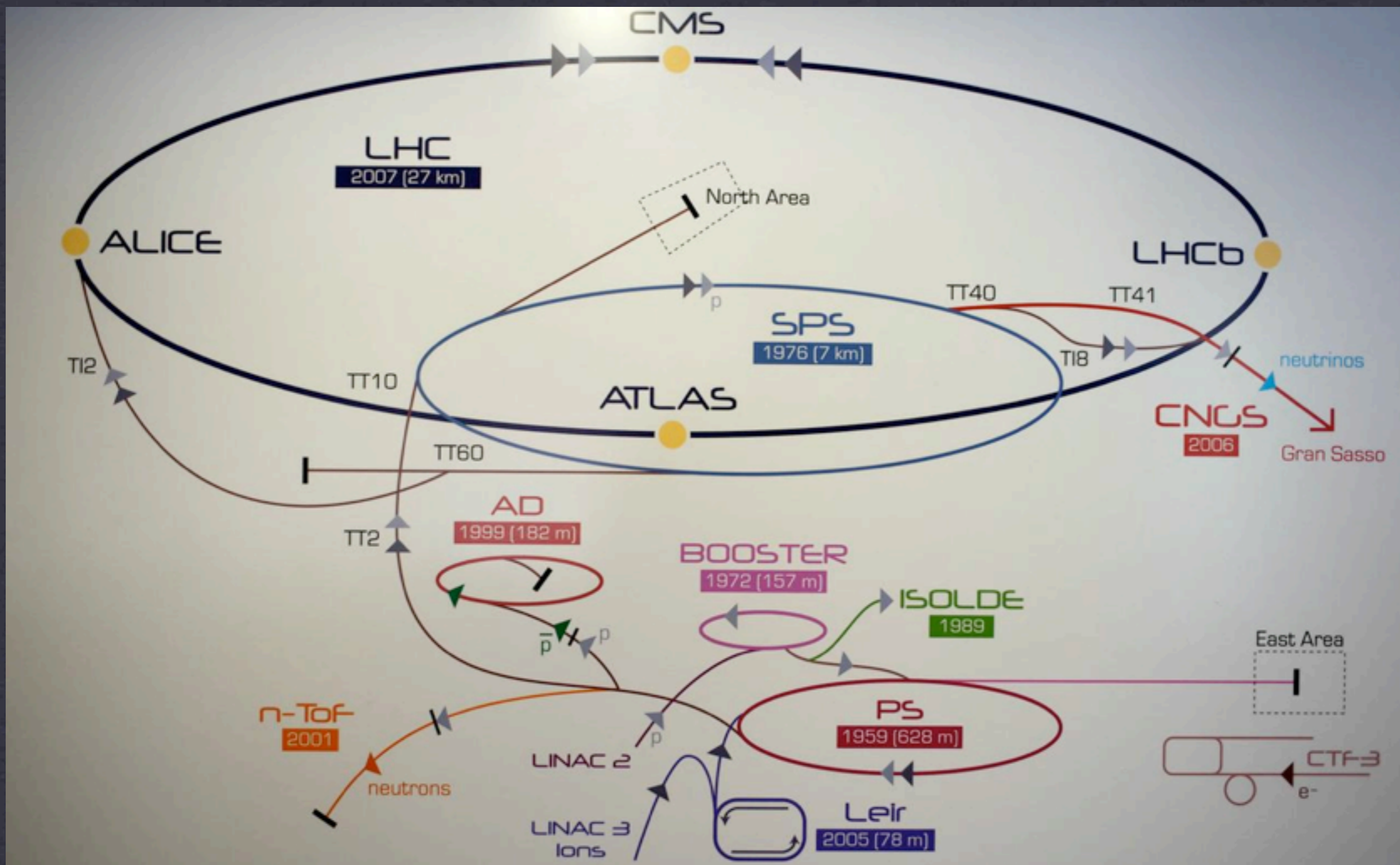


PROJECT

***RELATIVISTIC HEAVY ION COLLIDER
BROOKHAVEN NATIONAL LABORATORY, USA***

DATE ***JUNE 2000***

CLIENT ***HEAVY ION & SPIN COMMUNITIES***

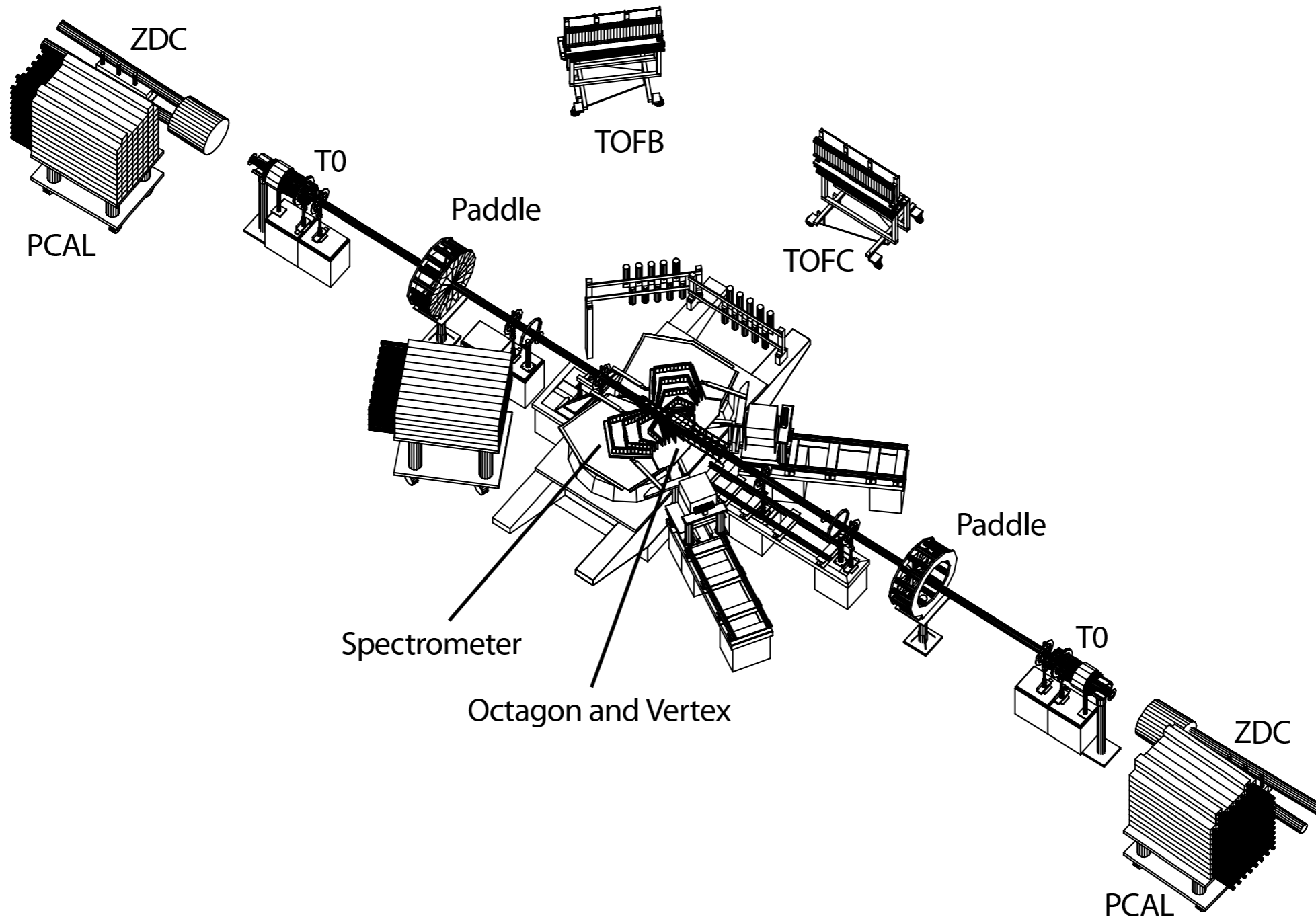


PROJECT

LARGE HADRON COLLIDER CERN, SWITZERLAND

DATE NOVEMBER 2009

CLIENT HEP & HI COMMUNITIES



PROJECT

PHOBOS IN THE LHC ERA

PETER STEINBERG, BNL

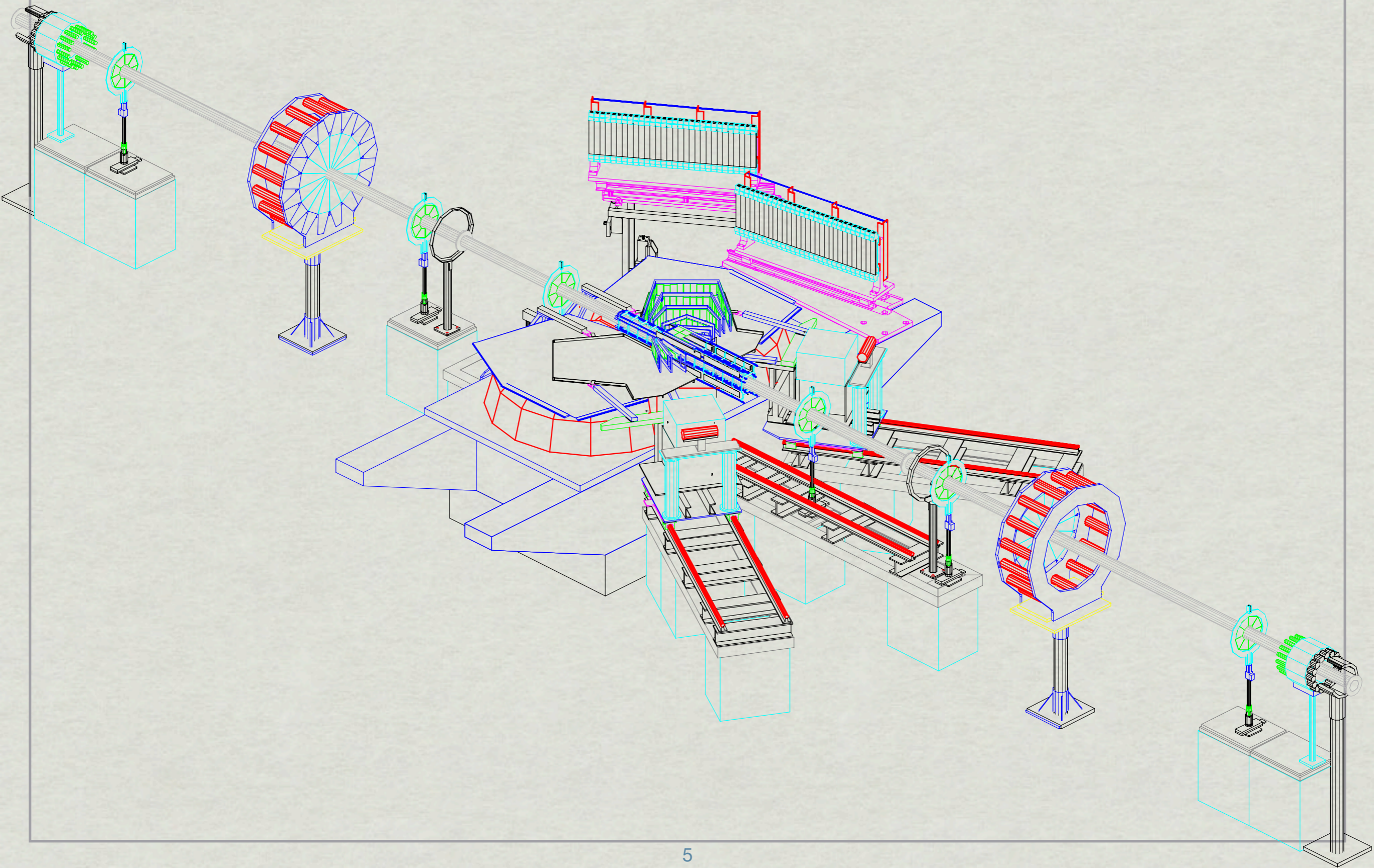
DATE MAY 17, 2013

CLIENT PA WORKSHOP@MIT

(MY) HISTORY OF PHOBOS

- * CANNOT DO THIS BETTER THAN WIT!*
- * I MET MANY PHOBOS COLLEAGUES HERE AT MIT IN 1992, AS YALE UNDERGRAD BEFORE STARTING AT MIT IN 1993 (20 YEARS AGO...)*
 - * SIGNED ON AS A STUDENT FOR "PHOBOS@AGS"*
 - * FOR MY THESIS, I HELPED BUILD AND COMMISSION PAD DETECTOR FOR WA98 TO MEASURE DCC'S*
- * IN 1998, WIT TOLD ME TO GO AWAY...AND COME BACK LATER*
 - * AND I DID, TO PHENIX, WORKING FOR BRIAN*
- * RETURNED TO PHOBOS JUST IN TIME FOR FIRST PHYSICS IN SUMMER OF 2000...*

2000

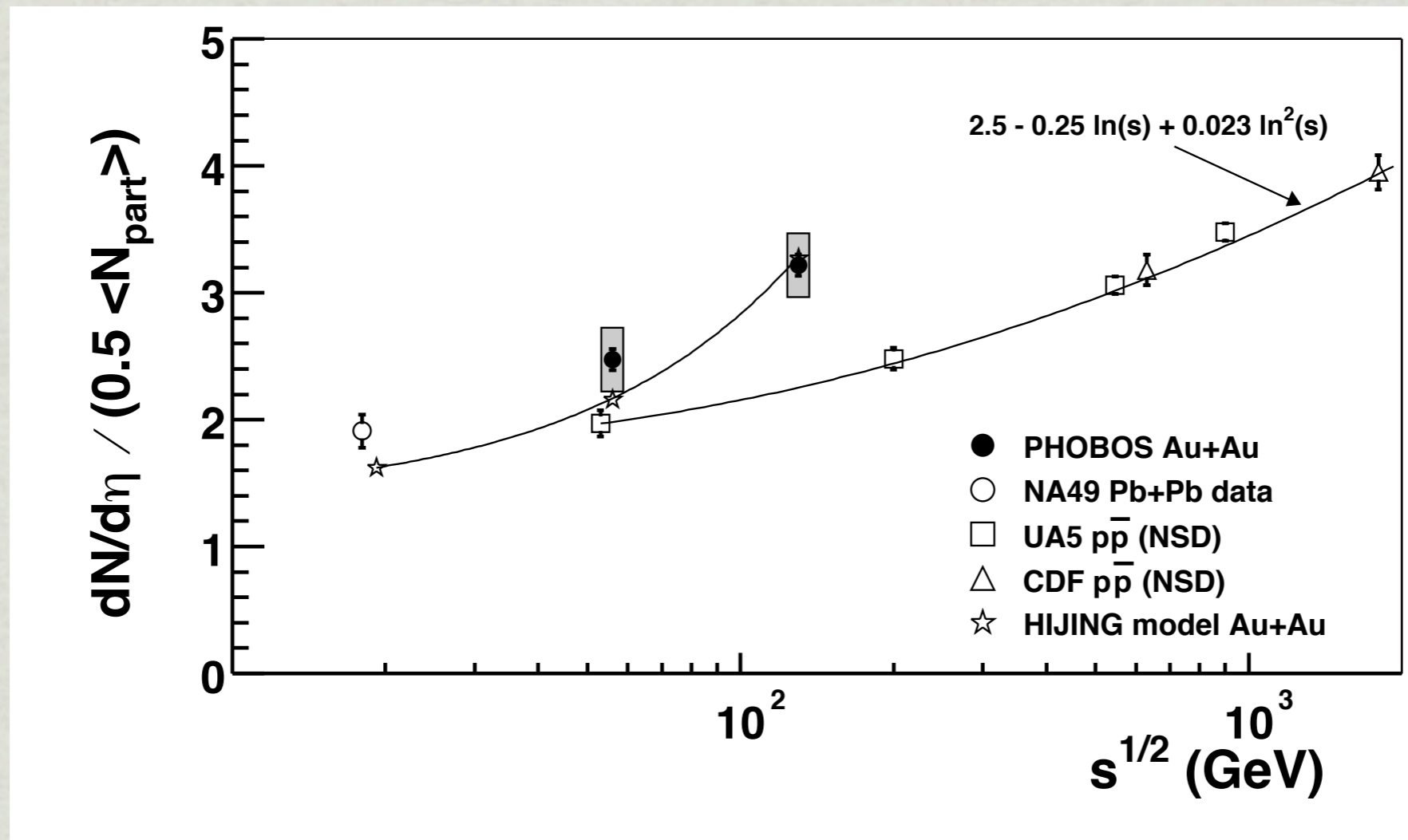


FIRST COLLISIONS...



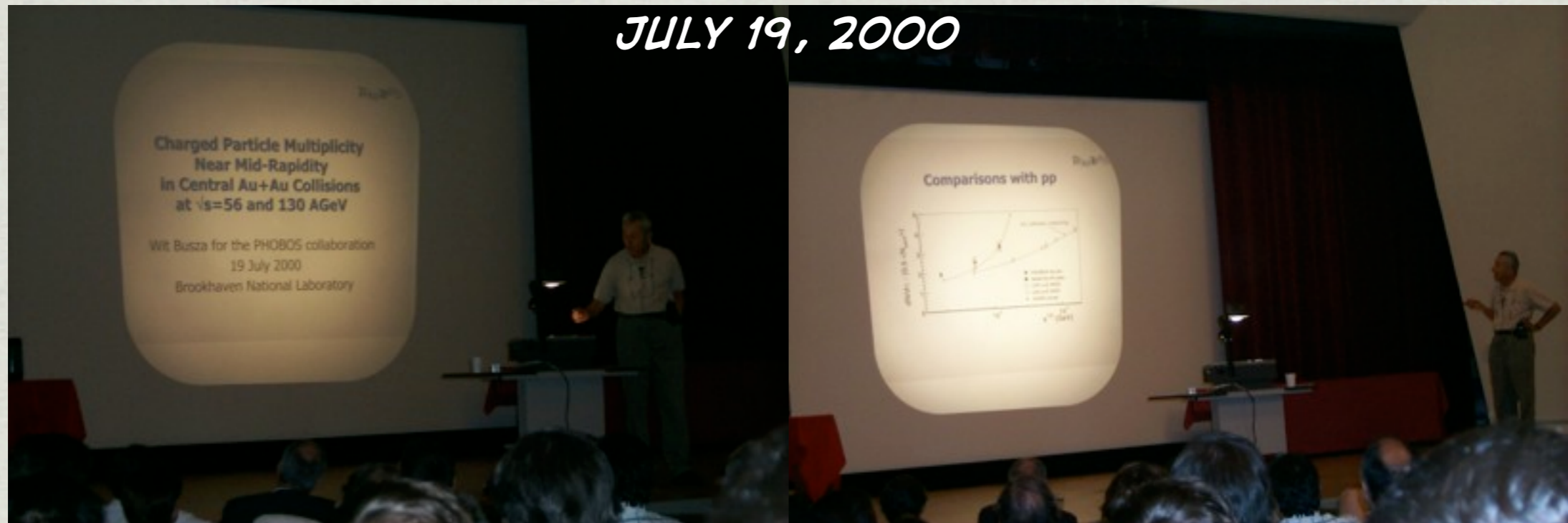
- * *EVEN ON THE FIRST NIGHT OF COLLISIONS SAW*
 - * *MACHINE AND DETECTOR WORKING WELL*
 - * *PADDLE ADC SUMS ($3 < \text{ETA} < 4.5$) FAMILIAR FROM SPS DATA (WE WEREN'T CALLING IT "GLAUBER" JUST THEN)*

...TO FIRST RESULTS!



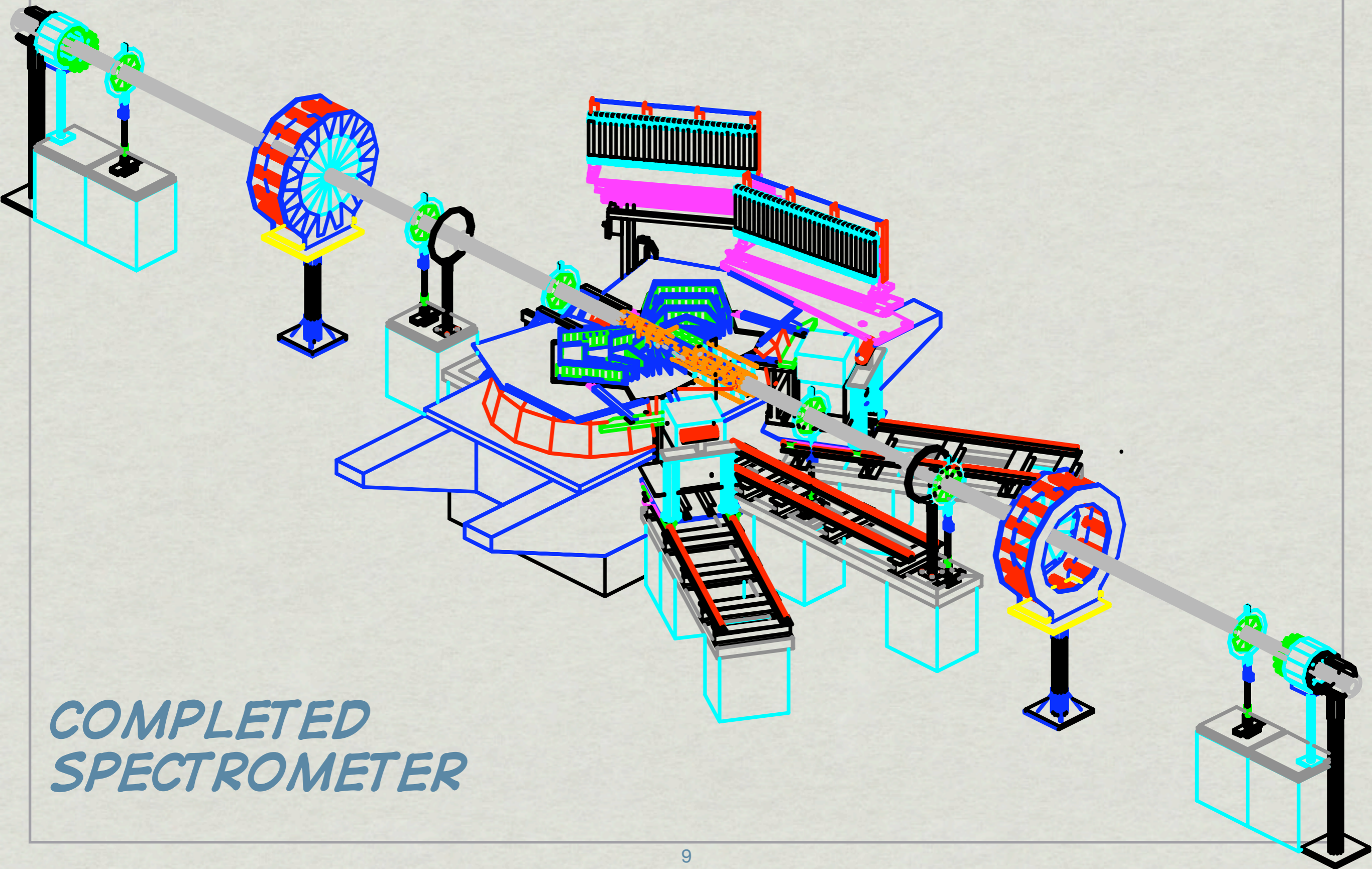
IMMEDIATELY CLEAR THAT HI IS MORE EFFECTIVE AT PRODUCING PARTICLES NEAR MID-RAPIDITY THAN PP

...TO FIRST RESULTS!



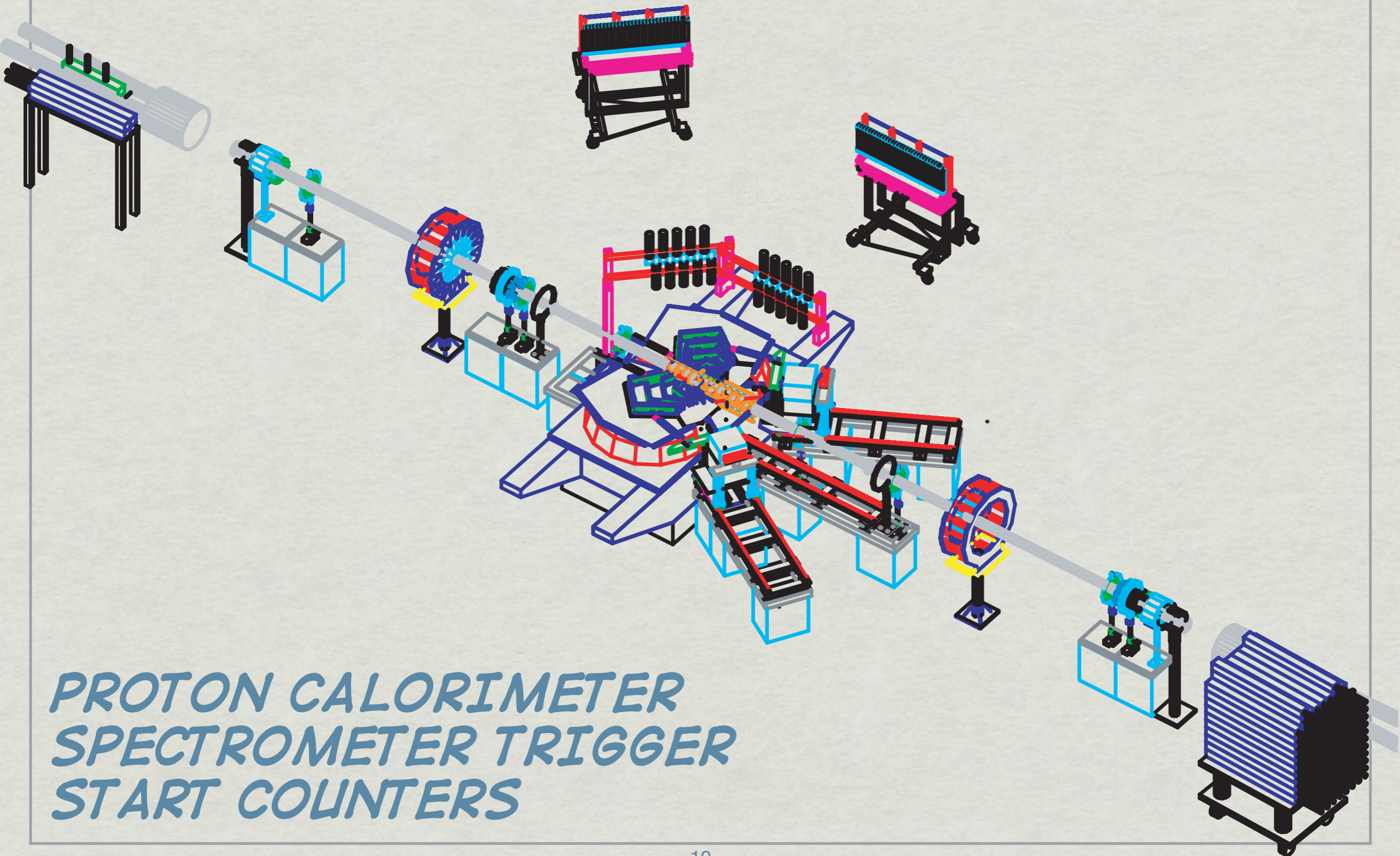
- * *BONDING EXPERIENCE FOR OUR SMALL GROUP*
 - * *RAISED OUR PROFILE IN HI COMMUNITY*
 - * *WAS A LOT OF FUN (IF EXHAUSTING) FOR OUR SMALL COLLABORATION*
- * *"FAST PUBLICATION" IS STILL WITH US @ LHC*
 - * *ALL LHC EXPERIMENTS HAVE HAD THEIR CHANCE BY NOW!*

