BaBar Bar Box Disassembly, Bars Inspection and Test Plan

Greg Kalicy[1], Joe Schwiening[2], and Andrew Lumanog[3]

[1] Catholic University of America
[2] GSI Helmholtzzentrum für Schwerionenforschung
[3] Jefferson Lab

April 12, 2026

Abstract

The baseline design of the ePIC hpDIRC at Electron-Ion Collider (EIC) requires 480 long, rectangular bars, made from synthetic fused silica, as radiators and light guides. The potential reuse of legacy DIRC bars from the BaBar experiment has been proposed to mitigate the cost and schedule risk.

A total of 384 BaBar DIRC bars, placed in 8 aluminum bar boxes, were made available to EIC. These bar boxes have been in storage at SLAC, CA since 2010 and have been transported from SLAC to TJNAF in early 2024. They are being disassembled at TJNAF to extract the individual DIRC bars for the ePIC hpDIRC. This note summarizes important information about the BaBar DIRC bar boxes, the bar box disassembly process, extraction of the individual DIRC bars, their cleaning, inspection, optical quality measurement, and finally long-term storage.

Contents

List of Figures

1. BABAR BAR PROPERTIES

The BaBar DIRC detector was constructed at SLAC about 25 years ago and installed in the BaBar experiment in 1999. The experiment took data from 1999 through 2007 before the detector was decommissioned in 2010 and the detector components were placed into storage at SLAC.

The BaBar DIRC components of interest for the ePIC experiment are the DIRC bars, which are made of synthetic fused silica in the form of highly polished, long, thin bars with a nominal rectangular cross section (17.25 mm x 35.0 mm). The individual 4.9 m-long bars, referred to as ‘‘long-bars’’ during the production process, are each made up of four shorter 1.225 m-long pieces, referred to as ‘‘short-bars’’, which are glued end-to-end using Epotek 301-2 epoxy glue. Each has a mirror attached on one end and a fused silica wedge on the other end.

Size tolerances and end-side squareness are required for gluing and assembly of the new ePIC bar boxes as assembled from individual short bars. This relates to the width, thickness and length of the DIRC bars. Measurements and documentation of each bar were part of the original series production contract for BaBar and this was cross-checked at SLAC. Information on the mechanical size measurements and documentation was transmitted with the bars. This mechanical property is not part of the further QA process.

The list of properties that affect the performance of hpDIRC are below. Each property also requires validation during QA process of the DIRC bars.

- Surface Quality: The physical state of the DIRC silica bars after they are taken out of the BaBar DIRC box. Surface roughness and edge sharpness is required across the entire DIRC bar. Excellent surface polish is required to ensure high photon transport efficiency, with a reflection coefficient > 0.999 at 400 nm wavelength. This is to limit photon loss during several hundred internal reflections.
- Geometrical shape: The shape of the DIRC silica bars after they are taken out of the BaBar DIRC box. The DIRC bars have very strict criteria on flatness, squareness and parallelism. This is essential to maintain the Cherenkov angle during reflections.
- Internal surface homogeneity: Internal inhomogeneity of the Silica bar itself, which is not directly visible by eye. Inhomogeneity contributes to the Cherenkov photon loss inside the bar. It can be attributed to bulk deformity inside the bar. Thus, it is important to measure attenuation of the photon passing through the bar before installing it in the final detector. This is done by using a laser and relevant optical setup.

2. PROCESS AND PROCEDURES

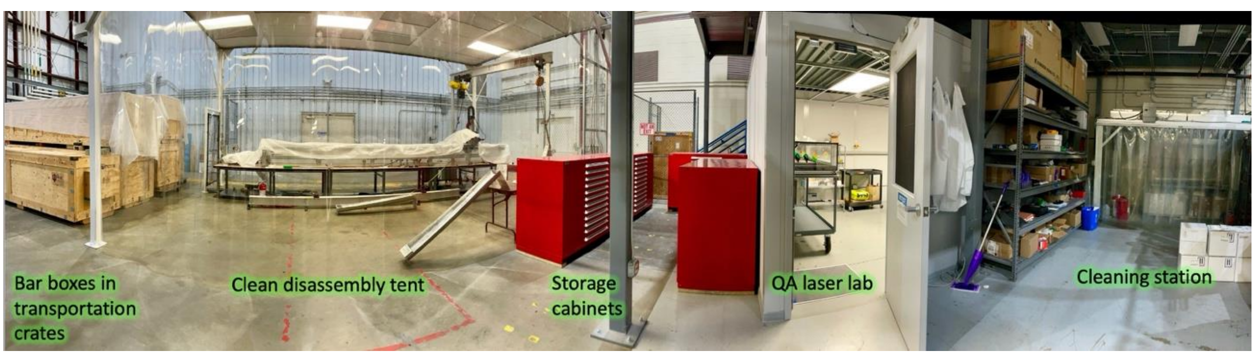

Figure 1. Photo of the DIRC space in JLab designated for disassembly, inspection, QA, and storage of the DIRC bars.

The DIRC bar QA process will proceed in three phases: 1) Disassembly, 2) Visual inspection of the bar, and 3) Performing QA in the laser lab by measuring reflectivity properties of the bars themselves.

