Transversely Polarized Timelike Compton Scattering

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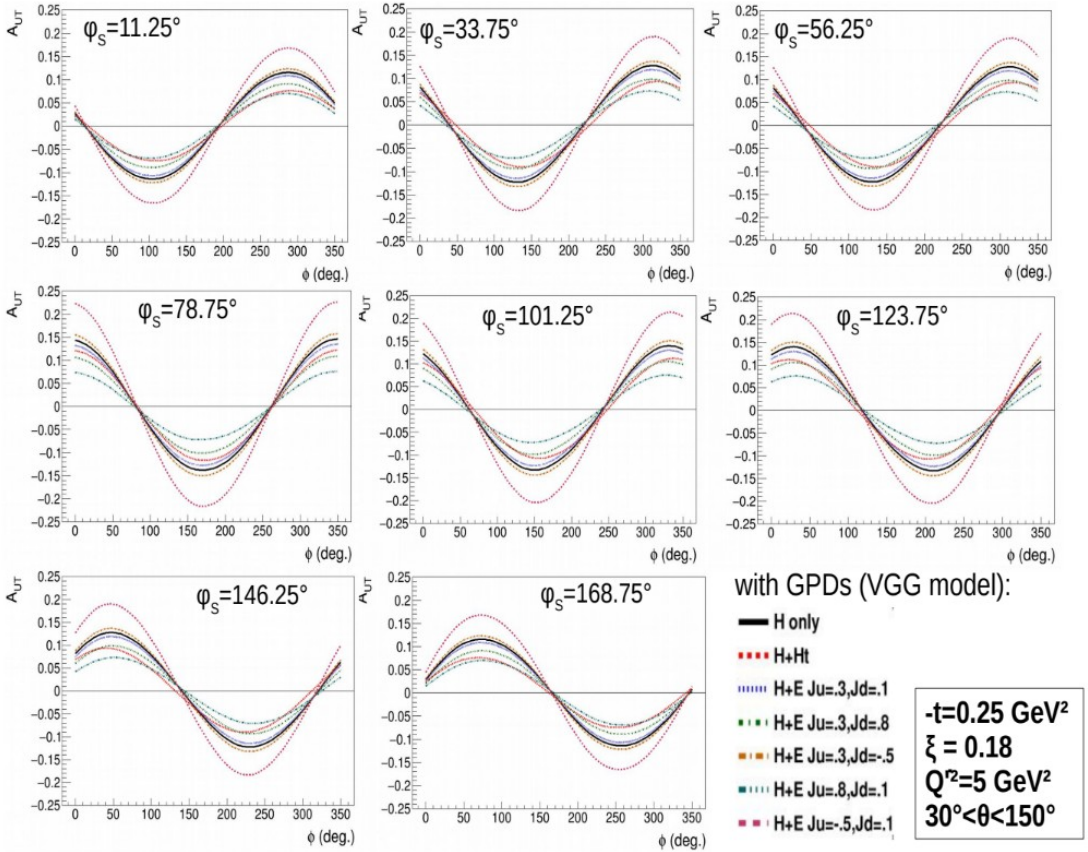
Goals
1. Double check Marie's TSA
2. Analyze double spin asymmetry, circularly polarized beam.
3. Propose observables for BTSA

Observable (proton target)	**Experimental challenge**	**Main interest for GPDs**	**JLab experiments**
Unpolarized cross section	1 or 2 order of magnitude lower than DVCS, require high luminosity	Im + Re part of amplitude. Re(H), Im(H)	CLAS 12, SoLID approved NPS conditionnal
Circularly polarized beam	Easiest observable to measure at JLab	Im(H), Im($\tilde{H}$) Sensitivity to quark angular momenta, in particular for neutron	CLAS 12, SoLID approved NPS conditionnal
Linearly polarized beam	Need high luminosity, at least 10x more than for circular beam, and electron tagging	Re(H), D-term. Good to discriminate models and very important to bring constrains to real part of CFF	GlueX (?)
Longitudinaly polarized target	Polarized target	Im($\tilde{H}$)	no / "for free"?
Transversely polarized target	Polarized target, and high luminosity: binning in θs, φs	Im($\tilde{H}$), Im(E)	NPS conditionnal
Double spin asymmetry with circularly polarized beam	Polarized target, very high luminosity, precision measurement	Real part of all CFF	no / "for free"?
Double spin asymmetry with longitudinally polarized beam	Polarized target, electron tagging, very high luminosity and precision	Not the most interesting, Im(CFFs) but difficult to measure	no

