Optics Commissioning Plan for G2P and GEP

Modofied based on real data taking procedure

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Estimated Change-Over-Time

- **30 minutes to drain liquid helium** below the C12 target by target expert or 60 minutes by target operator. **80 minutes to refill** by target experts.
- Assuming turning ON/OFF rasters and changing targets are quick enough to ignore the overhead time
- **35 minutes to change RHRS dipole**, 5 minutes to change LHRS dipole
- **5 minutes to change beam position** by MCC
- **30 minutes to change the sieve slit**
- **Estmated data taking time for beam goes to the Hall A dump based on sim.:**

  100nA 2.257 GeV beam, sieve in:

  2 minutes to take 20k data with 40mil C12, 8 minutes to take 50k data with 100 mil CH2. (G2P, GEP and logitudianl setting are almost have the same data rate because the tilted beam will compensate the effect from the field.)

  For lower beam energy it will be even shorter but I will use the same amount of time in the estimation.
- **Estimated data taking time for beam goes to the local dump based on sim.:**

  5T|90 deg target field and 100nA 2.257 GeV beam.

  10 minutes to take 20k data with 100mil C12, 25 minutes to take 50k data with 100 mil CH2.

Real Data Taking Time

100nA 2.253 GeV beam, sieve in:

1. 40 mil C12 with LHe, delta=0%, T1_rates=2.5kHz, T3_rates=3.1kHz.

   It takes 7 minutes to take 1M raw data, which contains about 35% of elastic data, but only 20% from C12.

➔ 7 minutes to get 200k C12 elastic data

2. 40 mil C12 with Lhe, delta=-4%, T1_rates=1.6kHz, T3_rates=1.5kHz.

   It takes 11 minutes to take 1M raw data. which contains about 35% of elastic data, only 16% of it from C12.

➔ 13 minutes to get 200k C12 elastic data

3. 100 mil CH2 with Lhe, delta=0%, T1_rates=2kHz, T3_rates=2.5kHz.

   It takes 9 minutes to take 1M raw data. which contains about 5% of C12 elastic data, only 2% of quasi-elastic data.

➔ 36 minutes to get 200k C12 elastic data

4. Estimation: for 5T|90deg target field situation:

   100 mil C12, delta=0%, 40 minutes to get 200k C12 elastic data

   100 mil C12, delta=-4%, 70 minutes to get 200k C12 elastic data

   100 mil CH2 with Lhe, delta=0%, 180 minutes to get 200k C12 elastic data

In delta scan, +/-4% and +/-3% will have lower rates. It usually takes twice the time of that for 0%.

Preparation

- Finished VDC T0 calibration, update DB. Done!
- Using snake, set an initial matrix for recostruction, whith help from John and Ole. Will be ready by March 1st.
- Set quardropoles initial parameters into control. With help from John and Javier. Will be ready by March 1st.
- Set septum “B vs I” function into control. With help from Jack and Javier, will be ready by March 1st.
- Using straight through 100nA 2.257 GeV beam, sieve IN and rasters(slow&fast) OFF, 40 mil C12 target in cell 3, do the following:

1. For 2.257 GeV beam energy, set dipole (HRS central momentum) at 2.254 GeV (dp=0%, elastic) 35min
2. Tune quadrupoles at right currents (detailed numbers and procetrue will be provided) 95min
3. Set septa current accordingly (detailed numbers will be provided), tune the current to get y_fp&phi_fp of sieve central hole rays to be zero 120min

Cross Section Calibration

- 2.5T|90deg target field, 100nA 2.257 GeV beam

  100 mil C12 in the 6th cell. Sieve OUT, Take 3 kenimatics settings: W=1.38, 1.42, 1.46 GeV.

  Take 2 runs (15 minutes each run) for each of the following:

  fast raster on + slow raster on

  fast raster on + slow raster off

  fast raster off + slow raster off

Estimated time: (20min x 2 + 20min(change dipole)) x 3 = 180 min.

Do this during taking production data.

Standard Optics @ 2.257 GeV

Straight through beam(no target field), 2.257 GeV, 100nA

- Sieve **OUT**, 40 mil **C12 target at the 3rd cell (count from the top).** We want to drain the liquid helium below the C12 target. Since there is no level meter inside the target incert, we have to take data during draining the liquid helium. We can use the event rates changes to tell if the LHe level is low enough to expose C12 foil.

  Estimated time: 30 min

- Calibration for full acceptance:

  40 mil C12 in the 6th cell(count from the top). Sieve **OUT**, dp=0%(2.254 GeV), take 2 runs (8 min each run) for each of the following:

  fast raster on + slow raster on

  fast raster on + slow raster off

  fast raster off + slow raster off

  Estimated time: 8min x 2 x 3 = 48 min.

