INTERFACE CONTROL DOCUMENT

(REQUIREMENTS AND DIVISION OF RESPONSIBILITY)

ACCELERATOR AND EXPERIMENTAL SYSTEMS

ACCELERATOR AND HALL D

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ACRONYMS

AC	Alternating current
ALARA	As low as reasonably achievable
CHL	Central Helium Liquefier
DI	Deionized
DOE	Department of Energy
DX	Direct Expansion
EH&S	Environment, Health and Safety
FSD	Fast shut down system
fpm	Feet per minute
FPC	Fundamental Power Coupler
ft	Feet
HEPA	High-efficiency particulate air
HOM	Higher-Order Mode
Hz	Hertz
ICS	Integrated Control System
ID	Internal diameter
in	Inch(es)
JLab	Thomas Jefferson National Accelerator Facility
kV	kilovolt
kW	kilowatt
LCC	Life-cycle cost
Linac	Linear accelerator
LLRF	Low level radio frequency
MHz	Megahertz
NFPA	National Fire Protection Association
ODH	Oxygen Deficiency Hazard
PSS	Personnel safety System
psf	Pounds per square foot
psi	Pounds per square inch
PLC	Programmable logic controller
rf/RF	Radio frequency
SBC	Standard Building Code
SF	Square feet
SRD	System requirements document
SRF	Superconducting Radio Frequency
TBD	To be determined
UL	Underwriters Laboratories
UPS	Uninterruptible power supply
WBS	Work Breakdown Structure

INTERFACE CONTROL DOCUMENT
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ACCELERATOR AND HALL D

1. Intent of Document

The intent of this document is to provide the requirements and divisions of responsibility for the interfaces between Hall D and the Accelerator Operations, Research and Development and Engineering Divisions, hereafter referred to as Accelerator Systems Groups.

2. System Roles

Accelerator System Groups:

The Accelerator Systems provide an electron beam of up to 12 GeV to the Hall D Tagger hall and 11 GeV to Halls A, B, and C. 12 GeV is the foreseen nominal electron energy for Hall D and it is understood that operating at a lower energy rapidly degrades the Hall D physics program. As the direction of the Hall D photon beam is determined by the direction of the electrons at the point where the photons are generated, the accelerator is also responsible for steering the Hall D photon beam.

Accelerator Systems is further divided into six systems [1]: 1) SRF Cryomodules, 2) Beam Transport, 3) Linac RF and DC Power Systems, 4) Instrumentation, Controls, and Safety, 5) Extraction, and 6) Cryogenics. Each system's design solution document details system requirements and design solutions for these requirements. [2, 3, 4, 5, 6, 7] (This information is not precisely correct with the reorganization the engineering and accelerator divisions last year: http://www.jlab.org/eng/superorgchart.pdf and http://www.jlab.org/accel/office/org_chart.pdf)

Operations or Accelerator Operations, as defined in this document, refers to Accelerator Operations Division and/or Accelerator Operators and/or Accelerator System Groups.

Experimental Systems (Hall D):

Hall D is responsible for the systems, which generate and monitor the Hall D polarized photon beam. Hall D will provide a diamond or an amorphous radiator, which can be precisely positioned in the 12 GeV electron beam in the tagger hall. The interactions in the radiator generate bremsstrahlung photons, which form the beam of photons to Hall D. The diamond or the amorphous radiator will be positioned using a precision goniometer. The overall setup of the electron and photon beam in relation to Hall D is shown in Figure 1. The momentum of the electrons, which radiate the polarized photons, is analyzed in the tagger spectrometer thereby measuring the energy of the radiated photons. The tagger magnet also directs the electrons, which did not radiate photons towards the electron beam dump. The photon beam propagates from the tagger hall to the Hall D collimator cave extension. Here a collimation system selects the photons radiated at small angles, which have a higher linear polarization. Additional sweeping magnets and secondary collimation ensure that the collimation of the primary photon beam does not produce significant background for the experiments in Hall D. Downstream of the collimator cave the photon beam enters Hall D. Located in Hall D are a pair spectrometer to analyze the collimated beam, the Hall D experimental apparatus, and the photon beam dump at the far end of the hall. (The photon beam dump is not the responsibility of Hall D).

Details of the tagger hall containing most of the elements discussed below are shown in Figures 2 and 3.

