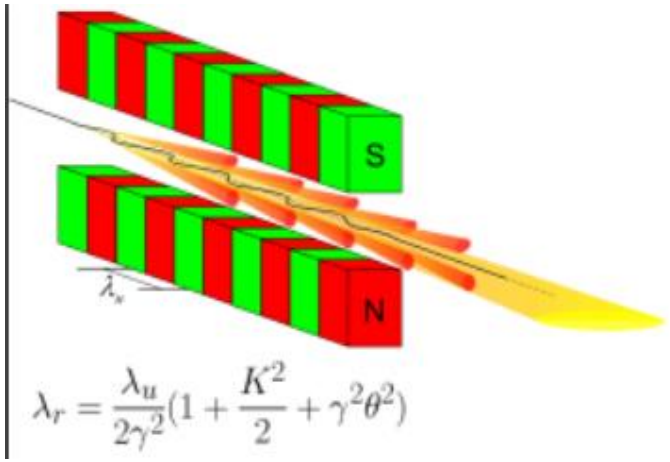
STERN: SUPERRADIANT THZ RADIATION GENERATION AT EUXFEL

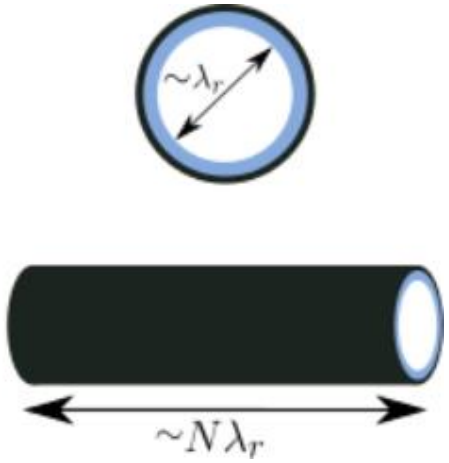
Francois Lemery, Karel Peetermans, Winni Decking, Klaus Floettmann, Nina Golubeva, Nils Lockmann, Bernd Steffen, Marie Kristin Czwalinna, Martin Dohlus, Igor Zagorodnov, Jonah Richards, Torsten Wohlenberg, Lukas Mueller, Daniel Thoden, Lucy Müller, Riko Wichmann, Stuart Walker, Marc Guetg, Shan Liu, Sergey Tomin, Weilun Qin, Tianyun Long, Serge Bielawski, Mikhail Krasilnikov, Gianluca Geloni, Dirk Lipka, Artem Novokshonov, Gero Kube, Ingmar Hartl, Evgeny Negodin, Matthias Scholz

HELMHOLTZ
DESY.

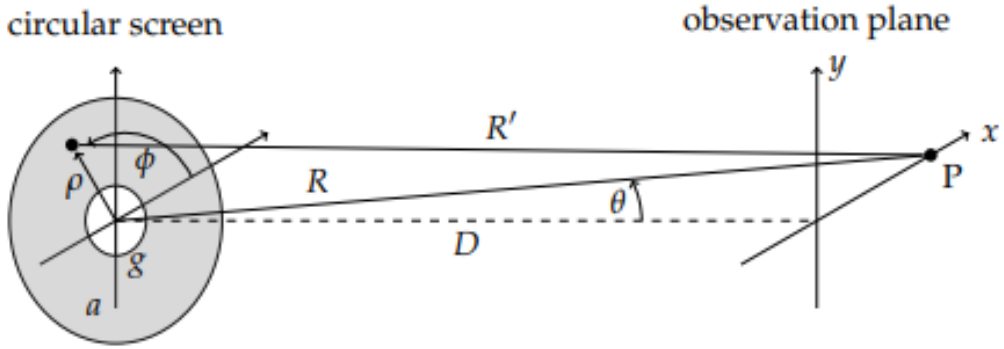
Electron beam based radiation sources



Undulator



Cherenkov
(wakefields)



