Staging at the Argonne Wakefield Accelerator Facility (AWA)

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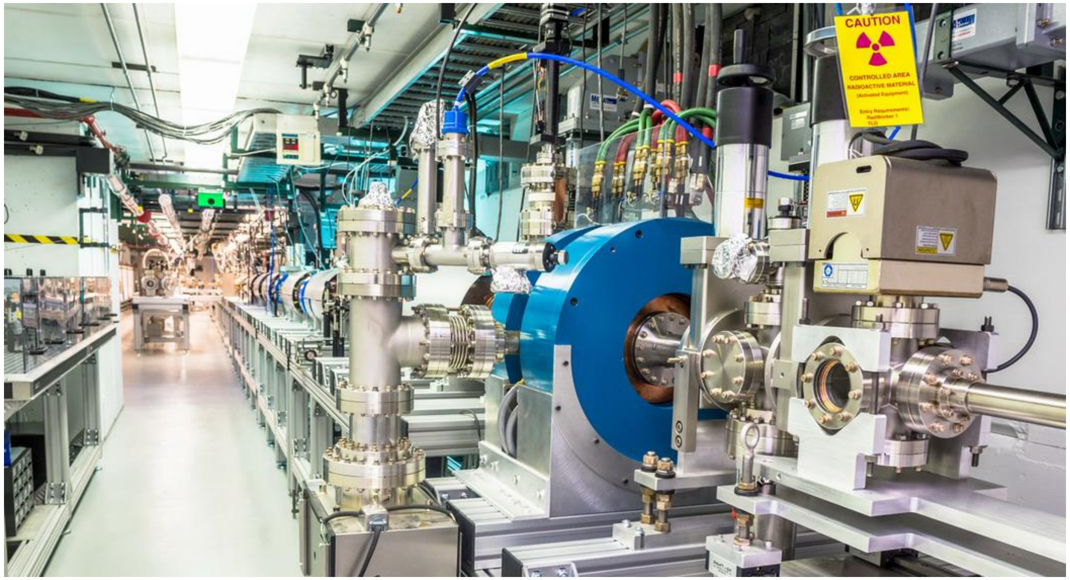
Outline

- AWA facility and its capabilities
- Two-beam-acceleration (TBA)
- TBA staging
- Dielectric loaded structure TBA

The AWA Facility:
A Flexible Testbed for Accelerator R&D

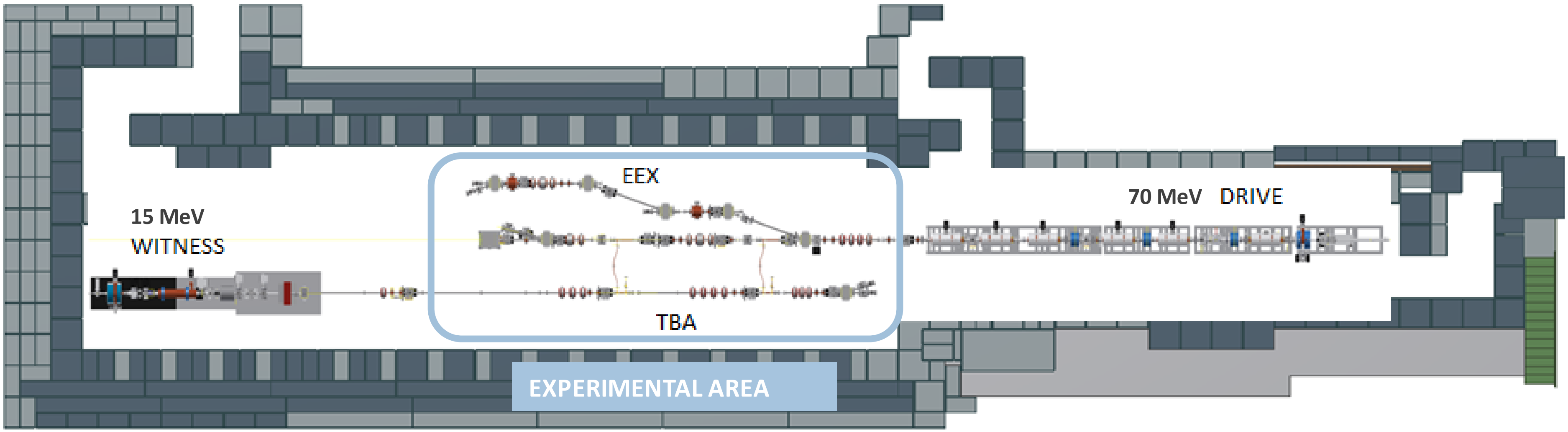


Mission:

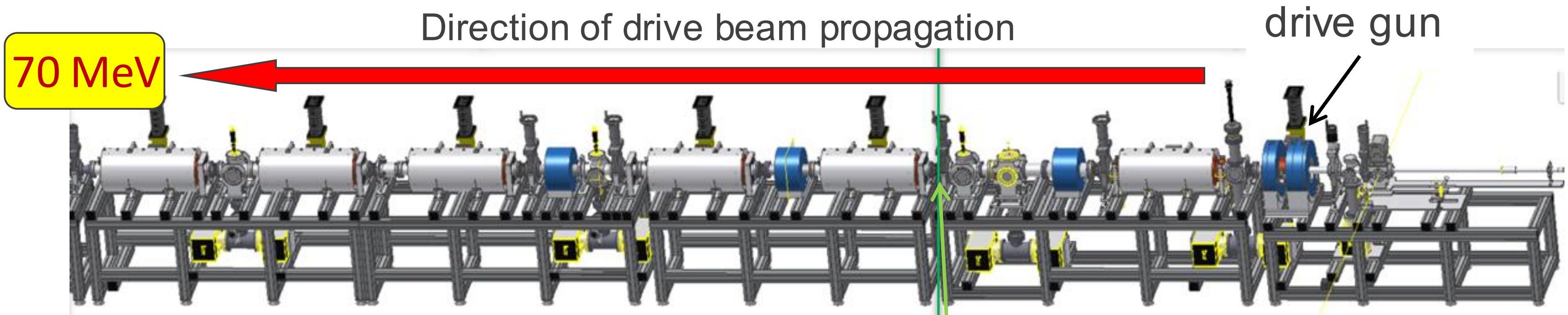
Studying the Physics and Developing the Technologies for Future Advanced Accelerators (primarily for HEP but also for other applications).

