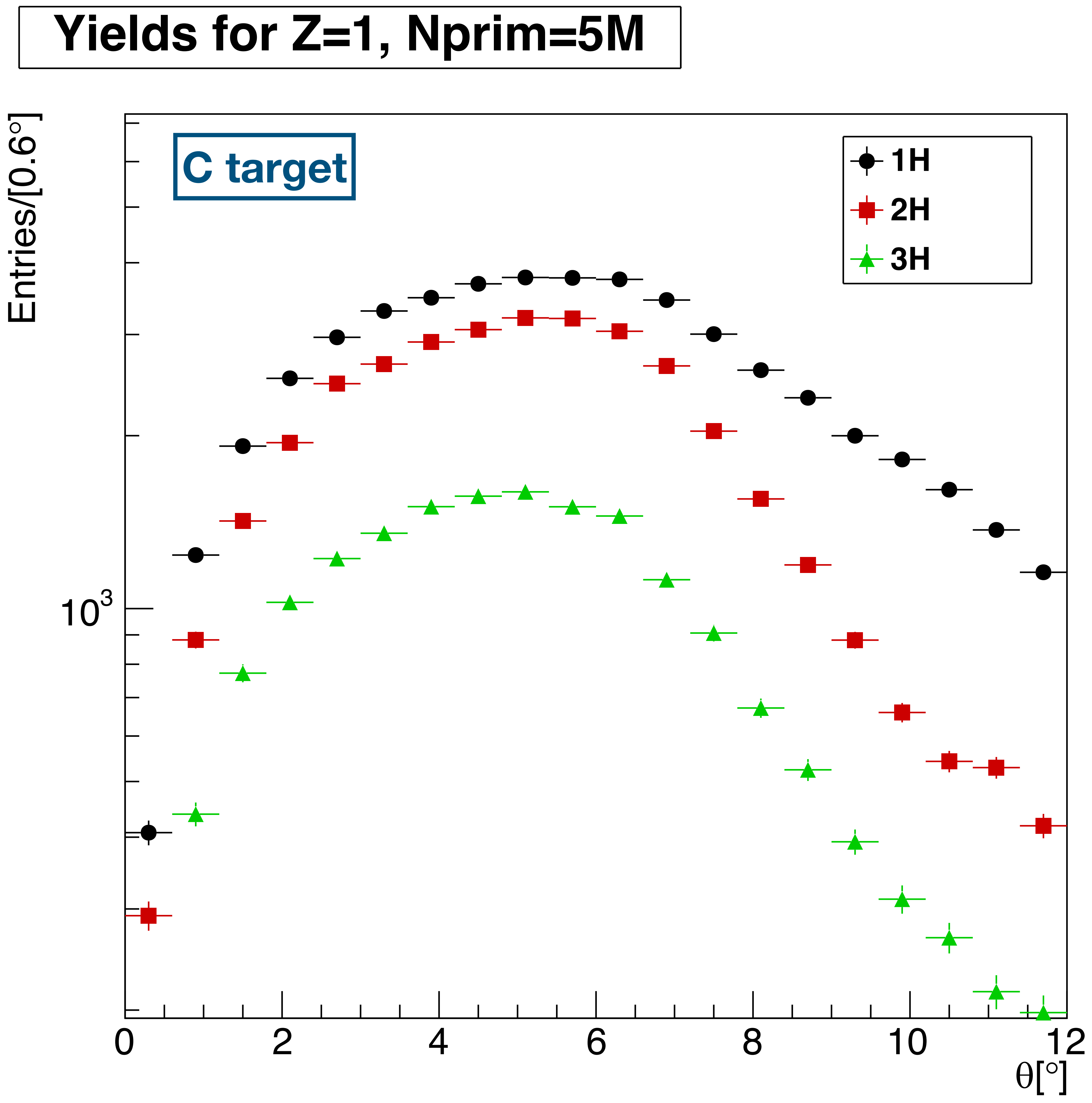
Some considerations about statistics needed @ CNAO2023

CNAO data taking meeting

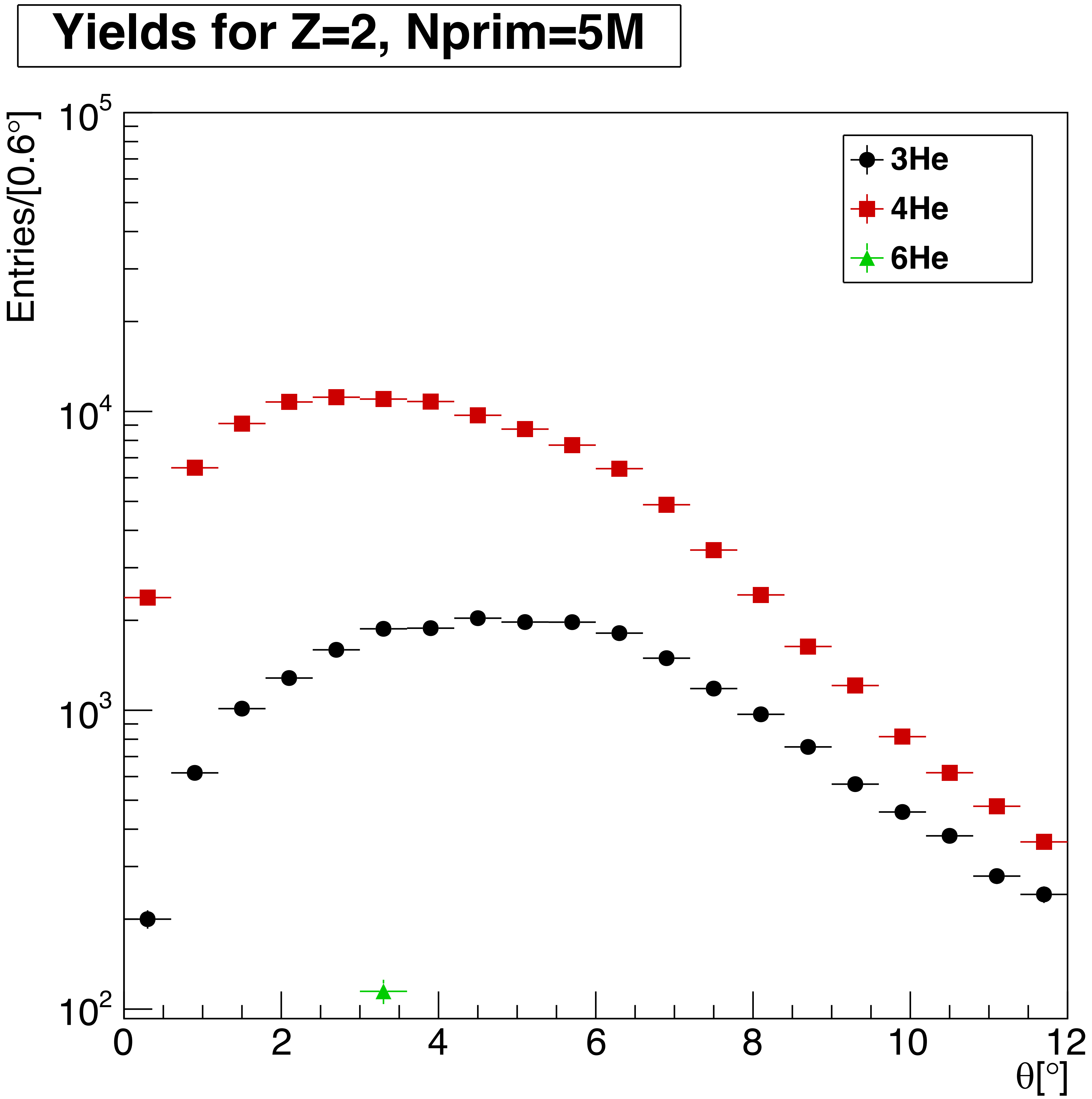
Marco and the Analysis group – 19/10/2023

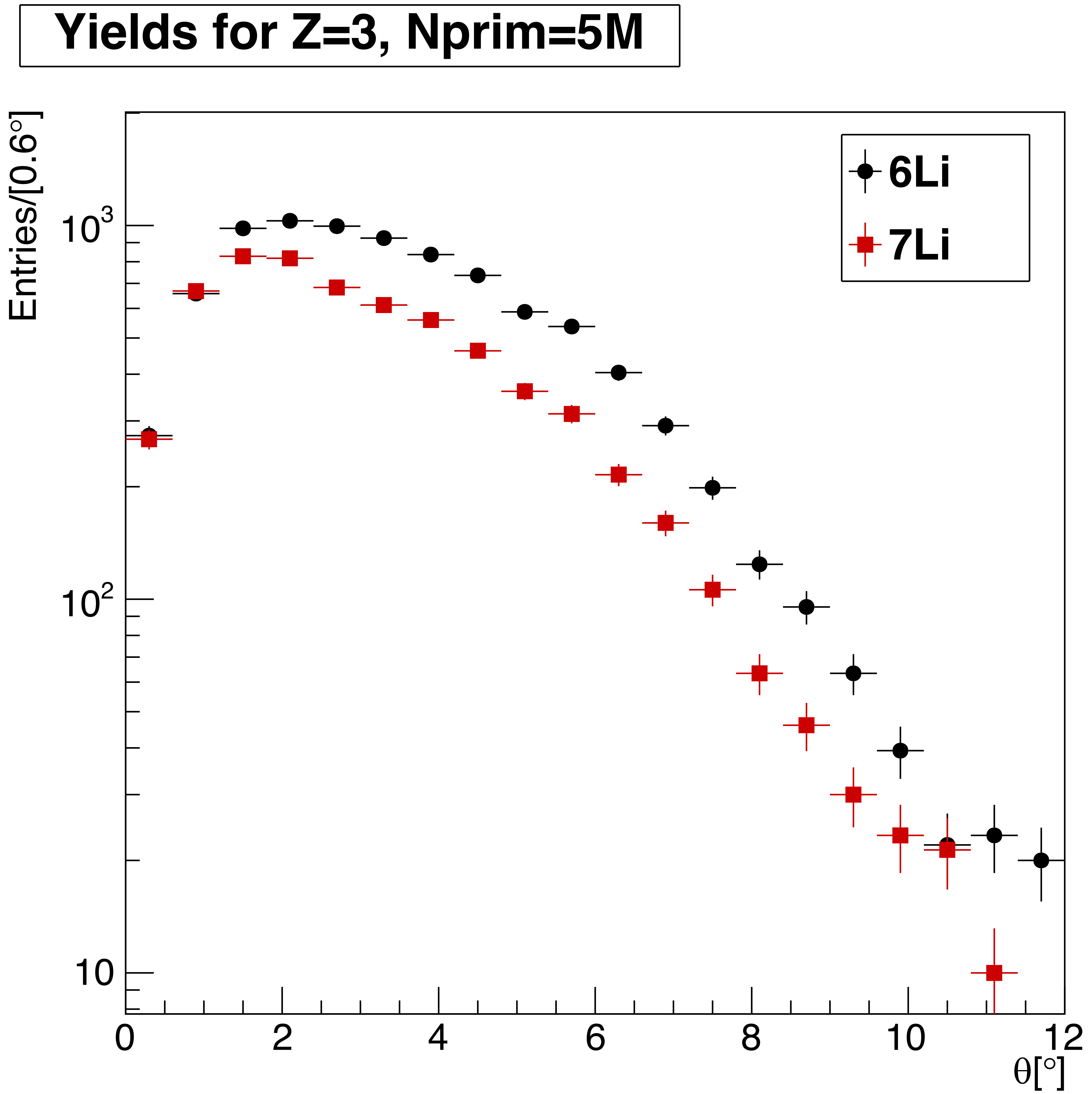
MC tracks selection @ CNAO2023

- Campaign MC: CNAO2023_MC with 1M events with C beam of 200 MeV/u on **C (5 mm) and C_2H_4 (1 cm) targets**
- Selected only tracks crossing the TW from the front with Ekin/u>50 MeV/u at production
- MC truth for isotopes identification (Z+A)
- Theta distribution at production in TG (no BM direction subtraction)
- Applied a flat 60% efficiency (see Yun) cut over all the Z and isotopes (looking already studied simulations efficiency grow up from protons~60% to Nitrogen>90%, without any cut on global tracks)
- Study done only for theta bin (not Ekin)

