YR DWG Calorimetry: Summary of the Parallel Session

Subconveners: *V.Berdnikov & E.Chudakov*

EICUG YR Meeting, Temple 2020 March

DWG Calorimetry Parallel Sessions on Mar 19

- Actual time: 14:30-17:00, 17:15-18:30
- Attendance: between 12 and 20
- 4 presentations:
  - A.Bazilevsky: “Initial Consideration for the EMCAL of the EIC Detector”
  - B.Page: “Jets and Calorimetry: First Look”
  - T.Horn: “EM Calorimeter Technologies for EIC”
  - O.Tsai: “Hadron Calorimeter for EIC”
- Discussions:
  - Still unclear requirements:
    - Granularity at large η - the hadron side
    - Hadron calorimeters - is the barrel needed?
  - Technical details - infrastructure, space etc
  - Path forward:
    - MC and feedback from Physics Working Groups
    - Preparations for the next meeting in May

ECAL and HCAL Coverage

"An Electron-Ion Collider Study" BNL, August 2019

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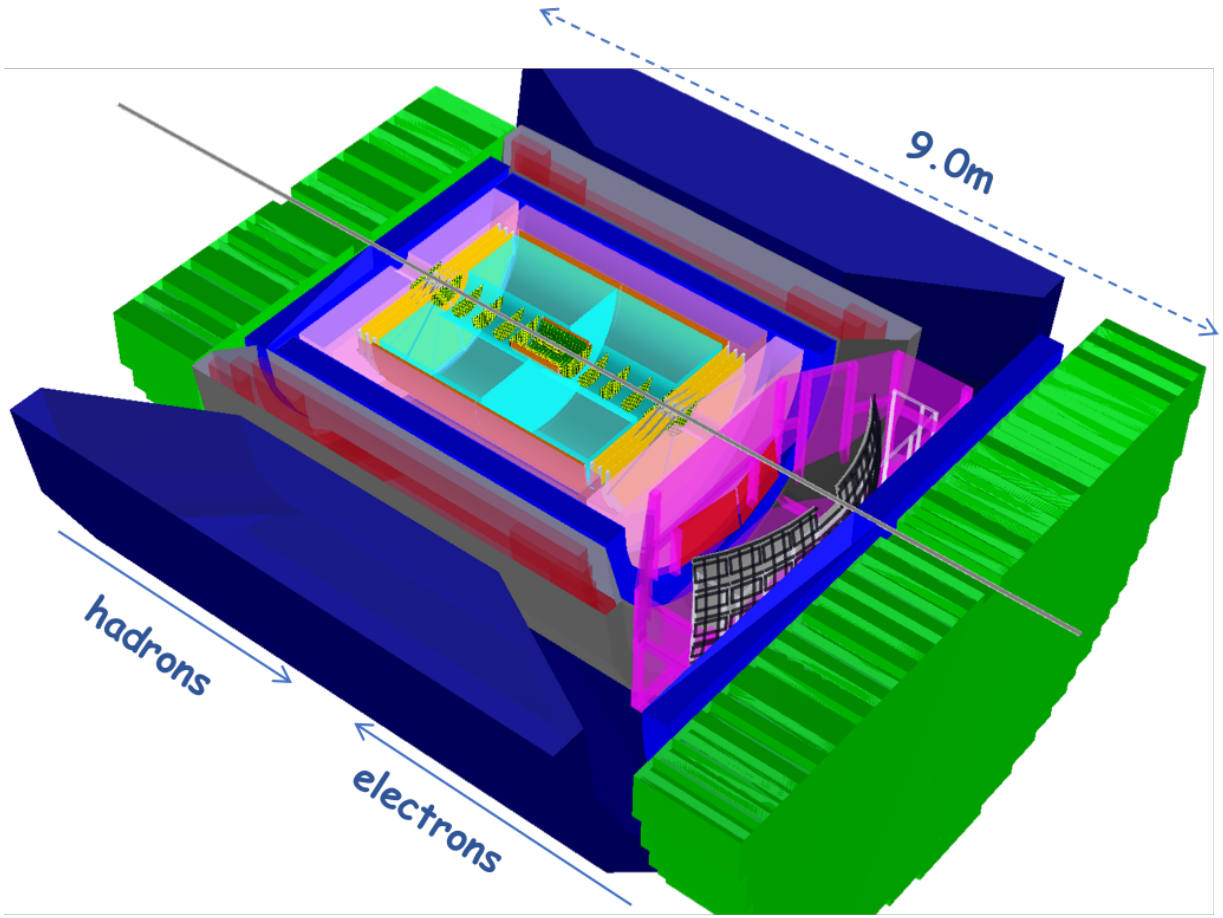
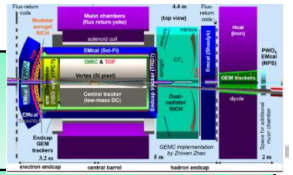
ECAL: $\sim 4\pi$
HCAL: ?

