RHIC forward experiment to study √s dependence of forward particle production

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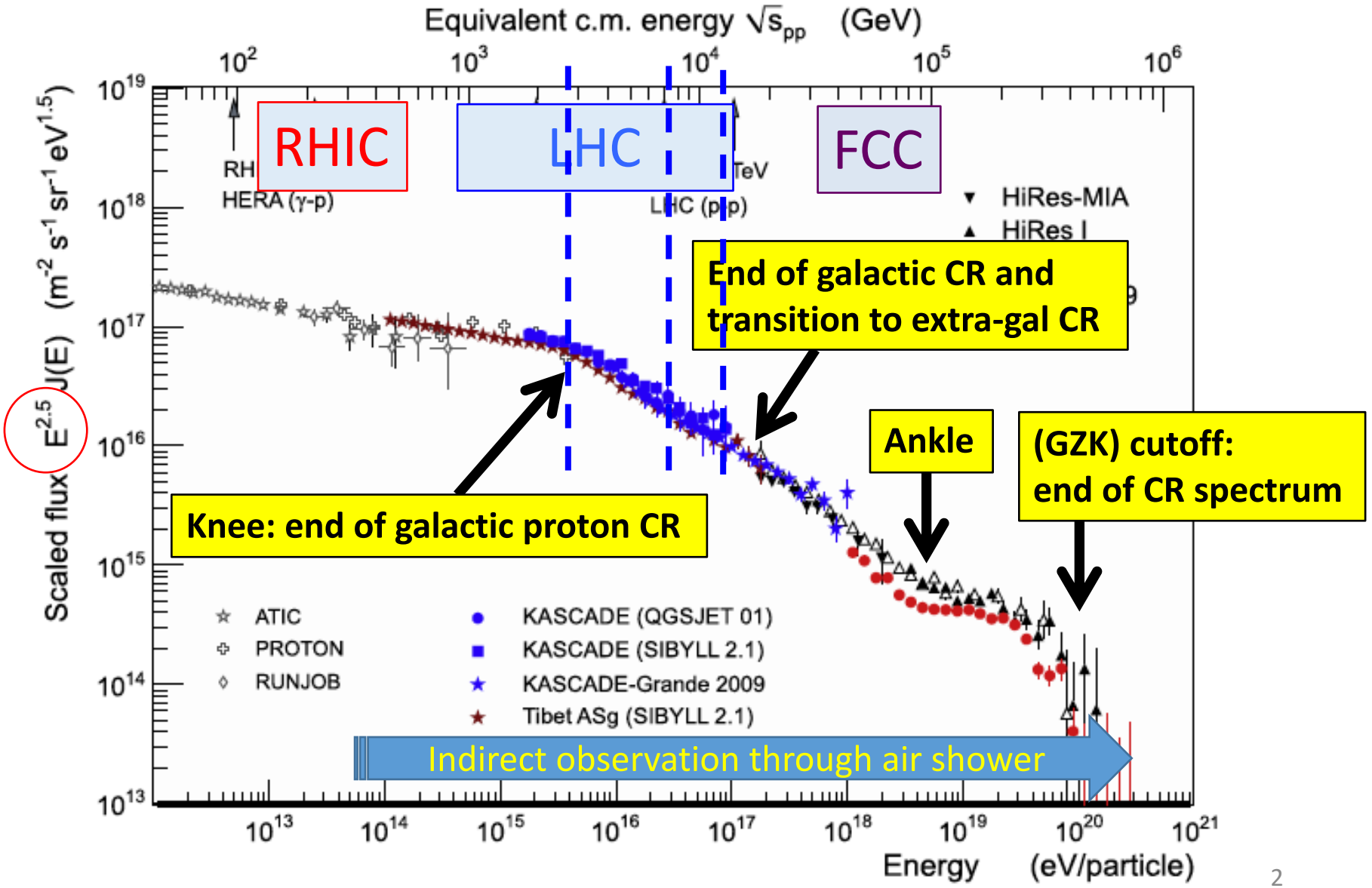
for the RHICf Collaboration

Cosmic-ray spectrum and collider energy

(D'Enterria et al., APP, 35,98-113, 2011)



