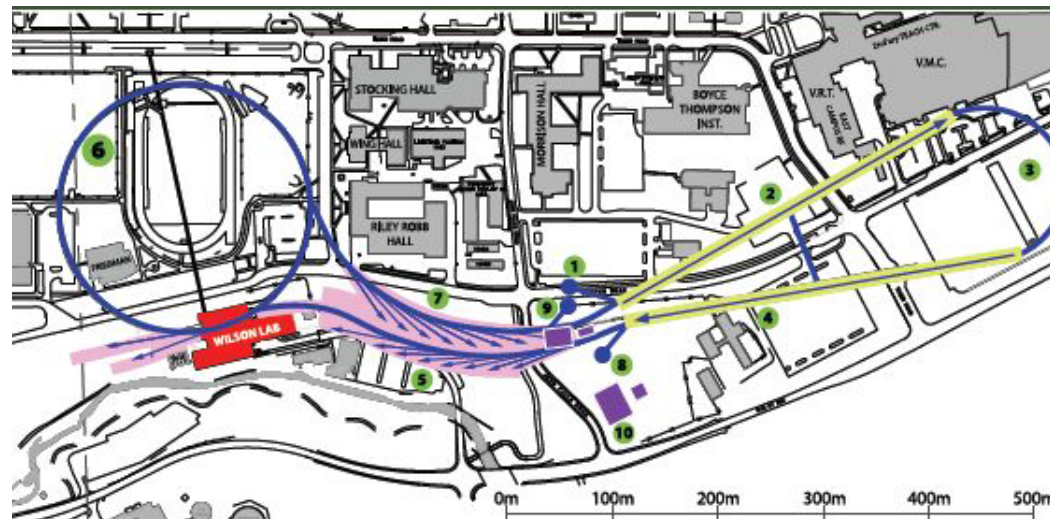


ERL R&D Update

Ivan Bazarov

Cornell University

- **Significant milestones reached for an ERL based x-ray source**
 - Photoelectron source
 - RF superconductivity



Cornell ERL team



D. H. Bilderback, M. G. Billing, J. D. Brock, B. W. Buckley, S. S. Chapman, E. P. Chojnacki, Z. A. Conway, J. A. Crittenden, D. Dale, J. A. Dobbins, B. M. Dunham, R. D. Ehrlich, M. P. Ehrlichman, K. D. Finkelstein, E. Fontes, M. J. Forster, S. W. Gray, S. Greenwald, S. M. Gruner, C. Gulliford, D. L. Hartill, R. G. Helmke, G. H. Hoffstaetter, A. Kazimirov, R. P. Kaplan, S. S. Karkare, V. O. Kostroun, F. A. Laham, Y. H. Lau, Y. Li, X. Liu, M. U. Liepe, F. Loehl, L. Cultrera, C. E. Mayes, J. M. Maxson, A. A. Mikhailichenko, D. Ouzounov, H. S. Padamsee, S. B. Peck, M. A. Pfeifer, S. E. Posen, P. G. Quigley, P. Revesz, D. H. Rice, D. C. Sagan, J. O. Sears, V. D. Shemelin, D. M. Smilgies, E. N. Smith, K. W. Smolenski, A. B. Temnykh, M. Tigner, N. R. A. Valles, V. G. Veshcherevich, Z. Wang, A. R. Woll, Y. Xie, Z. Zhao

+ collaborators from other institutions



Cornell ERL R&D effort



- **CHESS**
 - X-ray science case (XDL'11 series of 6 workshops in Ithaca, NY for diffraction limited X-rays), undulator R&D, ERL facility planning
- **SRF group**
 - Manufactured the first main linac 7-cell cavities, main linac cryomodule prototype
- **ERL photoinjector facility**
 - Operating the world's highest current and brightness CW photoinjector
- **Gun & cathode development lab**
 - Laser lab, Mark-II gun under construction, material science & engineering of high efficiency photocathodes

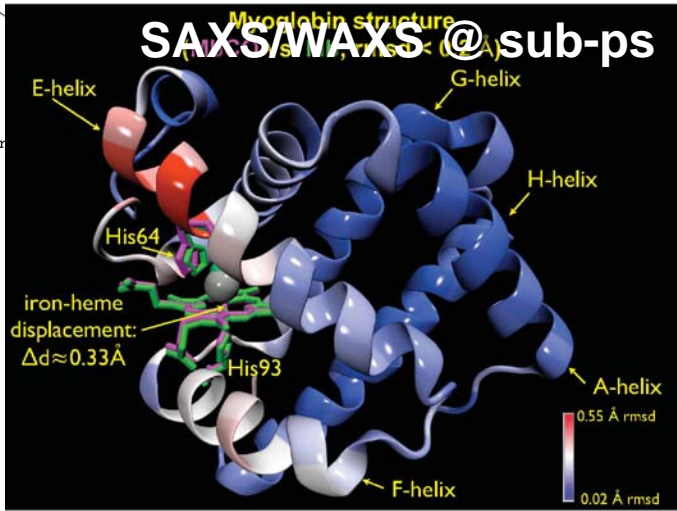
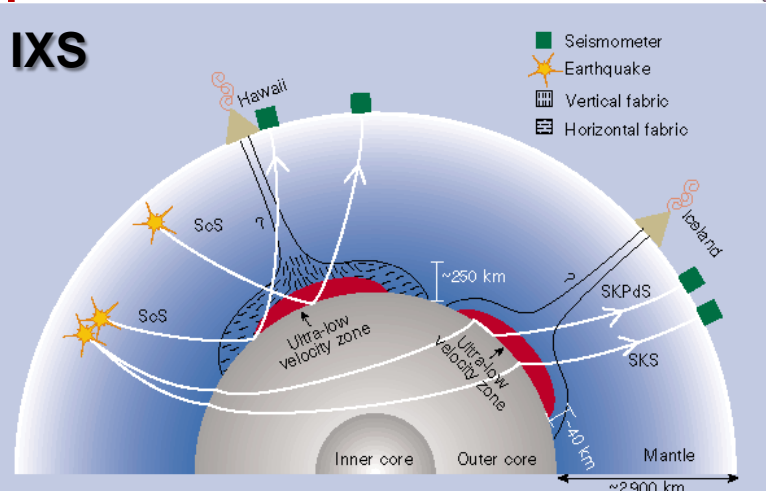
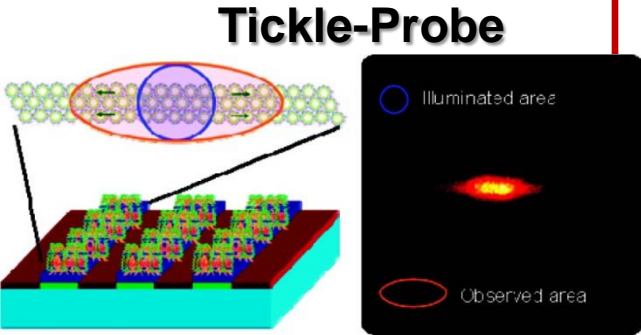
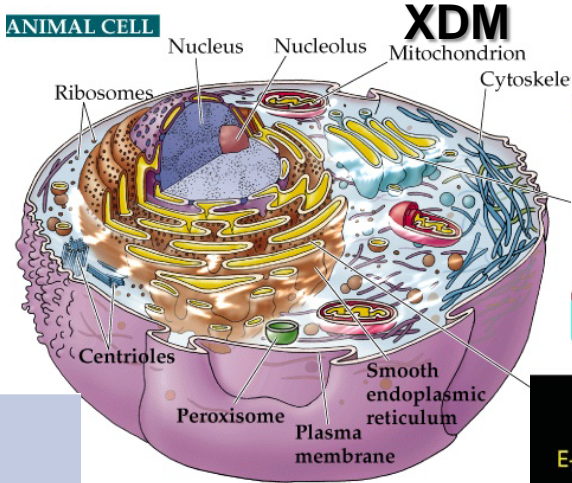
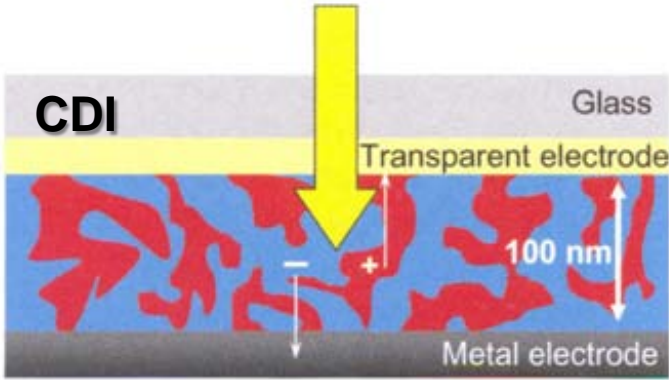


