# New Perspectives for the Gamma-Ray Spectroscopy at LNL: the GALILEO Project

C.A. Ur
INFN Sezione di Padova
(for the GALILEO collaboration)

# GAmma SPectrometer – GASP


- 40 HPGe(80%) + AC
  - $d_{target\text{-}det.}$ = 27 cm
  - $\Omega_{Ge}$ ~ 10%
  - $\varepsilon_{ph}$ ~ 3% @ 1332.5 keV
- BGO inner ball
  - 80 BGO elements
  - sum energy&multiplicity

Operational since 1992

High spin gamma-ray spectroscopy following fusion-evaporation reactions

VOLUME 74, NUMBER 6 PHYSICAL REVIEW LETTERS 6 FEBRUARY 1995

# $N$ = 40 Neutron Subshell Closure in the $^{68}$Ni Nucleus

R. Broda, B. Fornal, W. Królas, and T. Pawłat
*H. Niewodniczański Institute of Nuclear Physics, PL-31-342 Kraków, Poland*

D. Bazzacco, S. Lunardi, C. Rossi-Alvarez, and R. Menegazzo
*Dipartimento di Fisica dell'Universitá di Padova and INFN, I-35131 Padova, Italy*

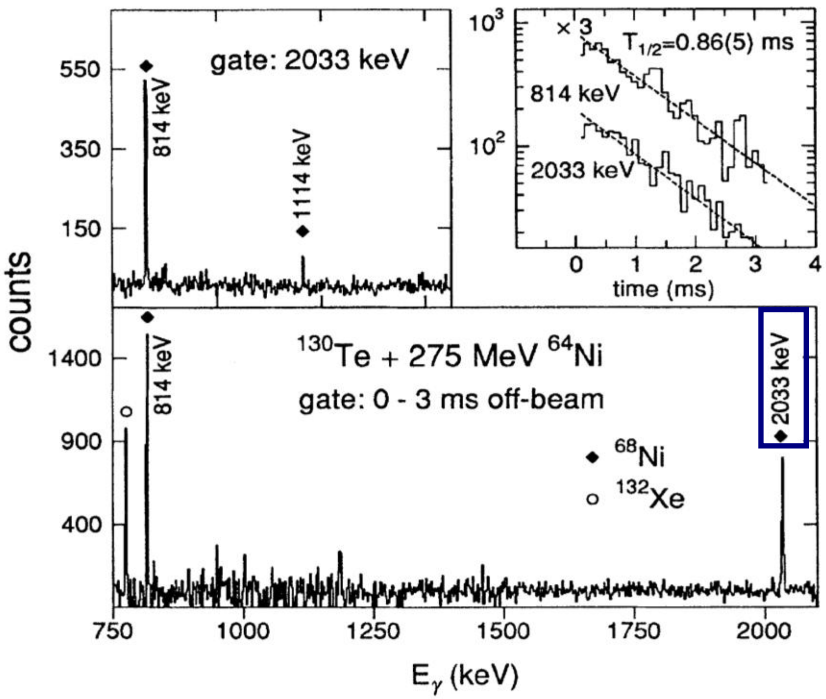
G. de Angelis, P. Bednarczyk, J. Rico, and D. De Acuña
*INFN Laboratori Nazionali di Legnaro, I-35020 Legnaro, Italy*

P. J. Daly, R. H. Mayer, and M. Sferrazza
*Chemistry Department, Purdue University, West Lafayette, Indiana 47907*

H. Grawe, K. H. Maier, and R. Schubart
*Hahn–Meitner–Institut Berlin, D-14109 Berlin, Germany*
(Received 28 June 1994)

GASP 1995

The increase of the $^{68}$Ni $2^+$ excitation energy, by more than 600 KeV compared with $^{66}$Ni, indicates a significant subshell closure at N=40



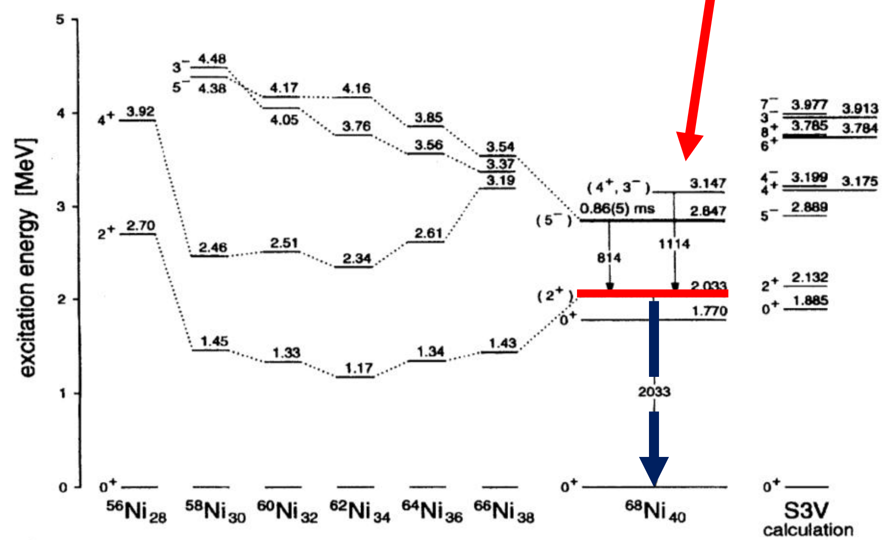
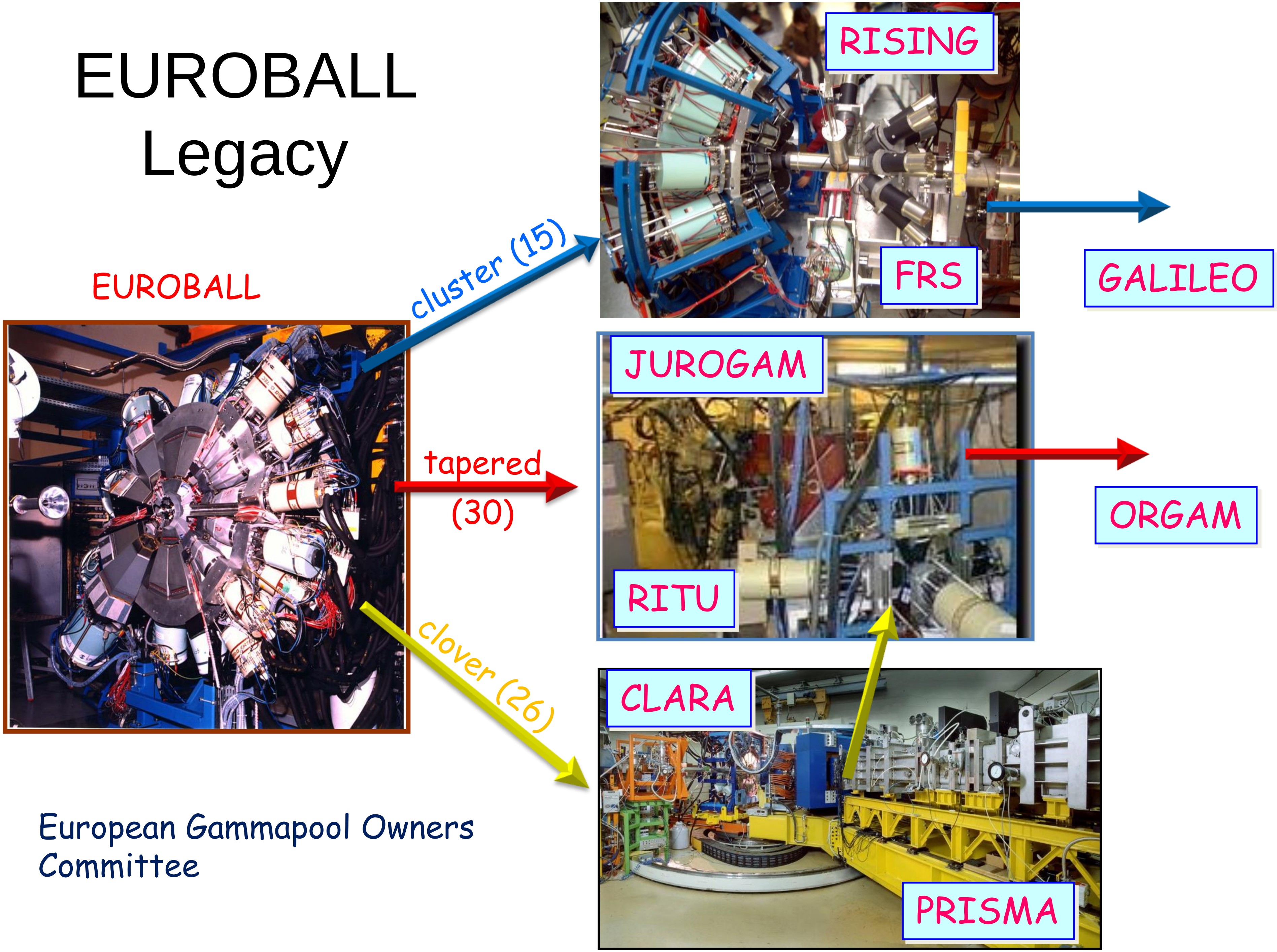




