

sPHENIX Annual MIE Review

EMCAL Subsystem Status

Craig Woody

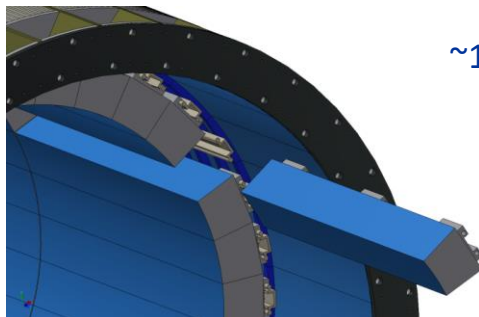
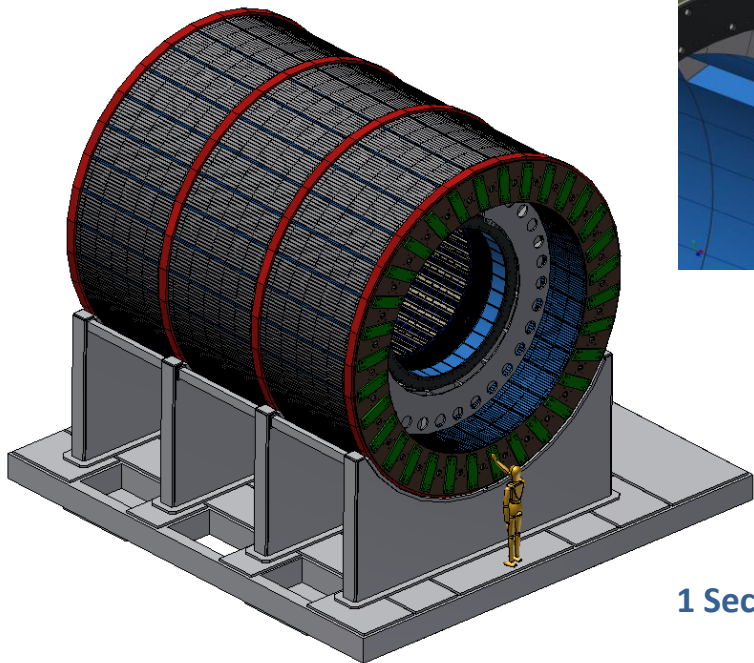
July 14-15, 2021

BNL

EMCAL Subsystem (WBS 1.3)

Electromagnetic calorimeter covering ± 0.85 in η and 2π in ϕ

$$2(\pm\eta) \times 32(\phi) = 64 \text{ Sectors}$$

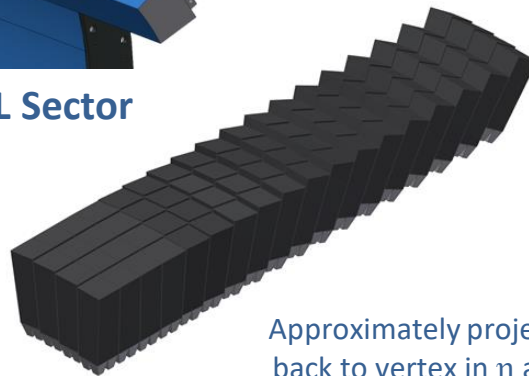
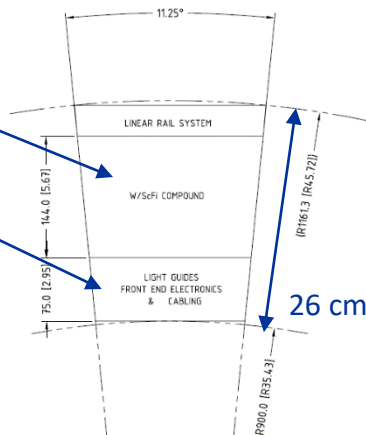


EMCAL Sector

Designed to be compact to fit inside the BaBar magnet

~14 cm absorber ($\eta=0$)

