



# Welding Developments

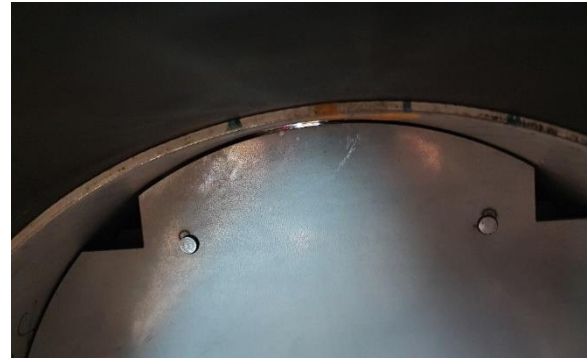
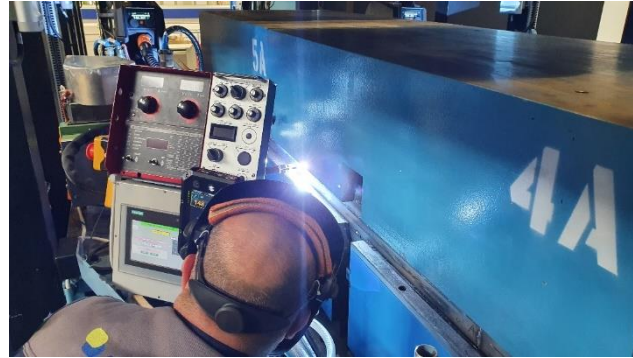
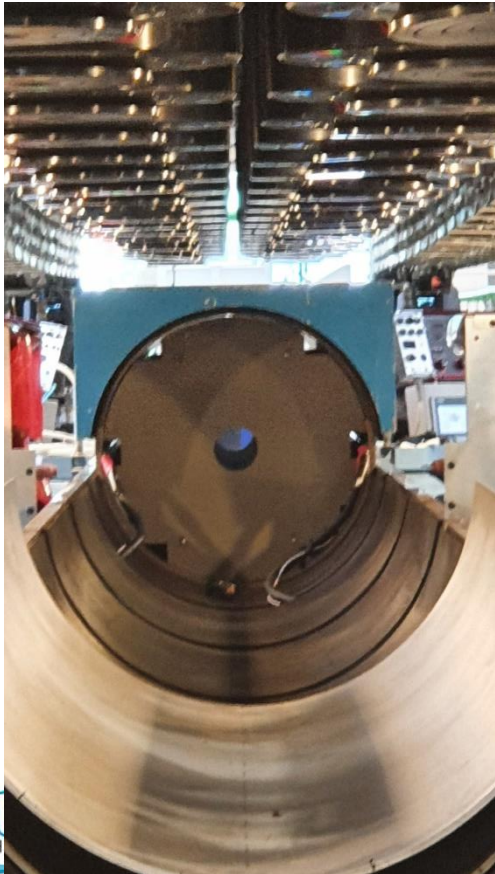
H. Prin

***CM Meeting***

<https://indico.cern.ch/event/1048827/>

***June, the 14<sup>th</sup> 2021***

# 1<sup>st</sup> Welding shrinkage determination



	Position	Initial	1st pass	2nd pass	3rd pass	total
side A	1	43.15	42.9	42.6	42	1.15
	2	43.2	41.3	40.7	40.4	2.8
	4	43.3	41.2	41.2	41.2	2.1
	5	42.3	41.4	40.8	40.6	1.7
	7	42.6	41.8	41.4	41.4	1.2

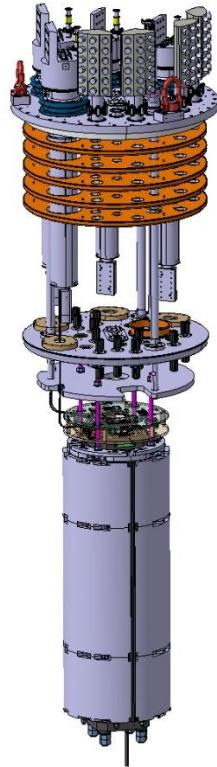
1.79 [-0.64,+1.01]

