ESS SPOKE LINAC (WP4)

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Index

- Work Package description
- Scientific Challenges

Scientific Collaboration

Work Package Description

WP4 Scope of work:

Address the engineering design of the complete spoke cryomodules which will compose the intermediate energy section of the ESS SCLinac.

- Cover the energy range: ~50 MeV to ~200 MeV
- Several possibilities for the Spoke cavity type :
  - Single spoke (SSR)
  - Double spoke (DSR)
  - Triple spoke (TSR)
- One or two families (β)
- About 30 cavities and 10 cryomodules

Work Package Description

WP4 SC SPOKE CAVITY LINAC	
WU4.1	WU4.1.1
Management	Meetings, WP monitoring
	WU4.1.2
	TDR contribution
WU4.2	WU4.2.1
Spoke cavity design	State of art analysis
	WU4.2.2
	EM design
	WU4.2.3
	Mechanical design
	WU4.2.4
	HOM coupler design
WU4.3	WU4.3.1
Cold Tuning System	Specification analysis
	WU4.3.2
	Design
WU4.4	WU4.4.1
Power coupler design	Specification analysis
	WU4.4.2
	Design
WU4.5	WU4.5.1
Cavity cryomodule design	Mechanical and cryogenic design
	WU4.5.2
	Cold box design
	WU4.5.3
	Vacuum system
	WU4.5.4
	Alignment system
	WU4.5.5
	Tooling design
	WU4.5.6
	Cryomodule ICD
WU4.6	WU4.6.1
Superconducting quadrupoles	Magnet design
	WU4.6.2
	Diagnostics integration design
	WU4.6.3
	Cryomodule design
WU4.7	WU4.7.1
Prototyping and testing	Cavity fabrication procedure validation
	WU4.7.2
	Cavity preparation procedure validation
	WU4.7.3
	Cavities vertical cryostat test
	WU4.7.4
	Power coupler test bench
	WU4.7.5
	Power Coupler fabrication procedure validation
	WU4.7.6
	Power Coupler preparation procedure validation
	WU4.7.7
	Power Coupler measurements and tests (low power)

Work Package Description

Early Prototypes (to -> to + 24 months)

- 2 spoke cavities - tested in vertical cryostat
- 2 power couplers - RF characterized

Late Prototypes (to + 48 months)

- A complete spoke cryomodule constructed, assembled and tested with at least the nominal RF power on at least one cavity at a time

Required Ressources (TDR phase, 2 years):

A total of 184 men.months

515 k€ for prototypes, consumables, and travel

Scientific Challenges

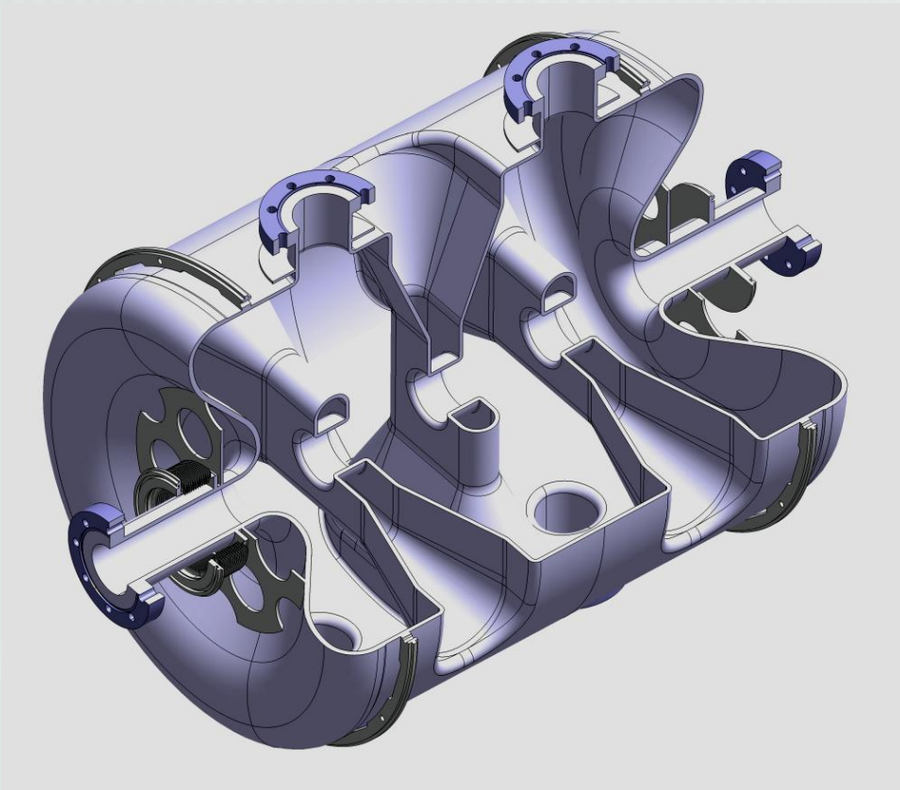
About 15 spoke resonators (SSR, DSR, TSR) have been constructed and tested worldwide.

Lab	Type	Frequency [MHz]	Optimal beta	E_{accMAX} [MV/m]	V_{MAX} [MV]	E_{pk}/E_{acc}	B_{pk}/E_{acc} [mT/MV/m]
IPN Orsay	Single	352	0.20	4.8	0.8	6.7	14.5
	Single	352	0.36	8.1	2.5	4.7	12.8
ANL	Single	855	0.28	4.4	0.3	5.5	12.7
	Single	345	0.29	8.7	2.2	4.6	12.1
	Single	345	0.40	7.0	2.4	6.3	16.7
	Double	345	0.40	8.6	4.5	4.7	9.2
	Triple	345	0.50	7.6	6.6	3.7	11.5
	Triple	345	0.62	7.9	8.7	3.9	12.0
FZ-Juelich	Triple	760	0.20	8.6	1.4	5.1	13.3
LANL	Single	350	0.21	7.5	1.3	5.1	13.3
	Single	350	0.21	7.2	1.3	5.0	10.1
Fermilab	Single	325	0.21	12.0	2.4	3.6	5.8
	Single	325	0.21	16.7	3.4	3.6	5.8

Scientific Challenges

- Most of the spoke cavity tests were performed in vertical cryostat. Only a few were done in an accelerator-like configuration.
- Tests with beam have never been performed !

BUT expected (and partially experimentally proven) performances are worth it !



Scientific Challenges

Spoke cavities have all advantages of SC structures

AND

- Potential for very high accelerating gradients
- They are compact and naturally stiff, making them less sensitive to static or dynamic vibration
- Multi-gap capability
- High cell to cell coupling => no need for field flatness
- Less sensitive to HOM or trapped modes
- No dipole steering effect
- Wide β range

Scientific Challenges

Challenges:

- High gradients (ex: 8 MV/m for a TSR)
- High peak power couplers (~ 400 kW nominal)
- Pulsed operation -> microphonics
- Series production of spoke cavities (real 3D geometry and performance reproducibility)
- Open questions :
  - HOM
  - Operation T° (2K or 4K)
  - Cryomodule type (segmented vs not segmented)
  - …

Potential Scientific Collaboration

CNRS/IN2P3/IPN Orsay (France): cavities, couplers, tuners, cryomodule, test facility

ESS BILBAO/TEKNIKER (Spain): cavities, tuners, engineering design (mechanical, RF)

CI (UK): cavity preparation, HOM studies

INFN (Italy): RF and cryo experts

ARGONE (USA) : Spoke cavity

JLAB (USA)

DARMSTADT (Germany)

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Thank you for your attention