FIG. 3. Systematics of selected states in even Ni isotopes. The $^{68}$Ni results are prominently displayed and compared with the S3V shell model calculations (see text).

# GASP – Difficulties

- obsolete analogue electronic modules
  - no spare parts
  - difficult to repair
- old Ge detectors
  - expensive repair (ORTEC)
  - repair do not restore the original detectors' performance
  - some hope from PSA!
- small space for external ancillary
- holding structure not flexible

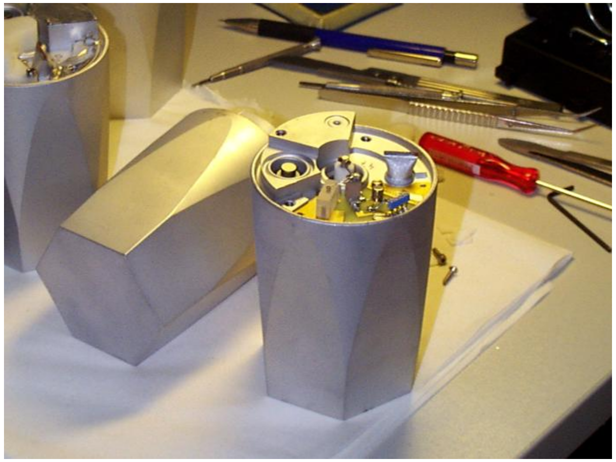
