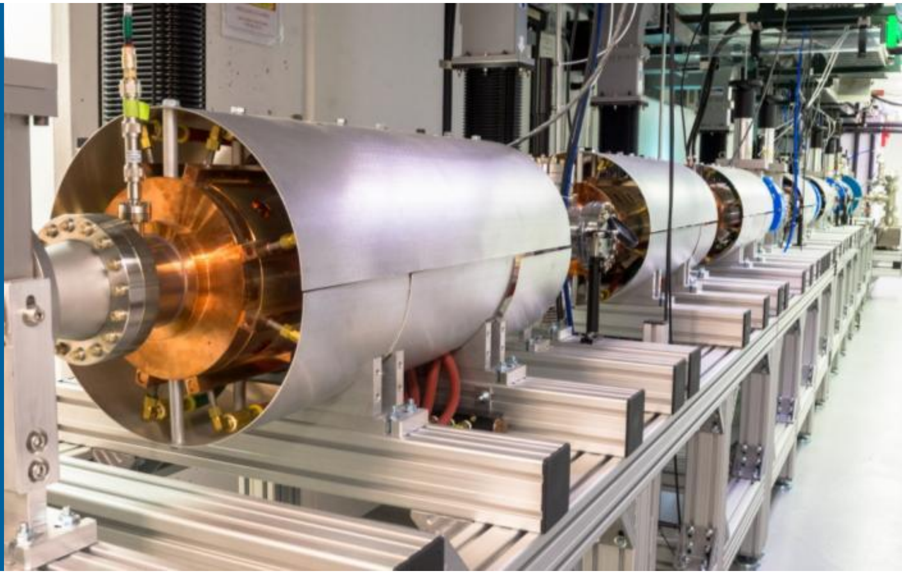
DIELECTRIC ACCELERATORS IN MICROWAVE REGIME AND A SHORT PULSE COLLIDER CONCEPT



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AWA & EUCLID TECHLABS

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June, 2017

OUTLINE

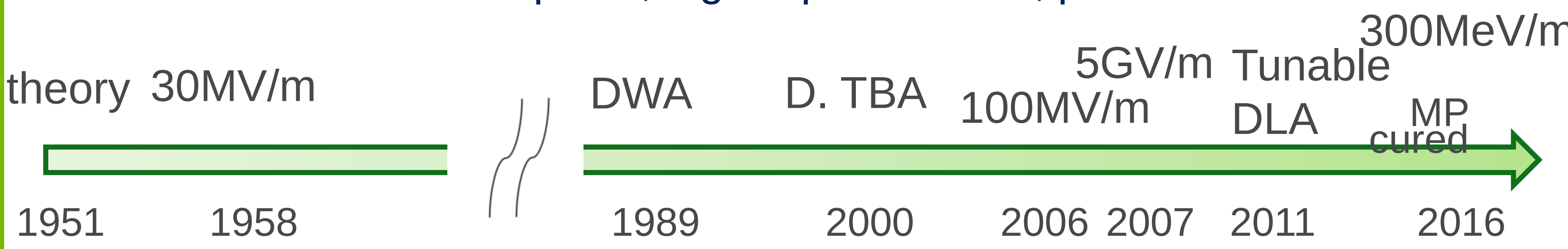
1. Introduction of Dielectric Accelerators
2. AWA’s concept of a multi-TeV linear collider
3. Progress updates
4. Summary

INTRODUCTION OF DIELECTRIC ACCELERATORS

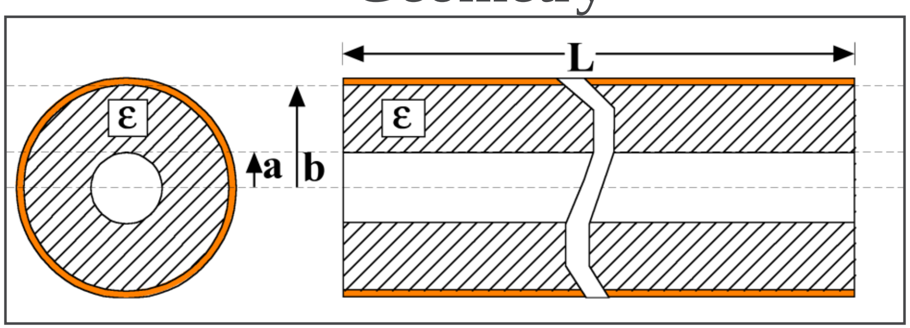
DIELECTRIC ACCELERATORS

Features:

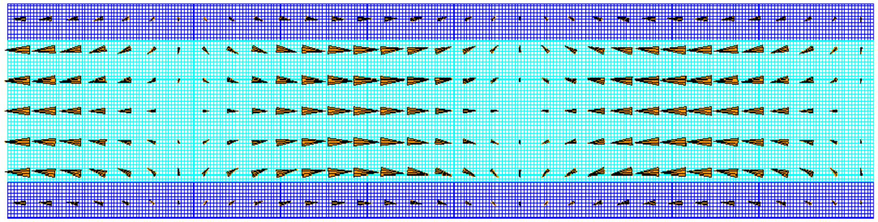
- Simple geometry.
- Small transverse size.
- Short rf pulse, high repetition rate, preferred.



Geometry

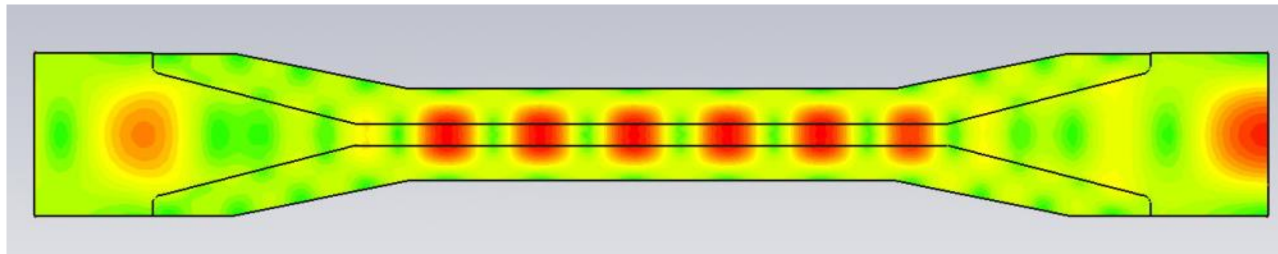


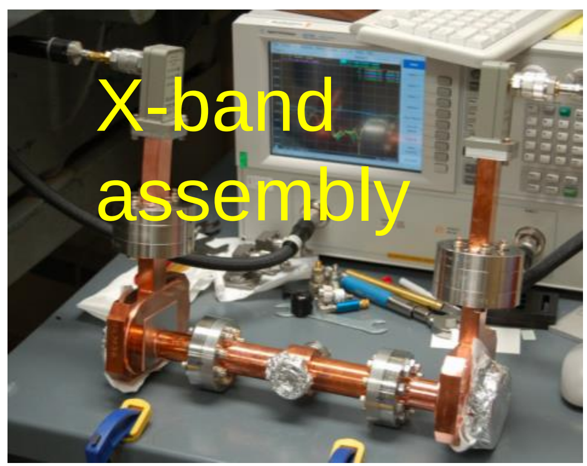
Electric Field Vectors



TRAVELING WAVE DLA

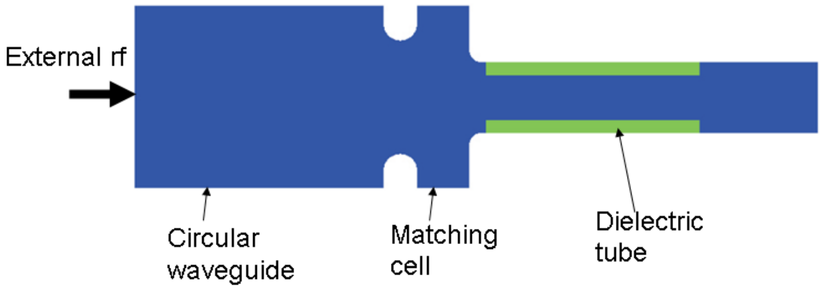
- Single piece dielectric tube
- Broad band
- no field enhancement at surface