Main focus of research at AWA

- Beam driven wakefield acceleration
  - High intensity electron beam
  - Development of novel wakefield structures
- High power RF generation
- Phase space manipulation (bunch shaping)



Drive linac: High Charge Measurements

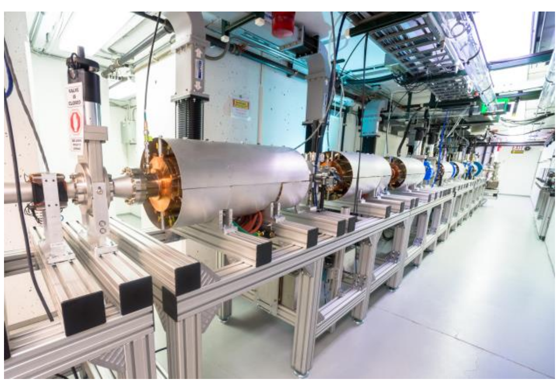


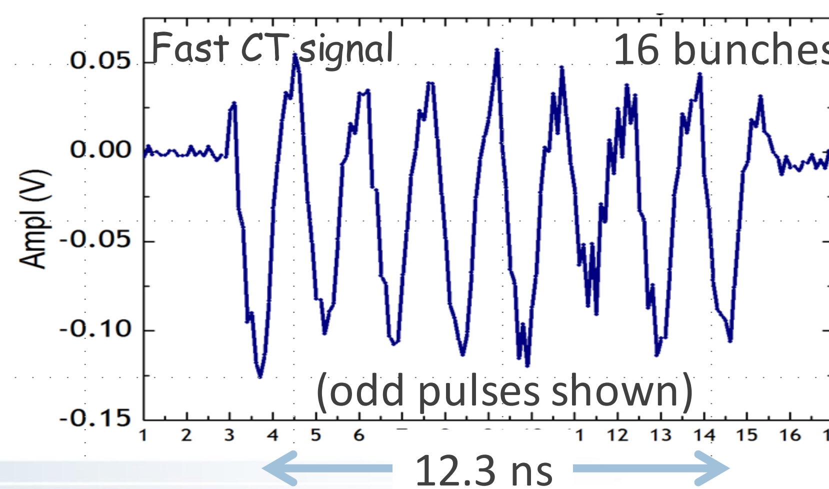
- Single bunch operation
  Q = 0.01-100 nC

- Bunch train operation
  Options of 2, 4, 8, 16, 32 bunches,
  with maximum charge in the train of about
  200 to 600 nC

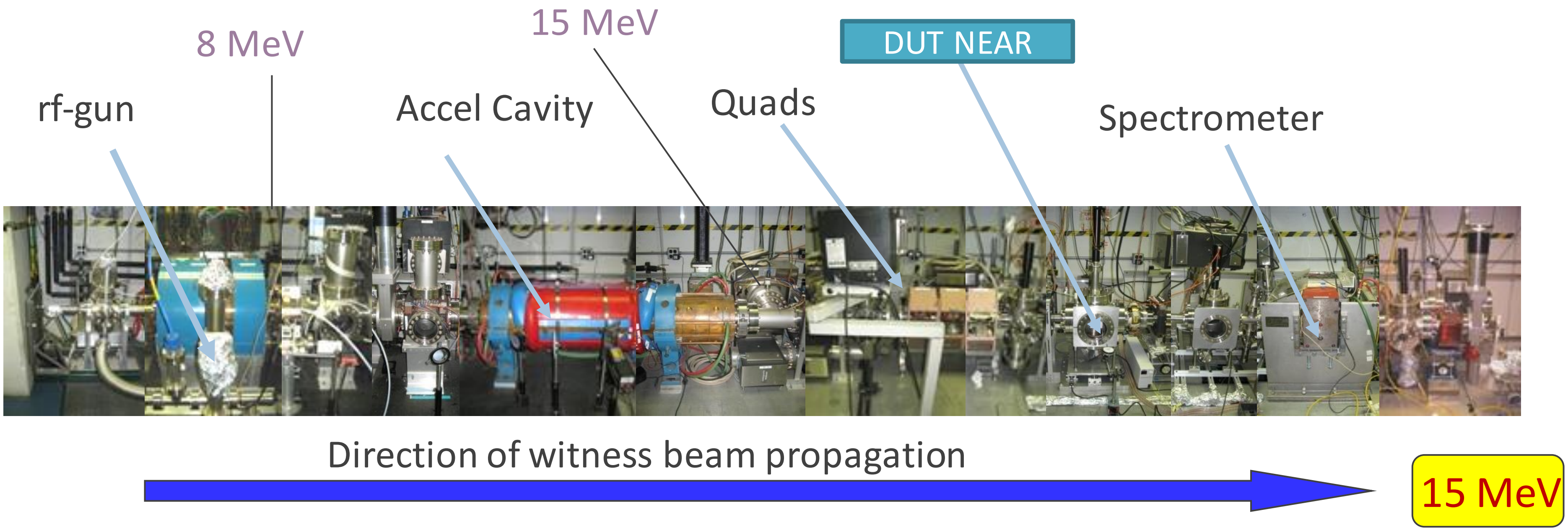
- **Drive RF photocathode Gun**
  - Cs_2Te photocathode
  - 248 nm laser
  - E_z = 85 MV/m

Variable duration = 6 – 12 ns





Witness Linac



- **Witness RF photocathode Gun**
  - Mg photocathode
  - 248 nm laser
  - E_z = 85 MV/m

