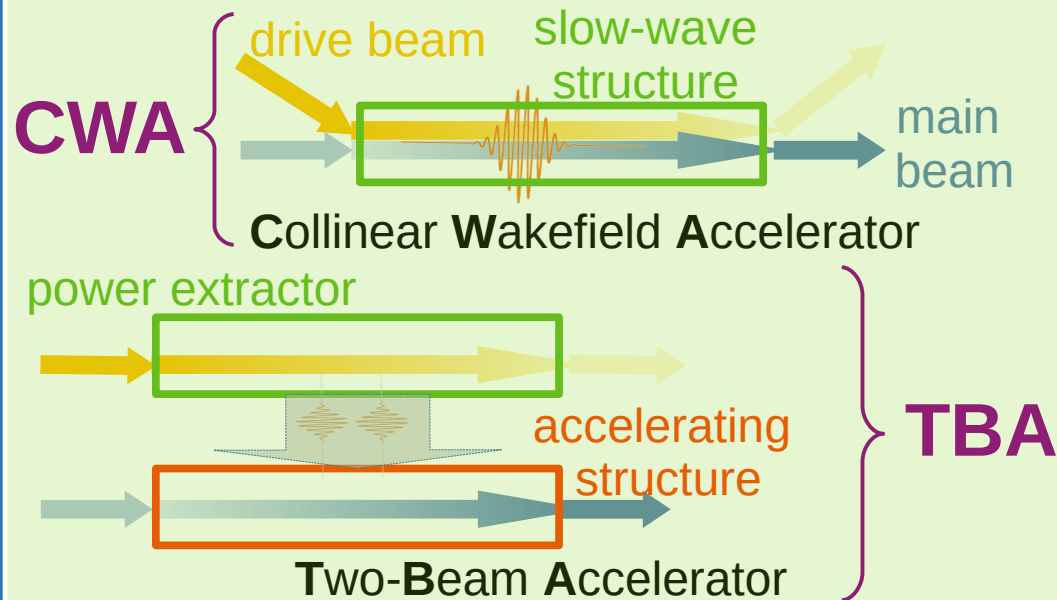


# Beam-Physics Research Needs for Structure\* Wakefield Accelerators



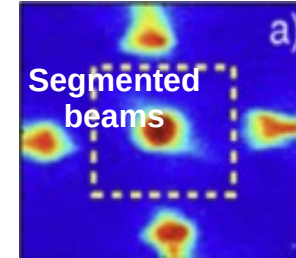
P. Piot, for LOI #041 authors, Argonne National Laboratory & Northern Illinois University  
see also LOIs # 056, 161, 225, 226, 056 - \*some of the topics are relevant to PWFA

# INTENSITY & CONTROL CHALLENGES

## Beam-driven techniques have unique requirements

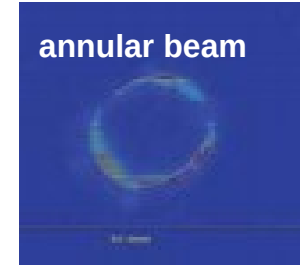
### Intense Drive Beams

- Multi-nC to sub- $\mu\text{C}$  drive-bunch trains (TBA/SWFA)
- New regime for collective effects (CSR, LSC,...)
- Beam stability in decelerating channel (trans. Wake + beam-break up)



M. Rihaoui, et al., PRAB (2008)

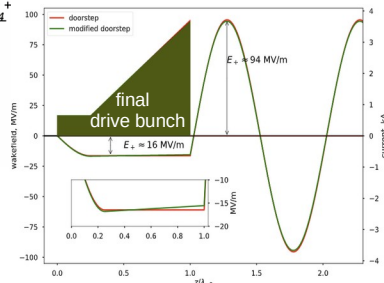
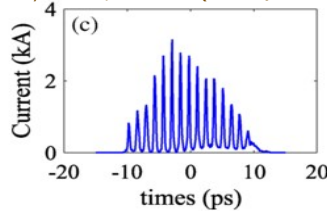
E. Wisniewski, et al., AAC14



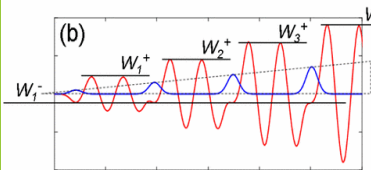
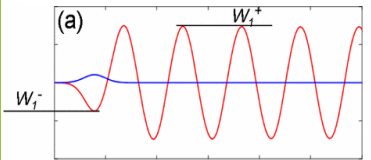
### Beam Control at Unprecedented Levels

- Drive e- beam: precisely-tailored distribution:
  - Transverse (matched to structures geometry)
  - Longitudinal (transformer ratio + BBU control)
  - Bunch trains with  $\sim\text{THz}$  frequency (TBA)
- Main e-/e+:
  - tailored current profile (beam loading)
  - Asymmetric-emittance beams

