In the pilot seat of the RNC

Grazyna Odyniec/LBNL

16 years is a long time ….

BES and HFT

but there was much, much more…

BES program in STAR

a little bit of archeology …

where did it come from …

ECT Workshop, Trento, 2004

Final Report on the ECT* Workshop:

Tracing the Onset of Deconfinement in

Nucleus–Nucleus Collisions,

Trento, April, 20-29, 2004

Main topics:

….

- presentation and discussion of directions of future experimental studies, in particular: heavy ion program at the GSI SIS200, a possible energy scan program with intermediate and light ions at the CERN SPS and a possible extension of the BNL RHIC program to lighter ions and lower energies.

From summary of Trento Workshop:

There is rapidly growing interest in the subjects covered by the Workshop: the experimental and theoretical study of nucleus-nucleus collisions in the energy range 10-200 GeV/nucleon. It was therefore suggested to establish a series of annual meetings.

and indeed:

http://web.ift.uib.no/criticalpoint/

2nd International Workshop on the Critical Point and Onset of Deconfinement

University of Bergen, Norway

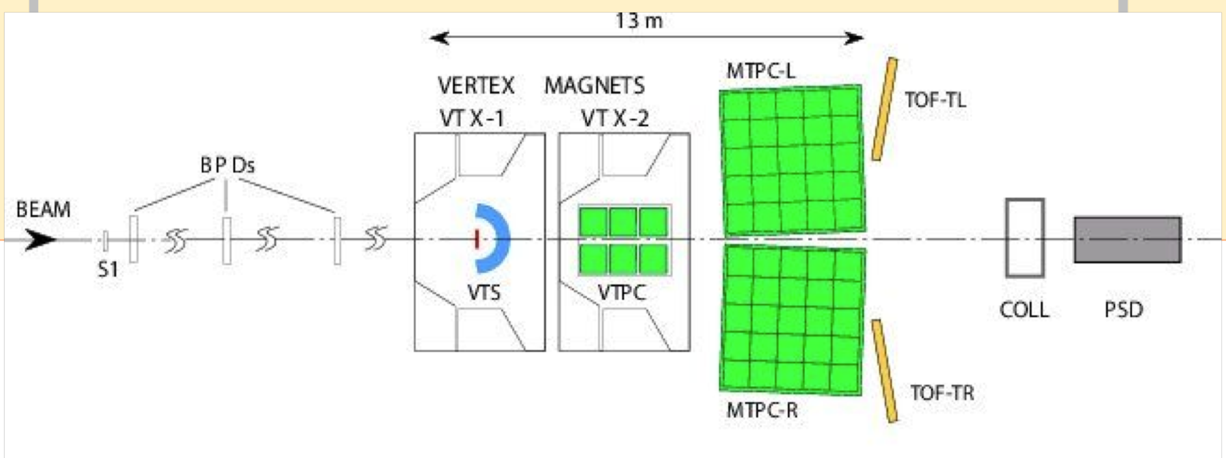
30 March - 3 April, 2005.

Only SPS discussed – *from M.Gazdzicki summary slides :*

September 2004:
A presentation (M.G.) at the special SPSC meeting in Villars
(search for the critical point at the CERN SPS)

preliminary conclusions (J. Dainton's seminar at CERN):
-search for the critical point important and unique for the CERN SPS,
-synergy with the LHC ion program,
-according to the current LHC commissioning schedule
proton beam in SPS is possible starting from 2006,
and ion beams starting from 2009

A possible "critical" experiment at the CERN SPS



M.Gazdzicki- continuation:

Summary:

- After observation of the onset of deconfinement the search for the critical point seems to be the most important goal of the further experimental study of nuclear collisions at high energies
- The best model estimates of the location of the critical point are inside the experimentally allowed domain: $E_{LAB} > 30A$ GeV or T > 140 MeV, $\mu_B < 430$ MeV
- A dedicated theoretical effort to establish quantitative signatures of the critical point in nuclear collisions is urgently needed
- The importance of the search for the critical point was recognized by the CERN SPSC and the corresponding experimental program is under construction

Search for CP in SPS moved to the rank of experiment ! (2005)

in the meantime …

16-17 November, 2004
Workshop on:
"Exploring the Phase Diagram of Strongly Interacting Matter"
Stony Brook

Only agenda on the web:

http://www.ikf.physics.uni-frankfurt.de/users/mitrov/Workshop/Program.html

first day - by invitations only (?)
second day - some talks on web, review of AGS and SPS physics, fixed target option mentioned, and theorists talks

No mentioning of possibilities of BES at RHIC

BNL – March 9-10, 2006

https://www.bnl.gov/riken/QCDRhic/

Organized by: T.Ludlam, H.Ritter, G.Stephans, M.Gazdzicki, B.Friman, F.Videbaek, T.Satogata, K.Rojagopal, L.McLerran

…….

"The goals of the workshop will be :

- to explore a practical set of measurements for such a program, based on expected performance of the RHIC facility at the low end of its energy range;
- to determine the accelerator development effort required for such a program; and
- to estimate the impact of such a program on the operations schedule for RHIC."

Talks posted …

- Introduction & Overview - K. Rajagopal
- Na49 Results - P. Seyboth
- RHIC Machine Considerations - T. Satogata
- AGS Low Energy Extraction Performance - N. Tsoupas
- Luminosity Monitoring Issues - A. Drees
- Low Energy Electron Cooling - A. Fedotov
- Experiments with STAR near the Critical Point - T. Nayak
- Experimental Overview and Prospects for RHIC - G. Roland
- Workshop Summary: Machine Aspects - T. Roser
- Workshop Summary: Discussion - H.G. Ritter
- Lattice Results on the QCD Critical Point - F. Karsch
- Signals of the First Order Phase Transition - H. Stoecker
- PHENIX Capabilities for the Low-Energy RHIC Run - Peter Steinberg
- + many talks which were NOT posted

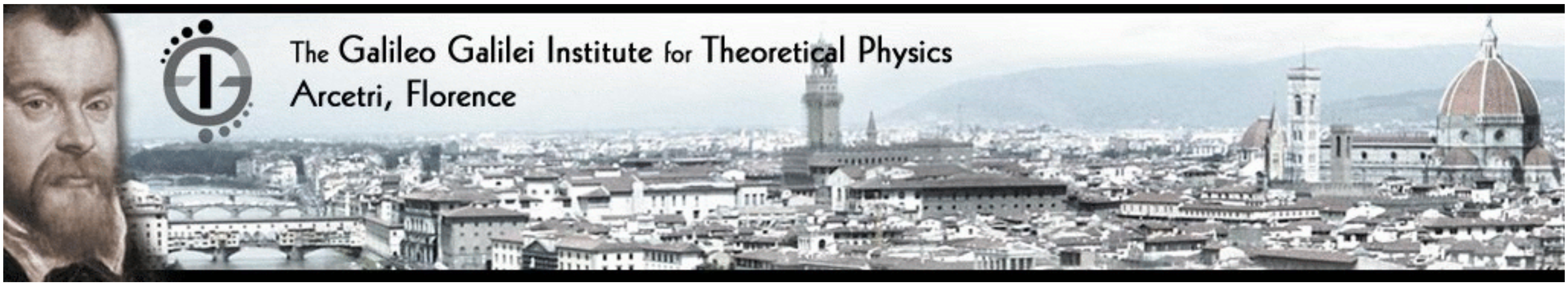
Summary by H.G.Ritter:

- Can we discover the QCD critical point at RHIC?
  - Too early to answer
  - We would be foolish not to try after what we heard during the last two days
- There is lots of interesting physics and lots of interest
- ……
- We should aim at an initial program of about 10 weeks
  - Assure decisive measurements
  - There is a promising set of initial measurements like fluctuations, flow, HBT
  - Need upgrades
  - One heavy system initially
  - Rare probes should not drive requirements
  - Do we need protons?
- RHIC program and FAIR/CBM are complementary
- …

BES at RHIC is on the map !

Florence 2006

http://pos.sissa.it/cqi-bin/reader/conf.cqi?confid=29



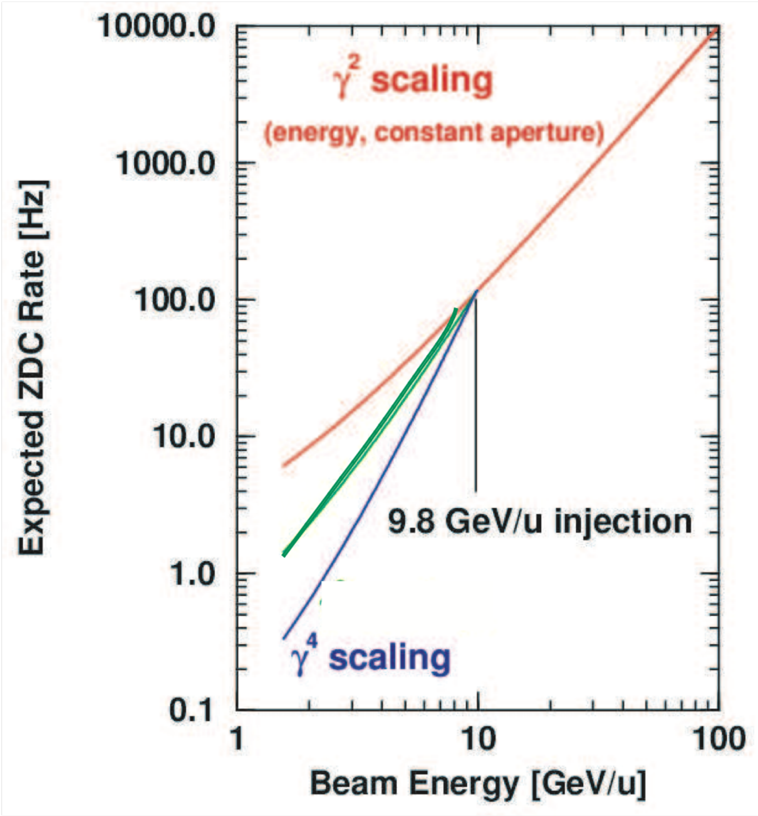
- The 3rd edition of the conference Critical Point and the Onset of Deconfinement was held in Florence, at the Galileo Galilei Institute for theoretical physics from July 3rd to 6th 2006. The goal of the conference was to get together experimental and theoretical physicists active in the field to discuss most relevant theoretical and phenomenological issues in the physics of ultrarelativistic heavy ion collisions.

Hans Georg speaks at Florence's CPOD and presents plans for BES at RHIC

Prospects for an energy scan program at RHIC
Hans Georg Ritter

Plans are developed at RHIC to perform an energy scan down to very low energies, corresponding to the fixed target equivalent of the top AGS energy. The physics motivation is the search for the QCD critical point. Both, the STAR and the PHENIX experiments, are very well suited for such a program. The physics motivation, the experimental opportunities, the accelerator implementation, and the relationship to other programs, in particular the planned CBM experiment at FAIR/GSI,are discussed.

from Florence talk:



At RHIC the injection energy into the rings is 9.8 GeV/u. As the energy is increased, the attainable luminosity increases as γ^2. Figure 2 shows the expected rate in the zero-degree calorimeter as a function of beam energy. γ^2 scaling is indicated by the top curve. Machine physicists expect γ^2 scaling to be too optimistic if the machine operates in a mode where the beams are injected below the present injection energy, as is anticipated for the planned low energy runs. It is believed that a more realistic assumption would be scaling with γ^3 (middle curve) and that γ^4 scaling (lower curve) would be a lower limit [17]. From this graph we can conclude that we might expect interaction rates of the order of 1 per second for a run with $\sqrt{s} = 5GeV/u$. Initial tests have shown that those expected rates might be realistic and no show stoppers have been identified.