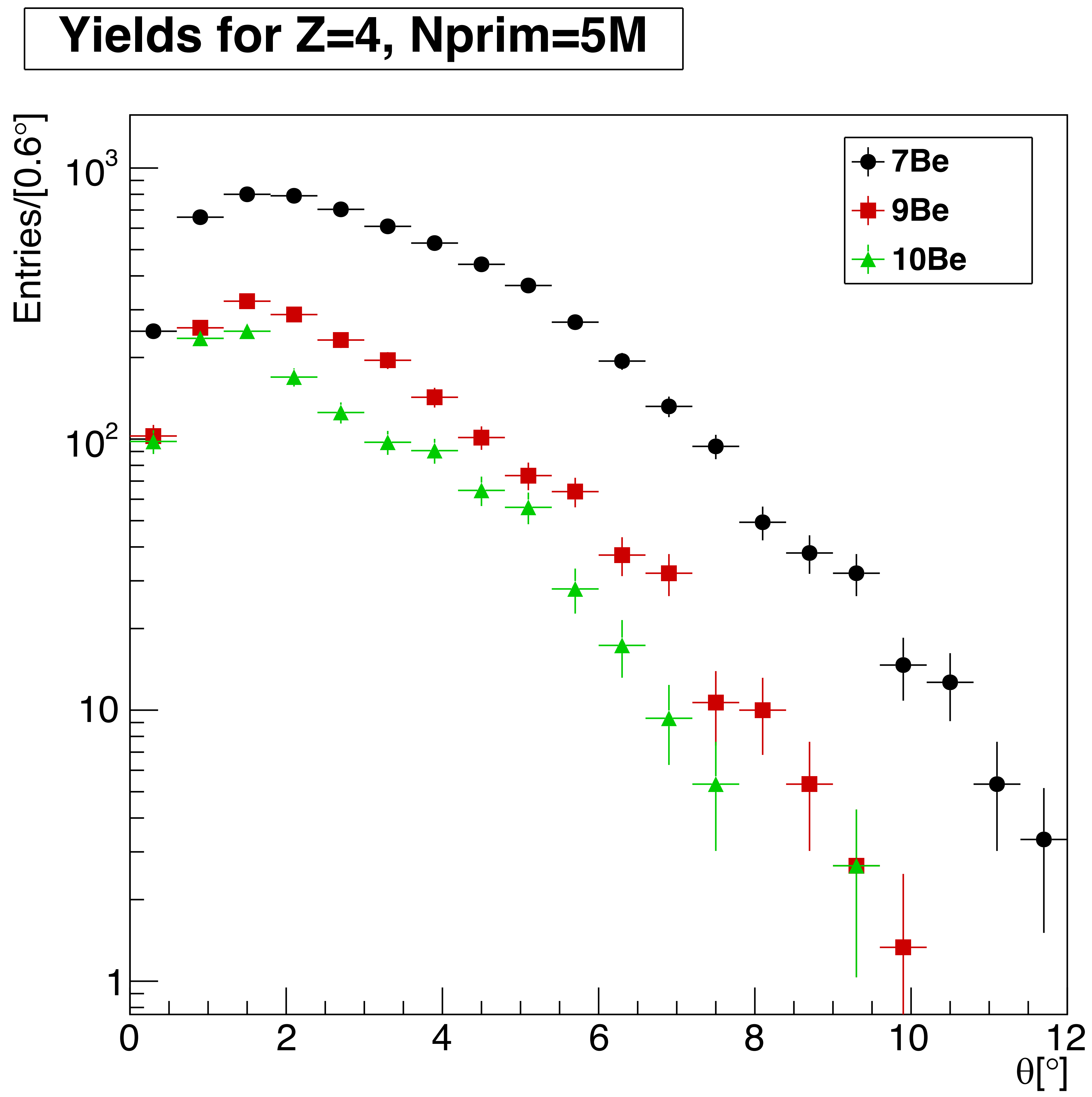


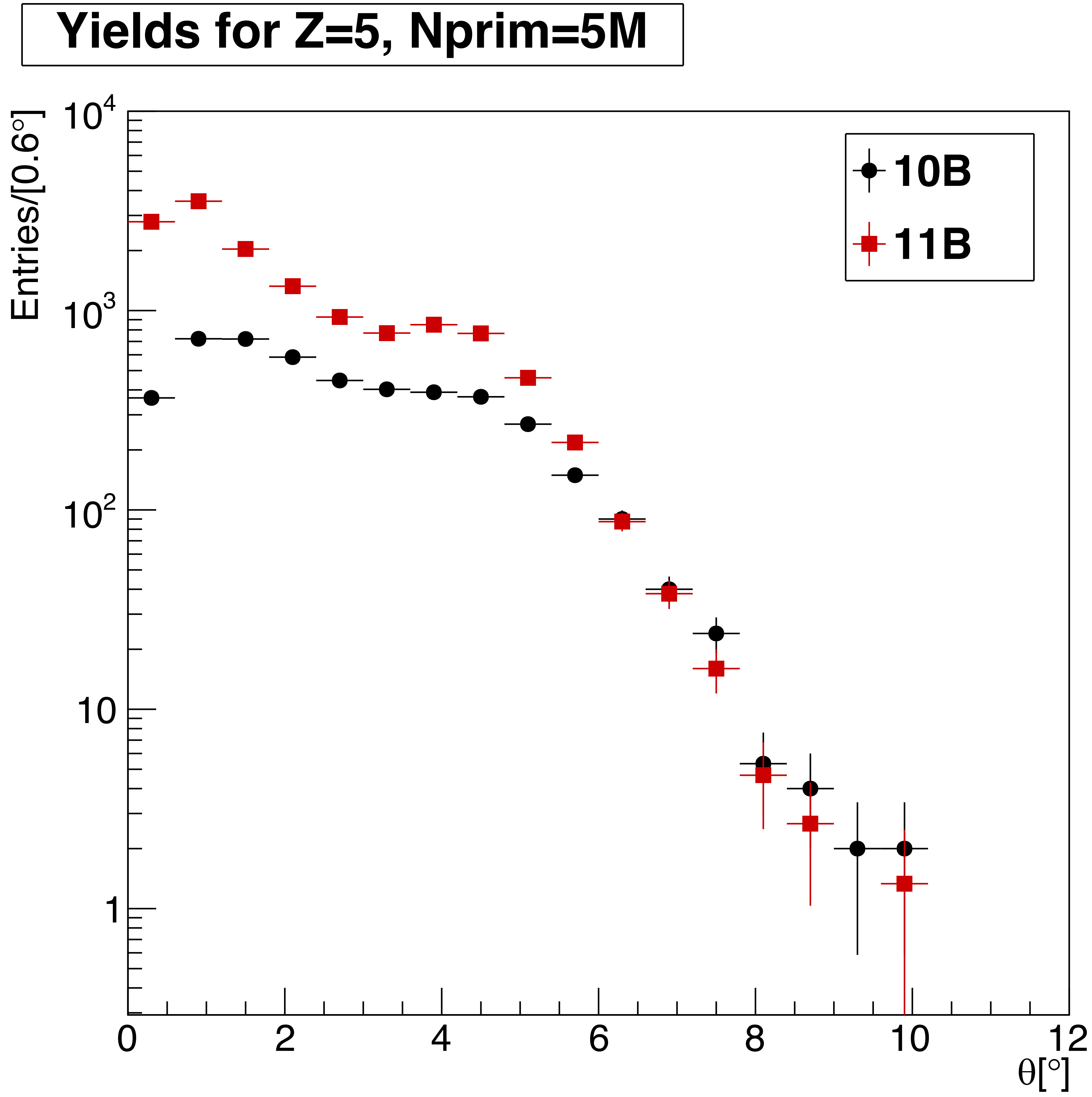
MC tracks selection @ CNAO2023 (12C_C_200)



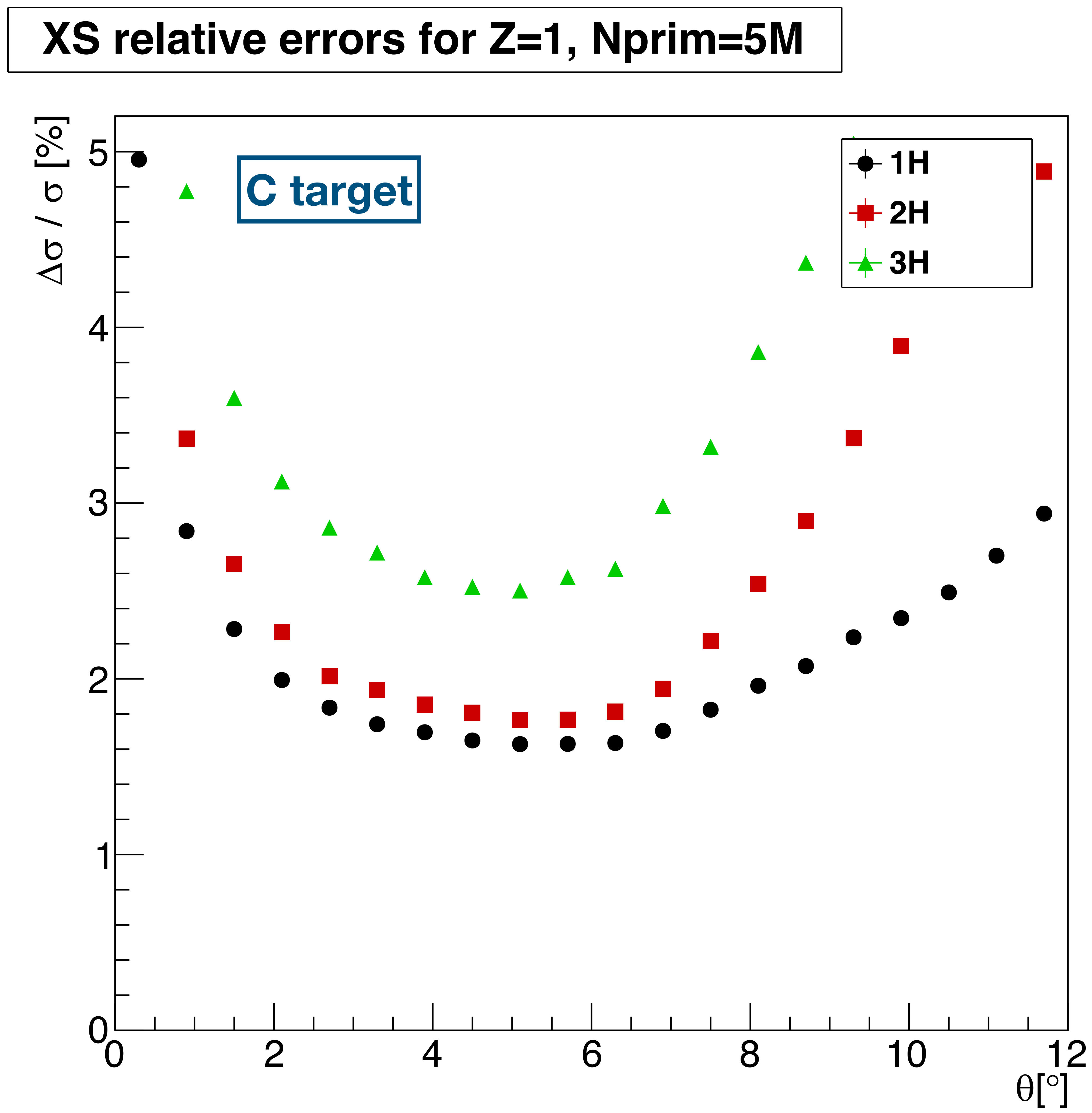


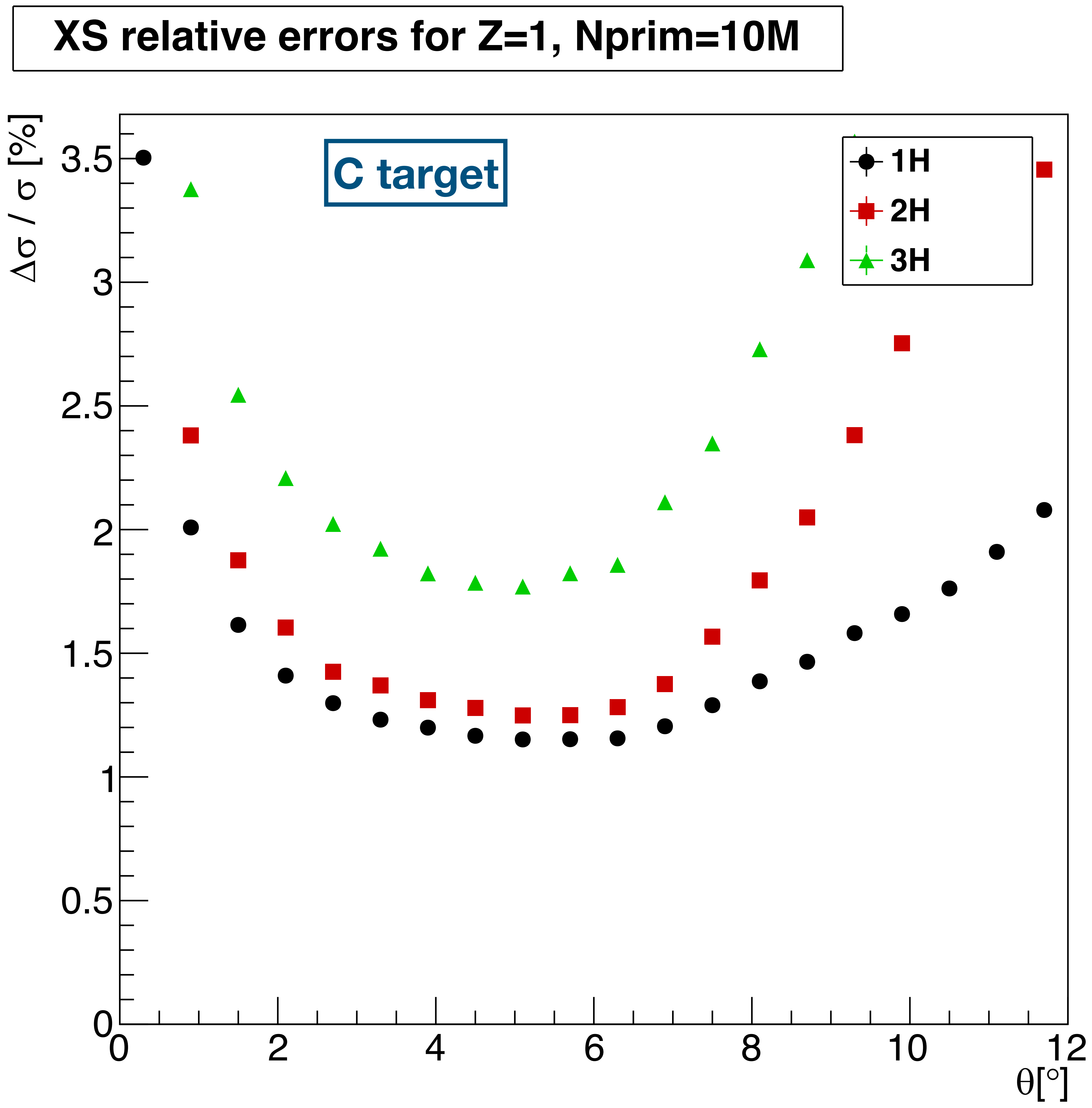
MC tracks selection @ CNAO2023 (12C_C_200)



