ATF Electron Beam and UED plans

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ATF User meeting
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The Accelerator Test Facility

BROOKHAVEN NATIONAL LABORATORY

U.S. DEPARTMENT OF ENERGY

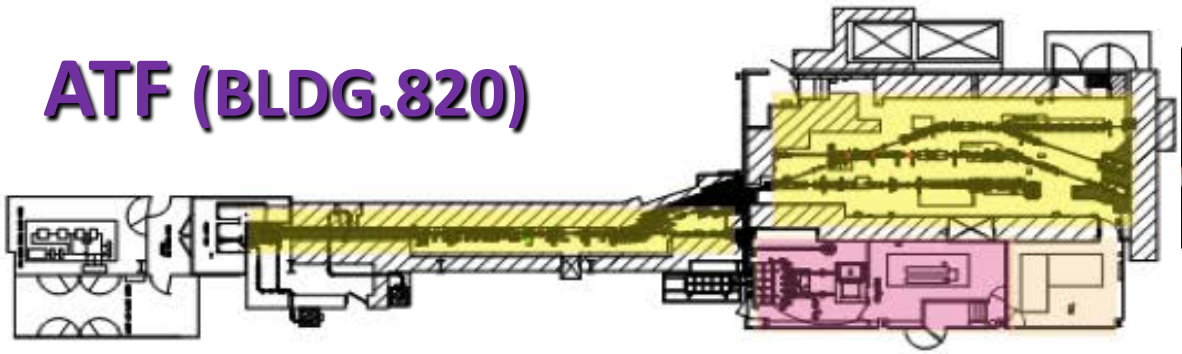
Outline

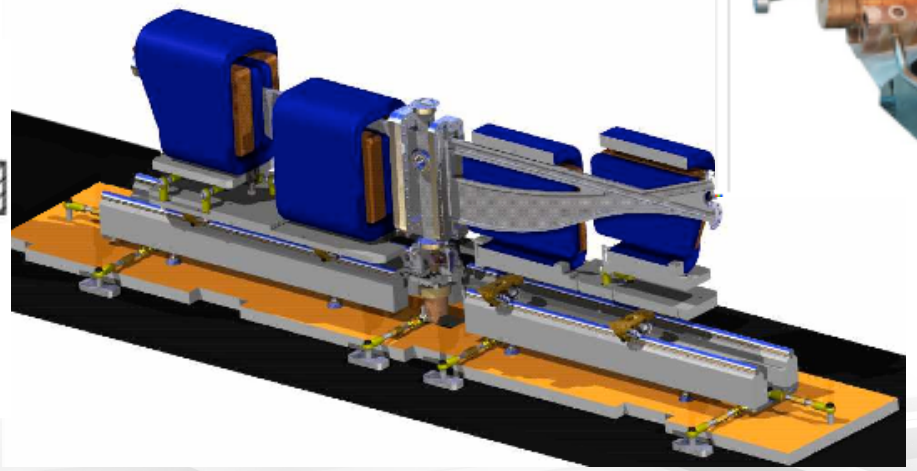
- ATF main beam parameters
- ATF beam diagnostic and manipulation capabilities
- FY20 e-beam improvements and plans
- Electron beam upgrade perspectives
- UED facility improvements
- UED plans

ATF linac main beam parameters

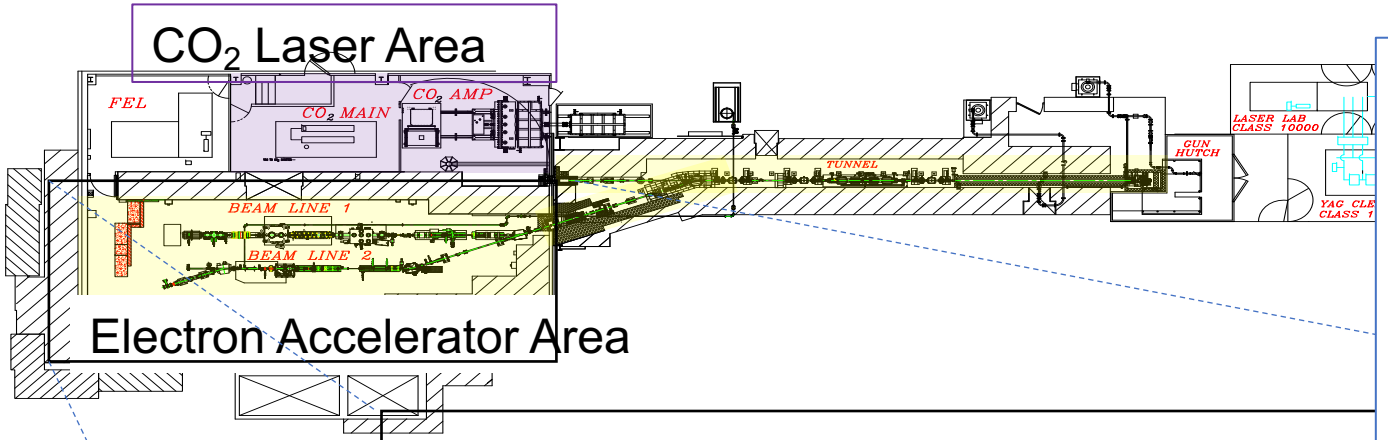
Parameter	Typical value / range	Best value
Energy	50-65 MeV	75 MeV
Charge	0.1 – 2 nC	2.5 nC
Repetition rate	1.5 Hz	3 Hz
Electron spot size on cathode	2.86 mm	0.2 – 4 mm
Bunch length	1-8 ps	100 fs with compression
Average bunch current	100 A	1.2 kA with compression
Emittance	1 – 3 mm mrad	0.8 mm mrad @ 0.5 nC

ATF (BLDG.820)