Progress in ERLs for Light Sources



XDL'11 workshops – exciting science enabled by X-ray ERLs

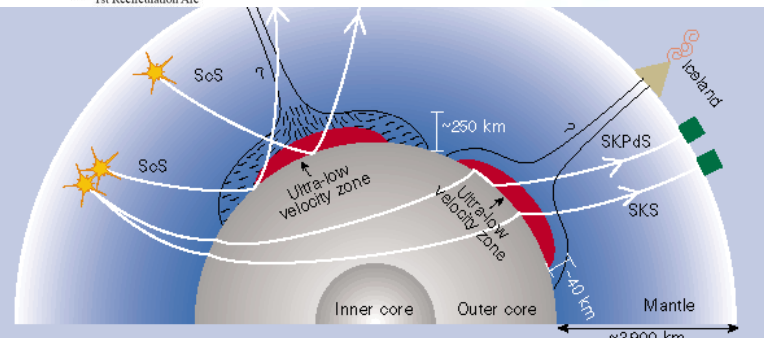
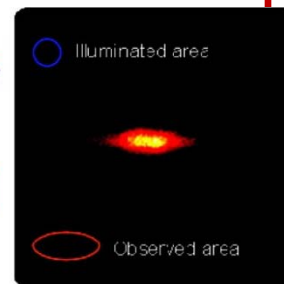
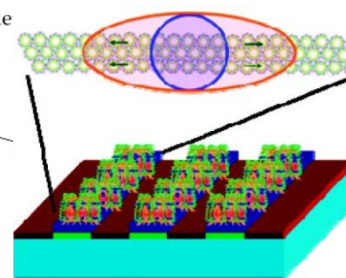
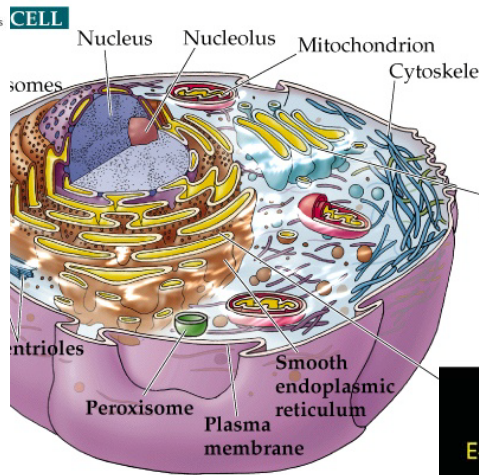
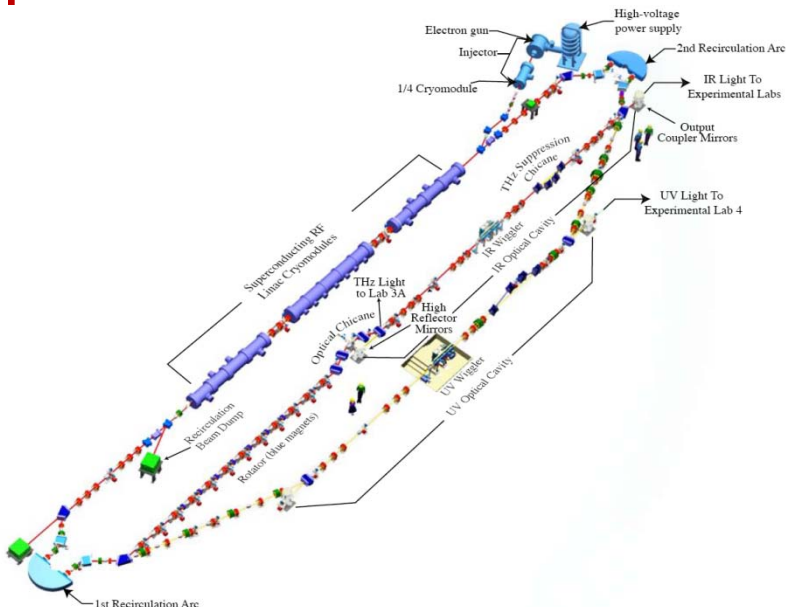
Beyond existing brightest x-ray sources



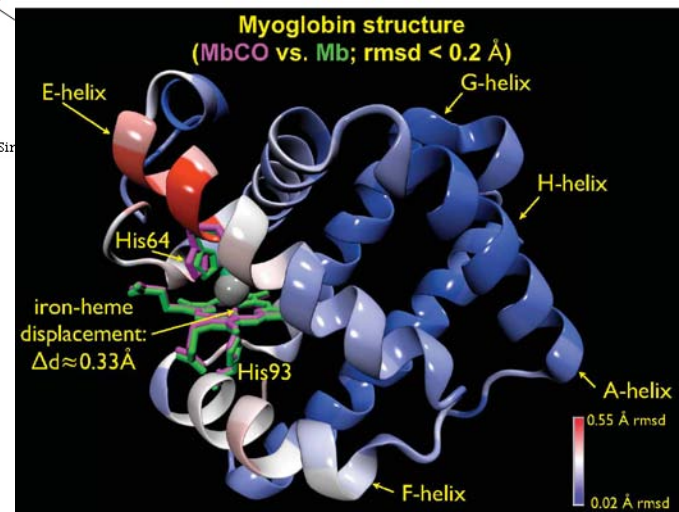
Progress in ERLs for Light Sources



Operations at JLAB



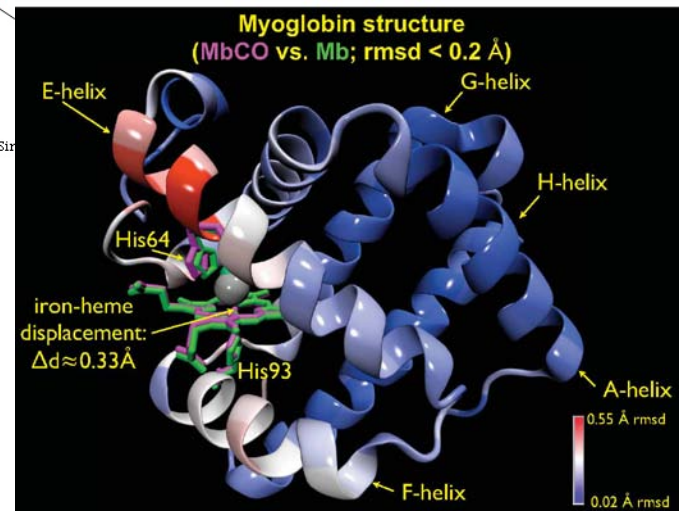
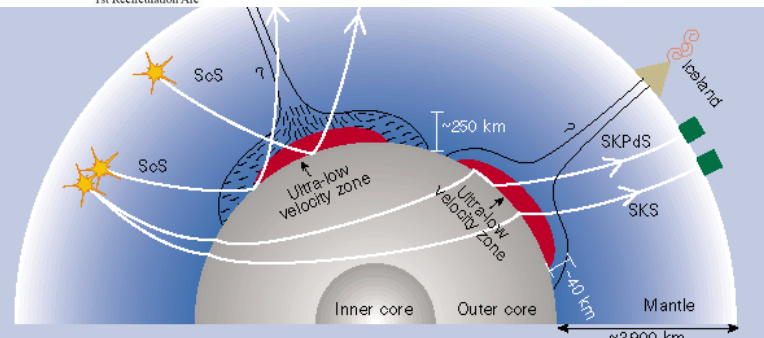
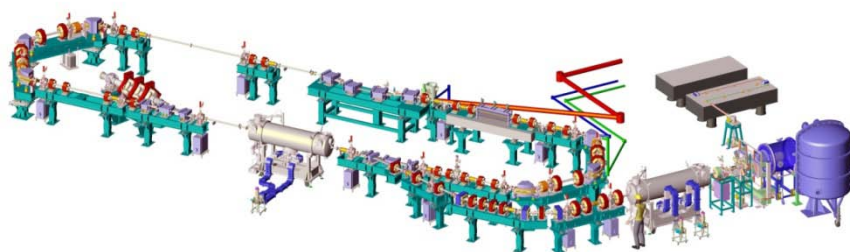
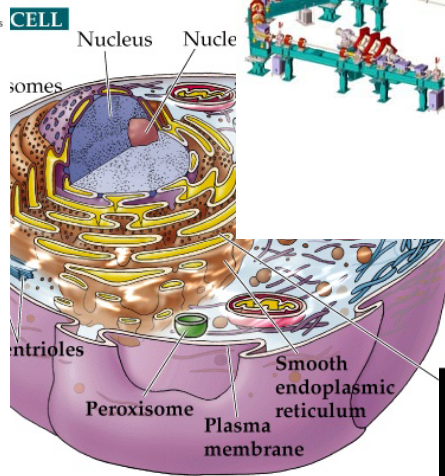
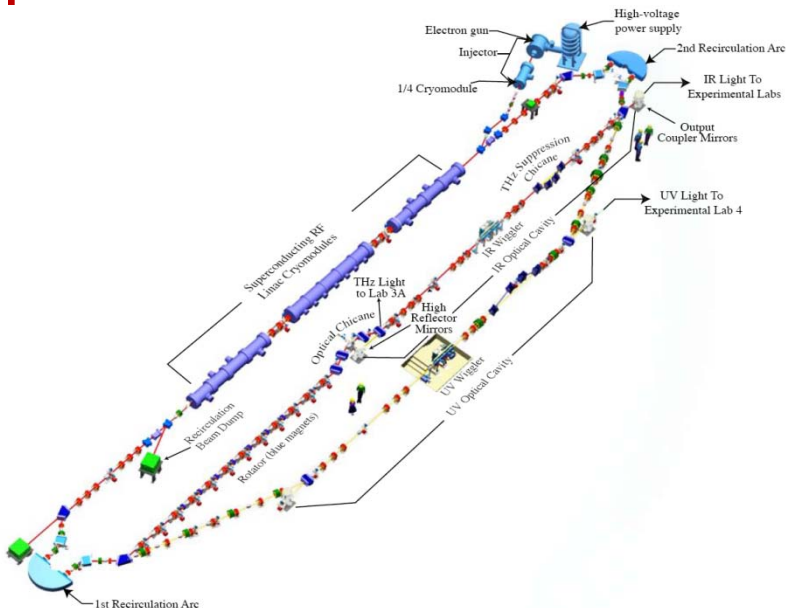
© 2001 Sir



