

# Optics Commissioning Plan for A1N and D2N

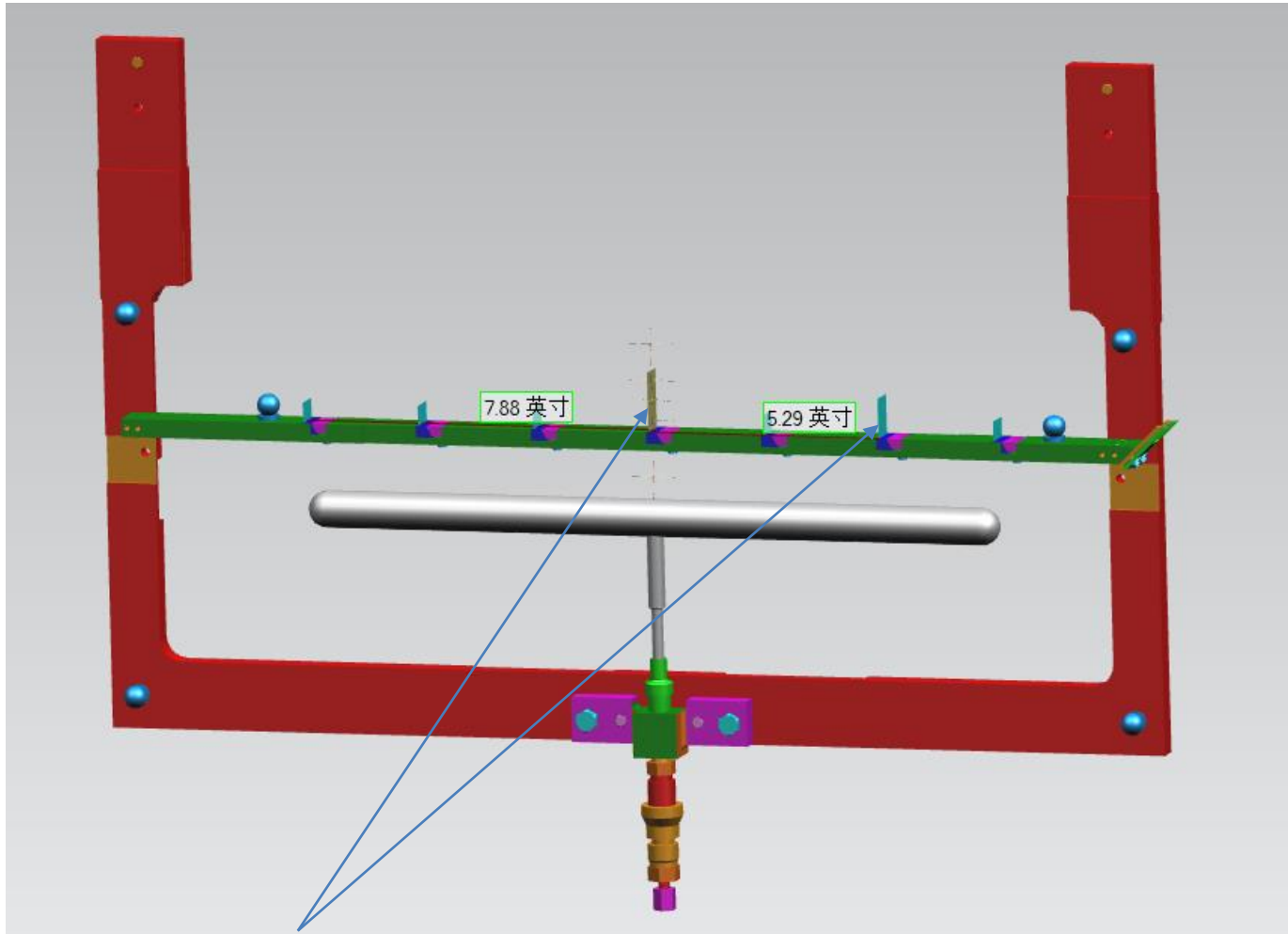
Jixie Zhang, Mingyu Chen, Xiaochao Zheng  
University of Virginia

A1N|D2N Collaboration meeting  
7/24/2019

# Why we need to do optics?

- The existing optics matrix are pretty good for both HMS and SHMS. But they can cover **Ytar** only from about -5.5 cm to +5.5 cm.
- For A1N|D2N, the 3He target is 40 cm long. For 12.5 degrees data set, it requires **Ytar** to cover -5.4 cm to 5.4 cm. For 30 degrees data set, it requires **Ytar** to cover -11.0 cm to 11.0 cm.
- In the first order, dP reconstruction does not depend on Ytar, therefore we do not need to **redo** a full dP scan. We only need to take some dP points to check how good the existing optics will apply to our data. (We will check dP in 5% step only at small angle).
- Angle (theta and phi) and vz (Ytar) reconstruction will need a brand new matrix only for 30 degrees data set, but without dP calibration.

# Optics Target



Carbon foil, with 1mm diameter hole.  
All is 10 mi thickness.

# Run Plan

## 12.5 degrees (and lower) data set:

- A simplified version of delta scan (0%, +/-5%, +/-8% for HMS at 11.7 degrees, and 0%, +/-5%, +/-10%, +15% for SHMS at 8.5 degrees).

For dP=0%:

- 1) 1 run without sieve on 2-foil target;
- 2) 1 run with sieve on 2-foil target;

For dP=5%, +/-8%, +/-10%, +15%:

- 1) 1 run with sieve on 2-foil target;

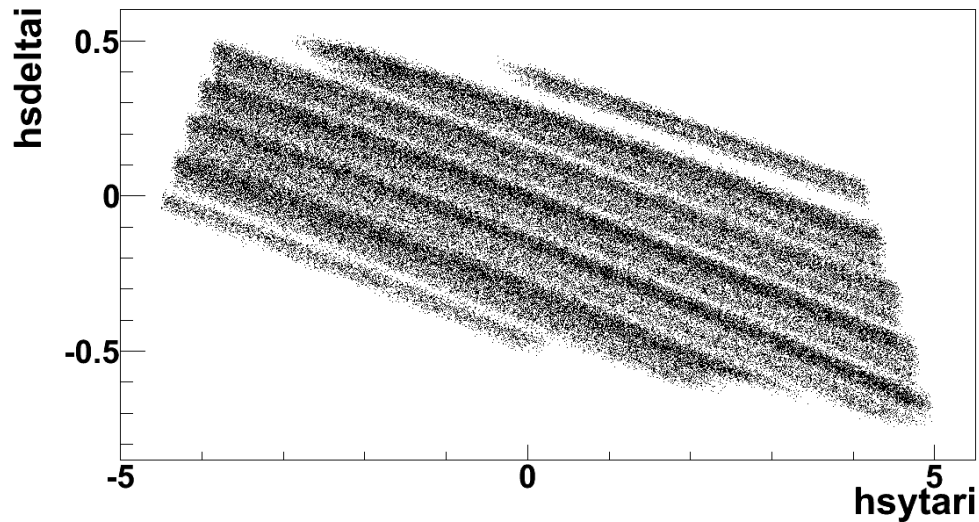
## 30 degrees data set:

- We need to do angle and Ytar calibration using resonance events from 7 foils and with sieve. (No need to be 1 pass beam.)
- Prefer to set spectrometer angle at 35 degrees other than 30 degrees to cover wider Ytar.

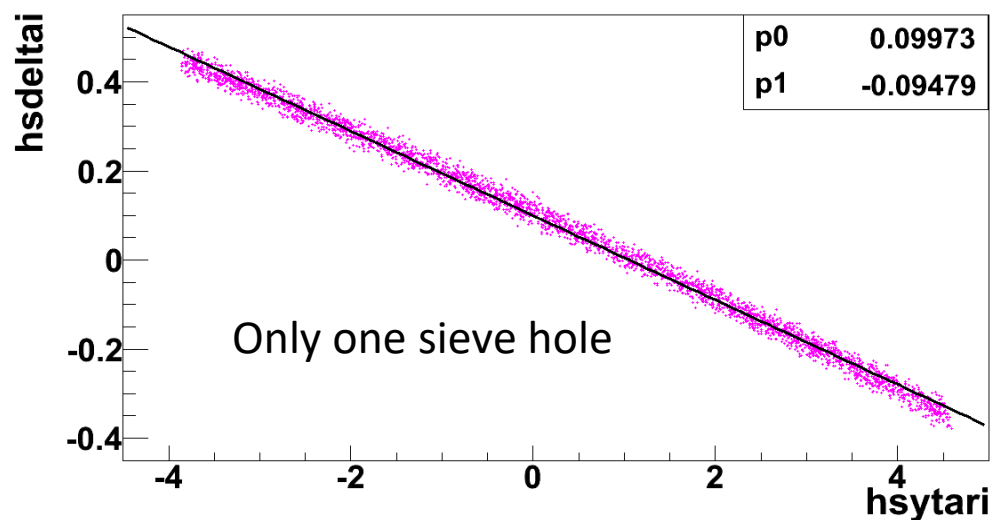
# HMS dP vs Ytar

In the first order, dP should not depend on Ytar.

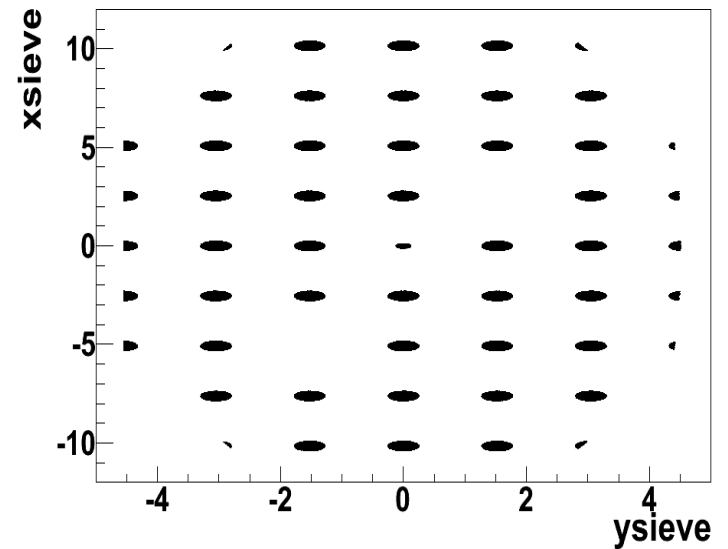
hsdeltai:hsytari {stop\_id==0}



hsdeltai:hsytari {stop\_id==0 && xsnum==2 && ysnun==1}



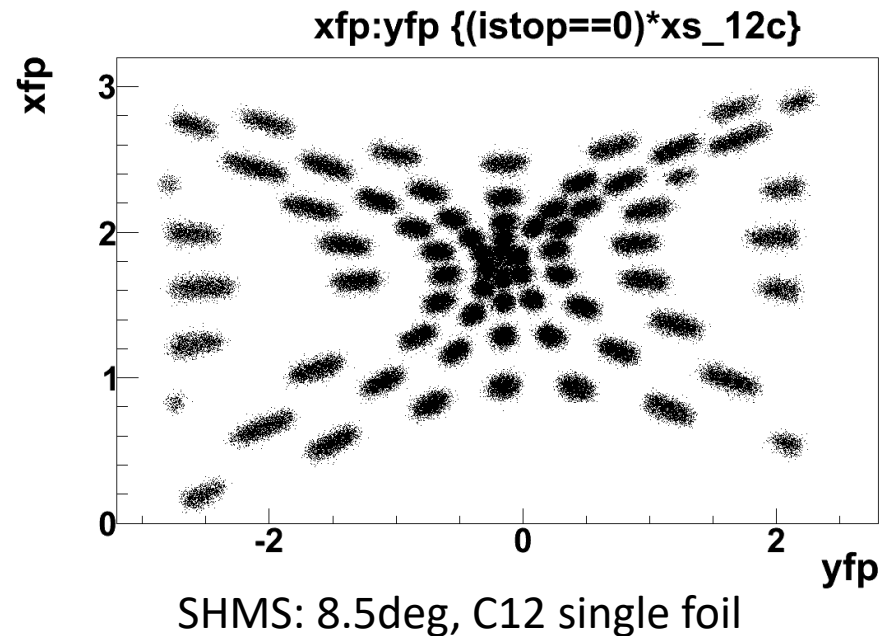
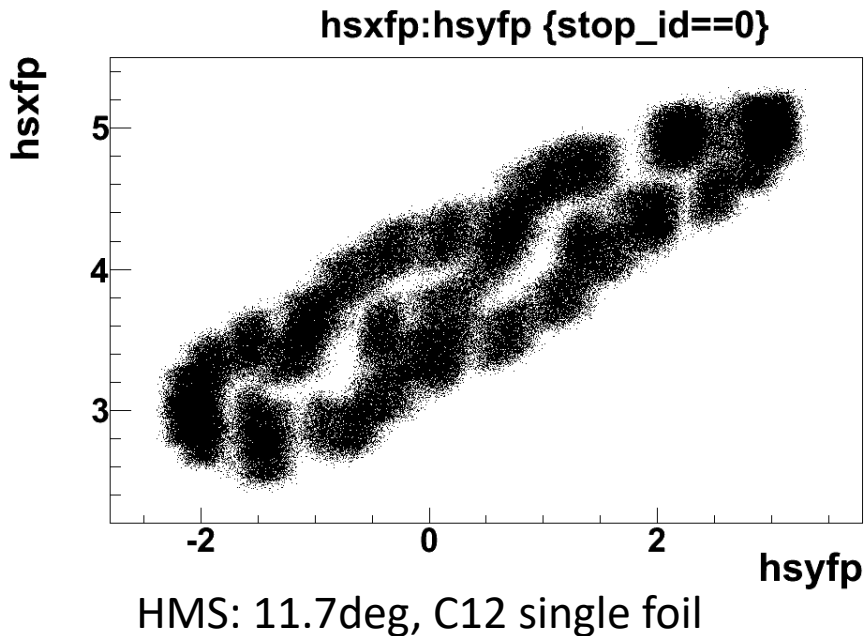
xsieve:ysieve {stop\_id==0}



