Developing the ATLAS Forward Proton Detector

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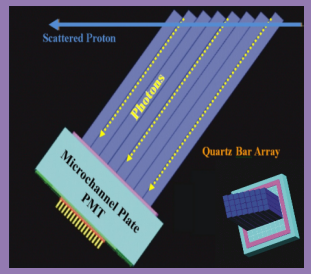
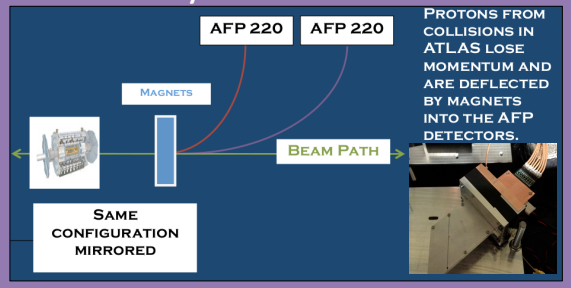
PICOSECOND TEST FACILITY

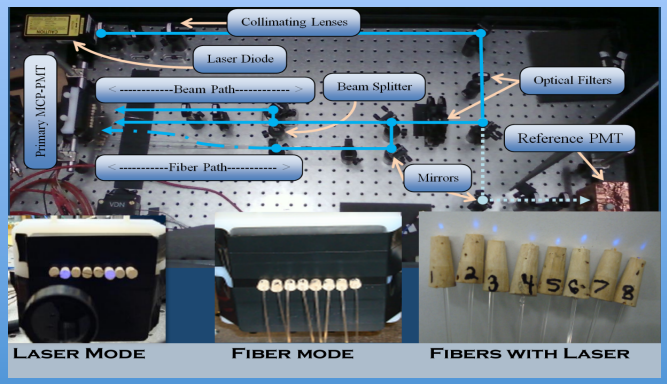
The AFP system incorporates position and timing detectors into specialized movable beam pipe sections upstream and downstream from ATLAS, and along with the LHC magnets forms a high resolution momentum spectrometer, enhancing the physics capabilities of ATLAS. This timing detector would have unprecedented accuracy on the 10 ps scale, providing rejection against the combinatoric background arising from the overlap of several proton-proton collisions in the same bunch crossing.

Detector Layout





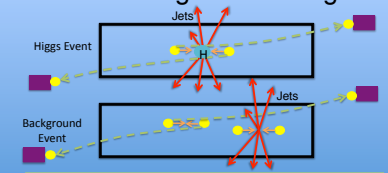
The Picosecond Test Facility (Laser Simulation of Cerenkov Radiation)



QUARTIC (QUARtz Timing Counter)

- 4x8 Array of 5x5mm quartz (Fuzed Silica) Bars
- Uses Cerenkov radiation with microchannel plate PMT
- 8 independent 30ps measurements would give ~10ps resolution overall

Small Angle Scattering



A precise measurement of the time these scattered protons arrive at our detector will enable us to determine the z vertex to within 3mm. This will allow us to eliminate the pile up background events.

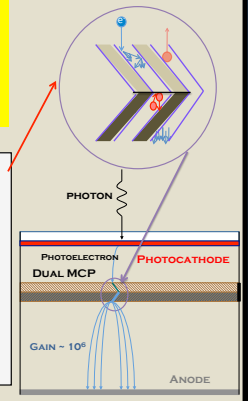
MCP-PMT Lifetime Issues

- The major issue with MCP-PMT's is the limited lifetime (loss of quantum efficiency – QE) attributed to positive ions damaging the photocathode. The effect is believed to be proportional to extracted charge (hence also the current).
- For an LHC year of 10^7 sec with <I>=2 μA/cm² Q=20 C/cm²/yr ! This is about 40x longer than the typical MCP-PMT lifetime
- An optimized detector can reduce this factor to ~20. We developed an R&D plan to suppress creation of positive ions (Arradiance Inc., UTA, with Photonis, Funded by NSF SBIR)
- Currently testing new PMT's with prototype micro-channel plates coated by Arradiance, designed to increase the electron shower. This allows us to run at a lower gain, increasing the lifetime of the PMT.

- Use a red laser (632 nm) to damage selected pixels of a standard and modified MCP-PMT (Loss in QE is expected First at high λ)
- Continuously Monitor pulse height and Number of Pe's using automated scope scripts.
- When a change is observed, can toggle a mirror to strobe tube with blue laser.
- Allows multiple lifetime tests with one tube

Ideal Long Life MCP-PMT Characteristics

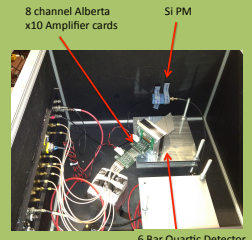
- Suppressed positive ion creation (NSF SBIR)
- Ion Barrier keeps positive ions from reaching photocathode (old idea, but recently improved through Nagoya, Hamamatsu collaboration)
- Use Photek Solar Blind photocathode or similar (responds only to lower wavelength/ more robust)
- Low resistance glass or coating allows for high rate with pore size as small as possible 6 to 10 μm)
- Increase anode voltage to reduce crosstalk 200V to 500V (UTA studies)
- Run at low gain (< 10^5 instead of 10^6 and then amplify) reduces integrated charge (UTA studies)



Results from Dec-2011 Test beam at MTest

- We tested a 6 bar QUARTIC detector
- Used a Silicon PM with a high number of PE as the trigger

Our plot of the SiPM-6 bar quartic average has roughly a 35% improvement over any single measurement.



We observe some optical/ electrical crosstalk which correlates the measurements from each bar. The next design will separate the bars, hopefully reducing the correlation in each measurement.

Outlook

- ✦The AFP system has been approved to be installed during the 2014 LHC shutdown.
- ✦Currently performing lifetime tests to help improve the PMT lifetime.
- ✦Will conduct a test beam in October at CERN in order to help optimize our detector design.