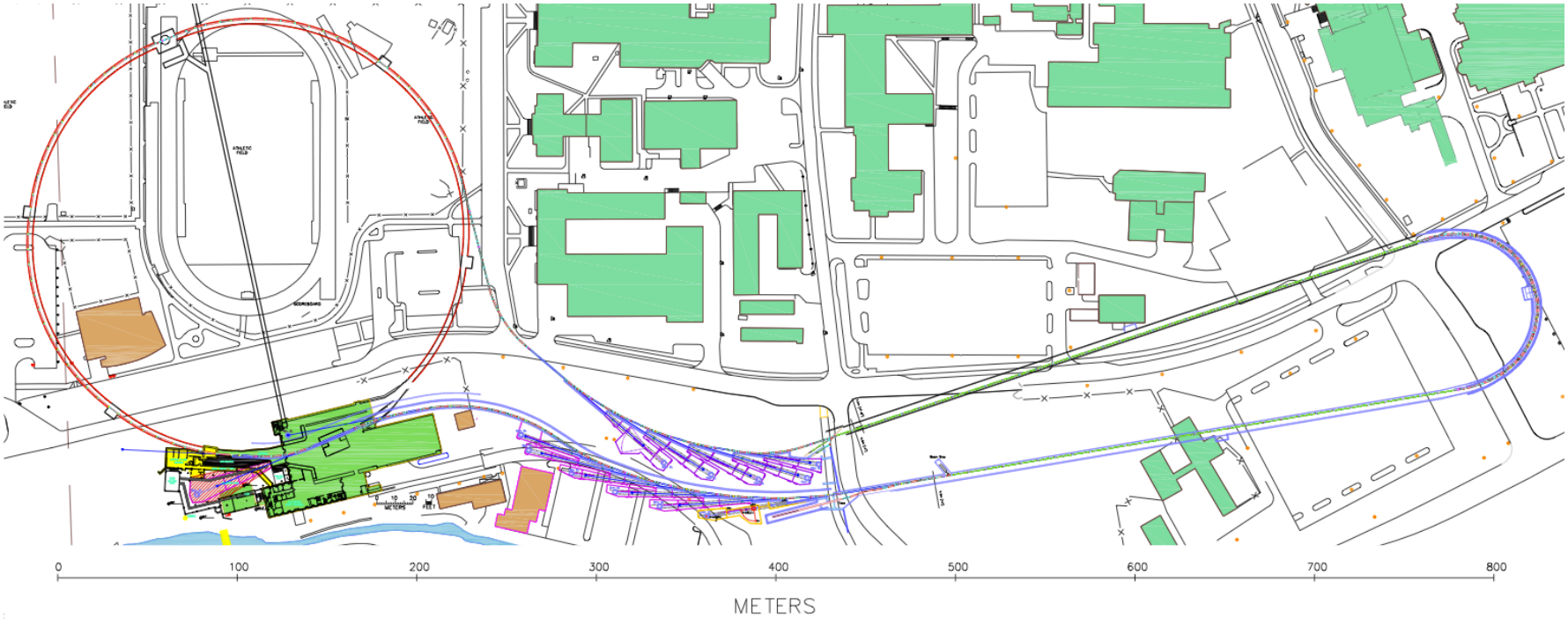
Cornell ERL
Research and Development



Christopher Mayes – March 29, 2011

ERL Concept (1965)

A Possible Apparatus for Electron Clashing-Beam Experiments (*).

M. TIGNER

Laboratory of Nuclear Studies, Cornell University - Ithaca, N. Y.

(ricevuto il 2 Febbraio 1965)

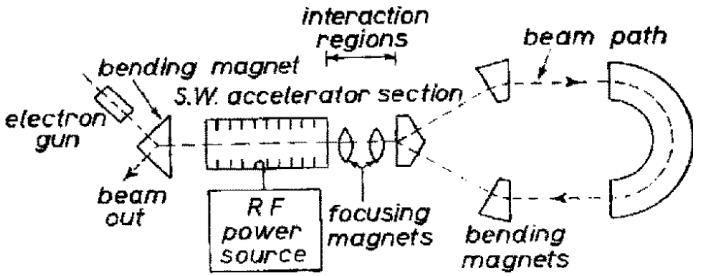
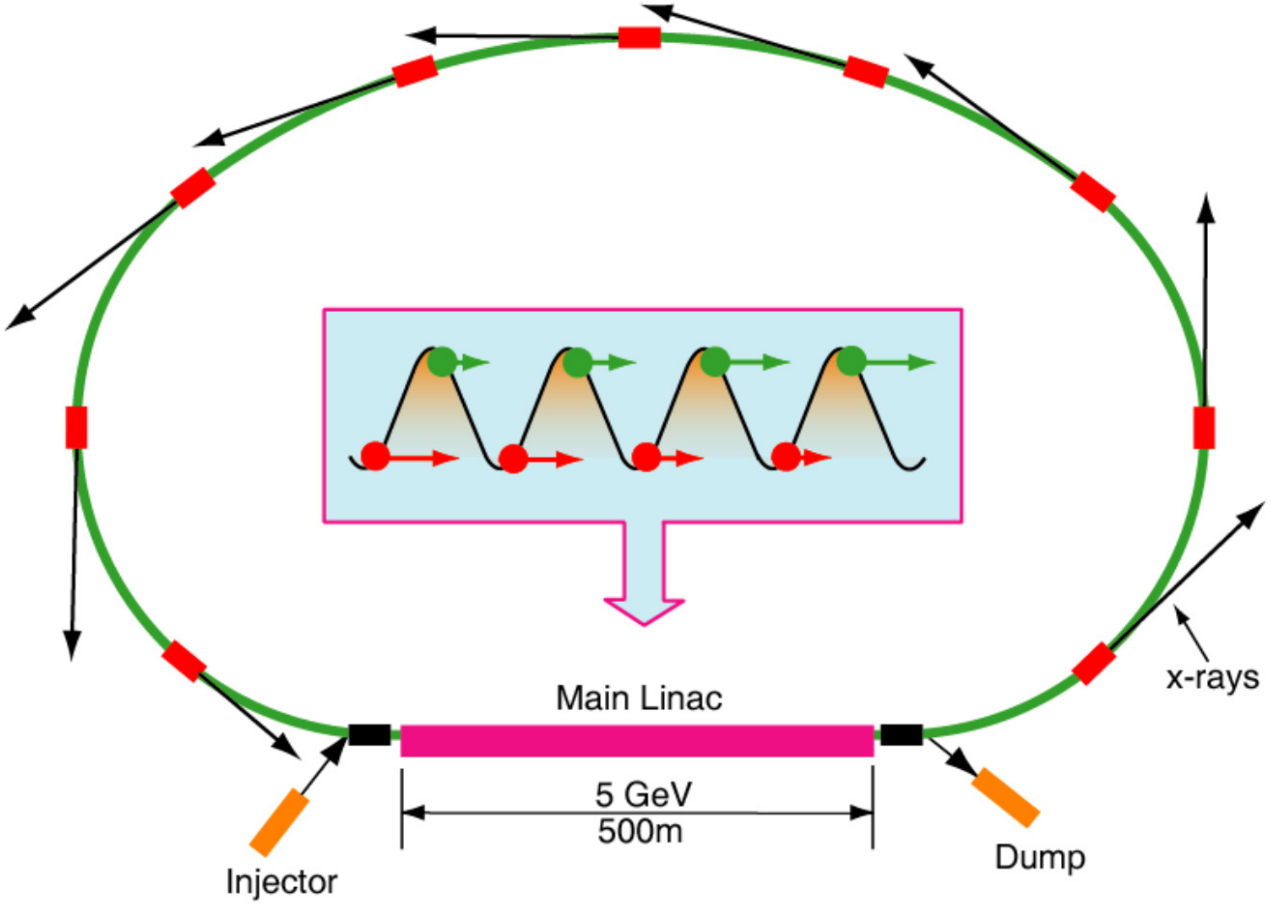


Fig. 3.

Cornell ERL Study (2001)

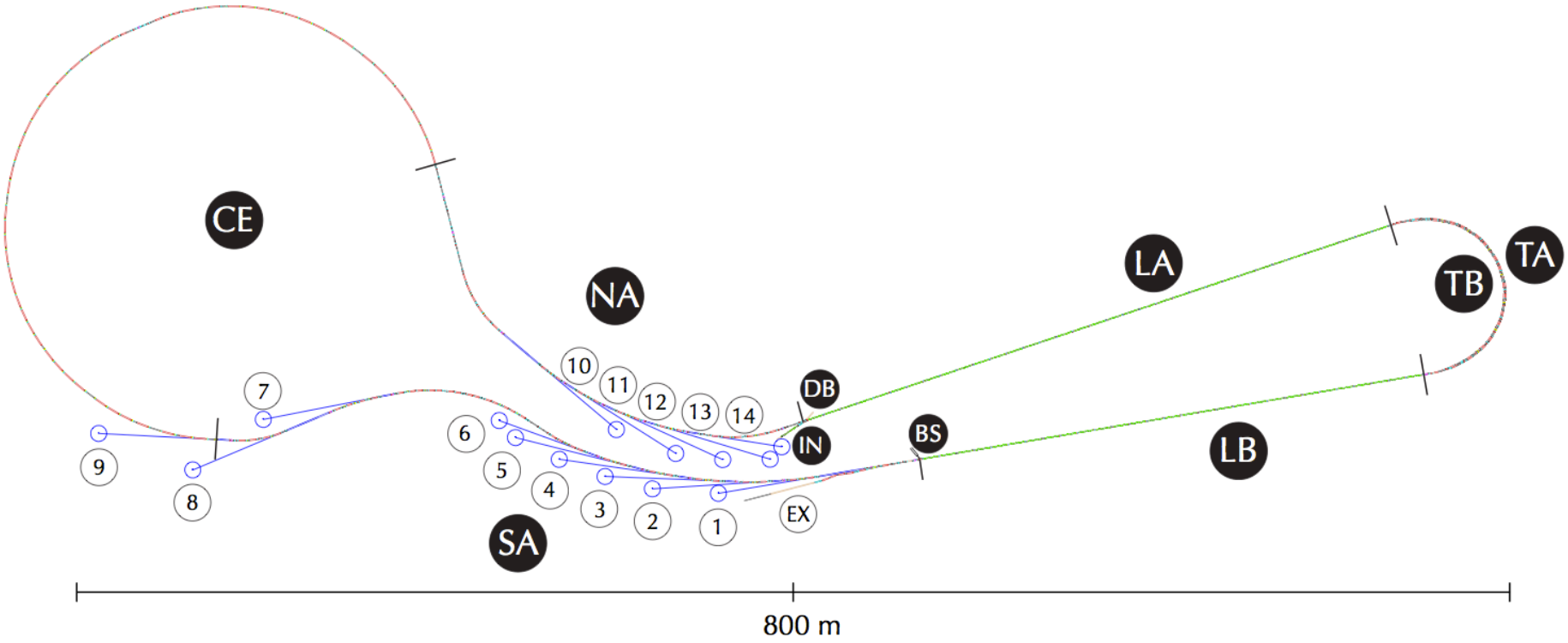


Without energy recovery . . .