2001/2



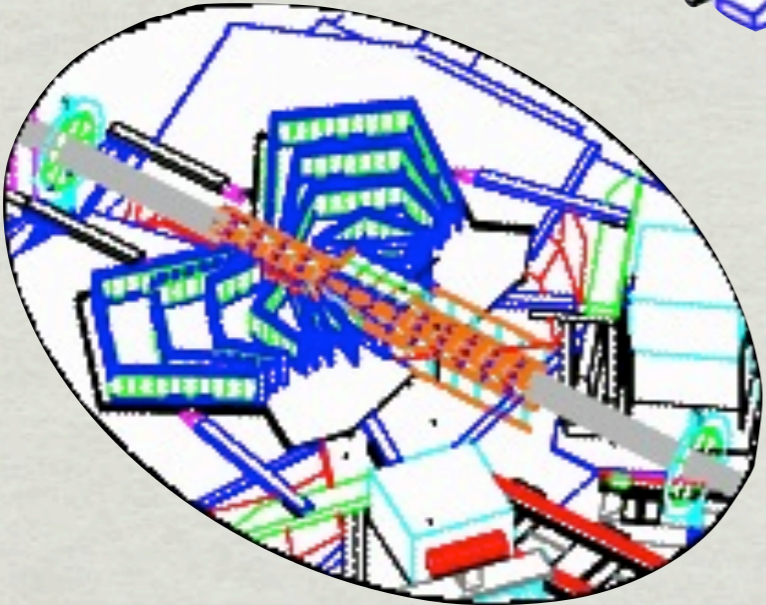
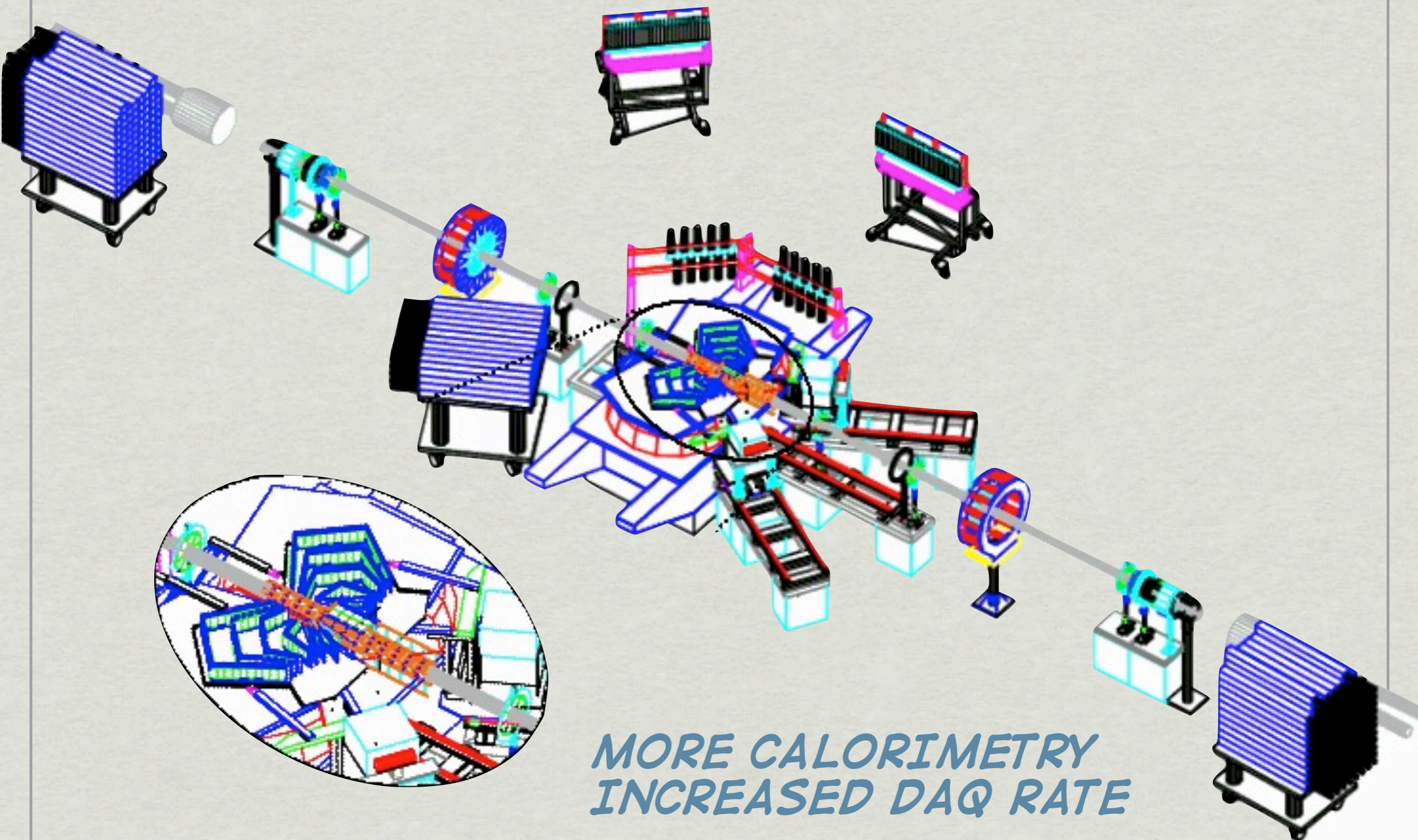
*COMPLETED
SPECTROMETER*

2003



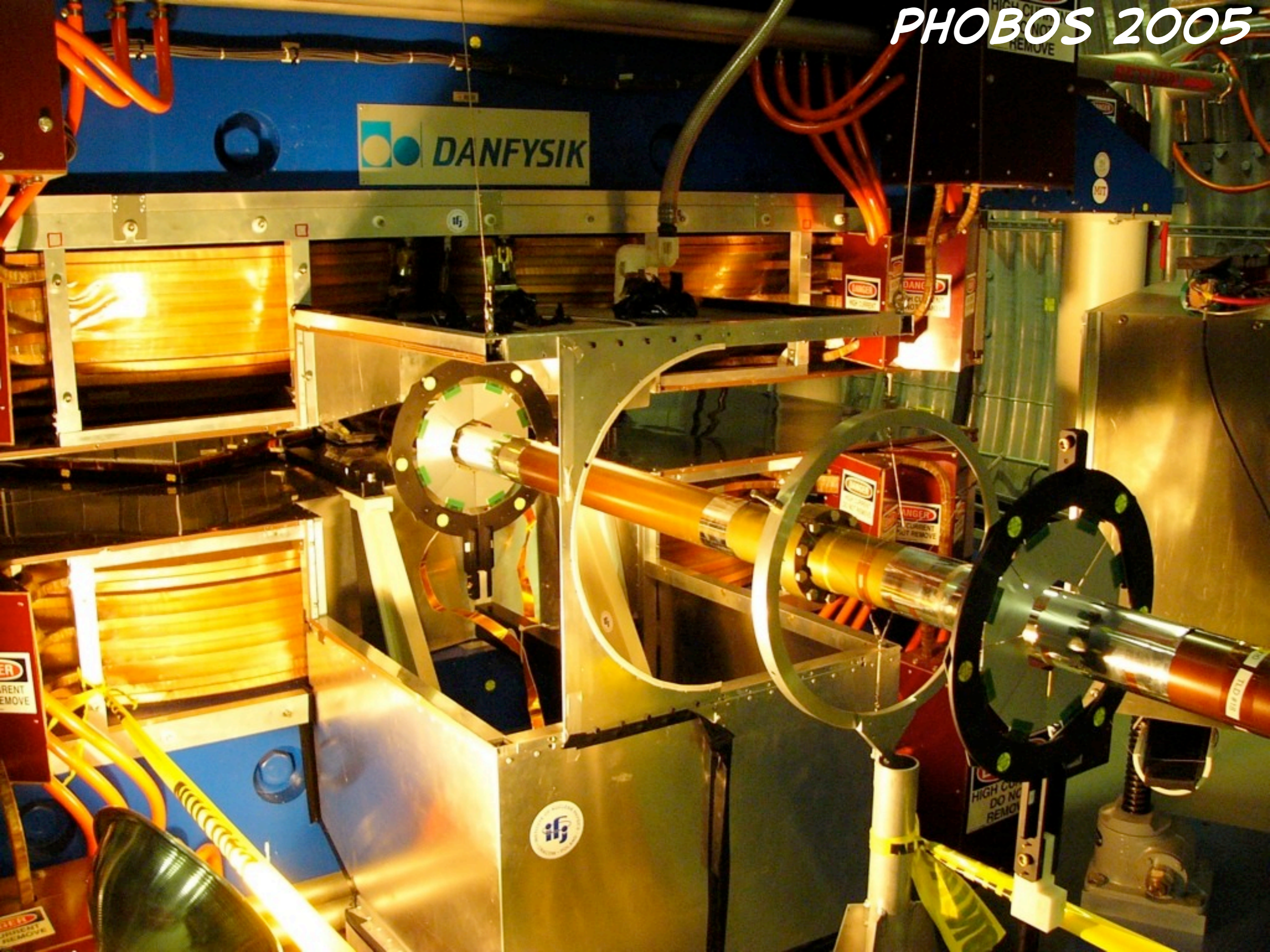
*PROTON CALORIMETER
SPECTROMETER TRIGGER
START COUNTERS*

2004/5



*MORE CALORIMETRY
INCREASED DAQ RATE*

PHOBOS 2005



PHOBOS COLLABORATION



2000



2003



2005



2006

LOTS OF DISCUSSIONS

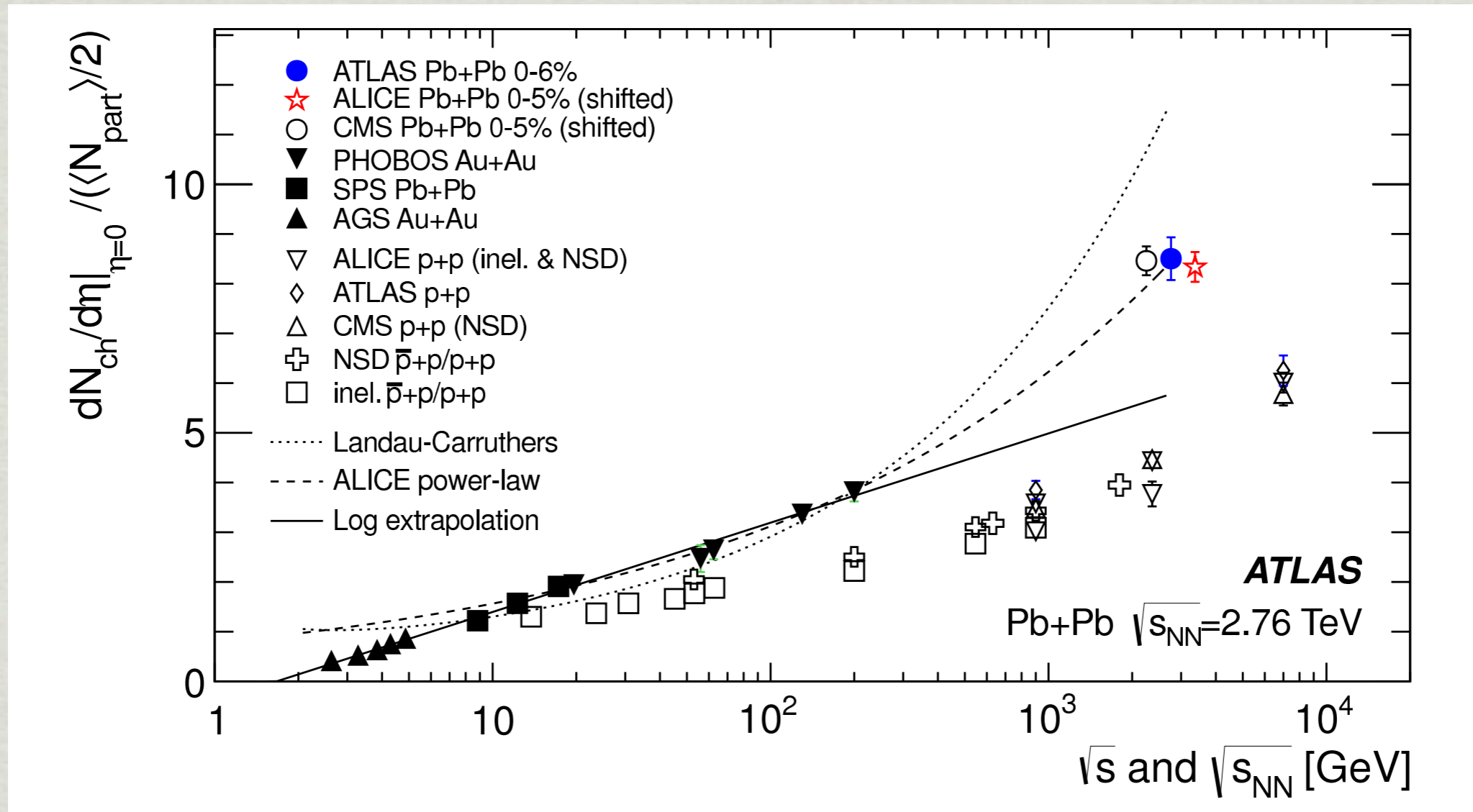


OUR FIVE YEAR MISSION

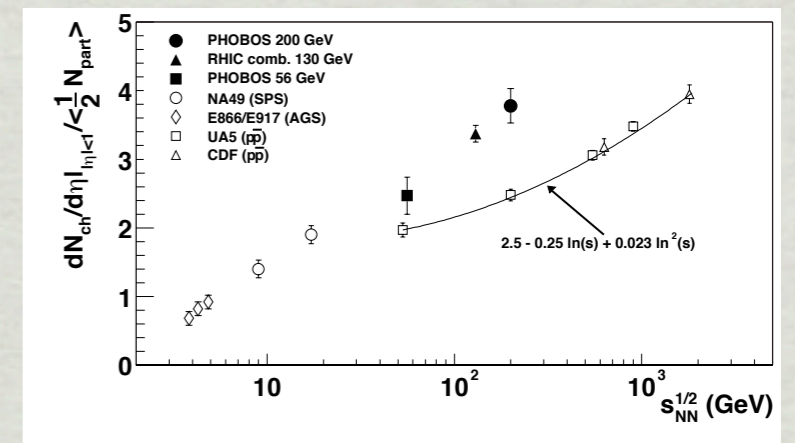
- * *TOPICS EXPLORED IN THE NEXT 5 YEARS*
 - * *4 π MULTIPLICITY VS. CENTRALITY & SYSTEM*
 - * *4 π DIRECTED & ELLIPTIC FLOW VS. η , p_T & CENTRALITY*
 - * *PARTICLE SPECTRA NEAR $\eta=0$ VS. CENTRALITY AND SYSTEM*
 - * *CORRELATIONS, INCLUSIVE & TRIGGERED*
- * *PRIORITY #1 WAS TO MAKE CORRECT MEASUREMENTS*
- * *HOWEVER, WE HAD A LOT OF FUN TRYING TO FIGURE OUT EMPIRICAL "RULES" TO HELP DESCRIBE THE DATA AS EFFICIENTLY AS POSSIBLE*
 - * *STRIVED TO BE DATA-DRIVEN W/ MINIMAL DEPENDENCE ON THEORY*

*HOW HAVE WE DONE, WITH LHC DATA:
A HUGE INCREASE IN CM ENERGY?*

MULTIPLICITY @ $\eta=0$

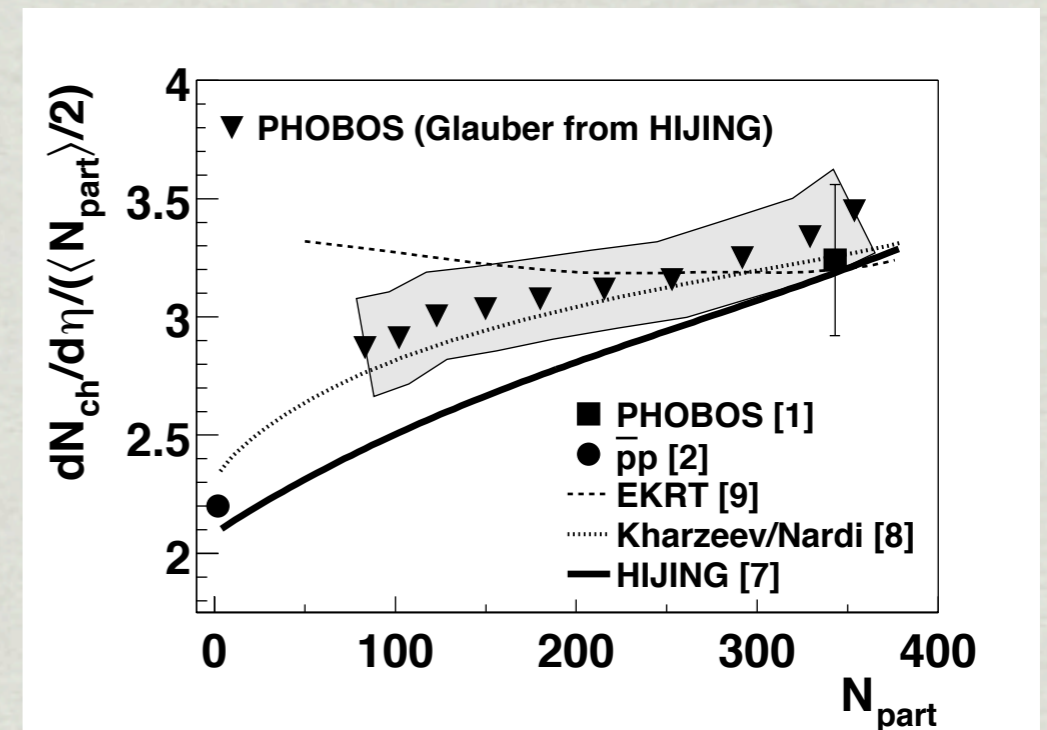


PHOBOS NOTICED THE LOGARITHMIC
 DEPENDENCE IN SUMMER 2001. -->
 WIT REASONABLY PREDICTED
 IT WOULD HOLD AT HIGHER ENERGIES...
 NATURE HAS ITS OWN IDEAS!

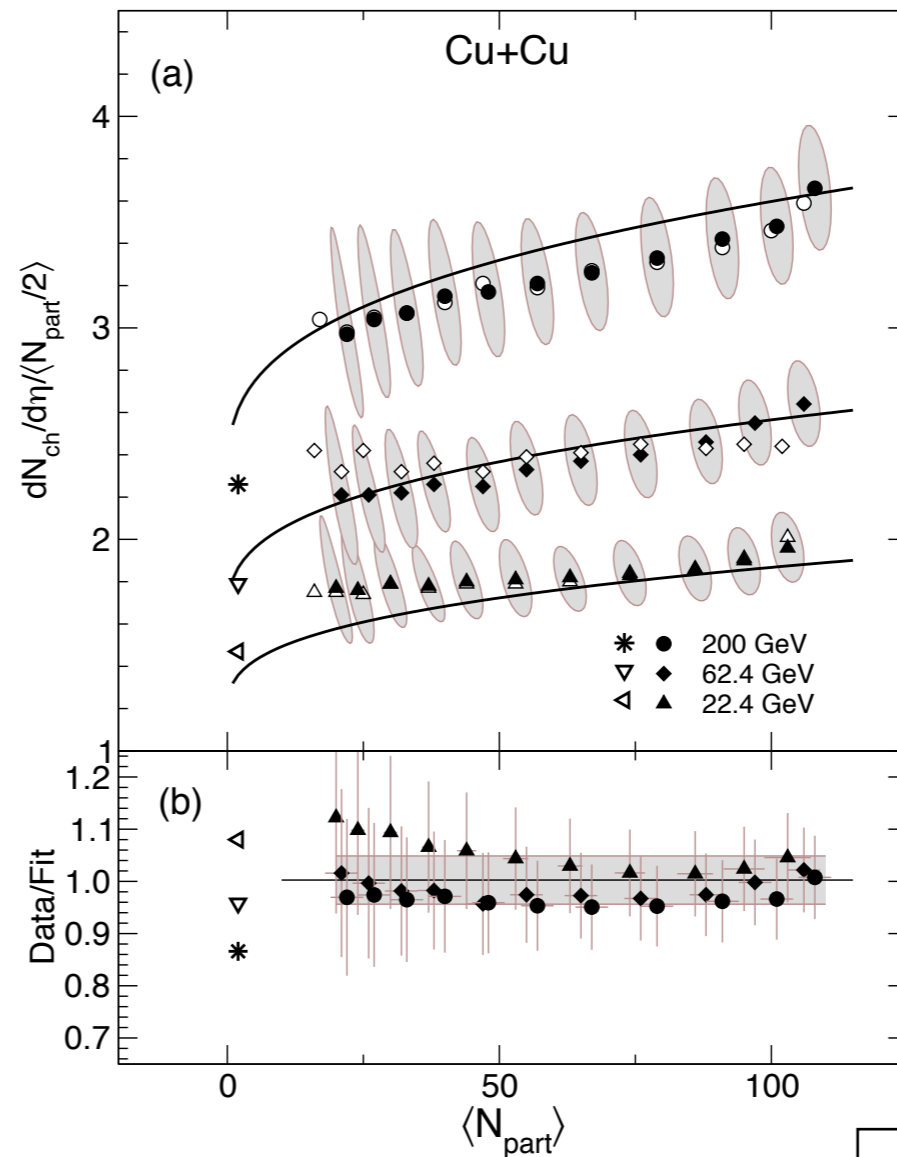
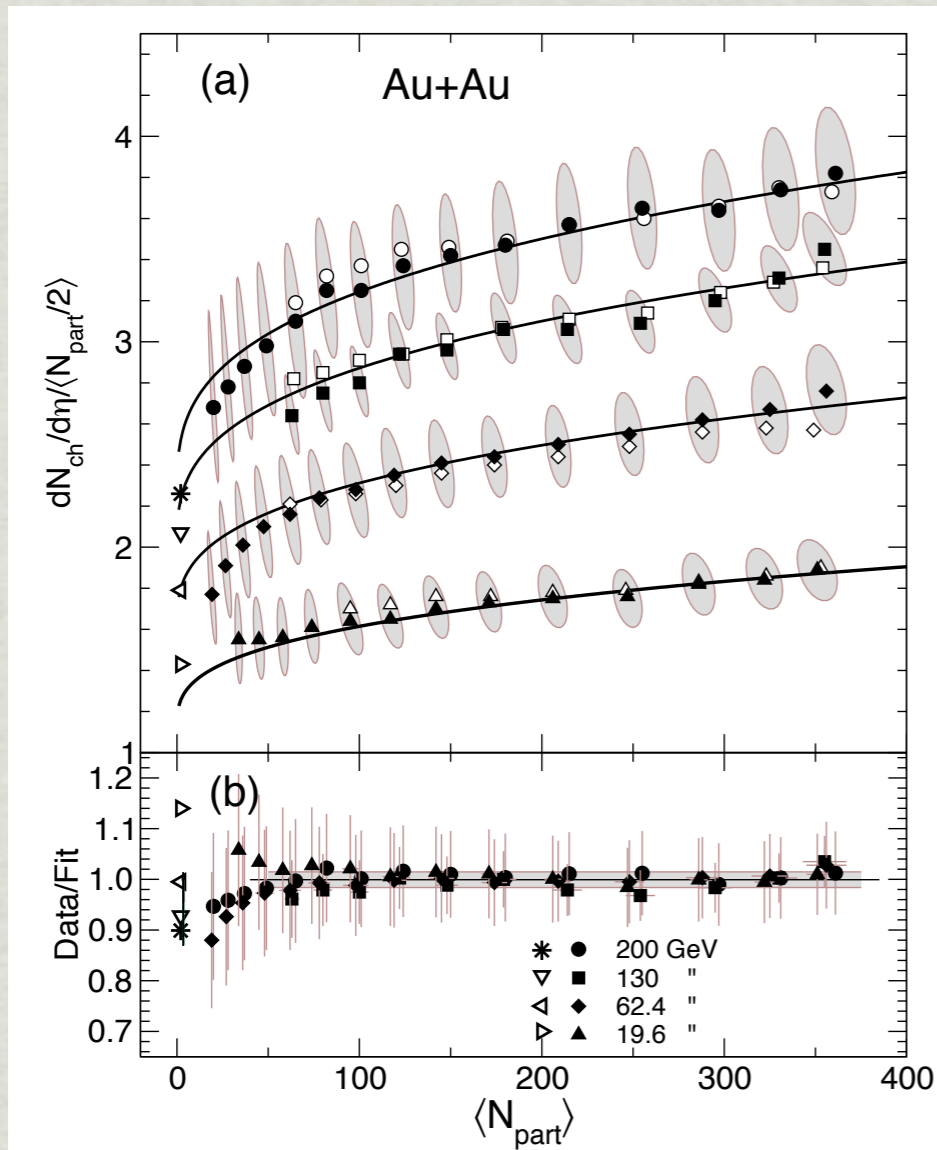


CENTRALITY DEP. @ $\eta=0$

- * IN THE EARLY DAYS, LOTS OF DISCUSSION OF WHAT CONTROLLED THE CENTRALITY DEPENDENCE NEAR $\eta=0$
- * TWO MAIN CONTENDERS:
 - * SATURATION PHYSICS
 - * E.G. $N_{PART} \log(N_{PART})$
 - * TWO COMPONENT ("SOFT+MINIJET") MODEL
 - * $\sim N_{PP} (X N_{COLL} + (1-X) N_{PART} / 2)$
- * ENERGY DEPENDENCE HELD OUT PROMISE OF OFFERING INSIGHT
 - * HIGHER ENERGIES SHOULD INCREASE "MINIJET" CONTRIBUTION



"FACTORIZATION" IN A+A



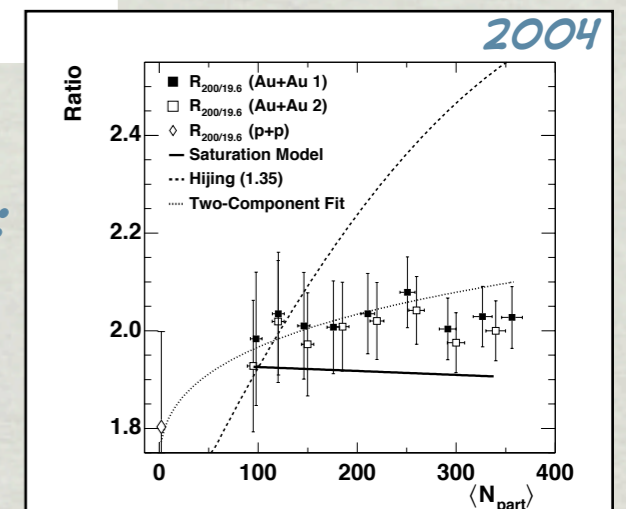
$$\frac{2}{\langle N_{part} \rangle} \frac{dN_{ch} |_{|\eta| < 1}}{d\eta} = f(s) \times g(N_{part})$$

$$f(s) = 0.0147(\ln s)^2 + 0.6$$

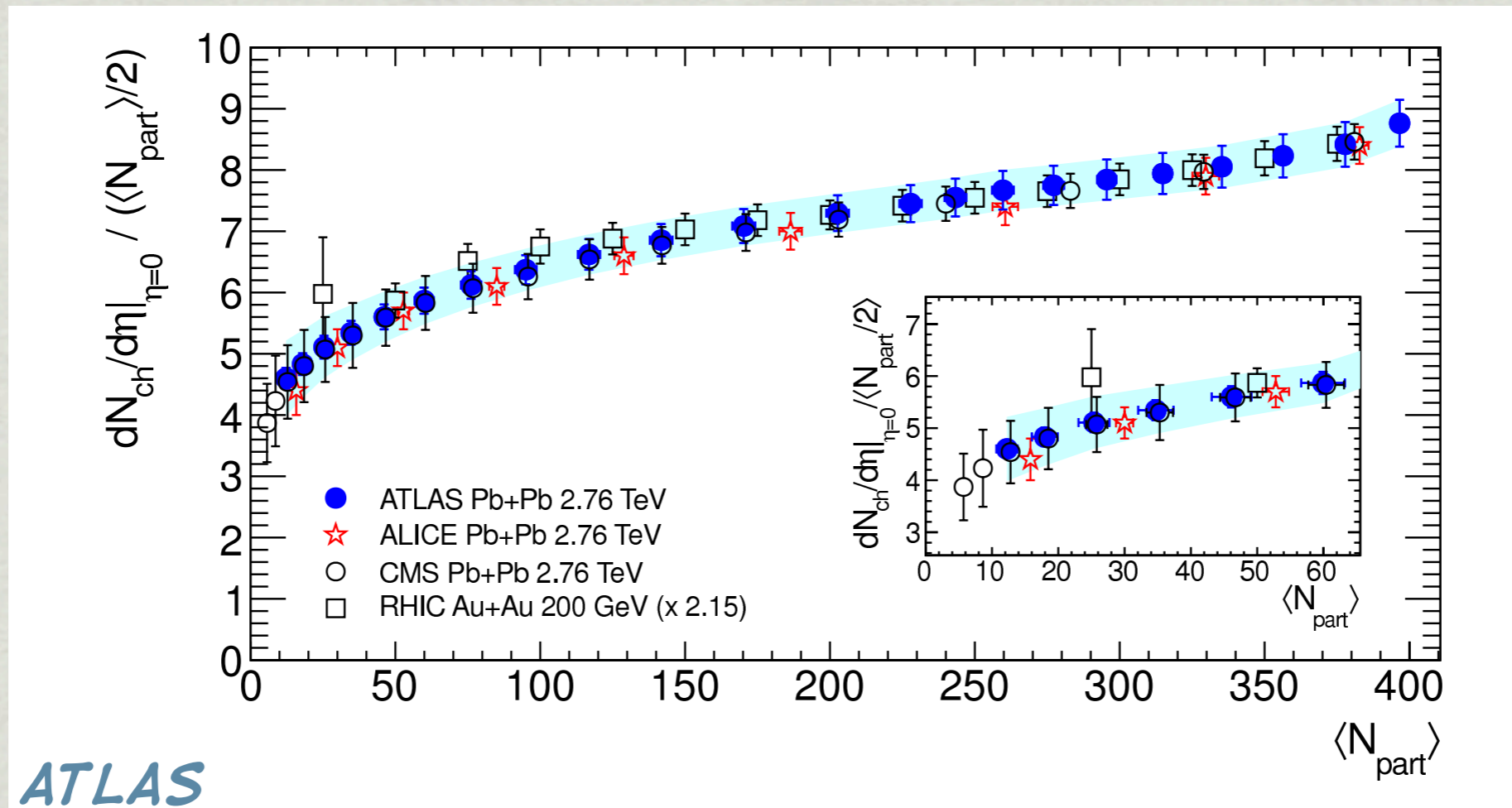
$$g(N_{part}) = 1 + 0.095 N_{part}^{1/3}$$

TWO-COMPONENT MODEL
SUGGESTS THAT THE
"MINIJET" CONTRIBUTION
SHOULD INCREASE W/ ENERGY
(E.G. HIJING)

