CEBAF Energy Recovery Experiment

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E02-102 Collaboration at J-Lab

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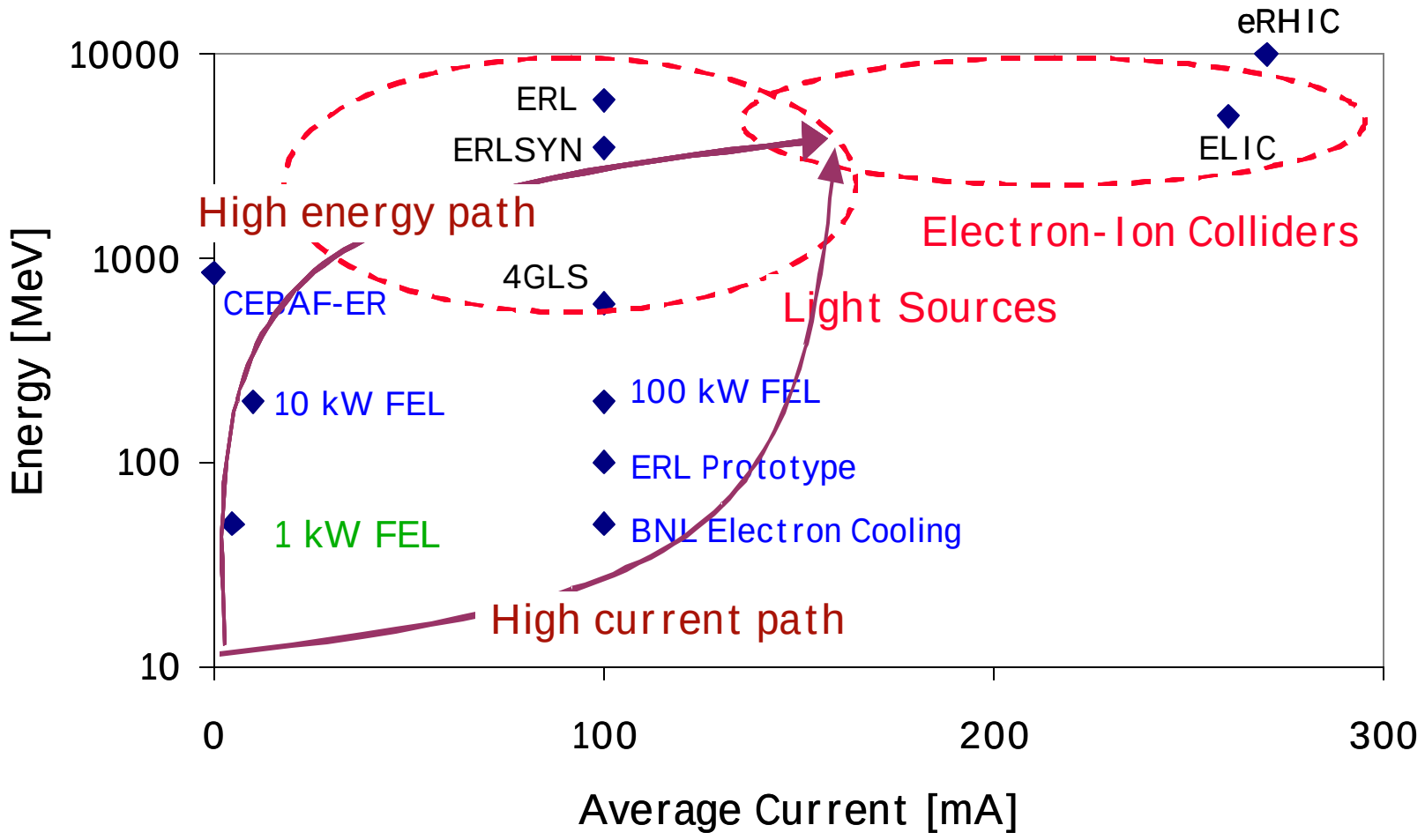
Overview

- Motivation, Future accelerators based on ERLs (Energy Recovery Linacs)
- Experiment layout, Beam transport, Instrumentation
- Measurements – characteristics of energy recovered beam
  - Emittance, momentum spread
  - Beam halo
  - RF cavity transients
- Preliminary results (energy recovered beam at 56MeV and 20MeV)
- Summary