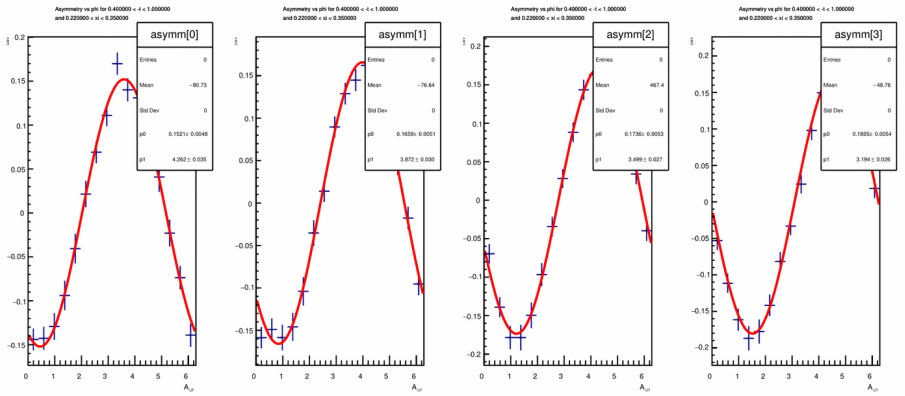
Theoretical Predictions for TSA, one example bin

TSA has strong dependence on GPD E parameterization and quark angular momenta.
[from C12-15-005]

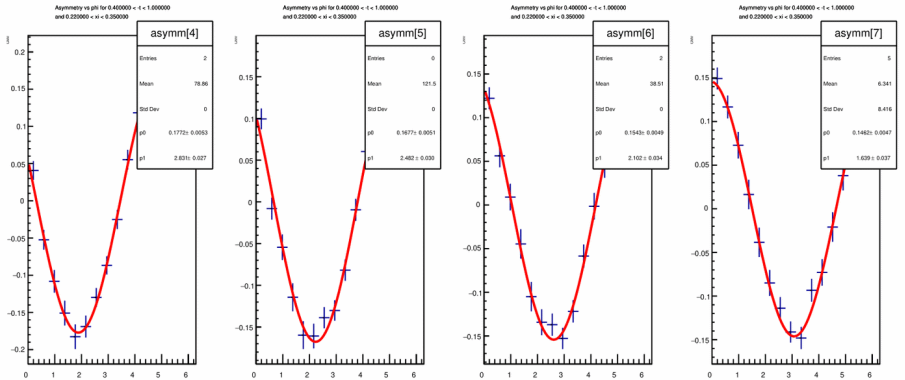


TSA

$0<\Phi_s<\pi/8$ $\pi/8<\Phi_s<\pi/4$ $\pi/4<\Phi_s<3\pi/8$ $3\pi/8<\Phi_s<\pi/2$

