Wakefield Experiments at AWA

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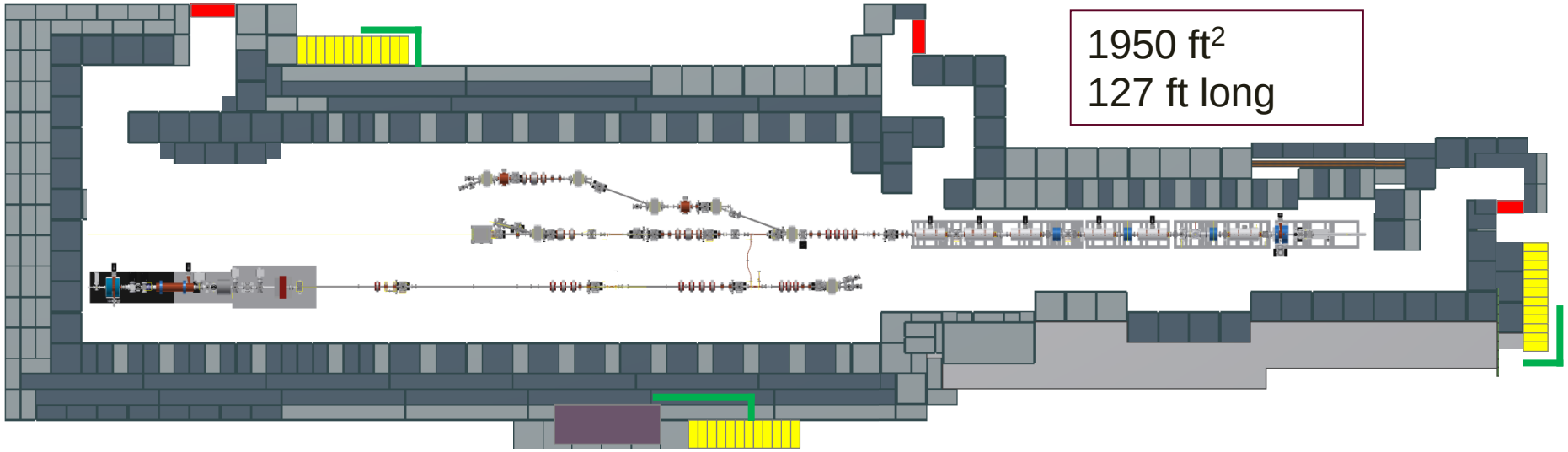
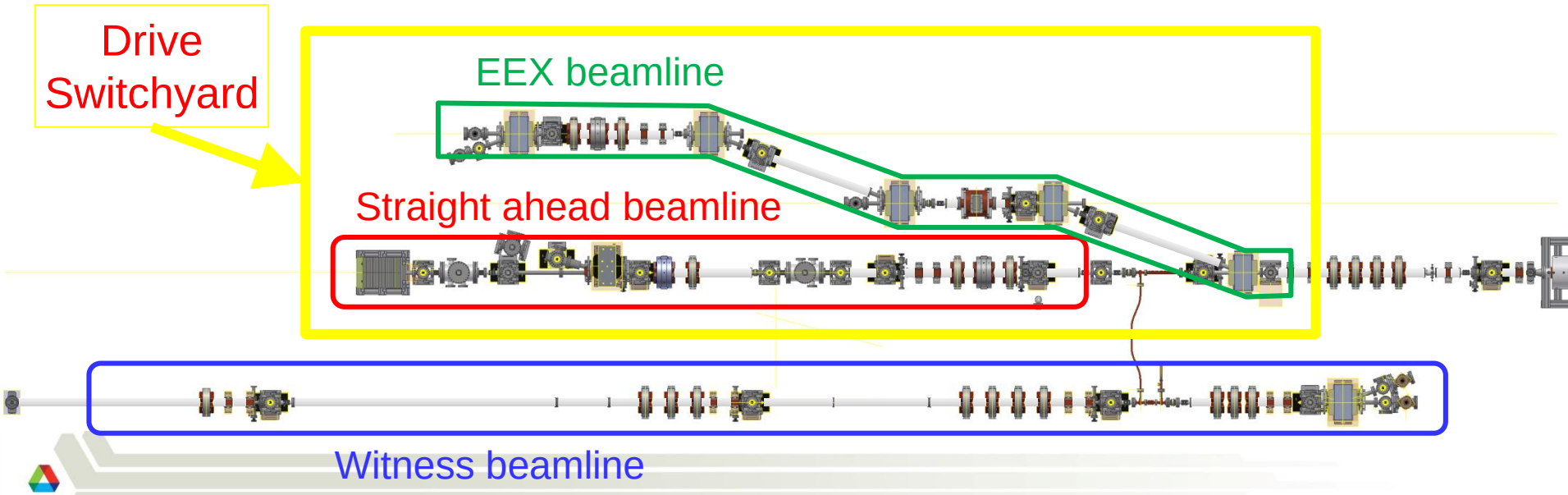
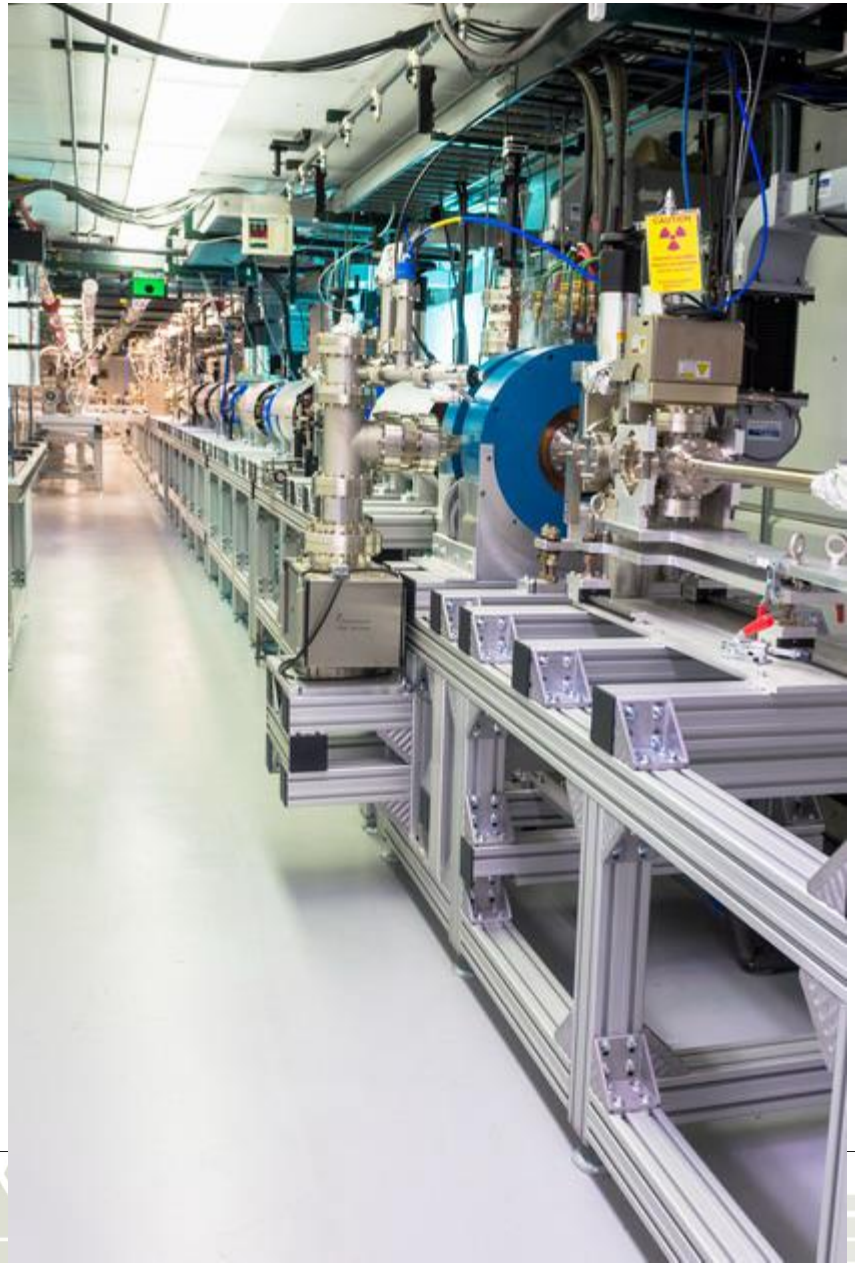
June 2015