7.5 cm readout

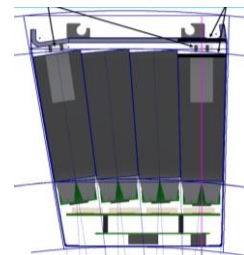


Approximately projective back to vertex in η and ϕ

1 Sector = 72 Modules
= 288 towers

Module = Block + Reflector + Light Guides + SiPMs

Module consists of 2x2 towers

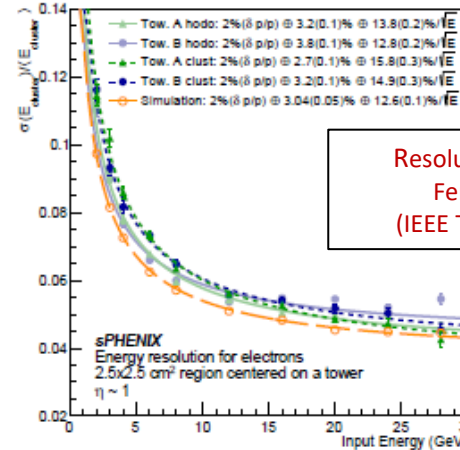


EMCAL Design Specs:

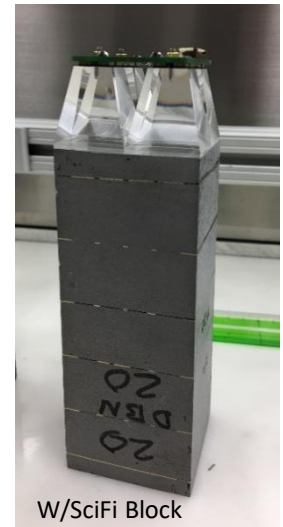
- Coverage: ± 0.85 in η , 2π in ϕ
- Segmentation: $\Delta\eta \times \Delta\phi \approx 0.025 \times 0.025$
- Readout channels (towers): $72 \times 256 = 18432$
- Energy Resolution: $\sigma_E/E < 16\%/VE \oplus 5\%$
- Provide an e/h separation $> 100:1$ at 4 GeV
- Approximately projective in η and ϕ
- Compact, works inside 1.4T magnetic field and reduces cost of HCAL

Technology

- W/SciFi SPACAL
Matrix of W powder and epoxy with embedded scintillating fibers
- 4 towers per module with each tower read out with 4 SiPMs (73,728 total)

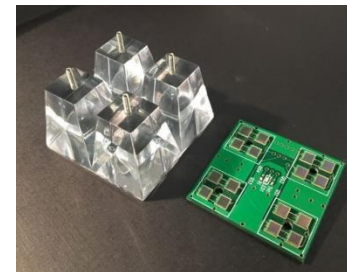


EMCAL Module



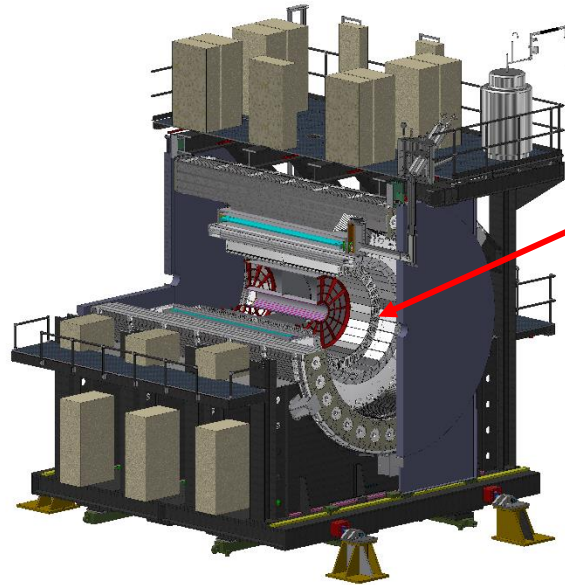
Fiber Readout End

Light Guides and SiPM Readout Card



W/SciFi Block

Scope and Deliverables (WBS 1.3)



WBS	sPHENIX MIE Project Elements
1.1	Project Management
1.2	Time Projection Chamber
1.3	Electromagnetic Calorimeter
1.4	Hadron Calorimeter
1.5	Calorimeter Electronics
1.6	DAQ-Trigger
1.7	Minimum Bias Trigger Detector

