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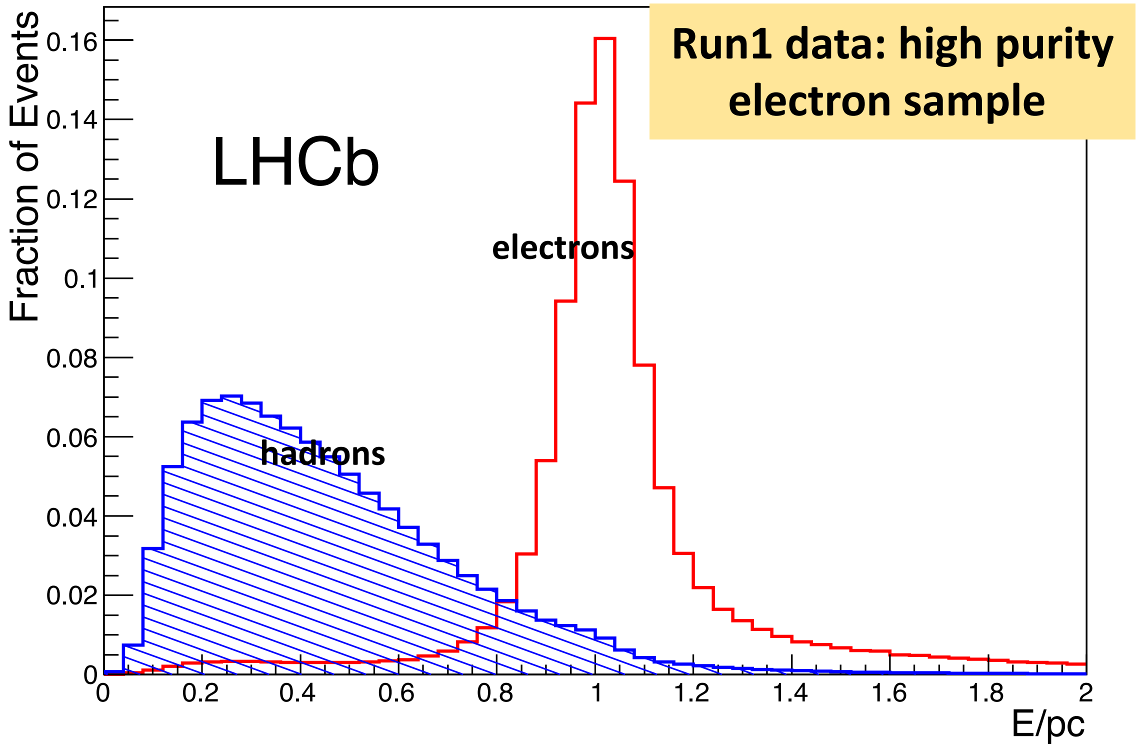
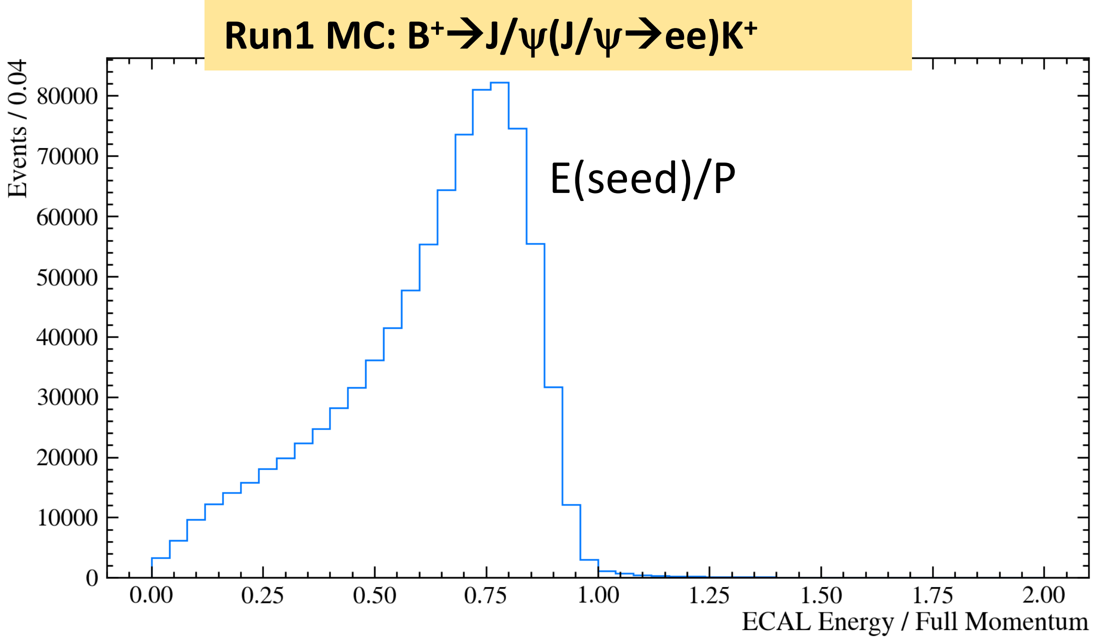
Impact of HCAL removal

