Review of alternative cooling options for Muon Accelerators

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IDS-NF Phone Meeting

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Work in collaboration with:

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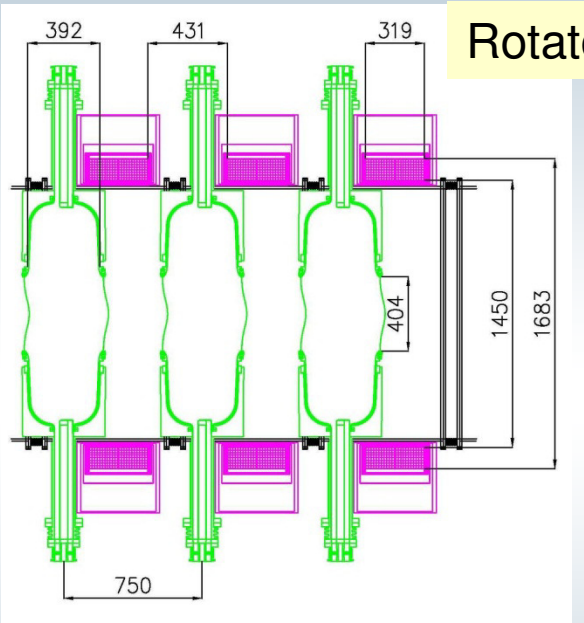
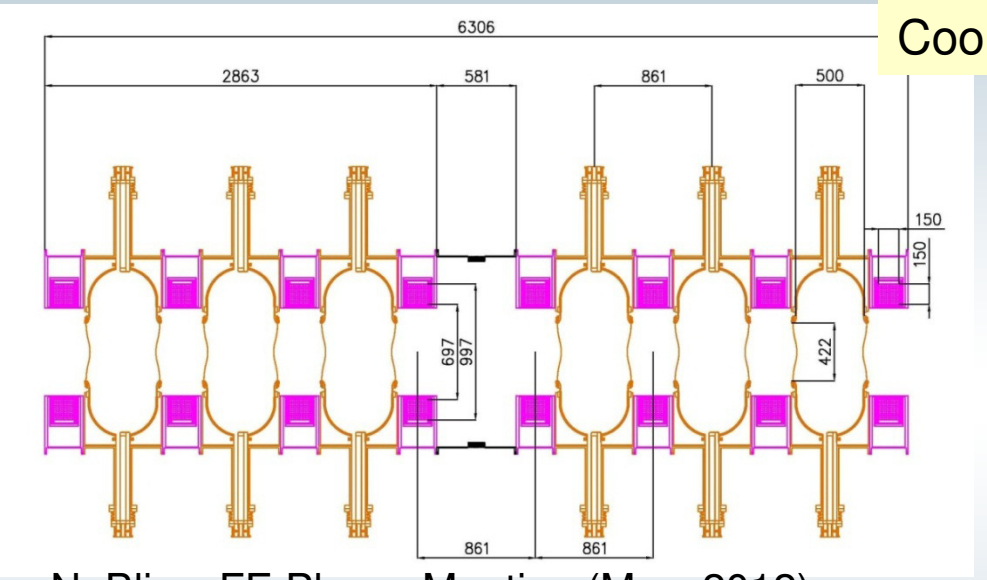
- Pavel Snopok (IIT/ FNAL)
- Androula Alekou (CERN)
- David Neuffer (FNAL)
- Hisham Sayed (BNL)
- Scott Berg (BNL), Rob Ryne (LBNL) and Steve Kahn (Muons Inc)

