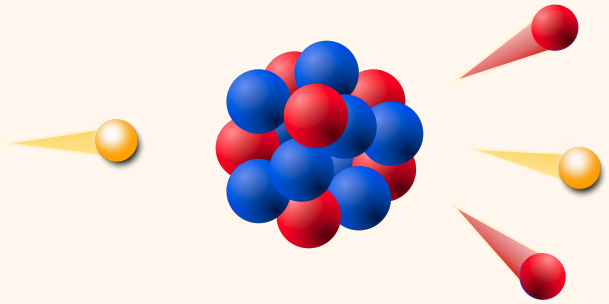


Preliminary study of Short-Range Correlations in $\pi^- + {}^{12}C$ reaction @0.69 GeV/c with HADES.

Fatima Hojeij, IJCLab

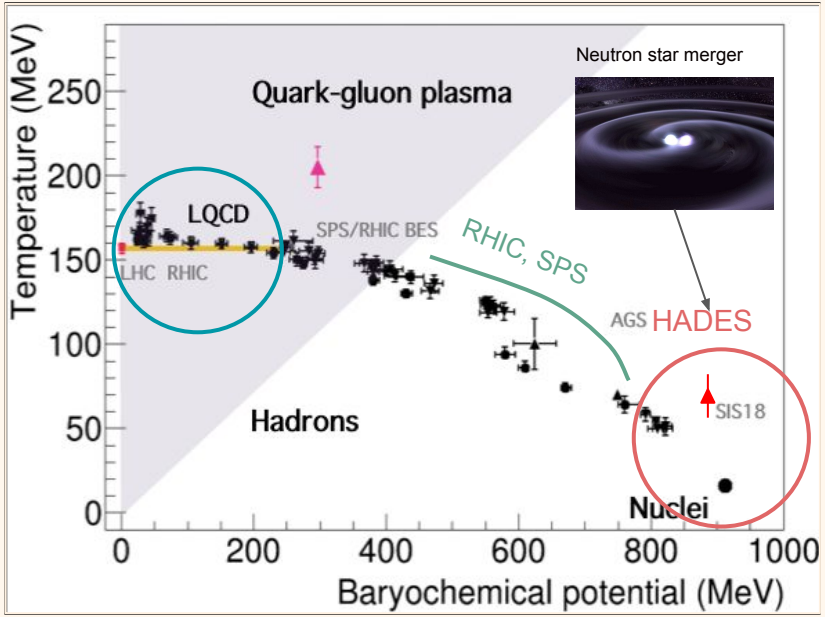
For the HADES Collaboration

4th International Workshop on Quantitative Challenges in Short-Range Correlations and the EMC Effect Research, 31.01.2023, Saclay

The QCD phase diagram studies

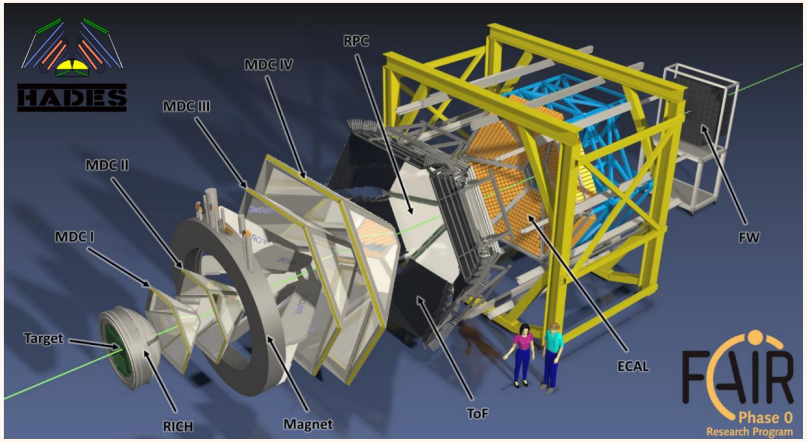
HADES objectives :

- Explore the high-μB region of the QCD matter phase diagram (heavy-ion beams)
  - Complementary to LHC, SPS, RHIC, etc …
    A+A: 1-3A GeV
    $\sqrt{s_{NN}}$=2-2.4 GeV
- Microscopic structure of baryon dominated matter.
  - Role of baryonic resonances (excited states of nucleons).



