AWA Overview and Activities

Dan Wang for Wei Gai

ANL HEP AWA

CLIC workshop 2016

Outline

- Mission & strategy
- AWA facility overview
- Recent experiments
- AWA beamlines & capabilities

Mission

Studying the Physics and Developing the Technologies for Future HEP Accelerators (and possibly other applications).

Reasons for the mission (Challenges for Future HEP Linear Colliders):

- High gradient (~ hundreds MV/m) and High Impedance (high R/Q)
  - Requires new or alternative accelerating structures.
- High Power RF Sources (~ GW Scale)
  - Requires new type sources.
- Higher order mode damping
  - Requires beam breakup control.
- Positron acceleration
- Find pathway to LC / Higgs factory

The AWA Approach: a Path to a Future HEP Machine

Short RF pulses

Shorter RF pulses are less likely to cause breakdown. The energy efficiency and structure bandwidth can be made appropriately high.

Advanced structures (e.g. dielectrics)

Dielectric materials are likely to withstand higher electric fields than metals, without arcing. Metallic structures also studied.

Structures that can accelerate electrons and also positrons

Since colliders are assumed to need electron beams and positron beams, we need to develop accelerating structures that can operate with either.

Schemes that allow for staging

Likely to need multiple stages to achieve desired energy. Need injection and precise control of the RF phase of multiple stages.

The AWA Group

Scientists / Engineers:

Wei Gai (group leader), Manoel Conde (Facility Manager), Scott Doran, Wanming Liu, John Power, Eric Wisniewski .

Euclid Resident Scientists:

Sergey Antipov, Sergey Baryshev, Chunguang Jing, Jiaqi Qiu.

Technical Support:

Charles Whiteford.

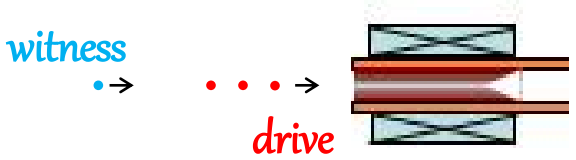
Current Students:

Jiahang Shao (Tsinghua Univ., China), Dan Wang (Tsinghua Univ., China), Gwanghui Ha (POSTECH, Pohang, S.Korea), Ben Barber (Univ. Chicago), Nicole Neveu (Illinois Inst. Tech.), Mark Warren (Illinois Inst. Tech.), Yanru Wang (IMP, China), Qiang Gao (Tsinghua Univ., China).

Two Different Schemes

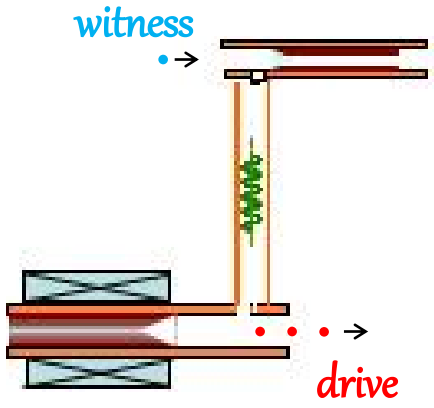
Collinear Acceleration

- 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

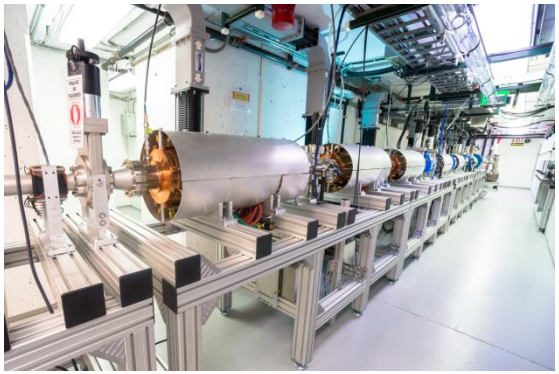


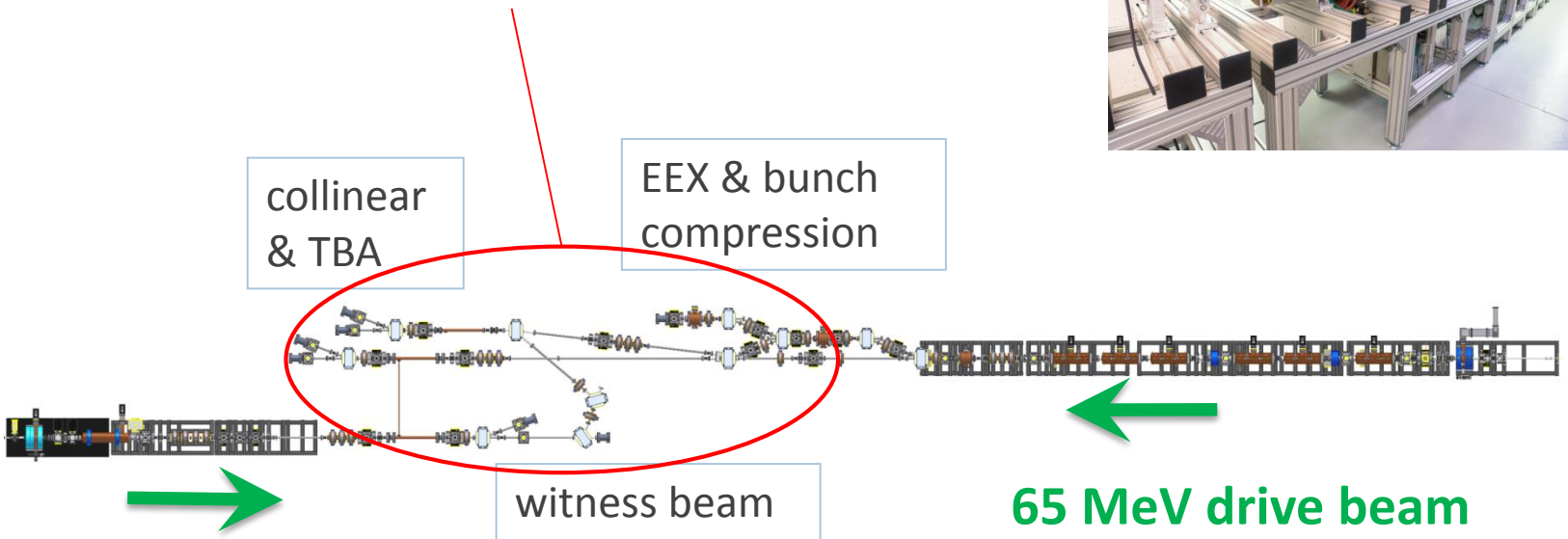
Two Beam Acceleration (TBA)

