Bunch Length Measurements

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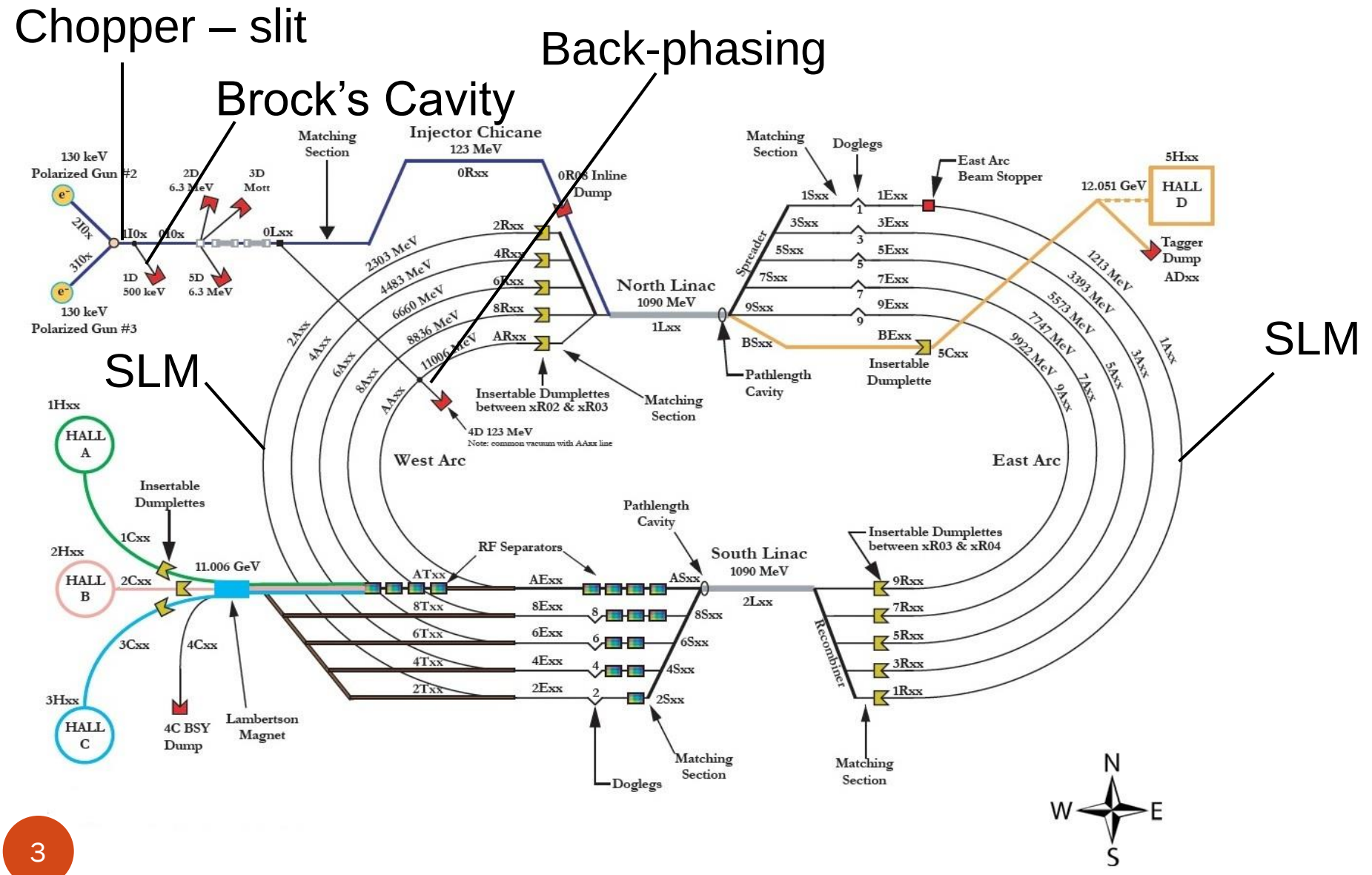
Stay treat, July 16, 2015

Jefferson Lab

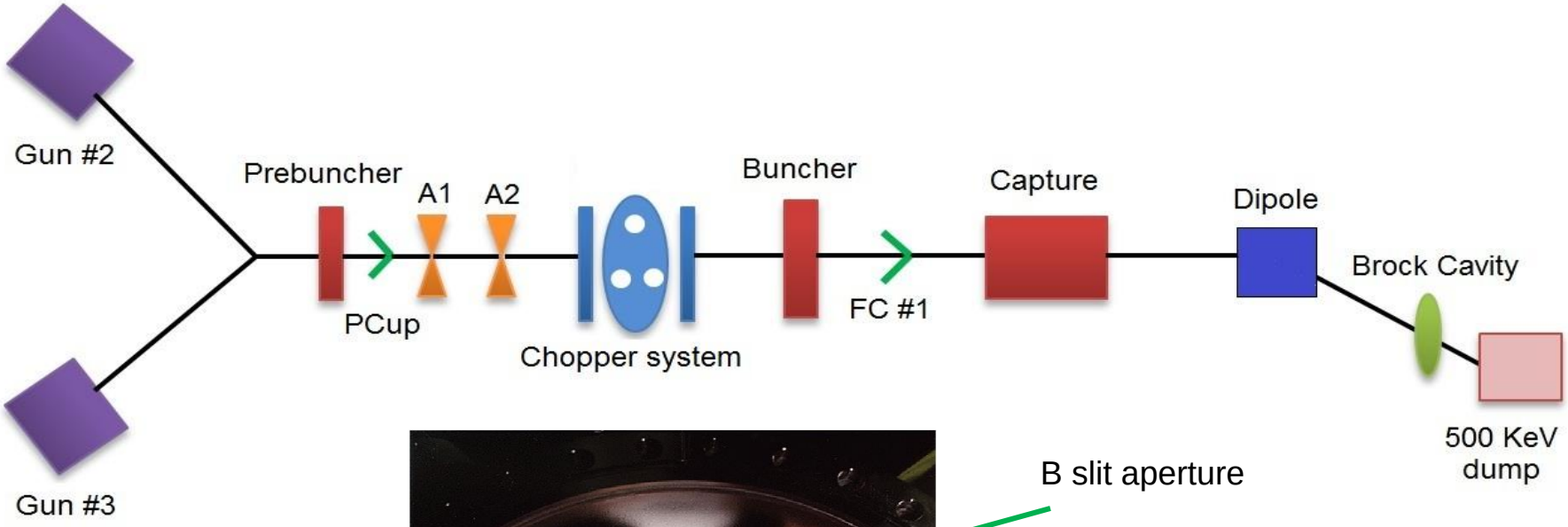
Outline

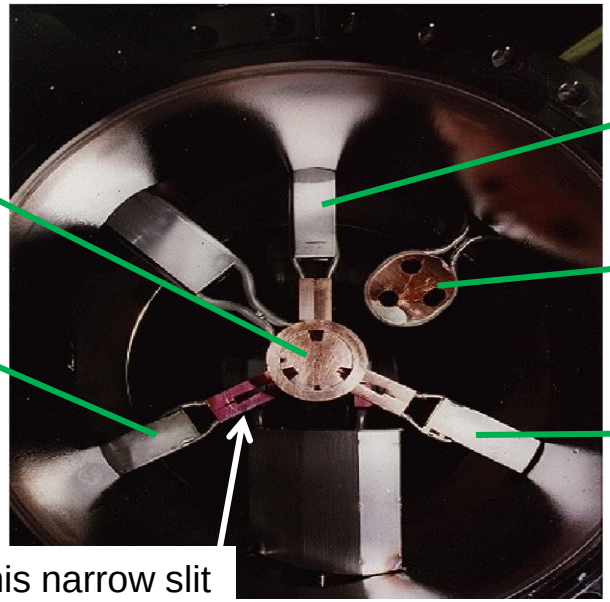
- Locations for bunch length measurements
- Slit - scan measurements
- Brock’s cavity measurements
- Back-phasing measurements
- SLM measurements
- Results summary

