TAXS Status of prototyping and next steps

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on behalf of WP8 (Collider-Experiment Interface)

12th HL-LHC Collaboration Meeting, Uppsala (Sweden), 19-22 September 2022

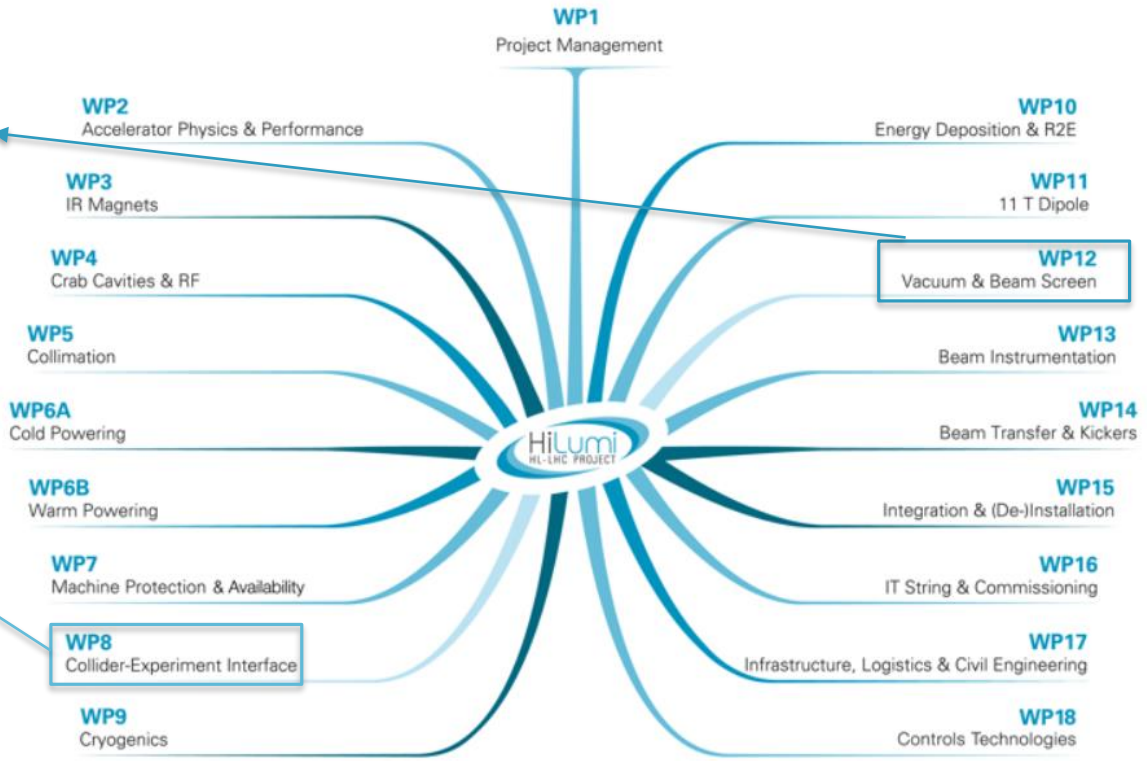
Content overview

- Introduction
- From TAS to TAXS
- Overview, status and next steps:
  - TAXS prototyping
    (incl. TAXS chamber, TAXS accessories)
  - Triplet-forward region prototyping
    (User tests with Q1-TAXS region mock-up)
- Conclusions

WP8 Collider-Experiment Interface / WP12 Vacuum Instrumentation

… The upgrade of the triplet-forward region of CMS and ATLAS experiments to cope with the increasing radiation dose is also under the mandate of WP12, requiring a newly designed vacuum instrumentation system which can be remotely controlled and connected/disconnected in full compliance with the ALARA approach. …

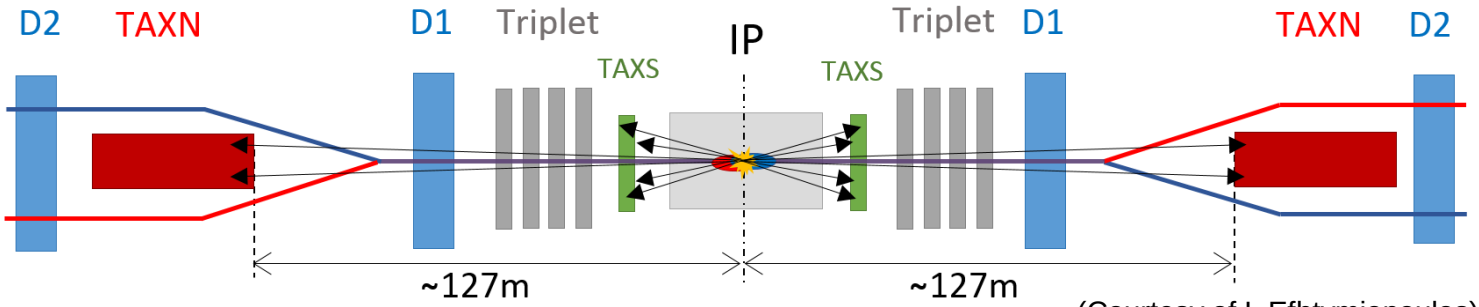
… The work package will be in charge of the deinstallation of the TAS and TAN absorbers, the design, manufacturing and installation of the Secondary and Neutral absorbers in the LHC machine, and the optimization of the machine-interface regions. This includes the integration studies performed together with other work packages, teams from vacuum groups, experiments and the machine, and the reporting to the correspondent HL-LHC and machine working groups.



Introduction to Absorbers in the HL-LHC

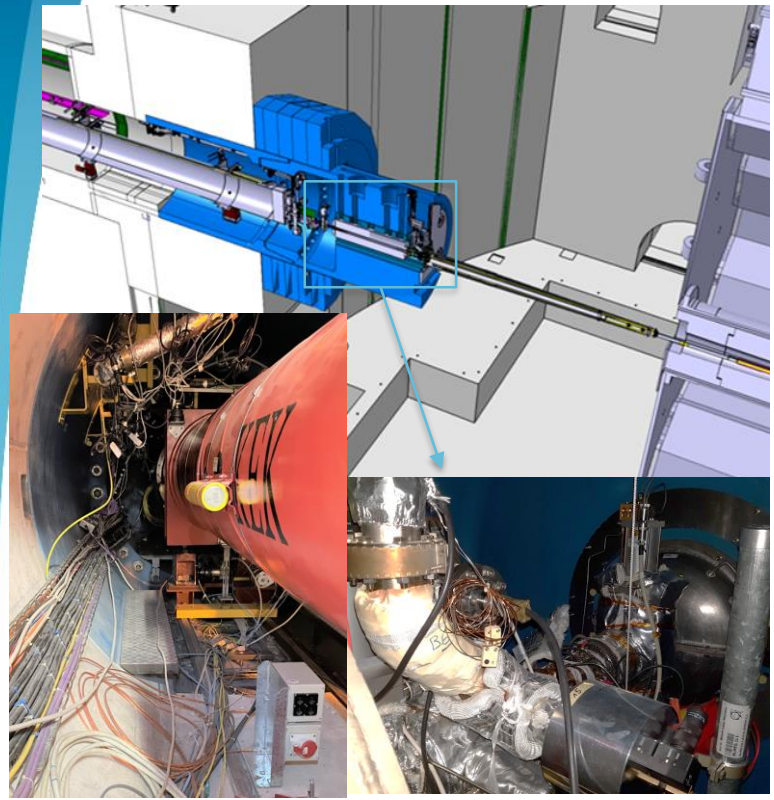
The passive absorbers for charged (TAS) and neutral (TAN) particles are designed to …