Standard Optics @ 2.257 GeV(cont.)

Rasters off, no target field, 100nA 2.257 GeV beam.

Move Sieve **IN**, *Estimated time: 30min(change sieve)*

- 1. Delta scan:

  40mil C12 in 3rd cell. Change delta (delta=(Phrs-P)/Phrs)) to the following values and take 20k good elastic sieve data each (need to find out how many raw data events):

  LHRS: -4%(2.344), -3%(2.322), -2%(2.299), -1%(2.277), 0% (2.254), 1%(2.231), 2%(2.209), 3%(2.186), 4%(2.164)

  R-HRS: -4%, -3.5%(2.333), -2%, 0%, 2%, 3.5%(2.175) (takes longer time to get dipole ready. **Try +/-4% for 30 minutes, will decide if we can do +/-4% in other delta scan**). *Estimated time: (20min(data) + 35min(change over)) x 5 + 100min(try +/-4% in RHRS) = 375 min*

- 2. Beam position cross scan:

  Set dp back to 0%(2.254), change to **large C12** target(40mil) at 6th cell, change beam position to (x=0, y=±4mm and ±8mm), (x=±8mm, y=±8mm) and (x=±4mm and ±8mm, y=0). Take 20k good elastic sieve data for each beam position.

  Estimated time: (15min(data) + 5min(change)) x 12 = 240 min

Note: Let MCC to try to move the beam 8 mm away from nominal. If they can not, just move it to the maximum distance, then move to half of it .....

Standard Optics @ 2.257 GeV(cont.)

- 3. Pointing:

  Refill LHe.

  Change to 100 mil CH2 target in the 2nd Cell(count from the top). Rasters off. Sieve IN.

  Set HRS momentum to 2.254 GeV/c (delta=0%) and 2.228 GeV/c. Take 200k good C12 elastic sieve data(36min) for each momentum setting.

  Estimated time: 80 min(refill Lhe) +
  (40min(data) + 35min(change)) x 2 = 230min

Total time for straight through optics = 954 min

At the end of this optics, change to NH3 target and take elastic evnets (2.228GeV) to find out the target thickness.

2.5T, 90deg Optics @ 2.257 GeV

Move sieve out. Ramp taget field up to 2.5T, drain liquid helium out during ramping the field.

Estimated time: 120 min. Do not count into optics time.

100nA 2.257 GeV beam.

- Calibration of full acceptance: Sieve **OUT**, dp=0%(2.254 GeV), take 2 runs (7 min each run) for each of the following:

  fast raster on + slow raster on
  fast raster on + slow raster off
  fast raster off + slow raster off

Estimated time: 7min x 2 x 3 = 42 min.

- 1. Delta scan:

  Change delta to the following values and take 200k C12 elastic data each(about 2M raw events, average 20min):

  LHRS: -4%(2.344), -3%(2.322), -2%(2.299), -1%(2.277), 0% (2.254), 1%(2.231), 2%(2.209), 3%(2.186), 4%(2.164)

  R-HRS: -3.5%(2.333), -2%, 0%, 2%, 3.5%(2.175)

Estimated time: (20min(data) + 35min(change over)) x 5 = 275 min

2.5T, 90deg Optics @ 2.257 GeV (cont.)

- 2. Beam position cross scan:

  Set dp back to 0%(2.254), change to **large C12** target(40mil) at 6th cell, change beam position to (x=0, y=±4mm and ±8mm), (x=±4mm and ±8mm, y=0) and additional 4 points (x=±8mm, y=±8mm). Take 20k good elastic sieve data at each beam position.

  Estimated time: (15min(data) + 5min(change)) x 12 = 240min

- 3. Pointing(measure HRS angle):

  Refill LHe, change to 100 mil **CH2** target. Take 200k good C12 elastic sieve data for each of the following HRS momentum:

  2.254 and 2.228 (GeV/c).

  Estimated time: 80min(refill) + ((40min(data)+35min(change)) x 2 = 230min

Total Time = 787 min

5.01T, 6deg Optics @ 2.257 GeV

5.01T target field, 100nA 2.257 GeV beam. Drain liquid helium out to expose target to the beam. **Sieve IN.**

- 1. Delta scan:

  40 mil C12 at 3rd cell. Change delta (delta=(Phrs-P)/Phrs)) to the following values and take 200k good C12 elastic sieve data each (about 20min in average):

  LHRS: -4%(2.344), -3%(2.322), -2%(2.299), -1%(2.277), 0% (2.254), 1%(2.231), 2%(2.209), 3%(2.186), 4%(2.164)

  R-HRS: -3.5%(2.333), -2%, 0%, 2%, 3.5%(2.175)

  Estimated time: (20min(data) + 35min(change)) x 5 = 275 min

- 2. Beam position cross scan:

  Set dp back to 0%(2.254), still use 100 mil **C12** target, change beam position to (x=0, y=±4mm and ±8mm) and (x=±4mm and ±8mm, y=0). Take 2M raw events for each beam position.

