FACET

Little Beams, Big Fields

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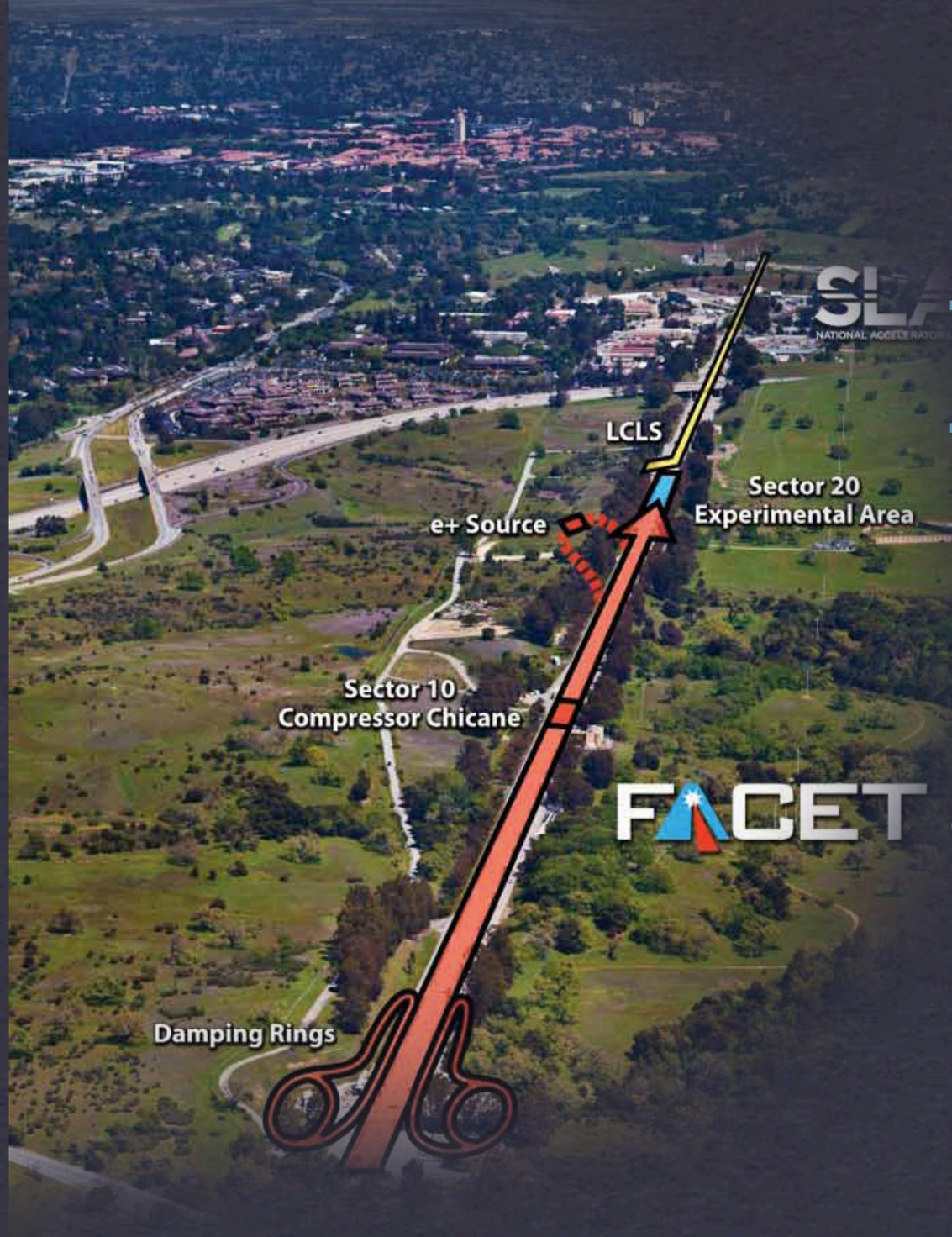
SASSin' it up
Febuary 15th, 2012

Happy Valentine's / Singles Appreciation Day!

OUTLINE

1. FACET - Mission, Goals, and Design
2. Experiments @ FACET - Ultrafast Magnetic Switching, Dielectric Wakefield Acceleration, THz Radiation, Beam Diagnostics
3. E200 - Plasma Wakefield Acceleration

What is FACET?



FACET is the first 2/3 of the SLAC Linac. It includes the damping rings, 2 km of accelerating RF cavities, a compressor chicane in Sector 10, and the W-chicane and experimental area in Sector 20.

Wherefore FACET?

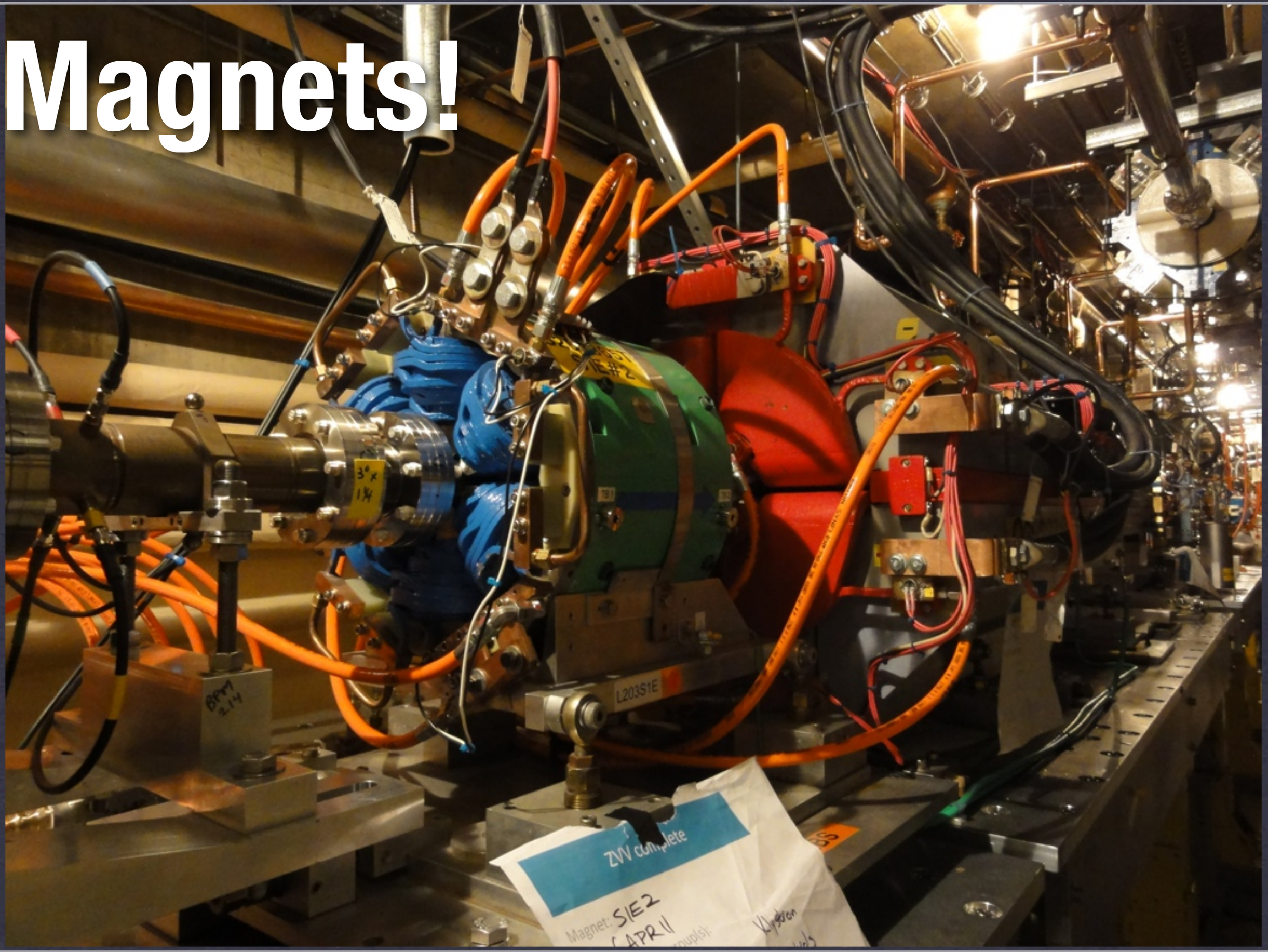
FACET was designed to meet the DOE's Mission Need Statement for an Advanced Plasma Acceleration Facility.

