Gamma Ray Spectroscopy for JT-60SA
Current status

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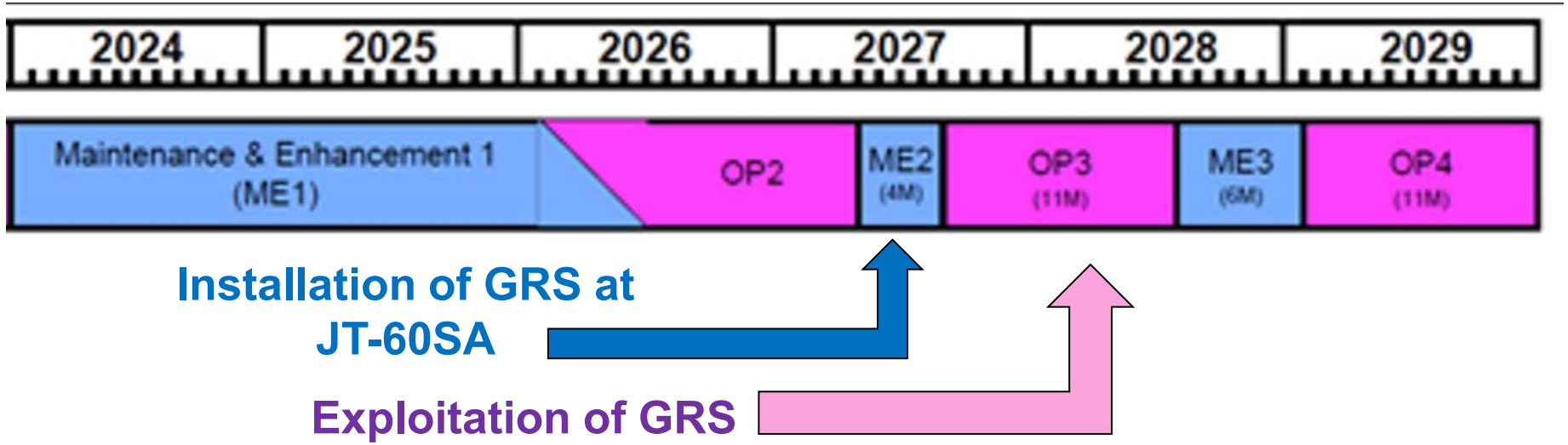
Outline

- Scientific motivation and timeline
- Information on installation location available from QST
- Status of detector design so far and input required to make progress
- Status of signal simulations so far

Scientific motivation

- **Runaway electron energies** can be measured by detecting their bremsstrahlung emission in the MeV range
- JT-60SA can reach **novel regimes of relevance for EP studies**, predominantly relying on the 500 keV NBI
- Scenarios for the **generation of alpha particles** can be obtained in mixed D-^{3}He plasmas (see later)
- **Fast proton** confinement can be studied by gamma-ray spectroscopy (p(d,γ)^{3}He reaction)
- **Alpha particle** generation and confinement can be studied using **gamma-ray measurements**
- **Fast deuteron confinement** can be studied using **neutron spectroscopy** (perhaps also with GRS, tbd)

Timeline as of today



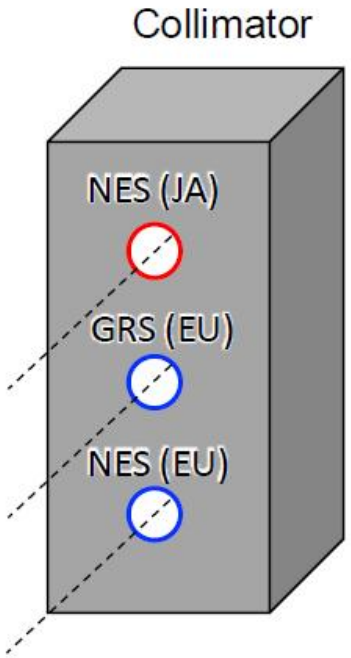
Physics program need: fast particle experiments (protons and alphas) using 500 keV NBI planned in OP3

Tentative project timeline as of today

2025-2026: full development
2027: delivery to JT-60SA and installation in ME2
2027-2028: Measurements in OP3

