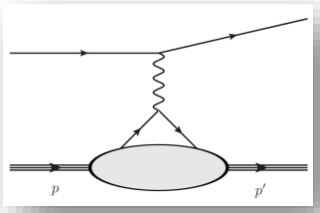
Run Group B status update

- RGB experiments
- Overview of the 3 run periods
- Status of calibrations and data processing
- Analysis updates
- Jeopardy preparation

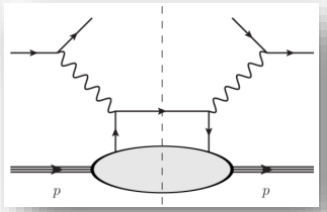
Silvia Niccolai, IJCLab
CLAS Collaboration meeting, 3/25/2020

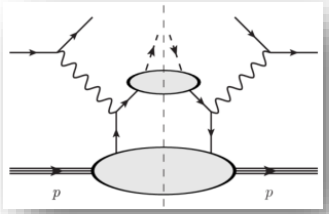
CLAS12 Run Group B: experiments



Elastic Scattering (G^n_M)

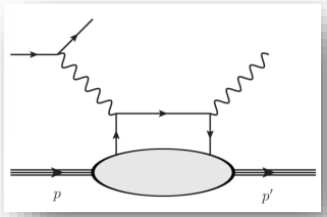
DIS (for SRC and EMC effect)

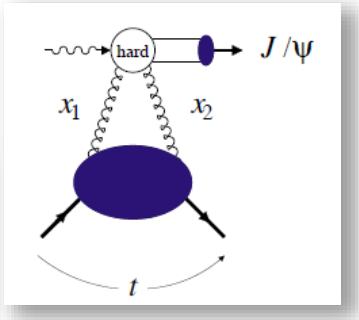




SIDIS (for PDFs and TMDs)

nDVCS





J/ψ photoproduction

E12-07-104	Neutron magnetic form factor	G. Gilfoyle	A- 30
E12-09-007a	Study of parton distributions in K SIDIS	W. Armstrong	A- 56
E12-09-008	Boer-Mulders asymmetry in K SIDIS	M. Contalbrigo	A- 56
E12-11-003	Deeply virtual Compton scattering on the neutron	S. Niccolai	A **(HI)** 90
E12-09-008b	Collinear nucleon structure at twist-3 in dihadron SIDIS	M. Mirazita	RG
E12-11-003a	In medium structure functions, SRC, and the EMC effect	O. Hen	RG
E12-11-003b	Study of J/ψ photoproduction off the deuteron	Y. Ilieva	RG
E12-11-003c	Quasi-real photoproduction on deuterium	F. Hauenstein	RG (*)

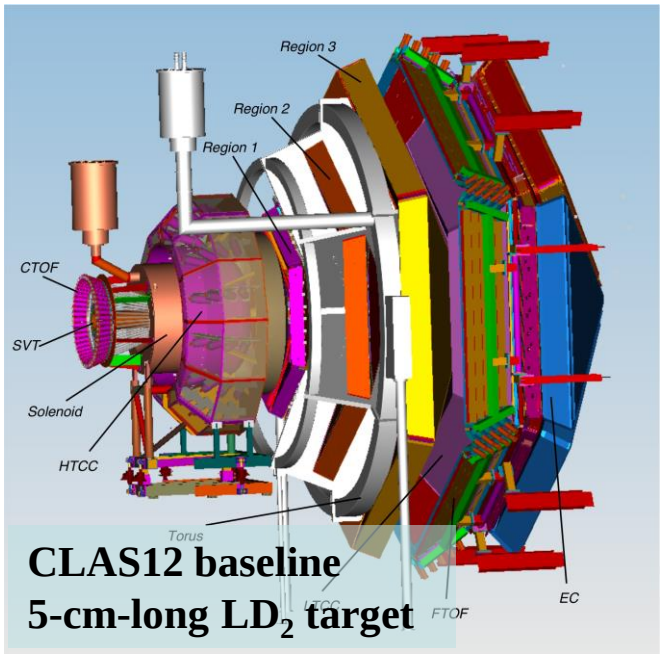
Common features to all experiments of RG-B:

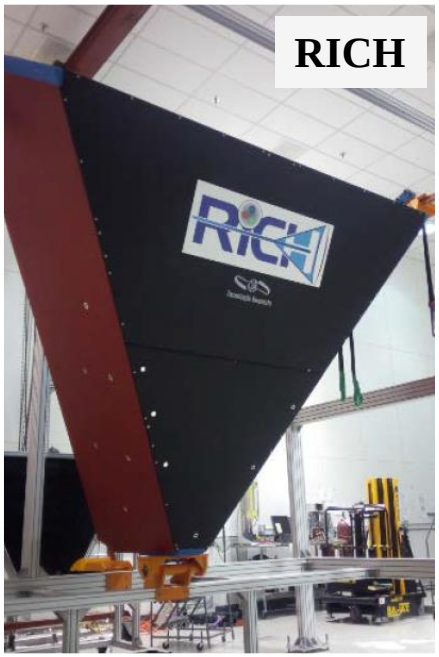
- **Liquid deuterium target**
- **Beam energy: « 11 » GeV**

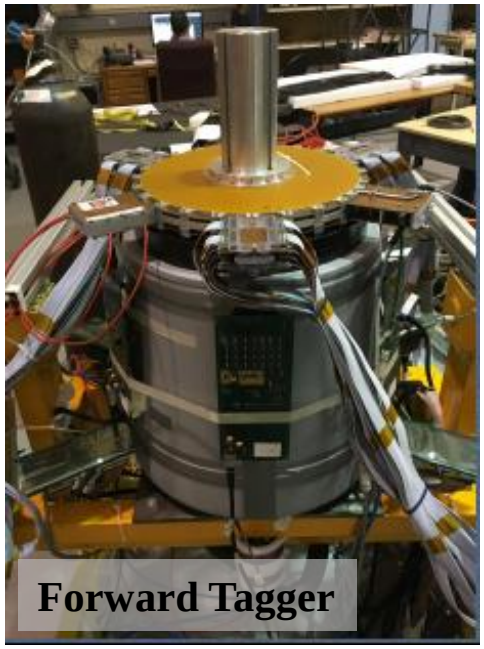
<u>Deuteron</u> luminosity in nDVCS proposal: 10^{35} cm^2/s
Total expected charge for 90 PAC days: 510 mC

(*) Joined RGB from fall run onwards

Experimental setup (common to the 3 run periods)







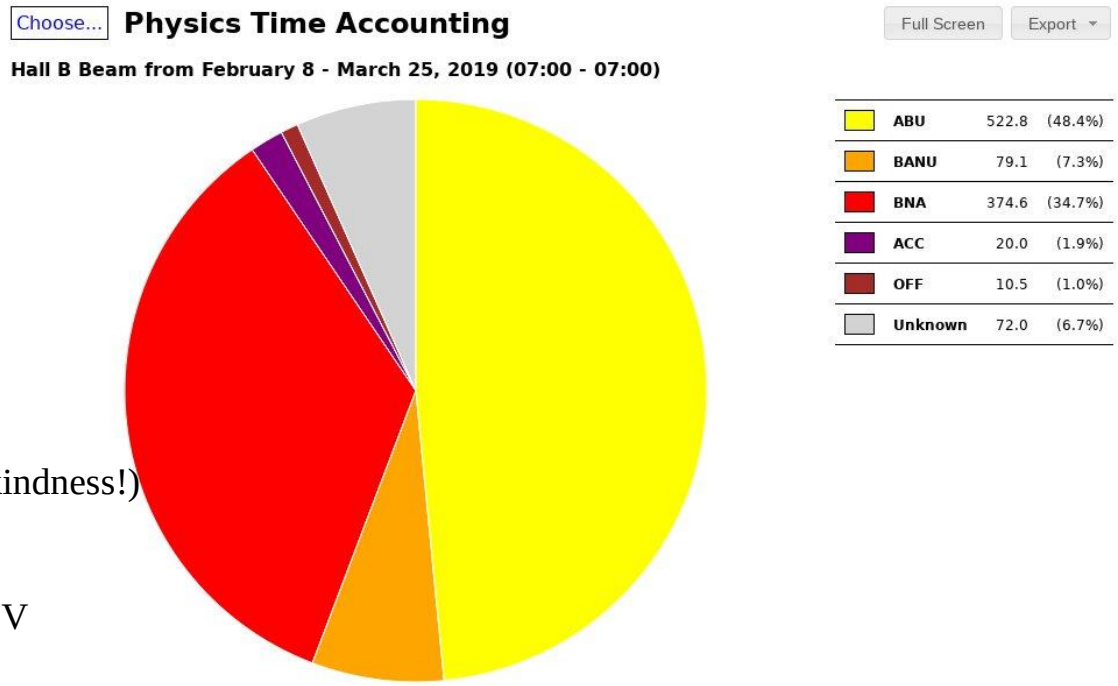
Run Group B spring 2019 run

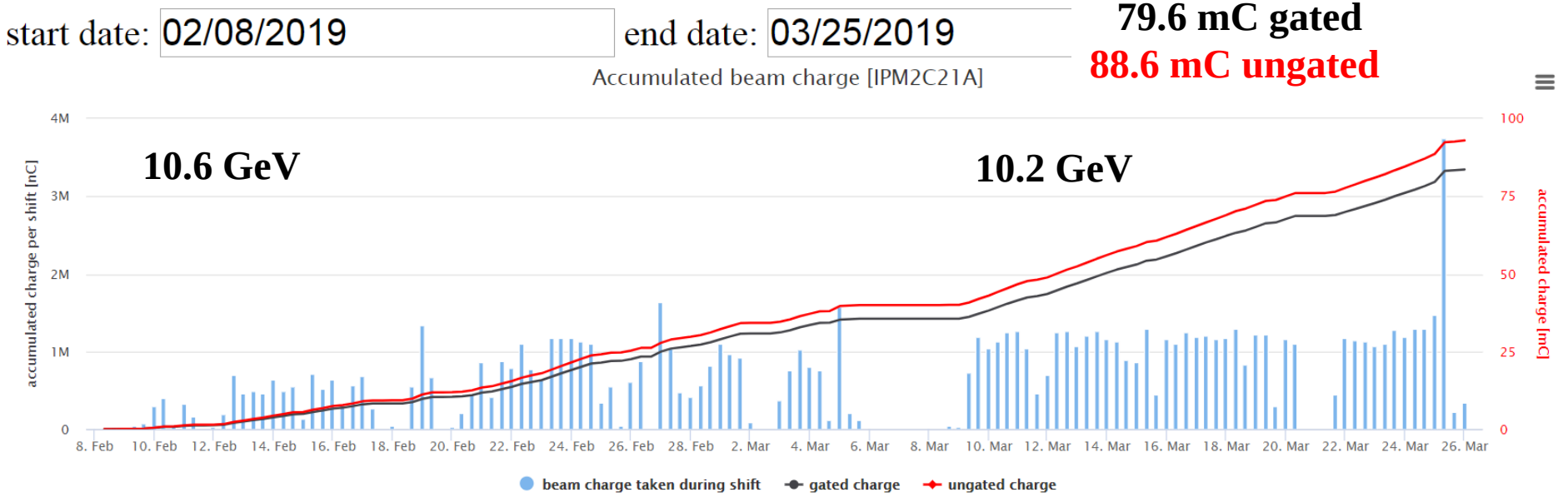
Running conditions:

- **10.6** – **10.2** GeV beam energy
- Torus ***inbending***
- Production current: 35 nA → 50 nA
- Event-weighed average current: 47.9 nA
- DAQ rate: ~14 kHz

Outcome:

- Original schedule: 1/30 – 3/10
- Final accelerator schedule: 2/8 – 3/17
- Actual days ran: 2/8 – 3/25 (thanks to RG-A's kindness!)
- 21.7 PAC days according to ABUs (48.4%)
- 237 good production runs
- ~9.7 B triggers at 10.6 GeV, ~11.7 B at 10.2 GeV





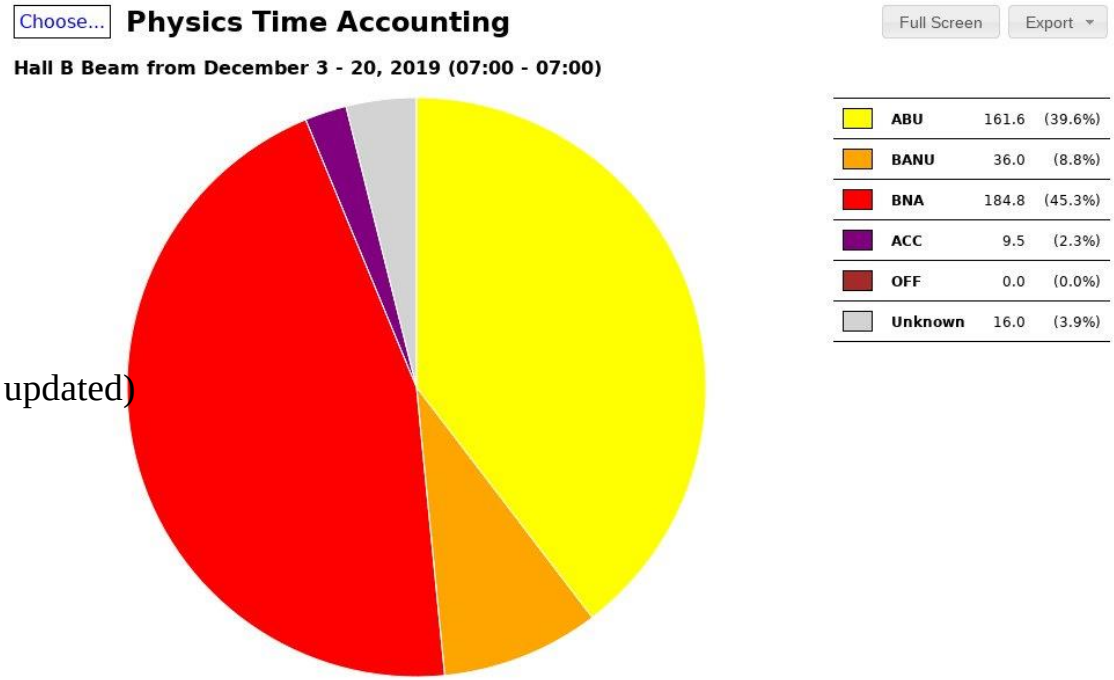
Run Group B fall 2019 run

Running conditions:

- **10.4** GeV beam energy
- Torus ***outbending***
- Production current: 40 nA
- Event-weighed average current: 38.8 nA
- DAQ rate: ~24 kHz
- ~1 day at 2-pass for BAND

Outcome:

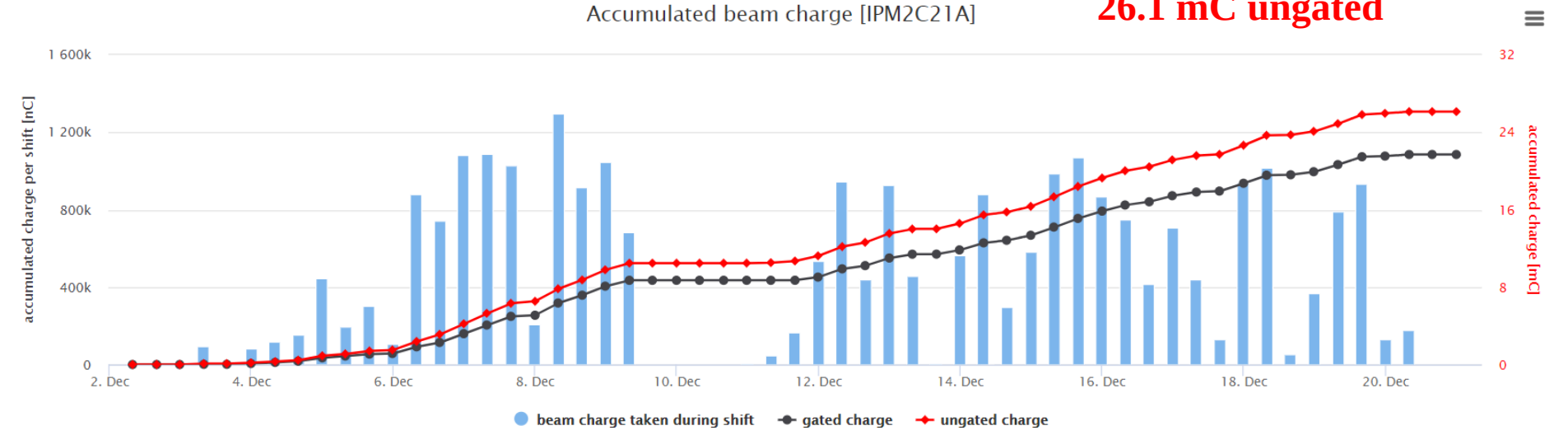
- Accelerator schedule: 11/25 – 12/19 (should be updated)
- Actual days ran: 12/3 – 12/20
- 6.7 PAC days according to ABUs (39.6%)
- 91 good production runs
- ~9. B triggers at 10.4 GeV



start date: 12/02/2019 end date: 12/20/2019

21.7 mC gated

26.1 mC ungated



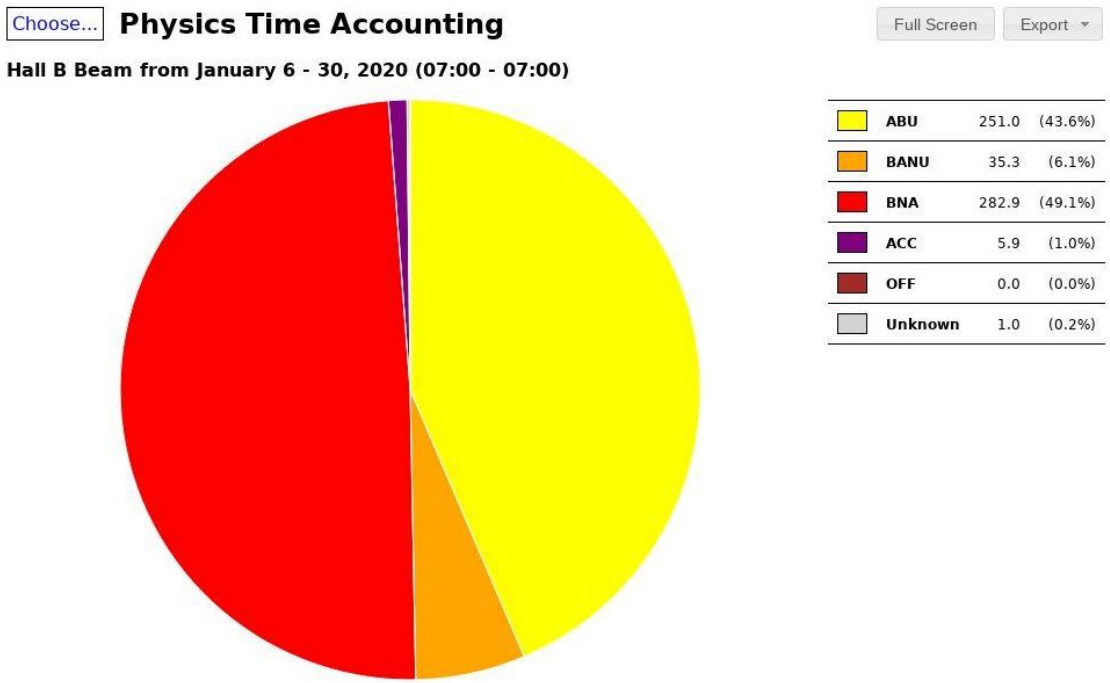
Run Group B winter 2020 run

Running conditions:

- **10.4** GeV beam energy
- Torus ***inbending***
- Production current: 40 → 50 nA
- Event-weighed average current: 45.1 nA
- DAQ rate: ~19 kHz

Outcome:

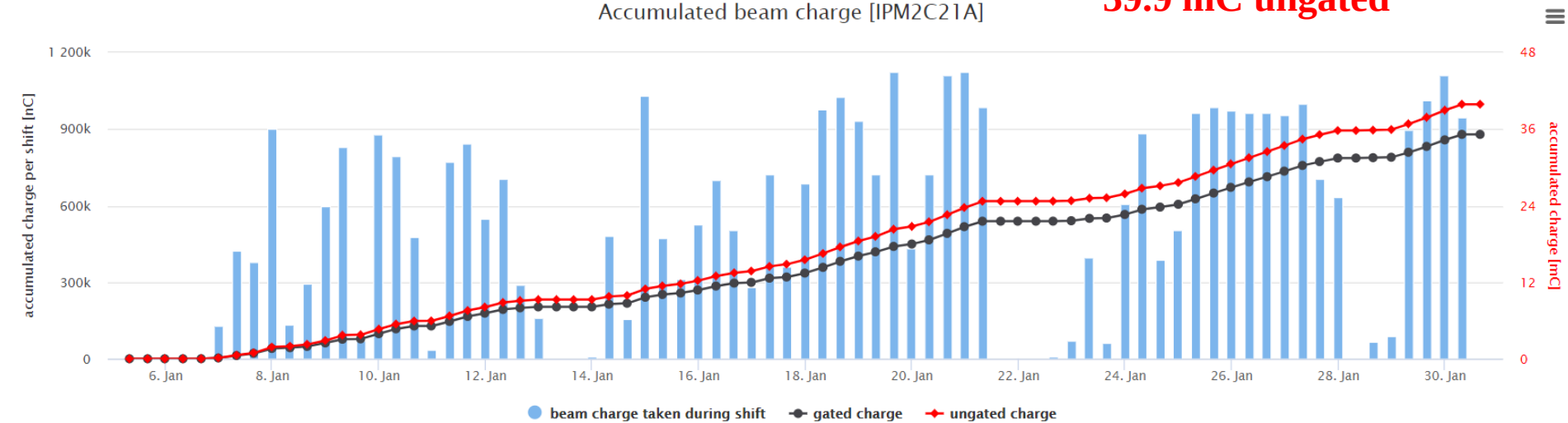
- Accelerator schedule: 1/10 – 1/29
- Actual days ran: 1/7 – 1/29
- 10.5 PAC days according to ABUs (43.6%)
- 181 good production runs
- 12.9 B triggers at 10.4 GeV



start date: 01/05/2020 end date: 01/30/2020

35.2 mC gated

39.9 mC ungated



Run Group B overall statistics

43.3 B triggers collected: 10.6 GeV (9.7 B), 10.2 GeV (11.7 B), 10.4 GeV (21.9 B – 9 B outbending)

38.9 total PAC days according to ABUs → **43.2% of the approved 90 PAC days**

Accumulated charge: 154.6 mC ungated (Andrey's tool), **30.3%** of the proposed 510 mC

Beam current necessary to reach L=10^{35} on a 5-cm-long deuterium target → 65.5 nA
Average beam current for RG-B: ~44.96 nA
30.3 % x 65.5/44.96 = **44.1%** → **numbers are ~consistent**

Special runs (all run periods):

- 27 low-luminosity runs
- 9 empty target/high-current runs
- Several random trigger runs
- 3 zero-field alignment runs

Calibrations and data processing

Spring19 data:

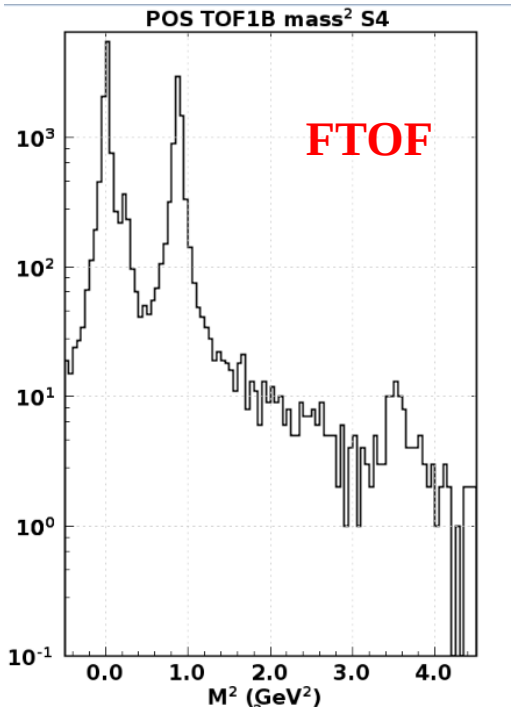
- A pass0 was done - All steps until timelines – « middle » runs to calibrate established
- BUT: FTOF calibration algorithm change: first run (6164) recalibrated
- RF recalibrated for all runs
- First run recalibrated for all subsystems
- Monitoring pass between 6150 and 6223
- FTOF and RF calib for middle runs (6223, 6228, 6351, 6420, 6546).
- ***Ongoing: calibration of middle runs for other detectors***
- ***To do: another pass of RF calib for all runs, new monitoring pass, timelines, and if all is good production cooking! ☺***

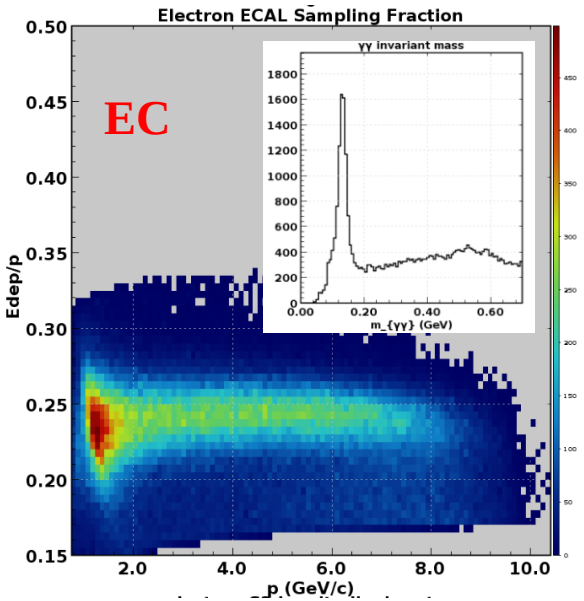
Fall19 and Winter20 data:

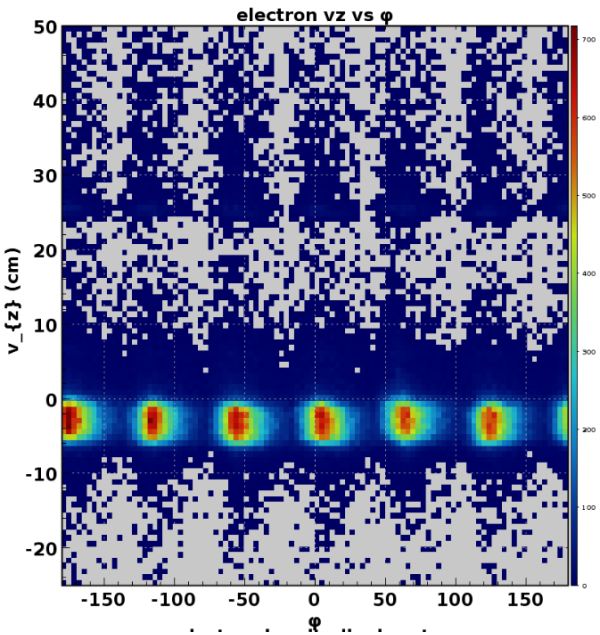
- Cooking of first runs (11093 - 11328), calibration done for FTOF
- RF calibrated for all runs
- First runs calibrated for FTOF, CTOF, FTCal, HTCC, CND
- **Monitoring pass and analysis of timelines done for fall data**
- **Established runs to calibrate for fall data**
- ***Ongoing: timelines for winter***
- ***To do: establish other runs to calibrate for winter, calibrations, new monitoring pass, timelines, and if all is good production coking! ☺***

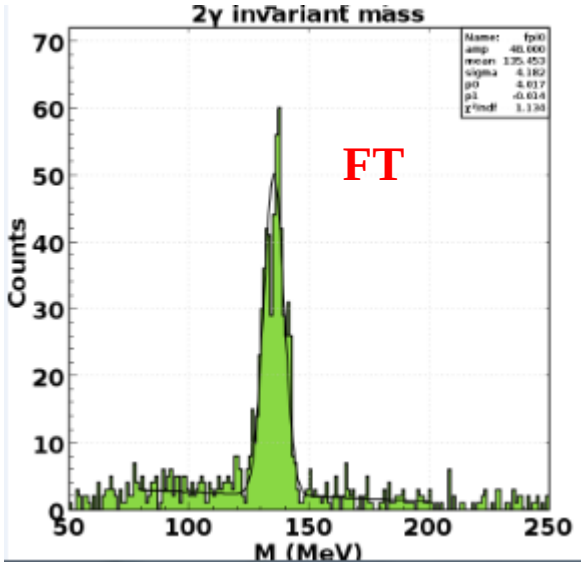
Plan: complete calibrations for *spring data* by the end of this week and start the review process for first part of pass-1 cooking (spring data only)

