Exclusive/Diffractive/Tagging PWG requirements for backward hadronic calorimeter construction

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Purpose:

- The point of this presentation is to get feedback from Exclusive/Diffractive/Tagging PWG about:
  - Which measurements could benefit from backward HCal(nHCal)
  - Start coordinating with the Exclusive/Diffractive/Tagging PWG on the performance checks
    - Extended acceptance, charged/neutral hadron identification and measurement
  - What parameters are most relevant?
    - Efficiency, acceptance, granularity/position resolution
  - How can we translate the acceptance into coverage in x, Q^2 plane

Physics processes of interest:

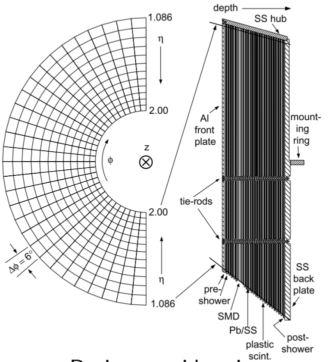
- Vector Meson production and measurement via dimuon channel
  - μ/π distinction, track-cluster matching
- Jets coming from low-x partons
  - Low energy neutrons $< E >= 2.38\mathrm{GeV}$
- Low-x physics in general, but more suggestions welcome!

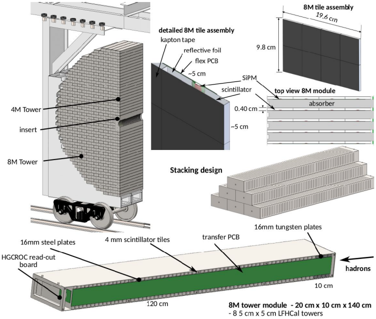
Simulations of physics processes including backward HCal:

- Track-cluster association should work (not tested for nHCal)
- Basic reco clusters available - further tests needed
- Truth clusters can also be used

Requirements: `https://eic.jlab.org/Requirements/`

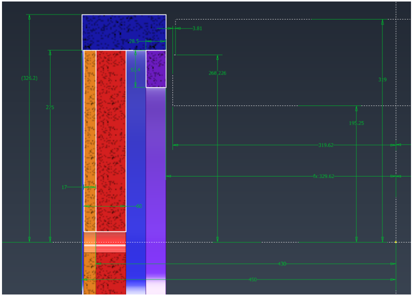
A future backward HCal shall provide functionality of a tail catcher for the high resolution e/m calorimeter in electron identification, as well as for jet kinematics measurement at small Bjorken x



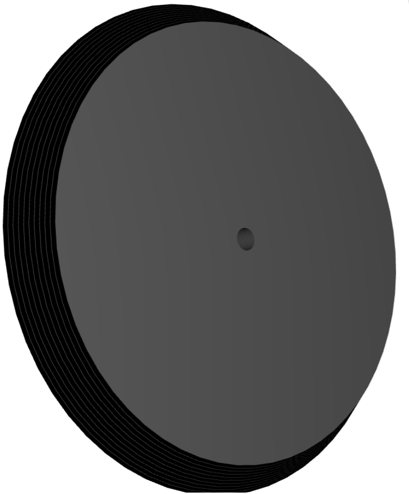


- Design considerations:
  - High efficiency for low energy neutron detection
  - Good spatial resolution to distinguish neutral/charged hadrons
- Follow similar solutions as Forward HCal instead of STAR EEMC megatiles
  - Due to required quick dissassembly of STAR - the EEMC megatiles are no longer an option
  - Can make adjustments to Forward HCal (LFHCAL) design, but no need to reinvent the wheel

- Sampling calorimeter with 10 alternating layers, $2.4\lambda^0$ (red), similar to Belle-II KLM:
  - stainless steel 4 cm
  - plastic scintillator 4 mm - follow forward HCal
- Light collection by SiPM:
  - Candidate (to verify): S14160-1315PS `https://www.hamamatsu.com/eu/en/product/optical-sensors/mppc/mppc_mppc-array/S14160-1315PS.html`
- Electronics to follow solutions of other calorimetry systems (HGCROCv3 or EICROC)