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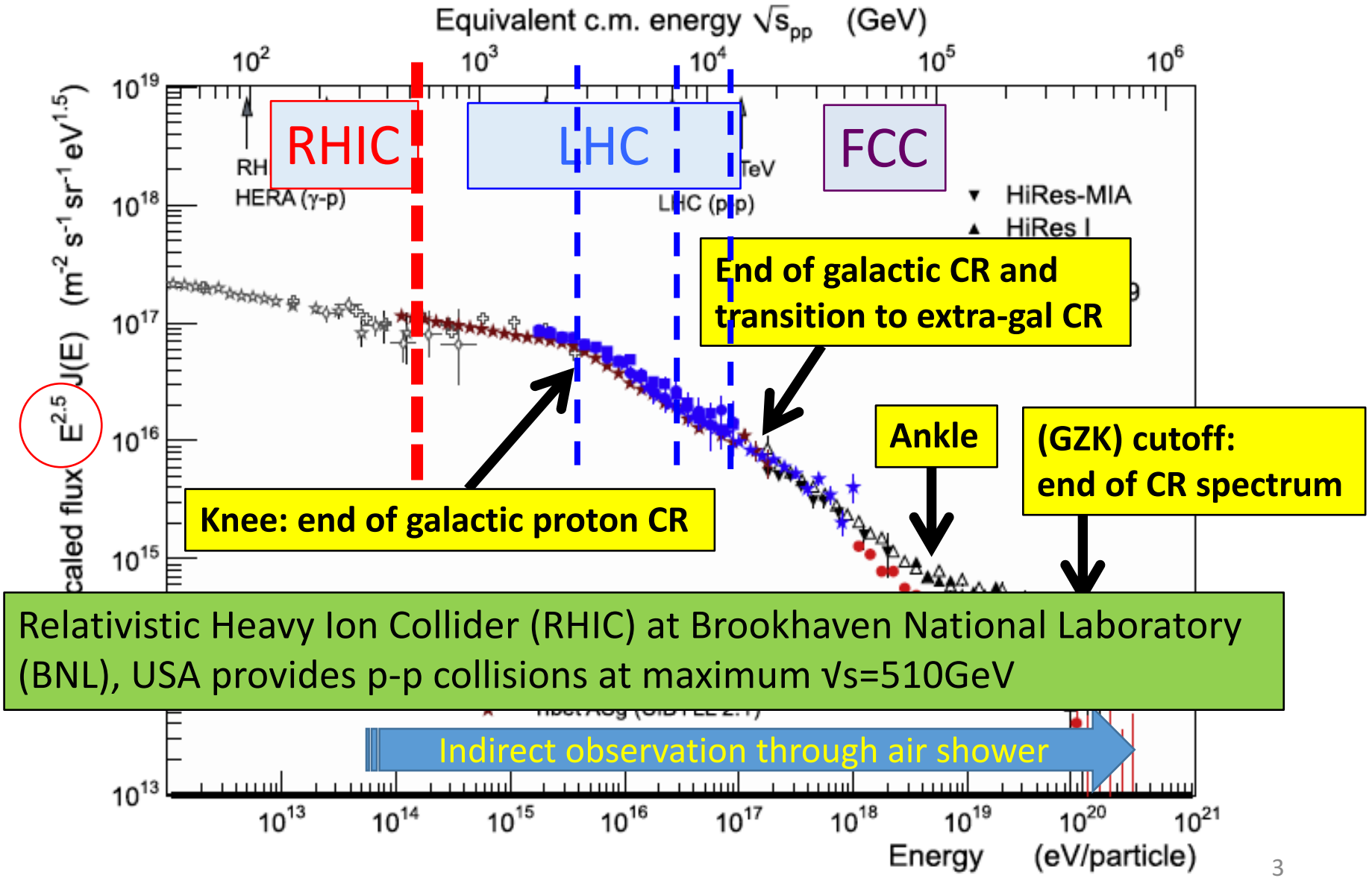
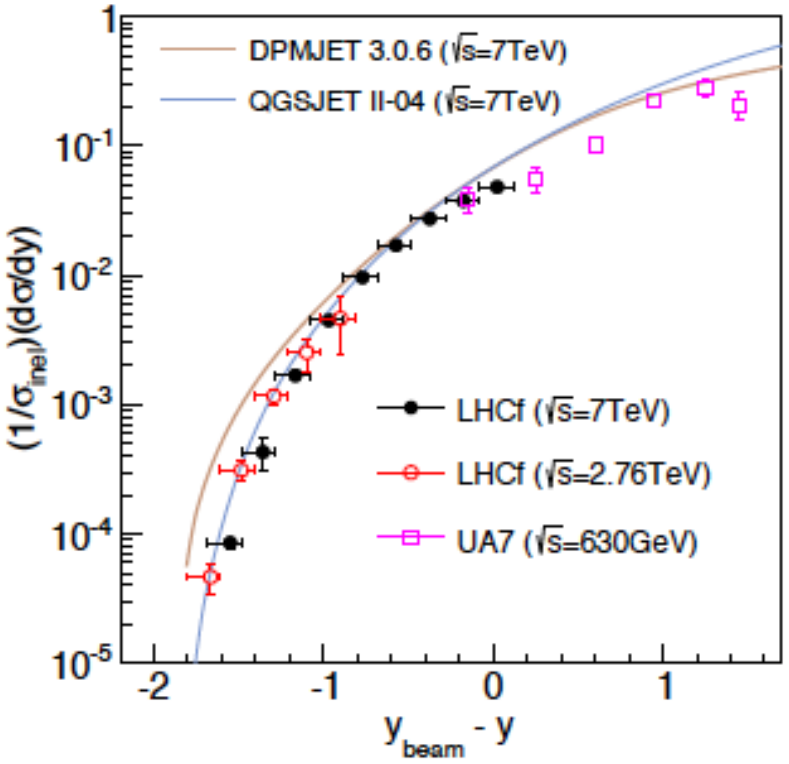
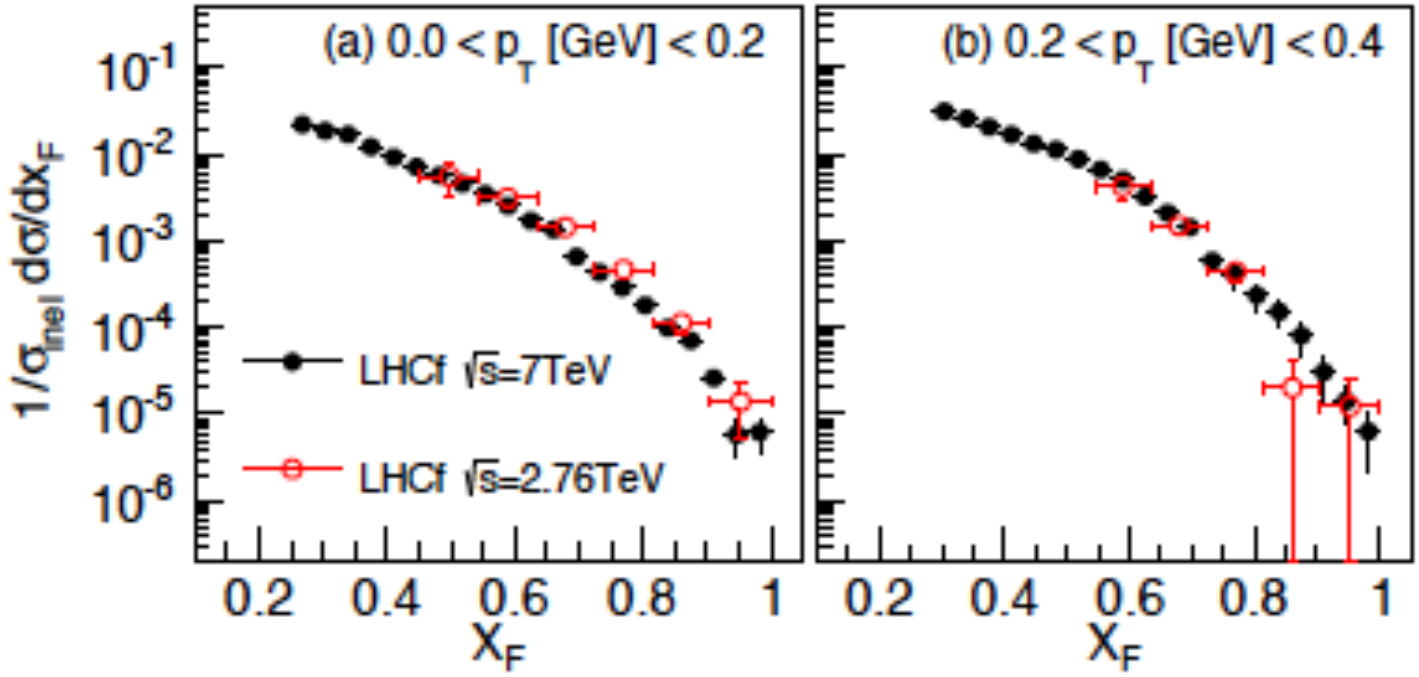