	Position	Initial	1st pass	2nd pass	3rd pass	total
Side B	1	43.4	42.5	41.7	41.5	1.9
	3	42.4	40.9	40.5	40	2.4
	4	43.9	42.9	42.4	42	1.9
	6	43.1	42	41.6	41.2	1.9
	7	41.8	41	40.7	40.4	1.4

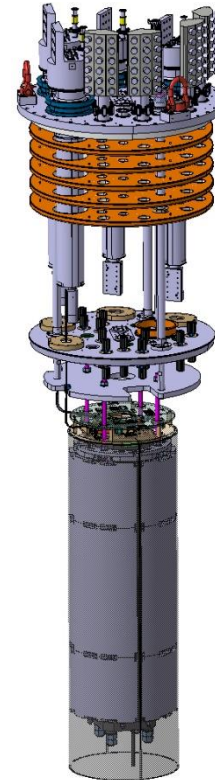
1.9 [-0.5,+0.5]

# 2<sup>nd</sup> MQXFS7 cold tests with shells

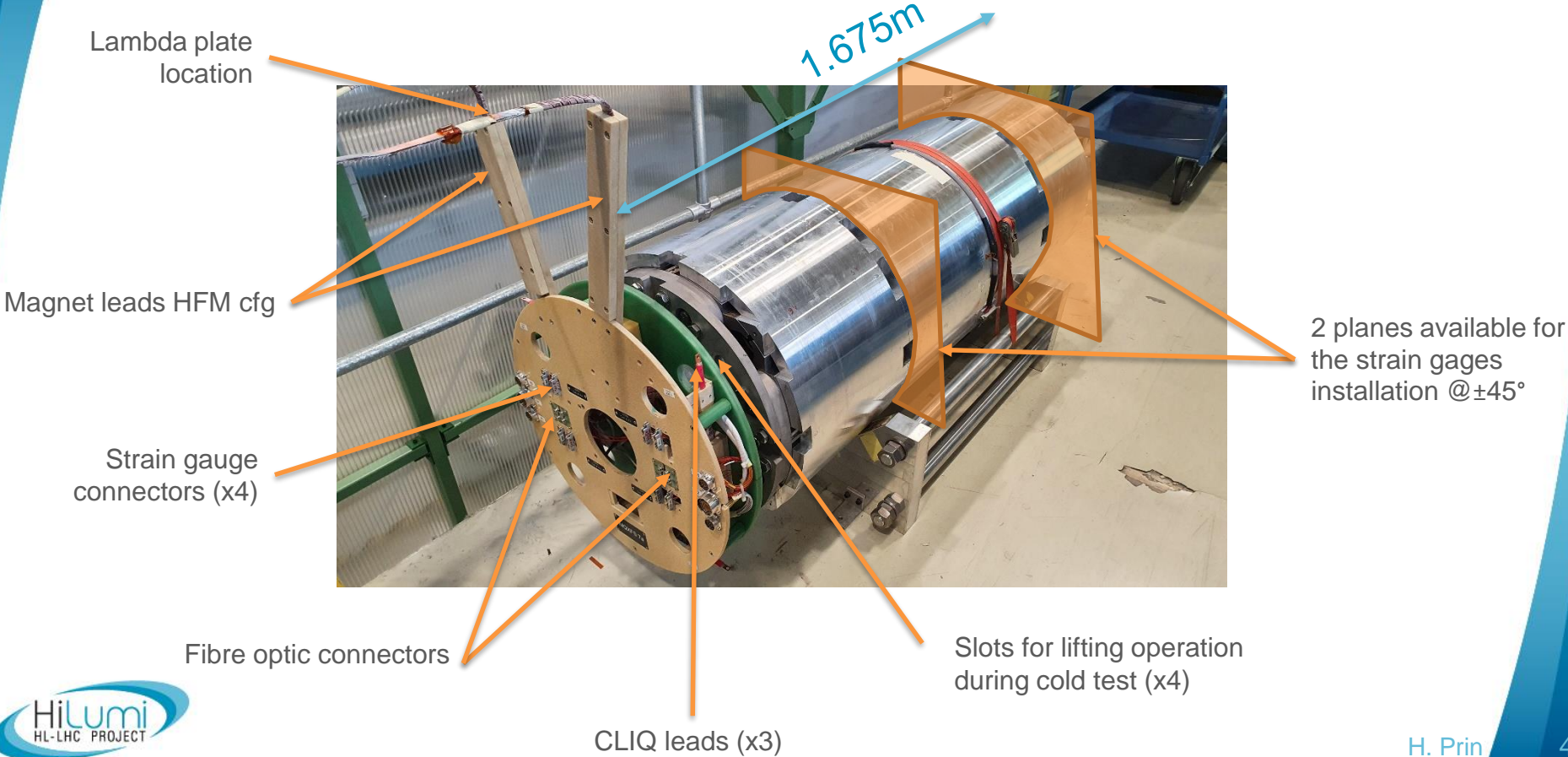
Standard MQXFS model configuration



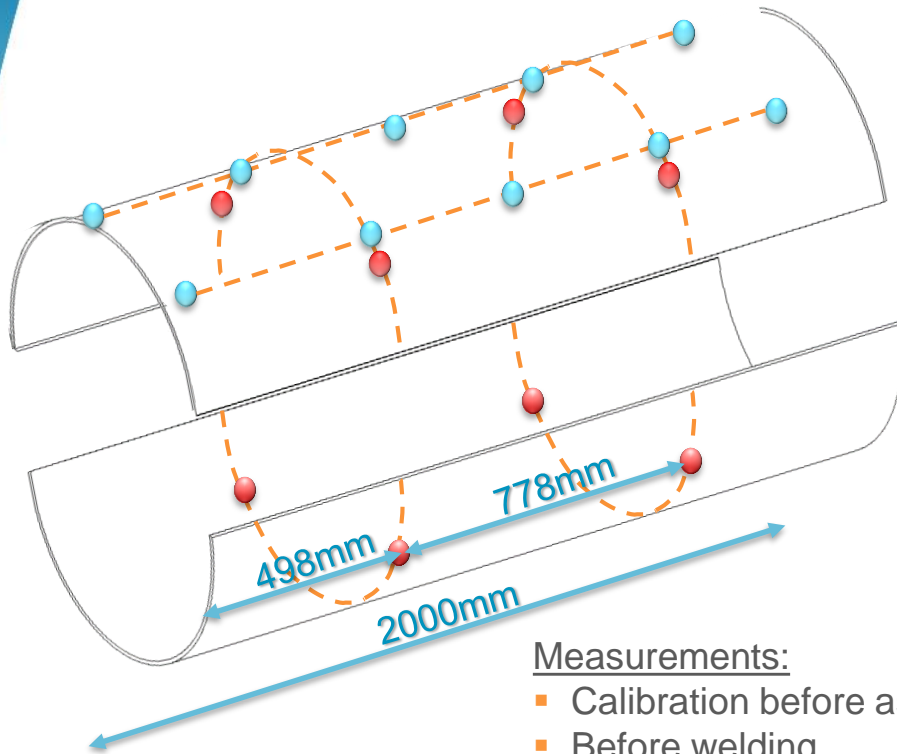
Configuration proposed for MQXFS07 with shells



# MQXFS07 magnet



# Shells instrumentation



## ■ Strain gauges:

- 16 Azimuthal (In and Out)
- 10 Longitudinal (Out only)
- + coil poles instrumented
- + optical fibers

$L_{dev1}$	=	964.5mm
$L_{dev2}$	=	968mm
$L_{dev\_mag\_theo}$	=	1928.9mm
$L_{dev\_mag\_real}$	=	to be measured as well as deformations in V (and H) plane

