UT-BATTELLE

# Development of Computational Tools for Halo Analysis and Study of Halo Growth in the SNS

**Dirk A. Bartkoski, Alexander V. Aleksandrov, Sarah M. Cousineau, Stuart Henderson, Jeffrey Alan Holmes**

**Spallation Neutron Source**

**June 29, 2006**

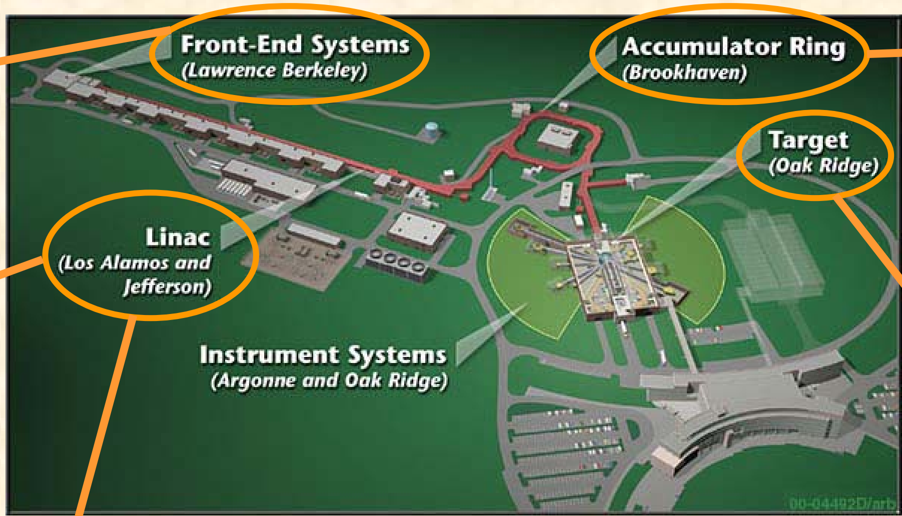
**European Particle Accelerator Conference**

SNS SPALLATION NEUTRON SOURCE

# Spallation Neutron Source (SNS)

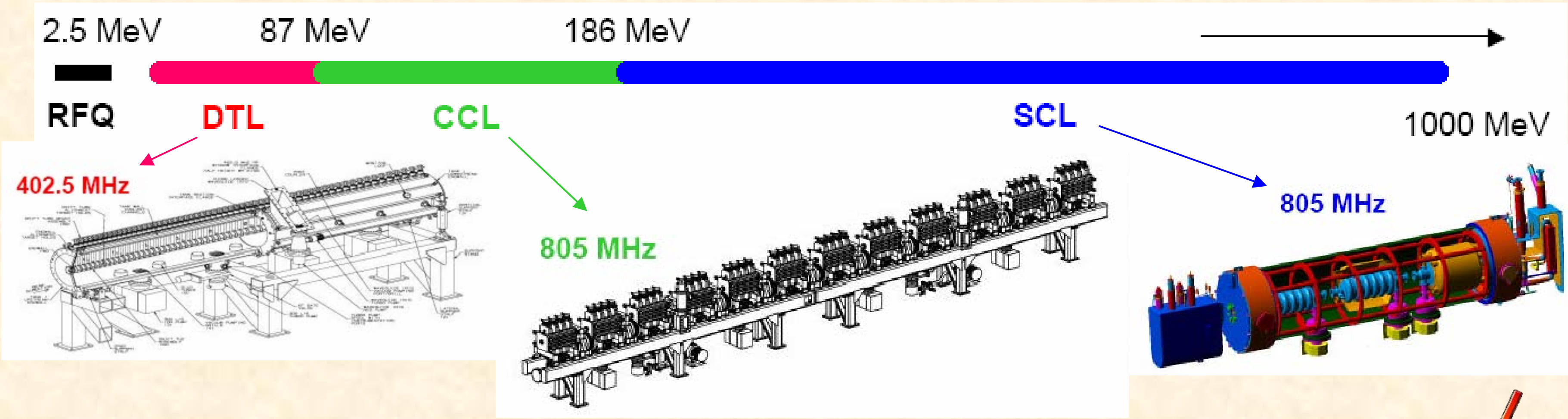
$H^-$ ions are created and bunched.

Ions are accelerated to 1GeV.



