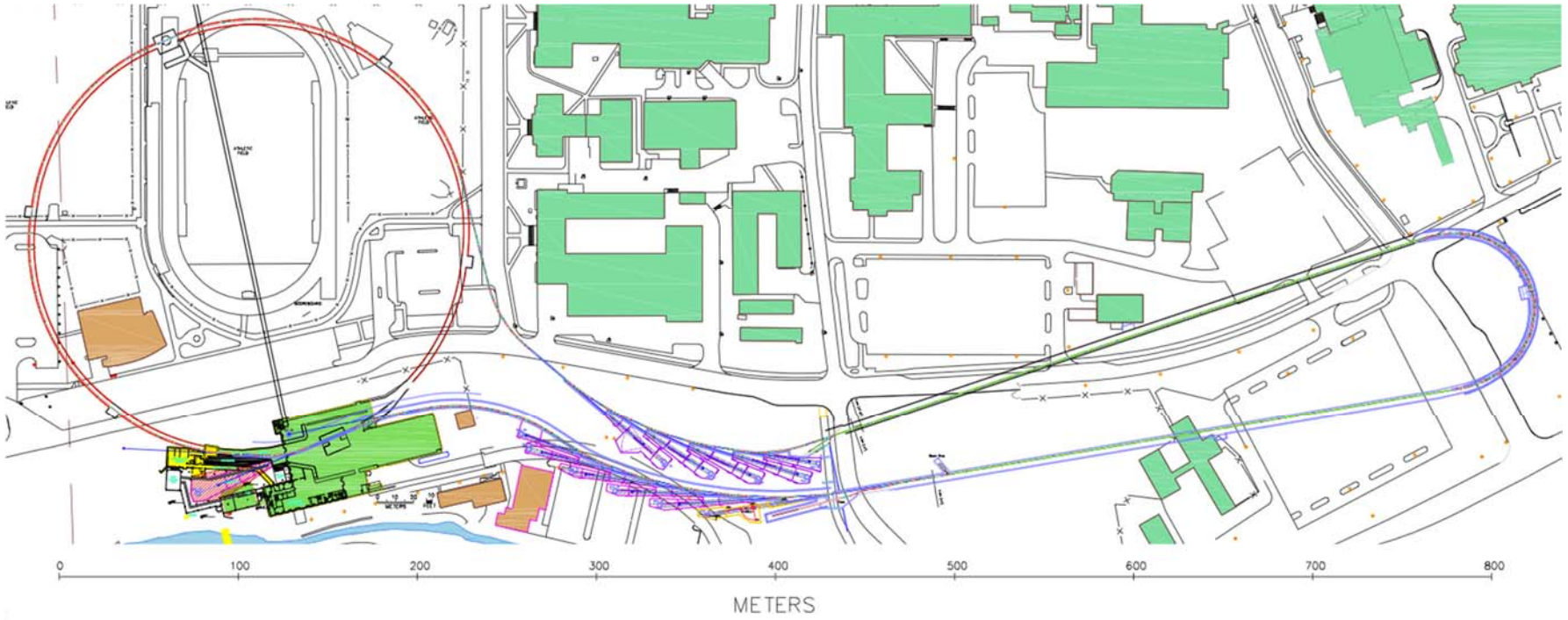
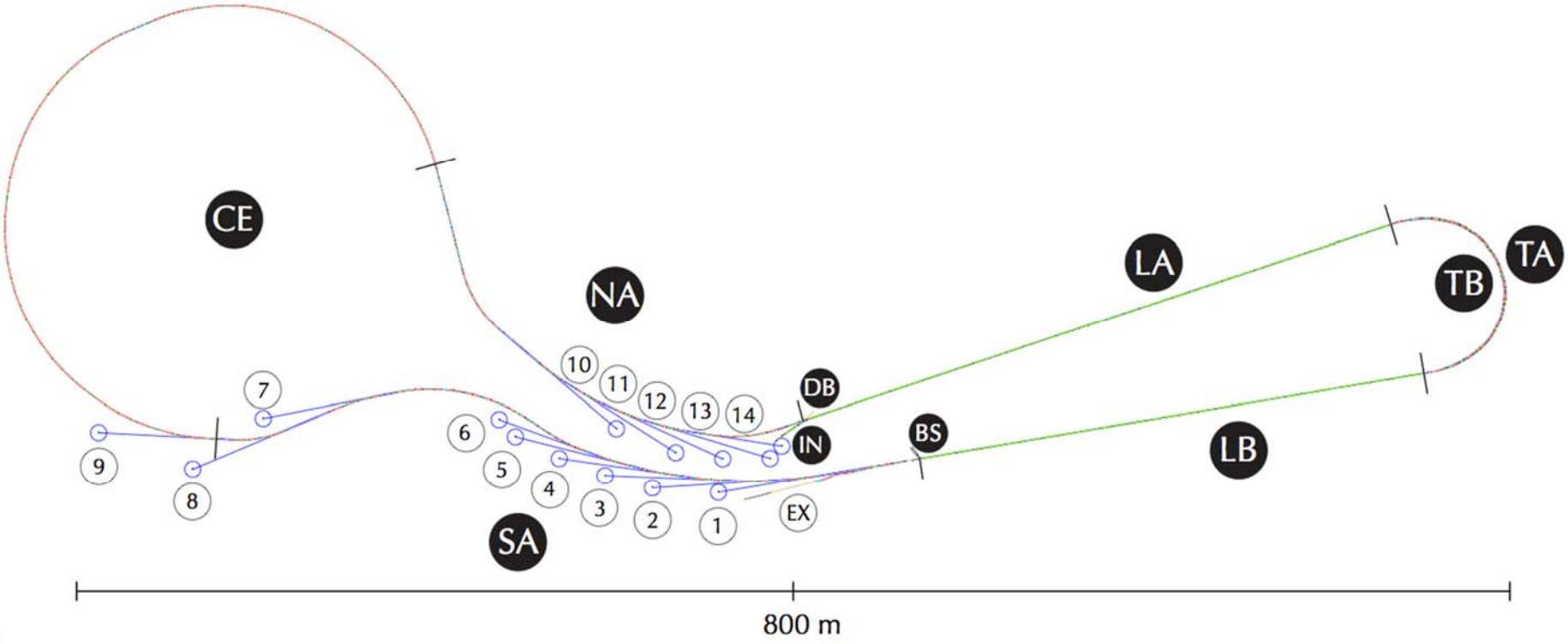
Cornell ERL
Lattice and Simulations