Inside the EMCAL Scope

- Fabrication of absorber blocks and assembly into modules & sectors (Sectors 1-12 $|\eta| < 1.1$, Sectors 13-64 $|\eta| < 0.85$)
- Design, procurement and mounting of light guides
- Design, procurement and construction of mechanical structures for modules and sectors
- Design, procurement and installation of cooling system inside the sectors
- Installation of front end readout electronics inside the sectors

Deliverables:

64 working EMCAL sectors ready for installation

Not inside the EMCAL Scope

- Design, procurement and fabrication of readout electronics (WBS 1.5)
- Design, procurement and construction of external support structures
- High rapidity blocks for Sectors 13-64

Subsystem Collaborators

L2 Manager (CAM)

Craig Woody (BNL)

L3 Managers

Caroline Riedl (UIUC) - Block Production

Sean Stoll (BNL) - Module Production & Sector Assembly

BNL Team

Physicists: Craig Woody (L2), John Haggerty,
 Martin Purschke, Jin Huang
 Physics Associates: Sean Stoll (L3), Rob Pisani
 Chief Engineer: Russell Feder
 Mechanical Engineer: Dan Cacace
 Mechanical Designers: Rich Ruggiero, Chris Pontieri
 Mechanical Techs: Bill Lenz (Sr. Tech)
 Jimmy LaBounty, Chris Ruggiero, Shana Prifte,
 Chris Cordovano, Ryan Weiss (on loan from CAD)
 Electrical Engineer: Steve Boose
 Electrical Techs: Mike Lenz (Sr. Tech), Sal Polizzo

UIUC Team

Physicists: Anne Sickles (PI), Caroline Riedl (L3)
 Postdoc: Tim Rinn
 Grad Student: Adin Hrnjic (part time)
 Academic Hourly: Saad Altaf (BA)
 Senior Tech: Eric Thorsland
 Mechanical Techs: Adam Wehe, Lucas Reeves
 Students: up to 30 undergraduates and hourly
 helpers as needed.

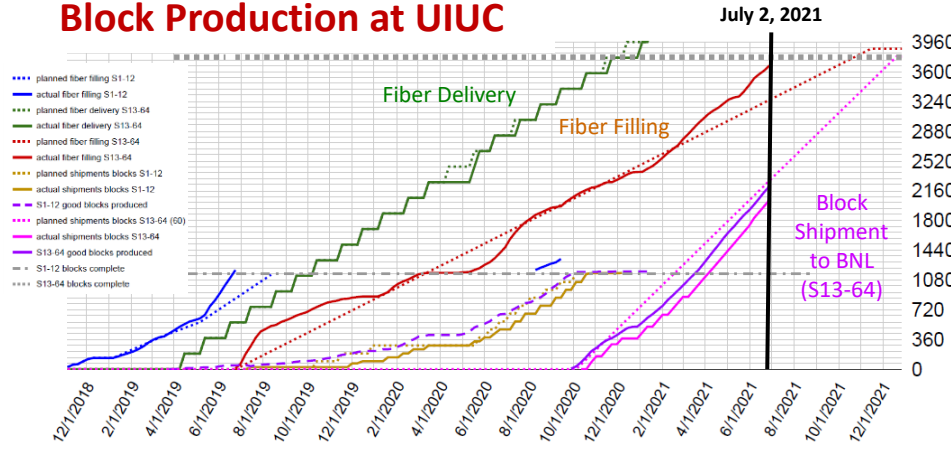
Collaborating Chinese Institutions

Fudan University: PI – Prof. Huan Huang (UCLA)
 Peking University: PI – Prof. Yayun Ma

