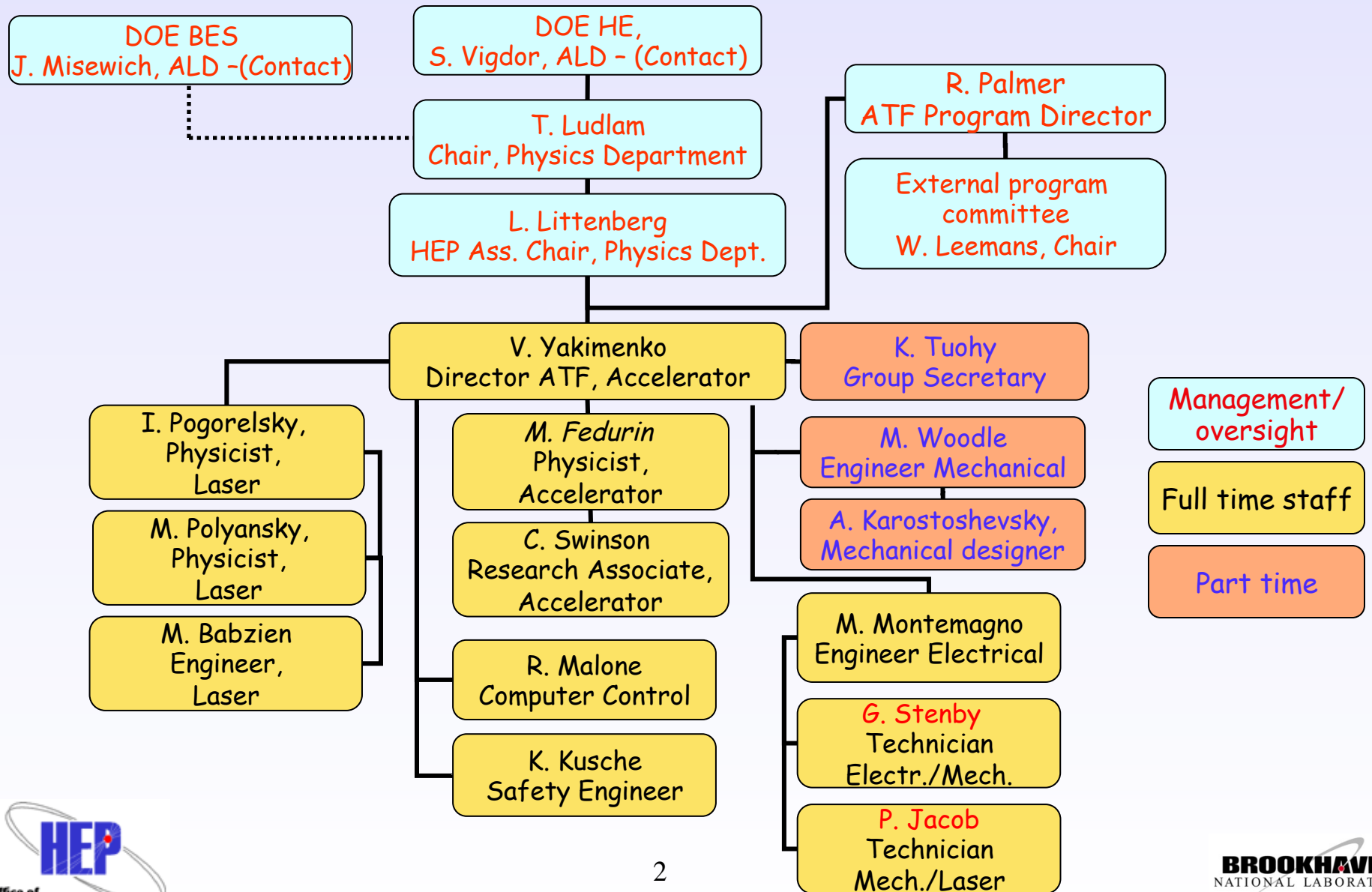


Accelerator Test Facility at BNL

Vitaly Yakimenko

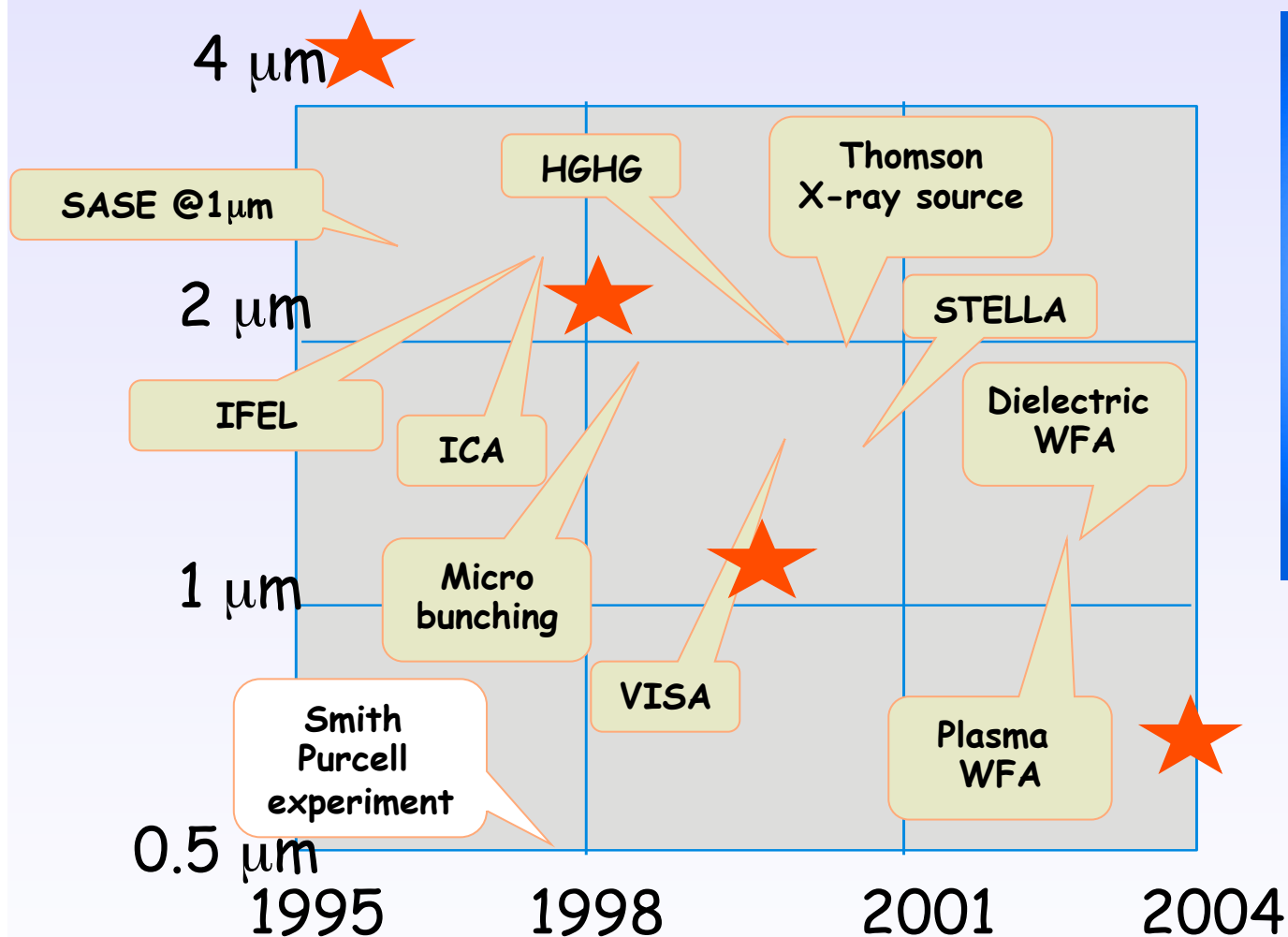
ATF Organization Chart



Operations statistics:

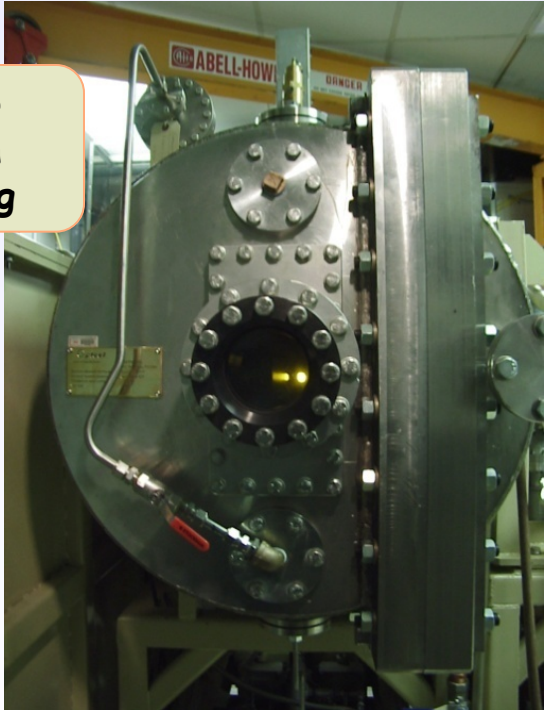
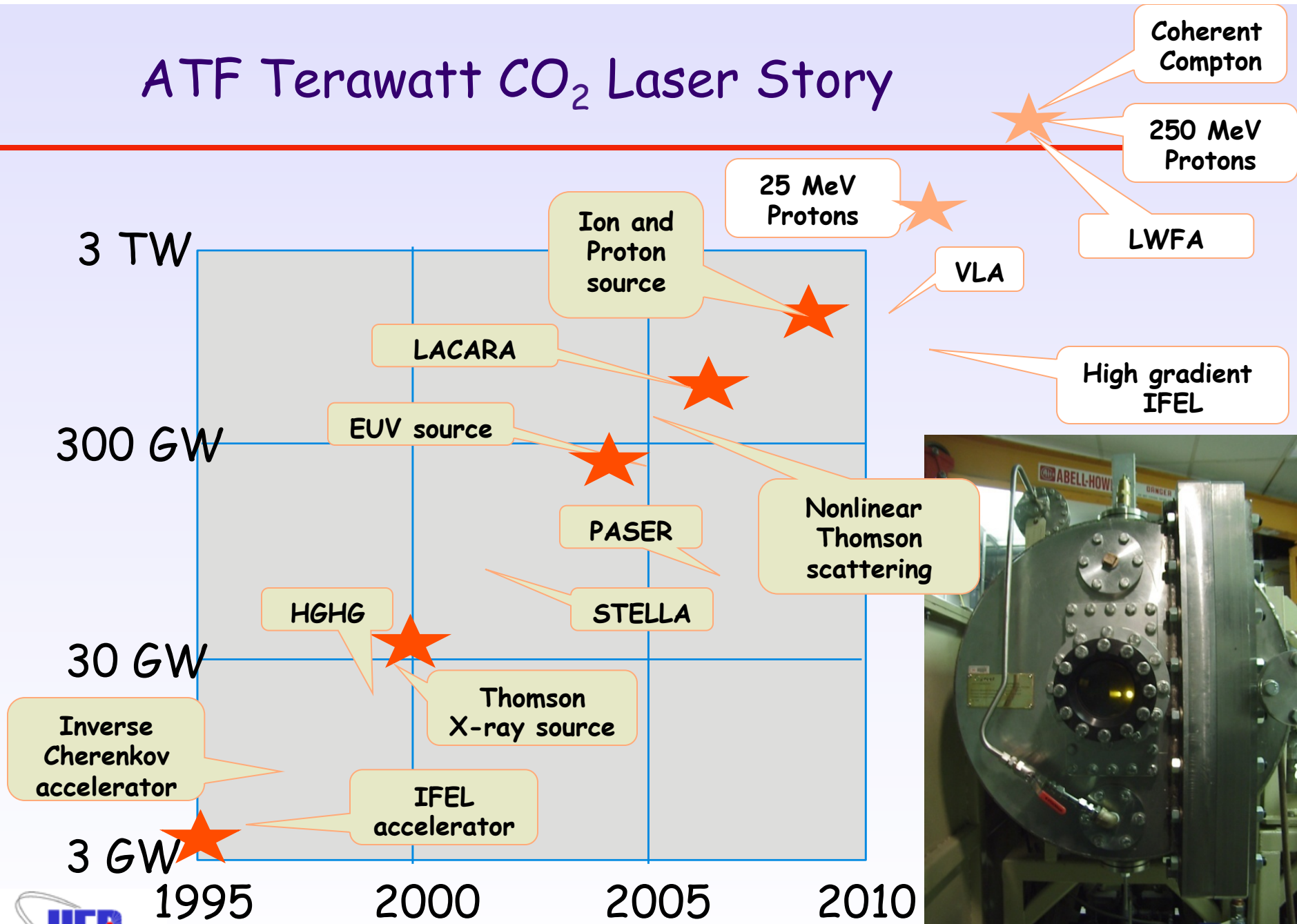
- ATF systems were operated for a total of 206 run-days during last twelve months:
 - 119 days of experiments that require electron beam only,
 - 67 days of accelerator development and training,
 - 30 days for experiments that exclusively use the CO_2 laser beam,
 - 50 days of CO_2 laser development and training
 - 18 days for experiments that require the interaction of electron and CO_2 laser beams.
- 34 users from 13 institutions have been setting up and conducting their experiments at the ATF.

1.6 Cell RF gun / Emittance



Coherent Compton

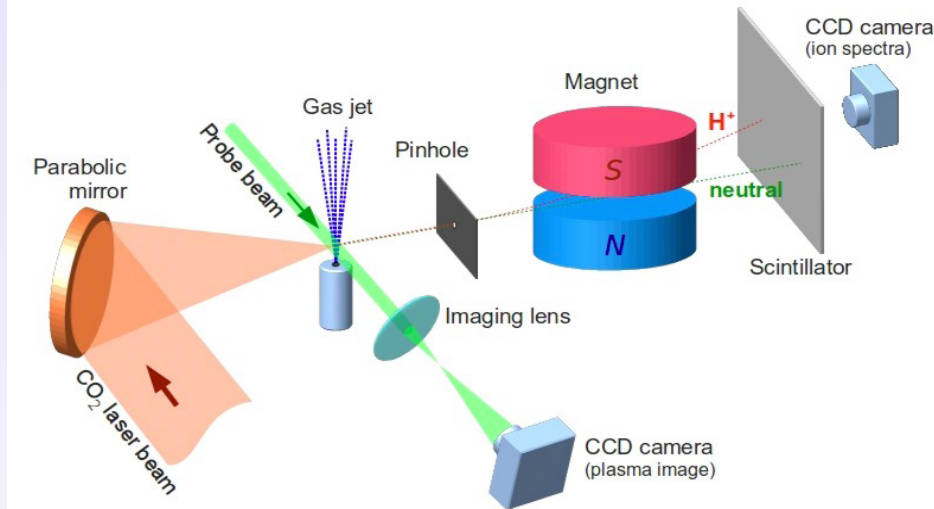
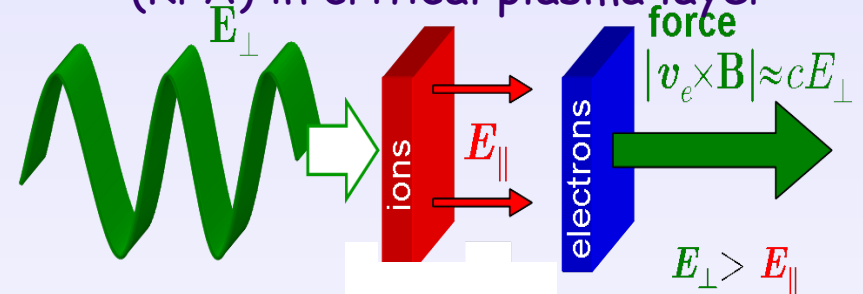
ATF Terawatt CO₂ Laser Story



