The CMS Pixel and Beam Pipe Support and Installation

OUTLINE

- Main “functional” specs for the supporting system
- Implications of combined functions of PIX & BP support
- The BP/PIX support system of CMS
- Alignment issues: materialization of the “tracker axis”
- Some implications on CMS PIX mechanics
- Importance of mock-ups and complete 3D models
- Installation sequences

Contributions (~ 1999 – 2008)

Integration/Interfaces

Basti, A.
Bos, J.
Calvo Alamiillo, E.
Faber, G.
Gomez, G.
Ingenito, P.
Moggi, A.
Opstaptchouk, A.
Palmonari, F.
Raffaelli, F.
Rodrigo Anoro, T.
Smilkovic, N.

Design & Construction

Algar Ruiz, M.
Petagna, P.
Rodrigues, N

Installation Tools

Bosi, F.
Chatelain, J.-P.
Di Vincenzo, S.
Massa, F.

The CMS Pixel and Beam Pipe Support and Installation

Beam Pipe

Blanchard, S.
Chauville, D.
Deville, T.
Foffano, G.
Lepeule, P.
Mermet, P.E.
Schneider, G.

Survey

Behrens, A.
Fuchs, J-F
Lasseur, C.
Goudard, R.
Maillefaud, J.-D.
Maurisset, A.

BPIX

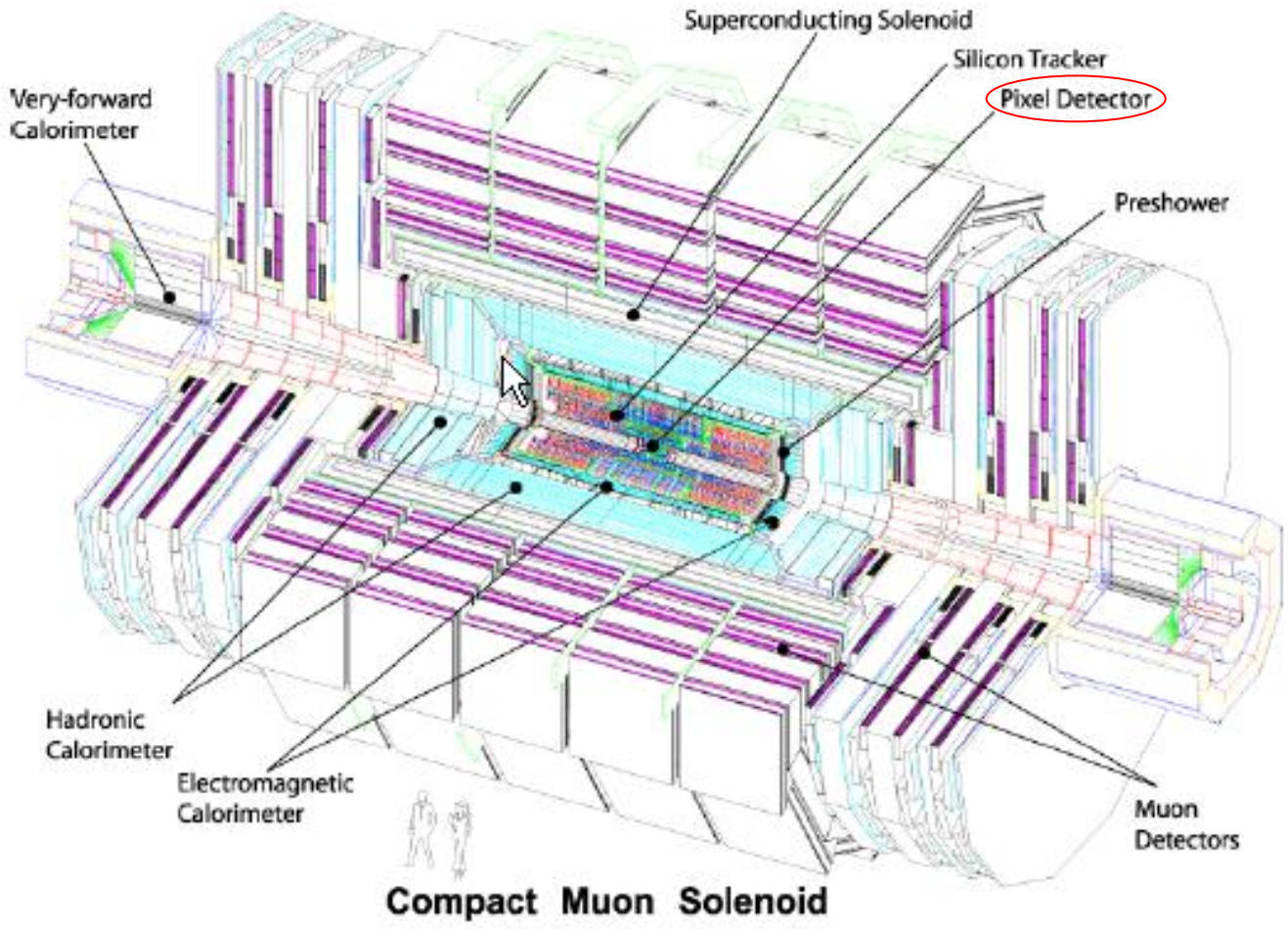
Bertl, W.
Gabathuler, K.
Koenig, S.
Streuli, S.

FPIX

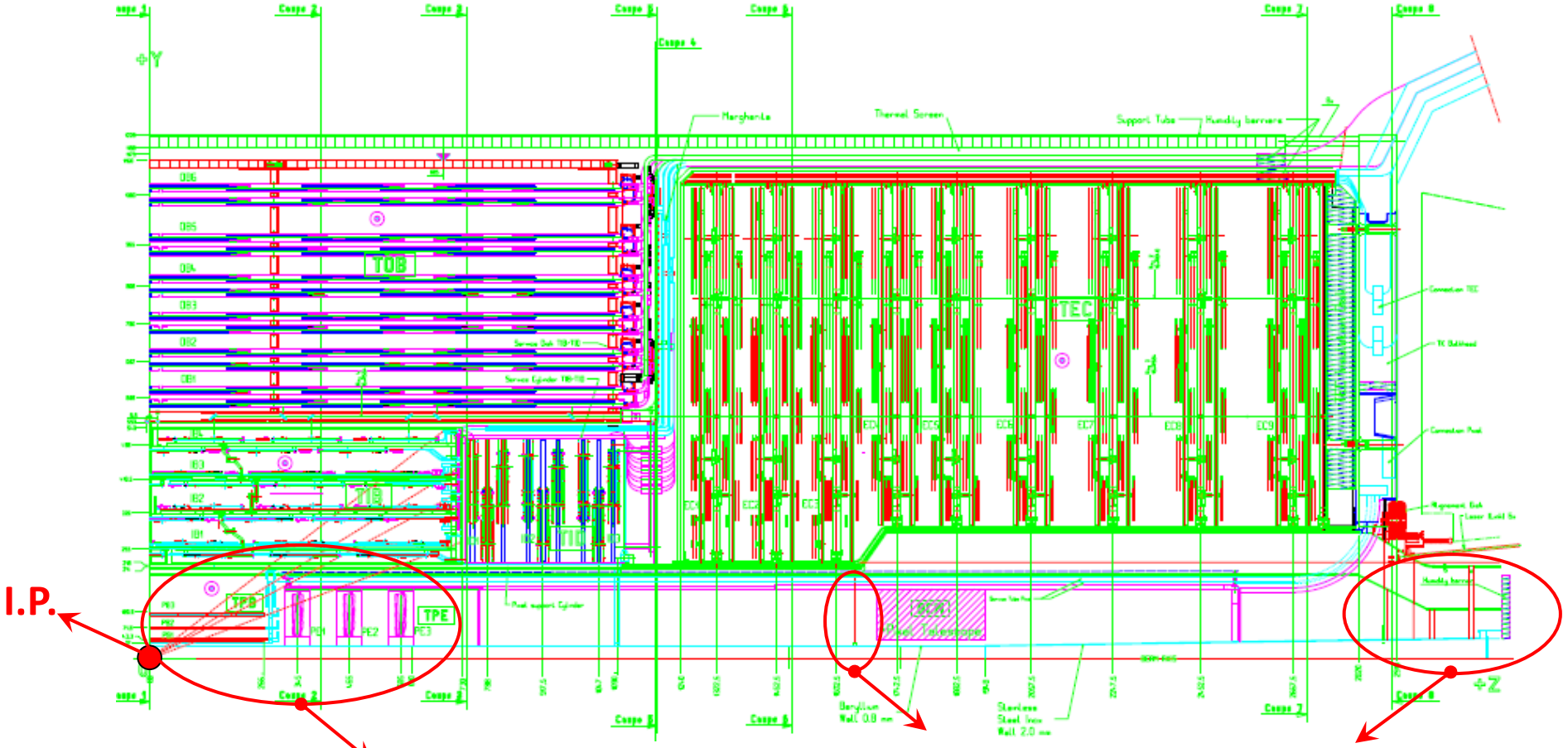
Chertok, M.
Dinardo, M.
Dominguez, A.
Gobbi, B.
Howell, J.W.
Kwan, S.
Newsom, C.
Pellet, D.
Rauch, J.
Velasquez, R.

… and probably many others (sorry!)

Geometrical location inside CMS



Geometrical location inside the Tracker (¼ shown)



Main Functional Specs of BP/PIX supports

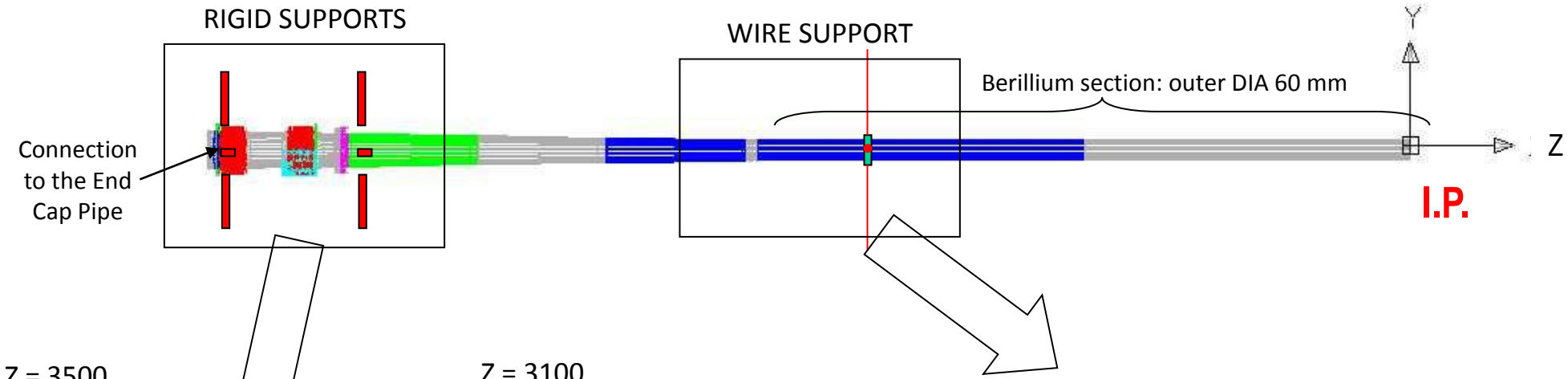
(Beam Pipe related constraints)

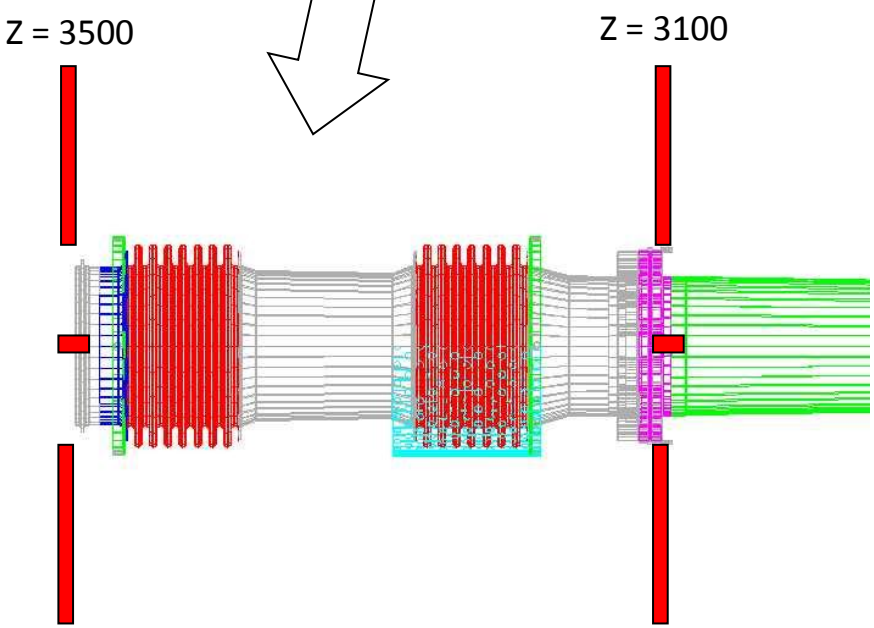
- Allow for independent installation of central beam pipe
- Beam pipe supports "independent" of TK sub-detectors
- Guide and support removable bake-out ovens and jackets
- Temporary support the full "end-cap" beam pipe (15 m) during CMS closing
- PIX fully removed during bake-out

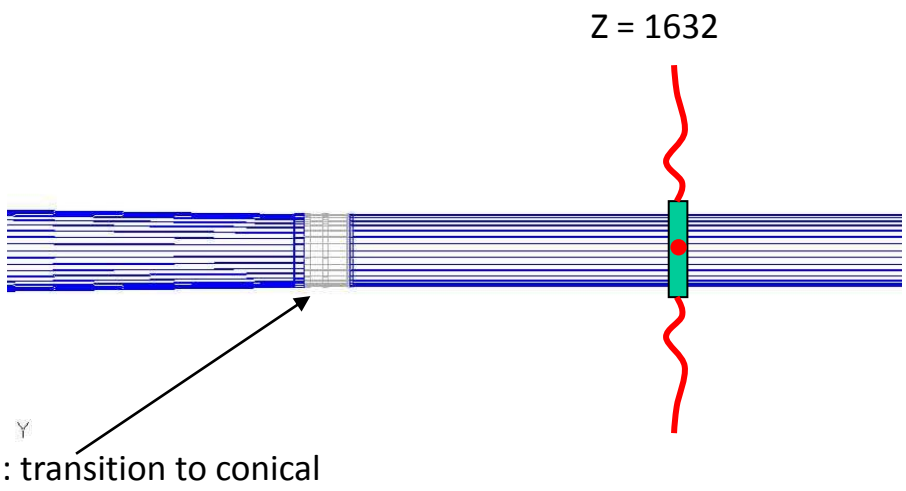
- Removal/insertion of PIX without "touching" the Strip TK *(includes connections)*
- Annual access to PIX granted if needed (repairs, replacing irradiated modules)
- Time required for PIX removal/installation ALARA *(includes connections)*
- High stability of PIX position once in place
- Reduced X/X_0

(Pixel related constraints)

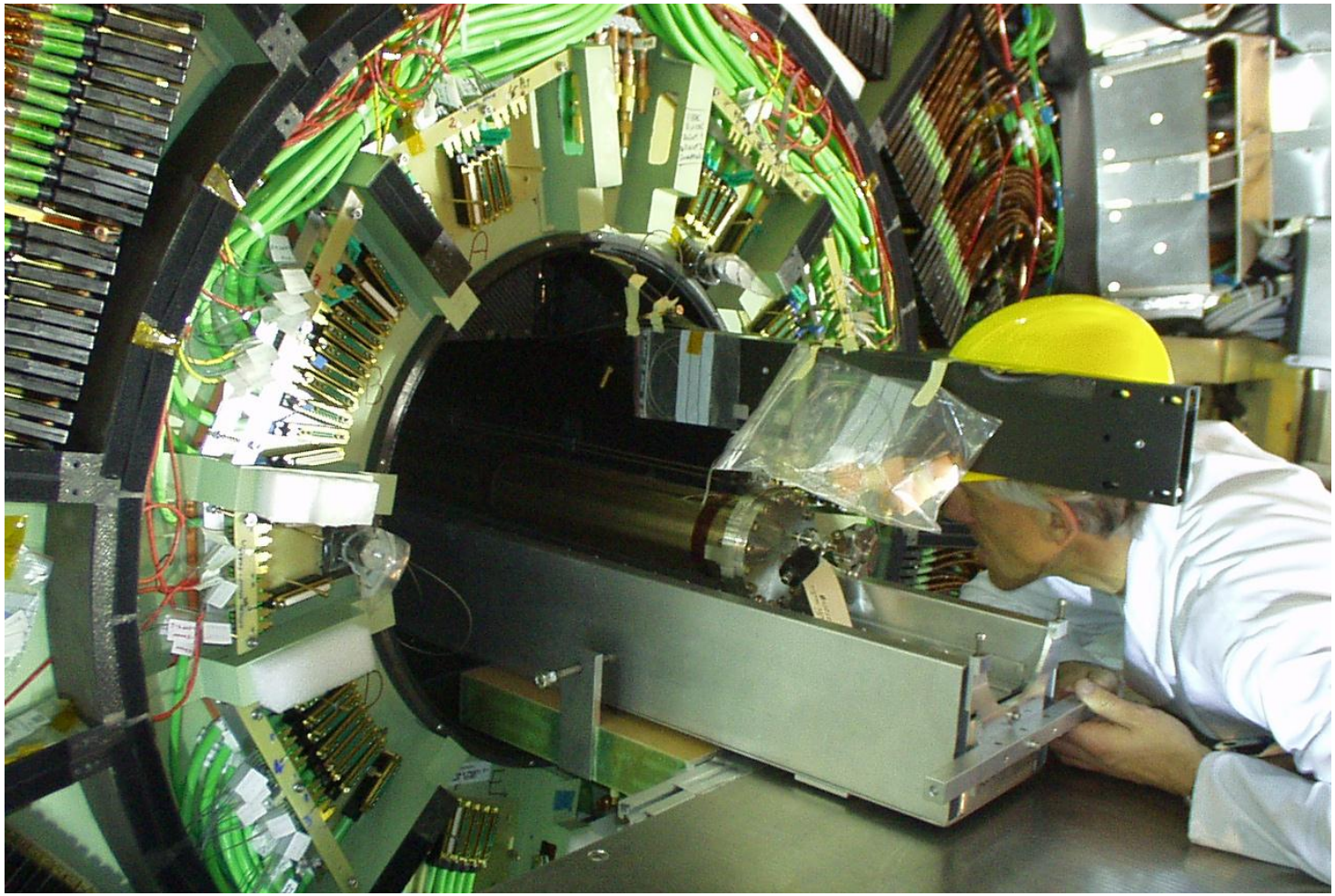
Central Beam Pipe Support Positions







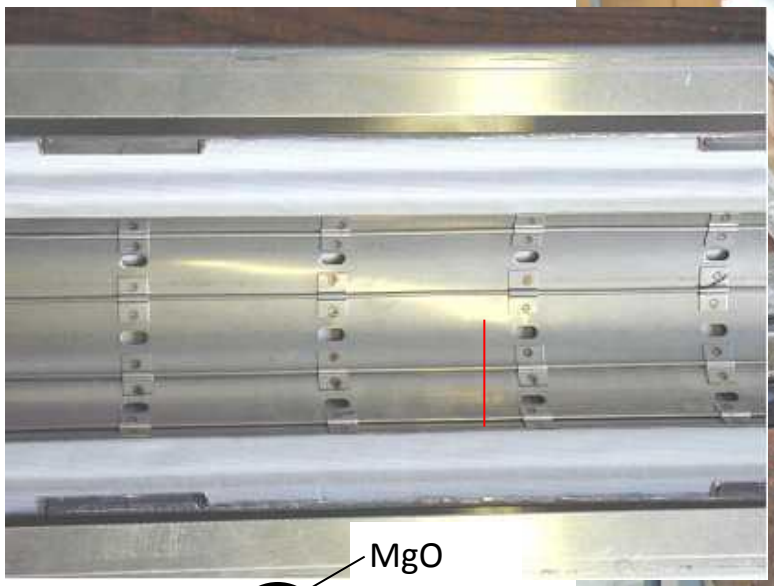
6m Long Central Pipe with Installation Cradle

