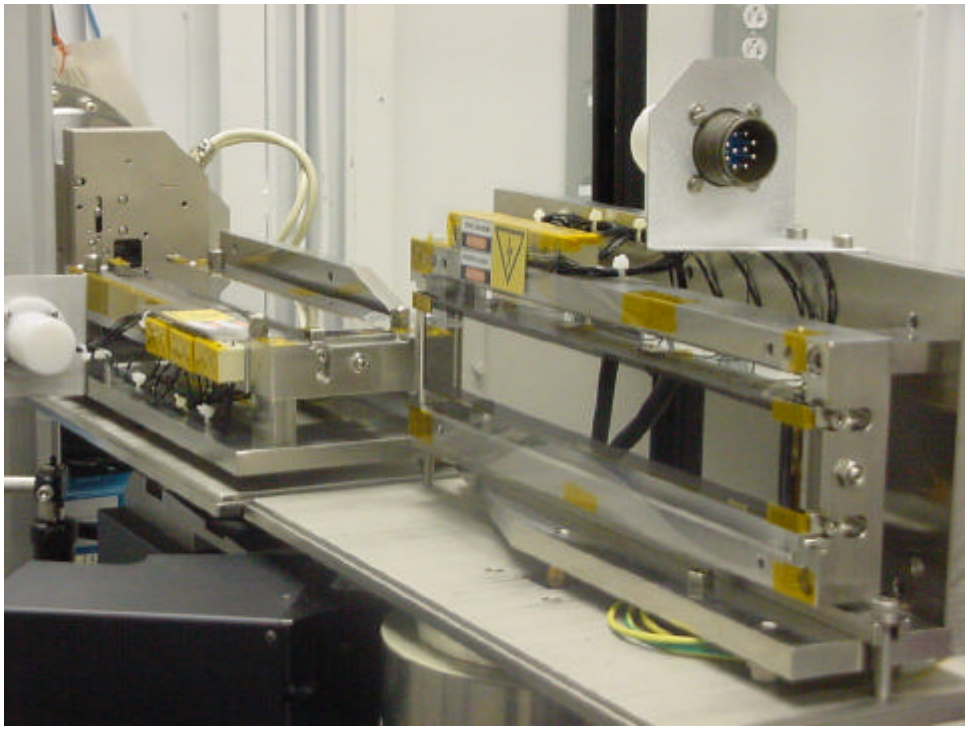
PBMs bending principle

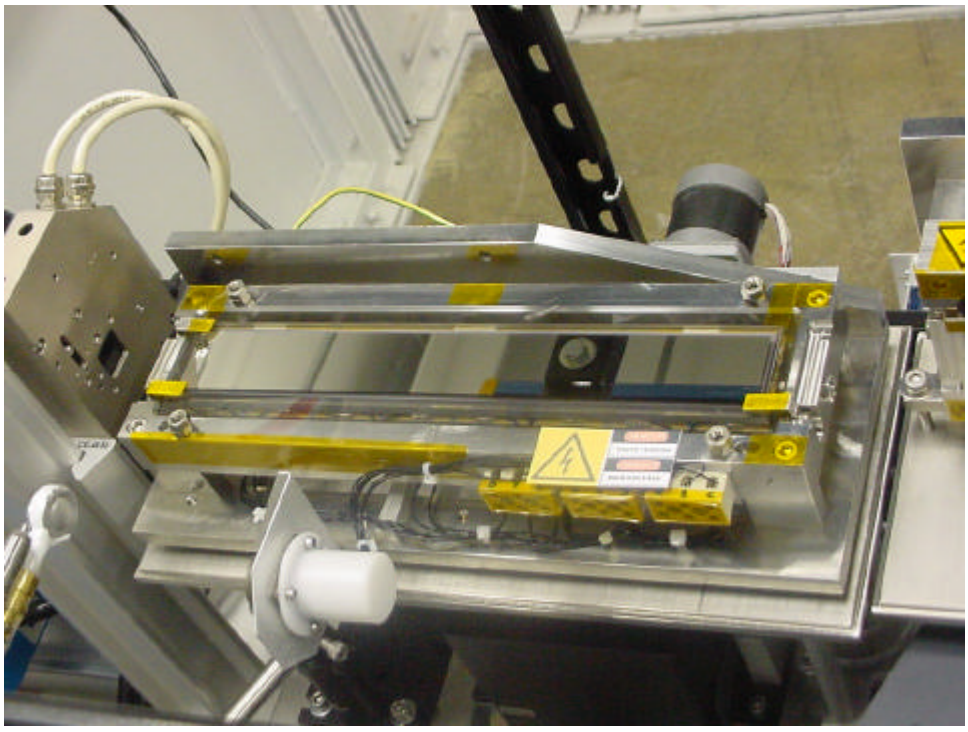
The inert plates on top of PZT1 and on the bottom of PZT2 are not represented for sake of clarity. The control electrode is situated at the Pzt-Pzt bonding interface. V_D represents the high voltage power supply.