T. Galatyuk, NPA-D-18-00411 (2018) QM18

High Acceptance DiElectron Spectrometer (GSI, Darmstadt)



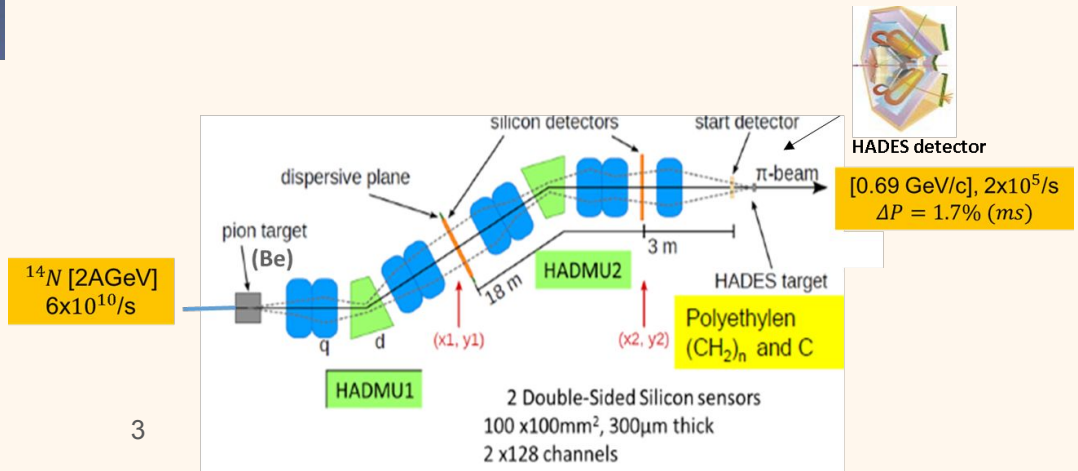
Fixed target experiment at SIS18 (GSI, Germany)

- Ring Imaging Cherenkov (RICH) for identifying e^+e^- 0.1 GeV < p < 1.5 GeV.
- Magnet spectrometer
- Tracking: Low mass Multi-wire-Drift-Chambers (24 trapezoidal planar MDCs)
- Identification of charged hadrons: Tracking + Time of flight walls RPC and ToF.
- Acceptance: Azimuthal angles 85% (6 sectors), Polar angles: 18° - 85°

Our aim :

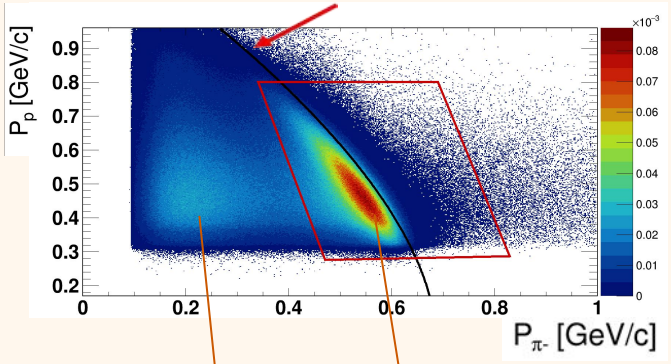
➢ Investigate various exit channels π^- + 12C reaction
($p\pi^-$ quasi-elastic, $p\pi^-\pi^-$, $pp\pi^-$, $\pi^-\pi^+$, $\pi^-\pi^-$, etc..)
for 2nd resonance region in order to constrain the description of various processes :
quasi-elastic, rescattering, pion absorption in cascade models (INCL++) and transport models (SMASH, rQMD, GIBUU).

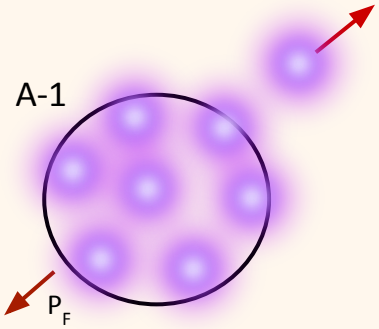
➢ **Sensitivity of our data to Short-Range Correlations ?**