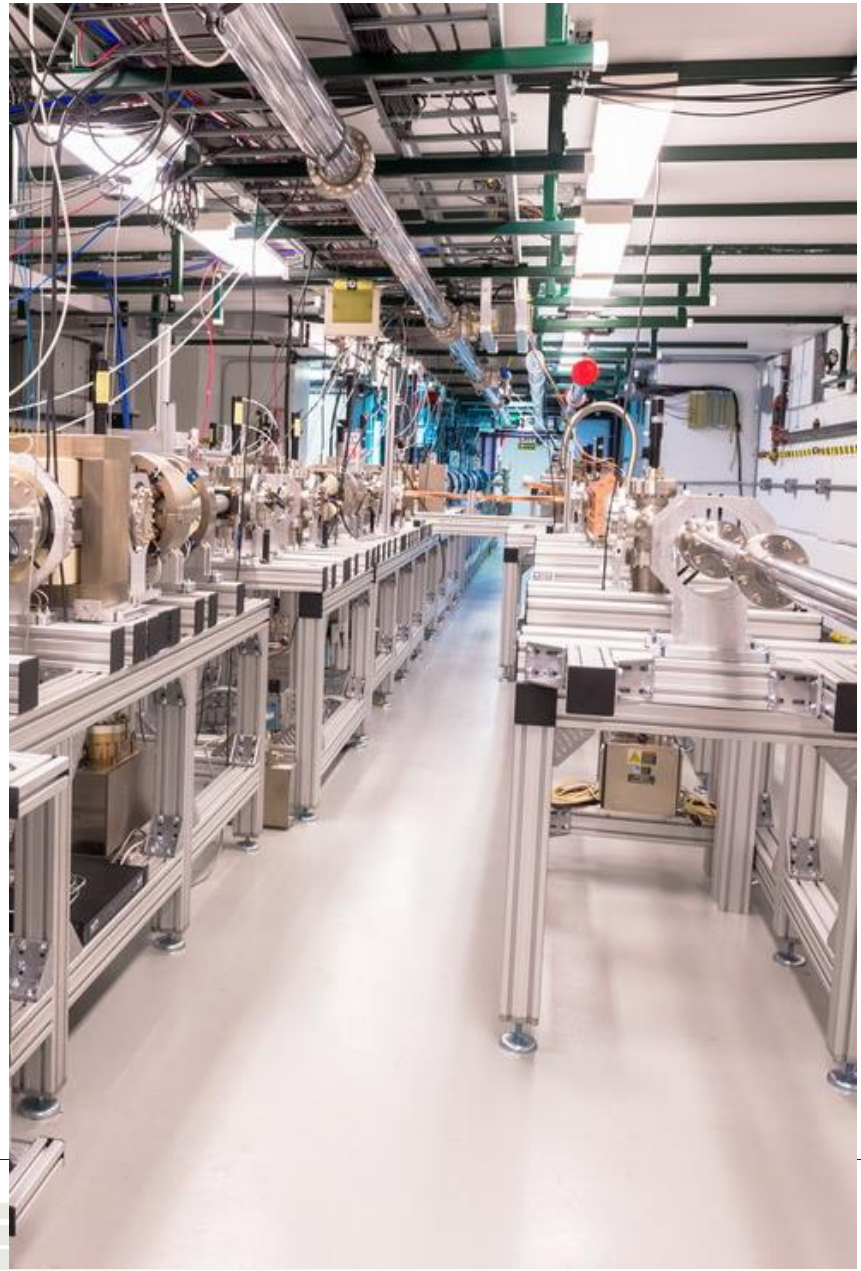
AWA Beamlines in 2015



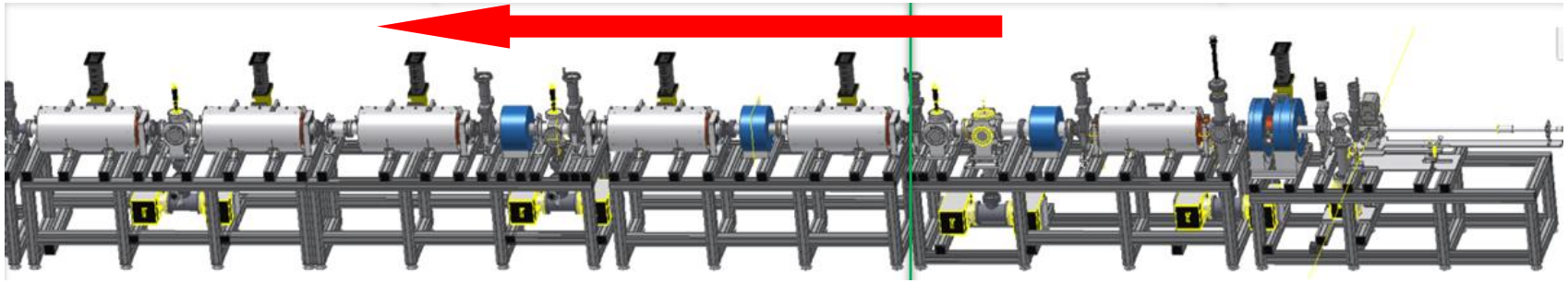


AWA Beamlines in 2015





GW Drive Beam Power

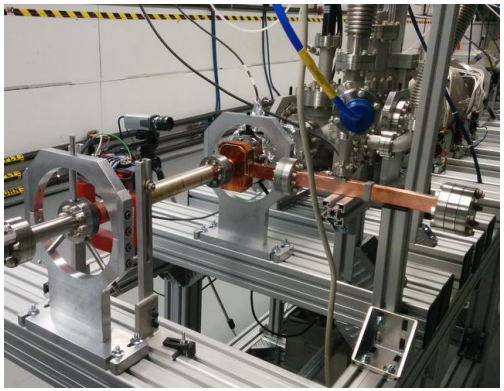


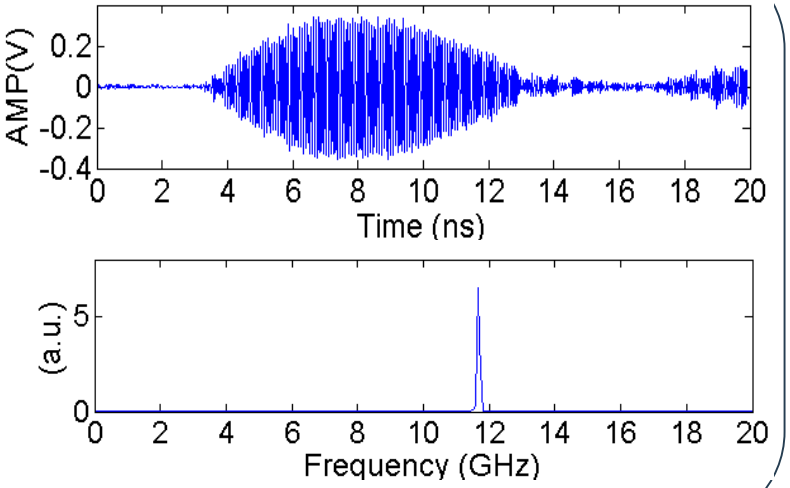
- Single bunch operation
  - 19 MeV; Oct 2013
  - 70 MeV; Dec 2014
  - Q = 0.1-100 nC
- Bunch train operation (19 MeV)
  - 16 bunches x 35 nC (560 nC); Feb 2014
  - 32 bunches x 17 nC (544 nC) Apr 2014
- Bunch train operation (70 MeV)
  - 8 bunches x 5 nC, (40 nC); Dec 2014
  - 8 bunches x 12 nC (~100nC); Jan 2015
  - 8 bunches x 50 nC (~400nC); Mar 2015 (0.2 Hz)
  - 8 bunches x 50 nC (~360nC); Apr 2015 (1 Hz)

Development of Wakefield Power Extractors

X-Band Metallic Wakefield Power extractor

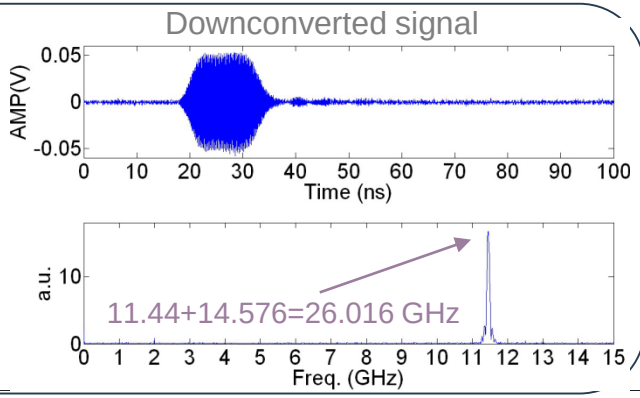
RF Generation of bunch train (25MW meas. to date)