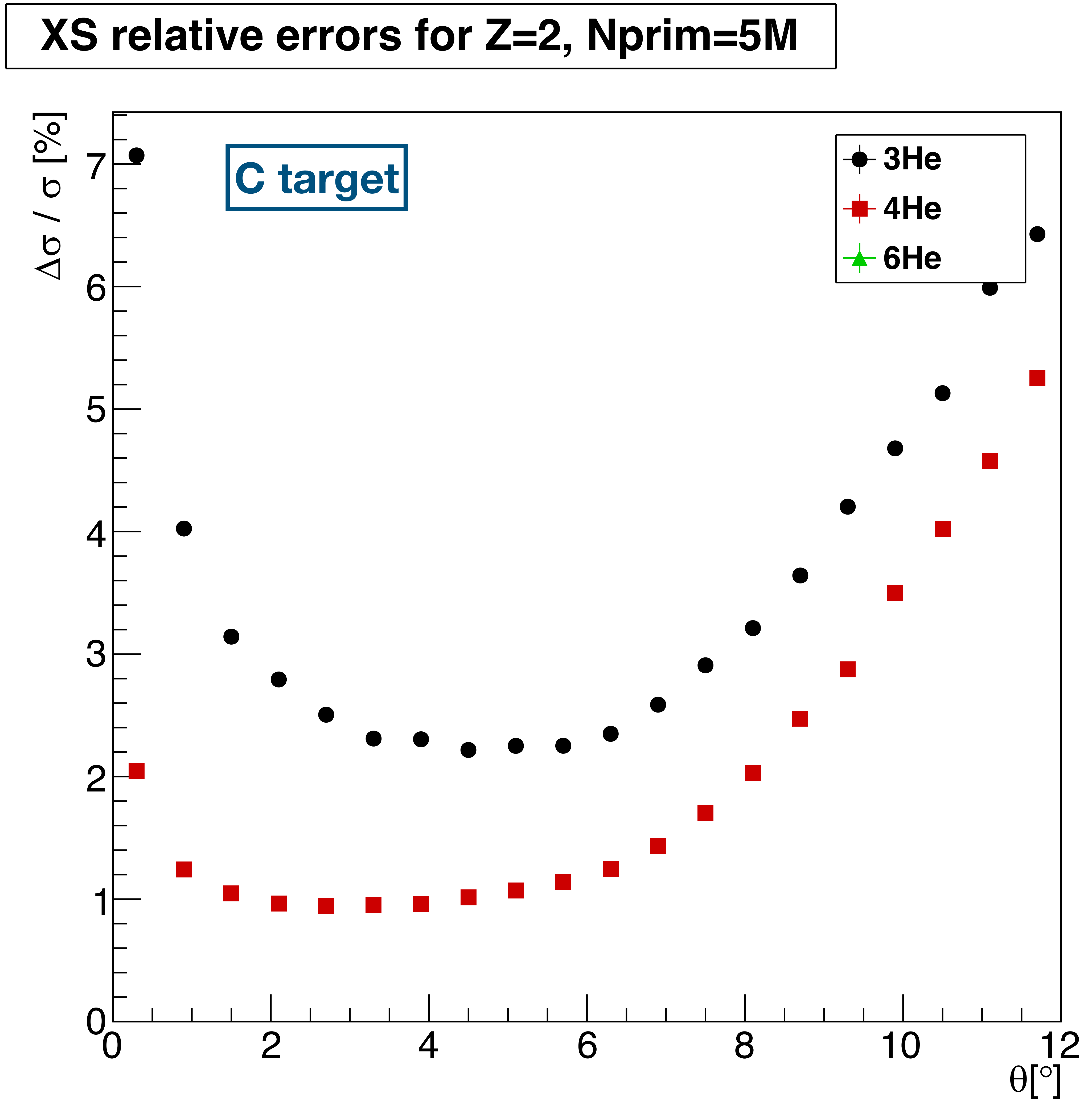


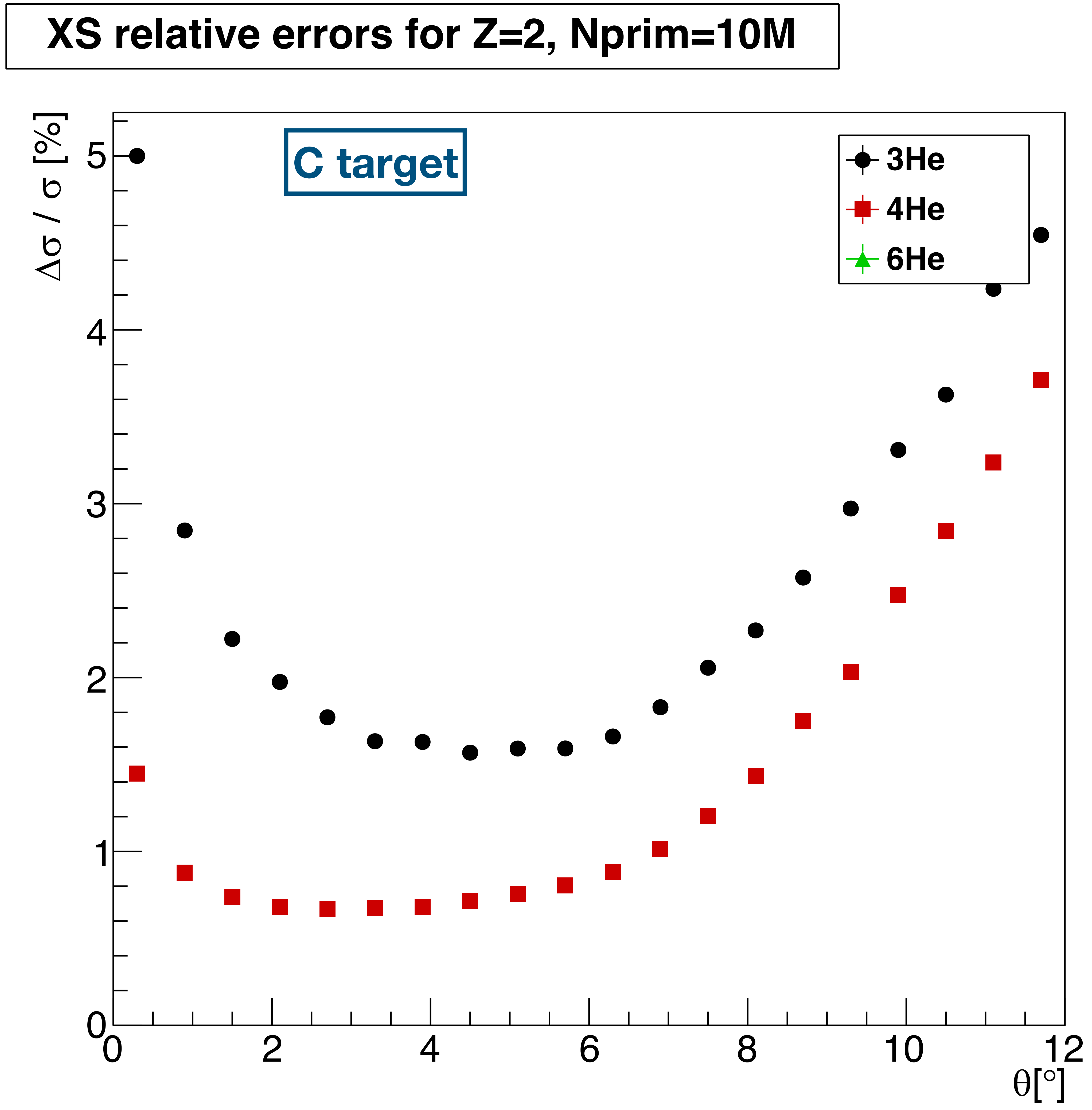
Cross section relative errors (taking into account only yields contribution to the error) – 5M vs 10M events - Z = 1



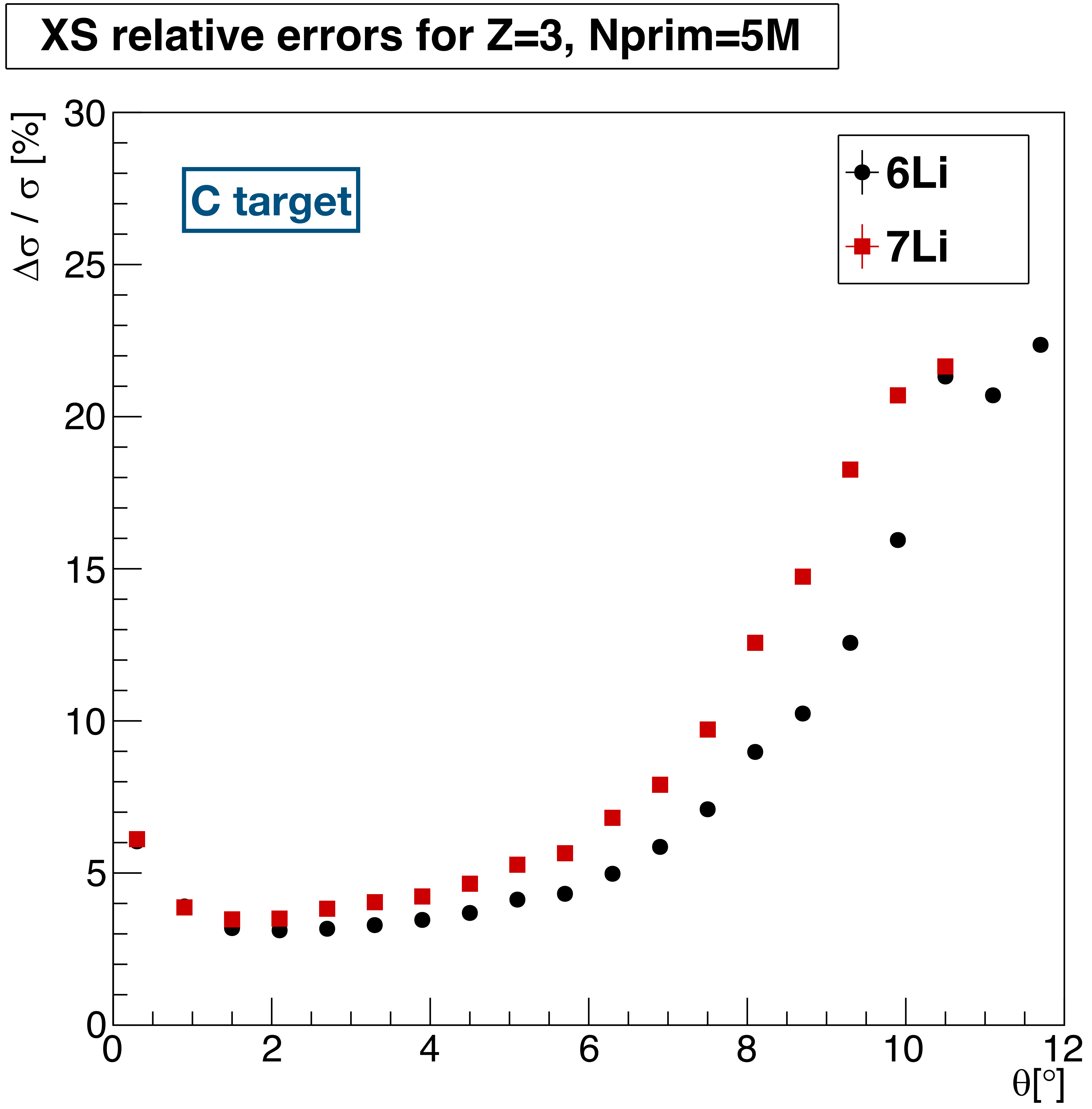


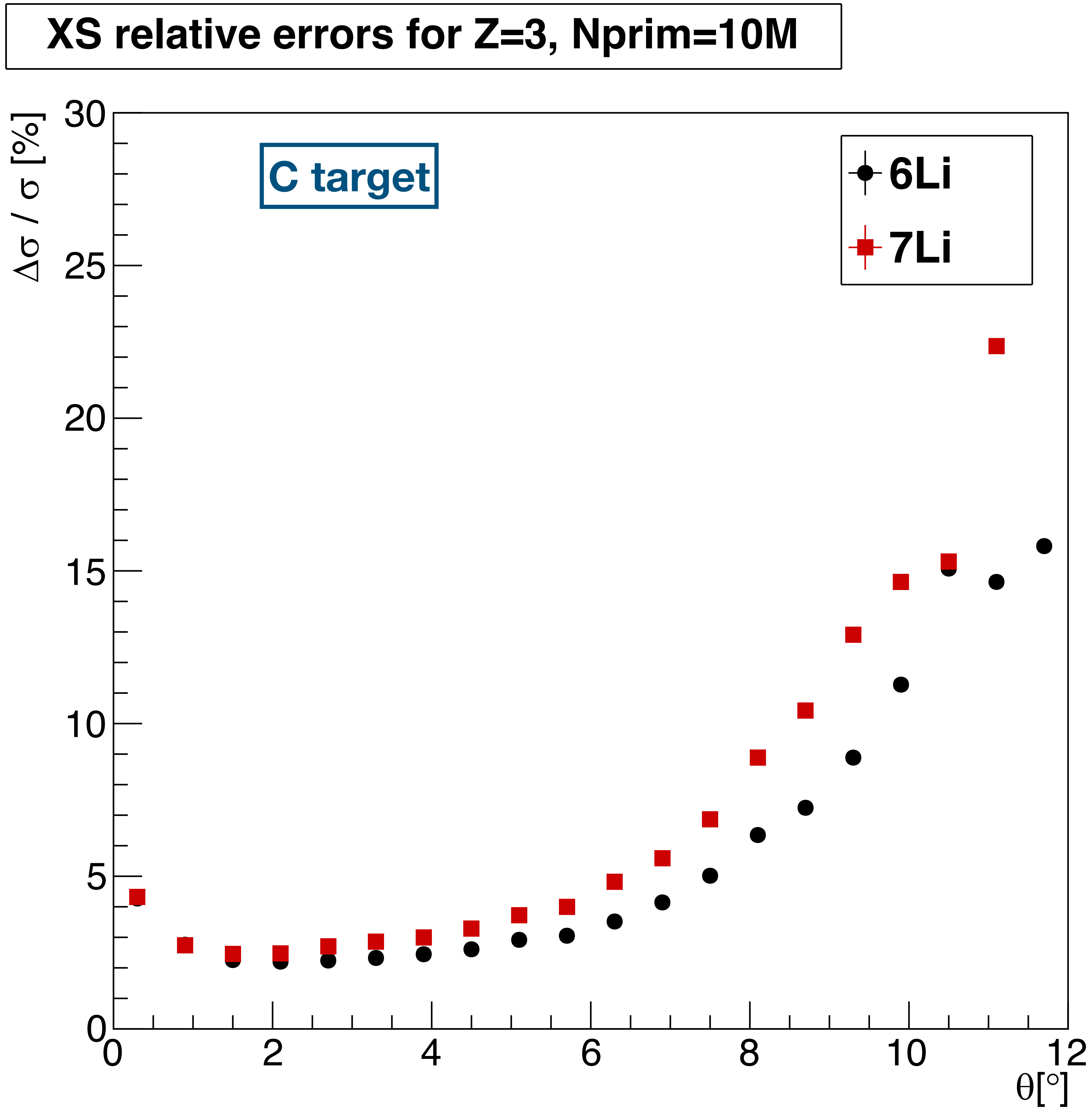
Cross section relative errors (taking into account only yields contribution to the error) – 5M vs 10M events – Z = 2



