# Summary of PHENIX Upgrades

**Axel Drees, Stony Brook University**
**Urbana, July 17th, 2008**

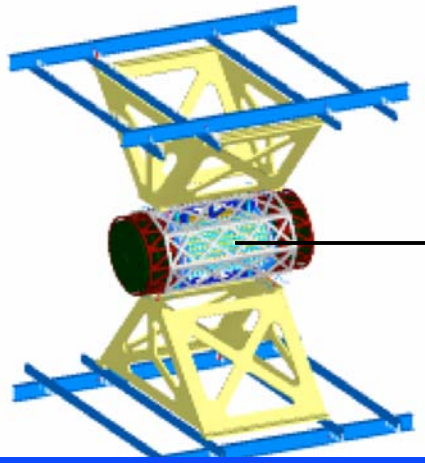
- **Overview of upgrades**
- **Individual projects: Status, Issues and Concerns**
  - **VTX**
  - **FVTX**
  - **NCC**
  - **Muon Trigger**
  - **DAQ/Trigger**
- **Summary and Outlook**

# Detailed Presentations at this Meeting

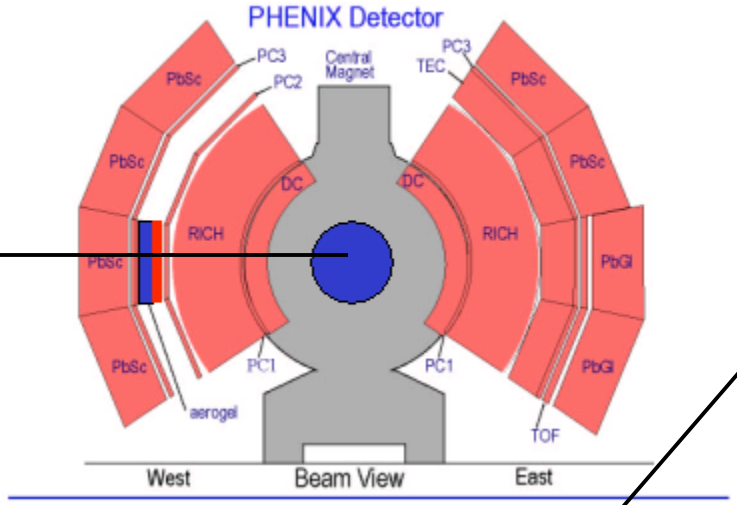
**Technical details and physics goals/performance presented by:**

- **Thursday 17th**
  - 15:30 Physics with the PHENIX Vertex Detector - *Eric Mannel, Columbia*
- **Friday 18th**
  - 9:30 Physics with the Forward Vertex Detector - *Xiorong Wang, NMSU*
  - 11:00 Physics of the NCC Upgrade - *Carla Vale , BNL*
  - 15:30 Proton Structure with W's - *Young Jin Kim, UIUC*
  - 16:30 DAQ Challenges: Luminosity and Detector Upgrades - *John Haggerty, BNL*
  - 17:00 PHENIX Triggering after the RHIC Luminosity Upgrade - *Jamie Nagle, Colorado*

