Intensity Frontier Beam Data System Requirements

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1 Introduction

This document provides the requirements for the Intensity Frontier Beam Data Extraction and Monitoring System (BDEM). The BDEM is a software suite that is common to many of the Intensity Frontier (IF) experiments and is used to extract and process accelerator and beam related data for use in the different experiment's analysis.

The BDEM system is responsible for extraction of data from the FNAL accelerator division systems, logging the data, and providing methods for experiments to access the information through a common interface. The goal of the BDEM system is to simplify and unify the acquisition of beams data for the current and future experiments in involved in the Fermilab Intensity Frontier program.

1.1 Terminology

Accelerator Data – Data produced by the accelerator systems related to the production, extraction and delivery of beam to the experiments.

Beam Data – Data produced by the accelerator system related to the characteristics of the beam delivered to the experiments.

Detector Data – Experiment specific data representing particle hits or other measured quantities in the experiment's detectors systems.

Data Acquisition System (DAQ) – the system that manages and performs the collection of particle hit data from an experiment's detectors.

Beam Data Logger – The BDEM subsystem that saves the accelerator and beam data in files on local disks at FNAL.

Central Storage – A mass file storage solution which can be accessed across wide segments of the Fermilab computing infrastructure. Examples of central storage include the "Bluearc" disk stations.

Permanent Storage System (PSS) – A mass file storage solution whose archival properties are to be considered functionally permanent for the duration of the experiment, including both the data taking and data analysis phases. Examples of permanent storage include archival tape system such as the Enstore system which is used at Fermilab.

Temporary storage – A storage location such as a local disk system, which is used for the short-term storage of newly created data files.

Beam Spill – The extraction of protons to a fixed target station over a fixed period of time with a well defined pulse structure.

Timestamp – A representation of the absolute time at which an event occurred. The BDEM will store timestamps in an internal representation as the number of clock ticks since the start of a defined epoch. Using this simple representation, timestamps can be converted and expressed in any desired time base for reporting (i.e. UTC, GPS, experiment specific.)

Client Application – An experiment or task specific program that can connect to the BDEM system and make requests for data.

1.2 Scope

The BDEM system is responsible for the acquisition, presentation and logging of accelerator and beam data to individual experiments, central [shared] databases, and permanent storage. This acquisition and presentation includes:

1. The extraction of accelerator data corresponding to specific beam pulses and other accelerator events, from AD maintained systems.
2. The extraction of beam data from AD maintained systems, corresponding to the instantaneous delivery of beam to target stations.
3. The association and correlation of accelerator and beams data with specific beam spill events.
4. The association of beam spill events with a universal time stamp.
5. The recording of all acquired data to temporary storage.
6. The processing, cataloging and recording of essential data to a high reliability central database.
7. The cataloging and recording of essential data to permanent storage.
8. The construction of spill related meta data records.
9. The construction of accelerator and beam data records and files.
10. The transmission of data records to requesting experiments.
11. The reporting of faults, errors or other failures to logging facilities, the DAQ system and human operators.
12. The reporting of faults, errors or other failures to each experiment that has requested notification of these events.

The BDEM does not perform any experiment specific calibrations or corrections to the extracted data, nor does the system tabulate experiment specific summaries or statistics (i.e. the BDEM reports only spill by spill statistics for a given target, and does not attempt to integrate total exposure for any given experiment)

1.3 Rationale

For modern Intensity Frontier experiments…..

Explain why we need it here and why we have our requirements

1.4 Actors

Data Logger – A system that writes event based data to physics data streams

Permanent Storage System - see Sec. 1.1

Data File Database – see Sec 1.1.

DAQ Experts – Individuals who have designed, built or maintain DAQ systems and have a level of expertise with the acquisition chain that allow them to provide modify and debug the systems.

Shift Operators – Individuals who are responsible for normal daily operation of the experiment and who will typically be interacting with the experiment from an approved control room facility

Experiment personnel – Individuals who are collaborators on an experiment or contracted with an experiment to perform tasks related to the experiment. This is the most general classification of personnel and includes other more restrictive classifications such as shift operators, DAQ experts and run coordinators.

