FDD o2 software

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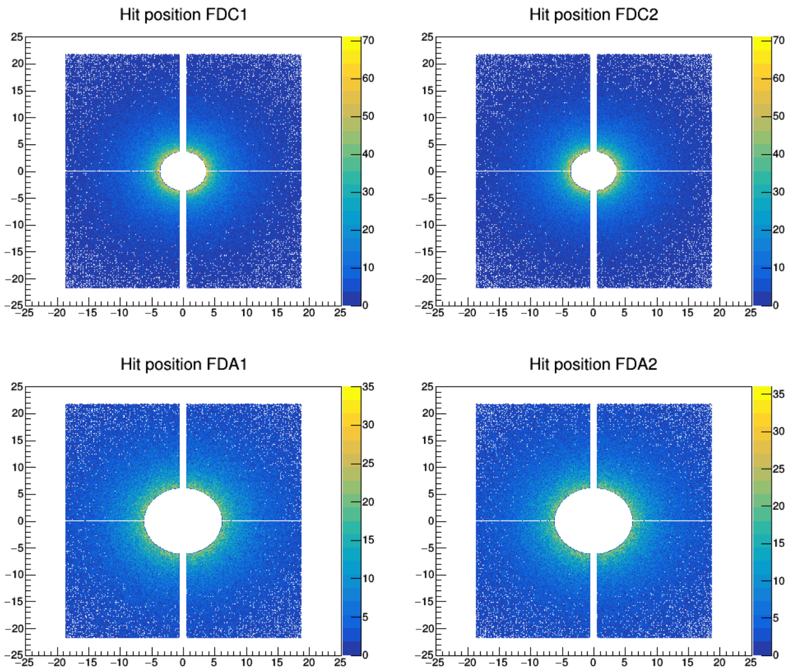
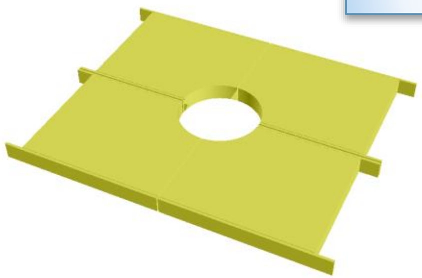
- Hits
- Digitizer
- Reconstruction

FDD O2 status - Geometry

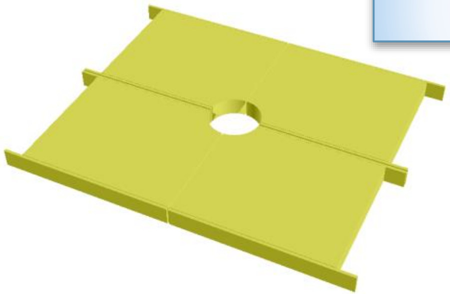
- Final active volume: scintillator blocks and wave-length shifting bars implemented in geometry
- Mechanical support to be ported/adjusted from AD