Figure 1 shows the DIRC workspace at JLab, including all stations associated with DIRC bar handling and processing. After being transferred from SLAC to JLab, the bar boxes are stored in custom-designed transport crates equipped with a double-suspension system and multiple foam layers to ensure mechanical safety during storage and handling.

2.1. Disassembly

For disassembly, each transportation crate is individually rolled into the clean disassembly tent. The bar box is then lifted from the crate using a dedicated gantry system and positioned on a precisely leveled CNC frame. There, the aluminum shells are carefully removed, and the individual bars are separated using a controlled heat-gun setup. Once a short bar is extracted, its ends are immersed in acetone baths to safely dissolve any residual epoxy from the glue joint as shown in fig 2.

Figure 2. Photos of the setup used to remove residue glue from separated DIRC bars.

Figure3 (a) shows the end surface of the bar right after the glue joints are broken, figure 3(b) shows the end surface after an hour of immersing the end of bars in acetone and figure 3(c) shows the bar end after scraping off the glue. The bar is then moved to the cleaning station for detailed inspection, cleaning, and documentation.

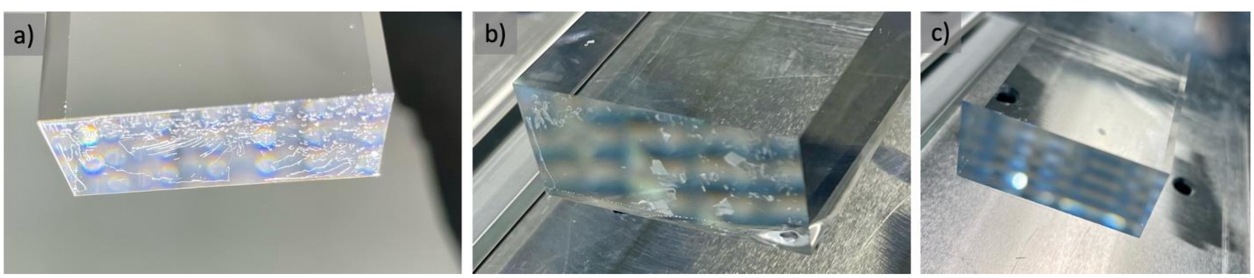

Figure 3. Photos of the bar end during three phases of residue glue removal from separated DIRC bar.

2.2. Surface Quality

The surface quality is important for the photon transport coefficient which determines how many photons are lost during multiple internal reflections within the DIRC bar. The surface quality is affected by impurity on the surface of the bar and also physical imperfection in the form of scratches and chips due to long term use, improper handling, or during the polishing process of the bars themselves after their production. The surface quality can be measured by internal reflection measurements using a laser and suitable optical setup.

2.2.1. In-Process Testing

The DIRC bars have already been produced by vendor to be used in the past BaBar experiment. During the production of the bars, they were tested for surface roughness before being sent to SLAC to be installed in the BaBar experiment. As the bars are being reused in ePIC, the in-process testing is not applicable.

2.2.2. Verification Testing

The separated DIRC bars are moved to a dark room where strong halogen light is used to illuminate the bars. This will show all the scratches and any other kind of deformity on the surface or on the edges of the bar. At the same time all the surface impurities on the bars are investigated. The cleaning procedure begins with de-ionized, filtered compressed air to remove larger dust particles. The bar is then sequentially rinsed with de-ionized water, wiped with acetone, wiped with Hastilite, rinsed again with de-ionized water, and finally wiped dry to prevent any residual smudges.

After cleaning, the bar undergoes a detailed visual inspection. All visible scratches are documented, distinguishing between original production marks and any new scratches that may have occurred during cleaning. The total scratched surface area is estimated and compared to the overall bar area to assess the potential impact on photon transmission efficiency in the detector. Figure 4(a) shows a DIRC bar before cleaning while figure 4(b) is after cleaning. Once the bars are cleaned, they are moved to the laser room where the internal reflection of the bar is measured

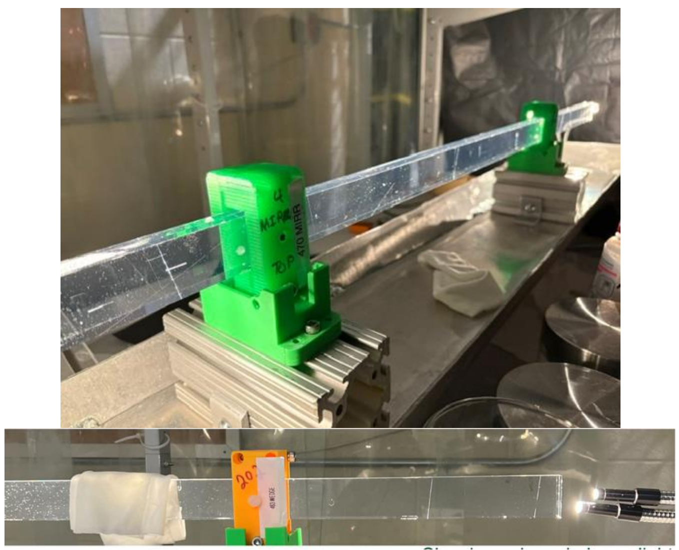

Figure 4. DIRC silica bar before (top) and after (bottom) cleaning

2.2.3. Failures and Non-Conformances

If during the visual inspection process there is large chip *(of the order of a few cm)* at the edge, the bar is rejected for use as DIRC bars, and instead they are utilized as light guides. If the internal reflection measurement in the laser lab shows a value less than 99%, the bar is re-cleaned. If there is no improvement in internal reflection (> 99%), the bar is rejected.

