Progress in Quad Ring Coolers

Ring Cooler Workshop

UCLA

March 7-8, 2002

BROOKHAVEN
NATIONAL LABORATORY

Harold G. Kirk
Brookhaven National Laboratory

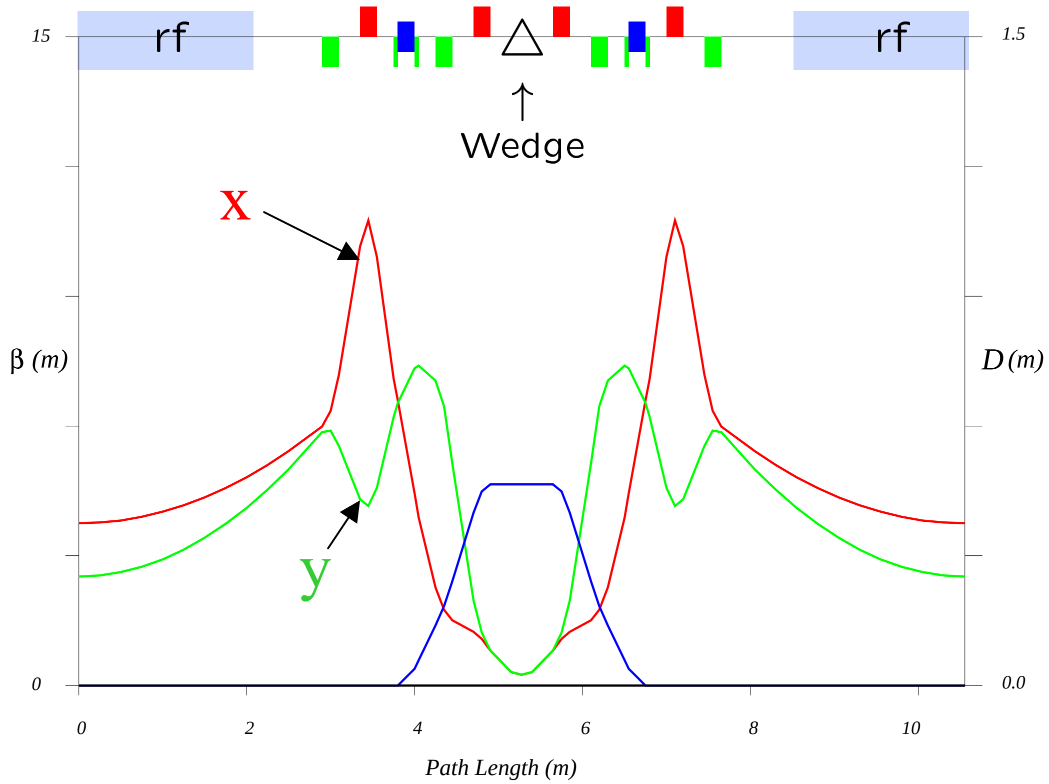
Snowmass 01

Strategy

- Explore Ring Cooling Designs
- Use only Quads & Dipoles
- Obtain Longitudinal Cooling
- Maintain/Reduce Transverse Emittance
- Linear Lattice Design (SYNCH)
- Cooling Simulation (ICOOL)

The Snowmass Lattice

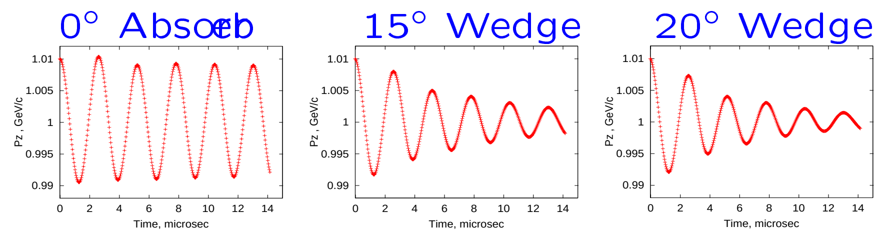
- 4 m drift available for rf
- Low β (25 cm) at absorber
- Pseudo-combined function dipole
- Allows for matching straight sections
- 45^0 bending cell
- $\beta_{x\ max} > \beta_{y\ max}$
- Cell tune is ~ 3/4