Client Application – A program run by an experiment or task that connects to the BDEM system

Run Control Systems – The central parent system that controls the DAQ acquisition subsystems and is responsible for starting and stopping data runs.

Messaging System – The DAQ subsystem which is responsible for passing communications between components of the acquisition system and associated systems.

Message Logging System – The DAQ subsystem which is responsible for the logging of certain classes of communications from or between systems. The logging system is designed to provide a persistent record of the states of the system, their warnings, errors and other information that is required for the operation of the DAQ.

IRM – Internet relay monitors, computer systems which access data from beam monitoring devices, buffer it and make it available for readout.

VME Systems – acnet

CAMAC front ends

CAMAC serial link (runs around ring)

Java Open Access Client (OAC) – client that does not speak ACNET but speaks via a JAVA client

HRM – Son of IRM (replacement for CAMAC systems)

Beam stamping of read data is not possible

1.5 Major Inputs and Outputs

Inputs: The BDEM will receive major input in the following forms:

1. Accelerator devices names and lists of accelerator devices names
2. Accelerator clock events and associated time offsets as well as lists of clock events and lists of offsets. Get32 (good timestamp returned from the front end system rather than the time stamp from the reading computing) other version starts a Java timer, does a 1 shot read and then returns back the value of the timer (100ms+ jitter) Need to specify types of delay to use (accuracy)
3. Devices setup parameters
4. Devices associated calibrations or data scaling factors

5. Accelerator event data and time stamps as decoded by AD supported decoding devices.
6. Beam data from beam position monitors, SWICs and other beam line devices as readout by AD supported decoding devices
7. Other beam line related data, corresponding to quantities such as magnet currents and polarities or resistive wall monitors output, as reported by either AD supported readout systems, or experiment specific hardware.
8. Messages published across the messaging system announcing requests for configuration/reconfiguration
9. Messages published across the messaging system requesting data
10. Messages published across the messaging system announcing errors
11. Messages published across the messaging system announcing major state change information

Outputs: The BDEM will produce major outputs in the following forms:

1. Accelerator data decoded and time stamped, corresponding to individual spill events, or other events of interest.
2. Beam data associated with a specific device in either raw or calibrated/scaled and an associated time stamp for the datum.
3. Beam data (raw or scaled) which is additionally correlated with specific spill events and published as a well defined data blocks that are self-describing and include devices specific formats.
4. Database records corresponding to spill events, with a well defined schema that includes all the beam data associated with a given spill event.
5. Accelerator/Beam Data files appropriate for writing to archival storage.
6. Log files representing the state and history of the system.
7. Messages published through the messaging system that contain requested information or data
8. Messages published through the messaging system that contain information on state changes, faults or other errors in the system.

1.6 Overview

Describe what the system really needs to do in terms of a flow of logical steps.

See the File Transfer document for an example of this narrative.

2 Functional Requirements (Use Cases)

This section lists the use cases that span the functionality that is desired from BDEM. *Where appropriate use cases may reference in their details operations that are encapsulated in other use cases described in this document.*

These use cases are common to all current intensity frontier experiments or exhibit major overlap in the desired functionality that the experiments need.

The use cases are organized into two major categories, those involving the extraction of beam related information from the accelerator complex and beam line systems, and those that involve the reporting of the resultant data to use systems.

Dervived and corrected values may be published at longer times muon monitors ~1 sec after beam. Want to be able to specify delays to device reads.

Pre-trigger

Use cases specific to an individual experiment are treated separately in Section

Additional use cases:

Beam time within super cycle (relative time to other events in the accelerator)

2.1 Extract NuMI Beam Spill Time

The BDEM will have a method of extracting accelerator information corresponding to a valid spill event to the NuMI target station. This information will include timing information sufficient to correlate the event to a universal time standard (i.e. GPS time, UTC time.) This acquisition of spill timing will be triggered by the reception and decoding of appropriate signals in the Accelerator.