# EUROBALL Legacy



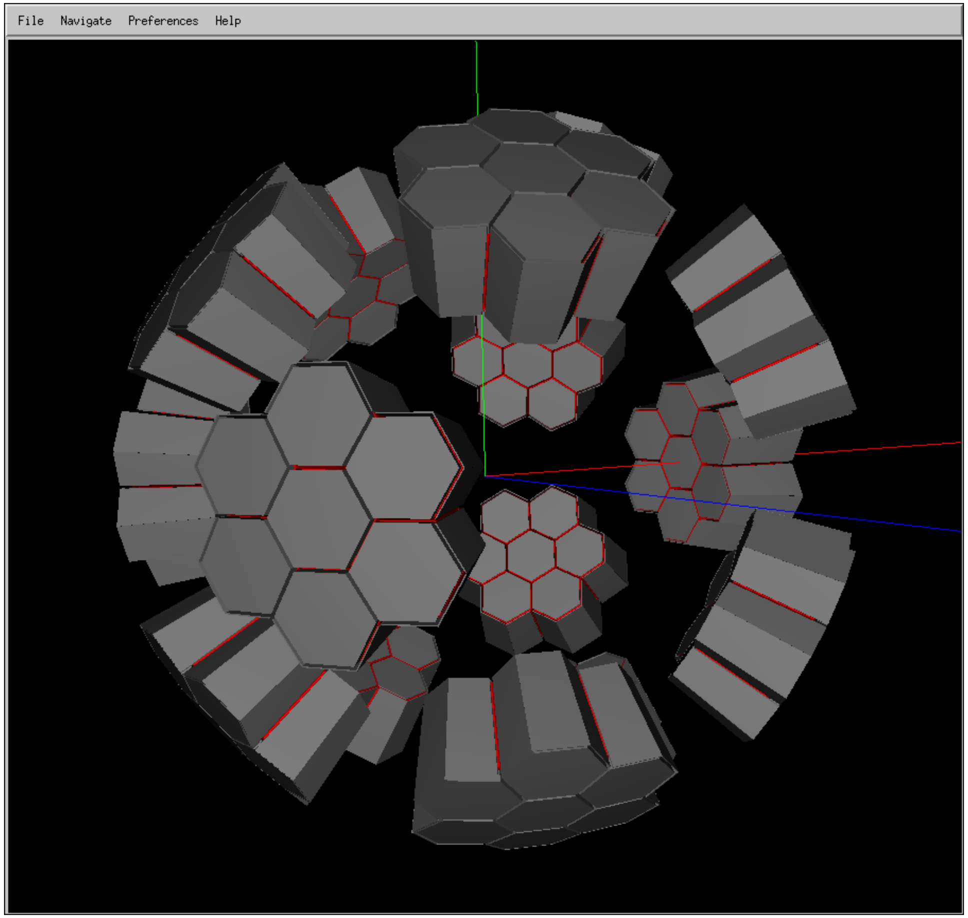

European Gammapool Owners Committee

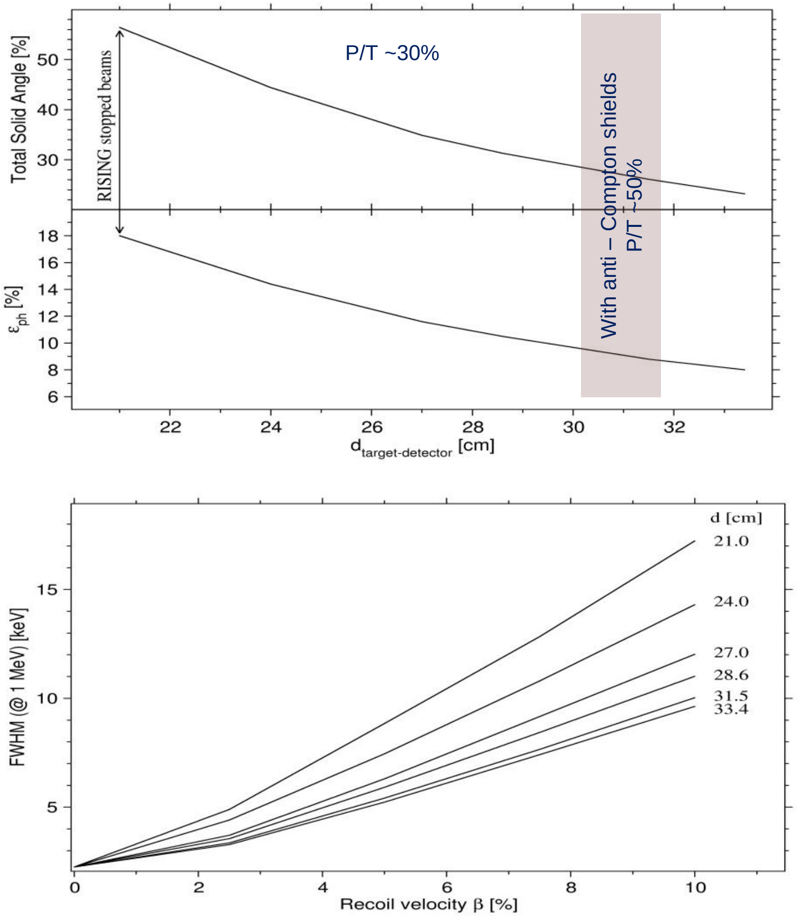
# EUROBALL Cluster Detectors

- 15 x 7-cluster detectors (GSI - RISING array)
  - Encapsulated n-type HPGe detector
  - FWHM < 2.4 keV @ 1332.5 keV
  - $\varepsilon_{int}$ ~60% @ 1332.5 keV
- common cryostat
- Independent HV/LV/FE for each capsule



# RISING Configuration



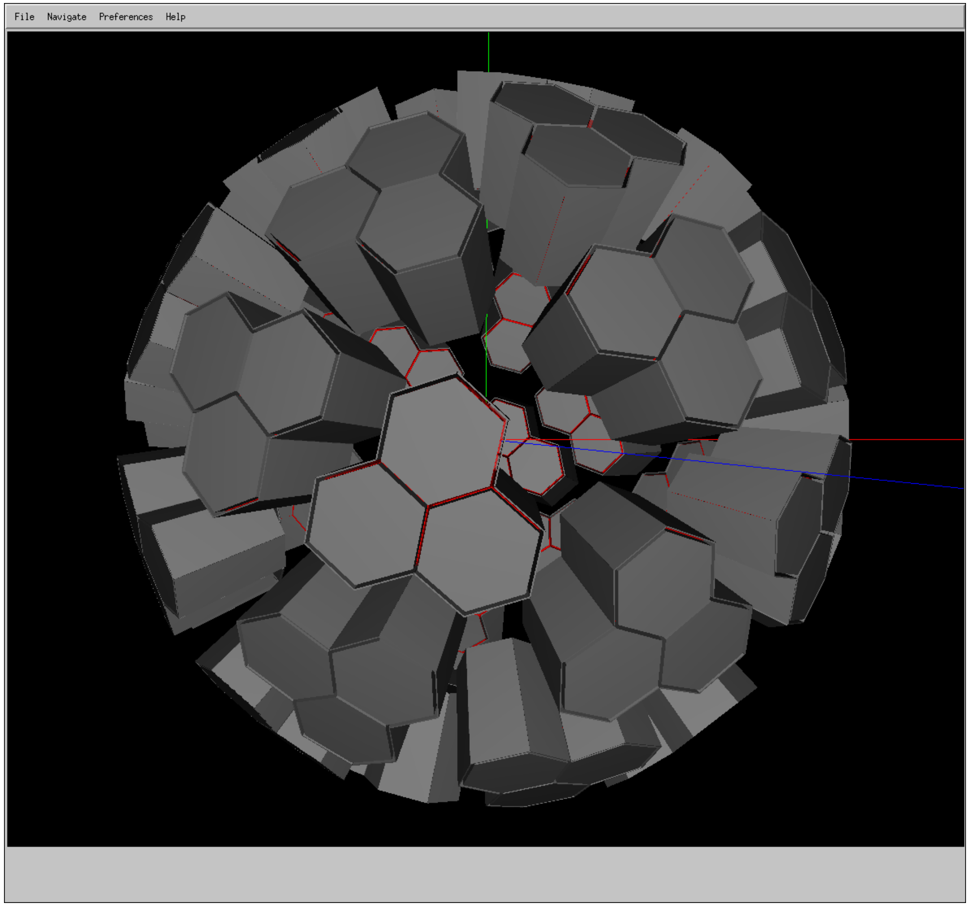




7-capsule packaging not efficient

- solid angle coverage
- gamma-ray energy reconstruction (add-back)

