WEAK BEAM DIAGNOSTICS UTILITY FOR ATLAS-CARIBU*

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Abstract

The CAlifornium Rare Isotope Breeder Upgrade (CARIBU) for the ATLAS facility requires the transport of very low intensity ion beams through the accelerator. Weak beam diagnostic stations at several strategic locations throughout the accelerator will be installed to duplicate beam position as measured with a more intense guide beam. One of these methods will be using an ANL designed Beam Profile Monitoring Device which will use secondary electrons directed onto a phosphor screen, and then the image is captured by a CCD camera. A video capture program to enable integration of weaker beam signals from video devices is being developed using ITT Visual Information Systems IDL [1] software on a Linux based PC. The software will process the image from the CCD camera and accumulate the frames together to produce a viewable image of the beam spot. This will allow an operator to adjust the beam and potentially match the live image and averaged images to previously saved images. The software will also allow the selection of a particular diagnostic location to view and control from a single interface.

OVERVIEW OF CARIBU

The CAlifornium Rare Isotope Breeder Upgrade (CARIBU) will extend ATLAS's (Argonne Tandem Linac Accelerator System), reach to include potentially hundreds of previously unstudied, unstable isotopes. CARIBU will use californium-252 to create specific neutron-rich heavy fission fragments at a rate of more than one million per second for acceleration through ATLAS. [2]

In order to assist in tuning the weak beams, several weak beam diagnostic stations will be placed at strategic locations throughout the accelerator to duplicate beam position as measured with the guide beam. [3]

DIAGNOSTIC STATION

A device is installed in the beamline and comprises several sensor types attached to a linear motion feed-through as seen in Fig. 1. One of these sensors is a target plate coated with a phosphor which fluoresces when exposed to heavy ions. A CCD (Charged Coupled Device) camera is mounted such that it is focused on the phosphor screen. The feed-through is connected to a stepper motor so that it can be moved into place as needed through the computer control system. When placed into the beam path the phosphor will fluoresce and the image displayed on a computer system.

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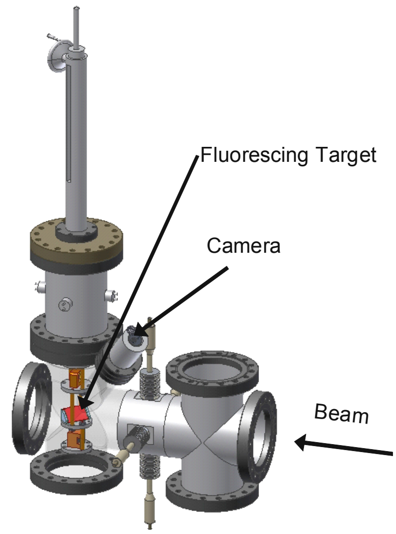

Figure 1: Weak beam diagnostic device.

Phosphors

Three phosphors are currently being tested in the system. The NP-3010-03, from Nichia America Corporation, uses a Gd^2O^2S:Tb phosphor. The NP-1045-250, also from Nichia America Corporation, uses Y^2O^2S:Tb. A third, GTE Blue Phospor. Type 130 uses ZnS:Ag.

CCD Camera

The CCD Camera in use (Fig. 2) is the KT&C KPC-EX230HL (EXView) and has the following featurs:

- Sony Black and White 1/3" Super HAD CCD Camera
- 420 TV Lines of Resolution
- Sensitivity of 0.003 Lux
- Interchangeable Lens
- 12VDC

Figure 2: KT&C KPC-EX230HL (EXView) CCD camera.

COMPUTER SYSTEM HARDWARE

The computer system is a generic machine with an Intel P4 2.0GHz processor and 2Mb RAM running Scientific Linux version 4.2. Installed is a Linux Media Labs LMLBT44 PCI video input board [4] which has 4 inputs on board and can be expanded to 8 inputs (Fig. 3). The LMLBT44 has the following features:

- Video digitized using YUV 4:2:2 color format :
    - NTSC 640x480 60 fps
    - PAL 758x576 50 fps
- 4 full rate channels
- 3 insulated 1A 115AC/30VDC alarm relay outputs
- 4 optically insulated sensor inputs
- 4 composite video inputs (BNC connectors)
- DB15 connector for sensor and alarm IO
- PCI board based on Bt878 chip

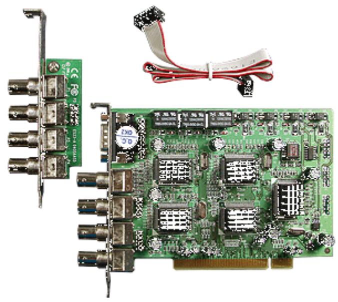

Figure 3: Linux Media Labs LMLBT44.

