

# sPHENIX Director's Review

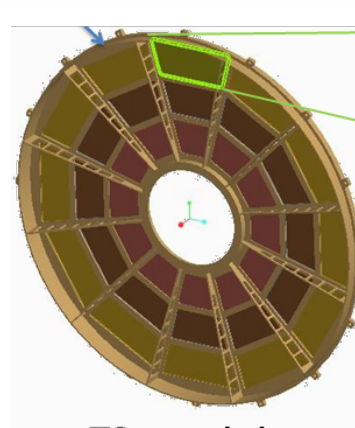
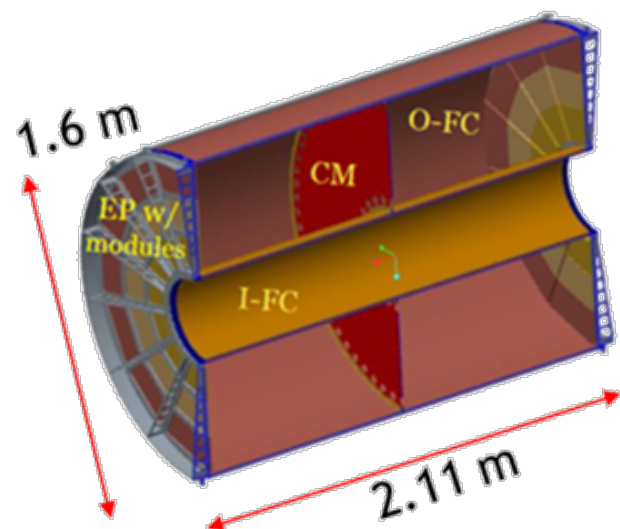
## 1.2.1 TPC Mechanics

**Klaus Dehmelt, Stony Brook University**

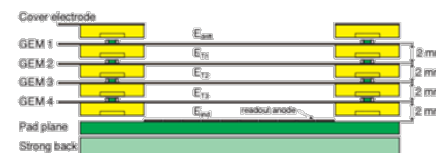
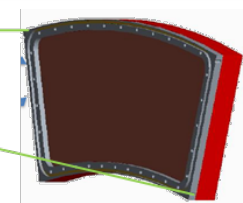
**August 2-4, 2017**

**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

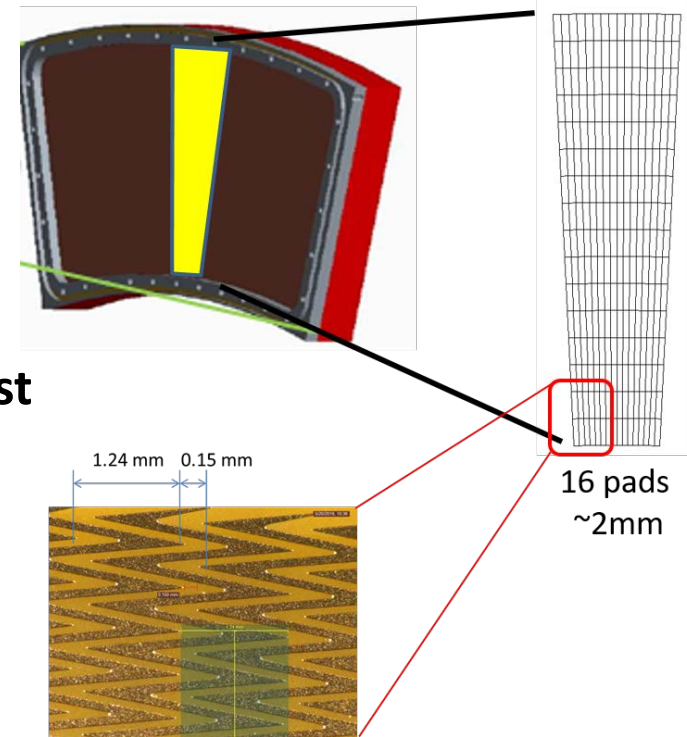
Endplates EP, 2 in z

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**

- 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)