Bunch length locations

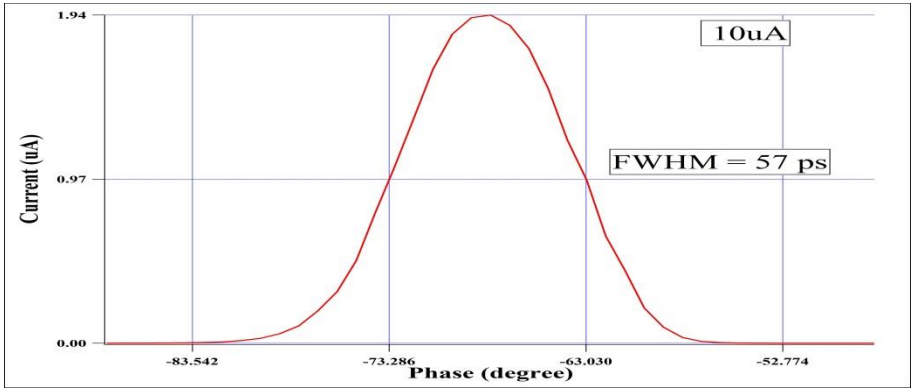


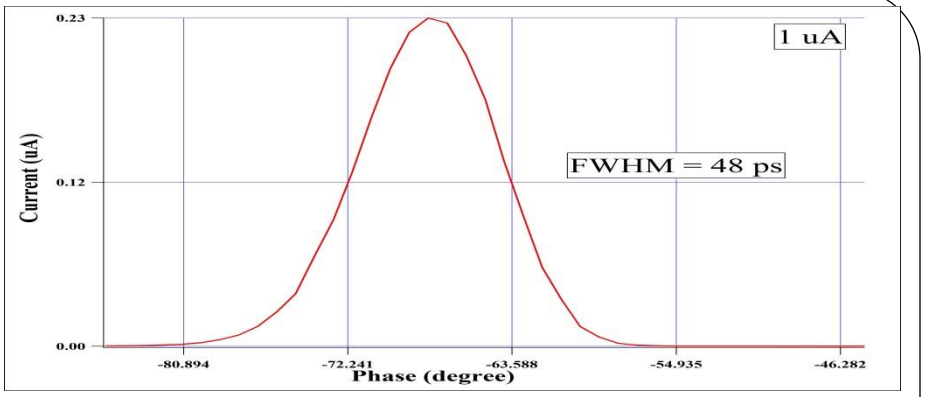
1- Slit – scan

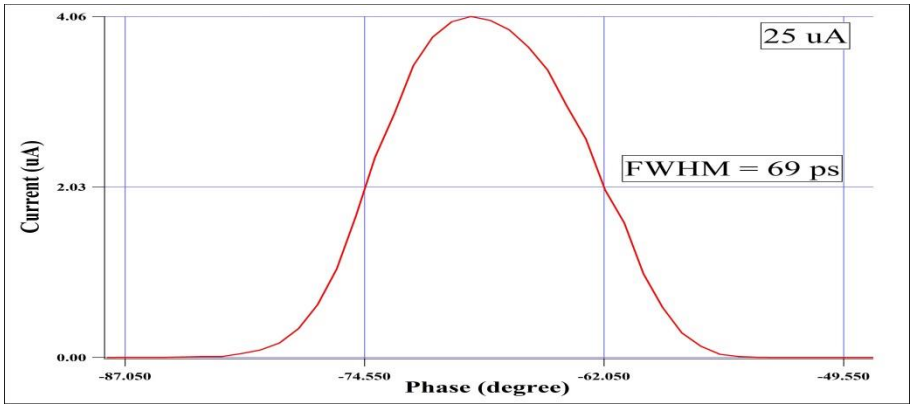


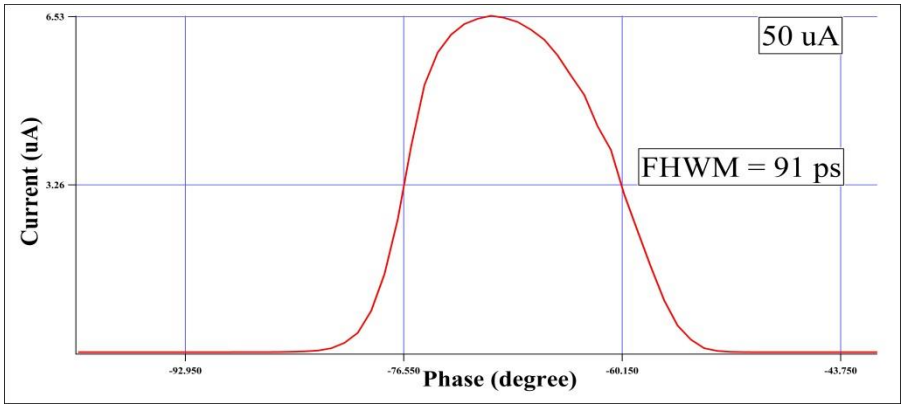


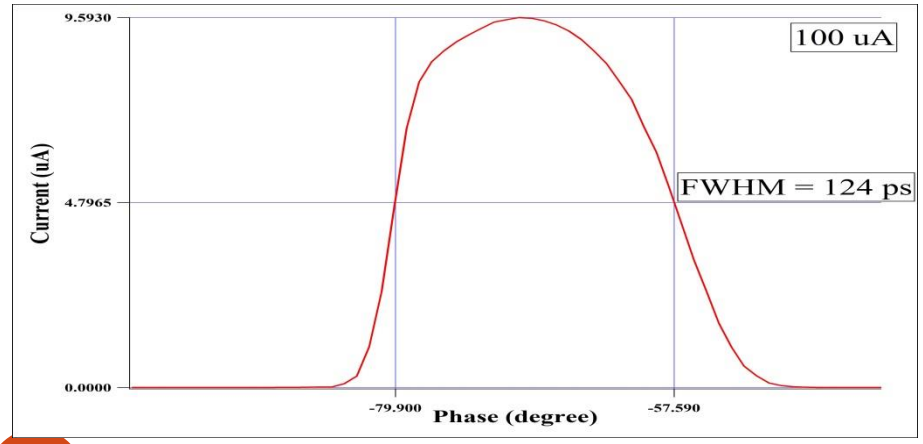
FROM TECHNOTE: BEAM BASED DIAGNOSTIC TESTS THAT INDICATE A POSSIBLE CHOPPING APERTURE MISALIGNMENT
J. Grames, M. Baylac, M. Poelker, M. Stutzman .

