



Northern Illinois
University

Arbitrary Transverse Correlation Generation using Transverse Wigglers

Gwanghui Ha
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Advanced beam manipulation

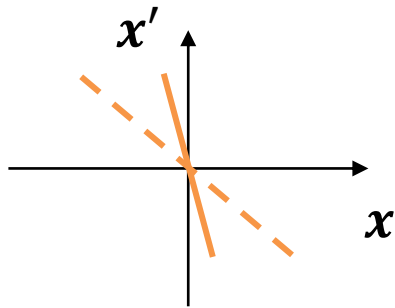


All 1 d.o.f. parameters

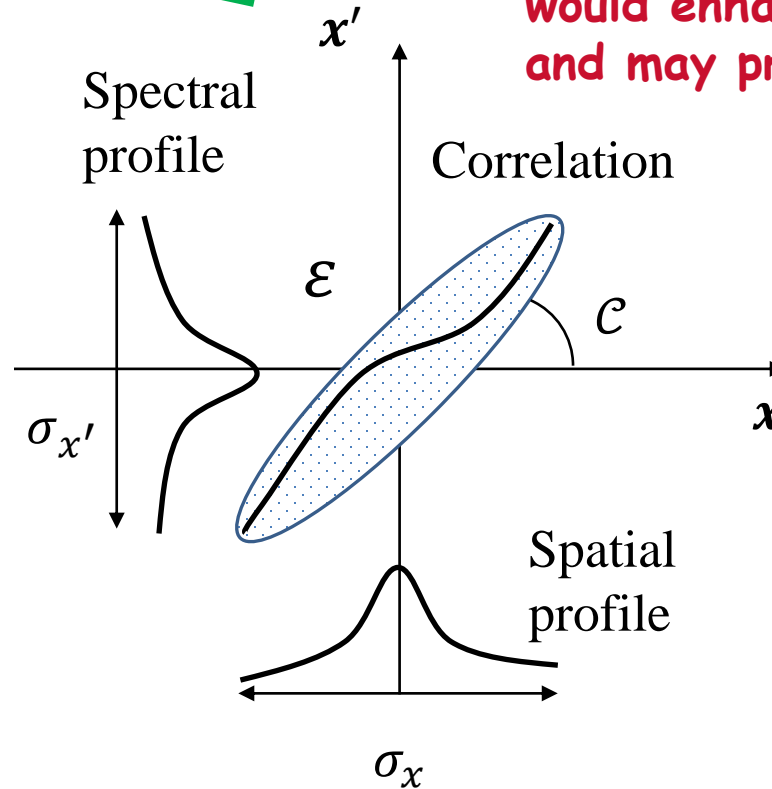
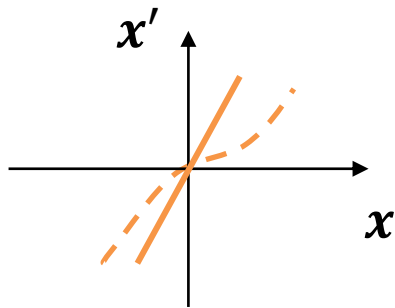


Arbitrary correlation would enhance manipulation quality and may provide new opportunities

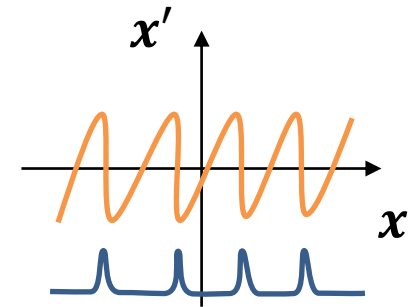
Focusing/compression



Linearization



Nonlinear pattern

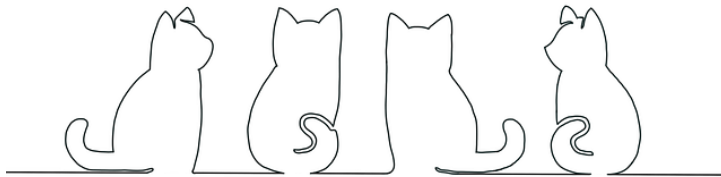


Control of these parameters \approx Control $x-x'$ correlation

How to accomplish arbitrary correlation control?