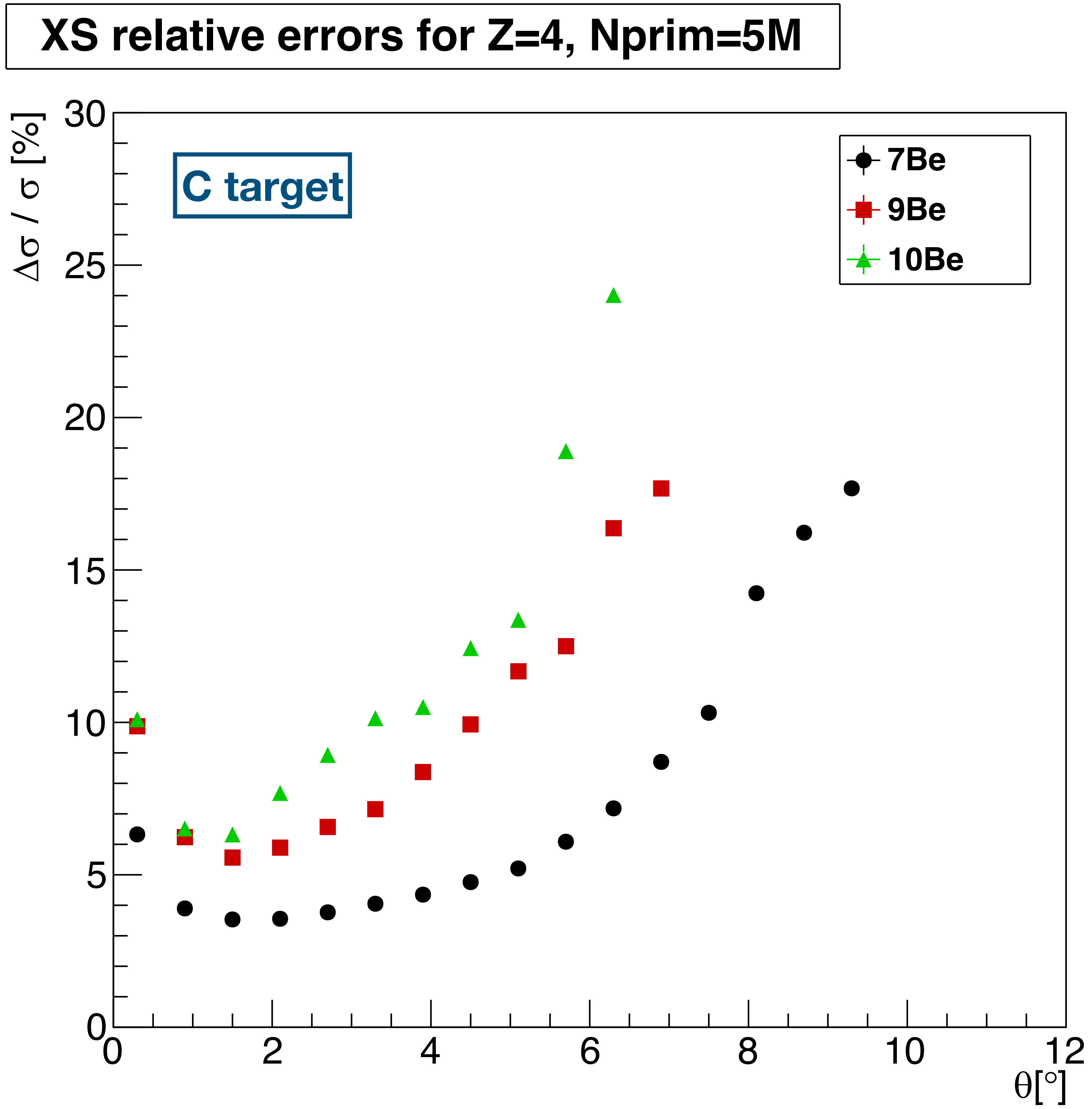


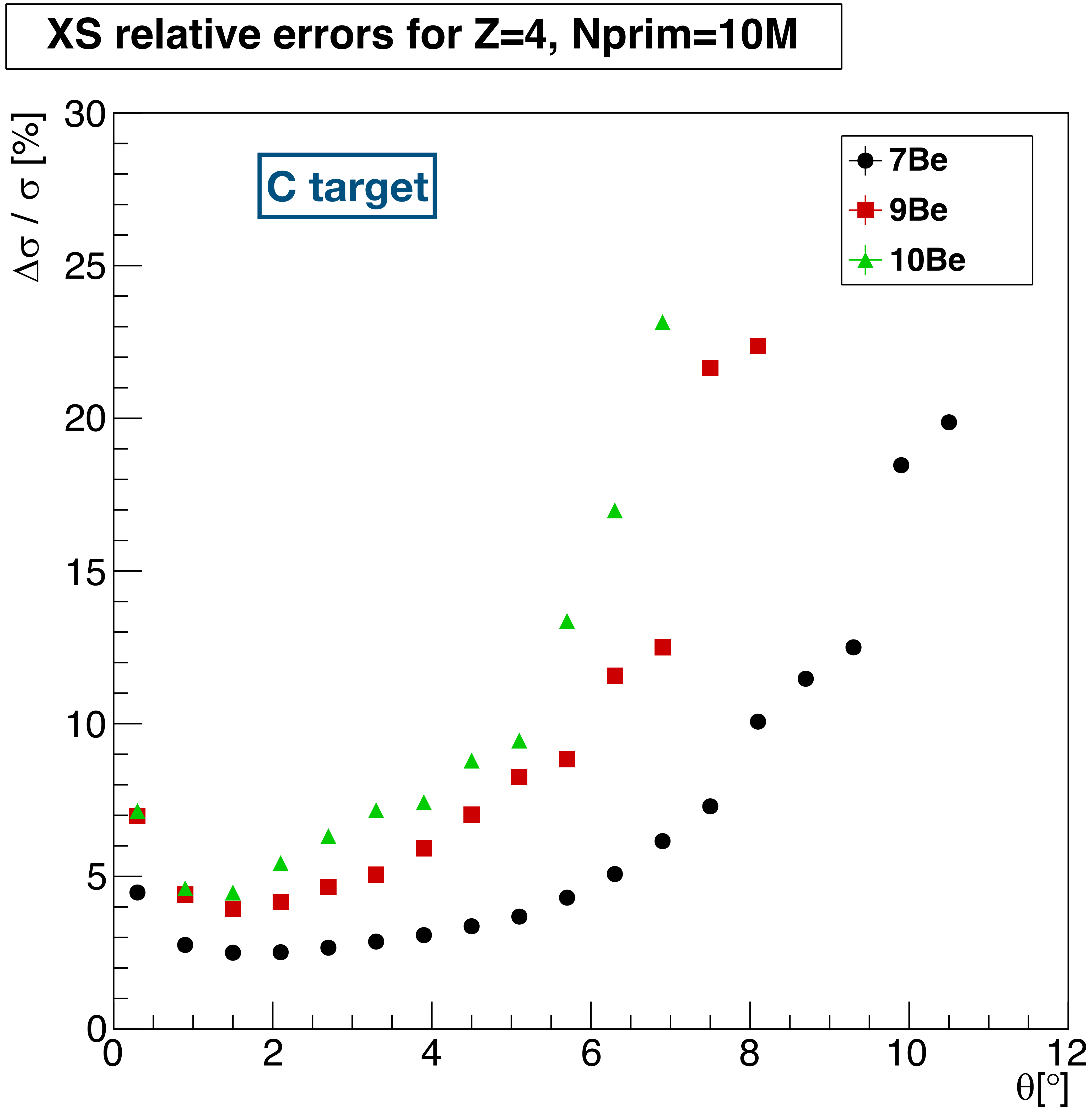
Cross section relative errors (taking into account only yields contribution to the error) – 5M vs 10M events – Z = 3



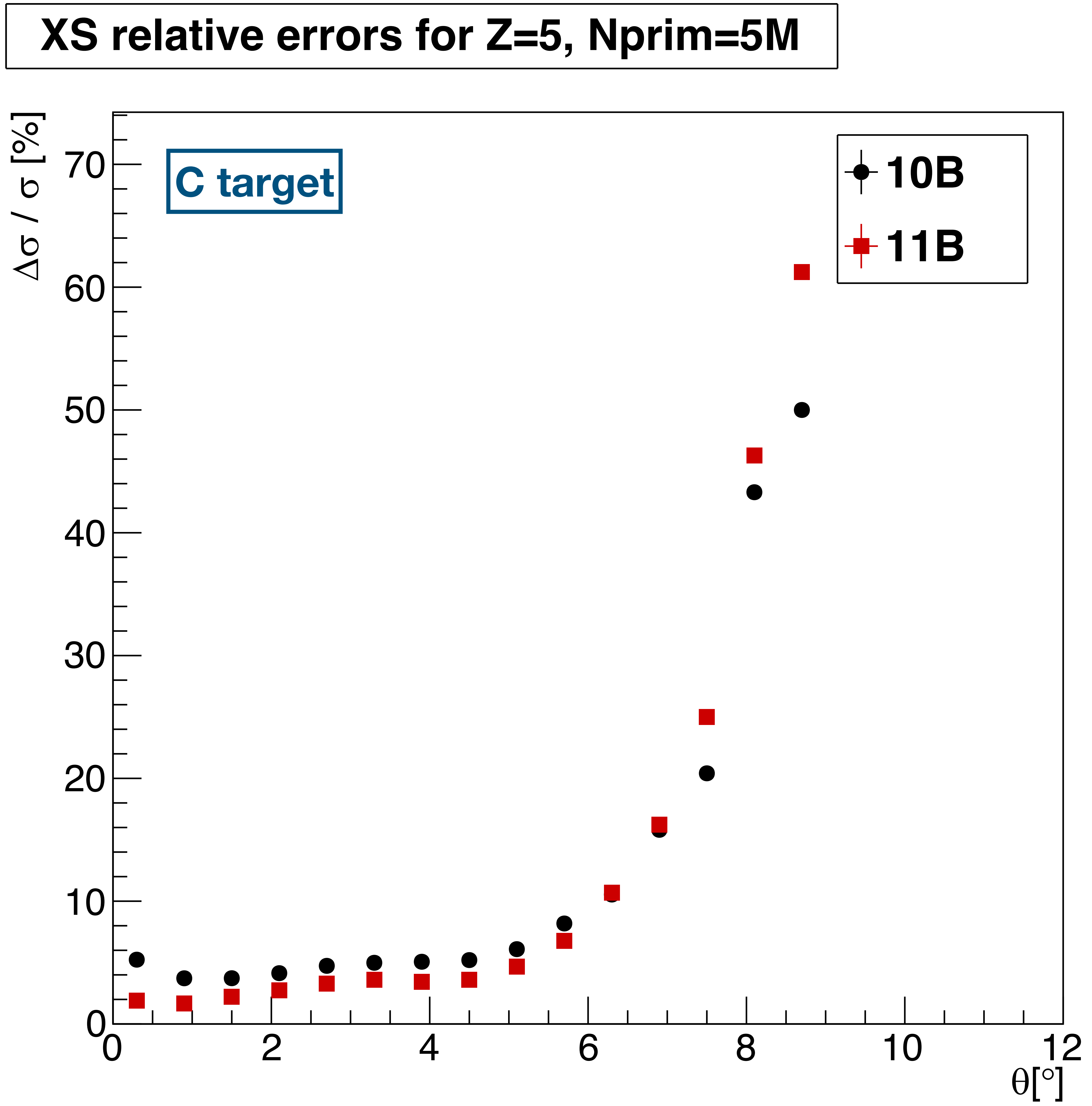


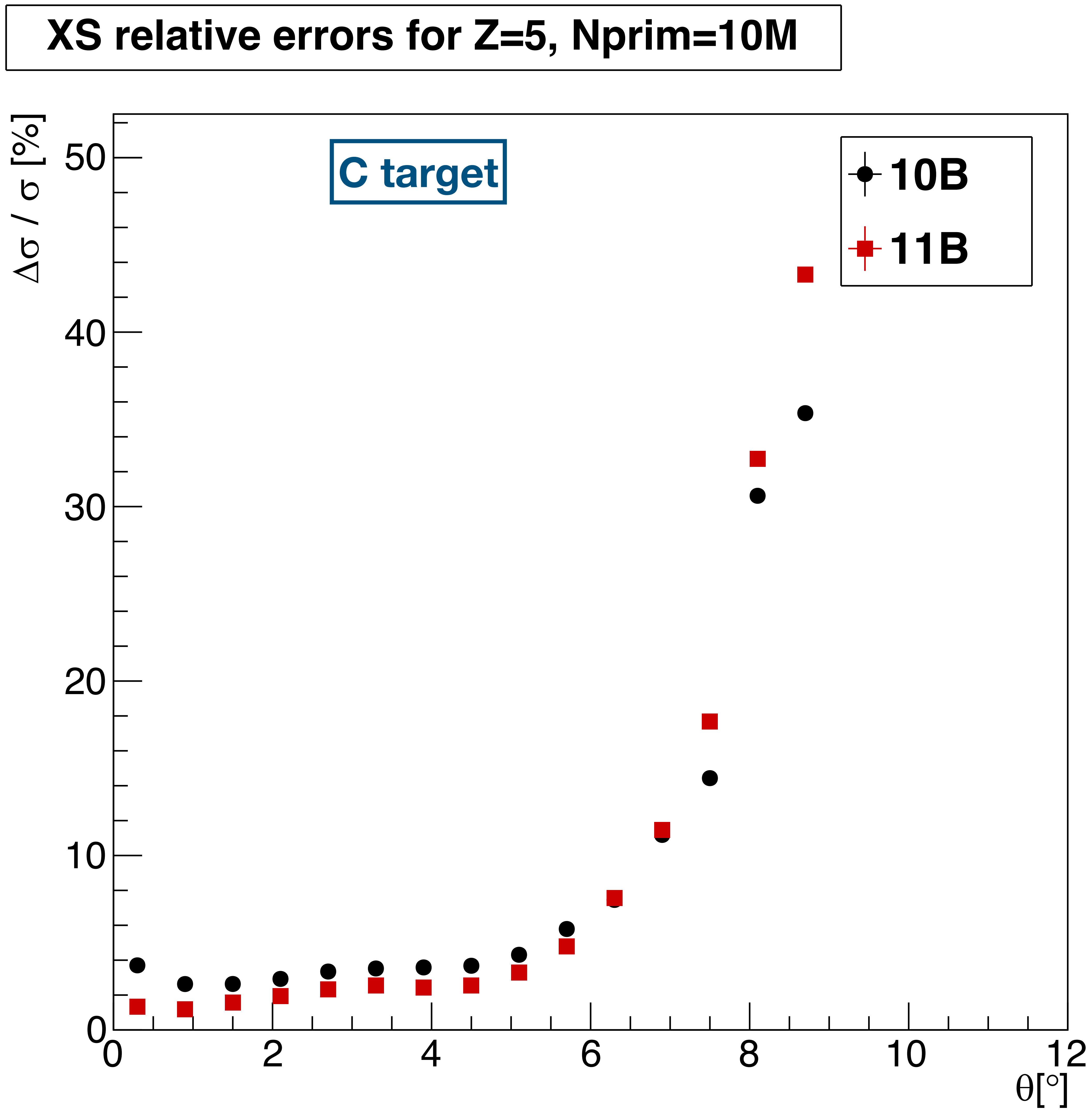
Cross section relative errors (taking into account only yields contribution to the error) – 5M vs 10M events – Z = 4



