Response to the comments

Mingyi Dong

2025, Oct. 14

Comments from Paul

From: COLAS Paul <paul.colas@cea.fr>
To: Daniela Bortoletto <daniela.bortoletto@physics.ox.ac.uk>
Cc: Joao Guimaraes da Costa <guimaraes@ihep.ac.cn>
Subject: RE: Draft version of the IDRC report
Date: Thu, 9 Oct 2025 07:42:44 +0000

Thank you for the report. I read the gaseous tracker part and it is very good.

However for the preliminary TDR I notice that the questionable definition of the separateon power is still there (Eq.5.5 p.170 and Eq.6.8 p. 209, and Fig.6.36 which makes use of this formula).

Also, the remark saying that the graphene must withstand a pressure of 1 atm is not correct (Section 6.6).

Paul

Response to Paul‘s Email

1. We have revised the equation defining particle identification capability according to the definition used in ILD TPC (page 1 in attached PPT), and have updated the PID result plots (page 3 in attached PPT). Compared to the previous results, the difference in K/π separation power between the two definitions is less than 0.5%, as shown in page 4(attached PPT).

- While carefully checking the software, we found a bug in the original plotting script. Specifically, An incorrect variable was used in the proton resolution (σ_p) calculation, resulting in a significantly lower value of σ_p. This led to incorrect K/p and π/p identification capabilities (better than the actual performance). We have fixed this bug and updated the plots for K/p and π/p separation power (page 2 and 3 in attached PPT). We sincerely apologize for any confusion this error may have caused.

2. The comment: "the remark saying that the graphene must withstand a pressure of 1 atm is not correct (Section 6.6)"

Answer:

- I think so, it is not correct to say" the graphene must withstand a pressure of 1 atm" . The graphene membrane is placed in a gas-filled volume of the TPC at a uniform pressure. There is no 1 atm pressure differential across the graphene membrane.
- We rewritten future IBF suppression study plan and removed the description of the graphene withstanding a pressure of 1 atm (page 5 in attached PPT).

3. Additionally, in Section 6.2.2 "Endplate and readout modules", we added descriptions of edge effects on the borders of the readout modules, as below: ((page 6 in attached PPT))

- The edge effects (the electric field non-uniformity near the inter-modular gaps)on the borders of the modules can cause track distortion and degradation of the spatial resolution. Reference[12] proposes a potential solution: keeping the mesh at ground potential and biasing the anode to a positive high voltage can effectively mitigate the track distortion caused by the edge effect Experimental validation of this approach will be conducted in subsequent studies.

Feedback from Paul：

发件人: "COLAS Paul" <paul.colas@cea.fr>
发送时间: 2025-10-11 23:33:46 (星期六)
收件人: "dongmy@ihep.ac.cn" <dongmy@ihep.ac.cn>
抄送: "daniela.bortoletto@physics.ox.ac.uk" <daniela.bortoletto@physics.ox.ac.uk>, "Joao Guimaraes da Costa" <guimaraes@ihep.ac.cn>
主题: RE: Response to the comments and suggestions for TPC (Chaper 6)

Dear Mingyi,

Thank you very much for your mail and for your very careful checks.

1. I acknowledge that you decided to go to the ALEPH definition of the separation power. Even if not numerically very different, I feel more comfortable like this (please note that the (wrong?) formula also appears in Chapter 5)
2. Yes, the membrane is immersed in the gas, so it has the same pressure both sides.
3. I think it is good that you decided to mention the non-uniformity of the electric field near the module edges, and the mitigation obtained by biasing the detector to a positive voltage. This requires however to encapsulate the pad plane in a high dielectric strength material. This is what we did in our test for LCTPC and in the T2K TPC.

Best Regards,
Paul

Mingyi：

Thank you very much for your prompt reply.

1. As you said, the same formula appears in Chapter 5. Both Chapter 6 and Chapter 5 have been updated simultaneously, including the formulas and the result plots.

3. Yes, applying a positive high voltage to the anode to mitigate track distortion caused by the edge effects will place the anode at a high potential. This requires encapsulating the pad plane in a material with high dielectric strength. Thank you very much for sharing your experience. For clarity, I have included a description of this requirement in Section 6.2.2.