Calibration curve

The squares represent the different measuring points.





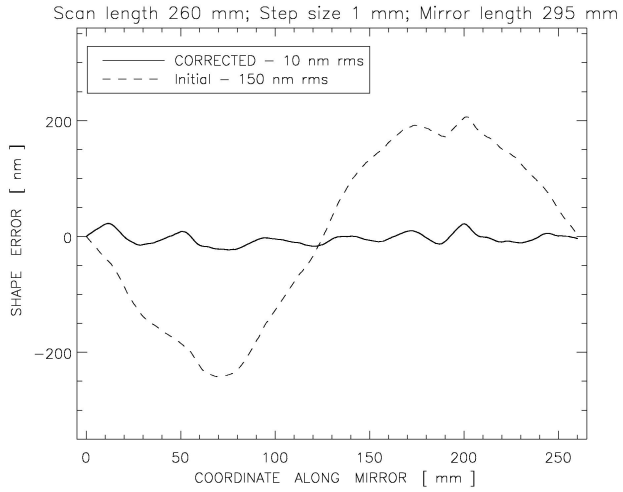
KB mirror installation at 16-ID-B

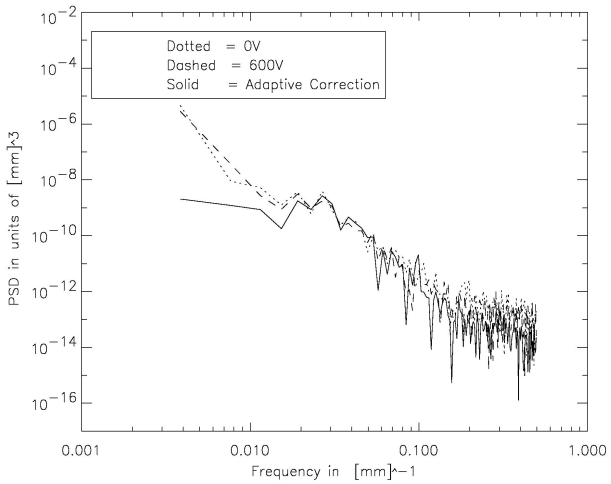
Characteristics of 16-ID-B KB bimorph mirrors

TOTAL LENGTH:	**300 mm**
OPTICAL LENGTH:	**260 mm minimum**
NUMBER OF PZT SEGMENTS:	**2, each 150 mm long**
PZT MATERIAL:	**Zirconate lead titanate ceramic**
INERT TOP AND BOTTOM PLATE:	**Fused silica**
METALLIC COATING:	**Pt**
NUMBER OF ELECTRODES:	**8**
HIGH VOLTAGE RANGE:	**+/- 1500 V**
	with possibility for extension to +/- 2000 V

GRAVITY SAG COMPENSATION:	**Not implemented as it is not needed**
FUNCTIONALITY:	**Exchangeable HFM – VFM (see next point)**
HOLDER:	**Each holder allows quick mounting in two orthogonal positions**
ELECTRONICS:	**Use of an extremely high stability, accuracy and resolution HV supply**
CONTROL SOFTWARE:	**Currently dedicated software with LabView GUI, EPICS version under development**
HV CHANNELS:	**All 8 electrodes of each mirror can be driven independently**

