

2026 Development of a runaway electron monitor

Task-specification: SA-EN.FE.14-T004



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Task overview

- **Progress** on the following activities planned **for 2026 according to task specifications and KOM:**
 - i. Definition of physical interfaces in the torus hall and the diagnostic room
 - ii. Finalization of the assembly of BF3 and NE213 front-end electronics and tests
 - iii. Update of detector performance analysis
 - iv. Evaluation of the static ferromagnetic forces acting on NE213 detector
- **Resources: 1PM**



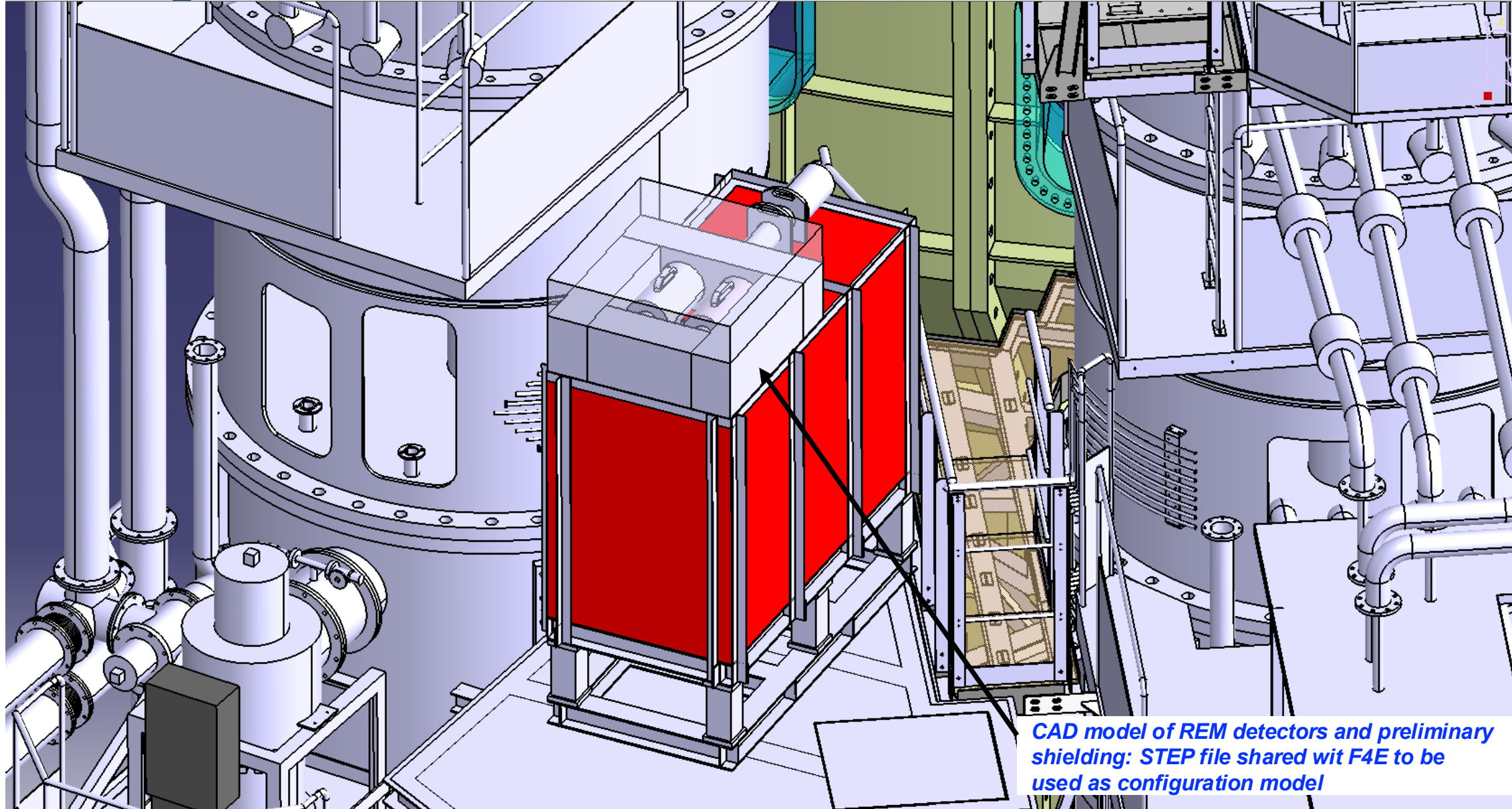
Definition of physical interfaces in the torus hall and the diagnostic room

Interfaces with Torus hall → detector positioning and shielding

- New diagnostic location agreed with QST → P12 on top of NES/GRS collimator
- A **preliminary design of an additional shielding for** BF_3 defined to extend the REM operating range up to 10^{17} n/s → **200 mm thick structure** made of **10% borated polyethylene** (same as NES/GRS collimator)
- The **shielding structure fits on top of NES/GRS collimators** and **weights ~ 400 kg** → total weight including detectors ~ 450 kg
- **Detectors and shielding fixation system to be designed** → Procedure agreed with F4E/QST:
 - REM Design Team will design the fixation system and provide models to F4E
 - F4E will perform the mechanical calculations with an integrated model including the collimator
 - Results of F4E calculations will be used by REM Design Team to finalise the design