Progress in ERLs for Light Sources



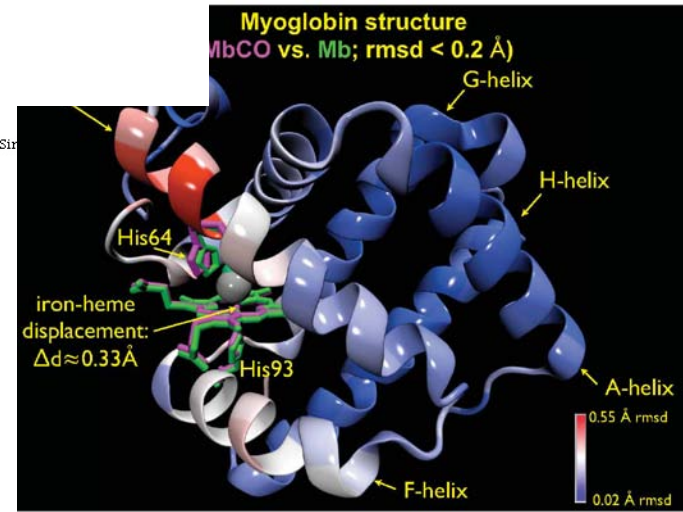
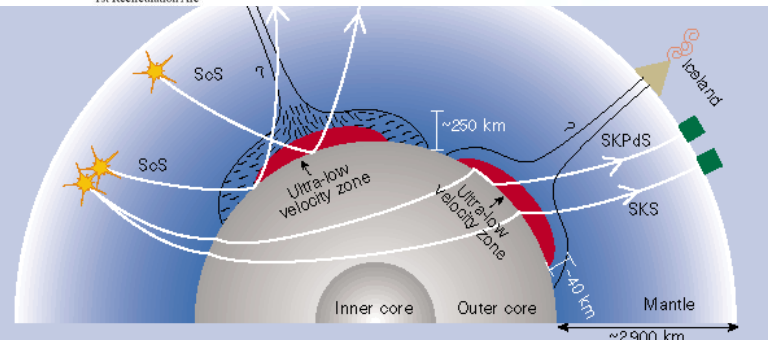
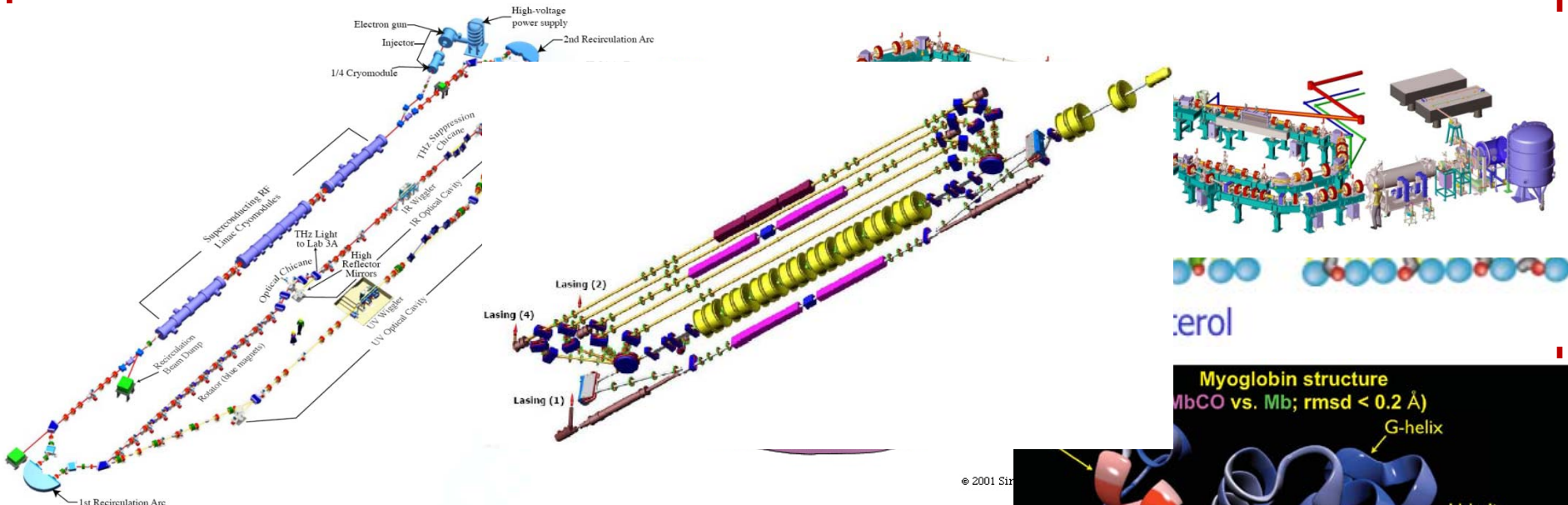
Operations at JLAB, Daresbury,



Progress in ERLs for Light Sources



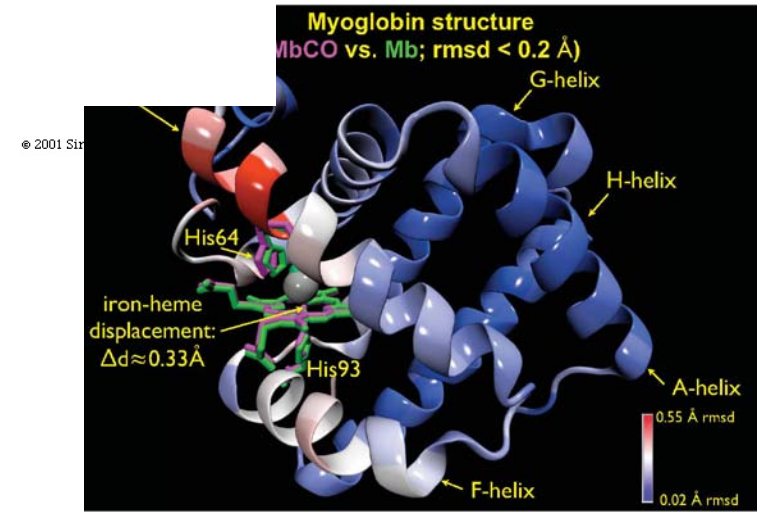
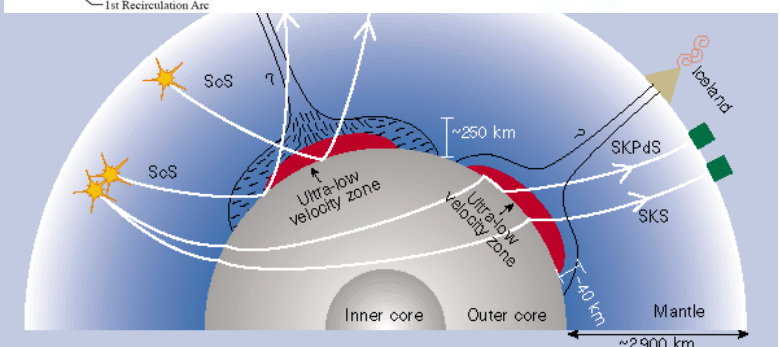
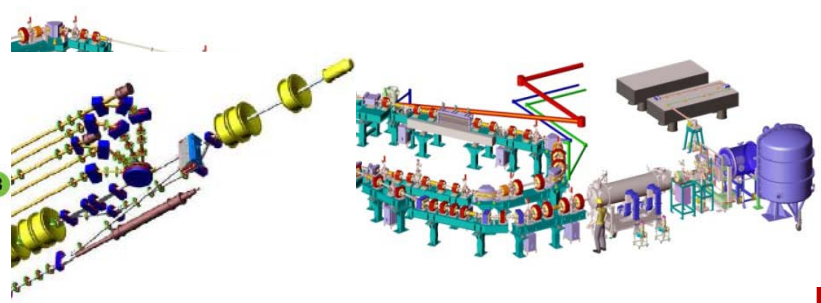
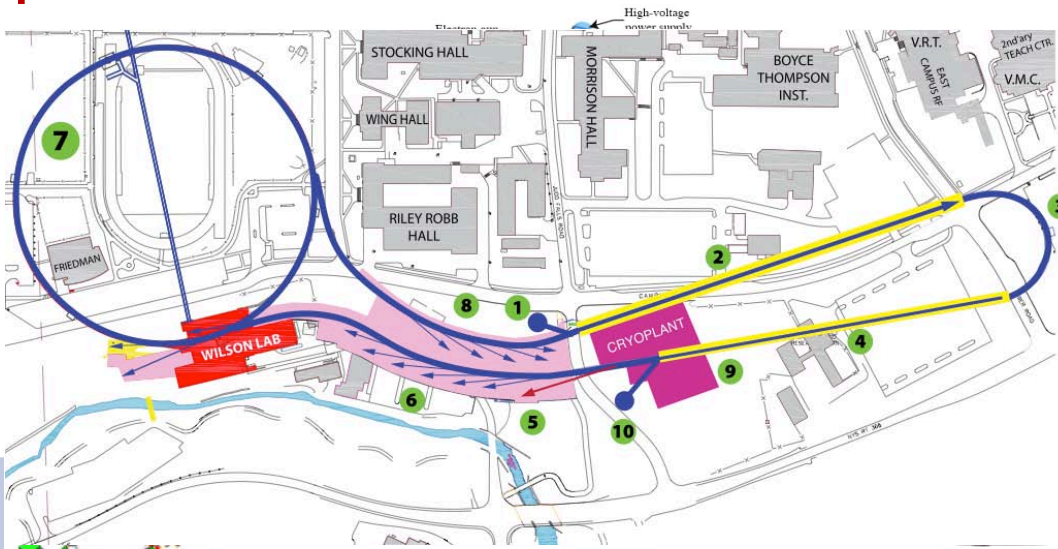
Operations at JLAB, Daresbury, BINP