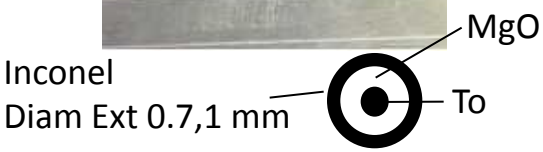


The 6 m long Central Beam Pipe was pre-stretched to its final shape in the installation cradle

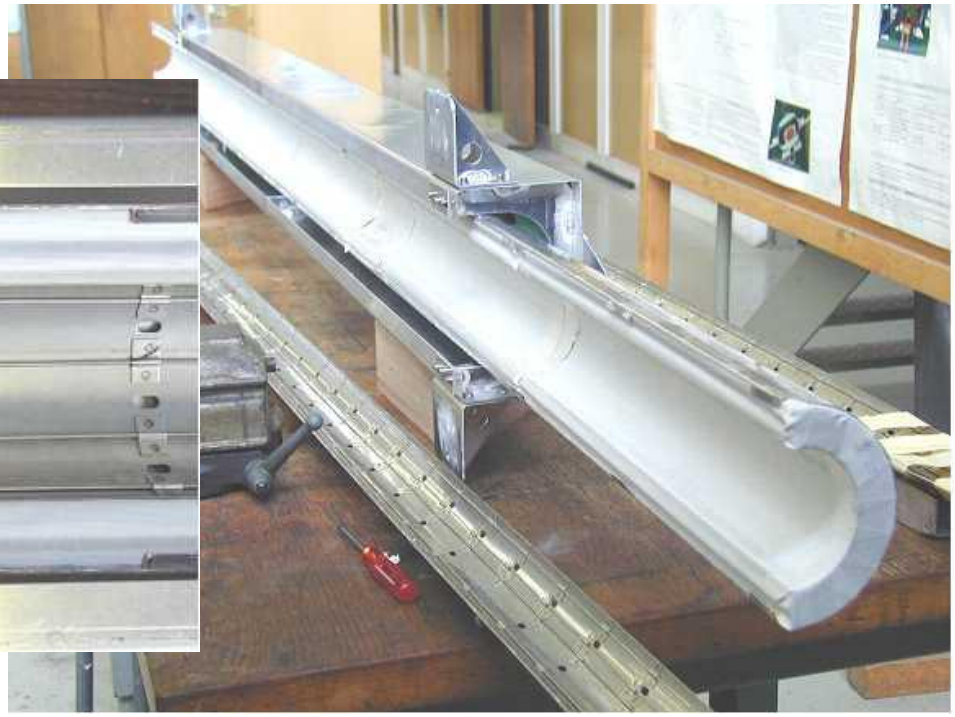
Removable Bake-out Oven (½ shown)

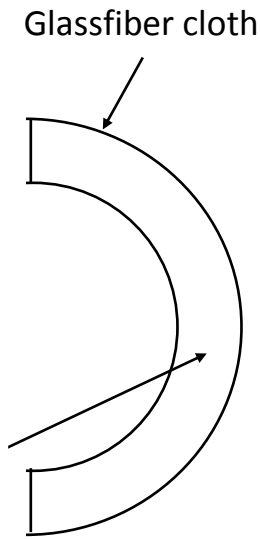
- Heater : Coaxial Heater





- Insulation : Microtherm MPS

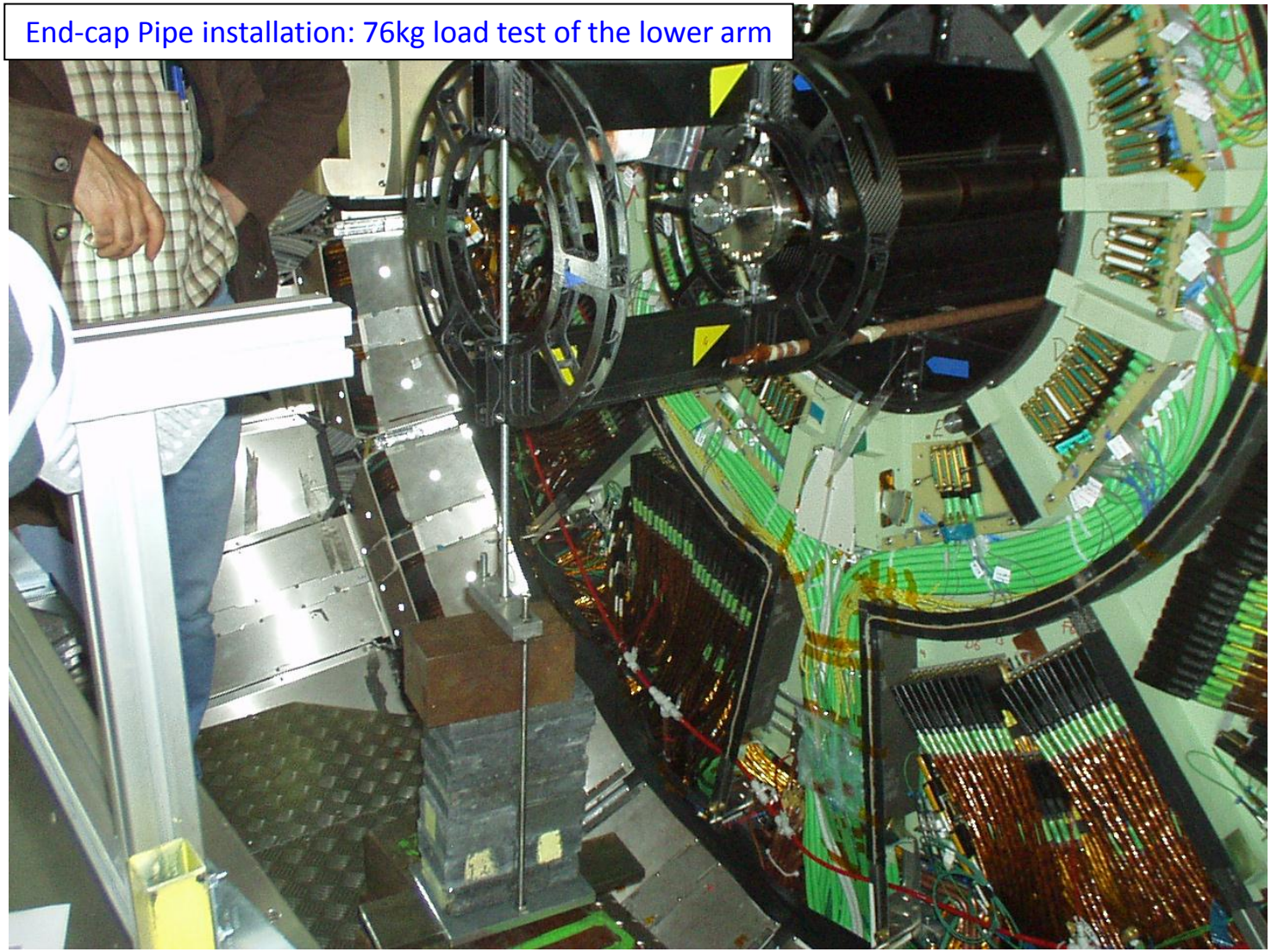




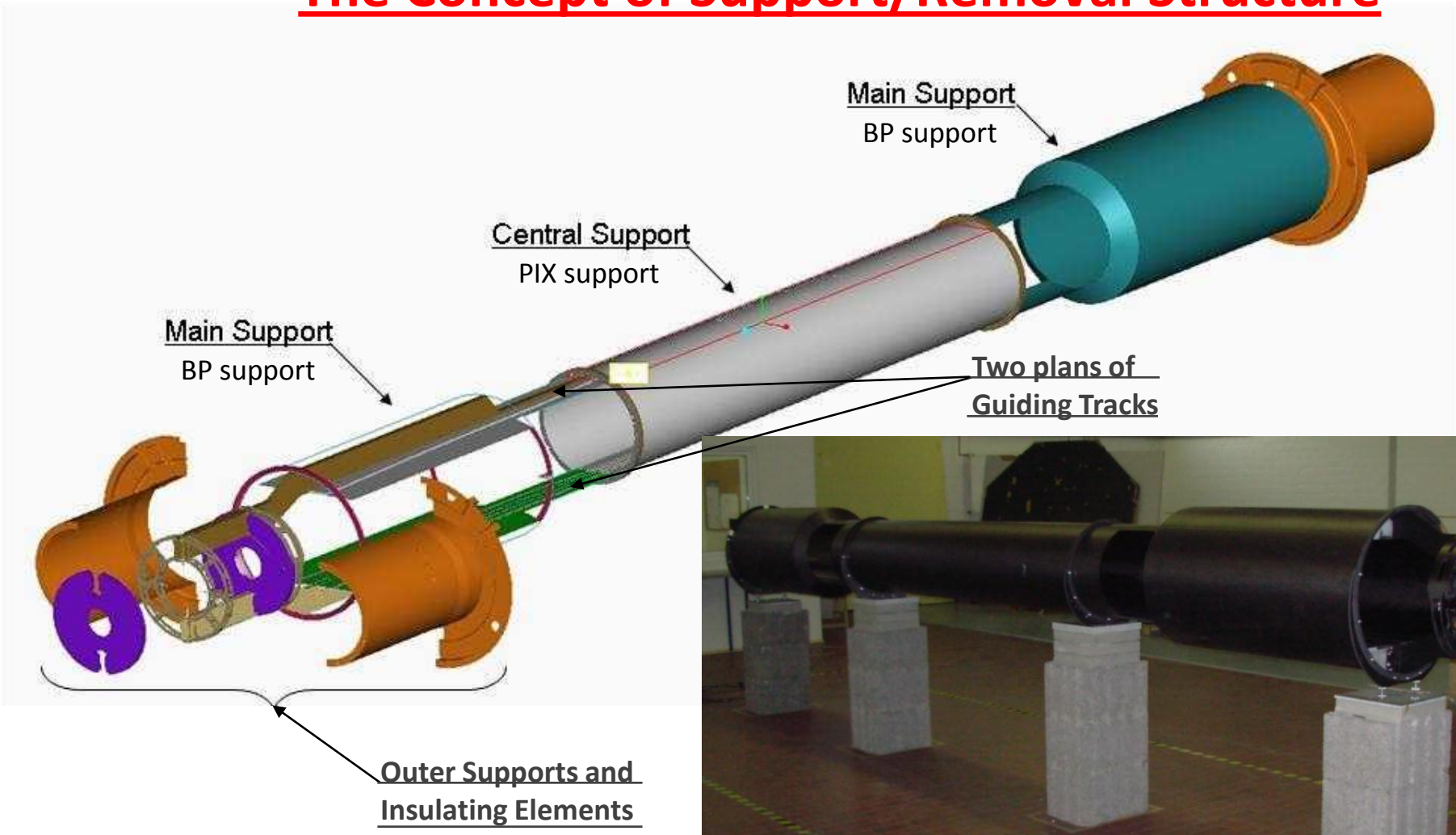
HEAVY OBJECT (> 20 kg)

Temporary Support of End-cap Pipe

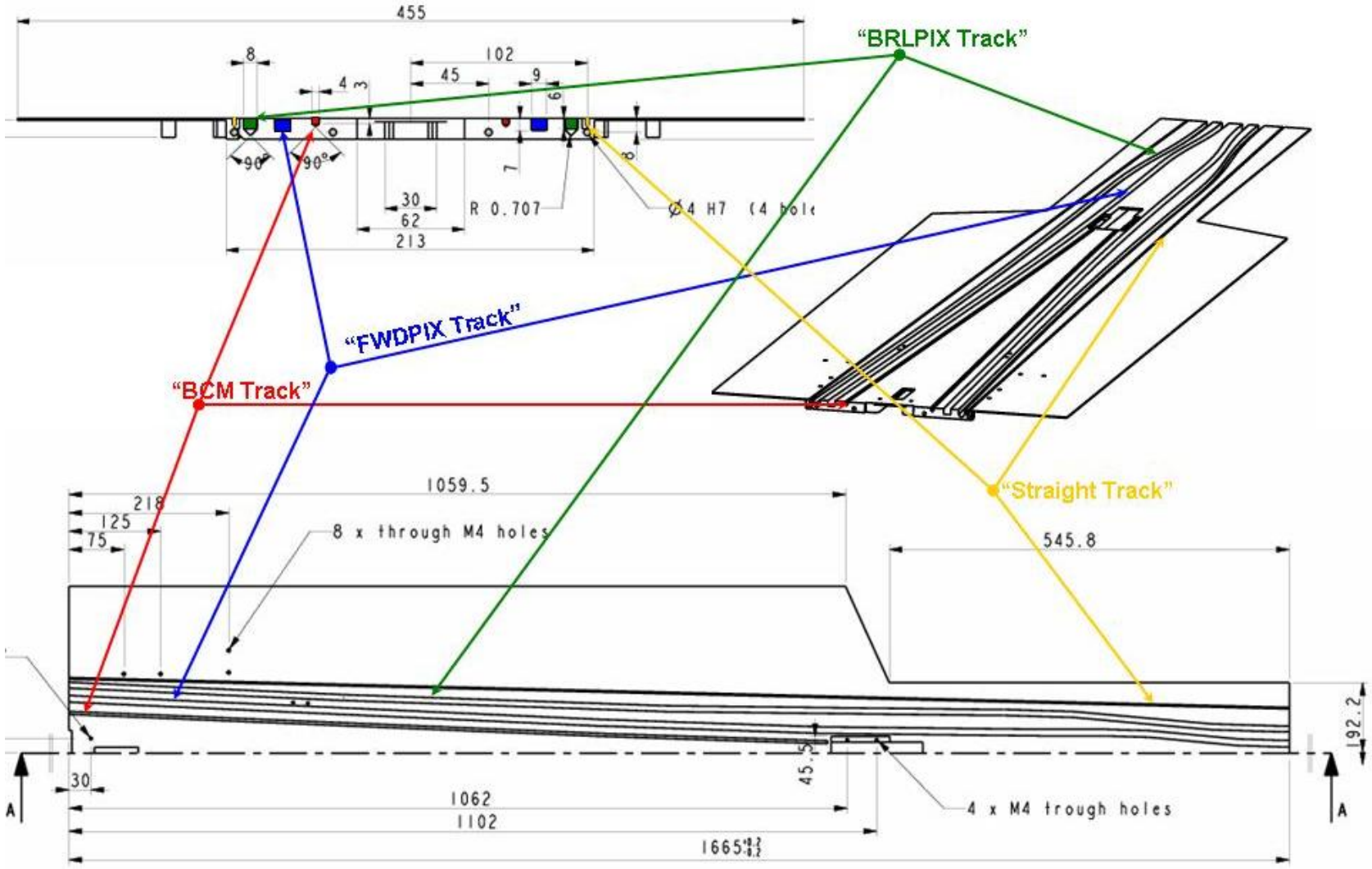
End-cap Pipe installation: 76kg load test of the lower arm