Challenge 1: Engineering constraints



Rotator

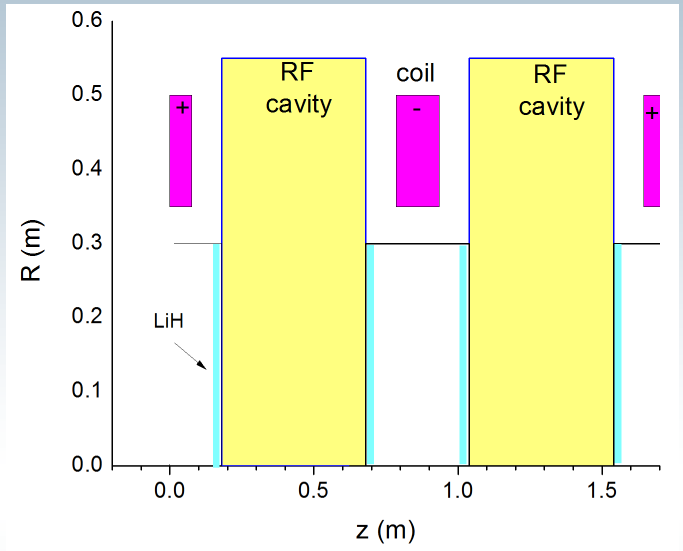


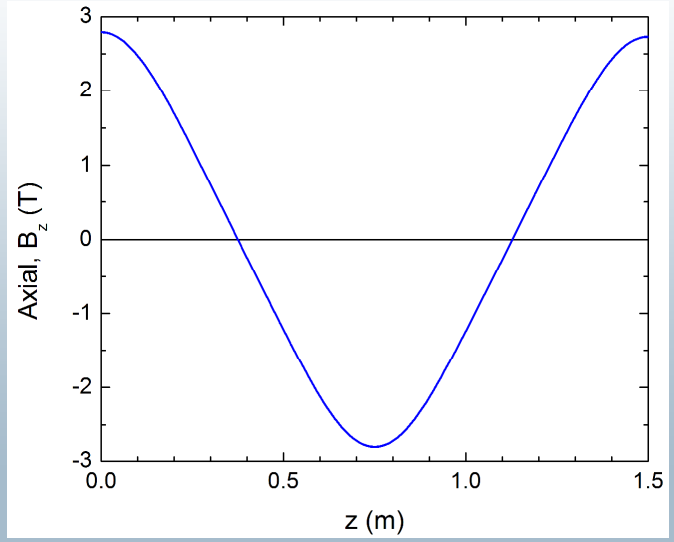
Cooler

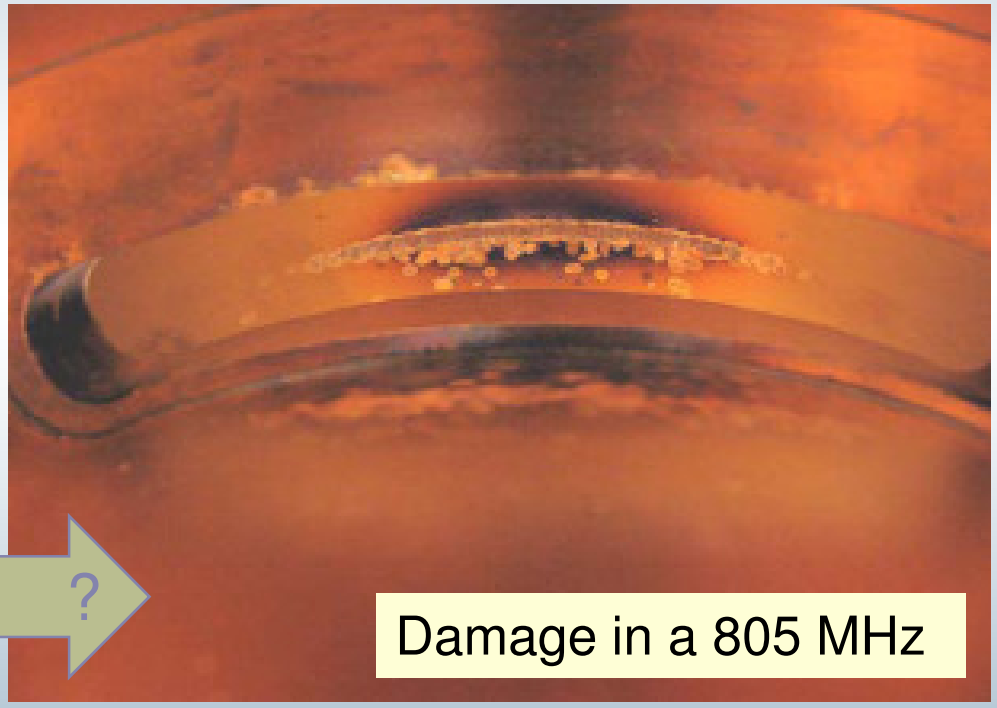
N. Bliss, FE Phone-Meeting (May, 2012)

- Recent engineering studies suggest to:
  - Increase the gap between coils in buncher & rotator
  - Increase cooler cell length from 0.75 m to 0.86 m
  - Have one “empty” cell after a series of cavities

Challenge 2: cooling channels with > 2 T







Challenge 3: Simulation Challenges

- In order to validate our models and benchmark our lattice designs we need more than one code.
- Important to do numerical calculations with 6-figure particle distributions for accurate statistics
- Unfortunately our previous simulations were limited to a few thousands particles mainly due time and hardware limitations.
- There have been efforts within the MAP program towards high performance computing (R. Ryne, MAP Phone meeting presentation, Nov. 2, 2012)

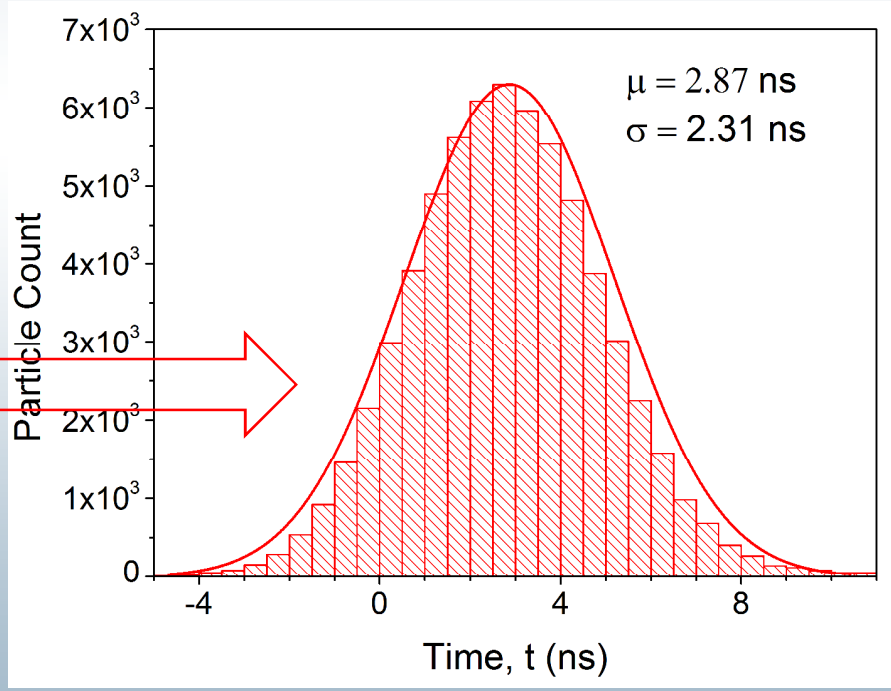
Outline

- Present three alternative cooling options for a NF
  - Engineered version of our existing IDS-NF baseline
  - Low B-field bucked coil lattice
  - Low B-field shielded coil lattice
- Develop simulation models for the above lattices
  - Simulation decks with G4Beamline and ICOOL
- Apply the existing high-performance computing tools for the NF-FE
  - Use Parallelized versions of ICOOL and G4BL
  - Multi–processor simulations with 300,000 particles or more.

