Royal Holloway
University of London

Development of a compact microwave and soft X-ray source in LUCX facility at KEK-ATF

A. Aryshev, S. Araki, M. Fukuda, P. Karataev, G. Naumenko, A. Potylitsyn, K. Sakaue, L. Sukhikh, J. Urakawa, D. Verigin

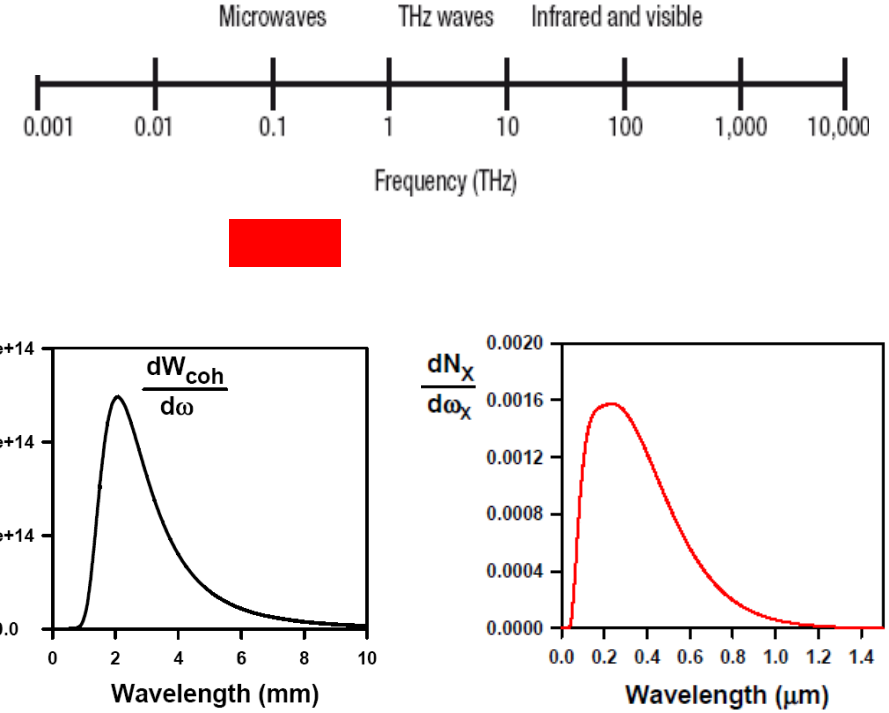
KEK, 1-1 Oho, Tsukuba, Ibaraki 305-0801, Japan
John Adams Institute at Royal Holloway, Egham, Surrey, TW20 0EX, UK
Tomsk Polytechnic University, Tomsk, 634050, Russia

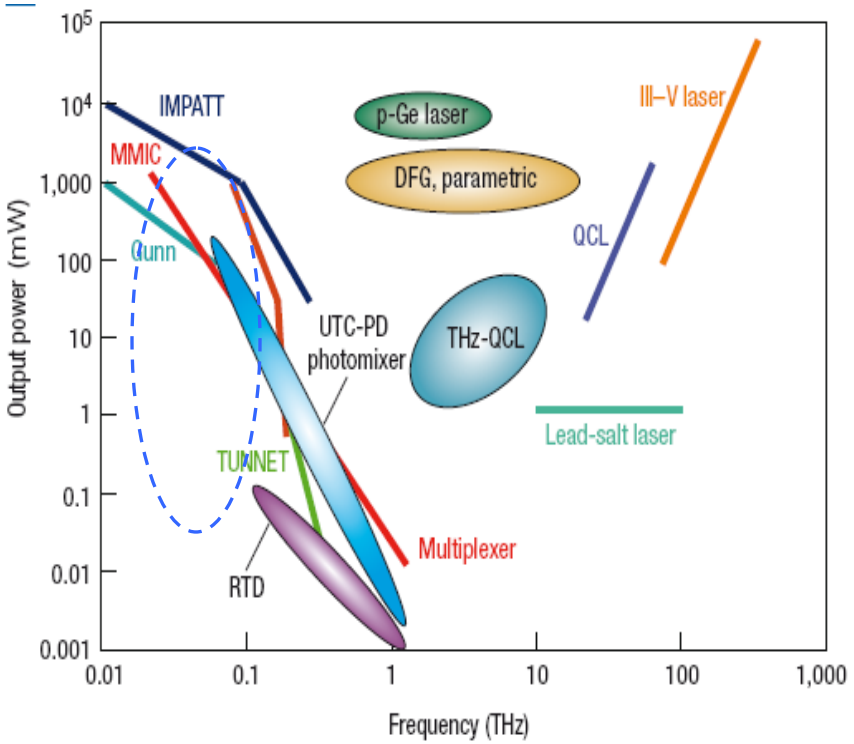
Outline

- Introduction
- Diffraction radiation
- Compact microwave and soft X-ray source Basic idea
- LUCX facility
- Microwave resonator: design, alignment
- Experimental results
- Summary and plans

Introduction

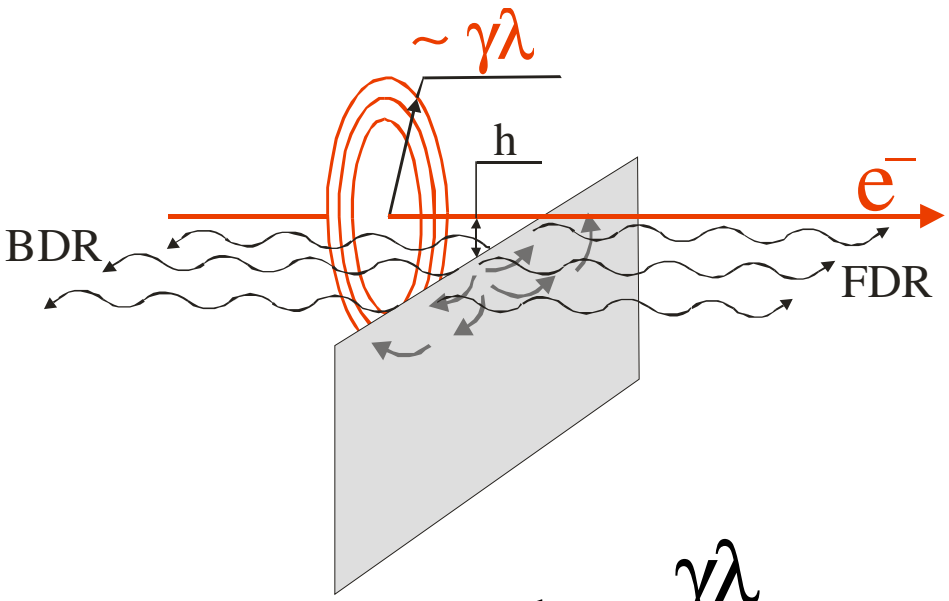
Introduction





MASAYOSHI TONOUCHI
Institute of Laser Engineering, Osaka University, Japan

Diffraction radiation



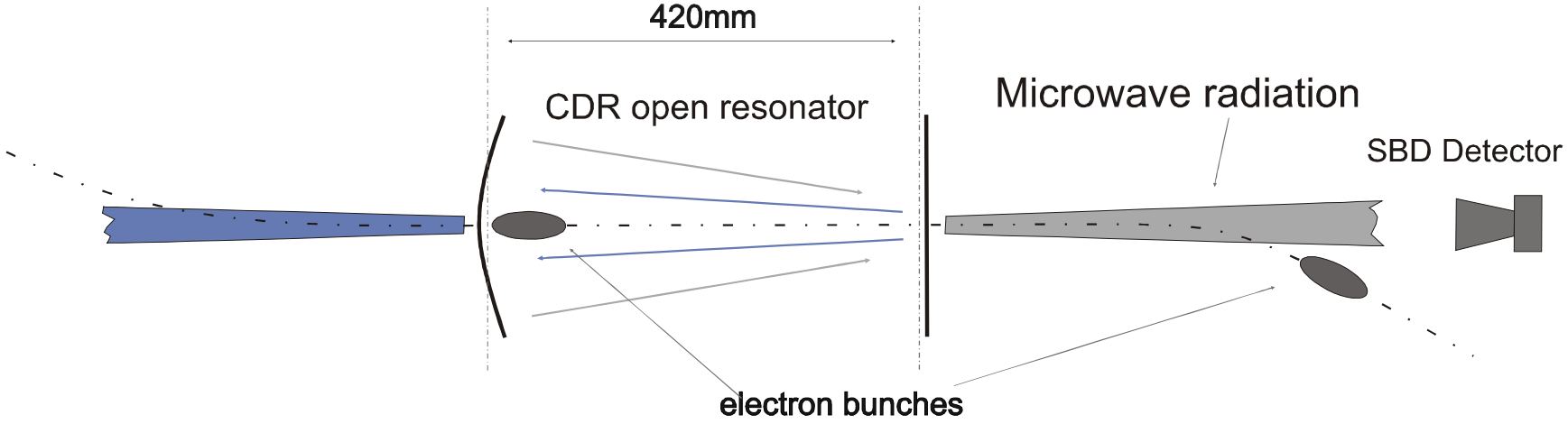
$$h \le \frac{\gamma\lambda}{2\pi}$$

λ - observation wavelength

γ = E/mc² – Lorentz - factor

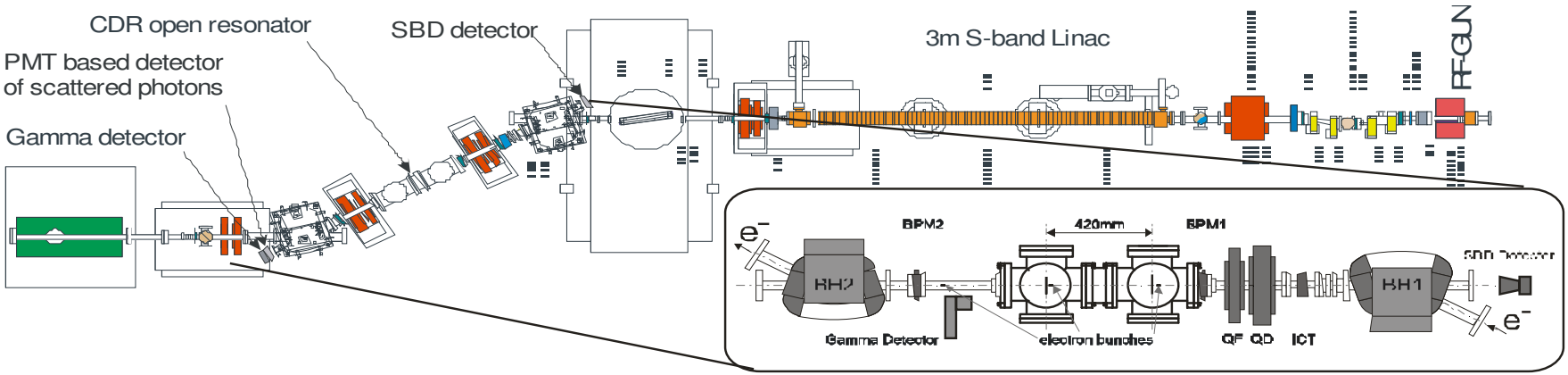
- **Diffraction radiation (DR) appears when a charged particle moves in the vicinity of a medium**
- **Impact parameter, h, – the shortest distance between the target and the particle trajectory**