Information on installation location from QST

P-12 NES/GRS collimator & detector



Diagnostics	Neutron energy spectrometer (NES)	Gamma-ray spectrometer (GRS)	Neutron energy spectrometer (NES)
Target	N-NBI fast D ion	D-^{3}He fusion α particle	N-NBI fast D ion
JA or EU	JA	EU	EU
Detector	CLYC-7 One option : use LHD's one	$LaBr_3(Ce)$	$LaCl_3(Ce)$
Characteristics	• Well established • Long time resolution of ~1 s		• First try (AUG) in 2025- • Short time resolution of < 1 ms
Desirable installation timing	M/E2	M/E2	≧M/E3

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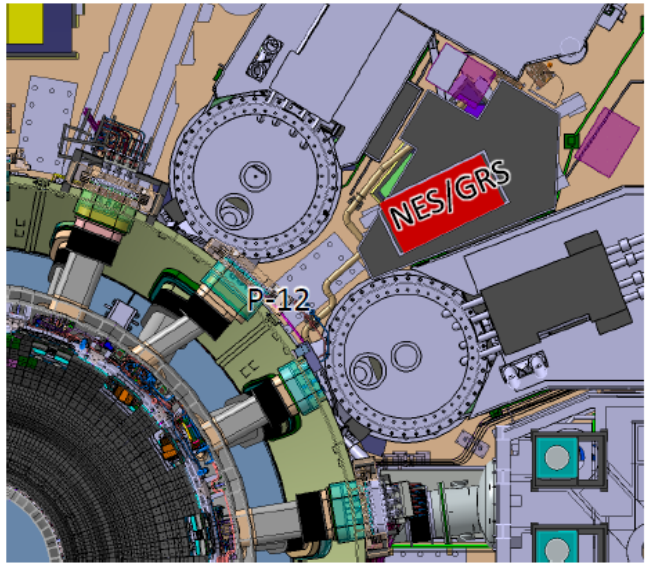
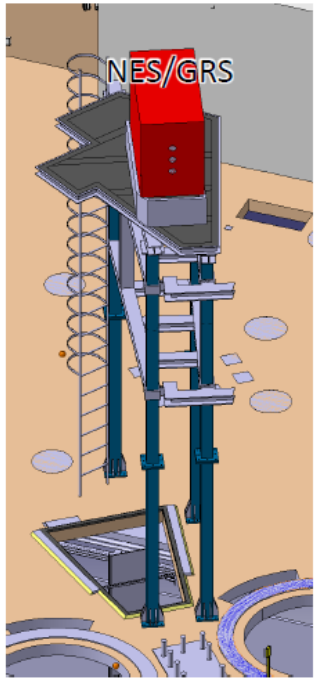
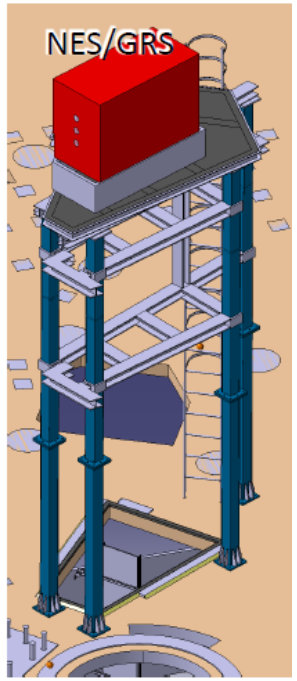
NES/GRS collimator being developed by QST

