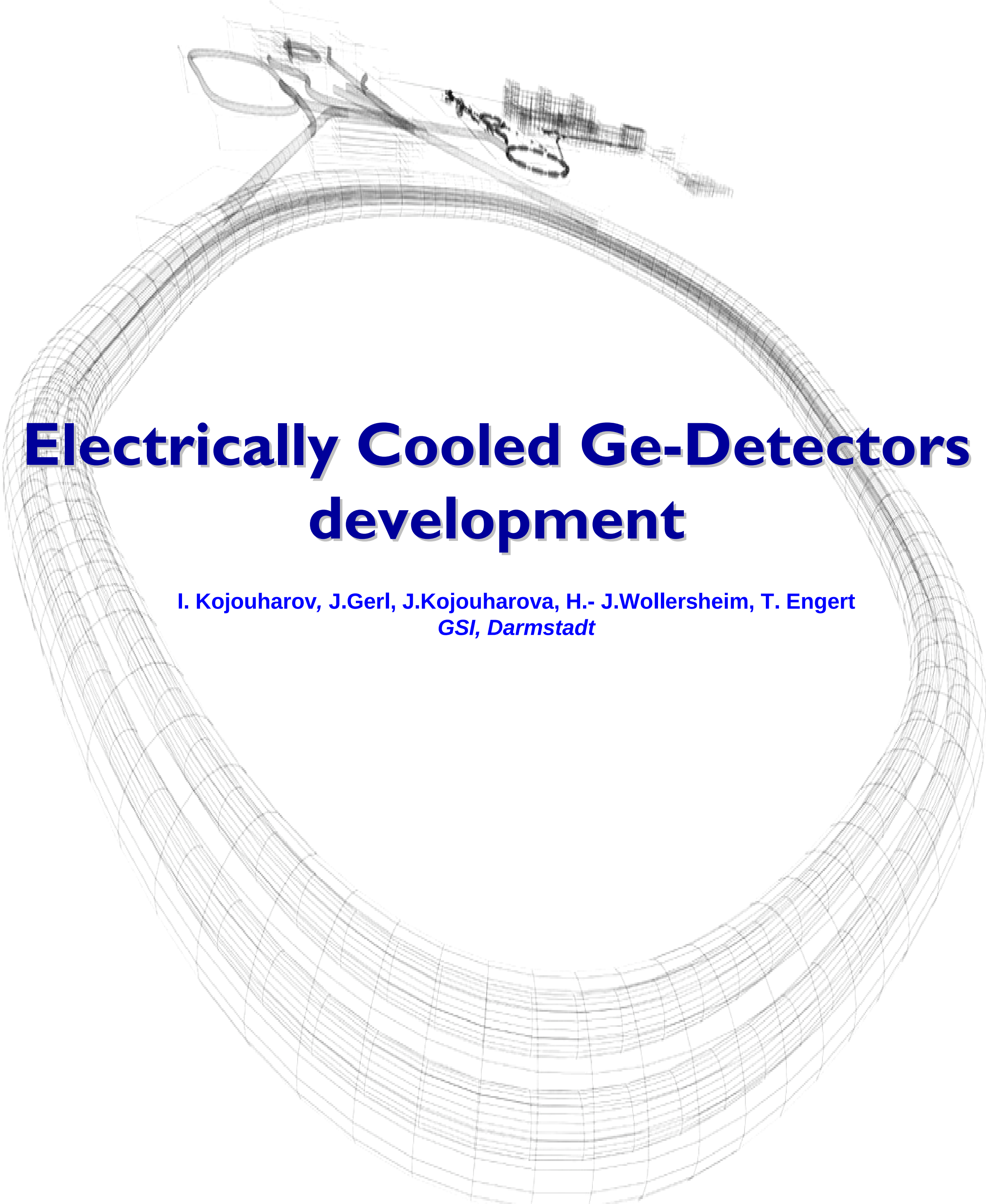

Electrically Cooled Ge-Detectors development

I. Kojouharov, J.Gerl, J.Kojouharova, H.- J.Wollersheim, T. Engert
GSI, Darmstadt

Electrically Cooled Ge-Detectors development

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Cooling HPGe detectors...