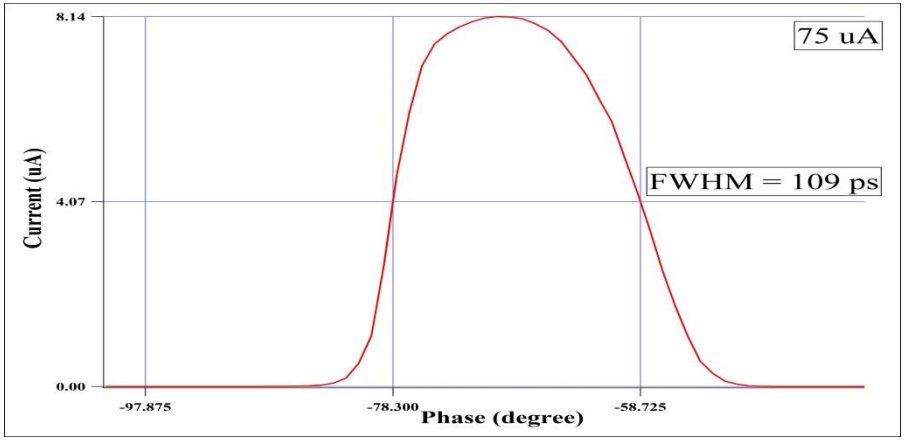








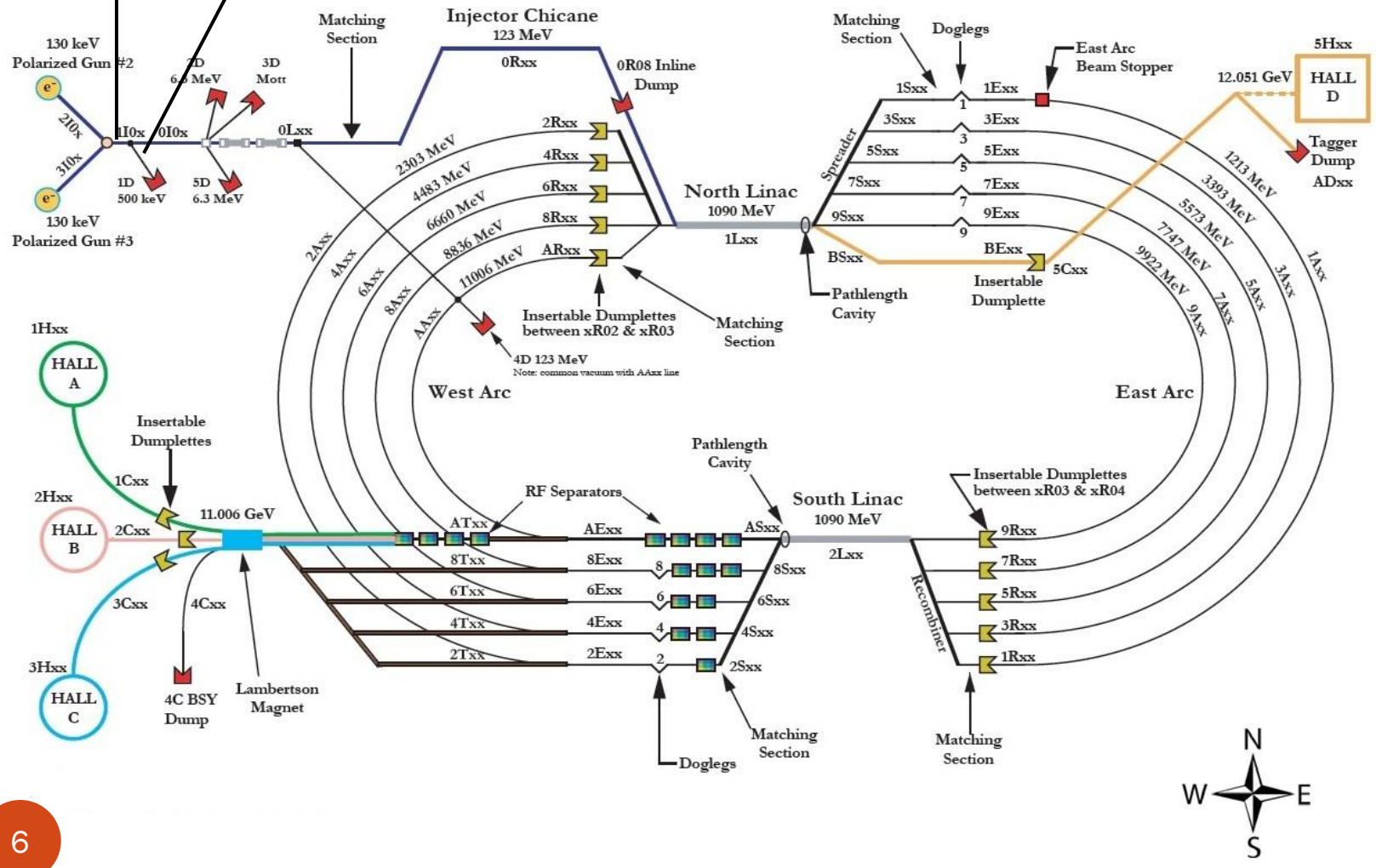




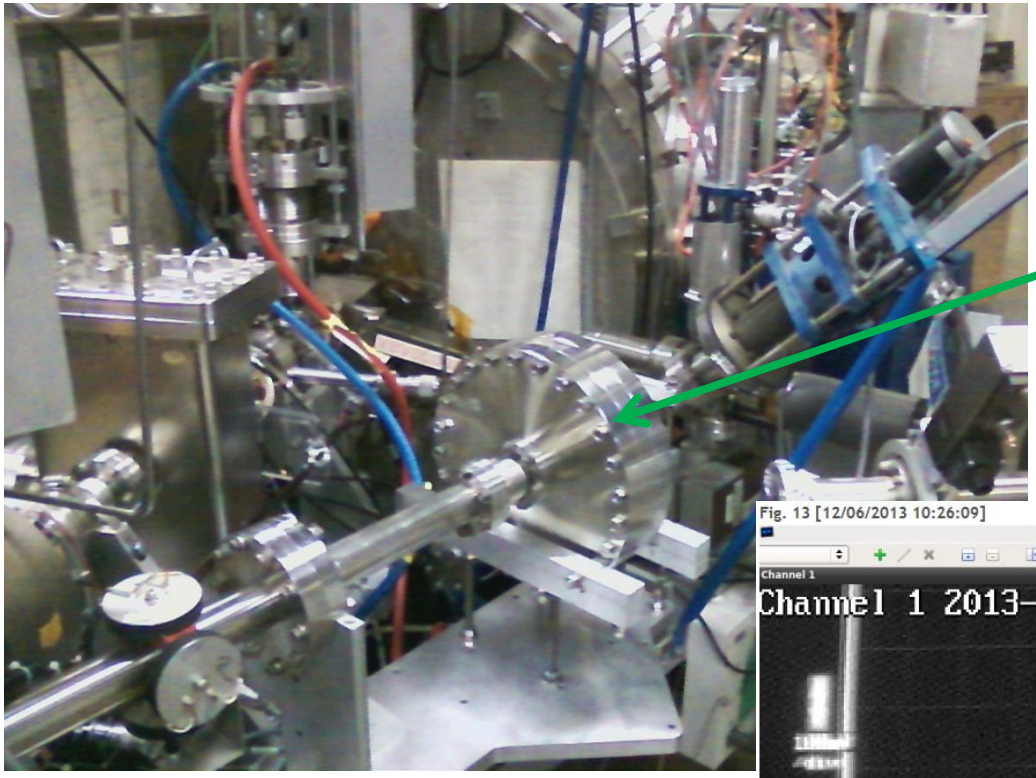
360(degree) : 2004(ps) → unit of length (m) = ps x $3*10^8$