3. System Requirements

Accelerator: The Accelerator Systems Group shall provide all equipment for delivery of beam of up to 12 GeV to the Tagger hall, and the electron beam dump. The maximum beam current to the tagger hall is 3 μA and the minimum current will be 1 nA. Necessary safety devices shall be implemented to prevent the transport of any electron beam to Hall D. The characteristics of the electron beam required for Hall D are summarized in Table 1[8, 9]. During the commissioning phase it is understood that the machine will not perform up to these specifications. Guidelines for expected parameters during the first years of operation are given in Appendix A. A detailed commissioning plan will be developed to allow for the machine to optimize its performance and commission all its subsystems while the Hall-D photon source and GlueX detector are commissioned in parallel.

Hall D: Hall D will provide all equipment necessary to produce the photon beam. This equipment includes crystal diamonds and amorphous targets to be used as bremsstrahlung radiators, a goniometer for precision alignment of the radiators, a quadrupole of type QP for focusing the scattered electrons on the Hall D tagger spectrometer, one dipole magnet with ∫Bdl sufficient to bend the 12GeV beam by 13.4°, detectors needed to analyze the electrons which generated the photon beam, an instrumented collimator (used to measure the photon beam centroid) in the entry cave of Hall D, and a pair spectrometer.

4. Interfaces between Hall D and the Accelerator

The Accelerator and Hall D systems, which require an interface between the two groups, are as follows, starting with systems in the tagger hall and then those in the experimental area:

1. The electron beam
2. Goniometer
3. Hall D Tagger quadrupole magnet
4. Hall-D Tagger dipole magnet
5. Electron beam dump
6. The vacuum system
7. The photon beam
8. Instrumented primary photon beam collimator and feedback system
9. Hall D collimator sweep magnets
10. Photon beam dump
11. Hall D machine inhibit (FSD)
12. Personnel safety systems (PSS)
13. Machine protection systems (MPS)

Appendix B contains a summary table of the active components in the beamline. In the following sections each of these interfaces will be defined in more detail.

1. The Electron Beam

The accelerator system groups will provide and install the beam transport system to the Hall D tagger hall. The beam transport system, as defined in this document, includes the beam pipe as well as numerous devices necessary to monitor and control the electron beam to include but not limited to BPMs, Harps, Viewers, Magnets, Ion Pumps, and BCMs [The devices closest to the tagger hall will be described, as they are most important for monitoring the beam quality. An instrumentation girder will be placed at the entrance to the tagger hall at 1860-NS on which the instruments in Table 2 will be mounted.

Device Name	Description
IPM5C11B	Beam Position Monitor
ITV5C11A	Viewer (phosphor screen)
IHA5C11A	Harp wire scanner
MBD5C11AH	Horizontal steering magnet
MBD5C11AV	Vertical steering magnet
VIP5C11A	Ion Pump

Table 1 Beam monitoring devices placed at the entrance to the tagger hall.

Directly after the instrumentation girder will be a low current beam position monitor (IPM5C11C) that is the last beam monitoring instrument in front of the Hall D goniometer.

Halfway along the labyrinth to the electron beam dump will be a beam position monitor (IPMAD00), a harp / wire scanner (IHAAD00), and a viewer (ITVAD00). Finally directly in front of the beam dump will be a beam current monitor (IBCAD00). The devices inside the labyrinth are summarized in Table 3.

Device Name	Description
IPMAD00	Beam position monitor
IHAAD00	Harp / Wire Scanner
ITVAD00	Beam Viewer
IBCAD00	Beam Current Monitor

Table 2 Devices places along the labyrinth to the electron beam dump.

All the beam line instruments above are under the responsibility of the accelerator systems group and will be controlled by the accelerator systems groups and/or accelerator operations division. Information from these instruments will be available to the Hall D experiments through the machine controls system EPICS.

2. Goniometer:

The goniometer is located upstream of the tagger magnet and is used to hold the diamond or other radiators which produce the photon beam. Hall D using its own control system will control the goniometer. The goniometer is an ultra-high vacuum device, which poses no contamination hazard to the accelerator. Accelerator Operations must ensure that the electron beam strikes the diamond crystal inside the goniometer, which is precisely positioned along the nominal beam line. The tuning of the beam on the goniometer radiator will be discussed in the startup plan and a standard operating procedure will be developed for the radiator alignment procedure. The alignment procedure for the crystals consists of rotating the radiator independently about different axes, while monitoring the energy spectrum of the bremsstrahlung photons. From this data set the exact orientation of the crystal planes can be measured and the optimum orientation of the crystal determined. Hall D will provide the information concerning the crystal position to accelerator operations via EPICS.