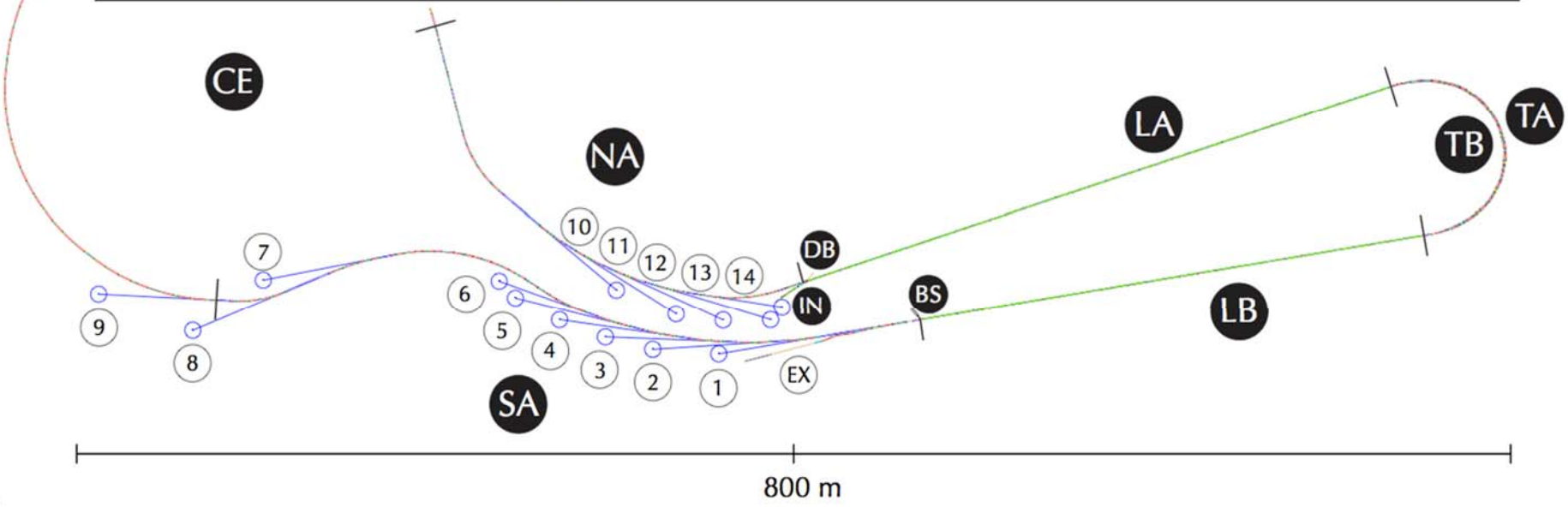
Christopher Mayes – October 18, 2011

Cornell ERL Layout (2011)

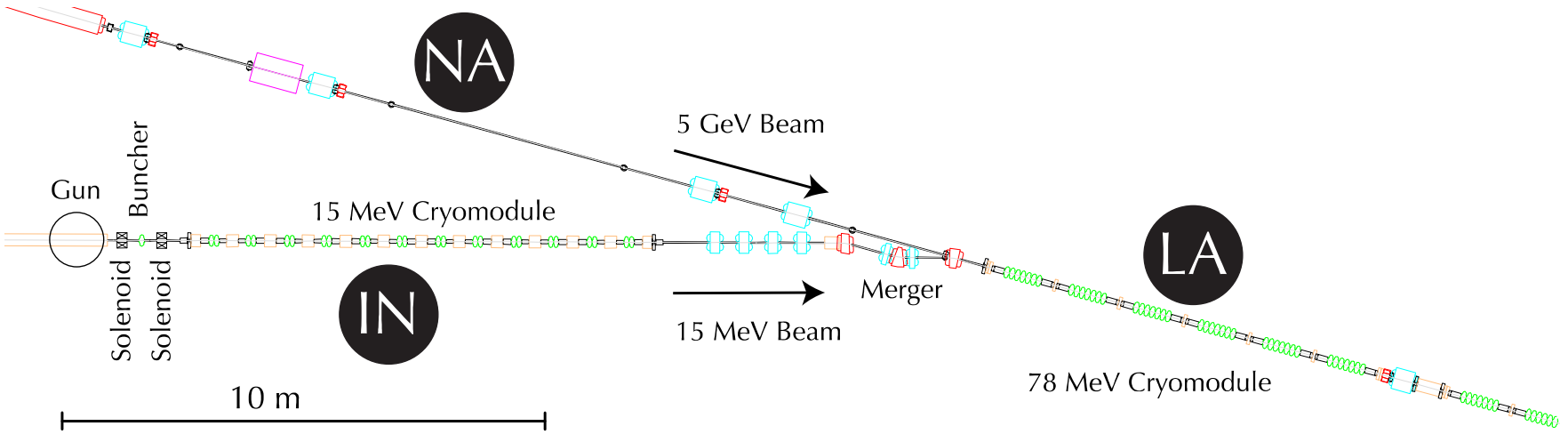


Cornell ERL Layout (2011)

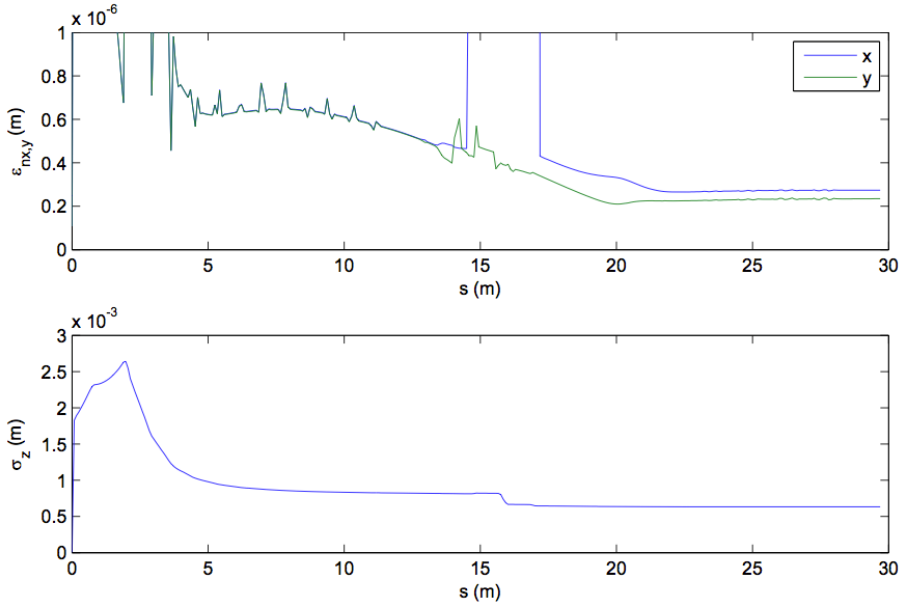
Operating Modes	A *High Flux*	B *High Coherence*	C *Short Bunch*	Unit
Energy	5	5	5	GeV
Current	100	25	25	mA
Bunch Charge	77	19	19	pC
Repetition Rate	1.3	1.3	1.3	GHz
ϵ_x (SA/NA)	31/52	13/34	21/66	pm
ϵ_y (SA/NA)	25/26	10/10	14/14	pm
σ_z/c (SA/NA)	2.1/2.1	1.5/1.5	1.0/0.1	ps
σ_δ (SA/NA)	1.9/1.9	0.9/1.0	9.1/9.3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

