Transfer line design from Recycler Ring to the P150 line for the Mu2e-project at Fermi National Accelerator Laboratory
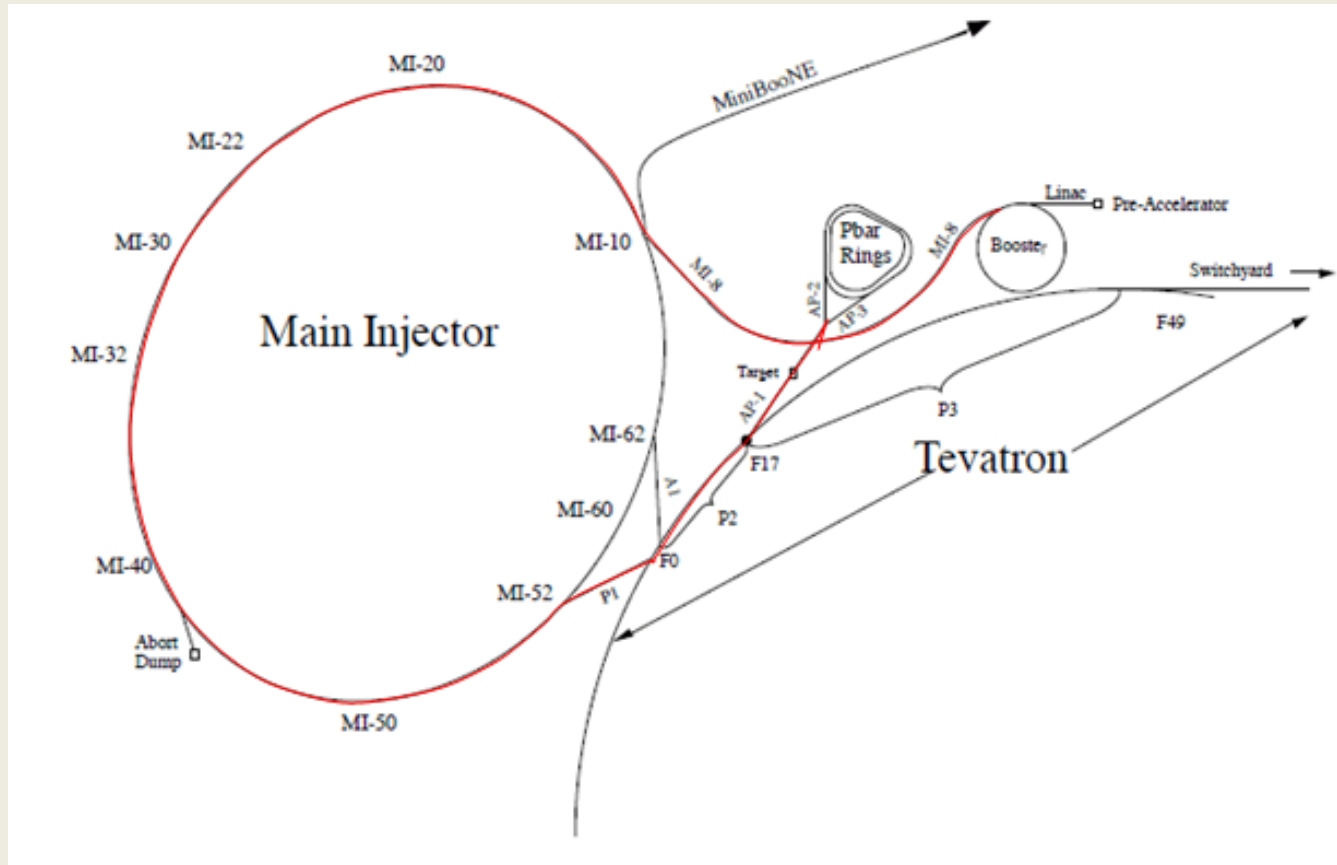
Shantanu Jain

