Argonne NATIONAL LABORATORY

... for a brighter future

Wakefields Study in a Beam-Driven Photonic Band Gap Accelerating Structure

Chunguang Jing[1,2], F.Gao[1,2,], S. Antipov[1], Z.Yusof[1], M.Conde[1], J.G.Power[1], W.Gai[1],P. Xu[3], S. Zheng[3], H. Chen[3], and C. Tang[3]*

1. *High Energy Physics Division, ANL*
2. *Euclid Techlabs LLC*
3. *Dept. of Engineering Phys., Tsinghua University, China*

U.S. Department of Energy

UChicago Argonne LLC

A U.S. Department of Energy laboratory managed by UChicago Argonne, LLC

*current with BNL

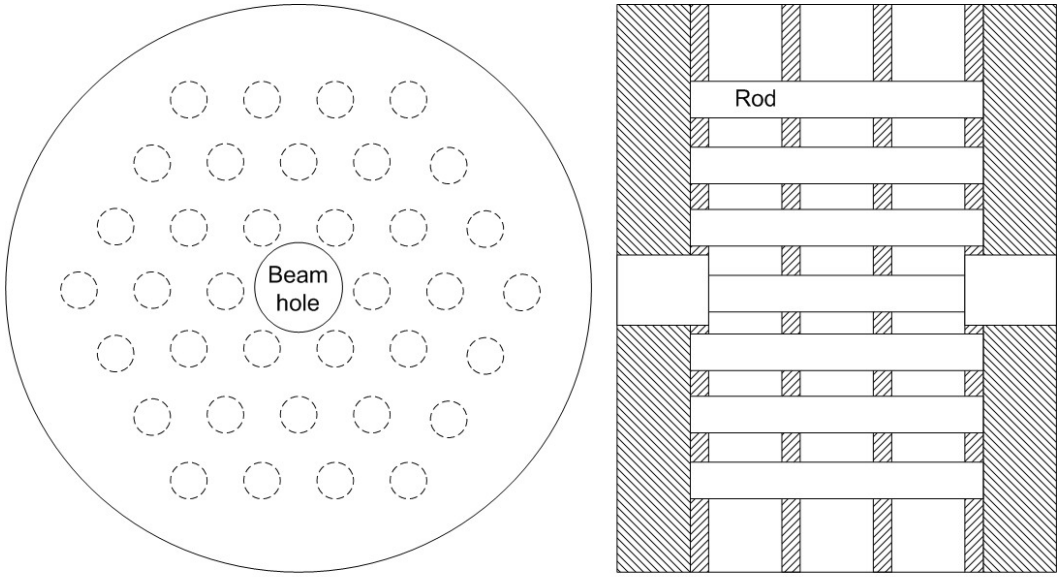
Sept. 2009

Contents

- Introduction
- Wakefield Experiment at Argonne Wakefield Accelerator Facility
- Further Exploration
- Summary

INTRODUCTION: PBG Accelerating Structures

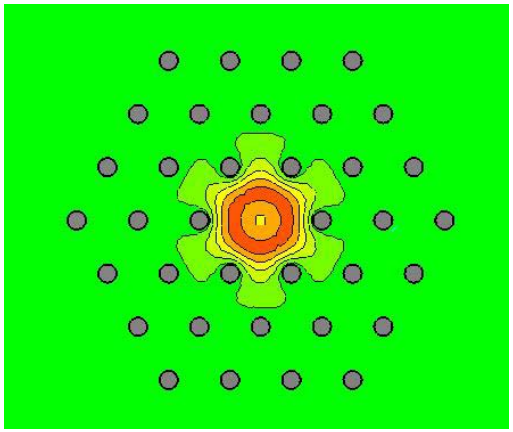
- Inception of the concept of the PBG as an accelerator(~1992, N. Kroll, UCSD)
- Electron been accelerated in a 17GHz 6-cell external powered traveling wave PBG structure. 35MV/m of gradient been reached. (~2005, R. Temkin, MIT)
- Intrinsic HOMs damping. Theoretically proved but never been systematically beam tested.