# PHENIX Upgrade Detector Systems

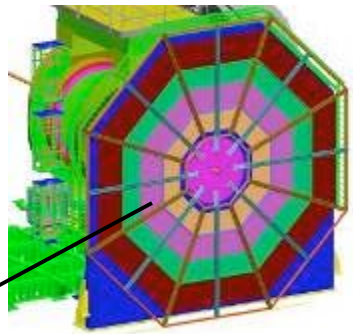


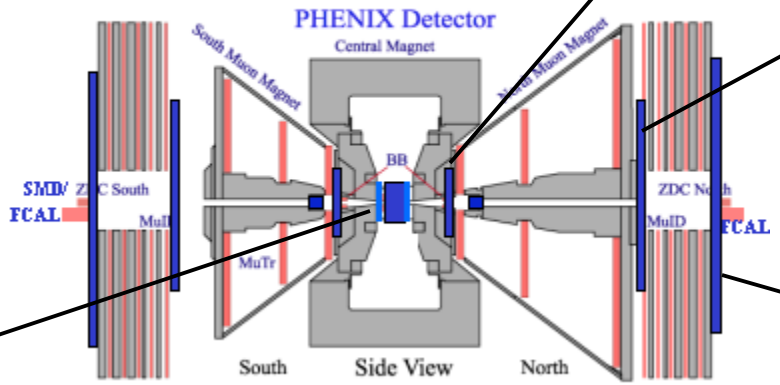
Silicon VTX and FVTX



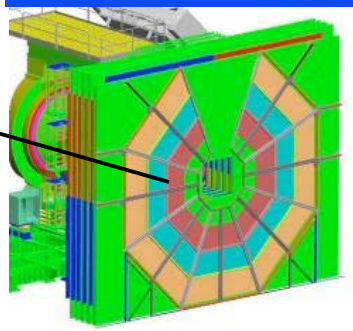

MuTrig Station 1

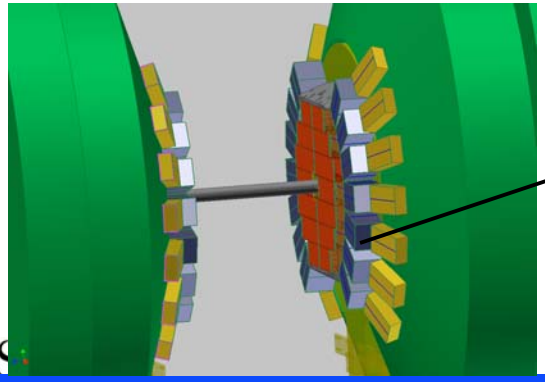
MuTrig Station 2






MuTrig Station 3

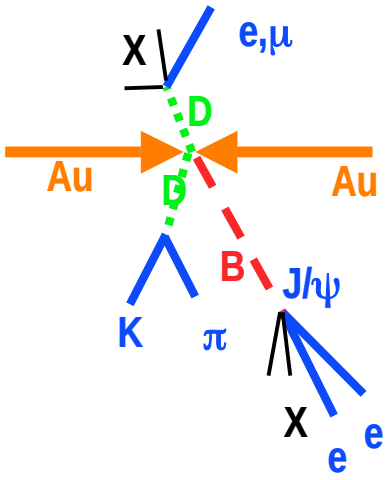


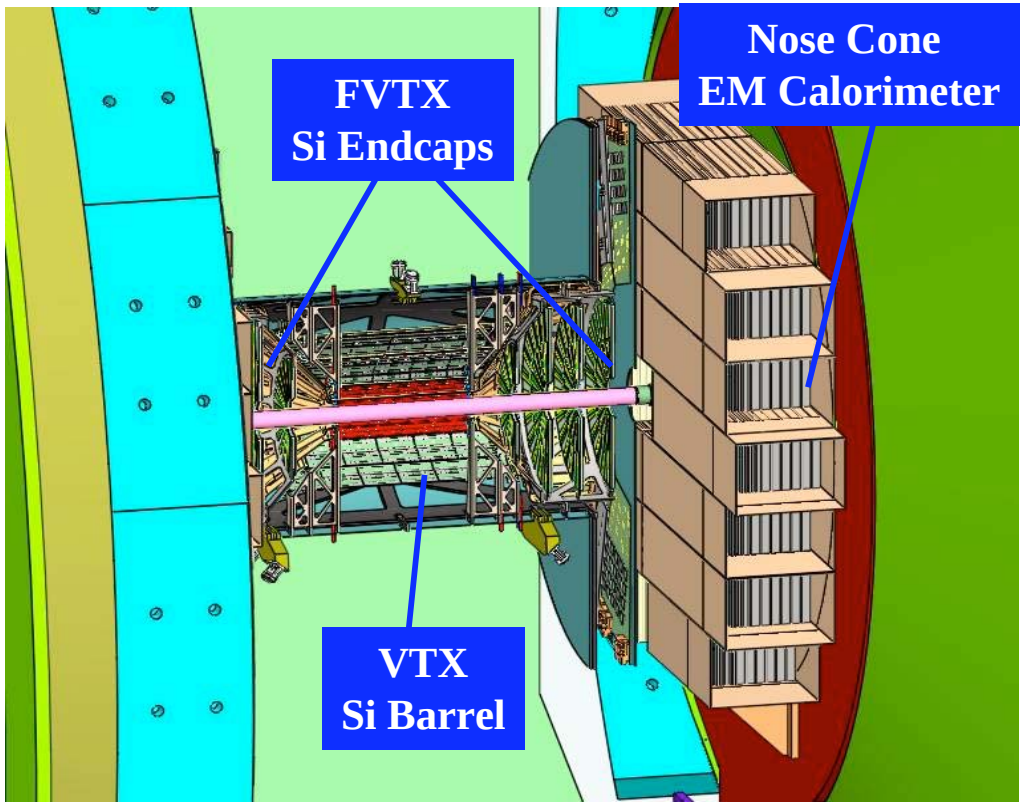


Nose Cone Calorimeter (NCC)