Dr. Meiqin Xiao

Motivation

- CERN's Large Hadron Collider has made the Tevatron less useful to physicists

- The Tevatron will be closed

- The Mu2e- project is a proposed experiment to convert muons to electrons

- Another project plans to guide an 8GeV proton beam from the booster to the accumulator and the debuncher via the recycler ring
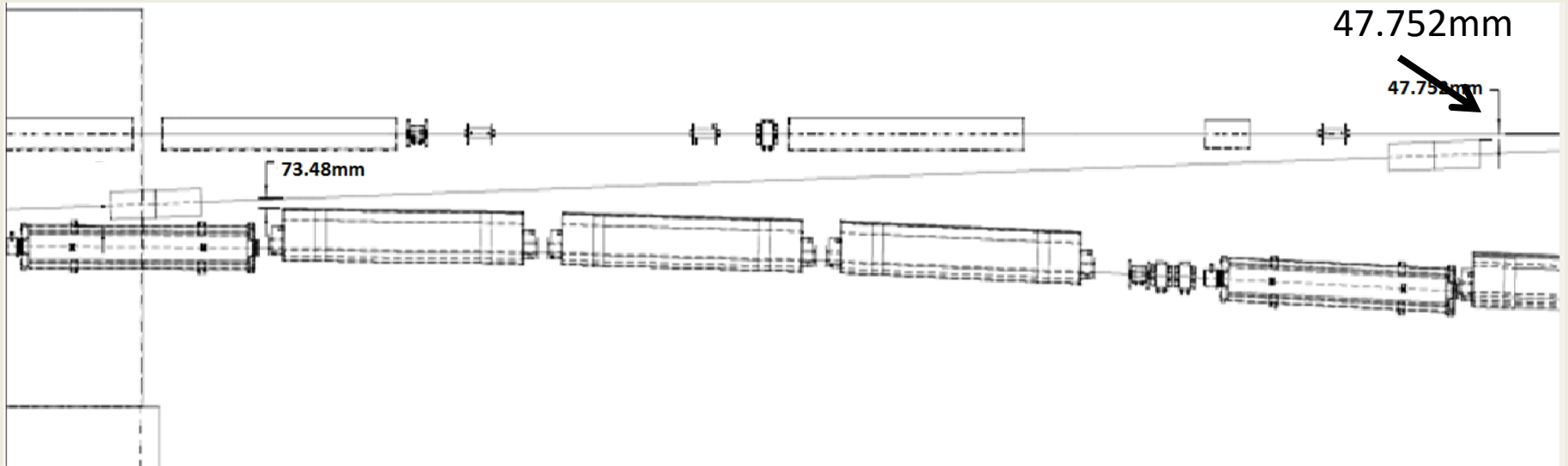
Motivation

- A transfer line is required between the recycler ring and the P150 line

Motivation

- Dr. Meiqin Xiao's previous design failed to account for the limited space between the elements of the magnet

- Required: 50.8mm, designed: 47.752mm

Focusing Question

The SIR seeks to investigate and understand the basic **concepts and theories of particle accelerator technology and physics**, with a focus on **linear beam dynamics**, and its **applications in transfer line design from the Recycler ring to the P150 line for Mu2e-Project at Fermilab.**

Background

- Beam defocuses as it travels because of like charges

- Magnets are used to direct beams

- Beam lines must refocus these beams using FODO cells – Focusing – Defocusing – Focusing

- The first and last element of a FODO cell must be equidistant from the center point.

Background

- Lattice Functions: β_x, β_y, α_x, α_y, D_x, Dp_x, D_y, Dp_y, μ_x, and μ_y
  - Describe effect that magnets will have on the particle beam
- Transfer line must match the initial lattice functions with the ending lattice functions

