Advanced RF Structures for Wakefield Acceleration and High-Gradient Research

Snowmass Accelerator Frontier
Topical Group 7: Accelerator Technology - RF

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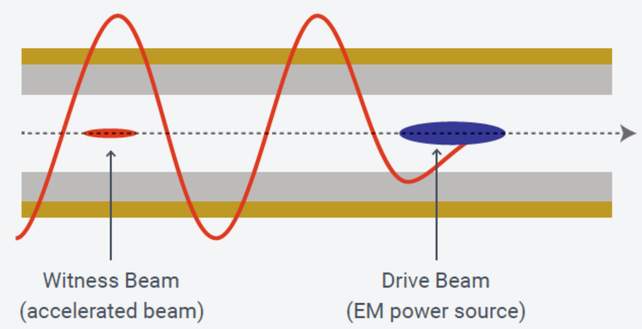
Abstract

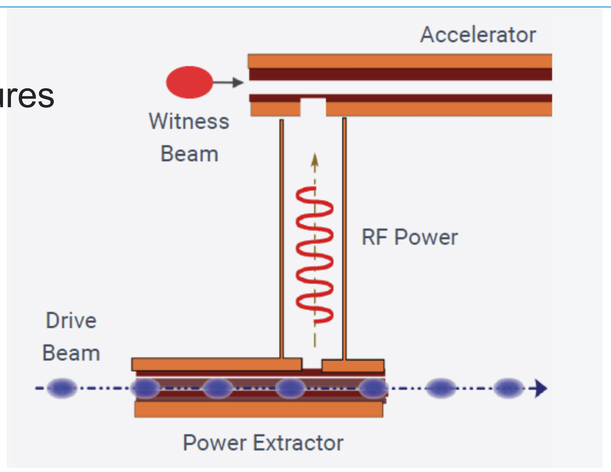
- **Structure wakefield acceleration (SWFA):**
  - One of the most promising advanced accelerator concepts (AAC) schemes in recent strategic reports
  - Aims to raise the gradient beyond limits of conventional radiofrequency (RF) accelerator technology
- **Research Topics of interest in the next decade:**
  - I. Advanced wakefield structures
  - II. Terahertz and sub-terahertz (THz) structures
  - III. RF breakdown physics
- **Future:** Linear Collider, Light Sources, and other synergies

Background: SWFA

- Particle-driven wakefield acceleration in RF structures



Collinear wakefield acceleration (**CWA**)

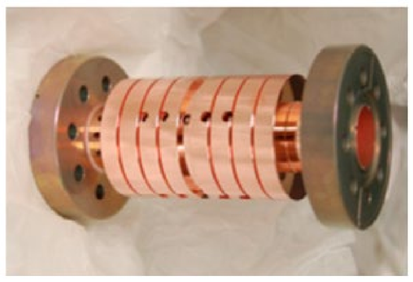


Two-Beam Acceleration (**TBA**)

I. Advanced Wakefield Structures

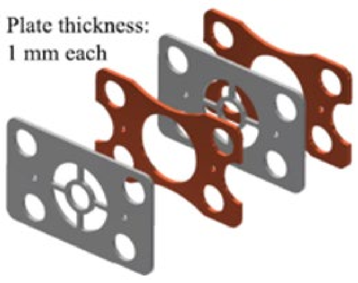
- SWFA with short RF pulses requires advanced structures **for high gradient** and **high efficiency**
  - Desired features: low RF loss, high group velocity, high shunt impedance