Definition of physical interfaces in the torus hall and the diagnostic room

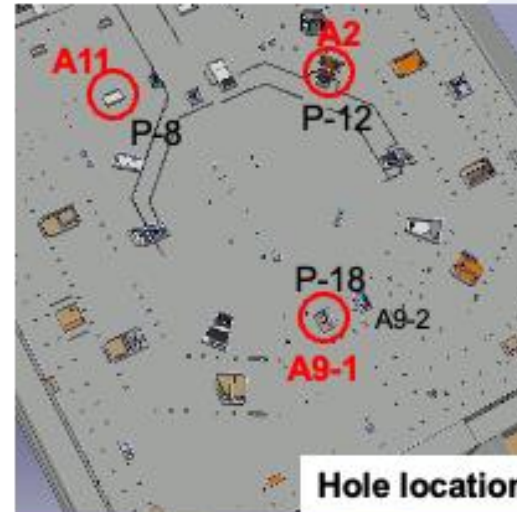
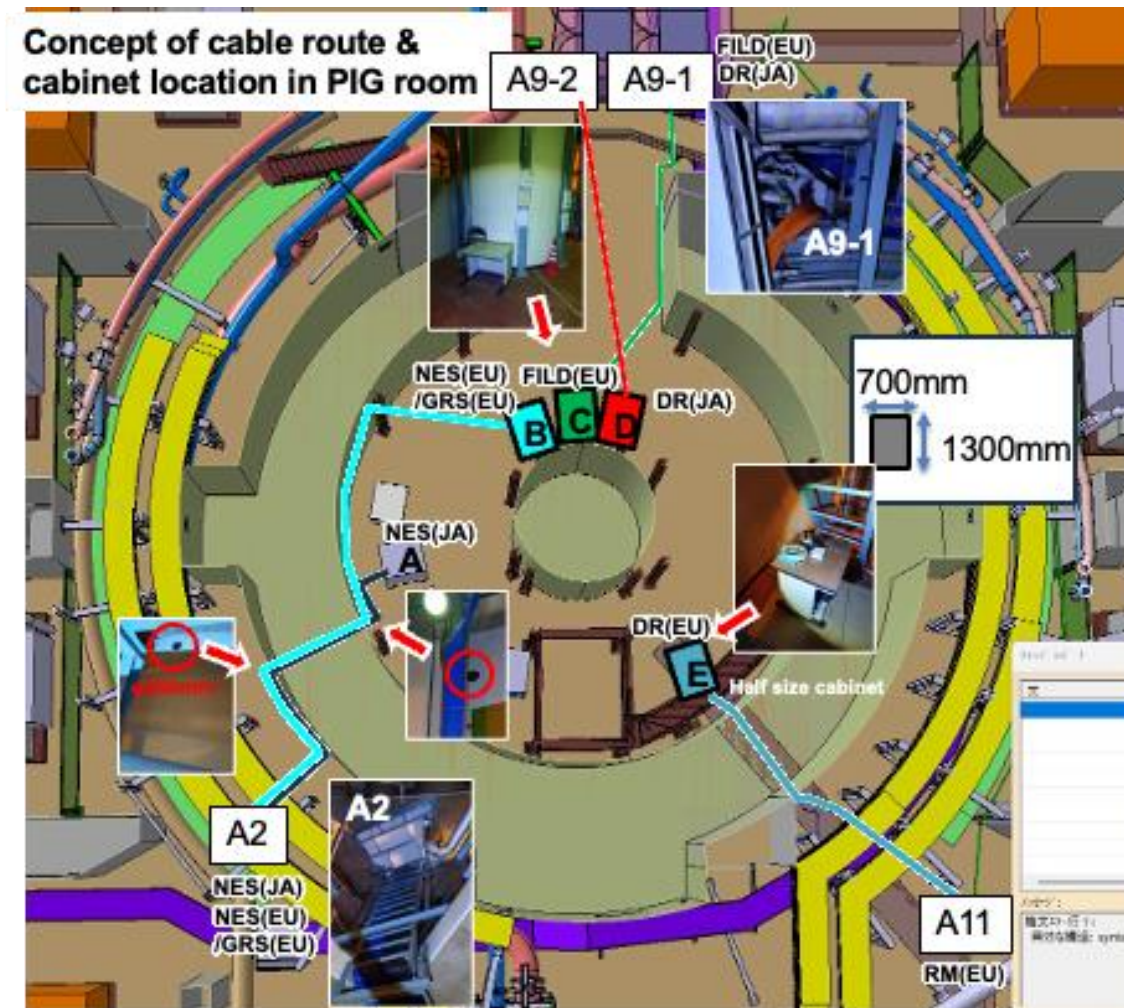


CAD model of REM detectors and preliminary shielding: STEP file shared with F4E to be used as configuration model



Definition of physical interfaces in the torus hall and the diagnostic room

Interface in the torus hall → Cable routing



	Port	Hole	Cabinet
Neutron emission spectrometer: NES(JA)	P-12H	A2	A(existing, shared with other diag.)
Neutron/Gamma-ray spectrometer: NES/GRS(EU)	P-12H	A2	B
Fast ion loss detector: FILD(EU)	P-18H	A9-1	C
Doppler reflectometer: DR(JA)	P-18H	A9-1	D
Doppler reflectometer: DR(EU)	P-9H	A11	E

- Cable details including external diameters provided to QST (Cables_connectors_RE_JT60SA_rev1_final.xlsx file attached to 2025 report)
- Agreement with QST: **same routing of EU NES/GRS** can be used for REM provided that all cables fit into 20 cm $\varnothing$ aperture in torus hall (**A2**)
- Identified need for **additional metallic conduit** to enclose and insulate cables
- **Action needed to close interface:** evaluation of total area of cables passing through A2 including insulating conduit



Definition of physical interfaces in the torus hall and the diagnostic room

- Information shared by Sumida-san on flexible metal conduit adopted for:
 - Neutron flux monitors
 - P-10 horizontal neutron profile monitor

A flexible metal conduit for cable protection by SANKEI MANUFACTURING CO.LTD

Stainless steel flexible metal conduit

ステンレス製ブリカチューブ

Type PSC (ビニル被覆ステンレスブリカ)