VACUUM REQUIREMENTS: **UHV compatible, but air / N_2 / He OK**





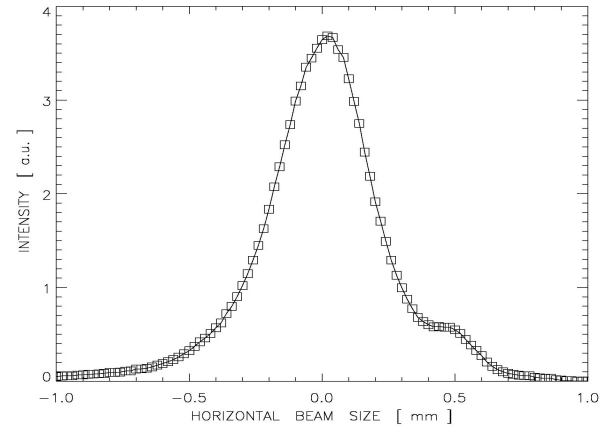
[TOP] shape error before –dashed- and after –solid- adaptive correction of the mirror shape. The bimorph can be shaped to a perfect sphere with a residual shape error as small as 100Å rms. [BOTTOM] PSD function at V_D= 0V & 600V on all electrodes and after adaptive correction (each electrode is independently set at a different V_D). Low frequency components of the PSD could be reduced by as much as 4 orders of magnitude.

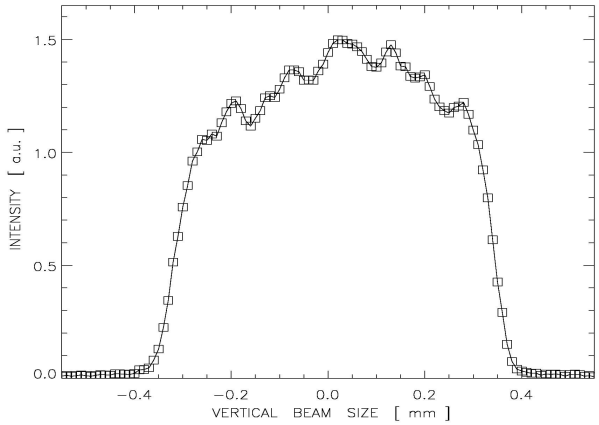
Repeatability and Hysteresis determination. The first three repeated measurements at 0V were carried out in order to characterize the repeatability of the LTP itself. The same voltage was applied to all electrodes and the cycle was carried out following the order for V_D as presented in the following table.

Voltage (V)	Spherical best fit radius (m)
0	632.0
0	631.1
0	631.7
+500	516.8
+1000	435.7
+500	517.7
+1000	436.4
+1500	374.2
+1000	434.1
+500	517.0
0	634.6
-500	842.5
+500	515.8

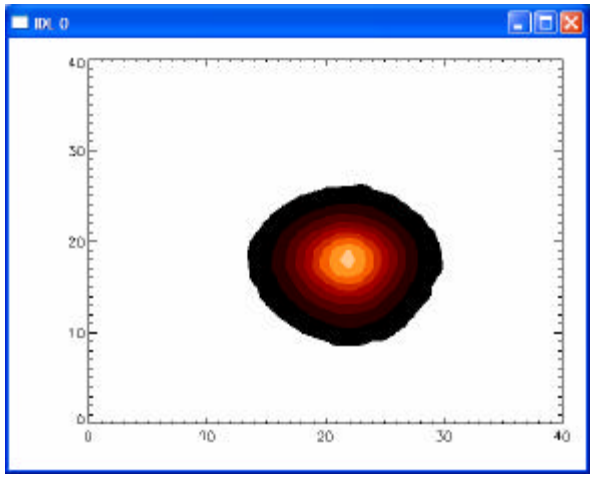
Determination of short and long term drifts in R for a given V_D

