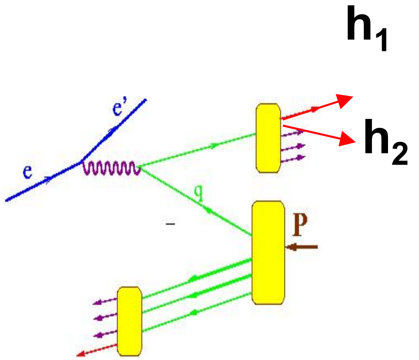
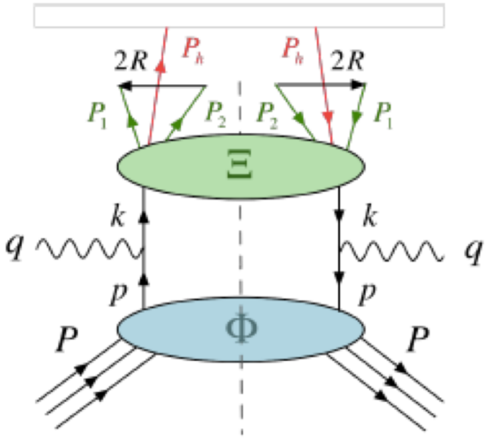
Di-hadron and other plans at CLAS

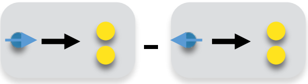
Anselm Vossen

Di-hadron fragmentation functins



- Formalism very similar to single hadron FF
- Additional degree of freedom (P_1-P_2=R)
- Relative momentum of hadrons can carry away angular momentum
  - Partial wave decomposition in θ
  - Relative and total angular momentum →In principle endless tower of FFs
  - Analogue of 1h production with spin in final state
- Makes 'new' FFs possible, such as $G_1^{\perp}$: T-odd chiral even. In 1h case, this needs polarized hadron in the final state





Example, SIDIS x-section

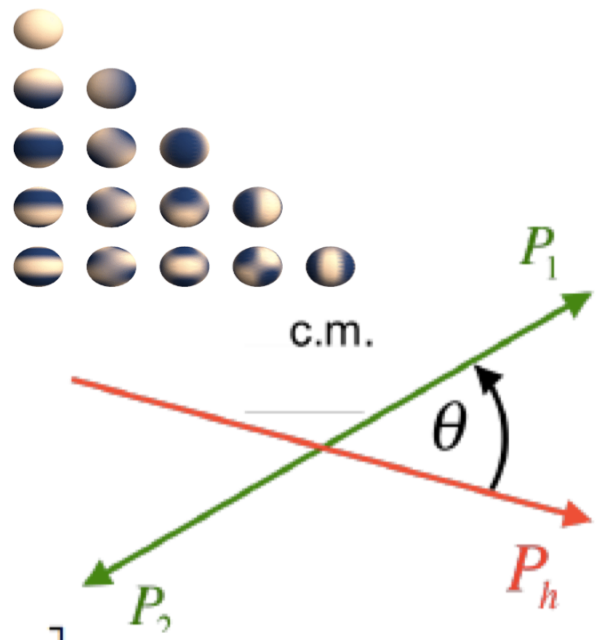
$$F_{LU}^{\sin(\phi_h-\phi_R)\sin\theta} = -\mathcal{I}\left[\frac{k_T \hat{P}_{h\perp}}{M_h} f_1 \left(\frac{|\boldsymbol{R}|}{M_h} G_{1,UT}^{\perp}\right)\right]$$

$$F_{LU}^{\sin(\phi_h-\phi_R)\sin 2\theta} = -\mathcal{I}\left[\frac{k_T \hat{P}_{h\perp}}{M_h} f_1 \left(\frac{|\boldsymbol{R}|}{2M_h} G_{1,LT}^{\perp}\right)\right]$$

$$F_{LU}^{\sin(2\phi_h-2\phi_R)\sin^2\theta} = -\mathcal{I}\left[\frac{2\left(k_T \hat{P}_{h\perp}\right)^2 - k_T^2}{M_h^2} f_1 \left(\frac{|\boldsymbol{R}|}{2|\boldsymbol{k}_T|} G_{1,TT}^{\perp}\right)\right]$$