- 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



AWA Beamlines





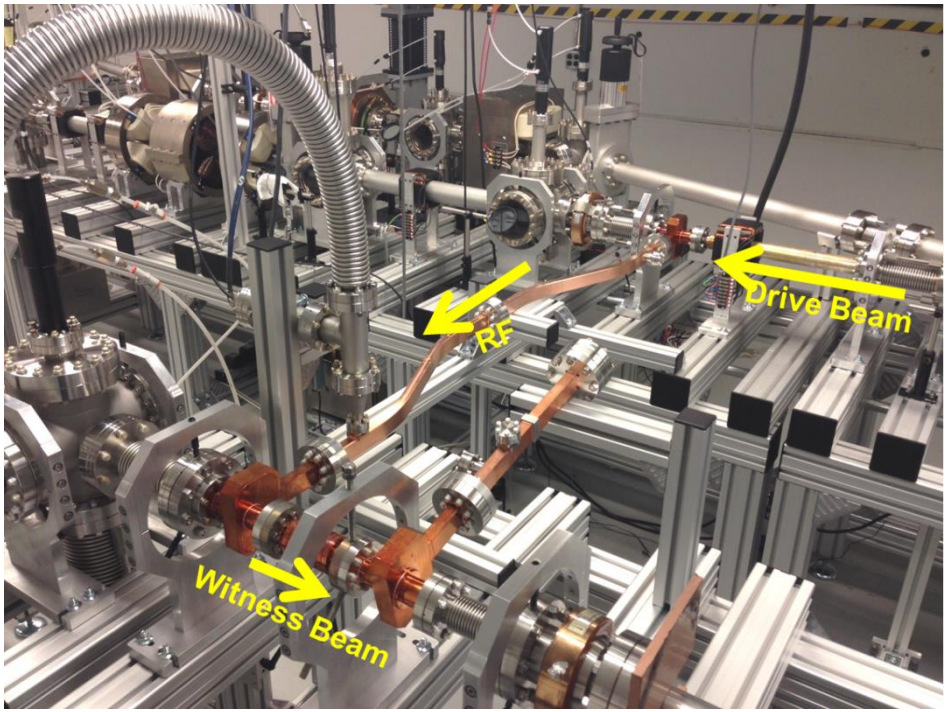
15 MeV witness beam

- single bunches
- bunch charge 0.05 to 60 nC

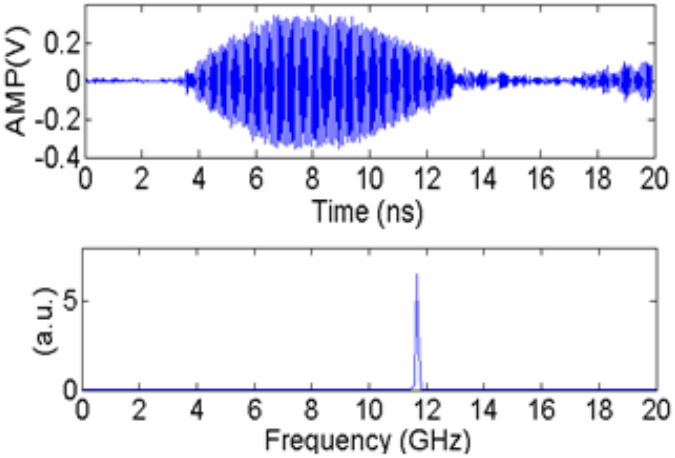
65 MeV drive beam

- bunch trains of up to 32 bunches
- Maximum charge in single bunch **100 nC**
- maximum charge in bunch train **600 nC**.

