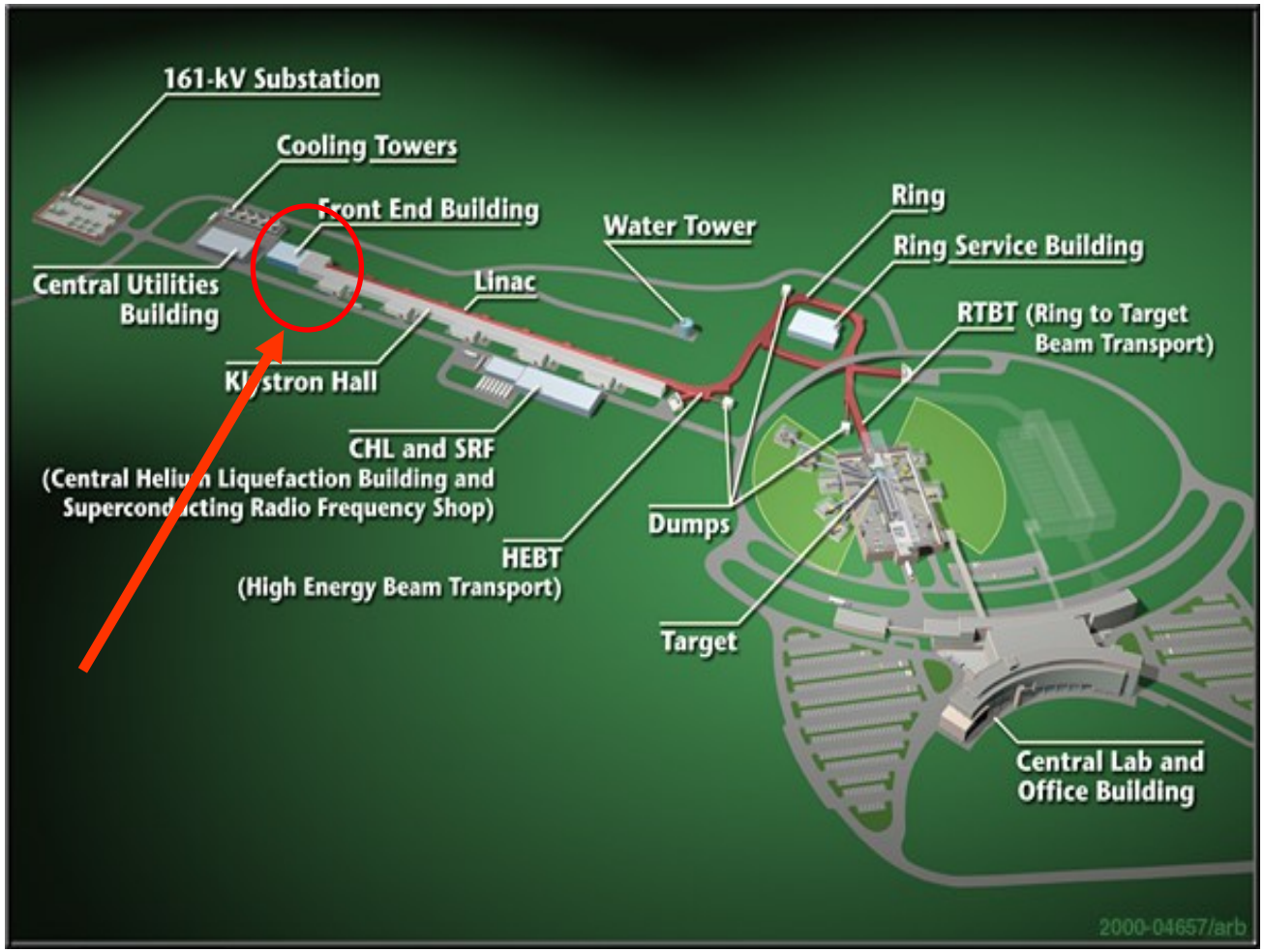
Results From the Initial Operations of the SNS Front End and Drift Tube Linac

A. Aleksandrov

for the SNS collaboration

Introduction: the SNS Project

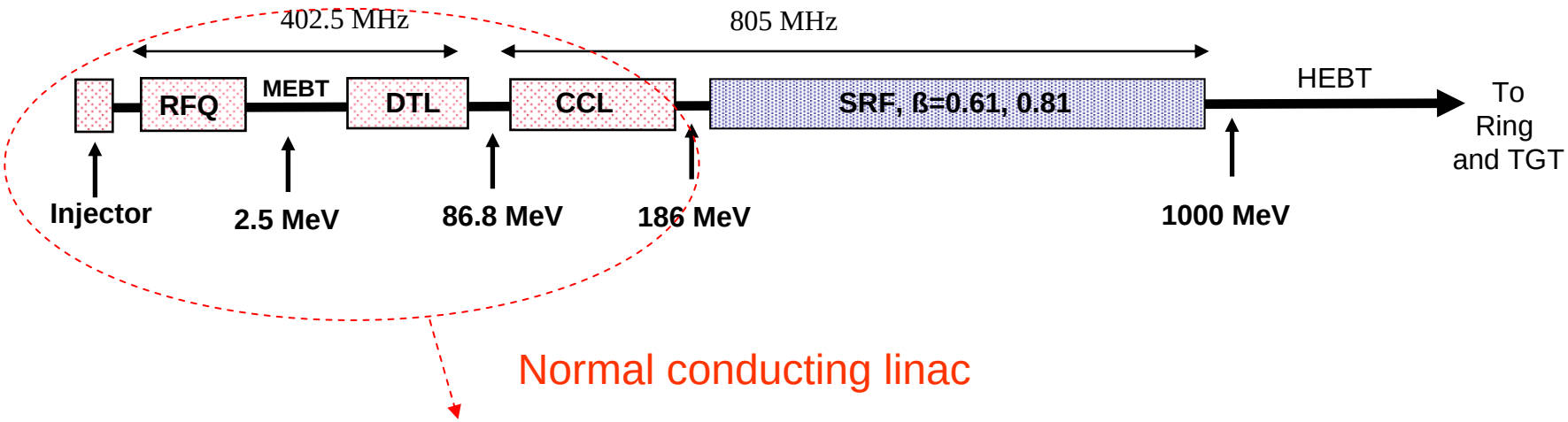


Parameters:

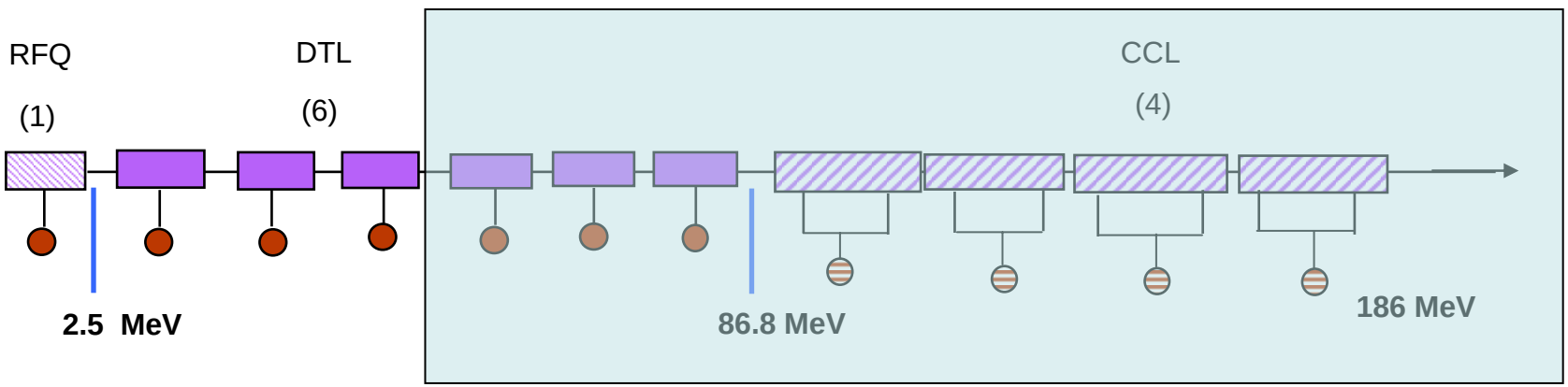
P beam on target	1.44MW
I beam aver.	1.44mA
Beam energy	1 GeV
Duty factor	6%
Rep. rate	60Hz
Pulse width	1ms

N. Holtkamp, FR103

SNS Linac Layout



Normal conducting linac



Commissioning runs

Run #1

- Front End
- beam stop for design beam power
- 800 hours of operation (24/7)

Run #2

- Front End & DTL tank 1
- beam stop and radiation shield for design beam power
- 1136 hours of operation (24/7)

Run #3

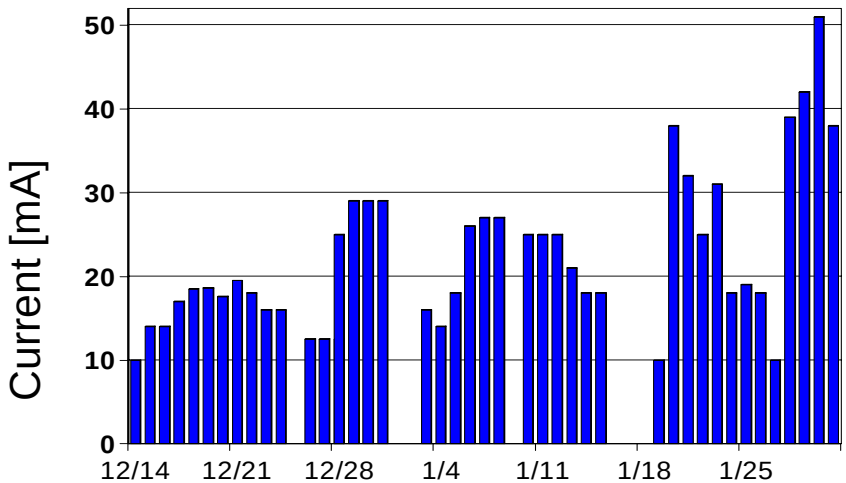
- Front End & DTL tank 1,2,3
- Beam stop and radiation shield for reduced beam power (50us, 1Hz)
- 288 hours of operation (24/7)

H^- Ion source and LEBT

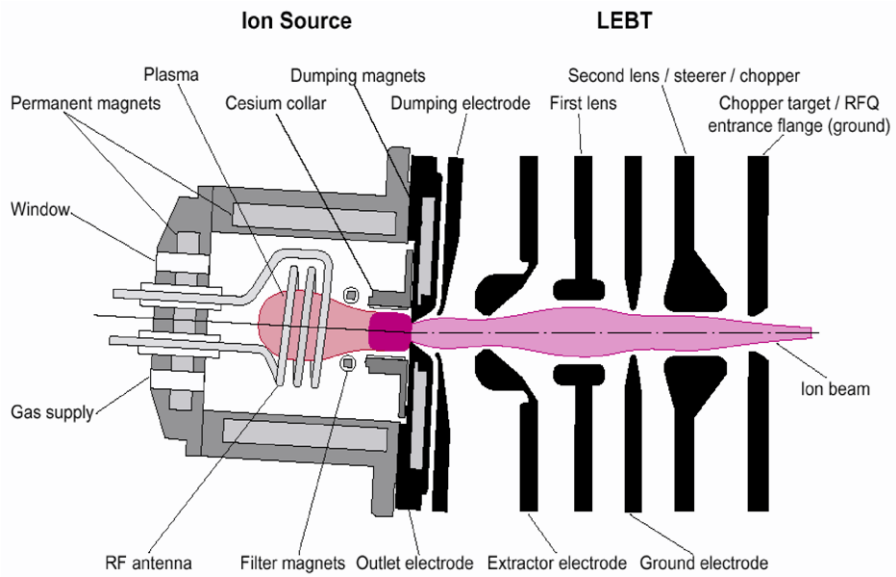
Radio frequency, multi-cusp ion source.

Electrostatic low energy beam transport line

Electrostatic pre-chopper in the LEBT



History of the beam current delivery during run#1

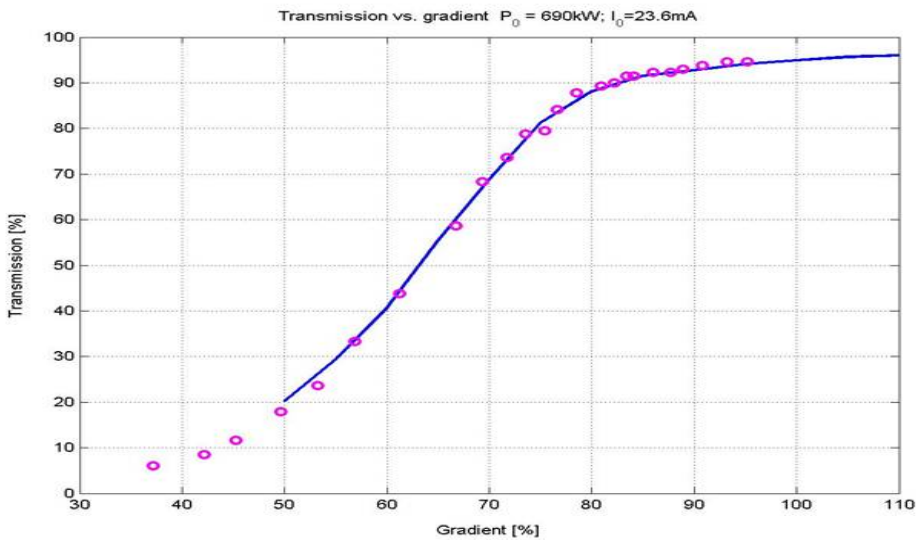


Ion source availability:

Run #1 : 85.6%
Run #2 : 92.4%
Run #3 : 97.8%

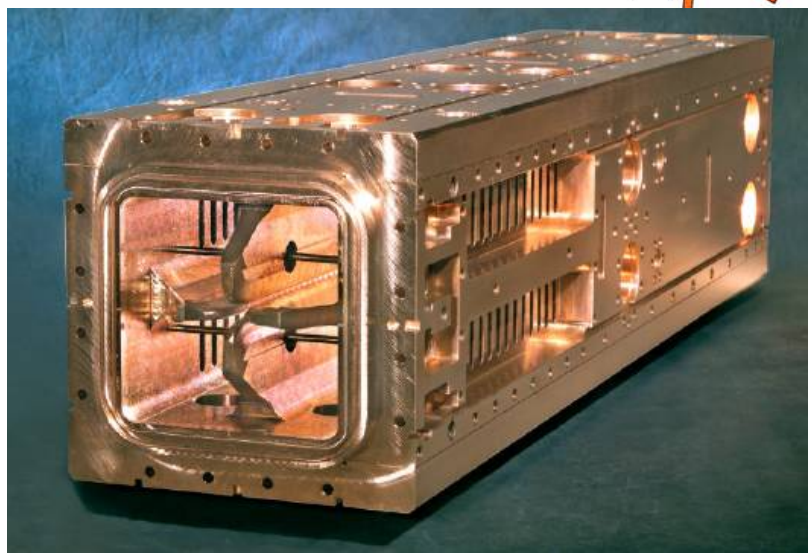
R&D program and life time tests at “hot spare stand”. ***N. Holtkamp, FR103***

402.5 MHz four-vane RFQ



RFQ transmission vs. RF power

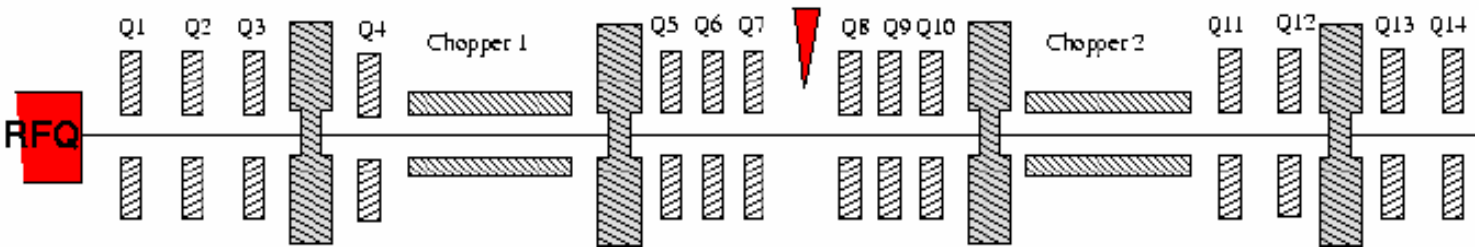
Simulations (blue) and measurements (red)



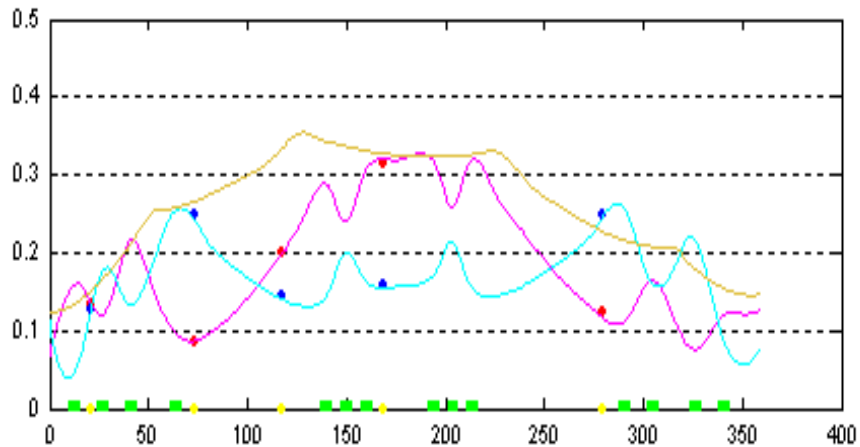
Output energy measured by Time Of Flight in MEBT = 2.45MeV (2% below design)

During run#2 experienced resonant frequency shift of 500kHz. Returned to operation after retuning the cavity.