Leading twist TMD

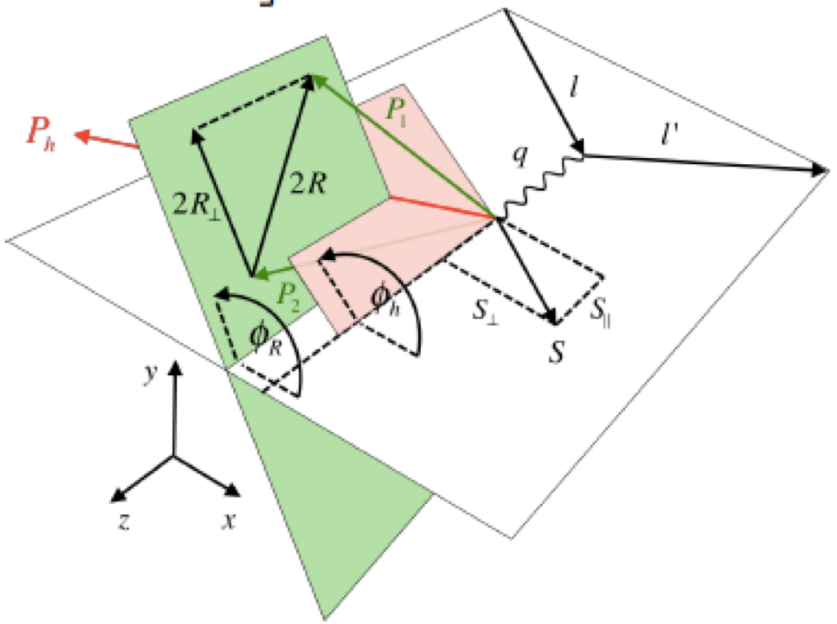
Bacchetta, Radici



$$F_{LU}^{\sin\phi_R} = -x\frac{|\boldsymbol{R}|\sin\theta}{Q}\left[\frac{M}{m_{hh}}\, x\, e^q(x)\, H_1^{\sphericalangle q}(z,\cos\theta,m_{hh}) + \frac{1}{z}\, f_1^q(x)\, \widetilde{G}^{\sphericalangle q}(z,\cos\theta,m_{hh})\right],$$

Twist3 (from Jlab proposal (not PW decomposed))

- Higher order PWs lead to different moments in θ and ϕ
- In models, evolution of the different PWs different
- Important to have a full picture to understand mixing effects in ratios/partial integrals/acceptance



Compare with 1h

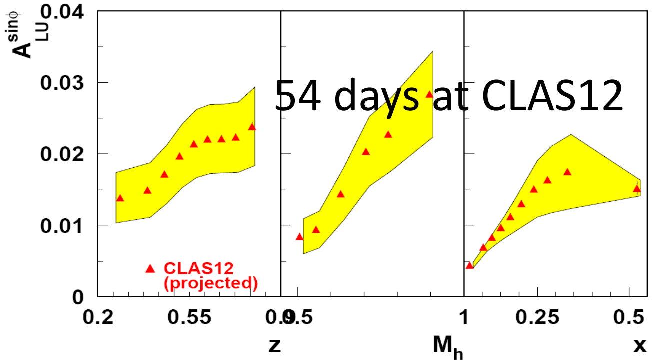
- In general more quantities at the same order mix
- Need TMD functions
- →di-hadron FFs allow us to more targeted access to nucleon structure

$$F_{LU}^{\sin(\phi_h)} = \frac{2M}{Q}\mathcal{I}\Big[-\frac{k_T \hat{P}_{h\perp}}{M_h}\left(xeH_1^{\perp} + \frac{M_h}{Mz} f_1 \tilde{G}^{\perp} \right) + \frac{p_T \hat{P}_{h\perp}}{M}\left(xg^{\perp} D_1 + \frac{M_h}{Mz} h_1^{\perp} \tilde{E} \right) \Big]$$

