



## **PITZ – Introduction to the Video System**

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## **Introduction to PITZ Video System** Agenda

1. Introduction to PITZ
2. Why a video system ?
3. Schematic structure
4. Client/Server architecture
5. Hardware
6. Software
7. Future Prospects



## Introduction to PITZ Video System

### Introduction to PITZ

- **Photo Injector Test Facility Zeuthen**
- test facility for free electron lasers and linear colliders
- **goal:** emittance of electron bunches -> as little as possible
- 5 rooms (tunnel, rack room, laser room, control room, klystron hall)
  
- video system is a very important diagnostic tool
- case 1: size and position of the electron bunch or laser beam must be determined
- case 2: video images used as the basis for further analysis and measurements

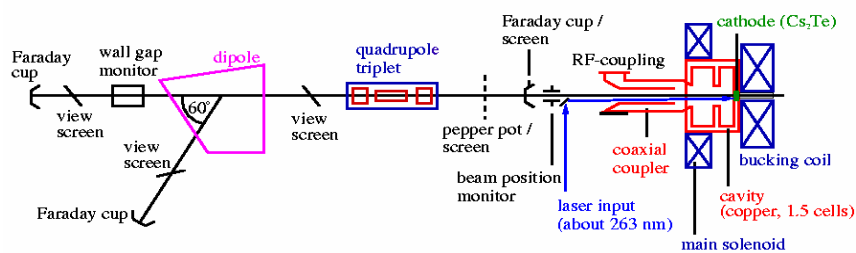
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## Introduction to PITZ Video System

### Introduction to PITZ (2)



- photoemission at cathode -> electron bunches -> acceleration
- examination of bunches using diagnostic tools
- 5 cameras mounted at diagnostic tools
- 1 camera to directly monitor the laser beam
- repetition rate of facility 1-10 Hz

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## Introduction to PITZ Video System

### Why a video system ?

- radiation inside the experiment hall (tunnel)
- ability to directly watch (like TV) and to save video data for later analysis (like a camera)
- electron beam hits fluorescent screen
- laser beam hits video camera directly
  - image is acquired at the same time
- repetition rate same like whole experiment: 1 - 10 Hz
- up to 10 video frames must be acquired, sent, received and analysed each second

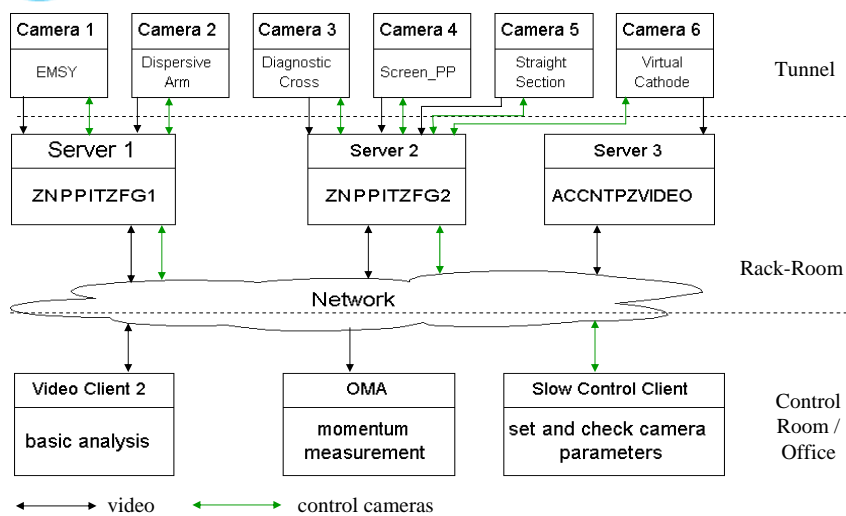
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## Introduction to PITZ Video System

### Schematic Structure



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## Introduction to PITZ Video System

### Why Client/Server ?

- **constructional conditions**
  - analogue camera cables end in rack-room
  - watching and analysing done
    - in the control room
    - at office of the physicists
- **flexibility**
  - more than one client can watch or analyse the video simultaneously
  - client program can run offline (using images from disk)
- **connection between server and client: network**

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## Introduction to PITZ Video System

### Hardware and Software - Overview

- **hardware used in the setup**
  - video cameras
  - framegrabber card
  - server computer
  - network
- **software used in the setup**
  - video software (GrabServer 2, Video Client 2, OMA)
  - slow control software (VideoCamServer, Camera Setup Client)

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## Introduction to PITZ Video System

### Hardware



## Introduction to PITZ Video System

### Cameras

- used to record laser beam and electron beam for diagnostic purposes
- required characteristics:
  - external triggering
  - full frames (no interlaced video)
  - resolution 768 x 574 pixels
  - luminosity signal (no colours), 8 bits per pixel
- additional characteristics:
  - parameters (gain, shutter-speed) can be set via RS232 connection



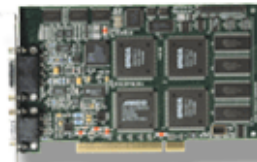
JAI M10RS



## Introduction to PITZ Video System

### Framegrabber card

- Coreco Imaging PCVision
- digitises the video signal
- characteristics
  - compatible with M10RS camera
  - full frames (768 x 574 pixels)
  - can work up to 10 Hz
  - luminosity with 8 bits per pixel
  - 4 camera inputs, but only one can be active !



