Muon Accelerator Front-End Status

Diktys Stratakis

Brookhaven National Laboratory

MAP Collaboration Meeting

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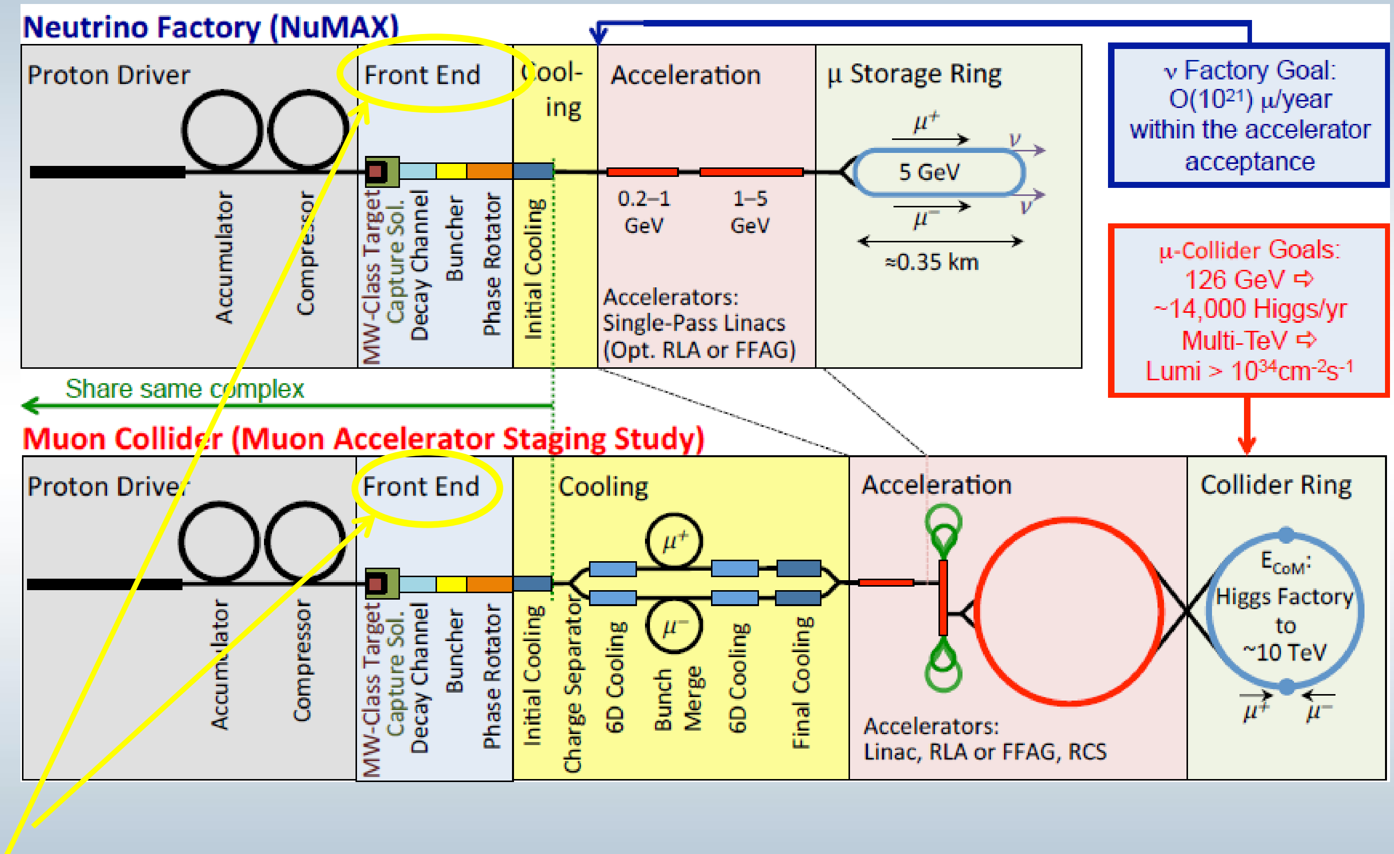
Acknowledgement

- A. Alekou, J.S. Berg, X. Ding, H. Kirk, K. McDonald, D. Neuffer, R. B. Palmer, C. T. Rogers, R. Ryne, P.Snopok, H. Sayed, B. Weggel