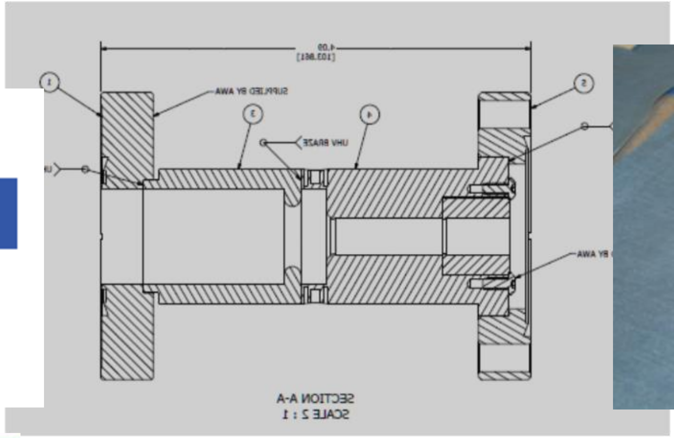


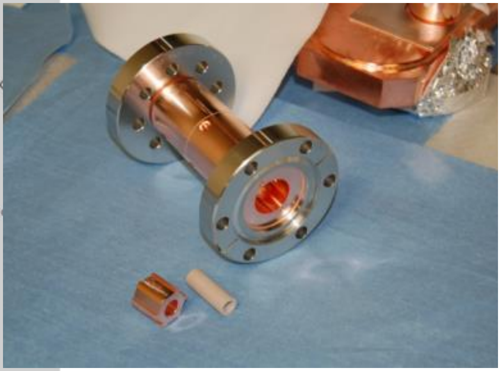


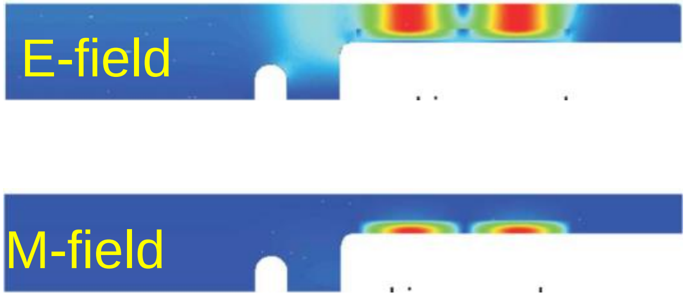
STANDING WAVE DLA

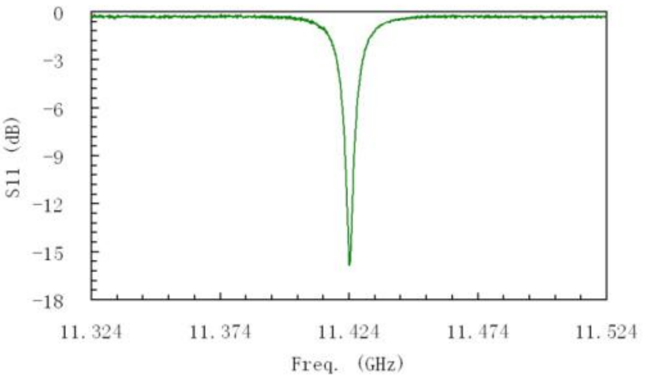
- Easy coupling
- Easy tuning
- no field enhancement at surface





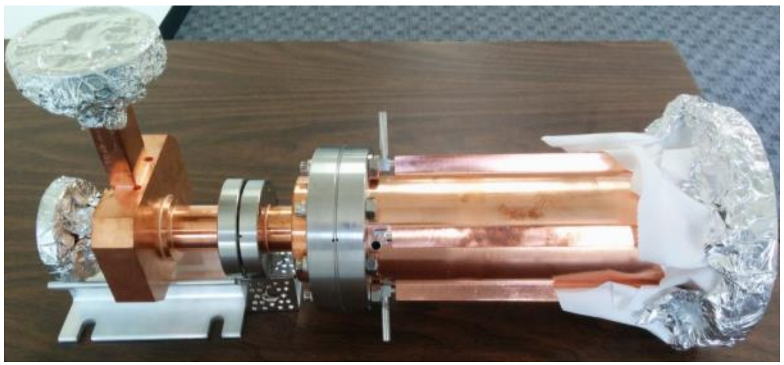


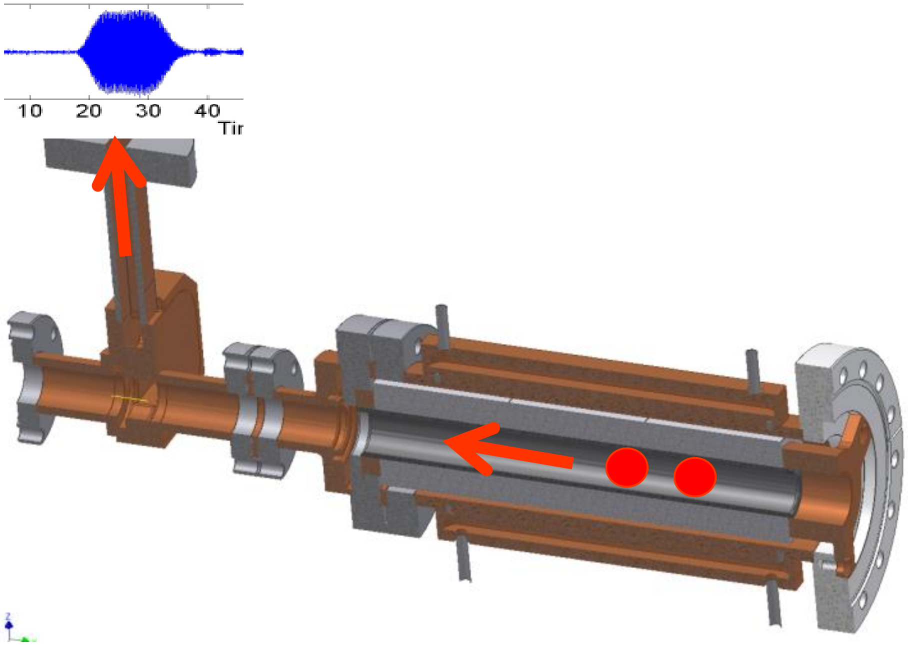




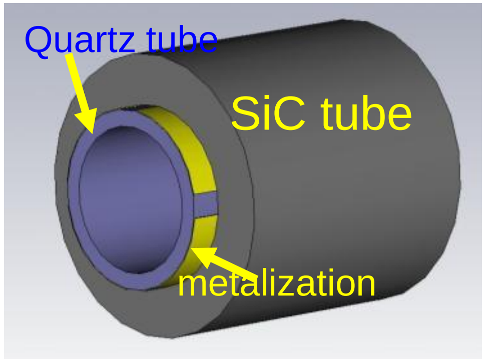
DIELECTRIC BEAM POWER EXTRACTOR (2014)

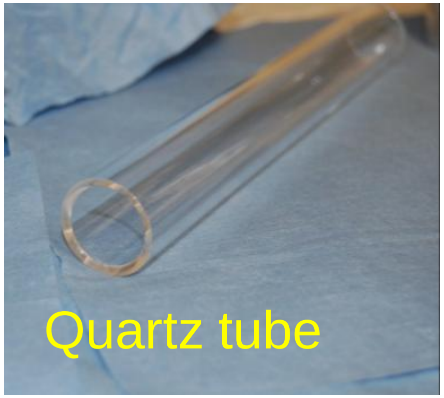
- Easy damping
- Low cost fabrication
- Low surface field