GEANT4 Simulation

# Possible 3–clusters Configuration




New configuration with triple clusters

40 detectors@24cm – Ω=50%

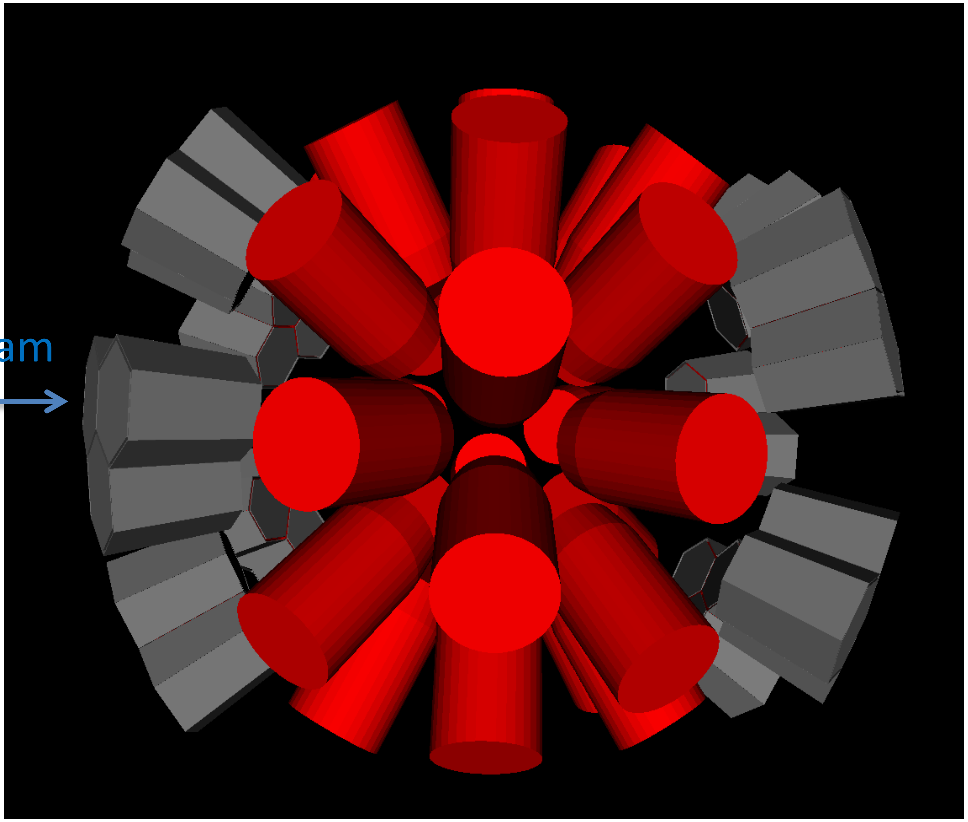
Pros:

- uniform coverage of the solid angle (ang.distr., DSAM)
- more efficient anti-Compton
- less impact on the total efficiency when detectors are removed from the array
- natural add-back (ener. res.)

Cons:

- anti-Compton shields not available
- new cryostat – high cost

# GALILEO Configuration



Beam

Mixed configuration with
GASP dets. and 3–clusters
40 10

- Symmetric configuration of the array
- GASP anti–Compton shields available

**Under study!**

Prolonged availability of all the detectors

# GALILEO – R&D Tasks

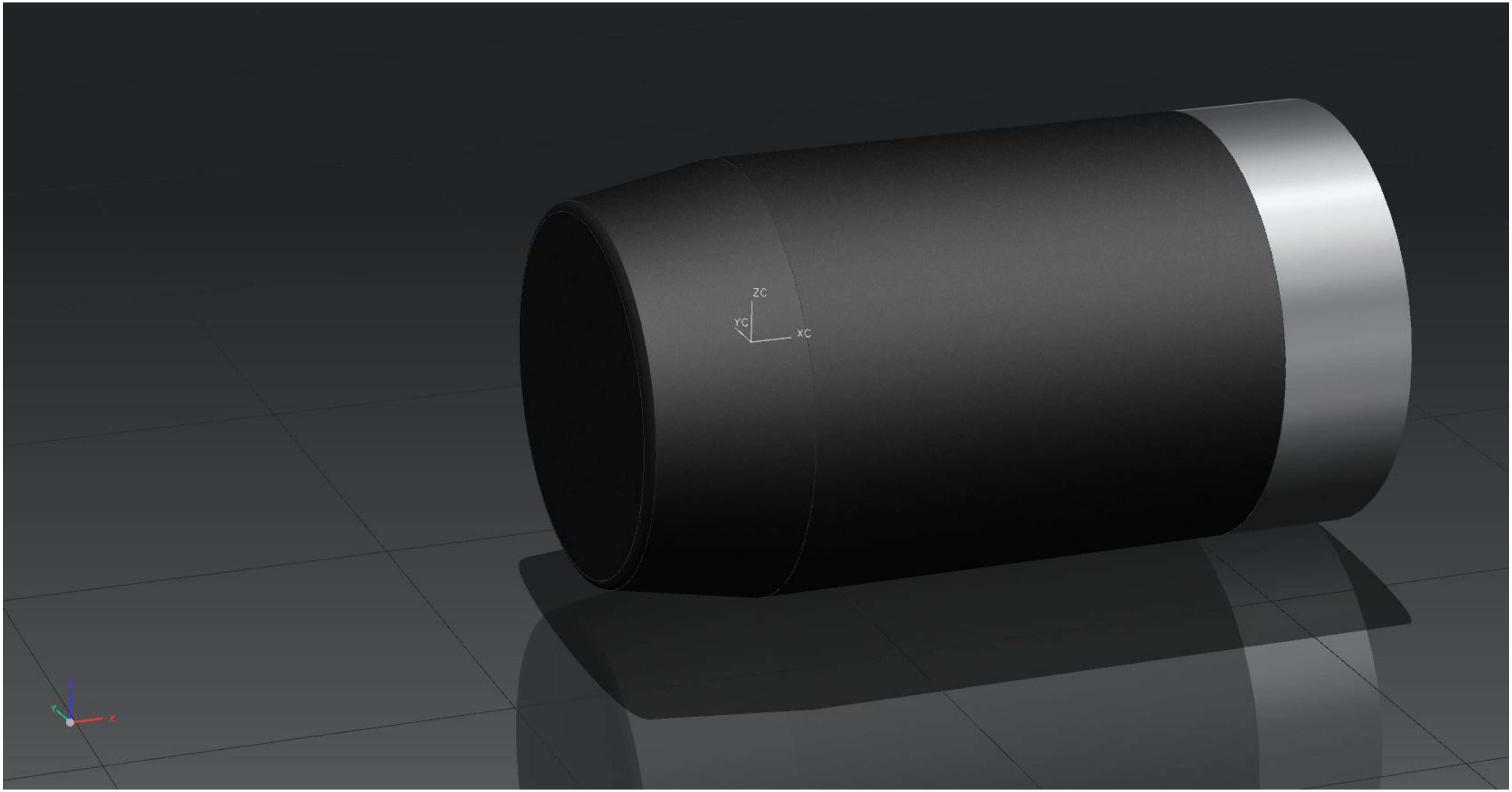
- Development of the cryostat (prototype financed 2010)
  - end-cap (low-cost)
  - dewar
  - cabling
  - thermal conduction
- Design of a new anti-Compton shield (prototype financed 2011)
  - recover crystals from EUROBALL
- Design of holding structure (partly financed 2011)
  - more space for ancillary detectors
  - flexible configuration
  - G.GALILEO infrastructure
- New electronics (prototypes financed 2011)
  - front end
  - digitizers
  - readout
- $LN_2$ filling system
  - recover distribution lines from GASP
  - new control NI CompactRIO architecture

# Cryostat R&D

- Optimize the cost
  - end-cap in carbon fibre produced at LNL
  - dewar with standard available materials
  - parts build at Padova and LNL workshops
- Optimize cryostat
  - easy repair (pumping, zeolite regeneration)
  - reduce LN2 consumption through better insulation
  - mechanical and thermal study (COMSOL Multiphysics)
- Carbon fiber
  - more resistant than Al
  - more transparent to low-energy gamma rays
  - Production time – few hours