Single Particle Dynamic
No Stochastic Processes

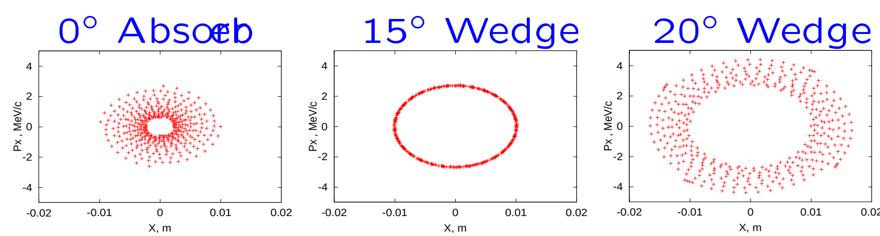
Cooling Ring: No Stochastic Processes

Longitudinal phase space damping increases with degree of wedge angle



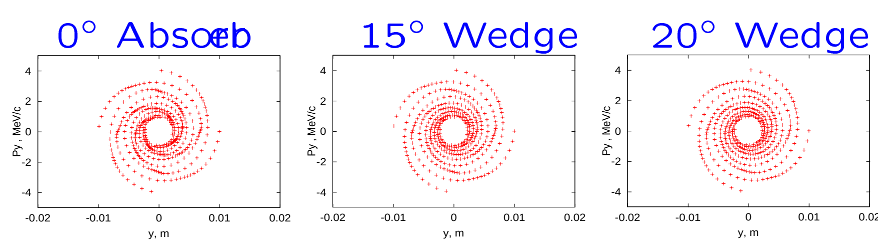
Longitudinal Momentum

Horizontal phase space reduces for wedge angles < 15^0 and increases for angles > 15^0



Horizontal Phase-space

Vertical phase space reduces at a rate independent of wedge angles



Vertical Phase-space

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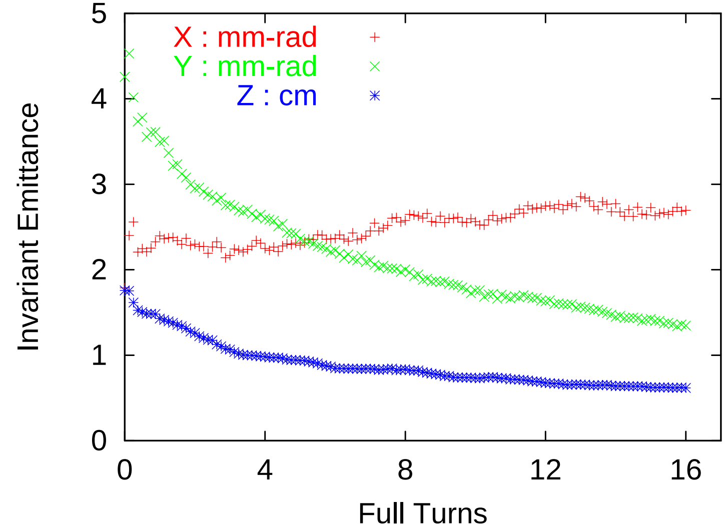
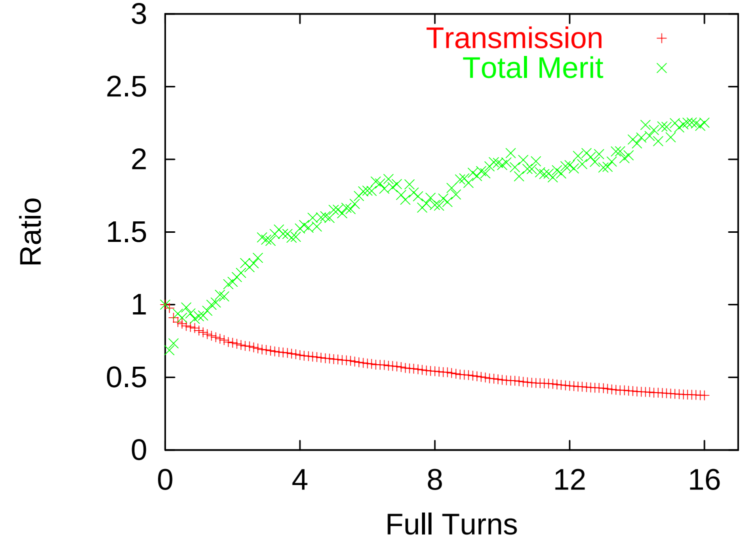
Snowmass Lattice Performance

