Lattice choices for Ring Cooler

Crieria include:

- $\beta_\perp$ at absorber
  determines minimum emittance

  Equilibrium emittance $\approx 45(\pi \text{ mm mrad}) \times \beta_\perp(\text{cm})$

  $\approx$ 50 cm at start $\approx$ 1cm later

- Transverse acceptance over minimum emittance
  determines rate of cooling and losses

  $$\text{Acceptance Factor} = \frac{\text{Acceptance}}{\text{Min Emittance}} \text{(Desired)} \approx 24$$

- Momentum acceptance
  $\approx$ +/− 22% at start $\approx$ +/− 10% later

		FOFO[1]	Quad Triplets[2]	FODO[3]
beta at absorber	cm	40	25	163
beta max	m	.95	10	3.13
aperture max	cm	21	10.5)[4] 21)[5]	30)[4] 60)[5]
$\beta\gamma$		2	4.8	2
Min Emittance	mm	**1.8**	**1.1**	**7.3**
Acceptance Factor		**50**	**5)[4] 20)[5]**	**8)[4] 32)[5]**
+/− p acceptance	%	**20**	**7.5**	**22**

Notes:

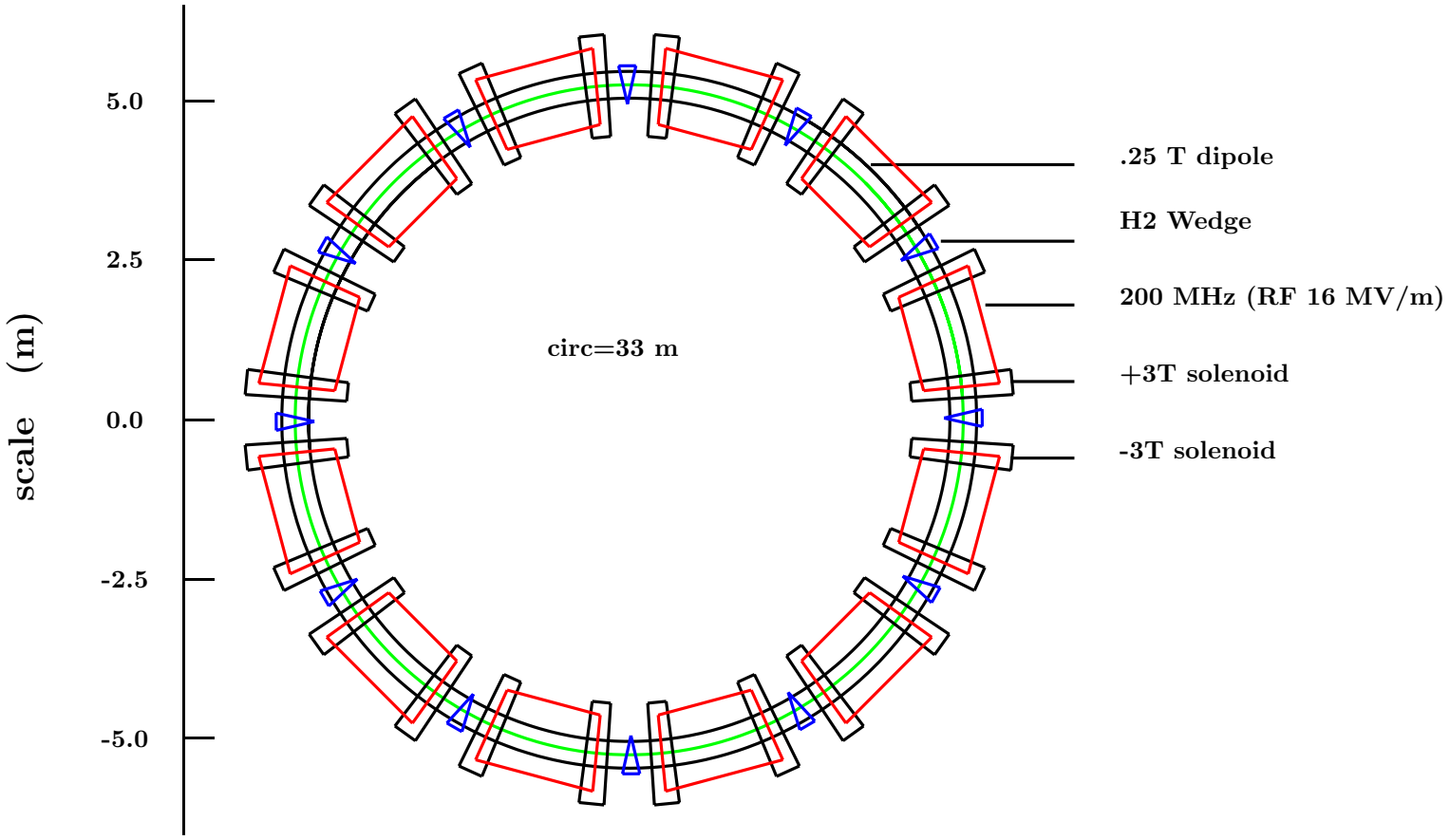
1. Solenoid RFOFO similar to Study 2, but with bends
2. Garren et al Lattice with bends
3. Carol Johnstone FOFO latice
4. Scaled to Quad bore/length = 1
5. Scaled to Quad bore/length = 2