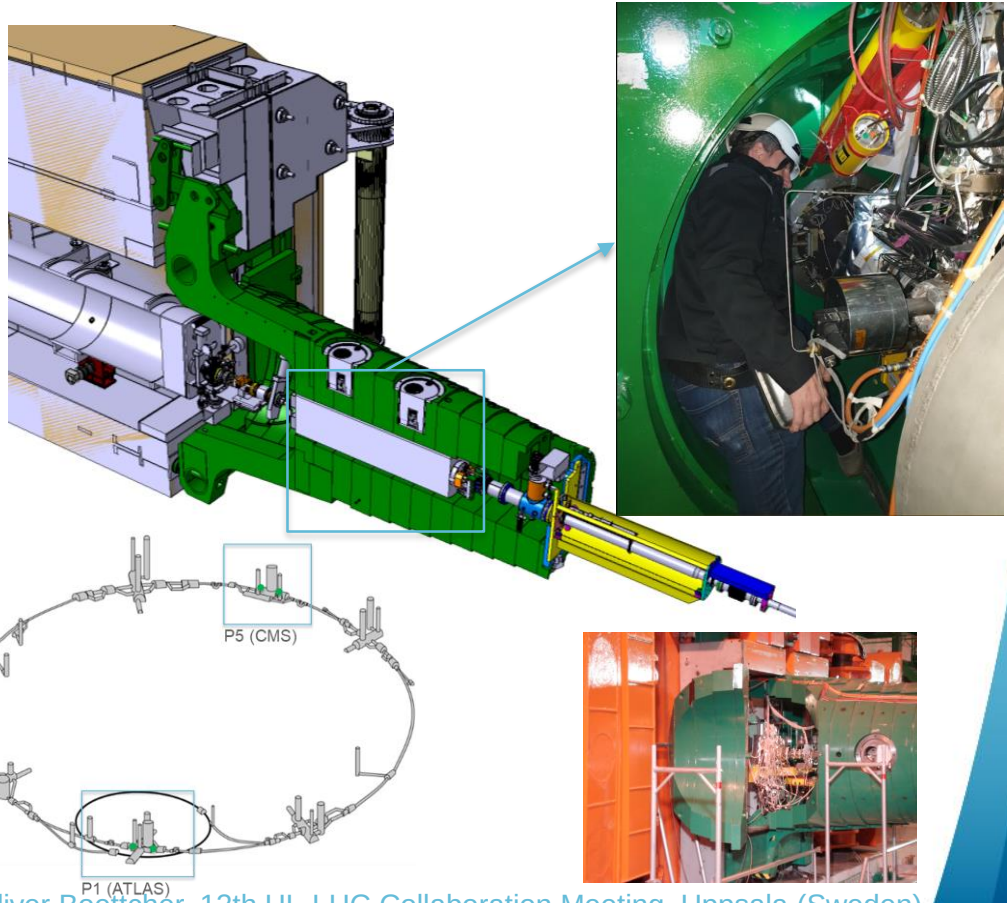
- primarily protect the nearby superconducting magnets from the radiation coming out from the interaction region and to **prevent them from quenching**.
- simultaneously provide a background reduction to the experiments for beam interactions in the collimators and beam gas.
- They are located on either side of IP1 and IP5.



(Courtesy of I. Efhtymiopoulos)

TAS absorbers in IP1 (ATLAS) and IP5 (CMS)



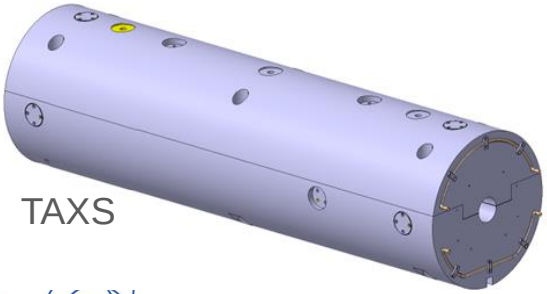


From TAS to TAXS - initial HL-LHC requests

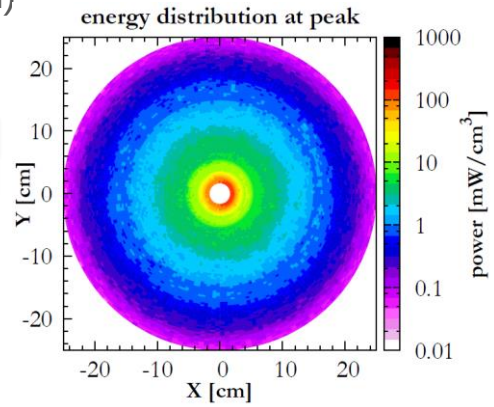
- Chamber aperture: ID60mm (TAS was 34mm)

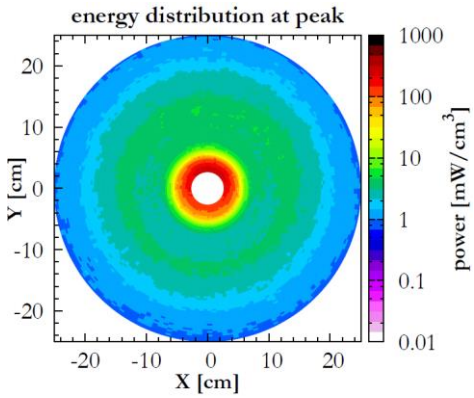
Experiment	Peak Luminosity [cm^{-2} s^{-1}]		IP
	HL-LHC	LHC	
ATLAS	5×10^{34}	2×10^{34}	1
CMS	5×10^{34}	2×10^{34}	5
ALICE	1×10^{31}	1×10^{31}	2
LHCb	2×10^{33}	4×10^{32}	8

- 750W of power deposition in TAXS
- Each TAXS will be equipped with:
  - Radiation hard heating elements and thermocouples
  - Radiation hard remote and survey alignment system

