University of Glasgow

2026 EICUG Early Career Workshop Summary

2026 Join ePIC/EICUG Collaboration Meeting
Sir Charles Wilson Building

Gary Penman*
University of Glasgow
14th July 2026

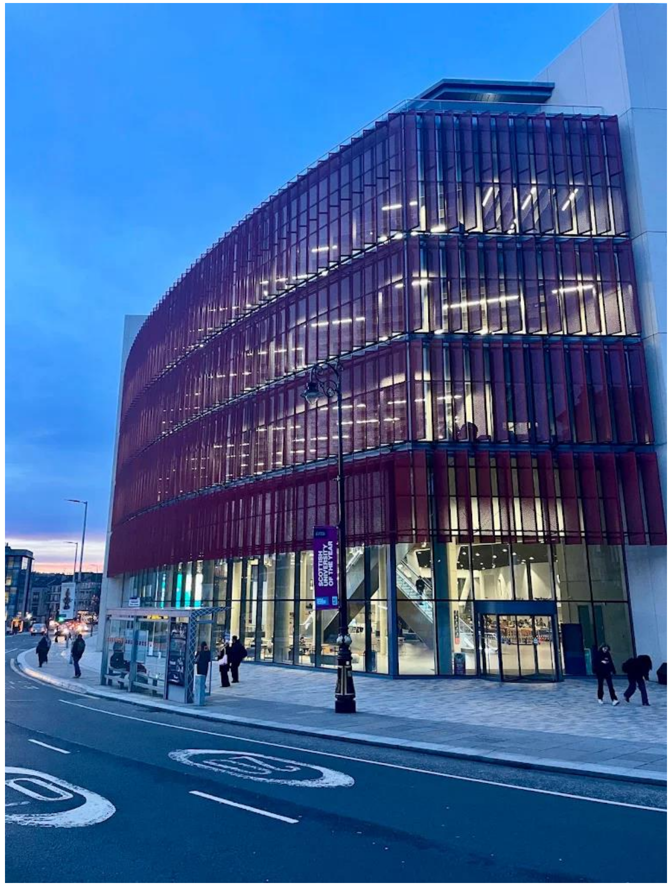
*On behalf of Akshaya, Bill, Derek, Doug, Jennifer & Yevheniia
And for the EIC Users Group

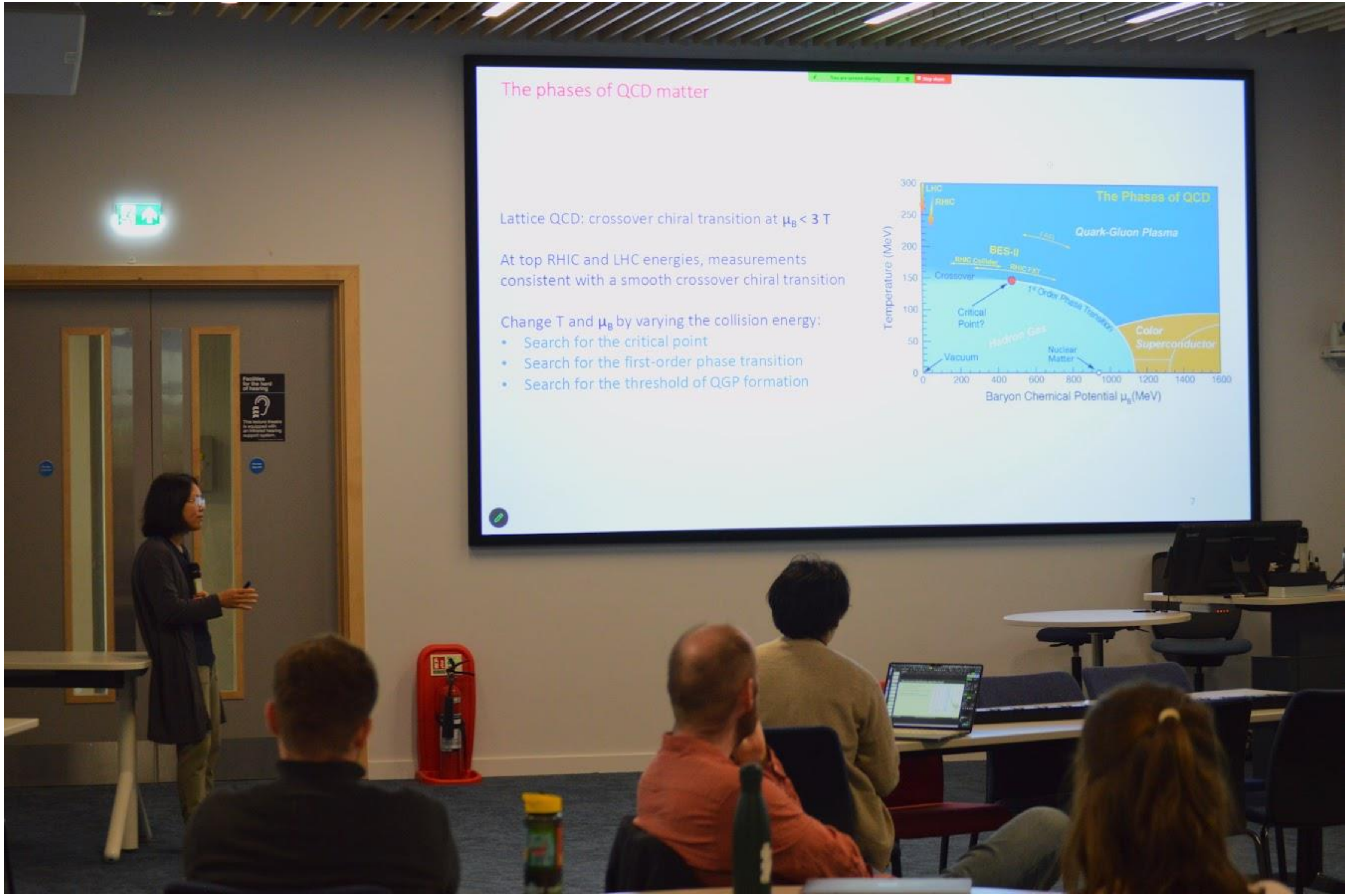
WORLD CHANGING GLASGOW

A WORLD TOP 100 UNIVERSITY

Overview of Workshop Schedule

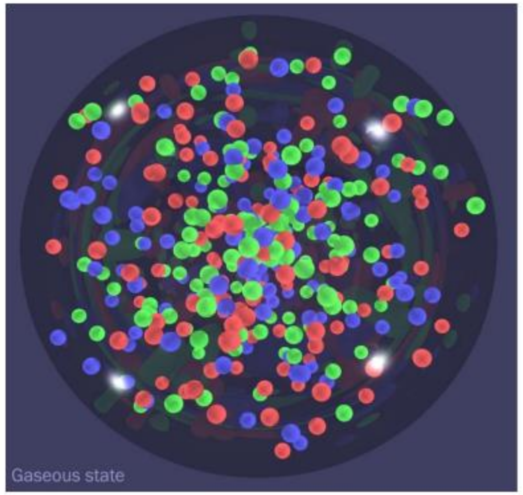
- Invited talks by Dr Lijuan Ruan and Dr Tarini Konchady
- 15 ECR talks over theory, hardware and phenomenology with ePIC and EIC
- 5 Poster contributions for our competition with flash talks
- Group Photo, Best Talk & Poster voting
- Software tutorial
- Town Hall Discussion
- Workshop dinner: Mother India Restaurant

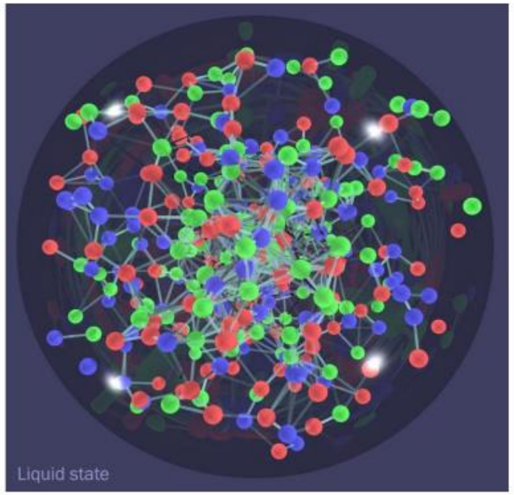


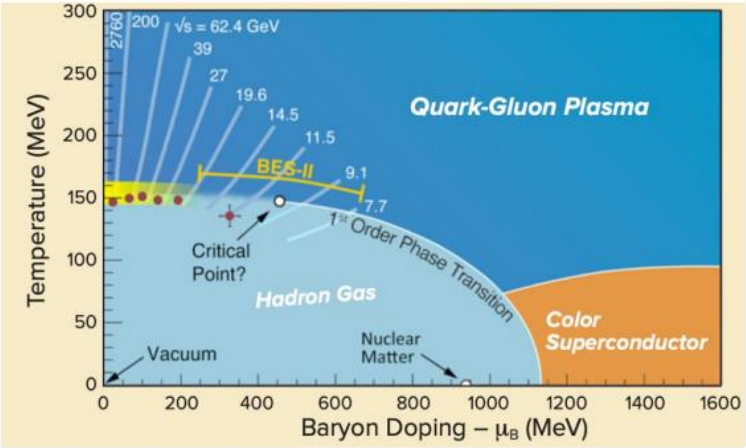

The phases of QCD matter
Lattice QCD: crossover chiral transition at $\mu_B < 3$ T
At top RHIC and LHC energies, measurements consistent with a smooth crossover chiral transition
Change T and μ_B by varying the collision energy:
• Search for the critical point
• Search for the first-order phase transition
• Search for the threshold of QGP formation
The Phases of QCD
LHC
RHIC
Quark-Gluon Plasma
BES-II
Crossover
Critical Point?
1st Order Phase Transition
Color Superconductor
Vacuum
Nuclear Matter
Temperature (MeV)
Baryon Chemical Potential μ_B(MeV)