# PHENIX Upgrades in the Vertex Region

**Heavy Flavor with silicon vertex tracking measure decay vertex**
**$-2.4 < \eta < 2.4$**




**$\pi^0$ and direct $\gamma$ with forward EMC Si-W sampling Cal.**
**$1 < \eta < 3$**

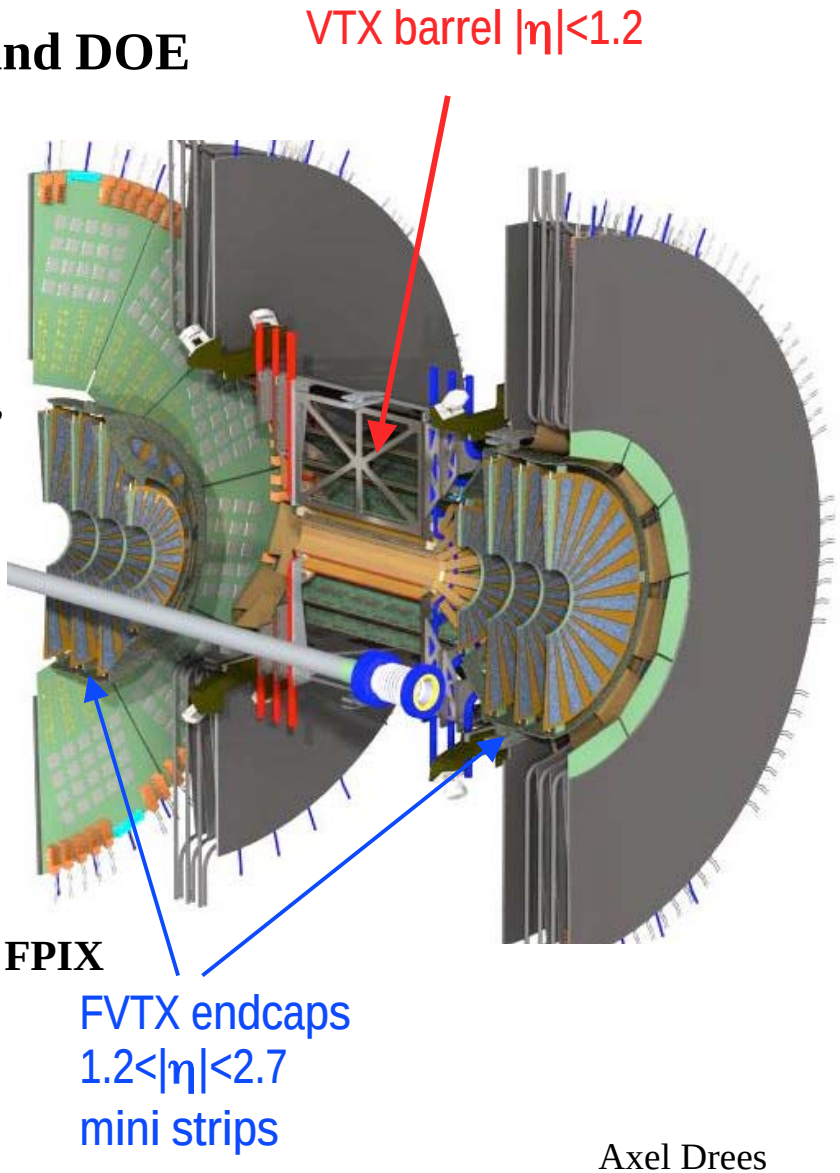
**PHENIX VTX, FVTX and NCC add key measurements to RHIC program:**

- **Heavy quark characteristics in dense medium**
- **Charmonium spectroscopy ($J/\psi$, $\psi'$ , $\chi_c$ and $\Upsilon$)**
- **Light quark/gluon energy loss through $\gamma$-jet**
- **Gluon spin structure ($\Delta G/G$) through $\gamma$-jet and c,b quarks**
- **A-, $p_T$-, x-dependence of the parton structure of nuclei**