Machine studies also have indicated that the rates shown in Figure 2 could be improved by orders of magnitude with a relatively modest investment. By installing electron cooling in the RHIC ring, rates are expected to increase by a factor of 100, and cooling in the AGS could increase rates by another order of magnitude. It should be noted that the electron cooling needed for the

RHIC currently plans to have a short run at one energy in 2007. Depending on the outcome a longer run could be planned for 2009 or 2010. It is planned to do the scan of energies at the energies that correspond to the fixed target beam energies run at CERN. The correspondence between the

Both experiments, STAR [20] and PHENIX [21] are performing feasibility studies and are developing an attractive physics program.

Next CPOD's:

IV - GSI (2007)

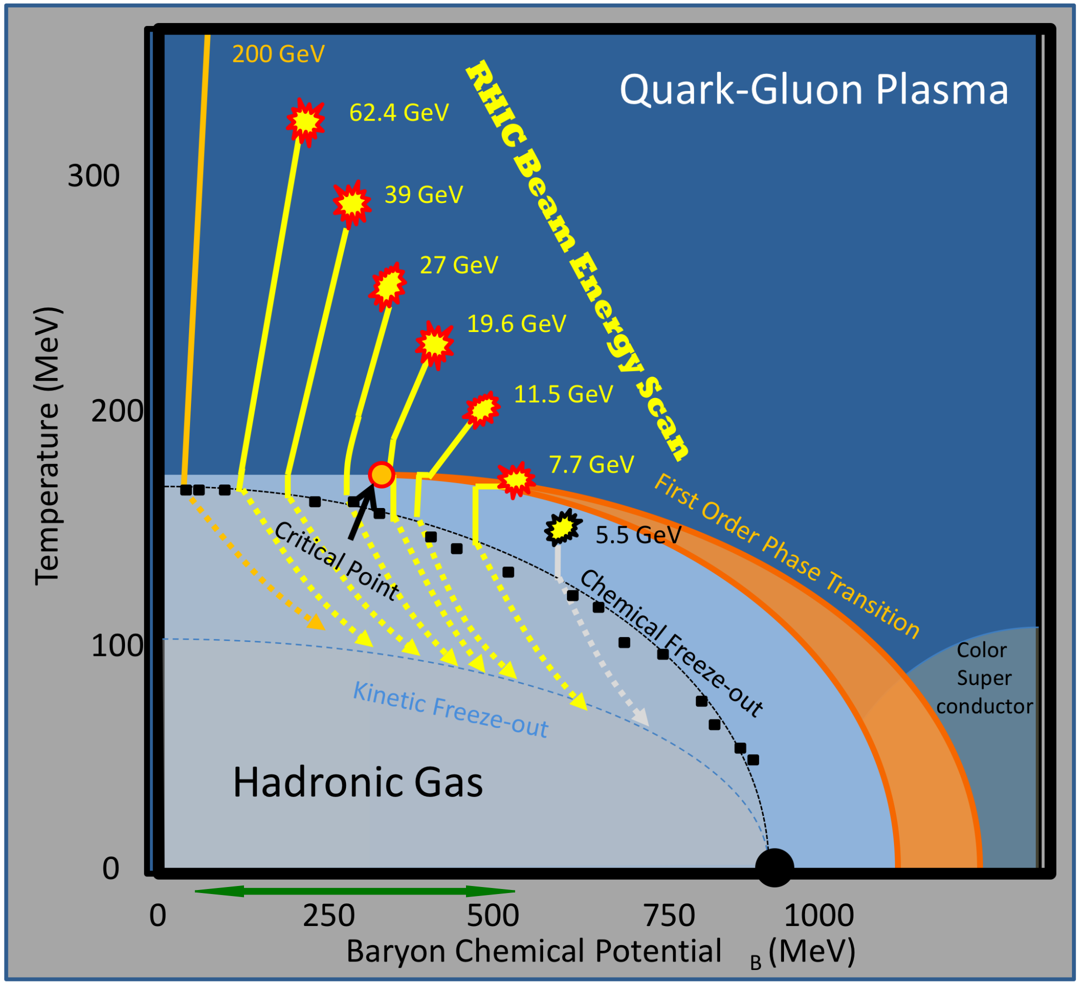
V - BNL (2009)

VI – Dubna (2010)

VII - Wuhan (2011)

VIII - Napa ! (2013)

Center of CPOD meetings: QCD Phase Diagram



BES at RHIC:

$\sqrt{s_{NN}}$ ~ 5-50 GeV

160 MeV<μ_B<500 MeV

History:

2008 – proposal

2009 – tested that RHIC & experiments can successfully operate below injection energy:

+) test run with Au+Au @ 9.2 GeV: STAR: PRC 81 (2010) 024911

2010 – Au+Au @ 7.7, 11.5 and 39 GeV

2011 – Au+Au @ 19.6 and 27 GeV

2012 – successful test at 5 GeV

2013 – 14.6 GeV (~15) ?

also: NA61 at SPS

future: FAIR at GSI (fixed trg), MPD at NICA

STAR: http://drupal.star.bnl.gov/STAR/starnotes/public/sn0493

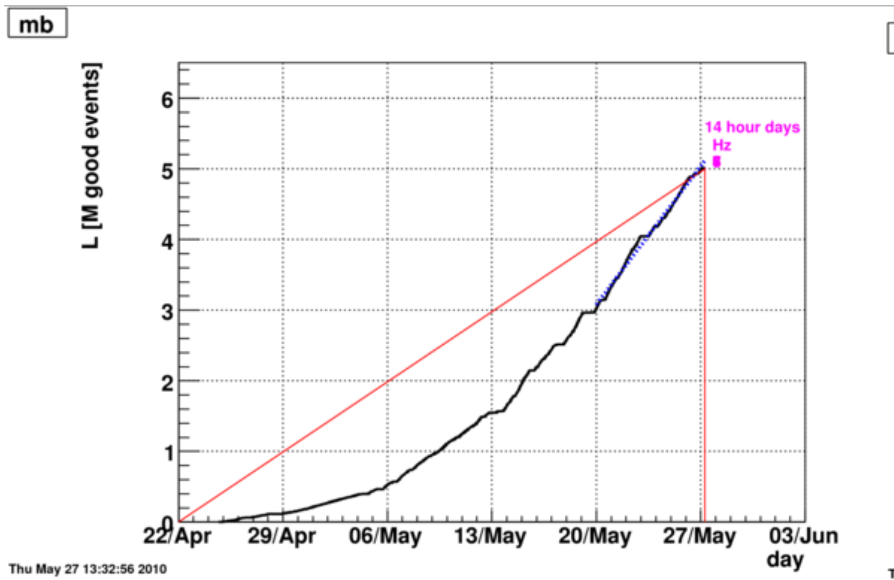
Collision Energies (GeV)	**5**	**7.7**	**11.5**	**17.3**	**27**	**39**
Observables	Millions of Events Needed					
v_2 (up to ~1.5 GeV/c)	**0.3**	**0.2**	**0.1**	**0.1**	**0.1**	**0.1**
v_1	0.5	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**
Azimuthally sensitive HBT	4	**4**	**3.5**	**3.5**	**3**	**3**
PID fluctuations (K/π)	1	**1**	**1**	**1**	**1**	**1**
net-proton kurtosis	5	**5**	**5**	**5**	**5**	**5**
differential corr & fluct vs. centrality	4	**5**	**5**	**5**	**5**	**5**
n_q scaling π/K/p/Λ $(m_T-m_0)/n<2$GeV	8.5	**6**	**5**	**5**	**4.5**	**4.5**
φ/Ω up to $p_T/n_q=2$ GeV/c		56	25	**18**	**13**	**12**
R_{CP} up to p_T ~4.5 GeV/c (at 17.3) 5.5 (at 27) & 6 GeV/c (at 39)				**15**	**33**	**24**
untriggered ridge correlations		27	13	**8**	**6**	**6**
parity violation		**5**	**5**	**5**	**5**	**5**

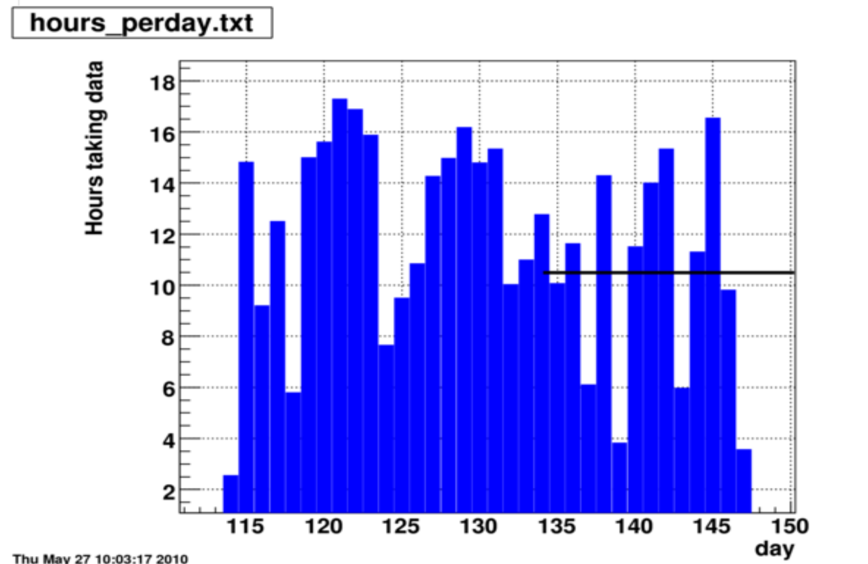
Data taken by STAR in 2010/2011:

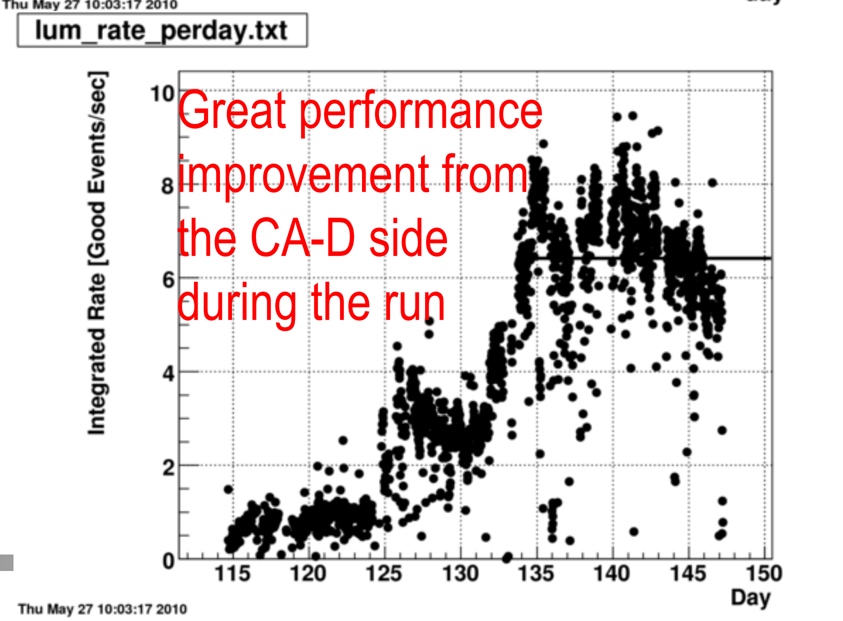
$\sqrt{s_{NN}}$ (GeV)	Good events in Million MB
5.0	
7.7	**4.3**
11.5	**11.7**
19.6	**35.8**
27	**70.4**
39	**130.4**

67.3 M @ 62.4 GeV

the hardest case: AuAu @ 7.7 GeV (STAR data summary)