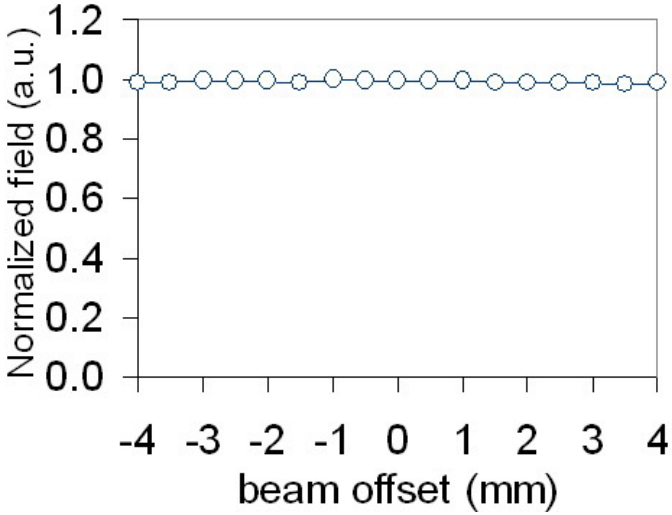


Front View Side View

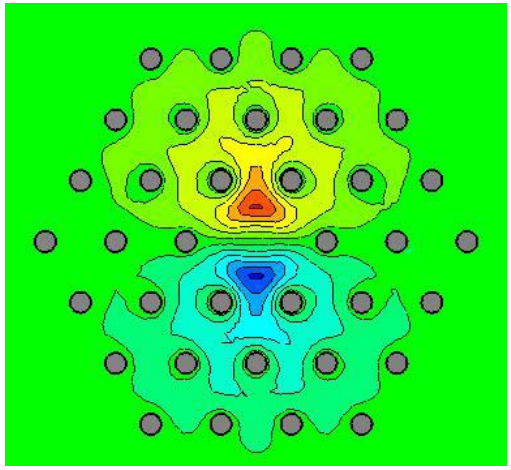
INTRODUCTION: Modes in a PBG structure

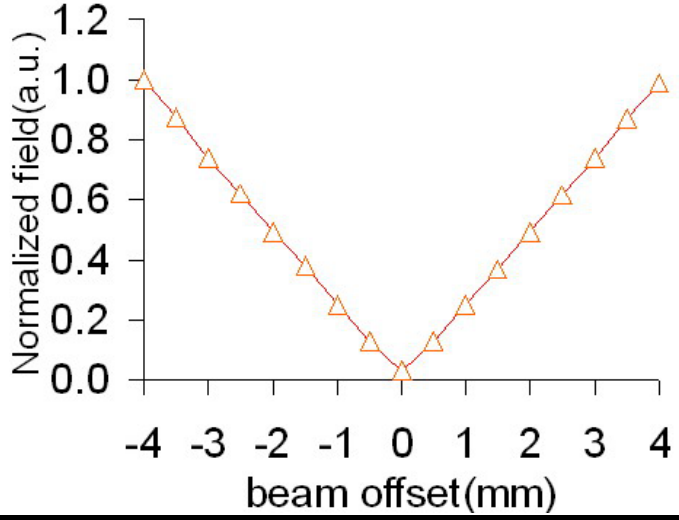
Accelerating Mode





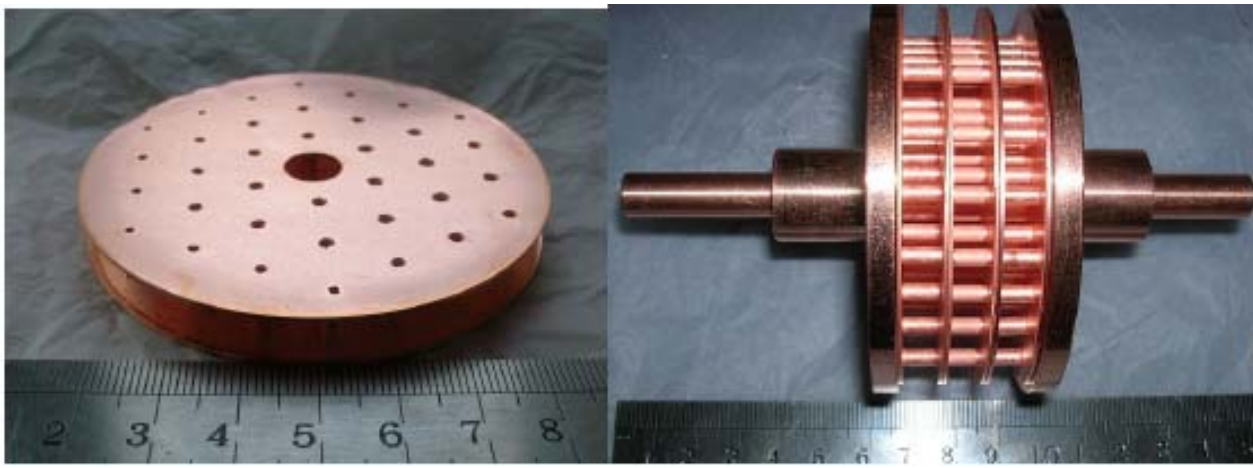
Dipole Mode

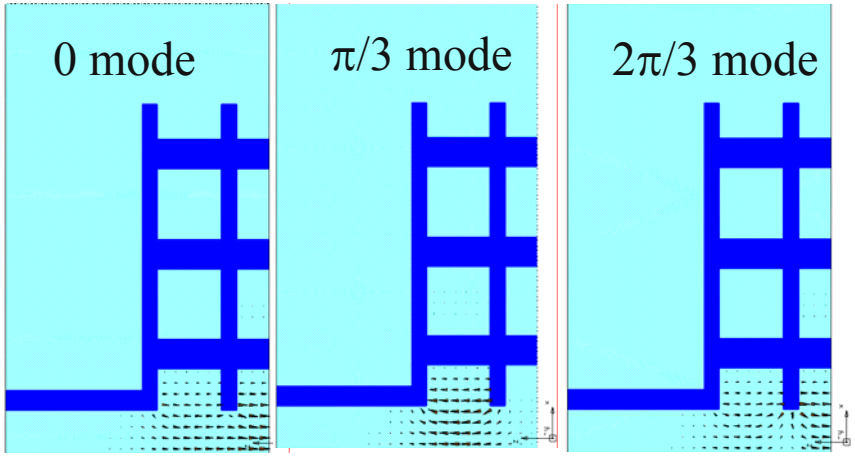




WAKEFIELD EXPERIEMENT OF THE PBG STRUCTURE @ AWA

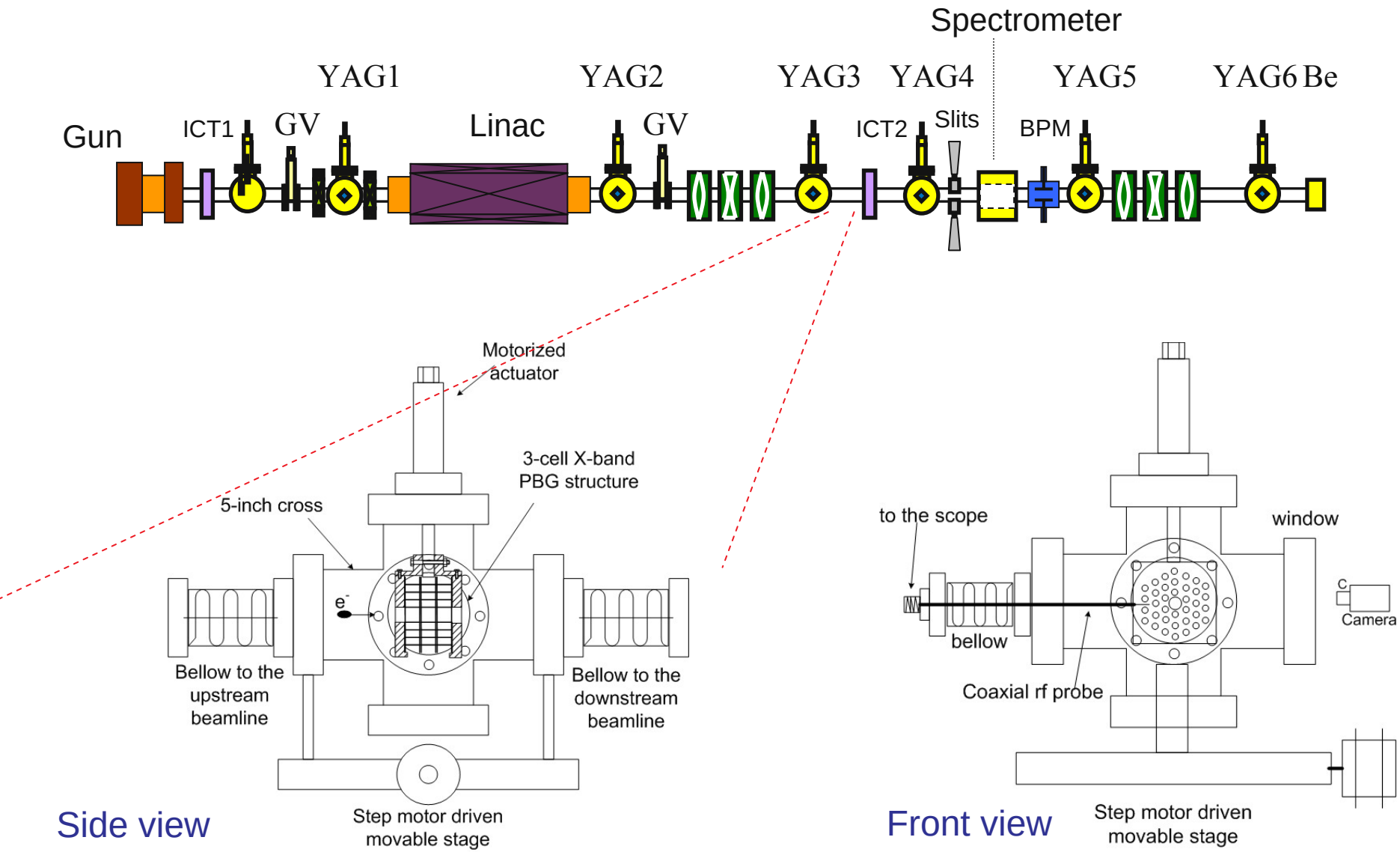
We designed and fabricated a X-band PBG structure using electroforming technique at Tsinghua University, China.