The particle beam produced at FACET is squeezed down to 10 x 10 x 10 microns and contains 10 billion e^-/e^+!

The high current and space charge are needed for Plasma Wakefield Acceleration research, but there are plenty of other experiments that can make use of the **super-huge fields** created by this beam!

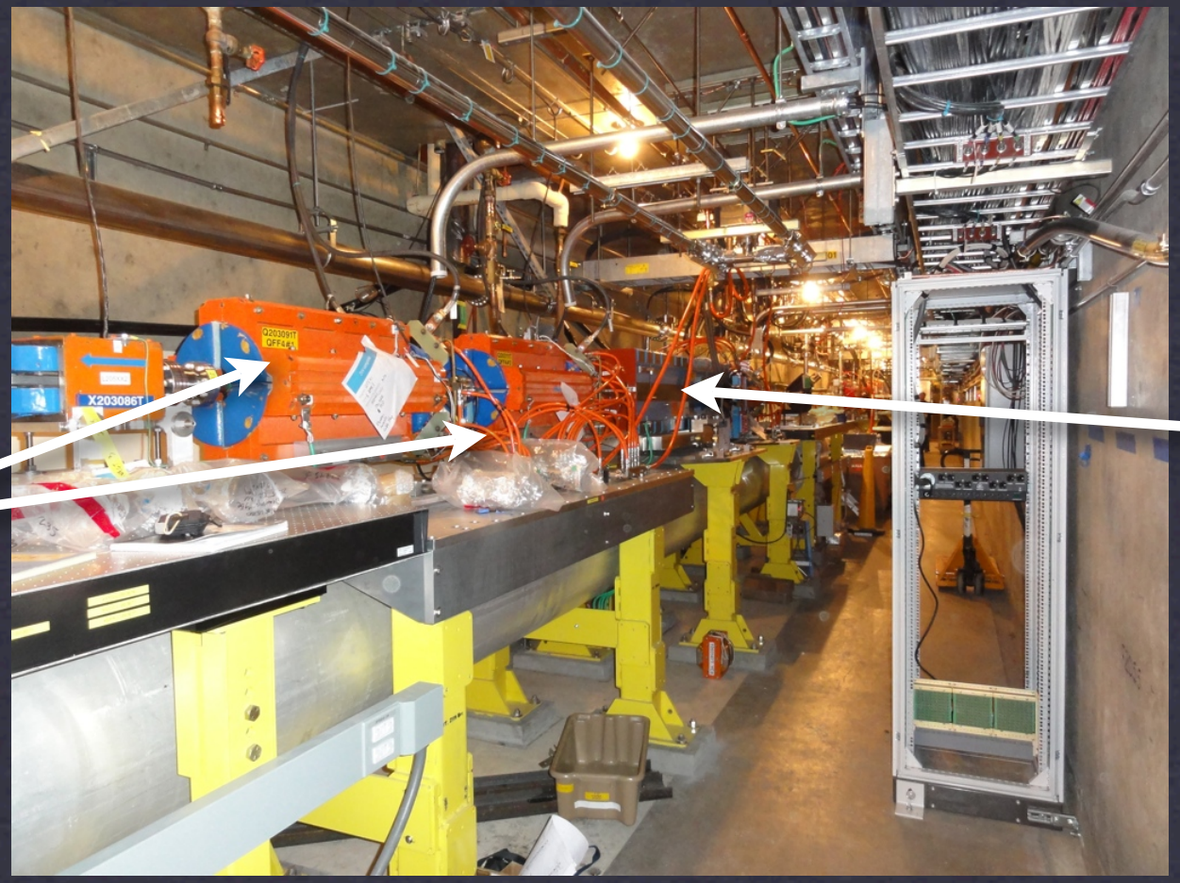
How’d you get your beam so small?

Magnets!



Transverse Focusing

Transverse focusing is achieved with quadrupole magnets. The field depends on how far the beam is from the center of the magnet. Analogous to optical lensing.