Chopper – slit

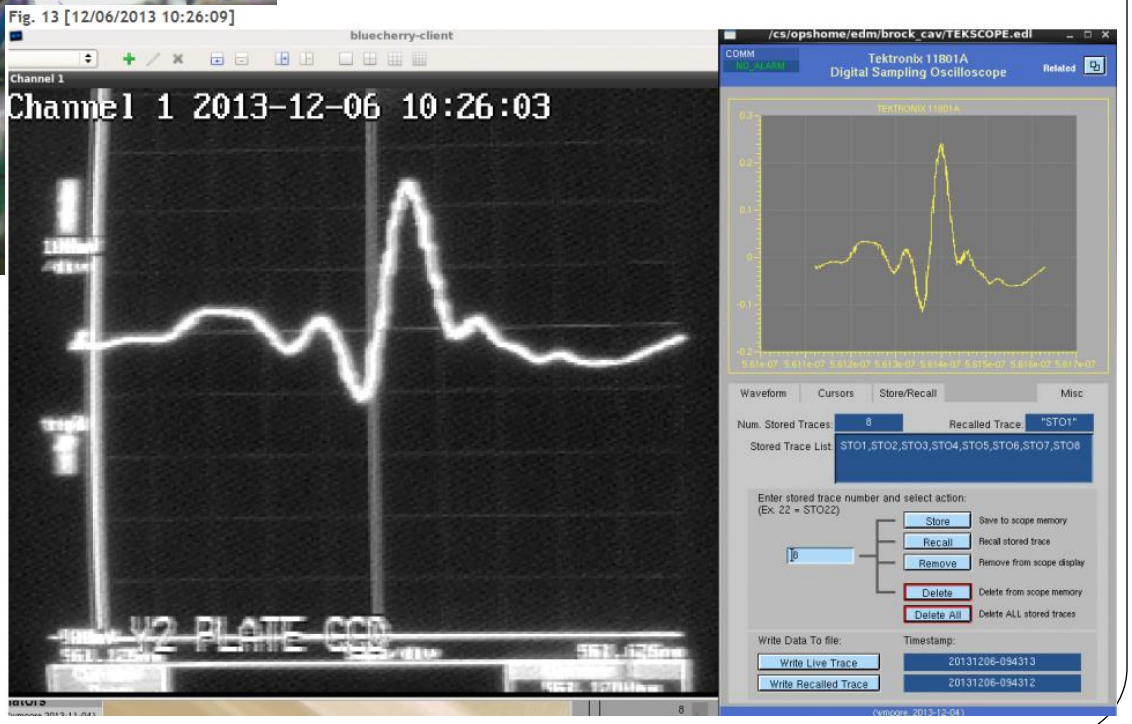
Brock's Cavity



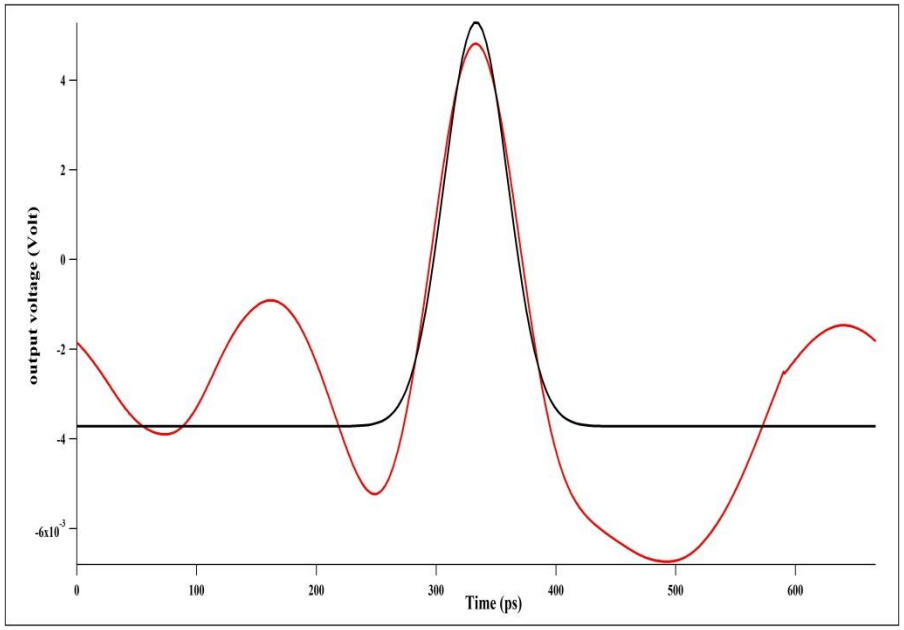
2- Brock's Cavity

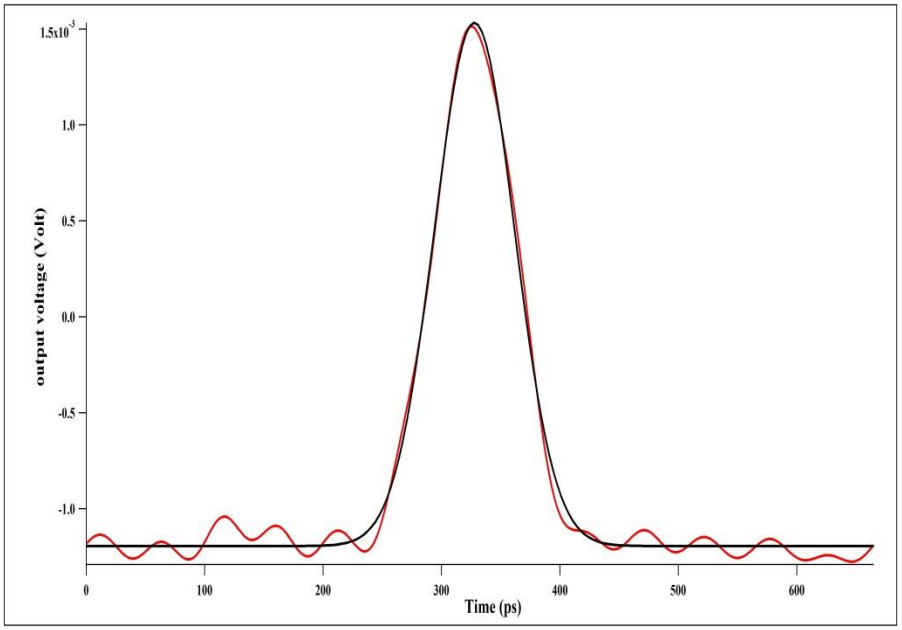


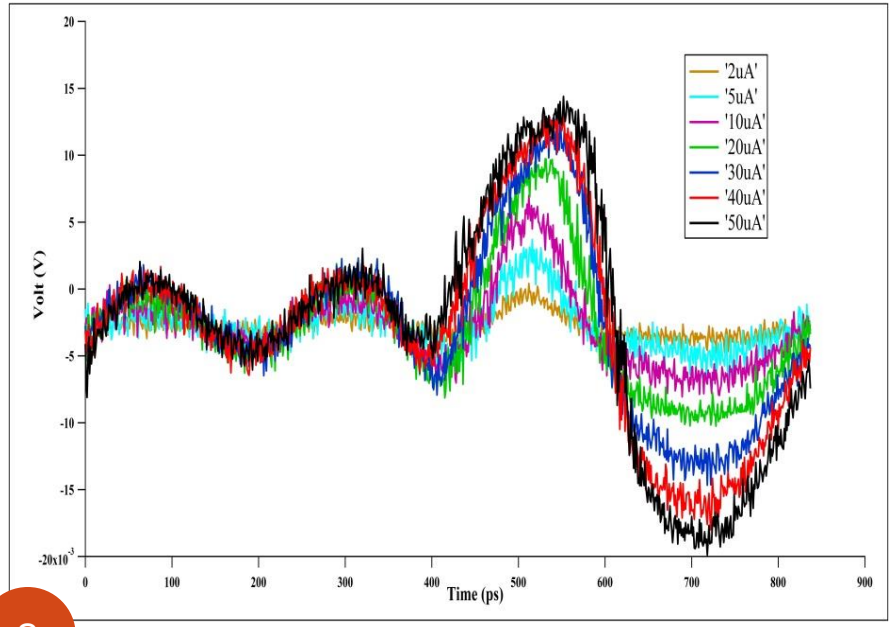
Cavity in the 1D line, aka "500keV spectrometer line"