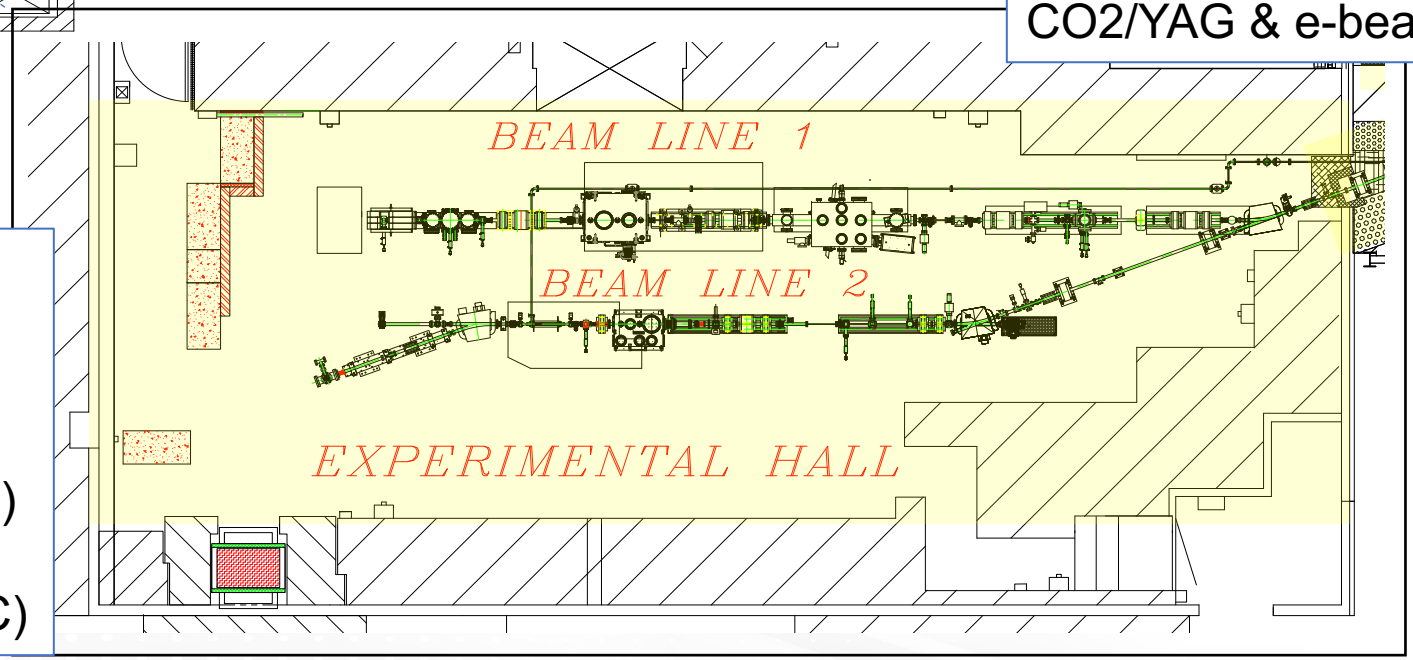




Facility Overview (Bldg. 820)



Beamline 1:
Experimental stations:
1) Inverse Compton,
2) LWFA with gas jet cell,
3) IGS (big in vacuum space)
Differential pumping (2 stages)
CO2/YAG & e-beam IP

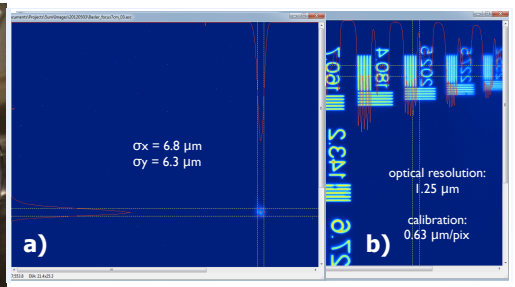


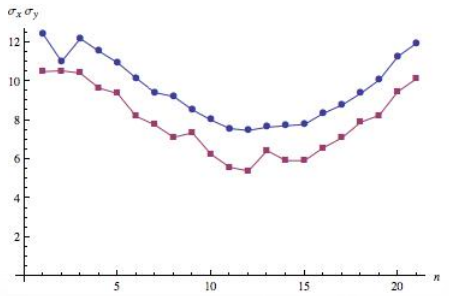
Beamline 2:
Experimental station with plasma cell capillary
Insertion device section
Differential pumping (1 stage)
CO2 & e-beam IP
X-band Deflector cavity (TDC)

ATF beam diagnostics

Beam profile measurements

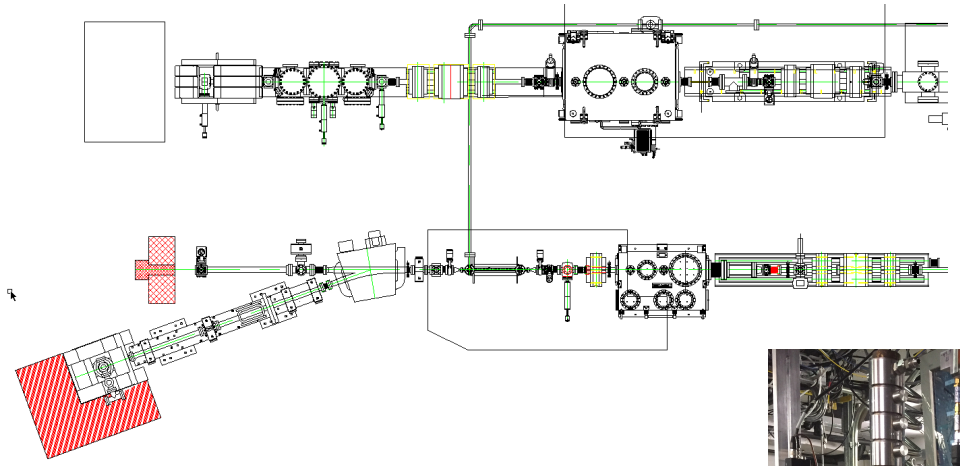
PMQ triplet assemblies:
G=50 T/m, focal length ~20 cm
G=500 T/m, focal length ~8 cm



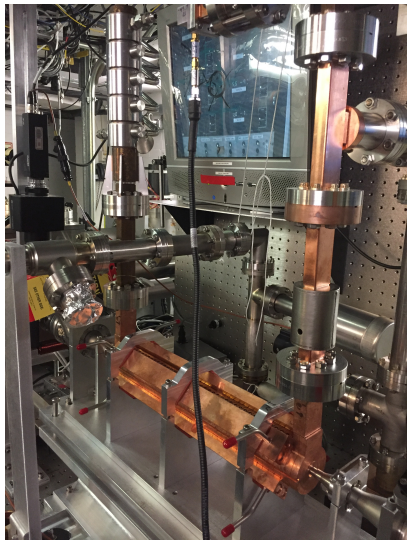


Microscope (25-0506 X15 Reflecting Objective NA 0.28, F~13 mm)
Basler Gigabit camera (scA 1400-17gm, F=135 mm).