The Concept of Support/Removal Structure

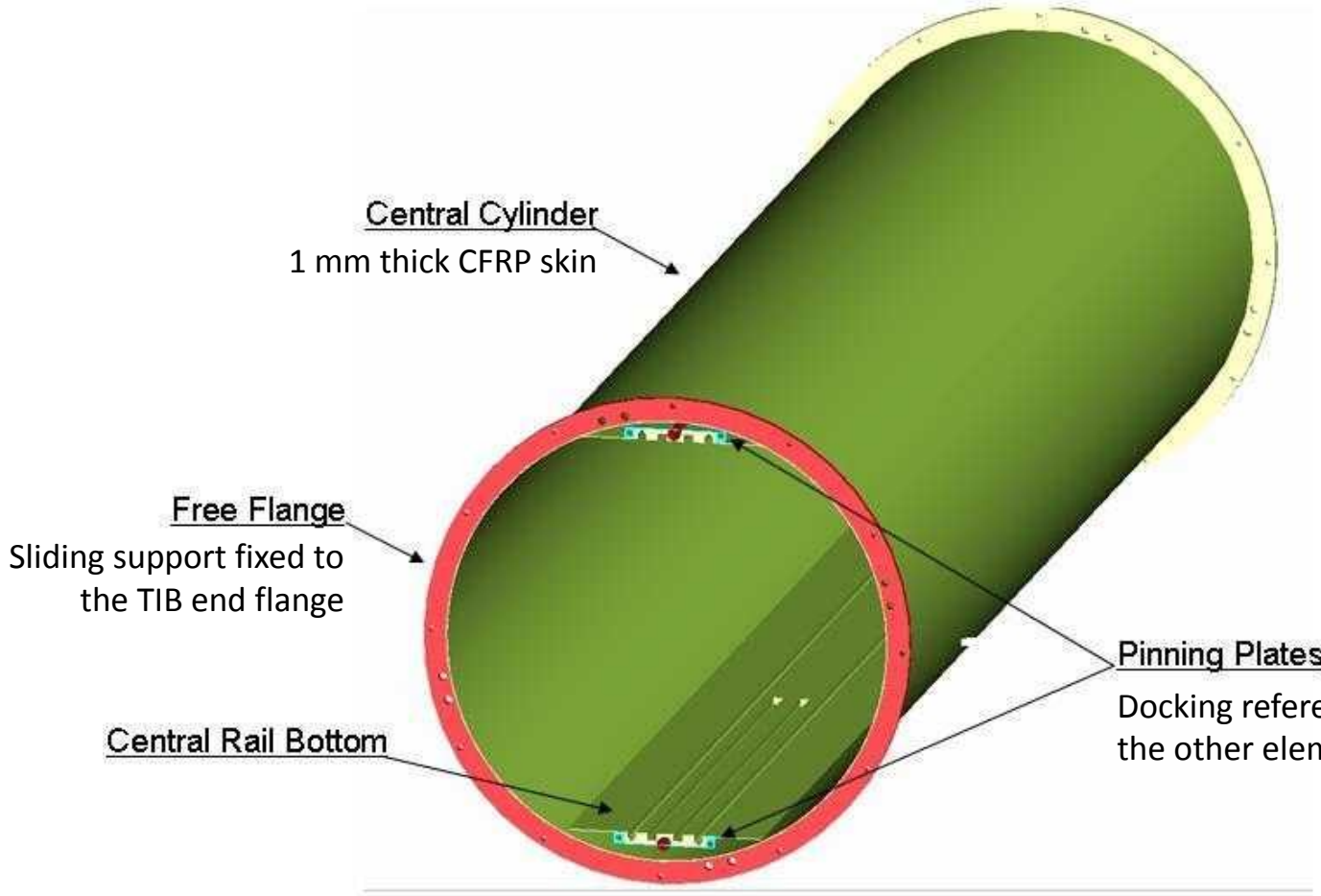


Guide Tracks for PIX Installation & Removal



Details of the Support/Removal Structure

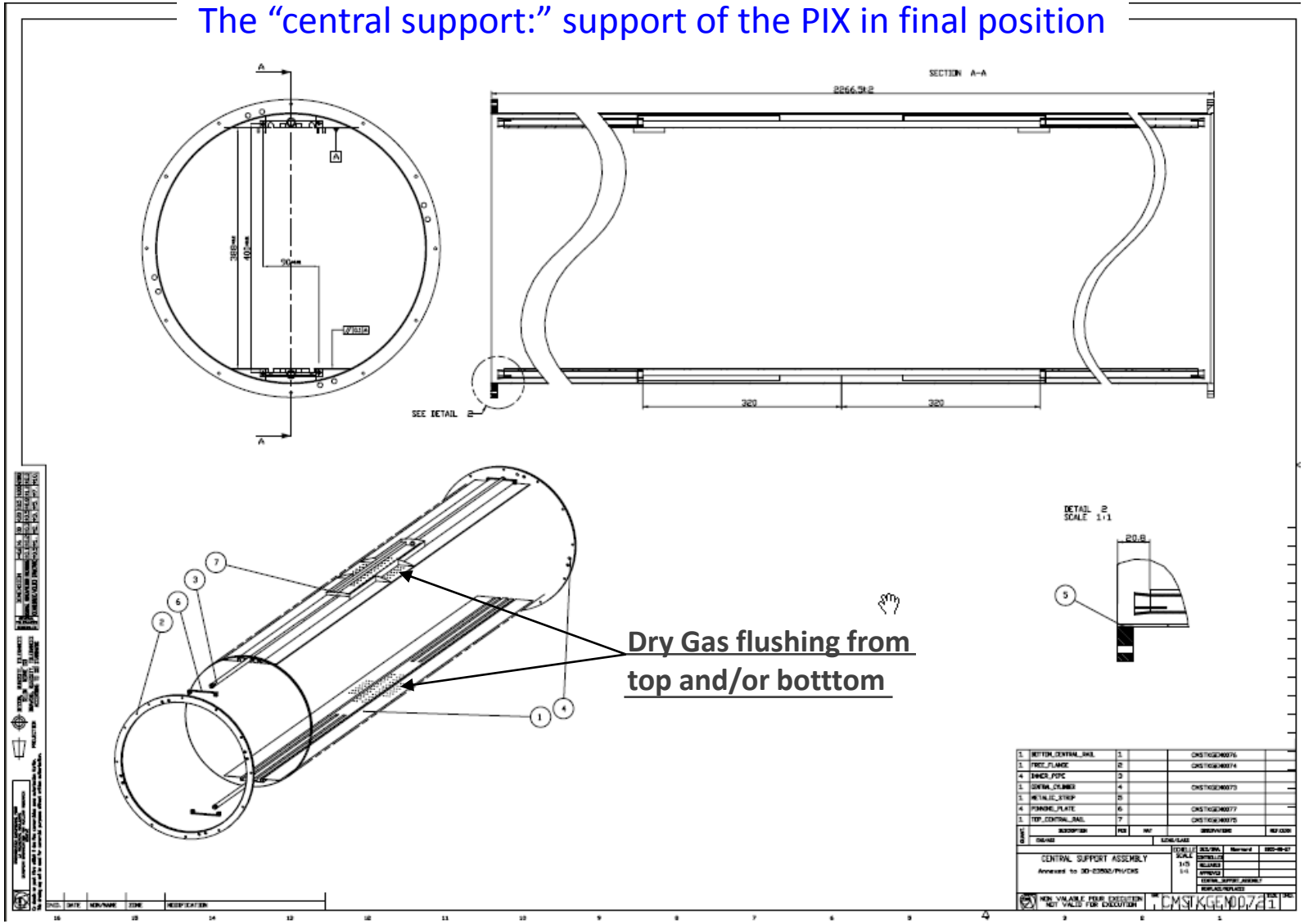
The "central support:" support of the PIX in final position



The two reference plans are the key elements: they were pre-assembled within tight position and parallelism tolerances in a specific jig and the cylinder was assembled around it

Details of the Support/Removal Structure

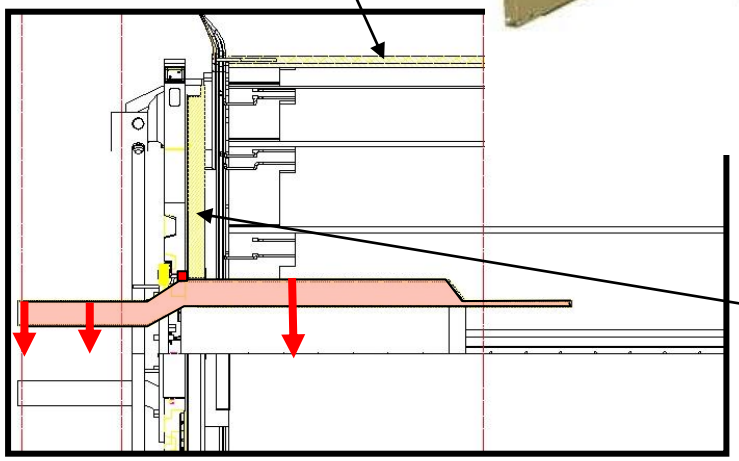
The “central support:” support of the PIX in final position

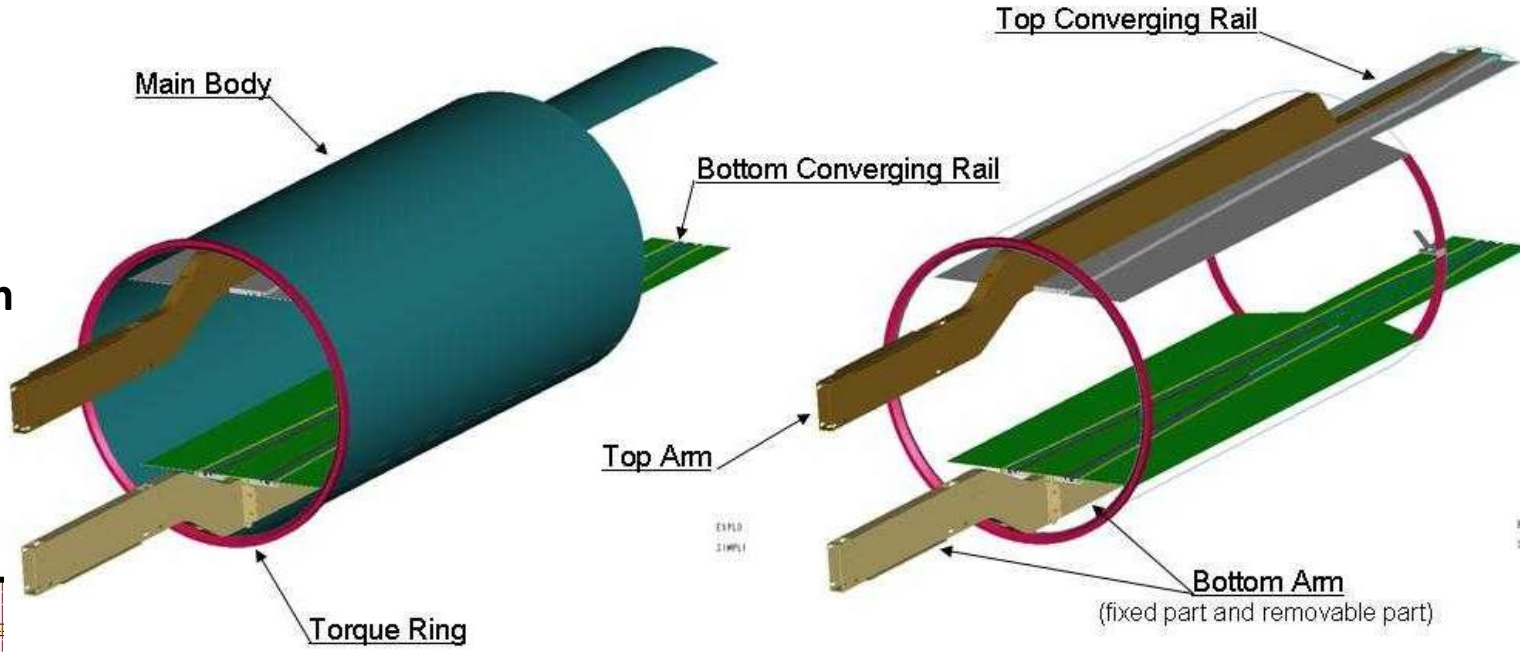


Details of the Support/Removal Structure

The "main body": support for the BP and converging track towards I.P.

The "Torque Ring" connects the BP support directly to the TK closing flange (the "Bulkhead") and from this to the main TK Support Tube

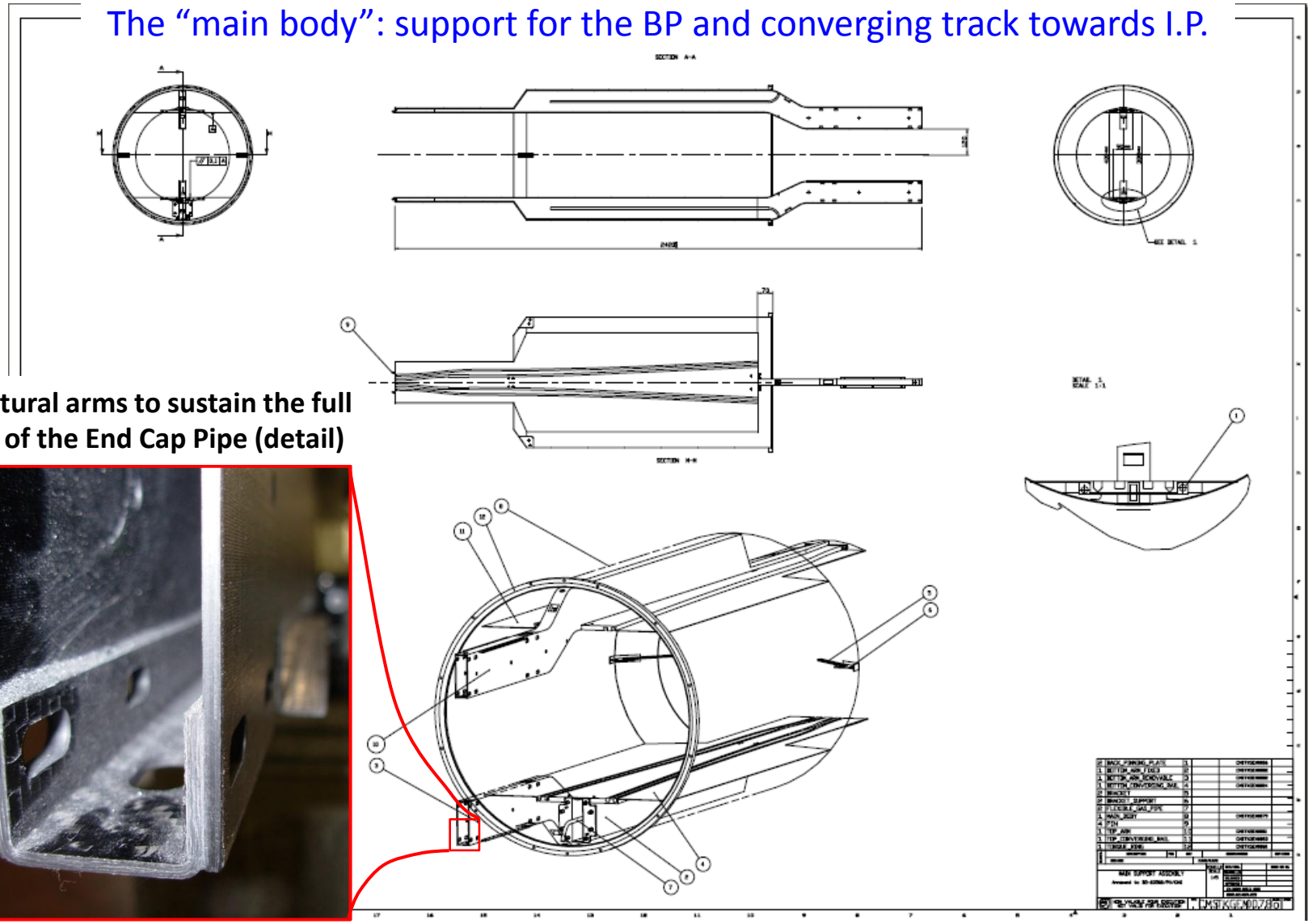




The main structural elements are the "arms": high aspect ratio closed section "backbones" of the structure

Details of the Support/Removal Structure

The "main body": support for the BP and converging track towards I.P.

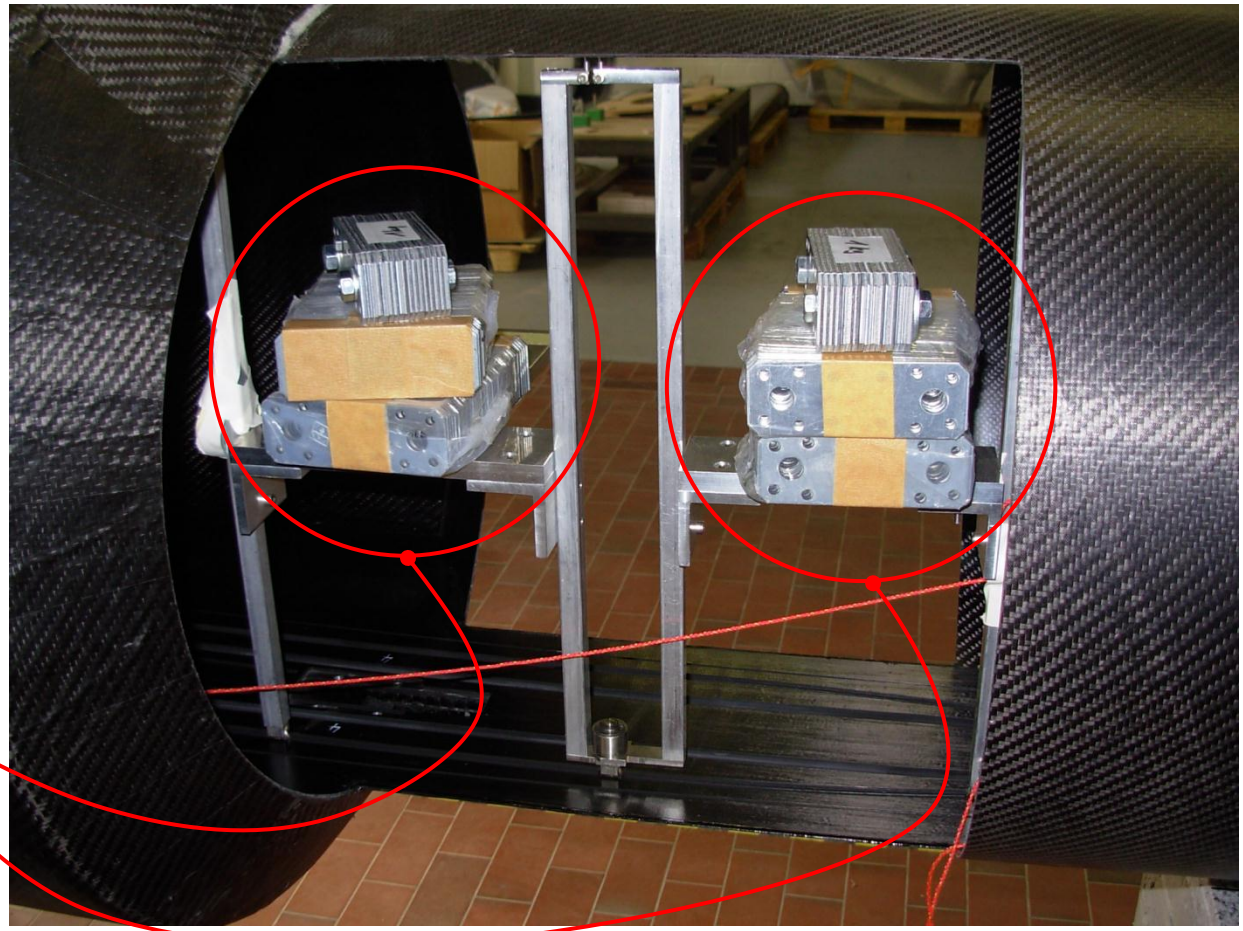


Structural arms to sustain the full load of the End Cap Pipe (detail)

Contradictory Constraints from BP and PIX

High bending stiffness requires additional material in specific locations

But clearance problems during PIX installation requires to remove unnecessary walls

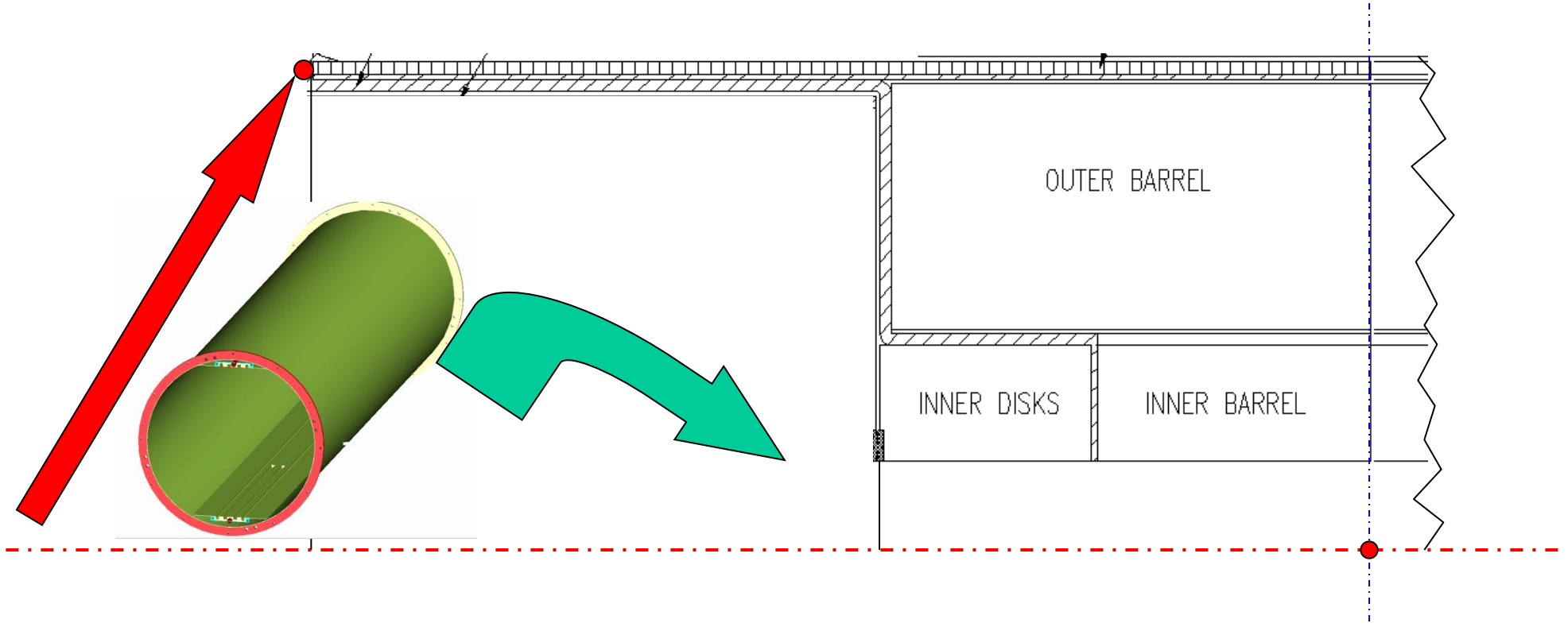


= 22 kg!

