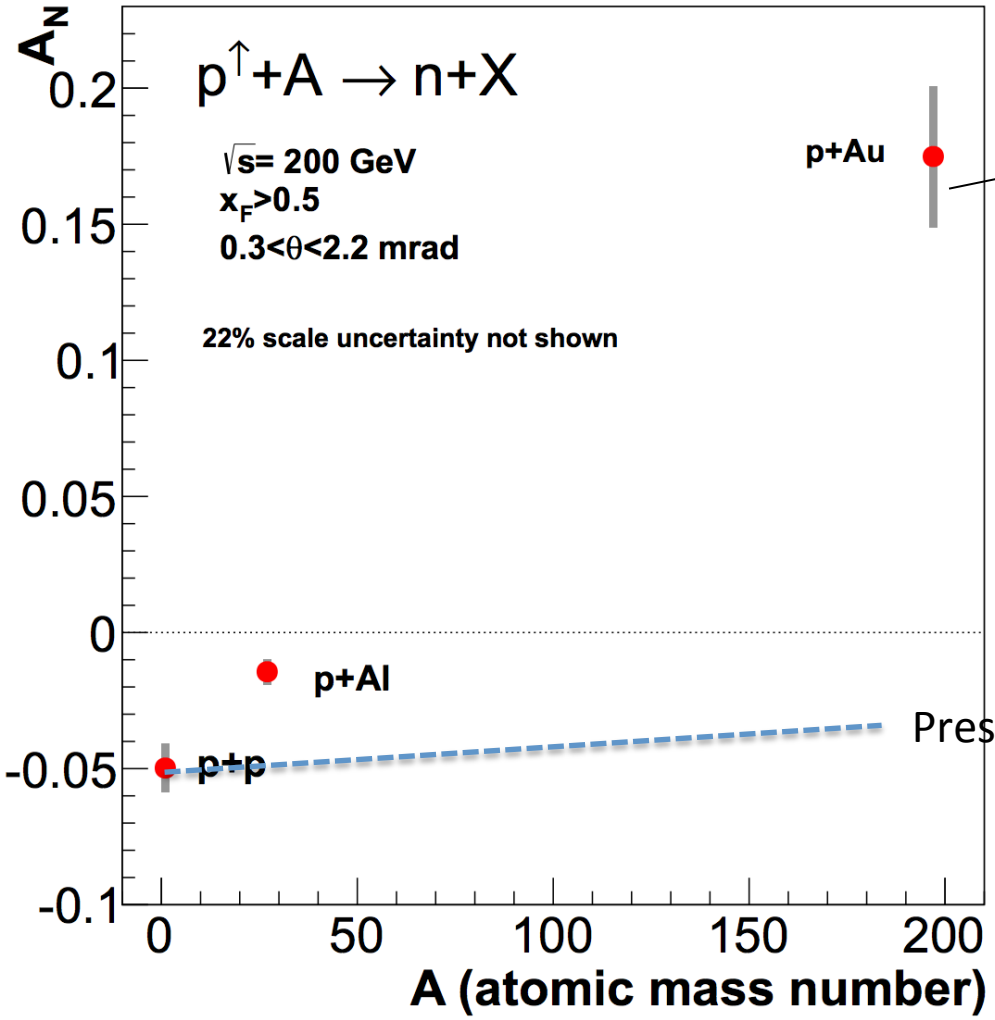
Forward Neutron Asymmetry of p+A Measurement using Fixed Target

I. Nakagawa
for the RHICf Collaobration

A-Dependent A_N (inclusive)



Major systematic error comes from poor position resolution of SMD.

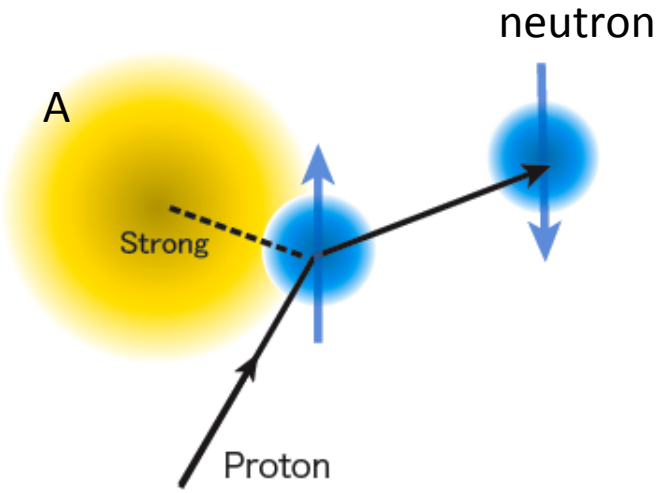
	# of proton	# of neutron
p	1	0
Al	13	14
Au	79	118

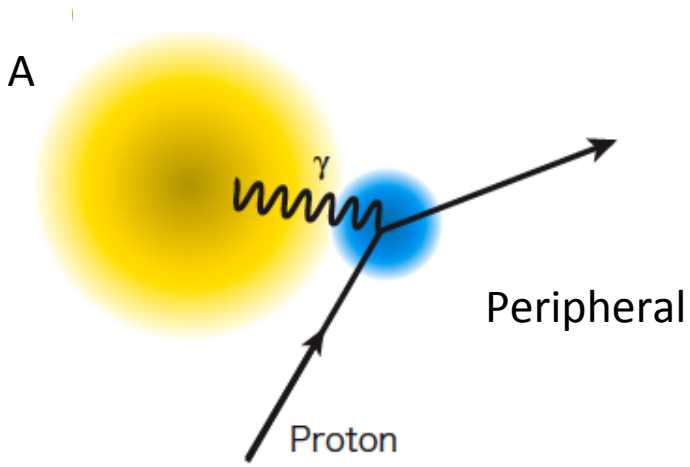
Present Frame Work

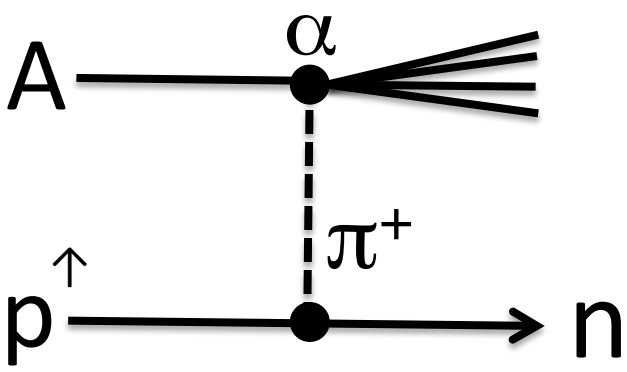
Absolutely Unexpected!

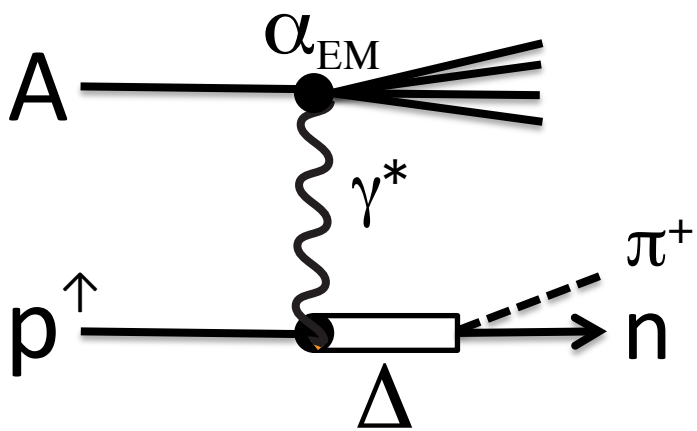
Analysis by
Minjung Kim (SNU/RIKEN)

Ultra Peripheral Collision (UPC)