# PHENIX Silicon Vertex Tracking Upgrades

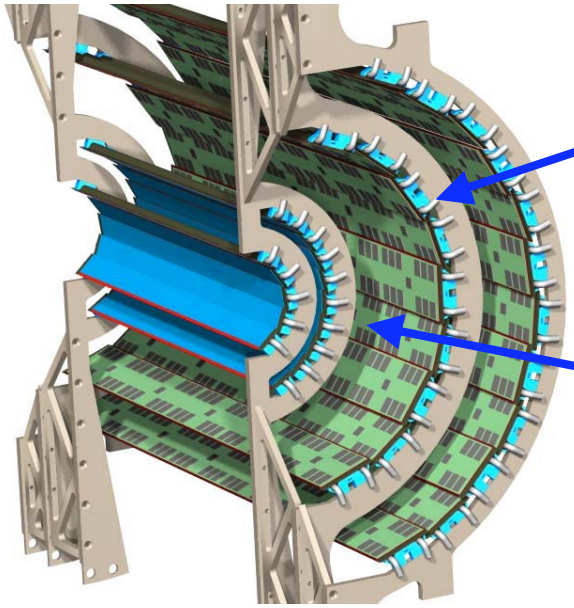
- **VTX: silicon VerTeX barrel tracker**
  **ongoing construction funded by RIKEN and DOE**
  - **2 inner hybrid pixel layers,**
    **Pixel sensor 50μm x 425μm,**
    **ALICE1LHCB chip**
  - **2 outer layers strip sensors,**
    **Novel single sided crossed strip design (BNL),**
    **(80μm x 3cm), SVX4 readout chip**

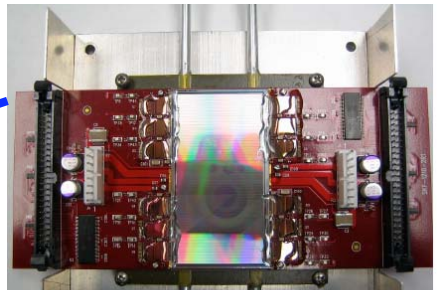
- **FVTX: Forward silicon VerTeX tracker**
  **ongoing construction funded by DOE**
  - **2 endcaps with 4 disks each**
    **pixel pad structure (75μm x 2.8 to 11.2 mm)**
    **FPHX readout chip, next generation FNAL's FPIX**




STONY BROOK

# VTX Status





Prototype strip sensor
+ Read Out Card (ROC3)

Prototype pixel ladder

- **Fully functional prototypes of detectors and readout chains**
- **Beam test at FNAL with 3 pixel and 3 stripixel plains in August**
- **Design of mechanical support structures and assembly procedures ongoing**
- **Planned schedule:**
  - **Pixel layers completed by 2009**
  - **Stripixel layers completed by 2010**
  - **Full system operational for run 11**

STONY BROOK

# VTX: Issues and Concerns

- **First annual review June 9-10 at BNL**

  - **Realistic evaluation of detector performance**

    **Monte Carlo simulation of final system and analysis with full software chain**
    **Effect of increased radiation length (~15% X/X0) on central arm physics**
    **Include realistic noise performance**

    **Full simulation including blind analysis are being prepared**

  - **Stripixel sensors and SVX4 readout cards more challenging than expected**

    **Marginal S/N performance, ROC-3 working only days before review**
    **Assembly of ROC-3 difficult due to component density**

    **Ongoing cosmic ray tests encouraging, beam test planed in August, Redesign of ROC underway, prepare backup plan with conventional strip detectors in parallel → decision how to proceed August/September**

  - **Project delays make schedule very aggressive**

    **Close cooperation of PHENIX and VTX management**

STONY BROOK

# FVTX: Status

- **Technology choices**
  - Standard silicon strip technology
  - "Data-Push" readout chip developed by FNAL (FPHX chip)
  - PHENIX-DAQ-compatible readout
  - Integrated design VTX/FVTX for mechanical structures

**R&D and prototyping ongoing for all components**

- **Time line of project**
  - DOE science review 7/2007
    - **Recommendation: realistic evaluation of detector performance to demonstrate physics performance**
  - Results of simulations submitted to DOE 10/2007
    - **b/c separation; J/ψ and ψ'**
  - DOE cost and schedule review 11/2007
    - **Homework see next page**
  - Management plan in place 4/2008
  - Progress report to DOE due 9/2008
  - First annual review to be scheduled ~11/2008
  - Installation into PHENIX Q2 of FY11