Collected 5.014 M events

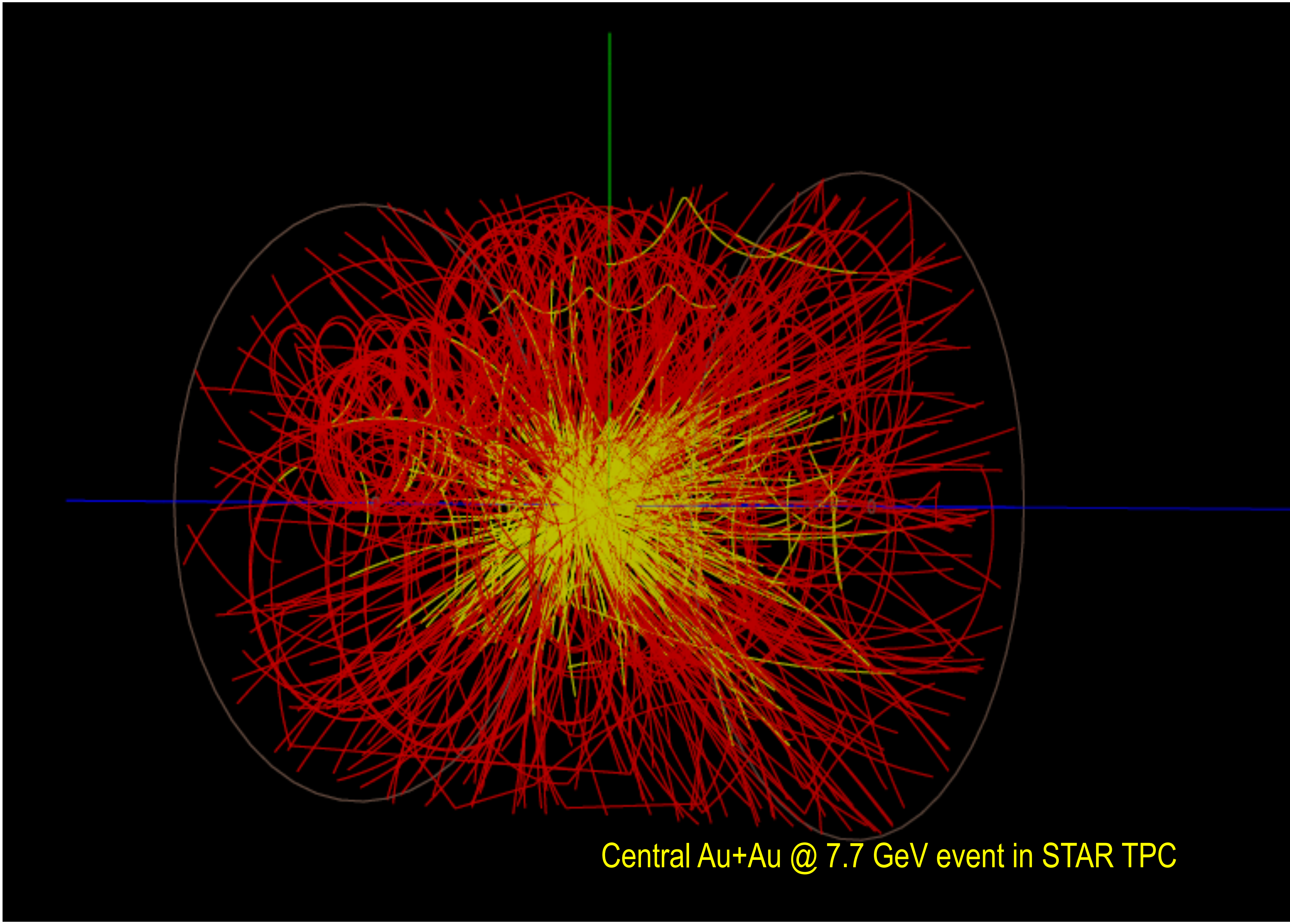
– met the goal !

Operated in 10 minutes stores environment

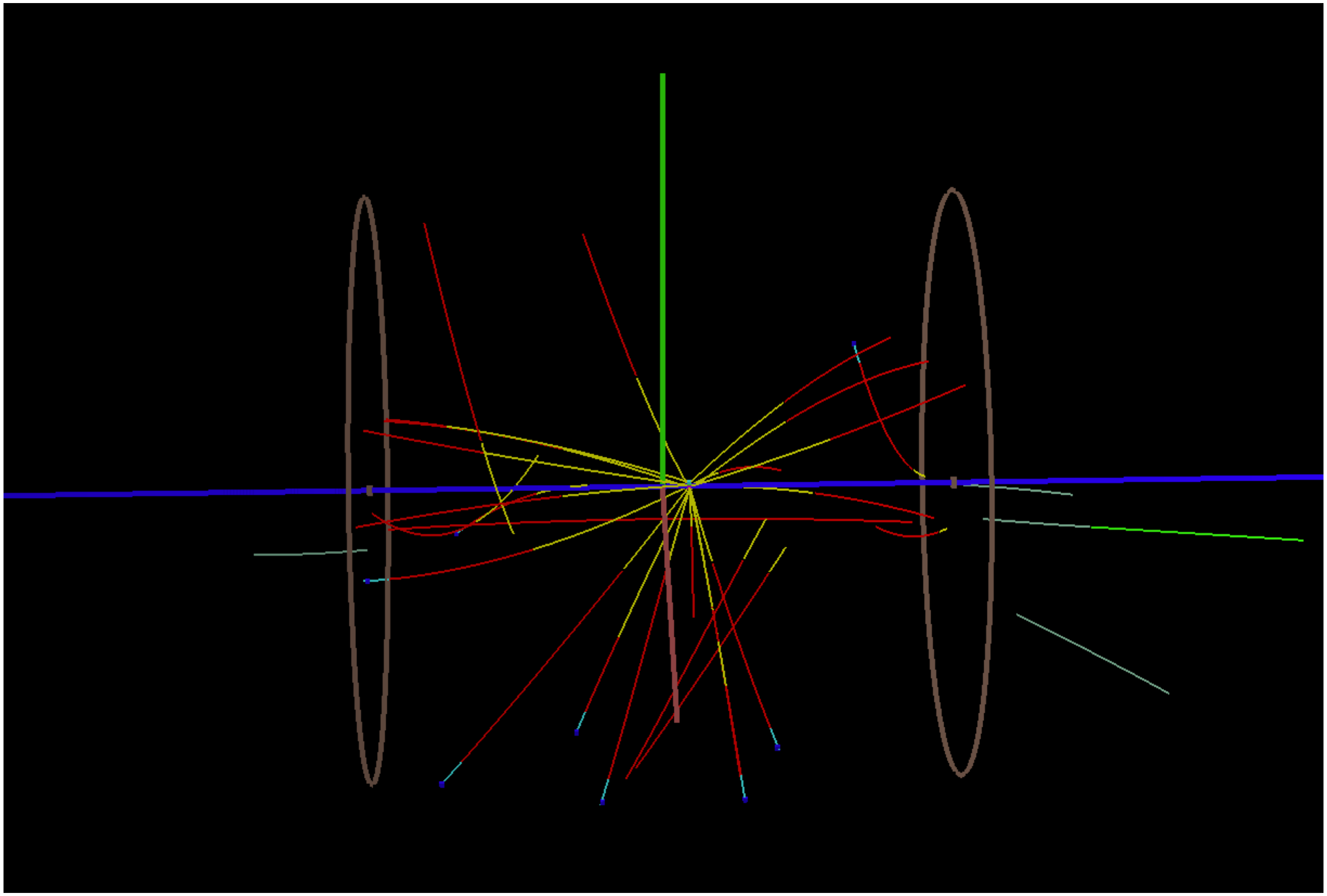
Average uptime ~ 11 hours

Collecting up to 350 k events per day

Grazyna Odyniec/LBNL


Central Au+Au @ 7.7 GeV event in STAR TPC

5 GeV test run (2012): Au+Au @ $\sqrt{s_{NN}}$ = 5 GeV



So, what have we learned from BES Phase-I

STAR and RHIC excellent performance down to 7.7 GeV (5 ?)

BES Phase-I data sets (39, 27, 19.6, 11.5 and 7.7 GeV) cover important region of QCD phase diagram with sufficient statistics for initial survey

but it is rather coarse coverage

Several key sQGP signatures NOT seen at low energies:

- $v_2(m_T - m_0)$ exhibits well-known baryon-meson splitting, but splitting is smaller at low $\sqrt{s_{NN}}$
- v_2 for particles & antiparticles diverges strongly at low $\sqrt{s_{NN}}$
- high p_t suppression R_{CP} disappears at low $\sqrt{s_{NN}}$, under investigation
- charge separation signal disappears at low $\sqrt{s_{NN}}$, interpretation unclear

Interesting hints:

- fluctuations are constant or monotonic with energy from 7.7 to 200 GeV
- higher moments of net-protons deviates from Poisson baseline
- dv_1/dy of net-protons (directed flow) changes sign with $\sqrt{s_{NN}}$: softening of EOS ?
- freeze-out eccentricity (aHBT) monotonically decreases with energy

RHIC's energy range is special …

RICH sits at a "sweet spot" in energy, in which rapid changes occur in a number of signatures for energies up to approximately 30 GeV, while remaining surprisingly stable beyond that over the two orders of magnitude to the LHC

→ so, did we answer our "three" questions ?

1. turn-off of QGP signatures ? **clear evidence** no need to search above 19.6
2. Evidence of the first order phase transition ? **hints** lower end of range
3. Search for the critical point ? **? !** **MORE** statistics !!!

Good chance for Au Au at $\sqrt{s_{NN}}$ = 15 GeV in 2013

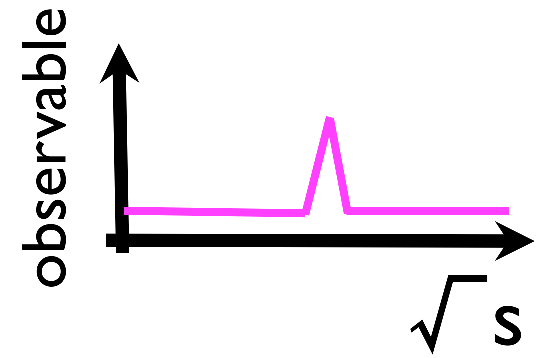
Data analysis …

- Besides having a vital and pioneering role in launching the BES program at RHIC and establishing series of CPOD meeting,
- Hans Georg took a shot at the hardest physics goal: **MOMENTS** of net-proton multiplicity distributions

Theorists tells us:

System at the QCD critical point region is expected to show a sharp increase in the correlation length, thus large non-statistical fluctuations

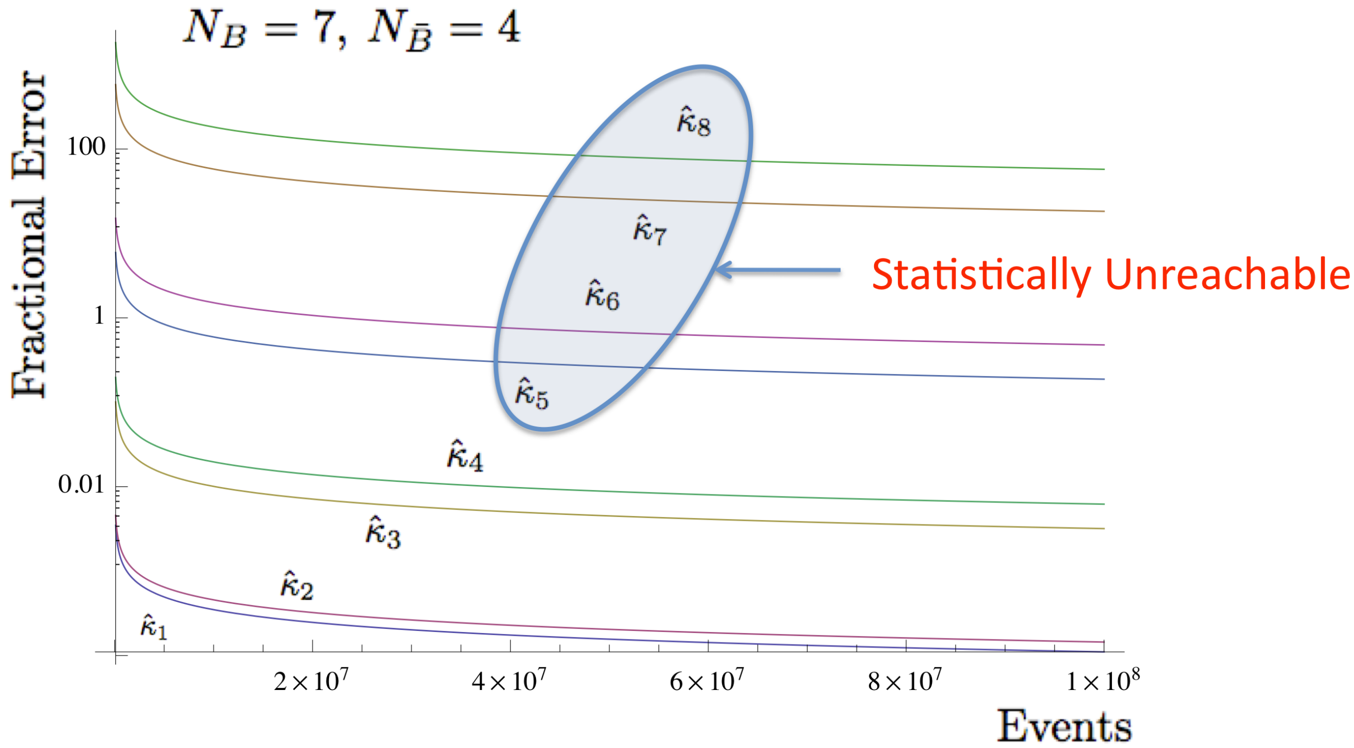
⟶ search for increase (/discontinuities) in fluctuations and correlations as function of $\sqrt{s_{NN}}$