Short term stability	
Time	**Spherical best fit radius (m)**
T0	503.2
T0 + 15 hours	499.1
ΔR/R @ 0.8%	
Long term stability	
T0	499.9
T0 + 8 days	490.6
T0 + 9 days	489.9
ΔR/R @ 2.0%	

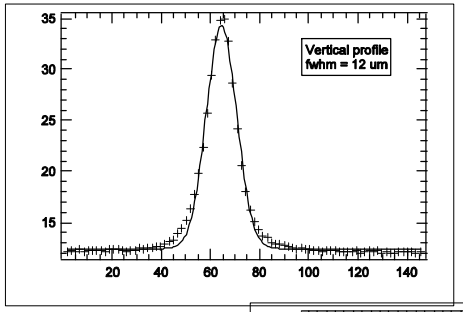


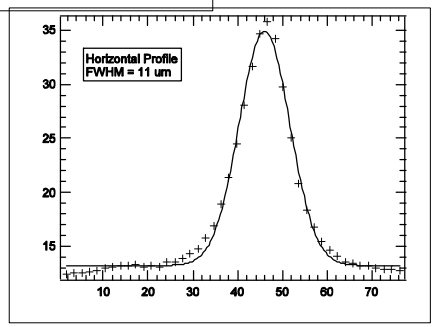


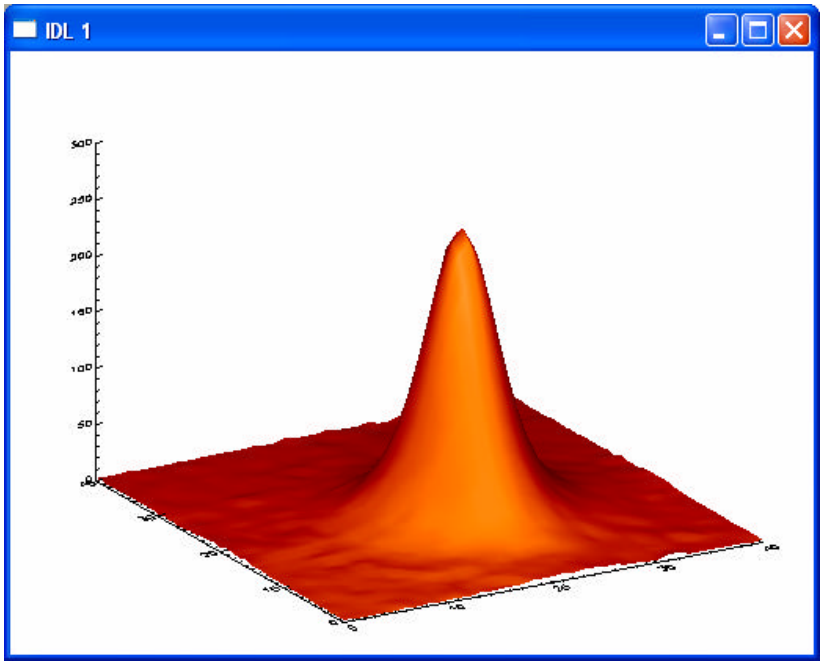
Beam profiles recorded immediately upstream of the bimorph K-B. Both projections of the beam intensity show highly structured profiles and/or lack of symmetry due to upstream optical elements (attenuators and crystals, see text)

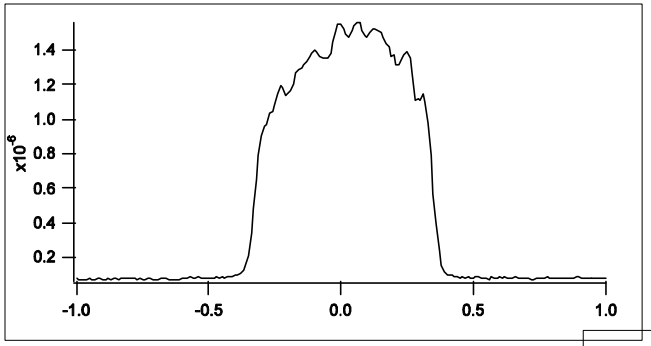


Incident beam : 0.5 x 0.5 mm
Angle : 2 mrad
Energy : 29.4 keV
Distance from HFM : 750 mm
Distance from VFM : 1050 mm



