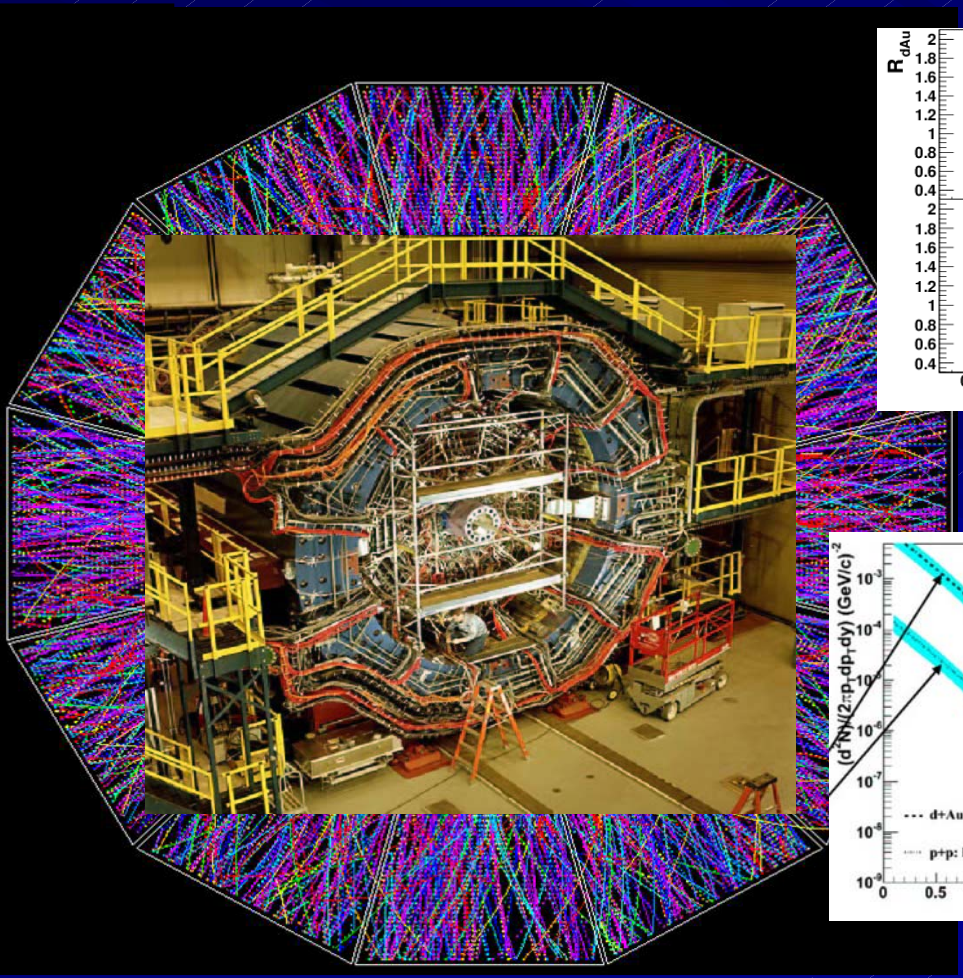
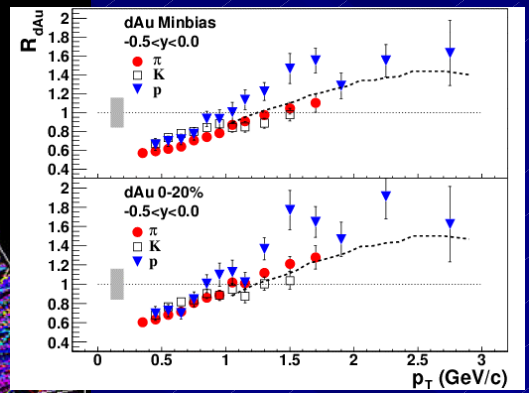
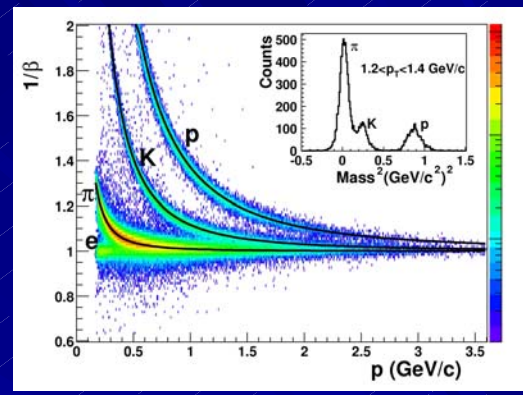
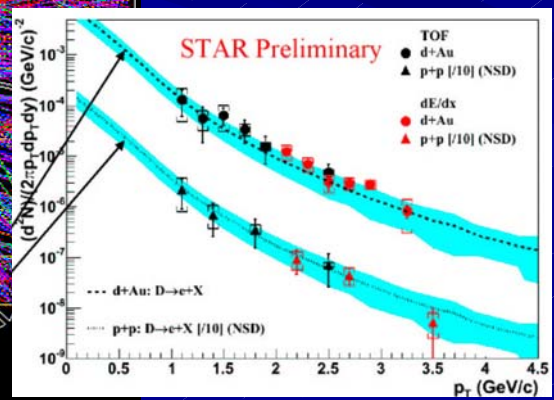
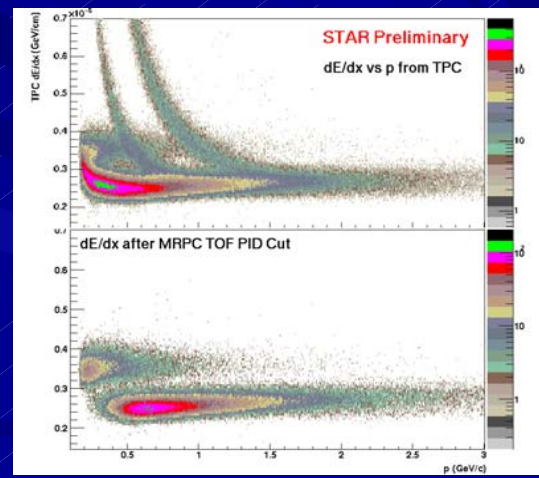
Proposal for a Large Area Time of Flight System For STAR











