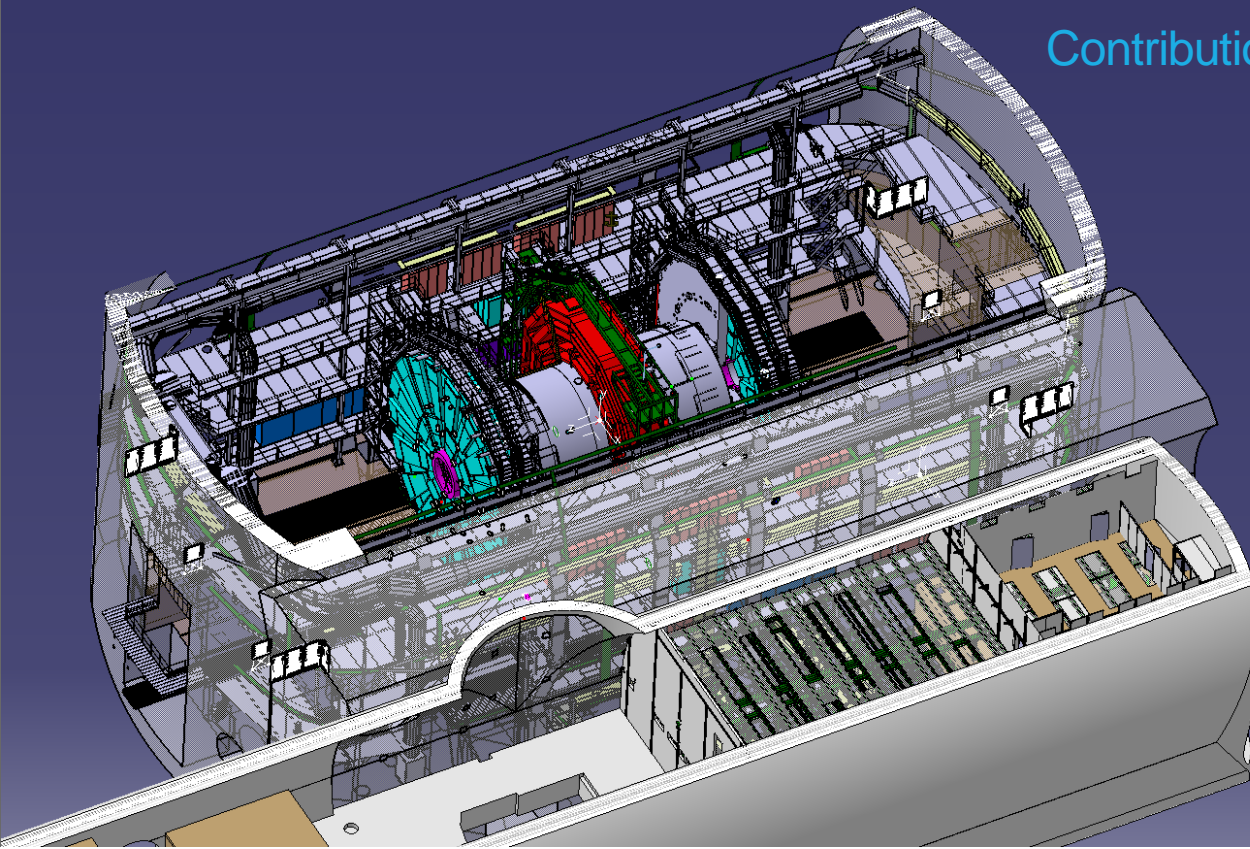


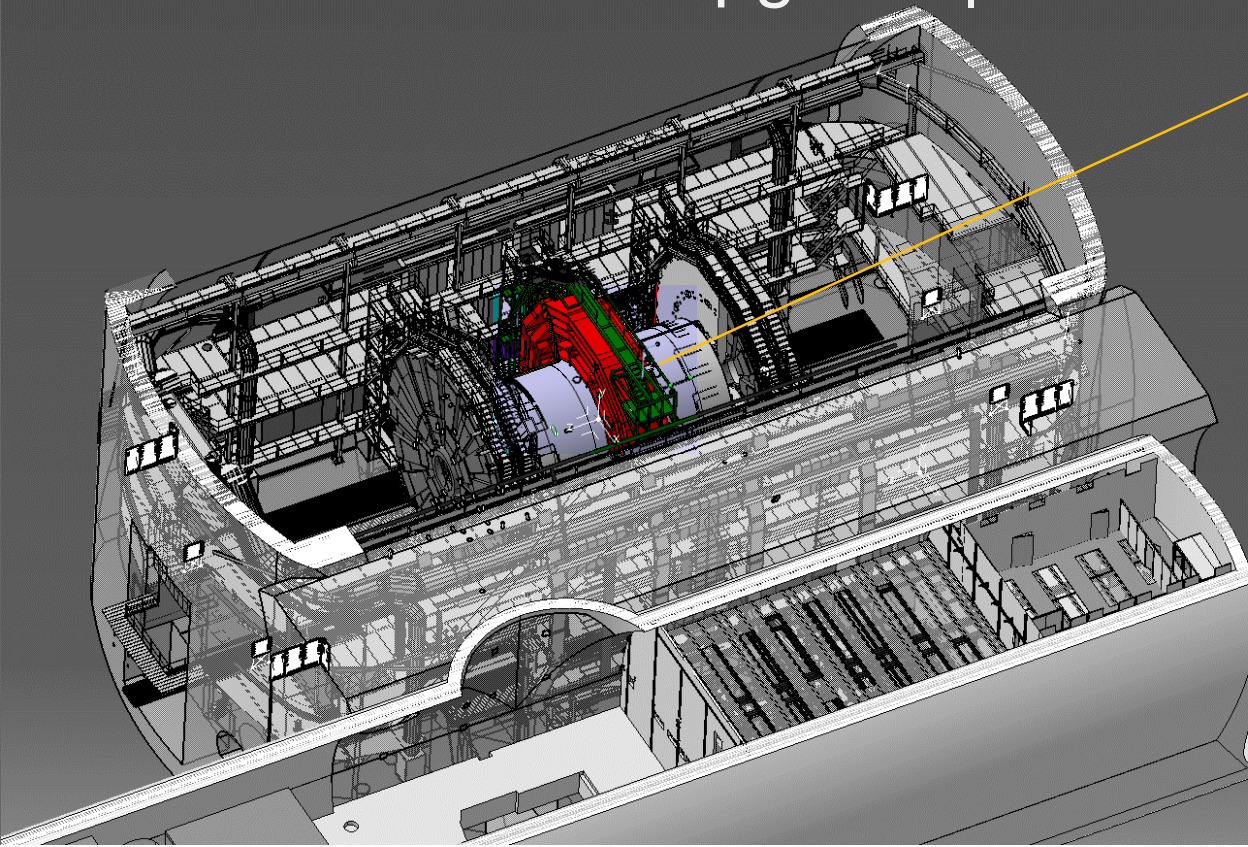
# DT Group Meeting 2019

## Contributions to CMS Phase II Upgrade

Tym Pakulski | EP-DT-FS



# CMS Phase II Upgrade | DT Contributions

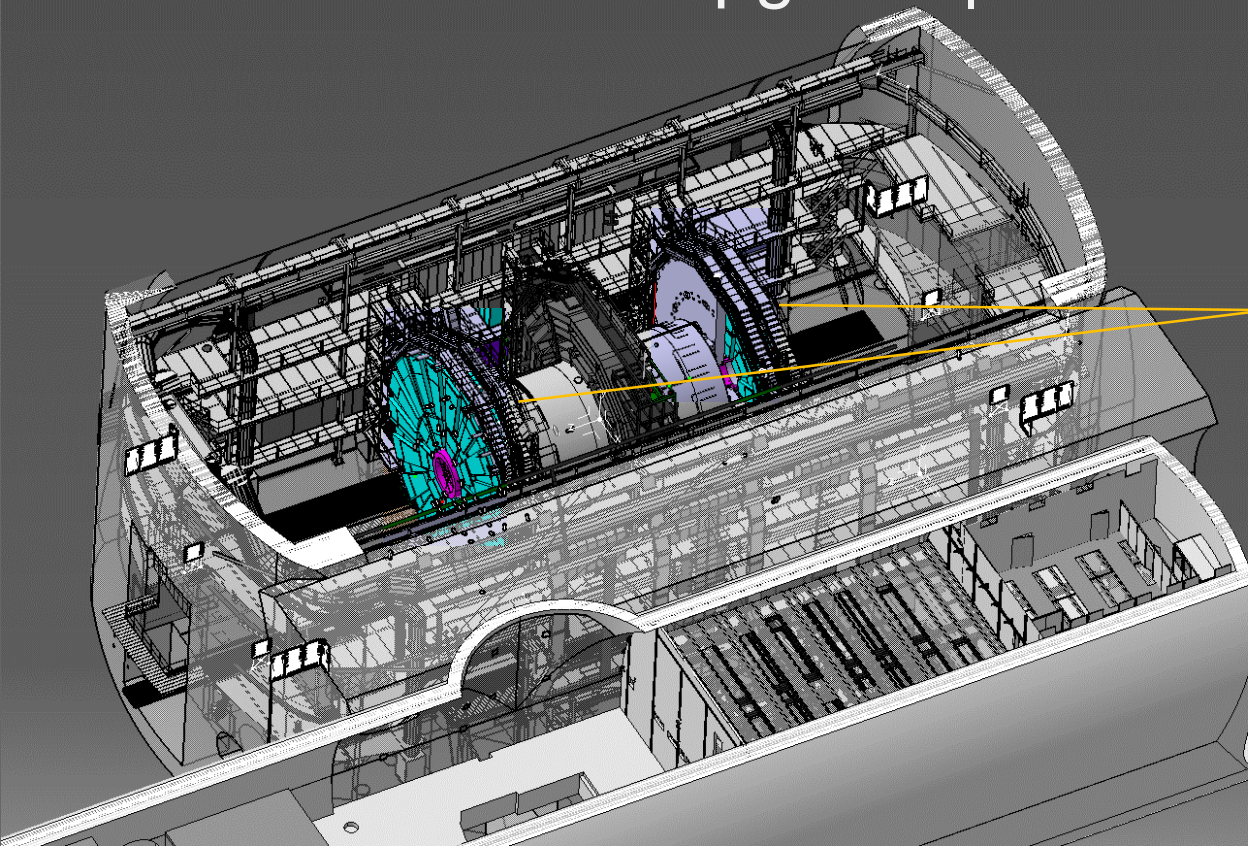


**Tracker** | 7.3 FTE  
4.3 Staff, 3 fell + tech

**Endcaps** | 1.2 FTE  
0.7 staff, 0.5 fell + tech