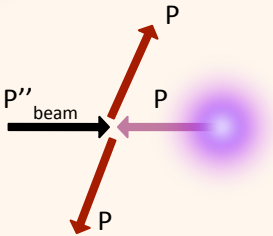


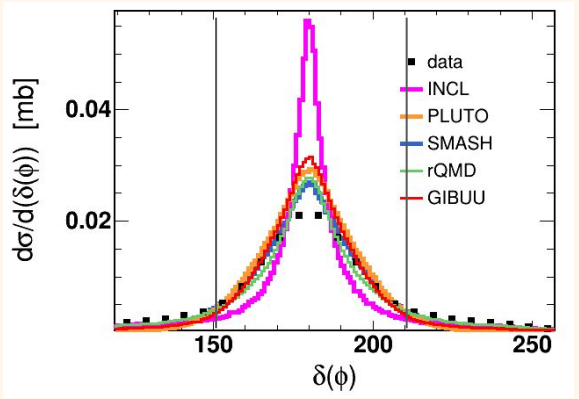
Selection of quasi-elastic channel

p_p vs p_π typical of binary reaction $\pi^- + p \rightarrow \pi^- + p$



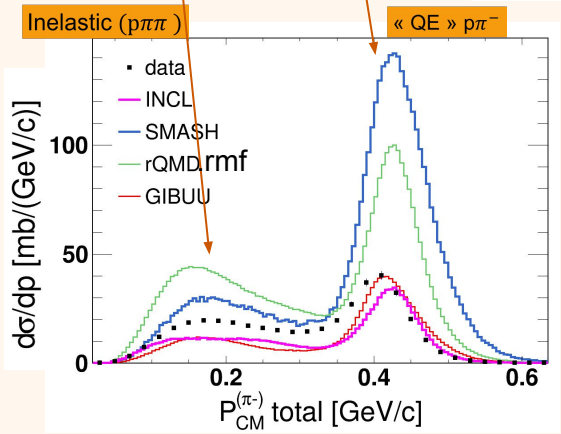






« QE selection » :
Momentum correlation + coplanarity condition

Inelastic ($p\pi\pi$) | « QE » $p\pi^-$



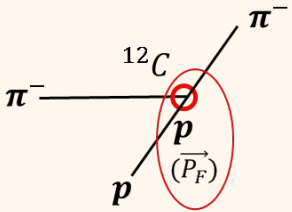
- SMASH & rQMD overestimate $p\pi^-$ channel.
- GIBUU & INCL : underestimates $\pi^- p$ channel especially inelastic channel.

Quasi-elastic for Short Range Correlations ?

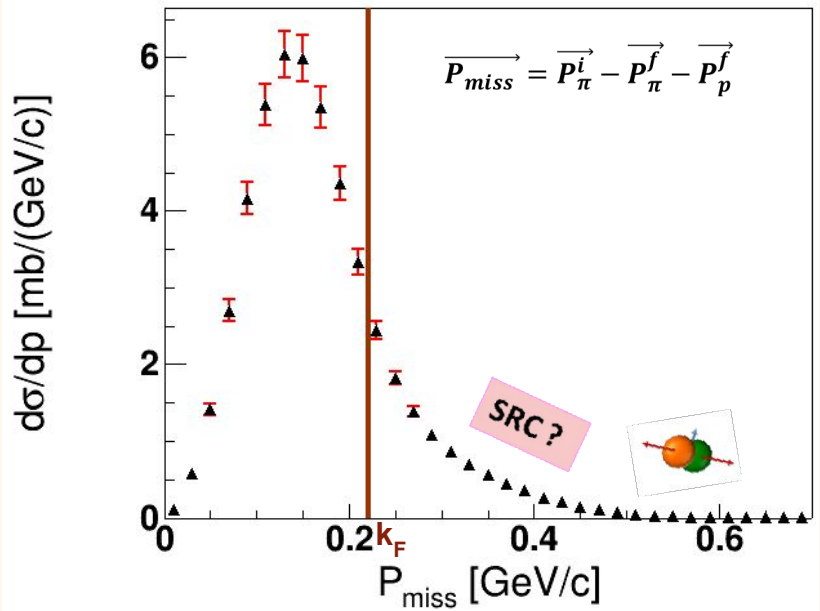
« pure quasi-elastic » :

one single $\pi^- + p \rightarrow \pi^- + p$ step, no rescattering.

$\overrightarrow{P_{miss}} = -\overrightarrow{P_F}$



SRC :
Nucleon pairs that are close together in the nucleus high relative and low c.m. momentum, compared to the Fermi momentum (kF)