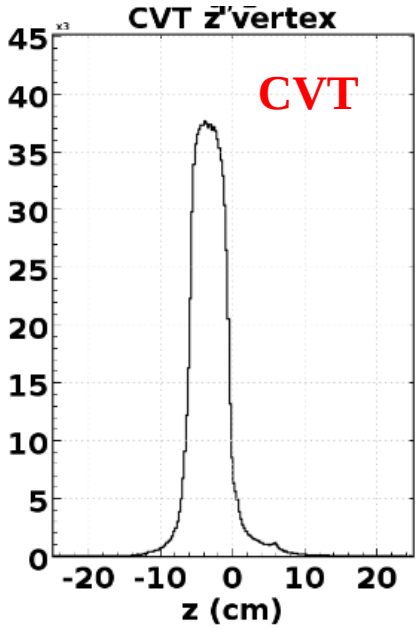
Data quality: monitoring

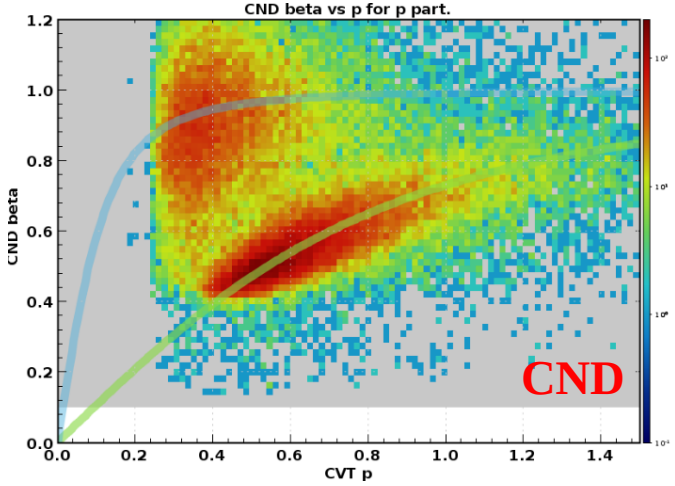






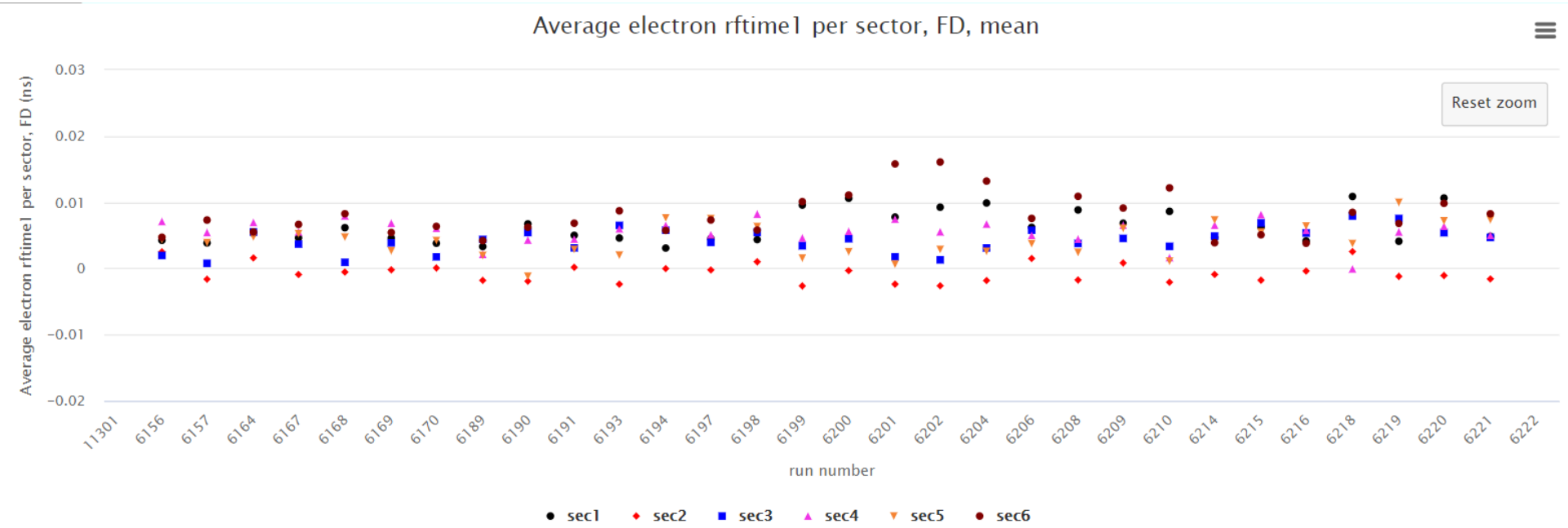


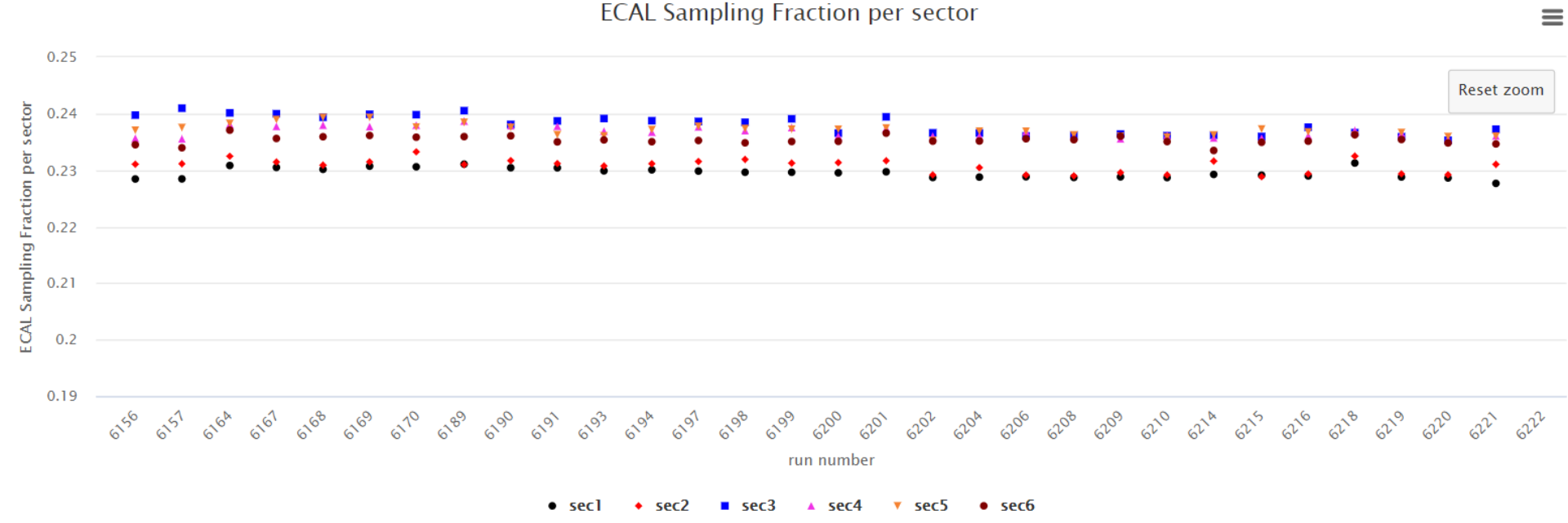




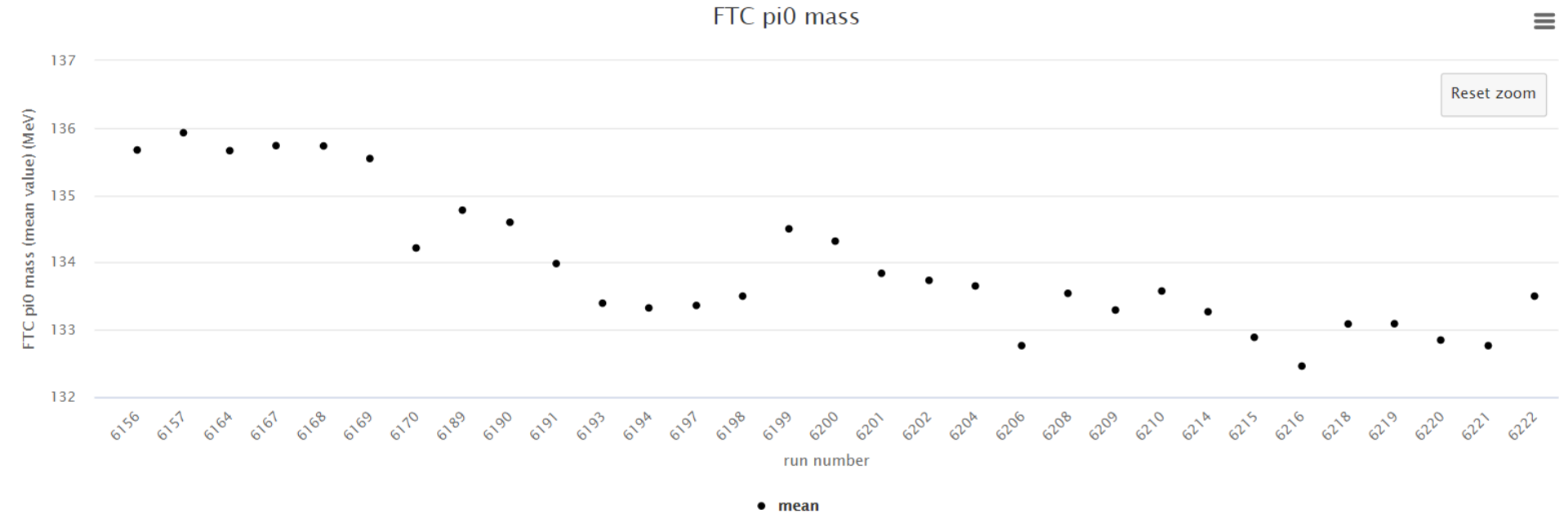
10 files of winter run 11324

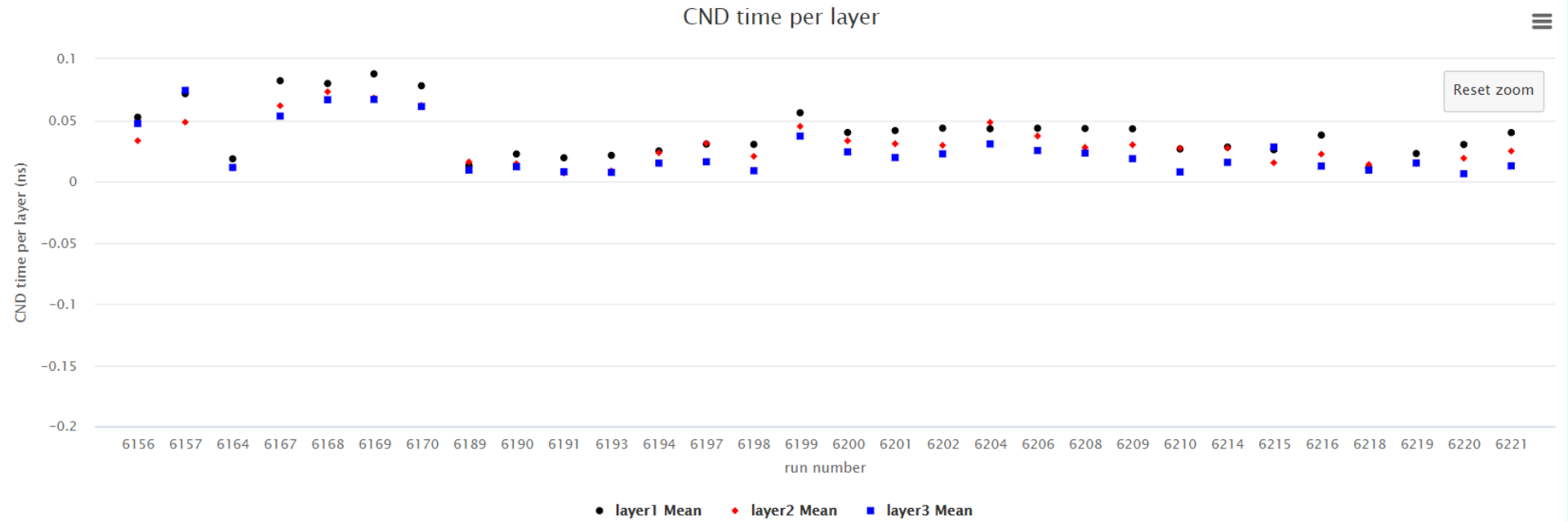
Examples of timelines for first set of spring runs





Examples of timelines for first set of spring runs

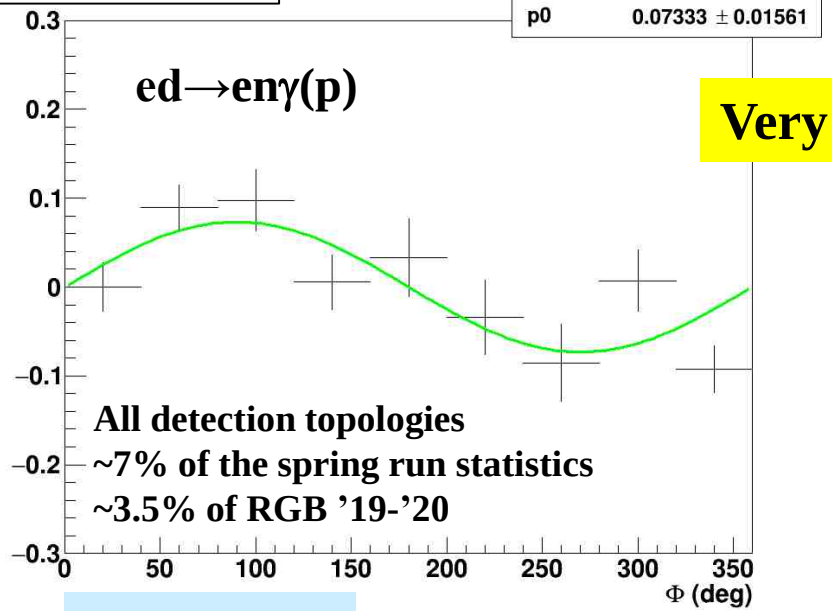




Analysis updates: n- and p-DVCS

- A first set of Pass0 calibrations+cooking was done in summer 2019
- Preliminary results for nDVCS shown at DNP'19 (7% of spring statistics)
- PID + preliminary exclusivity cuts based on MC