Transverse mode damping





AWA’S CONCEPT OF A MULTI-TEV LINEAR COLLIDER

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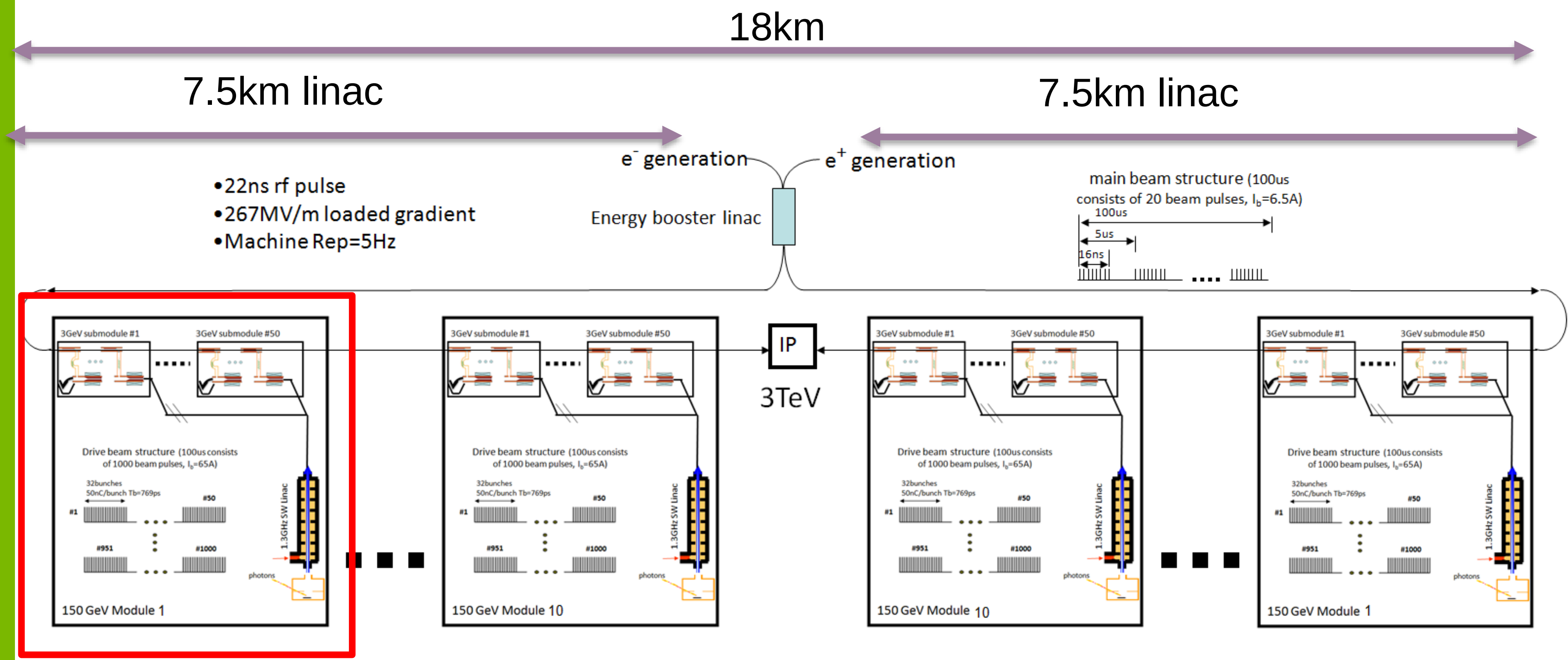
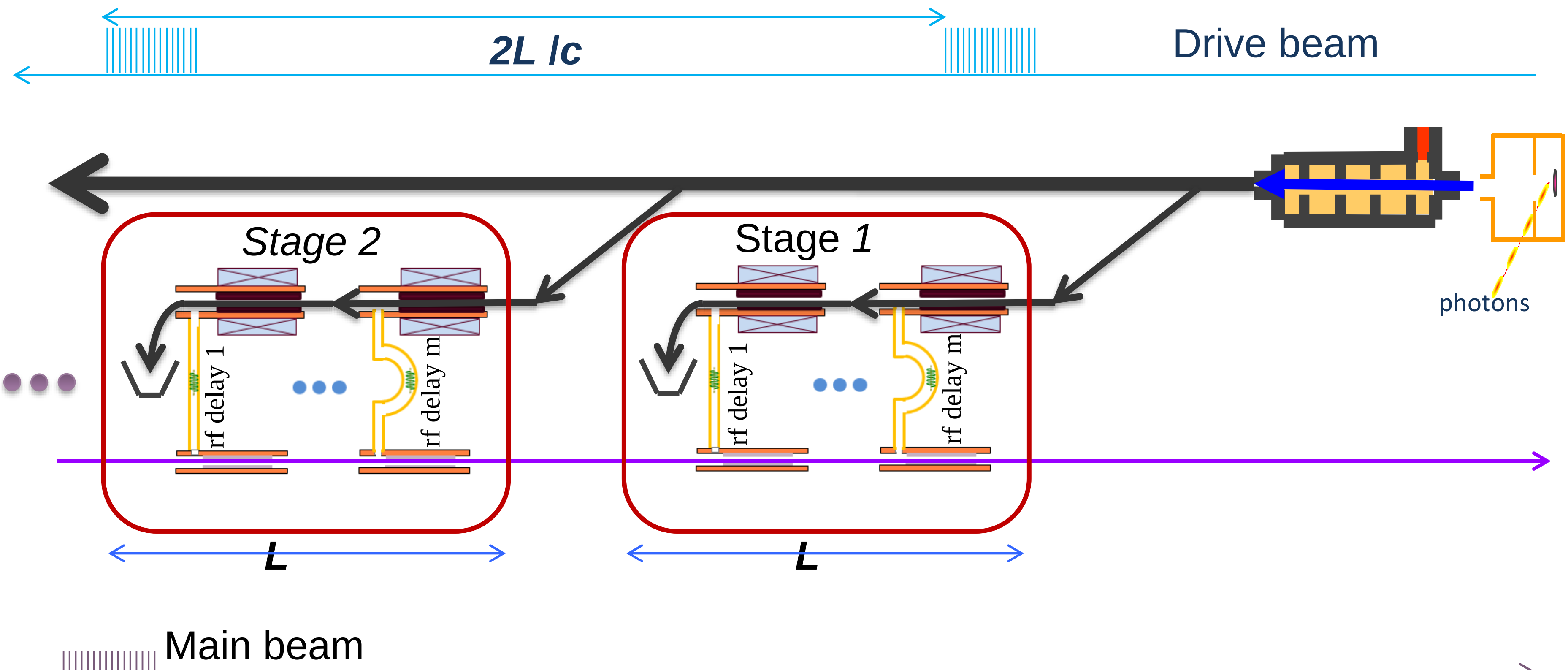
ARGONNE FLEXIBLE LINEAR COLLIDER

3TeV 30MW beam power TBA



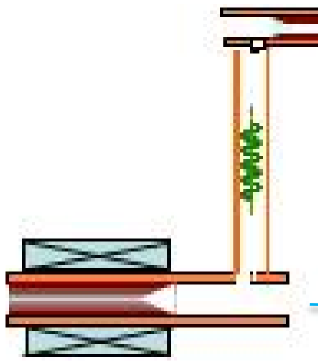
- ❑ **Based on scientifically mature and low cost Dielectric TBA technologies**
- Short rf pulse (**20ns**) for high gradient (**e^+ e^- 200MeV/m of effective gradient**)
- Modular design →easily staged
- Wall plug efficiency (~10%)

ZOOM-IN FOR EACH 150GEV AFLC MODULE

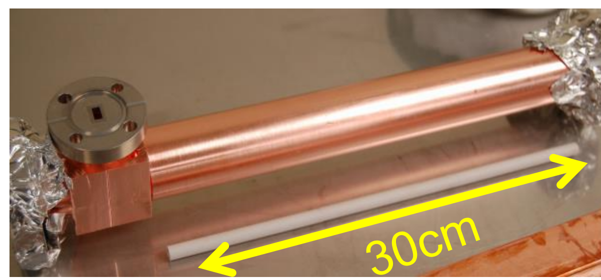


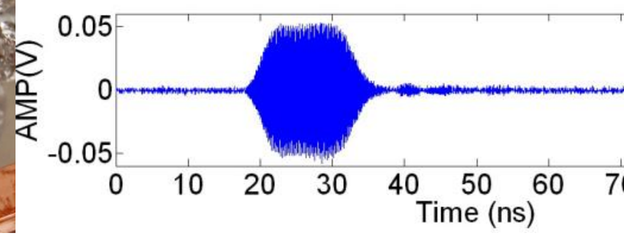
ZOOM-IN TO AFLC STRUCTURE LEVEL

Short pulse accelerator



Power Extractor





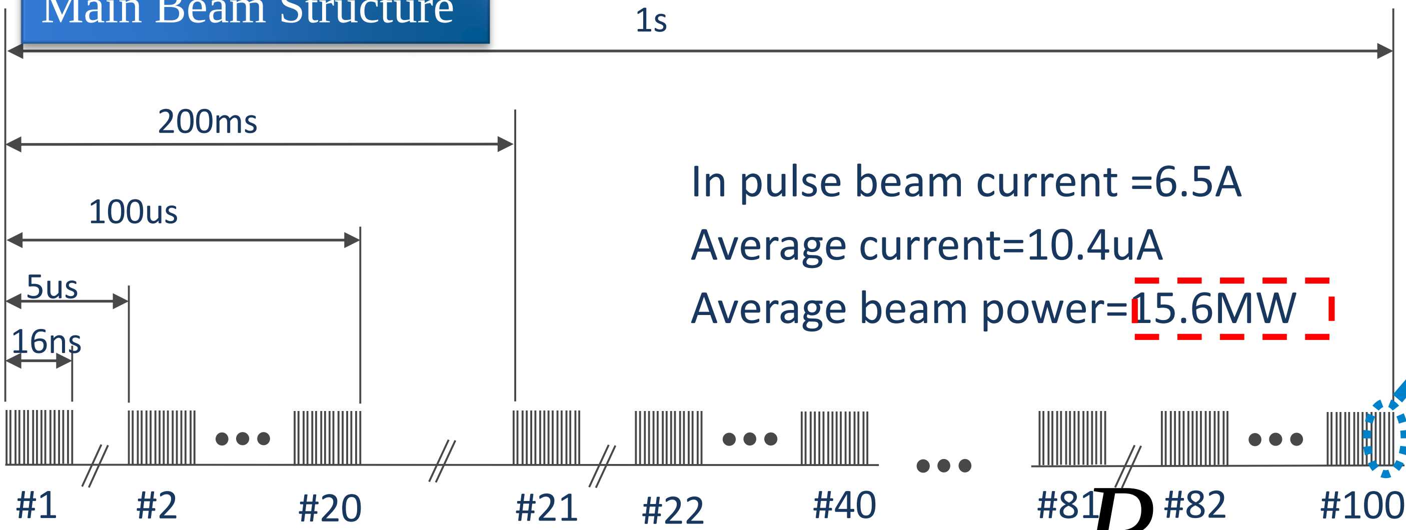
Gradient needs ~300MV/m → Shorten the rf pulse length ~20ns