Applications of Muon Accelerators

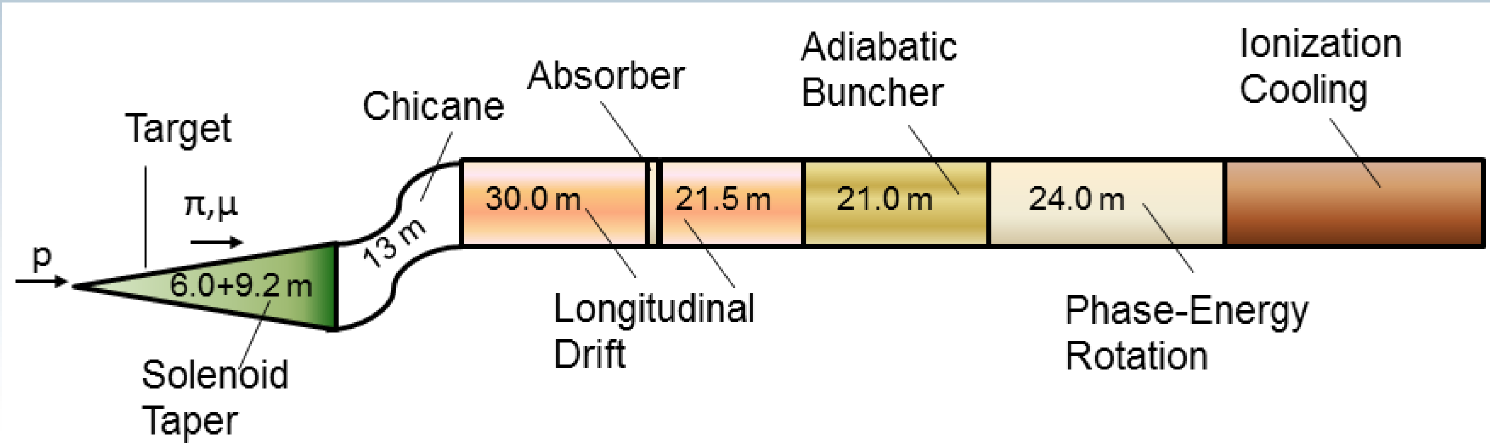


Neutrino Factory

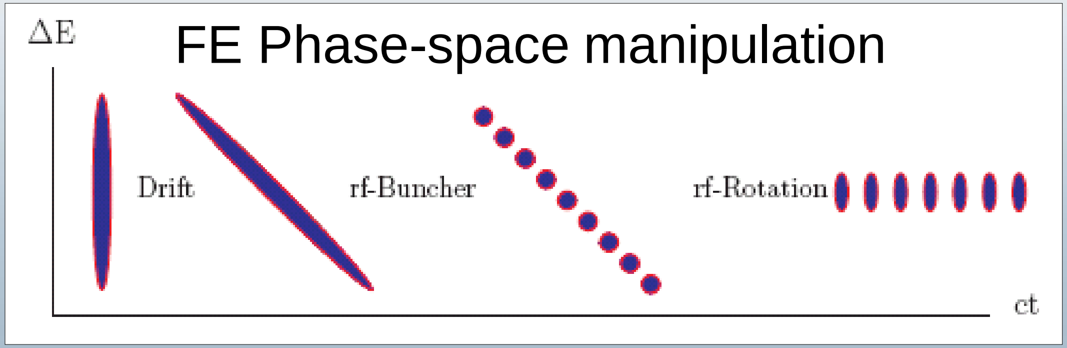
Muon Collider

- Front-End is a core building block of a Neutrino Factory and a Muon Collider

Front-End (FE) channel



- Major components include:
  - Target & capture
  - Chicane
  - Decay channel
  - Buncher
  - Phase-Rotator



Outline

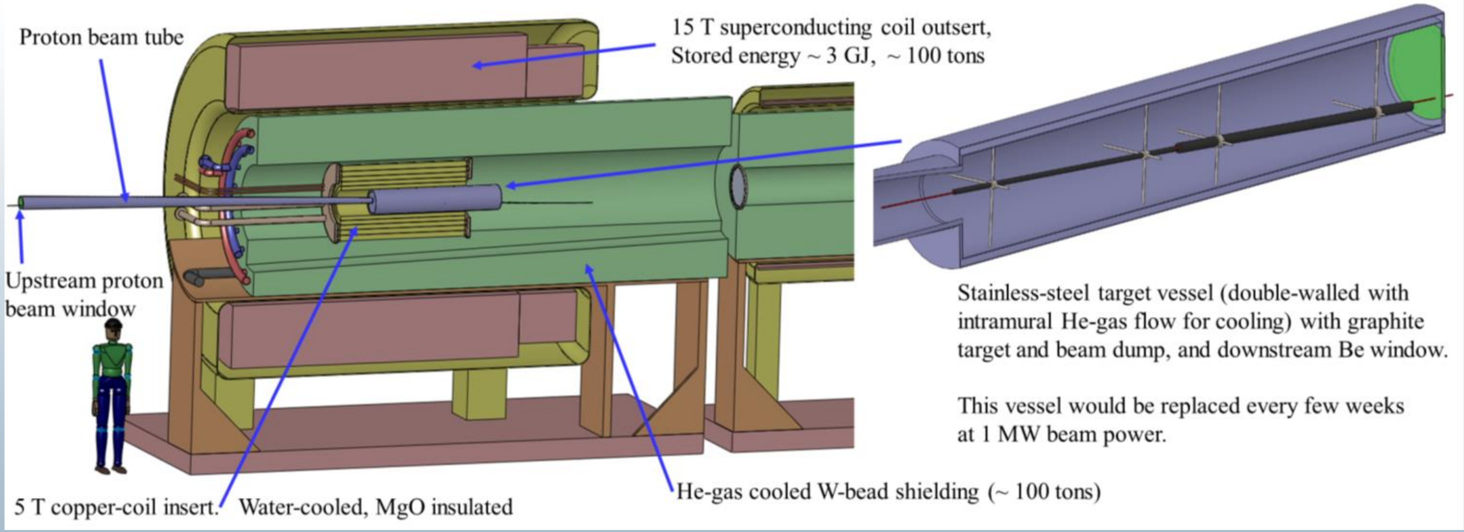
- Front-end major sub-systems
  - Target & Capture Solenoid
  - Chicane
  - Drift Channel
  - Buncher
  - Phase-Rotator
- Future work & challenges
- Summary

Accomplishments after DOE Review

- Conceptual design of a carbon target, optimized for 1 MW 6.75 GeV proton beam.
- Feasibility study of a magnet design to capture the produced muon beam.
- Following the findings from numerical simulations, the field drops from 20 T to 2 T within a short 6 m taper length.
- Previous discrepancies in modeling the chicane/ absorber system are now understood.
- Chicane is now optimized and integrated into the FE
- Reduced substantially the number of Buncher & Phase Rotator rf frequencies.