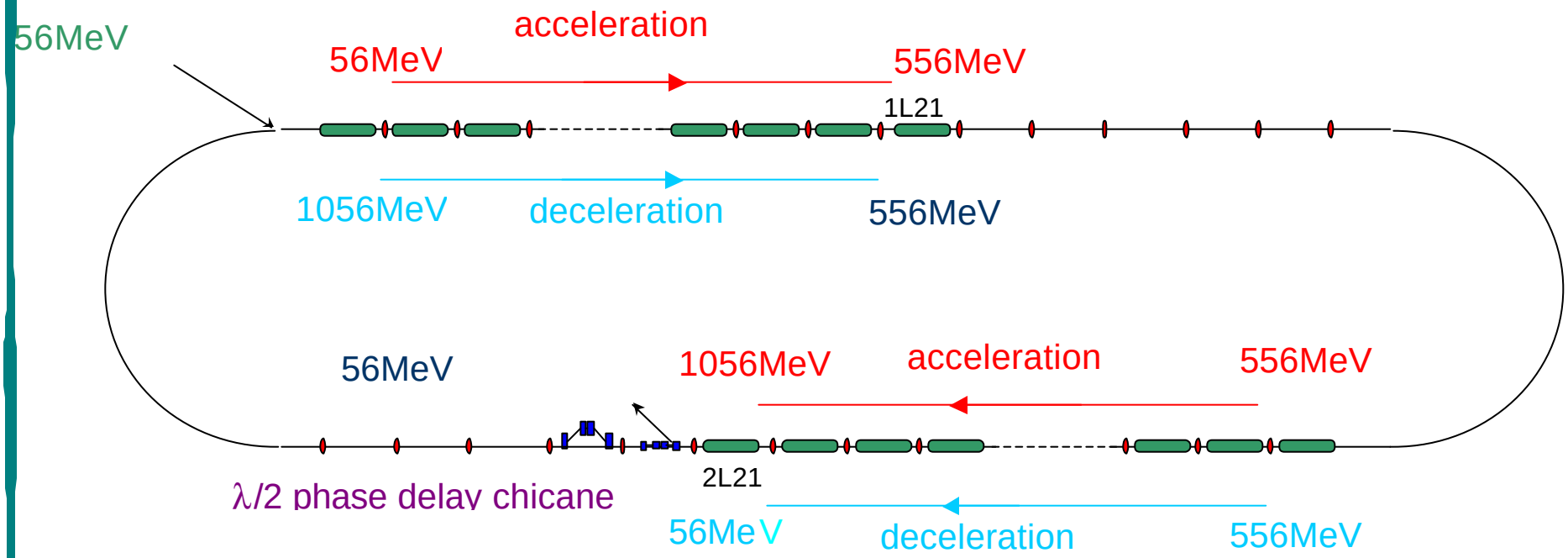
- Energy recovery* – process by which the energy invested in accelerating a beam is returned to the rf cavities by decelerating the same beam
- Why Energy Recover?
  - Required rf power becomes nearly independent of beam current
  - Reduces electron beam power to be disposed by ratio of E_{fin}/E_{inj}
  - Alleviates shielding, if beam dumped below the neutron production threshold
  - Promises efficiencies of storage rings, while maintaining beam quality of linacs: superior emittance and energy spread, short bunches (sub-pico sec.)
- Future Applications:
  - Free Electron Lasers
  - Synchrotron Light Sources
  - Electron Cooling Devices
  - Electron Ion Colliders

*Maury Tigner, Nuovo Cimento 37 (1965)