Basic idea of compact microwave and soft X-ray source



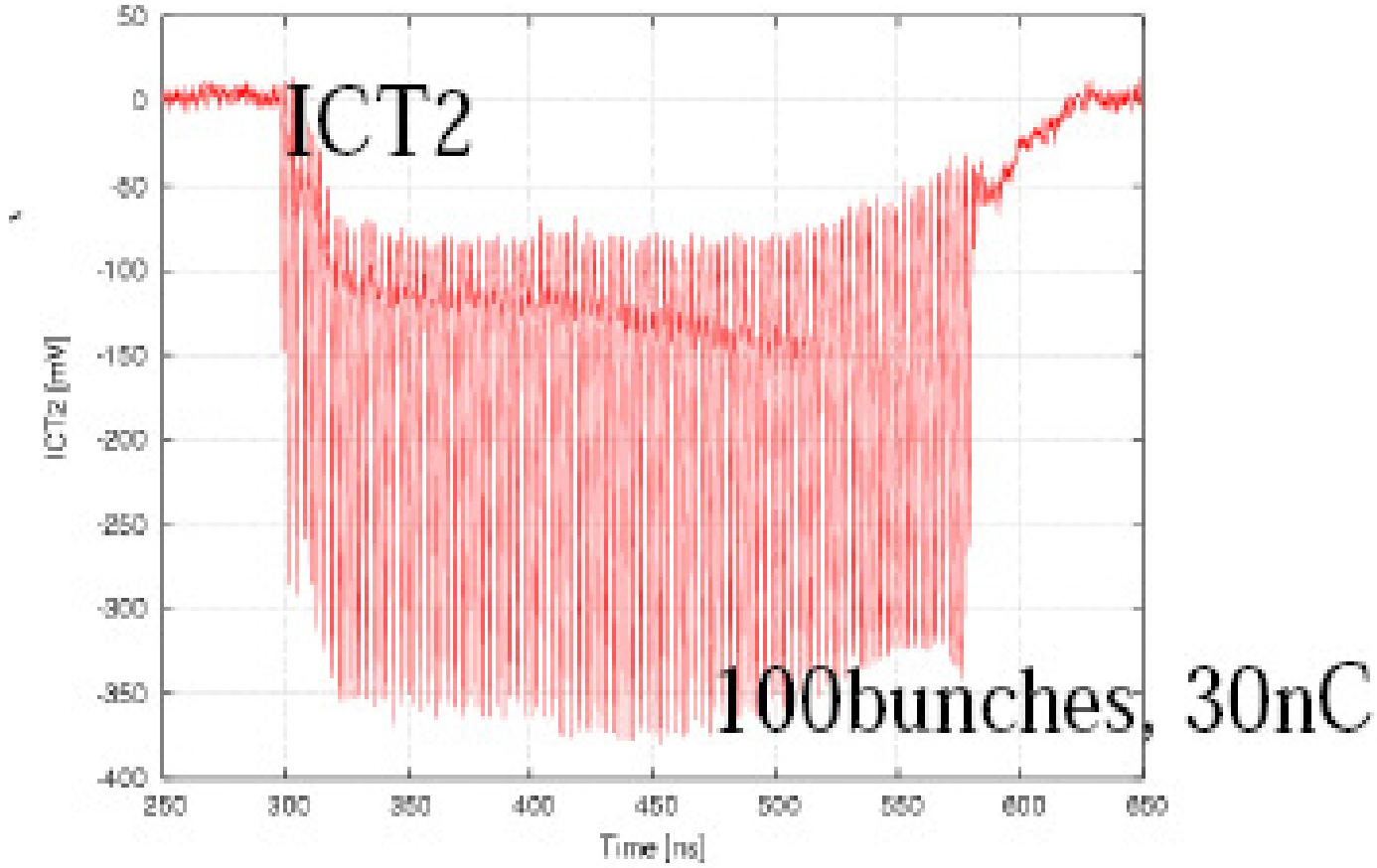
- Generate microwave radiation
- Stack it in open resonator.
- Scatter CDR on a subsequent bunches generating soft X-ray radiation.

LUCX facility

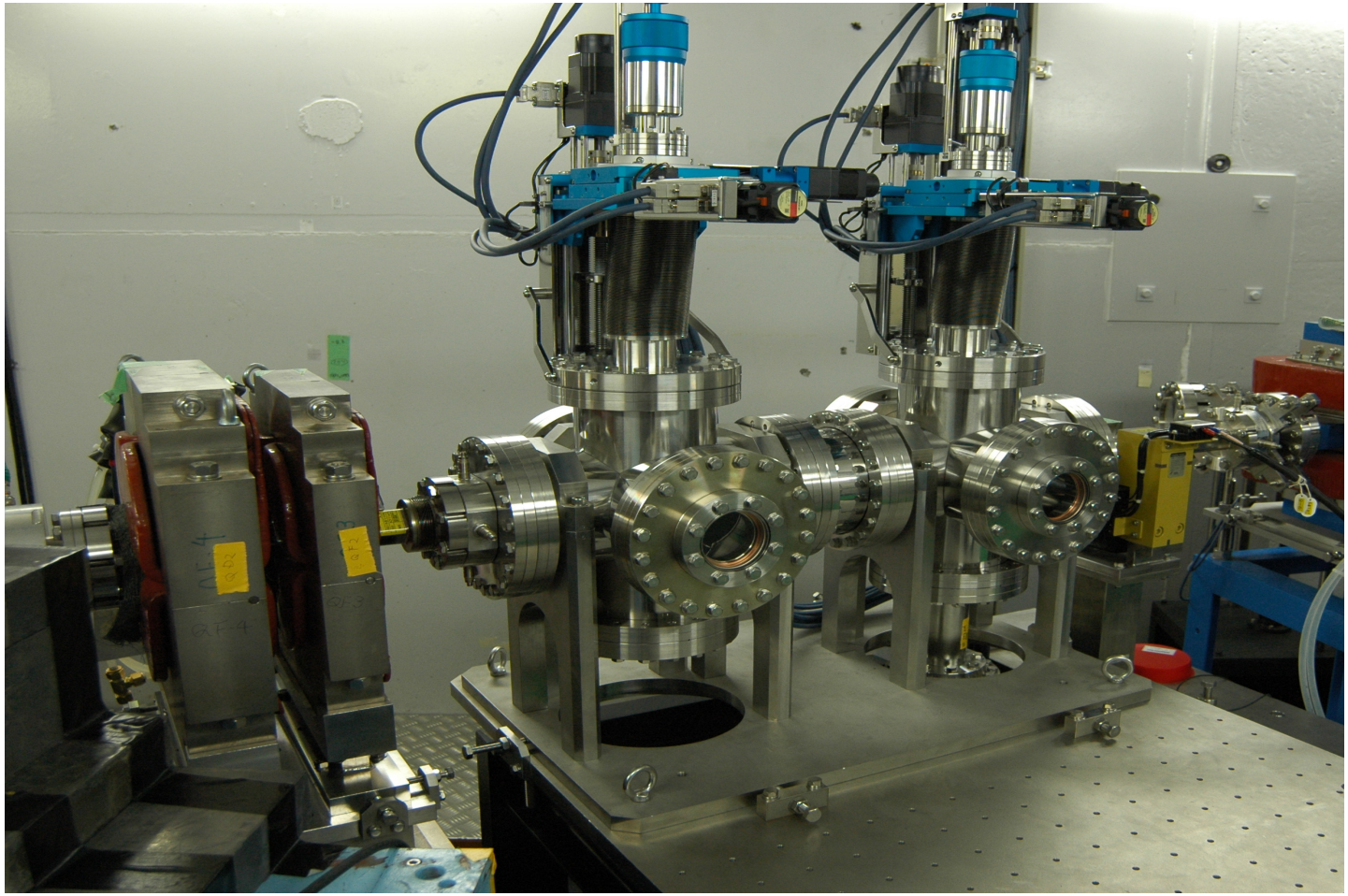


Parameter	Value	Units
Electron energy	43	MeV
Bunch charge	2 (1.25*10^10)	nC (e/bunch)
Bunch length	10	ps
Number of bunches per pulse	100	
Bunch spacing, lb	2.8 (840)	ns (mm)
Pulse repetition rate	12.5	Hz
Transverse beam dimensions in IP	200 x 200	um
Emittance	5	π mm mrad