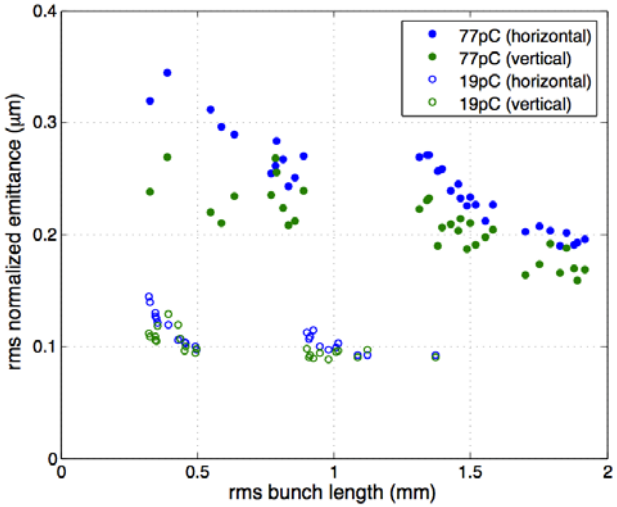


Injector optimization



Multi-objective optimization with GPT





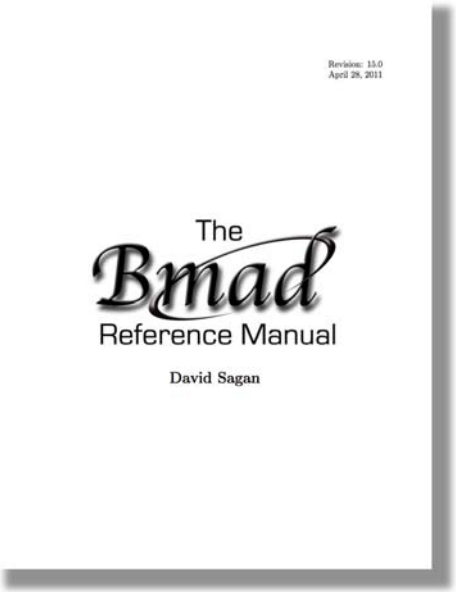
[similar to PRST-AB **8** 034202]

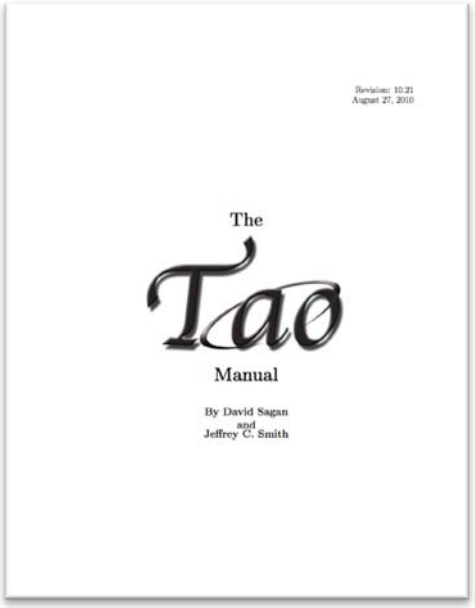
Full Optics


β_x, β_y (m)
β_x
β_y
η_x, η_y (m)
η_x
η_y
ϵ_N ISR (μm)
$\mathcal{E}$ (GeV)
s (m)
IN
BS
LA
TA
LB
SA
CE
NA
LA
TB
LB

Simulation Software

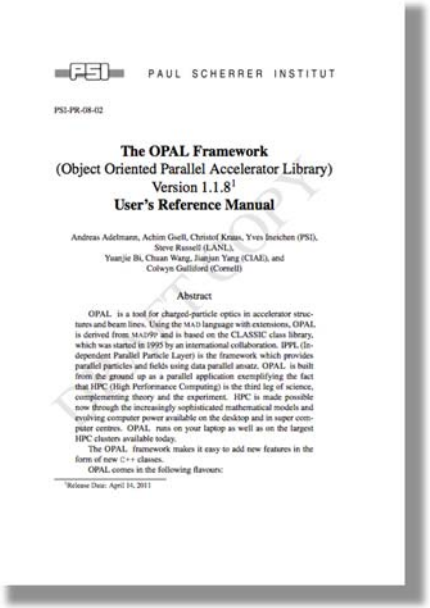
Bmad & Tao (Cornell)