STONY BROOK

# FVTX: Issues and Concerns

- **Issues and concerns:**
  - **Physics performance with realistic full simulation needed soon to confirm sensor geometry before procurement of sensors**

    **Blind analysis challenge in preparation**

  - **FPHX chip development at FNAL (cost & schedule)**
  - **Continuing Resolution in FY09 = challenging funding profile**

- **Homework for progress report**
  - **Evaluate trade-offs between noise level, data volume and trigger requirements, tracking efficiency, and physics performance**
  - **Provide "final" functional requirements that the FVTX system needs to satisfy within reasonable time following project completion in order to achieve the proposed physics goals**

# Blind Analysis Challenge

**Proof of principle to extract signal under (semi) realistic conditions**

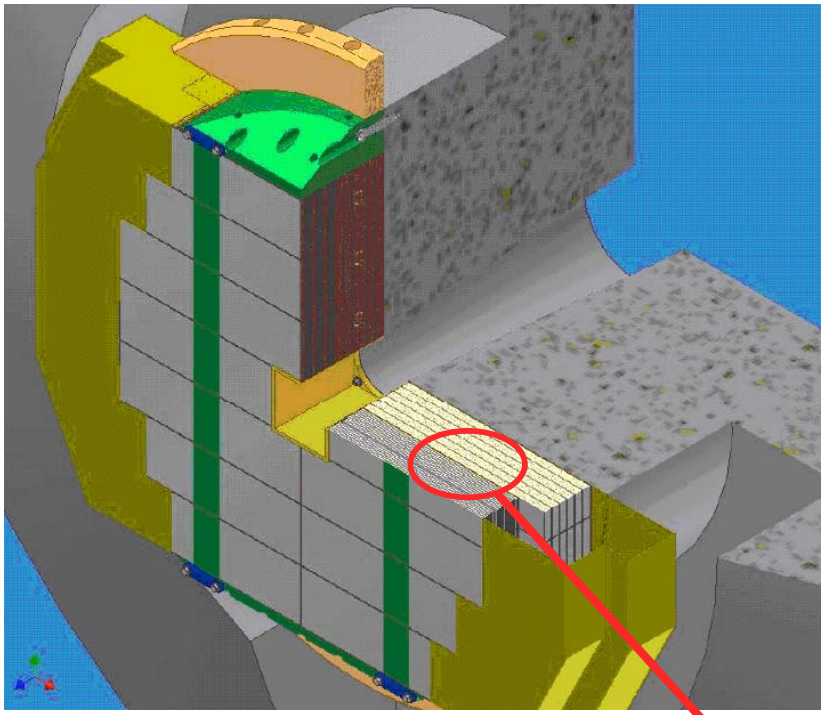
- **Underlying event sample ~1M AuAu Hijing+PISA events**
  - **VTX/FVTX, Central + muon arms**
  - **~3 weeks on 100 CPU's**
- **Signal events (prompt, c and b decays) through PISA**
- **Mix underlying events with signal produce DST's**
  - **Hijing + empty/prompt/c/b, e.g. at rates 10/1/1/5**
- **DST's analyzed by FVTX (VTX) group**

- **Issues to resolve before DST production:**
  - **Finalize and update VTX and FVTX geometry**
  - **Develop mechanism to synchronize vertex position**
  - **Match central and muon are mixing software**
  - **Allocate sufficient resources**