Beam momentum 500 MeV/c
25 cm LH_2 wedges
Wedge angle 10^0
Rf frequency 201.25 MHz
E_{max} = 10 MV/m



- initial ε_y > initial ε_x
- ε_y and ε_z decreases
- ε_x increases
- Transmission 40%

Total Merit = Transmission *x* $(\varepsilon_x \varepsilon_y \varepsilon_z)_{initial} / (\varepsilon_x \varepsilon_y \varepsilon_z)_{final}$



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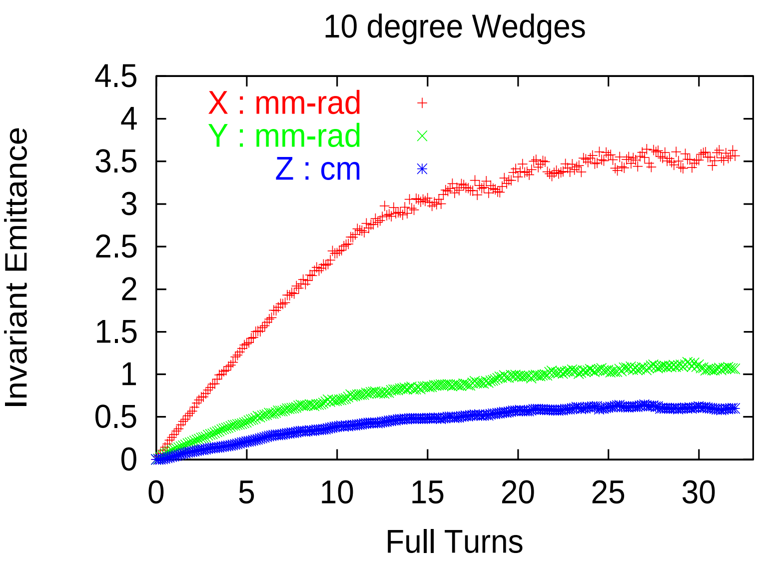
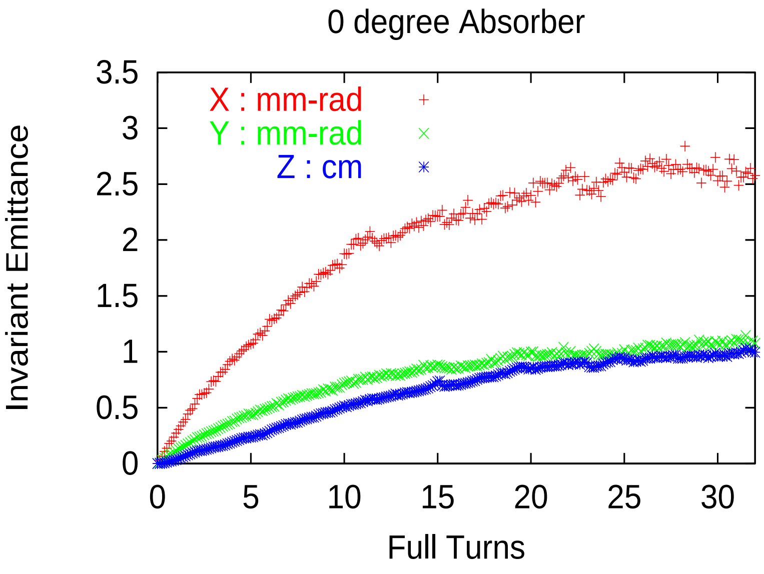
Equilibrium Emittances