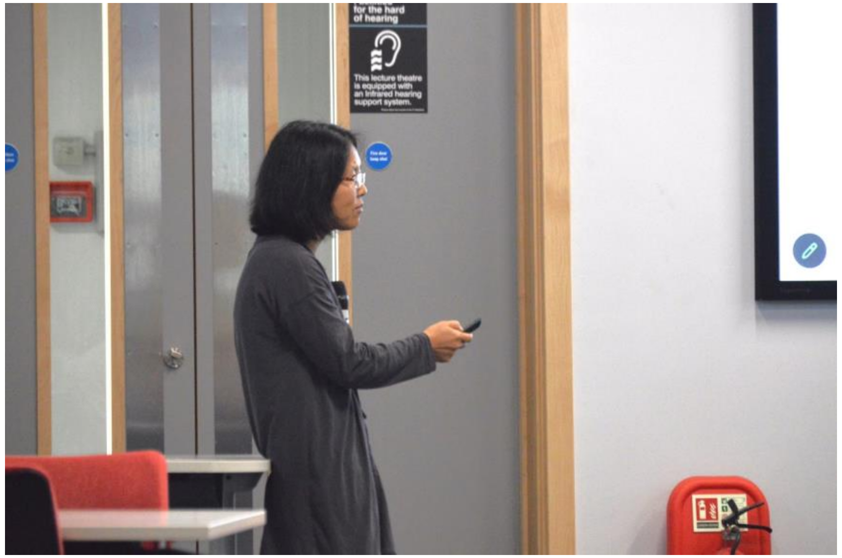
Dr Lijuan Ruan: From RHIC To The EIC

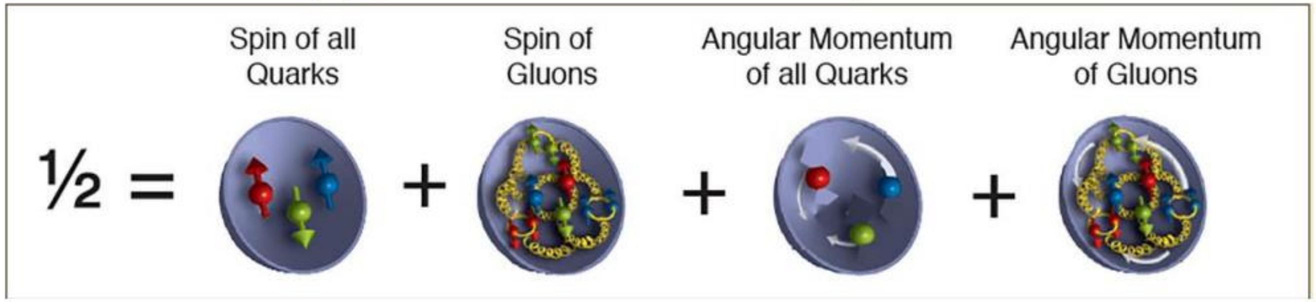
The science of RHIC





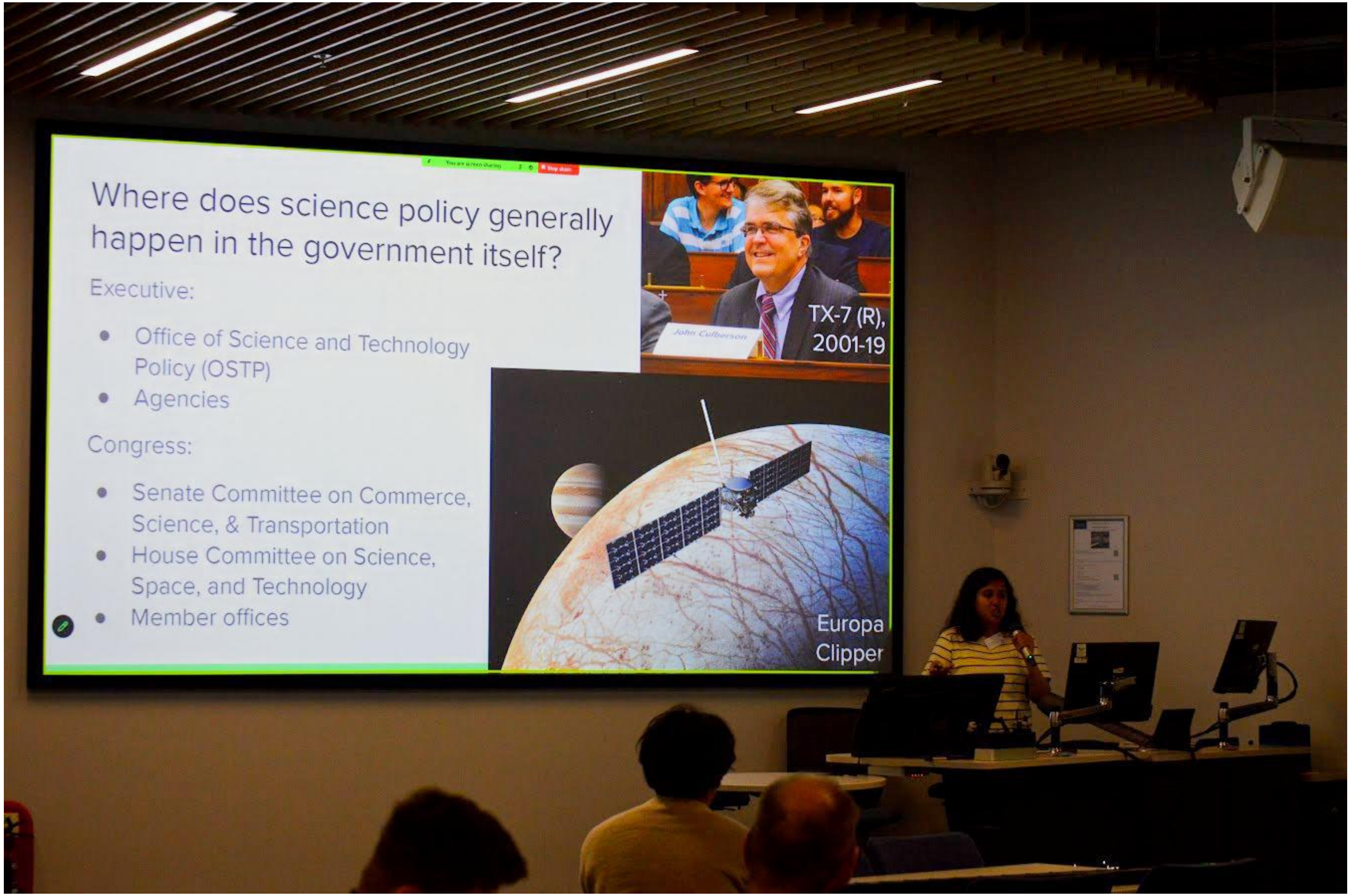






To probe the inner workings of the Quark-Gluon Plasma

To map the phase diagram of QCD


Where does science policy generally happen in the government itself?
Executive:
Office of Science and Technology Policy (OSTP)
Agencies
Congress:
Senate Committee on Commerce, Science, & Transportation
House Committee on Science, Space, and Technology
Member offices
TX-7 (R), 2001-19
Europa Clipper

National Academies Activities

- **Consensus & advisory activities**
- **Convening activities**
- Fellowships, grants, and awards
- Lectures and educational and outreach activities

G. Penman. "Overview of the ePIC Low-Q2 Tagger"

ECR Talks: Hardware

Requirements - Rates

We expect a high bremsstrahlung background (10-20 brem tracks per bunch cross @ peak luminosity) with a non-uniform distribution.

Maximum Rates

- Pixal (P1) 70 kHz
- 2 Column (C1) 8 MHz
- Tpix4 (T1) 600 MHz, 38 Gb/s
- Board (B1) 1500 MHz, 96 Gb/s
- Layer (L1) 2500 MHz, 160 Gb/s

Total Integrated Rates

- Tagger 1 2 GHz, 140 Gb/s
- Tagger 2 7 GHz, 480 Gb/s
- Total **9 GHz, 600 Gb/s**

Data Buffered & Filtered (Hadron in main Det)

- Trigger rate 500 kHz, 99.4% rejection (brem only)
- Data rate (signal) 4 Gb/s
- Data Rate (incl BG and rand) **<20 Gb/s to tape**

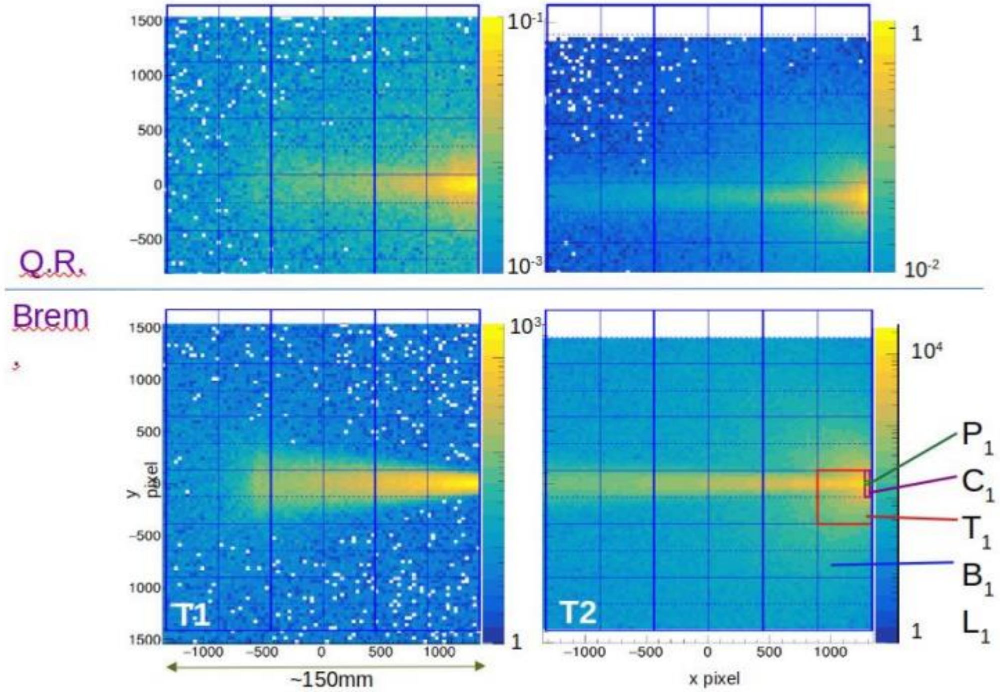


Figure 9: Low-Q^2 tagger rates kHz / pixel. (18x275 GeV @ 10^{34} $cm^{-2}s^{-1}$).

Work is ongoing to produce physically realistic brem background mixed physics analysis at the current Early Science luminosity and energy configurations (9GeV electrons @ ~1fb^-1 Luminosity)

G. Penman. "Overview of the ePIC Low-Q2 Tagger"

S. Preins. "Beam Test of a SiPM-on-Tile ZDC Prototype with 5.3 GeV Positrons at Jefferson Laboratory"

Beam Test Goals

- Measure energy response
- Study shower development
- Measure position resolution
- Compare with GEANT4 simulation
- Guide the final ZDC design

[Submitted on 15 Mar 2026]

Beam Test of a SiPM-on-Tile ZDC Prototype with 5.3 GeV Positrons at Jefferson Laboratory

Sean Preins, Weibin Zhang, Ryan Tsiao, Mia Macias, Brice Saunders, Love Preet, Miguel Arratia

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S. Preins. "Beam Test of a SiPM-on-Tile ZDC Prototype with 5.3 GeV Positrons at Jefferson Laboratory"