DATA HAVE ALWAYS
SUGGESTED OPPOSITE:
THE CHANGE IN DN/
DETA IS INVARIANT
WITH BEAM ENERGY



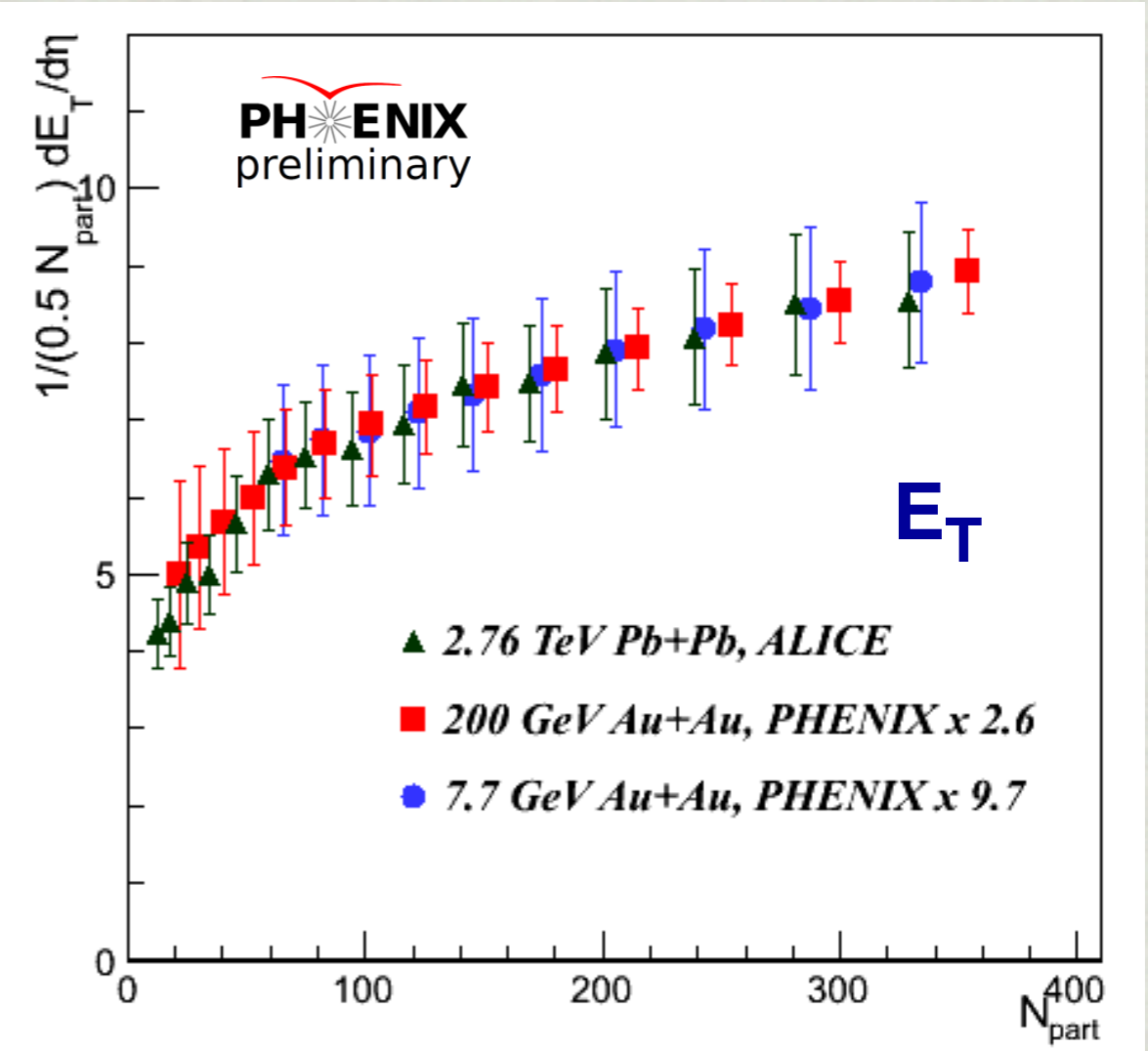
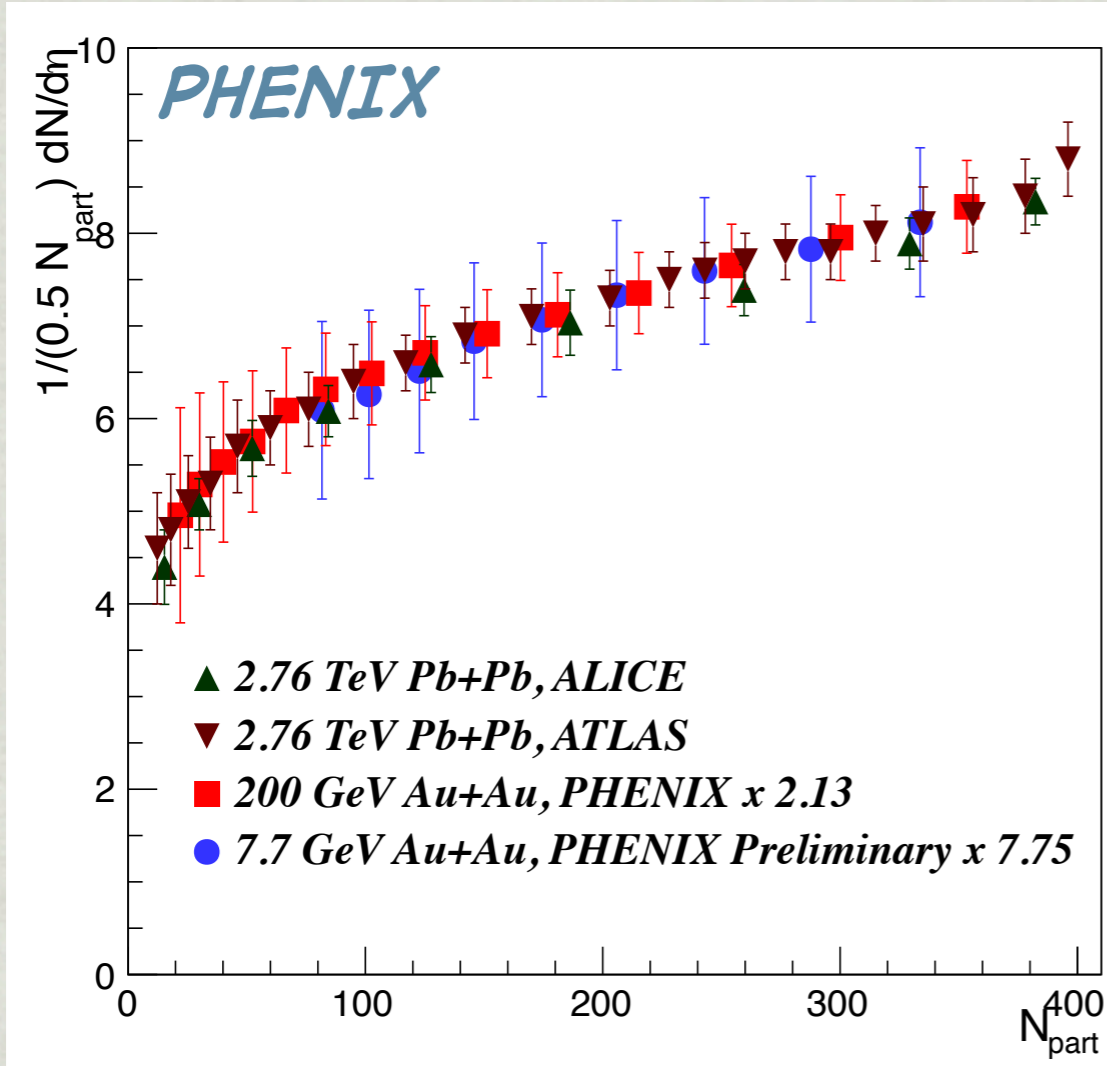
FACTORIZATION @ LHC



*GOOD AGREEMENT BETWEEN LHC EXPERIMENTS,
BUT AMAZING AGREEMENT OF CENTRALITY
DEPENDENCE WITH RHIC DATA (X 14 IN BEAM ENERGY)*

*(ALBEIT WITH A HINT OF A STRONGER INCREASE
AT THE LHC)*

FACTORIZATION @ RHIC



THE SCALING PERSISTS OVER A FACTOR OF
 $2760/7.7 = 358[!!]$ IN CM ENERGY.
 SUGGESTS ENERGY IS NOT A FACTOR: GEOMETRY?

THANKS TO J. MITCHELL

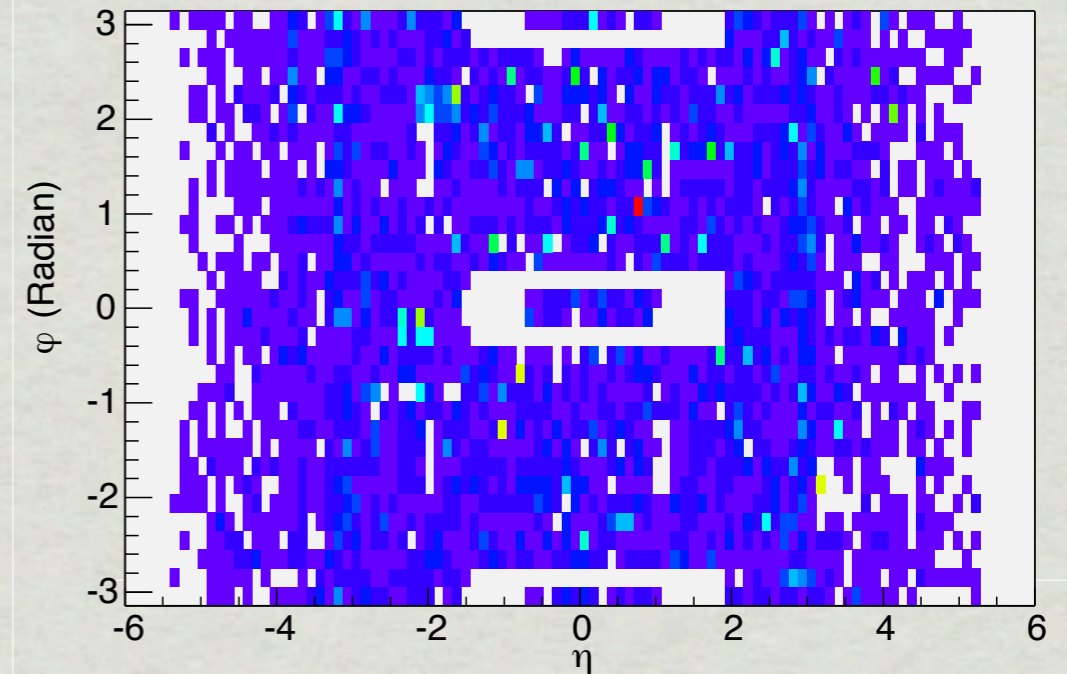
PHOBOS = 4π

* PHOBOS WAS BUILT SUCH THAT NEARLY ALL CHARGED PARTICLES EMITTED IN ALL PHASE SPACE REGIONS WOULD BE VISIBLE

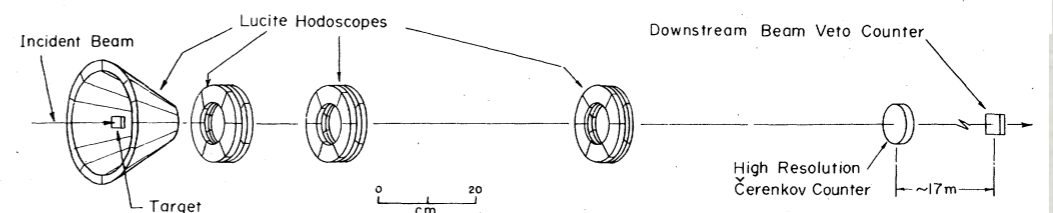
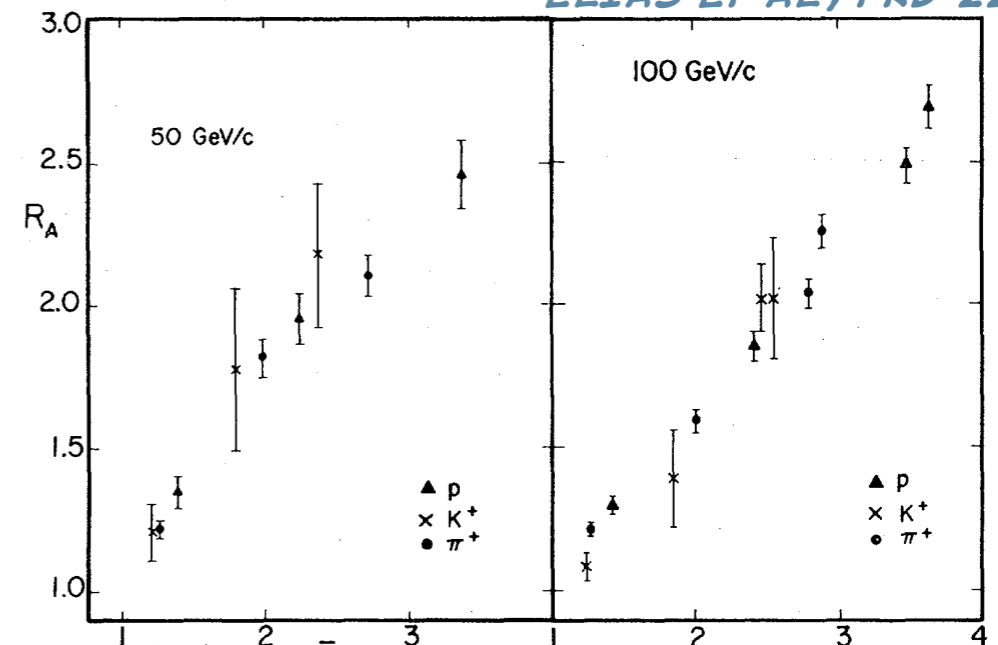
* LEGACY OF WIT'S EXPERIENCE WITH PROTON+NUCLEUS

* "WOUNDED NUCLEON SCALING" WAS ALWAYS FOR 4π MULTIPLICITIES

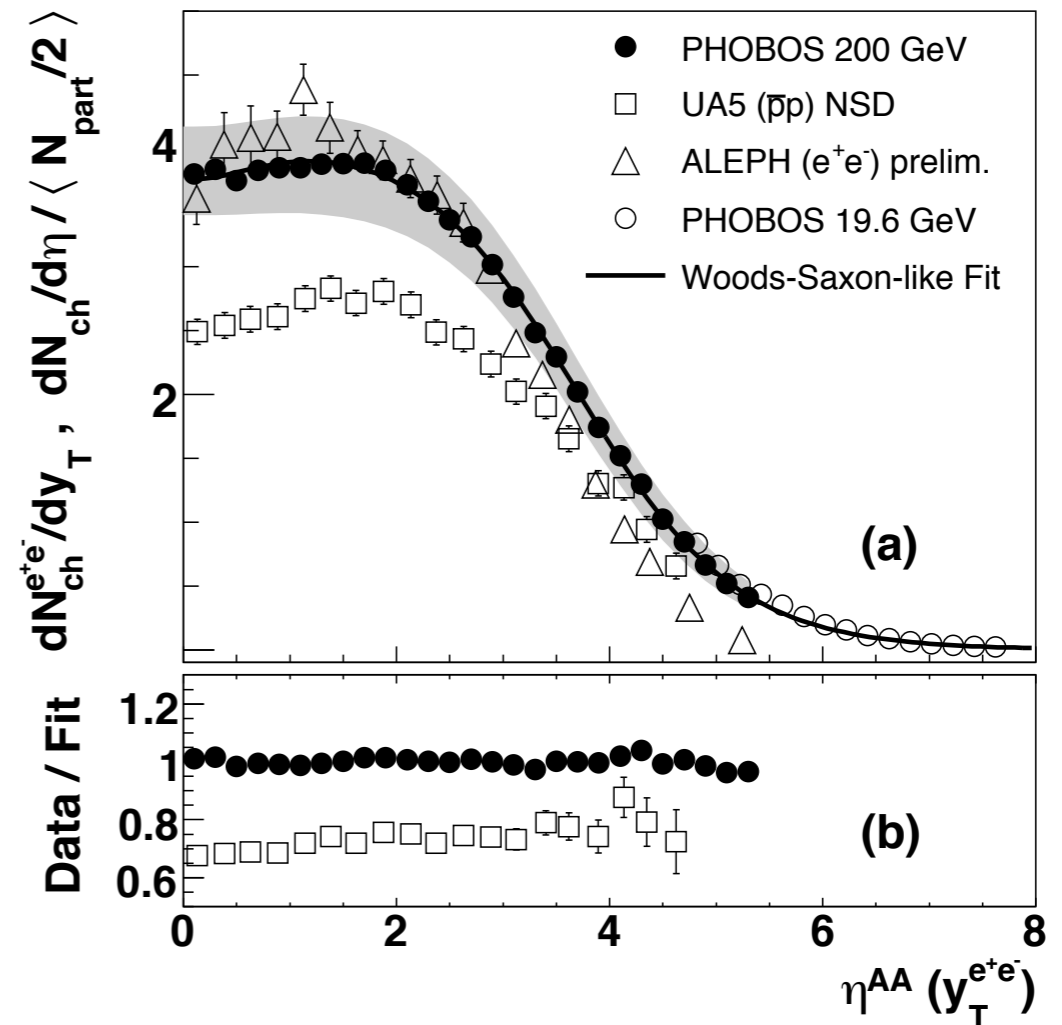
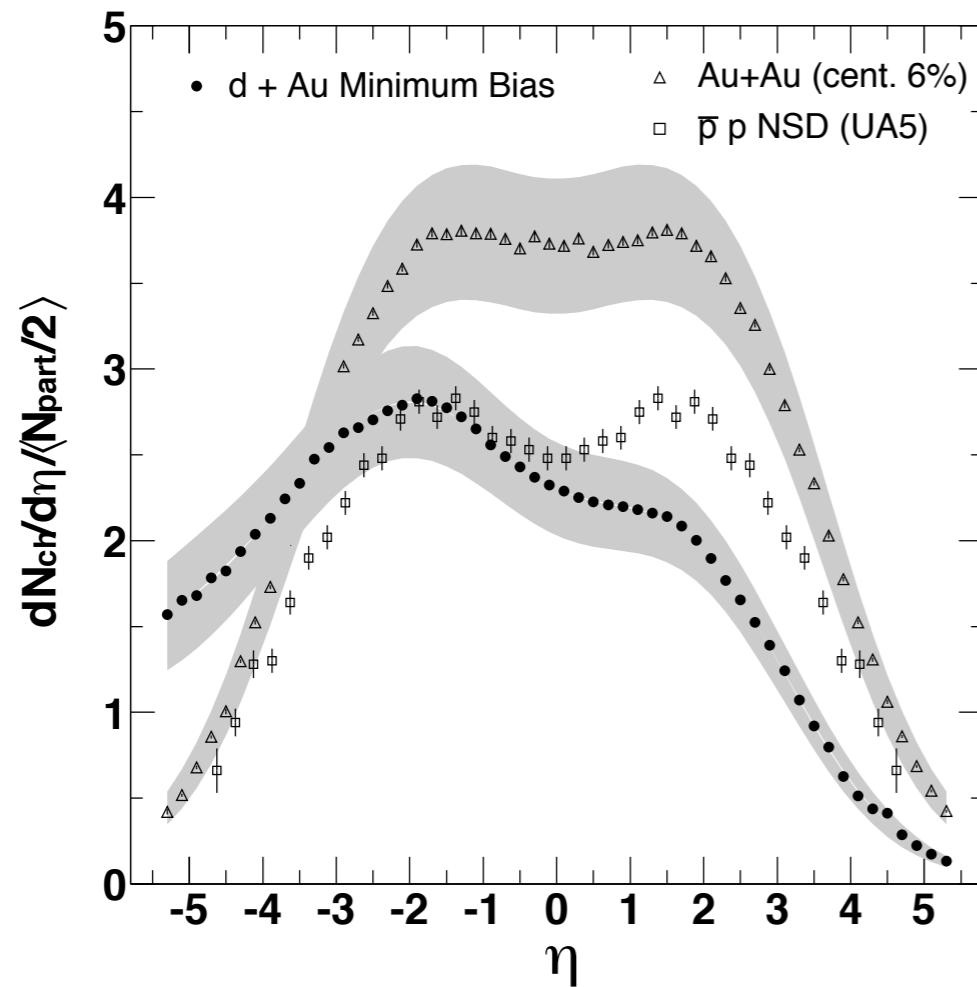
SINGLE EVENT AT 130 GEV



ELIAS ET AL, PRD 22



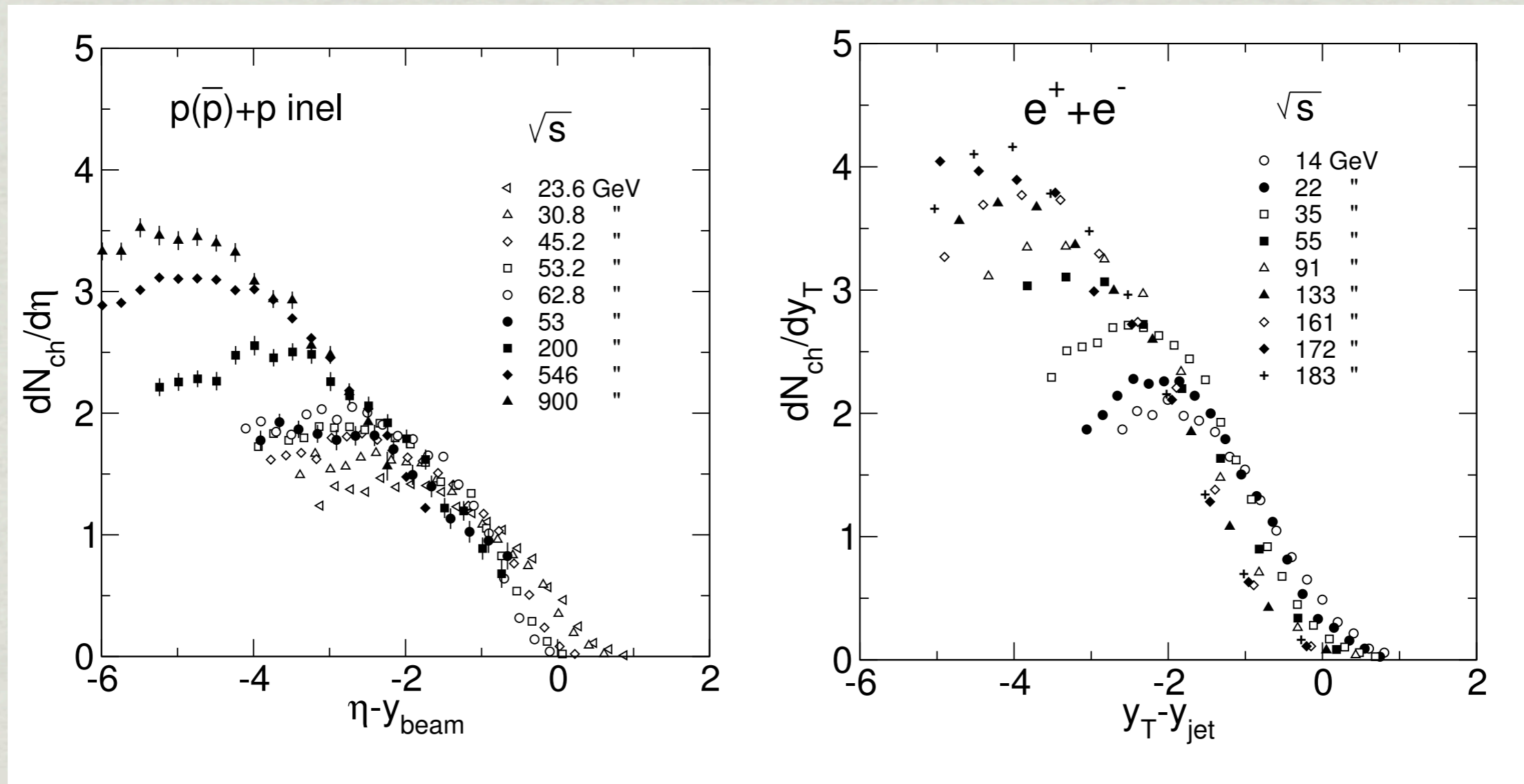
FULL ACCEPTANCE $dN/d\eta$



POTENTIALLY MORE INFORMATION ABOUT THE FULL DYNAMICAL EVOLUTION THAN AT $\eta=0$: COMPARISONS OF A+A WITH P+P, D+AU, E+E-(?)

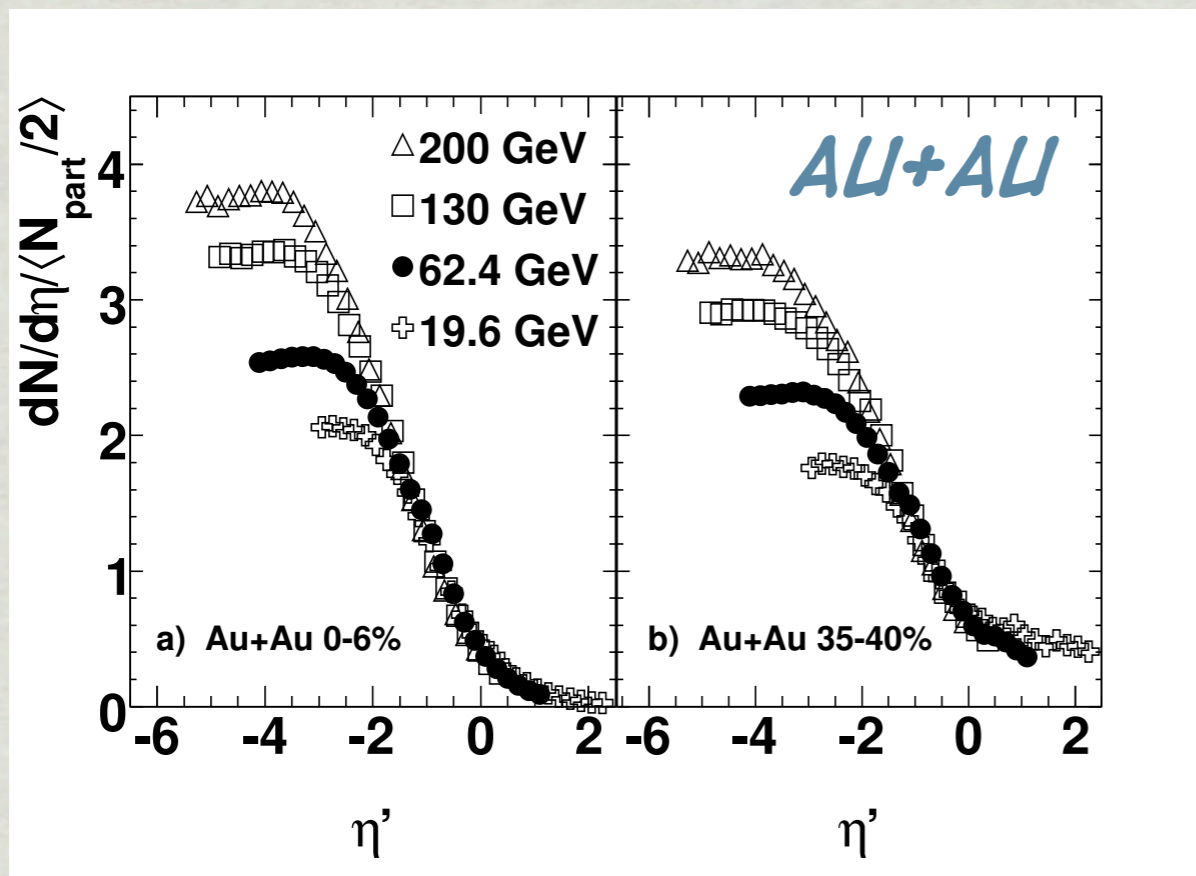
LONGITUDINAL SCALING

* INVARIANCE OF INCLUSIVE YIELDS WHEN VIEWED IN REST FRAME OF ONE PROJECTILE



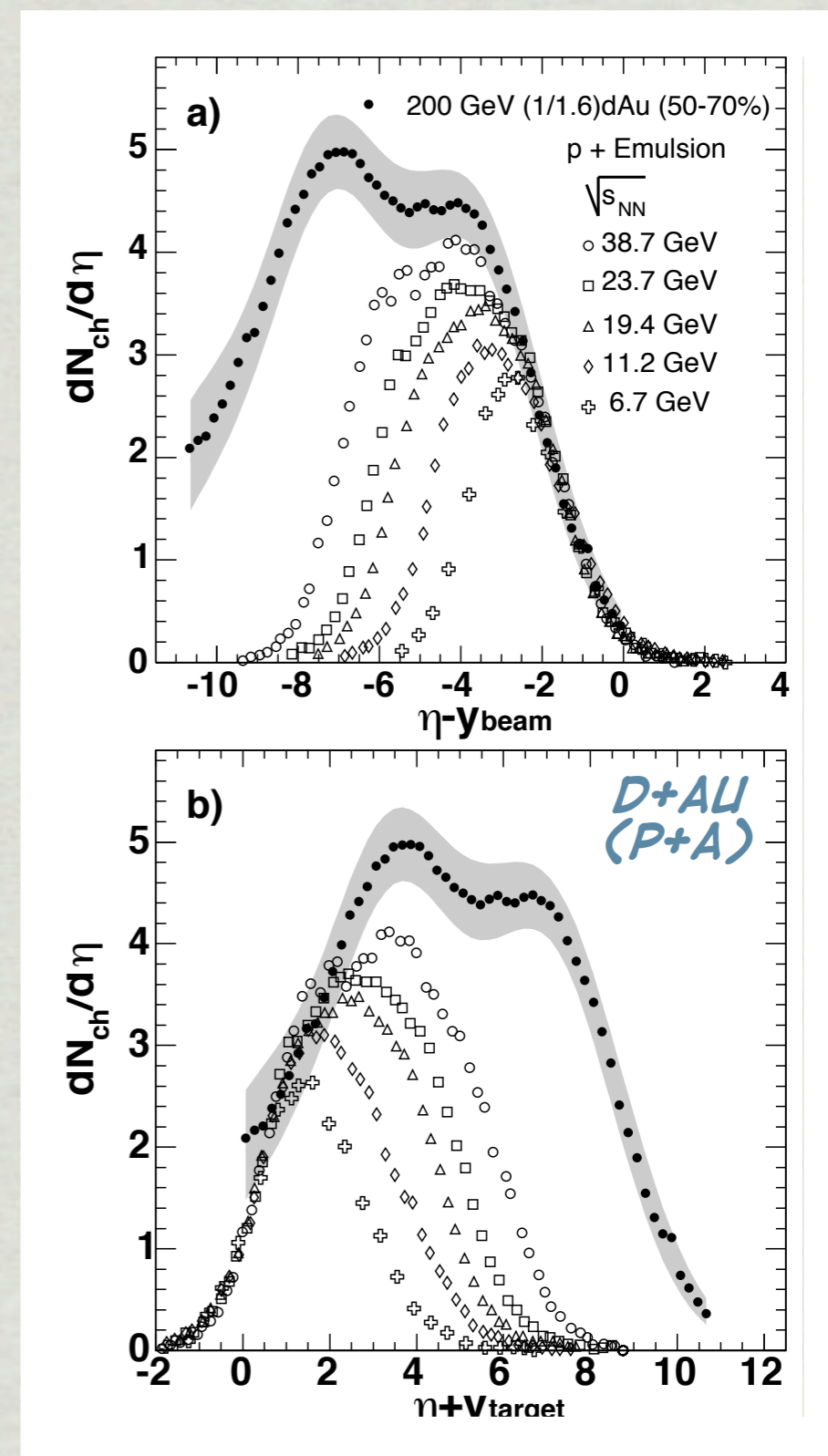
OBEYED APPROXIMATELY FOR P+P AND EVEN E⁺E⁻ (JETS).
SIMPLY EXPRESSING APPROXIMATE x_F SCALING OF PDF/FF?