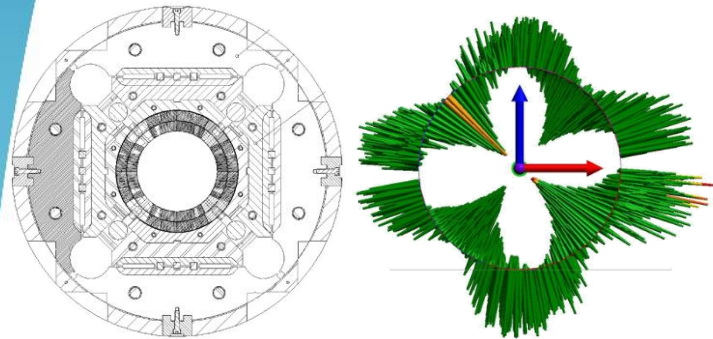
## Measurements:

- Calibration before assembly
- Before welding
- Between the welding passes
- During cool down and test at cold
- During warm up
- After disassembly





# Shells developed length determination



$$\begin{aligned}
 R_{\text{theo}} &= 614\text{mm} & \Leftrightarrow & L_{\text{dev}_{\text{theo}}} = 1928.9\text{mm} \\
 R_{\text{meas}} &= 614.27\text{mm} & \Leftrightarrow & L_{\text{dev}_{R_{\text{meas}}}} = 1929.8\text{mm} \\
 & & & L_{\text{dev}_{\text{meas}}} = 1929.9\text{mm (center)} \\
 & & & L_{\text{dev}_{\text{meas}}} = 1930\text{mm (ext)}
 \end{aligned}$$

$$\begin{aligned}
 L_{\text{dev}_{\text{sec}}} &= 1930.6\text{mm} \\
 \text{Weld shrinkage} &\sim 1.8\text{mm/side}
 \end{aligned}$$

$$L_{\text{dev}1} = 964.5\text{mm}$$

All Vectors Summary: Vector Group			
Analysis:GR-AVF-Cylindre Complet			
Statistic	dX (mm)	dZ (mm)	MagXZ (mm)
Min	-0.13	-0.13	-0.16
Max	0.18	0.12	0.18
Average	-0.00	-0.00	-0.00
StdDev from Avg	0.04	0.04	0.06
StdDev from Zero	0.04	0.04	0.06
RMS	0.04	0.04	0.06
Tol Range			-0.15
			0.15
In Tol		8653 (99.5%)	
Out Tol		47 (0.5%)	
Count	8700		



$$\begin{aligned}
 &\text{Target stress at warm } 0 \text{ MPa on the coils } [\pm 8\text{MPa}] \\
 \Leftrightarrow L_{\text{dev}2} &= L_{\text{dev}_{\text{sec}}} - L_{\text{dev}1} - 2x \text{ Gap} + 2x W_{\text{shrink}} \\
 &= 1930.6 - 964.5 - 2x 3 + 2x 1.8 \\
 &= 963.7 \Leftrightarrow 964\text{mm}
 \end{aligned}$$

Welding  
shrinkage  
compensation

Cylinder Relationship		
Analysis:Cylindre Complet		
Criteria	Measure	
Diameter	614.27	
Cylindricity	0.34	
RMS	0.06	
Measurements	8700	

# Action list

Shells

- 1) Machining according to agreed developed lengths ✓
- 2) Recording of the measurements ✓
- 3) Instrumentation ✓

Magnet

- 4) Removal of Aluminum shell instrumentation ✓
- 5) Leads bending to stay in the shadow on the cylinder + insulation ✓
- 6) Rotate the magnet 90 degrees ✓
- 7) Adapt CLIQ lead ✓
- 8) Install and fix lifting tie rods before welding (nut not accessible after) ✓
- 9) Shell strain gauge connectors to be fixed on the connection box top plate ✓

Welding  
press

- 10) Cradle caoutchouc modification to house the instrumentation ✓
- 11) Recording of root gaps along the length each sides
- 12) Welding with shrinkage and stress measurements in between the passes