Initial Distribution

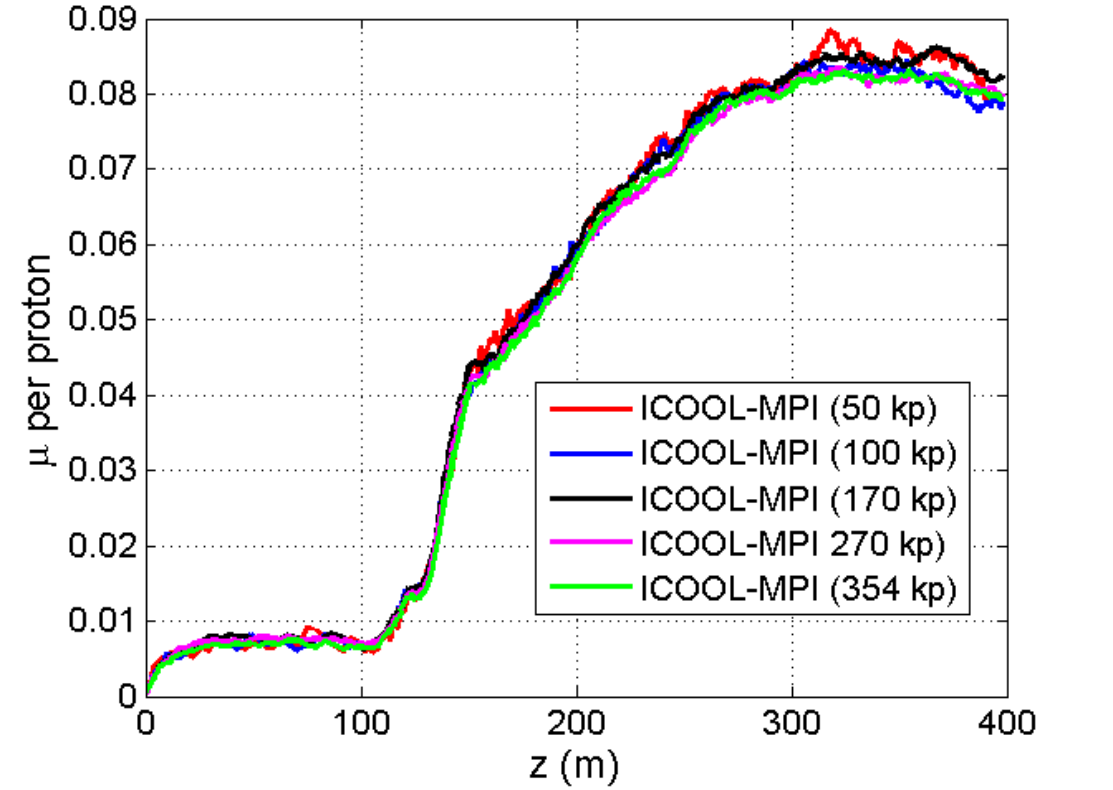
- Input distributions are available from the targetry group: pubweb.bnl.gov/~kirk/Target_Studies/Icool_for003_decks

Hg_8gev_0ns_p11_negatives	28-Oct-2010 10:24	15M
Hg_8gev_0ns_p11_positives	28-Oct-2010 10:22	37M
Hg_8gev_1ns_p11_negatives	28-Oct-2010 10:25	15M
Hg_8gev_1ns_p11_positives	28-Oct-2010 10:29	37M
Hg_8gev_2ns_p11_negatives	12-Oct-2010 14:53	15M
Hg_8gev_2ns_p11_positives	12-Oct-2010 14:53	37M
Hg_8gev_3ns_p11_negatives	18-Oct-2010 09:38	15M
Hg_8gev_3ns_p11_positives	12-Oct-2010 14:56	37M
Hg_8gev_4ns_p11_negatives	28-Oct-2010 10:19	15M
Hg_8gev_4ns_p11_positives	28-Oct-2010 10:19	37M



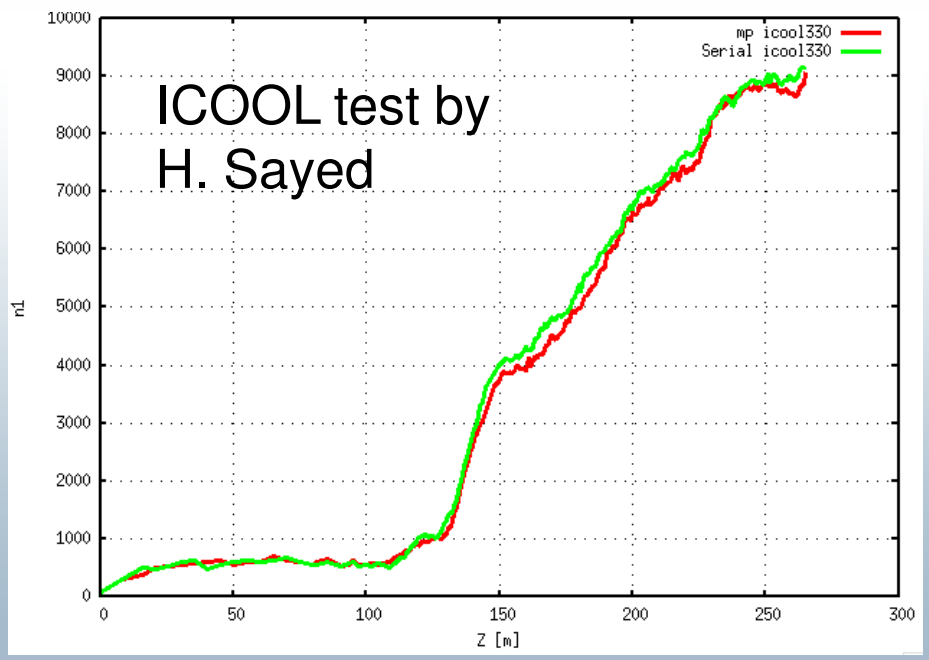
Simulation Details (1)

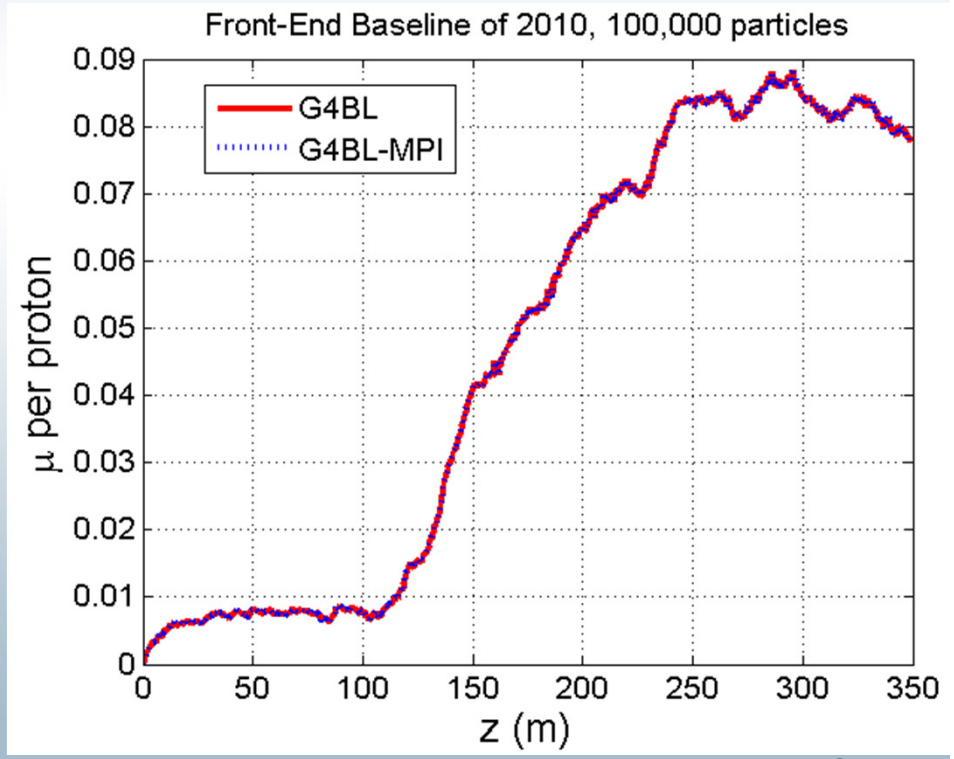
- Simulations with ICOOL 3.30 and G4BL 2.14.
- I used 354,000 particles in order to produce noise-free data.