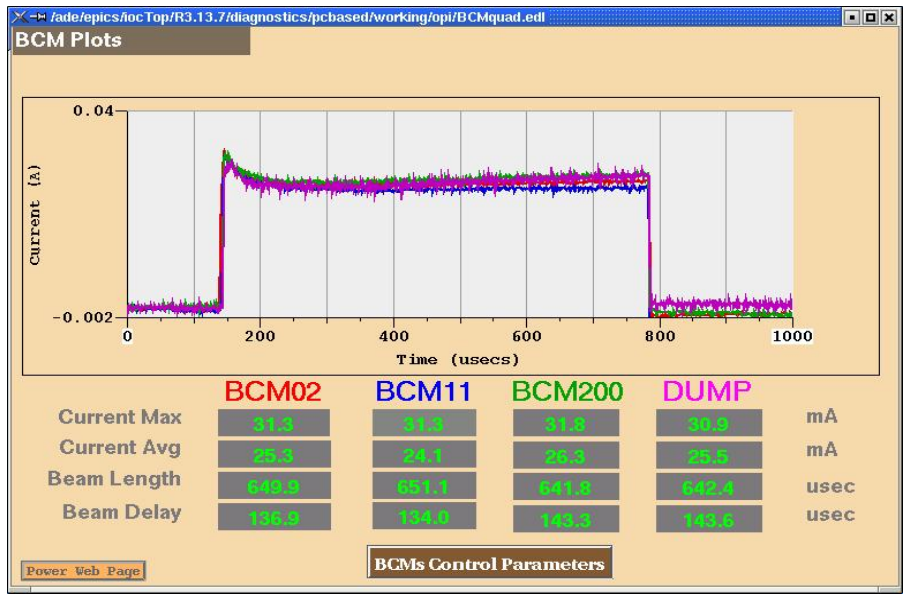
2.5MeV MEBT



Schematic MEBT Layout

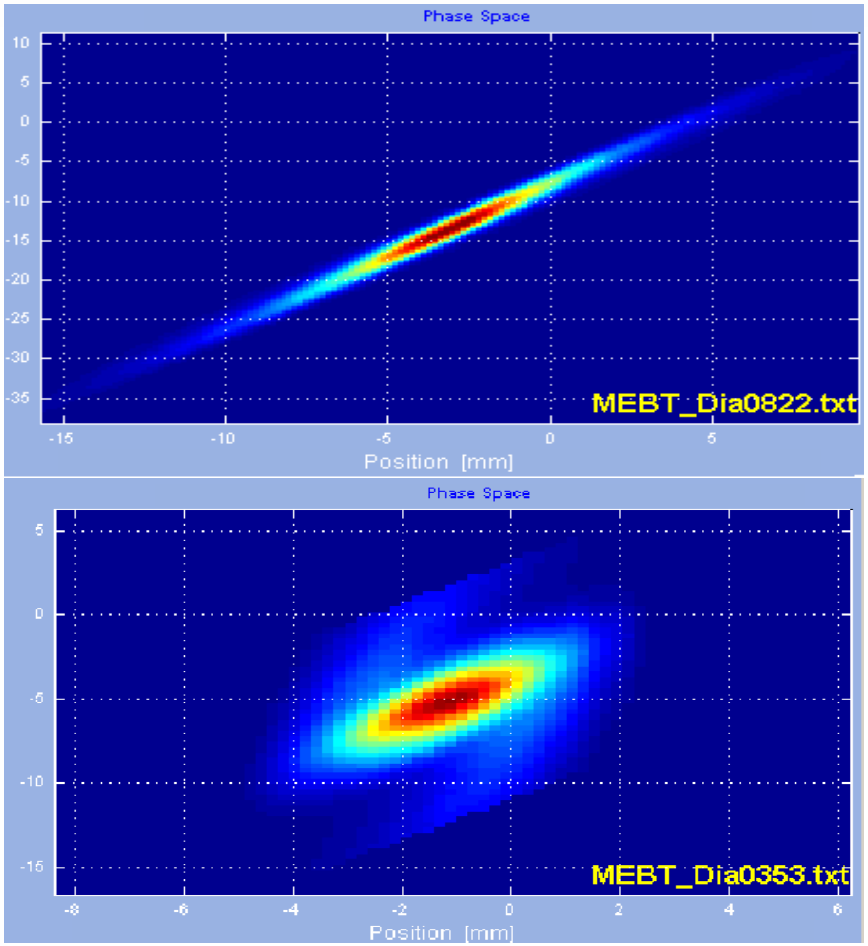


RMS beam envelope in MEBT. Simulation (solid) and wire scanner measurements (dots).



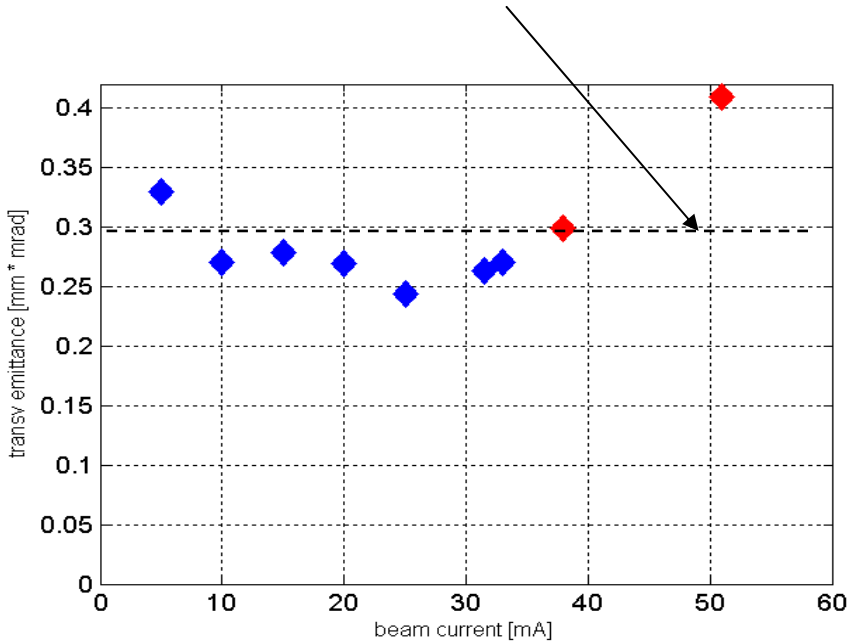
Beam current after RFQ (red), MEBT (blue)

Measured emittance after MEBT



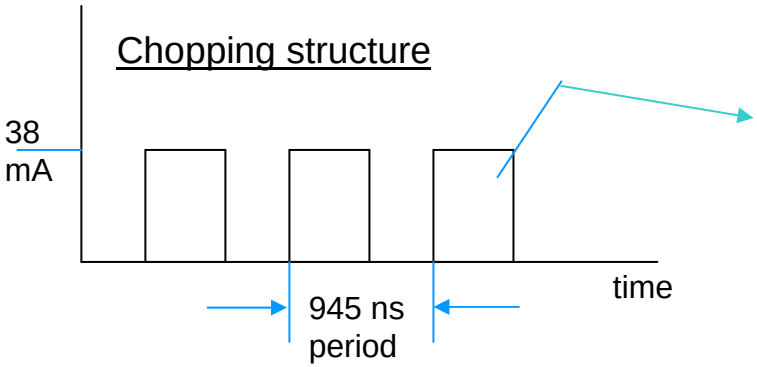
Beam emittance after MEBT. Vertical (top) and horizontal (bottom)

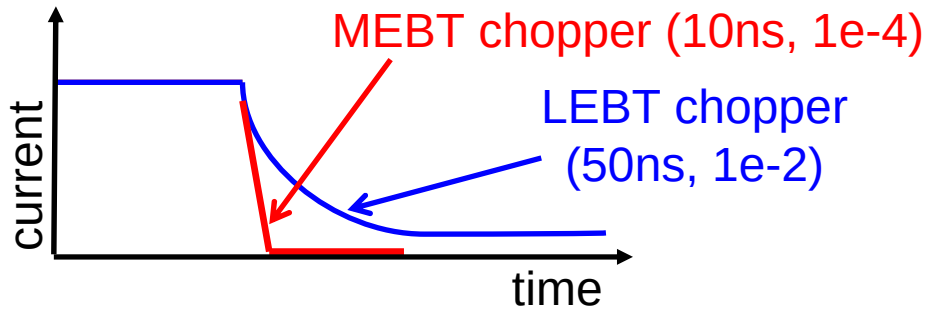
Design value = .3 □ mm mrad
(RMS normalized)



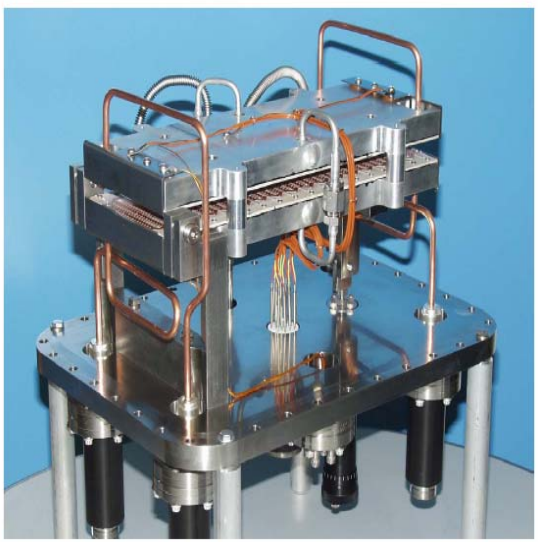
Dependance of RMS emittance upon peak beam current

