First Analysis Results of Disc DIRC Testbeam 2016

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PANDA Collaboration Meeting LX.

Cherenkov Group Meeting

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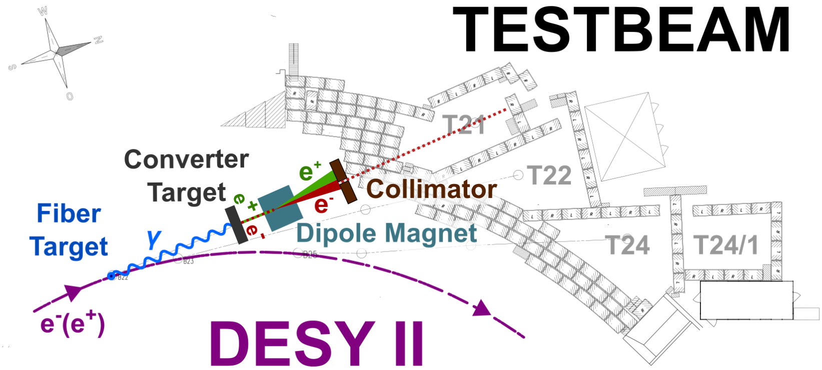
I. Testbeam Setup

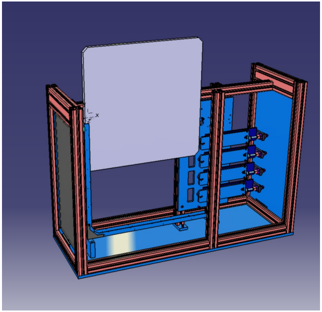
DESY Testbeam Area

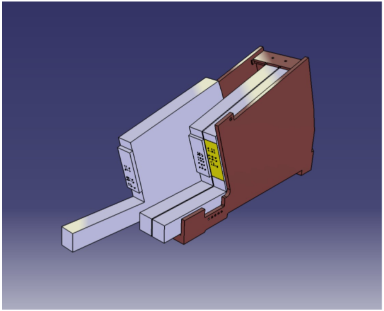
Creation of bremsstrahlung with Carbon Fiber Target → Creation of e^+e^- pairs → Filtering e^- with primary collimator



Mechanical Setup

Newly constructed frame for radiadator disk and ROM plastic holders with 3D printer:

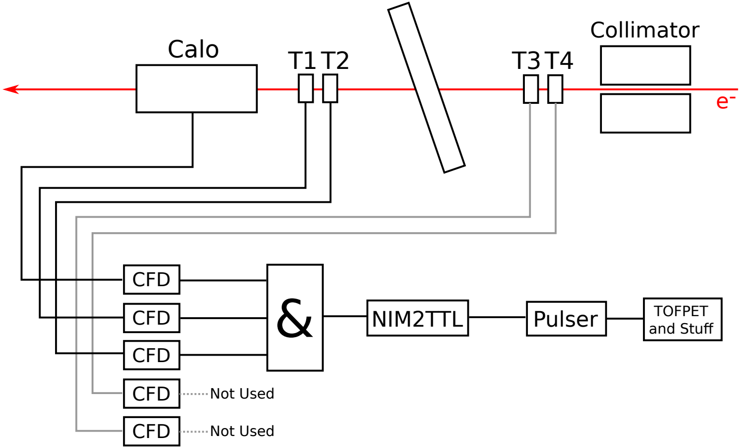




Only 3 focusing elements available $\rightarrow$ setup containing 1 complete readout module

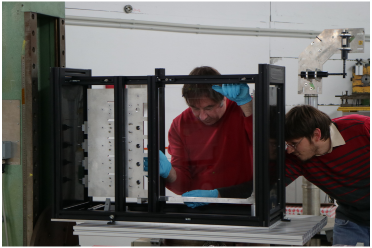
Trigger Scheme

Using 2 of 4 scintillators together with calorimeter for trigger logic (signals from T3/T4 too small)

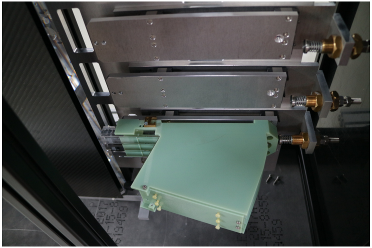


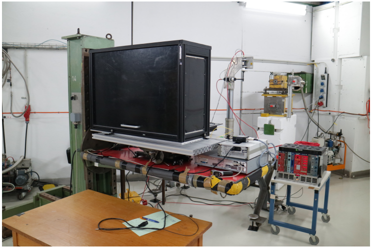
Trigger signals converted to TOFPET compatible pulses with additional pulser and capicator