3. Hall D tagger quadrupole magnet:

Hall D will provide and install a QP quadrupole magnet, the stand for the quadrupole, the water cooling, the power cables, and the power supply. Accelerator system groups will provide the mapping of the magnet and the controls for magnet and power supply including the temperature switch interlock [3,4]. The QP quadrupole, MQPAD00 with nominal field gradient of 0.8 kG/cm and a length of 31.26 cm, will be installed by Hall D downstream the goniometer. This magnet is needed to focus the electrons, which underwent bremsstrahlung on the tagger spectrometer consisting of a fixed scintillator hodoscope and movable high-resolution microscope. The quadrupole will be controlled by Accelerator Operations and/or Accelerator System Groups but set at the constant current specified by Hall D. Dedicated calibration measurements, which determine the focus of the electron fan on the tagging spectrometer detectors will need to be performed periodically by Accelerator Operations. Operating procedures for these calibration measurements will be developed between Hall D and Accelerator Operations.

4. Tagger dipole magnet:

Hall D will provide and install the tagger magnet, power supply, NMR probes used for field stabilization, and an EPICS-based control system. The Accelerator System Groups will provide and install any additional equipment needed to interface the magnet to the PSS and MPS systems [4, 5]. The tagger magnet has a 1.5T nominal magnetic field which bends the 12 GeV beam by 13.4° toward the electron dump. The tagger dipole magnet must be operated by accelerator operations because it is an integral part of the accelerator personnel safety system [5]. Small adjustments to the magnetic field during machine setup are acceptable, but once data collection has started the field must remain constant. The beam steering and control devices provided by the accelerator system groups must be sufficient to enable accelerator operations to correct the beam position on the electron dump without changing the current in the tagger magnet. This magnet has been mapped by Hall D at its nominal operating current.

5. Electron Beam Dump:

The Accelerator System Groups will be responsible for the electron beam dump. The gate to the labyrinth leading to the electron beam dump will be padlocked by the radiation control department. Access to the beam dump will be restricted by the radiation control department. Radiation from the beam dump could produce background in the tagger hodoscope. The projected rates of 2000 mrem/h at the start of the labyrinth under conditions of maximum operating beam current have been computed by the radiation control department and are acceptable for the Hall D experiments. Changes to the shielding design must be made in consultation with Hall D and the radiation control department [11].

6. Vacuum system

The accelerator system group provided a 1.5" (verify???) gate valve (VBV5C11B) and Hall D installed it directly downstream of the low current beam position monitor (IPM5C11C) at 1871-NS, which is in front of the goniometer. The accelerator system groups will be responsible for the vacuum upstream of this valve and Hall D will be responsible for the vacuum downstream. Neither Hall D nor the accelerator system groups may vent their section of the beam line unless this valve is closed. The valve may only be opened with the mutual agreement of both Hall D and the accelerator system groups. The accelerator system groups will resume responsibility for the vacuum in front of the beam dump between 2030-NS and 2040-NS where they will provide and install a 2" (verify???) gate valve (VBVAD00A) and Thermocouple gauge (VTCAD00). The vacuum system components at the entrance to the electron dump region are listed in Table 5 and detailed in the system's design solution document [5, 7]. See "Song" sheets for tags.

Device Name	Description
VBVAD00	2" gate (verify???) valve
VIPAD00	Vacuum Ion Pump
VRVAD00	Roughing Valve
VTCAD00	Thermocouple gauge

Table 3. The machine vacuum system components in the Hall D tagger hall dump region.

Further vacuum components including a roughing valve (VRVAD00B), thermocouple gauge (VTCAD00A), and Vacuum Ion Pump (VIPAD00A) are placed directly in front of the electron beam dump itself.