It would be great IF I can make any pattern....

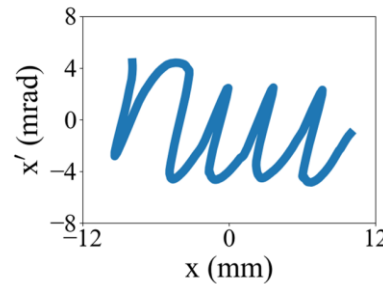


But starts from simpler version,
 $x' = f(x)$

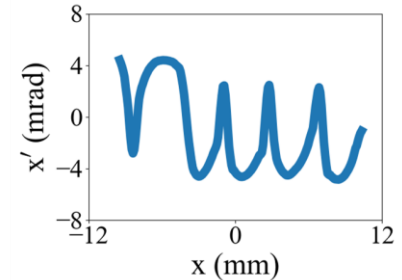
Target arbitrary correlation



Simplified TARGET correlation



Back-drifting to generate $x' = f(x)$ function

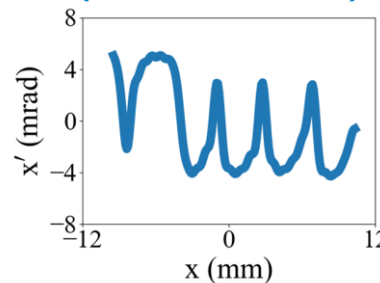


Approximation to cosine sum
(e.g., Fourier series)

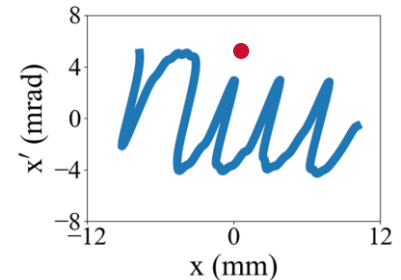
$$x' = f(x) \approx A_0 + \sum_{n=1}^N \left[A_n \cos\left(\frac{2\pi nx}{\lambda}\right) + B_n \sin\left(\frac{2\pi nx}{\lambda}\right) \right]$$



Fourier approximation
(70 harmonics)



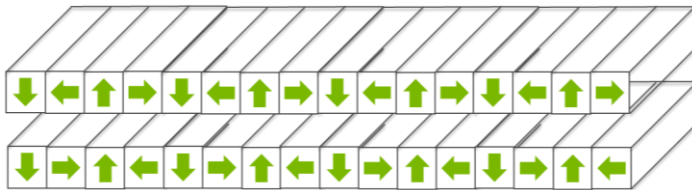
Final result after drift



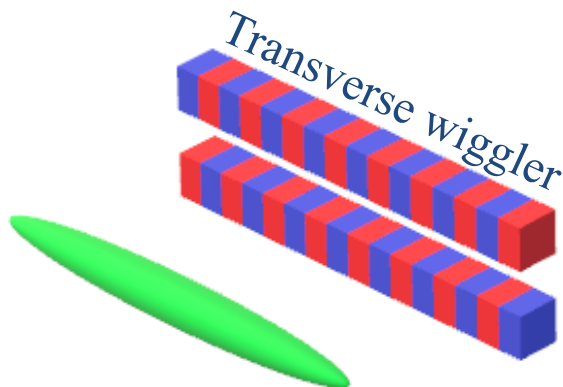
How to impart cosine correlation?



Transverse wiggler



$$B_y \approx -2B_r \cos\left(\frac{2\pi}{\lambda_u} x\right) \exp\left[-\frac{\pi g}{\lambda_u}\right]$$



Wakefield structure



$$E_z \approx -\sum_i 2k_i \int_{-\infty}^t I(\tau) \cos(\omega_i(t - \tau)) d\tau$$

- Transverse wiggler provides easy-control of field strength (gap), modulation phase (offset-to-axis).
- If tunable wiggler design is available, the period will become tunable too.
- Transverse modulations can be converted to longitudinal ones via EEX.