Progress in ERLs for Light Sources



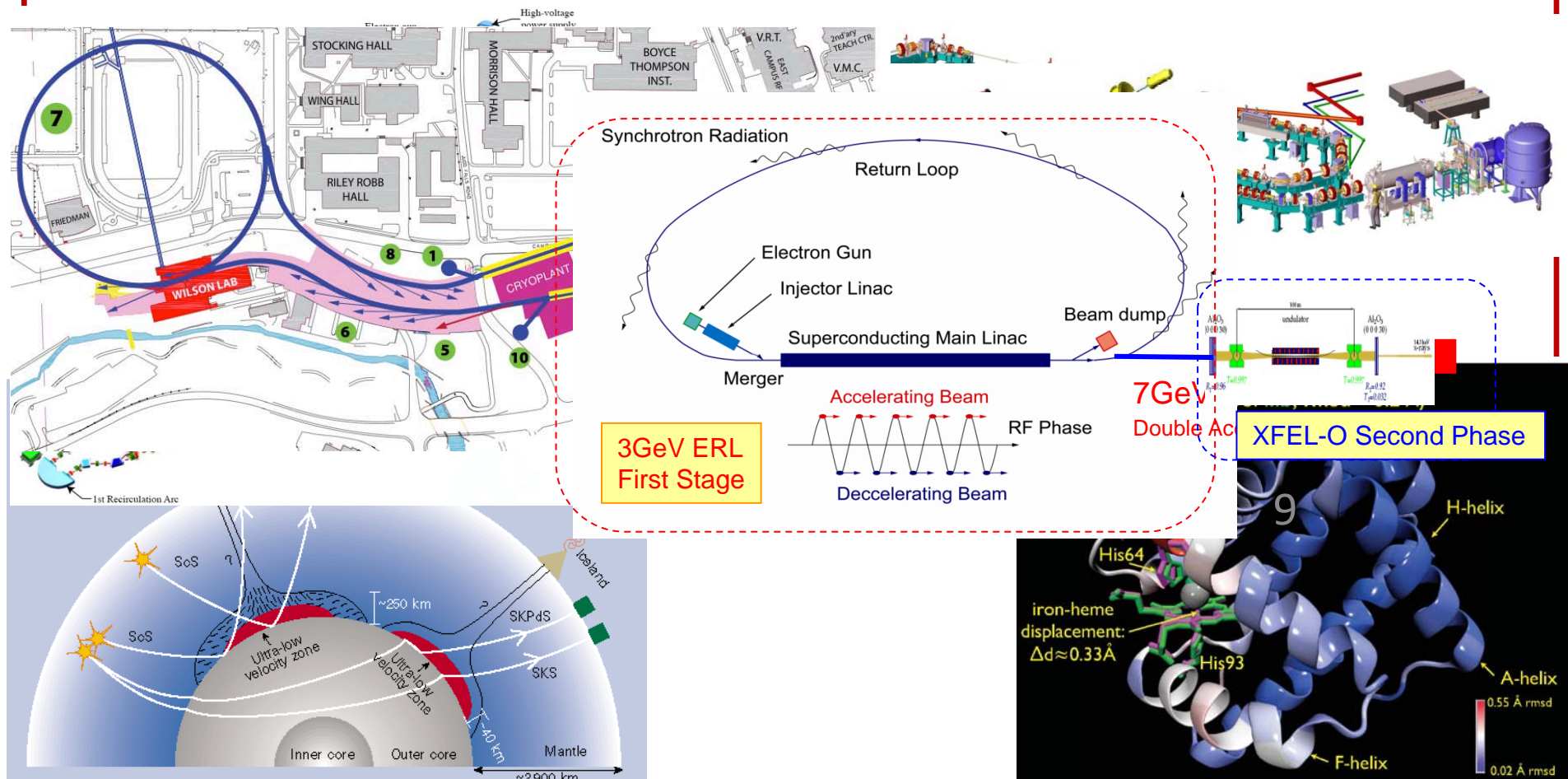
Operations at JLAB, Daresbury, BINP
 Designs at Cornell