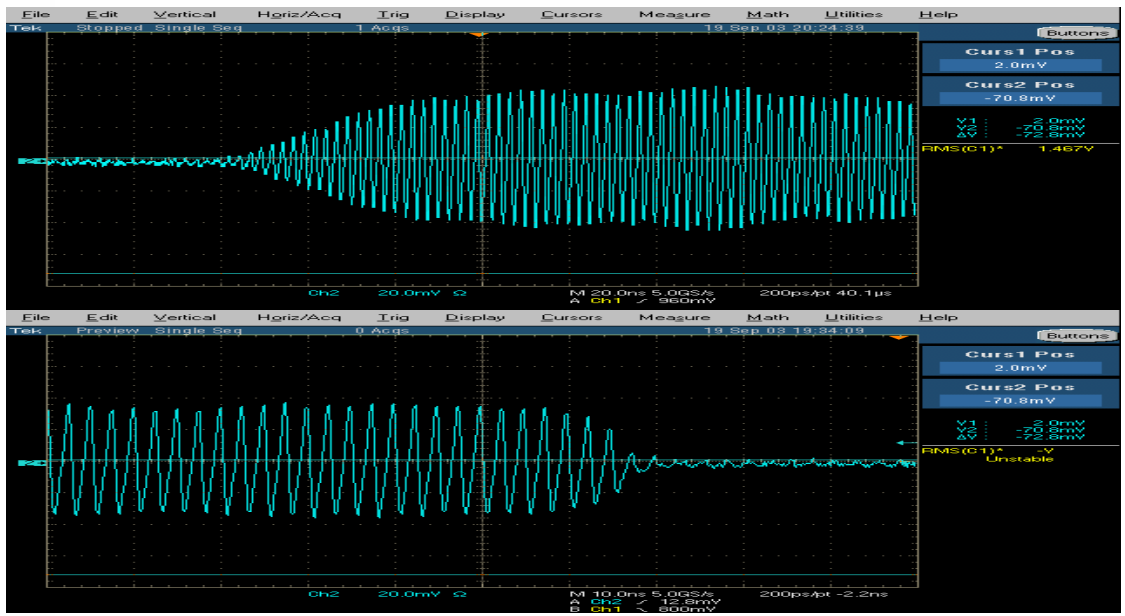
Chopping





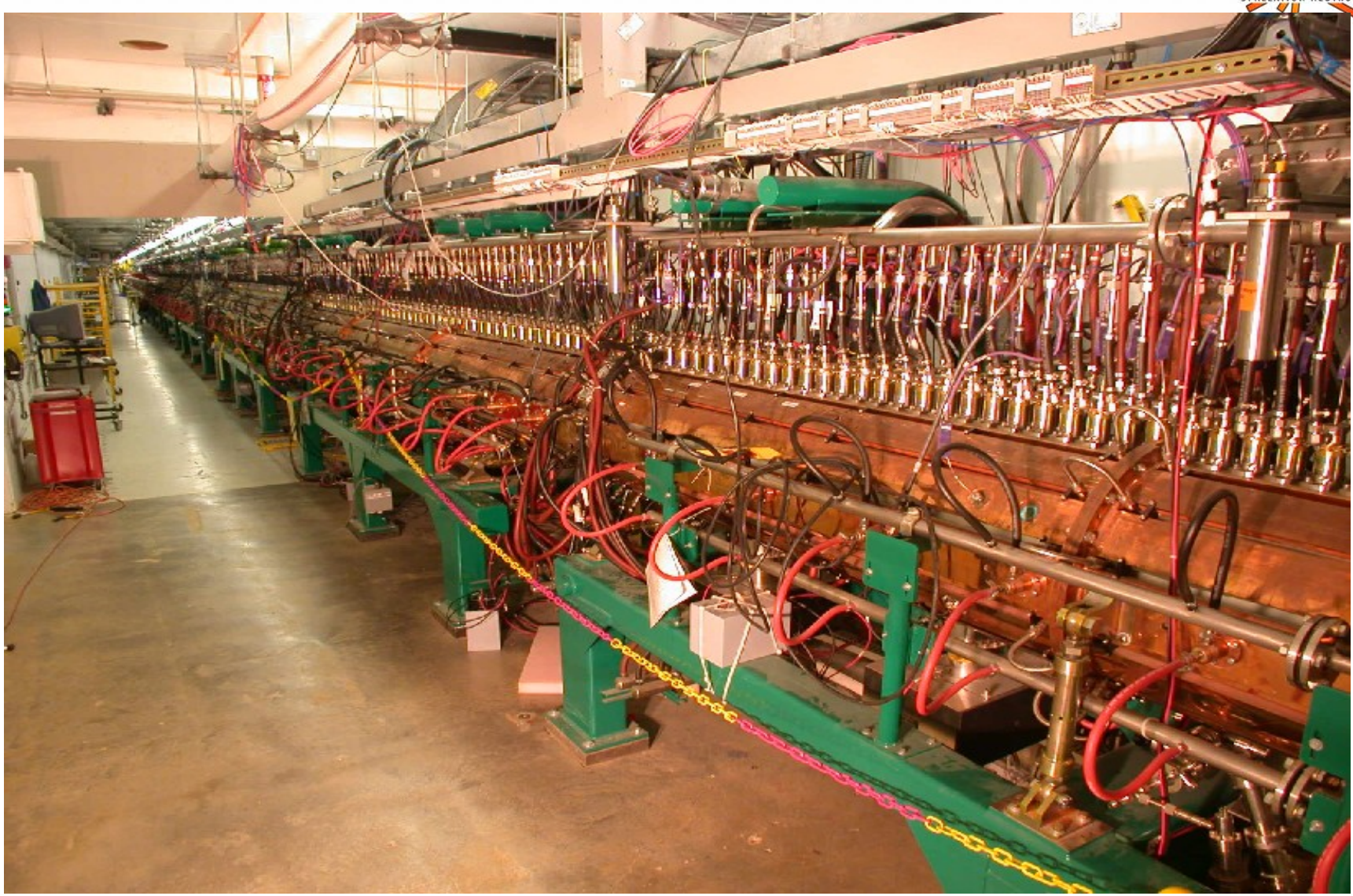
SNS CHOPPER ASSEMBLED TO VACUUM LID





Measured effect of chopper on the beam (LEBT top, MEBT bottom)