Hall D is responsible for the vacuum between the valves VBV5C11B and VBVAD00A. This is the region from the goniometer to the valve upstream of the electron beam dump. The ultimate pressure in the Hall D section when VBVAD00Ais closed will be below $_1$ mbar. Hall D will provide, install, and control three pumping stations using turbomolecular pumps, which will be used to evacuate the Hall D tagger beam line. One pump near the goniometer will reduce the pressure to the mbar level for the machine. A second pumping station near the East wall of the tagger hall services the beam line between the tagger hall and Hall D. The third pumping station on the vacuum vessel of the tagger spectrometer evacuates this large vacuum vessel and provides pumping to the short section of beam line between the tagger vacuum vessel and the beam dump. All pumping stations will be instrumented with thermocouple pressure gages and cold cathode gages. Near the pumping station at the East wall will also be a valve where a Hall D group portable roots blower pumping station can be attached for the initial evacuation of the vacuum system. After installation, all vacuum equipment instrumentation and controls and will be read out and controlled by Hall D. Hall D will provide all information via EPICS to accelerator operations and the machine safety system as required [7]. The accelerator system groups will be provided access to control the valve so the isolation valves can be closed in case of vacuum failure. The logic of the valve control will be such that either the machine or Hall D may close the valves but they can only be opened if both parties enable the valves [10].

7. The Photon beam

The photon beam is produced by bremsstrahlung interactions of the 12 GeV electron beam in the diamond radiator. In order to produce a usable linear polarization the photon beam is collimated after a 76m-drift length. After primary collimation, sweeping magnets and secondary collimation are needed to remove unwanted particles from the beam produced by interactions in the primary collimator. The collimated beam passes through the Hall D target and the Hall D experiment and finally enters the photon beam dump. The photon beam layout is shown in Figure 1. Hall D is responsible for the photon beam line and will provide information via EPICS to accelerator operations. The design of the photon beam line has been approved by the accelerator system groups and radiation control group.

8. Instrumented primary photon beam collimator and feedback system

An instrumented collimator will be installed at the entrance to the Hall D collimator cave and will measure the centroid of the bremsstrahlung photon beam with an accuracy of 200 μm and an update frequency of up to 1 kHz depending on electron beam current. This information will be provided to accelerator operations for purposes of precise steering the electron beam on the diamond radiator and the photon beam on the primary collimator. Accelerator System Groups will provide and install a fast feedback steering system to stabilize the position of the electron beam spot on radiator and the photon beam spot on the instrumented collimator to the precision listed in table 1 above [5].

9. Hall D collimator sweep magnets:

Hall D will provide and install a pair of sweeping magnets in the collimator extension of Hall D. One of these magnets will be a permanent magnet the other magnet an electromagnet. The electromagnet will be controlled by Hall D.

10. Photon Beam Dump:

The photon beam dump is the responsibility of the radiation control department. Hall D will place less than 20% of one radiation length of material in the path of the collimated photon beam under normal running conditions. During special calibration runs at low current a total absorption counter, provided and installed by Hall D, may be placed in the photon path. Procedures for these calibration runs and any other dedicated measurements will be established between Hall D and accelerator operations.

11. Hall D machine inhibit (FSD):

Hall D will provide signals to the accelerator FSD that will be used to inhibit the transport of beam to the tagger hall. In the event of equipment failure or large backgrounds, Hall D can inhibit the transport of the electron beam to the tagger hall. A beam shutter will be provided in the beam transport region, which is described in the accelerator design solution document for safety systems [5]. (What is this shutter? I am unable to locate the source document…)

12. Personnel safety systems (PSS):

Two parts of the Hall D provided equipment are integrated into the CEBAF PSS [5].

A Beam Transport Monitor (BTM) provided by the Accelerator System Groups will continuously monitor the currents in the magnets, which steer the beam into the tagger hall, and the tagger magnet current read back. The currents in these magnets are compared and if they deviate from the combination needed to transport the beam to the hall and beam dump then the beam will be dumped. The currents in each magnet will be measured with ~~a~~ 3-fold redundancy. To implement this system, the tagger magnet will be controlled by accelerator operations.

In the event there is a failure in the above active system, a passive fail-safe system is foreseen that makes it impossible for the electron beam to be transported to Hall D. Hall D will provide and install a permanent dipole magnet with an integrated field strength of 0.822 Tm in the photon beam line at about 2030-NS. This magnet was constructed at Fermi National Laboratory and is of type PDV [8]. The dipole gap is such that a 1 ½ by 3 ½ elliptical beam pipe fits down the bore. The magnet iron is 145" long. This magnet will be mounted downstream of the tagger magnet and forms part of the personnel safety system. It has sufficient strength to insure that the 12 GeV beam cannot be transported into Hall D. Any electron beam passing through the dipole will be steered down toward the floor of the tagger cave.

