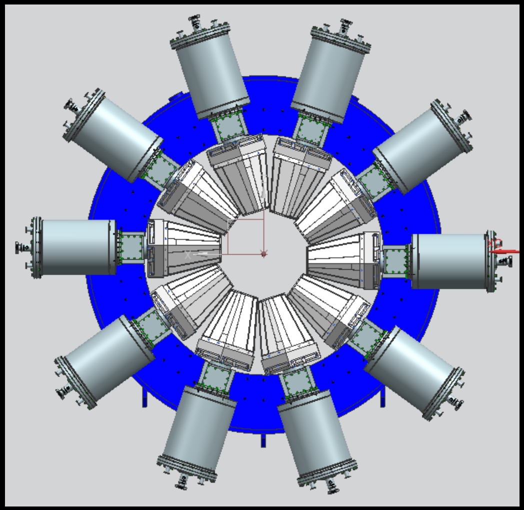
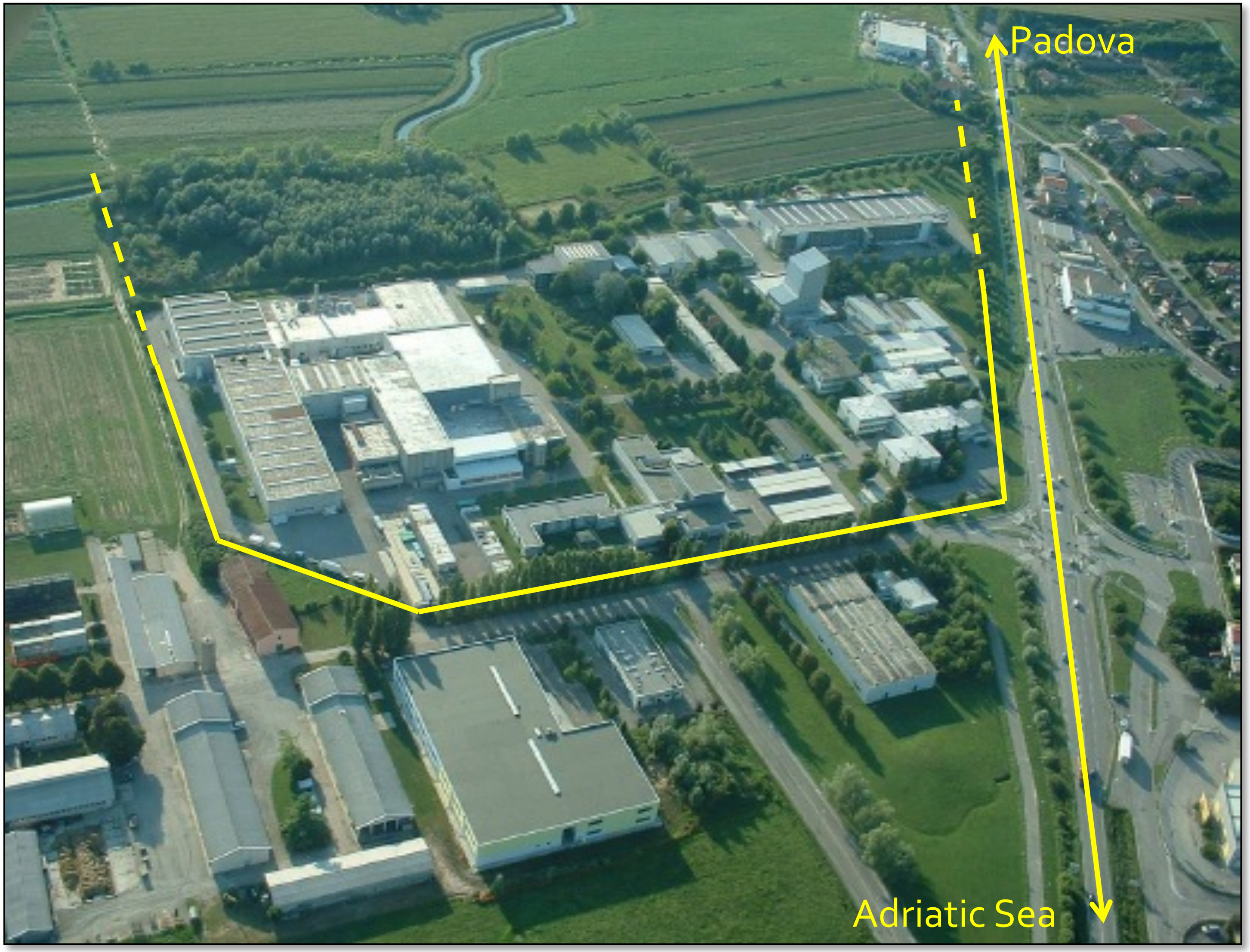
The GALILEO γ–ray array