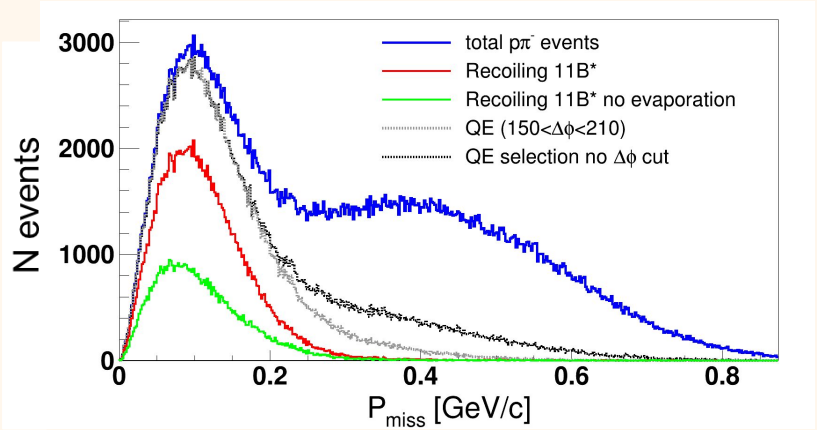


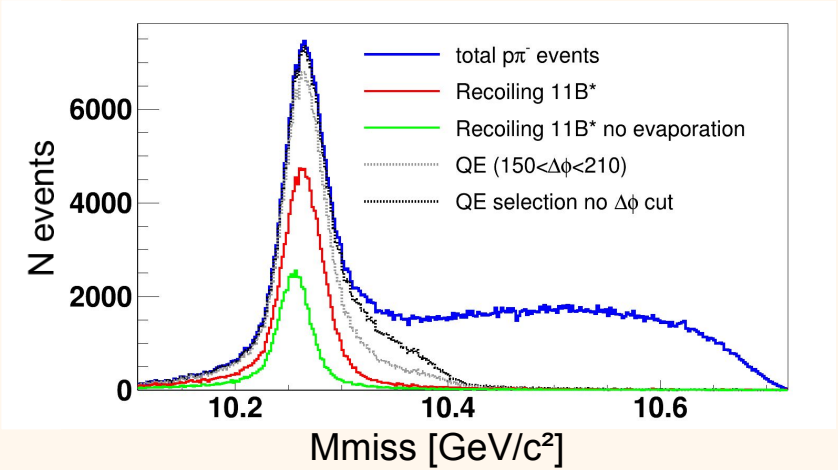
- Large tail for high proton momentum in Carbon. SRC or rescattering effects?

Investigation with INCL++

- Rescattering contribute at large M_{miss} and P_{miss}.
- Our cut only partly suppresses rescattering ; we go in more detail, as a function of P_{π^-}.

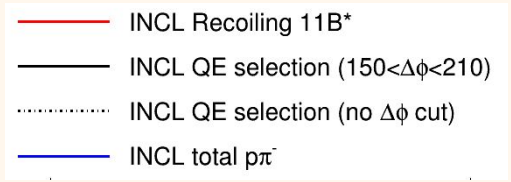
(A) (pure quasi-elastic) **red : First collision is elastic & $Ncollisions$ =1**
green : (A) & $Npart$ =3 & $Arem$ =6 & $Zrem$=5 (no rescat/evap)
QE selection : experimental cuts.