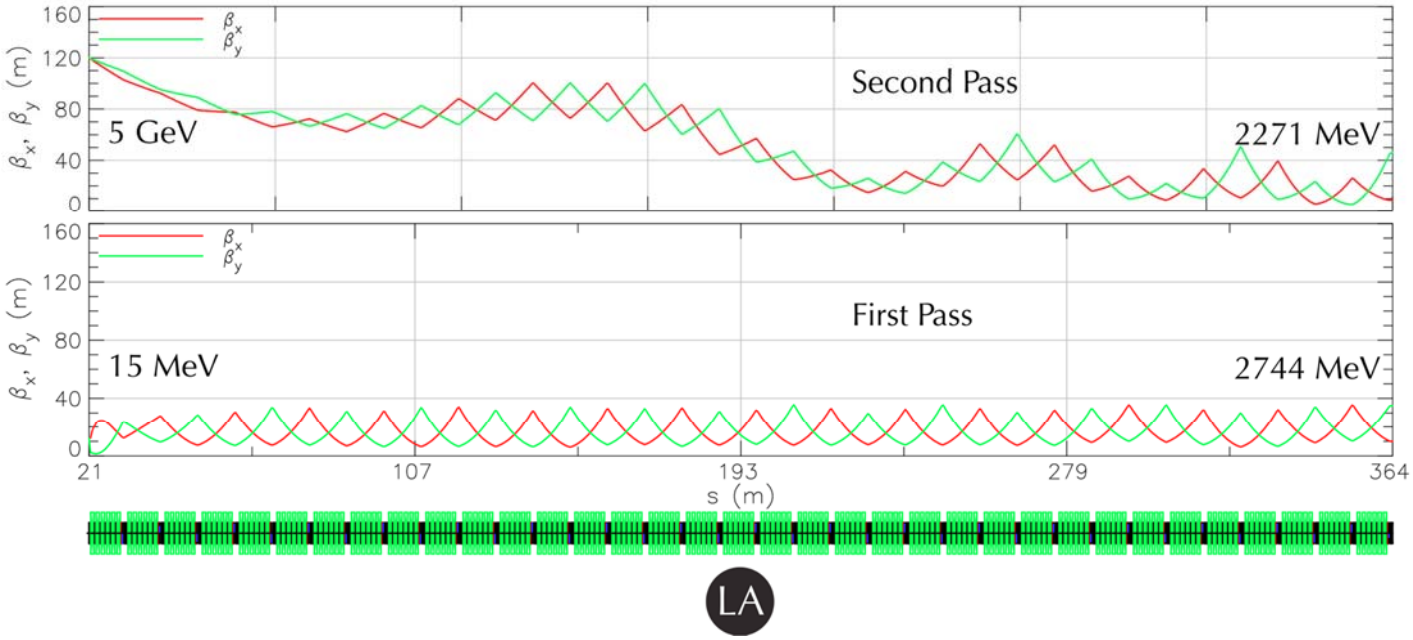
`www.lns.cornell.edu/~dcs/bmad`

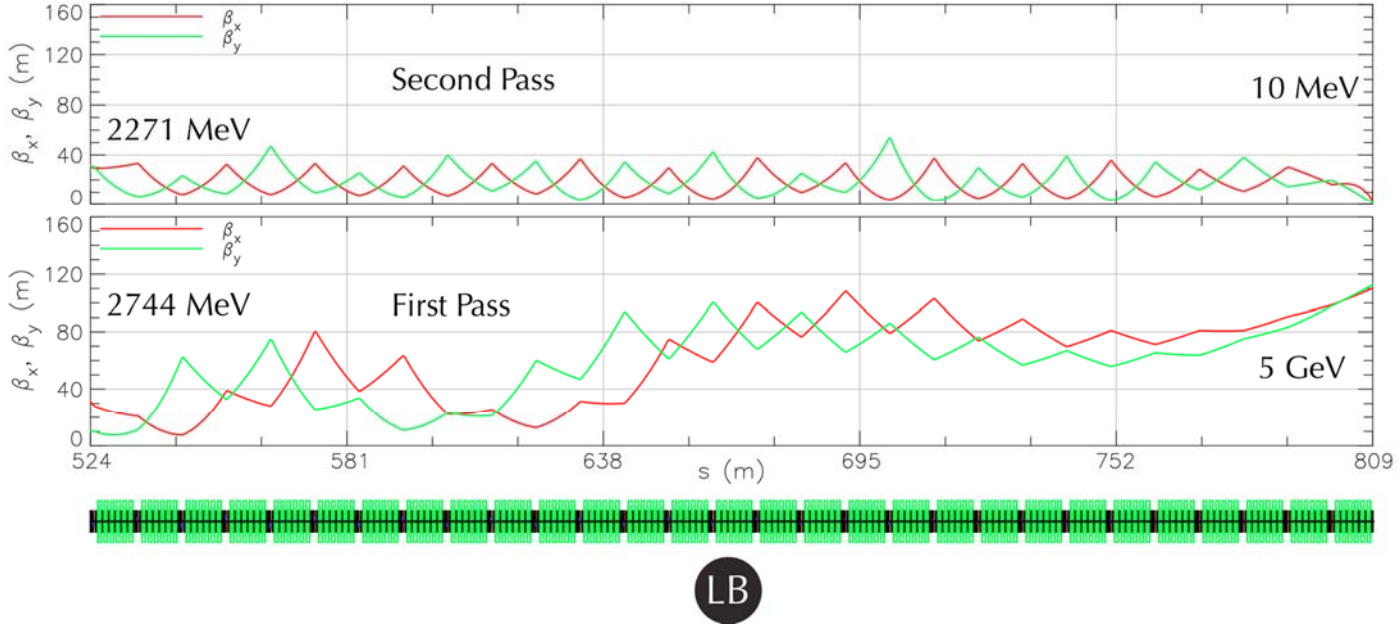
OPAL (PSI)