Single bunch operation

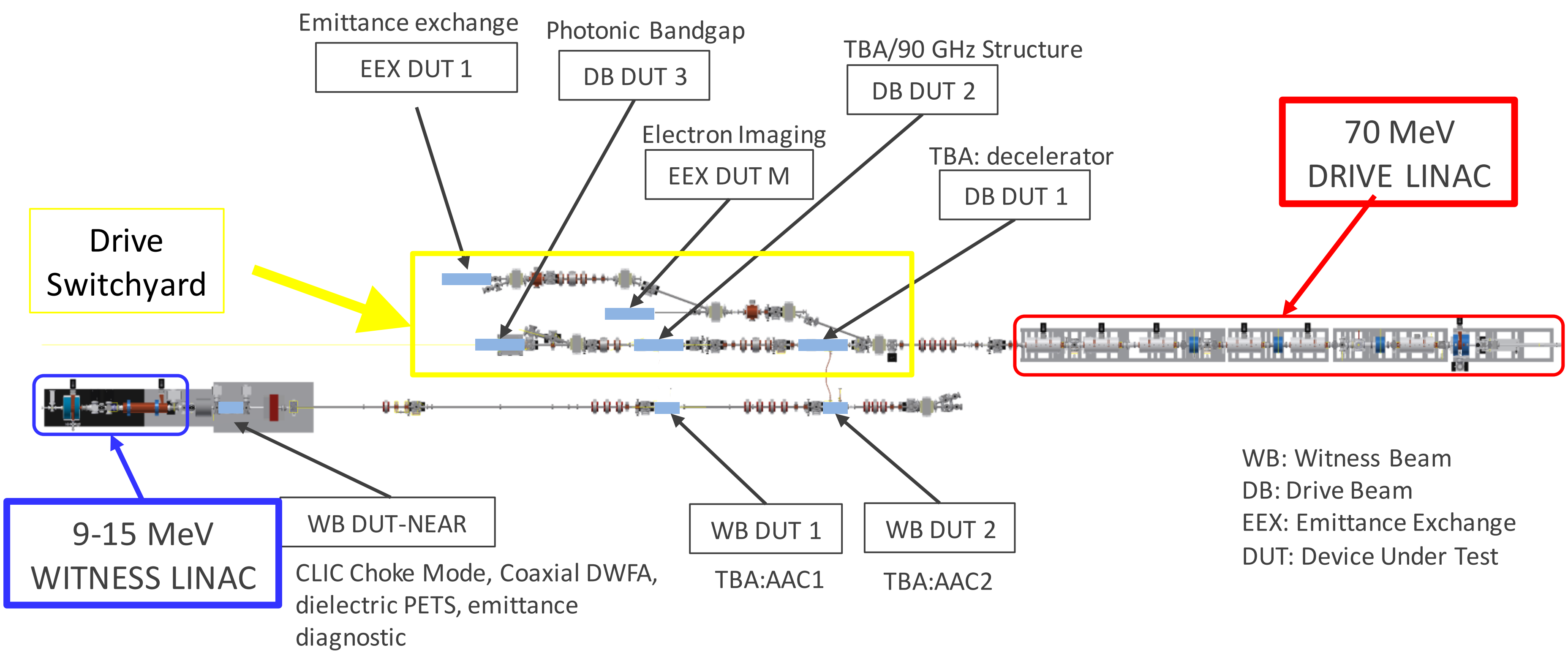
Q = 0.01-100 nC

Bunch train operation

Possible, with a total charge of about 80 nC

AWA Beamlines

Flexible and reconfigurable, with multiple experimental areas

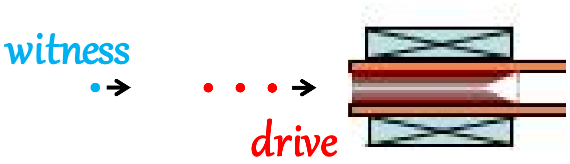


WB: Witness Beam
DB: Drive Beam
EEX: Emittance Exchange
DUT: Device Under Test

Two Different Schemes for Wakefield Acceleration

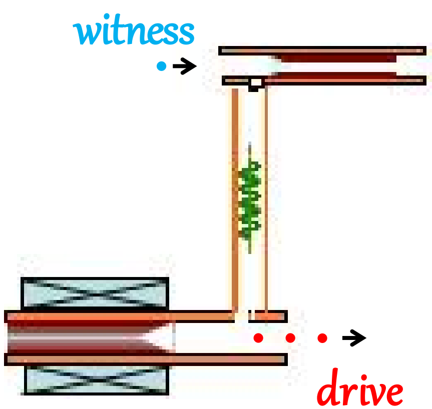
Collinear Acceleration

- Single wakefield structure
- No need for RF couplers
- Wide range of RF frequencies
- Easier to explore very high gradients at high frequencies
- Common transport optics for both beams (drive and witness) may create difficulties, especially for staging



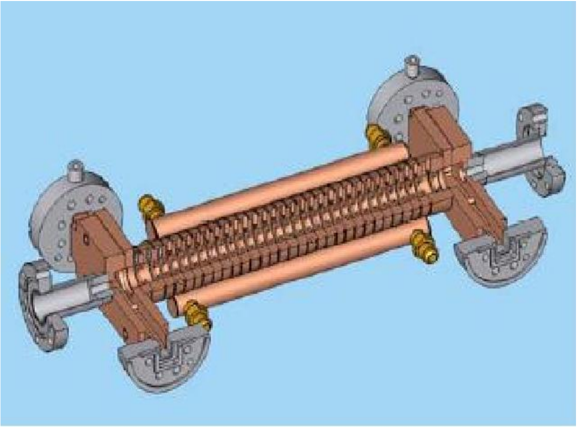
Two Beam Acceleration (TBA)

- Need for RF couplers on both structures
- Short RF pulses require broad bandwidth couplers
- Each structure can be optimized independently
- Independent beamline optics makes staging much simpler