# Update mc-singe-arm with **TURE** Sieve Slit

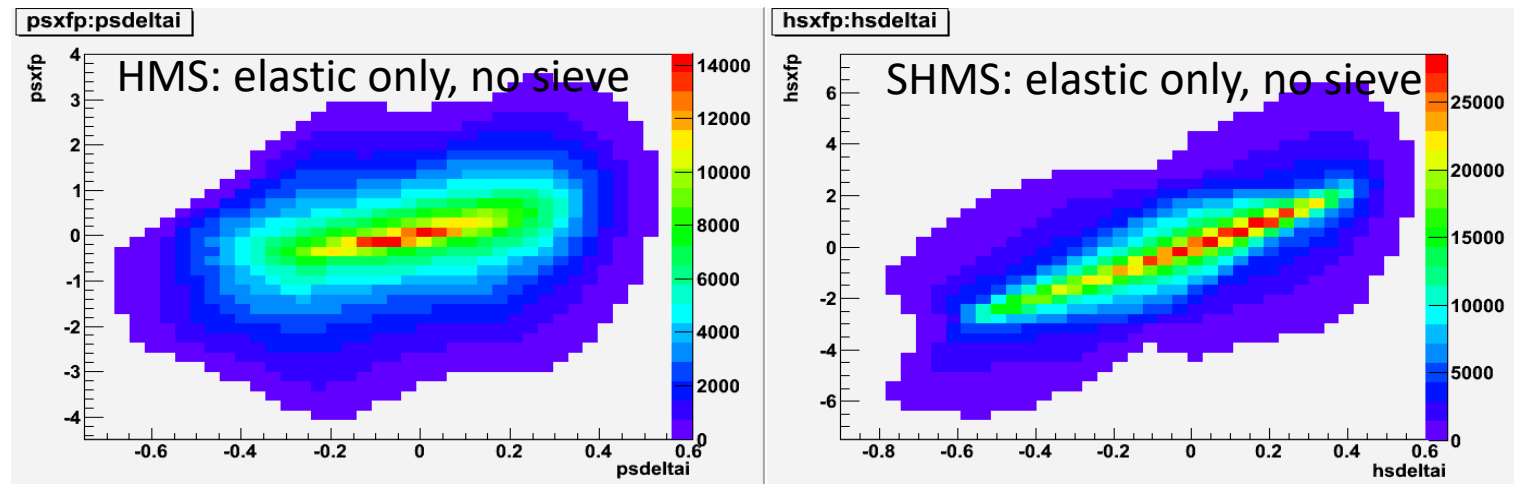
Updated mc-single-arm with the TRUE sieve hole pattern and diameters.

With sieve, HMS (@11.7 deg) carbon elastic rate drops to only **4.6%** of that without sieve, while SHMS (@8.5 deg) carbon elastic rate drops to **6.2%** of that without sieve.

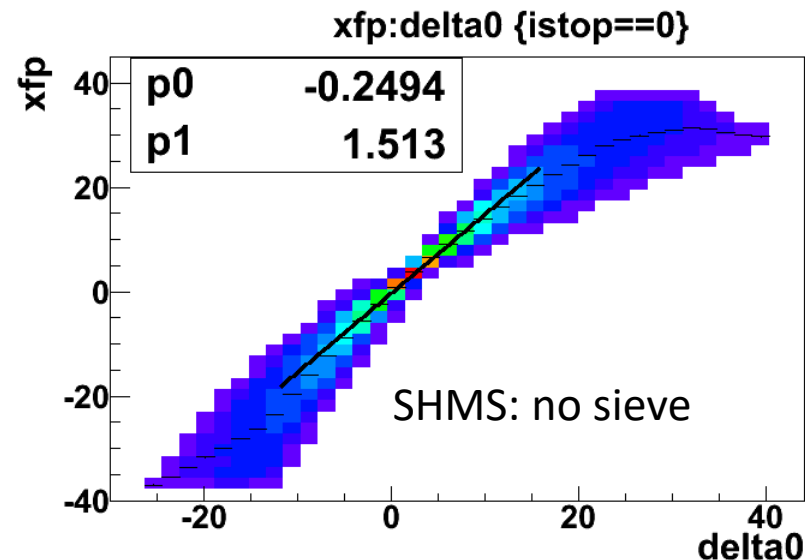
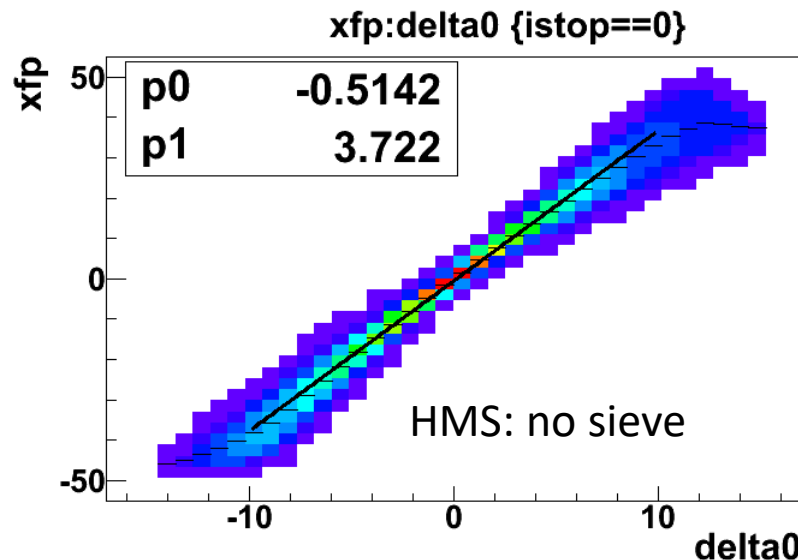


HMS and SHMS each SC bar is about 8cm wide. All elastic events will go into one single SC bar, if the P0 is set ideally.

# How to Determine Which 2 SC Bar Should Be On?

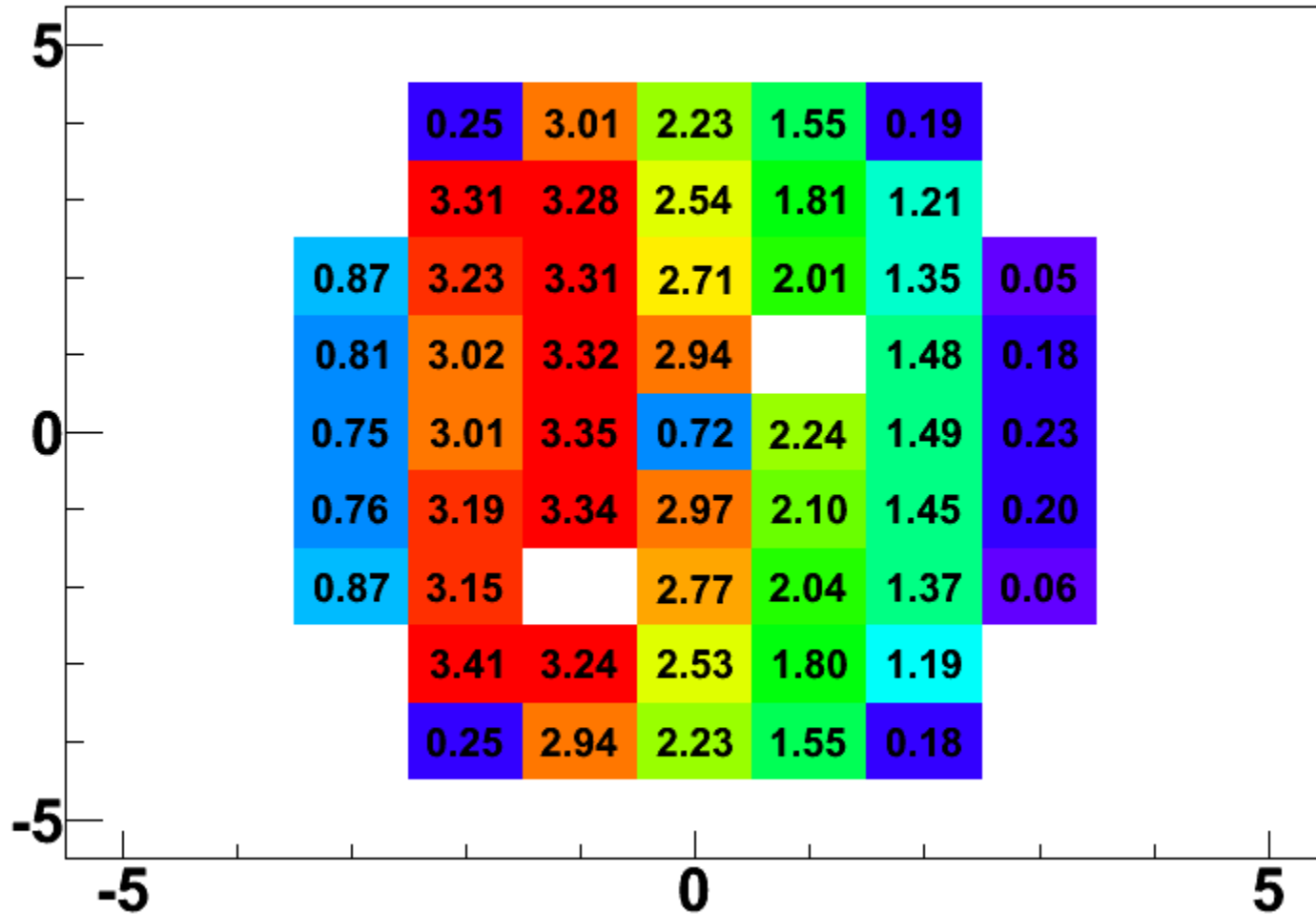


HMS and SHMS each SC bar is about 8cm wide. All elastic events will go into 2 SC bar, if the P0 is set ideally. With the following fit functions, we can predict which bars should be turned on.