Problem is noted with the equilibrium horizontal emittance, which is much higher than expected

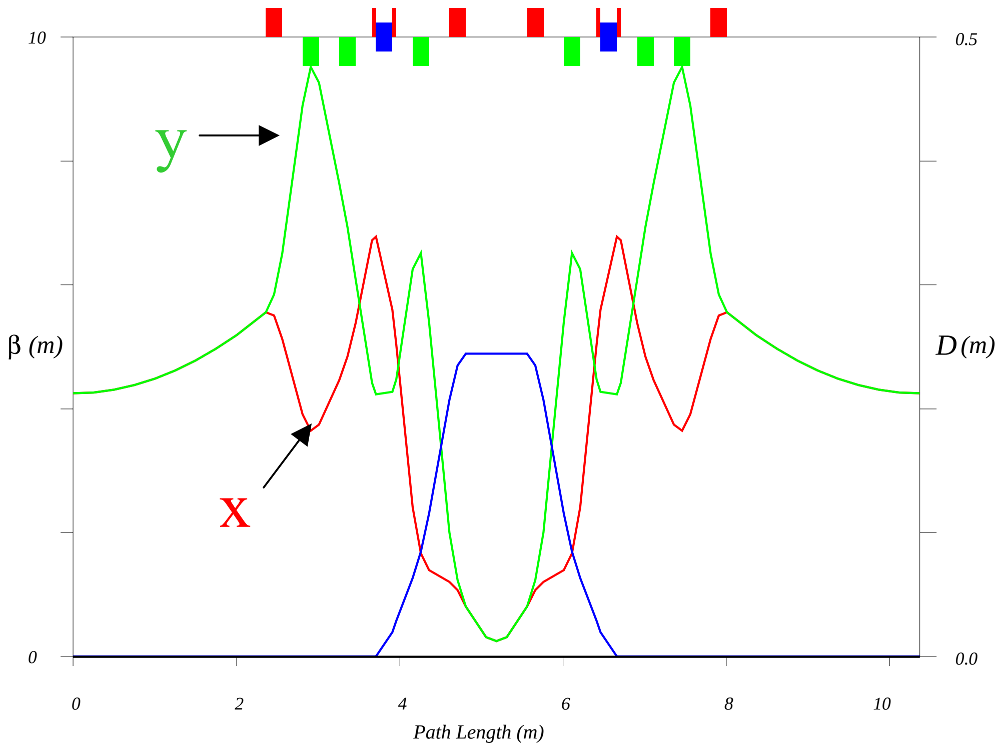




Horizontal equilibrium emittance persists even for 0^0 wedges. Higher order dispersion effects?