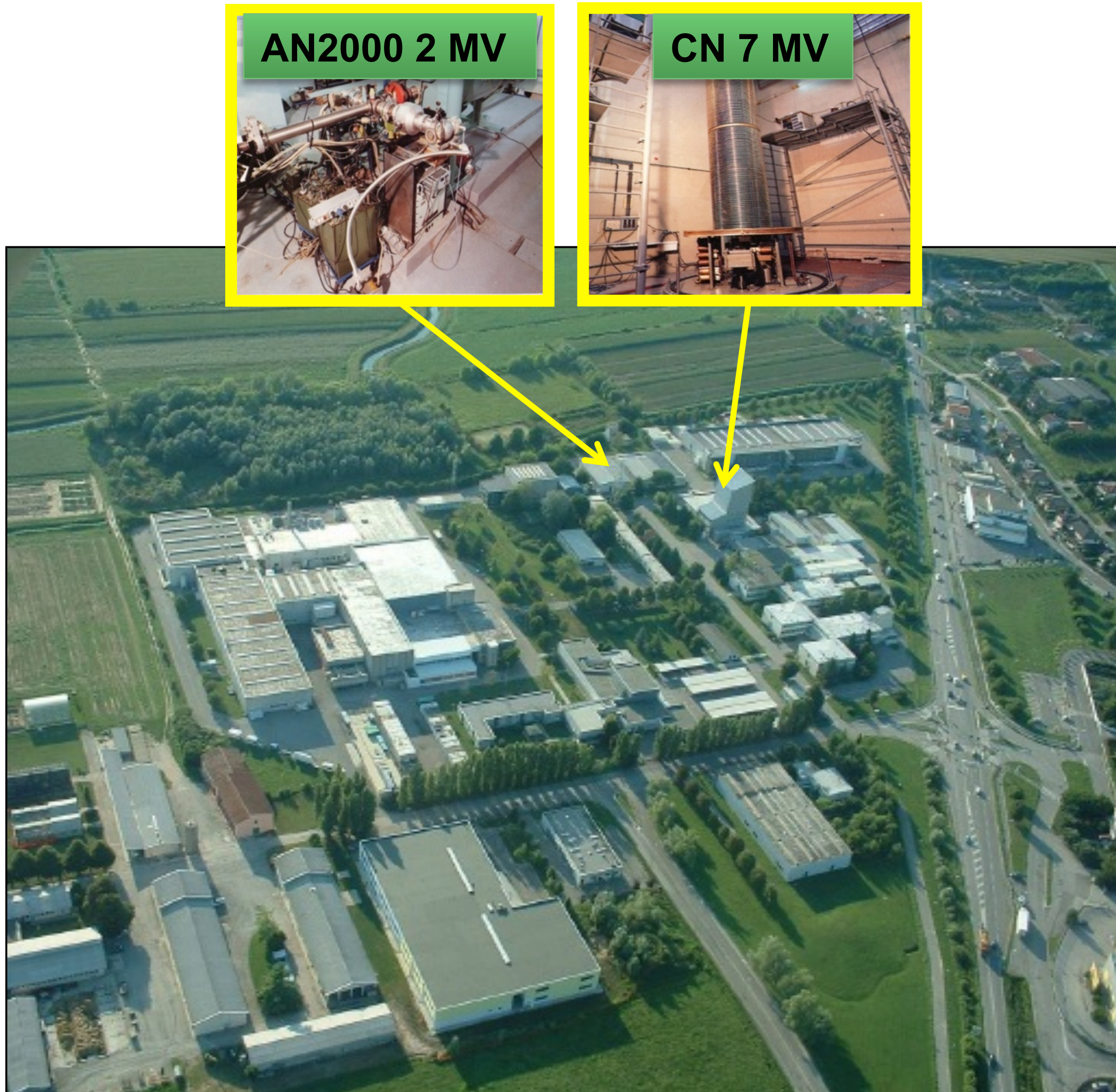
Călin A. Ur
INFN Padova

The Legnaro National Laboratories



The Accelerators of LNL

Applied Physics



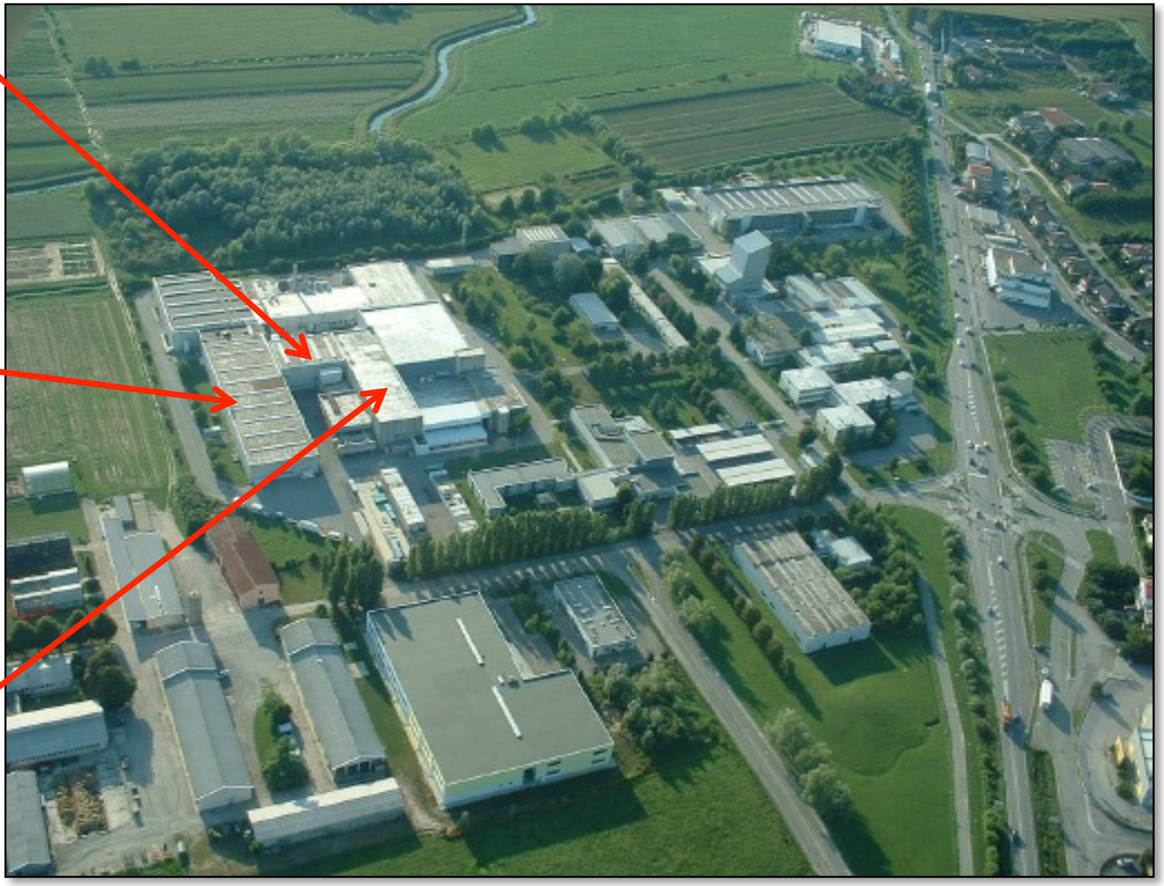
Heavy Ion Accelerators

PIAVE HI Injector

ALPI SC Linac

Tandem XTU

Nuclear Physics Experiments



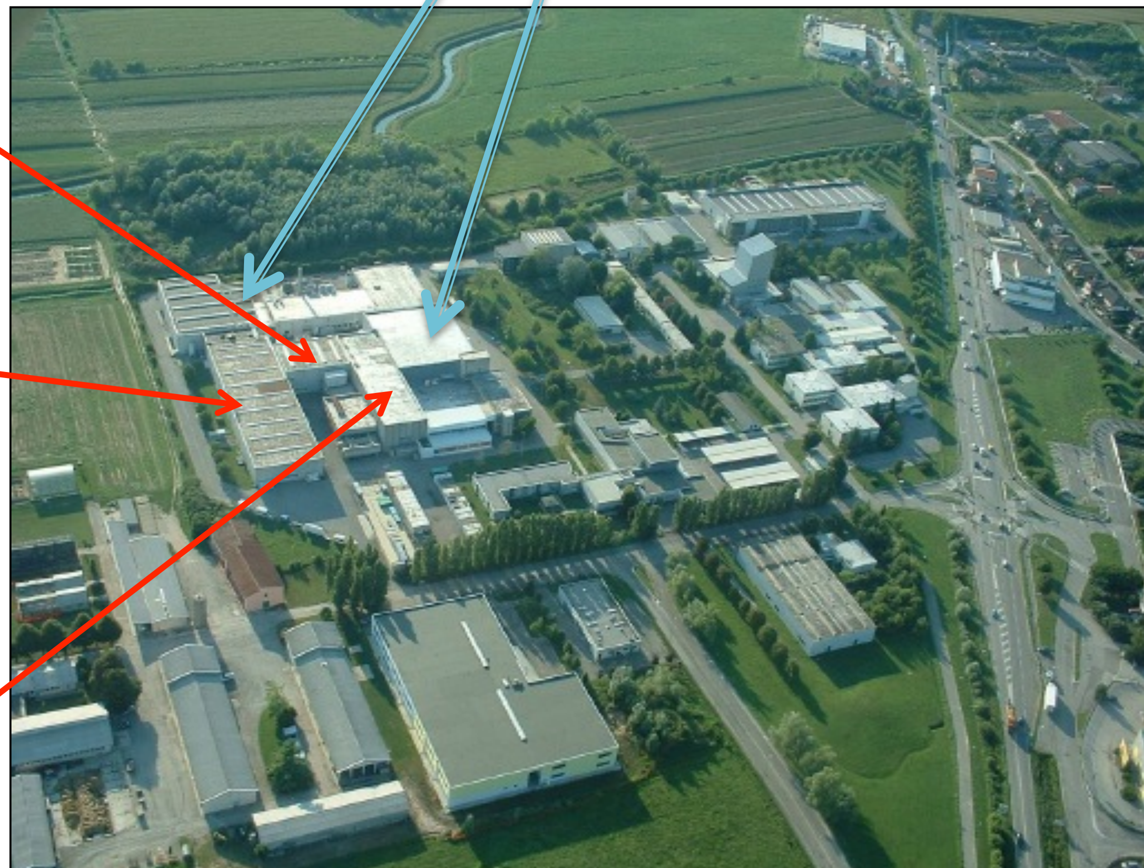
Heavy Ion Accelerators

PIAVE HI Injector

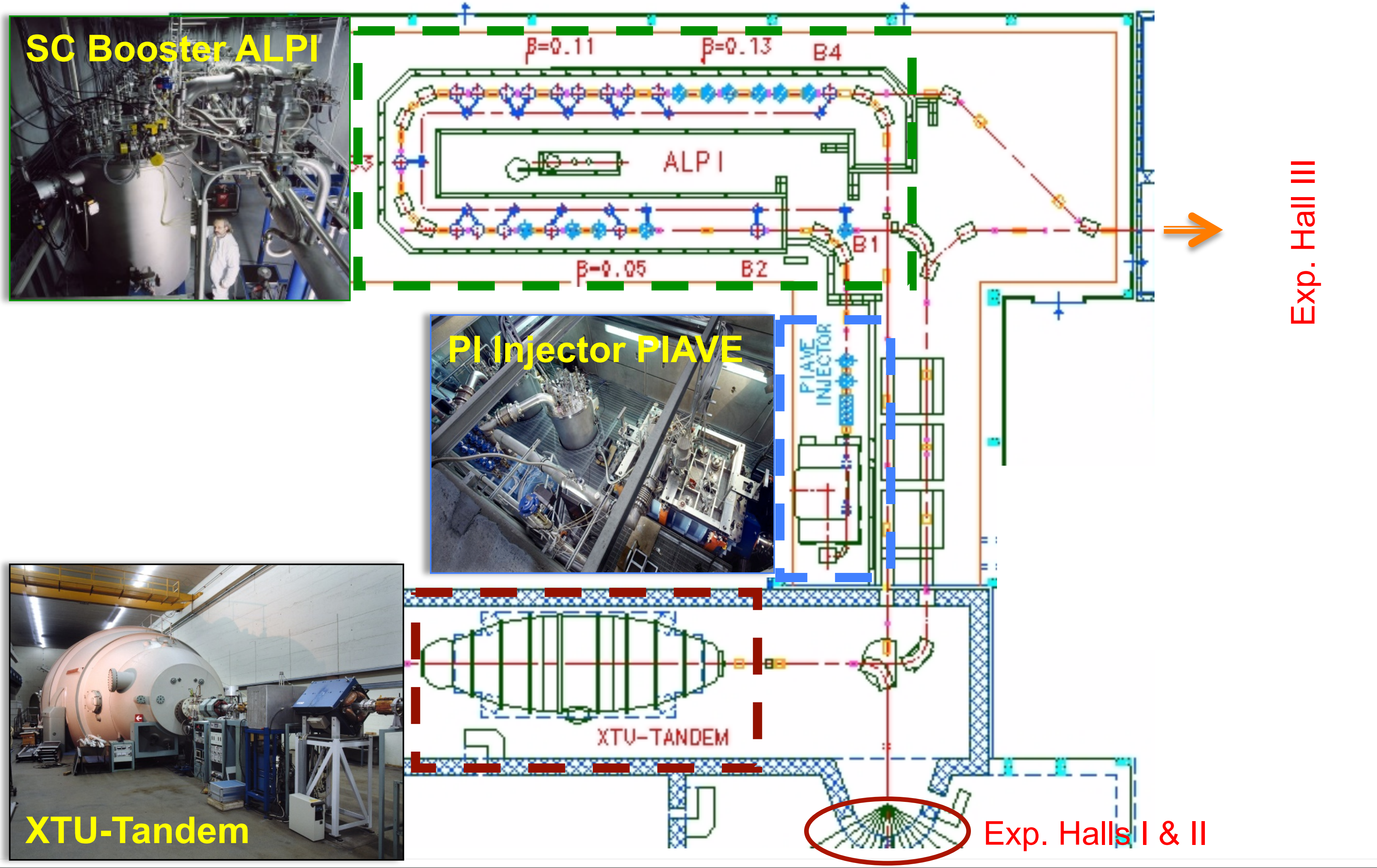
ALPI SC Linac

Tandem XTU

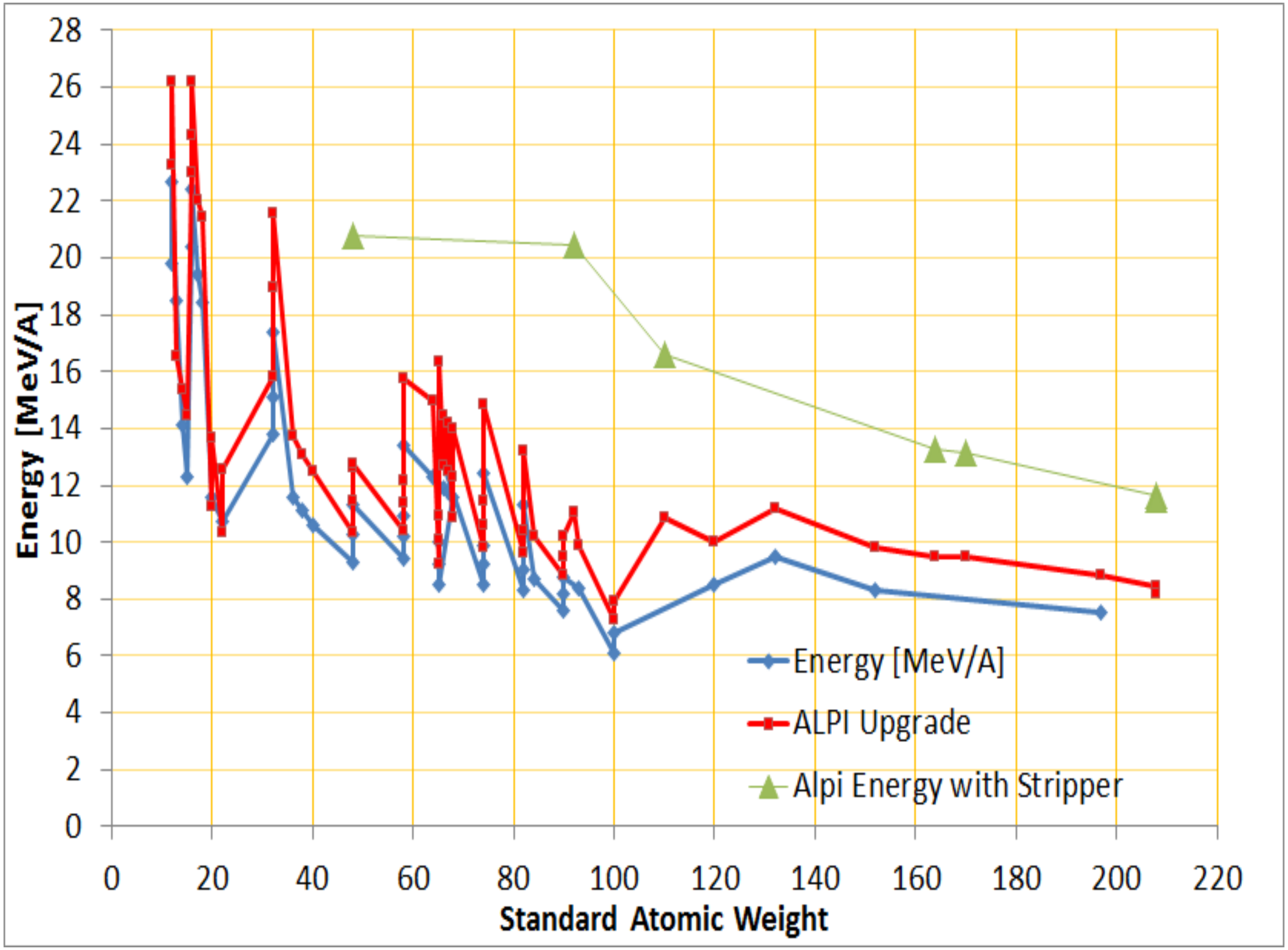
3 Experimental Halls



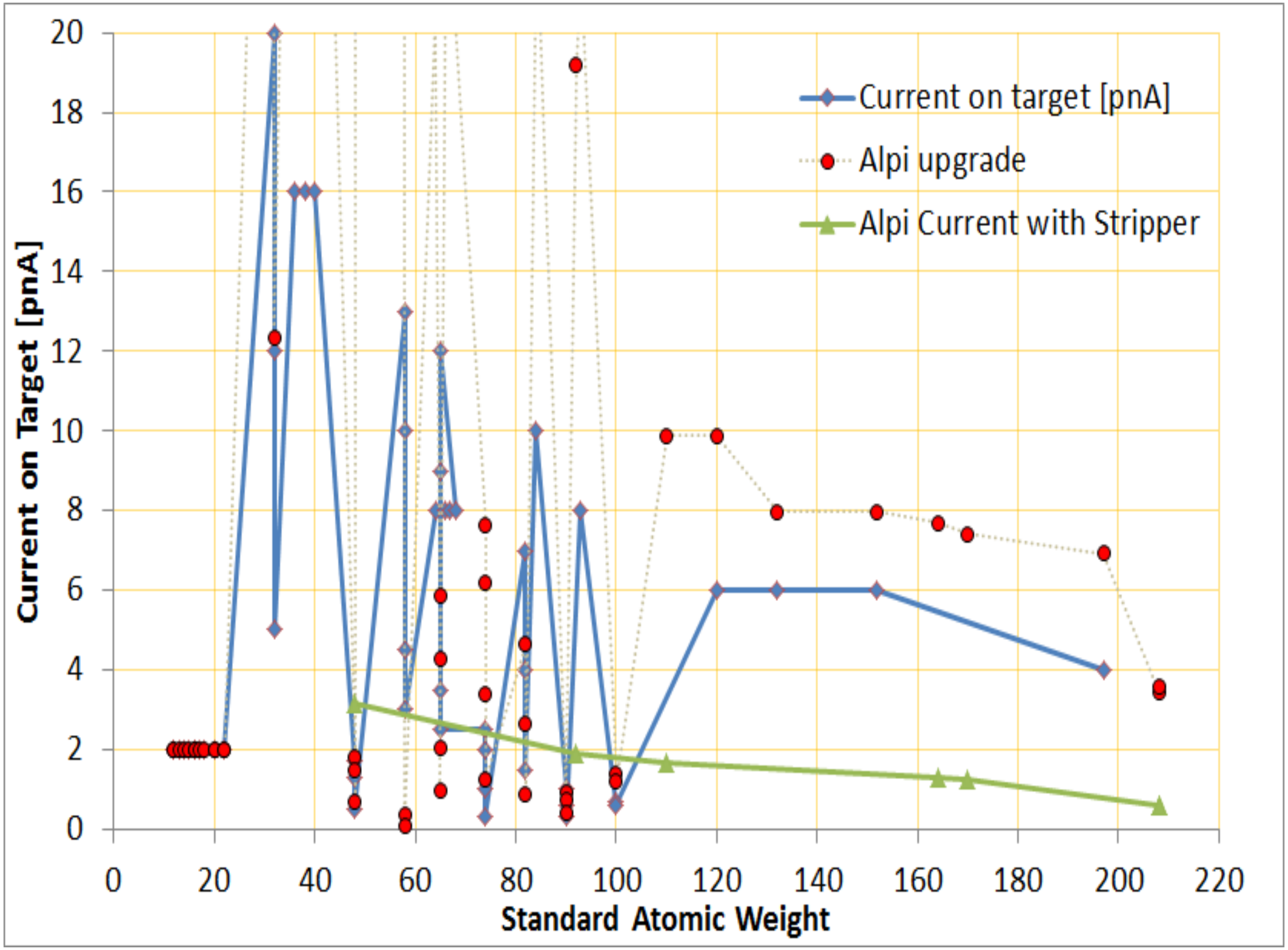
Schematic Layout of the TAP Complex



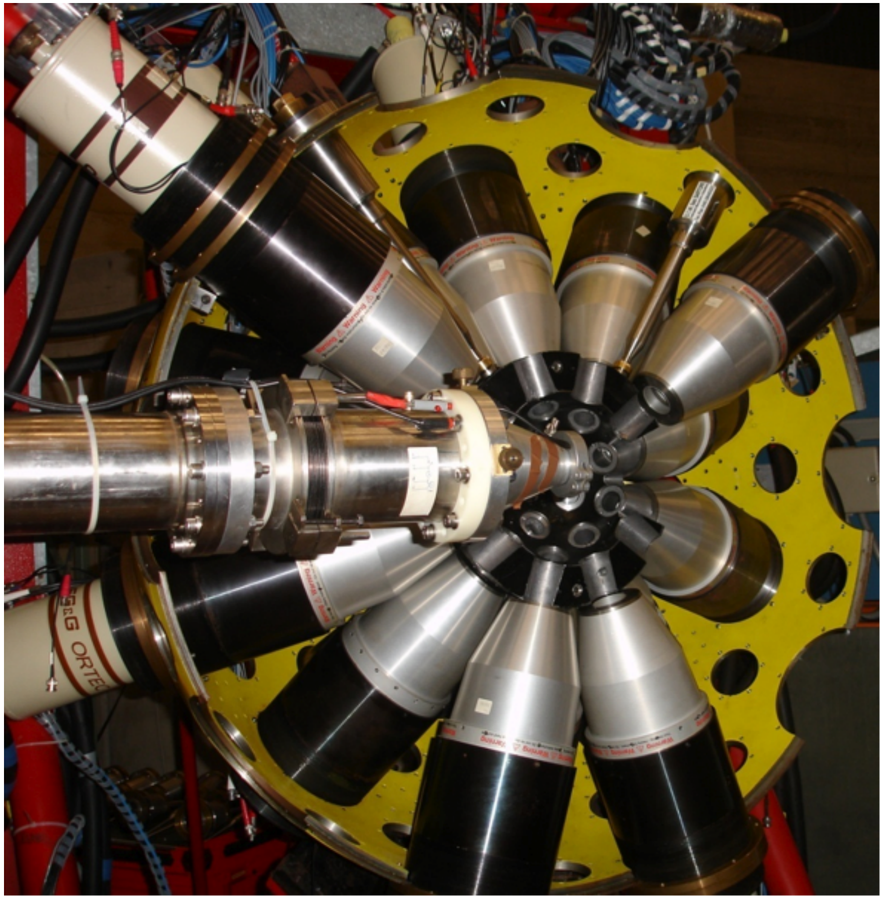
TAP – Beam Energies



TAP – Beam Currents



The GASP Array



GASP
1992 – 2012

40 HPGe (80%) + AC
ε_{ph} (1.3MeV) ~ 3%   (@ 27 cm)   I
~ 5.8% (@ 22 cm)   II
P/T ~ 60%

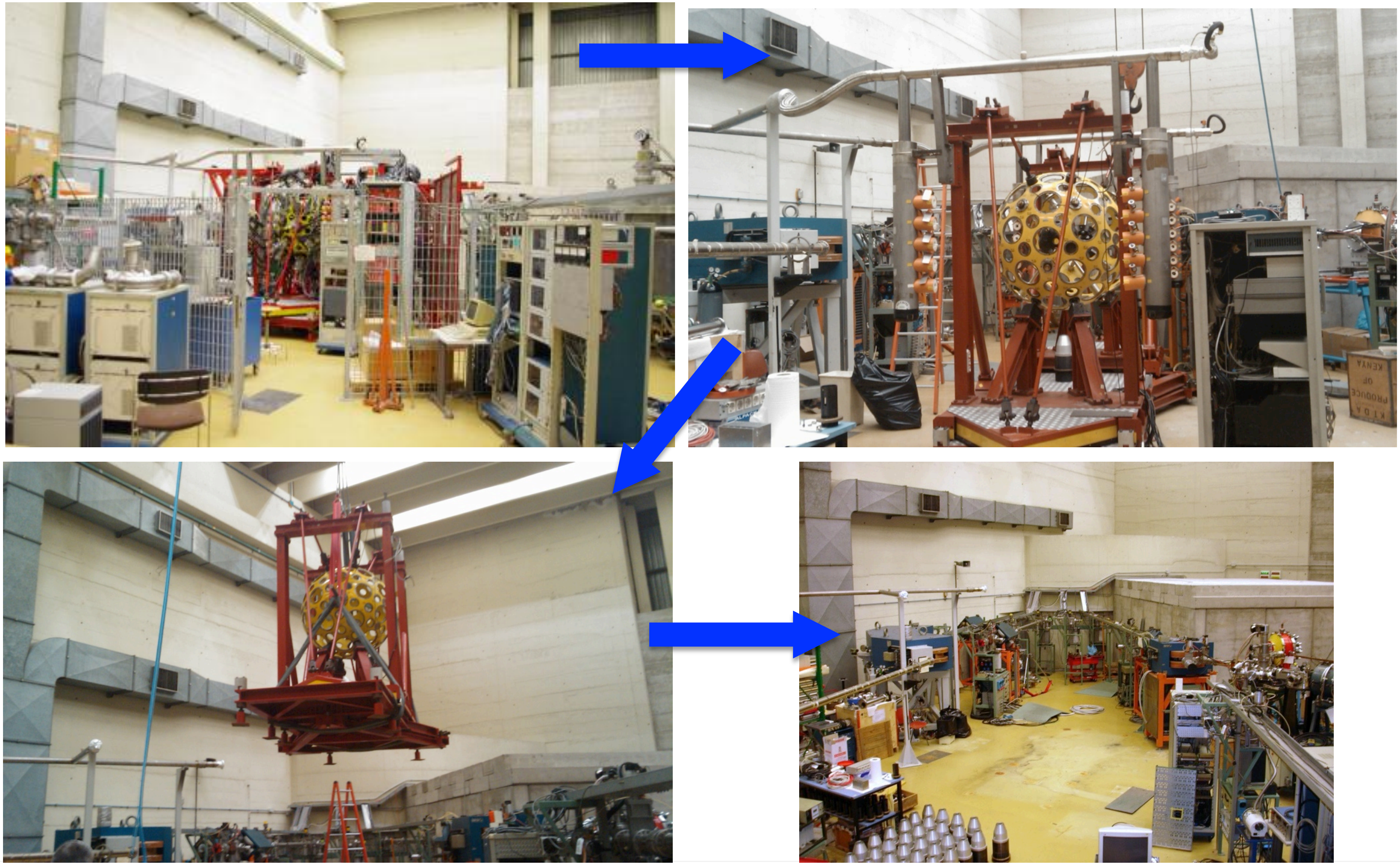
BGO multiplicity filter – 80 elements

Study of high–spin states populated in fusion–evaporation reactions coupled to ancillary detectors such as EUCLIDES, Plunger, n-Ring, RFD, LuSiA

