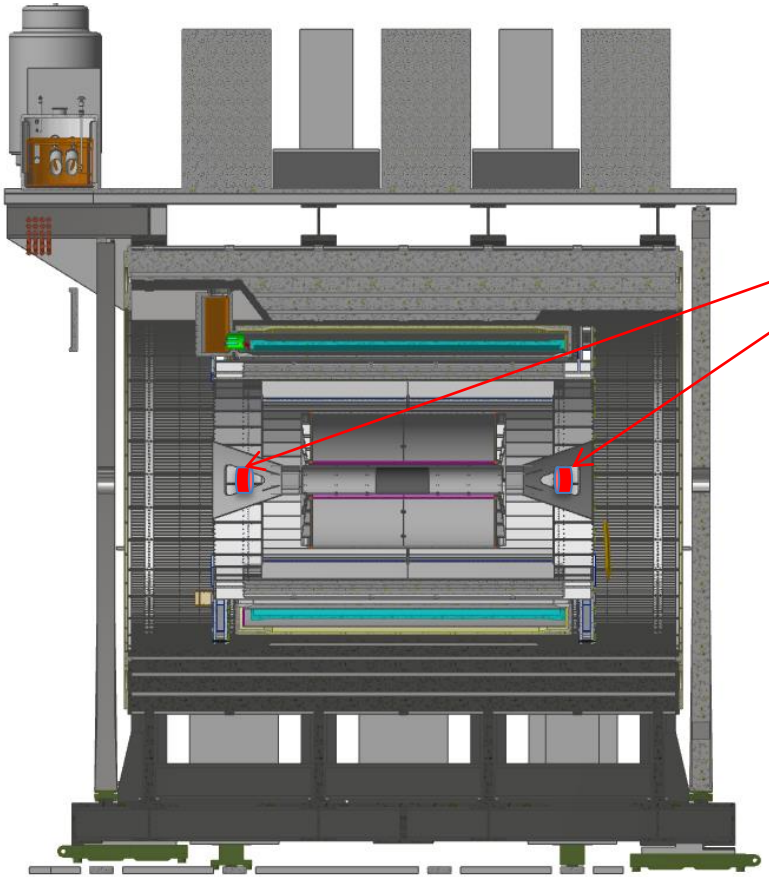
sPHENIX Annual MIE Review
WBS 1.7: Minimum Bias Detector

