Current Beam Time Schedule for 2026

▪ February 20, 2026	PRad-II	3.5 GeV
▪ March 28	PRad-II	0.7 GeV
▪ May 02	PRad-II	2.2 GeV
▪ June 01	PRad-II ends	2.2 GeV
▪ June 01 to June 05	Reconfigure to X17	
▪ June 06	X17	2.2 GeV
▪ July 27	X17 ends	2.2 GeV

Short Beamline Installation and Testing Plan (Updated)
(from September to December 2025)

1) Install all beamline elements in Hall B beam line — Starts from September 2025
   a) Photon tagger radiators
   b) Hallo collimator before the tagger magnet
   c) Collimator box with three collimators (~6, 12, 24 mm) just after the Tagger magnet
   d) Scattering chamber installed with its small window
   e) HyCal is installed on the cart
   f) GEMs are installed on HyCal
   g) Beamline elements after HyCal installed

2) We test all mechanical parts of the X17 beamline elements first, then remove them in December to install and test the PRad-II parts (target, Al-pipe, etc.) ("dress rehearsal" process for the X17 beamline elements): — by December 2025

   - ✓ install the beam pipe from the coll. box to target, the Harp with the target.
   - ✓ install the Harp and test the target movements
   - ✓ connect to the Vacuum box with the the smaller window
   - ✓ connect the He-pipe and test the vacuum system

3) Remove al X17 beamline elements from the beamline, prepare for the H2-target installation. — Nov.-December 2025

Short Beamline Installation and Testing Plan (Updated)
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3) Remove al X17 beamline elements from the beamline, prepare for the H2-target installation. — Nov.-December 2025

4) Install the H2-target with the scintillators inside. Perform a FULL test of the target and scintillators

5) HyCal and GEMs are still installed on the cart. Prepare them for cosmic ray tests — January 2026
   a) connect all HyCal and GEM cables (HV and signal cables)
   b) install new Chiller and start chilling HyCal down to ~17^{o}C
   c) connect cables for new scintillators and all other detectors (Tagger, etc.)

6) Install the Al-pipe and connect it to the window and to the downstream pipes. (first test of all mechanical parts)

5) Test the vacuum system

6) Start cosmic ray tests for GEMs, HyCal and new veto scintillators and Tagger detectors — up to Febr. 2026

Short Beamline Installation and Testing Plan (Updated, Cont.)

9) Remove GEMs from HyCal and locate aside to continue cosmic ray tests — start Feb. 1 2026

10) Install HyCal on the Transporter

11) Check precision motion systems with on-line software codes

12) Continue cosmic ray tests for HyCal and all detectors (GEMs, scintillators, …)

13) Vacuum box beam window is temporarily thin film

14) Check the vacuum in both upstream and downstream pipes

15) Experimental setup is ready for the photon beam ! — Feb. 20 2026

Photon Beam Tuning for HyCal Gain Equalizing and Calibration

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

a) establish a good electron beam (E_e = 3.5 GeV, I_e = 5 nA) on the tagger dump;
b) take electron harp scans 2C21A and 2C24A,
c) check the position, widths and peak to tails ratio;
d) study beam halo by setting the harp wire in the tail region and ramping beam current up to 100 nA;
e) lower beam current to 0.1 nA
f) insert radiator 10^{-5} r. l.;
g) check tagger counter scalars;
h) setup MOR logic for equalizing trigger T5-counter only;
i) etc.

2) Start HyCal gain equalizing process with photon beam

HyCal Gain Equalizing

3) HyCal Gain Equalizing and Trigger Checkout (~2-3 shifts):
   a) HyCal temperature is already at T=17^o and kept stable for few days;
   b) new collimator before tagger magnet is off;
   c) collimator after the Tagger is in, 6 mm (1/4”);
   d) X17 targe off the beam;
   e) HyCal is out of the beam;
   f) establish photon beam with I_e ~ 0.2 nA, E_e = 4.4 GeV;
   g) photon beam is off;
   h) set HyCal in “Bottom Right” $PbWO_4$ position;
   i) trigger is from MOR T5, establish a good timing with HyCal readout (?);
   j) adjust the trigger delay if necessary;
   k) set the gain value: E=2 GeV to ADC=4000 channel;
   l) start the gain equalizing process: scan to each module’s center, show the anode ADC distribution on computer screen, by changing the HV set anode ADC=4000 channel (with ~ 5% precision), save the HV;
   m) repeat for all HyCal $PbWO_4$ modules.

4) Run HyCal for 3-4 hours with the final HV, start HyCal gain equalizing process with photon beam

HyCal Gain Calibration

5) HyCal Gain Calibration (2-3 shifts)

a) HyCal is running with preset HV unchanged for ~ 3 hours after the "Gain Equalizing" process;
b) the beam and the beam line are the same as in "Gain Equalizing";
c) MOR trigger: Three ranges of T- and E-counters: upper few, middle few and down few (for linearity check);
d) DAQ without "sparsification";
e) start from the "Top Left" $PbWO_4$ position with a continuous motion (~1 min/module) "illuminate" all modules, store the data with HyCal's X,Y positions from EPICS;
f) stop the HyCal motion by the end of each row, make new DAQ run with pedestals and LMS (? Needs discussion), store the files;
g) run on-line calibration programs for calibration constants, store the data.