**CO<sub>2</sub> Cooling** | 5 FTE  
1.3 staff, 3.7 fell + tech

# CMS Phase II Upgrade | DT Contributions

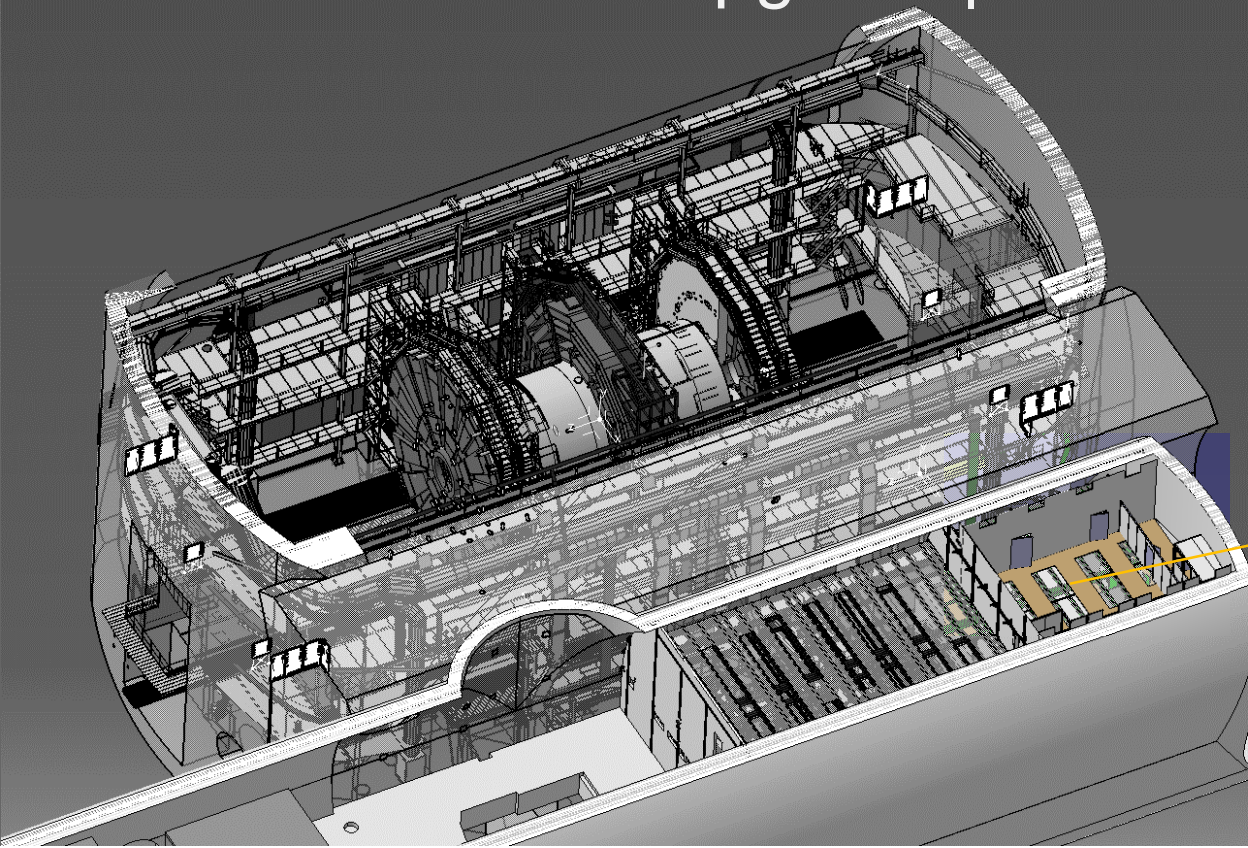


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# CMS Phase II Upgrade | DT Contributions

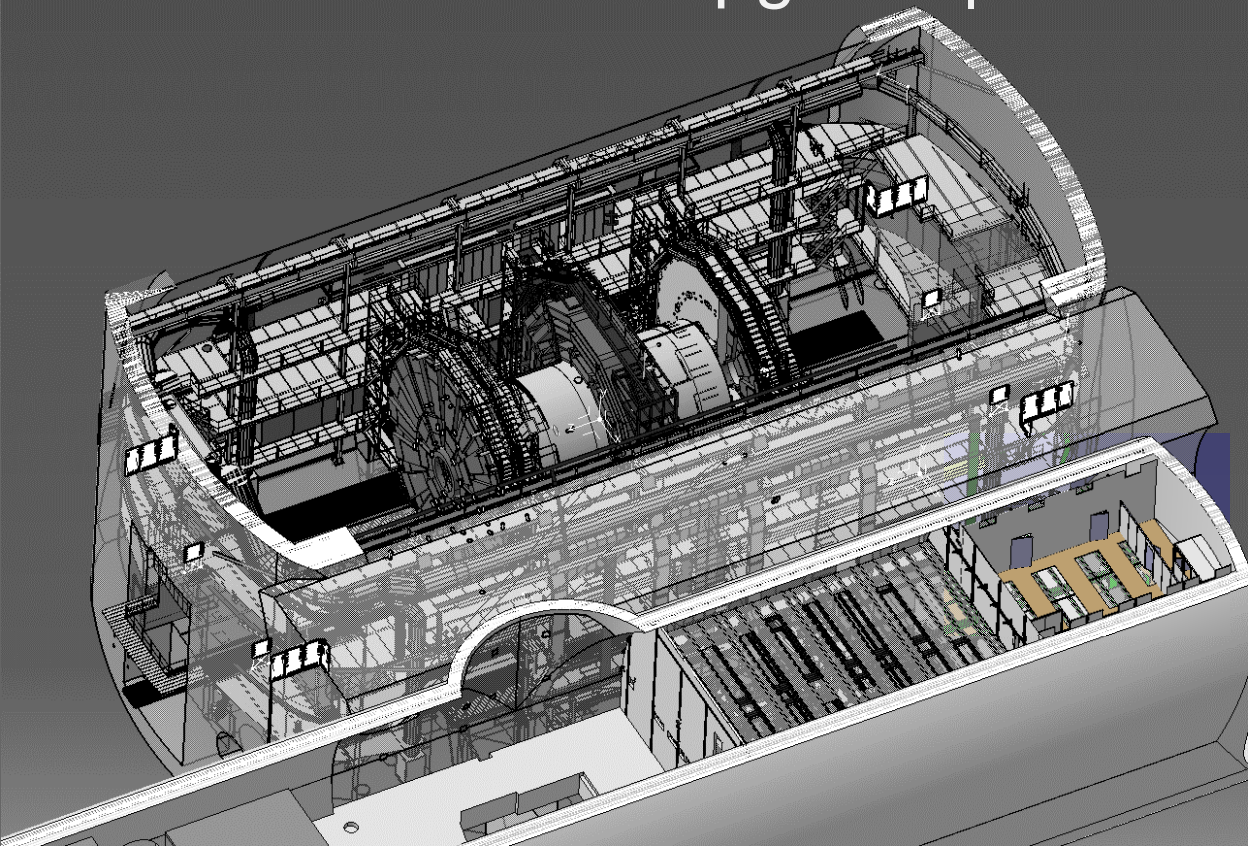


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# CMS Phase II Upgrade | DT Contributions



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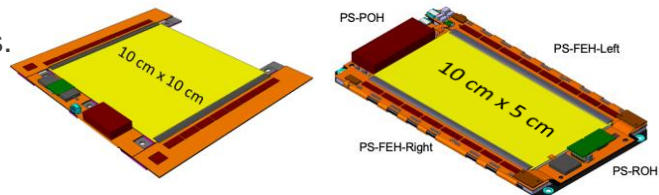
**TOTEM** | 0.3 FTE  
0.3 staff

# Tracker | Module Development

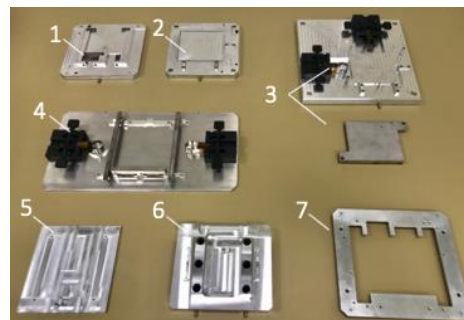
~15 000 detector modules needed. Assembly outside CERN at 10 institutes.