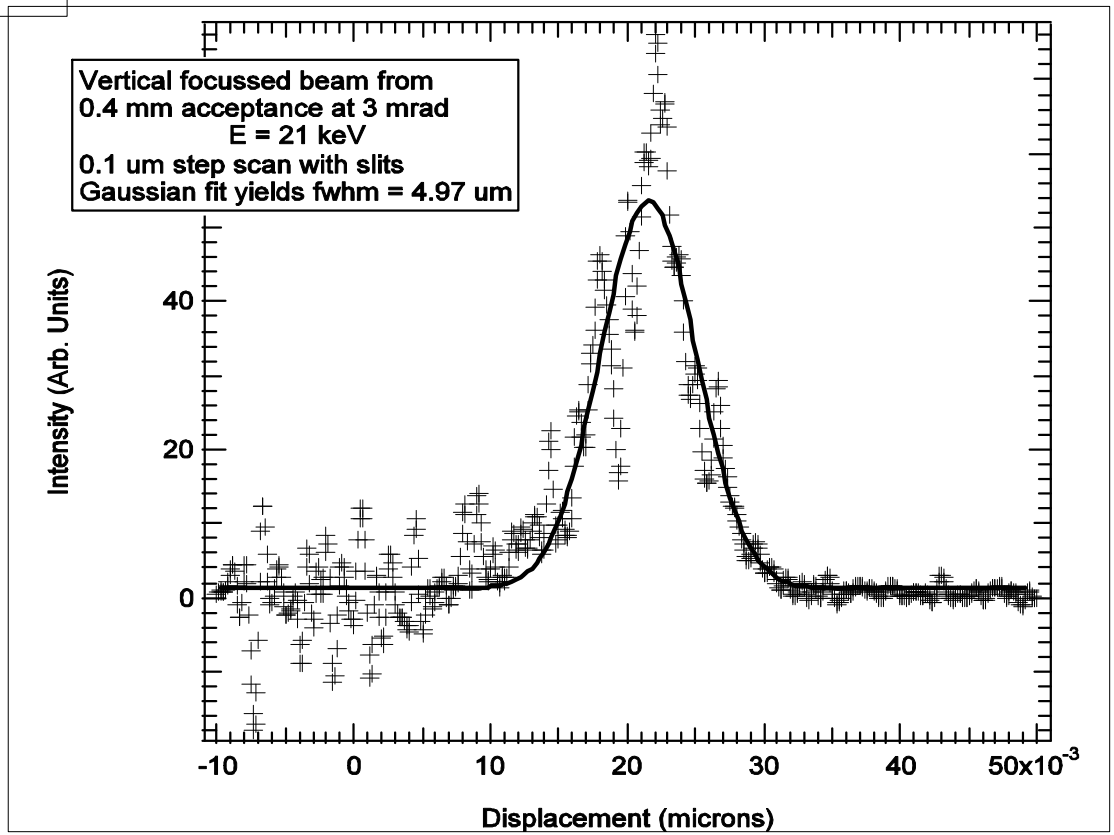


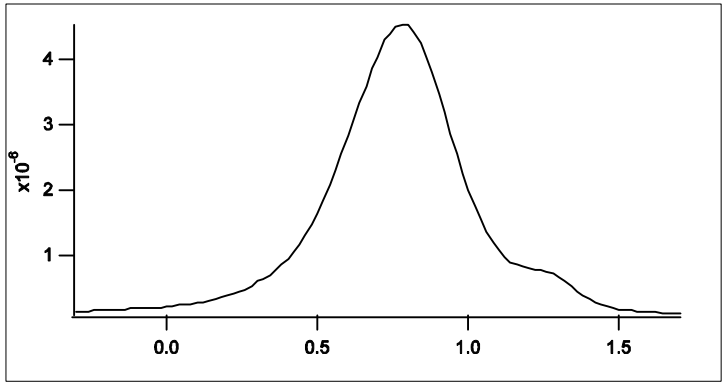




Applied Voltages (V)