Fluctuations maximized at Critical Point

They also tells us to go to higher moment analysis because it is more sensitive to the correlation length, which particularly statistics hungry (well above what running time allows for). So, this analysis is **VERY DIFFICULT**

HRG Errors For Higher Cumulants



Evan Sangaline – UC Davis – Bulkcorr Phone Meeting – August 17, 2011 – Slide 7/9

Analysis beyond second moments – statistically **challenging**

First analysis Xiaofeng Lou, Hans Georg's student

presently at Central China Normal University

$$\sigma^2 = \langle (N - \langle N \rangle)^2 \rangle$$
$$S = \langle (N - \langle N \rangle)^3 \rangle / \sigma^3$$
$$\kappa = \langle (N - \langle N \rangle)^4 \rangle / \sigma^4 - 3$$

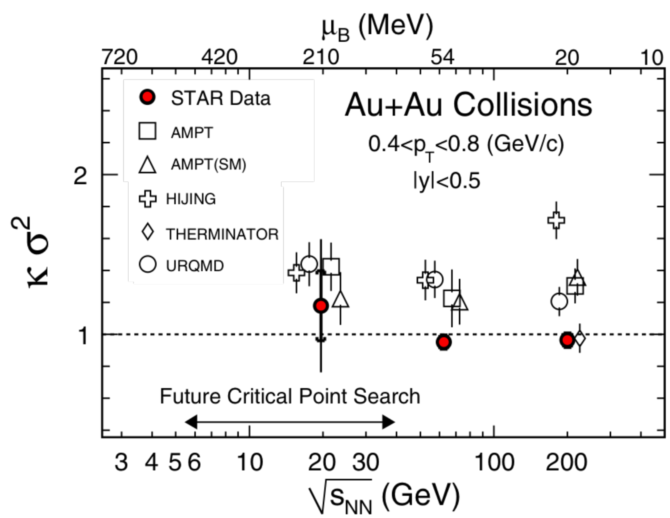


FIG. 4 (color online). $\sqrt{s_{NN}}$ dependence of $\kappa\sigma^2$ for net-proton distributions measured at RHIC. The results are compared to non-CP model calculations (slightly shifted in $\sqrt{s_{NN}}$). The left-right arrow at the bottom indicates the energy range for the CP search at RHIC.

Non-monotonic behavior could be indicative of the QCD critical point

in summary section:

susceptibilities. Within the uncertainties, $\kappa\sigma^2$ is found to be constant as a function of $\sqrt{s_{NN}}$ studied. This trend is consistent with models without a CP and in sharp contrast to models [13] which include a CP in this μ_B range. Our measurements show no evidence for a CP to be located at μ_B values $\lesssim$200 MeV in the QCD phase plane. The RHIC beam energy ($100 < \mu_B < 550$ MeV) scan will look for nonmonotonic variation of $\kappa\sigma^2$ for net protons as a function of $\sqrt{s_{NN}}$ to locate the CP.

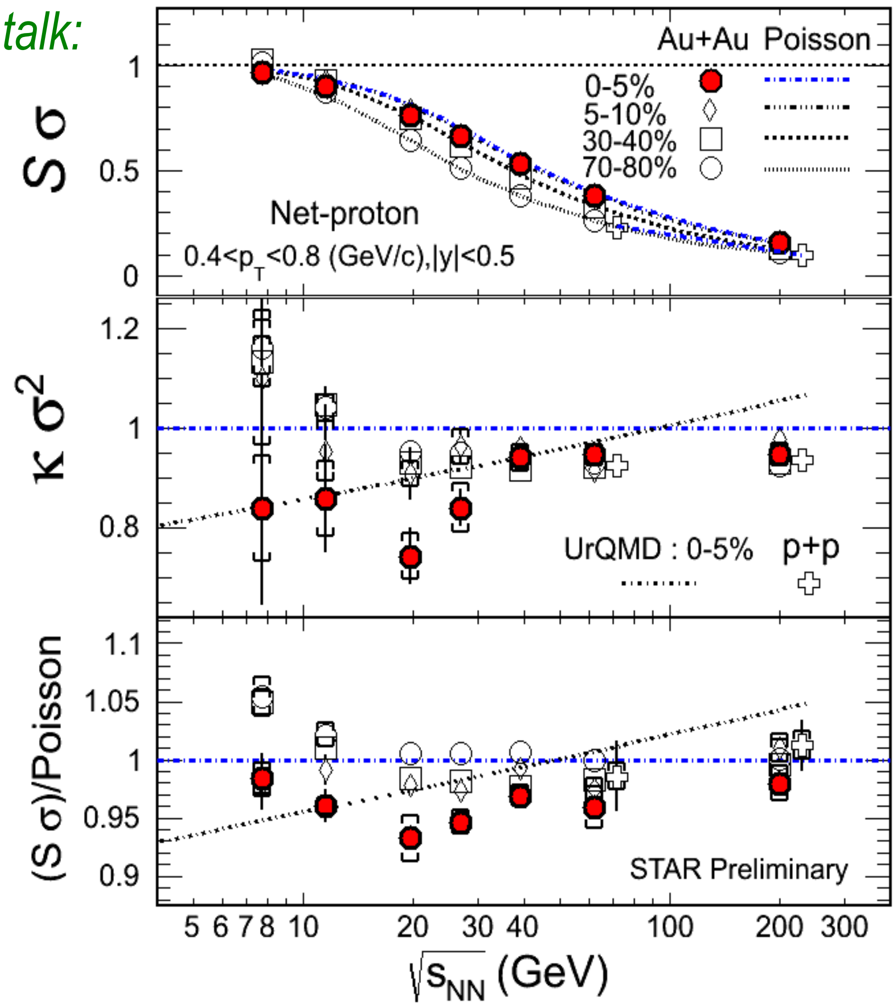
PRL **105,** 022302 (2010) PHYSICAL REVIEW LETTERS week ending 9 JULY 2010

Higher Moments of Net Proton Multiplicity Distributions at RHIC

M. M. Aggarwal,[31] Z. Ahammed,[22] A. V. Alakhverdyants,[18] I. Alekseev,[16] J. Alford,[19] B. D. Anderson,[19] D. Arkhipkin,[3] G. S. Averichev,[18] J. Balewski,[23] L. S. Barnby,[2] S. Baumgart,[53] D. R. Beavis,[3] R. Bellwied,[51] M. J. Betancourt,[23] R. R. Betts,[8] A. Bhasin,[17] A. K. Bhati,[31] H. Bichsel,[50] J. Bielcik,[10] J. Bielcikova,[11] B. Biritz,[6] L. C. Bland,[3] B. E. Bonner,[37]

QM 2012: Higher moments of net-protons
(proxy for net-baryon)

Xin Dong plenary STAR Highlights & Xiaofeng Lou parallel talk:



- Similar behavior at 39, 62 and 200 GeV
- Deviations below Poisson baseline in 0-5% central collisions, and above Poisson baseline in peripheral collisions below 19.6 GeV

  (could be due to other correlations)
- UrQMD shows monotonic behavior vs√**s**

Data points below 19.6 GeV have large uncertainties -> prevents conclusions (presently)

Needs: more statistics & larger acceptance

BES II: from hints to conclusions

from exploration to discovery

→ STAR will have BES Phase-II program of precision measurements with order of magnitude increase in data samples

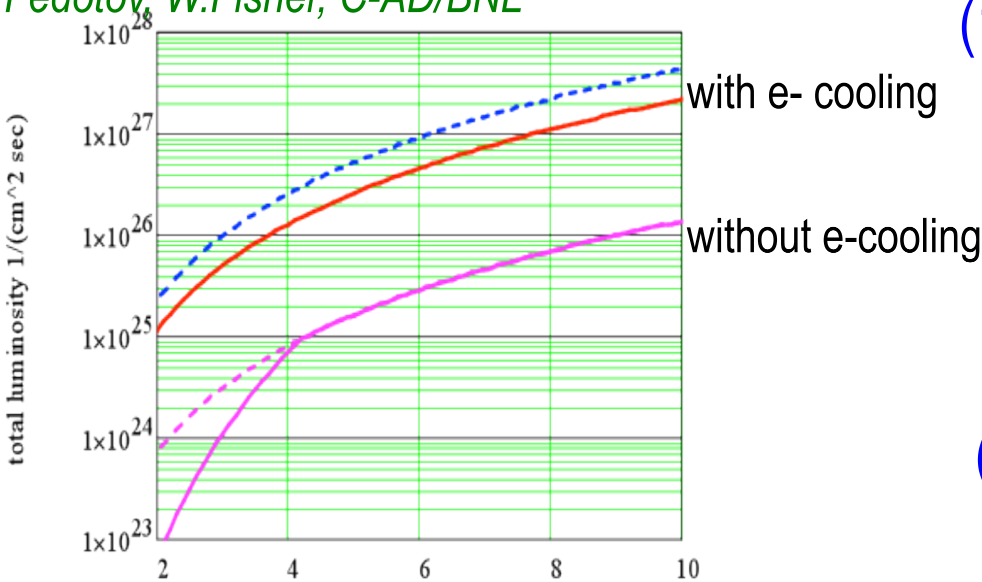
$\sqrt{S_{NN}}$ (GeV)	19.6	15	11.5	7.7
μ_B (GeV)	205	250	315	420
BES I (MEvts)	36	---	12	5
BES II (MEvts)	**400**	**100**	**120**	**80**

But that's a lot of data… at current rates, this would take ~70 weeks of RHIC operations!