SCALING IS UBIQUITOUS

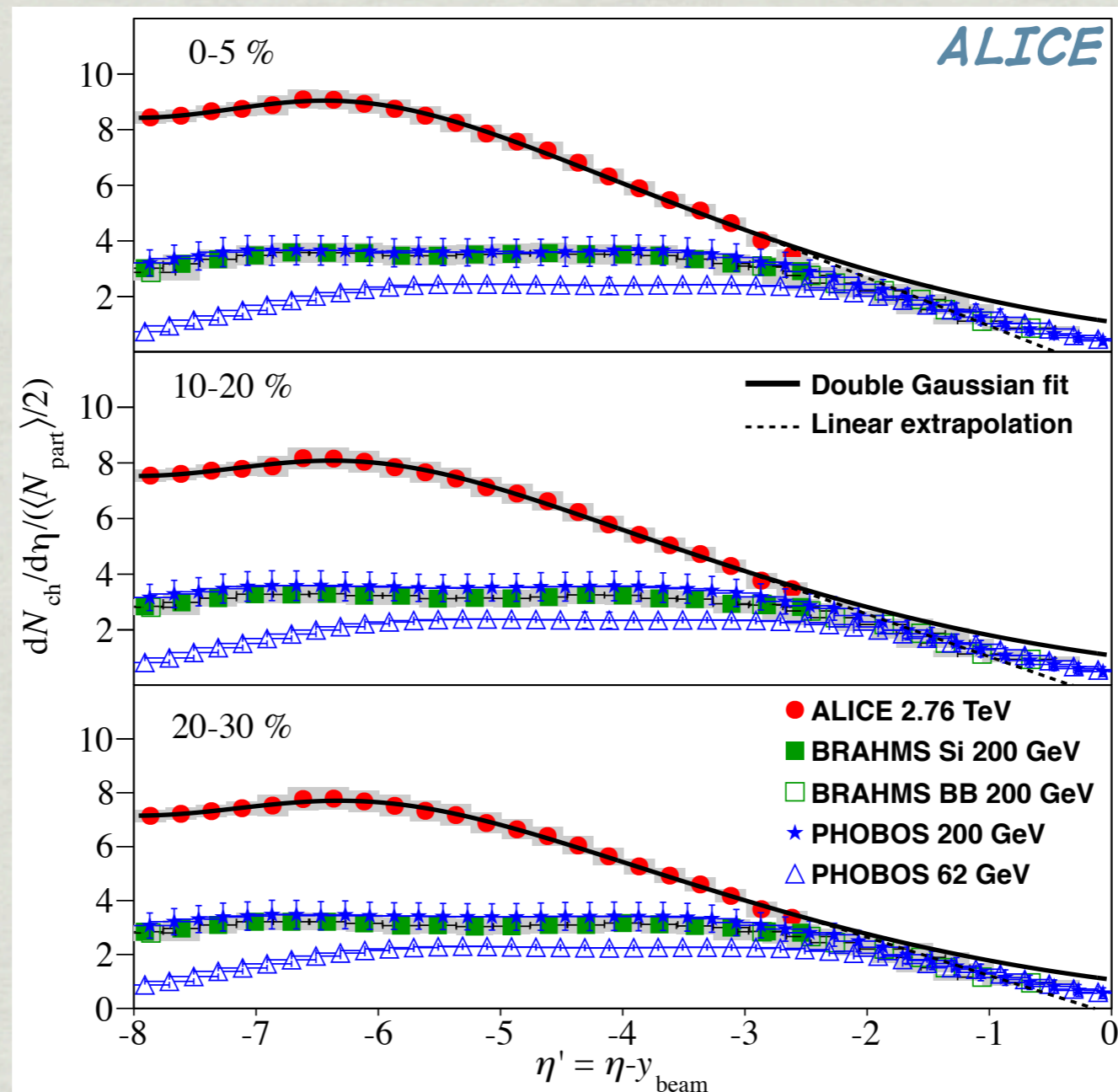


LONGITUDINAL SCALING
FOUND TO HOLD
TO A SURPRISING DEGREE
IN ALL SYSTEMS STUDIED

APPARENTLY AN INTEGRAL
PART OF STRONG INTERACTIONS



LONGITUDINAL SCALING AT LHC

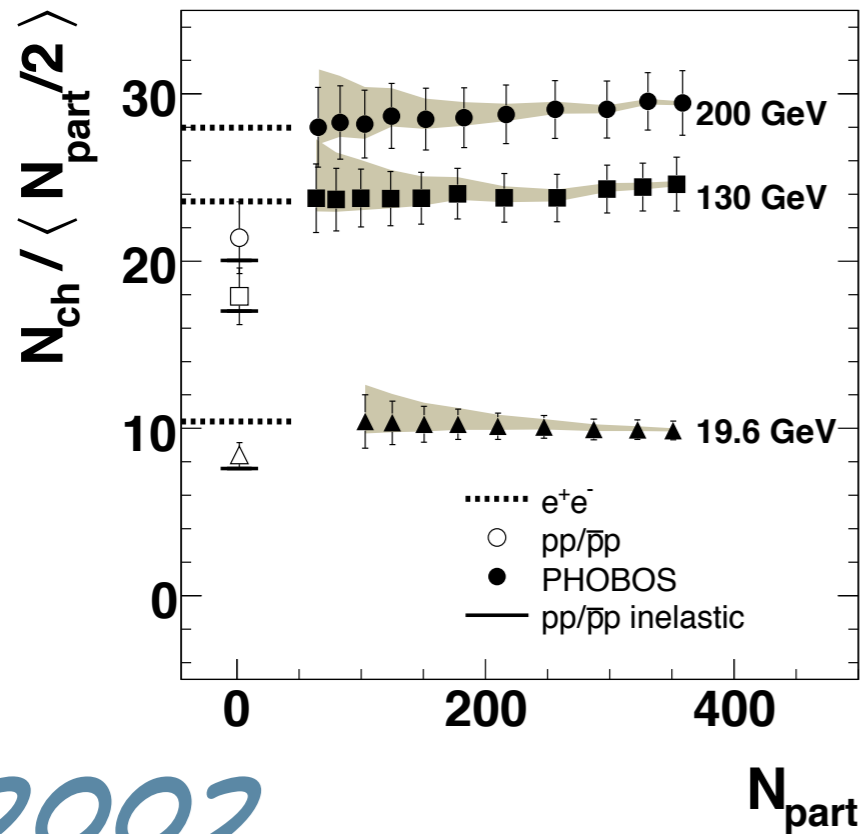


APPROXIMATE SCALING ALSO OBSERVED @ LHC!

(TOTAL MULTIPLICITY OBTAINED USING
A DOUBLE-GAUSSIAN FIT - WHY NOT USE PHOBOS DATA?)

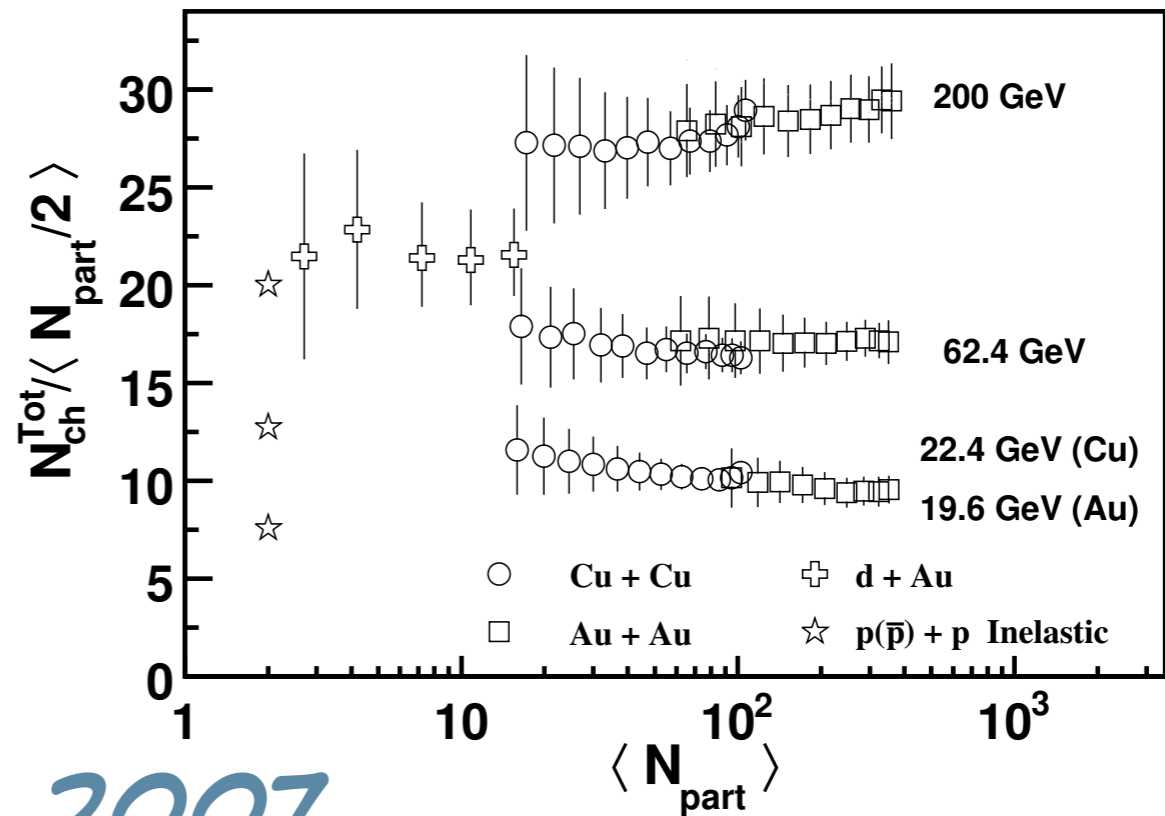
N_{part} SCALING

HOW MANY TOTAL CHARGED PARTICLES?



2002

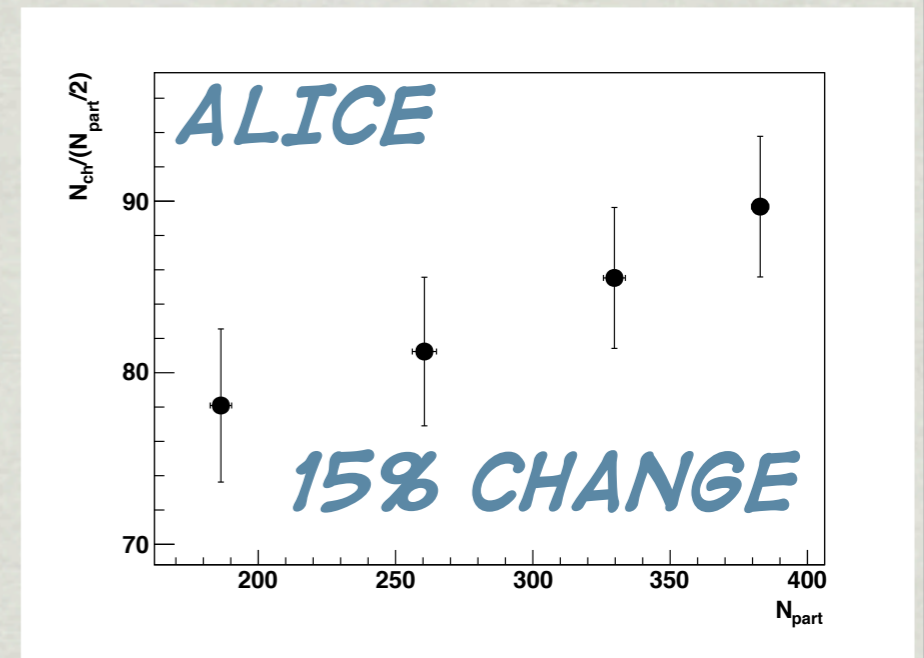
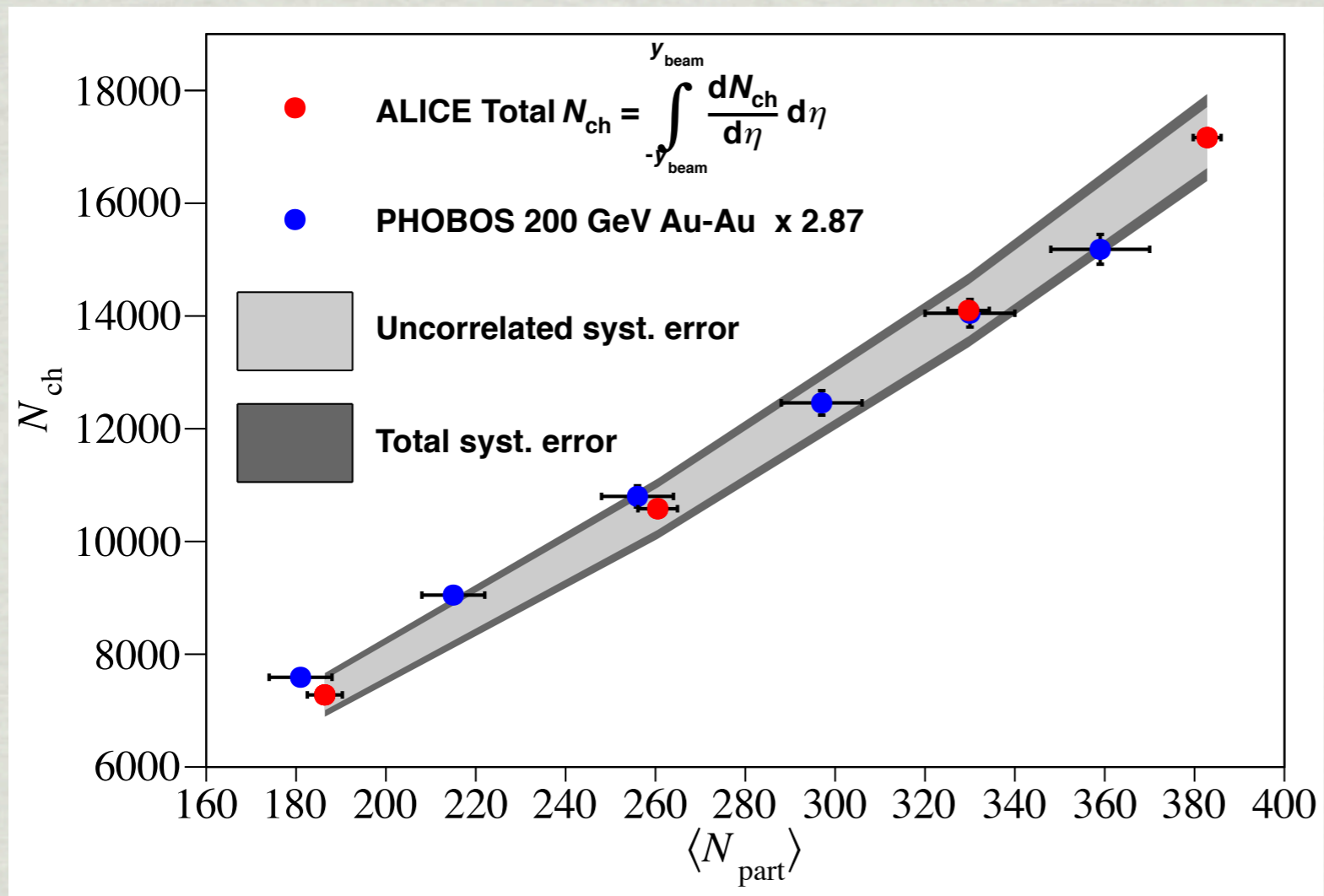
*HERE, "FACTORIZATION"
BECOMES TRIVIAL:
NO CENTRALITY
DEPENDENCE
IN A+A OVER 4π*



2007

*HOLDS WITHIN EACH SYSTEM,
IS ~SAME FOR A+A
BUT IS NOT CONTINUOUS
WITH D+AU (~P+P):
SOMETHING DIFFERENT*

N_{PART} SCALING @ LHC?

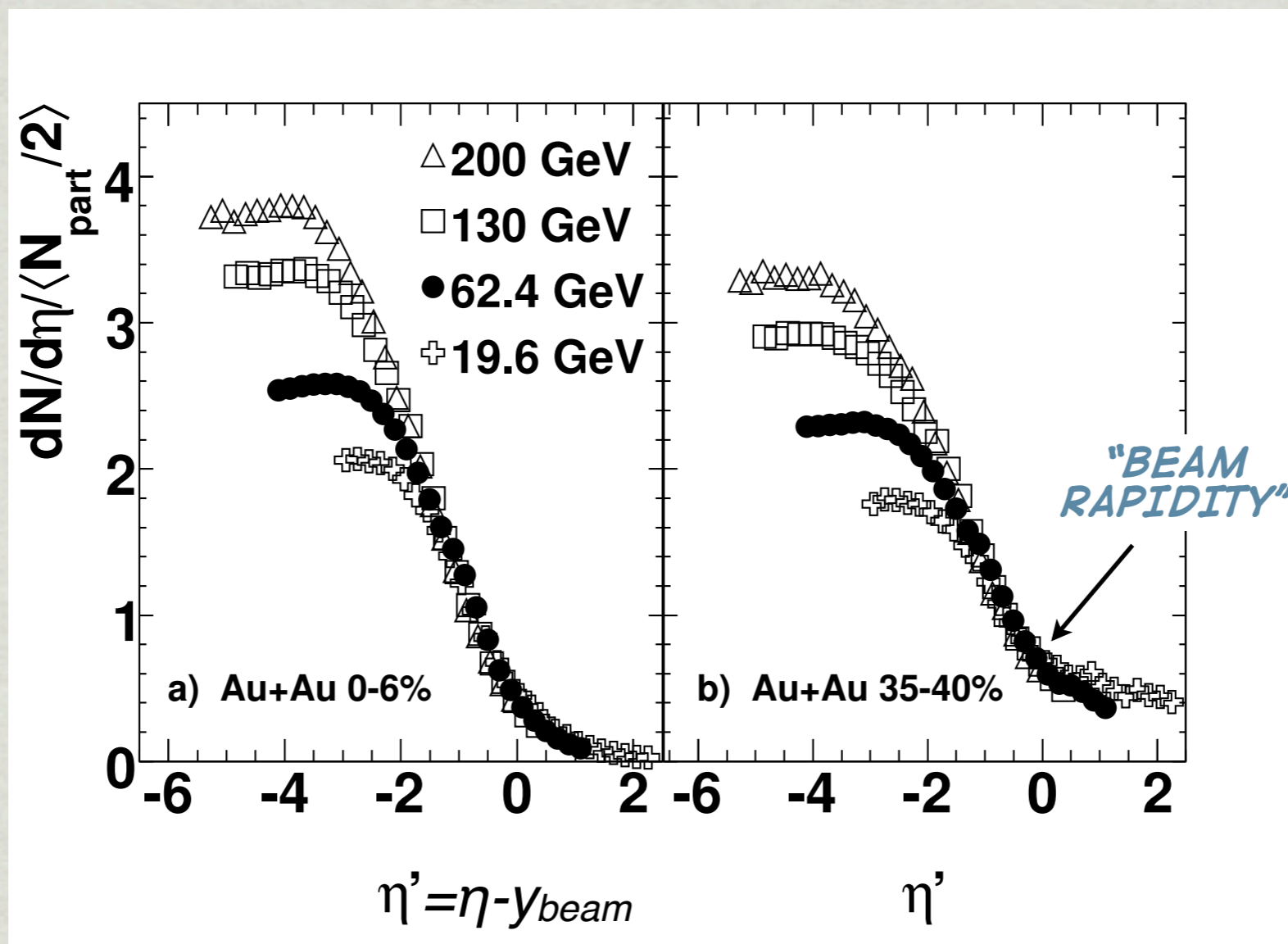


WITHIN LARGE ERRORS, ~SCALING APPEARS CONSISTENT WITH PHOBOS OBSERVATION

ON CLOSER INSPECTION, LINEARITY IS VIOLATED AT 15% LEVEL BETWEEN 0-5% AND 20-30%.

MY CONCERN WOULD BE LIMITING ETA INTEGRAL TO Y_{BEAM}

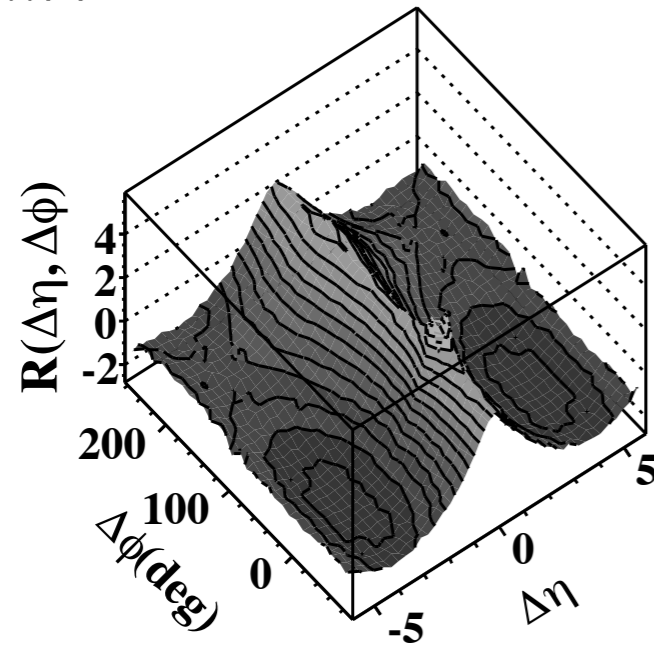
A CLOSER LOOK



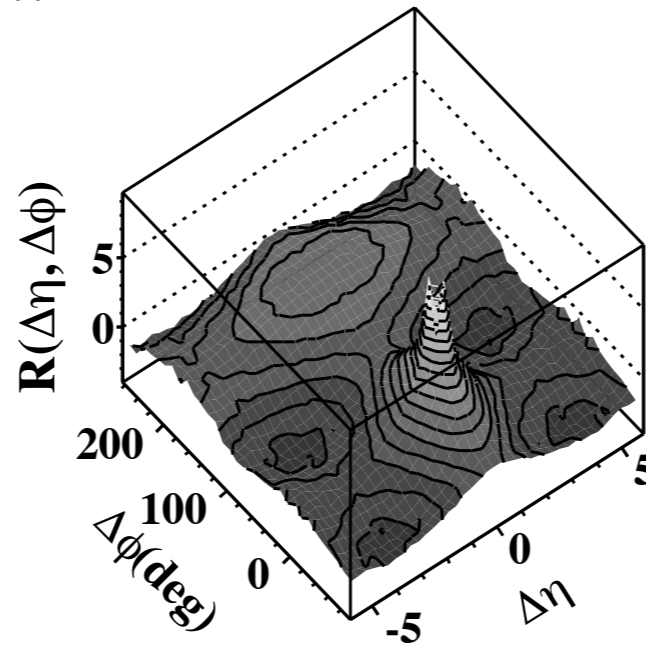
JUST FROM STARING AT PLOTS, NOTICED THAT WHILE
1) *YIELDS AT $\eta = 0$ INCREASE WITH CENTRALITY,*
2) *YIELDS AT LARGE η DECREASE WITH CENTRALITY*
YIELDS IN 4π ARE EVIDENTLY CORRELATED

"SHORT RANGE" CORRELATIONS

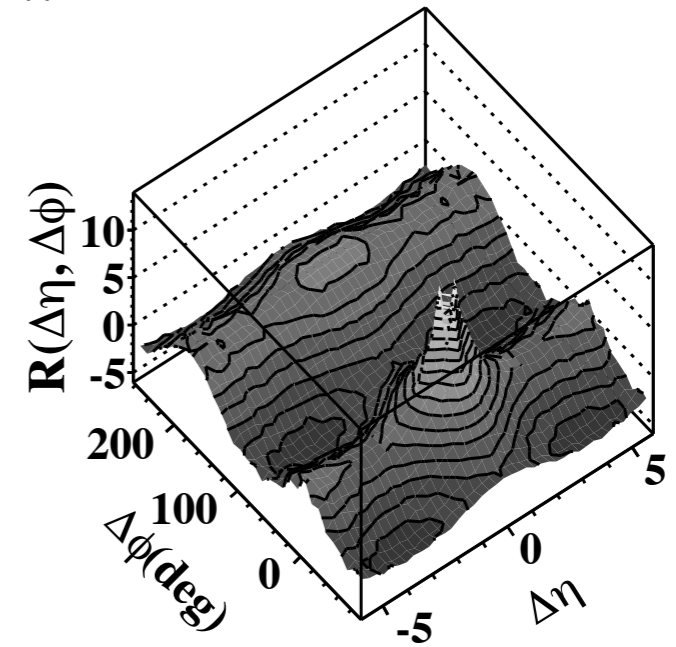
(a) p+p 200 GeV



(b) Cu+Cu 200 GeV, 0-10%



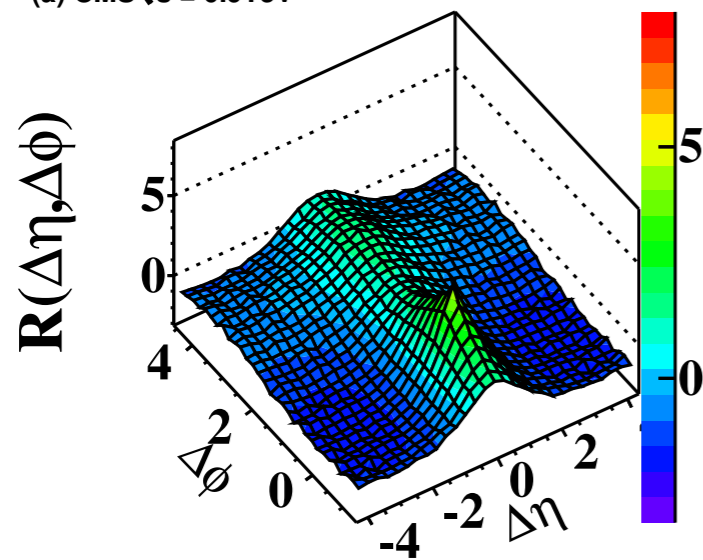
(c) Au+Au 200 GeV, 0-10%



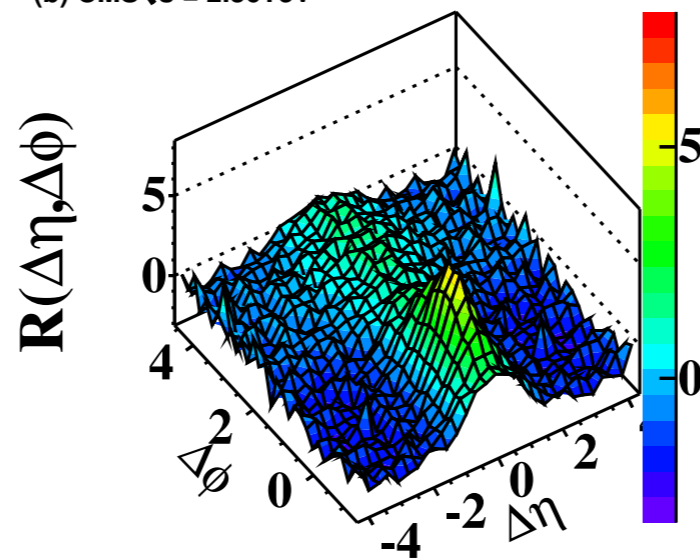
$$R(\Delta\eta, \Delta\phi) = \left\langle (n-1) \left(\frac{\rho_n^{\text{II}}(\Delta\eta, \Delta\phi)}{\rho^{\text{mixed}}(\Delta\eta, \Delta\phi)} - 1 \right) \right\rangle$$