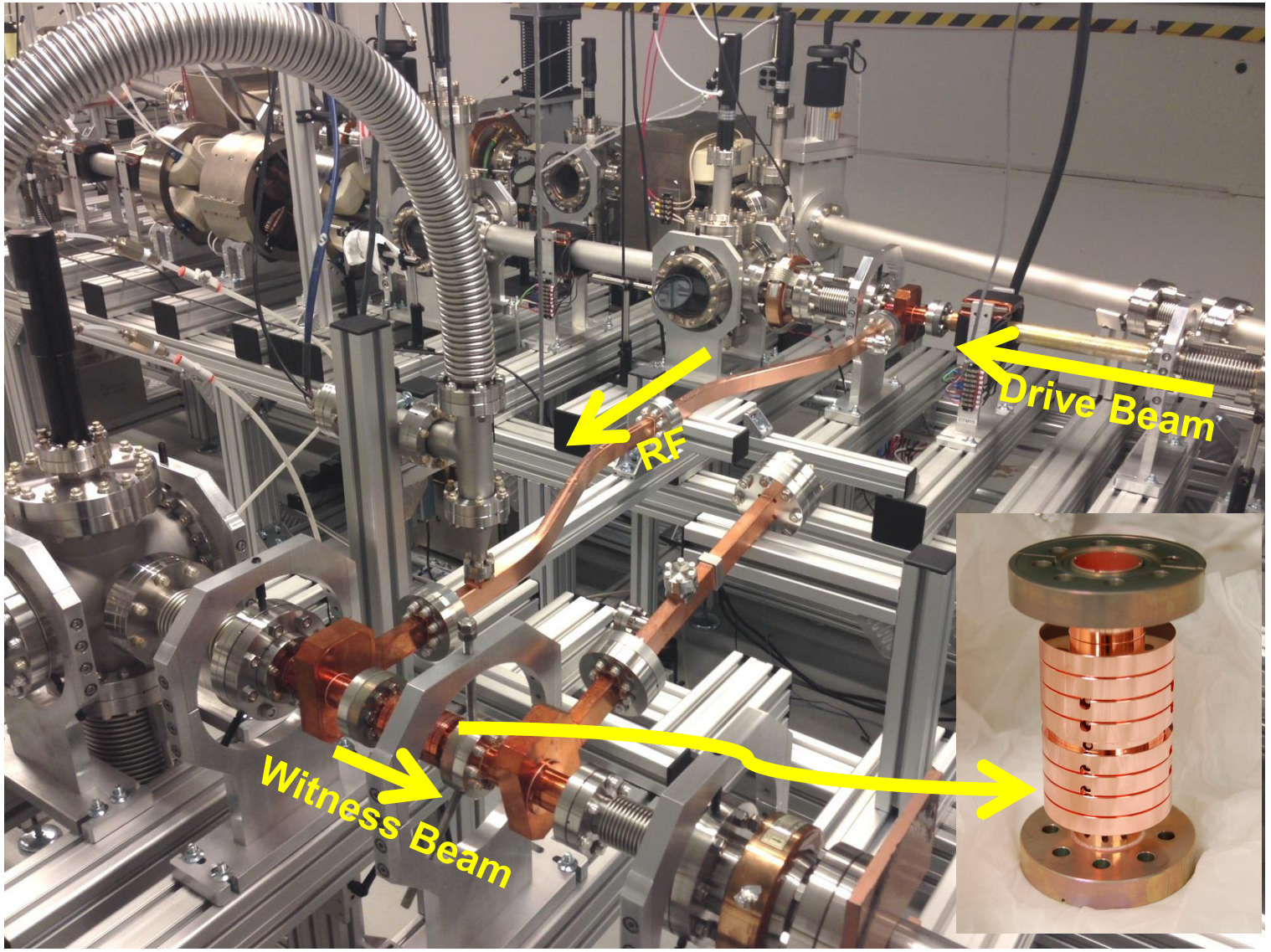


K-Band Dielectric Wakefield Power extractor

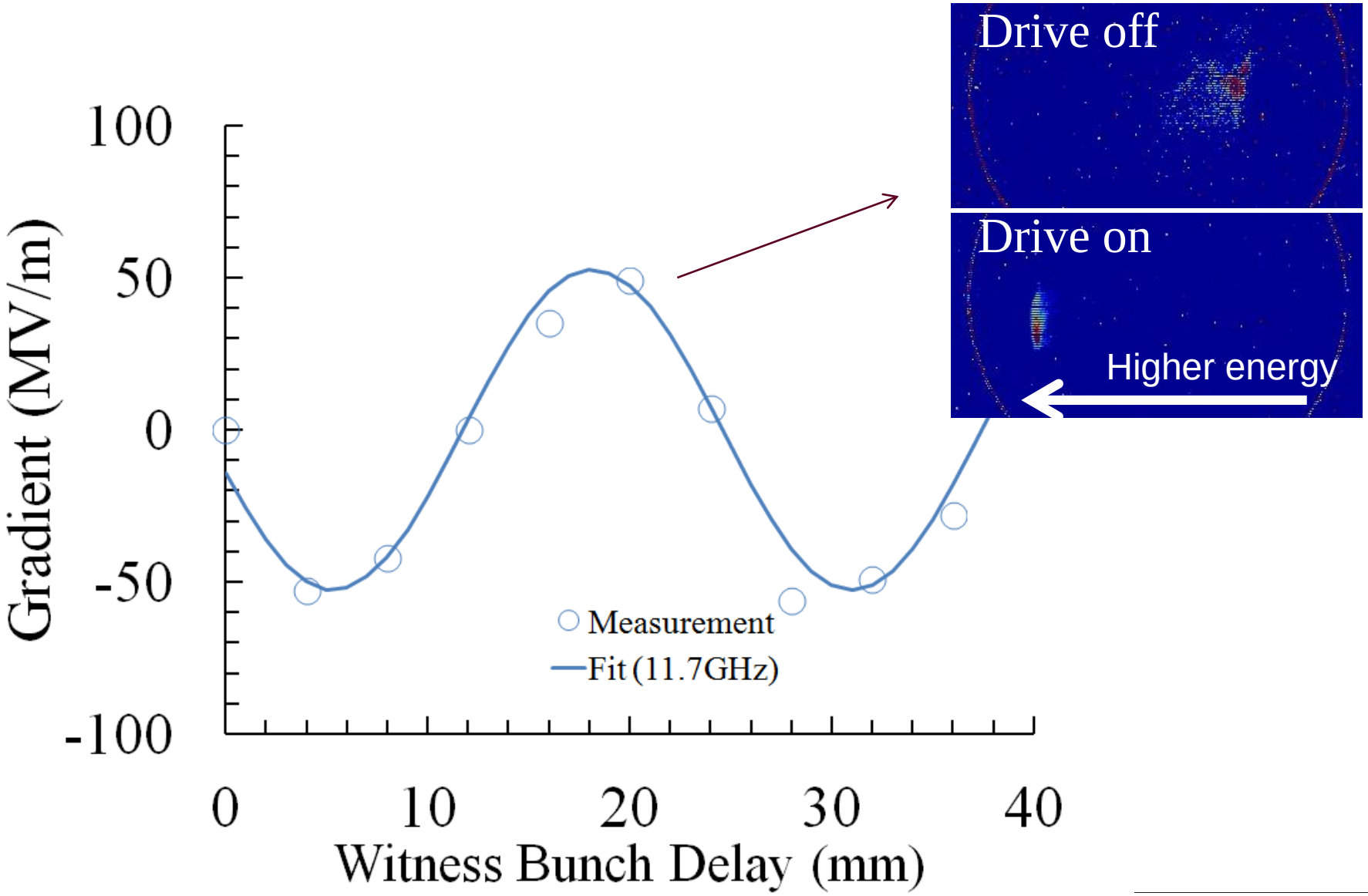
•16ns,1MW & 10ns, 20MW 26GHz rf pulse produced