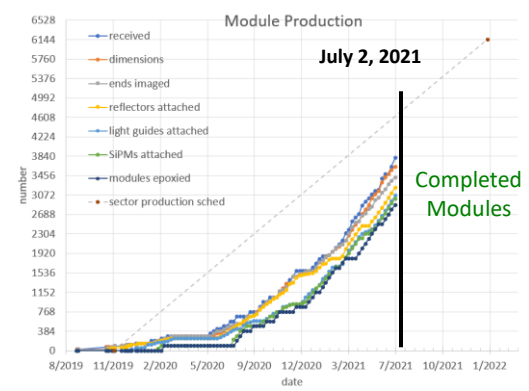
Schedule Performance and Schedule To Go



Block Production at UIUC



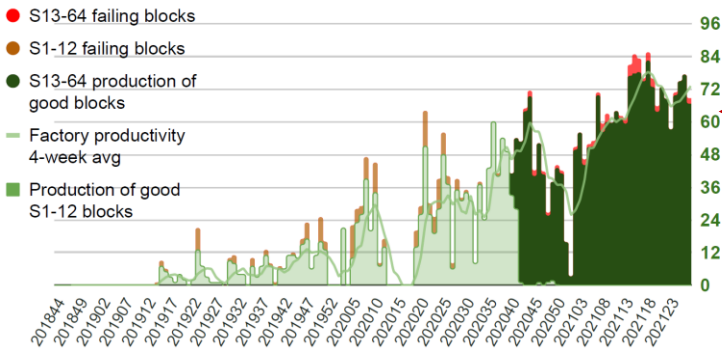
Module Production and Sector Assembly at BNL



Module production is proceeding at a rate that should be completed on schedule.

Sector production was lagging behind until April 2021 due to lack of components but has been gaining back schedule with additional technician labor.

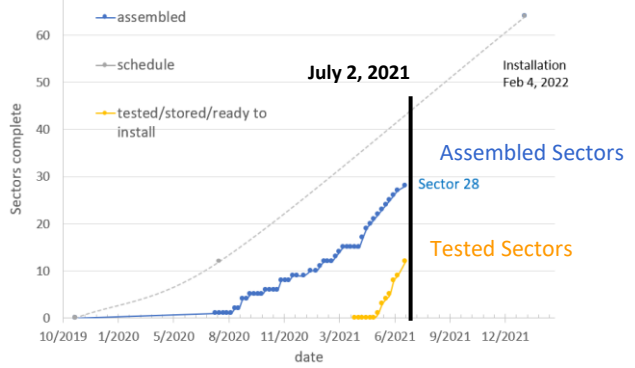
sPHENIX EMCal blocks: weekly output at UIUC



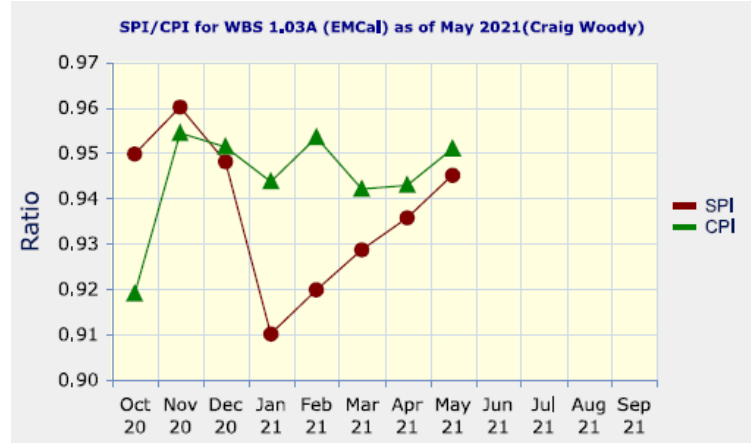
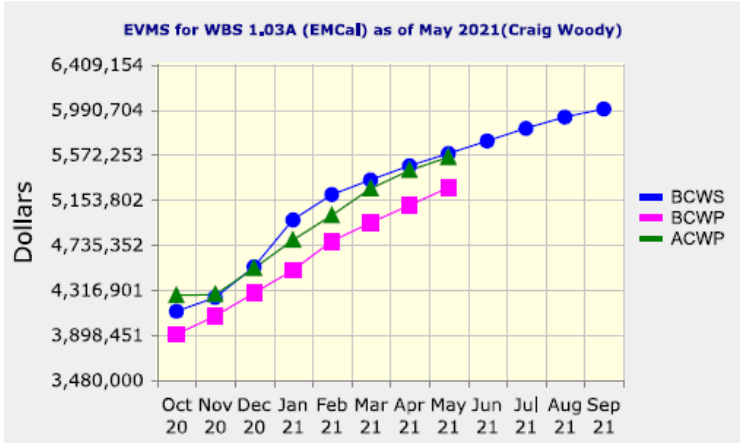
Current production rate is consistently above 60 blocks per week.