A-side



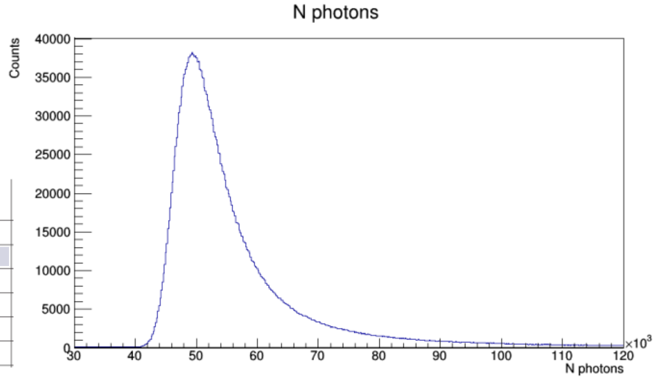
C-side

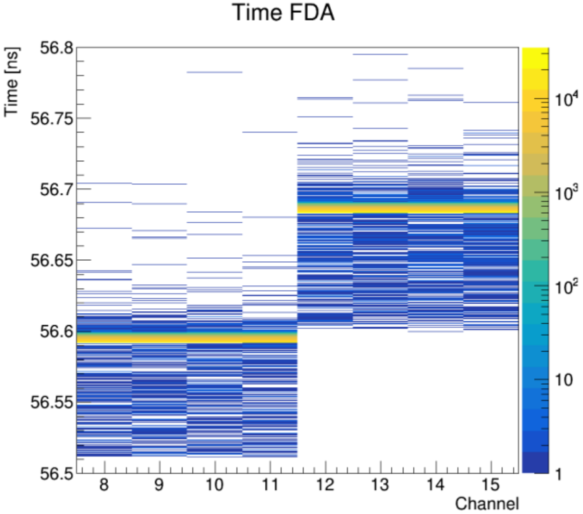


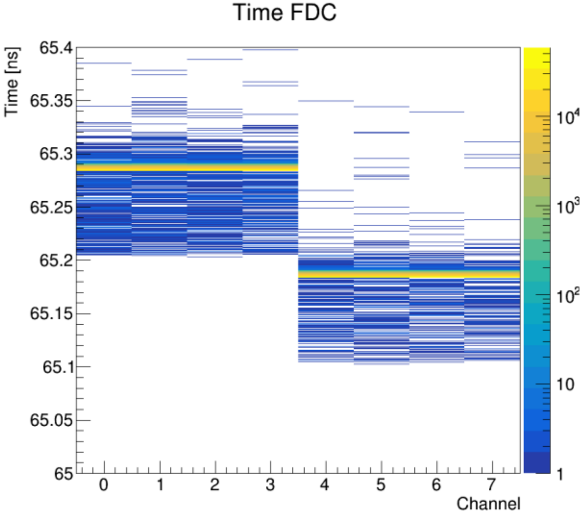
FDD O2 status - Hits

- FDD store one hit per charged track crossing the scintillator
- For every hit we integrate number of photons created at each step using energy deposition and light output of the scintillator (photons/eV)
- Figures shown here were done using box generator in detector acceptance and FDD geometry only

	BC-418	BC-420
Scintillation Properties		
Light Output, %Anthracene	67	64
Rise Time, ns	0.5	0.5
Decay Time (ns)	1.4	1.5
Pulse Width, FWHM, ns	1.2	1.3
Wavelength of Max. Emission, nm	391	391







FDD O2 status -Digitizer

- Two main parts:
  - Generation of the signal pulse
  - Processing of the signal pulse
- Signal pulse: Output of the PMT in bins with the width determined by FEE time resolution (one TVector<float> per channel)
- Digitizer simulates the route Photons->Photo-Electrons->PMT amplification-> Signal pulse
  - Intrinsic time resolution of the scintillator
  - Light loses during transport to photo-catode
  - Time spread due to light collection and transport
  - Quantum efficiency of the photo-catode
  - Time spread due to PMT transit time (per photo-electron)
  - PMT gain (real-life calibration curves in the future)
  - Gain variation due to variation of number of photo-electrons emitted from the first dynode

Digitization

- In FDD we use scintillator BC-420
  - Light output 64% of anthracene = 12.8e6/GeV
  - Wavelength of max emission 391 nm
- Coupled to NOL38 wavelength shifter
  - Absorption 382 nm
  - Luminescence 431nm 458nm

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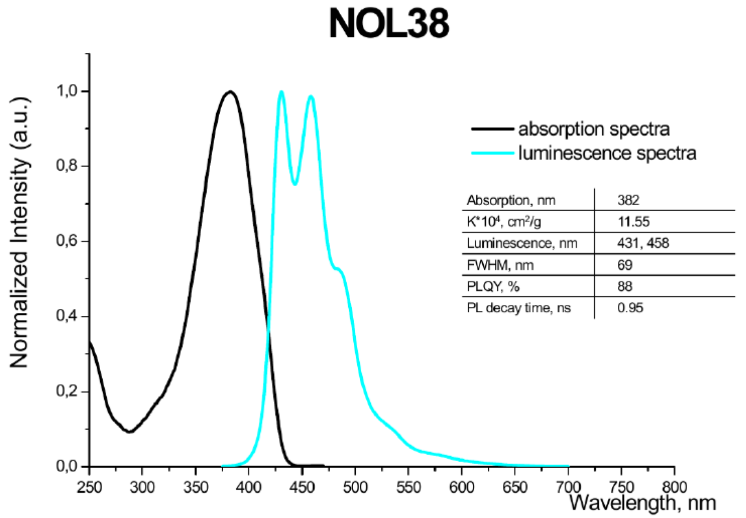
Physical Properties of Organic Scintillators