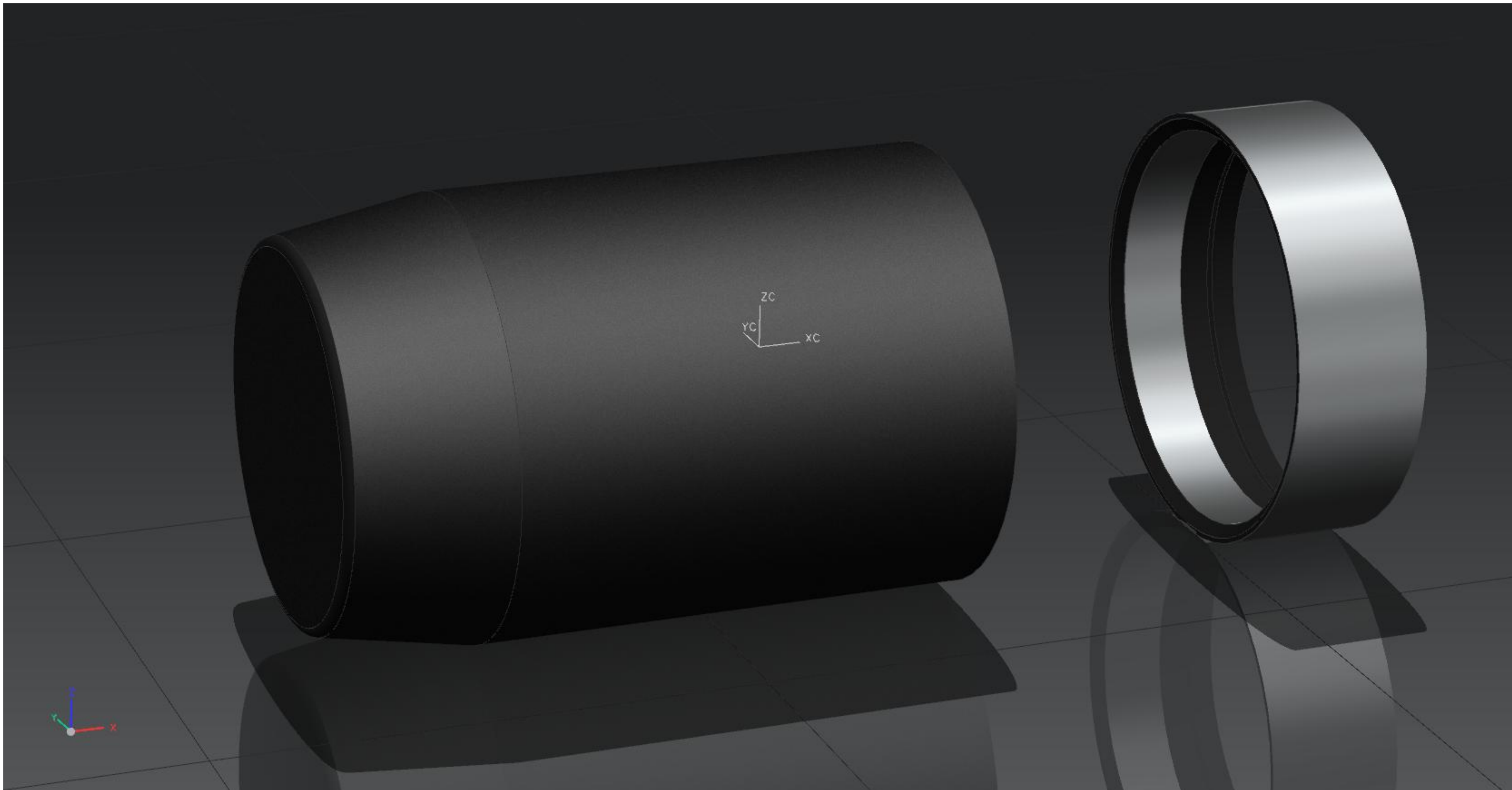
# Carbon Fiber end–cap – Demonstration

## GASP detector end-cap



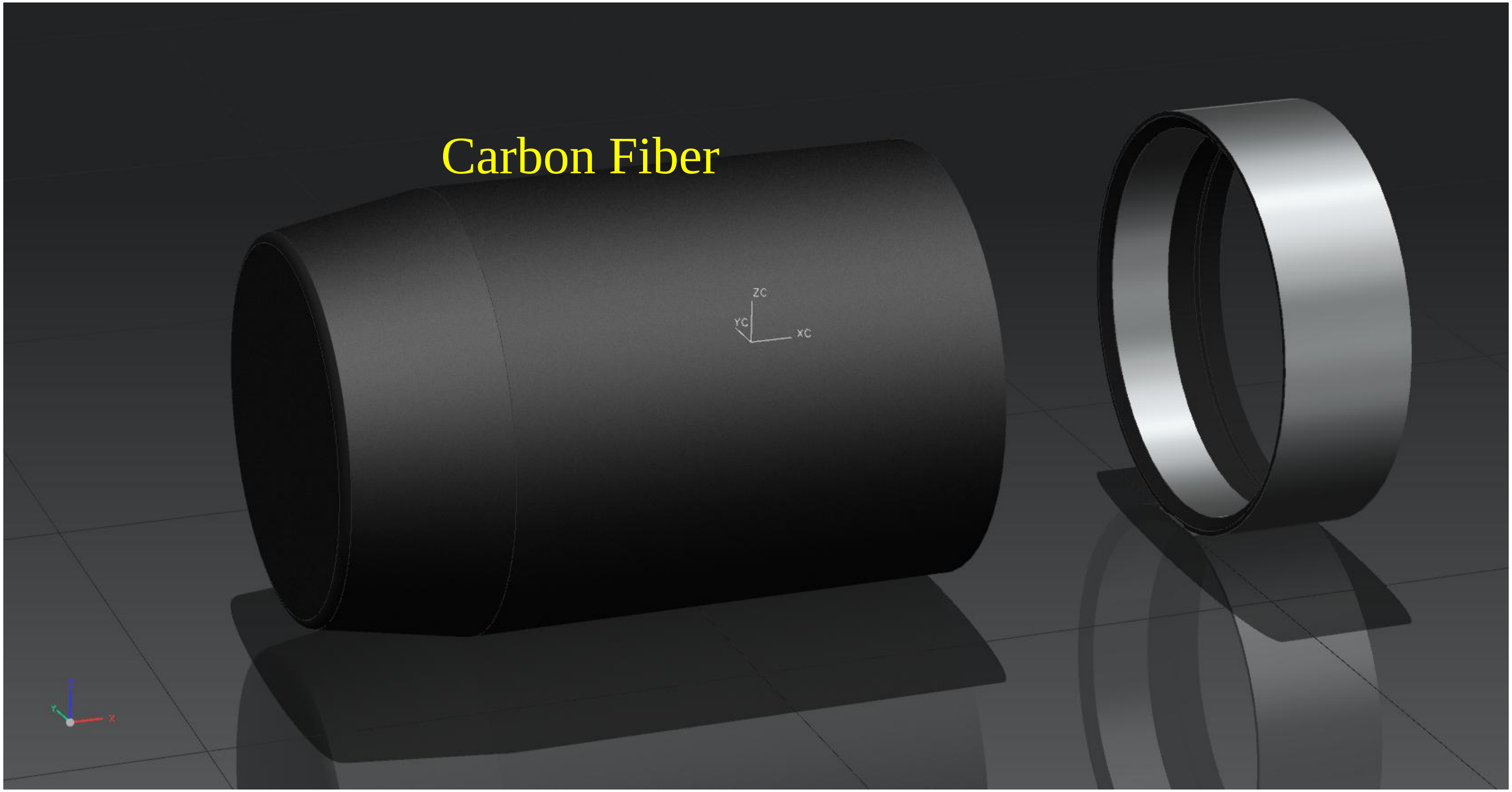
# Carbon Fiber end–cap – Demonstration

## GASP detector