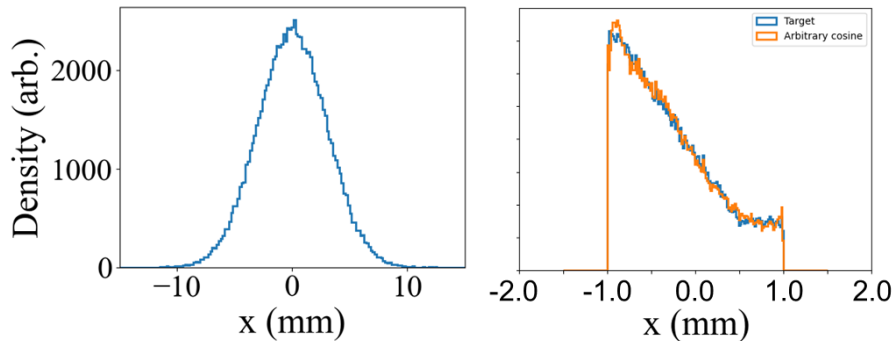
What kinds of experiments @ AWA?



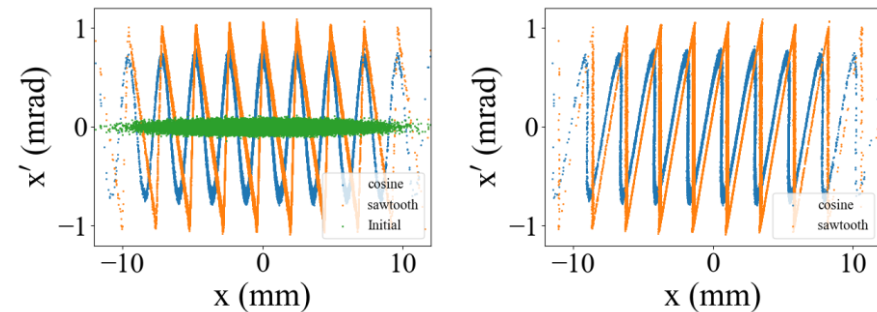
Proof-of-principle for first level functions