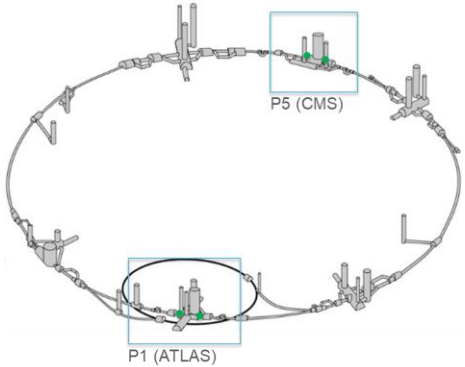


TAXS





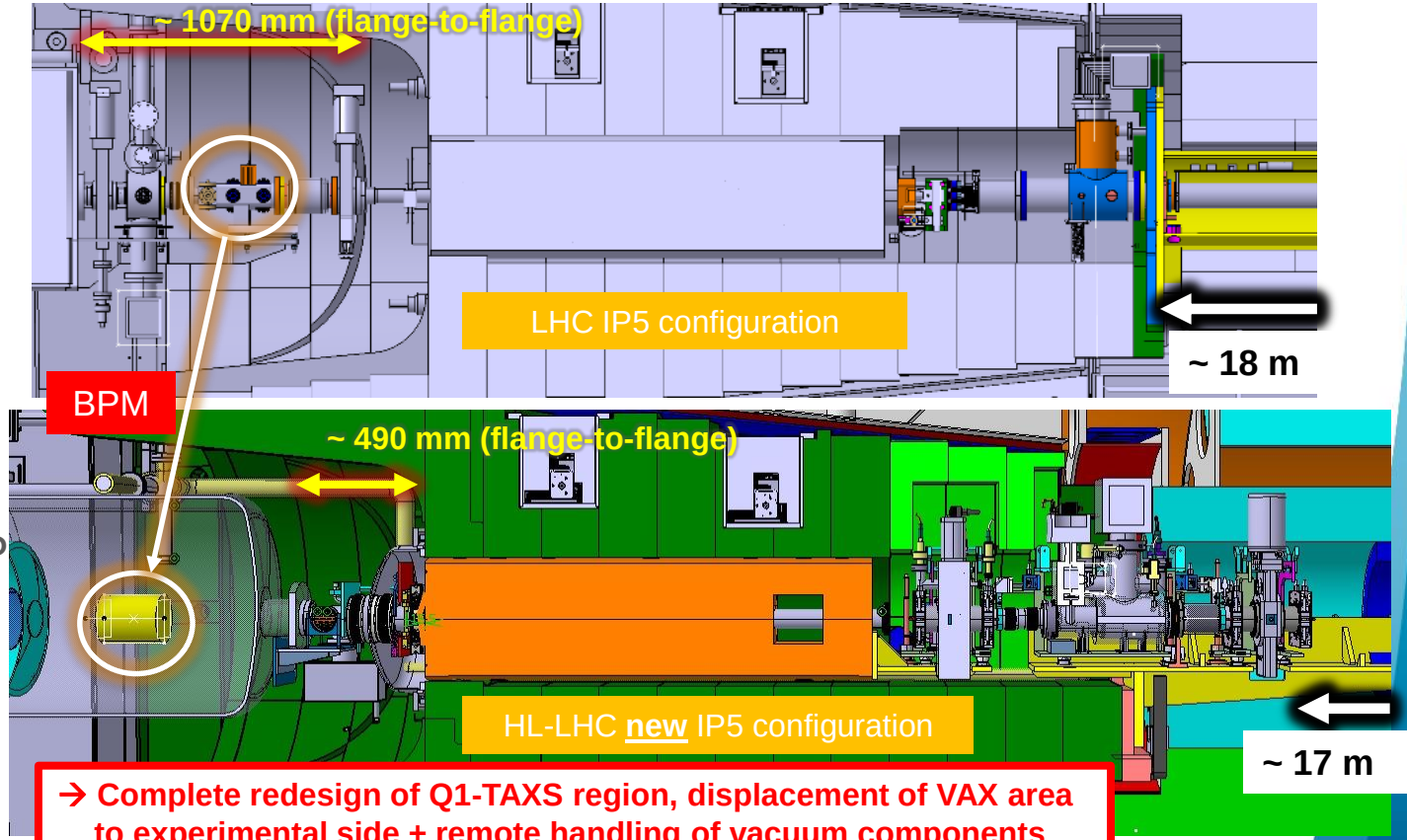
Power deposition plots (Fluka) comparing **TAS and TAXS**



(Courtesy of Miguel Lino Diogo dos Santos)

Upgrade Triplet-Forward Region of Experiments

- Residual dose increase requires redesign of TAXS area following ALARA principle
- BPM integration into Q1 service module moves Q1 flange 833mm to IP

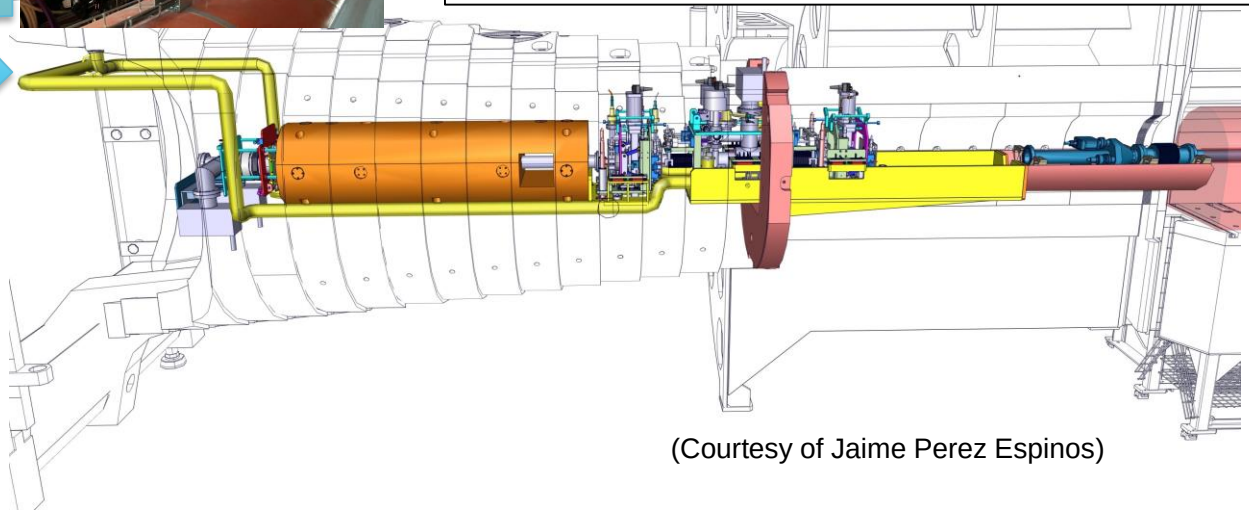


(Courtesy of Jaime Perez Espinos)

→ **Complete redesign of Q1-TAXS region, displacement of VAX area to experimental side + remote handling of vacuum components**

HL-LHC CMS VAX design + service lines

- Pumping/venting lines cross TAXS and ‘free maintenance area’ ⇒ **REDUNDANCY**
- Existing system will be prolonged until new VAX
- Shielding modifications
  - realized on VAX side for CMS
  - VAX passages on TAXS side during LS3 (WP8)

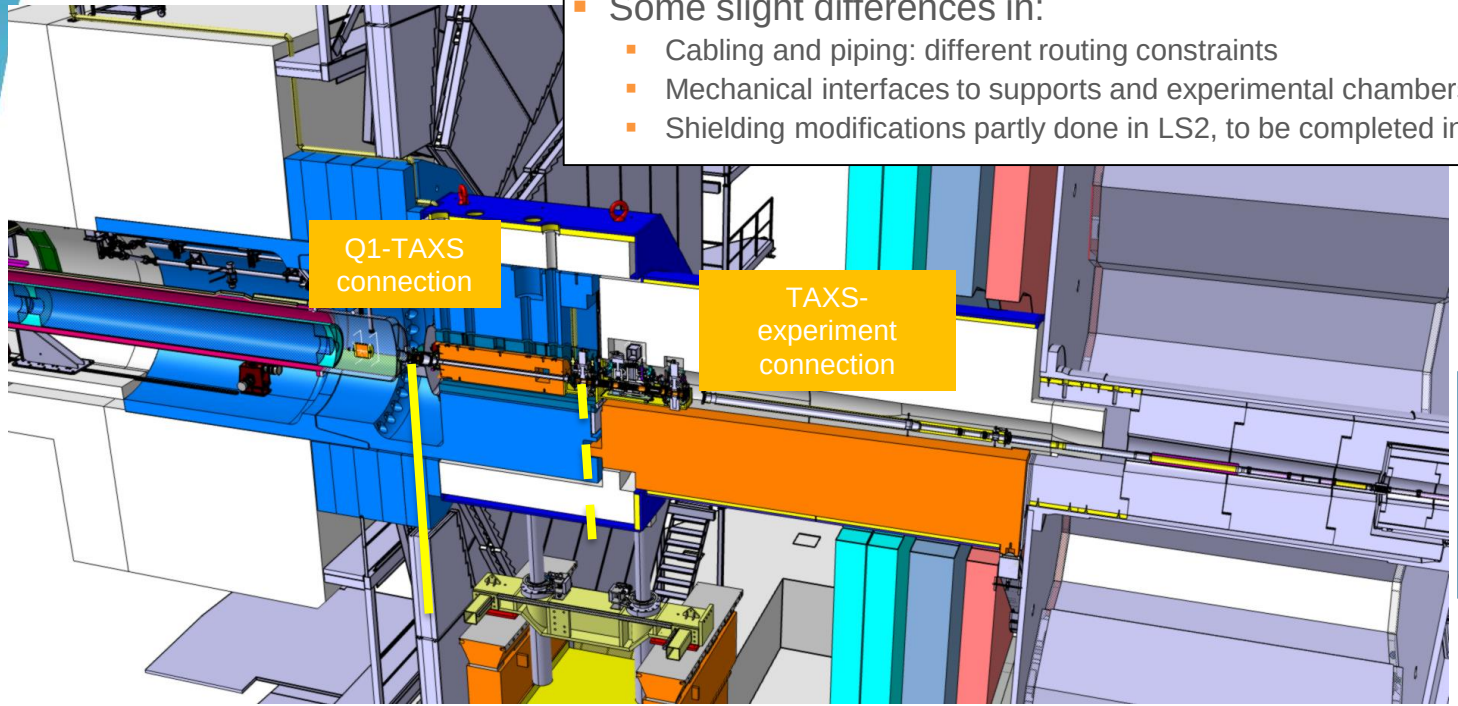


(Courtesy of Jaime Perez Espinos)

