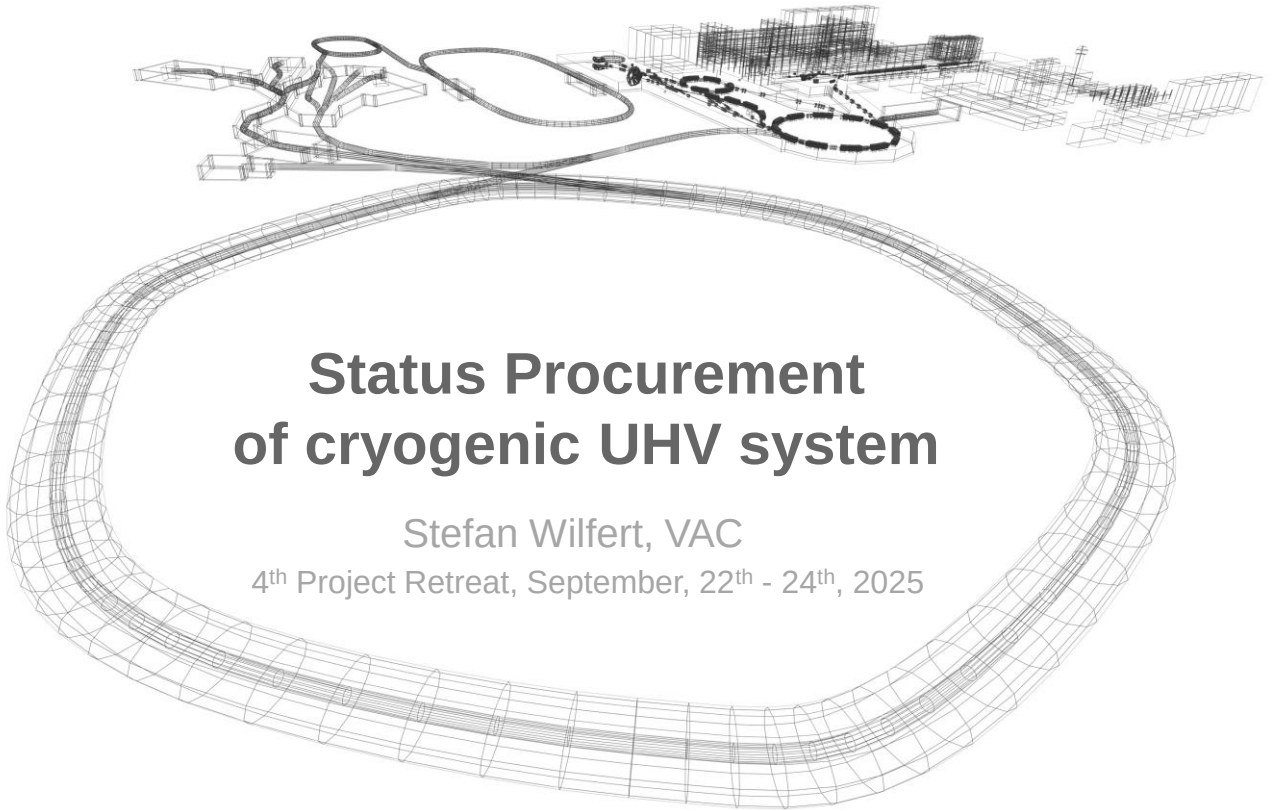


Status Procurement of cryogenic UHV system

Stefan Wilfert, VAC

4th Project Retreat, September, 22th - 24th, 2025

Overview on components needed for cryogenic beam vacuum system

quantity (+ spare)	quantity in total	component	Status Sep 2024	Status Sep 2025	Remarks and new estimated costs
108 (+12)	120	dipole chambers (DP)			
5	**5**	**Additional spare dipole chambers**			160 k€ (2023)
164 (+15)	179	quadrupole chambers (QP), elliptical-shaped			
6 (+2)	**8**	**quadrupole chambers (QP), star-shaped**			Order has been placed, in progress
12	12	missing dipole chambers (MDP)			
60 (+1)	61	cryo-collimators (COL)			
47 + 12	59	DP-DP + MDP-DP Interconnection bellow tees			
120 (+15)	**135**	**DP-QP + MDP-Q P Interconnection bellows**			Order has been placed, in progress
47 (+3)	50	Roughing CWTs (RCWT)			
47	**4**	**Beam Vacuum CWT (BVCWT)**			Tender is prepared
85 (+2)	87	Cryosorption pumps			

Preparation of procurement

Contract placed, order started

Delivered and accepted

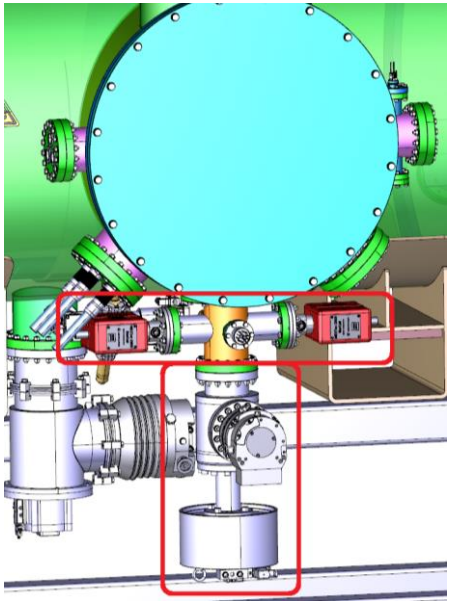
Overview on technical equipment needed for cryogenic beam vacuum system

