PRad Beam Commissioning Run Plan (April Test Run)

- **Goals:**
  - ✓ Initial test of entire apparatus with an electron beam;
  - ✓ Test of the H2 gas flow target initial performances in electron beam;
  - ✓ Test of the beam halo effect on the trigger rate;
  - ✓ Check the effect of the "beam halo collimator" on the trigger rate;
  - ✓ Check and setup all timings, check the new DAQ (mostly GEM);
  - ✓ Collect initial data set to test on-line and off-line monitoring codes;
  - ✓ Find out weaknesses of the setup and software to prepare for May run.
- **Experimental setup:**
  - ✓ HyCal with GEM off the Transporter on the "Run Cart" in the beam line and surveyed;
  - ✓ Vacuum box installed with the window;
  - ✓ Beam line completely assembled;
  - ✓ DAQ is ready, trigger is HyCal total sum (analog sum);
  - ✓ Target is ready (installation is done in January, 2016).
- **Beam:**
  - Electron beam (E_e = 2.2 GeV, I_e = 1 – 20 nA, focused on the target).

1) **Electron Beam Tuning (~0.5 shift):**
   - Target cell off the beam line, no gas flow in the chamber;
   - Collimator is in the "Beam Block" position;
   - Tagger radiator off the beam line;
   - Tagger magnet "on".

a) establish a good electron beam (E_e = 2.2 GeV, I_e = 5 nA) on the tagger dump;
b) take electron harp scans 2C21A and 2C24A,
check the position, widths and peak to tails ratio;
c) study beam halo by setting the harp wire in the tail region and ramping beam current up to 100 nA;
d) tagger magnet "off", prepare for an electron beam through the setup.

2) **Target Commissioning (2 shifts)**

a) target cell off the beam line, no gas flow in the cell and chamber;
b) beam collimator in "off" position;
c) set threshold energy for the HyCal trigger to E ~ 0.5 E_e ;
d) request electron beam (E = 2.2 GeV, I = 1 nA);

e) take harp scans 2C21A, 2C24A and 2H01, check position and widths, establish a good electron beam and fix the beam line parameters;
f) record HyCal trigger rate with no cell and no gas flow take one short DAQ run (record HyCal and GEM information);
g) electron beam off; insert the target cell in the beamline, still empty, ask for beam;
h) target cell is empty (no gas flow into the cell and chamber);
i) record HyCal trigger rate, take one short DAQ run (record all information);
j) gas flow in the cell (P_{cell} = 6 torr, P_{cham} = 5 mtorr);
k) record HyCal trigger rate, take one short DAQ run (record all information);
l) move the cell on X-axis by +/- 3 mm with 0.2 mm steps and take HyCal rate;
m) move the cell on Y-axis by +/-3 mm with 0.2 mm steps and take HyCal rate;
n) change the cell angles and record the HyCal rate, get optimal cell direction;
o) center the cell in the beam based on those measurements;
p) no gas flow into the cell and chamber, record HyCal rate;
q) gas flow into the cell (P_{cell} = 6 torr, P_{cham} = 5 mtorr);
r) record HyCal trigger rate, take one short DAQ run (record all information);

3) **Target Commissioning with the Beam Collimators (~0.5 shift)**

a) electron beam off;
b) 12.7 mm beam collimator in;
c) target cell is empty (no gas flow into the cell and chamber);
d) request electron beam (E = 2.2 GeV, I = 1 nA);
e) record HyCal trigger rate, take one short DAQ run;
f) electron beam off;
g) target cell is still off, gas flow in the chamber (P_{cham} = 5 mtorr);
h) request for beam;
i) record HyCal trigger rate, take one short DAQ run (record all information);
j) electron beam off;
k) Insert target cell in, gas flow in the cell (P_{cell} = 6 torr, P_{cham} = 5 mtorr);
l) request for beam;
m) record HyCal trigger rate, take one short DAQ run (record all information);
n) no gas flow in the cell and in the chamber;
o) record HyCal trigger rate, take one short DAQ run (record all information);
p) electron beam off;