6) HyCal is fully checked and calibrated, ready for the PRad-II experiment

Start the PRad-II Experiment
(E_e = 3.5 GeV)

7) Preparation for the PRad-II experiment.
   a) Take HyCal off from the Transporter. Install back on the cart;
   b) Reinstall GEMs back on the front of HyCal
   c) Install Al-beam pipe through GEMs and HyCal. Check the vacuum;
   d) keep HV on and the Chiller running;
   e) Engineering survey of GEMs, HyCal and all detectors (discussion)

PRad-II Data Taking

12) Data taking with **E_e = 3.5 GeV** (4 days, check this number)

a) intensity: : I_e ~ 10 nA;
b) collimator in (with the diameter defined in 11 a and b;
c) set HyCal trigger: $E_{total} > 0.5xE_{beam}$,
d) DAQ is ready, all slow control readout is ready;
e) target cell in with maximum density (~$2.x10^{17}$ H/cm^3);
f) take data for ~2 days, record all information on disk and on tape;
g) no gas in the cell, take data for 0.5 day (empty target run);
h) gas in the cell, run for ~1.0 day (same as in (e);
i) no gas in the cell, take data for 0.5 day (empty target run).

13) Data taking with **E_e = 0.7 GeV** (5 days, check this number)

a) beam intensity: I_e ~ 10 nA;
b) collimator in (as defined in 11 a, b);
c) set HyCal trigger: $E_{total} > 0.5xE_{beam}$
d) DAQ is ready, all slow control readout is ready;
e) target cell in with maximum density ($2.x10^{17}$ H/cm^3);
f) take data for 2 days, record all information on disk and on tape;
g) no gas in the cell, take data for 0.5 day (empty target run);
h) gas in the cell, run for 2 days (same as in (e));
i) no gas in the cell, take data for 0.5 day (empty target run);

PRad-II Data Taking

14) Data taking with $\mathbf{E_e}$ = **2.2 GeV** (4.5 days, check this number)

a) intensity: : I_e ~ 10 nA;
b) collimator in (with the diameter defined in 11 a and b;
c) set HyCal trigger: $E_{total} > 0.5xE_{beam}$
d) DAQ is ready, all slow control readout is ready;
e) target cell in with maximum density ($2.x10^{17}$ H/cm^3);
f) take data for 2 days, record all information on disk and on tape;
g) no gas in the cell, take data for 0.5 day (empty target run);
h) gas in the cell, run for 1.0 day (same as in (e);
i) no gas in the cell, take data for 0.5 day (empty target run).

Configuration Change to X17 Run Condition

15) Configuration change to X17 running configuration with. June 01 2026
HyCal on the cart.

a) move HyCal with GEMs back (on the running cart);
b) remove Al-pipe;
c) install He-pipe through the GEMs and HyCal;

16) Remove H2 gas target from the beamline (a parallel work).

17) Install X17 vacuum pipe with the harp/targets (a parallel work).

18) Establish good vacuum

19) Experimental setup is ready for the X17 experiment before June 5 2026

Extra Slides

Preparation and Run X17 Experiment

6) Preparation for the X17 Experiment

a) tagger radiator off;
b) upstream collimator off;
c) downstream collimator (after Tagger magnet) in, 12 mm diameter (0.5”);
d) set DAQ trigger: 3 clusters in HyCal with E_{clust} > 30-50 MeV AND E_{total} > 0.7xE_{beam} (correct these numbers with new MC simulations to optimize the trigger);
e) request electron beam E_e =4.4 GeV, I_e = 5 nA;
f) insert the 1 μm Tungsten target;
g) take data and measure the trigger rate;
h) insert upper collimator with 0.5” diameter, take date and DAQ rate;
i) optimize the upper collimator diameter;
j) gradually increase the beam intensity to reach the 25 kHz DAQ rate;
k) take data;

l) The sequence and duration of “empty target” runs needs to be discuss separately. What is the gain from “empty target” runs in X17 experiment and how much we need to take them?

Hydrogen Gas Flow Target Recommissioning with Beam

11) Target Commissioning (2 shifts)

a) target cell off the beam line, no gas flow in the cell and chamber;
b) beam collimators in “off” position;
c) set threshold energy for the HyCal trigger to E ~ 0.5 E_e (needs to be optimized);
d) request electron beam (E = 2.1 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 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 position and 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);

H2 Gas Flow Target Recommissioning with Beam (Cont.)

11) Selecting optimal “Collimator” combination.

a) beam energy is Ee = 2.1 GeV;

b) set HyCal trigger: $E_{total} > 0.5 \times E_{beam}$;

c) insert the downstream collimator (after tagger): 12 mm (0.5”) (check from PRad run);

d) sequentially insert different collimators in upstream collimator and select the optimum trigger rate condition.