TBA experiment
11.7 GHz iris loaded metallic structures

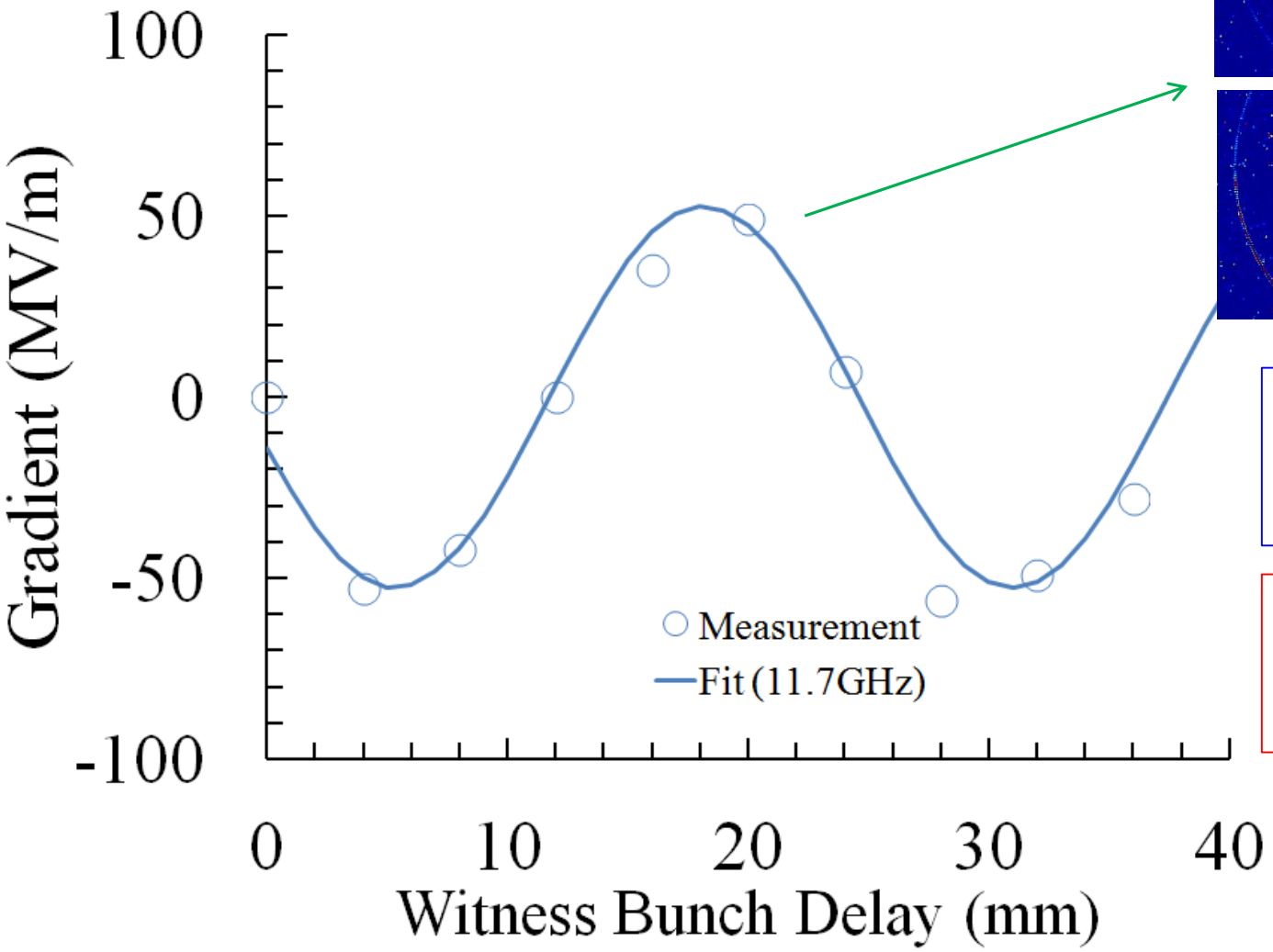


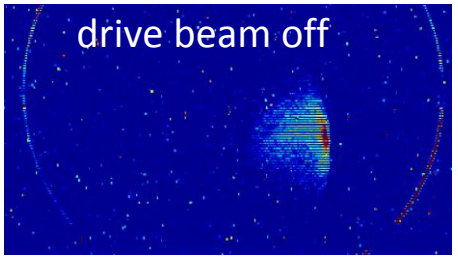
Decelerating structure:
2π/3 mode
35 cells + coupling cells
0.22c group velocity

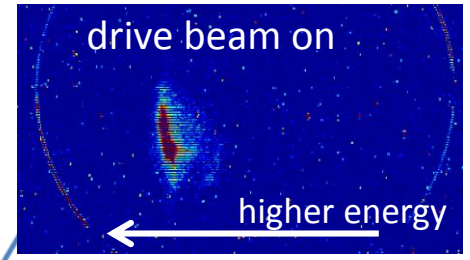


Accelerating structure:
2π/3 mode
3 cells + coupling cells
0.014c group velocity

TBA data
(initial results)



