06/28/2022

Put all together in one place:

1. Summary of optimization
2. Rate-estimation using the acceptance cut
   - Rate-estimation table for all targets both MF and SRC
   - Run plan with the most updated target information
3. Rate-estimation using the collimator compare to acceptance cut

07/01/2022:

Adding rate calculation and run plan for MF in the table.

Summary of the optimization step: it is reported on 02/18/2022

CAFe Report update: 02/18/2022

Step1: Re-optimize to determine kinematic for Ebeam = 10.6 GeV

Step2: Rate calculation for optimized kinematic from step 1

Step3: Run plan

Dien, Carlos, Holly, Florian

Step1: Re-optimize to determine kinematic for Ebeam = 10.6 GeV

PAC45: kinematic setting (For reference)

E_{Beam} GeV	E'_e GeV	θ_e	$\lvert \mathbf{p}_p \rvert$ GeV/c	θ_p	p_{miss} GeV/c	Q^2 GeV^2
11	9.85	8.0°	1.43	63.0°	0.40	2.1
11	9.85	8.0°	2.01	44.5°	0.15	1.8

Need to reoptimize to determine new kinematic for

1. Ebeam = 10.6 GeV

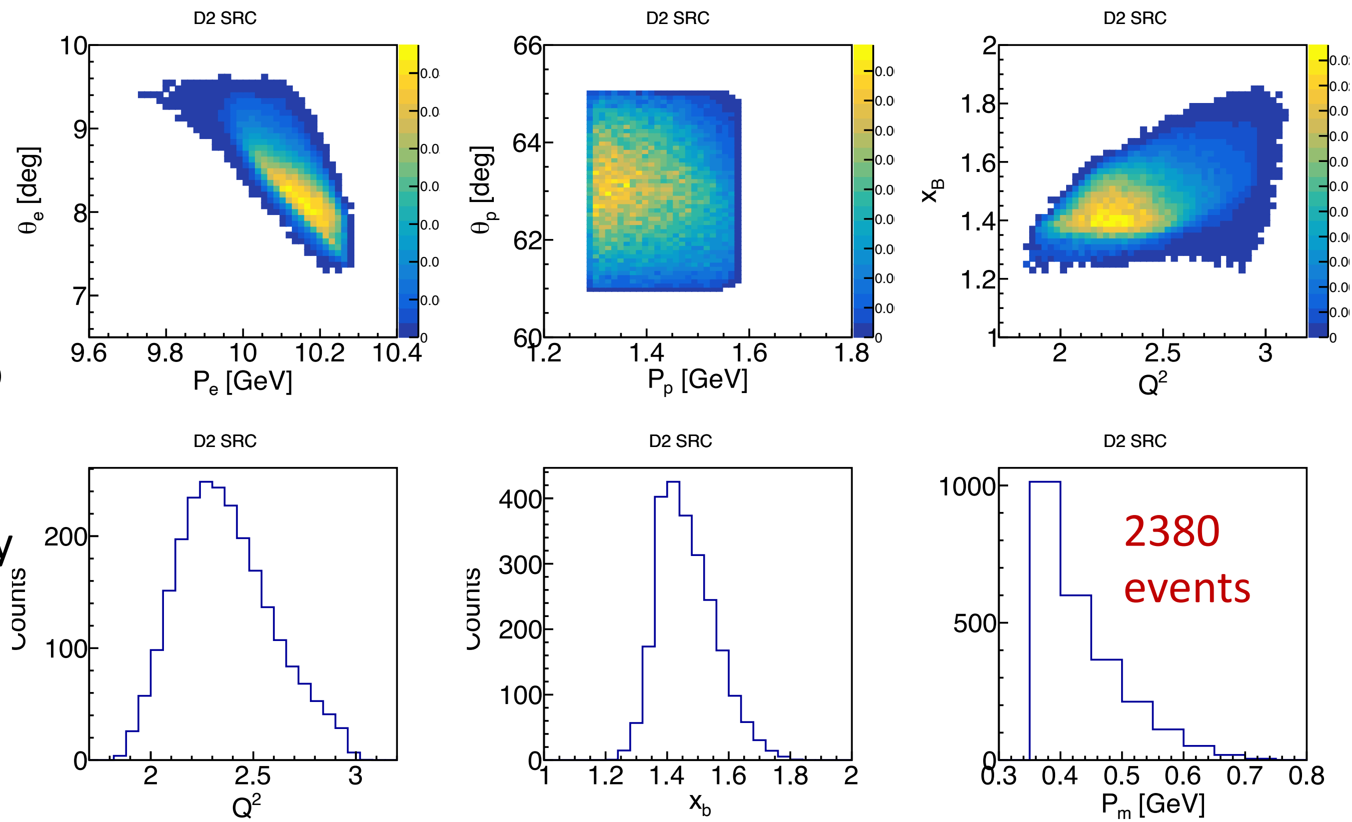
2. Pe = 8.55 GeV (For the best available optics matrix)