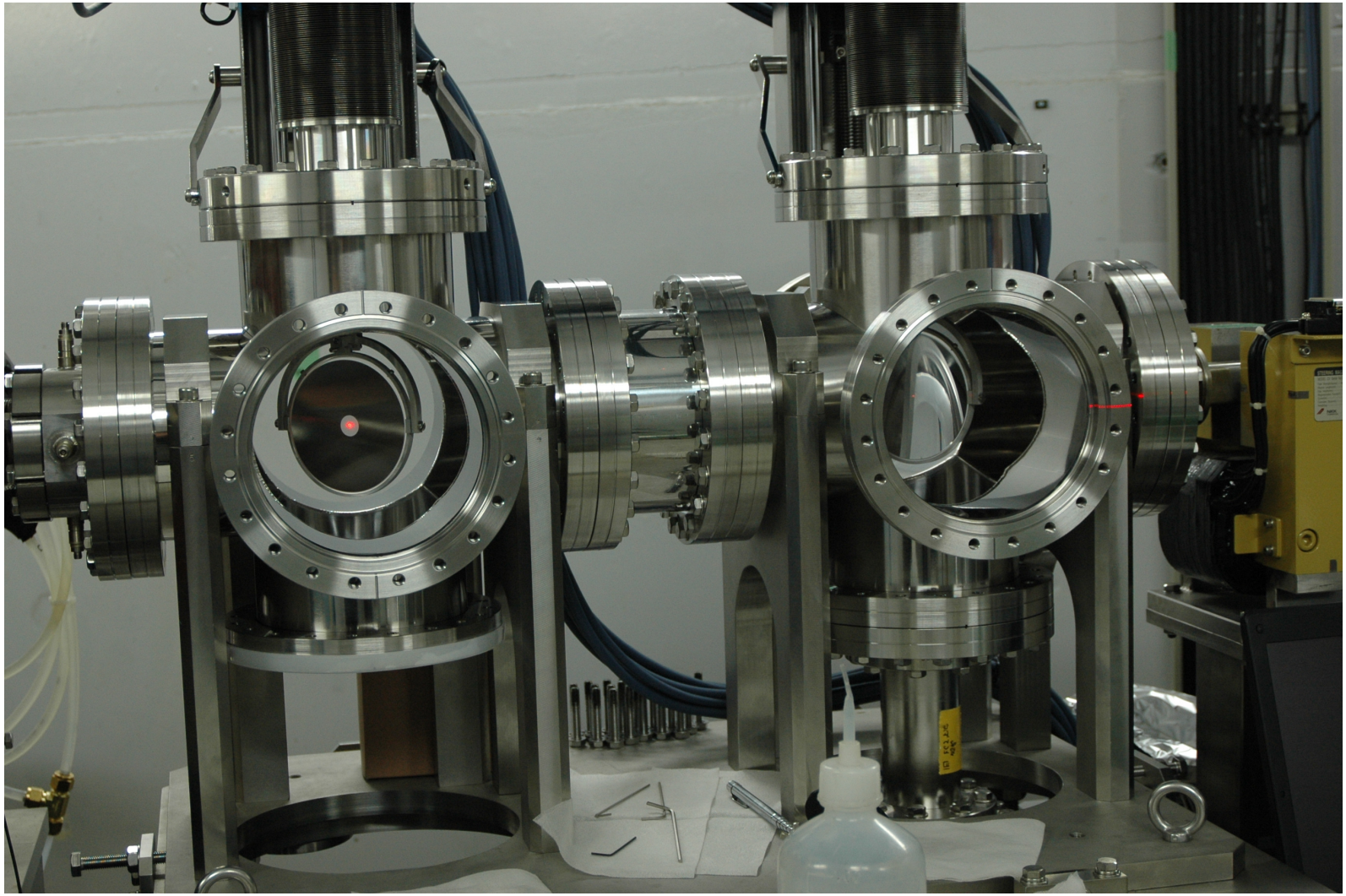
ICT multi-bunch traces



Microwave cavity



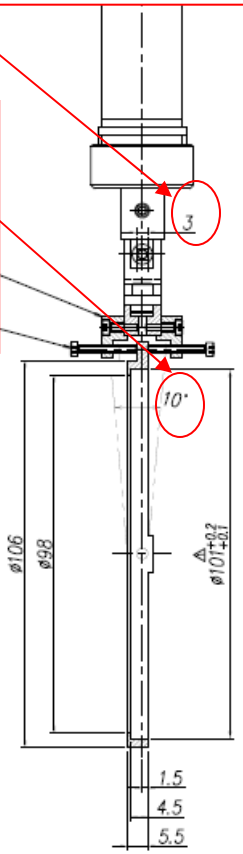
Microwave cavity

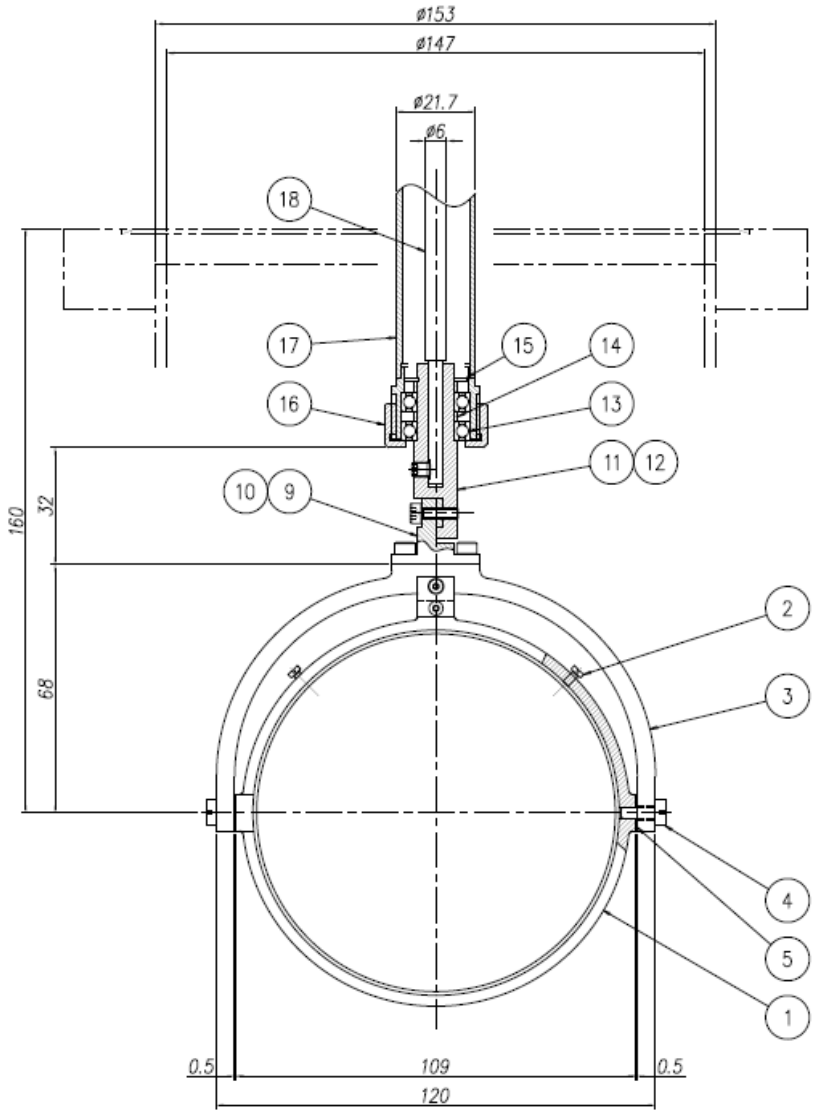


Mirror mount

θ rotation axis
vs Mirror position adjustment

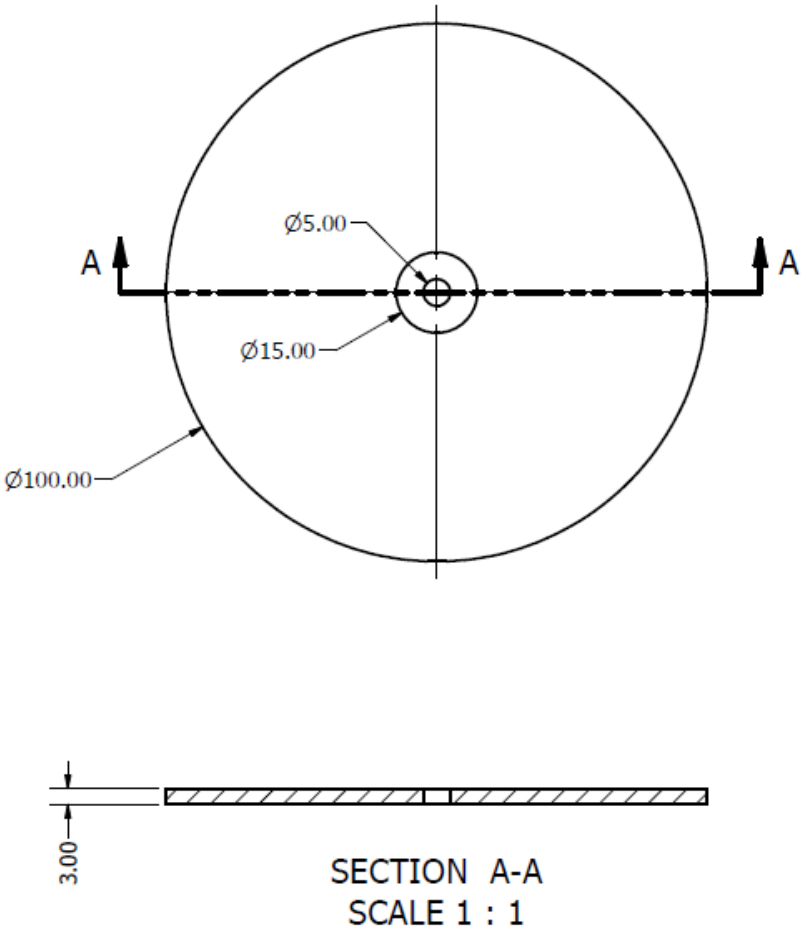
Mirror
inclination
Angle (α)
adjustment

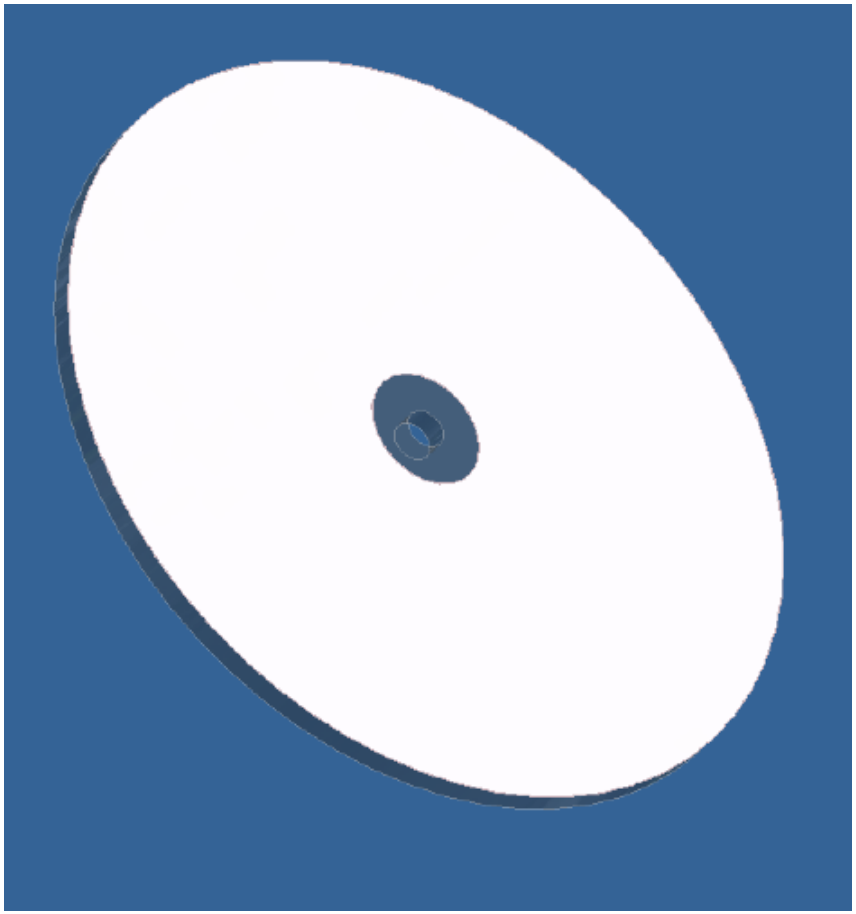




CDR mirror, Flat

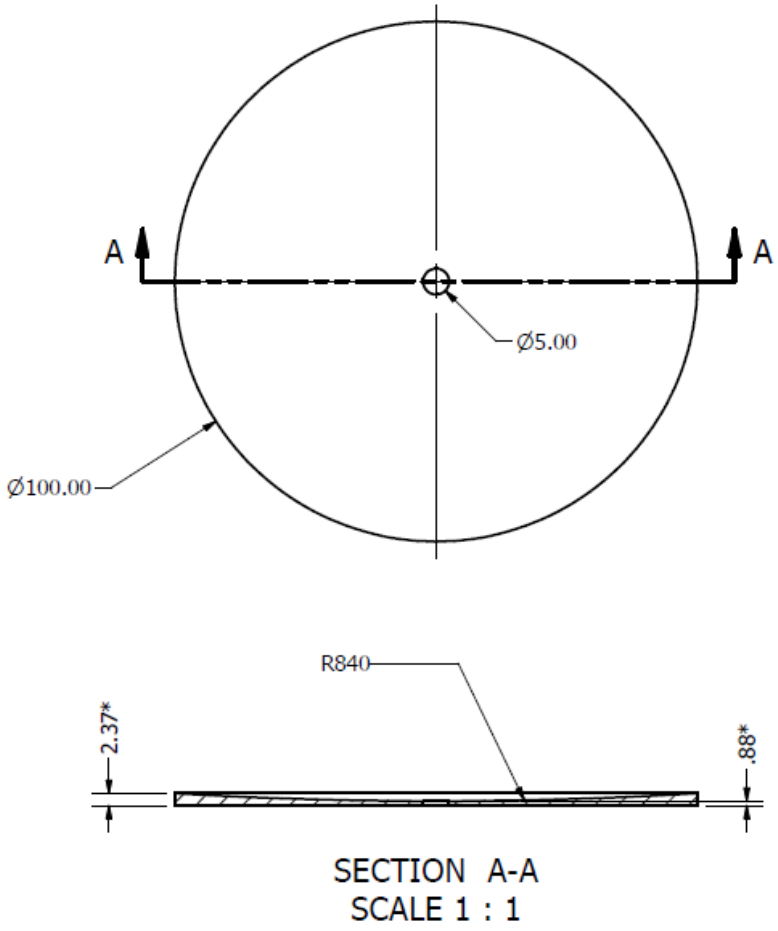
Aluminum mirror on fused silica substrate



