

# sPHENIX Director's Review

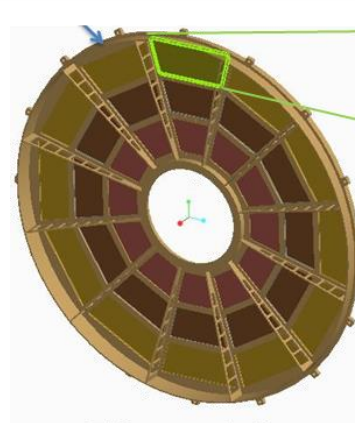
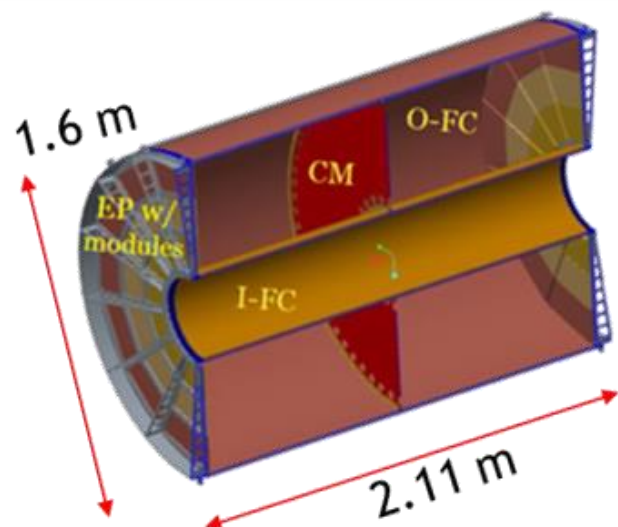
## 1.2.1 TPC Mechanics

**Klaus Dehmelt, Stony Brook University**

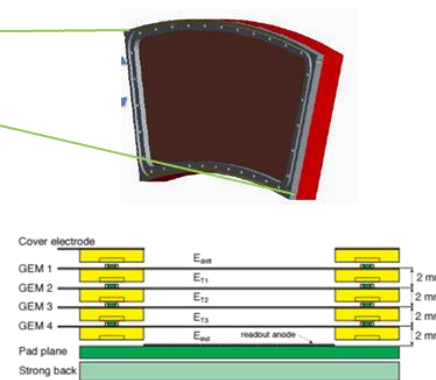
**August 2-4, 2017**

**BNL**

# The Subsystem



72 modules  
2(z), 12( $\phi$ ), 3(r)



Quad-GEM Gain Stage  
Operated @ low IBF

- WBS 1.2.1 - TPC Mechanics → Field Cage with full azimuthal coverage and  $|\eta| < 1.1$

**Outer Field Cage O-FC, R = 78 cm, L = 211 cm**

**Inner Field Cage I-FC, R = 20 cm, L = 211 cm**

**Central Membrane CM**

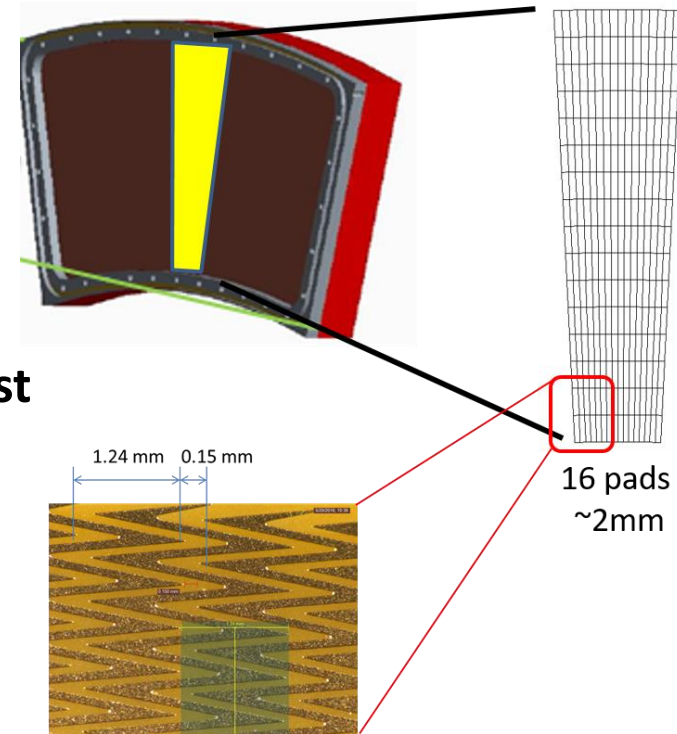
**Endplates EP, 2 in z**

**Modules, 12 in  $\phi$ , 3 in r**

- Modules based on Quad-GEMs for continuous readout and low Ion Back Flow IBF
- Present gas choice provides drift time of  $\sim 18 \mu\text{s}$ , single spatial point resolution  $< 250 \mu\text{m}$ , low IBF

# The Subsystem Technical Overview

- Dimensions and designs dictated by
  - Inner/outer radius → magnet and inner/outer detector design
  - Length → pseudorapidity
  - Design of field cages → minimum space and maximum stability
  - Design endplates → minimum material budget, maximum stability
  - Design modules → maximum integrity, least producibility, maximum performance