2.3. Geometrical shape

In order to preserve Cherenkov angle during internal reflections the bars have very strict criteria on flatness, squareness and parallelism.

2.3.1. In-Process Testing

The DIRC bars were produced by a vendor to be used in the BaBar experiment. During production of the bars, they were tested for geometrical shape. The vendors have provided the data sheet on each bar in terms of flatness, squareness and parallelism.

2.3.2. Verification Testing

The bars were already verified by the BaBar experiment for their flatness, squareness and parallelism and due to reuse of the same bars this parameter is not strictly measured for EIC.

2.3.3. Failures and Non-Conformances

Only visual tests are performed. If the bar is visibly bent, it is rejected.

2.4. Internal surface homogeneity

Internal inhomogeneity of the Silica bar itself which is otherwise not visible to the eye. Inhomogeneity itself contributes to the Cherenkov photon loss inside the bar can also be attributed to bulk deformity inside the bar.

2.4.1. In-Process Testing

The properties have been tested by the vendor and have been provided in the form of a data sheet to the BaBar experiment. See Section 5.1 on the manufacturer/producer records.

2.4.2. Verification Testing

The internal homogeneity is measured by using a laser and suitable optics by measuring the parameter bulk attenuation

2.4.3. Failures and Non-Conformances

If bulk attenuation is more than 0.5% the bar is rejected.

3. EXPERIMENTAL/TEST SETUPS

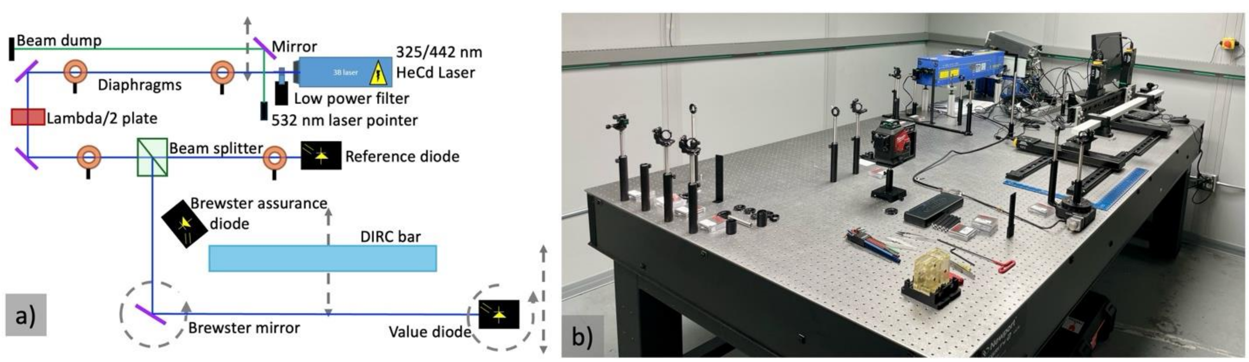

Figure 5. Schematic and photo of the laser setup used for the QA of the DIRC bars.

The laser setup, shown in Fig. 5, is based on the system developed at GSI for the PANDA Barrel DIRC and provides comparable measurement capabilities to those originally used at SLAC for the qualification of DIRC bars prior to the BaBar detector assembly. The setup utilizes a dual-wavelength laser source (325 nm and 442 nm) for measurements of the bulk transmission and reflection coefficients, enabling the determination of photon transport efficiency and assessment of bar surface quality with sub-nanometer precision. The results are compared to the reference data obtained during the BaBar DIRC pre-construction phase and two reference DIRC bars obtained from SLAC that were never used in detector.

A reference photodiode continuously monitors laser output to correct for any systematic fluctuations or instabilities in the setup. The DIRC bar under test, the mirror directing the laser beam into the bar, and the main photodiode are all mounted on precision motion-control stages that enable scanning across multiple positions on the bar surface. The sensors positions can be finely adjusted to ensure reproducible and reliable signal measurements. The motion control is fully integrated with the data acquisition (DAQ) software implemented in LabVIEW, while the sensors are read out through a PicoAmp connected to the PC.