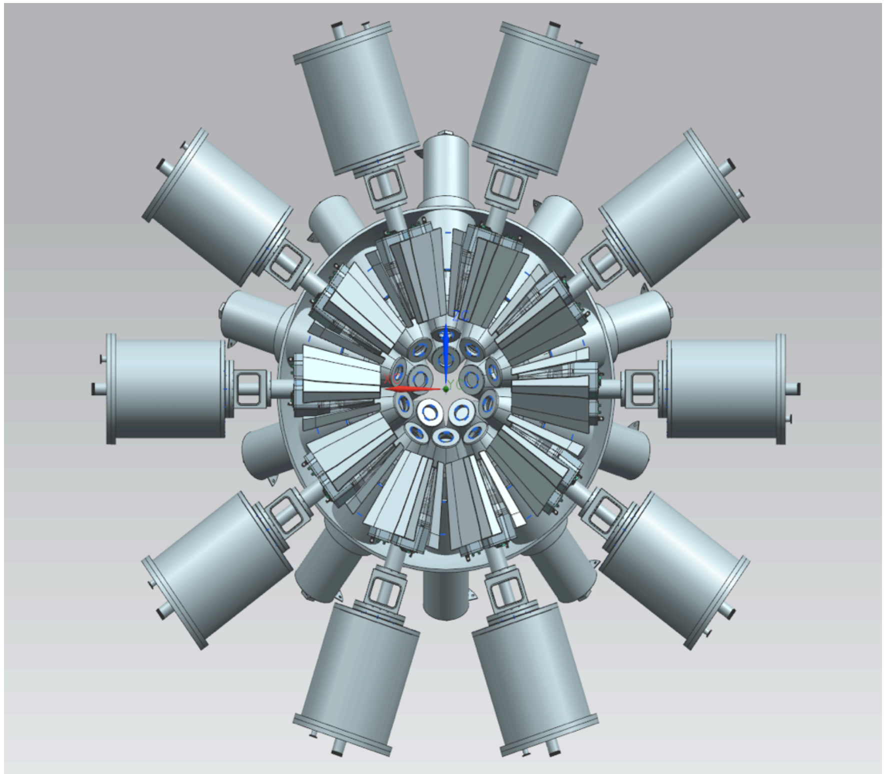
March 6 – 12 last experiment

<u>April 4 – official shutdown</u>

Dismounting the GASP Array



The GALILEO Array



30 GASP detectors @ 22.5cm

5	5	5	5	5	5
29°	51°	59°	121°	129°	151°

10 triple cluster (EB capsules) @ 24cm

90°

European Collaboration

call for LoI in 2009

take advantage of the recent technical developments for AGATA

preamplifiers, digital sampling, preprocessing, DAQ

→ **high counting rates (30–50 kHz/det)**

use of existing detectors

EB cluster detectors capsules

GASP detectors

→ **high photopeak efficiency**

ε_{ph} ~ 8%   **P/T ~ 50%**

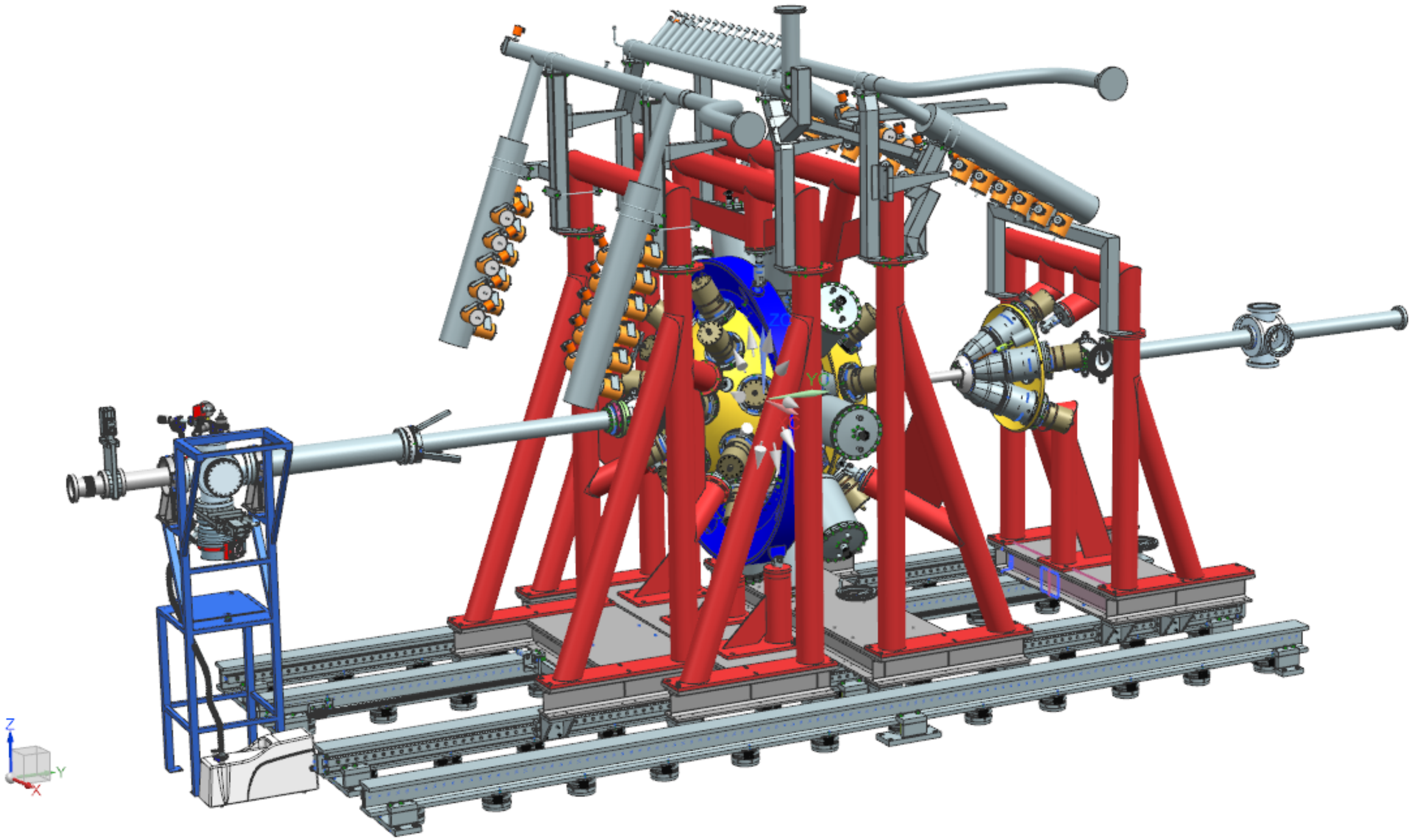
use beam facilities at LNL

Tandem, ALPI, PIAVE – stable

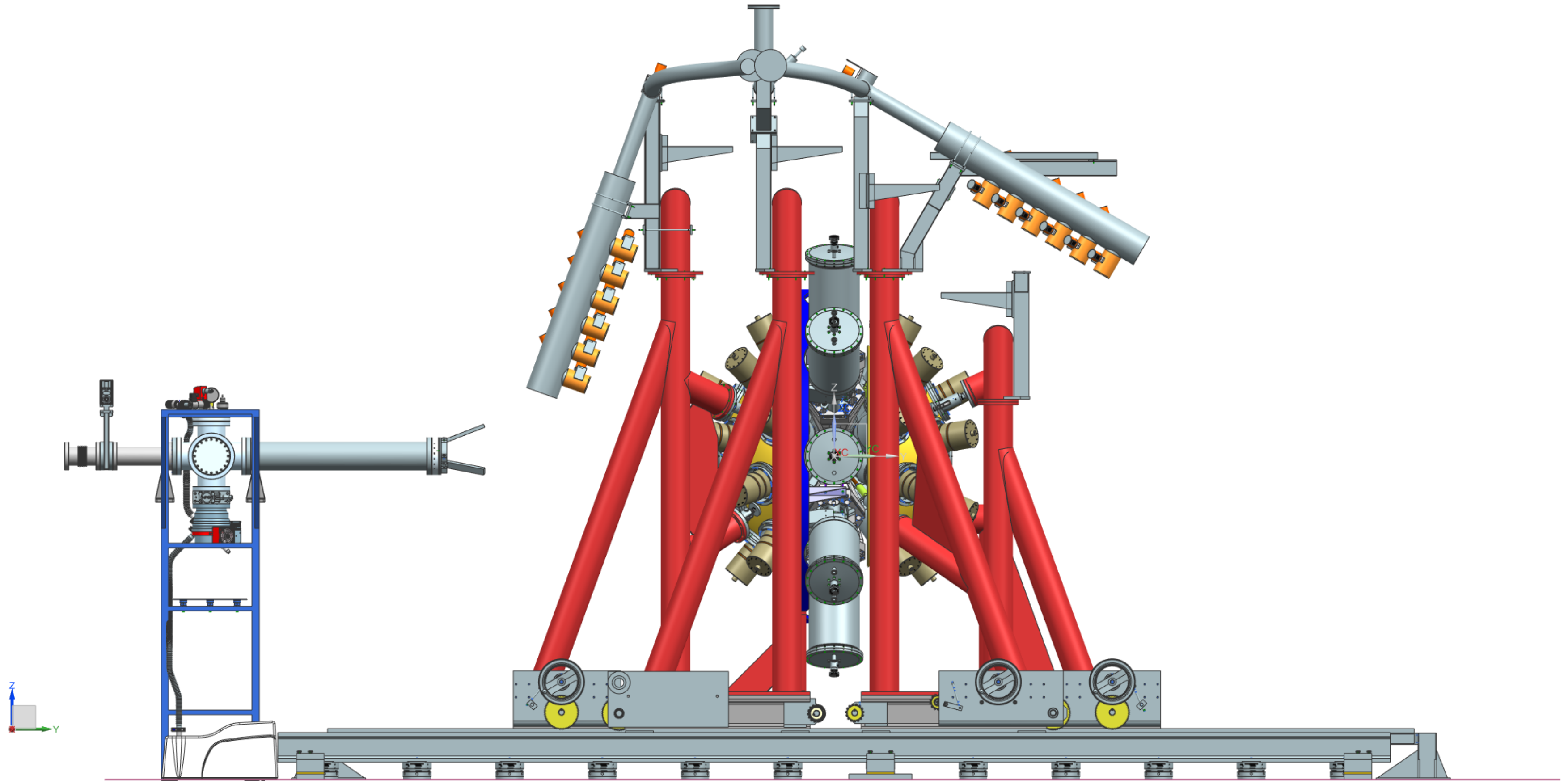
SPES – RIB

→ **production of new nuclei**