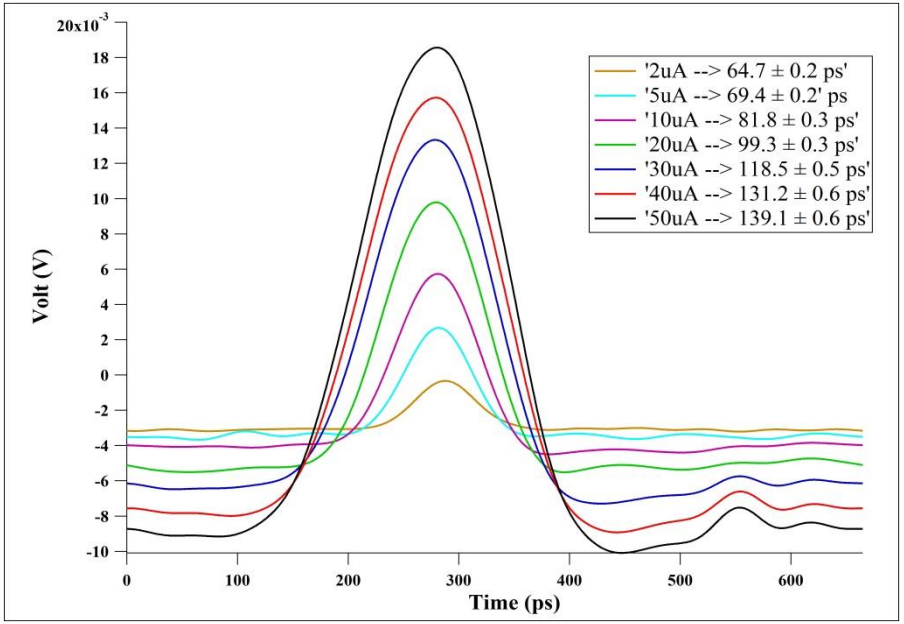


It works! Fast oscilloscope trace of 500kV beam through cavity. But what are the "wiggles"?


output voltage (Volt)
Time (ps)


output voltage (Volt)
Time (ps)

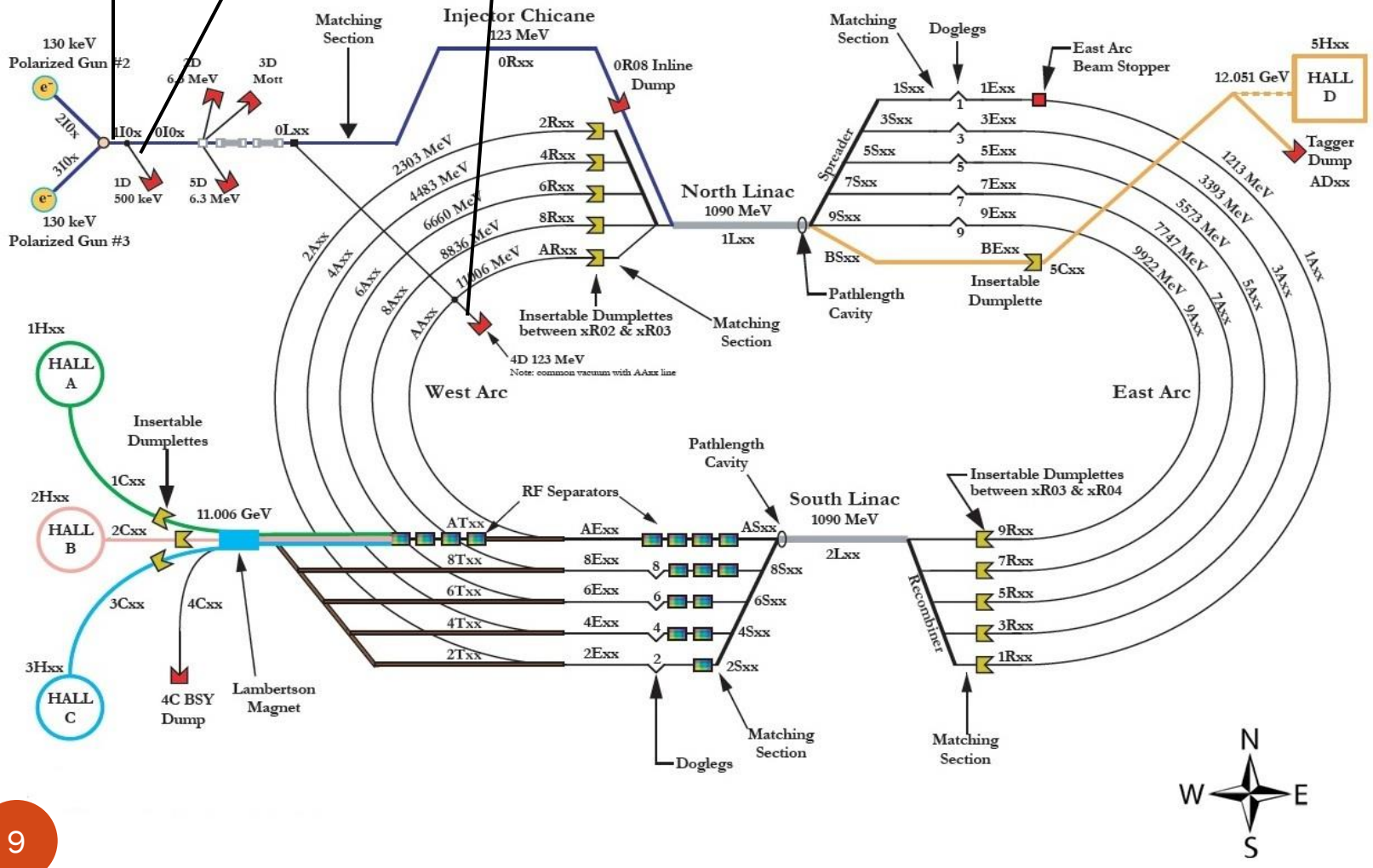

'2uA'
'5uA'
'10uA'
'20uA'
'30uA'
'40uA'
'50uA'
Volt (V)
Time (ps)


'2uA --> 64.7 ± 0.2 ps'
'5uA --> 69.4 ± 0.2' ps
'10uA --> 81.8 ± 0.3 ps'
'20uA --> 99.3 ± 0.3 ps'
'30uA --> 118.5 ± 0.5 ps'
'40uA --> 131.2 ± 0.6 ps'
'50uA --> 139.1 ± 0.6 ps'
Volt (V)
Time (ps)