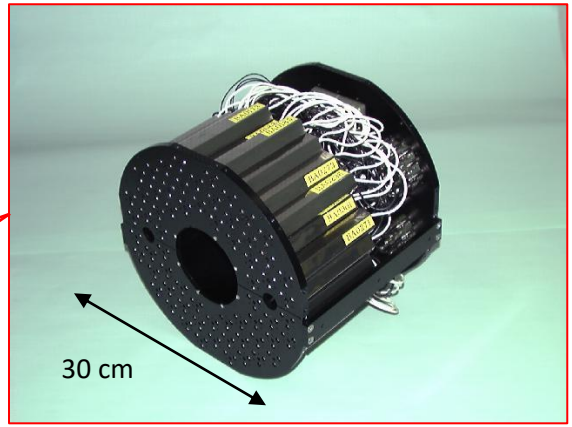
Mickey Chiu

July 14-15, 2021

BNL

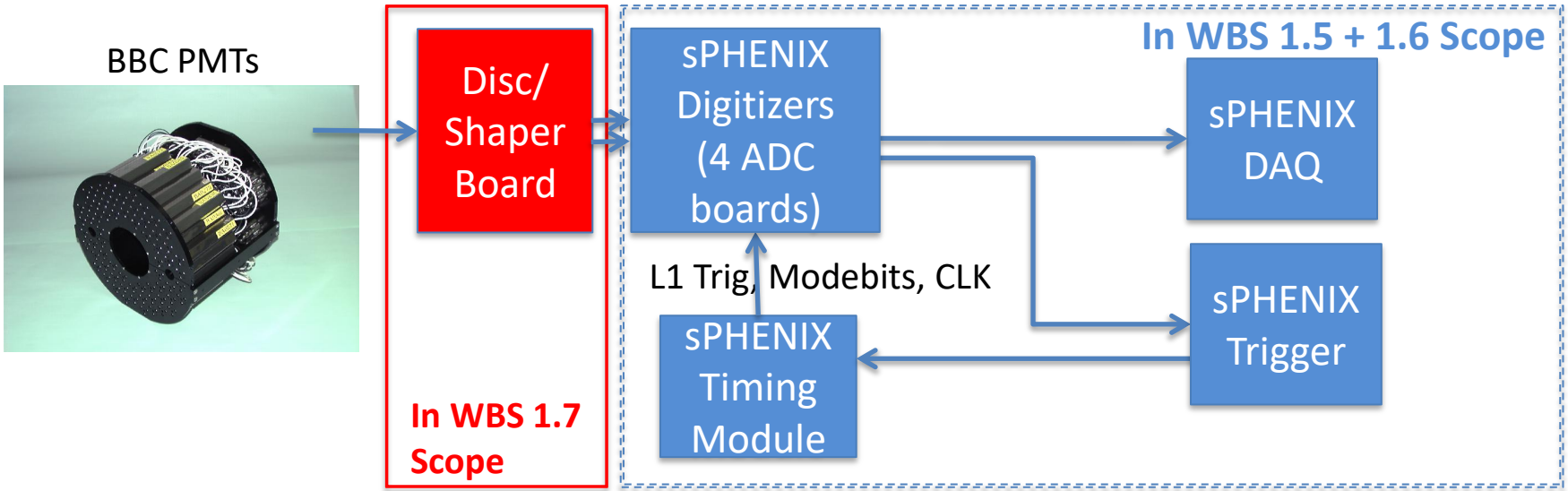
Minimum Bias Detector





1. Provide minimum-bias trigger with high efficiency for heavy ion collisions (>90%)
2. Reuse of PHENIX BBC to provide high quality, cost effective MB solution, covers $3.5<|\eta|<4.5$
3. Contributes to centrality, reaction plane, start time, and interaction vertex

MBD Technical Overview & Scope



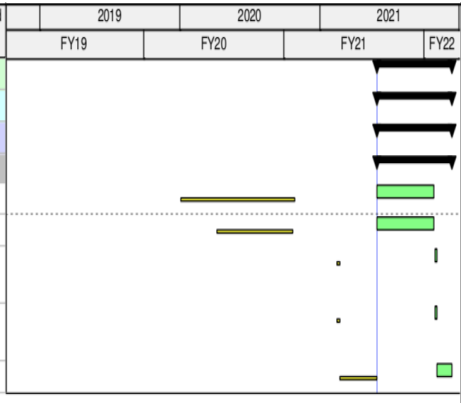
- Use sPHENIX EMCAL digitizers, and build a transition board to convert single-ended PMT signal to 100 ohm differential that stretches PMT signal to be recorded by 60 MHz ADC
- To satisfy the trigger and timing requirements, we process the PMT signal to produce
  - A shaped pulse for energy measurement
  - A ~1V discriminator signal (for timing at trigger level and precision timing in offline).

MBD Subsystem Collaborators

1. BNL — M. Chiu, R. Pisani
   - **Project L2 Lead, detector and electronics testing, simulation**
2. RIKEN — Y. Goto
   - **PHENIX BBCs**
3. Nevis/Columbia — C.Y. Chi, W. Sippach
   - **Disc/Shaper Board**
4. Florida A&M University — C. Scarlett
   - **Detector and electronics testing, simulation, operations support**
5. Howard University — M. Alfred
   - **Detector and electronics testing, simulation, operations support**