Paul：

发件人: "COLAS Paul" <paul.colas@cea.fr>
发送时间: 2025-10-12 22:52:11 (星期日)
收件人: "dongmy@ihep.ac.cn" <dongmy@ihep.ac.cn>
抄送: "daniela.bortoletto@physics.ox.ac.uk" <daniela.bortoletto@physics.ox.ac.uk>, "Joao Guimaraes da Costa" <guimaraes@ihep.ac.cn>
主题: RE: RE: Response to the comments and suggestions for TPC (Chaper 6)

Thank you very much and congratulations.
Paul

Attached PPT Sent to Paul and Daniela

- We have revised the equation defining particle identification capability according to the definition used in ILD TPC

Old definition

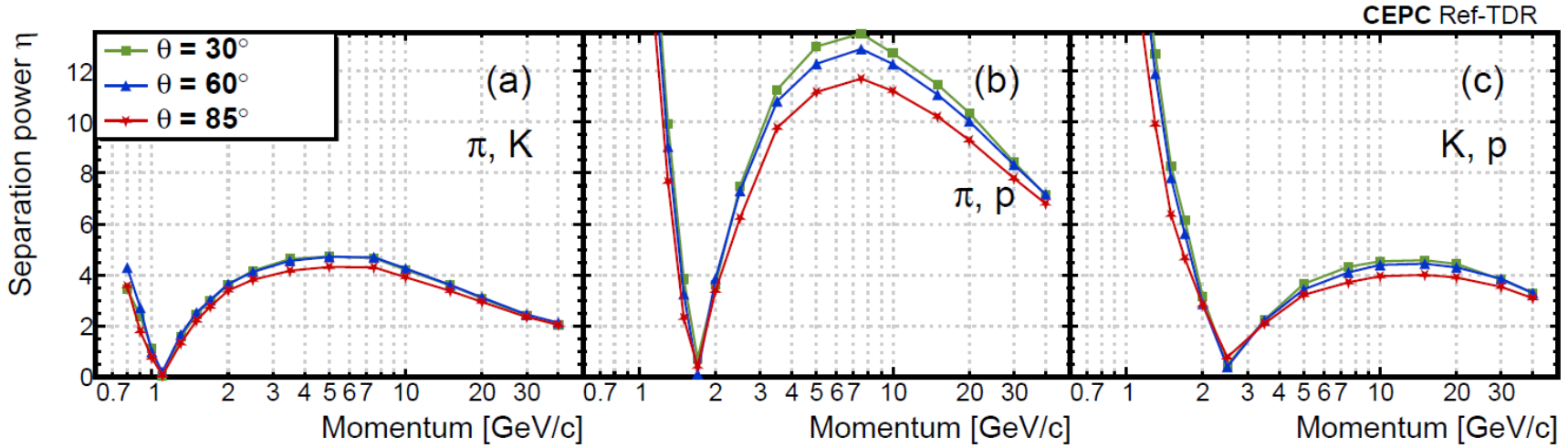
$$\eta_{A,B} = \frac{|\mu_A - \mu_B|}{\frac{1}{2}(\sigma_A + \sigma_B)}$$