Estimated time: (15min(data) + 5min(change)) x 8 = 160 min

5.01T, 6deg Optics @2.257 GeV (cont.)

- 3. Pointing(measure HRS angle):

  Refill LHe, change to 100 mil **CH2** target. Take 200k good C12 elastic sieve data for each of the following HRS momentum:

  2.254 and 2.228 (GeV/c).

Estimated time: 80min(refill) + ((40min(data)+35min(change)) x 2 = 230min

Total Time = 665 min

2.5T, 90deg Optics @ 1.706 GeV

- All procedures similar to the 2.5T|90 deg 2.257 optics, LHe will be drain out and sieve will be mvoed OUT during ramping the target field up. Will do the following:

1. Acceptance calibration,rasters on and off **30min**
2. Change sieve IN. Do delta scan.
   LHRS: -4%(1.770), -3%(1.754), -2%(1.736), -1%(1.719), 0%(1.702), 1%(1.685), 2%(1.668), 3%(1.651), 4%(1.634).
   RHRS: -3.5%(1.762), 2%, 0%, 2%, 3.5%(1.642) **275min**
3. Beam position scan (12 points). **200min**
4. Refill LHe then do pointing, only at delta=0. **120min**

- Total time: **625 min**

5.01T, 6deg Optics @ 1.706 GeV

All procedures similar to the 5.01T|6 deg 2.257 optics, Drain LHe out during ramping the target field. Sieve IN. Will do the following:

1. Delta scan.

   LHRS: -4%(1.770), -3%(1.754), -2%(1.736), -1%(1.719), 0% (1.702), 1%(1.685), 2%(1.668), 3%(1.651), 4%(1.634).

   RHRS: -3.5%(1.762), 2%, 0%, 2%, 3.5%(1.642) **275min**

2. Beam position scan (12 points). **200min**
3. Refill LHe then do pointing at delta=0. **120min**

- Total time: **595 min**

5.01T, 90deg Optics @ 2.257 GeV

Move sieve out. Ramp taget field up to 2.5T, drain liquid helium out during ramping the field. 100nA 2.257 GeV beam.100 mil C12 target in the 6th cell.

- 1. Calibration of full acceptance: Sieve **OUT**, dp=0%(2.254 GeV), take 2 runs (35 min each run) for each of the following:

  fast raster on + slow raster on
  fast raster on + slow raster off
  fast raster off + slow raster off

Estimated time: 35min x 2 x 3= 210 min.

- 2. Delta scan:

  Take 20k good sieve data(25 min each run in average):

  LHRS: -4%(2.344), -3%(2.322), -2%(2.299), -1%(2.277), 0% (2.254), 1%(2.231), 2%(2.209), 3%(2.186), 4%(2.164)

  R-HRS: -3.5%(2.333), -2%, 0%, 2%, 3.5%(2.175)

Estimated time: (70min(data) + 35min(change over)) x 5 = 525 min

5.01T, 90deg Optics @ 2.257 GeV (cont.)

- 3. Beam position cross scan: change beam position to (x=±4mm and ±8mm, y=0). Take 20k good elastic sieve data for each beam position.

  Estimated time: (35min(data) + 5min(change)) x 8= 320 min

- 4. Pointing(measure HRS angle):

  Refill LHe, change to 100 mil **CH2** target. Take 50k good elastic sieve data for delta=0:

  Estimated time: 80min(refill) + 70 = 150 min

Total Time = 1065 min

Standard Optics @ 1.159 GeV

Drain LHe out during changing the chicane.

- 1. Acceptance calibration, Sieve OUT, rasters on and off 30min
- 2. Move sieve IN. Do delta scan:
  LHRS: -4%(1.200), -3%(1.189), -2%(1.177), -1%(1.166), 0%(1.154), 1%(1.142), 2%(1.131), 3%(1.119), 4%(1.08)
  RHRS: -3.5%(1.195), 2%, 0%, 2%, 3.5%(1.114) 275min
- 3. Cross scan (do beam position scan in x and y axis: ±4mm, ±8mm) 160min
- Refill Helium then do pointing with CH2(only at 1.154GeV). 120min

Total time: 585 min

2.5T, 90deg Optics @ 1.159 GeV

Move sieve out, drain liquid helium to expose the C12 foil during ramping the target field up! Use **100 mil C12** target in the 6th cell.