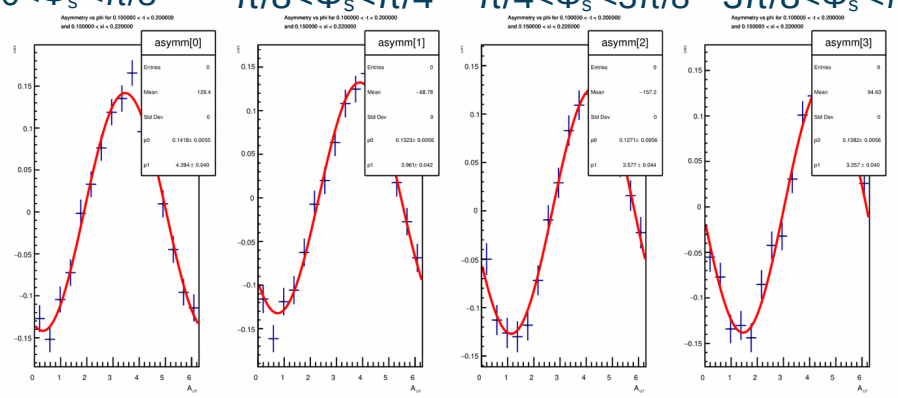


$0.22 < \xi < 0.35$, $0.4 < -t < 1$ GeV^2

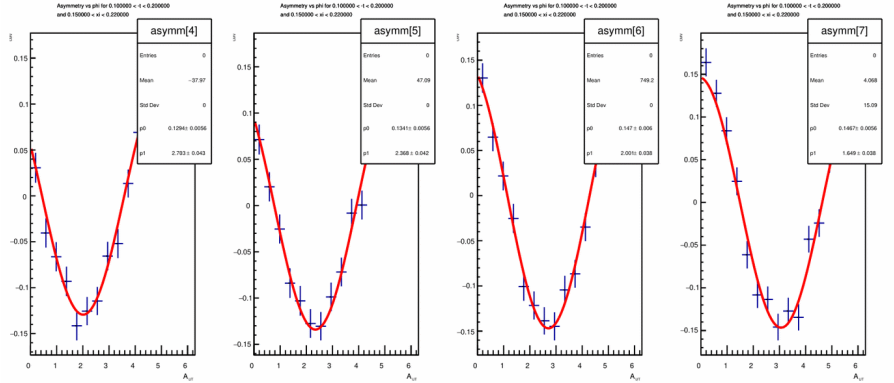


$\pi/2<\Phi_s<5\pi/8$ $5\pi/8<\Phi_s<3\pi/4$ $3\pi/4<\Phi_s<7\pi/8$ $7\pi/8<\Phi_s<\pi$

$0<\Phi_s<\pi/8$ $\pi/8<\Phi_s<\pi/4$ $\pi/4<\Phi_s<3\pi/8$ $3\pi/8<\Phi_s<\pi/2$



$0.15 < \xi < 0.22$ and $0.1 < -t < 0.2$ GeV^2



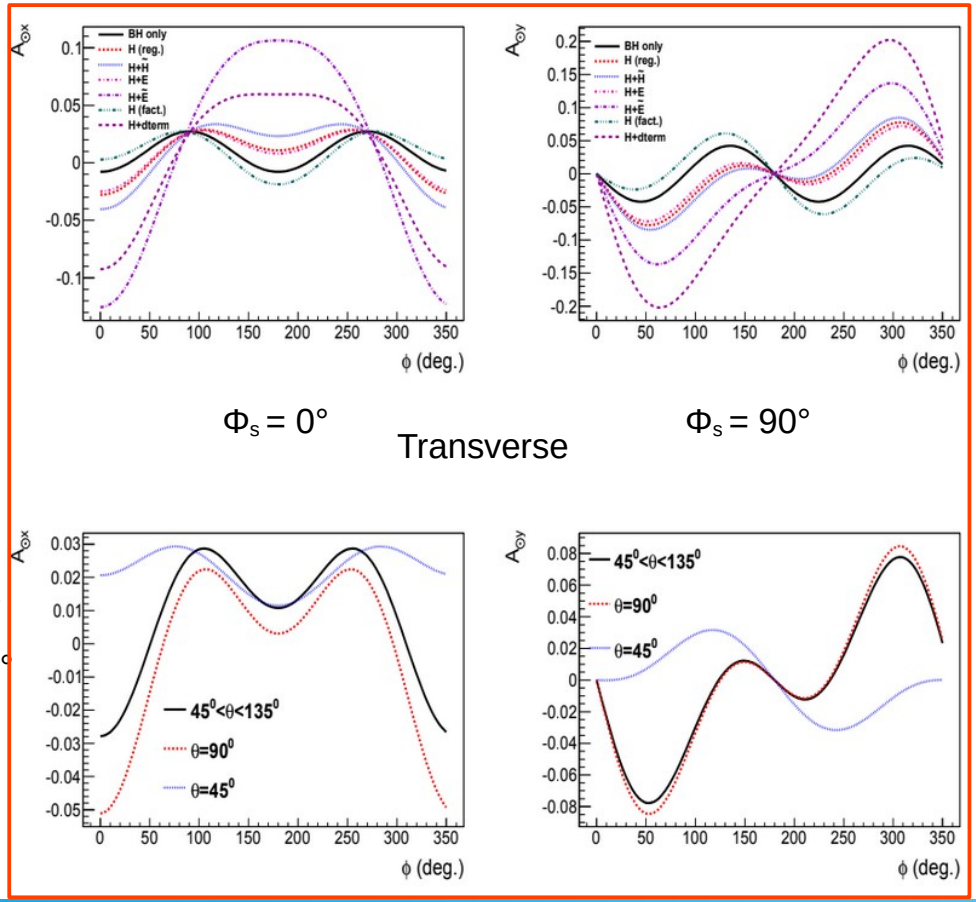
$\pi/2<\Phi_s<5\pi/8$ $5\pi/8<\Phi_s<3\pi/4$ $3\pi/4<\Phi_s<7\pi/8$ $7\pi/8<\Phi_s<\pi$