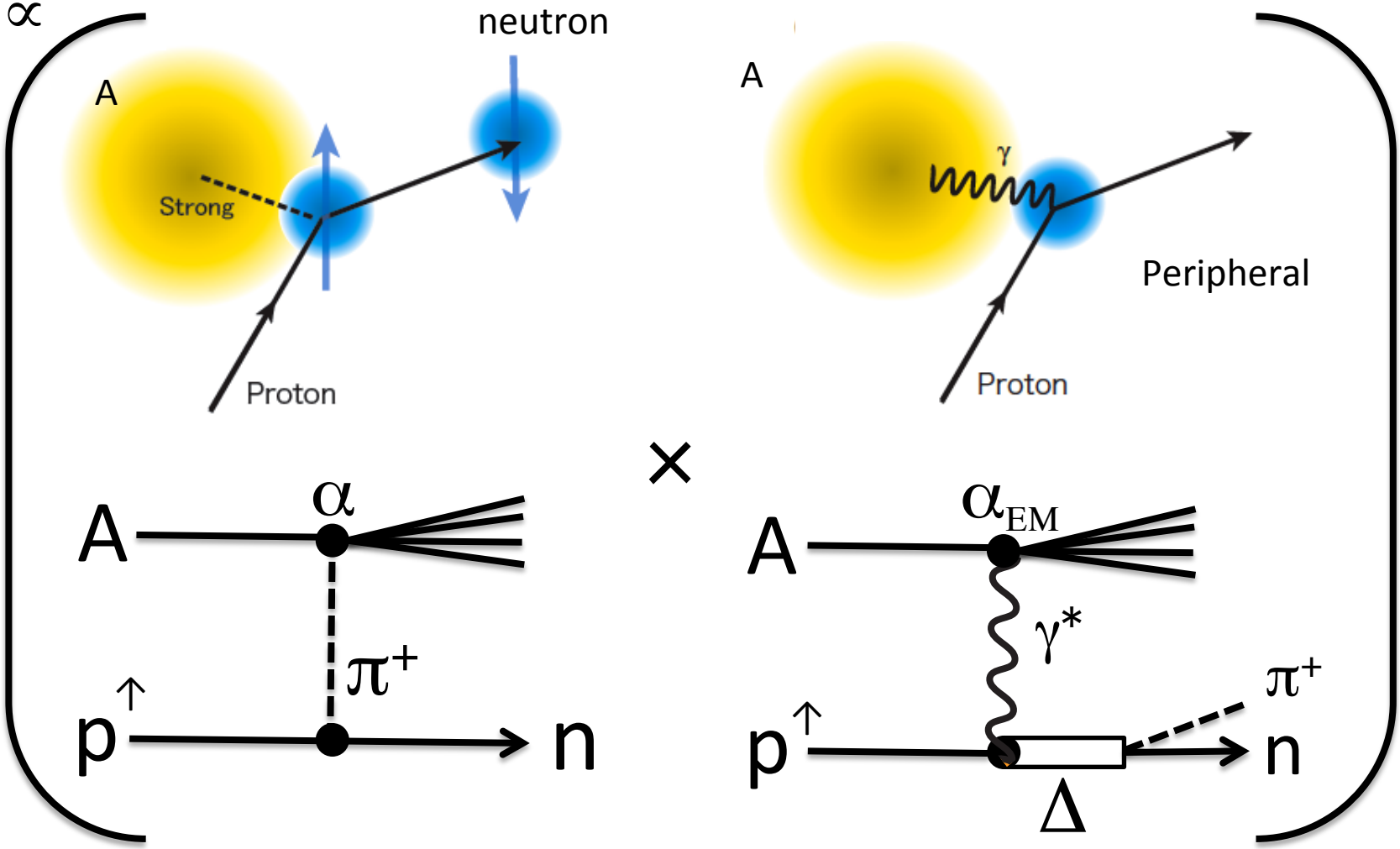




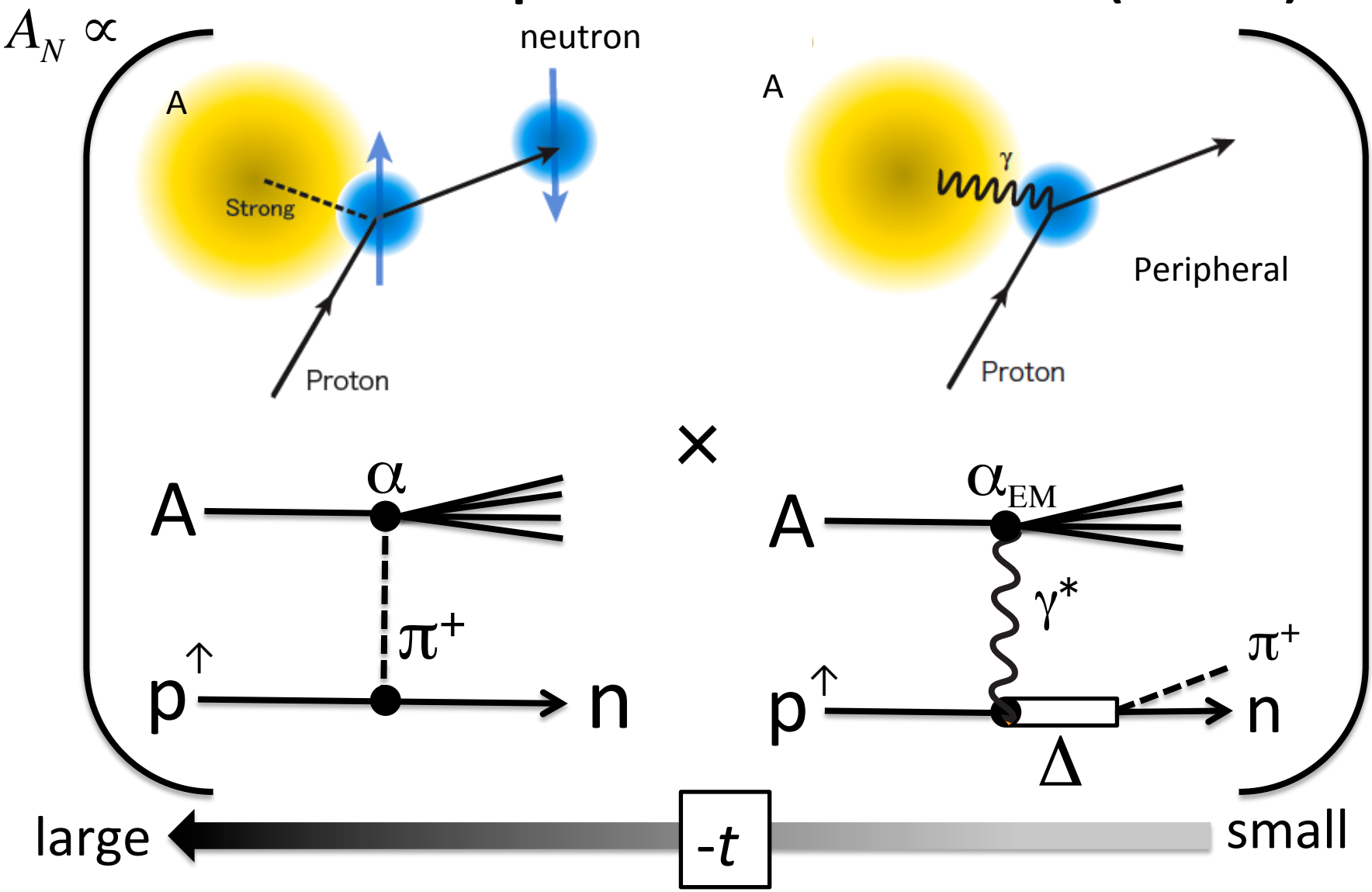


Ultra Peripheral Collision (UPC)

$A_N \propto$

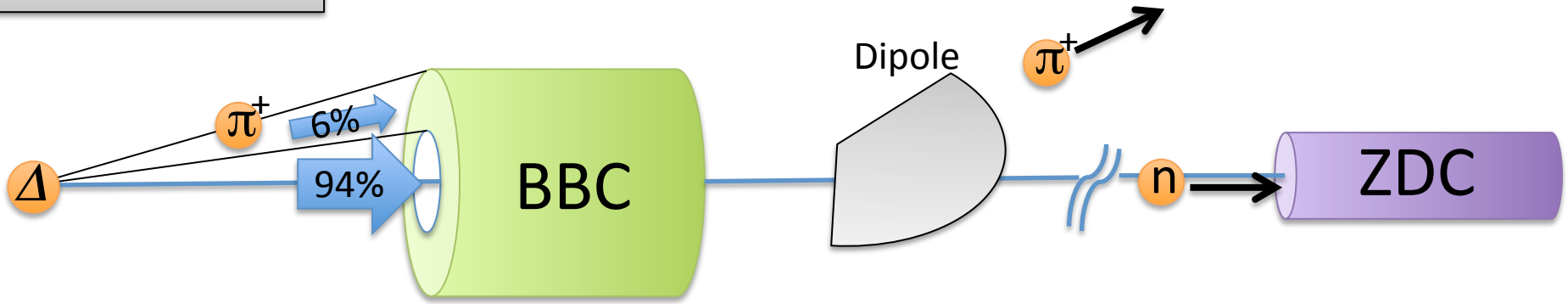


Ultra Peripheral Collision (UPC)



Can we identify UPC events?

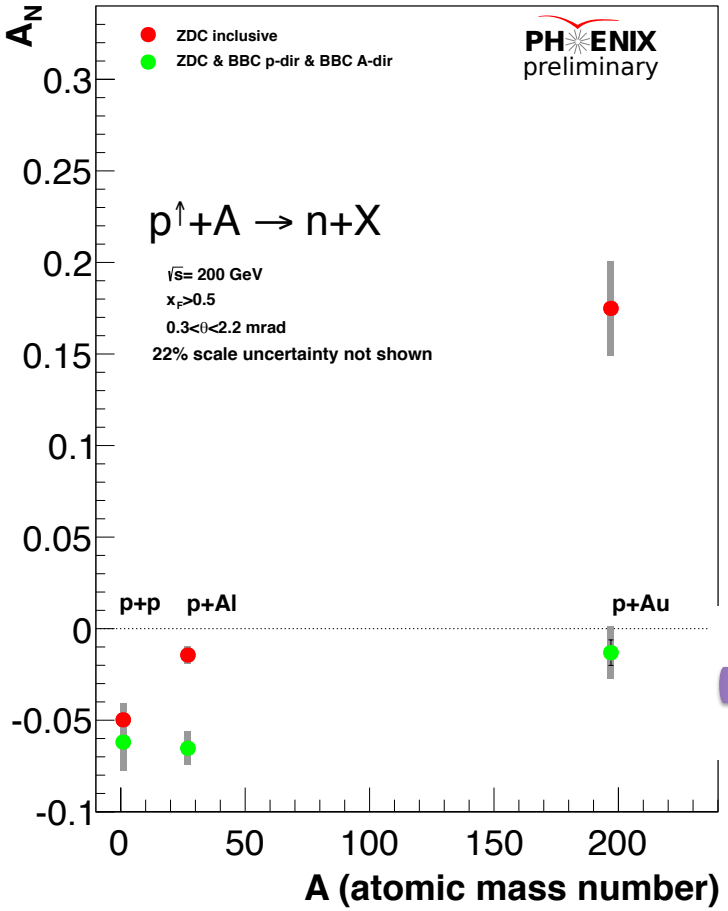
Semi-Inclusive

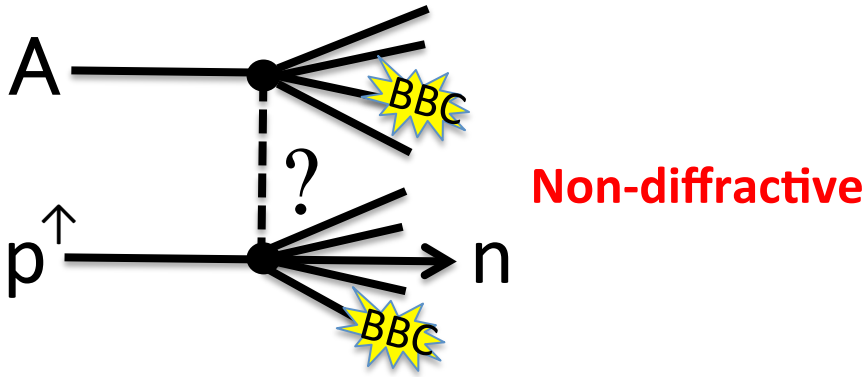


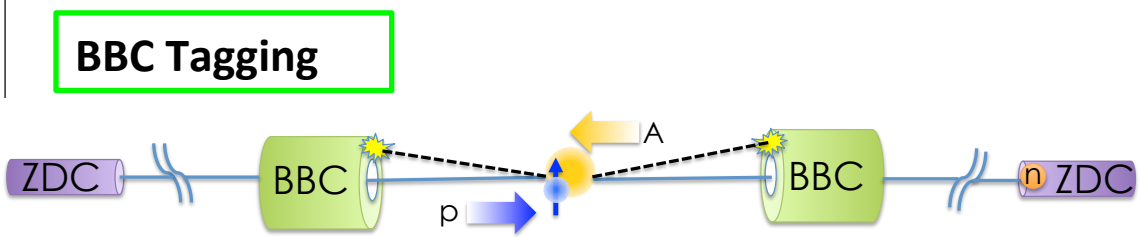
UPC MC : SOPHIA
G. Mitsuka, Eur. Phys. J.C. (2015) 75:614

BBC	tag	veto
UPC	Small	Large

BBC Tagging and Vetoing



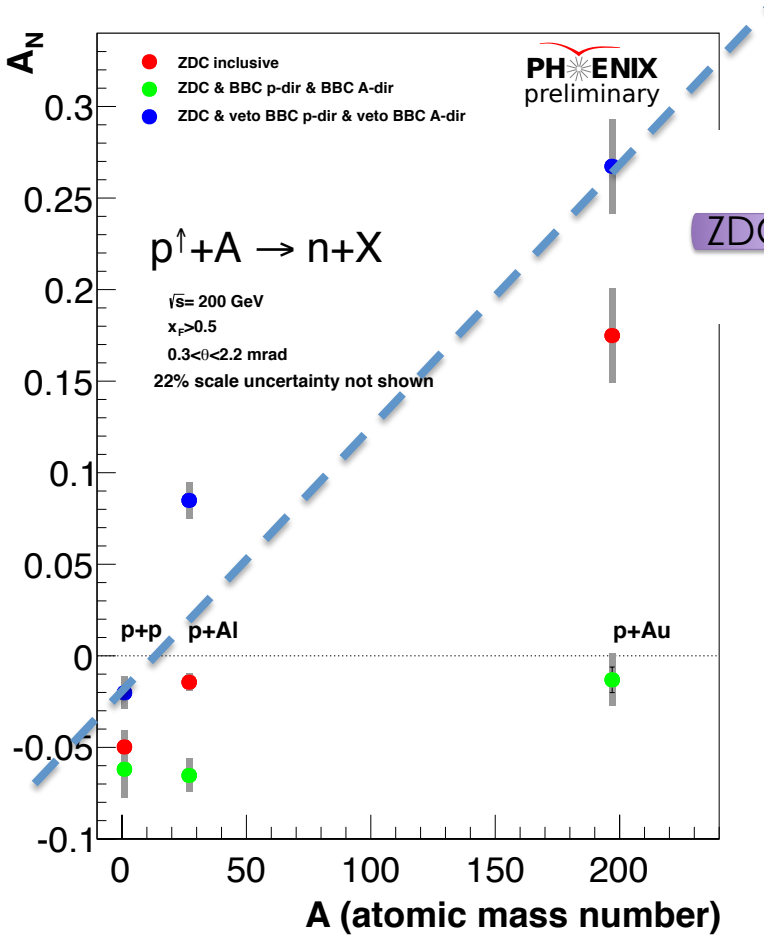




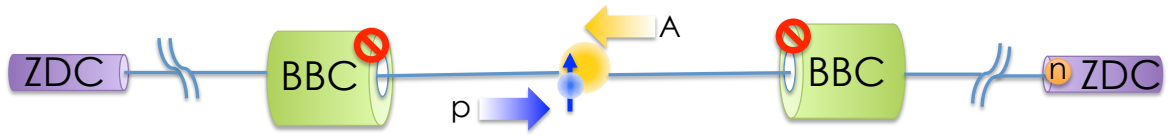
EM surpressed

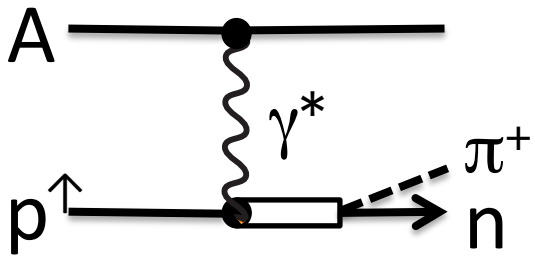
$$A_N \sim \boxed{had * had} + had * EM + EM * had + EM * EM$$