All done with 7-10 wigglers

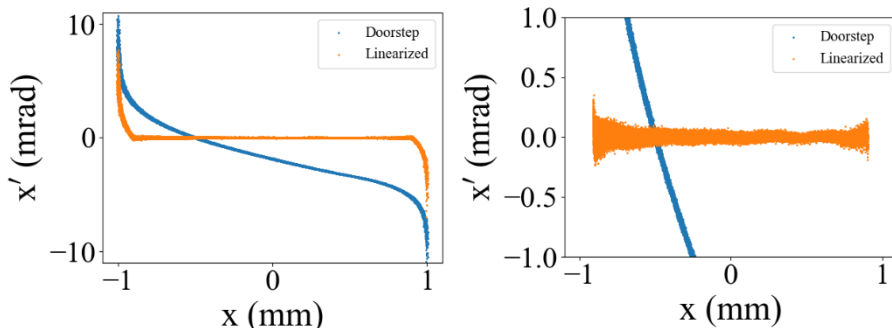
Profile shaping



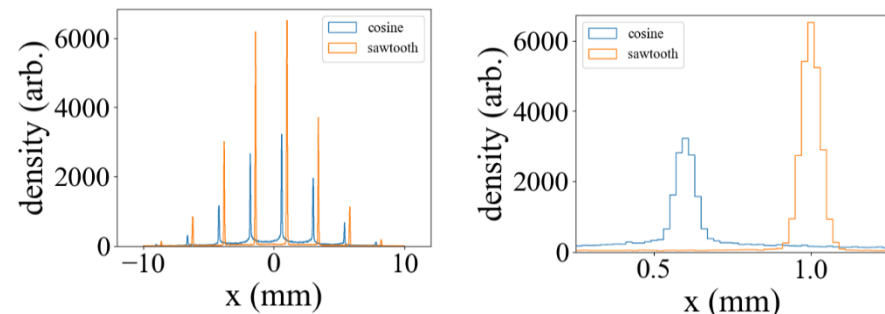
Bunch train & Sawtooth correlation



Linearization of complex correlation



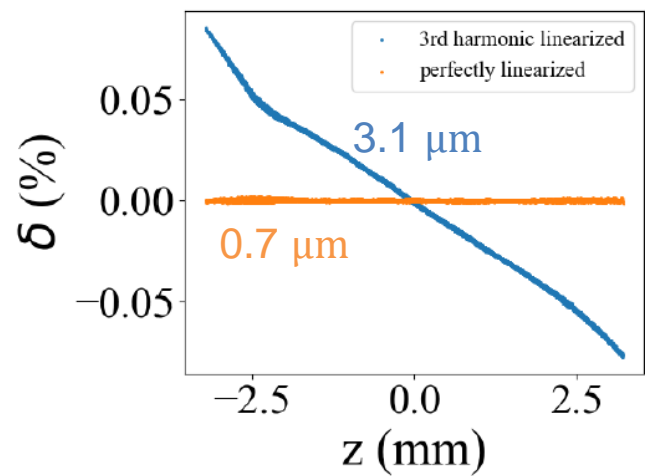
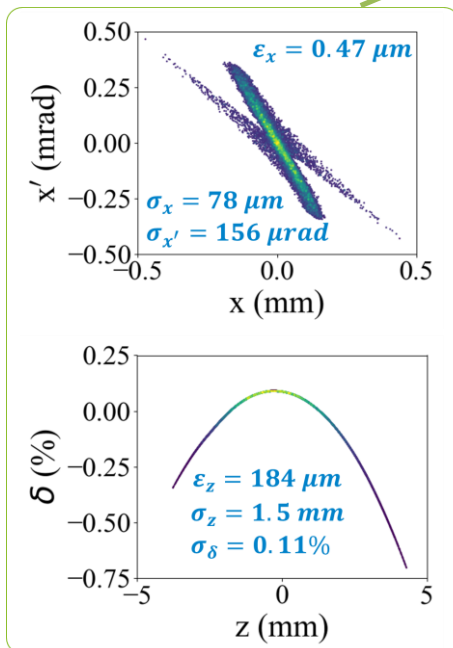
90%-cut, zoomed-in



What kinds of experiments @ AWA?