$$P_{\text{linac}} = 1\,\text{MW}\left(\frac{I_{\text{av}}}{\text{mA}}\right)\left(\frac{\Delta\mathcal{E}}{\text{GeV}}\right)$$

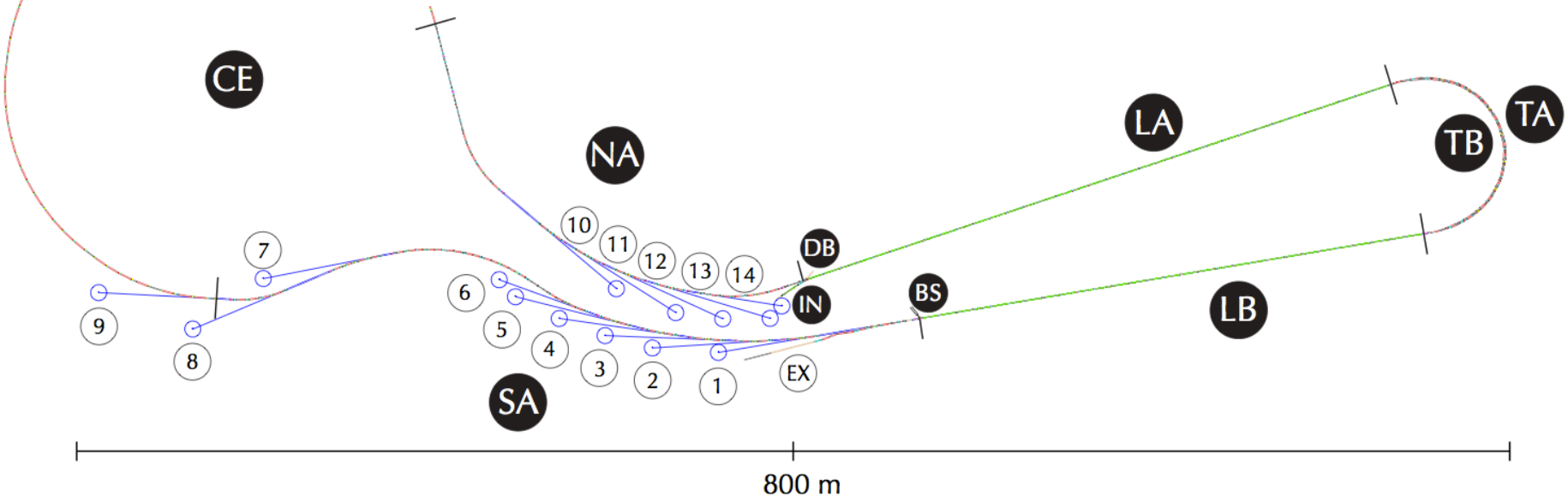
[Nine Mile Point Nuclear Power Plant, Oswego, NY]

Cornell ERL Layout (2011)

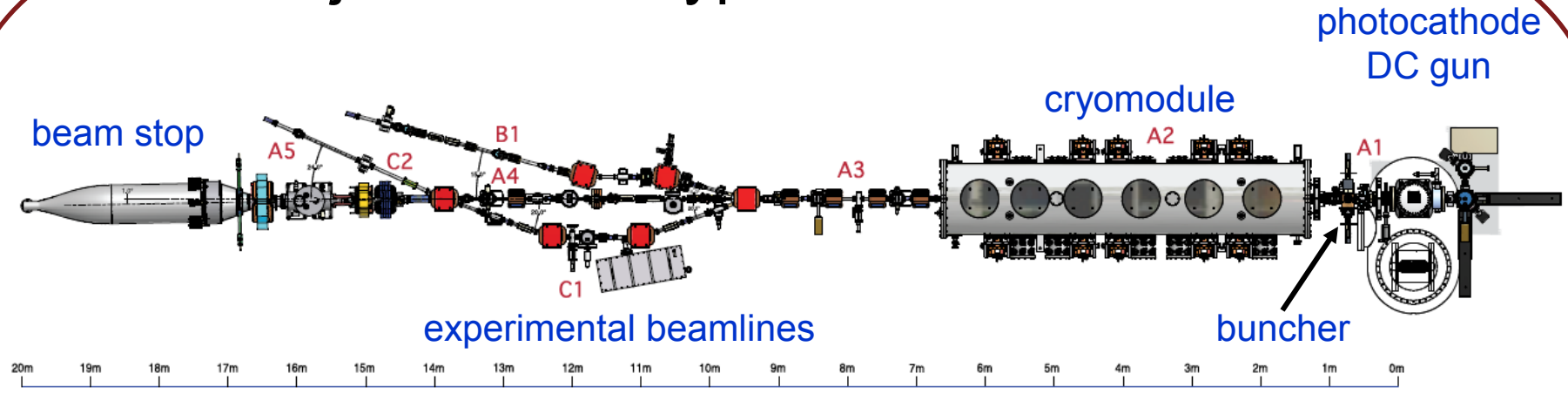


Cornell ERL Layout (2011)

Operating Modes	A *High Flux*	B *High Coherence*	C *Short Bunch*	Unit
Energy	5	5	5	GeV
Current	100	25	25	mA
Bunch Charge	77	19	19	pC
Repetition Rate	1.3	1.3	1.3	GHz
ϵ_x (SA/NA)	31/52	13/34	21/66	pm
ϵ_y (SA/NA)	25/26	10/10	14/14	pm
σ_z/c (SA/NA)	2.1/2.1	1.5/1.5	1.0/0.1	ps
σ_δ (SA/NA)	1.9/1.9	0.9/1.0	9.1/9.3	10^{-4}

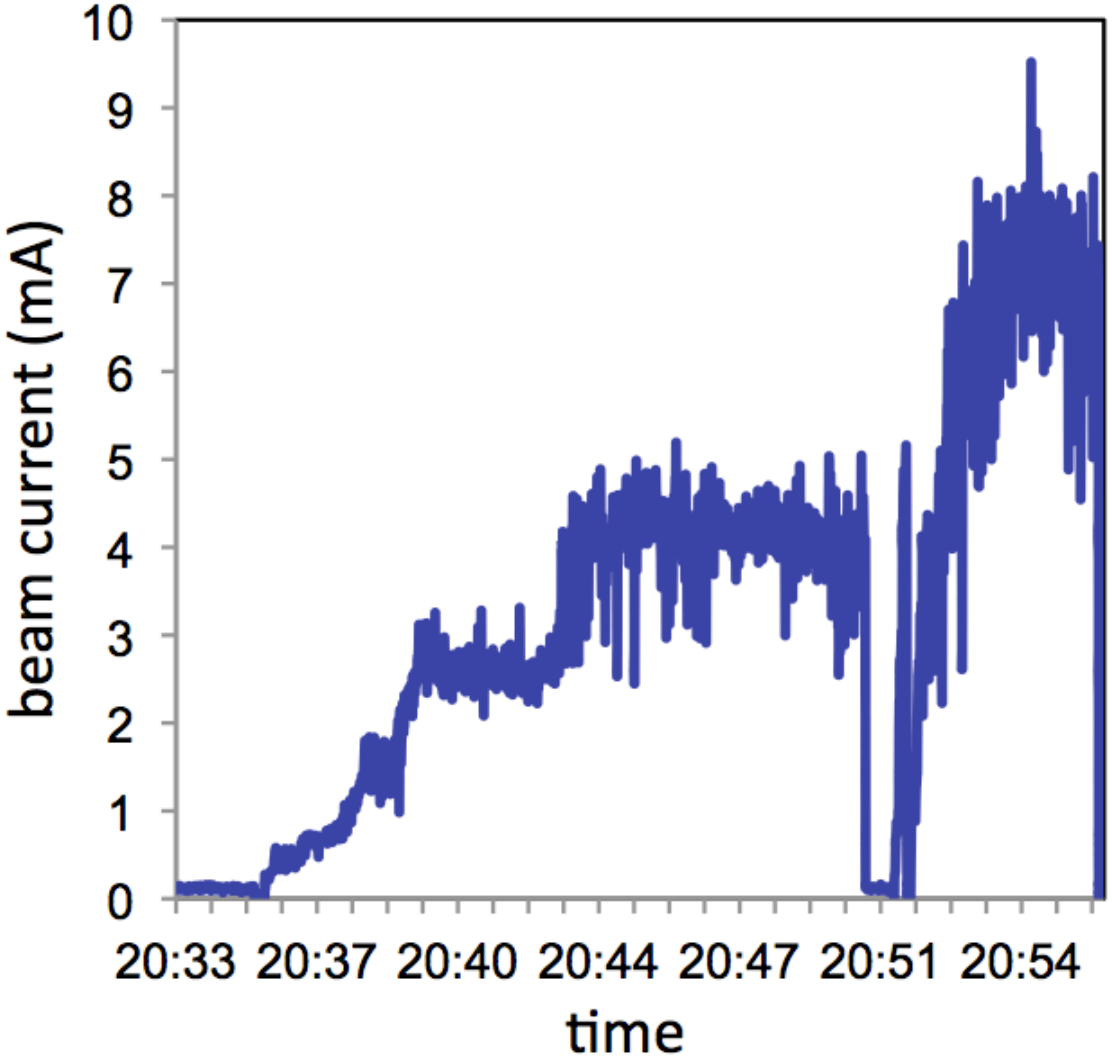


ERL Injector Prototype



	design parameters	**Achieved so far. . .**
Nominal bunch charge	77 pC	77 pC
Bunch repetition rate	1.3 GHz	50 MHz and 1.3 GHz
Beam power	up to 550 kW	125 kW
Nominal gun voltage	500 kV	350 kV
SC linac beam energy gain	5 to 15 MeV	5 to 13 MeV
Beam current	100 mA at 5 MeV 33 mA at 15 MeV	25 mA at 5 MeV, 20 mA for 8 hours
Bunch duration	2 ps	2 ps
Transverse emittance	< 1 mm-mrad	2.6, 0.5 (core 60%) mm-mrad (5 MeV)

High current operation. . .