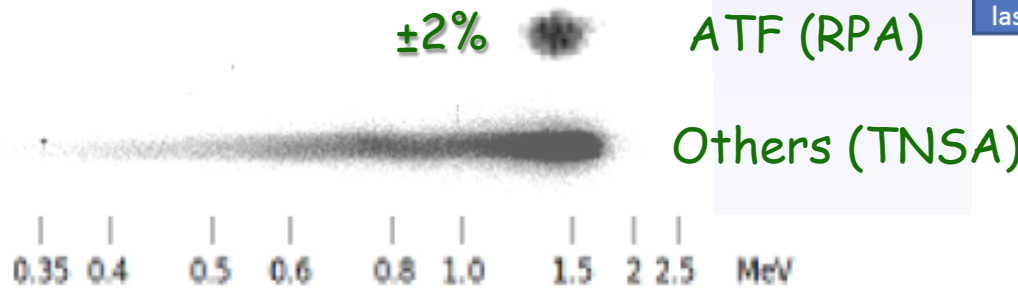
Ions beams from a gas jet



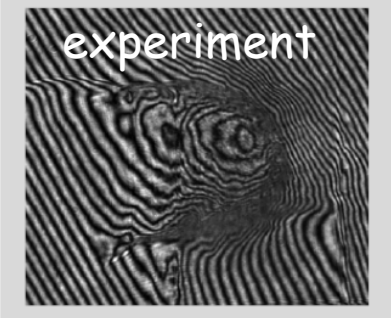
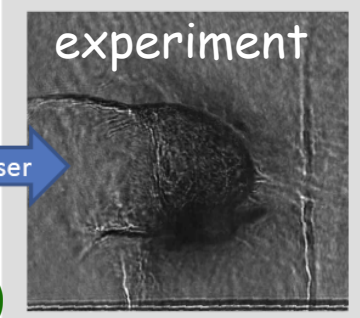
Radiation Pressure Acceleration (RPA) in critical plasma layer



Proton spectra

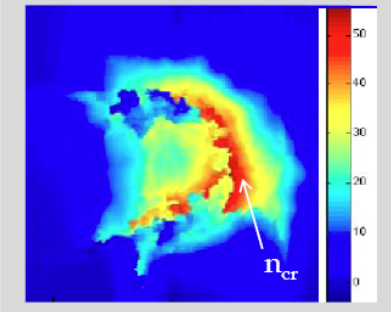
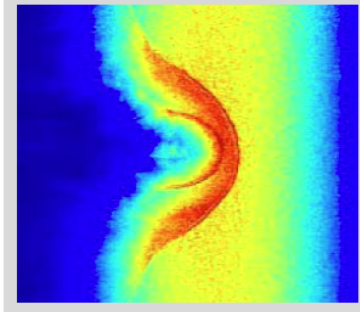


laser



simulation

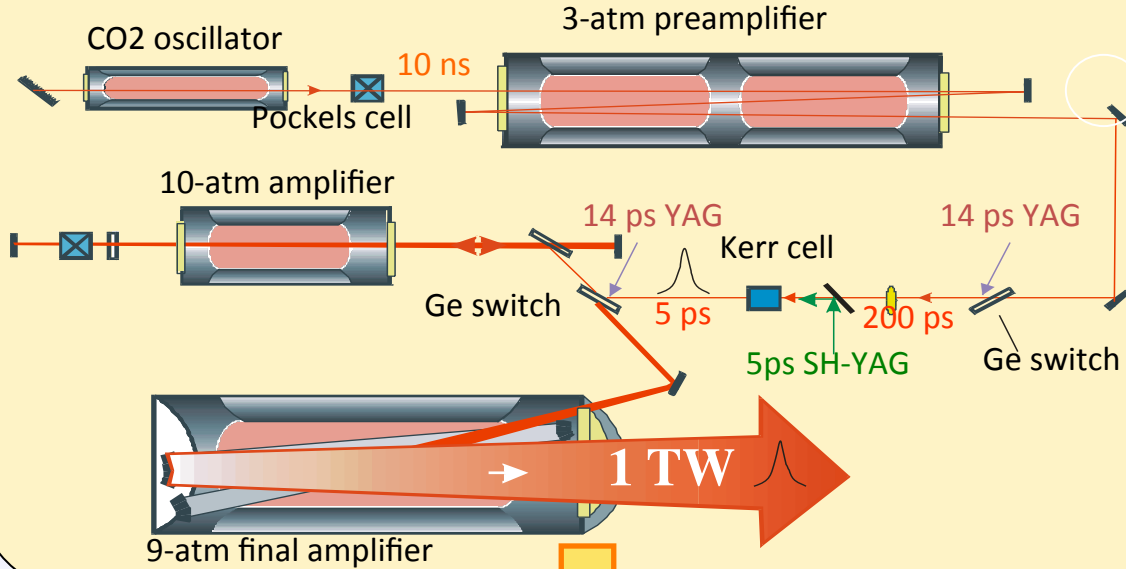
reconstruction



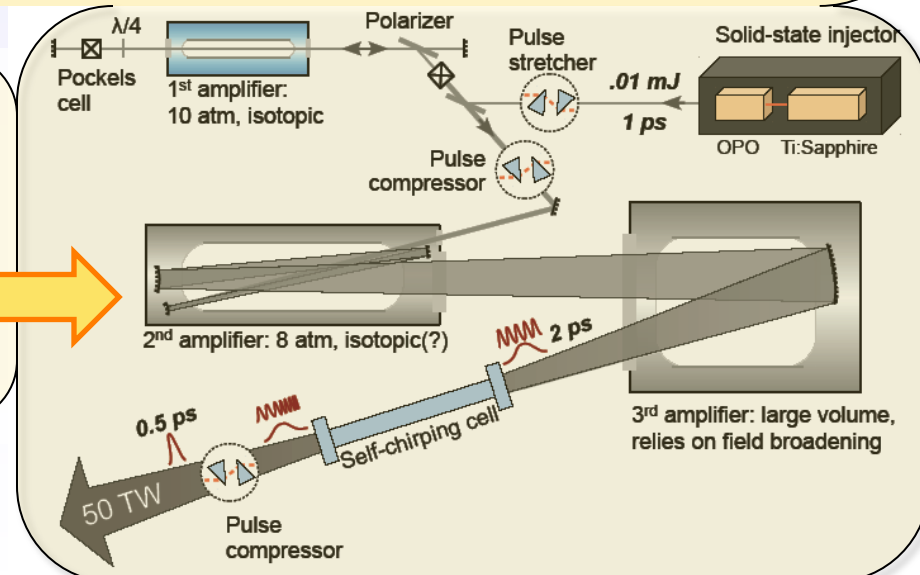
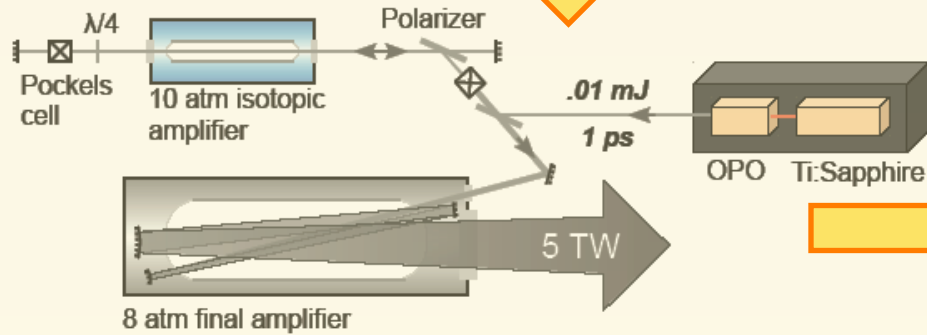
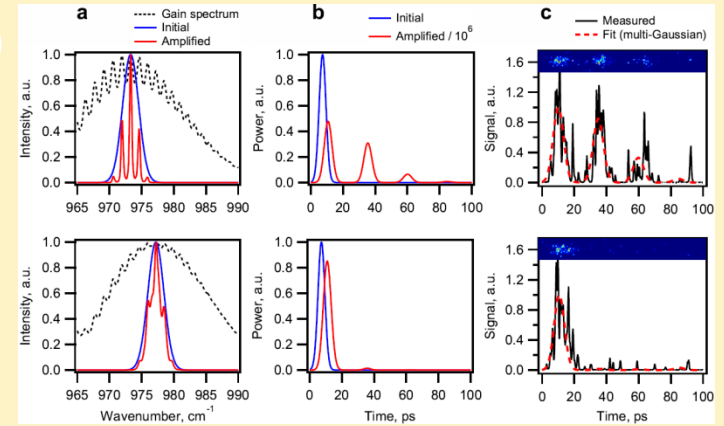
According to RPA scaling, 100X increase in laser intensity leads to 200 MeV protons