- WBS 1.2.1 contains all elements that lead to the successful assembly of the TPC mechanics (WBS 1.2.1.8) and eventually make the TPC ready to install
  - TPC v1 Field Cage Prototype**
  - TPC v2 Field Cage**
  - TPC Final Field Cage**
  - TPC v1 Modules**
  - TPC v1 Module Gas Enclosure**
  - TPC v1 Module Common Mechanics**
  - TPC v1a Module Prototype**
  - TPC v1b Module Prototype**
  - TPC v2 Modules**
  - TPC v2 Module Gas Enclosure**
  - TPC v2 Module Common Mechanics**
  - TPC v2a Module Prototype**
  - TPC Production GEM Acquisition**
  - TPC High Voltage System**
  - TPC Assembly**
- Support structure → Infrastructure WBS 1.9.2.2
- Installation fixture → Installation/Integration WBS 1.10.2.8

# Subsystem Collaborators

- CAM WBS 1.2.1 TPC Mechanics: Klaus Dehmelt (Stony Brook University)

- **Research Scientist**

Since 1999: HEP/HI Experiments: HERA-B (DESY-HERA), COMPASS (CERN-SPS), L3 (CERN-LEP), PHENIX (BNL-RHIC). Detector Systems: HERA-B Outer Tracker System (installation/commissioning), COMPASS-GEM Small Area Tracker (SAT) (design/construction/installation/commissioning), DESY-Large Prototype of a TPC (LC-TPC collaboration) (design/construction/installation/commissioning, management), PHENIX-Detector Council Member (Drift Chamber subsystem, 2011 – 2016), R&D: Csi-GEM RICH, large area GEM chambers, TPC Ion Back Flow

- L2 Manager WBS 1.2 TPC: Thomas K. Hemmick (Stony Brook University)

- **Distinguished Teaching Professor**

Since 1988: Heavy Ion Experiments: E814 (BNL-AGS), E877 (BNL-AGS), PHENIX (BNL-RHIC). Detector Systems: E814 drift/pad chambers (construction), E877 MWPC chambers (design/construction/management), PHENIX RICH (design/construction/management), PHENIX drift chambers (design/construction/management), PHENIX hadron blind detector (design/construction/management), PHENIX MPC-EX (construction). R&D: Csi-GEM HBD, Csi-GEM RICH, W-Si preshower, large area GEM chambers, TPC-Cherenkov hybrid, TPC Ion Back Flow

- John Cozzolino (CAD BNL)

- **Senior engineer**

25+ years involved in numerous aspects of the design development and construction of superconducting accelerator magnets. Specialized in computer-aided engineering analyses critical to the R&D, design and manufacture of such magnets primarily for RHIC at BNL and the LHC at CERN

- Steven Bellavia (CAD BNL)

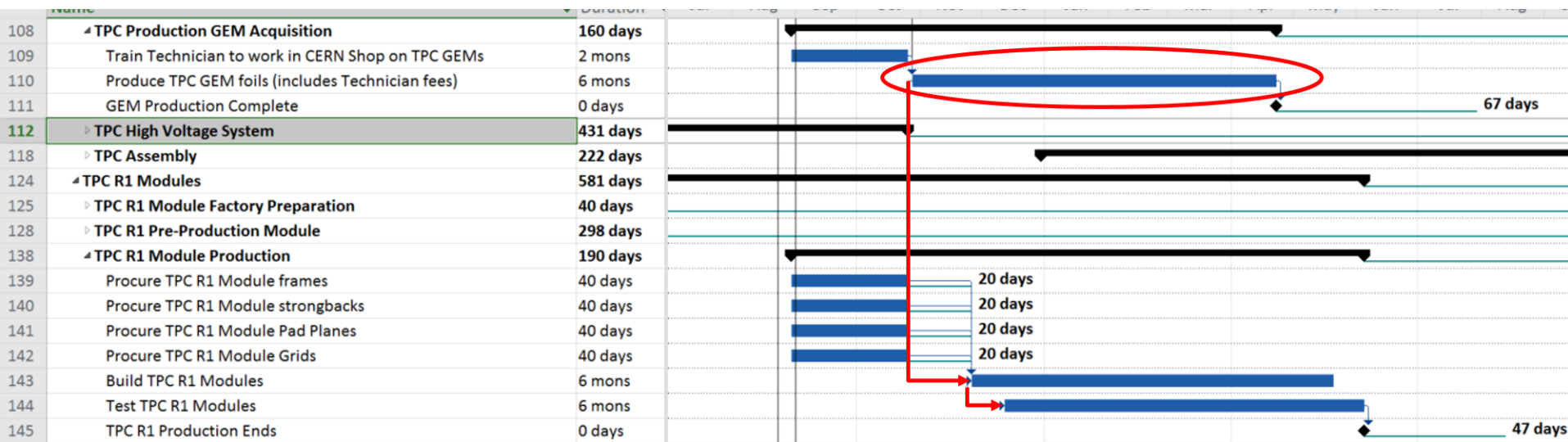
- **Senior engineer**

25+ years performing mechanical analysis, design and fabrication of detectors, for PHENIX (1992-1995), RHIC (1998-present), NSRL (1999-2003) and LSST (2013-present)

# Schedule Drivers

## WBS 1.2.1.6 TPC Production GEM Acquisition

- Factory production follows a Start-Start relationship to GEM production
- Module assembly takes less time than GEM production (PHENIX HBD experience)
- GEM schedule drives module production schedule and TPC overall schedule