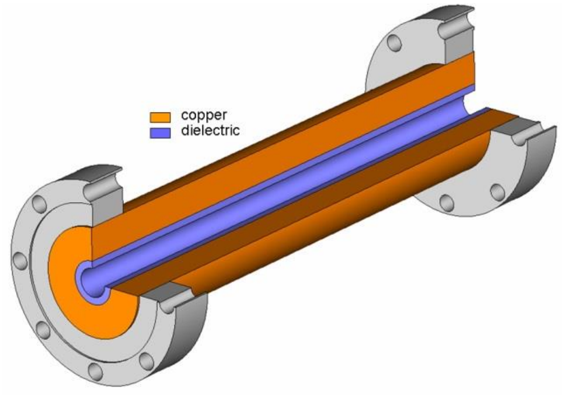


Advanced Accelerating Structure Development

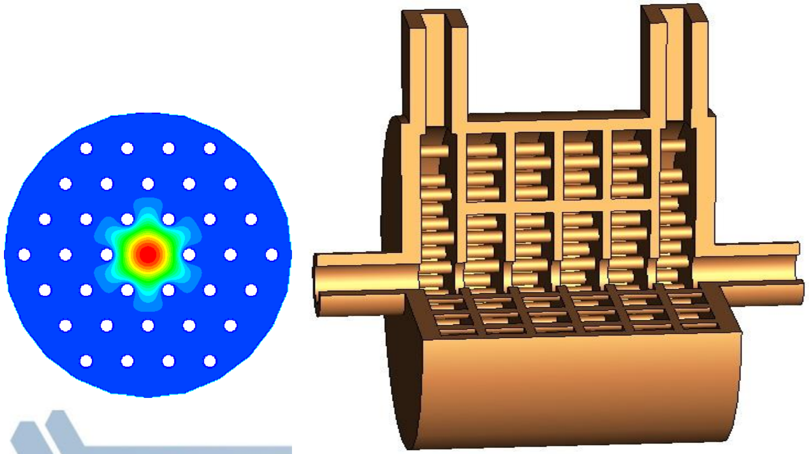
Iris loaded structures



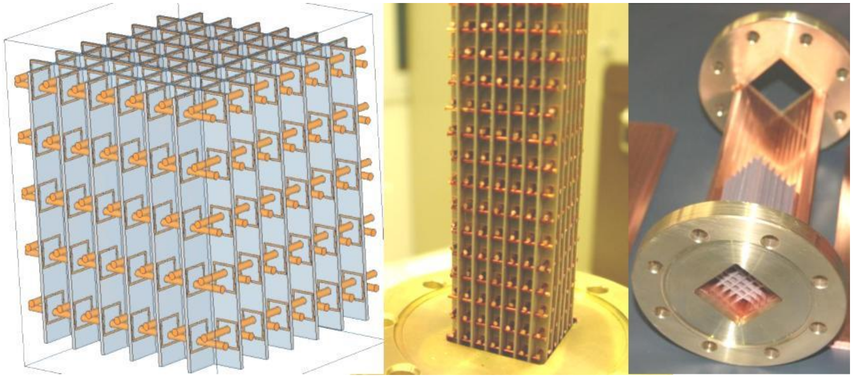
Dielectric loaded structures



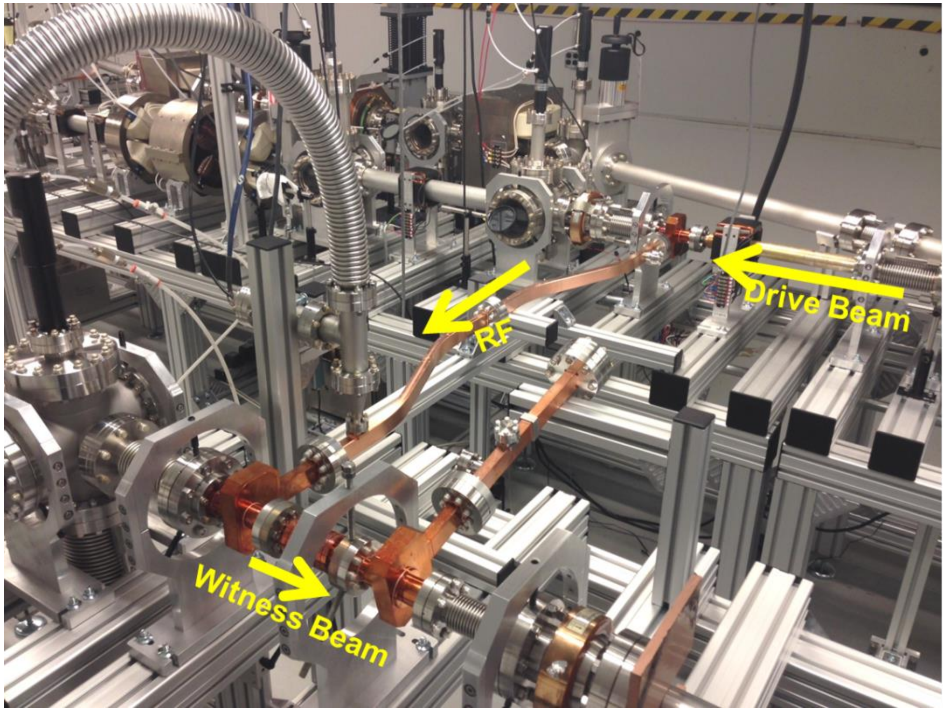
Photonic band gap structures



Meta/left-handed structures

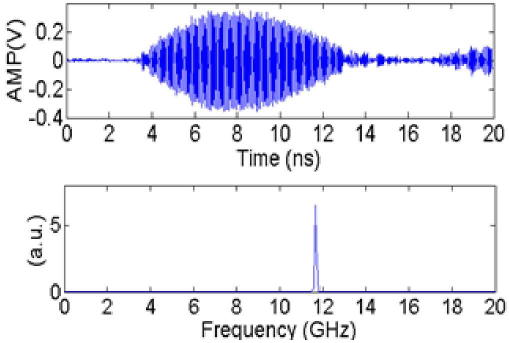


TBA experiment
11.7 GHz iris loaded metallic structures



Decelerating structure:
2π/3 mode
35 cells + coupling cells
0.22c group velocity