# HMS Sieve Slit Rates: 2.1 GeV, 11.7deg

HMS 11.7°: Sieve Hole Rate Fraction to Total Sieve Rate(%)

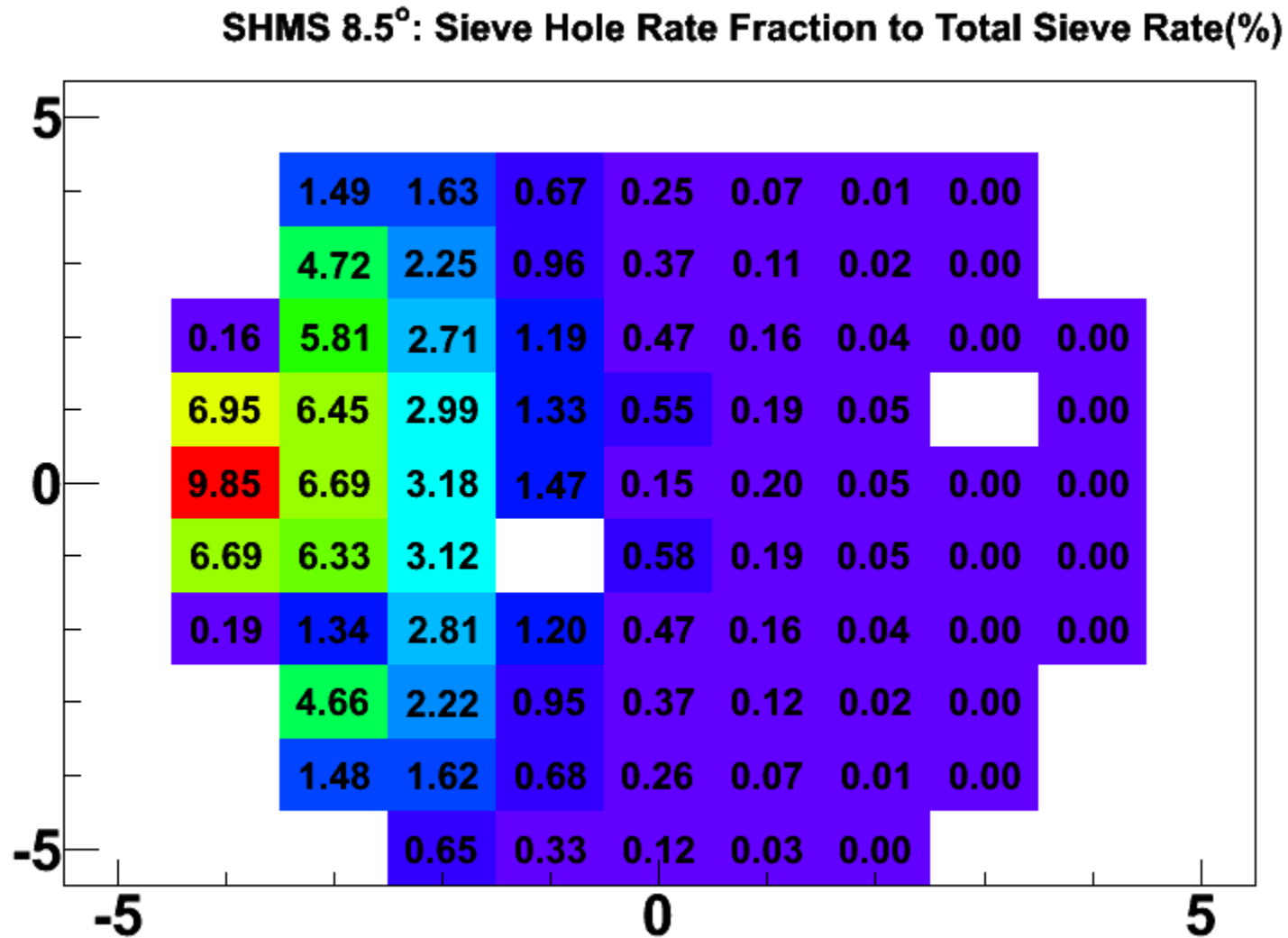


E=2.1 GeV, theta= 11.7 degrees, P0=2.092, Single C12 foil.

With sieve, HMS carbon elastic total rate drops to only **4.6%** of that without sieve.



# SHMS Sieve Slit Rates: 2.1 GeV, 8.5deg

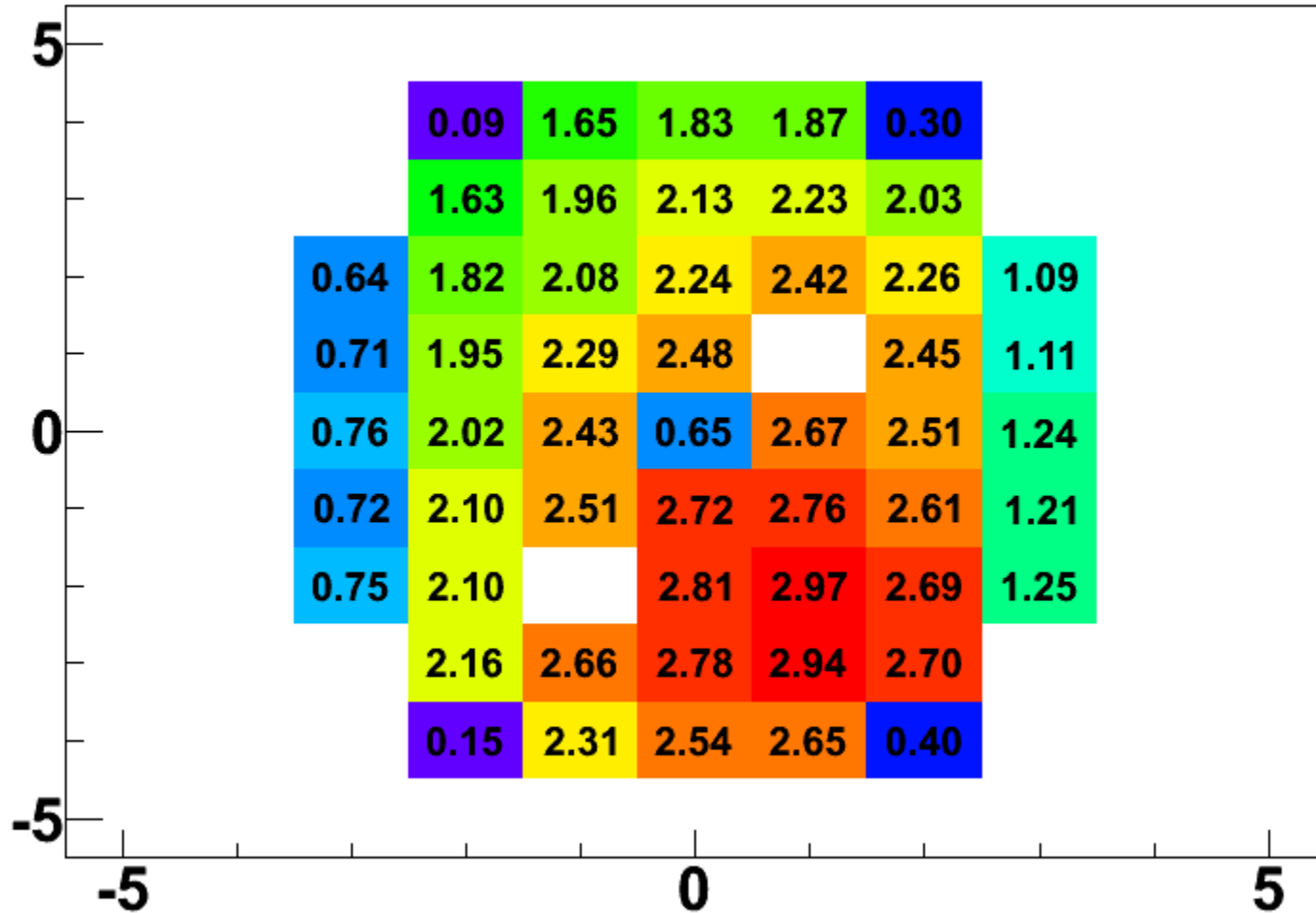


E=2.1 GeV, theta= 8.5 degrees, P0=2.096, Single C12 foil.

Wwith sieve, SHMS carbon elastic total rate drops to only **6.2%** of that without sieve.

# HMS Sieve Slit Rates: 10.5 GeV, 30deg

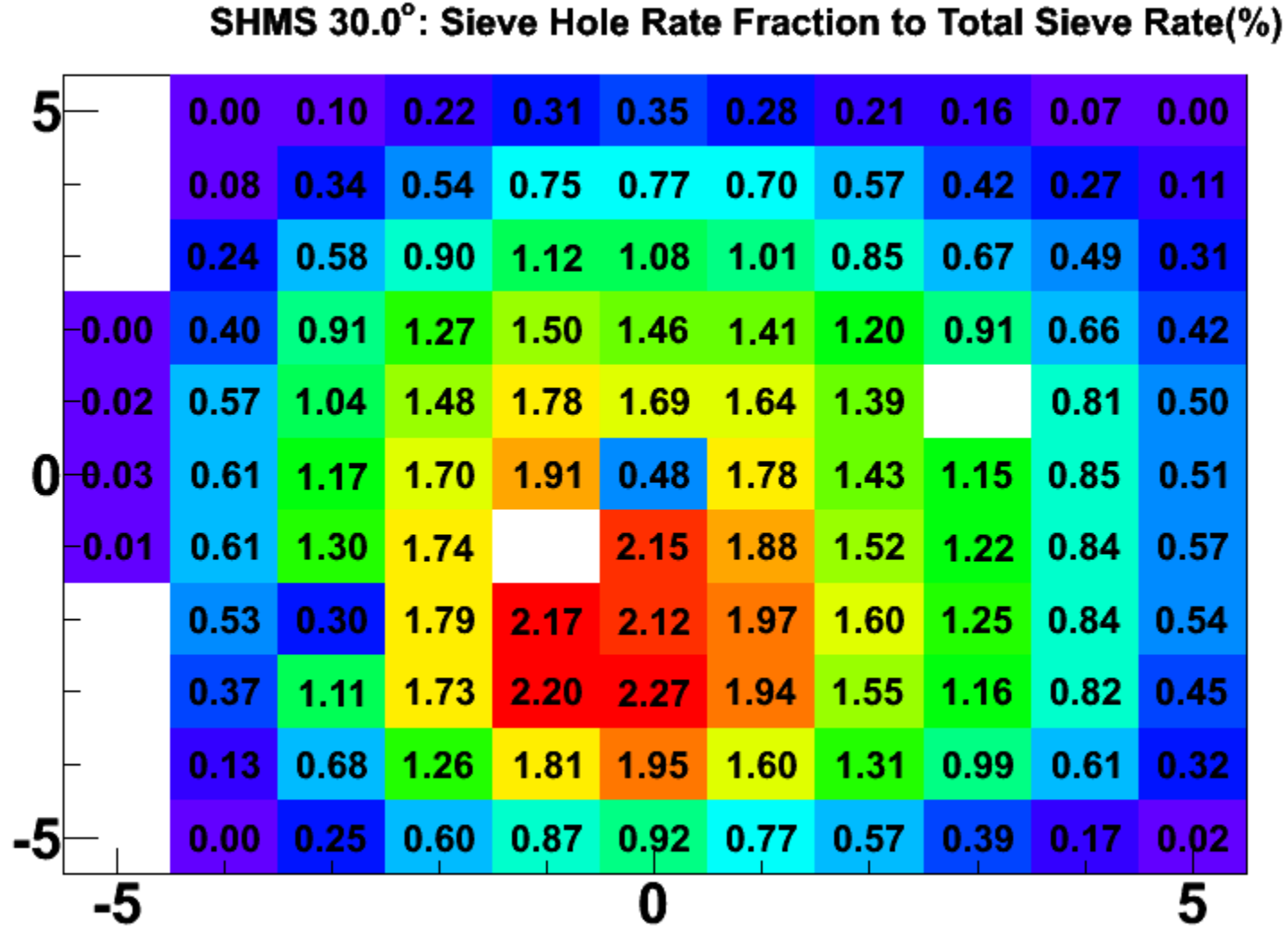
HMS 30.0°: Sieve Hole Rate Fraction to Total Sieve Rate(%)



E=10.5 GeV, theta= 30 degrees, P0=1.500, Single C12 foil.

With sieve, HMS carbon rate drops to only **4.77%** of that without sieve.