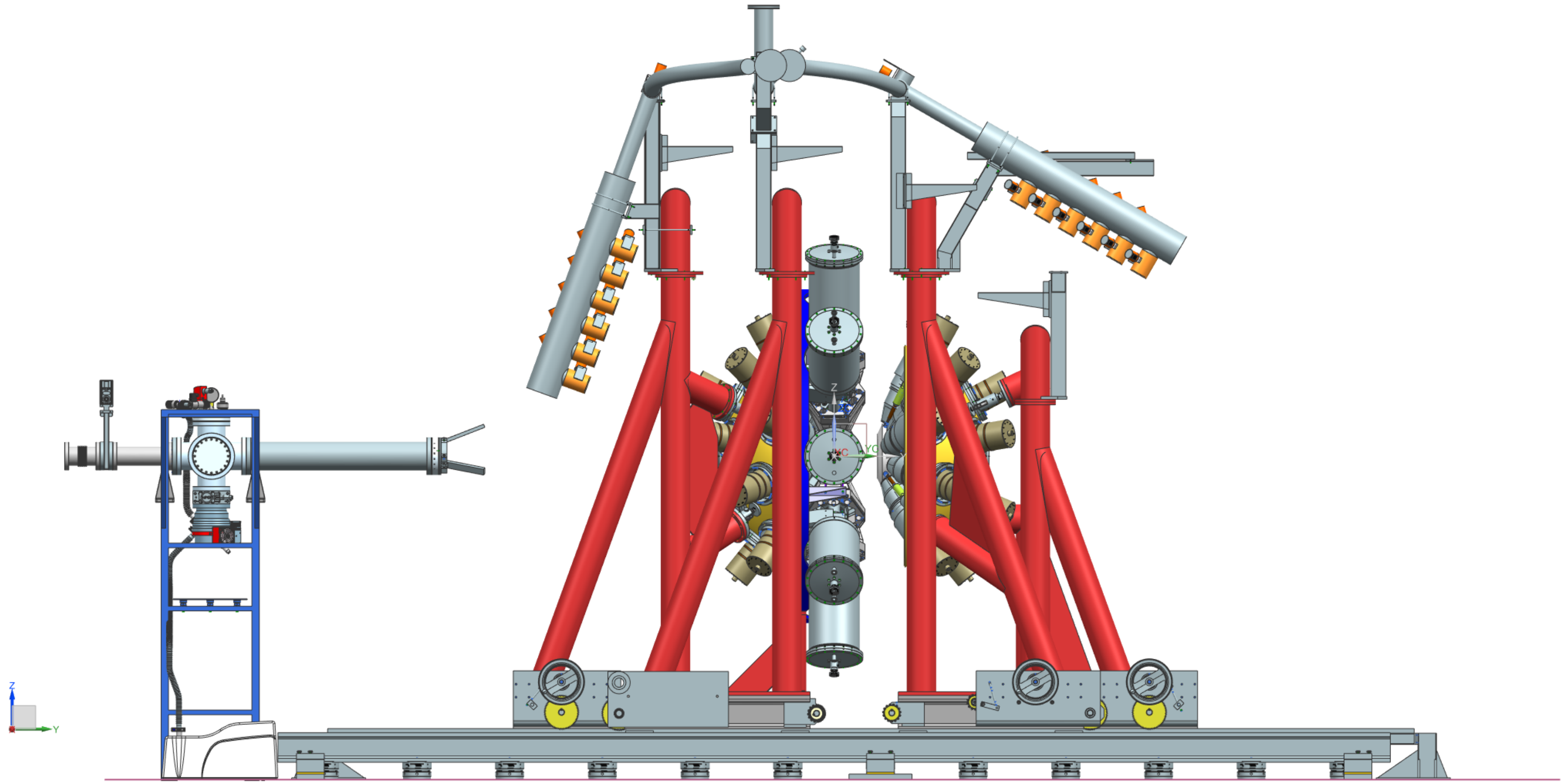
The GALILEO Array



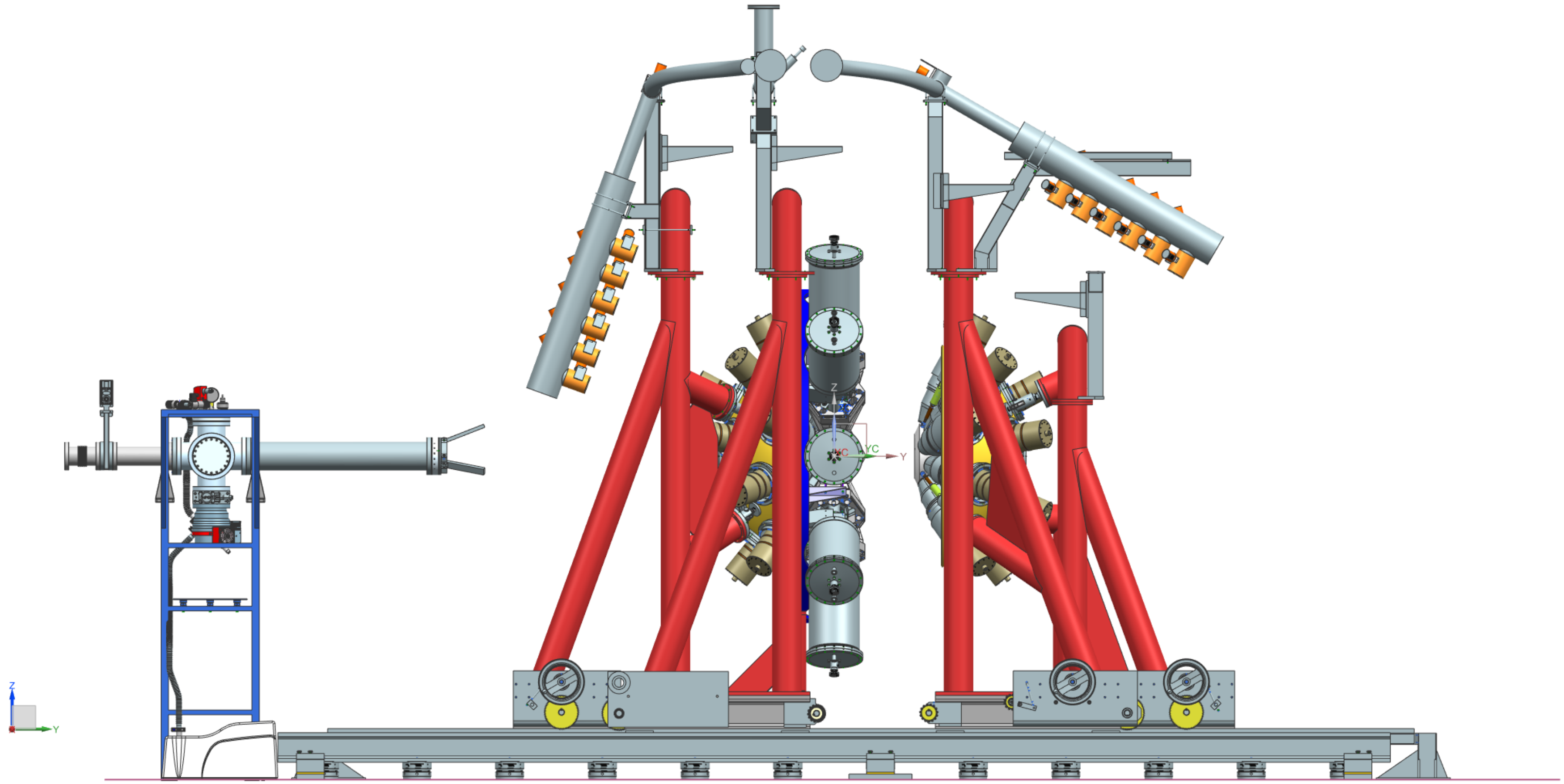
The GALILEO Array



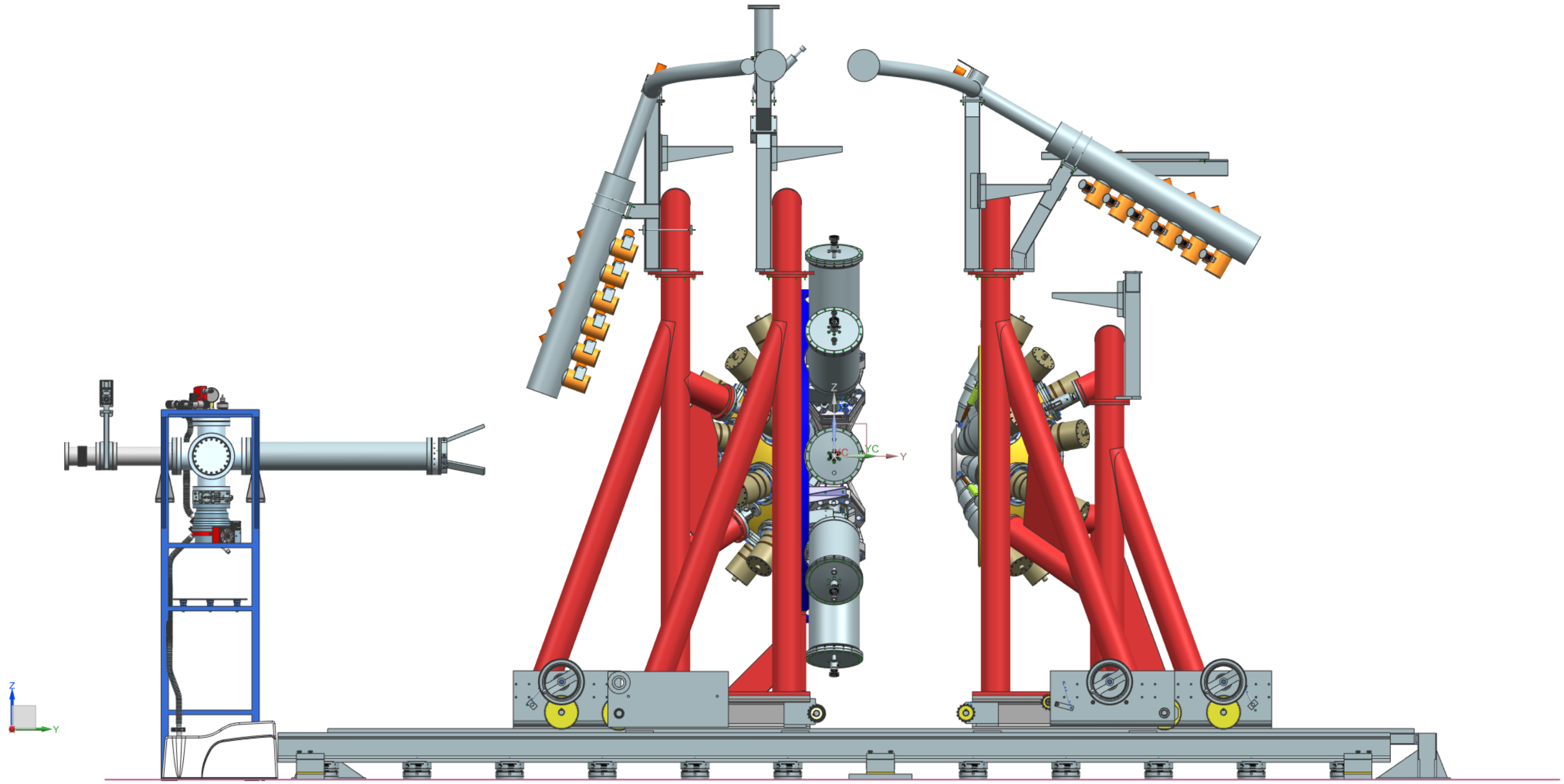
The GALILEO Array



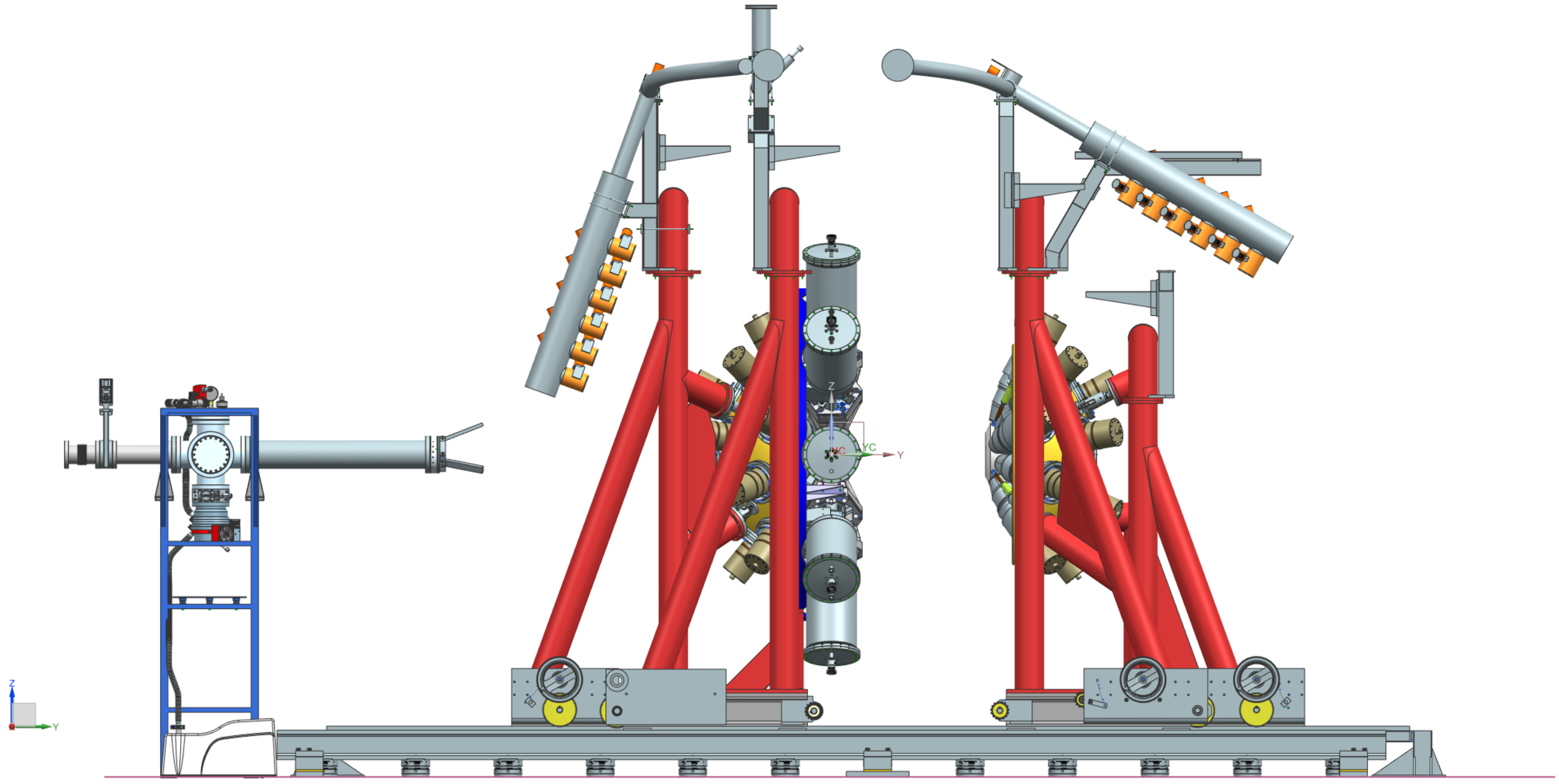
The GALILEO Array



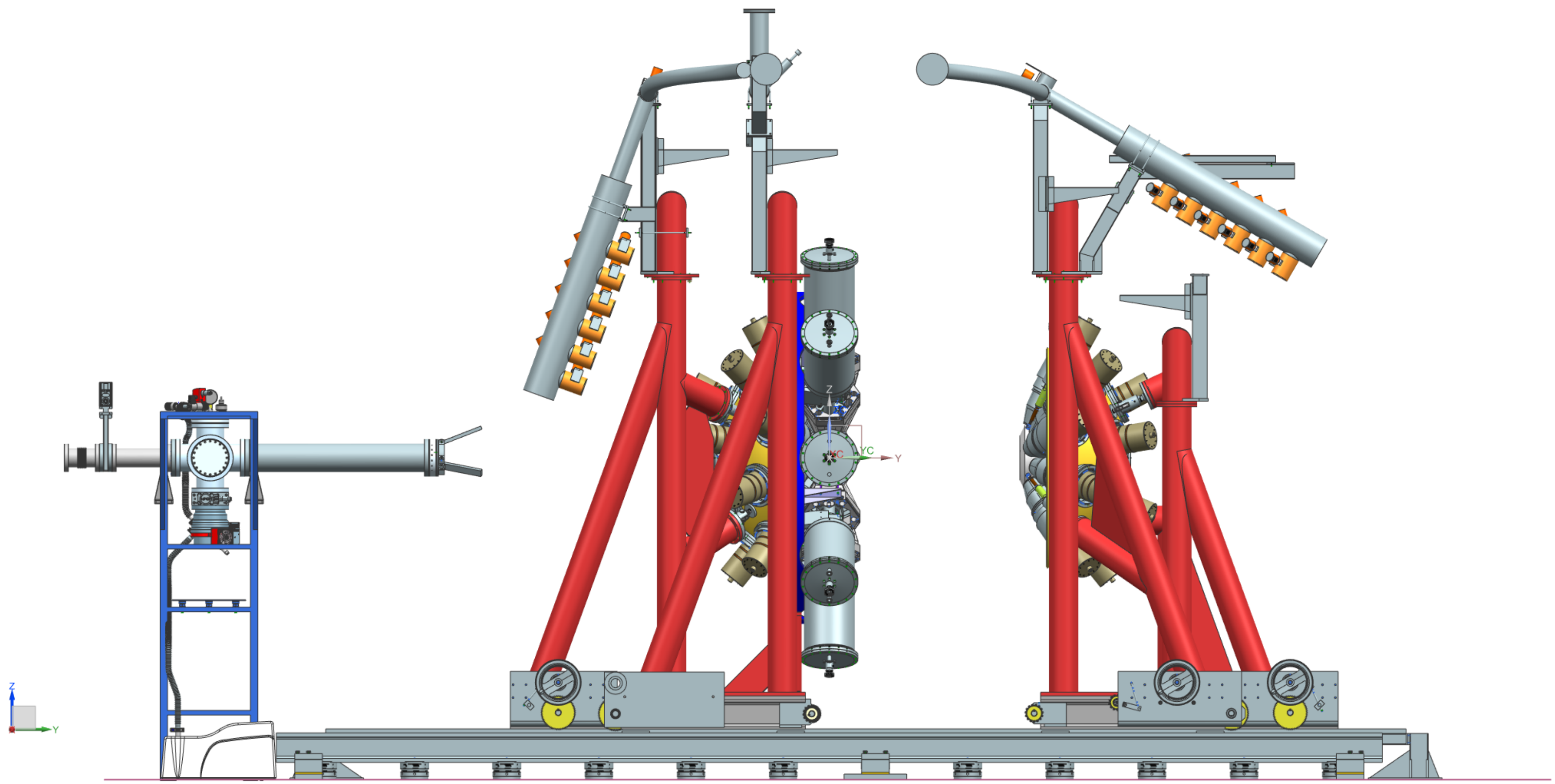
The GALILEO Array



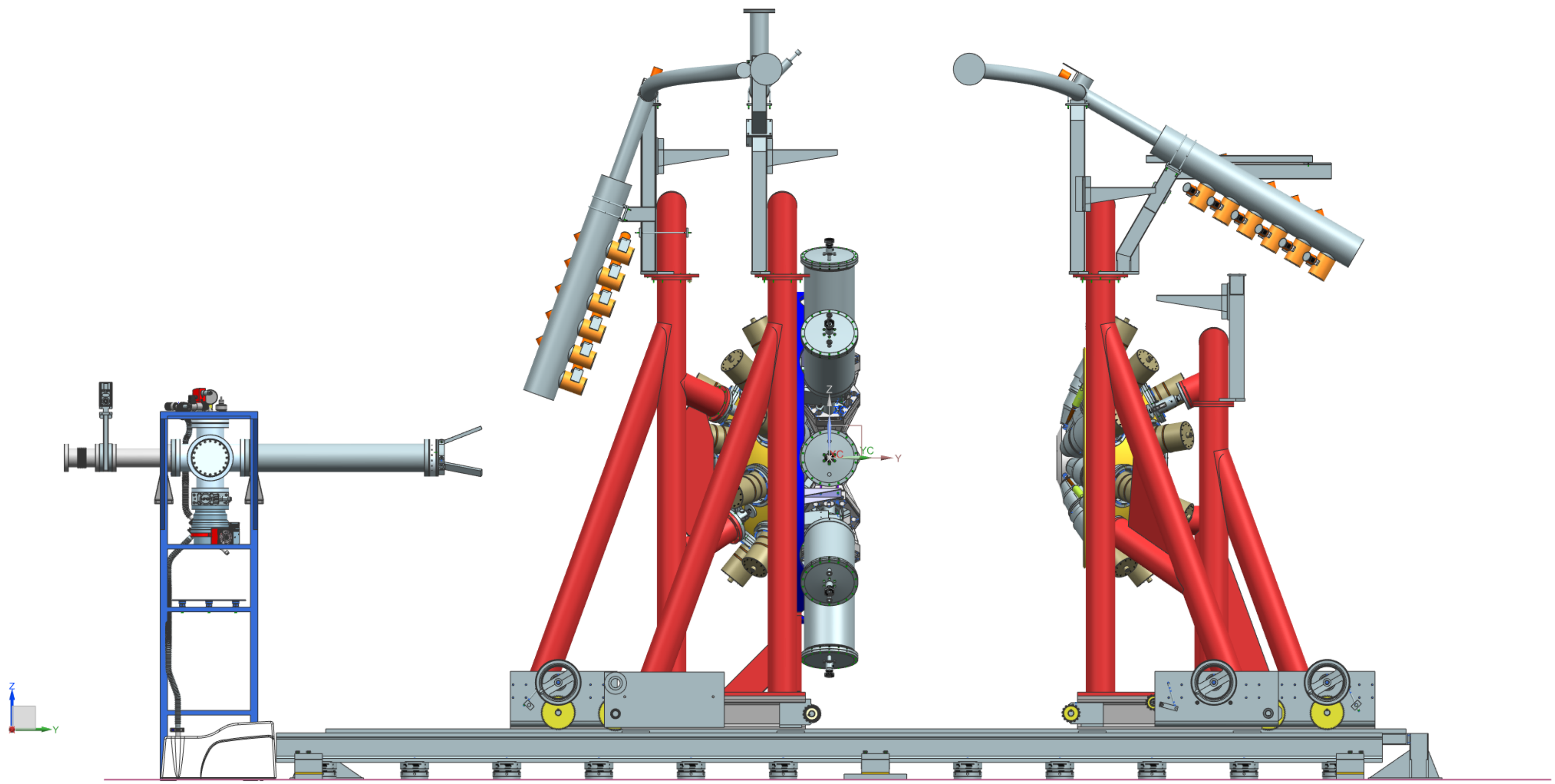
The GALILEO Array



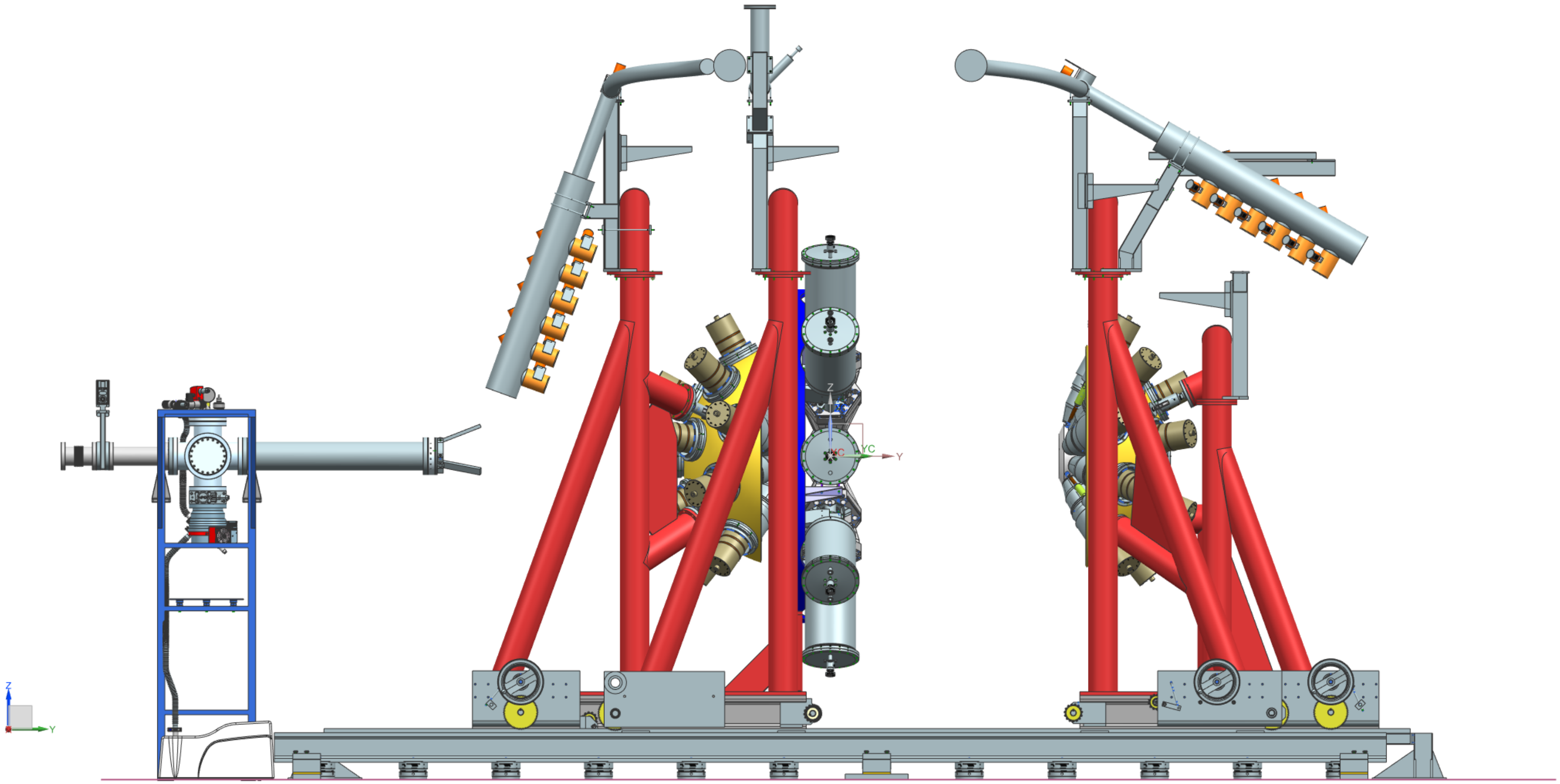
The GALILEO Array



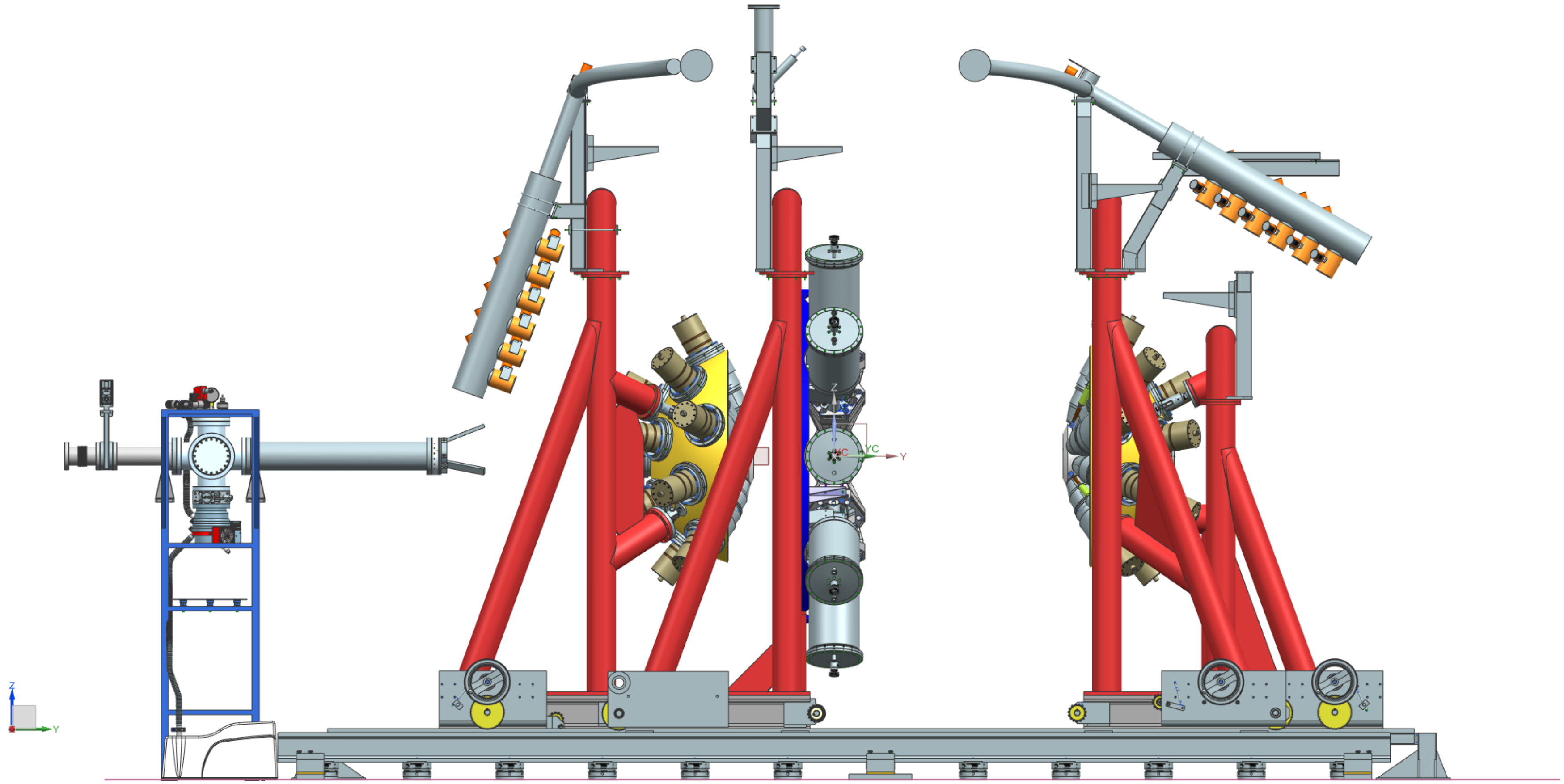
The GALILEO Array



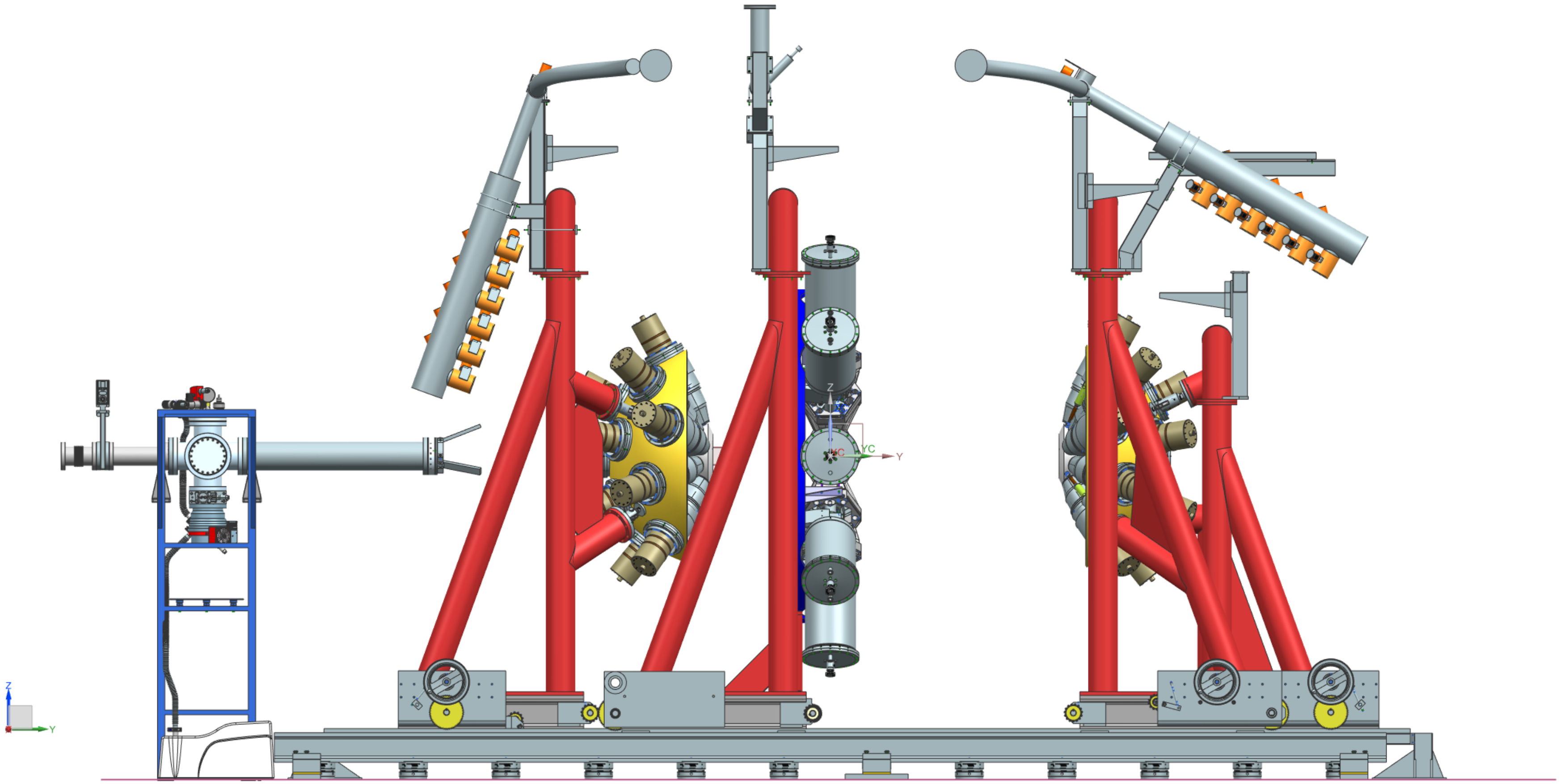
The GALILEO Array



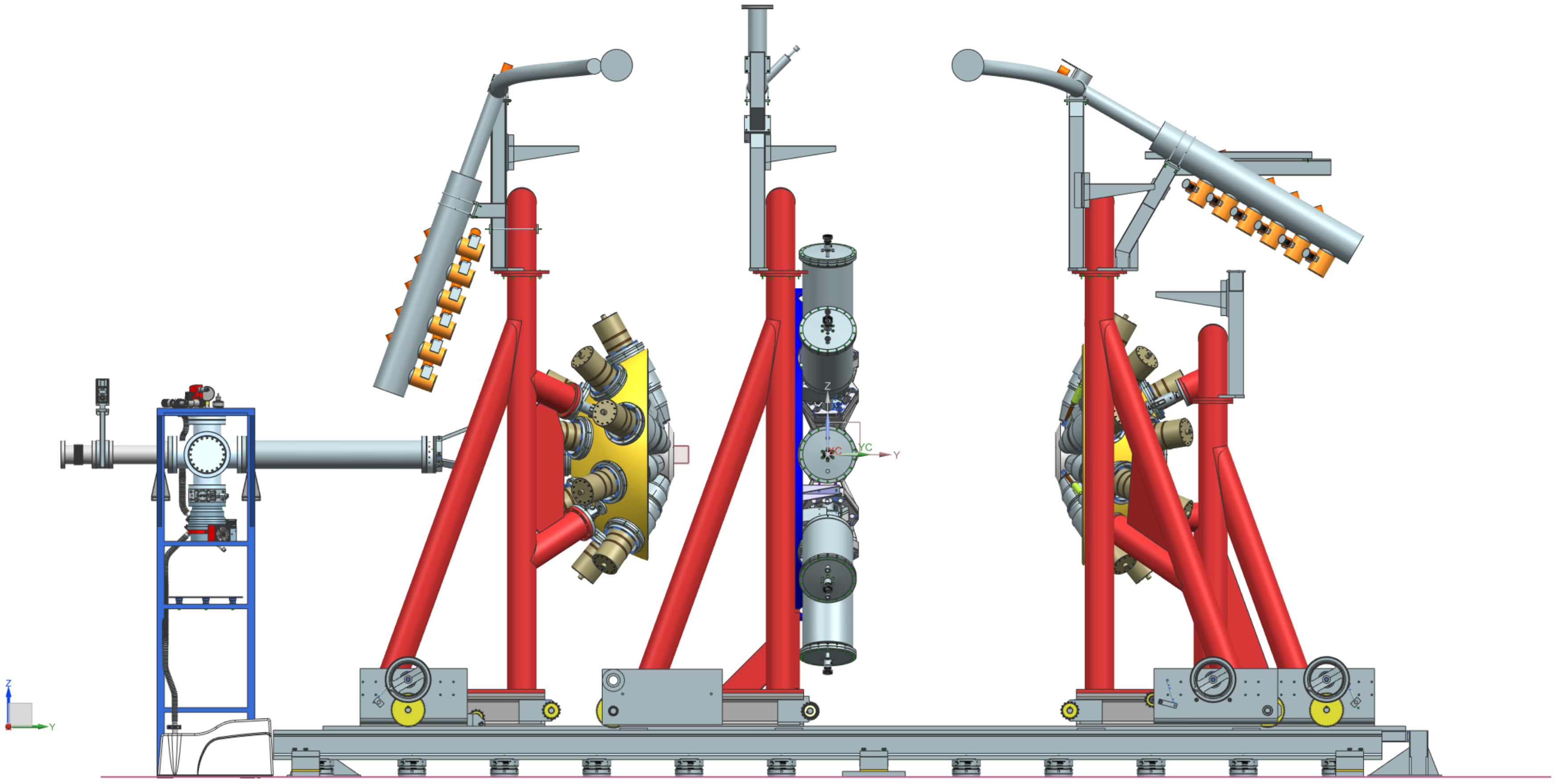
The GALILEO Array



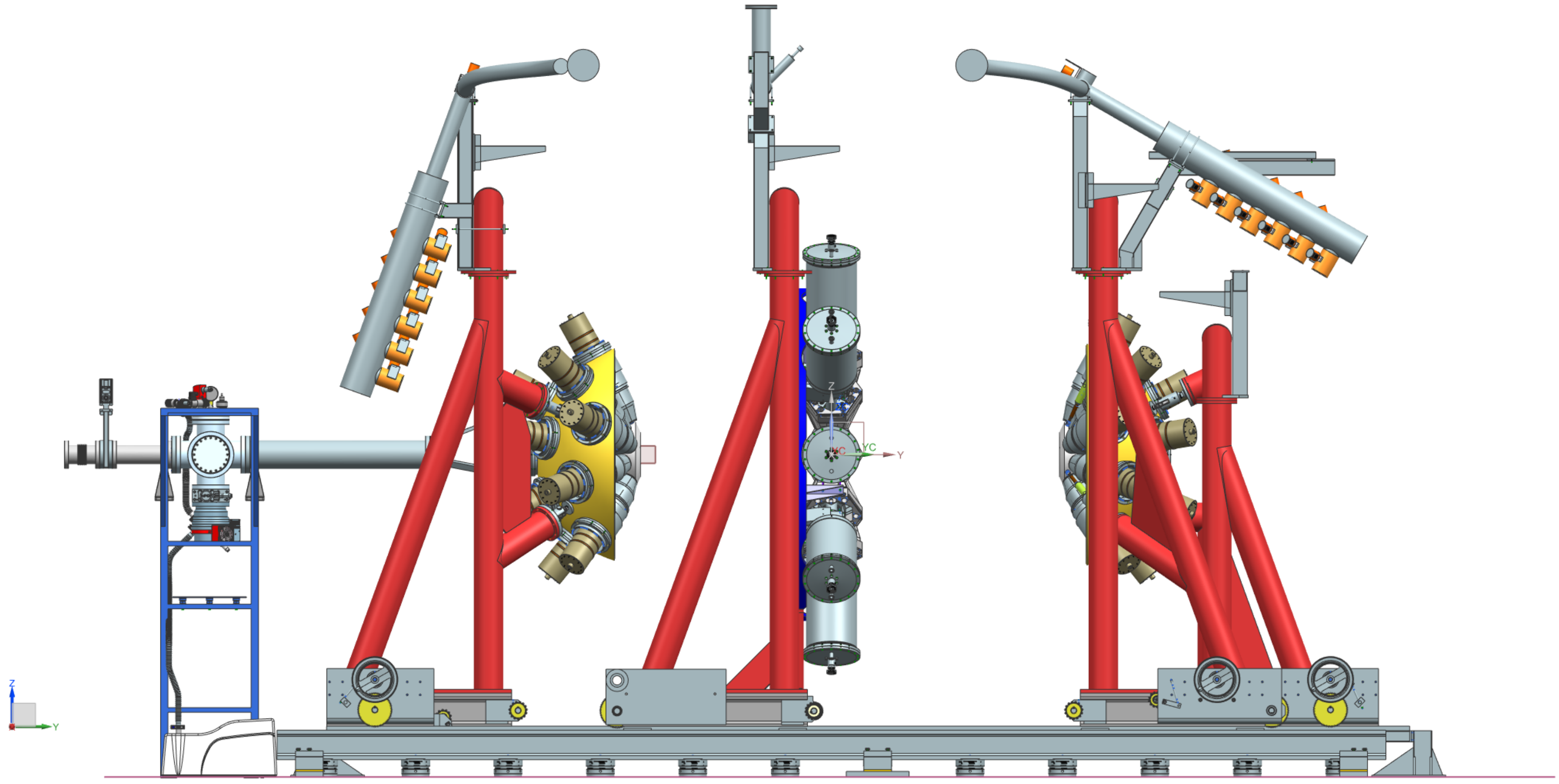
The GALILEO Array



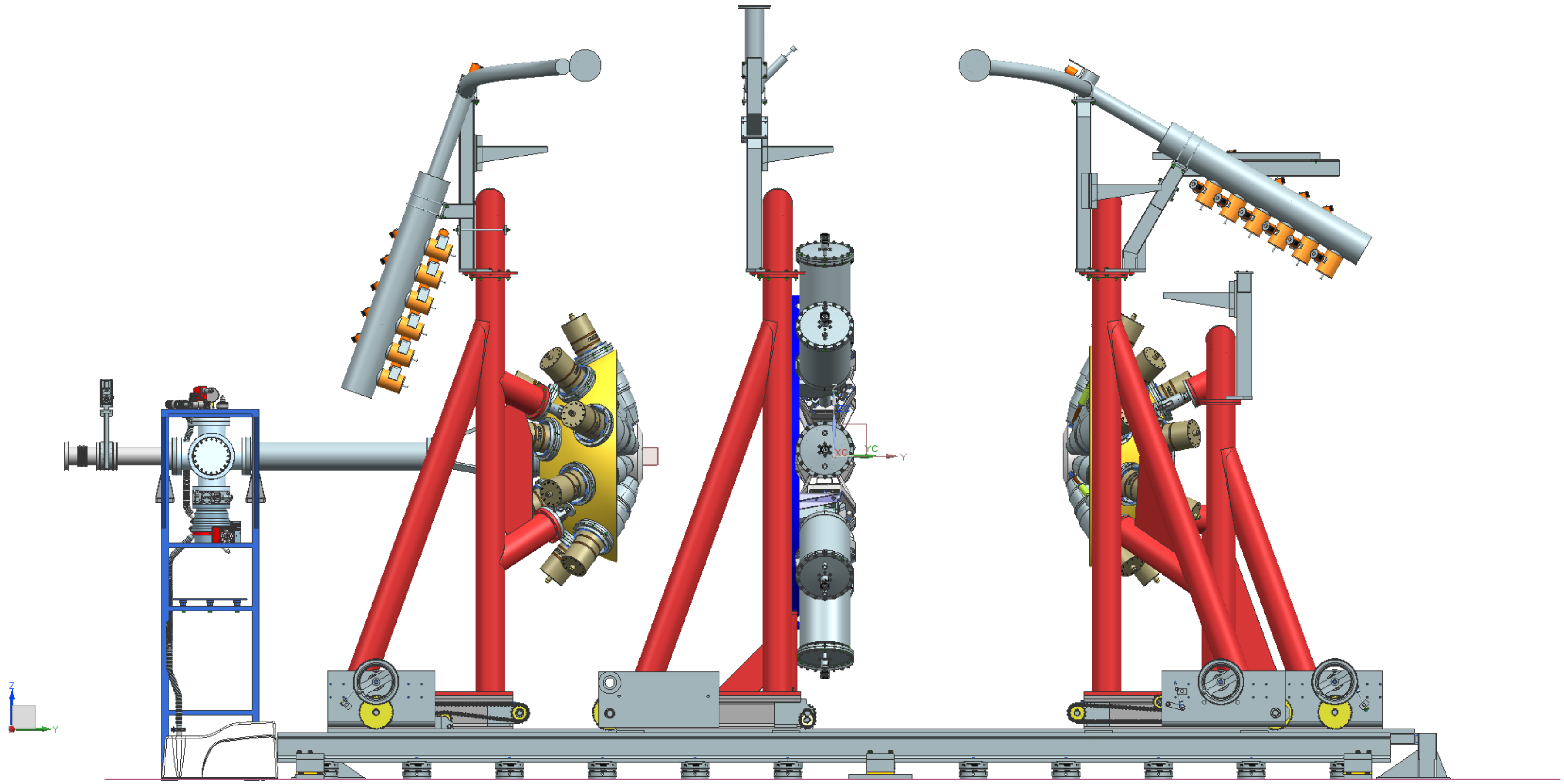
The GALILEO Array



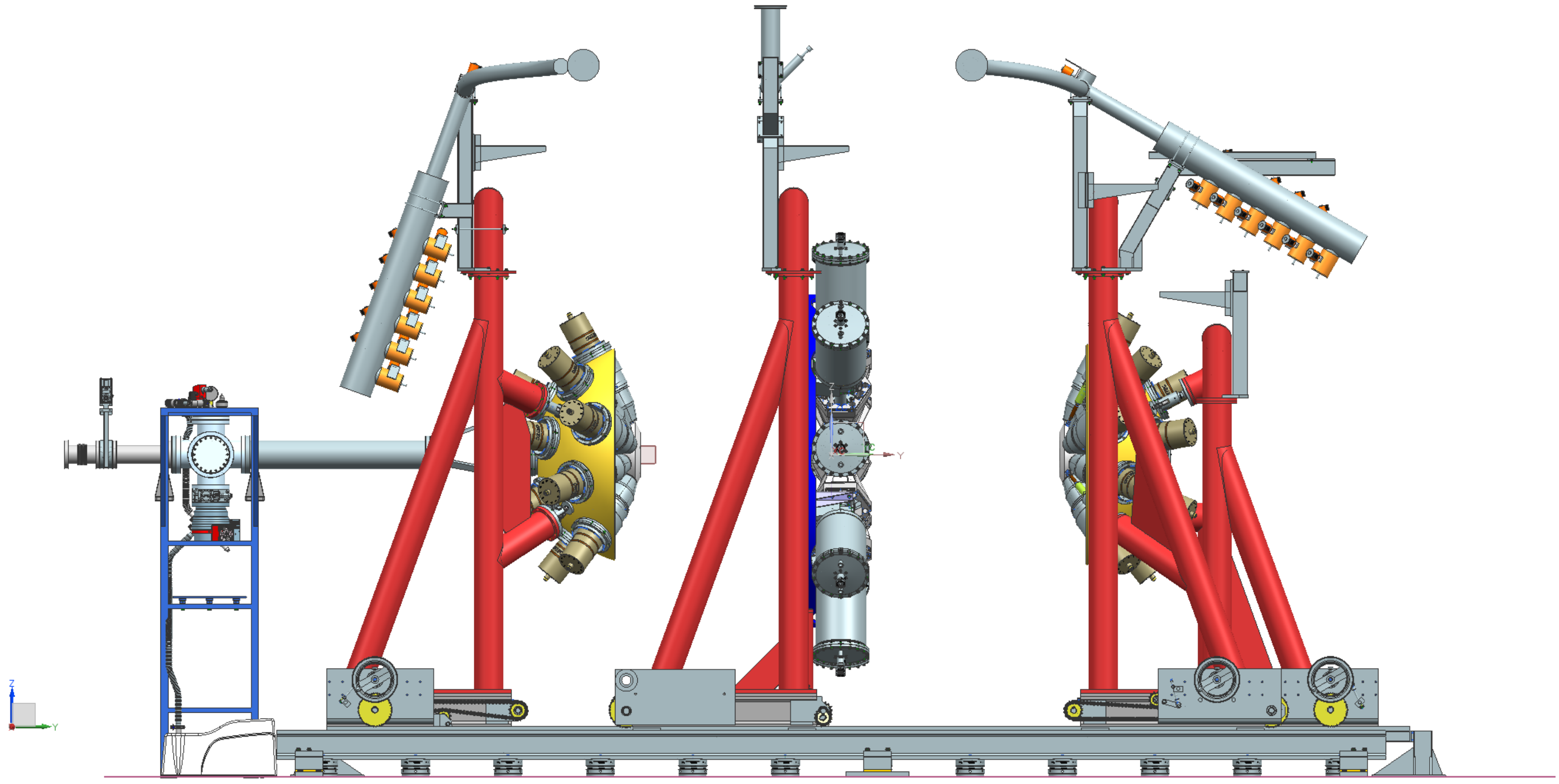
The GALILEO Array



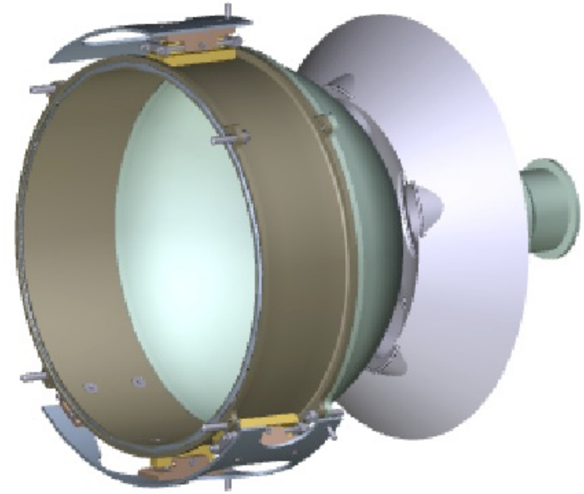
