MAINTAINING THE ACCELERATOR SAFETY ENVELOPE

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Abstract

The Accelerator Safety Envelope (ASE) defines boundaries for accelerator operation that may not be exceeded. Examples of parameters that are limited by the ASE [3] include beam intensity and particle loss, the radiation safety access control system, the fire protection system, and control room staffing. This paper will focus on BLAM, the Beam Loss Accounting Manager, a novel approach that is used to monitor beam loss at the Relativistic Heavy Ion Collider (RHIC).

1 INTRODUCTION

The US Department Of Energy order 420.2A [1], entitled ***Safety of Accelerator Facilities*** establishes accelerator-specific safety requirements. The Accelerator Safety Envelope defines physical and administrative bounding conditions for safe operation based on the safety analysis documented in the Safety Assessment Document (SAD), another requirement of the order. Accelerator Operations is charged with watching over a subset of the parameters that require control, most notably particle losses. We use software to monitor specific beam current transformers, to determine when losses occur, and to alert the operators when the losses approach thresholds that are judged to be significant.

2 RADIOLOGICAL AREAS

The accelerators at the Collider – Accelerator Department of the Brookhaven National Laboratory include two Tandem Van de Graff accelerators, a Linear accelerator, a booster synchrotron, the Alternating Gradient Synchrotron (AGS), and the two super conducting synchrotrons that make up the RHIC. Given the range of species and particle intensities accelerated at BNL, one finds the all of the types radiological areas throughout the complex. Radiological area classification determines the dose rates expected and protective measures required for that area. Uncontrolled areas require unrestricted access. A great deal of thought and effort has gone into guarding individuals in the uncontrolled area at the RHIC.

Table 1: Radiological Area Definitions

Area	Allowable Dose Rate
Very High Radiation	> 500 mRem/hr
High Radiation	> 100 mRem/hr
Radiation	> 5 mRem/hr
Controlled	25 mRem/yr<d<100 mRem/yr
Uncontrolled	< 25 mRem/yr

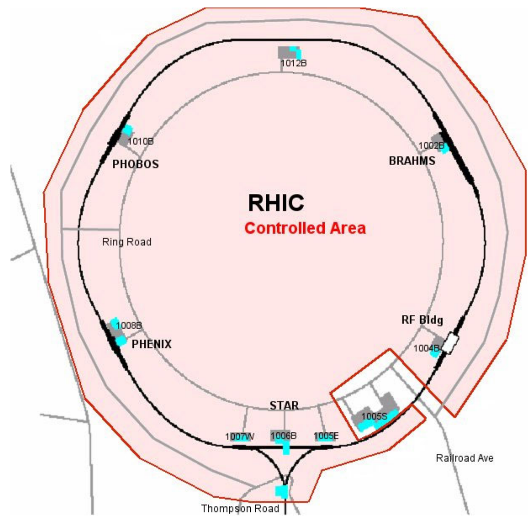

Figure 1: Controlled & Uncontrolled areas at RHIC

Protection of the uncontrolled area is challenging because it lies in the path of the injected beam for the RHIC yellow accelerator (see figure 1) and because the uncontrolled area classification requires that individuals who work in that area receive a dose less than 25 mRem per year (see table 1).

3 BLAM

BLAM is the "watchdog" used by the operators to monitor losses at the RHIC and in the injection arcs leading into the RHIC. Based upon the information from BLAM the operators decide whether to delay injecting beams in order to limit the hourly average loss. BLAM is only concerned with losses that occur when the beams are dumped and not with losses during the ramp up to full energy or during the store.

Knowing the allowable dose rates permitted in an uncontrolled area one could, in principal, calculate the maximum number of particles which, when lost at full energy, would produce the radiation field. This calculation is the source of the limiting value for the ASE for beam losses. BLAM learns about the loss limits from external servers. Unless told otherwise BLAM assumes that losses occur such that they are concentrated in the sextant that produces radiation in the uncontrolled area.

3.1 BLAM Dependencies

BLAM depends upon a number of server processes.

The Post Mortem (PM) server writes files containing loss monitor data when it sees an “abort” or “dump” event on the time line. The Loss Analysis (LA) server reads the files written by the PM server and determines whether the dump was a clean or “dirty” one based upon where losses are seen and whether the losses are correlated in time with the dump/abort event. If the LA server determines the dump is clean then it will issue a “credit” to BLAM for the number of ions previous circulating in the ring based on measurements from beam current transformers. The specification manager “specMan” is used by BLAM to determine which ion species is in each ring and the injection energy for each species. (See Fig. 2).