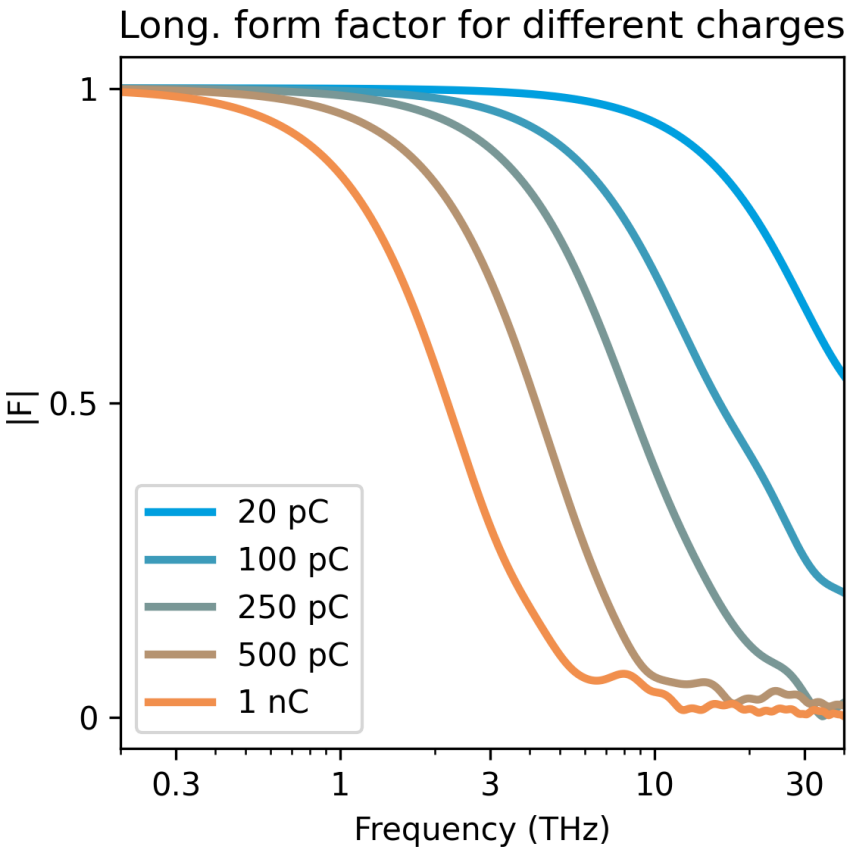
Diffraction

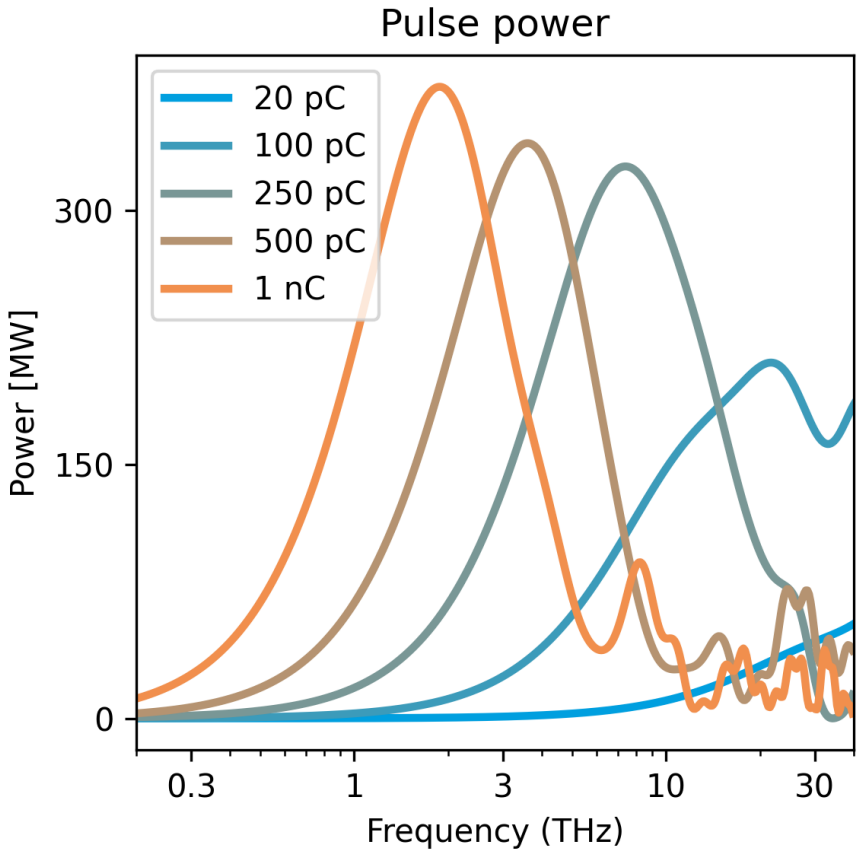
- At 16 GeV, undulator approaches are challenging to cover the THz regime ($\lambda_u \sim 1$ m for 18 GeV)
- Cherenkov approaches are energy independent and depend on inner aperture and thickness
- Diffraction radiation is also appealing for its ability to produce very broadband radiation on the order of uJ.

Spectral content of the XFEL operational modes

The XFEL's operational modes and their corresponding bunch form factors are shown (left).
The power can be calculated from the equation shown above,

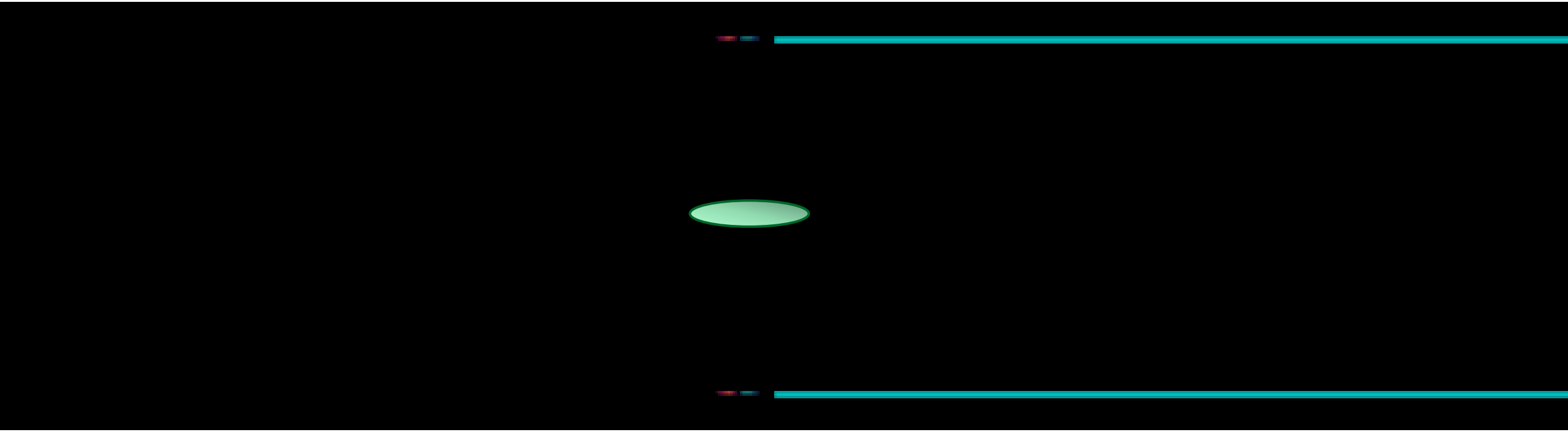
$$P = q^2 F^2 \frac{Z_0 k_0^2 c}{16\pi}$$