quantity (+ spare)	quantity in total	component	Status Sep 2024	Status Sep 2025	Remarks and new estimated costs
94	94	SAES D500-D NEG-IGP (star cell®) combination			
24	48	SAES NEG POWER C4 controller			
24	52	AGILENT 4UHV controller, negative polarity			
47	100	Leybold Extractor gauges IE514			
16	40	Extractor gauge controller PREVAC MG-15			
85	85	Cold-Cathode gauge IMG 422 (MKS)			
32	**32**	**Cold-Cathode gauge controller MKS 937B**			
12	27	DN40CF Pirani gauge			
20	**20**	**Inficon Controllers for Pirani gauges**			Ordered, to be delivered by end of this year.
47	47	DN100CF angle valves			Delivered, Operational capability still needs to be clarified
30	30	DN16CF burst disks			
44	**44**	**DN40CF venting valves (all metal)**			42 pieces delivered, further 8 valves ordered
23	23	DN40CF tees			
xx	xx	DN40CF crosses			newly added
23	**23**	**Bake-out jackets DN40CF tees**			
xx	**xx**	**Bake-out crosses DN40CF tees**			newly added
47	47	Bake-out jackets PSC			
6?	**12?**	**Mobile roughing pump system DN100CF (TMP+scroll pump)**			Detailed Specification writing in progress
		Numerous minor parts (metal hoses, …)			

Preparation of procurement

Contract placed, order started

Delivered and accepted



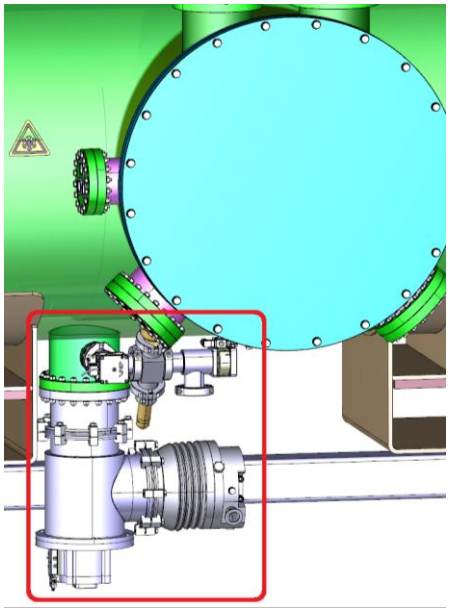
Overview on technical equipment needed for insulation vacuum system

quantity (+ spare)	quantity in total	component	Status Sep 2024	Status Sep 2025	Remarks and new estimated costs
60		Adapter DN160CF - ISO-K			delivered
60		Angle Valves DN160ISO-K			delivered
30		Turbomolecular Pump DN160ISO-K			delivered
30		Primary pumps (rad hard) 15 m³/h			delivered
30		DN25KF hoses, DN25KF T-Piece			delivered, additional T pieces needed
30		Pre-Vacuum Valve DN25KF			30 pcs available
30		Venting / LD Valve DN25KF			
33		Pirani gauge DN16KF			
35		Adapter DN40CF–KF + KF fastening material			delivered
35		Angle Valves DN40KF			
39		Special 5-way-cross DN40KF			delivered
39		Cold-Cathode gauge DN40KF			
38		Inficon Controller CCG			
38		Pirani gauge DN40KF			
38		Inficon Controller Pirani gauge			
30		Venting Valves DN40KF			
17		Venting valves DN16KF			10 pcs. Delivered, additional 8 ordered
10 (+ 2)	12	Mobile roughing pump system DN160ISO-K (TMP+scroll pump / large screw pump)			2 large screw pumps delivered
A lot	More	Gaskets (Viton, EPDM and Aluminum) and fastener (clamps, bolts, nuts, washers)			Mostly ordered and delivered