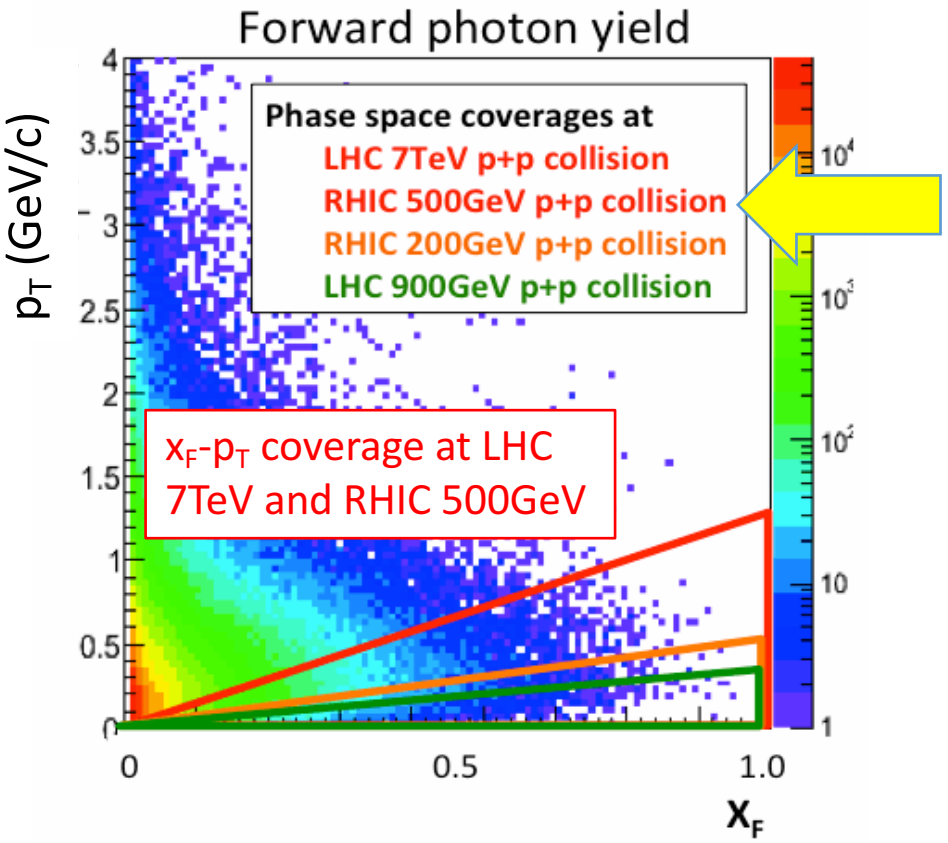
√s scaling ; π^0

- ✓ Scaling is essential to extrapolate beyond LHC
- ✓ (630GeV –) 2.76TeV – 7TeV
  good scaling within uncertainties
- ✓ Wider coverage in y and p_T with 13TeV data
- ✓ Wider √s coverage with RHICf experiment in 2017 at √s=510GeV