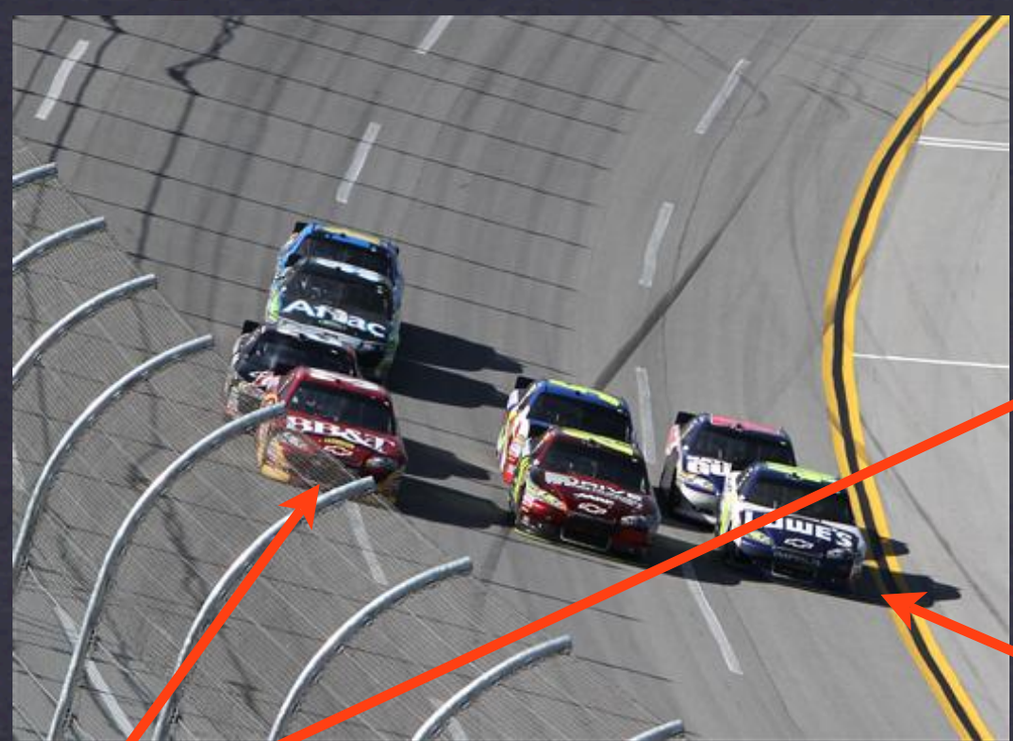
LIL' FOCUSING QUAD

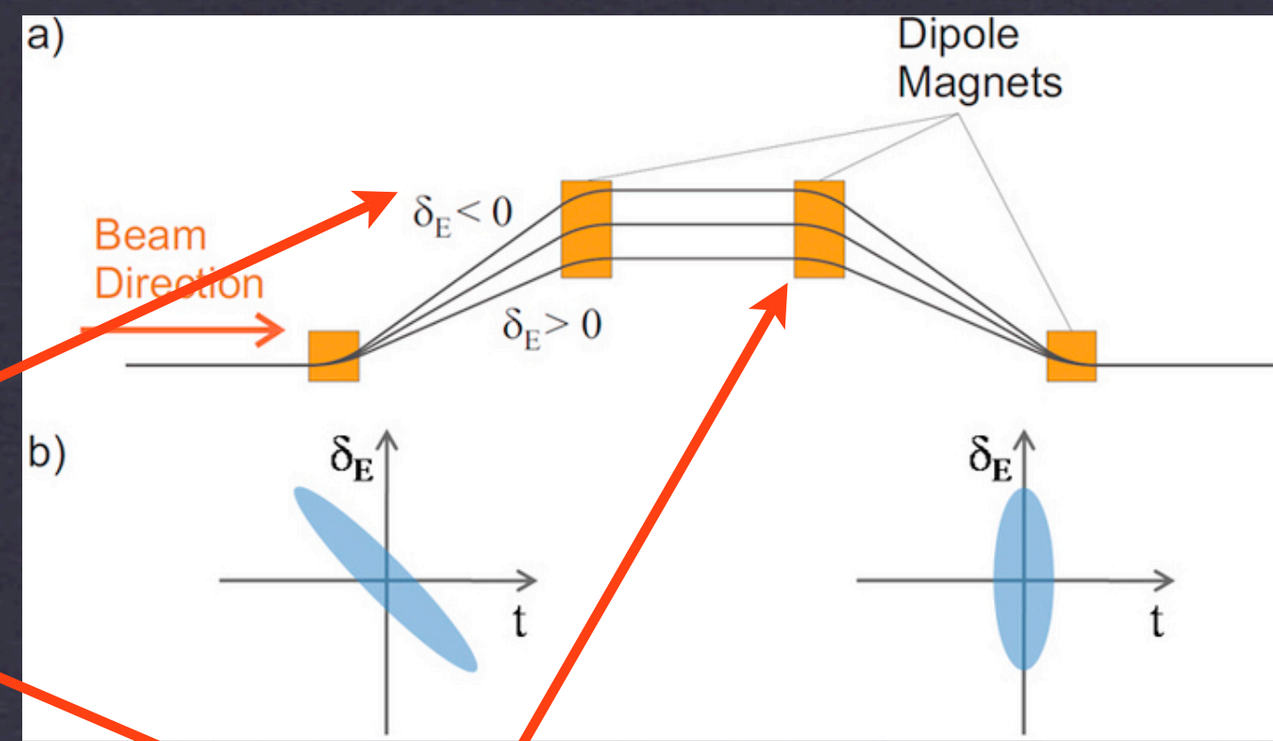
BIG FOCUSING QUAD (4.5 TONS!)

Longitudinal Compression

Relativistic particles all move at the same speed!

Need to change the path length of the particles to compress the bunch.



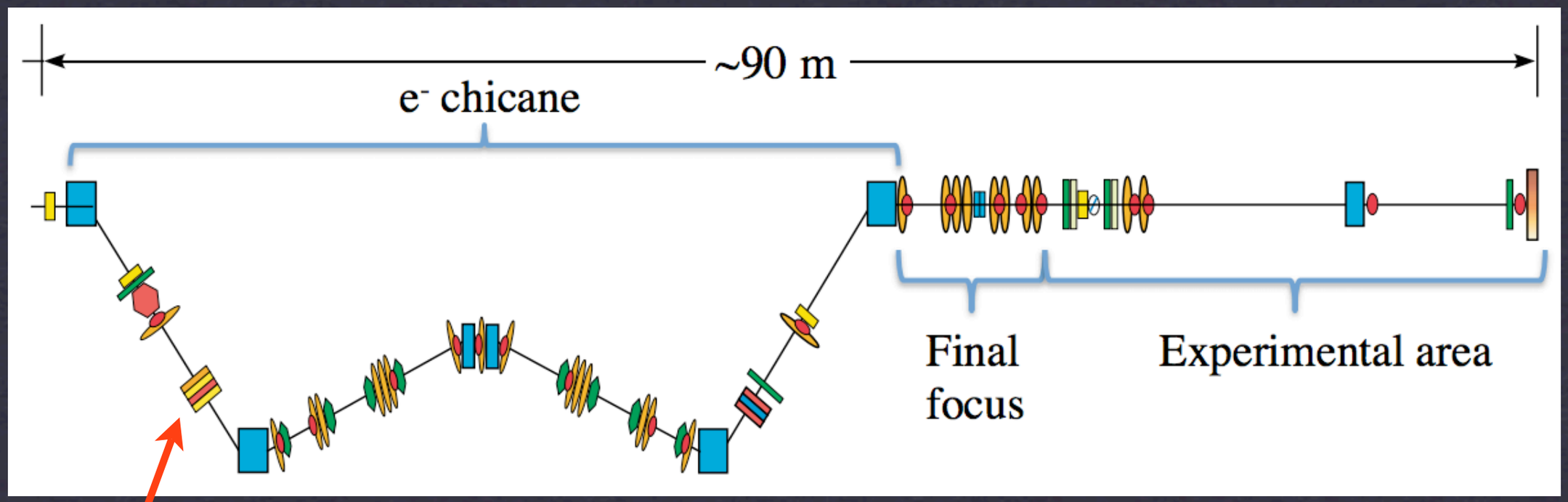


LOW ENERGY PARTICLES TAKE LONGER PATH

HIGH ENERGY PARTICLES TAKE SHORTER PATH

The W-Chicane

Why is FACET's beamline so kinky?