*SIMILAR TECHNIQUE
USED TO FIND THE
CMS RIDGE!*

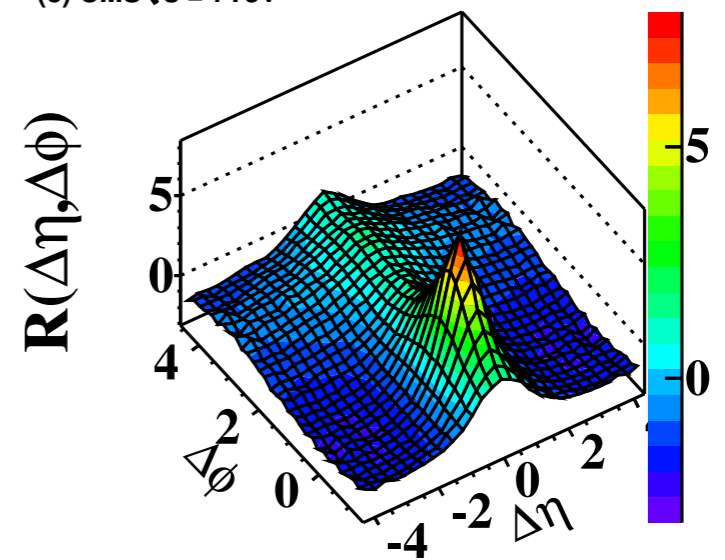
(a) CMS $\sqrt{s} = 0.9\text{TeV}$



(b) CMS $\sqrt{s} = 2.36\text{TeV}$

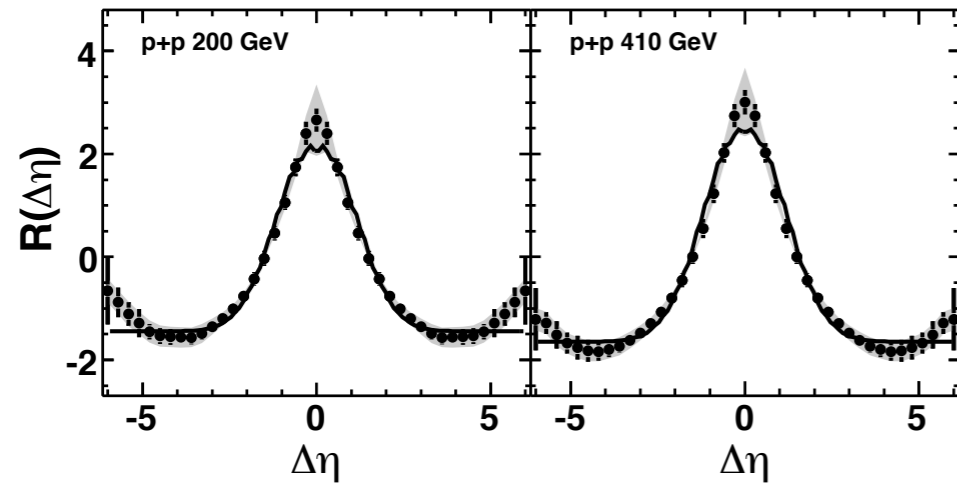


(c) CMS $\sqrt{s} = 7\text{TeV}$



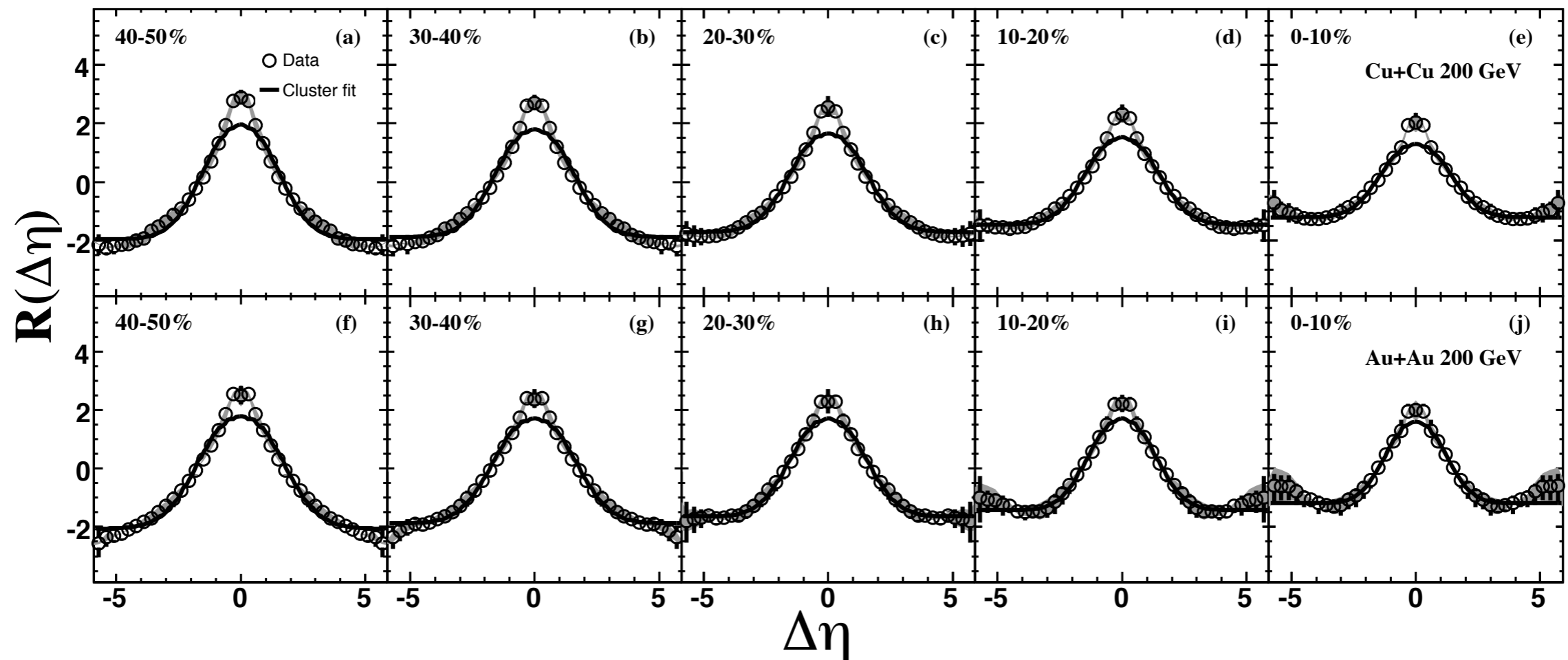
P+P VS. A+A

Phys. Rev. C75, 054913 (2007)



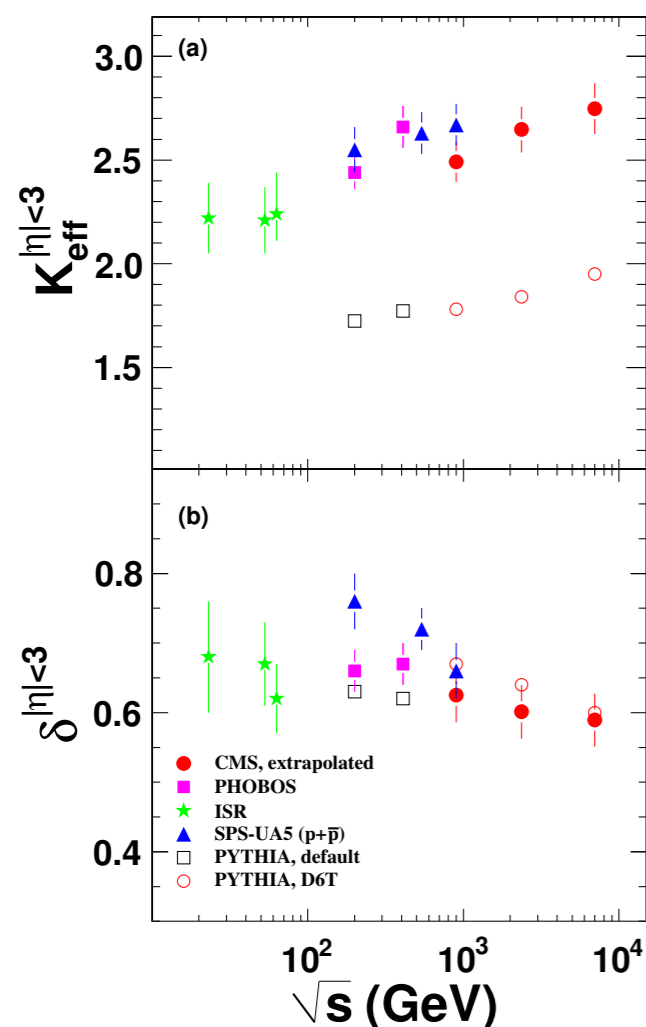
*PROJECTING ONTO $\Delta\eta$
REMOVES FLOW FROM A+A:
"SHORT RANGE" CORRELATIONS
ARE NOT SHORT -- BUT NOR ARE
THEY EXTENDING FULL η RANGE*

Phys. Rev. C81, 024904 (2010)



CLUSTERS IN P+P & A+A

CMS

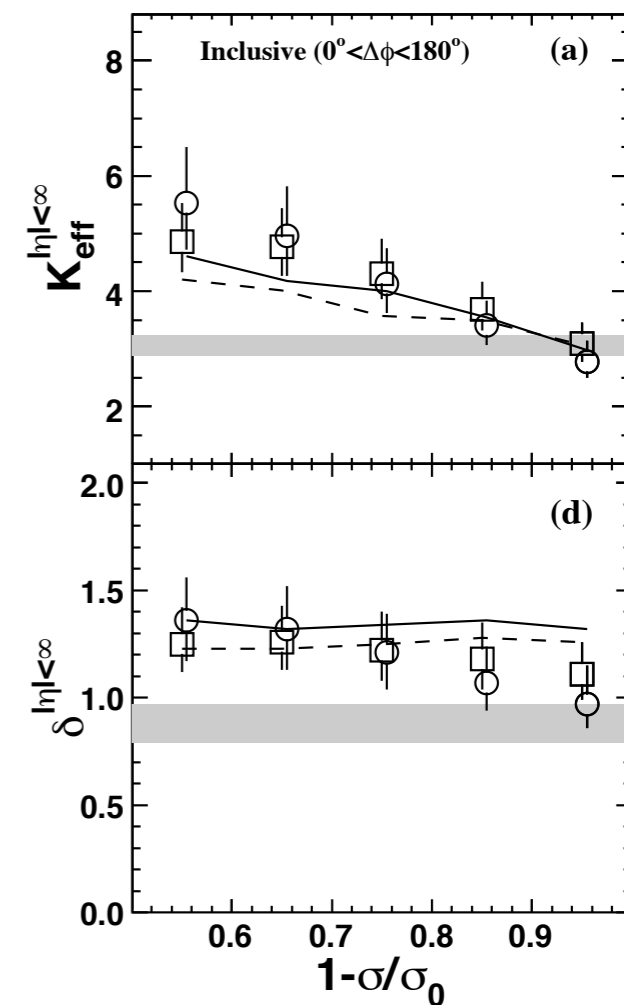


SIMPLE CLUSTER FITS
PROVIDE REASONABLE
DESCRIPTION OF $R(\Delta\eta)$
AND CHARACTERIZE
MULTIPLICITY (K_{EFF}) AND
WIDTH (δ) OF "CLUSTERS":
CORRELATED EMISSION

$K_{EFF}(DATA) > K_{EFF}(PYTHIA)$
(MAINLY RESONANCES)

SLOW GROWTH OF
 K_{EFF} WITH \sqrt{s} W/ LITTLE
CHANGE IN WIDTH

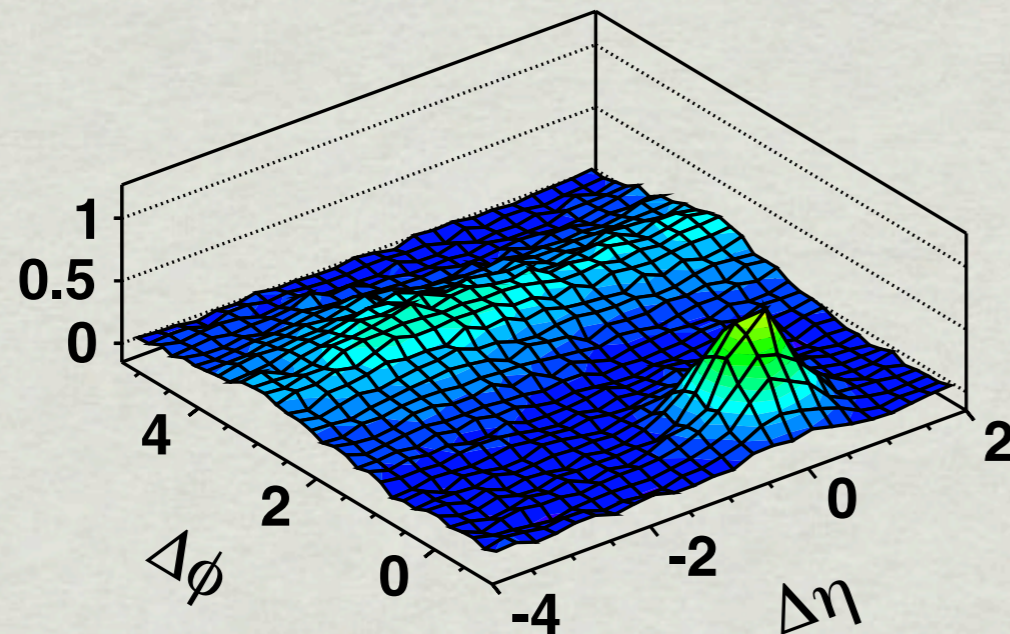
PHOBOS



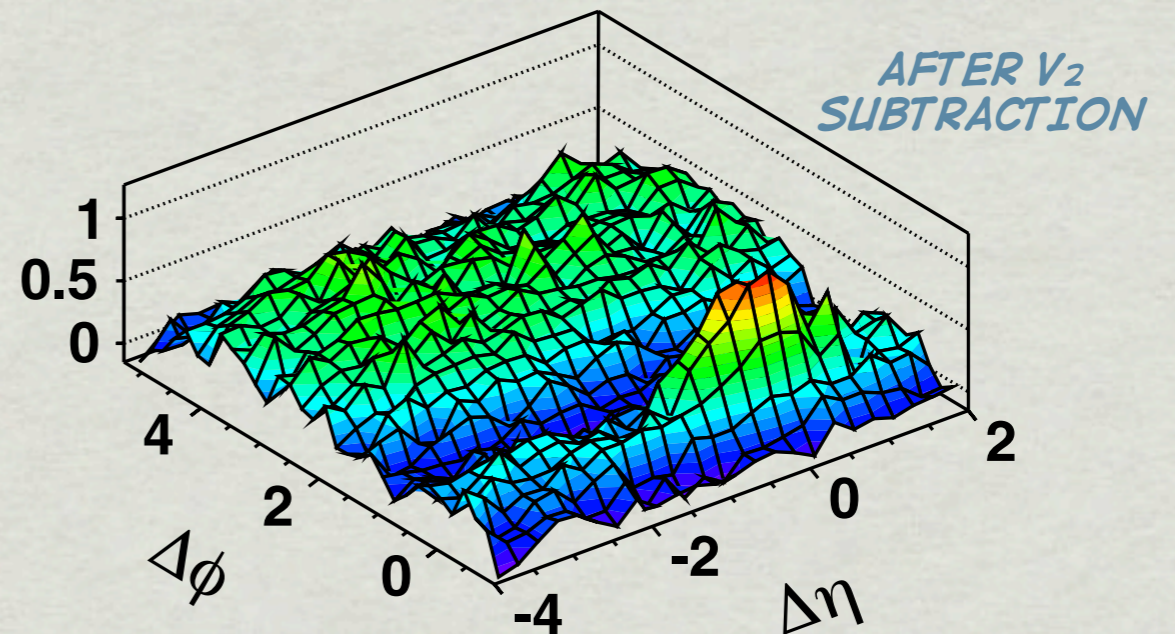
$K(A+A) \sim K(P+P)$ IN CENTRAL,
MUCH LARGER IN PERIPHERAL!

PHOBOS Au+Au RIDGE

PHOBOS, PRL 104 062301 (2010)



(a) p+p PYTHIA (version 6.325)



(b) Au+Au 0%-30% (PHOBOS)

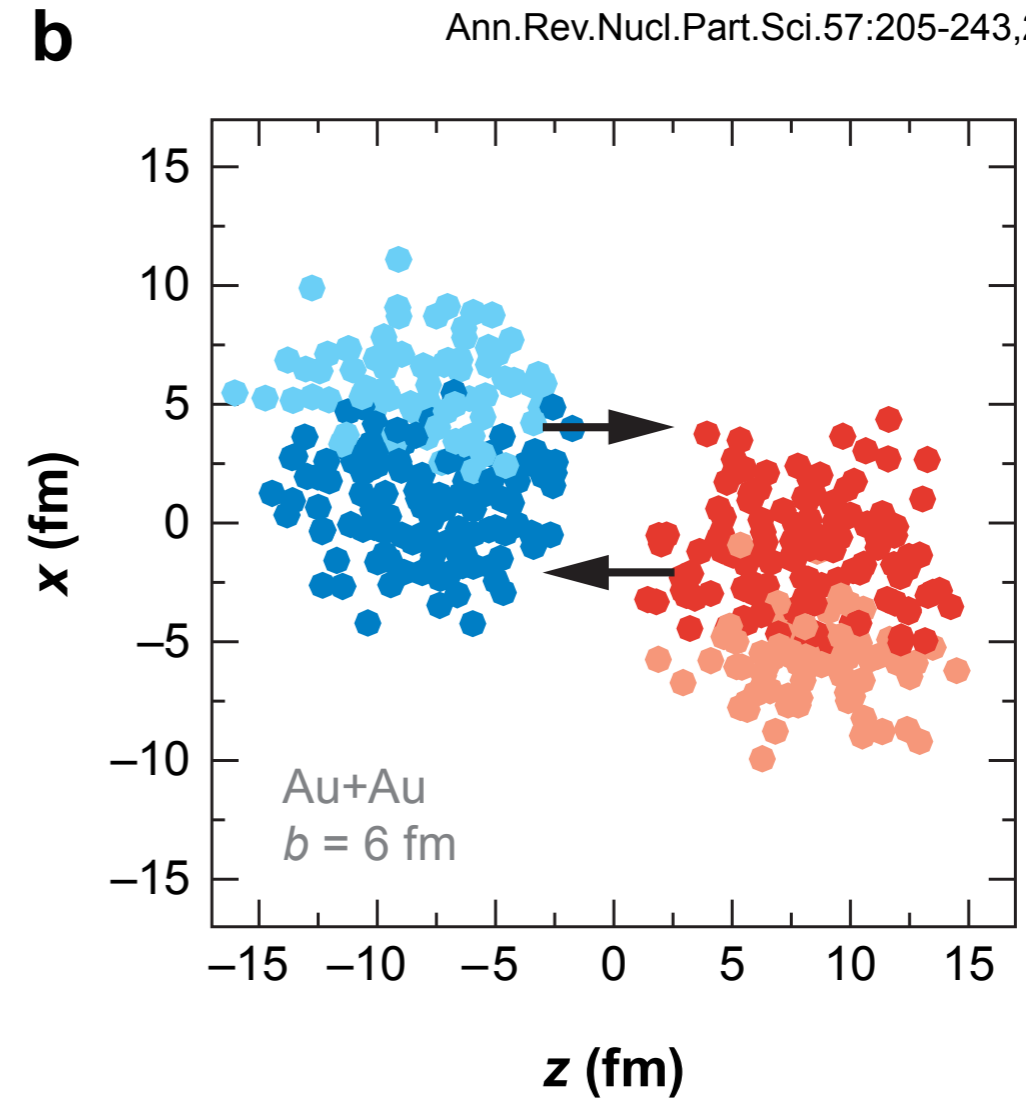
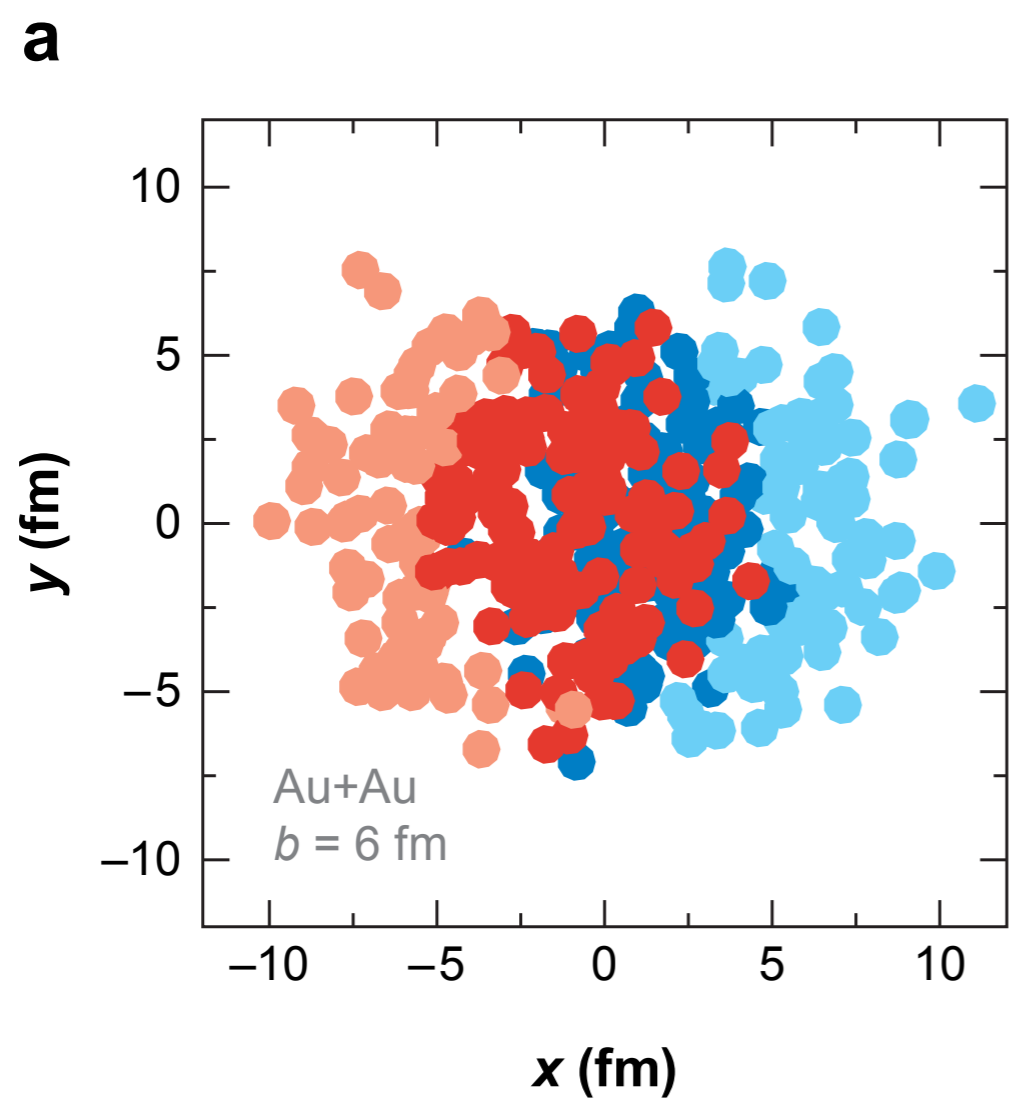
*WHILE PHOBOS COULD NOT PROVIDE
 P_T DEPENDENCE, THE LARGE η COVERAGE
GAVE FIRST LOOK AT THE RIDGE AT VERY
LARGE $\Delta\eta$ SEPARATIONS...
... NO END IN SIGHT!*

MANY EXPLANATIONS...

...FROM A 2008 TALK BY ED WENGER (PHOBOS)

- **Coupling of induced radiation to longitudinal flow**
Armesto et al., PRL 93, 242301
- **Recombination of shower + thermal partons**
Hwa, arXiv:nucl-th/0609017v1
- **Anisotropic plasma**
Romatschke, PRC 75, 014901
- **Turbulent color fields**
Shuryak, arXiv:0706.3531v1
- **Bremsstrahlung + transverse flow + jet-quenching**
Majumder, Muller, Bass, arXiv:hep-ph/0611135v2
- **Splashback from away-side shock**
Pantuev, arXiv:0710.1882v1
- **Momentum kick imparted on medium partons**
Wong, arXiv:0707.2385v2
- **Glasma Flux Tubes**
Dumitru, Gelis, McLerran, Venugopalan, arXiv:0804.3858; Gavin, McLerran, Moscelli, arXiv:0806.4718

"RIDGE & CONE" KEPT US BUSY FOR 6 YEARS!



PROJECT

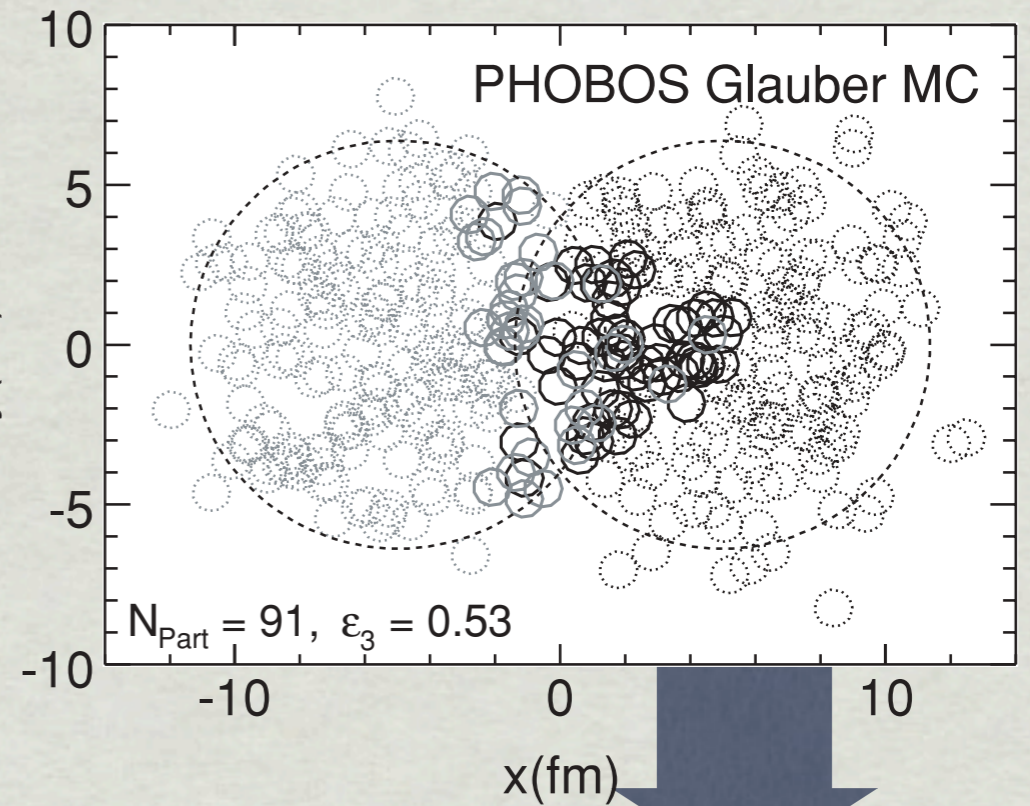
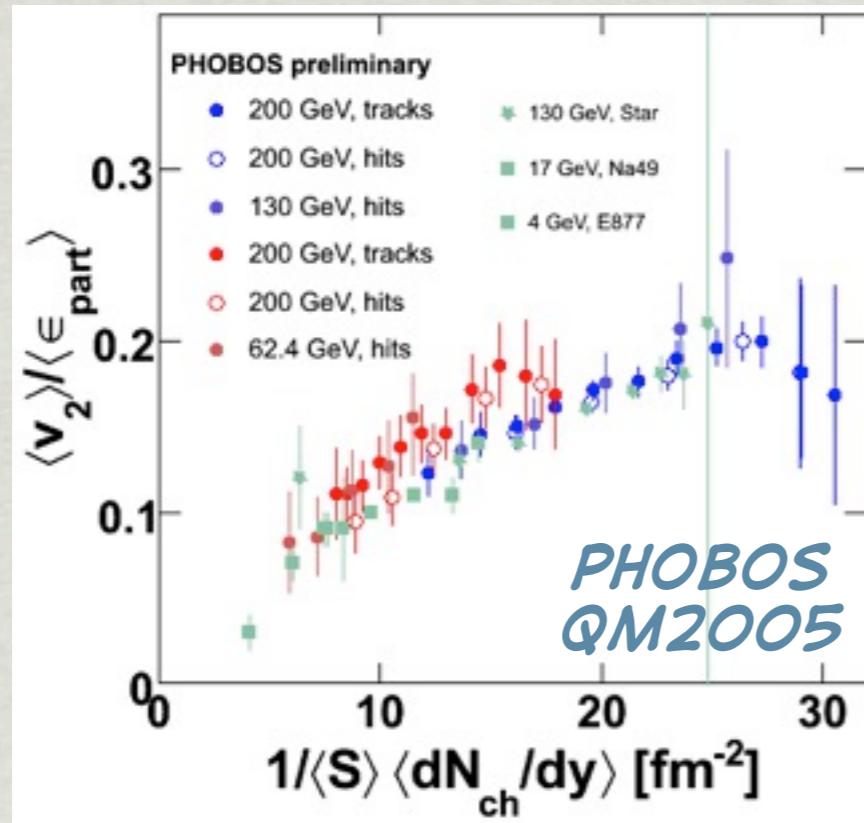
***MONTE CARLO GLAUBER
PHOBOS (& ALVER & ROLAND)***