Path towards multi-TW femto-sec CO₂ laser

Present CO₂ laser system



Single pulse



CO2 upgrade path

Past: **0.5 TW**

2 x 5 ps
5 J

1 MeV

Present: **1 TW**

5 ps
5 J

3→5 MeV

Near future: **5 TW**

2 ps
10 J

25 MeV

Future: **50 TW**

0.5 ps
25 J

250 MeV

		Apr.2009	Feb.2010	Nov.2010	Dec.2011	???
Energy	[J]	5	5	5	10 ^(IV)	25 (V)
Duration	[ps]	2 x 5 (I)	5 ^(II)	5	2 ^(IV)	0.5 (V)
Power	[TW]	0.5	1	1	5	50
a_0		1.2	1.7	2.2 ^(III)	5	16
E_p	[MeV]	1.5			25	250

- I. laser pulse was split into two due to modulated amplification spectrum
- II. isotopic mixture was used to demonstrate single pulse amplification
- III. improved laser focusing is expected to increase laser intensity
- IV. Ti:Sf seed laser is purchased (Sep.2010) to shorten CO2 seed to 1 ps. Shorter seed would allow for better laser energy extraction.
- V. Additional amplification stage and/or laser pulse plasma chirping/compression need to be developed to reach this stage (not funded)

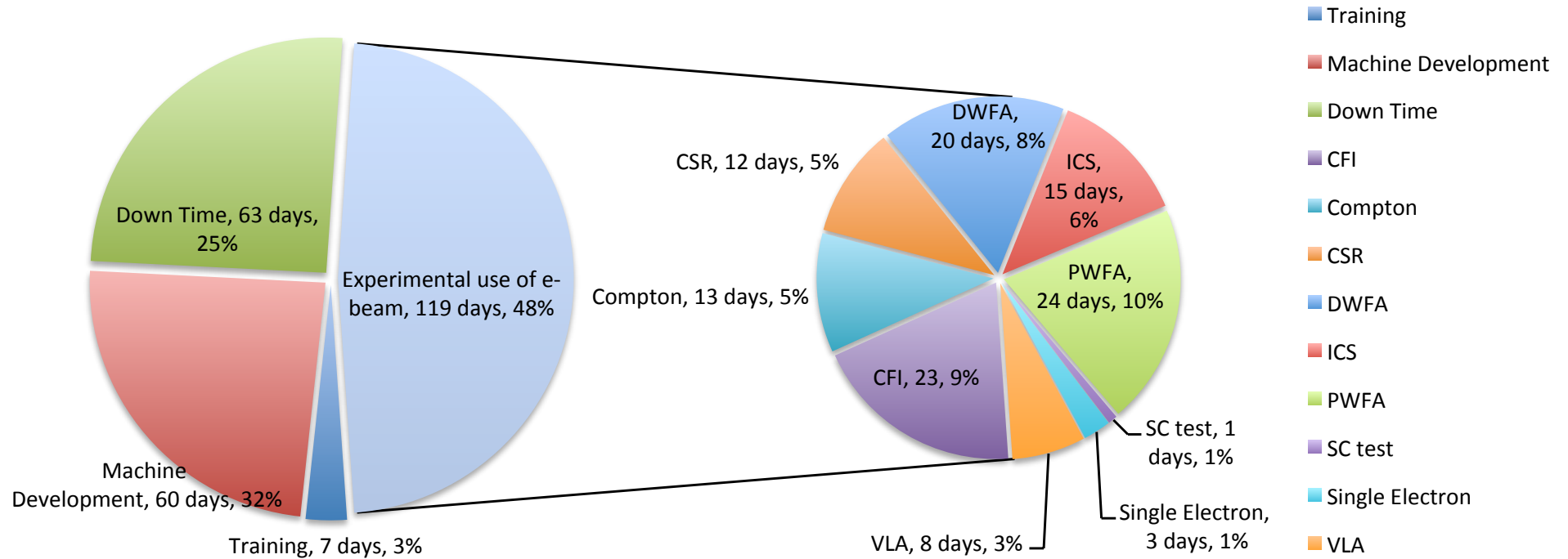
ATF experimental program summary

- High Gradient / X band option at ATF
 - 3fs resolution longitudinal diagnostics
 - Energy spread silencer
 - High gradient experiments with high brightness e^- beam
 - Testing high gradient S-band structures
 - Plasma WFA
 - Bunch train (completed)
 - High transformer ratio measurement (shaped train and triangular bunch)
 - Efficiency optimization
 - Weibel instability studies
 - Holographic characterization of wake fields from two bunch and “train”
 - Dielectric WFA
 - Bunch train - narrow band THz generation (completed)
 - High transformer ratio measurement (shaped train and triangular bunch)
- Medium range between ANL and FACET beams

ATF experimental program summary

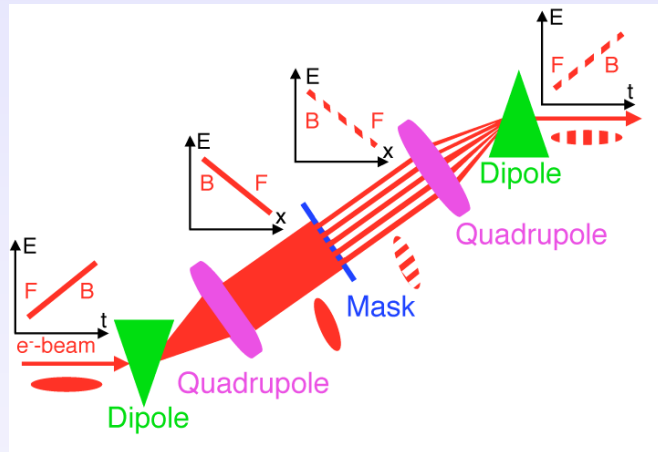
- **CO₂ laser development (5TW near term, 10-20TW later)**
 - Short pulse seeding using new Ti:Sapphire laser system
 - Stretched pulse amplification
 - Controlled dual pulse structure (for Ion beam generation)
 - Recirculation cavity
- **Laser Generated Ion beams**
 - Studies of monoenergetic ion beams generation with controlled dual pulse structure
 - Ion beam energy increase to 5, 10 and 20MeV.
 - Experimental program with generated beams
- **Compton back scattering generated X ray beams**
 - High intensity/brightness single shot experiments
 - Fast diffraction pump probe experiment
 - Multibunch interaction with CO₂ laser for ILC/CLIC polarized e⁺ source
 - Multibunch interaction with UV laser for DOD tests

Electron beam usage



Multi-bunch Plasma Wake Field Experiment

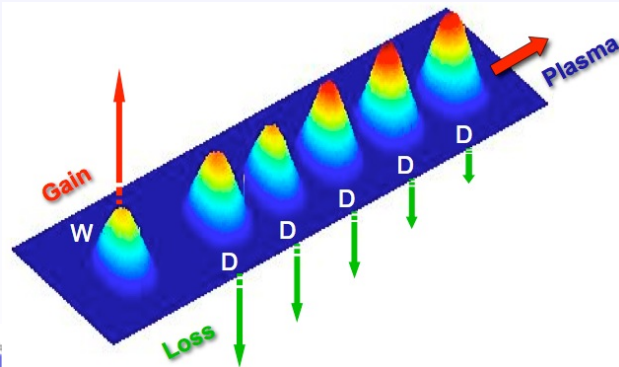
Bunch Train generated with the mask



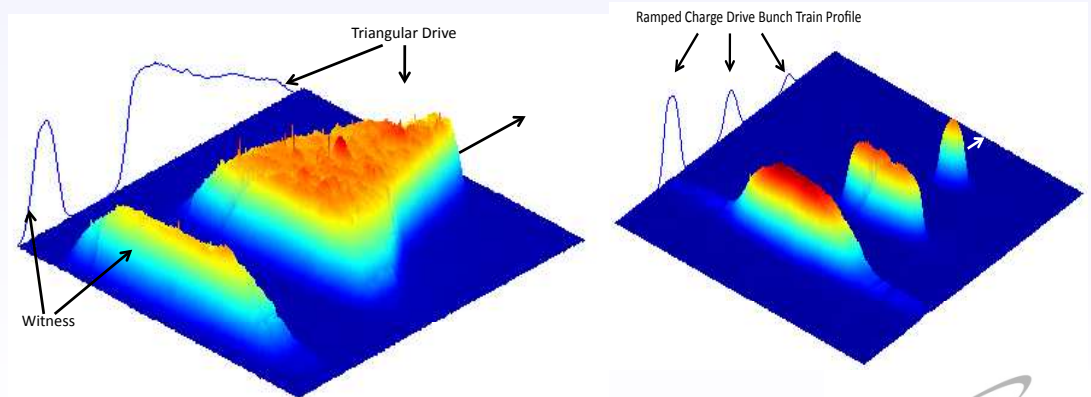
Currently we use setup with 5 masks to accommodate needs of 4 experimental groups studying:

1. PWFA (USC)
2. DWFA (Euclid and UCLA)
3. DWF THz generation (UCLA)
4. CSR shielding (CAD BNL)

Measured uniform train of drive bunches excites high amplitude wake field

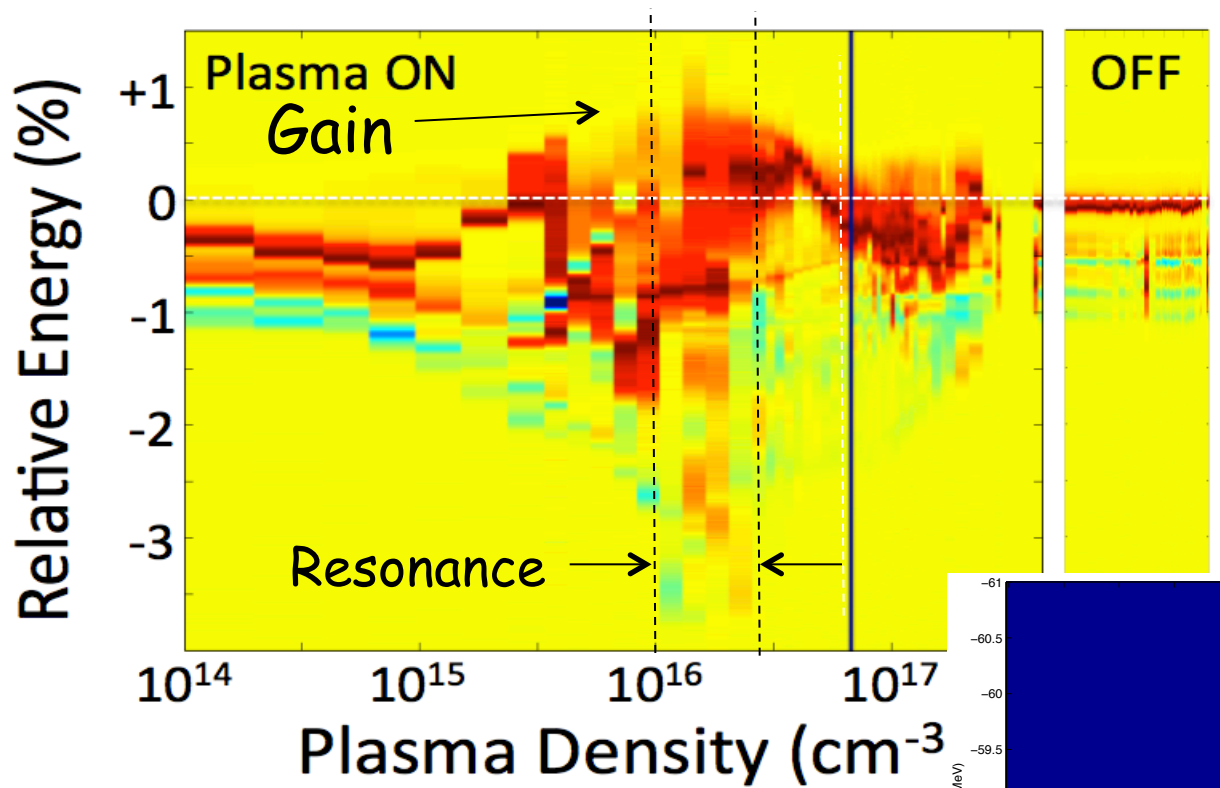
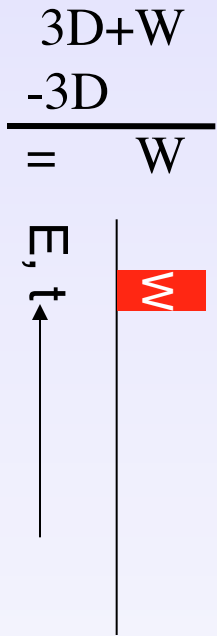


Shaped bunch train for efficiency and high transformer ratio studies

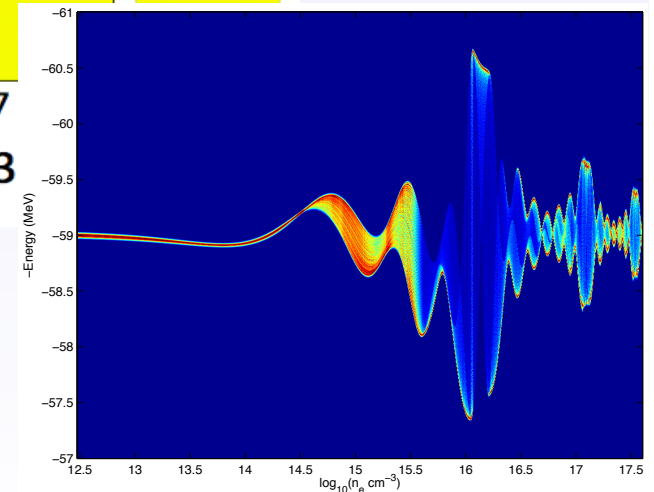


PWFA: ENERGY CHANGE

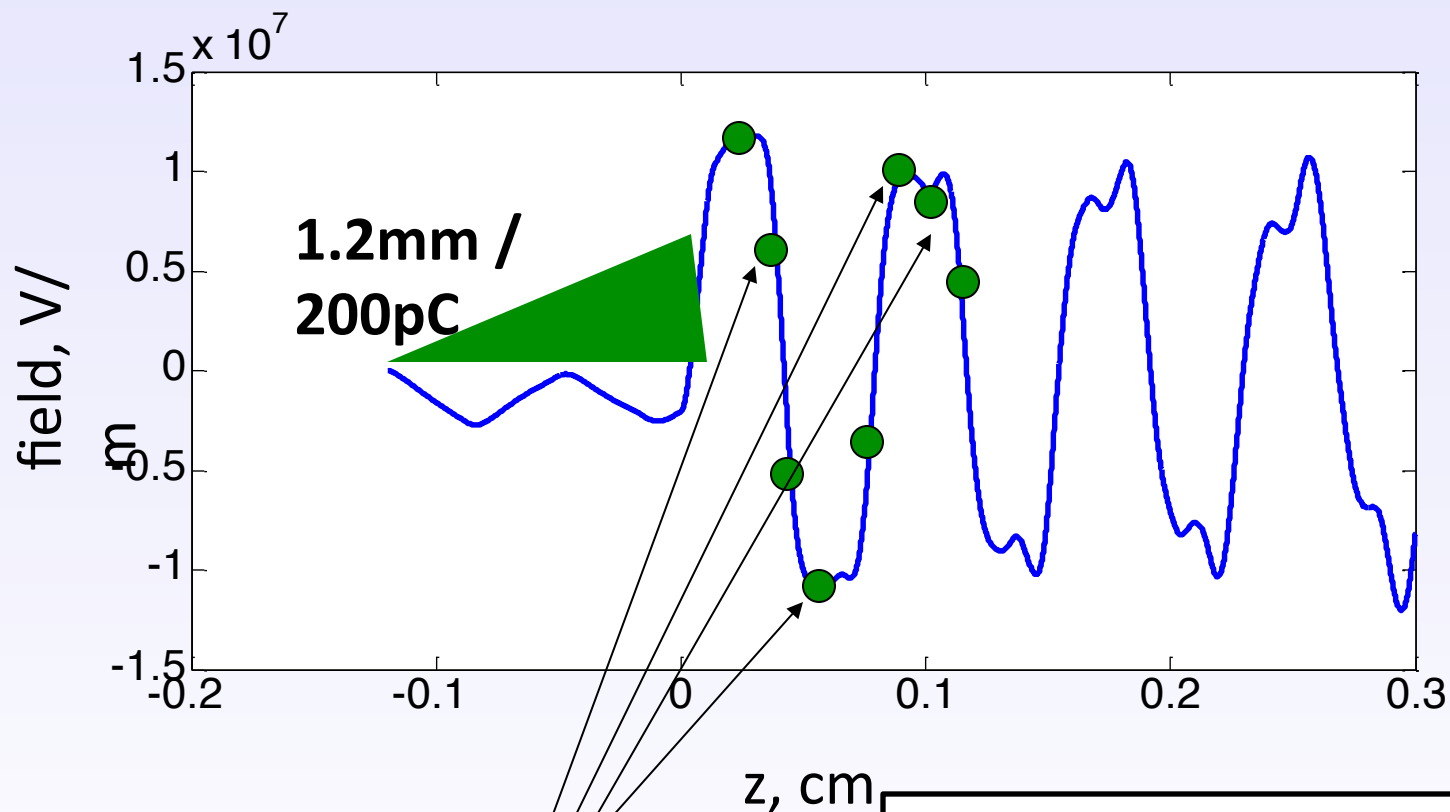
Experiment: normalized spectra



- ➔ Resonance clearly observed, $n_{e, res} \approx 1.4 \times 10^{16} \text{ cm}^{-3}$, as expected
- ➔ Very similar to 2D calculations