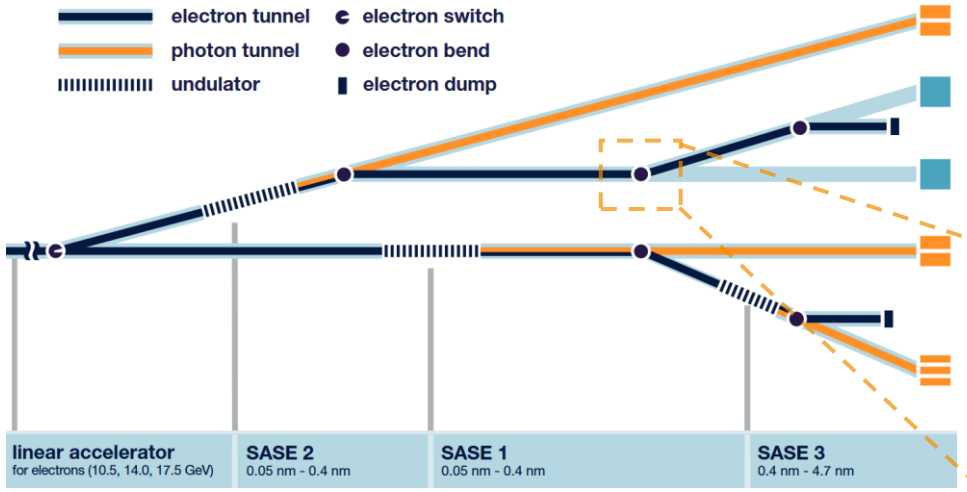
Dielectric Tube

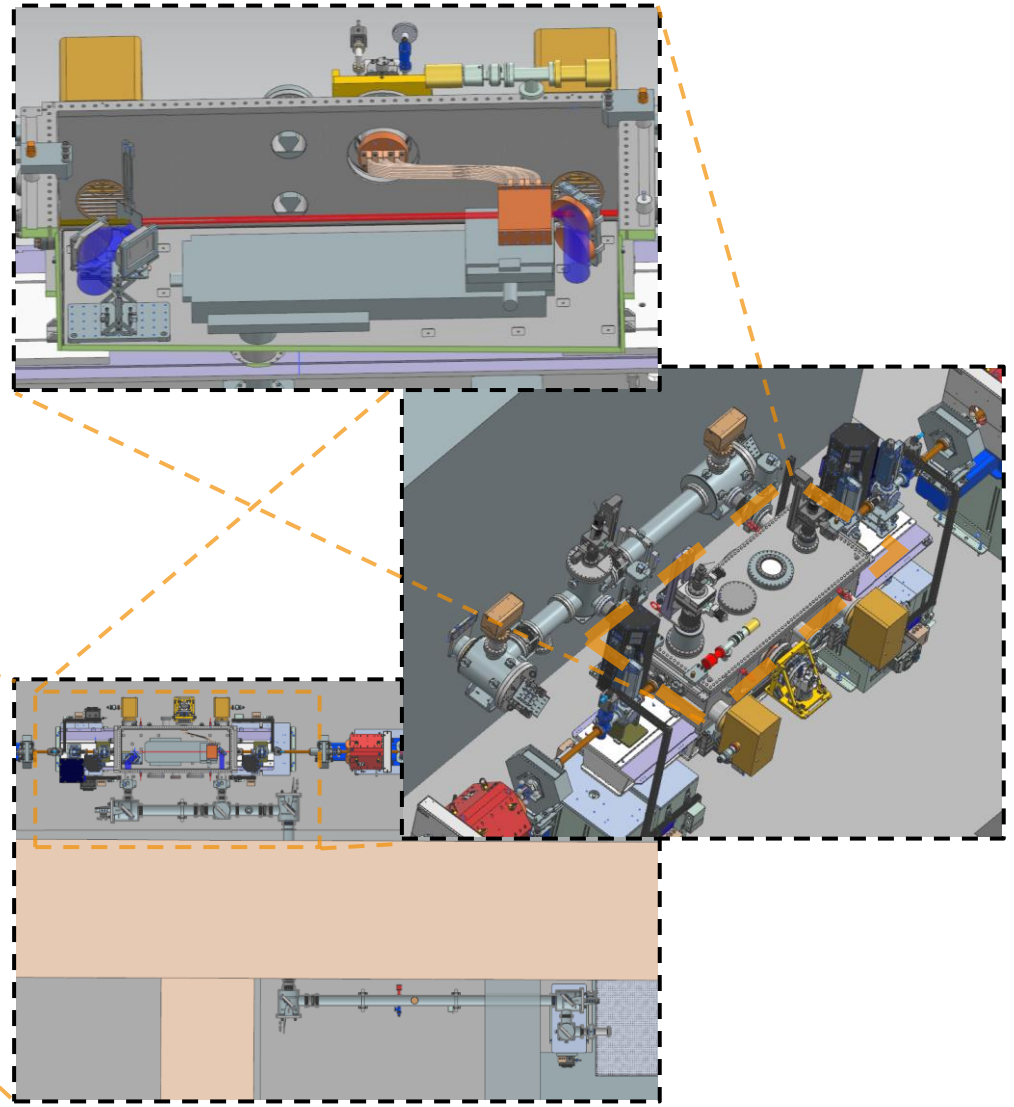
Simulation made in ECHO2D by summer student J. Richards (U. Calgary)