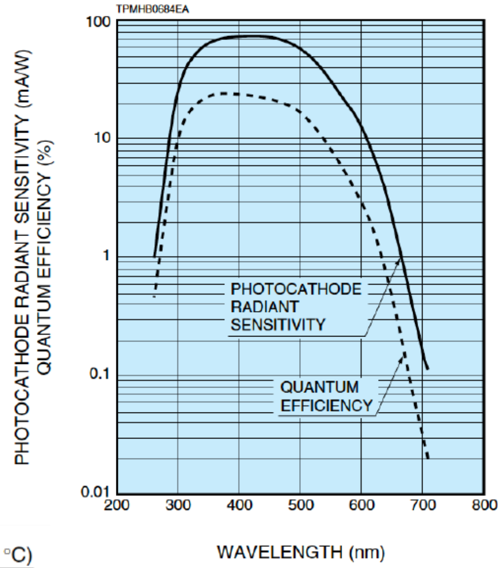
Properties	Anthracene ($C_{14}H_{10}$)
Molecular weight	178
Density, g/cm^3	1.25
H/C ratio	0.714
Melting point, °C	216
Luminescence max., nm	445
Refractive index	1.62
Light output, Photon/MeV	20,000
Decay time, ns	30
Hygroscopy	No
Radiation stability, rad	2 10^6



Digitization

- Light yield: Fraction of photons created in scintillator which will arrive on the pmt window
  - Unknown, ~1% (as seen in the old VZERO)
- Quantum efficiency: The ratio of the number of photo-electrons emitted by the photo-cathode to the number of photons incident on the window
  - ~18% for NOL 38 output wavelengths

■Spectral Response



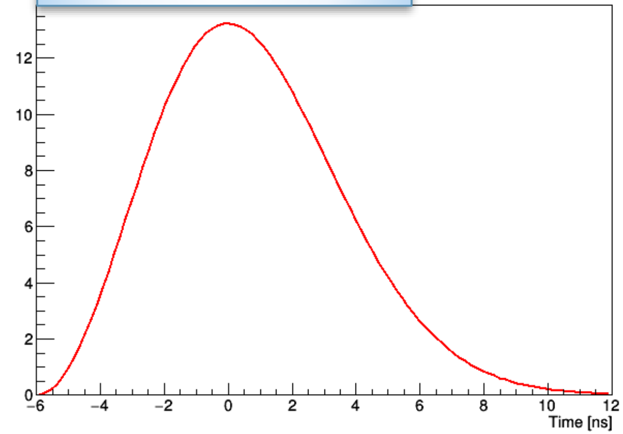
(at 25 °C)

Cathode Characteristics				Anode Characteristics M								
Luminous	Blue Sensitivity Index (CS 5-58)	Radiant K	Luminous	Gain			Dark Current (After 30 min.)		Time Response		Notes	Type No. A
Typ. (µA/lm)	Typ.	Typ. (mA/W)	Typ. (A/lm)	at 0 T Typ.	at 0.5 T Typ.	at 1.0 T Typ.	Typ. (nA)	Max. (nA)	Rise Time Typ. (ns)	Transit Time Typ. (ns)		
80	9.5	76	40	5.0×10^5	2.3×10^5	1.8×10^4	5	30	1.5	5.6	(For +HV operation) Assembly type: H6152-70 Recommended	R5505-70
80	9.5	76	800	1.0×10^7	3.0×10^6	1.5×10^5	15	100	2.1	7.5	(For +HV operation) Assembly type: H8409-70 Recommended	R7761-70
70	9.0	72	700	1.0×10^7	4.1×10^6	2.0×10^5	30	200	2.5	9.5	(For +HV operation) Assembly type: H6614-70 Recommended	R5924-70

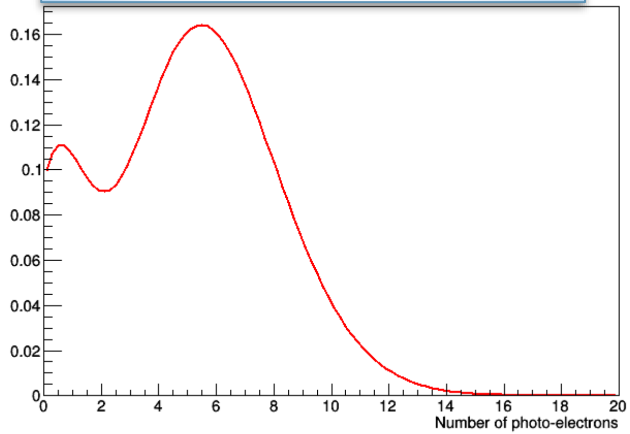
Digitization

- Generation of the signal pulse:
  - Total charge per Hit from PMT is computed using number of photo-electrons and PMT gain
  - Total charge is distributed over pulse per photo-electron using time and amplitude response of the PMT
  - For every photo-electron:
    - The mean ph.e. time should be further spread according to signal shape: function simulates the time of arrival of the photons at the photocathode (not do yet)
    - Gain variation is modeled using photo-electron spectrum
    - Photo-electron spectrum is parameterized by:
      - Number of secondary electrons emitted from first dynode (per ph.e.)
      - Transparency of the first dynode of the PM
    - Time distribution of the signal per photo-electron is parameterized by PMT transit time