Classic cooling – LN2 (with or without Autofill...)

Electrical or electromechanical cooling:

- Peltier cooling – small crystals, mostly applicable to silicon detectors
- Stirling engines – used for HPGe cooling; powerfull, but heavy, noisy...
- Kleemenko cycle (modification of Joule-Thompson process) – recently used for HPGe, flexible lines, silent, versatile, moderate cost. However – not for large crystals, supplied only through ORTEC.

X-Cooler II, MMR/ORTEC

But only for PopTop Capsules...

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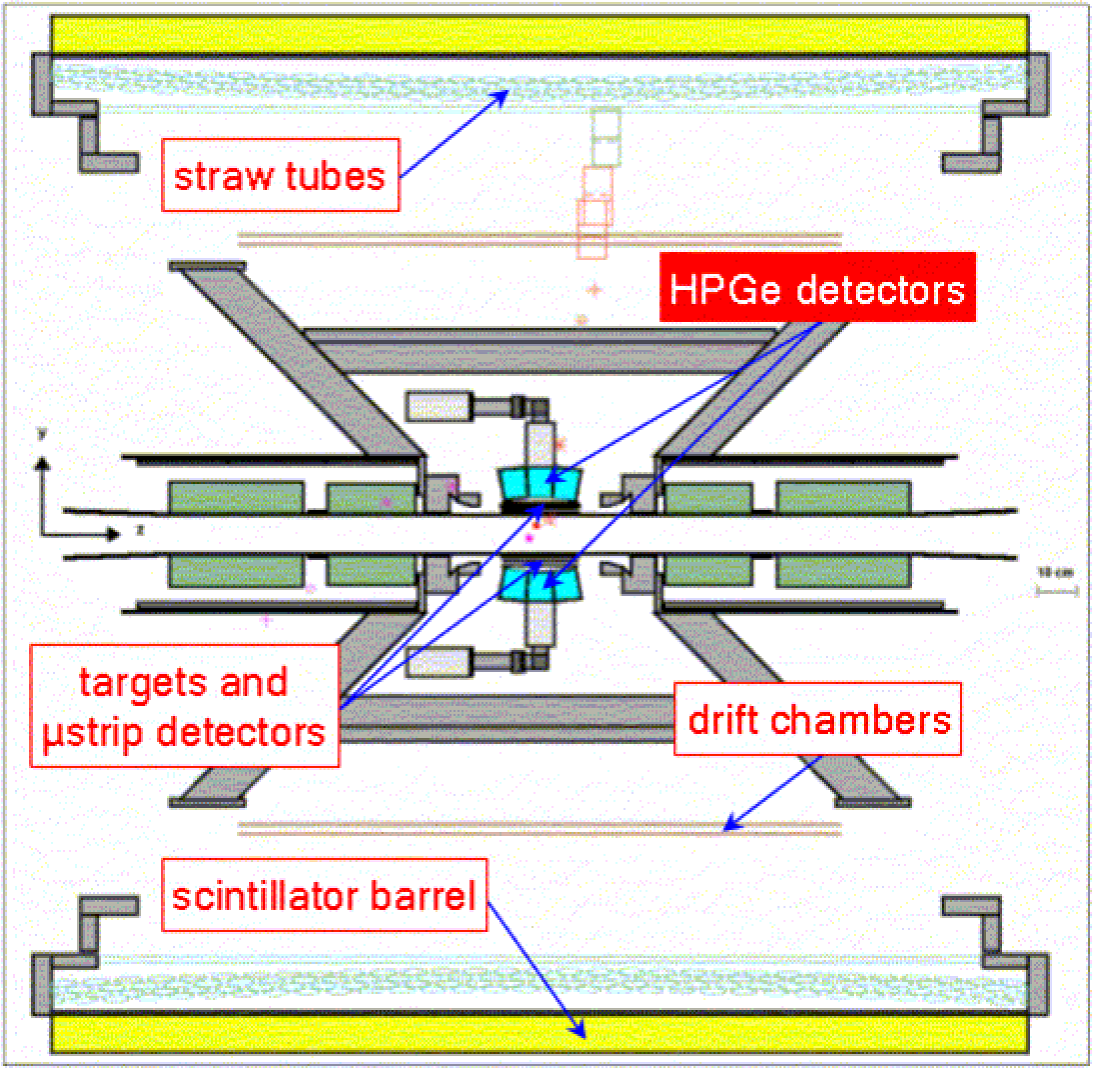
Motivation