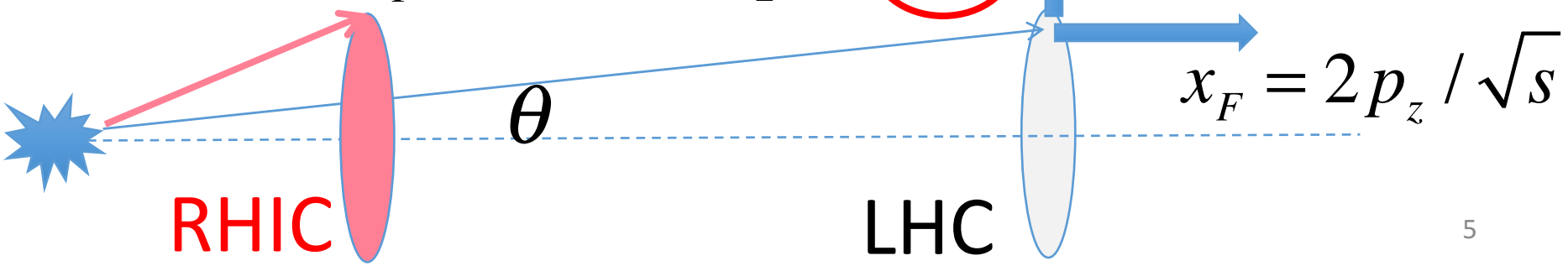
Why not LHC 900GeV?



- ✓ Wide x_F-p_T coverage is desired
- ✓ Maximum p_T coverage is proportional to $\theta\sqrt{s}$

- ✓ RHIC allows larger θ with smaller $\sqrt{s}$
- ✓ x_F-p_T coverage at LHC 7TeV and RHIC 500GeV are almost identical!!

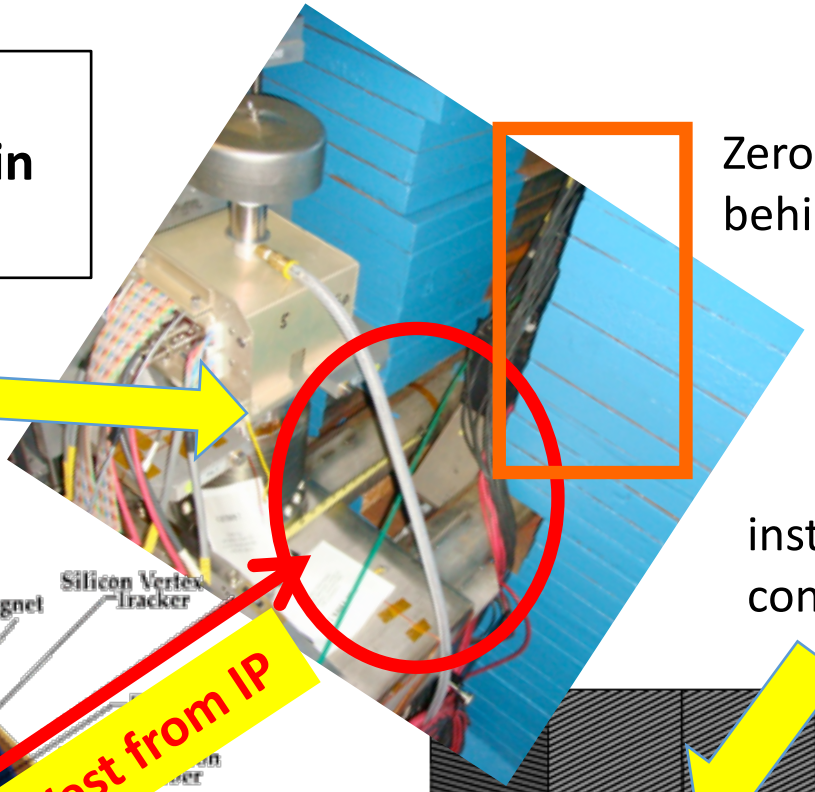
$$p_T = p\sin\theta \le \tfrac{1}{2}\sqrt{s}\sin\theta$$



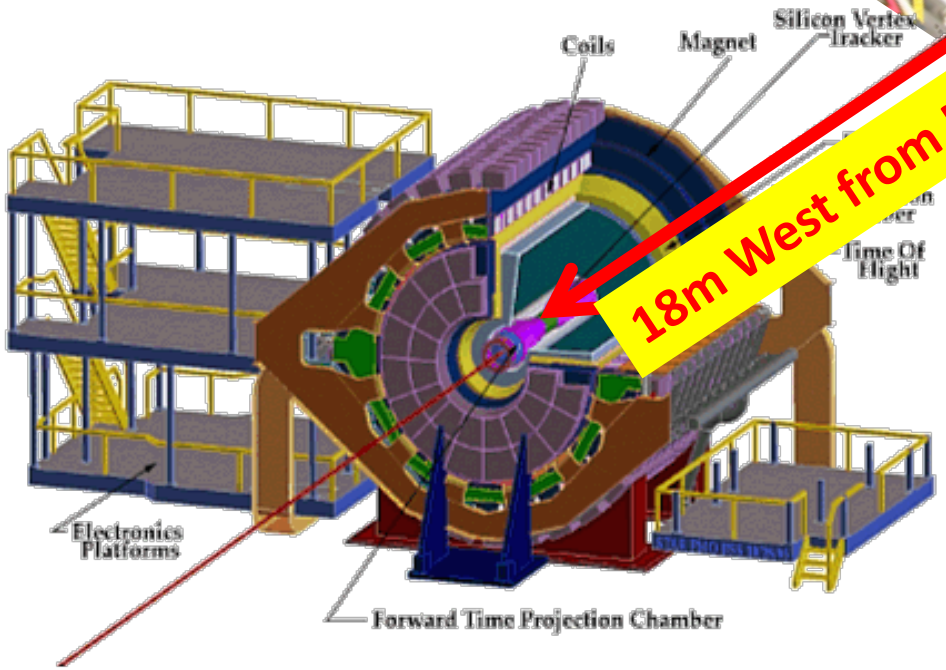
RHICf Installation @STAR interaction point