end-cap



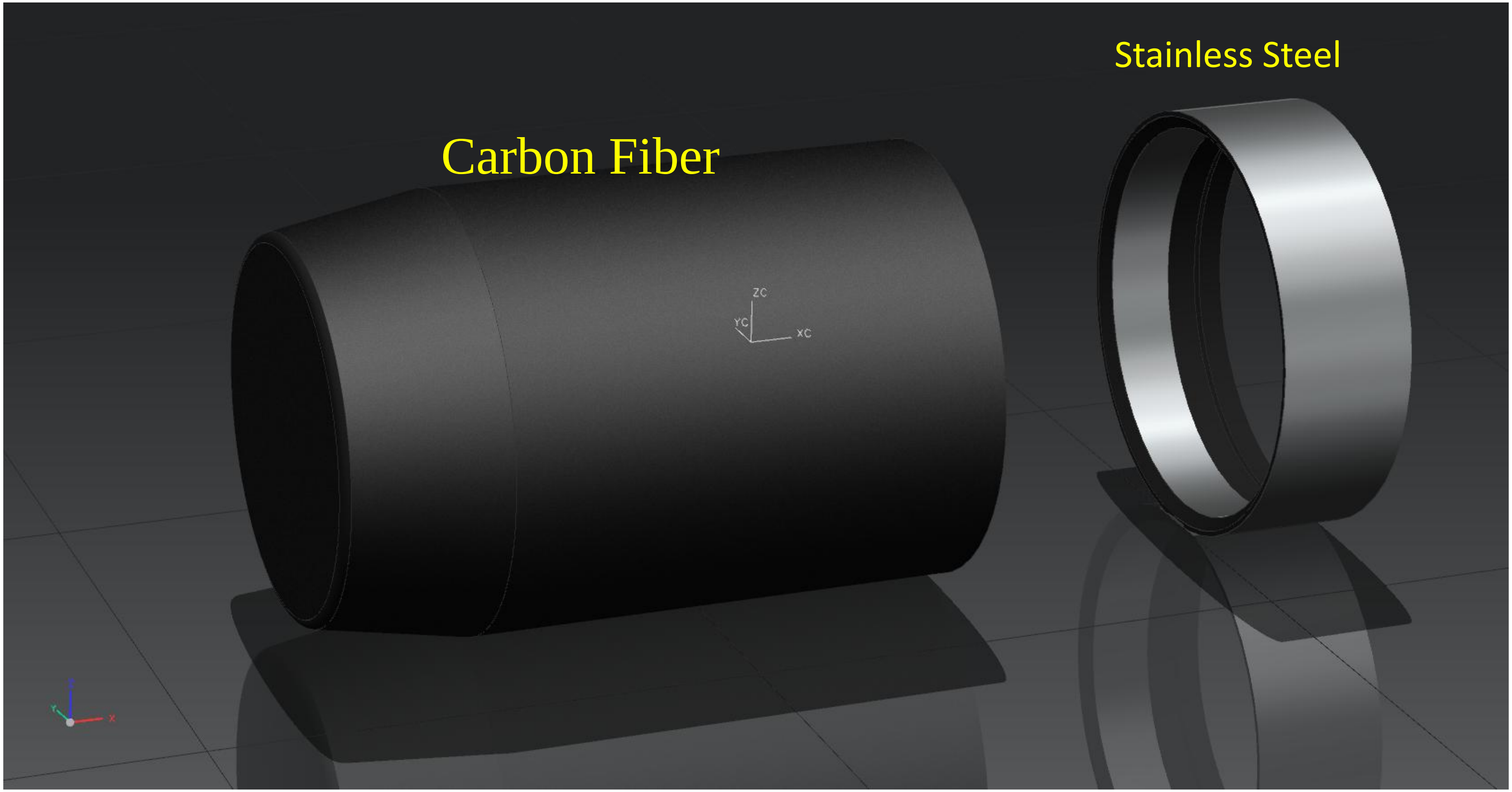
# Carbon Fiber end–cap – Demonstration

## GASP detector end-cap



# Carbon Fiber end–cap – Demonstration

## GASP detector end-cap



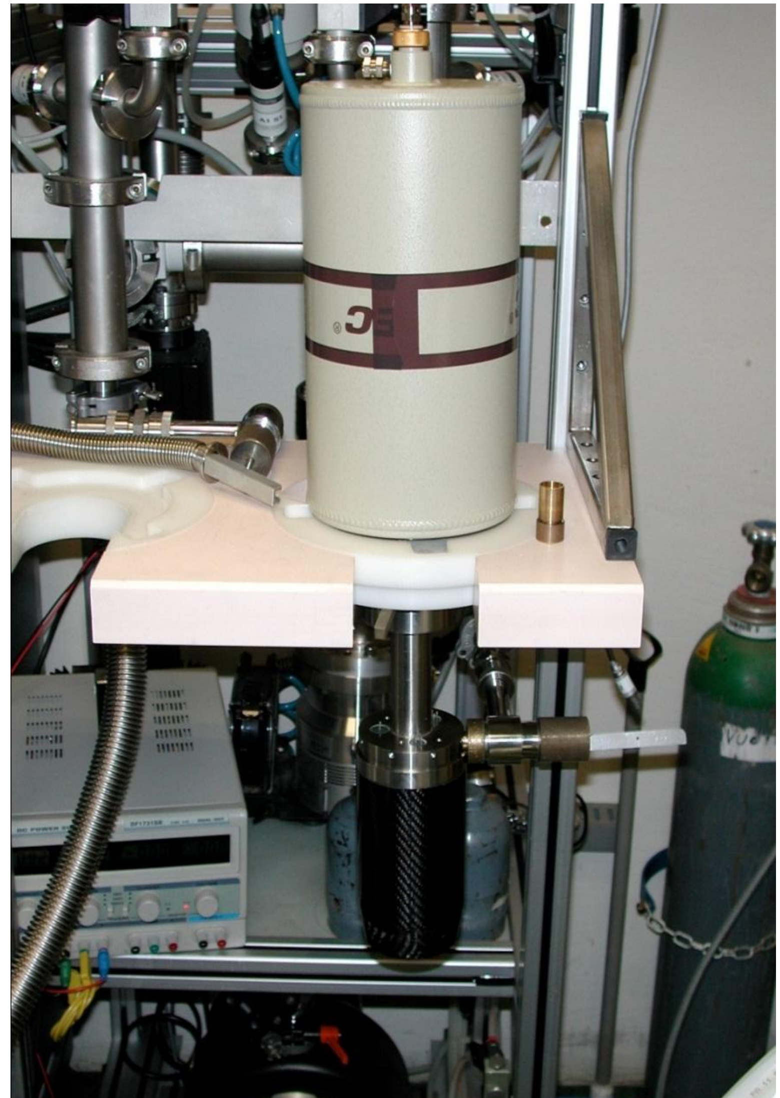