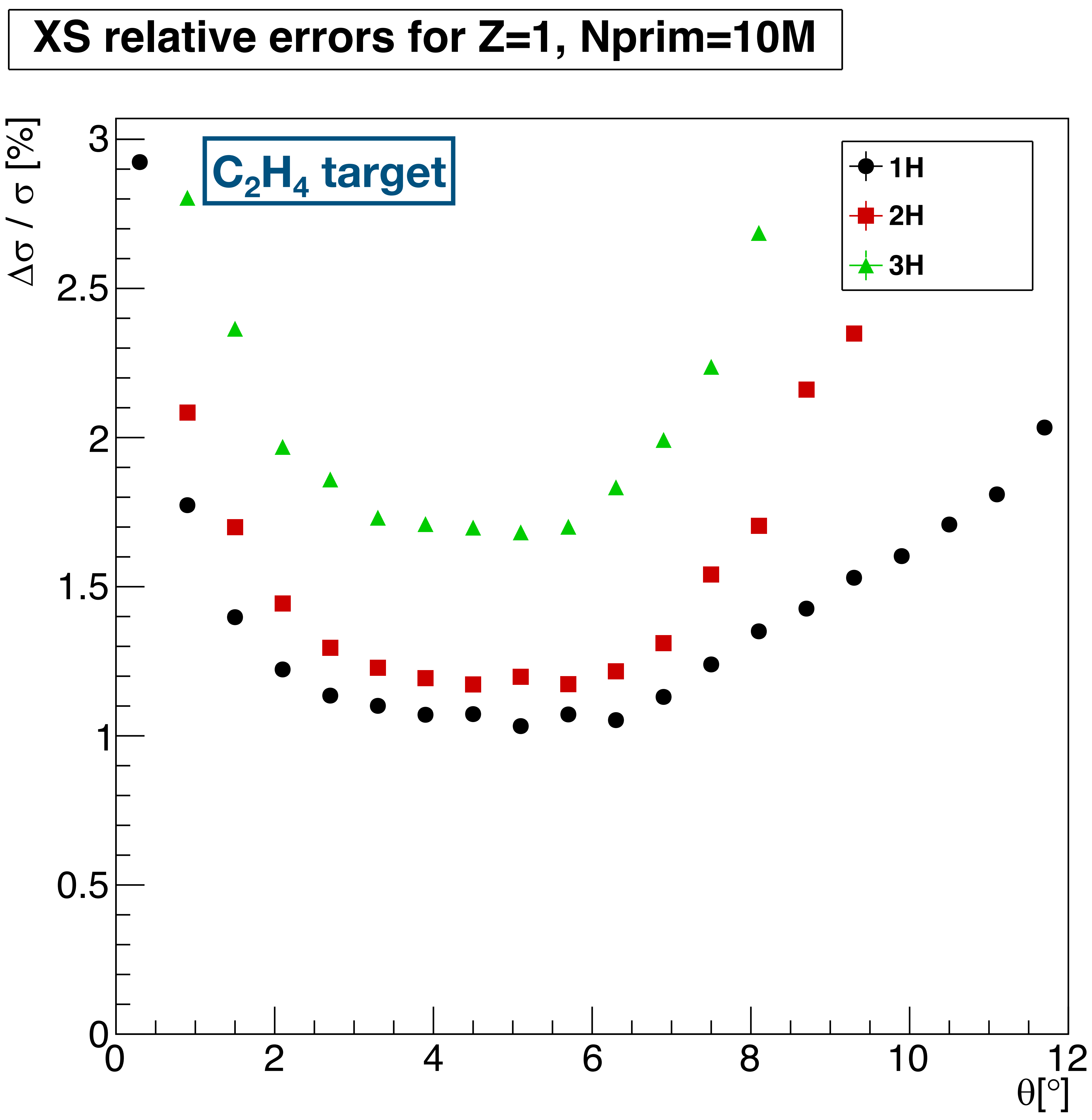


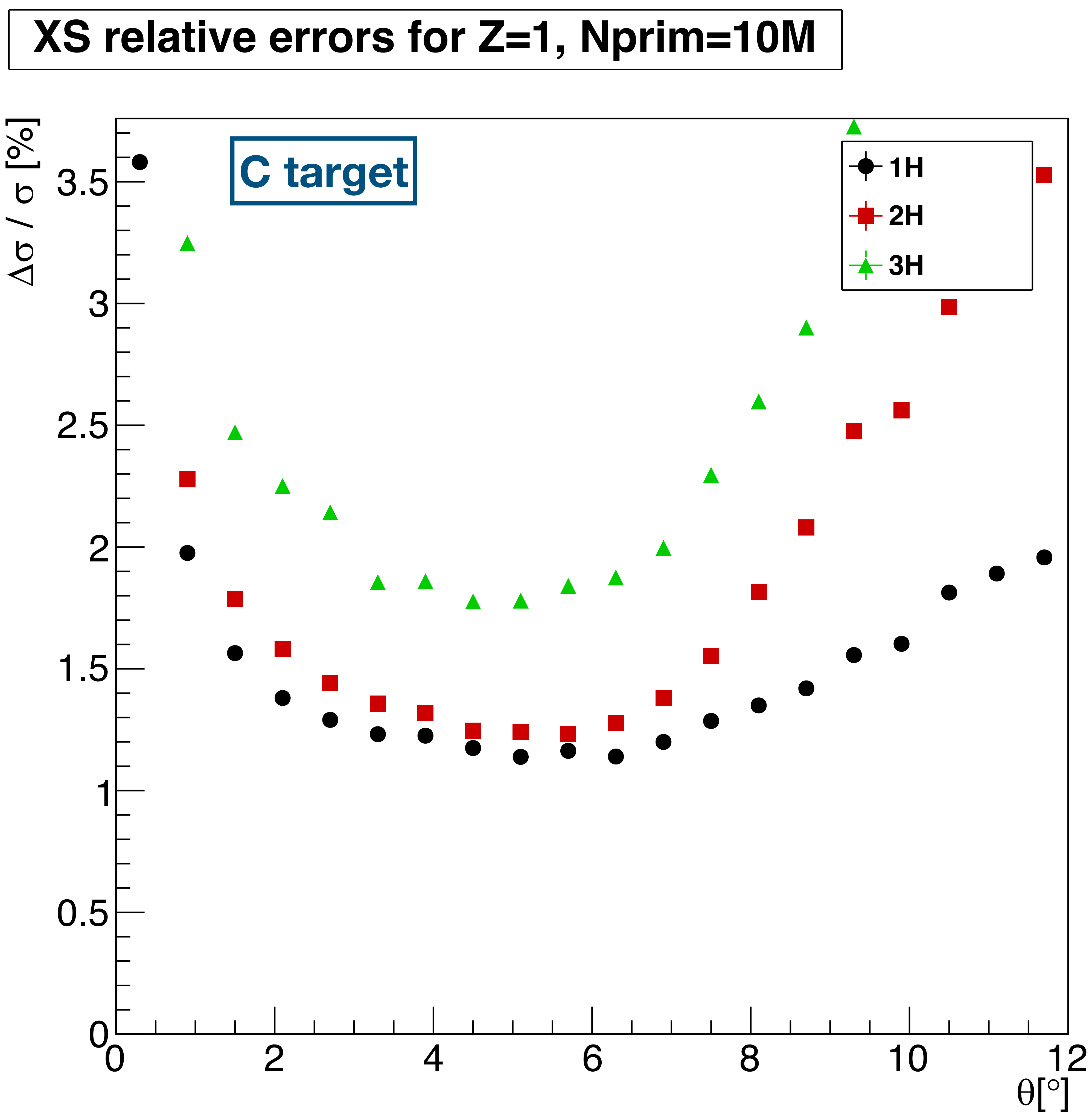
Cross section relative errors (taking into account only yields contribution to the error) – 5M vs 10M events – Z = 5





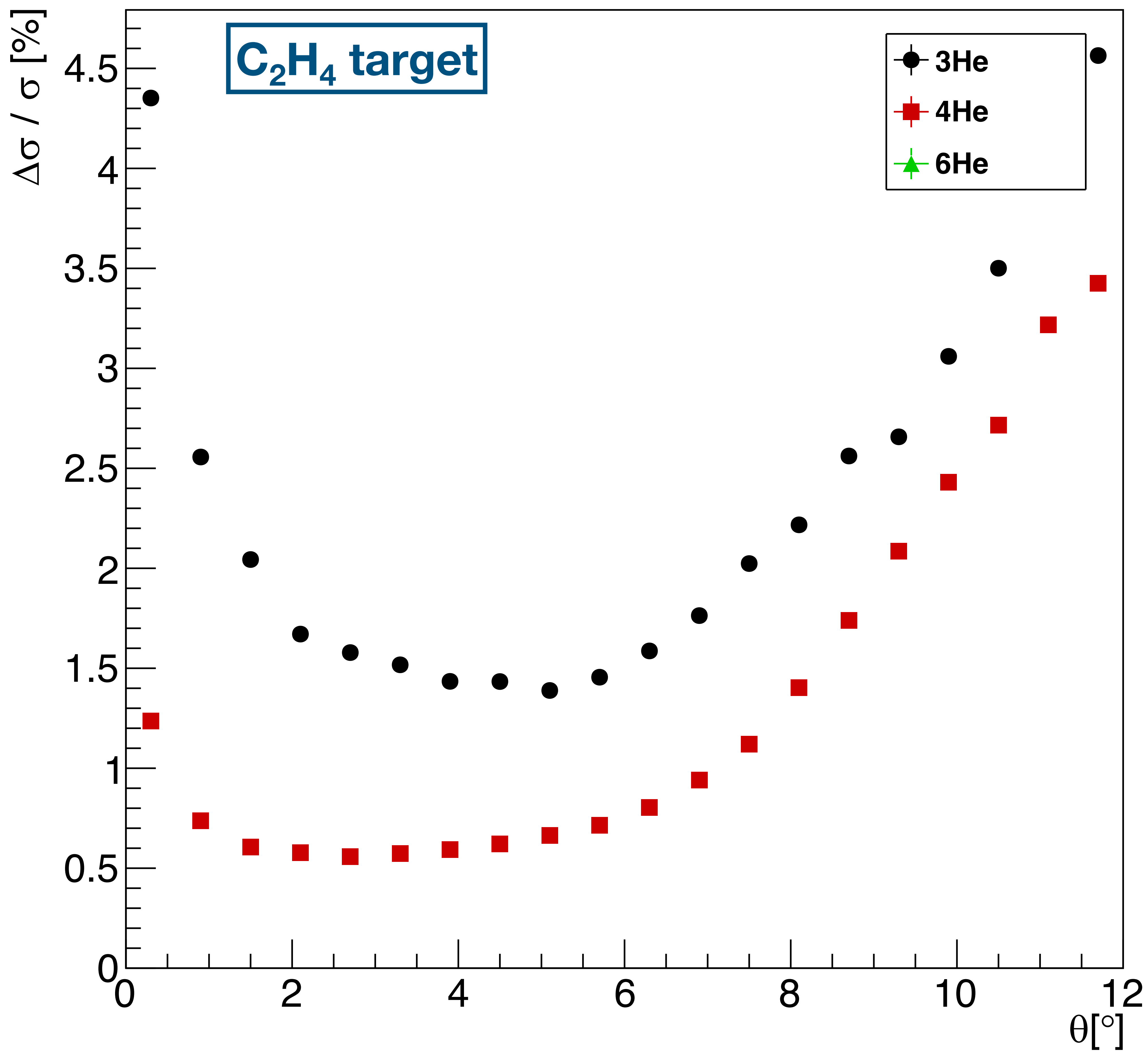
Cross section relative errors (taking into account only yields contribution to the error) – targets comparison - Z = 1