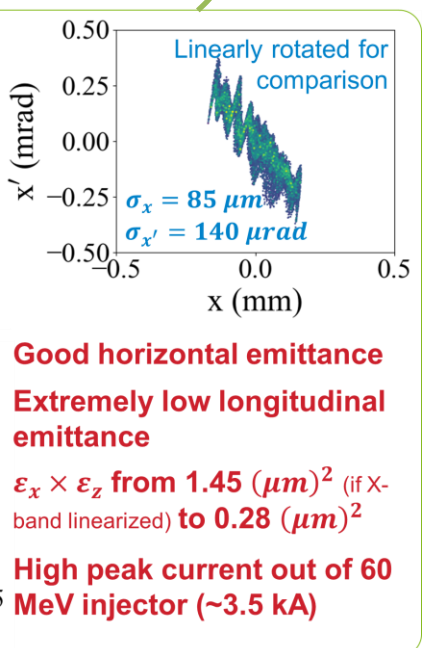
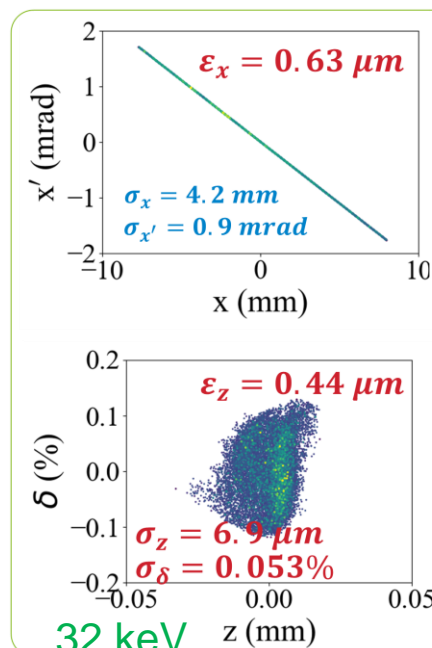
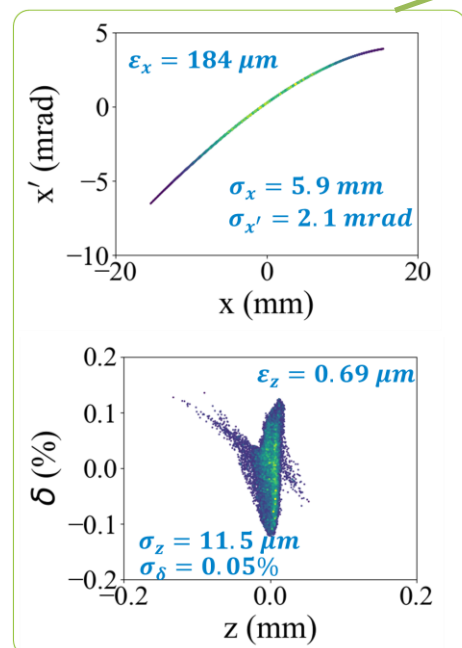
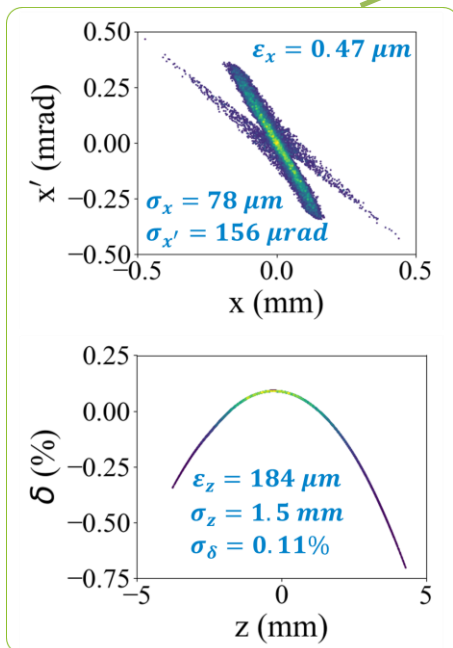
1. Application to high-brightness injector



What kinds of experiments @ AWA?



Application to high-brightness injector

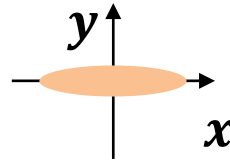


What kinds of experiments @ AWA?

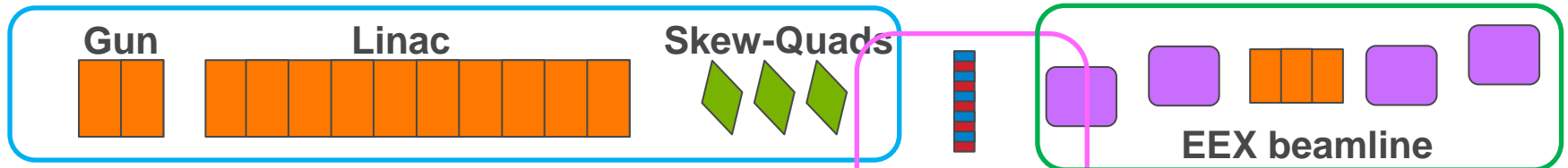
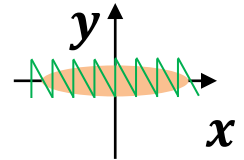