- e/π separation
- μ/π separation (and e/μ) separation
- Neutron reconstruction

CALO info used in PID

- ✓ *Efficient Electron ID and misID requires optimal combination of cuts on Prob(NNX) and corresponding DLL (see talk of Maarten)*
- ✓ *CALO contribution to PID is based on*
  - *E/P ratio (ECAL)*
  - *Energy deposited in HCAL*
- ✓ ***ECAL: For the Run1&2 physics analyses, using the E(seed) track matching in ProbNNe does not seem to be the optimal***



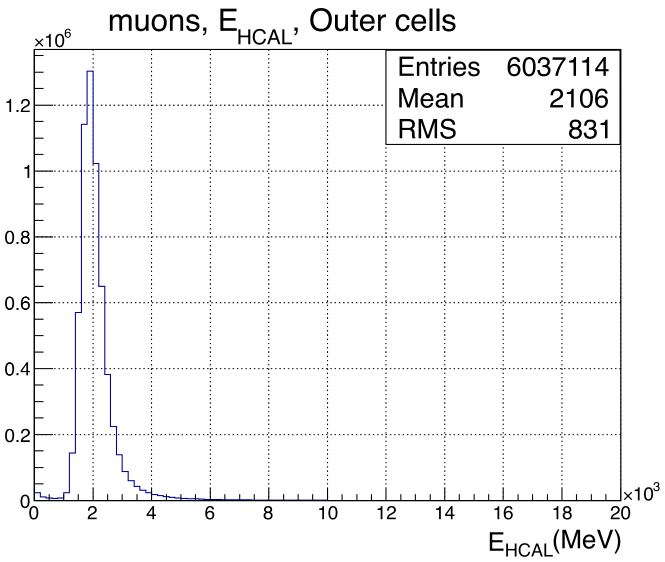


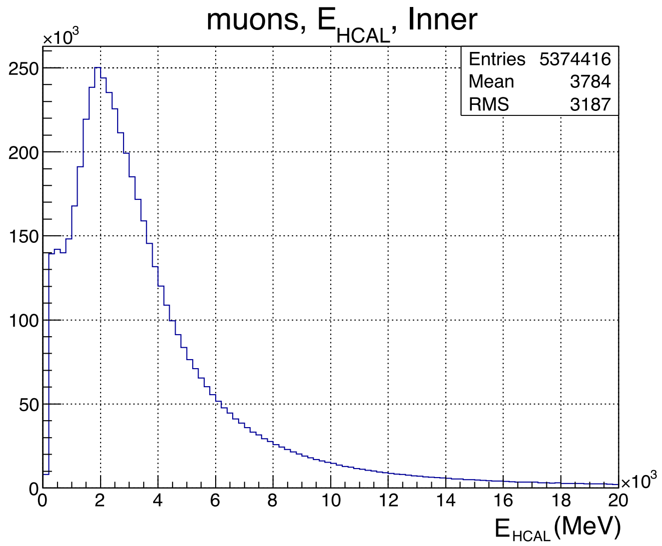
✓ *New approach for electron PID in Run3 (see talk of Maarten)*