STEP0: Checking the rate calculation using D2 with PAC45 kinematic

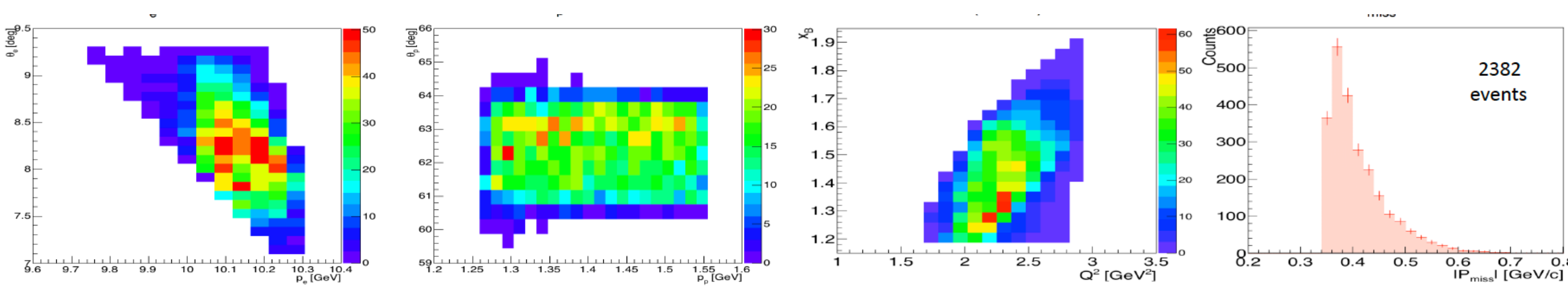
Using the same cuts, Lum, charge

Note:

- The shoulder in the xb distribution is due to the radiative effect.
- Can be solved by apply the cut Em < 50 MeV
- Em = omega – Tp - Tn



Rey and Florian report for PAC45 proposal on D2:



Step1: Re-optimize to determine kinematic for Ebeam = 10.6 GeV

Simulation parameters for optimization step:

Low Pm (MF): Using C12

E0 = 10.6 GeV
P_e_cen = 8.55 GeV
Th_e_cen = 8.3^{o}
P_p_cen = 1.8 GeV
Th_p_cen = 61^{o}

High Pm (SRC): Using D2

E0 = 10.6 GeV
P_e_cen = 8.55 GeV
Th_e_cen = 8.3^{o}
P_p_cen = 1.8 GeV
Th_p_cen = 53^{o}

Generating with open NO callorimator, wide Proton acceptance, RC on

-15% < $\delta_e < 25\%$
-40 < e_ytar < 40 mrad (Horizontal)
-60 < e_xtar < 60 mrad (Vertical)

-40% < $\delta_p < 40\%$
-250 < p_ytar < 250 mrad
-250 < p_xtar < 250 mrad

Selection cuts for optimization:

MF cuts:

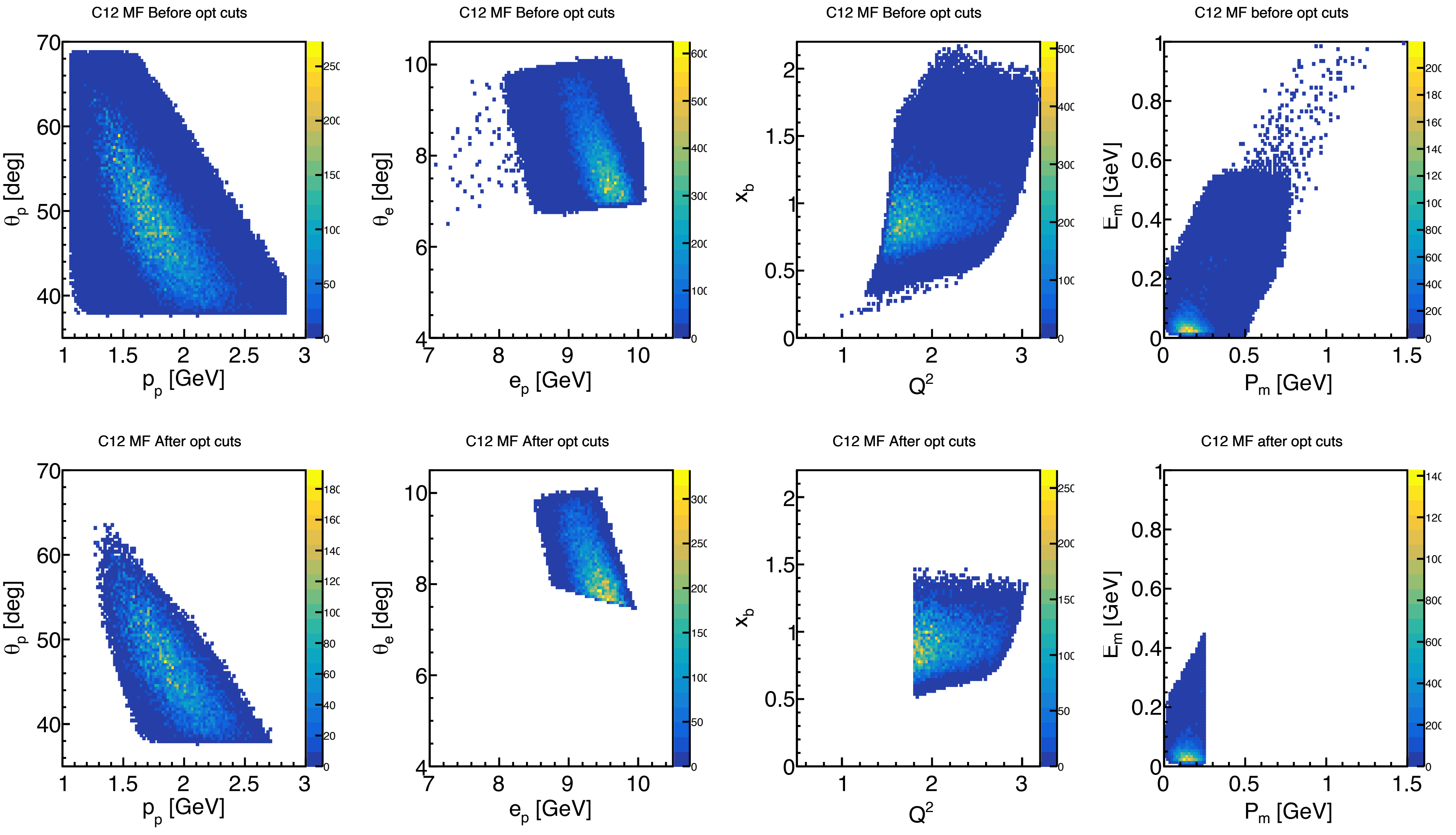
$Q^2 > 1.8$,
$P_m < 0.25$ GeV

SRC cuts:

$Q^2 > 1.8$,
$\theta_{rq} < 50^o$
$P_m > 0.35$ GeV
Xb > 1.2

Step1: Re-optimize to determine kinematic for Ebeam = 10.6 GeV

MF using C12 distribution with and W/o optimization cuts



Step1: Re-optimize to determine kinematic for Ebeam = 10.6 GeV

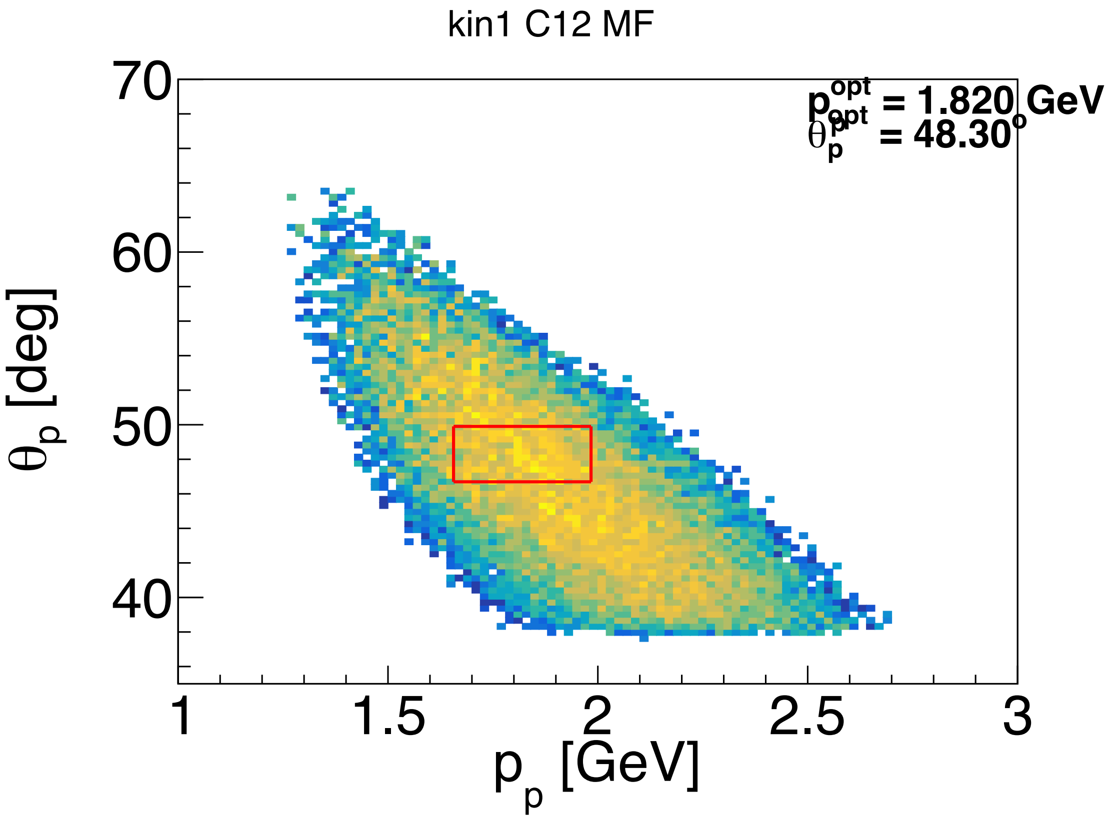
MF using C12: Proton arm Optimization

Red-box is defined as:

Optimization window side:

$\delta_p = \pm 9\%, \ \theta_p = \ \pm 28\, mrad$

Optimized kinematic is determined by the red-box with the largest count



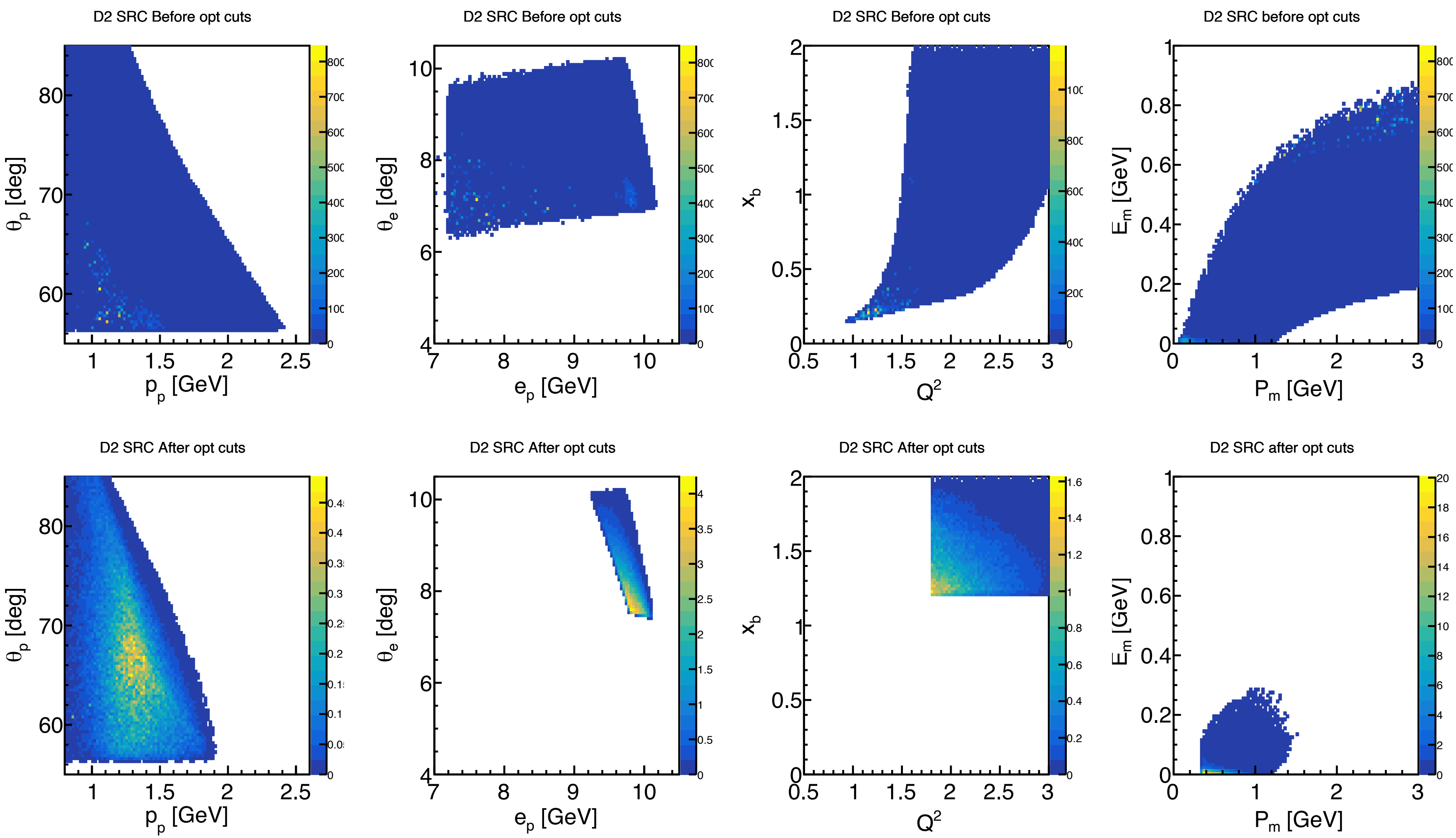
Results:

$\theta_p = 48.3^o$

Pp = 1.82 GeV

Step1: Re-optimize to determine kinematic for Ebeam = 10.6 GeV

SRC using D2 distribution with and W/o optimization cuts



Step1: Re-optimize to determine kinematic for Ebeam = 10.6 GeV

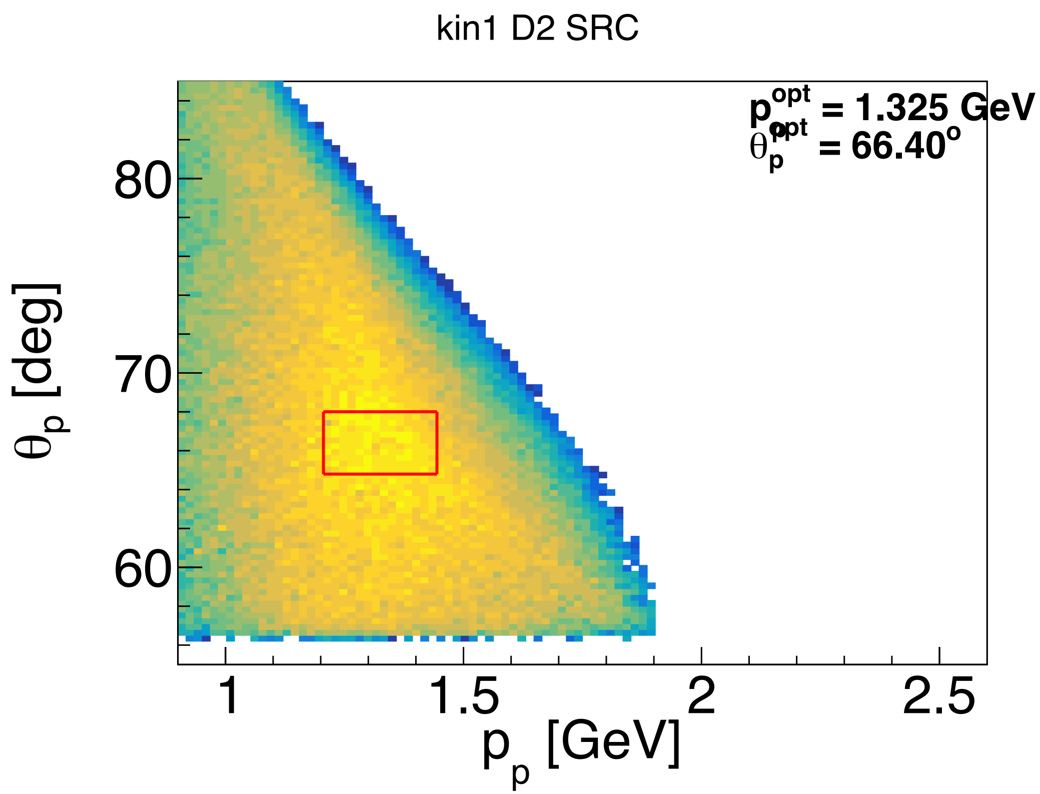
SRC using D22: Proton arm Optimization

Red-box is defined as:

Optimization window side:

$\delta_p = \pm 9\%,\ \theta_p = \pm 28\, mrad$

Optimized kinematic is determined by the red-box with the largest count



Results:

$\theta_p = 66.4^o$

Pp = 1.325 GeV

Step1: Re-optimize to determine kinematic for Ebeam = 10.6 GeV

PAC45: kinematic setting (For reference)