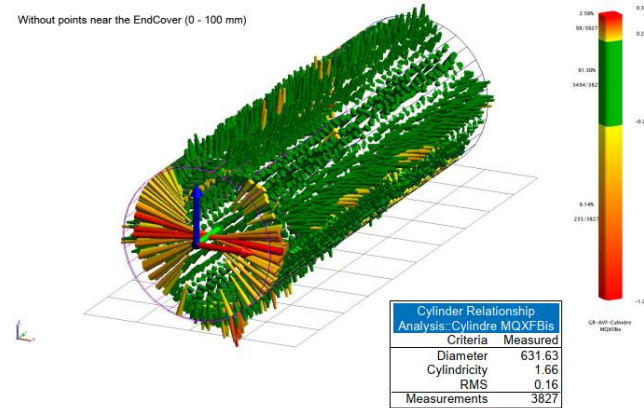
# LMQXFBT03 outer shape measurements



## Measurement Report Proto 3 MQXF : only 2 meters from NC Side

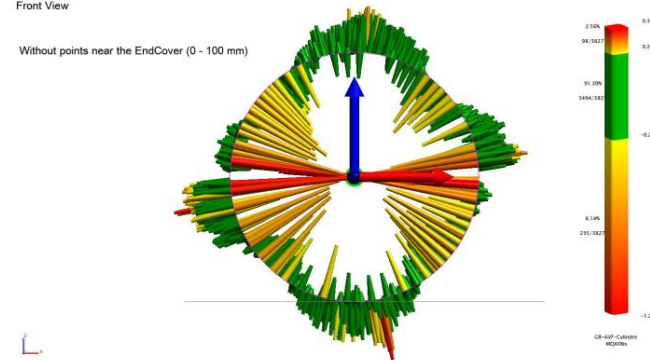
Oblique View

Without points near the EndCover (0 - 100 mm)



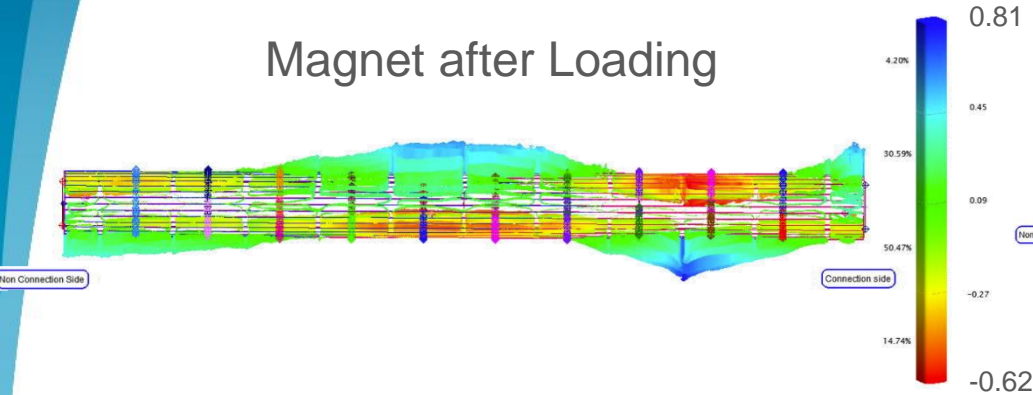
Front View

Without points near the EndCover (0 - 100 mm)