Task	*Retrieve/Decode accelerator spill signals corresponding to NuMI spill.*
Goal	*Acquire information on timing of the extraction of beam to the NuMI target*
Actors	*Accelerator Clock Signals/ BDEM*
Trigger	*BDEM receives indicator that spill has occurred.*
Preconditions	*BDEM is running, Accelerator event decoding is configured.*
Post-conditions	*BDEM has information pertaining to the time at which beam was extracted to the NuMI target*
Description	*1) BDEM receives spill signal* *2) BDEM readouts event and timing information* *3) BDEM filters data for NuMI events* *4) BDEM stores NuMI spill data*
Nonstandard	*Unable to read spill information: BDEM logs fault condition via the message logging system. BDEM adds "missing" spill to spill*

Flow	*list with time estimate of when the spill occurred.*
Comments	

2.2 Extract Booster Beam Spill Time

The BDEM will have a method of extracting accelerator information corresponding to a valid spill event to the Booster target station. This information will include timing information sufficient to correlate the event to a universal time standard (i.e. GPS time, UTC time.) This acquisition of spill timing will be triggered by the reception and decoding of appropriate signals in the Accelerator.

Task	*Retrieve/Decode accelerator spill signals corresponding to Booster spill.*
Goal	*Acquire information on timing of the extraction of beam to the NuMI target*
Actors	*Accelerator Clock Signals/ BDEM*
Trigger	*BDEM receives indicator that spill has occurred.*
Preconditions	*BDEM is running, Accelerator event decoding is configured.*
Post-conditions	*BDEM has information pertaining to the time at which beam was extracted to the Booster target*
Description	*1) BDEM receives spill signal* *2) BDEM readouts event and timing information* *3) BDEM filters data for NuMI events* *4) BDEM stores NuMI spill data*
Nonstandard Flow	*Unable to read spill information: BDEM logs fault condition via the message logging system. BDEM adds "missing" spill to spill list with time estimate of when the spill occurred.*
Comments	

2.3 Extract Other Fixed Target Beam Spill Time

The BDEM will have a method of extracting accelerator information corresponding to a valid spill event to a furture target station. This information will include timing information sufficient to correlate the event to a universal time standard (i.e. GPS time, UTC time.) This acquisition of spill timing will be triggered by the reception and decoding of appropriate signals in the Accelerator. Slow spill needs additional information.

Task	*Retrieve/Decode accelerator spill signals corresponding to future experiment's fixed target spill.*

Goal	*Acquire information on timing of the extraction of beam to the future experiment's target*
Actors	*Accelerator Clock Signals/ BDEM*
Trigger	*BDEM receives indicator that spill has occurred.*
Preconditions	*BDEM is running, Accelerator event decoding is configured.*
Post-conditions	*BDEM has information pertaining to the time at which beam was extracted to a target of interest*
Description	*1) BDEM receives spill signal* *2) BDEM readouts event and timing information* *3) BDEM filters data for the spill event of interest* *4) BDEM stores the spill data*
Nonstandard Flow	*Unable to read spill information: BDEM logs fault condition via the message logging system. BDEM adds "missing" spill to spill list with time estimate of when the spill occurred.*
Comments	

2.4 Extract External "Beam Present" Signal for Booster Line

The BDEM will have a method of extracting information from custom beam line monitoring systems in the Booster neutrino beam that indicate the extraction of beam to the Booster target area (i.e. the resistive wall monitor system.) This information will include timing information sufficient to correlate the event to a universal time standard (i.e. GPS time, UTC time.) This acquisition of spill timing will be triggered by the resistive wall monitor signal.

Task	*Retrieve/Timestamp additional booster beam present singals*
Goal	*Acquire and timestamp information from the Booster line's beam detection system.*
Actors	*Resistive wall monitor/ Accelerator Systems/ BDEM*
Trigger	*BDEM receives indicator that spill has occurred.*
Preconditions	*BDEM is running, Booster wall monitors are functional*
Post-conditions	*BDEM has information pertaining to the time at which beam was extracted to a target of interest*
Description	*1) BDEM receives spill signal* *2) BDEM readouts event and timing information* *3) BDEM stores the spill data*
Nonstandard	*Unable to read spill information: BDEM logs fault condition via the message logging system. BDEM adds "missing" spill to spill*

Flow	*list with time estimate of when the spill occurred.*
Comments	

2.5 Extract Protons on Target (PoT) for NuMI Beam Spill

The BDEM will have a method of extracting the number of protons delivered to the NuMI target for a given beam spill. This information is available from multiple devices in the NuMI beam and is essential for all physics related analysis. In the event that this information is not available from the primary source, the system must query the backup sources. Failure to acquire this information invalidates the associated beam spill. This acquisition is triggered off of a valid NuMI spill event.