From S. Sirtl thesis

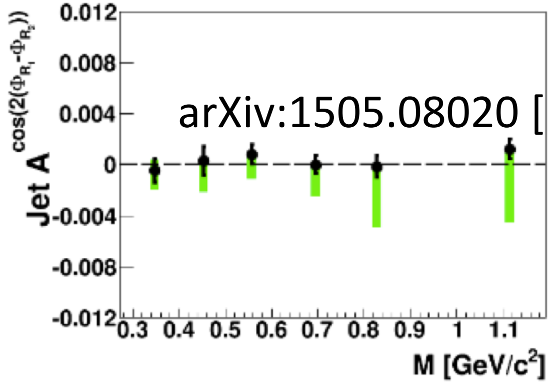
What to measure and why

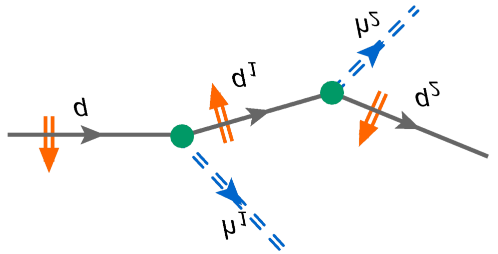
- Precision measurement of x-section including PW decomposition (of course this is really hard)
  - Understand detector
  - Extract unpolarized FFs
    - Add PW information
    - With new NLO calculation, some access to gluon FF (with e+e-)
- A_{LU}:e(x), $G_1^{\perp}$
- A_{LU}:g(x)$G_1^{\perp}$, worm gear $h_{1L}^{\perp}H_1^{<}$ (the latter we know is large)
  - However, COMPASS looked for this signal and did not find anything →unexpected given model calculations of $G_1^{\perp}$
  - CLAS has more statistics, higher x, lower Q^2

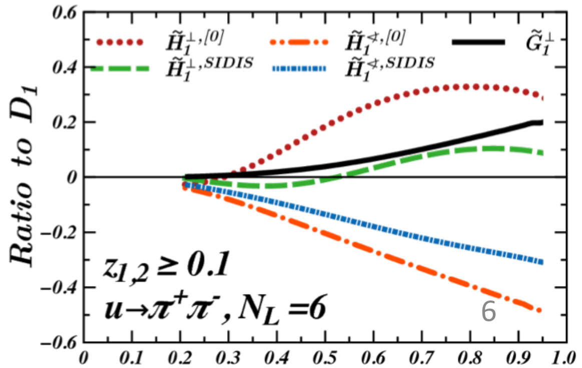


A bit on $G_1^{\perp}$

- Has been 'around' for some time, first suggestion by Boer et al "Interference fragmentation functions in electron positron annihilation:, PRD67 (2003) 094003
  - Postulate connection to jet handedness proposed by Efremov and Kharzeev some time ago (connection to chromomagnetic effects)
- Belle measurement following Boer et al: No signal:
- Process reconsidered by Matevosyan et al: Error in Boer et al. calculation, new proposal in
- Matevosyan et al: "Semi-inclusive production of two back-to-back hadron pairs in e+e− annihilation revisited", arXiv:1802.01578
- New model calculations by Matevosyan et al connecting $G_1^{\perp}$ with single hadron Collins effect in string fragmentation (a bit like worm gear functions)→Interesting to learn about spin momentum correlations in hadronization