SYSTEM SOFTWARE

The purpose of the diagnostics software is to read in the frames from the video card and display them. Since the fluorescing of the phosphor can be very slight, the frames are then saved into a stack and summed to produce a clear image of the beam spot. This software is created through multiple pieces: Video4Linux2 Application Programming Interface[5], C language capture functions, IDL widget user interface, and IDL iTools.

IDL

ITT Visual Information Solutions' IDL software is an integrated environment for data analysis, visualization, and application development. The Weak Beam Diagnostics is developed within the IDL environment and makes use of the widget user interface ability to present the images to the user and allow interaction. IDL is optimized for fast array processing, and provides many useful image processing and display functions.

User Interface

The user interface displays two images captured from the Weak Beam Diagnostics' CCD camera. As shown in Fig. 4, the upper image is a "live" image captured at 10 frames per second. The lower image is a summation of the equalized images allowing the user to more clearly see the beam image.

Several software functions are also provided for the user. A Save function prompts the user for a title and directory, and saves both the live and accumulated images to a JPEG format file. A Reset button allows the user to clear and reset the stack of saved images. A Create Contour Plot button creates a 3D contour map of the image in an iTool window similar to Fig. 5. The iTool window is independent of the diagnostic software, and allows further interaction of the plot. The user can also use iTools separately to manipulate the saved image data.

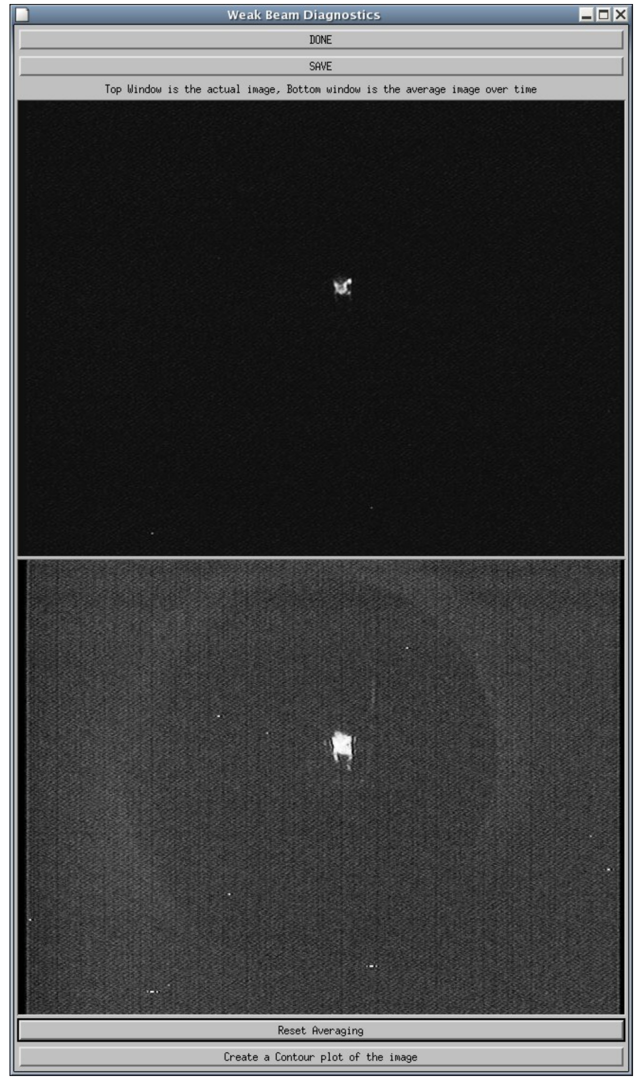

Figure 4: Weak beam diagnostics software display.

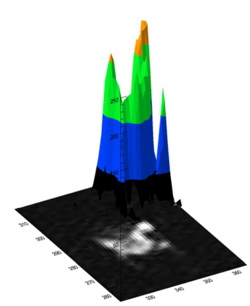

Figure 5: 3D contour plot of image.

Video Capture

IDL provides an interface to call C language functions from within IDL programs. Several functions were written to provide access to the video card to capture the images. These functions use the Video4Linux2 API, a kernel interface for analog video capture and output drivers. It provides functions for configuring, and reading the video input device.