Conclusions

- Garren Triplet lattice has lower emittance, but poor momentum acceptance
- Carol FOFO lattice has good momentum acceptance but high emittance
- Solenoid RFOFO has better trnasverse acceptances than quad lattices, and good momentum acceptance
- Balbakov alternating solenoid probably similar to RFOFO
- Lattices with less acceptance will cool, but at lower rates, and with less transmission.

Simulations of RFOFO Ring Emittance Exchange

R.B. Palmer R. Fernow S. Berg
(Oct 01 LBL)

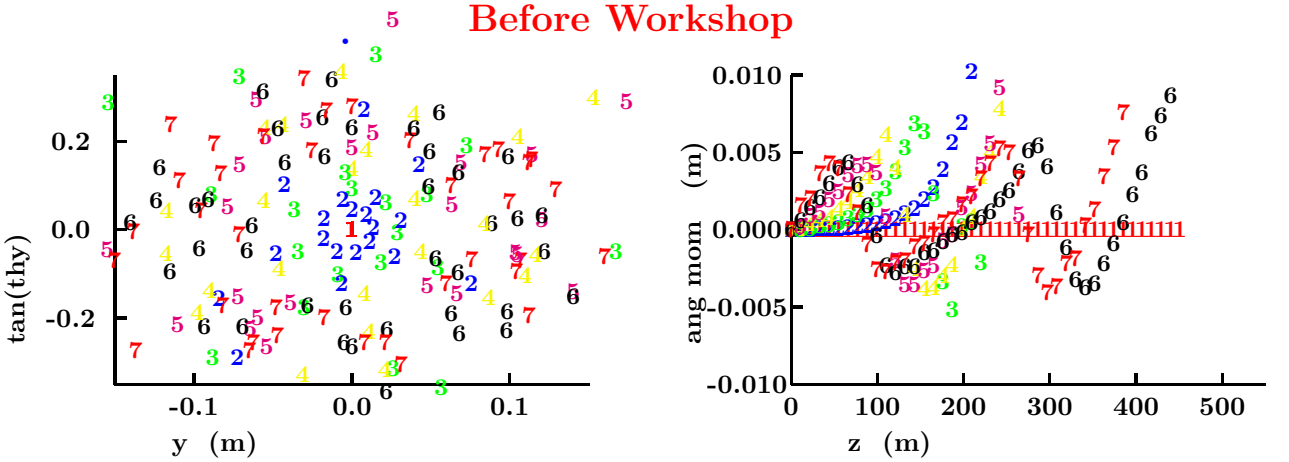


An upward spiral would solve injection/extraction problems and allow tappering of beta function to give continuous cooling