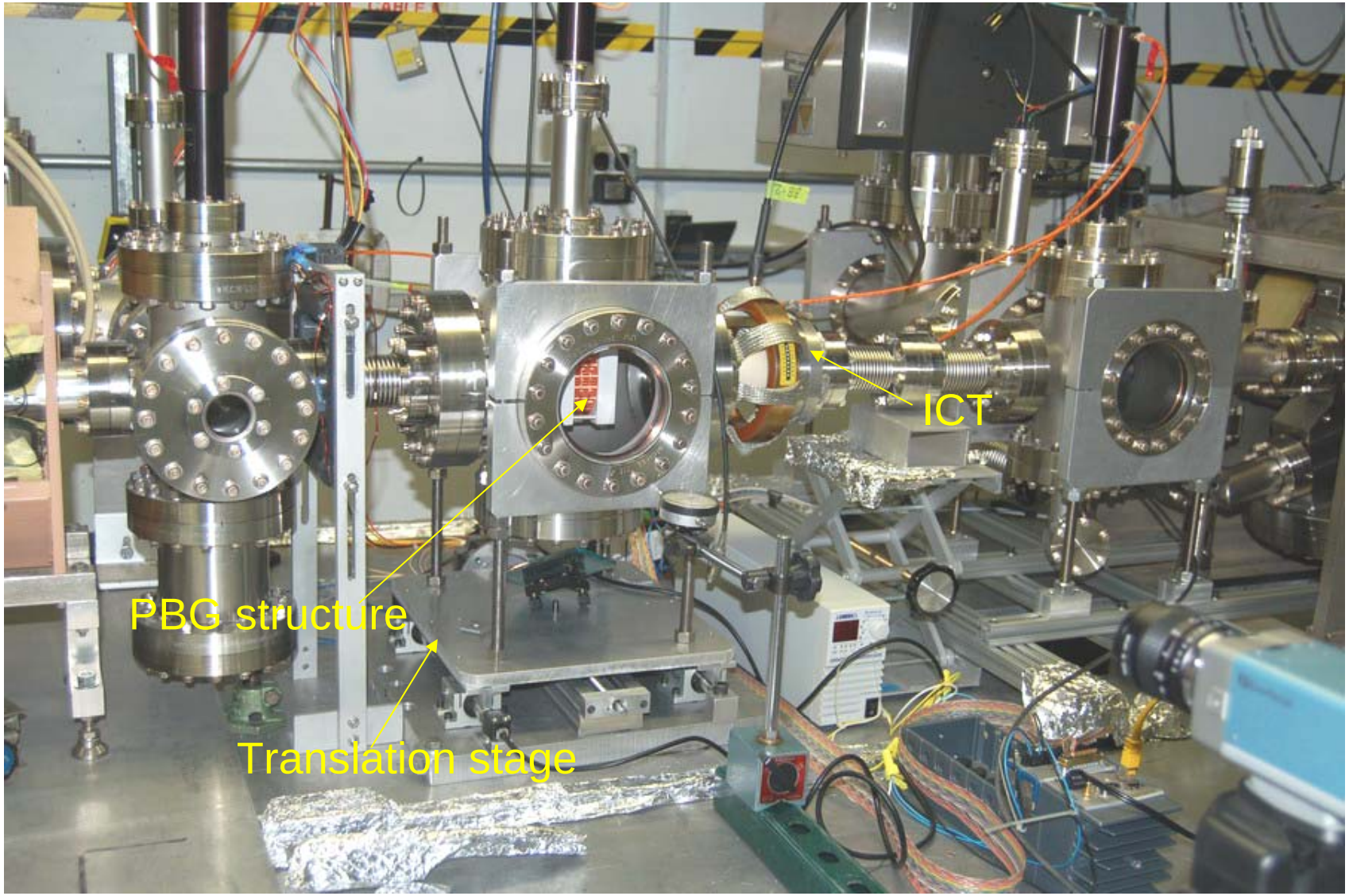


TM_{01} like Modes	Freq. (GHz)	R/Q (Ω)
0 mode	11.10	4.86
π/3	11.31	148.5
2π/3	11.52	148.1

Experimental Setup (I)