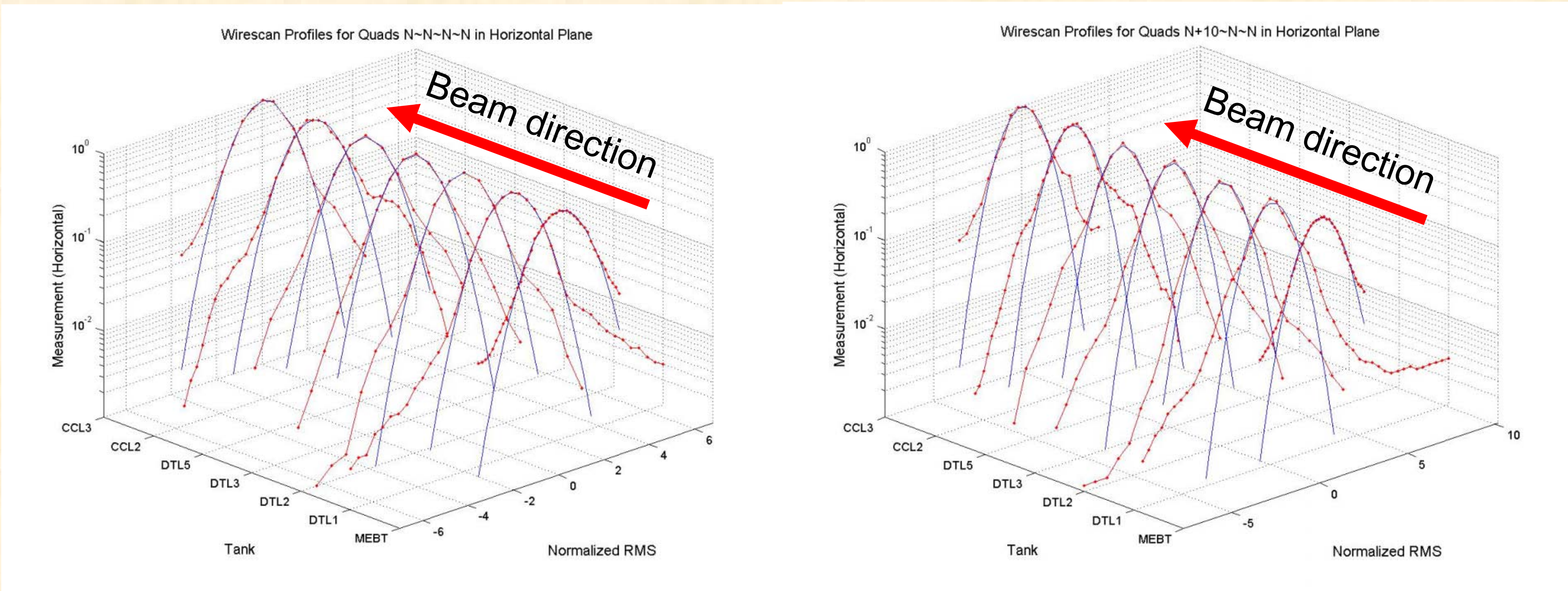

Delivers 1micro-second pulses.

Liquid mercury target produces neutrons.



# Minimize Beam Losses

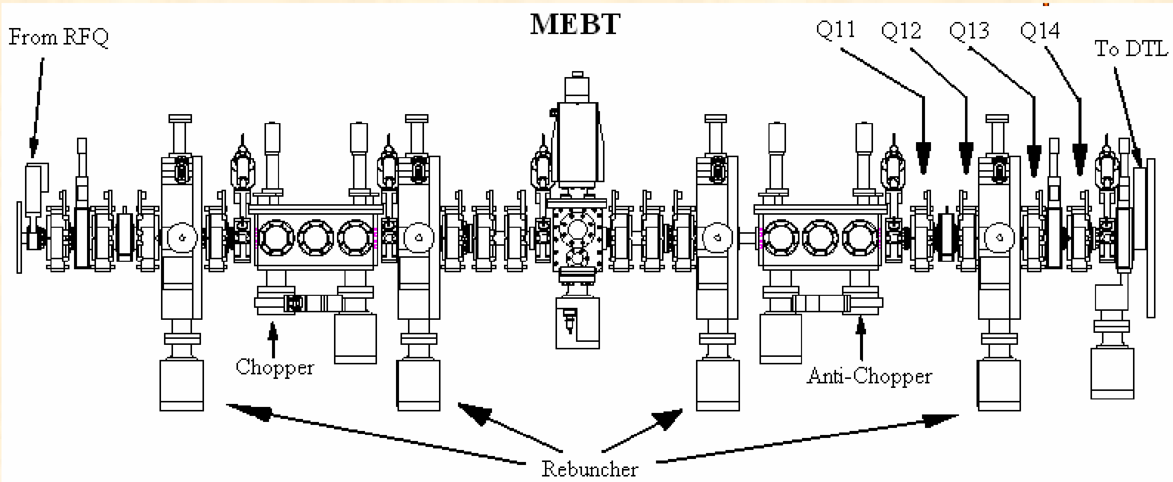
- **SNS design beam power is 1.44 MW**
- **SNS beam specification for beam loss is < 1W/m**
- **Beam halo has been identified as a contributing factor to beam loss as can be seen in the beam profiles.**
- **Halo production is attributed to mismatch.**



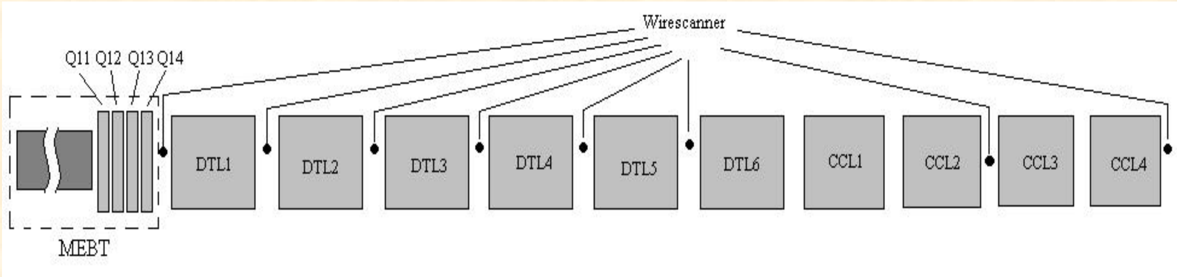

Wirescanner beam profiles for two quadrupole settings.