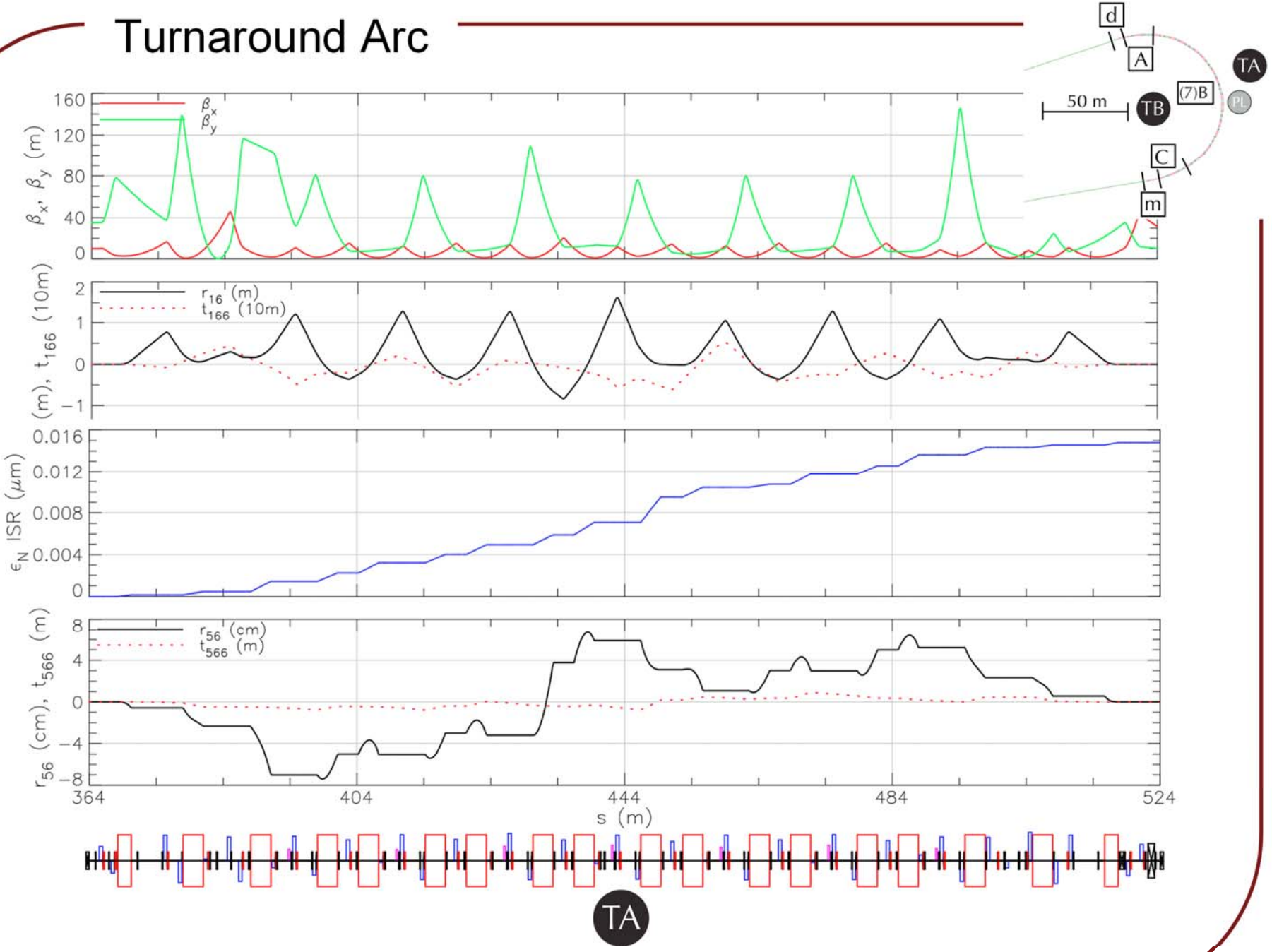
`amas.web.psi.ch`

Linacs

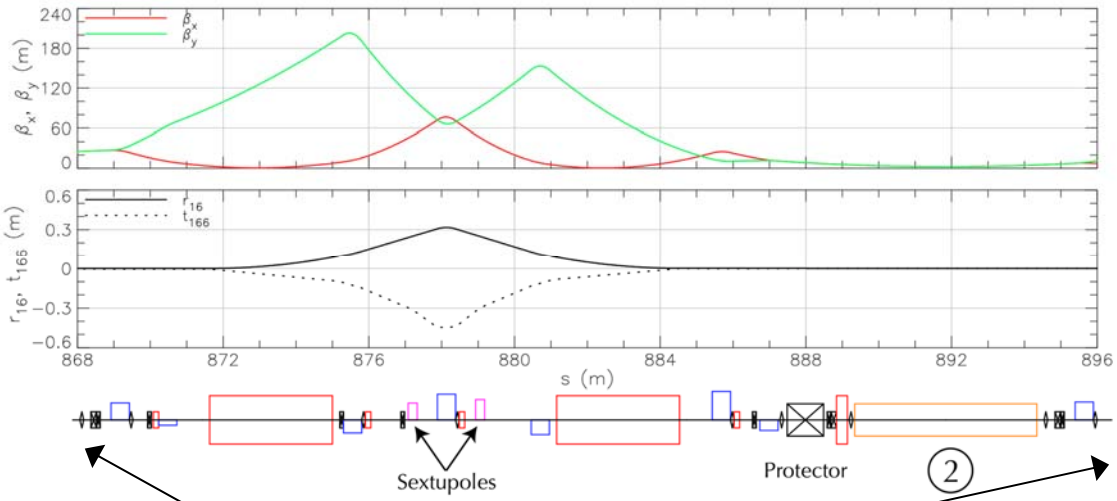

Second Pass
5 GeV
2271 MeV
First Pass
15 MeV
2744 MeV
β_x, β_y (m)
s (m)
LA

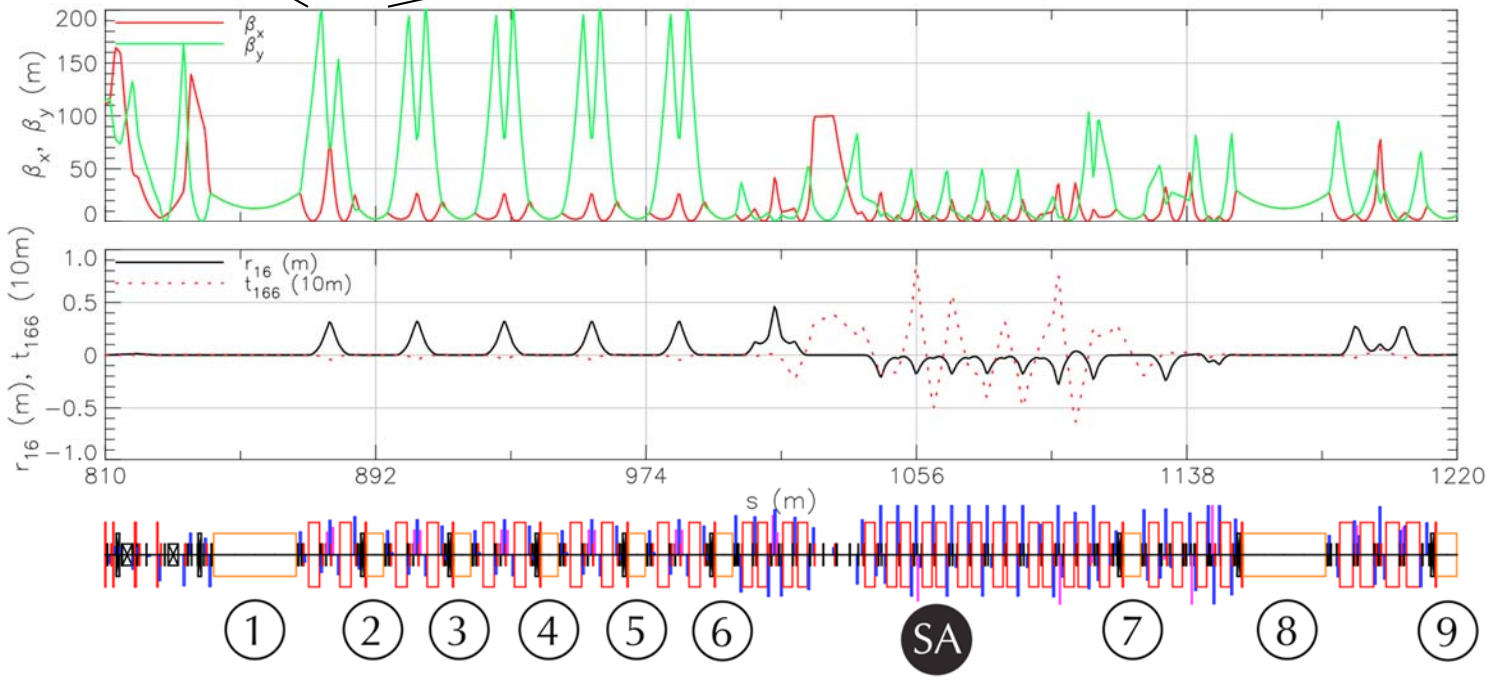

Second Pass
2271 MeV
10 MeV
First Pass
2744 MeV
5 GeV