BBC Tagging and Vetoing



BBC Vetoing





Diffractive

EM enhanced

$$A_N \sim had * had + \boxed{had * EM + EM * had + EM * EM}$$

Question arose from Run15

1. Is the evolution of A(Z)-dependence linear ***!?***

2. Diffractiveness plays key role***!?***

3. What is the role of hadronic and EM amplitudes***!?***

Proposal for Run17

1. Is the evolution of A(Z)-dependence linear ***!?***

Explore A(Z)-dependence (p+Al, **p+Sn,** p+Au) using the Fixed Targets at STAR

2. Diffractiveness plays key role***!?***

Larger acceptance coverage for Semi-Inclusive using STAR detector

3. What is the role of hadronic and EM amplitudes***!?***

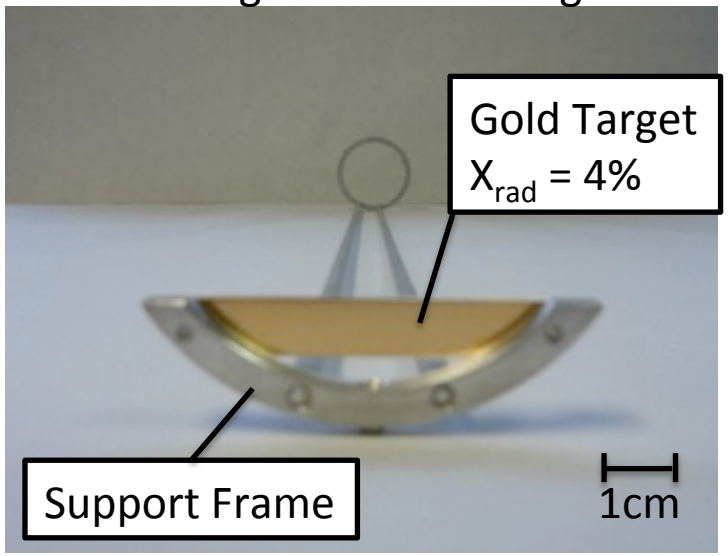
Larger P_T coverage with better resolution

Experimental Condition

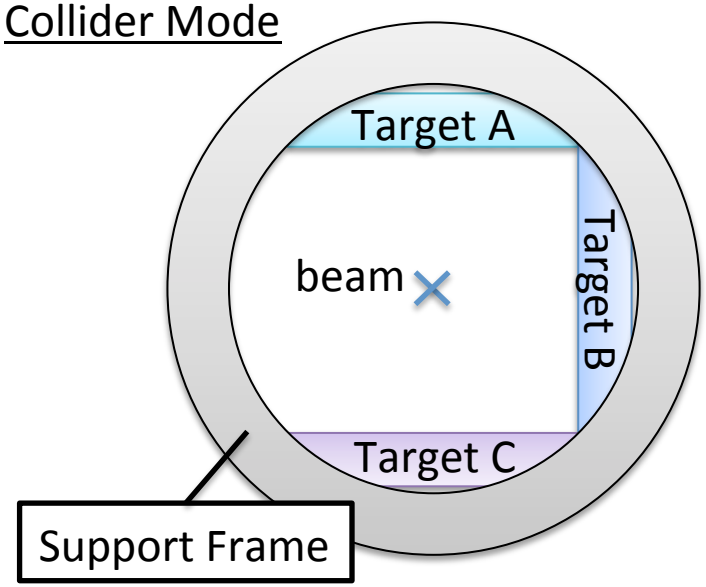
- Targets to be installed before Run17
- Same β^*=10m & radial pol tune with RHICf
- Only blue beam.
- Luminosity is not an issue (limited by DAQ bandwidth ~ 1kHz).
- Can be done at the end of RHICf store