The permanent magnet dipole has no active components. The exact position of the magnet in the hall has been agreed upon by Hall D and the accelerator system groups [3]. Accelerator system groups will inspect magnet installation for polarity to ensure the electron beam passing through this dipole will steer down toward the floor of the tagger cave [3].

In addition to the above the accelerator system groups will provide and install ion chambers in the Tagger hall along the East wall to detect transient beam loss associated with failed optics.

13. Machine Protection System (MPS):

The tagger Machine Protection System (MPS) is an extension of the existing CEBAF MPS architecture. Fast shutdown (FSD) modules are linked in a tree structure back to the CEBAF injector. The FSD will monitor interlocks on the beamline and electron dump. FSD inputs include vacuum/valve status, beam dump cooling, radiator status, and the experiments inhibit. Beam Loss Monitors (BLM) will be positioned at tight apertures and bends where loss is most likely. Ion chambers (ICs) will be positioned near the radiator to detect beam loss in a thick target. The existing CEBAF Beam Loss Accounting (BLA) System will include a cavity monitor at the electron beam dump. The BLM, ICs, and BLA trip the beam off through the FSD network when a fault is detected. If any gate valve closes or there is a vacuum failure the beam will also be disabled. The

Beam Envelope Limit System (BELS) monitors the total beam power in CEBAF to ensure the JLab operations and DOE safety envelopes are not exceeded. The existing BELS has been extended to account for beam power directed to the tagger/Hall D. Energy calculated from the BTM is multiplied with the value of the current measured in the BCA system. A local limit for the tagger area will provide protection for the beam dump. In addition, the beam power in the electron dump is combined with the beam power for the other experimental areas to verify the total beam power for the facility.

5. Figures

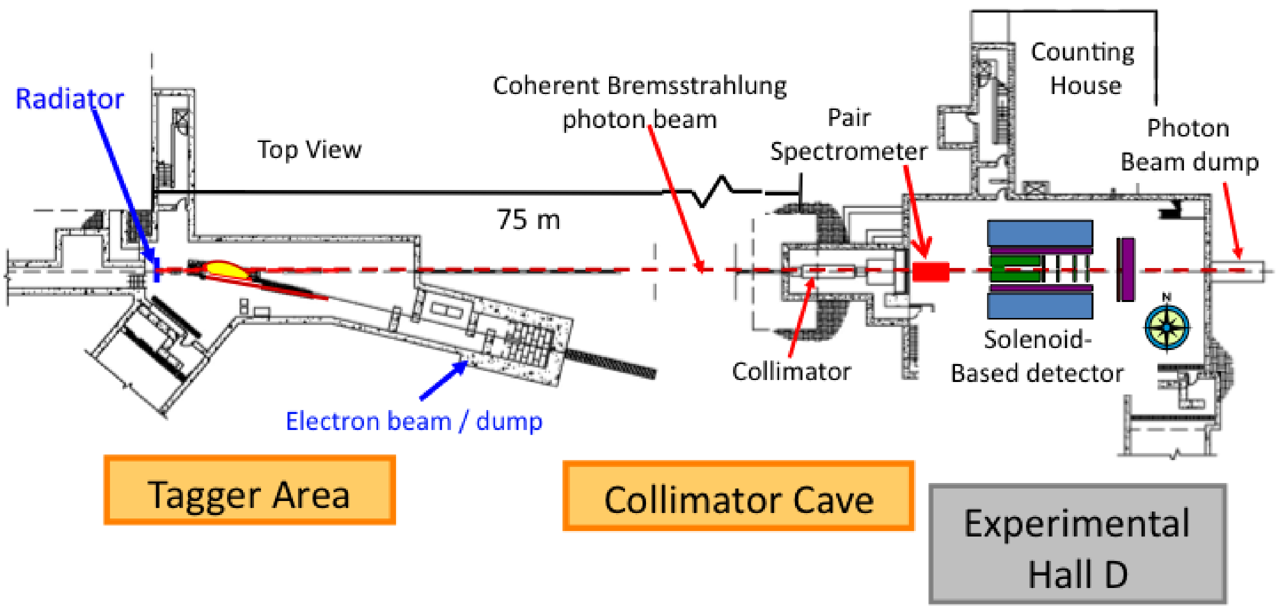

Figure 1 Overview sketch of the Tagger Hall and experimental Hall D. The configuration of walls and shielding is from the original design.