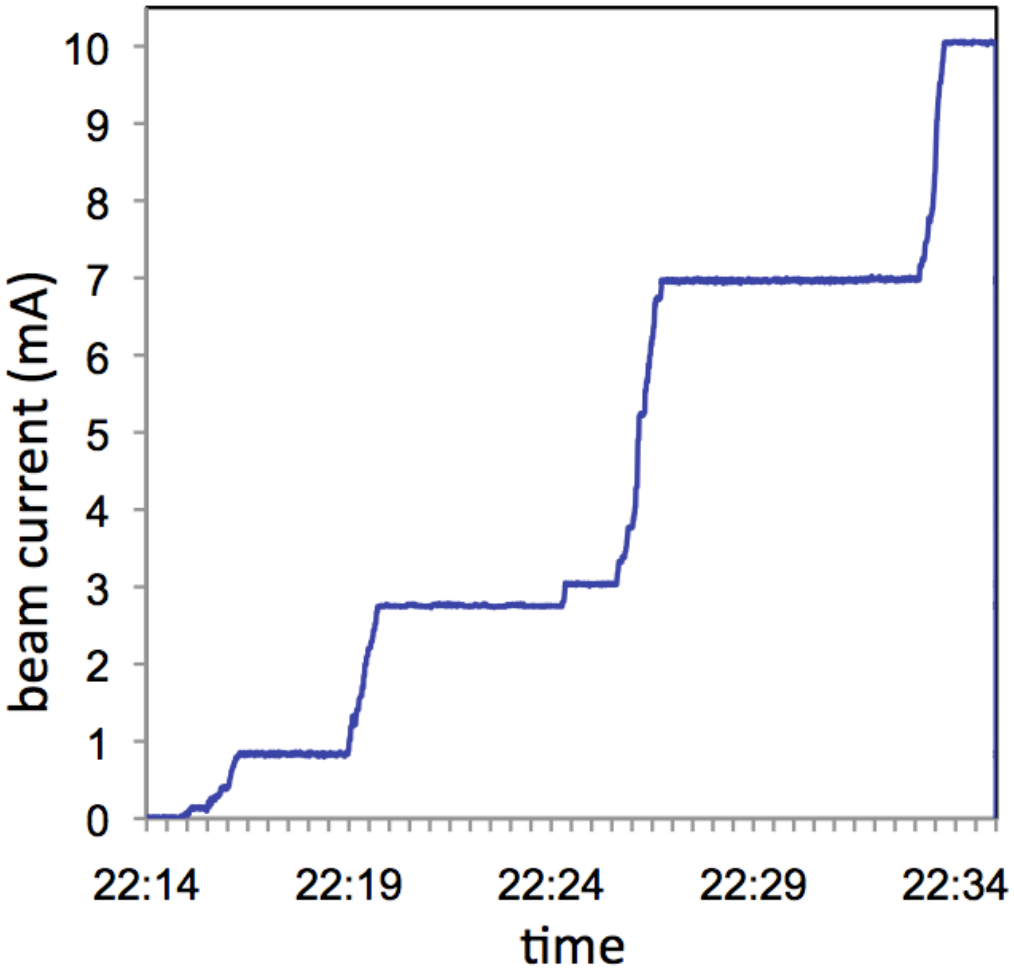


Experienced large and quite fast beam current variations

This causes beam loss and radiation due to beam loading effects in DC gun and SRF cavities

Huge radiation burst after some time, which degrades the cathode.

. . . with active beam current feedback



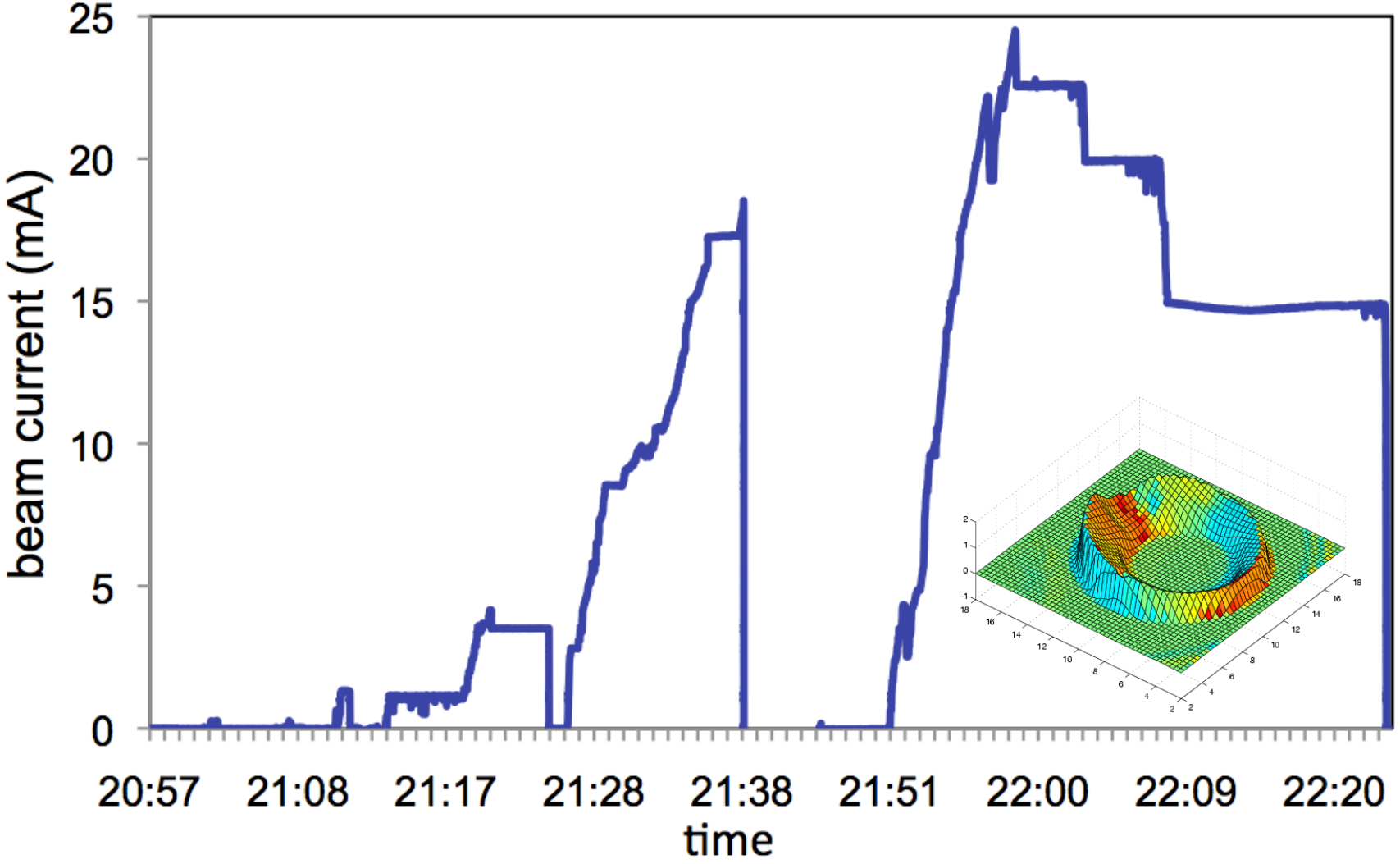
Current stability much better than 1%

Beam loss improved significantly

Radiation burst which causes cathode degradation is still present

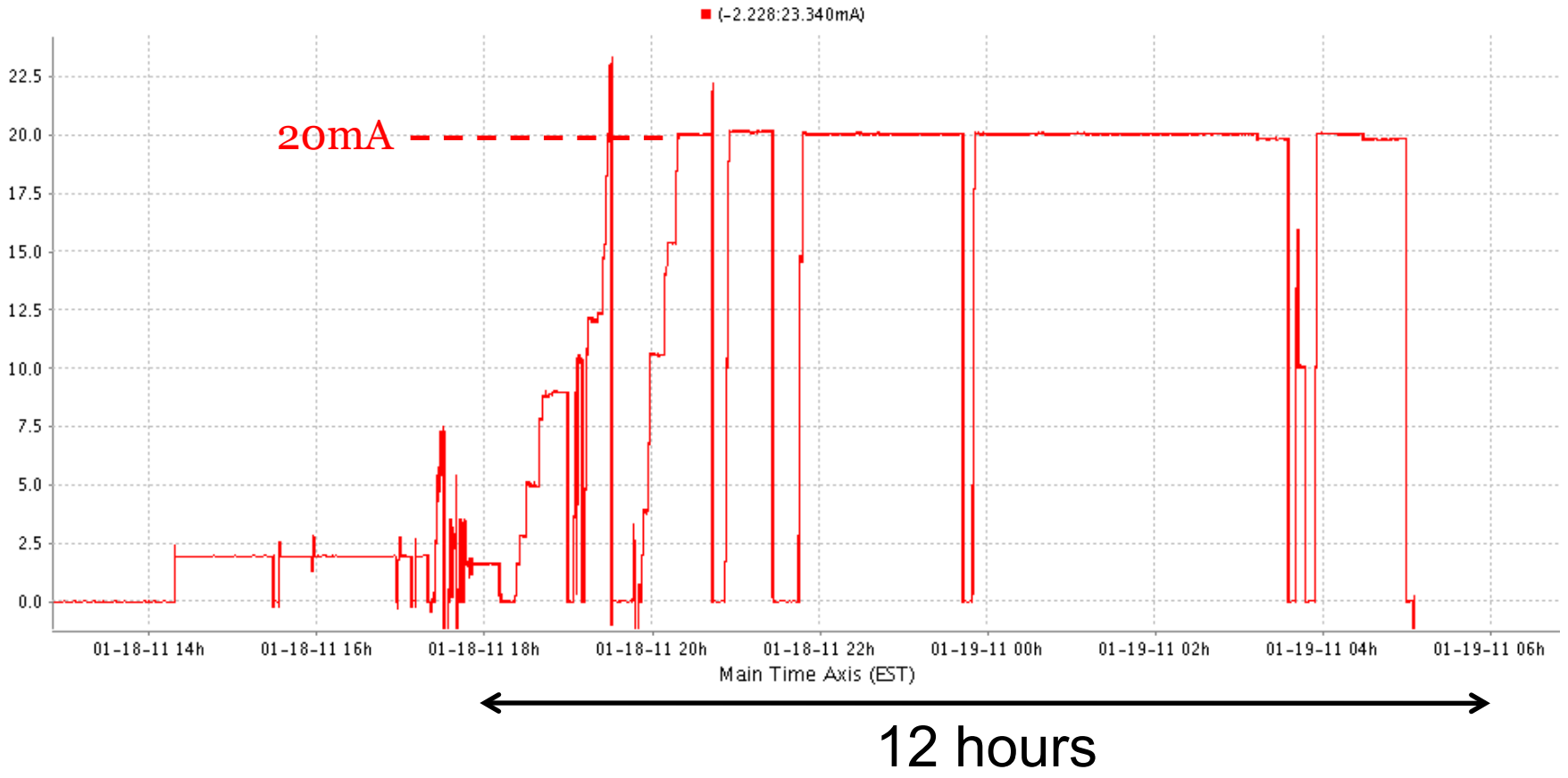
9 am Wednesday, North Ballroom
Linac Timing, Synchronization and Active Stabilization
Florian Loehl, CLASSE

High current



KCs2Sb Lifetime

8 hours – First attempt!