Need to maintain 62 blocks per week in order to finish by the end of 2021.

Sector Completion Progress



Cost Performance and Cost To Go



BAC: \$6,070,008 EAC: \$6,353,539 VAC: (\$283,531)

Cumulative to Date:	Oct-20	Nov-20	Dec-20	Jan-21	Feb-21	Mar-21	Apr-21	May-21
Schedule Var. (SV)	-213,726	-173,944	-243,284	-466,459	-435,025	-396,453	-365,454	-317,601
Sch. Var. (SV%)	-5.19	-4.10	-5.37	-9.40	-8.37	-7.43	-6.68	-5.69
SPI	0.95	0.86	0.95	0.81	0.82	0.83	0.83	0.94
Cost Var. (CV)	-360,537	-201,141	-226,854	-278,956	-240,495	-315,953	-321,322	-281,054
Cost Var. (CV%)	-9.24	-4.94	-5.29	-6.20	-5.05	-6.40	-6.30	-5.34
CPI	0.92	0.95	0.95	0.94	0.95	0.94	0.94	0.95

BCWS = Budgeted Cost for Work Scheduled
 BCWP = Budgeted Cost for Work Performed
 ACWP = Actual Cost for Work Performed

BAC = Budget at Completion
 EAC = Estimate at Completion
 VAC = Variance at Completion

SPI = Schedule Performance Index
 CPI = Cost Performance Index

- SPI < 1 is due partly to delays in delivery of components and partly due to COVID.
- CPI < 1 is due partly to some invoices for preproduction being paid after baselining and some cost escalation.

Risk Registry



Key	Risk Identification			Risk Handling Plan (Mitigations)	Residual Risk (Post- Mitigation Assessment)										
	Risk ID Number	Risk Title	IF/THEN	Risk Handling Plan (Mitigations)	Residual Risk Likelihood of Impact (%)	Low Cost Impact (\$K)	Likely Cost Impact (\$K)	High Cost Impact (\$K)	Low Schedule Impact (Mos)	Likely Schedule Impact (Mos)	High Schedule Impact (Mos)	Overall Impact Score (Residual)	Expected Value (\$K)	Average Expected Value (\$K)	Basis of Impact Estimates How were cost and schedule ranges (Columns Z through AE) developed?
24	sPH_EMCal_004	Delay of EMCaI block production at UIUC due to component supplies or technical issues	If EMCaI Block production rate is not on schedule, then there will be a delay in EMCaI schedule.	Add shifts or additional production when supplies are available or technical issues are resolved. Schedule early purchase &	10%	0	0	0	0.2	0.5	1.0	Low	0.00	0.00	Estimates based on experience with other projects
25	sPH_EMCal_005	Delay of EMCaI module production or sector assembly rate due to component supplies or technical issues	If EMCaI module production/assembly rate is not on schedule, then there will be a delay in EMCaI schedule.	Add shifts or additional production when supplies are available or technical issues are resolved. Store partially assembled	10%	0	0	0	0.2	0.5	1.0	Low	0.00	0.00	Estimates based on experience with other projects
29	sPH_EMCal_009	UIUC students not available for EMCaI Fiber Assemblies	If UIUC students are not available for fiber assemblies, then there will be a delay in EMCaI schedule and increased cost.	Get a list of participating students from collaboration institutions at least 3 months before activity begins.	5%	0	100	0	3	6	6	Low	5.00	1.67	Best: move effort to another University Likely: add new University
30	sPH_EMCal_010	UIUC students not available for EMCaI Final Block Fabrication	If UIUC students are not available for block fabrication, then there will be a delay in EMCaI schedule and increased cost.	Get a list of participating students from collaboration institutions at least 3 months before activity begins.	10%	0	0	0	3	6	6	Moderate	0.00	0.00	Best: move effort to another University Likely: add new University
31	sPH_EMCal_011	Loss of Students for Sector testing	If UIUC students are not available for sector testing, then there will be a delay in EMCaI schedule and increased cost.	Get a list of participating students from collaboration institutions at least 3 months before activity begins.	10%	0	0	200	1	3	6	Moderate	0.00	6.67	Estimates based on experience with other projects
	sPH_EMCal_013	EMCaI Sector Assembly is late due to shortage of TECH labor	If sector assembly rate is low, we will need more TECH labor	Monitor sector assembly rate closely.	30%	0	100	100	1	2	3	Low	30.00	20.00	Based on latest experience
	sPH_EMCal_014	TECH Labor at UIUC for EMCaI blocks	If rate of machining blocks is low, we will need another machinist at UIUC	Monitor block machining rate closely.	50%	0	200	200	0	0	0	High	100.00	66.67	Based on latest experience