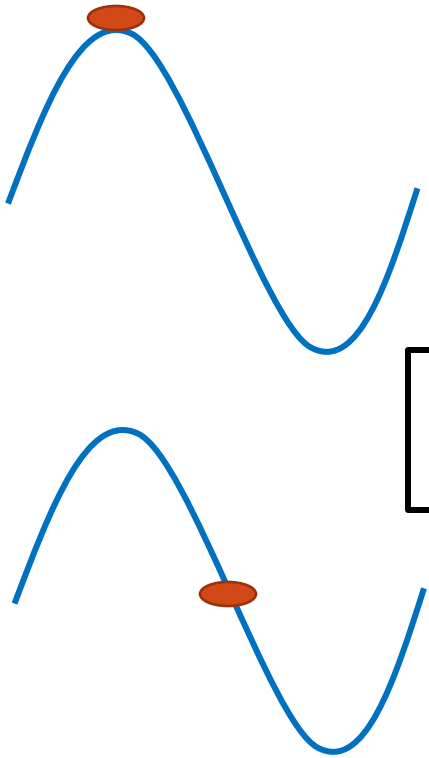
Chopper – slit

Brock's Cavity

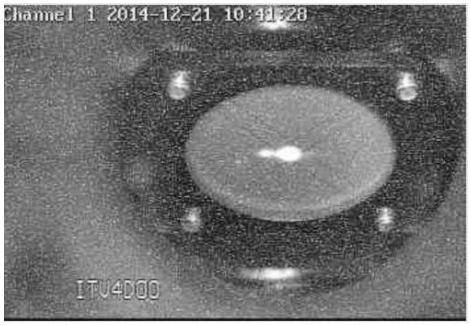
Back-phasing

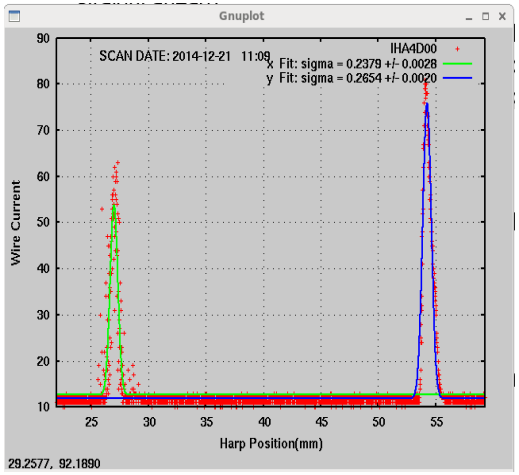


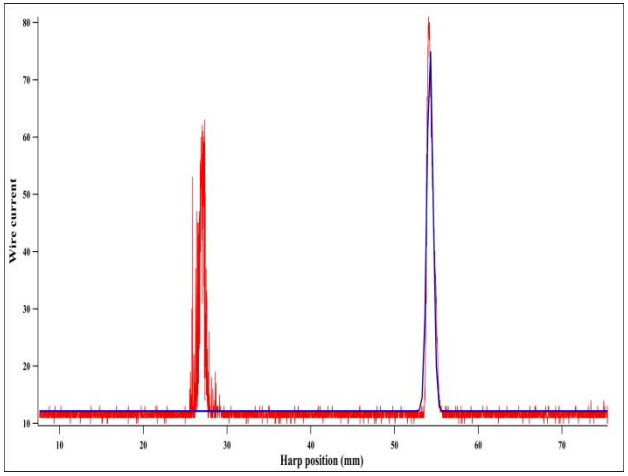
3- Back-phasing

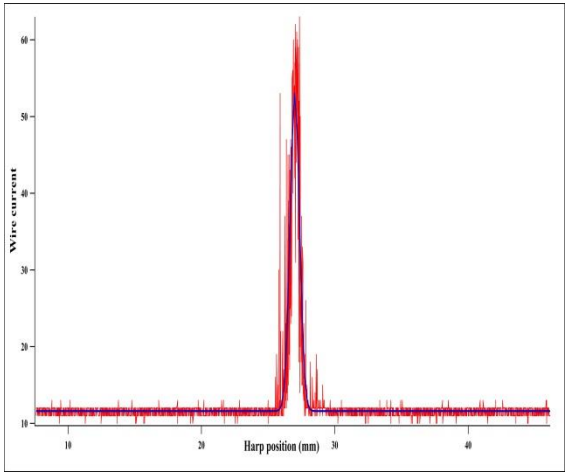


Dipole

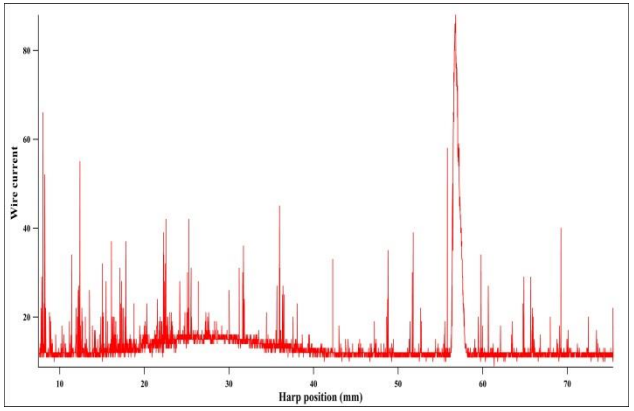


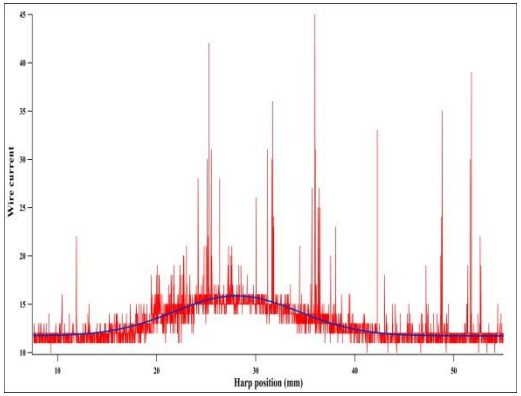


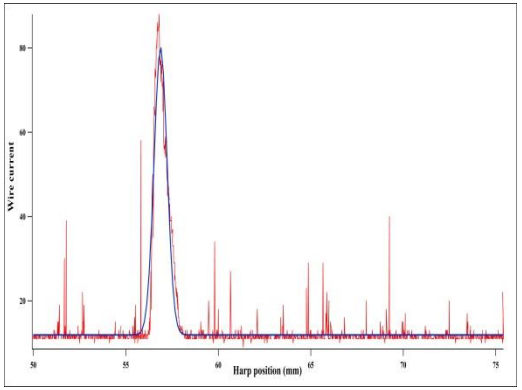




Harp scan when bunch is on crest







Harp scan when bunch is +90 off crest

Results

$$B.L\ (degrees) = \frac{180}{\pi}\left[\frac{B_+(X_+ - X_0)}{D(B_0 - B_+)}\right]$$

X_0 : Horizontal displacement at crest
X_+ : Horizontal displacement at +90 off crest
B_0 : Magnetic field at crest
B_+ : Magnetic field at +90 off crest
D : Dispersion

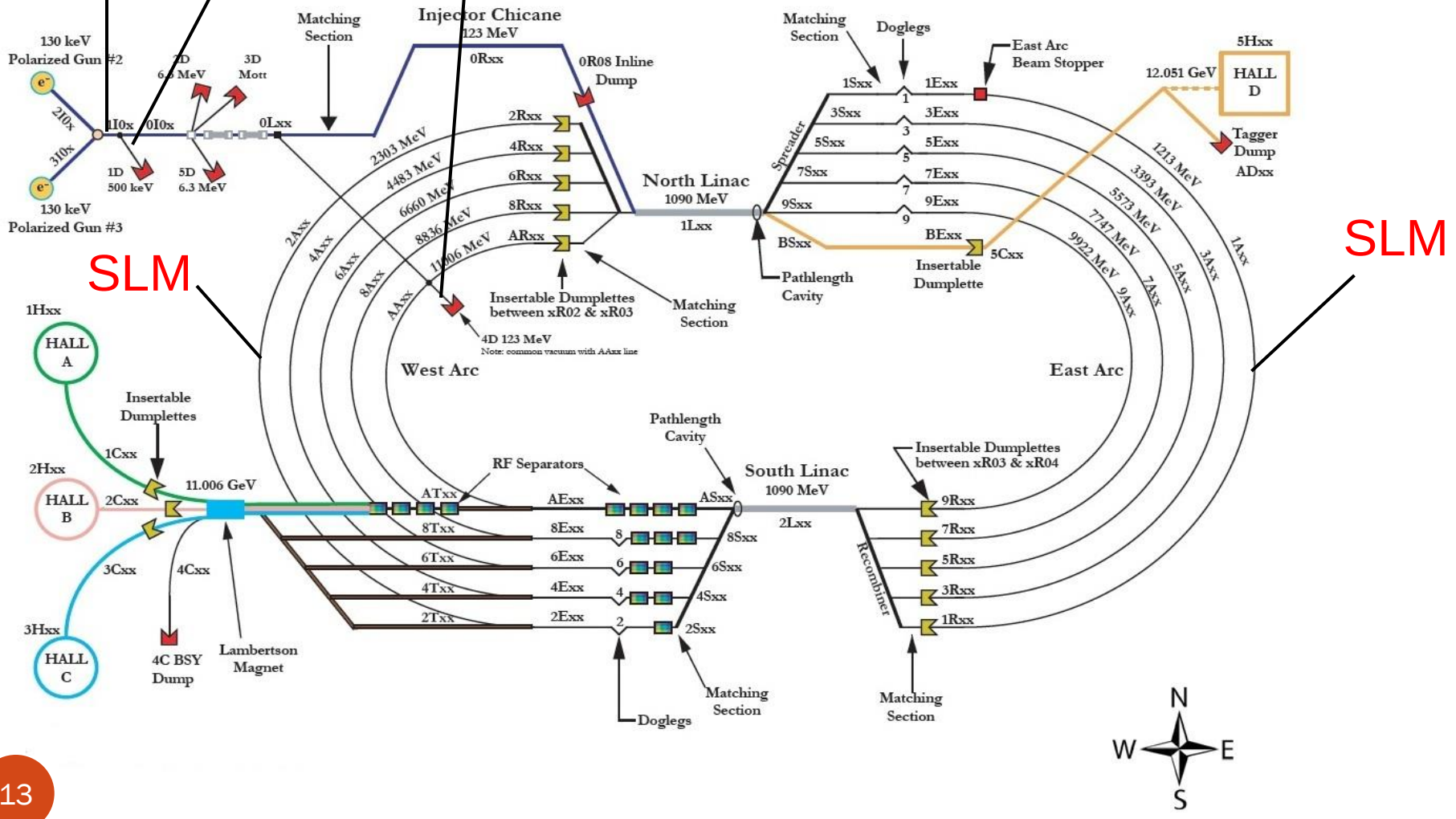
	Sigma X (cm)	Sigma Y (cm)	Bdl (T.cm)
On crest	0.026 ± 0.001	0.025 ± 0.001	148873.875
+90 off crest	0.444 ± 0.014	0.025 ± 0.001	93523.875