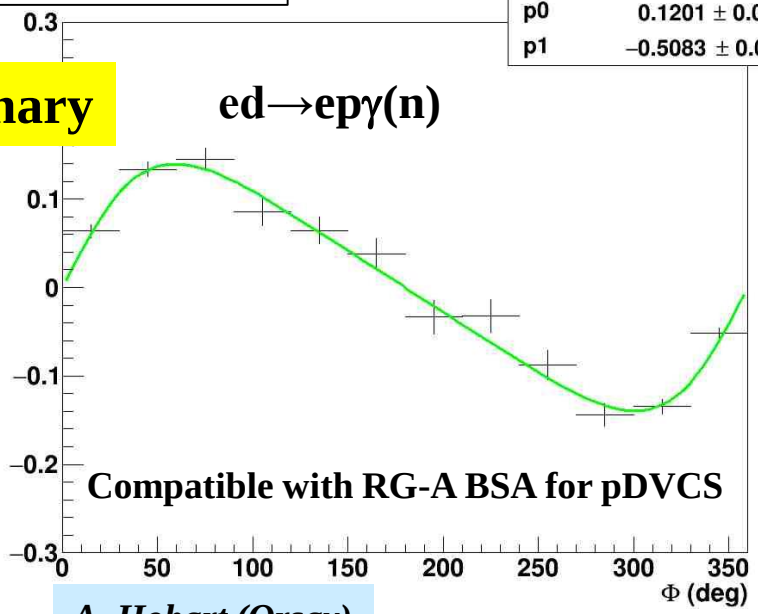
nDVCS raw BSA



K. Price (Orsay)

Very preliminary

pDVCS raw BSA



A. Hobart (Orsay)

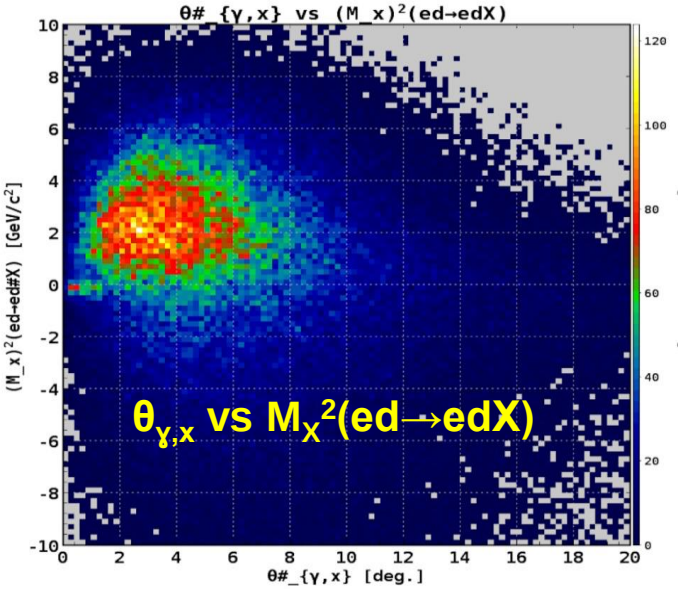
Ongoing work:

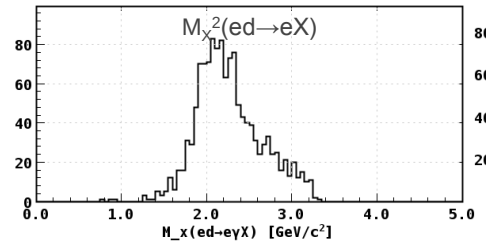
- π^0 background estimation
- Implementation of CND-CTOF veto for charged particles in COATJAVA
- Refinement of CD neutron PID in the EB

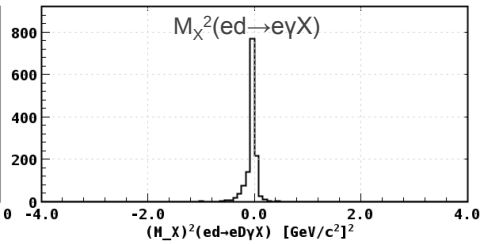
Coherent Deuteron DVCS

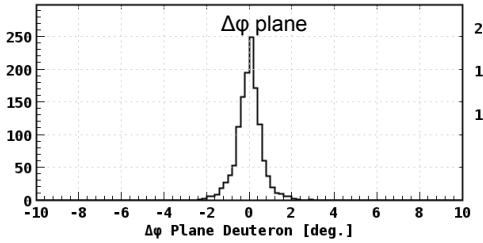
- 35 runs - pass0v16 (DNP cooking)
- e + D -> e + D + γ
- Exclusivity cuts for events with ɣ in FT:
  - $E_X(ed \rightarrow ed\gamma X) < 2$ GeV
  - $p_t < 0.5$ GeV/c
  - 2-dimensional cut on $\theta_{\gamma,x}$ vs $M_X^2(ed \rightarrow edX)$
- Similar cuts for FD

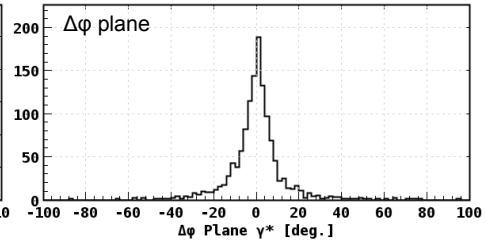
J. Dickovick,
A. Biselli
B. (Fairfield U.)

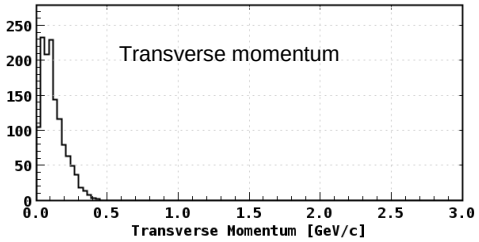


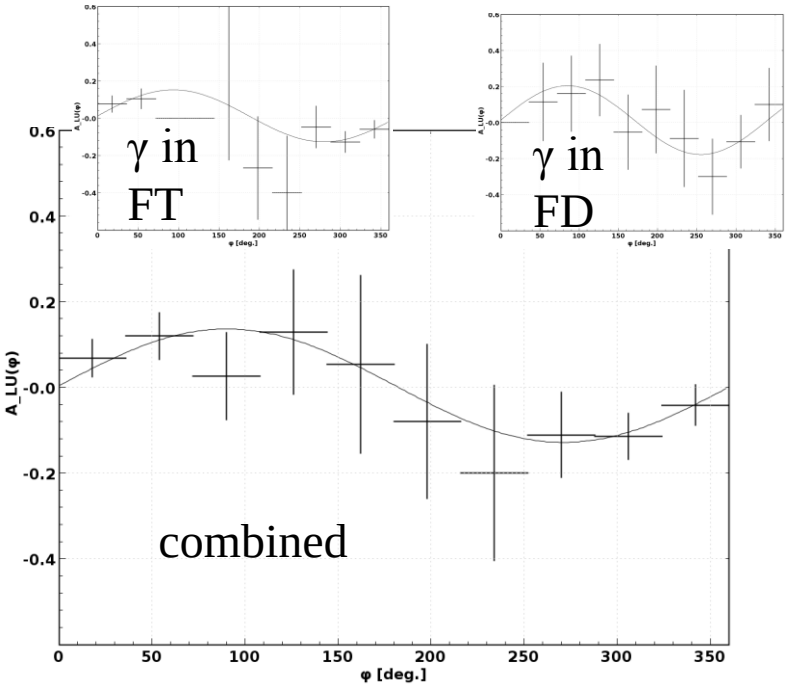












Measurement of the Neutron Magnetic Form Factor G_M^n at High Q^2 Using the Ratio Method on Deuteron

Work by L.Baashen (FIU), B.A. Raue (FIU) and G. Gilfoyle (Richmond)

Motivation : Fundamental quantity related to the magnetization in the nucleon.

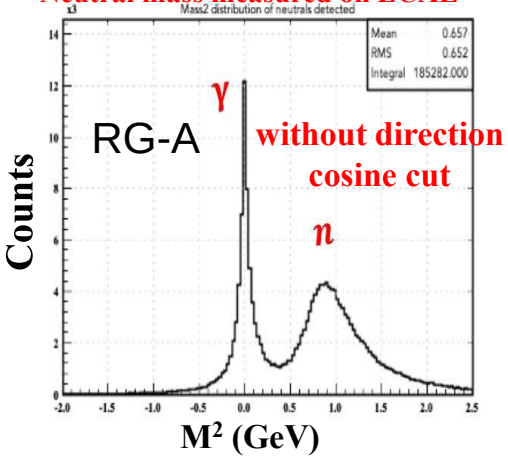
Method : Extract G_M^n using **ratio technique:** $\boldsymbol{R = \frac{d(e,e'n)p}{d(e,e'p)n}}$

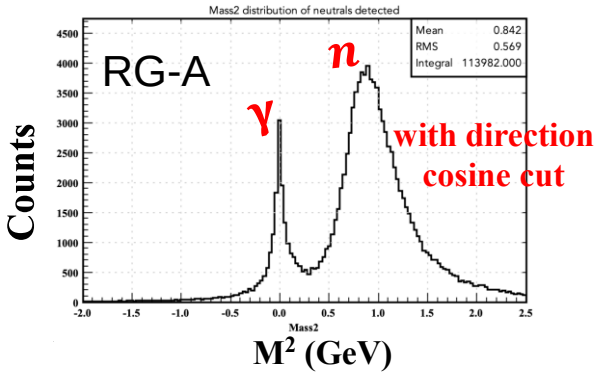
Required : Precise determination of the **neutron detection efficiency (NDE)** using $\boldsymbol{p(e,e'\pi^+n)}$ reaction on **hydrogen target** in **Run Group A.**

Analysis Status:

- **Production data:** Developed and tested codes to extract *R* on early DSTs and simulation.
- **NDE(1):** Optimizing event selection and extracting neutrons from higher mass background.
- **NDE(2):** (1) Swim expected neutrons from the track vertex to intersect ECAL and (2) then select neutral ECAL hit closest to the expected neutron point-of-intersection. (3) Apply direction cosine cut. See plots to the right.

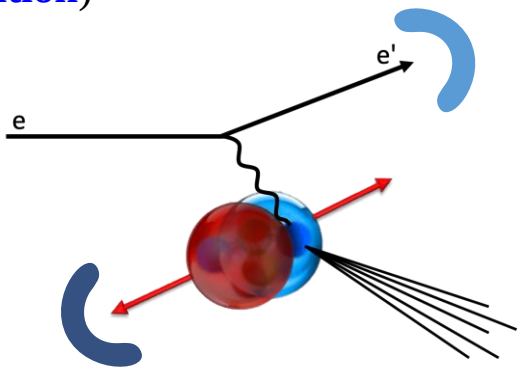
Neutral mass measured on ECAL





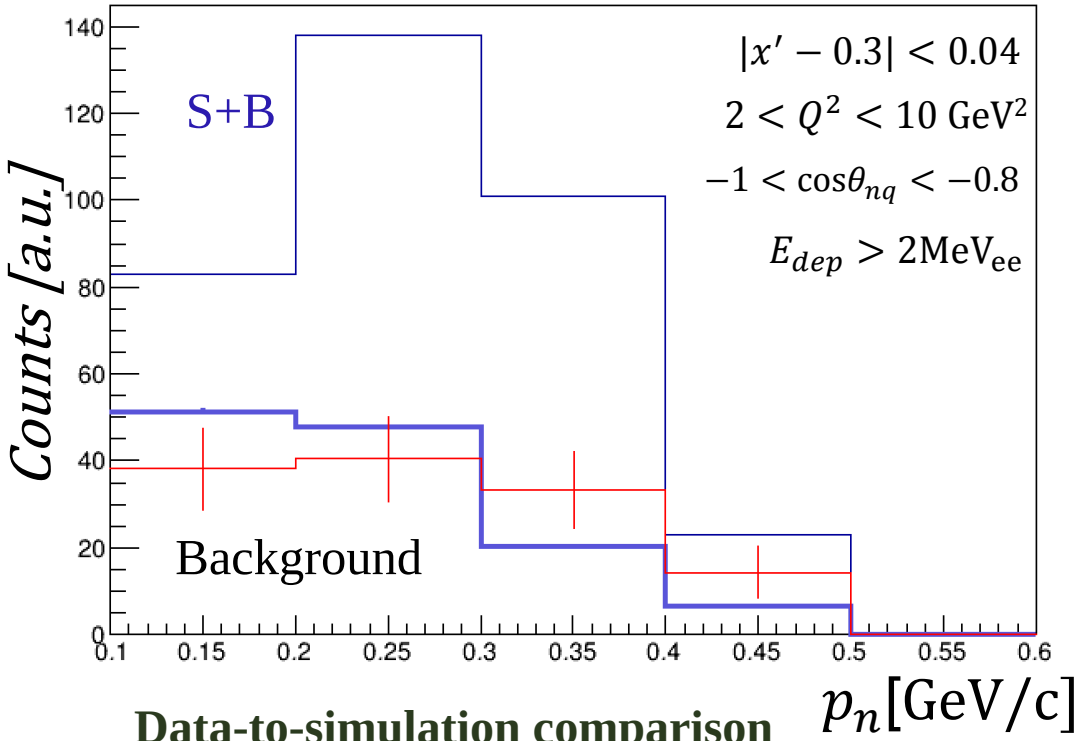
Tagged DIS for bound proton structure modification

- 4D binned events (**data**)
- Acceptance / bin-migration / etc.. (**simulation**)

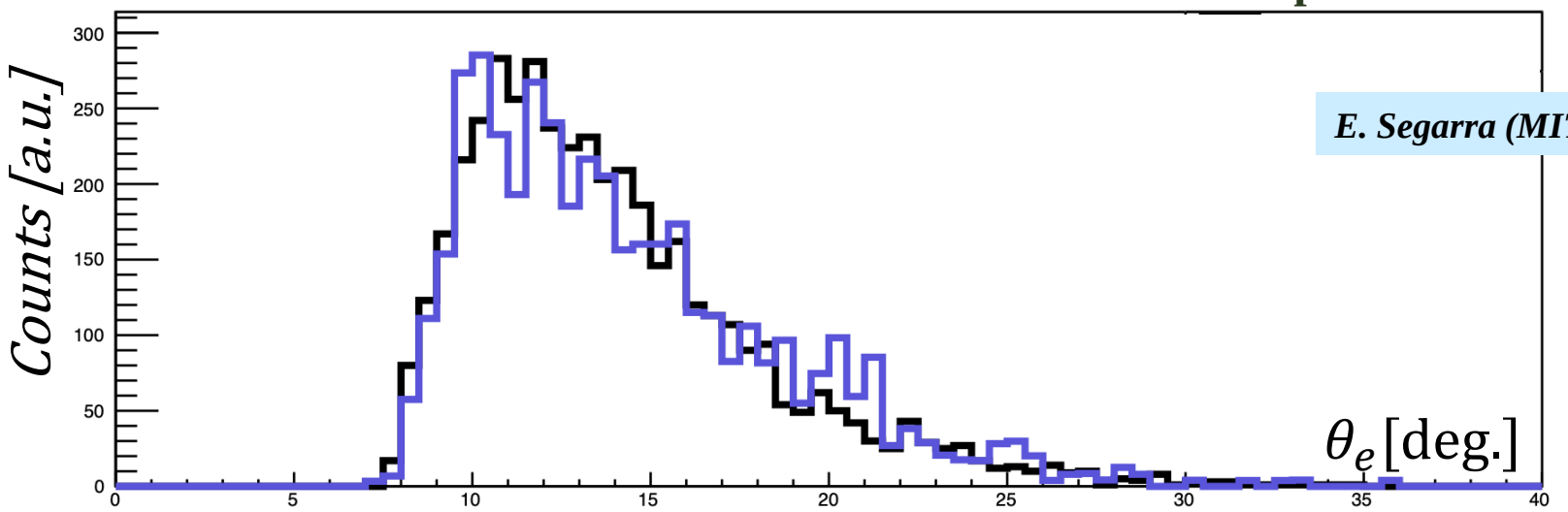


$$\frac{d\sigma^{bound}(Q_2^2, x_2', \theta_{nq}, p_n)}{d\sigma^{bound}(Q_1^2, x_1', \theta_{nq}, p_n)}$$