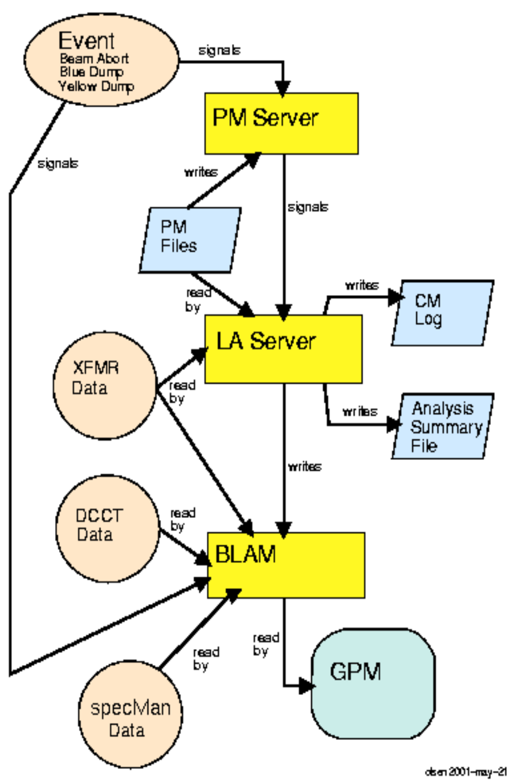

Figure 2: BLAM dependencies

3.2 Dose Arithmetic

BLAM calculates an effective dose for the beam as a function of beam energy according to the formula.

$$DoseIons = Ions * \left[\frac{Energy - RESTenergy}{InjEnergy - RESTenergy} \right]^{0.8}$$

BLAM takes into the account the energy of the beam and gives less weight in the accounting process to beam that is aborted before it reaches full energy.

3.3 Example of an evolution

Figure 3 shows and example of an evolution in the RHIC blue accelerator that lasted 65 minutes before the beam was aborted. The yellow accelerator is not shown. The dark blue horizontal line represents 50% of the allowable “dose ions” that may be lost. The light blue horizontal line represents 90% of the allowable dose ions that may be lost. During the evolution more than 100% of the allowable dose ions were injected. The other dark blue line represents the dose ions circulating in the blue ring, while the light blue line represents the “blue loss hourly sum”. Coincident with the loss of the beam one sees an increase in the blue hourly loss sum. BLAM issued a critical alarm telling the operators that 90% of the allowable dose ions were lost. Five minutes later the blue loss hourly sum returns to normal levels and the alarm disappears from the screen after BLAM learns from the LA server that the dump was a clean one. A clean dump is defined as one where the entire beam is dumped in the beam dumps designed for that purpose. A dirty dump assumes all the beam is lost such that the dose in the uncontrolled area will be unacceptable if operation is allowed to continue. An hour after the “loss credit” from the LA server the blue loss hourly sum is seen to go negative because the loss has expired. Five minutes later when the credit expires, the blue loss hourly sum is seen to return to normal. Each point on the blue (yellow) loss hourly sum is the sum of any losses or credits that occur at that time, plus the previous loss value, minus the value of the blue (yellow) loss hourly sum one hour ago.

3.4 Operator Response

The operator’s response to a loss of 50% of the allowable dose ions is to do nothing. The alarm will go away after five minutes if the loss was clean, or if an hour goes by without significant losses. The operator’s response to an alarm corresponding to a loss of 90% of the allowable dose ions is measured. If the alarm does not clear after five minutes then the dump or abort was a dirty one. The operators must not inject beams into the RHIC until enough time passes to ensure that the “limiting number” of ions cannot be lost in an hour.

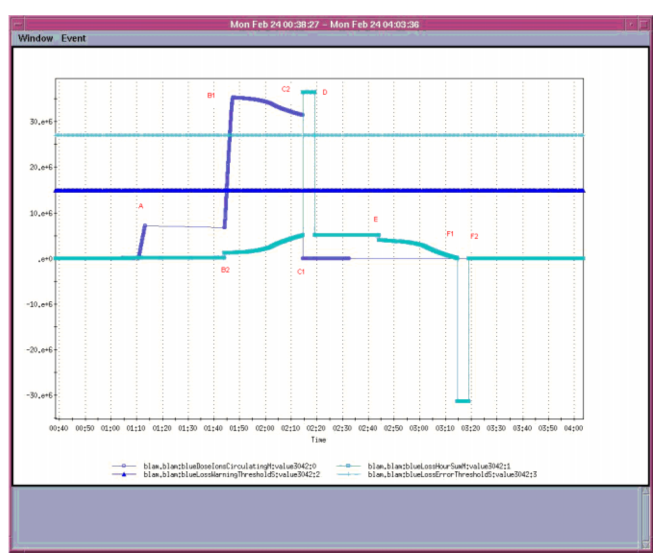

Figure 3. BLAM evolution in the Blue ring

4 CONCLUSION

The task of ensuring that the accelerator safety envelope is not violated becomes impossible without the BLAM software. BLAM is a tool that makes a potentially challenging task a relatively easy one for the operators.

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5 REFERENCES

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