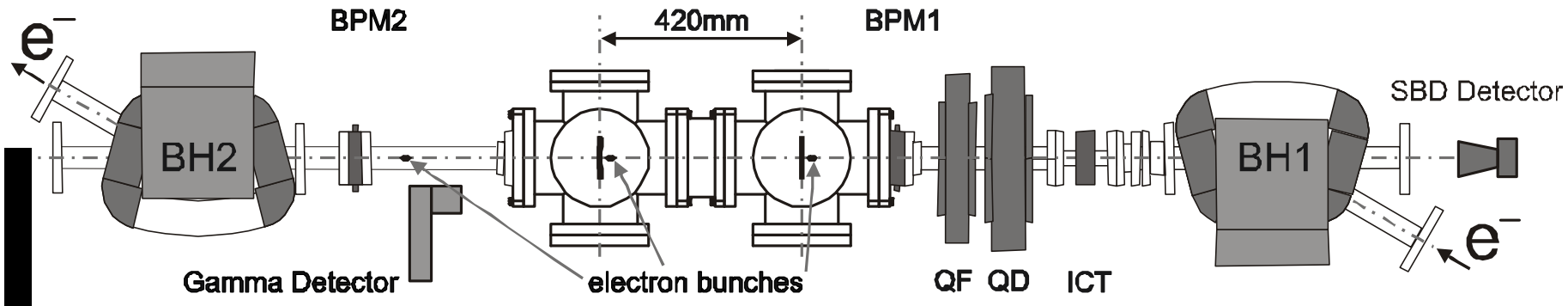


CDR mirror, Concave

Bulk aluminum mirror

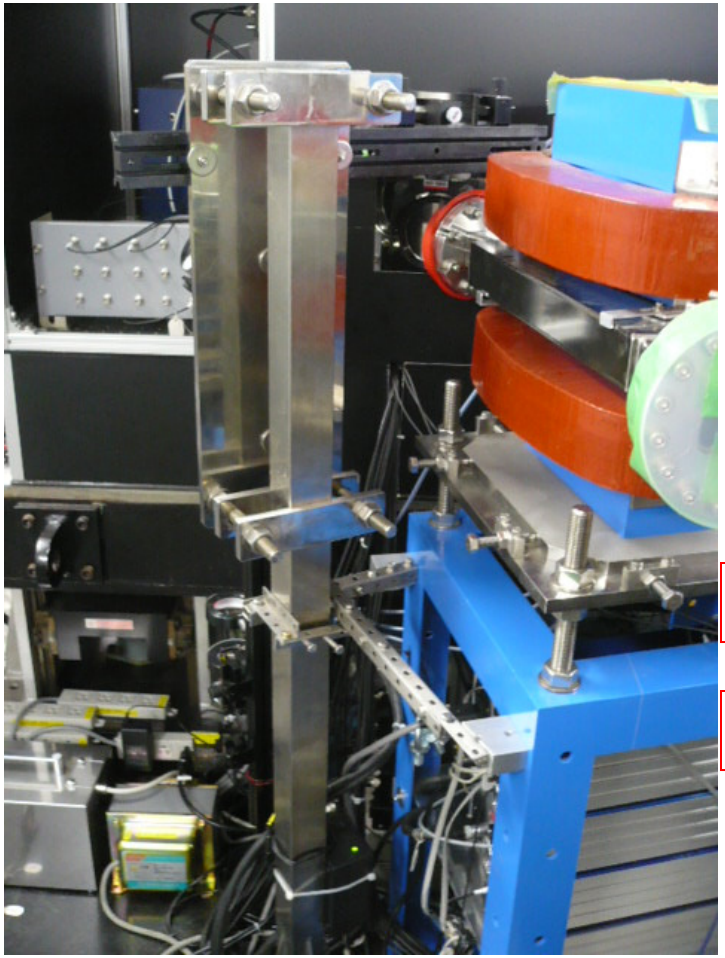


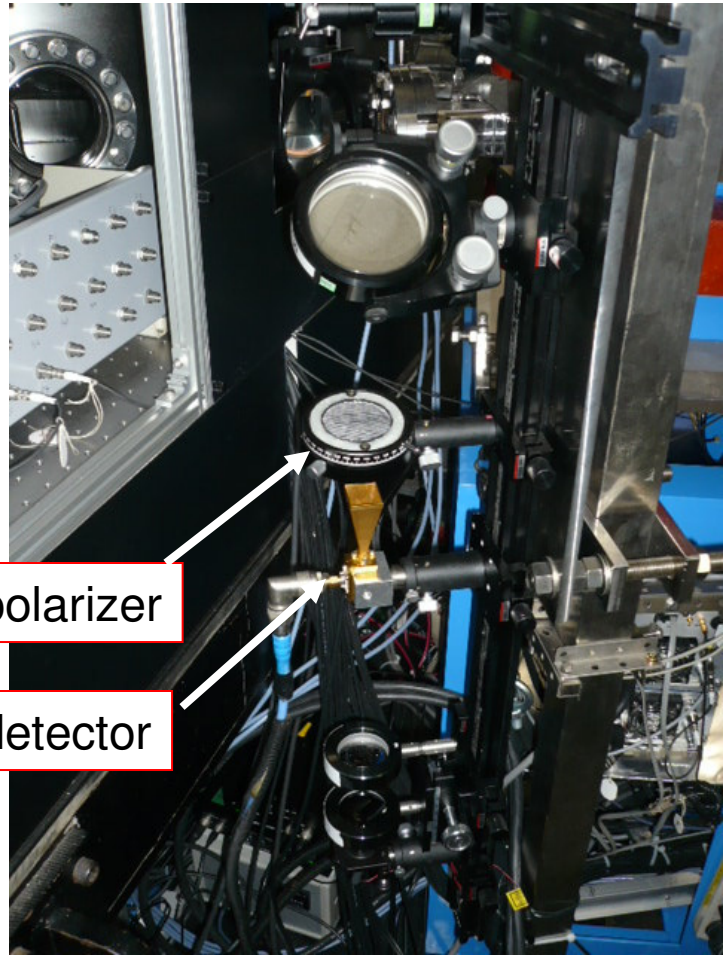
CDR beam line, detectors



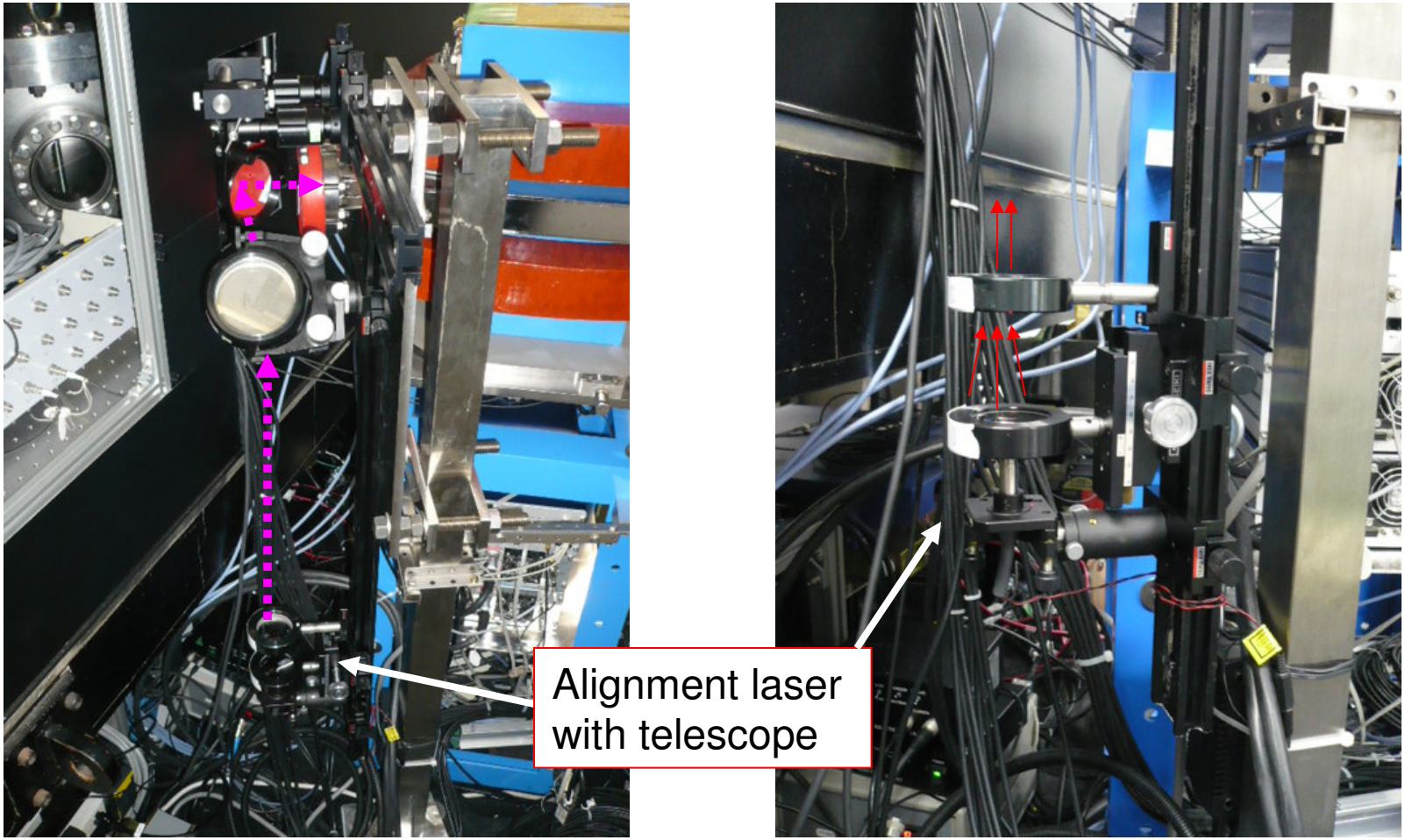
Detector of scattered photons

CDR (microwave) line



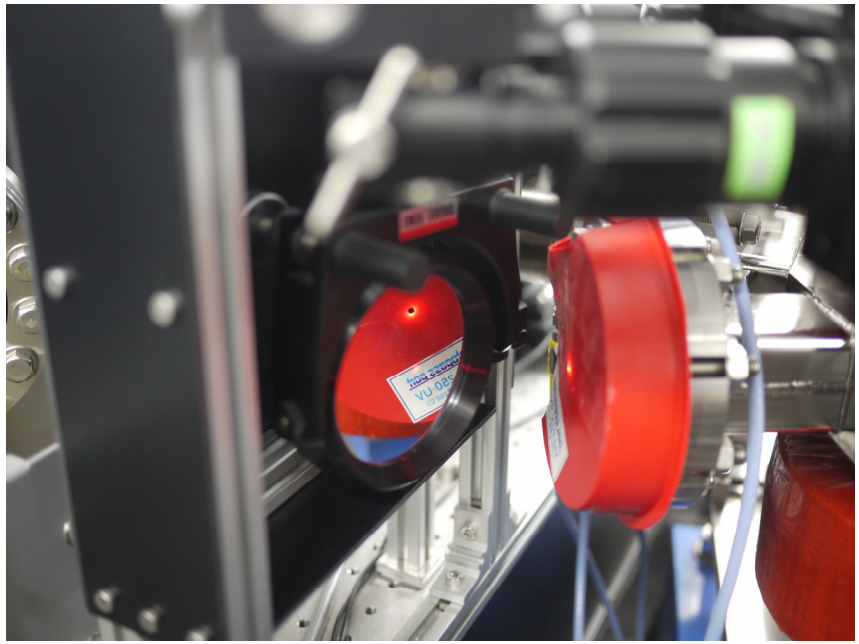


Alignment of CDR (microwave) line

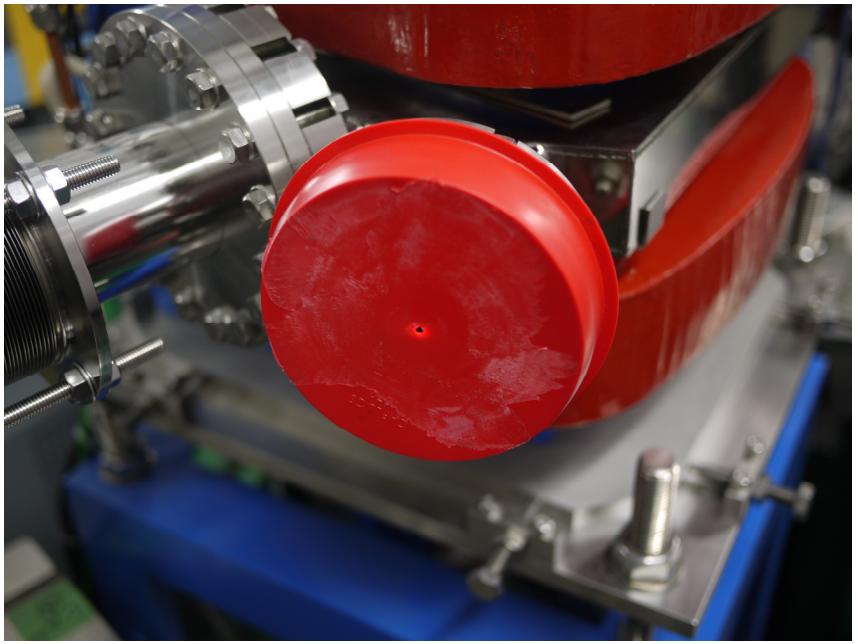


Alignment laser through CDR section