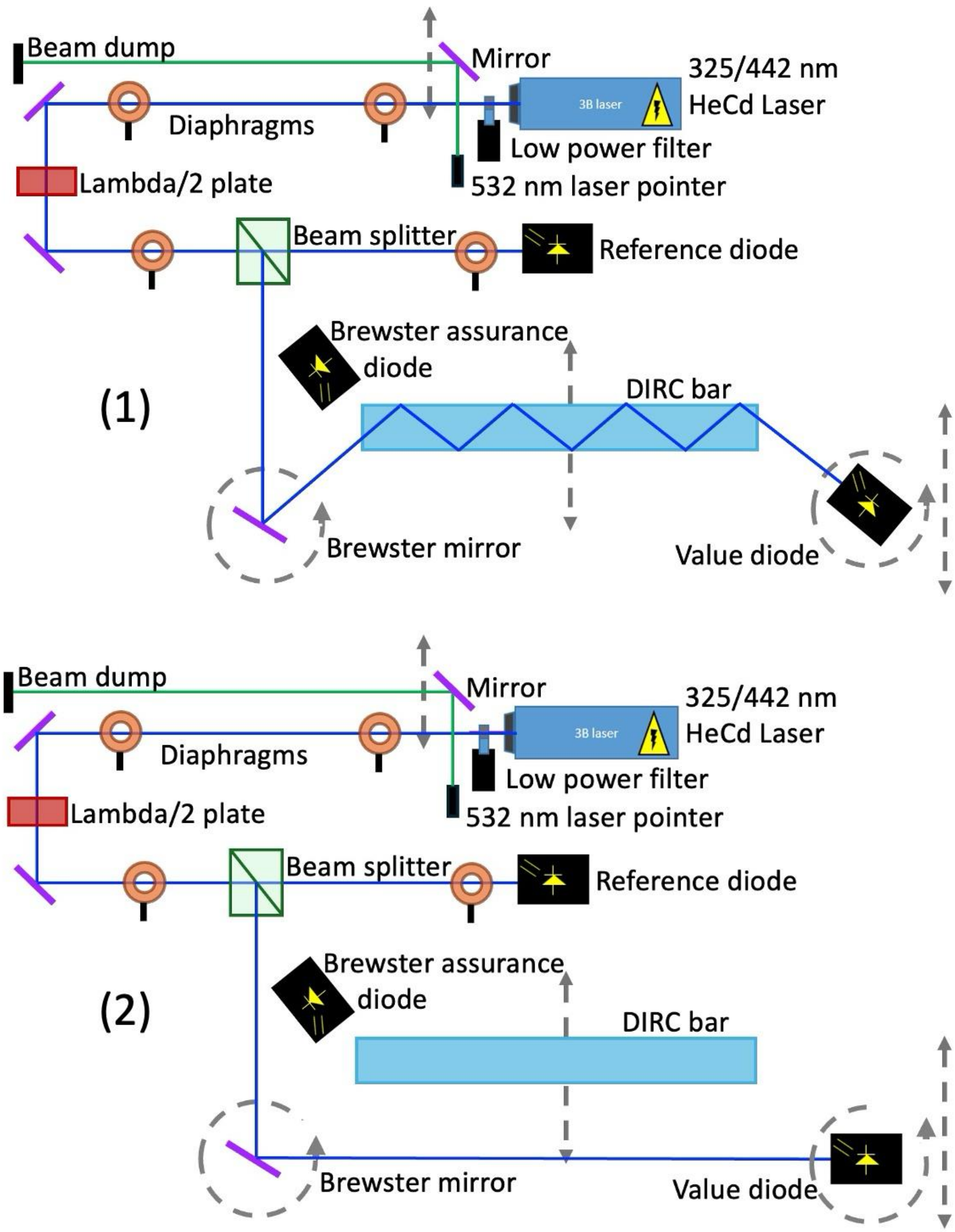

Figure 6. Schematic of the setup for Internal Reflection (1) and Bulk Attenuation (2) mode of measurement

This section defines the quality assurance (QA) measurement procedure applied to disassembled DIRC bars using a laser-based optical setup. The purpose of this procedure is to quantify the bulk attenuation and internal reflection performance of each bar and to extract the effective reflection coefficient, ensuring compliance with optical performance requirements.

The measurement procedure consists of two primary tests: **Bulk Attenuation** and **Internal Reflection** scans. These tests are conducted using a stabilized laser source, precision alignment optics, and photodiode-based readout. The procedure is applied after bar disassembly and cleaning, prior to integration into detector assemblies, and serves as a critical verification step of optical quality.

This procedure is sufficient to ensure functionality and performance because it directly probes the two dominant mechanisms governing photon transport in DIRC bars: bulk transmission losses and surface reflection efficiency. By comparing measured signals to a calibrated reference, systematic effects are minimized, allowing precise determination of bar quality.

Once the laser system is powered on, it must undergo a **warm-up period of at least 45 minutes** to reach thermal and intensity stability.

Following stabilization, the **beam alignment must be verified** throughout the entire optical path:

- The laser spot is tracked through all optical elements to ensure it does not clip on any diaphragm edges.
- Reflections from attenuation filters are monitored and directed safely (typically toward a designated corner of the room), ensuring no stray reflections interfere with measurements.

Next, the **DIRC bar is installed into the setup**. Proper alignment is critical and includes:

- Ensuring the laser beam is parallel to the longitudinal axis of the bar.
- Positioning a Brewster mirror at the Brewster angle (17.148°) to define and verify beam polarization and alignment.
- Adjusting linear motor stages controlling the bar position so that the beam undergoes total internal reflection within the bar.

Alignment is confirmed by verifying that the beam enters and exits the bar at the same vertical (Y) position.

Data acquisition is performed using the LabVIEW-based software **DIRCDAQMeasure**, which is operated in two modes:

- **Bulk Attenuation Mode**
- **Internal Reflection Mode**

Before starting measurements, the following checks must be completed:

- Verify the starting and ending positions of the laser for both scan modes.
- Ensure the laser beam fully enters the bar without encountering chips, cracks, or surface defects.
- Confirm that the beam spot is centered on the photodetector (PD3) for all configurations, including the reference "pure beam" case where the beam travels directly from the Brewster mirror to the sensor.