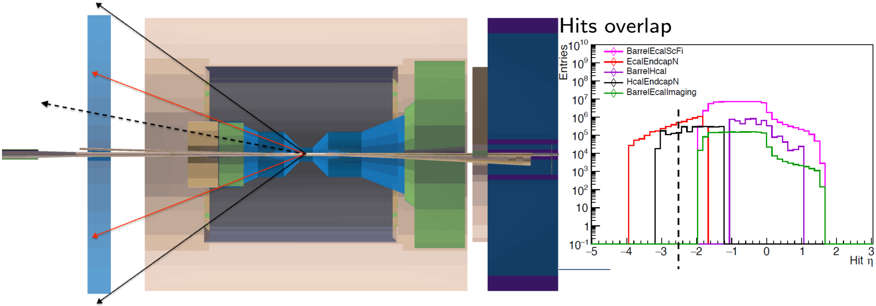


- nHCal decoupled from the magnetic steel ⇒ more flexibility



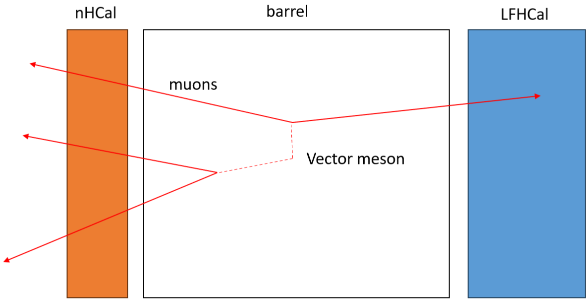
- A simplified version with STAR EEMC tiles already present in the main ePIC branch and included in the simulation campaigns up to November
  - Good enough for basic checks
- Forward HCal-type geometry with $10\,\mathrm{cm} \times 10\,\mathrm{cm}$ tiles implemented for December campaign

Acceptance

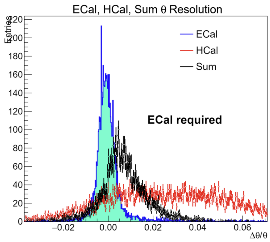


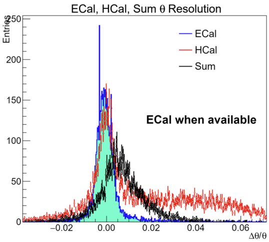
- Acceptance $-3.5 < \eta < -1.27$ - can still be extended to match the stainless steel absorber volume
- Overlaps with backward and barrel EMcals
- Scattering may be important in these overlap regions

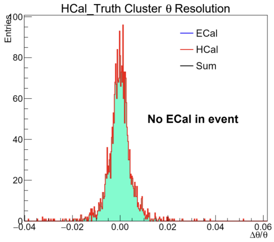
Vector meson studies



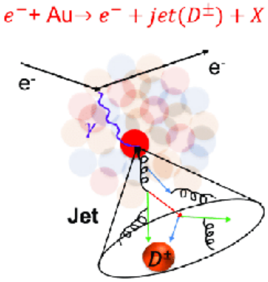
- Important for high y or low-p_T vector mesons - depends on type
- Increases acceptance
- Need projected MIP tracks and MIP signals in backward HCal and EMCal
  - μ/π distinction important, position resolution...