- TOF Project Overview
- Physics Motivation
- TOF in the RHIC II era
- Project timeline and budget

Proposal for a Large Area Time of Flight System for STAR

STAR-TOF

(The STAR TOF Collaboration)

P. Fachini, Zhangbu Xu
Brookhaven National Laboratory, Upton, NY 11973

Feng Liu, Lianshou Liu, Zhixu Liu, Jinghua Fu,
Yuan Hu, Zhiming Li, Yuanfang Wu, Yan Lu
HuaZhong Normal University, Wuhan, China

Jin Li, Junguang Lu, Bingyun Zhang
Institute of High Energy Physics (IHEP), Beijing, China

Wenlong Zhan, Zhiyu Sun
Institute of Modern Physics (IMP), LanZhou, China

D. Hardtke, F. Retiere, N. Xu
Lawrence Berkeley National Laboratory, Berkeley, CA 94720

L. Kotchenda
Moscow Engineering Physics Institute, Moscow, Russia

J.W. Mitchell
NASA - Goddard Space Flight Center, Greenbelt, MD 20771

G. Paic, E. Cuautle, A. Martinez, G. Calderon
UNAM & CINVESTAV, Mexico City, Mexico

B. Bonner, G. Eppley, F. Geurts, W.J. Llope,
G. Mutchler, T. Nussbaum, J. Roberts, P. Yepes
Rice University, Houston, TX 77005

Wenging Shen, Yugang Ma, Xiangzhou Cai
Shanghai Institute of Nuclear Research (SINR), Shanghai, China

Kejun Kang, Jianping Cheng, Yuanjing Li, Yulan Li, Yi Wang
Tsinghua University, Beijing, China

C. Whitten, H. Huang, G. Igo, V. Ghazikhanian,
S. Trentalange, A. Tai, H. Long
University of California - Los Angeles, Los Angeles, CA 90095

Hongfang Chen, Xin Dong, Xiaolian Wang, Ziping Zhang, Cheng Li,
Lijuan Ruan, Shuwei Ye, Jian Wu, Ming Shao, Shengli Huang
University of Science and Technology of China (USTC), Hefei, China

G. Hoffmann, A. Ishihara, C.F. Moore, L. Ray, J. Schambach, H. Ward,
M. Daugherity, K. Kajimoto, M. McCain
University of Texas, Austin, TX 78712

T. Trainor
University of Washington, Seattle, WA 98195

C. Markert
Yale University, New Haven, CT 06520

STAR TOF Team:

16 institutions

US

Electronics, tray assembly and integration

China

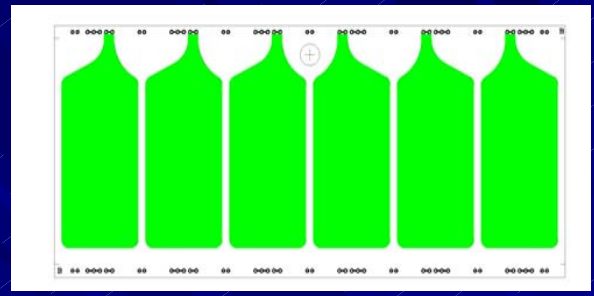
Module construction and QA

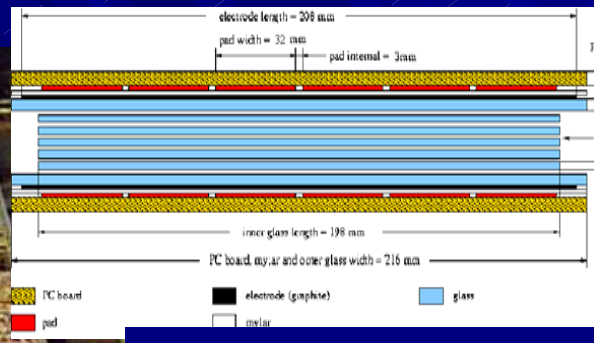
STAR Barrel TOF – Detector Overview

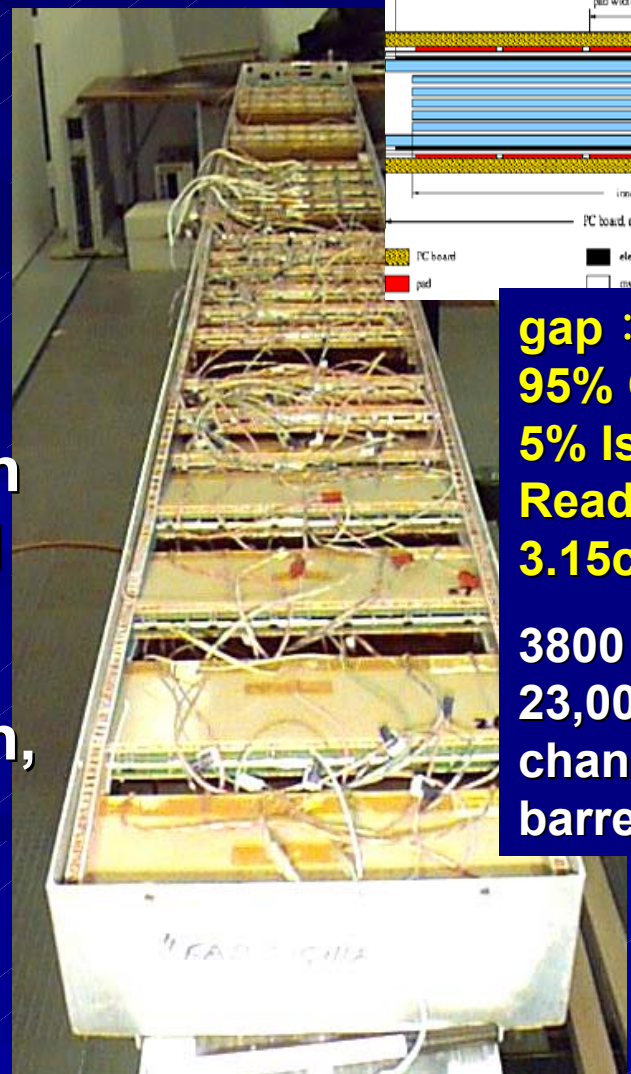
- Multigap Resistive Plate Chamber (MRPC) modules to cover outer barrel of STAR TPC
- $\Delta\tau$ < 100 ps
- Large coverage $-\pi<\phi<\pi$, $-1<\eta<1$, R≈2.1 m
- More than double momentum range of PID (95% of charged particles in acceptance)
- 3800 modules with 23,000 readout channels
- Fast detector – maintains (improves) trigger capability of existing CTB scintillators.

For RHIC run 3, one tray installed in STAR

- 28 MRPC modules
- 72 chan. of readout using final FEE components on prototype boards connected to CAMAC digitizers
- Run 4: Tray rebuilt using simplified mechanical design and prototype final front end electronics.
- Run5: Improved tray design, prototype layout using HPTDC and prototype cooling.