J. Demjancukova "Preamplifier circuit for Direct Photon Detector for luminosity measurement"

SiPM time characteristics at 50 MHz

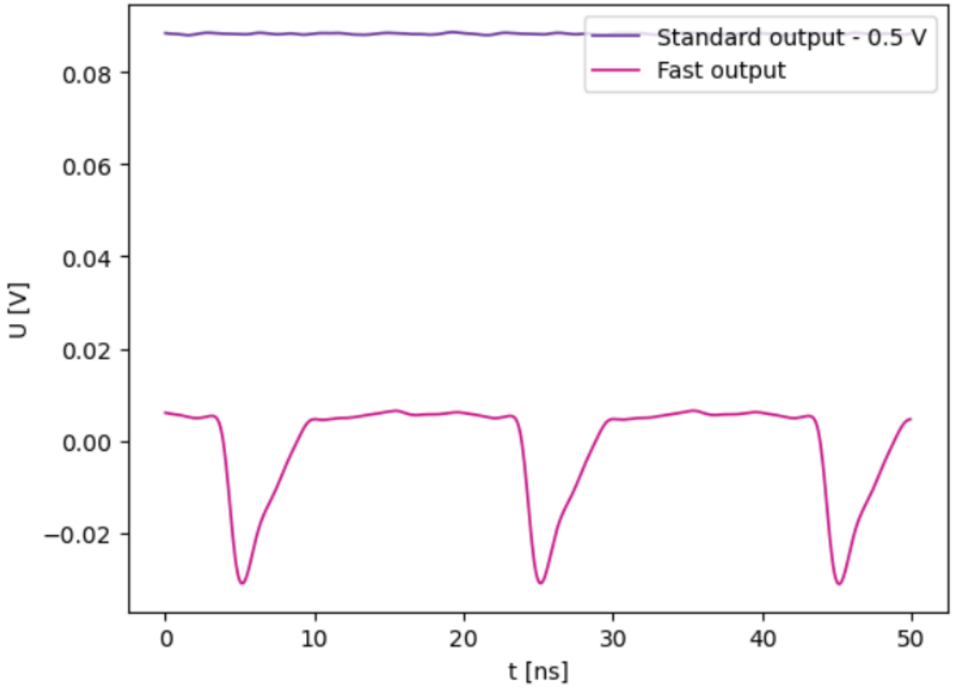
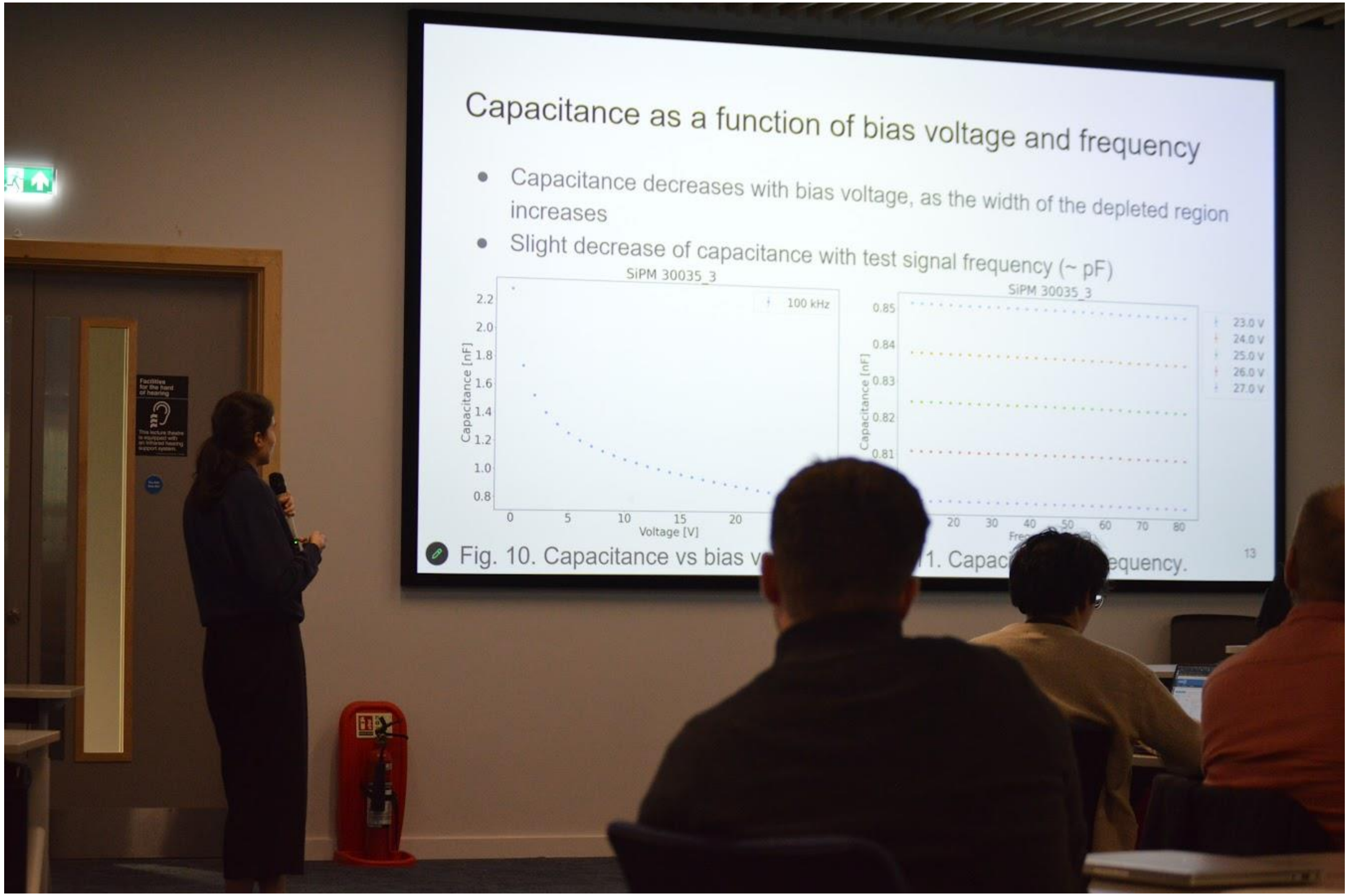


Figure: Output voltage at the standard and fast output of the onsemi C-Series 30035 SiPM with the amplifier circuit for the laser repetition frequency of 50 MHz.

J. Demjancukova "Preamplifier circuit for Direct Photon Detector for luminosity measurement"

ECR Talks: Hardware



L. Radmacherova "Electrical characteristic for SiPM for direct method for luminosity measurement"

Resistance and leakage current as functions of bias voltage

- Breakdown voltage determined from resistance and leakage current

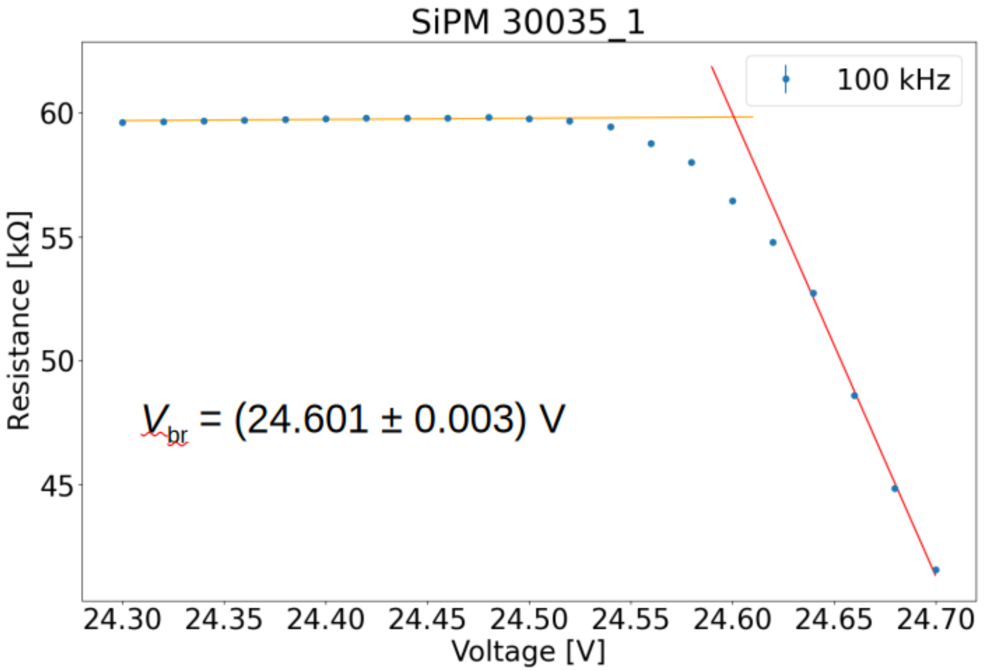


Fig. 8. Resistance vs bias voltage.