4D Signal-above-background extraction



Data-to-simulation comparison



E. Segarra (MIT)

Di-hadron SIDIS

➢ **e N → e π π X final state with 3 charge combinations**

O. Soto (LNF)

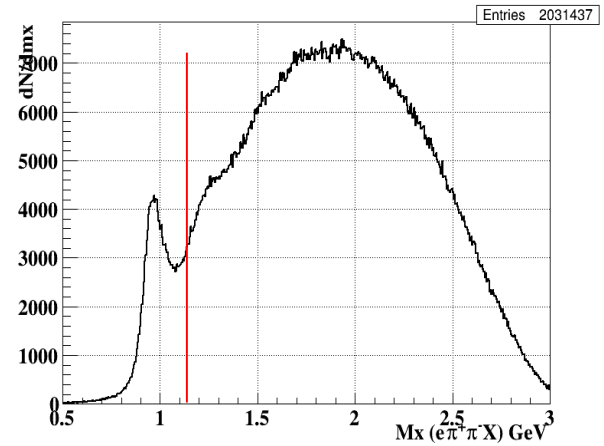
- All particles in the FD
- π^0 detected via the $\gamma\gamma$ decay
- DIS cuts: $Q^2 > 1$ GeV^2 $W > 2$ GeV^2 $y < 0.8$
- Inclusive cuts: MM > 1.15 GeV $z_{\pi\pi} < 0.95$

➢ **Comparison of rg-A and rg-B data → flavor separation**

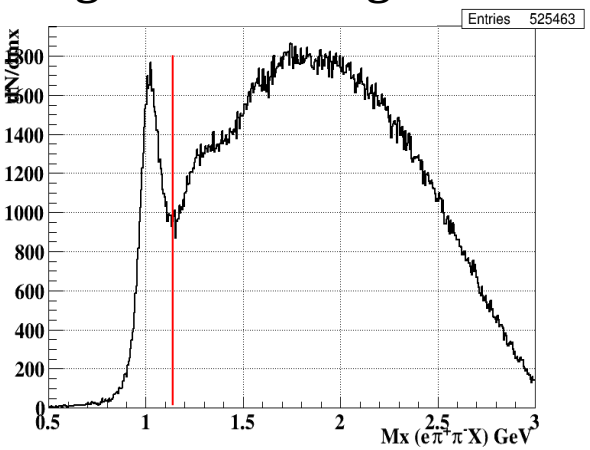
- analysis of DNP data to set up analysis procedures and cuts

MM(e π^+ π^- X)

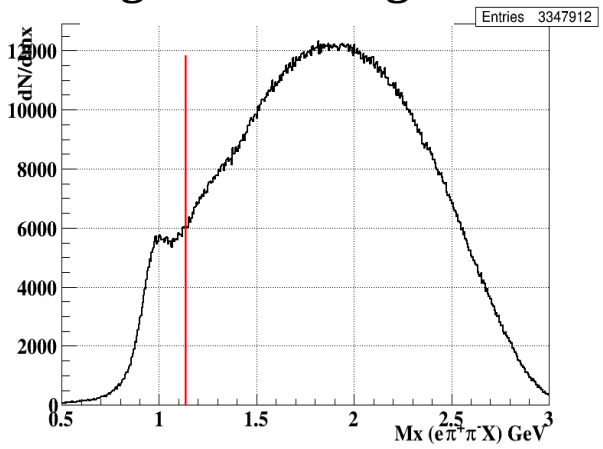
rg-A inbending



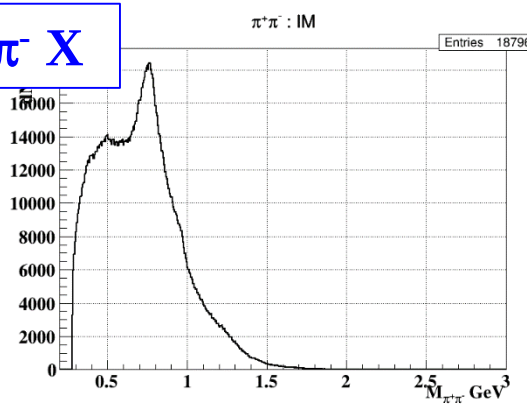
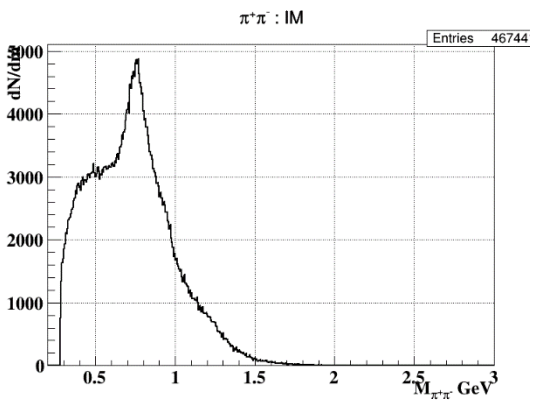
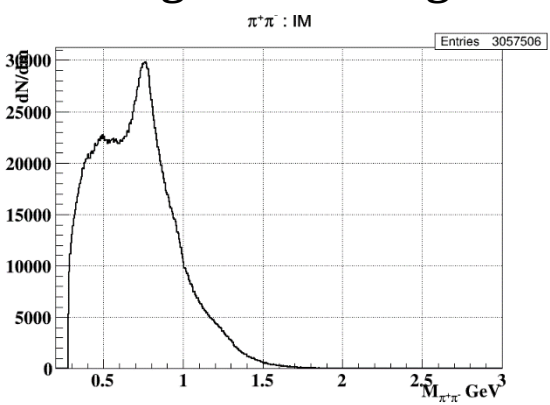
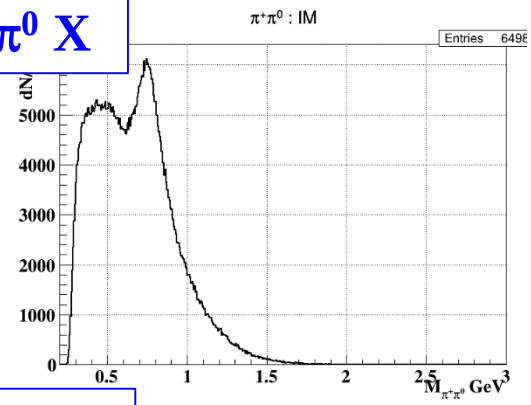
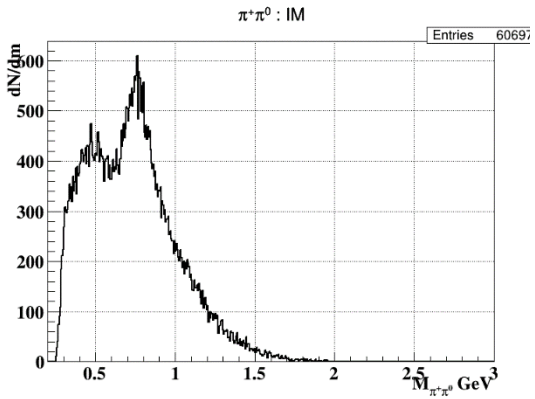
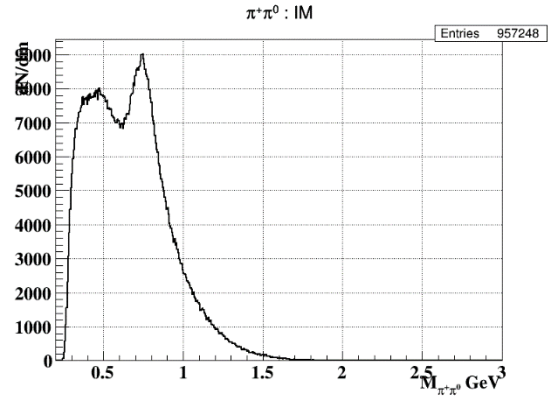
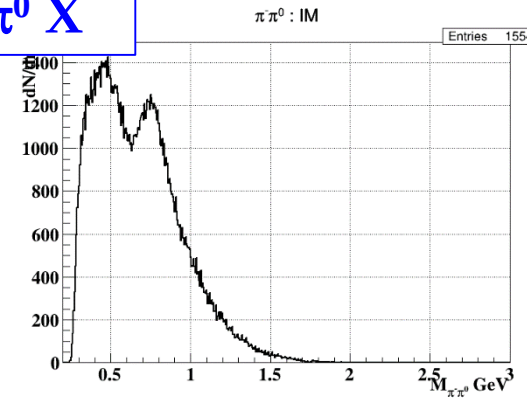
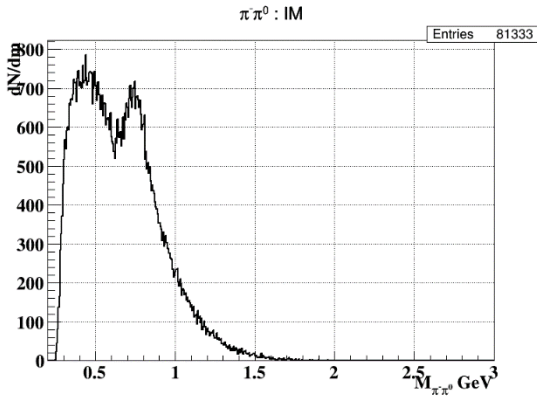
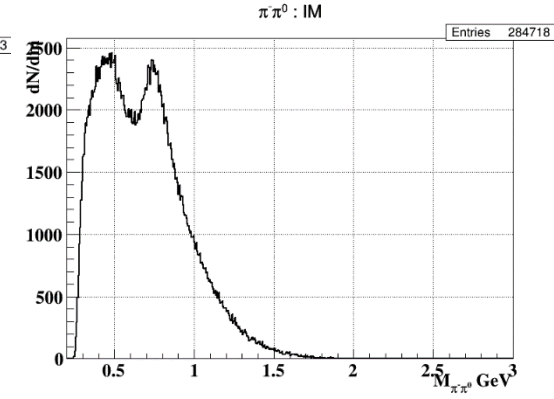
rg-A outbending



rg-B inbending

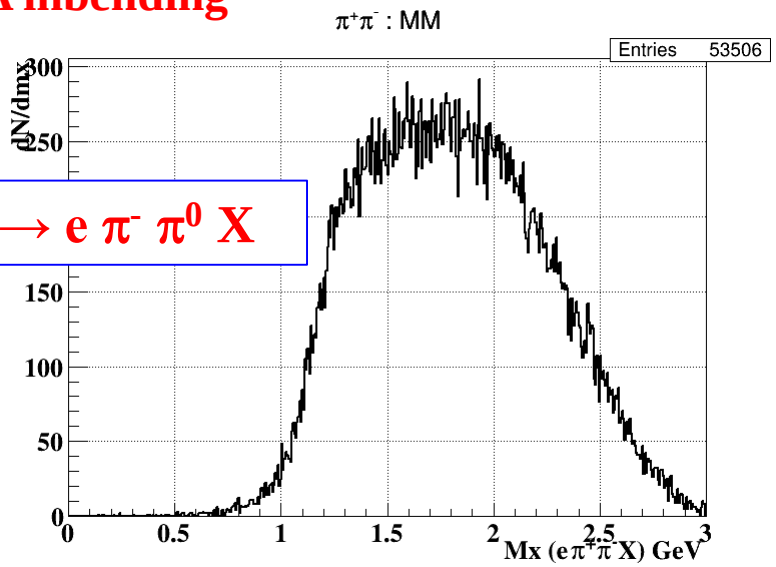


Two-pion invariant mass

	rg-A inbending	rg-A outbending	rg-B inbending
$e N \rightarrow e \pi^+ \pi^- X$			
$e N \rightarrow e \pi^+ \pi^0 X$			
$e N \rightarrow e \pi^- \pi^0 X$			

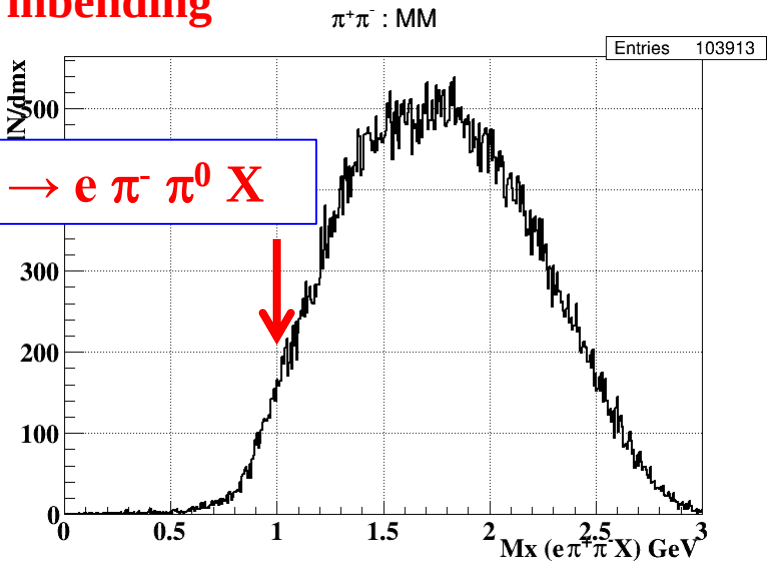
Exclusive ρ^- on the neutron

rg-A inbending



$e\ p \rightarrow e\ \pi^-\ \pi^0\ X$

rg-B inbending

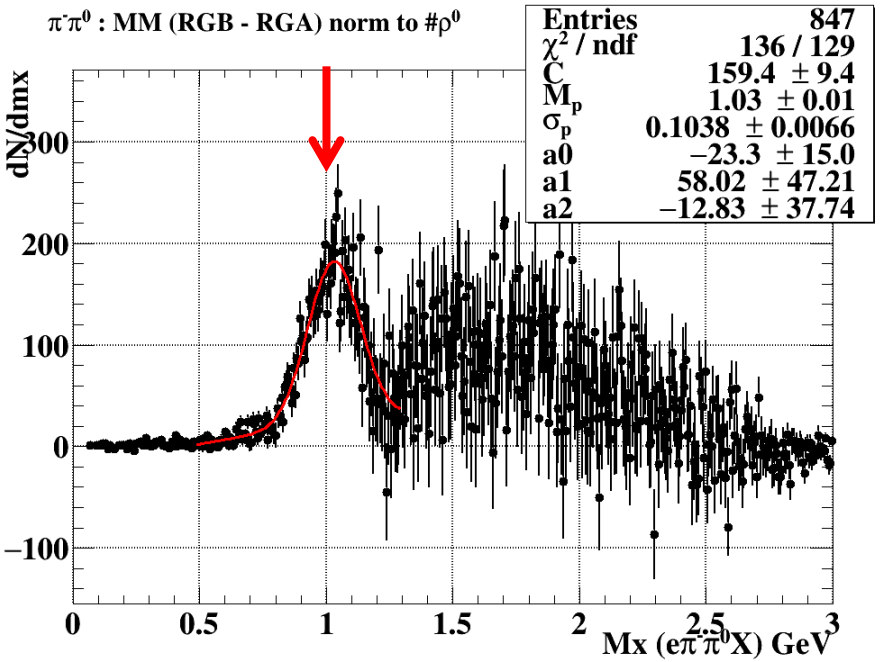


$e\ N \rightarrow e\ \pi^-\ \pi^0\ X$

$e\ n \rightarrow e\ \rho^-\ (p)$

$\pi^-\ \pi^0$

Normalized difference between deuteron and proton data



To be corrected by π^0 background, different resolutions, Fermi motion, etc.