- ビニル被覆ステンレスブリカは、構造が JIS C 8309 に規定するステンレス (SUS304) 製のビニル被覆金属製可とう電線管です。
- チューブの切断は、ブリカナイフ (品番 PFTL201) をご使用下さい。
- 電線は、ケーブル/ビニルコードをご使用下さい。
- 付属品は、ステンレス製のビニル被覆ステンレスブリカ用の耐腐品をご使用下さい。
- ビニル被覆ステンレスブリカの端のバリで手等を損傷する場合があります。取扱いに十分ご注意ください。
- チューブ表面に切断目安マークー◆ーを印字しています。1m ごと (公差 ±5%) に印字していますので切断長さの目安としてご使用下さい。



Internal Diameter (mm) External Diameter (mm)



納期区分		品番		内径	外径	PVC被覆の厚さ	固定最小内側曲げ半径	該当する電線管 サンバイブ/厚鋼/塩ビ管	重量 (kg)			1巻の長さ (m)	
									1m当り	1巻当り			
定尺品	10M巻	定尺品	10M巻品							定尺品	10M巻品	定尺品	10M巻品
○	○	PSC 17	PSC 17 10	16.6	23.1	0.8	50	LT(LE)20/C19/G16/VE16	0.47	14.1	4.7	30	10
○	○	PSC 24	PSC 24 10	23.8	30.4	0.8	70	LT(LE)25/C25/G22/VE22	0.70	21.0	7.0	30	10
○	○	PSC 30	PSC 30 10	29.3	36.5	0.8	90	LT(LE)32/C31/G28/VE28	0.86	25.8	8.6	30	10
○	○	PSC 38	PSC 38 10	37.1	44.9	0.8	150	LT(LE)40/C39/G36/VE36	1.23	24.6	12.3	20	10
○	○	PSC 50	PSC 50 10	49.1	56.9	1.0	200	LT(LE)50/C51/G42/VE42	1.58	31.5	15.8	20	10
○	—	PSC 63	—	62.6	71.5	1.2	310	LT(LE)63/C63/G54/VE54	2.07	20.7	—	10	—
○	—	PSC 76	—	76.0	85.3	1.2	380	LT(LE)70/C75/G70/VE70	2.40	24.0	—	10	—

