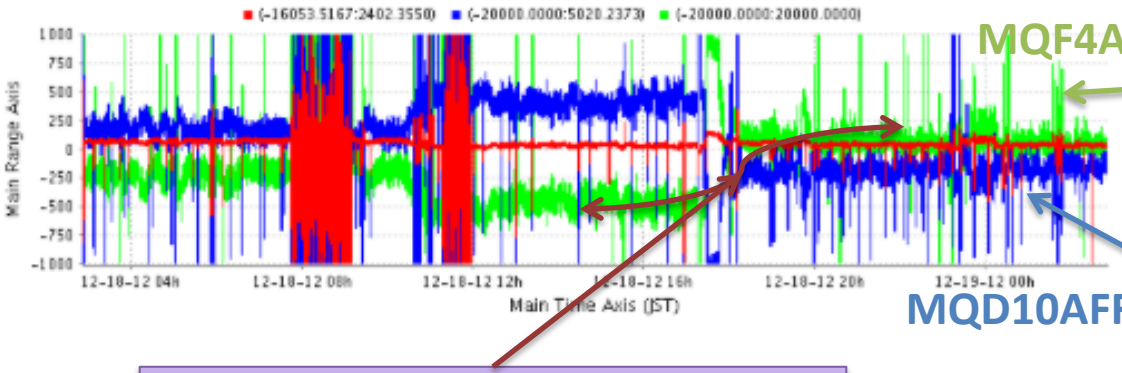
BPM Orbit Data Analysis with Wakefields

Glen White, SLAC

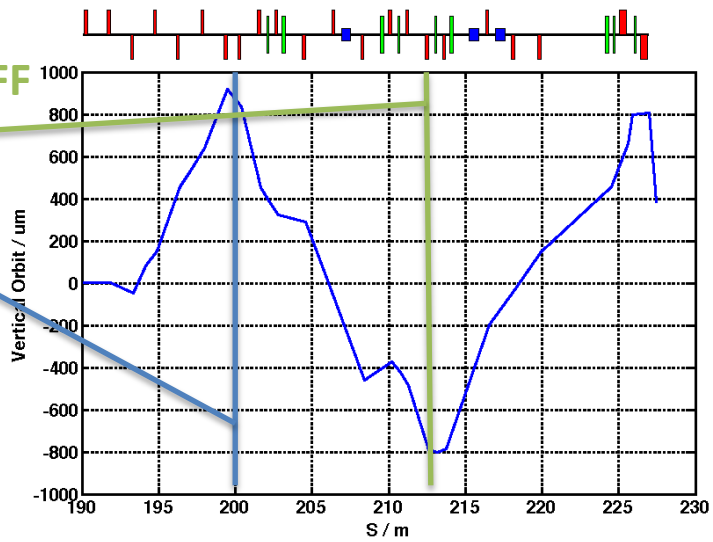
January 2013

FFS Orbit Stability



MQF4AFF

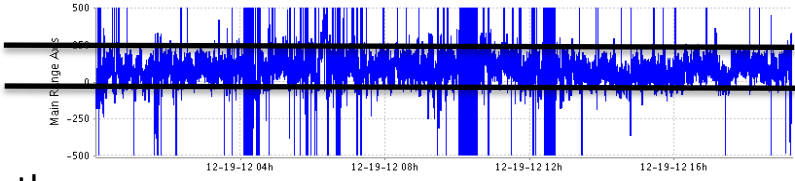
MQD10AFF



0.2M -> 0.4M (250nm -> 200nm)

- Swing shift 12/18 orbit changed by moving MQM16FF 60um vertically.
- Beam size improved by 50nm
  - 30nm due to change in oribit in FFS sextupoles
  - Rest due to wakefields?
- Orbit seen to drift around vertically in FFS with this pattern.
  - From simulation, tolerance for this is +/- 150um at the MQF4AFF/MQD10AFF beta peaks -> ~2nm beam size growth
  - Drift with EXT/FFS feedback active is observed to be less than this so OK.
  - This tolerance drops to 70um when including cavity wakes at 1E10 charge, and 125um at 1E9 charge.

