Phase I of LDRD Single-shot Electron Beam Technology Towards Ultra-fast Imaging

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19th ATF Program Advisory Committee (APAC) and ATF Users Meeting

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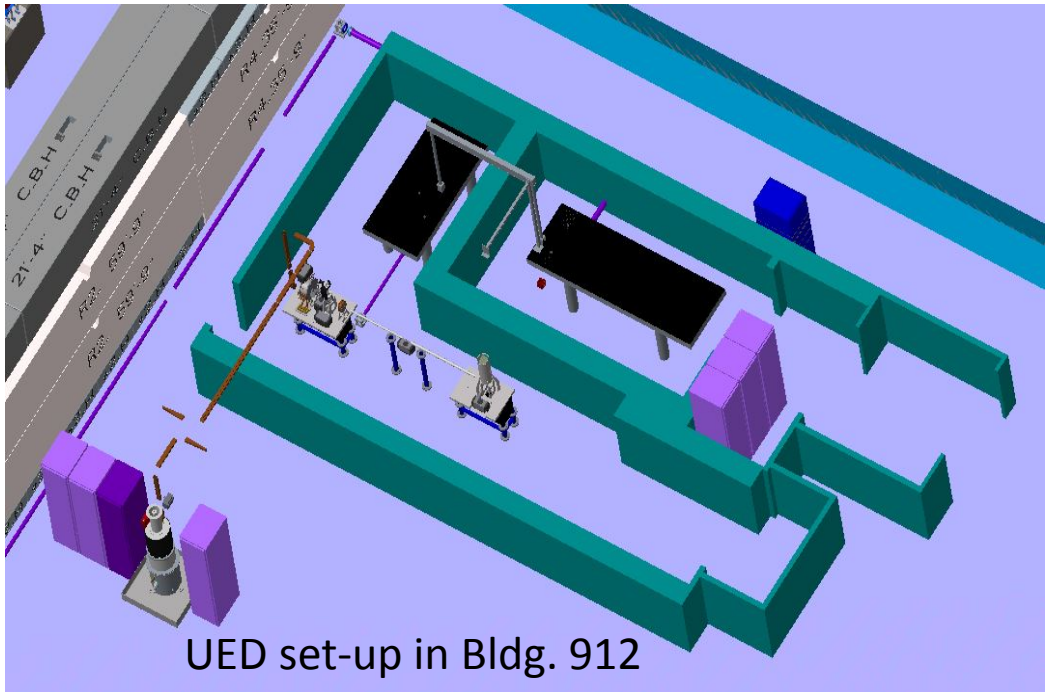
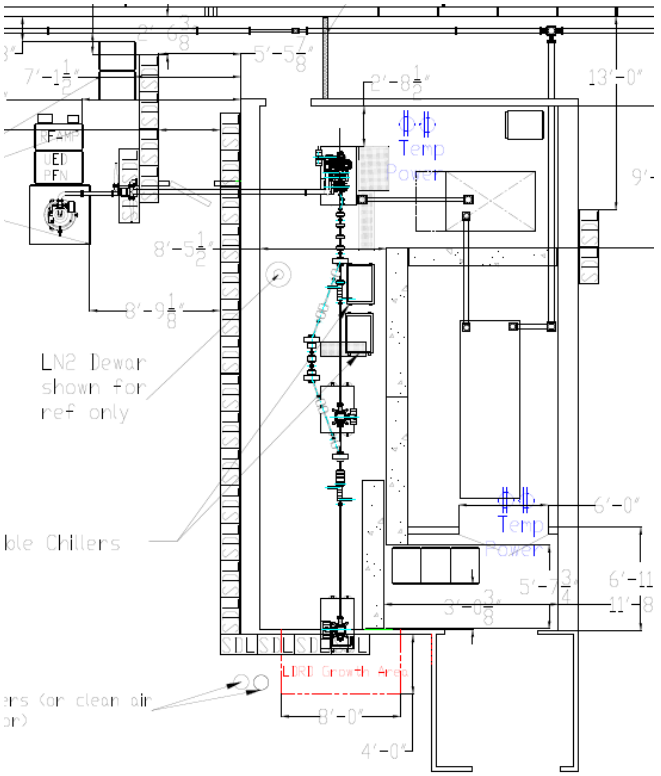
NSLS/NSLS-II UED: moving to CAD, installation and commissioning