4) **Target Commissioning with the Beam Collimator (~0.5 shift)**

a) electron beam off;
b) 6.8 mm beam collimator in;
c) target cell is empty (no gas flow into the cell and chamber);
d) request electron beam (E = 2.2 GeV, I = 1 nA);
e) record HyCal trigger rate, take one short DAQ run;
f) electron beam off;
g) target cell is still off, gas flow in the chamber (P_{cham} = 5 mtorr);
h) request for beam;
i) record HyCal trigger rate, take one short DAQ run (record all information);
j) electron beam off;
k) Insert target cell in, gas flow in the cell (P_{cell} = 6 torr, P_{cham} = 5 mtorr);
l) request for beam;
m) record HyCal trigger rate, take one short DAQ run (record all information);
n) no gas flow in the cell and in the chamber;
o) record HyCal trigger rate, take one short DAQ run (record all information);
p) electron beam off;

5) **Target Commissioning with the Beam Collimator (~0.5 shift)**

a) electron beam off;
b) 2.7 mm beam collimator in;
c) target cell is empty (no gas flow into the cell and chamber);
d) request electron beam (E = 2.2 GeV, I = 1 nA);
e) record HyCal trigger rate, take one short DAQ run;
f) electron beam off;
g) target cell is still off, gas flow in the chamber (P_{cham} = 5 mtorr);
h) request for beam;
i) record HyCal trigger rate, take one short DAQ run (record all information);
j) electron beam off;
k) Insert target cell in, gas flow in the cell (P_{cell} = 6 torr, P_{cham} = 5 mtorr);
l) request for beam;
m) record HyCal trigger rate, take one short DAQ run (record all information);
n) no gas flow in the cell and in the chamber;
o) record HyCal trigger rate, take one short DAQ run (record all information);
p) electron beam off;

6) **Target Commissioning with the Beam Collimator (~0.5 shift)**

a) electron beam off;
b) 2.7 mm beam collimator in;
c) target cell is empty (no gas flow into the cell and chamber);
d) request electron beam (E = 2.2 GeV, I = 1 nA);
e) record HyCal trigger rate, take one short DAQ run;
f) electron beam off;
g) target cell is still off, gas flow in the chamber (P_{cham} = 5 mtorr);
h) request for beam;
i) record HyCal trigger rate, take one short DAQ run (record all information);
j) electron beam off;
k) Insert target cell in, gas flow in the cell (P_{cell} = 6 torr, P_{cham} = 5 mtorr);
l) request for beam;
m) record HyCal trigger rate, take one short DAQ run (record all information);
n) no gas flow in the cell and in the chamber;
o) record HyCal trigger rate, take one short DAQ run (record all information);
p) electron beam off;

7) **Test Runs with Different Beam Intensities and Trigger Thresholds (~1 shift)**

(Runs with I_e =10 nA)

a) Repeat all steps in part (4) for E = 2.2 GeV, I_e = 10 nA)

PRad Data Taking Run Plan (May/June, 2016)

1) **Photon Beam Tuning (~1 day):**
   - HyCal with GEM on Transporter and off the beam line;
   - Target cell off the beam line;
   - Tagger radiator off, collimator off;
   - Tagger magnet on.

a) establish a good electron beam (E_e = 2.2 GeV, I_e = 5 nA) on the tagger dump;
b) take electron harp scans 2C21A and 2C24A,
check the position, widths and peak to tails ratio;
c) study beam halo by setting the harp wire in the tail region and ramping beam current up to 100 nA;
d) lower beam current to 0.1 nA
e) insert radiator 10^{-5} r. l.;
f) check tagger counter scalars;
g) setup MOR logic for calibration (gain equalizing) trigger T5 only;

2) **HyCal Gain Equalizing and Trigger Checkout (1.5 days):**
   a) establish HyCal temperature to T=16^o and keep it stable;
   b) collimator in, 6 mm;
   c) target cell off the beam;
   d) HyCal is in "Bottom Right" position;
   e) establish a good timing with HyCal readout;
   f) adjust trigger delay if necessary;
   g) set the gain value: E=2 GeV to ADC=4000 channel;
   h) start the gain equalizing process: scan to each module's center, show the anode and dynode ADC distributions on computer screen, by changing the HV set anode ADC=4000 channel (with ~ 5% precision), save the HV, ADC and anode/dynode ratio;
   i) repeat for all HyCal modules (~10 hours).

3) **GEM Beam Calibration (1.5 days, look for possibilities to combine with the item #2):**
   1"x1"l scintillator counters are installed in the beam line just after the Vacuum box.

   a. collimator with smallest diameter in (2.7 mm);
   b. insert thin ~ 1 μm ^{12}C target in the beam;
   c. insert radiator 10^{-5} r. l.;
   d. ask for photon beam with lowest intensity (I_e = 70 pA);
   e. adjust the timing of the scintillator detectors vs. tagger;

f. scan the GEM with HyCal with a predefined step size both on X and Y-axis, store the data from GEM, HyCal and trigger scintillator detectors;
g) measure the GEM's detection efficiency vs. position (uniformity).