New definition

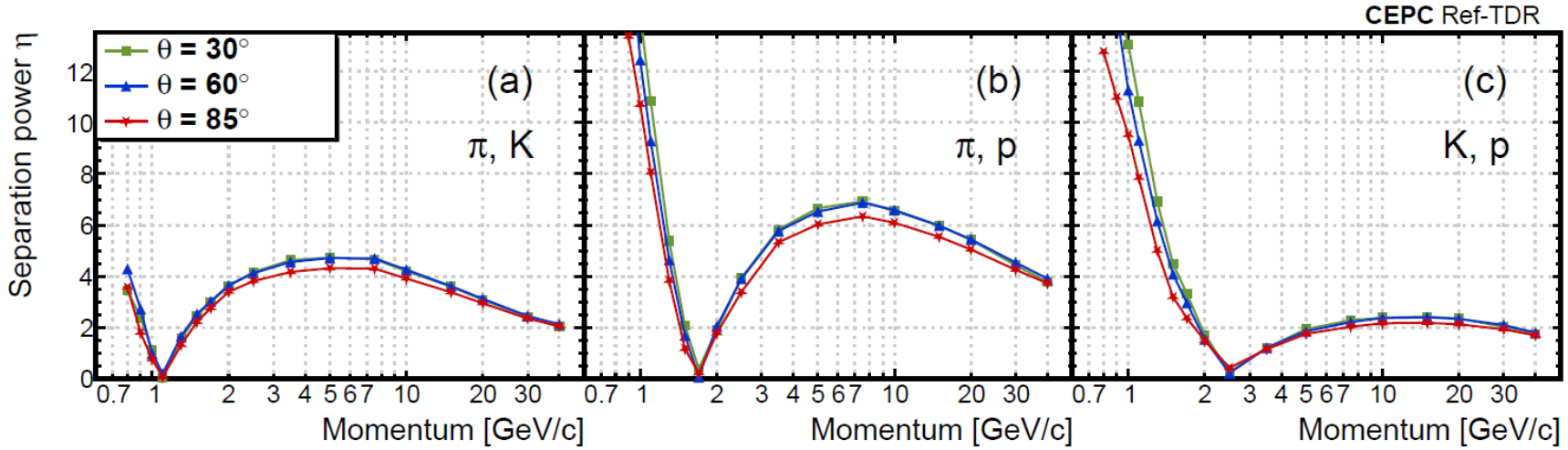
$$\eta_{A,B} = \frac{|\mu_A - \mu_B|}{\sqrt{(\sigma_A^2 + \sigma_B^2)/2}}$$

- While carefully checking the software, we found a bug in the plotting script. Specifically, An incorrect variable was used in the proton resolution (σ_p) calculation, resulting in a significantly lower value of σ_p. This led to incorrect K/p and π/p identification capabilities (better than the actual performance). We have fixed this bug and updated the plots for K/p and π /p separation power.

The results with the bug (Figure 6.36 (old))