DATE ***JUNE 2005-MARCH 2010***

CLIENT ***HI COMMUNITY***

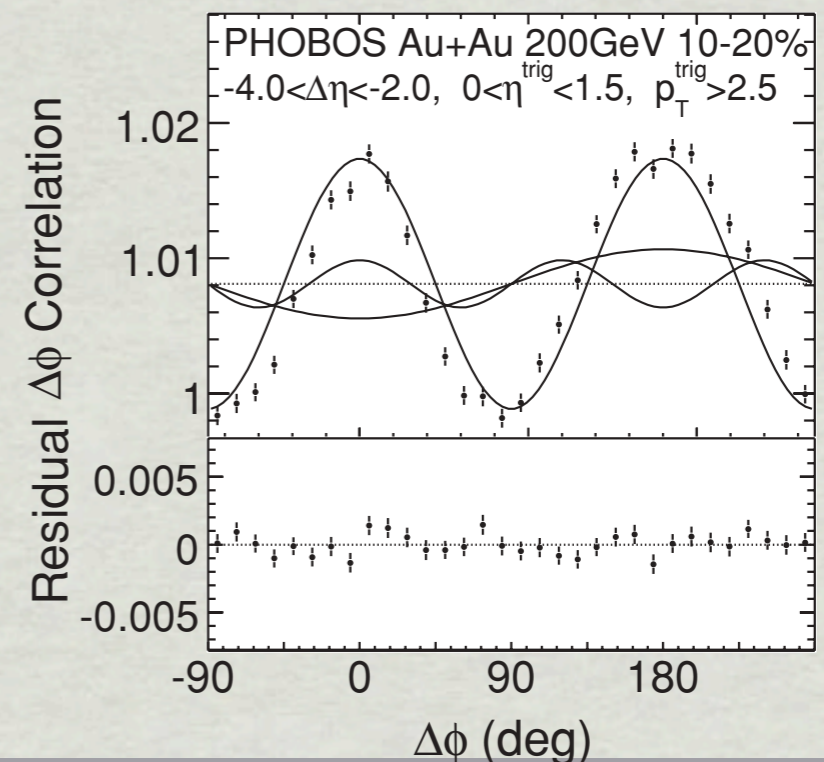
INITIAL STATE MATTERS

STAR, PRC 81 054905 (2010)



*PARTICIPANT ECCENTRICITY
BROUGHT AU+AU & CU+CU
TOGETHER! (PHOBOS 2005)*

*ALVER & ROLAND WERE FIRST TO
MAKE IT CLEAR THAT v_3 SHOULD
EXIST AND, MORE IMPORTANTLY,
RIDGE AND CONE ARE "LEFT
BEHIND" IF v_2 SUBTRACTED*



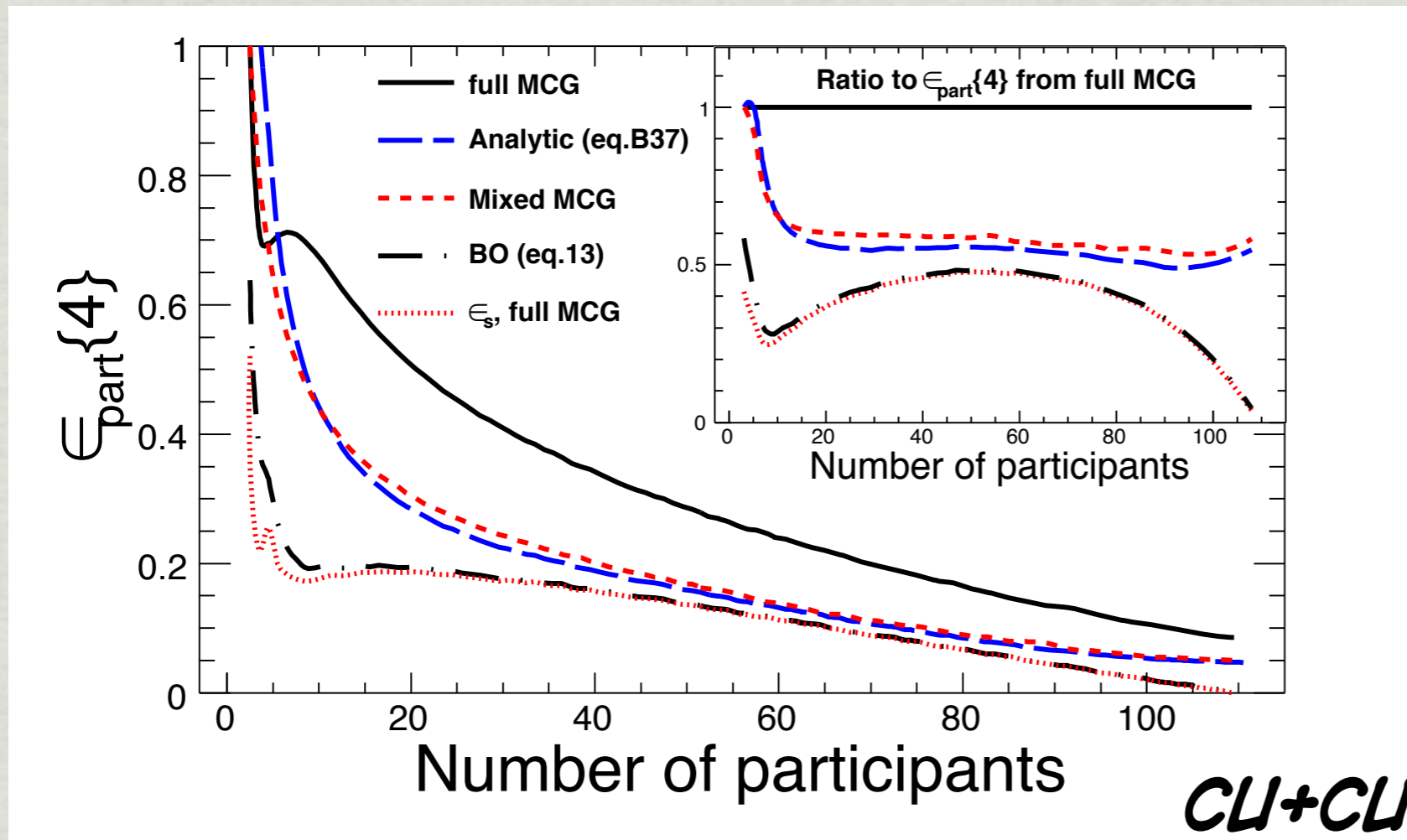
THE RIDGE, POST V_3

- * ONCE SEEN, DIFFICULT TO UN-SEE*
- * FLUCTUATIONS IN THE INITIAL STATE PROVIDE SIMPLEST WAY TO HARMONIZE FLOW SYSTEMATICS*
- * THEY ARE ALSO THE SIMPLEST WAY TO UNDERSTAND THE RIDGE AND MACH CONE*

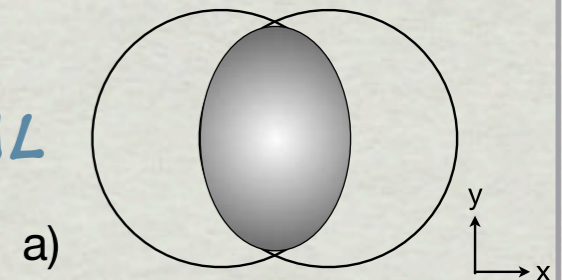
...THE END OF THE RIDGE??

(WILL LEAVE THIS FOR MY LHC FRIENDS!)

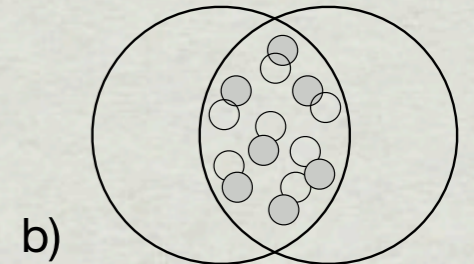
"TWO-TO-TANGO" EFFECT



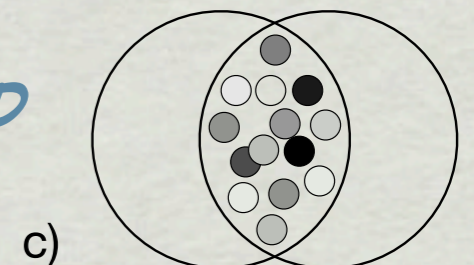
OPTICAL



MC



MIXED
MC

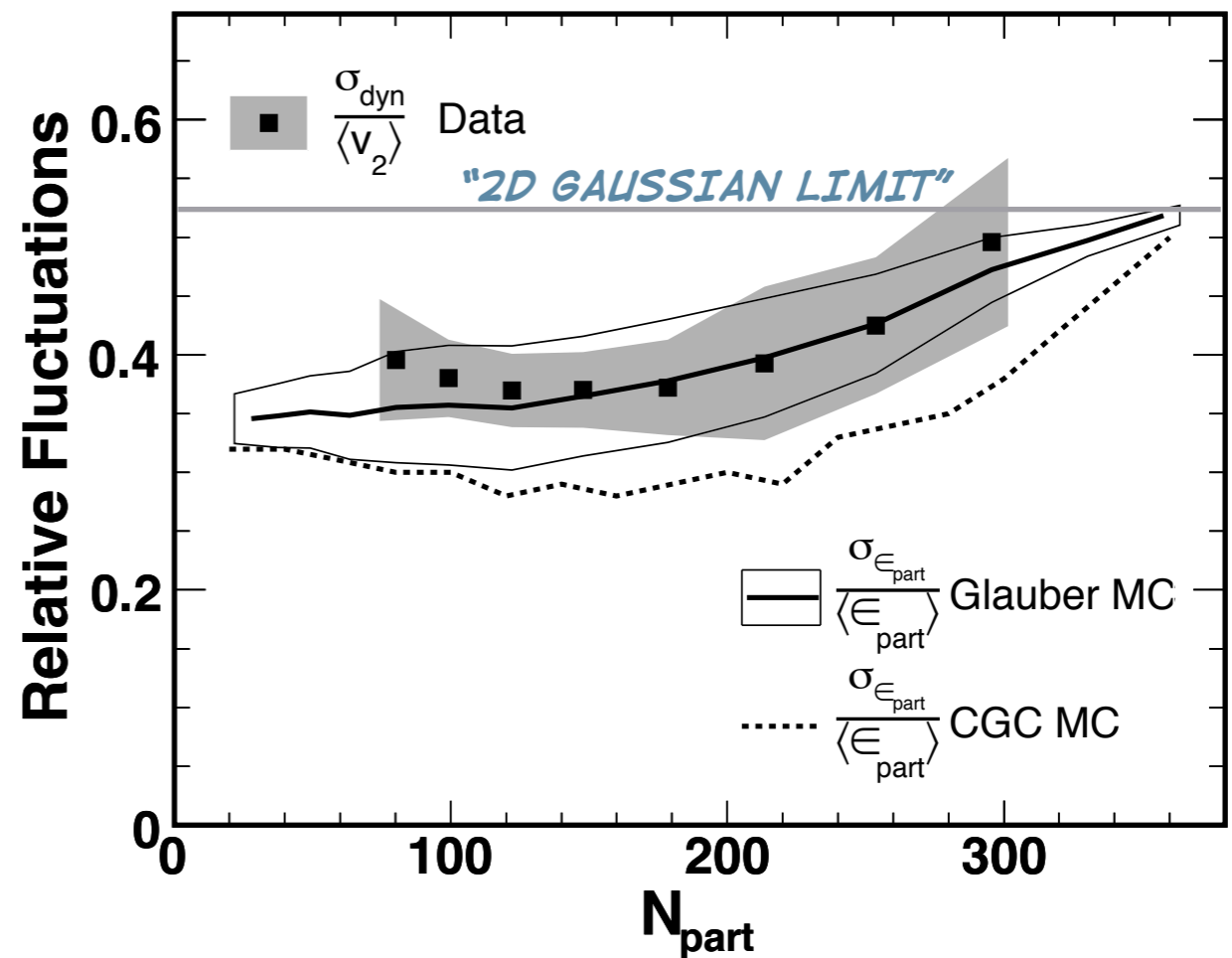
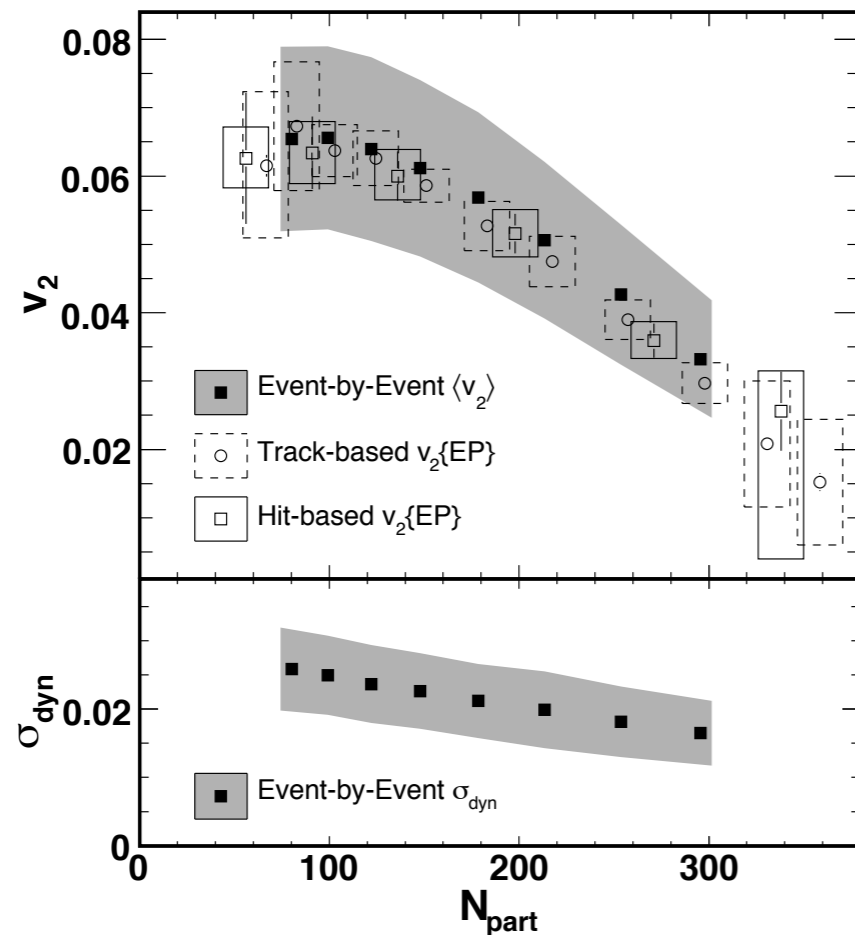


PHOBOS COLLABORATORS ALSO HELPED UNDERSTAND MORE ABOUT WHAT MADE PARTICIPANT ECCENTRICITY "WORK"

A KEY FEATURE WAS THAT PAIRS OF PARTICIPANTS ARE SPATIALLY CORRELATED BY THE NN INTERACTION $D < \sqrt{S_{NN}}/\pi$: SPATIAL CORRELATION AMPLIFIES ECCENTRICITY

MC GLAUBER IS NOW THE STANDARD APPROACH IN DATA & THEORY

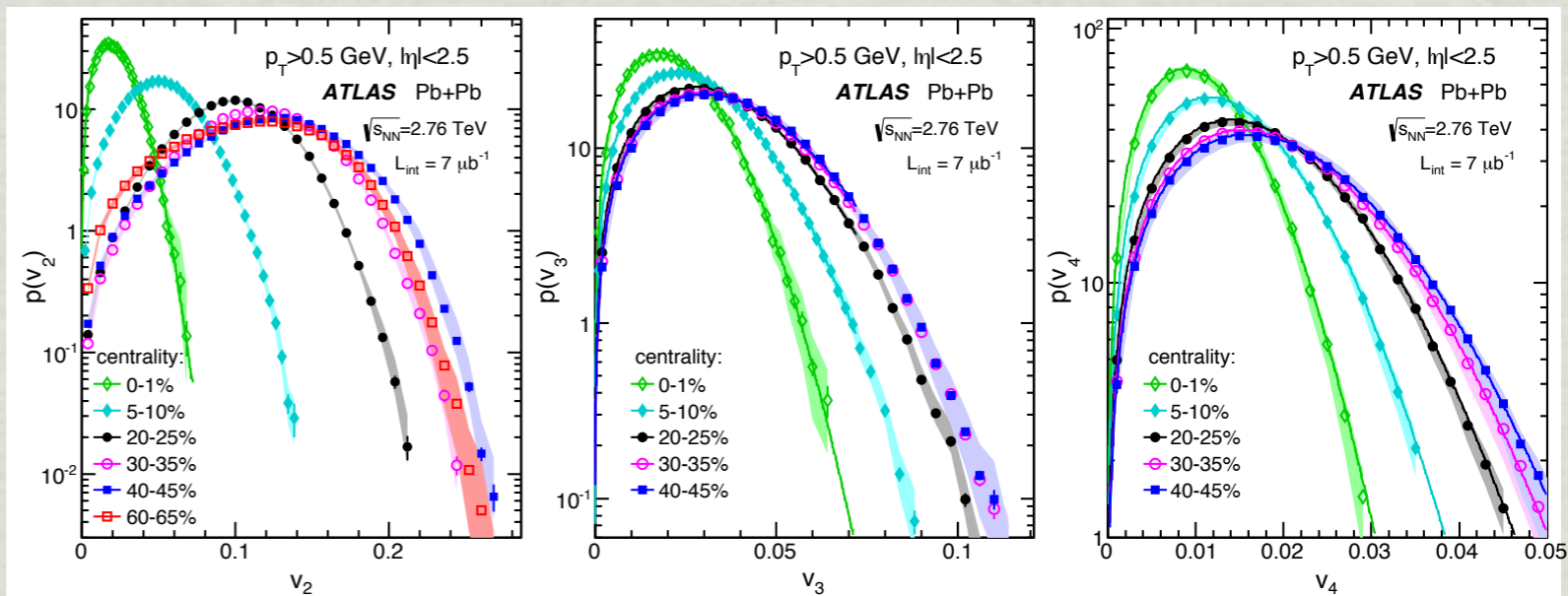
FLOW FLUCTUATIONS



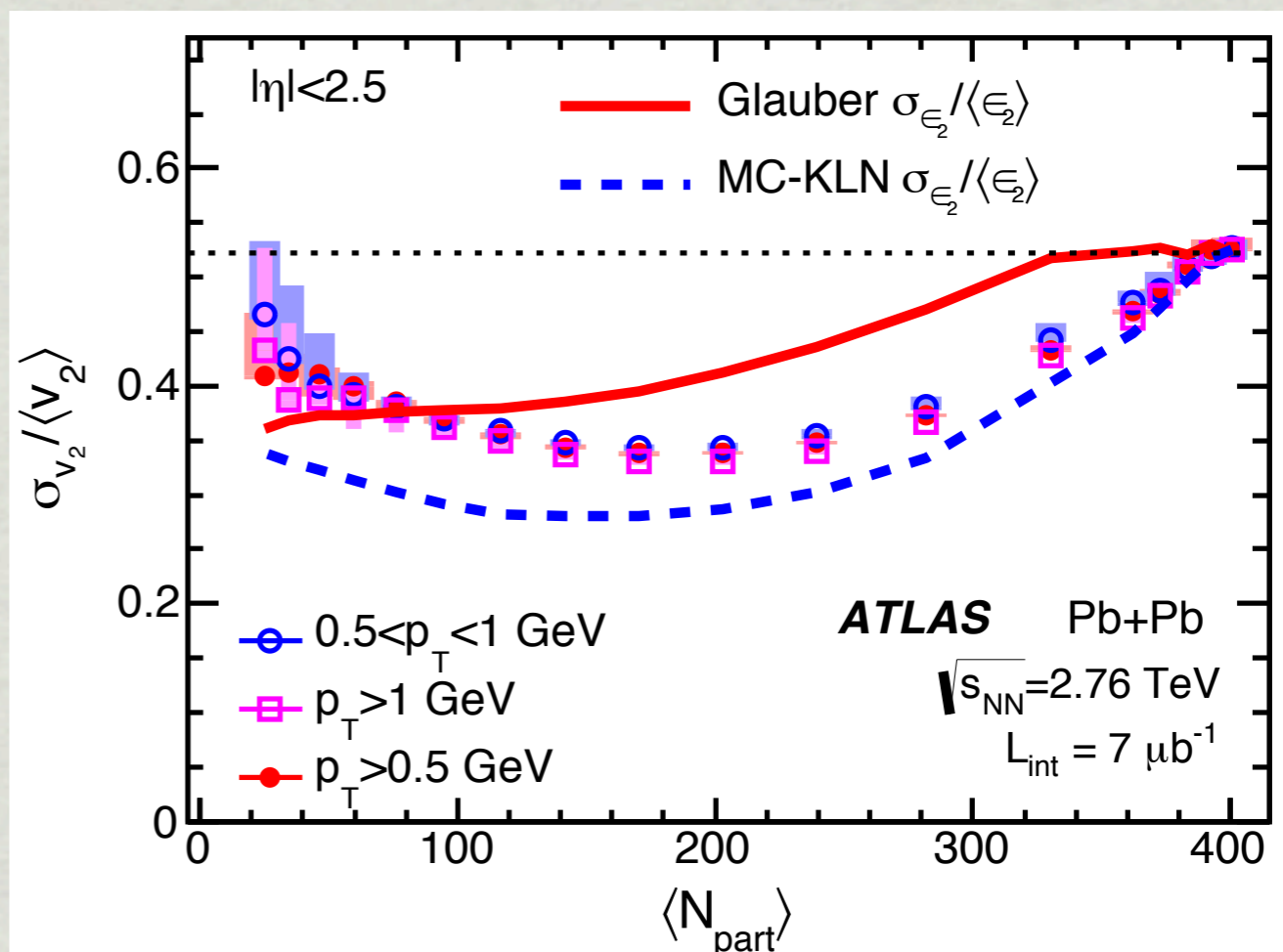
MEASURED BY A LIKELIHOOD METHOD,
FINDING THE BEST MATCH BETWEEN A
SMEARED v_2 DISTRIBUTION AND THE DATA:
EVENTWISE CONNECTION BETWEEN GEOMETRIC
FLUCTUATIONS AND FINAL STATE PARTICLES

FLOW FLUCTUATIONS

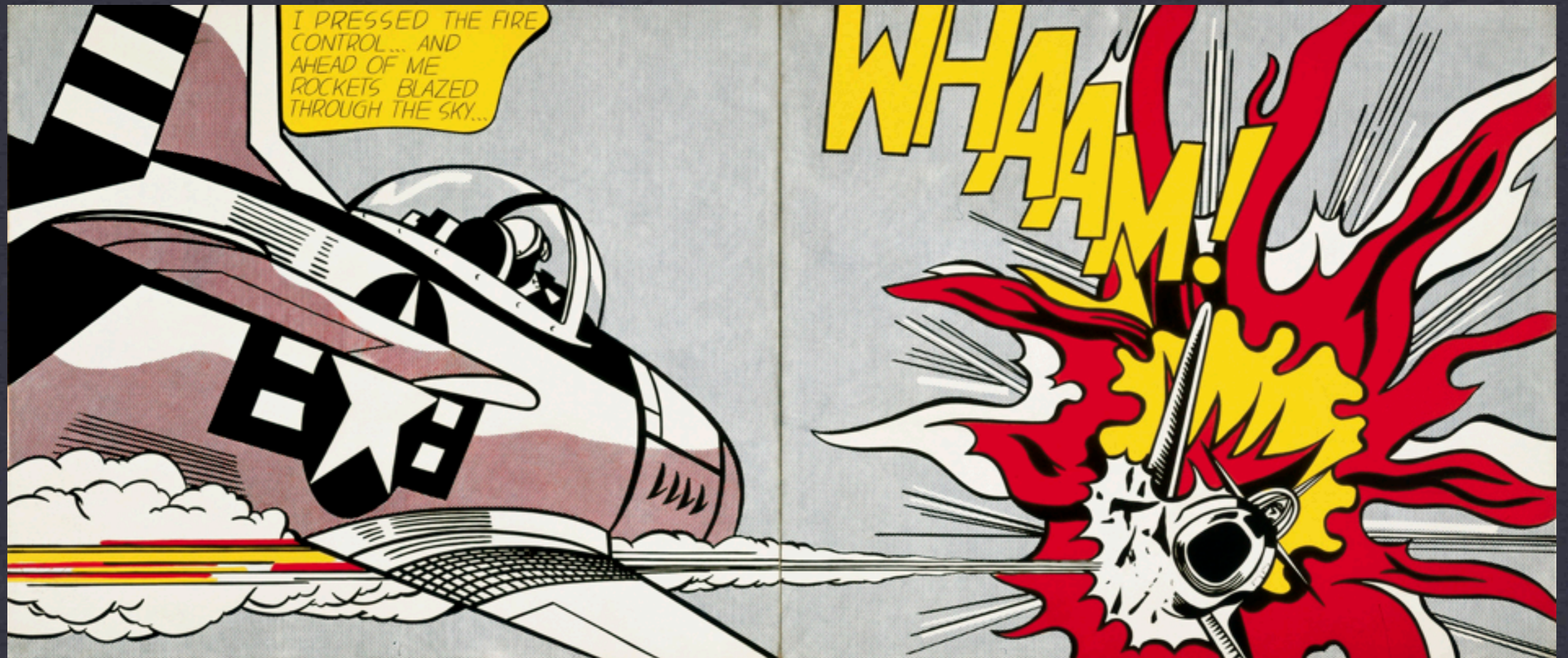
TODAY,
UNFOLDING IS
MUCH MORE
COMMON IN HEP
AND HI PHYSICS:
E.G. NEW ATLAS
MEASUREMENT



QM2012 SAW FIRST
DIRECT MEASUREMENTS
OF FULLY-UNFOLDED
 V_N FLUCTUATIONS
(OTHER EXPTS MEASURED
SIMILAR PHYSICS USING
CUMULANTS)



EAT GOLD, DEUTERONS!...