Metallic

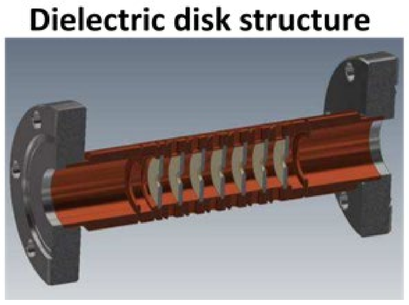


Dielectric

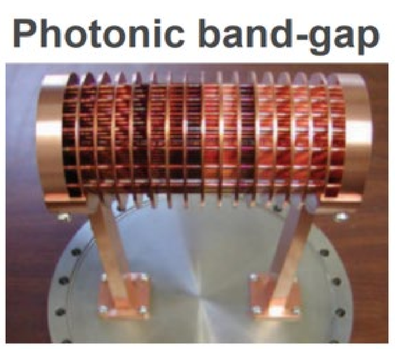
Metamaterial



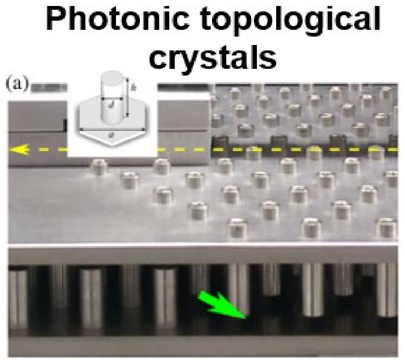
Dielectric disk structure



Photonic band-gap



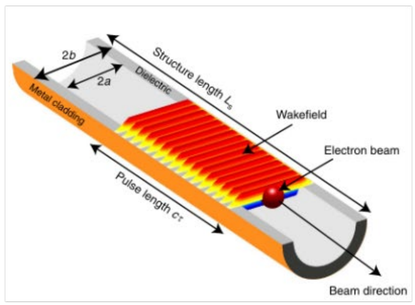
Photonic topological crystals



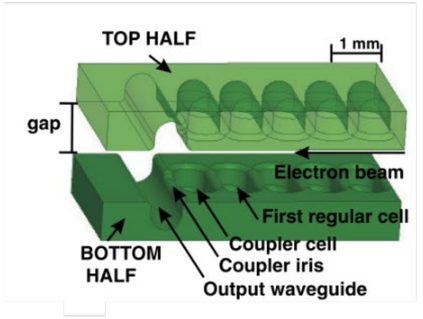
II. Terahertz (THz) Structures

- Advantages of THz wakefield structures
  - Strong beam-structure interaction (high gradient)
  - Small transverse size (compact and cost-effective)