The GALILEO Array

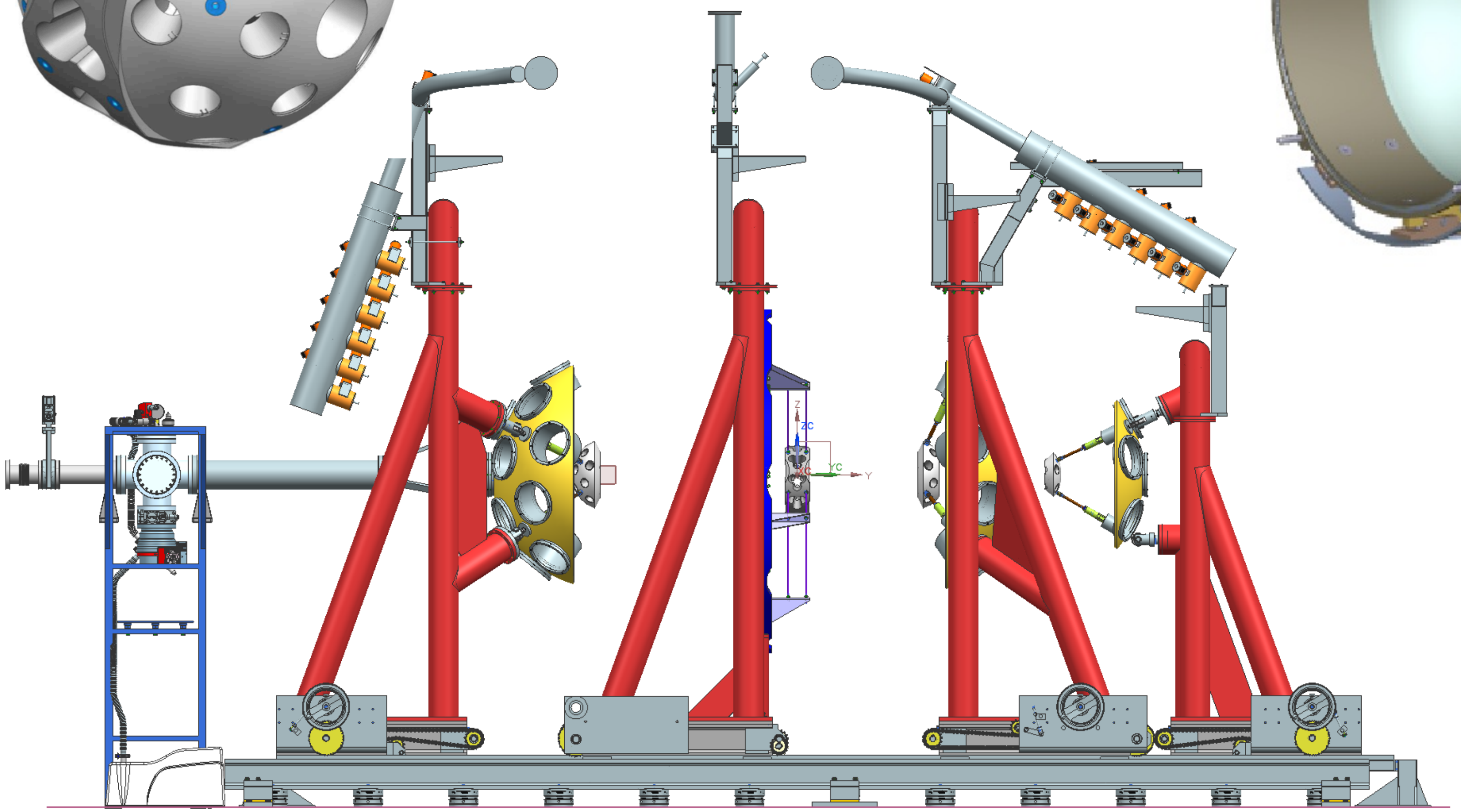


The GALILEO Array

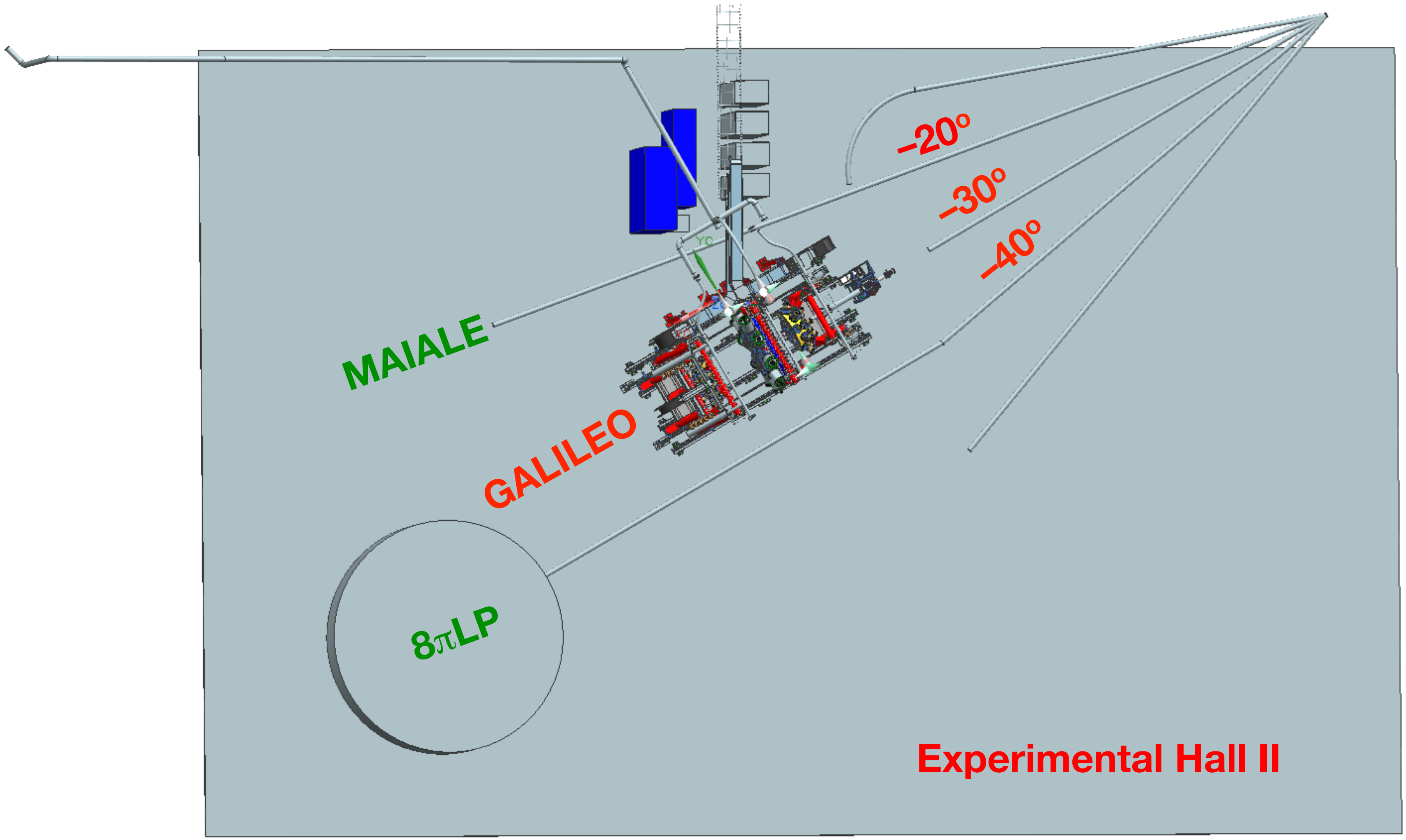


GALILEO – Pb Collimator

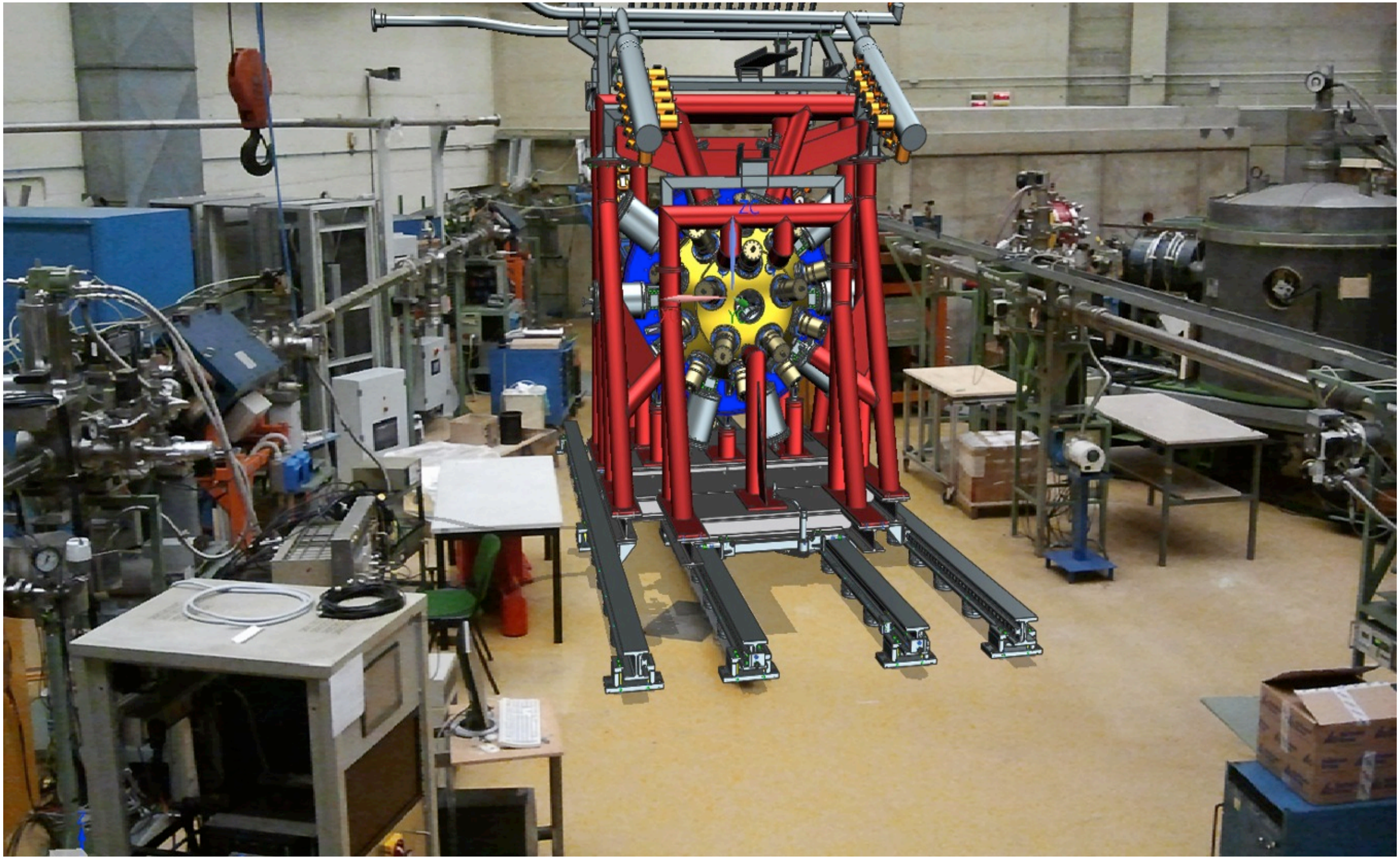




GALILEO – Location

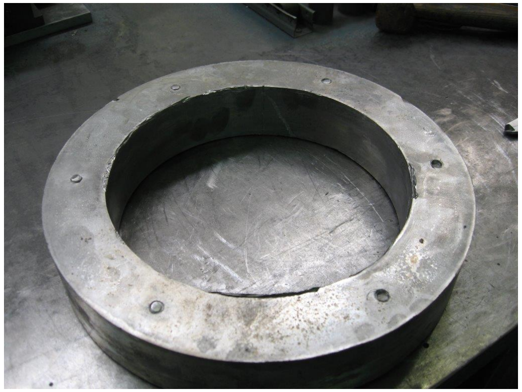


GALILEO in Hall II

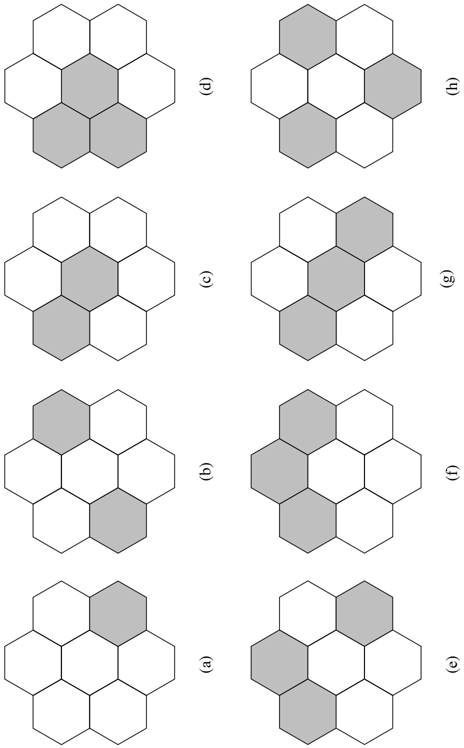


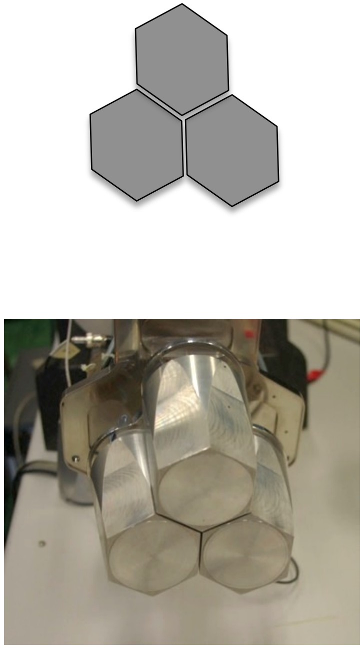
GALILEO in Hall II

GALILEO in Hall II



GTC – GALILEO Triple Cluster Detector





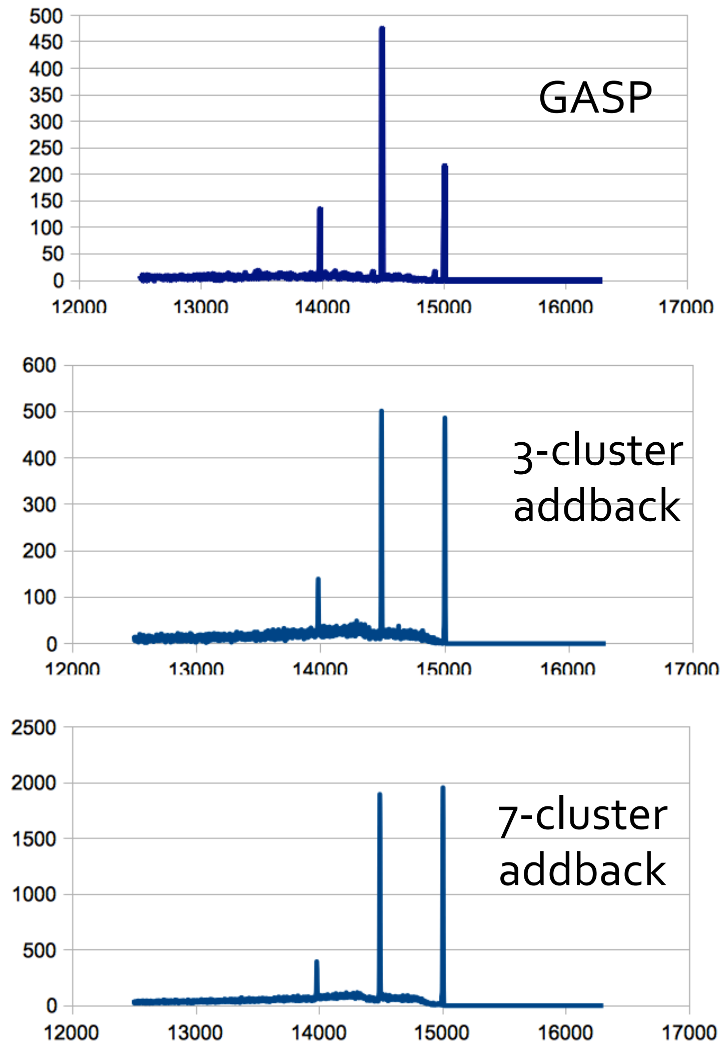
EB cluster detectors

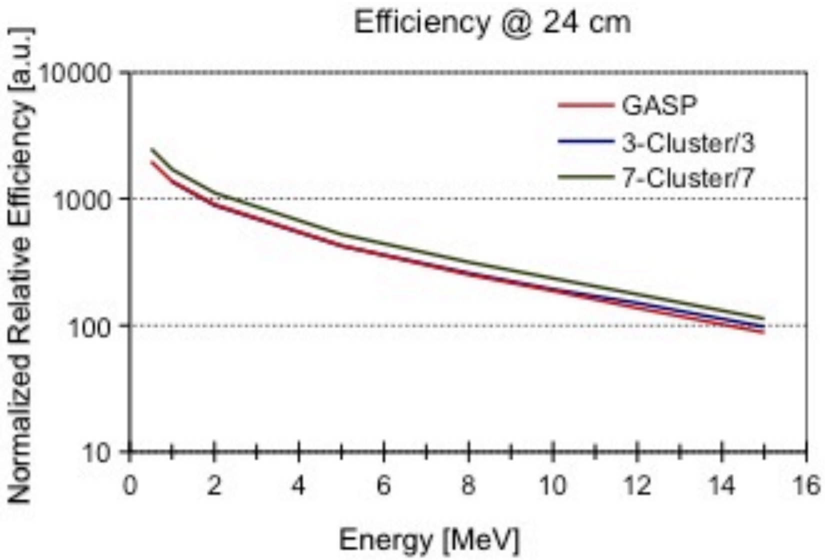
- 7 encapsulated n–type HPGe detectors
- FWHM < 2.4 keV @ 1332.5 keV
  - ε_{int} ~60%

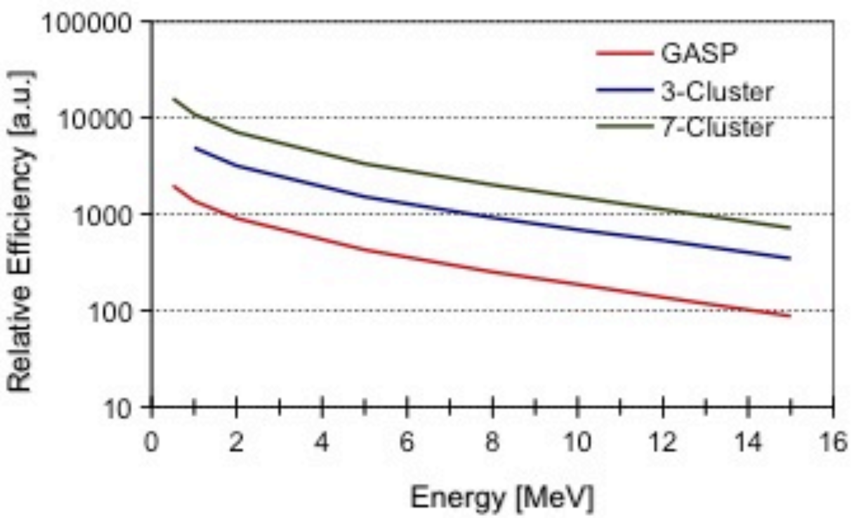
GALILEO cluster detectors

- 3 encapsulated n–type HPGe detectors
- FWHM < 2.4 keV @ 1332.5 keV
  - ε_{int} ~60%