→ needed electron cooling device for RHIC HI beams

Improvements for BES phase II

A.Fedotov, W.Fisher, C-AD/BNL

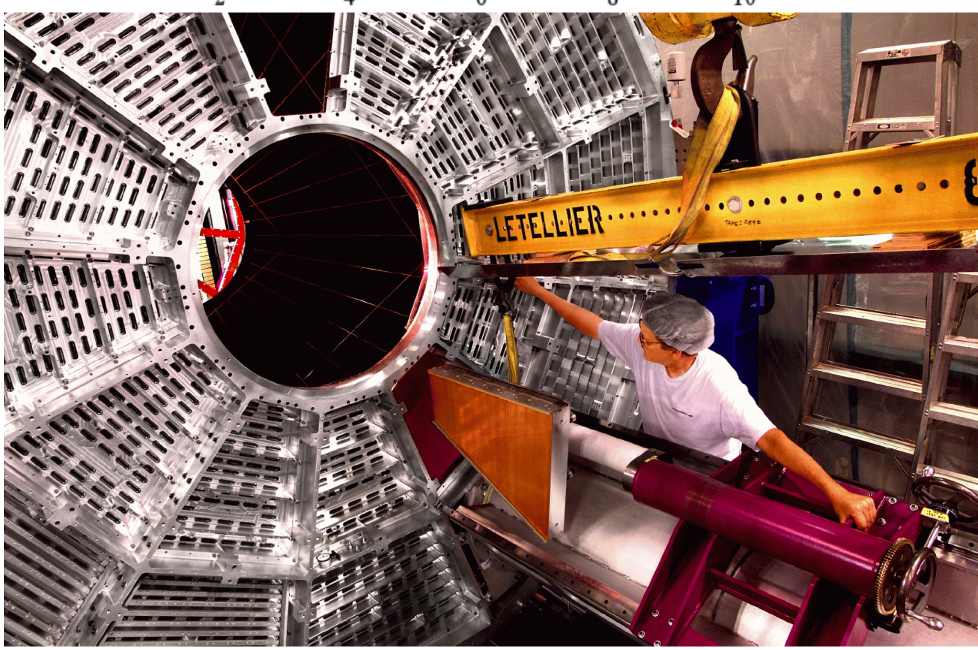


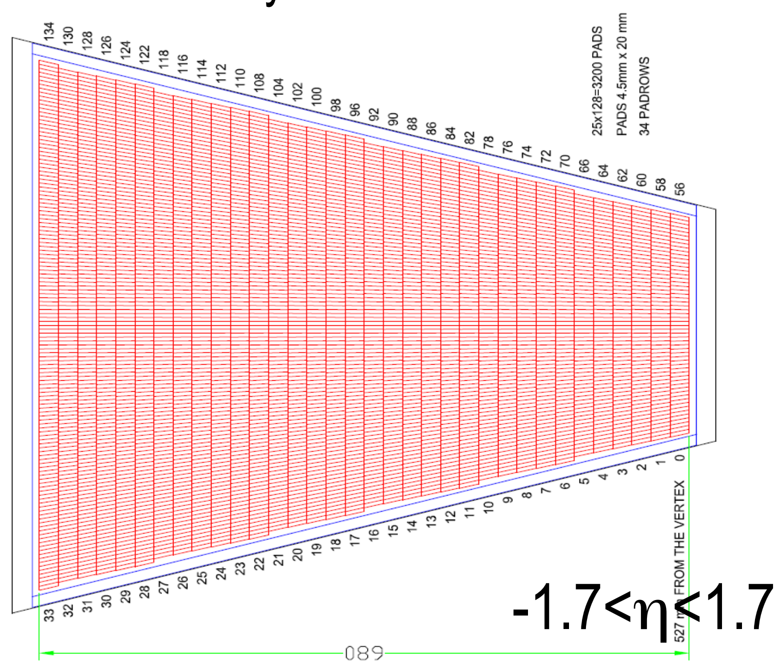
(1) Electron cooling at RHIC will raise luminosity by factor 3-10 in range $\sqrt{s_{NN}}$ 5-20 GeV

would not be ready before 2017

(2) iTPC: extends η range to 1.7

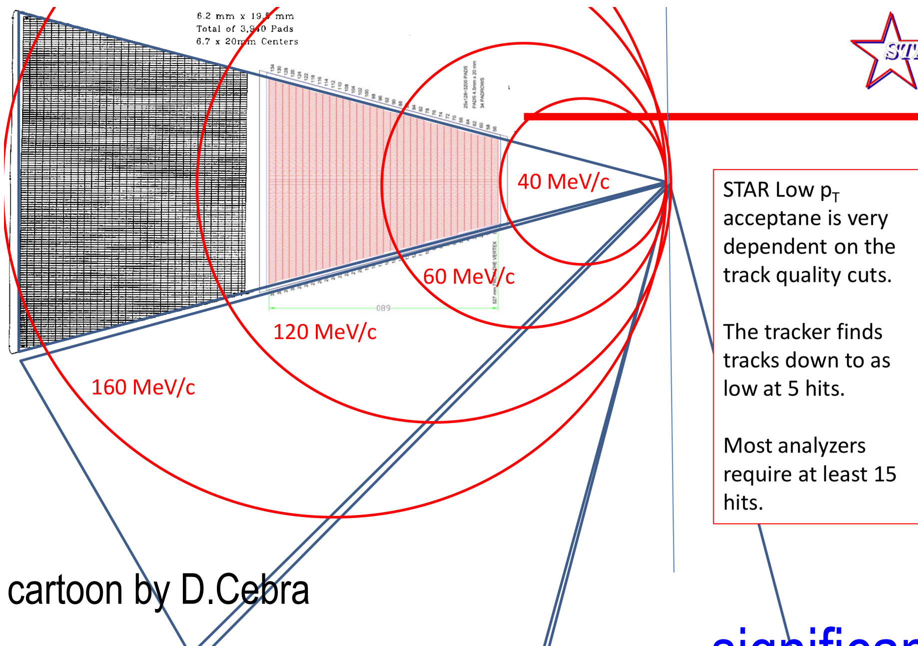
ready the same time as e-cooling





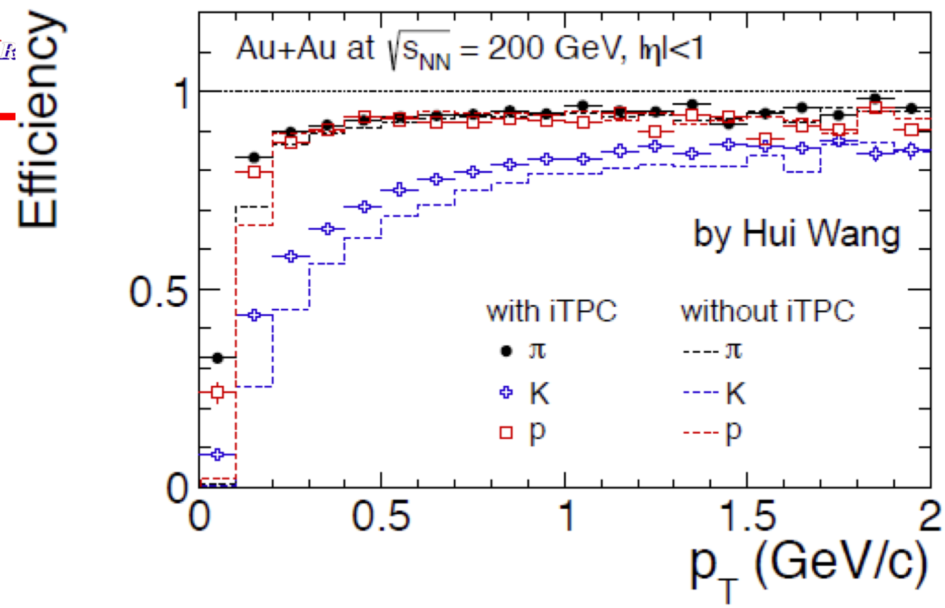
TPC inner sector upgrades is critical for 3 reasons:

1. It reduces the low p_t threshold
2. It extends the accessible rapidity/pseudo-rapidity range
3. It Improves dE/dx resolution



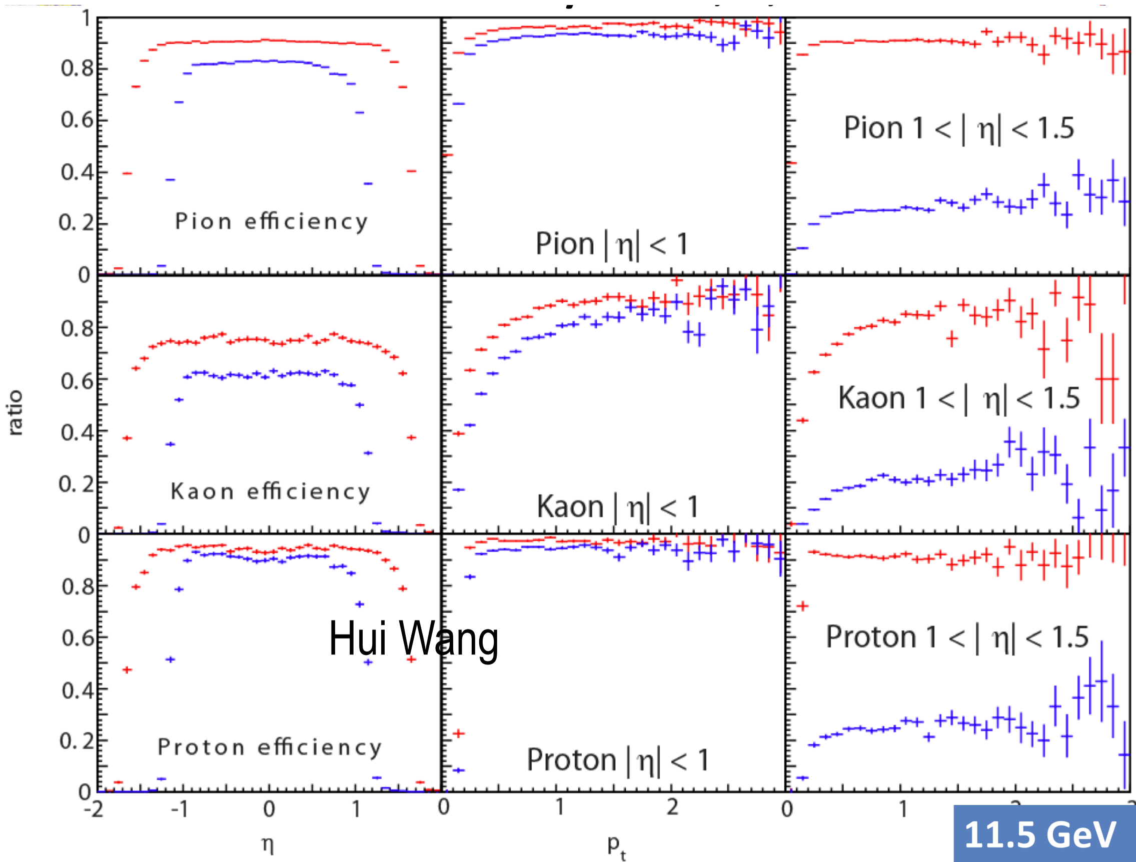
cartoon by D.Cebra

Eff. for π,K and p in $-1<\eta<1$



significant improvement at low p_t with iTPC upgrade

http://www.star.bnl.gov/protected/bulkcorr/wanghui6/my_talks/iTPC/9_20_iTPC.pdf



Efficiency of π, K, p

blue = TPC

red = iTPC

additional tracks available for physics:

11.5 GeV		Total	Standard TPC	Inner Upgrade
	Pions	234	152	+17%
|η|<0.5	Kaons	25.3	12.4	+30%
	Protons	34	26	+10%
	Pions	435	283	+21%
|η|<1.0	Kaons	47	22.9	+35%
	Protons	66	50	+13%
	Pions		<20%	90%
1.0<|η |<1.5	Kaons		<20%	80%
	Protons		<20%	90%

Physics, Physics, PHYSICS !

v_1 – Prashanth Shanuganathan (Declan Keane) – BES meeting, Nov. 2012

v_1 is about 0 at mid-y, entire structure develops at higher rapidity, essential to extend y coverage to claim softening of EOS,

v_1 – particularly important in BES program, because it may allow to claim softening of EOS and therefore the 1st order phase transition (CP ?)"

v_2 – Hiroshi Masui & Alex Schmah - BES meeting, Oct. 15, 2012

- improvements of second harmonic event plane resolution
  - larger η gap can further reduce short range $\Delta\eta$ correlation
- improvements of strange hadrons efficiency
  - improved statistical significance on v_2 (especially multi-strange)

2-, 4- particle cumulant analysis (flow, nonflow) – Li Yi , BES meeting, Oct. 2012

- relies on particle pairs with diff. η, with increase η range from $1 \rightarrow 2$, $\Delta\eta$: $2 \rightarrow 4$

  $\rightarrow$ will gain 4 times data points

Moments analysis – Evan Sangaline, BES meeting, Oct. 2012

- extremely sensitive, limited acceptance of kurtosis reduces the signal by approximately the forth (!) power
  - we lose 35% of our protons at 19.6 GeV due to the low p_t cut

Physics, Physics, PHYSICS !