STONY BROOK

# PHENIX Forward EM Calorimeter (NCC)

**W-silicon sampling calorimeter**

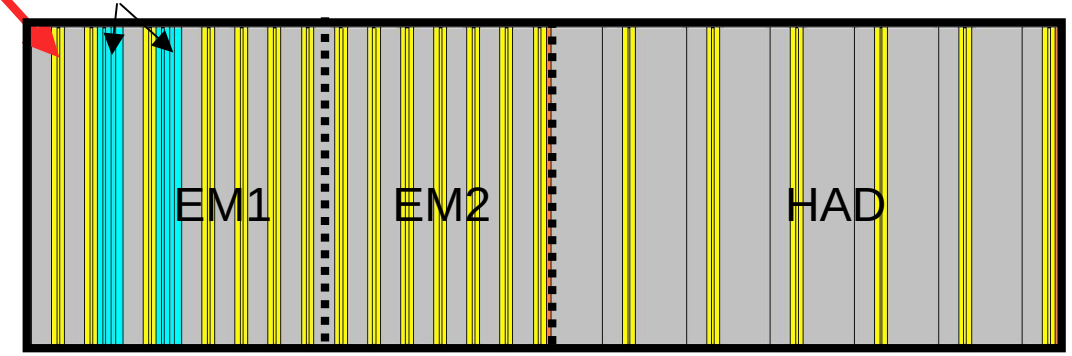


- **NCC characteristics (funding unclear)**
  - **40 cm from interaction point, 20 cm depth**
  - **2π coverage in azimuth and 0.9 < η < 3.0**
  - **W-silicon sampling calorimeter**
    - **1.4 cm Mollier radius**
    - **42 $X_0$ and 1.6 $\lambda_{abs}$**
    - **Lateral segmentation 1.5x1.5 $cm^2$**
    - **3 longitudinal segments**

$$\frac{\sigma_E}{E} = \frac{23\%}{\sqrt{E/GeV}} \oplus 1\%$$

  - **2x2 tracking layers with 500 μm strips**
    - **π–γ separation for overlapping showers**

**PS tracking layers**




**Main objective:**
**direct photon and $\pi^0$ measurements**

STONY BROOK

# DOE Science Review Fall Out

- **DOE Science Review 7/2007 together with FVTX**

  Committee: H.J. Crawford, M.J. Murray, R.L. Ray, P. Reimer, R. Roser, H. F.W. Sadrozinski + DOE E.A. Henry, G. Rai, W.B. Tippens

  - **Each detector group should demonstrate and document scientific feasibility for two or more topics of high importance and submit to DOE for evaluation. PHENIX should submit to DOE a report documenting these studies for evaluation, prior to a technical review.**

  - **The NCC group should demonstrate by simulations that the non-projective geometry and shower digitization does not preclude the ability to eliminate background at the level necessary to accomplish the proposed physics goals. PHENIX should submit to DOE a report documenting these studies for evaluation, prior to a technical review.**

- **Simulations prepared by NCC simulation task force**
  - **focus on $\chi_C$ and $\pi^0$**
  - **We explicitly did not choose $\gamma$-jet**
- **Report submitted 3/2008**
- **No official statement, but its clear that NCC will not be approved at this point in time!**

# What does that mean and what do we do?

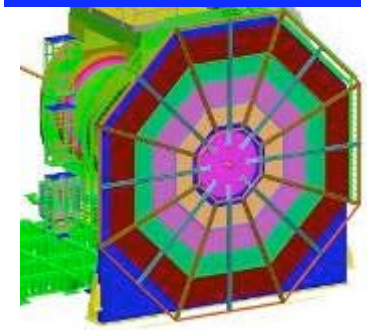
- **We do not exactly know what this mean it!**
- **R&D will continue, expect additional R&D funding from DOE through BNL**
  - **Technical development of calorimeter & electronics well advanced**
  - **Test beam with EM and hadronic section this year at CERN**
  - **Look into construction of "large full scale" prototype for installation in PHENIX**
- **Need to rethink overall plan once we know what the boundary conditions are.**

# Muon Trigger

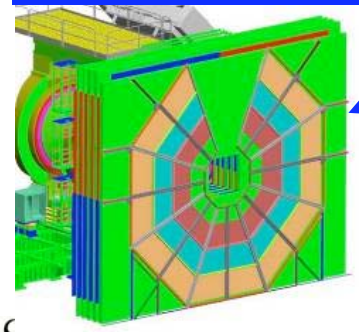
- Add timing and momentum information to LV1 to improve rejection from 200 to 10000
- 6 Stations of Resistive Plate Chambers
  - 3 North, 3 South
- Addition of LVL1 electronics to MuTracker
  - St1, St2 North and St1, St2 South