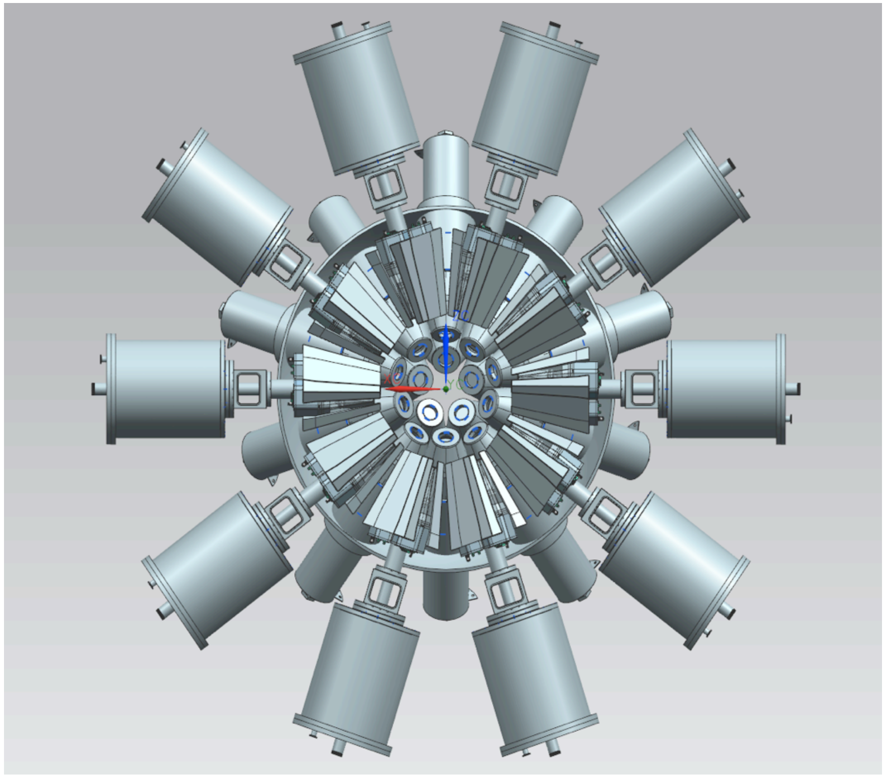
GTC – GALILEO Triple Cluster Detector







GTC – GALILEO Triple Cluster Detector



at 90°

10 GASP HPGe (80%) @ 22 cm

→ ε_{ph} ~ **1.5%**

10 triple cluster detectors (30 HPGe 60%) @ 24 cm

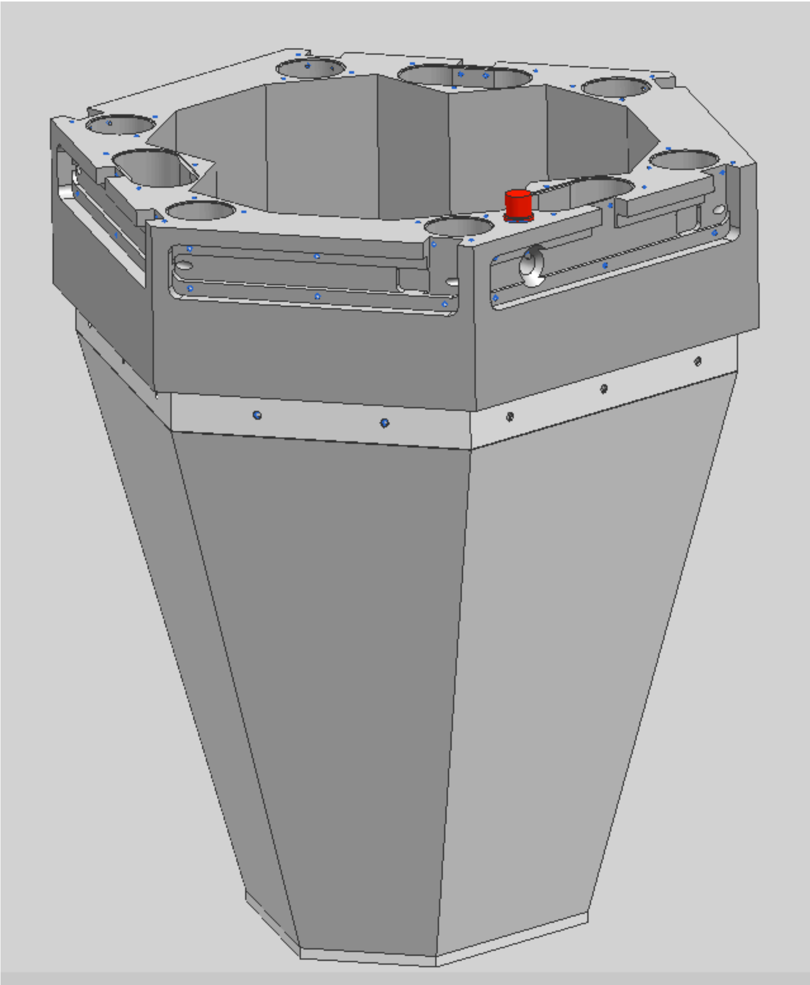
→ ε_{ph} ~ **4.0%**

+

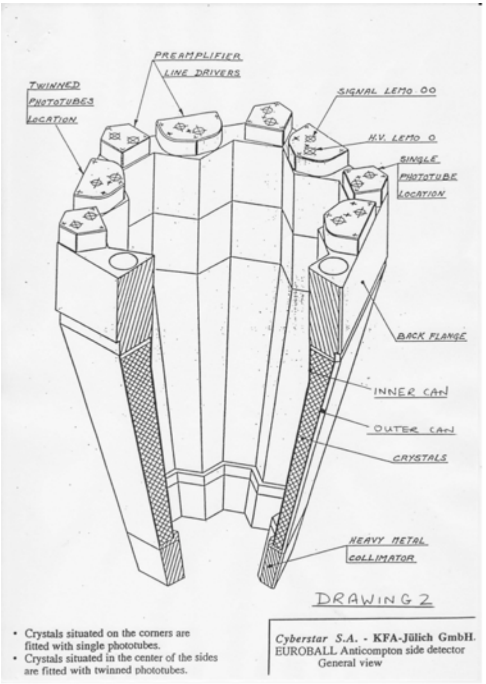
higher granularity

smaller solid angle covered by one capsule

GTC – Anti–Compton Shields

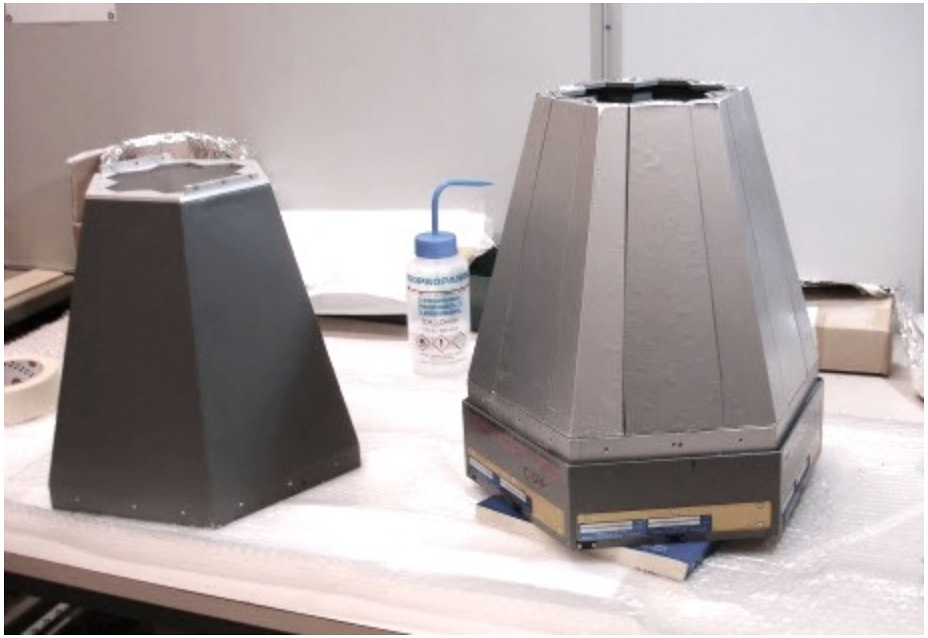


construction of the GTC AC shields with the individual crystals of the original EB cluster shields



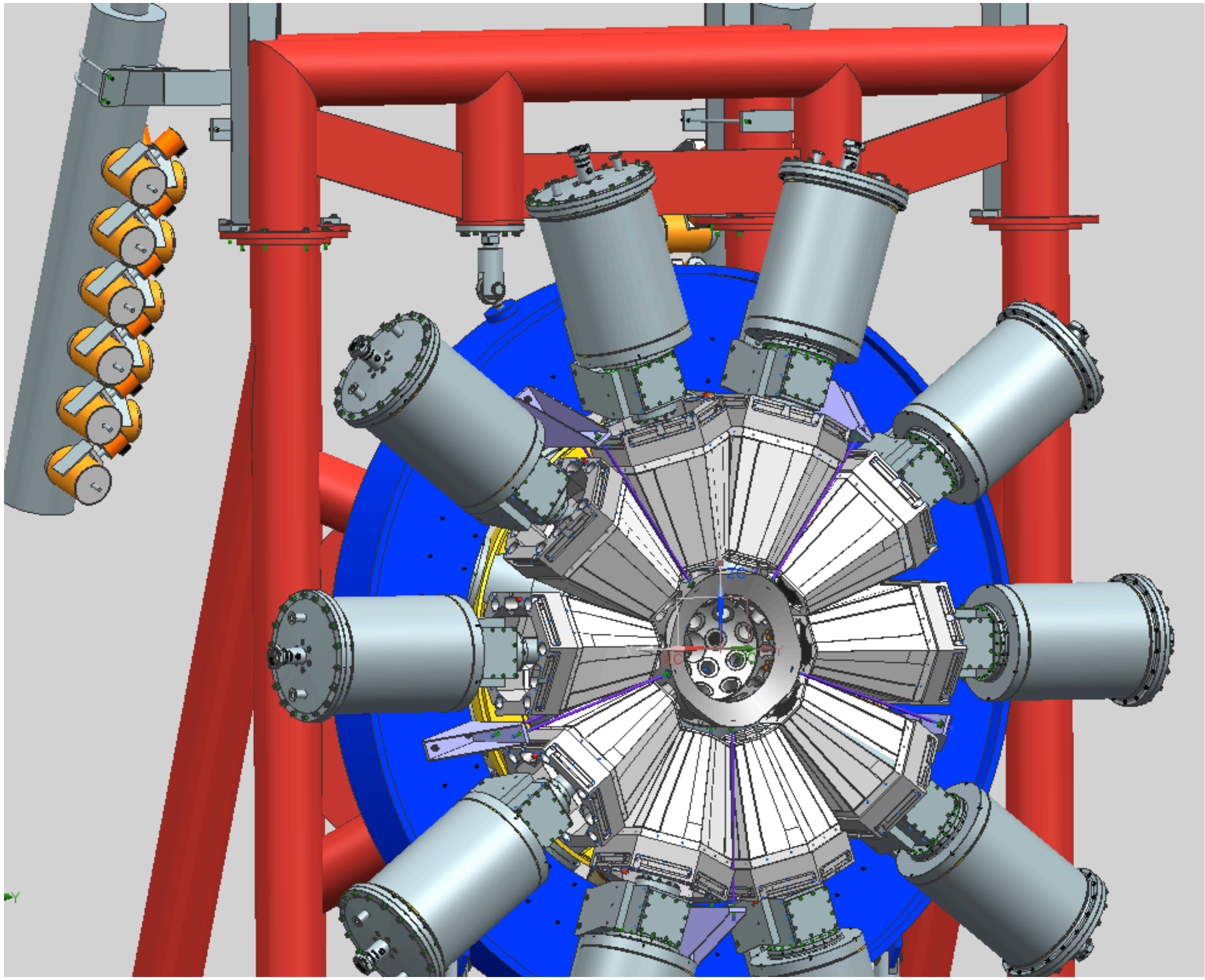
New design of the GTC AC shield

GTC – Anti–Compton Shields

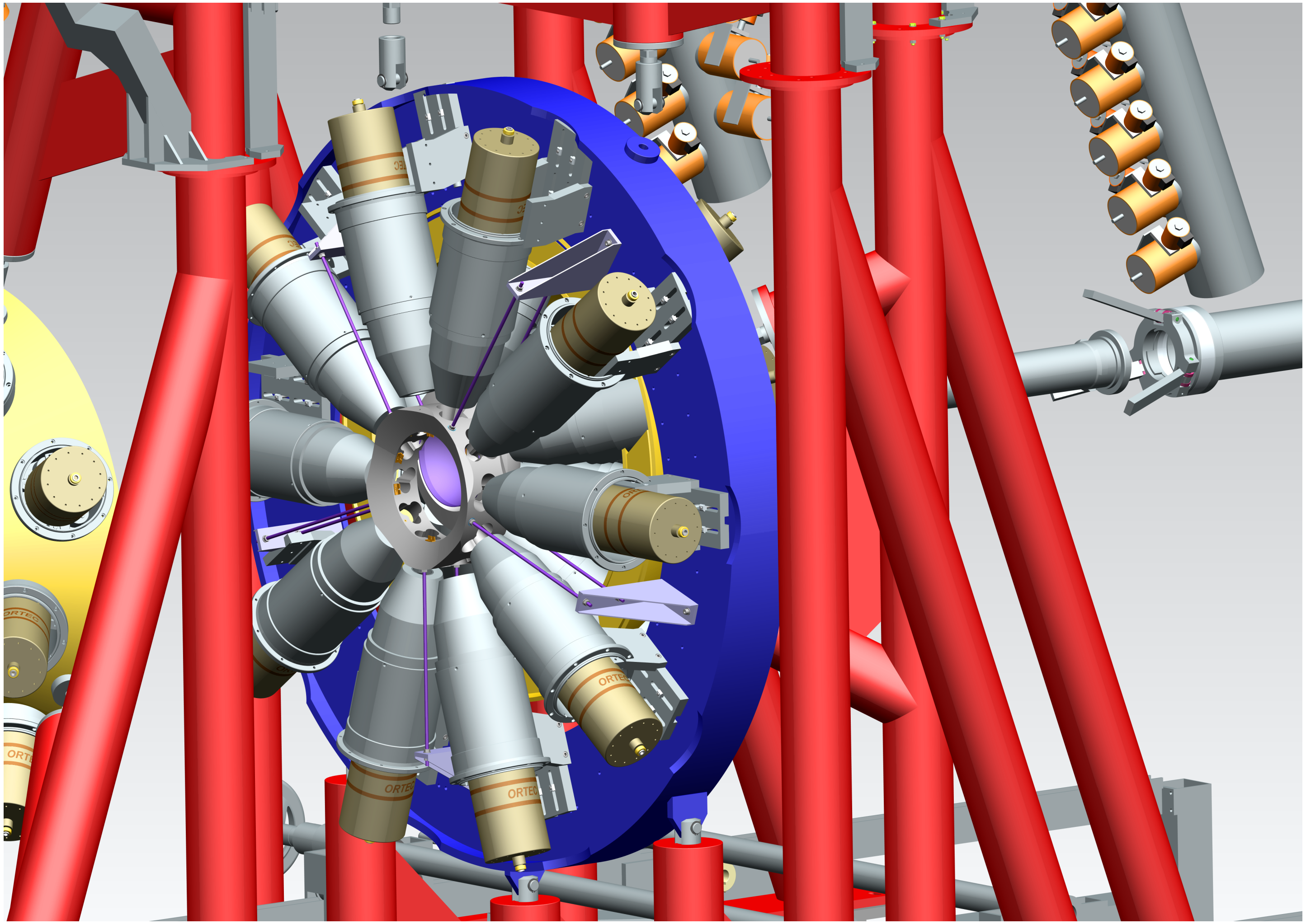


- ❑ **one EUROBALL anti–Compton shield transferred to Legnaro**
- ❑ **contacted Cyberstar Grenoble for information on the mechanical mounting of the casing**

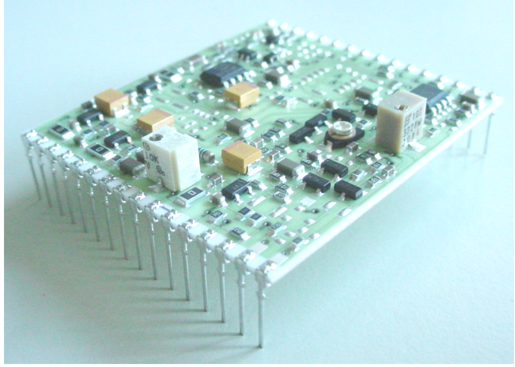
GTC + Anti–Compton Shields



GALILEO Phase Zero



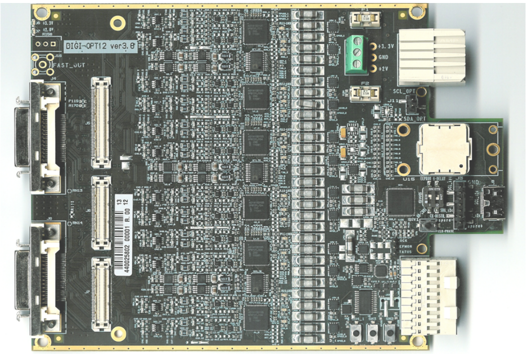
GALILEO – Electronics



a fast low–noise charge sensitive preamplifier based on the core–type AGATA preamplifier

used for both tapered and triple cluster detectors

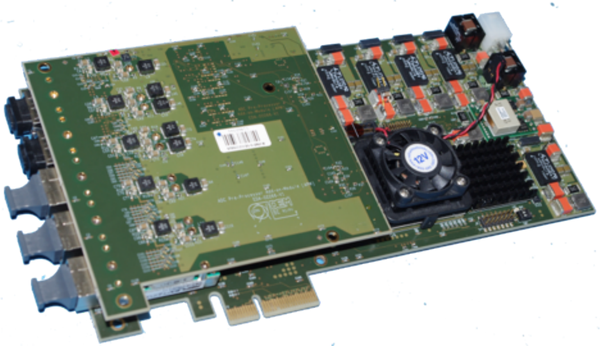
80 preamplifiers already available



Digi-opt12: 12-channel **14**/16-bit **100**/125-MS/s digitizer with optical output for GALILEO/AGATA

power consumption < 10 W / board

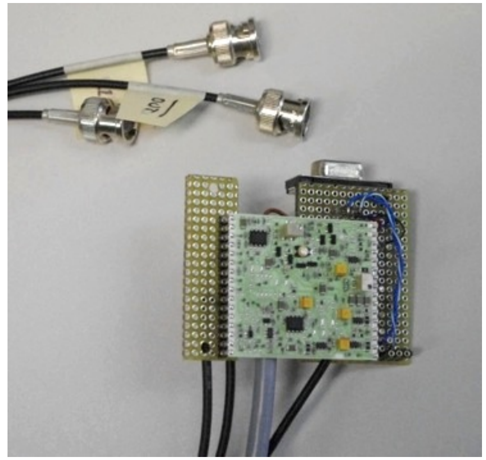
Prototypes under test

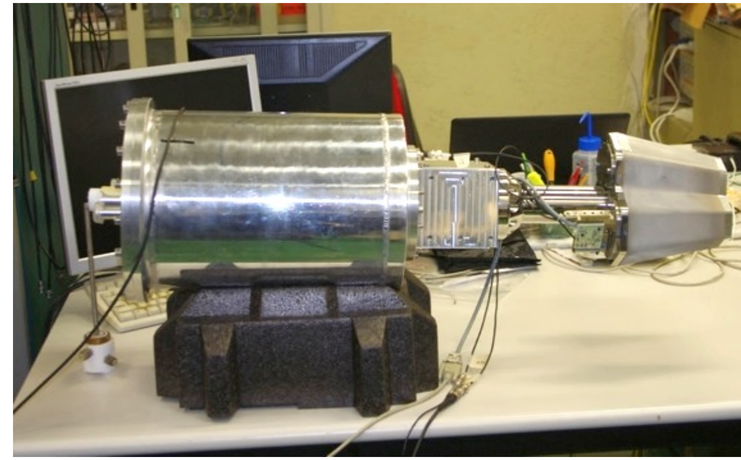


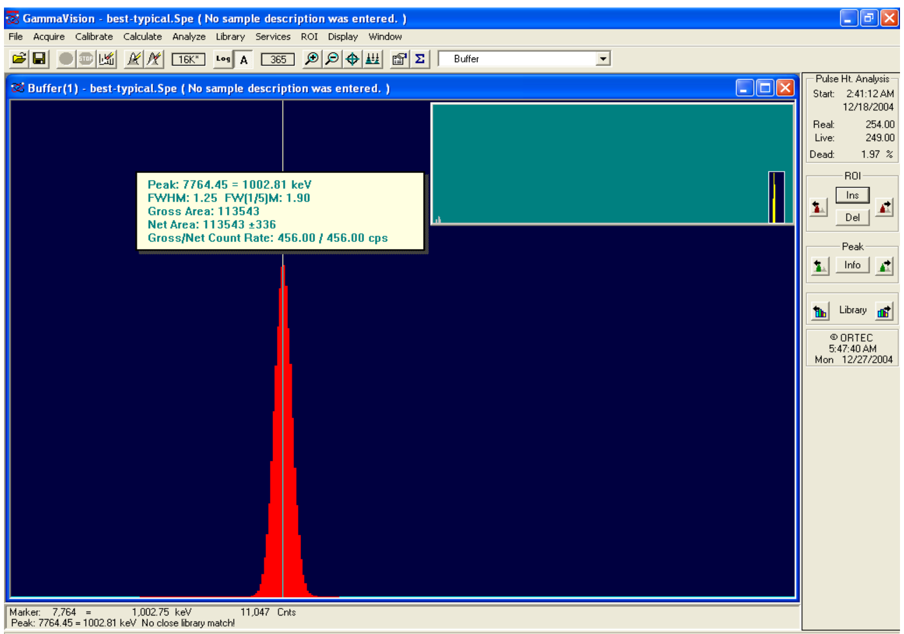
new low–power and low–cost readout and preprocessing PCI–express boards developed for GALILEO and AGATA

Prototypes under test

GALILEO – EDAQ





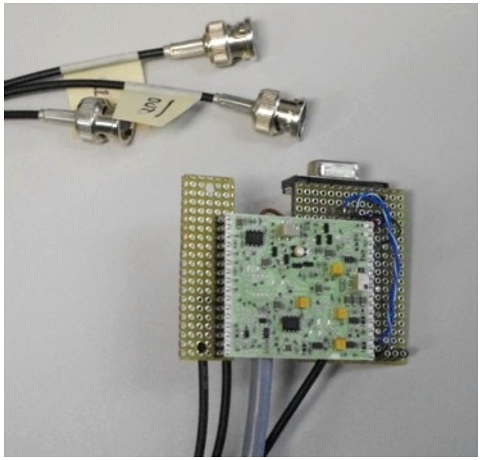


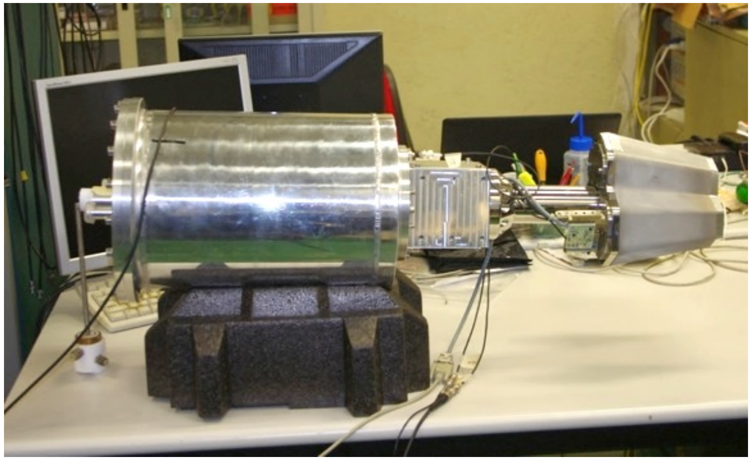
First tests in October 2012

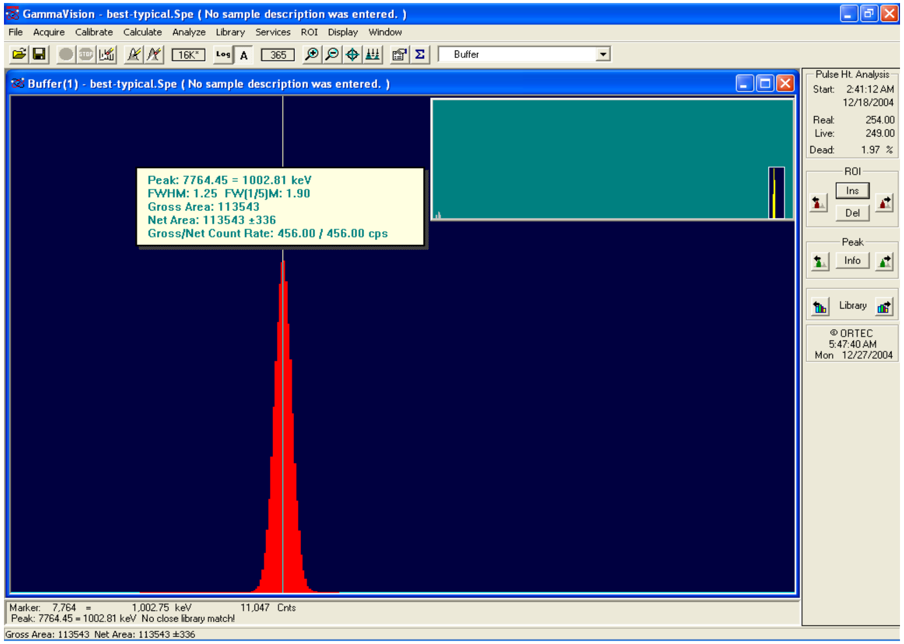
Warm FET&RF

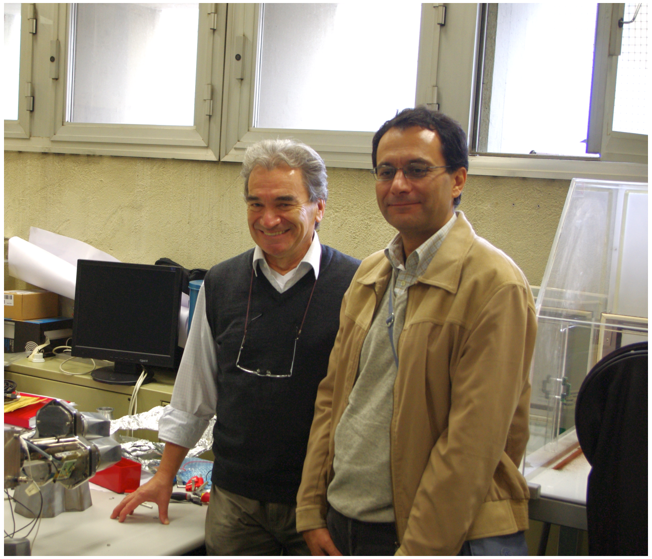
FWHM = 1.25 keV (C_{det}=30 pF)

