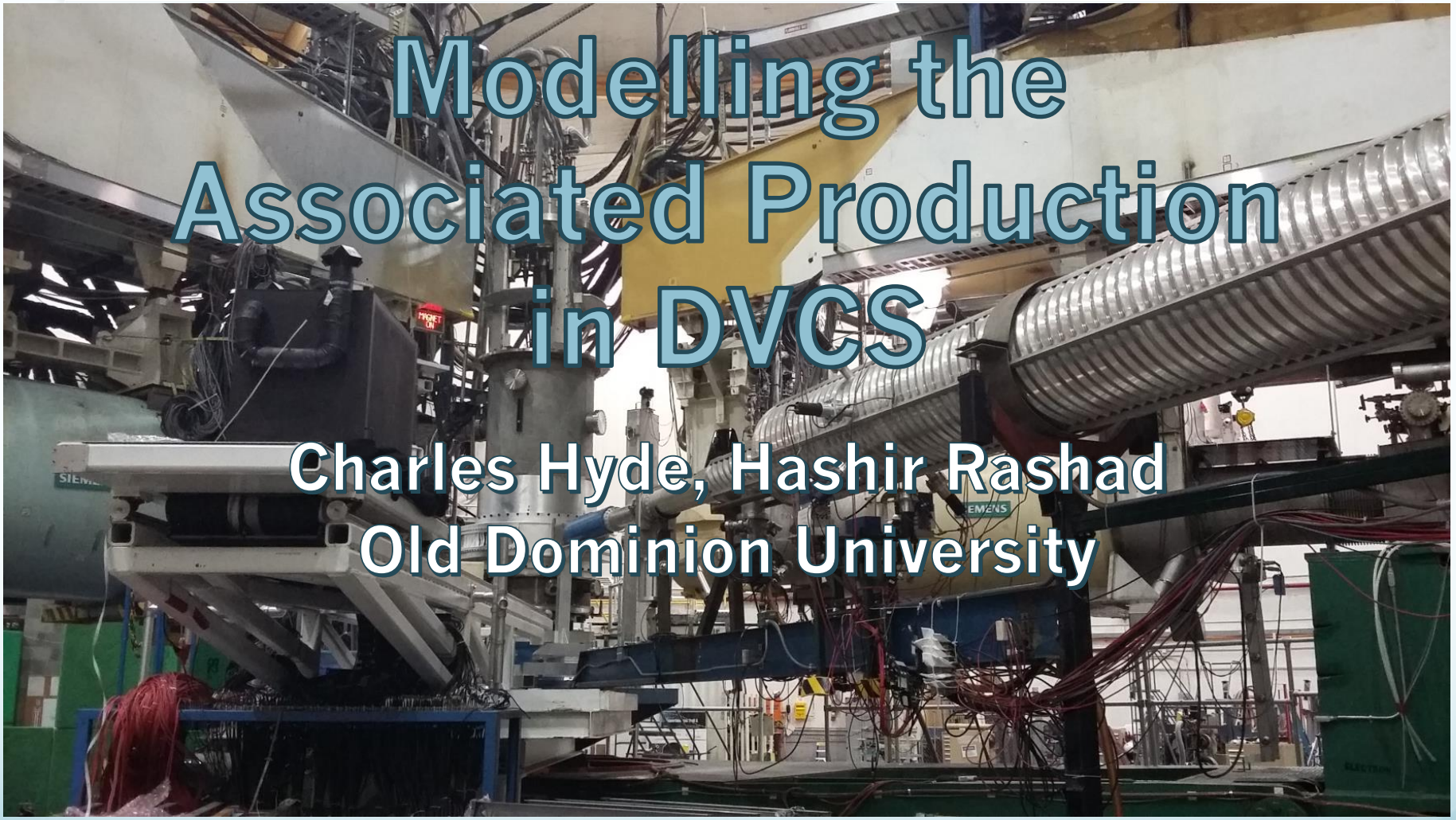

Modelling the Associated Production in DVCS

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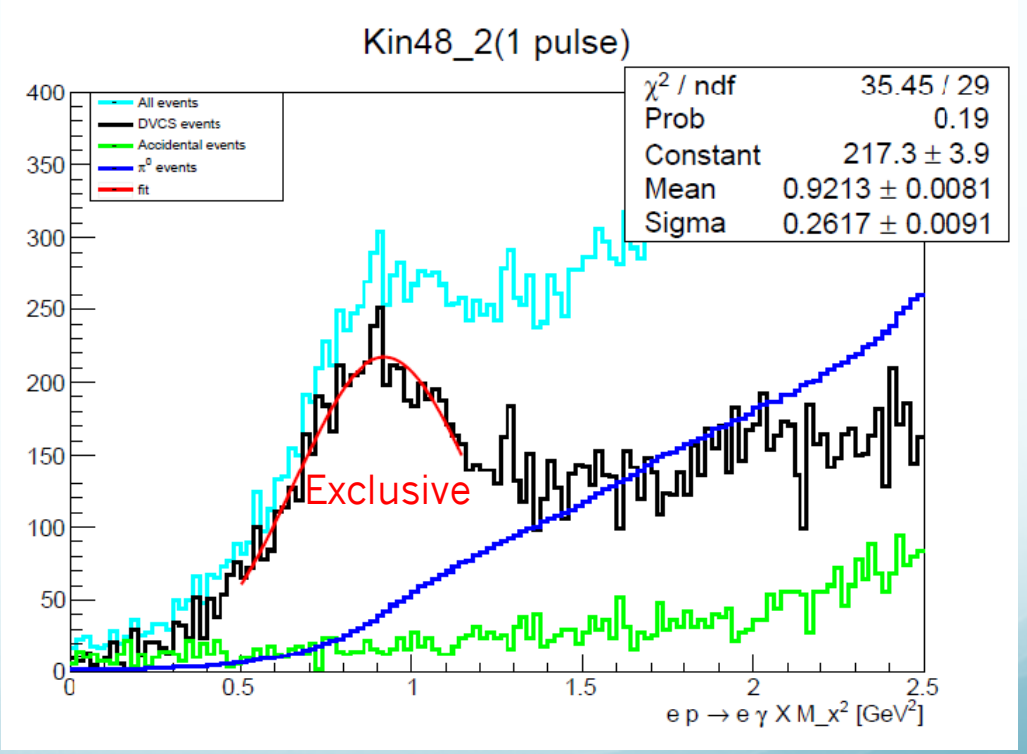
Old Dominion University

Hall A DVCS
Collaboration Meeting
16—17 January 2017

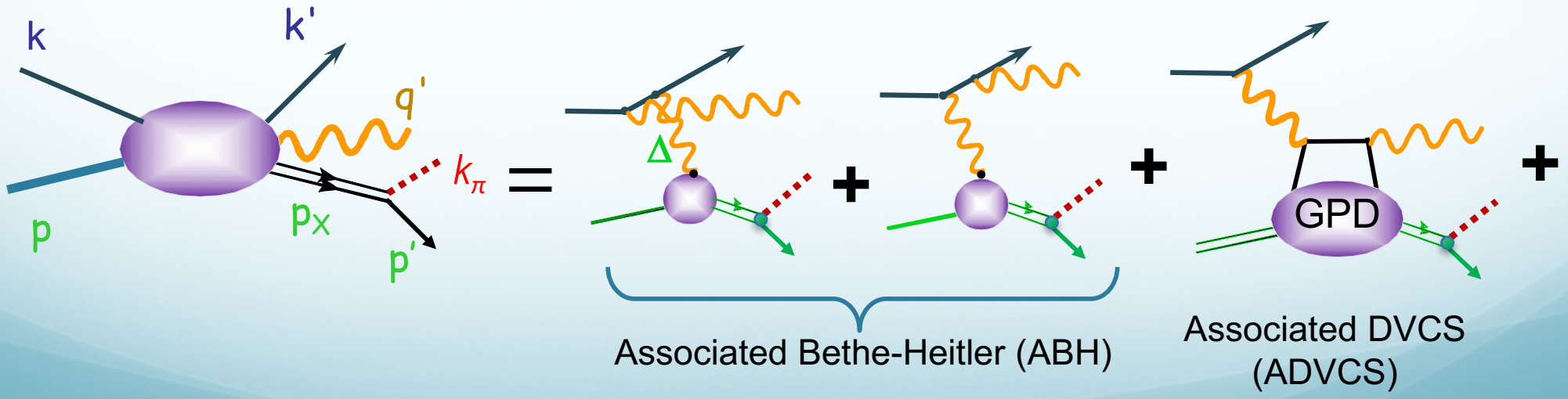
Exclusive DVCS & Associated Production

- Exclusive: H(*e*,*e'* γ)*p*
  - $M_X^2 = M_p^2$
- Associated Production H(*e*,*e'* γ)*N*π
  - $M_X^2 \geq (M_p + m_\pi)^2$
- Modelling the associated production:
  - Vary the exclusivity cut over a broader range, with greater precision
  - Extract some inelastic physics