E_{Beam} GeV	E'_e GeV	θ_e	$\lvert\mathbf{p}_p\rvert$ GeV/c	θ_p	p_{miss} GeV/c	Q^2 GeV^2
11	9.85	8.0°	1.43	63.0°	0.40	2.1
11	9.85	8.0°	2.01	44.5°	0.15	1.8

New optimized kinematic settings:

Ebeam (GeV)	E' (GeV)	θ_e Degree	$\lvert P_p\rvert$ GeV	θ_p Degree	Pm GeV	Q2_center	<Q2> GeV2
10.6	8.55	8.3	1.325	66.4	0.4	2.1	
10.6	8.55	8.3	1.820	48.3	0.15	2.1	

Step2: Rate calculation for New optimized kinematics

- Charge: 1152 mC (one 8-hour shift for 40 uA beam current)
- Area density = 1 g/cm2
- Collimator in, RC on

SHMS (electron) acceptance cuts:

1) $-10 < \delta_e < 22$ %
2) $-0.040 < \theta_e < 0.040$ rad
3) $-0.024 < \phi_e < 0.024$ rad

HMS (proton) acceptance cuts:

1) $-10 < \delta_p < 10$ %
2) $-0.060 < \theta_p < 0.060$ rad
3) $-0.035 < \phi_p < 0.035$ rad

Convention: In-plane = yptar (MC) = ϕ (Horizontal)
Out-plane = xptar (MC) = θ (Vertical)

MF cuts:

Pm < 0.25 GeV/c
Q2 > 1.8

SRC cuts:

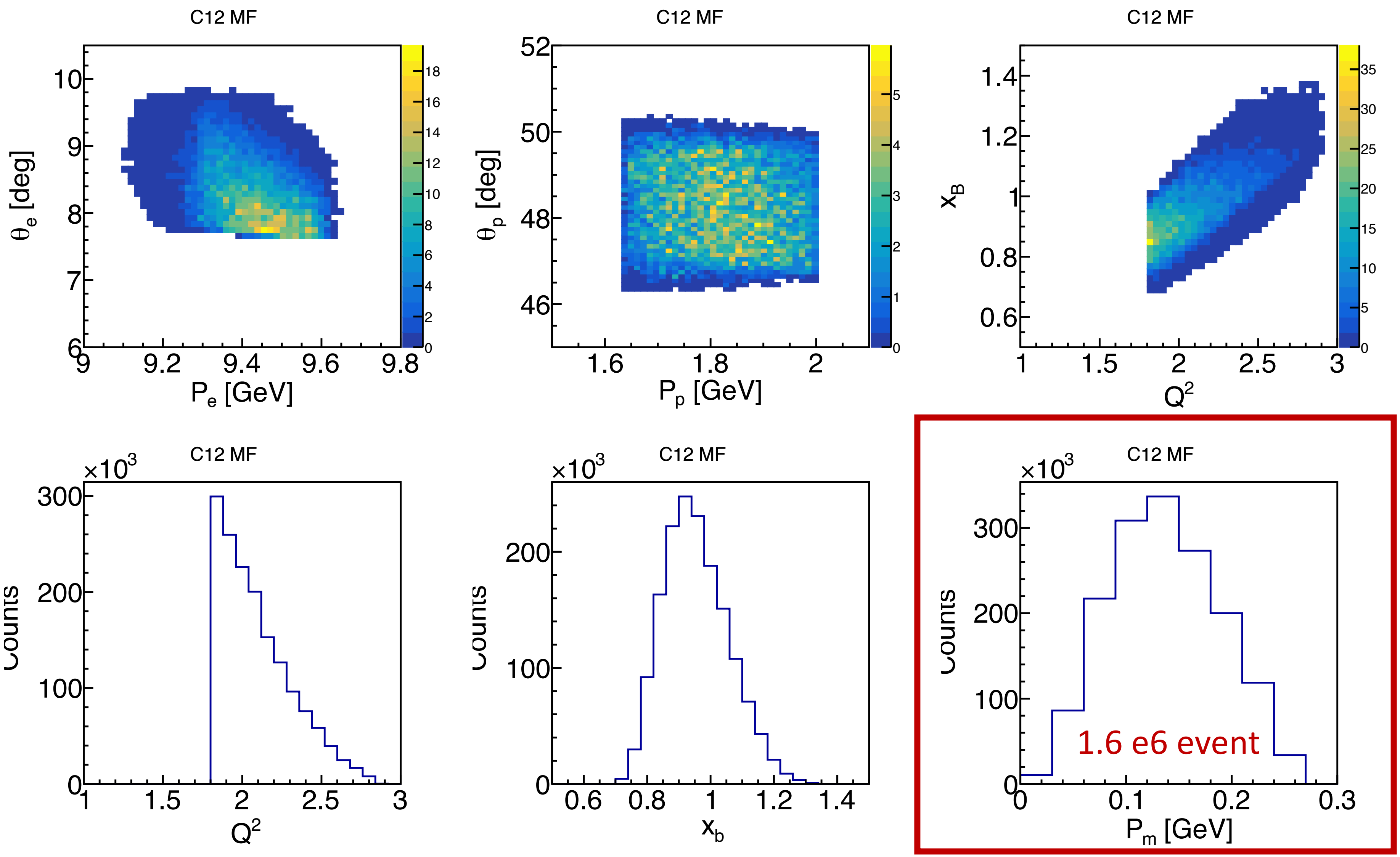
Q2 > 1.8
Pm > 0.35 GeV/c
Xb > 1.2
Theta_rq < 40
Em < 0.05 GeV (cut RC tail)

NOTE:

These cuts are the same as PAC44 proposal, the PAC45 have typo in the cut on table II in case you get confused