# Basis of Estimate and Resource-Loaded Schedule

- WBS 1.2.1 contains 8 work packages

sPHENIX Detector Relativistic Heavy Ion Collider BASIS of ESTIMATE (BoE)			
L2 Project Name	L2 WBS Number	L3 Project Name (Control Account)	L3 WBS Number
Time Projection Chamber	1.2	TPC Mechanics	1.2.1
Work Package Name	WBS Number	Basis of Estimate Link	
TPC v1 Field Cage Prototype	1.2.1.1	<a href="#">TPC v1 Field Cage Prototype</a>	
TPC v2 Field Cage	1.2.1.2	<a href="#">v2 Field Cage-Summary</a>	
TPC Final Field Cage	1.2.1.3	<a href="#">Final Field Cage-Summary</a>	
TPC v1 Modules	1.2.1.4	<a href="#">v1 Modules-Summary</a>	
TPC v2 Modules	1.2.1.5	<a href="#">v2 Modules-Summary</a>	
TPC Production GEM Acquisition	1.2.1.6	<a href="#">GEM Acquisition-Summary</a>	
TPC High Voltage System	1.2.1.7	<a href="#">High Voltage System-Summary</a>	
TPC Assembly	1.2.1.8	<a href="#">Assembly-Summary</a>	

- Each work package is linked from the Title Page

e.g.:

sPHENIX Detector Relativistic Heavy Ion Collider BASIS of ESTIMATE (BoE)		Date of Est:	Assumptions Used in Developing Estimate				
Work Package Name:	WBS Number:	Prepared By:					
TPC Production GEM Acquisition	1.2.1.6	DocNo. (refer Rev.)					
<b>WBS Dictionary Definition:</b> <b>TECHNICAL SCOPE:</b> THIS ITEM CONTAINS ALL TASKS WHICH ARE REQUIRED TO ACQUIRE COMPONENTS FOR THE GEM FOILS AND PRODUCE THESE FOILS, INCL. TECHNICIAN DEDICATED TO THE PRODUCTION OF SPHENIX GEM FOILS. <b>WORK STATEMENT:</b> PROVIDE ALL PARTS AND MANPOWER TO PRODUCE THE FINAL GEM FOILS.			The ongoing GEM foil work that must closely resemble our needs to bring done for the ALICE TPC Upgrade. GEM foils have single supplier (see the world (CERN) and say keep in CERN GEM production is a significant project task. To mitigate this risk, ALICE developed a model of GEM foil production that includes training and bringing a technician to work in the CERN shop. In this way, ALICE retains the authority to set the technician's priorities for work. We have decided that this risk mitigation strategy is a wise choice and so we plan to follow it closely. We have then based the initial costs of the GEM upon the existing contract between ALICE and the CERN Shop. As time passes, we will need to formulate a similar contract with constant and stable from BNL management and CERN management. In the interim, technical negotiations between the sPHENIX TPC group (Duke) and the CERN shop (de Oliveira) have concluded several things. First, the time release assumed by sPHENIX is realistic. Second, the technician fee is realistic. Third, the per foil cost will be lower than "quoted ALICE". The reason for this is that current foil production in the CERN shop involves large sheet cutting multiple foils. An analysis of our smaller foils shows that we will be able to more effectively use the area of a single production step as compared to ALICE. This adjustment to the per GEM cost has been applied to the cost summary found here.				
<b>Estimate Type (check all that apply):</b> <input checked="" type="checkbox"/> Work Complete <input checked="" type="checkbox"/> Existing Purchase Order <input checked="" type="checkbox"/> Catalog Listing or Industrial Construction Database <input checked="" type="checkbox"/> Documented Vendor Quotation based on Drawings/Sketches/Specifications <input checked="" type="checkbox"/> Budgetary Estimate by Vendor/Fabricator based on Sketches, Drawings, or other Written Correspondence <input checked="" type="checkbox"/> Engineering Estimate based on Similar Items or Procedures <input checked="" type="checkbox"/> Engineering Estimate based on Analysis <input checked="" type="checkbox"/> Expert Opinion				<b>Details of the Base Estimate (explanation of the Work)</b> The team of Duke (sPHENIX) and de Oliveira (CERN) has long experience working together since the first GEM development for the COMPASS experiment was done in collaboration by exactly these two gentlemen. Because of this relationship, we have found it easy to get detailed and realistic cost estimates from CERN.			
<b>Cost Summary</b> The present estimate including the bring and training of a CERN technician is included in the GEM acquisition.			<a href="#">(follow link for detailed summary)</a> <table border="1"> <tr> <th>Grand Total</th> <th>Grand Total of Contingencies</th> </tr> <tr> <td>\$174,296.00</td> <td>\$409,052.00</td> </tr> </table>	Grand Total	Grand Total of Contingencies	\$174,296.00	\$409,052.00
Grand Total	Grand Total of Contingencies						
\$174,296.00	\$409,052.00						