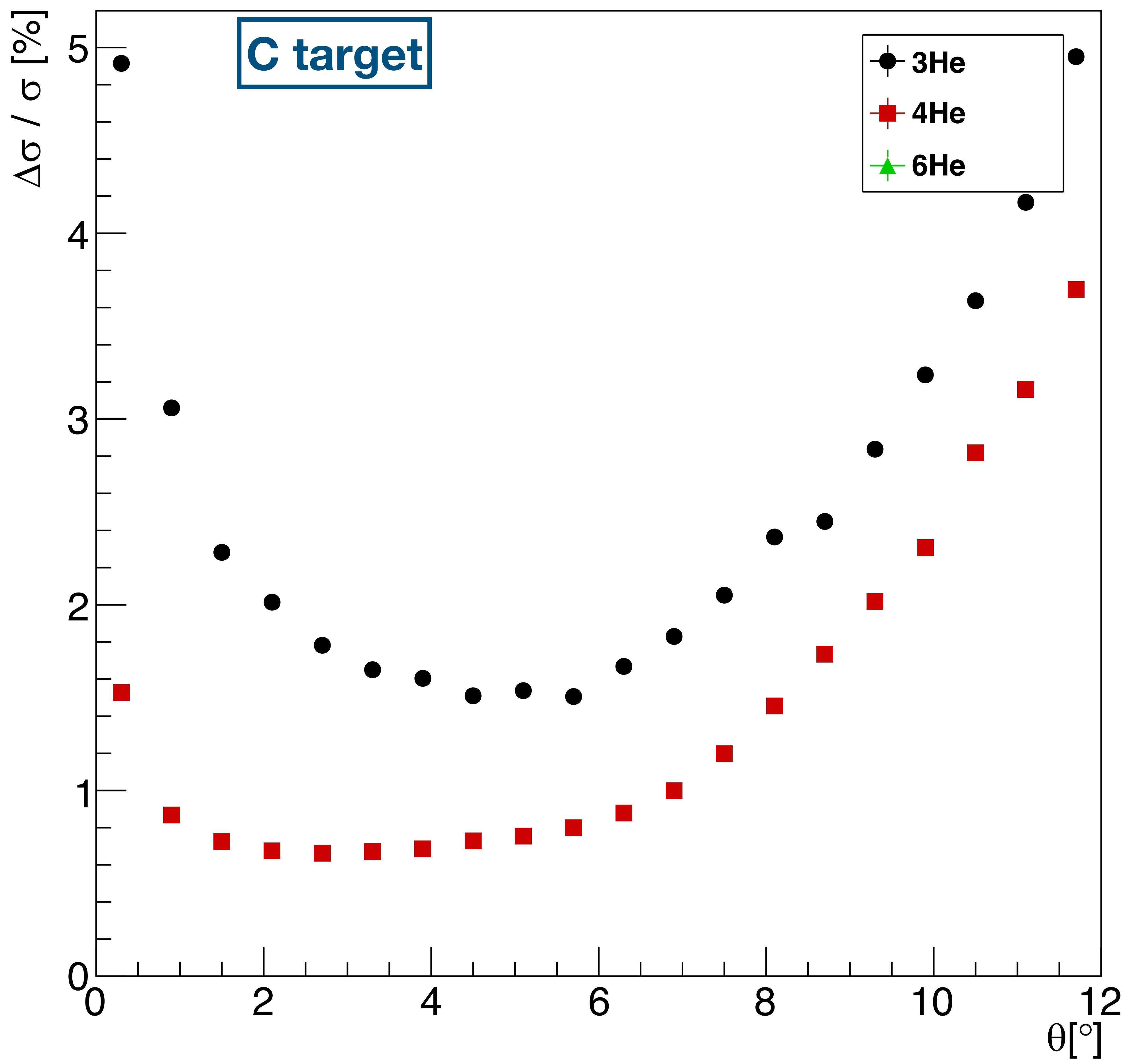


Cross section relative errors (taking into account only yields contribution to the error) – targets comparison – Z = 2