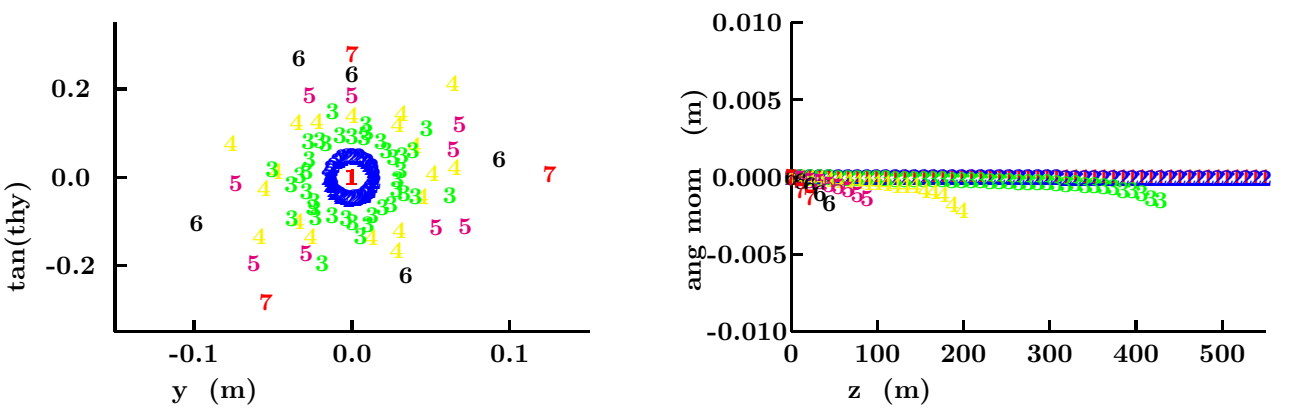
Study of tracking in ICOOL

RFOFO Lattice. No Bending, but 3rd order method allowing bends. Track single particles through 200 cells