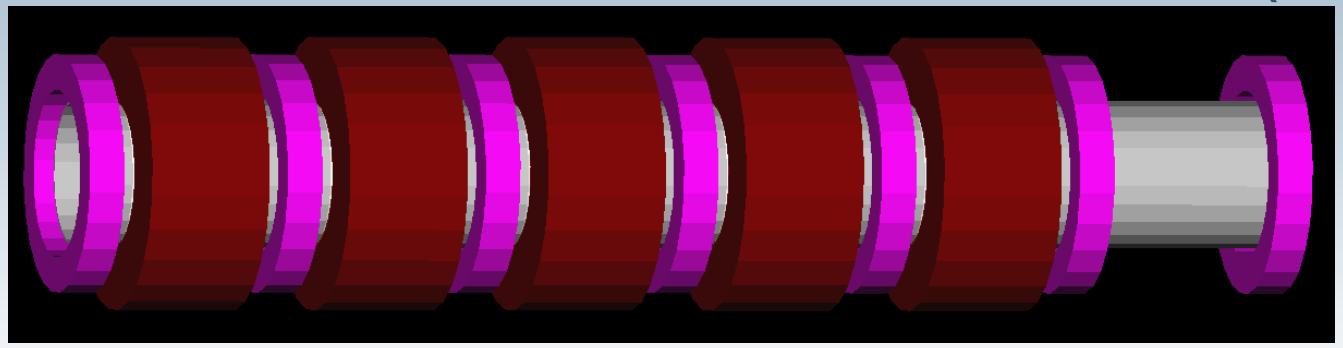
Simulation Details (2)

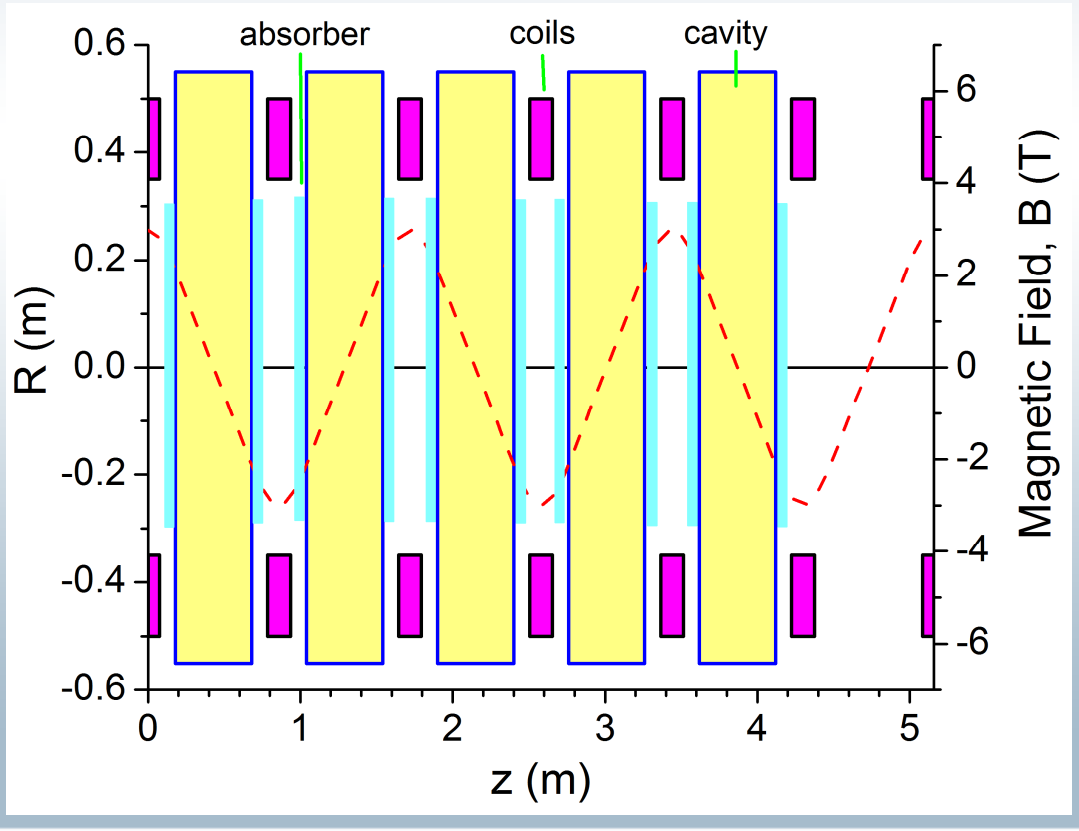
- Validated the parallelized versions of ICOOL and G4BL for the NF-FE
- Typical run takes a few minutes vs. several hours in a home computer.