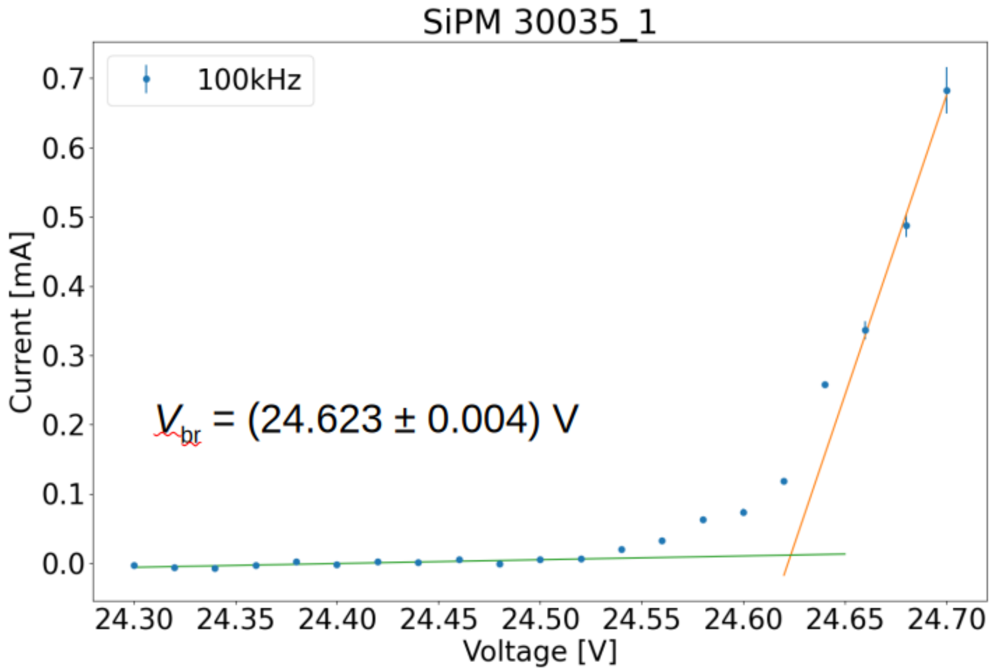
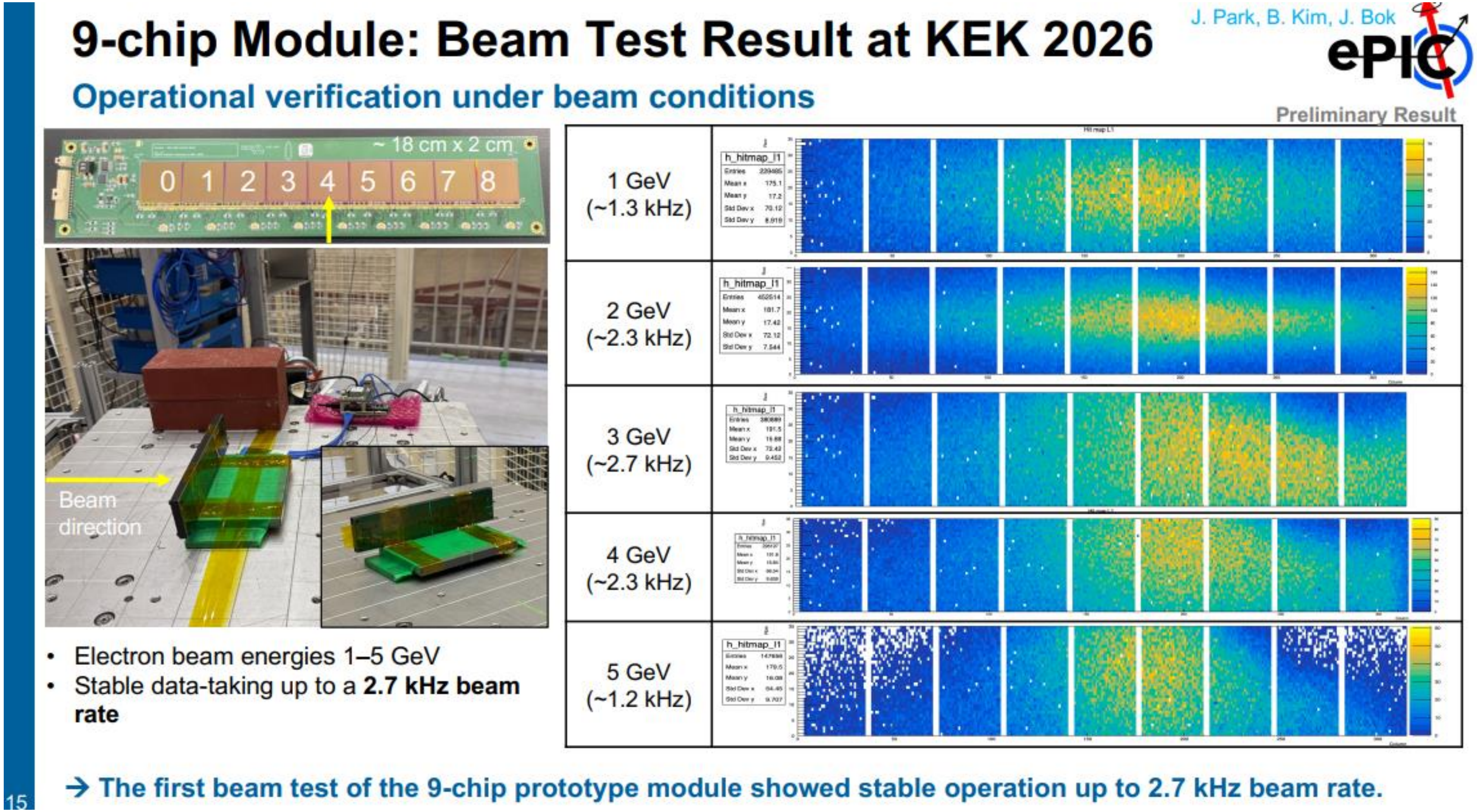
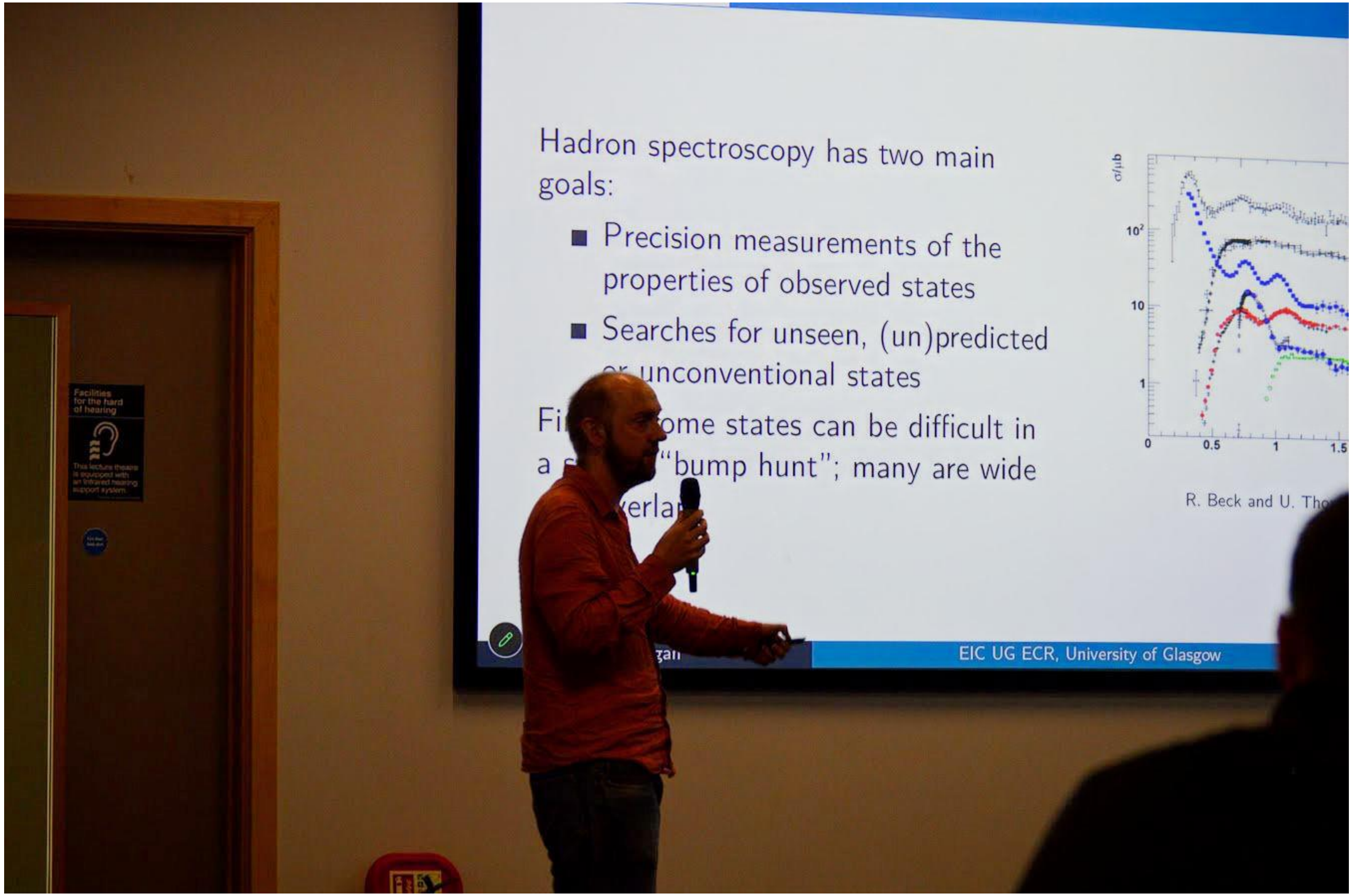


Fig. 9. Leakage current vs bias voltage. 11

L. Radmacherova "Electrical characteristic for SiPM for direct method for luminosity measurement"



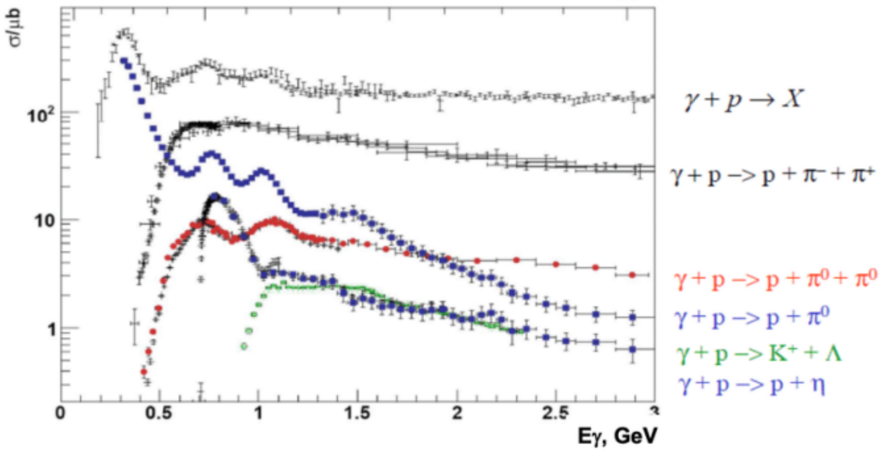
B. Kim "Recent Developments of the AstroPix Imaging Layers for the ePIC Barrel Imaging Calorimeter"



S. Fegan "Kaons, Kaons, I Like Kaons"

UNIVERSITY of York

A World of Polarisation (Observables)



R. Beck and U. Thoma, EPJ Web Conf 134, 04003 (2017)

- Even high quality, high statistics data is insufficient to resolve the full resonance spectrum purely from cross-section measurements
- Use alternative means; coupling strength to a reaction channel, manifestation in experimental observables, etc. to aid searches

- Polarisation of the reaction particles can be exploited to probe resonances in more detail by measuring *Polarisation Observables*

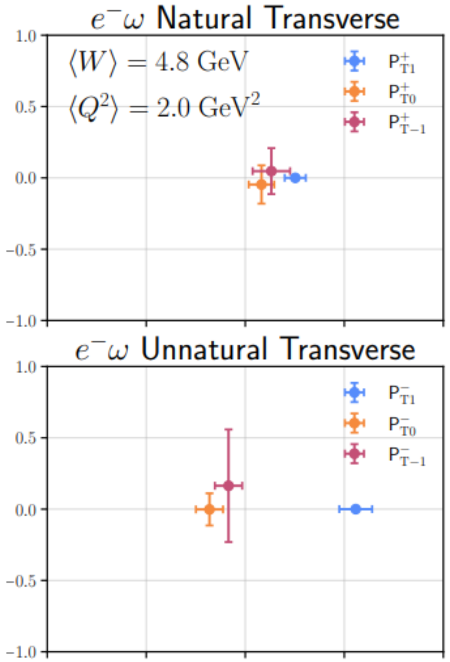
S. Fegan "Kaons, Kaons, I Like Kaons"

D. Leahy "A General Partial Wave Amplitude Formalism for Meson Electroprocution at the EIC"

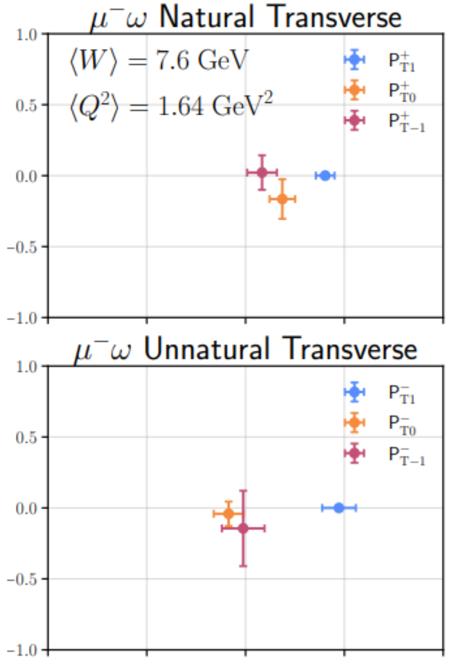
Real-World Data: ω Production (Transverse Sectors)

University of Glasgow

On ω data the minimizer does not work as well...