1. Three Fixed Targets for A-dependence

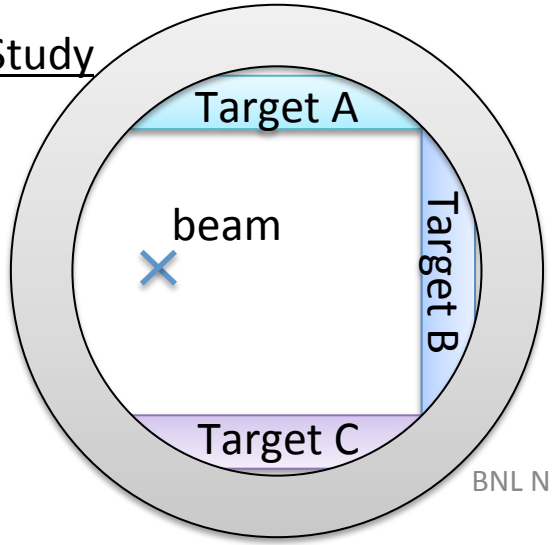
Existing STAR Fixed Target



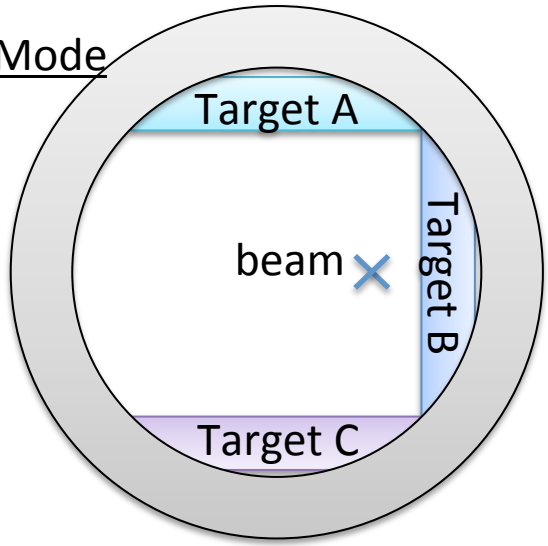
Collider Mode



Background Study Mode

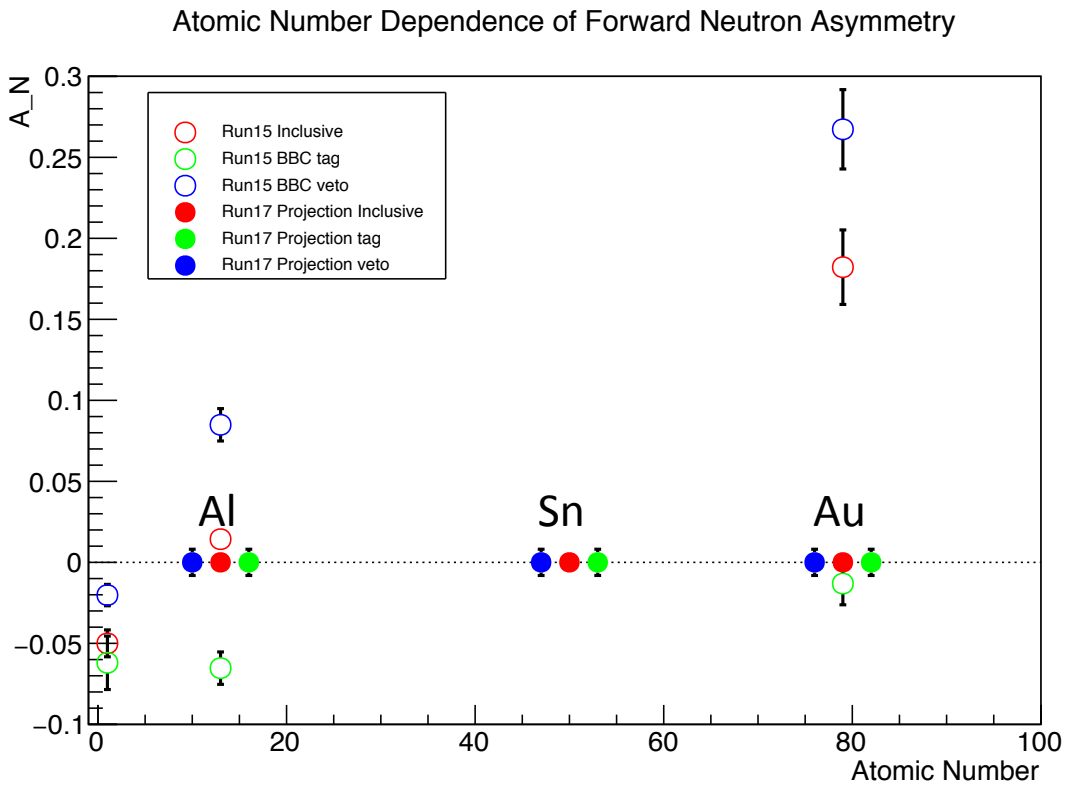


Fixed Target Mode

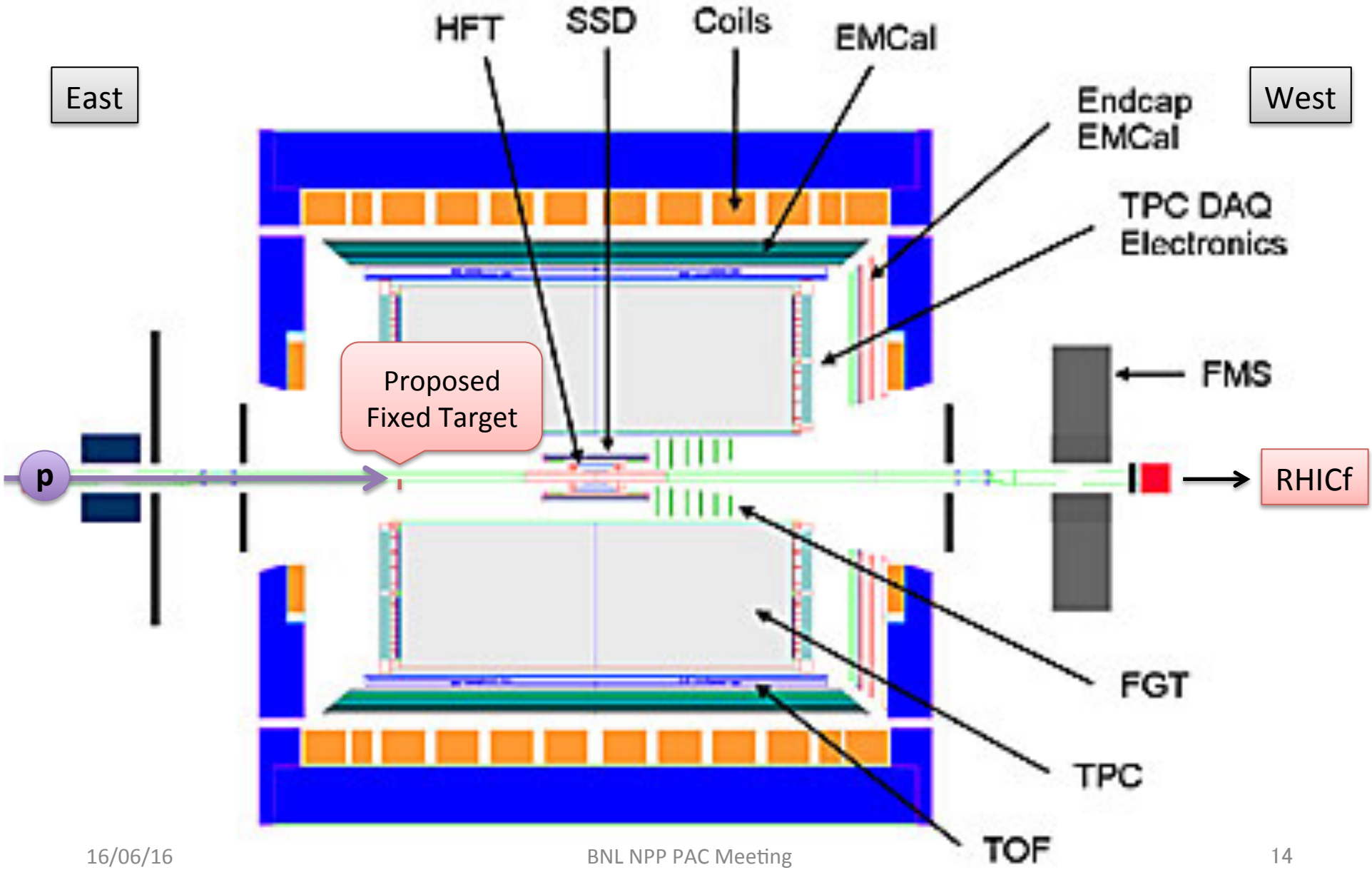


1. A(Z)-Dependent Analyzing Power

Beam Energy [GeV]	Collision √s [GeV]	Fixed Target √s [GeV]
100	200	14
250	500	22

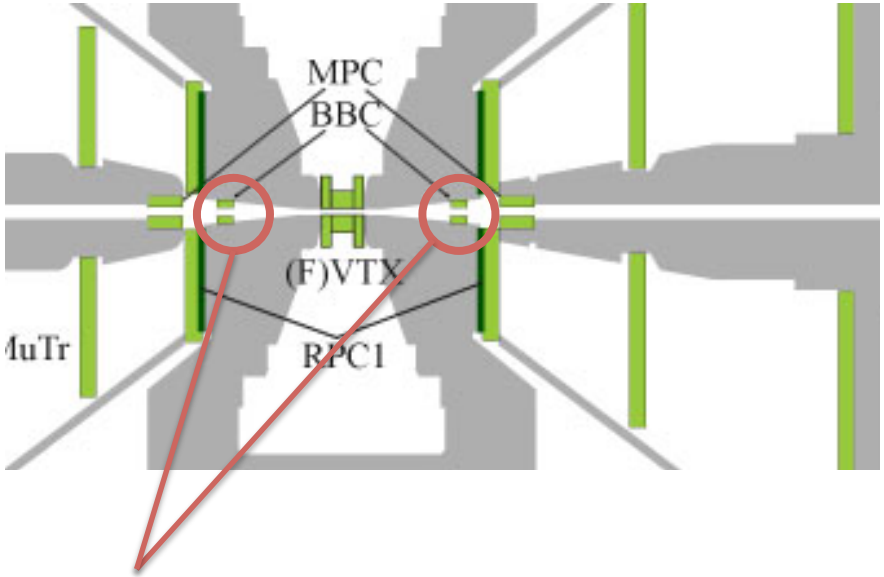


STAR Fixed Target



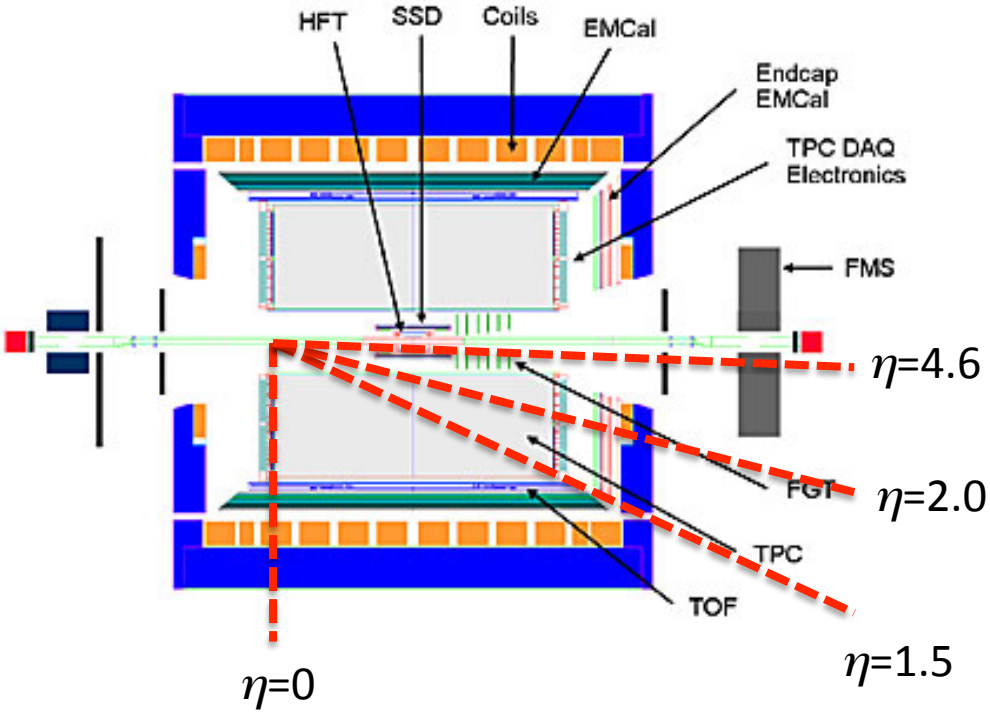
2. Acceptance for Semi-Inclusive

Run15 PHENIX

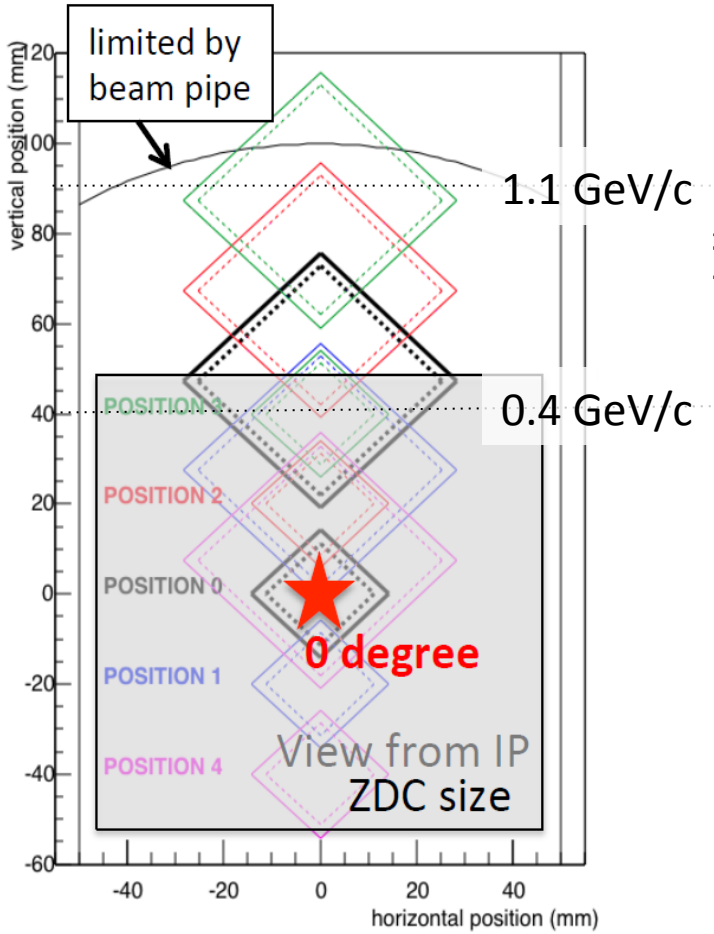


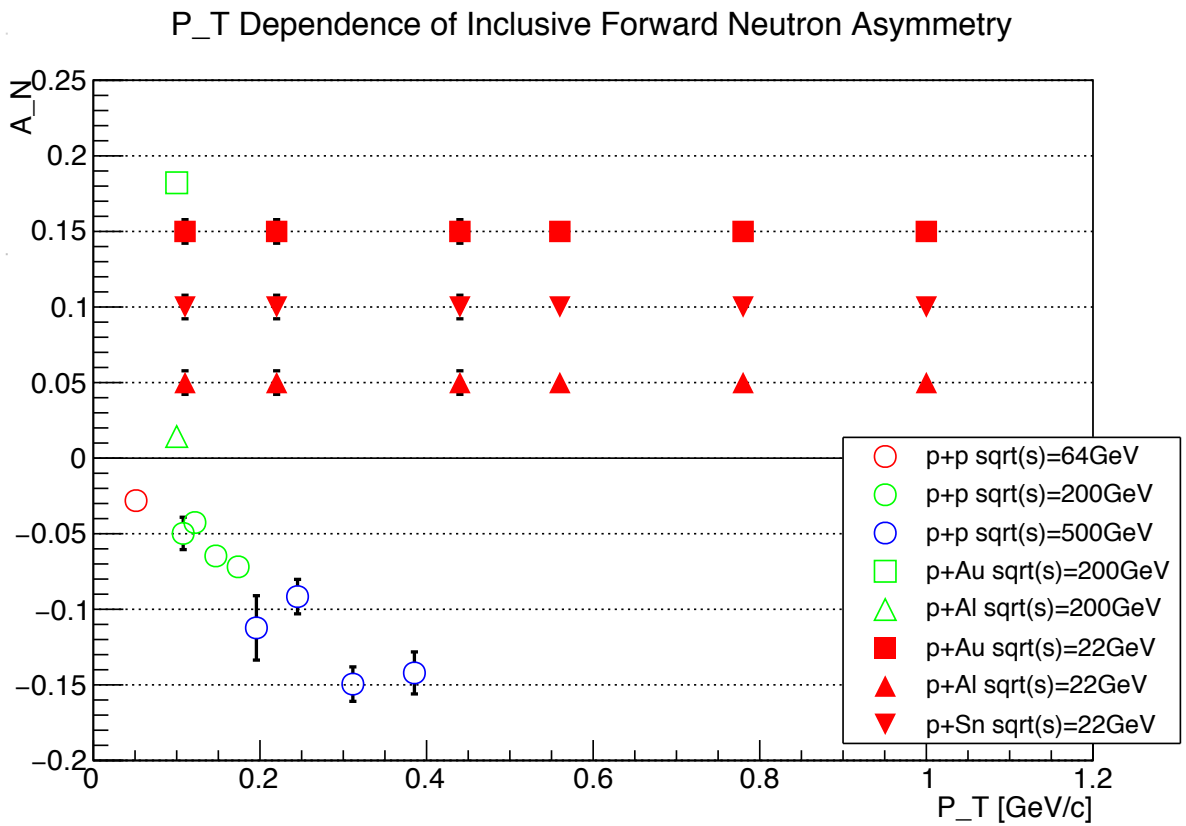
BBC 3.1 < $|\eta|$ < 3.9

STAR Fixed Target



3. Extended P_T Coverage





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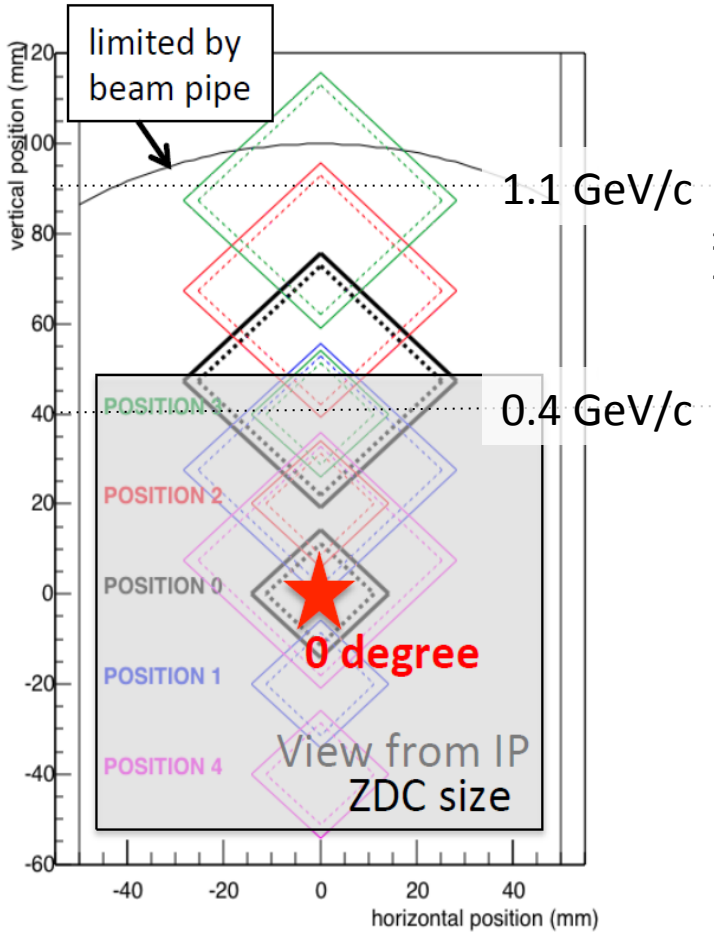
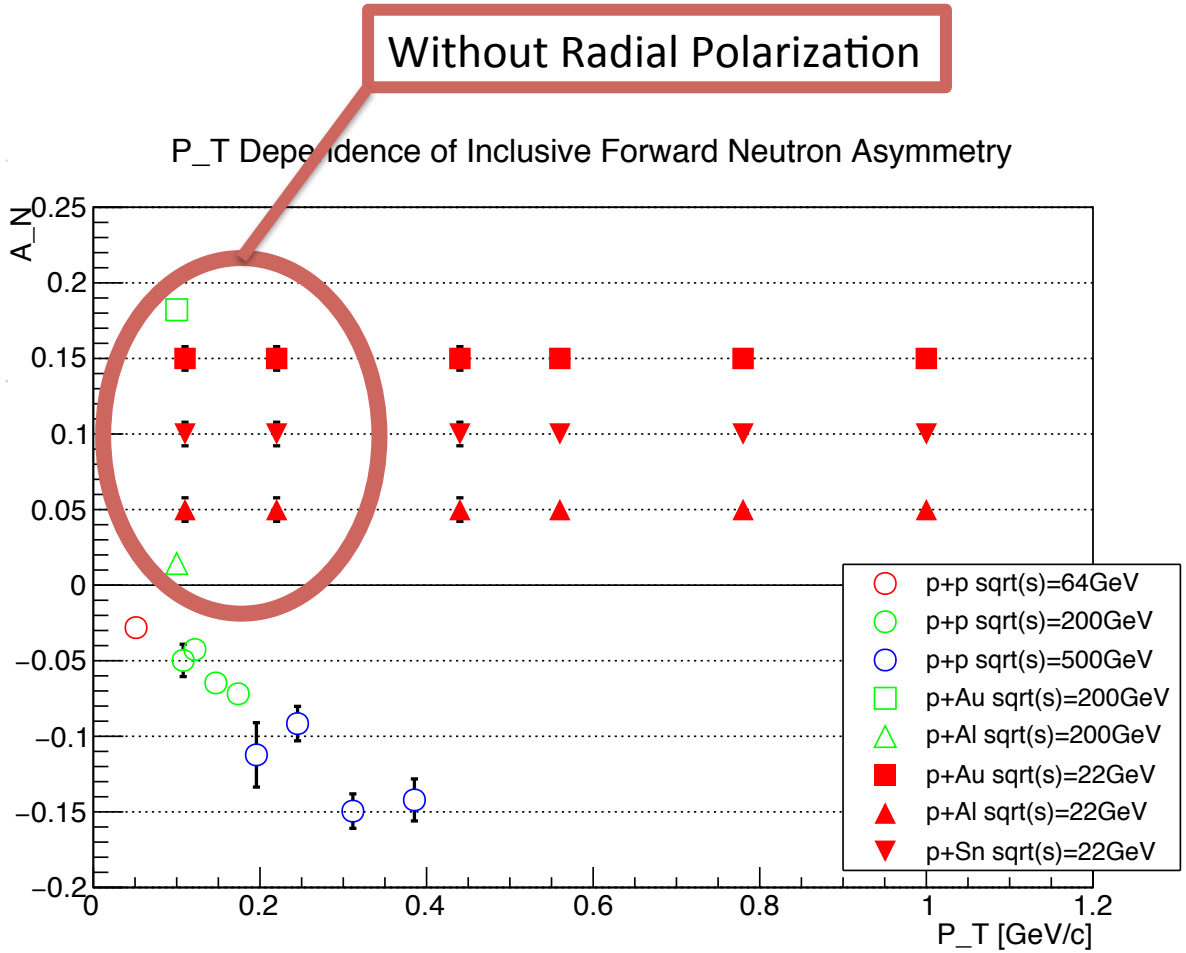




Run Plan

1. Physics Data (9h)