CERN (EP-DT, -ESE) contributes to module and hybrid design & QA. **DT:**

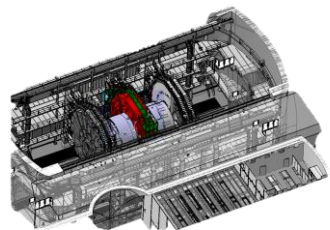
- Module 3D/2D design libraries (Catia & step files) for the full collaboration.
- Assembly and testing of proto modules
- Definition & qualification of assembly procedure
  - Design, prototyping of assembly methods and jigs
  - Definition of full assembly procedure
  - Qualification: thermal cycles and electrical functional tests
  - Documentation for institutes.
  - Procedure defined for 2S, to be repeated for PS



2S (strip-strip) and PS (pixel strip) modules



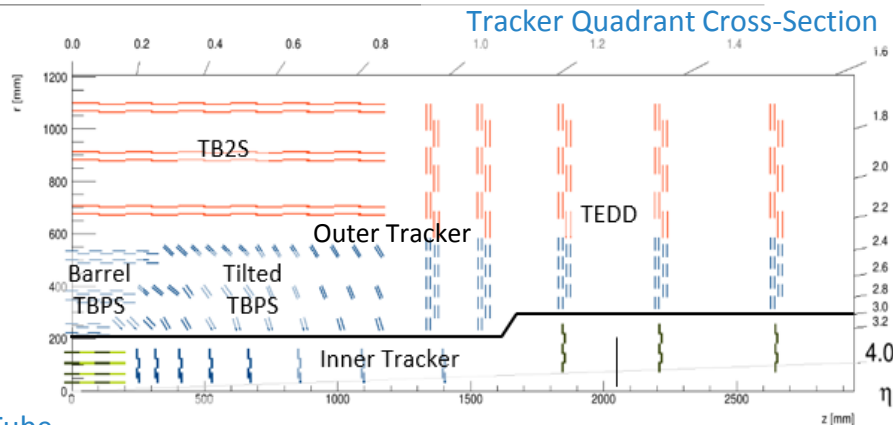
1. PI positioning-holding jig
2. Sensor backplane gluing plate
3. Sensor gluing jig (including weight plate)
4. Readout and service hybrids gluing jig
5. Glue transfer plate for long and stump bridges
6. Wire-bonding jig
7. Module carrier



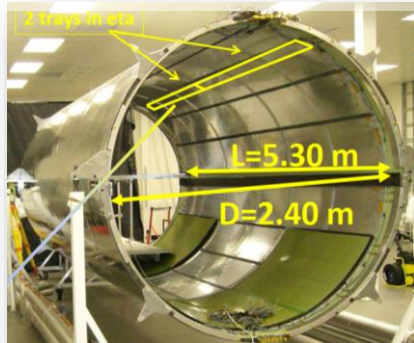
# Tracker | Mechanics and Integration

Coordination of mechanical design, definition of sub-detector envelopes, services routing, etc.

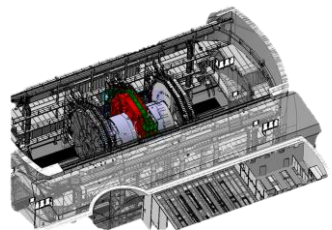
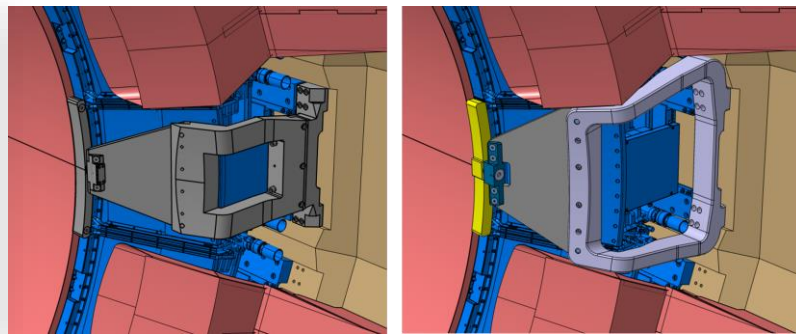
- 2018-2019: Adapting the Tracker layout and supports to match with a new Barrel Timing Layer detector.



BTL trays inside Support Tube  
 (photo from current CMS Tracker)



Tracker Support Bracket design



# Tracker | Tilted TBPS Development

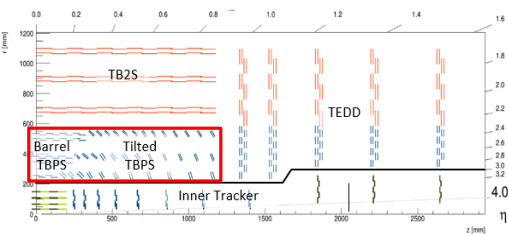
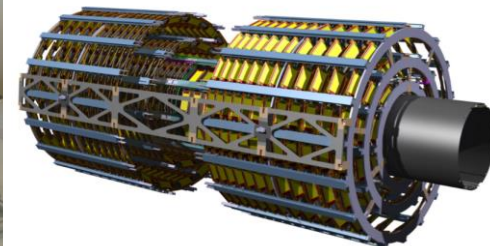
Tracker Barrel with PS modules | DT role:

- Design and manufacture of the tilted TBPS structures, cooling and integration.
  - Module production by INFN (Italy).
  - Barrel TBPS made by Fermilab (US).
- 2018-2019:
  - Integration and services mockups
  - First final-type proto ring, getting ready \*now\*

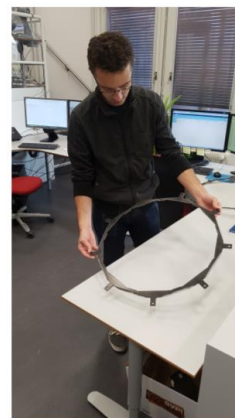
Services Mock-up



TBPS assembly model



Tilted ring





# Tracker | TB2S Development

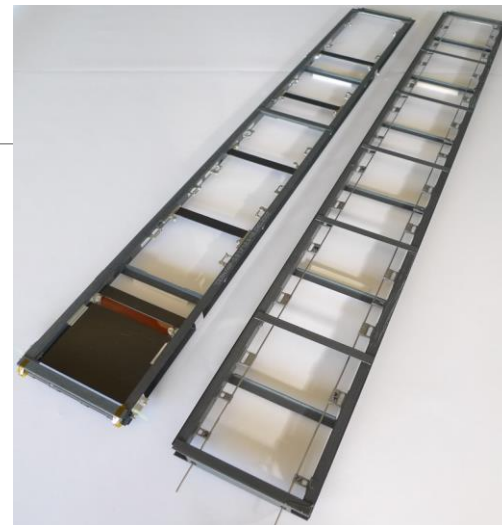
Tracker Barrel with 2S Modules | DT role uses CMS TOB heritage:

Contribute to the TB2S design and transmit know-how to collaborating institutes in charge of the production:

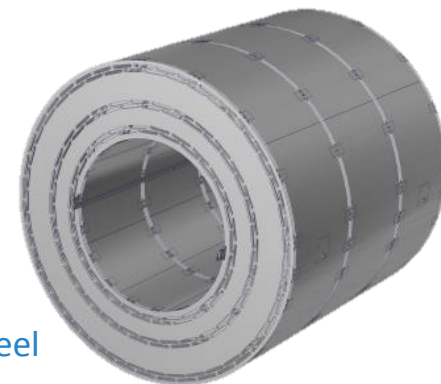
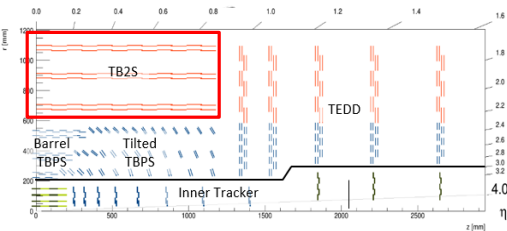
- National Center for Physics, Islamabad (PK): **TB2S Ladders**
- CNRS Strasbourg (FR): **TB2S Wheel**

2018-2019:

- First TB2S prototype made in PK. Now being measured at DT.
  - Geometry verification
  - Thermal performance planned in collaboration with EP-CMX



Old TOB (left) and new TB2S ladders



TB2S Support Wheel

# Tracker | On-Detector Cooling & Services

Cu-Be Test sample

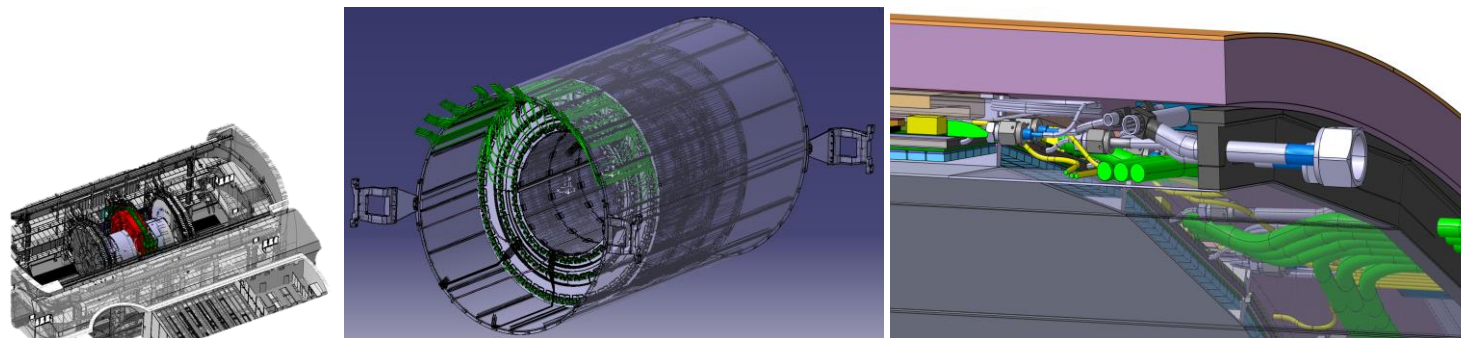


- Design
- Mock-ups and validation
- Envelope studies
- Collaboration with cooling team for services dimensioning
- Development and validation of new joining techniques for difficult integration constrains – See [Indico 812623](#)

Joining techniques studies



Outer tracker and BTL services design study

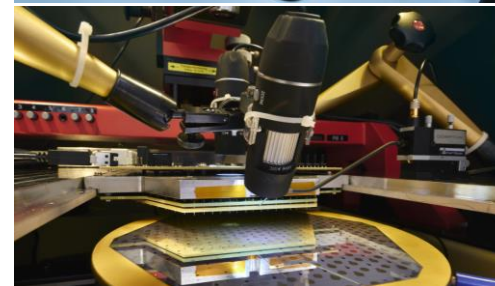


# Endcap | CE Module Development

 HGCal Sensor Testing  
 2019-04-17

Collaboration with LCD group to select HGCAL sensors

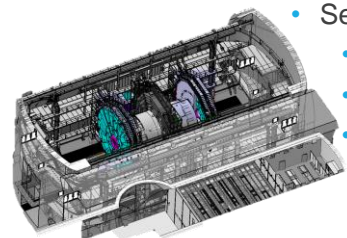
- Electrical characterization
  - Various sensor types: silicon bulk material, cell barriers, geometries, thicknesses
  - Development of testing systems:
    - 2D multiplexing grid and probe card
    - Read-out electronics probe card
- Performance measurement w/ test beams: DESY & CERN
  - Energy, position and time resolution
- Consulting for HGCal colleagues on sensor procurement
- Next activity: characterization of irradiated sensors
  - Sensors must be tested without annealing:
    - Transported cold from Slovenia
    - Purchase custom probe station: -30°C HV plate, light-tight, dry enclosure
    - Plans to combine with custom testing solutions



October 2018 run 517 - event 1:  
 250 GeV  $\pi^-$

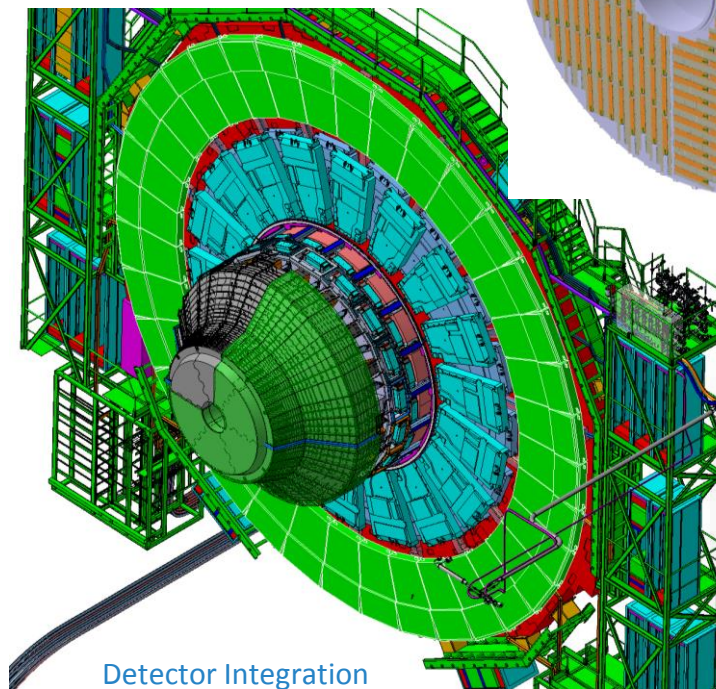
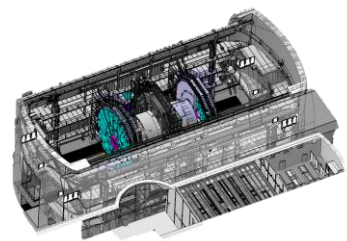