Measurements are performed in the following order:

1. Bulk Attenuation scan
2. Internal Reflection scan

During data acquisition, the system records:

- Motor positions
- Time stamps
- Signal intensities from three photodiodes (PD1, PD2, PD3)

Photodiode **PD1 is used as a reference detector** to normalize intensity fluctuations.

The measurement principle is based on comparing:

1. A beam undergoing total internal reflection within the bar
2. A reference beam propagating through air

In both cases, the ratio of measured intensity to reference intensity is used:

$$R = \frac{\text{Signal PD}}{\text{Reference PD (PD1)}}$$

Formula 1.

This normalization removes systematic variations in laser intensity and environmental conditions.

The **bulk attenuation length** is extracted from the exponential decrease of intensity with propagation distance:

$$I(x) = I_0 e^{-x/\lambda}$$

Formula 2.

where λ is the attenuation length.

The **internal reflection coefficient (r)** is determined by combining bulk attenuation with the number of internal reflections (N) along the optical path:

$$I = I_0 \cdot r^N \cdot e^{-L/\lambda}$$

Formula 3.

By comparing measured intensities for different path lengths and reflection counts, the reflection coefficient (r) for each bar is extracted.

An example of the measurements of the internal reflection coefficients for one bar is provided in Fig. 7. In this example, the SLAC measurements indicated 0.99962. The first graph, to the far left, is an illustration of the setup. The third graph shows the measurements over time where the laser scans the (x,y) area of the bar. The red line indicates a value of 0.9995, the minimum value we expect after cleaning the bars after successful disassembly. The second graph represents a 2D (x,y) map of this data, with the coloring indicating the value of the reflection coefficient R. The green box then highlights the area with worse reflection coefficients. The fourth graph, to the far right, optically illustrates the diffusion of the laser light there.

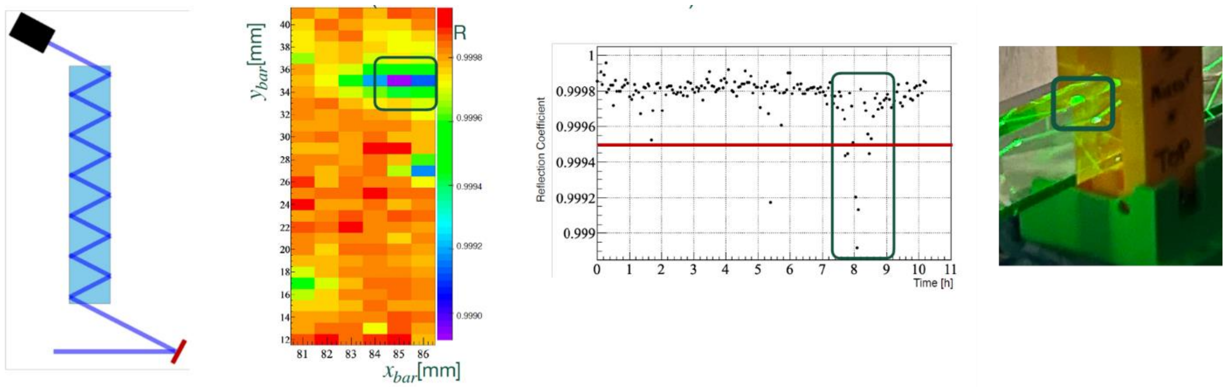

Figure 7. Example of the measurements of the internal reflection coefficients for bar 502.

3.1. Resource Requirements

Dark room with temperature modulated setting and laser safety interlock

3.2. Equipment

- He-Cd laser
- DAQ computer
- Several optical equipment (beam splitter, diaphragm, reflective mirror)
- Keithley picoammeters
- Velmex X-Y-Z translation stages
- Photo diode sensors

4. ENVIRONMENT, SAFETY & HEALTH CONSIDERATIONS

The procedures described above will be implemented in a way consistent with the environment, safety, and health policies of the relevant work areas. Within Jefferson Lab the process is described in the ES&H manual Chapter 3200, Work Planning and Control Program. Potential exposure to laser light will be mitigated via interlocked laser room. Also, proper disposal of chemicals along with personal protection equipment like glasses, gloves and closed toe shoes will be mandatory while cleaning the bars or operating the laser.

5. RECORDS AND DOCUMENTATION

All the records for number of bars separated, the measurement from each bar and cleaning status of each bar are being stored in database accessible by personnel involved in the project.

5.1. Manufacturer/Producer records

The vendor has already provided the specification sheets for each bar. Detailed QA results from the original manufacturer (Boeing) were shared with the SLAC group as part of the original series production contract for BaBar. Data was further cross-checked by the BaBar collaboration. The information passed on as travelers for the bars includes:

- A high-level summary spreadsheet is available for every bar, and inspection sheets are available for most of the bars.

- A spreadsheet is available for the long bars as assembled in the original BaBar DIRC bar boxes. This is crucial to keep track of bar IDs for future assembly for ePIC.

Examples of transmitted information by the original vendor and further inspection results are given below.