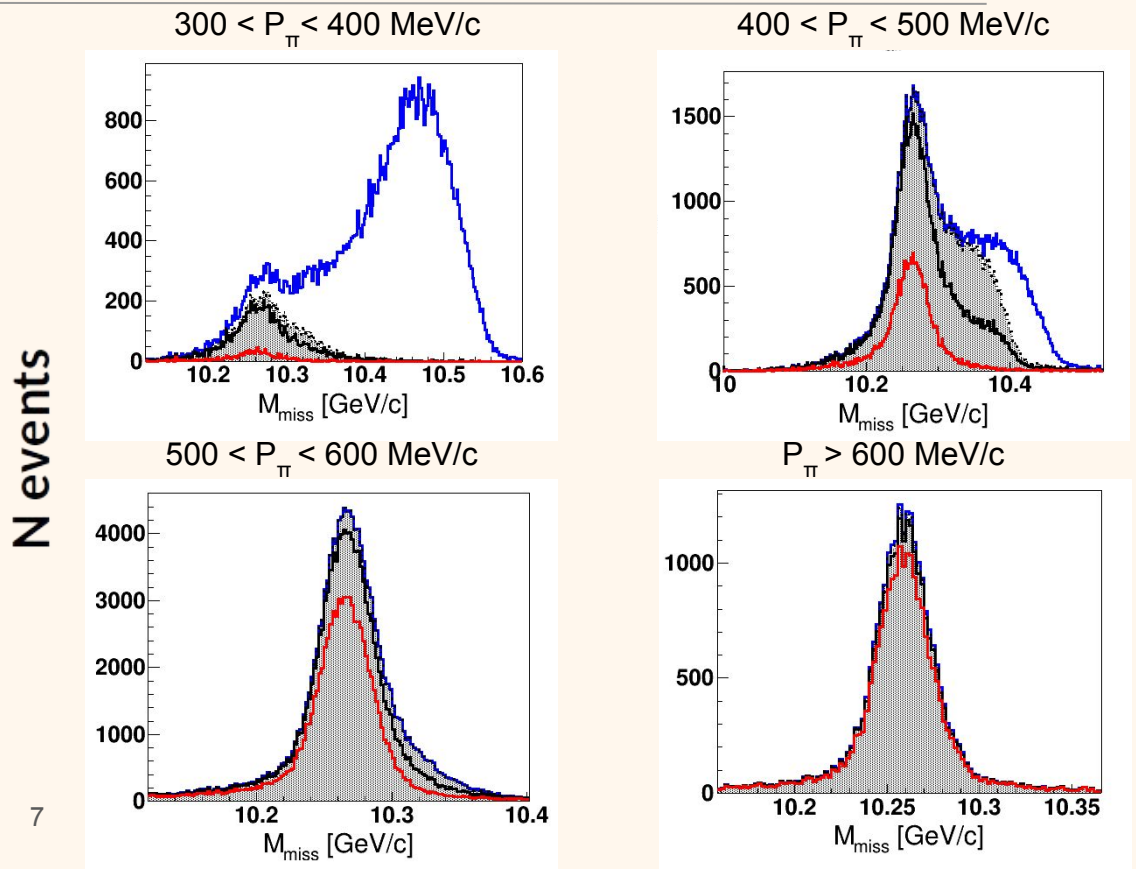




Pion momentum for rescattering cuts (1)

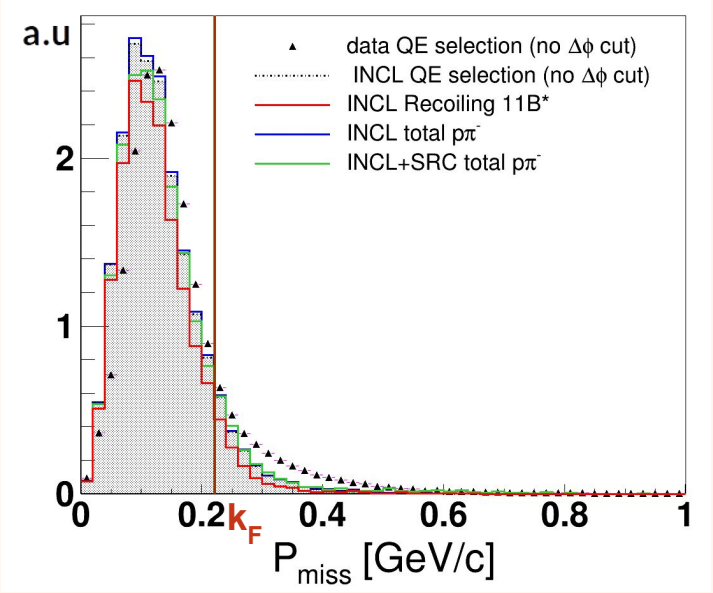
- Strong effect of rescattering at small pion momentum.
- According to INCL, rescatterings fully suppressed for P_π > 600 MeV/c.
- Our « QE » selections really identify pure quasi-elastic processes for P_π > 600 MeV/c.
- SRC could be visible (?).

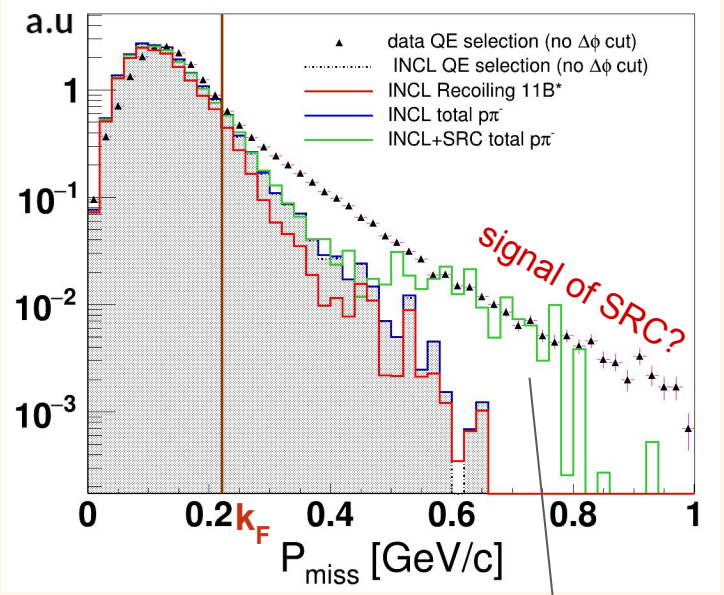




Pion momentum for rescattering cuts (2)