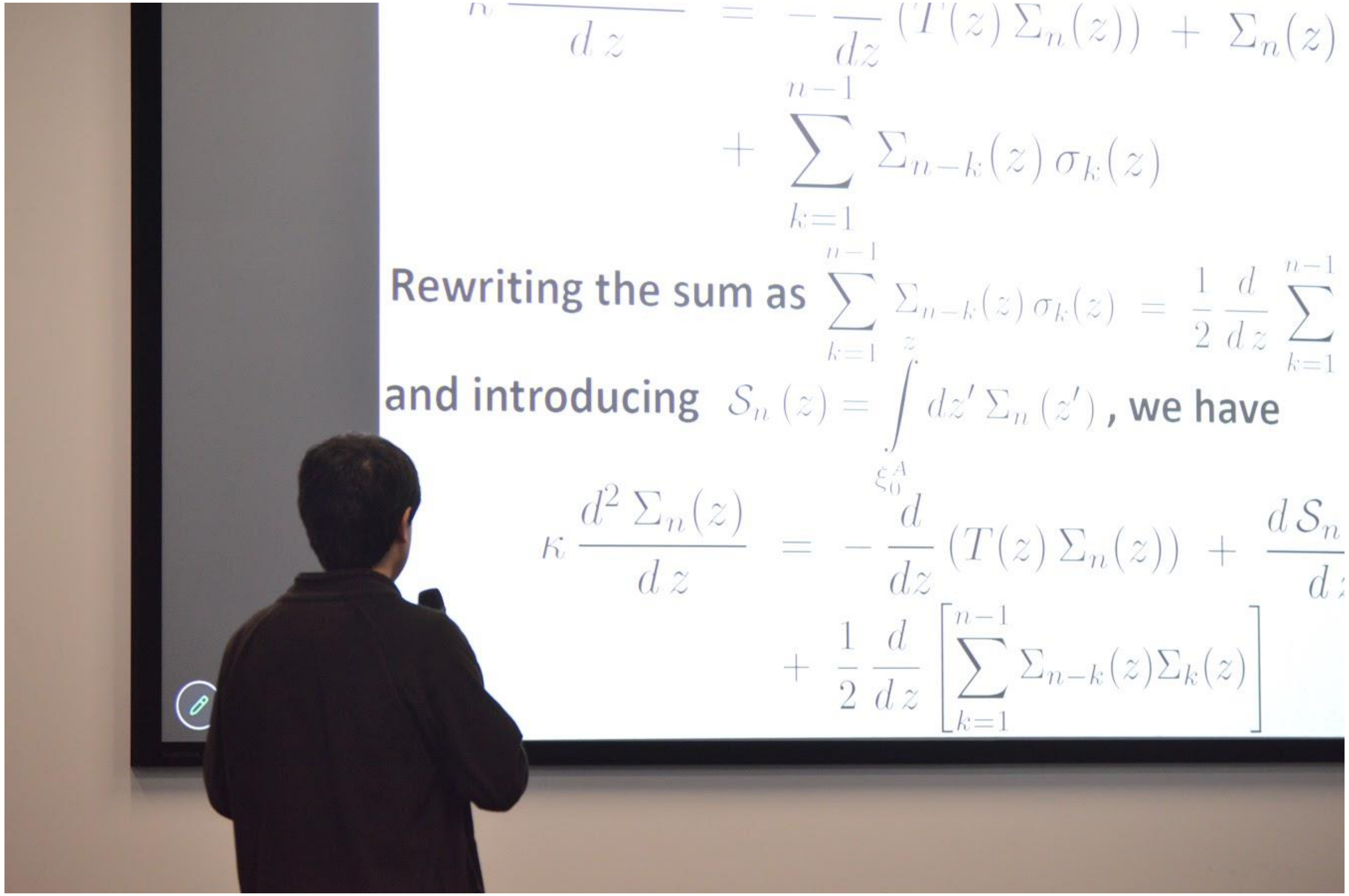
Electron Production: Extracted $e^-\omega$ transverse amplitudes .



Muon Production: Extracted $\mu^-\omega$ transverse amplitudes.

Observation: Minimizer solution is less certain than ρ^0, but can see a distinctly large Unnatural Transverse $m = 1$ corresponding to expected pion exchange.

D. Leahy "A General Partial Wave Amplitude Formalism for Meson Electroprocution at the EIC"



J. Garrido "High energy QCD: Evolution equations and particle production"

Gluon production at small-x

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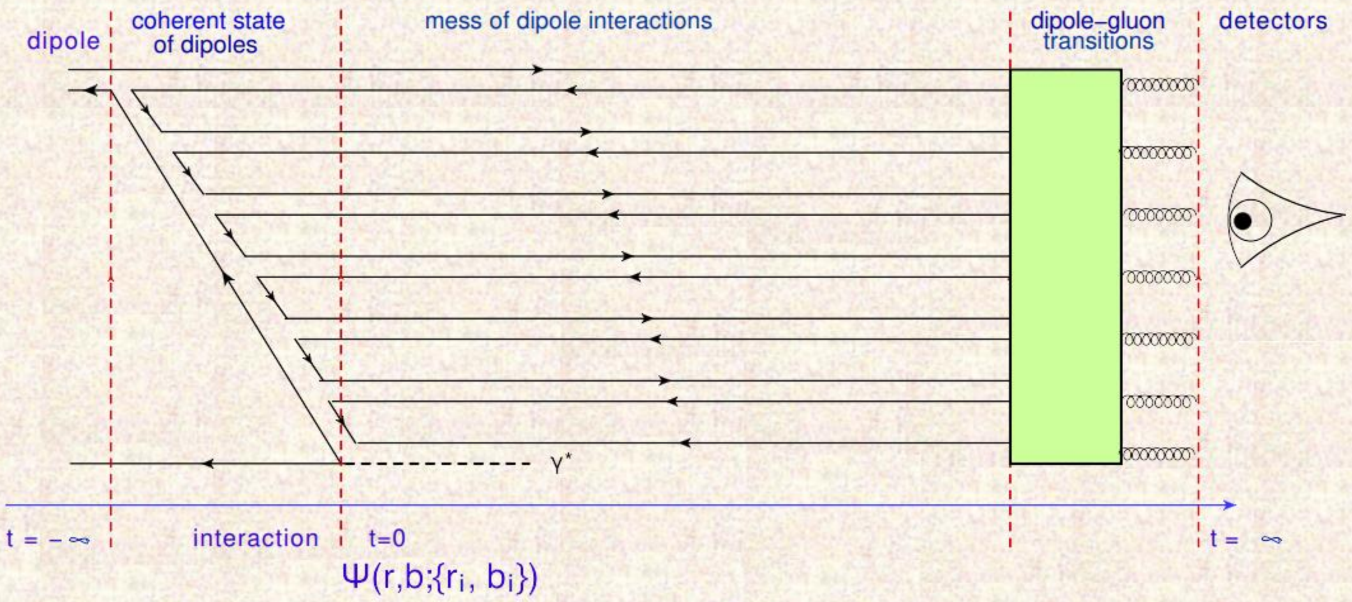
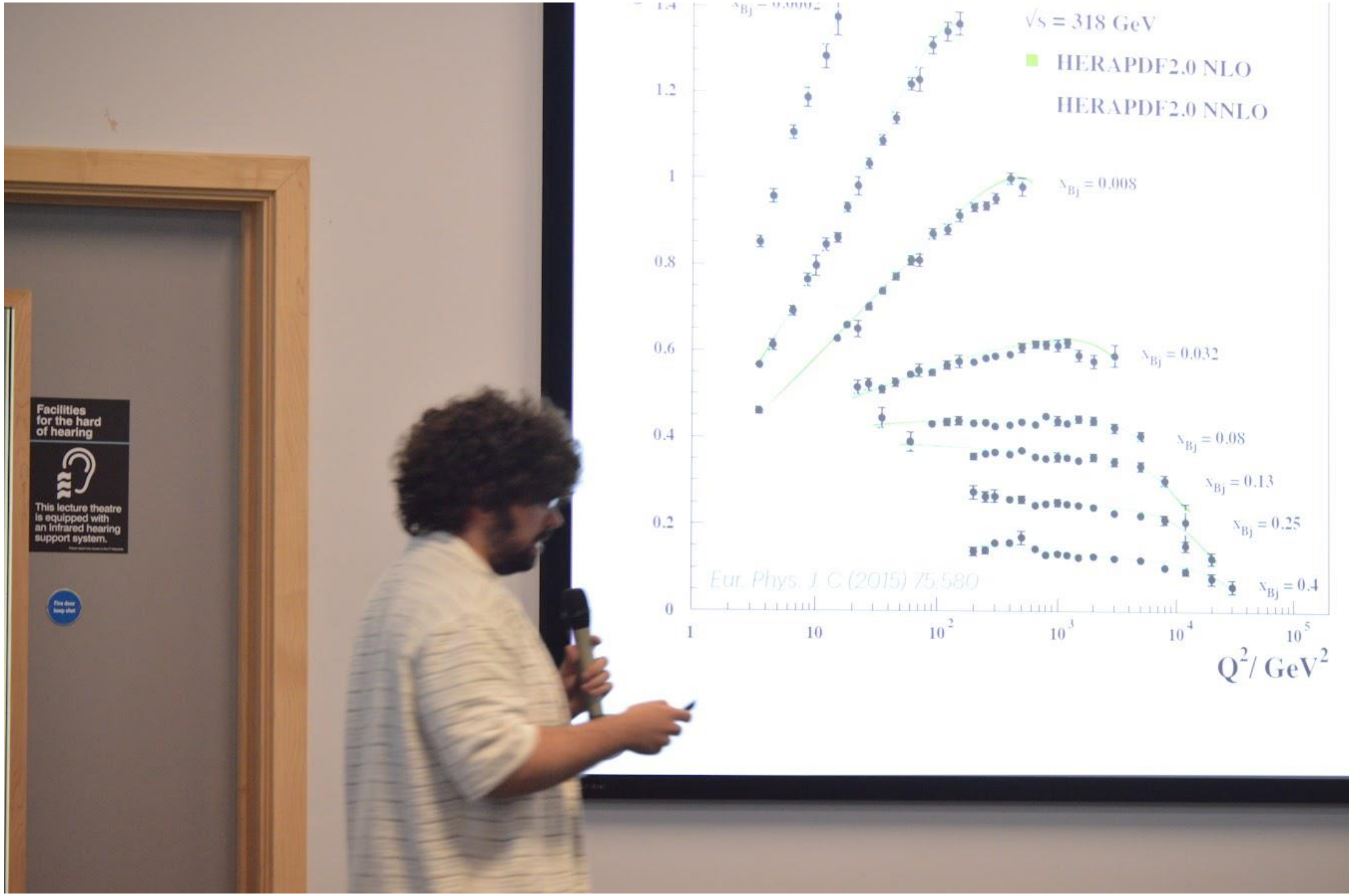


- **The interaction of fast hadron (dipole) with the virtual photon (γ∗). The coherence of the partonic wave function of the fast hadron is destroyed at t = 0, while the gluons can be measured at t = ∞.**