Preparation of procurement

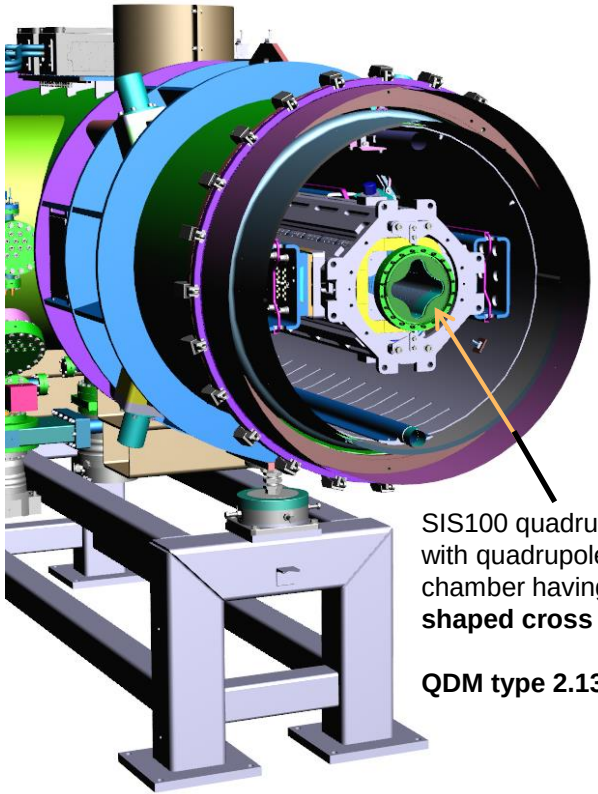
Contract placed, order started

Delivered and accepted



Cryogenic UHV system components

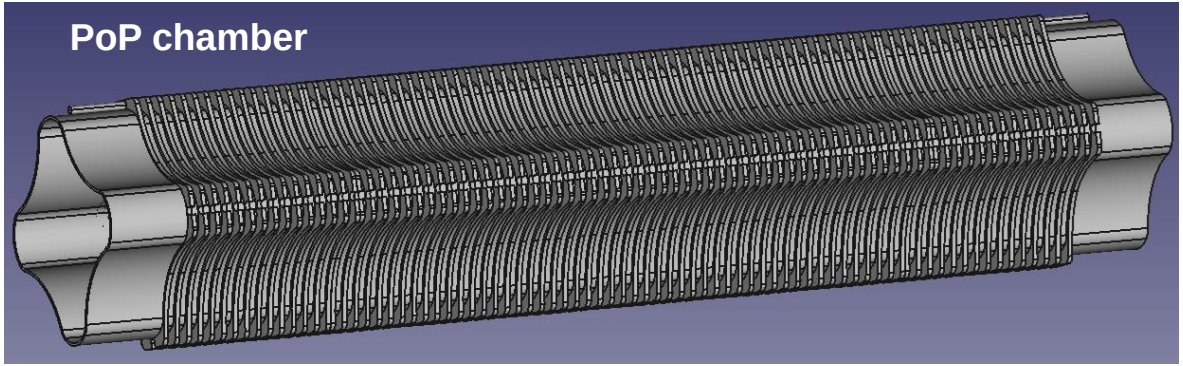
Production status SIS100 star-shaped quadrupole chambers



SIS100 quadrupole with quadrupole chamber having a **star-shaped cross section**

QDM type 2.13s

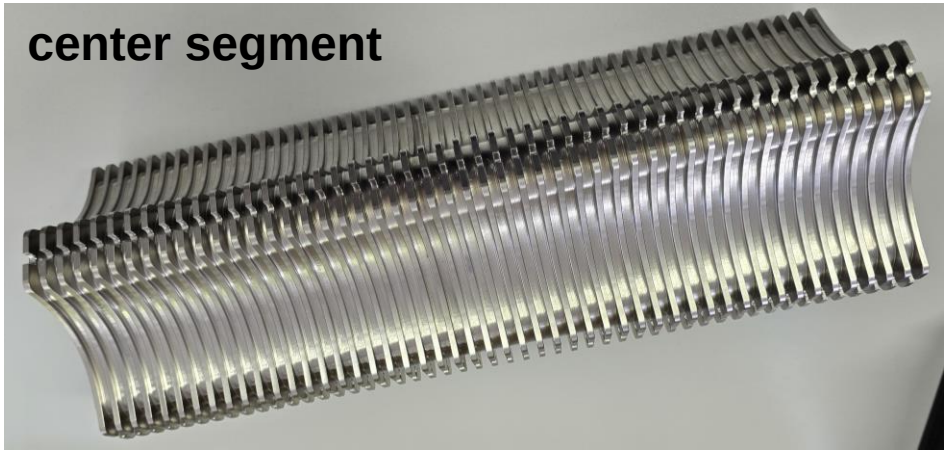
- envisaged production strategy: assembling the full-length chamber from individual transversal segments, each individual segment being milled from a solid tubular stainless steel cylinder,
- i.e. the chamber and rib structure are milled as one piece, the required vacuum-side surface quality is obtained by wire-cut EDM as a finishing process
- **Disadvantage** of this production method: **wall thickness ~ 0.5 mm instead 0.3 mm**

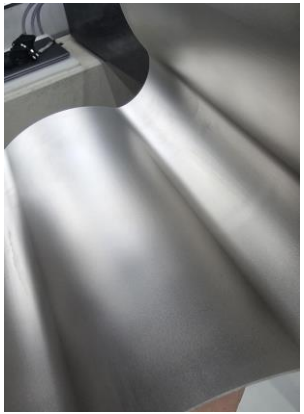


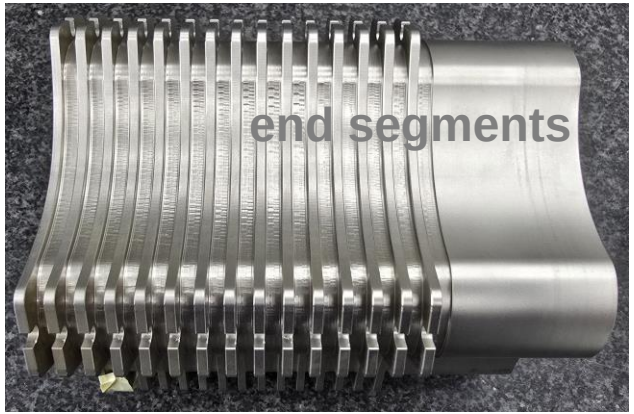
- only one segment design required, center segments identical in design, approx. 400 mm long,
- length of end segments varies to achieve target length PoP chamber (proof-of-principle) to confirm manufacturing process
- series production approval will be granted based on successful implementation of the PoP chamber

Cryogenic UHV system components

Production status SIS100 star-shaped quadrupole chambers



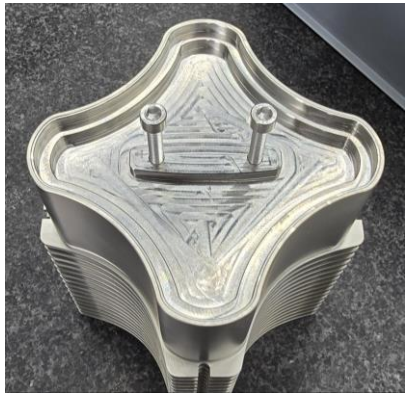


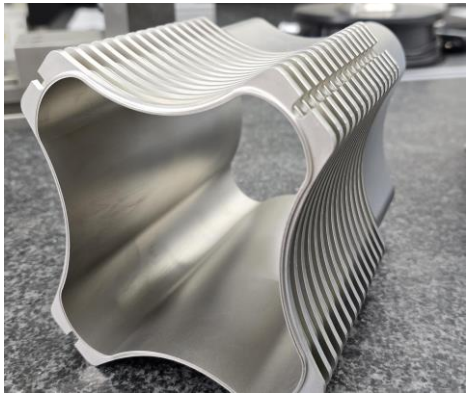


Latest status: **Contract successfully awarded to Research Instruments GmbH in Dec 2024**

