Beam Optics Studies for Step IV

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The existing (ε, p) matrix was created for a lead diffuser, but the MICE diffuser was re-designed with brass and tungsten irises.

The matrix needs to be updated for the new diffuser.

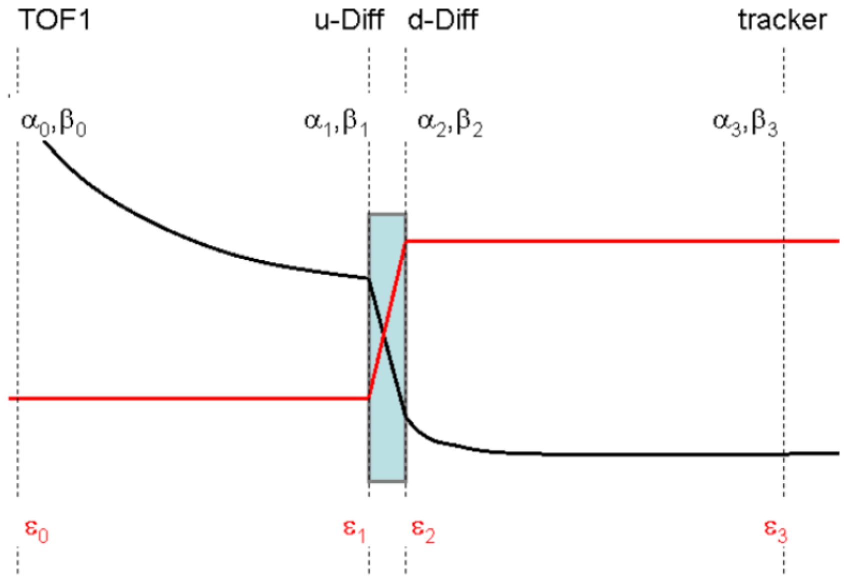
Beam line optics needs to be re-matched for the new diffuser settings.

Possible limitations of cooling channel magnet currents may call for different available β and ε values.

		p_z (MeV/c)		
		140	200	240
ϵ_N (mm·rad)	3	t=0.0 mm P_{dif}=151	t=0.0 mm P_{dif}=207	t=0.0 mm P_{dif}=245
		α=0.2 β=56 cm	α=0.1 β=36 cm	α=0.1 β=42 cm
	6	t=5.0 mm P_{dif}=148	t=7.5 mm P_{dif}=215	t=7.5 mm P_{dif}=256
		α=0.3 β=113 cm	α=0.2 β=78 cm	α=0.2 β=80 cm
	10	t=10.0 mm P_{dif}=164	t=15.5 mm P_{dif}=229	t=15.5 mm P_{dif}=267
		α=0.6 β=198 cm	α=0.4 β=131 cm	α=0.3 β=129 cm

Beam Optics Studies for Step IV

M. Appolonio, J.H. Cobb "Optimal size for the MICE diffuser"



Optics was transported back from center of the tracker to DS of diffuser
US diffuser optical functions related to DS diffuser optical functions

$$\epsilon_2\gamma_2 = \epsilon_1\gamma_1 + D \cdot t$$
$$\epsilon_2\beta_2 = \epsilon_1\beta_1 - 2\epsilon_1\alpha_1 t + \epsilon_1\gamma_1 t^2 + D \cdot t^3/3$$
$$\epsilon_2\alpha_2 = \epsilon_1\alpha_1 - \epsilon_1\gamma_1 t - D \cdot t^2/2$$

Where D is instantaneous energy loss, which depends on material and its thickness

$$D = \frac{(13.6)^2 Z^2}{X_0(\langle P_z\rangle\langle\beta\rangle)^2}$$

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M. Appolonio, J.H. Cobb “Optimal size for the MICE diffuser”

configuration	P (MeV/c) abs centre	δP (MeV/c) half abs	P (MeV/c) after diff	$B_{tracker}$ (T)	β_3 (cm)	β_2 (cm)	ϵ_3^N (mm rad)	β_1 (cm)	α_1	$\mathcal{T}$ (calculated) (mm)	$\mathcal{T}$ (chosen) (mm)
							2.8	52.0	0.14	1.25 4.06	
	140.0	8.4	148.4	2.8	35.4	36.5	6.0	111.6	0.32	4.94	
							10.0	186.6	0.56	9.40	
							2.8	36.4	0.08	0.17	
F (full)	200.0	7	207.0	4.0	34.8	35.6	6.0	82.7	0.44	7.24	
							10.0	152.5	1.11	14.3	
							2.8	-	-	<0	empty
	240.0	5.8	245.8	4.0	41.2	42.1	6.0	77.5	0.18	7.00	1.3 4.2
							10.0	129.7	0.33	15.5	4.9
							2.8	51.5	0.29	1.34 4.39	7.2
	140.0	0	140.0	2.8	33.3	34.1	6.0	110.8	0.65	4.88	9.3
							10.0	185.7	1.13	9.22	15.2
							2.8	36.2	0.09	0.43	
E (empty)	200.0	0	200.0	4.0	33.3	34.3	6.0	77.9	0.23	7.49	
							10.0	130.6	0.43	15.3	
							2.8	-	-	<0	
	240.0	0	240.0	4.0	40.0	40.8	6.0	77.2	0.13	7.12	
							10.0	129.2	0.25	15.6	

