Monte-Carlo studies for TCS: projection of observables and uncertainties

Marie Boër, April 5, 2018
NPS meeting

Monte Carlo and kinematic cuts

Generated kinematic:

• $7.5 < E_\gamma < 11$ GeV, implemented bremsstrahlung spectra with CPS luminosity, circular polarization assumed to be 100% for present studies. From correlations: $.1 < \xi < .45$

• $4 < Q'^2 < 9$ GeV^2,

• $.04 < -t < 1.04$

• $40° < \theta < 140°$ max →kinematic dependent cut to stay away from BH peaks (cf last presentation)

• $0 < \varphi < 360°$,

• $0 < \varphi_S < 360°$, polarization along x ($\varphi_S = 0°$), assumed to be 100% in present studies

Lab cuts:

• $2° < \theta_{lab}$(vertex) $< 120°$,

• P(p) > .1 GeV, P(e+ or e-) > .2 GeV

• Acceptance for current setup→cf Vardan's presentation

Events analyzed: # events 38660000.

• MC error not completly negligible (cf backup), more stat running

• L (CPS, E_γ = 5.5 →11 GeV)= 5.85e5 pb^{-1} ⇒ 3.27e5 pb^{-1} above 7.5 GeV

Reconstruction:

• P, e+ and e- are detected

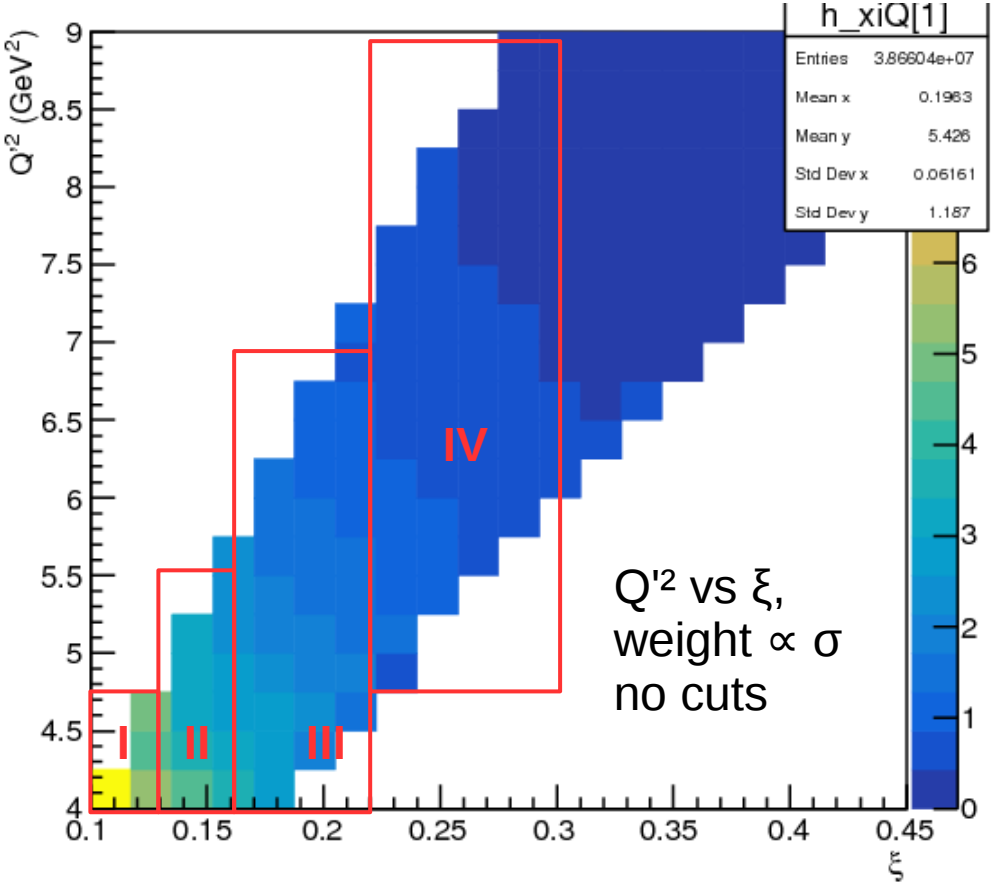
• Resolution effects are not included here, reconstructed observables are calculated from generated values

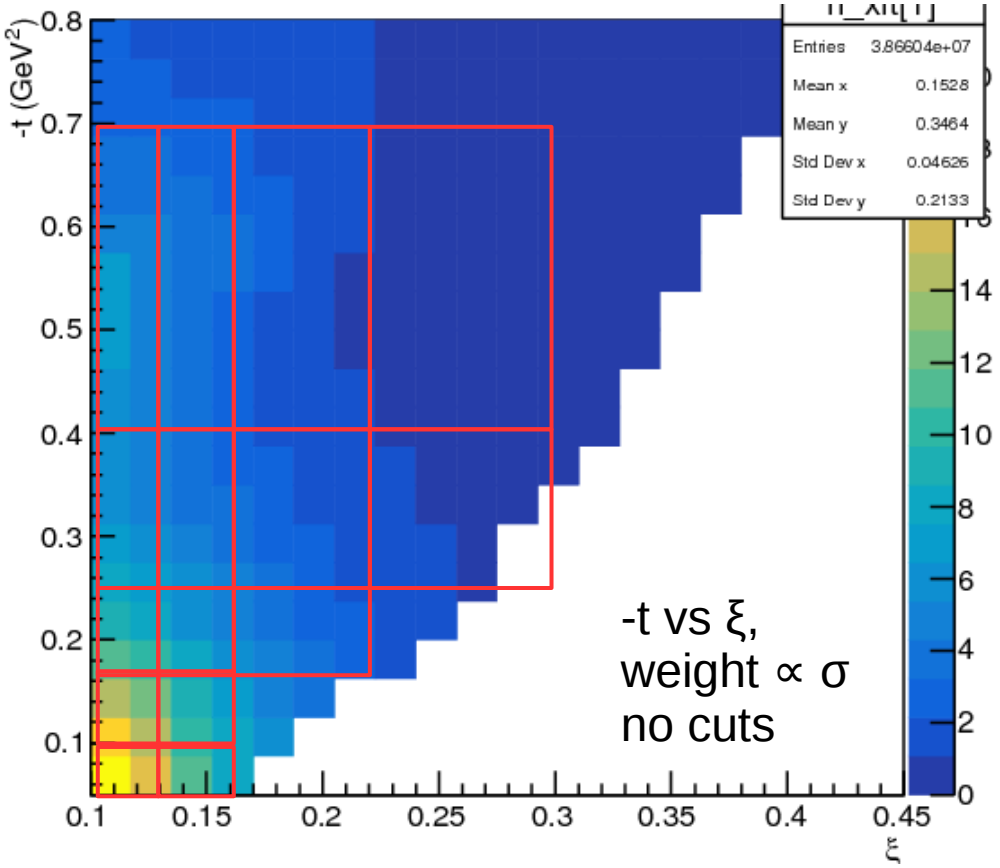
Choice of binning

Proposed binning for current studies, will be updated after setup optimization and more studies

Important for GPDs and target spin asymmetries: thin ξ and t bins

Option for unpolarized cross section and beam spin asymmetry: $Q'^2 \rightarrow$ not in presented approach





4 bins in ξ, Q'^2 (GeV²)

I) .1 <ξ<.13, 4<Q'^2<4.5
II) .13<ξ<.16, 4<Q'^2<5.5
III) .16<ξ<.22, 4<Q'^2<7
IV) .22<ξ<.3, 4.5<Q'^2<9

5 bins in -t (GeV²)