Engineered Based New Baseline (NBL)





New Baseline Parameters

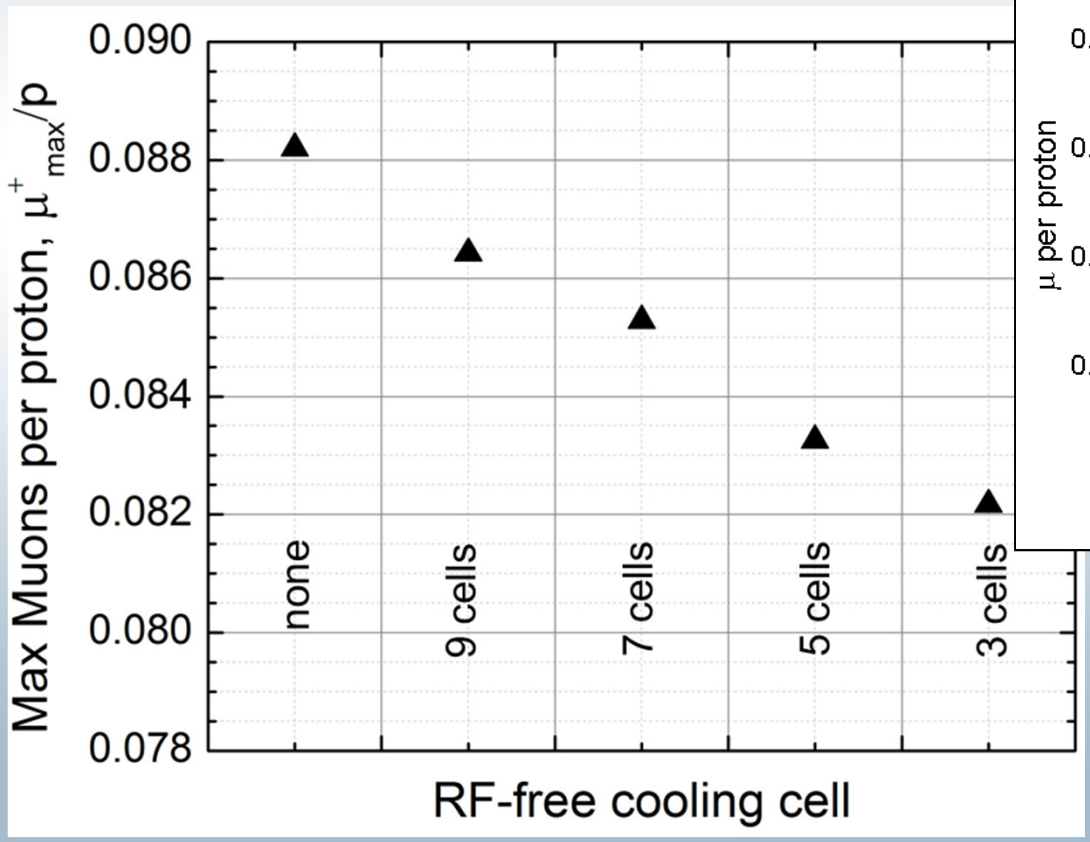
	Length [m]	Number of cavities	Frequencies [MHz]	Number of frequencies	Peak gradient [MV/m]
Capture	18.9				
Drift	60.7				
Buncher	33.0	33	319.6 to 233.6	13	3.4 to 9.7
Rotator	42.0	56	230.2 to 202.3	15	13
Cooler	>97.5	130	201.25	1	16
TOTAL	>252	219	319.6 to 201.25	29	

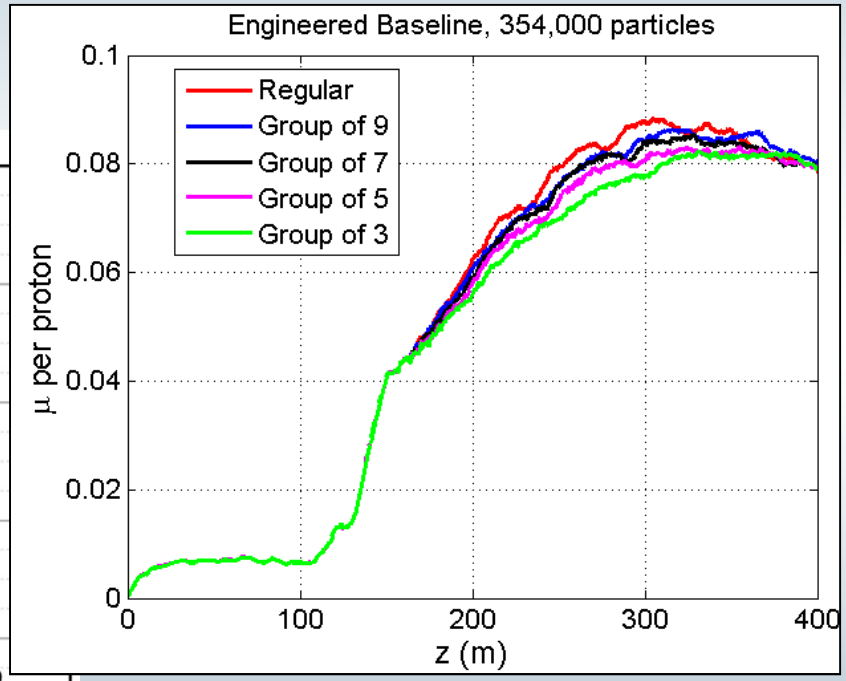
~160 m

~140

NBL Performance

- Results appear to be sensitive the location of the “empty cell”