- all PoP segments have been manufactured and measured meanwhile
- center element has slightly more crowning in the wall than the end segments
- despite smallest deviations, all segments fit together seamlessly
- cooling tubes fit into the grooves
- preliminary measurements show that all ribs have a flatness with an accuracy of 0.06 mm,
- Edge offset is very small, approximately 50 µm.
- Surface roughness Ra 0,4-1,8
- Brazing the PoP chamber segments (CuAu) this week

research instruments

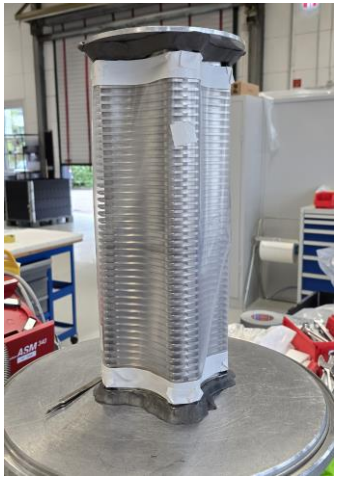


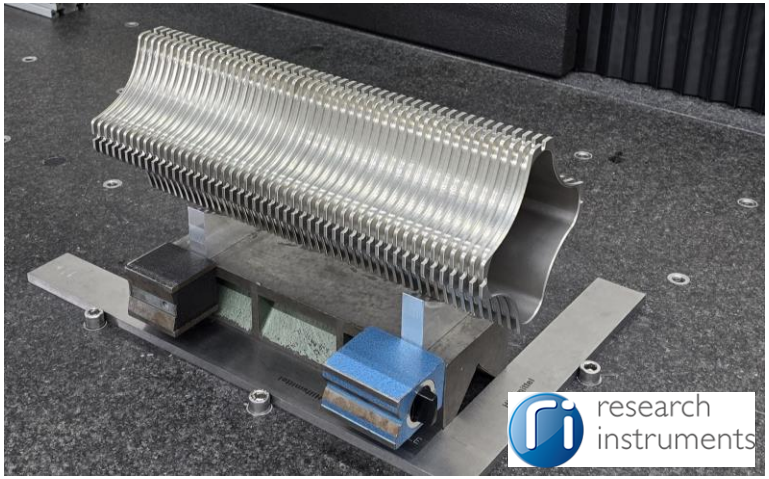


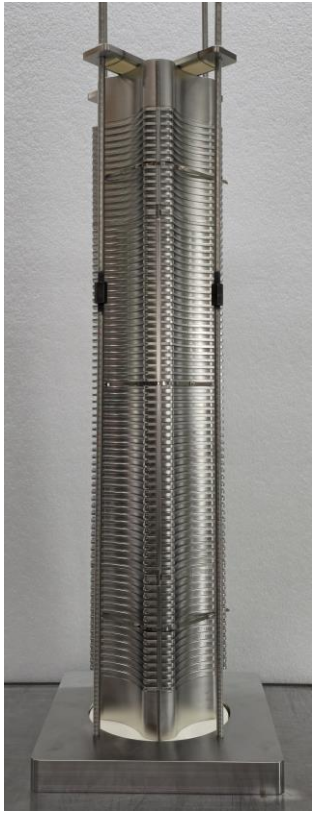
Photos provided by J. Zeutschel (Research Instruments GmbH)

Cryogenic UHV system components

Production status SIS100 star-shaped quadrupole chambers



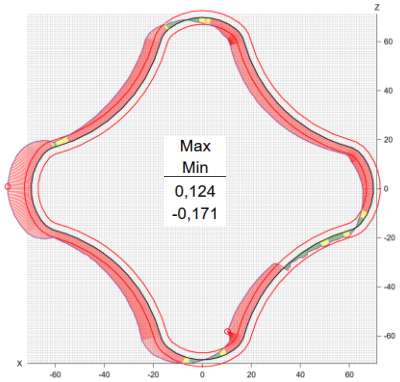


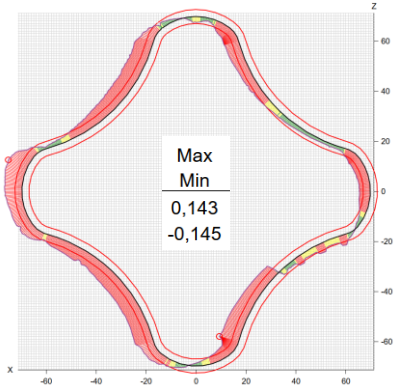


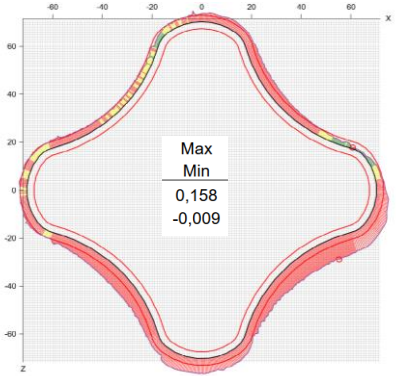
Photos provided by J. Zeutschel (Research Instruments GmbH)