1) .04<-t<.1, 2) .1<-t<.17, 3) .17<-t<.25, 4) .25<t<.4 5) .4<-t<.7
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3) .17<-t<.25 4) .25<t<.4 5) .4<-t<.7
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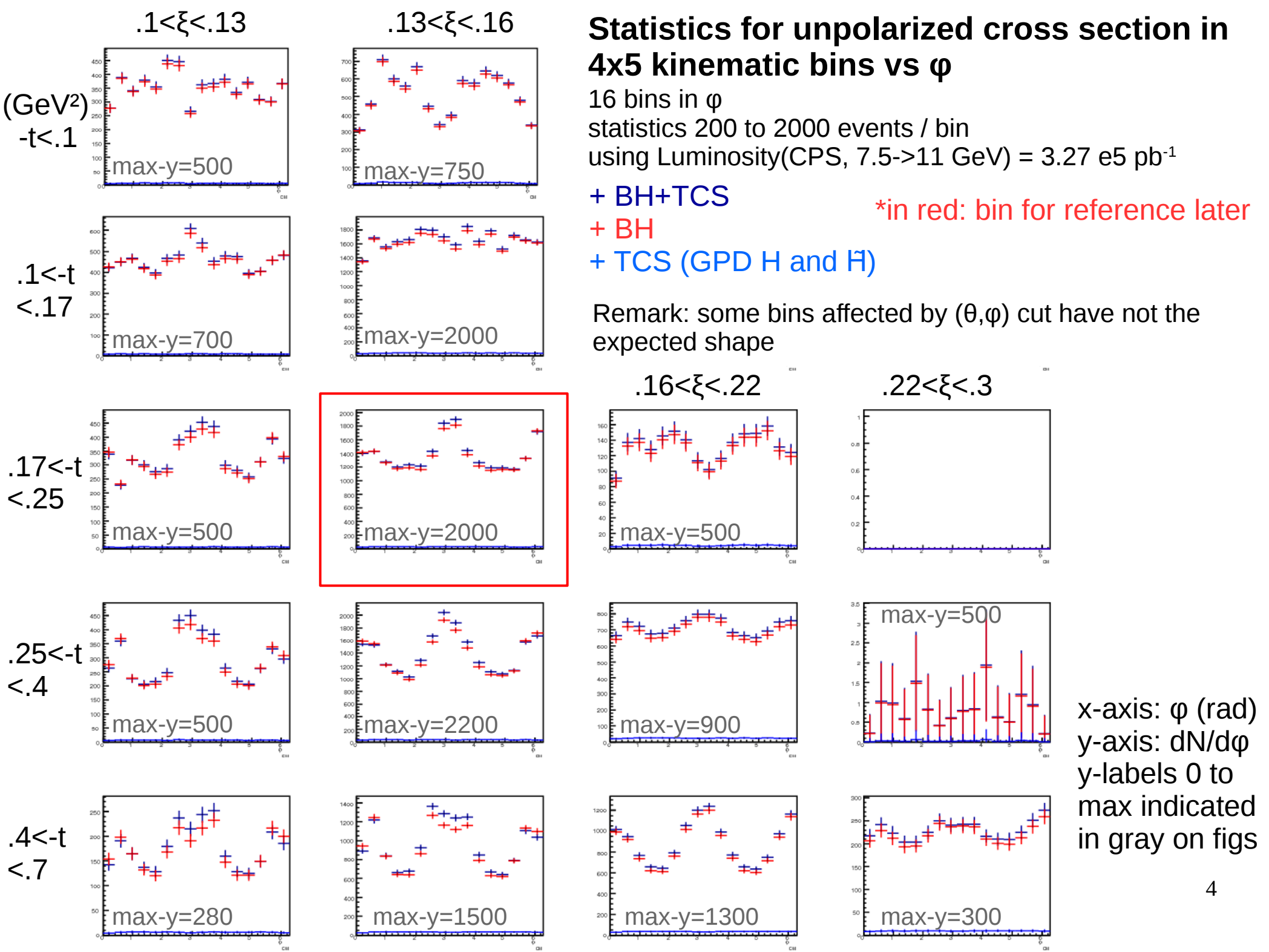
Statistics for unpolarized cross section in 4x5 kinematic bins vs φ

16 bins in φ
statistics 200 to 2000 events / bin
using Luminosity(CPS, 7.5->11 GeV) = 3.27 e5 pb^{-1}

+ BH+TCS
+ BH
+ TCS (GPD H and Ħ)