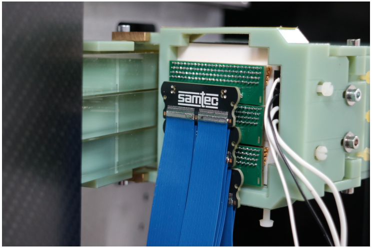
Testbeam Fotos



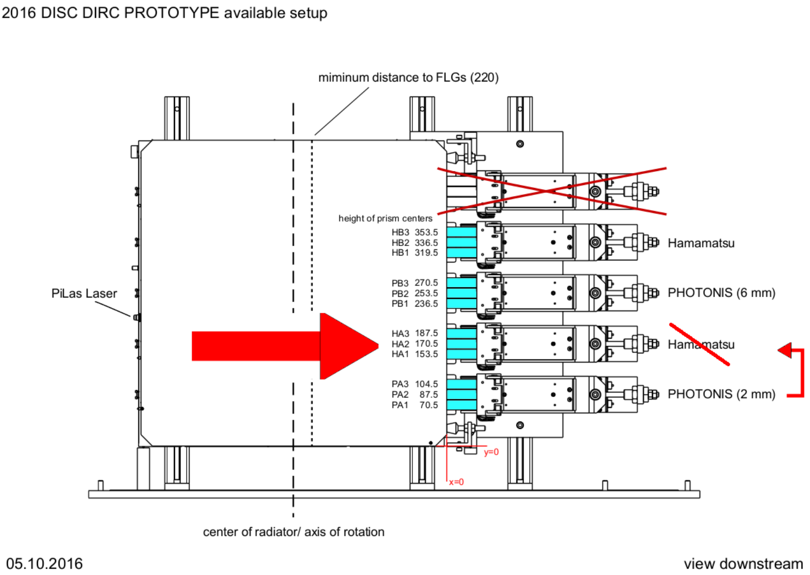
Testbeam Fotos







Radiator Setup



Testbeam Setup

- **Focusing Elements (FELs):**
  - Center: Best quality
  - Up: Good quality
  - Down: Bad quality (problems with glue between bar and focusing light guide)
- **Radiator disk:**
  - Production Company: Nikon
  - Size: 50 cm$\times$50 cm$\times$2 cm
  - Fused Silica
  - approx. 1 ns surface roughness
- **Sensor:**
  - Photonis MCP
  - Entry Window: 2 mm thickness
  - Collection Efficiency: approx. 65%
- **Readout System:**
  - Tofpet: Time resolution 50 ps
  - Continuous readout without gate
  - Time stamp of trigger channel for offline reconstruction

Scan

Different scans performed for 3 GeV beam momentum:

- HV scans
- Threshold scans
- Collimator scans
- Angular scans for different positions
- x and y scans for fixed angles

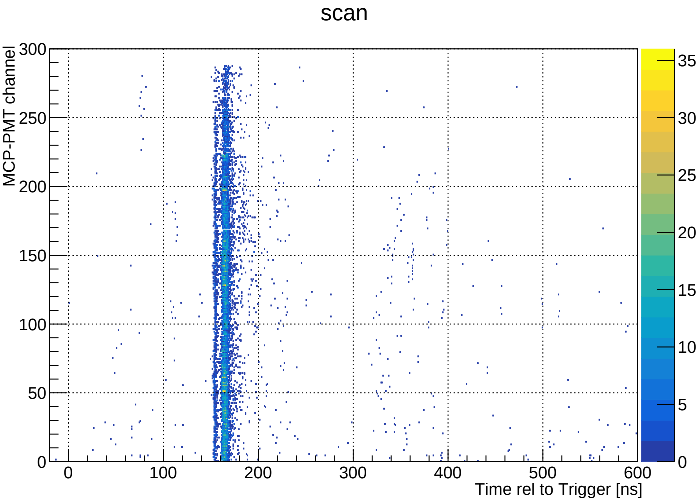
Testbeam parameters:

- Spatial Resolution: $r \approx 5\,\text{mm}$
- Angular Resolution: $\theta \approx 1\,\text{mrad}$
- Primary Collimator: 5x5x5x5 mm
- Secondary Collimator: 15x15 mm
- Beam momentum: 3 GeV/c