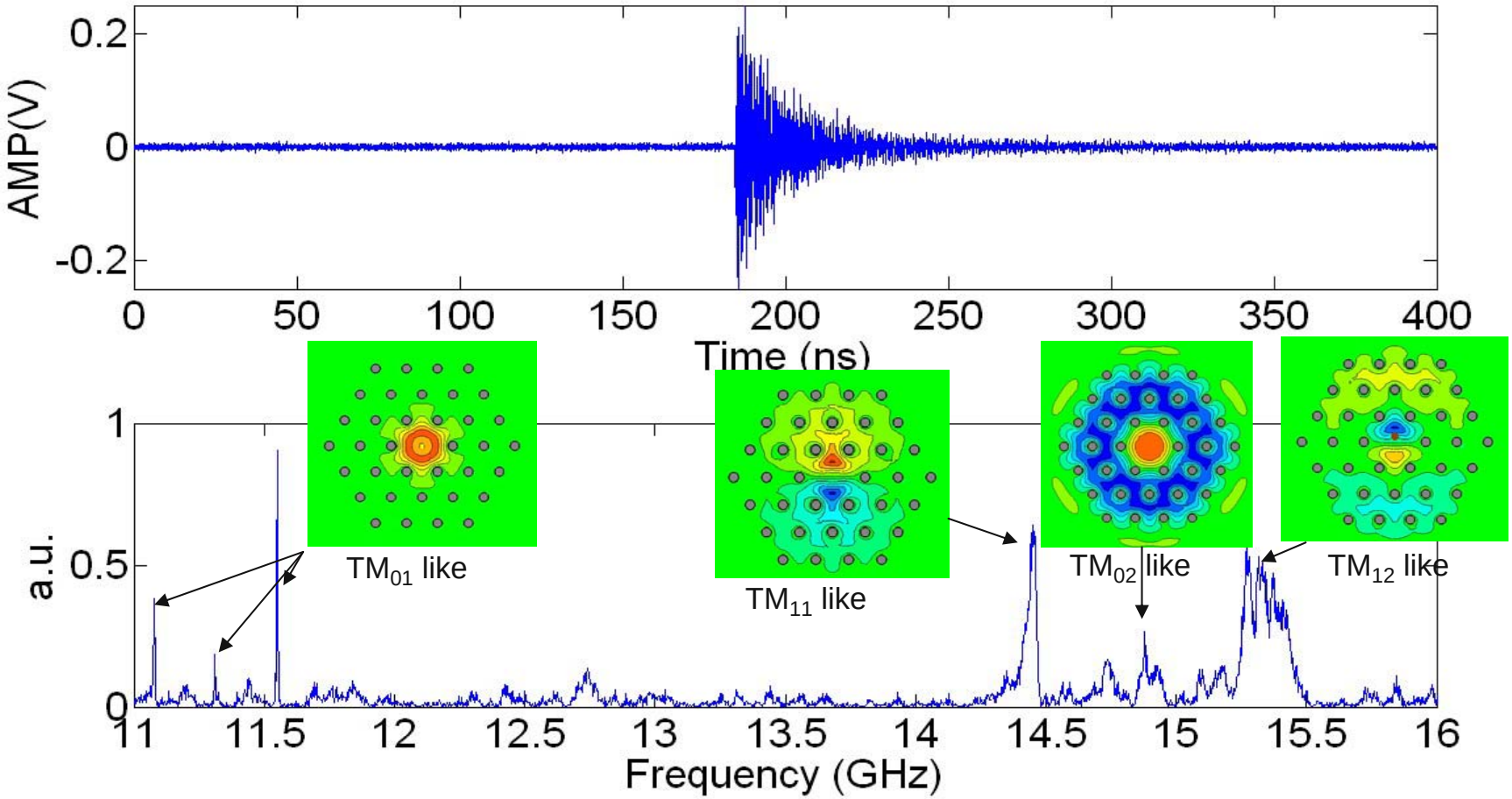


Experimental Setup (II)



Experimental Results (I)----mode identification

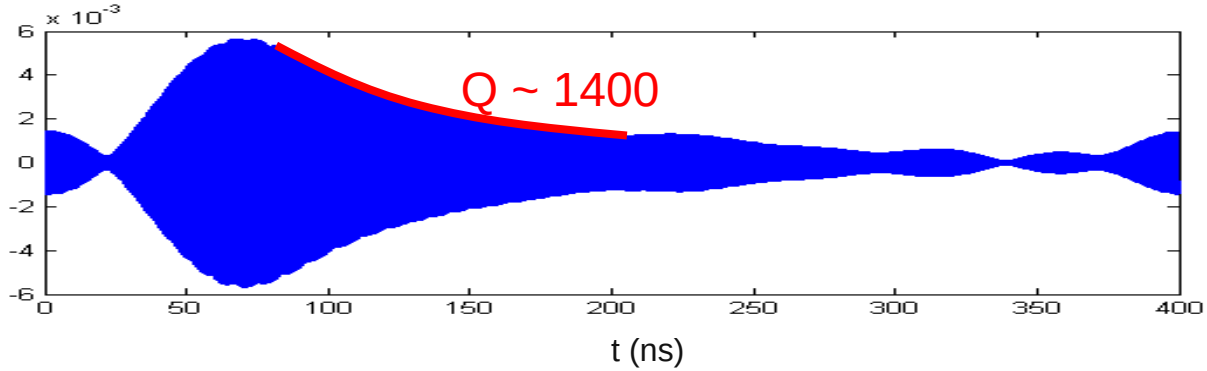
Probe signal @ ~3.5mm of beam off-axis



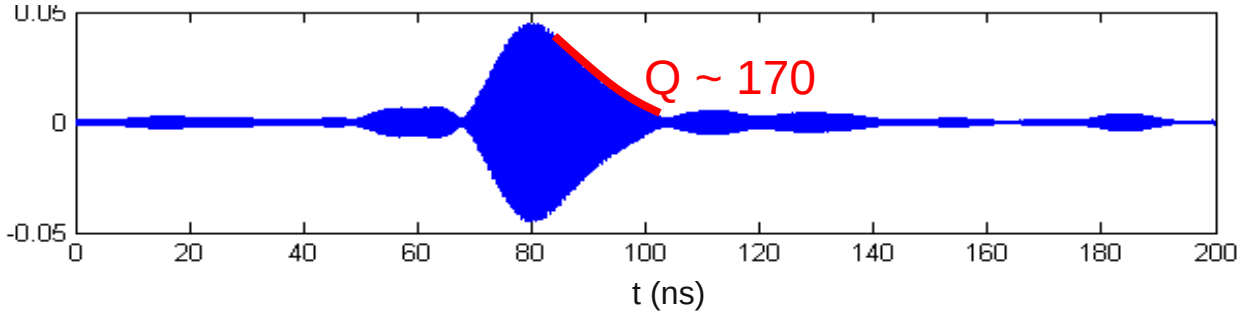
Experimental Results (II)----Q estimation