Task	*Retrieve the number of Protons on Target (PoT) for a spill*
Goal	*Acquire and correlate the number of protons delivered to the NuMI target with a given NuMI spill event*
Actors	*Accelerator Systems/BDEM*
Trigger	*BDEM receives indicator that NuMI spill has occurred.*
Preconditions	*BDEM is running*
Post-conditions	*BDEM has acquired information pertaining to the PoT of the spill*
Description	*1) BDEM receives spill signal* *2) BDEM queries all sources of sources PoT data* *3) BDEM matches PoT data with spill event via timestamps* *4) BDEM stores all PoT data in spill event record*
Nonstandard Flow	*Unable to read primary data source: BDEM attempts to read the secondary or tertiary sources for PoT data. BDEM logs fault condition via the message logging system. BDEM marks the spill as "invalid, no POT data not available" if it is unable to retrieve any data on the spill* *Unable to correlate spill time and PoT data via timestamps: The time stamps exhibit a large enough skew that they are not considered properly correlated. The BDEM logs the data to the "pending correlation" queue.*
Comments	*Periodically the system may try to re-correlate spills that are missing PoT values, with PoT values from the pending queue. This allows for recovery from certain situations where the spill data and PoT data arrive out of time with each other.*

2.6 Extract Protons on Target (PoT) for Booster Beam Spill

The BDEM will have a method of extracting the number of protons delivered to the Booster target for a given beam spill. This information is available from multiple devices in the Booster beam and is essential for all physics related analysis. In the event that this information is not available from the primary source, the system must query the backup sources. Failure to acquire this information invalidates the associated beam spill. This acquisition is triggered off of a valid Booster spill event.

Task	*Retrieve the number of Protons on Target (PoT) for a spill*
Goal	*Acquire and correlate the number of protons delivered to the Booster target with a given Booster spill event*
Actors	*Accelerator Systems/BDEM*
Trigger	*BDEM receives indicator that Booster spill has occurred.*
Preconditions	*BDEM is running*
Post-conditions	*BDEM has acquired information pertaining to the PoT of the spill*
Description	*1) BDEM receives spill signal* *2) BDEM queries primary source of PoT data* *3) BDEM matches PoT data with spill event via timestamps* *4) BDEM stores PoT data in spill event record*
Nonstandard Flow	*Unable to read primary data source: BDEM attempts to read the secondary or tertiary sources for PoT data. BDEM logs fault condition via the message logging system. BDEM marks the spill as "invalid, no POT data not available" if it is unable to retrieve any data on the spill* *Unable to correlate spill time and PoT data via timestamps: The time stamps exhibit a large enough skew that they are not considered properly correlated. The BDEM logs the data to the "pending correlation" queue.*
Comments	*Periodically the system may try to re-correlate spills that are missing PoT values, with PoT values from the pending queue. This allows for recovery from certain situations where the spill data and PoT data arrive out of time with each other.*

2.7 Extract Protons on Target (PoT) for Other Beam Spills

The BDEM will have a method of extracting the number of protons delivered to the other targets, that will be in use in the future, target for a given beam spill.

This information will be available from multiple devices in the beam and is essential for all physics related analysis. In the event that this information is not available from the primary source, the system must query the backup sources. Failure to acquire this information invalidates the associated beam spill. This acquisition is triggered off of a valid spill event to a target of interest.