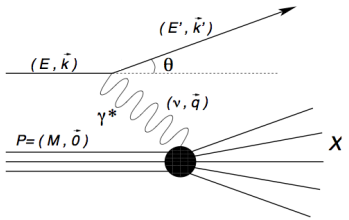


eRD1 Report, July 2018

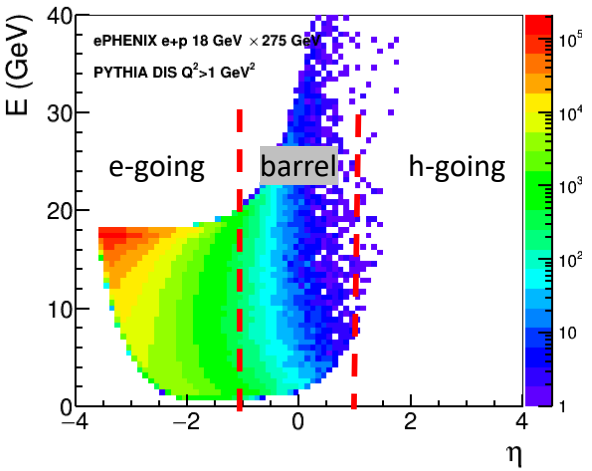


Regions and Physics Goals	Calorimeter Design
Lepton/backward: EM Cal ○ Resolution driven by need to determine (x, Q^2) kinematics from scattered electron measurement ○ Prefer 1.5%/√E + 0.5%	Inner EM Cal for for $\eta < -2$: ➢ Good resolution in angle to order 1 degree to distinguish between clusters ➢ Energy resolution to order (1.0-1.5 %/√E+0.5%) for measurements of the cluster energy ➢ Ability to withstand radiation down to at least 2-3 degree with respect to the beam line. Outer EM Cal for $-2 < \eta < 1$: ➢ Energy resolution to 7%/√E ➢ Compact readout without degrading energy resolution ➢ Readout segmentation depending on angle
Ion/forward: EM Cal ○ Resolution driven by deep exclusive measurement energy resolution with photon and neutral pion ○ Need to separate single-photon from two-photon events ○ Prefer 6-7%/√E and position resolution < 3 mm	
Barrel/mid: EM Cal ○ Photons and neutral pions from SIDIS and DES in range 1-10 GeV, so absolute energy uncertainty in photon should be 100 MeV ○ Leads to order 10%/√E	Barrel, EM calorimetry ➢ Compact design as space is limited ➢ Energy resolution of at least order 10%/√E, and likely better
Ion/Forward: Hadron Cal ○ Driven by need for x-resolution in high-x measurements ○ Need Δx resolution better than 0.05 ○ For diffractive with ~50 GeV hadron energy, this means 40%/√E	Hadron endcap: ➢ Hadron energy resolution to order 40%/√E, ➢ EM energy resolution to < (2%/√E + 1%) ➢ Jet energy resolution < (50%/√E + 3%)