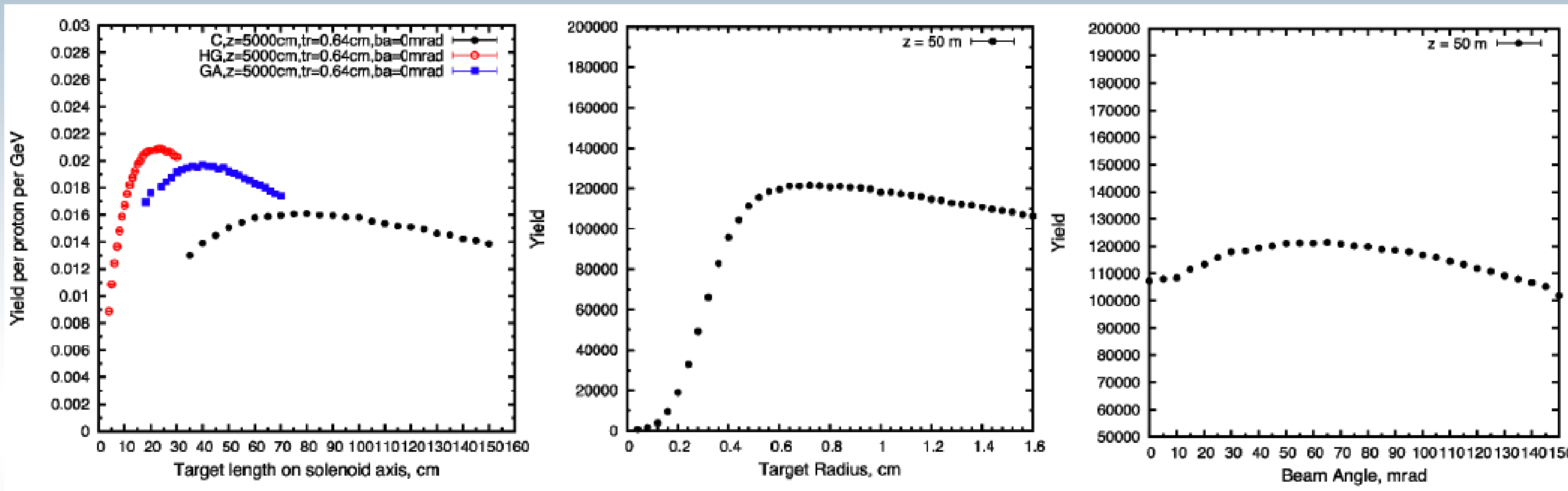
Target & Capture system

- Proton Driver:
  - 6.75 GeV (kinetic energy) proton with 3 ns pulse
  - 1 MW initial beam power
  - NF: 50 Hz rep rate, MC: 15 Hz rep rate
- Target Concept:
  - Graphite target
  - Inside 20 T magnet
  - Tilted in magnetic axis
  - Proton beam dump via graphite rod downstream of the target



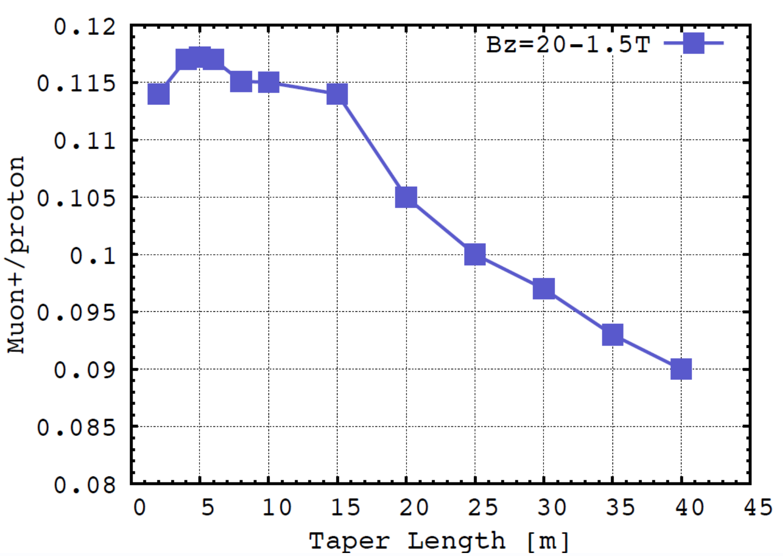
- Details: K.T. McDonald Talk on May 30th, 8:30 am