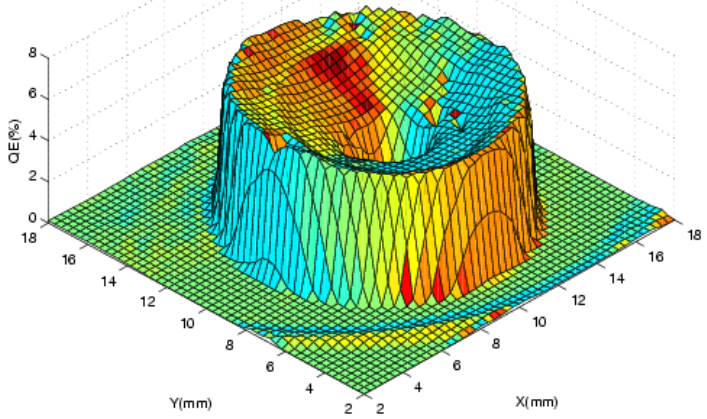


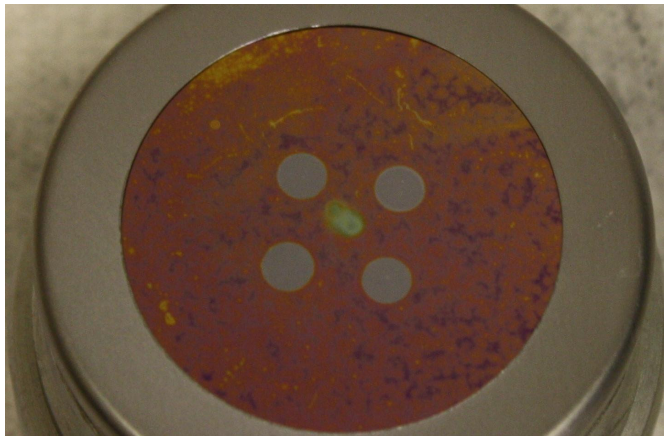
12 hours

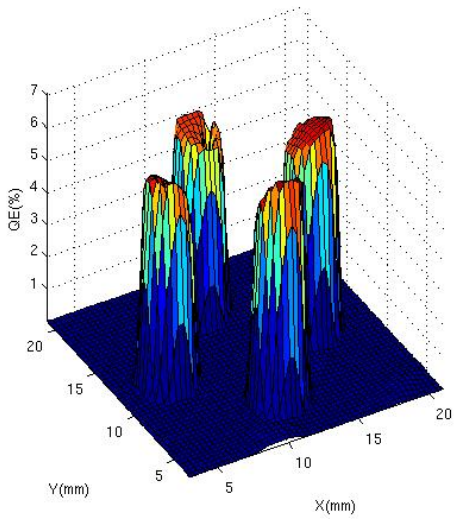
Cathodes

1:30 pm Thursday, North Ballroom
Cathodes for Photoemission Guns
Luca Cultrera, CLASSE

GaAs quantum efficiency map after reactivation (from 25 mA run)



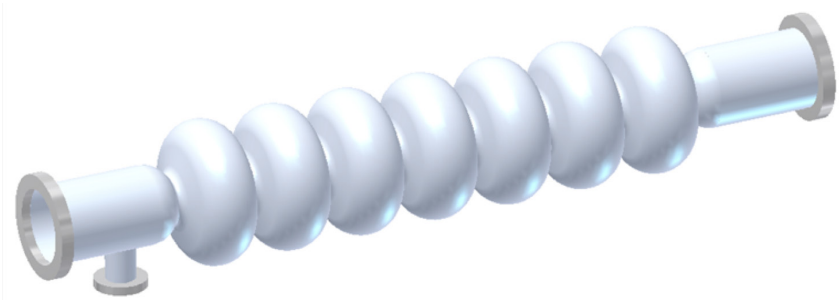




Workshop at Cornell:
Photocathode Physics for Photoinjectors 2
Fall 2012

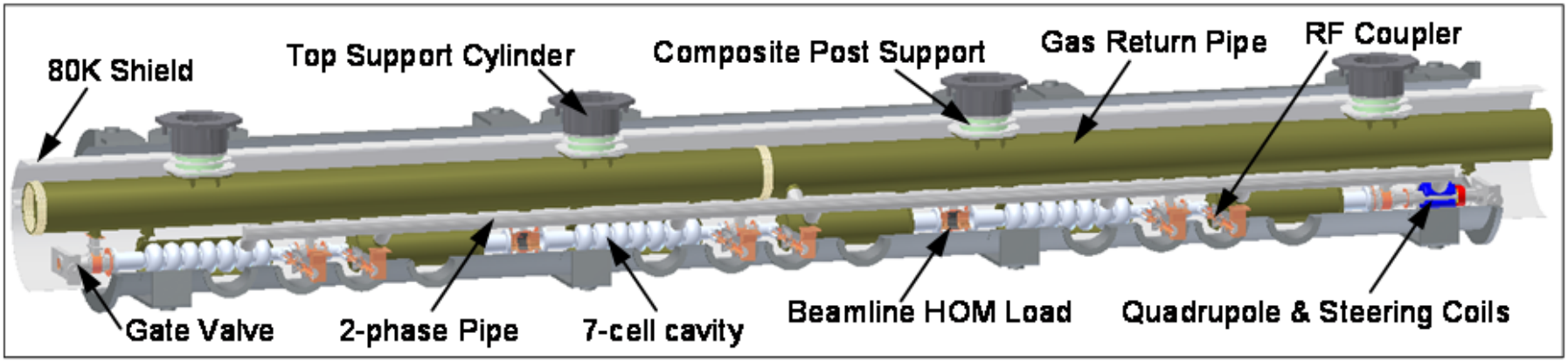
SRF

11 am Friday, South Ballroom
Progress on Superconducting RF for the Cornell ERL
Matthias Liepe, CLASSE



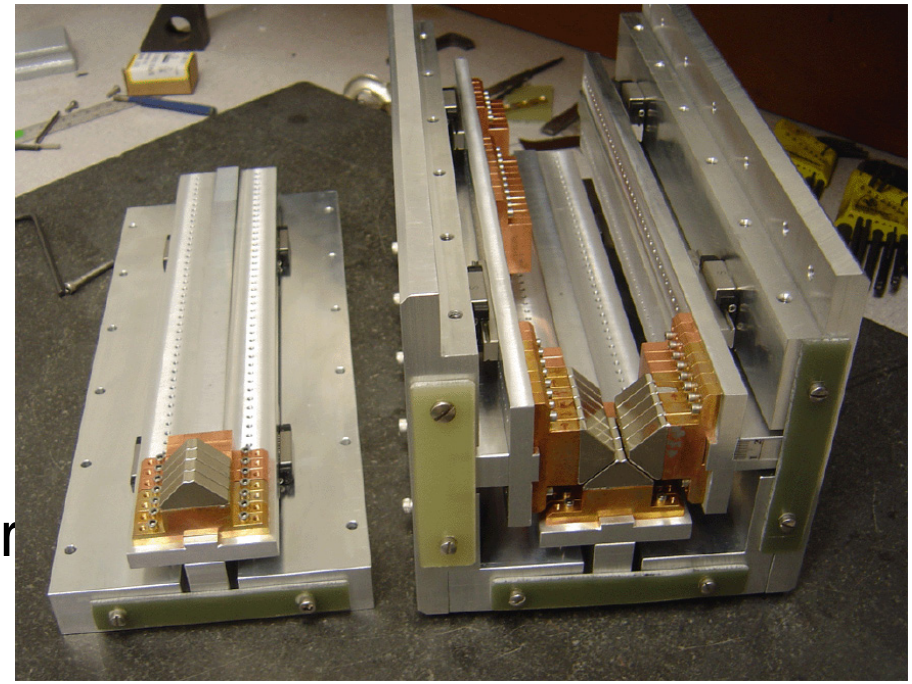
TUP 063 - *S. Posen & M. Liepe*
HOM Measurements with Beam at the Cornell Injector Cryomodule

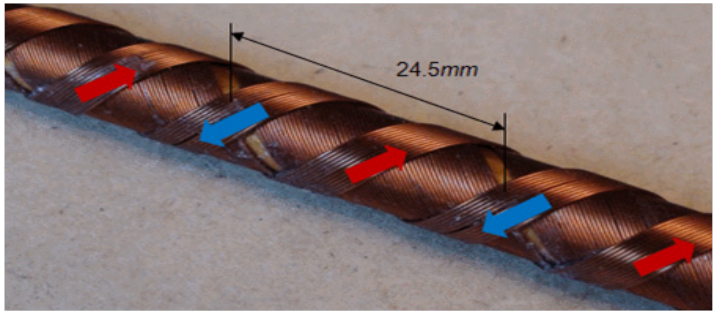
TUP 064 - *N. Valles & M. Liepe*
Designing Multiple Cavity Classes for the Main Linac of Cornell's ERL



ERL Undulators: Delta and Superconducting

- Full polarization control
- Strong fields (1.4 T)
- Very compact
- Tested ATF at BNL late 2009
- Working on a planar version (1 m) to test in CESR this year





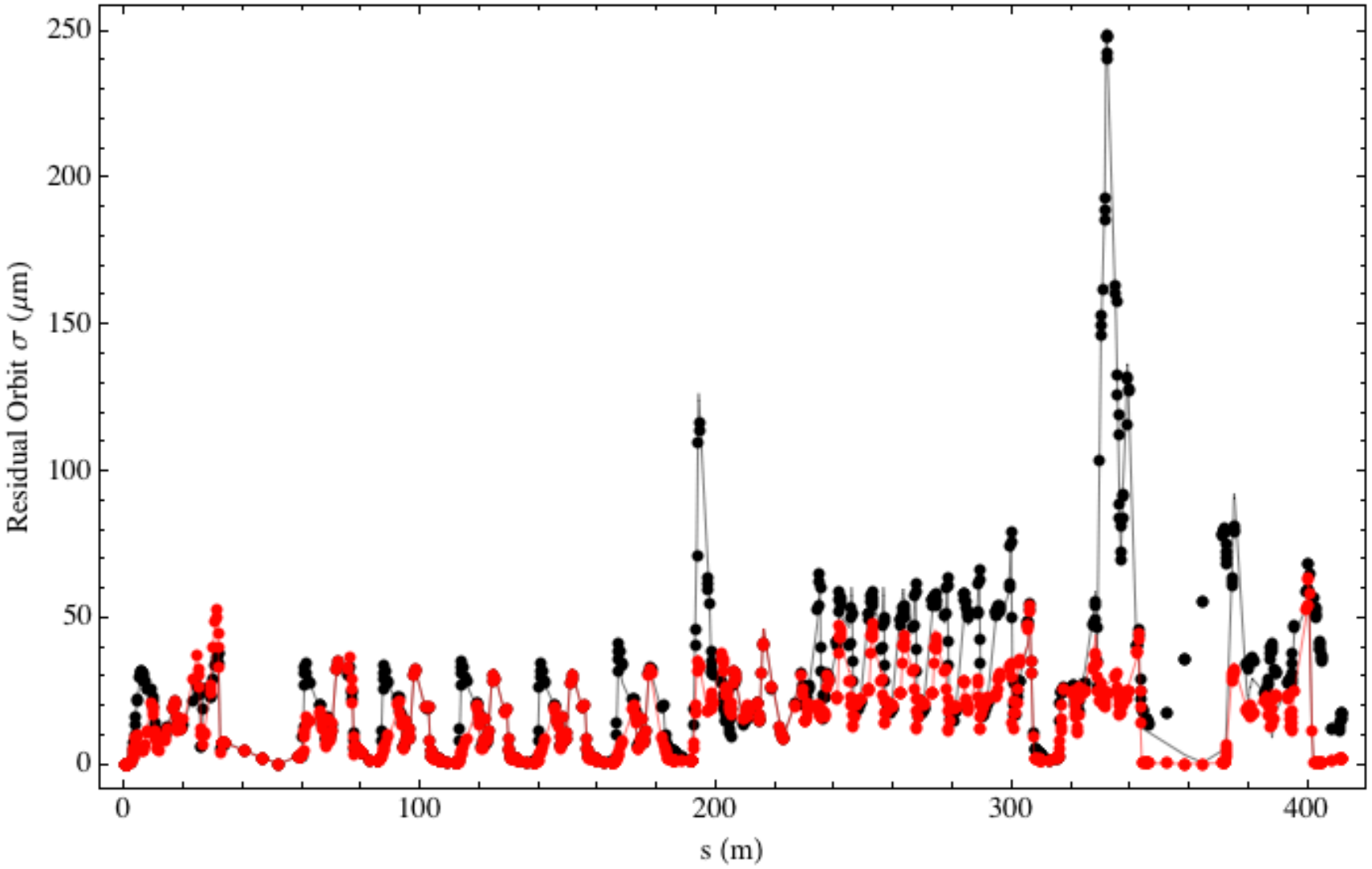
- Also have Strong fields (2.2 T)
- Very compact