GALILEO – EDAQ

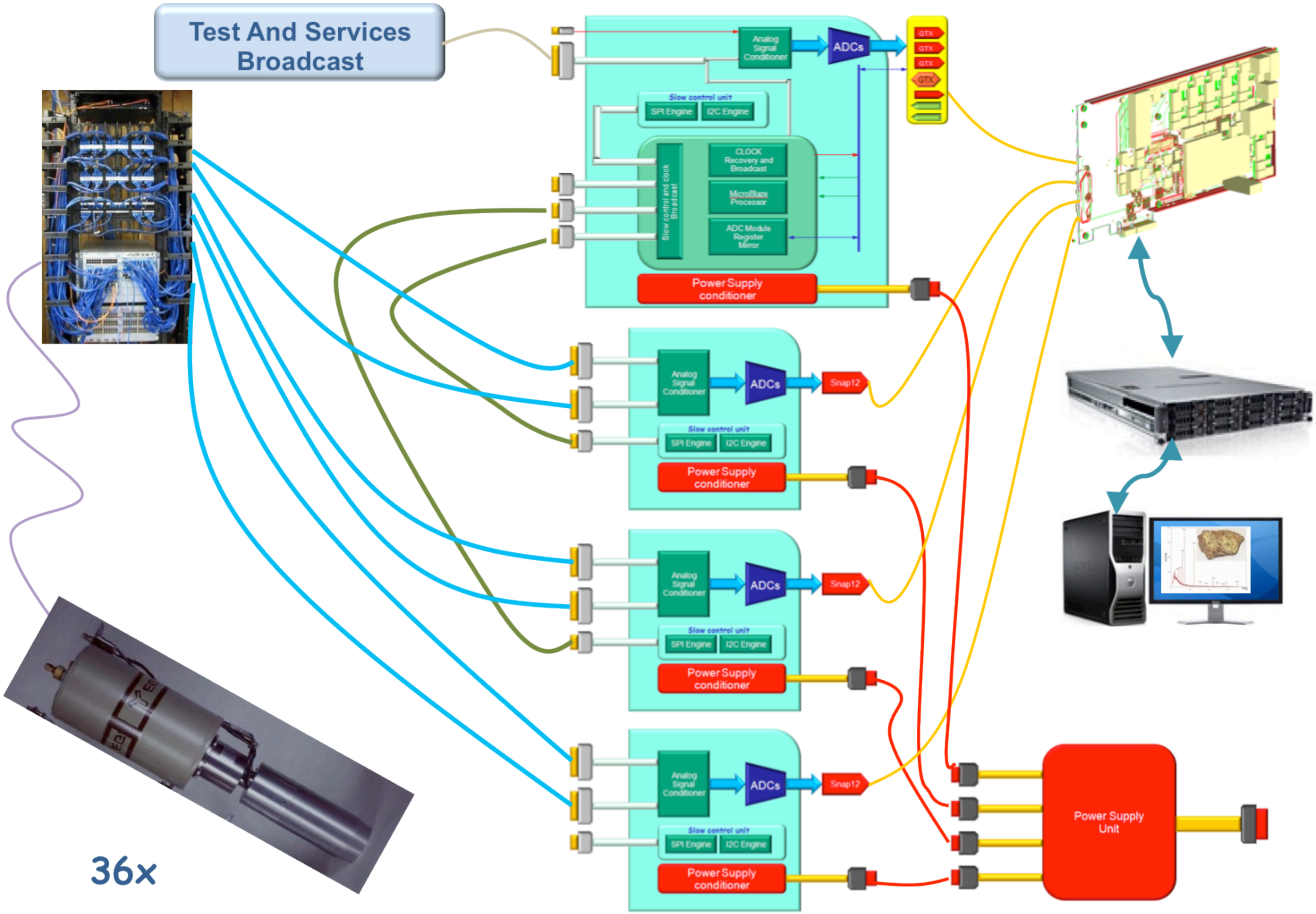




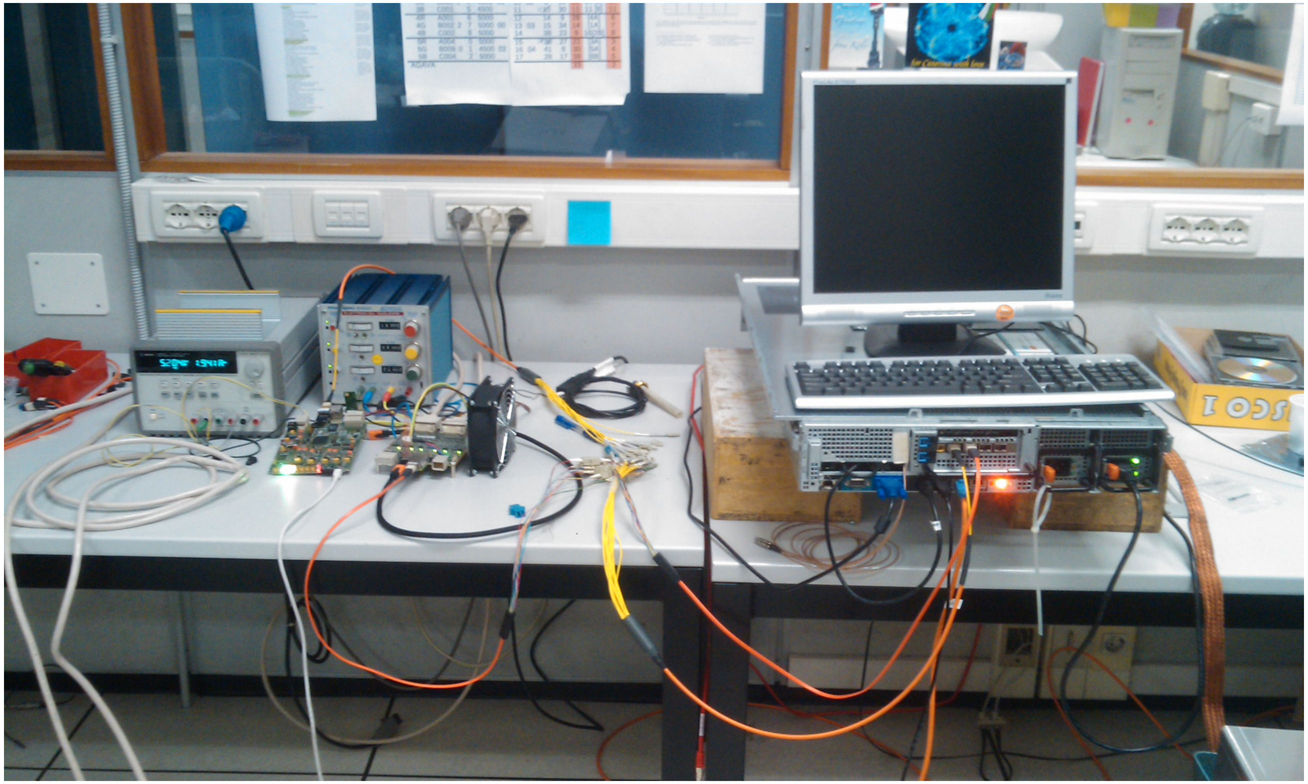




GALILEO – RO&Preprocessing



GALILEO – RO&Preprocessing



GALILEO – EDAQ

Fully synchronous system with global 100 MHz clock and time-stamp distribution

New AGATA core–like preamplifiers
differential output, one 10 MeV range

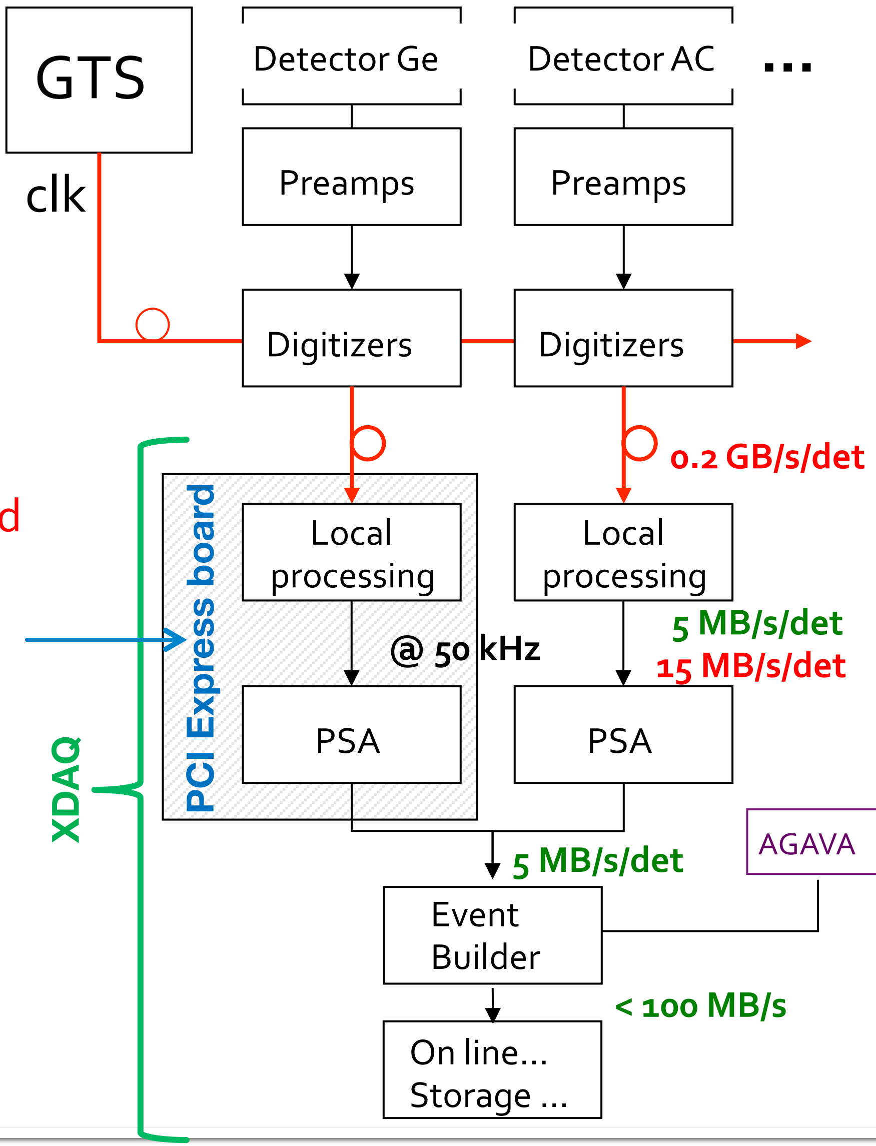
New Digitizers: 100 Ms/s, 14 bit
Optical fiber read-out of full data stream to pre-processing electronics

New local processing: determine energy, time and isolate ~ 500 ns of signal around rise-time
First prototype fully operational 38 channels

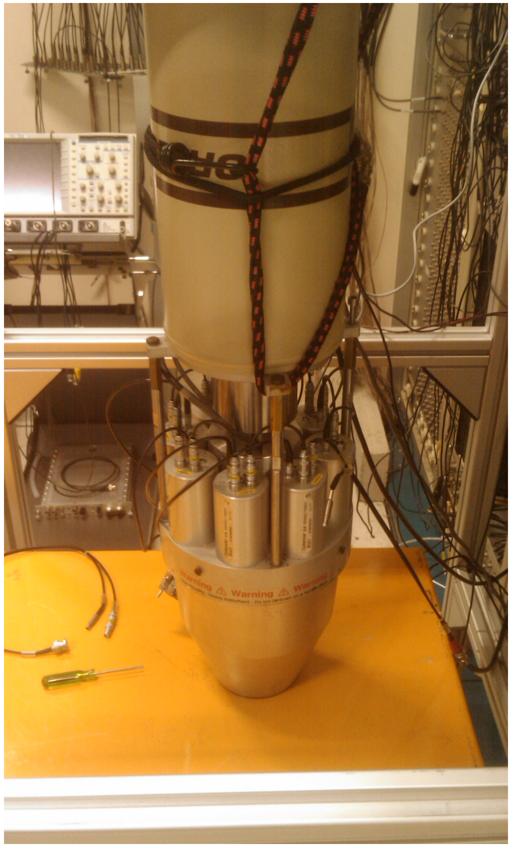
Buffers of time-stamped local events sent to PSA if needed neutron damage correction

Global event builder and software HL trigger

Control and storage, …



Digital Treatment of AC Signals

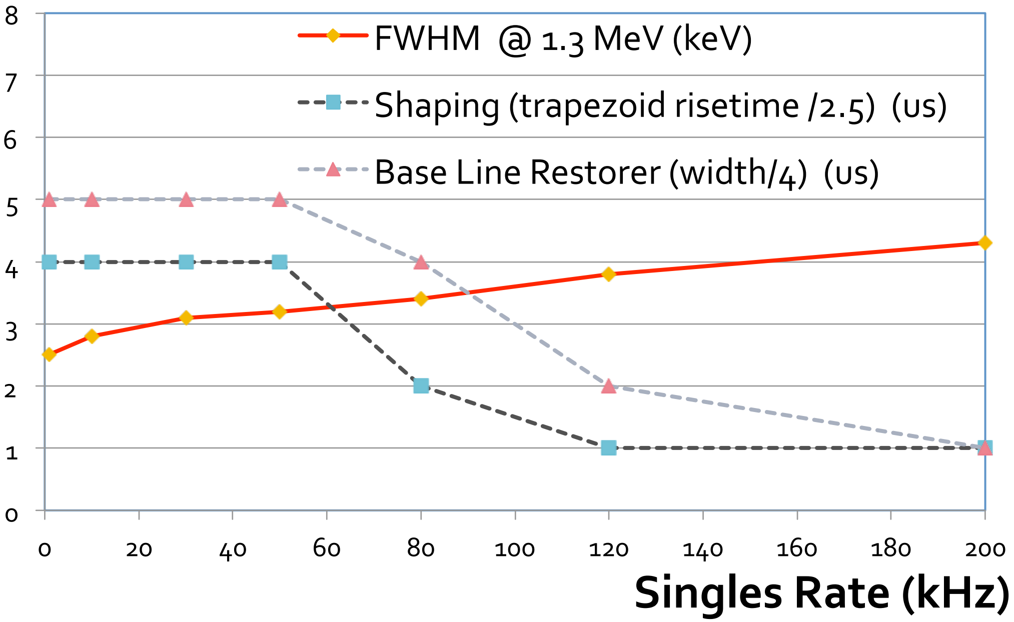


CAEN N1728 (TNT2)
Trigger: Ge detector
AC shield: acquired as slave
matrix: Eγ(Ge) vs Eγ(AC)
cut on Eγ(AC) at < 50 keV → P/T~50%

AGATA High Counting Rate Test

- The detection efficiency of AGATA is, so far, provided by a small number of crystals.
- Experiments want to collect big statistics ➔ need to run at high singles rates (> 50 kHz)?
- Digital Signal Processing allows to work at rates "impossible" with analogue electronics.
- Under these «extreme» conditions, the performance of the detectors is still acceptable.

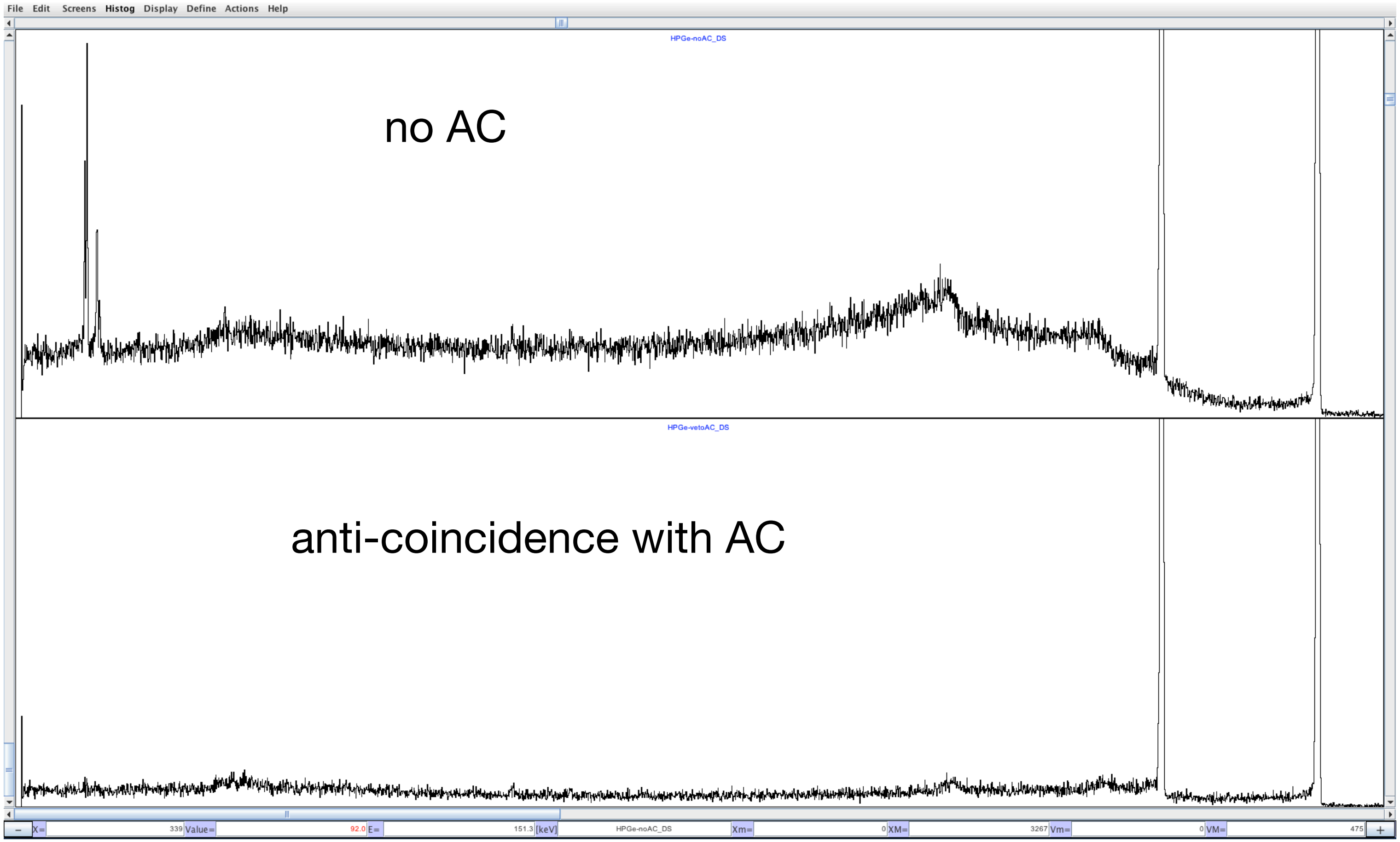
Two Sources Method



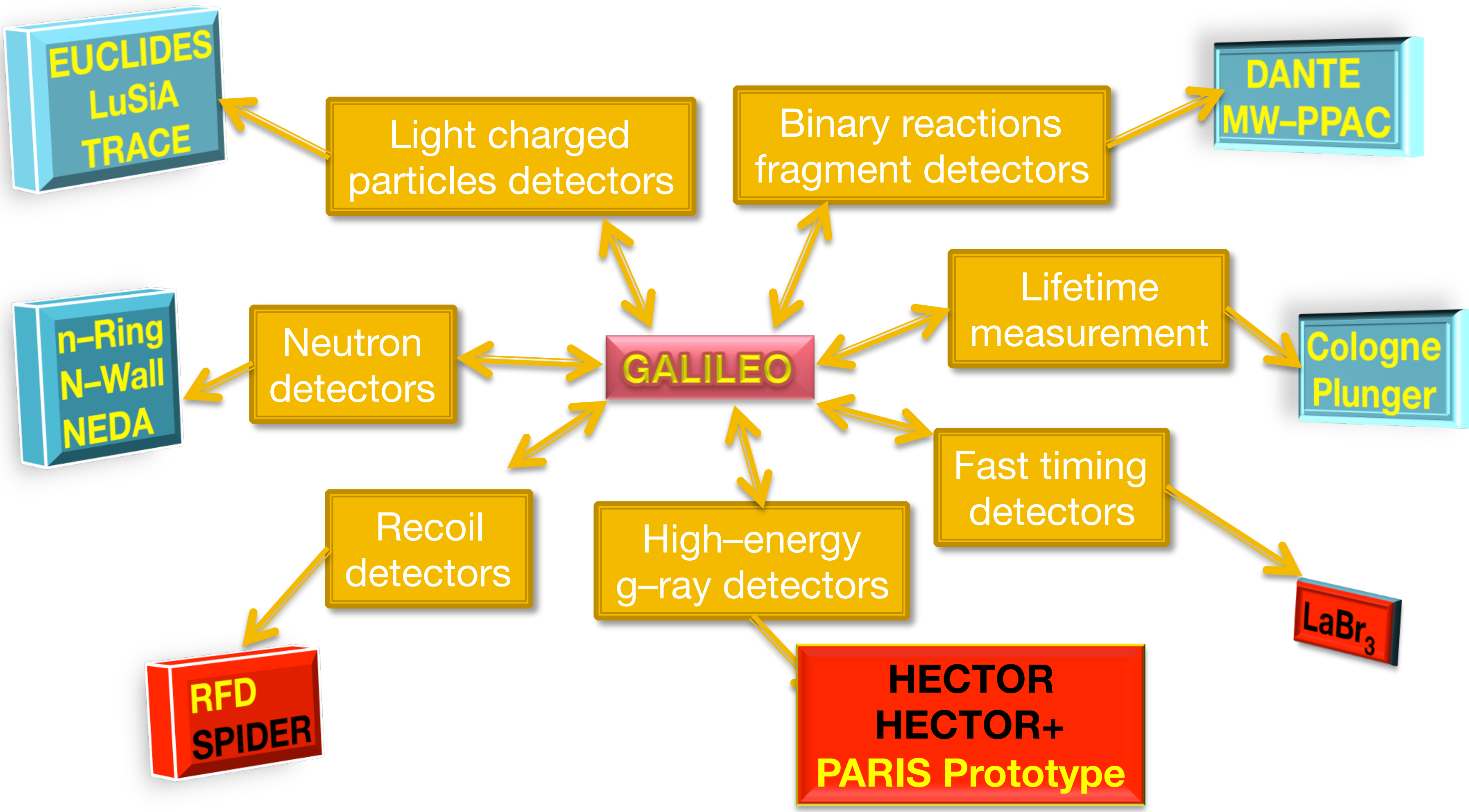
- A limit exists, due to pileup of the signals which exhausts the dynamical range of the FADC. Can counteract this by reducing the gain of the preamplifiers, but then energy resolution worsens also at low counting rate.