# Carbon Fiber end–cap – Demonstration

GASP detector end-cap

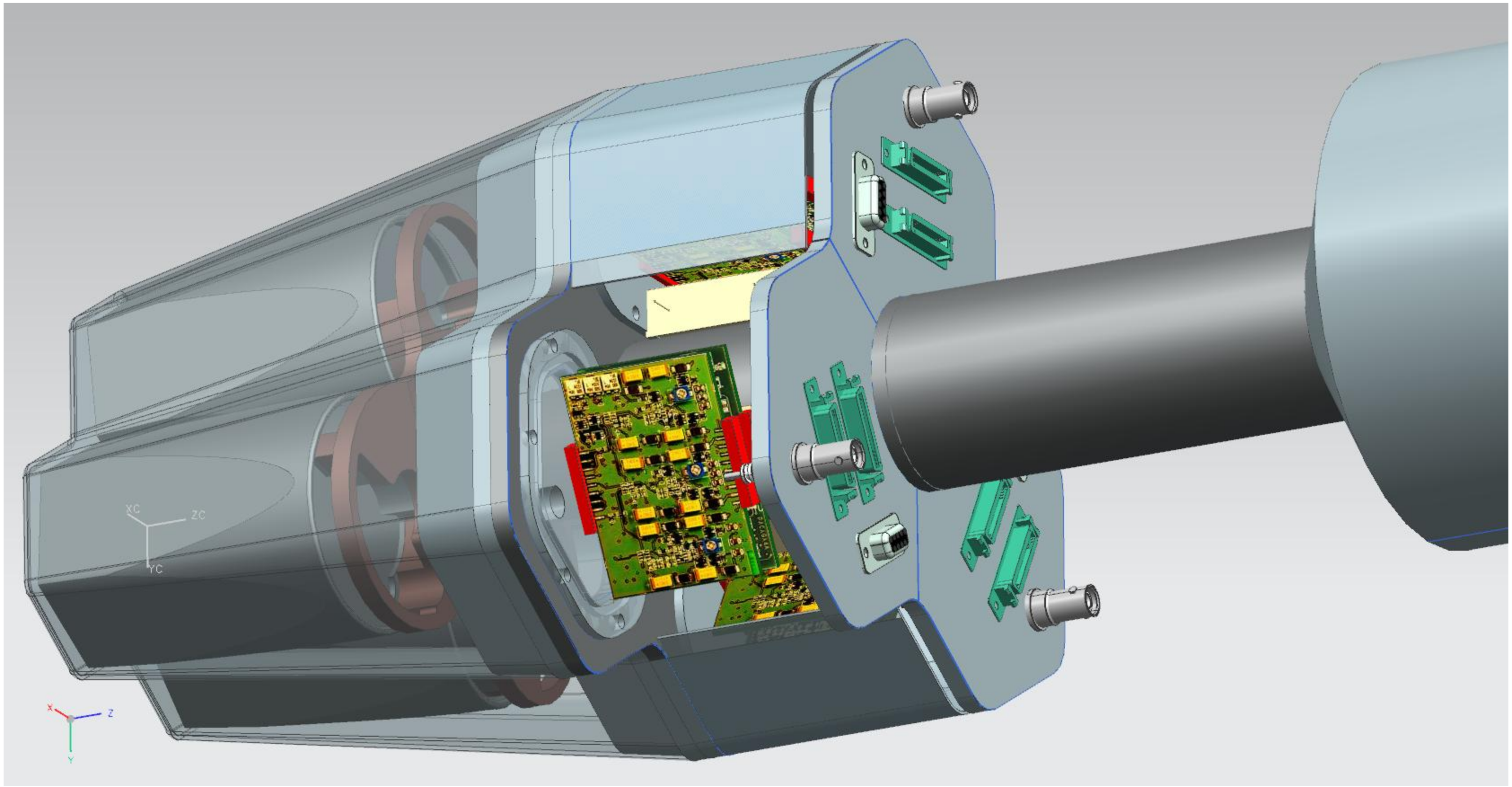
Vacuum tightness good

Mass analysis (water)

– fiber storage (-18°C)