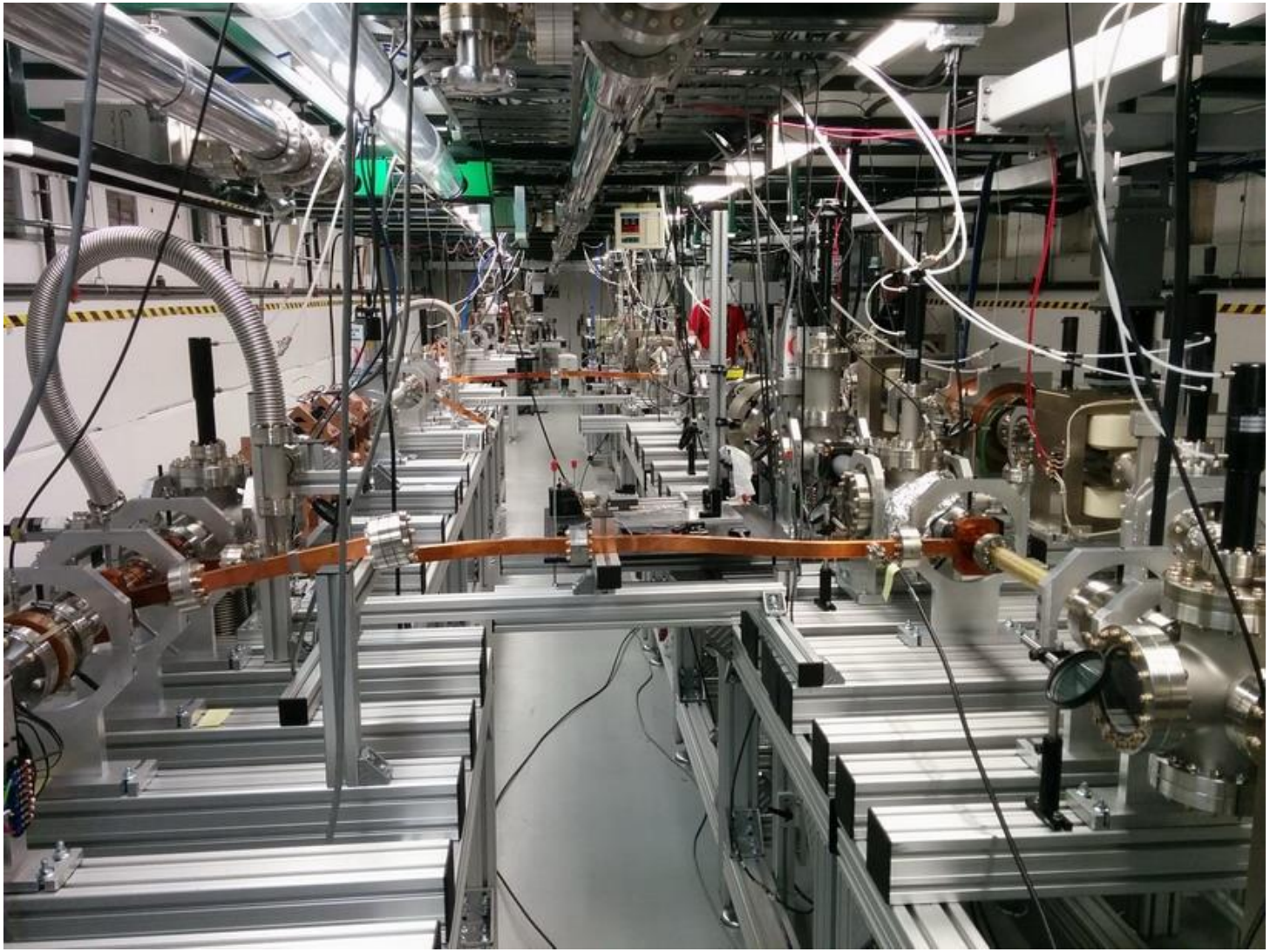




Witness beam:
8.5 ± 1.4 MeV
0.5 nC

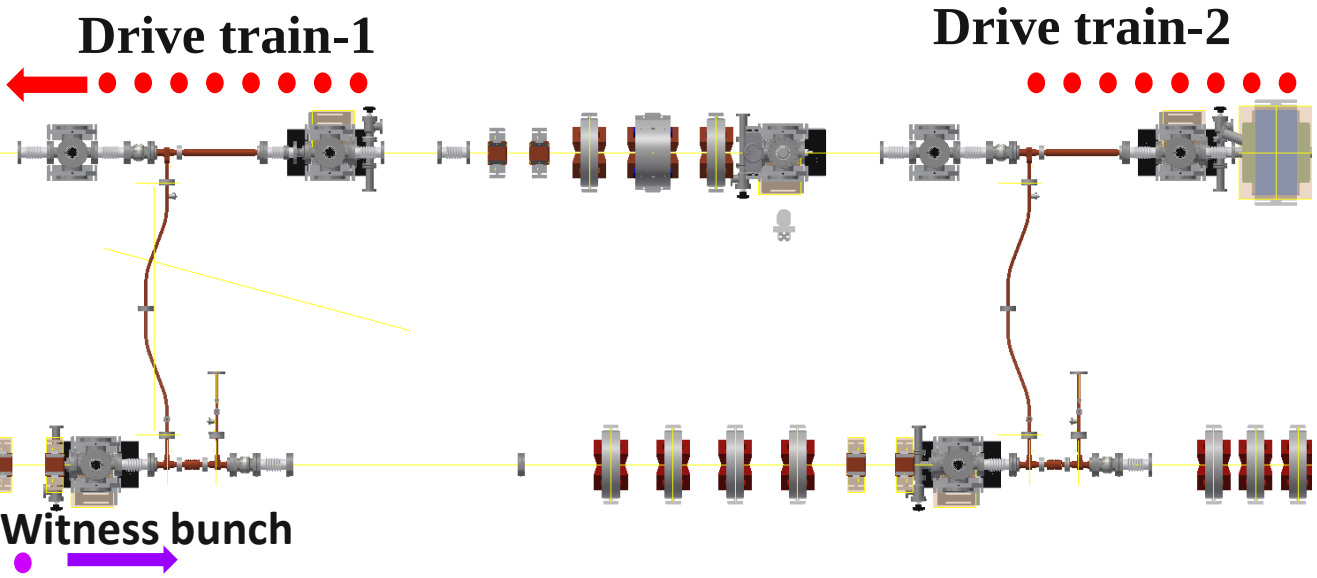
Drive beam:
8 bunches
90 nC charge in train

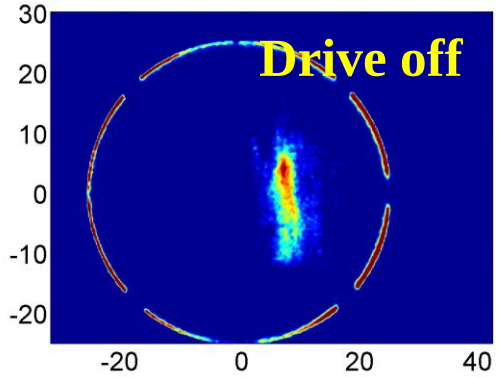
Staging Experiment
11.7 GHz iris loaded metallic structures