Q estimation based on the filtered mode signal

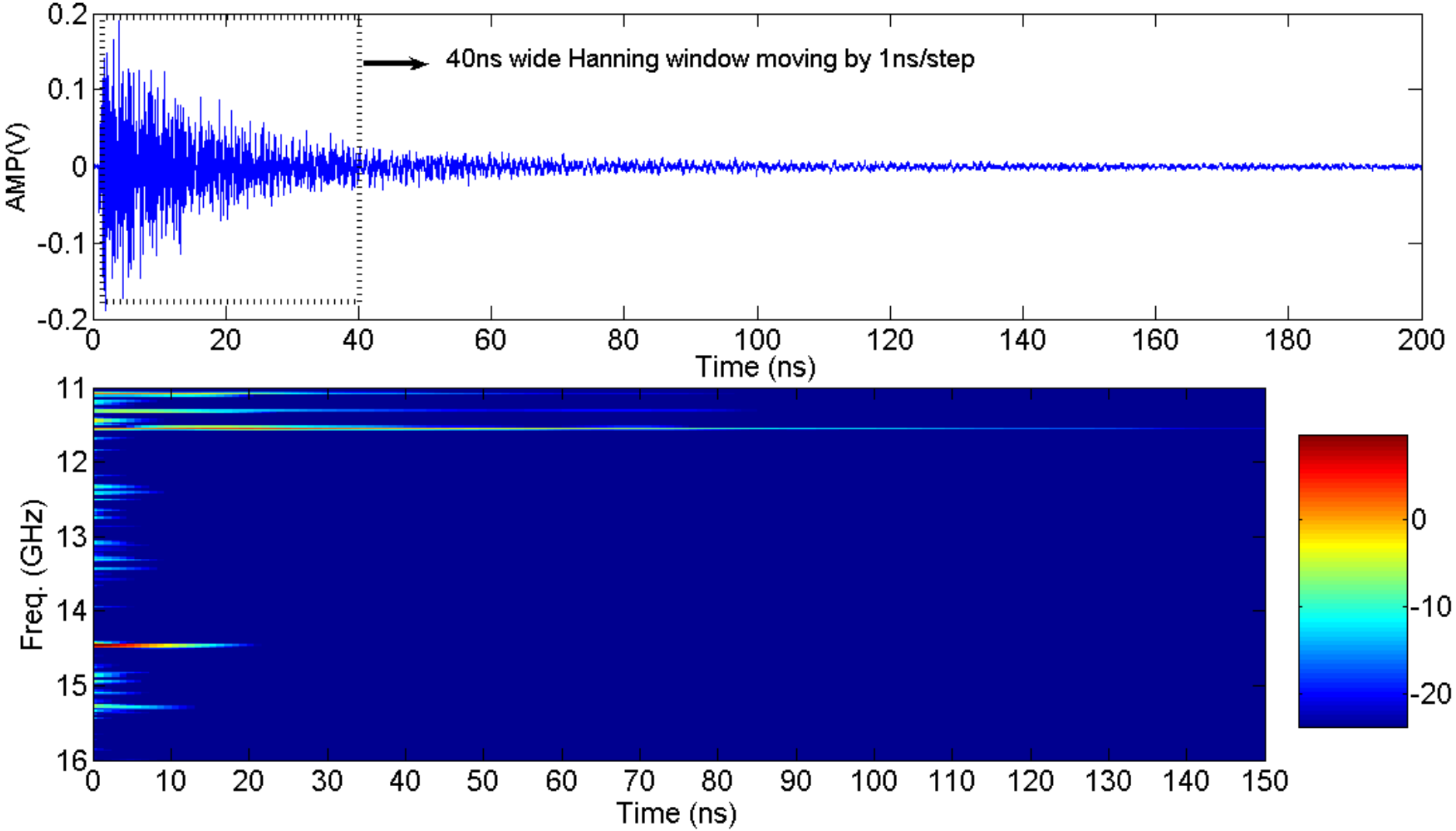
Acceleration mode
(11.55GHz)



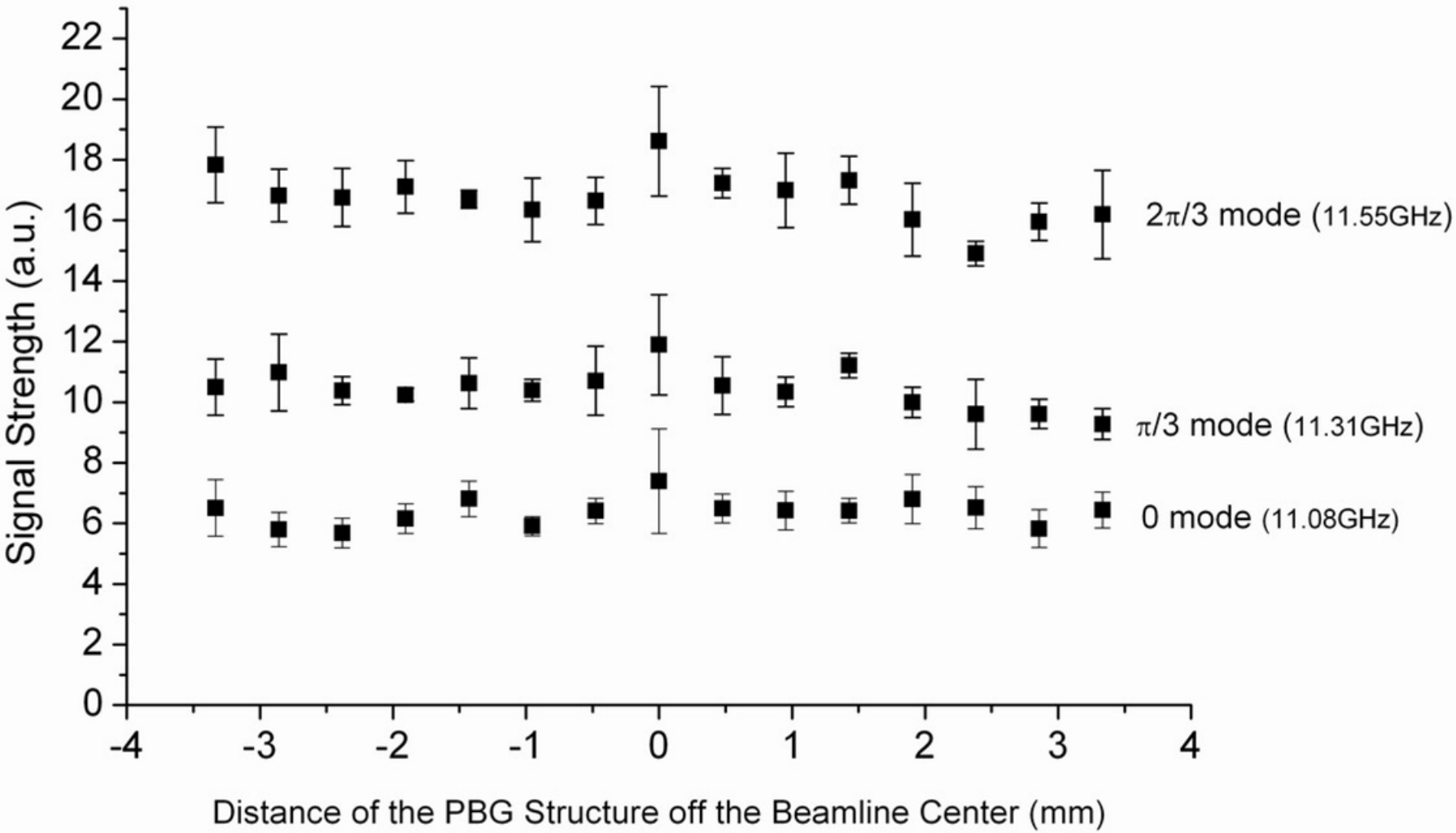
Dipole
(14.46GHz)