*in red: bin for reference later

Remark: some bins affected by (θ,φ) cut have not the expected shape

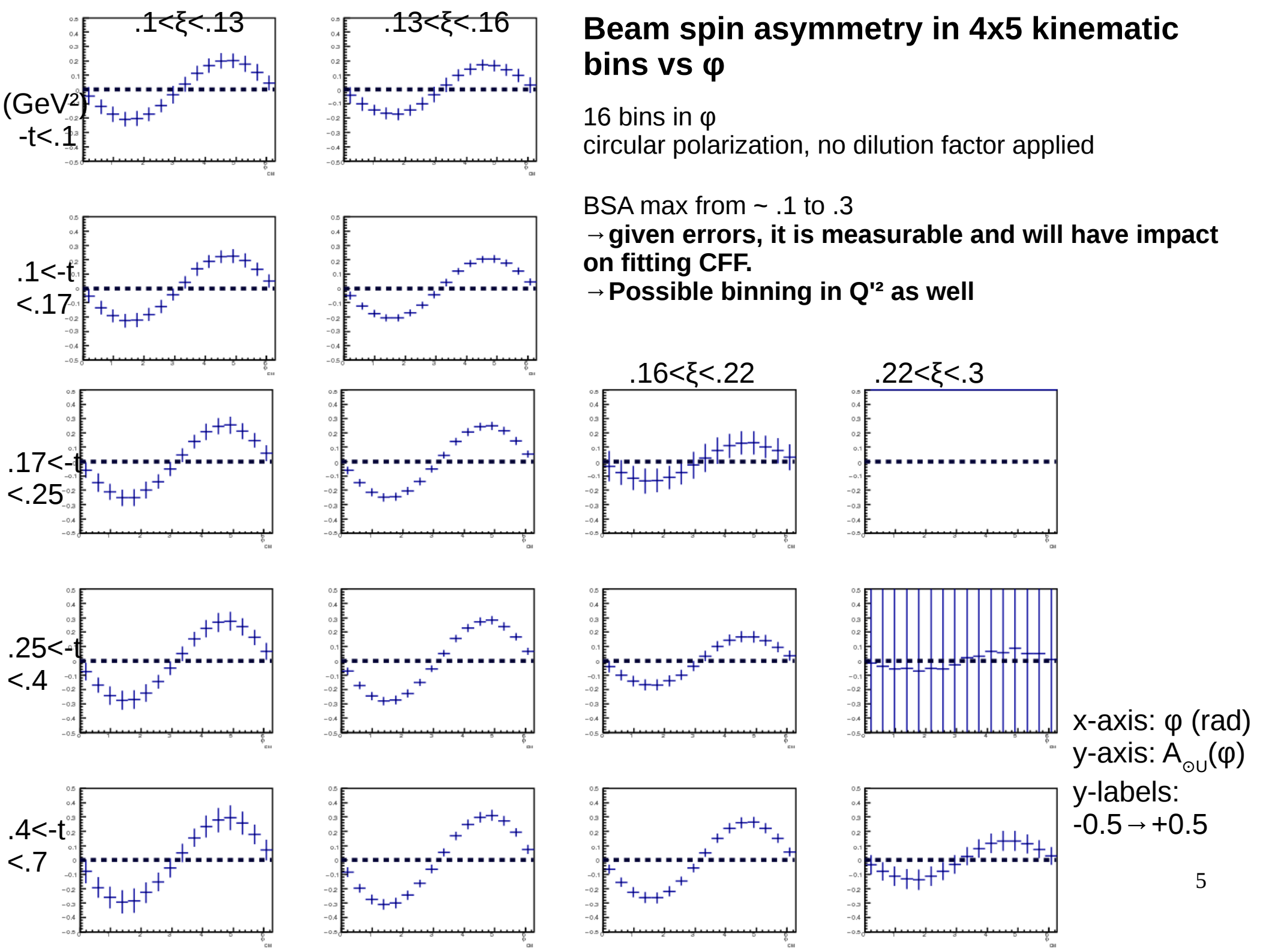


x-axis: φ (rad)
y-axis: dN/dφ
y-labels 0 to max indicated in gray on figs

Beam spin asymmetry in 4x5 kinematic bins vs φ

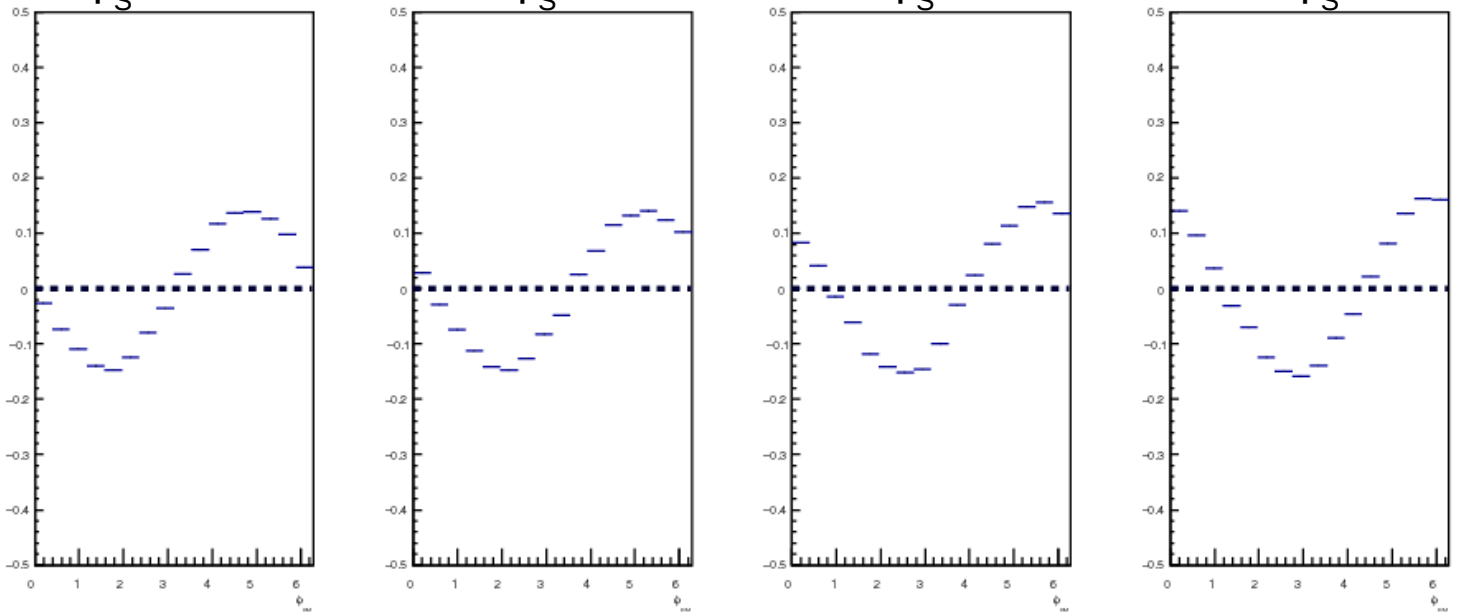
16 bins in φ
circular polarization, no dilution factor applied

BSA max from ~ .1 to .3
→**given errors, it is measurable and will have impact on fitting CFF.**
→**Possible binning in Q'² as well**

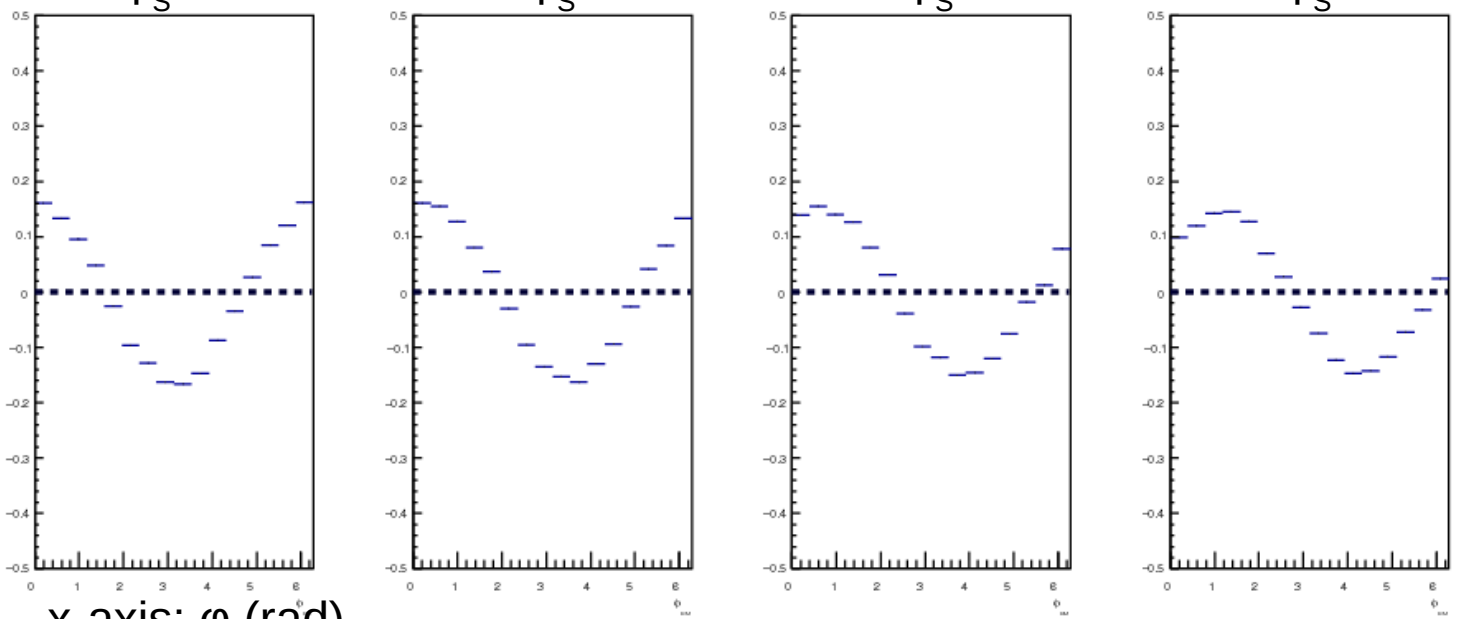


Target spin asymmetry for reference bin vs φ

$0<\varphi_S<\pi/8$ $\pi/8<\varphi_S<\pi/4$ $\pi/4<\varphi_S<3\pi/8$ $3\pi/8<\varphi_S<\pi/4$



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



x-axis: φ (rad)

y-axis: $A_{U\perp}(\varphi, \text{fix } \varphi_S)$, y-labels: -0.5 → +0.5

$A \propto \sigma(\varphi,\varphi_S)-\sigma(\varphi,\varphi_S+\pi)$

Error not displayed
dilution factor not included

Extracting physics:

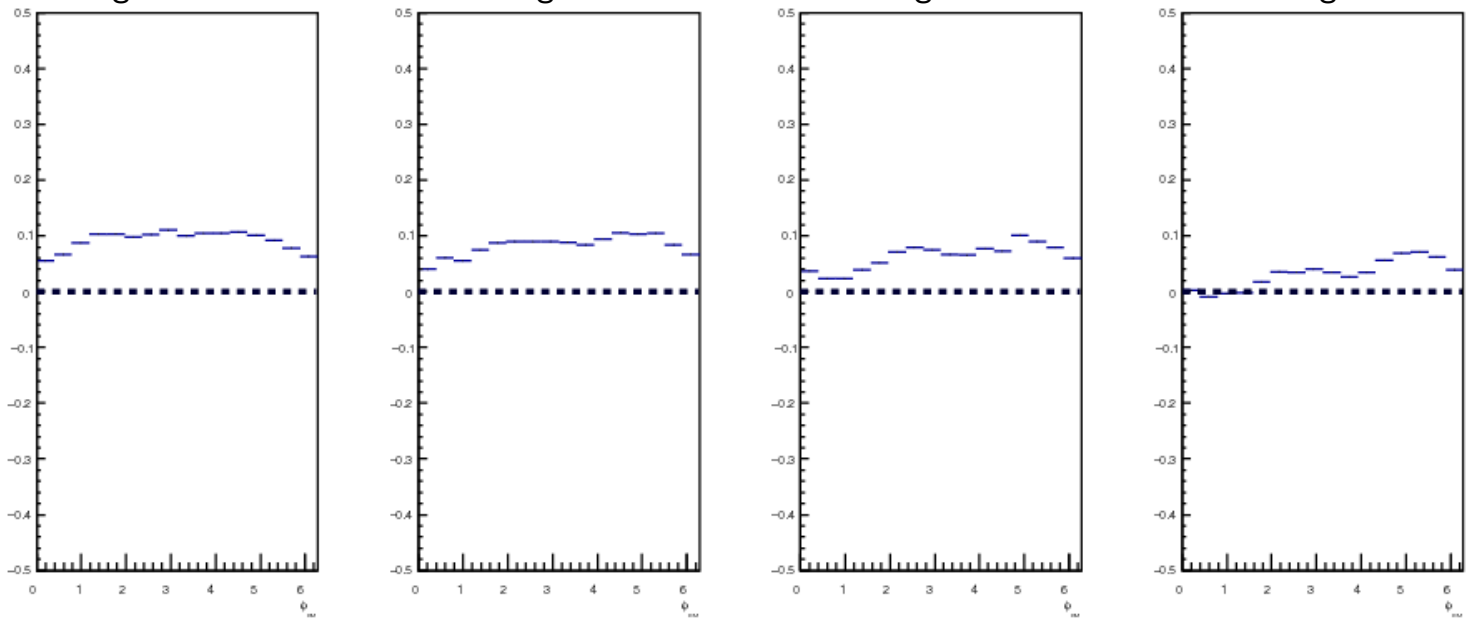
fitting CFF with 2 orthogonal bins in φ_S, i.e. line1 + line2 are two independent observables

in term of physics content, it is same as HERMES approach with 2D fits, but no "nice" analytic equations here

.13<ξ<.16
.17<-t<.25 GeV²
7.5<Eγ<11 GeV
θ: dynamic cut

Double spin asymmetry for reference bin vs φ

$0<\varphi_s<\pi/8$ $\pi/8<\varphi_s<\pi/4$ $\pi/4<\varphi_s<3\pi/8$ $3\pi/8<\varphi_s<\pi/4$



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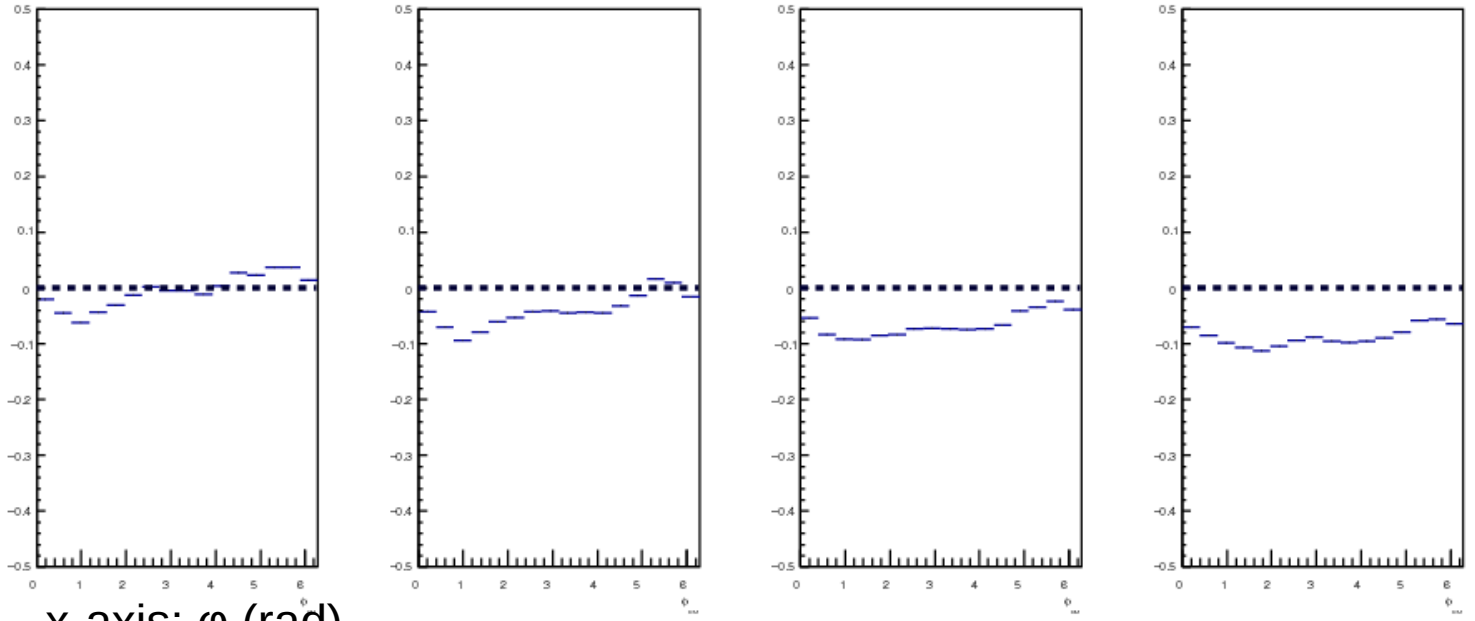

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• Not clear if it can be measured and/or physics extracted: larger dilution factor, non-zero BH asymmetry... Also strong kinematic dependence and may not be optimal to have such wide bins

$.13<\xi<.16$
$.17<-t<.25$ GeV²
$7.5<E\gamma<11$ GeV
θ: dynamic cut

x-axis: φ (rad)
y-axis: $A_{U\perp}(\varphi, \text{fix } \varphi_s)$, y-labels: $-0.5 \rightarrow +0.5$