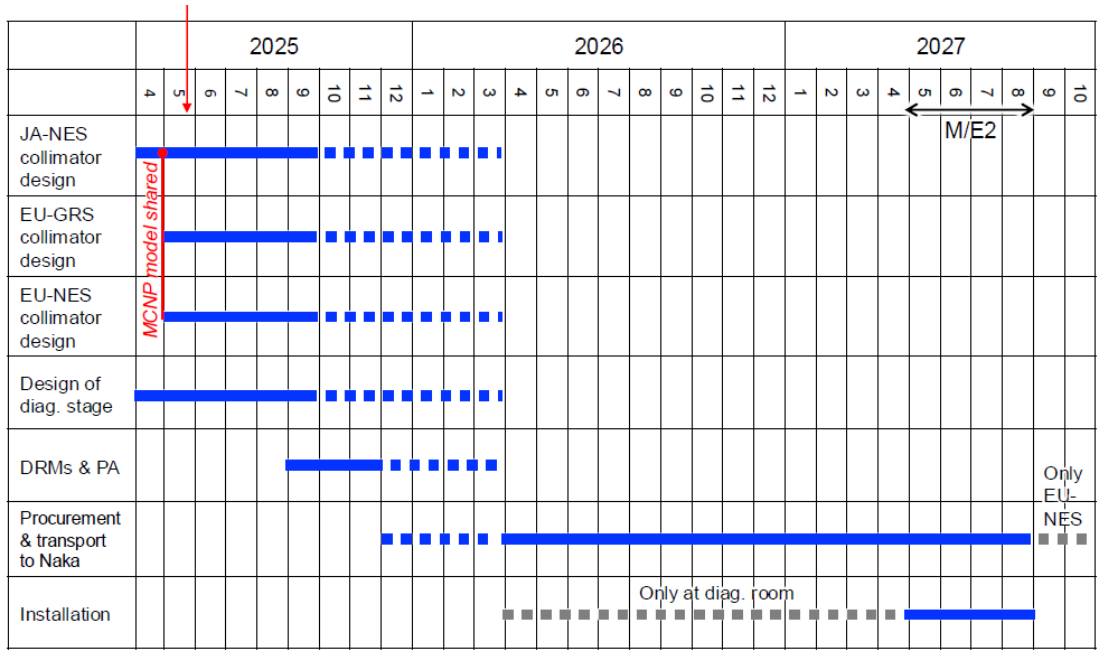
Conceptual design in progress







- Interference ... OK
- Neutronics design ... in progress
- Mechanical design ... in progress



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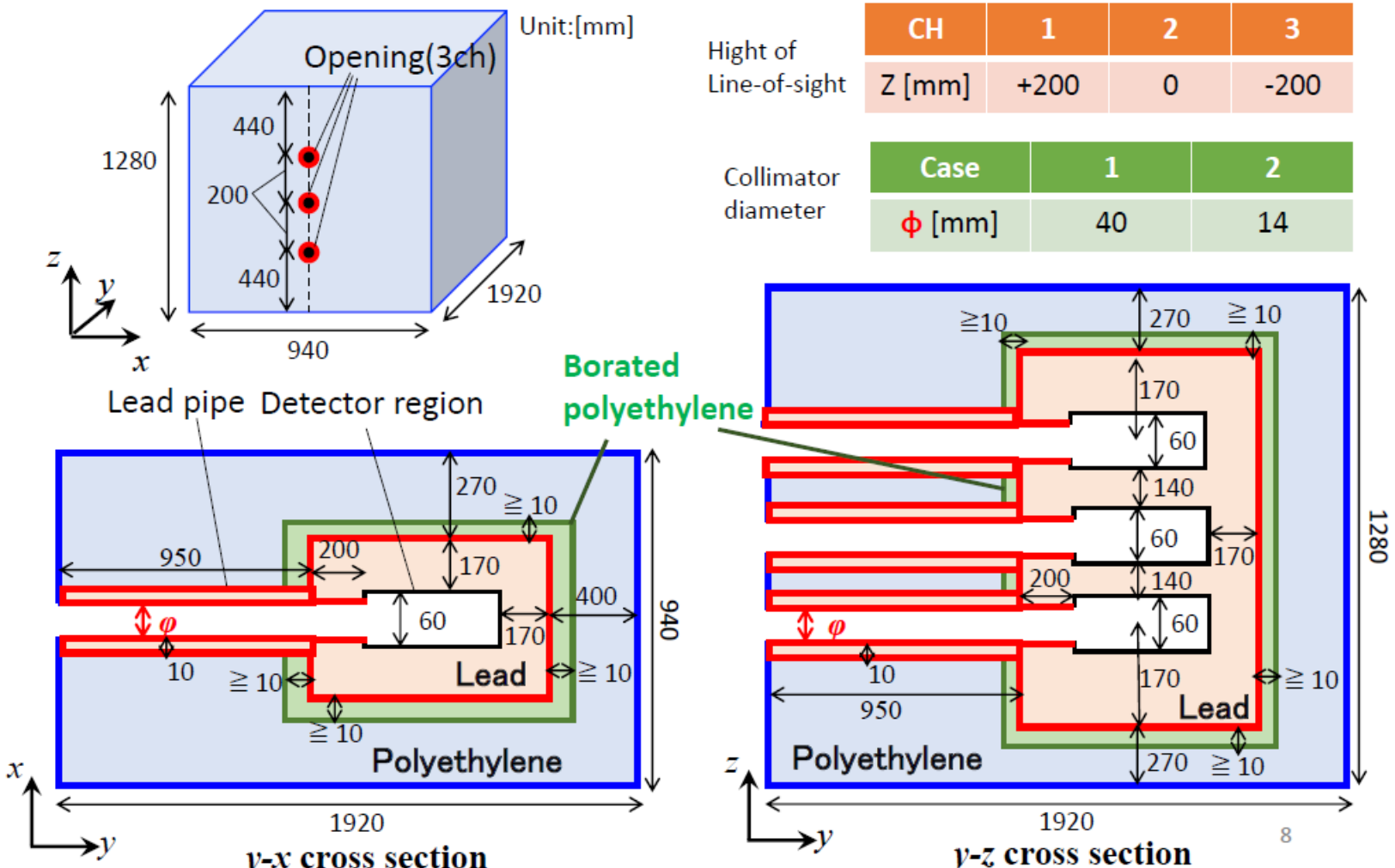
NES/GRS collimator tentative dimensions