Long term unattended operation of Composite HPGe Detectors.
Germanium detectors are typically cooled by liquid nitrogen. For gamma spectroscopy of hyper nuclei at collider facilities like FINUDA or PANDA the limited space for detector deployment makes LN2 cooling technologically unrealistic.

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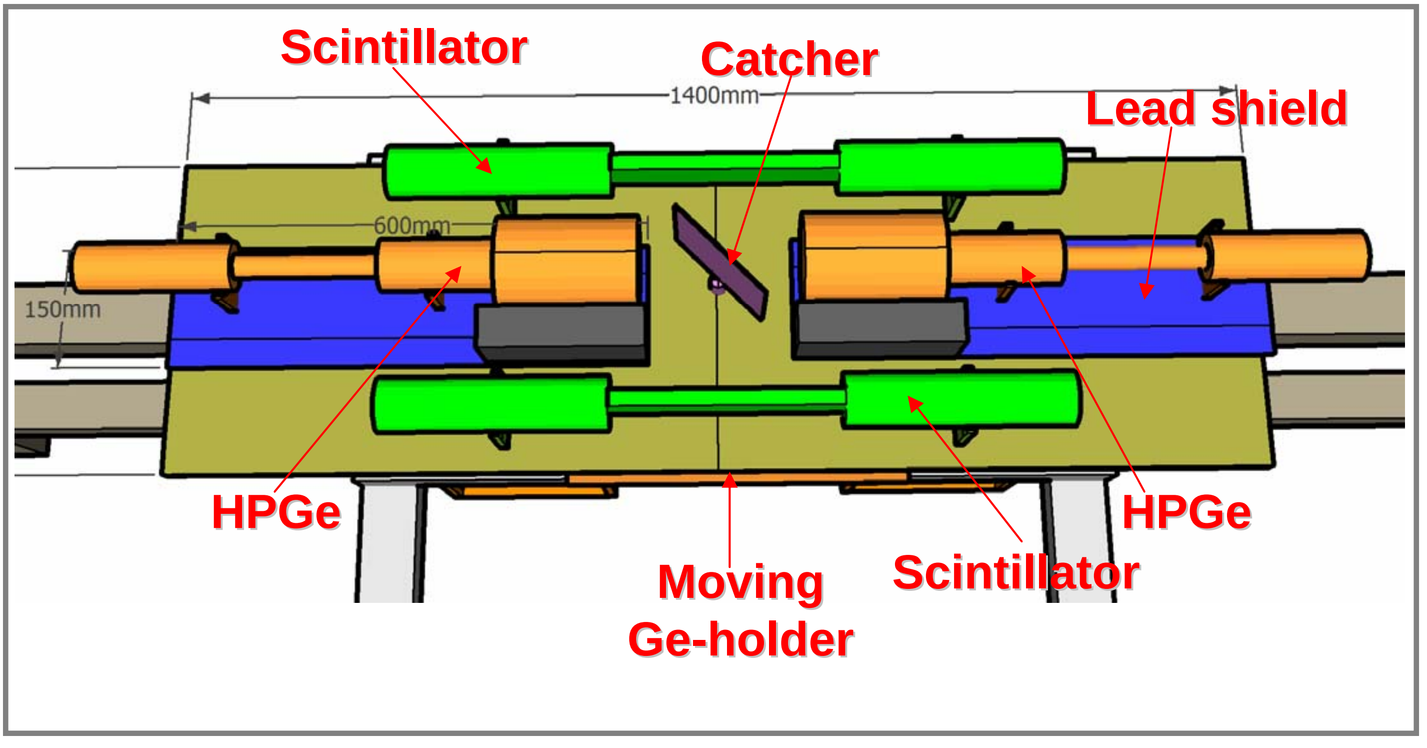