6. Reference Documents

[1] 12GeV Upgrade Accelerator Systems Requirements Document, Version 1.2

[2] 12GeV Upgrade Project Design Solution Document Cryomodules, Version 1.0

[3] 12GeV Upgrade Project Design Solution Document Accelerator Systems Beam Transport, Version 1.1

[4] 12GeV Upgrade Project Design Solution Document Accelerator Power Systems, Version 1.0

[5] 12GeV Upgrade Project Design Solution Document Instrumentation & Controls/Safety Systems, Revision 0

[6] 12GeV Upgrade Project Design Solution Document Accelerator Systems Extraction, Version 1.2

[7] 12GeV Upgrade Project Design Solution Document Cryogenic Systems, May 31, 2007

[8] E.S. Smith and E. Wolin, "Electron Beam Deflection by Permanent Magnet," GlueX-doc-599, February, 2006.

[9] R.T. Jones, "GlueX Requirements for 12 GeV Electron Beam Properties," GlueX-doc-646, June, 2006.

[10] GlueX Collaboration, "Mapping the Spectrum of Light Quark Mesons and Gluonic Excitations with Linearly Polarized Photons," GlueX-doc-1226, July, 2006.

[11] A detailed interface document for the logic of the valve controls for the vacuum system needs to be developed and referenced here.

[12] Erik Abkemeier, Pavel Degtiarenko, Keith Welch, Radiation Control Department, "Shielding Basis for Hall D Complex," JLAB-TN-08-033

Appendix A: Parameters of the Hall D beam

It is clear that the final parameters of the beam delivered to Hall D will not be achieved on day one. However, significant progress can be made in commissioning the beam line and detector systems with beams that do not meet the final specifications, shown in "year 2" in the table. These tables provide guidelines for the parameters of the beam during the first couple of years after turn-on. All parties involved will work together to plan for beam delivery that optimizes resources and technical priorities as we learn how to use the new facilities.

	first 6 months	**months 6-12**	**year 2**
minimum energy	10 GeV	11 GeV	12 GeV
maximum current	3 μA	3 μA	3 μA
minimum current	1 nA	1 nA	1 nA
maximum emittance	50 nm-rad	20 nm-rad	10 nm-rad
maximum energy spread	0.5%	0.5%	0.1%
uncertainty in beam energy	0.5%	0.5%	0.1%
spot size at radiator (horizontal)	0.5mmσ_x2.0mm	0.5mmσ_x1.5mm	0.8mmσ_x1.1mm
spot size at radiator (vertical)	0.3mmσ_y2.0mm	0.3mmσ_y1.5mm	0.3mmσ_y1.1mm
maximum halo fraction[1]	10^{-4}	10^{-4}	$5 \cdot 10^{-5}$
knowledge of e-[2] polarization	*unspecified*	*unspecified*	< 1%

Table 5. Guidelines for parameters of the Hall D electron beam during the first two years of operation.

	first 6 months	**months 6-12**	**year 2**
maximum x spot size	2 mm RMS	1 mm RMS	0.5 mm RMS
maximum y spot size	2 mm RMS	1 mm RMS	0.5 mm RMS
x and y position stability	1 mm RMS	0.5 mm RMS	0.2 mm RMS
position stabilization bandwidth @ 300 nA	1 Hz	60 Hz	1000 Hz
x and y range of motion[3] of virtual spot at coll.	±25 mm	±25 mm	±25 mm
x and y centering[4] of real spot at radiator	±1.0 mm	±0.5 mm	±0.5 mm

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[1] Fraction of electron beam outside a radius of 5 mm at goniometer

[2] Time average over 10 s.

[3] Refers to ability to move the virtual spot over a certain range on the collimator entrance plane, while independently keeping the real spot centered on the radiator, possibly through a sequence of steps. This has implications for the size of the electron beam dump and beam line leading to it.