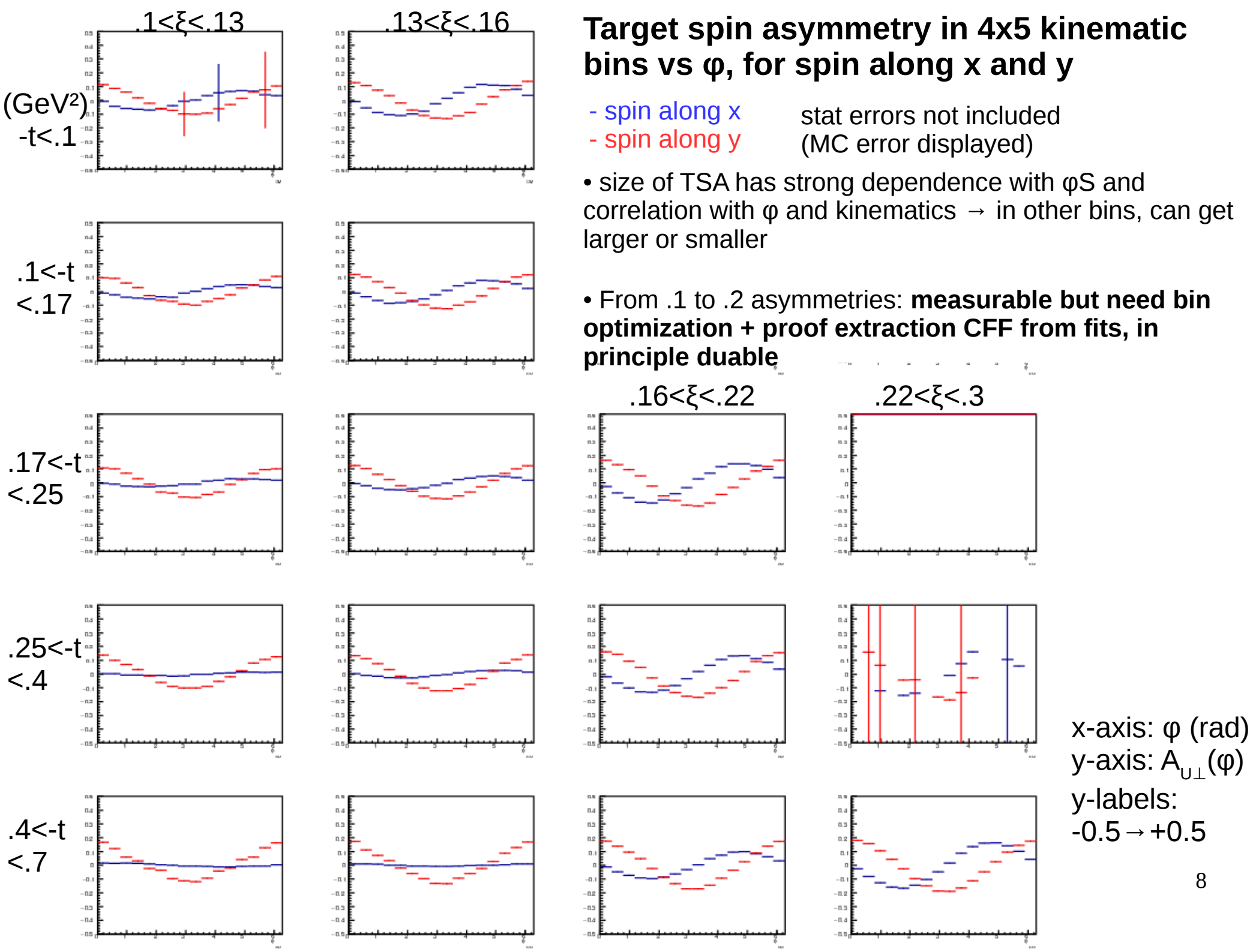
Target spin asymmetry in 4x5 kinematic bins vs φ, for spin along x and y

- spin along x
- spin along y

stat errors not included
(MC error displayed)

• size of TSA has strong dependence with φS and correlation with φ and kinematics → in other bins, can get larger or smaller

• From .1 to .2 asymmetries: **measurable but need bin optimization + proof extraction CFF from fits, in principle duable**



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y-axis: $A_{U\perp}(\varphi)$
y-labels:
-0.5 → +0.5

Double spin asymmetry for reference bin vs φ

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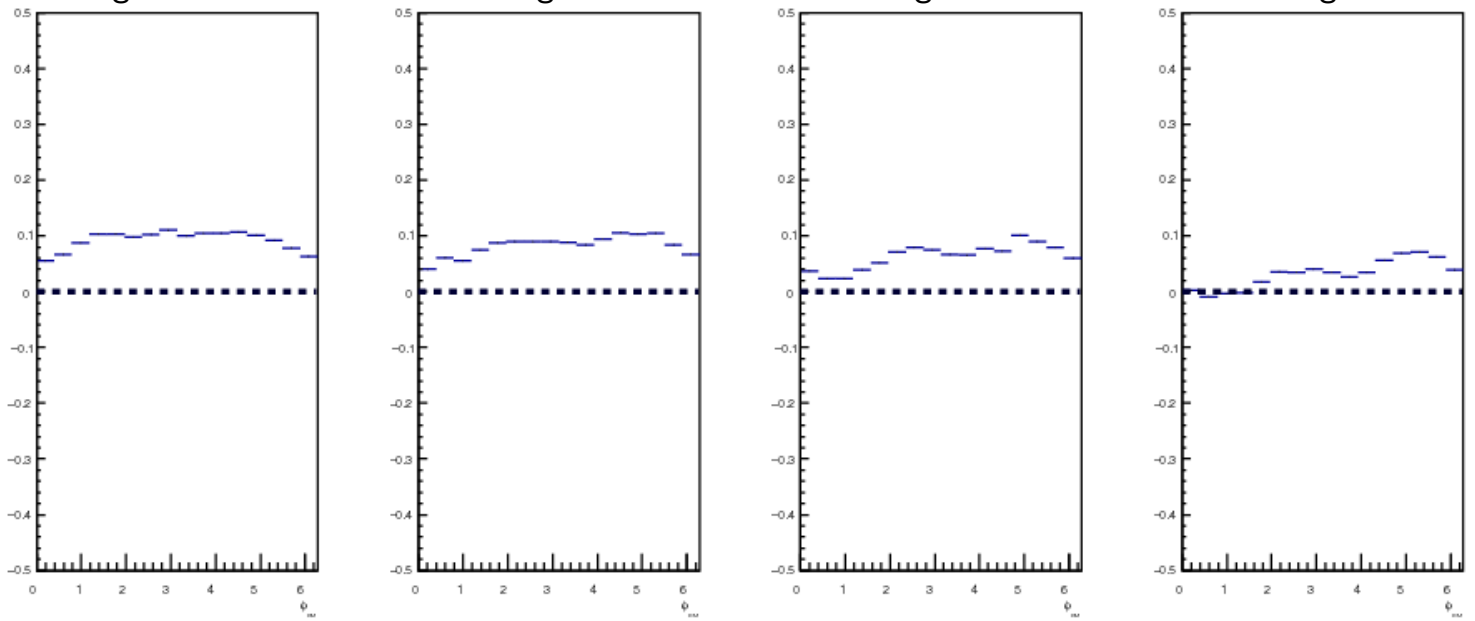