Image Processing

A timer widget is used in the IDL program to trigger a frame capture every tenth of a second. When the frame is captured it is first enhanced by using the IDL function HIST_EQUAL (). This function provides a histogram equalized image. The enhanced image is then stored into a circular array and then the "accumulated" image is created by summing the images and re-scaling to byte values for display. Fig. 6 shows an attenuated sample beam image as a single (live) frame image and an accumulated and equalized set of 25 image frames.

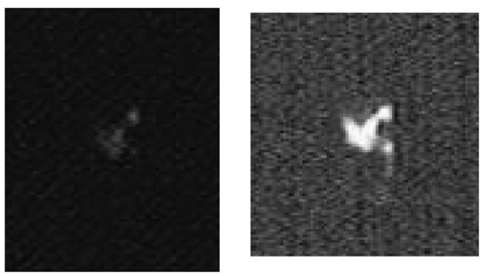

Figure 6: Live and accumulated images.

FUTURE ADDITIONS

Once the software is proven, and multiple devices are installed, the system will be expanded providing the option of choosing which video input to display. Options to change the number of frames summed in the accumulated image and the frame capture timing may also be added. Finally, a method of storing the images along with experiment information may be added to facilitate retrieval and comparison to current images.

RESULTS & CONCLUSIONS

We have found that devices within the beamline can create additional light and must be turned off while using the diagnostic utility. Since the CCD camera being used supports multiple lenses we may also choose to change the lens being used in order to "zoom in" a little closer to the target.

A comparison of the different phosphors with an attenuated sample beam is shown in Fig. 7.

Early results seem to indicate that the system will provide an effective method for tuning weak beams at ATLAS.

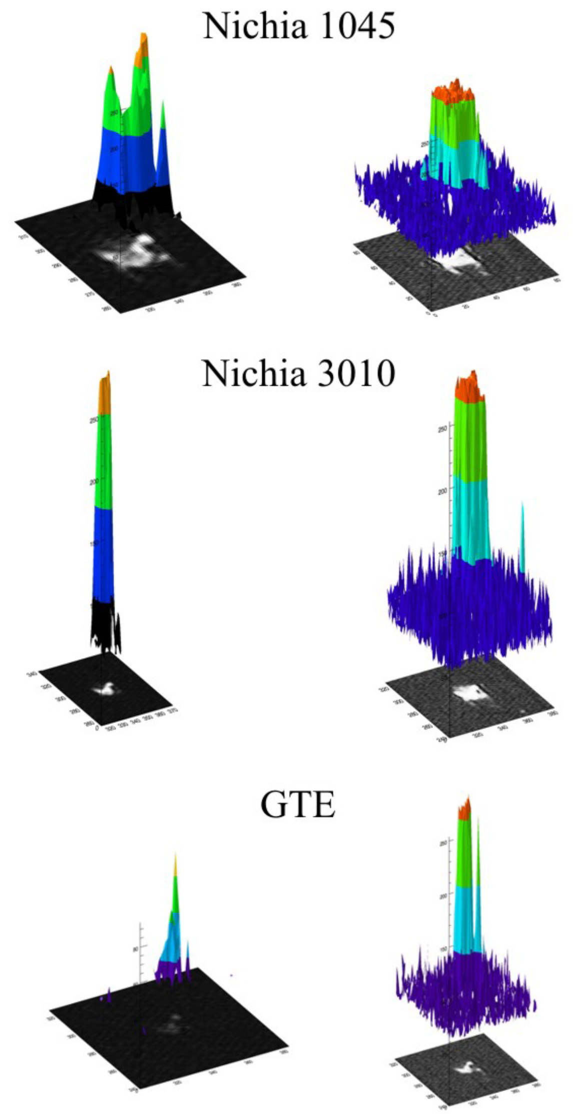

Figure 7: Phosphor comparisons.

REFERENCES

[1] IDL 7.1, ITT Visual Information Solutions, Boulder, CO; www.ittvis.com.

[2] Guy Savard and Richard Pardo, "Proposal for the 252Cf source upgrade to the ATLAS facility", Feb. 22, 2005.

[3] Gary Zinkann, "Caribu Weak Beam Diagnostics", Annual Progress Review of the Californium Rare Ion Beam Upgrade (CARIBU), February 3 - 4, 2009

[4] Linux Media Labs, Colorado Springs, CO; www.linuxmedialabs.com.

[5] Video4Linux, http://www.linuxtv.org/wiki/index.php/Main_Page.