II. Testbeam Analysis

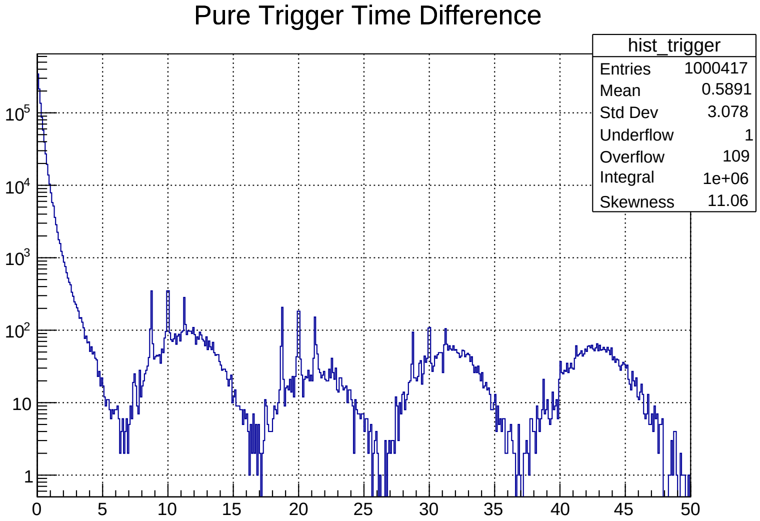
TOFPET Laser Run

Measurement results with laser run according to prediction for Photonis MCP



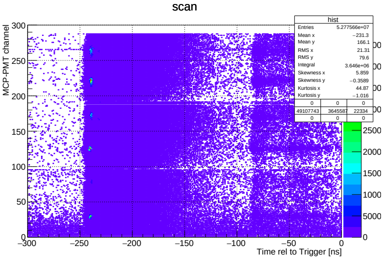
Trigger

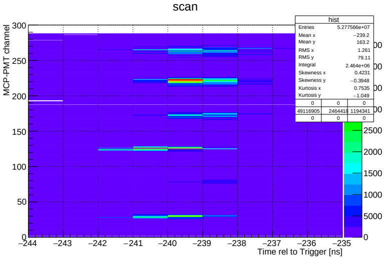
Sample measurement: $x = 200\,\mathrm{mm}$, $y = 187\,\mathrm{mm}$ (center position of ROM), $\theta = 16^\circ$



Time Spectrum

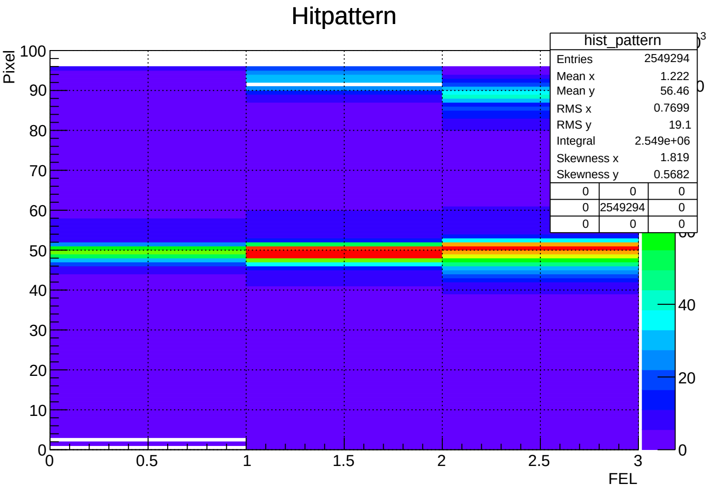
Timing as difference between photon and trigger signal
→ Cherenkov light around 240 ns before trigger





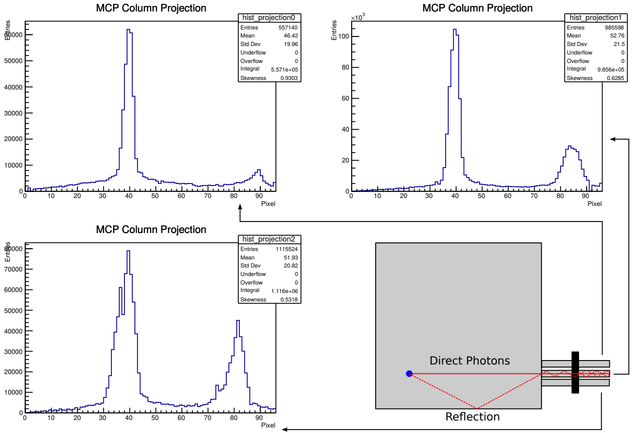
Constant time window for event filtering

Hit pattern for time window of 12 ns with direct Cherenkov light and reflection



MCP Column Projection

Channel distribution for each MCP column:

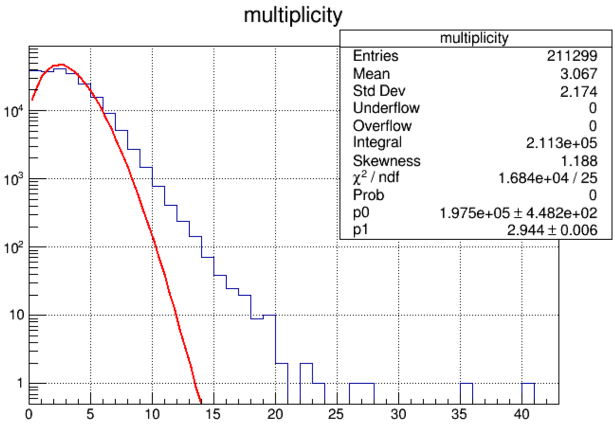


Projection resolution: $\sigma \approx 2.0$ pixel for Cherenkov peak

Approx. 1 hit per column per event (agreement with Monte-Carlo simulation)

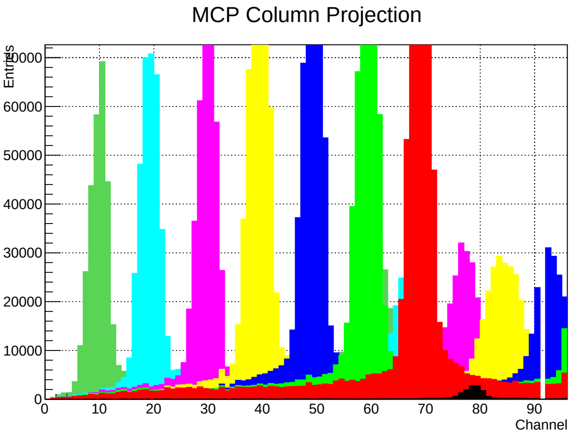
Hit Multiplicity

Number of hits per trigger (center FEL):



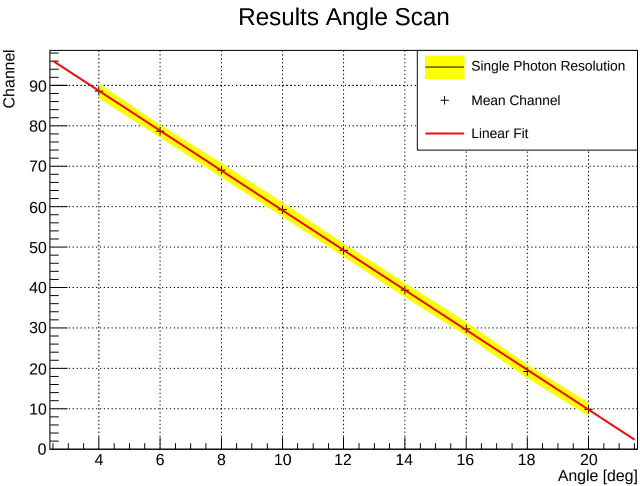
Discrepency for Poissonian fit and data for higher multiplicity due to dark counts and charge sharing (under investigation)

Results of angle scan for $\theta = 2^\circ \ldots 22^\circ$ in 2° steps ($\theta = 2^\circ$ and $\theta = 22^\circ$ out of range)



Smaller peaks belonging to direct reflection on rim

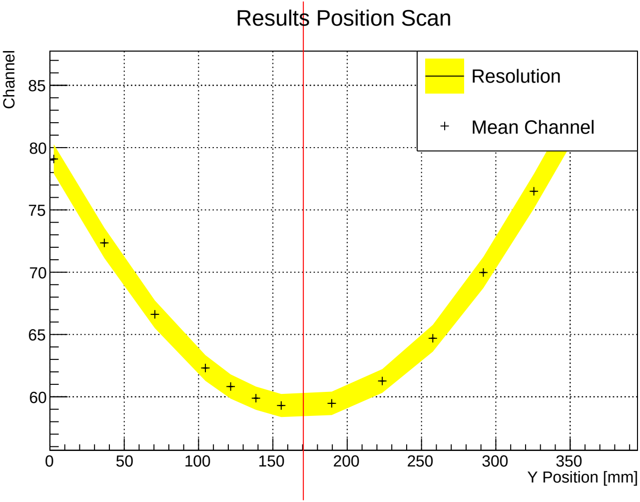
Linear dependency between channel number (pixel) and AOI:



Results of angle scan exactly according to prediction

First Position Scan

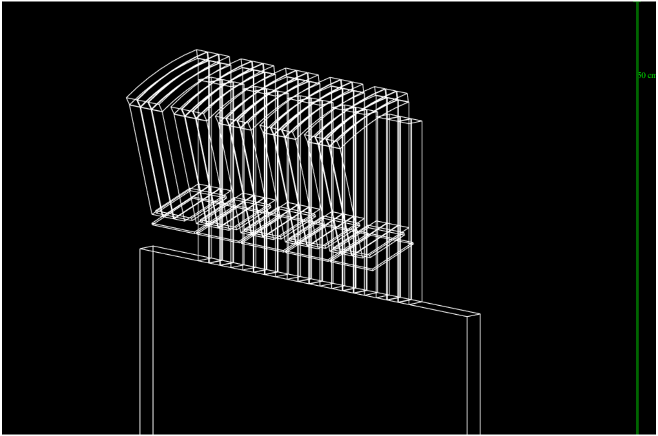
Results of y-position scan for $y = 0\,\mathrm{mm} \ldots 500\,\mathrm{mm}$ in $17.5\,\mathrm{mm}$ steps for $\theta = 10^\circ$



III. Monte-Carlo Simulations

Setup Geometry

All relevant objects included in Geant4 Monte-Carlo simulation (no passive volumes):

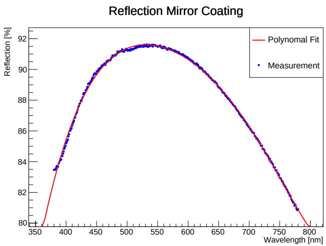


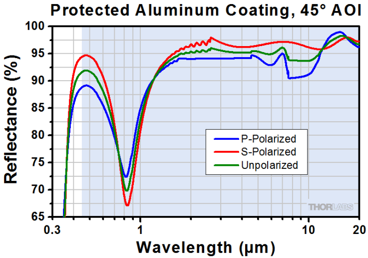
Simulation Parameters

- Standalone time-based simulations with Geant4
- Trigger timing according to measurement
- Smearing of particle track according to DESY information
- Wavelength dependency of...
  - refractive index of fused silica
  - mirror reflecivity
  - absorption length in fused silica
  - absorption coefficient of optical grease
  - MCP quantum efficiency
- Charge sharing, cross talk and dark counts additionally implemented

Adjusted Mirror Reflectivity

No measured data for wavelengths smaller than 380 nm available:

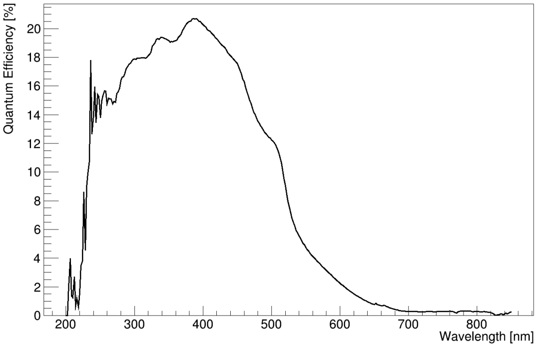




(Interpolated from measured data) (Assumed reflectivity)

Large influence of UV photons on single photon resolution according to simulations

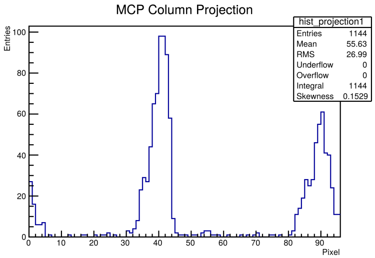
Measured quantum efficiency of Photonis MCP in Erlangen:



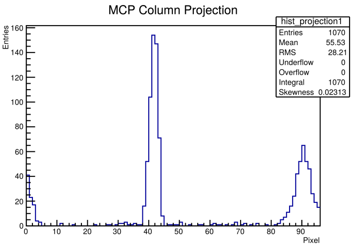
Again large influence of smaller wavelengths

Monte-Carlo results

Results for same parameters with different minimum wavelengths:



($\sigma \approx 2.3$ px for 200 nm)



($\sigma \approx 1.7$ px for 300 nm)

Simulation results highly influenced by dispersion (not all parameters known until now)

$\rightarrow$ *"Truth lies somewhere in between"*

Two possibilities: Measuring or tuning of mirror reflectivity

Conclusion & Outlook

- Succesfull testbeam with prototype setup almost identical to final detector $\rightarrow$ analysis planed to include in TDR next summer
- Changing input parameters in Monte-Carlo simulation necessary
- Only 1 ROM with different focusing elements available
- Photon yield reproducable with Monte-Carlo data (discrepency until now $\leq 20\,\%$ most likely due to dark counts and noise)
- Single photon resolution still under investigation (measured data of mirror important)
- Planing next testbeam at CERN with complete prototype setup and updated mechanics
- Testbeam with magnetic field should be prefered