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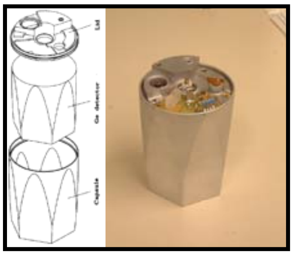
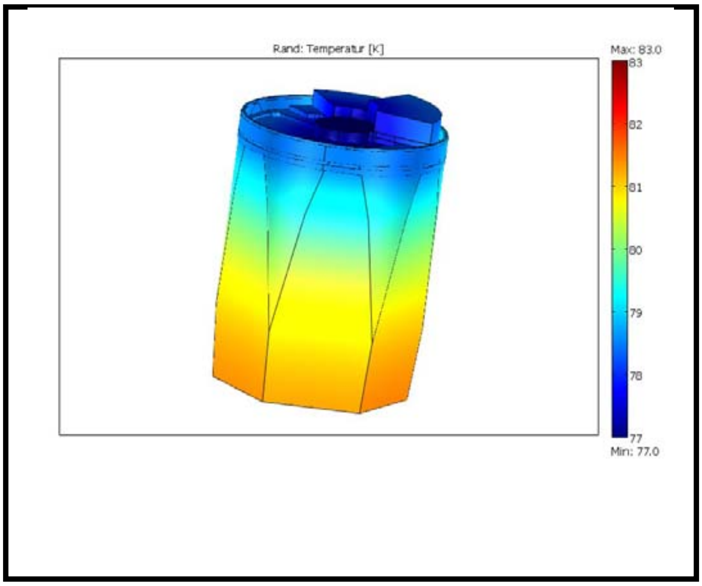
Development of single encapsulated crystal detector



Thermal Analysis

The heat transfer in the detector assembly is dominated by the radiative heat exchange between the outer parts of the cryostat, which are at room temperature, and the inner cold structure, which is at near liquid nitrogen temperature. The path of the transfer leads through the coldfinger to the cold frame, holding the encapsulated detectors, and further to the capsule structure, which cools the Ge crystal. This transfer strongly depends on the reflection capability of the capsule surface (emissivity). For polished aluminum, it is typically 0.05 and for oxidized or rough surface it increases to 0.14. The surface of the crystal capsules has a rather rough appearance and cannot be re-processed.



Surface temperature distribution of a single Ge-detector: the heat losses are 2.5 W for an aluminum capsule surface emissivity of 0.14.

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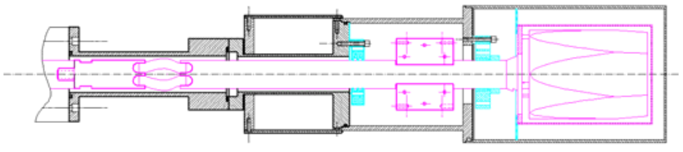
Development of single encapsulated crystal detector



The Single Capsule Cryostat

The Single Capsule Cryostat

The test cryostat design status:
- Conceptual design with single capsule is done ◊
-The mechanical design was modified in order to improve the performance ◊
- The cold line was modified with as few as possible joints and cold finger made by new technology ◊
- Test without capsule (only thermal shield) was performed – the temperature reached -170 ºC ◊
- Capsule HEX 146 was mounted and after vacuum conditioning was tested – temperature reached - < -160 ºC ◊
- Spectroscopy test ◊