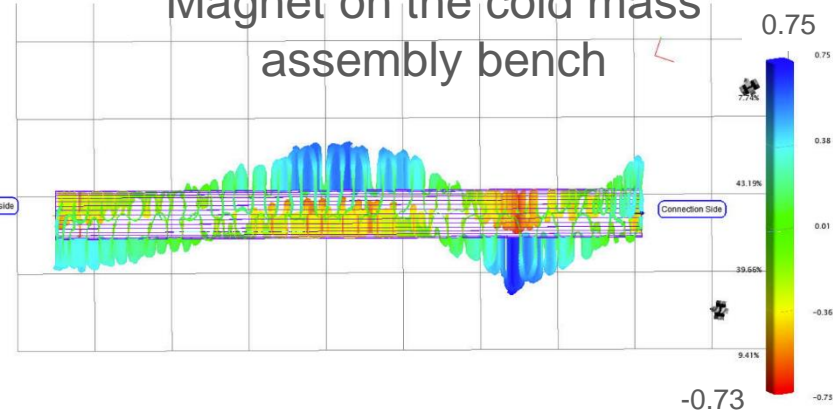


# MQXFBS01 shape

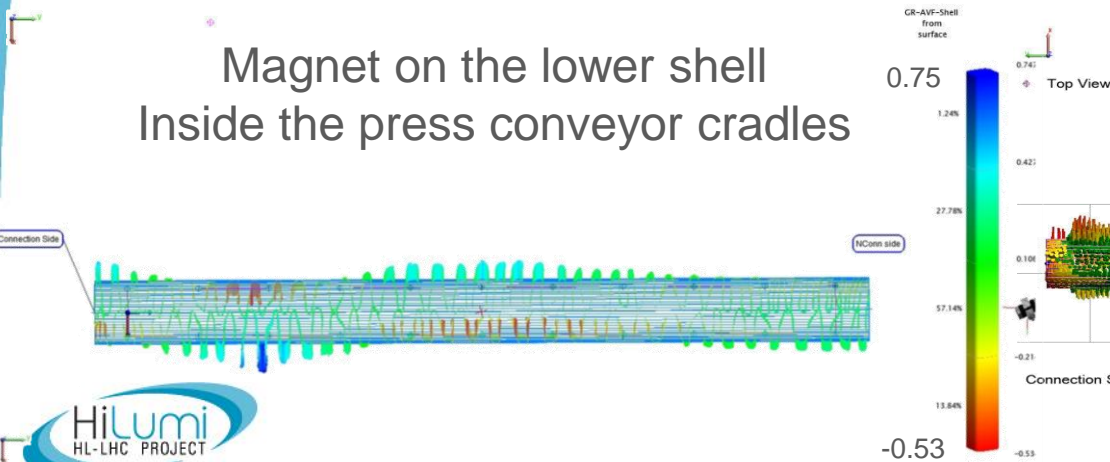
Magnet after Loading



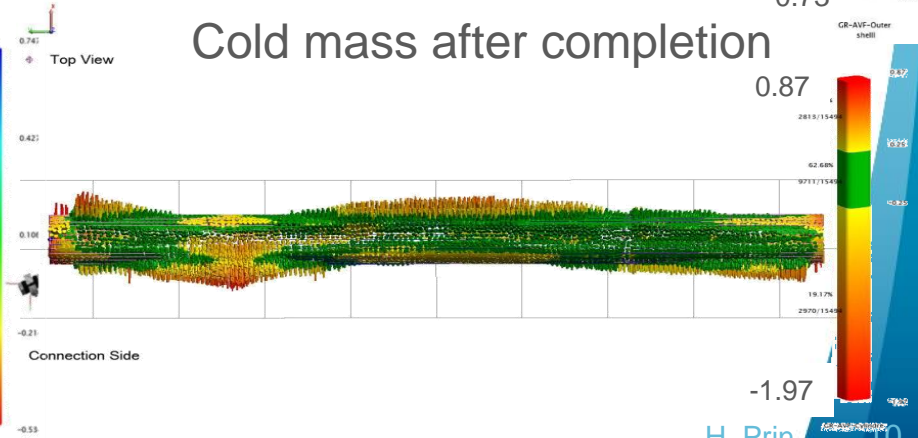
Magnet on the cold mass assembly bench



Magnet on the lower shell  
Inside the press conveyor cradles



Cold mass after completion



# Open points

- Confirm target stress and related tolerance and way to achieve it (shell developed length, welding parameters) with test on MQXFS7
- Expandable tooling to support ss shell during welding, to then be removed before welding end caps
- Impact on ongoing contract of half shells with AP-TELA
- Realistic target for tolerance in machining half shells dev. length [0, +0.75mm]
- Machining shells by pairs
- Longitudinal fixed point
- **Welding repairs**

# Shell adjustment milling machine