HGCal Sensor Prototype Beam Test  
 2019-04-17 Indico 731649

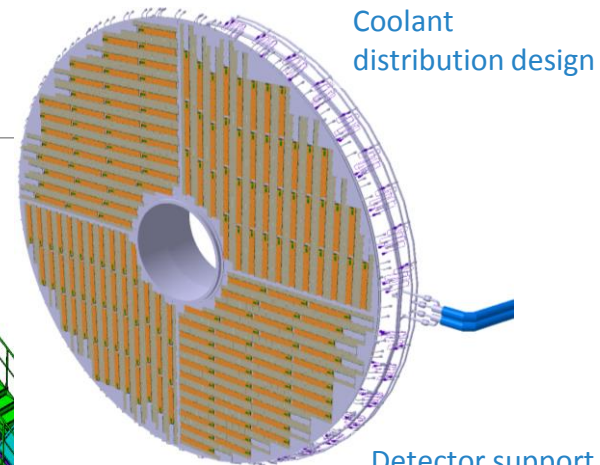


# Endcap | ETL Services

- Services definition and routing
- Mechanical integration procedures
- Definition of interfaces
  - ETL envelope
  - TK/ETL interfaces – i.e. TK bracket
- Soon: validation mock-ups
  - Detector rim, services feed-through
  - Cooling performance wedge mock-up

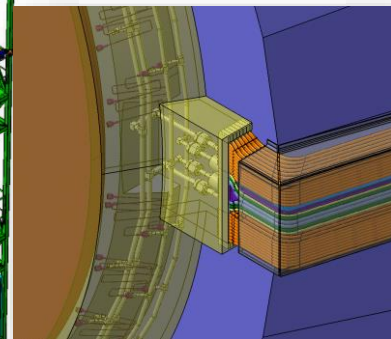


Detector Integration



Coolant distribution design

Detector support structure design

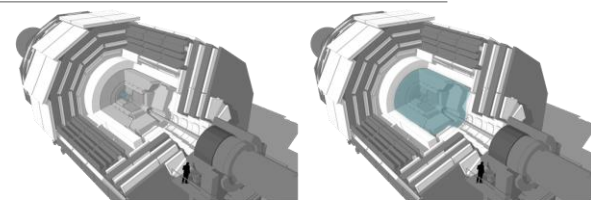


Services Design

# CO<sub>2</sub> Cooling | Scaling Up

Scaling up for CMS & ATLAS. See V. Bhanot presentation

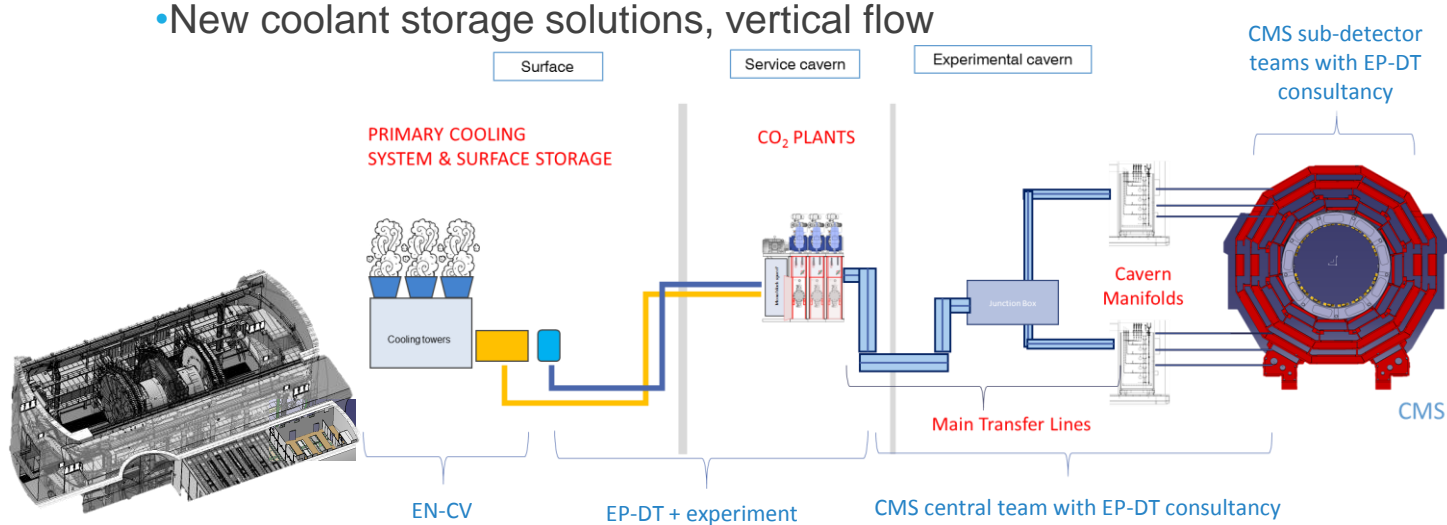
- >500 kW total CO<sub>2</sub> cooling capacity. kg/s-class pumps
- 150 transfer lines supplying more than 500 evaporator loops
- 8 plants cooling TK, BTL, ETL, CE. Commercialized production.
- New coolant storage solutions, vertical flow



Phase I: 15 kW Capacity

Phase II: 500 kW Capacity

3-head pump for Baby-DEMO prototype



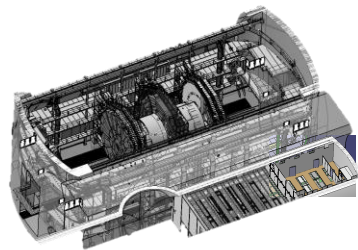
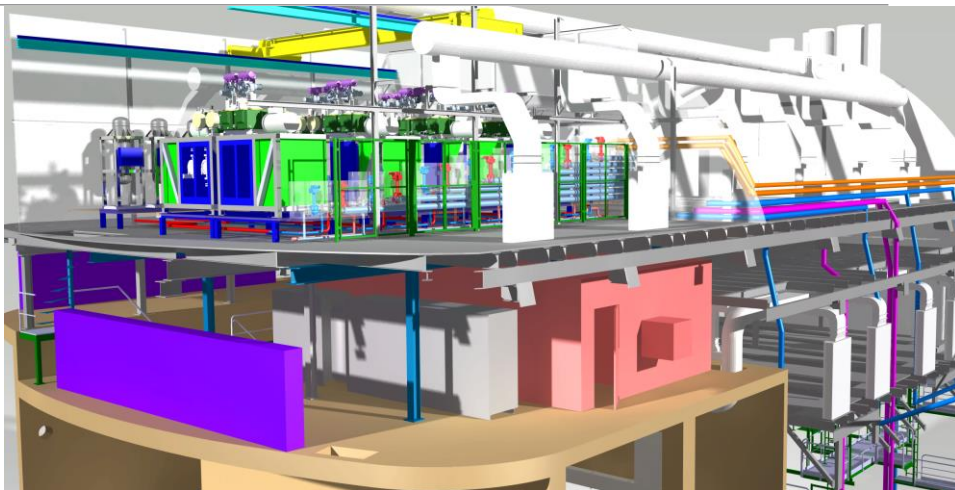
CMS sub-detector teams with EP-DT consultancy