Bar #	Boeing Label	4-Bar Ass'y	Date	SLAC Label	Length	Thickness end1	Thickness mid	Thickness end2	Width end 1	Width end1	Width mid	Width end2	Width end2	Face 1	Face 2	Side 1	Side 2	End 1	End 2
101	04-020	10-B	12/17/1998	101	48.199	0.6758	0.6762	0.675	1.3221		1.3243		1.32215	5	5	4.9	5.49	16.33	19.59
102	04-017	10-B	12/17/1998	102	48.199	0.6744	0.674	0.6726	1.3221		1.3243		1.32215	4.93	5	4.9	5.49	16.33	19.59
103	05-008	8-A	12/17/1998	103	48.217	0.675	0.6744	0.6754	1.3402		1.3414		1.3396	4.57	4.34	4.81	4.91	10.3	14.29
104	05-003	8-A	12/17/1998	104	48.217	0.6767	0.6761	0.6765	1.3402		1.3414		1.3396	4	4.74	4.81	4.91	10.3	14.29
105	05-011	8-A	12/17/1998	105	48.217	0.6744	0.6741	0.675	1.3406		1.3418		1.3396	4.74	4	4.82	4.95	10.3	14.29
106	04-029	8-A	12/17/1998	106	48.199	0.6759	0.6765	0.6759	1.3406		1.3418		1.3396	4.01	4.75	4.82	4.95	16.33	19.59
107	12-003	37-A	12/23/1998	107	48.219	0.6485	0.6485	0.6478	1.37505		1.3773		1.3749	4.58	4.56	4.89	4.51	6.96	11.35
108	12-010	37-A	12/23/1998	108	48.219	0.6509	0.6512	0.6511	1.37505		1.3773		1.3749	3.79	4.64	4.89	4.51	6.96	11.35
109	11-002	37-A	12/23/1998	109	48.219	0.652	0.6527	0.6515	1.3749		1.3773		1.3749	4.43	4.88	4.96	4.68	6.96	11.35
110	12-017	37-A	12/23/1998	110	48.219	0.6477	0.649	0.6484	1.3749		1.3773		1.3749	3.65	3.98	4.96	4.68	6.96	11.35
111	12-004	37-B	12/23/1998	111	48.219	0.6484	0.6482	0.6475	1.37505		1.3776		1.3754	3.82	4.54	4.99	4.97	6.96	11.35
112	12-009	37-B	12/23/1998	112	48.219	0.6507	0.6512	0.6512	1.37505		1.3776		1.3754	2.88	4.4	4.99	4.97	6.96	11.35
113	11-001	37-B	12/23/1998	113	48.219	0.6524	0.653	0.6517	1.3754		1.37745		1.37535	4.46	4.67	4.96	4.99	6.96	11.35
114	12-018	37-B	12/23/1998	114	48.219	0.6475	0.6488	0.6482	1.3754		1.37745		1.37535	3.98	4.13	4.96	4.99	6.96	11.35
115	17-016	31-A	12/23/1998	115	48.219	0.6661	0.6673	0.6666	1.37185		1.3747		1.3712	4.87	3.84	4.99	4.98	6.96	11.35
116	17-020	31-A	12/23/1998	116	48.219	0.6623	0.6636	0.6621	1.37185		1.3747		1.3712	4.83	3.73	4.99	4.98	6.96	11.35
117	15-012	31-A	12/23/1998	117	48.219	0.6649	0.6653	0.6655	1.37165		1.3746		1.37105	4.45	4.33	4.52	4.69	6.96	11.35
118	15-005	31-A	12/23/1998	118	48.219	0.6645	0.6643	0.6637	1.37165		1.3746		1.37105	3.71	3.69	4.52	4.69	6.96	11.35
119	17-030	30-A	12/23/1998	119	48.219	0.6667	0.6686	0.6671	1.36355		1.36625		1.3636	4.15	4.46	4.51	4.71	6.96	11.35
120	17-005	30-A	12/23/1998	120	48.219	0.6684	0.6704	0.6689	1.36355		1.36625		1.3636	3.95	4.3	4.51	4.71	6.96	11.35
121	08-006	30-A	12/23/1998	121	48.219	0.6697	0.6699	0.6693	1.36365		1.3662		1.3637	4.06	4.72	4.94	4.3	6.96	11.35
122	17-011	30-A	12/23/1998	122	48.219	0.6668	0.6686	0.6672	1.36365		1.3662		1.3637	4.24	3.45	4.94	4.3	6.96	11.35
123	11-030	32-B	12/29/1998	123	48.219	0.6506	0.6506	0.65	1.3747		1.3768		1.3749	3.03	4.67	4.93	4.56	6.96	11.35
124	11-028	32-B	12/29/1998	124	48.219	0.6509	0.6509	0.6507	1.3747		1.3768		1.3749	4.11	3.42	4.93	4.56	6.96	11.35
125	11-012	32-B	12/29/1998	125	48.219	0.6531	0.6532	0.6538	1.3747		1.37675		1.3746	4.96	4.58	4.98	4.78	6.96	11.35
126	10-014	32-B	12/29/1998	126	48.219	0.654	0.6554	0.655	1.3747		1.37675		1.3746	4.88	4.08	4.98	4.78	6.96	11.35
127	17-015	31-B	12/29/1998	127	48.219	0.666	0.6672	0.6667	1.3713		1.3733		1.37115	4.09	4.84	4.79	4.7	6.96	11.35
128	17-019	31-B	12/29/1998	128	48.219	0.662	0.6634	0.6619	1.3713		1.3733		1.37115	4.98	4.06	4.79	4.7	6.96	11.35
129	15-006	31-B	12/29/1998	129	48.219	0.6644	0.6641	0.6635	1.3712		1.3735		1.37105	3.87	3.61	4.75	4.82	6.96	11.35
130	15-011	31-B	12/29/1998	130	48.219	0.6652	0.6657	0.6658	1.3712		1.3735		1.37105	3.88	4.88	4.75	4.82	6.96	11.35