LHCf Arm1 detector, = RHICf, has been transported to BNL in May 2016

10cm gap between two separating beam pipes = RHICf space

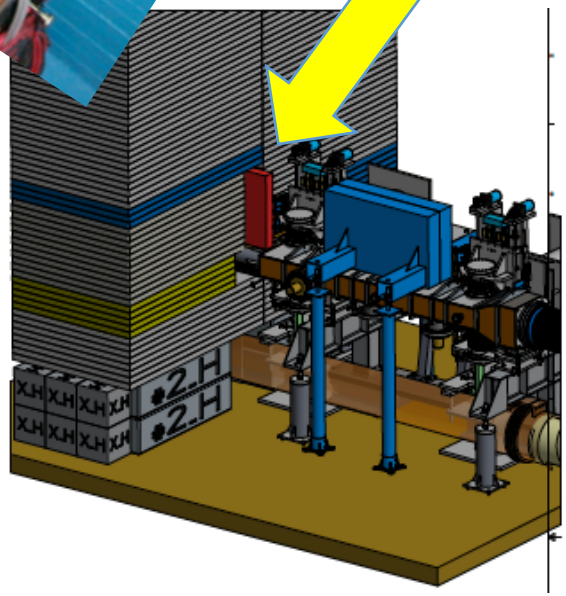


Zero Degree Calorimeter behind RHICf



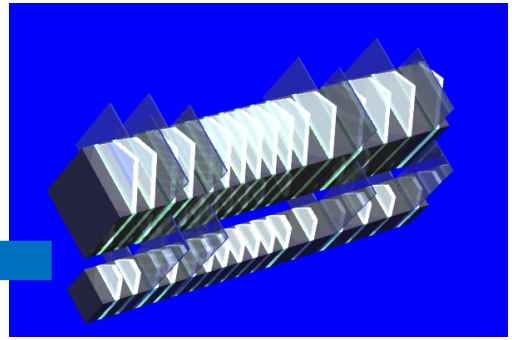
18m West from IP

installation space was confirmed in drawing

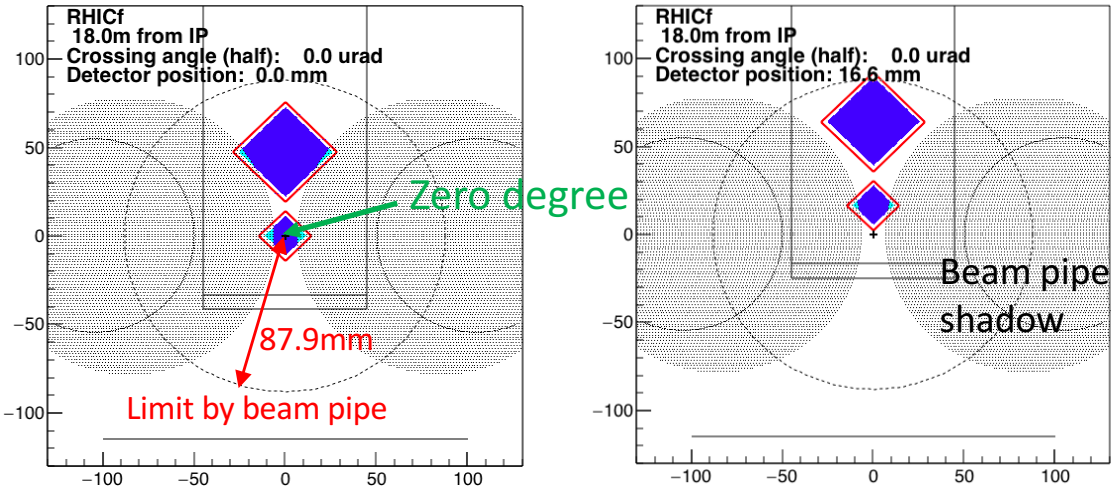


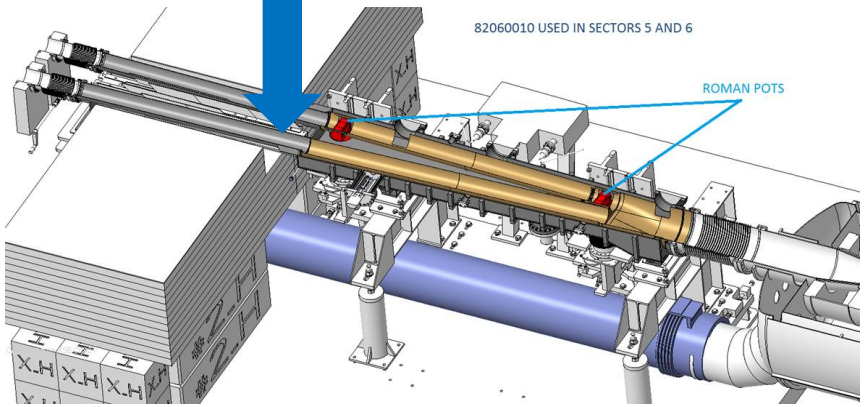
RHICf detector acceptance

Compact double calorimeters
(20mmx20mm and 40mmx40mm)