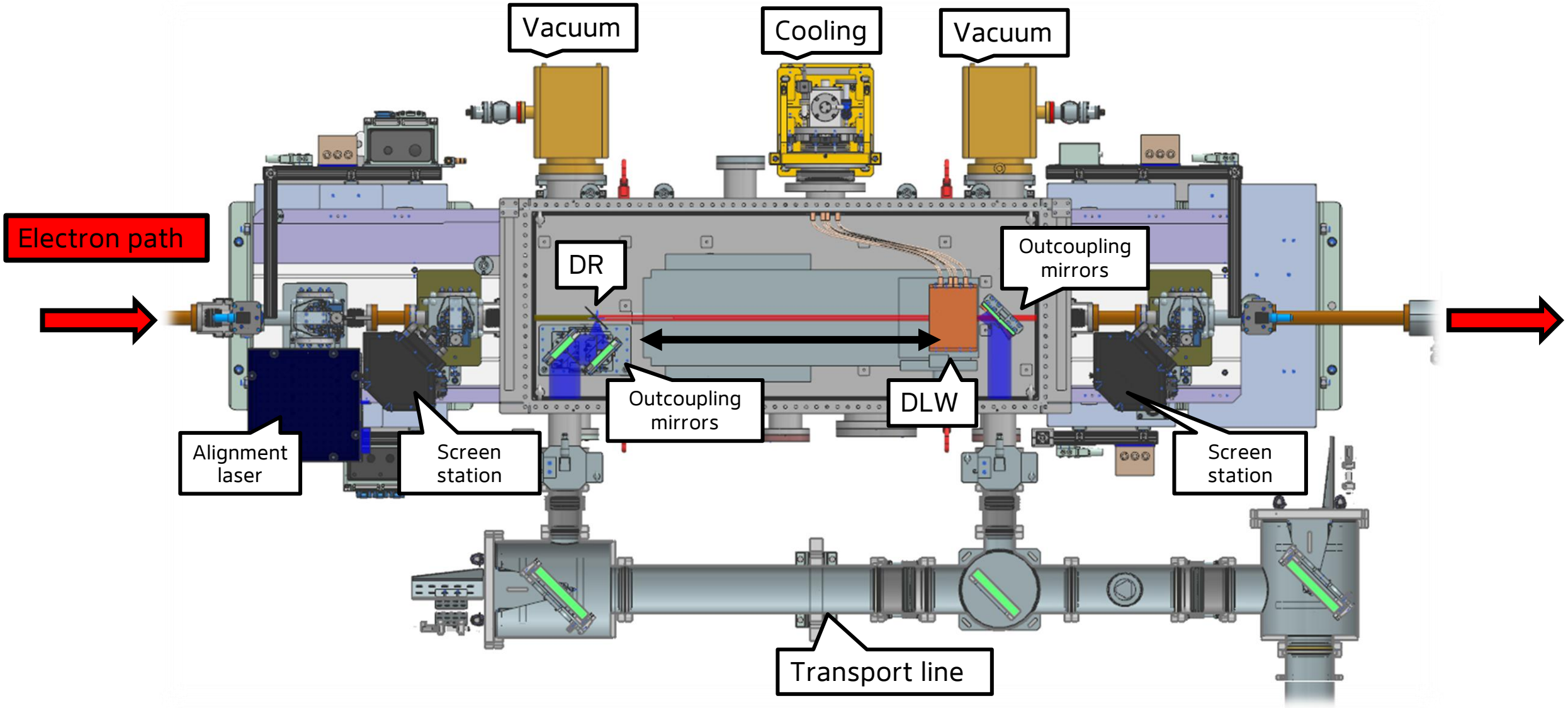


Electron beam based radiation sources

- Located after SASE2
- THz beam transport 10m to diagnostics lab
- Accessible during machine operation






Vacuum
Cooling
Vacuum
Electron path
DR
Outcoupling mirrors
Outcoupling mirrors
DLW
Alignment laser
Screen station
Screen station
Transport line