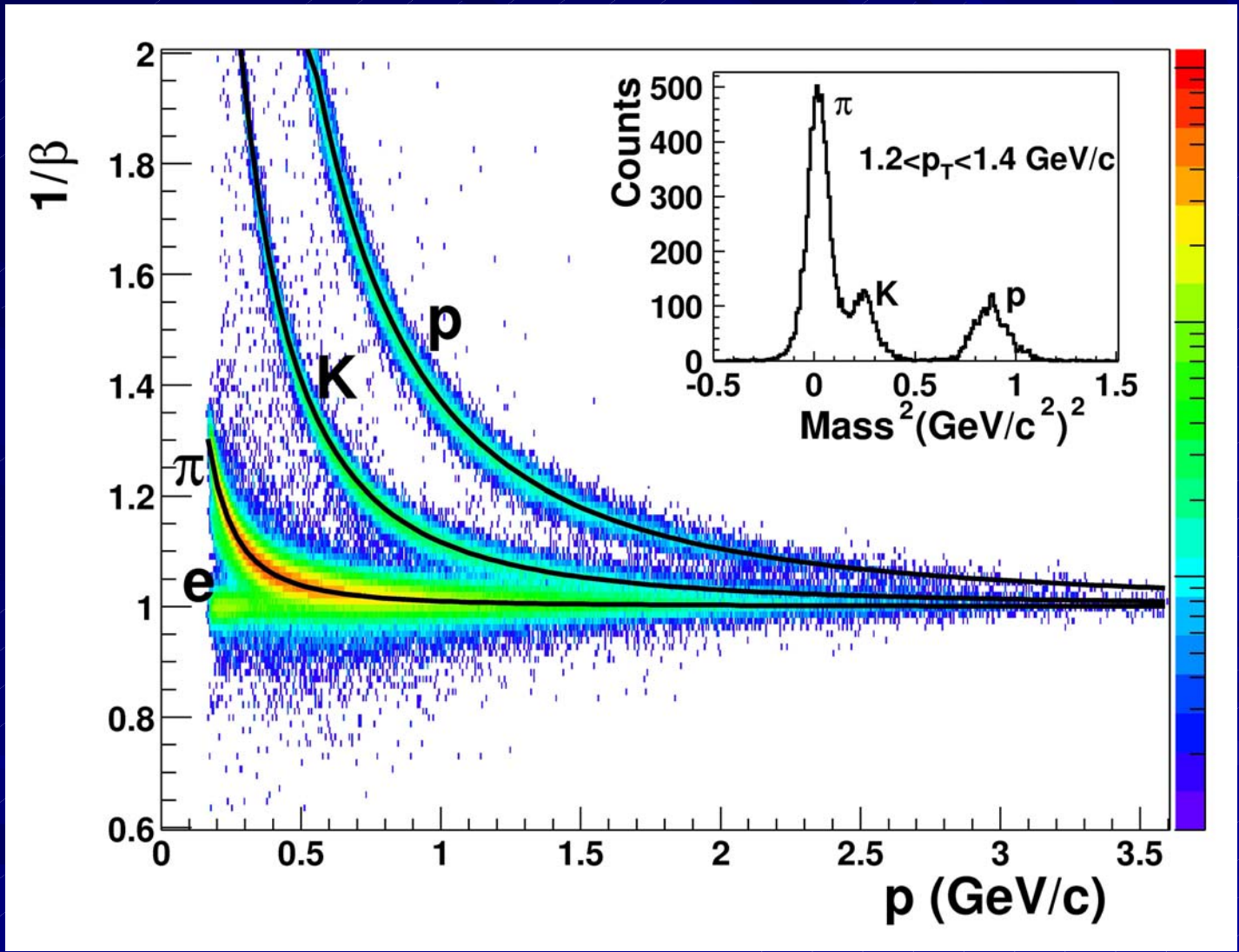




gap：6×0.22mm
95% $C_2H_2F_4$
5% Iso-butane
Read out pad size:
3.15cm×6.3cm

3800 modules, 23,000 readout chan. to cover TPC barrel