→ **Intensive studies ongoing (presentation WP12 by Jaime Pérez Espinós)**

HL-LHC ATLAS VAX design + service lines

- Same conceptual design ATLAS as for CMS
- Some slight differences in:
  - Cabling and piping: different routing constraints
  - Mechanical interfaces to supports and experimental chambers
  - Shielding modifications partly done in LS2, to be completed in LS3 (WP8)



(Courtesy of Jaime Perez Espinos)

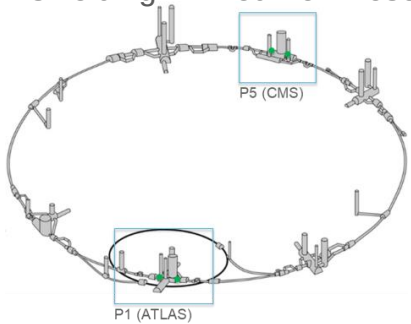
→ **Intensive studies ongoing (presentation WP12 by Jaime Pérez Espinós)**

Removal of TAS at beginning of LS3

ATLAS Forward Shielding (here Monoblock TX1S insertion into Fixtube)

CMS Forward Shielding (rotating shielding + Fixed Iron Nose FIN)

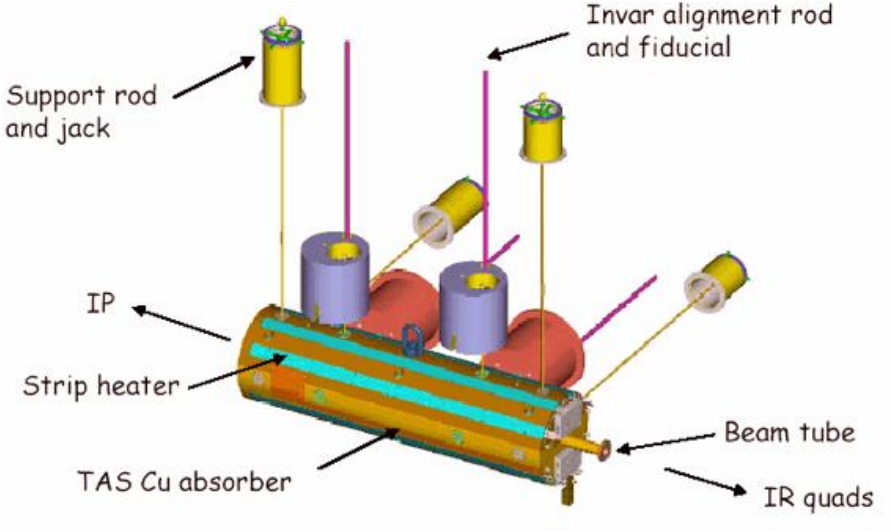
- Forward shielding had been installed with TAS inside.
- Removal process very different from installation.
- Procedure and adequate tooling need to be developed



→ **Intensive studies ongoing (presentation WP8 by Antonio Alonso)**

TAXS alignment and survey system

- Initial request for HL-LHC was to develop a remotely operated survey and alignment system to reduce exposure time following ALARA principle;
- Motorized systems however would require maintenance and repair interventions.
- Studies are ongoing simplifying alignment operation by system optimization.



(Courtesy of Miguel Lino Diogo dos Santos)

A motorized system would include:

- *Radiation hard, hi torque motors (4 per each absorber, 16 Total) with encoders*
- *Feedback system (potentiometers) for the position readout → **3.2 Ton object!***
- *Mechanical reference positions in case of problems (re-calibration of encoders, etc.)*

→ TAS system re-engineering study ongoing (WP8);
re-use of existing system strongly depends on TAS removal and TAXS installation scenario for ATLAS

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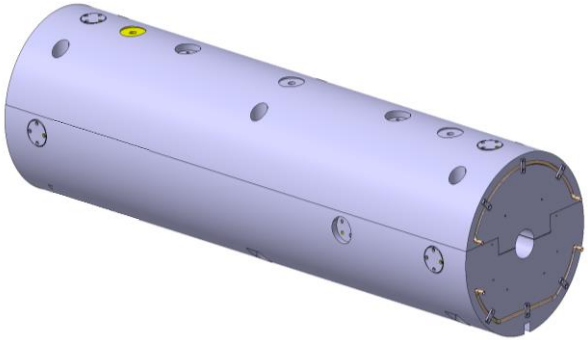
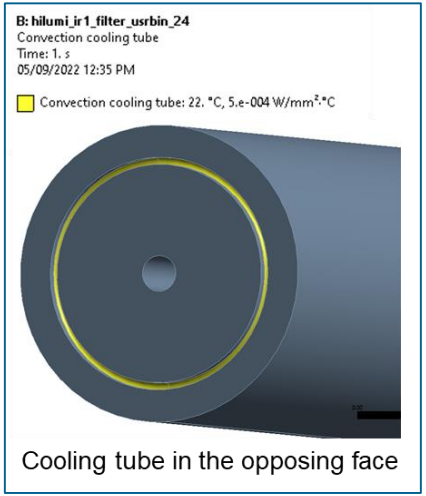
- Conclusions

Prototyping status – TAXS design

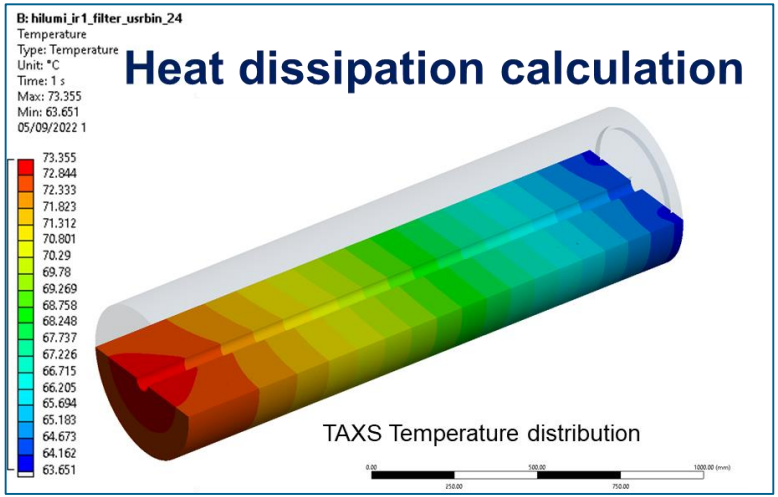
4x TAXS absorber: each 3.2 tonnes (Cu ETP); Ø 500mm; length 1800mm.

- Preliminary design realized
- Cooling system simulations realized in ANSYS using FLUKA data generated by RP (max. 73.5°C at 575 W).





Cooling tube in the opposing face

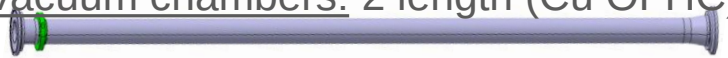


Next steps: Production of TAXS engineering documentation; procurement planned for 2nd half 2023!