HCAL info in PID
(courtesy of Yu. Guz)

Run1 data: high purity π/K sample

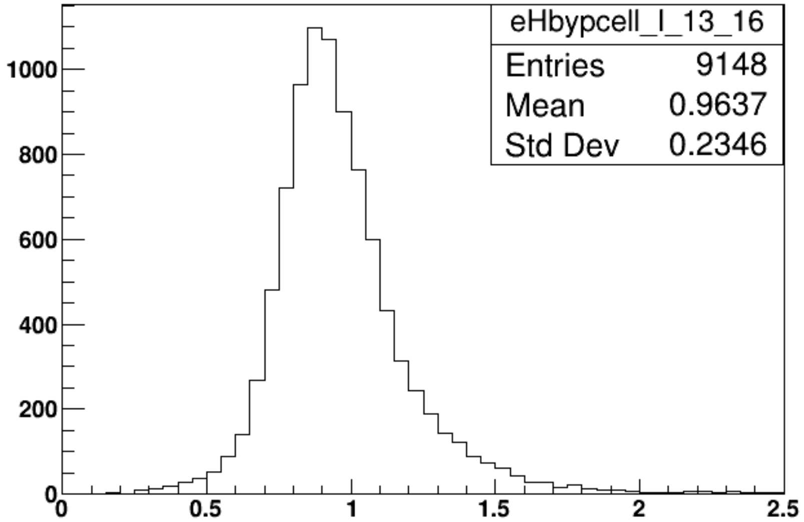
Clear MIP signal is seen in HCAL
→ Useful info for muon ID?

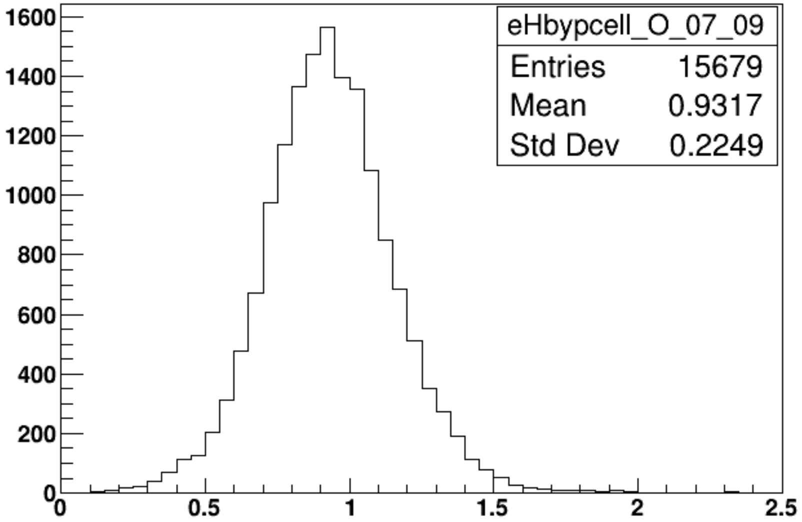




HCAL E/P ratio can be used for PID

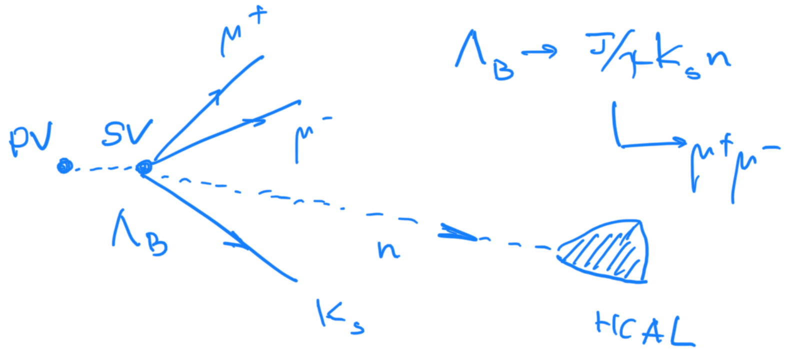
HCAL for neutron reconstruction ?
$\sigma(E)$ ~ 20% for. E_n > 20 GeV