β_x, β_y (m)
s (m)
LB

Turnaround Arc

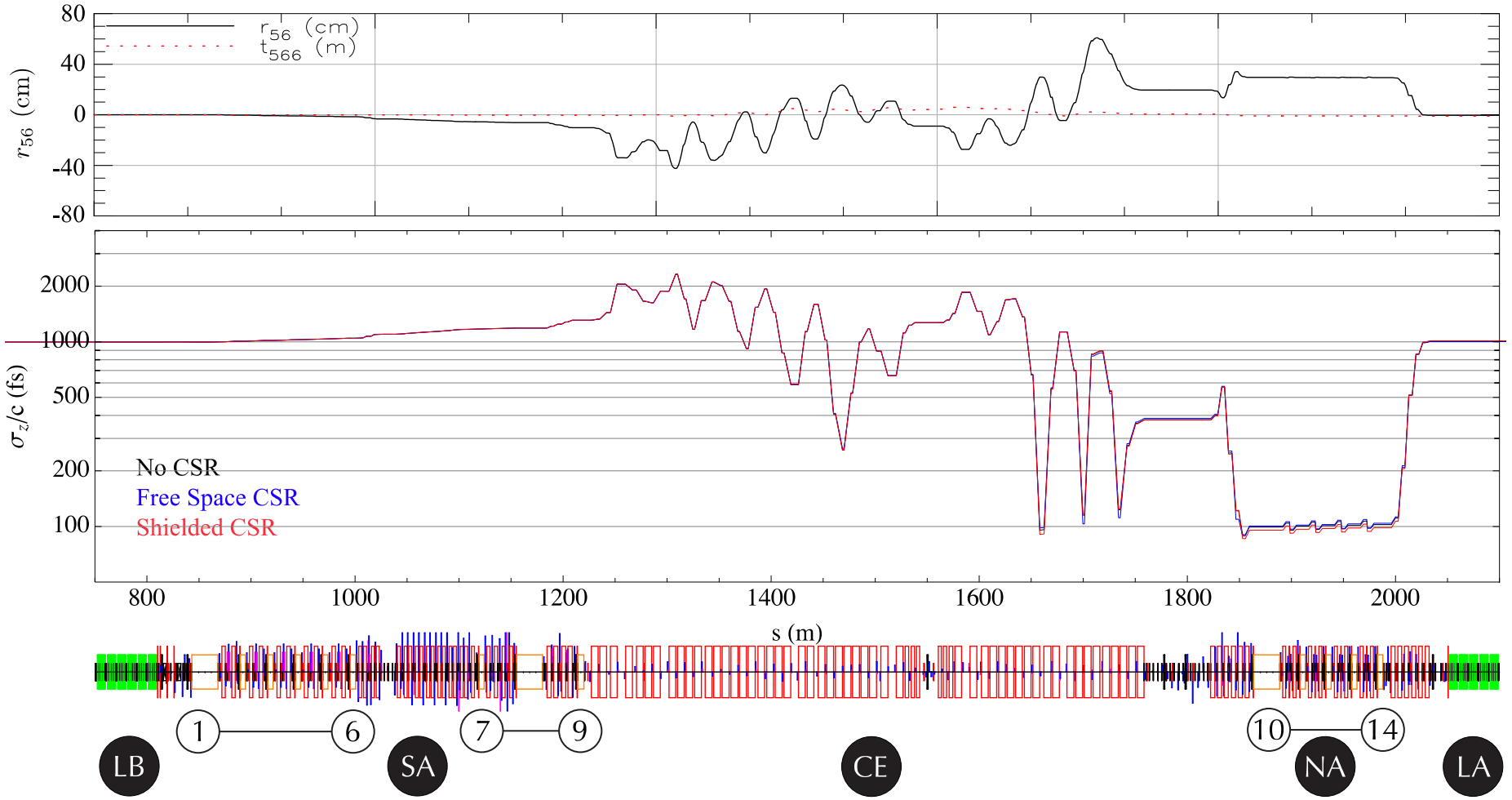


South Arc

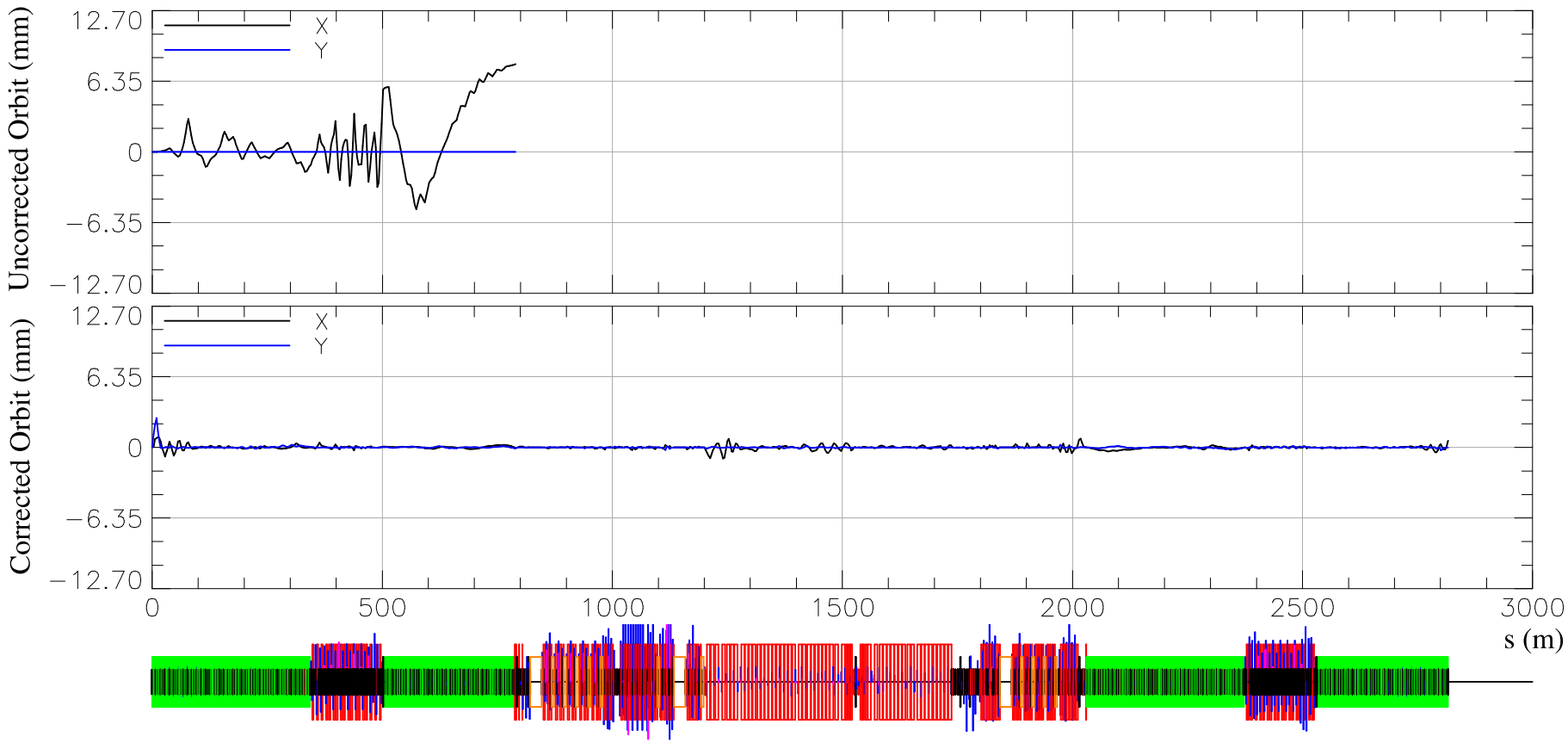

β_x, β_y (m)
r_{16}, t_{166} (m)
s (m)
Sextupoles
Protector
2


β_x, β_y (m)
r_{16} (m), t_{166} (10m)
r_{16} (m)
t_{166} (10m)
s (m)
1
2
3
4
5
6
SA
7
8
9