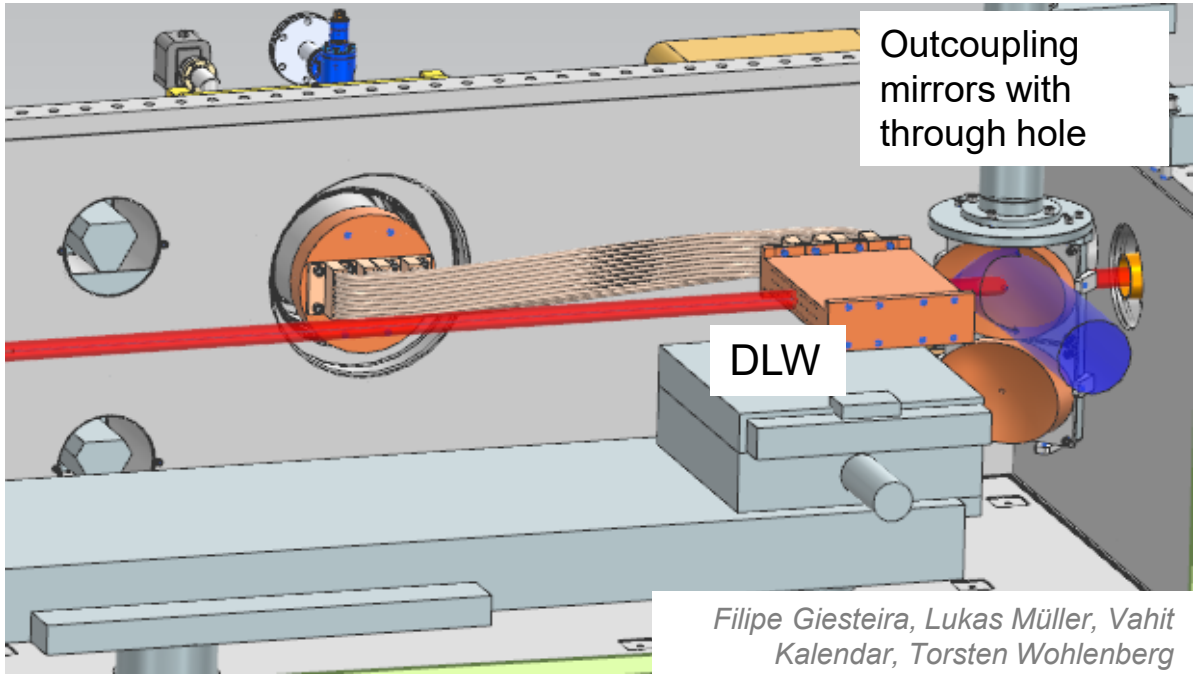
Waveguides planned

Dielectric lined waveguides (DLWs)

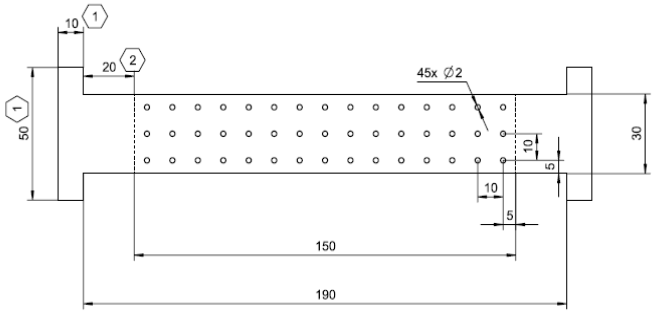
Split block approach will be used to enclose two or three layers of tubes.

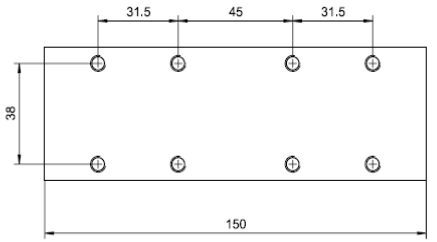
Will include:

- ALD – thin layers
- Normal thick glass capillaries (Multi mode)
- Tapered waveguides
- Fibers
- Spiral tubes
- Corrugated waveguides
- Bimetallic
- Low loss waveguides (Sapphire, Quartz)



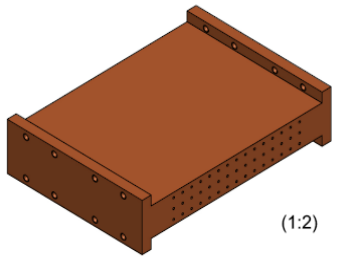
Filipe Giesteira, Lukas Müller, Vahit Kalendar, Torsten Wohlenberg