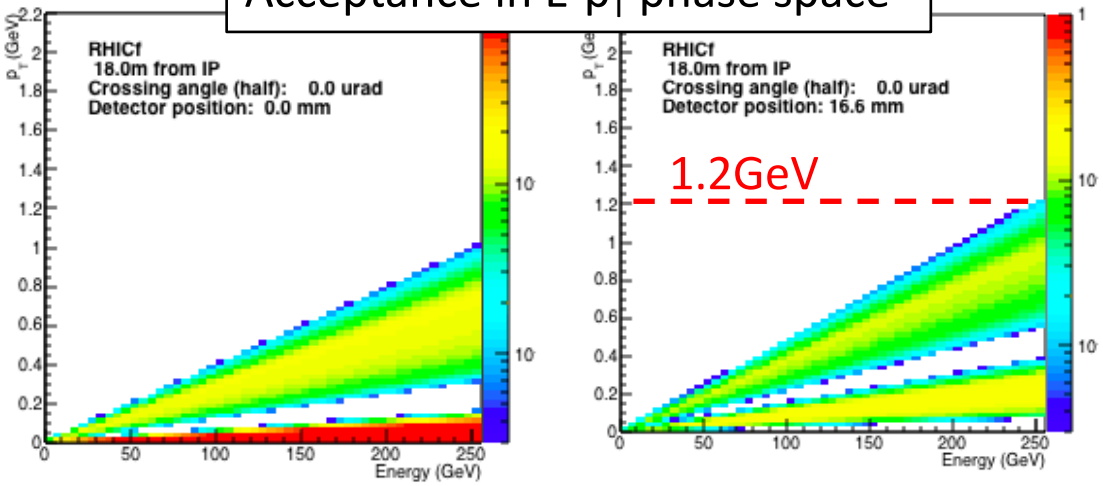


Cross section view from IP





Acceptance in E-p_T phase space



- ✓ Widest and gapless p_T coverage is realized by moving the vertical detector position.
- ✓ Beam pipes obscure photons but not neutrons.