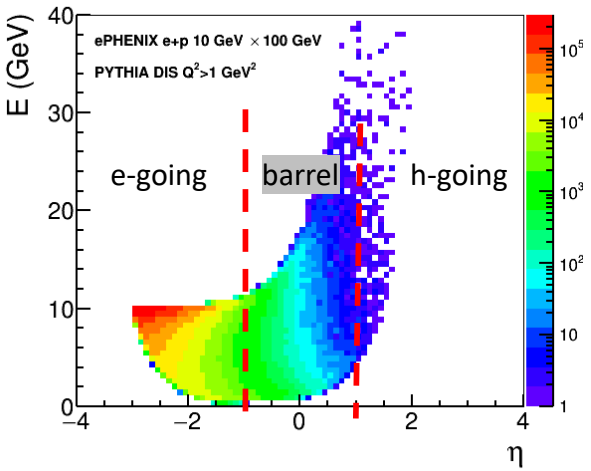
Inclusive DIS: scattered electron



e+p 18x275 GeV



e+p 10x100 GeV

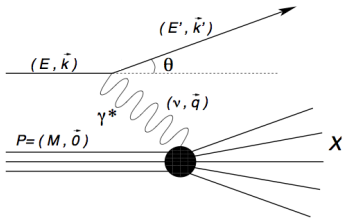


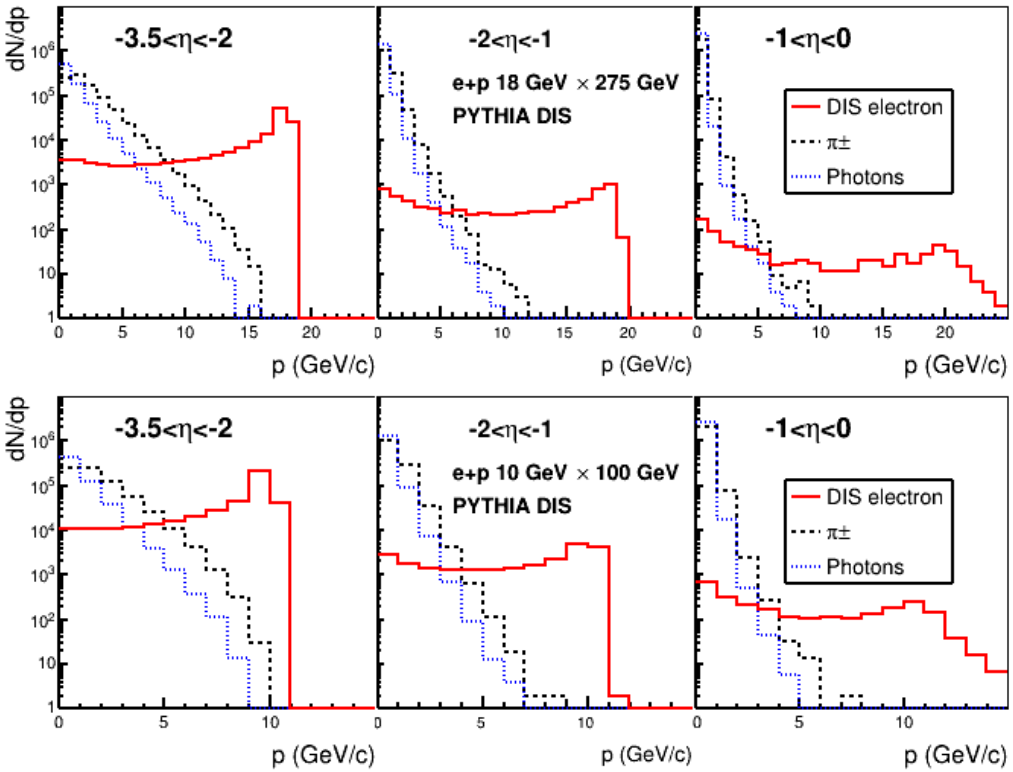
Mostly scattered in backward (e-going) and barrel
Electron energy varies from 0 to e-beam energy in backward (e-going)
And to higher energy in barrel and h-going region