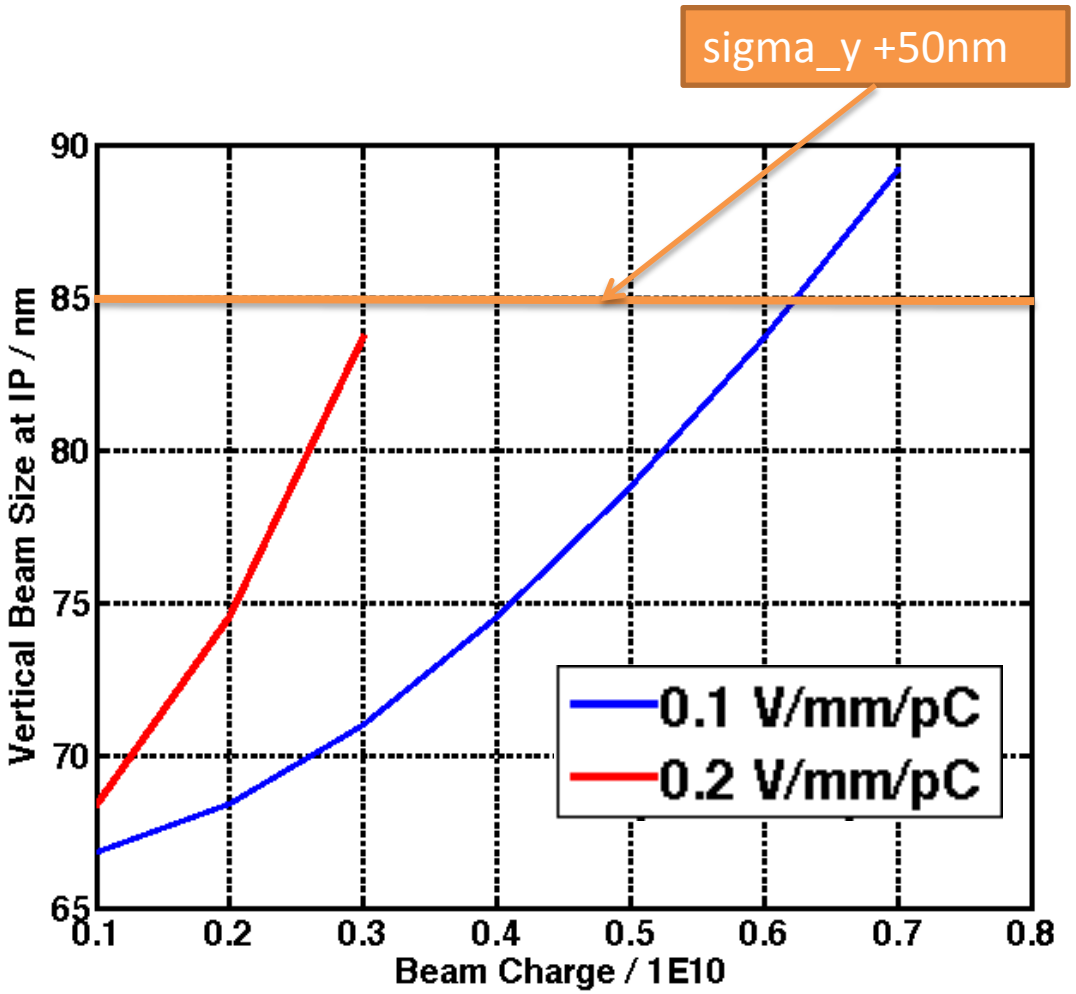
In model, this orbit generates 30nm beam size growth at IP due to change in vertical orbit in sextupoles