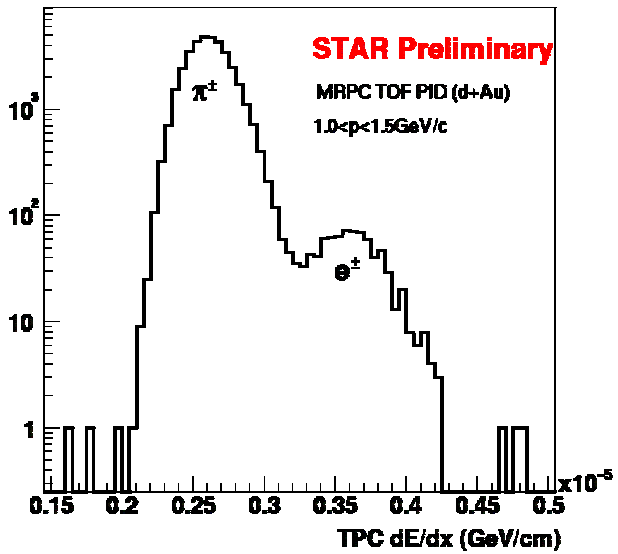
From TOF Triggered Data in d-Au Collisions



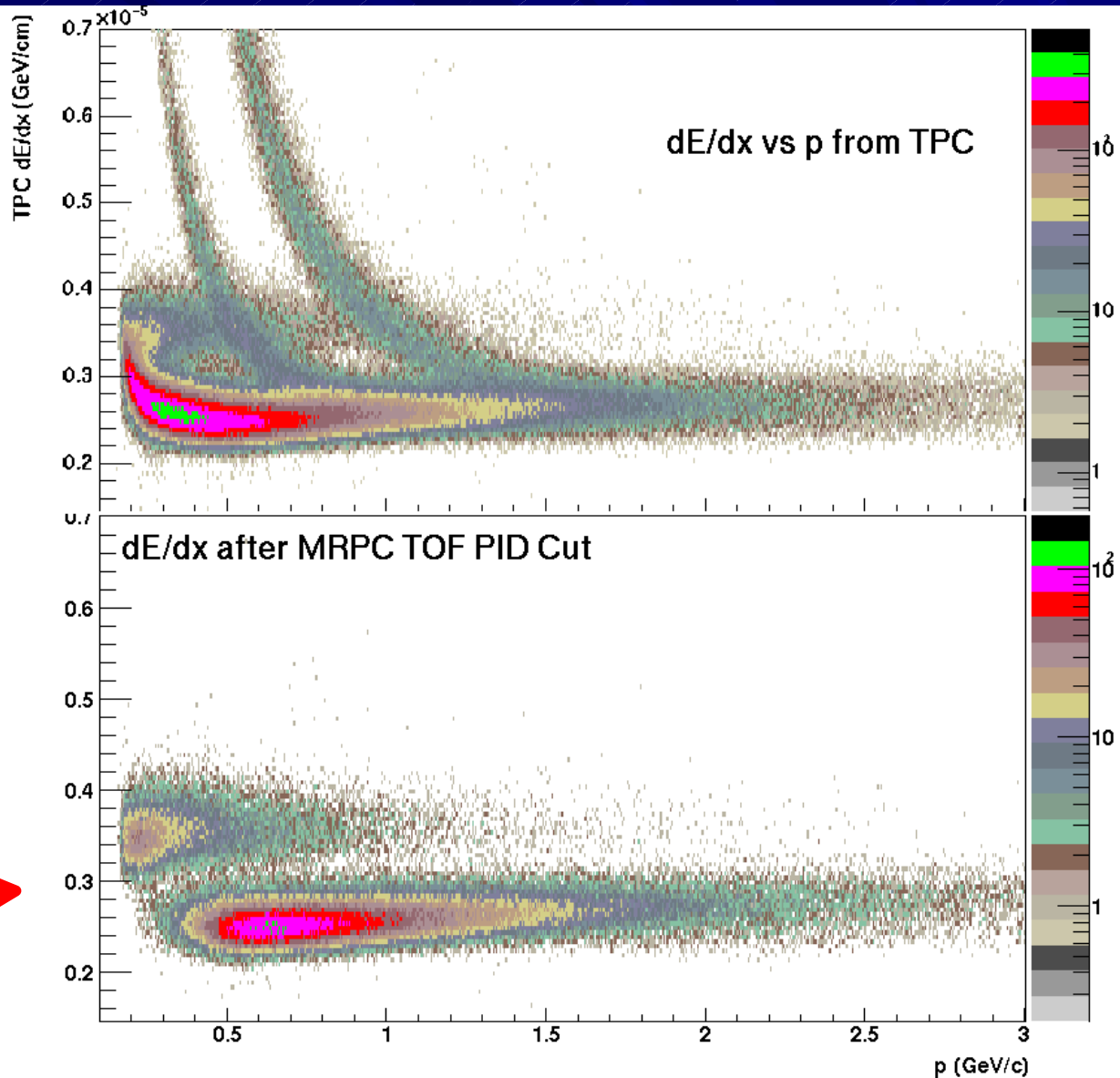
π/K separation p~1.6GeV/c, p/(K+π) p~3GeV/c