P_{π}>600 MeV/c





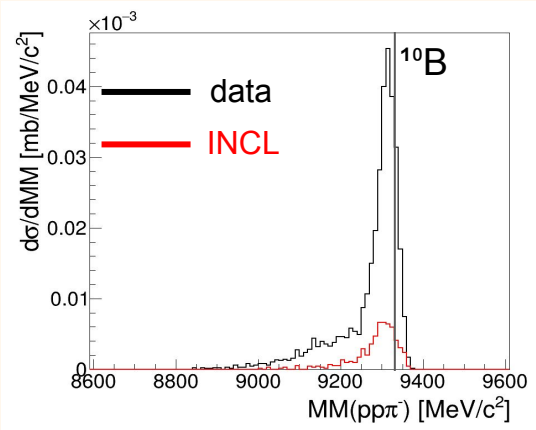
- Tail at large P_{miss} not due to rescatterings according to INCL++.
- Next step : look at pp & pn (neutron reconstruction using TOF & RPC and no track).

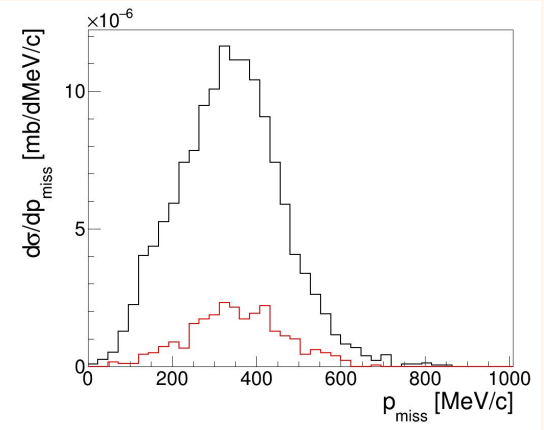
Jean-Christophe David's talk on Wednesday

Search of SRC in ppπ⁻events (I.Ciepal)

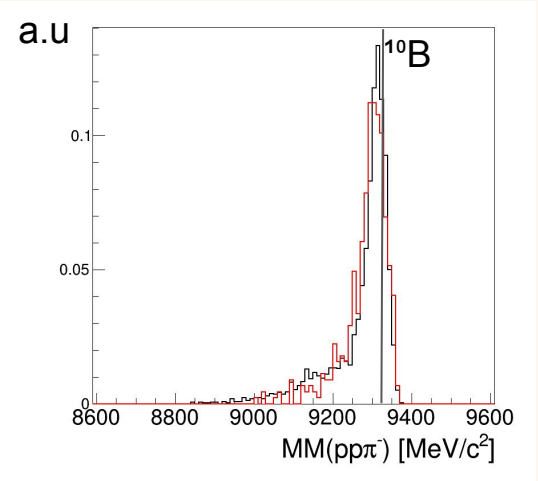
1) Select pπ⁻ pairs from quasi-elastic process :
   Graphical cut on P_p^{CM} vs $P_{\pi^-}^{CM}$
   Fullfill coplanarity condition Δφ

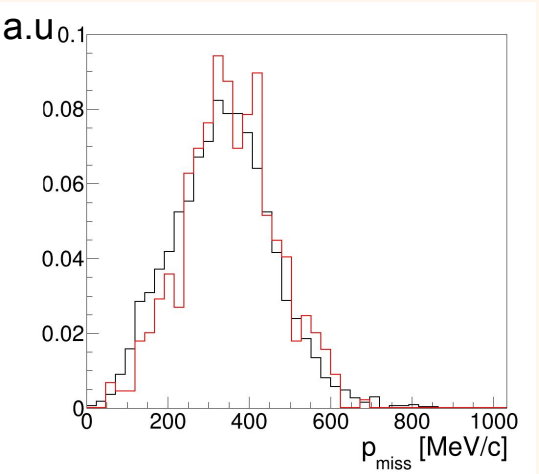
2) Suppress rescatterings :
   P_{π^-}> 500 MeV/c.





