Simulation Updates on PVDIS EC

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EC performance w/o background

- Cited from March collaboration Meeting

![Graph of π⁻ rejection vs. Momentum (GeV)](image1)

![Graph of e⁻ efficiency vs. Momentum (GeV)](image2)

- Preshower ID power drop significantly at this bin
Fifth update of CLEO background

* A.K.A. Babar More1 in Zhiwen’s notes
* Inputs received on Friday Sept 6

Data points saved to ROOT format and uploaded to SVN:
https://solid.physics.umass.edu/svn/solid/solidtech/calorimeter/figs
Comments on this update

- Use Babar More1 baffle in Zhiwen’s notes
- Two version background are generated:
  - With krypton baffle for hadron background and that with lead baffle
- Now only one region show significant radiation effect: inner radius in the higher-radiation phi slice
- The updated dominate background is photons, which can be attenuated by x10 with 4 radiation length of absorbing material (~2cm lead)
- Updated to use 30 ns-equivalent ADC integration window instead of 50 ns
  - Suggested in previous meetings
  - Confirmed again with Alex
- Simulated assuming NO supporting structure between preshower and shower
  - Supporting structure could be before the Pb absorber or between Pb and the preshower scintillator
- Updated plots and data points uploaded to SVN
  https://solid.physics.umass.edu/svn/solid/solidtech/calorimeter/figs
Updated: Per-event pion rate for 1+6 hexagon cluster at Mid radius, high radiation $\phi$-slice

4$^{th}$ Update

Krypton baffle

New 5$^{th}$ Update
Significant improvement in charged particle

- Electron
- Pion$^-$
- Pion$^+$
Updated radiation dose VS layers (High radiation $\phi$ slice)

- Photon (EM) <- dominant!
- Photon ($\pi^0$)
- Electron
- Pion- Pion+ Proton

**Krypton baffle**

**Soft EM $\gamma$**

**Improved**

$4^{th}$ Update

New: $5^{th}$ Update
Updated radiation dose VS layers

~ 11 layers per radiation length

High radiation $\phi$ slice

Low radiation $\phi$ slice

Krypton baffle

Less than x2 smaller
Updated radiation dose VS layers

~ 11 layers per radiation length

High radiation $\phi$ slice

Low radiation $\phi$ slice

Lead baffle

less than x2 smaller
Readout occupancy per shower channel for ~75MeV zero suppression

Krypton baffle
- High radiation phi slice
- Low radiation phi slice
Composition of background

inner radius region within the high-radiation azimuthal sectors

→ Photon dominated

Krypton baffle

- Photon (3.5GHz @ R=120 cm): EM and $\pi^0 \rightarrow \gamma$ origin
- Electron
- Pion- Pion+ Proton
PID performance – low radiation phi slice

Krypton baffle

Significantly improved
**PID performance**
– high radiation phi slice

**Figure:**
- **Electron**
  - Efficiency after PID cut vs. Momentum (GeV/c)
- **Pion**
  - Efficiency after PID cut vs. Momentum (GeV/c)

- **Graph Notes:**
  - Lower radius remains high
  - Krypton baffle
  - 4th update, last curve as reference
  - Improved now
Trigger curve
– low radiation phi slice

Electron

Pion

Krypton baffle
Trigger curve – high radiation phi slice

4th update as reference

improved now

Krypton baffle
PID performance – low radiation phi slice

Lead baffle

Graphs showing efficiency after PID cut for electrons and pions as a function of momentum for different radii (R=247 cm, R=230 cm, R=180 cm, R=150 cm, R=120 cm, R=113 cm). The x-axis represents momentum in GeV/c, and the y-axis represents efficiency after PID cut.
PID performance – high radiation phi slice

Lead baffle
Trigger curve
– low radiation phi slice

Lead baffle

Electron

Pion

Trigger Efficiency

Momentum (GeV/c)

R=230 cm, Trig = 1.5 GeV
R=180 cm, Trig = 2.0 GeV
R=150 cm, Trig = 2.5 GeV
R=120 cm, Trig = 3.5 GeV
R=113 cm, Trig = 3.8 GeV
Trigger curve
– high radiation phi slice

Lead baffle

Electron

Pion

4th update as reference
New trigger strategy

- Embedding bgd stochastically according to its 3D distribution
- Look for percentage of 30ns trigger window that pass trigger threshold
- Good for low energy background pile ups
- Can not handle rare events due to stat. limit
- Handle p<1GeV background particle trigger

- Embedding bgd stochastically according to its 3D distribution
- Produce trigger turn on curve for high energy particle
- Good for rare events, e.g. DIS
- Can not handle low energy particle dominated trigger, which is non-linear
- Handle p>1GeV particle dominated trigger