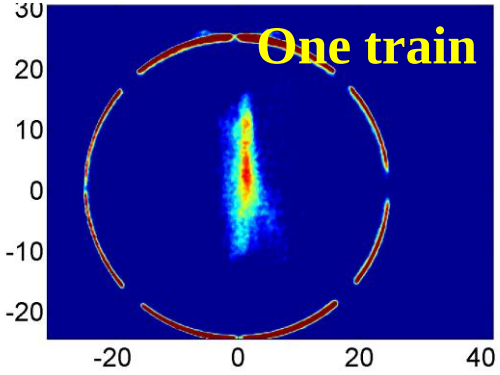


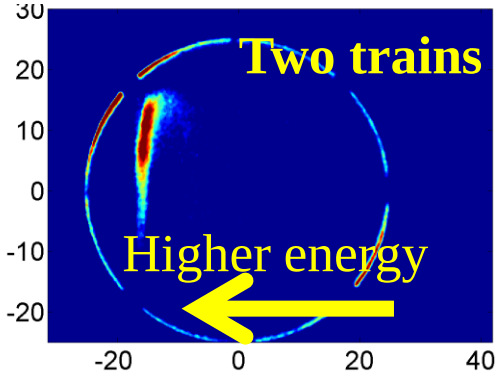
First Staging Experiment at AWA

Two Drive trains to continuously accelerate one witness bunch

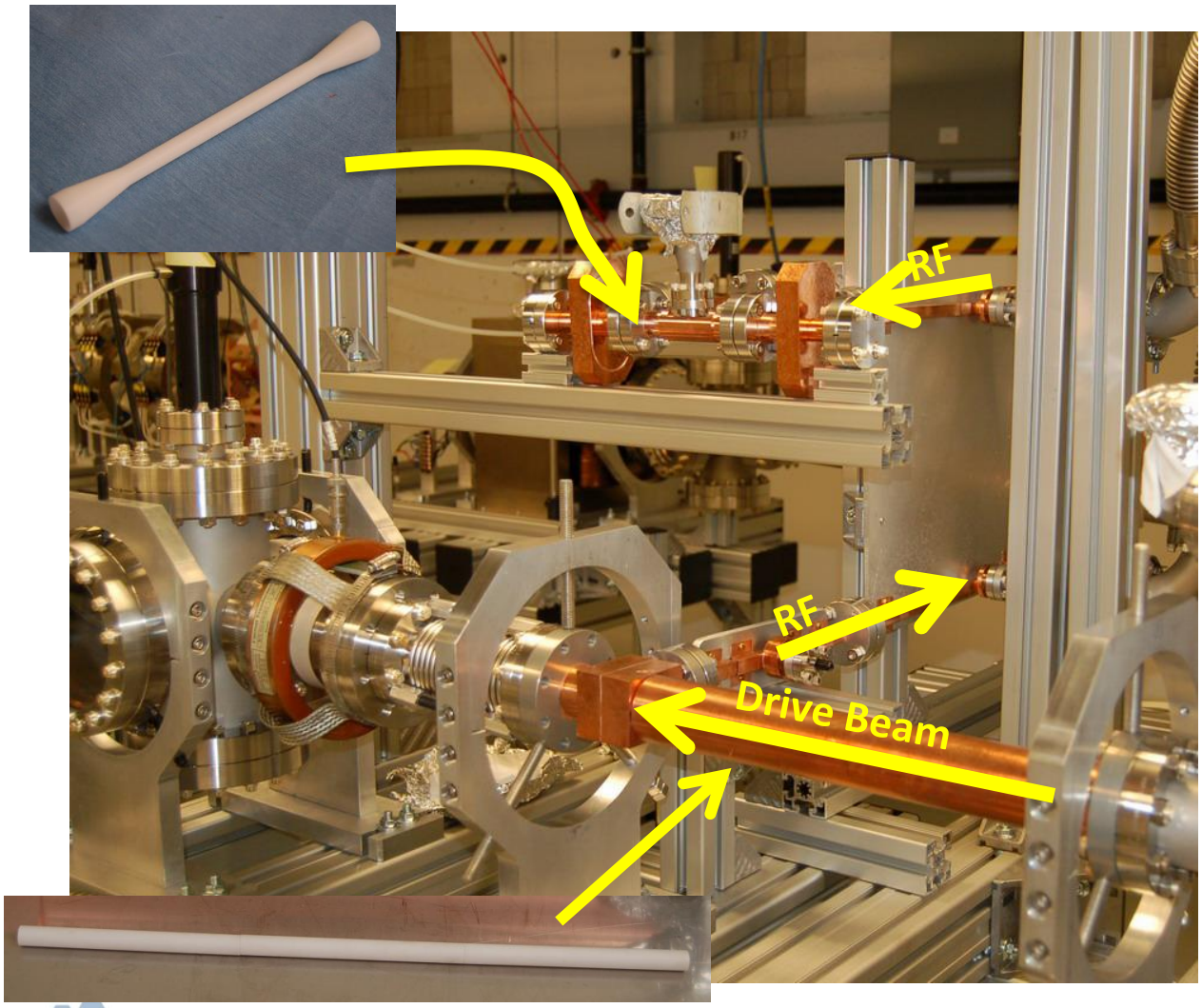






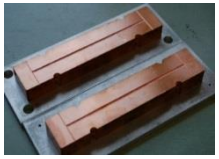


High power rf test of 26GHz Dielectric Loaded Accelerator using RF pulses extracted from the AWA Drive Beam



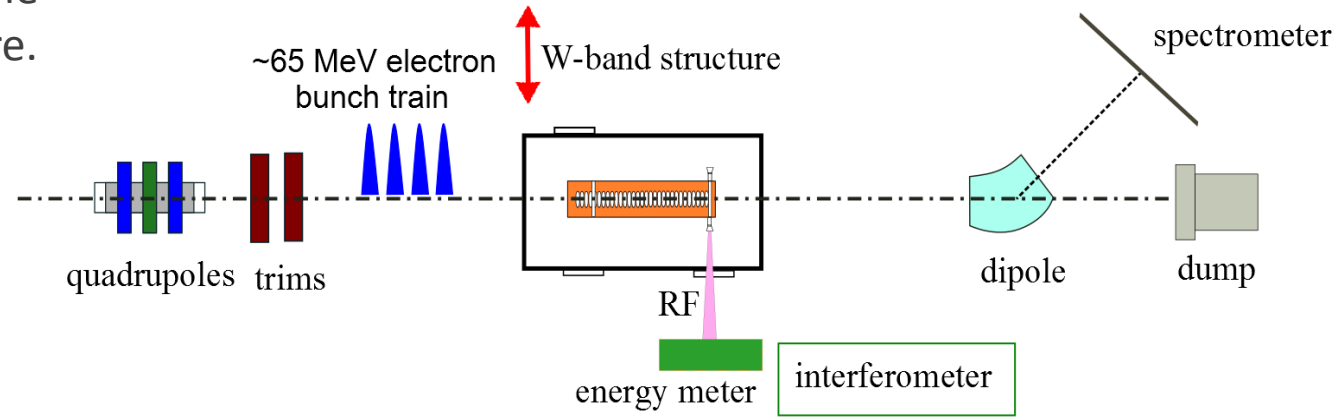
- 37MW max RF power measured out of the Power Extractor.
- Equivalent to 54MV/m gradient in the DLA structure.
- No breakdown was observed.
- RF pulse is ~ 5 - 15ns depending on the number of bunches in the train.