Accelerating structure:
2π/3 mode
3 cells + coupling cells
0.014c group velocity

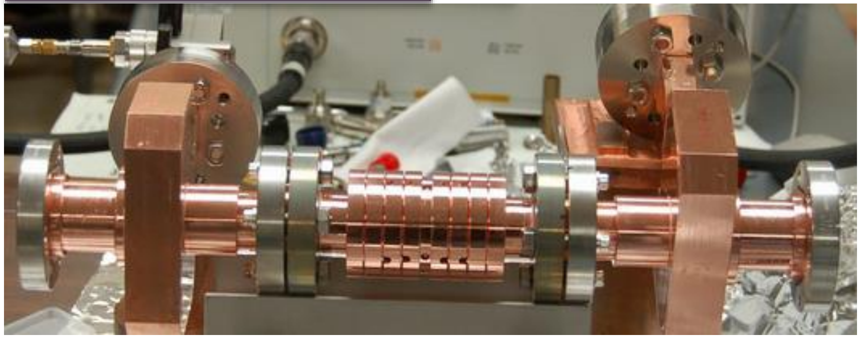


Structures used in the TBA/Staging Experiment

Power Extractor

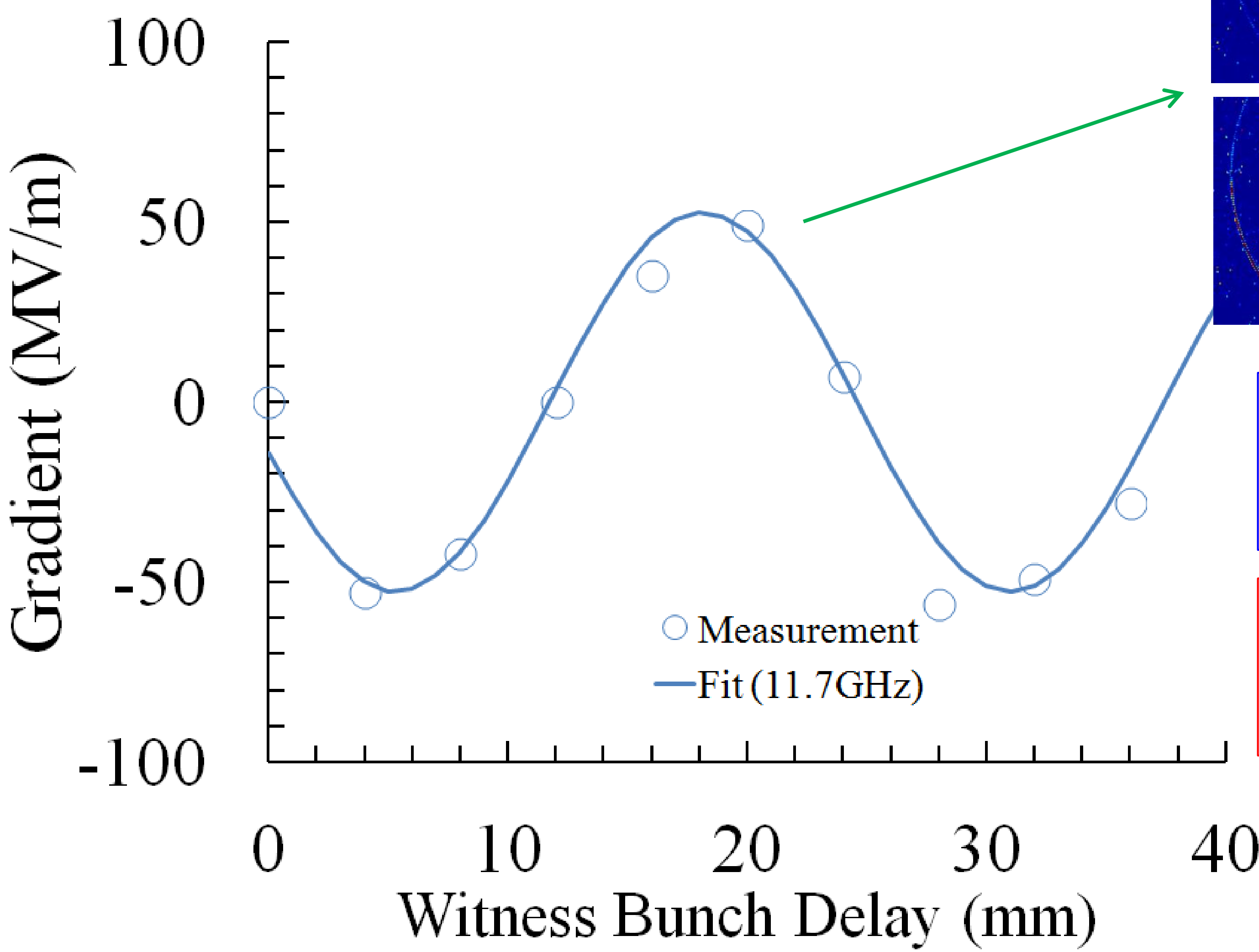
	Value
Freq.	11.7GHz
Mode	2pi/3
Aperture	17.6mm
Length	30cm
Passing Charge	8 x 20nC
Power	55MW

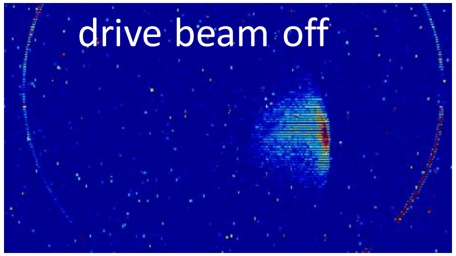
Accelerator

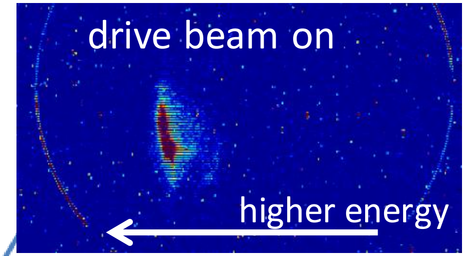


	Value
Freq.	11.7GHz
Mode	2pi/3
Aperture	6mm
Length	3cm
Input power	50MW
Gradient	100MV/m