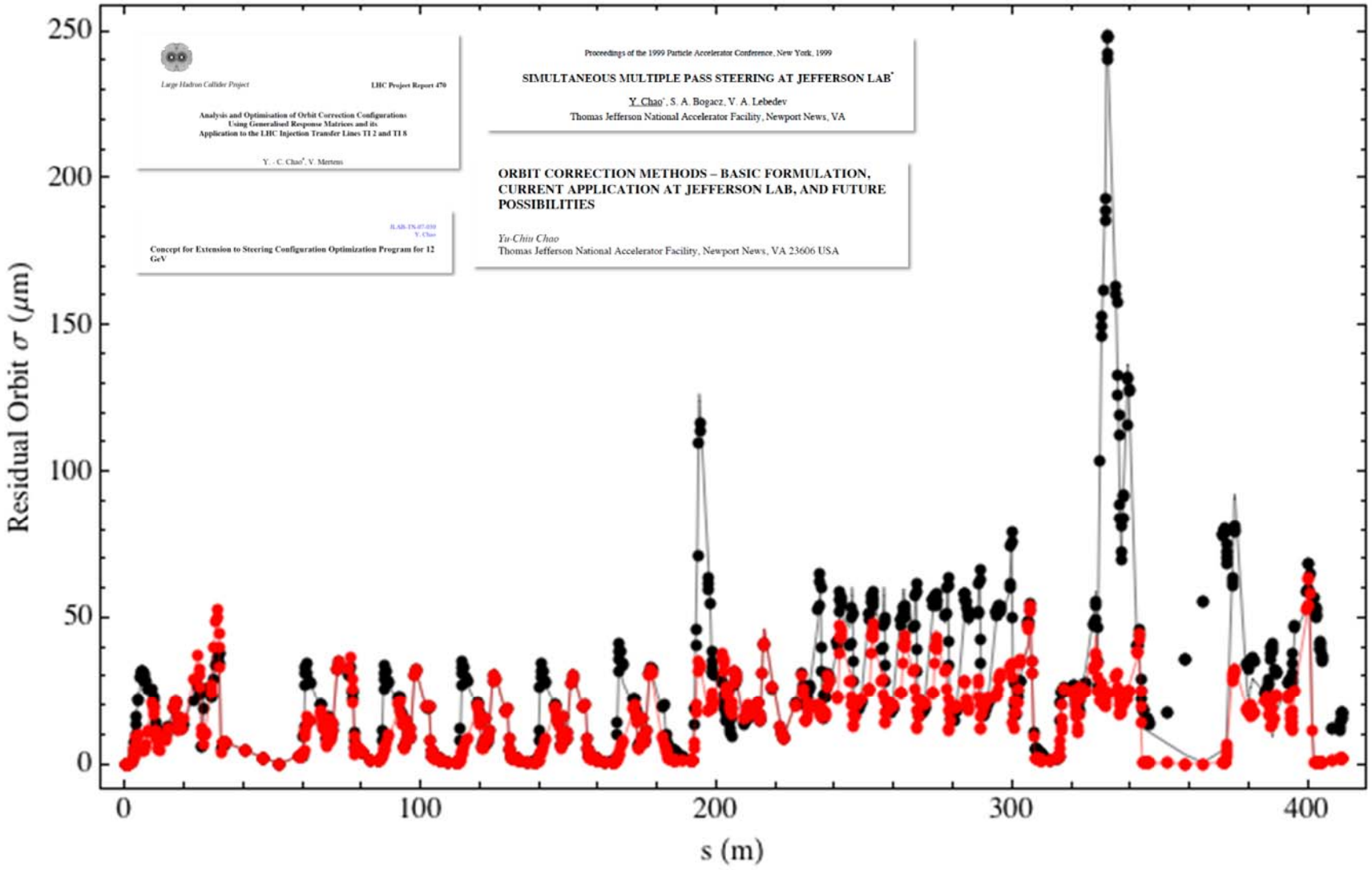
Bunch Compression



Errors and SVD Orbit Correction

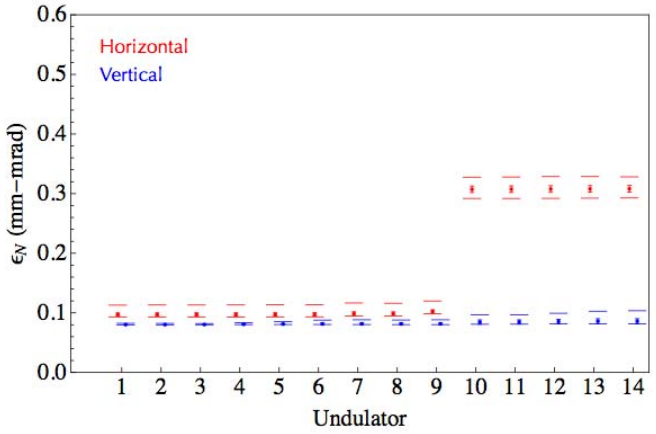


Orbit Correction Scheme: Before and After

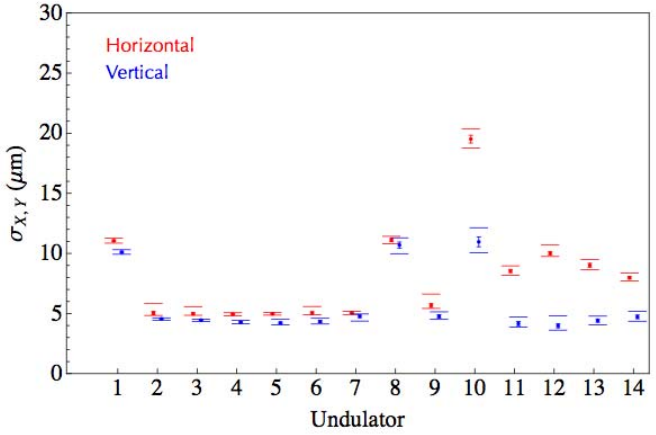


Tolerance

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}+	



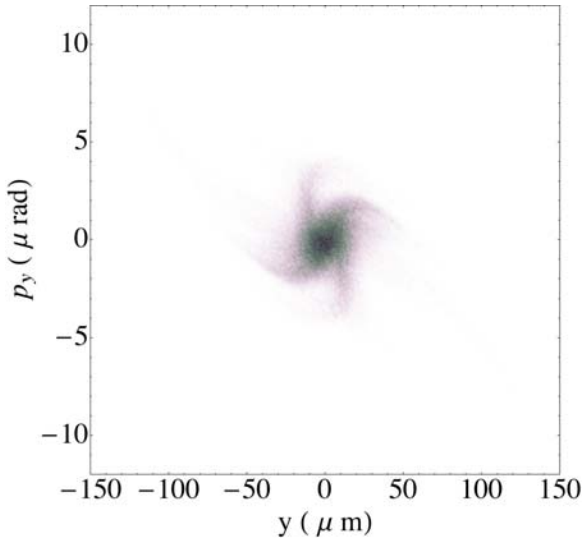
(a) Mode B emittance

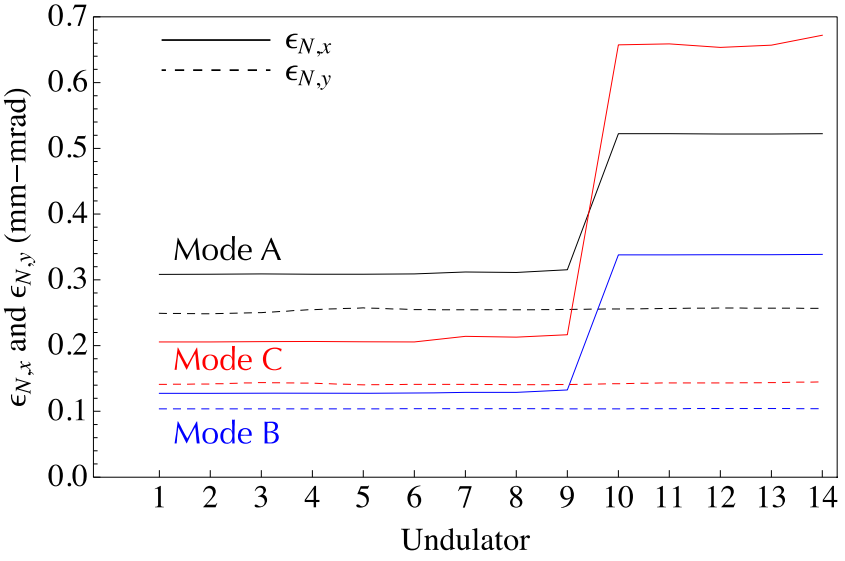


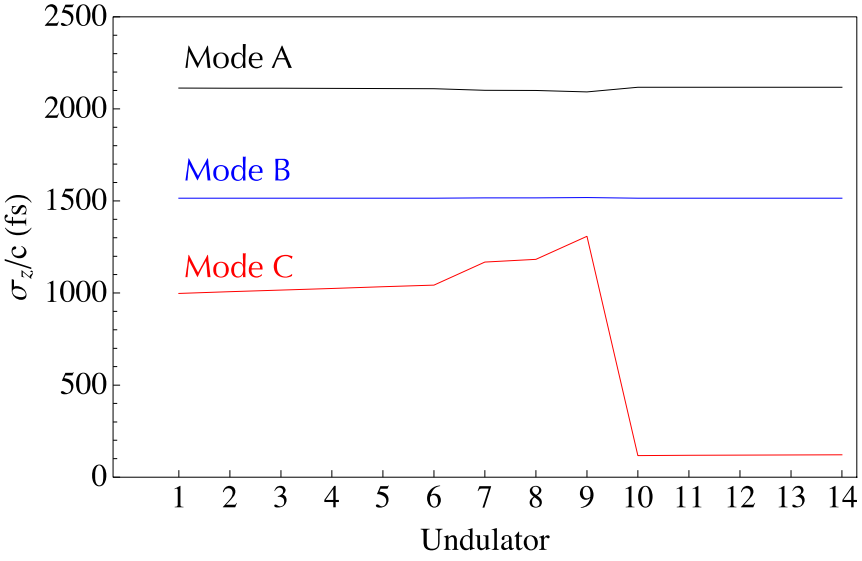
(b) Mode B beam size

Start to End simulation

- 200,000 particles from an optimized injector