4) **HyCal Gain Calibration (1.5 days)**:
   a) run HyCal with HV unchanged for ~ 3 hours after the "Gain Equalizing";
   b) the beam and the beam line are the same as in "Gain Equalizing";
   c) trigger: all T1-T19 tagger counters, DAQ without the "sparsification";
   d) start from the "Top Left" position with a continuous motion (~1 min/module) "illuminate" all modules, store the data with HyCal's X,Y positions from EPICS;
   e) stop the HyCal motion by the end of each row, make new DAQ run with pedestals and LMS, store the files;
   f) run on-line calibration programs for constants, store the data.

5) **Configuration change to running configuration with HyCal on the cart, engineering survey (~4 days).**

- **Request for Beam Energy Change to E_e = 1.1 GeV (0.5 day)**

6) **Electron Beam Tuning and Target Commissioning (2 days)**

   a) target cell off the beam line, no gas flow in the cell and chamber;
   b) collimator off;
   c) set threshold energy for the HyCal trigger E ~ 0.5xE_e ;
   d) request electron beam (E = 1.1 GeV, I = 1 nA);
   e) take harp scans 2C21A, 2C24A and 2H01, check position and widths, establish a good electron beam and fix the beam line parameters;
   f) record HyCal trigger rate with no cell and no gas flow take one short file with ADCs;
   g) electron beam off; insert the target cell in the beamline, still empty, ask for beam;
   h) target cell is empty (no gas flow into the cell and chamber);
   i) record HyCal trigger rate, take one short file with ADCs;
   j) gas flow in the cell (P_{cell} = 6 torr, P_{cham} = 5 mtorr);
   k) record HyCal trigger rate, take one short file with ADCs;
   l) move the cell on X-axis by +/- 2 mm with 0.2 mm steps and take HyCal rate;
   m) move the cell on Y-axis by +/-2 mm with 0.2 mm steps and take HyCal rate;
   n) change the cell angles and record the HyCal rate, get optimal cell direction;
   o) center the cell in beam based on those measurements;
   p) no gas flow into the cell and chamber, record HyCal rate;

q) gas flow into the cell (P_{cell} = 6 torr, P_{cham} = 5 mtorr);
r) record HyCal trigger rate, take one short file with ADCs;

7) **Target Commissioning (cont'd):**

a) gas flow into the chamber only (P_{cell} = P_{cham} = 5 mtorr);
b) record HyCal trigger rate, take one short file with ADCs (in-beam residual gas effect);
c) If there is no sizable effect between cell in/out, skip following steps.
d) beam off, 12.7 mm collimator in, target cell in, ask for beam;
e) no gas flow in cell, record HyCal rate;
f) gas flow in the cell (P_{cell} = 6 torr, P_{cham} = 5 mtorr), record HyCal rate;
g) beam off, insert 6.4 (?) mm collimator in, take beam and repeat items (w) and (x);
h) make a decision about the size of the collimator.

8) **Data taking with E_e = 1.1 GeV (5 days)**

a) beam intensity: I_e = 10 nA;
b) collimator in (with the diameter defined in 6 (z);
c) HyCal trigger is set, DAQ is ready, all slow control readout is ready;
d) target cell in with maximum density ($2.x10^{17}$ H/cm^3);
e) take data for 2 days, record all information on disk and on tape;
f) no gas in the cell, take data for 0.5 day (empty target run);
g) gas in the cell, run for 2 days (same as in (e));
h) no gas in the cell, take data for 0.5 day (empty target run);

9) **REQUEST FOR Beam Energy CHANGE to E_e = 2.2 GeV (0.5 day)**

10) **Data taking with E_e = 2.2 GeV (4 days)**

a) intensity: : I_e = 10 nA;
b) collimator in (with the diameter defined in 5 (r);
c) HyCal trigger is set, DAQ is ready, all slow control readout is ready;
d) target cell in with maximum density ($2.x10^{17}$ H/cm^3);
e) take data for 2 days, record all information on disk and on tape;
f) no gas in the cell, take data for 0.5 day (empty target run);
g) gas in the cell, run for 1.0 day (same as in (e);
h) no gas in the cell, take data for 0.5 day (empty target run).