Link to detailed cost summary

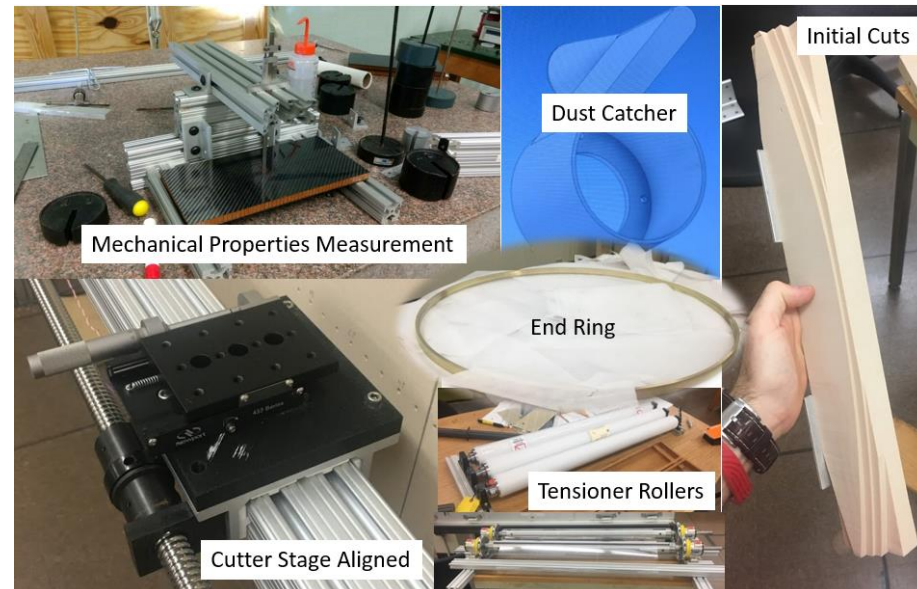
- Within each file 2 pages per L4 item:
  - Summary page explains BoE Details and Assumptions.
  - Intended to be readable without additional documents open and at the ready.