# Medium Energy Beam Transport (MEBT)

- **The MEBT is responsible for matching into the DTL.**
- **The DTL has permanent magnet quadrupoles.**
- **Quadrupoles 11, 12, 13, and 14 are main matching quads.**



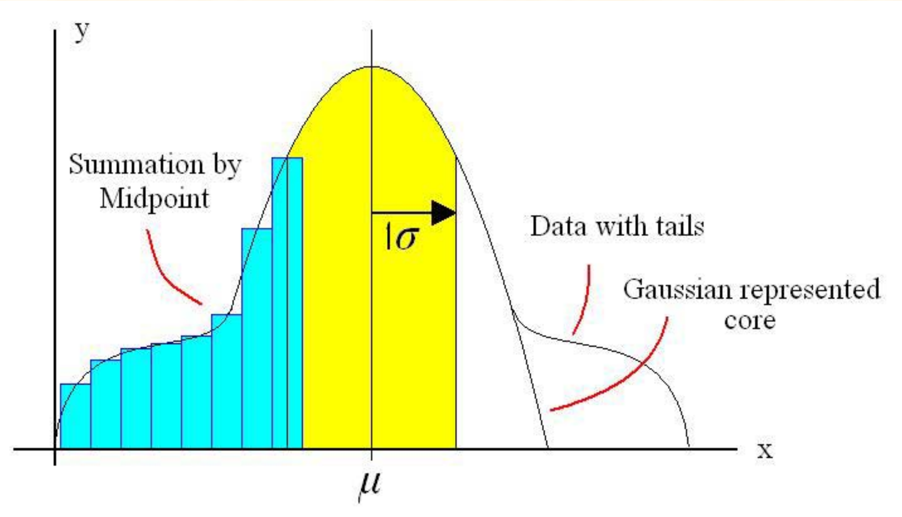

- **Wirescanners are used to measure beam profiles.**



# Quantifying Halo

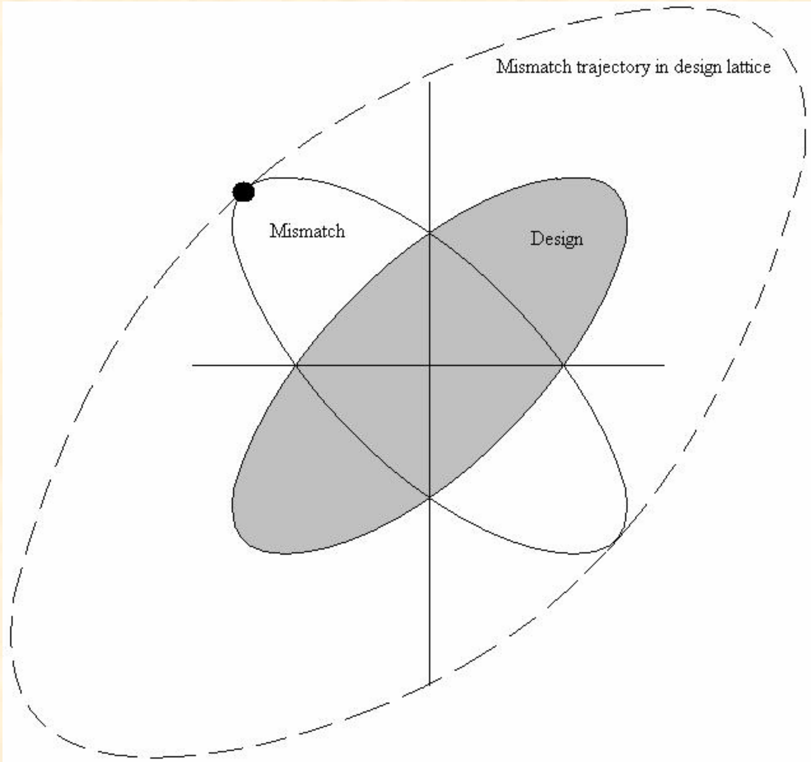
- Qualitatively halo are large amplitude particles outside a central beam core.
- Kurtosis method [ Wangler, XX International Linac Conference, 2000] was difficult to use on experimental data due to low signal to noise ratio.
- Area Ratio method was used.
- Gaussian is fitted to the top 90% of the profile.
- Using only data outside 1 sigma.
- Dividing the total area by the Gaussian area gives a ratio of halo.

$$f(x) = Ae^{\frac{-(x-\mu)^2}{2\sigma^2}}$$



# Matching

- **Purpose of this study was to control halo development by matching from MEBT to DTL.**
- **Pictorial representation of a mismatched particle.**
- **Quadrupoles 11-14 were used.**
- **Varying each quad 10% from the nominal value.**

