Summary of action Items from June 3, 2010, tritium target review at JLab:

Administrative (Rolf Ent, Cynthia Keppel)

(1) Appoint a lead person at JLab, a design authority, who will emphasize the engineering aspects of the target system and who will be responsible for the design, fabrication, procurement, installation and operation of the system (done, Dave Meekins)

(2) Establish an engineering team (done, Dave Meekins, Robin Wines, Tom O'Connor, …)

(3) Develop clear responsibilities for INL, JLab, and collaboration; and determine who will sign off on safety checkout plans

(4) Administrative requirement that beam blow-up optics are used in experiment

(5) Administrative limit on beam trip rate when cell is in the beam (safety algorithm: assumes 500 beam trips/day)

(6) Make a provision that if the H or He target fails, a failure mode determination is made before the experiment continues with tritium gas

(7) Extensive review of final cell design and test results should be performed by JLab, Argonne and outside experts

Target cell (Dave Meekins has lead responsibility for this section.)

(8) Develop a modular target design (done, see Meekins' design)

(9) Use a 1000 Ci source (done)

(10) Determine maximum target window thickness based on physics requirements (Patricia Solvignon, done)

(11) Target cell should comply with ASME Boiler and Pressure Vessel Code, sec VIII Div 2 2007 (done, see Meekins' design)

(12) Cell should be filled offsite and be designed to survive transport (Dave Meekins will organize this.)

(13) Cell should survive cyclic loading (beam trips) (Meekins' design and experience)

(14) W collimator should be better supported (Dave Meekins or beamline physicist)

(15) Valves should have all metal wetted parts (done, see Meekins' design)

(16) Cell must sustain a full vacuum load (done, see Meekins' design)

(17) Target system should be designed to be cooled with 90K N_2 (done, see Meekins' design)

(18) Verify that Al 2219 is a suitable material for tritium gas (Plan to use Al 7075-T6, Brian Somerday at Sandia National Lab verified that 7000 series Al alloys are impervious to hydrogen embrittlement even at extremely high pressures)

(19) Determine strength of welded Al 2219 (Meekins' design avoids issue.)

(20) Weld coupons should be tensile and bend tested (Meekins' design avoids issue.)

(21) Al –ss transition piece should be purchased and elbows should be used (Meekins' design avoids issue)

(22) An elastic plastic model of the cell (ASME D2 5.2.4) should be used (done, see Meekins' design)

(23) Proof tests on more than 3 endcaps and at least one complete cell should be performed (see test plan)

(24) Heat cycling tests with a tritium loaded cell should be performed for a period of 6 months (Studies at Savannah River for tritium in Al indicate that the swelling threshold for helium in Al occurs at 0.067 wt % He/Al. Estimates indicate that the He/Al ratio in our case should be more than 7 orders of magnitude smaller than this threshold. See technical note: "Beam-induced and Tritium-assisted Embrittlement of the Target Cell at Jefferson Lab", R. E. Ricker (NIST), R. J. Holt, D. Meekins, B. Somerday (Sandia).)
(25) Consult Wayne Kanady at INL and Walter Shmayda at University of Rochester regarding tritium diffusion (done, also consulted Richard Riker at NIST and Bryan Somerday at Sandia National Lab. See technical report: "Tritium Diffusion from the Target Cell at Jefferson Lab", R. J. Holt, T. O'Connor, R. Ricker (NIST), D. Meekins, B. Wojtesekhowski)
(26) If insufficient information exists on beam shock wave tests, perform such tests at JLab (There have been numerous beam hours on Al cells either for the cryotargets or for gas cells at JLab. This should not be a problem.)
(27) Cell must survive off-normal beam conditions for at least 3 times the amount of time that it takes for an interlock to turn the beam off (Dave Meekins to verify this.)
(28) Determine DOT and DOE regulations for shipping filled target cells to JLab (Dave Meekins or tritium supplier)

Scattering chamber, ventilation, beam line (Dave Meekins (lead), Robin Wines, Tom O'Connor, Wolfgang Korsch, Patricia Solvignon)

(29) Secondary containment should be physically isolated from beamline (Water-cooled thin Be windows will be used to isolate the scattering chamber from the beam line. See technical report: "Scattering Chamber Isolation for the JLab Tritium Target", T. O'Connor)
(30) The scattering chamber pumps shall be vented through tritium stack (This is planned.)
(31) The scattering chamber should be monitored for high and low levels of tritium (A rad-hard RGA (Granville-Phillips 830), already procured, will be used in the scattering chamber to monitor mass 6.)
(32) A U getter bed should be attached to the scattering chamber (A commercial NEG pump will be used to getter tritium in the event of a leak. See technical report: "Hydrogen Getter System for the JLab Tritium Target", T. O'Connor, W. Korsch)
(33) An additional long collimator should be placed upstream (JLab beamline physicist)
(34) Dedicated vent pumps/fans and lines should be installed over the scattering chamber and used for installation and removal procedures (Dave Meekins, Robin Wines)
(35) Airborne radioactivity detectors interlocked with the vent/fan stack system should be used (EHS and RadCon)
(36) Manual scram buttons in the hall and counting house for the ventilation (EHS and RadCon)
(37) Additional beam raster detector and interlock system (Hall A, JLab)