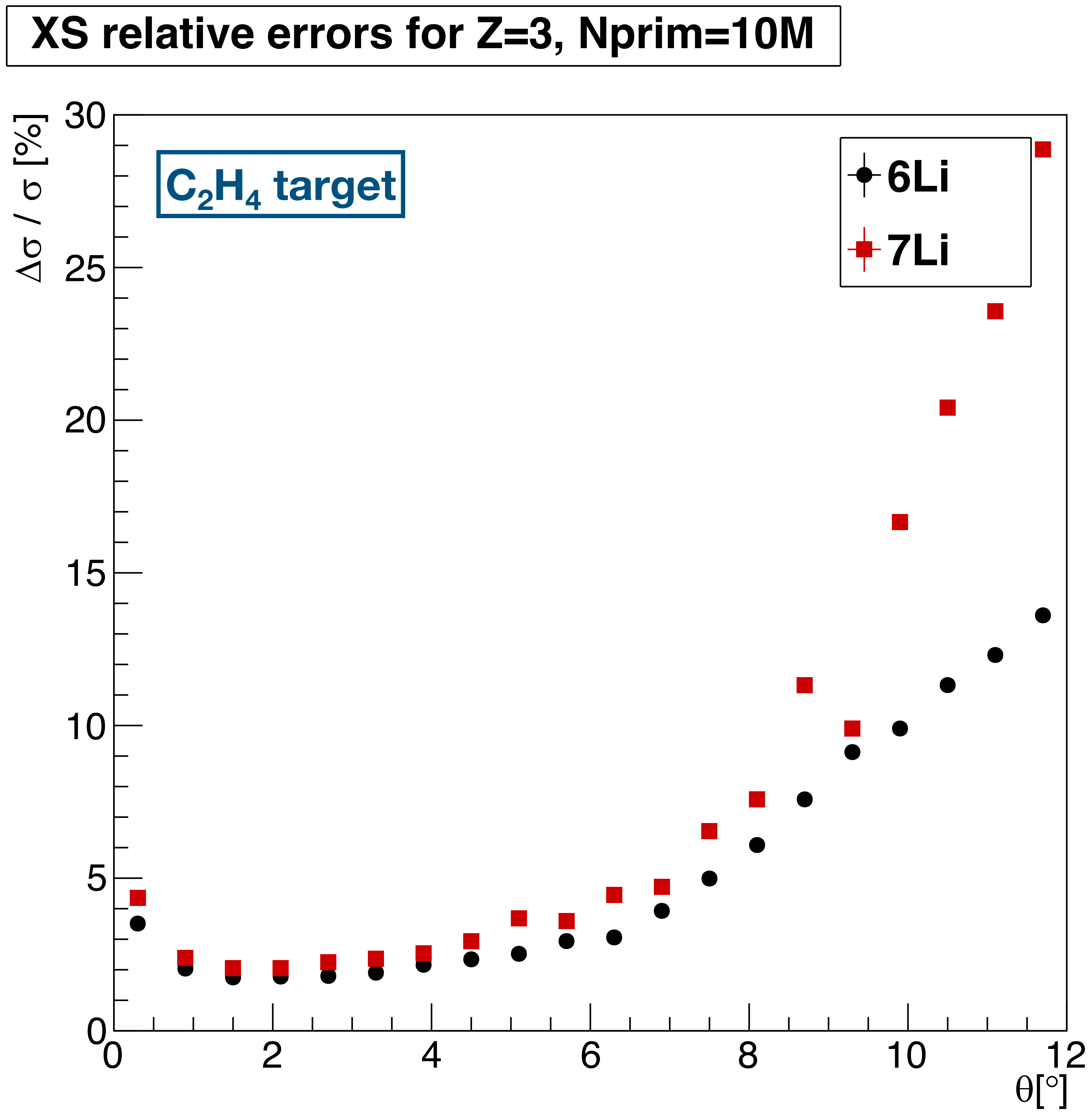
XS relative errors for Z=2, Nprim=10M

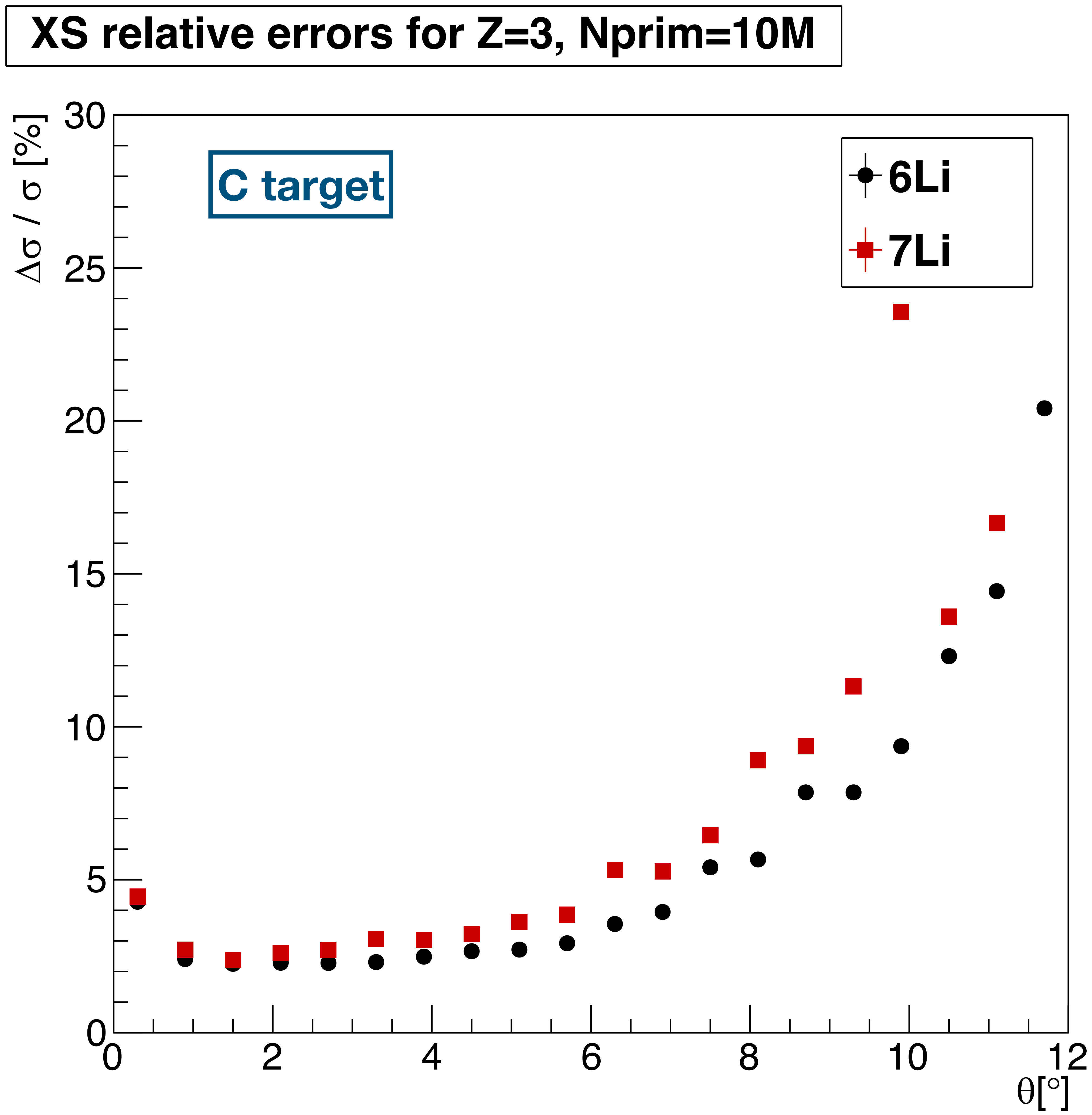


XS relative errors for Z=2, Nprim=10M

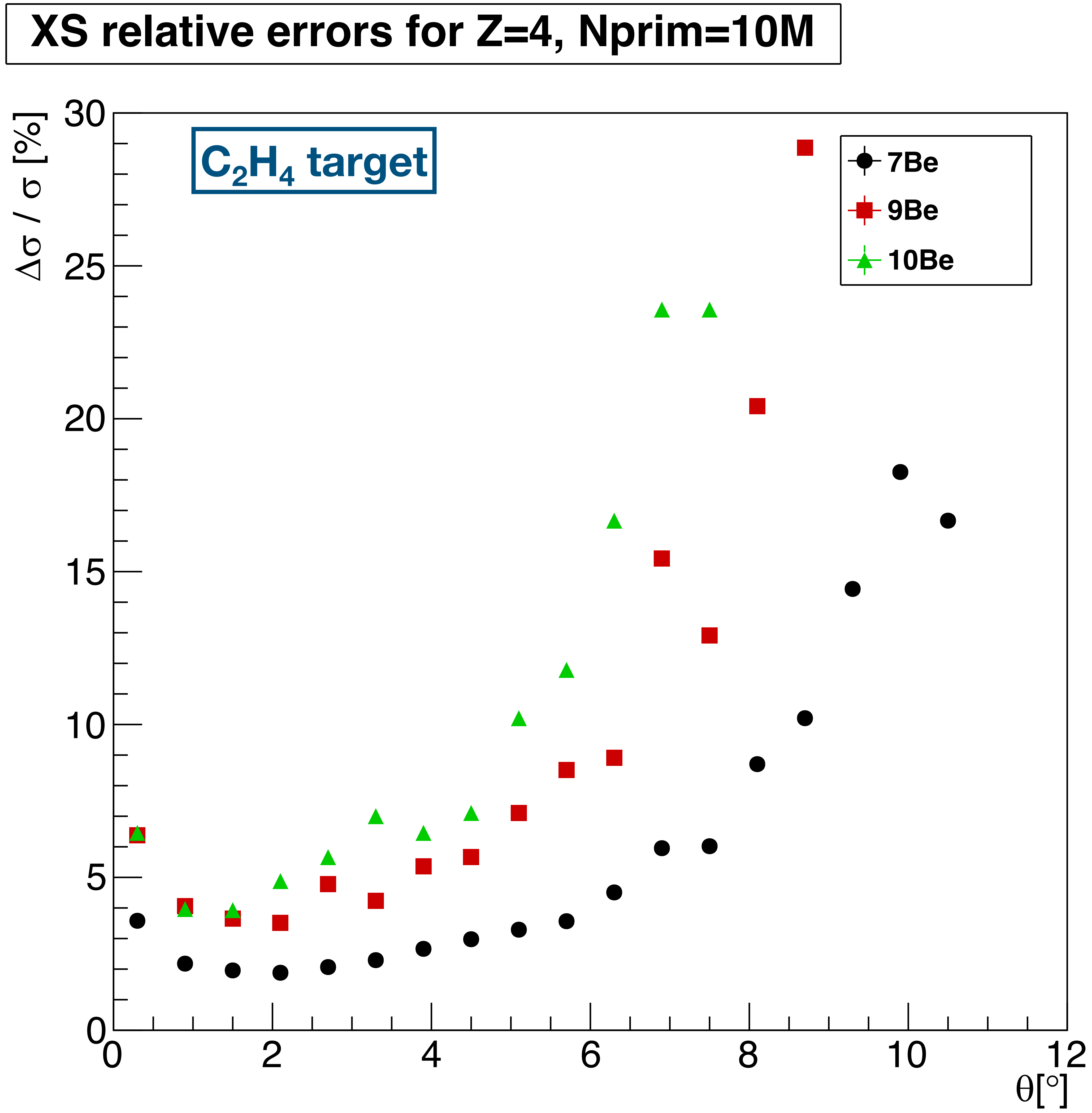


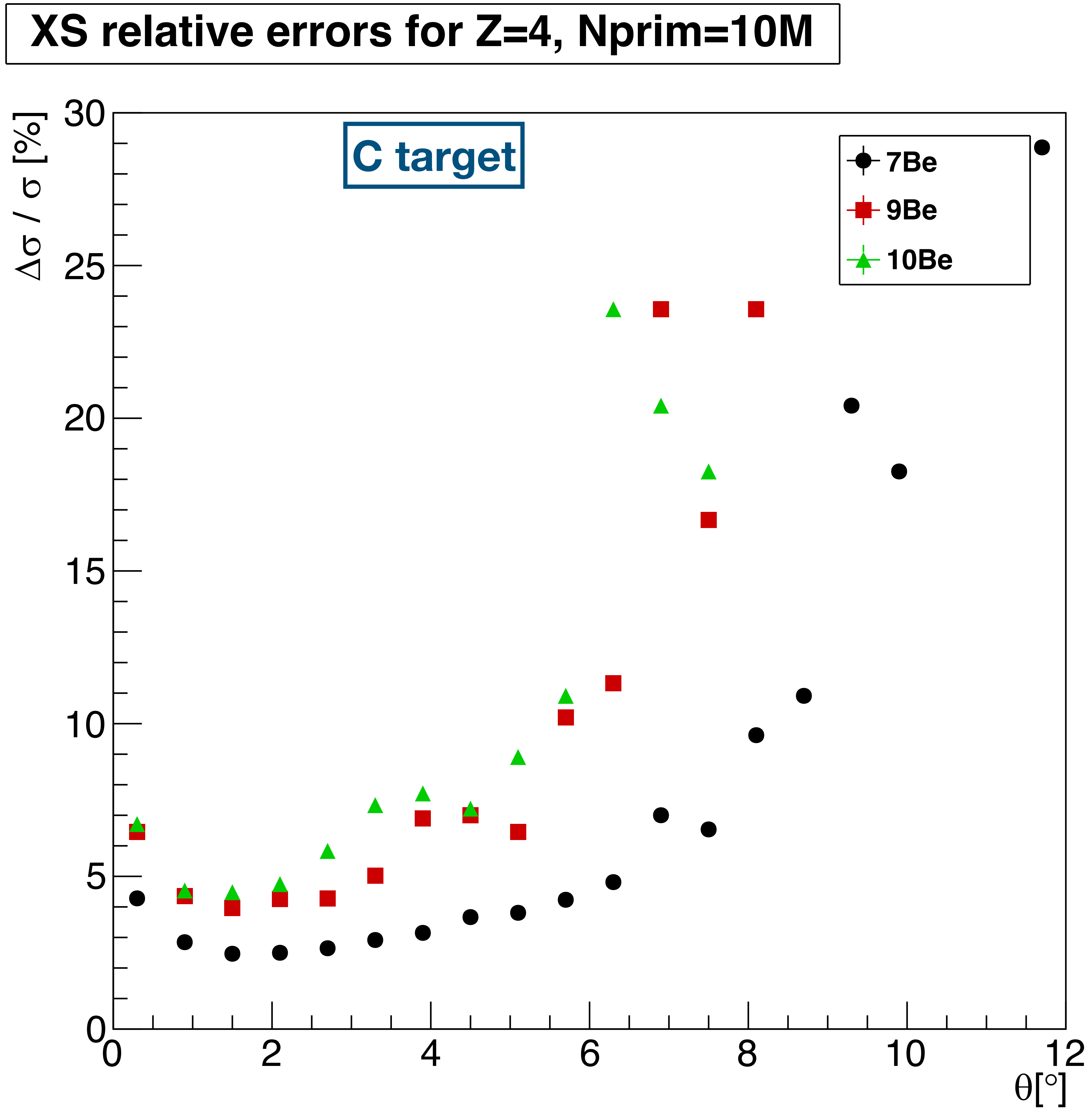
Cross section relative errors (taking into account only yields contribution to the error) – targets comparison – Z = 3



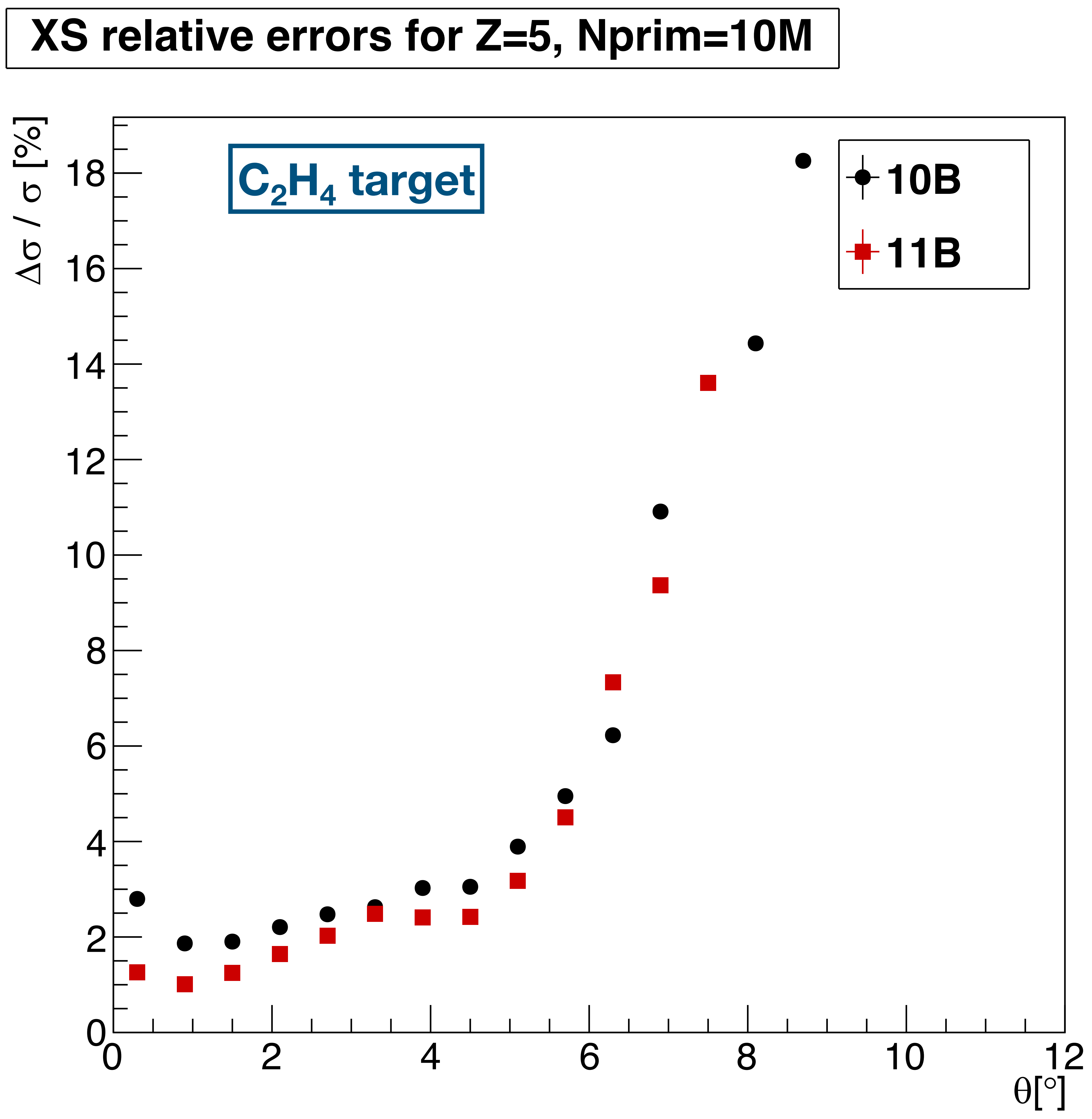


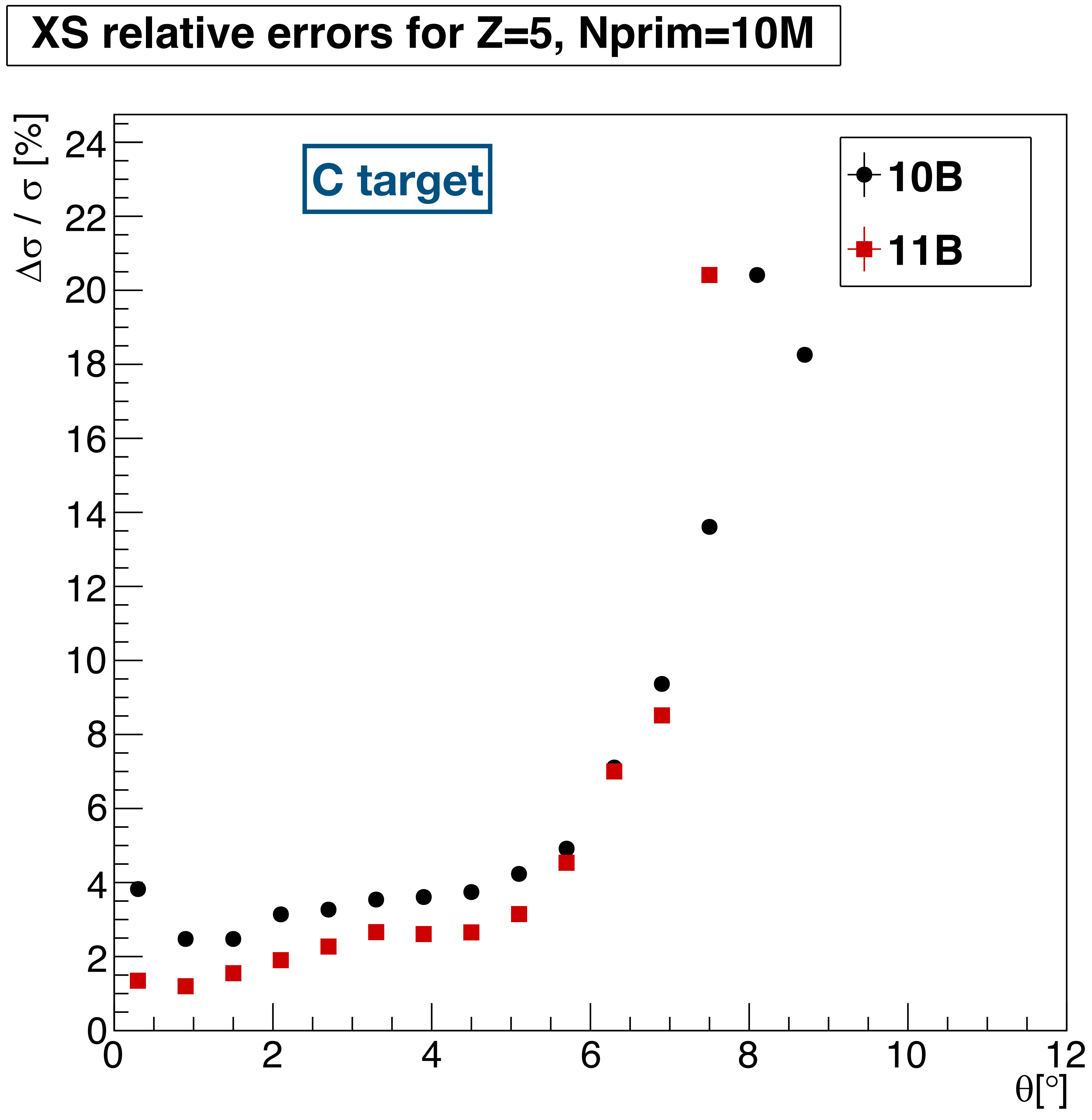
Cross section relative errors (taking into account only yields contribution to the error) – targets comparison – Z = 4





Cross section relative errors (taking into account only yields contribution to the error) – targets comparison – Z = 5





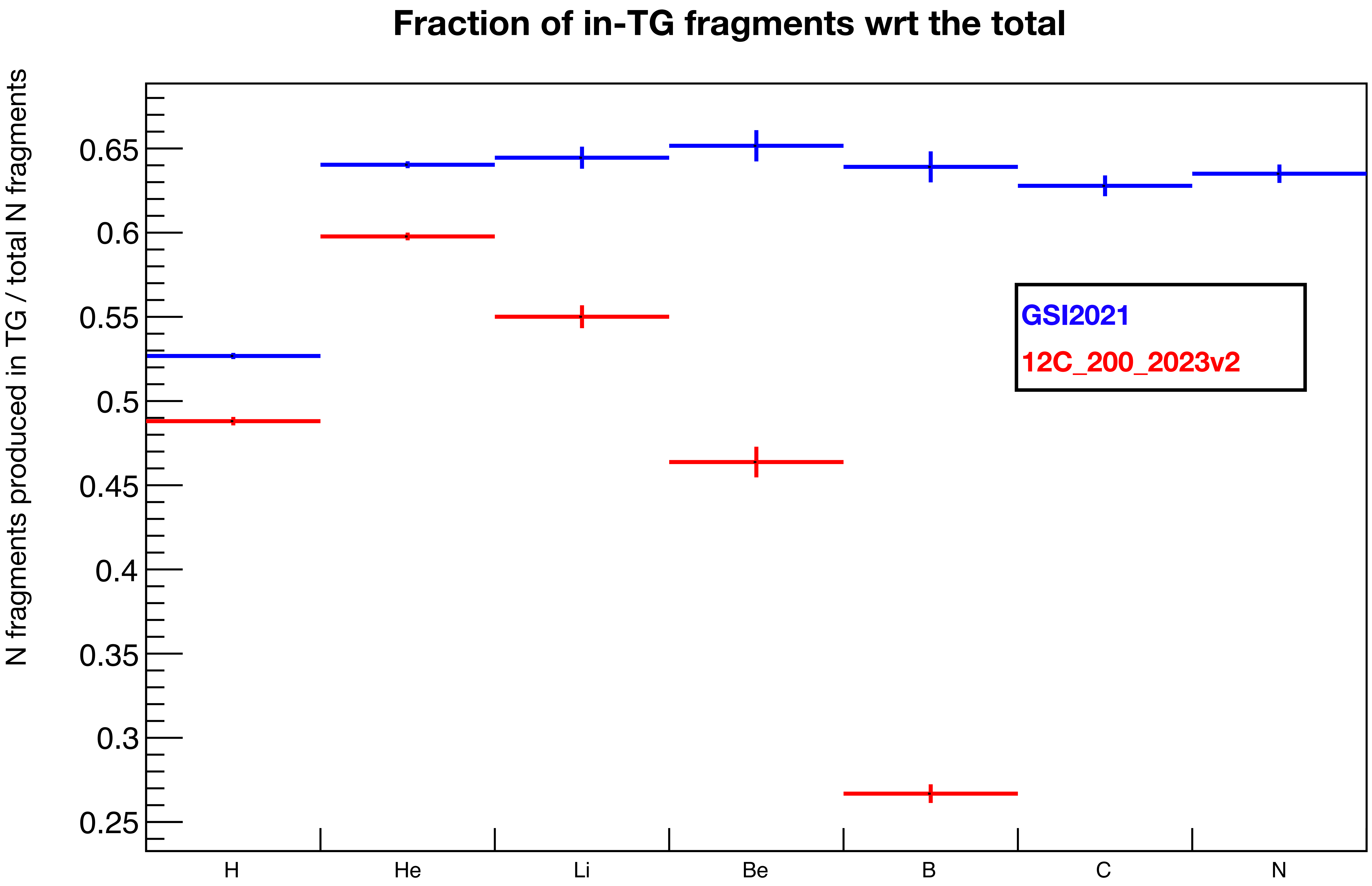
GSI2021 vs ”CNAO2023” (12C_200_2023v2)