- Looks like what Marie did
- No plans to change anything on TSA for the proposal
- Background contribution in progress (Camille and Marie)

Theoretical prediction for BTSA

BTSA has a dependence on the real parts of all CFF

$\xi = 0.2$, $-t = 0.4$ GeV^2 and $Q'^2 = 7$ GeV^2

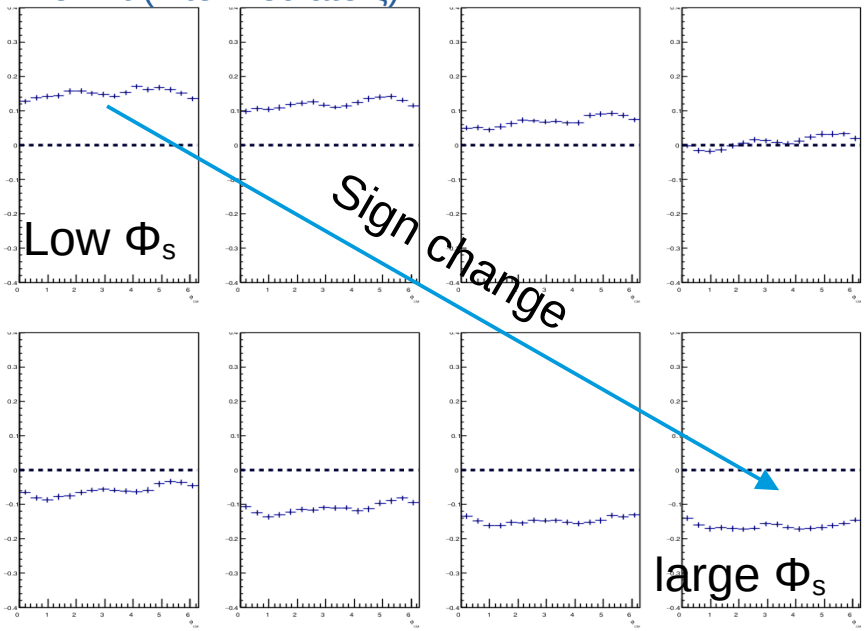


Asymmetry for transverse target isn't as different for 90° (Highest TCS vs BH) vs integrated as compared to 45° (Highest BH)
Because of this, we can use the integral to measure TCS