Electrically Cooled Ge-Detectors development

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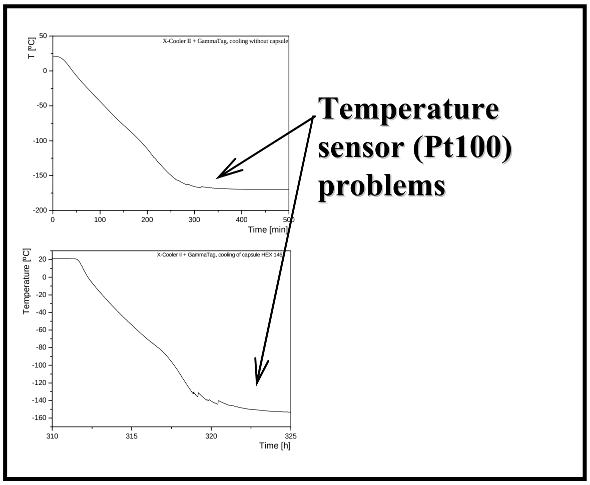
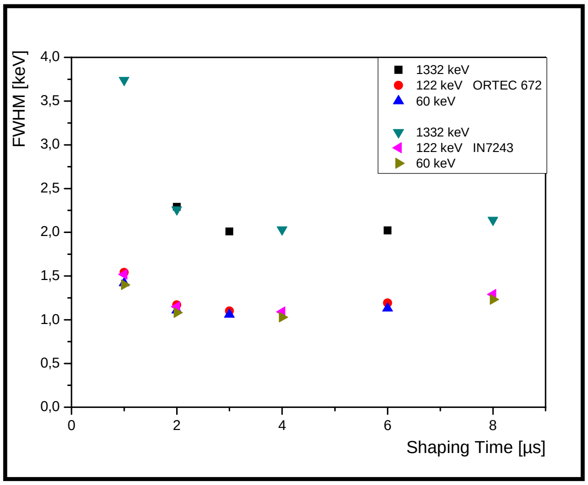
Performance of single encapsulated crystal detector



Cooling of the detector – without capsule (above) and with HEX 146



Energy resolution of HEX 146 vs. shaping time. Energy resolution at 1332 kev and LN2 cooling in Lab – 1.96 keV (GSI cold board !)

Electrically Cooled Ge-Detectors development

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Development of single encapsulated crystal detector – further activities

Problems:
•Temperature measurement – more reliable sensor - Pt100?
•Reliability of X-Cooler II – long measurement

Further activities:
•Improving the HV-filter and test with another PA
•Minor improvement of the mechanics – detector cup
•In-beam test for Isomer Tagging at FRS – already done!

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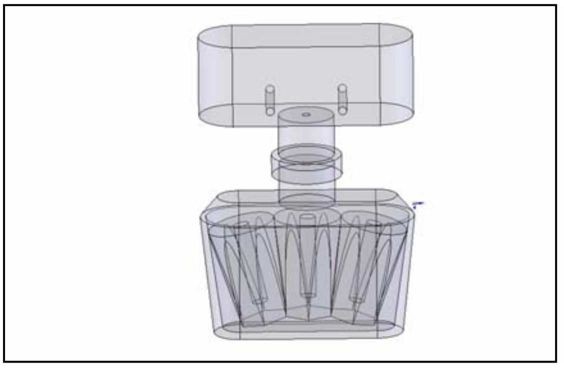
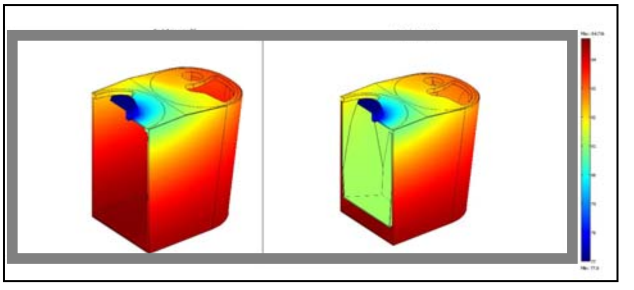
Toward triple cryostat



The HyperTriple Detector – the design concept



Thermal Analysis

Since the heat radiation process determines the energy transfer between the room temperature cryostat walls and the low temperature detector assembly, an intermediate thermal shield, applied as a heat reflector, would substantially reduce the heating of the encapsulated Ge crystals. The complexity of the design requires optimization of the components and therefore a careful thermal analysis and simulation by COMSOL MULTIPHYSICS package has been performed.