Methods

- △L – distance Q901 pair was moved downstream, Q902 pair was moved upstream

- MAD program was used to calculate the values of the field strength based on a parameter that is held constant: α or β matching
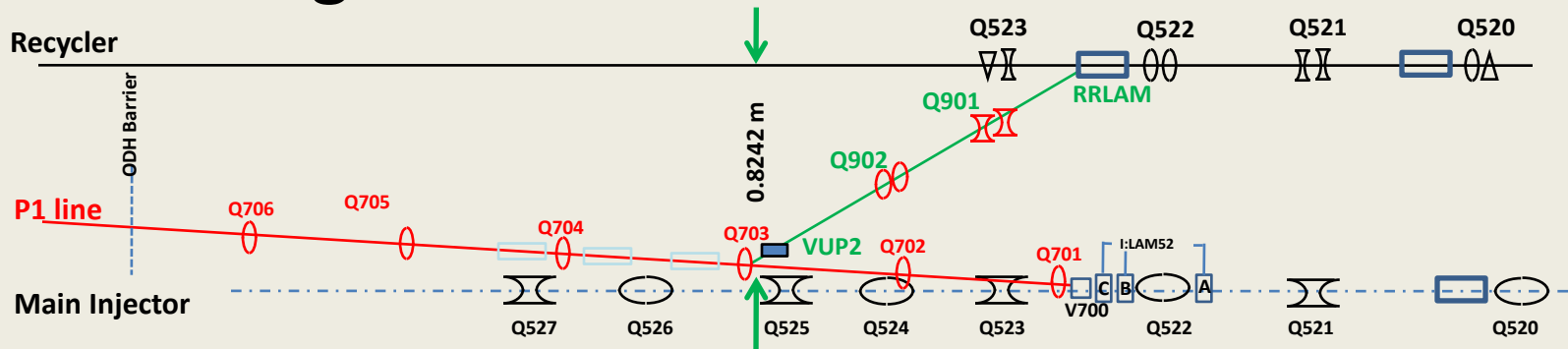
Results

- Space gained from various △L values

△L (m)	Gained space (mm)	Total space (mm)
0	0.000	47.752
0.25	32.886	80.638
0.5	65.771	113.523
0.75	98.657	146.409

Results: α matching

	△L = 0m	△L = 0.25m		△L = 0.50m		△L = 0.75m	
	Control	Matched	Percent difference	Matched	Percent difference	Matched	Percent difference
β_x	11.115	12.11	-8.952	13.826	-24.390	17.541	-57.814
α_x	0.618	0.618	0.000	0.618	0.000	0.618	0.000
β_y	66.278	64.513	2.663	63.032	4.898	61.503	7.205
α_y	-2.915	-2.915	0.000	-2.915	0.000	-2.915	0.000
μ_x	0.75	0.243	67.600	0.239	68.133	0.231	69.200
μ_y	0.75	0.34	54.667	0	100.000	0.371	50.533
D_x	0.013	0.108	N/A	0.115	N/A	0.129	N/A
D_{px}	0.001	-0.005	N/A	-0.004	N/A	-0.003	N/A
D_y	-0.043	0.615	N/A	0.575	N/A	0.527	N/A
D_{py}	0.007	0.004	N/A	0.002	N/A	-0.001	N/A

Results: β matching

	△L = 0m	△L = 0.25m		△L = 0.50m		△L = 0.75m	
	Control	Matched	Percent difference	Matched	Percent difference	Matched	Percent difference
βx	11.115	11.115	0.000	11.115	0.000	11.115	0.000
αx	0.618	0.604	2.265	0.568	8.091	0.526	14.887
βy	66.278	66.278	0.000	66.278	0.000	66.278	0.000
αy	-2.915	-3.028	-3.877	-3.094	-6.141	-3.145	-7.890
μx	0.75	0.246	67.200	0.251	66.533	0.256	65.867
μy	0.75	0.344	54.133	0.357	52.400	0.367	51.067
Dx	0.013	0.103	N/A	0.103	N/A	0.102	N/A
Dpx	0.001	-0.005	N/A	-0.005	N/A	-0.005	N/A
Dy	-0.043	0.616	N/A	0.568	N/A	0.559	N/A
Dpy	0.007	0.004	N/A	0.003	N/A	0.001	N/A

Conclusion

- β matched $\triangle L = 0.25$m was the best value

- Closest values of α and β – most important

- Acceptable error values:
  - Dp_x within 1.1m
  - Dp_y within 0.75m

- 80.6mm of space

- Reused existing magnets

Discussion

- No new civil construction
- Further work not required: met all goals of the project

Acknowledgements

- Dr. Meiqin Xiao - Advisor
- Dr. Scheppler – Set up investigation
- Dr. Mark Carlson – Create scientific documents
- SIR Department

Thank You