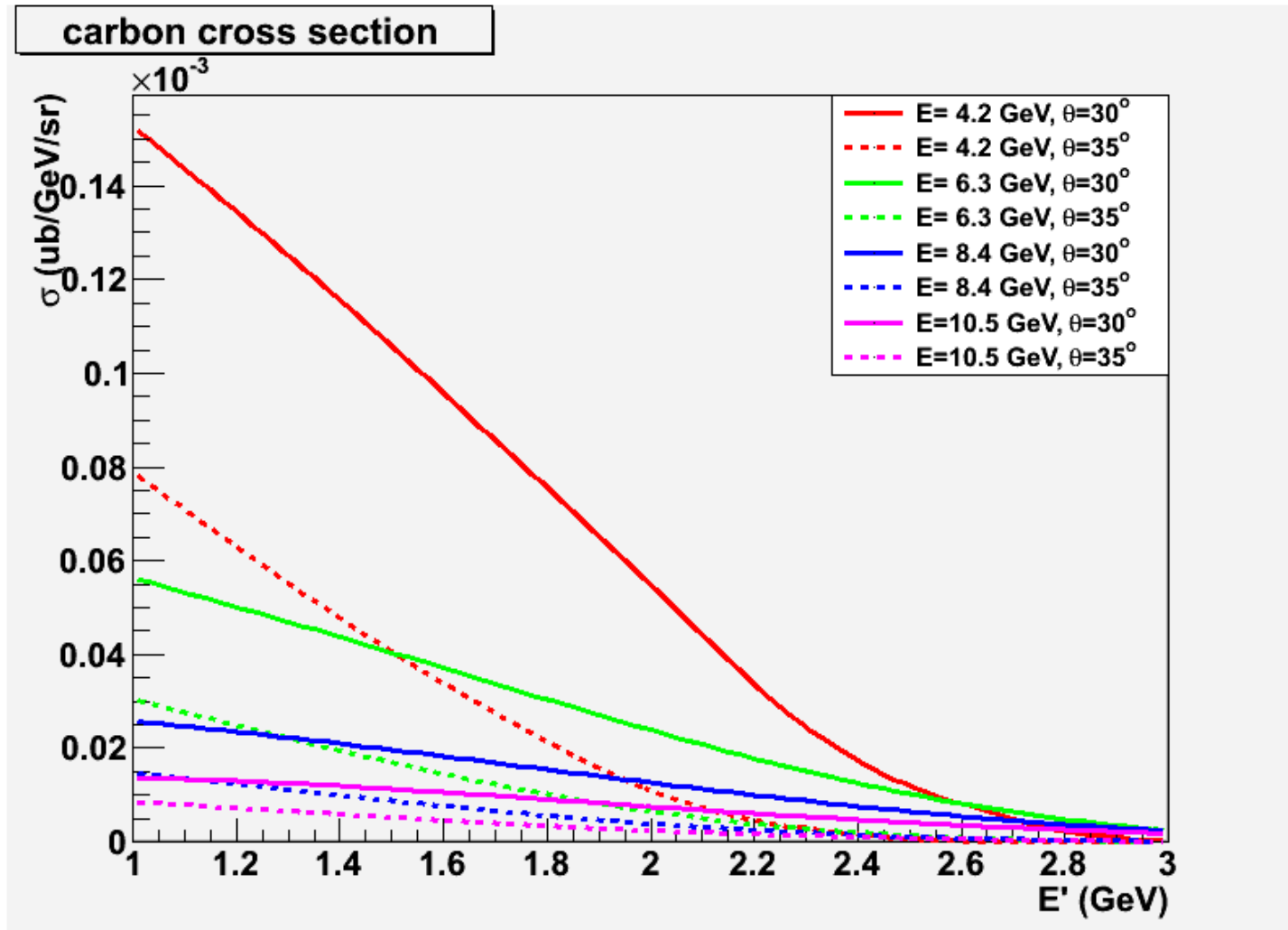
# SHMS Sieve Slit Rates: 10.5 GeV, 30deg



E=10.5 GeV, theta= 30 degrees, P0=1.800, Single C12 foil.

With sieve, SHMS carbon rate drops to only **6.6%** of that without sieve.

# Carbon Inclusive Cross Section



Prefer to choose 35 degrees other than 30 degrees in order to cover wider Ytar.

If possible, use 2-pass beam @ 35 degrees

Required beam time is limited SHMS whose “designed” minimum momentum is 2.0 GeV.

We will push it to 1.800 GeV.

# Change-Over-Time

- 30 minutes to cycle HMS or SHMS dipole.
- 5 minutes to change momentum (going down only).
- 3 minutes to change targets (switch between single-foil to 7-foil)
- 15 minutes to change the sieve slit in or out
- Estimate data taking time based on simulation, details will be present.

# Suggested Run List

=====dP calibration=====

Det	Target	Beam	Angle	Momentum	Current	Prescale	BeamTime(m)	Comment
HMS	C12_2Foil	2.100	11.7	2.092	0.79	1	21	dP=0%, No sieve, Full Acc
SHMS	C12_2Foil	2.100	8.5	2.096	0.79	5	18	dP=0%, No sieve. Full Acc

===Suggested beam Current and time to get 50 events in the center sieve hole===

Det	Target	Beam	Angle	Momentum	Current	Prescale	BeamTime(m)	Comment
HMS	C12_2Foil	2.100	11.7	2.092	6.39	1	24	dP= 0%, 2-bar Acc
SHMS	C12_2Foil	2.100	8.5	2.096	6.39	21	23	dP= 0%, 2-bar Acc
HMS	C12_2Foil	2.100	11.7	1.992	6.60	1	23	dP= +5%, 2-bar Acc
SHMS	C12_2Foil	2.100	8.5	1.996	6.60	21	23	dP= +5%, 2-bar Acc
HMS	C12_2Foil	2.100	11.7	1.937	6.00	1	25	dP= +8%, 2-bar Acc
SHMS	C12_2Foil	2.100	8.5	1.905	6.00	21	24	dP=+10%, 2-bar Acc
SHMS	C12_2Foil	2.100	8.5	1.822	0.16	1	24	dP=+15%, 2-bar Acc
HMS	C12_2Foil	2.100	11.7	2.274	6.12	1	25	dP= -8%, 2-bar Acc
SHMS	C12_2Foil	2.100	8.5	2.329	6.12	21	24	dP=-10%, 2-bar Acc
HMS	C12_2Foil	2.100	11.7	2.202	6.14	1	25	dP= -5%, 2-bar Acc
SHMS	C12_2Foil	2.100	8.5	2.206	6.14	21	24	dP= -5%, 2-bar Acc

=====Angle calibration=====

===Suggested beam Current and time to get 100 events in center sieve hole from center foil===

Det	Target	Beam	Angle	Momentum	Current	Prescale	BeamTime(m)	Comment
HMS	C12_7Foil	10.500	30.0	1.500	30.00	1	445	dP=0%, Full Acc, 10 mil
SHMS	C12_7Foil	10.500	30.0	1.800	30.00	1	368	dP=0%, Full Acc, 10 mil
HMS	C12_7Foil	10.500	35.0	1.500	30.00	1	958	dP=0%, Full Acc, 10 mil
SHMS	C12_7Foil	10.500	35.0	1.800	30.00	1	969	dP=0%, Full Acc, 10 mil

- dP scan total calendar time: 338 minutes + 70 overhead minutes
- Angle and Ytar calibration total calendar time: 890 minutes @ 30 degrees, assuming 10 mil thickness carbon foil is used.

# dP Scan Operation Procedure

- dP=0%, no sieve, 2-foil (21m)
- Move sieve in (15m)
- dP=0%, take 2-foil data (24m)
- Change both dP to +5% (5m), take 2-foil data(23m)
- Change dP to +8% for HMS and +10% for SHMS(5m), take 2-foil data(25m)
- Change both dP to +15% (5m), take 2-foil data(24m)
- Cycle Dipoles for both HMS and SHMS (30m), set dP to -8% for HMS and -10% for SHMS), take 2-foil data(25m)
- Change both dP to -5% (5m), take 2-foil data(25m)

If time allow, I prefer to add +20% and -15% for SHMS. Which will take 110 minutes more.

Color blue is overhead time.

# Summary

1. We suggest to do a simple version of dP scan at small angle using 2- foil target, with 1-pass beam. Turn on only 2 SC Bar during dP scan can save a lot of beam time. (Need to find out a way to identify quickly which 2 SC bars the elastic events will hit during data taking. Time for this task is not counted yet.)
2. We will do a brand NEW angle and Ytar calibration at 35 ( or 30) degrees using resonance events. We will need 100 mil C12 foils. We do not need 1-pass beam for this.
3. Total calendar time for dP scan is about 408 minutes (1-pass beam).
4. Total calendar time for angle and Ytar calibration is about 890 minutes (assuming 10 mil thickness carbon foils and spectrometer are at 30 degrees, 5-pass beam). If possible, we should use 2-pass beam at 35 degrees.



# Back up

# dP Scan: 0%, Full Acceptance

=====Full acceptance: Inelastic + Elastic =====

Detector= HMS Optics, Beam\_current= 1 uA, Angle= 11.7 deg

Det	Target	BeamE	Current	DetP0	DetAngle	VZ(cm)	Thick(cm)	Lumi(10^33)	InteXS(pb)	Rate(Hz)
HMS	C12_0	2.1000	1.00	2.092	11.70	-20.00	0.0254	18.02	190283.06	3429.20
HMS	C12_1	2.1000	1.00	2.092	11.70	-13.33	0.0254	18.02	199885.36	3602.24
HMS	C12_2	2.1000	1.00	2.092	11.70	-6.67	0.0254	18.02	204552.32	3686.35
HMS	C12_3	2.1000	1.00	2.092	11.70	0.00	0.0254	18.02	194917.62	3512.72
HMS	C12_4	2.1000	1.00	2.092	11.70	6.67	0.0254	18.02	158907.10	2863.75
HMS	C12_5	2.1000	1.00	2.092	11.70	13.33	0.0254	18.02	121014.02	2180.86
HMS	C12_6	2.1000	1.00	2.092	11.70	20.00	0.0254	18.02	93927.83	1692.73
HMS	C12_3N5	2.1000	1.00	2.092	11.70	0.00	0.0508	36.04	157965.82	5693.58
HMS	C12_All	2.1000	1.00	2.092	11.70	0.00	0.1778	126.15	166212.47	20967.85

=====Full acceptance: Inelastic + Elastic =====

Detector= SHMS Optics, Beam\_current= 1 uA, Angle= 8.5 deg

Det	Target	BeamE	Current	DetP0	DetAngle	VZ(cm)	Thick(cm)	Lumi(10^33)	InteXS(pb)	Rate(Hz)
SHMS	C12_0	2.1000	1.00	2.096	8.50	-20.00	0.0254	18.02	875295.35	15774.18
SHMS	C12_1	2.1000	1.00	2.096	8.50	-13.33	0.0254	18.02	845928.86	15244.95
SHMS	C12_2	2.1000	1.00	2.096	8.50	-6.67	0.0254	18.02	801356.97	14441.70
SHMS	C12_3	2.1000	1.00	2.096	8.50	0.00	0.0254	18.02	778510.79	14029.98
SHMS	C12_4	2.1000	1.00	2.096	8.50	6.67	0.0254	18.02	736318.16	13269.60
SHMS	C12_5	2.1000	1.00	2.096	8.50	13.33	0.0254	18.02	691955.81	12470.12
SHMS	C12_6	2.1000	1.00	2.096	8.50	20.00	0.0254	18.02	656087.68	11823.72
SHMS	C12_3N5	2.1000	1.00	2.096	8.50	0.00	0.0508	36.04	735233.30	26500.09
SHMS	C12_All	2.1000	1.00	2.096	8.50	0.00	0.1778	126.15	769350.52	97054.25

Strong VZ dependence

without sieve, all SC bars are on

# dP Scan: 0%, 2-Bar Acceptance

=====Only 2 SC bars: Inelastic + Elastic =====

Detector= HMS Optics, Beam\_current= 1 uA, Angle= 11.7 deg

Det	Target	BeamE	Current	DetP0	DetAngle	VZ(cm)	Thick(cm)	Lumi(10 <sup>33</sup> )	InteXS(pb)	Rate(Hz)
HMS	C12_0	2.1000	1.00	2.092	11.70	-20.00	0.0254	18.02	27412.75	494.02
HMS	C12_1	2.1000	1.00	2.092	11.70	-13.33	0.0254	18.02	27686.22	498.95
HMS	C12_2	2.1000	1.00	2.092	11.70	-6.67	0.0254	18.02	27534.38	496.21
HMS	C12_3	2.1000	1.00	2.092	11.70	0.00	0.0254	18.02	25303.74	456.01
HMS	C12_4	2.1000	1.00	2.092	11.70	6.67	0.0254	18.02	19223.44	346.44
HMS	C12_5	2.1000	1.00	2.092	11.70	13.33	0.0254	18.02	13770.84	248.17
HMS	C12_6	2.1000	1.00	2.092	11.70	20.00	0.0254	18.02	10172.02	183.32
HMS	C12_3N5	2.1000	1.00	2.092	11.70	0.00	0.0508	36.04	19537.29	704.18
HMS	C12_All	2.1000	1.00	2.092	11.70	0.00	0.1778	126.15	21586.20	2723.12