Adopted for neutron flux monitor and neutron profile monitor

<https://www.sankei-ss.co.jp/pdf/SANPIPE/33.P315-316.pdf>



Definition of physical interfaces in the torus hall and the diagnostic room

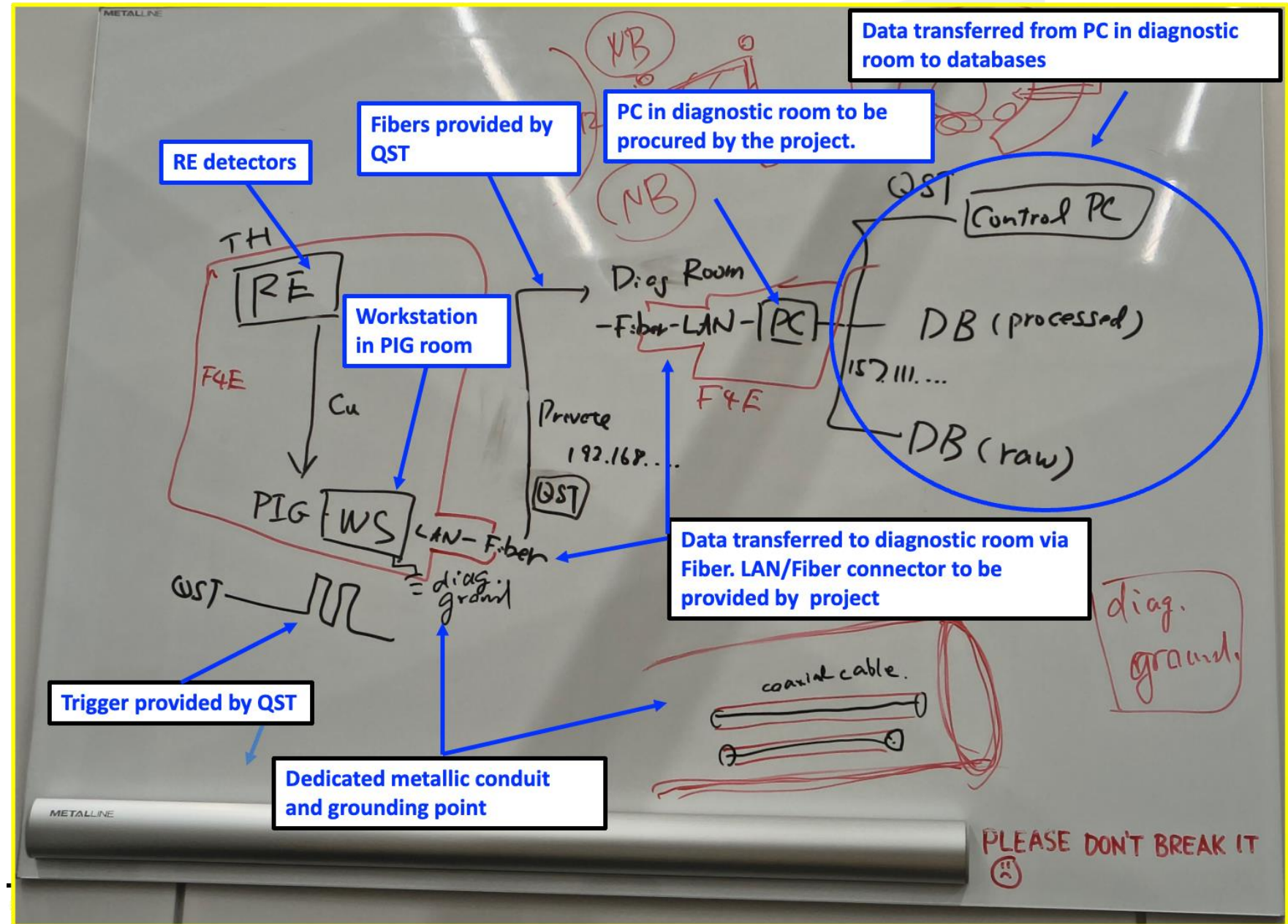
Interfaces with PIG/diagnostic room

- **Info on space needs** for components in PIG room shared with QST/F4E:
 - **Workstation** with PCIe acquisition board for NE213/BF3, including rack-mount kit and KVM (keyboard, video and mouse) switch: **8 U (rack units)**
 - **NIM modules** for HV and LV power supplies: **4 Single-width NIM module (It is assumed that QST will provide the NIM rack)**
- **New components/interfaces** identified with QST:
 - Dedicated grounding point at the level of PIG cubicle connected to the insulating metallic conduit
 - Additional PC in diagnostic room
 - LAN/Fiber - Fiber/LAN connectors for the connection between workstation and diagnostic room PC



Definition of physical interfaces in the torus hall and the diagnostic room

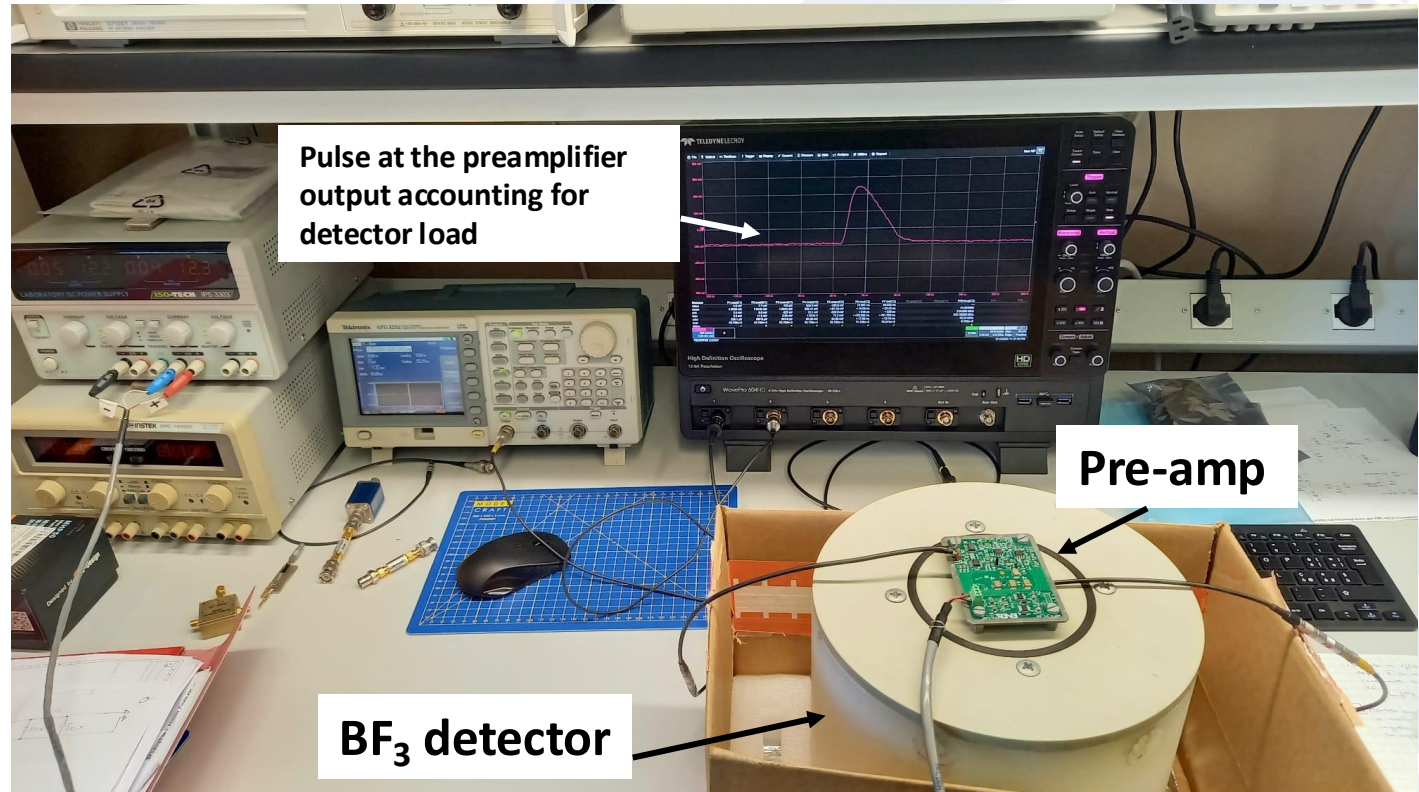
Summary of PIG/diagnostic room interfaces (from meeting with QST)





Finalization of the assembly of BF3 and NE213 front-end electronics and tests

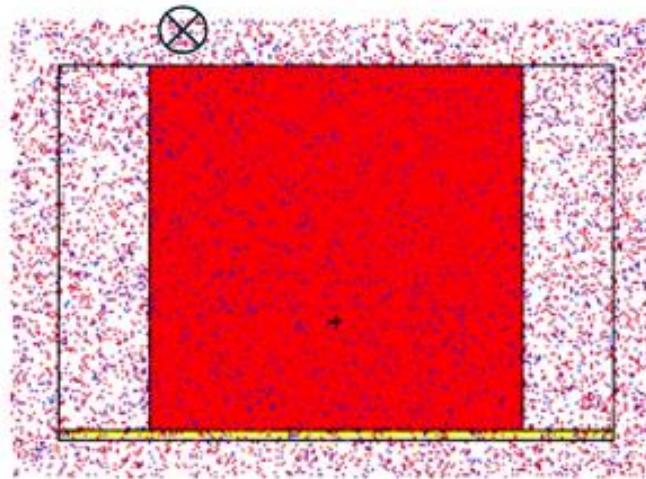
- **Prototypes of NE213 and BF3 front-end electronics developed, laboratory tests on-going**
- BF3 first round of Laboratory tests for BF3 completed
→ Preamplifier mounted on detector and supplied with external test pulses.
- Assembly to be finalized (HV insulating resin)
- Tests with neutrons (passive source/FNG) foreseen before the end of the year
- Design update and assembly of final items after tests with neutrons