From background embedding

From trigger turn on curve
Forth update of CLEO background

Cutting 2 cm away on 1st baffle inner radius

Received background simulation from Zhiwen on May 24
Updated: Per-event pion rate
for 1+6 hexagon cluster at Mid radius, high radiation φ-slice

- Electron (mostly absorbed in Pb)
- Pion-
- Pion+

3rd Update

New 4th Update
Updated radiation dose VS layers (High radiation $\phi$ slice)

- Photon (EM) <- dominant!
- Photon ($\pi^0$)
- Electron
- Pion- Pion+ Proton

**3rd Update**

**New: 4th Update**
Update on PID
Mid radius, higher $\gamma$ $\phi$-band shown
Other configuration also simulated

Pion Efficiency

Electron Efficiency
Trigger turn on curve for 2 GeV electron
Shower Hex 1+6 trigger > 1.6 GeV

Outer radius, higher γ φ-band, full bgd

100% pass for ~250 events/bin

Physics

Pion Efficiency

Electron Efficiency
Trigger turn on curve for **2.5 GeV electron**

Shower Hex 1+6 trigger > 2.1 GeV

Middle radius, higher $\gamma \phi$-band, full bgd

Pion Efficiency

Electron Efficiency
Readout occupancy per shower channel for ~75MeV zero suppression

Probability to for background -> 0.33 MIP per block

- High radiation phi slice
- Low radiation phi slice

Improvement
Third update of CLEO background

Received background simulation from Zhiwen on May 19
Running background imbedding
Updated radiation dose VS layers

• Photon (EM) <- dominant!
• Photon (π°)
• Electron
• Pion- Pion+ Proton

High radiation azimuthal region

Low radiation azimuthal region

From 2nd update
Background imbedding and distribution
Mid-R, High Radiation phi slice

- Photon (6GHz/6+1 Hex cluster)
- Electron
- Pion- Pion+ Proton

Jin Huang <jinhuang@jlab.org>
Updated: Per-event pion rate
for 1+6 hexagon cluster at Mid radius, high radiation $\phi$-slice

- Electron (mostly absorbed in Pb)
- Pion-
- Pion+

+ 6 GHz photon not shown (3GHz for lower $\phi$-radiation)
Update on PID with DC component removal (PS > MIP + Bgd + (2-3) σ)

Outer radius, higher γ φ-band

Due to Soft EM γ

Outer radius, lower γ φ-band

Pion Efficiency

Electron Efficiency
Update on PID with DC component removal (PS > MIP + Bgd + (2-3) $\sigma$)

Outer radius, higher $\gamma \phi$-band

Mid radius, higher $\gamma \phi$-band

Due to Hadron rate

Pion Efficiency

Electron Efficiency
More detail in PID cut
Middle radius, lower γ φ-band, full bgd

Pion Efficiency

Electron Efficiency
Update on PID with DC component removal (PS > MIP + Bgd + (2-3) σ)

Inner radius, higher γ φ-band

Inner radius, lower γ φ-band

Pion Efficiency

Electron Efficiency
Trigger turn on curve for 2 GeV electron
Shower Hex 1+6 trigger > 1.6 GeV

Inner radius, higher $\gamma \phi$-band, full bgd

Middle radius, higher $\gamma \phi$-band, full bgd

100% pass for ~250 events/bin

Pion Efficiency

Electron Efficiency
Trigger turn on curve for **2.5 GeV electron**

**Shower Hex 1+6 trigger > 2.1 GeV**

Middle radius, higher $\gamma \phi$-band, full bgd

Outer radius, higher $\gamma \phi$-band, full bgd

**Pion Efficiency**

**Electron Efficiency**
More detail in trigger cut
Middle radius, higher γ φ-band, full bgd
Shower Hex 1+6 trigger > 2.1 GeV

Pion Efficiency
Electron Efficiency
Readout occupancy per shower channel for ~75MeV zero suppression
Trigger Study for Second update of CLEO background

Reported May 7 Calorimeter Meeting

Jin Huang <jinhuang@jlab.org>
Update on PID with DC component removal (MIP + 2.5 $\sigma$)

Outer radius, higher $\gamma$ $\phi$-band

Mid radius, higher $\gamma$ $\phi$-band
Update on PID with DC component removal (MIP + 2.5 σ)

Inner radius, higher γ φ-band

Inner radius, lower γ φ-band

Pion Efficiency

Electron Efficiency
Pion Trigger Turn-On Curve (No background), Electron Eff. > 97%

