Pellet target development

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Requirements

• Minimal influence on the beam
• Minimal influence on vacuum system of the storage ring
• Frequency and speed of the target must be variable
• Must have precise triggering and TOF measurement
• Must be able to be synchronized with other parts of the detector
Different Target Systems

White Noise

Carbon target
Block Target System

- Horizontal and vertical targets
- Linear actuator using stepper motors
- Software and hardware interlock systems
- Industry standard instructions using G-Code
Ballistic pellet target system

Target chamber

Vacuum pipe

C-pellet target

exit window

COSY beam

$v=10\text{m/s}$

$t=1\text{ms}$

1cm
Pellet target system working diagram

- Synchronization and Triggering unit
- Data readout and processing
- Thrower catcher system
- Target
- Vector map
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SYSTEM DESIGN

TARGET SYSTEM

- electrical
  - Trigger & TOF
  - Laser & PIN diodes
- Image processing
  - High fps camera

mechanical
- throw
- catcher

FPGA → CPU

network

- TOF
- Pellet tracking data
- triggering
Triger system

Laser → PREAMP → AMP →...
Triger system testbench
FPGA Image processing

5MP – CMOS image sensor
MIPI CSI-2 interface
Resolution - QSXGA@15Hz, 1080p@30Hz, 720p@60Hz, VGA@90Hz and QVGA@120Hz
Formats - RAW10, RGB565, CCIR656, YUV422/420, YCbCr422, and JPEG

667 MHz dual-core Cortex-A9 processor
1G Ethernet, USB 2.0, SDIO
1 GB DDR3L RAM
FPGA – XC7Z020-1CLG400C
Look-up Tables (LUTs) 53,200
Flip-Flops 106,400
FPGA Image processing

Camera → Camera physical layer → Camera Frame decoder → Stream From camera → RAW To RGB

Gamma correction → Image processing → VDMA → ARM CPU

RGB to Grey → 2D filter → Gaussian blur → Erode

ARM CPU

Camera physical layer

Stream From camera

RAW To RGB
Vivado HLS IP development
Camera and image processing test

Image from custom linux
Running on FPGA board

Image processing test using color invert and Sobel filter

Image processing test using Pewitt filter
Summary

- First prototype of triggering system has been developed and tested with 400 µm ball.
- First camera tests were made on FPGA.
- Test image processing IP has been developed.
- Custom Linux distro was built with working programming, network, GPIO and camera interfaces.

Outlook

- Automatized mechanics should be developed for target tests (dropper/catcher system).
- Another trigger system must be assembled dedicated mechanical system should be developed for two trigger system to test TOF.
- AXI control interface should be implemented in image processing IP to control some parameters from CPU.
- Developing a stroboscopic system for image capturing.
- New system design must be created with image processing IP cores and implemented in Linux.
THANK YOU
Appendix
Optimal systems selection

- FPGA
- Camera
- Laser & Photo diode
- Geometry
- Timing
- Goal

Otari Javakhishvili
გრანულიანი სამიზნის 3D სქემა

- Mirrors
- beam
- camera
- Pellet target
- Throw catcher system
სამშობლოდ დროშის დროის გაზომვა

- Triggering
- Position reconstruction
**Camera requirements**

Minimum camera characteristics with window size 1x4 cm and pellet diameter 100µ:
- Minimum 26 fps to get 2 points (free fall)
- Minimum 400 pixels

- **Pco - pco.dimax HS4**
  - Fps = 2277 @ 4Mpix (2000x2000) or 7039 @ 1MPix (1000x1000)
  - Interfaces: USB 3.0, GigE/USB 2.0, Camera Link
  - Exposure time range 1.5 µs - 40 ms

- **Ximea - CB019MG-LX-X8G3**
  - Fps = 2500+ @ 2Mpix (1920x1080)
  - Interfaces: PCI Express (PCIe) Gen3
  - Exposure time range = 1µs – 1sec