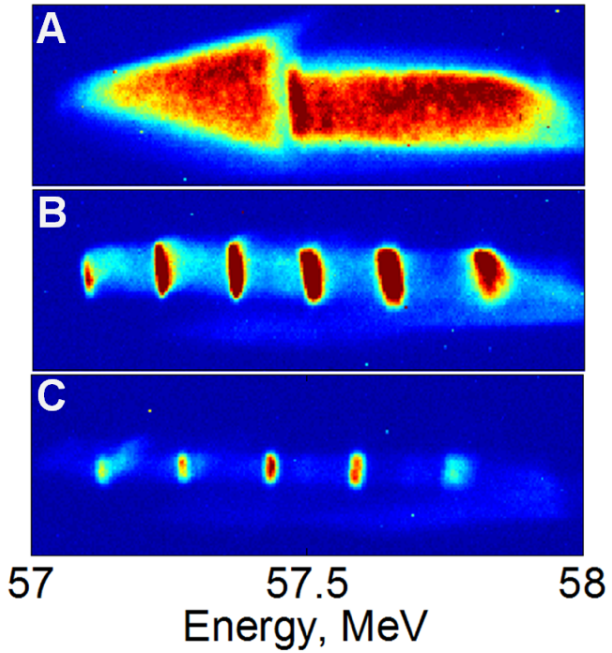
Bunch length measurements



Parameter	Value
Field amplitude, $\sqrt{E/P^{1/2}}$	8.48 kV/mW$^{1/2}$
Group velocity, v_g	0.0267c
Attenuation factor, α	0.66 m^{-1}
Cavity length, L_T	0.46 m
Number of cells, N	53
Power ratio, P_{out}/P_{in}	0.55

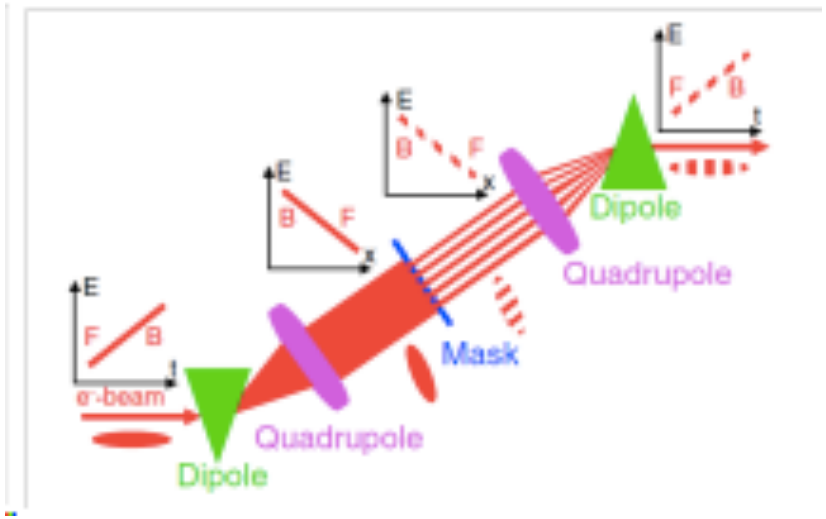


ATF beam manipulation and diagnostics

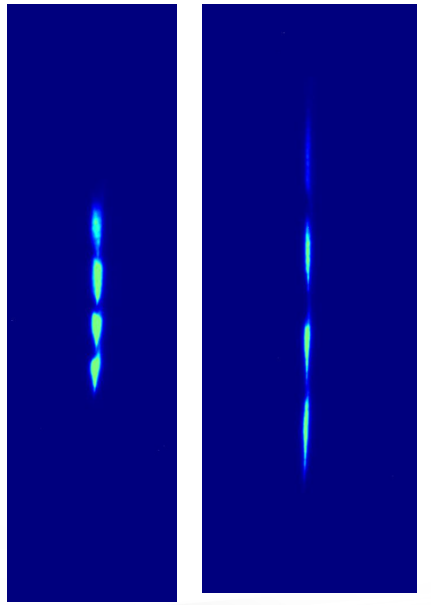


e-beam spectrometer

e-beam mask technique



Images on the screen after deflector



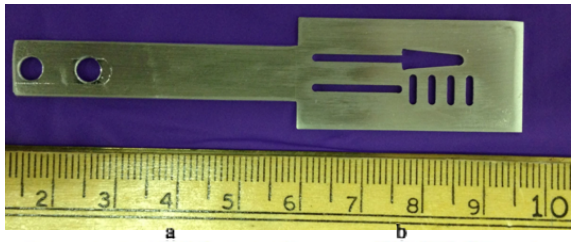
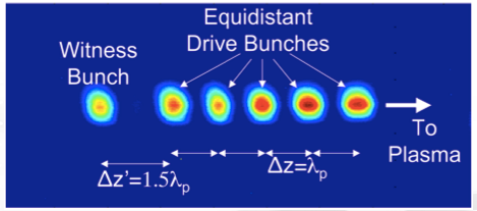
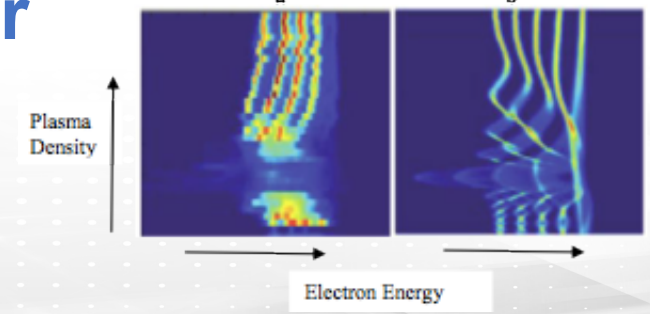