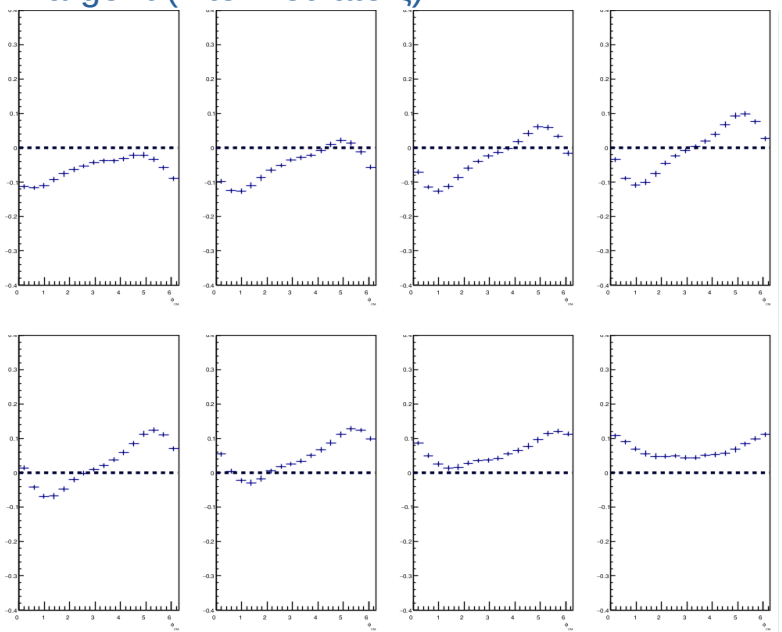
Projected (ideal) BTSA distributions in experimental bins

Evolutions of the shapes vs Φ, bins in Φ_s from 0 to π at intermediate ξ and for 2 bins in t

Low -t (intermediate ξ)



Large -t (intermediate ξ)

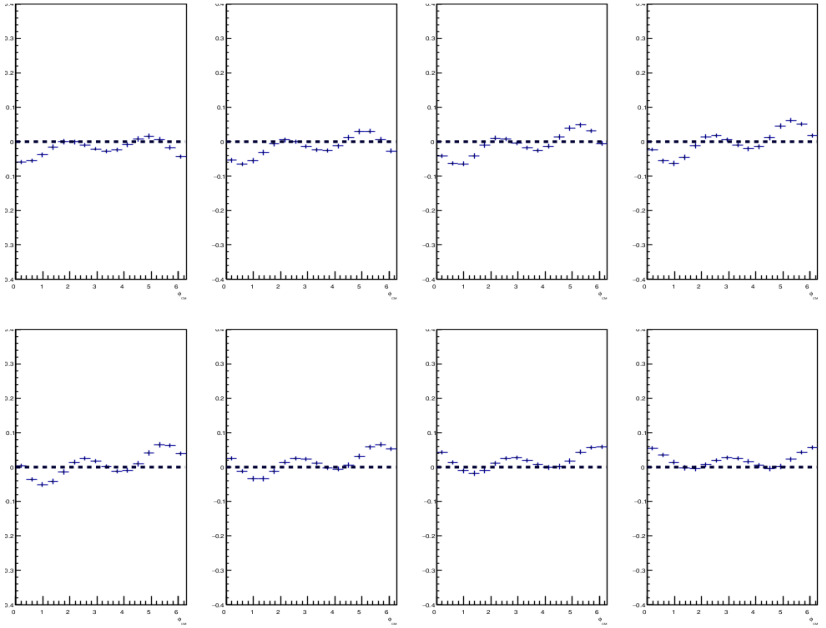


- **Harmonic structure of BTSA mostly depends on t & ξ bins**
- BH doesn't cancel, nor is it TCS "only". Harder to interpret **but**: best to access Re(CFF) and any information is a major input to models and especially for discriminating Double Distribution "types" vs other kinds (strongly differ on Re CFF)
- Total BTSA different enough to pure BH BTSA to extract CFFs [see next slide]
- Can decide to measure left/right asymmetry on some bins rather than full Φ distribution for statistics

- Shape also strongly dependent on ξ (compares to right panel Of last slide)
- Very fast evolution of real part of amplitudes with ξ, unlike for the imaginary part
Importance of selecting the right binning in ξ & t