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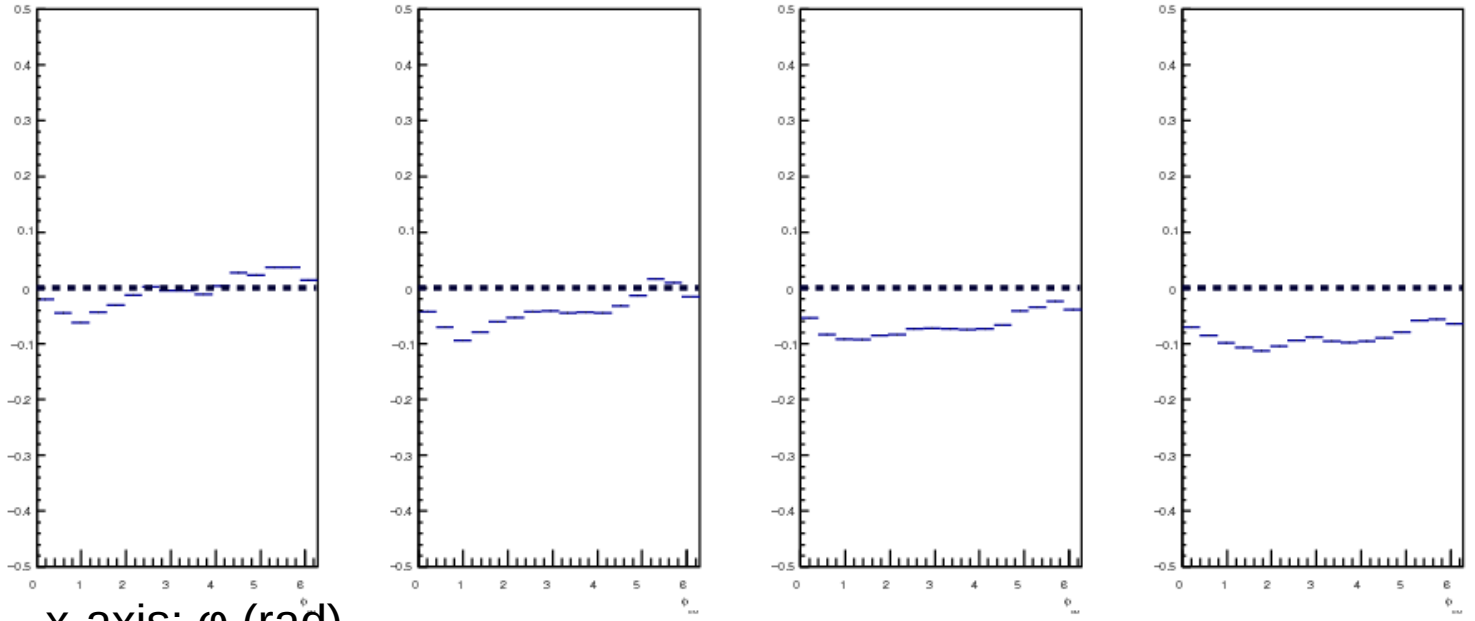

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• Not clear if it can be measured and/or physics extracted: larger dilution factor, non-zero BH asymmetry... Also strong kinematic dependence and may not be optimal to have such wide bins
(cf 2015 article)
⇒ I will study this question

.13<ξ<.16
.17<-t<.25 GeV²
7.5<Eγ<11 GeV
θ: dynamic cut

CONCLUSION / TO DO LIST

• Reasonnable statistics and sizeable BSA and TSA: measurement is feasible and will have an impact for CFF → for Im(H, H̃ , E) and Re(H)

• Lower uncertainties compared to other experiments

• This approach is for TCS multiparameter fits, and combination with DVCS. Possibility to divide in Q'^2 bins for NLO

<u>To do</u>:

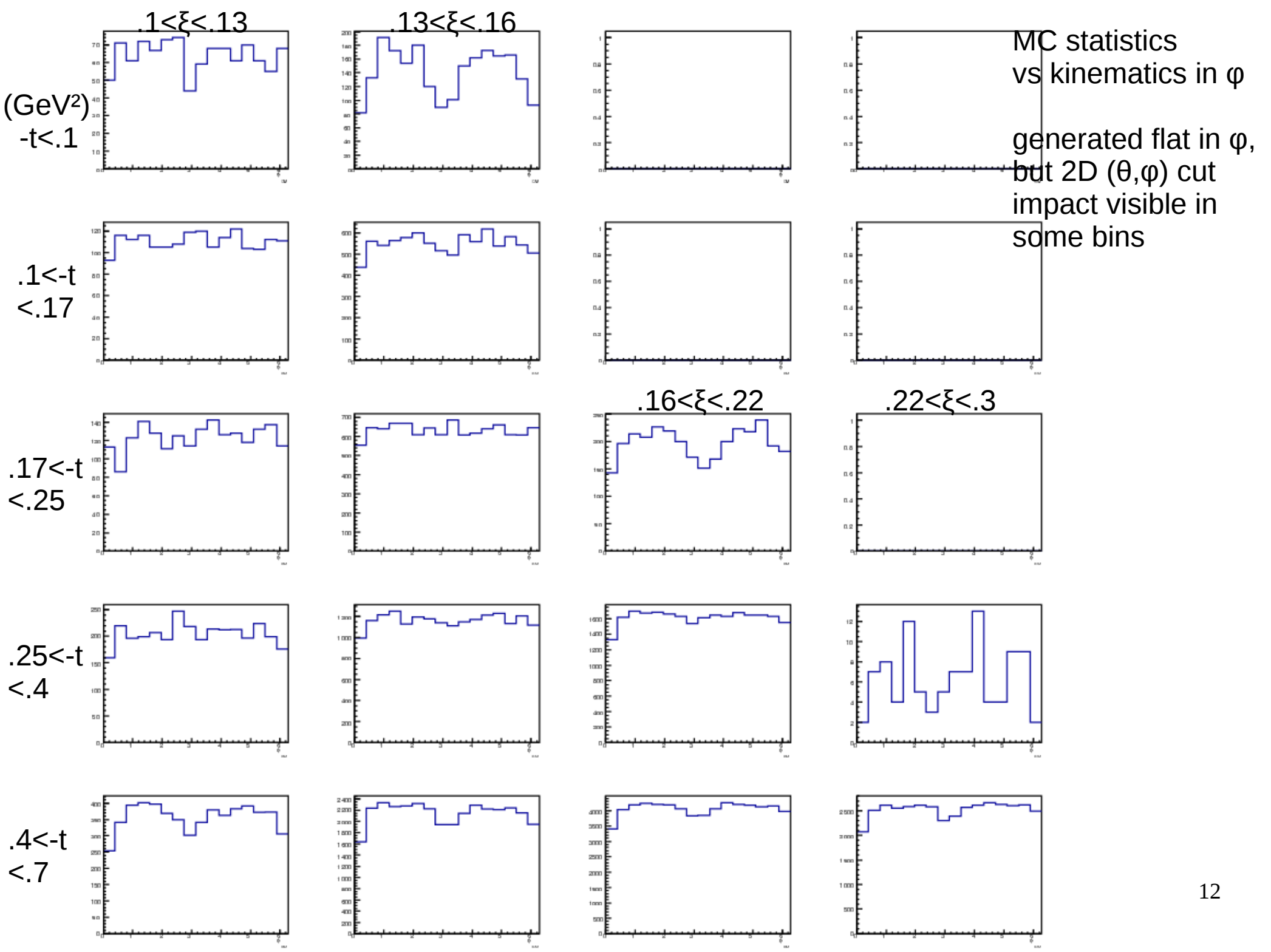
• include resolution and reconstructed variables

• optimization of current setup + comparision with modified setup at larger angles

• re-optimize binning and cuts (θ...) to enhance TCS/BH and asymmetries in balance with reasonnable counting rates, resolution, and (ξ, t) bin size