TUP 248 - *A. A. Mikhailichenko*
SC Undulator with the Possibility to Change Its Strength and Polarization by Feeding Current

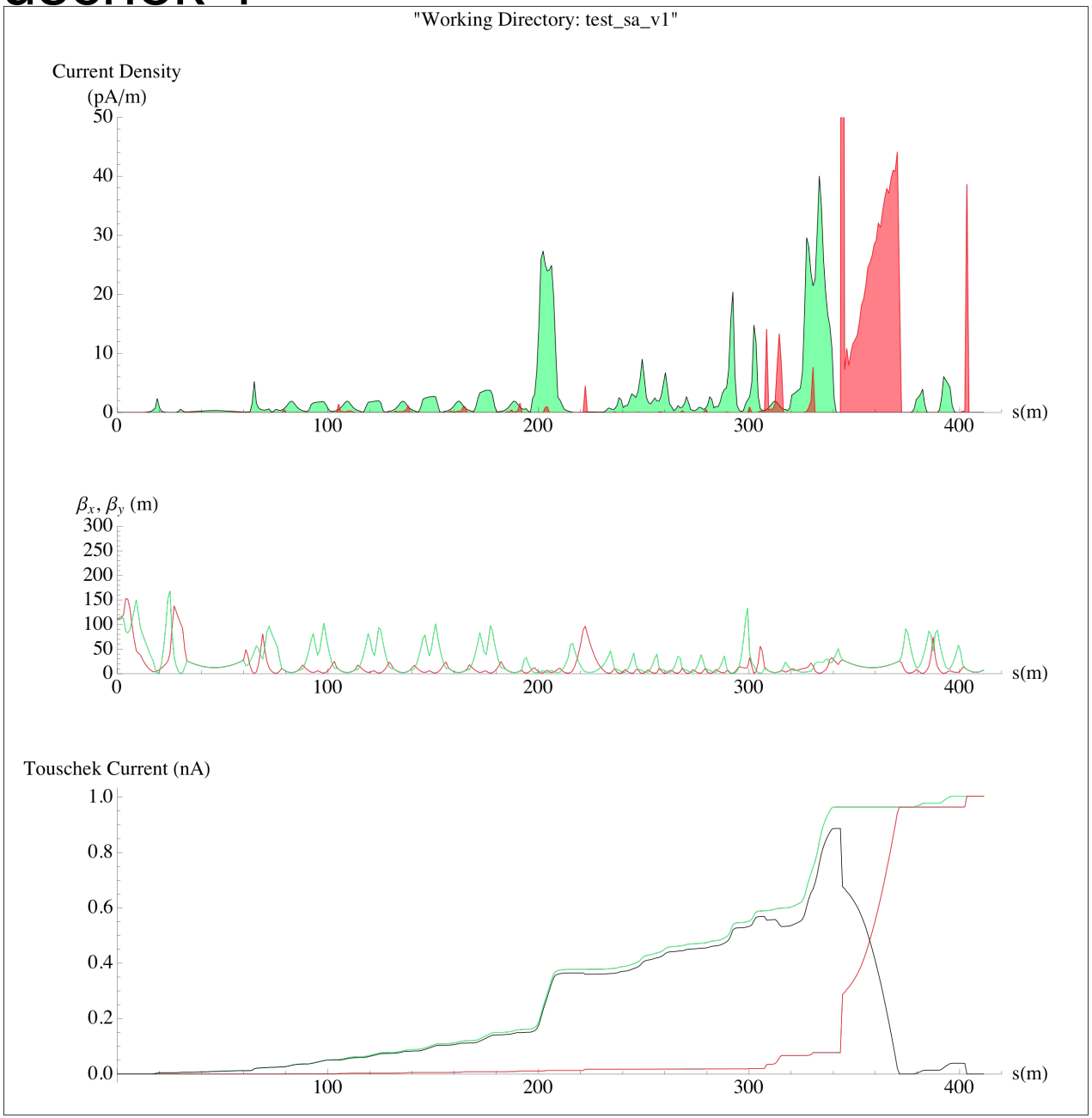
Tolerance Simulations

Error	Unit	Baseline (1σ)	Allowable (1σ)	Limiting Effect
Quadrupole x offset	μm	120	300	C_x
Quadrupole y offset	μm	100	250	C_y & OC
Sextupole x offset	μm	120	300	σ_y
Sextupole y offset	μm	100	200	ϵ_y & σ_y
Cryomodule quad x & y offset	μm	300	1600	C_x & C_y
Dipole roll	μrad	80	1000	ϵ_y
Quadrupole roll	μrad	80	200	ϵ_y
Dipole x & y pitch	μrad	80	5000+	ϵ_y
Quadrupole x & y pitch	μrad	80	1000+	ϵ_y
Acc cavity x & y offsets	μm	500	2000	σ_y & OC
Acc cavity x & y pitch	μrad	1000	1500	ϵ_x & ϵ_y & OC
Acc cavity gradient	relative	10^{-4}	60×10^{-4}	σ_y
Acc cavity ϕ_{rf}	degree	0.1	1.0+	σ_y
Dipole chain field	relative	10^{-4}	10×10^{-4}+	
Quadrupole k_1	relative	10^{-4}	5×10^{-4}	σ_y
Sextupole k_2	relative	10^{-4}	10^{-3}+	

Orbit Correction Scheme: Before and After



Touschek 1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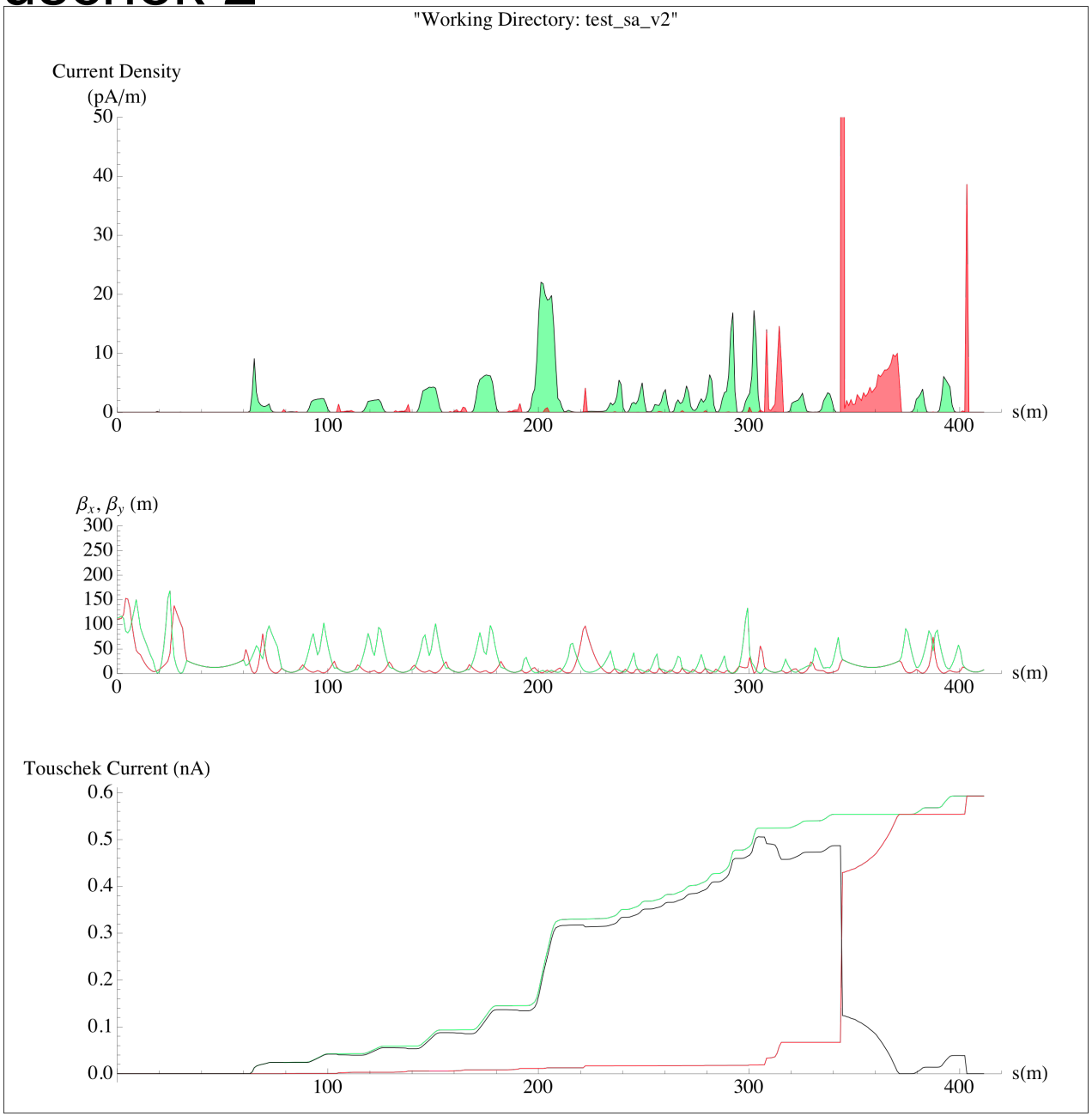
Current Density
(pA/m)
50
40
30
20
10
0
0
100
200
300
400
s(m)
β_x, β_y (m)
300
250
200
150
100
50
0
0
100
200
300
400
s(m)
Touschek Current (nA)
1.0
0.8
0.6
0.4
0.2
0.0
100
200
300
400
s(m)