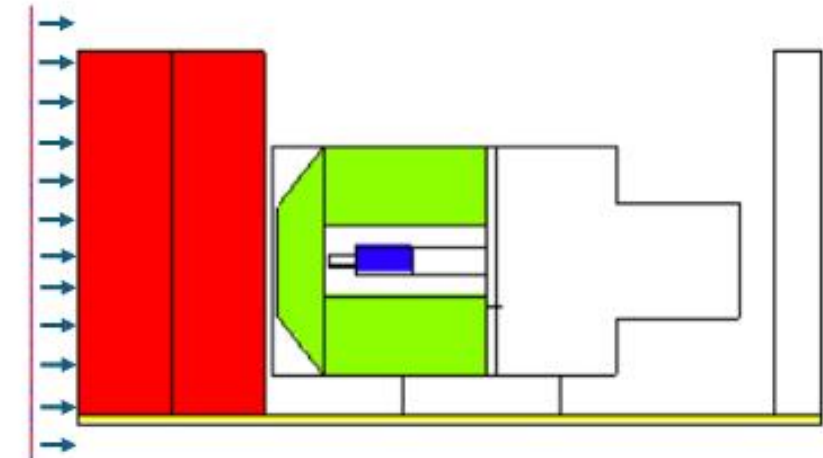


Update of detector performance analysis

- **No performance issues expected for NE213** (current mode): the NE213 output can be modified to match the the ADC input range by acting on:
 - PMT HV
 - Integrating circuit: selectable offset and gain
- 2025 BF_3 performance analysis performed using F4E-provided flux/spectra at BF_3 position + BF_3 flux efficiency estimates
- **2026 update → MCNP models of BF_3 detectors developed and new calculations performed:**
 - Using planar secondary source derived from F4E simulations
 - Including additional shielding