Image at mask

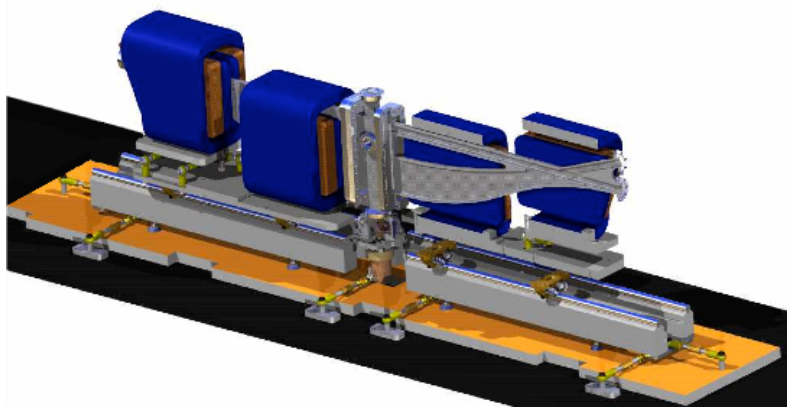




ATF beam manipulation capabilities

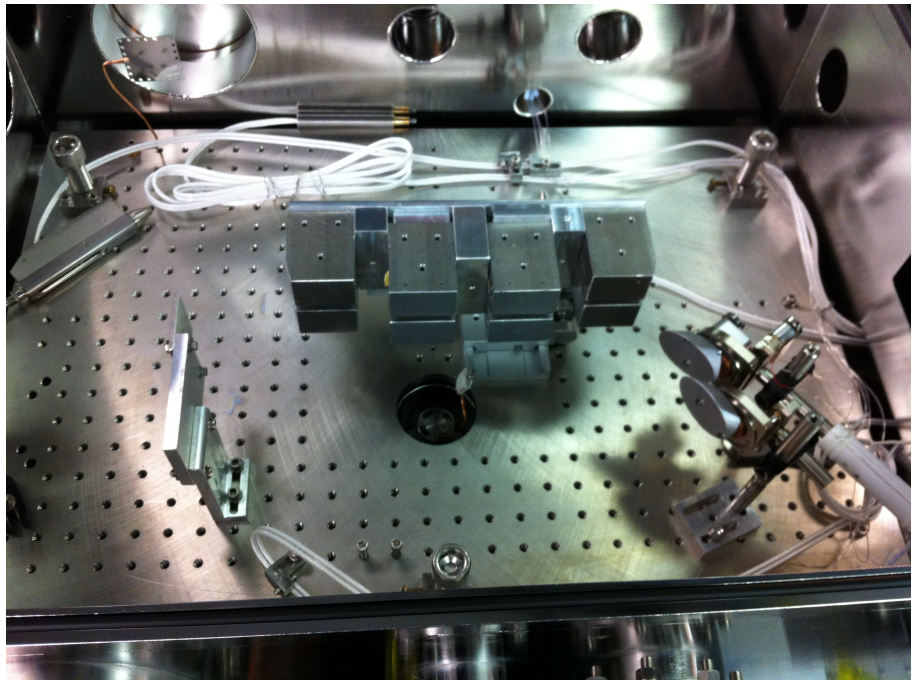
Bunch compression

Electromagnet chicane



Parameter	Value	Units
B-Field	2015	Gauss
Bend Angle	20	deg
Geometric Length	41	cm
Magnet Gap	2.1	cm