Touschek 2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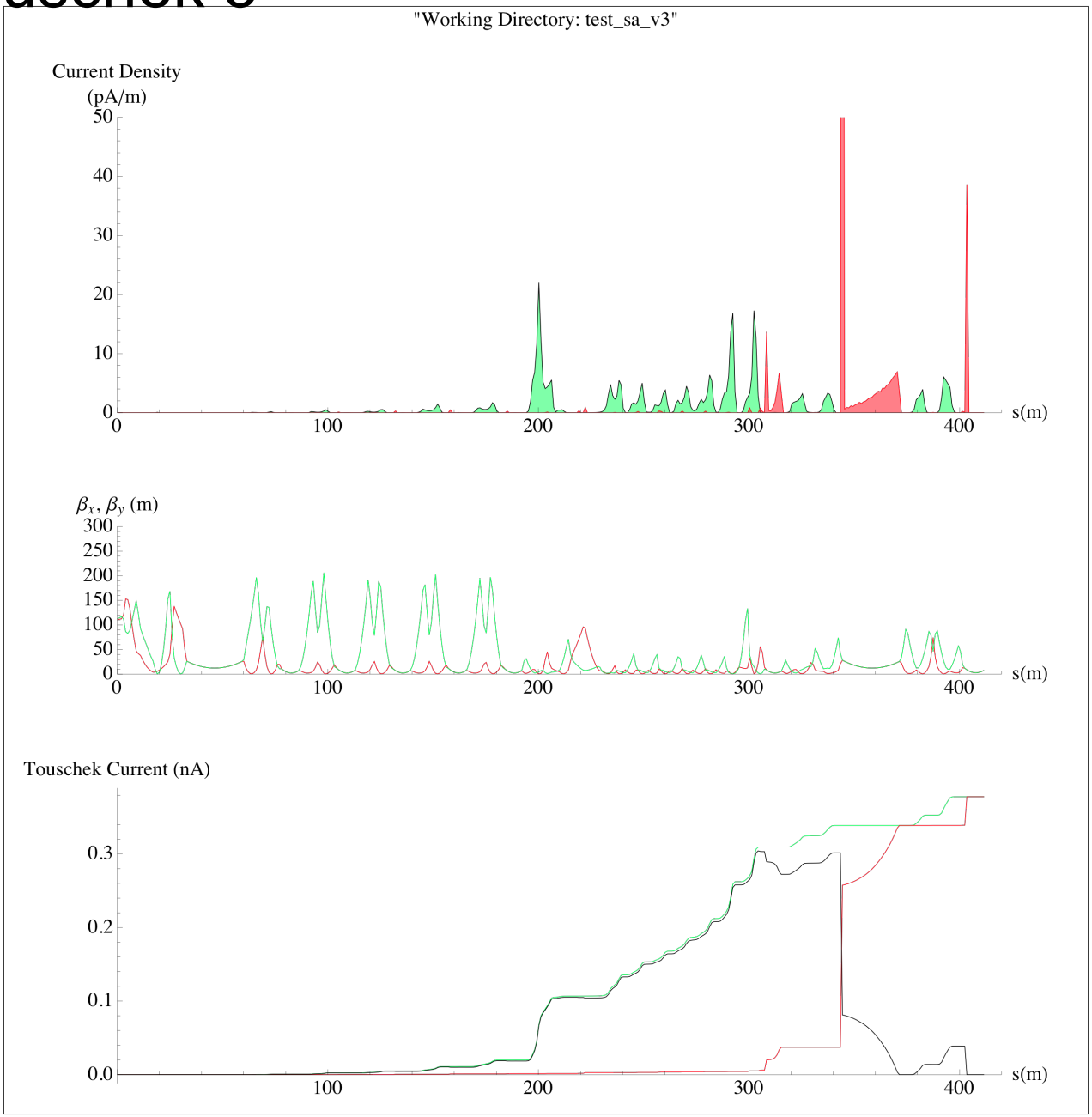
Current Density
(pA/m)
50
40
30
20
10
0
0
100
200
300
400
s(m)
β_x, β_y (m)
300
250
200
150
100
50
0
0
100
200
300
400
s(m)
Touschek Current (nA)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
100
200
300
400
s(m)

Touschek 3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Current Density
(pA/m)
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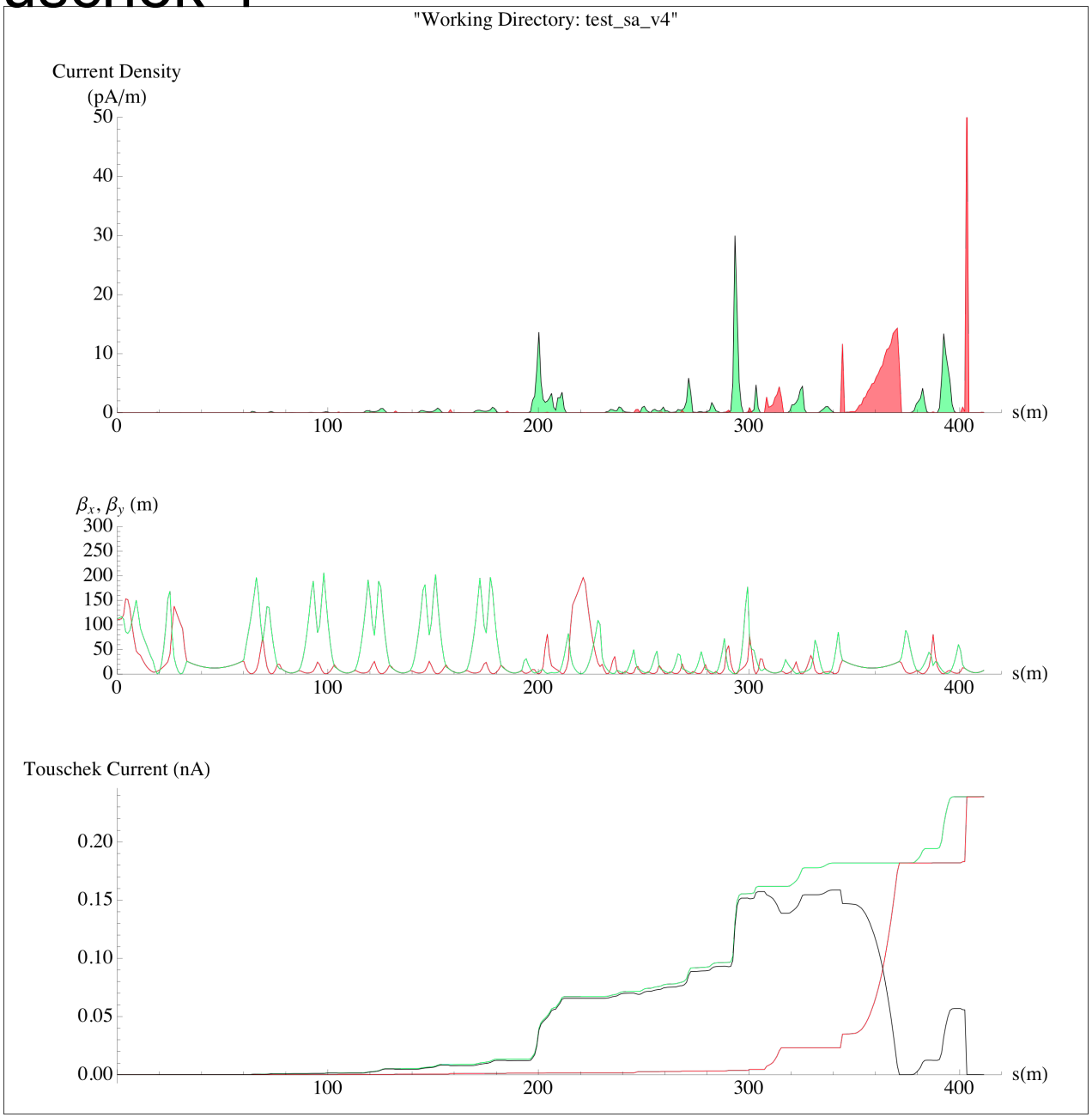
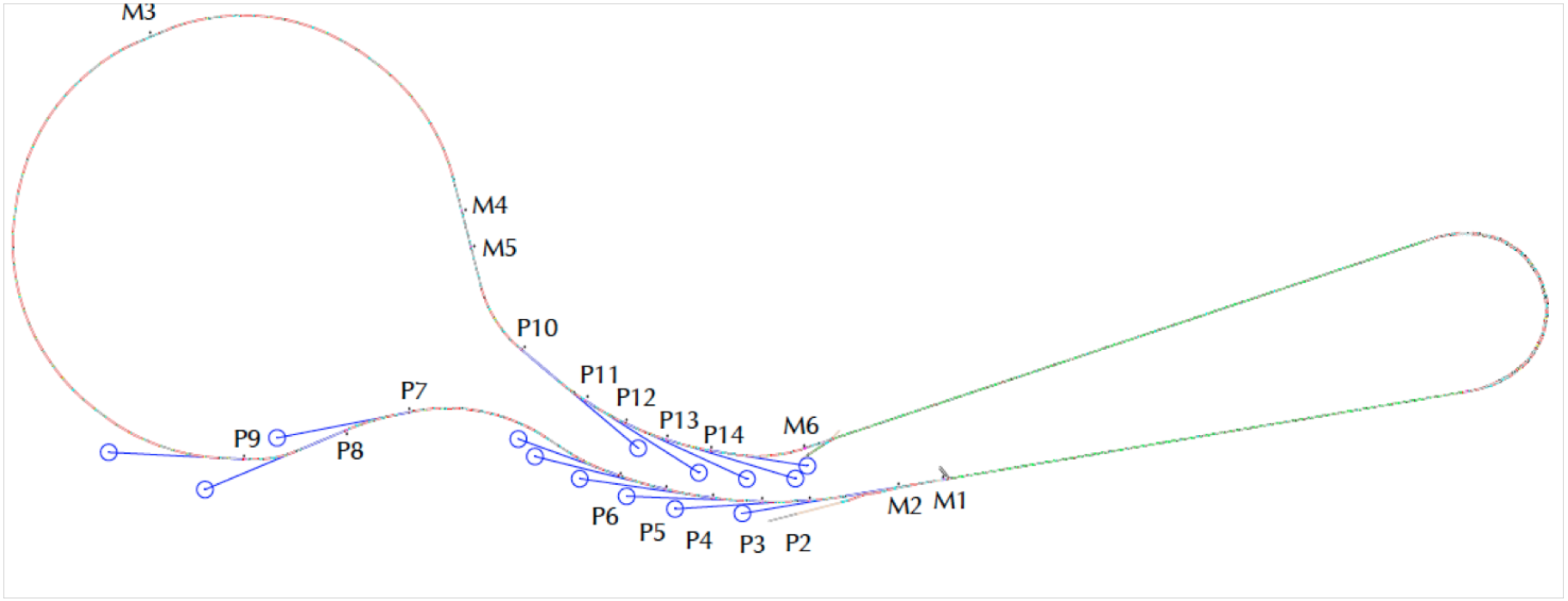
40
30
20
10
0
0
100
200
300
400
s(m)
β_x, β_y (m)
300
250
200
150
100
50
0
0
100
200
300
400
s(m)
Touschek Current (nA)
0.3
0.2
0.1
0.0
100
200
300
400
s(m)