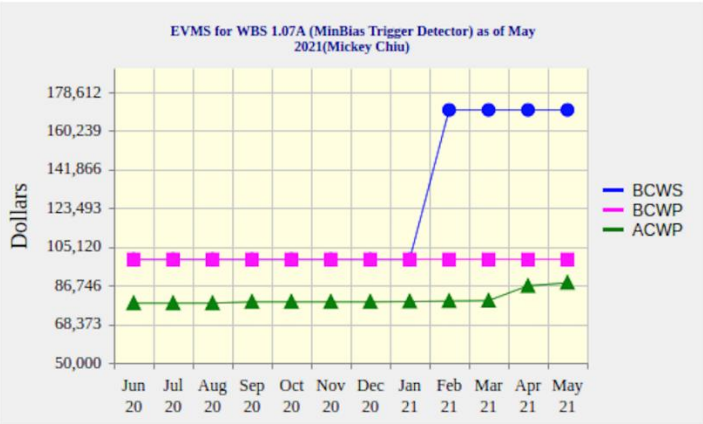
Schedule Performance and Schedule To Go

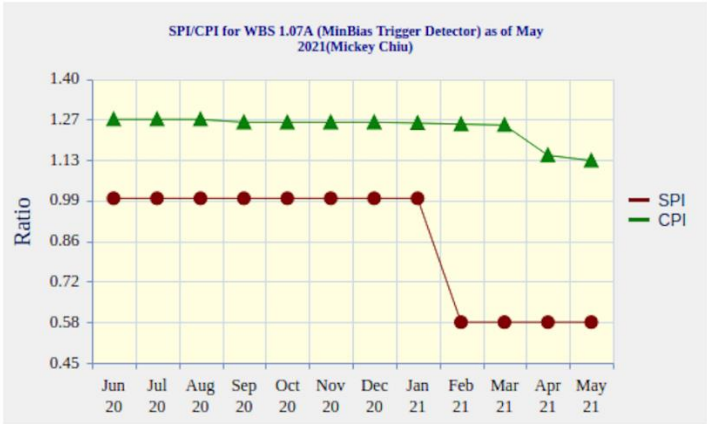
Activity ID	Activity Name	At Completion Duration	Activity % Complete	Start	Finish	BL Project Start	BL Project Finish	Budgeted Labor Units	Budgeted Nonlabor Units	Budgeted Total Cost	BL Project Total Cost	BNL_Accou Number	BNL_Fund Source
Mickey Chiu (BNL)		135		01-Jun-21	14-Dec-21	03-Jan-20	01-Jun-21	128	61190	86,206	84,378		
POM02 sPHENIX WBS 1.x, 2.x May 2021		135		01-Jun-21	14-Dec-21	03-Jan-20	01-Jun-21	128	61190	86,206	84,378		
MIE Project		135		01-Jun-21	14-Dec-21	03-Jan-20	01-Jun-21	128	61190	86,206	84,378		
Min Bias Trigger Detector		135		01-Jun-21	14-Dec-21	03-Jan-20	01-Jun-21	128	61190	86,206	84,378		
S273700	Oversight of sPHENIX MBD Digitizers Procurement	105	0%	01-Jun-21	28-Oct-21	03-Jan-20	29-Oct-20	16	0	2,852	2,762	16714	B
S273400	Procure Min/Bias Electronics - Contract/PO - Leadtime	105	0%	01-Jun-21	28-Oct-21	07-Apr-20	22-Oct-20	0	0	0	0		
S273500	Procure Min/Bias Electronics (sPHENIX Production Digitizers) - Delivery Acceptance	5	0%	29-Oct-21	04-Nov-21	16-Feb-21	22-Feb-21	0	14770	17,486	17,143	59722	A-TEC
S273600	Procure MBD Shaper/Disc Board 128 Channels - Delivery Acceptance	5	0%	29-Oct-21	04-Nov-21	16-Feb-21	22-Feb-21	0	46420	54,957	53,879	59722	A-TEC
S273800	Test Full Min/Bias Electronics	25	0%	05-Nov-21	14-Dec-21	23-Feb-21	01-Jun-21	112	0	10,912	10,594	16714	B_T



- In the middle of doing full chain test with prototype electronics
- MBD Digitizer Boards in production, expected in Jan ’22
- Full Production of MBD Disc/Shaper scheduled for Nov ’21

Cost Performance and Cost To Go





BAC: $170,170 **EAC:** $160,411 **VAC:** $9,759

- Cost Performance to Date:
  - Disc/Shaper production is later than expected
- Cost to go
  - MBD Digitizers were placed in large order w/ rest of sPHENIX
  - Production of Final MBD Disc/Shaper Boards now expected Nov‘21