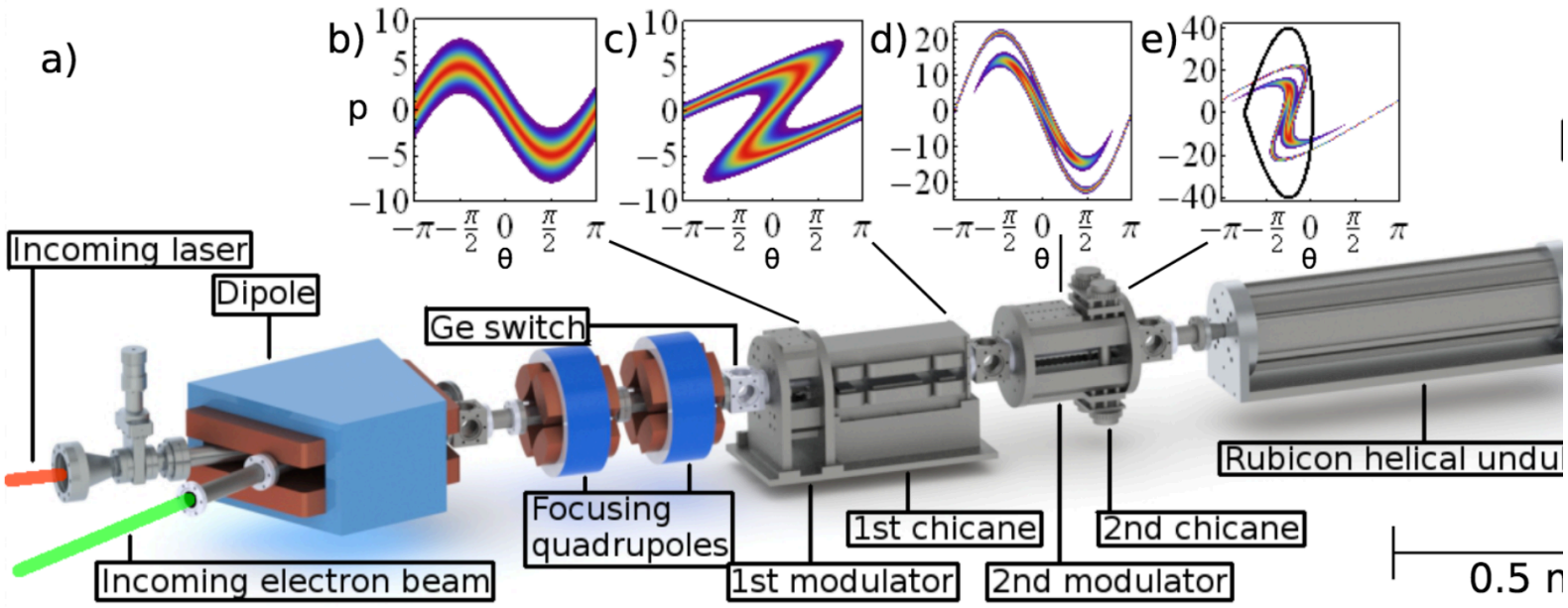
Permanent Magnet Chicane



~1 Tesla magnetic field
50 mm magnetic length

ATF beam manipulation capabilities

- 10 um microbunching with CO2 laser



N. Sudar, P. Musumeci, I. Gadjev, et al., PRL **120**, 114802 (2018)

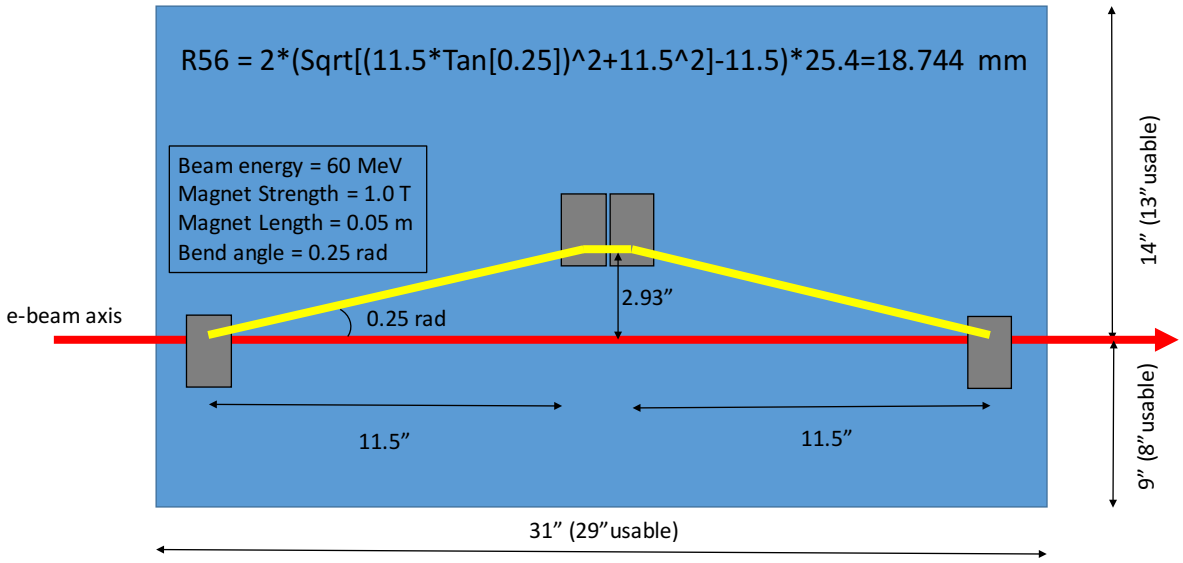
FY20 e-beam improvements and plans

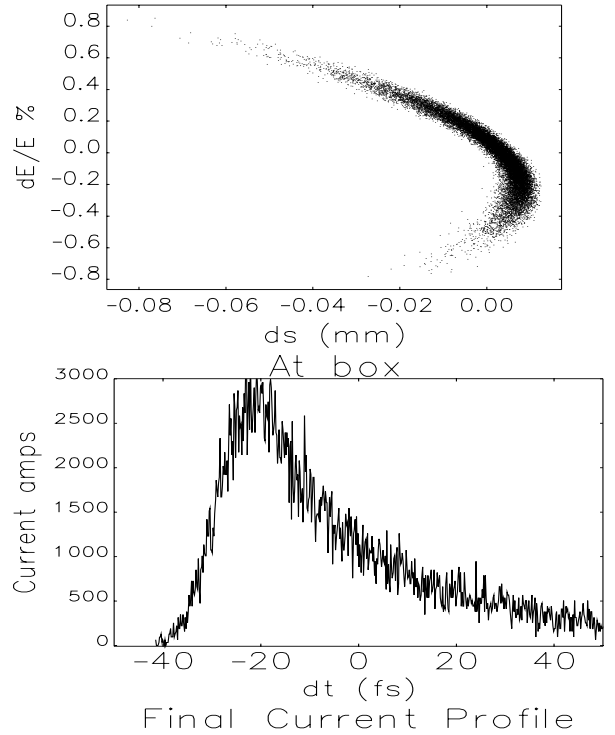
- Replacement of ATF old gun klystron in January significantly improved beam stability
- X-band klystron refurbish was arranged and may happen after FY21 (>1year repair due to present constraints)
- Control system continues upgrade
- Bunch compression design for LWFA experiments at beamline #1
- ATF received funding from BNL for maintenance work (crane replacement, YAG room air handlers)

Electron beam bunch compression design

e-beam compression with permanent magnet chicane (simulations by Yichao Jing)

Permanent Magnets Chicane installation in IGS chamber to maximize R56

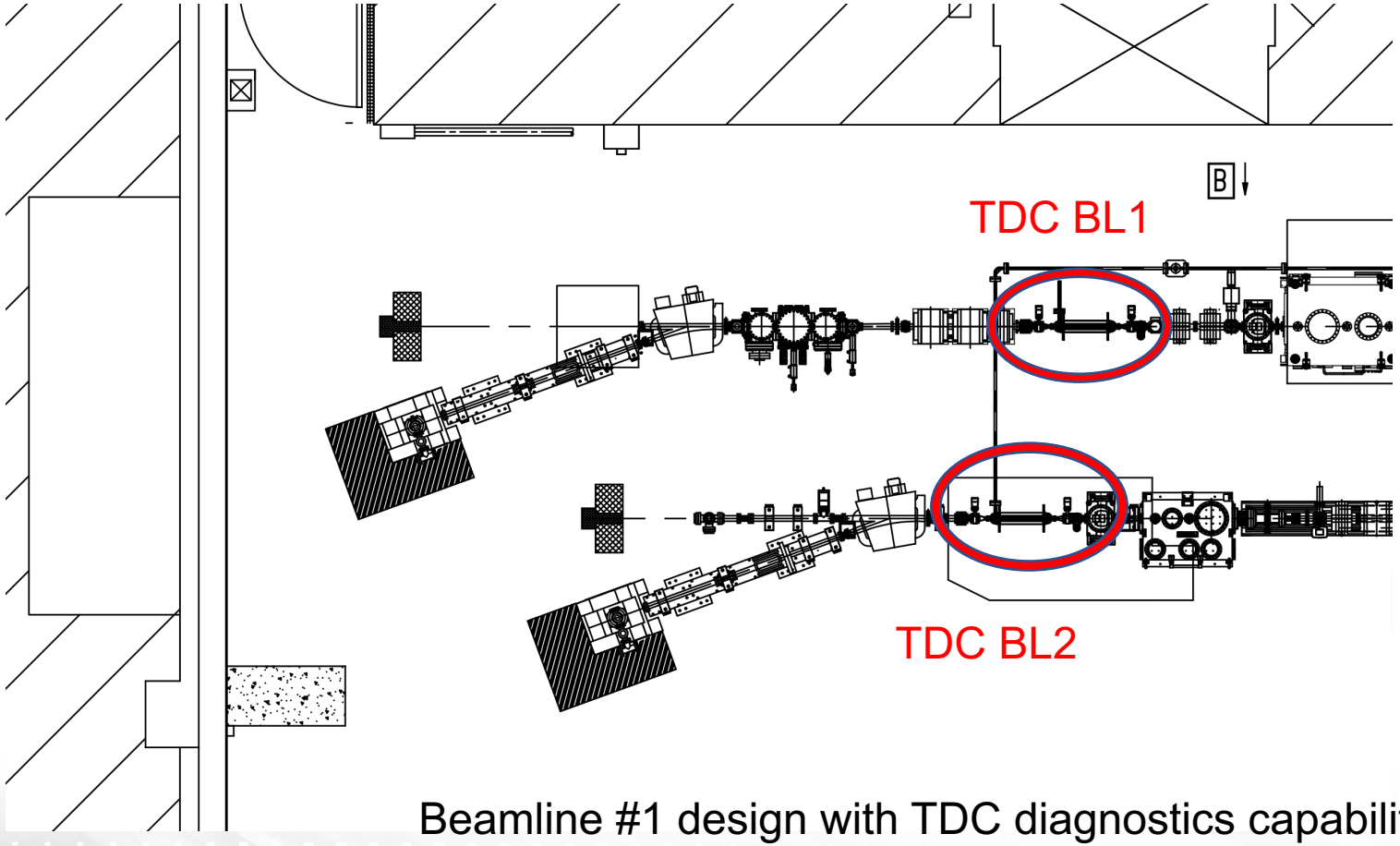




FWHM bunch length < 20 fs is achievable for higher charge (100 pC in this case) with the combination of the zigzag chicane together with CSR shielding