402.5 MHz DTL with permanent magnet focusing

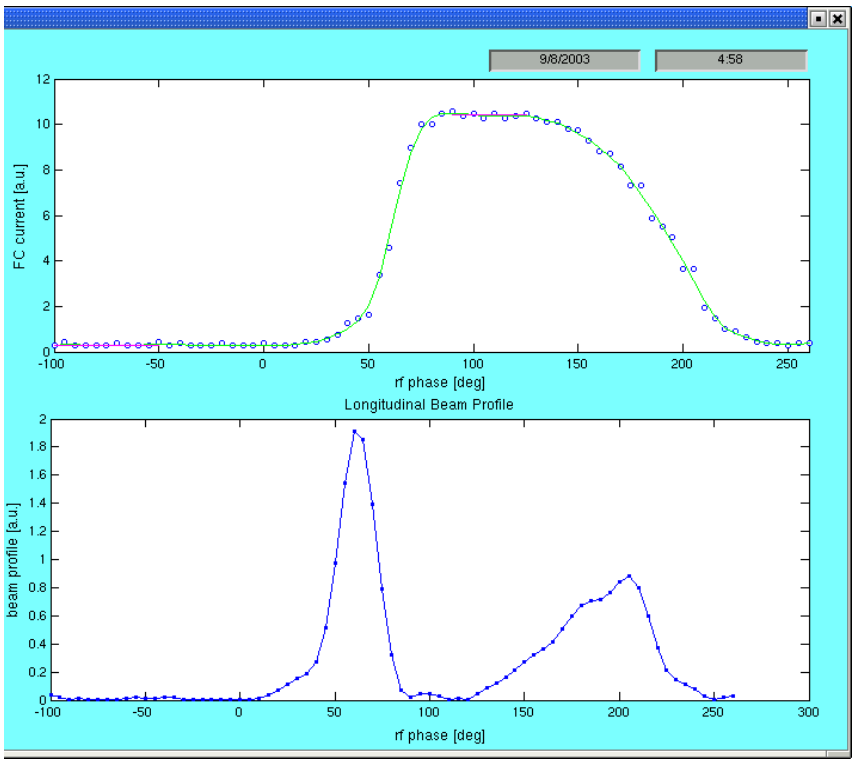


RF tuning: *C.Deibele, THP65*

Setting DTL phase and amplitude

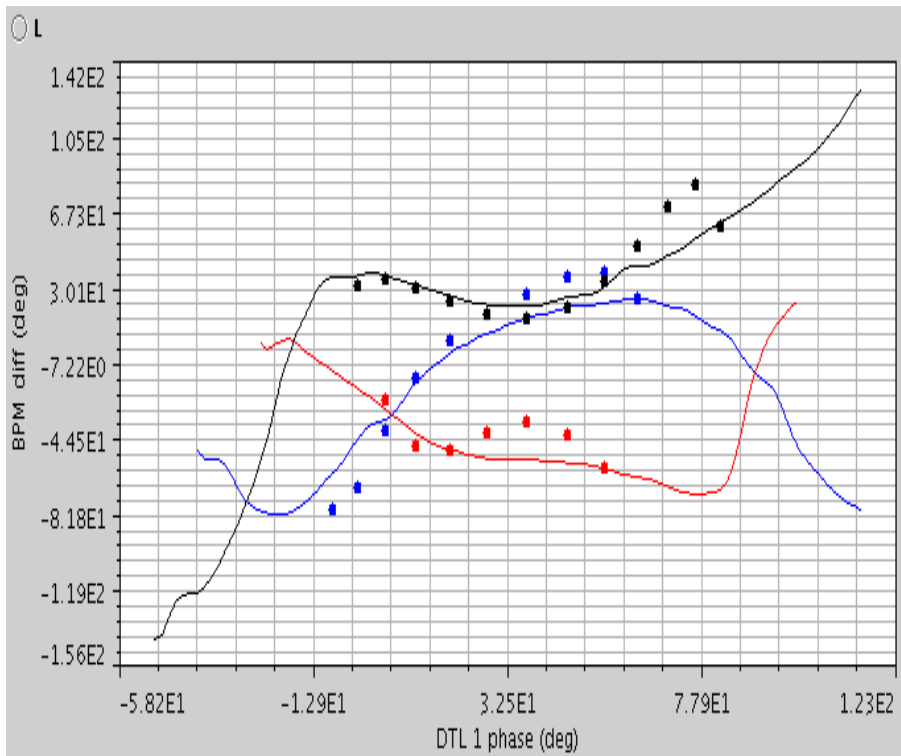
DTL acceptance scan.

Transmission through energy degrade vs. tank phase

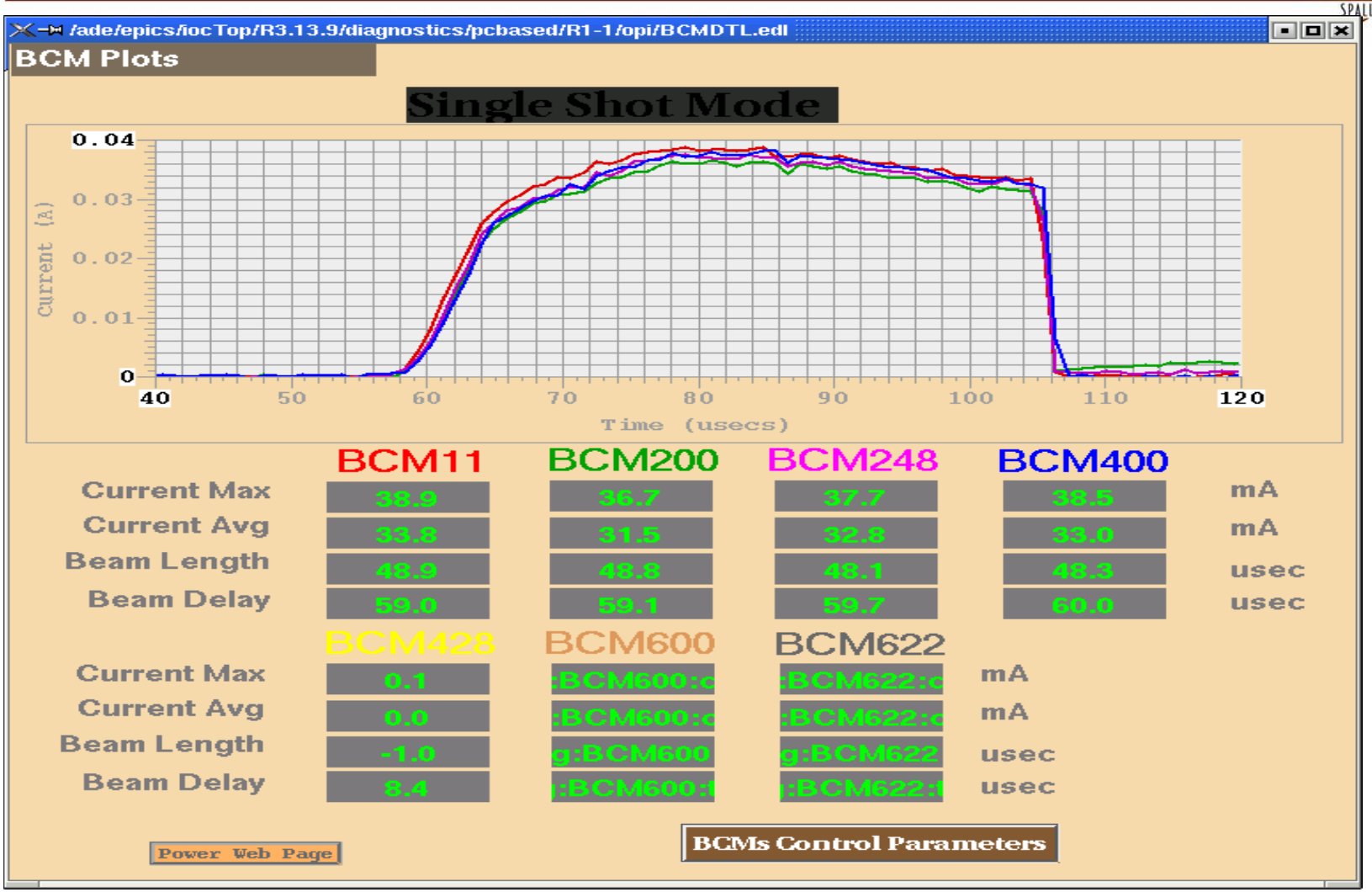


DTL phase scan.