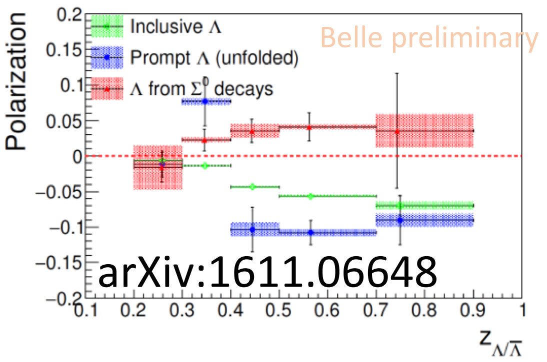


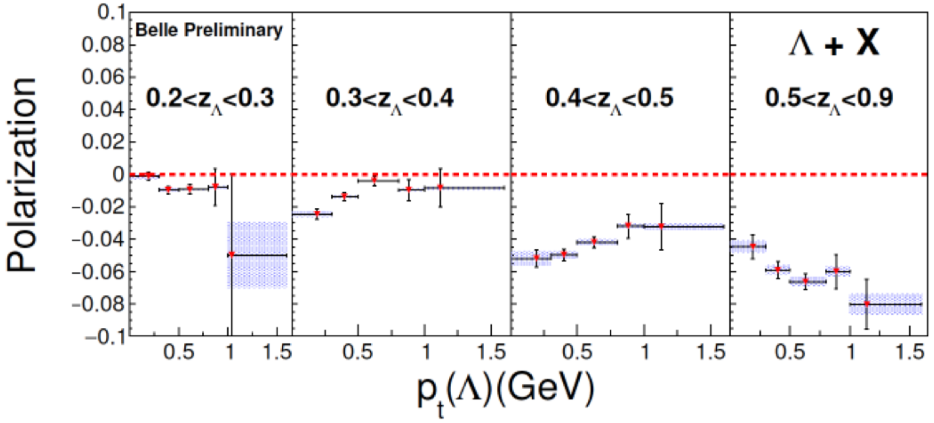
Tools needed

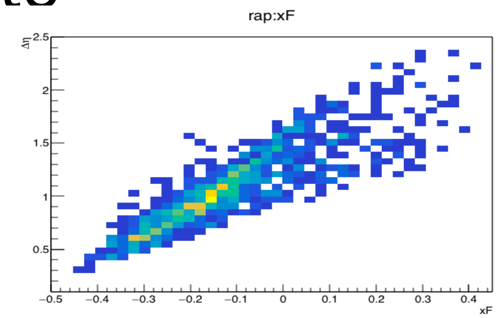
- Extraction (unfolding, closure tests) and estimation of systematics need MC simulations with realistic physics effects differential in all relevant variables
  - Extend EVA to 2h (some effort underway)
  - Evaluate TMDGen (HERMES) as x-check
  - Experience from Belle: SVD unfolding state of the art, but needs MC close to data otherwise results can be unexpected for modulations →Closure tests really important
- Need PID, tracking efficiencies, misidentification probabilities from data for all of phase space

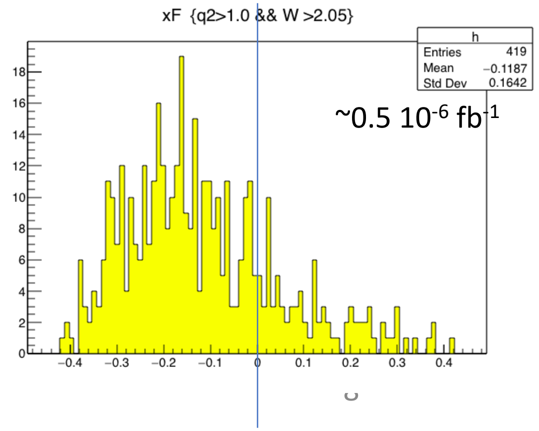
Lambda's

- Can we do current Λs?
- From simple Pythia simulation using just geometric CLAS acceptance, it seems there is a fair amount of $x_F > 0$ (but Berger $\Delta\eta$>2 seems not feasible)
- Would open up many physics topics
- Example, compare with $\Lambda^{\uparrow}$ production in e+e- (Boer, Kang, Vogelsang, Yuan,PRL. 105 (2010) 202001, learn about TMD factorization
- Can we expect the feed-down contribution to be the same?









That’s it for now