Electron beam upgrade perspectives

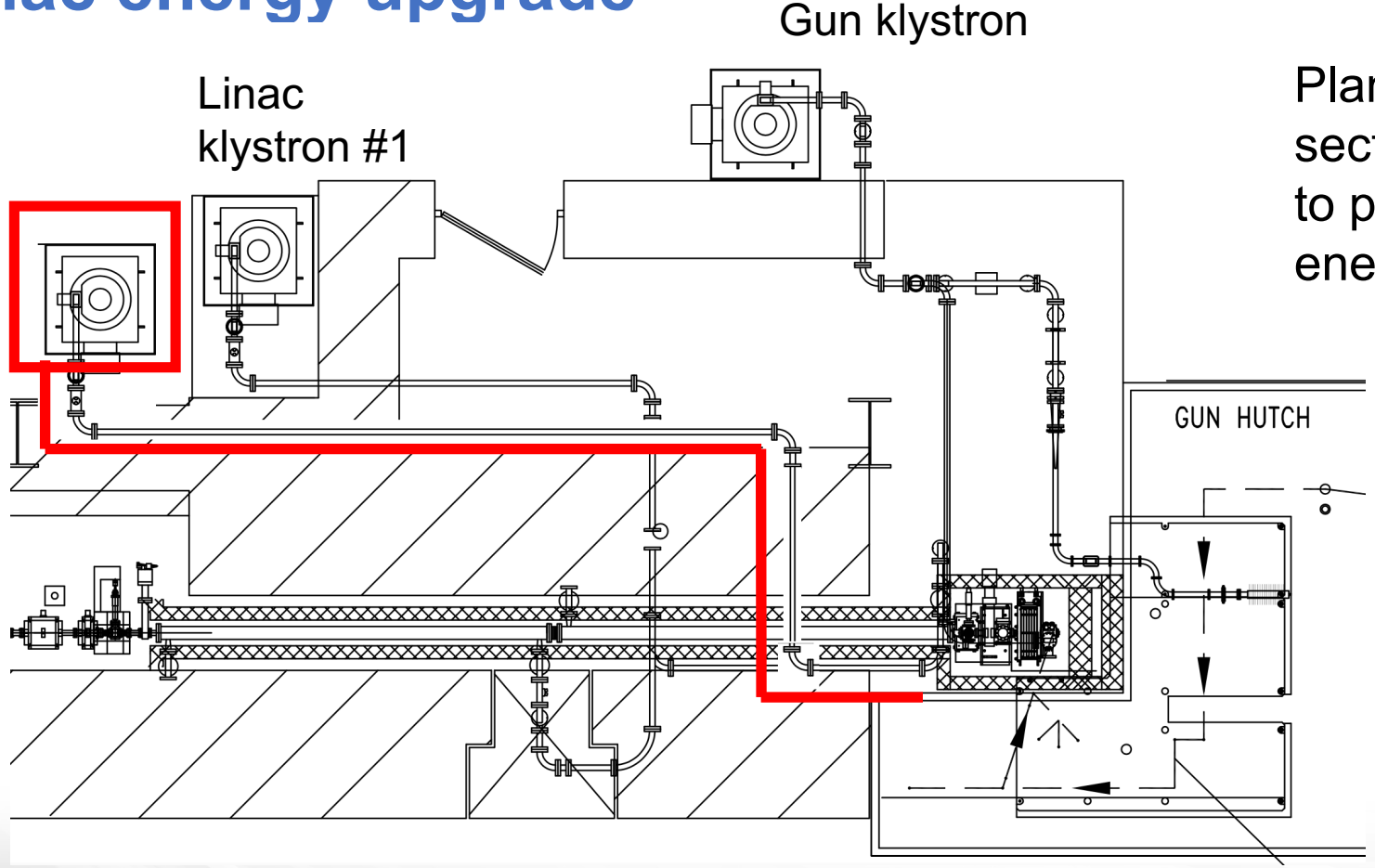
Deflector cavity for BL1



Beamline #1 design with TDC diagnostics capabilities after completion of laser transport

Electron beam upgrade perspectives

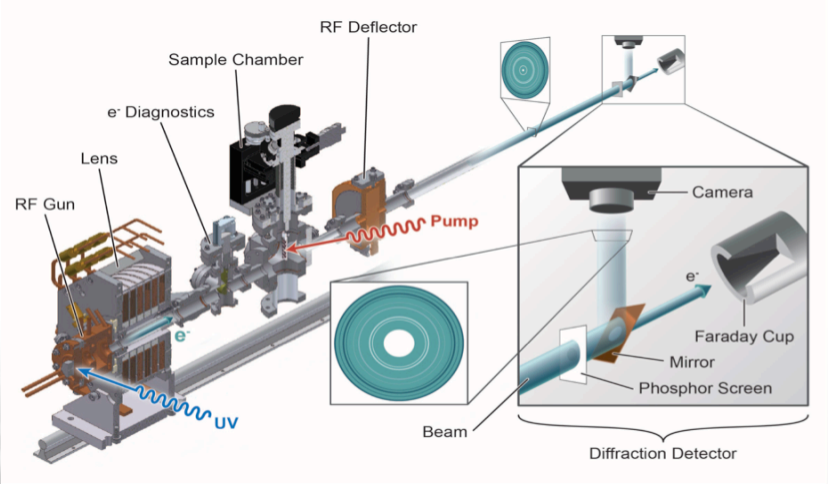
Linac energy upgrade

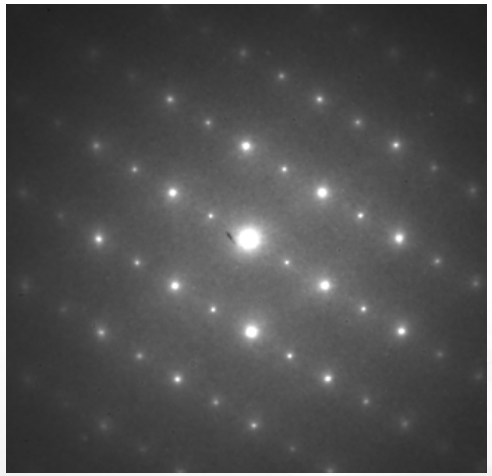


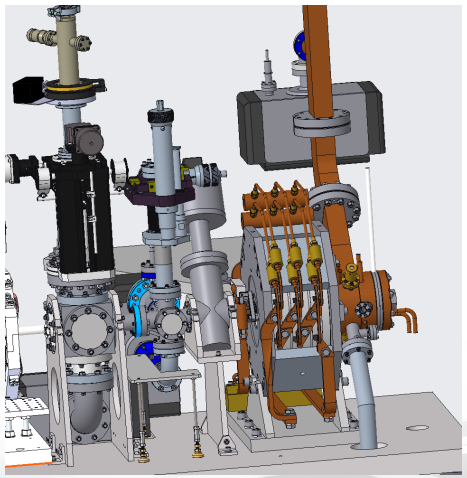
Plan to feed linac acceleration sections with separated klystrons to push maximum operational energy to 110-120 MeV