NOTCH COLLIMATOR

Experiments @ FACET

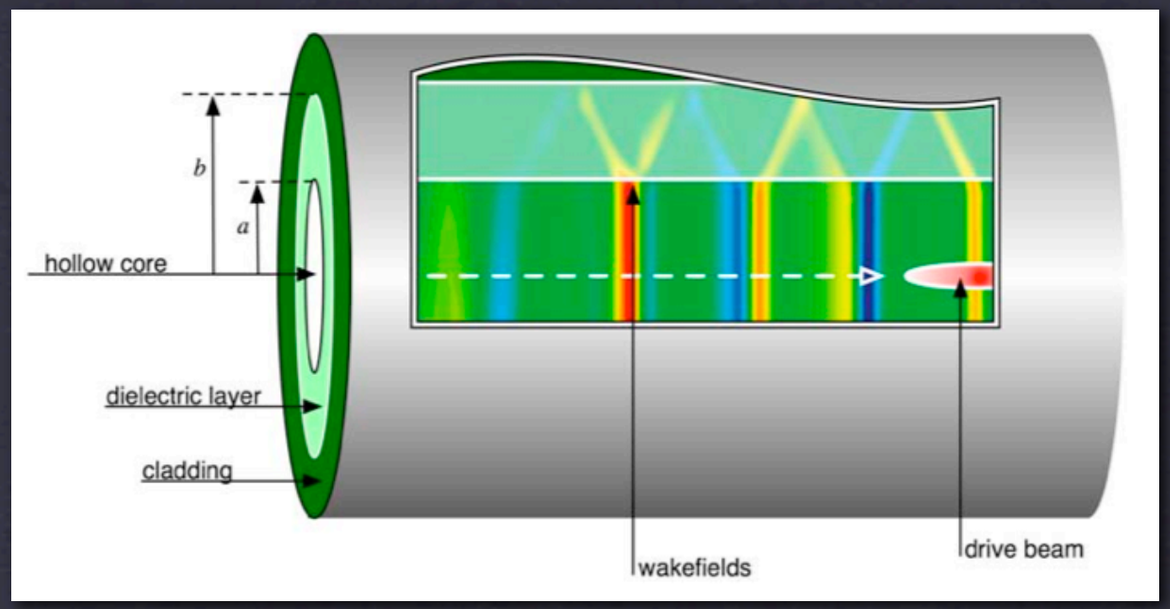
E201/205: Dielectric Wakefield Acceleration

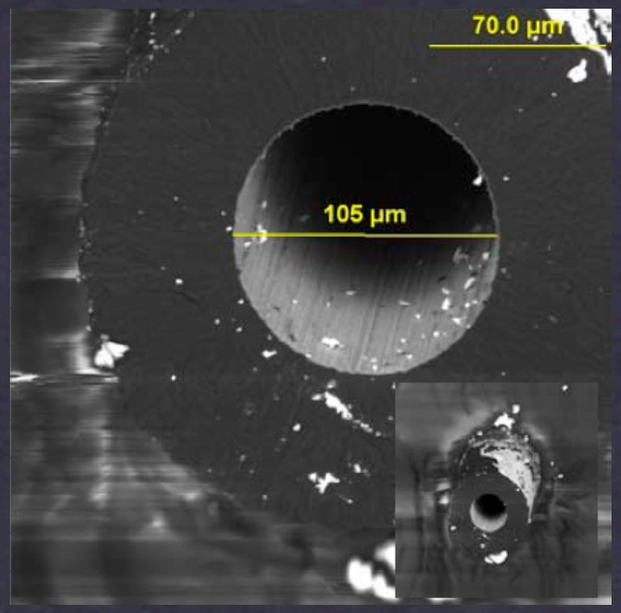
Why dielectrics? Dielectrics can support E fields of several GV/m without breakdown. Compare that to copper which can only withstand ~100 MV/m before breakdown.

What are the challenges? To induce large fields in the dielectric, you must pass a high charge density beam near the surface. But you should try not to smash your beam into the sample!

E201/205: Dielectric Wakefield Acceleration

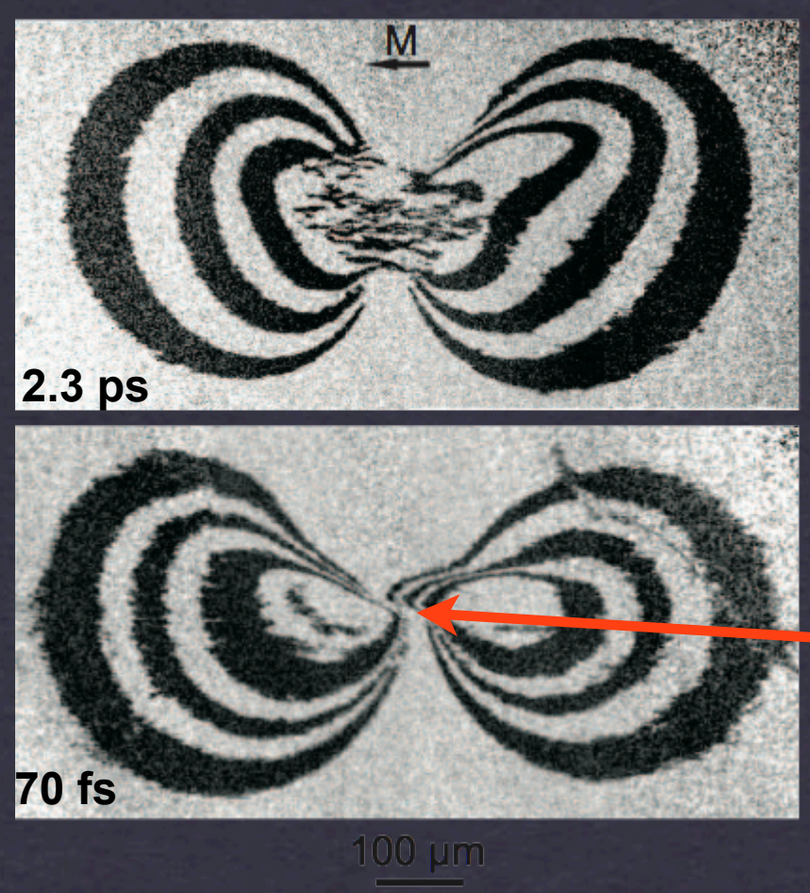
Early DWA experiments at SLAC will test the damage threshold of various materials.

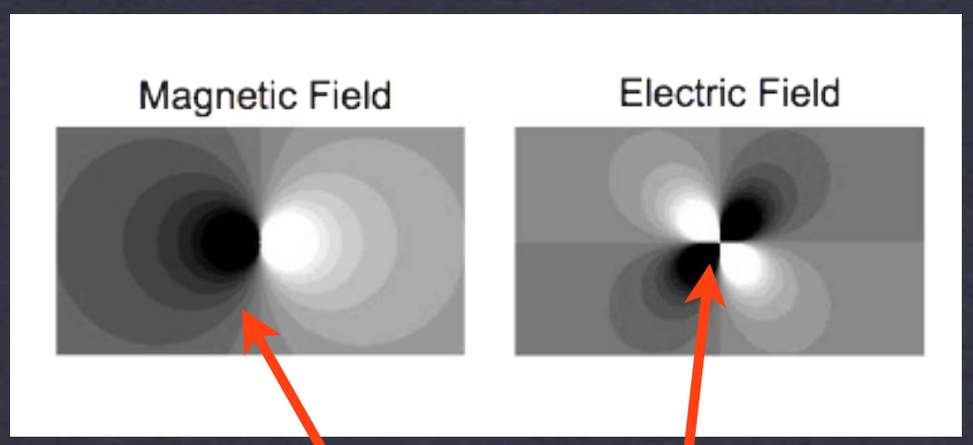




E202: Ultrafast Magnetic Switching

Idea: Use rapidly changing electric fields to flip spins in magnetic memory.