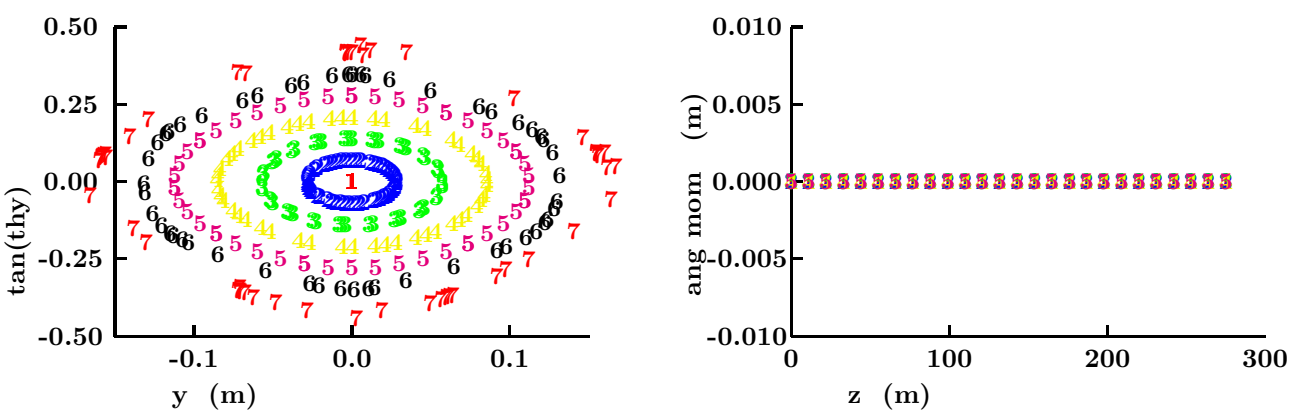
Before Workshop



Interpolation Fixed

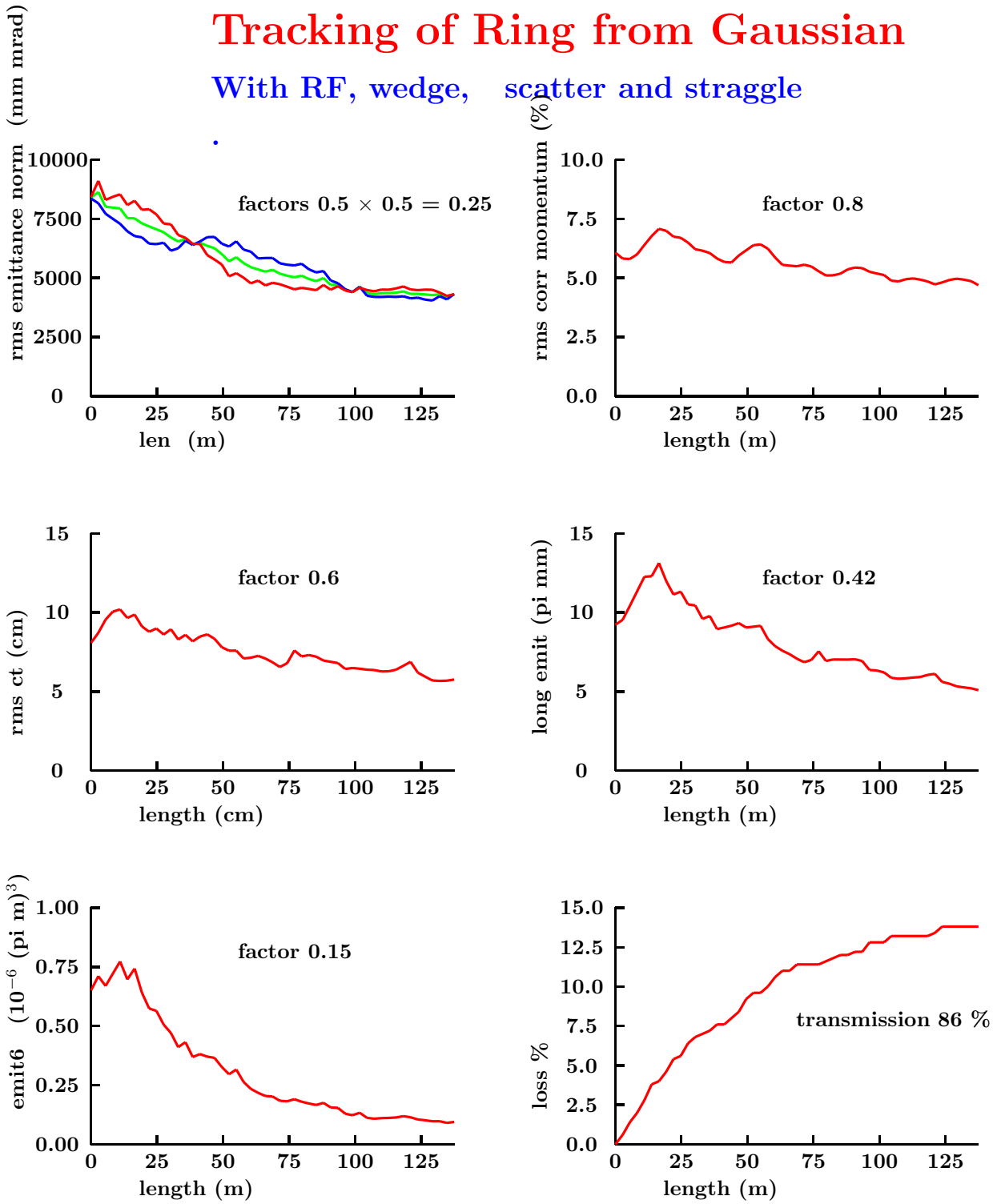


Fourier Definition of fields



Tracking of Ring from Gaussian

With RF, wedge, scatter and straggle



Summary

- **Longitudinal emittance** $\times$ 0.42
- **Transverse xy emittance** $\times$ $(.5)^2 = 0.25$
- **6D emittance** $\times$ 0.15
- **Transmission** **86 %**
- **Quality Factor** $(\epsilon_{in}/\epsilon_{out} \times$ Trans $=$ 5.7

Conclusions

- **There have been problems in tracking solenoid channels with bends in ICOOL, and several of them have been fixed;**
  - **Interpolation of tables of axial fields**
  - **Adding a missing term in the third order expansion**
  - **Allowing axial fields to be specified by Fourier components, thus elliminating discontinuities between cell fields.**
- **But the derivation of off axis fields is still limited to only 3rd order in radius (7th order is used in systems without bends), and this may still be causing difficulties.**
- **Using these third order calculations, 6D emittance cooling was achieved:**
- **Requires optimization, but should significantly improve study 2 performance.**
- **This, and the bend solenoid simulations, are the only emittance exchange demonstations with tracking in full Maxwellian focus and RF fields.**