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### Server computer

- located in the rack-room
- framegrabber card is located inside computer
- analogue camera cables end at framegrabber card
- server applications for acquiring video and controlling camera parameters are running there
- Microsoft Windows-based
- OS Windows NT 4



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## Introduction to PITZ Video System Network

- used to transfer
  - video frames from server to client
  - commands from server applications to client applications and vice versa using TINE protocol
- bandwidth problem
  - video frames are compressed before they are send out (loss-less compression, ratio about 1:2 - 1:4)
  - video frames are transferred in multicast mode to save network resources
  - standard socket connections as backup possible



## Introduction to PITZ Video System

### Software

1. GrabServer 2
2. Video Client 2
3. Online Momentum Analysis
4. Slow Control Software



## Introduction to PITZ Video System

### GrabServer 2

- running on server computer
- acquires video images from framegrabber card
- fast loss-less compression of video frames (reduces amount of data by 1:2 - 1:4 on the network)
- data connection (video images) by
  1. streaming sockets (receiving can be implemented almost anywhere)
  2. TINE protocol multicast (reduces required network bandwidth and server load)



## Introduction to PITZ Video System

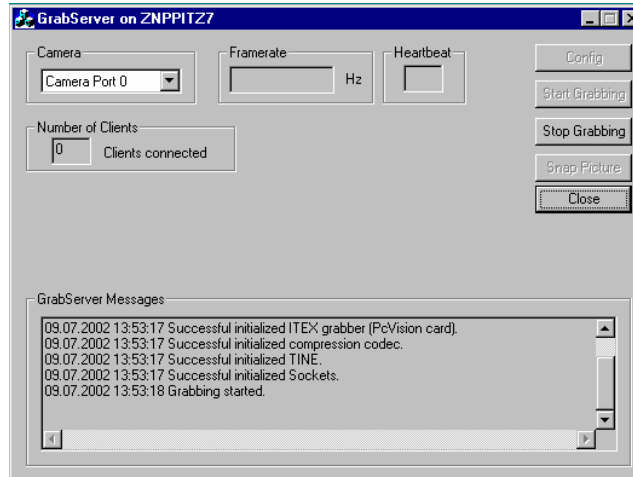
### GrabServer 2

- continuous analysis can be done on the server
  - laser spot centre and size can be remotely read out
- control connections using TINE protocol
  - switch camera port
  - clients can download important information (e.g. camera names)
- client programs:
  - Video Client 2
  - Online Momentum Analysis Tool





## Introduction to PITZ Video System GrabServer 2



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## Introduction to PITZ Video System Video Client 2 - Basics

- basic online and offline video analysis of beam spots
- works in realtime up to 10 Hz on a fast PC with all analysis and filtering functions switched on
- calculation of spot centre and size based on multiple algorithms
- DAQ function (readout of experiment's parameters to correlate with spot centre and size)

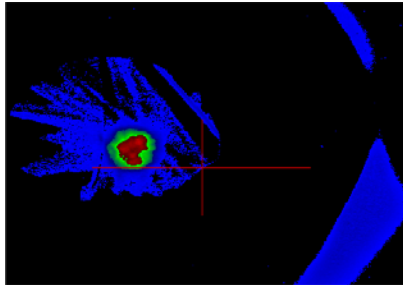
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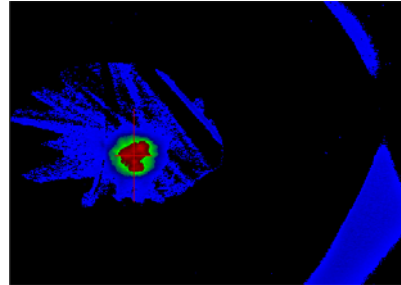


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### Video Client 2 - Analysis modes



- straightforward mode (fast, sensitive to noise)



- Fourier mode (slow, insensitive to noise)



## Introduction to PITZ Video System

### Video Client 2 - Features

- Features
  - live and offline processing mode
  - selectable Area of Interest
  - Laser power measurement
  - loading and saving of video images and backgrounds
  - scale factor to obtain results directly in millimetres (instead of pixels)
  - printing of video images as well as the whole application window (logbook)
  - drawing of X and Y projections