# CO<sub>2</sub> Cooling | Integration Studies

USC55 Control Room Study

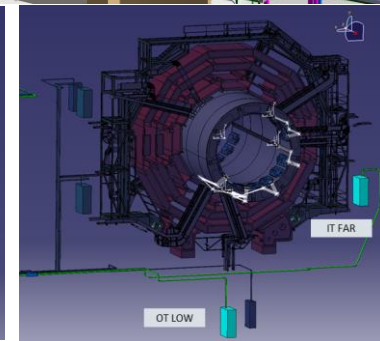
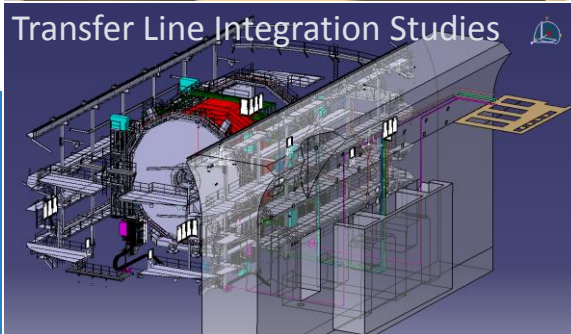
- EP-DT takes first integration studies:
  - To optimize system performance
  - Within general integration constraints
  - In collaboration with CMS E&IO
- Results used for:
  - Cooling plant design (control room)
  - Transfer line sizing – route length
  - Input for CMS Integration Office
- CMS E&IO produce detailed proposal



## Workflow has addressed:

- Main transfer lines
- USC55 control room

**Next:** Detector Transfer Lines

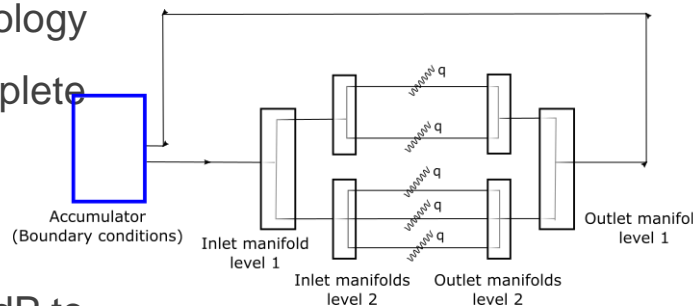


# CO<sub>2</sub> Cooling | Performance Calculations

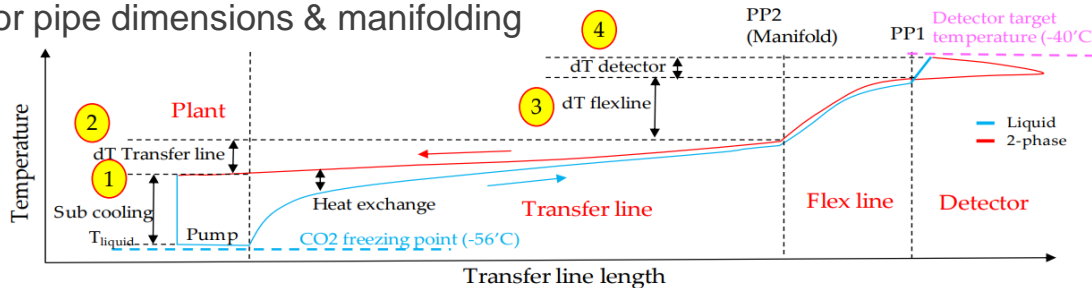
2PACL detector temperature determined by:

- Accumulator  $T_{\text{sat}}$  – limited by technology
- 2-phase pressure drops along complete return path
  - Transfer Lines
  - On-detector distribution
- DT produces simulations of return dP to evaluate coolant distribution designs
  - Transfer line routings and cross sections
  - On-detector pipe dimensions & manifolding

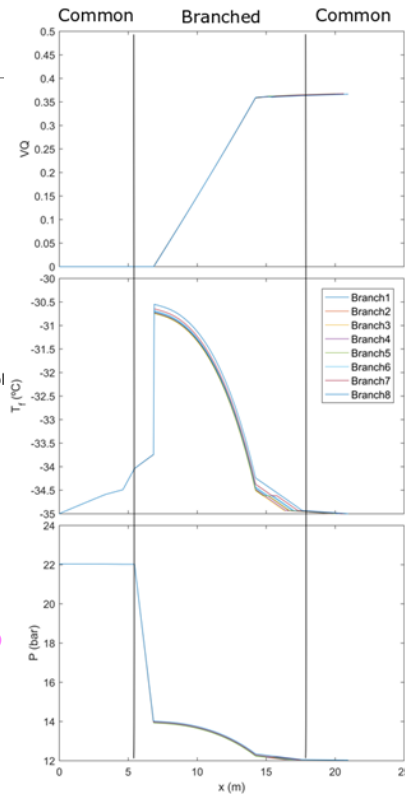
Schematic of multi-line simulation model