Cryogenic UHV system components

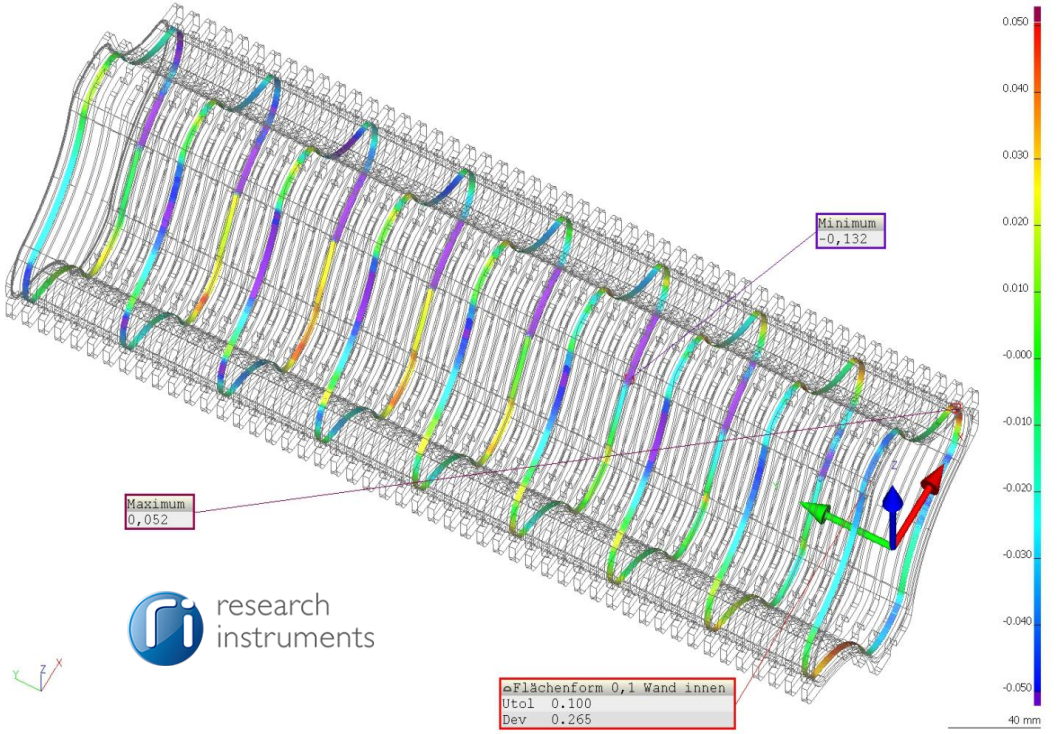
Production status SIS100 star-shaped quadrupole chambers







- **wall thickness varies** along the circumference between **0.37** and **0.62** mm
- affect on the chamber stability?
- affect eddy current distribution

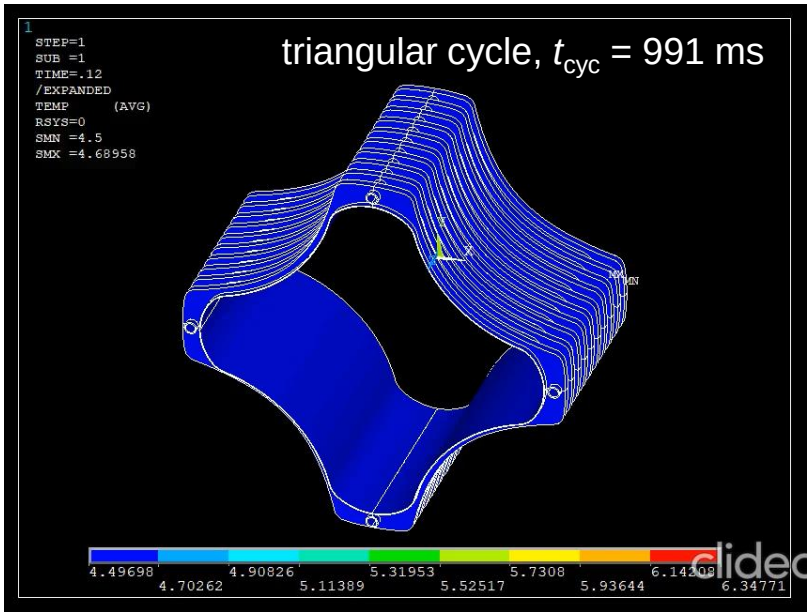


Mechanical scanning results provided by J. Zeutschel (Research Instruments GmbH)