Measured dependence of beam phase at tank exit vs. tank RF phase compared with simulations (solid lines) for different RF amplitudes (different colors).

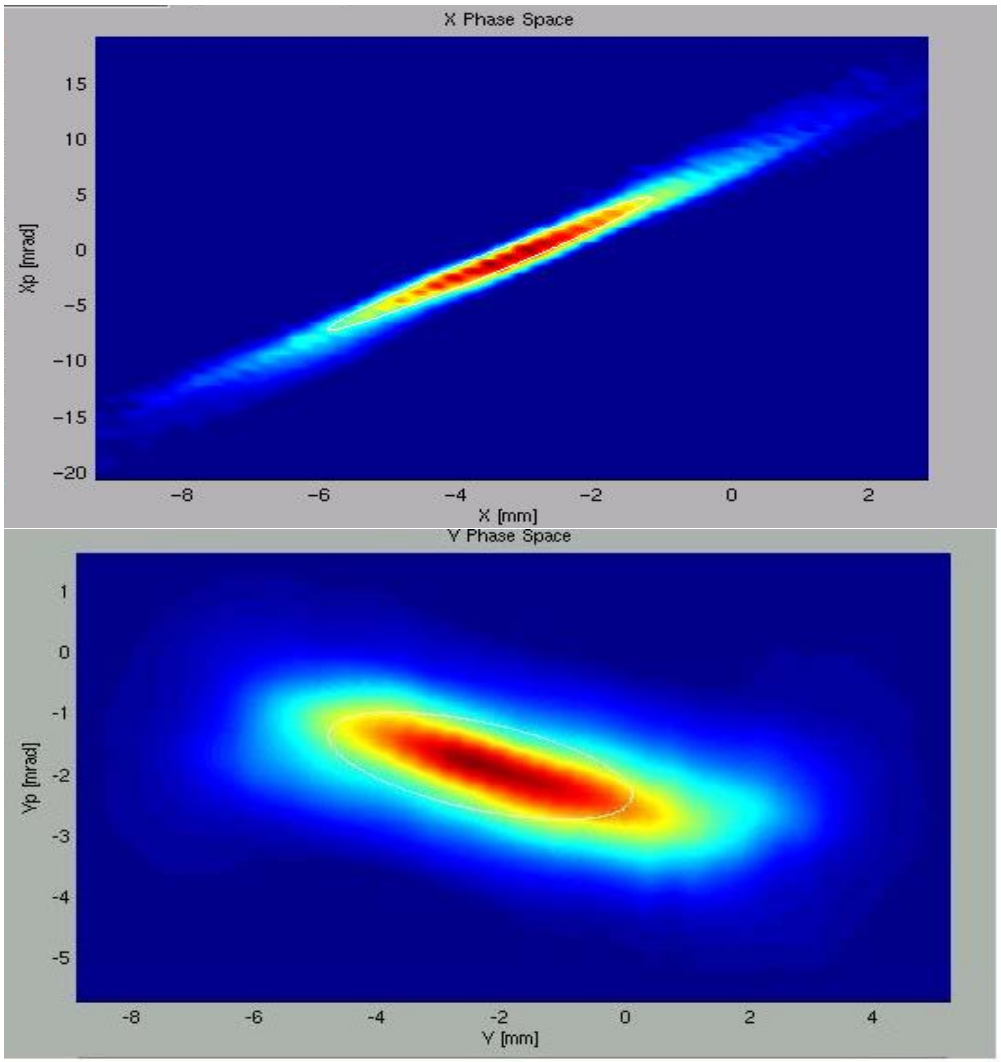


Transmission through DTL1-3



Beam current after MEBT (red), DTL tank1 (green), DTL tank2 (pink), DTL tank3 (blue)

Measured emittance after DTL tank 1



Vertical normalized RMS emittance = 0.3 □ mm*mrad

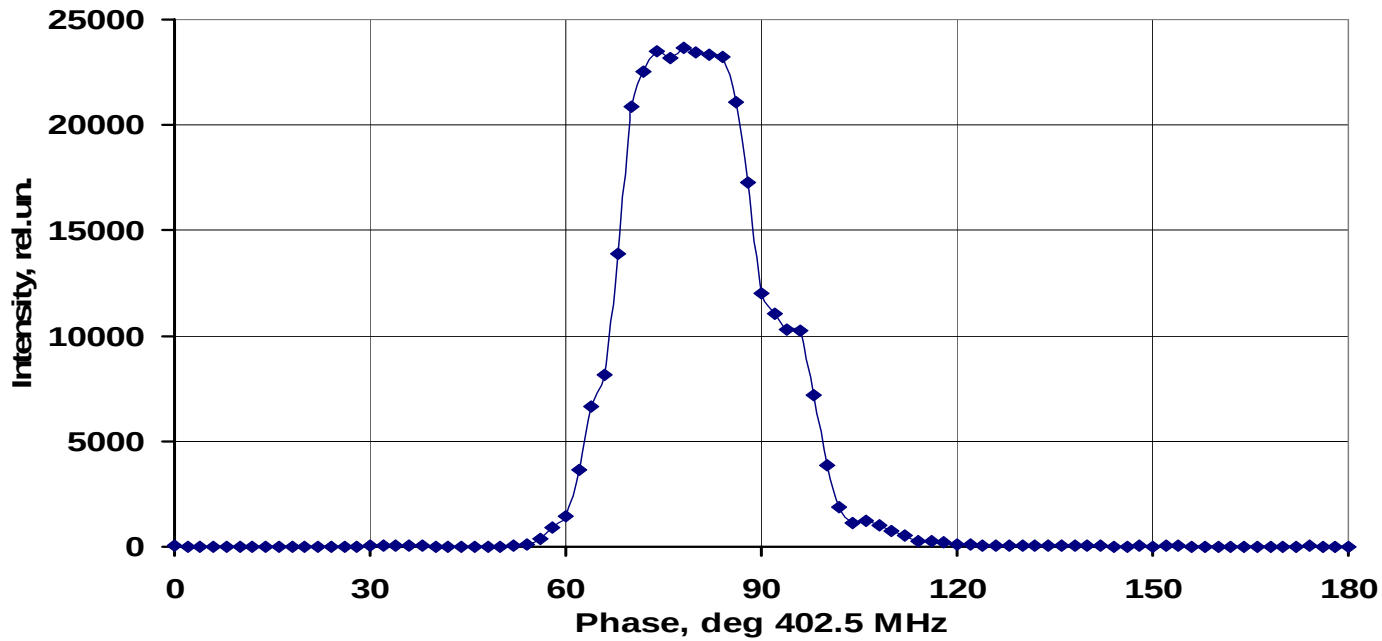
Horizontal normalized RMS emittance = 0.4 □ mm*mrad

Absolute calibration of horizontal scanner is under investigation due to discrepancy with wire scanner measurements

Longitudinal beam parameters

Beam energy after DTL tank1 and tank2 measured using Time of Flight between two BPMs in downstream tanks. Within measurement accuracy from design value.