Good resolution is needed at $\eta < -2$

3

Inclusive DIS: background



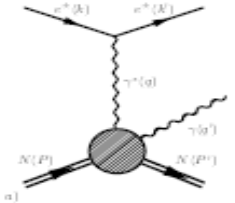


18x275 GeV

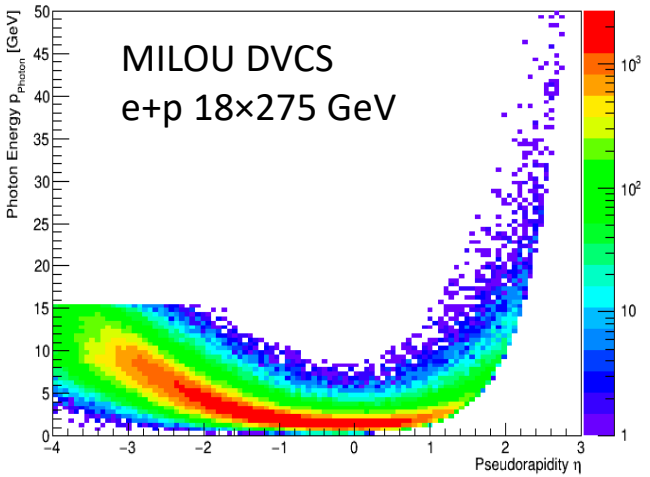
10x100 GeV

Clean measurements at higher momenta
Huge background at lower momenta

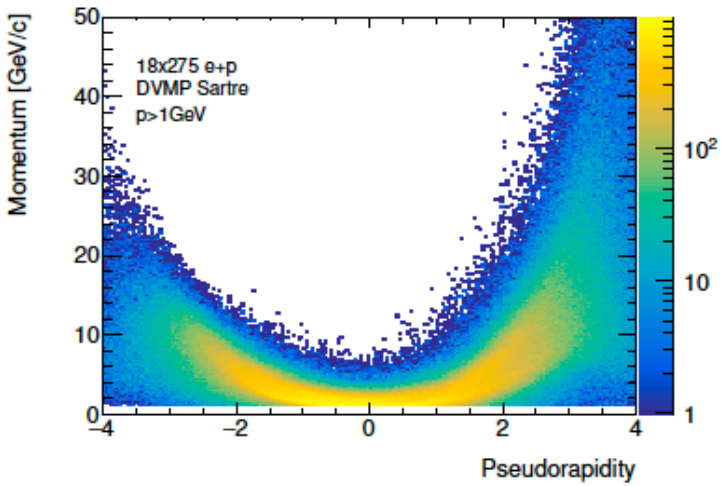
Exclusive DIS: DVCS and DVMP



DVCS photon kinematics

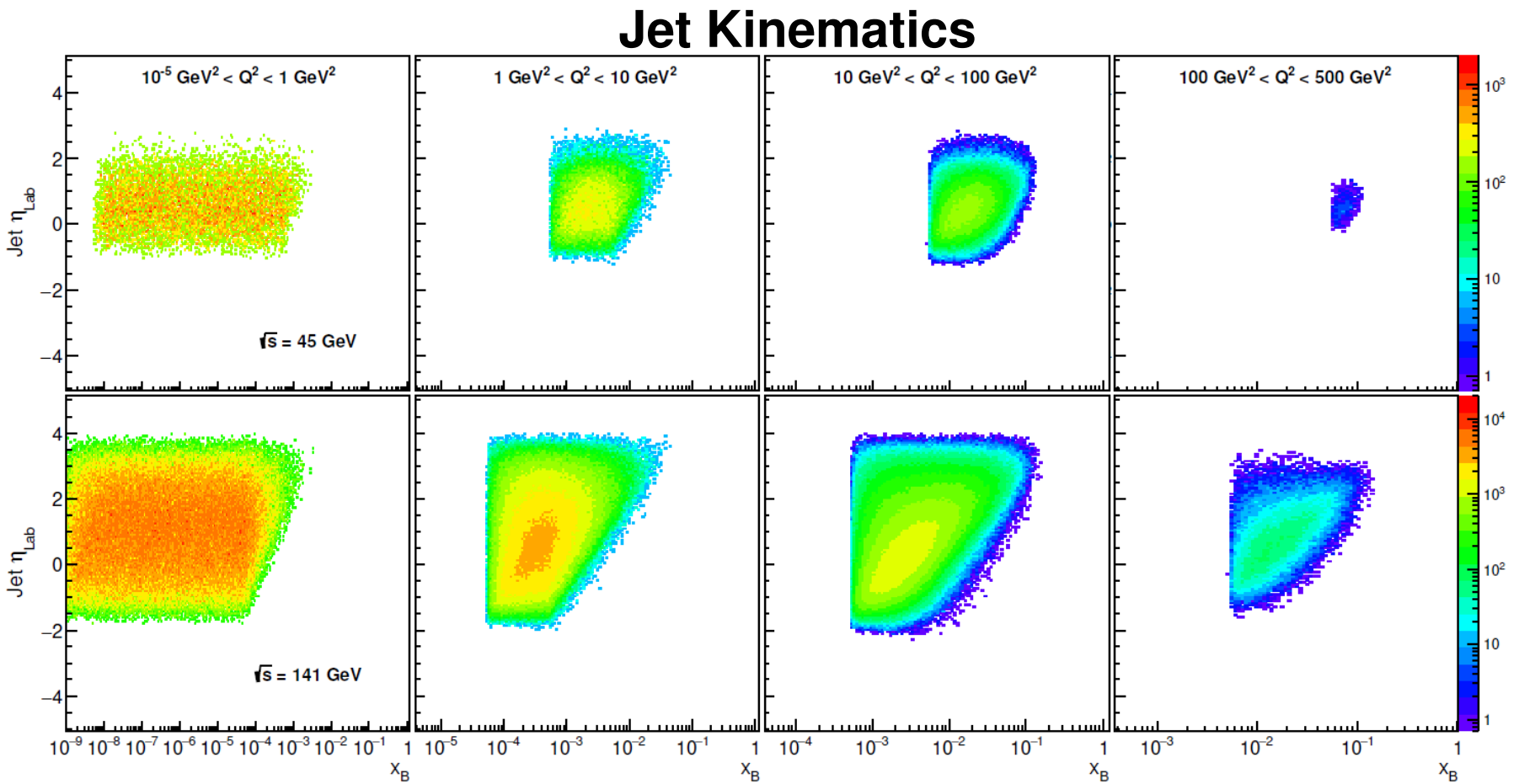


J/ψ→ee kinematics



Wide rapidity coverage is crucial

B.Page: Jets and Calorimetry



- Assumption: HCAL $-4 < \eta < 4$
- Showers are “sparse”
- Low momenta: $\sigma E/E_{HCAL} \gg \sigma p/p$

- Role at $\eta > 3$
- Neutrals ($\sim$ 33% of showers)
- Needed coverage?
- Granularity?

Calorimeter Technologies

ECAL - T.Horn

Description of technologies

- $2\%/\sqrt{E} \oplus 0.7\%$ $PbWO_4$ crystals
- $> 6\%/\sqrt{E} \oplus 2.0\%$ - several technologies

$> 30k$ channels

HCAL - O.Tsai

Description of technologies

- $50\%/\sqrt{E} \oplus 10\%$ seems possible

Light sensor of choice: SiPM
SiPM rad. hardness study
Large neutron fluence expected
Issues: space in Z is tight!

- Energy resolution: several affordable technologies exist to meet the specs for the most of the parts
  Exceptions:
  - backward ECAL specs $\eta < -2$
    $1.0 - 1.5/\sqrt{E} \oplus 0.5\%$ may be achievable with other crystals
  - HCAL $\eta > 2$
    $40/\sqrt{E} \Rightarrow 50/\sqrt{E} \oplus 10\%$
- Issues: space, radiation hardness of the Si light sensors

Next Steps

- Continue the work on:
  - Granulation at $\eta > 3$
  - HCAL barrel - is it needed?
  - Backward ECAL - can we meet the specs? (CsI or something)
  - Study calibration options - processes, statistics
  - Determine more or less realistic dimensions of the ECAL/HCAL and the material budget
- Planned communication with the PWGs via simulation
  Assumed: simplified but full model(s) of the spectrometer
  - Provide to *EIC Smear*: functions for efficiency, resolution, electron identification
  - PWG: feedback from the the PDGs
  - Next iteration?