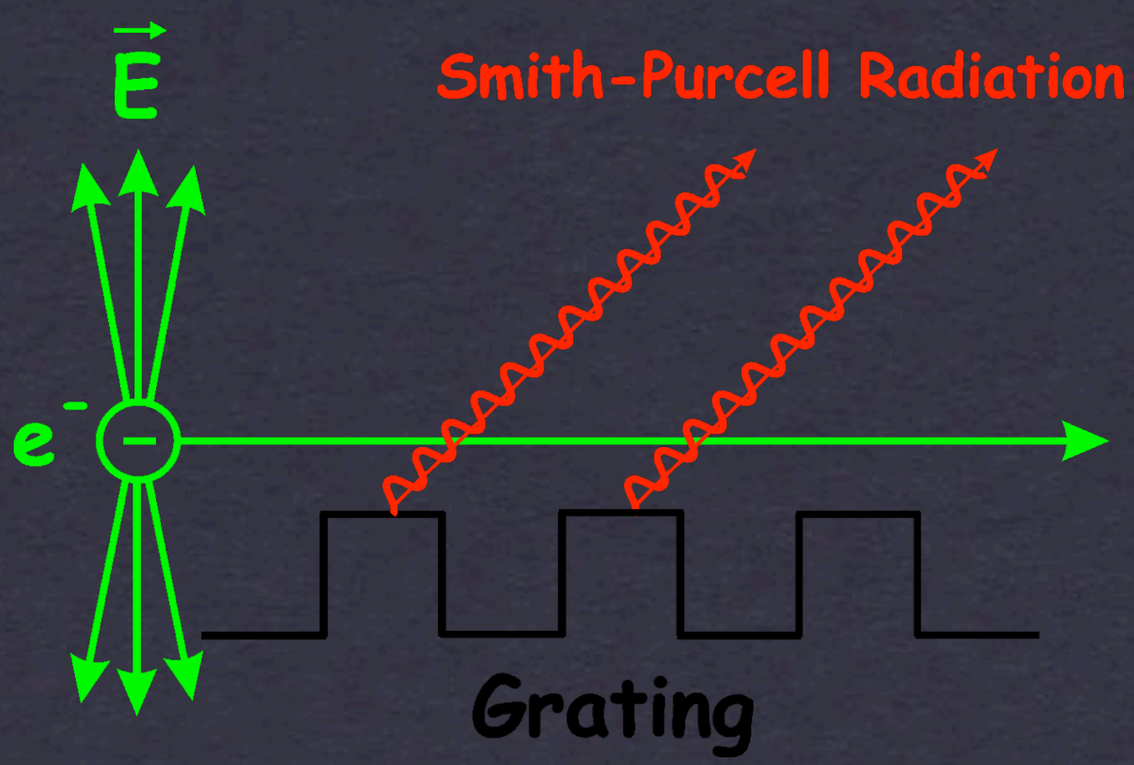


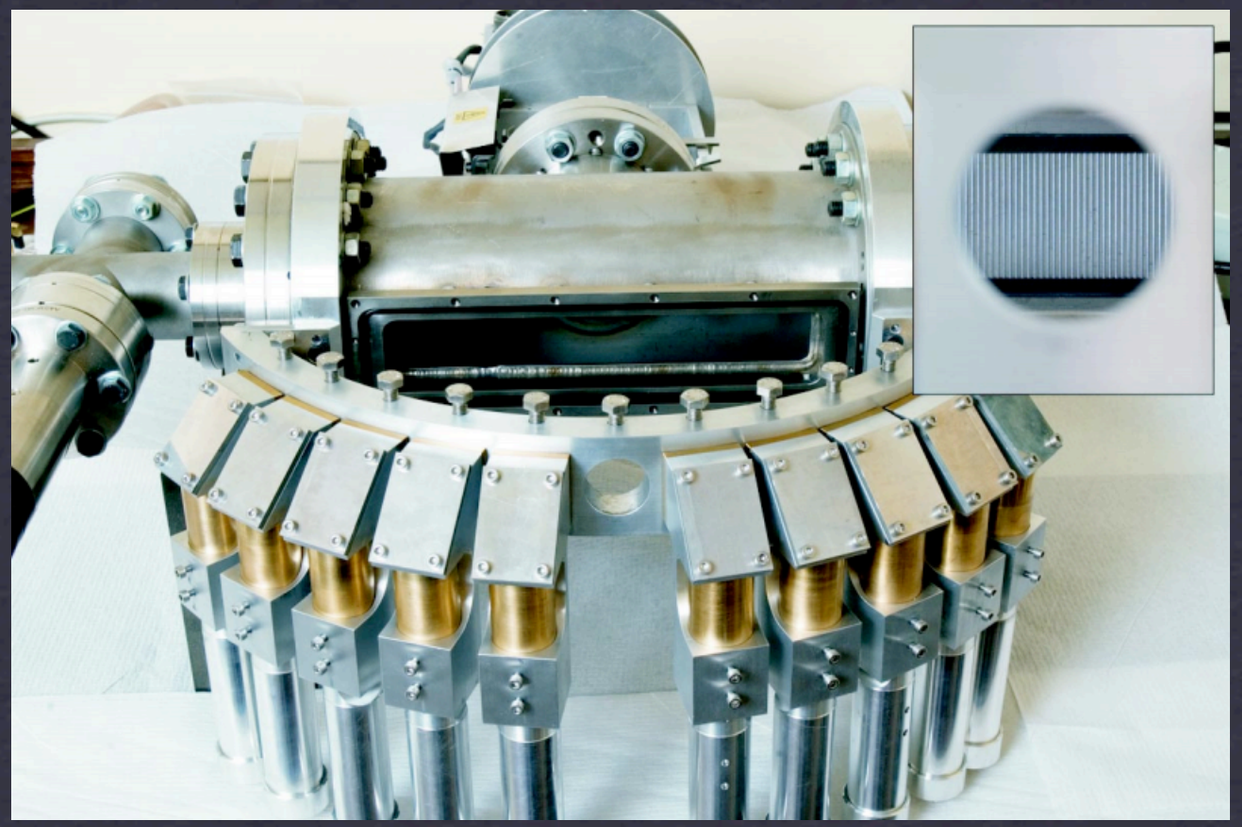
THIS = THAT + THAT

SUPERPOSITON!

E203: Smith-Purcell Radiation

Smith-Purcell radiation can be used as a bunch length diagnostic for ultra-short bunches.