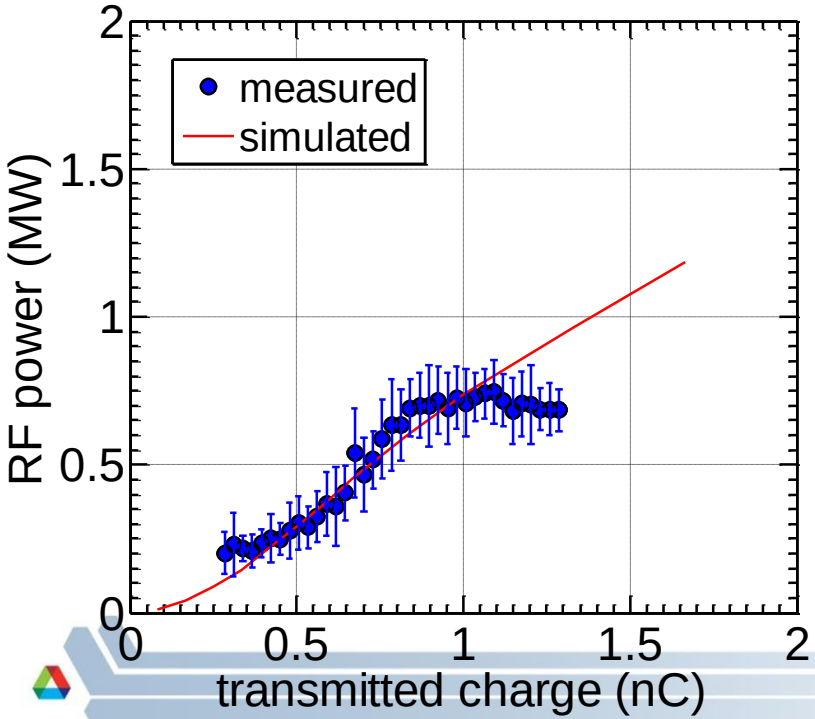
W-Band Structure at AWA

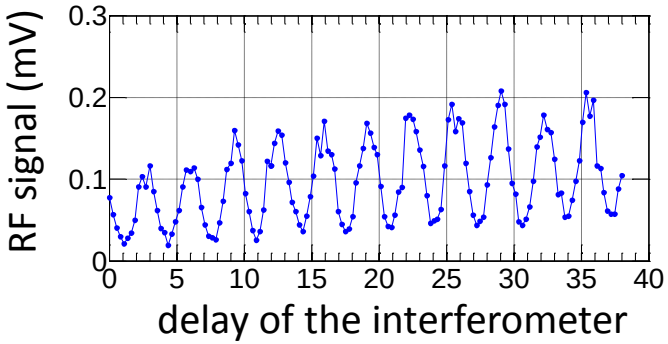


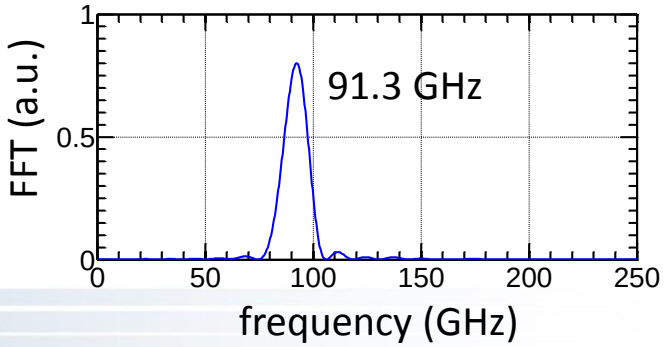
15 cm total length

Thank Valery for sharing the design of W-band structure.