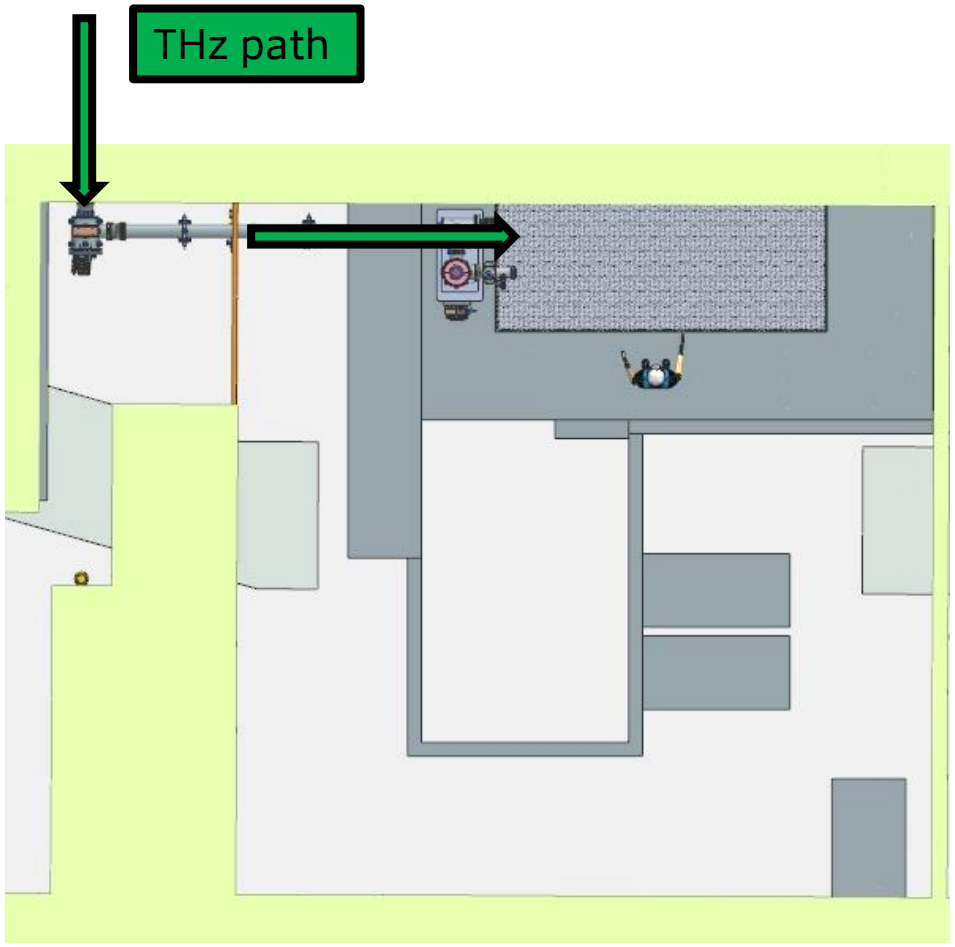


1 Cryo Interface

2 Out-of-the-Beam



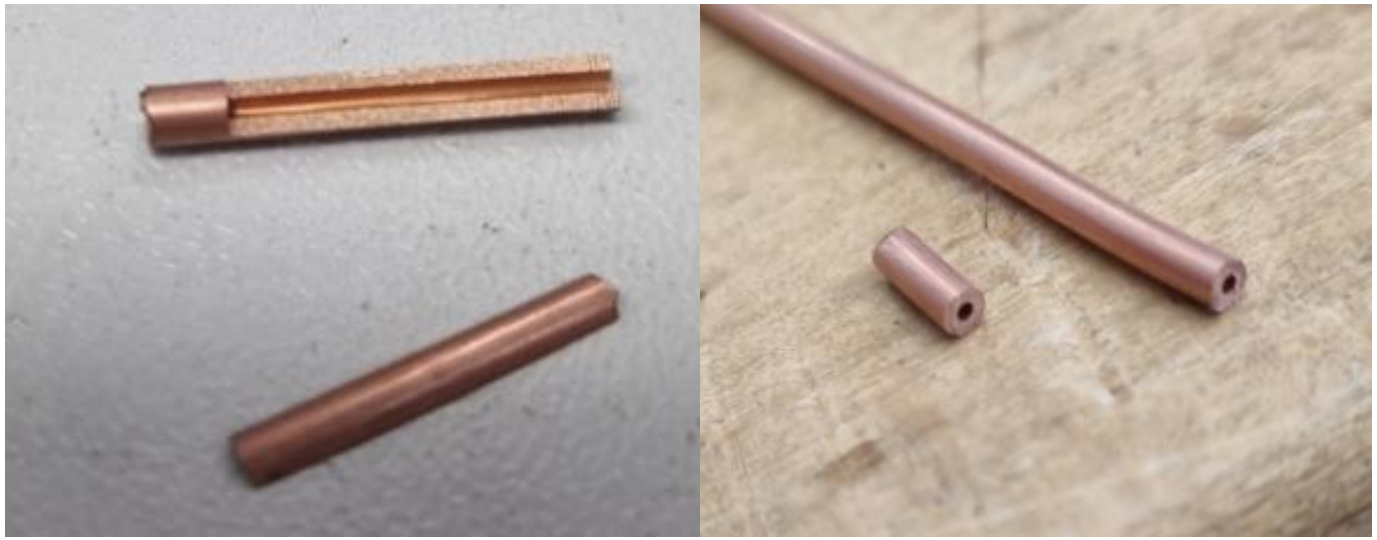
Lab Area for THz Diagnostics

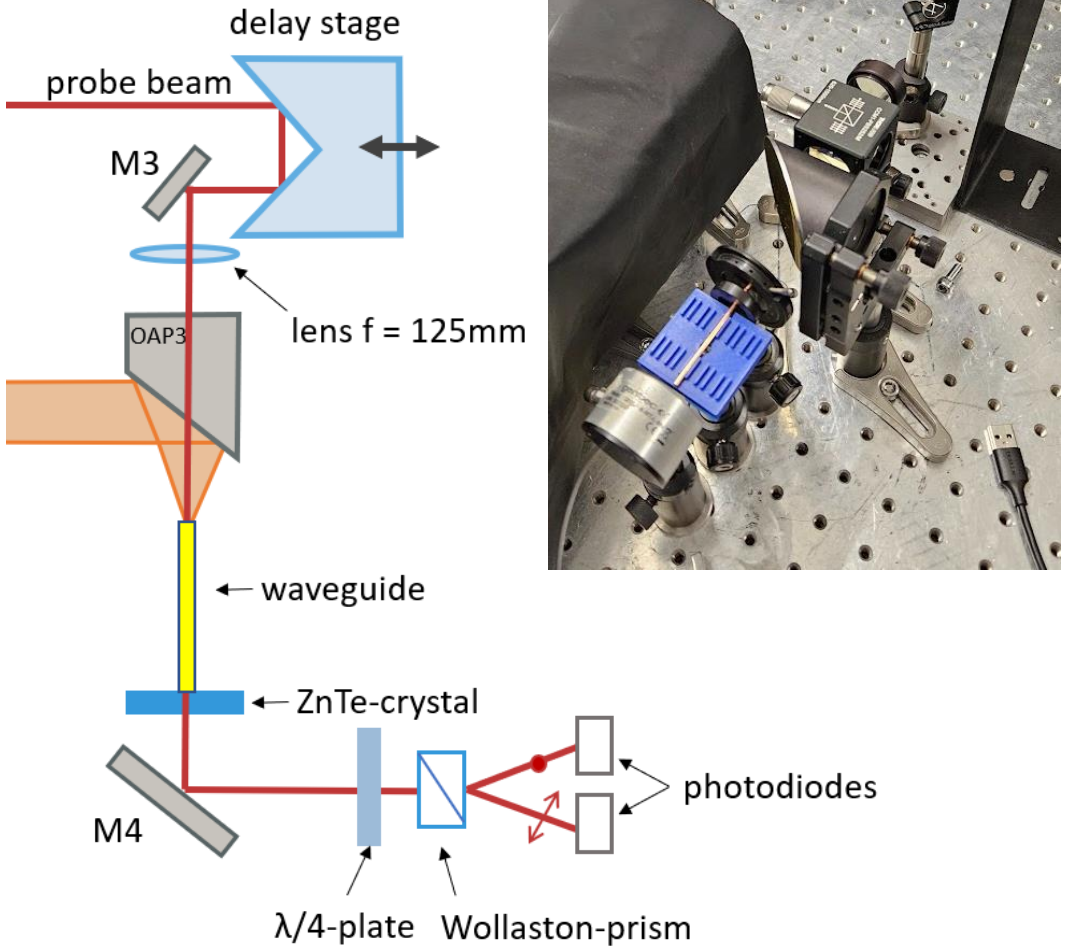


- THz radiation is brought to safe Diagnostics lab via transport line
- planned **THz Diagnostics**
  - THz camera
  - Autokorrelator for Pulselength
  - Spectrometer (multiple gratings and Pyro detector)
  - Electro Optic Sampling, with 1030nm fiber laser