PROJECT

THE D+AU RUN

RELATIVISTIC HEAVY ION COLLIDER

DATE

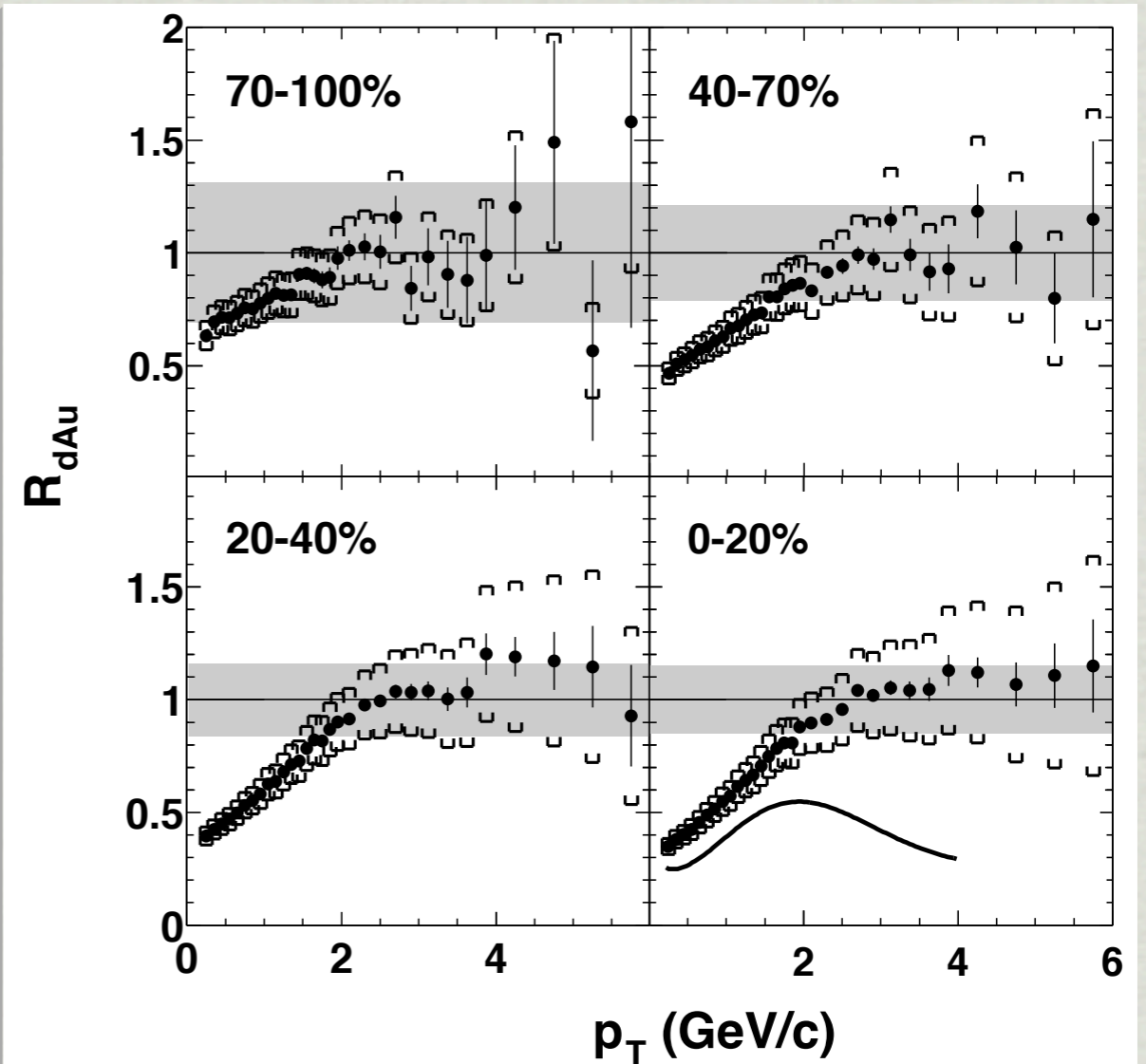
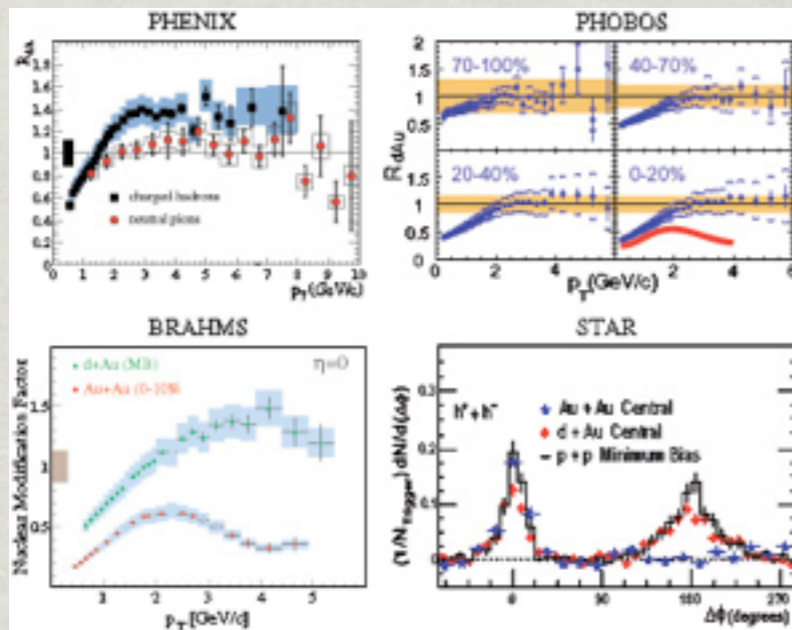
2003 (FOR PHOBOS)

CLIENT

HI COMMUNITY

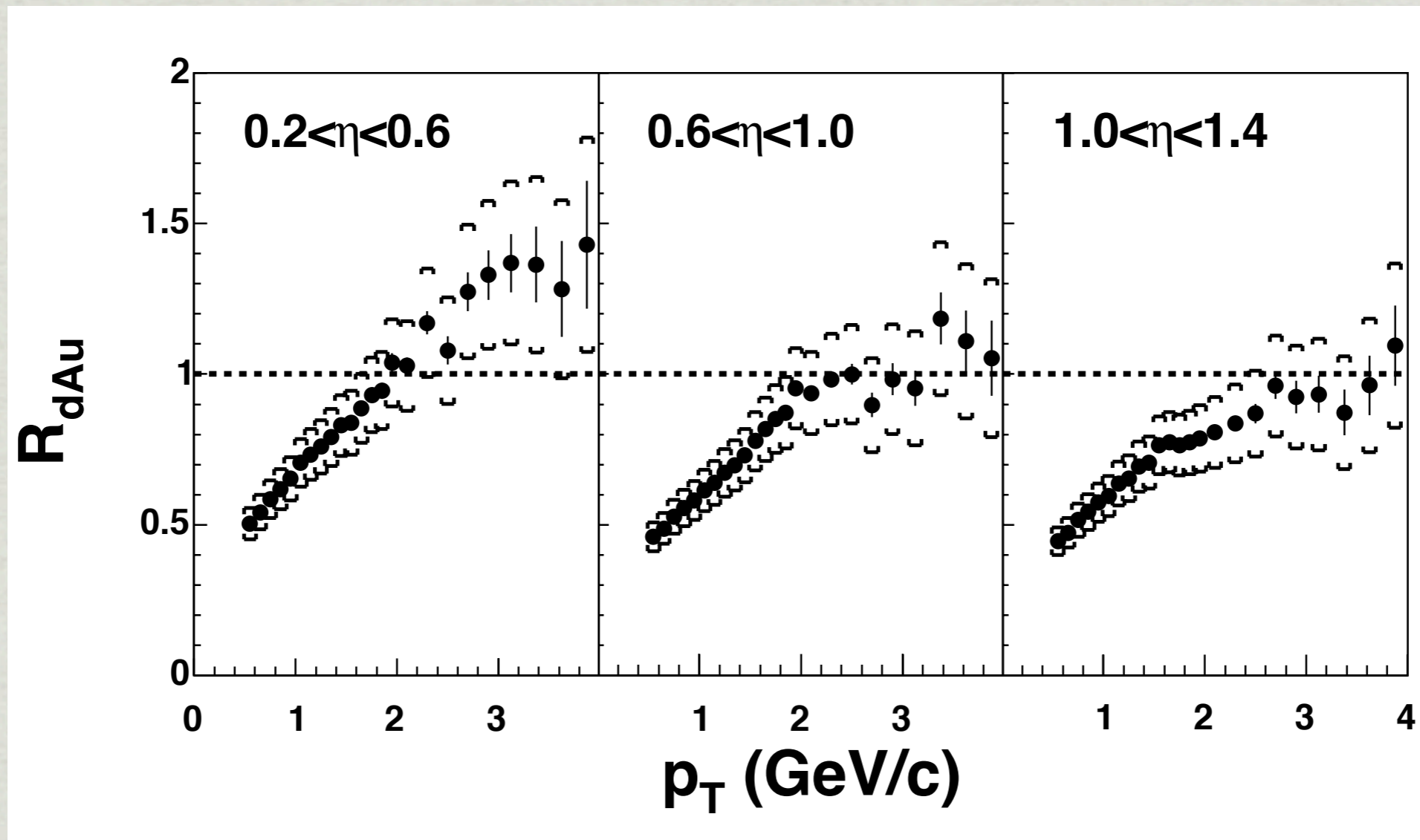
HADRON SUPPRESSION

PRL 91, ISSUE 7



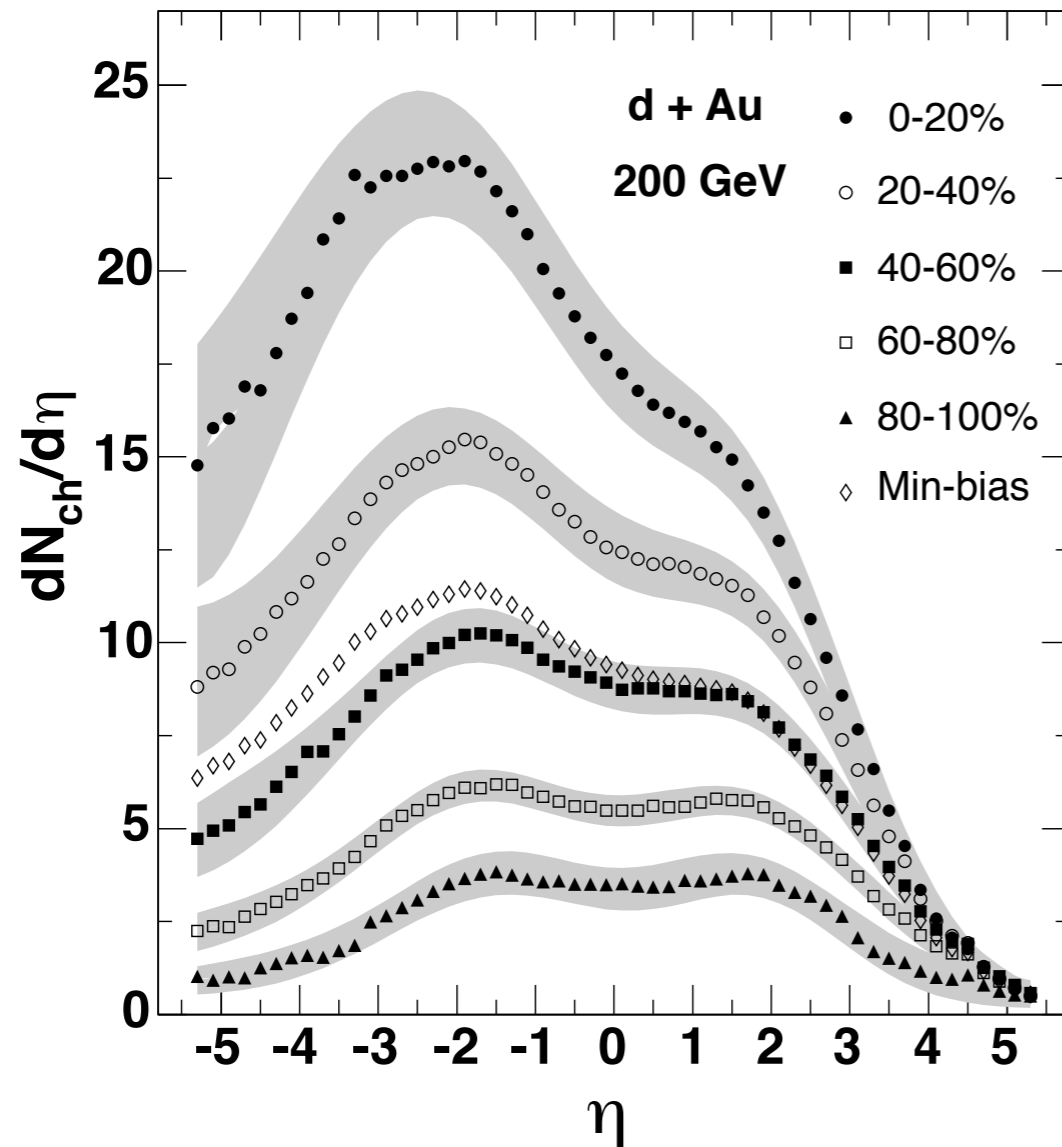
PRIMARY INTEREST IN THE FIELD WAS TO ESTABLISH THAT HIGH p_T SUPPRESSION WAS A FINAL STATE EFFECT IN AU+AU:
 PHOBOS WAS HAPPY TO OBLIGE FOR COVER OF PRL

PSEUDORAPIDITY DEPENDENCE

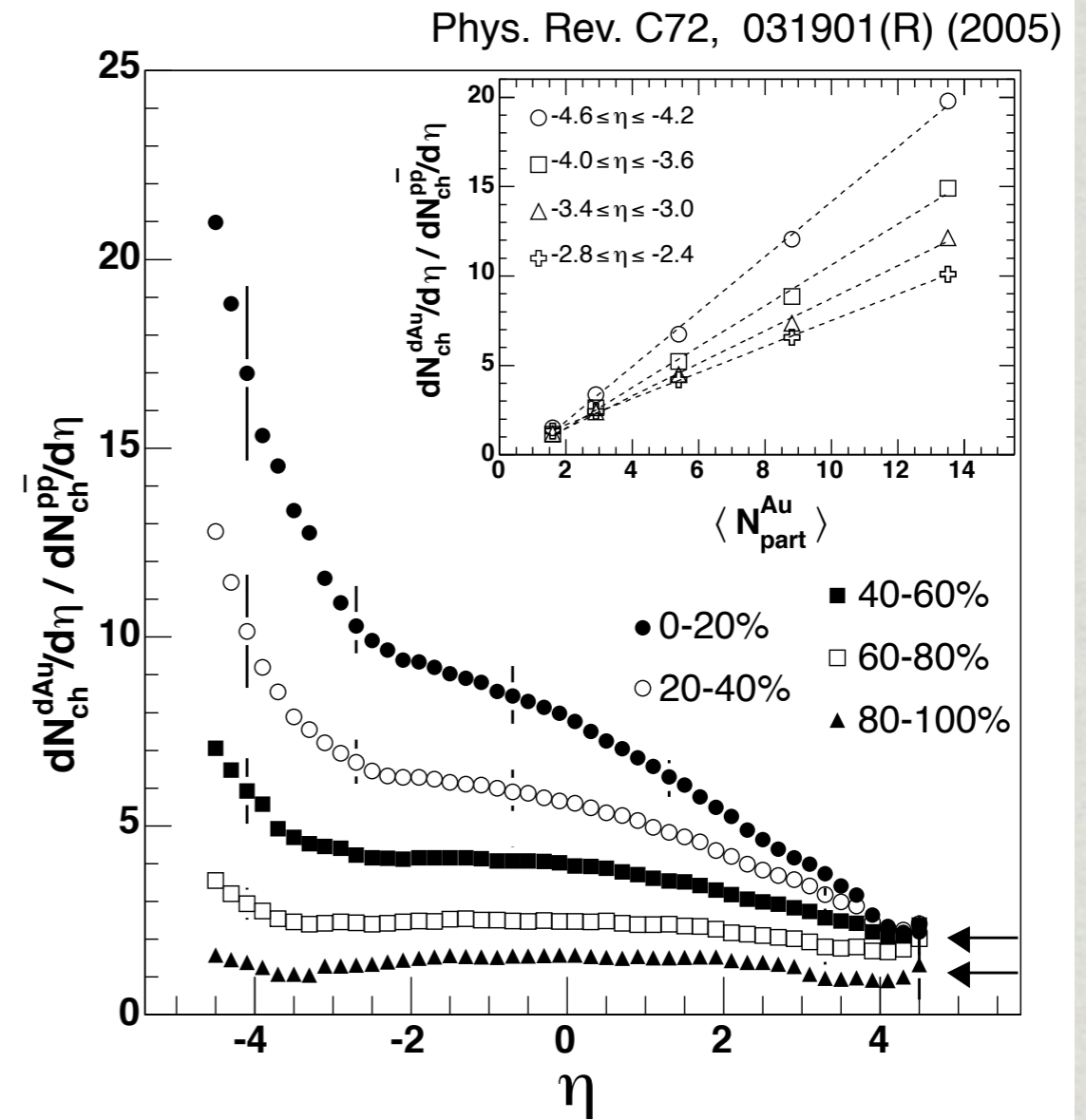


*OF COURSE, THINGS ONLY LOOK STRAIGHTFORWARD
WHEN AVERAGING OVER ETA:
DIFFERENTIALLY, "SUPPRESSION" CHANGES SUBSTANTIALLY
EVEN NEAR MID-RAPIDITY--> BRAHMS IN FAR FORWARD?*

MULTIPLICITY VS. CENTRALITY



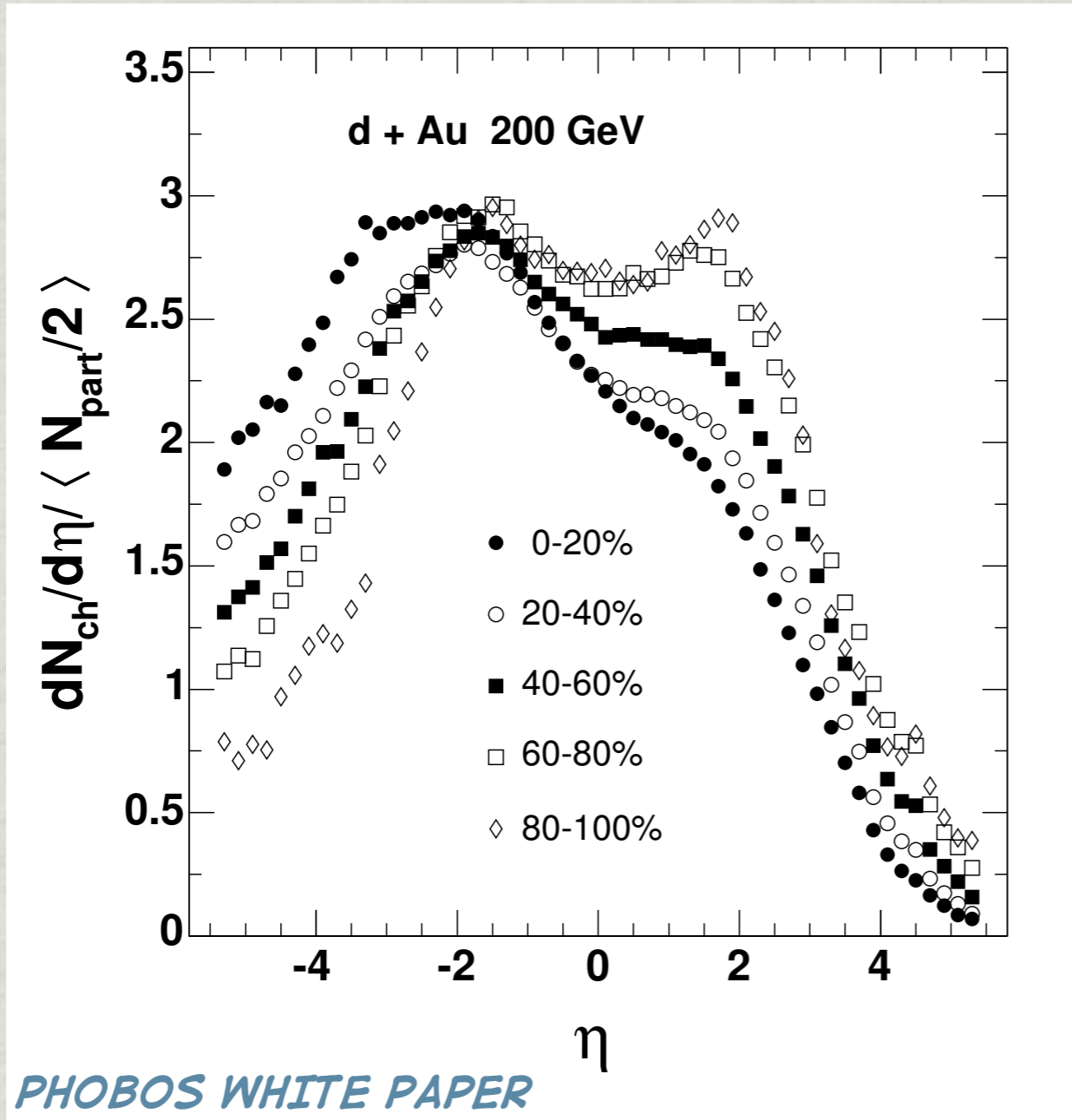
*STRONG INCREASE WITH N_{PART} ,
ALSO BECOMES ASYMMETRIC
IN η .*



*IN FAR-FORWARD REGION,
~SCALING WITH $N_{PART,D}$!
IN FAR-BACKWARD REGION,
~SCALING WITH $N_{PART,AU}$!*

VISUALIZING N_{PART} SCALING

SIMPLY SCALE BY $N_{\text{PART}}/2$



*PHOBOS DATA GIVES
AN INTERESTING
PERSPECTIVE*

*FORWARD
"SUPPRESSION"
IS OBSERVED
AT ALL P_T*

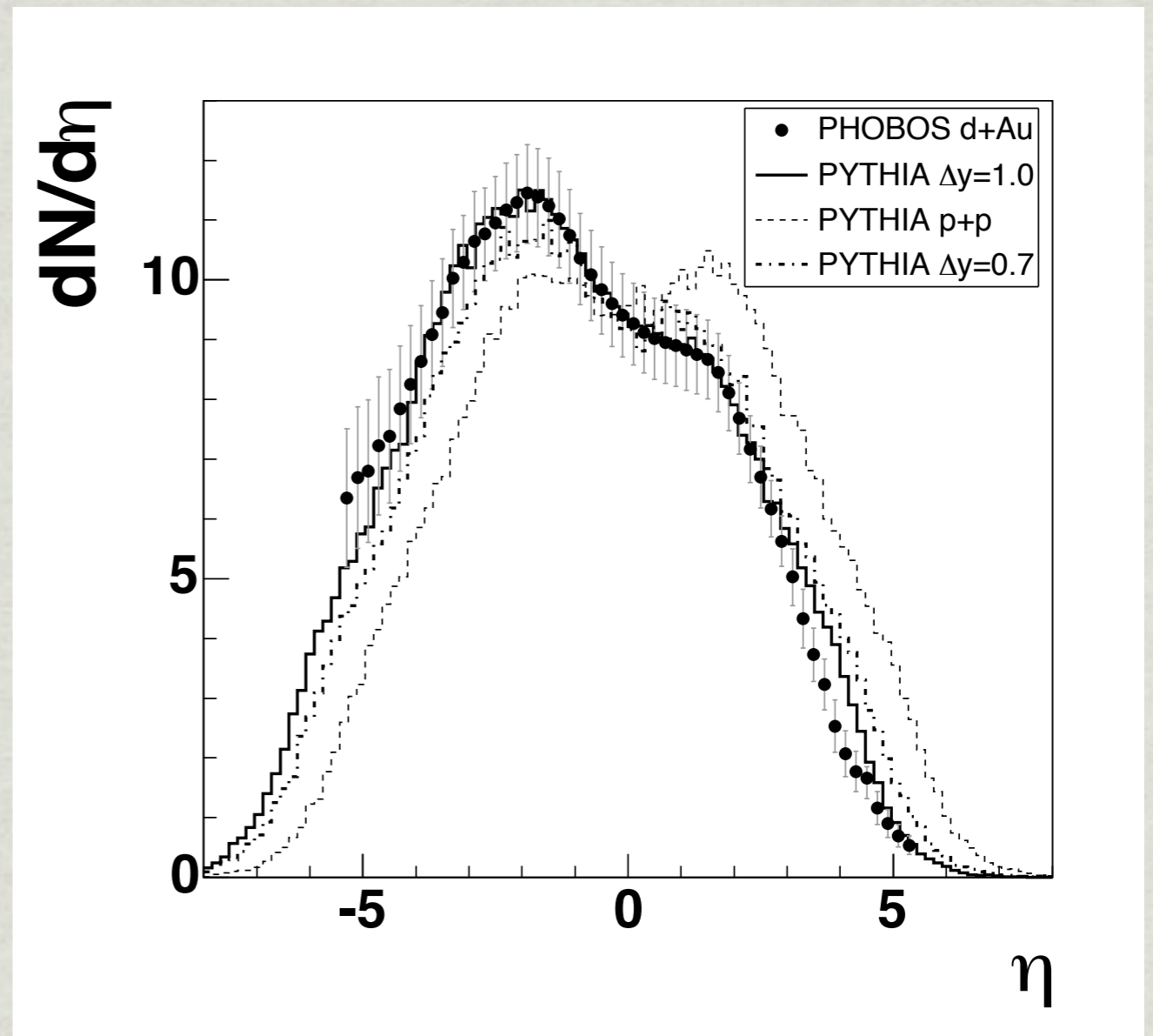
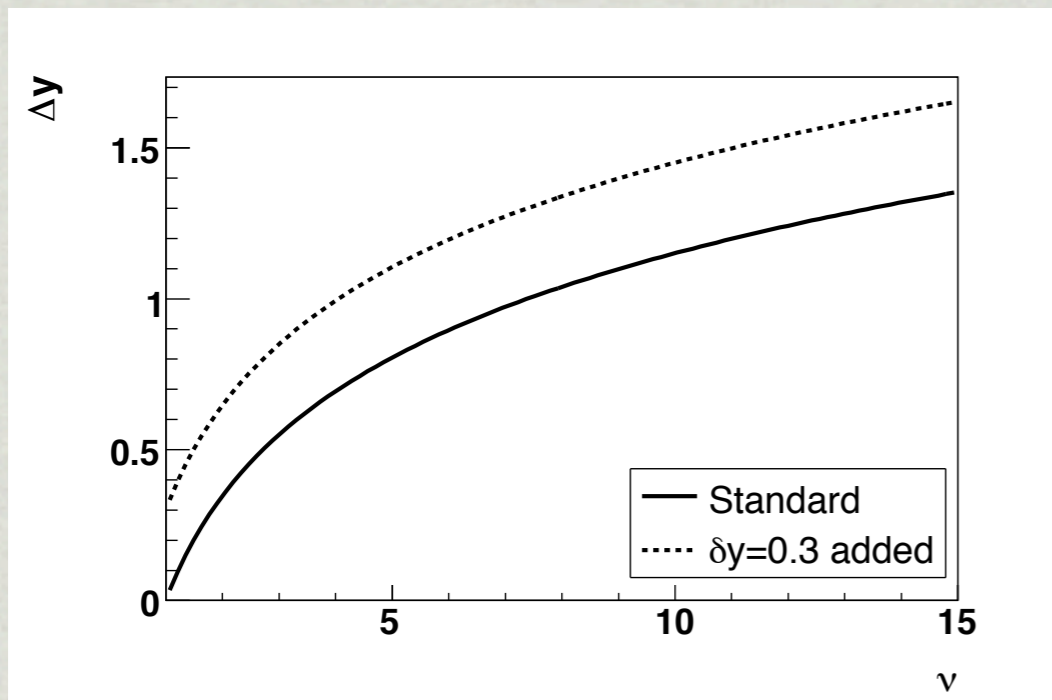
*EQUAL VOLUME
(N_{PART} SCALING),
BUT DISTRIBUTION
SHIFTS "GOLDWARDS"*

PERSONAL INTERLUDE: A "SHIFT"?

IN A D+AU COLLISION,
THE CM RAPIDITY IS:

PAS, NUCL-EX/0703002

$$\Delta y_{d+Au} \sim \frac{1}{2} \ln \left(\frac{N_{Au}}{N_d} \right)$$

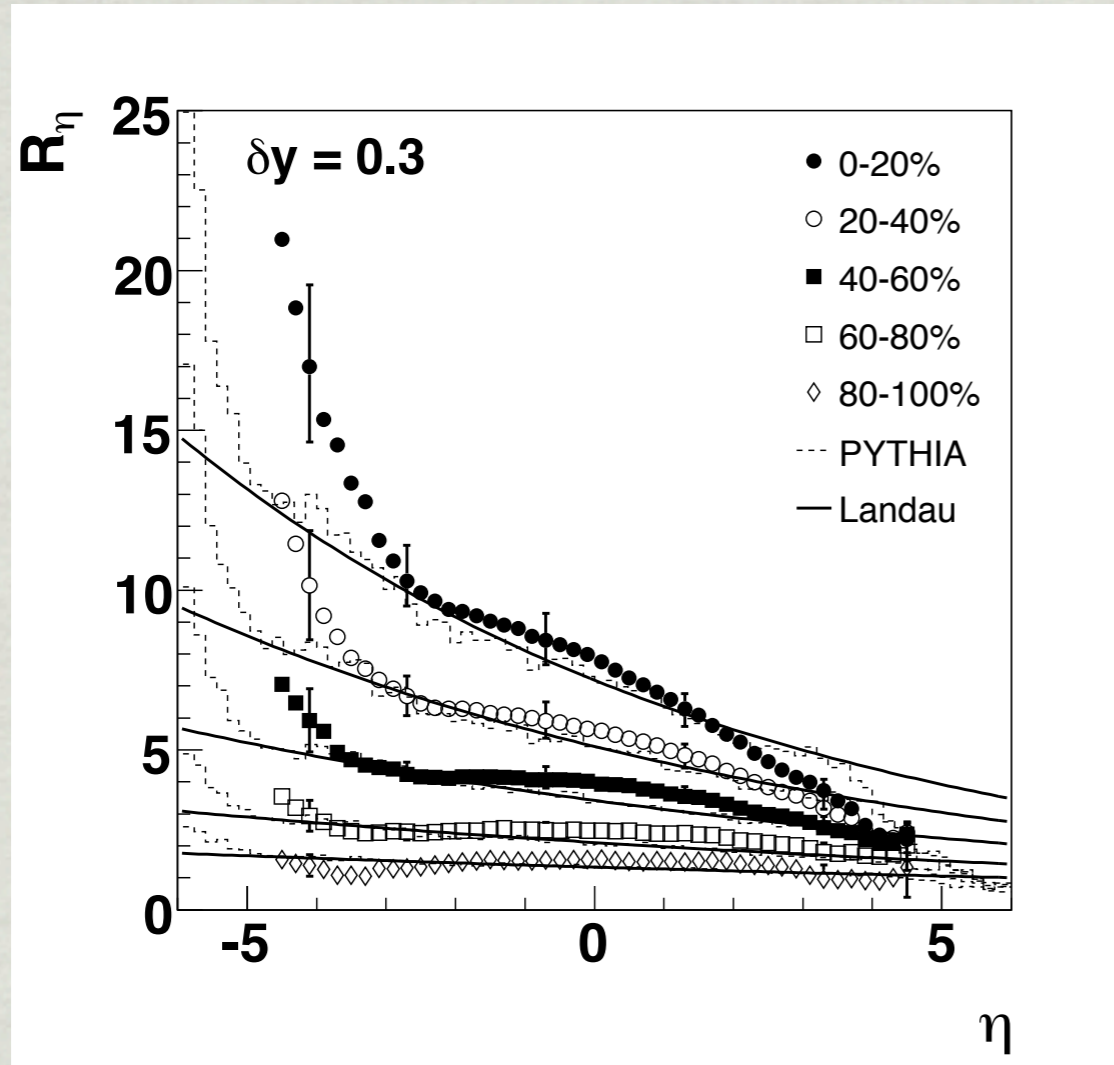


SCALING PYTHIA P+P BY NPART AFTER
SHIFTING ALL RAPIDITIES BY ΔY GIVES
A SURPRISINGLY GOOD DESCRIPTION OF THE
MINBIAS D+AU MULTIPLICITY DATA

$$y = y_b + \ln(x_F) - \frac{1}{2} \ln \left(\frac{m_T^2}{M_P^2} \right)$$

INCREASE IN P_T
INDUCES A BACKWARD SHIFT:
 $1.3 \langle M_T \rangle$ GIVES EXTRA 0.3 SHIFT!