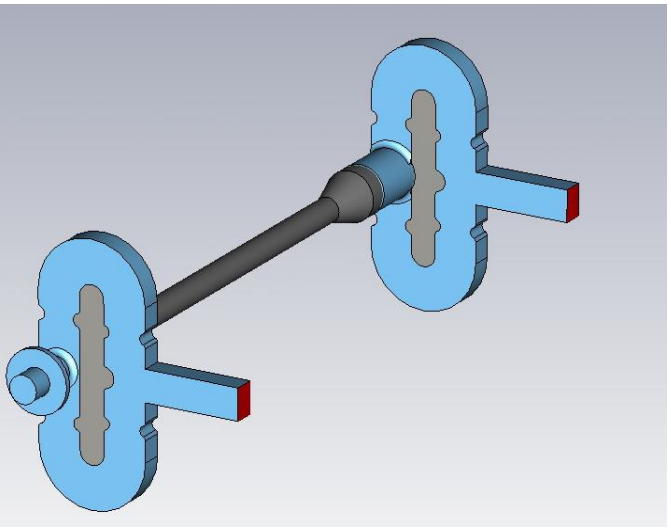
Current Setup for TBA



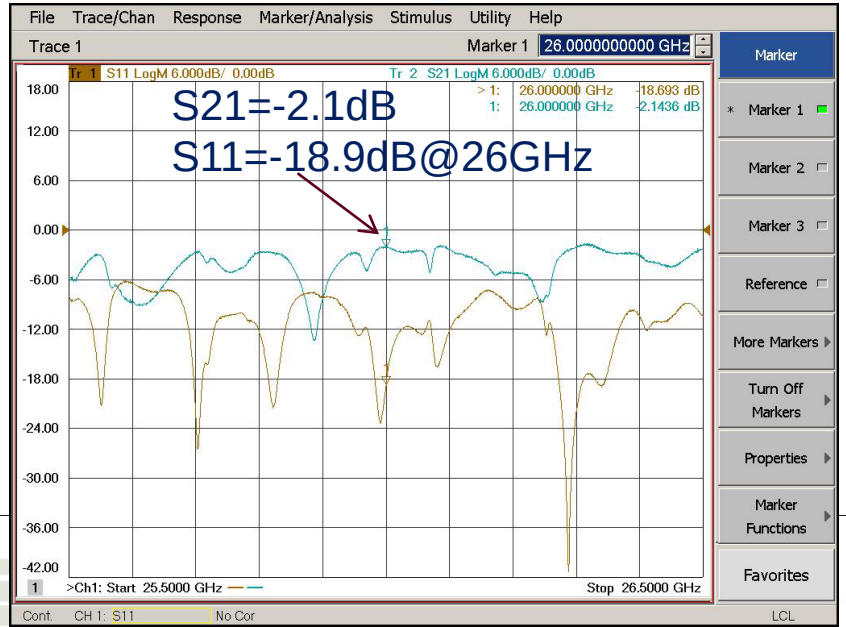
TBA Experiment at AWA (ongoing efforts)



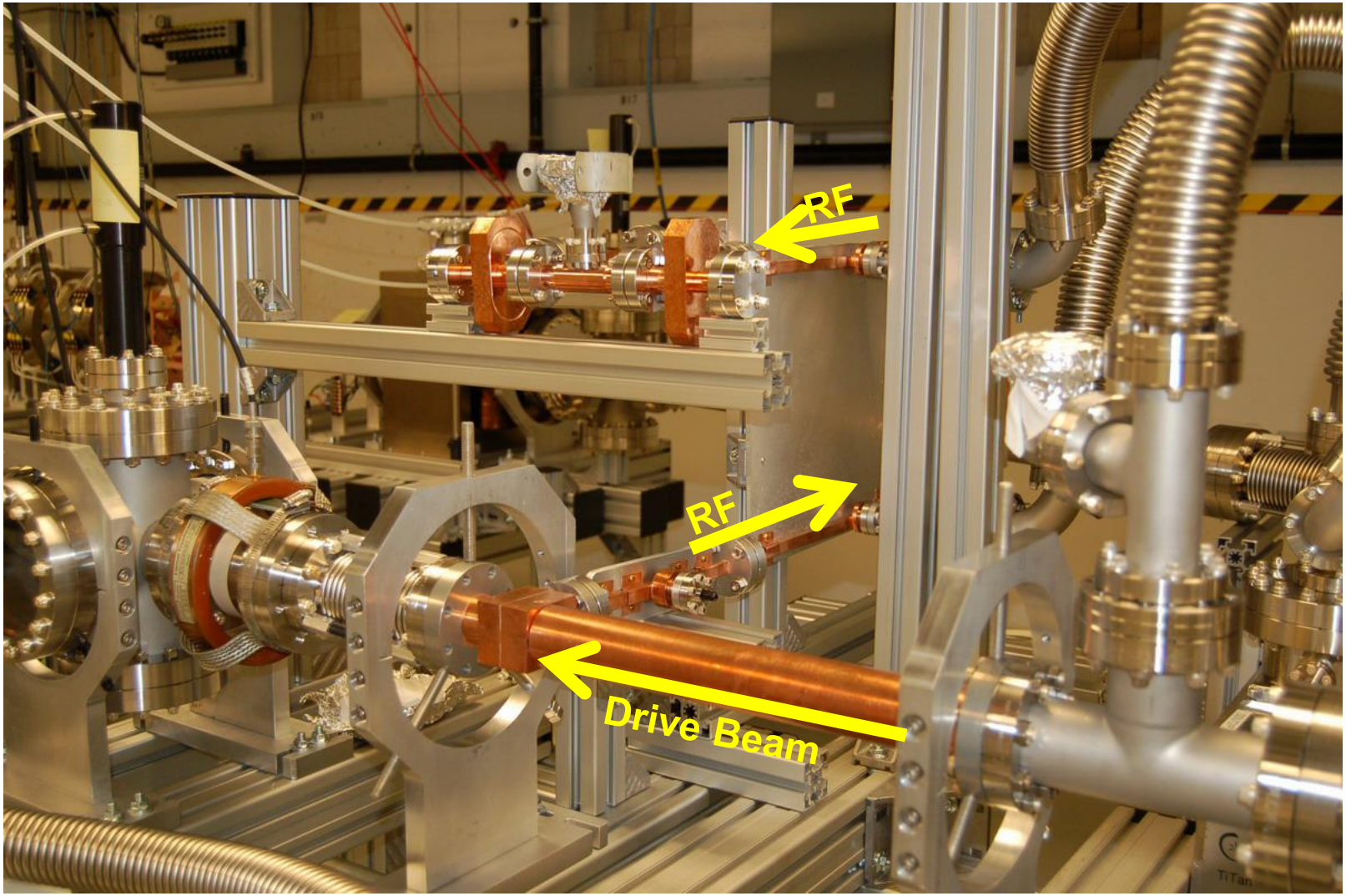
Fabricated 26GHz short pulse DLA Structure



parameters	value
ID / OD of dielectric tube	3 mm /5.025 mm
Dielectric constant	9.7
Length of dielectric tubes	105 mm
Vg	11.13%c
R/Q	21.98 kΩ/m
Q (loss tan=10^-4)	2295
Shunt impedance	50.44 MΩ/m
E_{acc} for 316MW input	158 MV/m



Ongoing experiment @AWA---High power rf test of 26GHz DLA

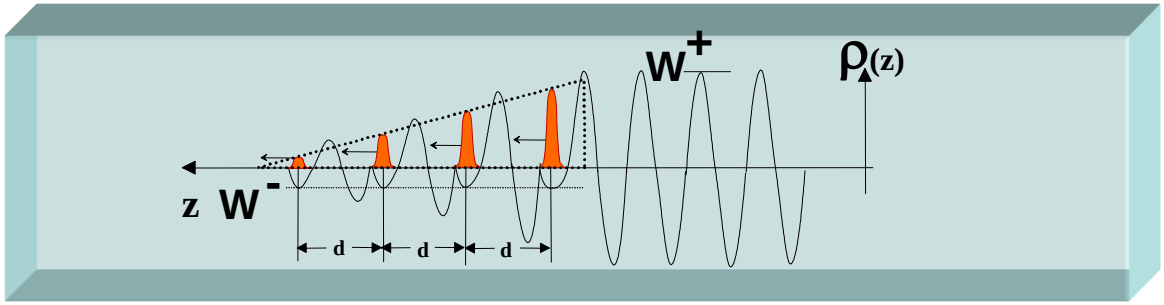


Bunch Shaping and High Transformer Ratio @AWA

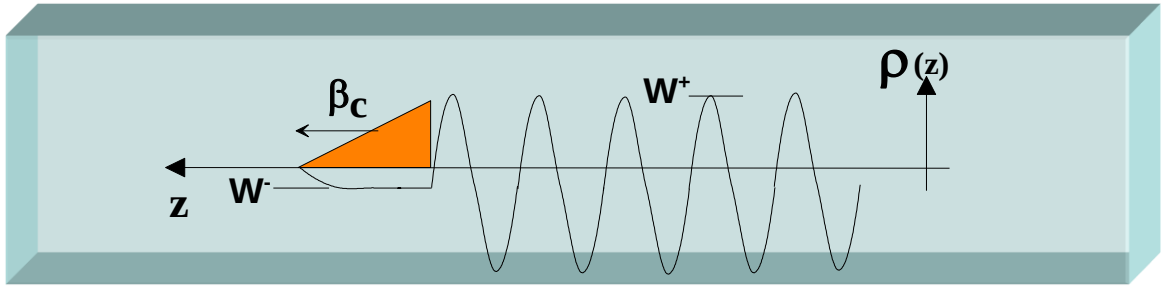
High Efficiency Wakefield Acceleration

Ramped Bunch Train

- R=2.3@PRL 98, 144801, 2007.
- R=3.4. @PR ST-AB, 14, 021302, 2011.