Electron tag from combining TPC dE/dx and TOF

TPC dE/dx for all tracks



TPC dE/dx for tracks with TOF $\beta \sim 1$



Physics Measurements which require or benefit from TOF

Measurement	Physics Goal
Elliptic flow for hadrons with no light valence quarks	Evidence of partonic collectivity and thermalization
Charmed hadron flow and yield ratios	Partonic collectivity and charmed quark thermalization
Fluctuation/ correlation studies with PID	Distinguish QCD dynamical effects on temperature and velocity distributions
Away-side jet fragmentation yields, spectra	Search for effects of chiral and $U_A(1)$ symmetry restoration
Λ^o longitudinal polarization correlations	CP violation search
Yields, spectra of high-mass resonances	Duration and properties of the late-stage hadronic medium

Physics Measurements which require or benefit from TOF *(cont.)*

Measurement	Physics Goal
Unlike-particle (e.g., π-Ξ) correlations	Spatial and temporal distributions of hadron production
Exotic Particle searches (pentaquark, Ω–Ω, H)	QCD and spectroscopy beyond qqq and $q\bar{q}$ states
Heavy quark jets; D,B-meson spectra at high p_T	Energy loss of heavy vs. light quarks in partonic matter
Lepton, di-Lepton Spectra, Vector Meson e^+e^- decays (charm yield, flow)	In medium modification, Partonic collectivity
e^+e^- pair production in UPC	Strong field QED effects

Some Examples of Benefit from TOF:

- **Charmed Meson yields, spectra, flow:** For low to moderate p_T TOF reduces required data volume (running time) by 2.5 to 5.
- **Resonance studies:** For low to moderate p_T TOF reduces required data volume (running time) by 2 to 11
- **Particle correlation Studies: TOF enables** untangling temperature vs. velocity
- **Low energy di-lepton spectra:** Enabled by TOF.

TOF and RHIC II:

The detector is designed to operate at full RHIC II luminosity.

Technical benefit for high luminosity operation: 23,000 chan. of fast detector covering TPC outer barrel gives good rejection for pile-up tracks in TPC

The following physics measurements will benefit from higher luminosity, although they will start before RHIC II operation.

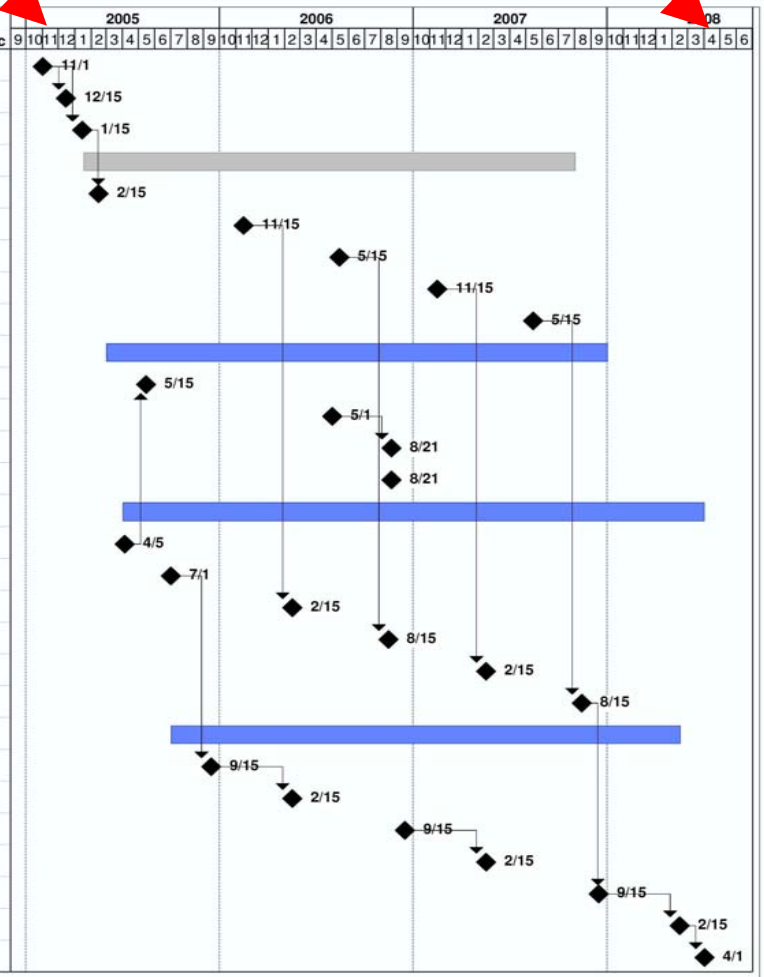
Measurement	Physics Goal
Away-side jet fragmentation yields, spectra	Search for effects of chiral and $U_A(1)$ symmetry restoration
Λ^o longitudinal polarization correlations	CP violation search
Heavy quark jets; D,B-meson spectra at high p_T	Energy loss of heavy vs. light quarks in partonic matter