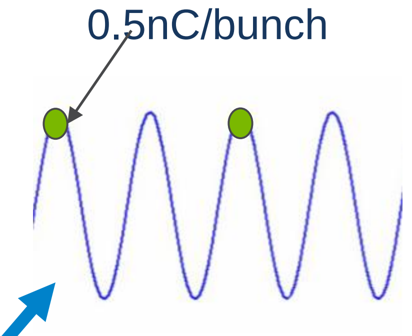
High group velocity accelerator (10%c) to reduce rf filling time → GW level rf power → TBA

high frequency (26GHz) to high shunt impedance → Dielectric accelerator for low cost

AFLC Beam Power for high luminosity:

Main Beam Structure





In pulse beam current =6.5A

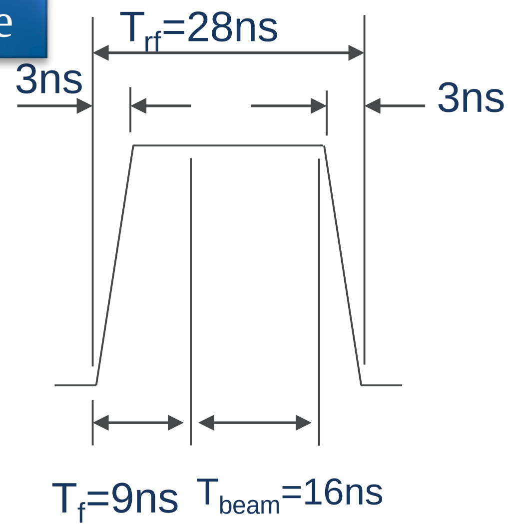
Average current=10.4uA

Average beam power=15.6MW

$$Luminosity \propto \frac{P_{beam}}{\sqrt{\varepsilon_y}}$$

AFLC RF-to-beam efficiency:

RF Structure

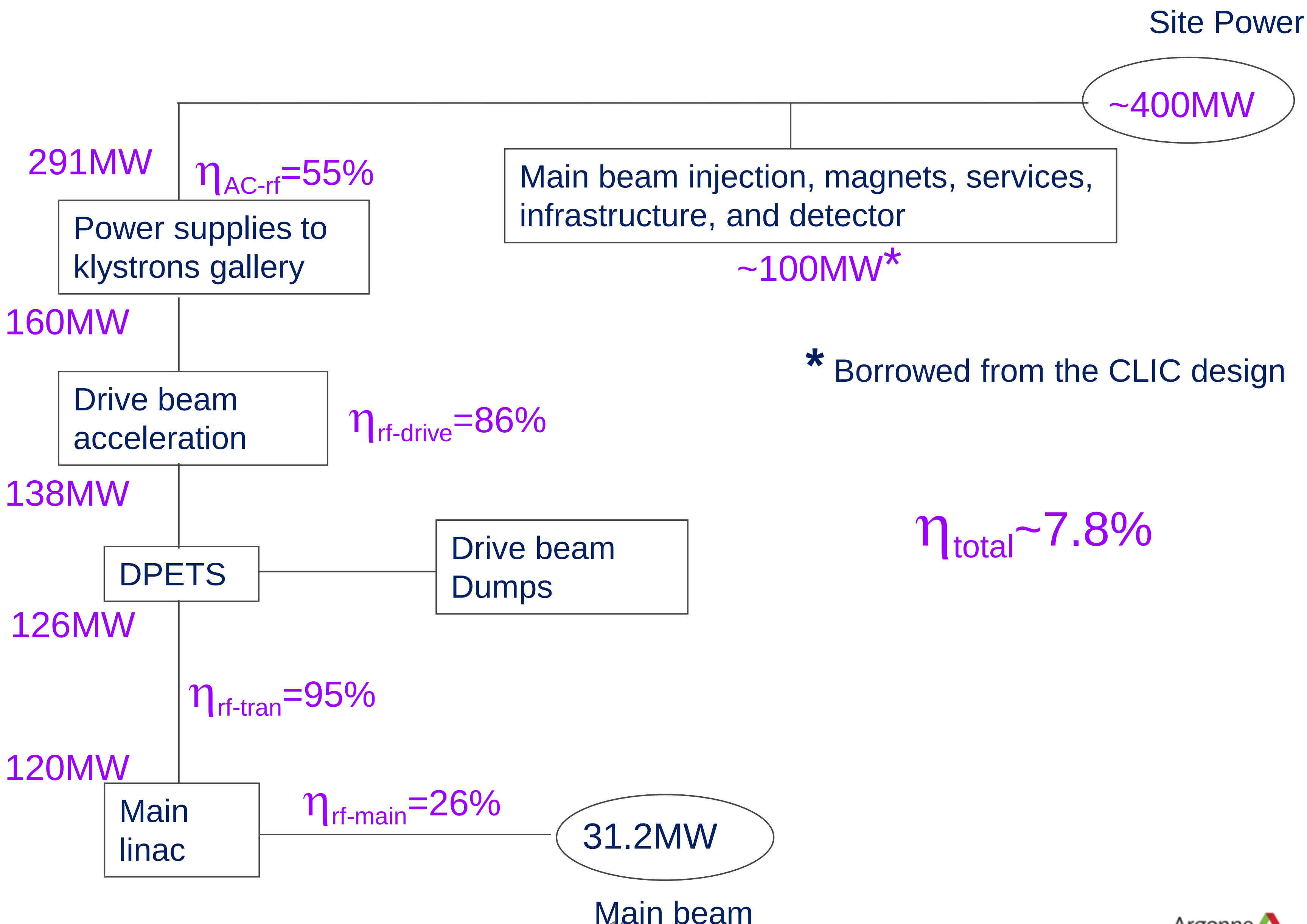


Competitive rf-beam efficiency for the short pulse TBA

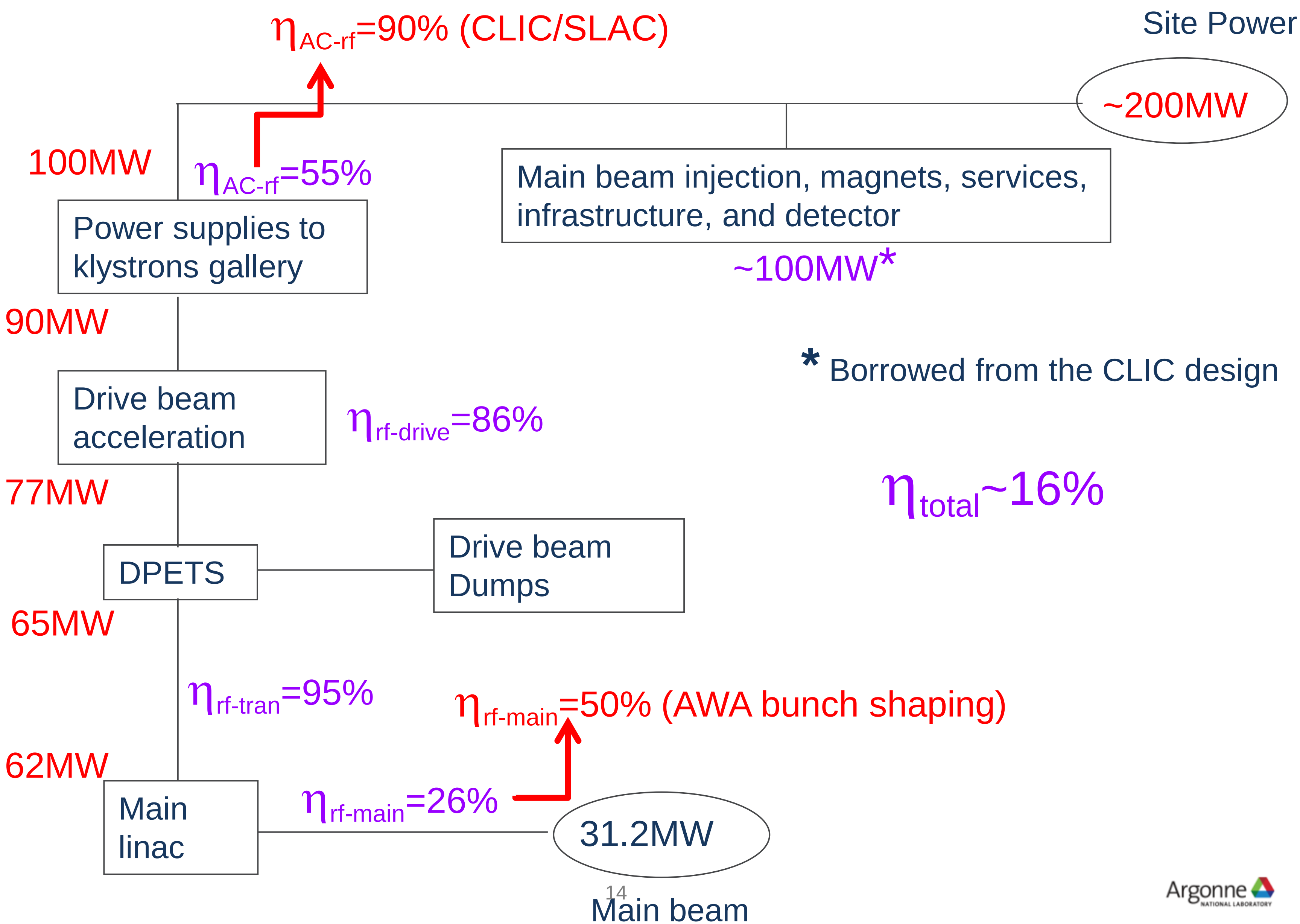
$$\eta_{bRF} = \frac{I_{beam}E_{load}L_s}{P_{rf}} \times \frac{T_{beam}}{T_{rf}} = 26\%$$