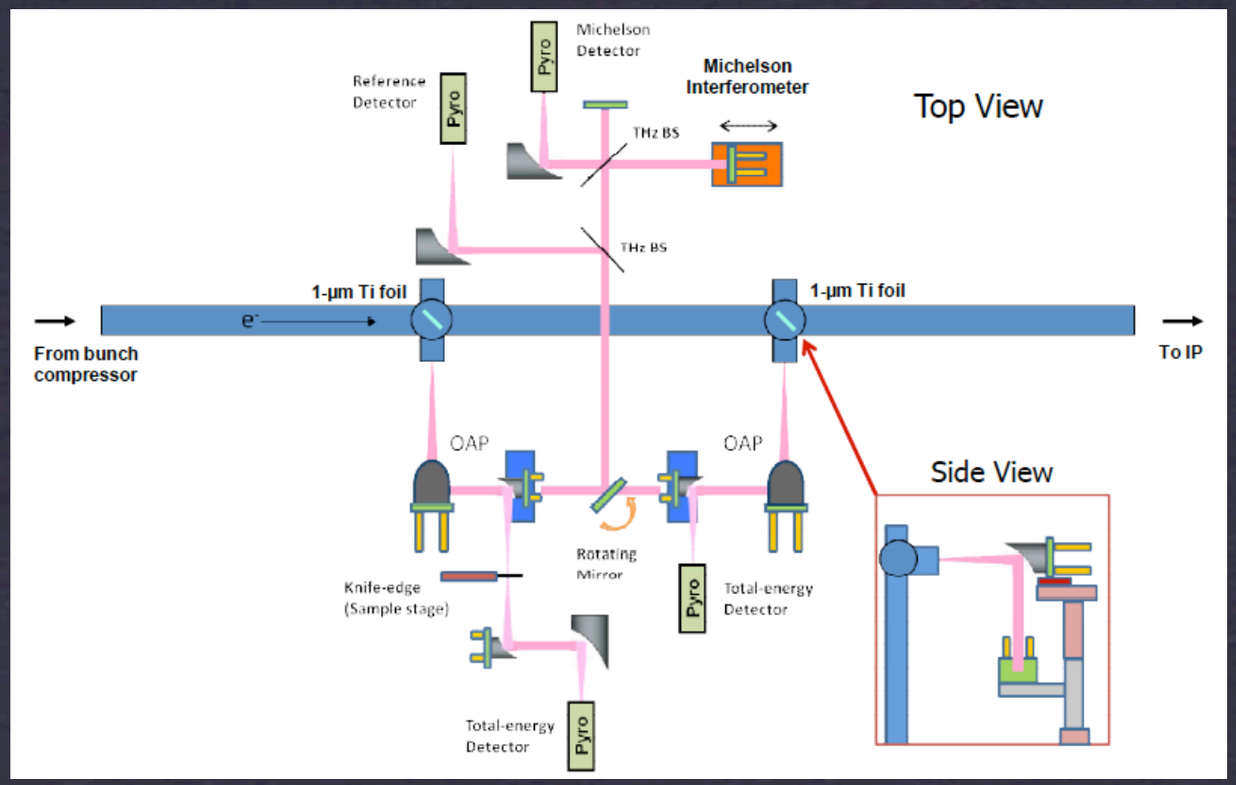
T500: Terahertz Radiation

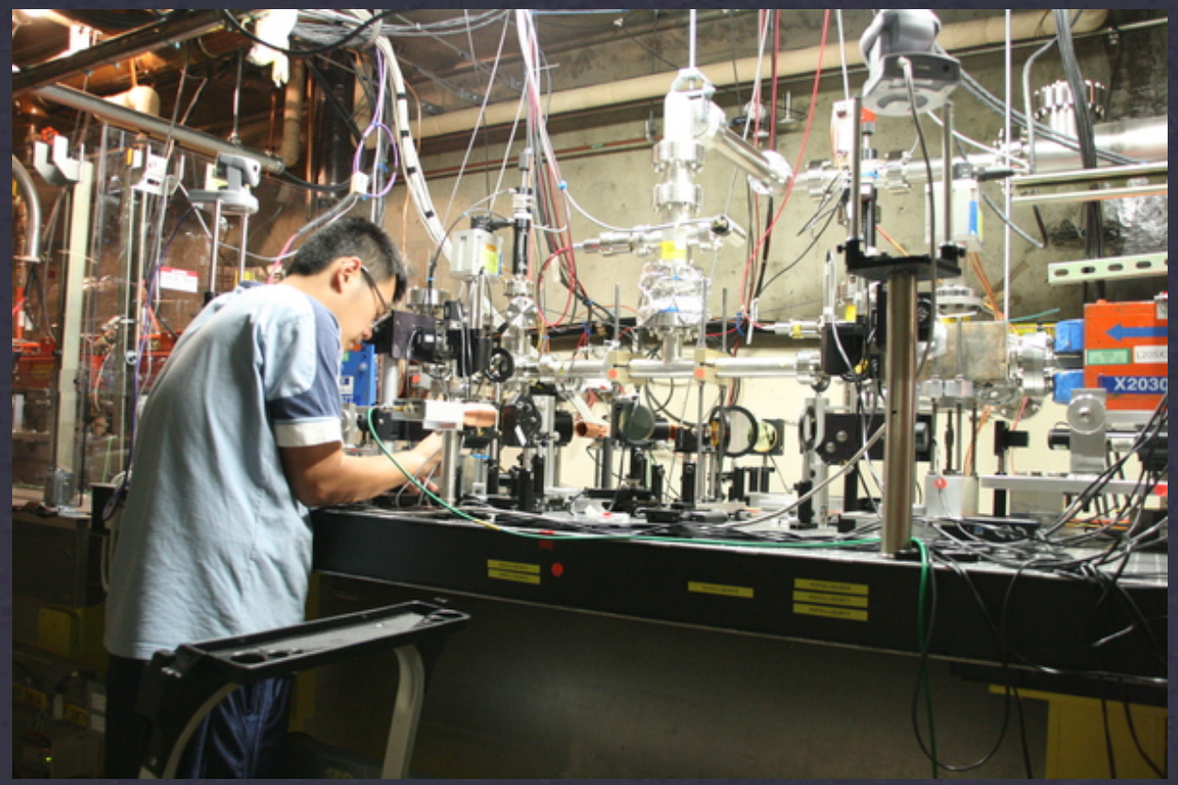
Terahertz radiation is notoriously difficult to produce. It is above the frequency of microwave electronics and below the frequency of IR lasers. It is also strongly absorbed by water vapor.

FACET will be the brightest source of THz radiation in the world. The radiation will be used as a bunch length diagnostic and can also be used in spectroscopy and imaging experiments.

T500: Terahertz Radiation

Terahertz radiation is produced when the beam passes through a metal foil via a process called transition radiation. The process is coherent when the bunch length is equal to the foil thickness.





E200

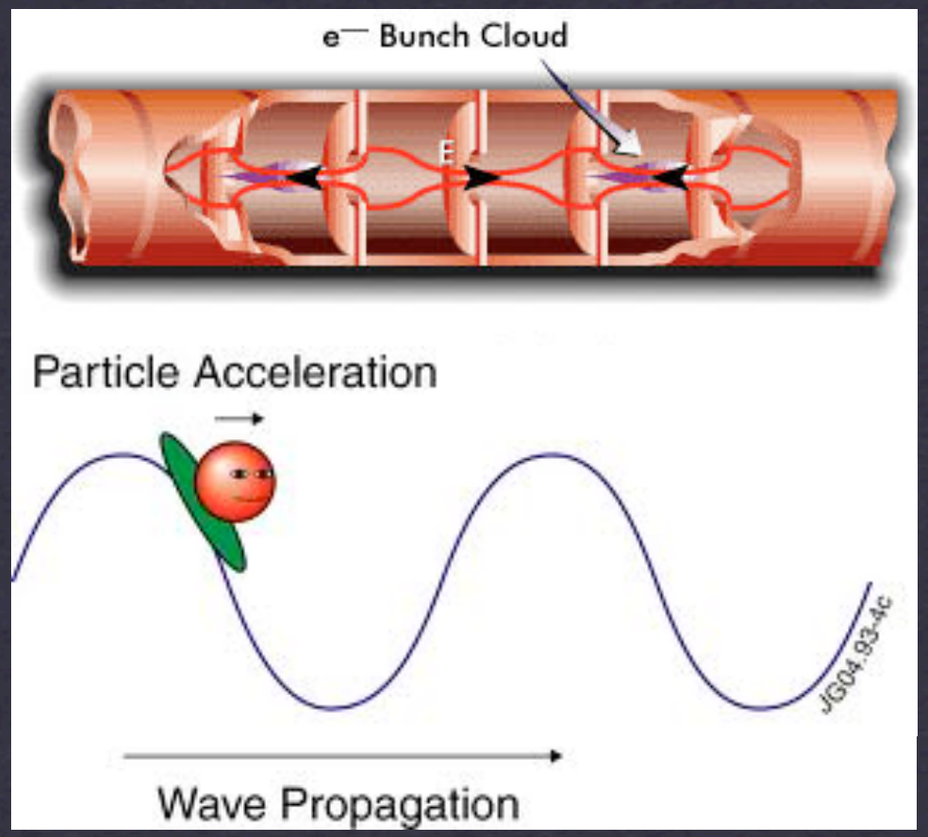
Plasma Wakefield Acceleration (PWFA)