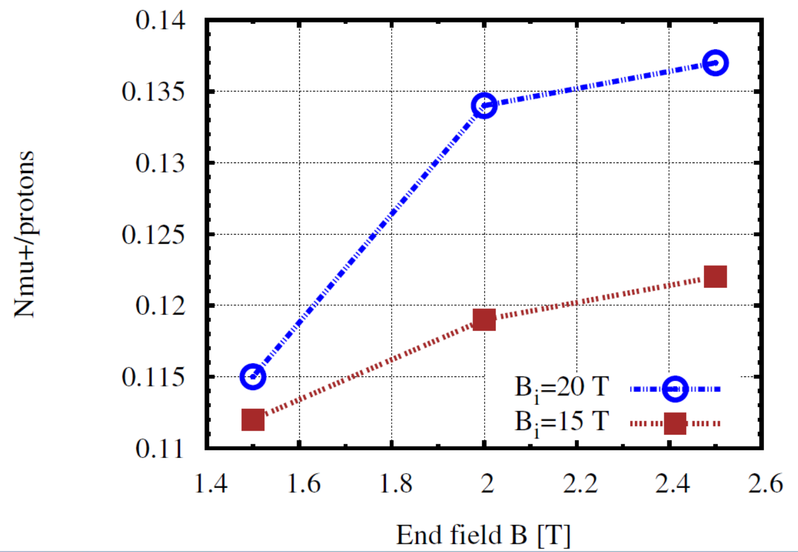
Target System Optimizations



- Optimum C target: len.=80 cm, rad=8 mm, tilt = 65 mrad
- Optimum Graphite beam dump: len.=120 cm, rad=24 cm to intercept most of the proton beam
- **Details: X. Ding, Talk on May 29th , 1:55 pm**

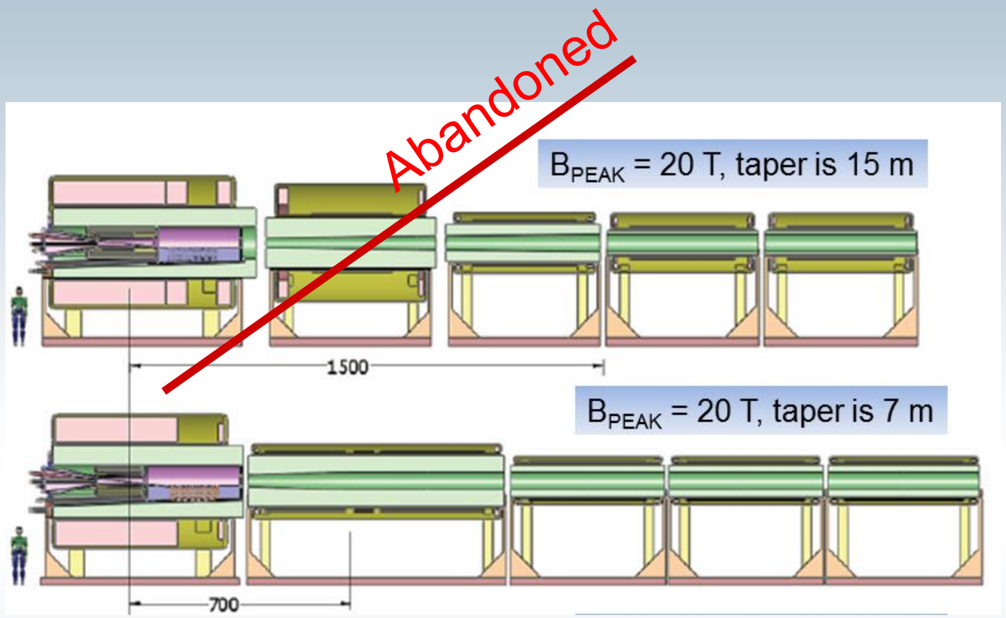
Optimizations of Muon Capture

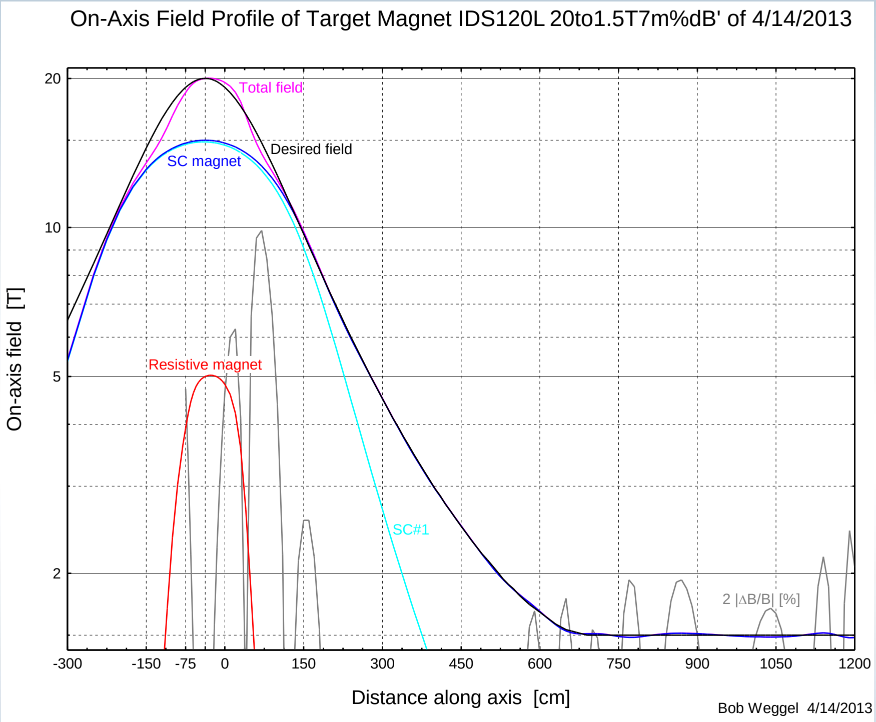




- Global optimization for:
  - Peak target field, end field, length of field taper
- Results showed:
  - Shorter taper leads to higher muon yield (~6 m)
  - Favorable to increase the baseline end field (2.0 T)
  - Higher target peak field improves performance (20 T)
- **Details: H. Sayed Talk on May 29th, 11:10 am**