Progress in ERLs for Light Sources



Operations at JLAB, Daresbury, BINP
 Designs at Cornell, KEK/JAEA

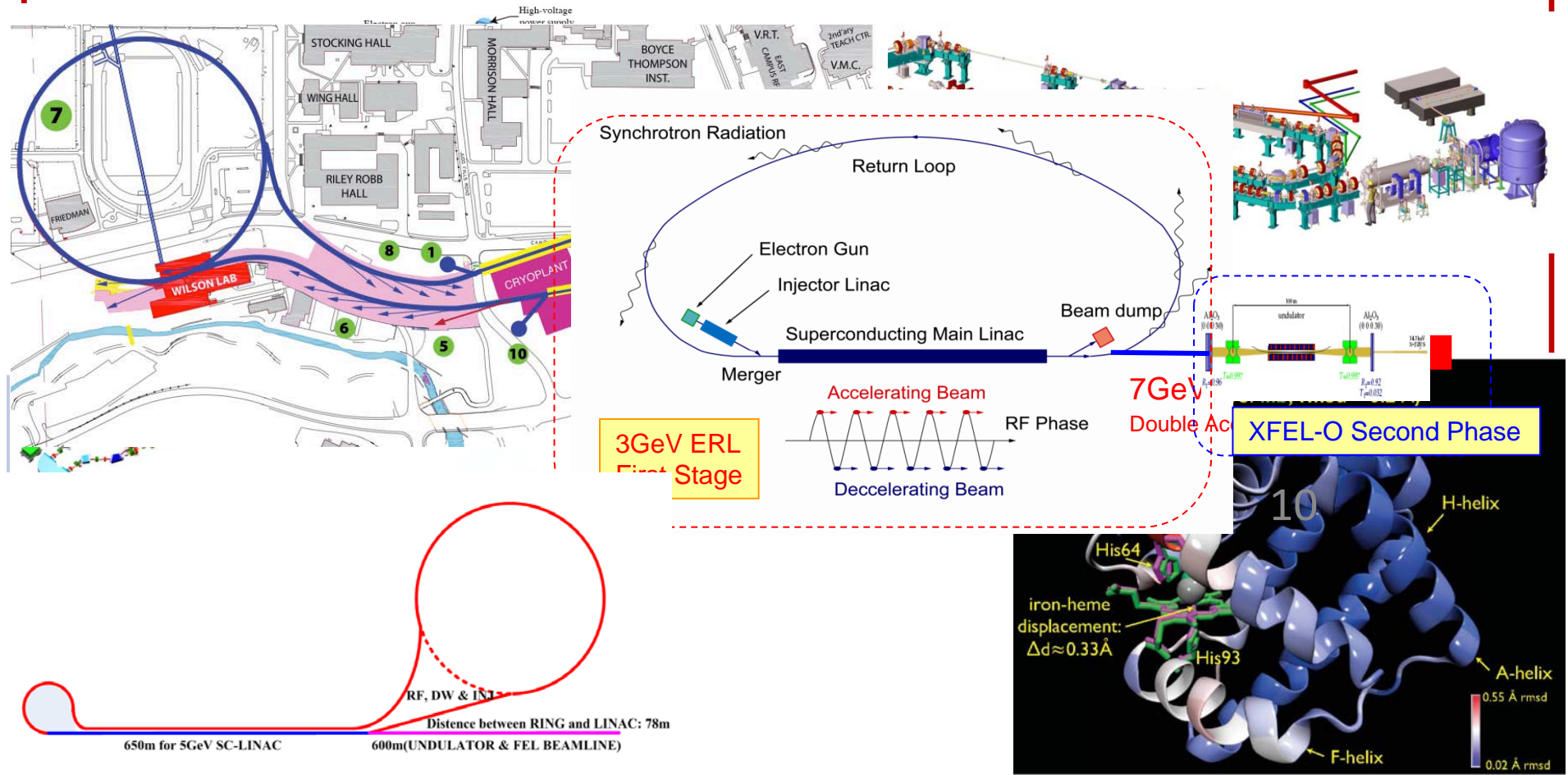


7GeV Double Ac XFEL-O Second Phase

Progress in ERLs for Light Sources



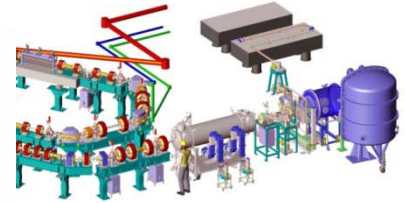
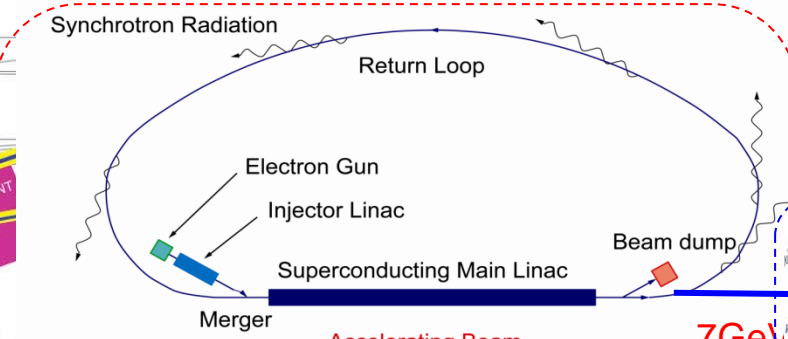
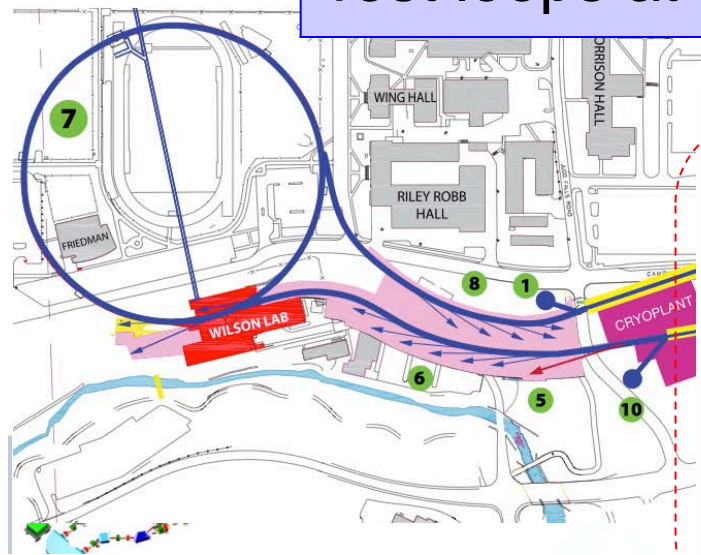
Operations at JLAB, Daresbury, BINP
 Designs at Cornell, KEK/JAEA, BAPS



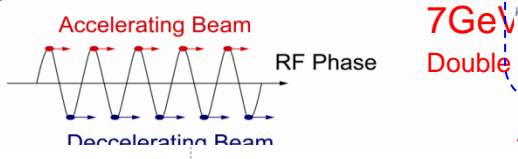
Progress in ERLs for Light Sources



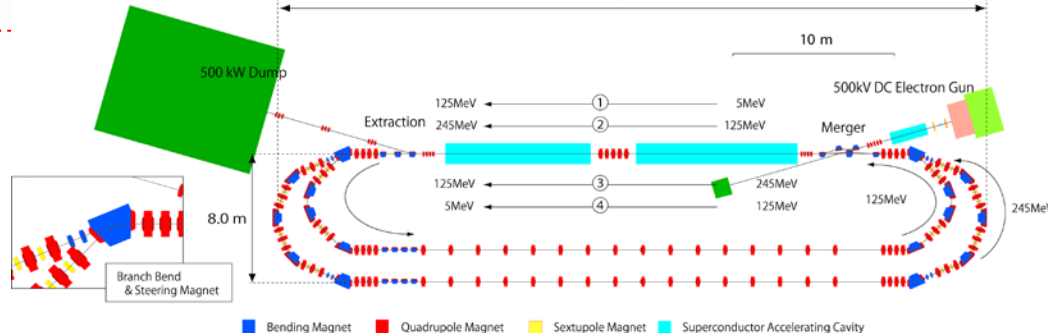
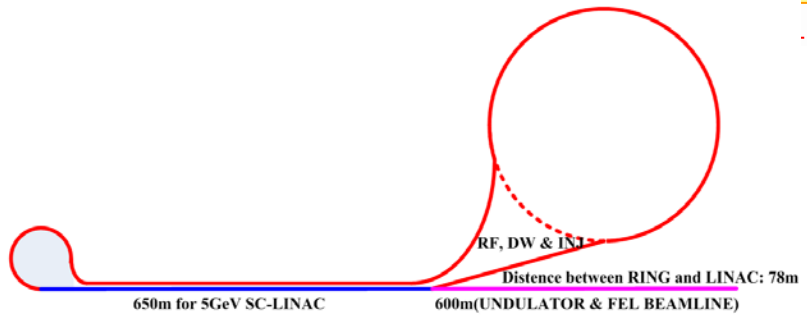
Operations at JLAB, Daresbury, BINP
 Designs at Cornell, KEK/JAEA, BAPS
 Test loops at KEK



3GeV ERL
 First Stage



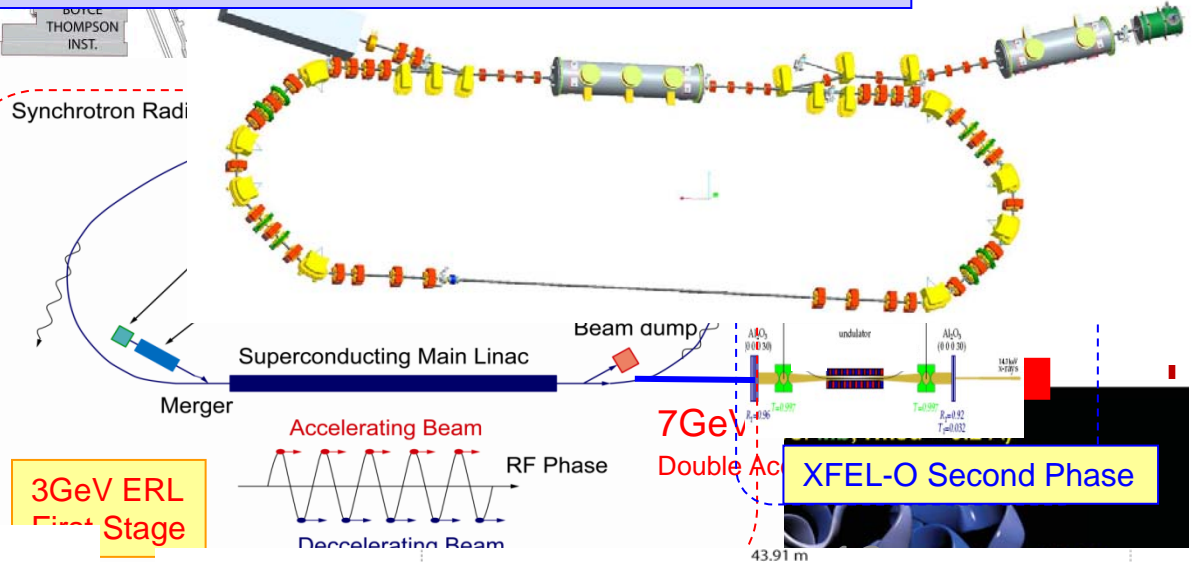
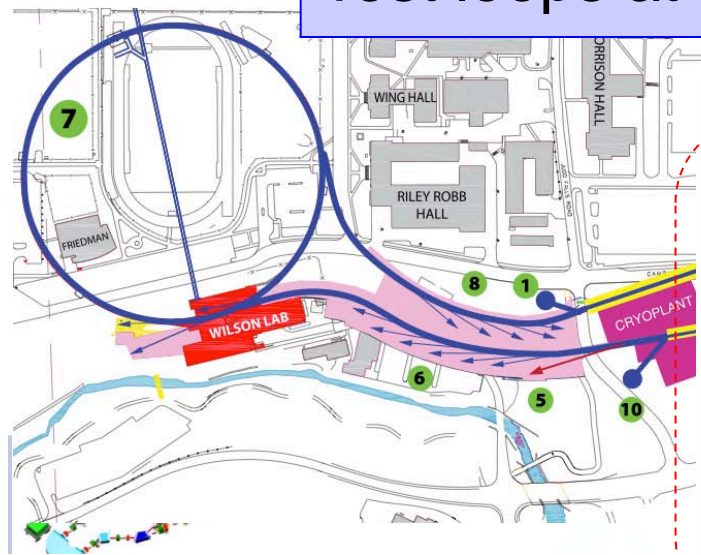
7GeV
 Double Ac
 XFEL-O Second Phase