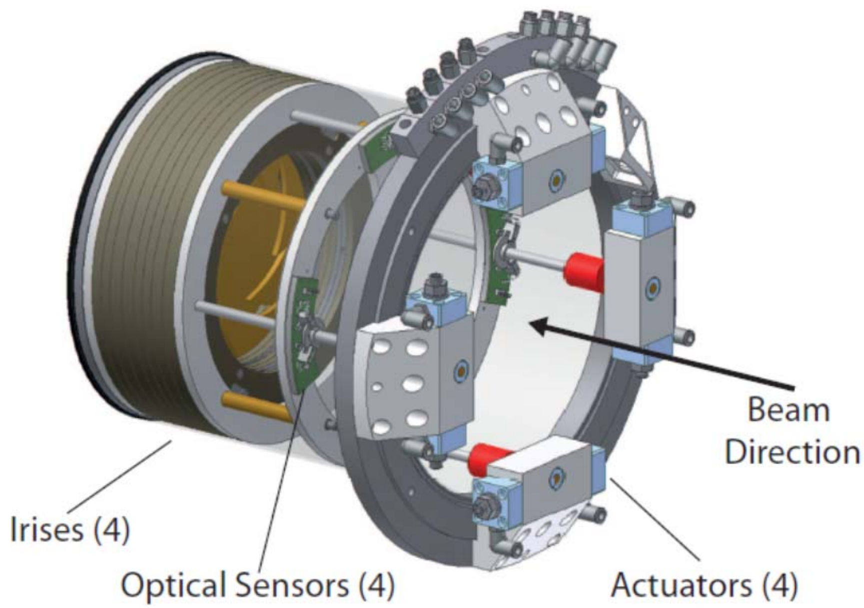
Beam Optics Studies for Step IV

V. Blackmore "Particle Tracking and Beam Matching Through the New Variable Thickness MICE Diffuser"

Contains 4 Irises

Iris	Material	Thickness (mm)
1	Brass	2.97
2	Brass	5.94
3	Tungsten	2.80
4	Tungsten	5.60

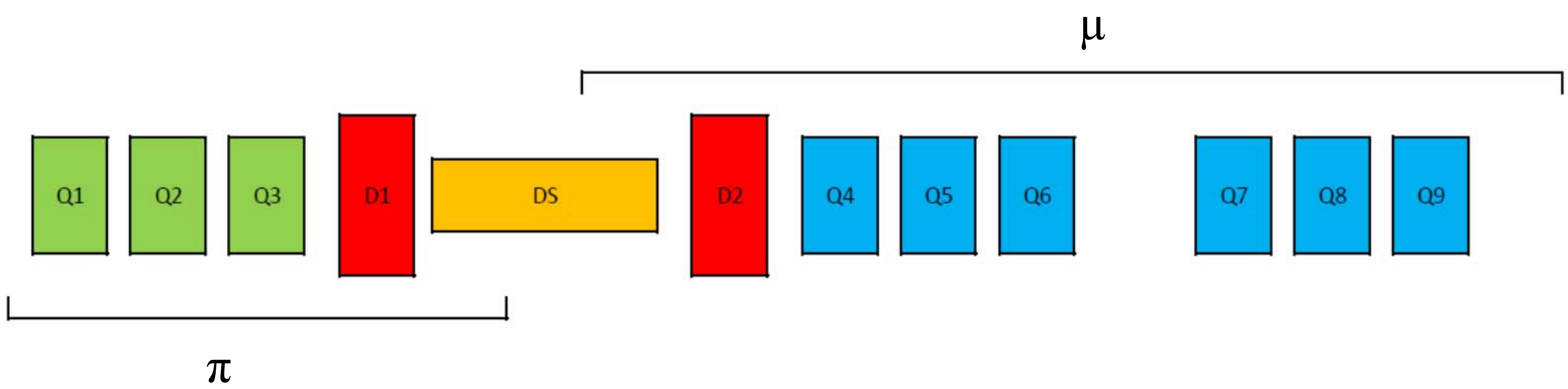
Allows for up to 3 radiation lengths X_0 in steps of 0.2, thus, better flexibility than the old diffuser.



Since energy loss depends on material and its thickness, the energy loss could be slightly different for the re-designed diffuser. Matching for 2 different materials is required, creating additional step.

But
Expect to find diffuser settings that give the solution very close to existing, the available thicknesses are already given.

Beam Optics Studies for Step IV



- Upstream beam line:
  - maximize pion transmission
  - choose momentum using D1
- Decay solenoid
- **Downstream beam line**:
  - choose momentum using D2 (for high purity $P_{D1} \approx 2 P_{D2}$ *)
  - maximize muon transmission and
  - optically match the beam at the entrance of MICE

Expect to re-optimize only the **downstream beam line**

Beam Optics Studies for Step IV

G4Bealmline simulations are very time-consuming for good statistics

- makes it impossible to run any matching program on a PC
- created a user account on NERSC (National Energy Research Scientific Computing Center), available through MAP account
- so far only figured out that can not figure out on my own how to submit jobs, going to seek help

Milorad Popovic helped create Trace 3D model of MICE beamline

- immediate graphic display
- available element-fitting and beam-matching option

but

- no material, thus, for constant momentum
- can use with "magic tables" to re-scale elements strengths to account for momentum loss in beam line

➢ This would produce an analog to "M0" settings (that were obtained using TRANSPORT)

Beam Optics Studies for Step IV

- Obtain the desired (available) β, and ε at the tracker
- Propagate back to DS of diffuser
- Use Eqs. on slide 2 to find optical functions US of diffuser
  - ➢ available material thicknesses are defined
  - ➢ expect solution to be close to existing
- Use Trace 3D to match the beam at US of diffuser (constant momentum)
- Scale magnetic elements strengths to account for momentum losses in beam line using "magic tables"
  - ➢ This would produce an analog to "M0" settings
- Insert obtained magnetic elements strengths in G4Beamline simulation
  - ➢ High statistics simulations would be possible only after figure out how to use NERSC
- Further tune downstream beam line in G4Beamline (perhaps using GMINUIT)
  - ➢ Is not going to work on laptop, need to figure out NERSC

Suggestions are welcome