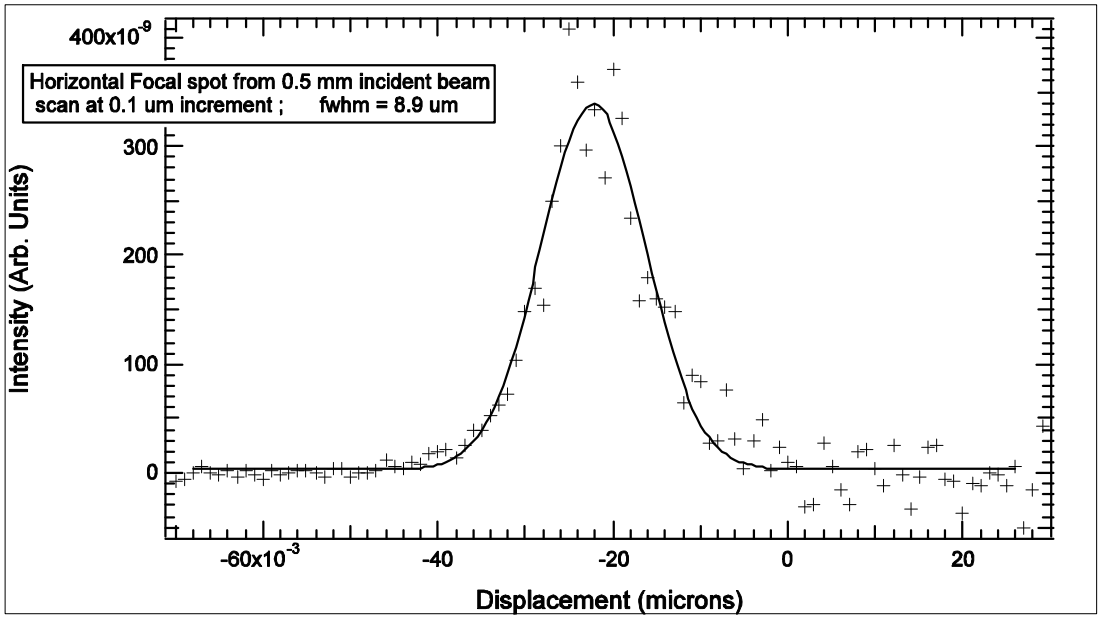
-7.8
-207
-557
-687
-686
-887
-837
-837

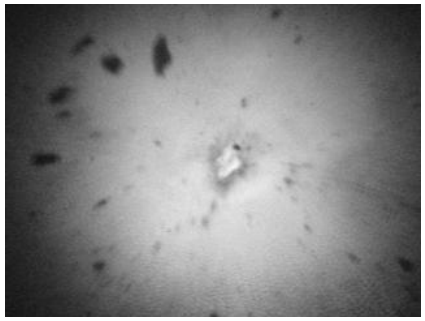


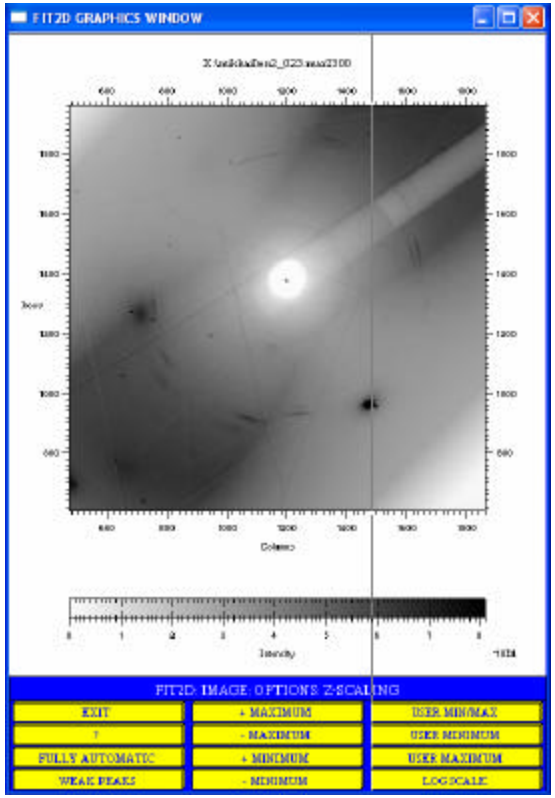


Applied Voltages (V)