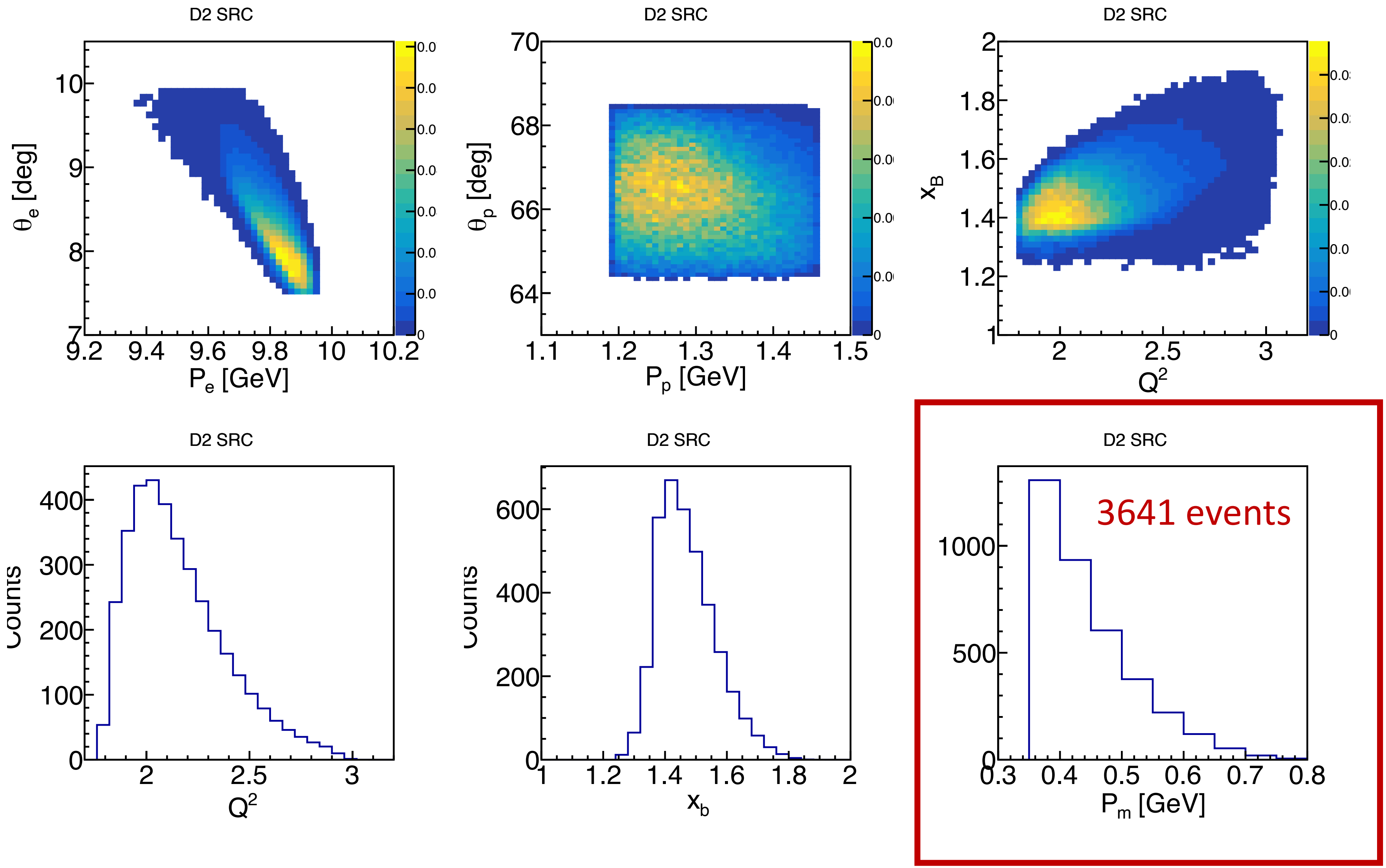
Step2: Rate calculation for New optimized kinematics

MF using C12: Rate estimation



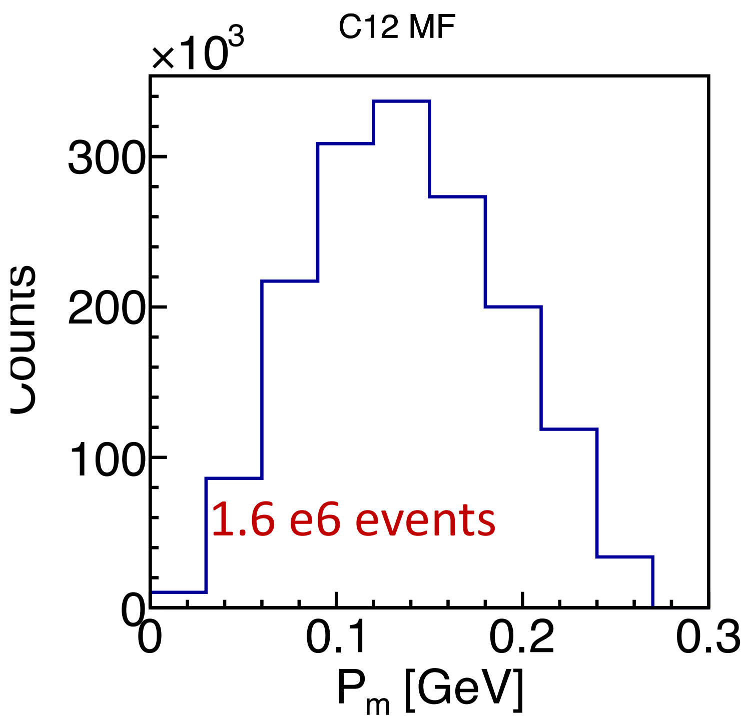
Step2: Rate calculation for New optimized kinematics