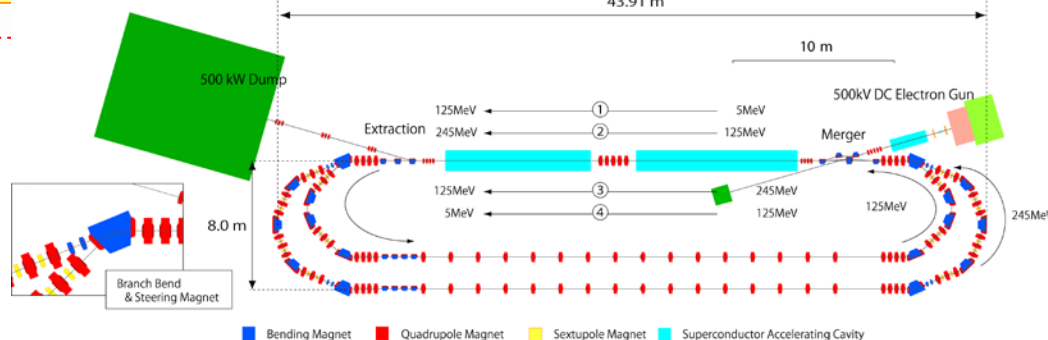
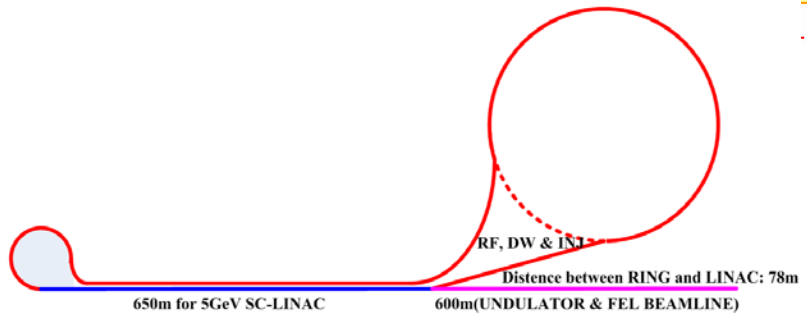
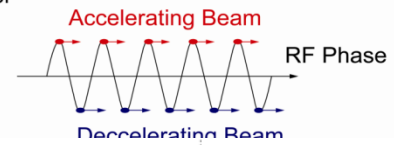
Progress in ERLs for Light Sources



Operations at JLAB, Daresbury, BINP
 Designs at Cornell, KEK/JAEA, BAPS
 Test loops at KEK, HZB



3GeV ERL First Stage

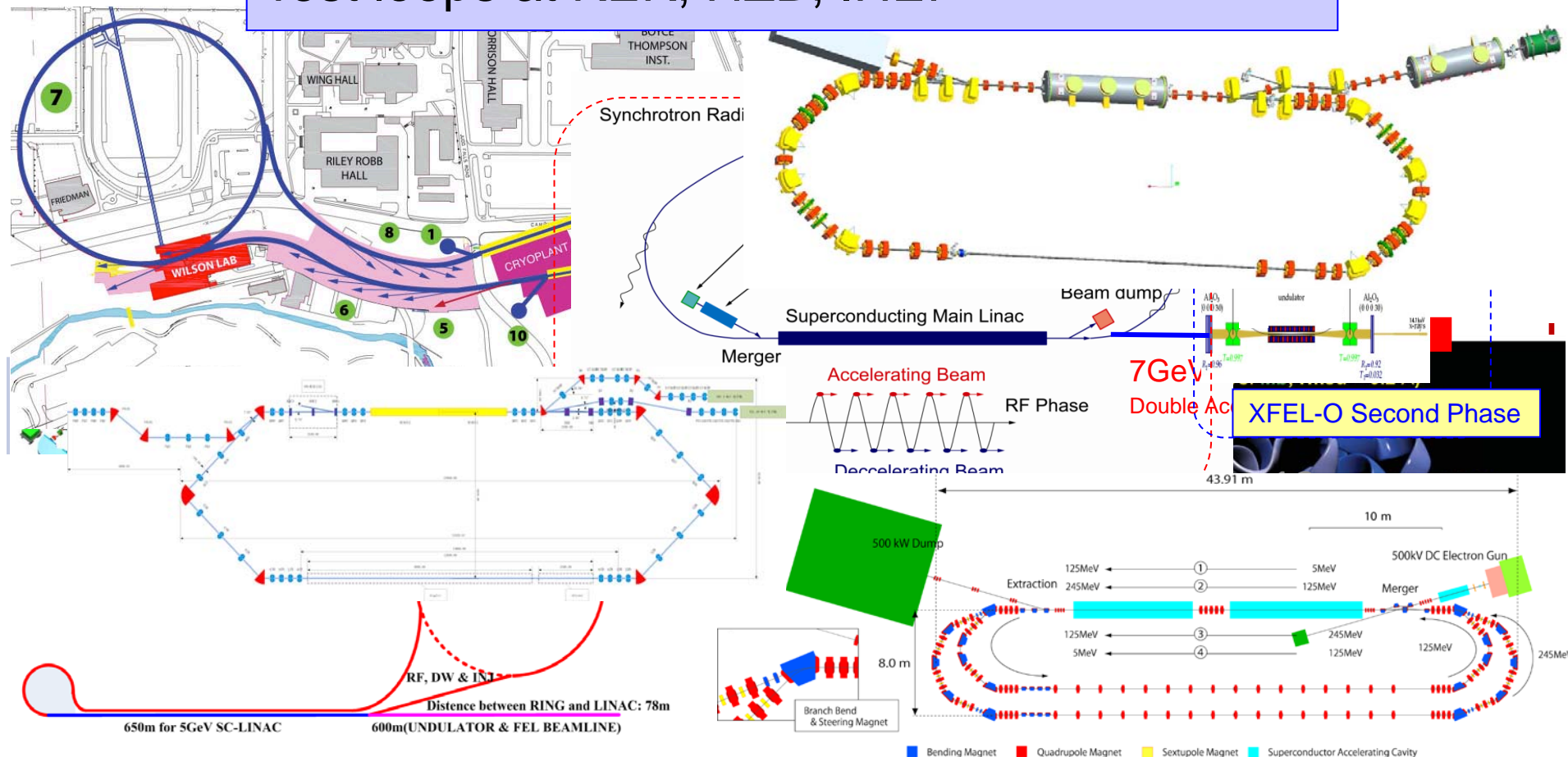


■ Bending Magnet ■ Quadrupole Magnet ■ Sextupole Magnet ■ Superconductor Accelerating Cavity

Progress in ERLs for Light Sources



Operations at JLAB, Daresbury, BINP
 Designs at Cornell, KEK/JAEA, BAPS
 Test loops at KEK, HZB, IHEP



■ Bending Magnet ■ Quadrupole Magnet ■ Sextupole Magnet ■ Superconductor Accelerating Cavity

ERL X-ray source R&D



- **Essentials**

- Superconducting RF (high Q_0 , Q_L for low operation cost; HOM damping for $> 100\text{mA}$; cost-efficient cryomodule design & fabrication)
- Photoinjector (demonstrate high current, longevity, brightness)
- Generic facility strawman (undulators, beamline, magnets, power budget, cryoplant)

- **And beyond**

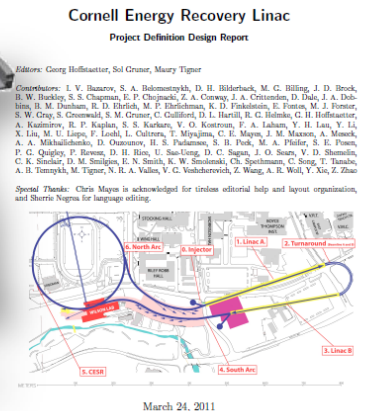
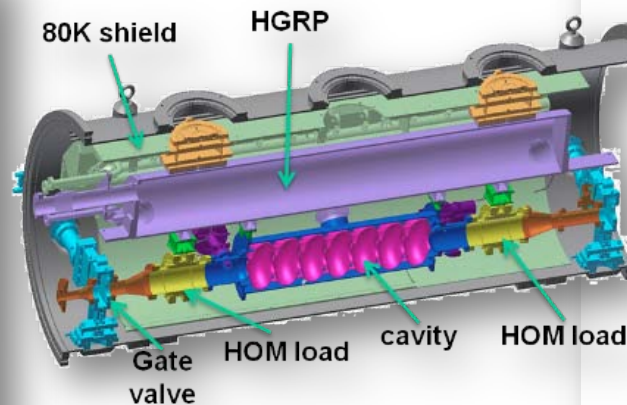
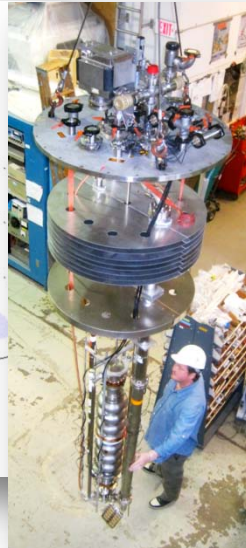
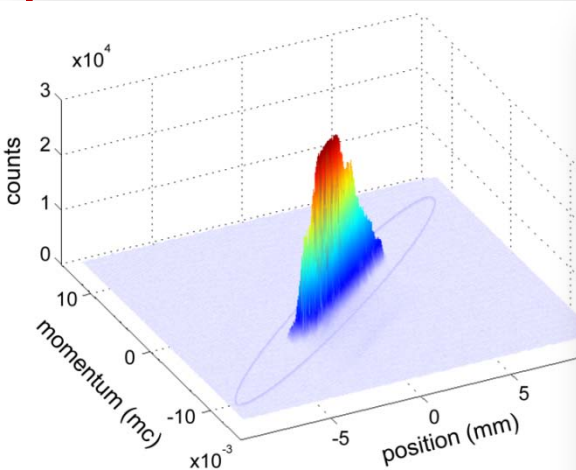
- Multi-turn designs (depends on how cheap/efficient SRF can be made)
- Marry XFEL solutions (simultaneous low rep rate beam operation with high current – e.g. KEK design)