(Courtesy of Marta Sabate Gilarte and Antonio Alonso)

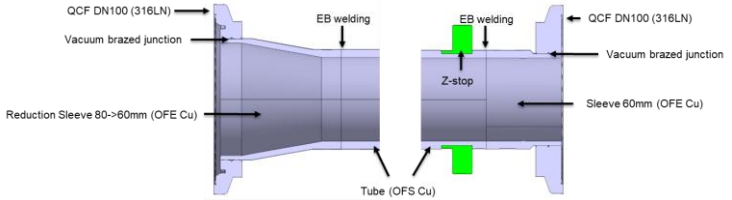
Prototyping status – TAXS chamber design (WP12)

4x Vacuum chambers: 2 length (Cu OFHC)

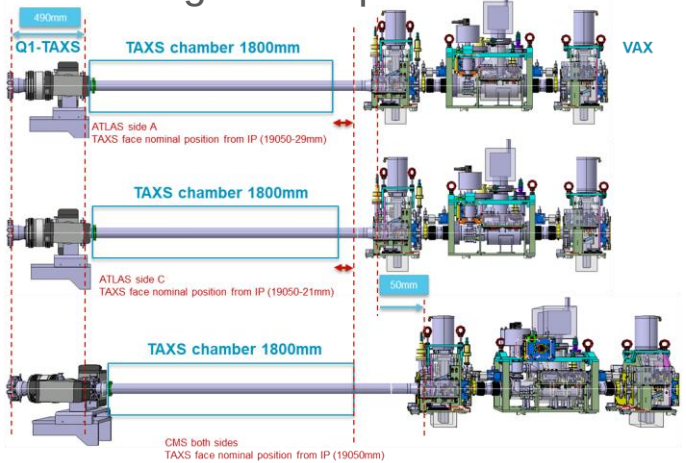


PARAMETER	ATLAS	CMS
Total chamber length	1982 mm	2061 mm
Tapered sleeve length	90 mm	
Sleeve length	55 mm	
Tube length	1837 mm	1916 mm
Tube thickness	5.35 mm (0/-0.05 tolerance)	
Tube inside diameter	60 (unknown tolerance)	
Tube outside diameter	70.7 (-0.1/0)	
TAXS absorber inside diameter	71 mm (0/+0.2)	
Maximum gap between chamber and absorber (in diameter)	0.3 mm (0/0.3)	
Minimum gap between chamber and absorber (in diameter)	0 mm	
Tapered sleeve angle	10°	
Position of Z-stop	To be agreed with EN-EA-PE	

Flanges, sleeves, Z-stop solution defined!



Different lengths and positions studied!



EDMS 2243804

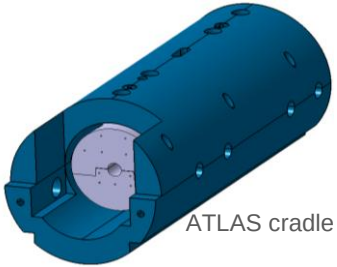
Next steps: finalize design parameters (Procurement WP12)

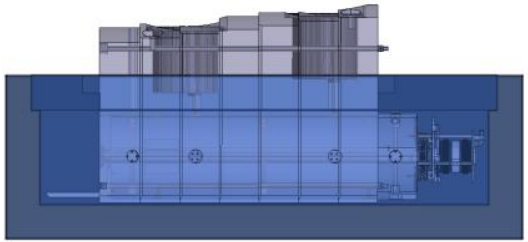
(Courtesy of Maria Luque and Lukasz Krzempek)

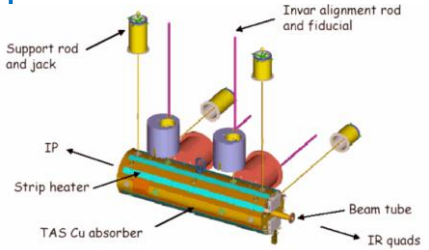
Prototyping status – TAXS accessories
Steel shields, sarcophagus, alignment system

- ATLAS: Removal of TAS in cradle → direct transport to RWTC
  needed: 2x ATLAS cradle / eventually: alignment system (tbd)
- CMS: Removal of TAS with or without plug and alignment system (in case of dismantling, cooldown required)
  needed: sarcophagus / eventually: plug + alignment system (tbd)

(Status of dismantling and installation scenario discussions is presented in dedicated talk!)


ATLAS cradle


CMS TAS with Plug in sarcophagus



TAS alignment system

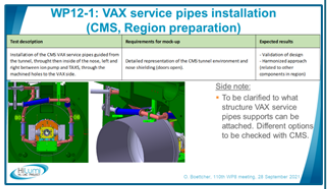
Next steps: decision on dismantling + installation scenario, include accessories in engineering design and purchase processes

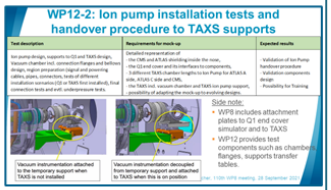
Upgrade of the triplet-forward region

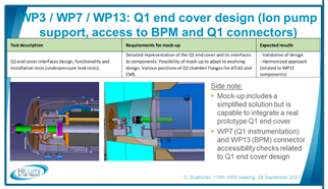
Overview Q1-TAXS mock-up user tests

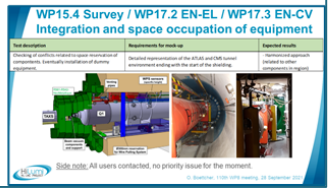
- Resume WP8 meeting – 31 August 2021

UserCat.	User-Case	User test title	Regions	LS3 related	Test description
Main Users	WP8-1	VAX service pipe passages drilling in CMS nose (d=140mm, l=250mm)	CMS only	Region preparation	Simulation of the machining process, realization of approx. 15mm drilling in narrow envirionment (CMS shielding doors open).
	WP8-2	Development and installation of TAXS Z-stopper	ATLAS + CMS	TAXS installed	TAXS z-stopper design, functionality and installation tests (incl. mechanical stress tests). Additional z-stopper between Cradle and Monobloc for ATLAS.
	WP8-3	HiLumi Helium barrier - for CMS: TAXS-shielding - for ATLAS: TAXS-Cradle-Shielding	ATLAS + CMS	TAXS installed	Helium barrier design, functionality and installation tests (He leak simulation)
	WP12-1	VAX service pipes installation in CMS tunnel through nose shielding	CMS only	Region preparation	Installation of the CMS VAX service pipes guided from the tunnel, throught then inside of the nose, left and right between ion pump and TAXS, through the machined holes to the VAX side.
	WP12-2	Ion pump design and installation tests incl. Q1 supports, handover to TAXS supports. (3 different TAXS chamber lengths to Ion Pump for ATLAS A side, ATLAS C side and CMS)	ATLAS + CMS	Region preparation TAXS preparation Q1 preparation Q1+TAXS installed Q1+TAXS connected	Ion pump design, supports to Q1 and TAXS design, Vacuum chamber incl. connection flanges and bellows design, region preparation (signal and powering cables, pipes, connectors, tests of different installation scenarios (Q1 or TAXS first installed), final connection tests and evtl. underpressure tests.
Secondary Users	WP3-1	Q1 end cover design + Ion pump support plate	ATLAS + CMS	Q1 preparaton Q1 installed	Q1 end cover interfaces design, functionality and installation tests (underpressure leak tests).
	WP13-1	Access and functional test of Q1 BPM cryostat flange connections	CMS only	Region preparation Q1 preparaton Q1 installed	Verification of accessibility of the Q1 BPM cryostat feedthrough flanges for connection and disconnect of long coaxial cables linking the BPM with the electronics in a technical gallery.
	WP7-1	Access and functional test of to Q1 instrumentation connectors	CMS only	Region preparation Q1 preparaton Q1 installed	Verification of accessibility of the Q1 instrumentation flanges for connection and disconnect of cables linking the in the Q1 with the electronics in a technical gallery.
Services-with-Equipm.	WP15.4-1	Integration and space occupation of the survey alignment system.	ATLAS + CMS	all phases: from region preparation to finalization	Checking of conflicts related to space reservation of compontents. Eventually installation of dummy equipment.
	WP17.3-1	Integration and space occupation of cooling + ventillation equipment.	ATLAS + CMS	Region preparation	Checking of conflicts related to space reservation of compontents. Eventually installation of dummy equipment.
	WP17.2-1	Integration and space occupation of the electrical power supply and other EN-EL equipment.	ATLAS + CMS	Region preparation	Checking of conflicts related to space reservation of compontents. Eventually installation of dummy equipment.
Services-Integration	WP15-1	Optimisation of space occupation	ATLAS + CMS	all phases: from region preparation to finalization	Ongoing reporting, dicussions and updates of evolving components and integration designs related to HL-LHC integration environment.
Services-Planning	WP15-1	Planning optimisation of LS3 activities and installation sequences	ATLAS + CMS	all phases: from region preparation to finalization	Ongoing reporting and documentation of test results related to HL-LHC planning.
Services-Operation	WP15.5-1	Validation of TAXS and Q1 insertion and adjustment procedure	ATLAS + CMS	TAXS installation Q1 installation	In case of possible conflicts, reporting and demonstration of risks, distances and margins and discussions of measures.