SRC using D2: Rate estimation

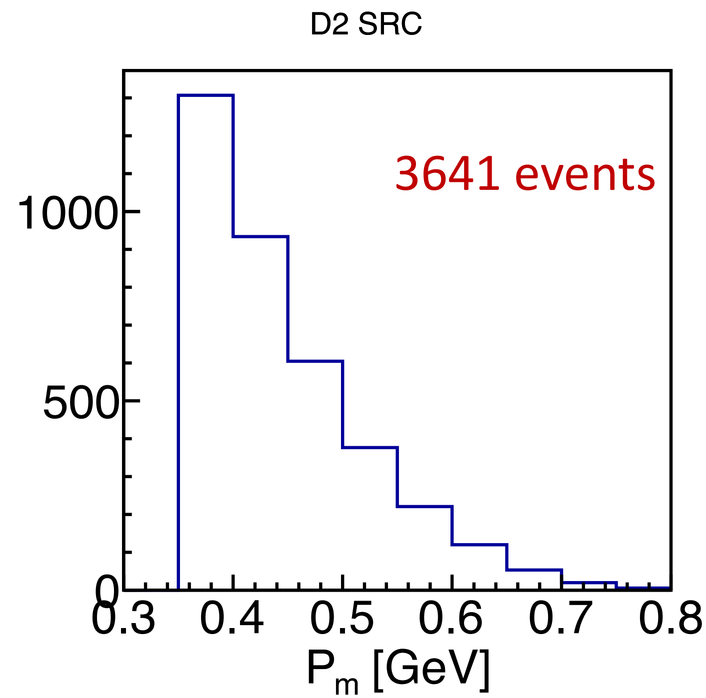


Step2: Rate calculation for New optimized kinematics

MF using C12: Rate estimation



SRC using D2: Rate estimation



NOTE:

This number of events are for C12 (MF) and D2 (SRC) corresponding to:

- Charge = 1152 mC (8 PAC hours of 40 uA beam)
- Target area density: 1 g/cm2
- Transparency factor (TF): C12 (0.56) and D2 (1.0)

Step3: Run plan

MF & SRC event count for each target have to:

- Scale to transparency factors for different target (TF)
- Scale to corresponding target areal density (Den)
- Scale to corresponding maximum current (Cur)
- Scale down to factor of 2 for conservative rate estimation (2)
- Only For SRC: scale to a2 factor A/D2 (a2)

Conservative estimation

#event_A_SRC = #event_D2_SRC (3641) * TF * Den * Cur *a2 /2

Note: Proposal 45 apply additional factor:

Hall A simulation D2 => #C12_SRC_MC =#D2_SRC *TF *Den *Cur * a2/2
Hall A Data C12 => #C12_SRC_data

Additional factor = #C12_SRC_data/#C12_SRC_MC ~ 2.5

=> Optimistic run plan will include this additional factor

Step3: Run plan

This is the most updated target information from Meekin on 05/18/2022

Target information used in calculation

Target	Max current (uA)	Areal Density (g/cm2)
D2	80	1.67
Ca40	80	0.8
Ca48	80	0.8
Fe54	80	0.4152
C12	80	0.5244
Be9	80	0.978
B10	80	0.5722
B11	80	0.6344

Rate-estimation tables summary using acceptance cuts

SRC										
Targets	a2	transparency	l	areal density	a2 ratio	trans ratio	l ratio	areal density		events
				g/cm2	to d	to d	to d	to d	total ratio	in 8h
d in simulations			40	1						3641
d	1	0.9	80	1.67	1	1.00	1.00	1	1	**6080**
Ca-40	4.5	0.4	80	0.8	4.5	0.44	1.00	0.48	0.96	5825
Ca-48	4.5	0.4	80	0.8	4.5	0.44	1.00	0.48	0.96	5825
Be-9	3.9	0.6	80	0.978	3.9	0.67	1.00	0.59	1.52	9257
B-10	4	0.6	80	0.572	4	0.67	1.00	0.34	0.91	5553
B-11	4	0.6	80	0.634	4	0.67	1.00	0.38	1.01	6155
C-12	4.5	0.6	80	0.524	4.5	0.67	1.00	0.31	0.94	5723
Fe-54	5.2	0.4	80	0.4152	5.2	0.44	1.00	0.25	0.57	3493

MF										
Targets	a2	transparency	l	areal density	a2 ratio	trans ratio	l ratio	areal density		events
				g/cm2	to C	to C	to C	to C	total ratio	in 8h
C12 from simulations			40	1						1600000
C-12	4.5	0.6	80	0.524		1.00	1.00	1.00	1.00	**838400**
Fe-54	5.2	0.4	80	0.4125		0.67	1.00	0.79	0.52	440000
Ca-40	4.5	0.4	80	0.8		0.67	1.00	1.53	1.02	853333
Ca-48	4.5	0.4	80	0.8		0.67	1.00	1.53	1.02	853333
d	1	0.9	80	1.67		1.50	1.00	3.19	4.78	4008000
Be-9	3.9	0.6	80	0.978		1.00	1.00	1.87	1.87	1564800
B-10	4	0.6	80	0.572		1.00	1.00	1.09	1.09	915200
B-11	4	0.6	80	0.634		1.00	1.00	1.21	1.21	1014400

Updated Run plan (07/01/2022)

- Beam setup/checkout/MF kinematics 5h PAC
- Calibration (BCM, boiling?, Optics, hydrogen?) 4h PAC
- SRC kinematics (HMS move and magnet change) 2h PAC
- SRC kinematics checkout 3h PAC
- Overall target changes (MF and SRC) 2.5 PAC