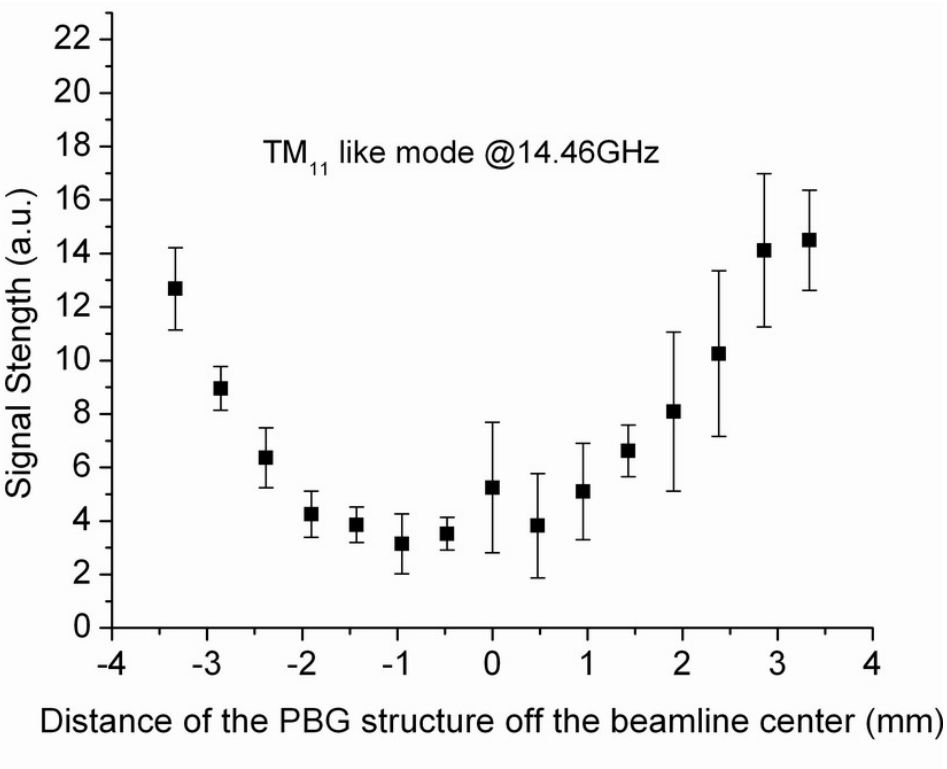
Experimental Results (III)----time-frequency analysis