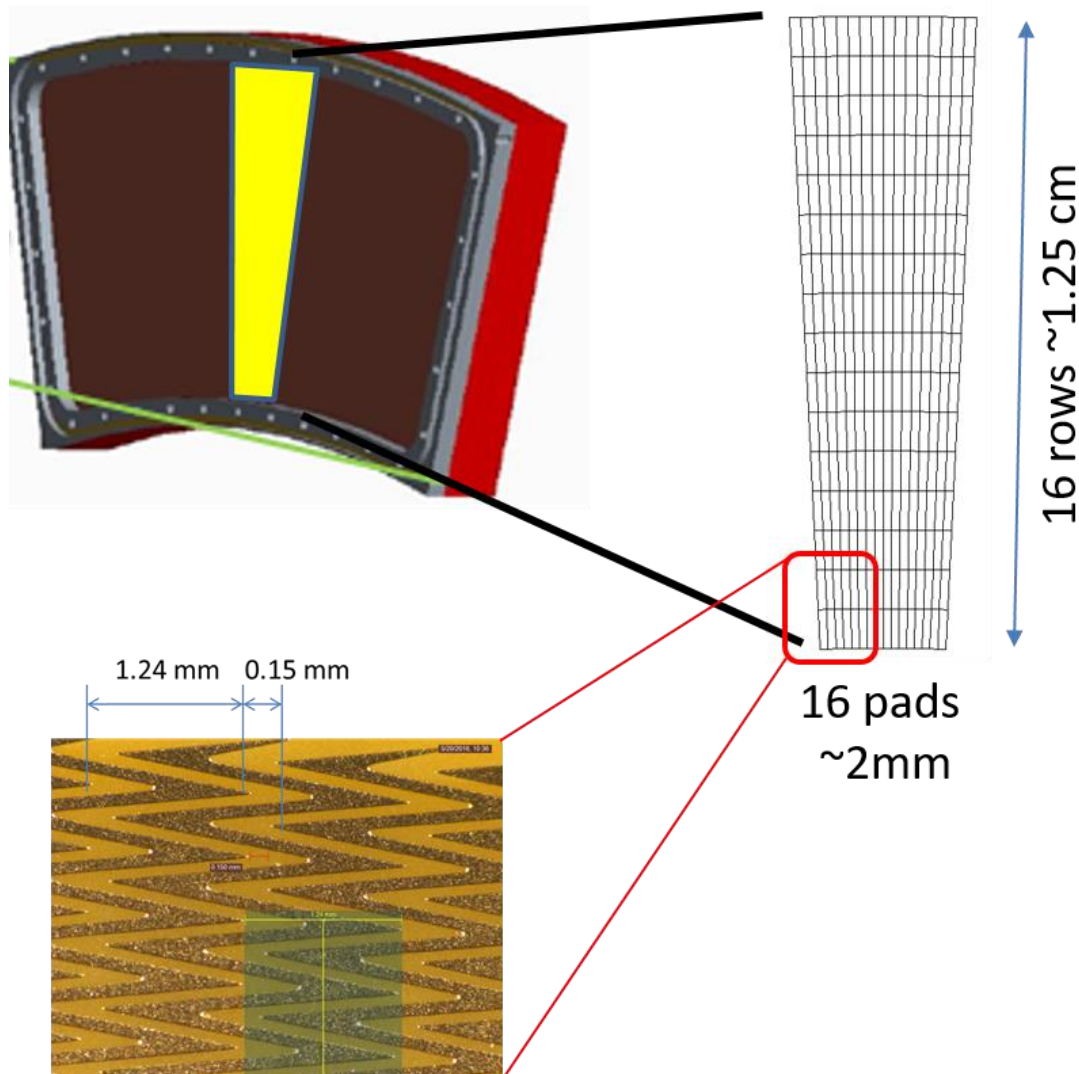
# Status and Highlights

## Field Cage Prototyping

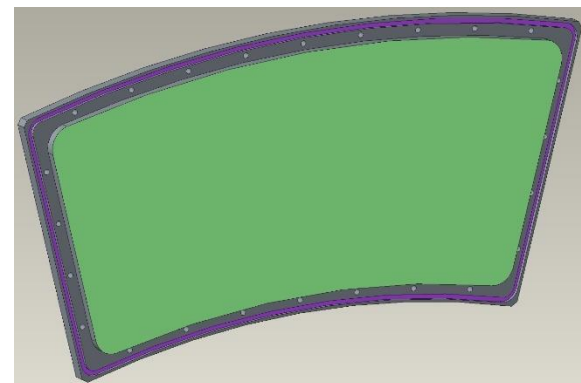
- Outer Field Cage v1 prototype
  - Mandrel being finalized
  - Start field cage production



# Status and Highlights



- TPC v1 modules
  - Common mechanics designed  $\rightarrow$  submit to SBU workshop
  - TPC v1a module prototype: GEM design finalized  $\rightarrow$  submit to CERN workshop
  - Readout board with zig-zag shaped pads designed  $\rightarrow$  submit to provider



# Issues and Concerns or Summary

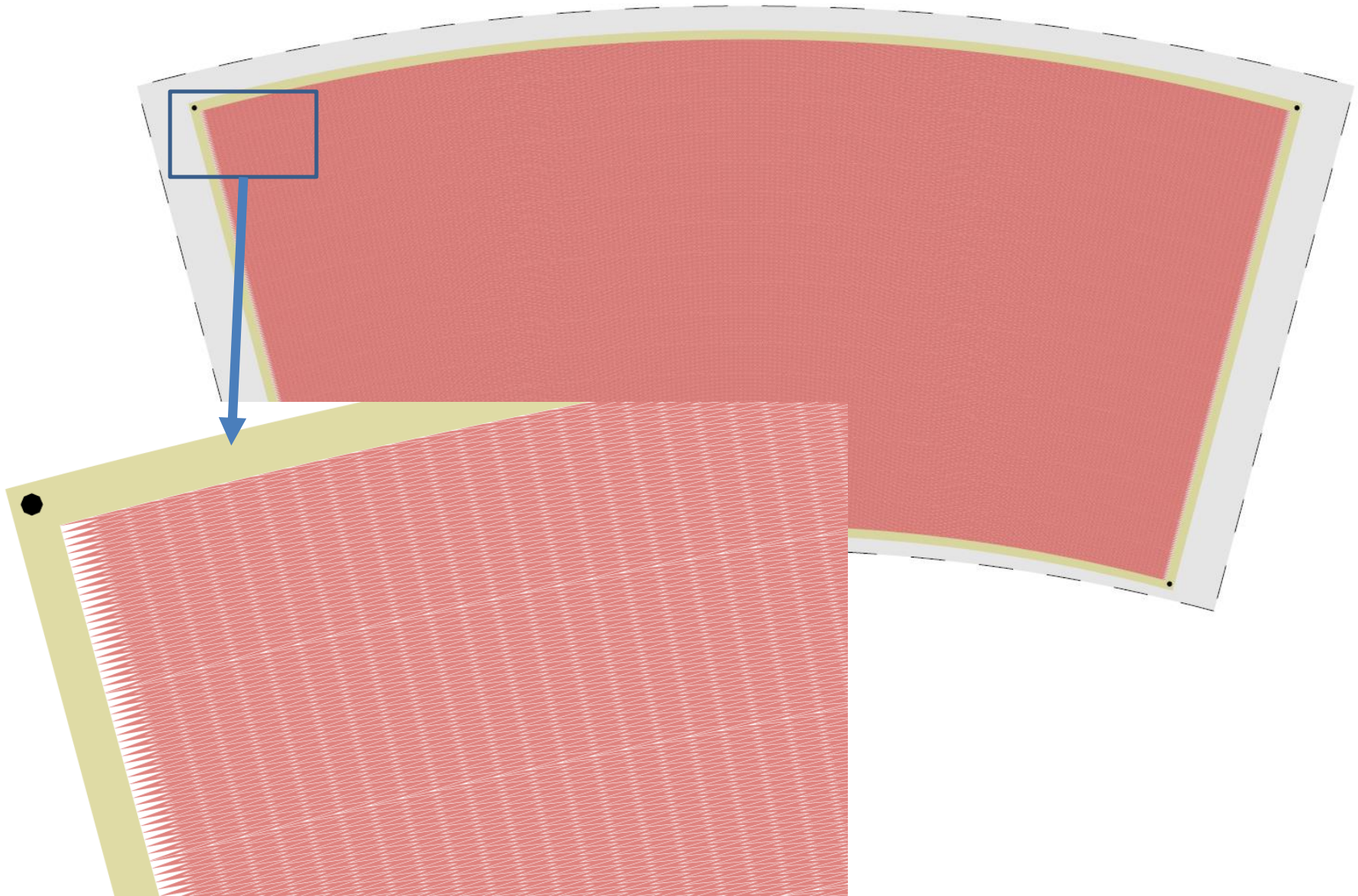
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- Issues and concerns
  - **GEM production exclusively at CERN**
  - **Mitigated by hiring technician exclusively for sPHENIX production**
  - **Big GEM production (ALICE TPC, CMS) completed in 2017/2018**
- Summary
  - **All WBS items in BoE well understood**
    - Purchases, quotes, contracts, analysis, experience
  - **All WBS items have contingencies on a very mature level**
  - **Risk items on a very low level**
  - **Tasks are well progressing**
    - TPC O-FC v1 prototype nearly completed
    - TPC Modules v1 well on track