- With baseline alignment & Field Errors
- Automatic SVD Orbit Correction







Cornell Energy Recovery Linac

Project Definition Design Report

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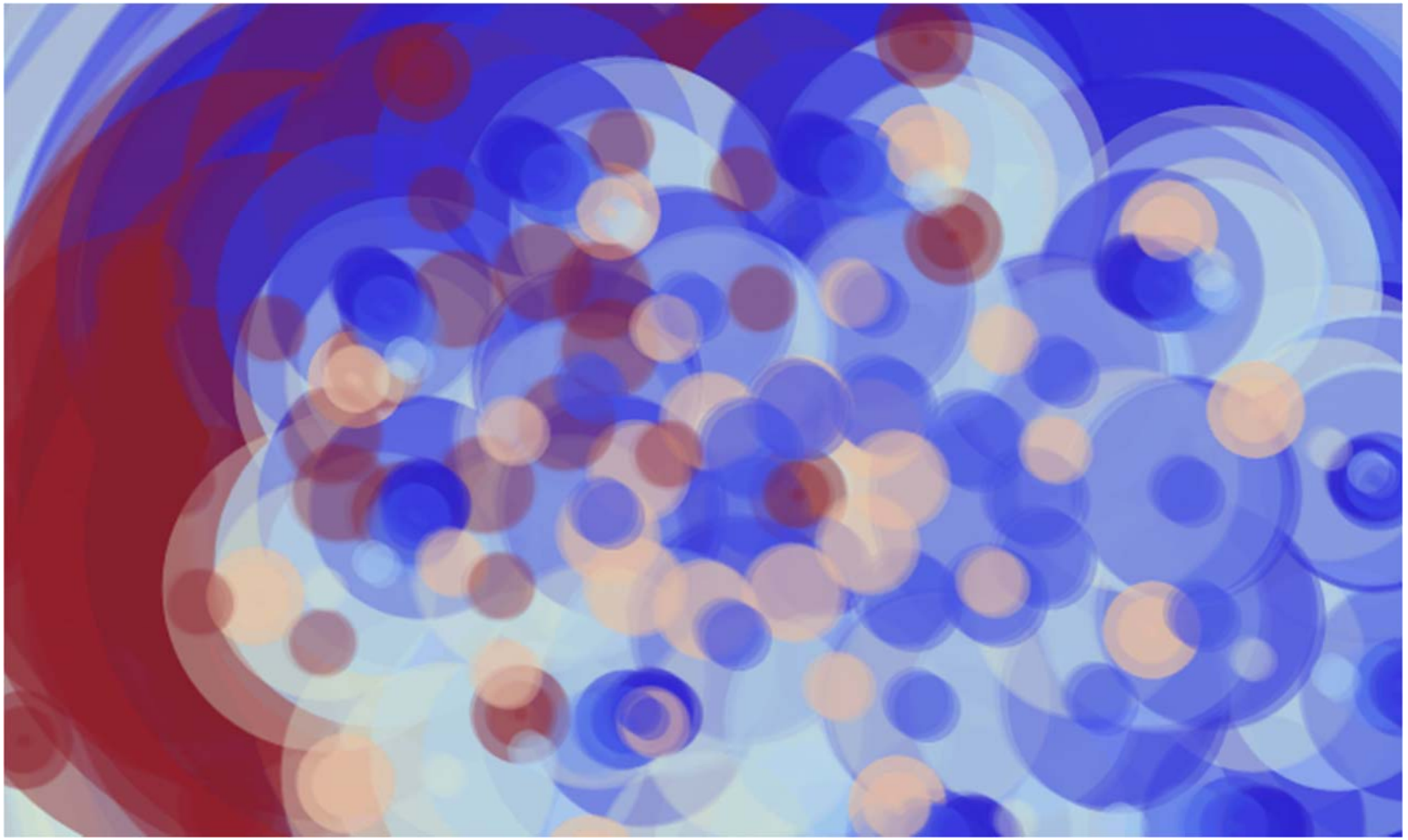

End

Dark Current Tracking

$$I_{\mathrm{FN}}(E_{\perp}) = a_0 A_{\mathrm{FN}} (\beta_{\mathrm{FN}} E_{\perp})^2 \exp\left(-\frac{a_1}{\beta_{\mathrm{FN}} E_{\perp}}\right) \qquad Q_n = N_A \cdot A_n \cdot \frac{\Delta\phi_{\mathrm{n}}}{2\pi f_{\mathrm{rf}}} \cdot I_{\mathrm{FN}}(E_{\perp}(t_n))$$