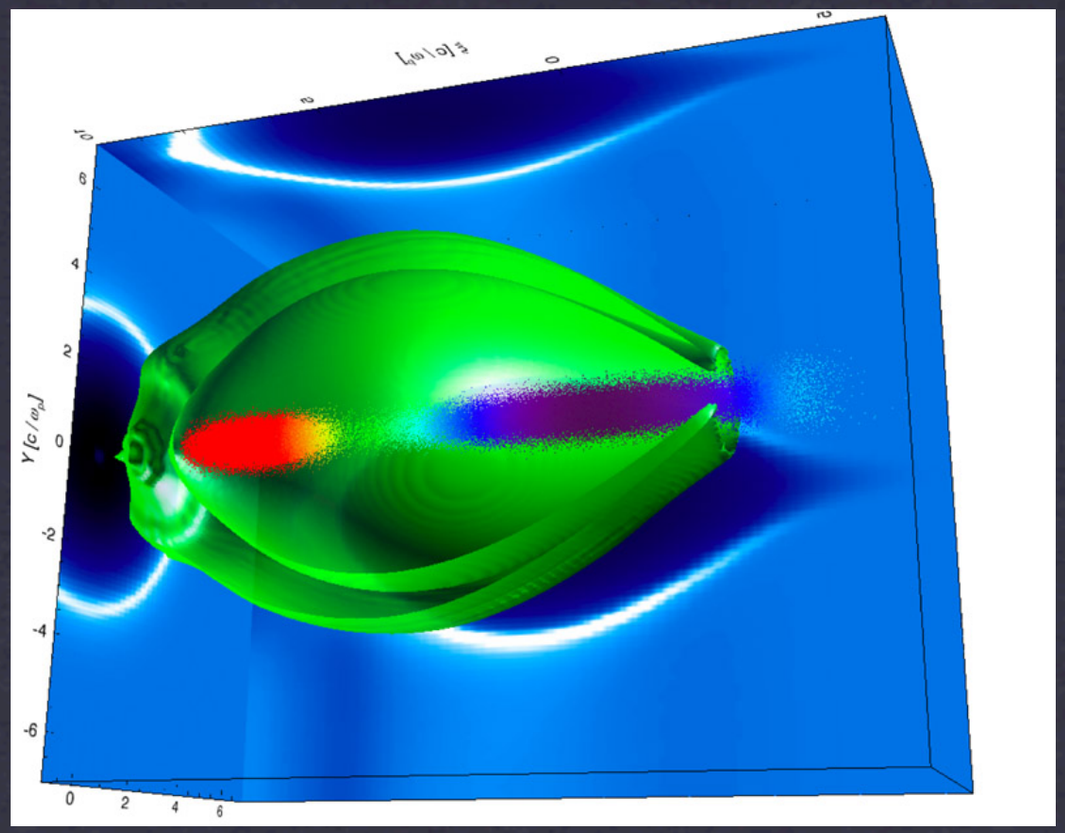
PWFA is a method for accelerating particles that replaces electromagnetic waves in RF cavities with large field gradients in a plasma.
In 2007 the E167 experiment at the FFTB demonstrated accelerating gradients of 50 GV/m. By comparison, the gradient in the SLAC linac's copper RF cavities is 20 MV/m. That's a factor of 2500 improvement!

RF vs. PWFA

If you put too much energy into an RF cavity, you will strip electrons from the surface and induce breakdown.

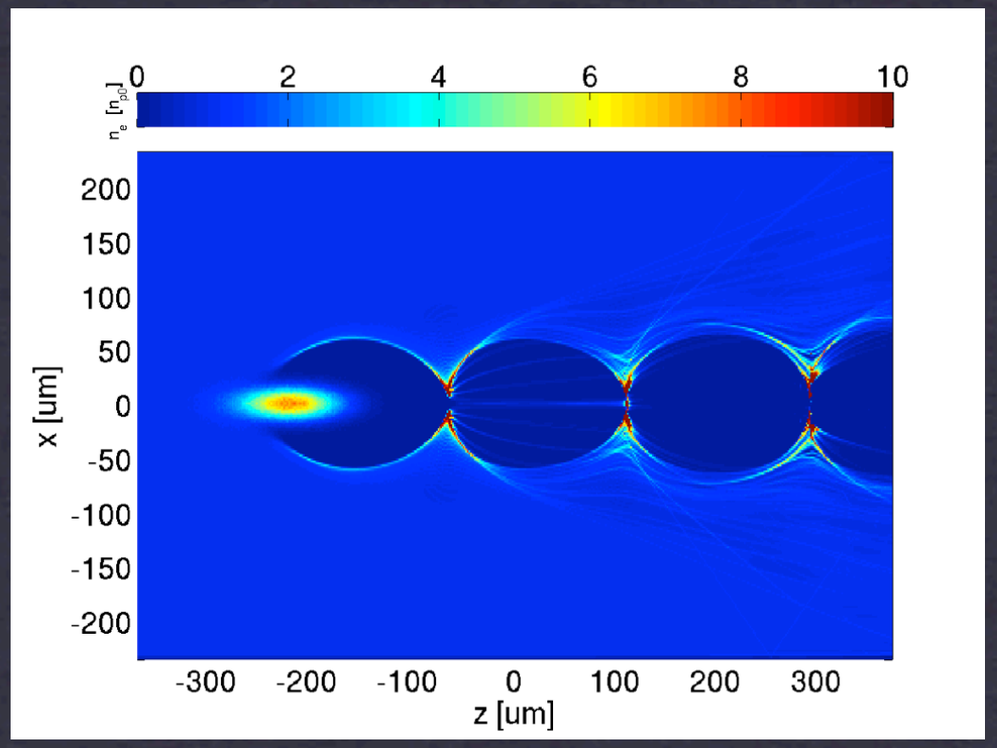
But you can't break a plasma . . .