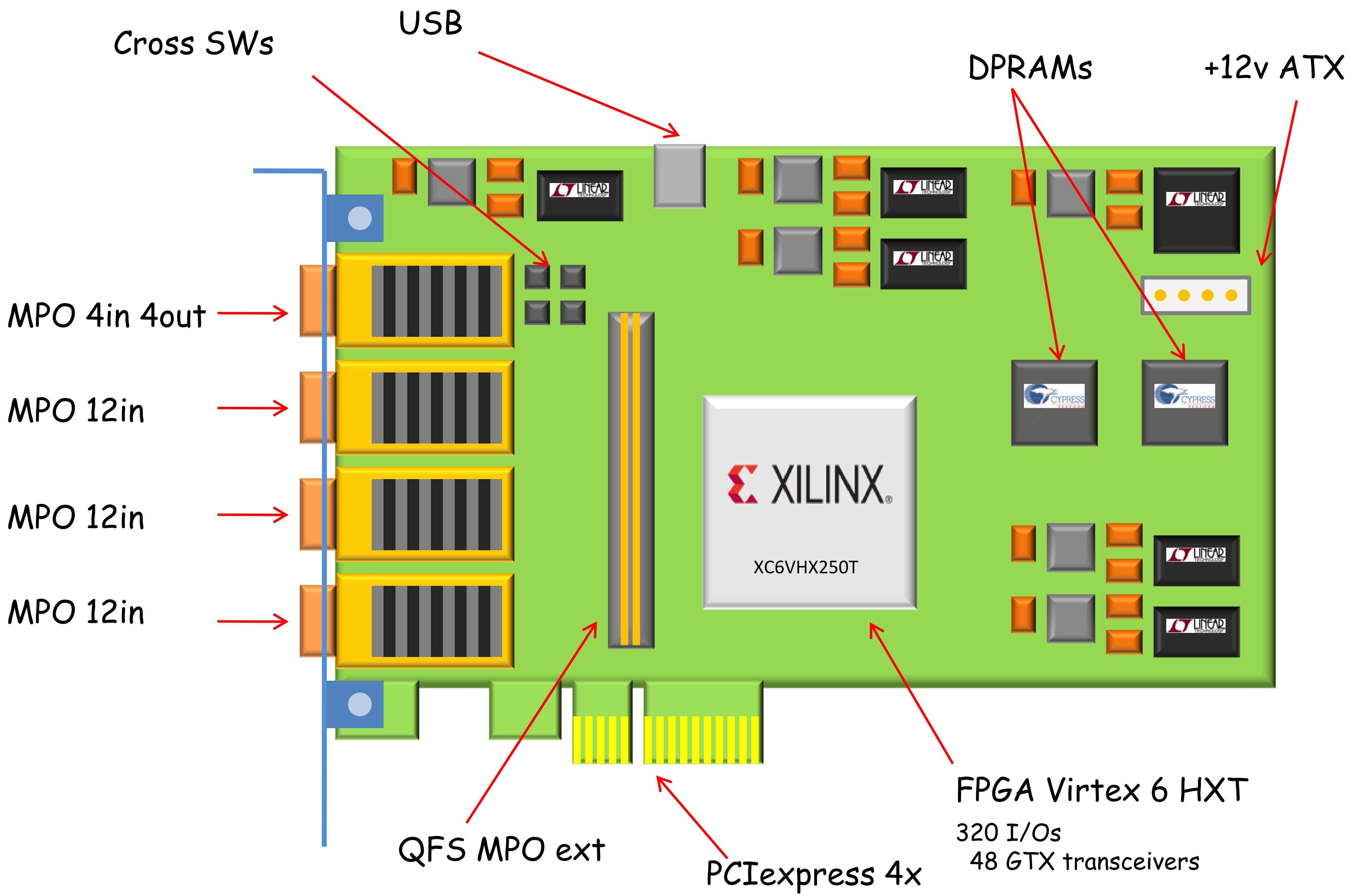
# Triple Cluster Cryostat – Design



# Electronics R&D

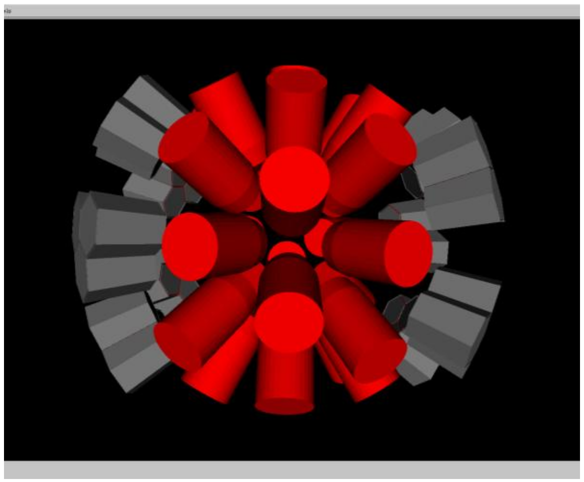
- Take advantage of the work done for AGATA
  - single core preamplifier (extended energy range)
  - GTS
  - AGAVA
- New developments
  - digitizers – first step towards a 'digital preamp.'
  - readout (optical fiber)
  - pre-processing (PCI-express cards)
- Opened questions
  - readout of the anti-Compton elements

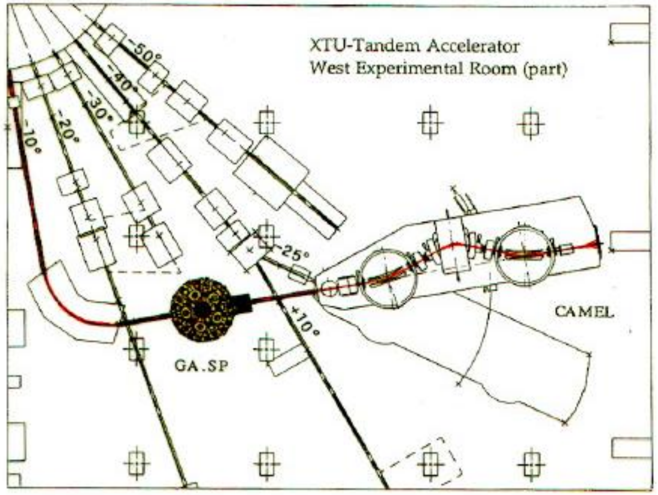
# Pre–processing Electronics R&D



# Holding Structure R&D

- Eliminate bending of the beam at 90°
  - rotate the structure by 90° and build a new beam line
  - more space to add ancillary at 0°






- Flexible
  - configuration without *AC* close to the target $\varepsilon_{ph}$ ~15%
  - configuration with *AC* at ~ 26 cm from target $\varepsilon_{ph}$ ~6%
  - removable front part (RFD, neutron)
  - multiplicity filter ?

# Time Schedule – Main Milestones

- Request to EOC – 1st July 2010
- Cryostat design completed – end of 2010
- Working triple cluster prototype – March-April 2011
- Digitizer and readout prototypes – end of 2011
- Design of the structure – end of 2011
- Production – first half 2012
- Complete the $LN_2$ filling system – first half 2012

# Request to EOC

- 15 letters of intent – research groups from 19 institutes
- *Structure of N~Z nuclei at high spin*
- *Isospin Symmetry*
- *Neutron-rich nuclei*
- *Exotic decay of high-spin states*
- *Nuclear structure close to $^{100}Sn$*
- *Cluster and highly deformed states in sd-shell nuclei*
- *Giant resonances and warm rotations*
- *Symmetries and shape-phase transitions in nuclei*
- *Shape coexistence in neutron-deficient nuclei*

***Extend the physics case with LoI' for SPES***

# Coupling to Complementary Detectors

- *Study of weak reaction channels & SPES beams*
  - *High efficiency*
  - *High resolving power*

- *Light charged particle detectors*
  - *EUCLIDES*
  - *TRACE*
  - *LUSIA*
- *Neutron detectors*
  - *n-Ring*
  - *N-Wall*
  - *NEDA*
- *Binary reaction products detection*
  - *DANTE*
- *Recoil detectors*
  - *RFD*
- *High-energy gamma-rays detectors*
  - *HECTOR*

# Collaborators

- C. Fanin
- D. Rosso
- M. Bellato
- D. Bortolato
- R. Isocrate
- A. Pullia
- S. Riboldi
- E. Farnea
- D. Bazzacco

# Summary

- the development of a new gamma-ray array is proposed
  - detectors from GASP
  - capsules of the EUROBALL cluster detectors
- important R&D is going on
  - triple clusters
  - carbon fiber end-cap
  - dewar
- coupling with state-of-the-art ancillary detectors
  - charged particles
  - neutrons
  - fragments