Preparation for jeopardy PAC

« New developments since PAC approval »

- Creation of RGB
- New RG proposals joining RGB
- Hardware: new detectors (CLAS12! + FT, CND, RICH, BAND)
- The **running** of the « first half » of RGB:
  - ✓ Overall performances: ABUs, luminosity, number of triggers
  - ✓ **Beam energy differences and impact on data** →
  - ✓ Conditions (inbending, outbending)
- **Preliminary results** (with a subset of data)
  - ✓ nDVCS BSA
  - ✓ G_M^n
  - ✓ SIDIS? Di-hadron?
  - ✓ Tagged DIS with BAND
  - ✓ New « unplanned » results (pDVCS, dDVCS,…)

Study done for nDVCS:
Strong variations (up to a factor of 2) of BH+nDVCS CS at fixed kinematics for the 3 different beam energies
→ definition of central kinematics to combine BSA bin-by-bin is challenging and model dependent

Beam-time request

- ***How much beam time will we ask for?***
  nDVCS was approved for 90 days. Should we use **ABUs** or **charge collected vs expected at 10^35**?
  Days left according to ABUs ~ **51.1**
  Days left according to expected charge ~ **61.1**
- ***Do we account for the beam energy differences in the request?***
- ***Do we include extra days due to outbending/inbending running?***

Conclusions

- The first « half » of RG-B running ended on January 30
- ~38.9 PAC days collected out of 90
- Three different beam energies for the 3 periods
- Calibrations almost complete for the spring dataset
- Calibrations well advanced for fall and winter datasets
- We would like to start the review for pass-1 (spring data)
- Physics analyses in good progress: n/p/d-DVCS, Di-hadron SIDIS, G^n_M, Tagged-DIS
- Preparation for jeopardy PAC underway

All this is possible thanks to our great RG-B team
Special thanks to:
Chef: Zhiwen Zhao
Monitoring: Yordanka Ilieva
Timelines: Sangbaek Lee
+ all detector experts and **calibrators**!

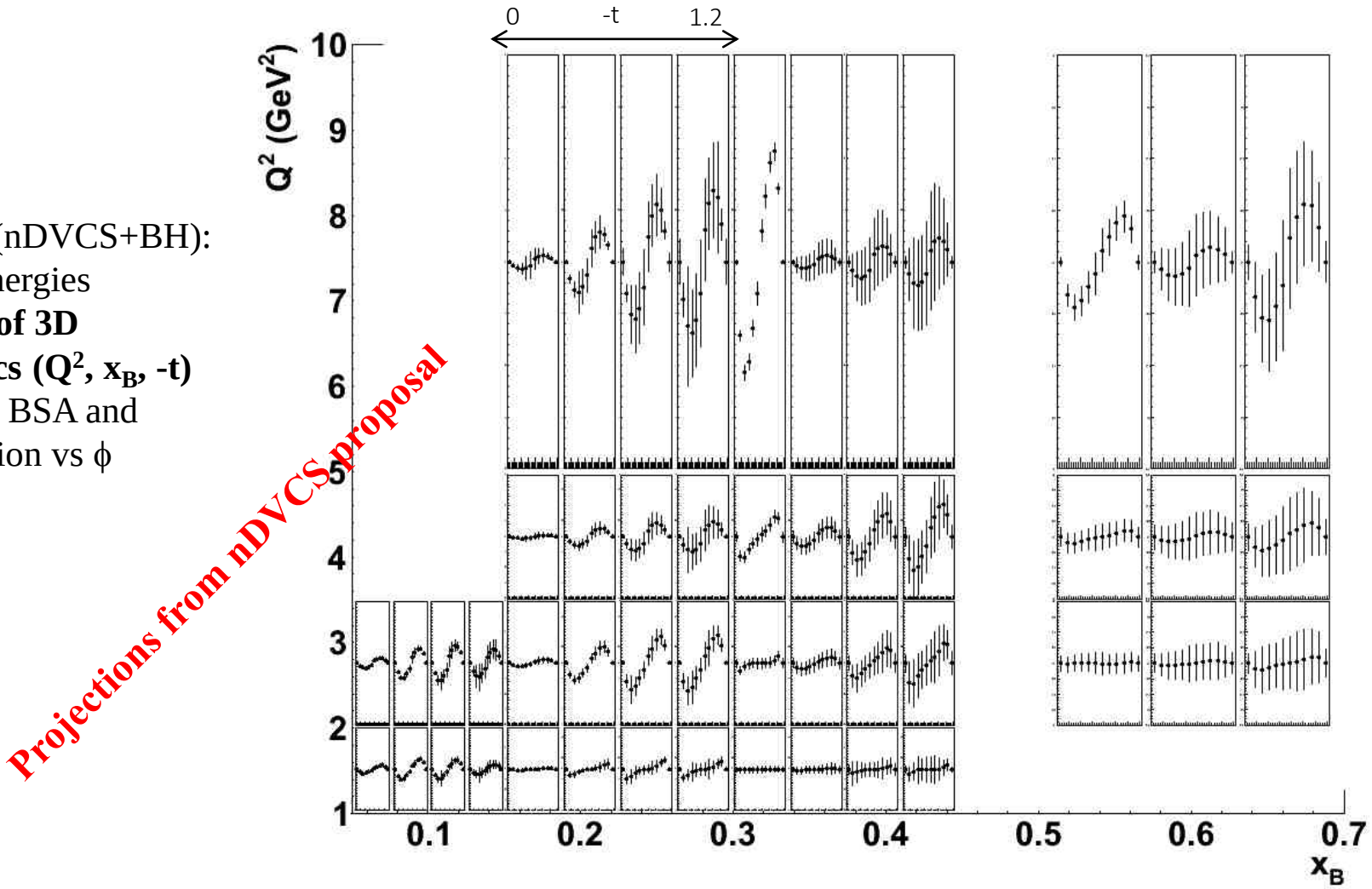
Back-up slides

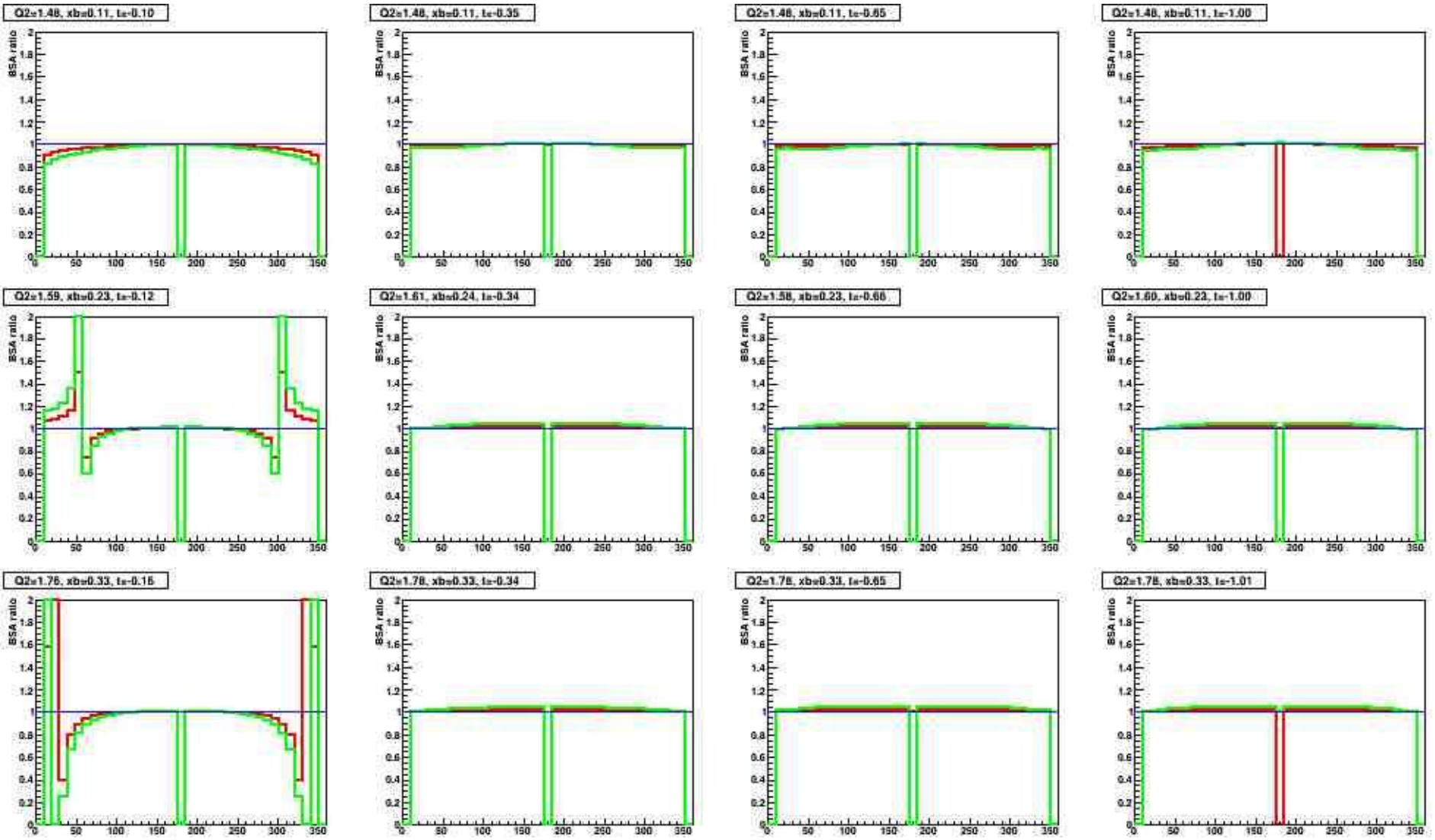
Measurement of BSA for nDVCS-BH with 3 different beam energies

RG-B ran at 3 different beam energies: 10.6 GeV, 10.2 GeV, 10.4 GeV
Can we combine (and how?) the BSA extracted from the 3 sets?

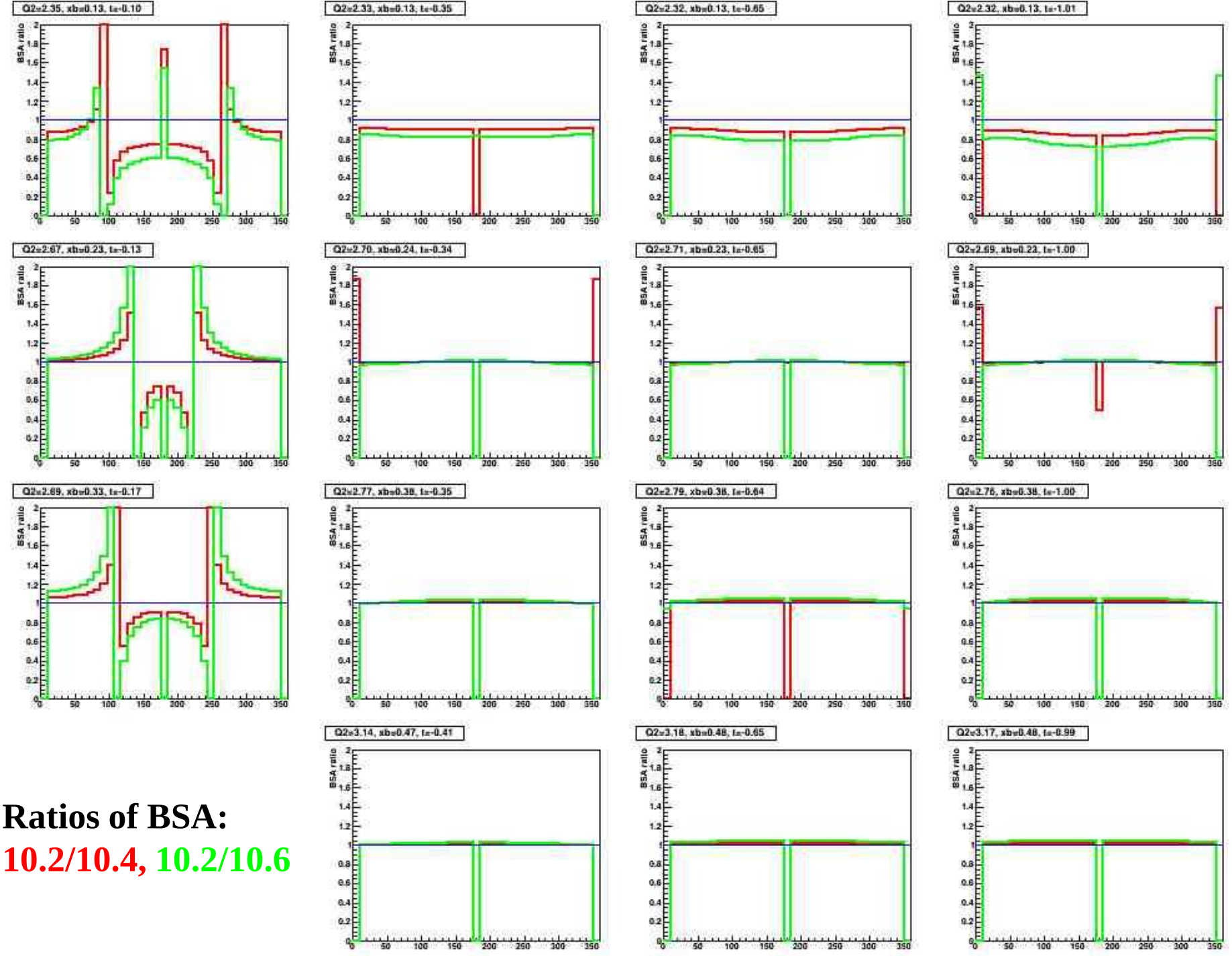
VGG model (nDVCS+BH):