Transformer ratio with triangular bunch

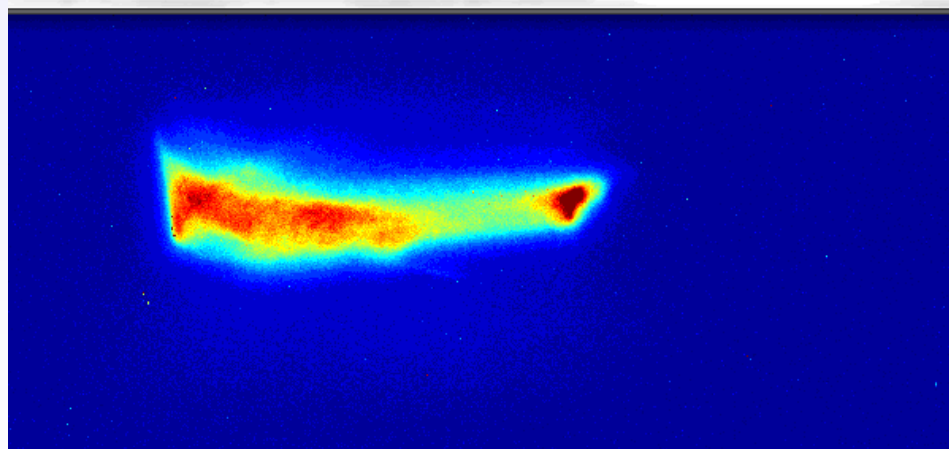
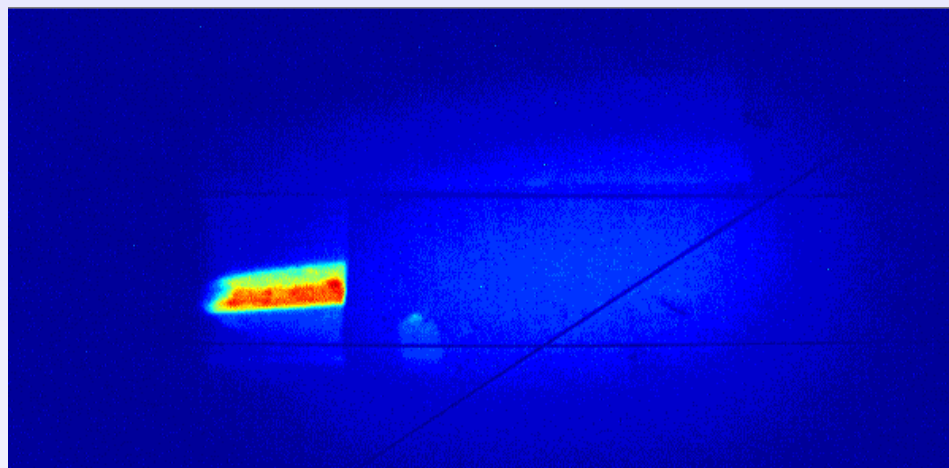


Position of witness beam is adjusted to map wakefield

- triangular drive beam
- witness beam spacing sweep
- drive beam deceleration meas