Status of Reviews (since 2020 Annual Review)

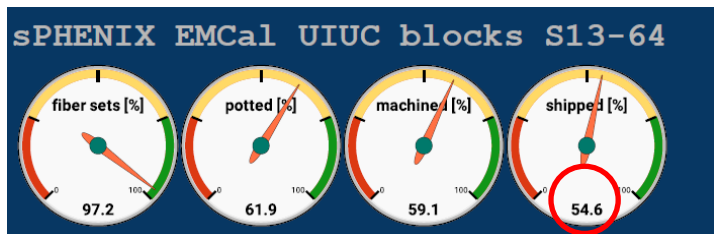
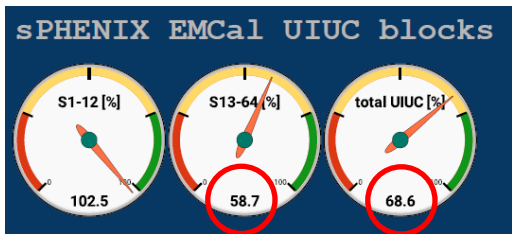


- EMCAL Production Readiness Review completed July 31, 2020
- EMCAL HCAL TPC Installation Review completed December 22, 2020
- EMCAL Experimental Safety Review scheduled for July 26, 2021

Progress since the Annual Review (July 2020)

- ❑ Block production at UIUC has reached its full production rate of > 60 blocks/week and is proceeding on schedule to be completed by the end of 2021.
- ❑ Almost 70% of the all blocks being produced at UIUC have been completed and more than half of the blocks for Sectors 13-64 have been shipped to BNL (enough for up to Sector 40).
- ❑ Block production from Chinese collaborating institutions is proceeding on schedule (~ 24 blocks/week). A total of 613 blocks have been shipped to BNL (enough for up to Sector 37).
- ❑ Module production has been proceeding at a rate that should have all modules completed by the end of 2021. Enough modules have been produced to complete up to Sector 30.
- ❑ Components are now being supplied at a steady rate that can keep up with production (light guides, SiPM daughter cards, preamp boards, epoxy and mechanical components).
- ❑ Sector production was lagging behind but gained back schedule when components became available and with additional personnel (+ 2 techs).
- ❑ Sector testing is proceeding well and will now include cosmic ray testing of all sectors.

Status and Highlights - UIUC



- Approximately 69% of all the UIUC blocks have been completed.
- Approximately 59% of the blocks for Sectors 13-64 have been completed and ~ 55% have been shipped to BNL.

Block production status
for Sectors 13-64
(as of 7/2/21)

- Fiber sets filled: 3,672
- Blocks potted: 2,346
- Blocks machined: 2,246
- Blocks produced: 2,210
- Shipped to BNL: 2045
- Production loss: 70 blocks (3%)



Status and Highlights - BNL

Module production is proceeding at a steady pace given the steady supply of components

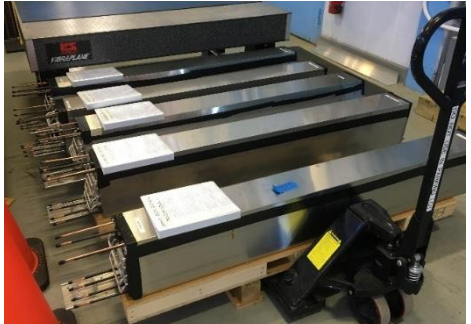


Light guide assemblies.