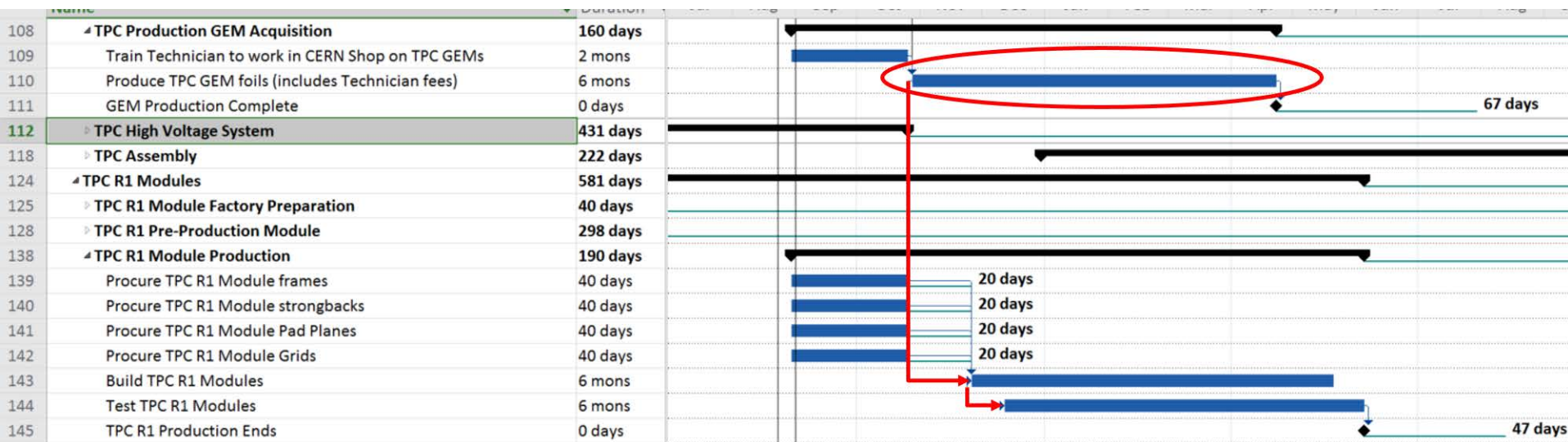
- **Senior engineer**

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:	<p>The ongoing GEM foil work that must already exist before we can do the ALICE TPC upgrade. GEM foil has never been made in the world (CERN) and any attempt to make GEM foil production is a significant project risk. To mitigate this risk, ALICE developed a model of GEM foil production that includes making and testing a production to work in the CERN shop. In this way, ALICE can test the ability to use the technical production 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 scope of the GEM foil on the existing contract between ALICE and the CERN shop. As time passes, we will need to formulate a similar contract with cost and risks from GEM management and CERN management. In this negotiation, technical negotiations between the sPHENIX TPC group (Duke) and the CERN shop (di Olivera) have concluded several things. First, the time release is limited by ALICE. Second, the technical risk is realistic. Third, the per foil cost will be lower than "standard ALICE". The reason for this is that current foil production in the CERN shop involves large sheet cutting and is not fully automated. Our analysis of our model fully shows that we will be able to more effectively use the area of a single production shop or compared to ALICE. This adjustment to the per foil cost has been applied to the cost summary found here.</p>				
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, INCLUDING TECHNICIAN DEDICATED TO THE PRODUCTION OF SPHENIX GEM FOILS. <b>WORK STATEMENT:</b> PROVIDE ALL PARTS AND MANPOWER TO PRODUCE THE FINAL GEM FOILS.		<b>Details of the Base Estimate (explanation of the Work)</b> The team of Duke (sPHENIX) and di Olivera (CERN) has long experience working together since the first GEM development for the COMPASS experiment was done in collaboration by exactly these two groups. Because of this relationship, we have found it easy to get detailed and realistic cost estimates from CERN.					
<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>Cost Summary</b> The present estimate including the labor and to making of a CERN technician is included in the GEM acquisition. <div style="text-align: right;"> <a href="#">(click link for detailed summary)</a> </div> <table border="1"> <tr> <td>Base Cost</td> <td>Base Cost (including CERN)</td> </tr> <tr> <td>\$124,336.00</td> <td>\$405,995.00</td> </tr> </table>		Base Cost	Base Cost (including CERN)	\$124,336.00	\$405,995.00
Base Cost	Base Cost (including CERN)						
\$124,336.00	\$405,995.00						

Link to detailed cost summary

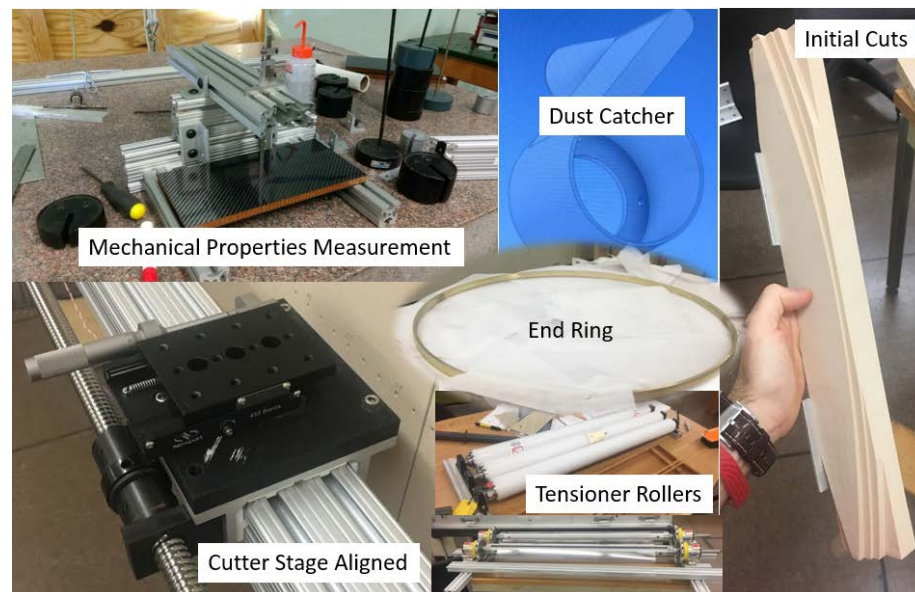
- Within each file 2 pages per L4 item:
  - Summary page explains BoE Details and Assumptions.
  - Intended to be readable without additional documents open and at the ready.