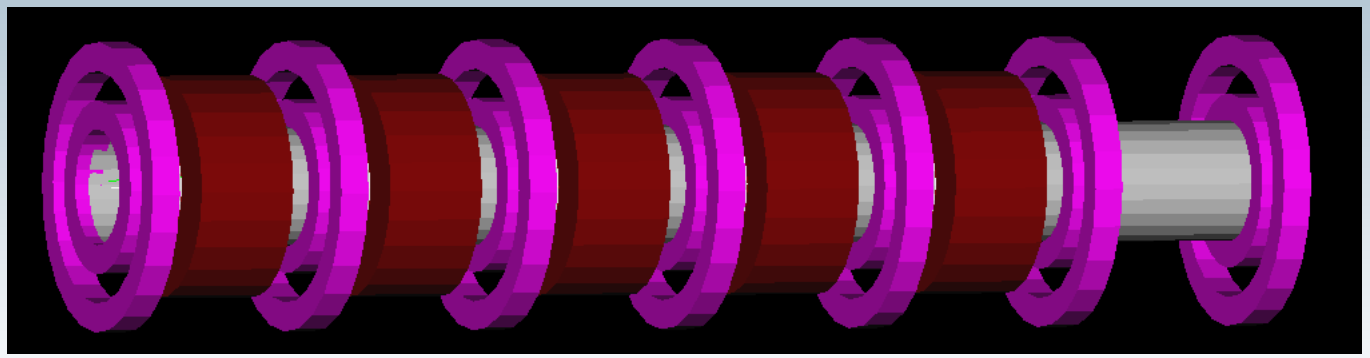


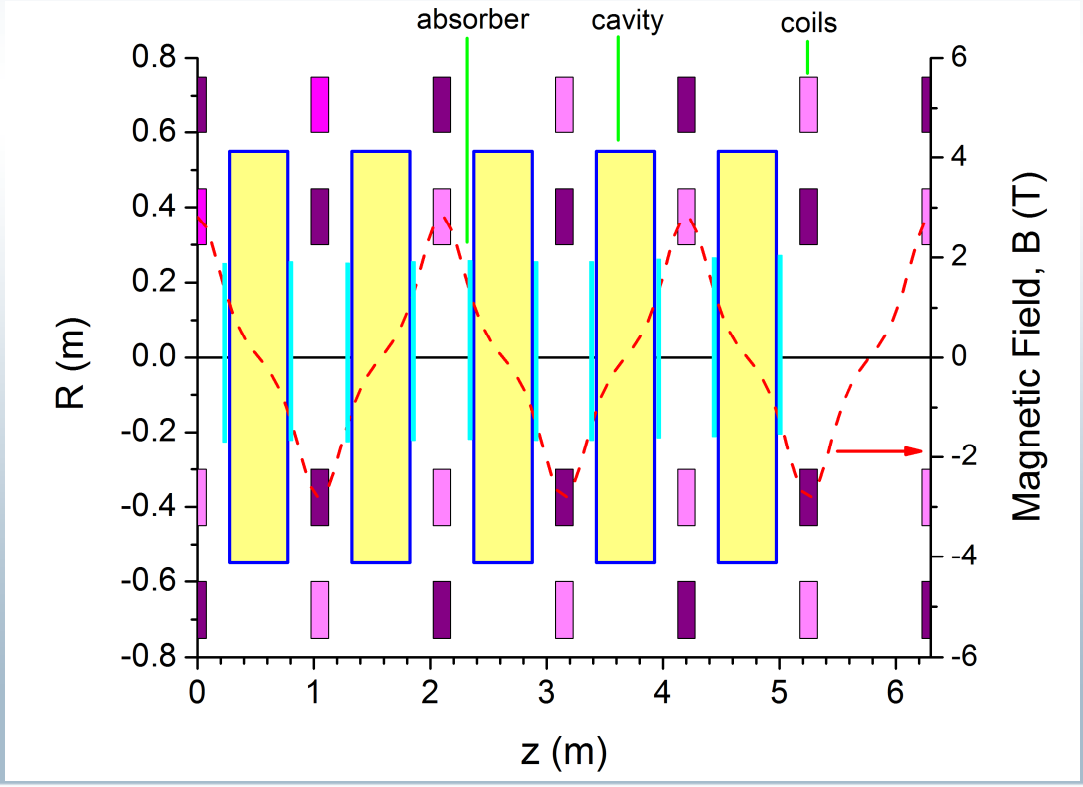
- μ/p rate within A_T < 30 mm, A_L< 150 mm and cut in momentum 100<Pz<300 MeV/c

Cooling with Bucked Coil Lattices

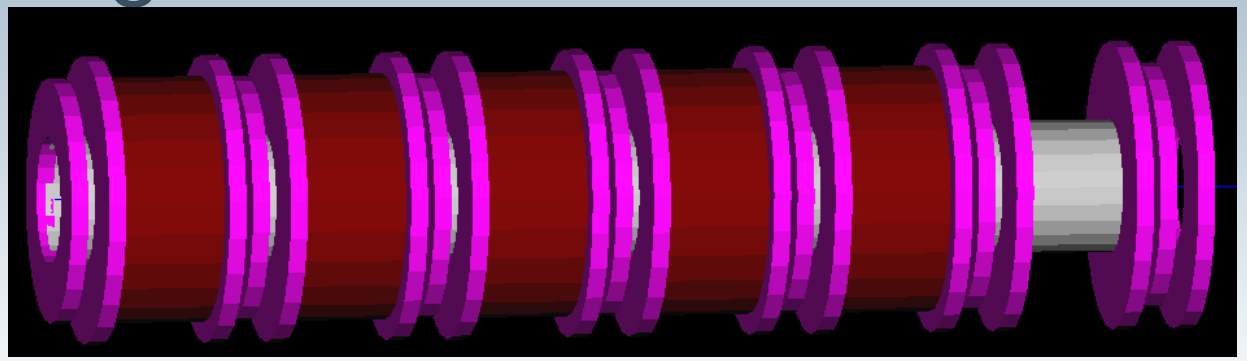
- Case 1: Radial Bucked Coil Scheme (RBC)
  - Field in rf is less than a Tesla
- Case 2: Longitudinal Bucked Coil Scheme (LBC)
  - Achieves lower B-field than RBC
  - Narrow space between coils and cavities

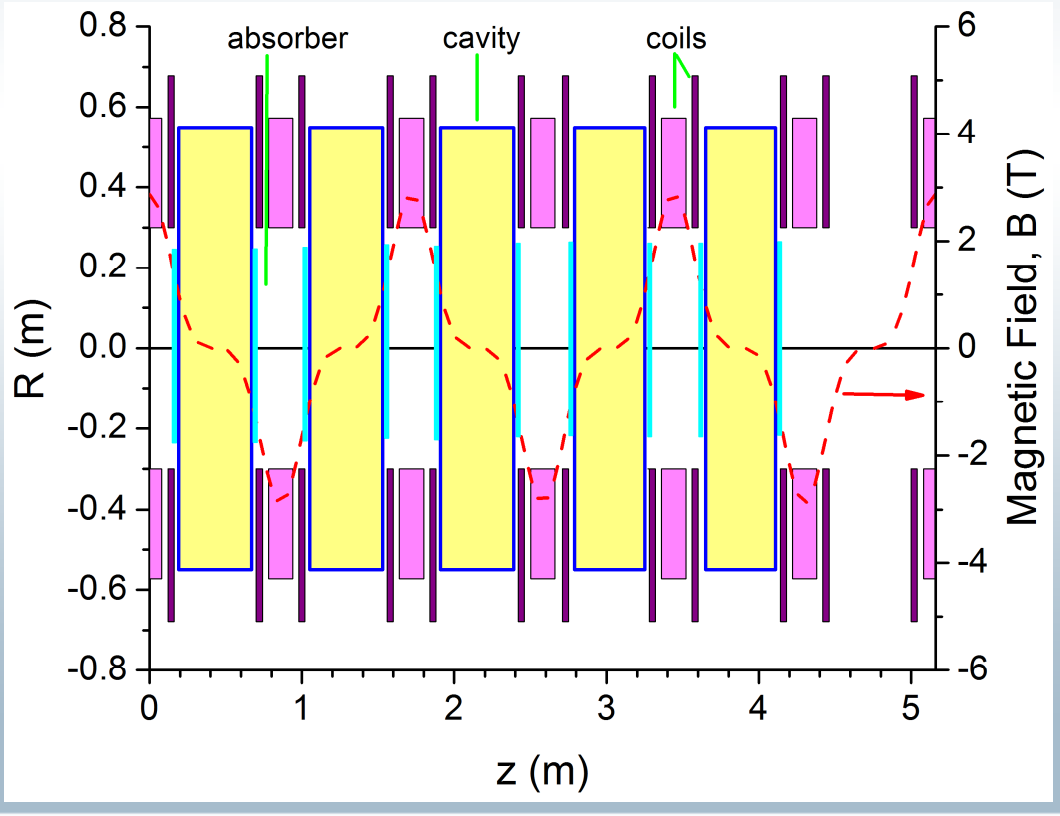
Radial Bucked Coil Scheme (Alekou)