J. Garrido "High energy QCD: Evolution equations and particle production"

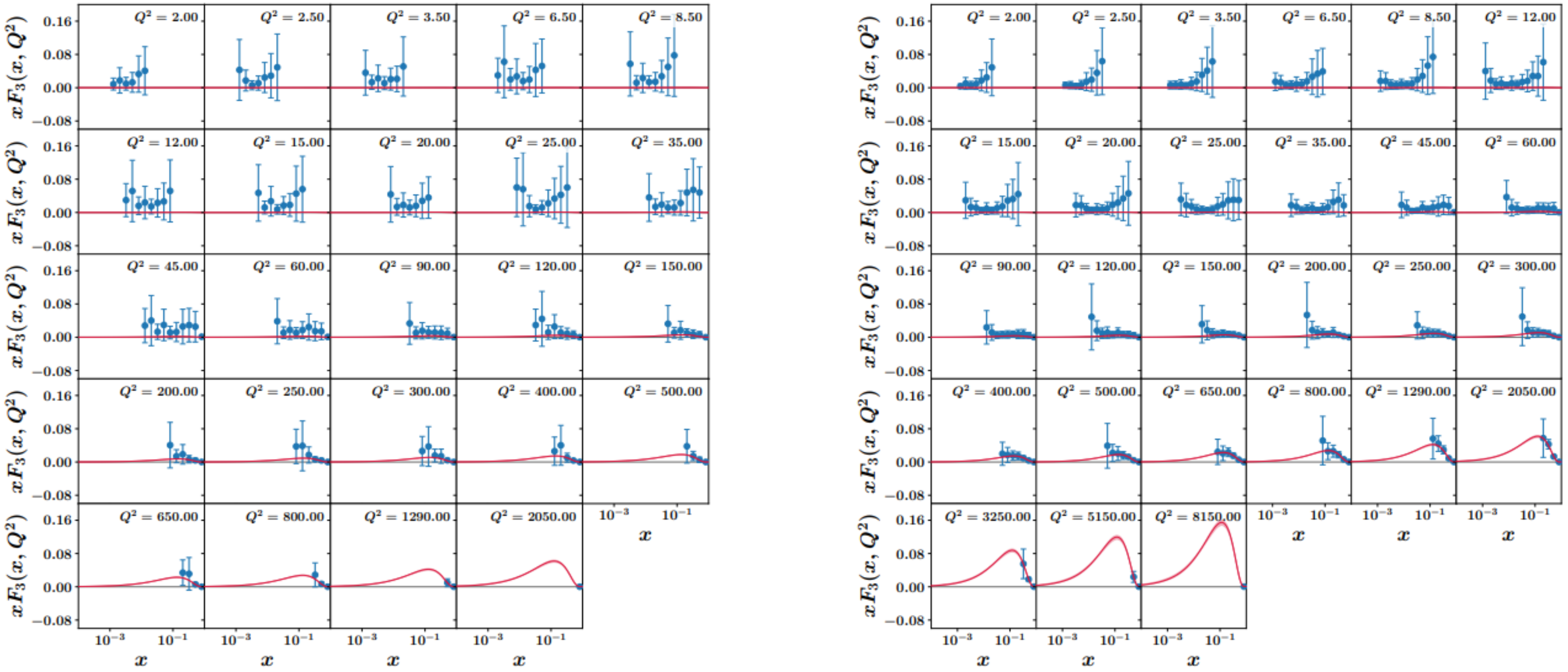
ECR Talks: Theory, Phenomenology & Beyond



J. Jimenez-Lopez "Model-independent determination of proton structure functions at the Electron-Ion Collider"

Results for xF_3 (optimistic scenario)

S5 S17



Predictions to compare with are done with HERAPDF2.0 NNLO using YADISM (*Eur.Phys.J.C (2024) 84:697*) and points whose uncertainty is above 0.1 are not displayed for visual clarity.

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J. Jimenez-Lopez "Model-independent determination of proton structure functions at the Electron-Ion Collider"

Where Do We Fit In?

Annual per capita carbon footprint by region [31]

Region	**Average (tCO_2e)**	**EIC Physicist (tCO_2e)**
Africa	0.99	44.25
Asia	4.87	48.13
Europe	6.54	49.80
North America	9.99	53.25
Oceania	9.53	52.79
South America	2.55	45.81

- 64,891.7 tCO_2e annual footprint (operation + community), 1,500 collaborators, **additional 43.3 tCO_2e per capita**

→ CERN's per capita footprint estimated to be $\sim$ 33 tCO_2e per year [10, 22]

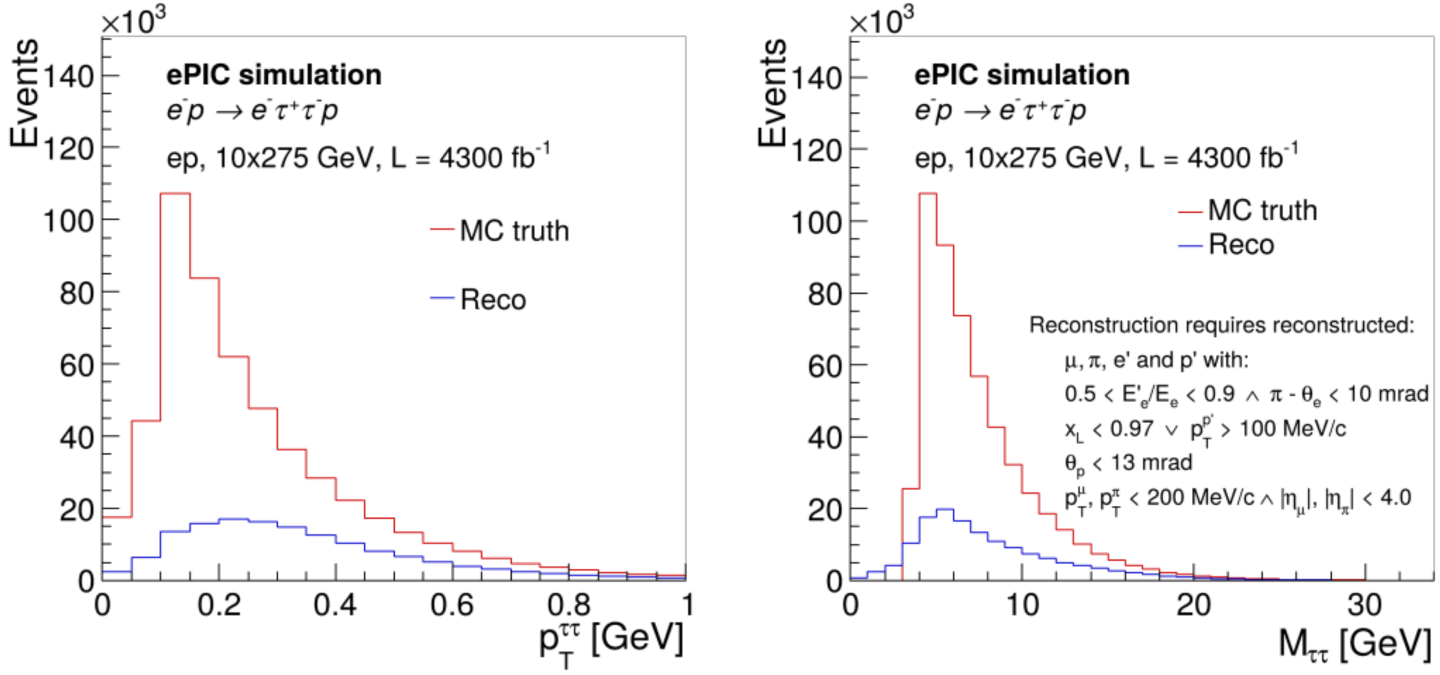
A. Collins "The Carbon Footprint of the EIC"

Invariant mass and transverse momentum of the tau-pair

- The $\tau^+\tau^-$ four-momentum is reconstructed from the initial beams and the scattered electron and proton four-momenta:

$$p_{\tau\tau} = p_e + p_p - p_{e'} - p_{p'}.$$

Only events with fully reconstructed visible decay products (muon and pion) are used.



K. Ozog "Exclusive Production of Tau Lepton Pairs in Electron-Proton Collisions at the Electron-Ion Collider"

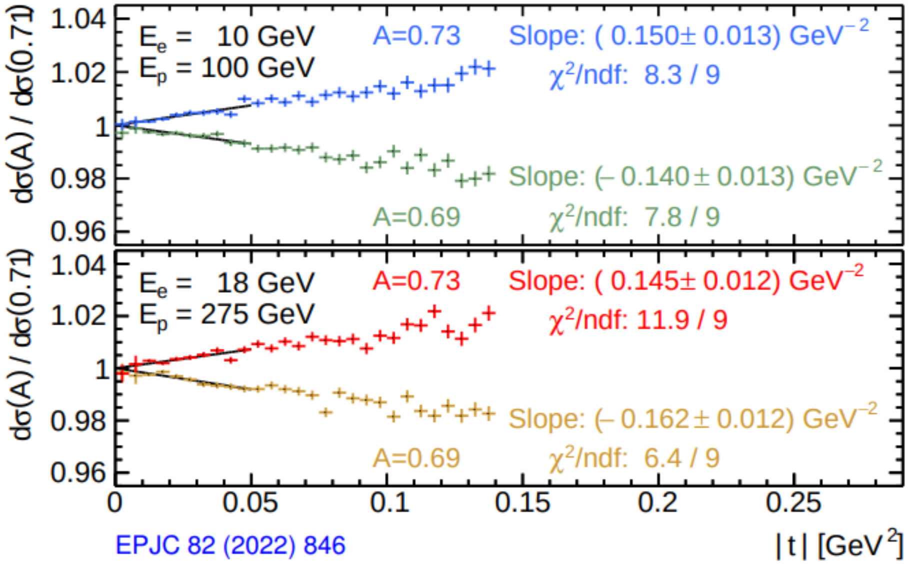
A method for determination of the proton radius at the EIC

- Results presented on this slide are based on the true level only for $ep \to ep + \mu^+\mu^-$.
- The mean proton charge radius R_p can be obtained from the proton form factor G_E:

$$G_E(t) = \left(1 - \frac{t}{A_0}\right)^{-2} \quad \Rightarrow \quad A_0 = \frac{12}{R_p^2} \quad \Rightarrow \quad R_p^2 = 6\, \frac{dG_E(t)}{dt}\Big|_{t=0}$$

For the "standard" dipol: $A_0 = 0.71\,\mathrm{GeV}^2 \;\Rightarrow\; R_p \approx 0.811$ fm

- Slope of the cross sections ratio: $\frac{d}{dt}\left(\frac{d\sigma(A_1)/dt}{d\sigma(A_2)/dt}\right)\Big|_{t=0} = \frac{d\sigma}{dt} \propto G_E^2 = \frac{1}{3}\left(R_1^2 - R_2^2\right)$



- Expected values of the slope for $A_2 = A_0$:

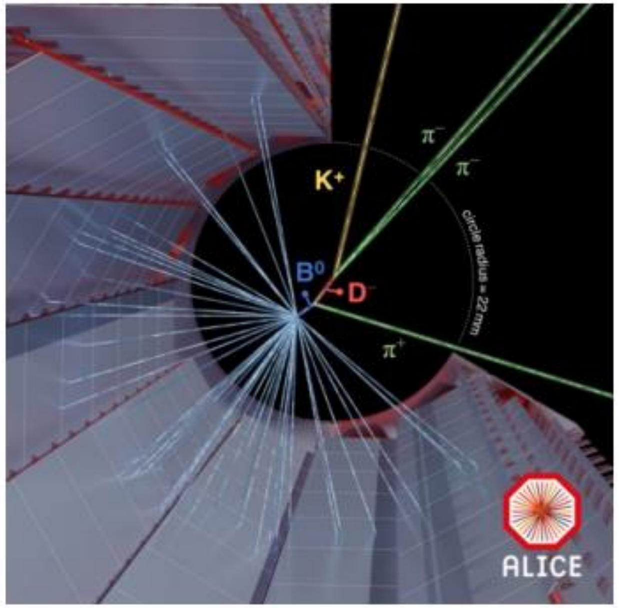
A_1 [GeV^2]	slope [GeV^{-2}]
0.73	0.154
0.69	-0.163

- No scattered electron required to increase σ_{vis} and to avoid sensitivity to bremsstrahlung overlays.
- Stat. errors correspond to $\mathcal{L}_{int} \approx 100$ fb^{-1}.