Preliminary structure of collimator



Hight of Line-of-sight	CH	1	2	3
	Z [mm]	+200	0	-200

Collimator diameter	Case	1	2
	ϕ [mm]	40	14

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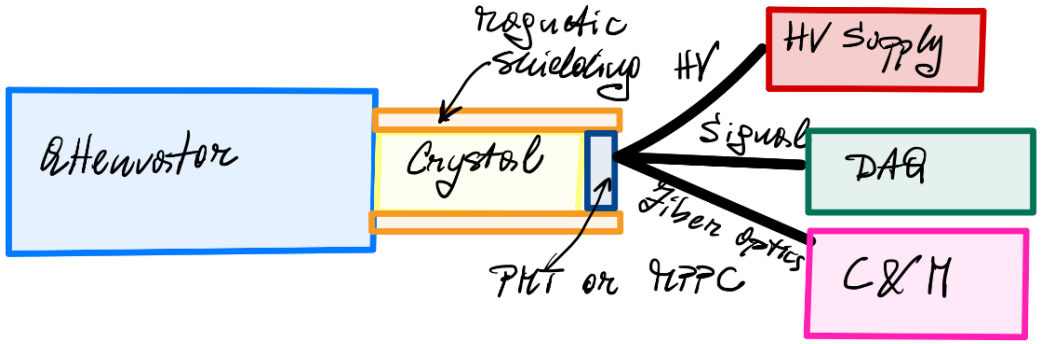
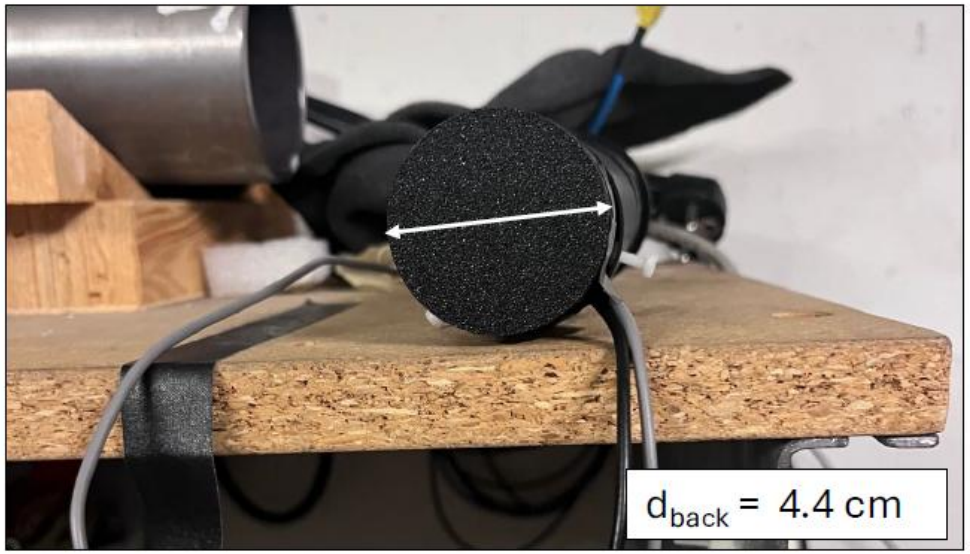
Detector design status