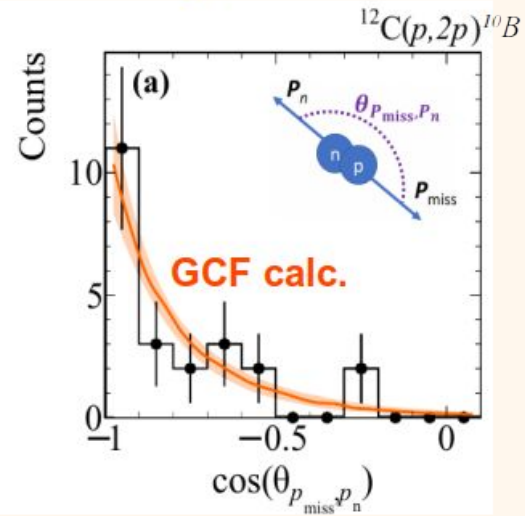
In INCL++, the two protons are emitted sequentially. Yield smaller than in the data, but distributions look similar.
→ no signals of SRCs





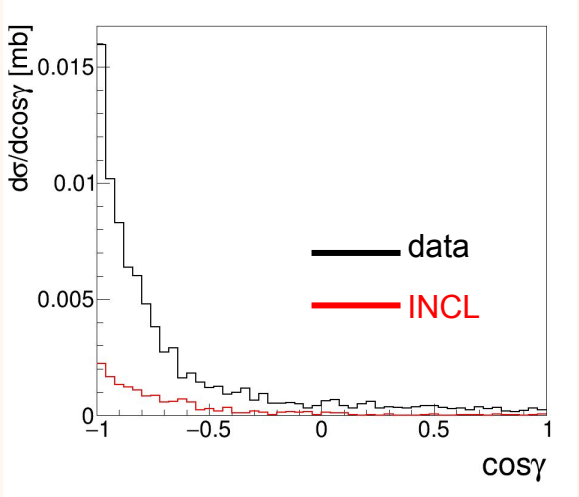
Angular correlation (1) (I.Ciepal)

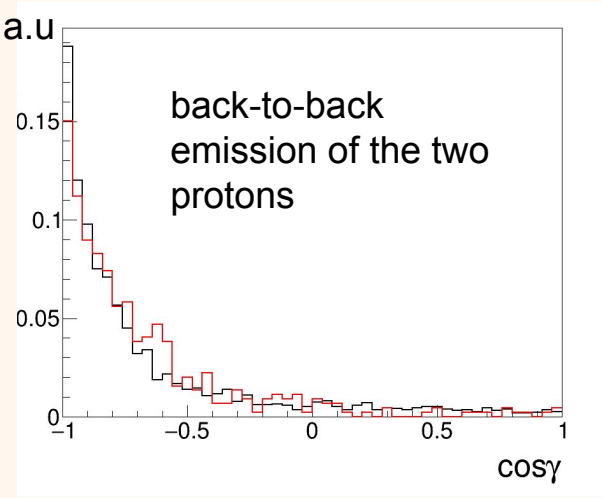
we expect back-to-back scattering with SRC