Longitudinal beam profile after tank measured using Bunch Shape Monitor. Longitudinal emittance derived from profile measurements is close to design value. *A. Feshenko, TUP63*



Diagnostics performance

- Beam position and phase monitors
  - Position resolution <.2um
  - Phase resolution <.5 deg
- Beam current monitors
  - 1-2% accuracy for short pulses
- Wire scanners
  - ~ 1000 dynamic range
  - Require individual bias adjustment depending on energy, beam current
- Loss monitors
  - Commissioned but did not use
- Other devices tested
  - Laser based profile monitor for superconducting linac
  - Laser based beam in gap measuring system
  - Fast Faraday cup

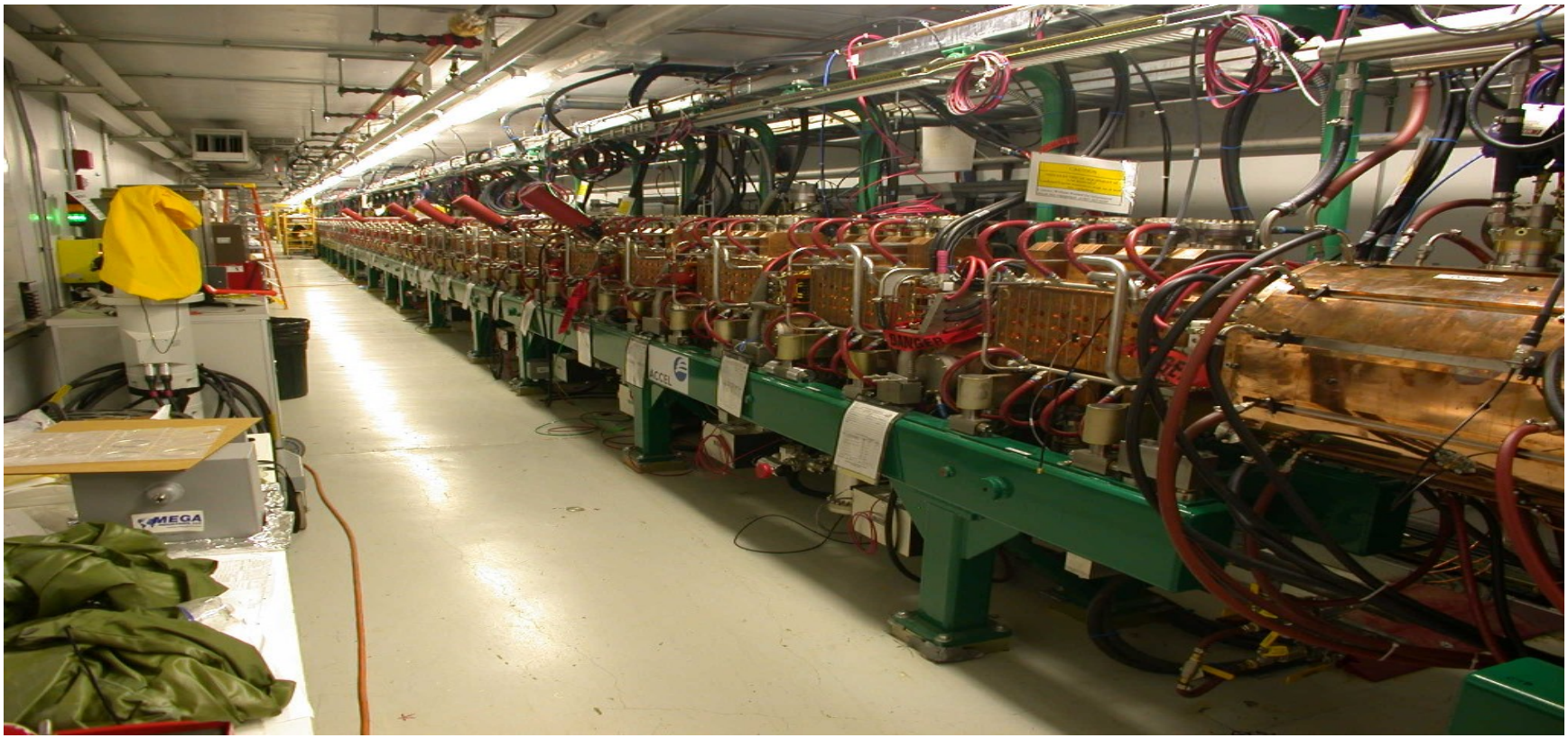
Commissioning results vs. goals

	Baseline Design or Goal	Achieved
MEBT peak current [mA]	38	52
DTL1 peak current [mA]	38	40
DTL1-3 peak current [mA]	38	38
DTL1 beam pulse length [msec]	1.0	1.0
DTL1 average current [mA]	1.6	1.05
MEBT horiz. emittance [π mm mrad (rms,norm)]	.27	< .3
MEBT vertical emittance [π mm mrad (rms,norm)]	.27	< .3
DTL1 horiz emittance [π mm mrad (rms,norm)]	0.3	0.30 (fit), 0.40 (RMS)
DTL1 vertical emittance [π mm mrad (rms,norm)]	0.3 (RMS)	0.21 (fit), 0.31 (RMS)
DTL1 beam duty factor	6.0%	3.9%
MEBT Beam Energy [MeV]	2.5	2.45 ± 0.010
DTL2 output energy [MeV]	22.89	22.94 ± 0.11

Operational statistics

	Run #3	Run #2	Run#1
Total time [hours]	288	1136	800
Beam available [%]	75	62	53
Planned shutdown [%]	6	2	2
Equipment breakdown[%]	19	36	45
Breakdown statistics by equipment group [%]			
RF	15	28	34
Power supplies	0	22	4
Ion Source	6	21	32
Diagnostics	0	6	7
Controls	4	17	12
Water, vacuum, etc.	75	6	11

Status and plans



- Installation of warm Linac (DTL and CCL) has been completed
- DTL4,5,6 and CCL1,2,3 cavities have been RF processed and ready for beam
- Commissioning run#4 will start on September 2nd