Task	*Retrieve the number of Protons on Target (PoT) for a spill*
Goal	*Acquire and correlate the number of protons delivered to the a future target with a given spill event*
Actors	*Accelerator Systems/BDEM*
Trigger	*BDEM receives indicator that a spill of interest has occurred.*
Preconditions	*BDEM is running*
Post-conditions	*BDEM has acquired information pertaining to the PoT of the spill*
Description	*1) BDEM receives spill signal* *2) BDEM queries primary source of PoT data* *3) BDEM matches PoT data with spill event via timestamps* *4) BDEM stores PoT data in spill event record*
Nonstandard Flow	*Unable to read primary data source: BDEM attempts to read the secondary or tertiary sources for PoT data. BDEM logs fault condition via the message logging system. BDEM marks the spill as "invalid, no POT data not available" if it is unable to retrieve any data on the spill* *Unable to correlate spill time and PoT data via timestamps: The time stamps exhibit a large enough skew that they are not considered properly correlated. The BDEM logs the data to the "pending correlation" queue.*
Comments	*Periodically the system may try to re-correlate spills that are missing PoT values, with PoT values from the pending queue. This allows for recovery from certain situations where the spill data and PoT data arrive out of time with each other.*

2.8 Extract Horn Currents and Polarities for NuMI/Booster Beam Spills

The BDEM will have a method of extracting the horn current and polarity of the focusing horn that is associated with a given spill event. This acquisition is triggered off of a valid spill event to either the NuMI or Booster targets.

Task	*Retrieve the horn current and polarity of a focusing horn*

Goal	*Acquire and correlate the the horn current and polarity of the focusing horn associated with a given beam spill event*
Actors	*Accelerator Systems/BDEM*
Trigger	*BDEM receives indicator that NuMI/Booster spill has occurred.*
Preconditions	*BDEM is running*
Post-conditions	*BDEM has acquired information pertaining to the horn current of the current spill*
Description	*1) BDEM receives spill signal* *2) BDEM queries primary source for horn current(s) associated with the spill event.* *3) BDEM matches horn data with spill event via timestamps* *4) BDEM stores the horn data in spill event record*
Nonstandard Flow	*Unable to read data source: BDEM logs fault condition via the message logging system. BDEM marks the spill as "spill incomplete"* *Unable to correlate spill time and horn data via timestamps: The time stamps exhibit a large enough skew that they are not considered properly correlated. The BDEM marks the spill as "spill incomplete" and pushes the horn current data to the "pending correlation" queue.*
Comments	*Periodically the system may try to re-correlate spills that are missing horn current values, with horn values from the pending queue. This allows for recovery from certain situations where the spill data and horn data arrive out of time with each other.*

2.9 Extract Beam Positions at Target for NuMI/Booster Beam Spills

The BDEM will have a method of extracting the X and Y position of the beam in a beam position monitor that is associated with a given spill event. This acquisition is triggered off of a valid spill event to either the NuMI or Booster targets. BPM system will drop beam permit if either the BPM is down or the targeting is way off.

Task	*Retrieve the X an Y position of the beam*
Goal	*Acquire and correlate the X and Y position of the beam at its relavent target, associated with a given beam spill event*
Actors	*Beam Position Monitors/BDEM*
Trigger	*BDEM receives indicator that NuMI/Booster spill has occurred.*
Preconditions	*BDEM is running*

Post-conditions	*BDEM has acquired information pertaining to the X and Y positions of the beam during a spill*
Description	*1) BDEM receives spill signal* *2) BDEM queries primary source for beam position data associated with the spill event.* *3) BDEM matches beam position data with spill event via timestamps* *4) BDEM stores the beam position data in spill event record*
Nonstandard Flow	*Unable to read data source: BDEM logs fault condition via the message logging system. BDEM marks the spill as "spill incomplete"* *Unable to correlate spill time and beam data via timestamps: The time stamps exhibit a large enough skew that they are not considered properly correlated. The BDEM marks the spill as "spill incomplete" and pushes the beam position data to the "pending correlation" queue.*
Comments	*Periodically the system may try to re-correlate spills that are missing beam position values, with horn values from the pending queue. This allows for recovery from certain situations where the spill data and horn data arrive out of time with each other.*

2.10 Extract Beam Non-Critical Beam data for NuMI/Booster Beam Spills

The BDEM will have a method of collecting all other beam line data of interest which is associated with a spill but not considered critical to the physics integrity of the spill. Systems that fall into this class are devices such as muon monitors, hadron monitors, beam position devices along the transport lines, beam profile/width monitors and beam power measurements. This non-critical data may be used only for real time monitoring and may not in some cases be persisted to the logging chain. All data in this class is however time stamped to allow for monitoring and trend analysis. This acquisition is triggered off of a valid spill event to either the NuMI or Booster targets.