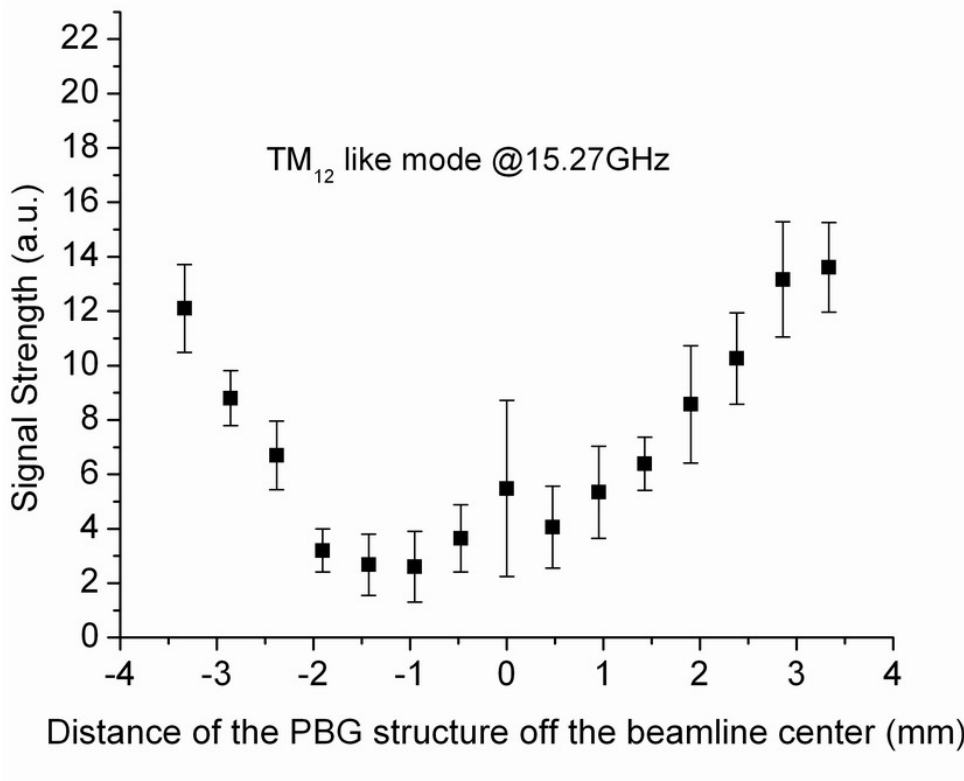


Experimental Results (IV)----monopole mode characterization

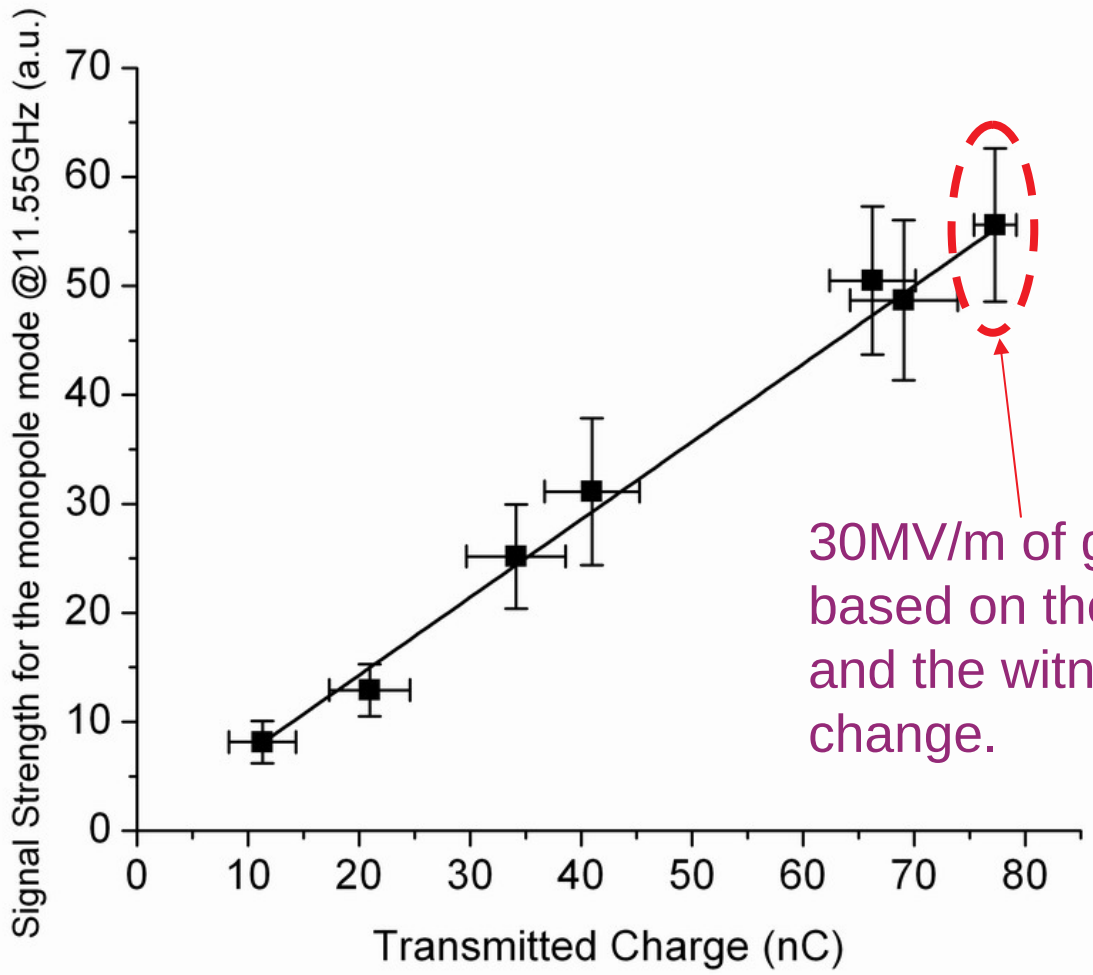


Experimental Results (V)----dipole mode characterization



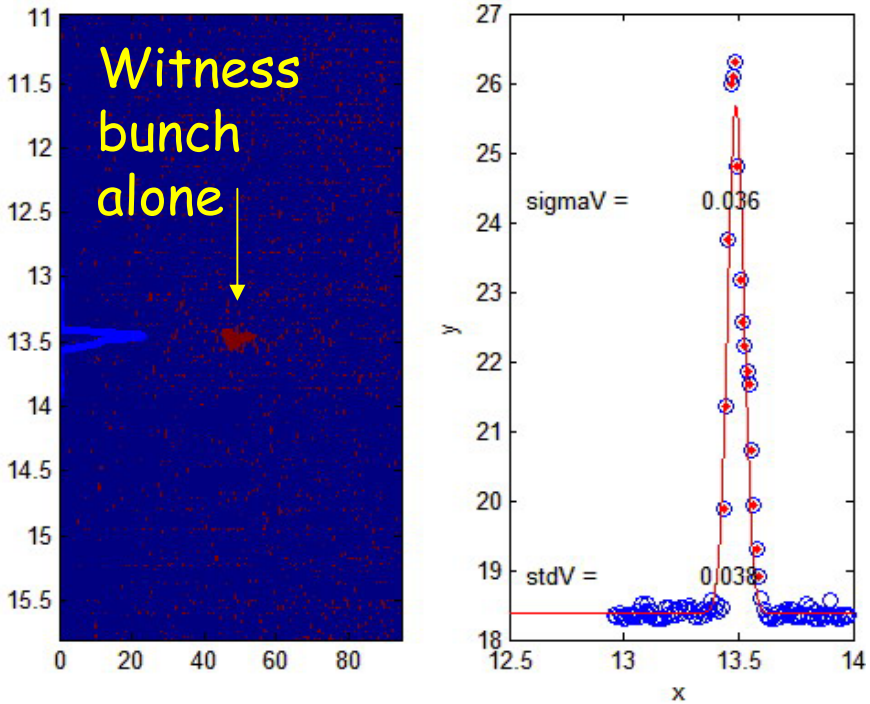


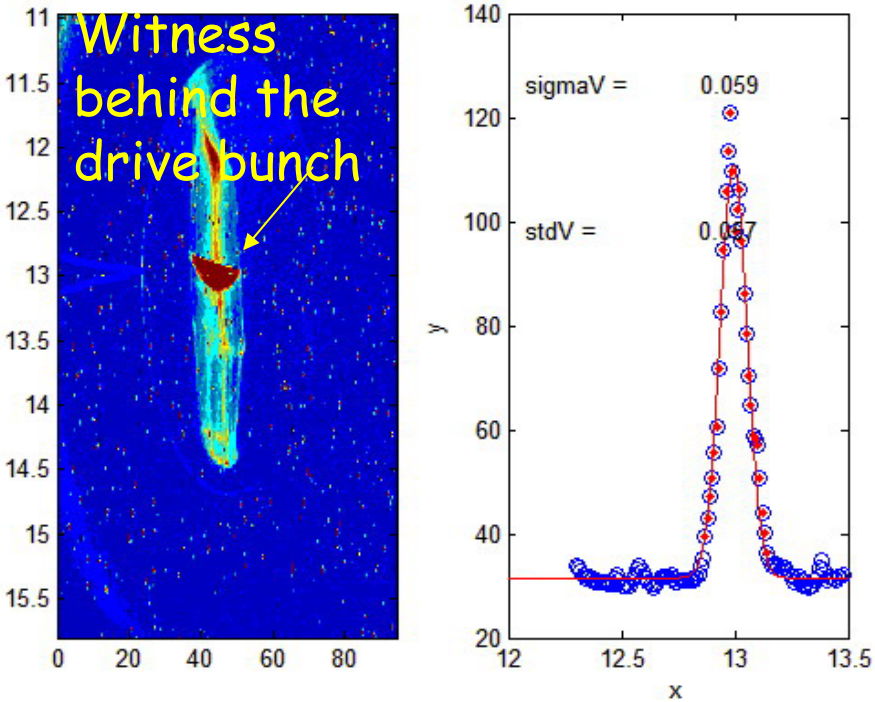
Experimental Results (VI)----charge sweeping



30MV/m of gradient based on the simulation and the witness energy change.

Experimental Results (VII)----two-bunch collinear acceleration

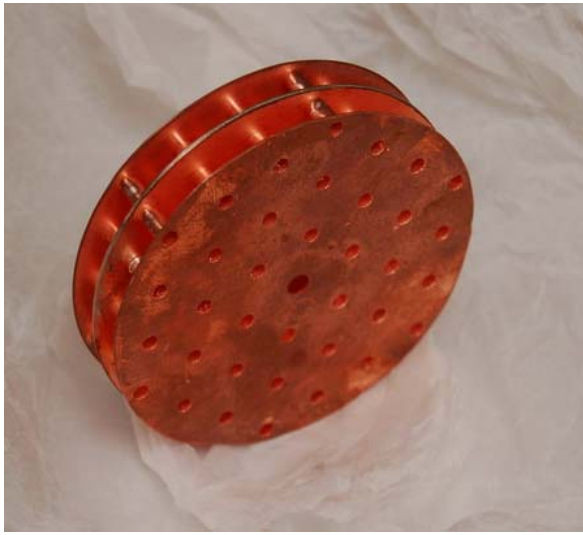




We observed 0.44MeV/m/nC Deceleration.