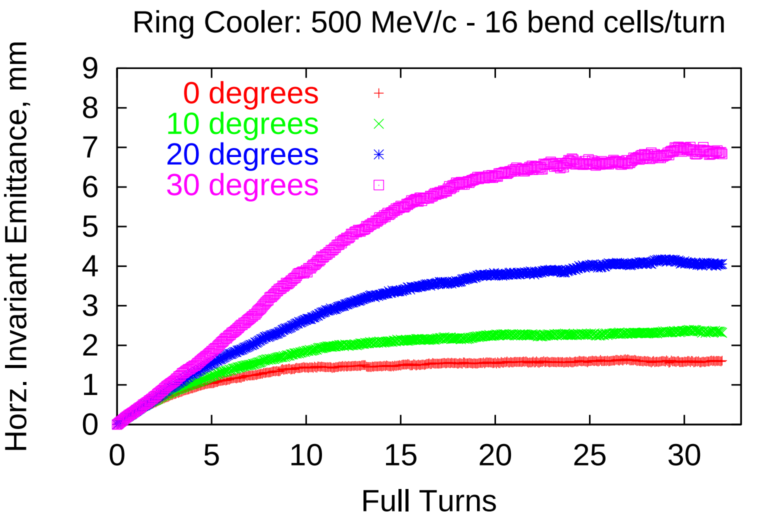
The Tucson Lattice

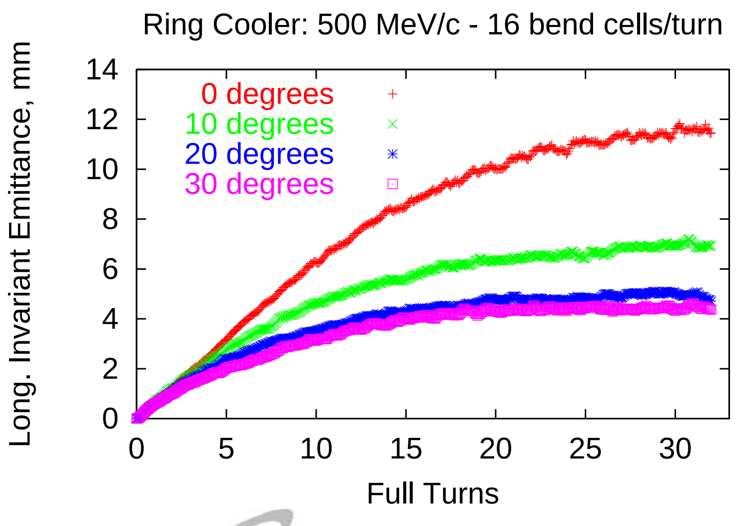
- 4 m drift available for rf
- Low β (25 cm) at absorber
- Pseudo-combined function dipole
- Allows for matching straight sections
- 22.5^0 bending cell
- $\beta_{y\ max} > \beta_{x\ max}$
- Cell tune is ~ 3/4



Tucson Lattice Equilibrium Emittances

Horizontal equilibrium emittance increases with wedge angle but 0^0 wedge angle behaves as expected





Longitudinal equilibrium emittance declines with increasing wedge angle

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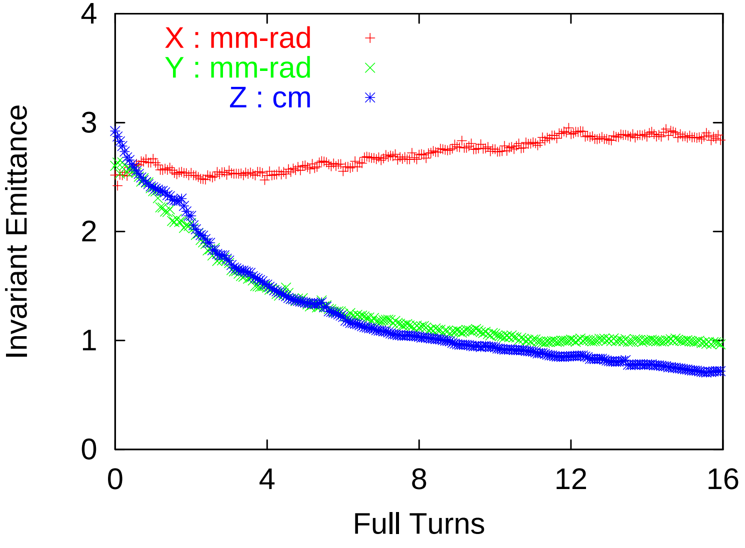
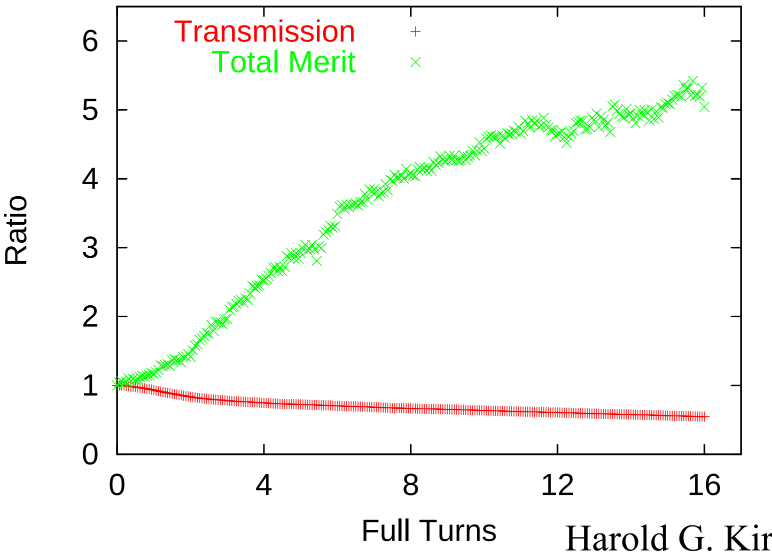
Tucson Lattice Performance