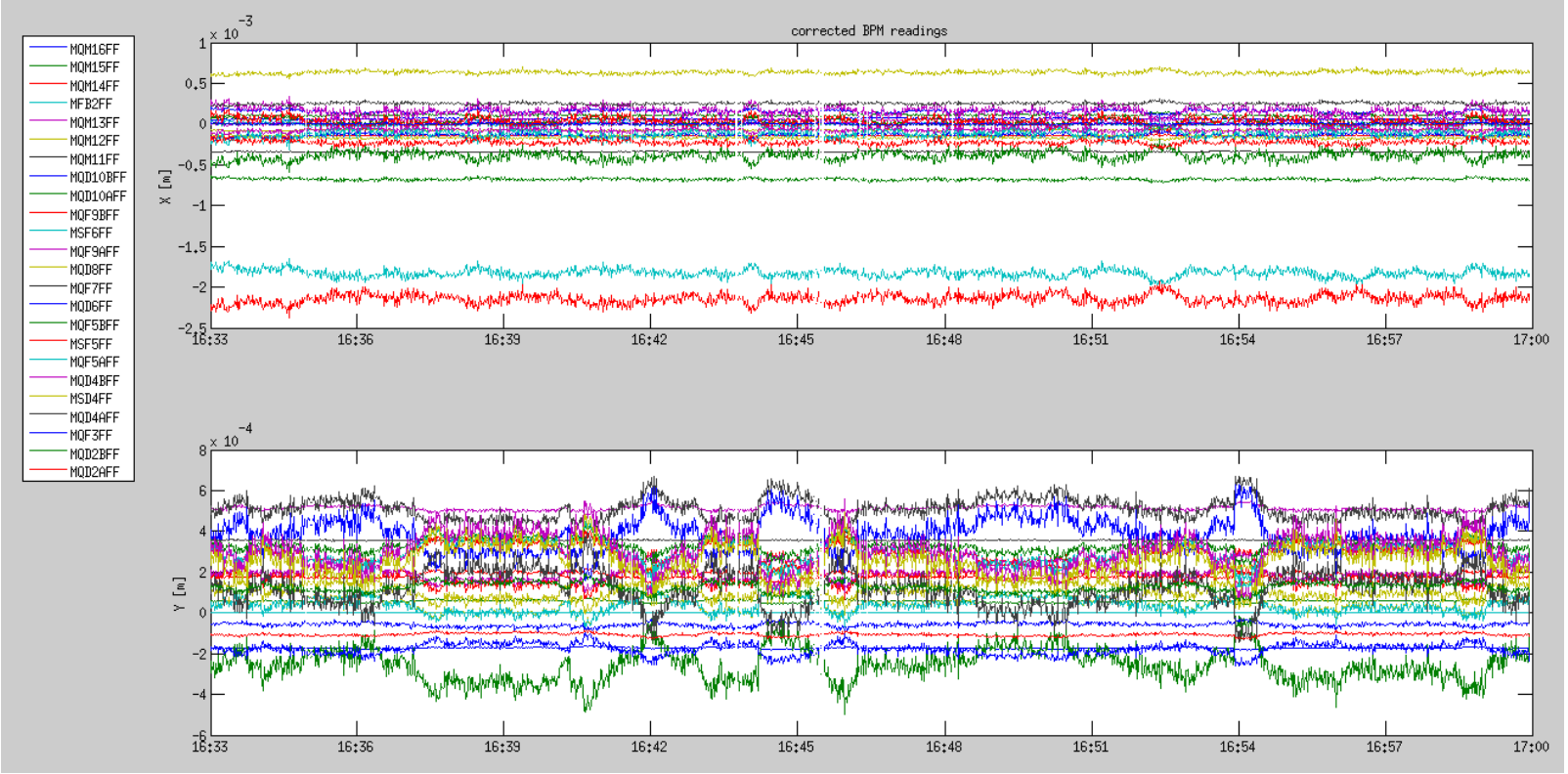
+/- 125um at MQD10AFF over 12 hours

Simulate FFS Orbit Offset

- Beam size at IP from tracking simulation.
- Start perfect lattice, offset QM16FF by 60um.
- Include 0.1V/mm/pC wake in cavities.