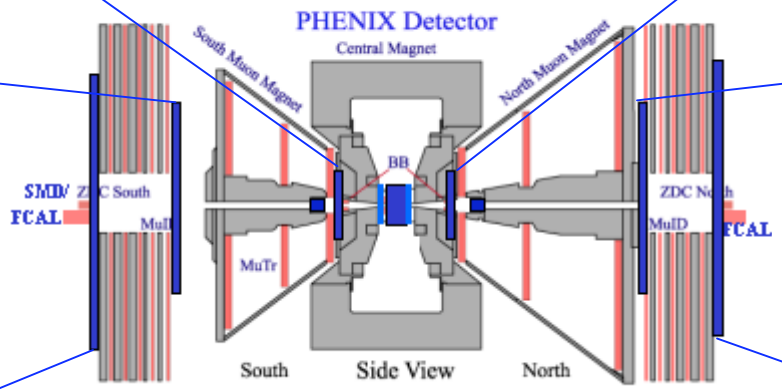
MuTrig Station 1

MuTrig Station 2



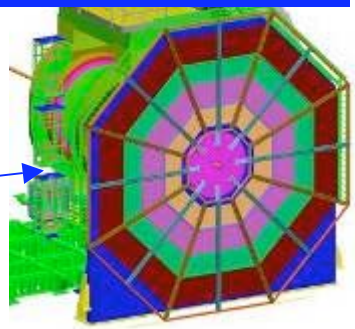
MuTrig Station 3



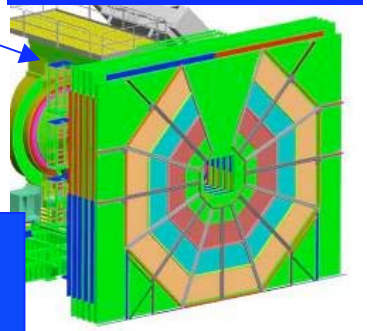



MuTrig Station 1

MuTrig Station 2



MuTrig Station 3



**W-physics (spin structure of quark see) in 500 GeV p+p**

# Muon Trigger Upgrade: Status and Concerns

- **Status: Muon Electronics (funded through Japan)**
  - **Successful in situ test in run 8**
  - **Staged installation starting for 2008 through 2011**
- **Status: RPC's (funded through NSF)**
  - **Factory setup at BNL**
  - **First module (full scale prototype) under construction for run 9**
  - **Staged installation from 2009 to 2012**

- **Concerns:**
  - **Synchronization of p+p 500 GeV RHIC running with availability of MuTrigger**
  - **RPC budget under pressure from changes in exchange rate changes and inflation for Bakelite (Italy), RPC Gas gaps (Korea) and Detector boxes (China)**

- **BNL/PHENIX review July 10/11 2008**
  - **Recommendation: Build RPC station 1 and 3 first with available budget**

STONY BROOK

# Continuous Update and Improvement of DAQ

| Project | Groups | Development Cost (approx.) | Goal | Implementation Cost (approx.) |
|---|---|---|---|---|
| DCM II + jSEB II | Nevis, Colorado | $420k | High bandwidth readout of new subsystems | Board costs in upgrade budgets |
| Event Builder + Network Upgrades | Columbia, BNL | $60k | Develop 10 Gigabit network systems | Full system ~ $500k |
| Buffer boxes | BNL | $50k | Increase data recording capacity | Full system ~ $250 k |
| Upgraded DCM daughter cards | BNL, SUNYSB, Nevis, Colorado | $20k | Investigate improvement in FPGA comp. | No estimate yet. Pending R&D. |
| Demultiplexing | BNL, ORNL | $10k | Test setup to investigate speed doubling option | No estimate yet. Pending R&D. |

STONY BROOK

Total is ~ $400k/year over the next three-four years.