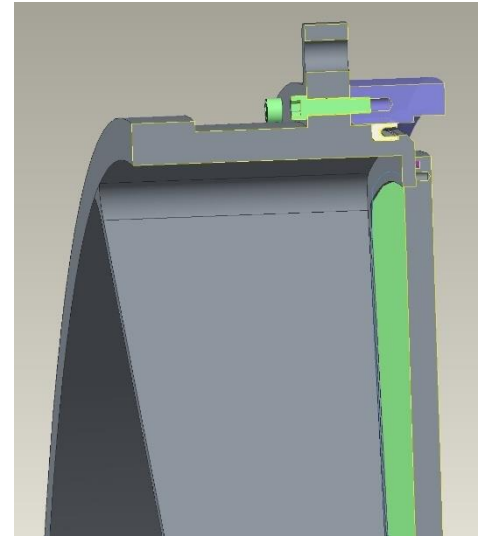
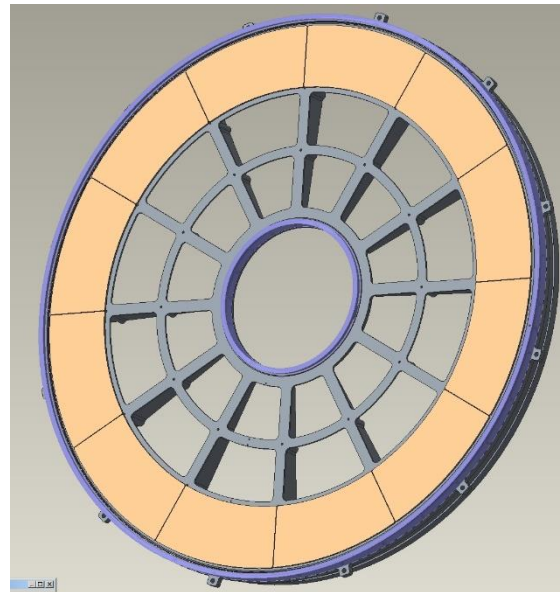
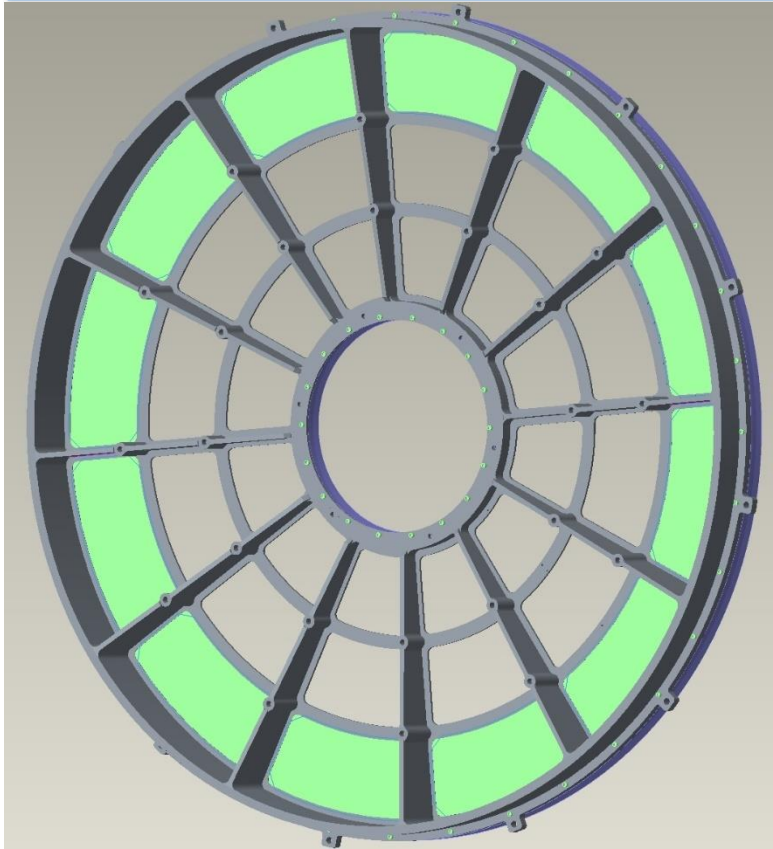
# Back Up