- 3 beam energies
- **same set of 3D kinematics (Q^2, x_B, -t)**
- computed BSA and cross section vs ϕ





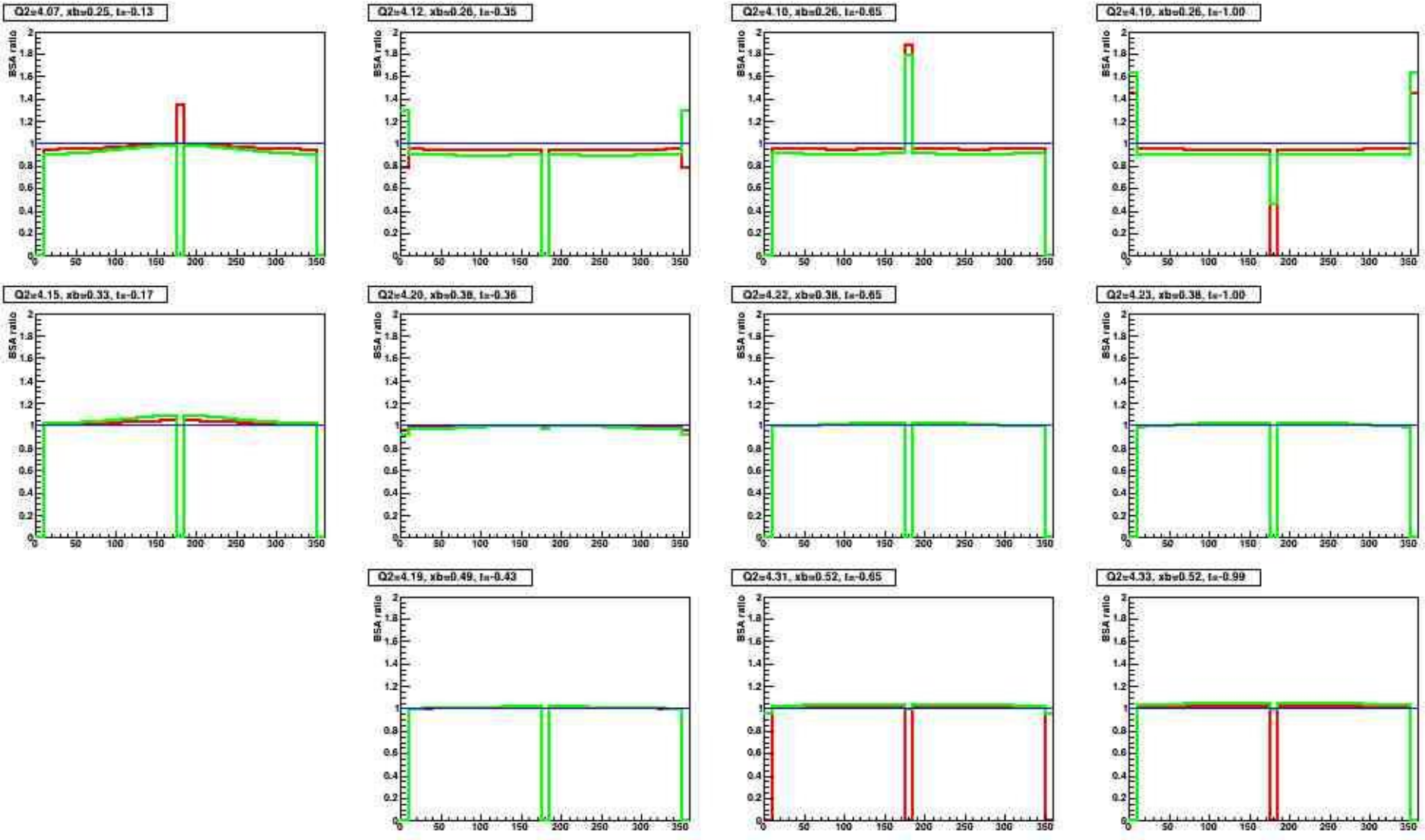
Ratios of BSA: 10.2/10.4, 10.2/10.6



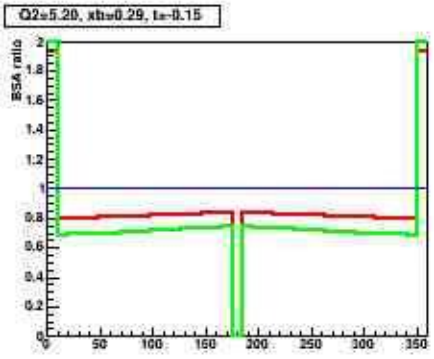
Ratios of BSA:

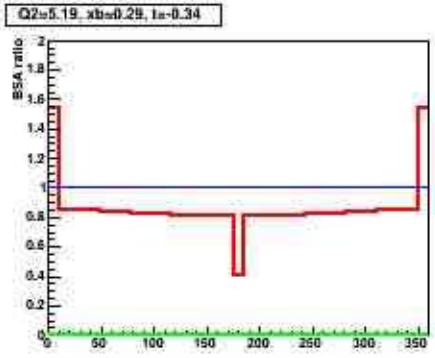
10.2/10.4, 10.2/10.6

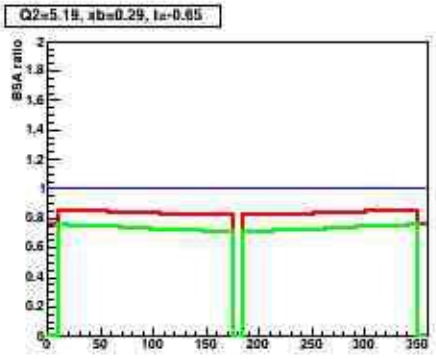
Ratios of BSA: 10.2/10.4, 10.2/10.6

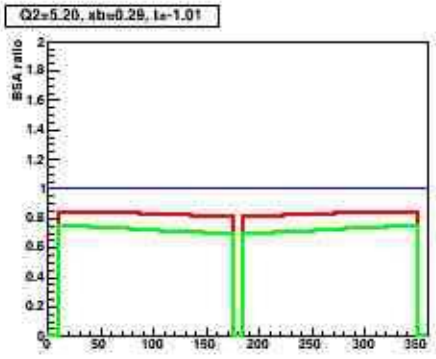


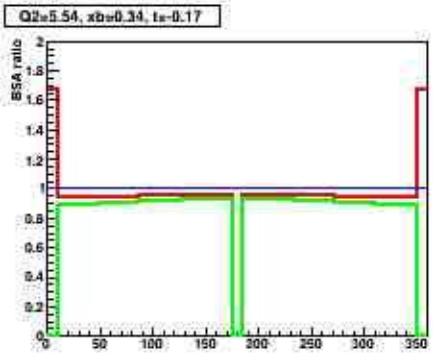
Ratios of BSA: 10.2/10.4, 10.2/10.6

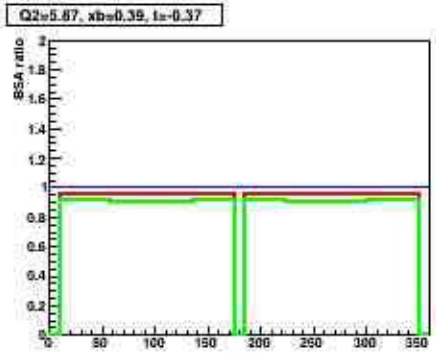


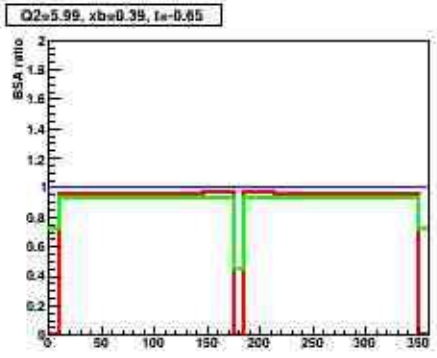


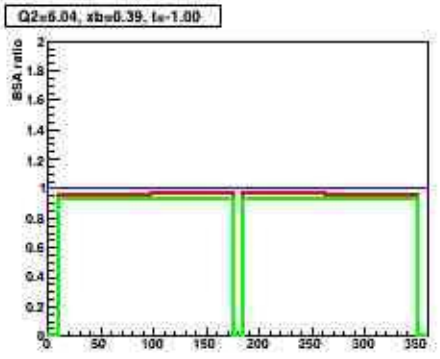


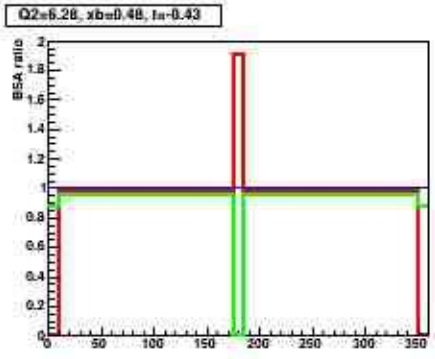


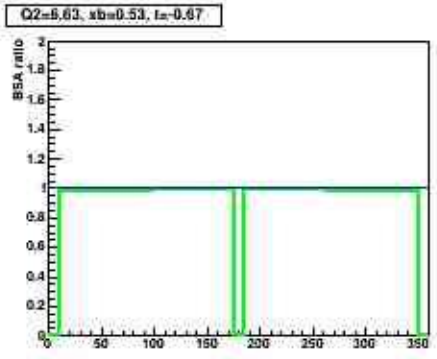


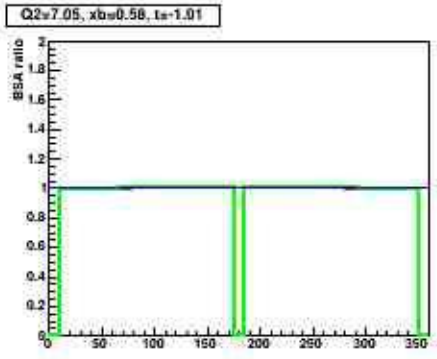


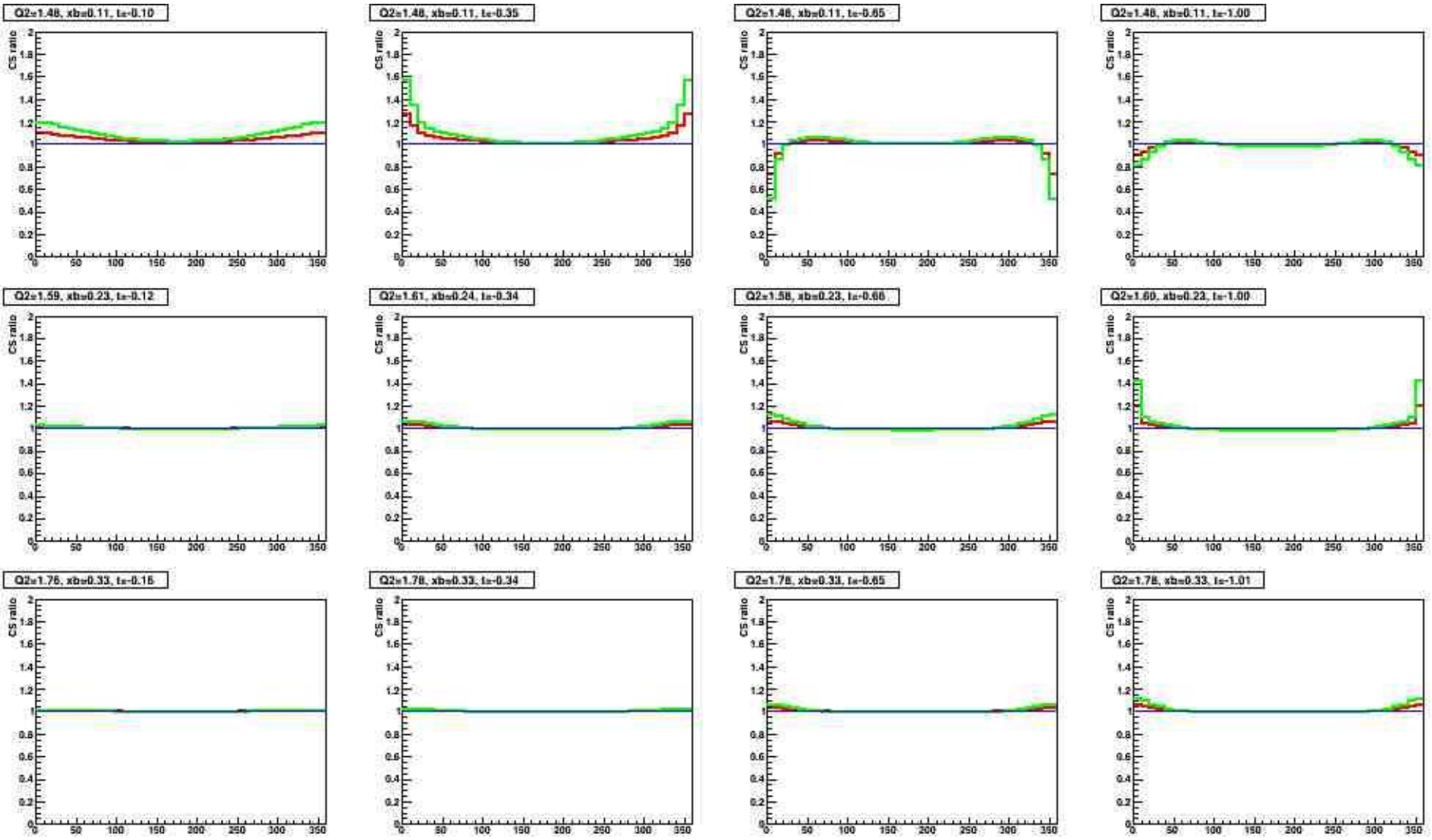




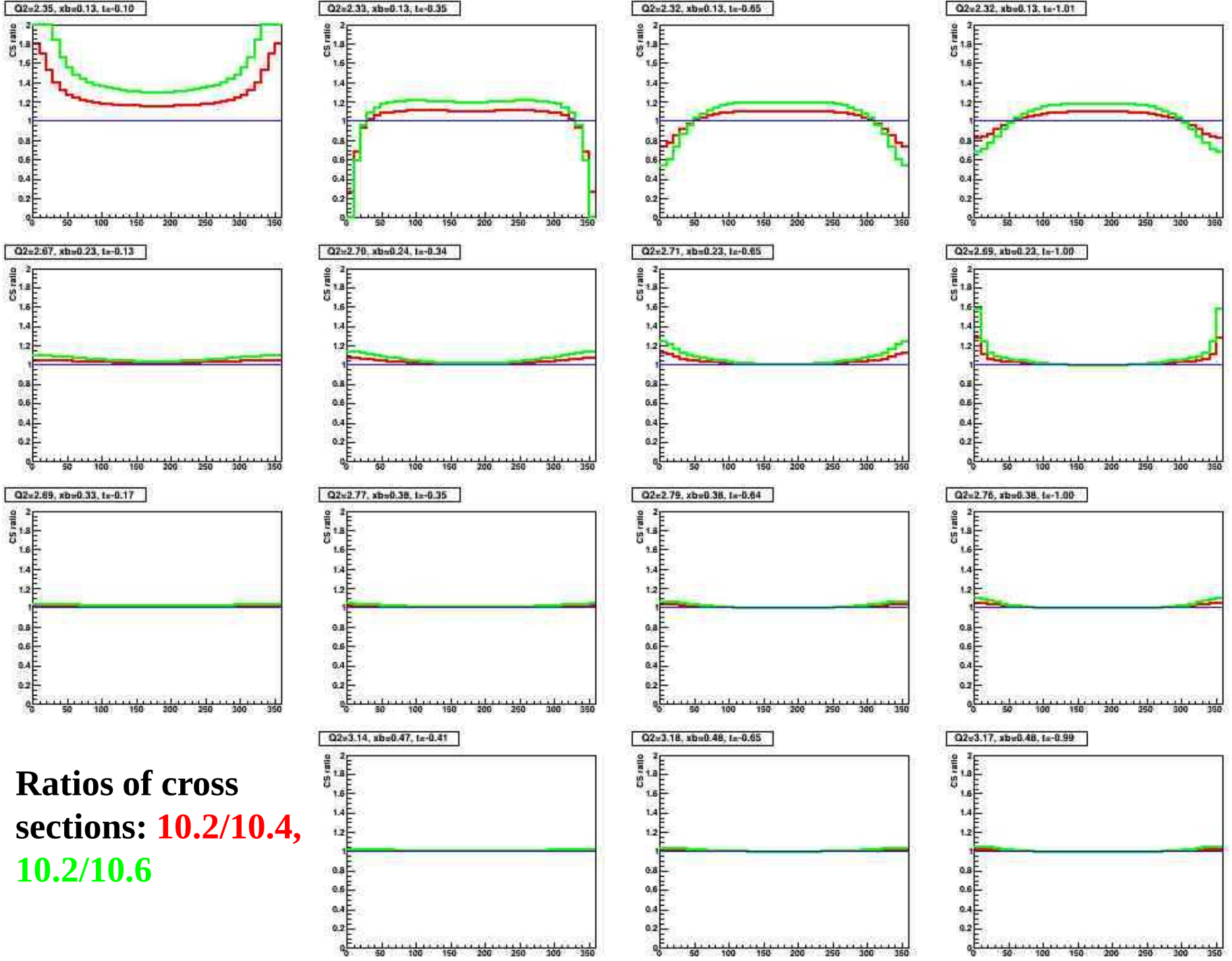






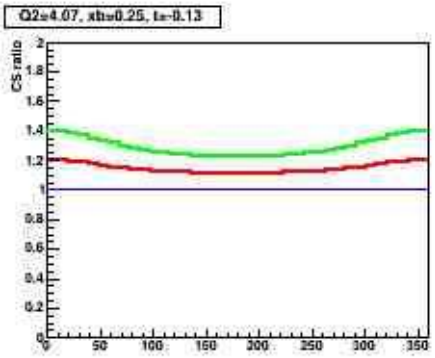


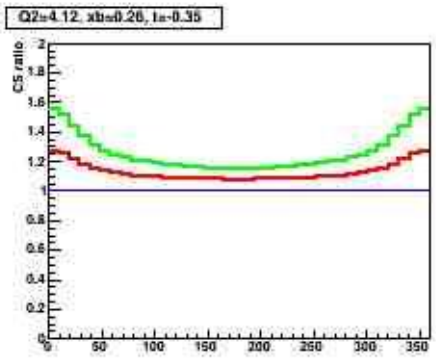
Ratios of cross sections: 10.2/10.4, 10.2/10.6

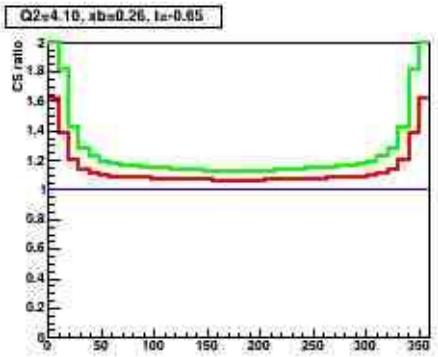


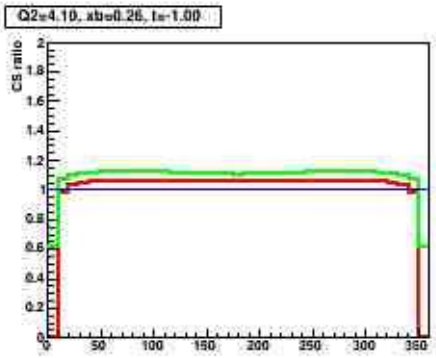
Ratios of cross sections: 10.2/10.4, 10.2/10.6

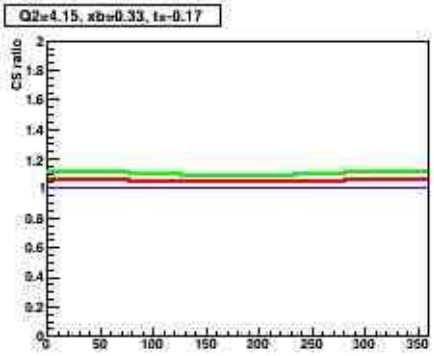
Ratios of cross sections: 10.2/10.4, 10.2/10.6

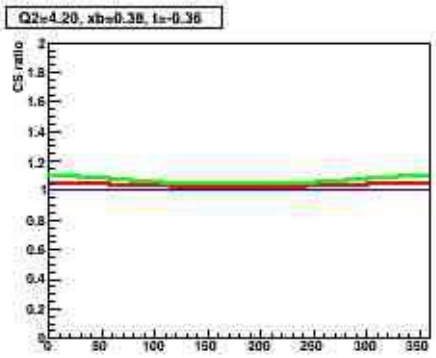


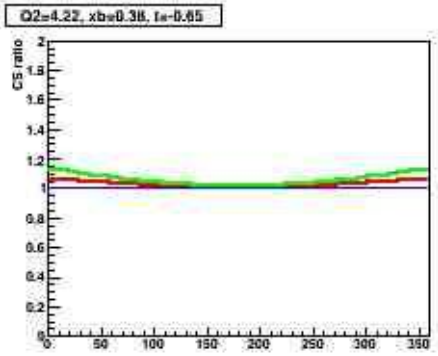


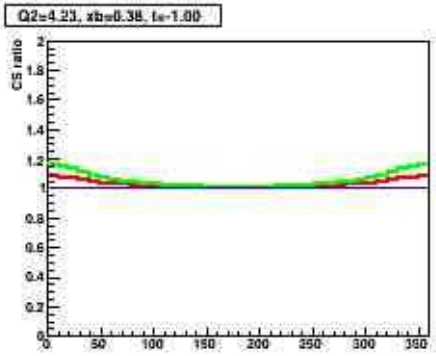


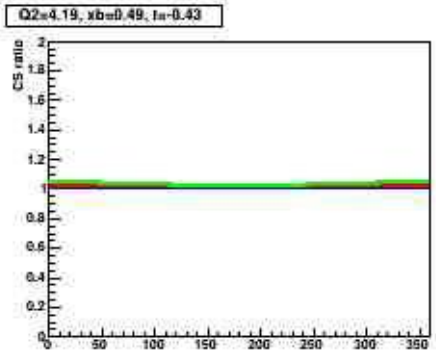


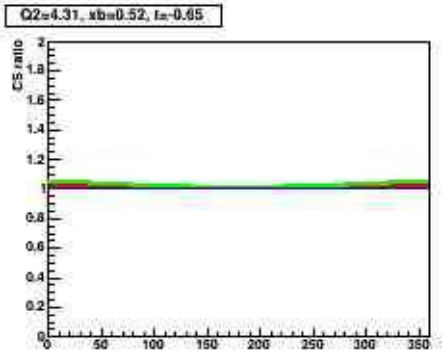


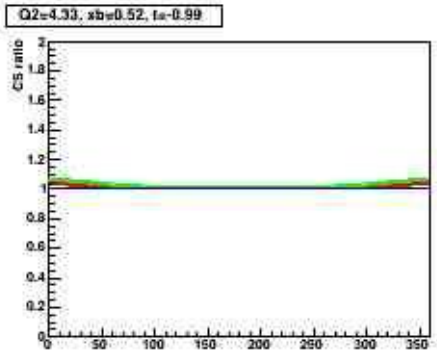




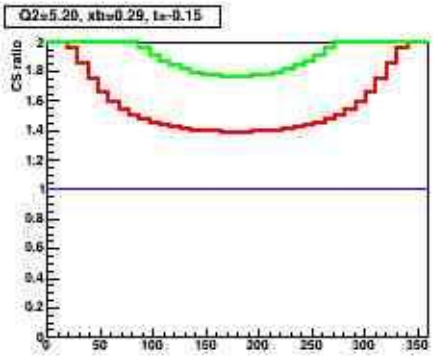


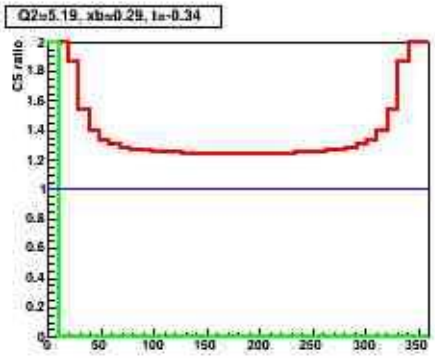


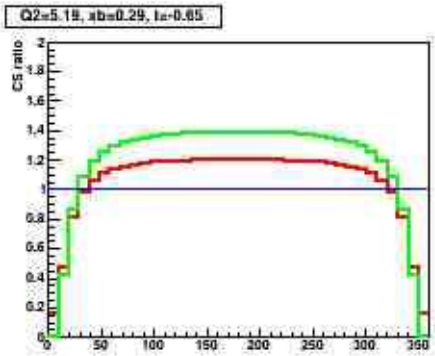


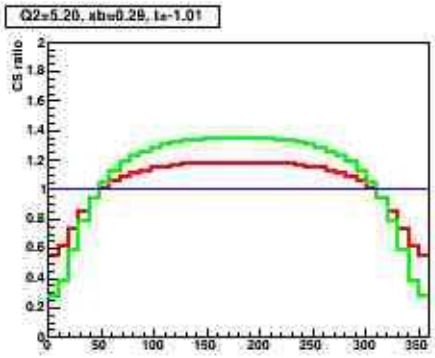


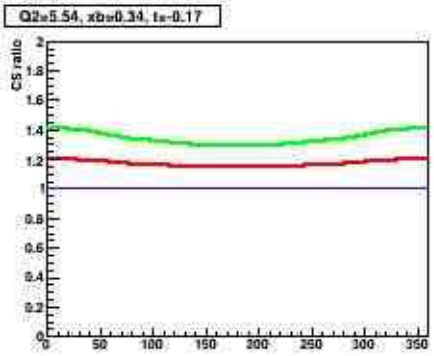
Ratios of cross sections: 10.2/10.4, 10.2/10.6

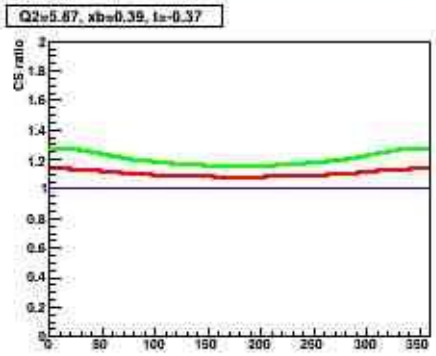


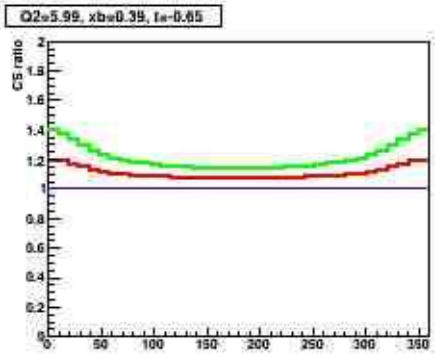


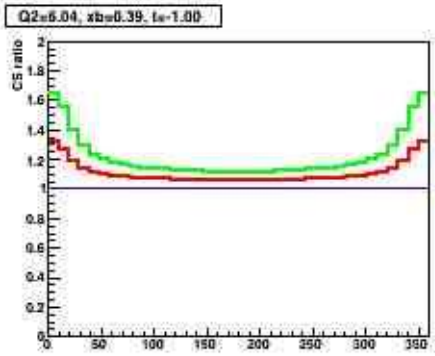


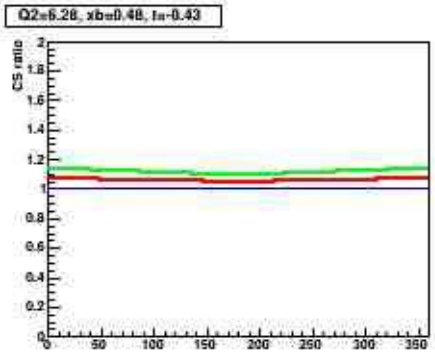


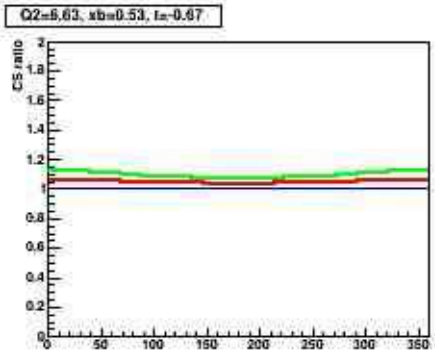


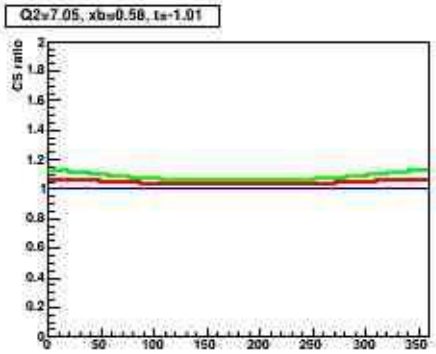












Conclusions

- The BSA is less sensitive than the absolute cross section to the variations of beam energy
- Depending on the kinematics, the BSA varies from a % to 20-30% (especially for 10.2-10.6)
- Strong variations of the CS impact the definition of the central kinematics of each bin
- The edges in ϕ are the most affected (that's where BH dominates), but at the highest Q^2 the effect is over all ϕ
- It will need to be restudied with a more realistic grid of bins
- Definition of central kinematics of the bins quite crucial and not trivial