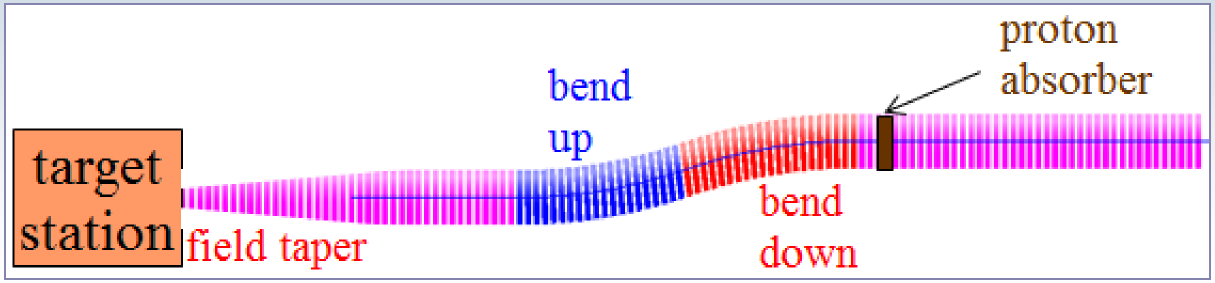
Magnet design for short taper

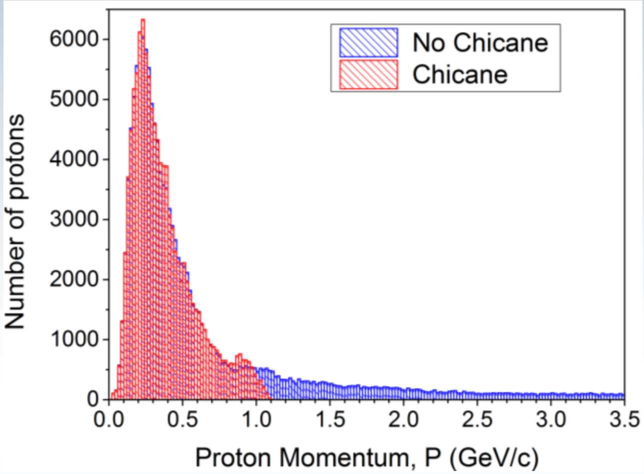




- Magnet design for 5-7 m short taper delivered
- Tapers from 15T – 20 T to 1.5-3 T magnetic field
- Implemented to the new Front-End