# Status and Highlights

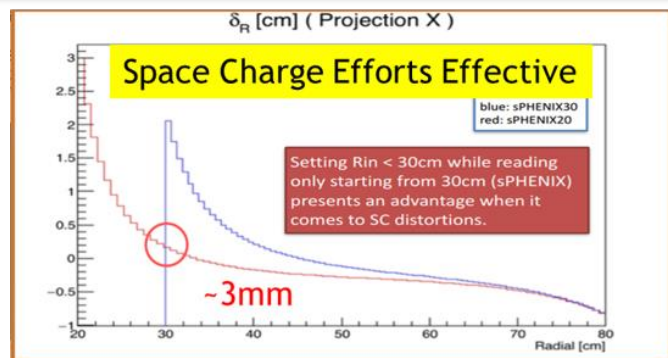


# Status and Highlights

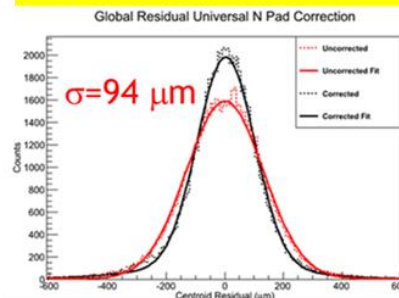




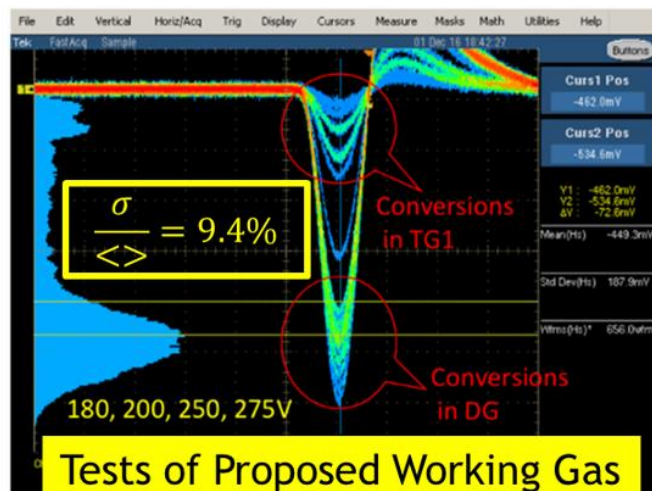
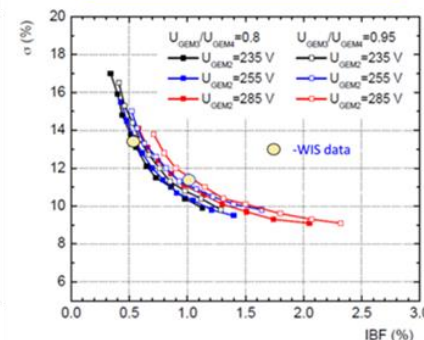
# Status and Highlights



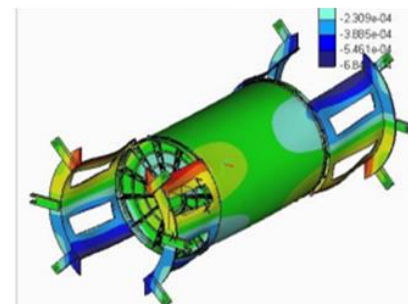
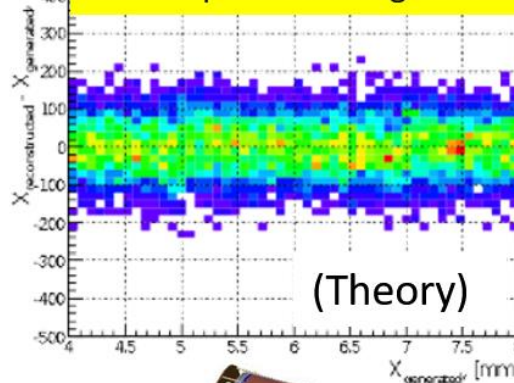
## Position Resol Achieved



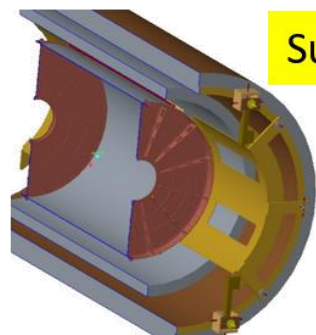
## In House IBF Meas.