Proposed Budget and Schedule

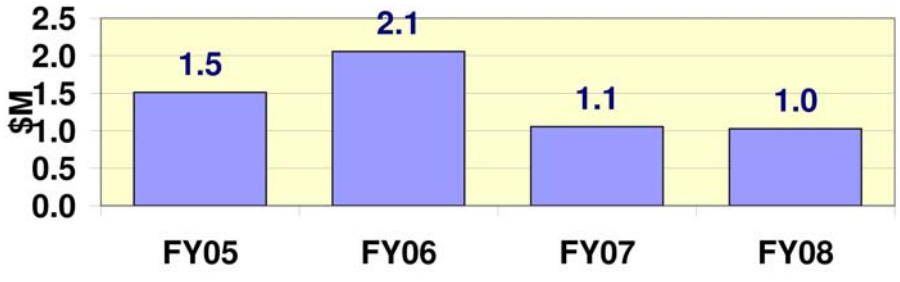
Nov. 2004

Apr. 2008

ID	Task Name	Duration	Start	Finish	Predec
1	Project funding approved	0d	11/1/04	11/1/04	
2	Order HPTDC chips	0d	12/15/04	12/15/04	1
3	Project accounts open	0d	1/15/05	1/15/05	1
4	MRPC Modules	663d	1/17/05	8/1/07	
5	MRPC construction begins	0d	2/15/05	2/15/05	3
6	20% of 3840 MRPCs complete	0d	11/15/05	11/15/05	
7	40% of 3840 MRPCs complete	0d	5/15/06	5/15/06	
8	65% of 3840 MRPCs complete	0d	11/15/06	11/15/06	
9	3840 MRPCs complete	0d	5/15/07	5/15/07	
10	Detectors & Mechanical Systems	675d	3/1/05	10/1/07	
11	Tray assembly begins	0d	5/15/05	5/15/05	16
12	Gas system design complete	0d	5/1/06	5/1/06	
13	Gas system complete	0d	8/21/06	8/21/06	12
14	Start Detector complete	0d	8/21/06	8/21/06	
15	Electronics	782d	4/1/05	3/31/08	
16	TAMP,TDIG R&D complete	0d	4/5/05	4/5/05	
17	TCPU, THUB, TMIT,DAQ R&D complete	0d	7/1/05	7/1/05	
18	20% of 120 Trays complete	0d	2/15/06	2/15/06	6
19	40% of 120 Trays complete	0d	8/15/06	8/15/06	7
20	65% of 120 Trays complete	0d	2/15/07	2/15/07	8
21	120 trays complete	0d	8/15/07	8/15/07	9
22	System Installation and Commissioning	686d	7/1/05	2/15/08	
23	4-tray system installed	0d	9/15/05	9/15/05	17
24	4-tray system commissioned	0d	2/15/06	2/15/06	23
25	48-tray system installed	0d	9/15/06	9/15/06	
26	48-tray system commissioned	0d	2/15/07	2/15/07	25
27	120-tray system installed	0d	9/15/07	9/15/07	21
28	120-tray system commissioned	0d	2/15/08	2/15/08	27
29	Project complete	0d	4/1/08	4/1/08	28



Total DOE Request
$4.7M



Key points from time line:

- Construction funding in FY05
- Construction, Installation and Commissioning FY05 – FY08 (Full system installed by 9/15/07)
- Partial (and increasing) coverage (and physics capability) available during construction phase.
- Chinese funding coordinated with US DOE funding

MRPC ToF Upgrade

Doubles the momentum range of PID over the STAR TPC acceptance. Exciting physics results even from one prototype tray.