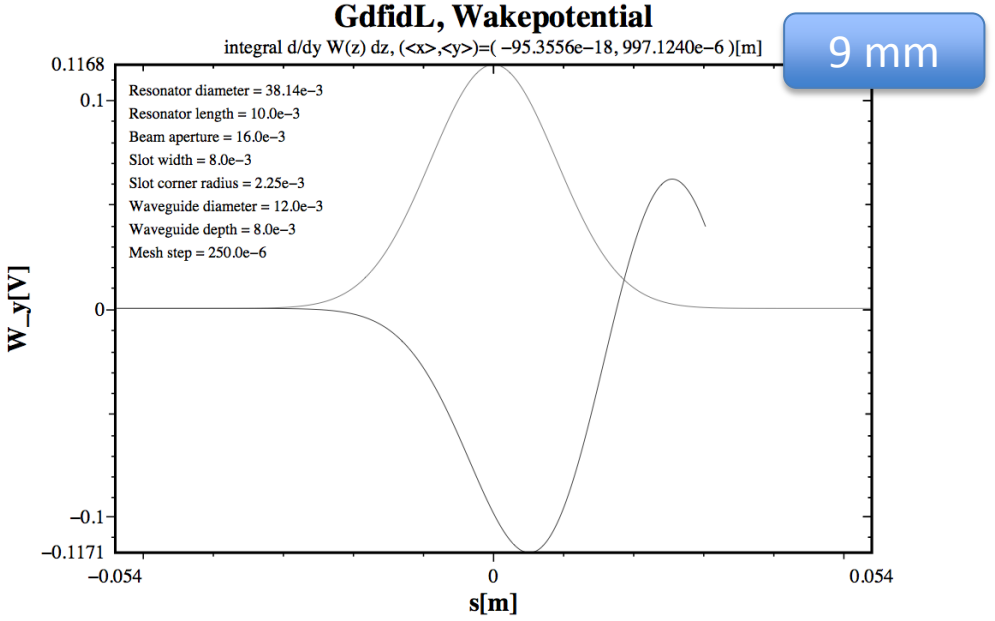


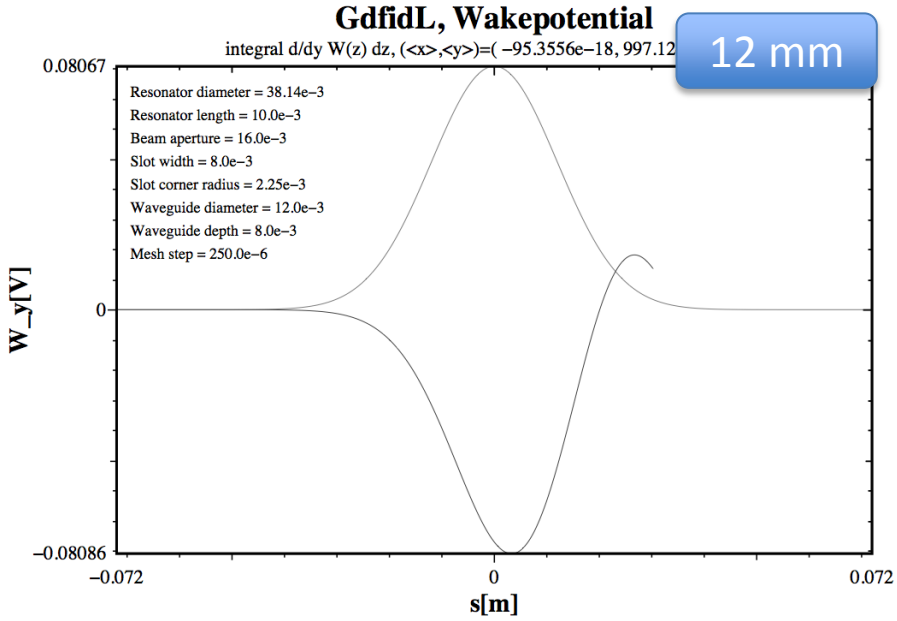
BPM Orbit With Respect to BPM Centres



- 30 mins data taken from Friday Dec 21 archive.
  - (Data archived at 1Hz)
- Charge cuts applied based on reference cavity data.

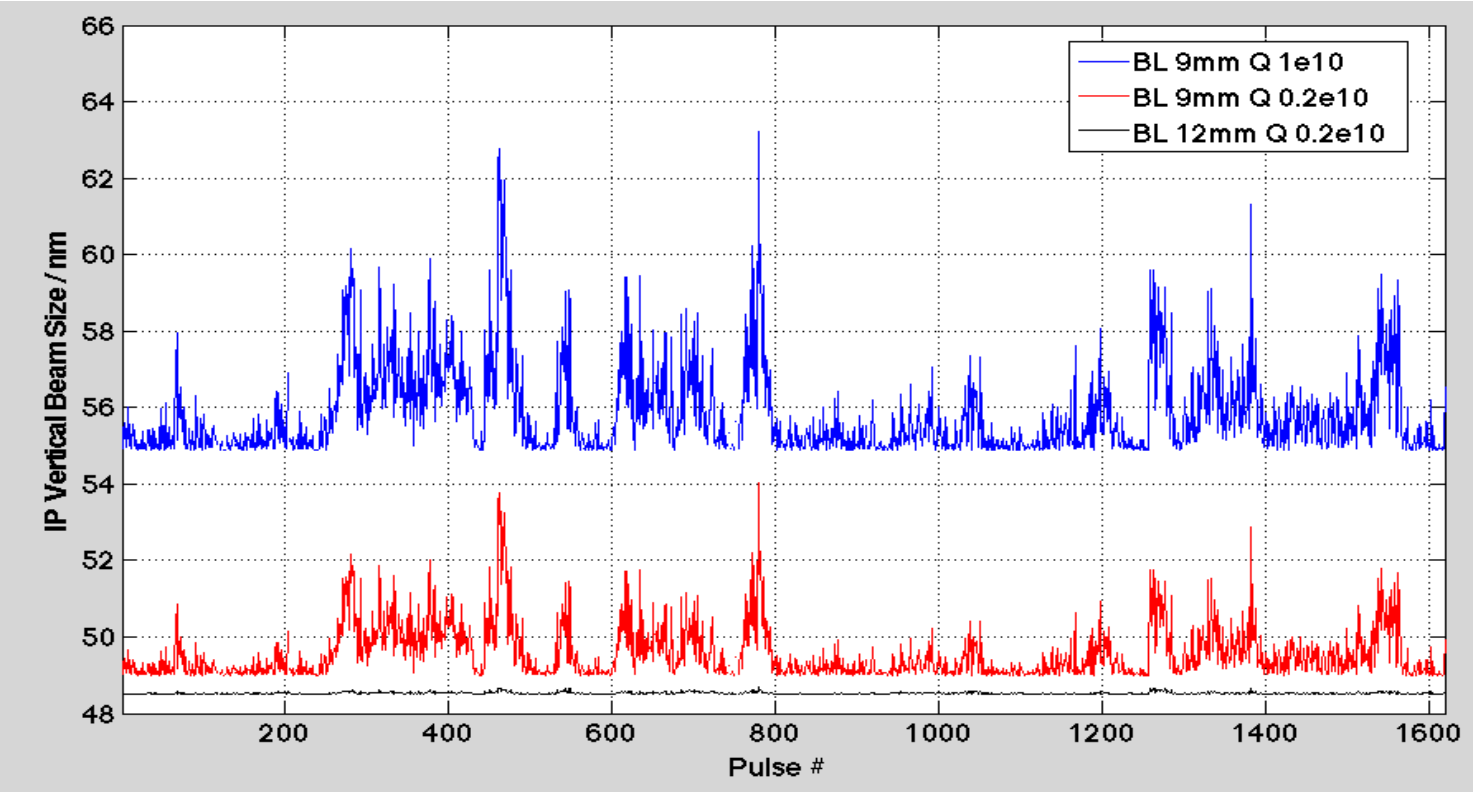
Simulate Wakefield Effect on IP Beam Size