Bar #		microns	Face to Side Squareness A	B	C	D	E	F	G	H	End to Side Squareness I	J	K	L	End to Face Squareness M	N	O	P	RMS angle	Max angle
101	30.5	55.88	-0.14	0.16	0.16	-0.24	-0.24	0.26	0.26	-0.34	0.02	0.29	0.19	0.03	0.25	0.27	0.29	0.47	0.23	0.34
102	45.7	55.88	-0.34	0.26	0.16	-0.34	-0.34	0.36	0.26	-0.54	0.12	0.11	0.61	0.93	0.16	0.16	0.41	0.61	0.34	0.54
103	25.4	45.72	-0.14	-0.14	-0.34	0.16	-0.14	-0.14	-0.24	0.26	0.04	0.22	0.03	0.26	0.27	0.07	0.1	0.23	0.21	0.34
104	15.2	45.72	0.26	0.06	-0.34	0.46	0.16	0.06	-0.24	0.36	0.04	0.29	0.07	0.29	0.11	0.11	0.2	0.17	0.28	0.46
105	22.9	55.88	0.06	-0.24	-0.54	0.36	0.06	-0.24	-0.44	0.16	0.03	0.21	0.09	0.15	0.11	0.29	0.22	0.1	0.31	0.54
106	15.2	55.88	0.26	-0.04	-0.04	0.06	0.26	-0.04	0.06	0.06	0.16	0.06	0.29	0.29	0.47	0.31	0.36	0.27	0.14	0.26
107	19	60.96	0.46	-0.64	-0.74	0.46	0.36	-0.74	-0.74	0.56	0.05	0.2	0.28	0.55	0.1	0.05	0.05	0.05	0.6	0.74
108	8.9	60.96	0.46	-0.64	-0.64	0.36	0.36	-0.64	-0.54	0.36	0.11	0.14	0.41	0.15	0.05	0.05	0.07	0.05	0.51	0.64
109	30.5	60.96	0.36	-0.74	-0.64	0.46	0.46	-0.64	-0.64	0.46	0.17	0.16	0.44	0.1	0.04	0.16	0.04	0.07	0.56	0.74
110	33	60.96	0.36	-0.64	-0.64	0.46	0.36	-0.74	-0.64	0.46	0.07	0.3	0.44	0.73	0.14	0.16	0.07	0.05	0.55	0.74
111	24.1	64.77	0.26	-0.44	-0.34	0.16	0.36	-0.44	-0.54	0.16	0.03	0.22	0.21	0.55	1.72	1.69	0.73	0.7	0.36	0.54
112	14	64.77	0.16	-0.34	-0.34	0.36	0.26	-0.34	-0.44	0.26	0.07	0.16	0.67	0.41	1.72	1.72	0.73	0.76	0.32	0.44
113	33	53.34	0.36	-0.44	-0.64	0.36	0.46	-0.54	-0.64	0.46	0.29	0.08	0.58	0.32	1.66	1.77	0.7	0.73	0.5	0.64
114	33	53.34	0.46	-0.54	-0.54	0.36	0.46	-0.44	-0.64	0.36	0.23	0.52	0.44	0.67	1.66	1.63	0.79	0.81	0.48	0.64
115	30.5	88.9	0.06	-0.14	-0.24	0.06	-0.04	-0.04	-0.14	-0.04	0.15	0.58	0.2	0.52	0.09	0.11	0.38	0.27	0.12	0.24
116	38.1	88.9	-0.14	-0.04	-0.14	0.06	-0.14	0.06	0.06	-0.14	0.44	0.21	0.47	0.05	0.11	0.05	0.32	0.31	0.11	0.14
117	15.2	90.17	-0.14	-0.14	-0.04	0.06	-0.14	-0.04	0.06	0.06	0.13	0.47	0.07	0.41	0.05	0.05	0.32	0.18	0.1	0.14
118	20.3	90.17	-0.04	-0.04	-0.14	-0.14	-0.04	-0.06	-0.14	-0.04	0.1	0.52	0.11	0.41	0.13	0.2	0.16	0.07	0.09	0.14
119	48.3	68.58	0.16	-0.14	-0.14	0.06	0.06	-0.14	-0.14	-0.04	0.58	0.87	0.7	0.99	0.25	0.25	0.18	0.14	0.12	0.16
120	50.8	68.58	0.16	-0.14	-0.24	0.06	0.16	-0.04	-0.24	-0.04	0.87	0.49	0.93	0.55	0.2	0.22	0.1	0.14	0.16	0.24
121	15.2	64.77	0.06	-0.14	-0.14	0.16	-0.04	-0.14	-0.14	0.16	0.58	0.87	0.55	0.84	0.16	0.27	0.04	0.14	0.13	0.16
122	45.7	64.77	0.16	-0.14	-0.14	0.06	0.06	-0.14	-0.14	0.06	0.81	0.55	0.84	0.55	0.23	0.25	0.13	0.18	0.12	0.16
123	15.2	53.34	0.06	-0.34	-0.24	0.26	0.06	-0.34	-0.24	0.26	0.15	0.38	0.2	0.07	0.58	0.67	0.14	0.23	0.25	0.34
124	5.1	53.34	0.06	-0.14	-0.14	0.06	0.16	-0.24	-0.24	0.16	0.38	0.15	0.02	0.22	0.58	0.47	0.16	0.04	0.16	0.24
125	17.8	54.61	0.16	-0.14	-0.34	0.06	0.26	-0.24	-0.44	0.16	0.03	0.29	0.22	0.05	0.31	0.47	0.1	0.13	0.25	0.44
126	35.6	54.61	0.16	-0.34	-0.24	0.26	0.06	-0.34	-0.14	0.16	0.07	0.38	0.2	0.05	0.23	0.34	0.04	0.04	0.23	0.34
127	30.5	54.61	0.26	-0.34	-0.34	0.36	0.26	-0.24	-0.34	0.26	0.17	0.47	0.14	0.41	0.2	0.25	0.23	0.29	0.3	0.36
128	38.1	54.61	0.26	-0.34	-0.44	0.36	0.26	-0.34	-0.34	0.26	0.16	0.44	0.07	0.38	0.25	0.25	0.27	0.23	0.33	0.44
129	22.9	62.23	0.36	-0.44	-0.44	0.36	0.36	-0.44	-0.44	0.26	0.19	0.23	0.14	0.14	0.07	0.16	0.04	0.04	0.39	0.44
130	15.2	62.23	0.26	-0.44	-0.34	0.46	0.16	-0.44	-0.34	0.36	0.52	0.28	0.49	0.15	0.27	0.14	0.23	0.11	0.36	0.46