I_{beam}: 6.5A; E_{load}: 267MV/m; L_s: 0.3m; T_{beam}: 16ns; P_{rf}: 1.264GW; T_{rf}: 25ns

AFLC Power and efficiency flow chart

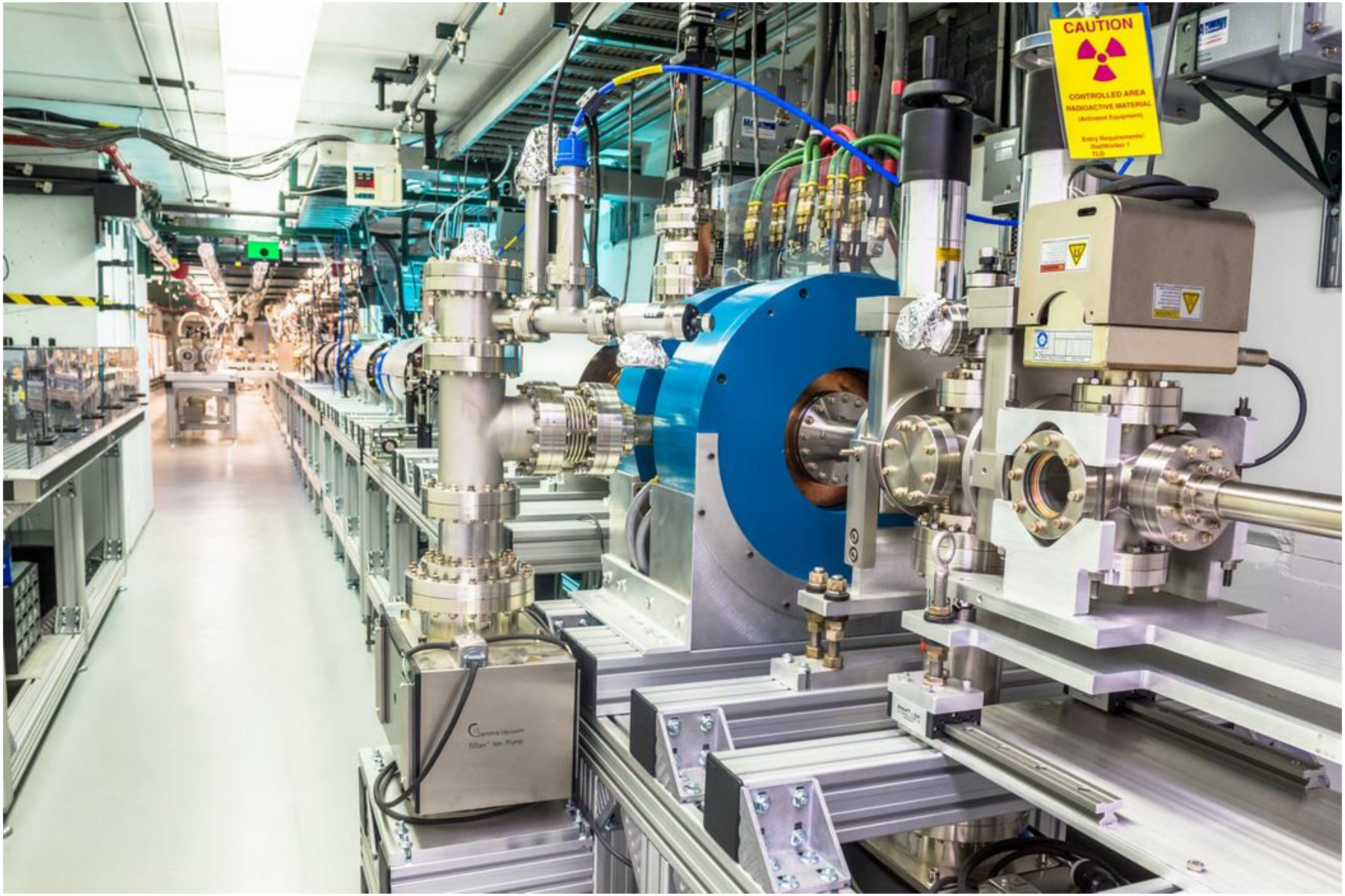


Improved AFLC Power and efficiency

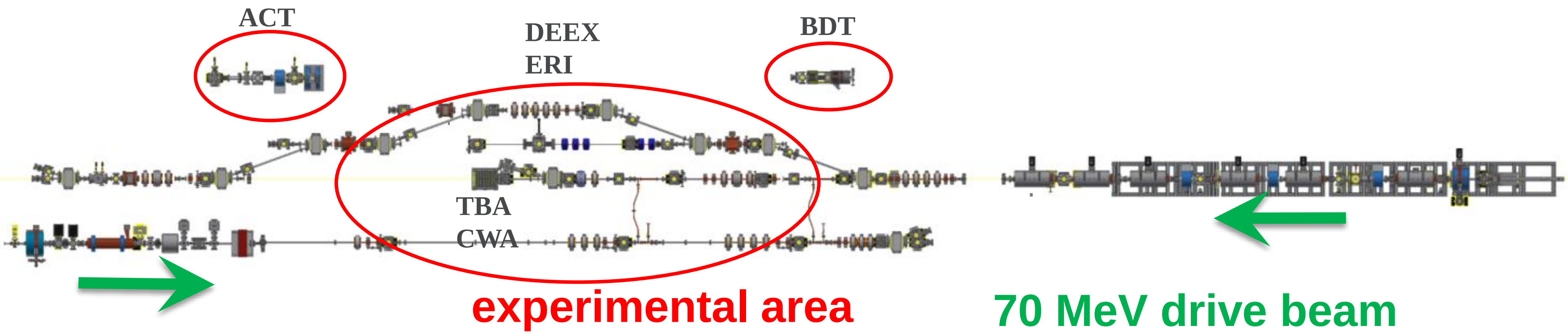


LATEST PROGRESS UPDATES

AWA FACILITY



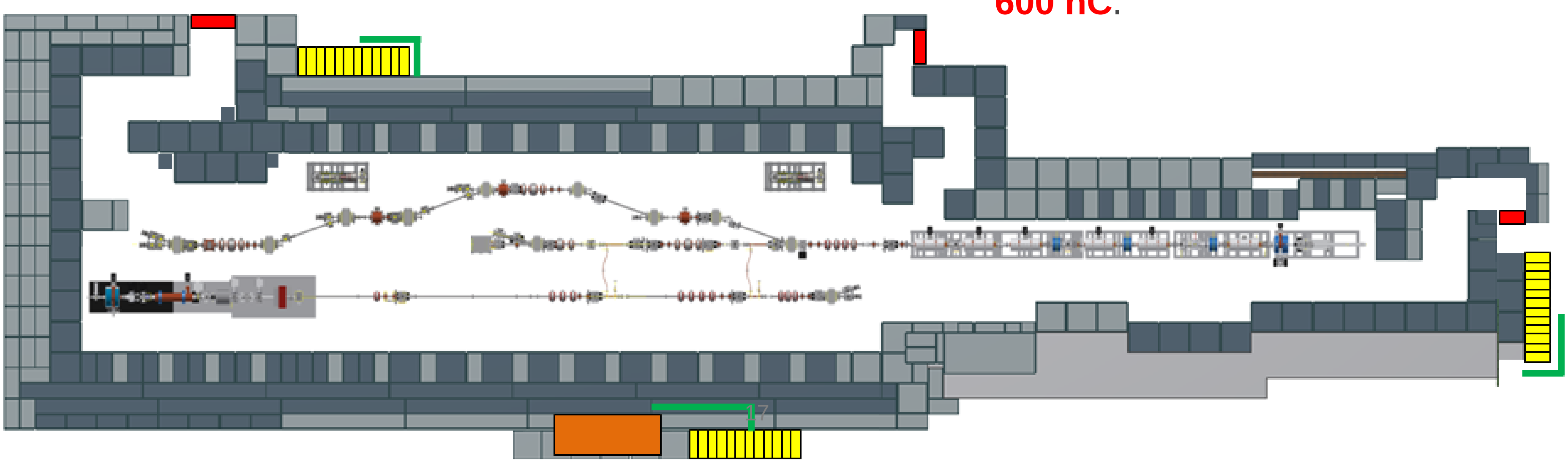