Task	*Retrieve non-critical data from beam line systems*
Goal	*Acquire and correlate non-critical beam line information and data with a given beam spill event*
Actors	*Accelerator Devices/BDEM*
Trigger	*BDEM receives indicator that NuMI/Booster spill has occurred.*
Preconditions	*BDEM is running and is configured with a devices readout list*
Post-	*BDEM has acquired information pertaining beam devices that*

conditions	*report information regarding the beam lines during a spill*
Description	*1) BDEM receives spill signal* *2) BDEM queries a list of devices for information associated with the spill event.* *3) BDEM matches beam position data with spill event via timestamps* *4) BDEM adds the data that has been read out to a buffer of recent beam line parameters* *5) BDEM stores some of the non-critical data in the spill event record.*
Nonstandard Flow	*Unable to read data source: BDEM logs fault condition via the message logging system.* *Unable to correlate spill time: BDEM adds the data only to the recent beam parameters buffers. No spill event records are modified.*
Comments	

2.11 Extract Beam Data Over a Fixed Time Interval

The BDEM will have a method of collecting beam line corresponding to a specific set of devices over a fixed time interval. All of the returned data must have individual time stamps correspond to the time at which the data originated (not when it was retrieved by the system.) Data collected in this fashion can be used to perform specialized studies (target scans, beam quality checks) or merged and correlated directly with experiment specific data. (example: BPM data is buffered on “now”)

Task	*Retrieve data from beam line systems for a time period*
Goal	*Acquire a stream of data from beam line systems that correspond to a definite time interval.*
Actors	*Accelerator Devices/BDEM*
Trigger	*Configured/Schedule time for readout is reached or external request for readout of time period is recieved*
Preconditions	*BDEM is running and is configured with a device readout list*
Post-conditions	*BDEM has acquired information pertaining beam devices over the time period of interest*
Description	*1) Readout time is reached or Readout of time window is triggered* *2) BDEM queries a list of devices for information matching*

	the time window of interest *3) BDEM merges data from multiple sources and sorts the resulting lists into a time ordered list, or sorts by both device identify and time order.* *4) BDEM produces a time window data block object*
Nonstandard Flow	*Unable to read data source/sources: BDEM logs fault condition via the message logging system for each device that is unavailable. An empty records is generated in the final data block for each device that failed to report.*
Comments	

2.12 Accept Connection from Client Application

The BDEM will have the ability to act as a server and accept direct connections from client applications.

Task	*Accept client connection*
Goal	*Accept an incoming client connection and initialize resources to service the client requests*
Actors	*BDEM/Client Application/Message System*
Trigger	*Client application attempts to connect*
Preconditions	*BDEM is running*
Post-conditions	*BDEM has an open connection with a client application and is ready to service requets for data*
Description	*1) Client application initiates connection* *2) BDEM accepts connection and presents authentication challenge* *3) BDEM verifies authentication* *4) BDEM promotes the connection to full service status* *5) BDEM initializes resources to permit client requests for data*
Nonstandard Flow	*Unable to verify authentication: BDEM logs the authentication failure. Connection is closed* *Maximum Number of Connects Reached: BDEM responds with error message to client application. BDEM Logs the failure. Connection is closed.* *Unable to allocate resources: BDEM logs the failure. BDEM responds with error message to client. Connection is closed.*

Comments	

2.13 Close Connection with Client Application

The BDEM will have the ability to close the connection with a client application and detect that the connection has been closed. In both case the BDEM will recover previously allocated resources.

Task	*Close client connection*
Goal	*Close a successfully connected client connection and recover resources from the server servicing the client requests*
Actors	*BDEM/Client Application/Message System*
Trigger	*Client application terminates connection, client application request the connection be closed or an error condition requires the connection to the client be closed*
Preconditions	*BDEM is running, client application is connected*
Post-conditions	*BDEM has no connection to the client application and all resources devoted to the connection are recovered*
Description	*1) Connection is closed (or terminated)* *2) BDEM cleans up resources* *3) BDEM logs the end of connection* *4) BDEM server thread completes*
Nonstandard Flow	*Unable to recover resources: Issue critical error to message systems. Terminate the server thread.*
Comments	*This use case assumes a standard threaded server model as part of the implementation. There is the potential that a different server model would modify the functionality of this use case.*

2.14 Report Spill Event List

The BDEM will have a method of reporting a list of know spill events. The information reported will include the spill event type and the timestamp corresponding to when the event occurred.