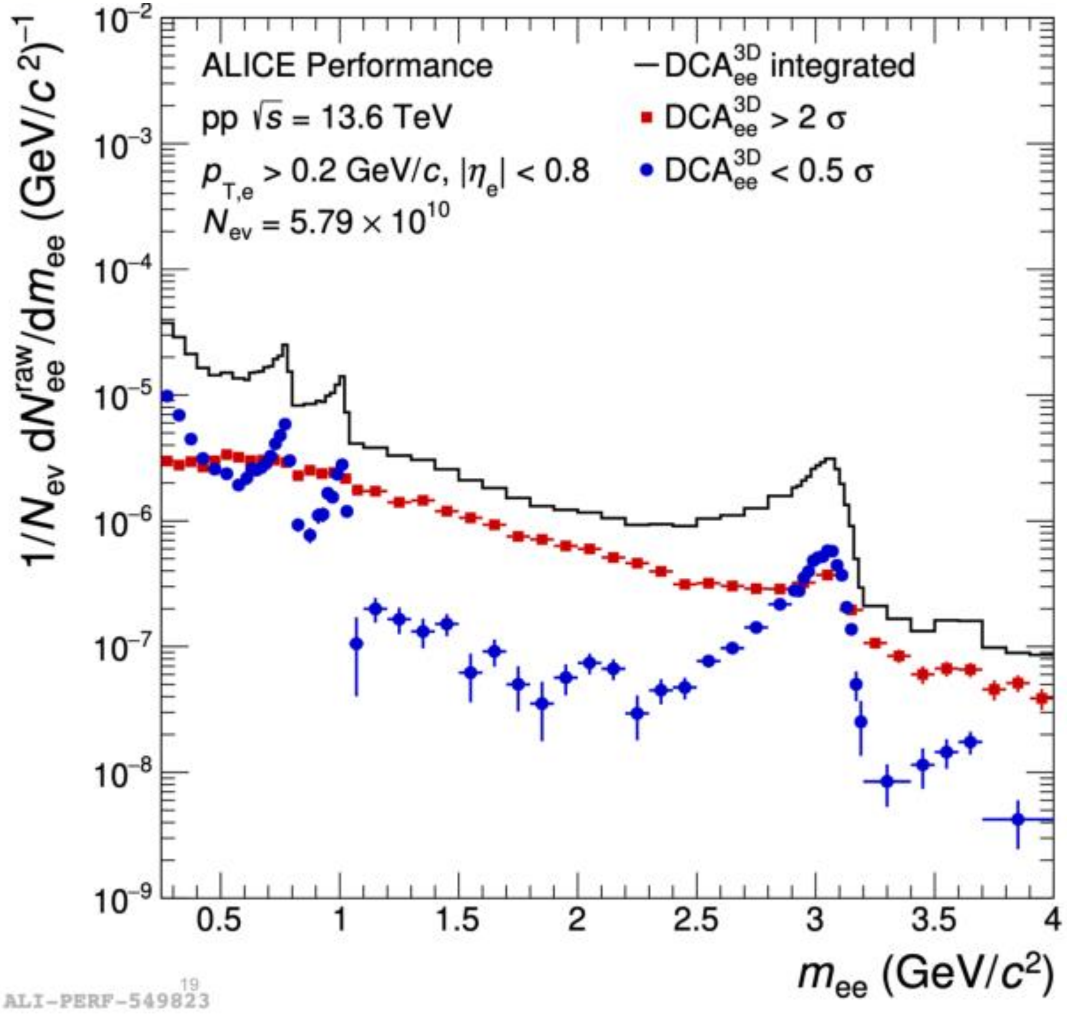
K. Kopec "Exclusive Production of Electron and Muon Pairs in Electron-Proton Collisions at the Electron-Ion Collider"

BACKGROUNDS

- Factor ~ 50 suppression of open heavy flavor achieved in ALICE by cutting out displaced vertices!
  - **EIC can do better!**



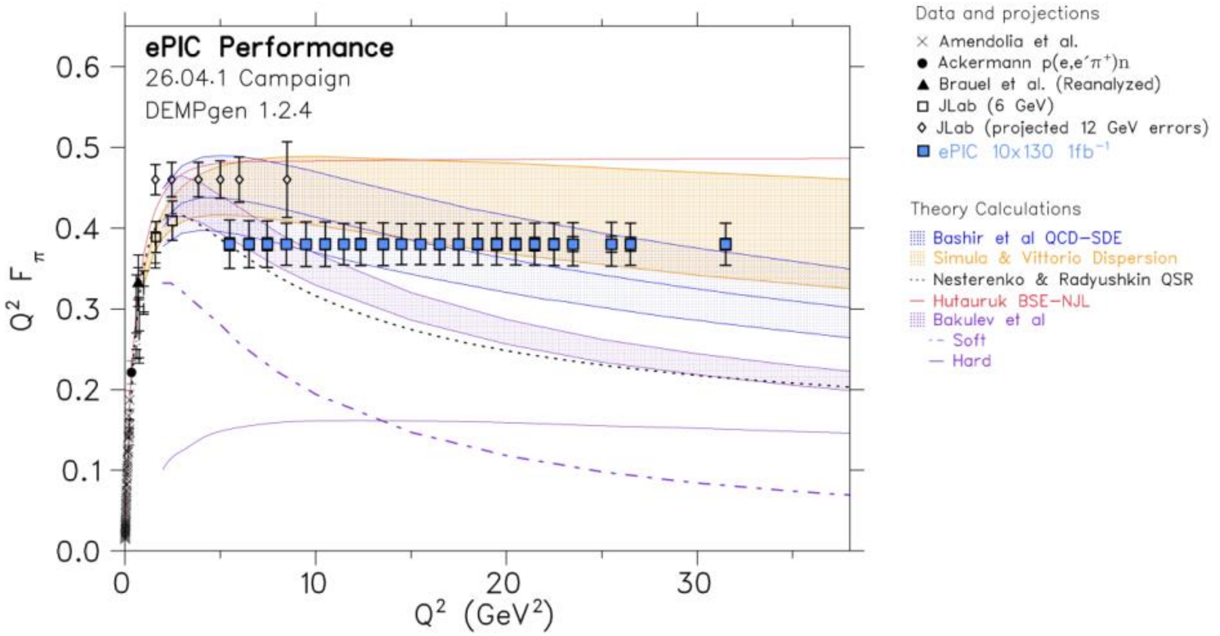
U.S. DEPARTMENT OF ENERGY Argonne National Laboratory is a U.S. Department of Energy laboratory managed by UChicago Argonne, LLC.



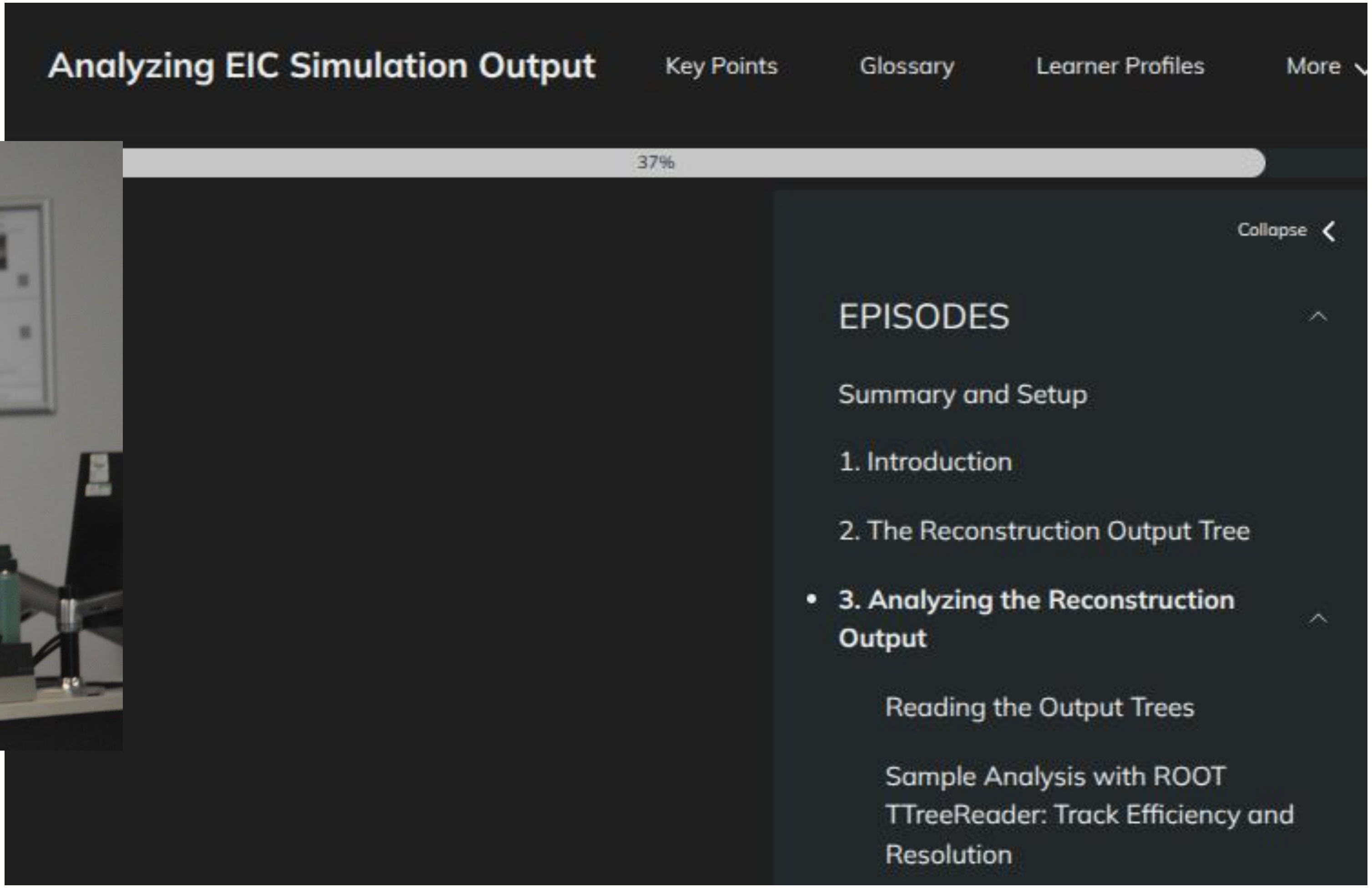
H. Klest "Drell Yan at the EIC"

Pion Form Factors at the EIC

- ePIC → F_π to high Q^2 , even in early science period
- Error bars represent real projected error bars
- More details on analysis in Analysis Note
- Results featured in Early Science Report
- Results to be updated with latest 9x130 and 9x275 configs very soon!