## Introduction to PITZ Video System

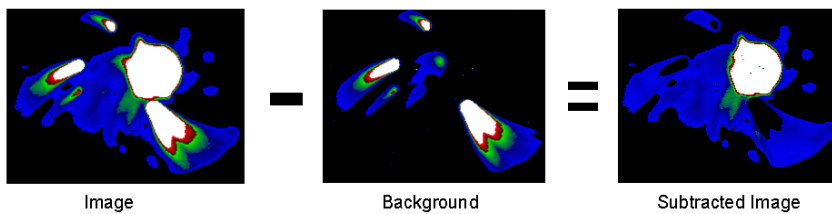
### Video Client 2 - Filtering functions

- useful functions to improve video quality
  - advanced background subtraction using multiple algorithms when taking backgrounds
  - normalisation (amplification of the video image)
  - X-Ray filtering (cut off small peaks)
  - false colour mode (improve recognisability of weak signals and signal differences)



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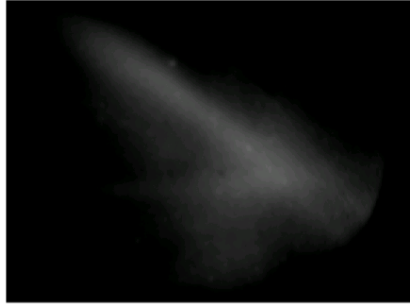
### Video Client 2 - Background subtraction



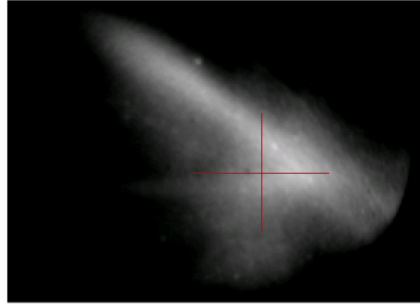
- background subtraction of dark current



## Introduction to PITZ Video System Video Client 2 - Normalisation



weak spot



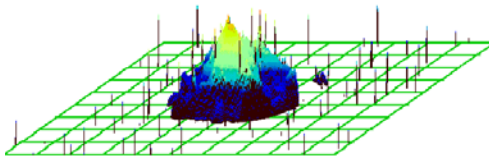
normalised (amplified)

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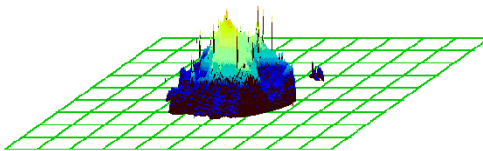
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## Introduction to PITZ Video System Video Client 2 - X-Ray filtering



unfiltered beam profile



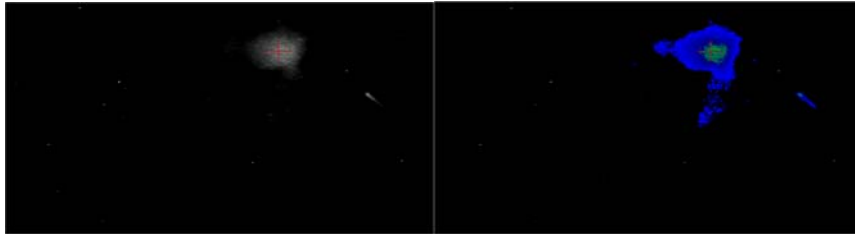
filtered beam profile

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## Introduction to PITZ Video System Video Client 2 - False colour mode



Grayscale mode

False colour mode

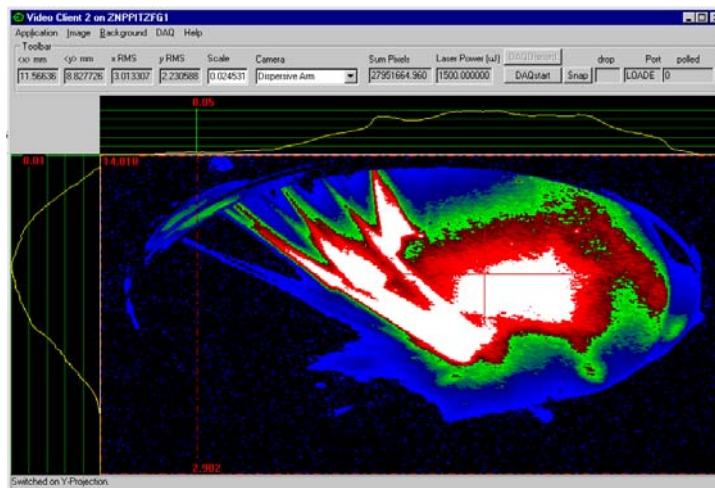
- spot looks very small
- spot is actually bigger
- one can better check the intensity

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## Introduction to PITZ Video System Video Client 2 - Screenshot