- 1. Acceptance calibaration, rasters on and off. *30 min*
- 2. Move sieve in. Do delta scan: change delta to the following values and take 20k good sieve data(or 2k good data at the center hole):

  LHRS: -4%(1.200), -3%(1.189), -2%(1.177), -1%(1.166), 0% (1.154), 1%(1.142), 2%(1.131), 3%(1.119), 4%(1.08)

  RHRS: -3.5%(1.195), 2%, 0%, 2%, 3.5%(1.114)

Estimated time: 30min(change sieve) +(20min(data) + 35min(change dipole)) x 5 = 305 min

- 2. Set delta back to 0%(1.154), do beam position scan in x and y axis: ±4mm, ±8mm. 2M raw seive data each point.

Estimated time: (15min(data) + 5min(change)) x 8 = 160 min

- Refill Helium then do Pointing with CH2(only at 1.154GeV).

Estimated time: 80min(refill) + 40min(data)= 120 min

Total Time = 615 min

5.01T, 6deg Optics @ 1.159 GeV

Move sieve in, drain liquid helium to expose the C12 foil during ramping the target field up! Use **40 mil C12** target in the 6th cell.

- 1. Delta scan: change delta to the following values and take 20k good sieve data(or 2k good data at center hole):

  LHRS: -4%(1.200), -3%(1.189), -2%(1.177), -1%(1.166), 0% (1.154), 1%(1.142), 2%(1.131), 3%(1.119), 4%(1.08)

  RHRS: -3.5%(1.195), 2%, 0%, 2%, 3.5%(1.114)

Estimated time: (20min(data) + 35min(change)) x 5 = 275 min

- 2. Set delta back to 0%(1.154), do beam position scan in x and y axis: ±4mm, ±8mm. 20k good seive data.

Estimated time: (15min(data) + 5min(change)) x 8 = 160 min

- Refill Helium then do Pointing with CH2(only at 1.154GeV).

Estimated time: 80min(refill) + 40min(data) = 120 min

Total Time = 555 min

Total time for optics

Tuning dipoles, septum and quardroples: 240 min = 4 h

1. 0T, 90deg, 2.257GeV optics: 873 min = 15 h
2. 2.5T, 90deg, 2.257GeV optics: 787 min = 13 h
3. 5.0T, 6deg, 2.257GeV optics: 665 min = 11 h
4. 2.5T, 90deg, 1.706GeV optics: 625 min = 11 h
5. 5.0T, 6deg, 1.706GeV optics: 595 min = 10 h
6. 5.0T, 90deg, 2.257GeV optics:1065 min = 18 h
7. 0T, 90deg, 1.159GeV optics: 585 min = 10 h
8. 2.5T, 90deg, 1.159GeV optics: 615 min = 11 h
9. 5.0T, 6deg, 1.159GeV optics: 555 min = 10 h

Total time: 117 hours

Short Optics Plan

Define the following jobs:

A. Acceptance calibration, sieve out, raster on and off (large C12, no LHe)
B. Delta scan, (sieve in, C12, no LHe)
C. Beam position scan (Sieve in, large C12, no Lhe, 12 points or 8 points)
D. Pointing (Sieve in, CH2, need to refill LHe)

Here is the summary of all optics:

1. 0T @ 2.257: Do A, move sieve in, do B and C(12 points), refill LHe do D
   At the end take elastic NH3 data to check NH3 thickness.
   When finish: move sieve out; Ramp field up to 2.5T; Drain LHe
2. 2.5T|90deg @ 2.257: Do A, move sieve in, do B and C(12 points), refill LHe do D
   When finish: Ramp field up to 2.5T; Drain Lhe out
3. 5.01T|6deg @ 2.257: Do B and C(8 points), refill LHe do D
4. 2.5T|90deg @ 1.706: Do A, move sieve in, do B and C(8 points), refill LHe do D
   When finish: Rotate target field to 6 deg; Ramp up to 5.01T; Drain Lhe out
5. 5.01T|6deg @ 1.706: Do B and C(8 points), refill LHe do D
   When finish: Move sieve out; Rotate target field to 90 deg; Ramp up to 5.01T; Drain LHe out
6. 5.01T|90deg @ 2.257: Do A, move sieve in, do B and C(8 points), refill LHe do D
   When finish: Turn off target field; Drain Lhe, move sieve out.
7. 0T @ 1.159: Do A, move sieve in, do B and C(8 points), refill LHe do D
   At the end take elastic NH3 data to check NH3 thickness.
   When finish: move sieve out; Ramp field up to 2.5T; Drain Lhe out
8. 2.5T|90deg @ 1.159: Do A, move sieve in, do B and C(8 points), refill LHe do D
   When finish: Ramp field up to 5.01T; Drain Lhe out
9. 5.01T|6deg @ 1.159: Do B and C(8 points), refill LHe do D