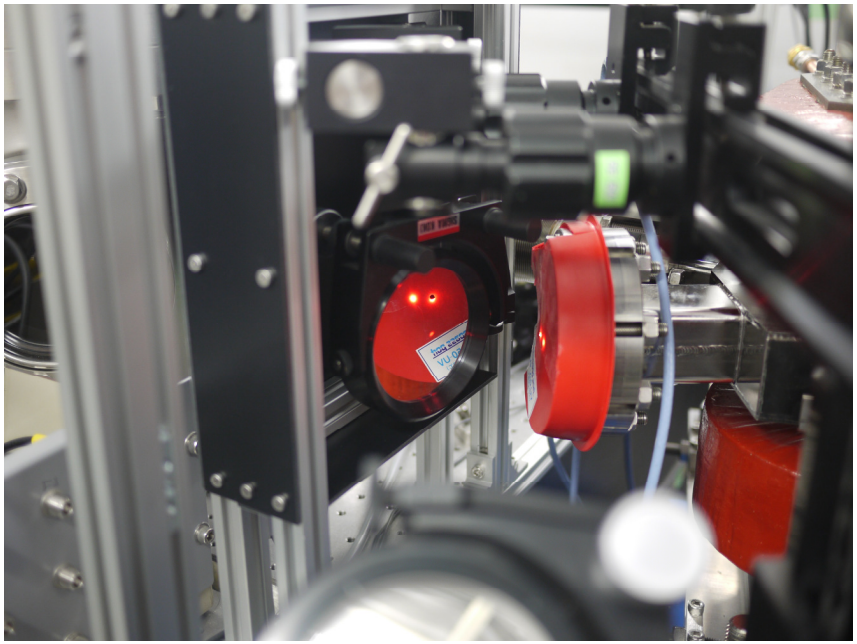
upstream

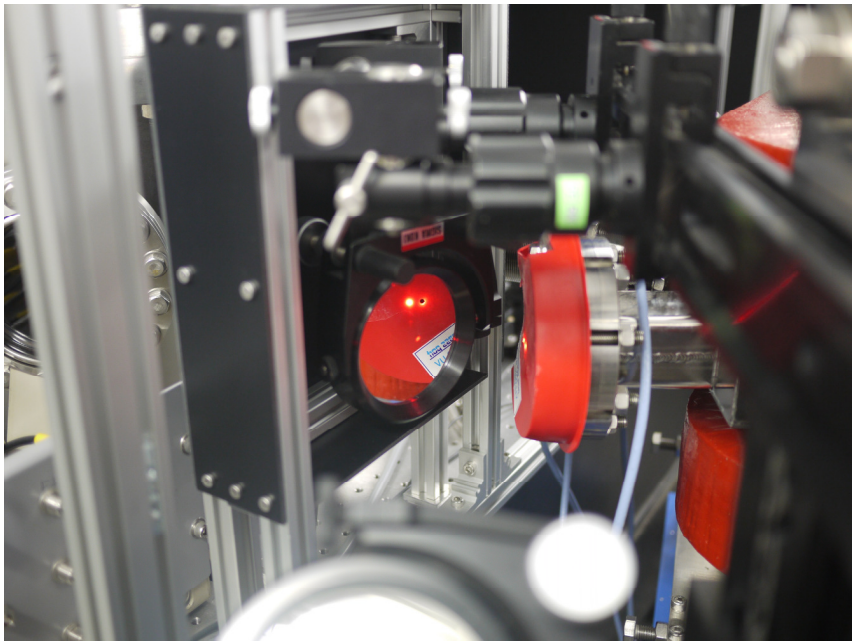


downstream



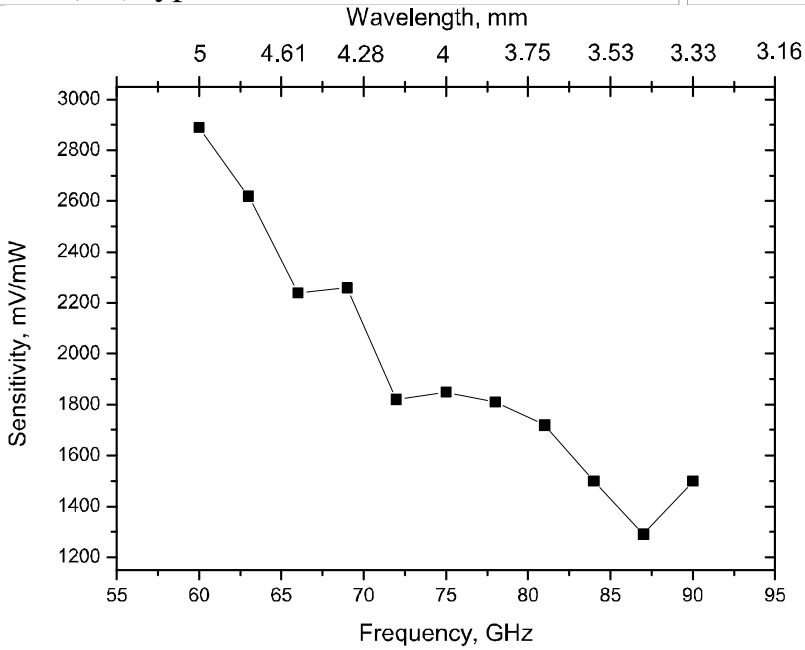
New mirrors back-reflection check



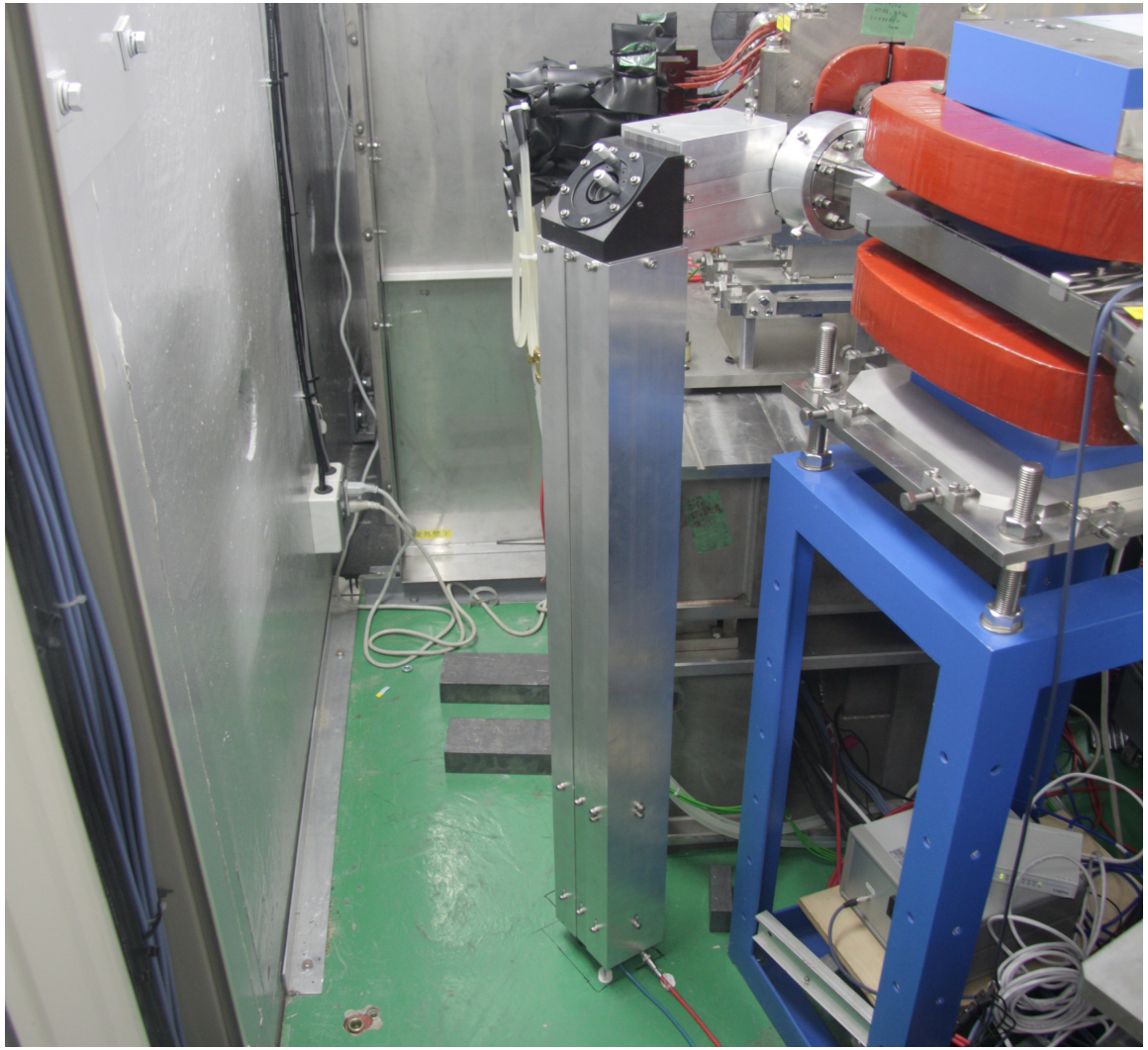


Schottky Barrier Diode

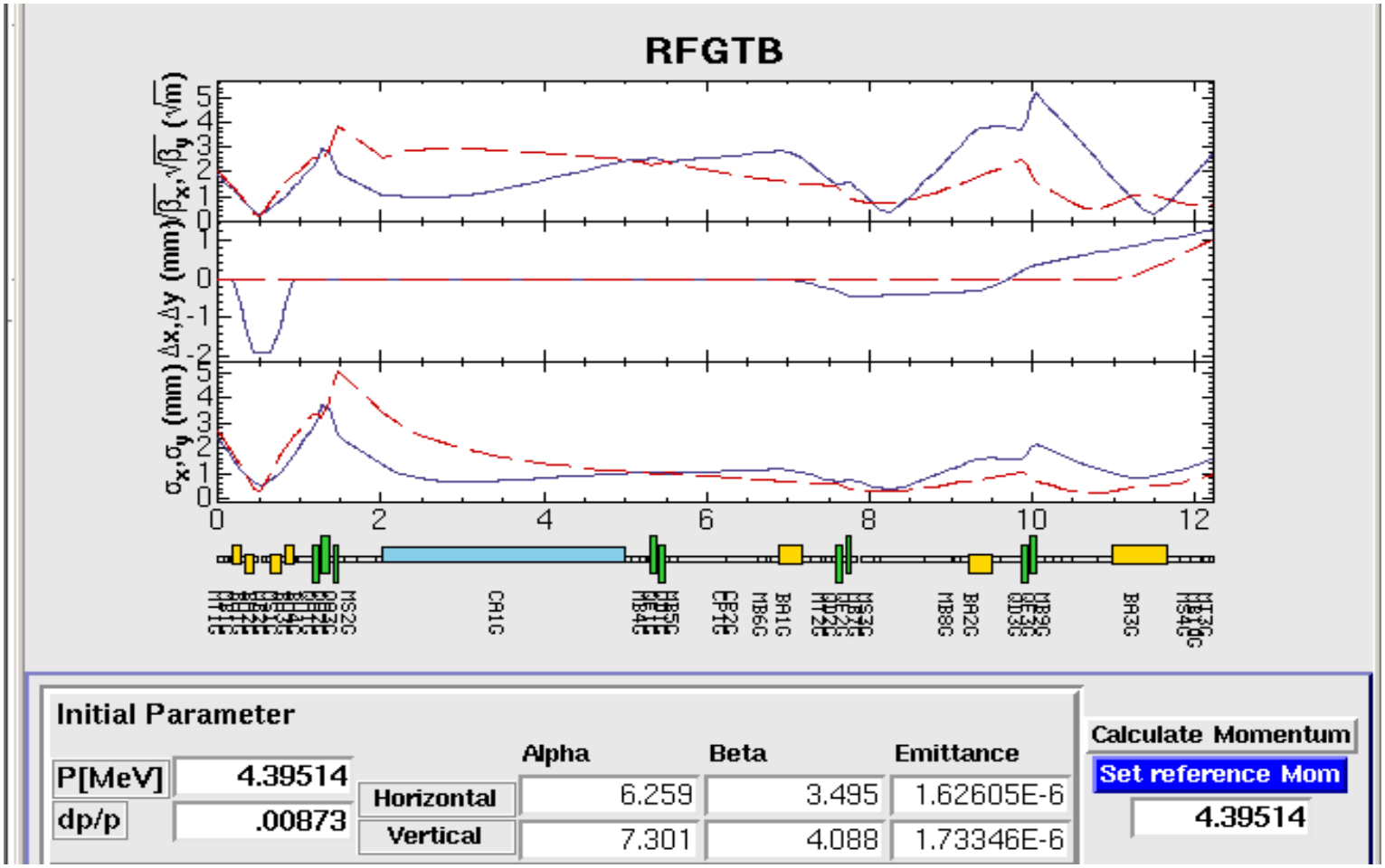
Model	DXP-12
Frequency Range (GHz, mm)	60-90, 3.33-5
Sensitivity (mV/mW at 10 μW input), typ.	1800
Flatness (dB) typ.	± 2.0