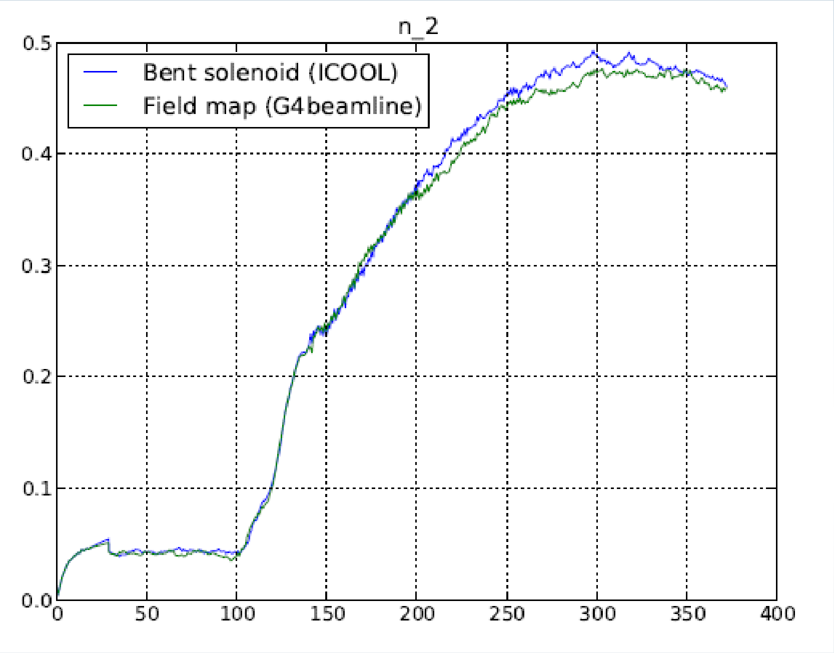
Front-End Chicane

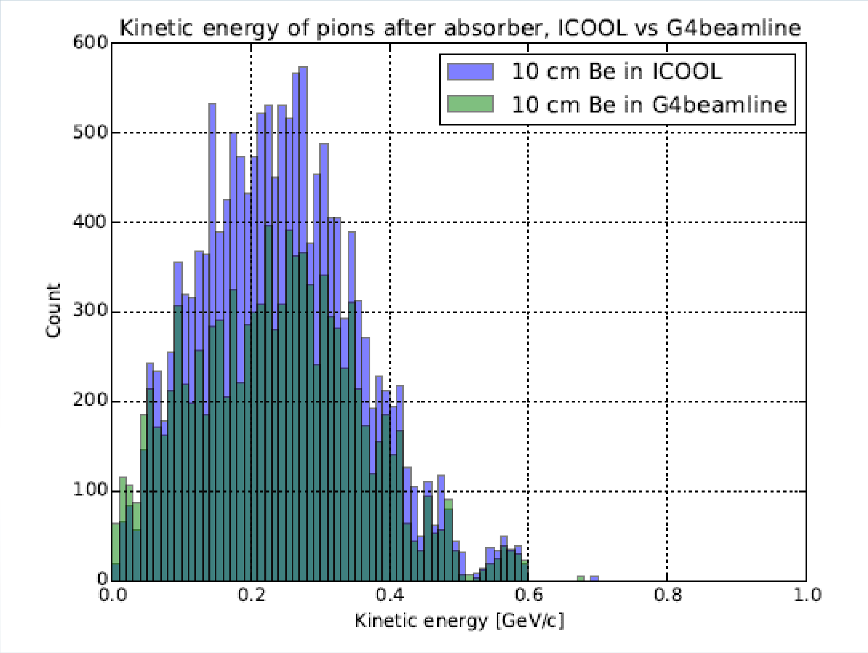




- High energy particles could activate the entire FE channel
- Bent solenoid chicane induces vertical dispersion in beam
  - High-Momentum particles scrape
  - Single chicane for both muon signs
- Proton absorber to remove low momentum protons

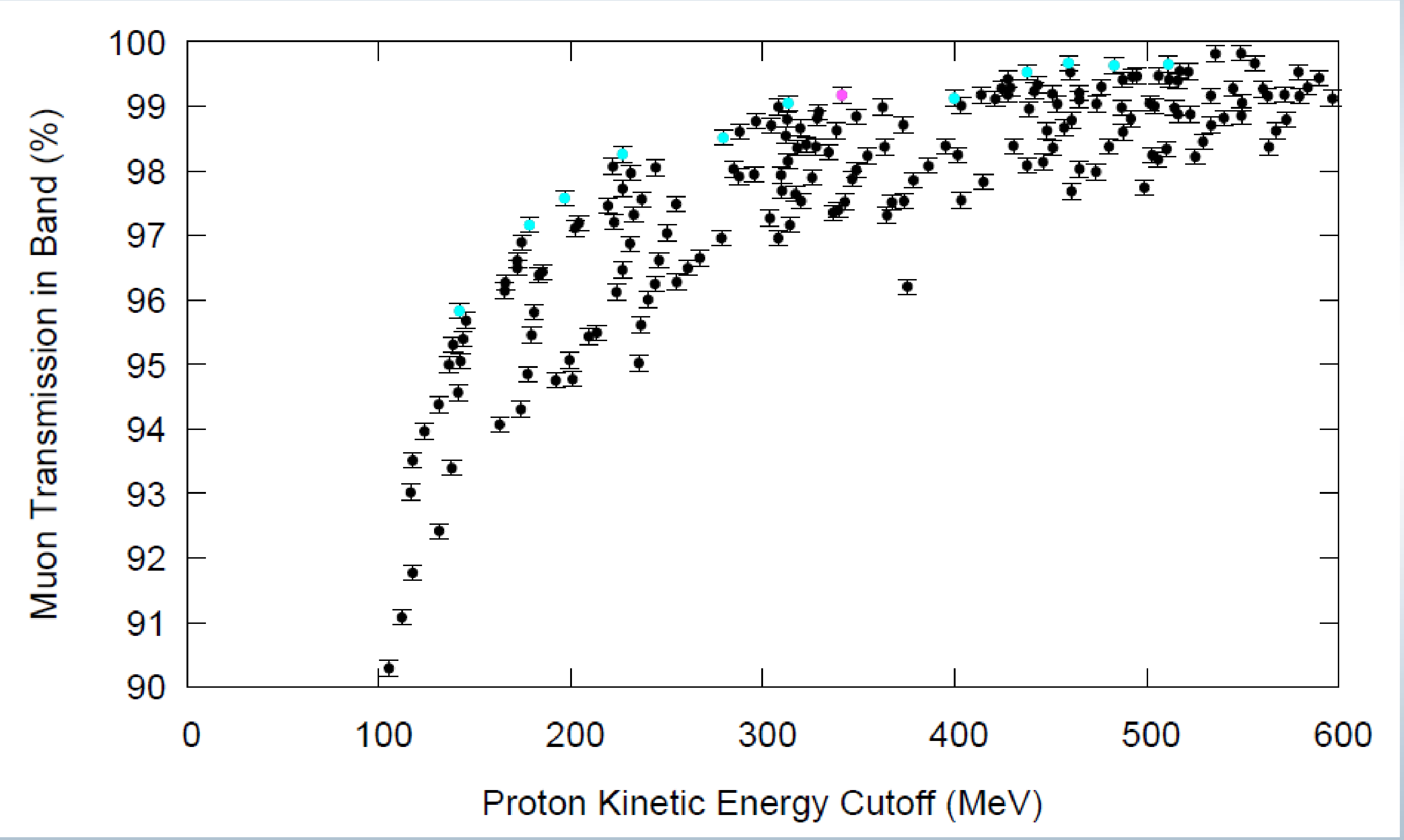
Chicane Modeling (P. Snopok)