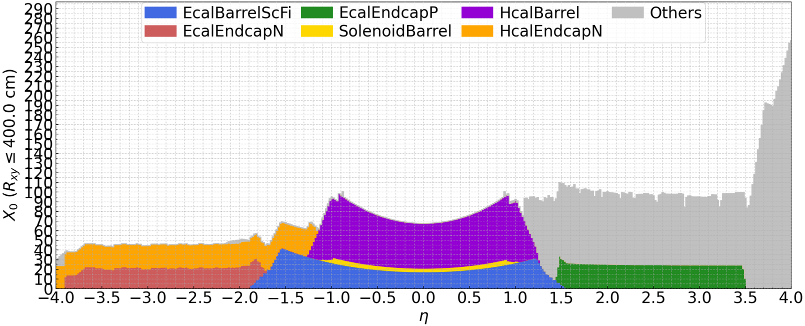




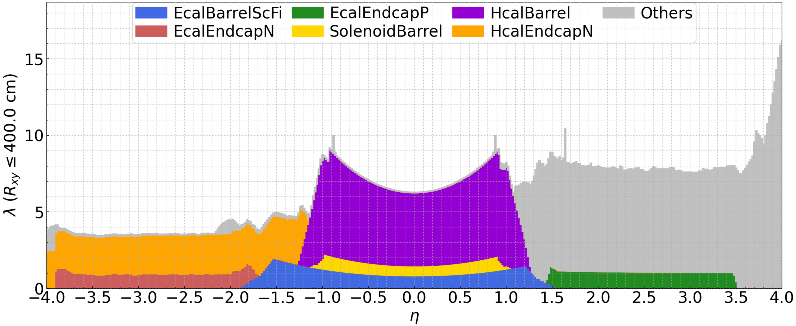
- 50% of neutrons scatter in backward EMCal
- Scattered neutron may fall out of a jet reconstruction cone
- We need to study this in coordination with Jet-HF PWG



Radiation length - brycecanyon geometry



- $\sim 24 X_0$ for backward HCal
- Scintillator tiles do not cover the same volume as steel absorber yet



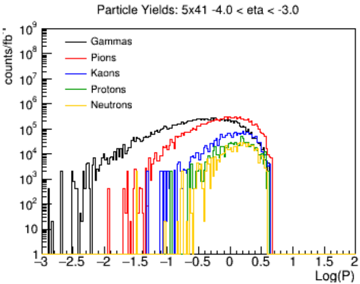
- $\sim 2.4\lambda_0$ for backward HCal
- Scintillator tiles do not cover the same volume as steel absorber yet

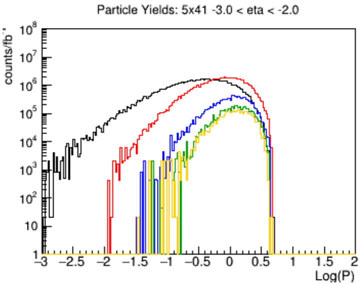
Conclusions

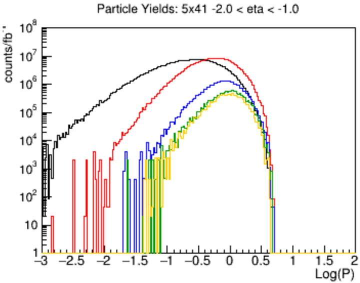
- Presented basic concept for backward HCal for ePIC
- Simplified geometry already in simulation campaign:
  - for STAR EEMC geometry+extensions until November
  - For LFHCAL-style until November
- Need guidance from physics on the coverage in η
- Starting point for a discussion/coordination between PWG(effects on physics) and detector design