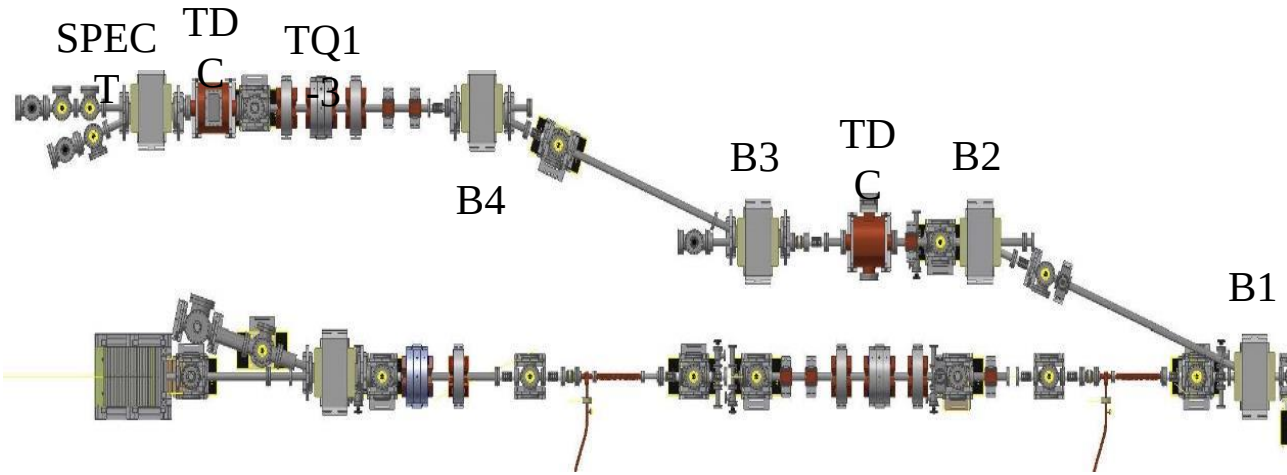








Bunch Shaping w/ EEX



Five masks on ac

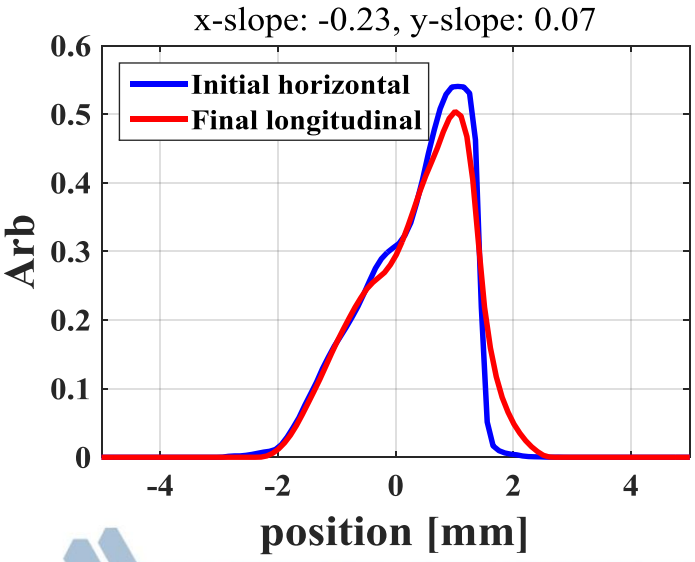
45 MeV

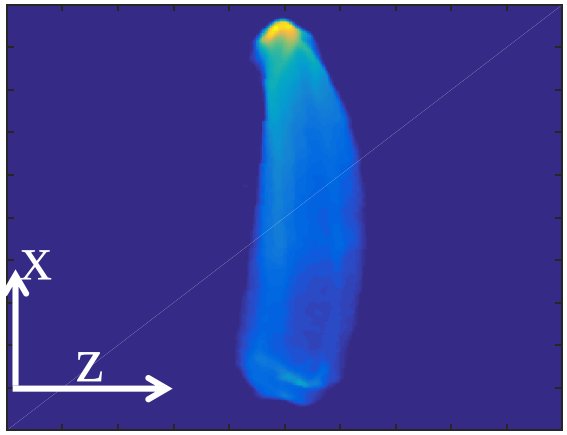
Q Q Q Q
4 3 2 1

x-x' & y-y' beam size & slope

Lina c chir p

tunable parameters

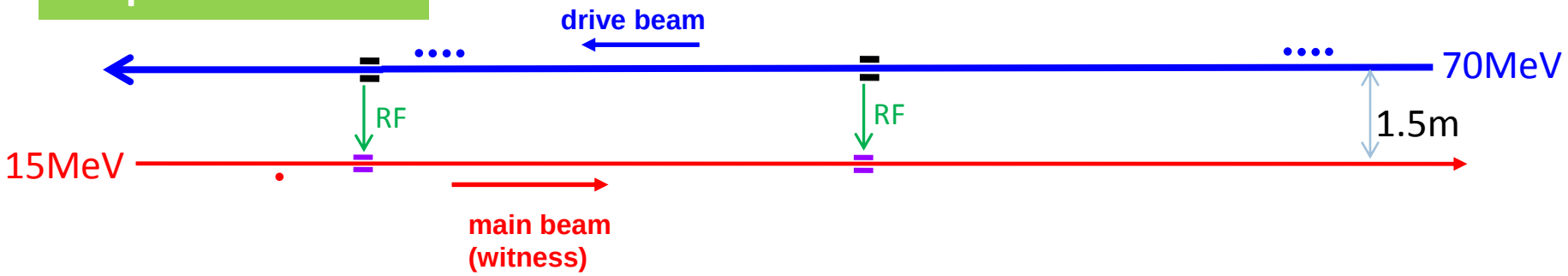




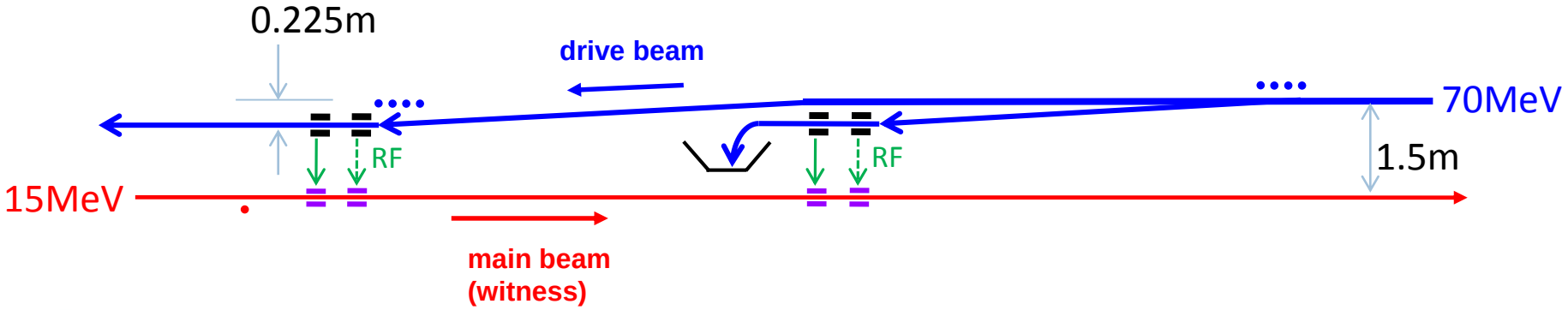
*Gwanghui Ha Ph.D. work

Staging Demonstration at AWA

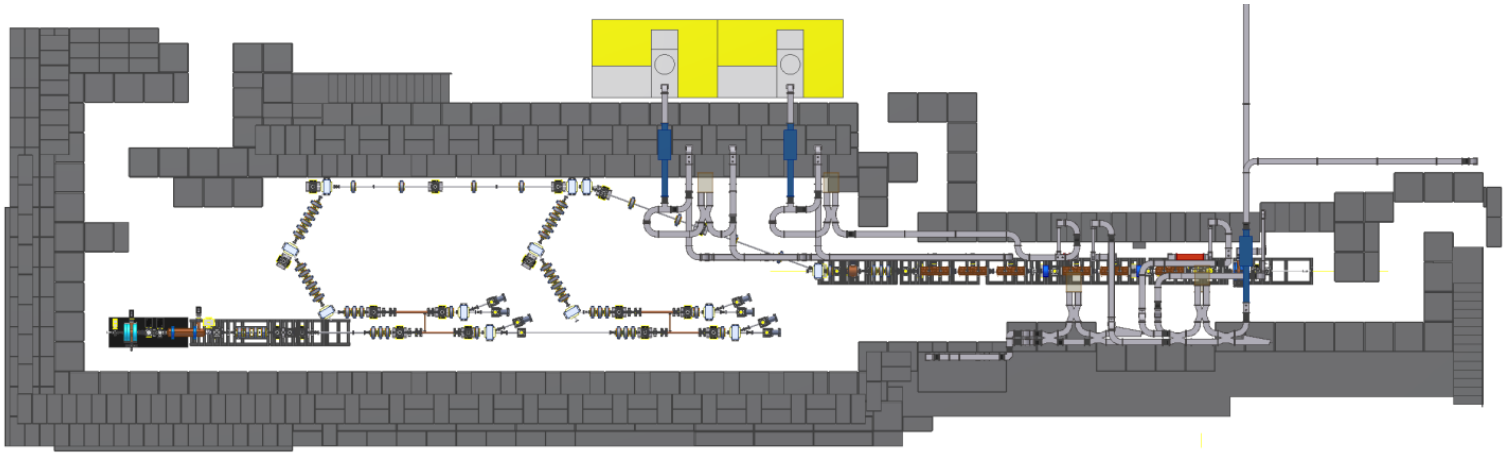
Simplified Version

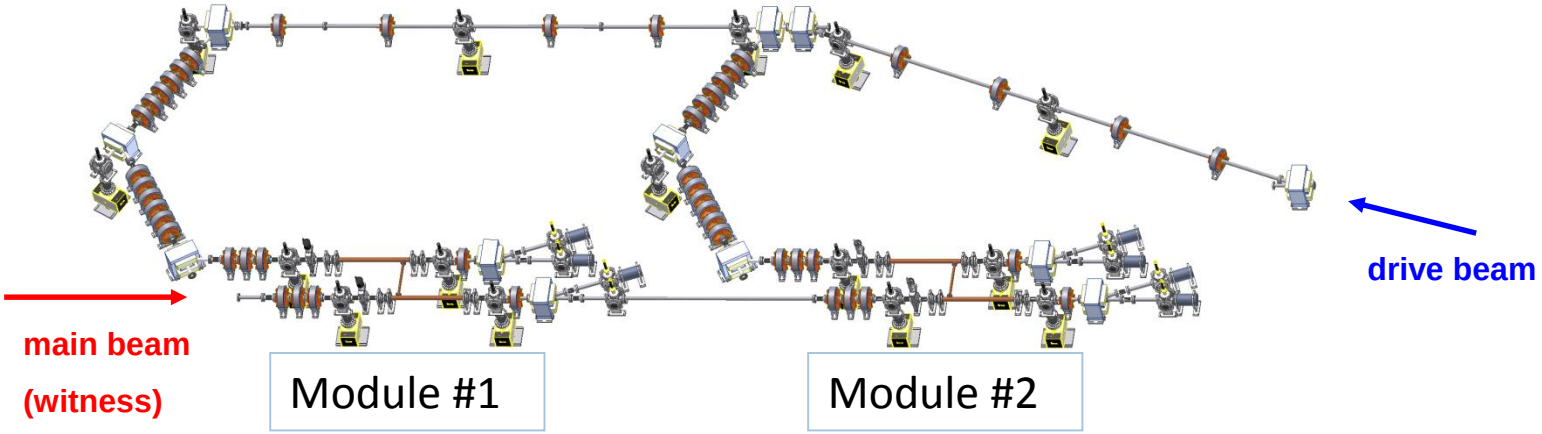


Full Demonstration



Staging: U-turn Option





Summary: Beamlines to study wakefield acceleration are operating at the AWA facility

➢ AWA facility: designed to demonstrate LC milestones

Unique Capabilities of the AWA Facility

- Two independent linacs allow experiments with excitation and probing of wakefields
- Extremely high charge, short electron bunches
- Flexible and reconfigurable beamline switchyard to host various experiments

Program Objectives

- High gradient excitation: **hundreds of MV/m** in long structures.
- Acceleration of witness beam: **~ 100 MeV**
- Higher RF power extraction: **~ GW level**
- Demonstration of staging schemes

Welcome to High Gradient Workshop at Argonne National Laboratory on June 6-8, 2016 (the most beautiful season of Chicago)

International Workshop on Breakdown Science and High Gradient Accelerator Technology (HG2016)

6-8 June 2016
Argonne National Laboratory
US/Central timezone

Details: https://indico.hep.anl.gov/indico/conferenceDisplay.py?confId=963

Organizing Committee Members: Gerardo D'auria (Elettra Sincrotrone Trieste) Wei Gai (ANL) Toshiyasu Higo (KEK) Chunguang Jing (Euclid) Jiaru Shi (Tsinghua University) Sami Tantawi (SLAC) Walter Wuensch (CERN)

Thanks !