Hex 1+6 Shower Trigger > 1.6GeV (for 2GeV electron)

+ Preshower Pad on top of central shower block > MIP + 1σ
Trigger turn on curve with background

Middle radius, higher $\gamma$ $\phi$-band

Inner radius, higher $\gamma$ $\phi$-band

Pion Efficiency

Electron Efficiency

Electron $> 2$ GeV
Look at single Hexagon shower blocks which passed 0.75 MIP cut.
- Full background spectrum used
- ADC integration window = 50ns

~10% blocks will produce a 0.75MIP signal for clock trigger
- Data readout is least 10% of modules
- A shower MIP trigger is likely just trigger on lower energy particles

- higher $\gamma \phi$-band
- lower $\gamma \phi$-band
Radiation on preshower is high for PVDIS
- Last meeting we showed that preshower will show radiation damage in a few months run in PVDIS configuration (assuming no cure for photon bgd)
- Estimated light loss is a fraction depending on the choice of scintillator and fibers

Our preshower was designed to produce high photon yield
- Scint. thickness = 2cm with WLS imbedding
- Expected photon / MIP = 140 $e_\gamma$
- After 50% radiation damage ($70 e_\gamma$), MIP resolution from photon fluctuation = 12%
- Intrinsic fluctuation on MIP sampling = 23%, PID cut on MIP + 2.5 $\sigma$
- Therefore, effect on radiation damage to MIP resolution is expected to be minimal, as long as we calibrate the photon yield online

Beam test for LHCb pad (1.5cm thick)
From LHCb technical design report

1.5cm -> 105 $e_\gamma$
Second update of CLEO background

Reported Apr 30 Calorimeter Meeting
For each sector, background rate were calculated in high and low regions in phi

- Photon (EM) <- dominant!
- Photon (Pion$^0$)
- Electron
- Pion- Pion+

High radiation azimuthal region

Low radiation azimuthal region
Background distribution
New: with photon and pi+, Mid R, High Rad phi slice

- Photon (7 GHz/6+1 Hex cluster!)
- Electron
- Pion - Pion+
PID Performance (pion eff. w/ 94% elec. eff) w/o photon and pi+, Mid R, High Rad phi slice

[Diagrams showing scatter plots and efficiency graphs]
PID Performance (pion eff. w/ 94% elec. eff) w/o photon, w/ pi+, Mid R, High Rad phi slice
PID Performance (pion eff. w/ 94% elec. eff) w/ photon, w/ pi+, Mid R, High Rad phi slice
Look elsewhere, Outer/Inner R
PID Performance (pion eff. w/ 94% elec. eff)

* w/ photon, w/ pi+, Outer R, High Rad phi slice
* w/ photon, w/ pi+, Outer R, Low Rad phi slice
* w/ o photon, w/ pi+, Inner R, High Rad phi slice
* w/ o photon, w/ pi+, Inner R, Low Rad phi slice
First update of CLEO background

Reported Apr 23 Calorimeter Meeting
Zhiwen Updated background contribution for all configurations. PVDIS shown here:

- Photon
- Electron
- Pion- Pion+
Updated: Per-event pion rate for 1+6 hexagon cluster at inner radius

Background particle per trigger

- Electron
- Pion-
- Pion+

Lower pion rate in new simulation
Updated: electron efficiency
Only electron and pi- background used

Not much change in electron eff.
Updated: pion rejection
Only electron and pi- background used

- Preshower VS E/p
- PS-E/p cut efficiency: $p > 2\text{GeV}$, x2 improved from last version
- Preshower VS $p$
- $E/p$ VS $p$
PVDIS trigger turn on curve
2GeV electron cut based on shower Hex1+6 cluster only

Preshower VS E/p

PS-E/p cut efficiency

Preshower VS p

E/p VS p
Layer #1 is 2cm preshower scint.
Layer #1 is 2cm preshower scint.

γ get reduced by ~5

π become important here

Layer ID
Last Version of Background Simulation (reported last week)
Why it is hard – lots of deep pions

- Photon
- Electron
- Pion- Pion+
Per-event pion rate for $1+6$ hexagon cluster at inner radius

Background particle per trigger

- Electron
- Pion-
- Pion+

High pi+ rate?? Need to be checked
Electron efficiency w/ background at inner radius. Ignore gamma and pi+ bgd

Background pile ups

Preshower VS E/p

PS-E/p cut efficiency

Preshower VS p

E/p VS p
Pion efficiency w/ background at inner radius. Ignore gamma and pi+ bgd

Significant drop in rejection
What we can further try

- Position or kinematic dependent trigger threshold and cut threshold
- Use track multiplicity to assist calorimeter cuts