Milestones reached at Cornell in 2011/12



- In all of the following:
 - Superconducting RF (high Q_0 , Q_L for low operation cost; HOM damping for $> 100\text{mA}$; cost-efficient cryomodule design & fabrication)
 - Photoinjector (demonstrate high current, longevity, brightness)
 - Generic facility strawman (undulators, beamline, magnets, power budget, cryoplant)



<http://news.chess.cornell.edu/index.html>

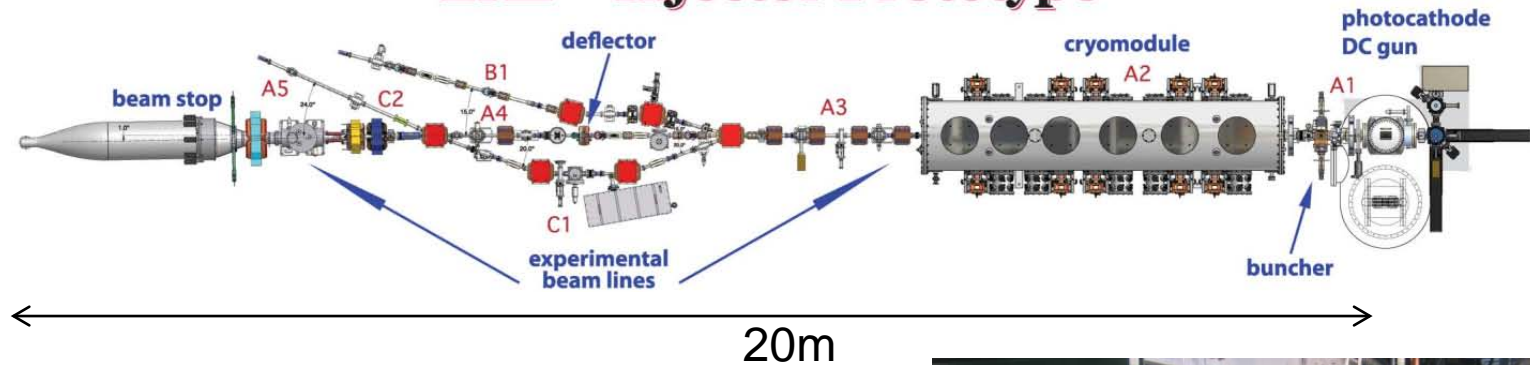


Frontier photoinjector work @ Cornell

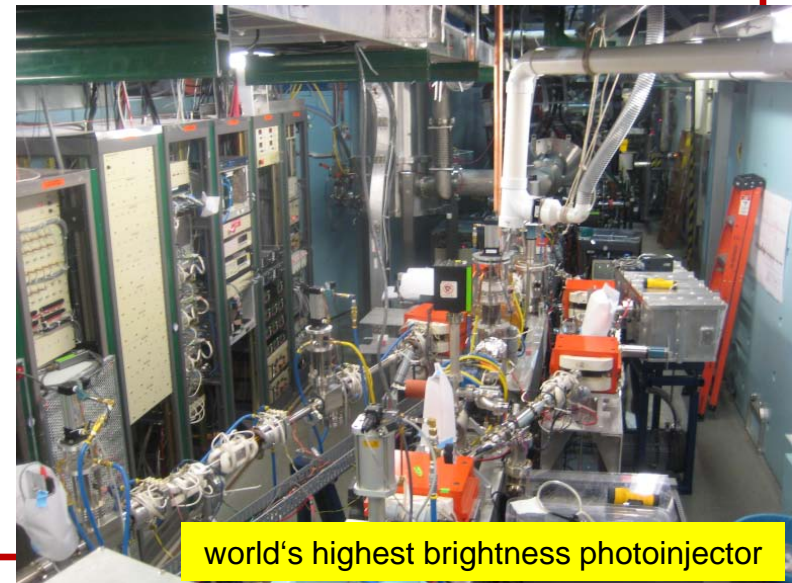


- Pushing the state-of-the-art: 10MeV photoinjector

ERL – Injector Prototype



- Now world's highest brightness and current photoelectron source



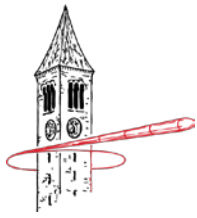
Cornell photoinjector highlights



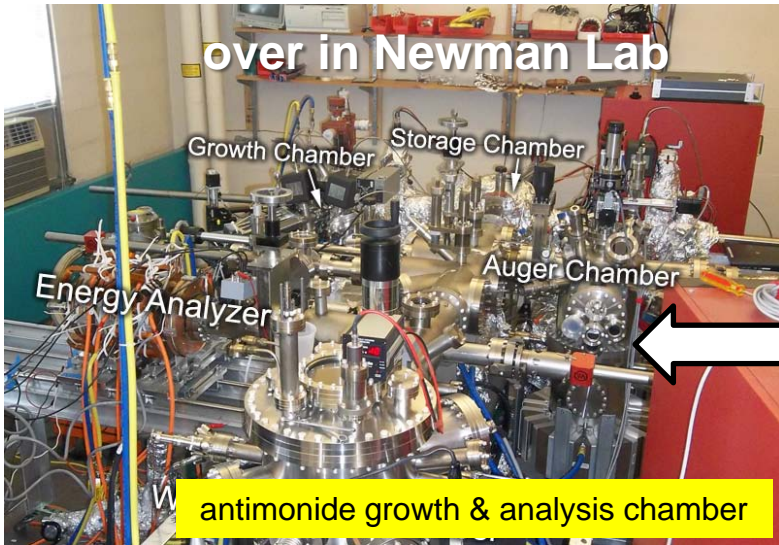
- **Over the last year:**
 - Maximum **average current of 52 mA** from a photoinjector demonstrated
 - Demonstrated **feasibility of high current operation** (> kiloCoulomb 1/e lifetime from the same laser spot)
 - *measured beam brightness already would surpass any existing storage ring if 5 GeV energy recovery linac were to be built today*
- **Clear path exists for further improvements**
 - Better photocathodes will result in brighter beams
 - The photoinjector itself was built to be future-looking R&D machine with highly optimized performance (yet to be fully realized)



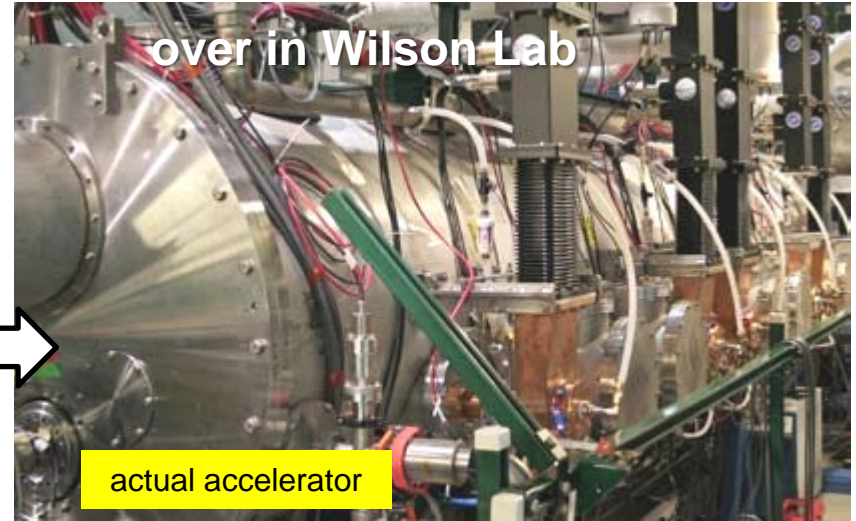
Developing advanced photocathodes for accelerators