AWA FACILITY: DEMONSTRATING CRITICAL TECHNOLOGY ELEMENTS



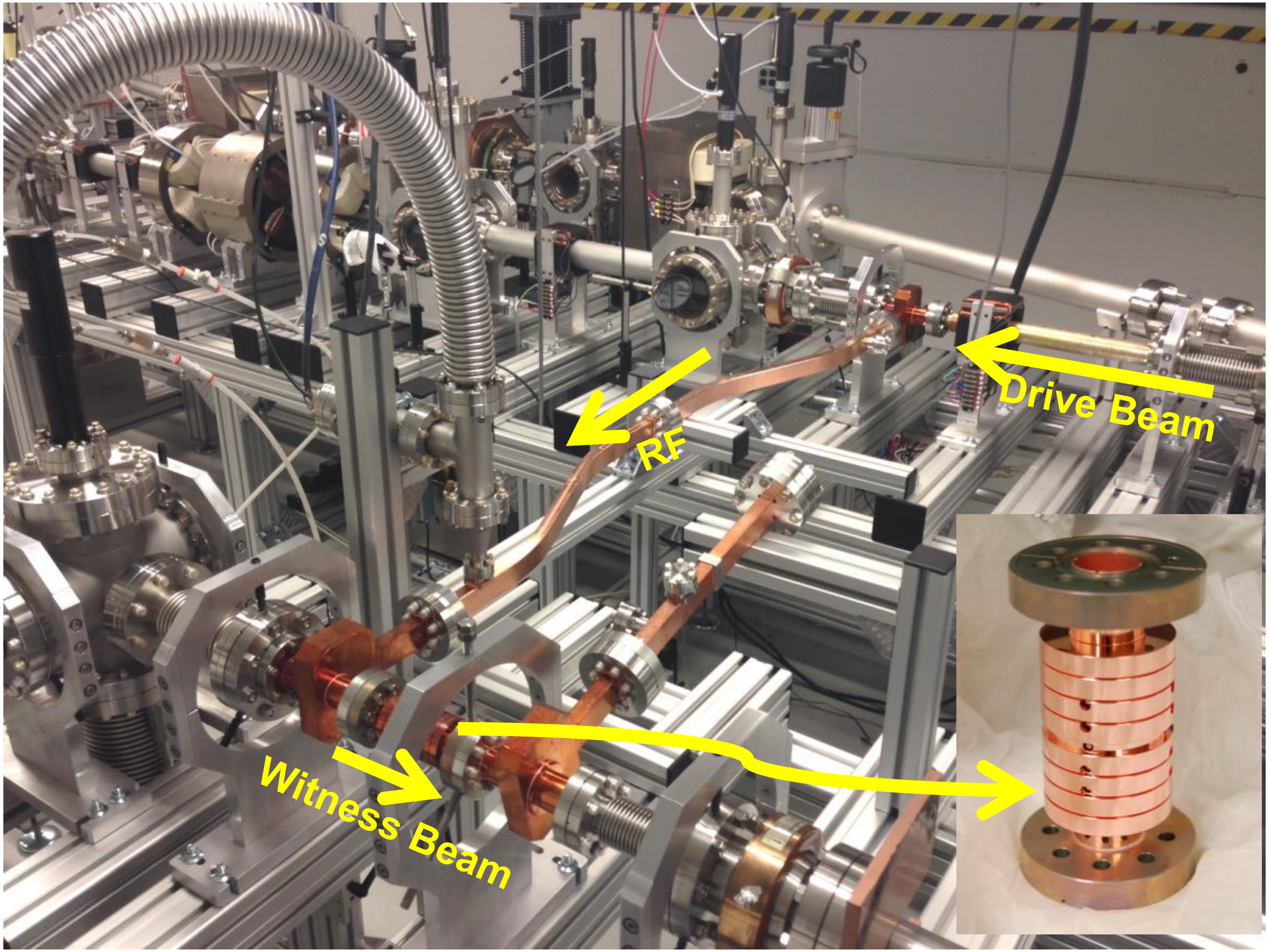
15 MeV witness beam

- single bunches
- bunch charge 0.05 to 60 nC

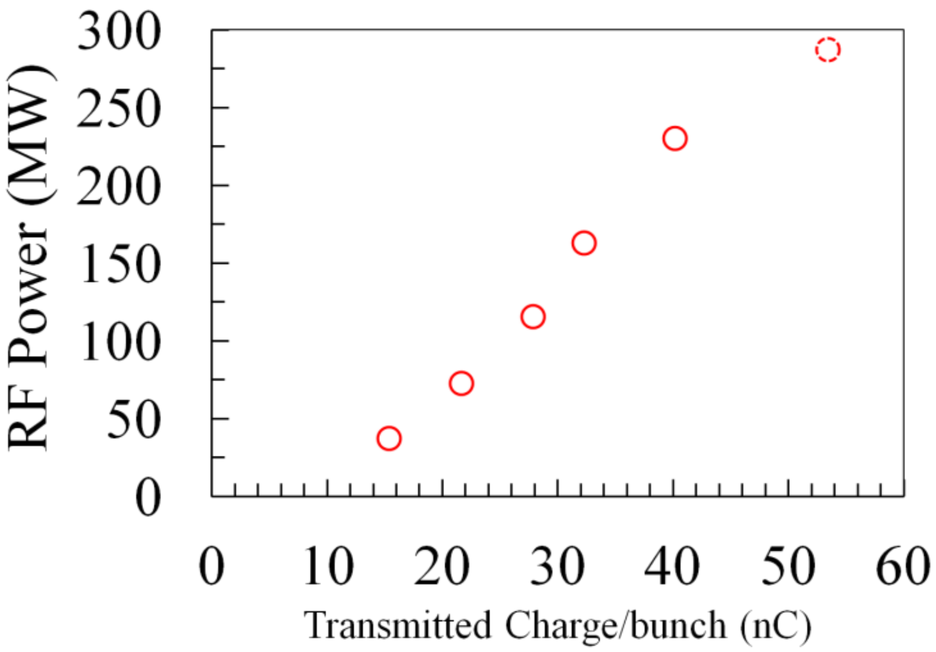
- bunch trains of up to 32 bunches
- Maximum charge in single bunch **100 nC**
- maximum charge in bunch train **600 nC**.

