Characterization of new PMTs and fibers for the LUCID-3 prototypes

Davide Cremonini

Unibo e INFN BO

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Luminosity in a collider

Revolution frequency

Number of protons



LUCID-2



2 modules symmetric wrt interaction point placed 17m away from IP

- 4 block of 4 PMTs + 4 quartz fiber in each side
- PMT calibration: ²⁰⁷Bi
- Fiber calibration: only LED
- Algorithm used:
 - Hit counting
 - Particle counting

- Long-term stability less than 1%
- Offline precision $\approx 1\%$

NOT SUSTAINABLE IN **HL-LHC CONDITIONS**

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LUCID-3 prototypes

- PMT-type prototype
 - Reduced particle flux:
 - New custom-made smaller PMTs (R1635)
 - Farther from the beampipe (LUCID 2-JFC)
 - PMT's behind shielding (LUCID 2-JN-A)
- PMT-Fiber prototype(LUCID 2-FIB-C)
 - New fiber bundles and new PMT (R7459) with advanced calibration technique: ²⁰⁷Bi to calibrate PMT, LED to monitor fiber degradation





LUCID 2-FIB-C - a two channel fiber detector with the PMTs calibrated by Bi-207 and the fibers by LED signals.

Prototypes characterization

- New PMT (R1635 and R7459) and new fiber (UVNSS 600/624/660) used in prototypes and LUCID-3
- PMT characterization:
 - > Gain vs High voltage
 - > Absolute gain
 - Compatibility with present electronics
- Fiber characterization:
 - > Opacification wrt absorbed dose





R1635

- Signals generated by bismuth measured in 2 different ways:
 - Picoammeter measures current
 - LUCROD* measures amplitude of the signals
- Discrepancy for HV>1000V
- R1635 has short signal, LUCROD sampling rate not enough for acquisition

*LUCROD: custom VME board used by LUCID for data acquisition



R1635 absolute gain

- LED in single photon regime
- 1 ph converted into 1 photo-electron
- Q_{1PE}/e gives the absolute gain
- Absolute gain @ $1000V = 7.9 \times 10^5$



Signal timing

- LED pulses synchronized with LUCROD sampling
- Change delay of the pulses
- Fluctuations in the amplitude of 28%
- Fluctuations in the charge of 5%
- Sample creates artifacts
 - needs to be increased to 640-1000 MHz
 - pulse widening circuitry under study
 - hit redefinition based on charge under study





Fiber characterization

- Fiber tested in gamma irradiation facility (Calliope at Enea, Rome).
- 6 wavelengths (285-627 nm) cycled.
- Transmission loss measured over 6 m rescaled to effective 3.2m exposed length.
- Large losses observed in UV -> filter inserted in one of the prototype bundles.
- Possible luminosity correction using characterization and test-beam data.



Conclusions

- ► Good performance from LUCID during Run-2, expected also for Run-3
- New LUCID required for Run-4 (HL-LHC)
- Prototypes installed and tested during Run-3
- Characterization of new PMT and fiber used by prototypes:
 - > LUCROD not able to digitize new R1635 properly:
 - Increased sampling rate
 - RC circuit to widen signal
 - Offline correction
 - > Large loss in UV region in fibers when irradiated
 - UV filter inserted in one prototype to improve time stability

Backup



Fiber calibration system

 ^{207}Bi to monitor PMT ageing

- 6 LEDs (λ=285-627 nm) to monitor fiber degradation:
 - > LED distribution box split LED light
 - Part of it goes directly to PMT
 - > Part of it goes through the fiber
 - Ratio used for offline L correction



Experimental apparatus at ENEA

- 4 different LEDs for light injection:
 - MTE280F13-UV (λ=280 nm)
 - MTE340H21 (λ=340 nm)
 - VCC VAOL-5GUV8T4 (λ=385 nm)
 - > LEDRGBE (λ=627.5, 525, 467.5 nm)

2 Pin diodes for output measurements

- LED pin diode: monitoring of light emitted from LEDs
- Fiber pin diode: monitoring of light at the end of fibers