- Using cavity wakes calculated by A. Lyapin for 9 and 12 mm
- Track 2E4 macro-particle bunch through FFS, apply convoluted wake function at each cavity BPM location using measured BPM offset. Record IP vertical spot size for each pulse.
- Beamline is otherwise perfect, using 24pm input beam vertical emittance.

IP Beam Size from Cavity Wakes



- Used double wake potential (peak ~0.2 V/pC/mm)
- Design beam charge (1E10)
- With December conditions (Bunch length ~12mm?, 1E9 charge), effect is negligible

Emittance in EXT

- Q=3E9
  - 1.9nm x 30pm
- Q=1E9
  - 1.4nm x 20pm
- @IP
  - 44nm -> 54nm
- No EXT emittance change observed with DR RF V

Horizontal projected emittance parameters at first OTR

energy	=	1.2690	GeV	
emit	=	1.8721 +-	0.0145	nm
emitn	=	4649.0634 +-	35.9473	nm
emit*bmag	=	1.9647 +-	0.0251	nm
bmag	=	1.0495 +-	0.0081	(1.0000)
bmag_cos	=	-0.2113 +-	0.0000	(0.0000)
bmag_sin	=	0.2178 +-	0.0000	(0.0000)
beta	=	5.2190 +-	0.0464	m (6.3052)
alpha	=	-3.4915 +-	0.0299	(-4.4943)
chisq/N	=	23.3655		

Horizontal projected emittance parameters at IP

sig	=	32.2819 +-	0.4708	um (8.6422)
sigp	=	226.7201 +-	2.5252	ur (216.6846)
beta	=	556.6579 +-	17.3926	mm (39.8952)
alpha	=	-3.7794 +-	0.1114	(-0.0238)

Horizontal projected emittance parameters at waist

L	=	-0.1376 +-	0.0008	m
beta	=	36.4209 +-	0.8749	mm
sig	=	8.2573 +-	0.1151	um

Vertical projected emittance parameters at first OTR

energy	=	1.2690	GeV	
emit	=	30.0855 +-	0.7682	pm
emitn	=	74.7126 +-	1.9077	nm
emit*bmag	=	30.3844 +-	0.6406	pm
bmag	=	1.0099 +-	0.0071	(1.0000)
bmag_cos	=	0.0034 +-	0.0000	(0.0000)
bmag_sin	=	-0.1399 +-	0.0000	(0.0000)
beta	=	6.2729 +-	0.1290	m (6.1903)
alpha	=	2.4694 +-	0.0745	(2.5763)
chisq/N	=	7.4851		

Vertical projected emittance parameters at IP

sig	=	3.7743 +-	0.0949	um (0.0550)
sigp	=	525.6568 +-	0.4376	ur (546.8062)
beta	=	473.4091 +-	14.6192	mm (0.1006)
alpha	=	-65.9370 +-	2.0664	(0.0019)

Vertical projected emittance parameters at waist

L	=	-0.0072 +-	0.0000	m
beta	=	0.1069 +-	0.0035	mm
sig	=	0.0572 +-	0.0008	um