[4] Refers to ability to reproducibly center the real electron beam spot on a fixed location at the radiator position, while independently moving the virtual spot on the collimator, possibly through a sequence of steps. Spot moves on the diamond surface are accomplished by translations of the diamond goniometer mount.

virtual spot placement[5]	±5 mm	±5 mm	±5 mm

Table 6. These parameters describe the size, stability and range of motion of the virtual electron beam spot projected forward from the radiator to the primary photon beam collimator in Hall D. This spot is what the electron beam intensity pattern would look like if there were no magnetic fields between the radiator and the collimator.

Beam Emittances
Emittance Initial (Arne): emittance,x < 50nm*rad;   emittance,y < 10nm*rad
Emittance Physics (Arne): emittance,x = 10nm*rad;   emittance,y < 5nm*rad
Electron beam emittance: emittance,x < 10 mm-µrad; emittance,y < 2.5 mm-µrad (ICD9 table)

Beam Sizes:
radiator(Arne):   sx < 1550 um; sy < 550 um
Spot size at radiator: sx < 1600 um; sy < 600 um (ICD5)
Spot size @ radiator   800 µm < sx <1600 µm (ICD9 table)   300 µm < sy <600 µm (ICD 9 table)

[5] Refers to ability to place the virtual spot within the active collimator acceptance during initial beam tune-up using electron beam instrumentation alone, before the active collimator is switched on.

Appendix B: Active Systems in the Beamline.

This document lists the beamline active systems from the shield wall at the entrance of the tagger area to the Hall D photon beam dump. It defines the control responsibilities (accelerator or/and Hall D) for these systems, what signals should be send to MCC and what signals are connected to FSD. Passive components such as collimators or permanent sweeping magnets are not listed. Devices belonging to the electron beam line are in blue. Devices belonging to the electron beam line are in red.

System	Purpose	Control	Signals	In FSD?
Ion chambers	System protection	MCC	MCC	Yes
Neutron detectors	System protection/beam tuning	Hall D	HallD/MCC	No
Goniometer	Polarized photon beam production	Hall D	Hall D. Some to MCC	No[6]
Amorphous radiators/Wire scanner	Incoherent bresmsstrahlung production/ Beam halo monitoring & Beam profil	Hall D /MCC[7]	Hall D. Some to MCC. Ladder position interfaced with FSD	Yes
Halo PMT	Beam halo monitoring	Hall D	Hall D/MCC	No
Quadrupole	Beam transport	MCC	MCC	No
Tagger magnet	Photon energy determination	MCC	MCC and Hall D. Magnet current B-field from NMR	No
Line Vacuum	Beam transport	Hall D	Hall D/MCC	Yes
Beam profiler	Rough beam position. (Present during commissioning)	Hall D	Hall D/MCC	No
Active collimator	Beam position monitoring and fast feedback. Collimate the beam	Hall D	MCC/Hall D	No
Sweeping magnet	Beam clean-up	Hall D	Hall D	No

[6] φ rotations and x, y linear translations must be disabled when beam is on. θ rotations are permitted with beam on (ref.: Fig 2.14, GluEx TDR, 12/17/2013). If φ, x or y changes with beam on, MCC must trip the beam (standard shutdown: ~100 μs??). If the two previous levels of protection fail, ion chambers will FSD the beam.

[7] Wire scanner only. To be used by MCC as a Harp. There should be a procedure at MCC so that the Hall D shift crew is informed when MCC runs the harp (beam may not be acceptable for physics when the harp is used). Specific limit to be set on the ion chambers when in use.

Polarimeter	Photon beam polarization	Hall D	Hall D only	No[8]
Pair spectrometer's converter/Harp	Photon beam flux measurement / Photon beam profile	Hall D	Hall D only	No[8]
Target	Nuclear physics program	Hall D	Hall D, send Full/Empty Liquid/gas info to MCC	No
TAC	Photon beam flux measurement	Hall D	Hall D. Some to MCC	No[9]
Line Vacuum	Beam transport	Hall D	Hall D/MCC	Yes

[8] No Need for FSD: frame is thinner than LH2 target.

[9] Signals to be sent to MCC so that no more than 2 nA can be delivered when TAC is in. Limit on the EPICS signal should trip the beam if signals are above it (standard shut down: 100 μs is enough rather than 10 μs FSD).