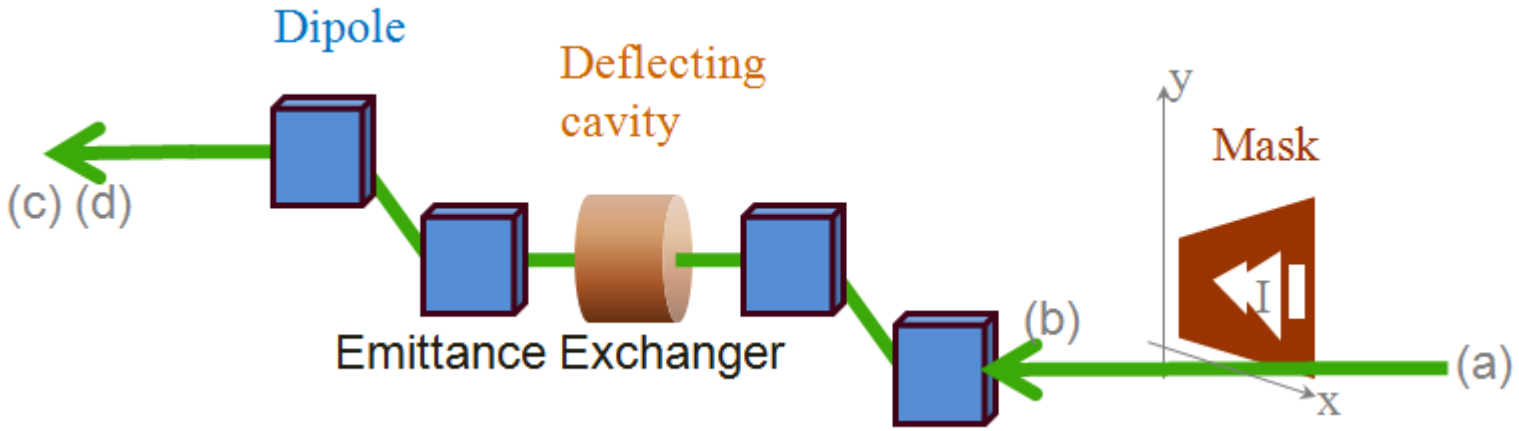
Ramped Bunch

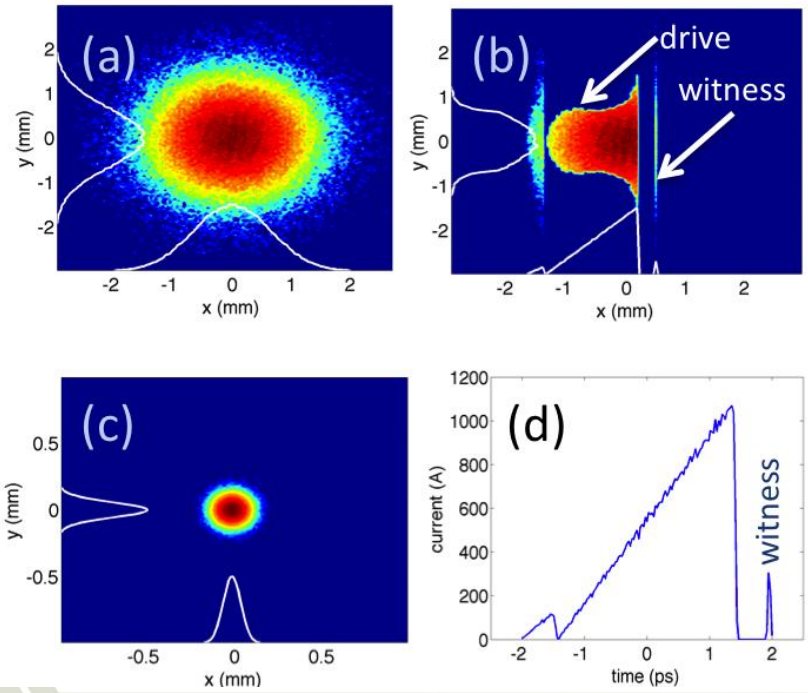


Transformer Ratio: $TR = \frac{E_{\max\, gain}}{E_{\max\, loss}}$ (Trailing bunch) / (driving bunch)

- Directly related to efficiency;
- >>2 is preferred;
- temporal shape of the bunch determined;
- favors ramped charge profile and its variations;

Bunch shaping for high transformer ratio



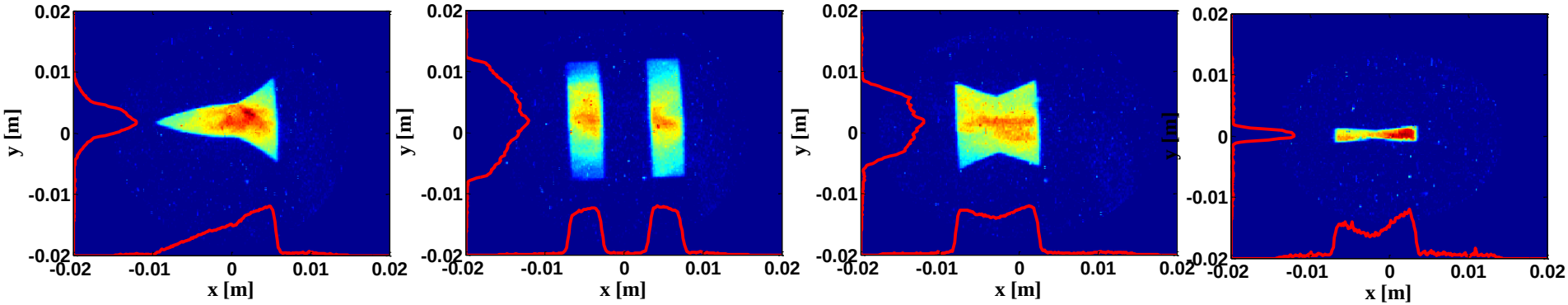


- Works well for a few nC charge after mask;
- flexible with mask shape
- witness bunch can be produced with the same mask to avoid the timing jitter;

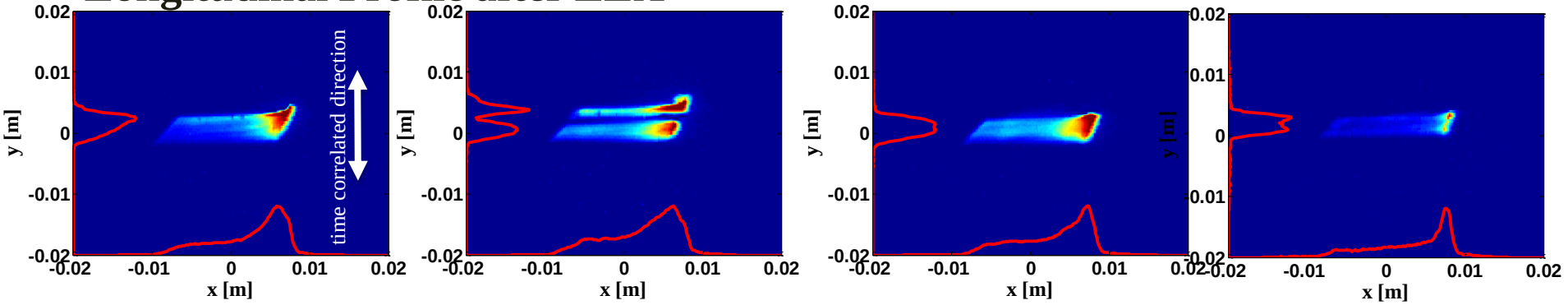
Simulation by P. Piot (NIU)

First EEX-Bunch Shaping Experiment (Gwanghui Ha)