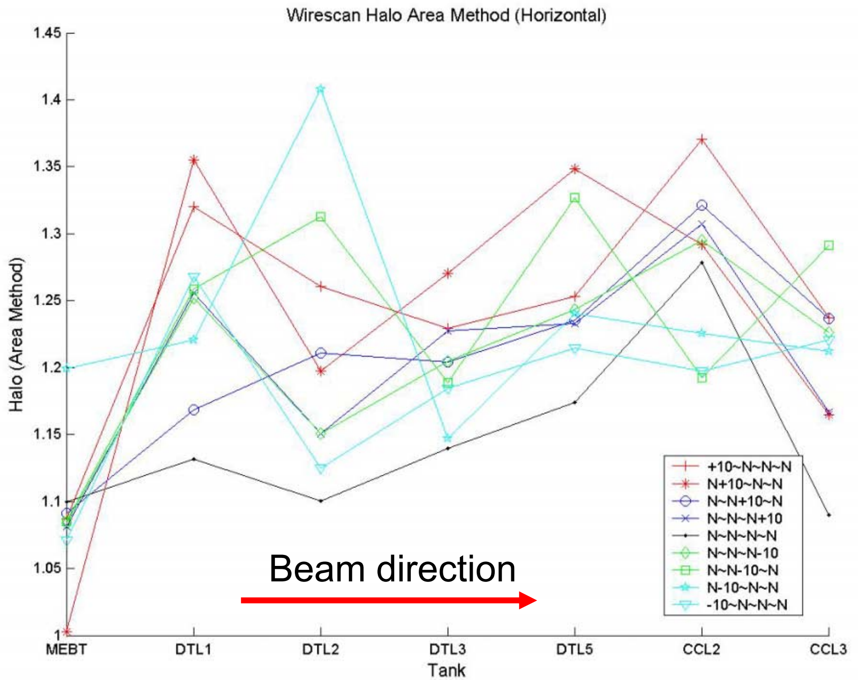


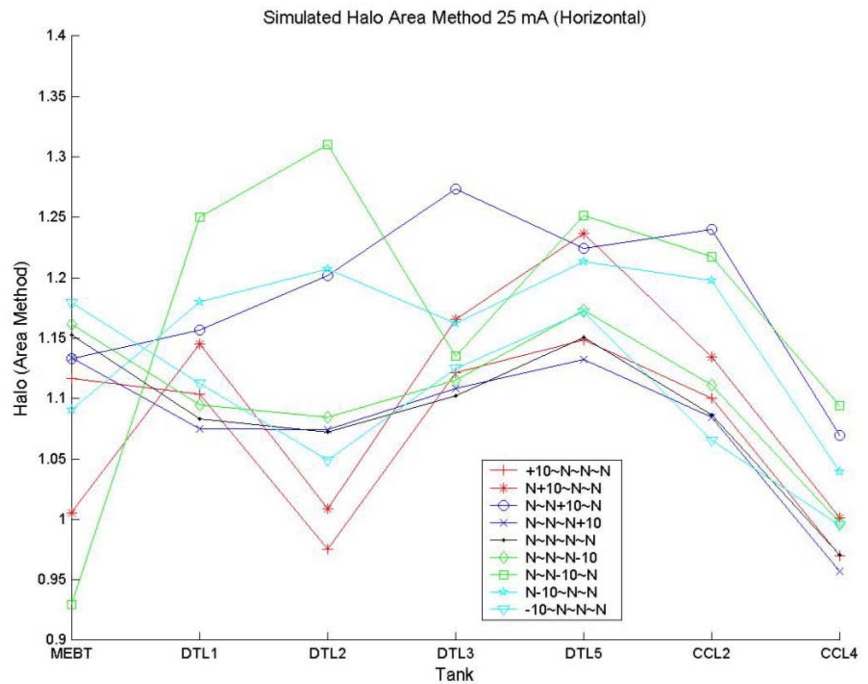
# Simulations

- **Parmila using the 3DPicnic routine was used.**
- **Run for nine quadrupole settings.**
- **Cases are named by the amount each quadrupole was varied from nominal.**
- **Using three input distributions**
  - **Reference Distribution (measured)**
  - **Gaussian Distribution**
  - **Waterbag Distribution**
- **Tracked from the beginning of the MEBT through the DTL to the end of the CCL.**

| Q11 Q12 Q13 Q14 |
|---|
| +10~N~N~N |
| N+10~N~N |
| N~N+10~N |
| N~N~N+10 |
| N~N~N~N |
| N~N~N-10 |
| N~N-10~N |
| N-10~N~N |
| -10~N~N~N |