As expected, the surface emissivity ε strongly influences the maximal temperature Tmax achieved and the heat flux q , which are given in Table 1. The heat reflector thickness has minor impact on the heat transfer. For highly polished Al-reflectors (ε<0.06) the heat losses can be reduced substantially, so that three Ge-detectors can be cooled with one X-Cooler II.

ε	$\dot{q}\ [W]$	$T_{max}\ [K]$
0.02	0.82	78.14
0.04	1.64	79.27
0.06	2.45	80.41
0.08	3.27	81.54
0.10	4.09	82.68
0.12	4.91	83.81
0.14	5.72	84.94
0.16	6.74	86.07

Table 1. Heat flux $\dot{q}$ and the maximal temperature T_{max} for the composite Ge-detector as function of the emissivity ε.

Electrically Cooled Ge-Detectors development

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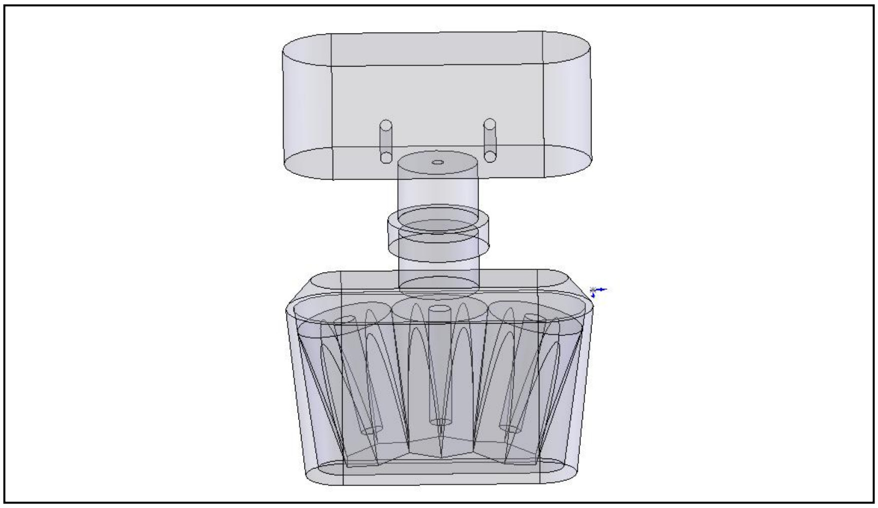
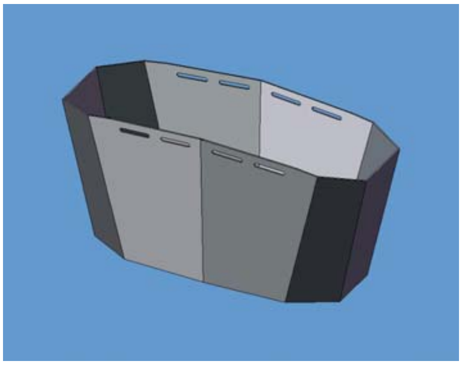
Toward triple cryostat

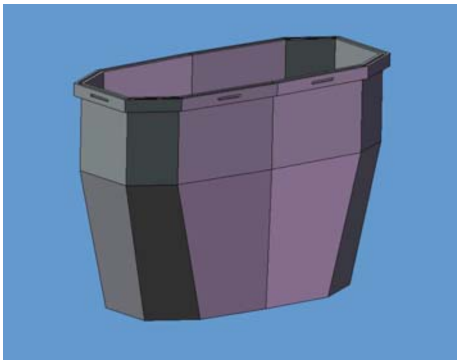


The HyperTriple Detector – the design concept



Thermal Shield

The cold frame with 3 capsule models



Cryostat Cup

Electrically Cooled Ge-Detectors development

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Toward triple cryostat

•**Processing of the Cryostat Cup and the Thermal shield is ongoing, had to be finished up to now, but delayed due to other projects which booked the machine.**

•**Design of the mechanics is in advanced stage, expected to finish until Easter.**

•**Manufacturing of the components is expected to finish until end of May-middle of June.**

•**Assembly and test in June-July.**

What next?

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H.- J.Wollersheim, T. Engert

Thank you