Status of Reviews

MBD PDR and FDRASR
Wednesday May 8, 2019, 9:30 AM → 4:00 PM US/Eastern

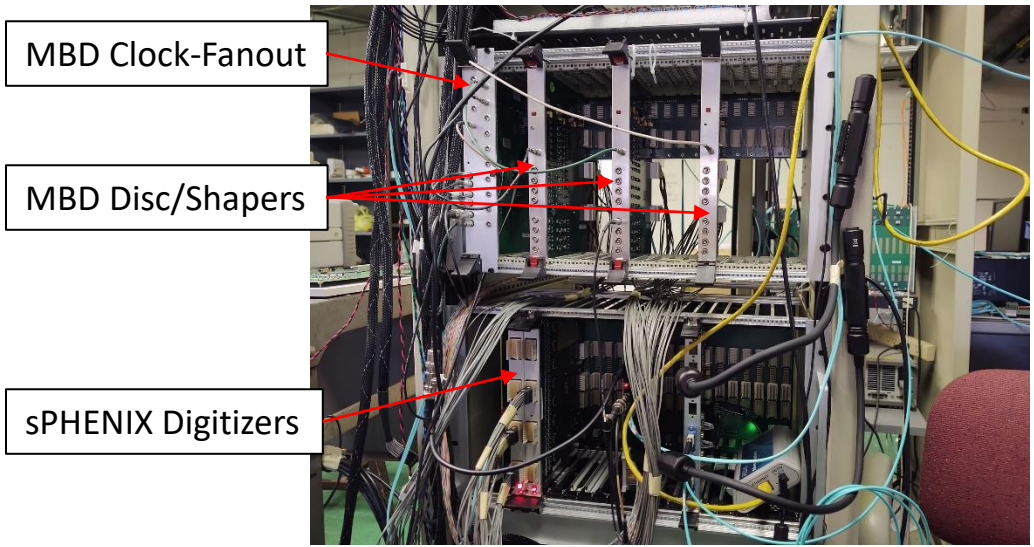
AC and DC Power Distribution Preliminary Design Review
Wednesday Jun 17, 2020, 10:00 AM → 12:10 PM US/Eastern

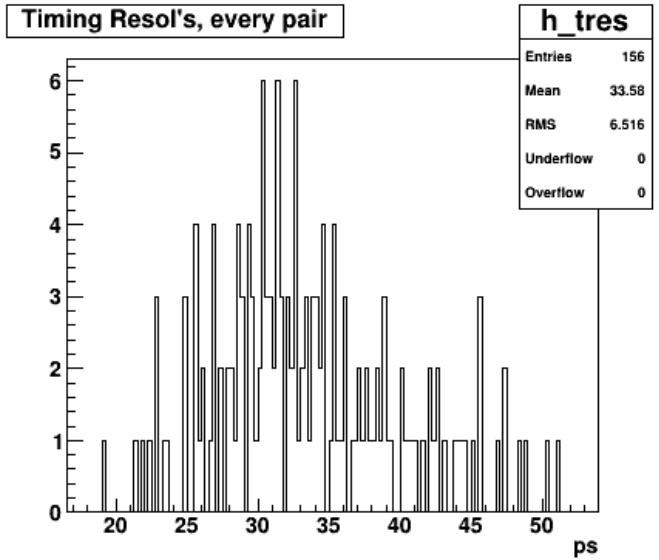
ESRC Review of sPHENIX AC and DC Power Distribution
Wednesday Jul 15, 2020, 10:00 AM → 12:10 PM US/Eastern

MBD Electronics Final Design Review
Monday Feb 8, 2021, 1:30 PM → 3:30 PM US/Eastern

- One recommendation from the FDR was to do a chain test with the BBC PMT and the exact signal cables to be used in the experiment
- Test stand currently being set up at BNL after receiving prototypes from Nevis a couple of weeks ago