Figure 8. Example of the high-level summary spreadsheet that is available for every bar: this example is for bar number 101-130 (out of 698 produced bars)

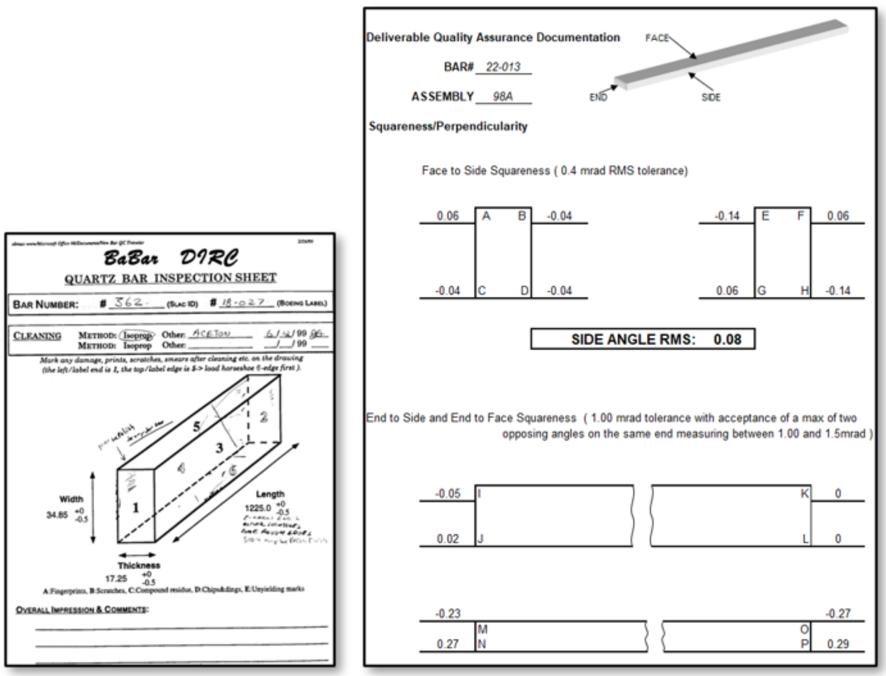

Figure 9. Examples of the information transmitted for each individual bar. This consists of a drawing with measured width, thickness and length, including a visual of any minor damage (smudges, small cracks, etc.) and measurements of the squareness of each bar.

5.2. Deliverable Documentation and Records

The results of each QA investigation, including extracted parameter values and pass/fail determinations, will be recorded in an agreed upon format (database, spreadsheet, etc.) and shared with the project. Detailed parameter tables that may be useful in simulation and/or reconstruction will additionally be stored in format convenient for use in these applications.

6. REFERENCES

[1] EIC Systems Engineering Group, "Requirements Management Plan," Brookhaven National Laboratory, Brookhaven, NY, 2022.

[2] EIC Systems Engineering Group, "Systems Engineering Plan," Brookhaven National Laboratory, Brookhaven, NY, 2022.

[3] EIC Systems Engineering Group, "Interface Management Plan," Brookhaven National Laboratory, Brookhaven, NY, 2022.