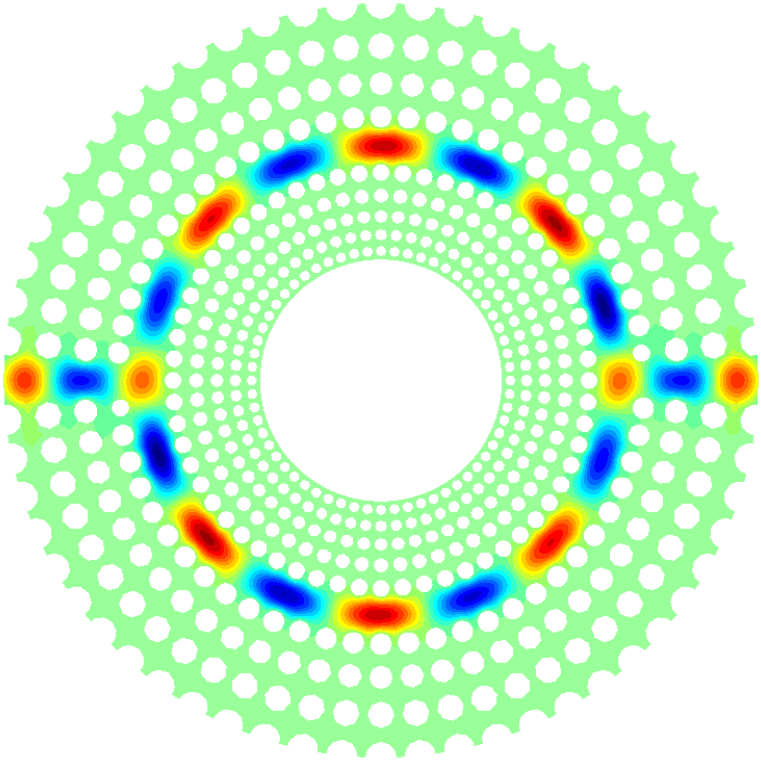
FURTHER EXPLORATION---test of a high gradient PBG structure

We will test the other high gradient 2-cell PBG structure (iris is 2.5 time smaller than the tested one), which leads to much higher gradient with a certain amount of charge passing through.

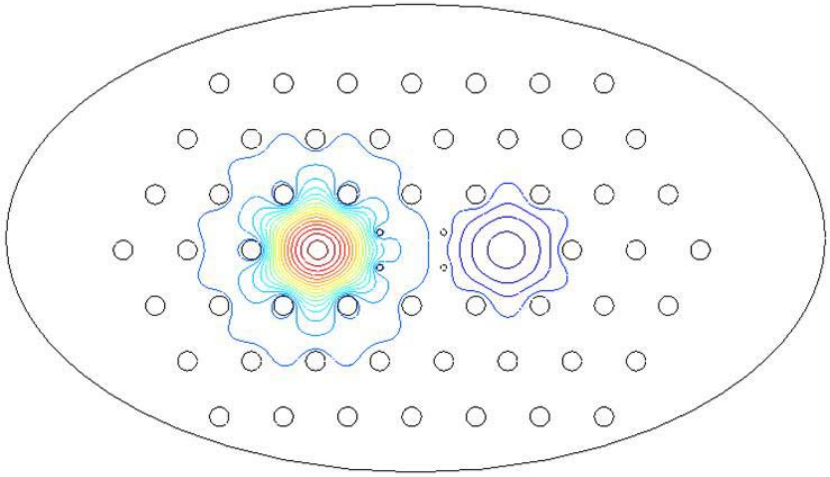


FURTHER EXPLORATION---exotic ideas

PBG Circulating waveguide

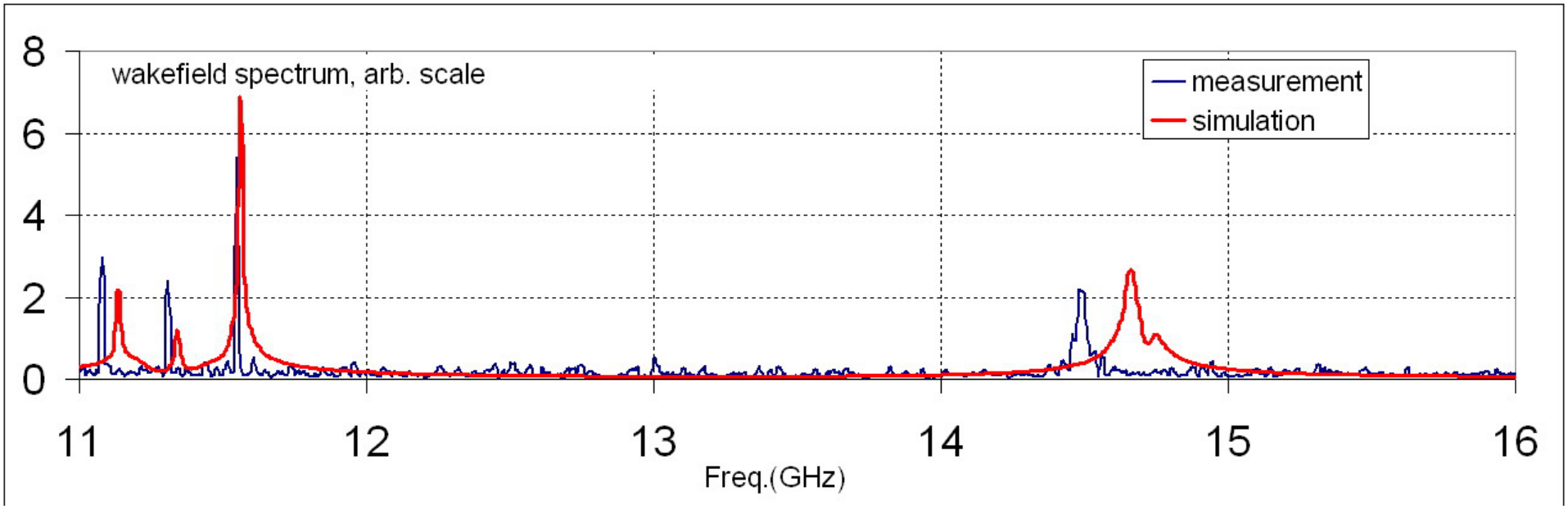


PBG Two channel accelertor



SUMMARY

- Wakefield of a PBG structure has been successfully characterized, including mode identification, Q estimation, and the beam offset sweeping.
- Demonstrated Q of the accelerating mode is ~10 times higher than the other HOMs.
- High charge wakefield excitation has been performed using up to 80nC single bunch. ~30MV/m of gradient on axis in this case. Collinear wakefield acceleration has been performed to calibrate this gradient.
- New Ideas to be explored.


wakefield spectrum, arb. scale
measurement
simulation
8
6
4
2
0
11
12
13
14
15
16
Freq.(GHz)