ERL Landscape

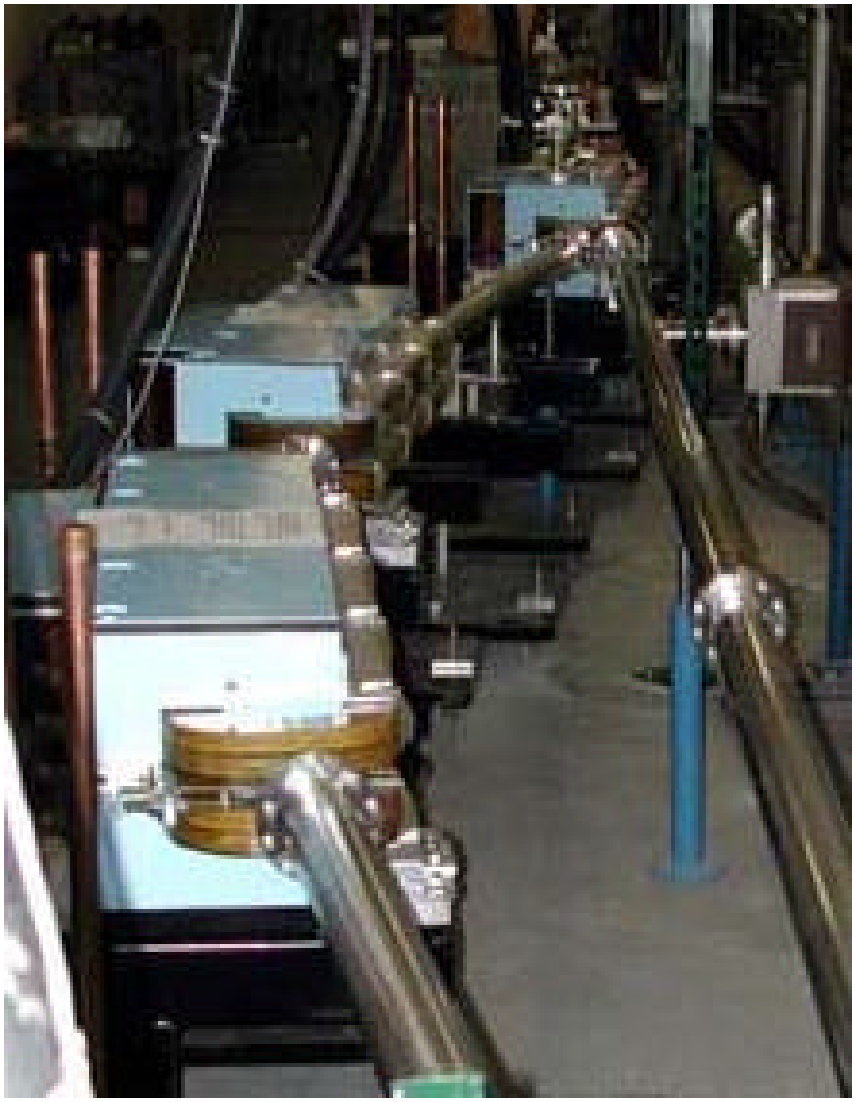


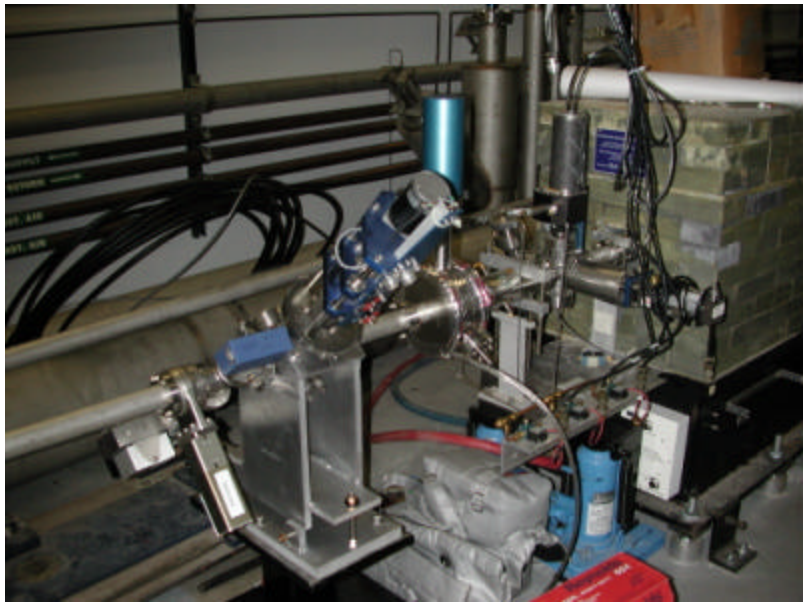
Experiment Layout



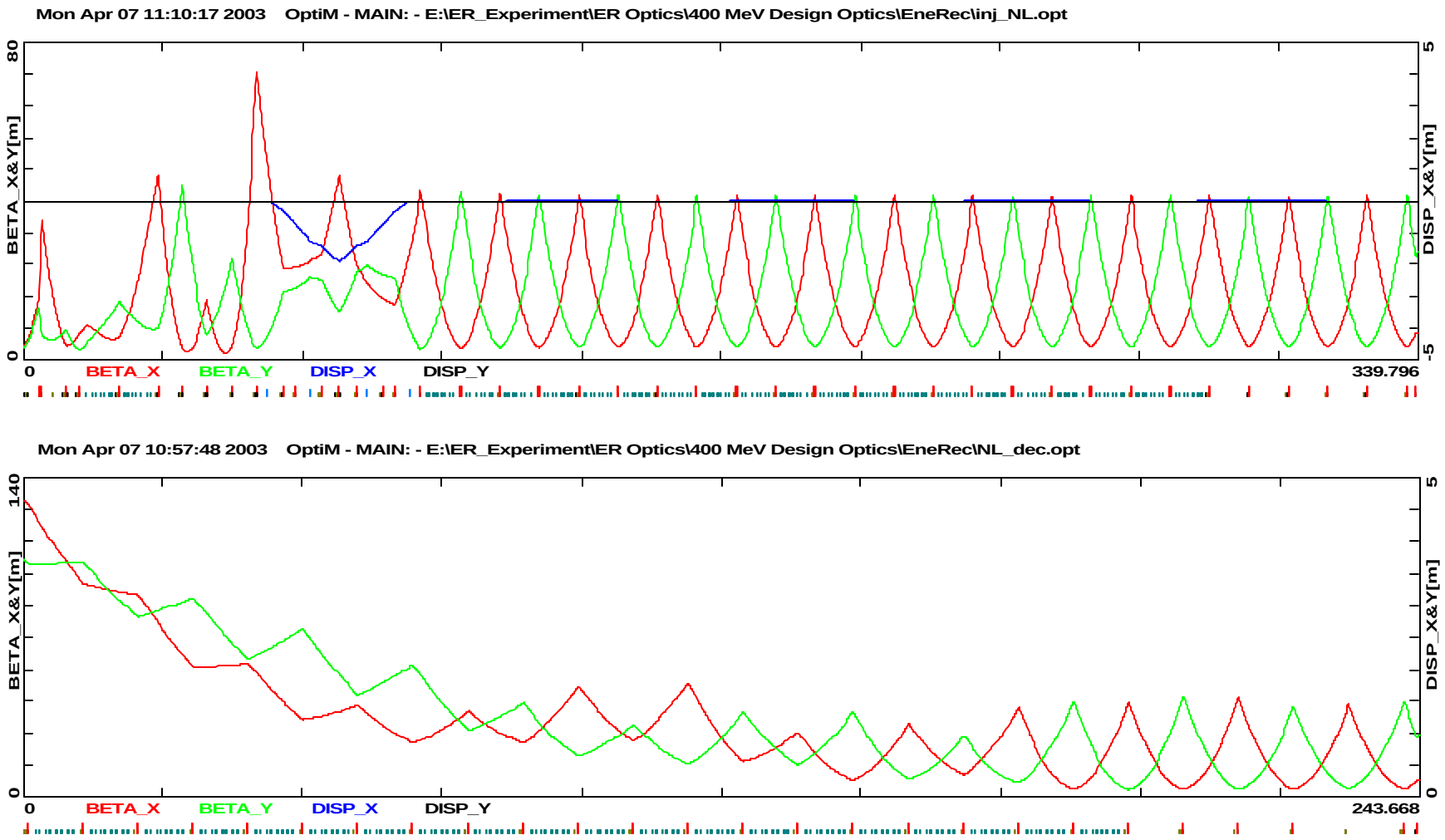
- New hardware – a λ/2 chicane and a beam dump/chicane at the end of the South Linac. The beam is accelerated in the North Linac and South Linac then decelerated through the North Linac and South Linac.