Sector assembly is proceeding with a steady supply of components and was gaining back schedule with two additional technicians



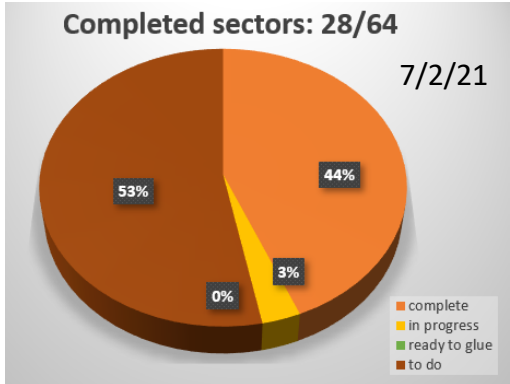
Sawteeth and Cooling Loops.



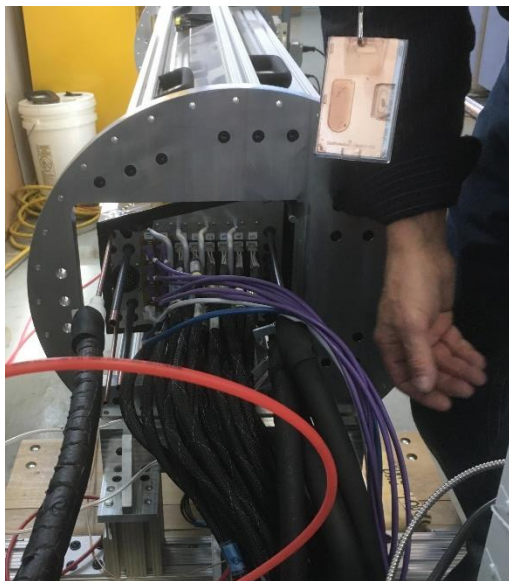
Completed modules



Sector assembly



Status and Highlights – Sector Testing

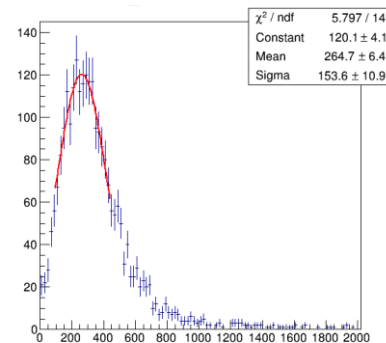


Sector in cosmic ray test stand.

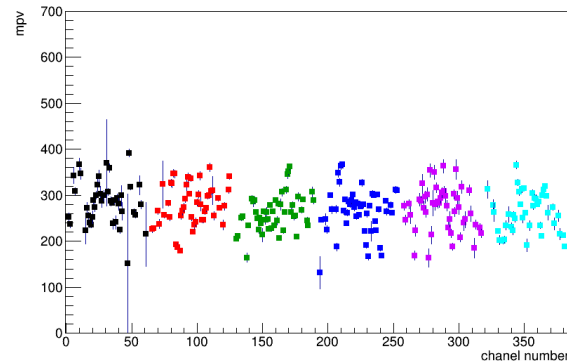


Sectors in burn-in facility

- Can collect $\sim 1.2\text{K}$ tracks per tower in 2 days
- Allows measuring MIP peak in each tower for initial energy calibration
- We now plan to calibrate all sectors and all towers with cosmic rays



Cosmic ray spectrum for a single tower



MIP peaks for all towers in a sector

ES&H :

- All work done at BNL is controlled under current ESRs for specific labs (PPE, training, work planning, etc.)
- Work at the UIUC is overseen by their respective Safety Departments and regulations and has also been inspected and reviewed by BNL ES&H personnel.
- Review by the CAD Experimental Safety Review Committee is scheduled for July 26, 2021

QA : Procedures have been implemented for specific tasks

- Block production (UIUC)
- Module production, sector assembly, handling and testing (BNL)



NPL at UIUC

Physics High Bay
at BNL

- ❑ With six techs we were maintaining schedule. However, with fewer techs we will **not** be able to maintain schedule.
- ❑ Sector testing has been proceeding well but we need additional postdoc and graduate student help to complete our calibration and testing procedures.

- ❑ The EMCAL design is complete and has been shown to meet its design requirements. Deliverables are well defined.
- ❑ Block production is almost 70% complete and is on schedule to be completed by the scheduled completion date.
- ❑ Module production is proceeding well and is expected to be completed by the scheduled completion date.
- ❑ Sector production is almost half complete and should be completed by the scheduled completion date if the necessary resources are available.