   1 hour × 3 Targets × 3 RHICf positions = 1 hour × 9 physics runs

1h ~ 3.6M events : ΔA_N ~ 0.0026

2. Empty Target (3h)
   1. 1 hour × 3 RHICf positions = 3h
3. Beam position tuning (2h)

   0.5 hour × 4 positions = 2 hours
4. RHICf position change (1.5h)

   0.5 hour × 3 positions = 1.5h
5. Contingency (8.5h)

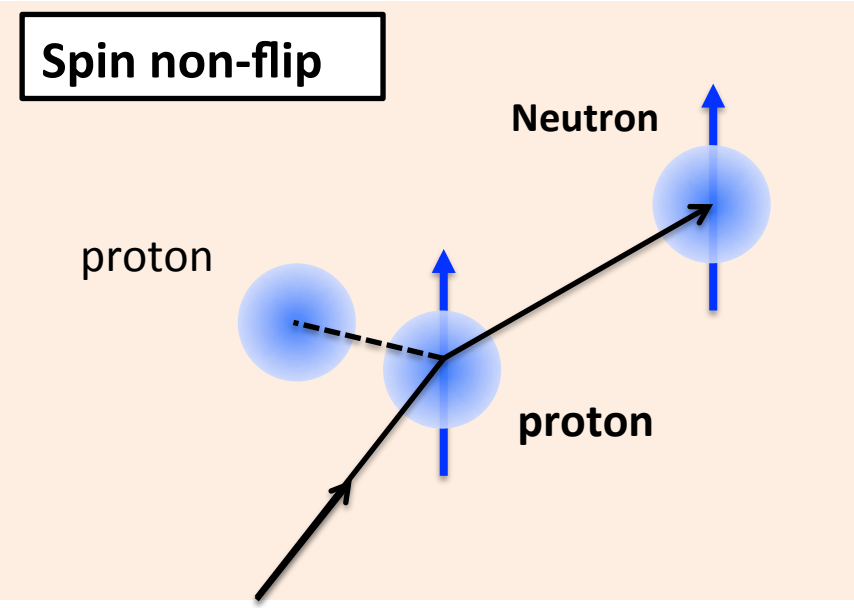
(9h + 3h) + 2h + 1.5h + 8.5h ~ 24 hours

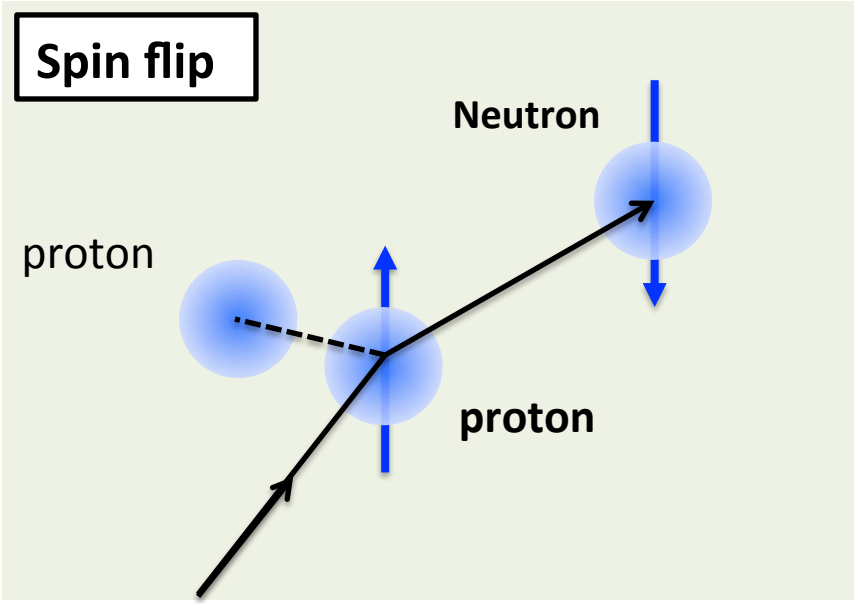
Summary

- Proposal to explore forward neutron asymmetry in pA to address mysteries arose from Run15.
- 3 Fixed Targets at STAR
- Requesting 24 hours (12hours data taking)
- Same beam tune as RHICf (β^*, radial) no special tune. Only blue beam and can be done at the end of RHICf store.

BACKUP

$p^{\uparrow}$+p Forward Neutron A_N



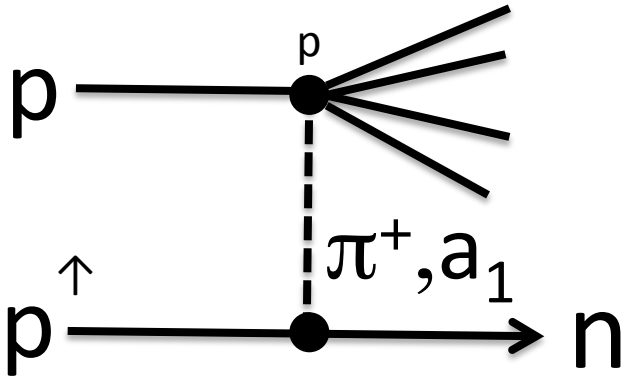


$$A_N \approx \frac{\left(\phi^*_{non-flip}\phi_{flip}\sin\delta\right)}{\left|\phi_{non-flip}\right|^2 + \left|\phi_{flip}\right|^2}$$