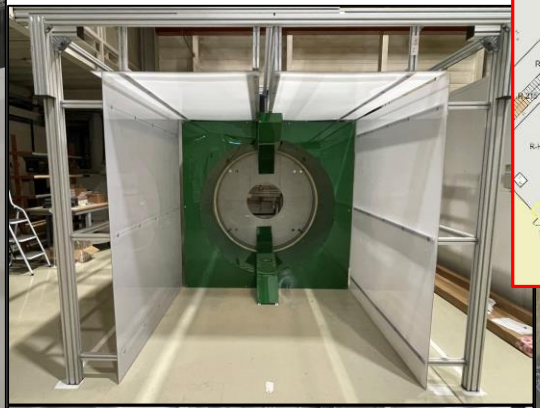






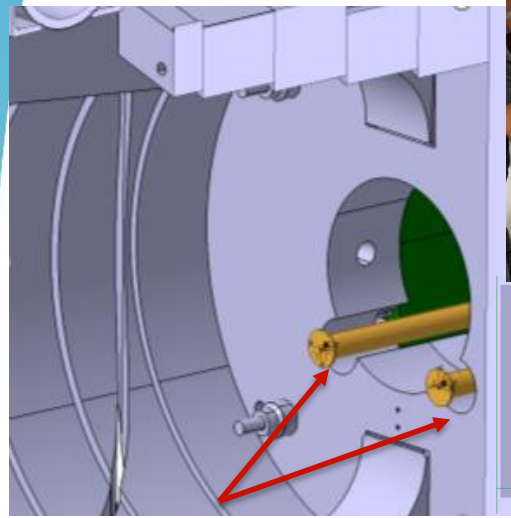


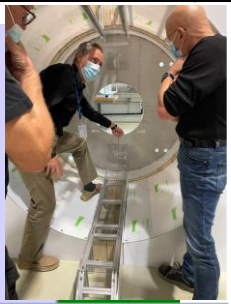
Q1-TAXS region mock-up - ready to be used for prototyping studies!

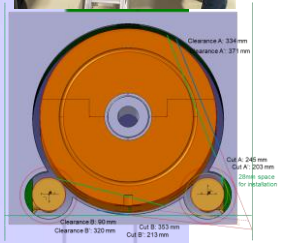


WP8-1: VAX service pipe passages machining
(CMS, Region preparation)

Test description	Requirements for mock-up	Expected results
Demonstration of passages machining ∅=160mm in 235mm thick steel probes. Fitting of machine into Q1-TAXS mock-up. Study of operation procedure.	Detailed representation of the CMS shielding inside FIN (doors closed, tunnel empty).	- Feasability approved - Procedure+Safety document







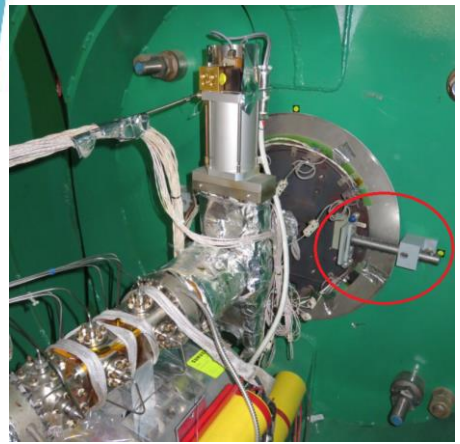
Passages up to ∅ = 160 mm and through 235mm shielding

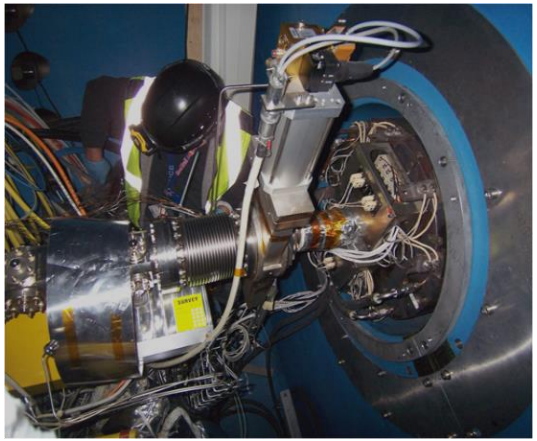
- Investigation of different machining methods in collaboration with different CERN service ongoing:
  - BE-CEM robotic team (ready for tests)
  - SY-STI beam dump destruction (contacts machining specialist),
  - SCE-SAM civil engineering (MARTI confirmed)

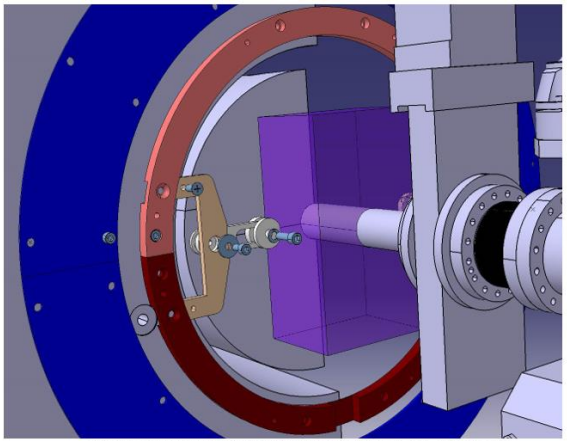
Next steps: make available steel probes for tests, continue investigating different methods to find machining with lowest risks for LS3 planning, (take decision mid 2023)

WP8-2: Development of TAXS Z-stop

Test description	Requirements for mock-up	Expected results
TAXS z-stopper design, functionality and installation tests (incl. mechanical load tests)	Detailed representation of all possible positions of the TAXS related to shielding.	- Technical solution - Harmonized approach (ATLAS+CMS)



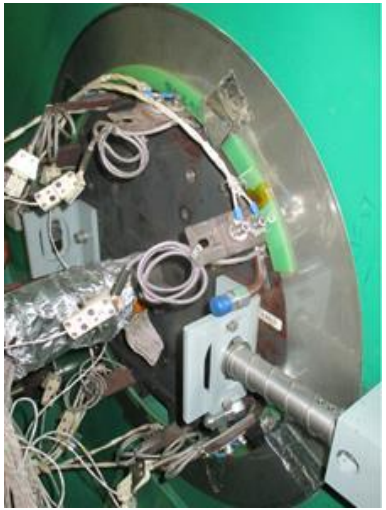


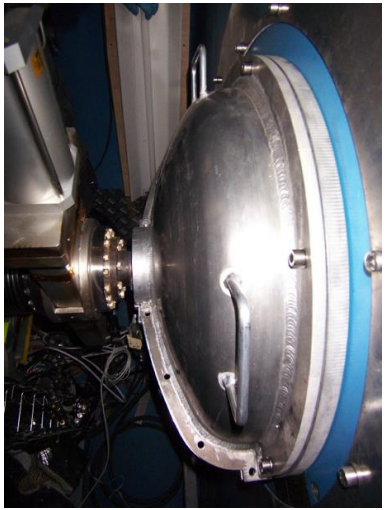


Next steps: Design discussions to be started! Review of studied Z-stop solutions (see EDMS 1386628). Implementation of system into Q1-TAXS mock-up for demonstration and tests.