PMT transit time

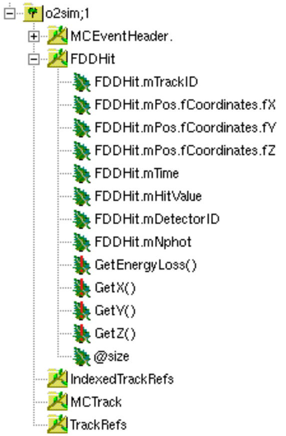


N photoelectrons from first dynode

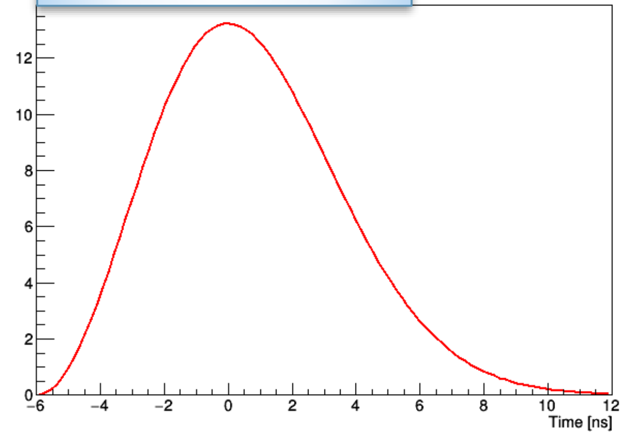


FDD O2 status -Digitizer

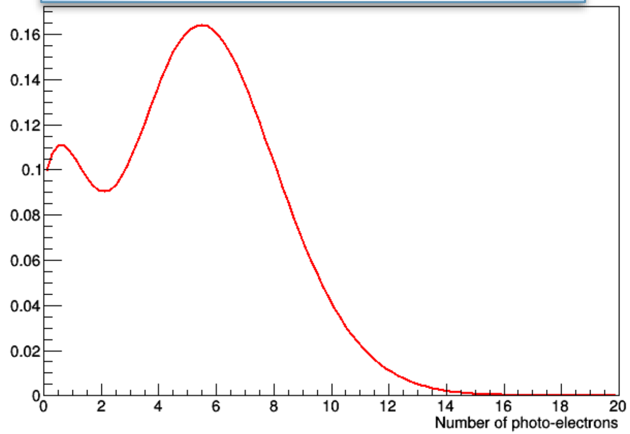
- Hit contains:
  - Base hit info + Number of photons
- Digit contains:
  - Channel data structure with ADC charge, Time and various bits (bool) as sent by FEE
  - IR, Event time