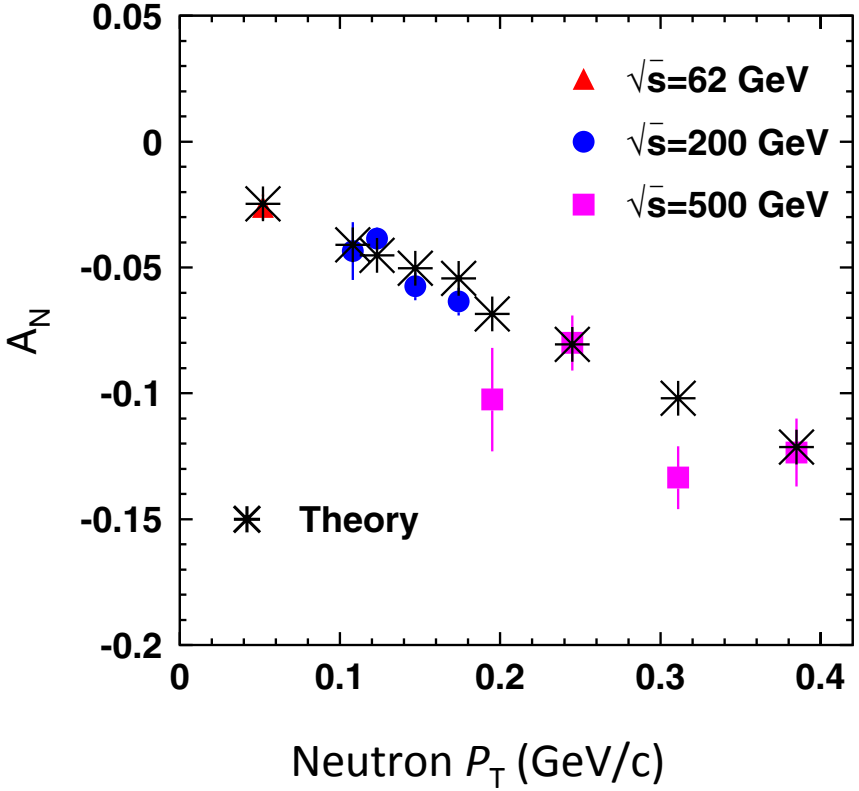
δ : phase shift

Unpolarized Cross Section

$p^{\uparrow}$+p Forward Neutron A_N



PRD84,114012(2011)



Data are well reproduced by the interference between π and a_1 Reggeon

Full Description of A_N

$$A_N \propto 2\,\mathrm{Im}\left\{\phi^*_{non-flip}\phi_{flip}\sin\delta\right\}$$

$$\phi_{flip} = \phi^{had}_{flip} + \phi^{EM}_{flip}$$

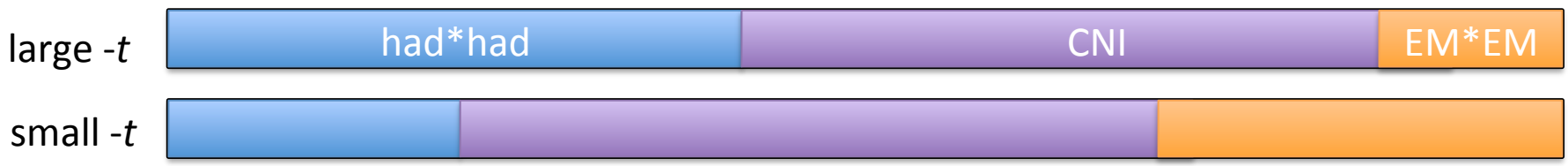
$$\phi_{non-flip} = \phi^{had}_{non-flip} + \phi^{EM}_{non-flip}$$

$\Delta_{1\sim4}$: relative phase of amplitudes

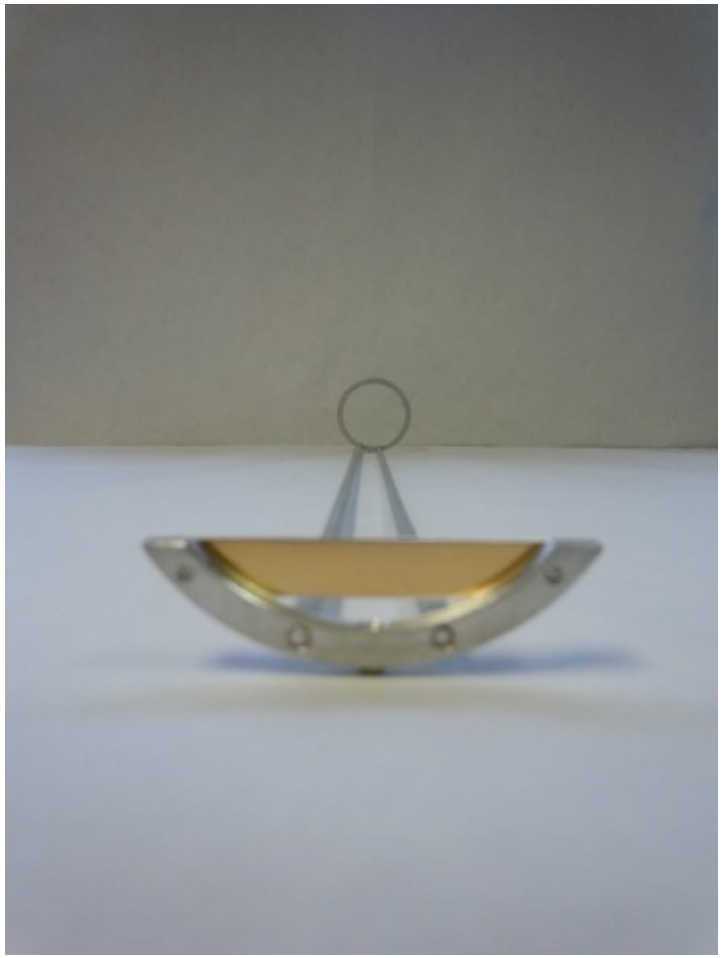
$$A_N \propto 2\,\mathrm{Im}\left(\phi^{had}_{non-flip} + \phi^{EM}_{non-flip}\right)\left(\phi^{had*}_{flip} + \phi^{EM*}_{flip}\right)$$

$$= 2\,\mathrm{Im}\left(\underbrace{\phi^{had*}_{non-flip}\phi^{had}_{flip}\sin\delta_1}_{pp} + \underbrace{\phi^{EM*}_{non-flip}\phi^{had}_{flip}\sin\delta_2 + \phi^{had*}_{non-flip}\phi^{EM}_{flip}\sin\delta_3}_{\text{CNI}} + \underbrace{\phi^{EM*}_{non-flip}\phi^{EM}_{flip}\sin\delta_4}_{\text{Primakoff}}\right)$$