Task	*Report a list of spill events*
Goal	*Transmit a list of spills and timestamps to a client application*
Actors	*BDEM/Client Application/Message System*
Trigger	*Client application requests a spill list*

Preconditions	*BDEM is running and is configured with a device readout list*
Post-conditions	*BDEM has acquired information pertaining beam devices over the time period of interest*
Description	*1) Readout time is reached or Readout of time window is triggered* *2) BDEM queries a list of devices for information matching the time window of interest* *3) BDEM merges data from multiple sources and sorts the resulting lists into a time ordered list, or sorts by both device identify and time order.* *4) BDEM produces a time window data block object*
Nonstandard Flow	*Unable to read data source/sources: BDEM logs fault condition via the message logging system for each device that is unavailable. An empty records is generated in the final data block for each device that failed to report.*
Comments	

2.15 Accept Client Request for Data

The BDEM will have a method of accepting a client request for data. The request mechanism must support both simple (single item) requests and request lists.

Task	*Accept a client request*
Goal	*Accept and be able to parse a client request for data or lists of data from the system*
Actors	*BDEM/Client Application/Message System*
Trigger	*Client application requests information*
Preconditions	*BDEM is connected to client application*
Post-conditions	*BDEM has validated the request and has a list of data or devices to return information on.*
Description	*1) Request from client is recieved* *2) Request from client is validated for formatting/parsing structure* *3) Request is parsed to obtain requested targets* *4) Targets are validated* *5) Request is acknowledged and accepted into retrieval queue*

Nonstandard Flow	*Malformed Request: BDEM rejects request with error message.* *Unable to Parse Request: BDEM rejects request with error message.* *Invalid Target in Request: The request references data targets that do not exist. BDEM rejects the requests with error message and invalid target identifier*
Comments	

2.16 Report Spill Event List

The BDEM will have a method of reporting a list of know spill events that have occurred during a span of time. The information reported will include the spill event type and the timestamp corresponding to when the event occurred.

Task	*Report a list of spill events*
Goal	*Transmit a list of spills and timestamps to a client application*
Actors	*BDEM/Client Application/Message System*
Trigger	*Client application requests a spill list*
Preconditions	*BDEM is connected to client and received a valid request*
Post-conditions	*BDEM has transmitted the data to the client*
Description	*1) Time range of request is validated* *2) List of spills within the range is built* *3) List of spills is sorted on the time index* *4) List of spills is transmitted to the client*
Nonstandard Flow	*Time range invalid: The time range requested is invalid (in the future?) An error is generated and an empty spill list is returned* *No spills found in Queue: The data queue is empty, a critical error is generated.* *No spills found in time range: Empty list is returned*
Comments	

2.17 Report Spill Event Record

The BDEM will have a method of reporting the full spill event record to a client. The information reported will include all of the information that the BDEM system

has been able to correlate with a given spill event. In some cases individual parts of the record maybe unavailable at the time when a record is requested. Records in this state are marked as incomplete and returned.

Task	*Report a spill event record*
Goal	*Transmit a specific spill event record*
Actors	*BDEM/Client Application/Message System*
Trigger	*Client application requests a spill record*
Preconditions	*BDEM is connected to a client and has accepted a request*
Post-conditions	*BDEM has transmitted the information to the client*
Description	*1) The requested spill's existence is validated.* *2) The spill record of interest is packaged into the requested report format.* *3) The spill record is transmitted to the client.*
Nonstandard Flow	*Spill invalid: The requested spill does not exist. Client is returned an error message*
Comments	

2.18 Report General Beam Data (Time range)

The BDEM will have a method of reporting generalized beam data corresponding to a time window of interest. The method of reporting takes as input a device identifier or list of identifiers, and will generate a well defined (self describing) block of data that can be utilized by the client application.