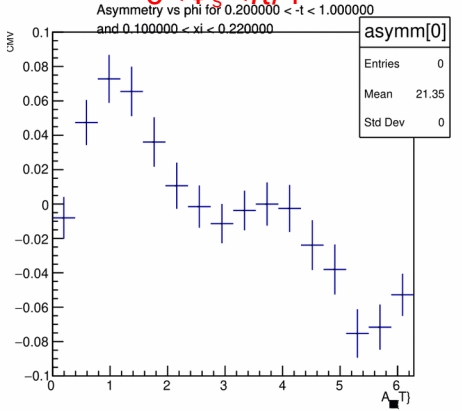
- For statistics, we want less bins, for physics we want more. Compared to TSA binning [from Marie], we use 4 total bins in Φ_s instead of 8 after balancing statistics & physics needs

Large -t (large ξ)

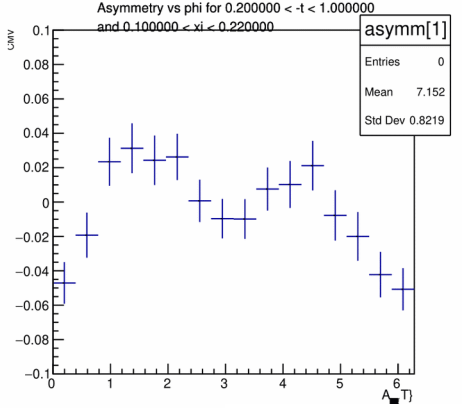


Large -t, Low ξ (Reconstructed)

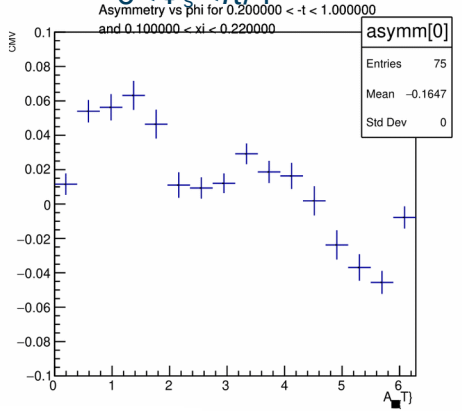
$0<\Phi_s<\pi/4$



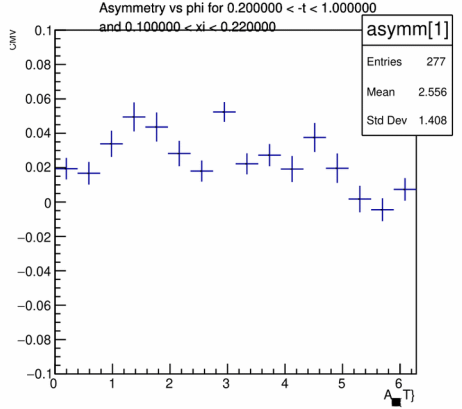
$\pi/4<\Phi_s<\pi/2$



$0<\Phi_s<\pi/4$



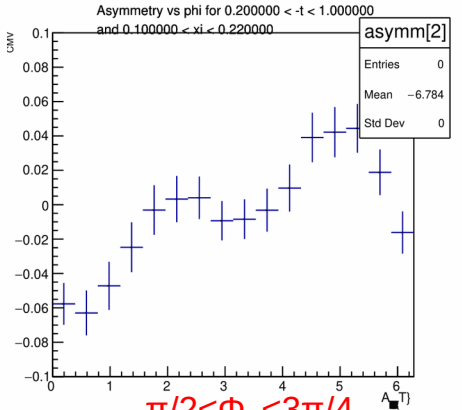
$\pi/4<\Phi_s<\pi/2$



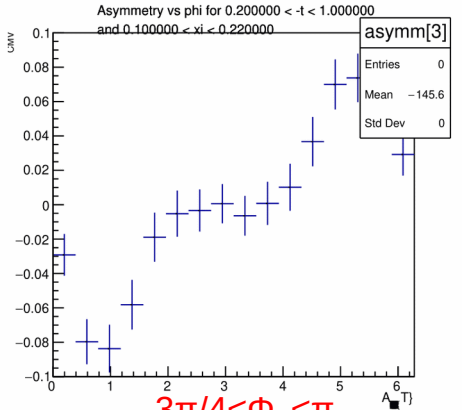
θ integrated over [70°, 110°]