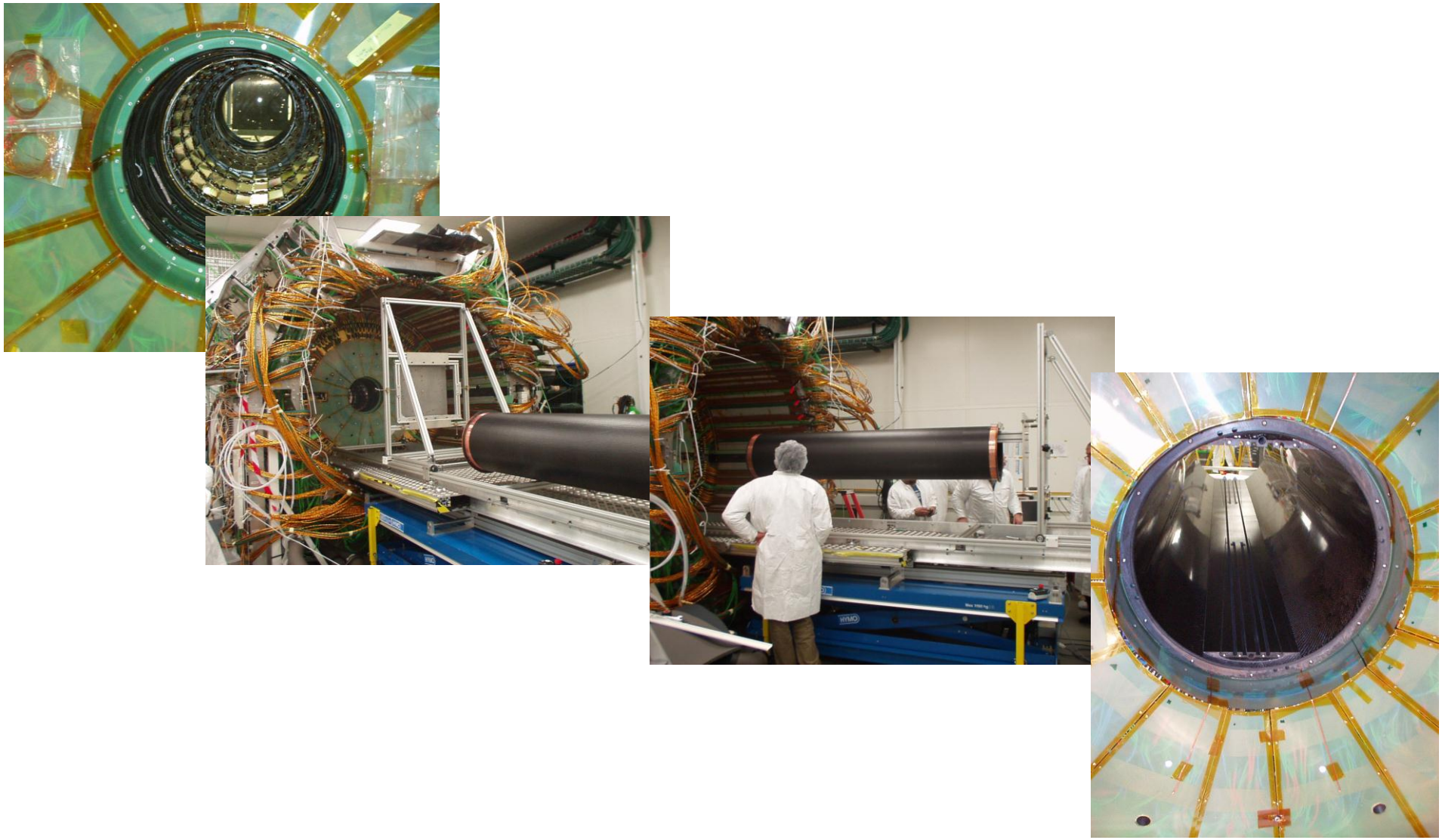
Alignment: Materialization of the "Tracker Axis"

1 – Central support installation

After installation of the TIB/TID, the Central Support is inserted and aligned with the TK rails. Once positioned, the Survey measures its axis, WHICH BECOMES THE TK AXIS. This information is then transported at the outer perifery of the TK Tube



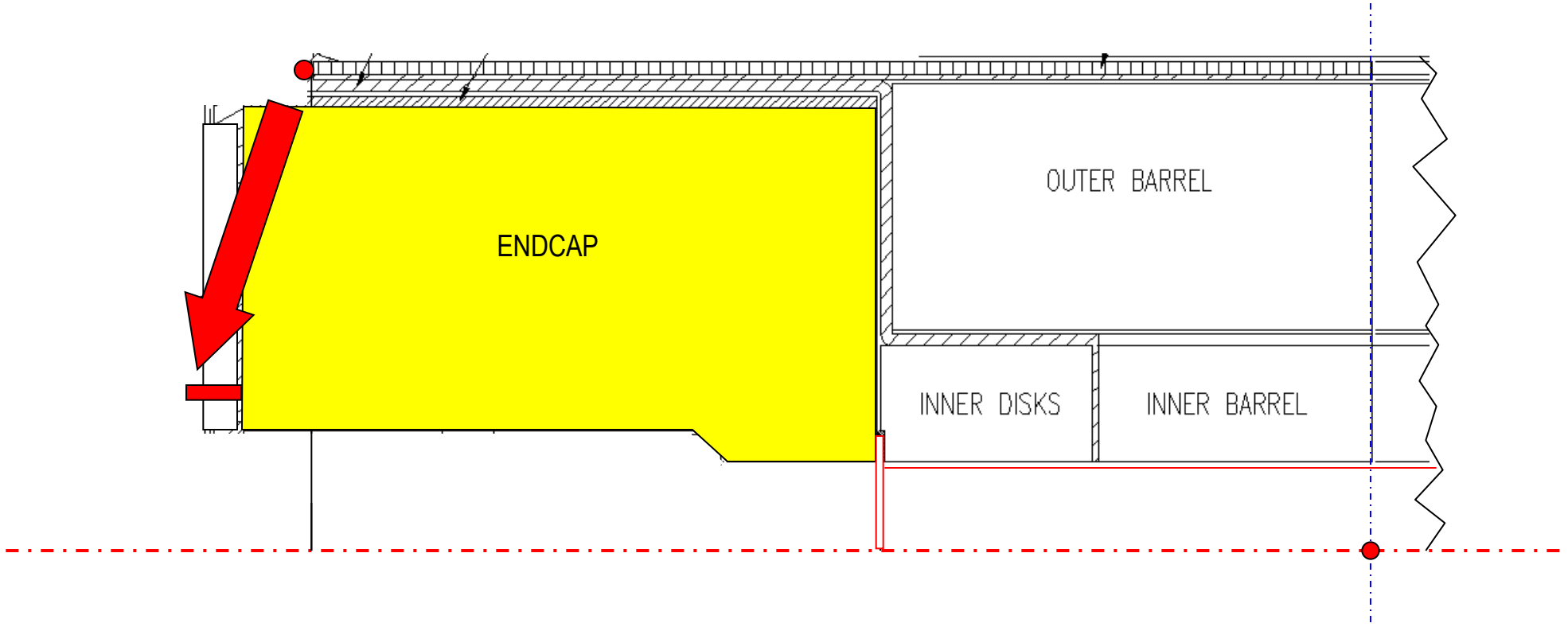
(Sequence of the central support installation)



Alignment: Materialization of the "Tracker Axis"

2 – Transfer @ end-cap insertion

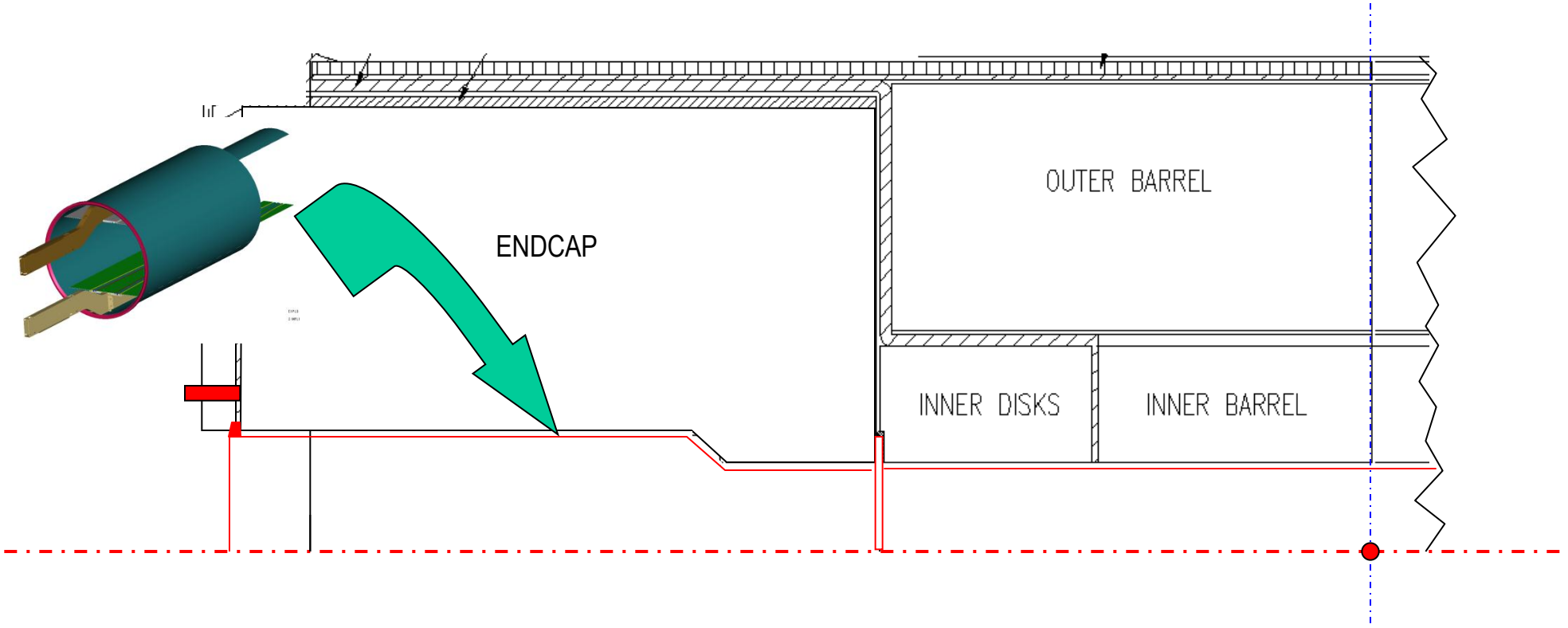
When TEC is installed, the references at the outer perifery of TK are temporary still visible: the "TK axis" is then transferred on the Alignment Ring pillars, whic are always visible (special survey adaptors have been produced by RWTH)



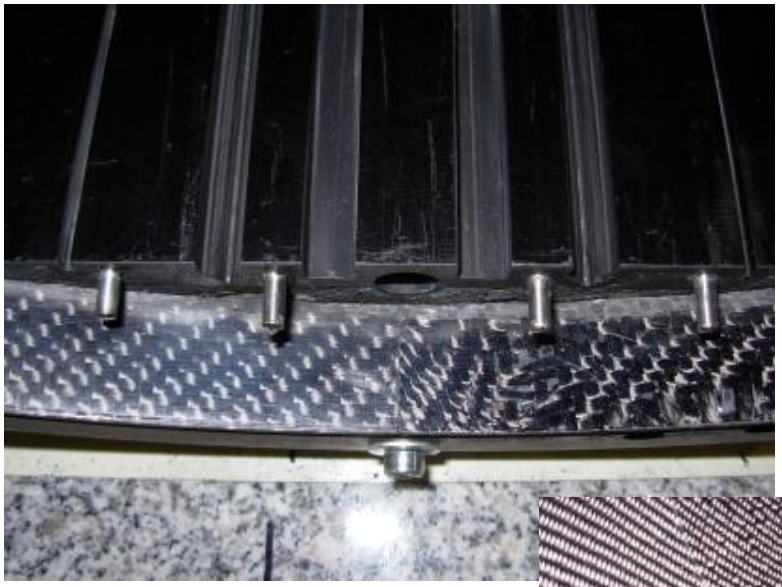
Alignment: Materialization of the "Tracker Axis"

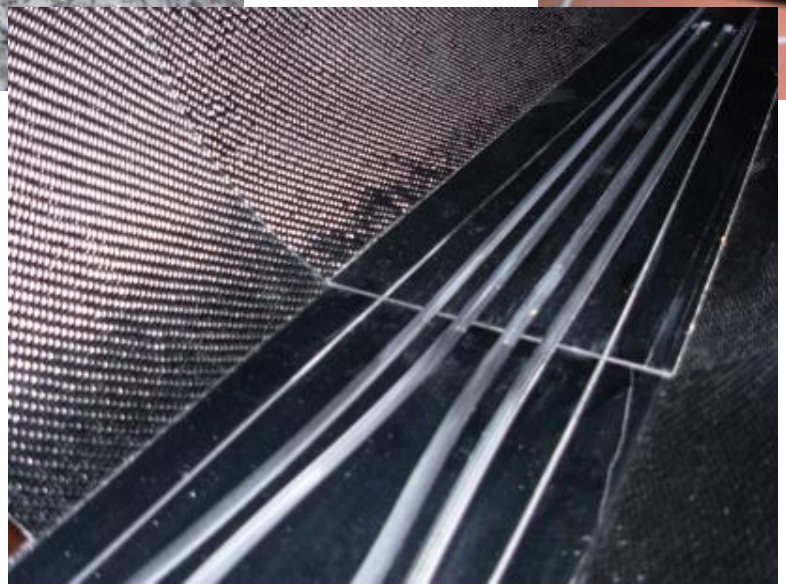
3 – Main body installation

The Main Bodies are then inserted on both sides and, upon docking to the Central Support, they are also aligned to the "TK axis": by aligning the Beampipe to the "TK axis" the reciprocal alignment errors between the BP and the PIX tracks are minimized

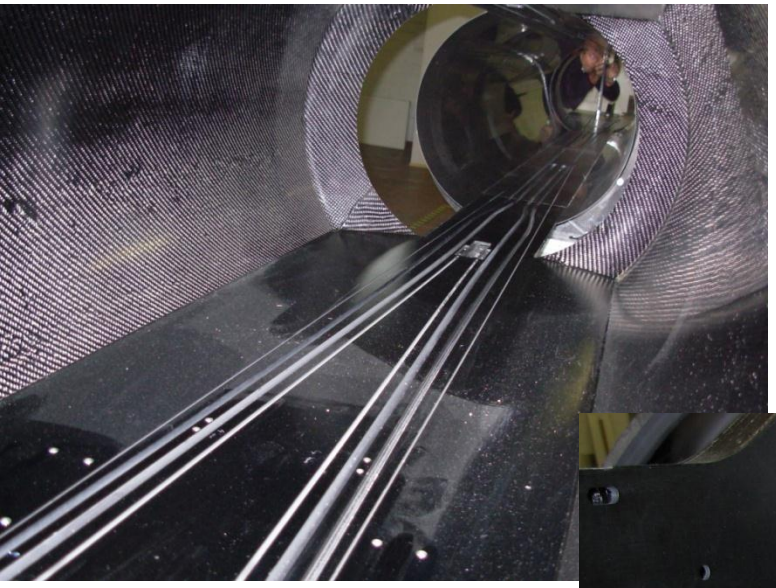


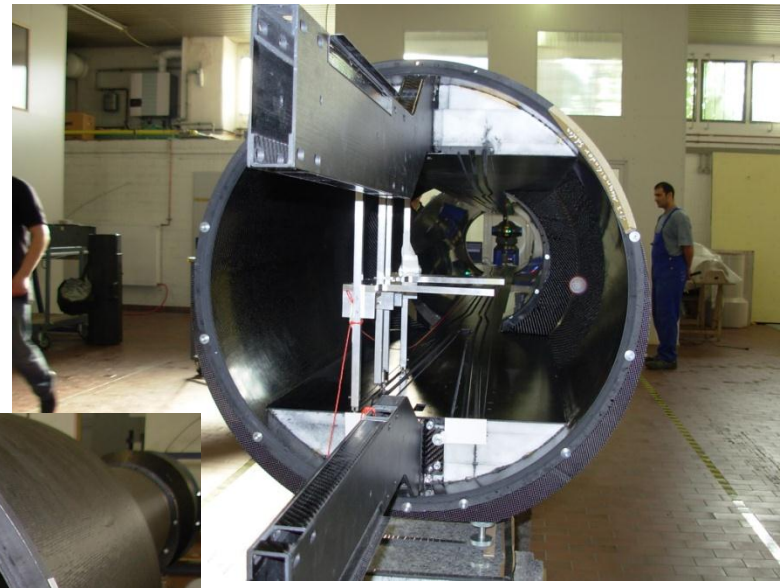
(Pinned connection of main body and central support)