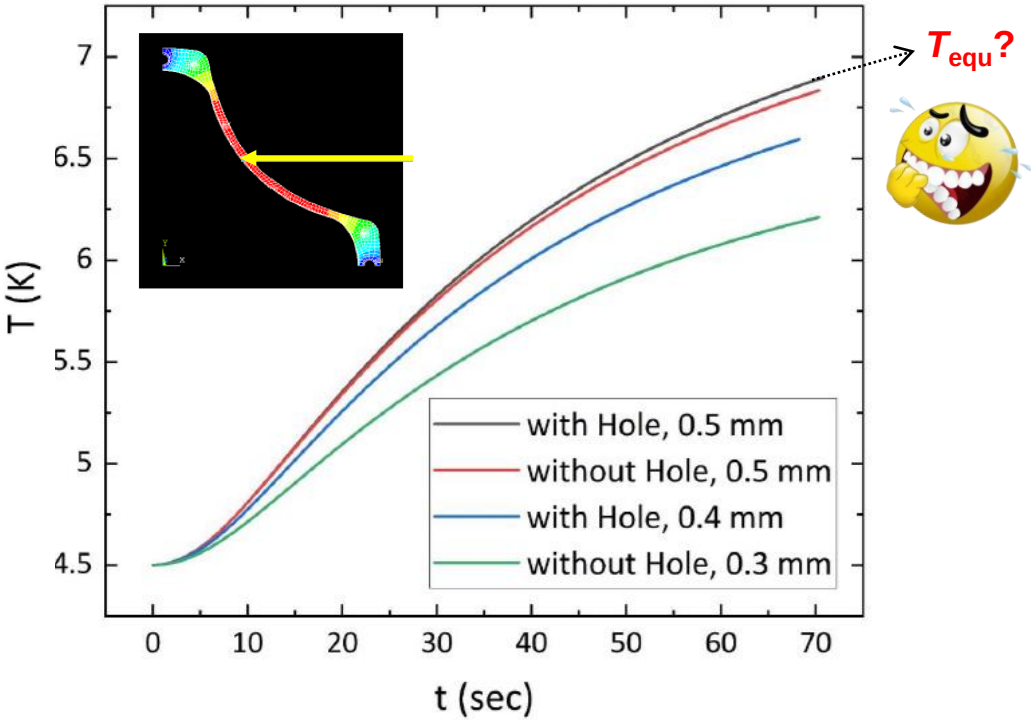
Cryogenic UHV system components

Thermal loads SIS100 star-shaped quadrupole chambers

time dependent temperature distribution profile during magnet ramping



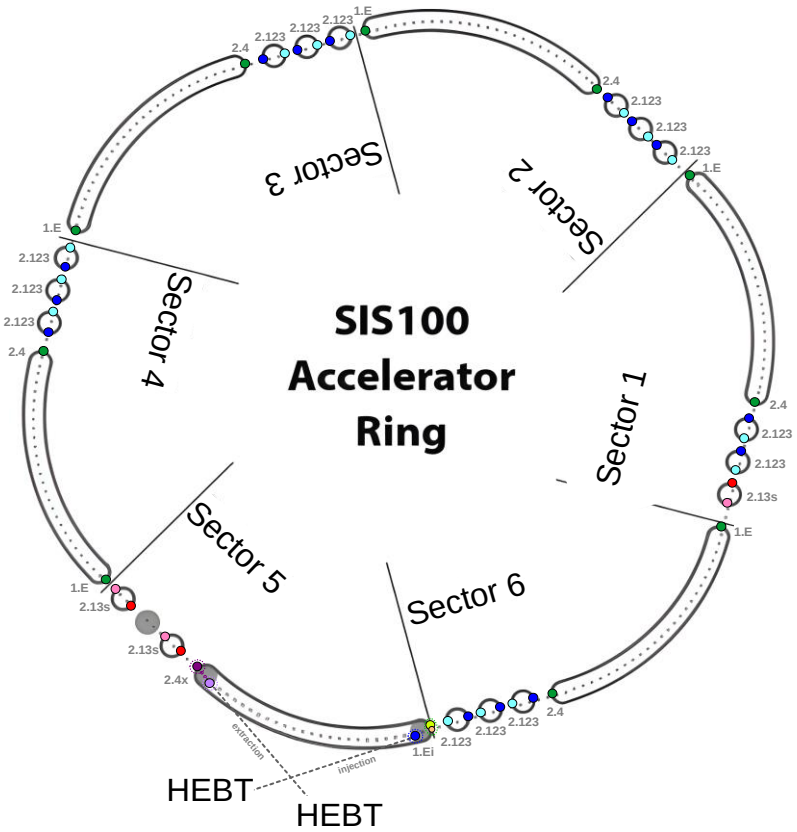
ANSYS simulation by Y. Shim, GSI (2023)



If simulation results are correct, the eddy current-induced "warm-up" of the chambers takes longer than that of the quadrupole chambers with elliptical cross-section, and the ultimate temperatures T_{equ} are also higher.

Cryogenic UHV system components

Beam Vacuum Cold-Warm-Transitions (BVCWT)