=====Only 2 SC bars: Inelastic + Elastic =====

Detector= SHMS Optics, Beam\_current= 1 uA, Angle= 8.5 deg

Det	Target	BeamE	Current	DetP0	DetAngle	VZ(cm)	Thick(cm)	Lumi(10 <sup>33</sup> )	InteXS(pb)	Rate(Hz)
SHMS	C12_0	2.1000	1.00	2.096	8.50	-20.00	0.0254	18.02	510267.37	9195.81
SHMS	C12_1	2.1000	1.00	2.096	8.50	-13.33	0.0254	18.02	485071.31	8741.74
SHMS	C12_2	2.1000	1.00	2.096	8.50	-6.67	0.0254	18.02	454907.93	8198.15
SHMS	C12_3	2.1000	1.00	2.096	8.50	0.00	0.0254	18.02	435771.01	7853.27
SHMS	C12_4	2.1000	1.00	2.096	8.50	6.67	0.0254	18.02	404401.24	7287.94
SHMS	C12_5	2.1000	1.00	2.096	8.50	13.33	0.0254	18.02	373310.93	6727.64
SHMS	C12_6	2.1000	1.00	2.096	8.50	20.00	0.0254	18.02	348100.74	6273.32
SHMS	C12_3N5	2.1000	1.00	2.096	8.50	0.00	0.0508	36.04	404540.97	14580.91
SHMS	C12_All	2.1000	1.00	2.096	8.50	0.00	0.1778	126.15	430261.51	54277.87

Strong VZ dependence

without sieve, only 2 SC bars are on

# dP Scan: 0%, Full Acceptance, Elas only

=====Full acceptance: Pure elastic =====

Detector= HMS Optics, Beam\_current= 1 uA, Angle= 11.7 deg

Det	Target	BeamE	Current	DetP0	DetAngle	VZ(cm)	Thick(cm)	Lumi(10 <sup>33</sup> )	InteXS(pb)	Rate(Hz)
HMS	C12_0	2.1000	1.00	2.092	11.70	-20.00	0.0254	18.02	385.19	6.94
HMS	C12_1	2.1000	1.00	2.092	11.70	-13.33	0.0254	18.02	468.90	8.45
HMS	C12_2	2.1000	1.00	2.092	11.70	-6.67	0.0254	18.02	527.21	9.50
HMS	C12_3	2.1000	1.00	2.092	11.70	0.00	0.0254	18.02	534.90	9.64
HMS	C12_4	2.1000	1.00	2.092	11.70	6.67	0.0254	18.02	464.99	8.38
HMS	C12_5	2.1000	1.00	2.092	11.70	13.33	0.0254	18.02	349.42	6.30
HMS	C12_6	2.1000	1.00	2.092	11.70	20.00	0.0254	18.02	252.98	4.56
HMS	C12_3N5	2.1000	1.00	2.092	11.70	0.00	0.0508	36.04	442.16	15.94
HMS	C12_All	2.1000	1.00	2.092	11.70	0.00	0.1778	126.15	426.23	53.77

=====Full acceptance: Pure elastic =====

Detector= SHMS Optics, Beam\_current= 1 uA, Angle= 8.5 deg

Det	Target	BeamE	Current	DetP0	DetAngle	VZ(cm)	Thick(cm)	Lumi(10 <sup>33</sup> )	InteXS(pb)	Rate(Hz)
SHMS	C12_0	2.1000	1.00	2.096	8.50	-20.00	0.0254	18.02	73828.23	1330.50
SHMS	C12_1	2.1000	1.00	2.096	8.50	-13.33	0.0254	18.02	64199.58	1156.98
SHMS	C12_2	2.1000	1.00	2.096	8.50	-6.67	0.0254	18.02	54223.56	977.19
SHMS	C12_3	2.1000	1.00	2.096	8.50	0.00	0.0254	18.02	46704.47	841.69
SHMS	C12_4	2.1000	1.00	2.096	8.50	6.67	0.0254	18.02	38681.26	697.10
SHMS	C12_5	2.1000	1.00	2.096	8.50	13.33	0.0254	18.02	29134.28	525.04
SHMS	C12_6	2.1000	1.00	2.096	8.50	20.00	0.0254	18.02	24656.51	444.35
SHMS	C12_3N5	2.1000	1.00	2.096	8.50	0.00	0.0508	36.04	37919.37	1366.73
SHMS	C12_All	2.1000	1.00	2.096	8.50	0.00	0.1778	126.15	47346.84	5972.85

Strong VZ dependence

without sieve, all SC bars are on

# Beam Time for dP Scan: 0%

=====Suggested beam Current and beam time to get 25|50|175 events in the center sieve hole=====

=====Full acceptance=====

Det	Target	Beam	Angle	Momentum	Current	Prescale	DAQRate	GoodRate	SieveRate	CenterHoleRate	BeamTime (m)	Comment
HMS	C12_1Foil	2.100	11.70	2.092	1.28	1	4496.28	12.34	NA	NA	13	dP=0%, No sieve
SHMS	C12_1Foil	2.100	8.50	2.096	1.28	4	4489.59	269.34	NA	NA	11	dP=0%, No sieve
HMS	C12_2Foil	2.100	11.7	2.092	0.79	1	4497.93	12.59	NA	NA	21	dP=0%, No sieve
SHMS	C12_2Foil	2.100	8.5	2.096	0.79	5	4187.01	215.94	NA	NA	18	dP=0%, No sieve
HMS	C12_7Foil	2.100	11.70	2.092	0.21	1	4403.25	11.29	NA	NA	79	dP=0%, No sieve
SHMS	C12_7Foil	2.100	8.50	2.096	0.21	5	4076.28	250.86	NA	NA	61	dP=0%, No sieve

=====Full acceptance=====

Det	Target	Beam	Angle	Momentum	Current	Prescale	DAQRate	GoodRate	SieveRate	CenterHoleRate	BeamTime (m)	Comment
HMS	C12_1Foil	2.100	11.70	2.092	1.28	1	4496.28	12.34	0.5676	0.0042	99	dP=0%, Full Acc
SHMS	C12_1Foil	2.100	8.50	2.096	1.28	4	4489.59	269.34	16.6991	0.0234	18	dP=0%, Full Acc
HMS	C12_2Foil	2.100	11.7	2.092	0.79	1	4497.93	12.59	0.5791	0.0043	194	dP=0%, Full Acc
SHMS	C12_2Foil	2.100	8.5	2.096	0.79	5	4187.01	215.94	13.3885	0.0187	45	dP=0%, Full Acc
HMS	C12_7Foil	2.100	11.70	2.092	0.21	1	4403.25	11.29	0.5194	0.0038	605	dP=0%, Full Acc
SHMS	C12_7Foil	2.100	8.50	2.096	0.21	5	4076.28	250.86	15.5533	0.0218	109	dP=0%, Full Acc

=====Only 2 SC bars=====

Det	Target	Beam	Angle	Momentum	Current	Prescale	DAQRate	GoodRate	SieveRate	CenterHoleRate	BeamTime (m)	Comment
HMS	C12_1Foil	2.100	11.70	2.092	9.86	1	4496.29	95.05	4.3722	0.0324	13	dP=0%, 2-bar Acc
SHMS	C12_1Foil	2.100	8.50	2.096	9.86	18	4301.85	461.06	28.5856	0.0400	11	dP=0%, 2-bar Acc
HMS	C12_2Foil	2.100	11.7	2.092	6.39	1	4499.74	101.84	4.6844	0.0347	24	dP=0%, 2-bar Acc
SHMS	C12_2Foil	2.100	8.5	2.096	6.39	21	4436.76	415.88	25.7844	0.0361	23	dP=0%, 2-bar Acc
HMS	C12_7Foil	2.100	11.70	2.092	1.65	1	4493.15	88.72	4.0810	0.0302	77	dP=0%, 2-bar Acc
SHMS	C12_7Foil	2.100	8.50	2.096	1.65	20	4477.92	492.76	30.5511	0.0428	62	dP=0%, 2-bar Acc

Use only 2 SC bars can save a lot of time (a factor of 8 for HMS and 1.7 for SHMS)

Suggest to use 2-foil target

# Beam Time for Other dP Scan Runs

=====Suggested beam Current and beam time to get 25|50|175 events in the center sieve hole=====

=====Full acceptance=====

Det	Target	Beam	Angle	Momentum	Current	Prescale	DAQRate	GoodRate	SieveRate	CenterHoleRate	BeamTime (m)	Comment
HMS	C12_1Foil	2.100	11.7	1.992	1.08	1	4471.69	10.44	0.4801	0.0036	117	dP=5%
SHMS	C12_1Foil	2.100	8.5	1.996	1.08	4	4003.85	163.75	10.1525	0.0142	29	dP=5%
HMS	C12_2Foil	2.100	11.7	1.992	0.66	1	4454.93	10.63	0.4892	0.0036	230	dP=5%
SHMS	C12_2Foil	2.100	8.5	1.996	0.66	4	4642.64	161.37	10.0052	0.0140	60	dP=5%
HMS	C12_7Foil	2.100	11.7	1.992	0.18	1	4444.56	9.75	0.4484	0.0033	882	dP=5%
SHMS	C12_7Foil	2.100	8.5	1.996	0.18	4	4637.78	195.56	12.1250	0.0170	172	dP=5%

Det	Target	Beam	Angle	Momentum	Current	Prescale	DAQRate	GoodRate	SieveRate	CenterHoleRate	BeamTime (m)	Comment
HMS	C12_1Foil	2.100	11.7	1.937	0.98	1	4464.33	9.67	0.4448	0.0033	127	dP= 8%
SHMS	C12_1Foil	2.100	8.5	1.905	0.98	4	3662.88	129.16	8.0079	0.0112	37	dP=10%
HMS	C12_2Foil	2.100	11.7	1.937	0.60	1	4453.24	9.81	0.4513	0.0033	250	dP= 8%
SHMS	C12_2Foil	2.100	8.5	1.905	0.60	4	4272.79	127.83	7.9254	0.0111	75	dP=10%
HMS	C12_7Foil	2.100	11.7	1.937	0.16	1	4340.34	8.70	0.4003	0.0030	985	dP= 8%
SHMS	C12_7Foil	2.100	8.5	1.905	0.16	4	4134.22	145.69	9.0328	0.0126	231	dP=10%

Det	Target	Beam	Angle	Momentum	Current	Prescale	DAQRate	GoodRate	SieveRate	CenterHoleRate	BeamTime (m)	Comment
HMS	C12_1Foil	2.100	11.7	2.202	2.15	1	4485.58	20.67	0.9507	0.0070	59	dP=-5%
SHMS	C12_1Foil	2.100	8.5	2.206	2.15	6	4508.89	321.65	19.9423	0.0279	15	dP=-5%
HMS	C12_2Foil	2.100	11.7	2.202	1.37	1	4493.85	21.85	1.0052	0.0074	112	dP=-5%
SHMS	C12_2Foil	2.100	8.5	2.206	1.37	8	4061.61	249.27	15.4548	0.0216	39	dP=-5%
HMS	C12_7Foil	2.100	11.7	2.202	0.35	1	4398.74	18.80	0.8649	0.0064	456	dP=-5%
SHMS	C12_7Foil	2.100	8.5	2.206	0.35	7	4348.80	312.71	19.3880	0.0271	108	dP=-5%

Det	Target	Beam	Angle	Momentum	Current	Prescale	DAQRate	GoodRate	SieveRate	CenterHoleRate	BeamTime (m)	Comment
HMS	C12_1Foil	2.100	11.7	2.274	6.69	1	4497.08	67.61	3.1098	0.0230	18	dP= -8%
SHMS	C12_1Foil	2.100	8.5	2.329	6.69	17	4409.26	405.71	25.1538	0.0352	12	dP=-10%
HMS	C12_2Foil	2.100	11.7	2.274	4.32	1	4493.22	72.98	3.3571	0.0248	34	dP= -8%
SHMS	C12_2Foil	2.100	8.5	2.329	4.32	20	4517.92	358.59	22.2324	0.0311	27	dP=-10%
HMS	C12_7Foil	2.100	11.7	2.274	1.08	1	4497.80	61.39	2.8240	0.0209	140	dP= -8%
SHMS	C12_7Foil	2.100	8.5	2.329	1.08	19	4425.65	415.39	25.7543	0.0361	81	dP=-10%