Errors – Evan Sangaline – BES meeting, Nov. 2012
- errors on many observables scale as $1/\mathrm{sqrt}(N_{tracks})$
  role of efficiency corrections

J/ψ, Upsilon – Barbara Trzeciak, Daniel Kikola - BES meeting, Sept., 2012
- J/ψ increased significance by factor 1.6,
- Upsilon (statistics will go up by ~ factor 2), perhaps separation of Upsilon states ?

3- body decays (Ω, Ξ, D) – needs MC

ϕ - with higher statistics (2x or better) → verify a claim of departure from NCQ scaling ?

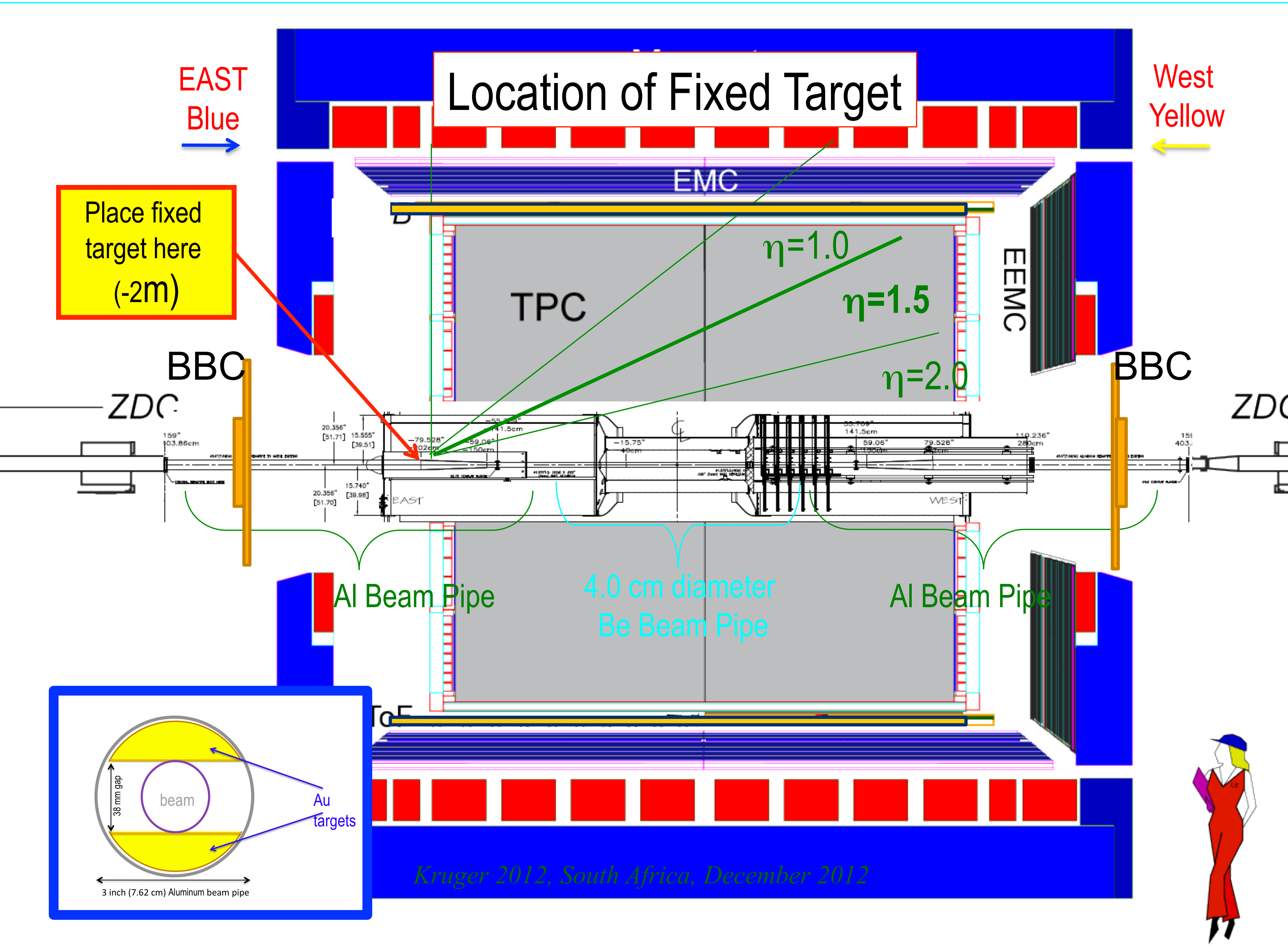
HBT – extended to low p_t, important as entire effect is in low p_t region – needs HBT expert

T_{ch}, T_{kin}, β, μ_B – "new" valus of freeze-out parameters with thermal fits including low p_t region

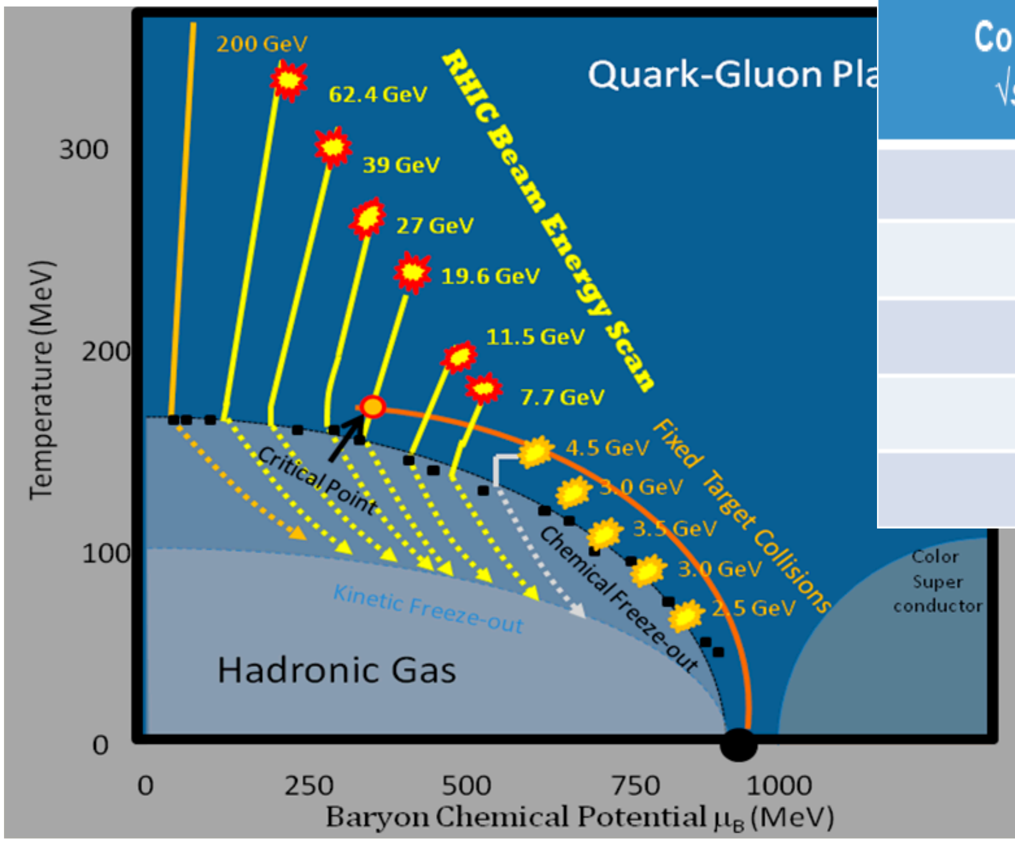
…. **TPC inner sector upgrade is critical,**
but it will not happen very soon – therefore …

therefore

we will run STAR in fixed target mode


Location of Fixed Target
EAST
Blue
West
Yellow
Place fixed
target here
(-2m)
EMC
TPC
EEMC
η=1.0
η=1.5
η=2.0
BBC
BBC
ZDC
EAST
WEST
Al Beam Pipe
4.0 cm diameter
Be Beam Pipe
Al Beam Pipe
ToF
beam
38 mm gap
Au
targets
3 inch (7.62 cm) Aluminum beam pipe
Kruger 2012, South Africa, December 2012

μ_B extended range in STAR due to fixed target program

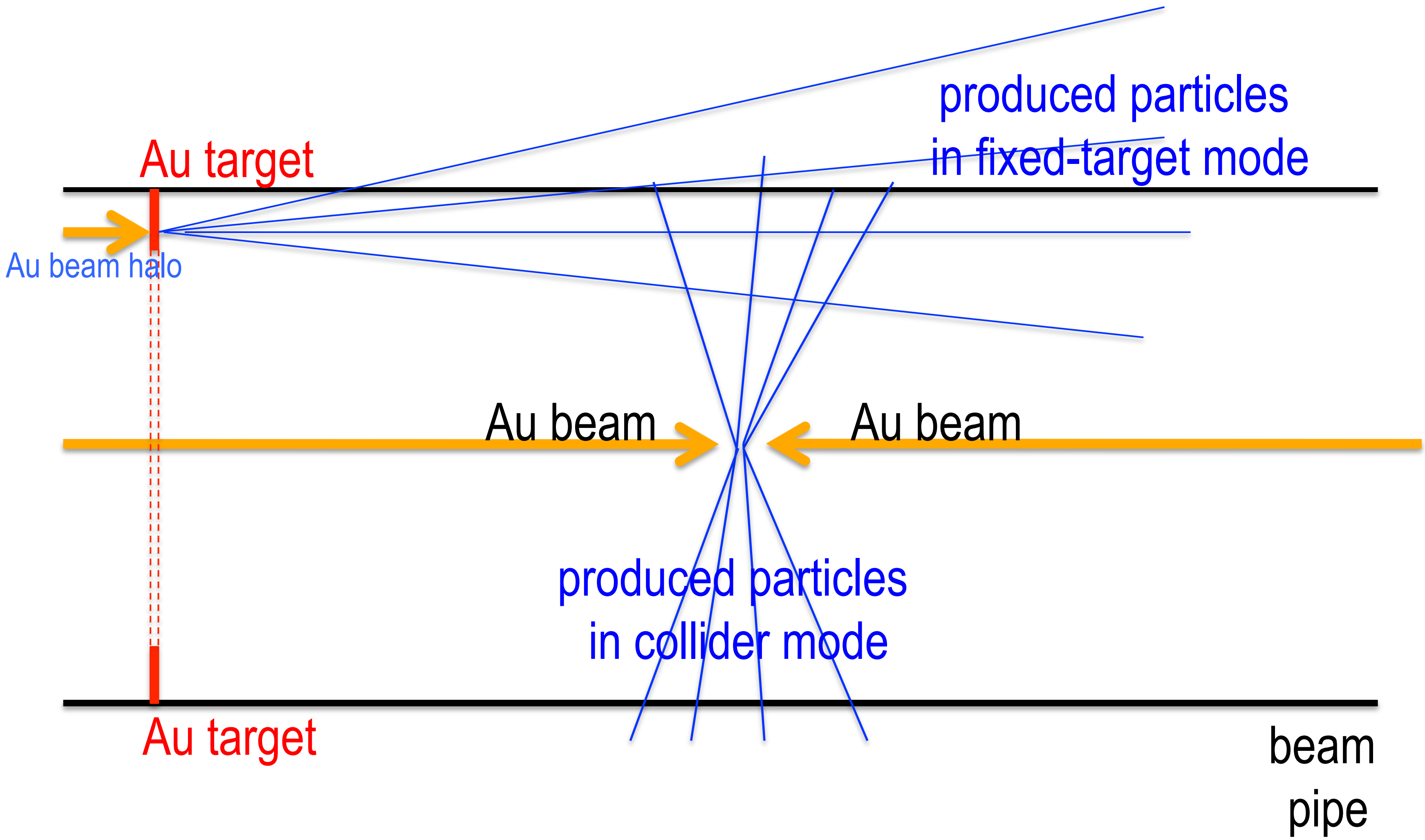


Collider mode $\sqrt{s_{NN}}$ (GeV)	Fixed-target mode $\sqrt{s_{NN}}$ (GeV)	Fixed-target mode μ_B (MeV)
19.6	4.5	585
15	4.0	625
11.5	3.5	670
7.7	3.0	720
5	2.5	775