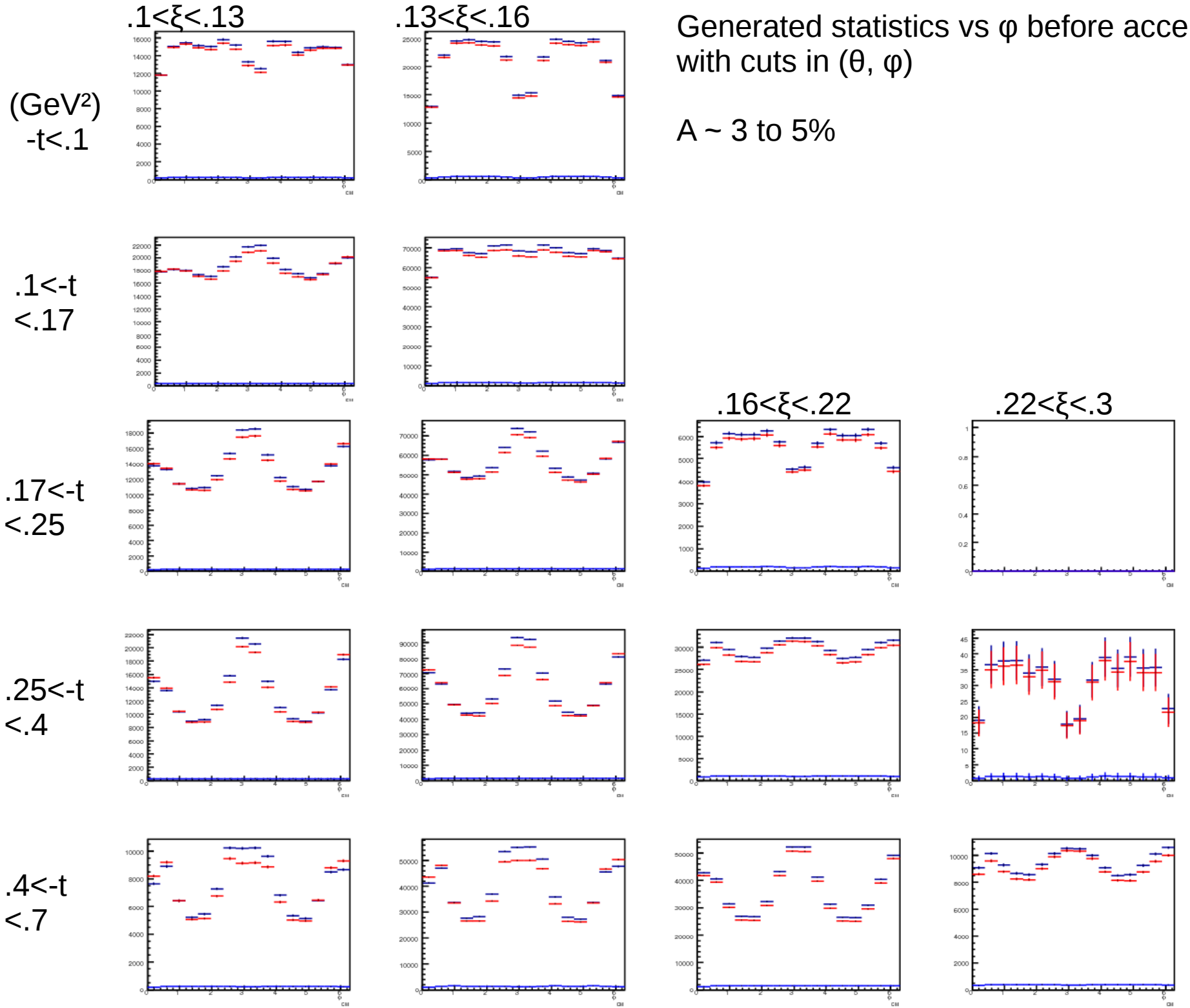
• CFF fits with expected uncertainties

Backup
more counting rates



MC statistics vs kinematics in φ

generated flat in φ, but 2D (θ,φ) cut impact visible in some bins



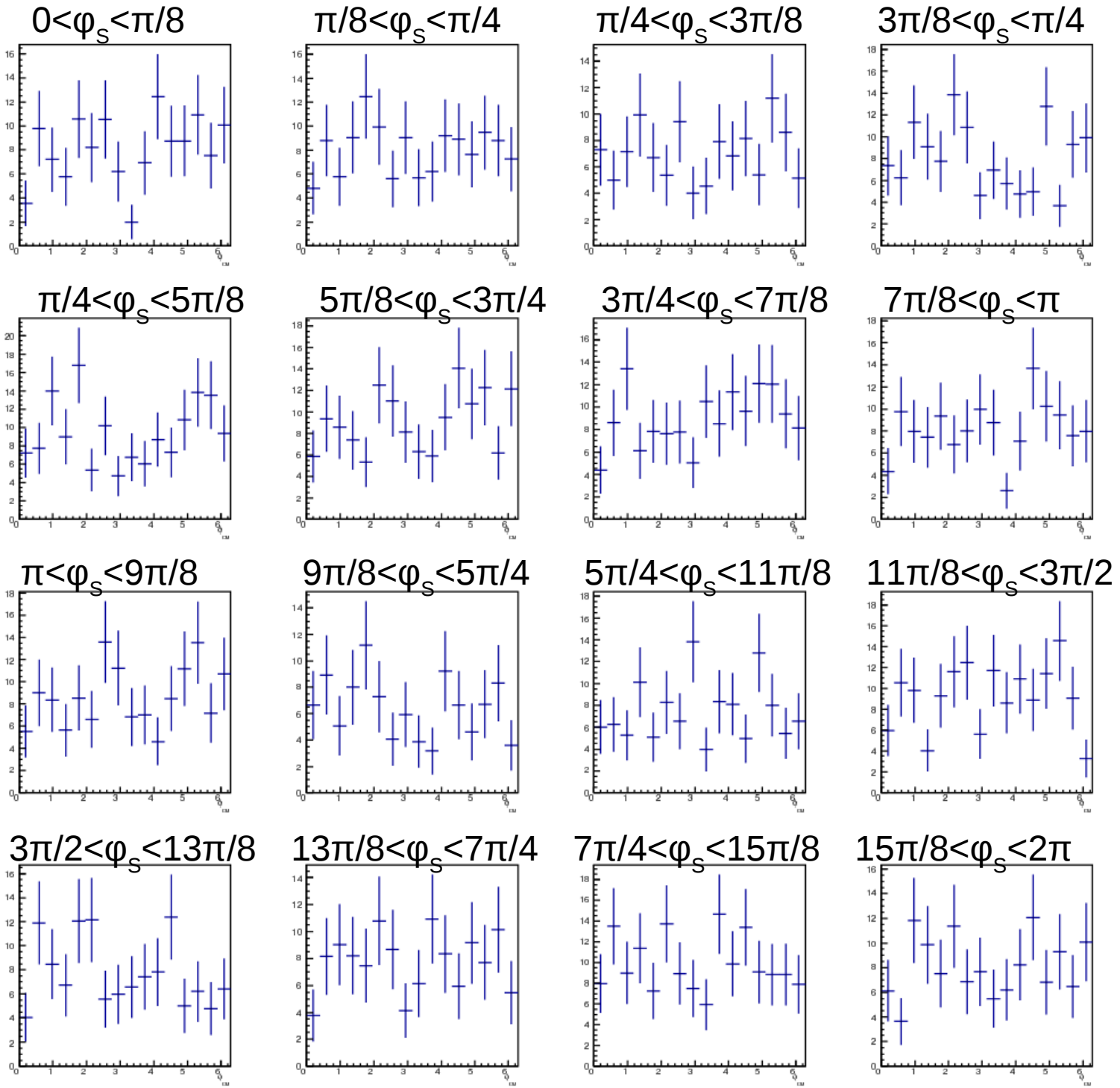
Generated statistics vs φ before acceptance, with cuts in (θ, φ)

A ~ 3 to 5%

Expected statistic in φ and φS bins for reference bin in kinematic

y-axis:
dN/dφ

x-axis:
φ(rad)