Beam momentum 500 MeV/c
25 cm LH_2 wedges
Wedge angle 20^0
Rf frequency 201.25 MHz
E_{max} = 8 MV/m

- ε_y and ε_z decreases
- ε_x nearly constant
- Transmission 60%

Total Merit = Transmission *x* $(\varepsilon_x \varepsilon_y \varepsilon_z)_{initial} / (\varepsilon_x \varepsilon_y \varepsilon_z)_{final}$





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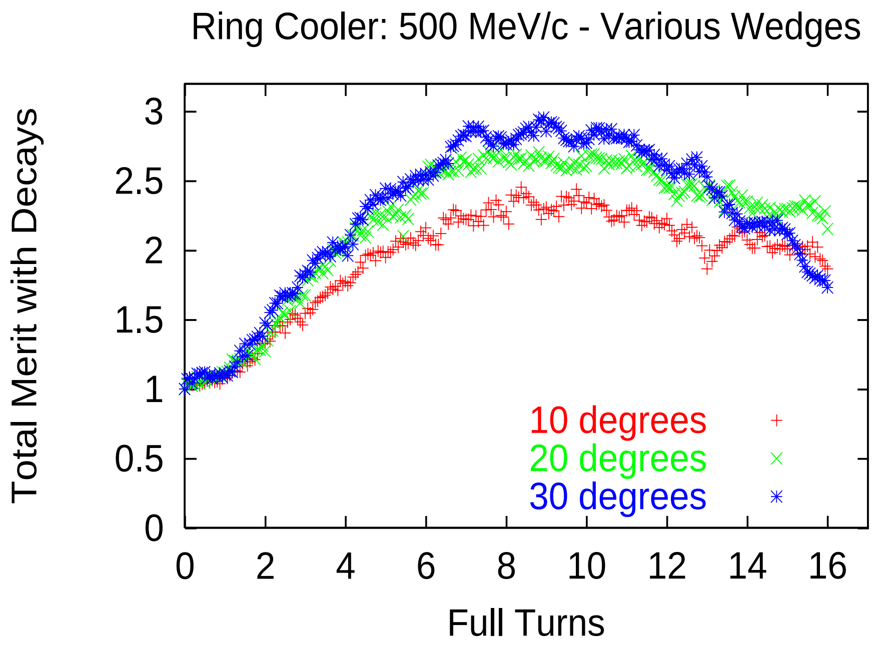
Consider Decay Losses

		Ratio ($\frac{\text{initial}}{\text{final}}$)	
	Initial	After 8 Turns	After 16 Turns
$\gamma\beta\varepsilon_{x,\ mm}$	2.5	0.93	0.87
$\gamma\beta\varepsilon_{y,\ mm}$	2.6	2.33	2.65
$\gamma\beta\varepsilon_{z,\ mm}$	29.2	2.83	4.02
Transmission	1.0	0.67	0.55
Decay survival	1.0	0.65	0.43



Total merit peaks near 8 full turns. 20^0 to 30^0 wedges are best.

What has been accomplished

- The SYNCH + ICOOL approach works well
- Emittance exchange has been demonstrated
- This quad ring design does not replace Study II front end but can follow it
- Transmission losses are still high
- Need to consider realistic quads (L = 20cm ; R = 20 cm)
- Horizontal - vertical coupling should be considered
  - Skew quads
  - Solenoids
- Need to incorporate soft edges