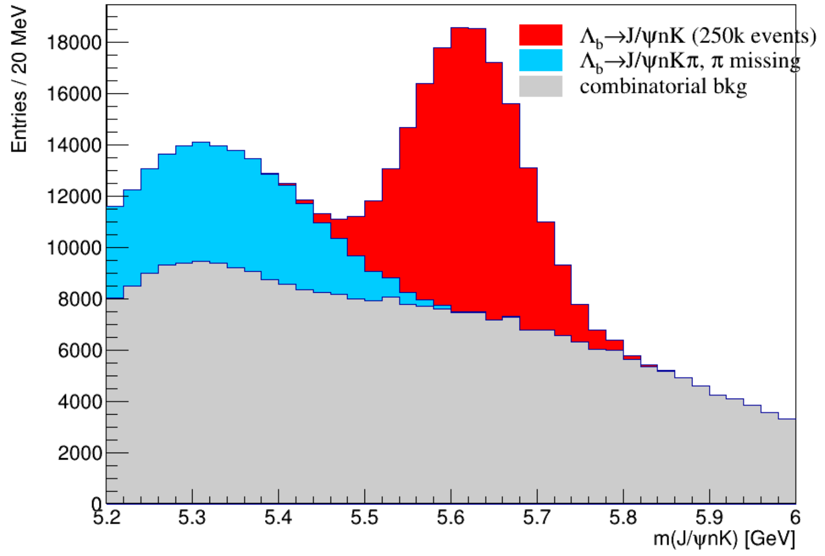


Spectroscopy with neutrons
(courtesy of Ivan Polyakov)

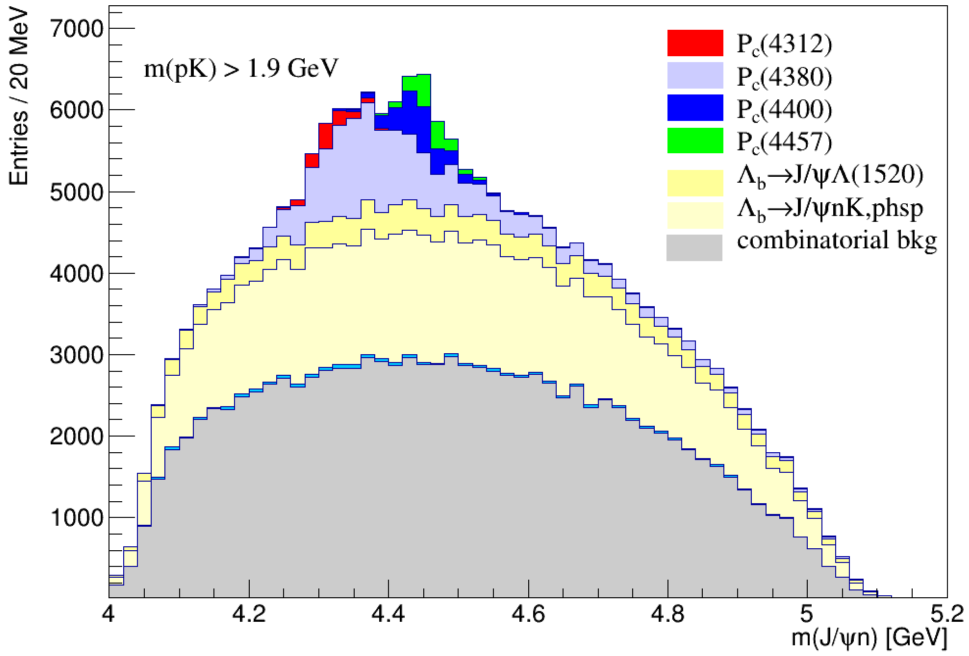
- ✓ *Consider $\Lambda_B \rightarrow J/\psi K$**n** similar to $\Lambda_B \rightarrow J/\psi K$**p**, which is the source of LHCb pentaquark (P_C) observations*
- ✓ *Assume the same kinematics of daughters and the same level of combinatorial background*
- ✓ *Use isolation criteria in HCAL to get $\sigma(E)/E = 65\%/\sqrt{E} \oplus 10\%$, and spatial resolution ~1cm*
- ✓ *Applying vertex and mass constraint fits gives $\sigma(M(\Lambda_B))$ ~ 65 MeV and $\sigma(M(P_C))$ ~ 30 MeV*