ATF UED main beam parameters

	BNL	SLAC	MSU
Beam energy, MeV	3	3.68	0.03
N e^- per pulse	1.25 E+6	3.8E+5	500
Temporal resolution, fs	180	102	300
Beam size diameter, μm	300 (100 best)	400 (10 best)	20-40
Max repetition rate	48	120 (180 best)	1,000
N e^- per sec per μm^2	880	360	400
Advantage	short bright pulse	short bright pulse	DC (no jitter)

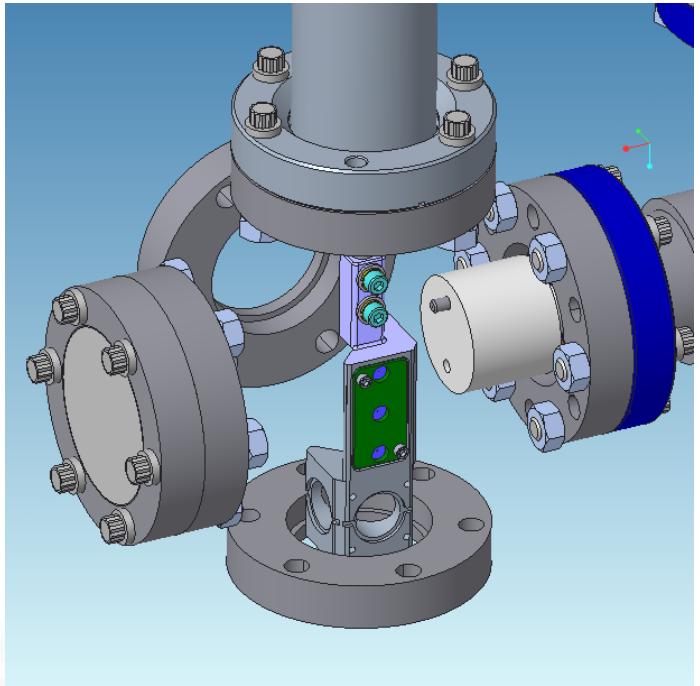






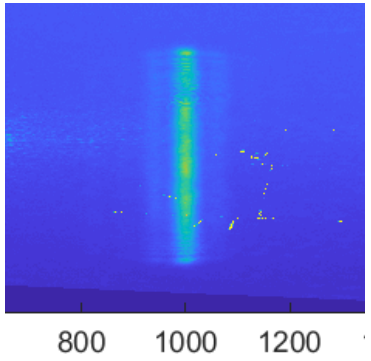
FY20 UED facility improvements

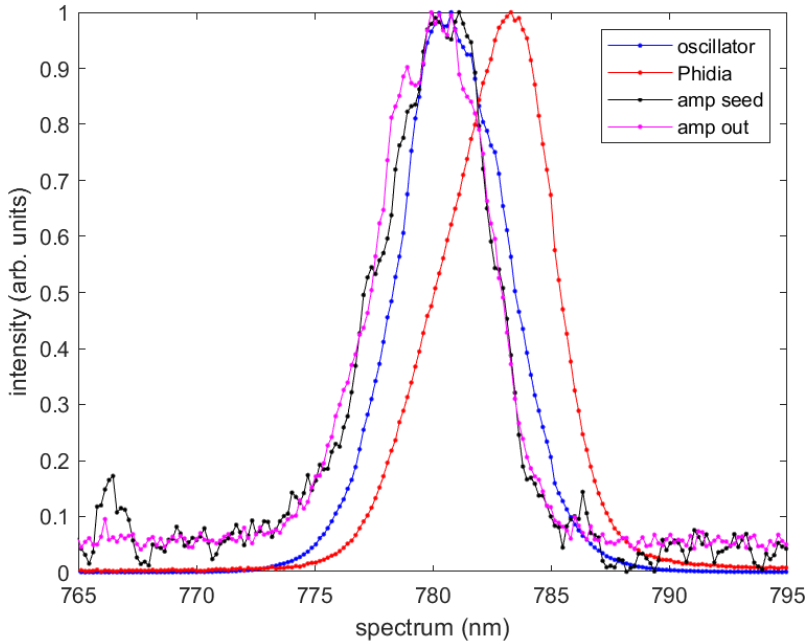
- Repetition rate upgrade from 5Hz to 48Hz obviously speed up user scan rate and decrease systematic drifts influence
- Stable performance during last summer
- e-beam collimator was replaced with new design