TBA data
Acceleration Measured: ~ 50 MV/m





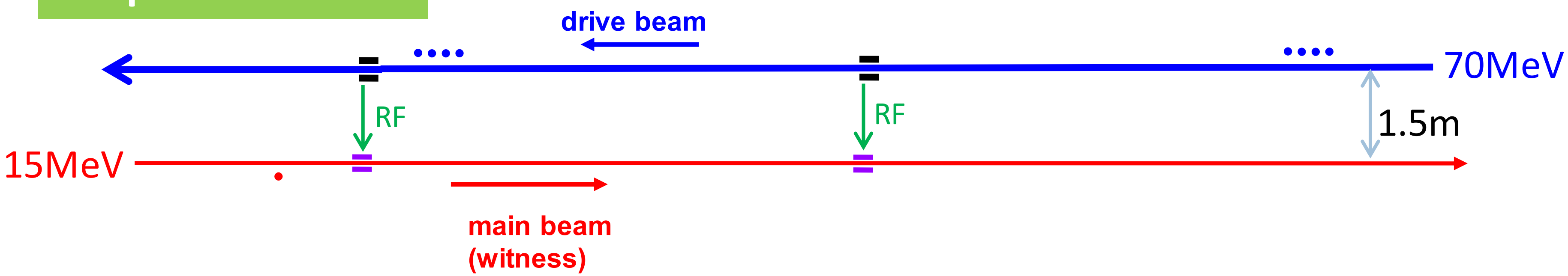


Witness beam:
8.5 ± 1.4 MeV
0.5 nC

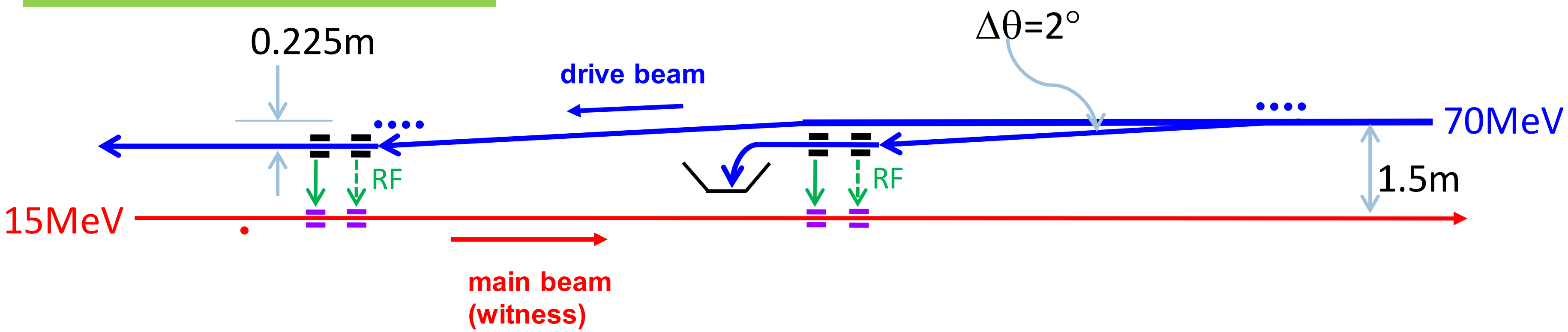
Drive beam:
8 bunches
90 nC charge in train