- UED set-up was developed at NSLS-II SDL by X.J. Wang et al. in 2010
- In 2015 NSLS-II bldg. 729 was repurposed
- We moved UED set-up from NSLS-II Source Development lab
- CAD and NSLS-II joint project
  - NSLS-II delivered T-controlled room and all equipment for UED set-up
  - NSLS-II accelerator physicists, engineers and technicians made transition to operations at 912 a success
  - Installation and testing, beam diagnostics, LLRF

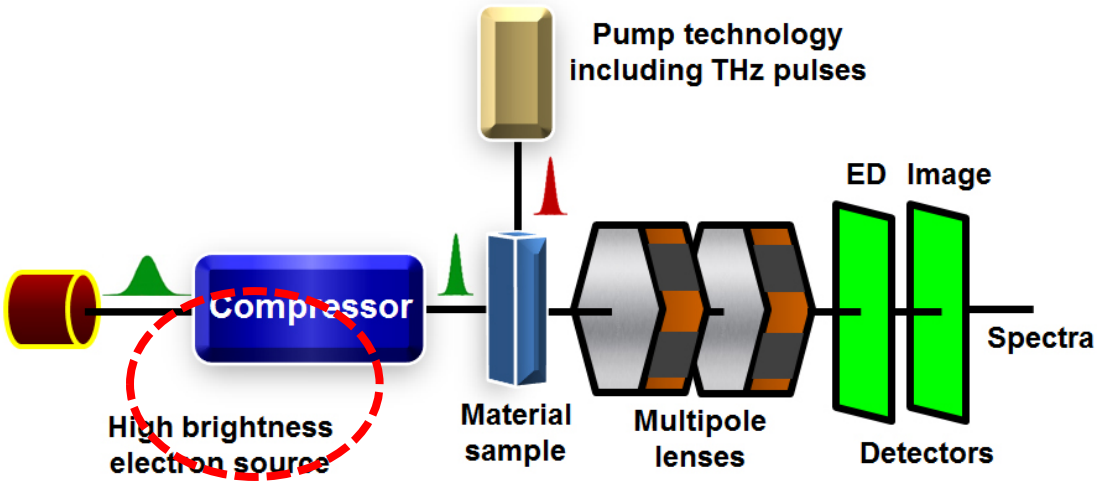


UED set-up in Bldg. 912



UED LDRD Objectives

- UED: compress electron bunch of 50pC (~10^8 electrons/bunch) to ~100fs, focus to 30 micron size
- UEM: image scattered electrons from the sample to detector with high spatial / temporal resolution (10 nm/ 10 ps)