- Phase delay chicane and energy recovery extraction line

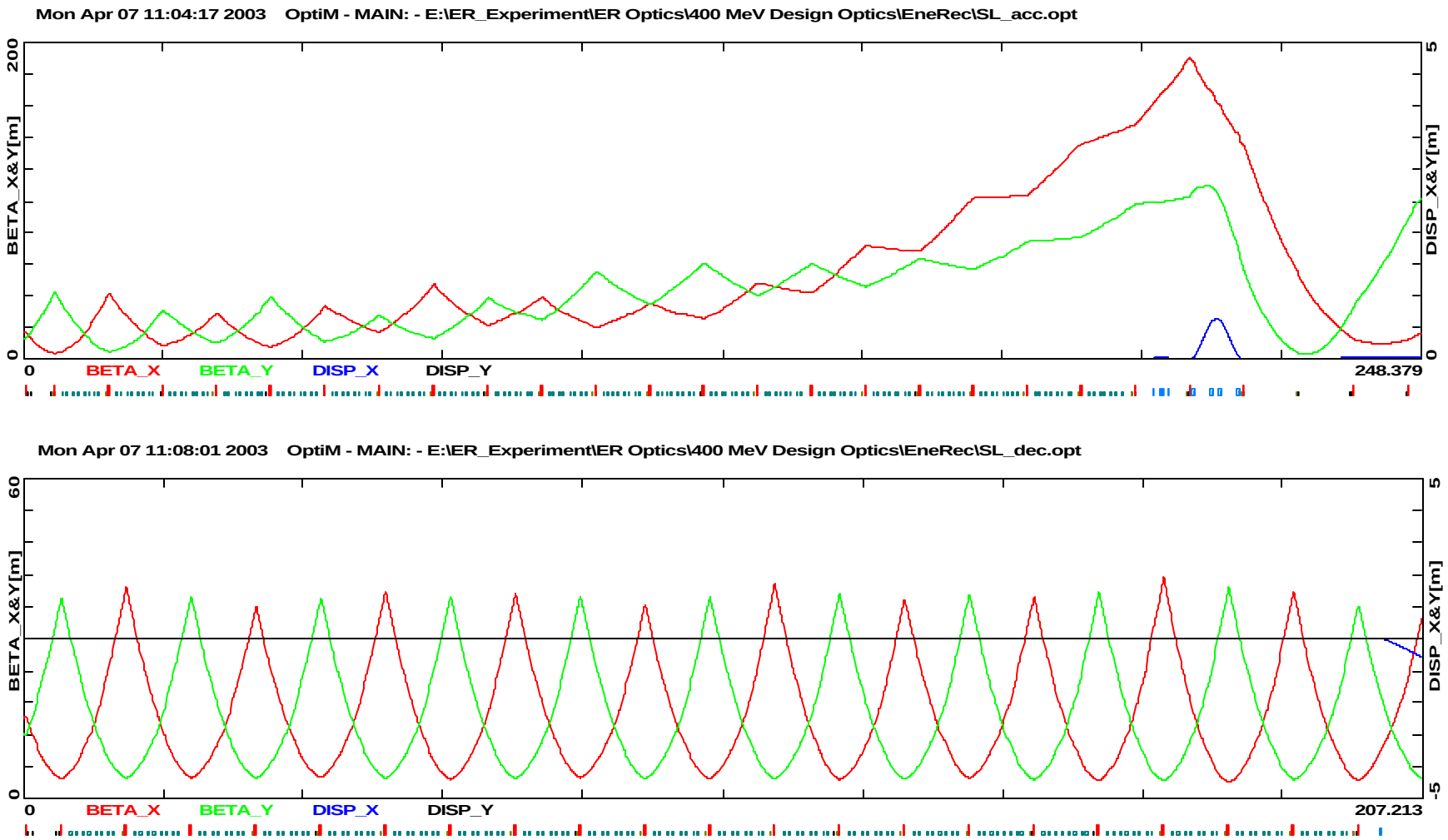




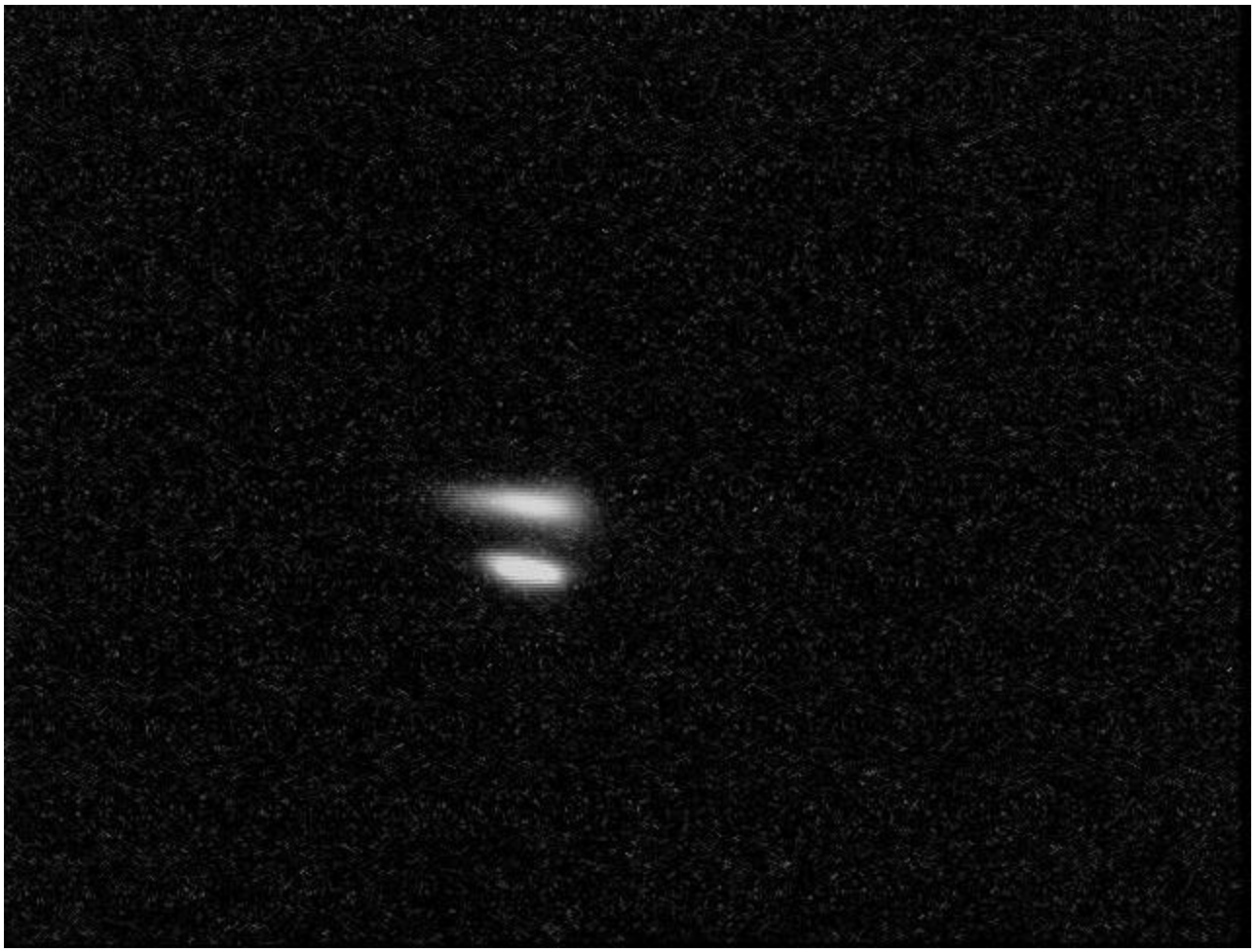
- North Linac – standard 120° lattice for the accelerating beam (56–556MeV) and mismatched optics for the decelerating beam (1056–556MeV)