$0.1 < \xi < 0.22,\ 0.2 < -t < 1\ \text{GeV}^2$

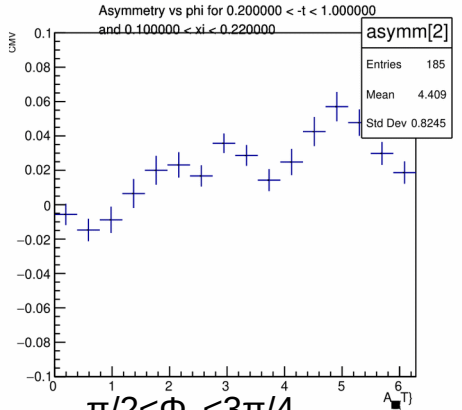
θ integrated over [0°, 70°) and (110°, 180°]



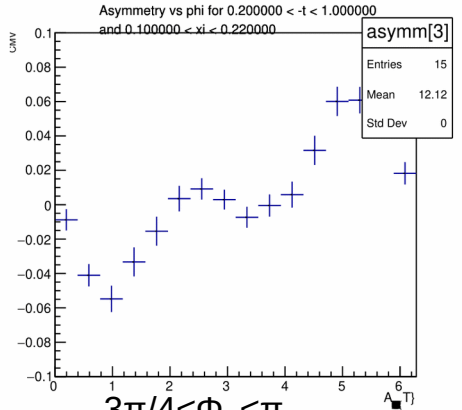
$\pi/2<\Phi_s<3\pi/4$



$3\pi/4<\Phi_s<\pi$



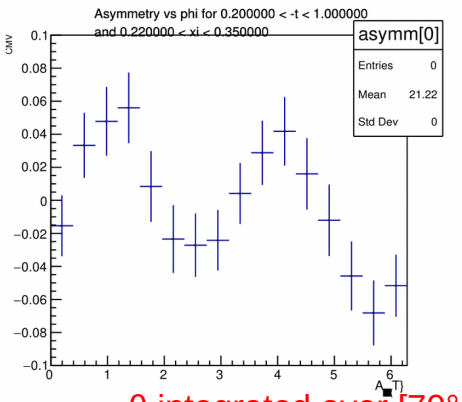
$\pi/2<\Phi_s<3\pi/4$



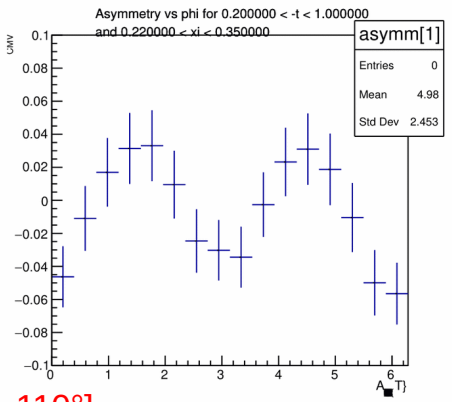
$3\pi/4<\Phi_s<\pi$

Large -t, Large ξ (Reconstructed)

$0<\Phi_s<\pi/4$



$\pi/4<\Phi_s<\pi/2$



θ integrated over [70°, 110°]