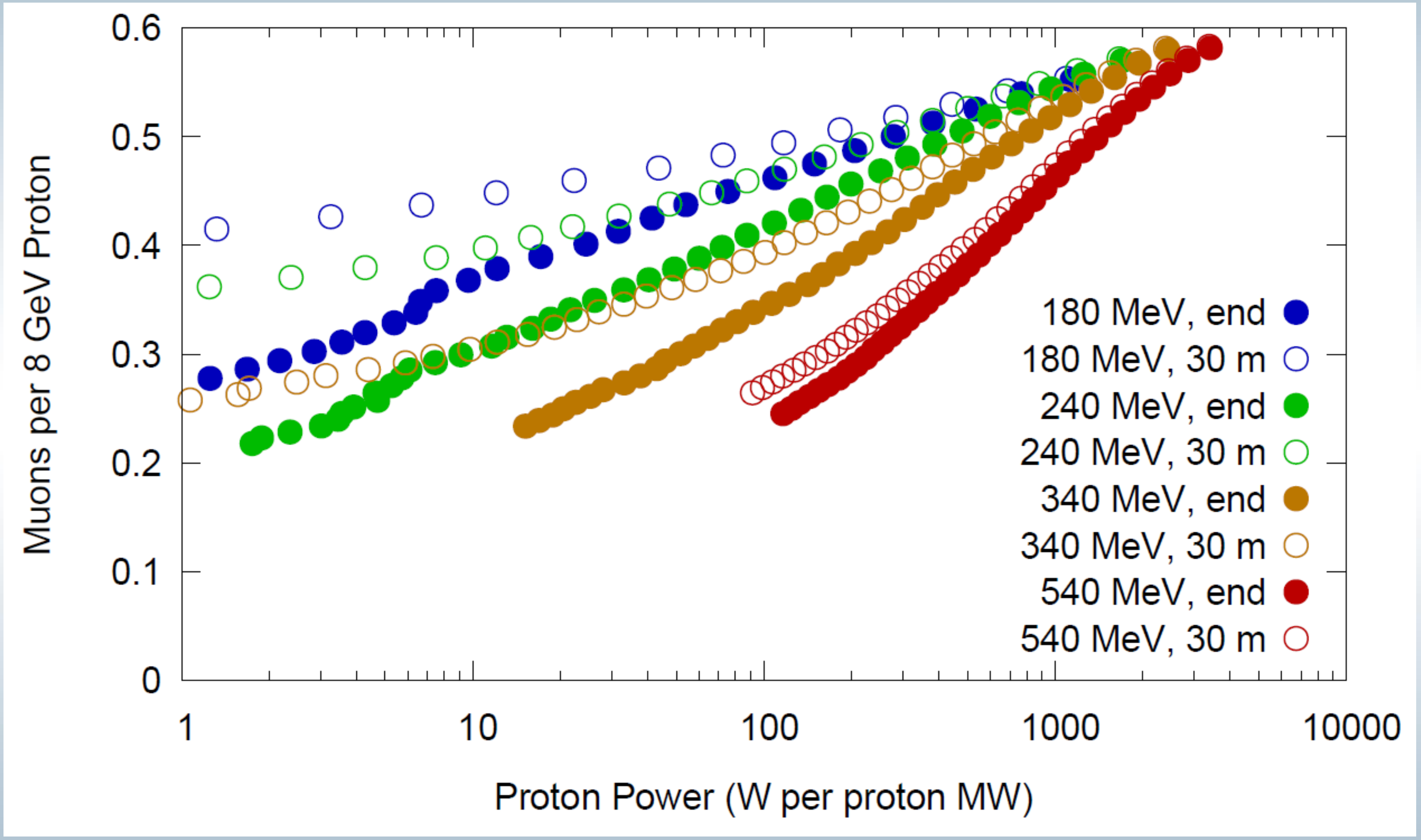
- Earlier simulations showed 15% discrepancy between ICOOL & G4BL
- It was thought that this was due the different field model
- Later simulations showed that this was due the Be model in ICOOL

Chicane Optimization I (Berg)



- **Details: J.S. Berg Talk on May 30th, 8:55 am**

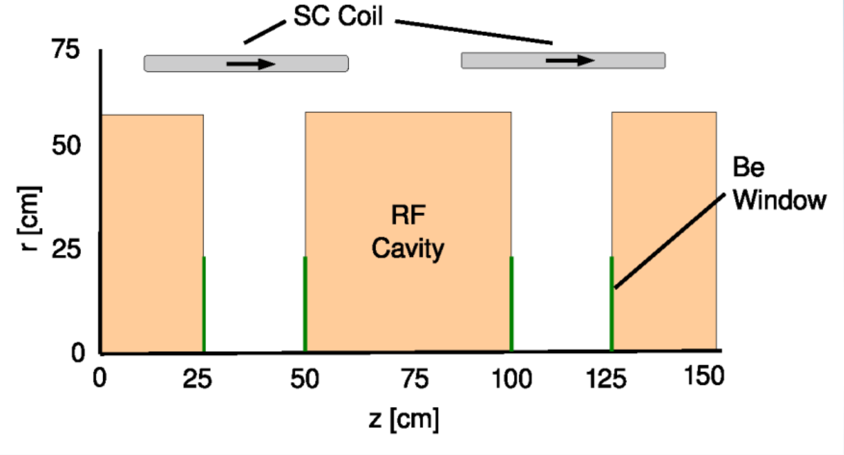
Chicane Optimization II (Berg)



- Significant tradeoff between muon transmission and downstream proton power

Buncher & Rotator parameters

- Re-designed to match to a 325 MHz cooler
- Buncher (21 m long)
  - 490 to 365.0 MHz (56 freq.)
  - RF voltage: 0.3 to 15.0 MV/m
  - 2.0 T magnetic field
- Rotator (24 m long)
  - 364.0 to 326.0 MV/m (64 freq.)
  - RF voltage: 20 MV/m
  - 2.0 T magnetic field
- **Details: D. Neuffer, Talk on Th. May 29th, 2:20 pm**



Baseline has 120 different frequencies!