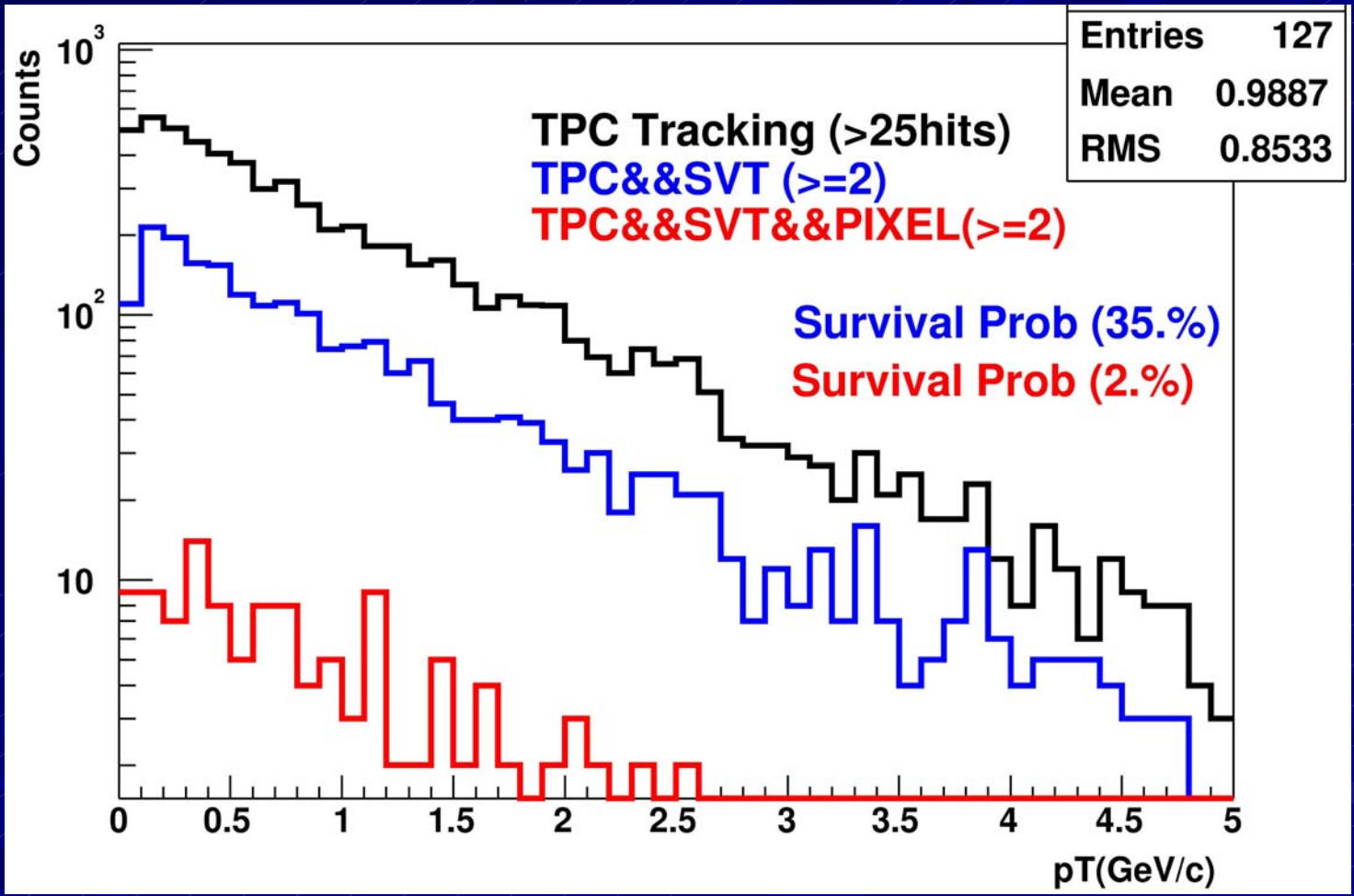
Impacts a wide array of key physics measurements in STAR (*Proposal for a Large Area Time of Flight System for STAR*, pp. 14-52):

Enabling technology

- Low-moderate energy $e^{\pm}$
- Charm flow (even better with pixel detector)

Comprehensive measurements in reasonable length runs

- Large acceptance for jet tomography – fate of the away side jet.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Mean 0.9887
RMS 0.8533
TPC Tracking (>25hits)
TPC&&SVT (>=2)
TPC&&SVT&&PIXEL(>=2)
Survival Prob (35.%)
Survival Prob (2.%)
Counts
10^3
10^2
10
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
pT(GeV/c)