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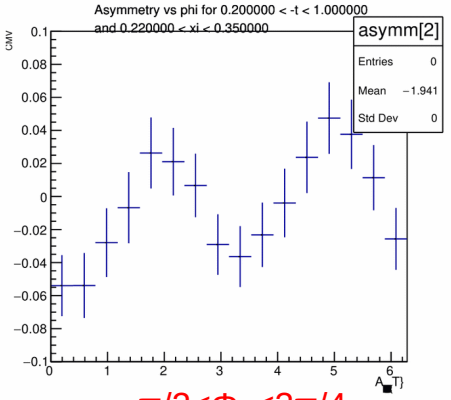
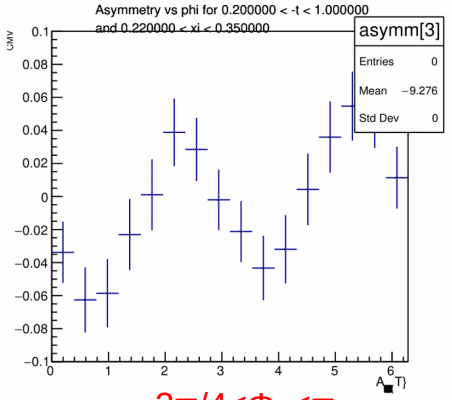
$\pi/2<\Phi_s<3\pi/4$



$3\pi/4<\Phi_s<\pi$



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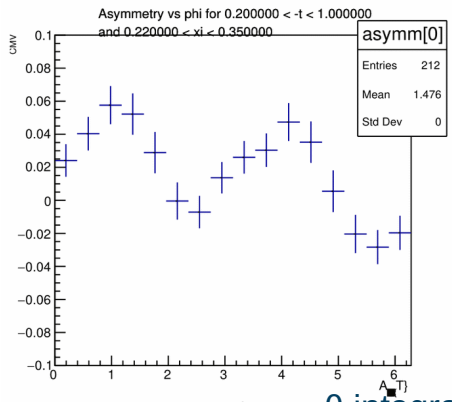
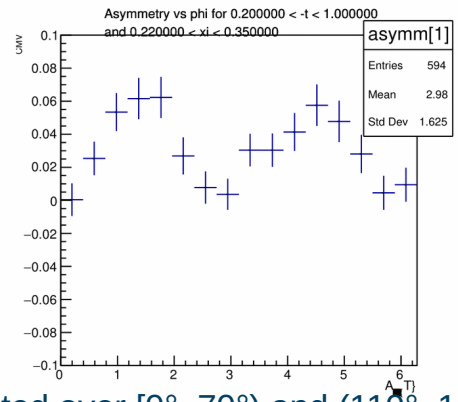
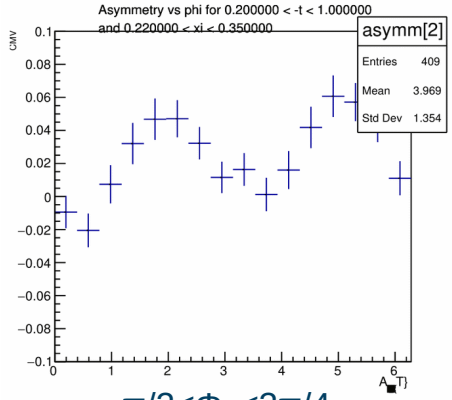


$\pi/4<\Phi_s<\pi/2$

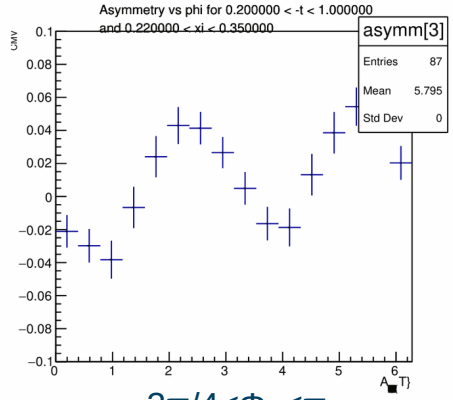


θ integrated over [0°, 70°) and (110°, 180°]

$\pi/2<\Phi_s<3\pi/4$



$3\pi/4<\Phi_s<\pi$



- Asymmetry integrated around 90° have larger negative values
- Integrated asymmetry is different enough from BH to extract physics, in particular the real part of the CFF (Re(H) etc.)

Summary

- TSA is consistent with previous analysis.
- BTSA is more difficult but wouldn’t take any extra experimental work just analysis
- Should BTSA be included in next proposal?