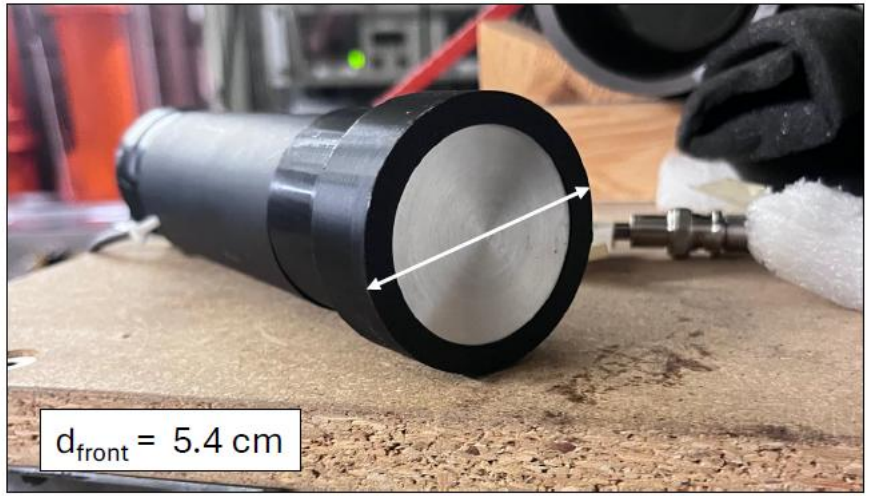


- Plasma centre to detector distance is about 7 m; for comparison, detectors in the JET neutron camera were at about 6 m.
  - *20 cm length available for full detector*: need to shrink the detector from 3”x6” (ITER/JET large spectrometers) to 1.5”x1.5” (similar to JET neutron camera, 1”x1”).
  - **Suitable DAQ identified**, tested in the lab and being tested at MAST-U (Teledyne model ADQ14DC-4C-VG-PXIE)
  - **PMT model Hamamatsu R9420-100-10-Y001** used at AUG can also be used at JT-60SA: ~10 cm length.

Crystal + PMT length = 14 cm tentatively; 5 cm of extra space left for casing, cables etc.

Development of detector prototype (without C&M) with casing to check actual dimensions





3D printed case

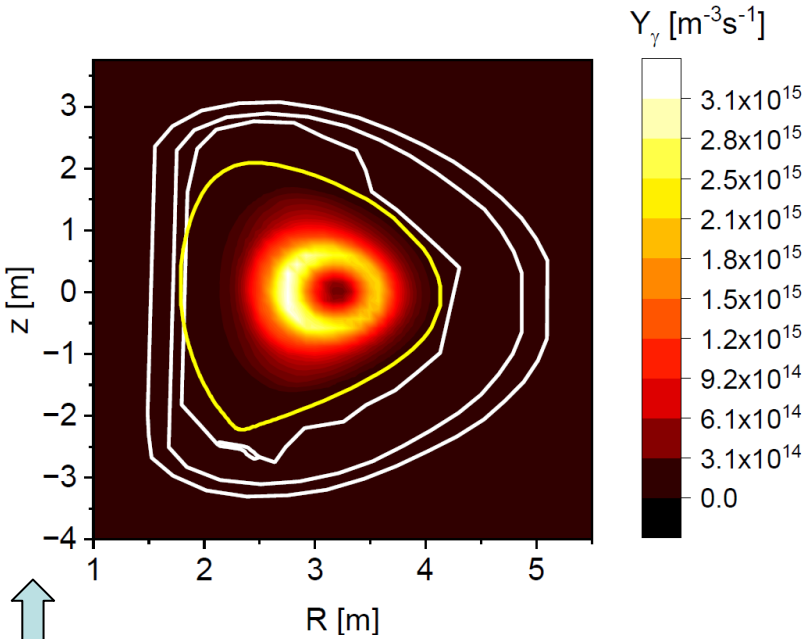
Prototype fits the available space.
Little extra space left
(2 cm along lenght; 0.6 cm along diameter).
Prototype works well.