Com + Calib Time
16.5 PAC hours

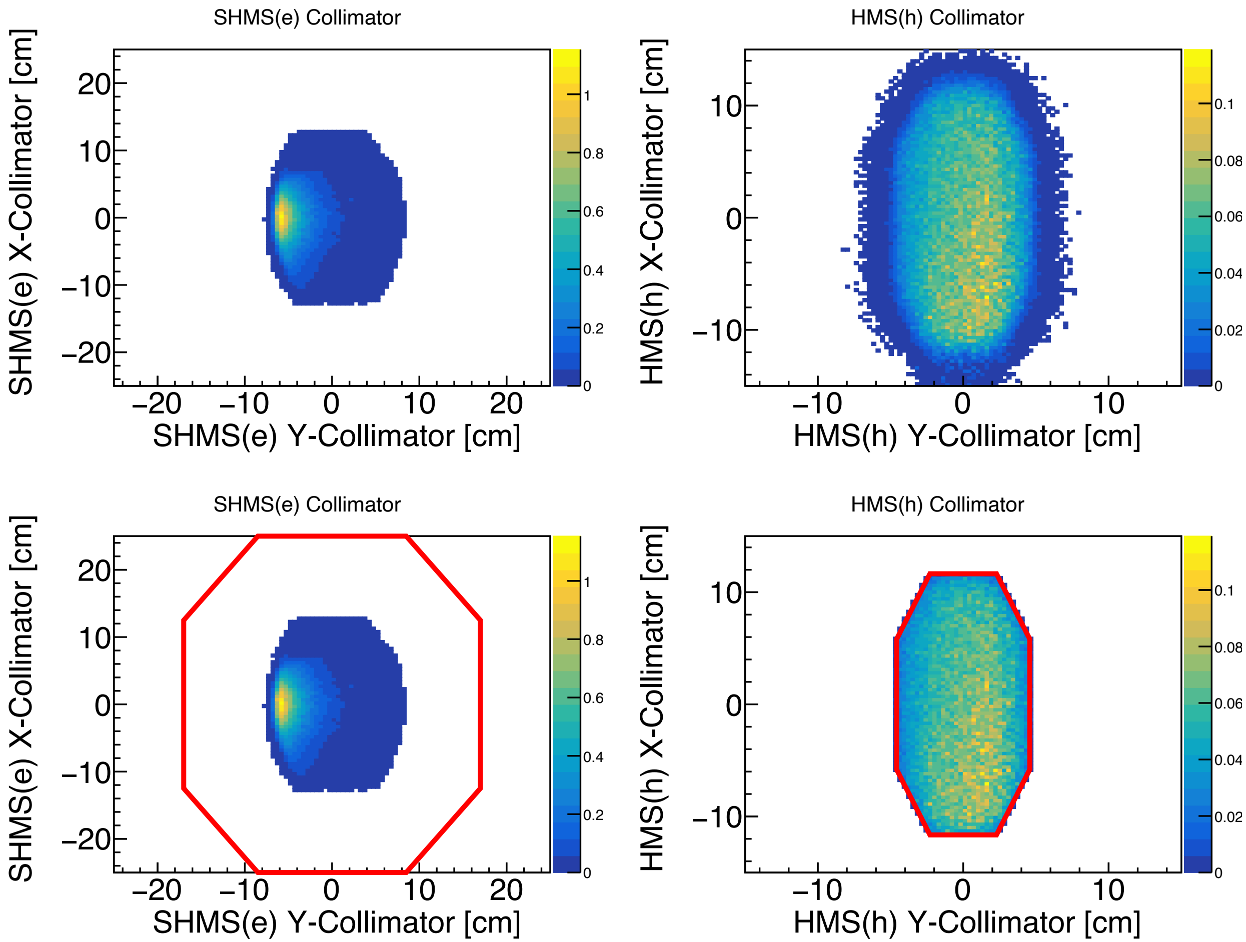
+ MF data taking
4.5 PAC hours

Run plan (PAC hour): SRC data taking (75 PAC hours)

Target	Run Hour SRC (PAC hour)	Number of event (SRC)	Run hour MF (PAC hour)	Number of event (MF)
D2	7	5.3k	0.5	250k
C12	7	5.0k	0.5	52k
Ca48	12	8.7k	0.5	53k
Ca40	12	8.7k	0.5	53k
Fe54	20	8.7k	1.0	55k
Be9	4	4.6k	0.5	98k
B10	6.5	4.5k	0.5	57k
B11	6.5	5.0k	0.5	63k

TOTAL: 16.5 + 4.5 + 75 = 96 PAC hours = 4 PAC days

Using the Collimator cuts instead of acceptance cuts to see the difference



Note: We may want to use this collimator cuts in real analysis. Need to check how big the effect of this cut.

SRC rate in comparison:

Acc-cut & Q2 > 1.8 & xb >1.2 & Em < 0.05 & Pm > 0.35 #3641

Acc-cut & Q2 > 1.8 & xb >1.2 & Em < 0.05 & 0.7 > Pm> 0.35 #3615

Acc-cut & Q2 > 1.8 & xb >1.2 & Em < 0.05 & Pm> 0.35 & **Coll-cut** #3516

Acc-cut & Q2 > 1.8 & xb >1.2 & Em < 0.05 & 0.7 > Pm> 0.35 & **Coll-cut** #3492

This number of events are for C12 (MF) and D2 (SRC) corresponding to:

- Charge = 1152 mC (8 PAC hours of 40 uA beam)
- Target area density: 1 g/cm2
- Transparency factor (TF): C12 (0.56) and D2 (1.0)

Conclusion:

- The upper limit cut on Pm = 0.7 GeV has a very small effect
- Coll-cut cuts off 4% of events more than w/o coll-cut