WP8-3: Helium barrier
differences ATLAS and CMS

Test description	Requirements for mock-up	Expected results
Helium barrier design, functionality and installation tests (evtl. He leak simulation)	Detailed representation of the CMS and ATLAS shielding inside FIN and Monobloc.	- Technical solution - Harmonized approach (ATLAS+CMS)





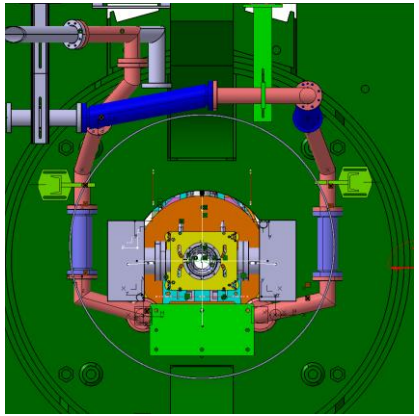
Remark:

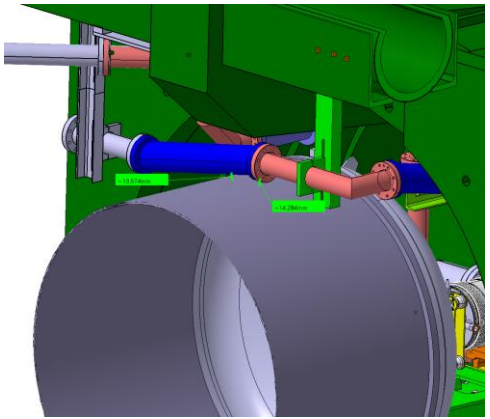
- Solution to be adapted to VAX service pipes passages for CMS (see WP8-1).

Next steps: Design discussions to be started! Implementation of system into Q1-TAXS mock-up for demonstration and tests.

WP12-1: VAX service pipes installation
(CMS, Region preparation)

Test description	Requirements for mock-up	Expected results
Installation of VAX service pipes into the Q1-TAXS region mock-up up to the VAX passages in shielding. Check of compatibility with all other components. Definition of the installation sequences.	Detailed representation of the CMS tunnel environment and nose shielding.	- Validation of design - Harmonized approach (related to other components in region)





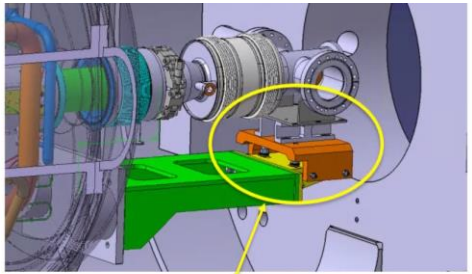
- Q1-TAXS region mock-up ready to be filled and used!
- Design discussions ongoing at WP12.

(Courtesy of Rita Perez Martinez)

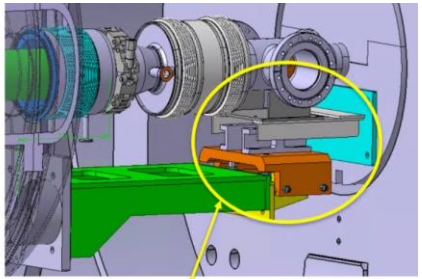
Next steps: Decide on piping materials for flexible use for mock-up simulations at low costs!

WP12-2: Ion pump installation tests and handover procedure to TAXS supports

Test description	Requirements for mock-up	Expected results
Ion pump design, supports to Q1 and TAXS design, Vacuum chamber incl. connection flanges and bellows design, region preparation (signal and powering cables, pipes, connectors, tests of different installation scenarios (Q1 or TAXS first installed), final connection tests and evtl. underpressure tests.	Detailed representation of - the CMS and ATLAS shielding inside the nose, - the Q1 end cover and its interfaces to components, - 3 different TAXS chamber lengths to Ion Pump for ATLAS A side, ATLAS C side and CMS, - the TAXS incl. vacuum chamber and TAXS ion pump support, - possibility of adapting the mock-up to evolving designs.	- Validation of Ion Pump handover procedure - Validation components design - Possibility for Training



Vacuum instrumentation attached to the temporary support when TAXS is not installed



Vacuum instrumentation decoupled from temporary support and attached to TAXS when this is on position

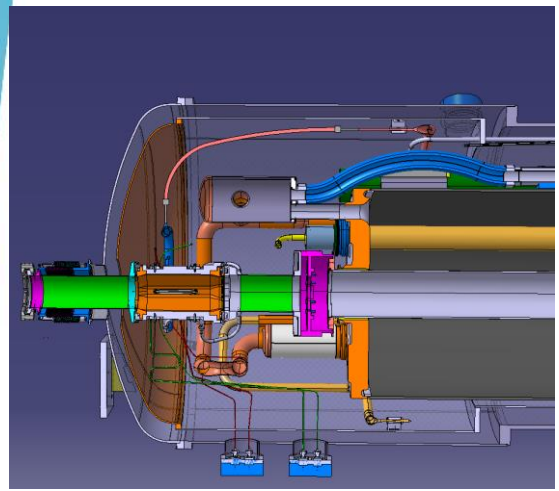
- Q1-TAXS region mock-up ready to be used!
- Depending on components supply WP12.
- Review of components design ongoing.

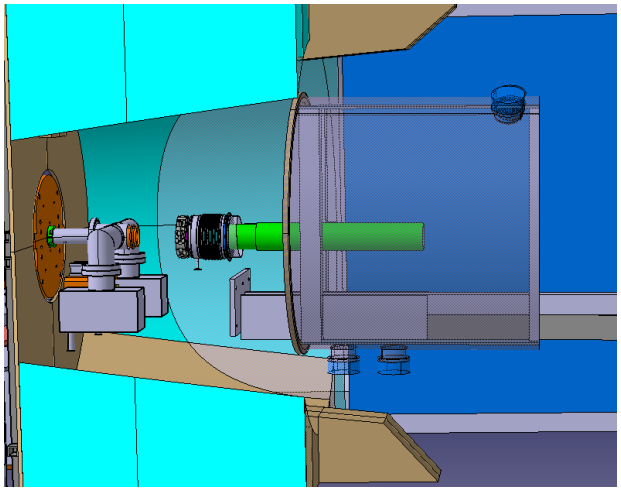
Next steps: WP12 to decide on components design and final Q1-TAXS region layout!