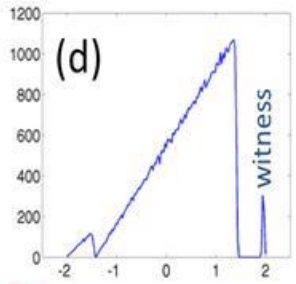
Transverse Profile after the mask

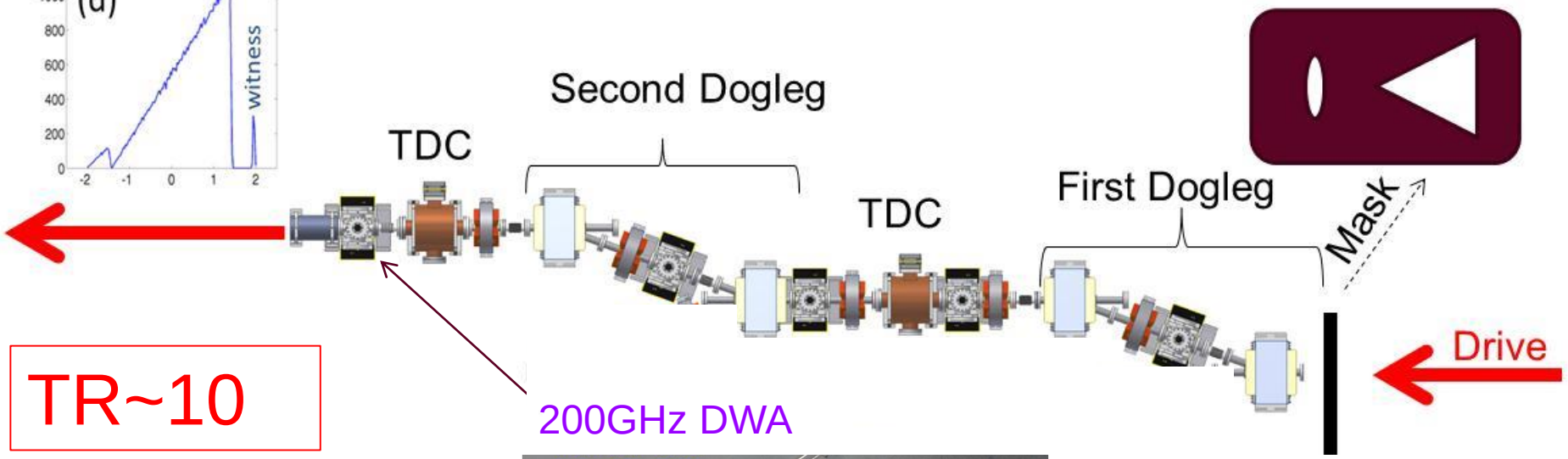


Longitudinal Profile after EEX



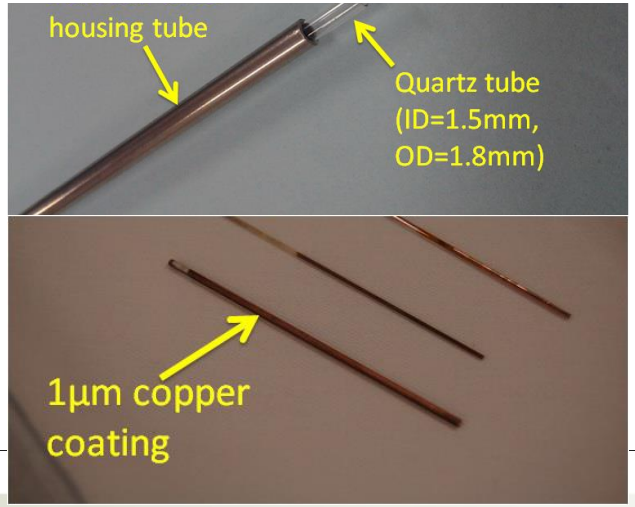
High Transformer Ratio Collinear Wakefield Experiment