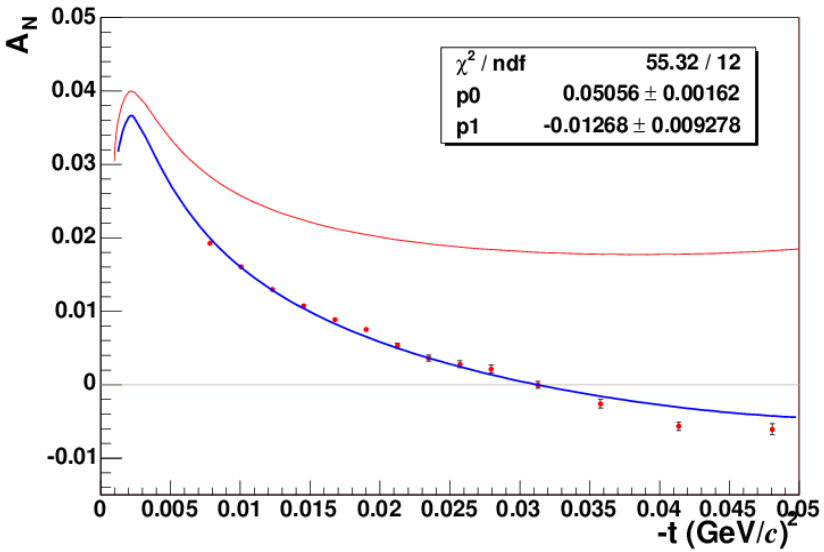
large ← $\boxed{-t}$ → small

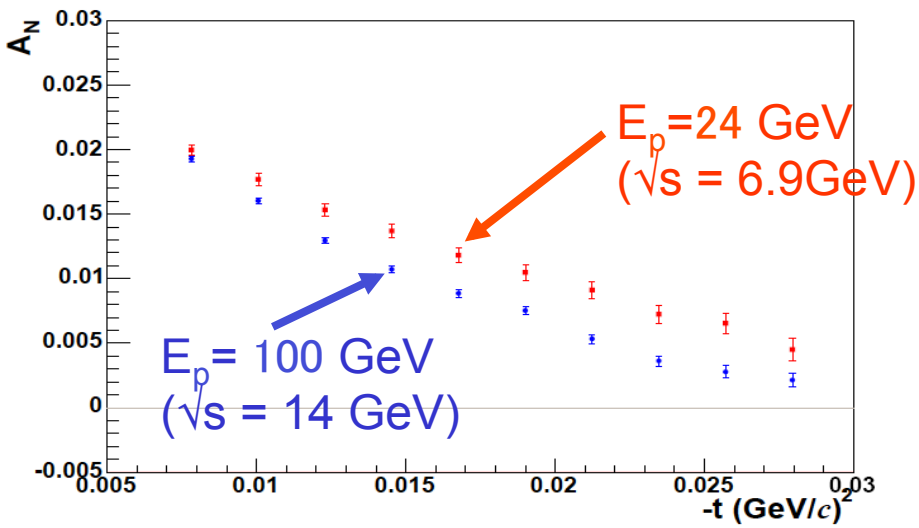


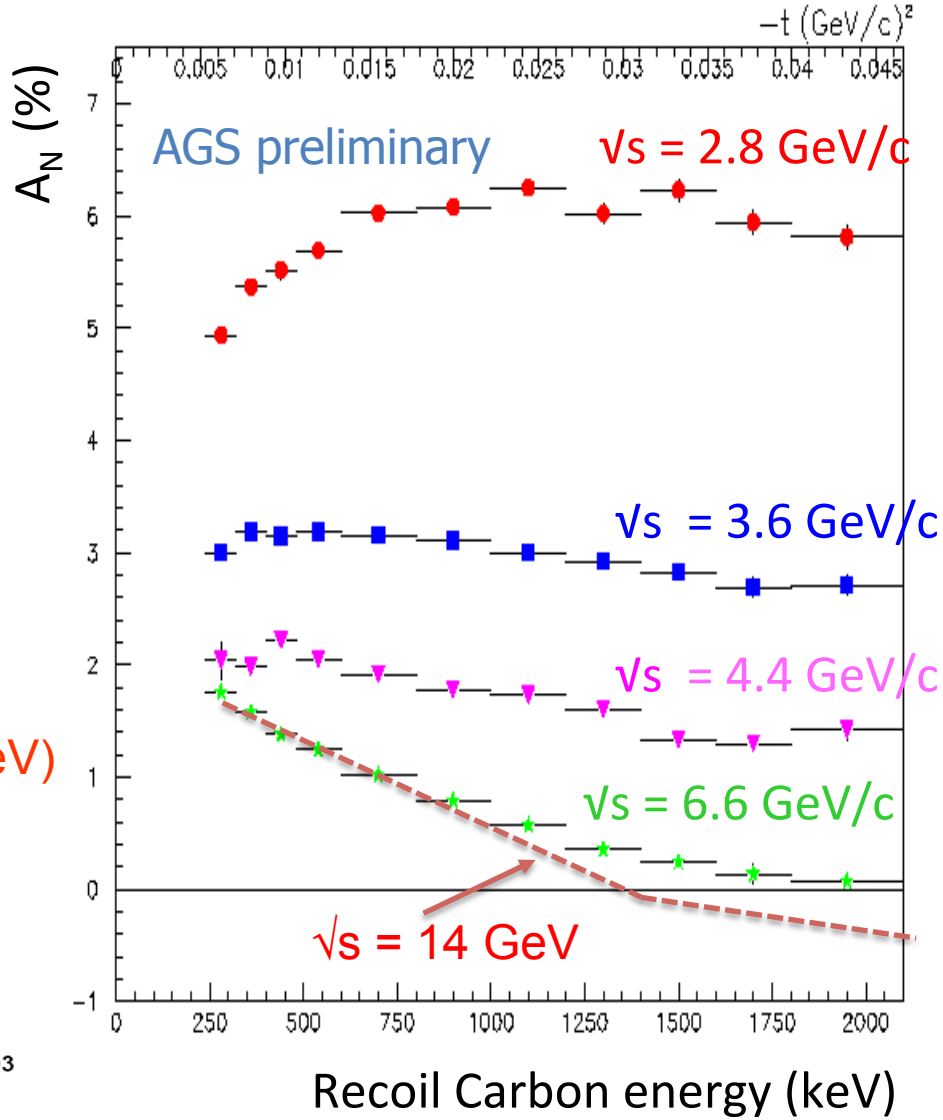
Existing STAR Fixed Au Target



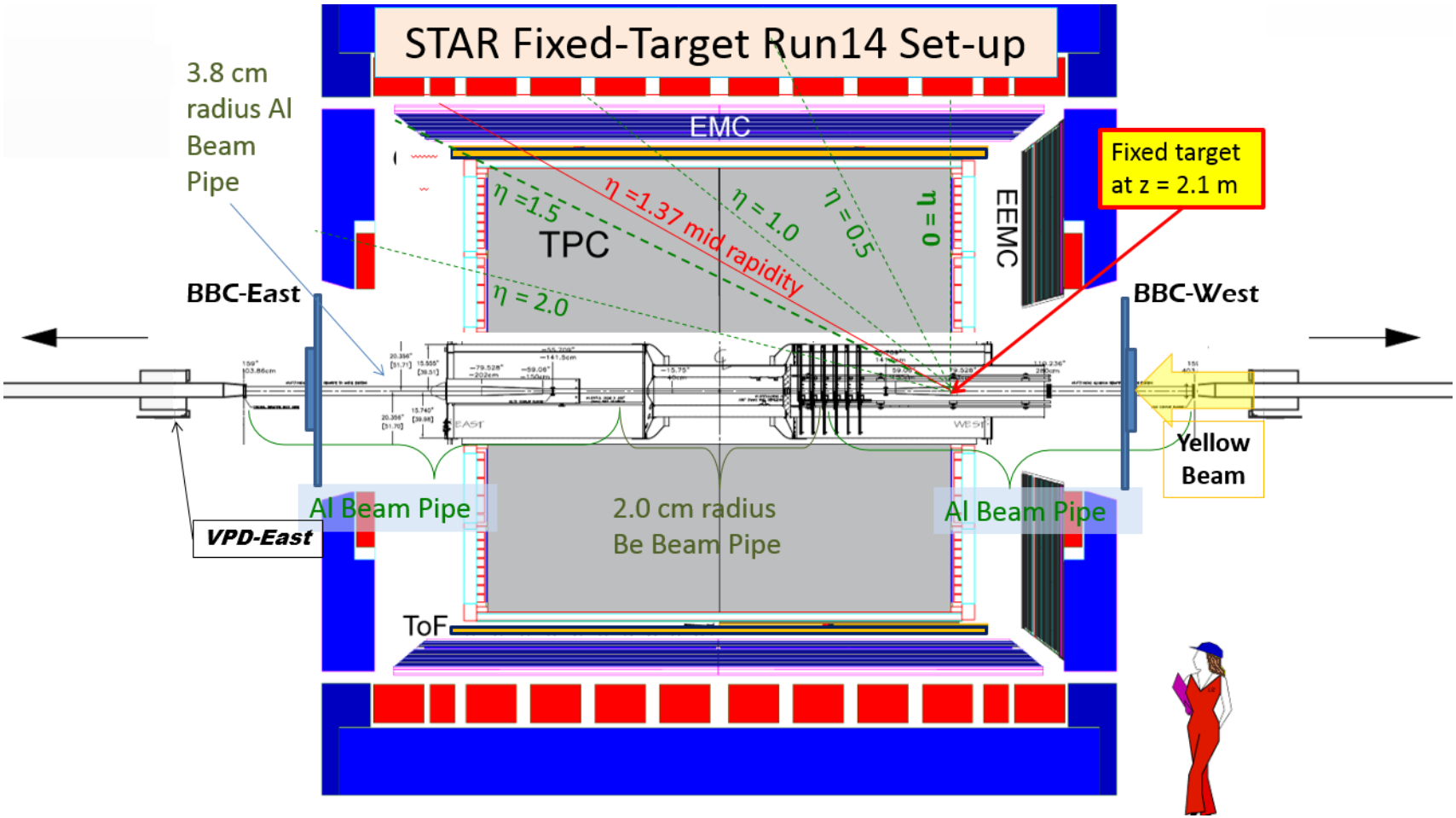
Elastic p+C : Energy Dependent A_N



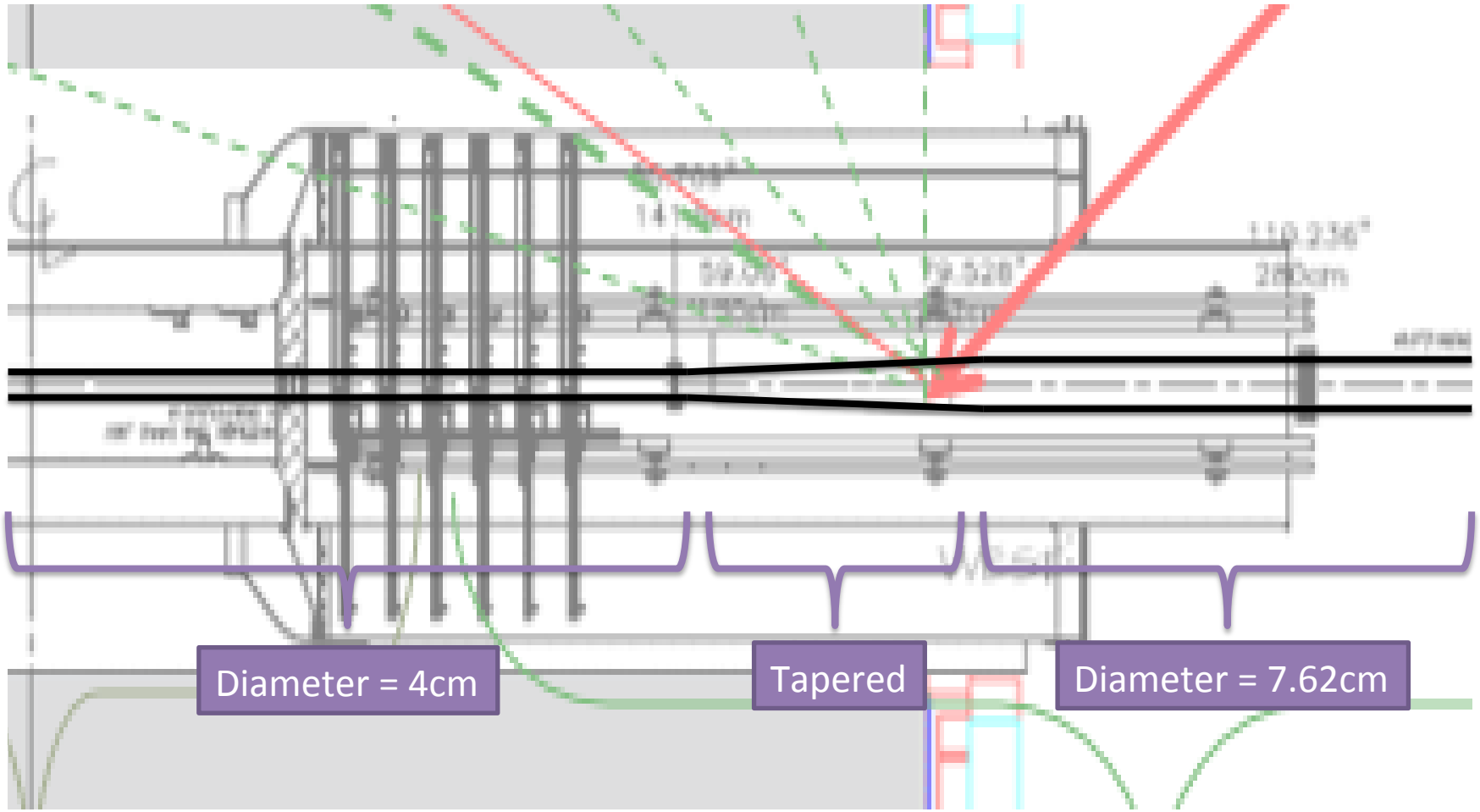




Run 14 Test Run



Beam Pipe Diameter



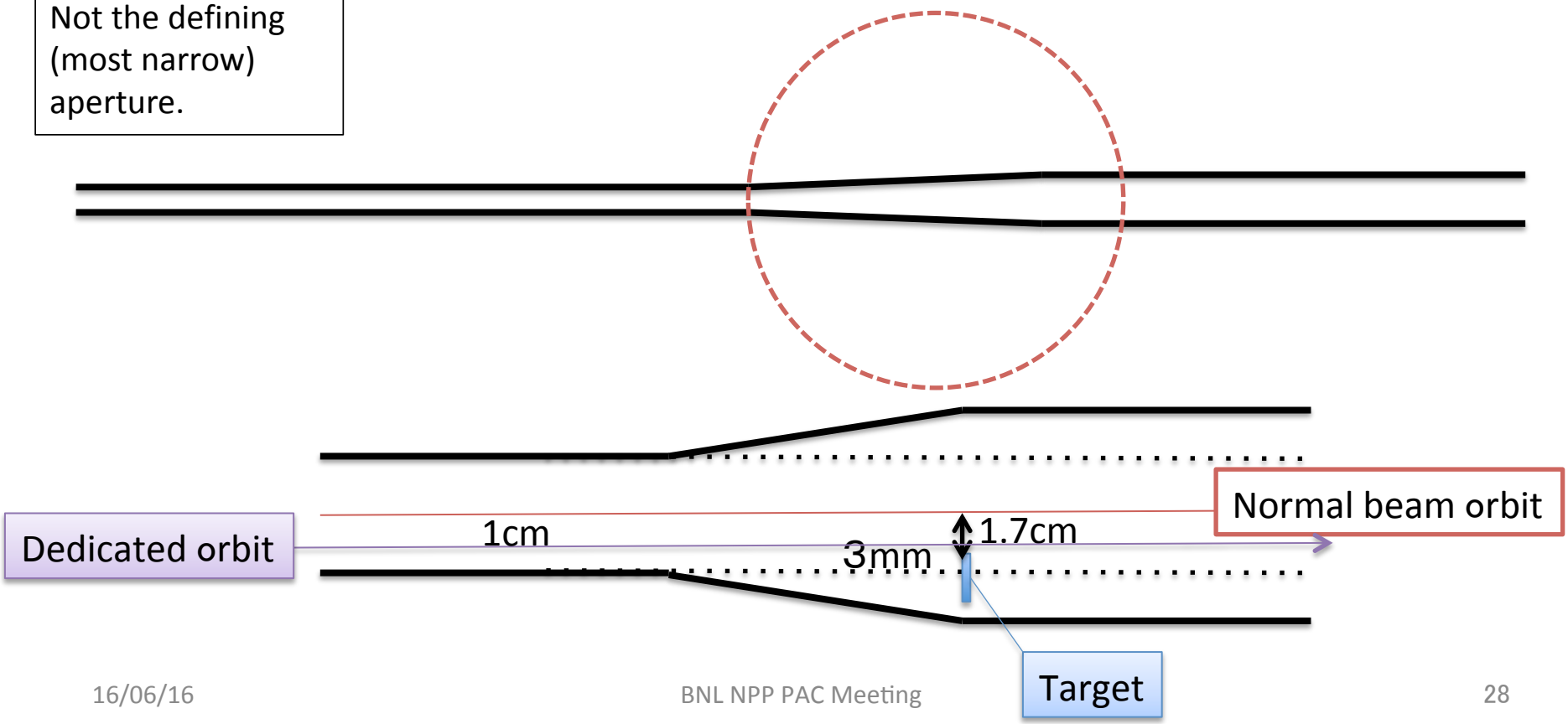
Run 14 details:

The target foil is held 2 cm below of the beam axis.