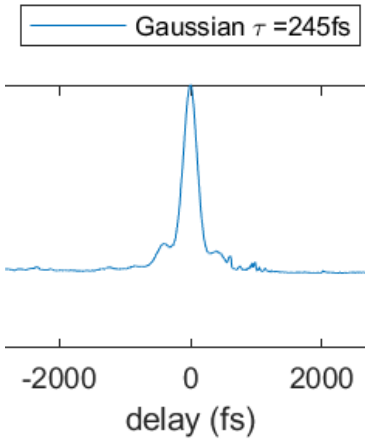


UED plans: Support Tunable Pump Wavelength

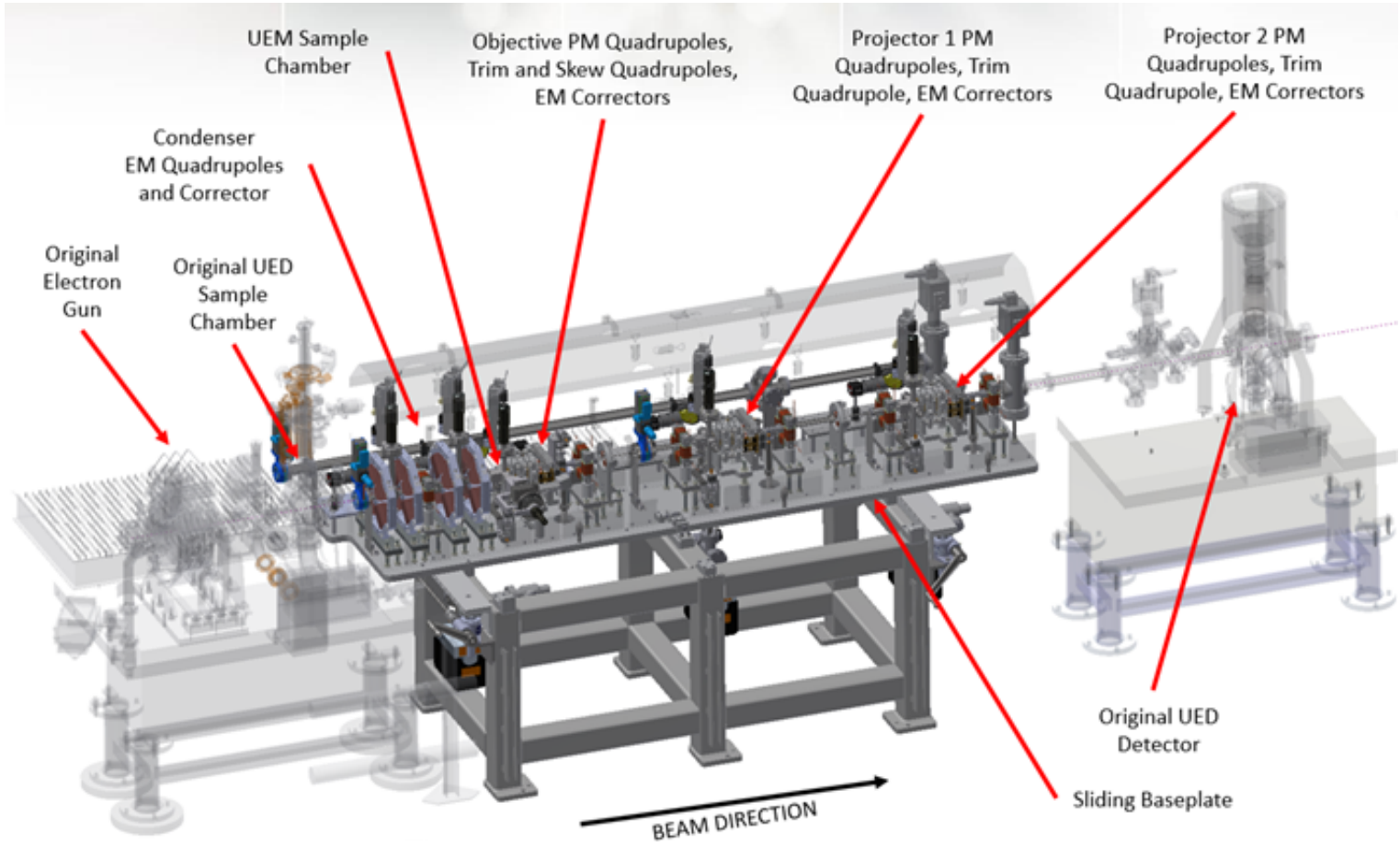
- mid-IR pump-probe materials science requires an Optical Parametric Amplifier to access the full range of wavelengths
- To reach the needed OPA output energy levels of ~100 μJ at λ=10-11 μm, a more energetic pump pulse from a new Ti:sapphire booster amplifier is needed
- "Topas HE" OPA from SpectraPhysics **installation starts next week**





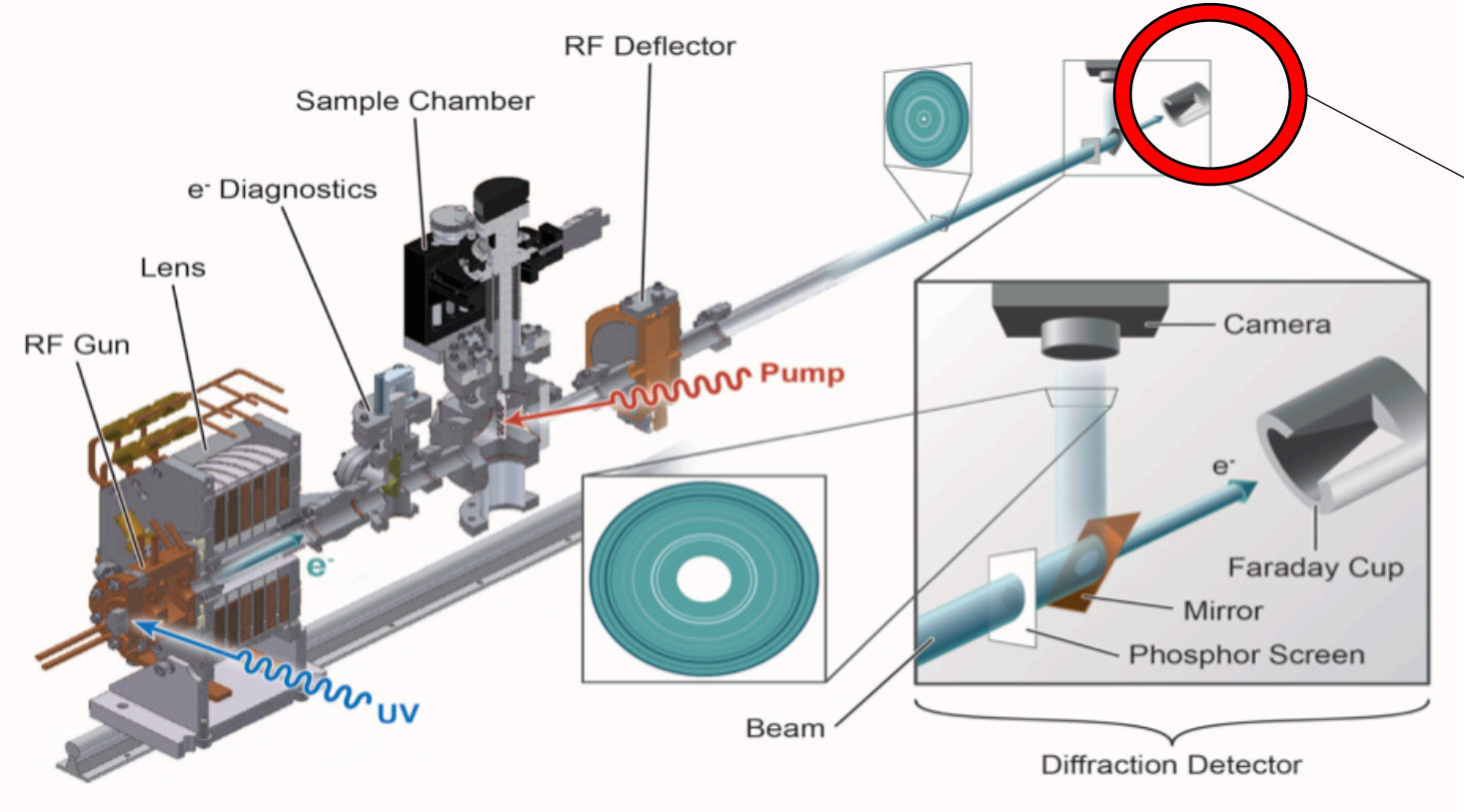


UED plans: Flexible UED-UEM translation table



Quick change design to switch between UEM and UED baseline drift tube configuration

UED plans: beam diagnostic beamline extension



Beamline extension
for real-time beam diagnostic at the end of beamline will include spectrometer magnet for shot-to-shot energy fluctuations, Faraday cup for charge fluctuations

Thank you!