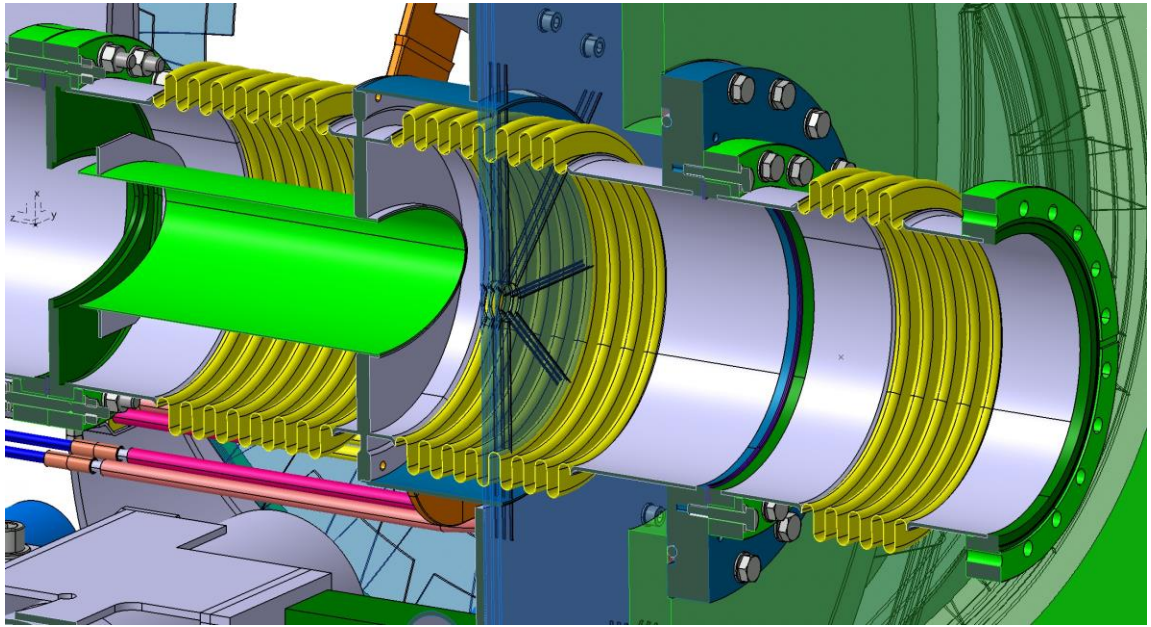


9 different types

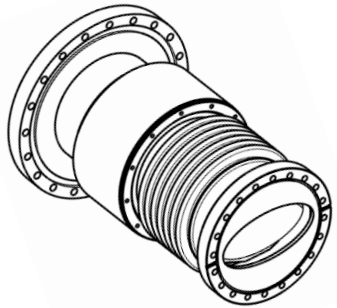
BVCWT Farbcode	Anzahl (im Ring)	DN ... CF	BVCWT type	Installations-position	SAP Nummer	BVCWT Länge	Benötigt wann?		Modell
	10	160	160-573e	**5 x 1.E, 5 x 2.4**	VC-1028210-A-V03	573 mm	Q1/2026	elliptisches Innenrohr	
	1	160	160-471e	**1 x 1.Ei**	VC-1028210-A-000	471 mm	Q1/2026	elliptisches Innenrohr	
	15	160	160-428e	**14 x 2.123** (DS seitig), **1 x 1.Ei** (HEBT seitig)	VC-1014488-A-V02	428 mm	Q4/2026	elliptisches Innenrohr	
	3	160	160-428s	**3 x 2.13s** (DS seitig)	VC-1014488-A-000	428 mm	Q2/2027	sternförmiges Innenrohr	
	14	160	160-463e	**14 x 2.123** (US seitig)	VC-1014488-A-V04	463 mm	Q2/2027	elliptisches Innenrohr	
	3	160	160-463s	**3 x 2.13s** (US seitig)	VC-1014488-A-V03	463 mm	Q2/2027	sternförmiges Innenrohr	
	1	160/100	160-100-Y	**1 x 2.4x**	MG-1013901-A-E01		Q3/2026		
	1	160	160-471e-3.333	**1 x 2.4x** (HEBT seitig)	VC-1028210-A-V02	471 mm	Q3/2026	elliptisches Innenrohr	
	1	100	100-471r-4.22	**1 x 1.Ei** (SIS seitig)	VC-1028191-A-000	471 mm	Q1/2026	rundes Innenrohr	
	Σ 49								

Cryogenic UHV system components

Beam Vacuum Cold-Warm-Transitions (BVCWT)



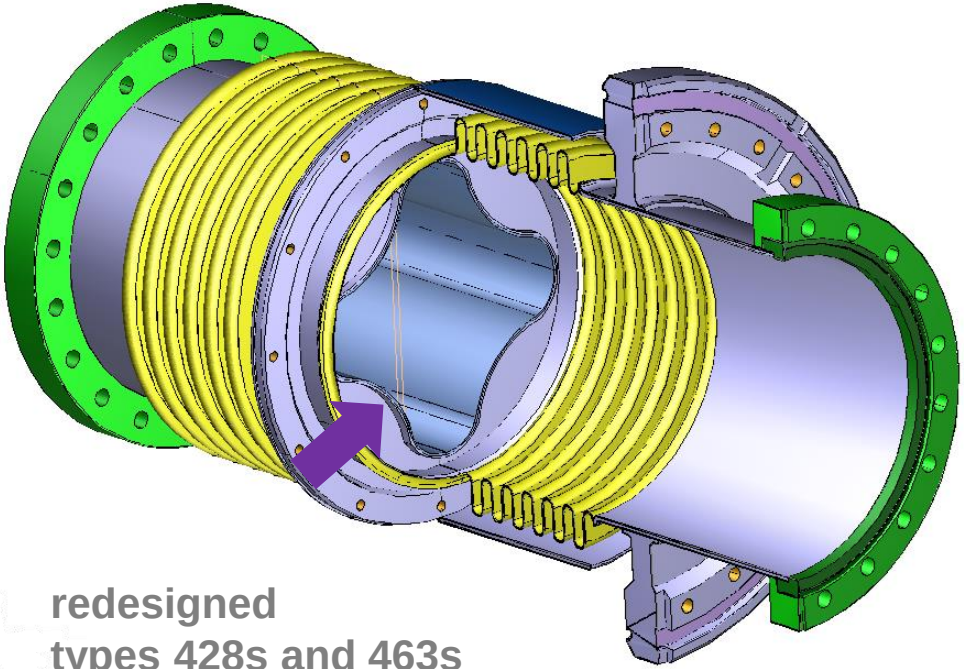
redesigned type 573e



- **type 573e** will be installed into the end caps of 2.4, 2.4x, 1.E and 1.Ei
- Beam line component has been redesigned due to installation concerns
- BVCWT has been splitted into two individual components
  - BVCWT component itself and
  - an additional 3rd bellow separably mountable
  - connecting flange to end cap (blue) is now rotatable, proof of concept must first be checked with a prototyp

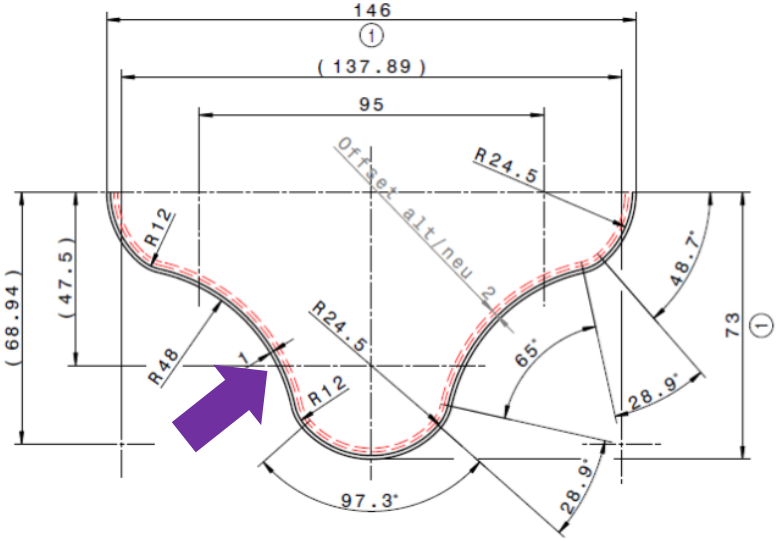
Cryogenic UHV system components

Beam Vacuum Cold-Warm-Transitions (BVCWT)



redesigned
types 428s and 463s

- **types 463s and 428s** will be installed into the end caps of QDM type 2.13s
- BVCWT has been redesigned due to beam-dynamical concerns
- the aperture of the thermal screen has been enlarged
- this could make milling more difficult.