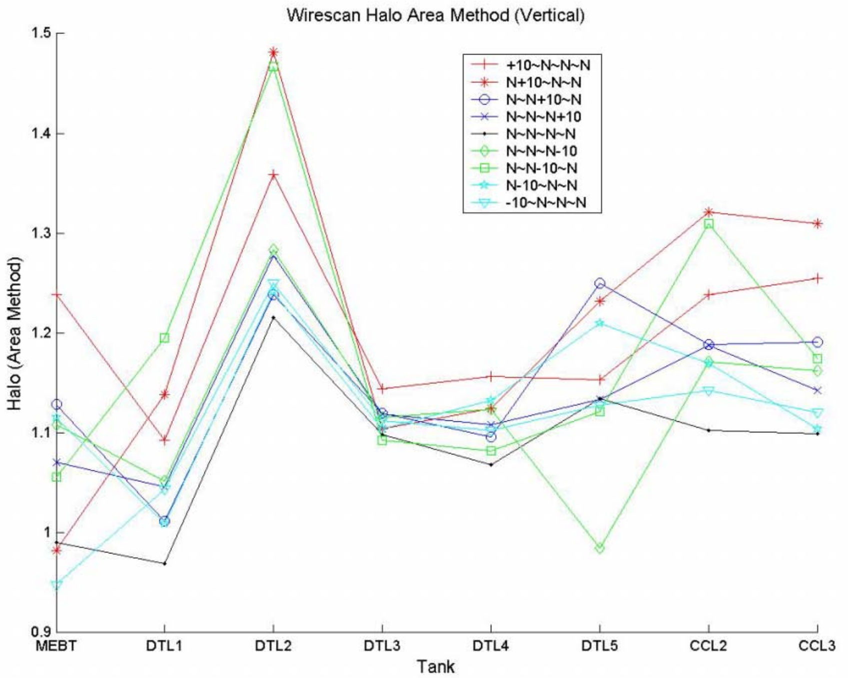
# Results: Measured vs. Simulation

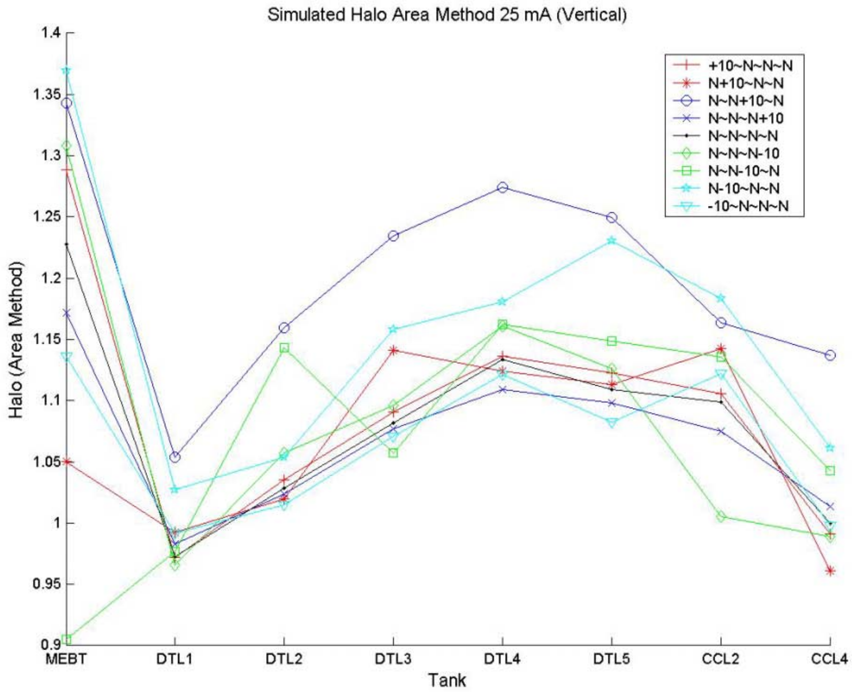



- **Halo plots for all quadrupole cases at different positions in the horizontal transverse direction.**
- **Halo decreases at the end of the CCL in both simulation and experimental data.**
- **Difference between simulated and experimental halo data in the DTL.**
- **Certain quadrupoles appear to be more sensitive to halo production with the Nominal case having the least halo.**