- South Linac – mismatched optics for the accelerating beam (556–1056MeV) and standard 120° lattice for the decelerating beam (556–56MeV)



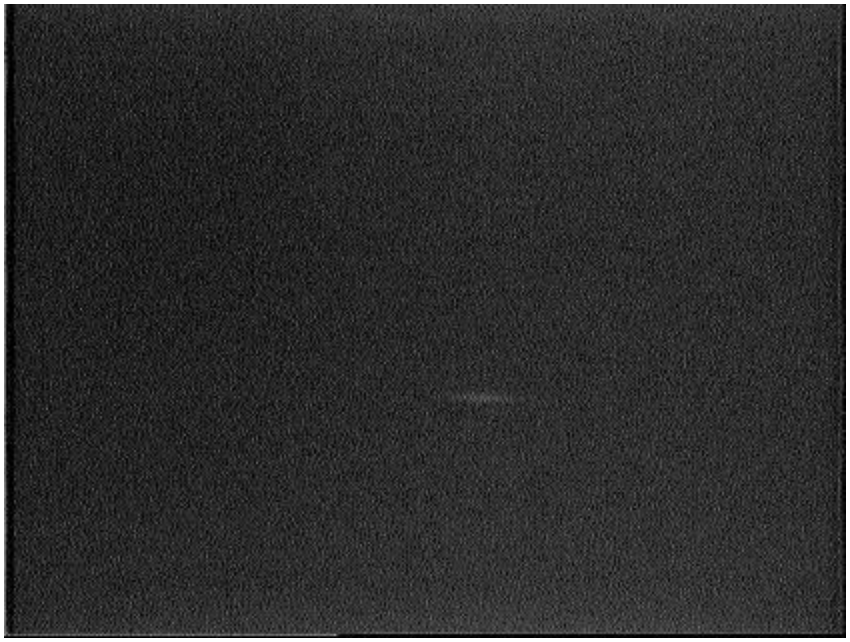
- Arc1 synchrotron light monitor – accelerated/decelerated beams at 556 MeV



- Two beams (~ 1 GeV and ~ 100 MeV) at the end of South Linac – SL16 beam viewer (E_{inj} = 20 MeV)