BACKUP

Jet particle distributions

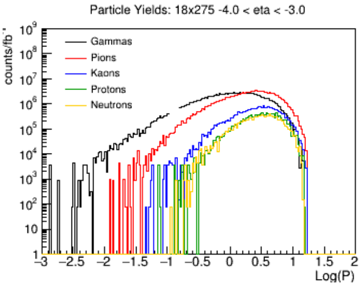


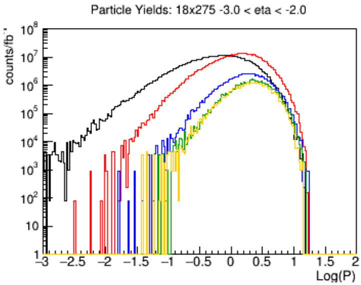


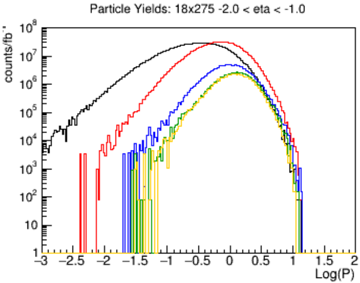


- Pythia simulation by Brian Page

Jet particle distributions







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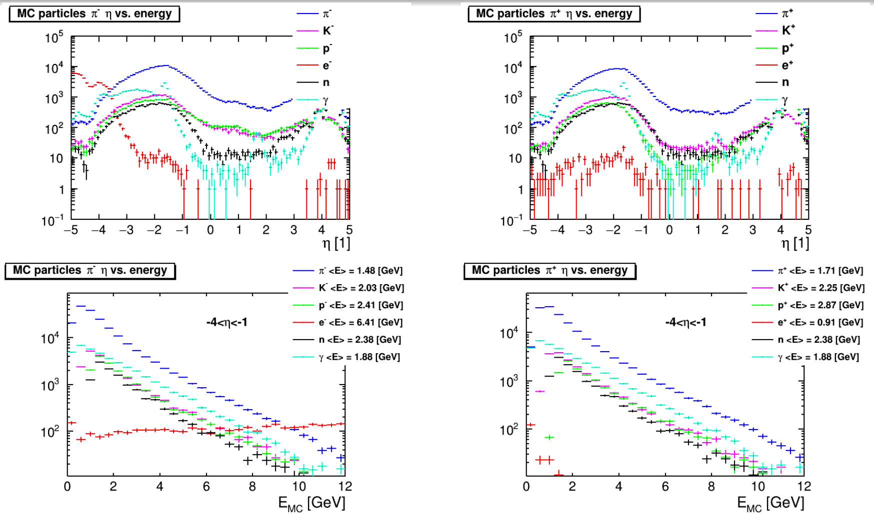
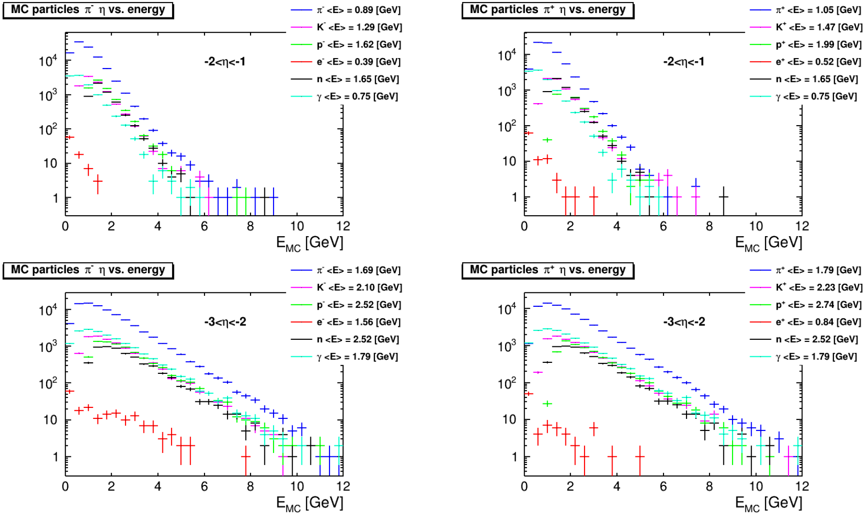
Primary particle distributions - eta and energy

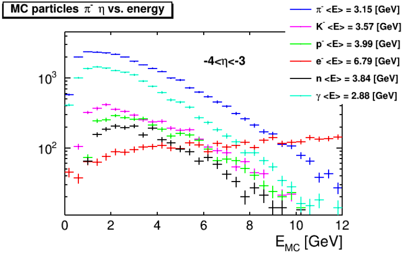


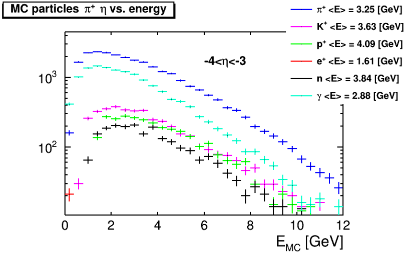
- Primary (generated) MC particles hitting nHCal
- Mean energy of neutrons $< E >= 2.38\,\mathrm{GeV}$
- Large number of high E e^- - from beam? (but these should have generator status=4)

Primary particle distributions - Energy vs. eta

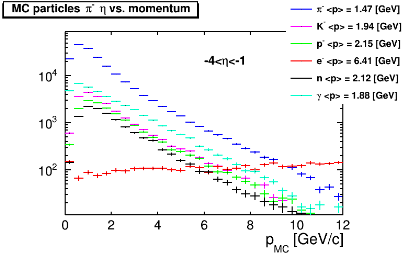


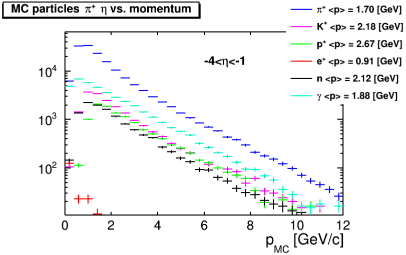
- Primary (generated) MC particles hitting nHCal
- Mean energy of neutrons $< E >_{-2<\eta<-1} = 1.65\ \mathrm{GeV}$ and $< E >_{-3<\eta<-2} = 2.52\ \mathrm{GeV}$