Bunch length (rms) = 86.5 ± 2.9 um

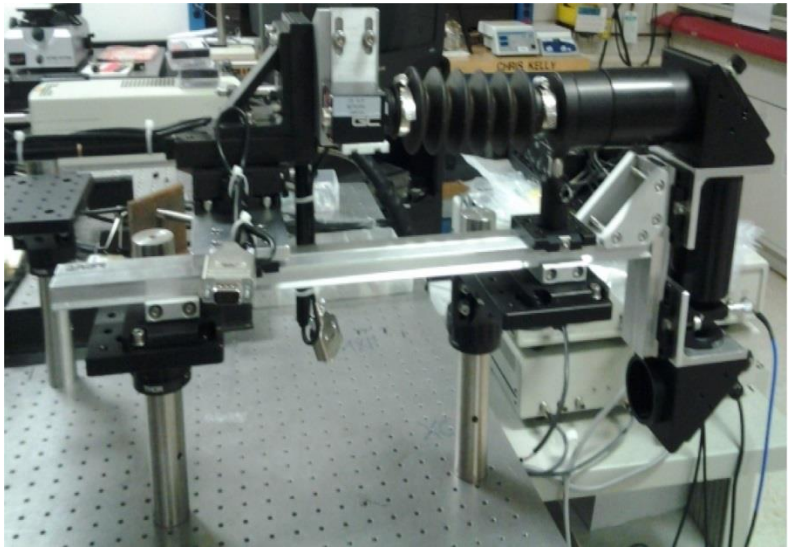
Chopper – slit

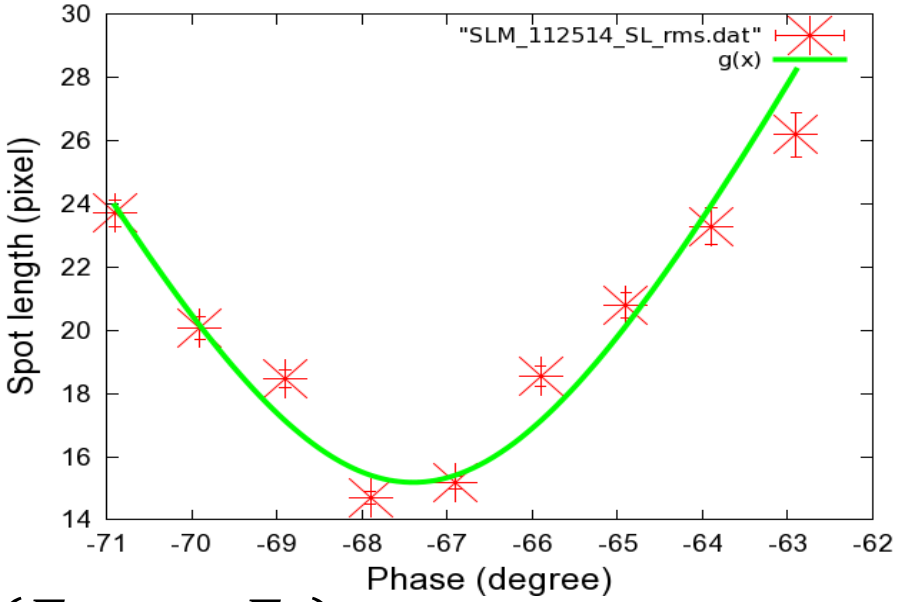
Brock's Cavity

Back-phasing



4- Synchrotron Light Monitor

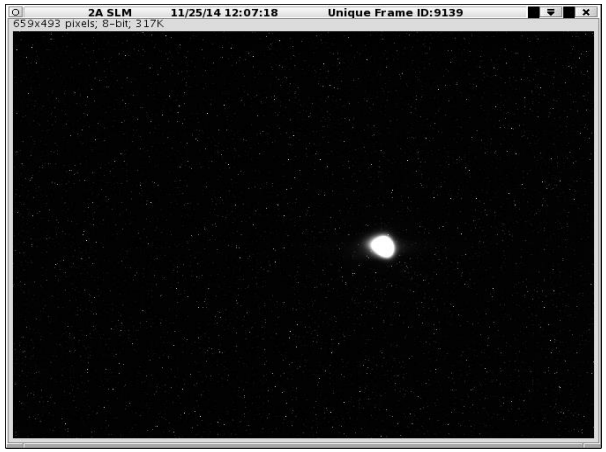


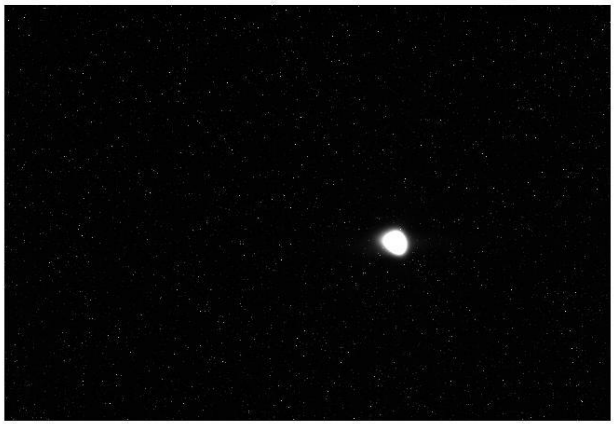


$$B.L = \frac{b * (E_{inj} + E_L)}{\eta_x E_L k}$$

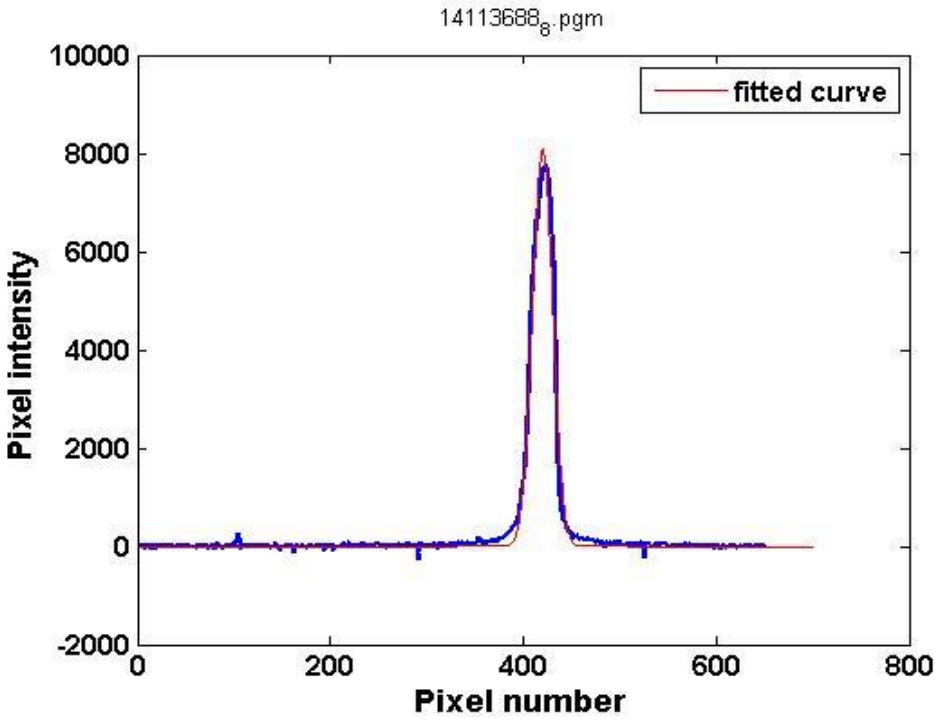
Where b : is the slope of the hyperbola, E_{inj}: is the injector energy (MeV), E_L: is the linac energy (MeV), η_x: is the dispersion (cm) and k: is the wave number (cm $^{-1}$)