F.Recchia, D.Bazzacco

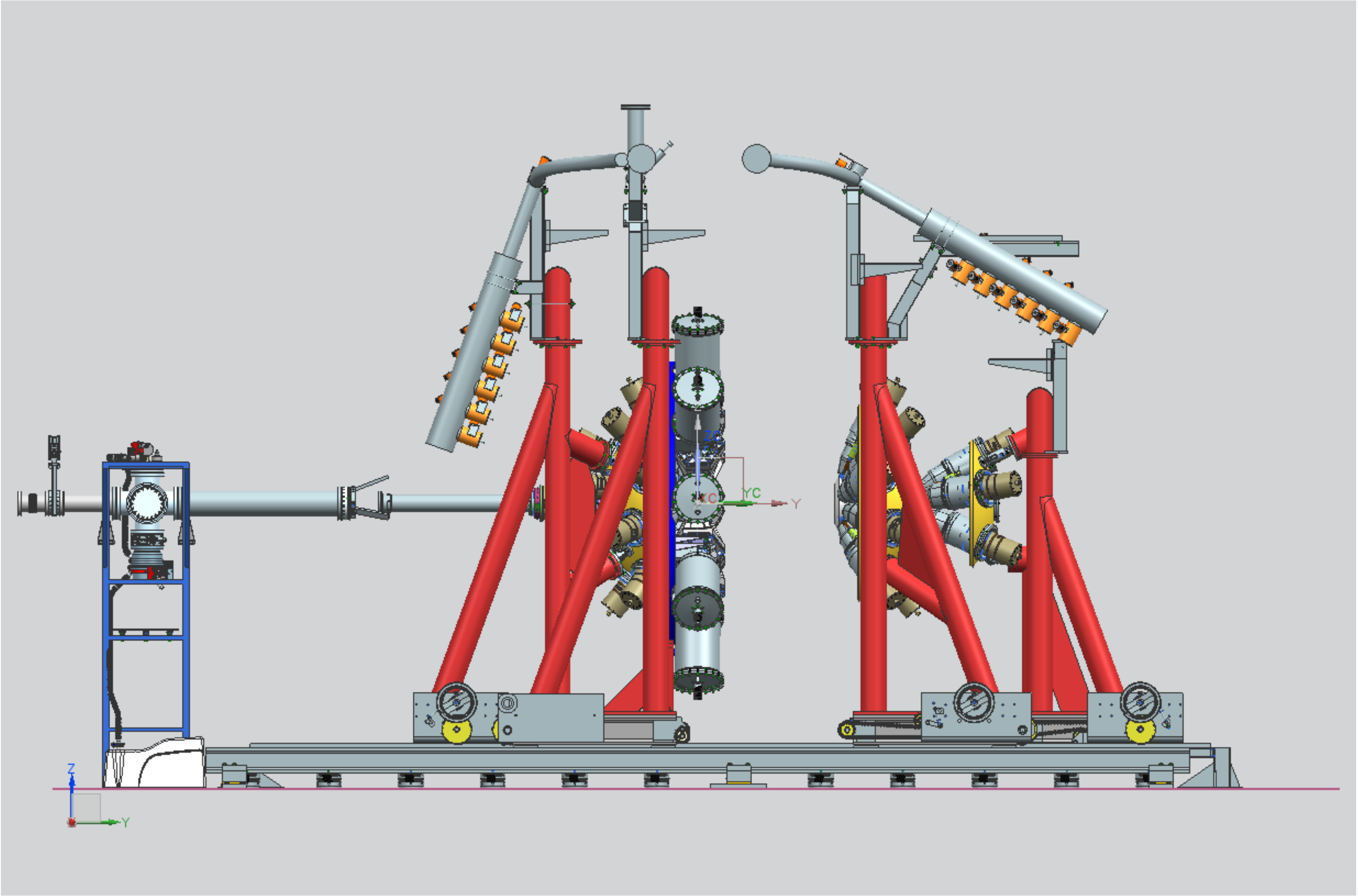
Digital Treatment of AC Signals



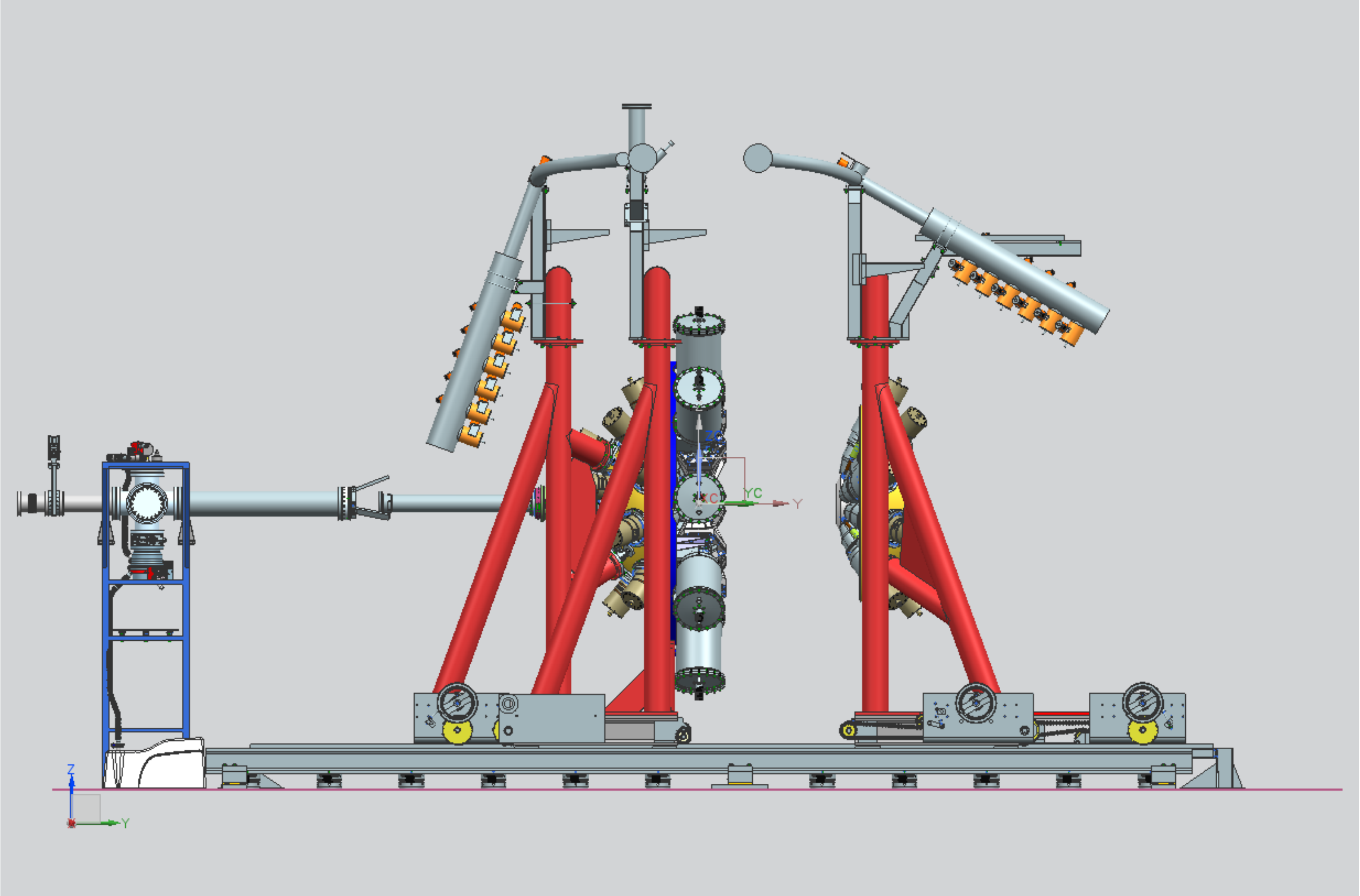
Integration with Ancillary Detectors



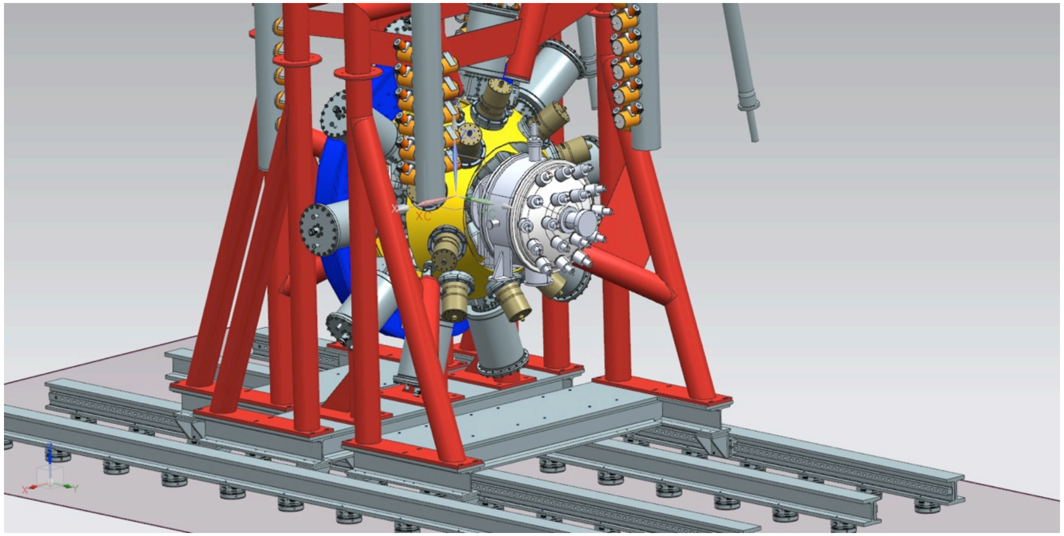
Integration with Ancillary Detectors



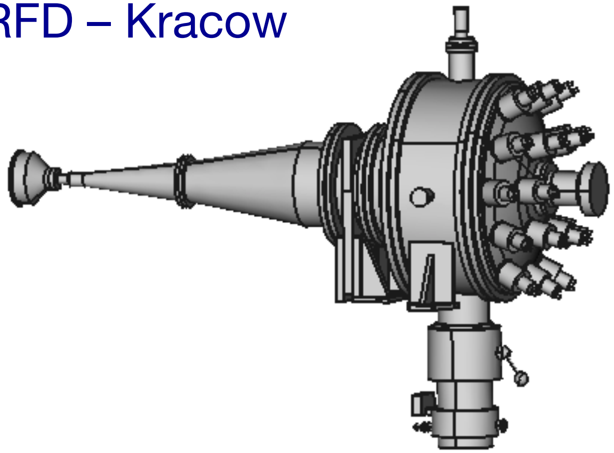
Integration with Ancillary Detectors



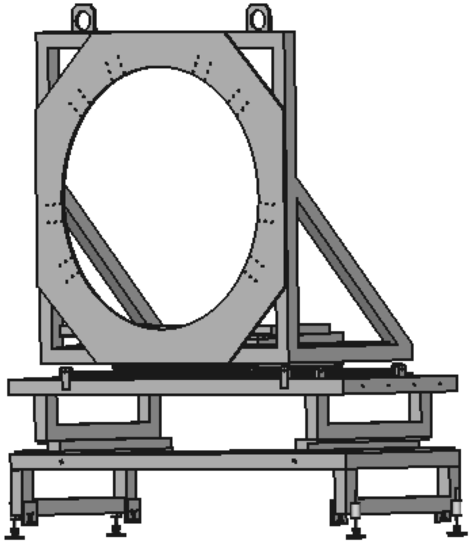
Integration with Ancillary Detectors

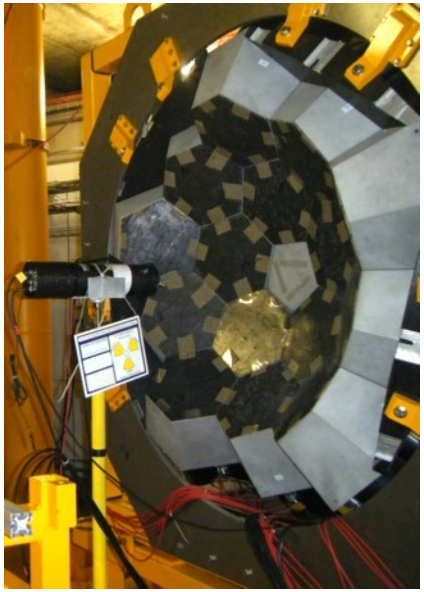


RFD – Kracow



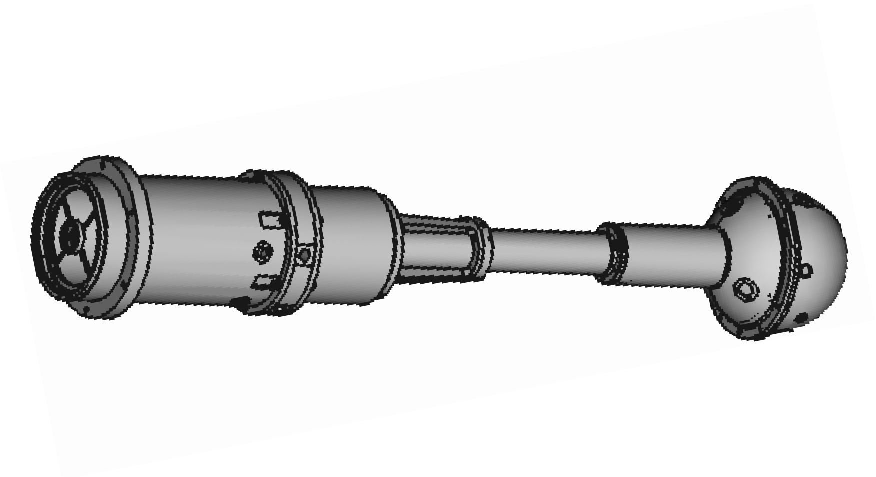
N – Wall
GANIL



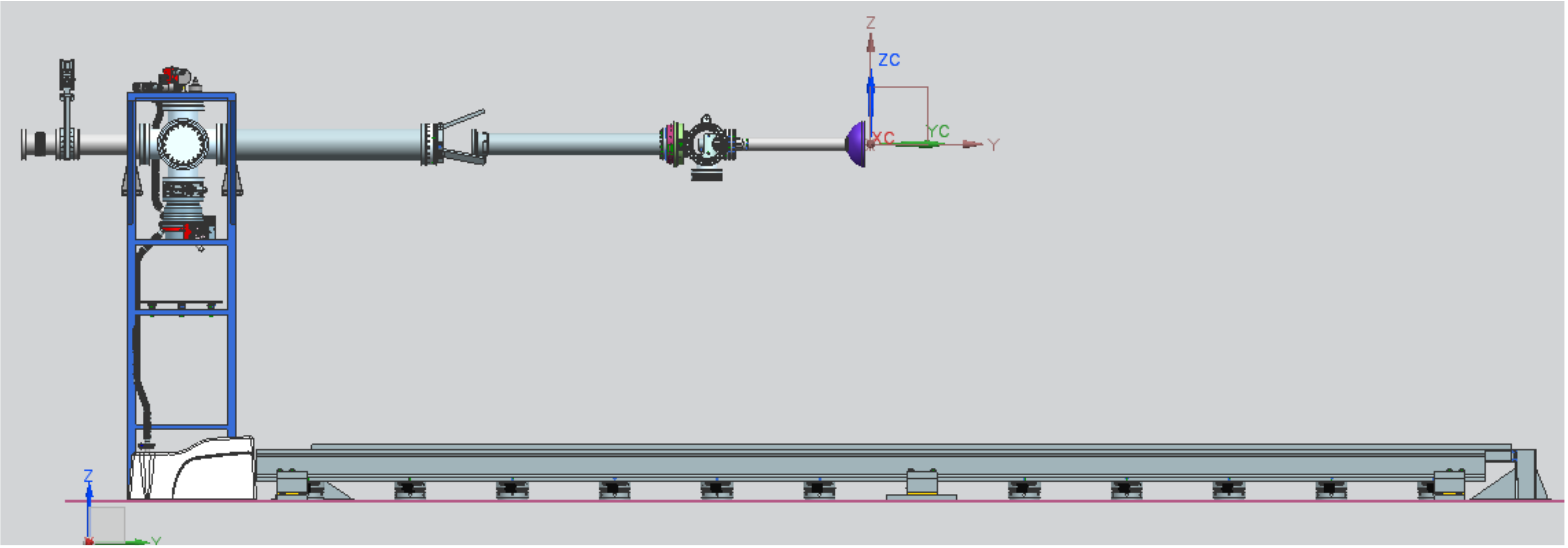


Integration with Ancillary Detectors

Plunger – Cologne

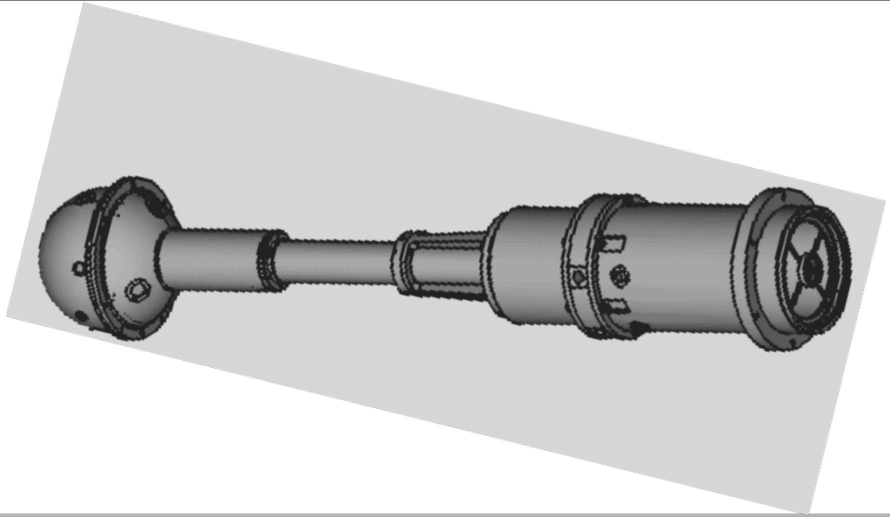


Beam

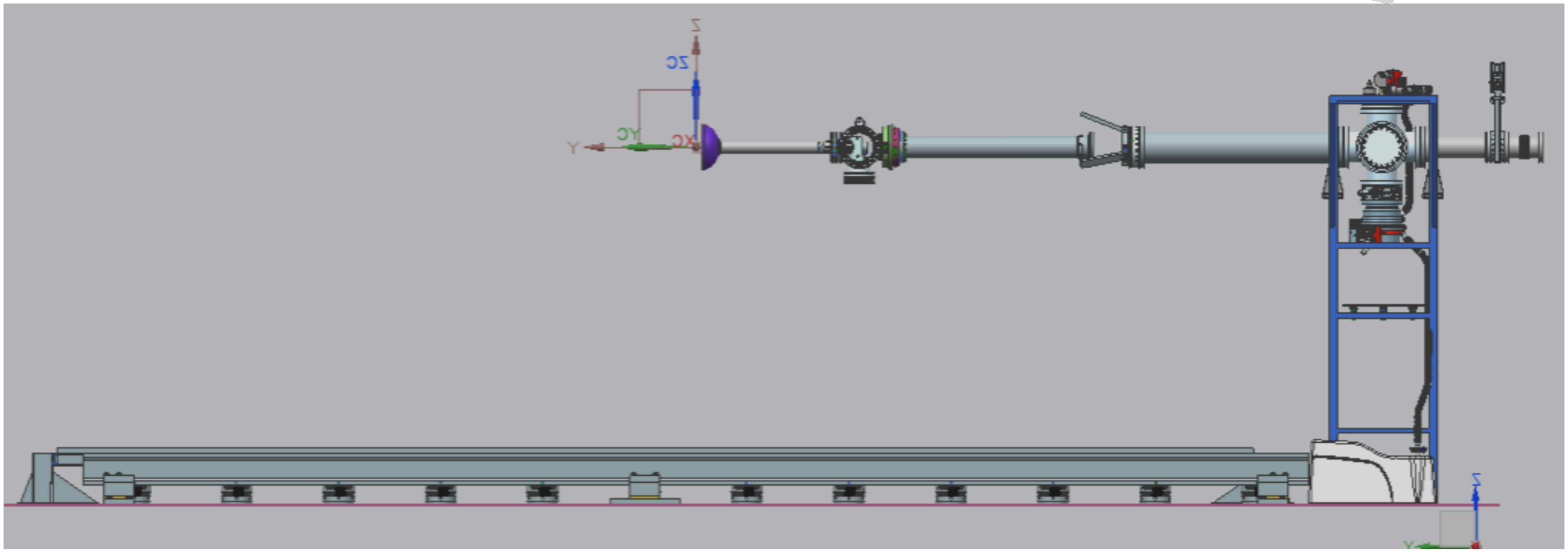


Integration with Ancillary Detectors

Plunger – Cologne



Beam



Collaborators

- GAMMA group
  - **INFN Padova, Legnaro, Milano, Firenze**
- Mechanical design and production
  - **Technical Service – INFN Padova, Mechanical workshops – INFN Padova, Legnaro, Milan**
  - C.Fanin, M.Turcato, M.Rampazzo, M.Romanato, L.Ramina, D.Conventi, S.Coelli, F.Tommasi
- Electronics developments
  - **Nuclear physics groups – INFN Padova and Milan, Computing service – INFN Legnaro**
  - D.Bazzacco, M.Bellato, A.Pullia, D.Bortolato, R.Isocrate, G.Rampazzo, L.Berti
- Vacuum, LN_2 filling systems, cabling
  - **Users Service – INFN Legnaro, Nuclear physics group & Electronic workshop – INFN Padova**
  - D.Rosso, L.Costa, P.Cocconi, R.Menegazzo, M.Nicoletto, M.Bettini
- Ancillary detectors integration
  - **Nuclear physics group – INFN Milan, Legnaro, IFJ PAN Cracow, Computing service – INFN Legnaro**
  - S.Brambilla, N.Toniolo, P.Bednarczyk, J.J.Valiente Dobon
- Beam line design
  - **Accelerator Division – INFN Legnaro, Nuclear physics group – INFN Legnaro**
  - G.Bisoffi, A.Pisent, M.Comunian, J.J.Valiente Dobon
- Monte Carlo simulations
  - **Nuclear physics group – INFN Padova**
  - E.Farnea
- DAQ
  - **Computing service – INFN Legnaro**
  - G.Maron, M.Gulmini, N.Toniolo, L.Berti

Outlook

EPPUR SI MUOVE !

Outlook

- GALILEO – a new gamma–ray array for LNL
  - stable beams from TAP
  - **RIBs from SPES**
- Combines
  - old detectors from GASP and EUROBALL
  - new EDAQ based on the AGATA experience
- **for improved specification as compared to GASP**