Task	*Report beam data to client*
Goal	*Transmit a specific collection of beam information to the client corresponding to a time window of interest*
Actors	*BDEM/Client Application/Message System*
Trigger	*Client application requests a report on a device or set of devices*
Preconditions	*BDEM is connected to a client and has accepted a request*
Post-conditions	*BDEM has transmitted the information to the client*
Description	*1) BDEM receives a list of devices, time range and report format*

	2) *Time range is validated* 3) *Device List is validated* 4) *Current device data is searched for data in time window* 5) *Data matching the search is sorted by device type and time order* 6) *Data is formatted into requested report format* 7) *Data is transmitted to the client*
Nonstandard Flow	*Invalid Time Range: BDEM reports an error to client* *Invalid Device List: BDEM reports an error to the client with the invalid device description* *Data Queue Empty: BDEM reports an error to the client. BDEM logs the error to the message system* *Data Not Found in Queue: No data was found matching the search. An empty data block is returned to the client*
Comments	

2.19 Log General Beam Data (Time range)

The BDEM will have a method of logging to a database or archival storage the generalized beam data corresponding to a time window of interest. The method of logging takes as input a device identifier or list of identifiers, and will populate a well defined data record in the logging destination of choice.

Task	*Log beam data to database or logging destination*
Goal	*Record a specific collection of beam information corresponding to a time window of interest to the database or archival logger.*
Actors	*BDEM/Logging Facility/Message System*
Trigger	*Logging cycle is triggered on a predefined time interval, or by request from a message*
Preconditions	*BDEM is running and connected to the logging facility*
Post-conditions	*BDEM has logged information to the logging facility*
Description	1) *Logging time is reached or logging of the time window is triggered via message* 2) *BDEM uses cached list of devices to log or retrieves a device list to the current logging cache* 3) *BDEM verifies device list and time window validity* 4) *BDEM searches the current device data is searched for*

	records matching the logging request *5) Matching data is packaged into the required record format for the logging destination* *6) Data record is written to the logging destination* *7) Data record is verified as being written correctly*
Nonstandard Flow	*Invalid Device List: BDEM logs an error to the message logger* *Invalid Time Range: BDEM logs an error to the message logger* *Data Queue Empty: BDEM logs a critical error to the message logger (i.e. no data is being read out, yet logging is active)* *Data Not Found in Queue:*
Comments	

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3 Experiment Specific Use Cases

No use cases for the Minos, Minerva, MiniBooNE or NOvA experiments have been identified that are unique to the individual experiment and require special treatment.

The Mu2e beam line monitoring, due to the high rate environment, requirements on pulse by pulse extinction monitoring, and monitoring related to the other beam line conditions is not included in this document. Those special requirements will be addressed when the experiment has competed the design and preliminary engineering of the beam line systems.

4 Non-Functional Requirements

4.1 Performance Requirements

The following performance requirements must be met by the File Transfer System.

ID	Requirement
P00	*BDEM will only allow authenticated systems to connect to the running system and request data.*
P01	*BDEM must be able to support queries from a minimum of 10 simultaneous sources (or two per active experiment)*
P02	*BDEM must be able to support logging of data to a minimum of 12 independent devices (or two per active experiment + one primary and one backup master logging station)*
P03	*BDEM must be able to deliver beam spill data within 20 seconds of spill event*
P04	*BDEM must be able to deliver general beam line data to clients within 30 seconds minutes of initial acquisition*
P05	*BDEM must be able to log general beam and spill data to a logging facility within 20 minutes of initial acquisition*
P06	*BDEM must be able to operate with a 99.9% uptime during normal accelerator/beam operations (i.e. induce no more than 8 hours of beam data loss per year. 8x5 operational support schedule.*
P07	*Be capable of fulfilling its requirements under an 8x5 operational supports schedule*
P08	*Be capable of deferring upgrades/updates to scheduled beam down time (i.e. no auto updates/patches during normal operations)*

4.2 External Constraints

The following general requirements must be supported by the FTS system.

ID	Requirement
E00	*FTS must be compatible with the operational requirements of the Fermilab Accelerator Division network.*
E01	*FTS must be compatible with the operational requirements*

	of the Fermilab Accelerator Division monitoring hardware and interfaces
E02	*FTS must be compatible with Fermilab computing policies*
E03	*FTS must be compatible with Fermilab network security policies*