Must use only 2 SC bars to save time (**expect final beam time to be similar to 0% case**)

Suggest to use 2-foil target



# dP Scan: +5%, Full Acceptance

=====Full acceptance: Pure elastic =====

Detector= HMS Optics, Beam\_current= 1 uA, Angle= 11.7 deg

Det	Target	BeamE	Current	DetP0	DetAngle	VZ (cm)	Thick(cm)	Lumi (10 <sup>33</sup> )	InteXS (pb)	Rate (Hz)
HMS	C12_0	2.1000	1.00	1.992	11.70	-20.00	0.0254	18.02	384.63	6.93
HMS	C12_1	2.1000	1.00	1.992	11.70	-13.33	0.0254	18.02	469.29	8.46
HMS	C12_2	2.1000	1.00	1.992	11.70	-6.67	0.0254	18.02	527.79	9.51
HMS	C12_3	2.1000	1.00	1.992	11.70	0.00	0.0254	18.02	536.21	9.66
HMS	C12_4	2.1000	1.00	1.992	11.70	6.67	0.0254	18.02	470.02	8.47
HMS	C12_5	2.1000	1.00	1.992	11.70	13.33	0.0254	18.02	357.83	6.45
HMS	C12_6	2.1000	1.00	1.992	11.70	20.00	0.0254	18.02	259.42	4.68
HMS	C12_3N5	2.1000	1.00	1.992	11.70	0.00	0.0508	36.04	447.02	16.11
HMS	C12_All	2.1000	1.00	1.992	11.70	0.00	0.1778	126.15	429.31	54.16

=====Full acceptance: Pure elastic =====

Detector= SHMS Optics, Beam\_current= 1 uA, Angle= 8.5 deg

Det	Target	BeamE	Current	DetP0	DetAngle	VZ (cm)	Thick(cm)	Lumi (10 <sup>33</sup> )	InteXS (pb)	Rate (Hz)
SHMS	C12_0	2.1000	1.00	1.996	8.50	-20.00	0.0254	18.02	54453.15	981.33
SHMS	C12_1	2.1000	1.00	1.996	8.50	-13.33	0.0254	18.02	50403.84	908.36
SHMS	C12_2	2.1000	1.00	1.996	8.50	-6.67	0.0254	18.02	37642.59	678.38
SHMS	C12_3	2.1000	1.00	1.996	8.50	0.00	0.0254	18.02	33653.09	606.48
SHMS	C12_4	2.1000	1.00	1.996	8.50	6.67	0.0254	18.02	27852.17	501.94
SHMS	C12_5	2.1000	1.00	1.996	8.50	13.33	0.0254	18.02	20616.88	371.55
SHMS	C12_6	2.1000	1.00	1.996	8.50	20.00	0.0254	18.02	16527.63	297.85
SHMS	C12_3N5	2.1000	1.00	1.996	8.50	0.00	0.0508	36.04	27134.98	978.03
SHMS	C12_All	2.1000	1.00	1.996	8.50	0.00	0.1778	126.15	34449.91	4345.89

Strong VZ dependence

without sieve, all SC bars are on

# dP Scan: +8% or +10%, Full Acceptance

=====Full acceptance: Inelastic + Elastic =====

Detector= HMS Optics, Beam\_current= 1 uA, Angle= 11.7 deg

Det	Target	BeamE	Current	DetP0	DetAngle	VZ (cm)	Thick(cm)	Lumi (10^33)	InteXS (pb)	Rate (Hz)
HMS	C12_0	2.1000	1.00	1.937	11.70	-20.00	0.0254	18.02	242422.51	4368.83
HMS	C12_1	2.1000	1.00	1.937	11.70	-13.33	0.0254	18.02	255058.42	4596.55
HMS	C12_2	2.1000	1.00	1.937	11.70	-6.67	0.0254	18.02	264503.67	4766.77
HMS	C12_3	2.1000	1.00	1.937	11.70	0.00	0.0254	18.02	252777.24	4555.44
HMS	C12_4	2.1000	1.00	1.937	11.70	6.67	0.0254	18.02	206661.71	3724.37
HMS	C12_5	2.1000	1.00	1.937	11.70	13.33	0.0254	18.02	159066.53	2866.63
HMS	C12_6	2.1000	1.00	1.937	11.70	20.00	0.0254	18.02	124769.38	2248.54
HMS	C12_3N5	2.1000	1.00	1.937	11.70	0.00	0.0508	36.04	205921.88	7422.07
HMS	C12_All	2.1000	1.00	1.937	11.70	0.00	0.1778	126.15	215037.06	27127.12

=====Full acceptance: Inelastic + Elastic =====

Detector= SHMS Optics, Beam\_current= 1 uA, Angle= 8.5 deg

Det	Target	BeamE	Current	DetP0	DetAngle	VZ (cm)	Thick(cm)	Lumi (10^33)	InteXS (pb)	Rate (Hz)
SHMS	C12_0	2.1000	1.00	1.905	8.50	-20.00	0.0254	18.02	910816.05	16414.32
SHMS	C12_1	2.1000	1.00	1.905	8.50	-13.33	0.0254	18.02	897936.57	16182.21
SHMS	C12_2	2.1000	1.00	1.905	8.50	-6.67	0.0254	18.02	838278.60	15107.08
SHMS	C12_3	2.1000	1.00	1.905	8.50	0.00	0.0254	18.02	829591.40	14950.53
SHMS	C12_4	2.1000	1.00	1.905	8.50	6.67	0.0254	18.02	791387.10	14262.03
SHMS	C12_5	2.1000	1.00	1.905	8.50	13.33	0.0254	18.02	751030.95	13534.75
SHMS	C12_6	2.1000	1.00	1.905	8.50	20.00	0.0254	18.02	716069.50	12904.69
SHMS	C12_3N5	2.1000	1.00	1.905	8.50	0.00	0.0508	36.04	790311.17	28485.27
SHMS	C12_All	2.1000	1.00	1.905	8.50	0.00	0.1778	126.15	819301.45	103355.60

Strong VZ dependence

without sieve, all SC bars are on



# dP Scan: -5%, Full Acceptance

=====Full acceptance: Inelastic + Elastic =====

Detector= HMS Optics, Beam\_current= 1 uA, Angle= 11.7 deg

Det	Target	BeamE	Current	DetP0	DetAngle	VZ (cm)	Thick(cm)	Lumi (10^33)	InteXS (pb)	Rate (Hz)
HMS	C12_0	2.1000	1.00	2.202	11.70	-20.00	0.0254	18.02	123546.50	2226.50
HMS	C12_1	2.1000	1.00	2.202	11.70	-13.33	0.0254	18.02	126962.52	2288.06
HMS	C12_2	2.1000	1.00	2.202	11.70	-6.67	0.0254	18.02	124964.24	2252.05
HMS	C12_3	2.1000	1.00	2.202	11.70	0.00	0.0254	18.02	115767.76	2086.32
HMS	C12_4	2.1000	1.00	2.202	11.70	6.67	0.0254	18.02	90581.36	1632.42
HMS	C12_5	2.1000	1.00	2.202	11.70	13.33	0.0254	18.02	66246.77	1193.87
HMS	C12_6	2.1000	1.00	2.202	11.70	20.00	0.0254	18.02	49308.15	888.61
HMS	C12_3N5	2.1000	1.00	2.202	11.70	0.00	0.0508	36.04	91007.27	3280.18
HMS	C12_All	2.1000	1.00	2.202	11.70	0.00	0.1778	126.15	99625.33	12567.82

=====Full acceptance: Inelastic + Elastic =====

Detector= SHMS Optics, Beam\_current= 1 uA, Angle= 8.5 deg

Det	Target	BeamE	Current	DetP0	DetAngle	VZ (cm)	Thick(cm)	Lumi (10^33)	InteXS (pb)	Rate (Hz)
SHMS	C12_0	2.1000	1.00	2.206	8.50	-20.00	0.0254	18.02	791107.09	14256.98
SHMS	C12_1	2.1000	1.00	2.206	8.50	-13.33	0.0254	18.02	772822.07	13927.46
SHMS	C12_2	2.1000	1.00	2.206	8.50	-6.67	0.0254	18.02	710018.22	12795.63
SHMS	C12_3	2.1000	1.00	2.206	8.50	0.00	0.0254	18.02	698216.34	12582.94
SHMS	C12_4	2.1000	1.00	2.206	8.50	6.67	0.0254	18.02	655020.50	11804.49
SHMS	C12_5	2.1000	1.00	2.206	8.50	13.33	0.0254	18.02	617842.73	11134.49
SHMS	C12_6	2.1000	1.00	2.206	8.50	20.00	0.0254	18.02	581195.28	10474.04
SHMS	C12_3N5	2.1000	1.00	2.206	8.50	0.00	0.0508	36.04	658029.53	23717.43
SHMS	C12_All	2.1000	1.00	2.206	8.50	0.00	0.1778	126.15	689460.32	86976.03

Strong VZ dependence

without sieve, all SC bars are on

# dP Scan: -8% or -10%, Full Acceptance

=====Full acceptance: Inelastic + Elastic =====

Detector= HMS Optics, Beam\_current= 1 uA, Angle= 11.7 deg

Det	Target	BeamE	Current	DetP0	DetAngle	VZ(cm)	Thick(cm)	Lumi(10 <sup>33</sup> )	InteXS(pb)	Rate(Hz)
HMS	C12_0	2.1000	1.00	2.274	11.70	-20.00	0.0254	18.02	44019.56	793.30
HMS	C12_1	2.1000	1.00	2.274	11.70	-13.33	0.0254	18.02	44315.94	798.64
HMS	C12_2	2.1000	1.00	2.274	11.70	-6.67	0.0254	18.02	41840.51	754.03
HMS	C12_3	2.1000	1.00	2.274	11.70	0.00	0.0254	18.02	37300.26	672.21
HMS	C12_4	2.1000	1.00	2.274	11.70	6.67	0.0254	18.02	28365.86	511.20
HMS	C12_5	2.1000	1.00	2.274	11.70	13.33	0.0254	18.02	20413.81	367.89
HMS	C12_6	2.1000	1.00	2.274	11.70	20.00	0.0254	18.02	14835.38	267.36
HMS	C12_3N5	2.1000	1.00	2.274	11.70	0.00	0.0508	36.04	28857.04	1040.10
HMS	C12_All	2.1000	1.00	2.274	11.70	0.00	0.1778	126.15	33013.05	4164.63

=====Full acceptance: Inelastic + Elastic =====

Detector= SHMS Optics, Beam\_current= 1 uA, Angle= 8.5 deg

Det	Target	BeamE	Current	DetP0	DetAngle	VZ(cm)	Thick(cm)	Lumi(10 <sup>33</sup> )	InteXS(pb)	Rate(Hz)
SHMS	C12_0	2.1000	1.00	2.329	8.50	-20.00	0.0254	18.02	715669.33	12897.47
SHMS	C12_1	2.1000	1.00	2.329	8.50	-13.33	0.0254	18.02	695476.16	12533.56
SHMS	C12_2	2.1000	1.00	2.329	8.50	-6.67	0.0254	18.02	645067.92	11625.13
SHMS	C12_3	2.1000	1.00	2.329	8.50	0.00	0.0254	18.02	621722.64	11204.41
SHMS	C12_4	2.1000	1.00	2.329	8.50	6.67	0.0254	18.02	590013.40	10632.96
SHMS	C12_5	2.1000	1.00	2.329	8.50	13.33	0.0254	18.02	538903.37	9711.88
SHMS	C12_6	2.1000	1.00	2.329	8.50	20.00	0.0254	18.02	513450.72	9253.18
SHMS	C12_3N5	2.1000	1.00	2.329	8.50	0.00	0.0508	36.04	580313.00	20916.29
SHMS	C12_All	2.1000	1.00	2.329	8.50	0.00	0.1778	126.15	617186.22	77858.59