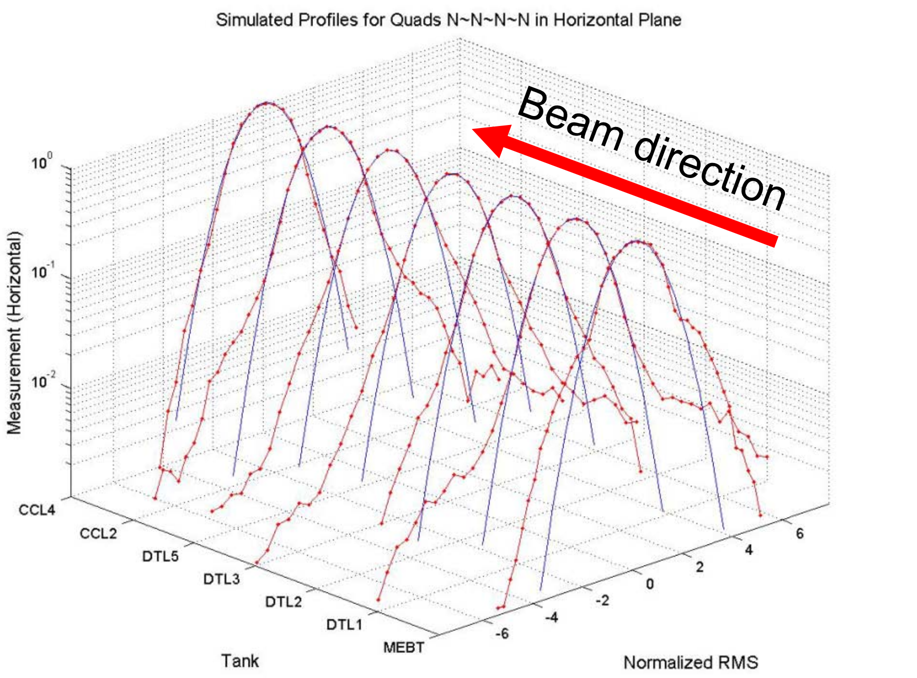
# Results: Measured vs. Simulation

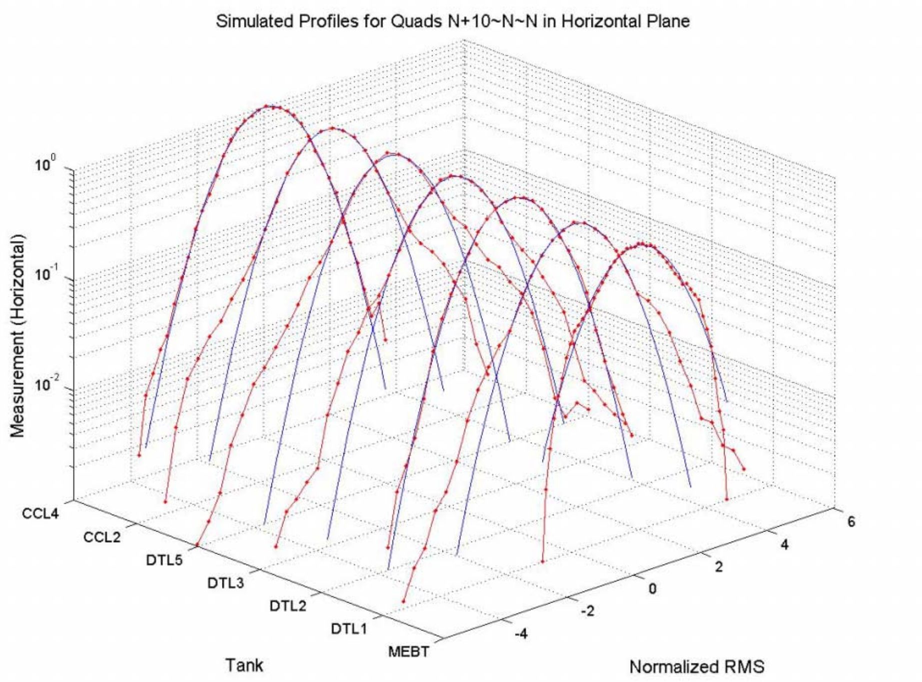



- **Measured halo trends show little similarity with simulation in the vertical direction.**
- **Vertical results show similar quadrupoles produce more halo.**
- **Simulations for both horizontal and vertical show a decrease in halo in the CCL**