Application to superradiant radiation source

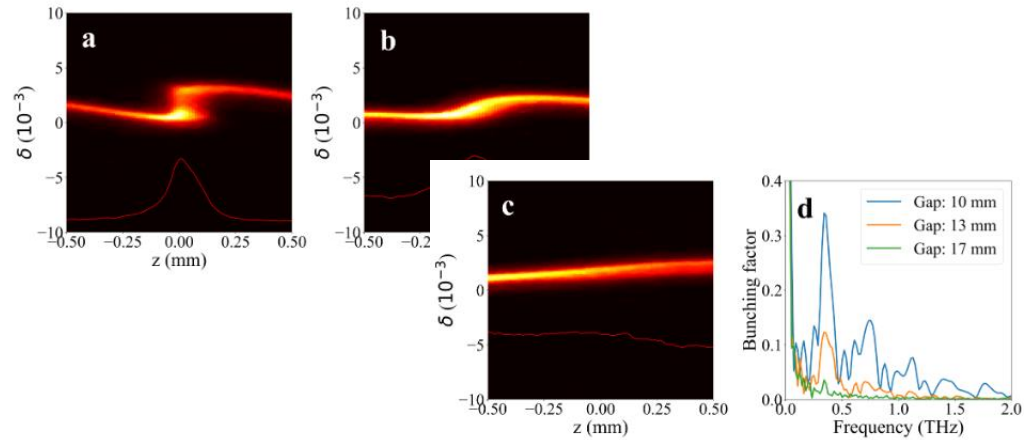
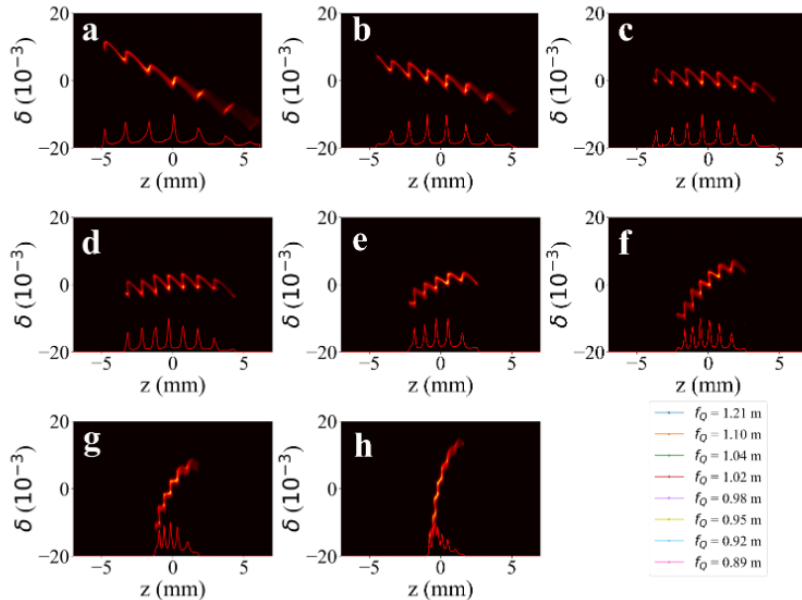
1. Flat-beam generation



2. Applying modulation



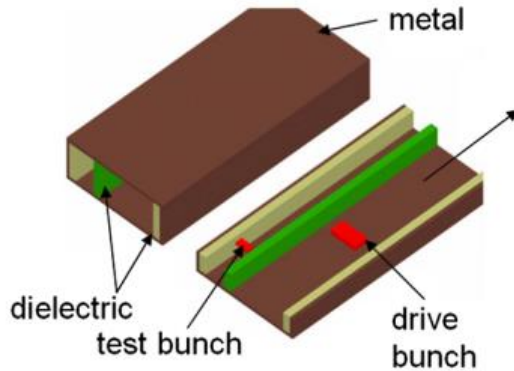
3. Density bunching & conversion to longitudinal