Discretization of rf frequencies

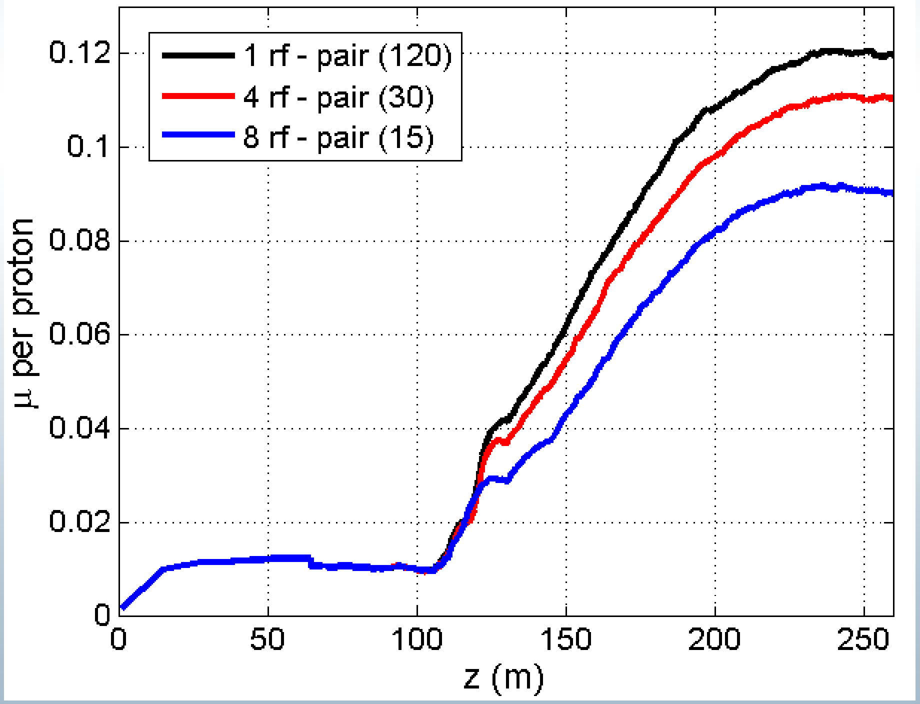
- Our goal is to reduce the number of frequencies.
- Going from 120 to 30 frequencies -> 8% loss

Buncher rf parameters

Frequency (MHz)	Gradient (MV/m)
493.71	0.30
482.21	1.24
470.27	1.95
458.40	3.38
448.07	4.45
437.73	5.52
427.86	6.60
418.43	7.67
409.41	8.74
400.76	9.81
392.48	10.88
384.53	11.95
376.89	13.02
369.55	14.30

Rotator rf parameters

Frequency (MHz)	Gradient (MV/m)
363.86	20.0
357.57	20.0
352.20	20.0
347.59	20.0
343.65	20.0
340.27	20.0
337.39	20.0
334.95	20.0
332.88	20.0
331.16	20.0
329.75	20.0
328.62	20.0
327.73	20.0
327.08	20.0
326.65	20.0
326.41	20.0



Six Contributions to IPAC

- Target Concept:
  - Poster: TUPRI008
- Muon Capture Magnet Concept:
  - Poster: THPRI087
- Target Optimizations:
  - Poster: THPRI089
- Muon Capture Optimizations:
  - Poster: MOPRI007
- Chicane Integration in the FE:
  - Poster: TUPME022
- Buncher & Phase-Rotator Discretization:
  - Poster: TUPME023

IBS Schedule

Front End (incl. Target)	Concept Specification	Lattice/Layout & Performace Eval	Lattice Sign-off	Global Optimization of Internal Systems	Interface Params	Technology Specification	Technology Sign-Off	IBS Review Ready Date	IBS Initial Review (where needed)	IBS Review	IB Specifications (Dependent on results from previous system)
Target Module	6/2/2014	9/2/2014	10/1/2014	6/23/2015	7/22/2015	3/2/2015	4/1/2015	7/22/2015		1/5/2016	2/3/2016
Capture Solenoid	6/2/2014	9/2/2014	10/1/2014		7/22/2015	3/2/2015	4/1/2015	7/22/2015			
Proton Dump	6/2/2014	9/2/2014	10/1/2014		7/22/2015	3/2/2015	4/1/2015	7/22/2015			
Chicane	10/1/2014	1/2/2015	2/2/2015		7/22/2015	7/1/2015	7/31/2015	11/2/2015			
Pion Decay Channel	10/1/2014	1/2/2015	2/2/2015		7/22/2015	7/1/2015	7/31/2015	11/2/2015			
Buncher/Phase Rotator	10/1/2014	1/2/2015	2/2/2015		7/22/2015	7/1/2015	7/31/2015	11/2/2015			
FE-Cool Interface Parameters	*10/1/2014*				*7/22/2015*						*2/3/2016*

- We are on good standing based on the IBS schedule:
  - A conceptual design for target, capture solenoid and beam dump has been delivered.
  - On our way to deliver a concept for chicane, buncher & rotator
- Still a lot of work to do (next slide).

Future Steps

- Specify buncher and phase-rotator parameters for the new chicane & absorber settings [Person A, Person B]
  - Evaluate performance
  - Energy deposition downstream of the chicane
  - Detailed MARS simulation for specific areas
- Repeat the process for different B-fields [Person A, Person B]
- Energy deposition chicane/ target [Person C, Person D]:
  - Detailed studies in the chicane & target for different target configurations
- Finalize buncher & phase-rotator [Either A, B, C. D]
  - Windows and realistic coils