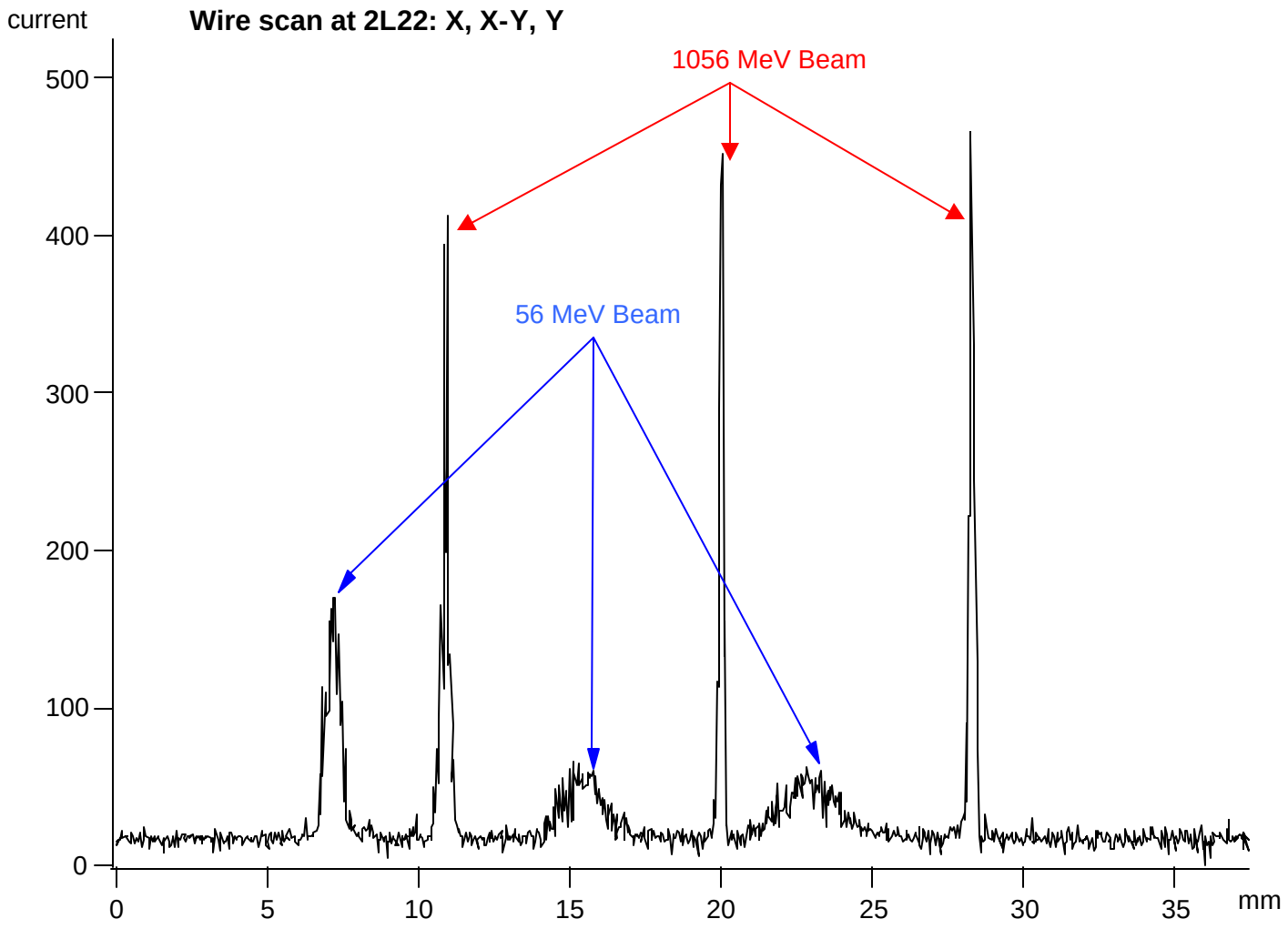
- Energy recovered beam at the dump (Optical Transition Radiation view)