Associated Production: H(e,e'γ)Nπ

- Incoherent sum
  - Sum over π^+ and π^0 final states
  - Integration over pion decay angular distribution
  - $d\sigma \sim |M(ep \to e\gamma p\pi^0|^2 + |M(ep \to e\gamma n\pi^+|^2$
- Coherent sum ABH + ADVCS



ADVCS+ABH Theory

P.Guichon, L.Mossé, M.Vanderhaeghen, Phys Rev D 68 (2003) 034018

- (Nπ) *s*-wave near threshold
  - Soft Pion Theorems (Chiral Perturbation Theory)
  - Form factors and GPDs determined from (u,d) flavor separated Nucleon form factors and GPDs
- (Nπ) *p*-wave: 'Δ' Resonance
  - P_{33}(1232MeV) (Isospin=3/2, Spin=3/2)
  - Use large N_{color} limit
  - N→Δ transition GPDs derived from Nucleon GPDs
- M.Polyakov & S.Stratmann hep-ph/0609045
  - Deep Virtual H$(e,e'\pi_{Hard})N\pi_{Soft}$

Associated BH

$t_\gamma = (q\text{-}q')^2 = \Delta^2$

$$T^{\rm BH} = e^3 J_\nu(M_X^2)\frac{1}{-\Delta^2}\overline{u}(k',h')\left[\gamma\cdot\epsilon'(\lambda,q)^\dagger\frac{\gamma\cdot(k'+q')+m_e}{2k'\cdot q'}\gamma^\nu + \gamma^\nu\frac{\gamma\cdot(k-q')+m_e}{-2k\cdot q'}\gamma\cdot\epsilon'(\lambda,q)^\dagger\right]u(k,h)$$

$$J_\nu(M_X^2) = \left\langle N(p',\sigma')\pi\left|\hat{J}_\nu(q-q')\right|p(p,\sigma)\right\rangle$$

- *Nπ* Threshold (χPT)

$$\left\langle N(p',\sigma')\pi^a\left|\hat{J}_\nu(q-q')\right|p(p,\sigma)\right\rangle = T^a_{\nu,\rm Born}(p'|p) + \frac{1}{f_\pi}\epsilon_{a3b}\left\langle N(p',\sigma')\left|\hat{J}^b_{5\nu}(q-q')\right|p(p,\sigma)\right\rangle$$

  - $T_{Born} \sim F_{1,2}^{p,n}(-t_\gamma)$
  - $J_5 \sim F_A(-t_\gamma)$
- *Δ-Resonance:* ➔ *Dominated by* $G_M^\Delta(-t) \approx 3\,G_D(-t)$

$$\langle (N\pi)_\Delta\,|J^\nu|\,p\rangle = -\mathcal{I}\frac{f_{\pi N\Delta}}{m_\pi}(k_\pi)^\alpha\overline{U}(p',\sigma')\frac{i\,(\gamma\cdot P_X + M_X)}{M_X^2 - M_\Delta^2 + iM_X\Gamma_\Delta(M_X)}$$
$$\left\{g_{\alpha\beta} - \frac{\gamma_\alpha\gamma_\beta}{3} - \frac{[\gamma_\alpha(P_X)_\beta - \gamma_\beta(P_X)_\alpha]}{3M_X} - \frac{2(P_X)_\alpha(P_X)_\beta}{3M_X^2}\right\}$$
$$\left\{G_M^\Delta(-\Delta^2)(-\mathcal{K}^M)^{\beta\nu} + G_E^\Delta(-\Delta^2)(-\mathcal{K}^E)^{\beta\nu} + G_C^\Delta(-\Delta^2)(-\mathcal{K})^{\beta\nu}\right\}U(p,\sigma)$$