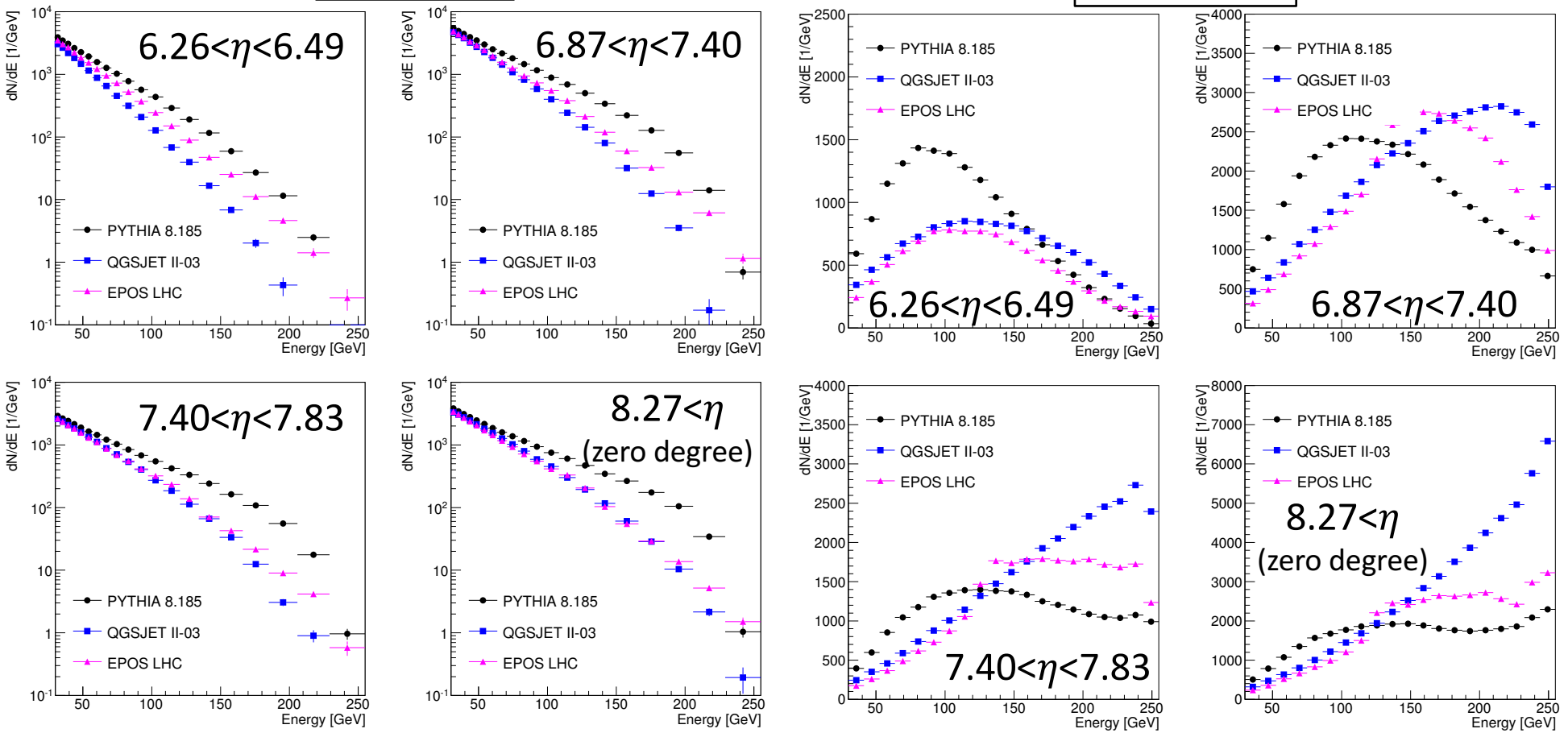
LHCf/RHICf History

- 2004 LOI submitted to CERN
- 2006 TDR approved by CERN
- 2009 First data taking at $\sqrt{s}$=900GeV p-p collision
- 2010 $\sqrt{s}$=7TeV p-p collision
- 2013 $\sqrt{s}$=2.76TeV p-p & $\sqrt{s_{NN}}$=5TeV p-Pb collisions
- 2013 RHICf LOI submitted to BNL
- 2014 RHICf proposal (PHENIX site) submitted to BNL
- 2015 $\sqrt{s}$=13TeV p-p collision
- 2015 RHICf proposal (STAR site) submitted to BNL, partially approved
- 2016 RHICf BUR submitted to BNL and approved
- 2016 $\sqrt{s_{NN}}$=8.2TeV p-Pb collision
- 2017 RHICf $\sqrt{s}$=510GeV p+p collision

Model to model difference and 12 hours statistics

Photon

Neutron



- ✓ Behavior is very similar to the 7TeV, 13TeV cases
- ✓ Good statistics except for photon highest energy

Schedule of RHICf

- Sep-Oct 2016:
  - Modification of detector to fit the installation slot
  - DAQ test
  - Electronics installation in the STAR site
  - Cabling
- Nov-Dec 2016:
  - Detector installation, commissioning and removal out of beam line
- Jan-Mar 2017:
  - Commissioning with collisions in RUN17 (out of beam line)
- May (TBD) 2017:
  - Installation into beam line
  - Physics data taking (STAR detectors will record data according to the RHICf trigger!!)
  - 1 week is assigned for whole procedure (installation, beam tuning, uninstallation)

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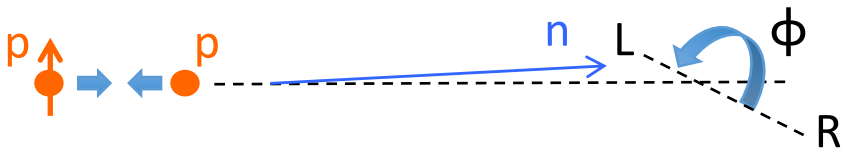
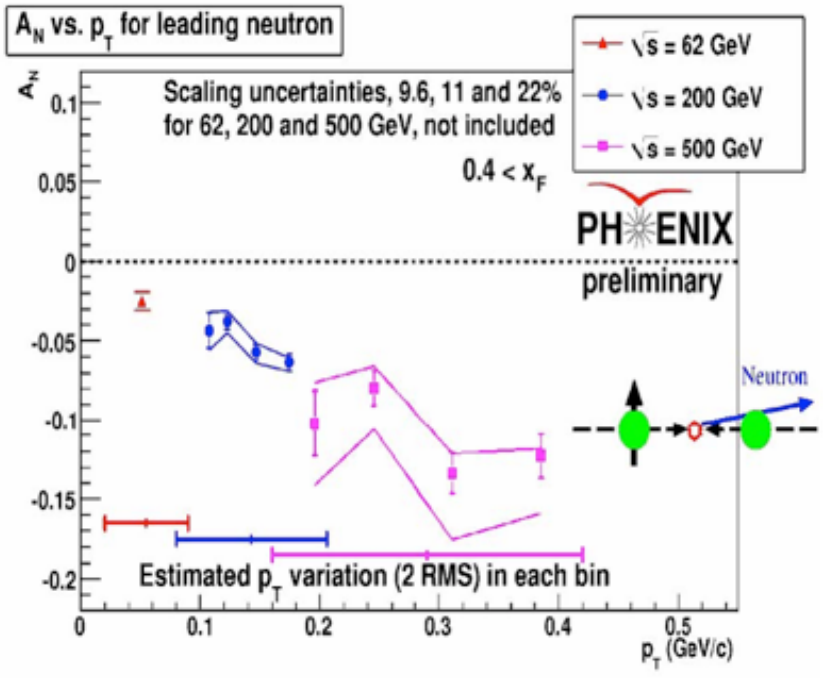
- 2018
  - Results in ISVHECRI2018 at Nagoya, Japan