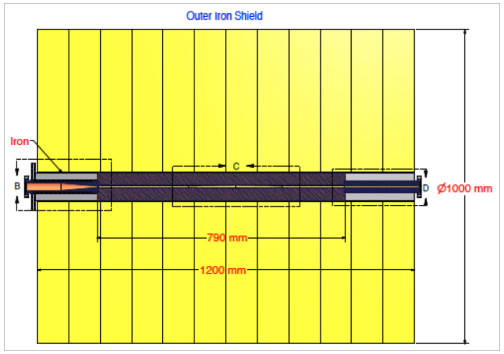
Touschek 4


"Working Directory: test_sa_v4"
Current Density
(pA/m)
50
40
30
20
10
0
0
100
200
300
400
s(m)
β_x, β_y (m)
300
250
200
150
100
50
0
0
100
200
300
400
s(m)
Touschek Current (nA)
0.20
0.15
0.10
0.05
0.00
100
200
300
400
s(m)

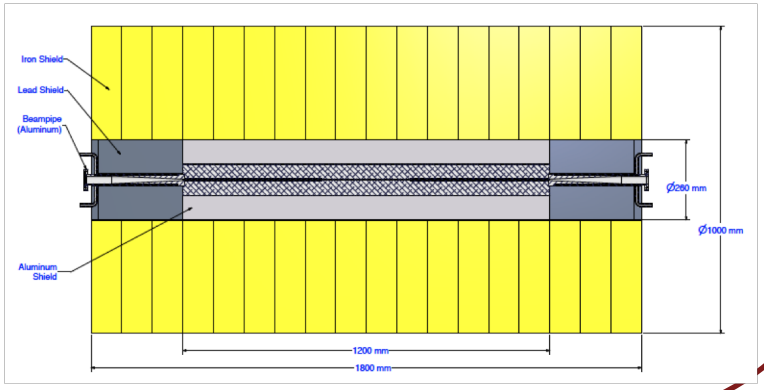
Halo Collimation



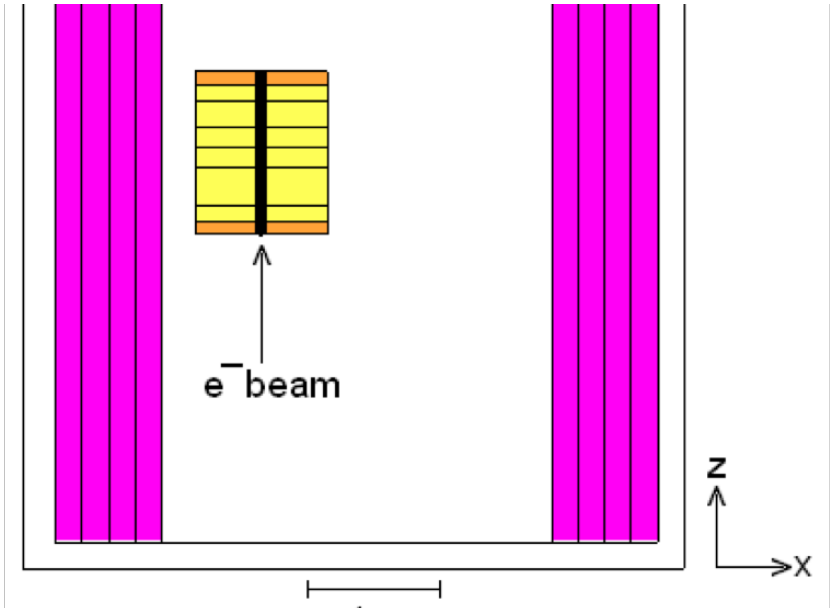
Protector

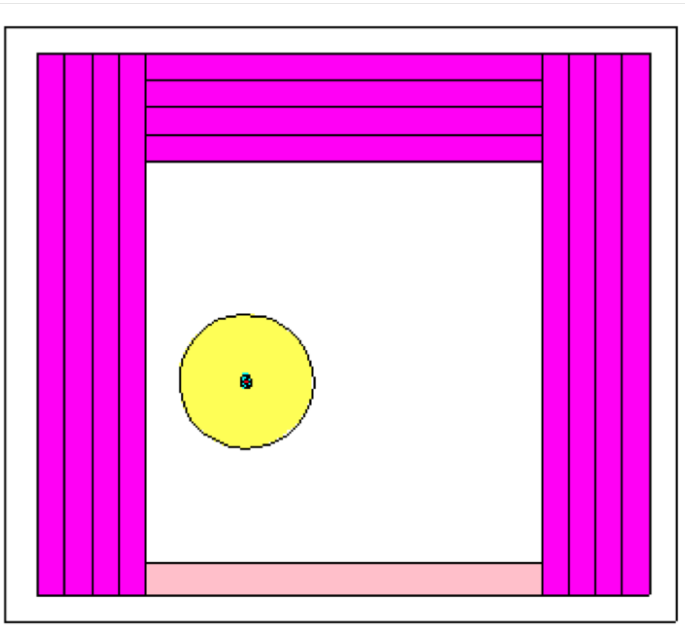


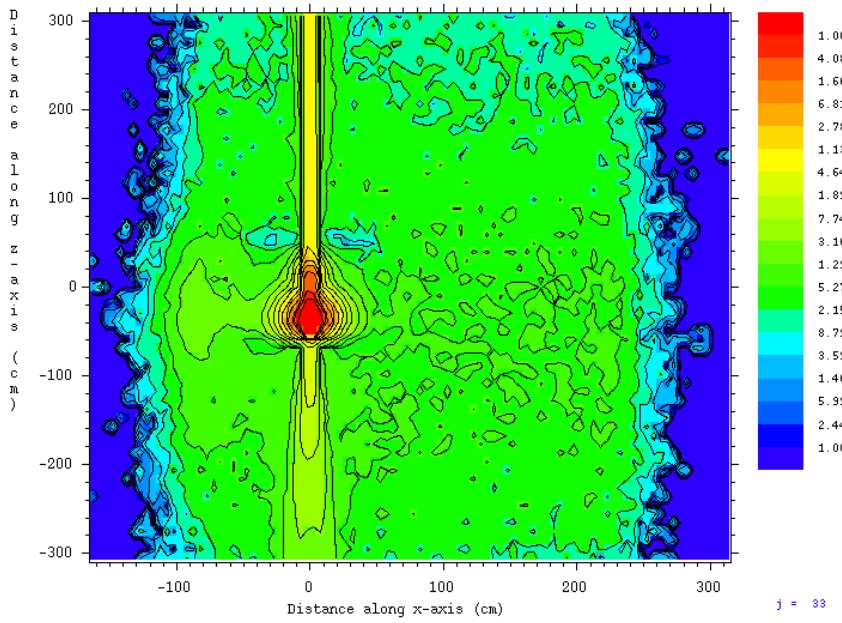
Collimator

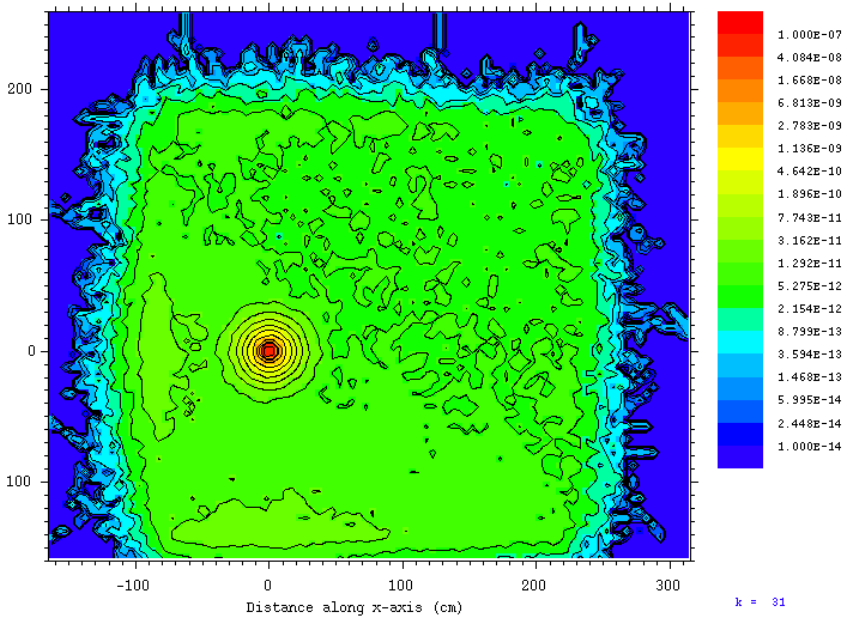


Photon Dose Rates



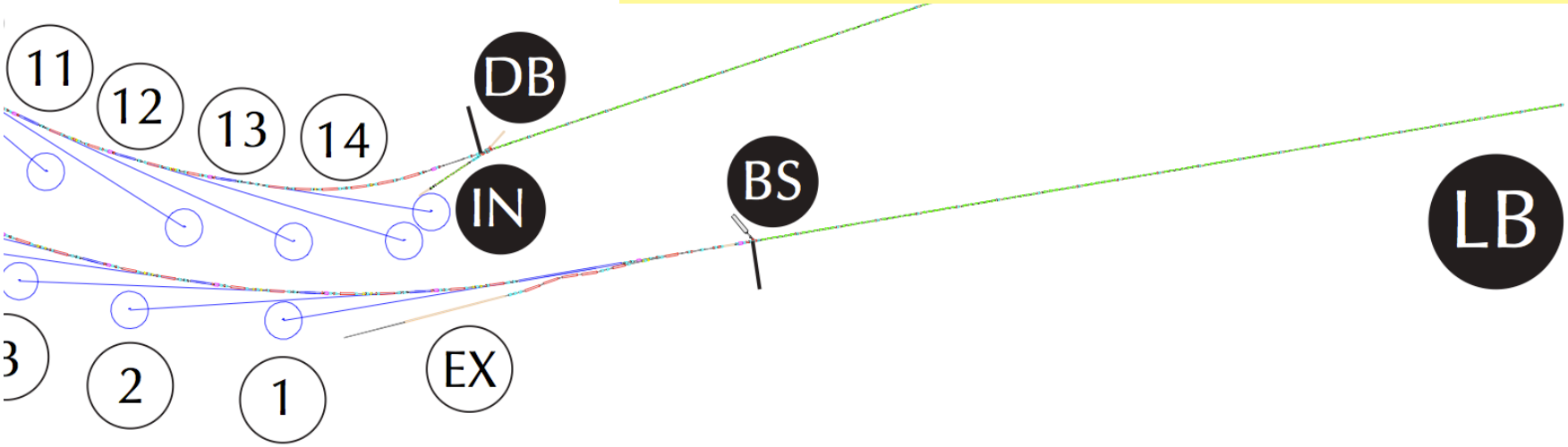


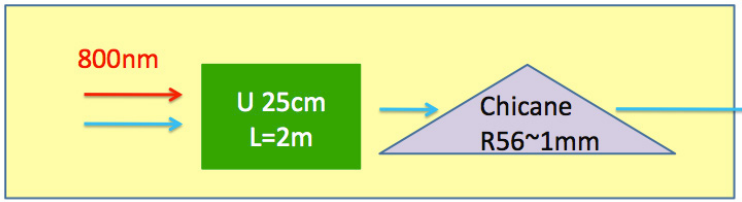


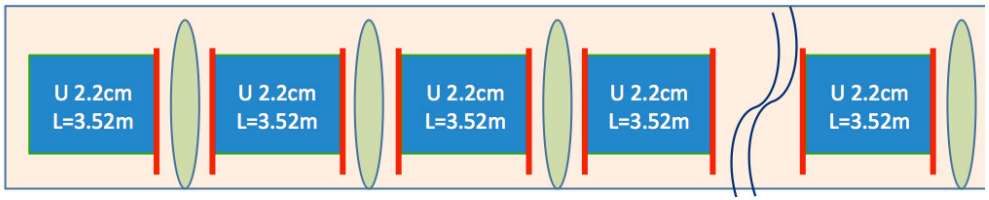


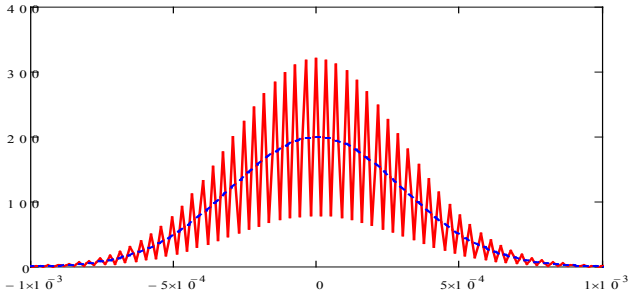
FELs in ERLs

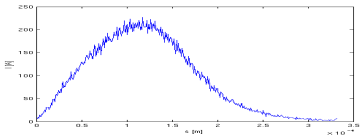
THP 144 - *A. Meseck et al.*
FELs as X-ray Sources in ERL Facilities

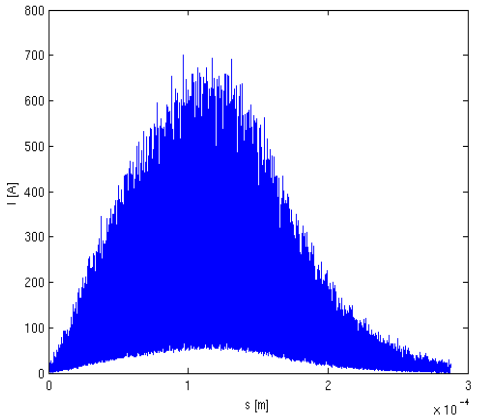












Science at the Hard X-ray Diffraction Limit

erl.chess.cornell.edu/gatherings/2011_Workshops

June 6 & 7: Diffraction microscopy, holography and ptychography using coherent beams.
Janos Kirz (Lawrence Berkeley National Lab), Qun Shen (Brookhaven National Lab), Darren Dale (Cornell University)

June 13 & 14: Biomolecular structure from nanocrystals and diffuse scattering.
Ed Lattman (Hauptmann-Woodward Medical Research Inst.), Mavis Abandje-McKenna (Univ. Florida), Keith Moffat (Univ. Chicago), Sol M. Gruner (Cornell Univ.)

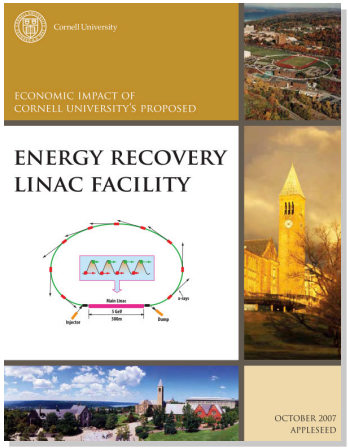
June 23 & 24: High-pressure science at the edge of feasibility.
Russell J. Hemley (Carnegie Institution of Washington), Neil Ashcroft (Cornell University), Raould Hoffmann (Cornell University), Zhongwu Wang (Cornell University)