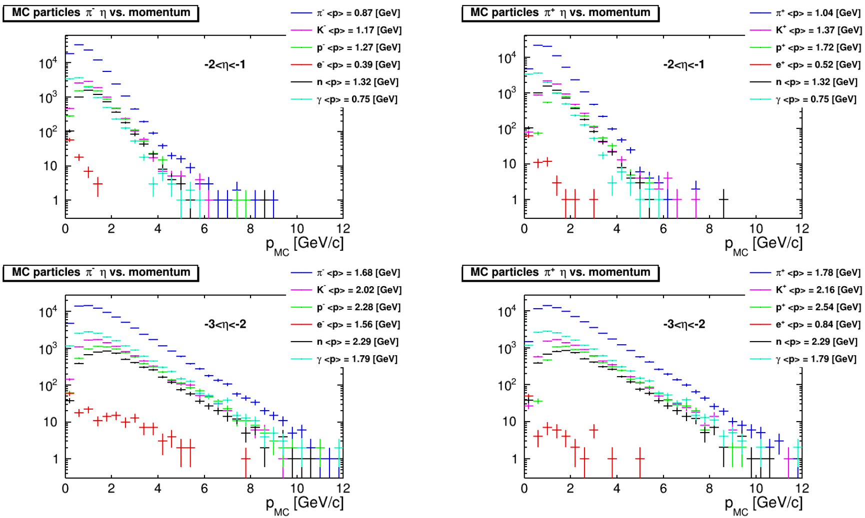


- Primary (generated) MC particles hitting nHCal
- Mean energy of neutrons $< E >_{-4<\eta<-3} = 3.84\ \mathrm{GeV}$



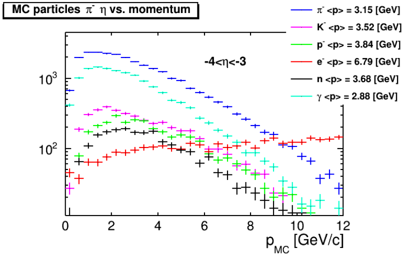


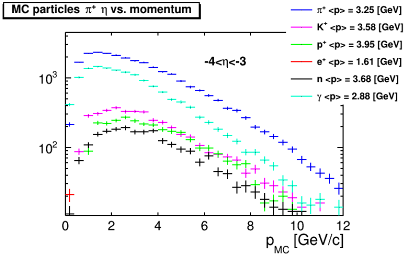
- Primary (generated) MC particles hitting nHCal
- Mean momentum of neutrons $< p >= 2.12\,\mathrm{GeV/c}$



- Primary (generated) MC particles hitting nHCal
- Mean momentum of neutrons $< p >_{-2<\eta<-1} = 1.32\ \mathrm{GeV/c}$ and $< p >_{-3<\eta<-2} = 2.29\ \mathrm{GeV/c}$

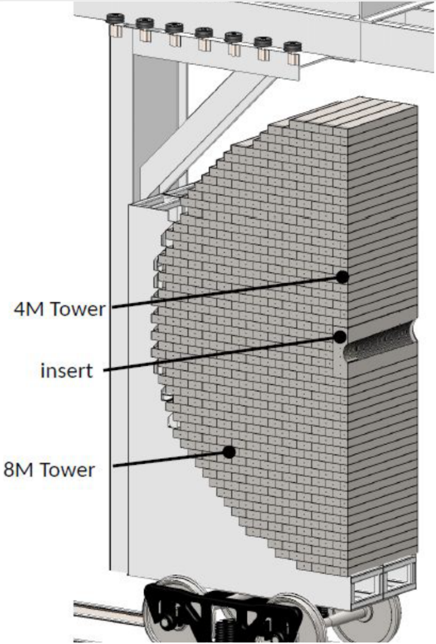
Primary particle distributions - Momentum vs. eta