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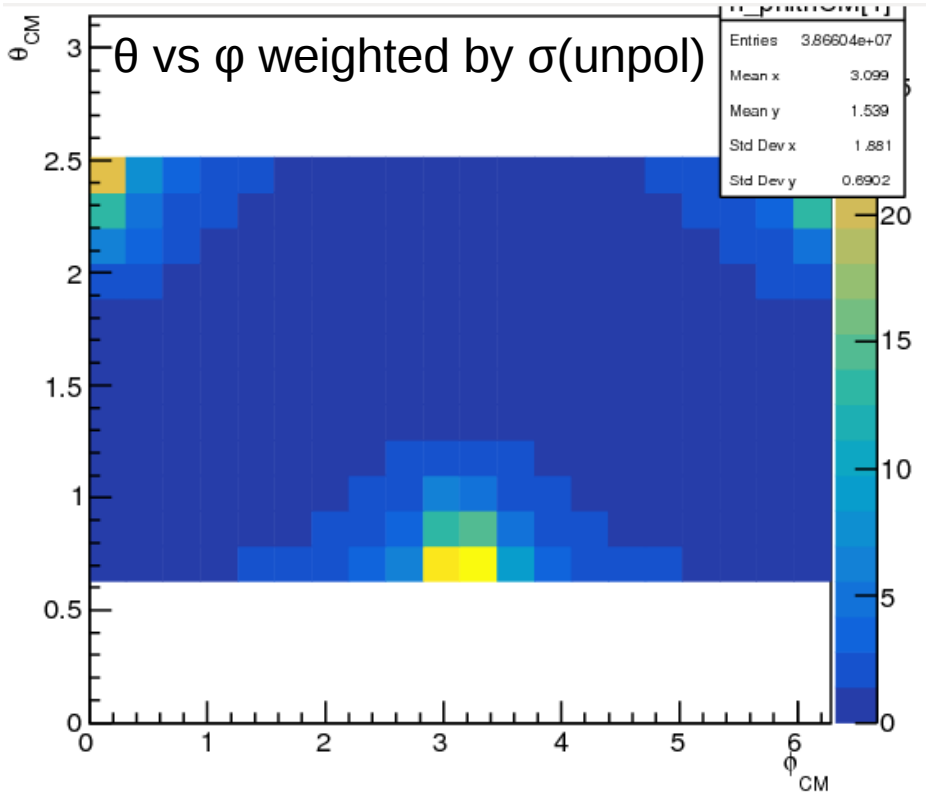
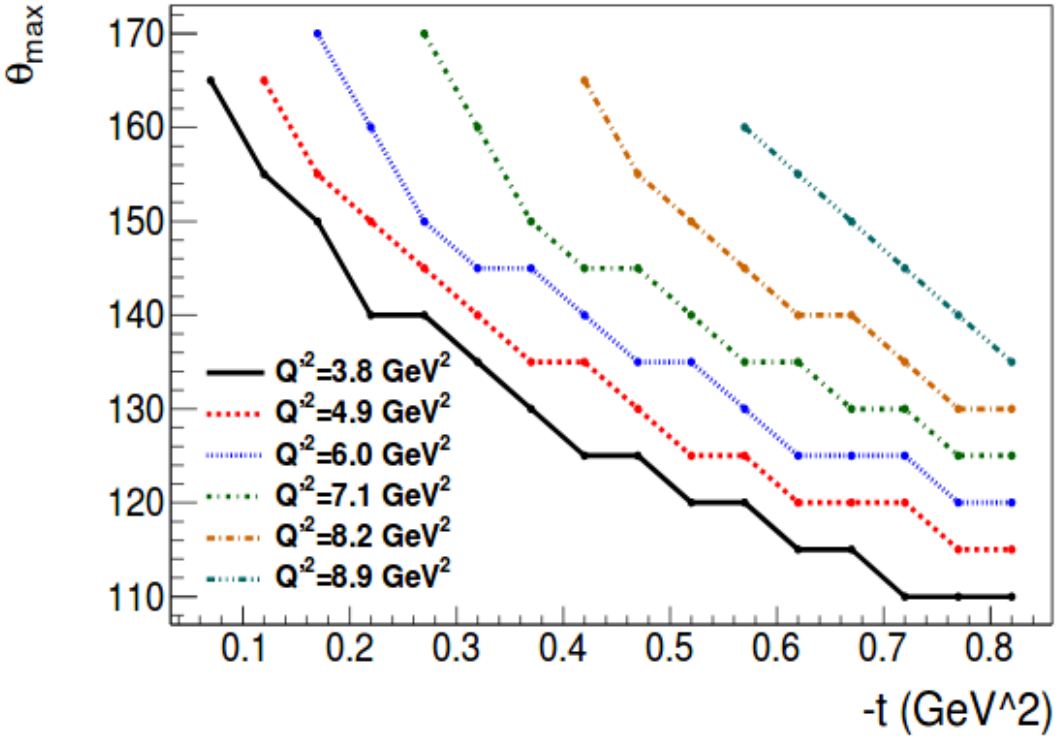
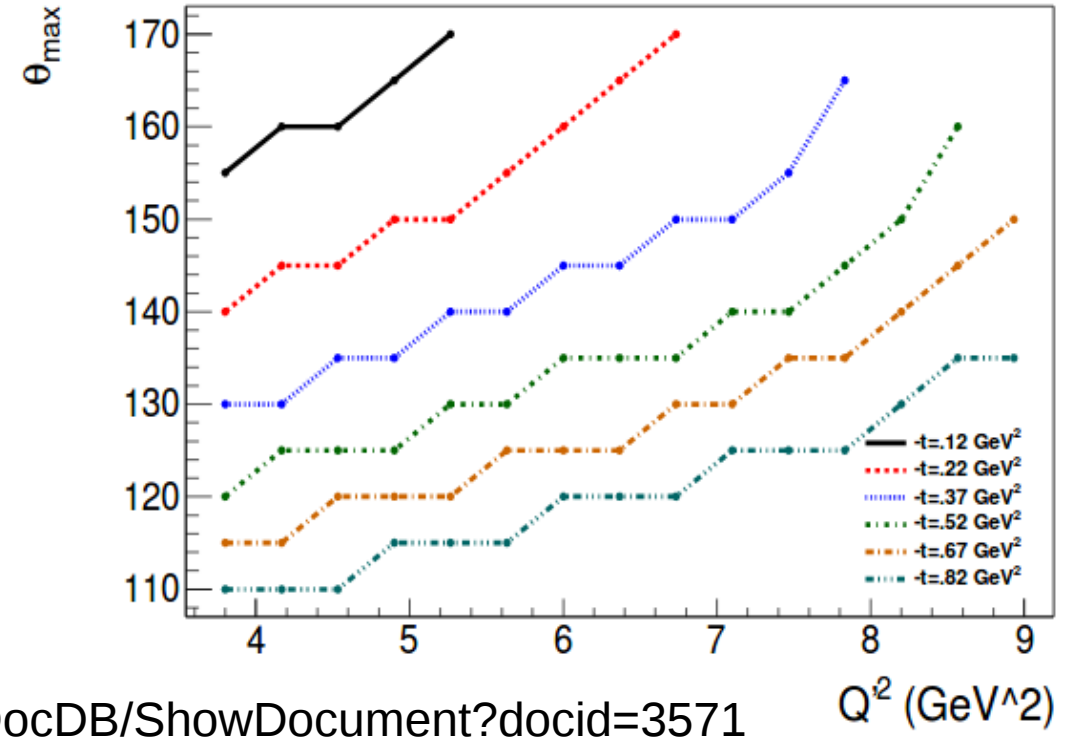
2D kinematic cut



BH peaks in yellow, mostly out of acceptance (small θlab for one lepton, low momentum for the other one) →cut as a function of (E, Q'², t)

2 figs on right: θmax cut, all what is above is rejected in case φ=0±30° or φ=180°±30°





cf note: https://halldweb.jlab.org/doc-public/DocDB/ShowDocument?docid=3571