CENTRALITY DEPENDENCE

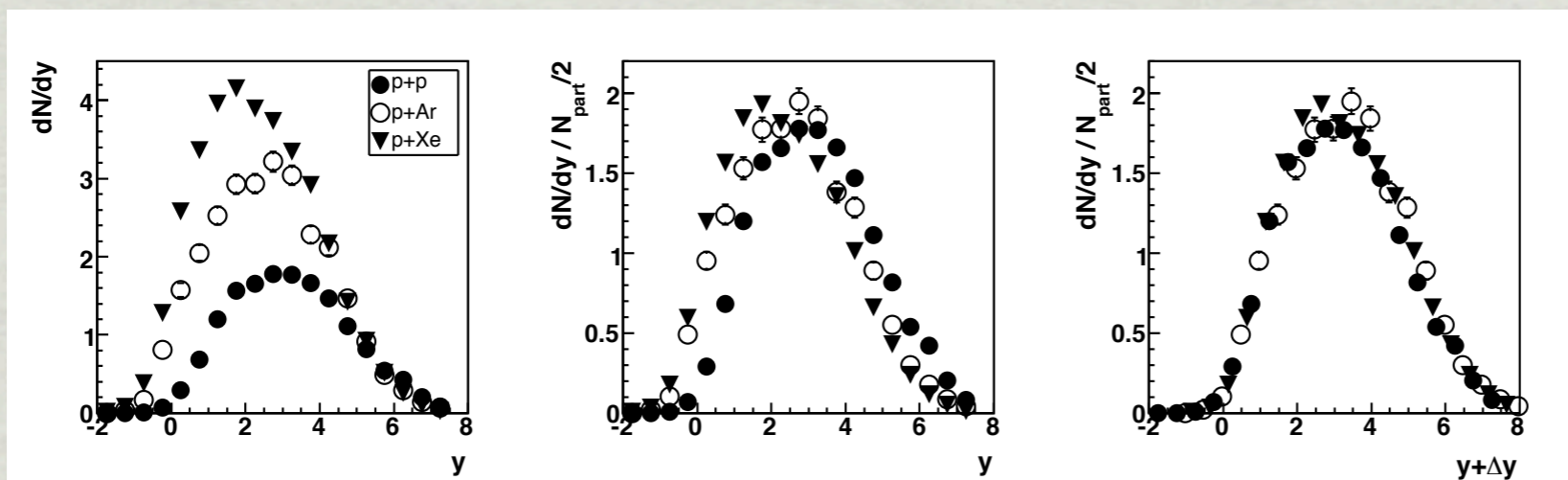


SHIFT PERFORMED
BRUTE-FORCE W/
PYTHIA AND WITH A
"GAUSSIAN" ANSATZ

$$R_y = \frac{N_{part} e^{-(y+\Delta y)^2/2\sigma^2}}{2 e^{-y^2/2\sigma^2}}$$

$$= \frac{N_{part} e^{-\Delta y^2/2\sigma^2}}{2} e^{-(y\Delta y)/\sigma^2}$$

COULD THE "TRIANGLE"
BE AN EXPONENTIAL IN Y ?



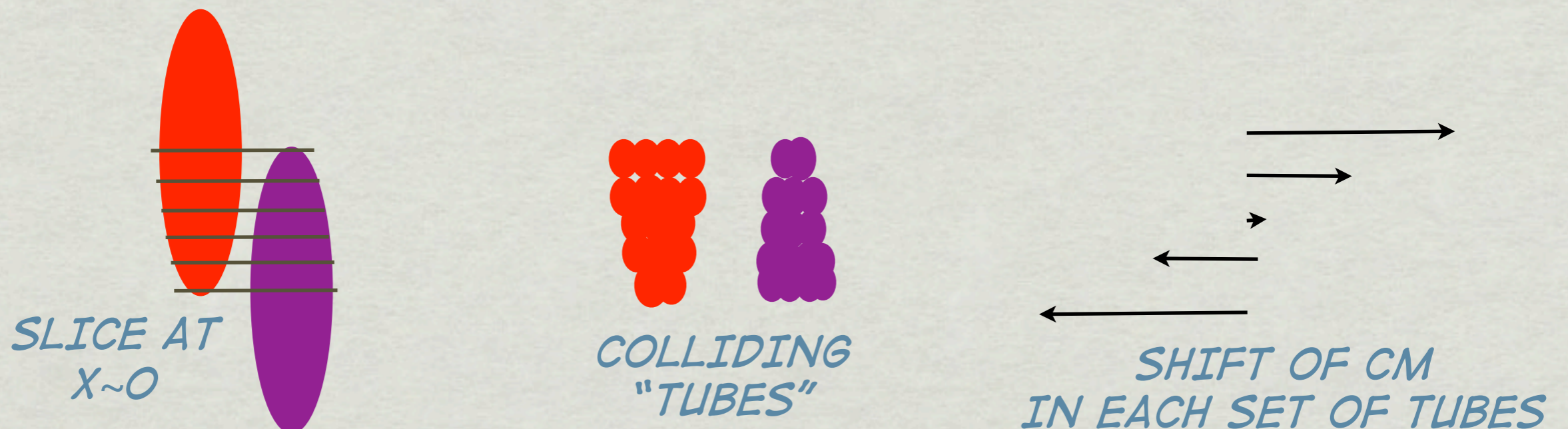
WORKS NICELY
WITH NA5 DN/DY

FULL DISCLOSURE

- * WIT DID NOT LIKE THIS IDEA!
- * A SHIFT OF ALL RAPIDITIES IN A PP COLLISION VIOLATES MOMENTUM CONSERVATION
- * ANSATZ CAN'T MAKE SENSE NEAR BEAM RAPIDITY
- * LUCKILY, PHOBOS HAS A ROBUST TRADITION OF DEBATE
 - * BUT WE ALWAYS AGREED THAT IF CONSENSUS WAS NOT REACHED, PEOPLE SHOULD WAIT FOR DATA AND PUBLISH THEMSELVES (E.G. NUCL-EX/0703002)
- * NO OBVIOUS MECHANISM TO UNIFORMLY TRANSLATE INITIAL CM TO ENTIRE SYSTEM
 - * AND EVEN MORE DIFFICULT TO EXPLAIN SUCH A SHIFT APPLYING, E.G. TO HIGH P_T JETS? [AHEM, CMS...]
- * SOME FORTUITOUS COMBINATION OF SHADOWING AND ANTI-SHADOWING VS. CENTRALITY?

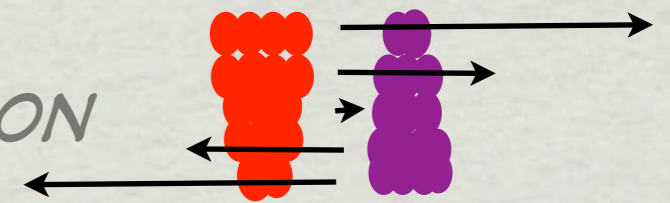
A SUGGESTION...

- * PARTICIPANT ECCENTRICITY IMPLIED V_3
 - * BUT MOST OF US DIDN'T TAKE GEOMETRIC FLUCTUATIONS SERIOUSLY ENOUGH, UNTIL GUNTHER & BURAK THOUGHT HARD ABOUT IMPLICATIONS
- * NOW ARE WE IGNORING ANOTHER POTENTIAL IMPACT OF FLUCTUATIONS?
 - * THEIR EVENTWISE EFFECT ON LONGITUDINAL DISTRIBUTIONS!
- * IF EVEN AN "EFFECTIVE" RAPIDITY SHIFT CAN BE SEEN IN $D+Au$ ($P+PB$), WHAT MIGHT IT IMPLY FOR $A+A$?



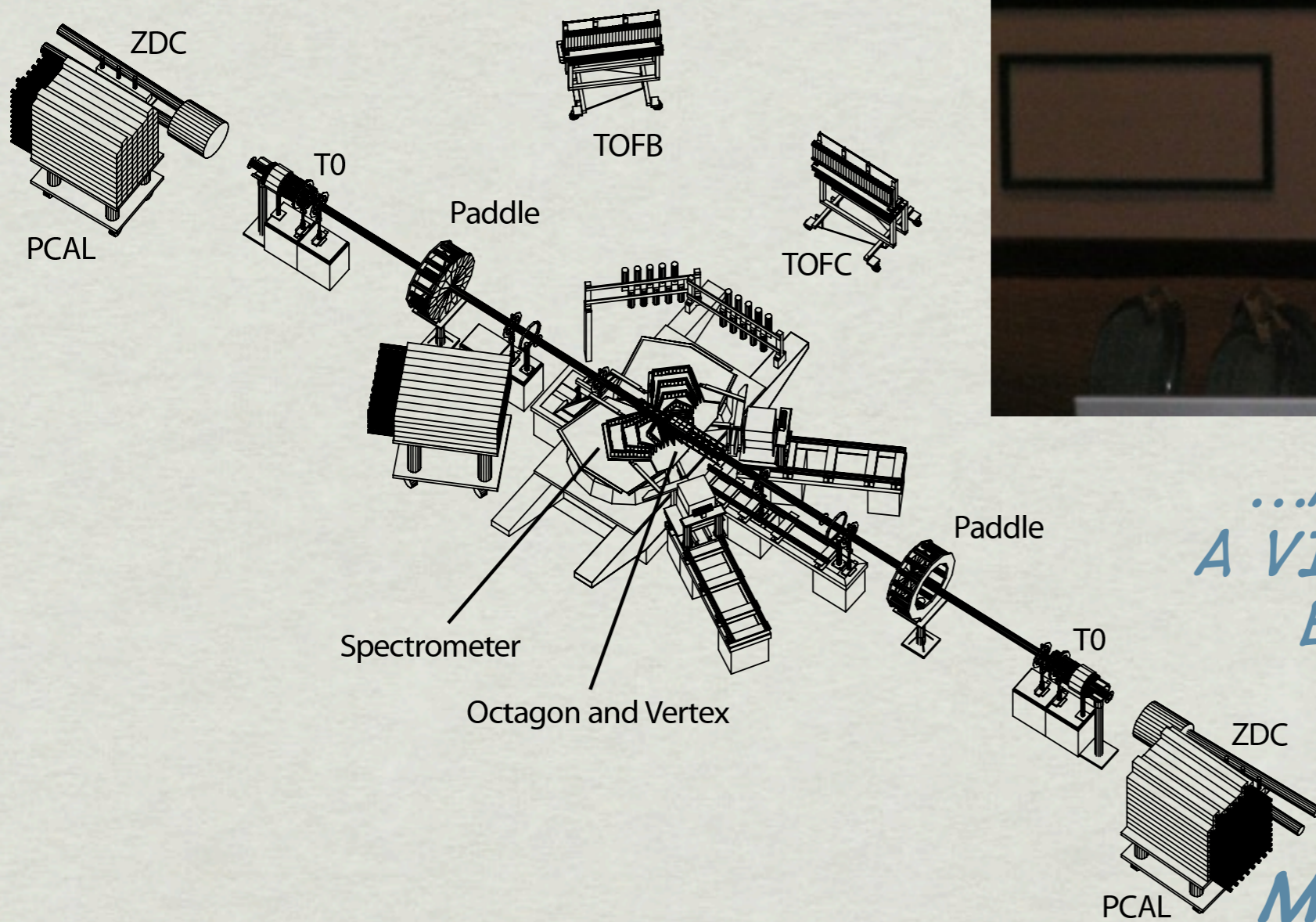
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 - * CENTRAL EVENTS WILL SEE NO EFFECT ON AVERAGE
 - * PERIPHERAL EVENTS ARE ASYMMETRIC (LIKE $P+A$) IN SMALL REGIONS IN TRANSVERSE SPACE: LOCAL SHIFTS
 - * BOTH WILL HAVE A FLUCTUATING CM IN SMALL REGION $-->$ AND A FLUCTUATING $DN/DETA$ SHAPE
 - * PERHAPS THESE ARE THE "VERY LONG RANGE" CORRELATIONS IMPLIED BY THE LONGITUDINAL SCALING DATA (SUPPLIED BY GEOMETRY!)?
 - * PERHAPS THESE INDUCE THE LARGE K_{EFF} IN PERIPHERAL DATA?



BUT BACK TO WIT...

THANK YOU FOR
LEADING A GREAT
EXPERIMENT WITH A
GREAT COLLABORATION...



...AND FOR FOSTERING
A VIBRANT INTELLECTUAL
ENVIRONMENT FOR
PHYSICS

(THERE'S CLEARLY
MORE TO LEARN!...)

PHOBOS IN THE LHC ERA!

- * CLAIMS OF SCALING REQUIRE TESTING AT HIGHER ENERGIES
- * EXAMPLES GIVEN OF SUCH TESTS
 - * MULTIPLICITY
 - * LONGITUDINAL SCALING & N_{PART} SCALING
 - * CORRELATIONS
 - * CLUSTERS & THE RIDGE
 - * FLUCTUATIONS
 - * V_N AND THEIR DISTRIBUTIONS
- * A UNIQUE (4π) PERSPECTIVE ON D+AU
 - * SPECULATION ABOUT RAPIDITY SHIFT TO PARTICIPANT CM
- * WITH THE NEW P+PB DATA SUGGESTING POSSIBILITY OF COLLECTIVE EFFECTS IN SMALL SYSTEMS, WILL BE INTERESTING TO SEE HOW P+P, P+A AND A+A INFORM EACH OTHER GOING FORWARD!

PHOBOS IN THE LHC ERA

ACTIVE IN MANY HI EXPERIMENTS

* CMS

* BUSZA, WYSLOUCH, ROLAND & ROLAND, STEPHANS, VERES, HOFMAN, LI, MIGNEREY, TONJES, PARK, (HENDERSON)...

* ATLAS

* OLSZEWSKI, STEINBERG, TRZUPEK, WOSIEK, WOZNIAK (PERNEGGER, KATZY)...

* ALICE

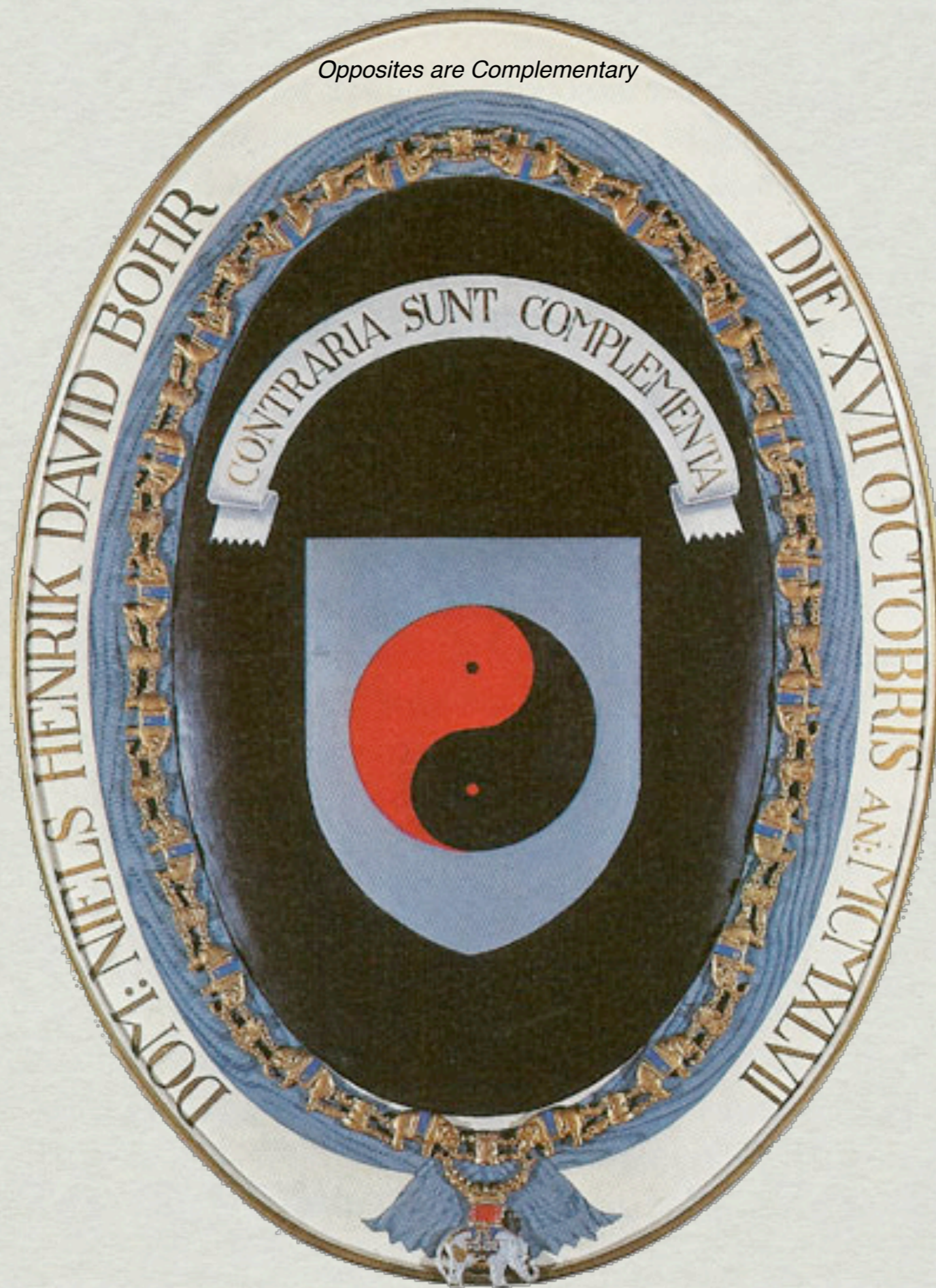
* LOIZIDES, GULBRANDSEN

* RHIC

* PAK, NOLICER, SUKHANOV, IORDANOVA, HOLLIS, VAN NIEUWENHUIZEN...

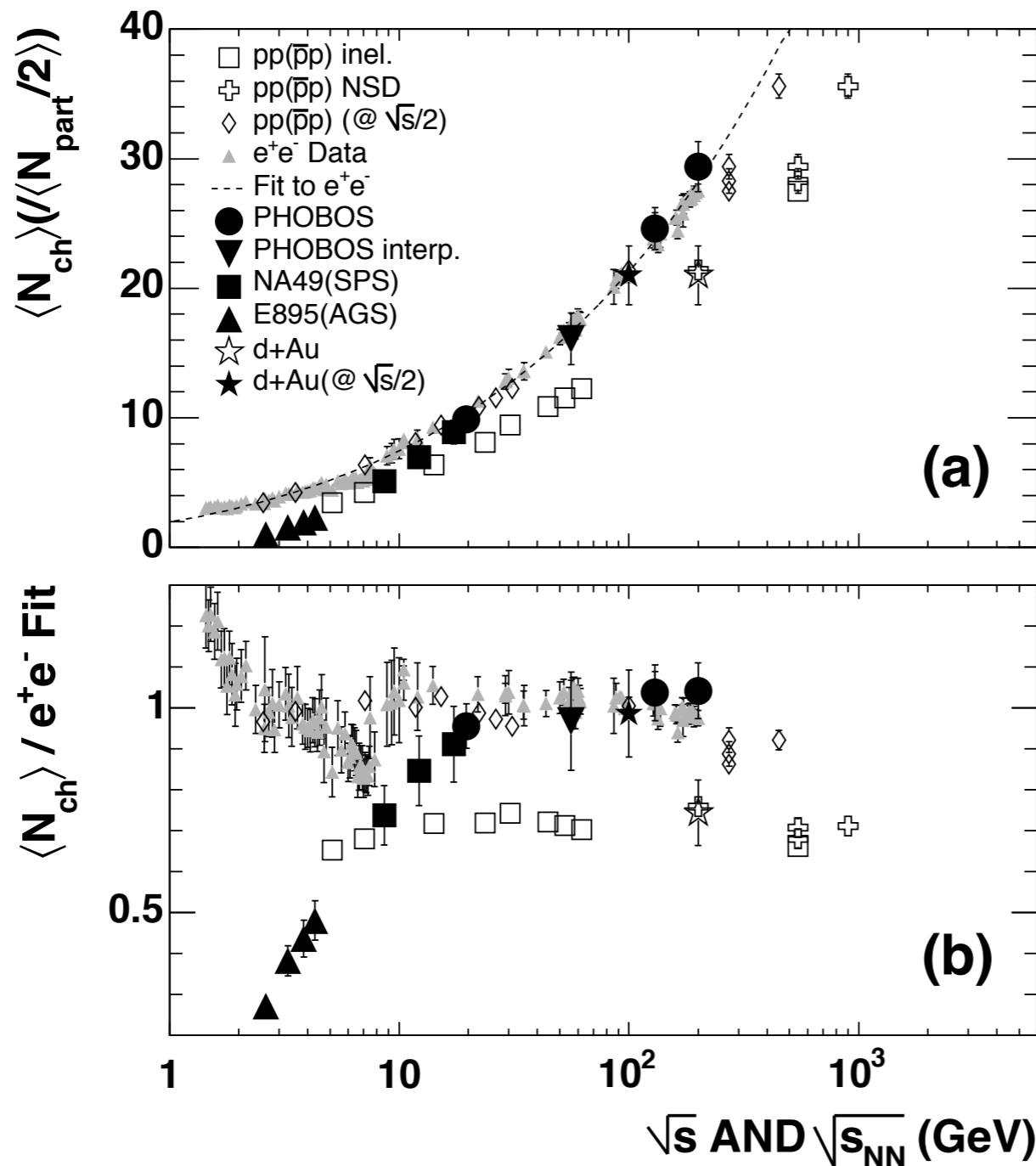
OUR DNA IS WOVEN INTO THE HI PROGRAM

Opposites are Complementary



Crest of N. Bohr

HI VS. ELEMENTARY PROCESSES

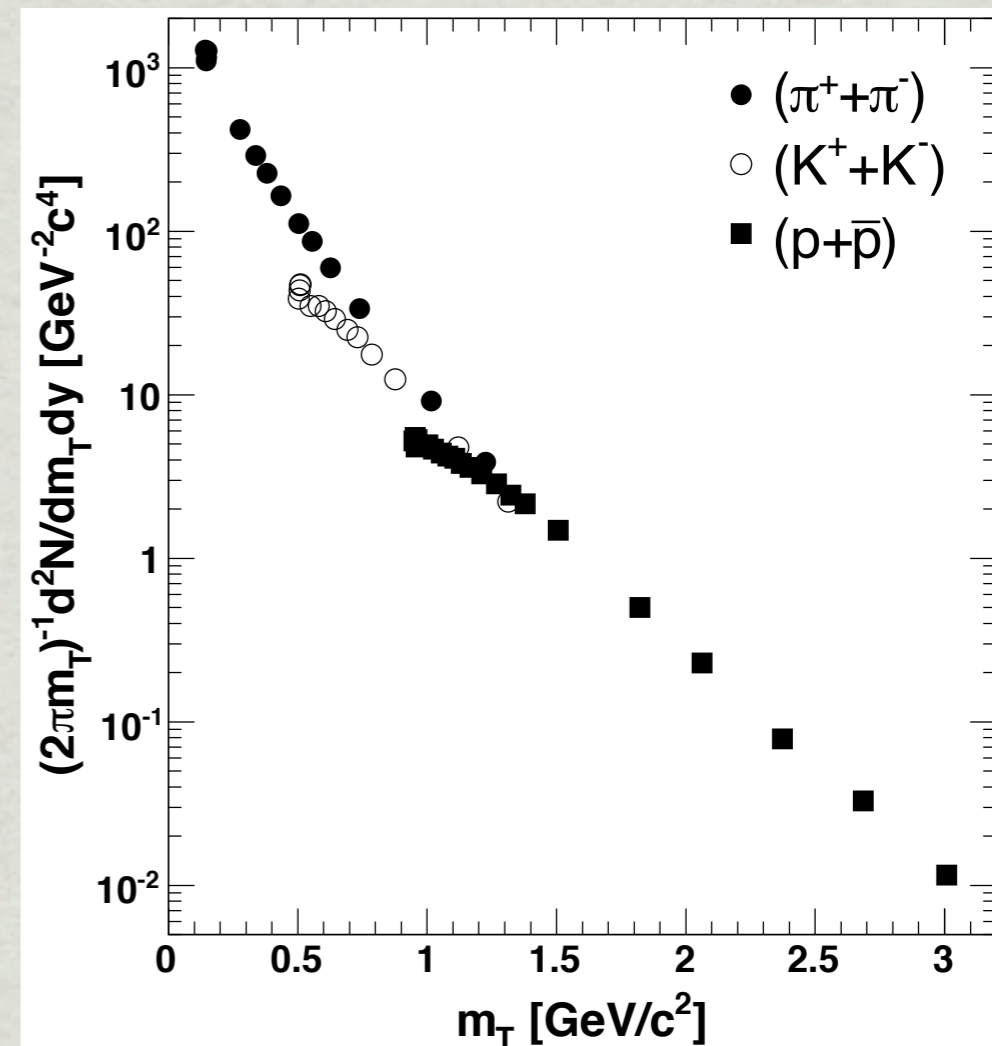
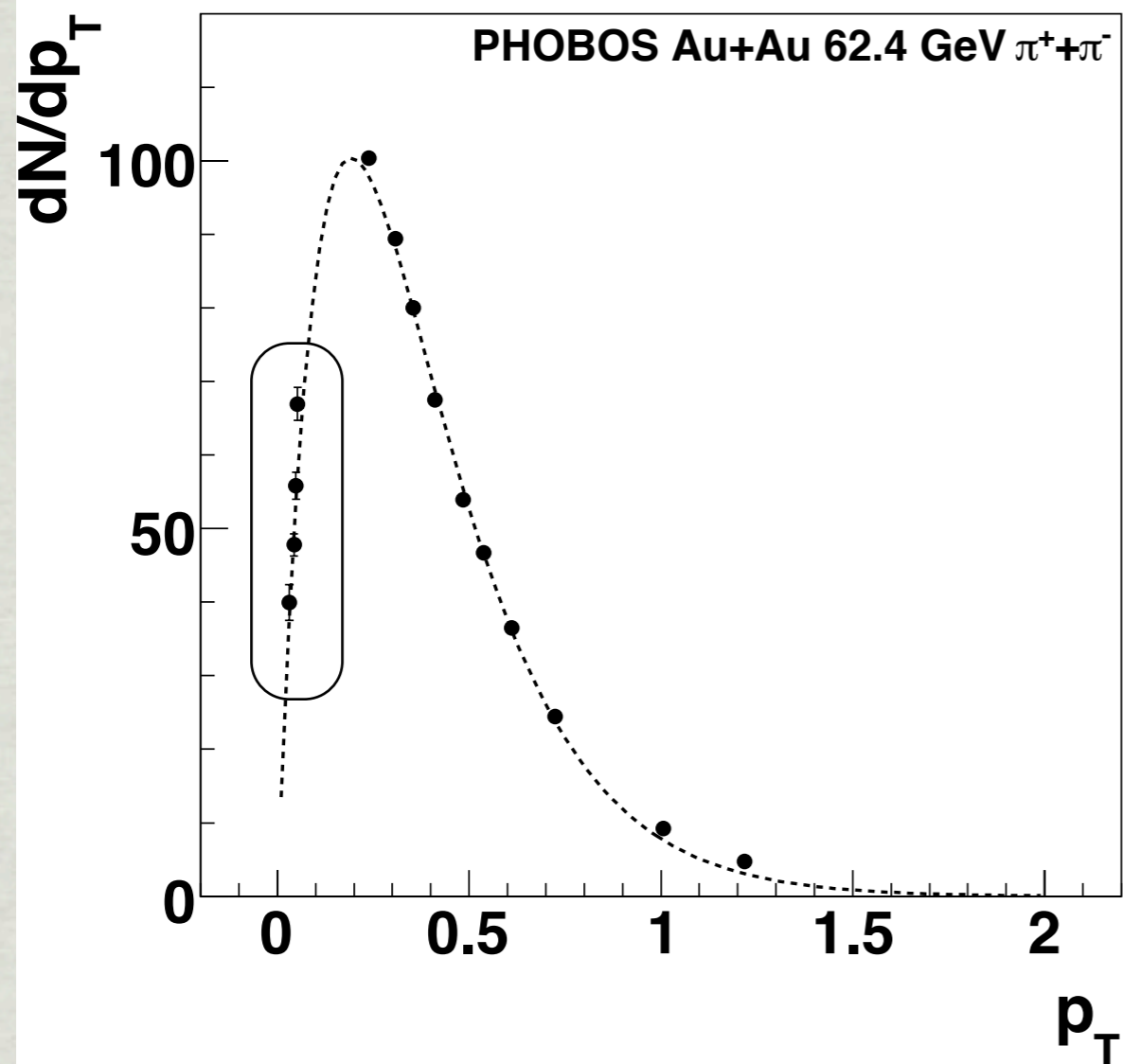


*MULTIPLICITY
MEASURED IN HEAVY ION
COLLISIONS TURNS OUT
TO BE SIMILAR TO E^+E^-
AT HIGH ENERGIES,*

*ALSO TRUE FOR PP AFTER
CORRECTING FOR KNOWN
LEADING PARTICLE
EFFECT (HERE ASSUMING
LEADING PARTICLES ARE
FLAT IN X_F)*

PHOBOS = LOW P_T

Phys.Rev.C75:024910,2007



PHOBOS MEASURE IDENTIFIED PARTICLES
DOWN TO THE LOWEST P_T (RANGE-OUT IN SI):
DIRECT OBSERVATION OF FULL "BLACKBODY SPECTRUM"

PANELIST