- Fraction of fragments produced in the TG wrt the total N fragments per Z→ [N MC true trks at TW crossing produced in TG (Z) / N MC true trks at TW crossing (Z)]

- GSI2021_MC and 12C_200_2023v2 with 1M events run

- Selected only tracks crossing the TW from the front with 50MeV/u<Ekin/u<1 GeV/

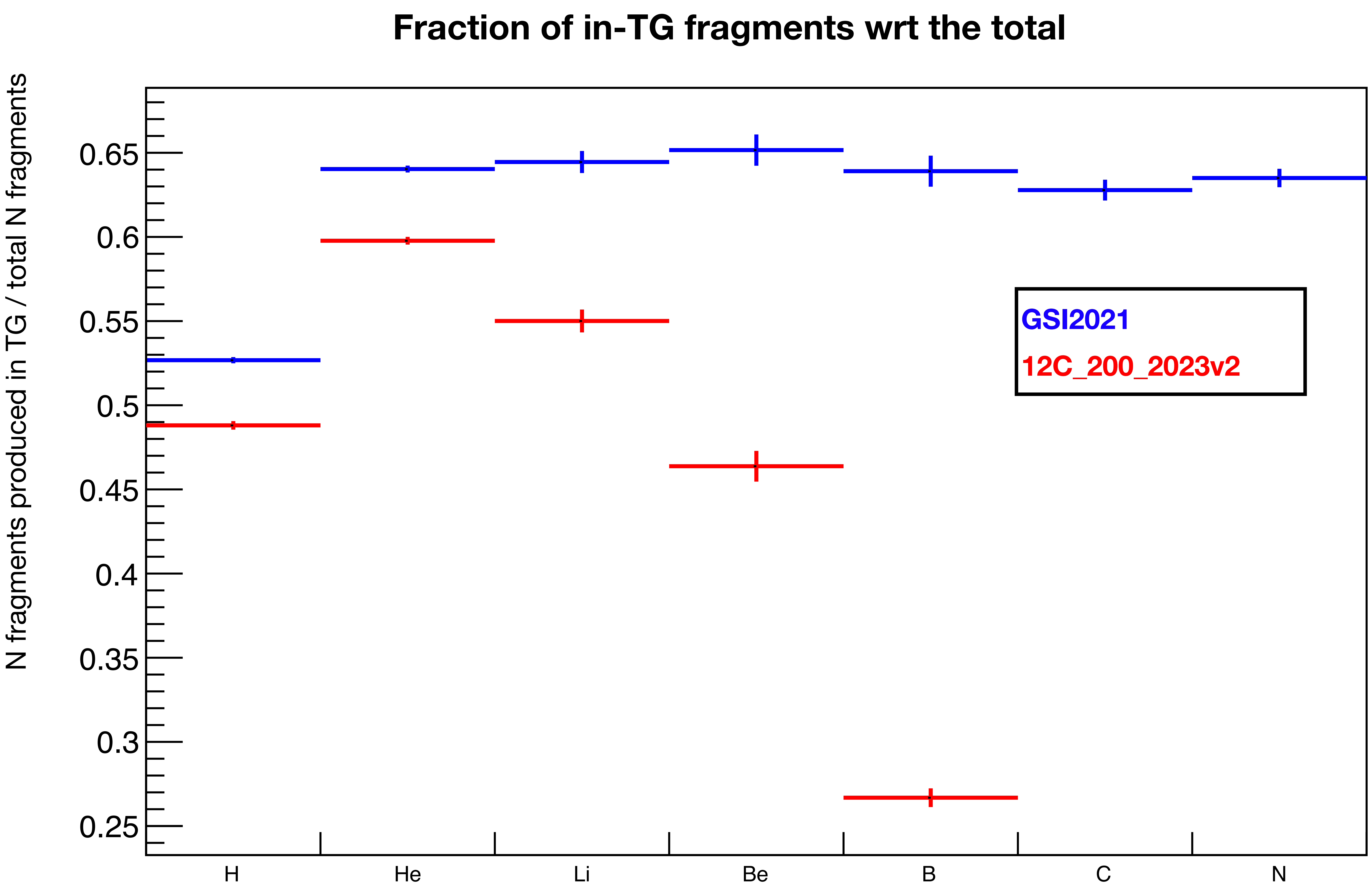
(*) At GSI2019 total fragmentation out of target was ~ 25% (done with reconstructed TW points)--> reasonable, less material budget on the beam line (neither MSD nor CALO



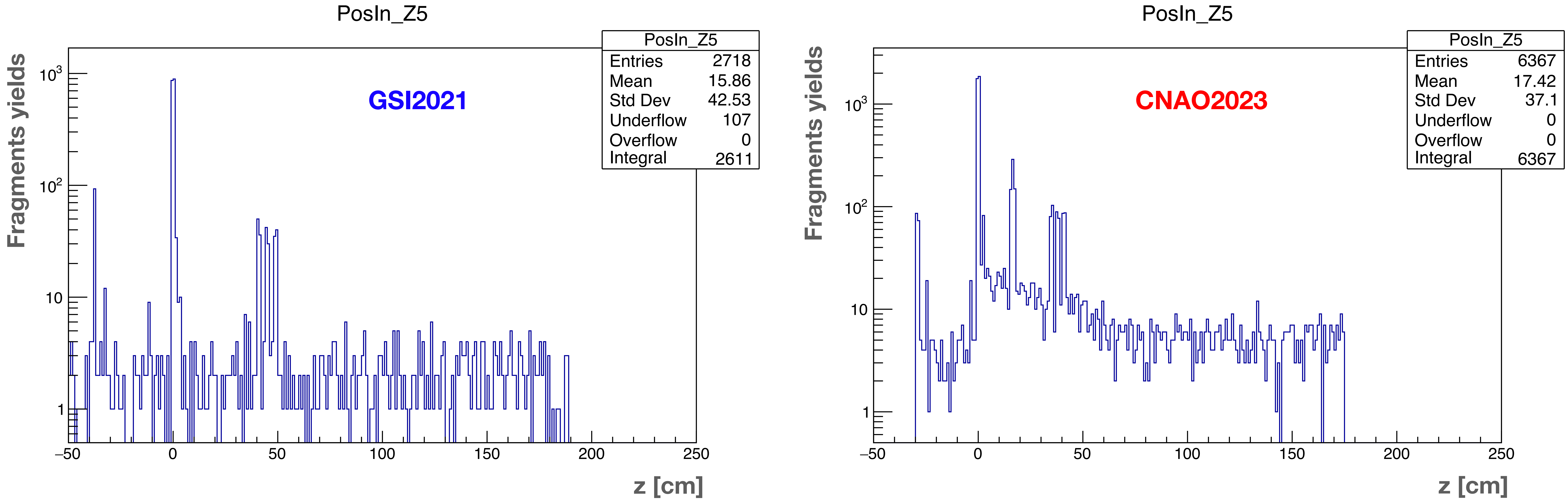
GSI2021 vs "CNAO2023" (12C_200_2023v2)

- This plot brings two further questions:
- 1- Are we still able to reject background with global tracking + Z rec in MSD and VTX? (I guess yes…)
- 2- If this is true the efficiency when we will ask for good track will go further down? (a factor 2 for B)

(*) At GSI2019 total fragmentation out of target was ~ 25% (done with reconstructed TW points)--> reasonable, less material budget on the beam line (neither MSD nor CALO



GSI2021 vs "CNAO2023" (12C_200_2023v2)



It is clear that the fragmentation out of target in CNAO2023 is more than at GSI (full setup)

Some considerations about available acquisition time

- We need to find the right compromise between MB and frag trigger to acquire 10M events per target (5 mm of C and 1 cm of C_2H_4), reminding the goal of FOOT in XS precision and reminding that the value shown are underestimate (efficiencies could be less, no syst included, no fit procedure for yield extraction)

- Clearly if we acquire less stat we can play with the bin width.

- For inverse kinematic the relative error will propagate in finding the C+H XS from subtraction procedure. With the estimated needed acquisition time we saturate the available time but I think it is fine for inverse kinematic because we want to prove we are able to do it and we can integrate the XS or use only few bins of Ekin

- From different studies (yun roberto giacomo) I think we could not need to implement bkg subtraction procedure. In this moment I don't have idea how it could be useful. Only one: extract background template for mass fitting. This could be checked wit a simulazion with a Air TG

Some considerations about available acquisition time

- Hypothesis:
  - DAQ rate 200Hz with MB and 100 Hz with fragmentation trigger (from previous data takings);
  - Let's suppose we are able to set thresholds for veto in fragmentation trigger in order to reject ~50% of the primaries (that it would be a good choice in order to keep pile-up under control in VTX and IT)
  - Let's suppose that in MB trigger 90% of the events are from primaries
- Consequences:
  - In 1h of MB trigger we can acquire 200x3600=7.2×10^5 events (of which ~10% of fragmentation: 7.2×10^4). In order to have 10^7 events and get the relative errors we have seen in XS (only stat (no syst) and only yields from MC (no fit), so NOT conservative) we need 14 h [per target]
  - In 1h of frag trigger we can collect 100x3600=36×10^4 events (of which 50% of fragmentation this time: 18×10^4). In this condition we gain with frag trigger 18/7.2~2.5 the fragmentation statistics we collect with MB in 1h

Some considerations about available acquisition time

- The previous hypothesis translate in an average beam rate of 250 Hz, that means also a pile–up fraction in VTX of ~ 15% (with VTX dead time of ~600us)
- The final pile-up could be worse than this due to micro-bunch structure of the beam (big fluctuations on the average beam rate)
- As alternative let's try again to compute the statistics acquirable moving the average DAQ rate to 100 Hz with MB trigger (~110 Hz beam rate, so pile–up fraction in VTX of ~ 6%) and 50 Hz with frag trigger (at 50% primaries rejection the beam rate is about the same)
- Consequences:
  - In 1h of MB trigger we can acquire 100x3600=3.6×10^5 events (of which ~10% of fragmentation: 3.6×10^4). In order to have 10^7 events and get the relative errors we have seen in XS (only stat (no syst) and only yields from MC (no fit), so NOT conservative) we need 28 h [only one target!!!]
  - In 1h of frag trigger we can collect 50x3600=18×10^4 events (of which 50% of fragmentation this time: 9×10^4). So in this condition we gain with frag trigger 9/3.6~2.5 the fragmentation statistics we collect with MB in 1h

Conclusions

- 10^7 primaries per target (5 mm of C and 1 cm of C_2H_4) provide the possibility to have a final XS relative error compatible with the goal of FOOT
- First hypothesis: DAQ rate 200 Hz in MB and 100Hz in frag trigger.
  - Needed 14h of MB. 1h of frag trigger equivalent to 2.5 h of MB
  - 3 h of MB + 7 h of frag trig per target.
  - Total 10 h C + 10 h C2H4 + 4h no target = 24h/28h tot (TW cal?)
- Second hypothesis: DAQ rate 100 Hz in MB and 50Hz in frag trigger.
  - Needed 28h of MB --> 1h of frag trigger equivalent to 2.5 h of MB
  - 1 h of MB + 11 h of frag trig per target.
  - Total 12 h C + 12 h C2H4 + 4h no target = 28h/28h tot

Schedule

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
16 Oct. Accelerator downtime	17 Oct.	18 Oct. *Table-magnet integration test at LNF*	19 Oct.	20 Oct. *Night Shift (8h-6h)* *22:00* ***Beam Tuning***	21 Oct. *Night Shift (8h)* ***22:00*** ***Beam Tuning***	22 Oct.
23 Oct. *Calo and magnet at CNAO* *Installation*	24 Oct. *Magnet in Exp. Room.* *Installation*	25 Oct. *Installation*	26 Oct. *Installation*	27 Oct. *Night Shift (8h-6h)* ***22:00*** ***Calo Screen Saver Run***	28 Oct. *Night Shift (8h)* *22:00* *Installation* ***VTX + IT Calib.*** ***During alignment runs (in MB) setup trigger thresholds and check primary rejection***	29 Oct. *Night Shift (6h)* *22:00* ***12C @ 200MeV/u Target C:*** ***3h MB (check primary rejection and M28 pile-up btw 100-200 Hz DAQ rate)*** ***3h frag trigger***
30 Oct.	31 Oct.	1 Nov.	2 Nov.	3 Nov.	4 Nov. *After. Shift (8h)* *14:00-22:00* ***12C @ 200MeV/u Target C:*** ***4h frag trigger*** ***4h no target***	5 Nov. *After. Shift (8h)* *14:00-22:00* ***Target C2H4:*** ***3h MB*** ***5h frag trigger***
6 Nov. *Night Shift (6h)* *22:00* ***2h frag trigger*** ***2h TW cal*** ***2h spare***	7 Nov. *Night Shift (6h)* ***22:00*** ***Emulsion Run***	8 Nov. *Uninstallation*	9 Nov. *Uninstallation*	10 Nov. *No Material in the room*	11 Nov. *Next Exp. In Exp. Room.*	12 Nov.

Come fai..SBAI