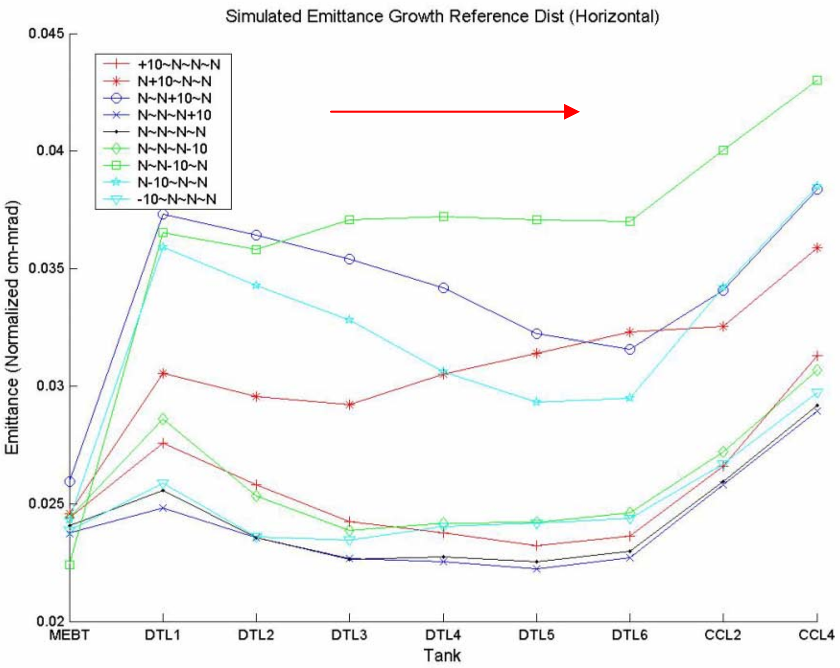
# Simulated Halo Growth

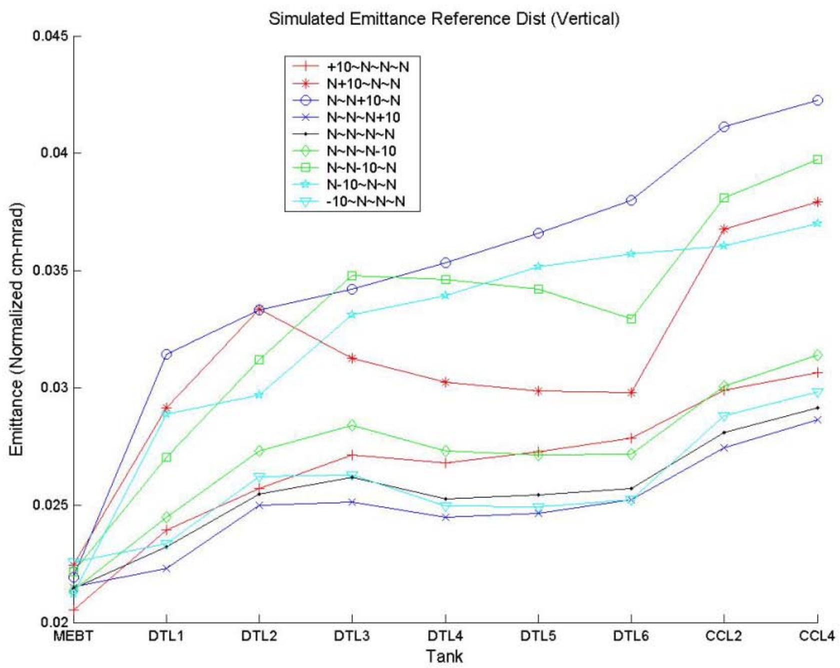



- **Simulation profile data shows a decrease in halo at the end of the CCL.**

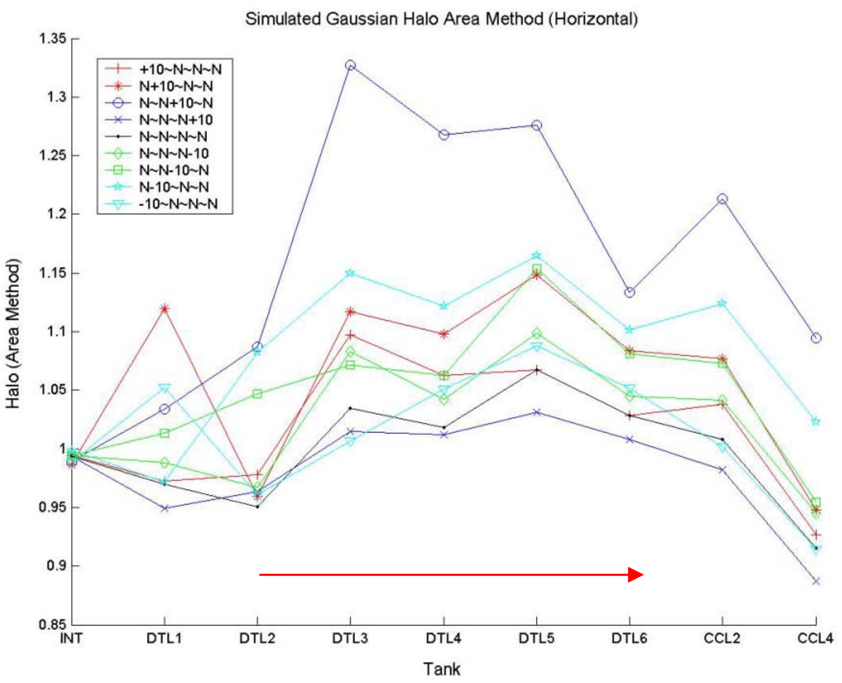
# Results: Emittance Analysis

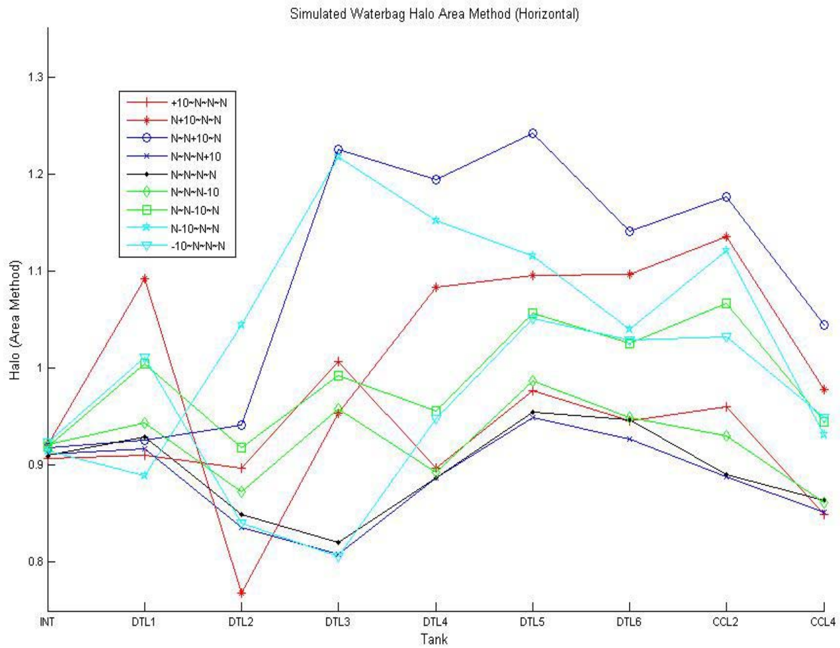



- **Simulated emittance data showing core growth.**
- **Simulations conclude that the core grows and consumes the halo particles.**
- **Phase space orientation could explain disappearance of halo in experimental data.**