(Courtesy of WP12)

WP3 / WP7 / WP13: Q1 end cover design (Ion pump support, access to BPM and Q1 connectors)

Test description	Requirements for mock-up	Expected results
Q1 end cover interfaces design, functionality and installation tests (underpressure leak tests).	Detailed representation of the Q1 end cover and its interfaces to components. Possibility of mock-up to adapt to evolving design. Various positions of Q1 chamber flanges for ATLAS and CMS.	- Validation of design - Harmonized approach (related to WP12 components)



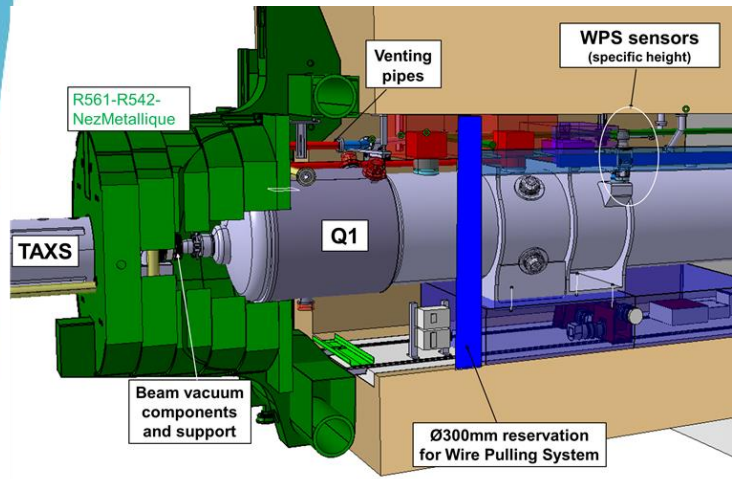


- Real prototype Q1 end cover and Q1 service module will be integrated for mock-up!

Next steps: Prepare for connector accessibility checks with WP7 (Q1 instrumentation) and WP13 (BPM).

WP15.4 Survey / WP17.2 EN-EL / WP17.3 EN-CV Integration and space occupation of equipment

Test description	Requirements for mock-up	Expected results
Checking of conflicts related to space reservation of compontents. Eventually installation of dummy equipment.	Detailed representation of the ATLAS and CMS tunnel environment ending with the start of the shielding.	- Harmonized approach (related to other components in region)

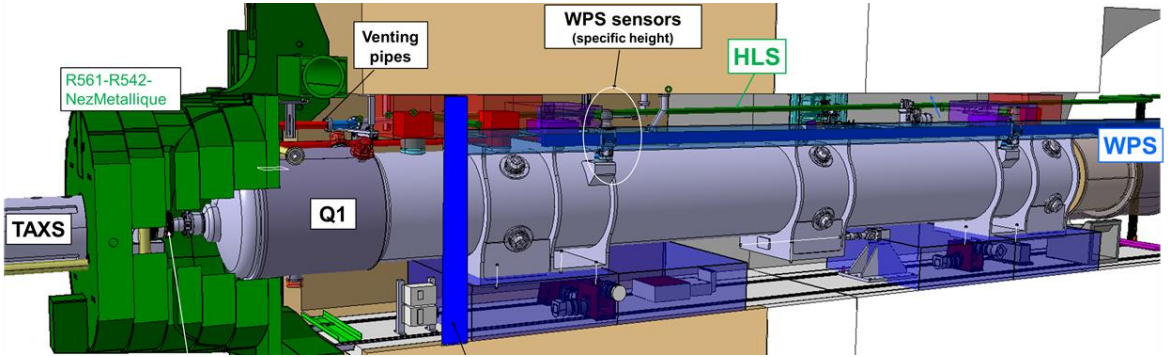


- Q1-TAXS region mock-up ready to be filled and used

Next steps: Contact equipment owners, find solutions for mock-up components schedule completion of Q1-TAXS region mock-up.

WP15 Integration and Planning + WP15.5 Transport

User	UserCat.	Test description	Requirements for mock-up	Expected results
WP15	Services-Integration	Ongoining reporting, dicussions and updates of evolving components and integration designs related to HL-LHC integration environment.	Repeatability of tests for demonstration. Possibility of adapting the mock-up to evolving designs.	- Harmonized approach + synergies (related to all equipment in Q1-TAXS region)
WP15	Services-Planning	Ongoining reporting and documentation of test results related to HL-LHC planning.	Flexibilty of mock-up to remove and reinstall different components several times and in different sequences to optimise HL-LHC installation schedule and planning.	- Harmonized approach + synergies (related to activity planning)
WP15.5	Services-Operation	In case of possible conflicts, reporting and demonstration of risks, distances and margins and discussions of measures.	Repeatability of tests for demonstration.	- Clarity of situation at the moment of installation of Q1 and TAXS

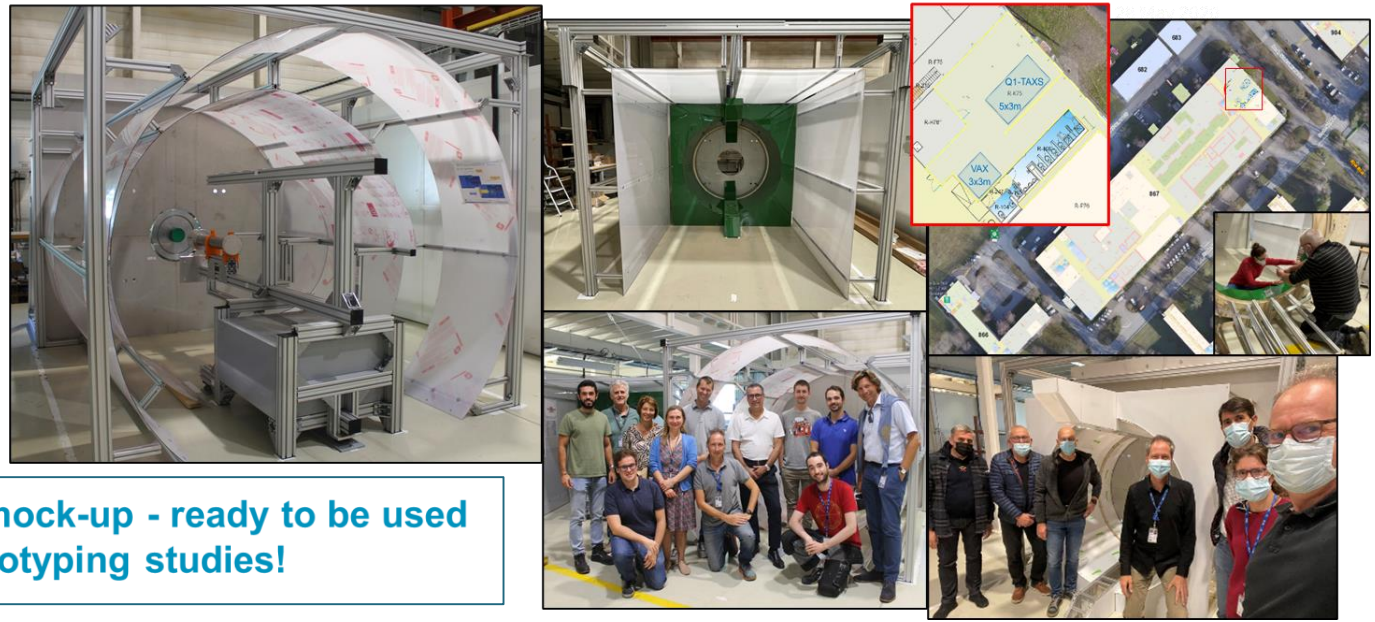


Next steps: Fill Q1-TAXS region mock-up. Practically apply drafted LS3 planning work sequences, check practicality, document findings.

Conclusions

- TAXS engineering documents production will be started before end 2022.
- Layout and designs studies should be finished by before summer 2023. Procurement of TAXS components should start in 2nd half 2023.
- Many elements depend on dismantling and installation scenario. (Discussions are on their way.)
- Q1-TAXS region mock-up is ready to support prototyping and integration studies. WP8 will contact equipment owners to advance studies and completion of the test environment with prototype components.

Thanks to all for help and support!



Q1-TAXS region mock-up - ready to be used for prototyping studies!

Special thanks: - François Morel, Rafael Fernandez Gomez + Kevin Buffet (BE-EA-DC design support + 3D printing)
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- Rita Perez Martinez + Jaime Perez Espinos (WP12 – 3d models, components etc.)
- Ruth Diaz Vez (TE-MSC before WP8 – mock-up development and installation)

Thank you for your attention