Strong VZ dependence

without sieve, all SC bars are on

# Angle and Ytar Calibration, 30 degrees

=====Full acceptance: Inelastic + Elastic =====

Detector= HMS Optics, Beam\_current= 30 uA, Angle= 30 deg

Det	Target	BeamE	Current	DetP0	DetAngle	VZ(cm)	Thick(cm)	Lumi(10 <sup>33</sup> )	InteXS(pb)	Rate(Hz)
HMS	C12_0	10.5000	30.00	1.500	30.00	-20.00	0.0254	540.65	7.36	3.98
HMS	C12_1	10.5000	30.00	1.500	30.00	-13.33	0.0254	540.65	13.63	7.37
HMS	C12_2	10.5000	30.00	1.500	30.00	-6.67	0.0254	540.65	19.58	10.59
HMS	C12_3	10.5000	30.00	1.500	30.00	0.00	0.0254	540.65	22.33	12.07
HMS	C12_4	10.5000	30.00	1.500	30.00	6.67	0.0254	540.65	15.62	8.45
HMS	C12_5	10.5000	30.00	1.500	30.00	13.33	0.0254	540.65	7.97	4.31
HMS	C12_6	10.5000	30.00	1.500	30.00	20.00	0.0254	540.65	0.00	0.00
HMS	C12_3N5	10.5000	30.00	1.500	30.00	0.00	0.0508	1081.29	15.15	16.38
HMS	C12_All	10.5000	30.00	1.500	30.00	0.00	0.1778	3784.53	12.36	46.76

=====Full acceptance: Inelastic + Elastic =====

Detector= SHMS Optics, Beam\_current= 30 uA, Angle= 30 deg

Det	Target	BeamE	Current	DetP0	DetAngle	VZ(cm)	Thick(cm)	Lumi(10 <sup>33</sup> )	InteXS(pb)	Rate(Hz)
SHMS	C12_0	10.5000	30.00	1.800	30.00	-20.00	0.0254	540.65	19.79	10.70
SHMS	C12_1	10.5000	30.00	1.800	30.00	-13.33	0.0254	540.65	28.49	15.41
SHMS	C12_2	10.5000	30.00	1.800	30.00	-6.67	0.0254	540.65	27.75	15.00
SHMS	C12_3	10.5000	30.00	1.800	30.00	0.00	0.0254	540.65	26.37	14.26
SHMS	C12_4	10.5000	30.00	1.800	30.00	6.67	0.0254	540.65	24.38	13.18
SHMS	C12_5	10.5000	30.00	1.800	30.00	13.33	0.0254	540.65	11.99	6.48
SHMS	C12_6	10.5000	30.00	1.800	30.00	20.00	0.0254	540.65	0.00	0.00
SHMS	C12_3N5	10.5000	30.00	1.800	30.00	0.00	0.0508	1081.29	19.18	20.74
SHMS	C12_All	10.5000	30.00	1.800	30.00	0.00	0.1778	3784.53	19.83	75.03

Rates are very low, we need 100 mil thickness carbon foils.

The 7<sup>th</sup> foil rate here is limited by the transportation package in simulation.

We can lower P0 to 1.0 GeV for HMS if necessary.

Rates here are without sieve, all SC bars are on.

# Angle and Ytar Calibration, 35 degrees

=====Full acceptance: Inelastic + Elastic =====

Detector= HMS Optics, Beam\_current= 30 uA, Angle= 35 deg

Det	Target	BeamE	Current	DetP0	DetAngle	VZ(cm)	Thick(cm)	Lumi(10^33)	InteXS(pb)	Rate(Hz)
HMS	C12_0	10.5000	30.00	1.500	35.00	-20.00	0.0254	540.65	0.00	0.00
HMS	C12_1	10.5000	30.00	1.500	35.00	-13.33	0.0254	540.65	6.20	3.35
HMS	C12_2	10.5000	30.00	1.500	35.00	-6.67	0.0254	540.65	8.96	4.84
HMS	C12_3	10.5000	30.00	1.500	35.00	0.00	0.0254	540.65	10.38	5.61
HMS	C12_4	10.5000	30.00	1.500	35.00	6.67	0.0254	540.65	6.68	3.61
HMS	C12_5	10.5000	30.00	1.500	35.00	13.33	0.0254	540.65	2.68	1.45
HMS	C12_6	10.5000	30.00	1.500	35.00	20.00	0.0254	540.65	0.00	0.00
HMS	C12_3N5	10.5000	30.00	1.500	35.00	0.00	0.0508	1081.29	6.53	7.06
HMS	C12_A11	10.5000	30.00	1.500	35.00	0.00	0.1778	3784.53	4.99	18.87

=====Full acceptance: Inelastic + Elastic =====

Detector= SHMS Optics, Beam\_current= 30 uA, Angle= 35 deg

Det	Target	BeamE	Current	DetP0	DetAngle	VZ(cm)	Thick(cm)	Lumi(10^33)	InteXS(pb)	Rate(Hz)
SHMS	C12_0	10.5000	30.00	1.800	35.00	-20.00	0.0254	540.65	0.00	0.00
SHMS	C12_1	10.5000	30.00	1.800	35.00	-13.33	0.0254	540.65	11.30	6.11
SHMS	C12_2	10.5000	30.00	1.800	35.00	-6.67	0.0254	540.65	10.87	5.88
SHMS	C12_3	10.5000	30.00	1.800	35.00	0.00	0.0254	540.65	10.02	5.42
SHMS	C12_4	10.5000	30.00	1.800	35.00	6.67	0.0254	540.65	8.56	4.63
SHMS	C12_5	10.5000	30.00	1.800	35.00	13.33	0.0254	540.65	3.00	1.62
SHMS	C12_6	10.5000	30.00	1.800	35.00	20.00	0.0254	540.65	0.00	0.00
SHMS	C12_3N5	10.5000	30.00	1.800	35.00	0.00	0.0508	1081.29	6.51	7.04
SHMS	C12_A11	10.5000	30.00	1.800	35.00	0.00	0.1778	3784.53	6.25	23.65

Rates are very low, we need 100 mil thickness carbon foils.

The 1<sup>st</sup> and 7<sup>th</sup> foil rates here are limited by the transportation package in simulation.

Rates here are without sieve, all SC bars are on.

# Beam Time for Angle and Ytar Calibration

=====Suggested beam Current and time to get 100 events in center sieve hole=====

=====Full acceptance=====

Det	Target	Beam	Angle	Momentum	Current	Prescale	DAQRate	GoodRate	SieveRate	CenterHoleRate	BeamTime (m)
HMS	C12_1Foil	10.500	30.0	1.500	30.00	1	12.07	12.07	0.5757	0.0037	445.4
SHMS	C12_1Foil	10.500	30.0	1.800	30.00	1	14.26	14.26	0.9426	0.0045	368.4
HMS	C12_2Foil	10.500	30.0	1.500	30.00	1	16.38	16.38	0.7813	0.0051	328.2
SHMS	C12_2Foil	10.500	30.0	1.800	30.00	1	20.74	20.74	1.3709	0.0066	253.3
HMS	C12_7Foil	10.500	30.0	1.500	30.00	1	46.76	46.76	2.2305	0.0145	115.0
SHMS	C12_7Foil	10.500	30.0	1.800	30.00	1	75.03	75.03	4.9595	0.0238	70.0

=====Full acceptance=====

Det	Target	Beam	Angle	Momentum	Current	Prescale	DAQRate	GoodRate	SieveRate	CenterHoleRate	BeamTime (m)
HMS	C12_1Foil	10.500	35.0	1.500	30.00	1	5.61	5.61	0.2676	0.0017	958.2
SHMS	C12_1Foil	10.500	35.0	1.800	30.00	1	5.42	5.42	0.3583	0.0017	969.2
HMS	C12_2Foil	10.500	35.0	1.500	30.00	1	7.06	7.06	0.3368	0.0022	761.4
SHMS	C12_2Foil	10.500	35.0	1.800	30.00	1	7.04	7.04	0.4653	0.0022	746.2
HMS	C12_7Foil	10.500	35.0	1.500	30.00	1	18.87	18.87	0.9001	0.0059	284.9
SHMS	C12_7Foil	10.500	35.0	1.800	30.00	1	23.65	23.65	1.5633	0.0075	222.1

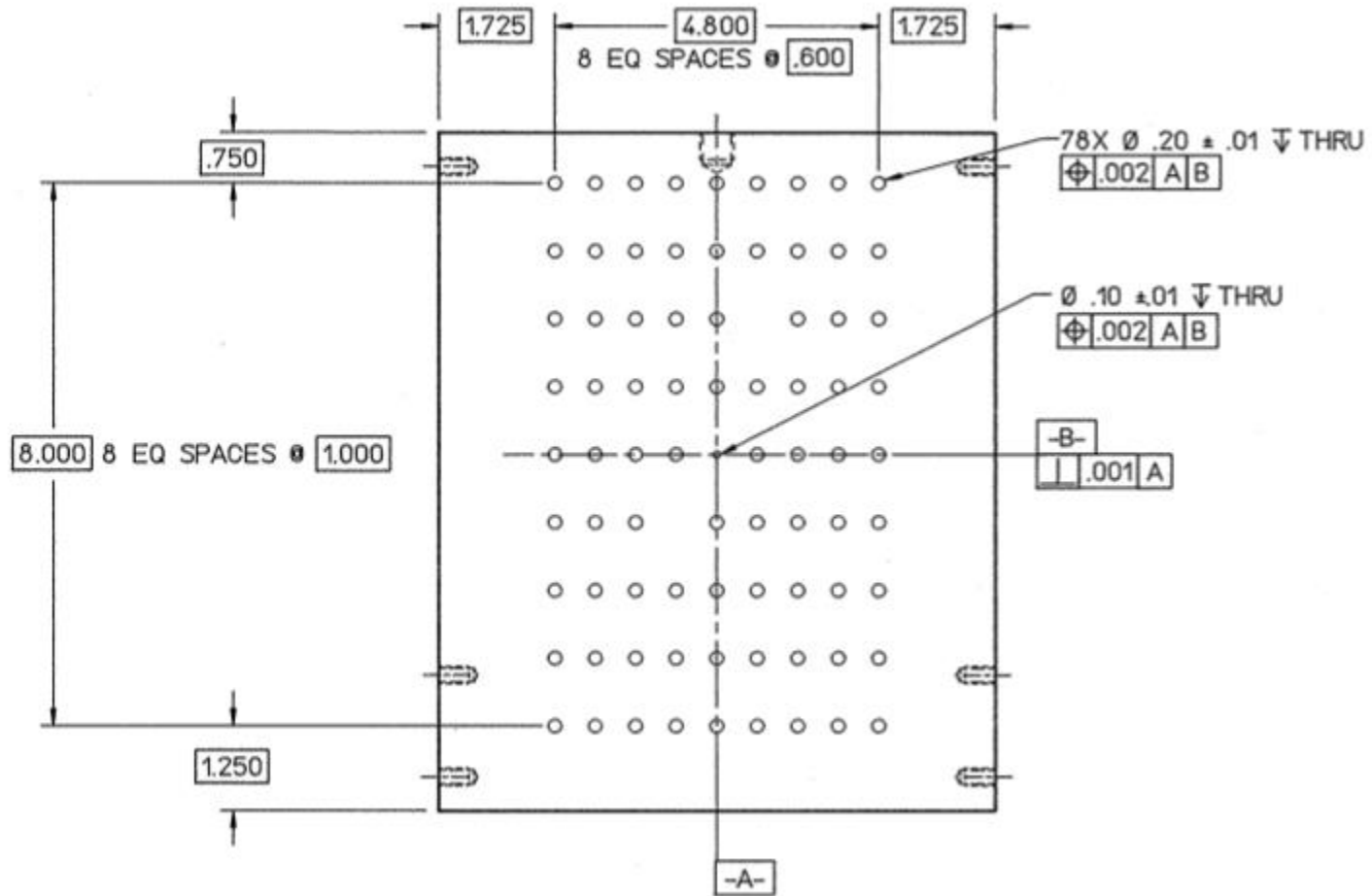
Suggest to use only 7-foil target.

Suggest to increase the carbon foil thickness from 10 mil to 100 mil.