Image processing



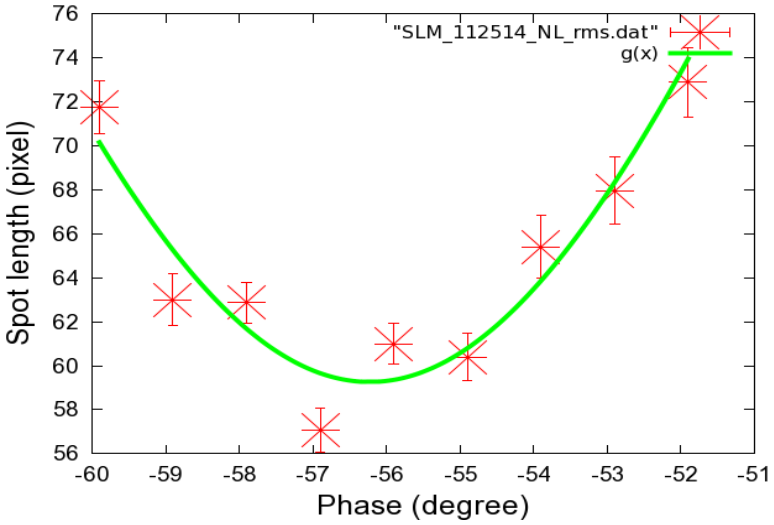


Spot at SLM1 for NL gang phase = -67.9
before and after frame removing

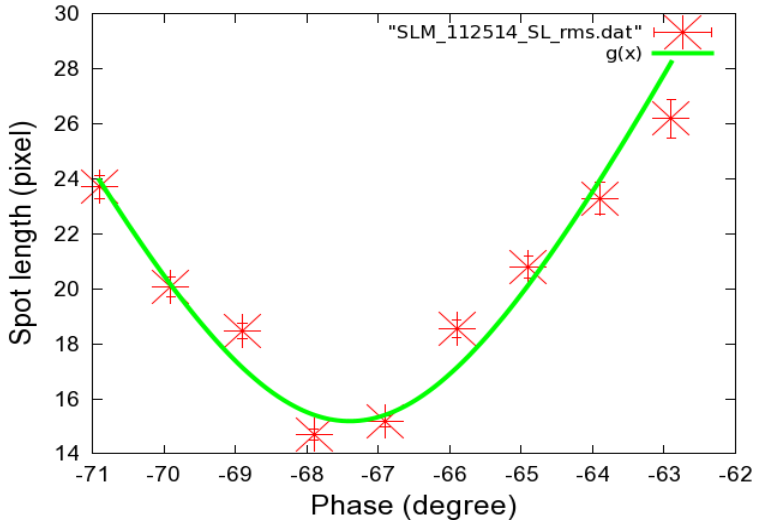


Gaussian fitting for the same spot after subtracting the back ground and applying a horizontal projection

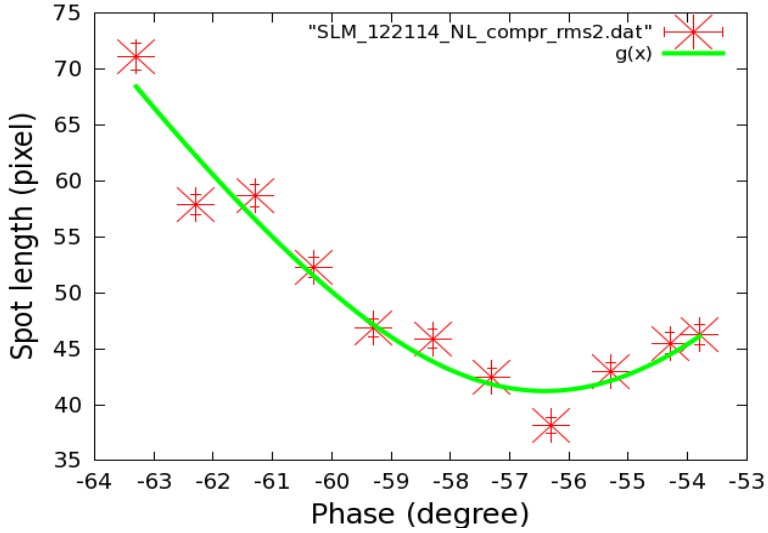
Results



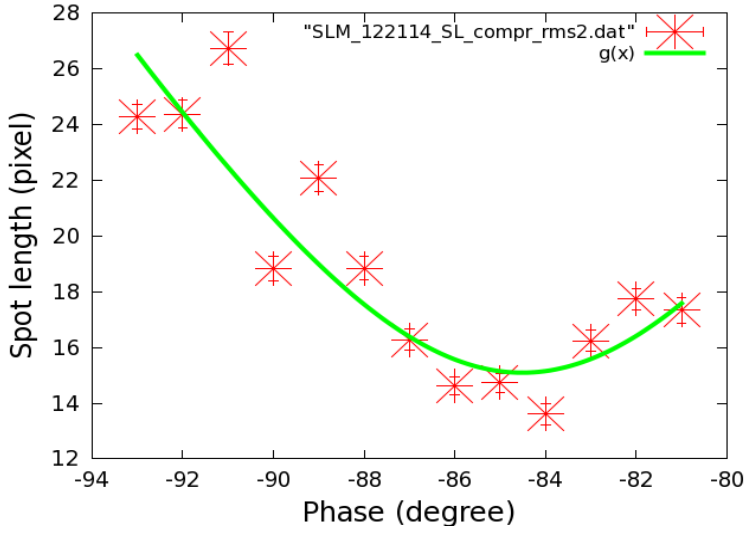
B.L = (91.4 ± 6.5) um



B.L = (112.8 ± 5.8) um



B.L = (46.1 ± 3.5) um



B.L = (42.5 ± 5.1) um

B.L evolution summary

Technique	Location	Beam Energy	Measured B.L (rms)	Estimated B.L (rms)
Slit - Scan	Chopper chamber	130 KeV	16.2 ± 0.1 mm	17.1 mm (GPT)
Brock	1D dump	130 KeV	24.5 ± 0.1 mm	19.1 mm (GPT)
Back-phasing	4D dump	102 MeV	86.5 ± 2.9 um	60 um (Krafft et al.)*
SLM 1 compress	ARC 1	1052 MeV	91.4 ± 6.5 um 46.1 ± 3.5 um	 56 um **
SLM2 compress	ARC 2	2002 MeV	112.8 ± 5.8 42.5 ± 5.1 um	 56 um **

* Measuring and controlling energy spread in CEBAF

** Optimization of M56 in the CEBAF injector

Which one is the best ?

Technique	Beam Energy	Estimated operation time	Reliability	Accuracy
Slit - Scan	130 KeV	45 – 90 min	Very Good	Excellent
Brock	130 KeV	1 min	Excellent	Good
Back-phasing	102 MeV	60 - 90 min	Very Good	Excellent
SLM 1	1052 MeV	15 – 30 min	Very Good	Very Good
SLM 2	2002 MeV	15 - 30 min	Very Good	Very Good

Special Thanks

Michael Tiefenback

Matthew Poelker

Arne Freyberger

Geoff Krafft

Alicia Hofler

Thank you