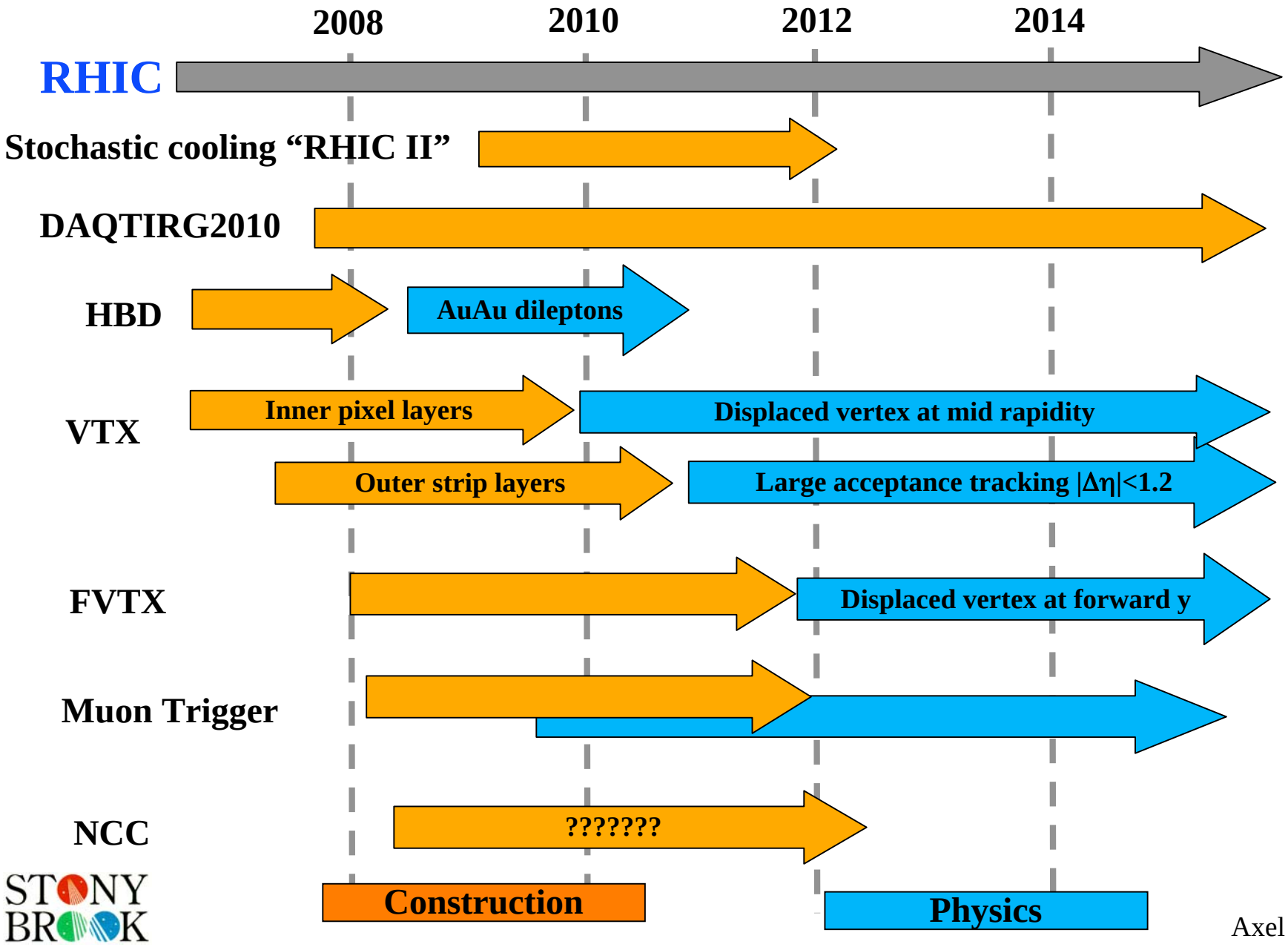
# Trigger developments for RHIC II Luminosity

| Project | Groups | Development Cost (approx.) | Goal | Implementation Cost (approx.) |
|---|---|---|---|---|
| BBC w/ multiple vertex selections | ISU, Nevis | -- | Level-1 trigger capability to select ±10 or ± 30 cm | $50k |
| MuID Trigger FPGA Upgrade | ISU | -- | Allow 2-D muon road finding | Institutional Contribution |
| VTX Interaction Trigger | ISU, ORNL, BNL, SB | $25k | Develop VTX pixel interaction trigger (for pp and low energy) | No estimate yet. Pending R&D. |
| Electron/Photon Trigger Upgrade* | Nevis, Colorado, BNL | $25k | Engineering support to test new calorimeter electronics | No estimate yet. Of order $2M |

* PHENIX is just in an R&D phase and after completed, discussion of possible funding sources needed.

STONY BROOK

# Timeline of PHENIX upgrades




STONY BROOK

# Summary and Outlook

- **Status of upgrades**
  - **VTX, FVTX and muon trigger under construction**
  - **NCC funding unclear, R&D at very advanced state**
  - **DAQ/Trigger continuously being improved, plans developing**

- **Issues and Concerns**
  - **We need more realistic simulations! This has been an issue at ALL reviews over the past year. Establish blind analysis tests.**
  - **Construction projects face some technical challenges, but not out of the ordinary for projects at this stage.**
  - **Cost and schedule challenges require close management overview. This was pointed out at the VTX review but other upgrades face same challenges. The challenge is that PHENIX has moved from Construction → 2000 → Operations → 2008 → Construction/Operation**