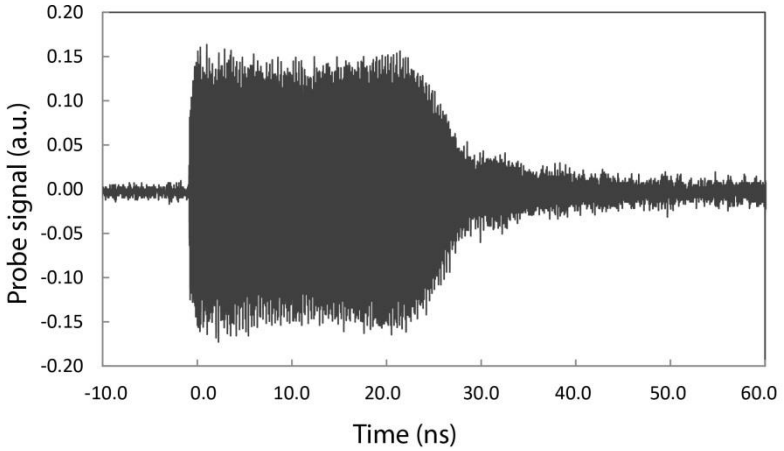
TR~10

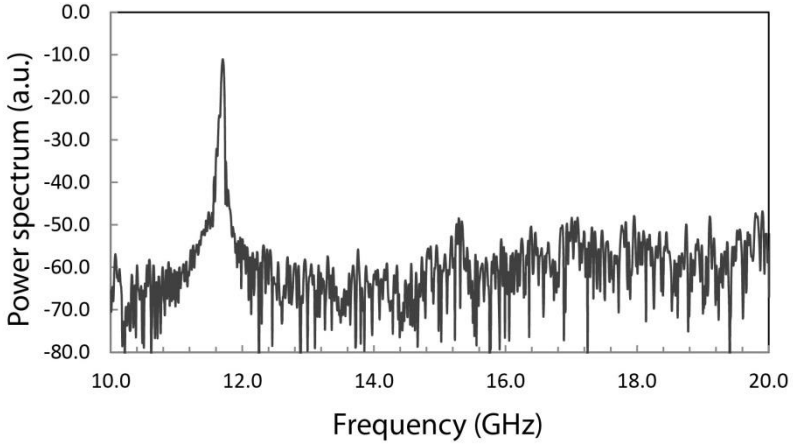
200GHz DWA

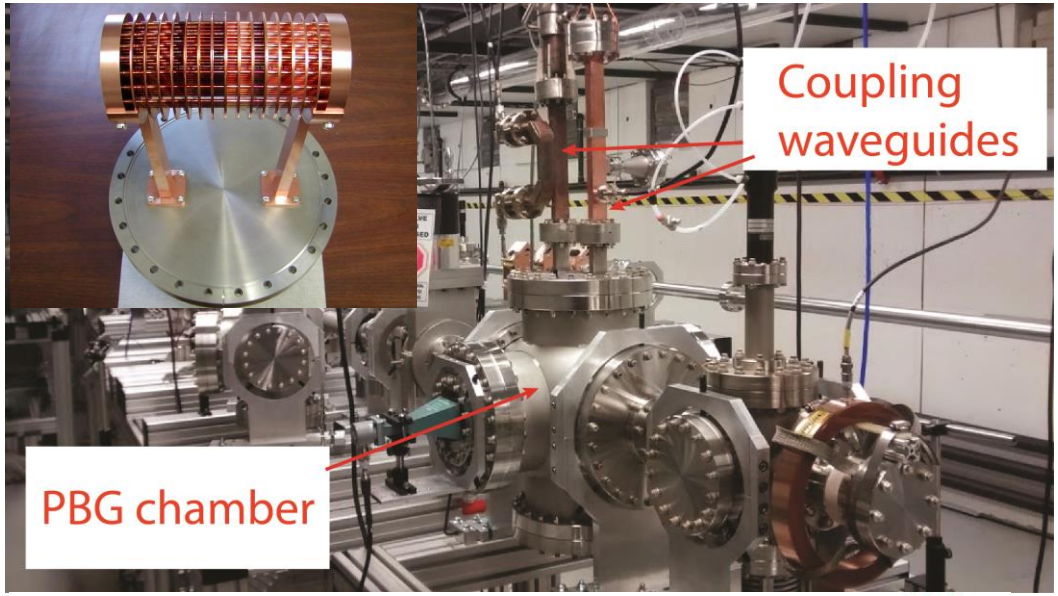


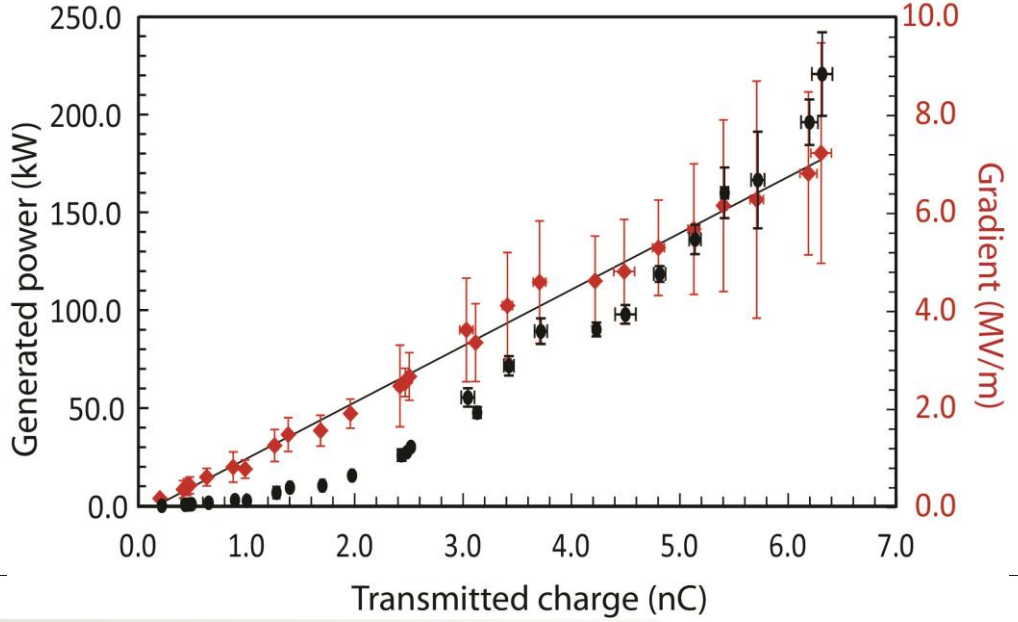
PBG Experiment

Fundamental mode



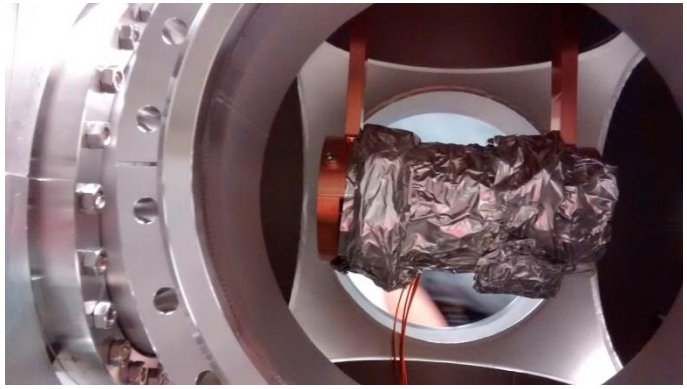


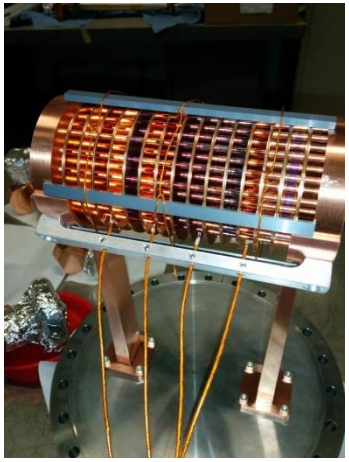




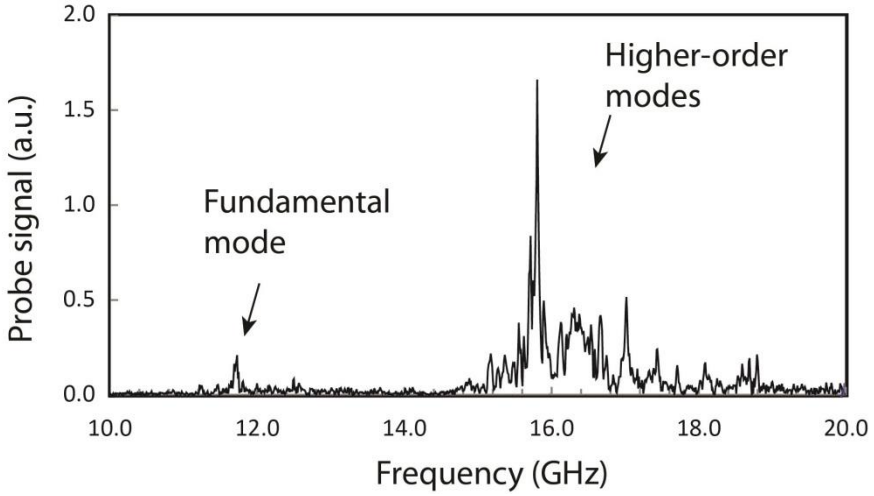
Higher Order Modes

HOMs were measured with 4 loop antenna probes installed at the periphery of the structure.

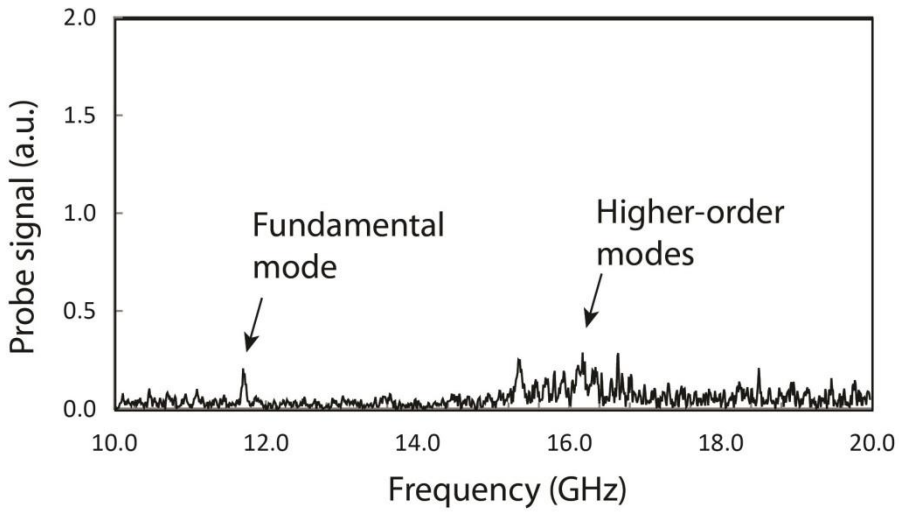




PBG structure wrapped in foil:



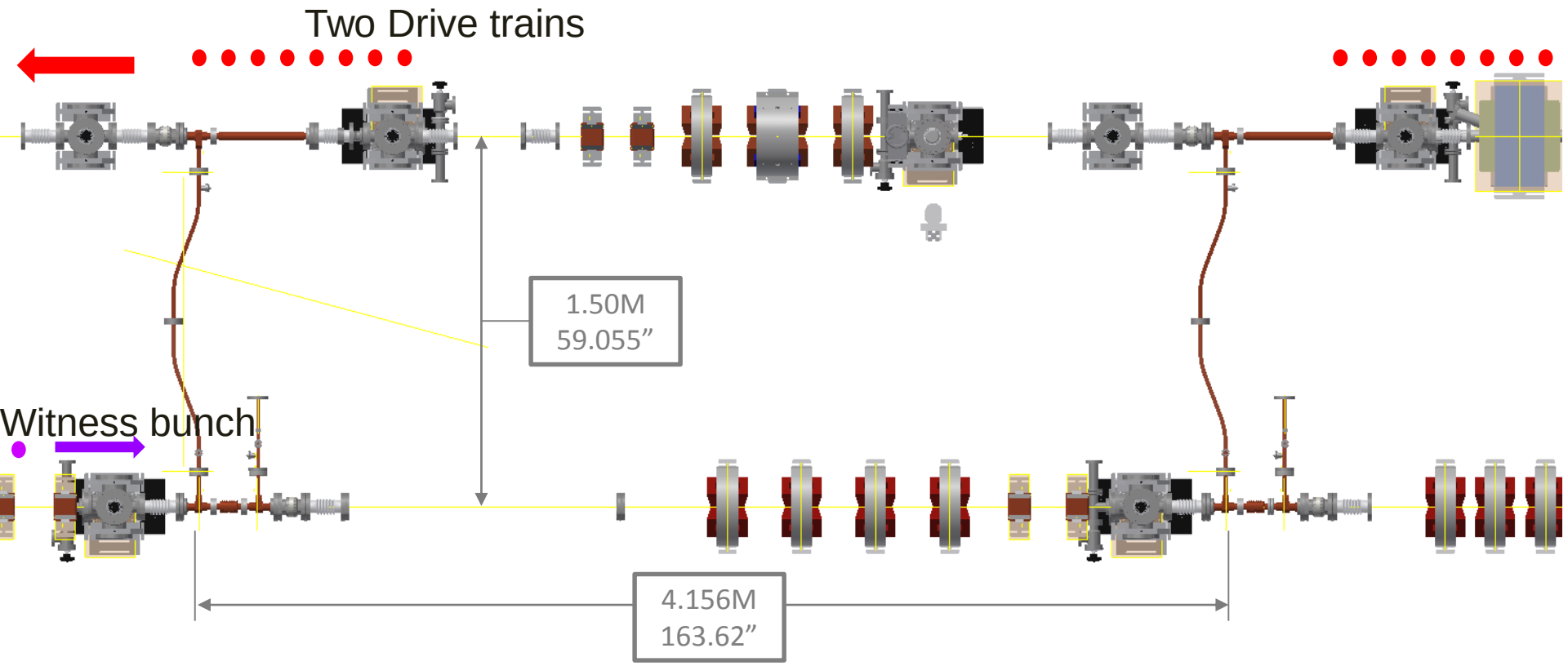
Open PBG structure with 6 SiC slabs:



Experiments in the next 3 Years

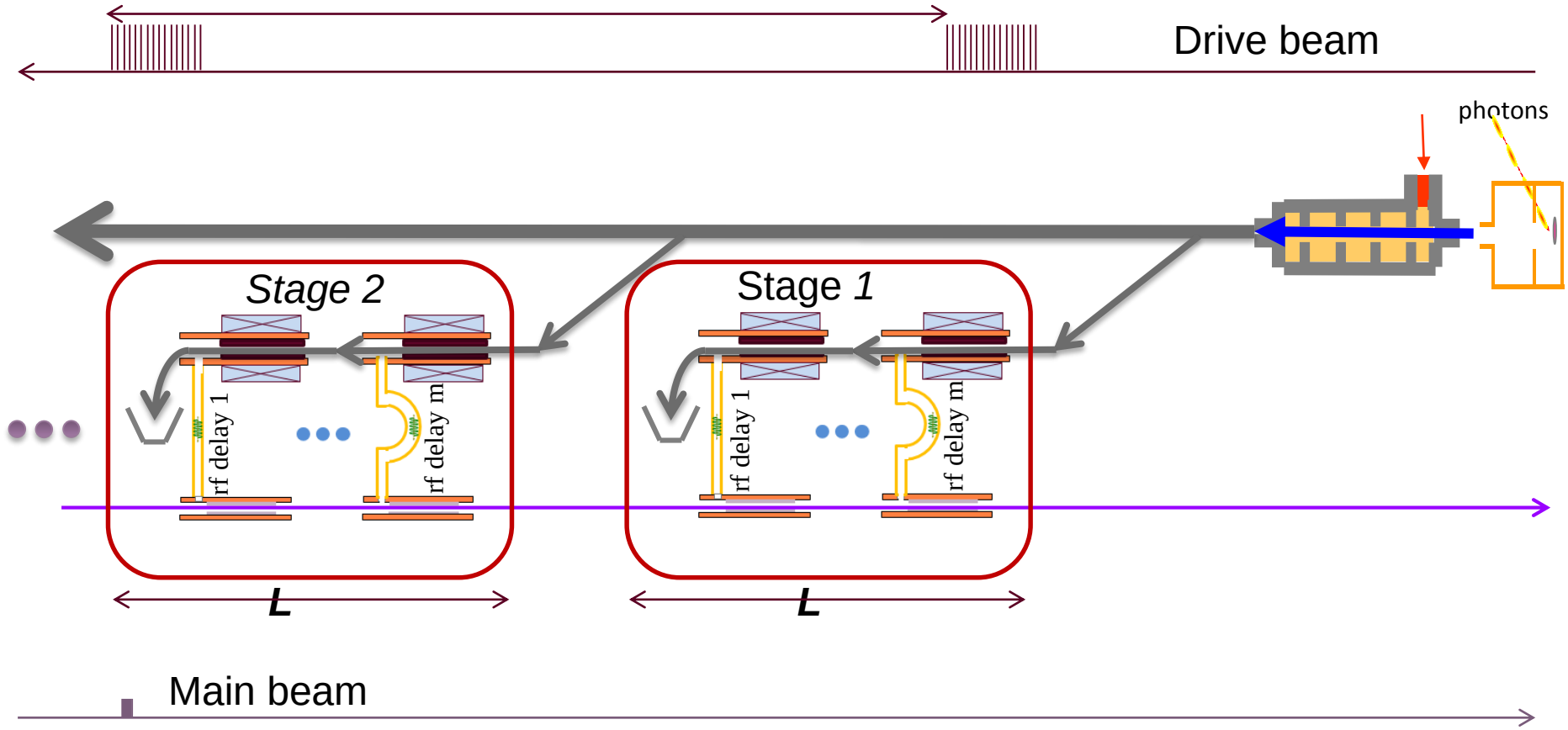
- High power rf generation beyond X-band
- Staging
- High Gradient TBA
- Ultrahigh Transformer Ratio
- Others

Staging Experiment at AWA--- Simplified Staging



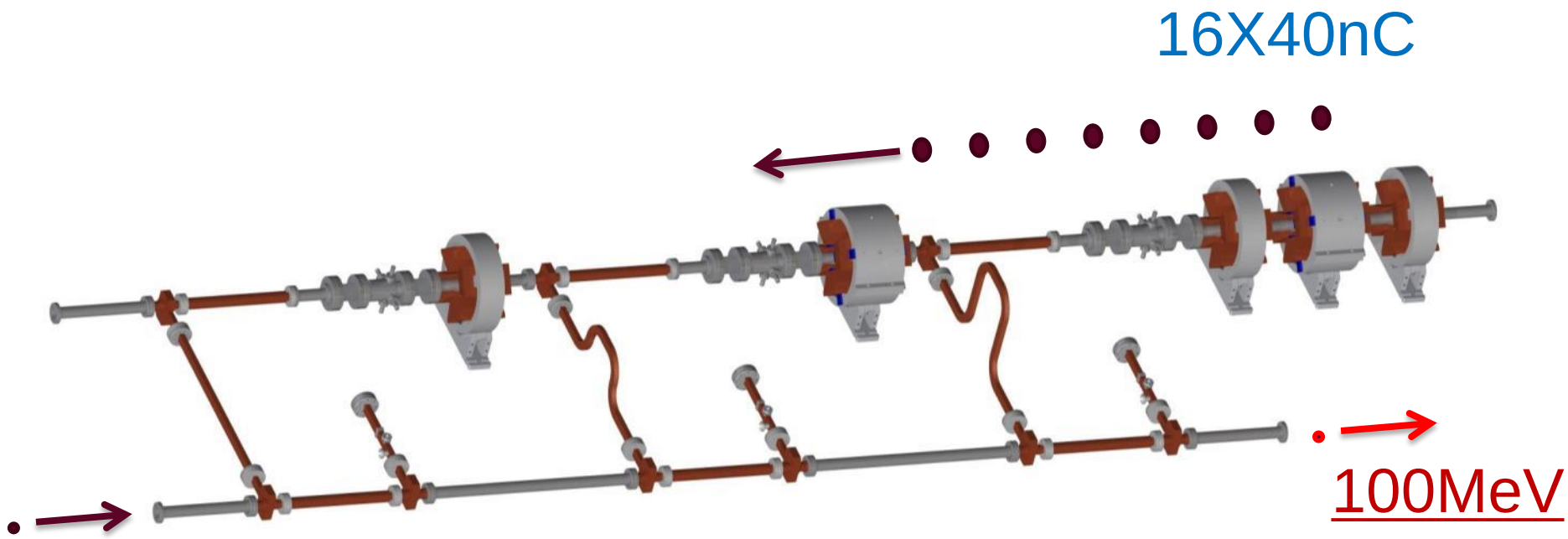
Full Staging

2L Ic



rf delay1=0;
rf delay2=$2L_s/c$;
rf delay m=$2*(m\text{-}1)*L_s/c$,
m is the # of structures in each stage,
L_s is the length of a single structure.

Goal of Two Beam Acceleration @ AWA in near term



SUMMARY

- Developing and demonstrating the key technologies for Future Accelerators. Potential applications of Argonne's wakefield technology include Linear Colliders and future light sources.
- In the recent past, the effort in the group has been balanced between the major upgrade of the AWA facility and maintaining an active Experimental program with excellent progress on both fronts.
- As the upgrade finished, the AWA program is entering a new phase, which concentrates on demonstration of Staging, High Efficiency Collinear Wakefield Acceleration, and High Gradient Acceleration. The Argonne technology may open up a path to new accelerator applications reliant on compact and efficient acceleration schemes.