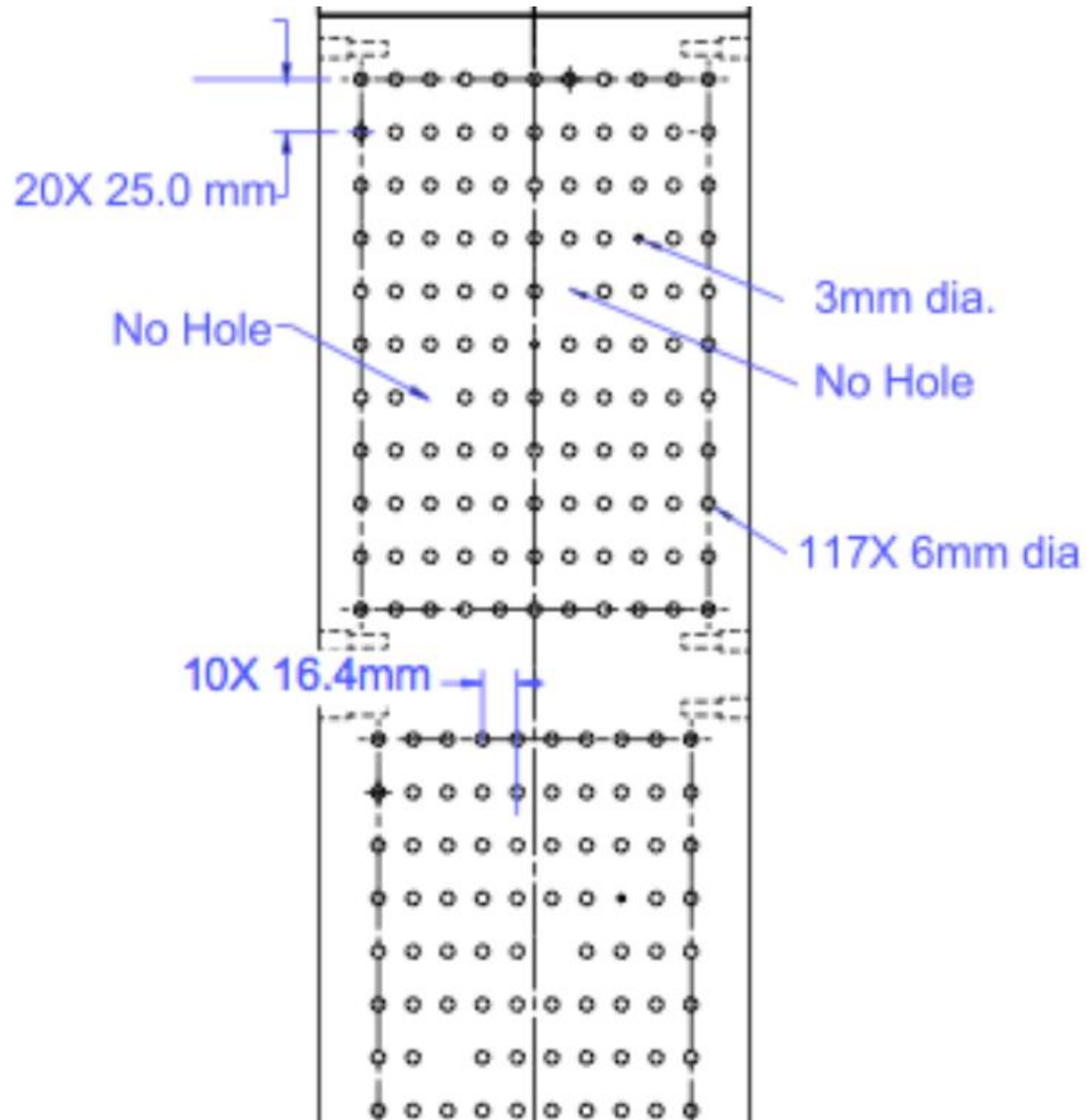
Suggest to have 100 events in center sieve hole from center foil since this is a brand NEW optics.

Prefer to do this with 35 degrees angle to cover wider Ytar, but also need to compromise with rates. (Or we can set 1<sup>st</sup> and 7<sup>th</sup> foil to +/-22.0 cm).

# HMS Sieve Drawing



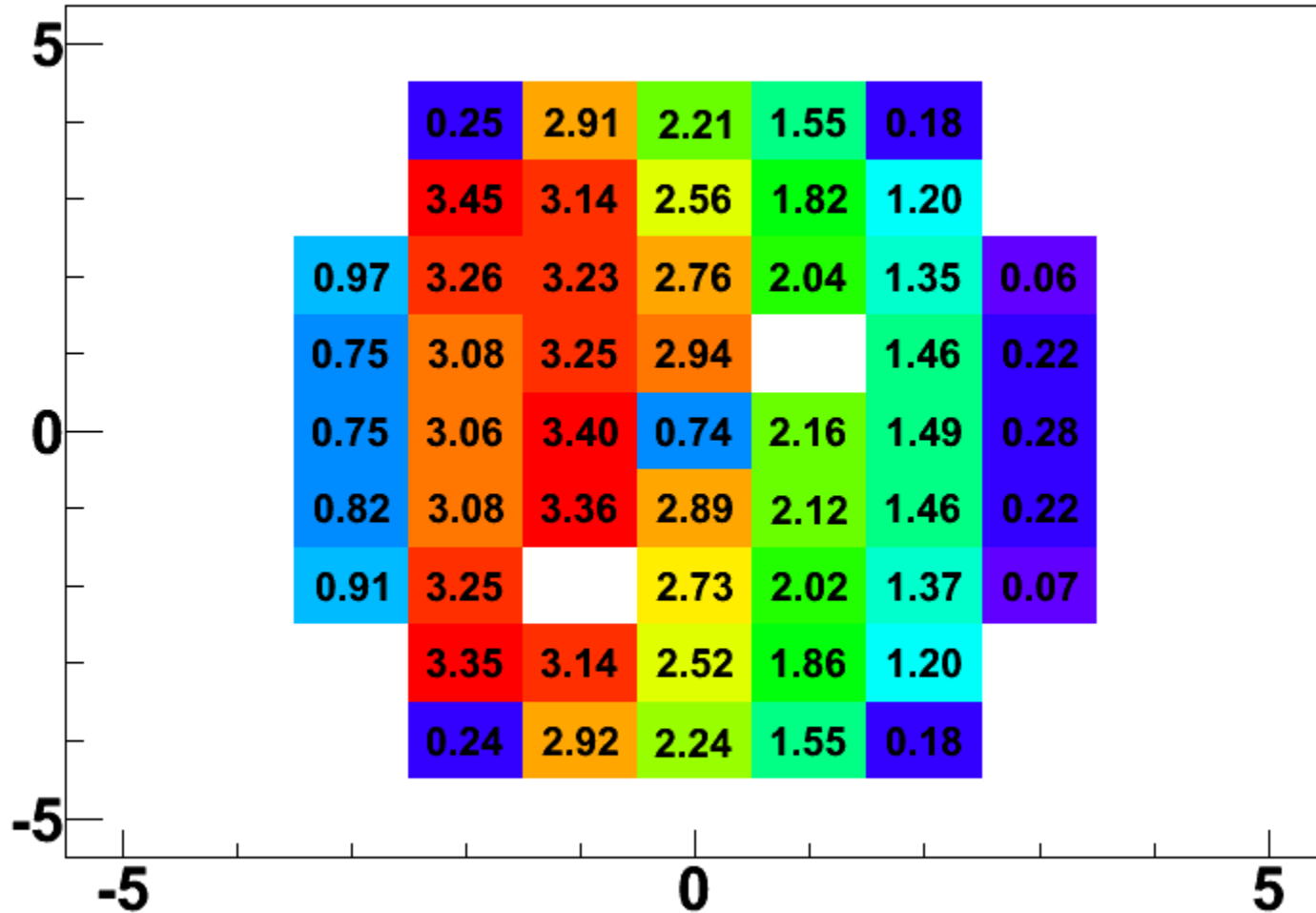
# SHMS Sieve Drawing





# HMS Sieve Slit Rates: 2.1 GeV, 11.7deg

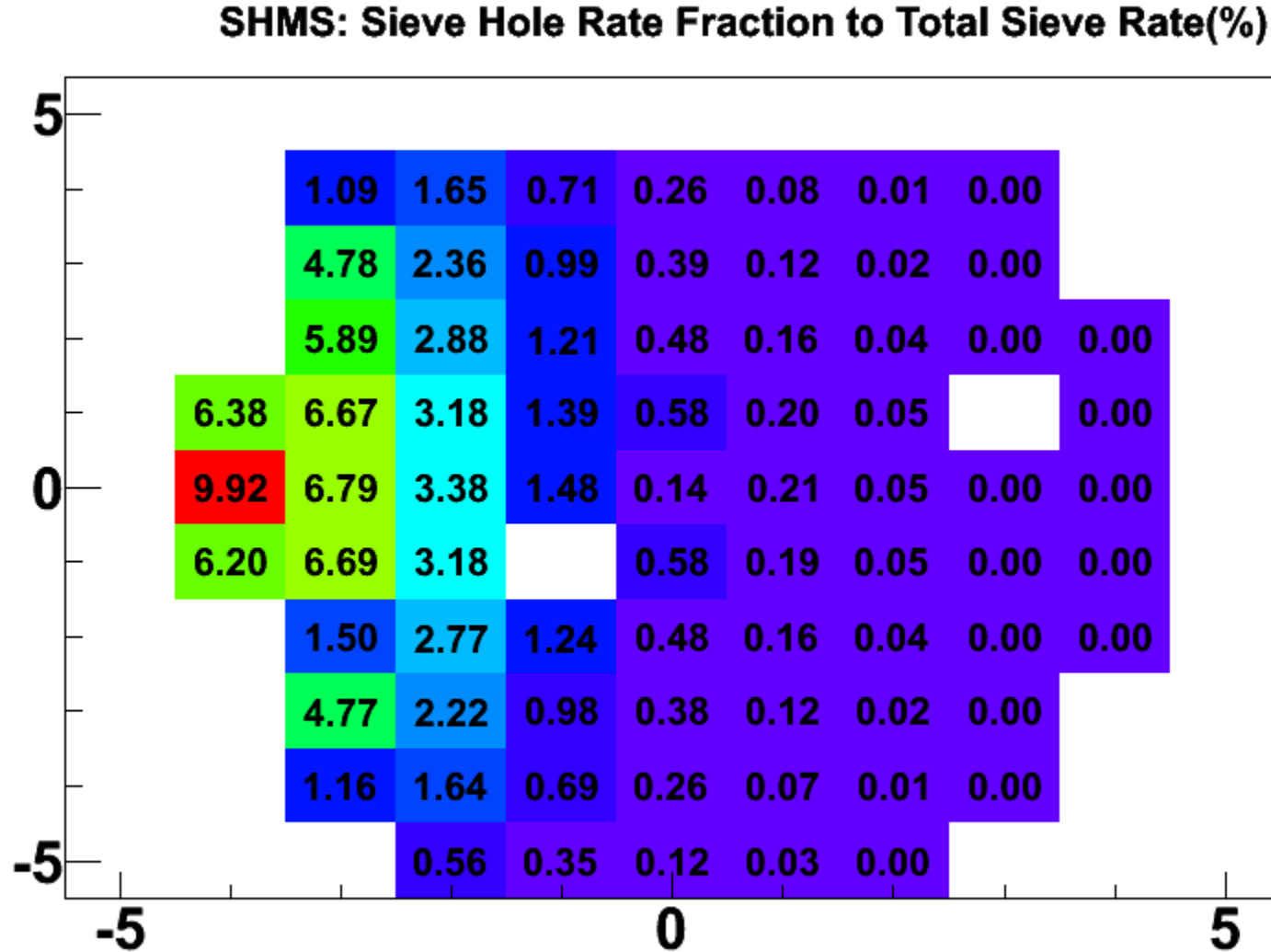
HMS: Sieve Hole Rate Fraction to Total Sieve Rate(%)



E=2.1 GeV, theta= 11.7degrees, P0=2.068, Single C12 foil  
with sieve, HMS carbon elastic total rate drops to only **4.6%** of that without sieve.



# SHMS Sieve Slit Rates: 2.1 GeV, 8.5deg



E=2.1 GeV, theta= 8.5degrees, P0=2.083, Single C12 foil

with sieve, SHMS carbon elastic total rate drops to only **6.2%** of that without sieve.