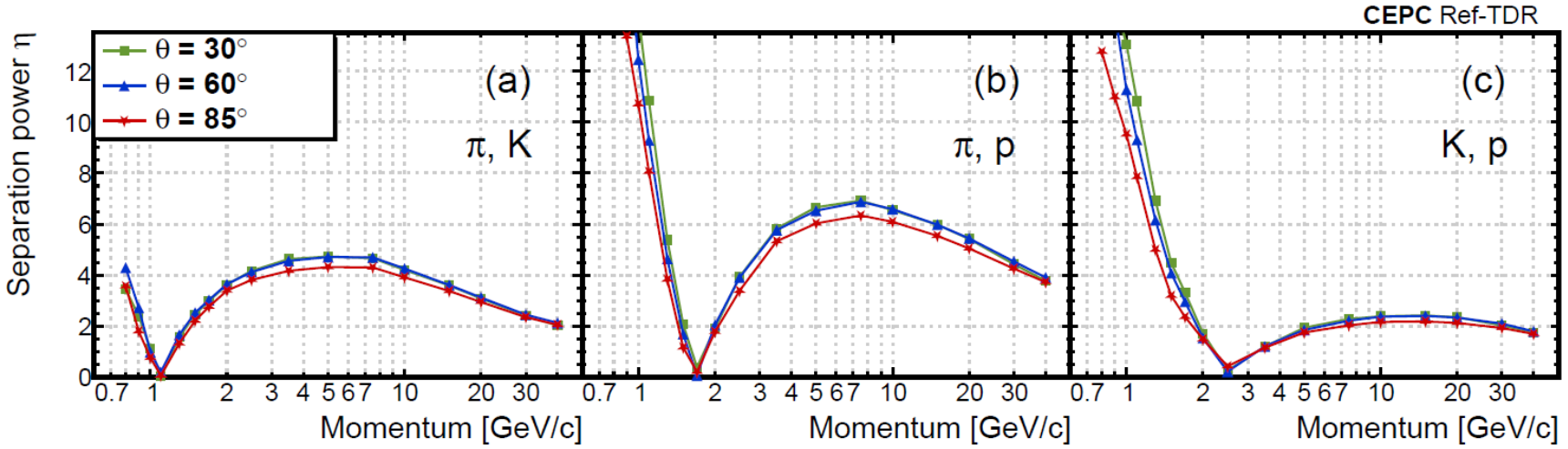
The results after the bug was fixed



- We have updated the PID result plots using new definition of separation power

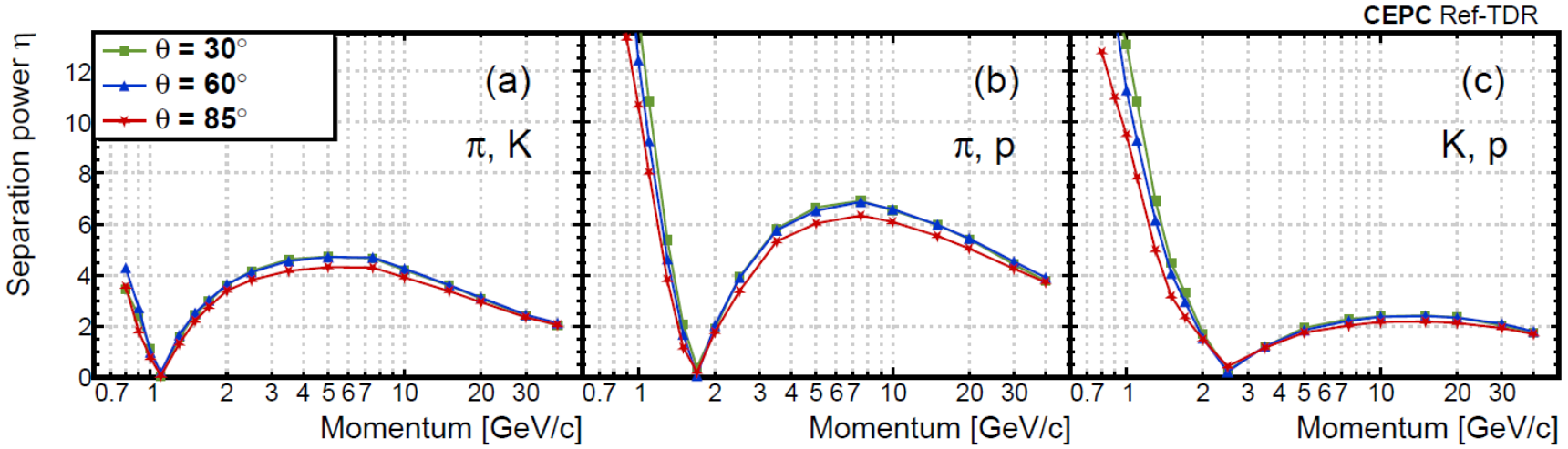
The results by using old definition after the bug was fixed