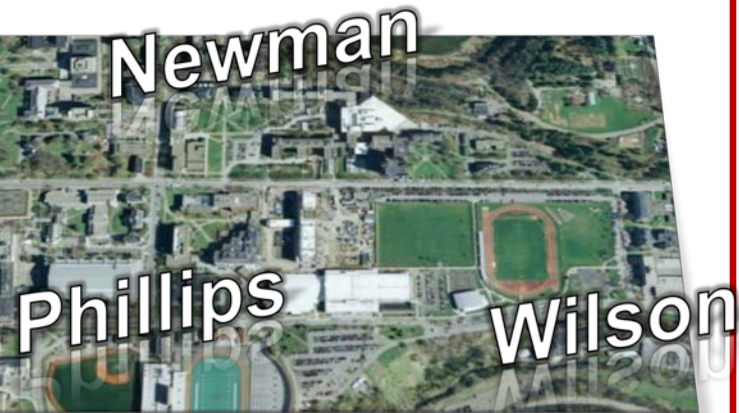
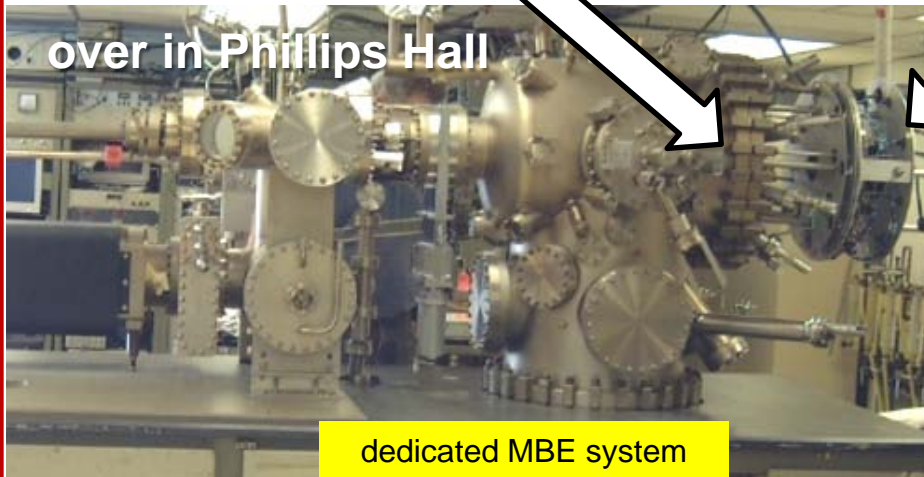
over in Newman Lab



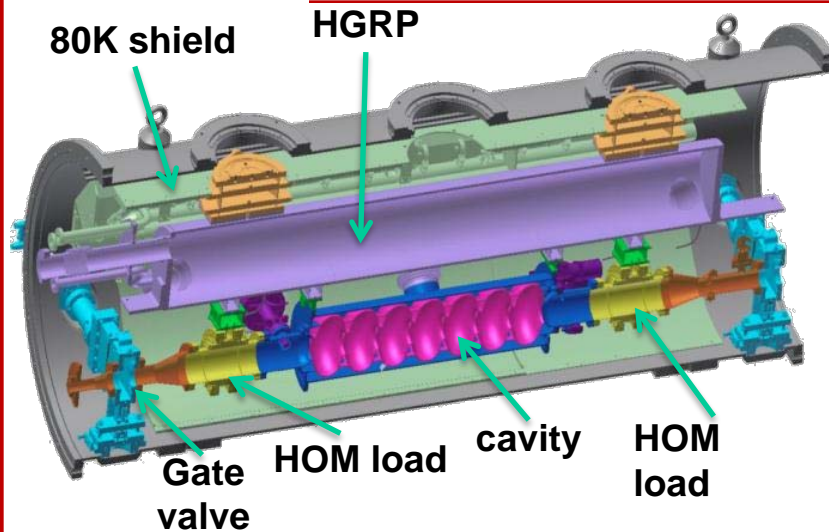
over in Wilson Lab



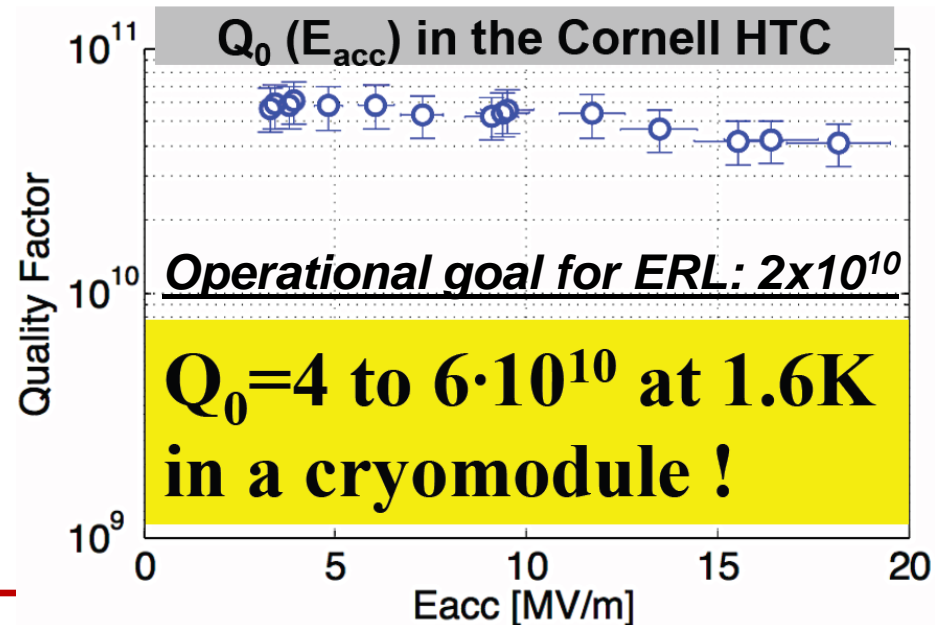
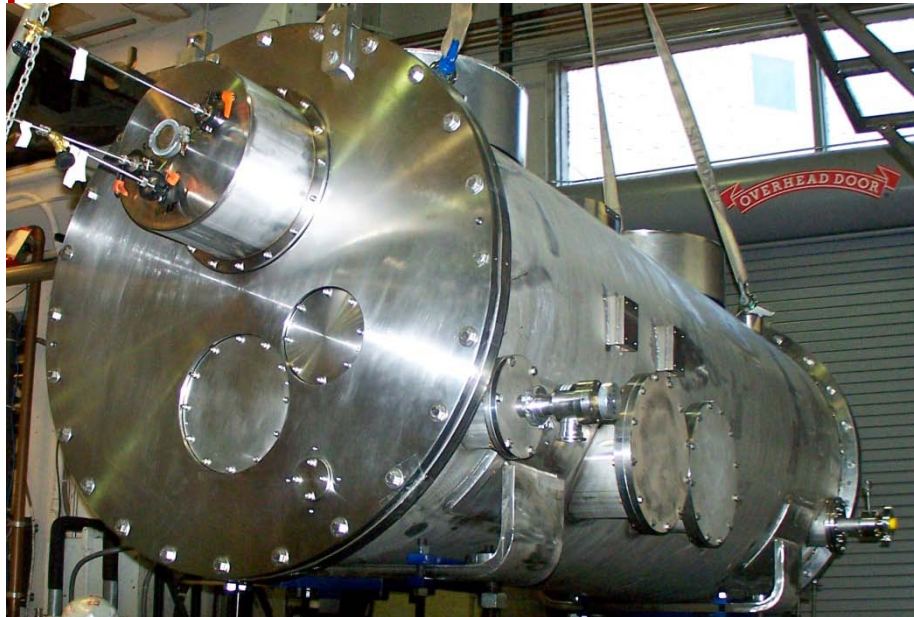
over in Phillips Hall



SRF milestone: high Q_0 for efficient operation of future high current accelerators!



- Cornell Horizontal Test Cryomodule:
 - Dedicated to high Q_0 studies
 - **Goal:** show that (and how) high Q_0 can be maintained when cavity is installed in cryomodule
 - Reached $Q_0 > 4 \times 10^{10}$ in first test
>50% improved efficiency!



Conclusions



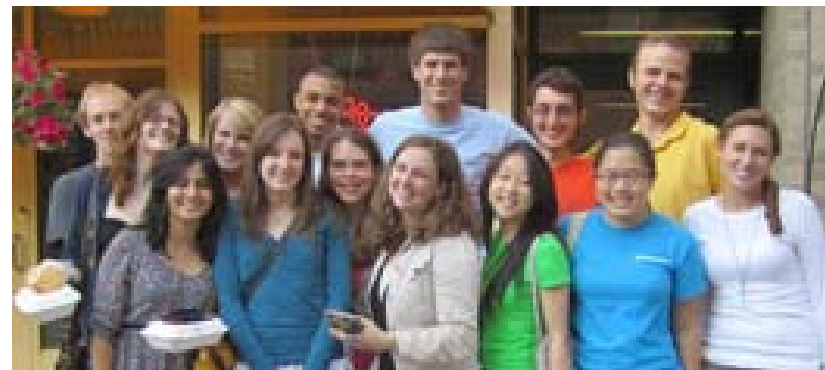
- **World-wide interest in super-bright ERL x-ray source and much R&D effort underway**
- **Cornell team is significantly ahead of the competition**
 - 2011/12 was year of many major accomplishments
 - ERL being redefined from a great concept to ‘it will work’ category
- **Much remains to be done, but no showstoppers**



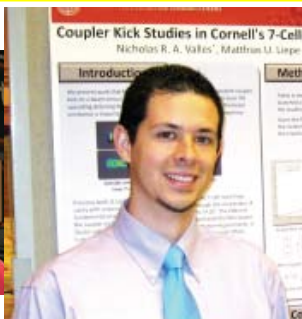
Preparing our future



2011 CLASSE summer students



PhD students



> 30 Cornell undergrads throughout academic year