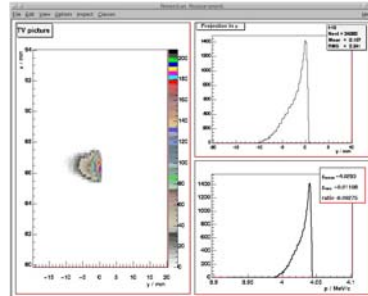
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## Introduction to PITZ Video System OMA

- **Online Momentum Analysis**
- online measurement of momentum distribution of an electron bunch coming from a photo injector
- calculation of the mean momentum and momentum spread



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## Introduction to PITZ Video System Slow Control

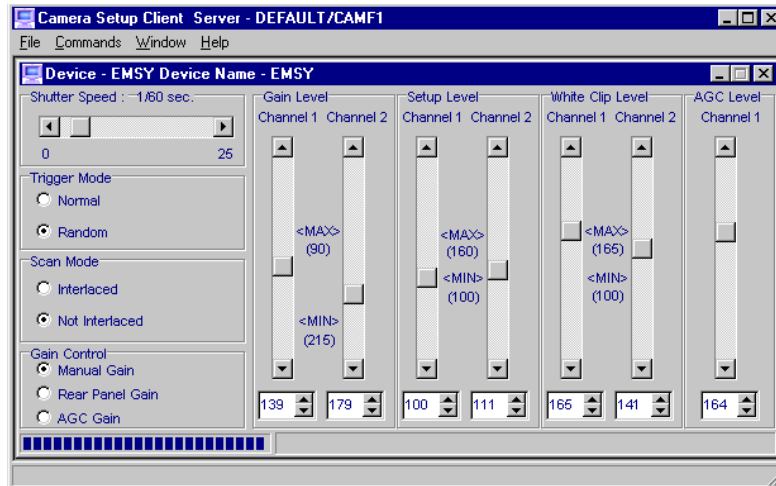
- used to remotely set and check parameters of any camera to adjust the quality of the video signal the camera delivers
- control of gain, shutter speed, setup and white clip level, trigger mode etc.
- server is connected to cameras using serial ports
- two clients talk to server via TINE protocol
  - control system GUI (UNIX)
  - Slow Control Client (MS Windows)

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## Introduction to PITZ Video System Slow Control Client

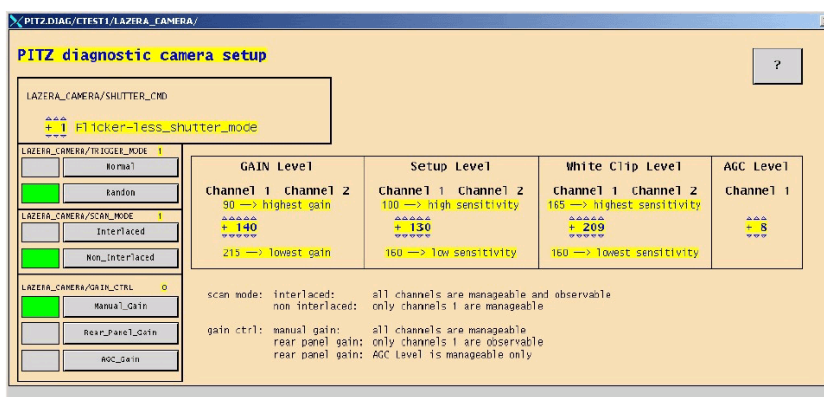


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## Introduction to PITZ Video System Control System GUI



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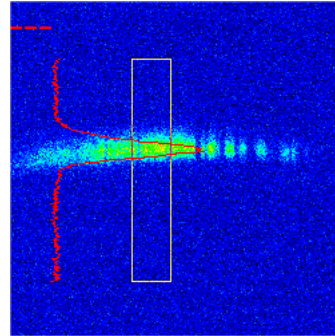
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## Introduction to PITZ Video System

Future prospects

- integration of Streak Camera into Video System
- analyse laser spot
- tune laser parameters to create more ideal spot
- analyse  $\Leftrightarrow$  tune (feedback)



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## Introduction to PITZ Video System

Future prospects (2)

- laser mirror control system
- take video image from Virtual Cathode
- calculate spot centre
- move mirrors so that the spot is in e.g. always in the middle of the video image
- corresponding spot on real cathode is always on a defined point

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## Introduction to PITZ Video System Future Prospects (3)

- radiation hardened cameras
  - currently used video cameras gets destroyed because of radiation inside the tunnel
  - shielding with big lead blocks sometimes not possible
  - new cameras must be selected that are radiation hardened
  - at the moment: checking selected camera against our requirements is ongoing
  - based on our investigation there is only one camera that fulfils our requirement of being radiation hardened



## Introduction to PITZ Video System

The End.

Thank you for listening.

Questions ?