56 MeV beam

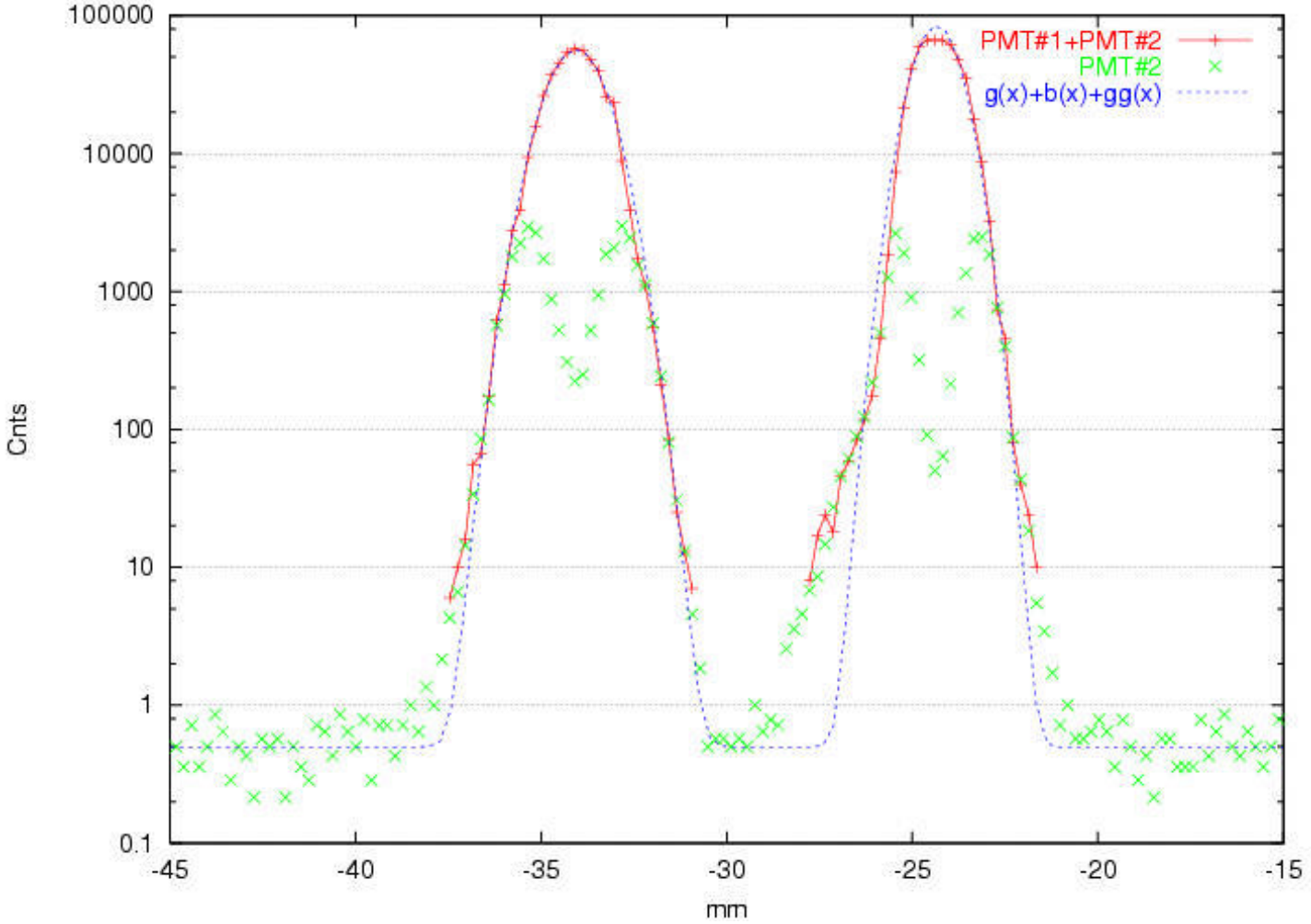


20 MeV beam

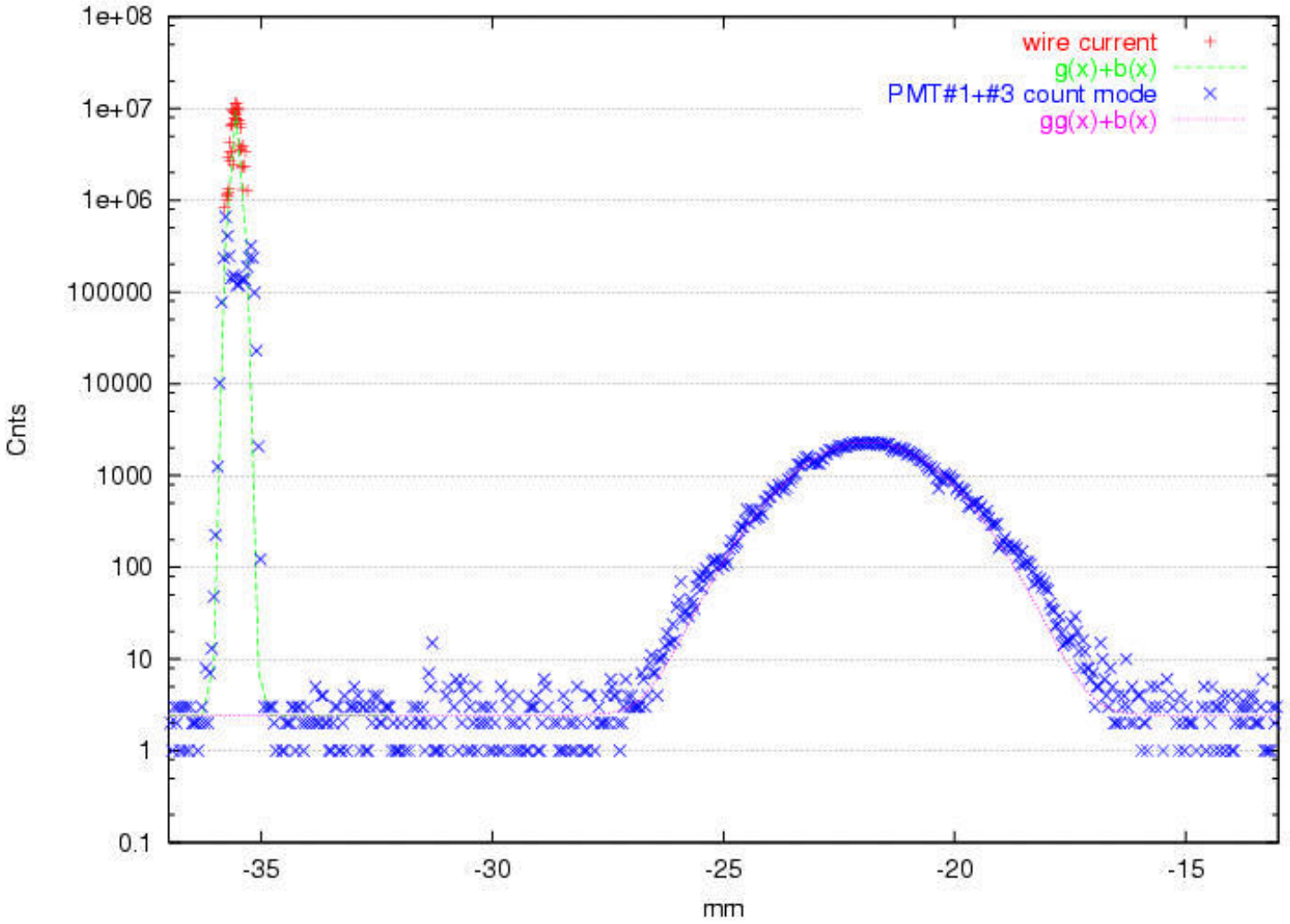
- Typical wire scan with two beams – fully accelerated and energy recovered beams