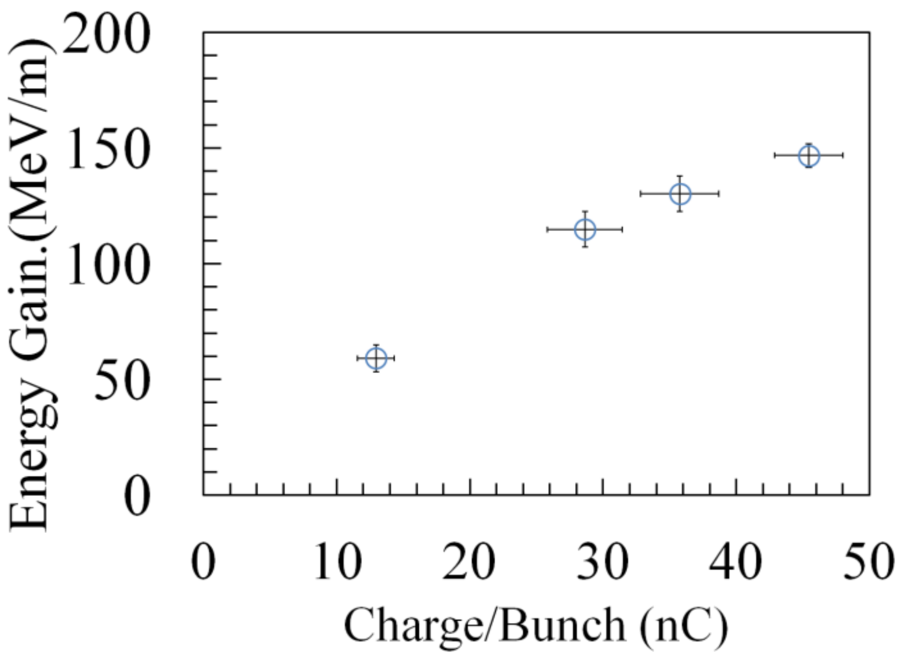


11.7 GHZ METALLIC TBA ACCELERATION



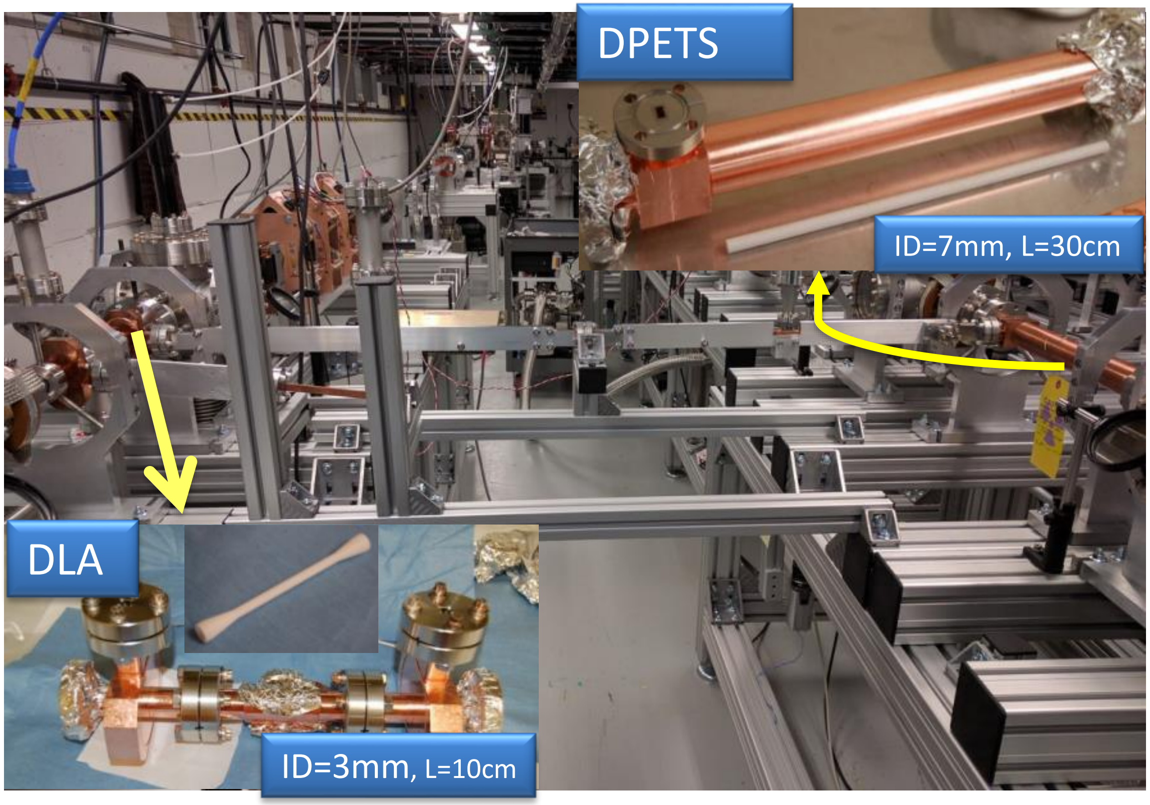
HIGHLIGHTED RESULTS

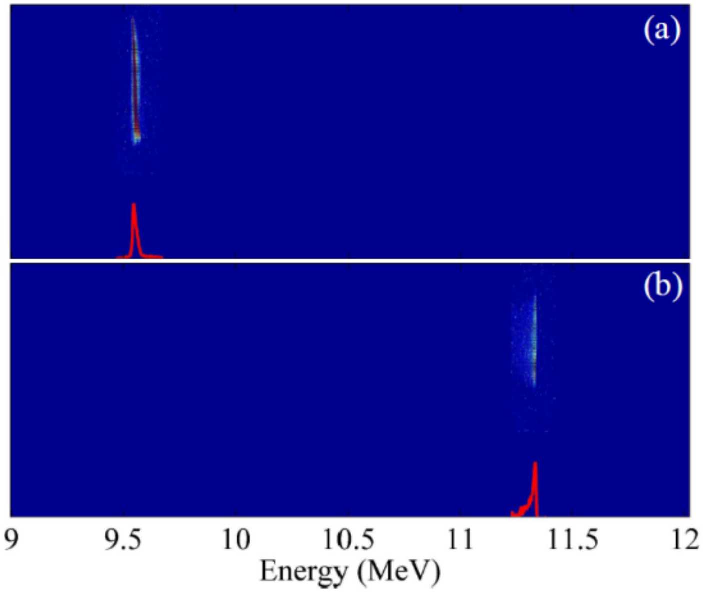




- ~300MW RF power at X-band
- ~150MeV/m acceleration gradient
- demonstration of staged acceleration

THE 26GHZ FULL DIELECTRIC SHORT PULSE TBA TEST





- 55MW rf power output were measured.
- 1.8MeV witness energy gain, eqv. to 54MeV/m gradient.

Note: RF power/gradient is lower than the ideal case due to the combination of RF loss in the waveguide, miss-match of the phase advance, and inefficient rf coupling, etc.

X-BAND (11.7GHZ) DIELECTRIC TBA (TO BE TESTED IN 2017)

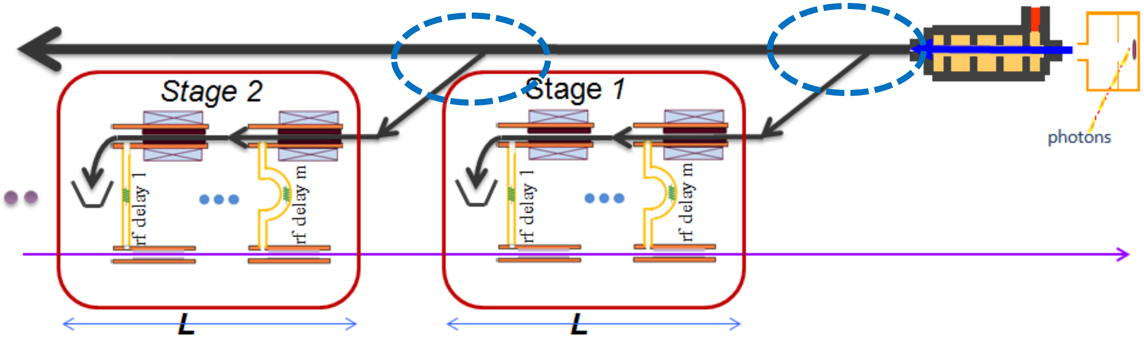
Power Extractor

	Value
Freq.	11.7GHz
Material	Al2O3
Aperture	15mm
Length	30cm
Passing Charge	8 x 40nC
Power	280MW

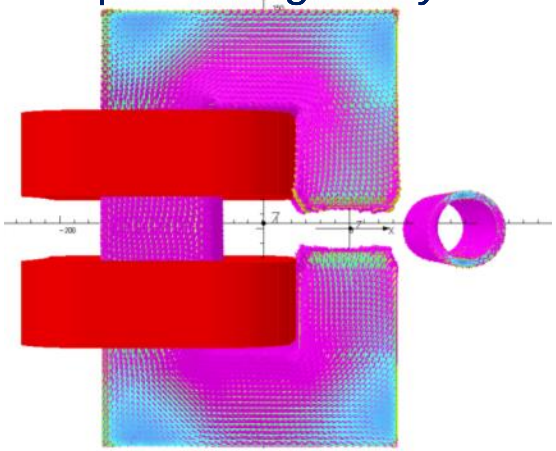
Accelerator

	Value
Freq.	11.7GHz
Material	MCT16
Aperture	6mm
Length	15cm
Input power	280MW
Gradient	100MV/m

ULTRAFAST KICKER FOR DRIVE BEAM DISTRIBUTION (2017)