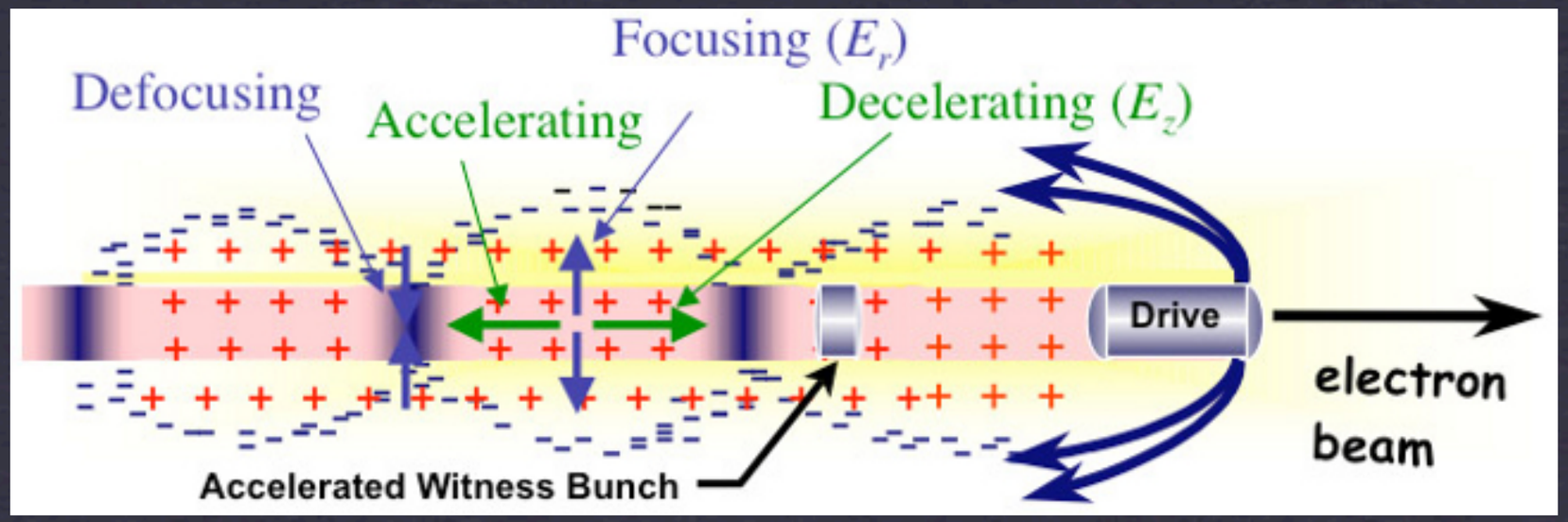




The Blowout Regime

E200 operates in the "blowout" regime.





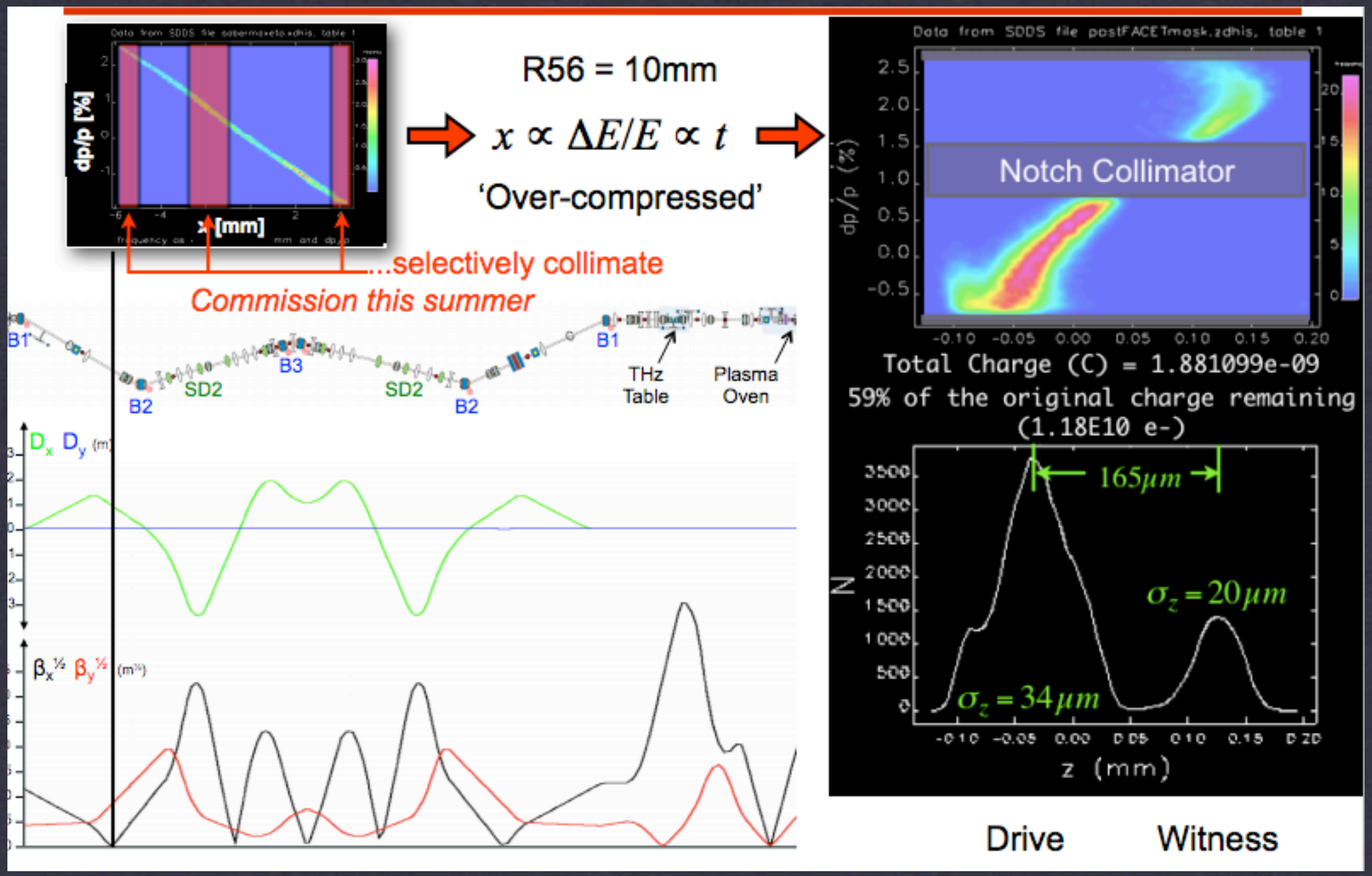
Drive/Witness Scheme

E200 will operate at plasma wavelengths from 20 to 200 microns. That means the witness bunch will have to follow the drive bunch by about 100 microns or roughly 1/3 of a picosecond.

No way to get two bunches out of Linac that close together.

The solution is dicey. . .

The Notch Collimator



Goals for this run

Reproduce results from E167; high gradient, high energy-spread acceleration.

Use the notch collimator to produce two bunches separated by less than a picosecond.

Demonstrate the acceleration of “collider quality” bunches using the drive witness beam. The bunch must have a small energy spread and not much emittance growth during the PWFA stage.

Future runs

Study high luminosity PWFA by passing bunches through the plasma separated by a few nanoseconds. This is crucial for the development of a PWFA linear collider.

Use the collimator system to produced “ramped” bunches that have high transformer ratios. Potentially reduces the number of plasma stage need to produce TeV scale beams.

Positrons . . .

Summin' it up

SAREC is the committee that reviews experiments for the FACET User Facility. At the most recent review, 10 experiments applied for beam time and 9 experiments were approved.

Great if you are applying for beam time, bad for FACET as a facility.

Do you have a use for FACET's beam? Possible science includes materials studies, THz studies, plasma studies, high field studies, and anything else that can make use of FACET's unique beam.