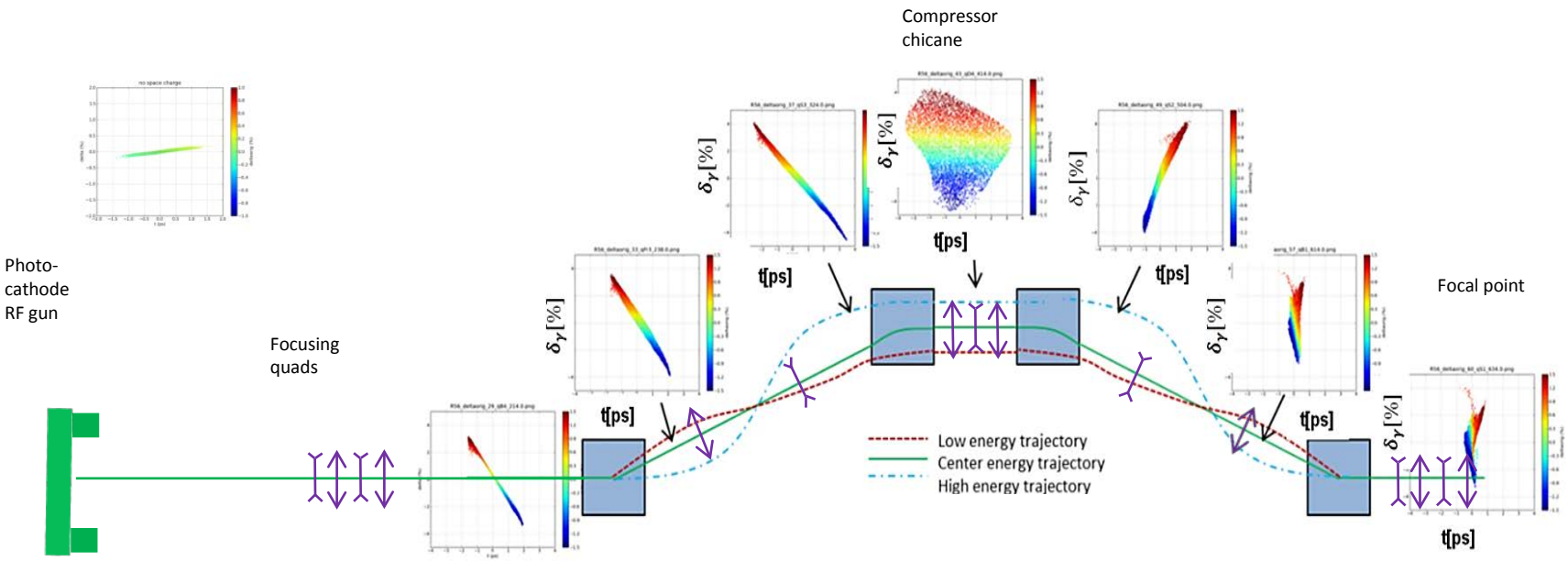
Accelerator based MeV electron microscopes with time resolution

PR-AB: http://journals.aps.org/prab/pdf/10.1103/PhysRevSTAB.18.014201
PR-AB: http://journals.aps.org/prab/abstract/10.1103/PhysRevSTAB.17.040701

Compression set-up for UED in 912

We developed a novel unconventional scheme to combine the correlated energy spread with the energy dependent path length to compress the electron bunch. The main point is to use space charge to generate the time-energy correlation.

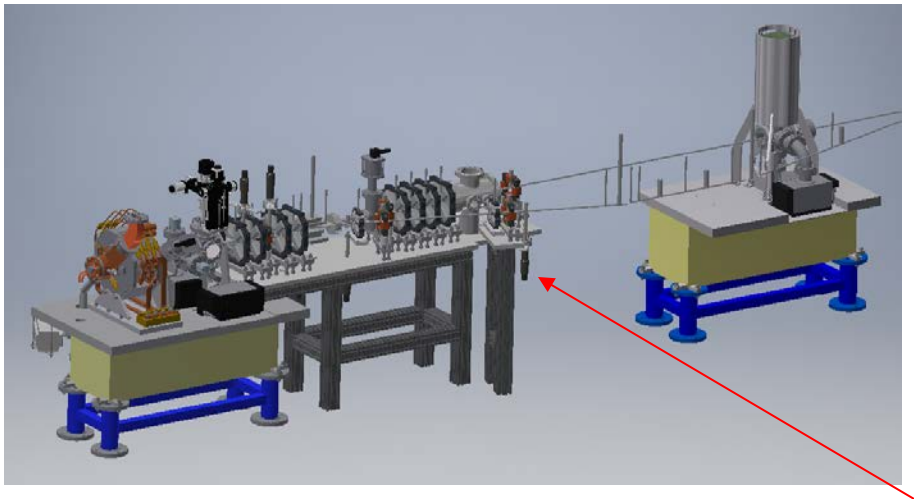
Unconventional compressor developed in electron beam slicing :
Focusing→ space charge increase energy of electrons at head (chirped bunch)→
high energy particle comes earlier, but takes longer path (R56>0) → compression