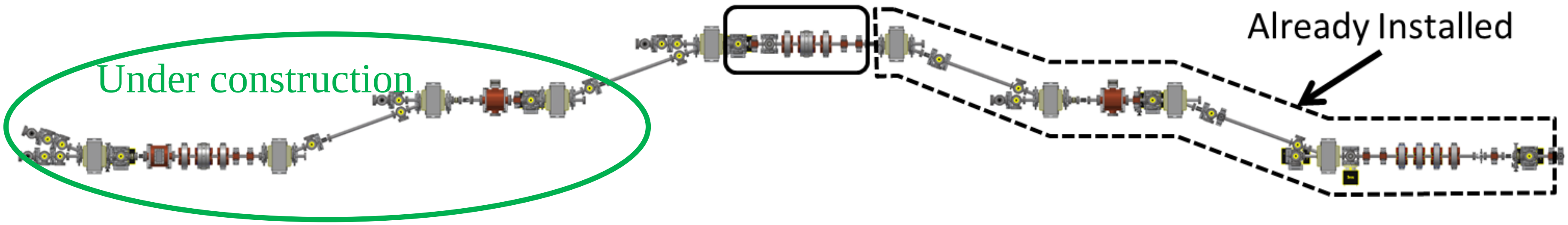
Septum magnet by IMP

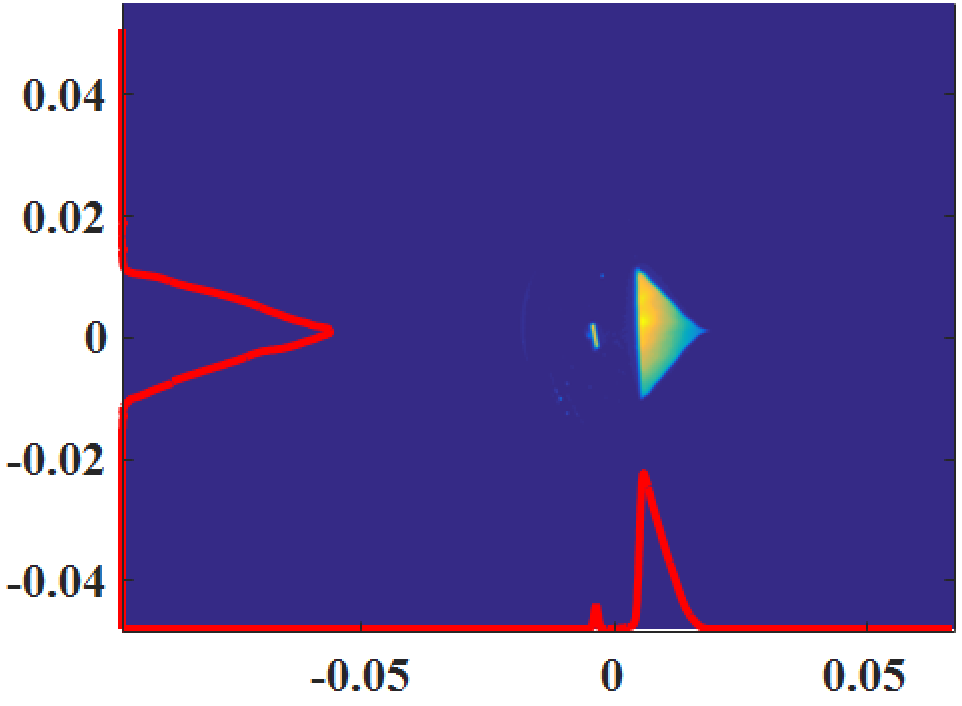


1meter stripline kicker

30kV dual channel dual polarization fast pusler by FID

ARBITRARY BUNCH SHAPER USING EEX OR DEEX





- Using Micro-Lens Array and mask produce the “ideal” transverse shaped bunch (Drive + witness bunches).
- Using Emittance Exchanger or Double Emittance Exchanger to transform the beam transverse profile to the current temporal profile.

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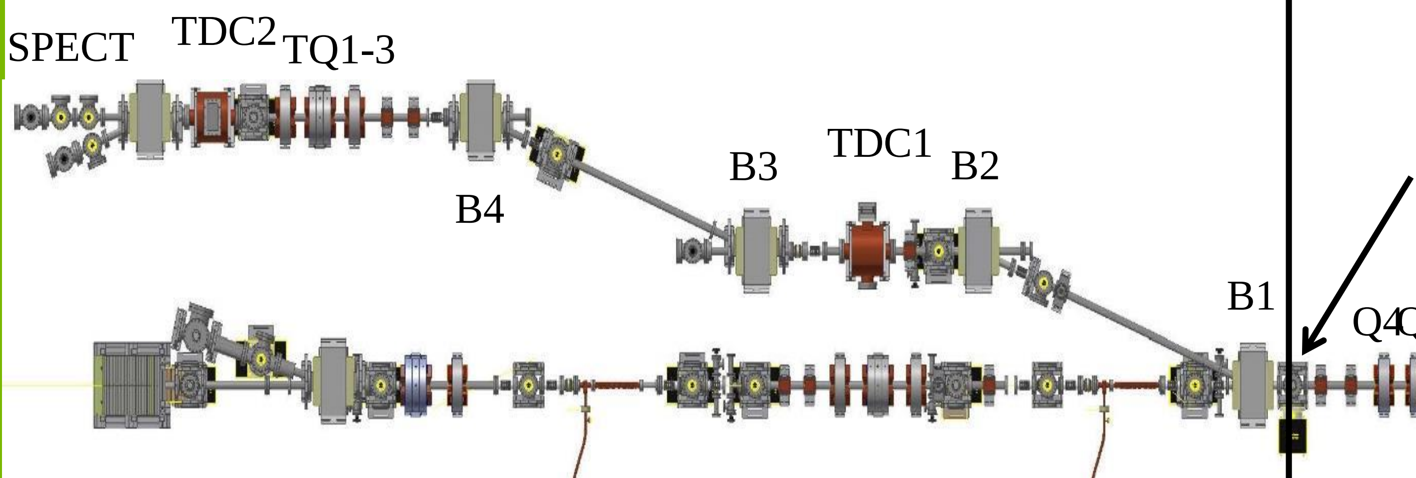
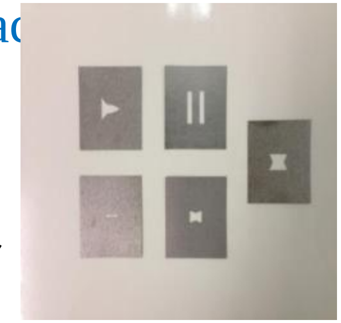
BUNCH SHAPING WITH EEX DEMONSTRATED



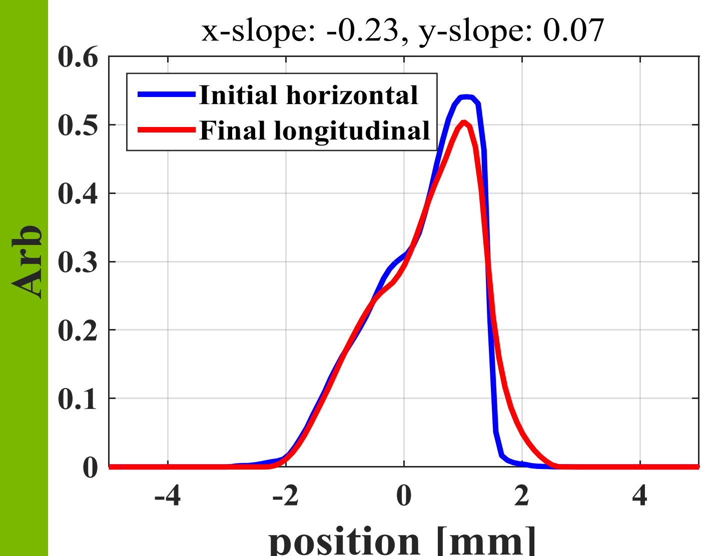
Five masks on
ac

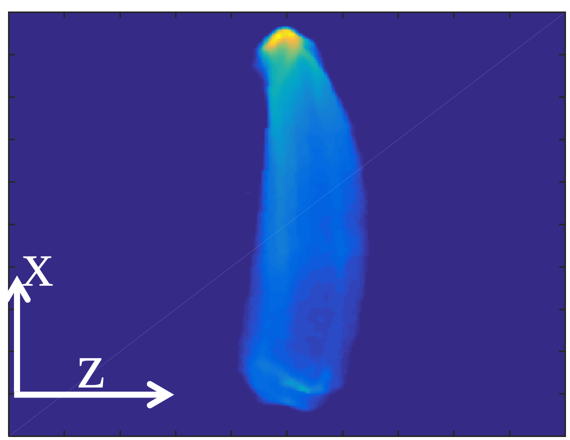


x-x’ & y-y’ beam size & slope

Linac chirp

tunable parameters





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SUMMARY

•AWA actively participates global HEP collider R&D.

•AWA continues working on the critical technical elements to meet requirements of the future linear collider design.

• AWA welcomes students, users, and collaborators.