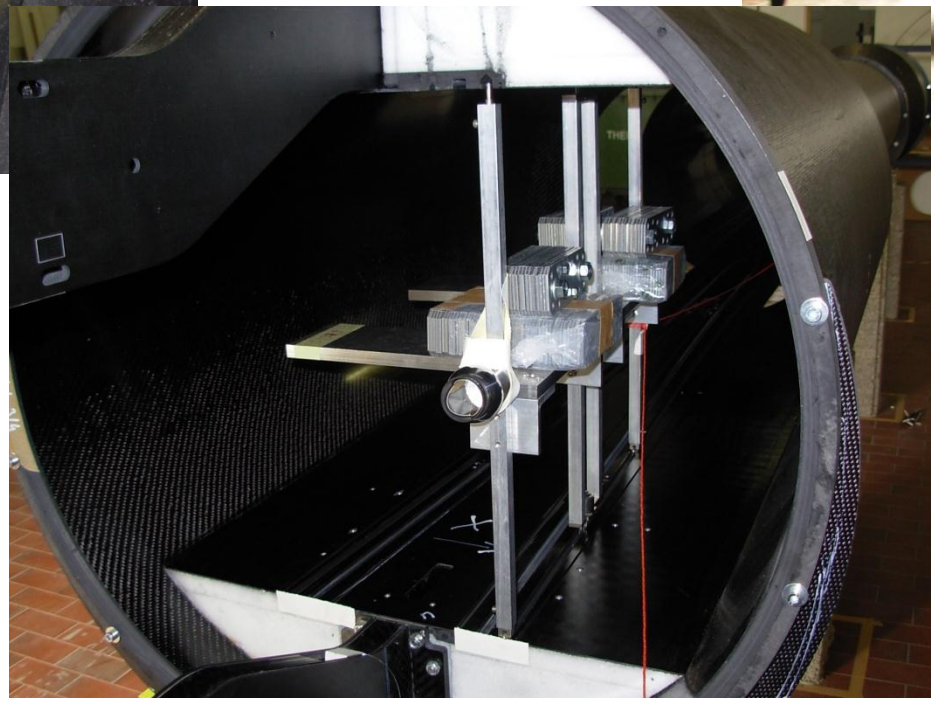




(Commissioning of the reference plans / guiding tracks @ ADCO GmbH)



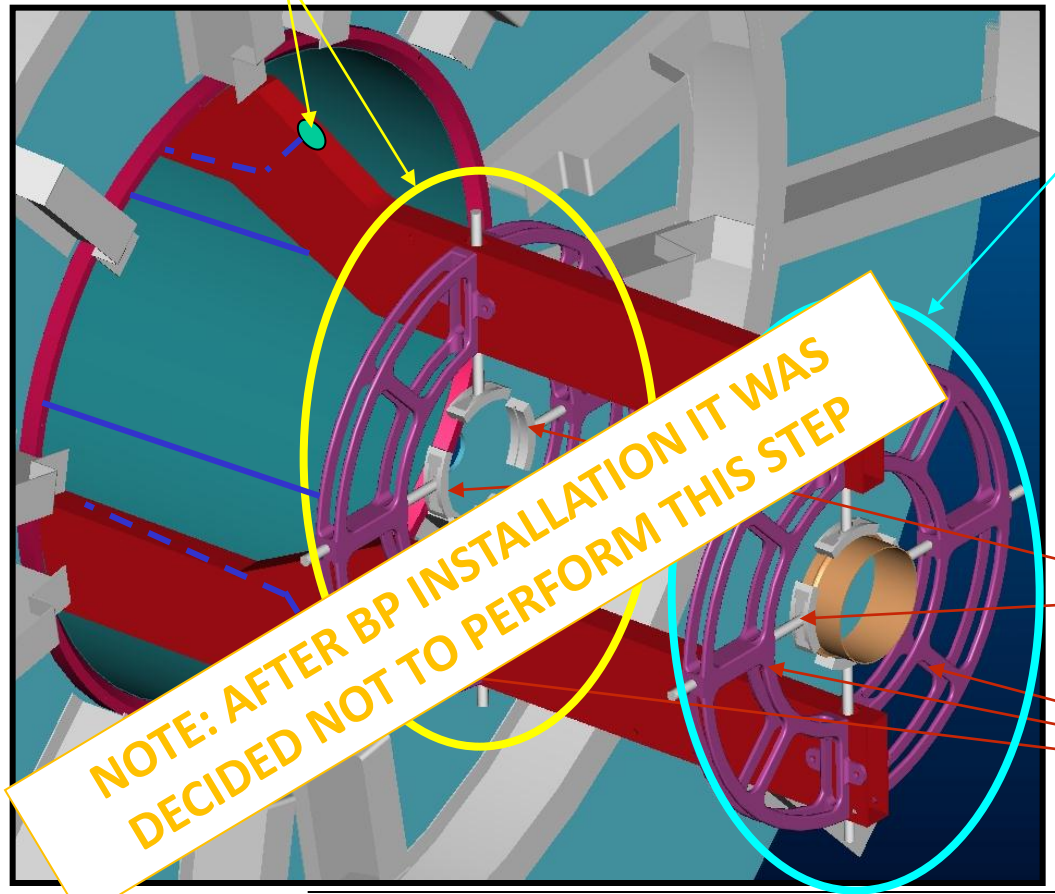




Alignment: Materialization of the "Tracker Axis"

4 – Tuning of the beam pipe axis

At this level we position the central part of the BP with respect to the axis of the Tracker

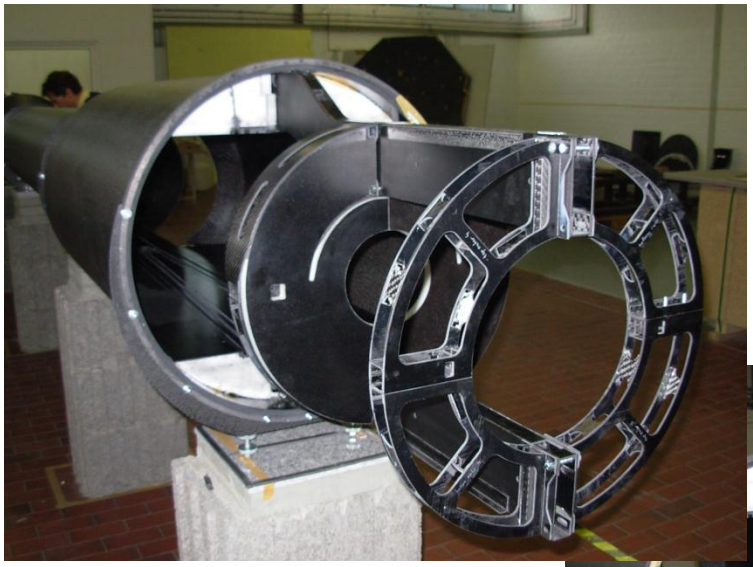


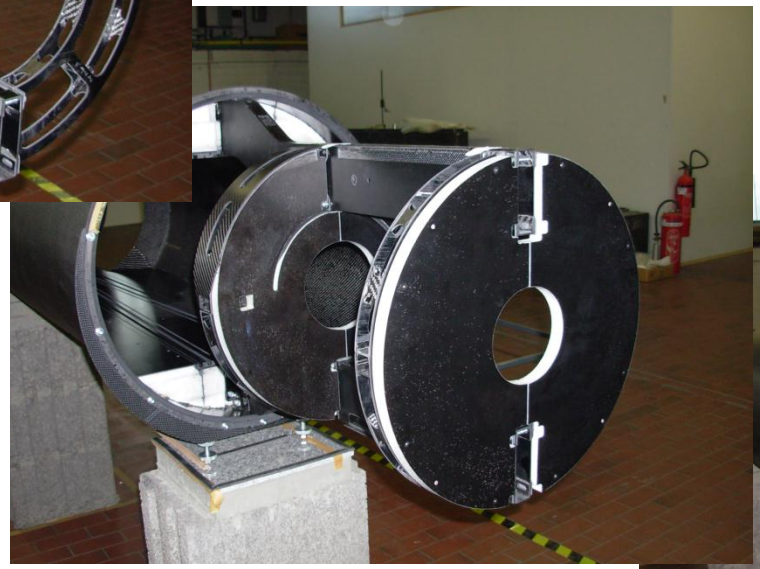
Mount of the rings and alignment of the outer part of the BP with respect to the axis of the machine. The bellows take over for misalignments between the Tracker and the machine

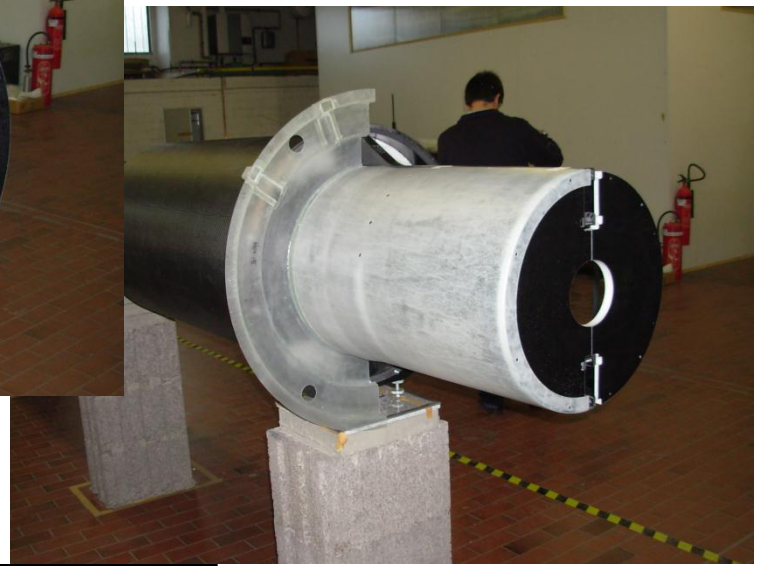
Horizontal fixation

Half rings

(Outer system of BP stabilization / alignment + TK volume insulation)

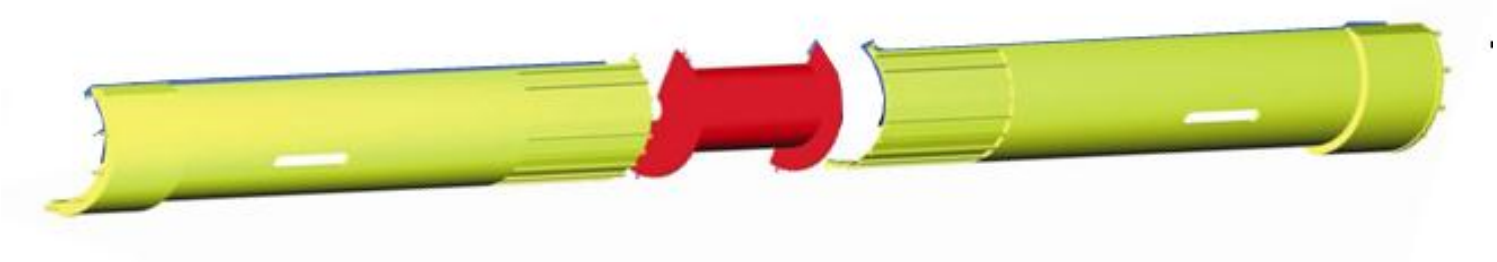


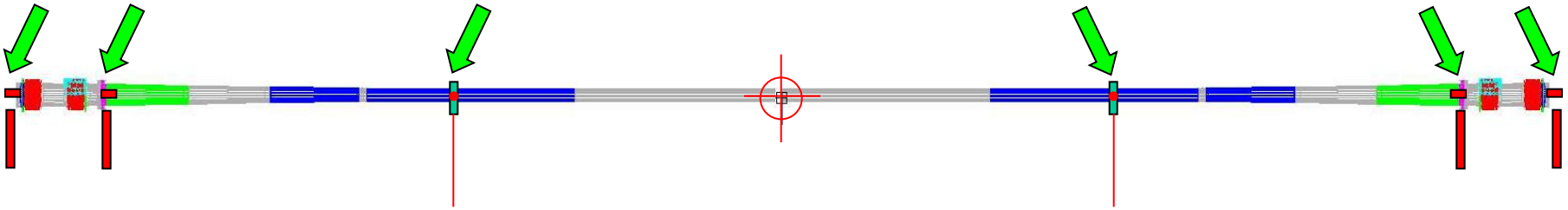




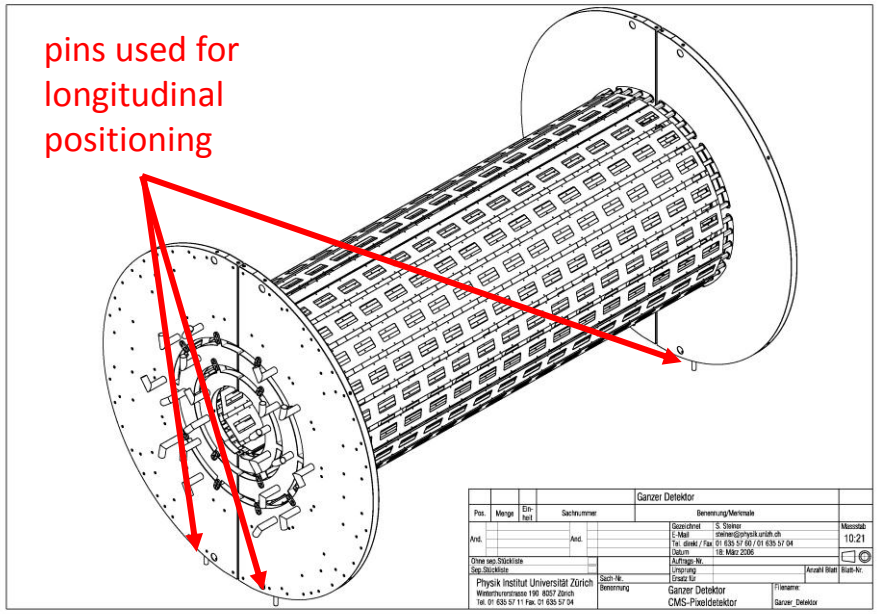
BPIX Design for Insertion/Removal

The 5.7 m long train formed by the BPIX detector and its service cylinders require **removal of lateral supports on one side at a time at both ends**



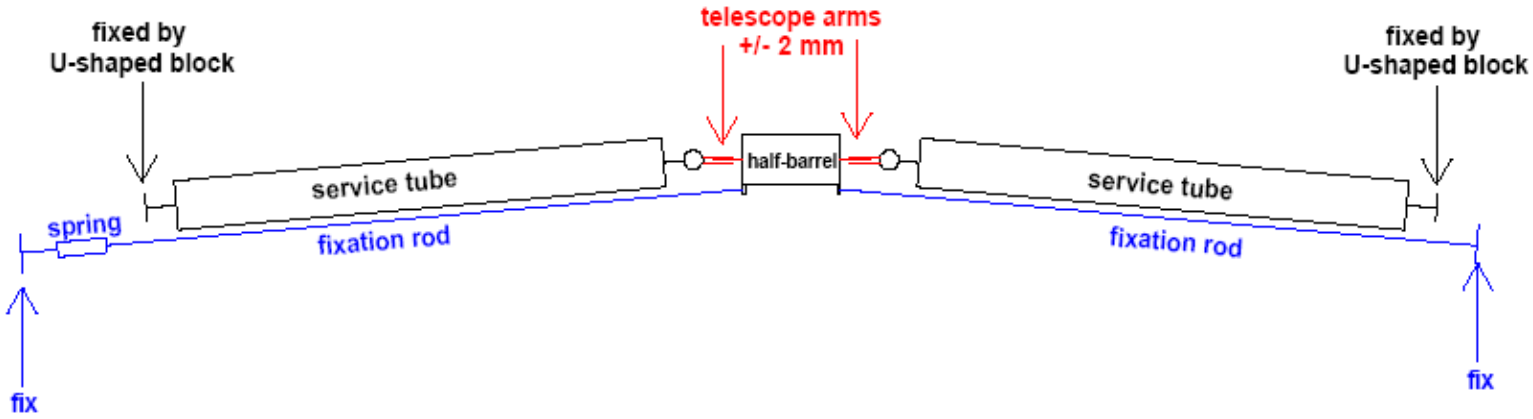


Some Detailed Features of BPIX

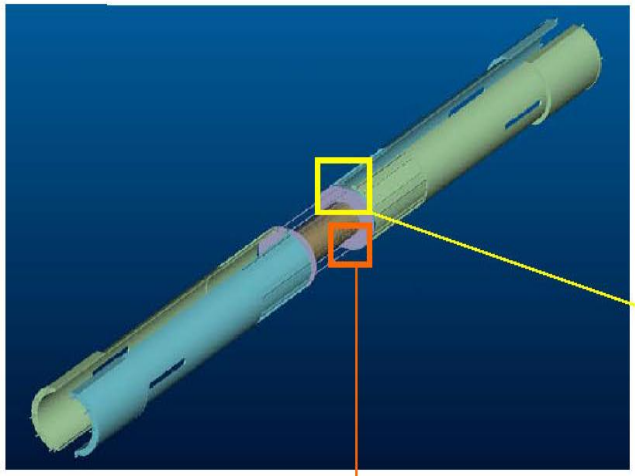


Rigid carbon fibre rods are used to fix longitudinally the Barrel.