Clear Λ_B signal in $J/\psi K$n final state assuming 250k signal events as in $\Lambda_B \rightarrow J/\psi K$p in RUN 1&2



Various P_C states are more difficult to separate



Efficiency of the neutron isolation in HCAL to be understood

Goals of the Calorimeter Upgrade (with or without HCAL???)

✓ *Preserve the current performance to provide*

- *Reconstruction of particles in the final states including photons / π^0 (HCAL is not essential here)*

- ***Efficient Electron PID and discrimination of e/h, and also μ/h, and e/μ. Can CALO information help in the latter two cases?***

  Contribution from HCAL to:

  e/h discrimination

  D/B → ee, Kee in presence of peaking backgrounds from D/B → hh, Khh

  E(HCAL) = 0 for electrons

  (see talk of Davide)

  μ/h discrimination (for slow muons)

  D/B → $\mu\mu$, K$\mu\mu$ in presence of peaking backgrounds from D/B → hh, Khh

  Search for super rare B_d → $\mu\mu$ is of particular importance to minimise the background from B_d → $\pi\pi$

  MIP signal vs Hadronic shower in HCAL

  e/μ discrimination (for slow muons)

  LFU tests in R_K, and in R_D

  MIP signal vs "0" in HCAL

Running at high occupancy

Potential problems for PID at the upgrade conditions:

- Accidental hadron track overlapping with electromagnetic cluster in ECAL, e.g. with photons from π^0 decays → results in large E/P ratio typical for electron → worsening e/h discrimination Longitudinal ECAL segmentation should help to reduce the effect
→ Using HCAL should improve e/h discrimination
To be studied

- Increased hadron punch-through to the muon system (or random overlap of muon and pion tracks at high occupancy)
→ Using HCAL info may improve μ/π discrimination (MIP signal vs hadron shower)
To be studied

- Accidental overlap of muon and electron tracks may worsen e/μ separation at low moments
→ Using HCAL: MIP vs "0" signal
To be studied

Conclusion

- ✓ *HCAL can be used for neutron reconstruction → may open a new page in spectroscopy*

- ✓ *Removal of HCAL may have an impact both on the efficiency of electron identification and on the e/h separation, and even on the μ/π and e/μ separation. The HCAL electronics is compatible with the LS4 upgrade. So, HCAL could be kept at no cost.*

- ✓ *Replacement of HCAL with the iron absorber can provide better protection of the muon chambers against higher flux of the pion punch-through when running at higher luminosity. Study other means of protecting muon system, e.g. by adding a layer of W behind the HCAL*

- ✓ *Replace HCAL with iron (technically non-trivial), if really needed?*
  Study the potential improvement of the e/hadron separation by instrumenting the iron with an active layer of scintillator tiles ***(see talk of Vasilisa)***

Impact of HCAL removal

10:50 Introduction to electron-hadron separation

Speaker: Andrei Golutvin (Imperial College London)

11:05 Role of HCAL in current PID and impact of its removal

Speaker: Maarten Van Veghel (Nikhef National institute for subatomic physics (NL))

11:20 Impact of HCAL removal on physics measurements

Speaker: Lorenzo Sestini (Universita e INFN, Padova (IT))

11:35 Ideas on instrumenting the iron with a scintillating layer

Speaker: Vasilisa Guliaeva (M.V. Lomonosov Moscow State University (RU))

11:50 Discussion