Approach: Use space charge effect to compress and focus electron bunches in space charge dominated domain

Phases in UED Beamline development

Phase I

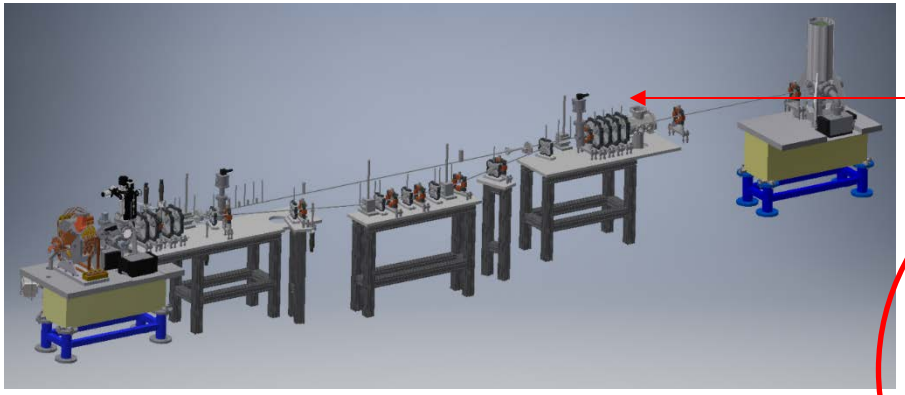


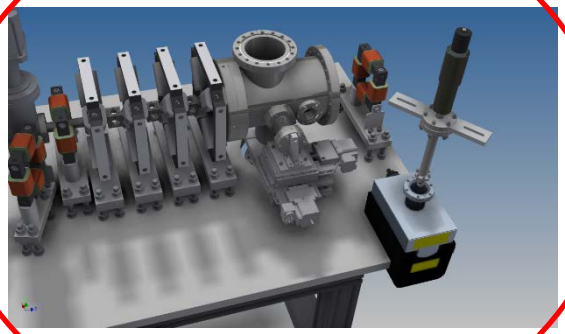
Objectives:

I. Characterize beam focusing
Measure beam distributions

II. Bunch compression
Beam Characterization
Transition to operations with short bunch at high Q

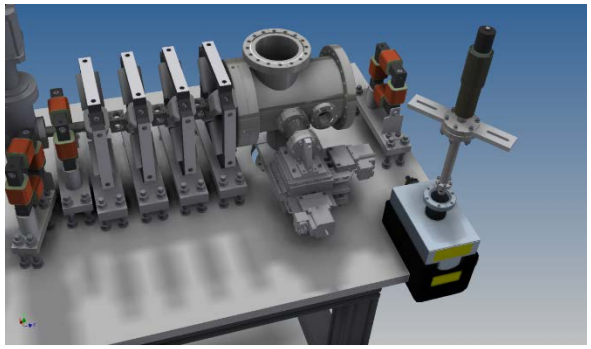
Phase II

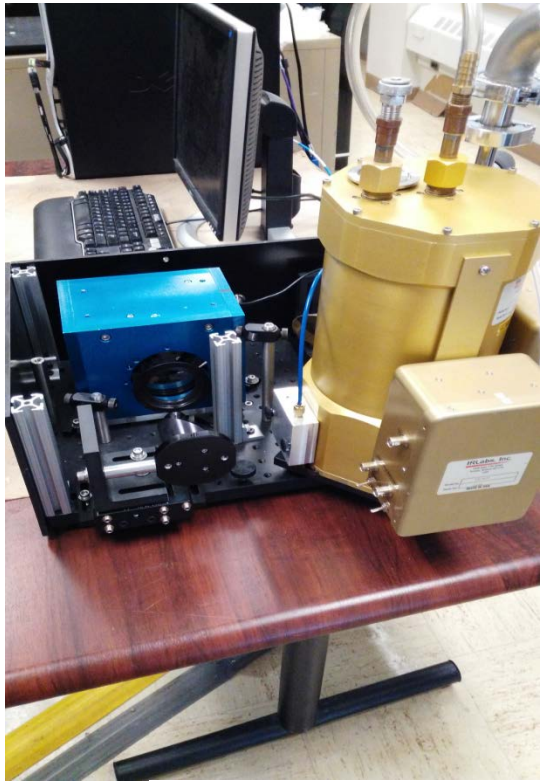




Bunch length diagnostics chamber

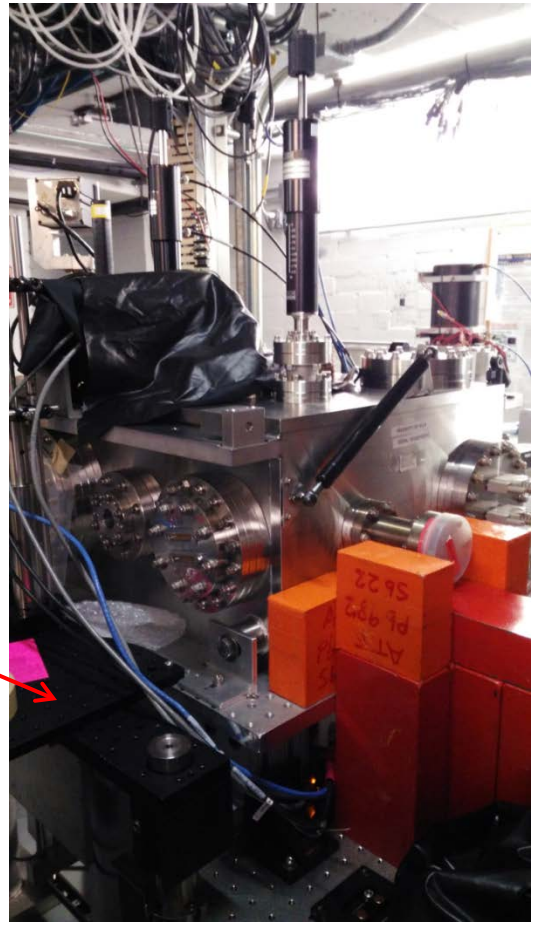
ATF CTR bunch length measurement setup





Interferometer
+ bolometer

TPX window
~1'' diameter



Looking forward to collaboration with M. Fedurin of ATF and Larry Carr on ATF tests in near term

Status as of today and Plans for FY17:

- UED LDRD magnets have been designed. Tender was awarded, expecting deliveries in February
- Vacuum chambers are being designed, Phase I chambers are coming to procurement
- Will be reusing diagnostics from our NSLS UED facility
- PS are specified, first is procured for testing

In FY17 we are planning:

1. Finish vacuum chamber design, procurement
2. Construction of phase I beamline
3. Commissioning of phase I beam line
4. Test beam size measurement
5. Assess bunch length measurements

Plans for UEM

- Meeting with two teams of future UEM users (BNL's Material Science Dept. and Physics / Instrumentation Div.)

- Proposed a concept of UEM following high-resolution X-ray microscopy beamlines at NSLS-II

- Partnership on SBIR for UEM (proposal submitted)

- Modeling/ designing beam line for UEM
- Assessing magnet properties for UEM beam line