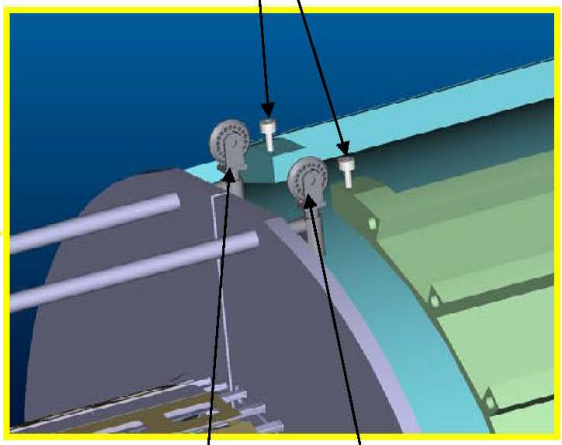
The telescopes absorb possible thermal contractions of service tubes



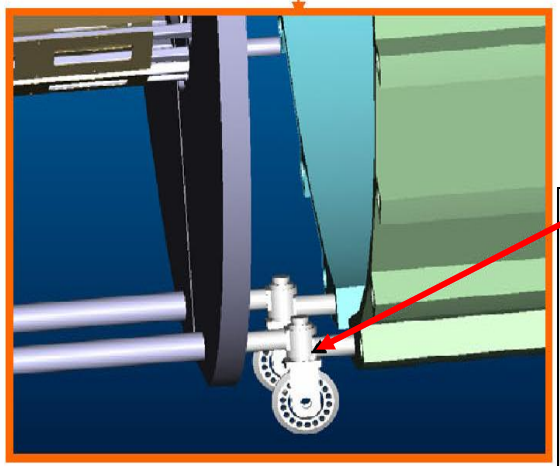
More Detailed Features of BPIX



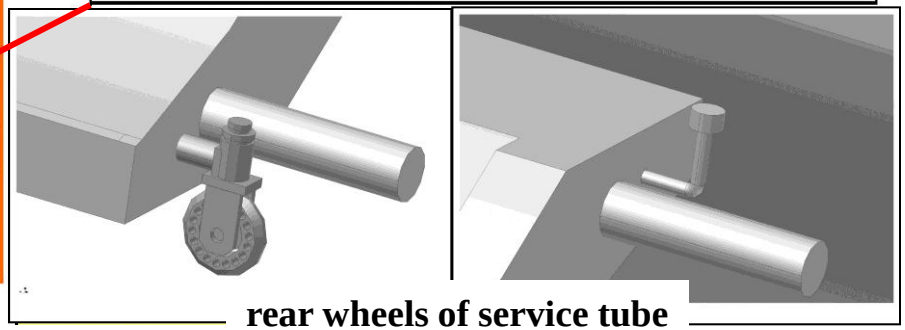
These pieces on the services cylinders are used to guide along the slot



Top feet are only for the barrel. Top feet are vertically aligned with bottom feet.



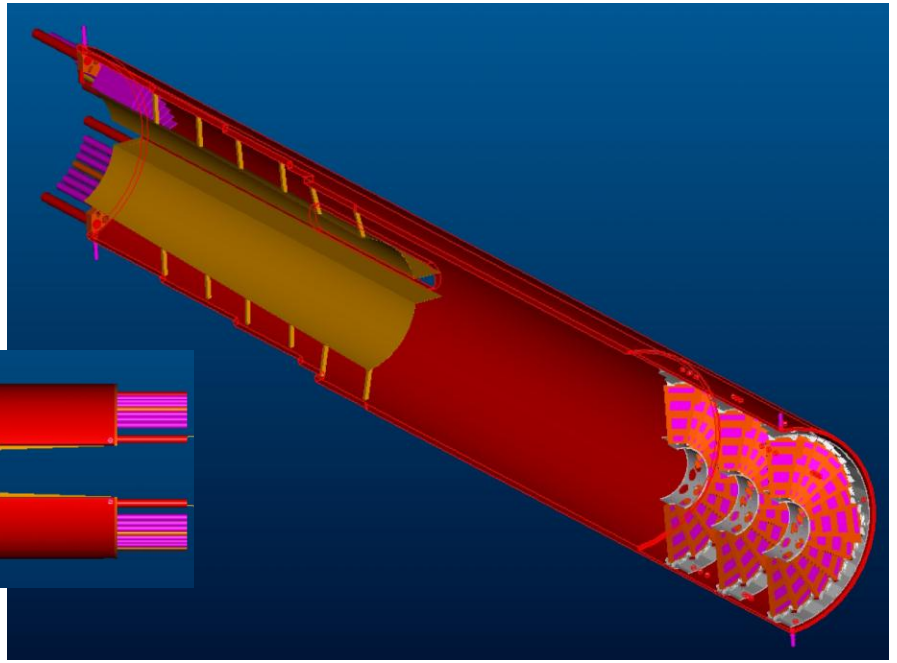
bottom feet are shared by barrel and service cylinder

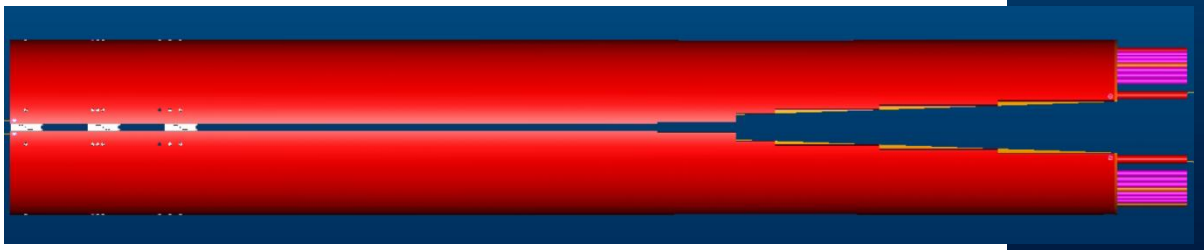


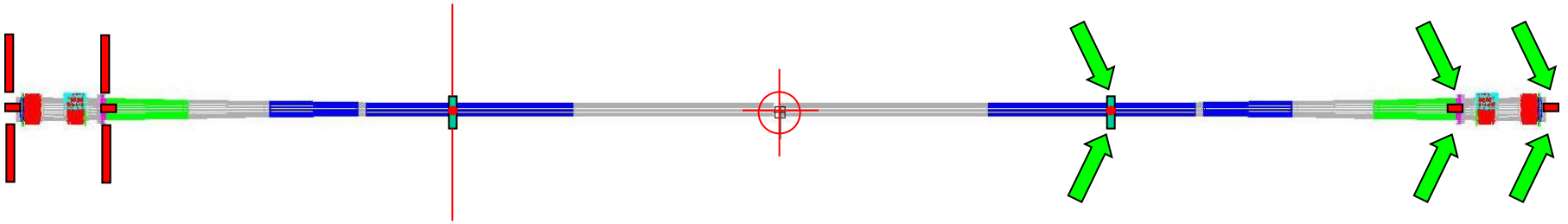
rear wheels of service tube

FPIX Design for Insertion/Removal

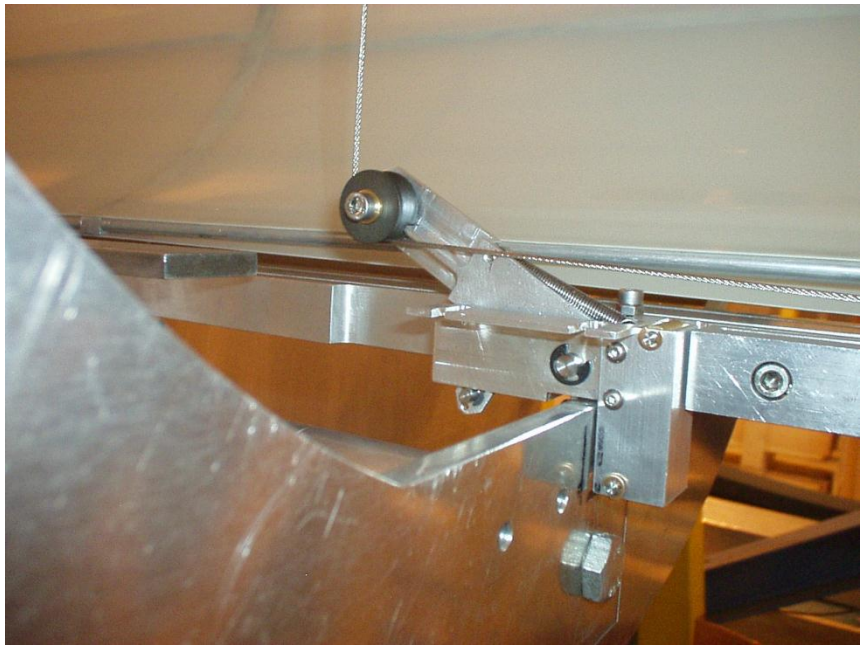
The two rigid shells of the FPIX require **removal of lateral supports on both sides at one end at a time** (combined insertion of +y and –y shell)



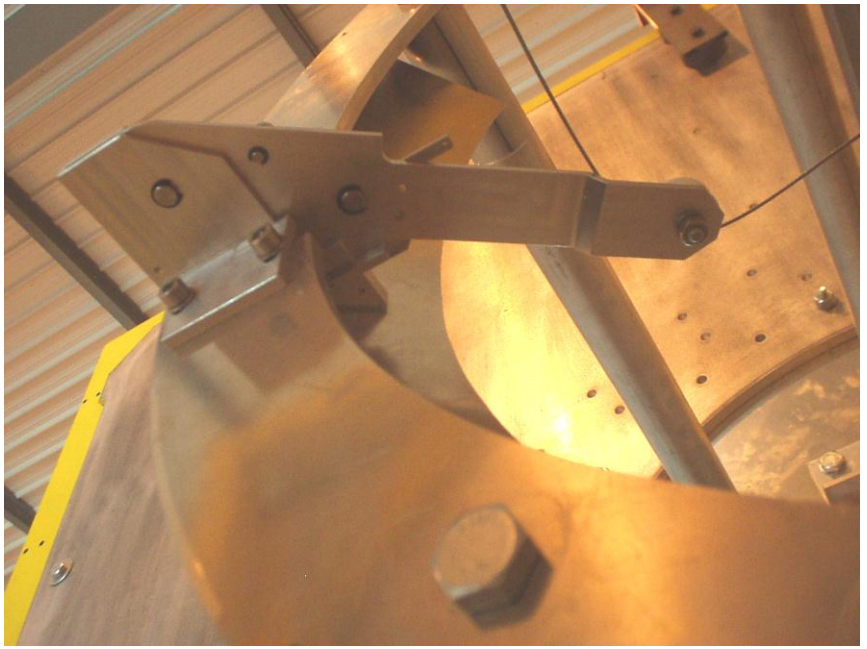




Thorough Mock-up Testing…



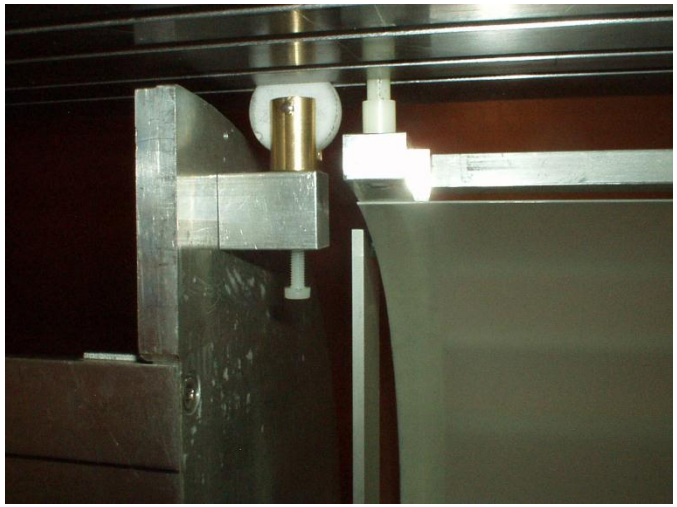
Vertical beam pipe pulleys

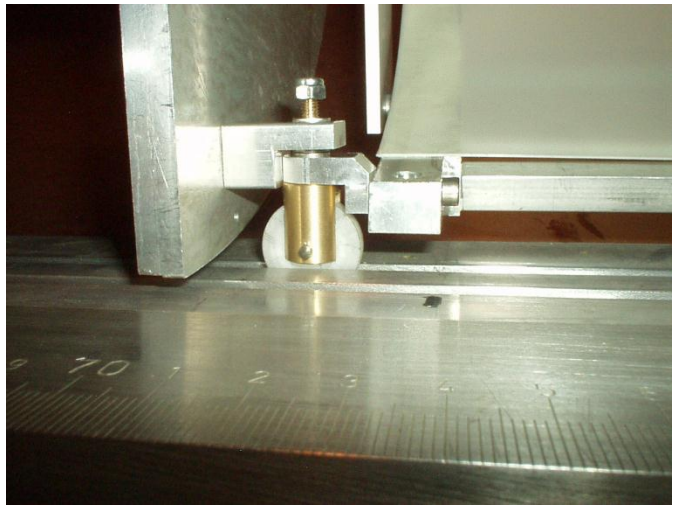


Horizontal beam pipe pulleys

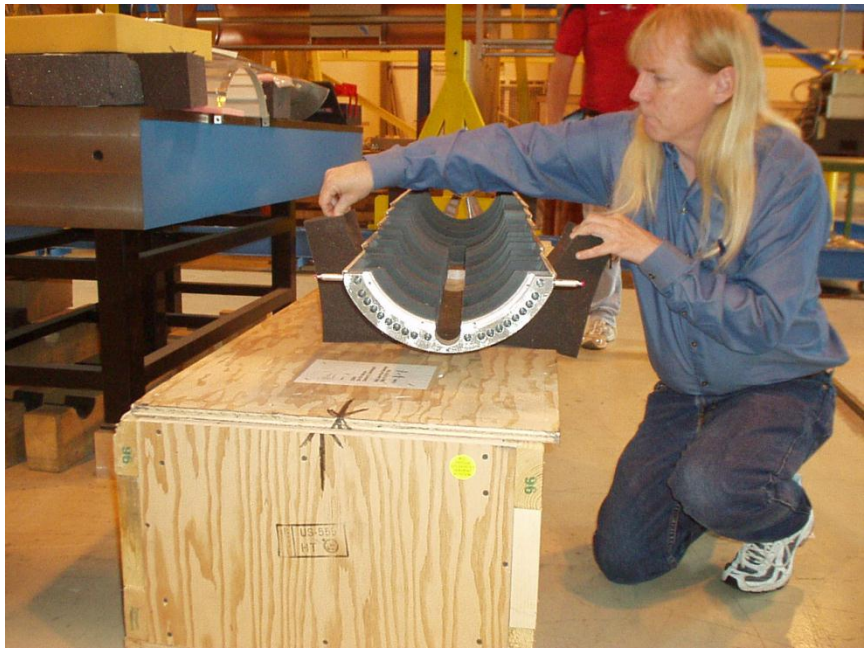
Thorough Mock-up Testing…

New BPIX feet (pivoting wheels)