Associated DVCS

- *(Nπ)* Threshold:
  - Nucleon *GPDs:* $H_{p,n}(x,\xi,t),\ E_{p,n},\ \tilde{H}_{p,n},\ \tilde{E}_{p,n}$
  - Isovector GPDs: $H_u(x,\xi,t) - H_d(x,\xi,t),\ \ldots$
  - Compton Form Factors
- P_{33} Resonance: Dominant terms are
  - $H_M^{\Delta}(x,\xi,t) \to \frac{2}{\sqrt{3}}\left[E_u(x,\xi,t) - E_d(x,\xi,t)\right]$
  - $C_1^{\Delta}(x,\xi,t) \to \sqrt{3}\left[\tilde{H}_u(x,\xi,t) - \tilde{H}_d(x,\xi,t)\right]$

Model results for Photo-Production

- Guichon, Mossé, Vanderhaegen apply their hadronic current model to photo-production
  - ≈ "calibrates" BH Cross section
  - π^+ dominates threshold region.

PHYSICAL REVIEW D **68**, 034018 (2003)

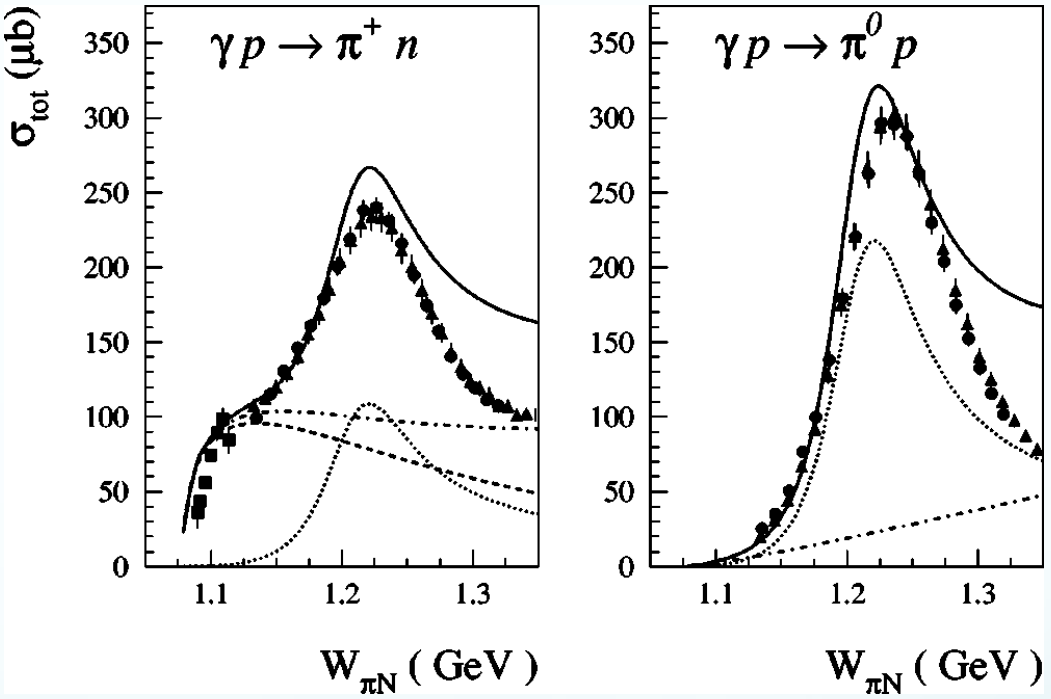


FIG. 9. Total pion photoproduction cross sections for the different model contributions considered in this paper. Dashed curves: commutator contribution. Dash-dotted curves: commutator+Born contributions. Dotted curves: Δ contribution. Solid curves: commutator+Born+Δ contributions. The data are from Ref. [36] (diamonds), Ref. [37] (circles), and Ref. [38] (triangles).

Program

- Detailed notes from PRD68 paper:
  - https://hallaweb.jlab.org/dvcslog/12+GeV/414
- Simulation code in development
  - Event Generator with resolution and radiation tail completed by Hashir R.
  - Skeleton of code (C.H.) implementing Dirac algebra with qft++ classes of M. Williams.
- Keep only dominant terms, apply global normalizations ABH, ADVCS amplitudes to fit near threshold inclusive data.
- Apply to 2010 data and 12 GeV data