Fixed-target running allows much higher rates without e-cooling at lower energies

Minimal impact on concurrent operation

Concurrent running in STAR



fixed-target events taken while waiting for collider mode collisions

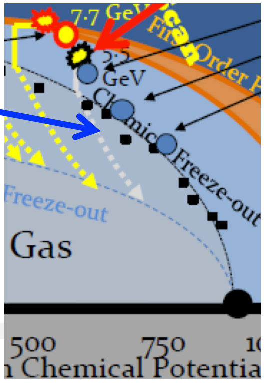
Fixed target at STAR

STAR will have adequate coverage (from mid-rapidity to target rapidity) in fixed-target mode, which is sufficient for some BES studies (detailed analysis of limitations in progress)

Main detectors TPC and TOF tested, work in progress on EEMC/BEMC, and trigger
Tracking, vertexing, PID reasonable, may be improved with optimization

An internal fixed target can be used to take collisions with beam halo at injection energy, which will provide collisions at approximately $\sqrt{s_{NN}}$ of 5 GeV (data point missing from existing BES data)

If successful – this may open a way for fixed target runs with other beams used in BES program in collider mode experiments ($\sqrt{s_{NN}}$= 3.5 and 3 GeV, μ_B up to 800 MeV)



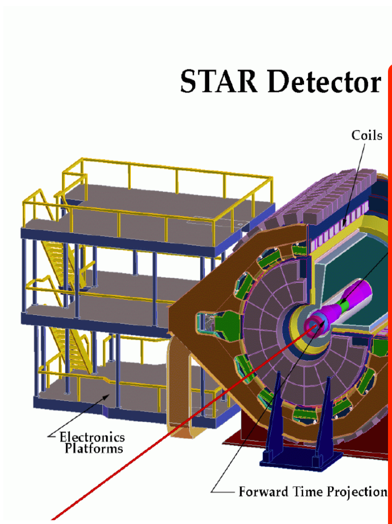
BES: analysis focused on evolution of trends with $\sqrt{s_{NN}}$ (not a single energy results)
with fixed target runs: $0 < \mu_B < \sim 800$ MeV !

but not only BES was on Hans George agenda at this time … is

Since ~ 2000 Howard Wieman was thinking about “micro vertex detector”
April 2000 NSD review:

Vertex Upgrade to STAR

- High resolution vertex detector inside SVT
- After RHIC running experience permits working closer to the beam: < 2.8 cm



Development Plan

- Proof of principle simulations June 00
- Detector device evaluation Aug. 00
- Preliminary Design Sept. 00
- Proposal Oct. 00
- Installation June 02
- Operation 03

Soon after:
Hans Georg - project leader
Howard – project director (technical stuff)

2002- 2006 - Preparation to CD 0
Mounting a strong group:
- simulations for early design, design algorithm, D^0 – heroic effort
- firmware
- Si wafers + large part of read-out electronics integrated MAPS, MIMOSA (Strasbourg)

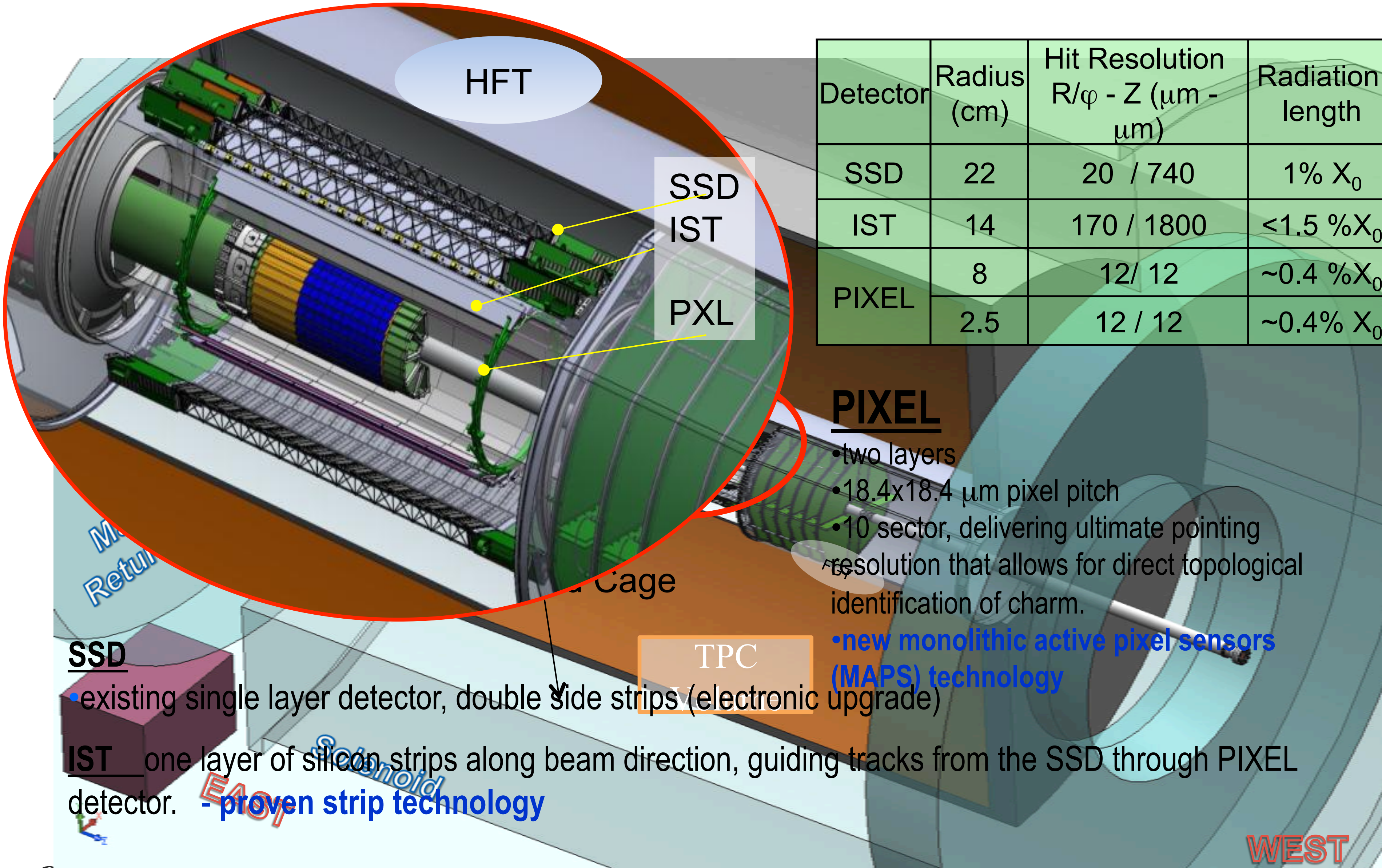
Hans Georg behind all activities, always active (usually in the background), facilitating, talking to DOE, BNL management, making things happen

2006 – merge of pixel detector and IST (Inner Strip Detector, MIT) + SDD (Silicon Strip Detector, Nantes) ⟶ HFT was born !!!

2007 (October) – CD 0

2008 - Hans Georg recruits Flemming Videbaek (BNL) to lead HFT
(it took 2 years to get him)
HG – deputy project leader, continues to be present on all fronts,
and it remains this way till now
2008 (October) – CD 1
2011 (summer) – CD 2/3 – HFT was approved

Heavy Flavor Tracker (HFT)



Detector	Radius (cm)	Hit Resolution R/φ - Z (μm - μm)	Radiation length
SSD	22	20 / 740	1% X_0
IST	14	170 / 1800	<1.5 %X_0
PIXEL	8	12/ 12	~0.4 %X_0
	2.5	12 / 12	~0.4% X_0

PIXEL

- two layers
- 18.4x18.4 μm pixel pitch
- 10 sector, delivering ultimate pointing resolution that allows for direct topological identification of charm.
- **new monolithic active pixel sensors (MAPS) technology**

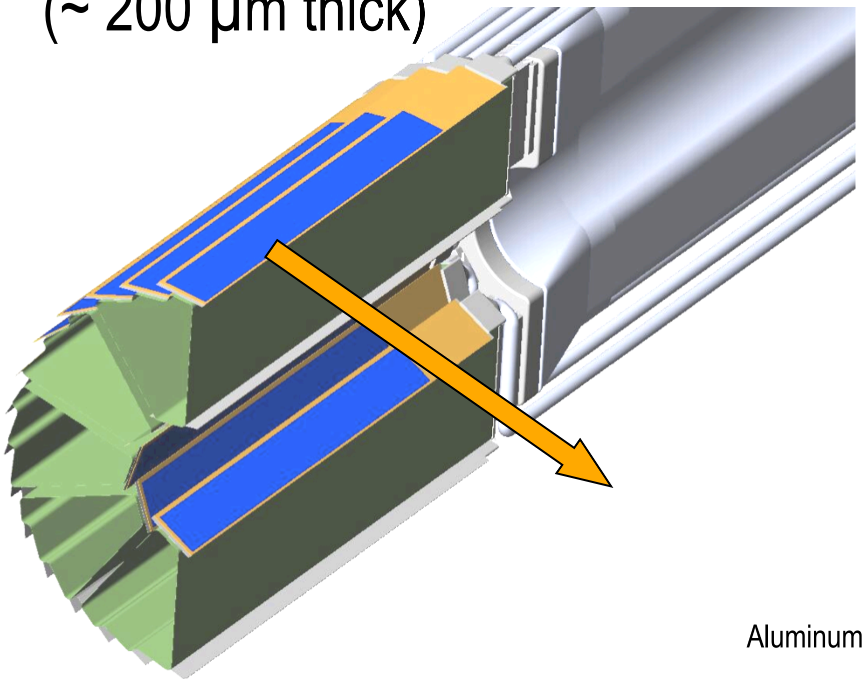
SSD

- existing single layer detector, double side strips (electronic upgrade)

IST one layer of silicon strips along beam direction, guiding tracks from the SSD through PIXEL detector. **- proven strip technology**

PXL detector

carbon fiber sector tubes
(~ 200 µm thick)



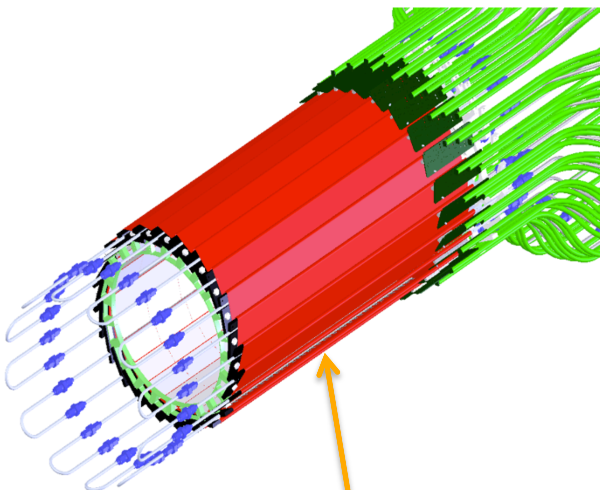
Ladder with 10 MAPS
sensors (~ 2×2 cm each)