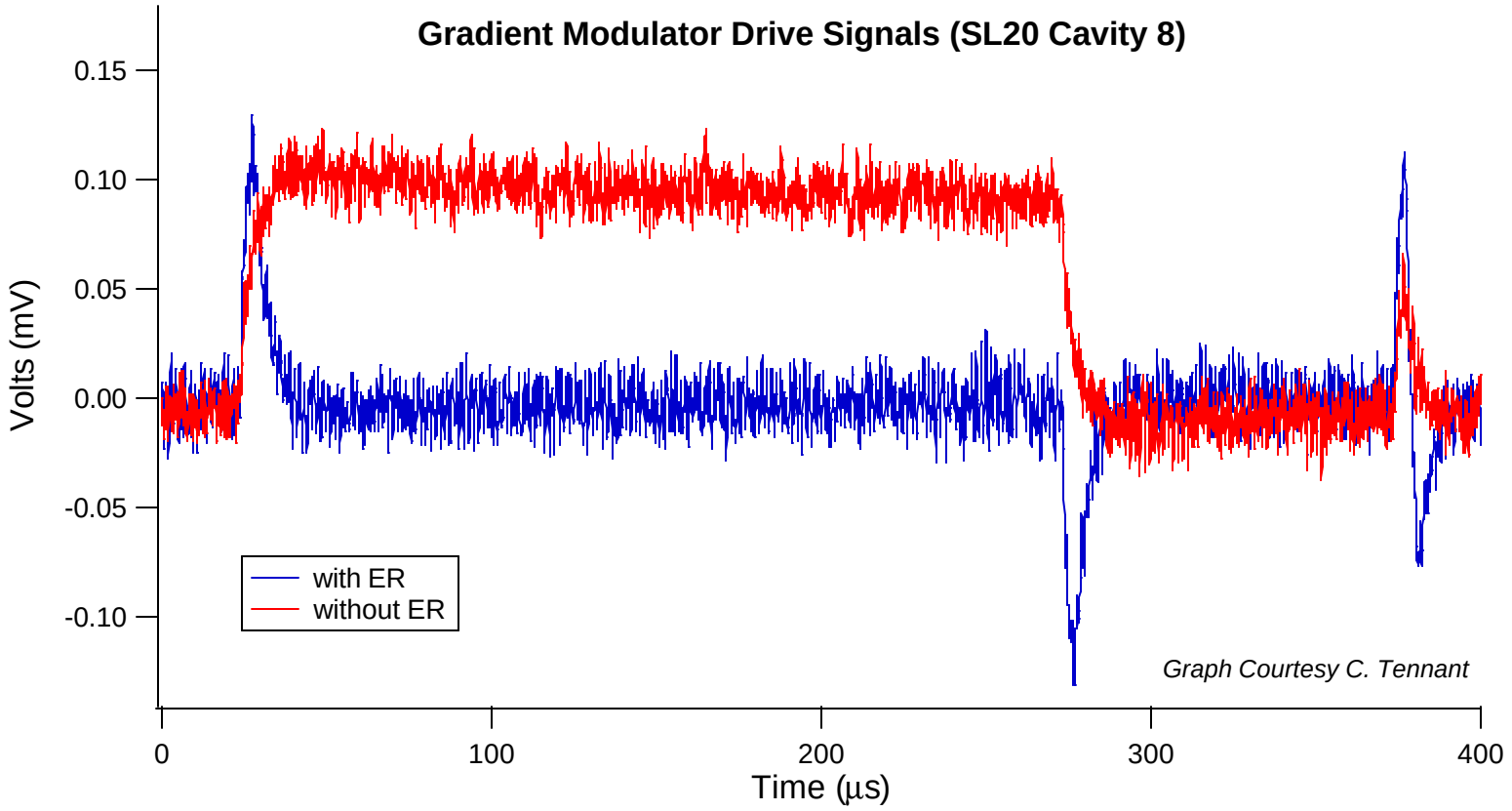
- Beam halo (56MeV, 1μA beam) measured with a wire scanner and 3 PMTs



- Beam halo (20 MeV, 1μA beam) measured with a wire scanner and 3 PMTs



- rf power measurement – selected cavity at the end of South Linac



Summary

- 1 **GeV** scale demonstration of energy recovery at CEBAF
- **80 mA** of CW beam accel. to 1056 MeV and energy recovered at 56 MeV
- Demonstration of high final-to-injection energy ratios – 20:1 and **50:1**
- Measurements – Characteristics of energy recovered beam:
  - Emittance
    - Injector and Arcs – wire scans with varying quads
    - Extraction line (energy recov. beam) – wire scans with 'closed beta bump'
  - Beam halo (wire scanner and PMTs) – 6 decades of intensity covered
  - rf transients at full charge (50 μA pulsed beam)
- Data analysis in progress…..
- Expectation for ongoing machine activities at CEBAF