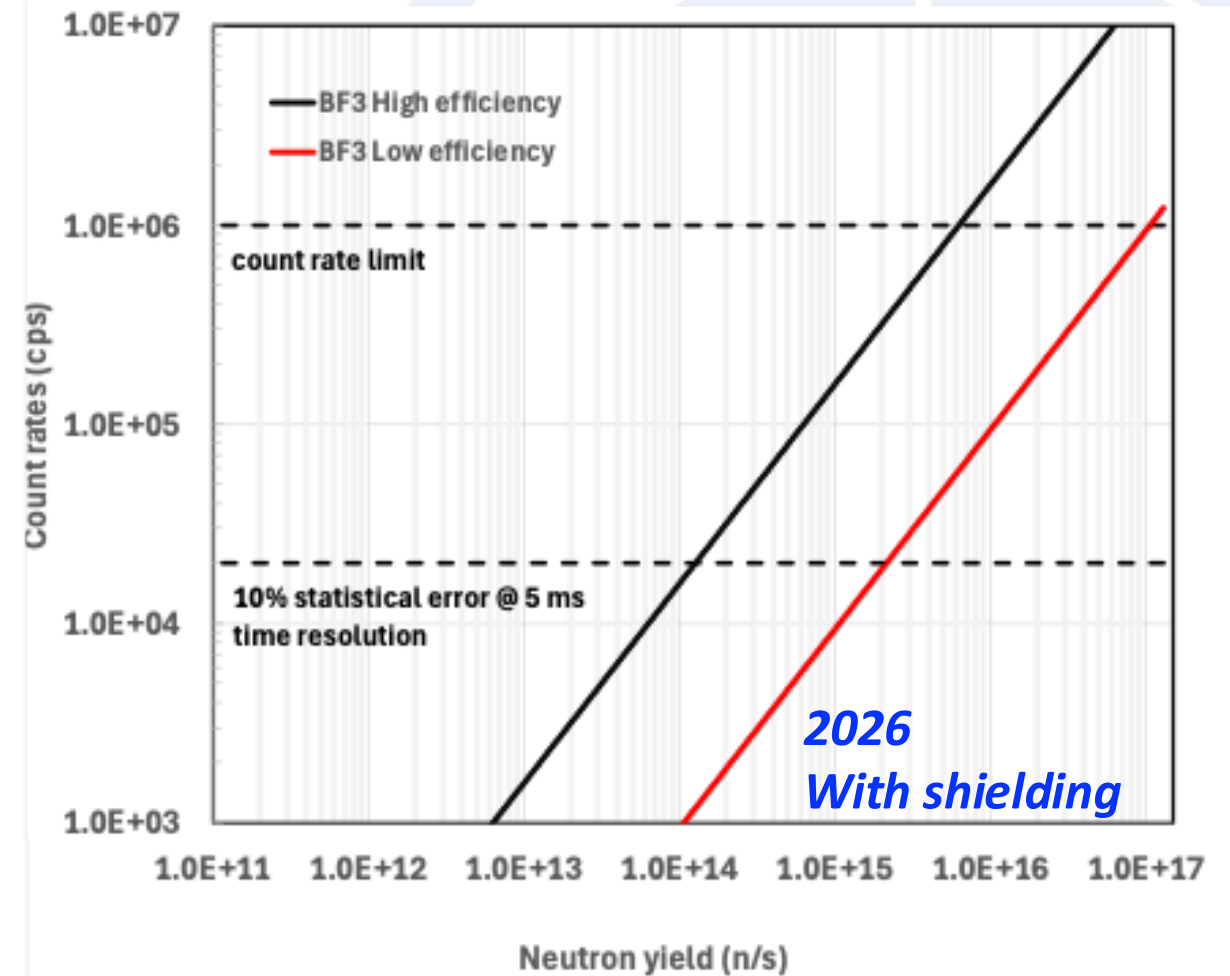
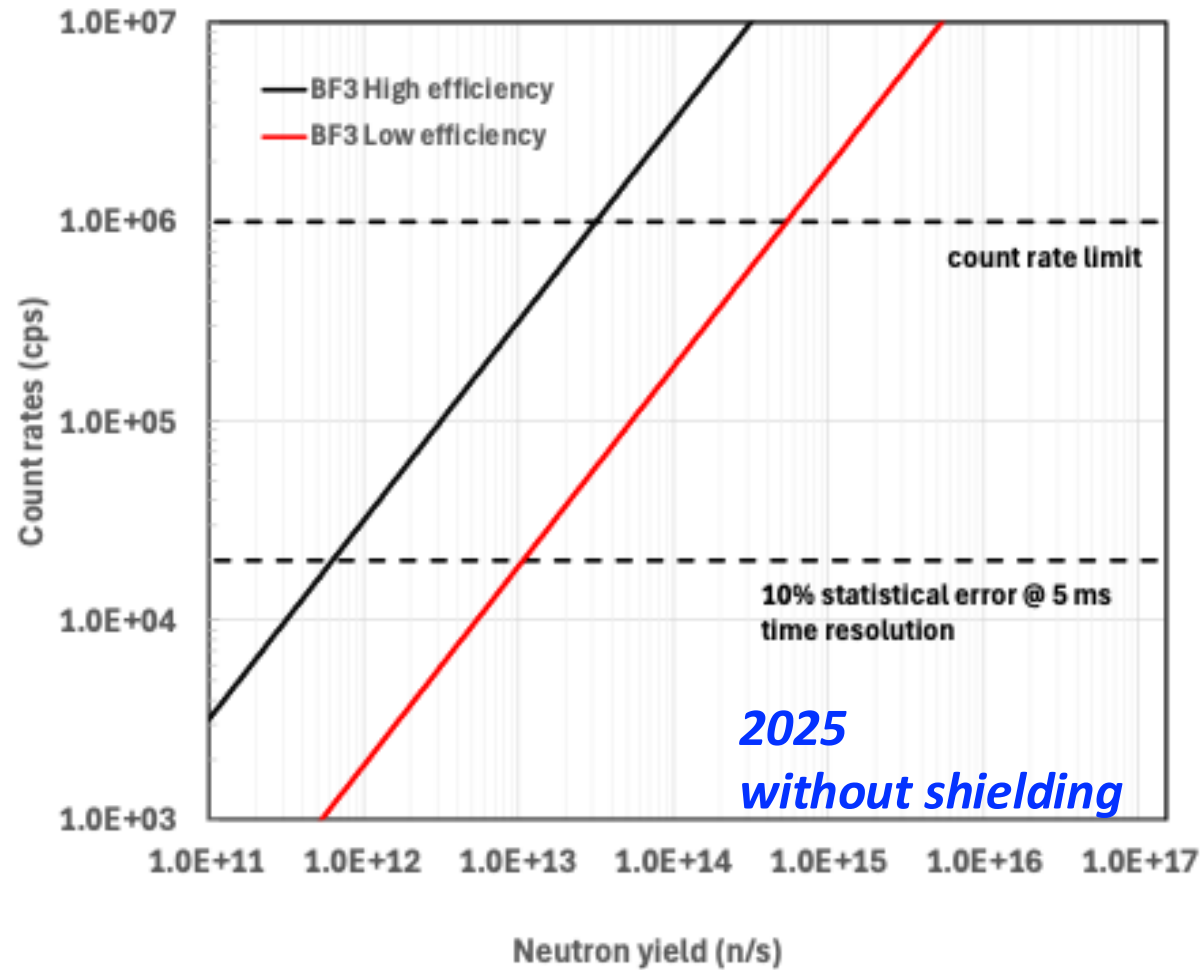
XY plane