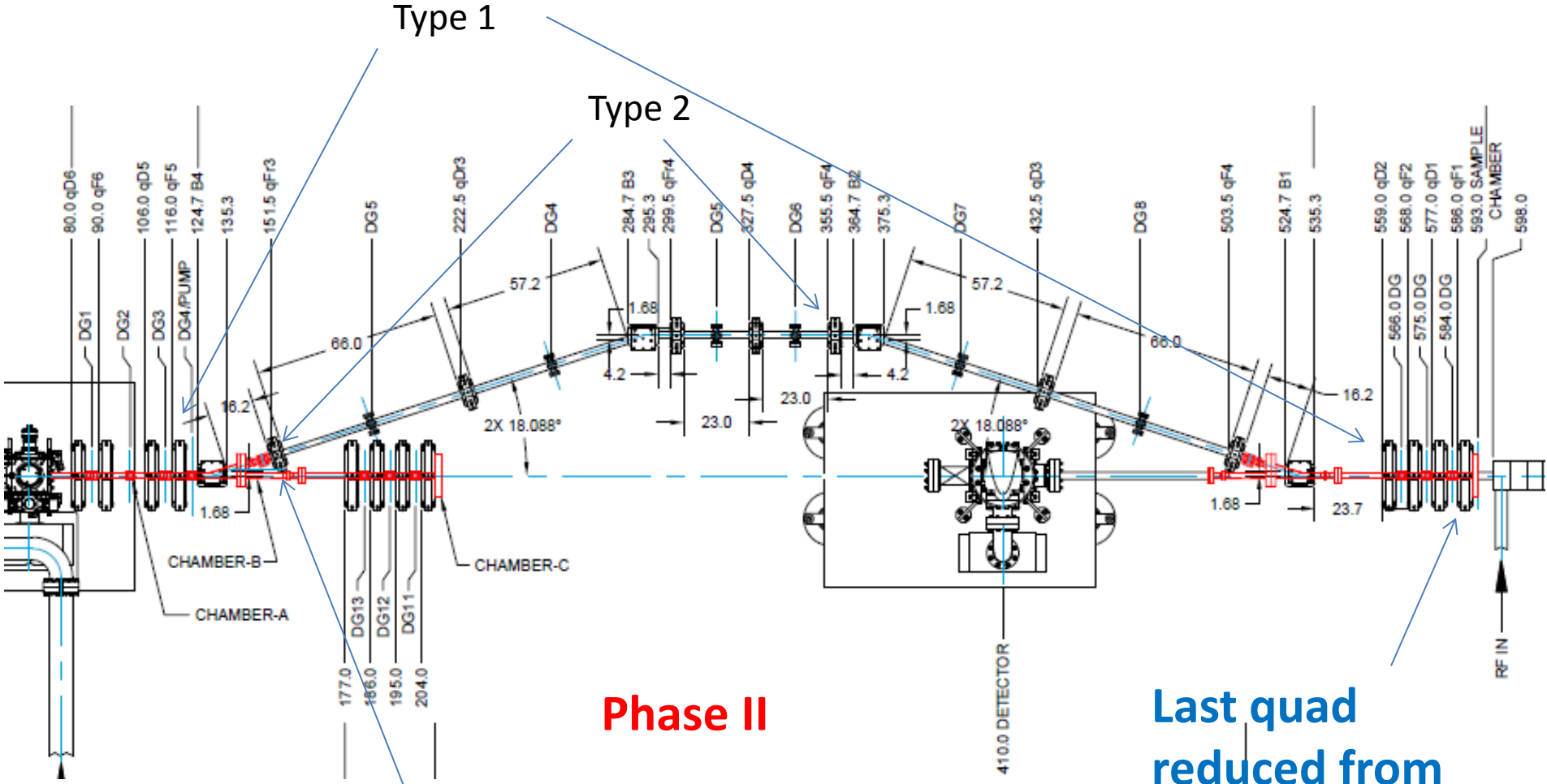
Acknowledgements

- NSLS-II: M. Fulkerson, J. Rose, V. Smalyuk, L.H. Yu, L. Doom, A. He, W. Cheng, A. Blednykh, Y. Hidaka, B. Kosciuk, C. Stelmach, F. Willeke, T. Shaftan
- BNL's Material Science Dept: Y. Zhu,

  T. Konstantinova, J. Li, J. Tao
- BNL's H. Takai and J. Kierstead
- M. Palmer, M. Fedurin, M. Babzien, B. Malone from ATF
- Director's office, CAD

Move first quad from present 72 cm (reference to cathode) to 80

Number of Quad types is reduced to 2. Magnet procurement started (calling for tender)



Phase II

Removed interference

Last quad reduced from 45T/m to 9.5T/m

Sample chamber from Bernie and Weixing