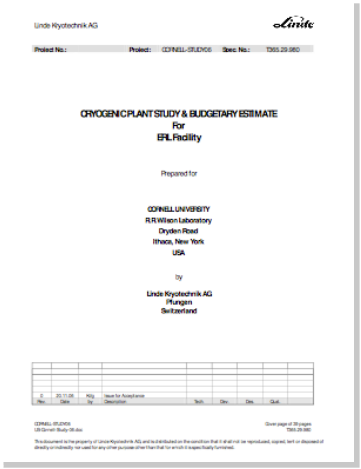
June 20 & 21: Ultra-fast science with `tickle and probe'.
Robert Schoenlein (Lawrence Berkeley National Laboratory), Brian Stephenson (Argonne National Laboratory), Joel Brock (Cornell University)

June 27 & 28: Materials science with coherent nanobeams at the edge of feasibility.
Christian Reikel (ESRF), Simon Billinge (Columbia University), Kenneth Evans-Ludderodt (Brookhaven National Laboratory), Don Bilderback (Cornell University)

June 29 & 30: Frontier science with x-ray Correlation spectroscopies using continuous sources.
Mark Sutton (McGill University), Simon Mochrie (Yale), Arthur Woll, (Cornell University)

Supporting Studies for Phase 2





a) Proposal for electron-beamline construction

b) Two proposals for a large cryogenic plant

c) X-ray science building design

d) Tunnel design and construction study

e) Underground Technology advisory panel report

f) Economic Impact study

g) Environmental impact study (ongoing)

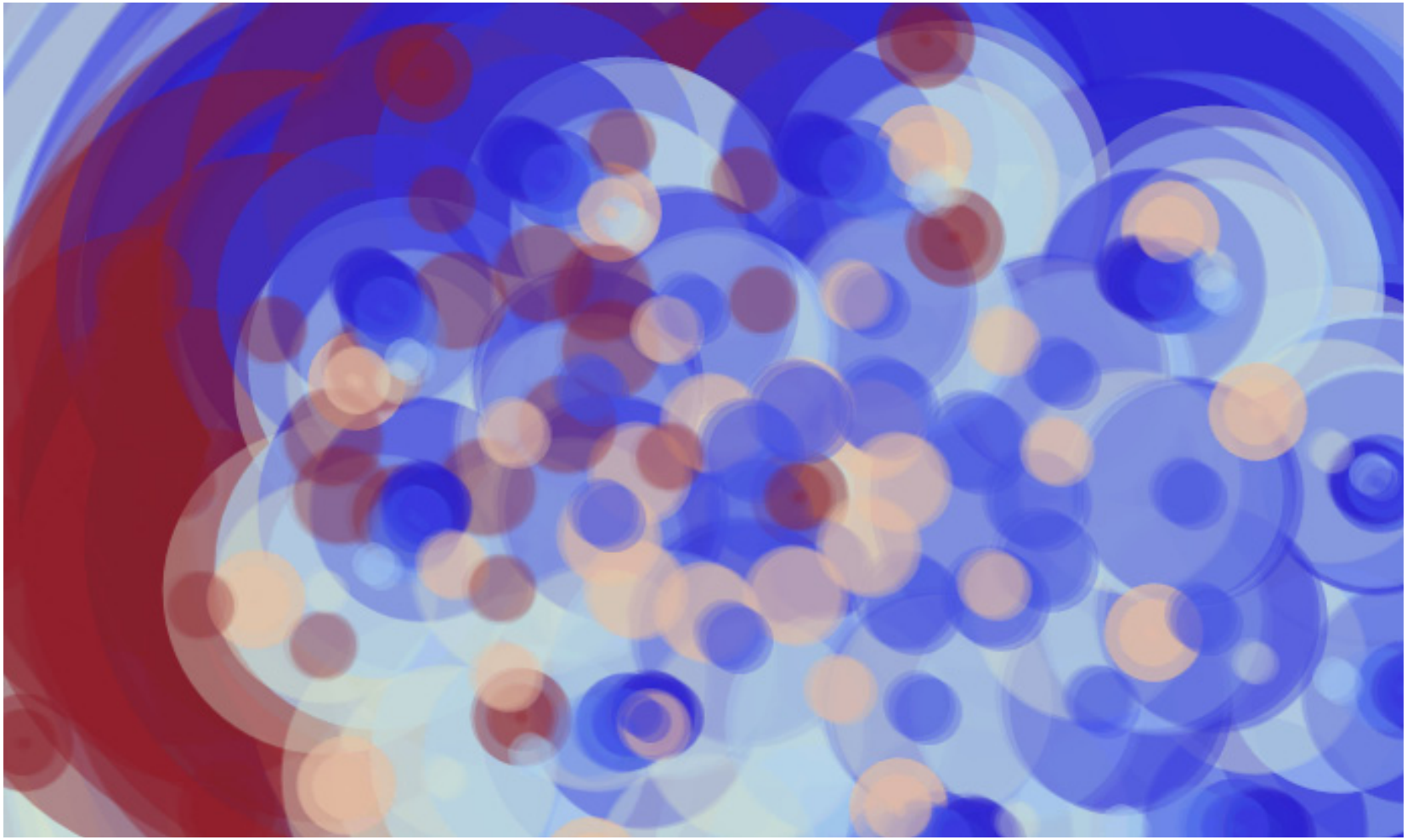
Cornell Energy Recovery Linac

Project Definition Design Report

Editors: Georg Hoffstaetter, Sol Gruner, Maury Tigner

Contributors: I. V. Bazarov, S. A. Belomestnykh, 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, T. Miyajima, C. E. Mayes, J. M. Maxson, A. Meseck, 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, U. Sae-Ueng, D. C. Sagan, J. O. Sears, V. D. Shemelin, C. K. Sinclair, D. M. Smilgies, E. N. Smith, K. W. Smolenski, Ch. Spethmann, C. Song, T. Tanabe, A. B. Temnykh, M. Tigner, N. R. A. Valles, V. G. Veshcherevich, Z. Wang, A. R. Woll, Y. Xie, Z. Zhao

erl.chess.cornell.edu/PDDR



End