PMT transit time

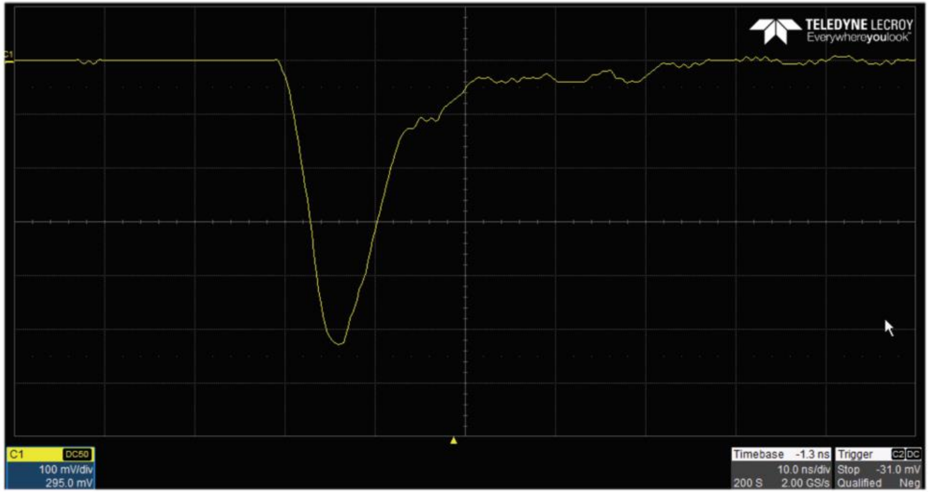


N photoelectrons from first dynode



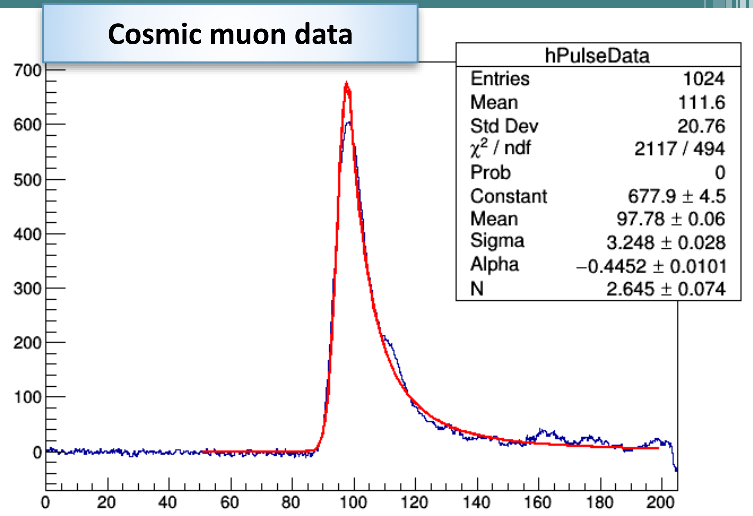
FDD O2 status -Digitizer

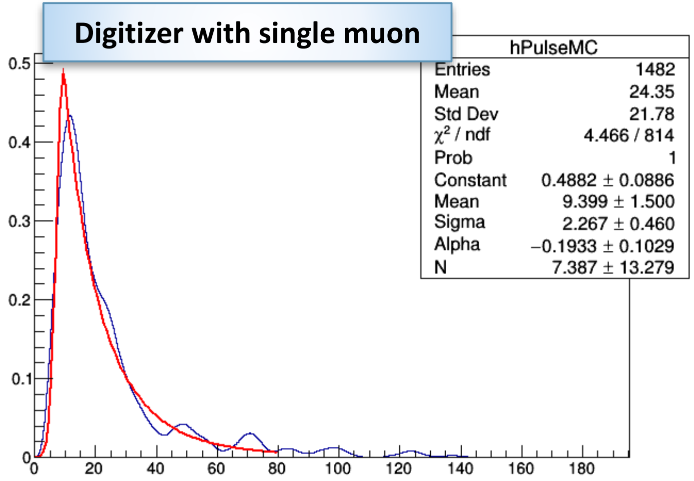
- Comparison to test bench data
- Test bench consist of one complete channel looking at cosmic muons
- The PMT output seen on the oscilloscope is something we would like to reproduce in digitizer
- System is still "work in progress", the pulse shape is not final



FDD O2 status -Digitizer

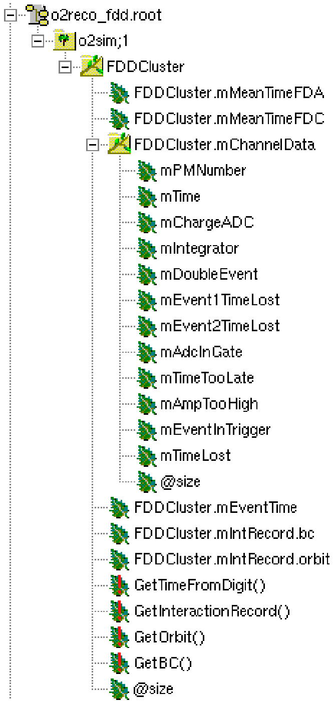
- Comparison to test bench data
- Test bench consist of one complete channel looking at cosmic muons
- The PMT output seen on the oscilloscope is something we would like to reproduce in digitizer
- The main shape of the pulse can be described by Crystal ball function
  - Due to time spread during light collection and transport
- Digitizer working with single 1-2GeV muons can reproduce the data
- Digitization parameters will be fine tuned to data once the final pulse etc. will be available





FDD O2 status -Reconstruction

- Reconstruction from Digits implemented
  - Copy the channel data structure from Digits as it is
  - Compute the mean time per side (charge weighted average)



Summary and outlook

- Done:
  - Geometry of active volume
  - Hits
  - Digitization
  - Reconstruction from Digits

- Next:
  - Geometry of support and other passive parts
  - Raw2Digits, Digits2Raw
  - Calibration object(s)