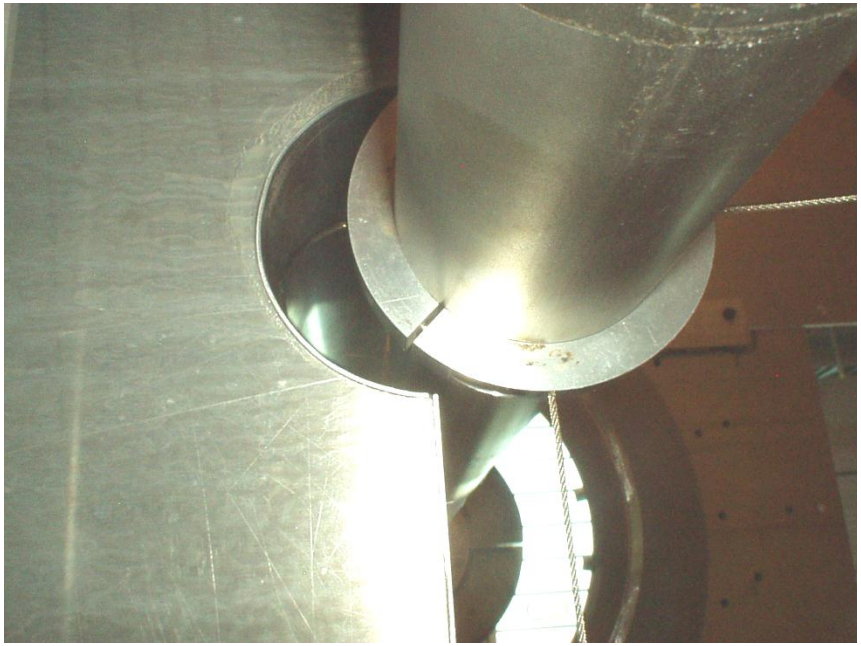


- Thorough Mock-up Testing… -

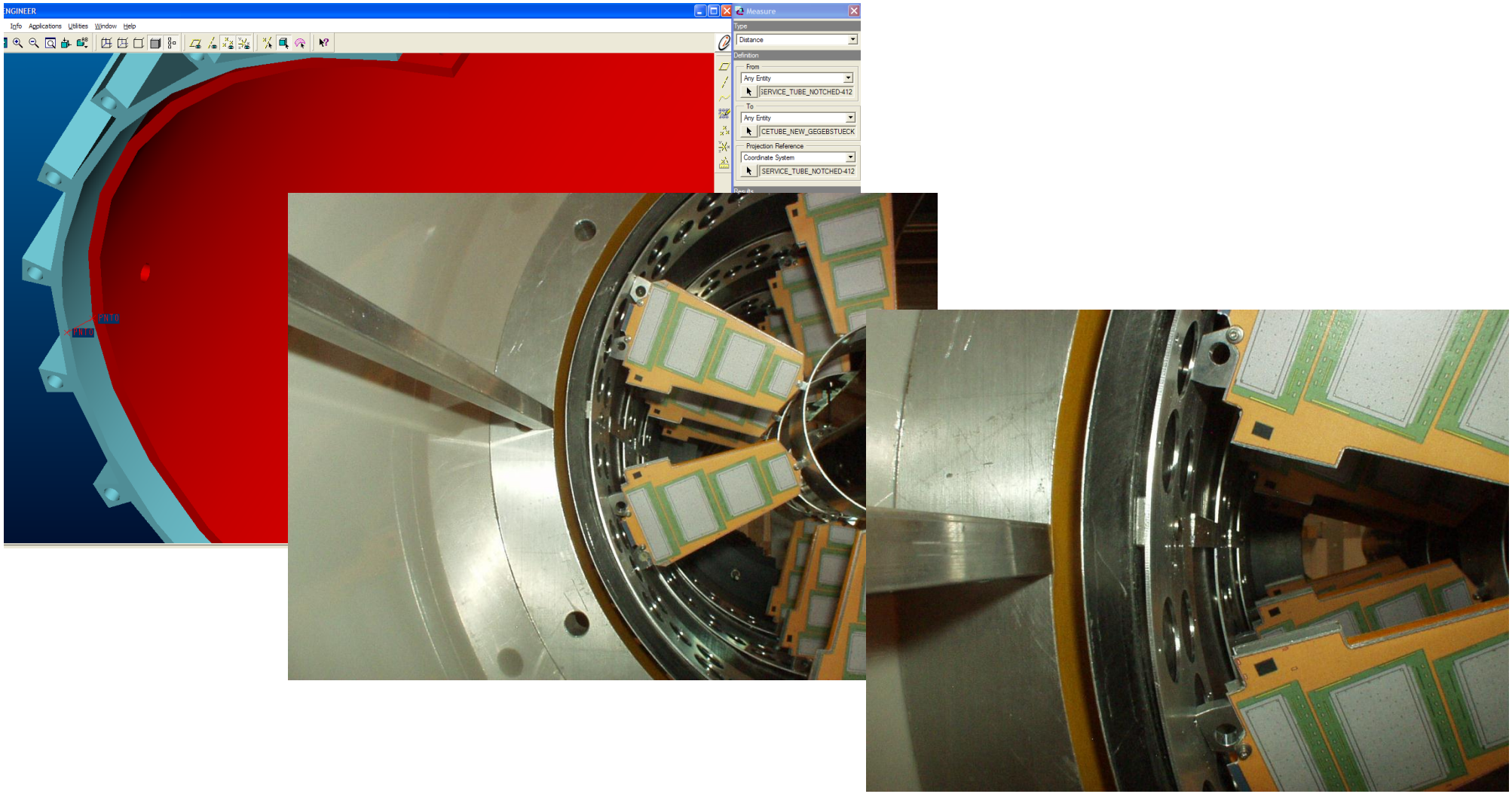


Realistic FPIX mockup

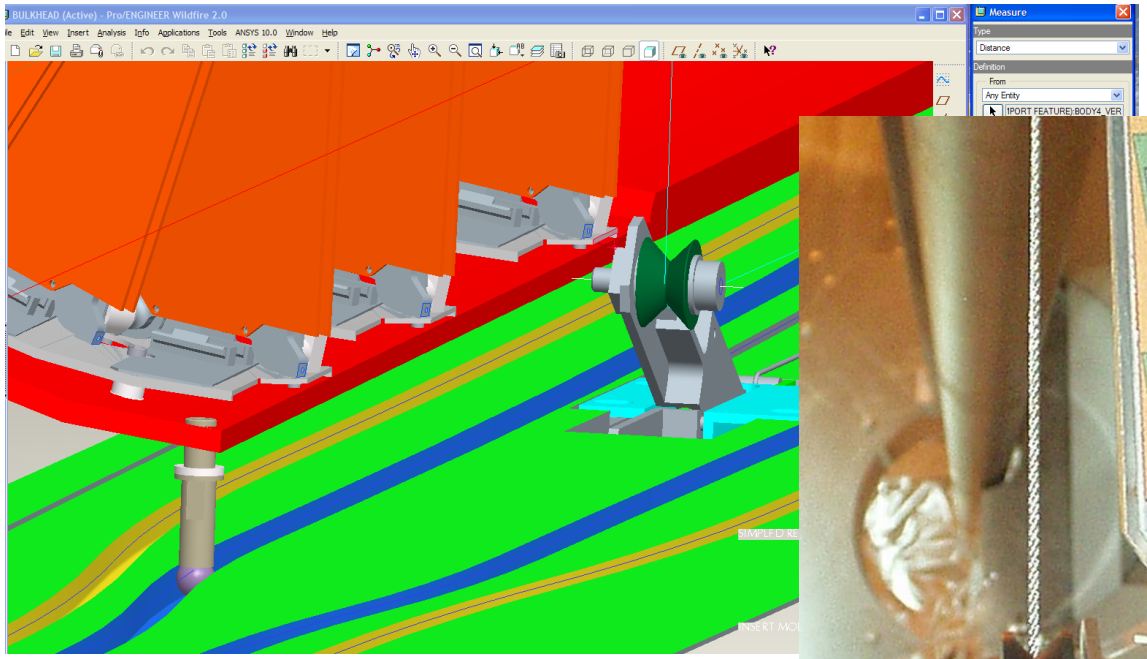
- Thorough Mock-up Testing… -

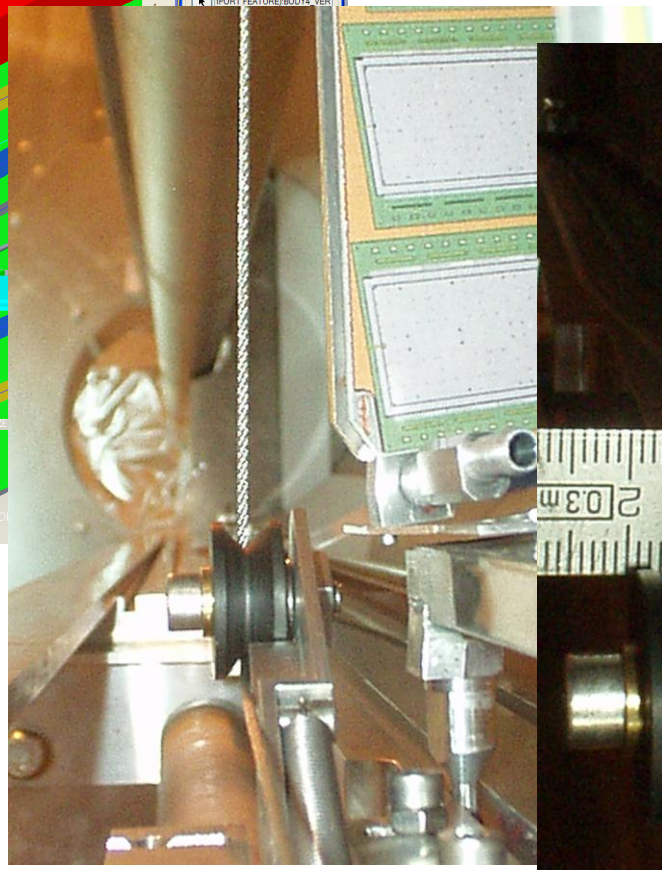


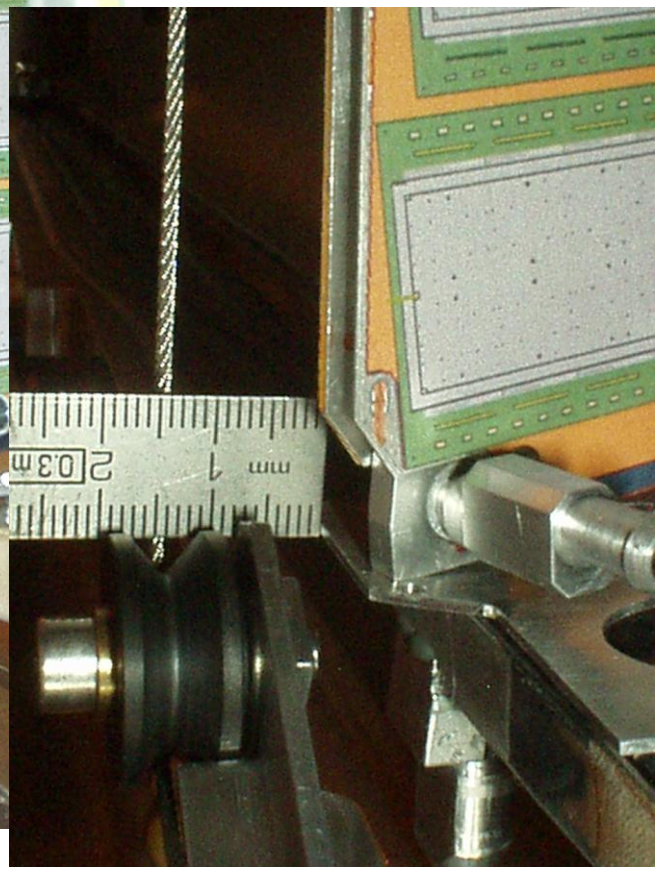
…and Verification of 3D Model Forecasts



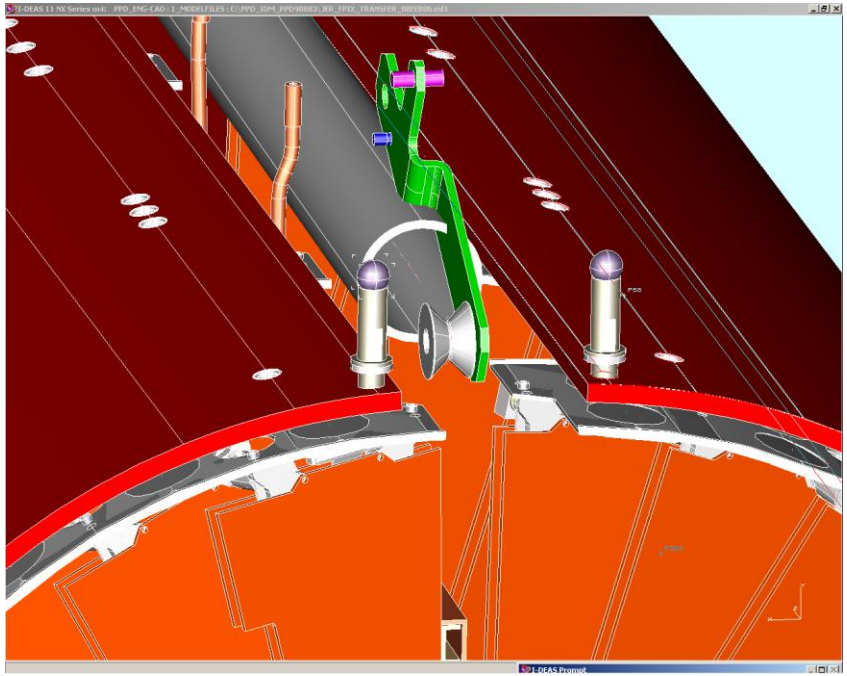
…and Verification of 3D Model Forecasts

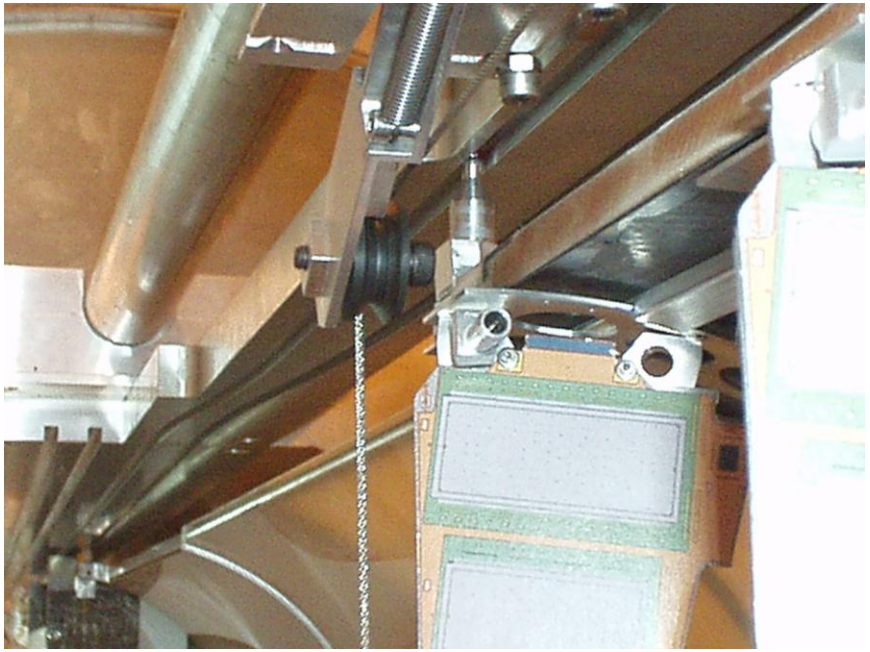






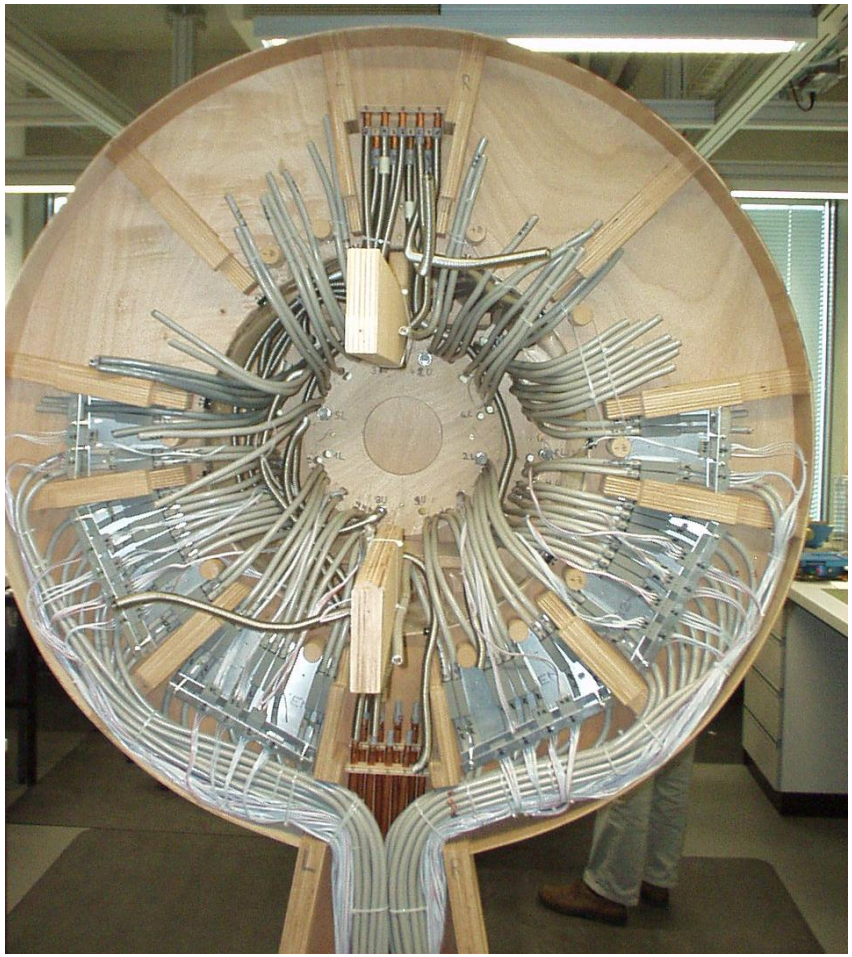
…and Verification of 3D Model Forecasts



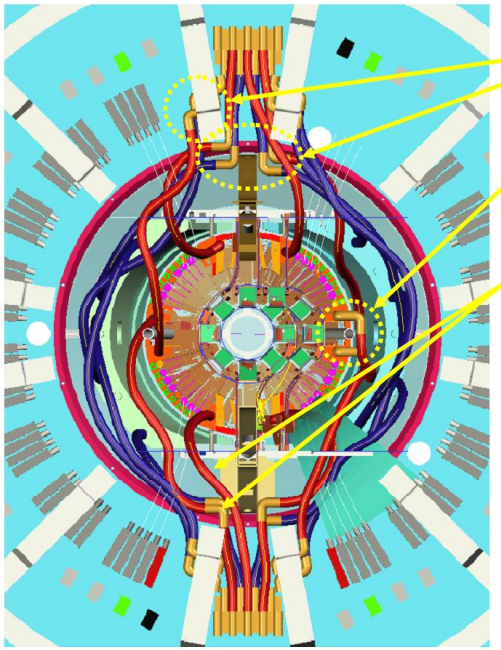


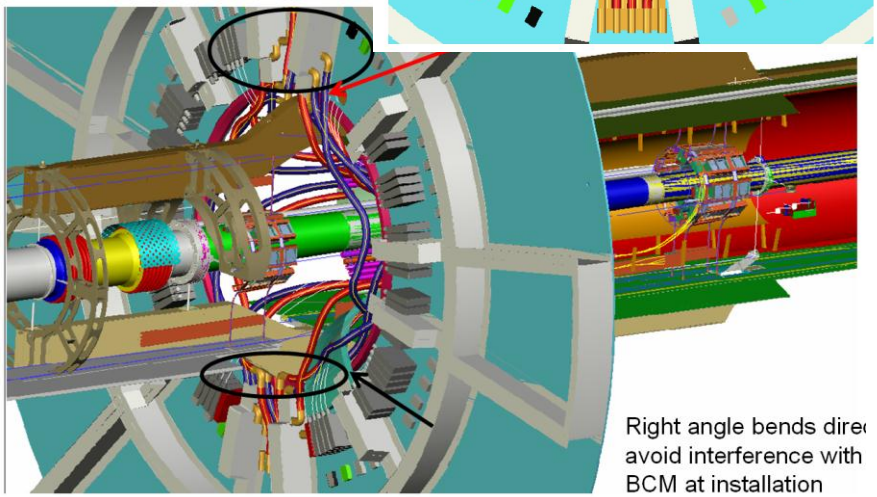
Detailed Pre-organization of Services

More mock-ups...