$$\eta_{A,B} = \frac{|\mu_A - \mu_B|}{\frac{1}{2}(\sigma_A + \sigma_B)}$$

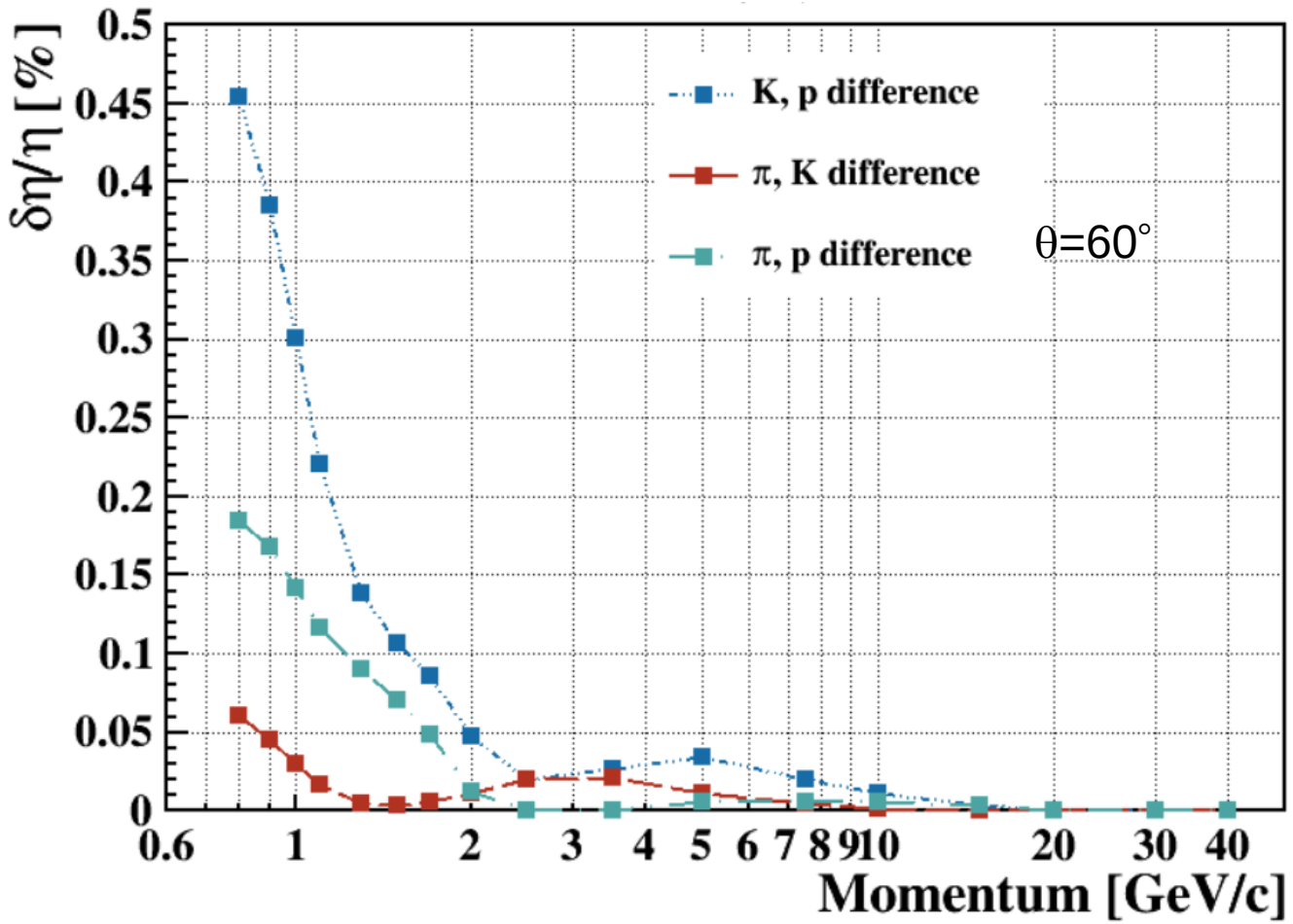


Updated Figure 6.36 using new definition

$$\eta_{A,B} = \frac{|\mu_A - \mu_B|}{\sqrt{(\sigma_A^2 + \sigma_B^2)/2}}$$



- Compared to the previous results, the difference in K/π separation power between the two definitions is less than 0.5%



Comments: the remark saying that the graphene must withstand a pressure of 1 atm is not correct (Section 6.6)

Answer:
I think so, it is not correct to say" the graphene must withstand a pressure of 1 atm" . the graphene membrane is placed in a gas-filled volume of the TPC at a uniform pressure. There is no 1 atm pressure differential across the graphene membrane. The forces are electrostatic forces.
We rewritten future IBF suppression study plan as below and removed the description of the graphene withstanding a pressure of 1 atm.

795 Future IBF suppression studies will utilize TPC prototypes with standard mesh coated
796 with a monolayer of graphene. This design merges the extreme thinness and ion-blocking
797 capability of graphene with the mechanical strength of the mesh. The studies will focus
798 on the fabrication process of this graphene-coated mesh and experimentally validate its ion
799 suppression performance. These studies will be conducted in collaboration with CEA-Saclay,
800 Lyon University and NIKHEF.

Added descriptions of edge effects on the borders of the modules in section 6.2.2

In the mechanical design, the dimensions of the FEE board are consistent with those of the aluminum alloy support frame. To accommodate the installation requirements of the detector modules, the FEE board incorporates a curved edge and two precision positioning holes, ensuring accurate alignment and reliable connection between the FEE board and the aluminum alloy support frame. The FEE board also integrates HV connectors to provide HV (300–500 V) for the double-mesh Micromegas detector. The edge effects (the electric field non-uniformity near the inter-modular gaps) on the borders of the modules can cause track distortion and degradation of the spatial resolution. Reference [12] proposes a potential solution: keeping the mesh at ground potential and biasing the anode to a positive high voltage can effectively mitigate the track distortion caused by the edge effect. Experimental validation of this approach will be conducted in subsequent studies.

[12] DS Bhattacharya *et al.* "A numerical investigation on the track distortion at the Micromegas based LPTPC endplate". *Journal of Physics: Conference Series*. Vol. 1498. 1. IOP Publishing. 2020, p. 012021.