M. Patsyuk et al. , Nat. Phys. 17, 693 (2021)

ppπ⁻



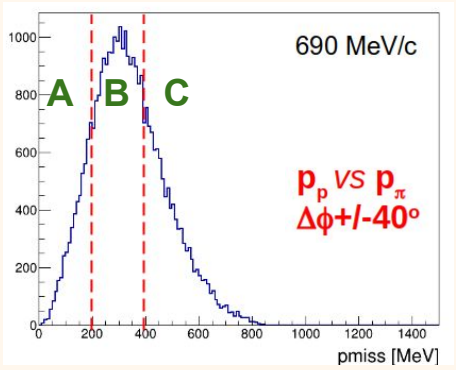


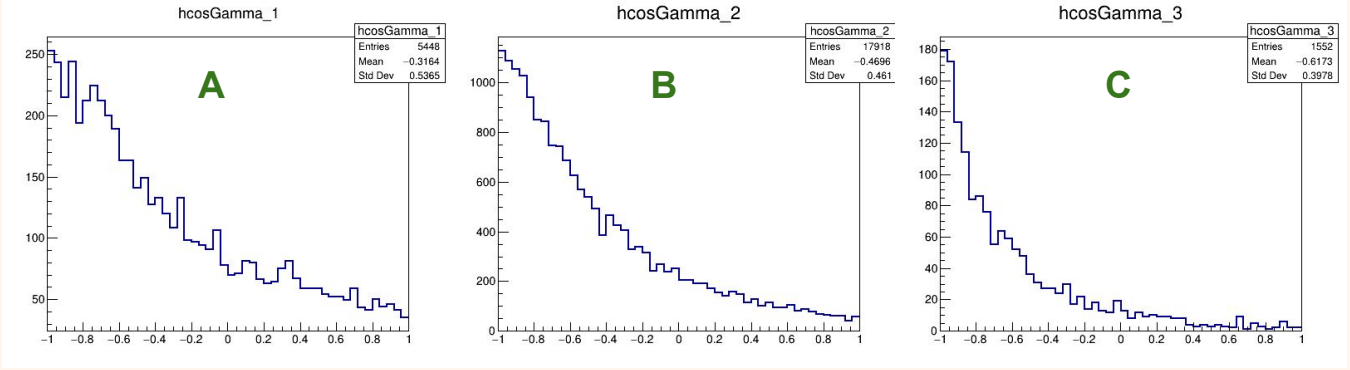
angle between initial momentum of participant proton and the recoil proton

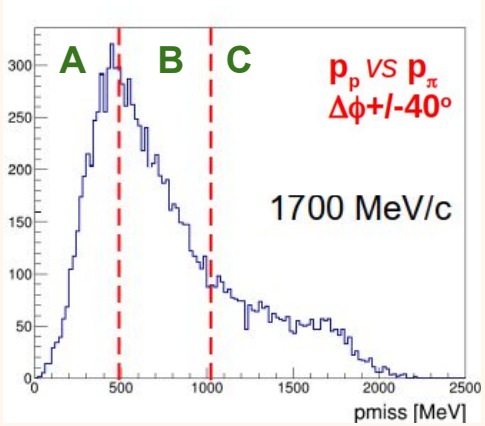
Events from sequential emission also show the "back-to-back peaking"

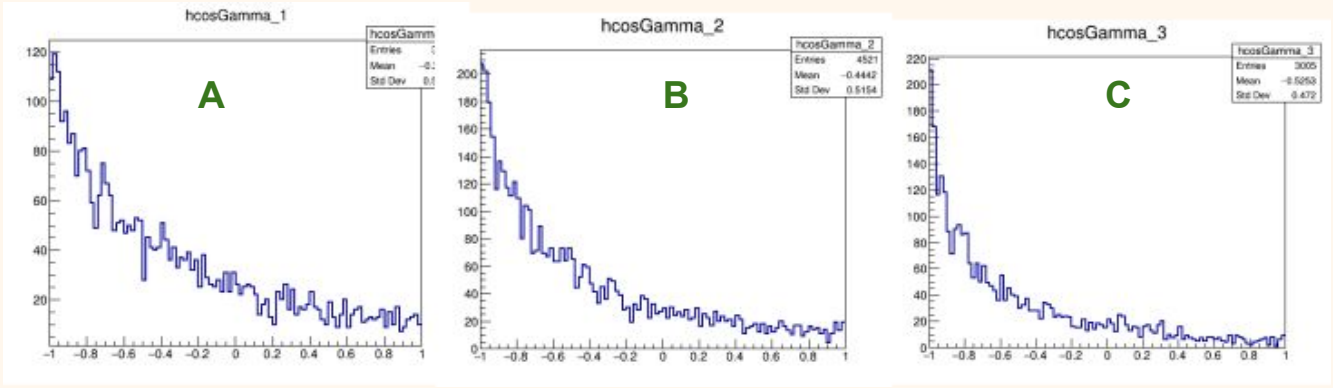
Angular correlation (2) (I.Ciepal)

ppπ^-









peaking more pronounced if P_{miss} is larger (^{11}B more boosted)

Conclusion

- Recent investigation of the sensitivity of HADES data to SRCs using INCL++ cascade model :
  - From the quasi-elastic process, use of kinematic selection (P_{π^-}>600 MeV/c) to suppress rescatterings.
  - Small effect seen at large P_{miss} in data and comparison with INCL calculations including SRCs for quasi-elastic processes : signal of SRCs?
  - Study of ppπ (I.Ciepal) : peaking not specific to SRC, but can be seen in sequential emission.

❑ Outlook:
  - Explore deeper SRC effects, in both 2 and 3-particle channels and test SRC models.
  - Test the INCL+SRC model at higher pion momentum 1700 MeV/c (data available).
  - Future experiment being prepared at GSI with HADES + neutron detectors
    Study Ag(p,p'pn) and Ag(p,ppp) Ep=4.5 GeV (see Tom Aumann presentation)

Thank you for your attention !