- **Modular Lab Design:** Temporarily extend the lab space into the crane shaft area, easily disassembled
  - false floor for improved working height and cable management

Waveguide Characterization

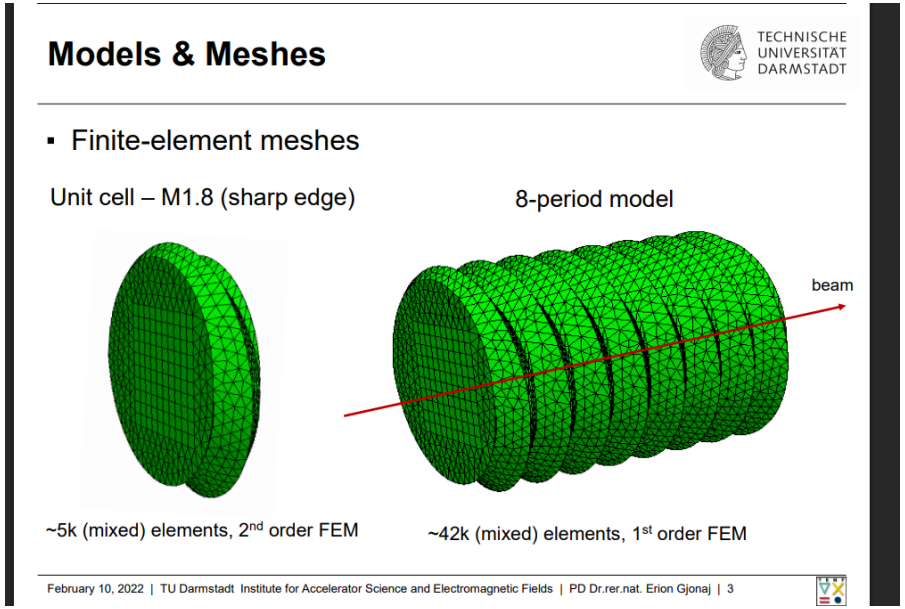
- Measure THz dispersion properties in waveguides using electro optic sampling (EOS)
- Characterize waveguide coating produced using atomic layer deposition.
- Use the TPF and EOS setup to analyze waveguide mode dispersion and losses in waveguides