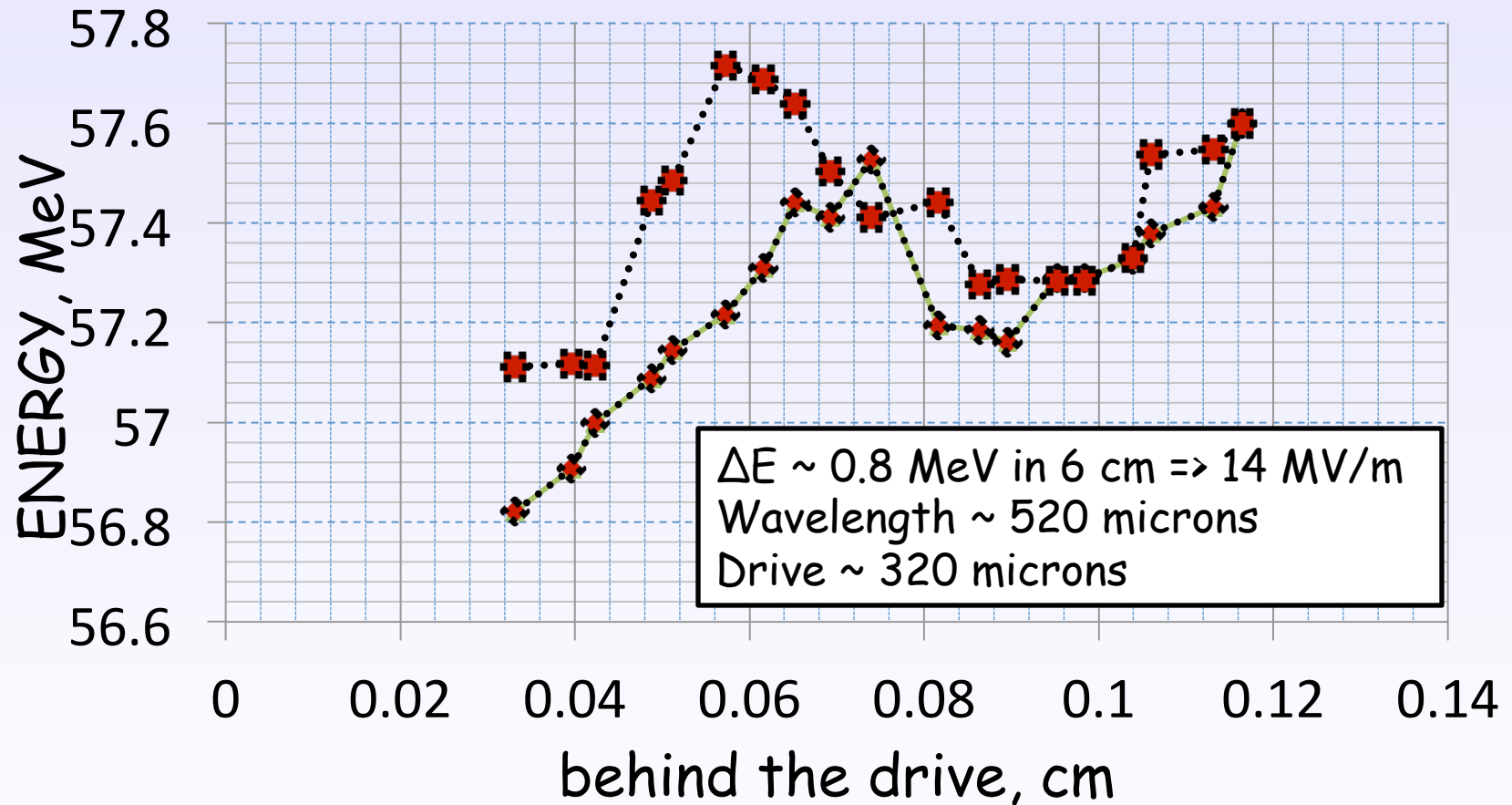
What we observed

Time



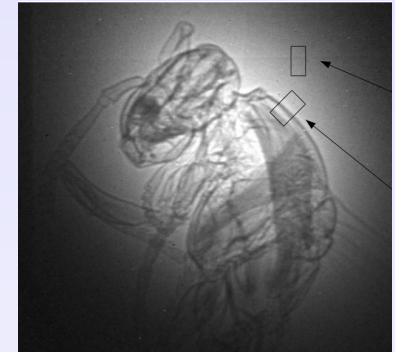
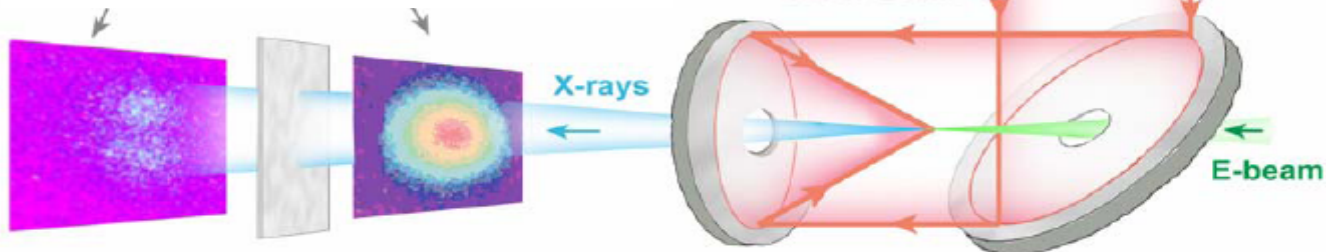
Energy

Preliminary analysis

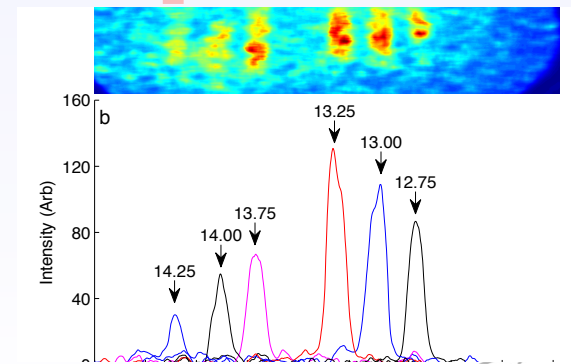
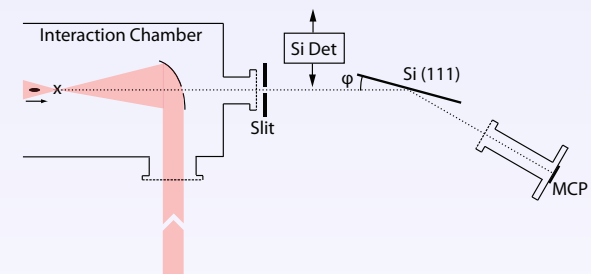


Compton X ray Source

Measured CCD images
Nonlinear and linear x-rays

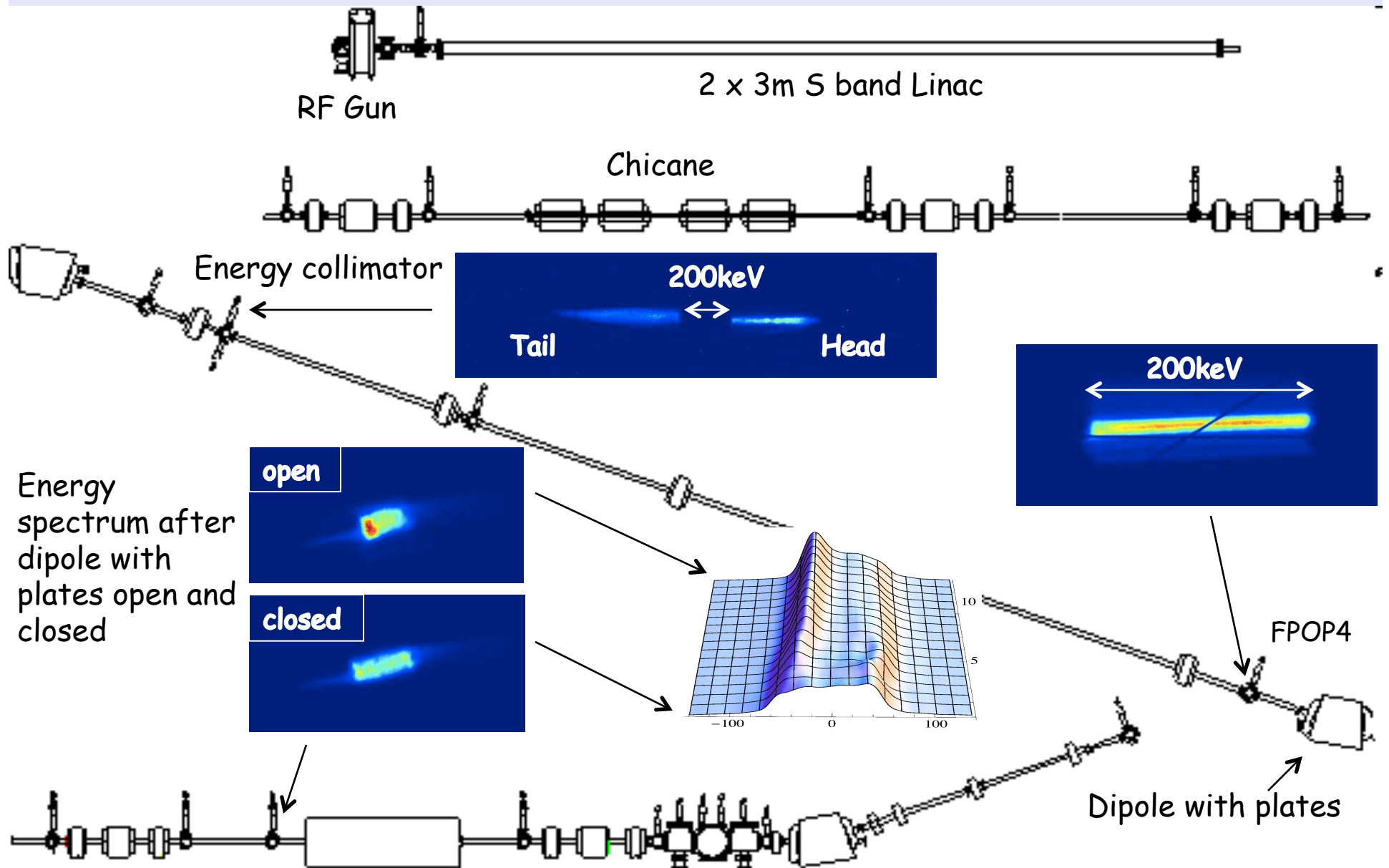


- Compton based 6KeV x ray source with a record number of photons (PRE 1998)
- Observation of the second harmonic (PRL 2001)
- Single shot phase contrast imaging (APL 2010)
- Single shot Diffraction (in preparation)
- 100fs X ray camera
- Recirculation cavity to increase average flux
- Gamma source for polarized positron source