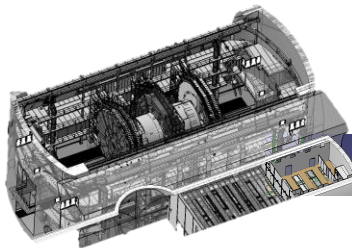
dT Budget produced example



## Design pint

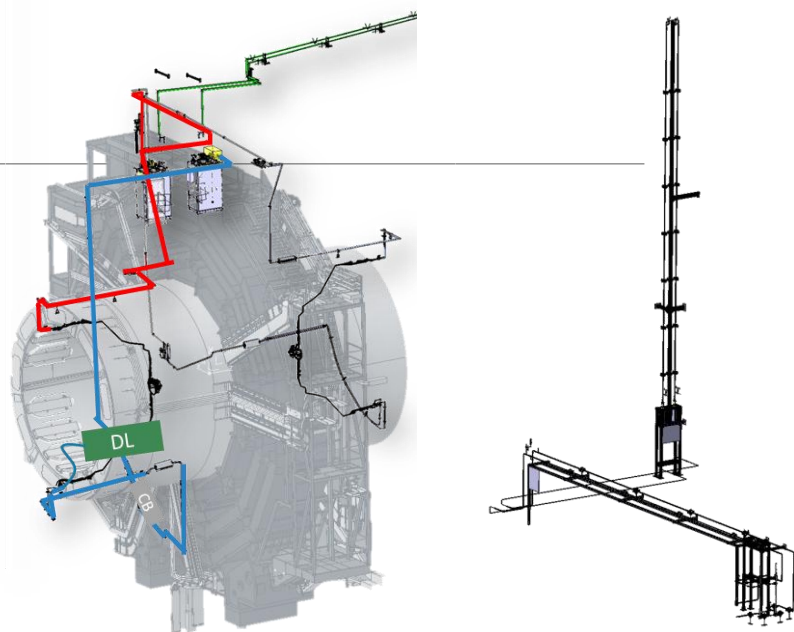


Example of multi-line simulation results

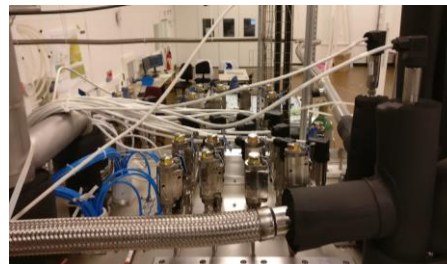


# CO<sub>2</sub> Cooling | R&D

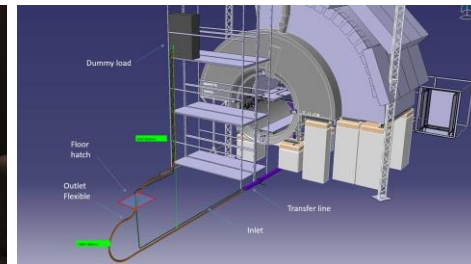
- Vertical flow testing | [See V. Bhanot presentation](#)
  - Most significant open question in TL dimensioning
  - 2 set-ups to test vertical flow dPs
  - 1 laboratory set-up enabling optical characterization of flow regimes
  - 1 test set-up at P5 to study 2-phase vertical flows with real detector transfer lines
  
- Flexibles testing in collaboration with HGICAL
  - To characterize 2-phase dP
  - In collaboration with EP-CMX (HGICAL)
  - Promising first results – horizontal,  $T_{\text{sat}} > -25^{\circ}\text{C}$
  - Testing to continue at Baby-DEMO:
    - $-40^{\circ}\text{C}$
    - Vertical orientation to replicate path in CMS



Vertical test set-ups at CMS (left) and b.153 laboratory



First flex test set-up TIF



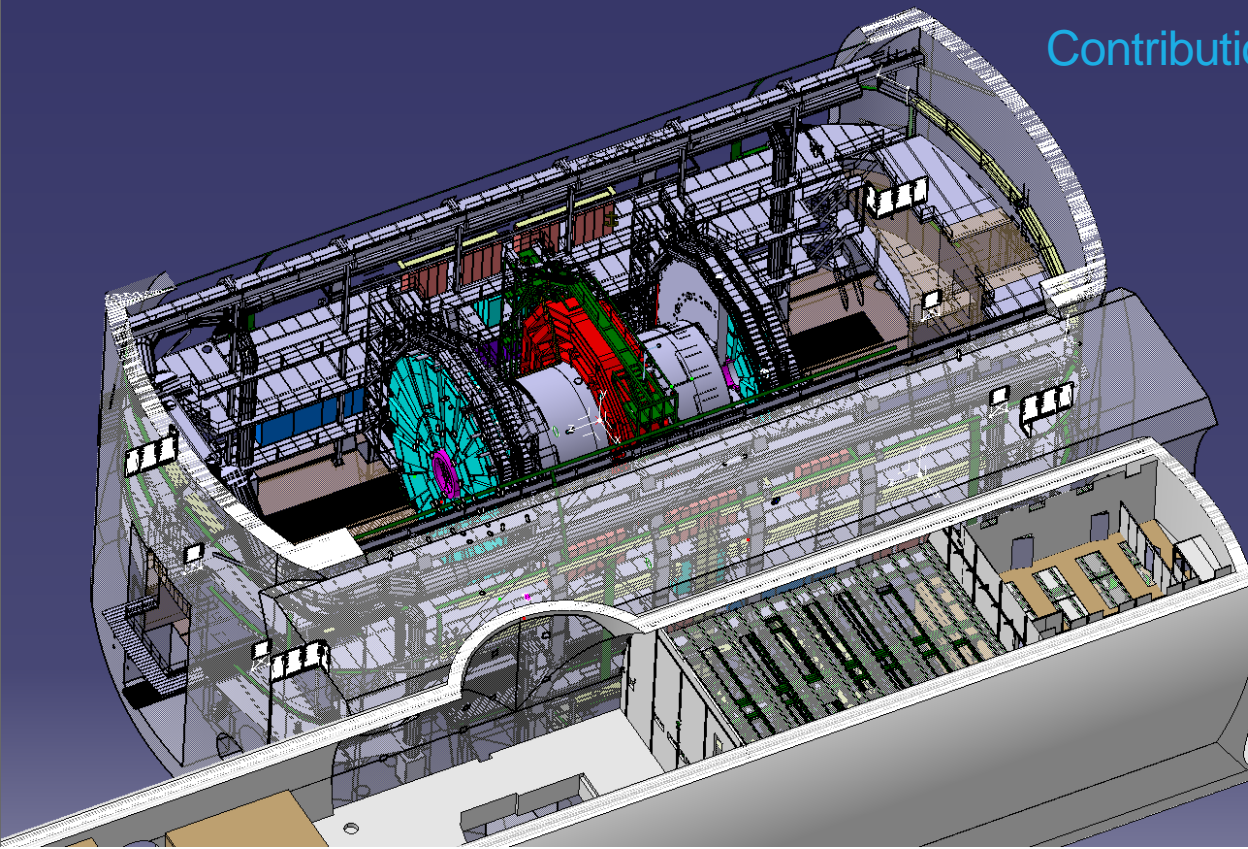
Planned flex test set-up Baby-DEMO



# DT Group Meeting 2019

## Contributions to CMS Phase II Upgrade

Tym Pakulski | EP-DT-FS



Thanks to all who contributed  
to the presentation

R. Carlos Puente	P. Lopez
K. Cichy	A. Onnela
J. Daguin	K. Rapacz
A. Filenius	D. Schmid
D. Giakoumi	E. Sicking
N. Koss	N. Smiljkovic
A. La Rosa	P. Tropea