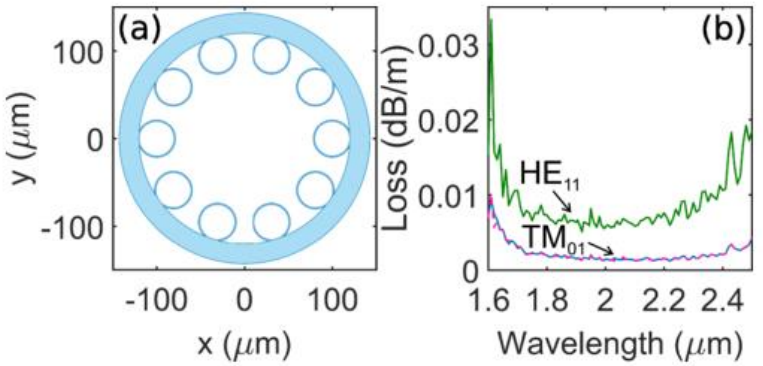




Ongoing Collaborations

- We are interested in collaborating and simulation support on two topics in the short term:
  - **Spiraled waveguides to generate circularly polarized wakefields**
    - Initial investigation with Erion
    - Possible investigations into alternative geometries
  - **Anti resonant fiber excitation**
    - An anti-resonant fiber supports windows of transmission.
    - These can be considered over-moded waveguides with group and phase velocity very close to c.
    - Would be interested in investigating mode excitation from XFEL beams to generate MIR.



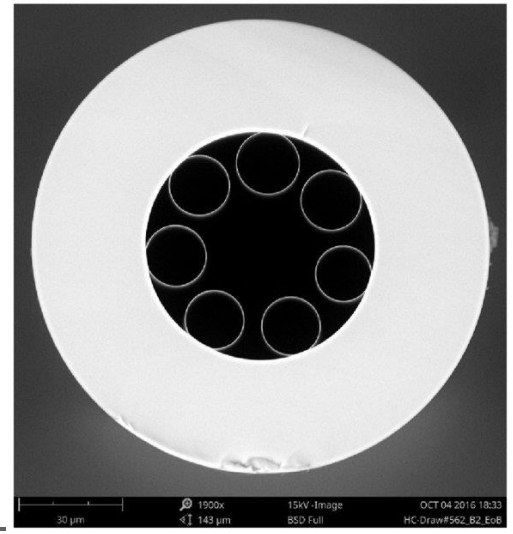


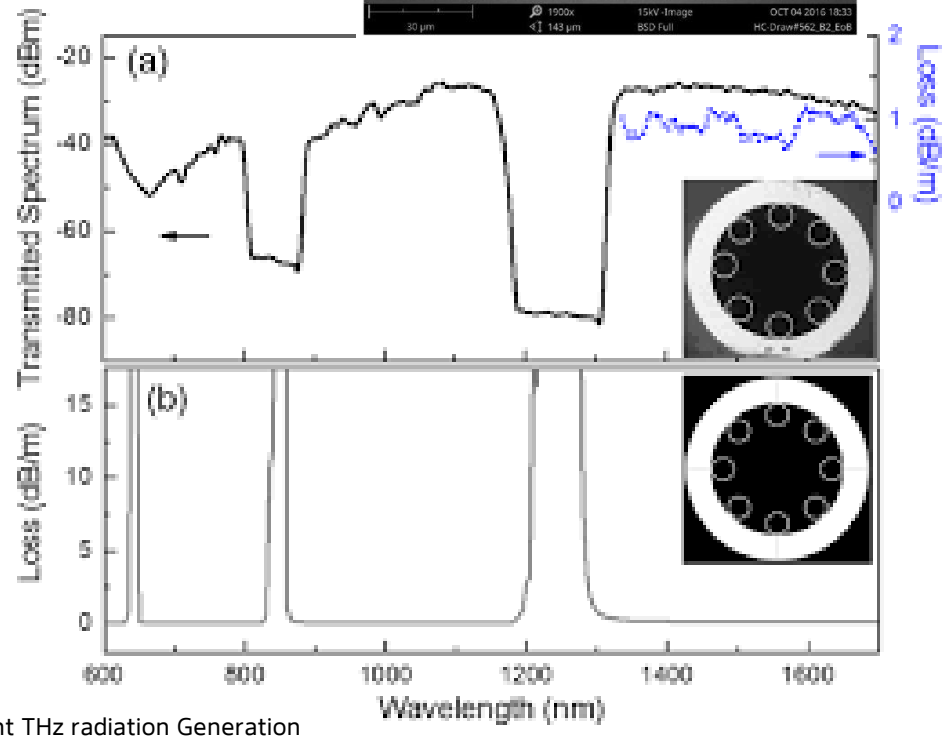
Hollow Core Anti-Resonant Fiber (HC-ARF)

- Extremely low losses across trasnsmission bands
- Large diameters (140 um)
- TM-like mode in the core ($v_{ph} \gtrapprox c$)
  - What happens if we shoot an electron beam through it?!
  - Investigating with Igor and Erion
  - Similar to phase matching in a crystal?

$$\lambda_k = \frac{4t\sqrt{n_s^2 - n_{gas}^2}}{2k+1}$$

$k = 1,2,3,..$ →anti-resonant windows





Thank you for your attention!

Do you have any questions?