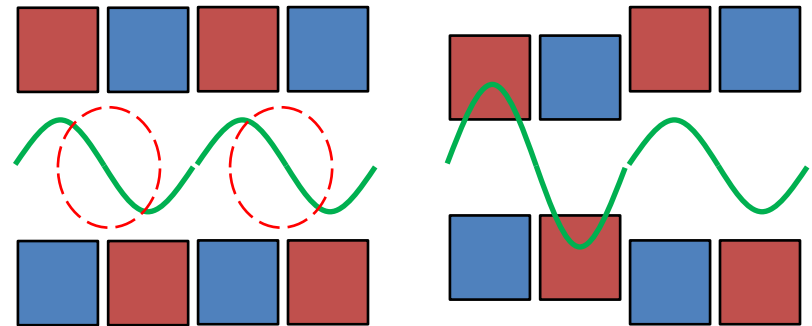
What kind of experiments @ AWA?



3. Application to two-channel wakefield structure

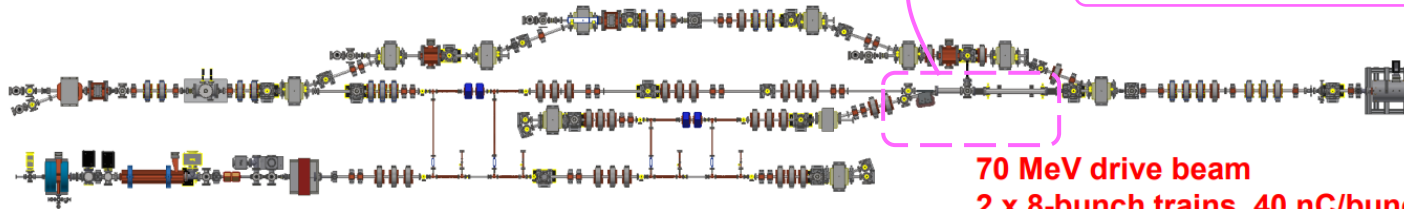


TW provides separate focusing field to each transverse beamlet



4. Application to beam separator

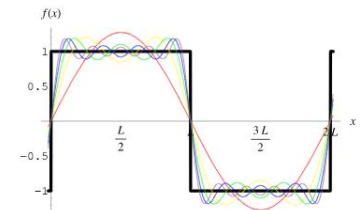
500-MeV demonstrator



15 MeV main beam
Low charge single bunch
Accelerated to ~500 MeV

70 MeV drive beam
2 x 8-bunch trains, 40 nC/bunch
Decelerated to ~20 MeV

Series of TWs may replace septum



What would be required?



General requirements

- Various beam conditions (e.g., charge-level, longitudinal configuration, etc.)
- Reasonably large flexible test area (3-4 m)
- Beamline (5-10 m) construction availability
- Various high-performance diagnostics

Special requirements

- Advanced manipulations (e.g., FBT, EEX, etc.)
- High quality low-charge beams

Improving drive gun would be good

Dedicated high-brightness low-charge beamline would be great

- Extra-acceleration

More energy selection would be good

Higher energy would significantly help most of applications and output qualities

Personal requirement Close to sofa at home

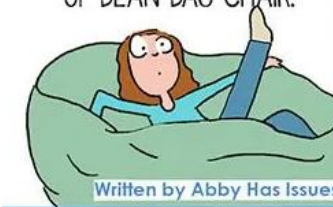
1. GET IN BEAN BAG CHAIR.



2. RELAX.



3. TRY AND GET OUT OF BEAN BAG CHAIR.



4. PANIC.



5. DON'T FIGHT IT.
ACCEPT THIS IS WHERE
YOU LIVE NOW.



*from hedgerhumor.com/accept-it/

Summary



- Transverse wiggler (or wakefield structures) is a tool enabling the generation of arbitrary correlation.
- We plan to explore this new functions and opportunities through various proof-of-principle experiments.
- AWA facility is able to provide great experimental environment including its unique capability of FBT and EEX.
- Further upgrades in beam brightness and energy seem required. They are showstoppers for certain applications, and such upgrades would significantly impact output quality.