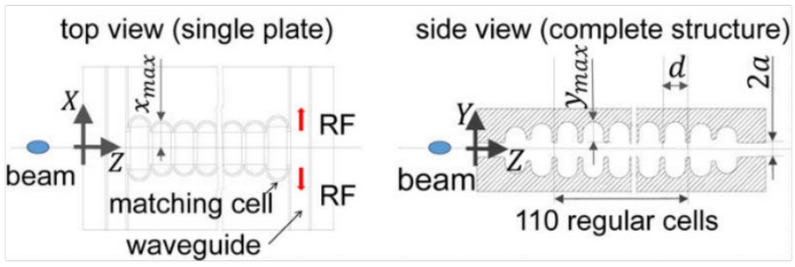
Dielectric-lined waveguide



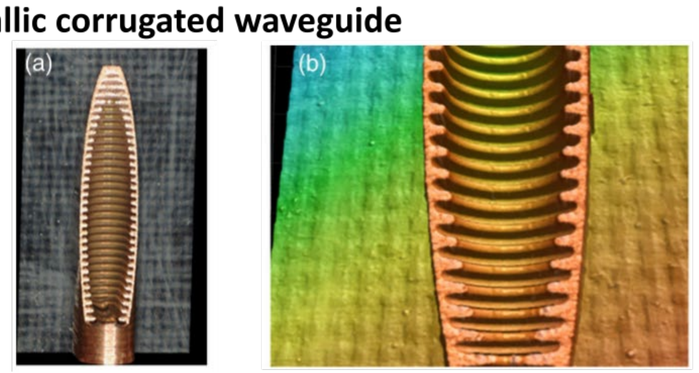
Metallic two-half structure 1



Metallic two-half structure 2

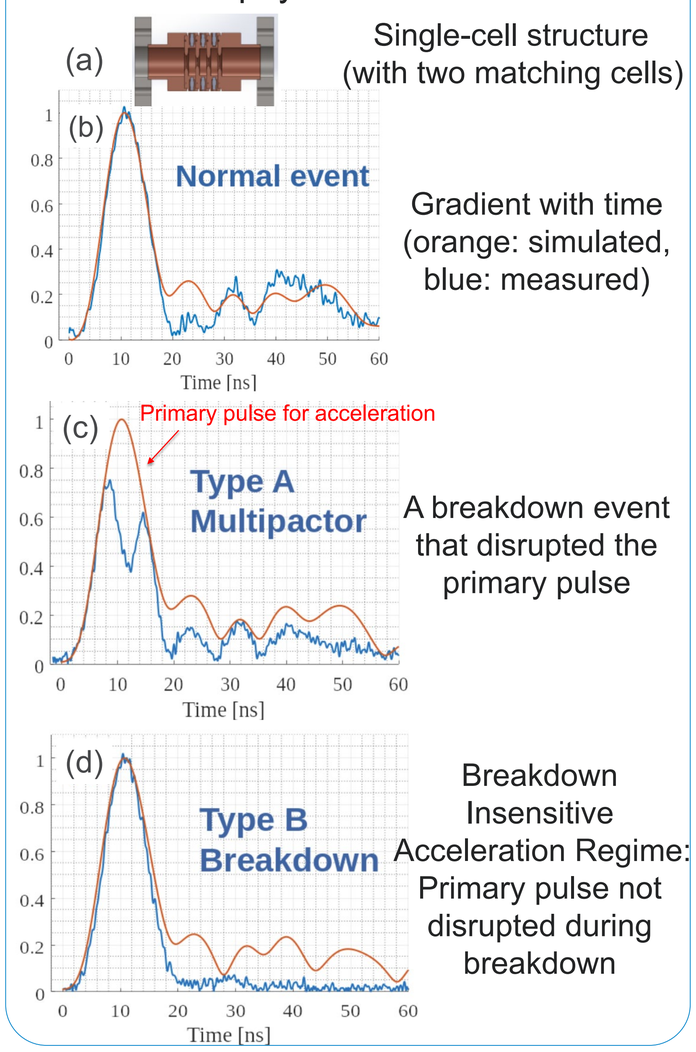


Metallic corrugated waveguide

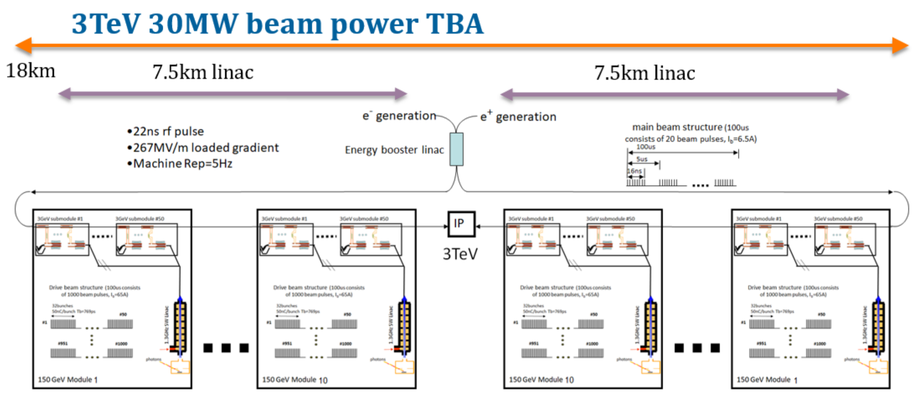


III. RF Breakdown Physics

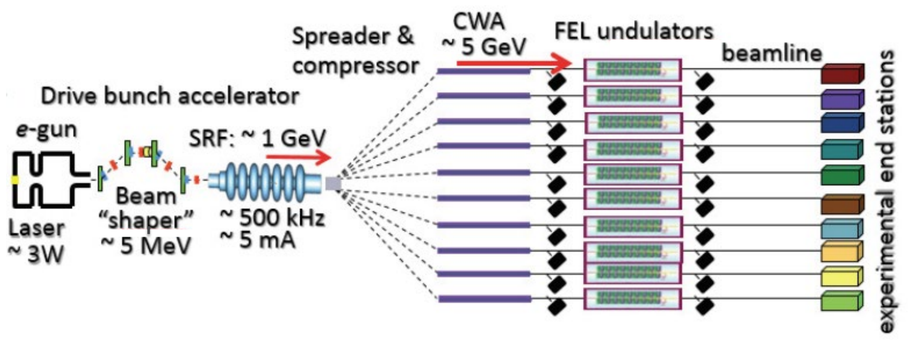
- Short-pulse operation (a few ns) in SWFA has the potential to dramatically increase the accelerating gradient
- New parameter space for RF breakdown physics



Linear Collider based on TBA



Compact Light Source based on CWA



Conclusions

- SWFA is one of the promising AAC schemes for future linear colliders, compact light sources, etc.
- Advanced structures, THz structures and RF breakdown physics are important topics in the next decade.
- White paper submitted to AF7:
  X. Lu et al., arXiv:2203.08374

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