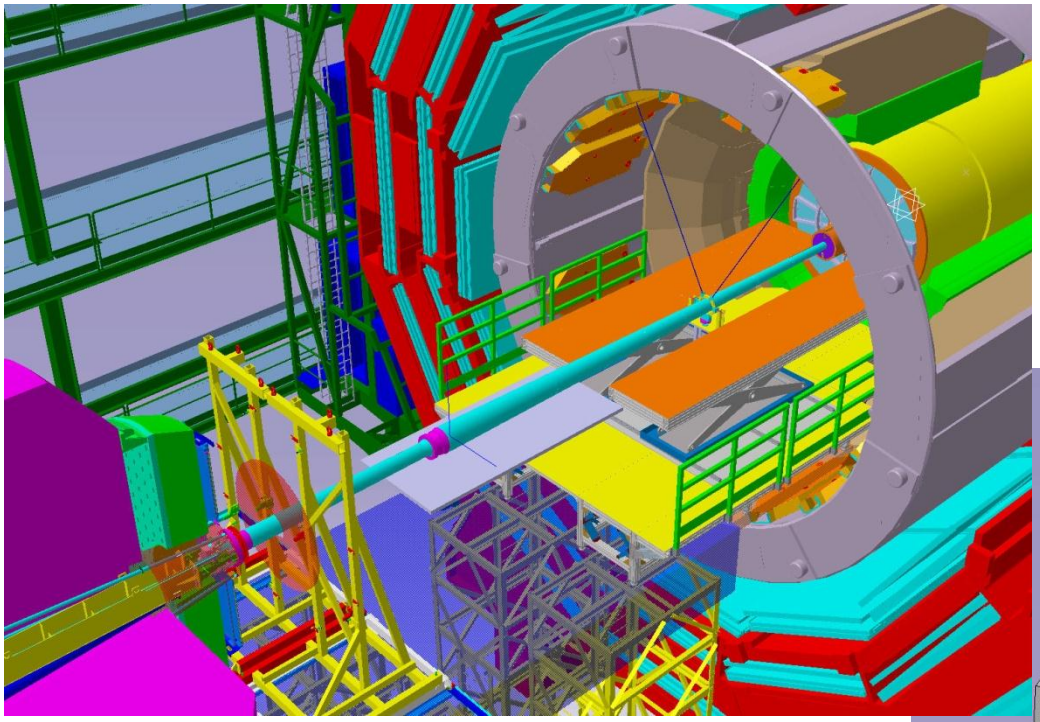


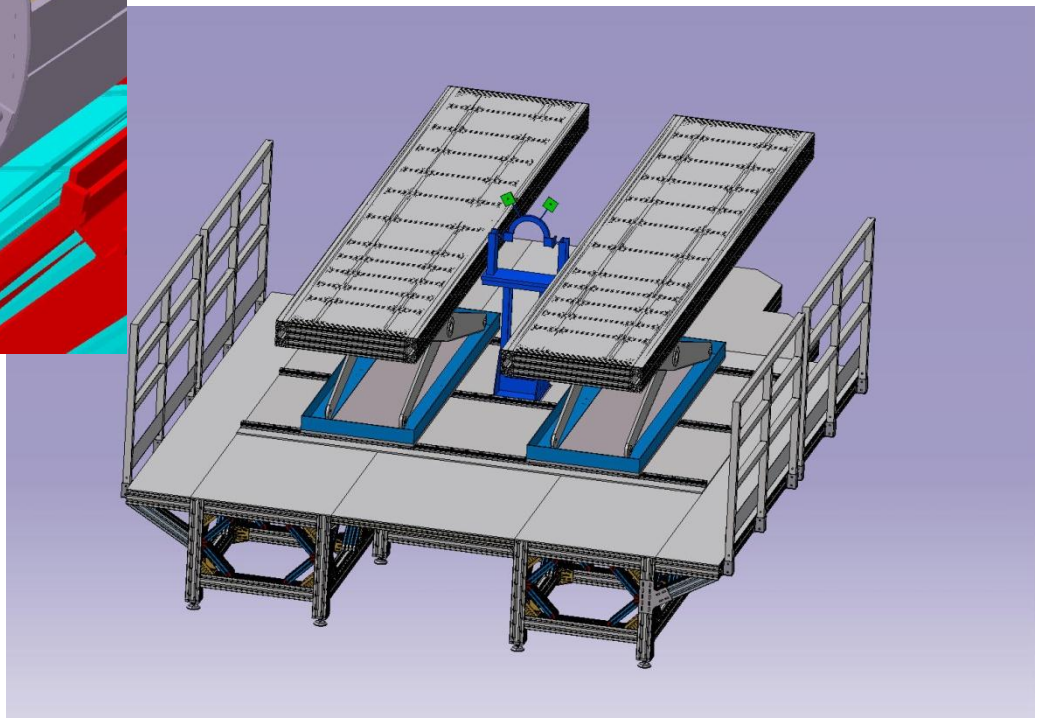
...and more 3D models





Design and Fabrication of Specific Installation tools



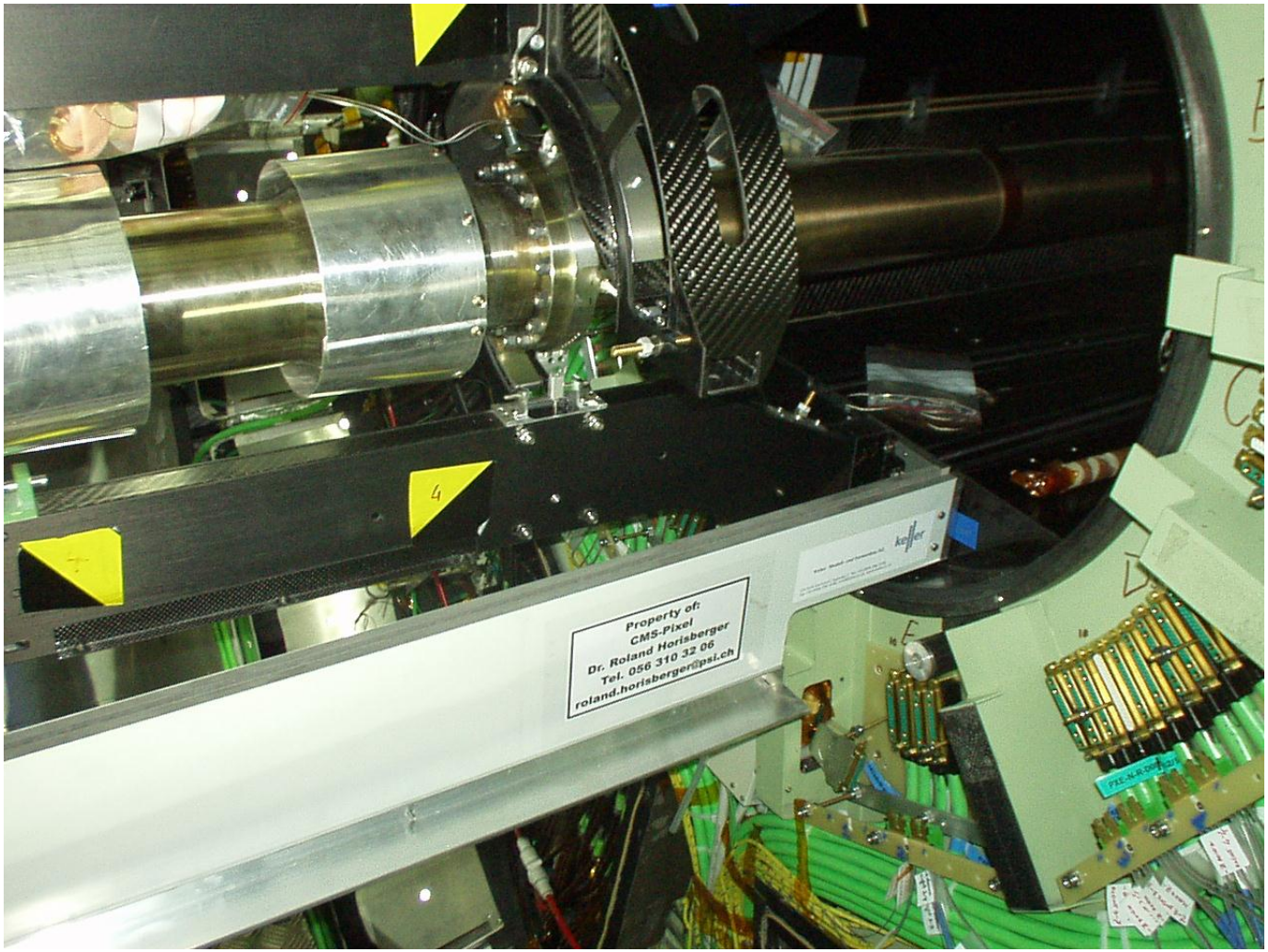


May 2008: First PIX Installation Rehersal

BPIX in the cavern inside its installation cassette

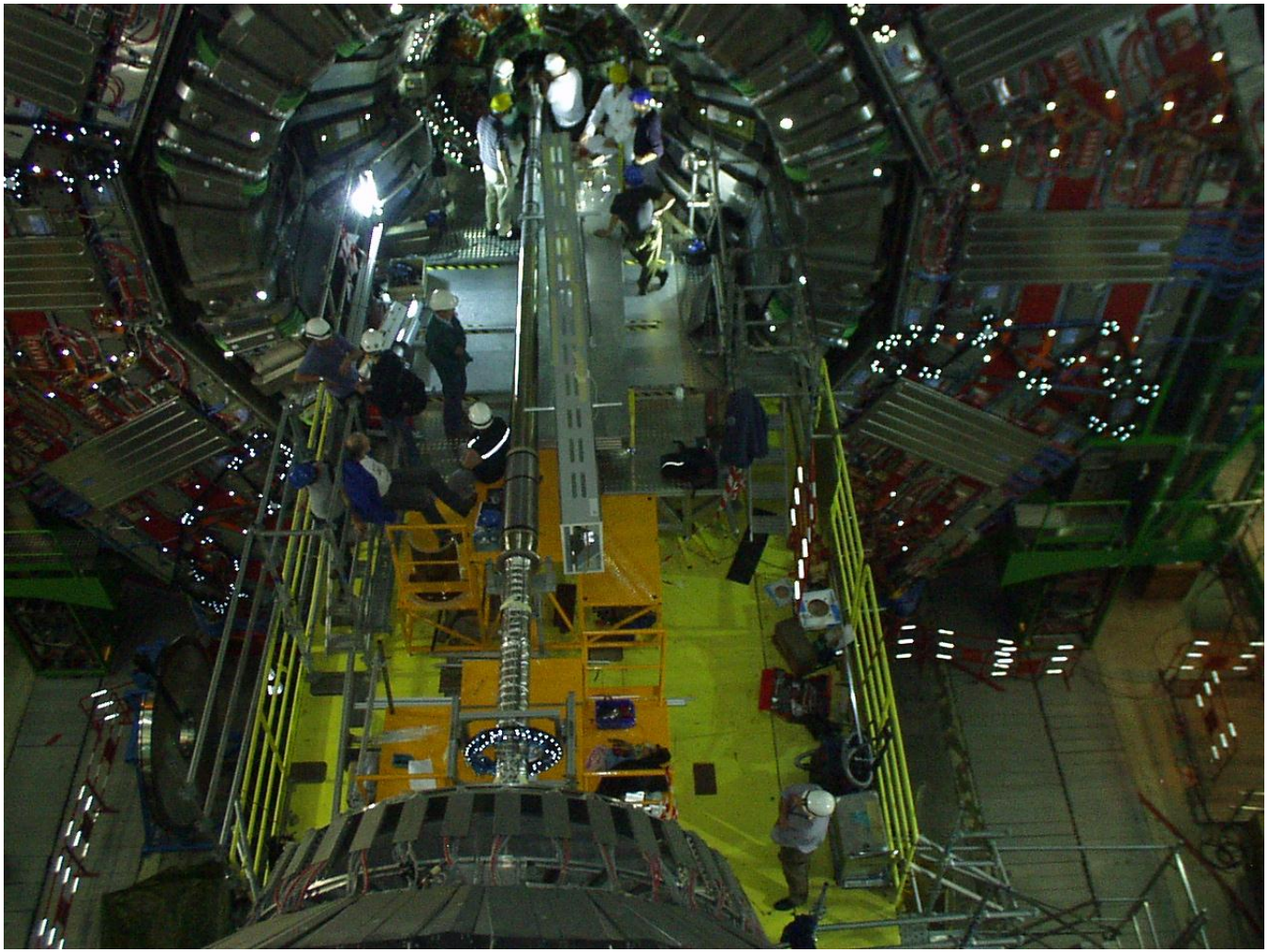
May 2008: First PIX Installation Rehersal

BPIX cassette extension rail docked to the guiding/support system



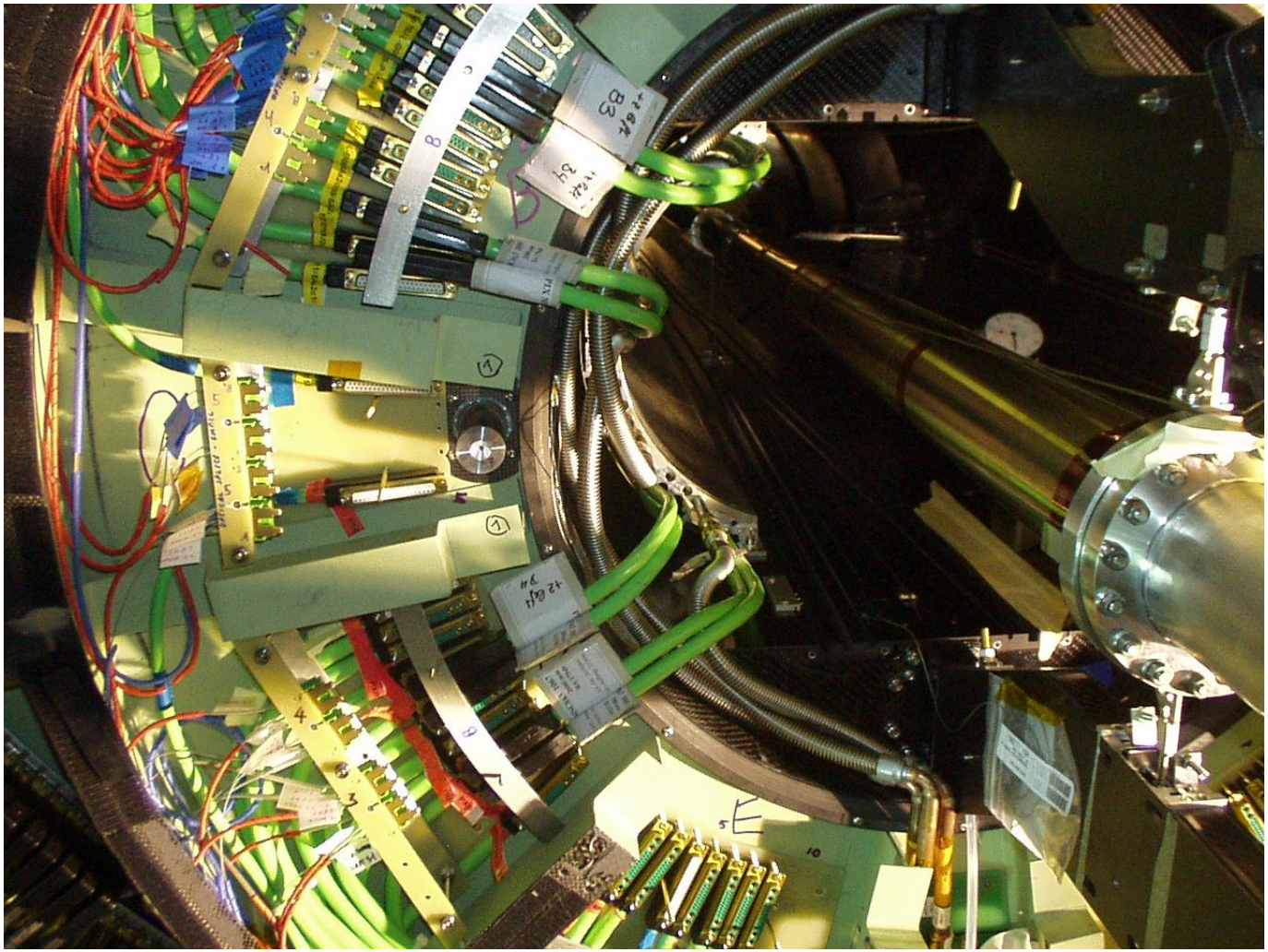
May 2008: First PIX Installation Rehersal

BPIX ready to slide in position



May 2008: First PIX Installation Rehersal

BPIX in final position: trial connection of some cables and pipes



May 2008: First PIX Installation Rehersal

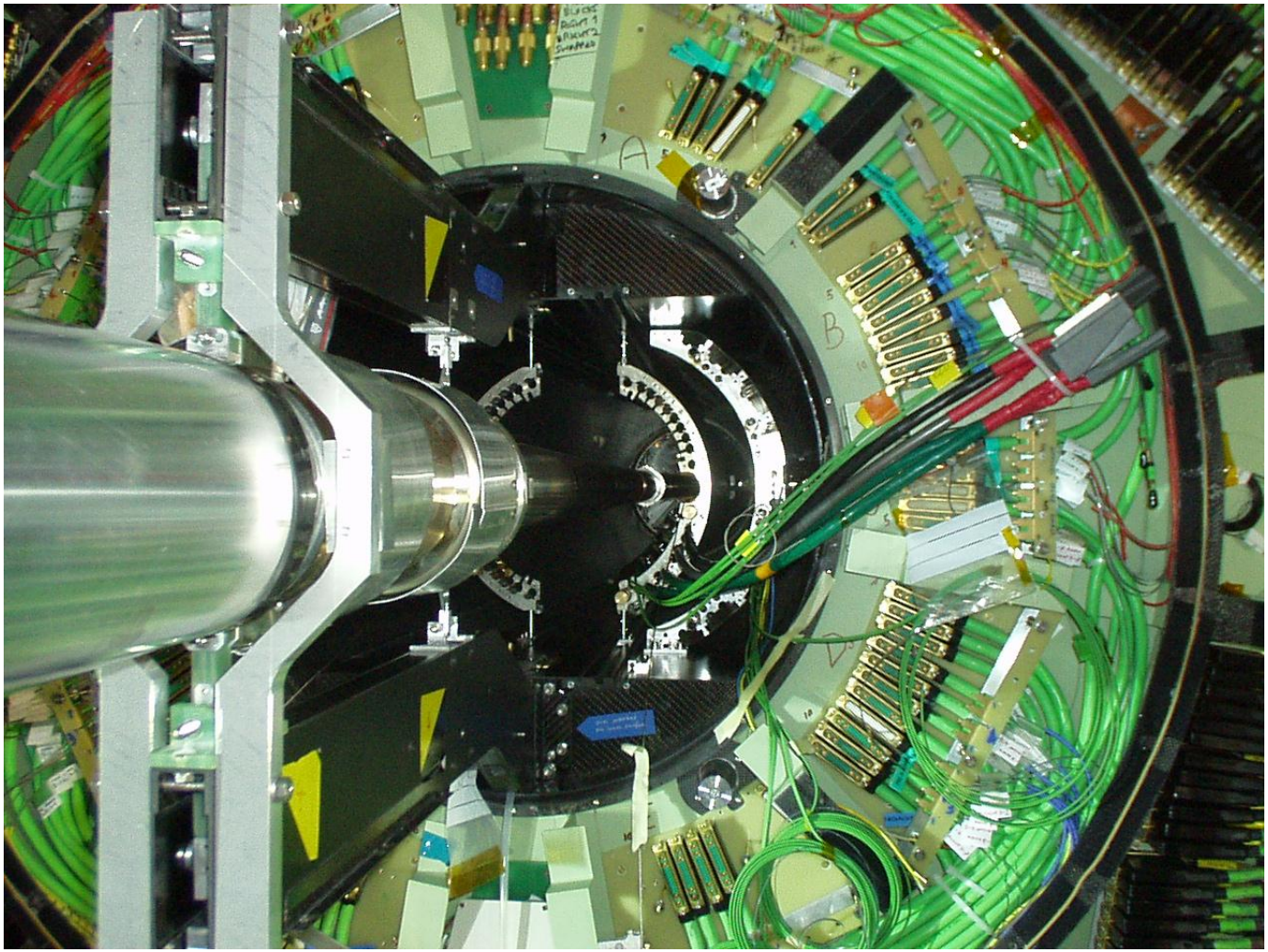
FPIX first half in the installation cradle ready to slide-in

May 2008: First PIX Installation Rehersal

FPIX partially in: connection to the push-pull device for final sinchronizd insertion of both halves

May 2008: First PIX Installation Rehersal

Whole PIX completely in (no connection)



Time for Installation / Removal

5 days from CMS opening are needed for the complete operation of PIX insertion, including:

- Assembly and positioning of the platforms
- BPIX installation and connection
- BPIX connection test
- FPIX installation and connection
- FPIX connection test

(one additional day is needed afterwards to seal the volume)

3 days are enough for complete removal

(Real) Maintenance Access to PIX