Staging Demonstration

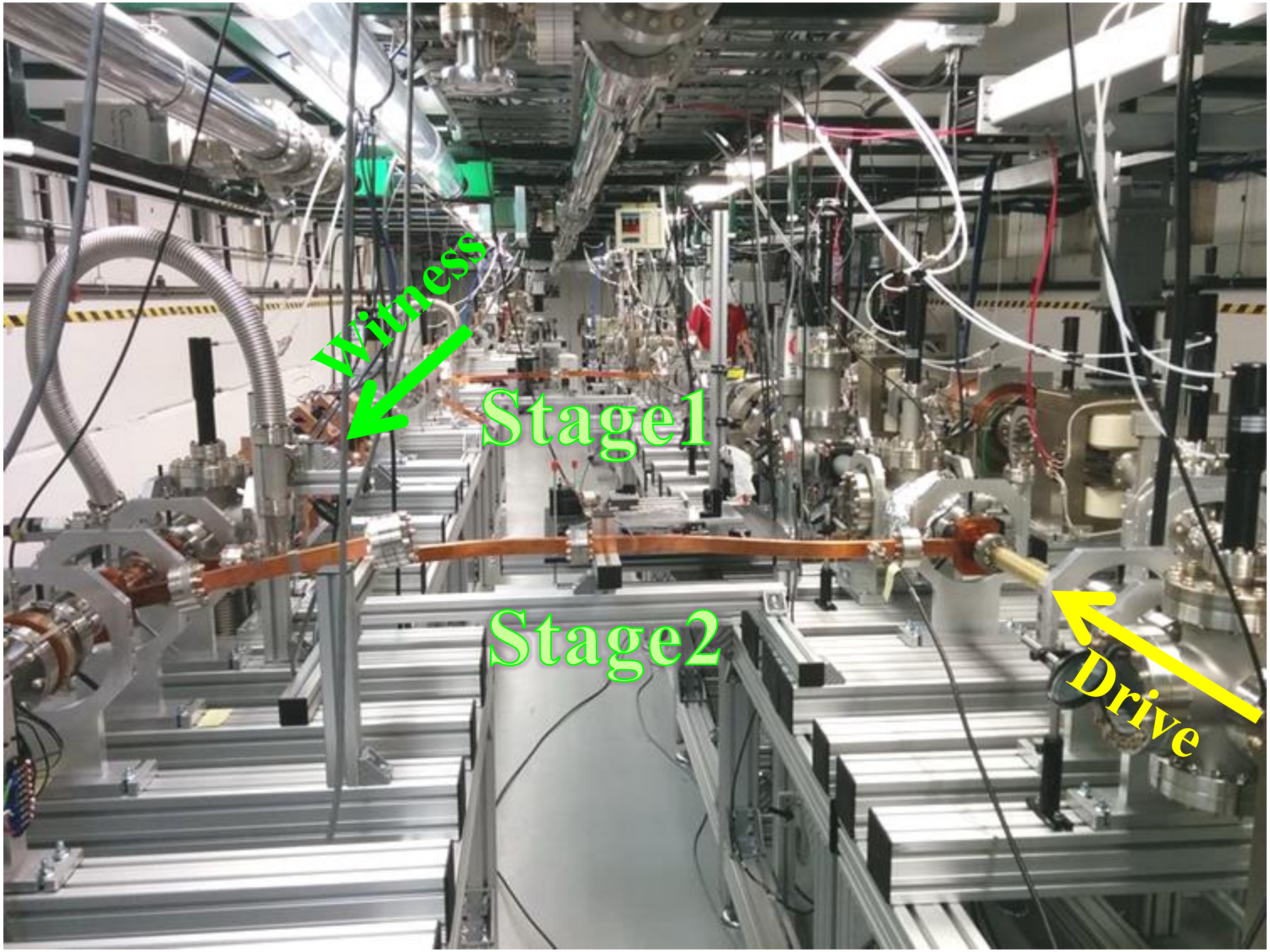
Simplified Version



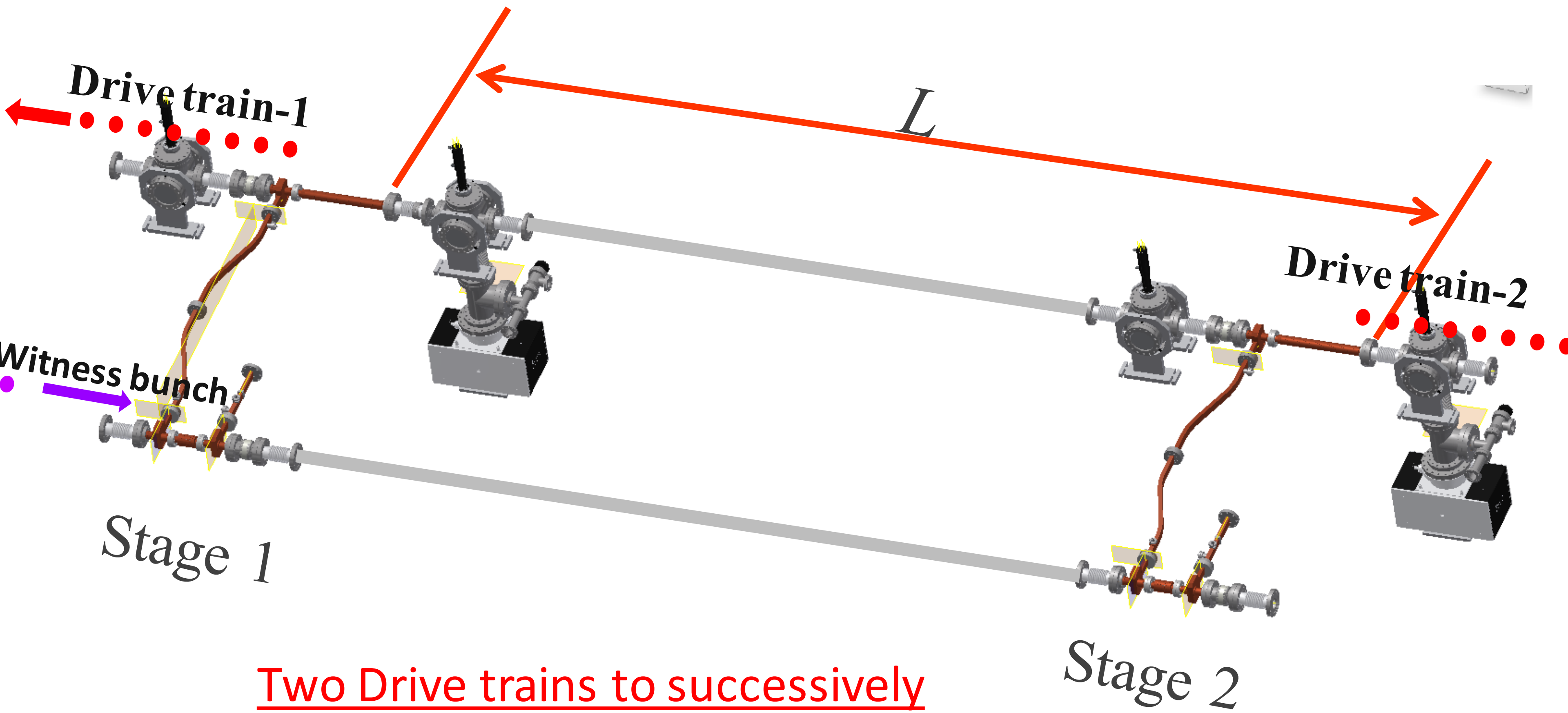
More realistic Version



Staging Demonstration at AWA

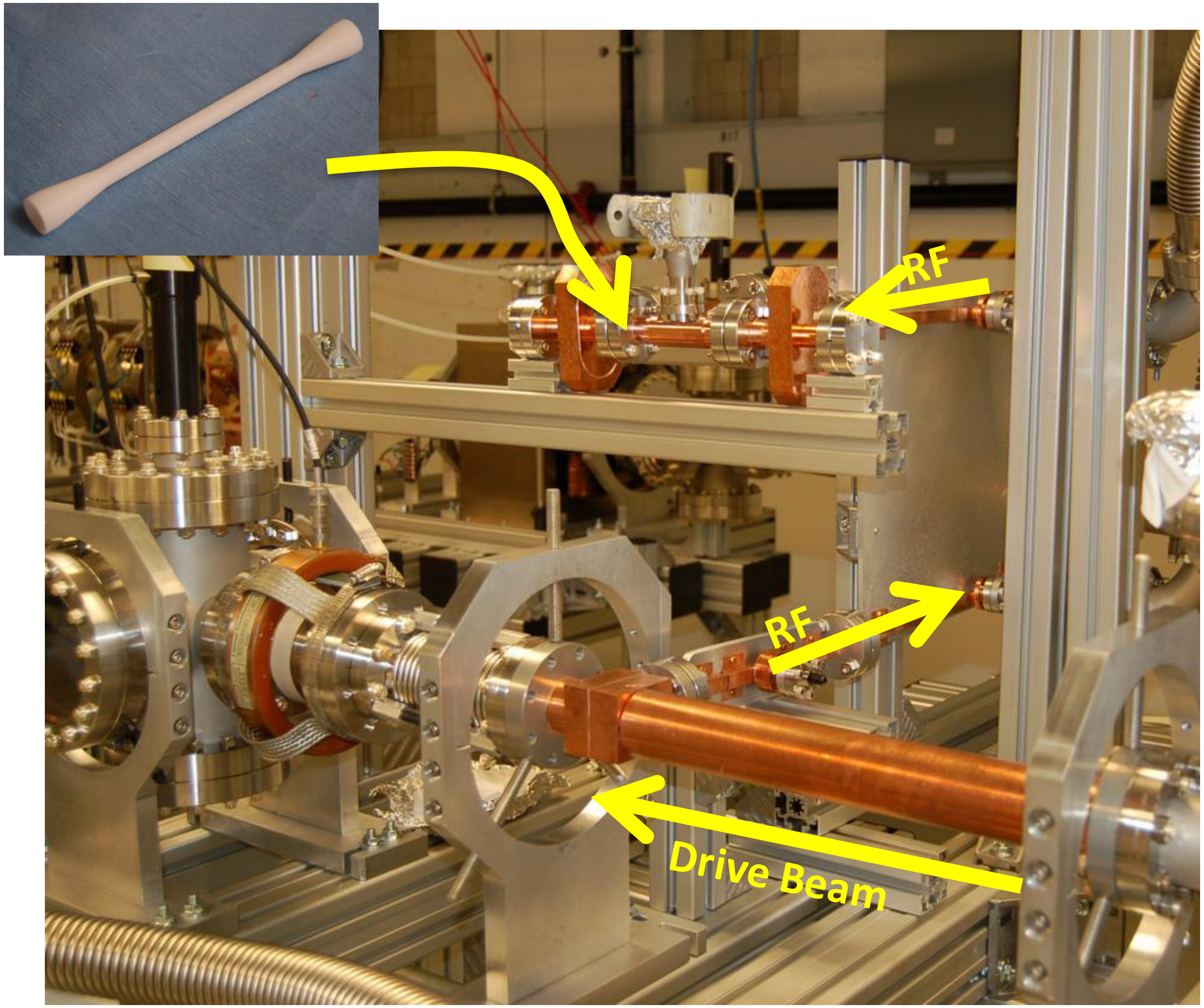


Timing Required for Staging Experiment



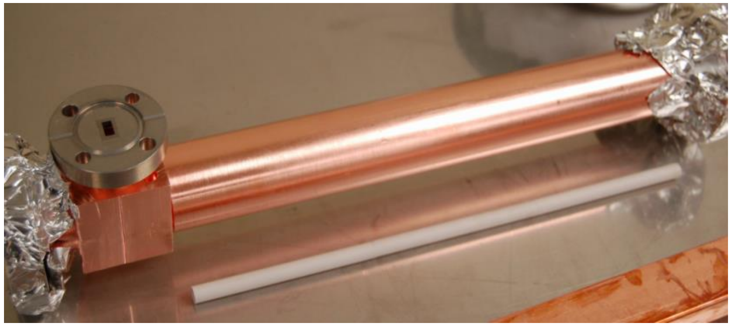
Two Drive trains to successively accelerate one witness bunch while preserving its beam quality

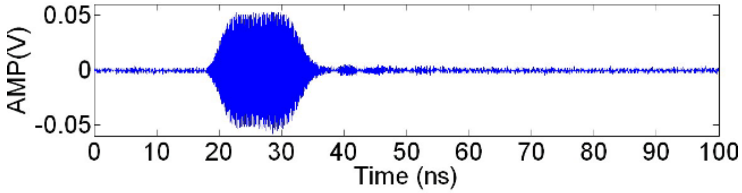
Next TBA experiment:
26 GHz dielectric loaded structure



- 37MW max RF power measured out of the Power Extractor.
- Equivalent to 54MV/m gradient in the DLA structure.
- No breakdown was observed.
- RF pulse is ~ 5 - 15ns depending on the number of bunches in the train.
- Aiming for ~300 MW power & ~150 MeV/m

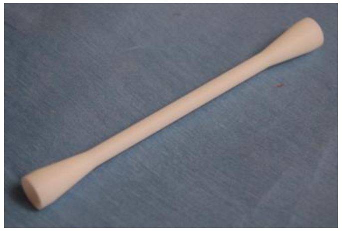
26 GHz Structure Parameters: Power Extractor





Dielectric ID / OD	7 mm / 9.068 mm
Dielectric constant	6.64
Length	30 cm
V_g / c	0.25
R/Q	9.79 kΩ/m
BW_{3dB} of coupler	120 MHz
Bunch charge	25 nC
Peak gradient	84 MV/m

26 GHz Structure Parameters: Accelerator



Dielectric ID / OD	3 mm / 5.025 mm
Dielectric constant	9.70
Length	10 cm
V_g / c	0.11
R/Q	22 kΩ/m
Q (loss tan = 10^{-4})	2295
Shunt impedance	50.4 MΩ/m
Input power	300 MW
Gradient	150 MV/m

Thank you for your attention!

And big thanks to DOE for the continued support!