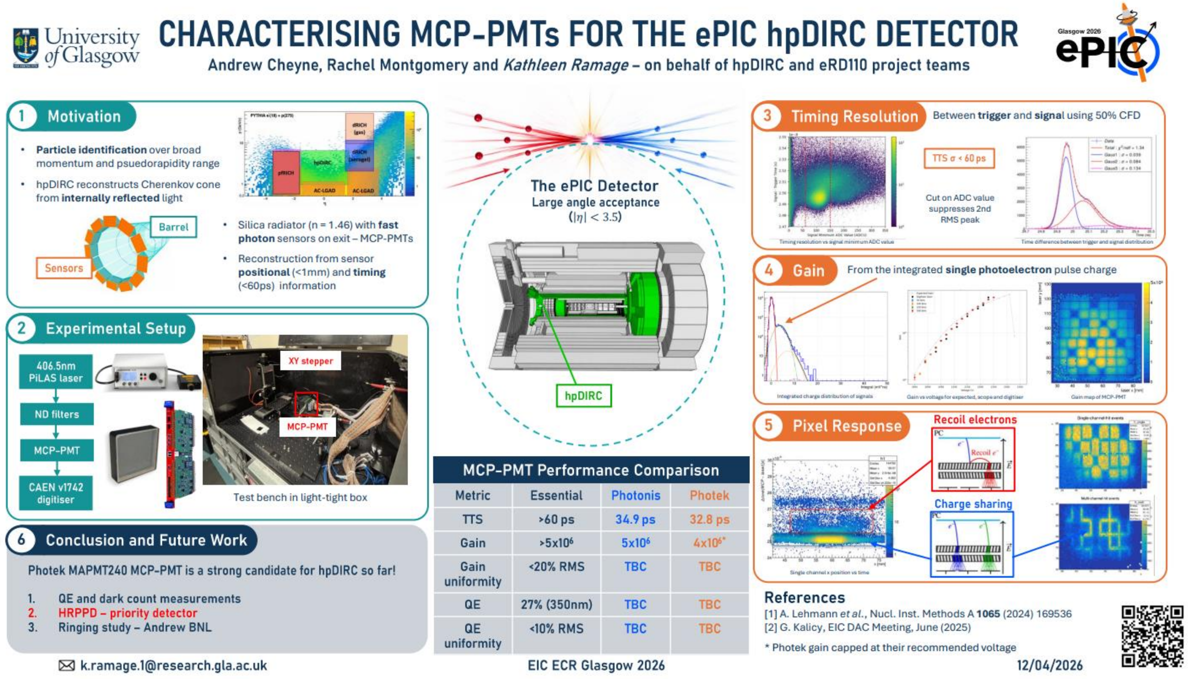


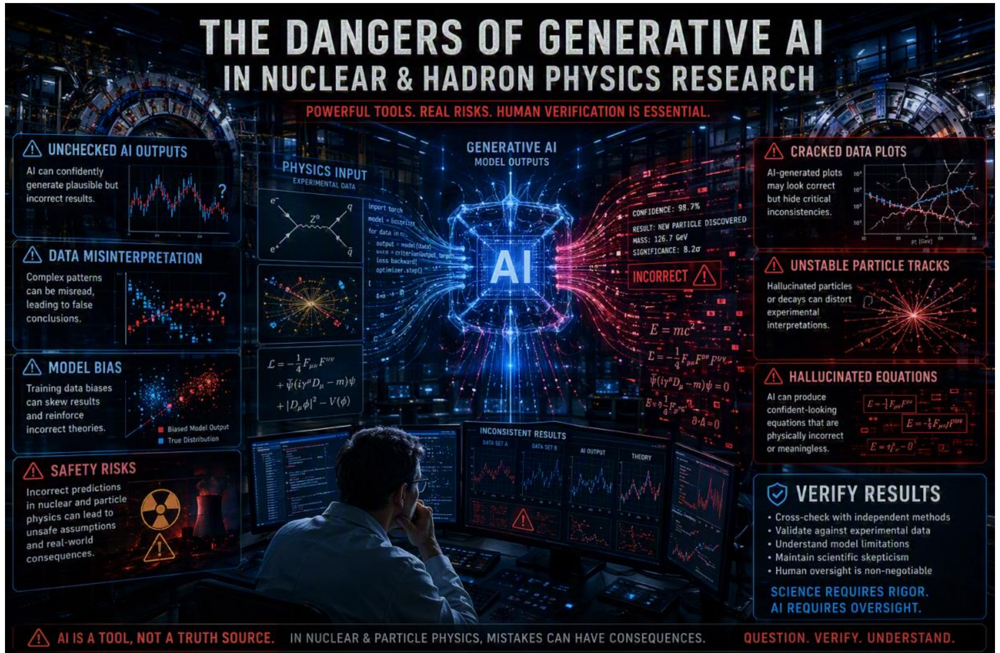
S. Kay "Meson Structure/Lumi Measurements at the EIC"

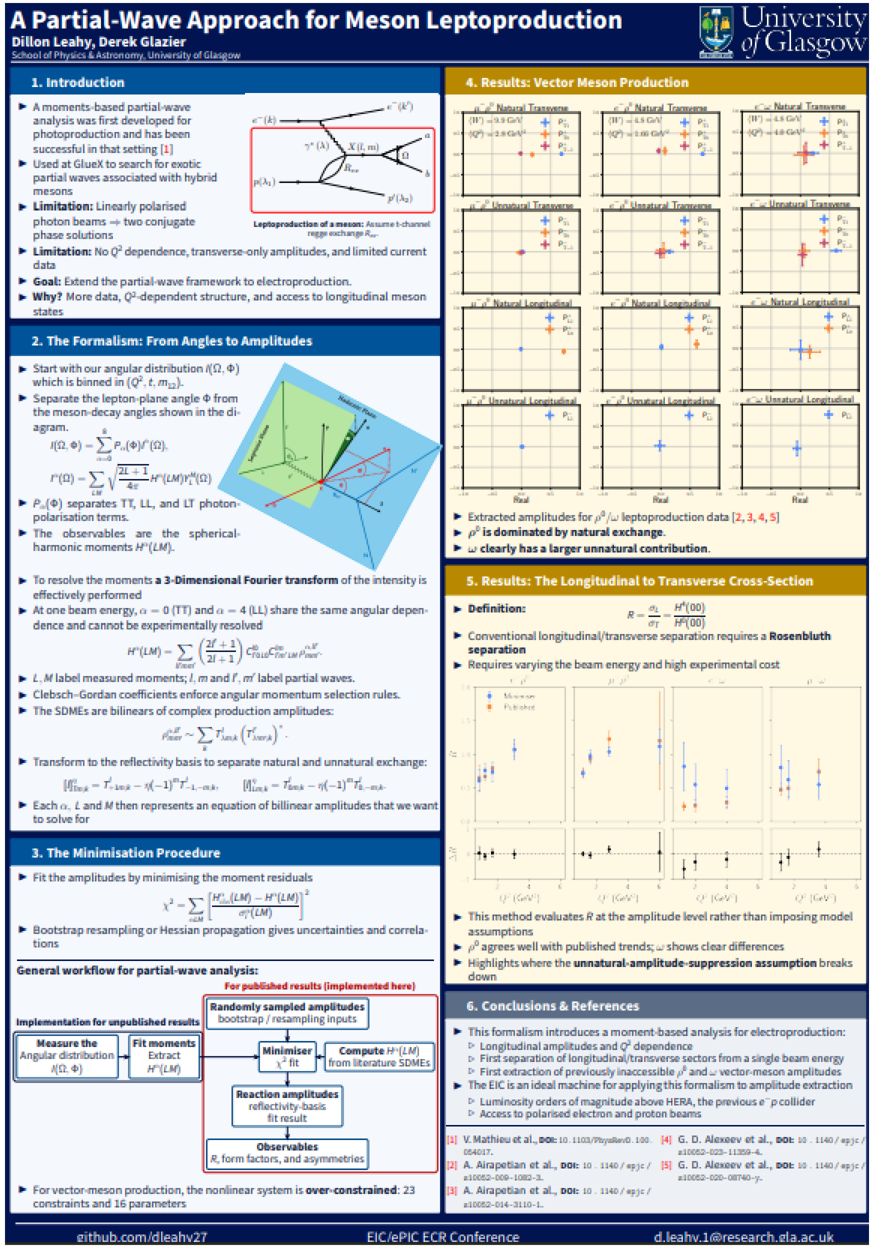


A Massive thank you to Derek, as well as the User Learning Group and Software and Computing team for coordinating to make this happen!

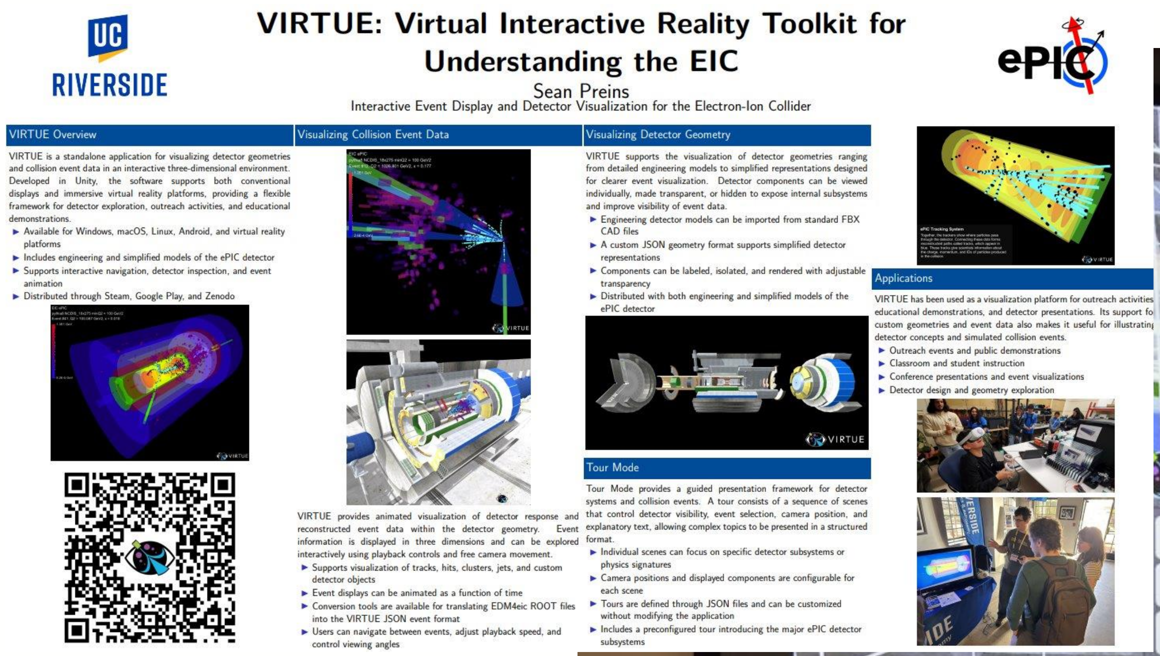
Poster Competition







Poster Competition



Prizes

- Prizes (3 x £50)
  - CFNS Bjorken Fellowship (Best Student Presentation)
  - Best Postdoc(+) Presentation
  - Best Poster

Prizes were voted for by the ECR themselves. Students voted on postdoc(+) talk prize and postdocs voted on the student talk prize

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  - Best Poster

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Prizes

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  - CFNS Bjorken Fellowship: **Ada Collins**
  - Best Postdoc(+) Presentation: **Henry Klest**
  - Best Poster: **Sean Preins**

A massive well done to all presenters this weekend, and congratulations to Prize winners!

Prizes were voted for by the ECR themselves. Students voted on postdoc(+) talk prize and postdocs voted on the student talk prize

Sponsor Acknowledgements

We would like to thank and acknowledge the UK Institute of Physics (IOP) and the UKRI Science and Technology Facilities Council for their generous support for this meeting

UKRI Science and Technology Facilities Council

IOP Institute of Physics High Energy Particle Physics Group

IOP Institute of Physics Nuclear Physics Group


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University of Glasgow

Thank You!