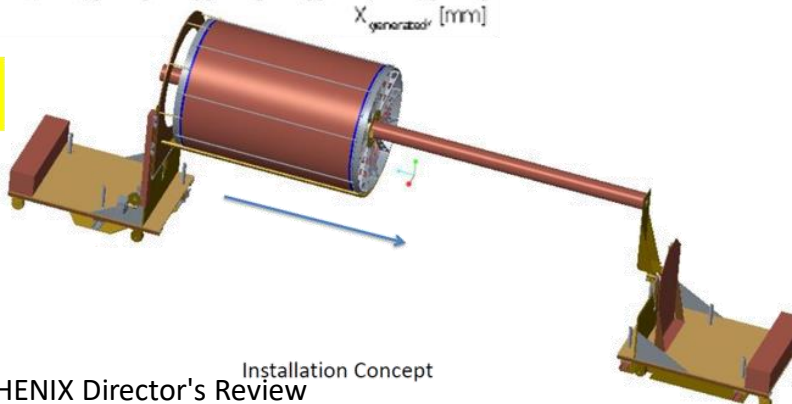
## Pad Shape Minimizing DNL



## Advanced Mech Modeling



## Support Concept



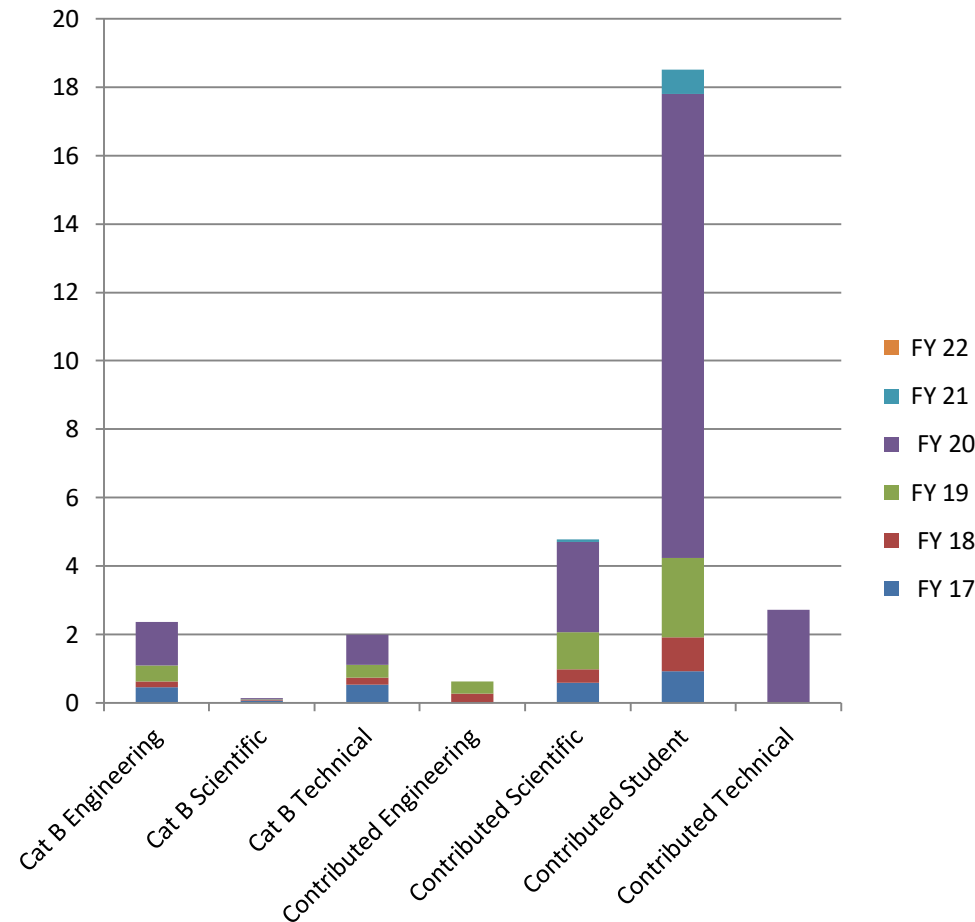
Installation Concept

sPHENIX Director's Review



# Labor Profile

- FTE Profile by Category



- FTE Profile by Fiscal Year

Row Labels	FY 17	FY 18	FY 19	FY 20	FY 21	FY 22
<b>Cat B</b>	<b>1.08</b>	<b>0.37</b>	<b>0.87</b>	<b>2.21</b>	<b>0.00</b>	<b>0.00</b>
Engineering	0.47	0.16	0.48	1.28	0.00	0.00
Scientific	0.07	0.01	0.02	0.04	0.00	0.00
Technical	0.54	0.20	0.37	0.89	0.00	0.00
<b>Contributed</b>	<b>1.51</b>	<b>1.65</b>	<b>3.78</b>	<b>18.92</b>	<b>0.79</b>	<b>0.00</b>
Engineering	0.00	0.27	0.36	0.00	0.00	0.00
Scientific	0.59	0.39	1.09	2.63	0.08	0.00
Student	0.92	0.99	2.33	13.56	0.70	0.00
Technical	0.00	0.00	0.00	2.73	0.00	0.00
<b>Grand Total</b>	<b>2.59</b>	<b>2.02</b>	<b>4.65</b>	<b>21.12</b>	<b>0.79</b>	<b>0.00</b>

# Risk Analysis

Excerpt of risk registry for WBS 1.2

T. Hemmick	1.2 TPC	Procure v1a GEMs	Delivery date on v1-shapes GEMs leaves less than one month before magnet test.	The test will require that we use existing GEMs which will be 10x10cm <sup>2</sup> . This will require a special module to adapt the smaller square GEMs to the	R&D Phase	20%	Cost \$10k for square-GEM adapter parts	Low	In case the proper GEMs for the v1a prototype are not in hand, an adapter plate will be requires to fit an existing GEM-stack to allow the magnet test to proceed.
T. Hemmick	1.2 TPC	Performance failure of v2 prototype	The v2 prototype fails in any performance criterion that requires more than trivial re-design.	If the v2 prototype fails, then there will need to be a v3 prototype added to the cycle.	R&D phase	5%	Schedule: 2 months of float lost. Cost:\$15k (only gain	Moderate	We will add a design cycle of a smaller device than the full sized field cage if the v1 prototype fails. We will proceed on v2 only after success of the small version.
T. Hemmick	1.2 TPC	Failure or delay of CERN production	Factories wait upon GEM foil delivery and suffer schedule shifts.	The factory production of modules is critical path and will directly affect schedule.	production	10%	Schedule: 3-5 months	Moderate	We will monitor carefully the success of CERN foil production and will hire a technician who will exclusively work on producing GEM foils for our project. If delays still occur, we will seek a second vendor.
T. Hemmick	1.2 TPC	SAMPA Chip Failure	SAMPA chips fail to match performance specifications.	Affects delivery of the TPC since FEE must be applied before delivery.	production	2%	Schedule: Unknown since mediation	Moderate	ALICE and STAR shall be forced to mitigate the situation and if not, alternatives such as the sALTRO and DREAM chips must be considered.