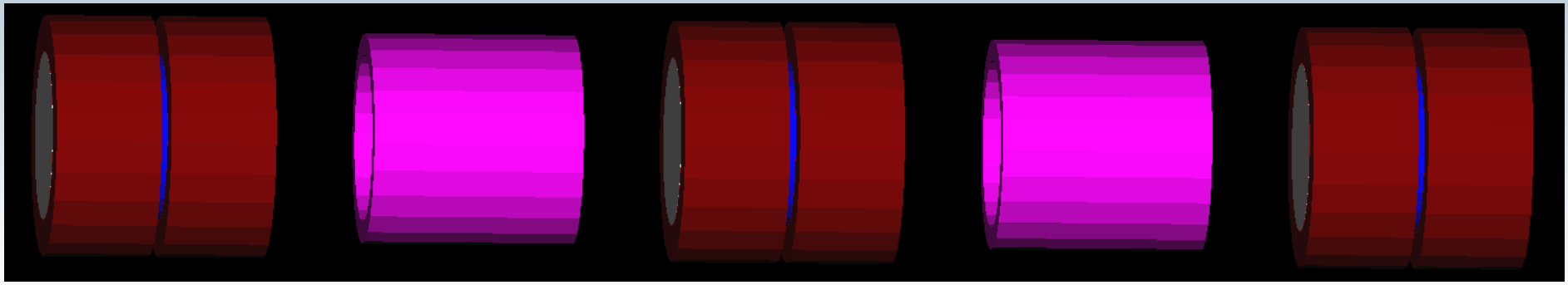


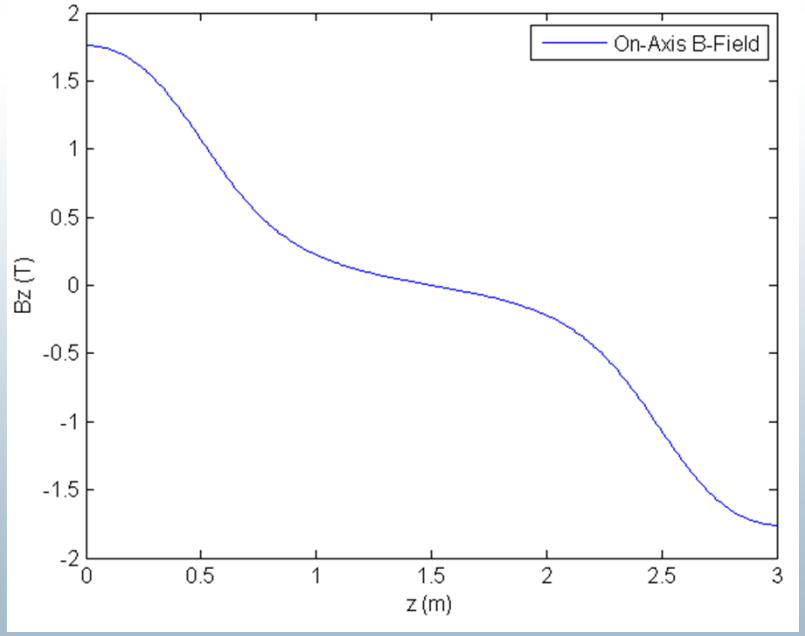
Longitudinal Bucked Coil Scheme



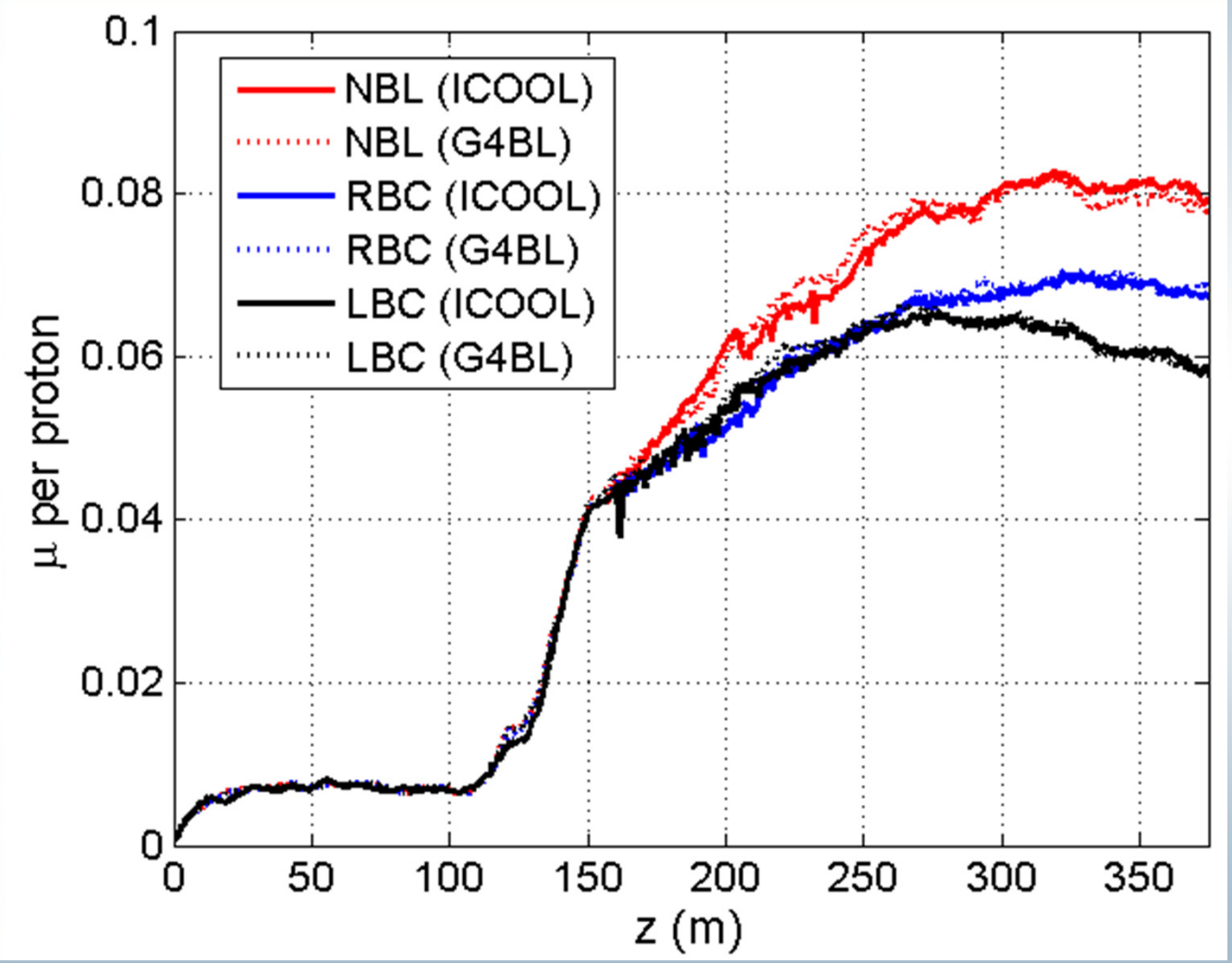


Shielded Coil Scheme (Rogers)

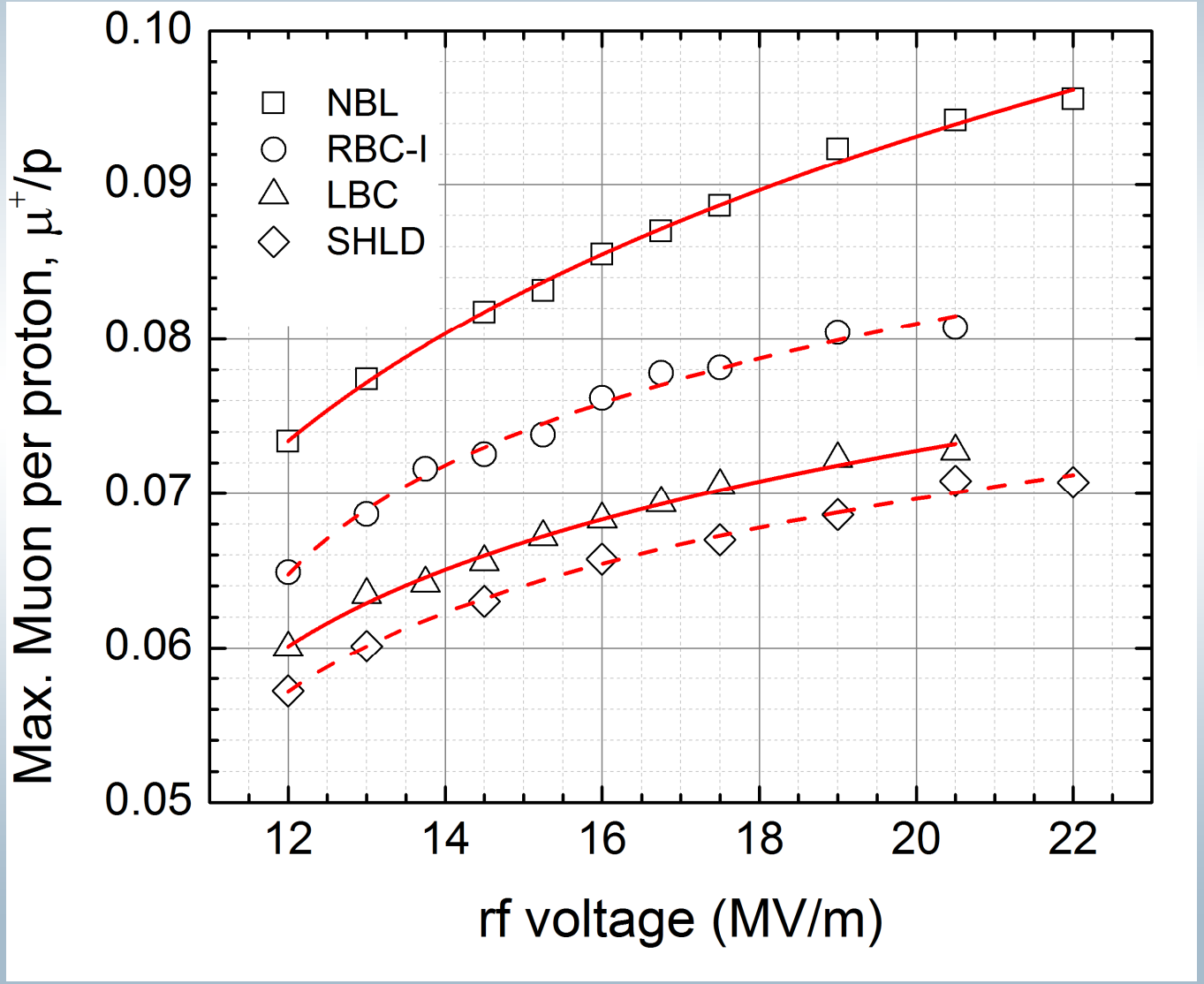




Lattice Comparison (1)



Lattice Comparison (2)



Summary & Outlook

- Presented three alternative cooling lattices for a NF
- Developed simulation decks with both G4BL and ICOOL
- Simulated using high-performance computing tools
- Present work:
  - Higgs workshop (Los Angeles, CA)
  - IDS-NF workshop (RAL, UK)
- Write-up a PRST-AB level paper