ZY plane



Update of detector performance analysis





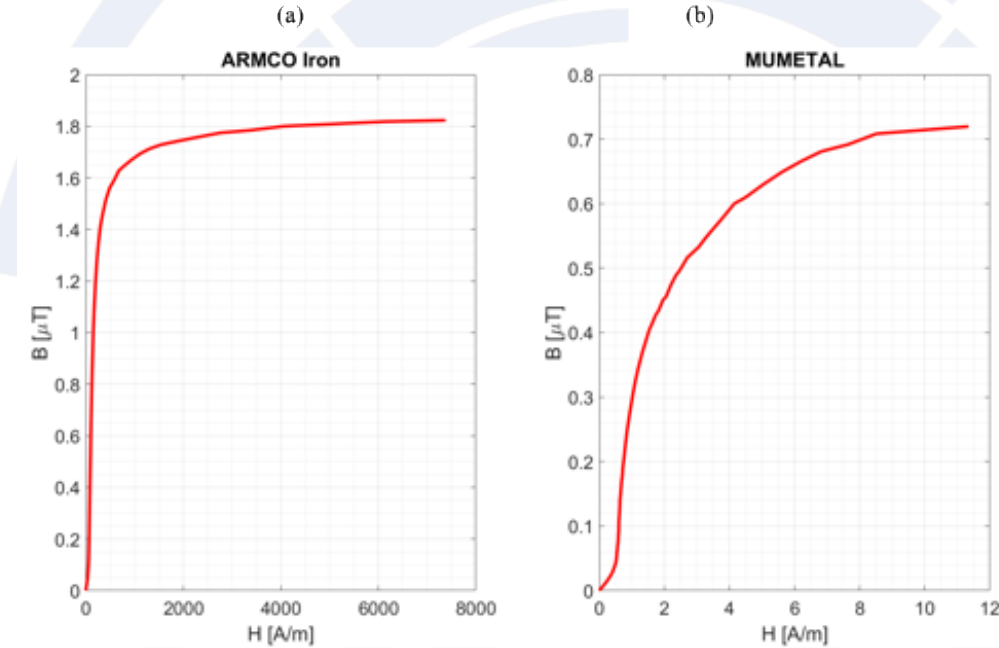
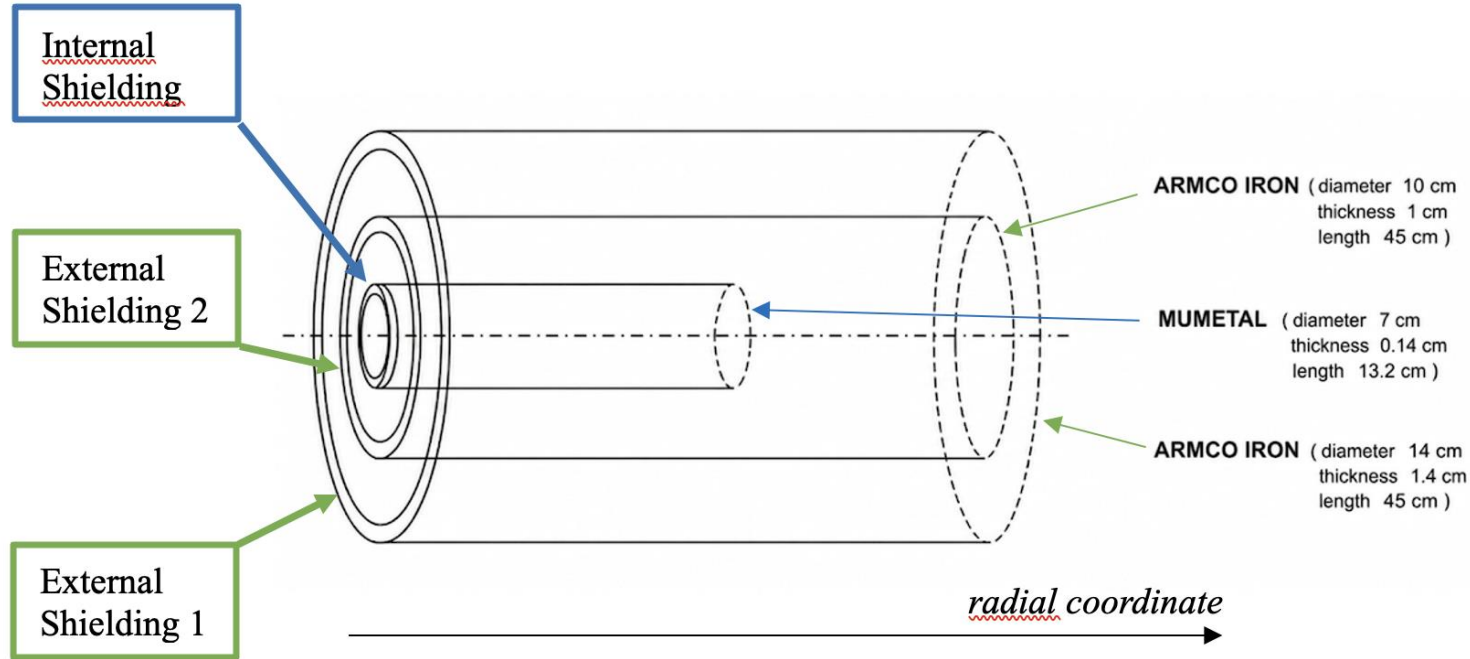
Update of detector performance analysis

- **Further calculations on-going in collaboration with F4E** using 360° JT-60SA model to:
 - Optimize shielding weight/size
 - Introduce modularity to maximize coverage of the JT-60SA neutron yield range
- **MCNP detector and shielding models + tallies shared** with F4E neutronics team
- Agreed **simulation plan**:
 - Simulation with **NES collimator only**
 - Simulation with **NES collimator + REM detectors**
 - **F4E provision of secondary sources from 360° model calculations** for simplified simulations with different shielding configurations



Evaluation of the static ferromagnetic forces acting on NE213 detector

- NE213 liquid scintillator equipped with magnetic shielding for the photomultiplier tube (PMT)