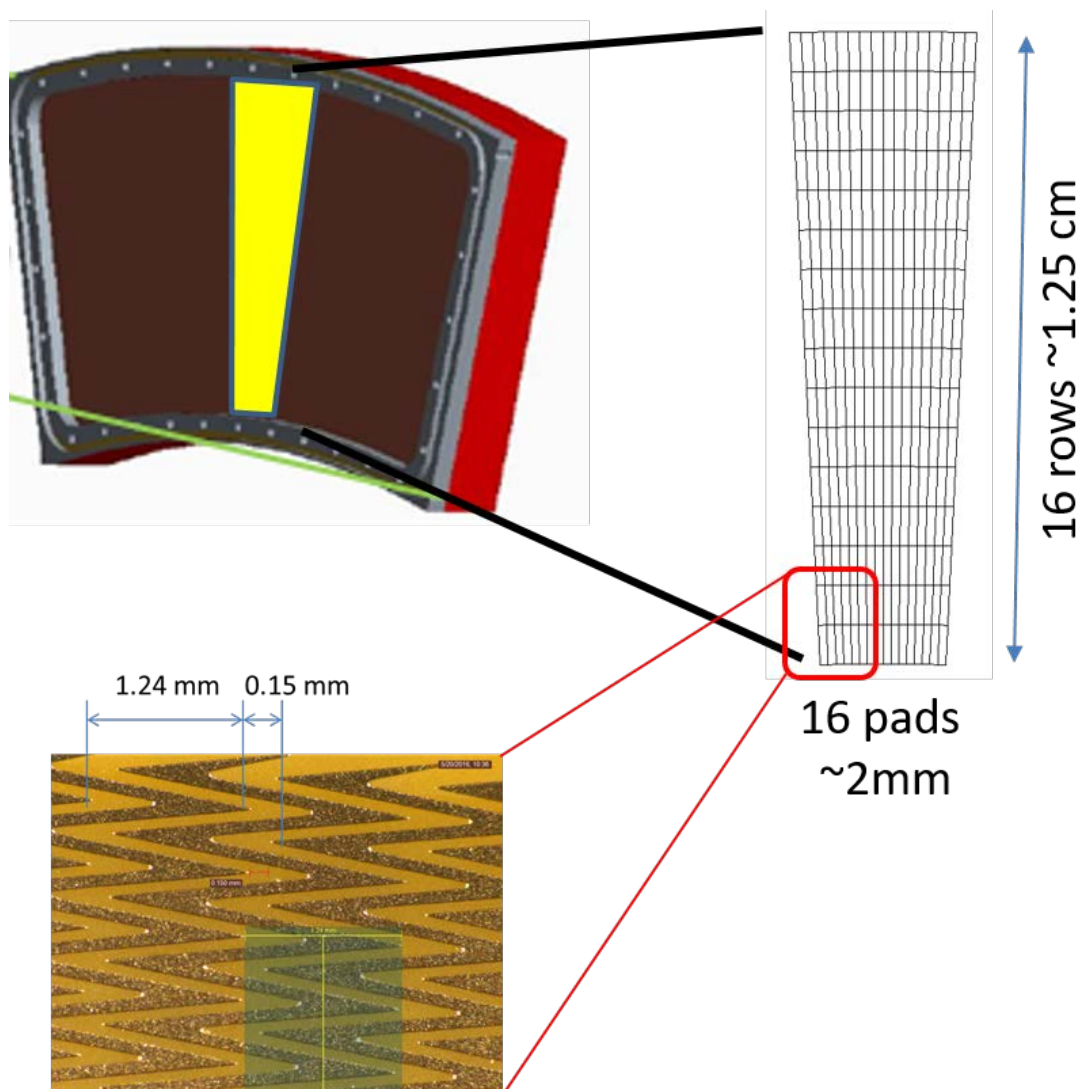
# Status and Highlights

## Field Cage Prototyping

- Outer Field Cage v1 prototype
  - Mandrel finalized
  - Field cage in production



# Status and Highlights



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