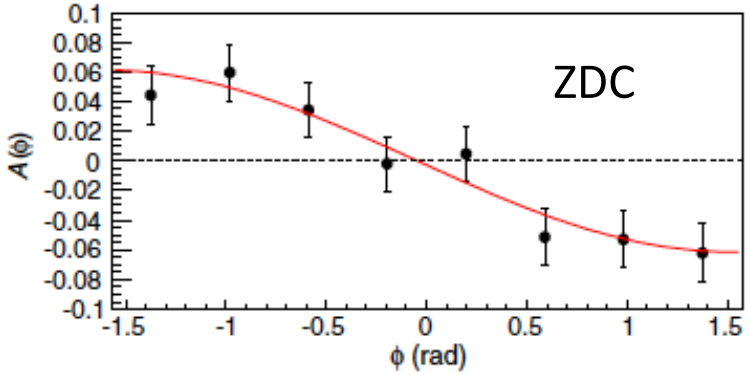
Single spin asymmetry by PHENIX

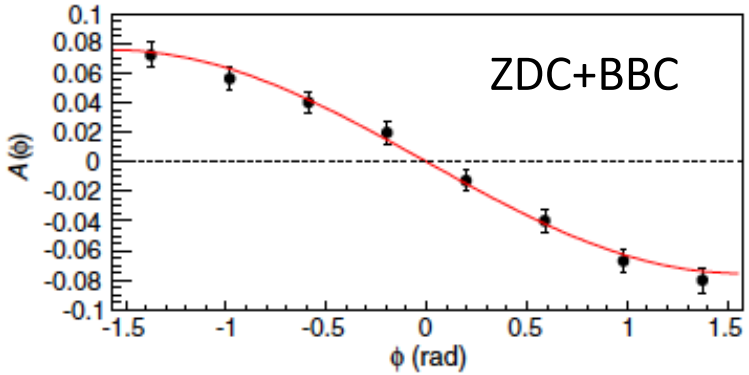
(PRD, 88, 032006, 2013)



- ✓ strong asymmetry in forward neutrons was discovered at RHIC
- ✓ scaled with pT at √s = 62, 200, 500 GeV?







PHENIX results at 200GeV

RHICf can cover pT<1GeV only with √s = 510 GeV operation!

Theoretical explanation

- Pion-a_1 interference: results
  - The data agree well with independence of energy
- The asymmetry has a sensitivity to presence of different mechanisms, e.g. Reggeon exchanges with spin-non-flip amplitude, even if they are small amplitudes

$$A_N \quad \frac{2\,\mathrm{Im}\left(fg^*\right)}{|f|^2+|g|^2}$$

f : spin non-flip amplitude
g : spin flip amplitude

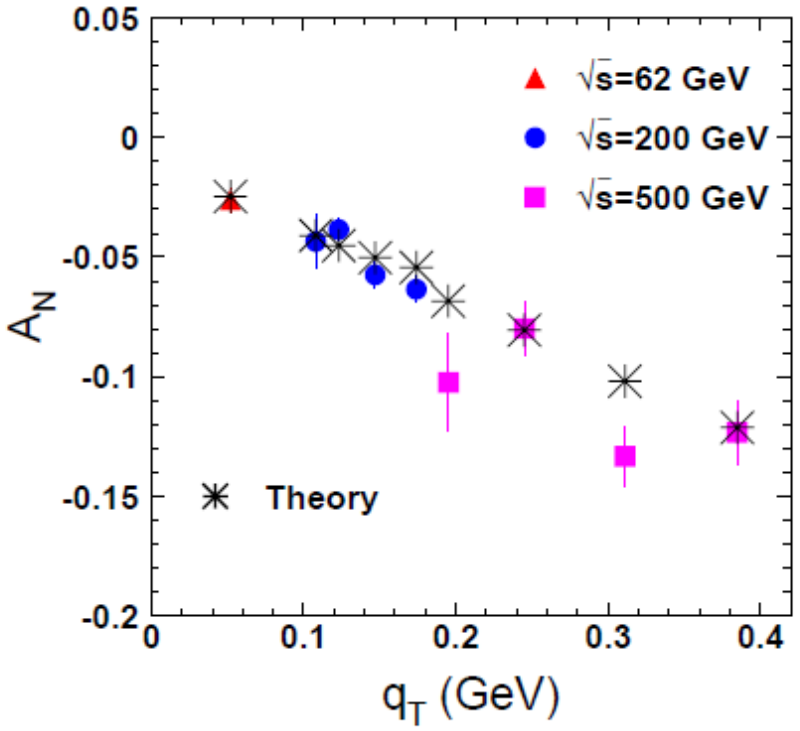


FIG. 1: (Color online) Single transverse spin asymmetry A_N in the reaction $pp \to nX$, measured at $\sqrt{s} = 62,\ 200,\ 500$ GeV [1] (preliminary data). The asterisks show the result of our calculation, Eq. (38), which was done point by point, since each experimental point has a specific value of z (see Table I).

Kopeliovich, Potashnikova, Schmidt, Soffer: Phys. Rev. D 84 (2011) 114012.

Summary

- ✓RHICf measures forward particle production in √s=510 GeV p-p collisions at RHIC
- ✓Comparing with the LHCf results, √s dependence of particle production can be experimentally determined => useful to extrapolate beyond the LHC energy, even to interpolate below LHC
- ✓Single spin asymmetry measurement may give a hint for the fundamental process in the hadronic interaction
- ✓Experiment is approved and operation is planned in mid 2017!!

Backup

Requested Beam Condition

Parameter	Value
Beam energy (GeV)	255
Beam intensity (protons per bunch)	2×10^{11}
Number of colliding bunch	100
Number of non-colliding bunch	20
Beam emittance (mm mrad)	20
β^* (m)	10
Luminosity ($cm^{-2}s^{-1}$)	1.1×10^{31}
Polarization direction	radial
Polarization amplitude	0.4–0.5
Operation time	1 day

to reduce beam divergence

to measure up-down asymmetry

1day for β* setup, 1 day for polarization direction, 1 day for physics + contingency
=> 5 days of dedicated time needed