ESH tasks (Douglas Higinbotham (lead), Vashek Vylet, Wayne Kanady, Roy Holt, …)

(38) Establish baseline for detectable tritium at the JLab site (EHS and RadCon)

(39) Develop algorithm for safety involving amount of tritium, beam current, beam time (done, see technical report: "Tritium Gas Target Safety Algorithm for Jefferson Lab", R. J. Holt)

(40) Worst-case scenarios for worker exposure and all dose calculations should be analyzed or calculated by qualified personnel (See technical report: "Tritium Inhalation Risks for a Tritium Gas Target at Jefferson Lab", R. J. Holt)

(41) A more detailed assessment of impact of target loss on Hall A should be performed by qualified personnel (See technical report: "Absorption Risks for a Tritium Gas Target at Jefferson Lab", R. J. Holt)

(42) Use a 15 m elevation and a vertical tritium stack as necessary for limiting site boundary doses (See technical report: "Analysis of a Tritium Target Release at Jefferson Lab", B. Napier (PNNL) and R. J. Holt)

(43) Use the ICRP-68 dose coefficient of 1.8E-11 Sv/Bq reference for exposure evaluations (done)

(44) Use 10 mrem as the maximum allowed site boundary dose (done)

(45) The risk analysis should follow tables 4.2-4.5 of JLab's FSAD, rev. 6 and use realistic target failure probabilities (done, See technical report: "Tritium Gas Target Hazard Analysis for Jefferson Lab", Tritium Target Task Force)

Summary of the Tritium Target Meeting at JLab on May 30, 2012
(From notes by R. Holt and D. Higinbotham)

In attendance were K. de Jager, D. Higinbotham, R. Holt, C. Keith, D. Meekins, R. Ransome (by phone), P. Solvignon, V. Vylet, K. Welch, B. Wojtsekhowski.

The meeting was focused on some technical developments and EHS issues. In particular, some unsolved action items from our June 3, 2010, meeting were emphasized.

Some key decisions were taken:

(1) Plan to re-use existing BB scattering chamber and lifting mechanism (should save ~$200k). This plan requires approval from Thia Keppel.
(2) Use 15 K coolant on target rather than LN2. Operate cells at 40 K.
(3) Maximum operating pressure for hydrogen, deuterium and ^{3}He cells should be 450 psi at room temperature, if possible. Maximum operating pressure of the tritium target should be 200 psi at room temperature.
(4) Use cryo-compression to load ^{3}He target since compressor is limited to 250 psi.
(5) Use two solid targets with 2-mm central holes separated by the gas target length rather than a BeO foil.
(6) Cryotarget group responsibilities end at the scattering chamber (Chris Keith).
(7) Engineering and construction of exhaust stack must be handled by civil engineering and construction or outside group. (Dave will look into this.)
(8) Best option appears to be to route the ventilation to the side of Hall A truck ramp where a stack of 20-25 m will be located.
(9) Place tritium expert on yearly EHS review panels and have this panel review radiological issues rather than hire outside experts to develop plans. In particular, the stack height plan should be reviewed.
(10) RadCon plans to install a tritium monitor in Hall A and establish tritium baseline detection. Tritium monitor may already exist according to Keith Welch.
(11) Idaho State plan should test more than one Al window, possibly 4 windows. Dave Meekins has a conceptual design and plan for this.
(12) RadCon or JLab must determine whether the Lab can receive 0.1 g shipment of tritium gas from vendor.
(13) Beam shock wave tests recommended by June 3, 2010, review likely are not necessary since JLab has successfully operated many liquid and gas targets with thin Al windows.
(14) Patricia Solvignon will determine rate in BB from endcaps and Be window. She will also provide information about multiple scattered beam from the Be window and upstream Al window hitting the side walls of the target cell.

Technical progress:

(1) Rutgers provided a target cell and six window assemblies for testing. Tests will be conducted after test facility is upgraded for high pressure, perhaps early June.
(2) Dave Meekins engineered a target stack and other assemblies associated with cooling and lifter. Several more months of work will be necessary for the complete design.

(3) Tom O'Connor designed Be isolation window assembly and NEG pump emergency tritium absorber assembly.

(4) Patricia Solvignon used GEANT3 to determine power dumped into cell and W collimator under various scenarios. Having the beam impinge on a side of the cell results in ~6 kW of beam power dumped in cell and having the beam impinge on a 1" thick W collimator raises the power to ~12 kW dumped into the target cell. Data from a run with 120 μA on a ^{3}He cooled-high-flow gas cell with 0.011" Al windows, 20 cm long and 20mm diameter for side walls showed no problem with this potential background source.

Other items discussed:

(1) Possible test of ventilation system with deuterium or SF6 gas

(2) Possible use two RGA's in scattering chamber, one as a backup

(3) Upstream W beam collimators – dimensions, spacing

(4) Use at least two BPM's or equivalent after first beam collimator for FSD

(5) Possible active corrections to pitch and yaw of target cells

(6) May be possible to fill tritium target at Savannah River rather than INL

(7) Hall A priorities will have to be sorted out because of limited engineering resources

(8) Use existing target lifter or a new design

(9) Possibly use ~8.3 MeV electron beam at JLab injector rather than ~20 MeV beam at Idaho State for the cell test (saves ~$10k and possibly time and travel, minimizes activation of target cell).