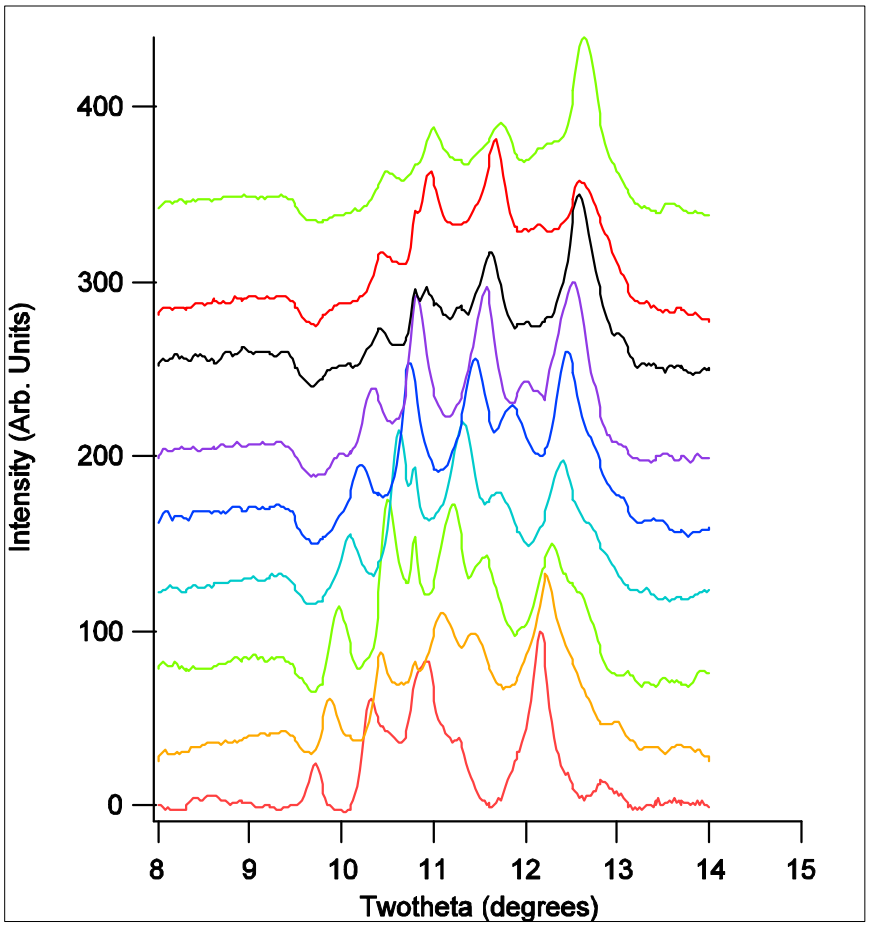
-340
-340
-640
-640
-500
-500
0
0







Nitrogen at 155 GPa
cBN gasket : 18 um dia



Summary

- **EXTREMELY HIGH OPTICAL QUALITY**

- **VERY STABLE**

- **ADAPTIVE ZONAL CONTROL**

- **WAVEFRONT CORRECTION**

- **VERY REPRODUCIBLE**

  -- **FAST FOCAL DISTANCE,**
  HENCE FOCAL SPOT SIZE CHANGE

- **HIGH QUALITY CLEAN FOCAL SPOT**

Status

- **ROUTINE OPERATION ON 16-ID-B**
  SINCE NOVEMBER 2002

- **AUTOMATIC OPTIMIZATION PROGRAM**
  UNDER DEVELOPMENT (Sept 03)

- **More mirrors about to be ordered:**

  - Up to 600 mm long
  - Some with cooling channels for white beam
  - Several coating strips including multi-layers
  - Maybe with COATINGS ON BOTH SIDES
  - New electronics