G. Ha, et al., PRAB (2020)



W. H. Tan et al., NIU



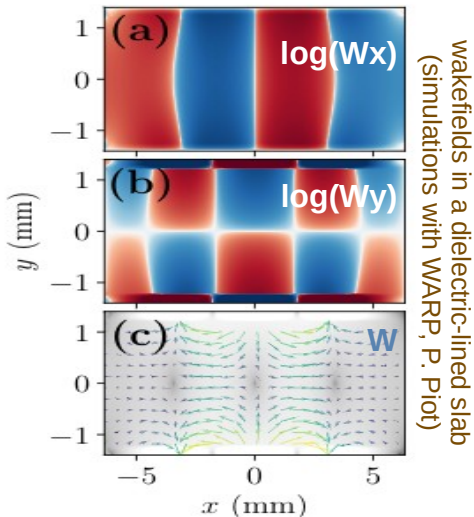
C. Jing et al., PRAB (2011)

# QUALITY, MEASUREMENT & PREDICTION CHALLENGES

## Beam driven techniques have unique requirements

### ■ High-Quality Beams

- Fast/compact beam cooling or phase-space repartitioning (beyond the damping-ring...)
- Emittance preservation in S/PWFAs

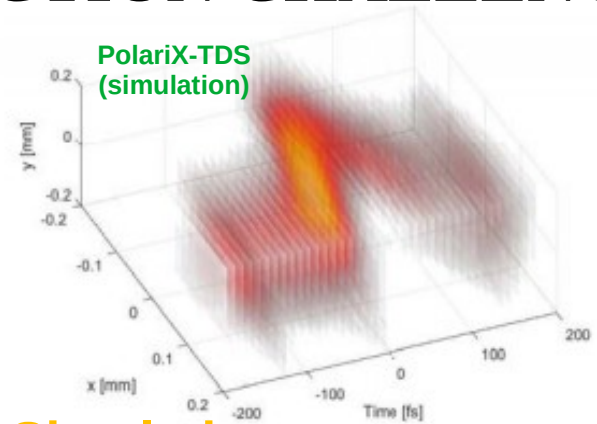


### ■ High-Fidelity Beam-Dynamics Simulations

- Fast accurate modeling of beam-wave interaction (beyond the 1D Green's function especially for SWFA)
- Coupling material-science to beam-dynamics simulations

### ■ Precise Beam Diagnostics

- Measurement of the full 3D charge distributions (incl. cross-plane phase-space correlations)
- Wakefield field-distribution diagnostics



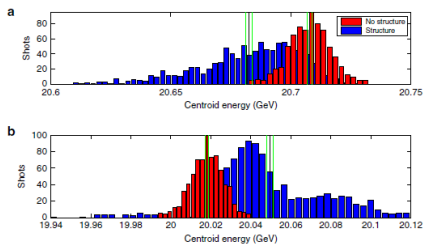
D. Marx, et al. IPAC18-  
IOP Proc. (2018)

# CONCLUDING REMARKS

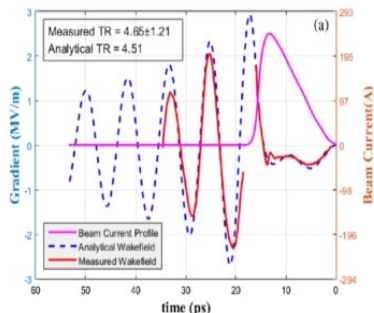
## Recent Achievements & Foreseen Developments

GeV-class module(s)  
integration w/  
pilot applications

High TR [control]  
High  $E_{acc}$  [quality]



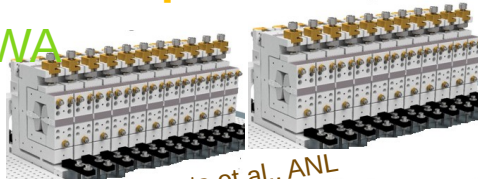
B. O'Shea et al., Nat. Comm. (2016)



Q. Gao, et al., PRL (2018)

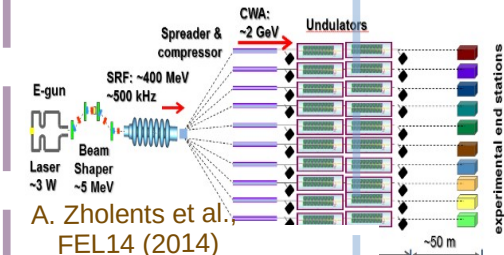
Prolonged Interaction  
[control+quality+intensity]

CWA



A. Zholents et al., ANL

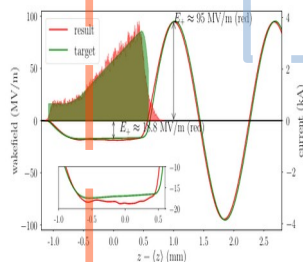
TBA



A. Zholents et al., FEL14 (2014)

J. Shao, NAPAC19

High TR + high  $E_{acc}$   
simultaneously  
[control+quality+  
diagnostics]



W. H. Tan et al., ANL/NIU

beam-quality preservation  
for main bunches  
[control+quality  
+diagnostics]

2020

2025

2030

time