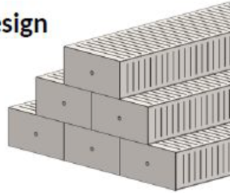


- Primary (generated) MC particles hitting nHCal
- Mean momentum of neutrons $< p >_{-4<\eta<-3} = 3.68\ \mathrm{GeV/c}$

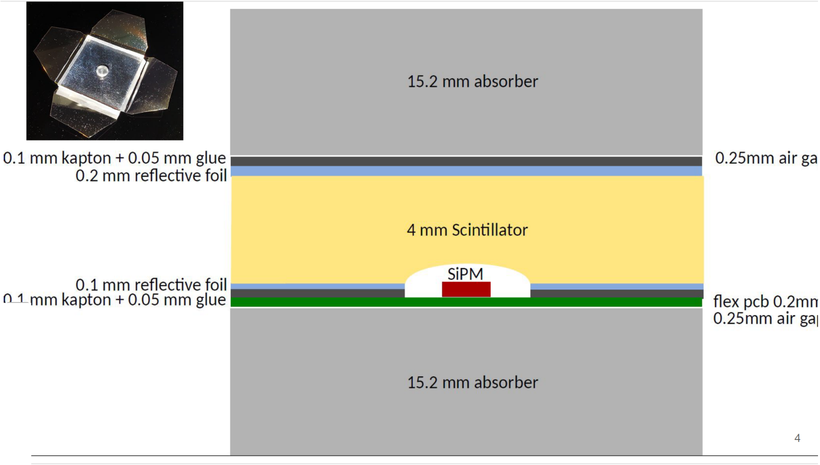
LFHCal design



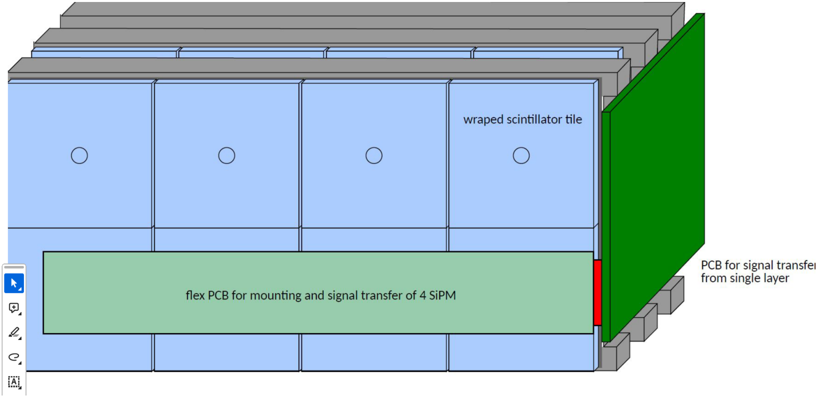
Stacking design



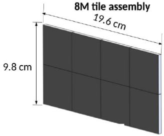
LFHCal layers

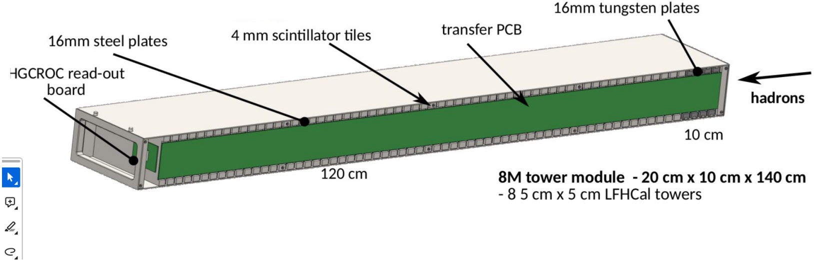


LFHCal PCBs


wraped scintillator tile
flex PCB for mounting and signal transfer of 4 SiPM
PCB for signal transfer
from single layer

LFHCal PCBs


8M tile assembly
19.6 cm
9.8 cm


16mm tungsten plates
16mm steel plates
4 mm scintillator tiles
transfer PCB
HGCROC read-out board
hadrons
10 cm
120 cm
8M tower module - 20 cm x 10 cm x 140 cm
- 8 5 cm x 5 cm LFHCal towers