Aluminum conductor Ladder Flex Cable

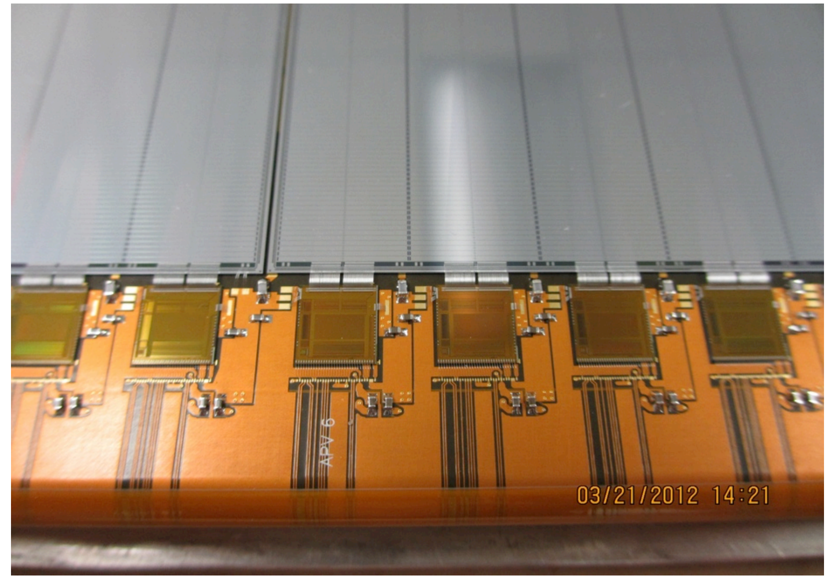
improvement in resolution:

TPC → ~1mm → SSD → ~ 300µm → IST → ~250µm → PXL → <30µm → vertex

Intermediate Si Tracker (IST)



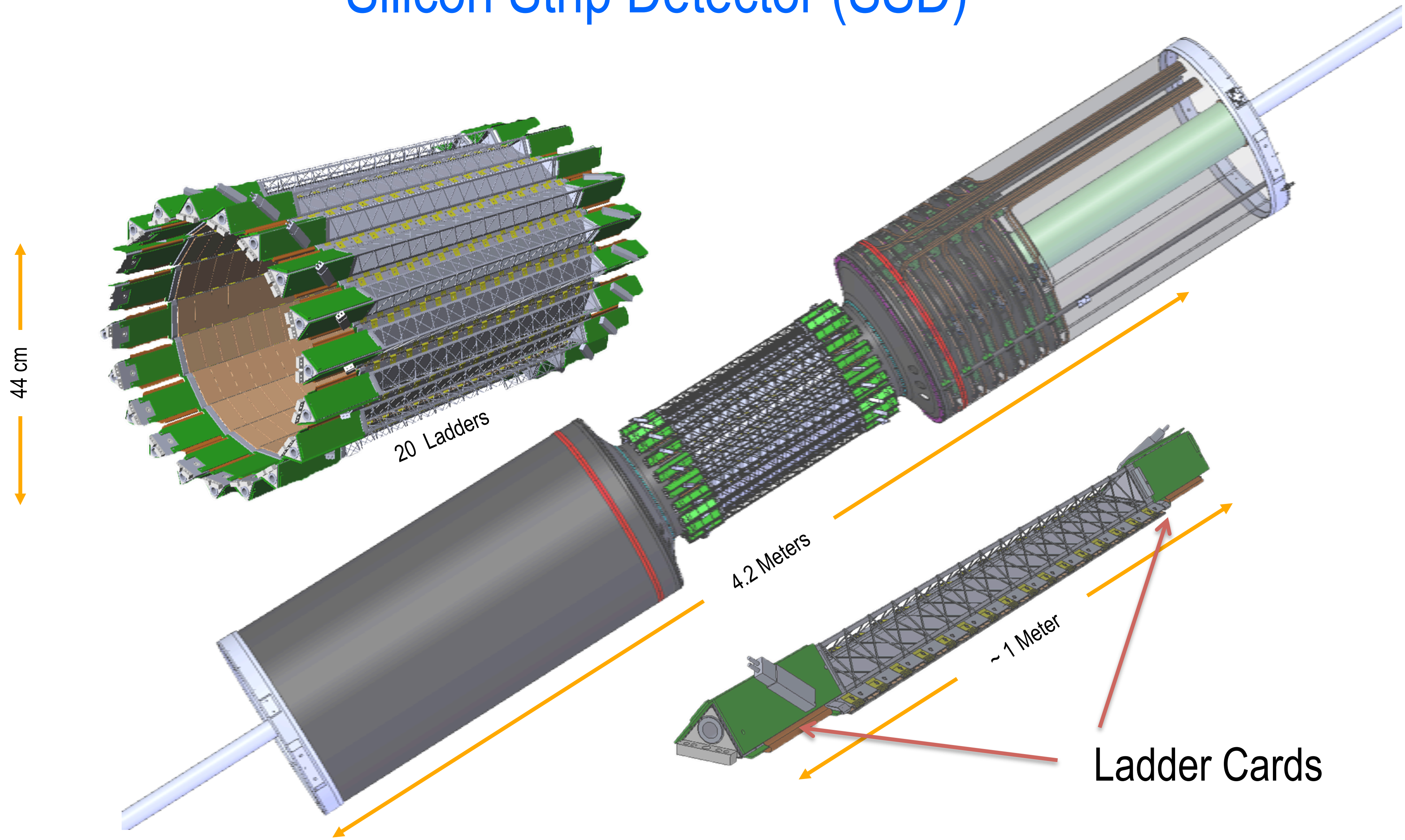
24 ladders, liquid cooling.



Details of wire bonding

Prototype Ladder
S:N > 20:1
>99.9% live and functioning channels

Silicon Strip Detector (SSD)



HFT will provide direct topological reconstruction for charm

(detect charm decays with small $c\tau$, including $D^0 \rightarrow K + \pi$)

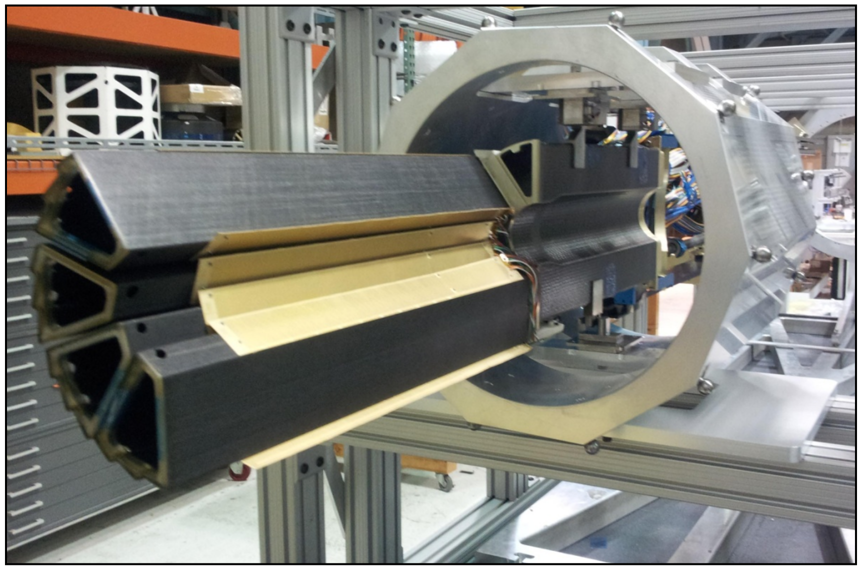
Physics of the Heavy Flavor Tracker at STAR:

(1) Heavy-quark cross sections: $D^{0\pm*}$, D_S, Λ_C , B…
(2) Both spectra (R_{AA}, R_{CP}) and v_2 in a wide p_T region: 0.5 - 10 GeV/c
(3) Charm hadron correlation functions, heavy flavor jets
(4) Full spectrum of the heavy quark hadron decay electrons
(5) Measure heavy-quark hadron v_2, heavy-quark collectivity, to study the medium properties e.g. light-quark thermalization
(6) Measure heavy-quark energy loss to study pQCD in hot/dense medium e.g. energy loss mechanism
(7) Measure di-leptons to study the direct radiation **from the hot/dense medium**
(8) Analyze hadro-chemistry including heavy flavors
(9) …

see Kai's talk (next)

Presently

- A PXL prototype with 3+ sectors instrumented is planned for an engineering run and data taking in STAR in early 2013.

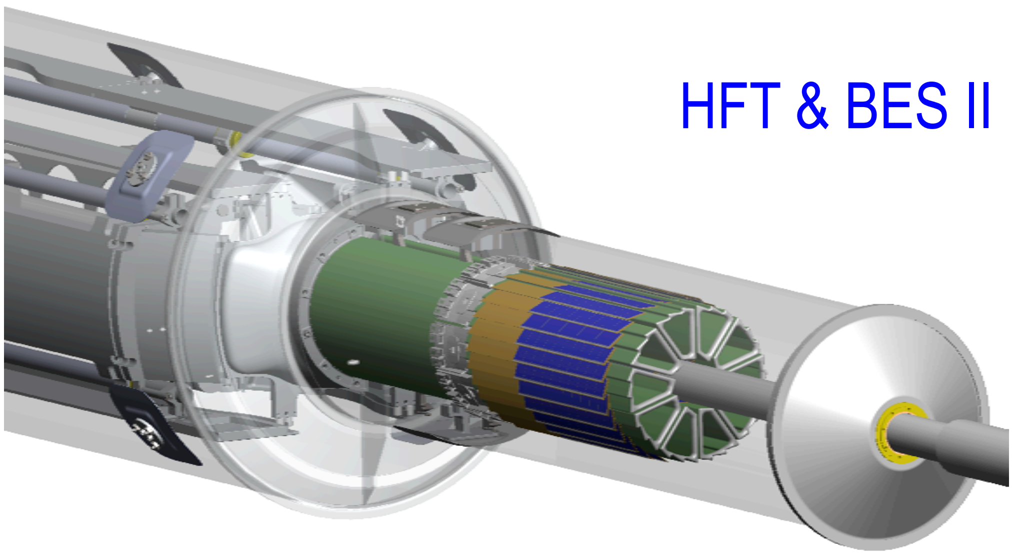


- The full assembly including PXL, IST and SSD should be available for RHIC Run-14, which is planned to be a long Au-Au run

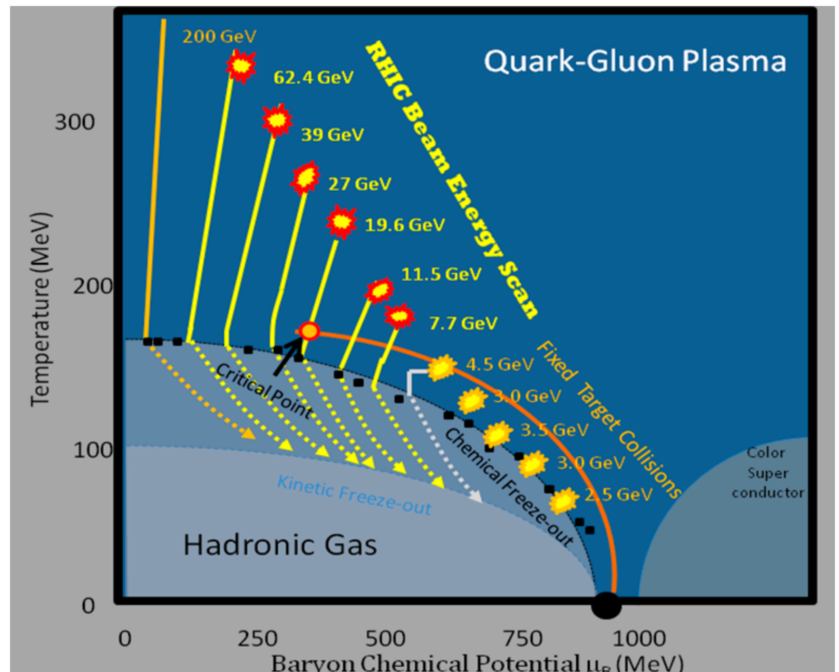
and, of course, will be here for BES II in 2017

So, next few runs are going to be very interesting …

Thank you, Hans Georg !



HFT & BES II



Congratulations
Hans Georg !!!!!

and