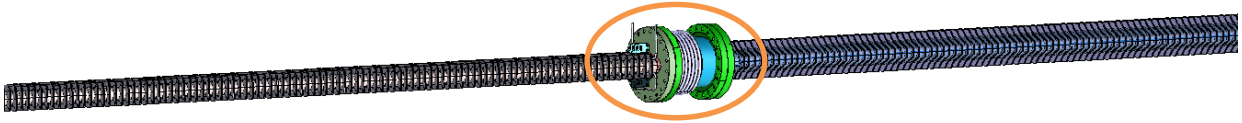
Cryogenic UHV system components

Beam Vacuum Cold-Warm-Transitions (BVCWT)

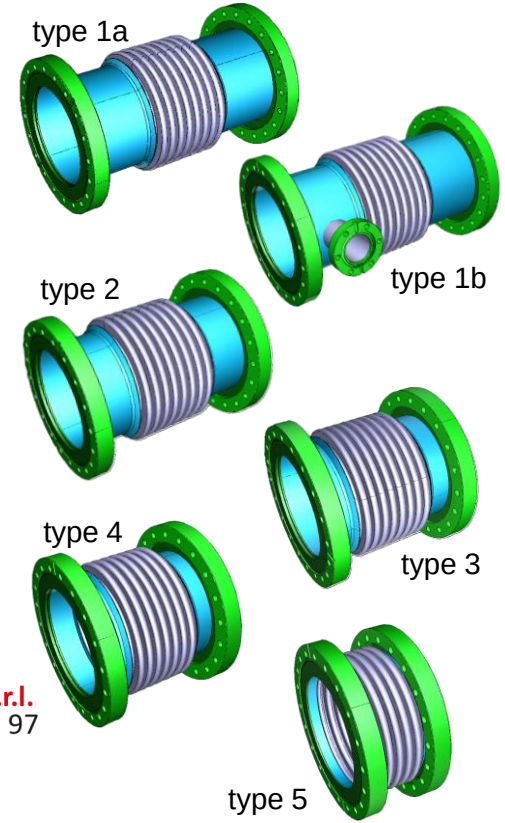
- corrections and changes have significantly delayed the start of procurement (originally planned for March 2025)
- deadlines for supplying BVCWT components to BNET cannot be met
- call for tender of the five most frequently installed BVCWT types must have top priority
  - Beam Vacuum CWT type 160-428s
  - Beam Vacuum CWT type 160-428e
  - Beam Vacuum CWT type 160-463s
  - Beam Vacuum CWT type 160-463e
  - Beam Vacuum CWT type 160-471e 3.333
  - Beam Vacuum CWT type 160-573e
- 3 BVCWT types cannot be procured at this time (not finally designed)

Cryogenic UHV system components

QP–DP, MDP–QP Interconnection bellows



type	Interconnection length (flange-to-flange) [mm]	Designation	Numbers of convolutions	quantity required per sector	quantity required for SIS100
1a	314,8	QP-DP-Interconnection Bellow_160_314.8 (type 1a)	8	6	36
1b	314,8	QP-DP-Interconnection Bellow_160+40_314.8 (type 1b)	8	3	18
2	253,6	QP-DP-Interconnection Bellow_160_253.6 (type 2)	8	7	42
3	190,6	QP-DP-Interconnection Bellow_160_190.6 (type 3)	8	2	12
4	170,8	QP-DP-Interconnection Bellow_160_170.8 (type 4)	7	1	6
5	95,8	QP-DP-Interconnection Bellow_160_95.6 (type 5)	5	1	6
				20	120



Latest status:

- **Contract successfully awarded to SAES Rial Vacuum S.r.l. (Italy) in August 2025**
- Order costs within estimates
- Order is currently running
- Combined CDR+FDR is planned for end of September
- GSI check of submitted technical drawings is pending
- Targeted project end date: **autumn 2026**

SAES Rial Vacuum S.r.l.
Strada Argini Parma, 97
43123 - Parma
www.saesrial.com

Cryogenic UHV system components

Overview of the cryogenic beam line vacuum system

Vacuum chambers	108 DN160CF dipole chambers 12 DN160CF missing dipole chambers 168 DN160CF quadrupole chambers with elliptical cross section 6 DN160CF quadrupole chambers with star-shaped cross section 17 DN160CF cryogenic drift tubes (2.123+2.13s) 12 DN100CF short cryogenic drift tubes (2.4 + 2.4x) 60 DN160CF DP-DP interconnecting bellows 120 DN160CF QP-DP interconnecting cryogenic bellows 60 DN160CF Ion Collimators 83 DN160CF Cryogenic Beam position monitors (BPM) 49 DN160CF Beam Vacuum Cold-Warm-Transitions 47 DN100CF Roughing Cold-Warm Transitions	**742 chamber components**	90% available
Vacuum pumps	85 DN100CF customized cryosorption pumps (CAP) 94 DN100CF NEG+IGP pump combinations incl. controller 47 DN100CF Turbomolecular pumps for roughing 47 DN 25 KF Roughing pumps for roughing	**273 pumps**	100% available
Vacuum diagnostic	77 DN40CF Cryogenic Cold-Cathode Gauges incl. Controller MKS422+937B 47 DN40CF Warm Extractor gauges incl. Controller IE514+Prevac 15 29 DN16CF Warm Pirani gauges incl. Controller 6 DN40CF Warm Residual Gas Aanalyser incl. Controller	**159 gauges**	96% available
Vacuum valves	47 DN100CFall-metal angle valves, pneumatically-actuated 44 DN40CF all-metal venting valves, manually-actuated 94 DN25KF closing valves (not permanent installed)	**185 valves**	50 % available
Burst disks	6 DN40CF burst disk per arc (p_{over} ~ 0.3 bar) 17 DN40CF burst disk per quadrupole module on the straights (p_{over} ~ 0.3 bar)	**23 burst disks**	100% available

Thanks!