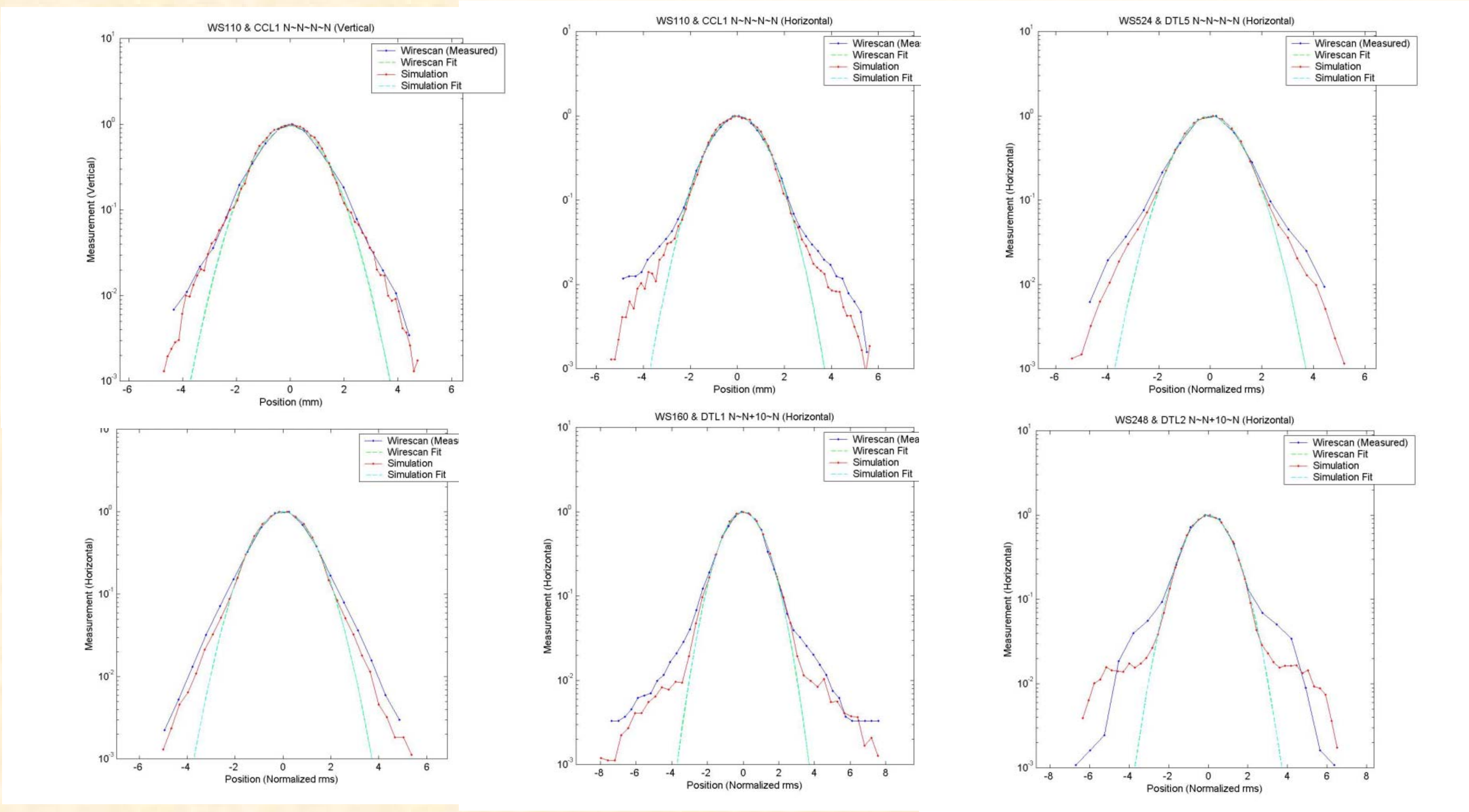
# Initial Distribution Dependence




- Gaussian and Waterbag distributions were used to study sensitivity to initial halo.
- Halo is produced regardless of initial distribution.
- Halo production is primarily dependent on mismatch, not initial distribution.

# Simulation vs. Experimental Data




- **Partial success of simulating profiles.**

# Conclusions

- Gaussian Area Ratio method is useful for quantifying halo.
- Partial success of simulations to model halo profiles.
- Simulations show a decrease in halo with an increase in emittance. This has not yet been experimentally confirmed.
- Phase advance may be a reason for the apparent disappearance of halo in experimental data.
- Finding an initial distribution, matched to measured Twiss parameters, that accurately represents the beam is currently being sought.