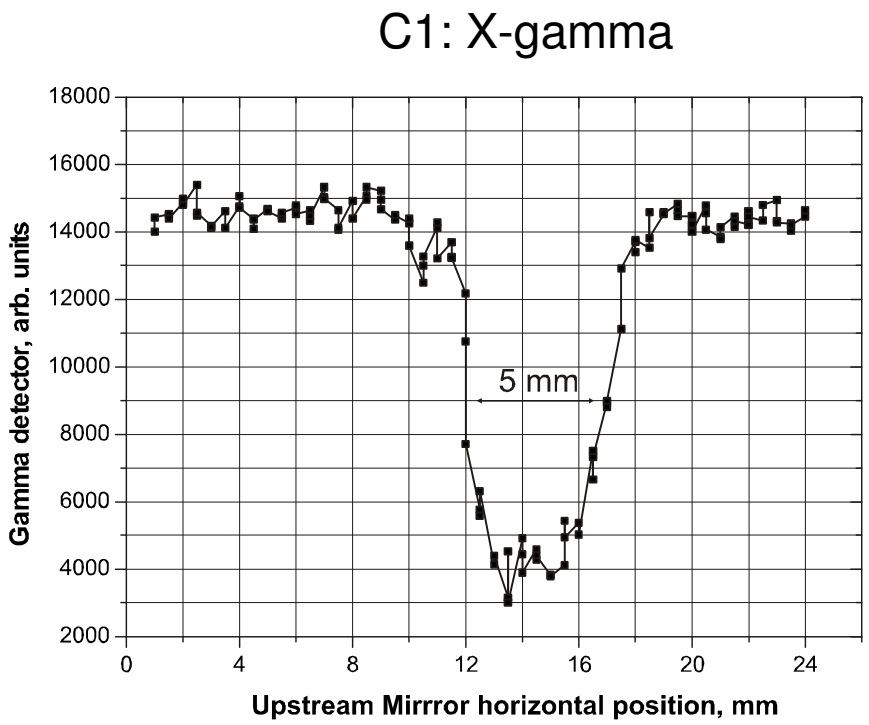
Detector of scattered photons

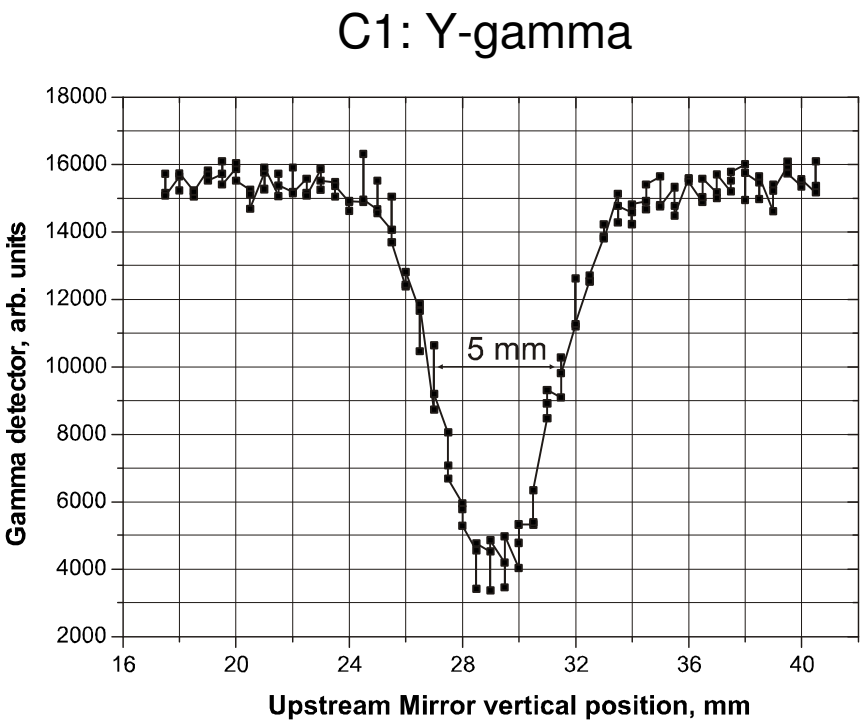


Electron beam optics

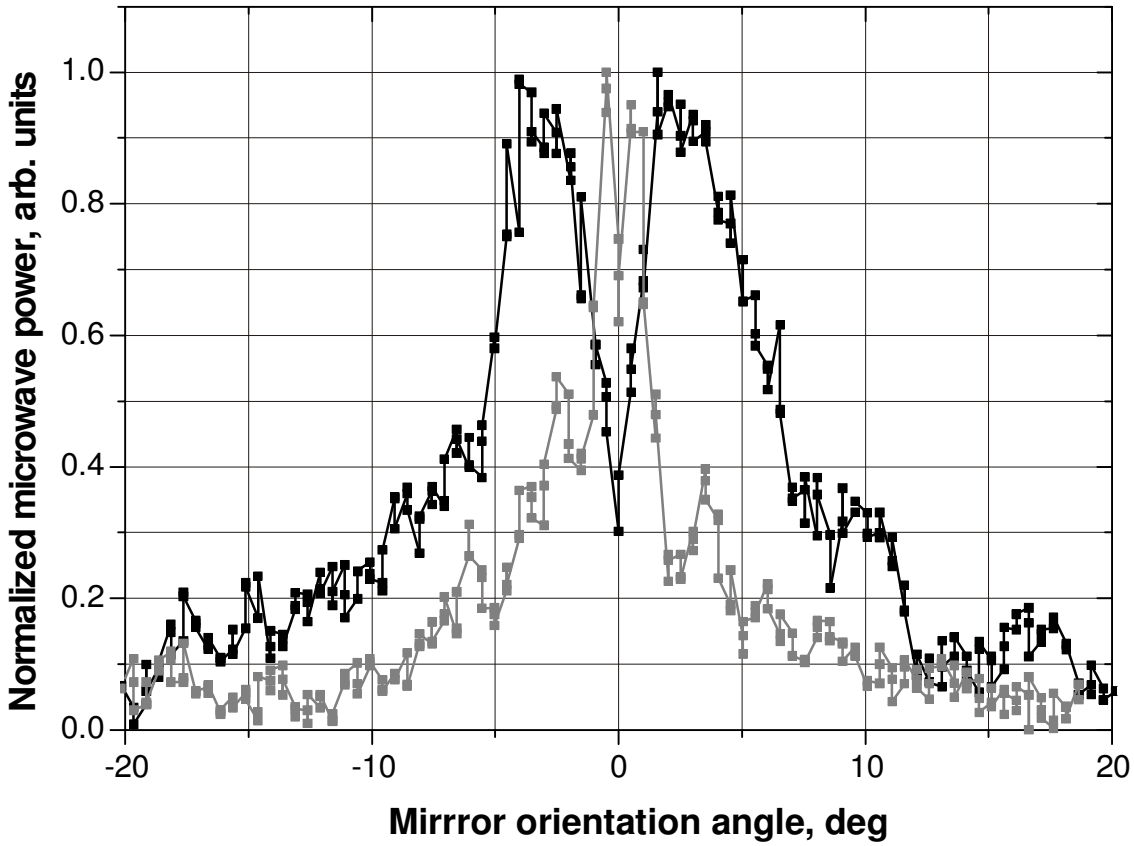


X-Y scans for C1 and C2

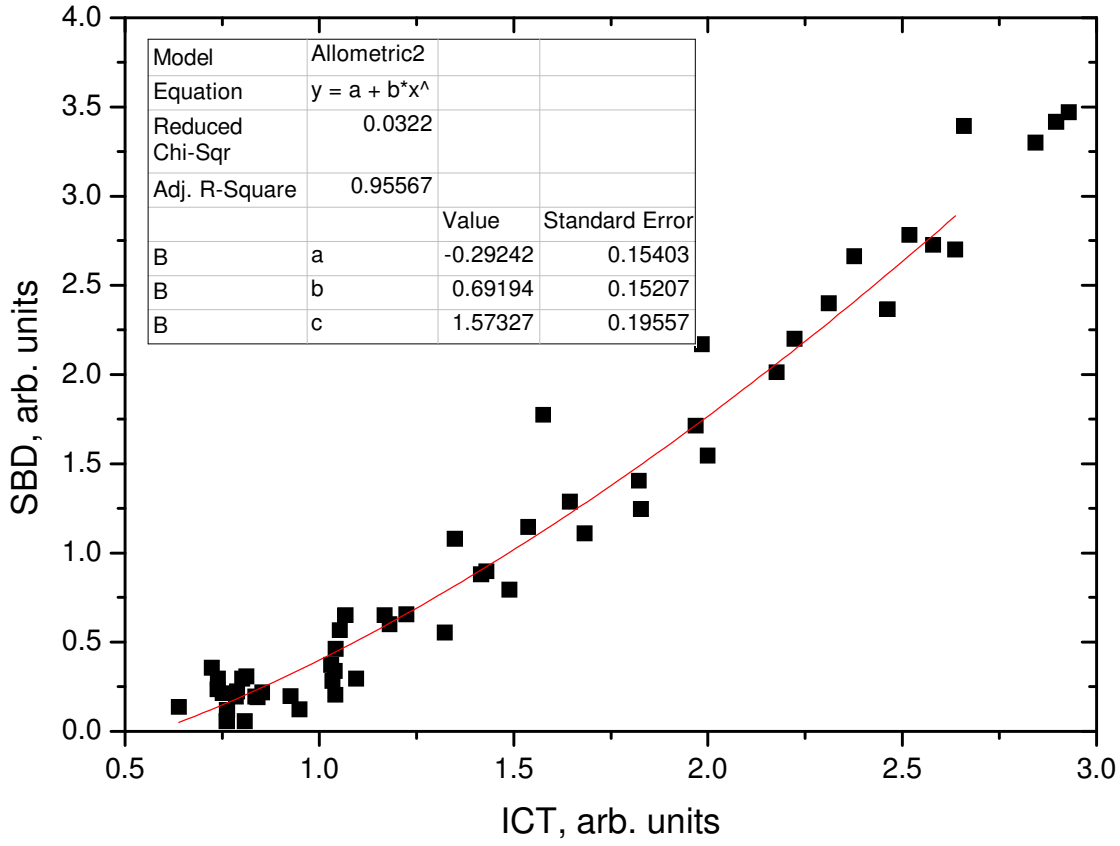




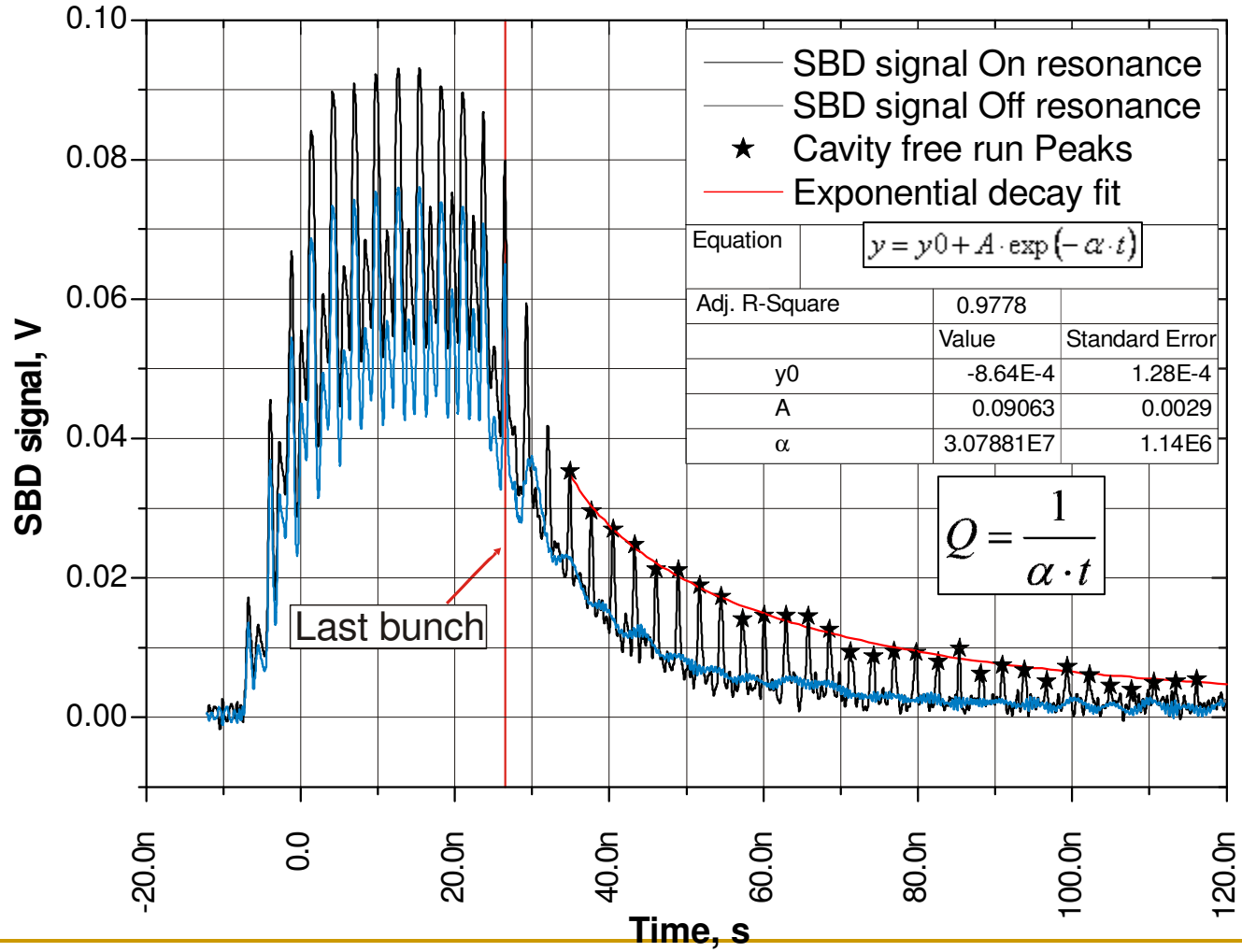
Angular dependences



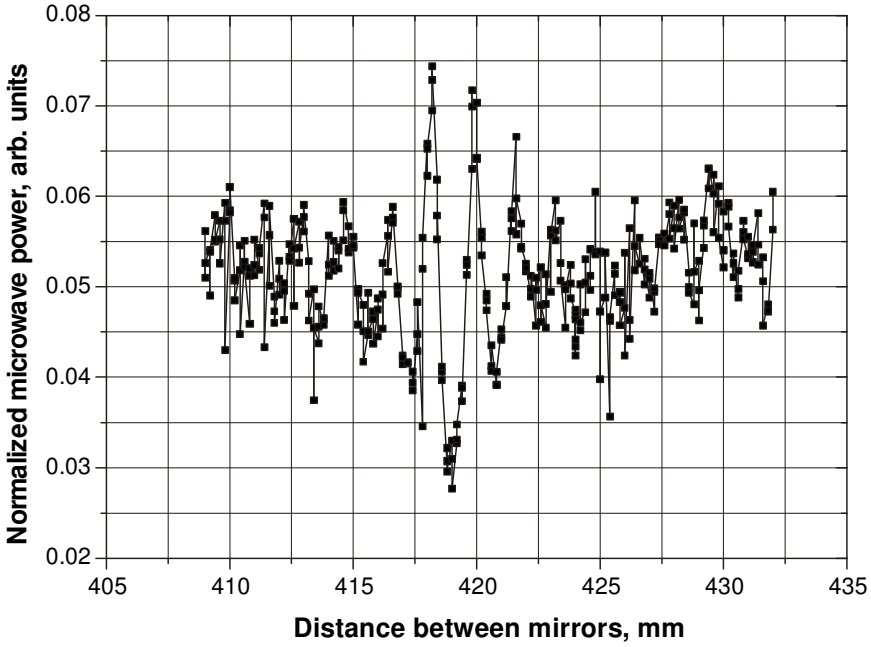
Dependence on bunch charge

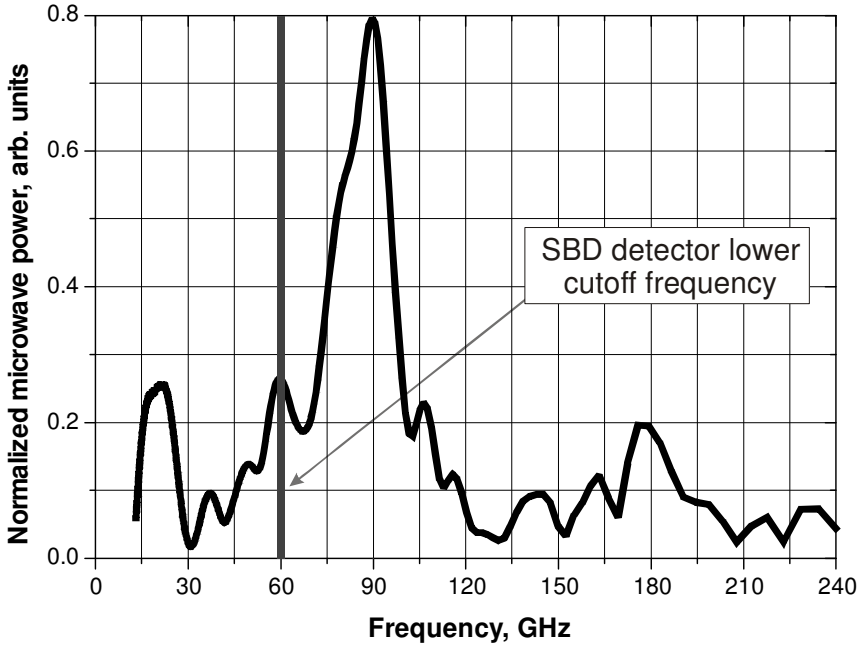


SBD scope trace, cavity Q-factor

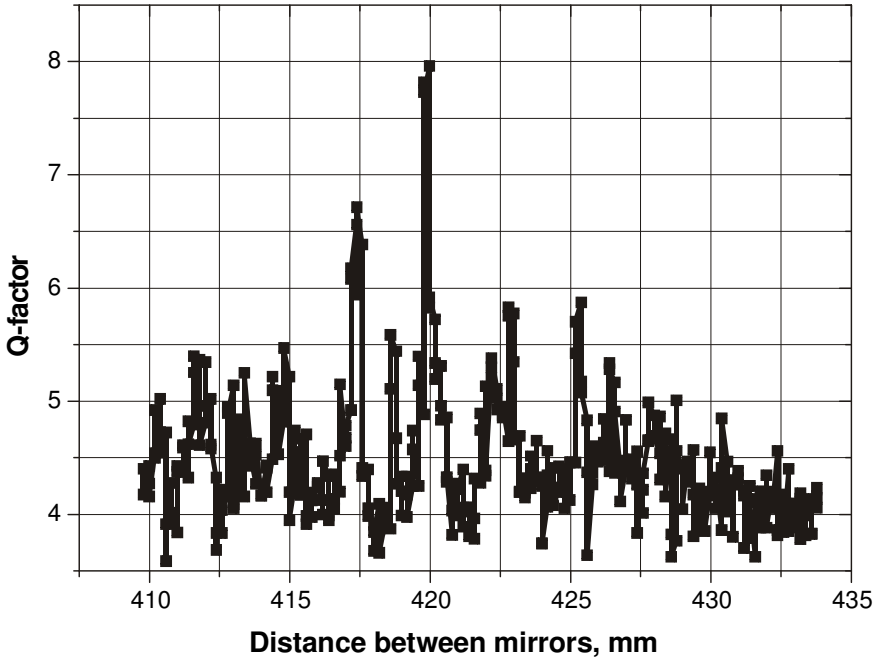


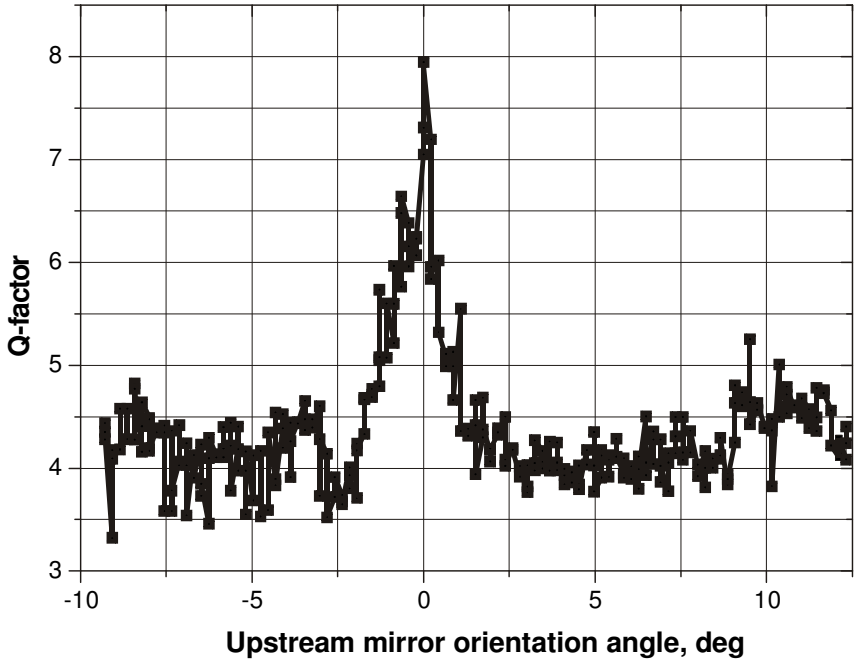
Autocorrelation, spectrum



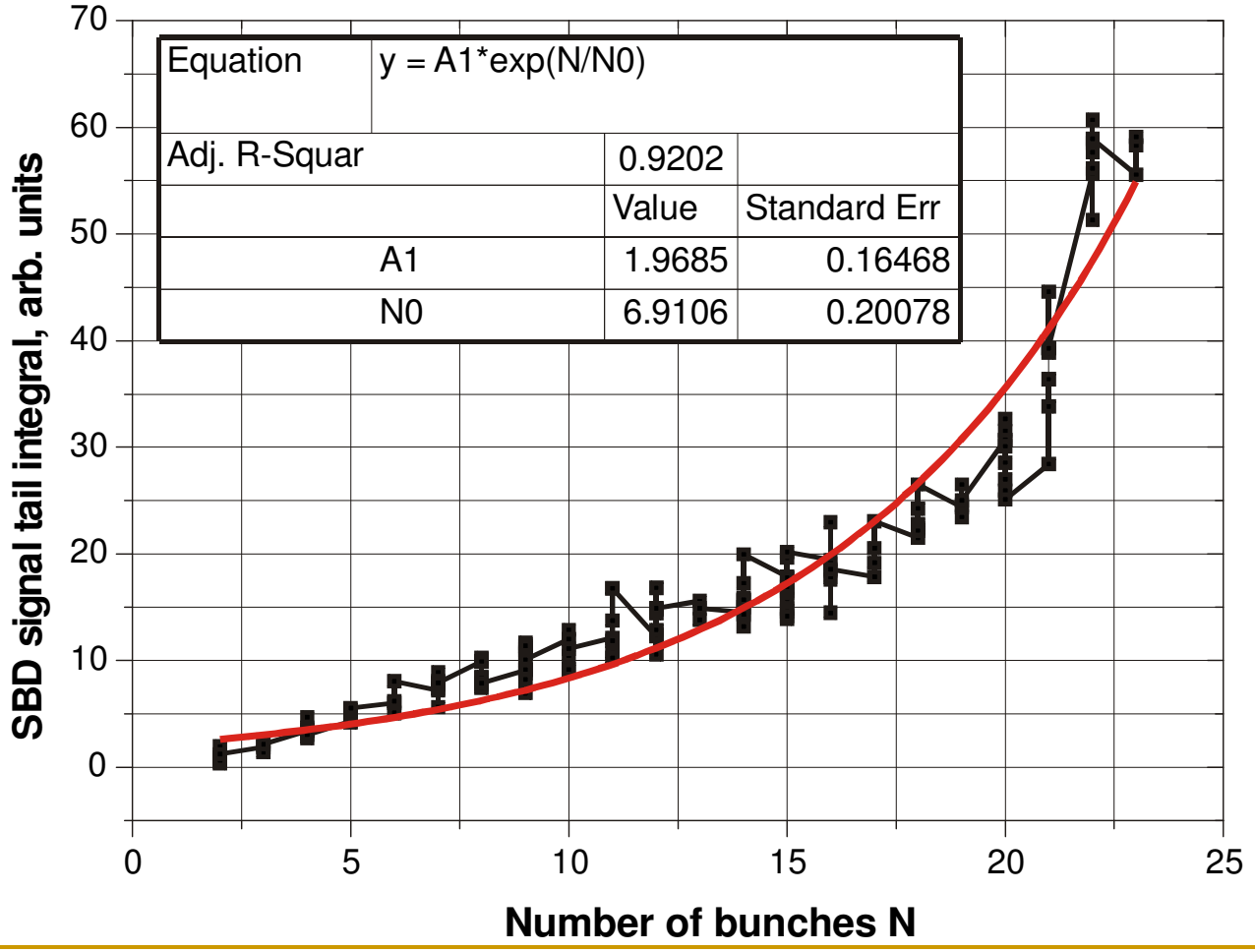


Q-factor


Q-factor
8
7
6
5
4
410
415
420
425
430
435
Distance between mirrors, mm


Q-factor
8
7