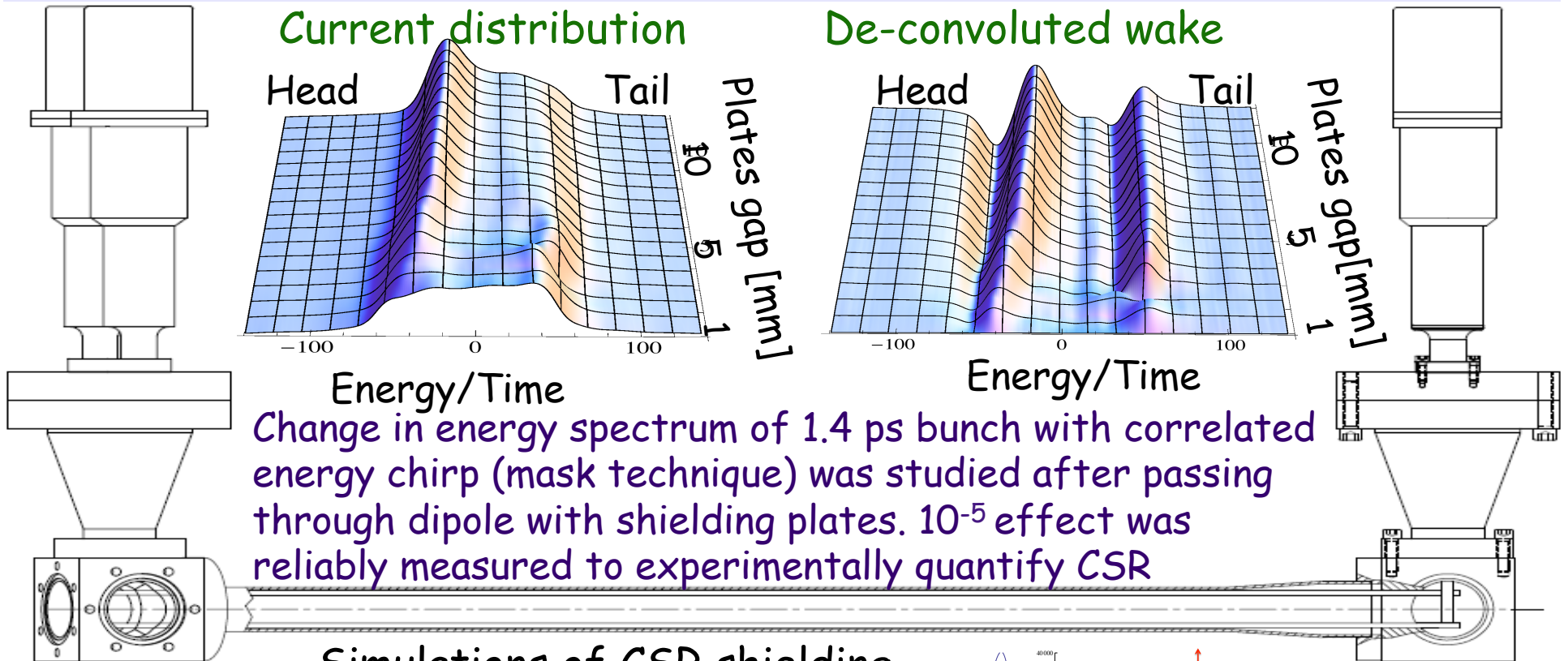


BROOKHAVEN
NATIONAL LABORATORY

Coherent Synchrotron Radiation Suppression

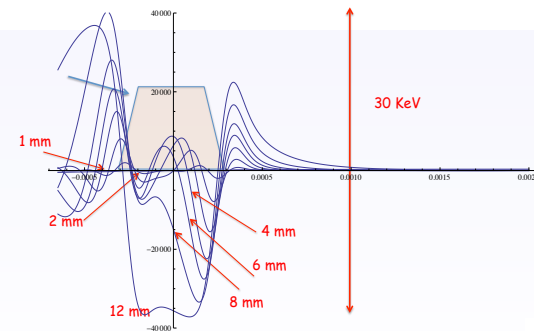
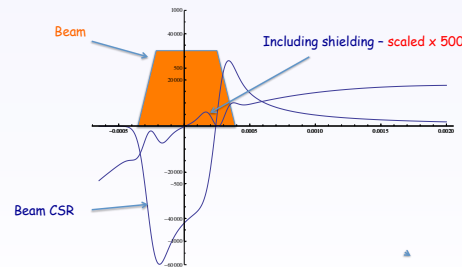
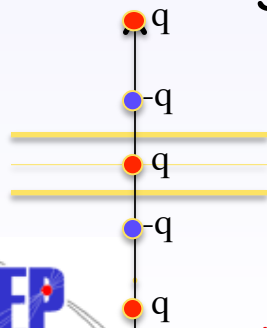


Coherent Synchrotron Radiation Studies



Change in energy spectrum of 1.4 ps bunch with correlated energy chirp (mask technique) was studied after passing through dipole with shielding plates. 10^{-5} effect was reliably measured to experimentally quantify CSR

Simulations of CSR shielding



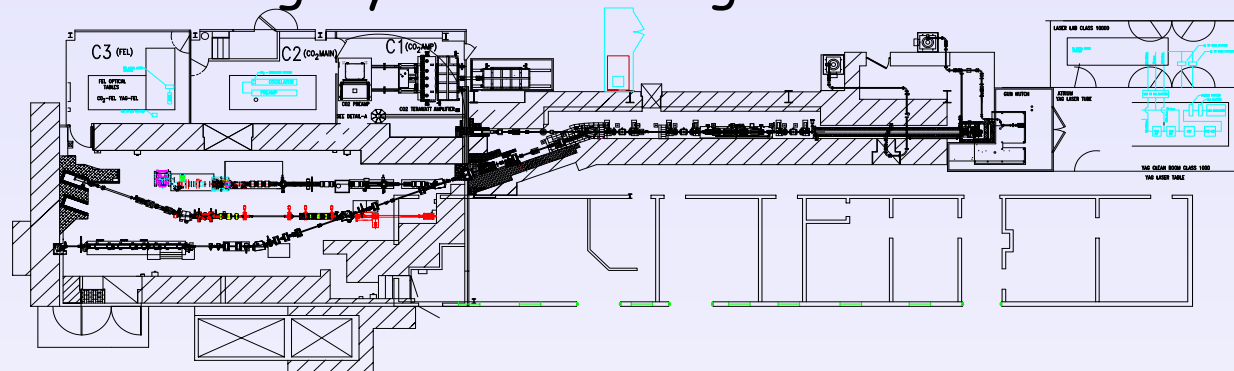
This result could reduce eRHIC cost by \$150M

ATF move

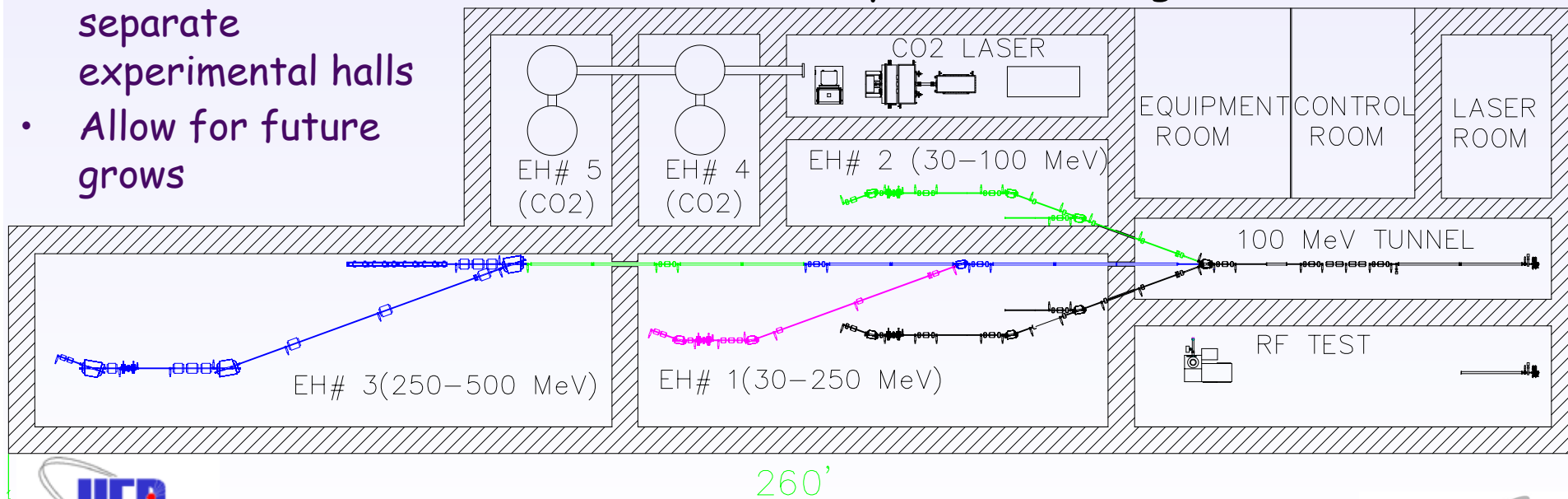
Goals:

- Address "space issue" at ATF
- Shielded space for medical experiments with ion beams
- Improve efficiency with number of separate experimental halls
- Allow for future grows

Existing layout in building 820



Potential layout in building 912



Conclusion

- The R&D program at ATF is very diverse
- Well characterized and controlled high brightness electron beam and synchronized TW picosecond CO₂ laser are main capabilities
- Operations at ATF are organized as a user facility:
 - Regular User meeting and PAC review of proposals
 - Schedule
 - Discussion of planned upgrades with users
- The main thrust towards long range research that is not part of the construction projects