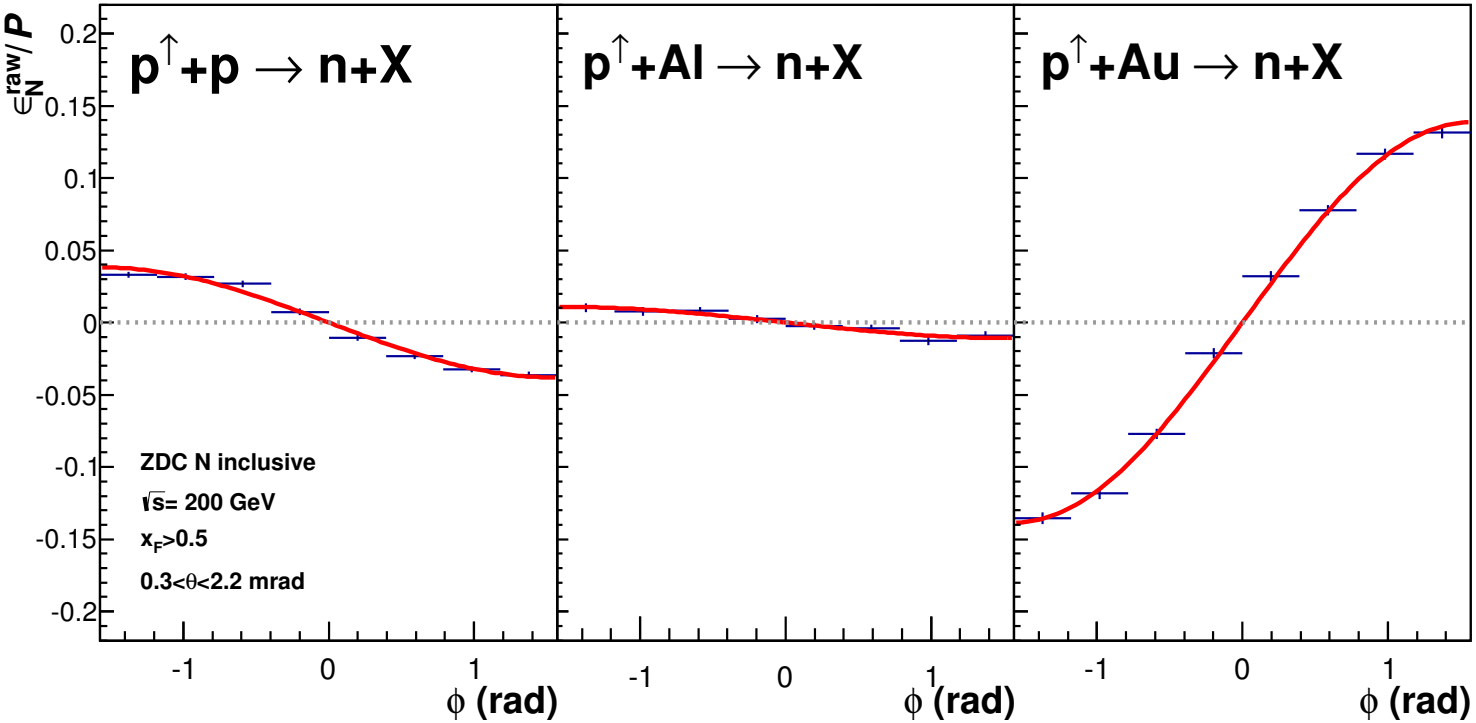
The foil is 1 mm thick (4%).

Not the defining (most narrow) aperture.

Beam Pipe Diameter



Run15 Statistics



	p+p	p+Al	p+Au
$A_N \pm \Delta A_N$	-0.0500±0.0014	-0.0143±0.0019	0.1822±0.0019
$\Delta A_N/A_N$ (relative)	3%	15%	1%

Approximately accumulated >10M ZDC triggers @ DAQ rate 4 to 5 kHz.
Survival fraction after QA cuts is about 20 ~ 30%.
Absolute error is very small : 0.0014 – 0.0019

DAQ time estimate

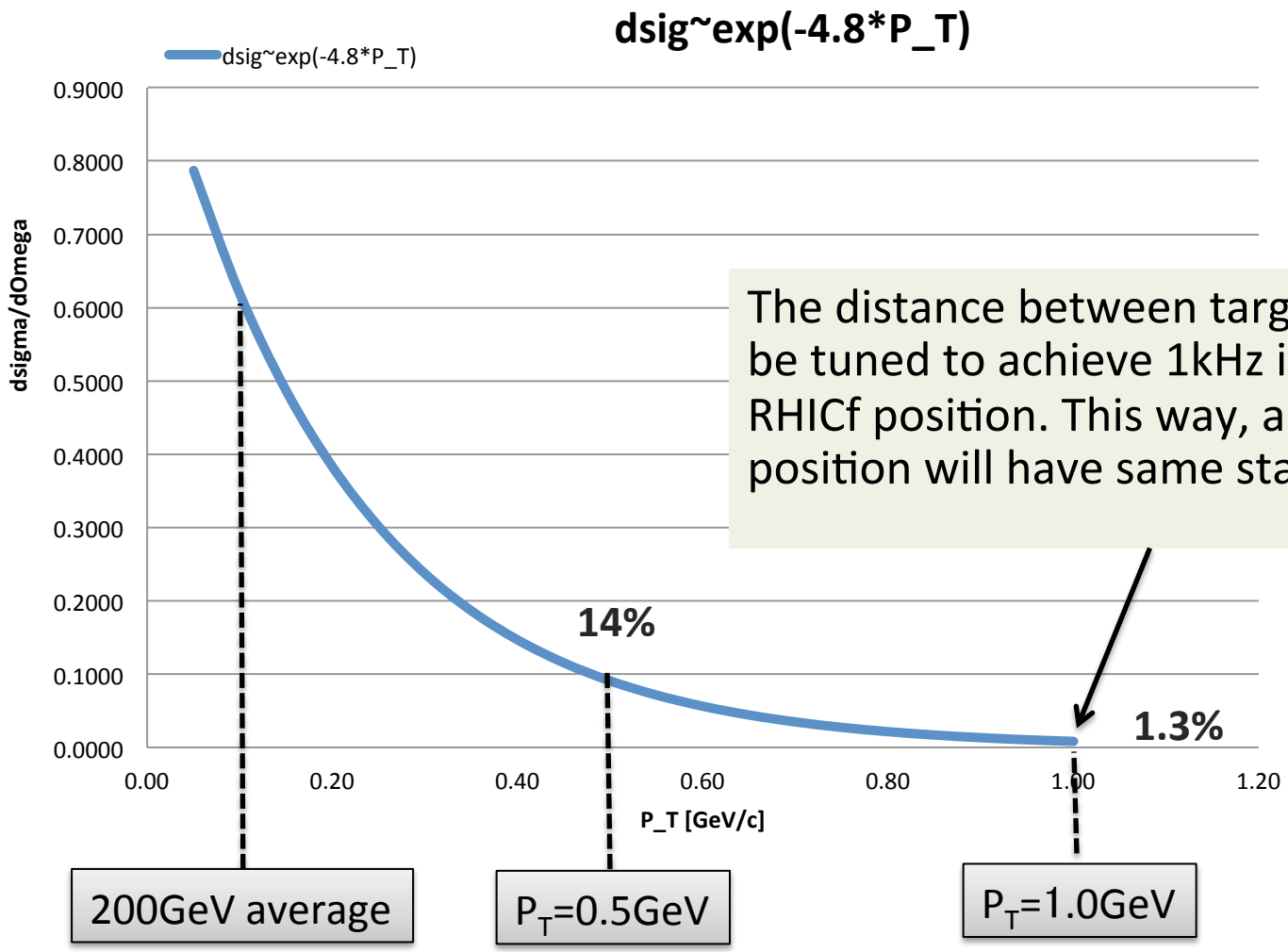
DAQ rates ~ 1kHz

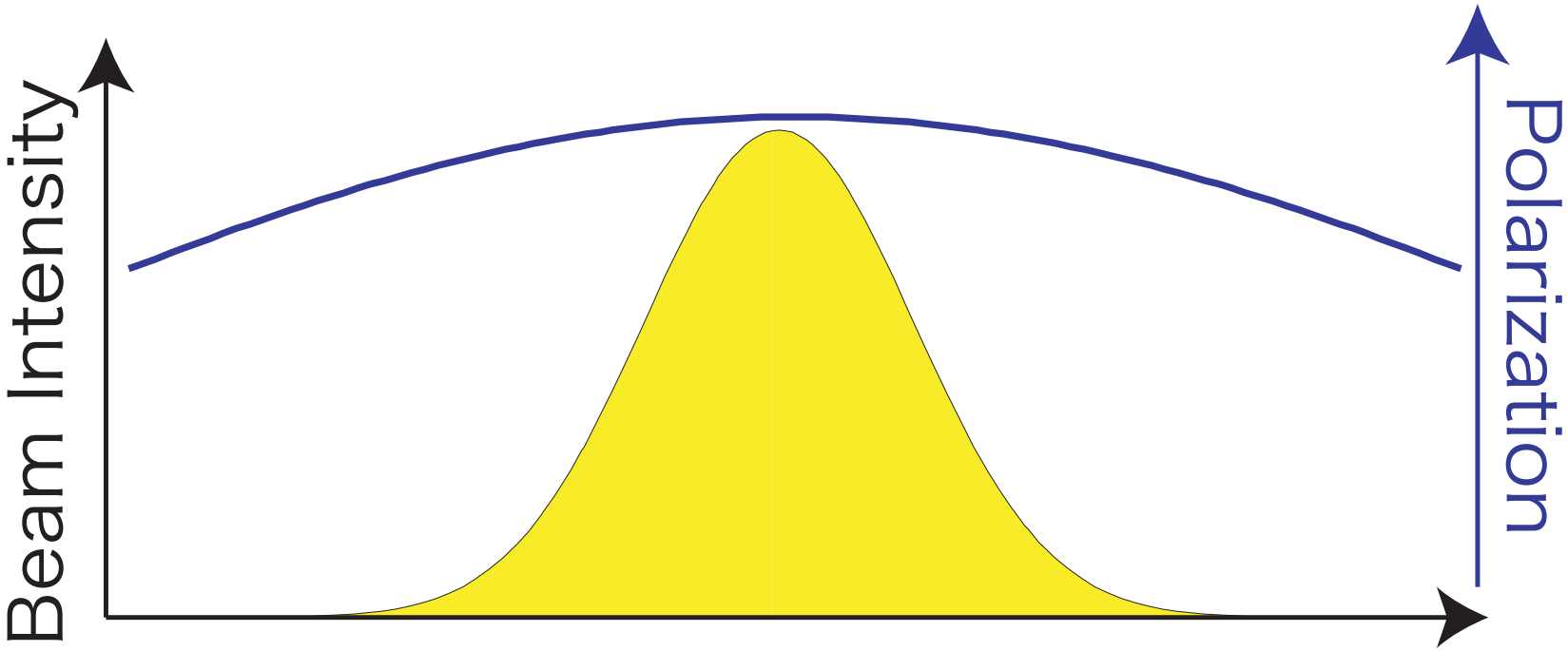
(detection efficiency is included in 1kHz)

Time [hours]	Total Events	ΔA_N
1	3.6 M	0.0026
2	7.2 M	0.0018
3	10.8 M	0.0015

- 1Hour data taking achieves ΔA_N ~ 0.0026 which is factor of 4 smaller than the goal ΔA_N ~ 0.01. This leaves factor of 16 contingency in statistics.
- The contingency will be consumed by:
  1. Increased background (including EM) fraction in the trigger compared to collider mode.
  2. Active volume cut.

P_T-Dependent Yield



The distance between target and beam will be tuned to achieve 1kHz in the largest P_T RHICf position. This way, all 3 RHICf position will have same statistical precision.

Polarization Profile