6
5
4
3
-10
-5
0
5
10
Upstream mirror orientation angle, deg

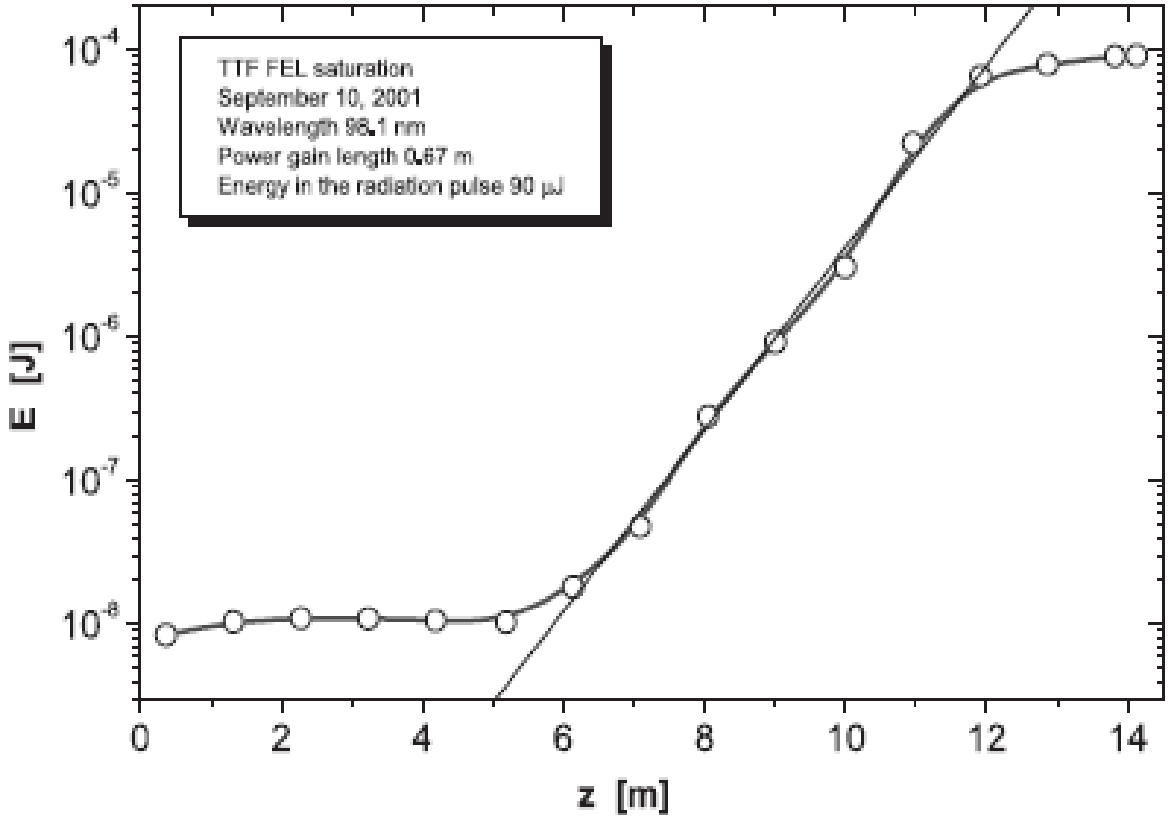
Stimulated CDR



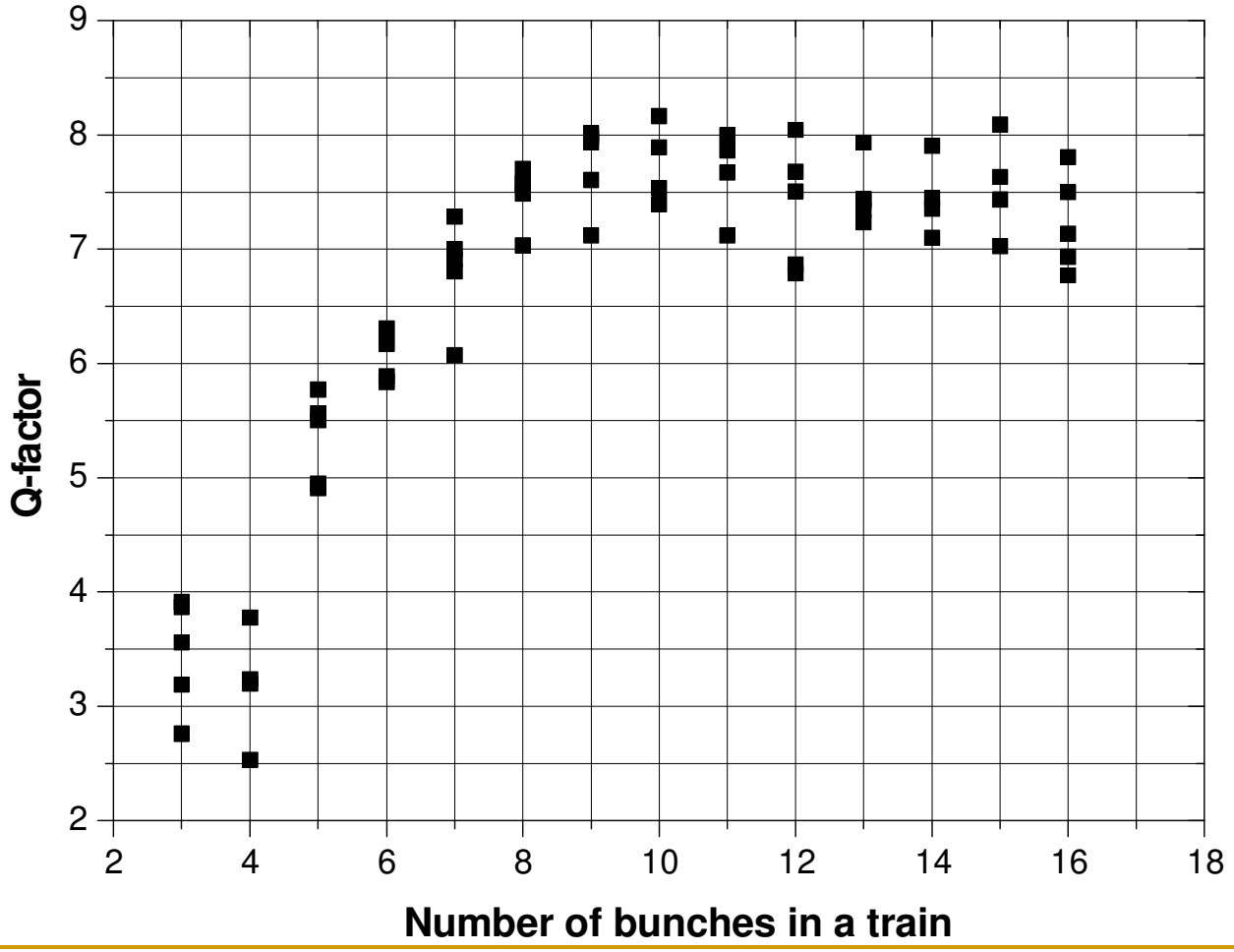
A. Aryshev, et. al., Observation of the Stimulated Coherent Diffraction Radiation in an Open Resonator at LUCX Facility, submitted to PRL

Demonstration of SASE exponential growth and saturation at the TTF FEL.

J. Rossbach, et. al., Demonstration of gain saturation and controlled variation of pulse length at the TESLA test facility FEL, NIMA 507 (2003) 362–367



Q-factor saturation



Summary and plans

- We have successfully commissioned microwave resonator system.
- Demonstrated a good power stacking of the Stimulated Coherent Diffraction Radiation.
- Further work remains to fully optimize this system.
- Achieve higher quality factor of the cavity what will gain soft X-ray production via Thomson scattering.

Acknowledgements

We would like to thank the LUCX supporting personnel for helping to conduct the experiment. The authors acknowledge W. Ekkapong and T. Takatomi for their help in mirrors preparation.

The work was carried out with the partial support from the "Grant-in-Aid for Creative Scientific Research of JSPS (KAKENHI 17GS0210)" project and Quantum Beam Technology Program of the Ministry of Education, Science, Sports, Culture and Technology of Japan (MEXT), grant No. 790 of the Ministry of Education and Science of Russian Federation.