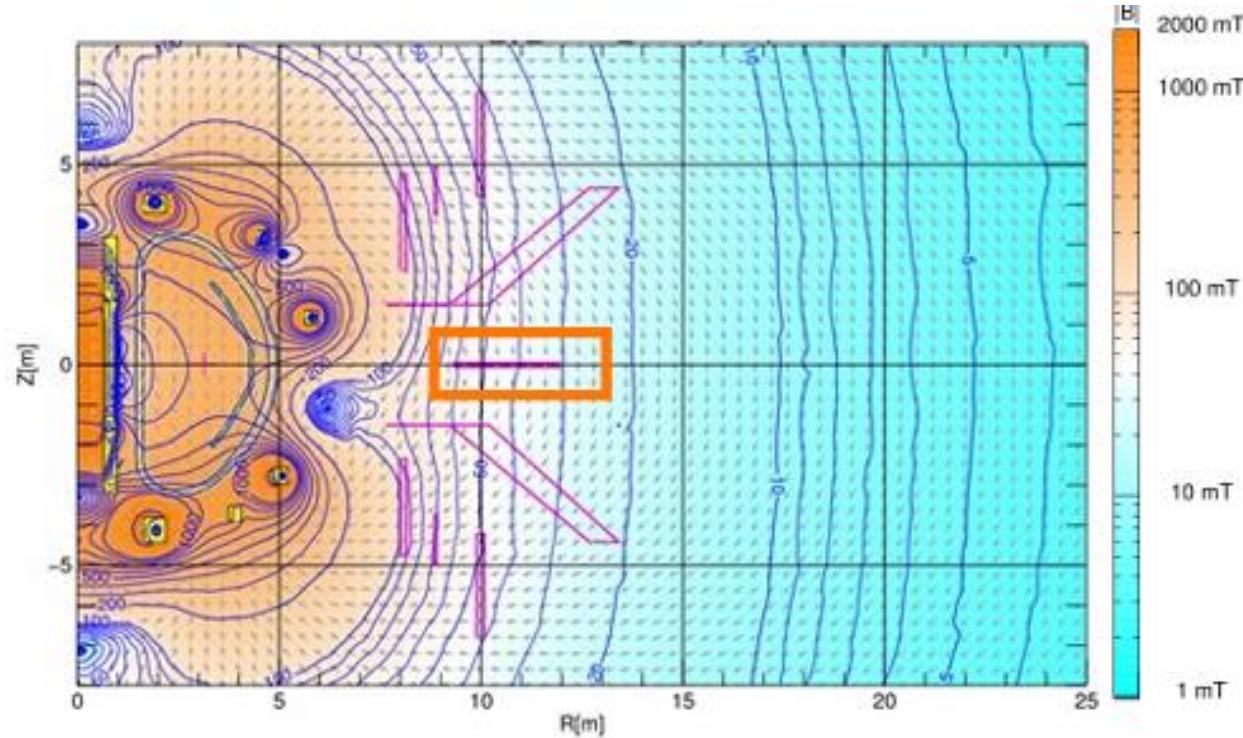
B-H magnetization curves for ARMCO iron and Mumetal

- Suitability of shielding addressed in 2025
- 2026 → evaluation of ferromagnetic forces acting on shielding during plasma discharges

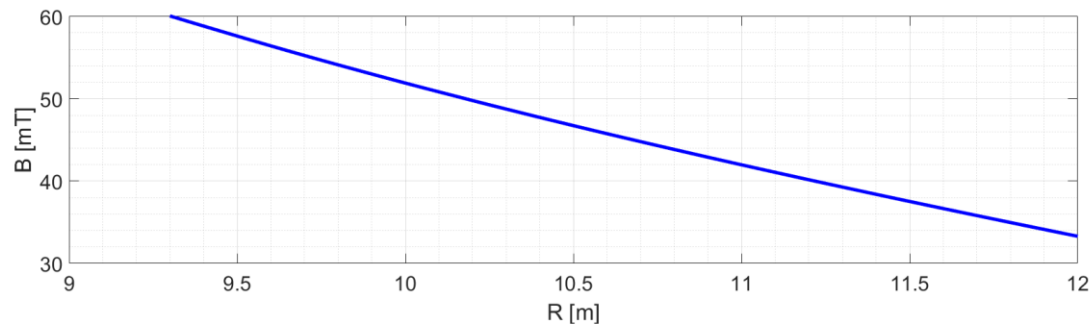


Evaluation of the static ferromagnetic forces acting on NE213 detector

- Magnetic field data from maps in JT-60SA PID (Input shared by EUROfusion)



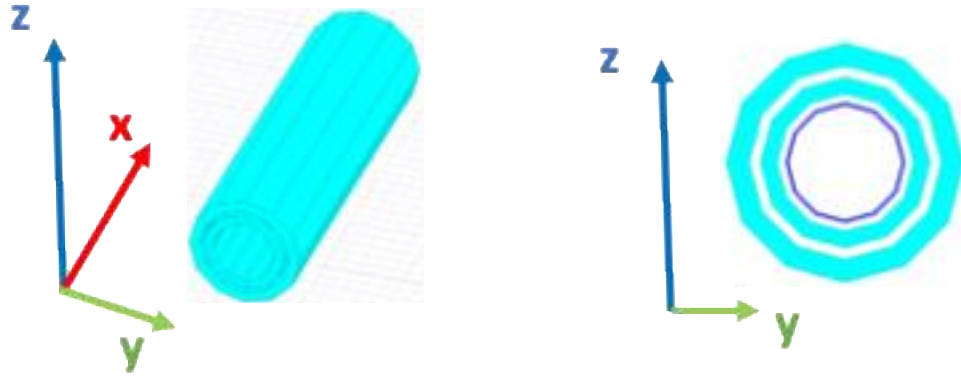
- Poloidal component of the JT60SA static magnetic field
- Orange box highlights the region of interest for REM installation.
- Toroidal component neglected due to small gradient



Poloidal component of B field vs radial coordinate in the region of interest (used for the analysis)



Evaluation of the static ferromagnetic forces acting on NE213 detector



- **Numerical model** implemented in **Ansys Maxwell** (2024R1)
- X=radial, Y=poloidal, Z=vertical
- **Shielding axis aligned to radial coordinate** (worst case in terms of the resulting force)

Component	POSA		
	Fx [N]	Fy [N]	Fz [N]
External shielding 1 (ARMCO Iron)	-7.78	-0.02	0.03
External shielding 2 (ARMCO Iron)	-0.71	--	-0.01
Internal shielding (MUMETAL)	--	--	--
Whole Object	-8.49	-0.02	0.02

- Force oriented along x axis (magnetic field gradient direction)
- Outermost layer absorbs most of the magnetic field and is subjected to highest force
- **Overall force on shielding < 8.5 N → negligible**



LAST SLIDE