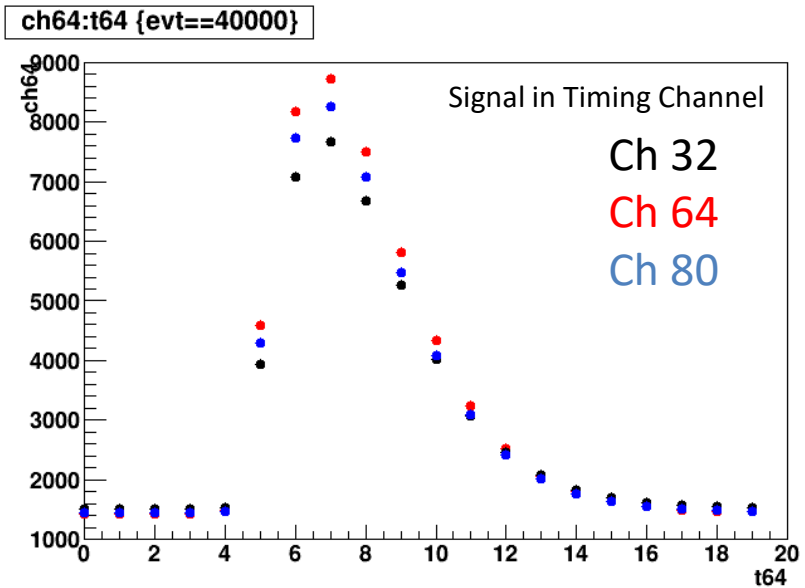
Status and Highlights – Test Results



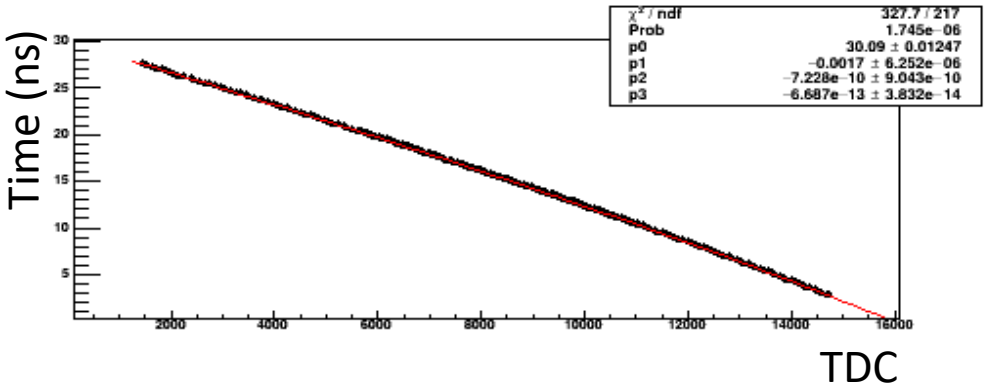


- Use time diff between two channels reading out the same test pulse to determine the time resolution of the electronics chain
- Sub-120 ps is our goal for the trigger, 30 ps is what we achieved in PHENIX, achieving about 34 ps here
- Testing looked at cross-talk and interference within and between boards, stability over time, cross-checks of calibration to look for temperature dependent effects

Status and Highlights – Test Results



Pol3 fit to delay steps calibration curve



- sPHENIX MBD Trigger relies on time measurement (done via timing channel)
- Time measured by producing a shaped pulse whose amplitude depends on arrival time
- Tested simple algorithm to extract time, using just peak of sampled shaped pulse that is corrected for non-linearity by calibration

ES&H

- MBD ESRC Review scheduled for Oct 18, 2021

- MBD Detector follows all the safety protocols that were established during PHENIX running
  - Reusing PHENIX BBC cables, thermocouples, Air/N_2 cooling system
  - Needs to be updated to new sPHENIX safety interface
  - New Discriminator/Shaper and Clock Fanout Boards follows established safety protocols
    - LV custom electronics board, properly fused

- Testing at Nevis was done in accordance with safety protocols at Nevis

Risks: Issues and Concerns

Risk Identification			Risk Handling Plan (Mitigations)	Residual Risk (Post- Mitigation Assessment)									
Risk ID Number	Risk Title	IF/THEN	Risk Handling Plan (Mitigations)	Residual Risk	Low Cost Impact	Likely Cost Impact	High Cost Impact	Low Schedule	Likely Schedule	High Schedule	Overall Impact Score	Expected Value	Average Expected
MinBias_001	Failure of D/S Board Prototype	If the D/S Board does not meet specifications, then we need to redesign to more conservative design	Work with the vendor, Columbia University	10%	0	0	0	0.0	2.0	3.0	Negligible	0.00	0.00
MinBias_002	Nevis Labor not available	If Nevis labor is not available, then there will be schedule delays.	Work with the vendor, Columbia University	50%	35	70	105	1.0	3.0	6.0	Low	35.00	35.00

- Prototyping of Disc/Shaper boards done except for final chain test with BBC PMT
  - Required a 2nd prototype of Clock Fanout board to add fine delay circuit that enables in-situ timing calibration
- Production is single source at Nevis
  - Kept as a risk because COVID could resurface, for example
  - Likely much of the production could be managed by Nevis scientists/engineers working remotely
  - However, as a mitigating factor, production can be handled by BNL if needed

Summary

- Testing of prototypes for new electronics successful on test bench
  - **Requires one last chain test, which is now in progress at BNL**
- Production boards expected in November 2021
- Discussions on implementation of L1 trigger now advanced
- At least 3 Grad students from Howard and FAMU identified to help with production board testing, as well as installation, commissioning, and operations support
- Integration of MBD in sPHENIX progressing
  - Beampipe mods, MBD mechanical supports, installation of Si Trackers