What we need to progress from this (questions shown at TCM-43; no answer yet)

- **What is the estimated magnetic field at the position of the collimator house? Magnitude and direction? If standard mu-metal not enough to shield the PMT, then we must go for a smaller crystal or consider SiPM.**
- How will the detectors be installed in the collimator house? Can the collimator house be opened from the top (e.g. if there is a lid on top)? Can it be opened from the back? Some other way?
- Where is the DAQ system going to be installed? Do we need long BNC and HV cables from the detector to the DAQ? How long?
- Can the C&M system be installed near the detectors? Or should it also be installed in the same place as the DAQ? In such case, do we need long optical fibers from the C&M to the collimator house? How long? The optical fiber path also has an impact on the detector arrangement in the collimator.
- There are two options for the diameters of the collimators. Will both be implemented or only one of them? If only one, which one?
- What is the expected cable route from the detectors to the DAQ?

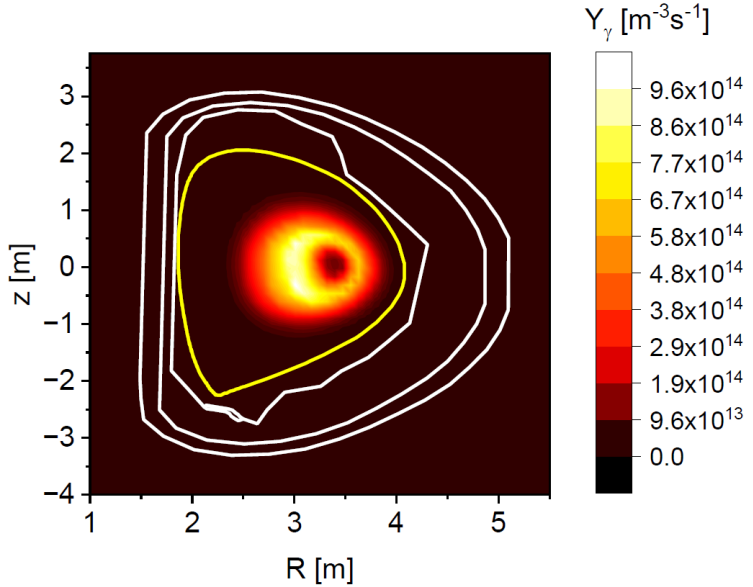
Status of signal simulation

First simulation of the ~17 MeV gamma-ray intensity map made



Scenario 2:
/work/stholer/cmg/catalog/jetto/jet/70000/feb0224/seq#1/ascot.h5
(E. Tholerus)

Scenario 5.1:
/work/stholer/cmg/catalog/jetto/jet/70005/feb0224/seq#1/ascot.h5
(L. Garzotti)



- ASCOT simulation of the 500 keV DNNBI used
With 10% ^{3}He
~ 17 MeV γ-ray emission from d+^{3}He→^{5}Li + γ

Overall intensity comparable to JET 3-ion scenarios

Optimized simulations of the α particle source have been recently made by R. Novara (master student) supervised by R. Coelho and myself.

Next steps:

- Use **optimized simulations** for improved γ-ray intensity map
- Evaluation of **counting rate at the detector position**

Conclusions

- Design of the gamma-ray detector for JT-60SA has **progressed using the information available so far**. Preliminary prototype of detector developed for dimensions check.

- It is now **critical to have answers to the technical questions made at TCM-43** to progress further.

- **First simulations of the gamma-ray intensity map have been made**. Better simulations recently made. They will be used to evaluate the expected counting rate at the detector.