



CLEARPET

The European Small Animal PET Scanner

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Crystal Clear Collaboration

Lisboa, 1 July 2002



CLEARPET, a project from the Crystal Clear Collaboration



- ◆ The Crystal Clear Collaboration at CERN initiated 3 years ago a european coordinated effort to develop a high performance small animal PET scanner,

the CLEARPET project

capitalizing on:

- Spin-off from High Energy Physics detector development
- Large experience on scintillating crystals
- > 10 years experience in multidisciplinary collaborations involving:
 - » Technical experts in different disciplines
 - » Industry
 - » End users



The CLEARPET in a few words



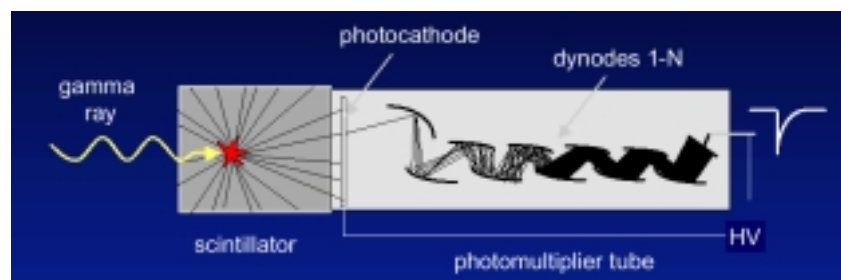
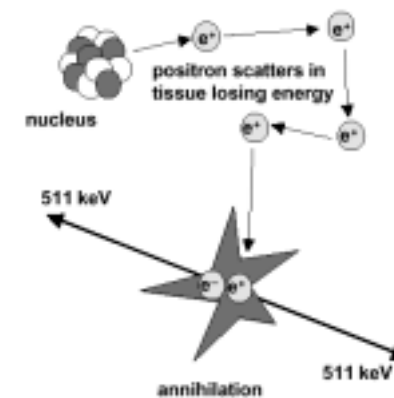
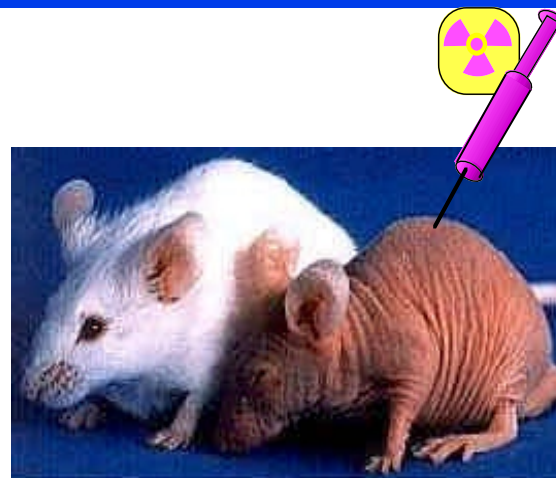
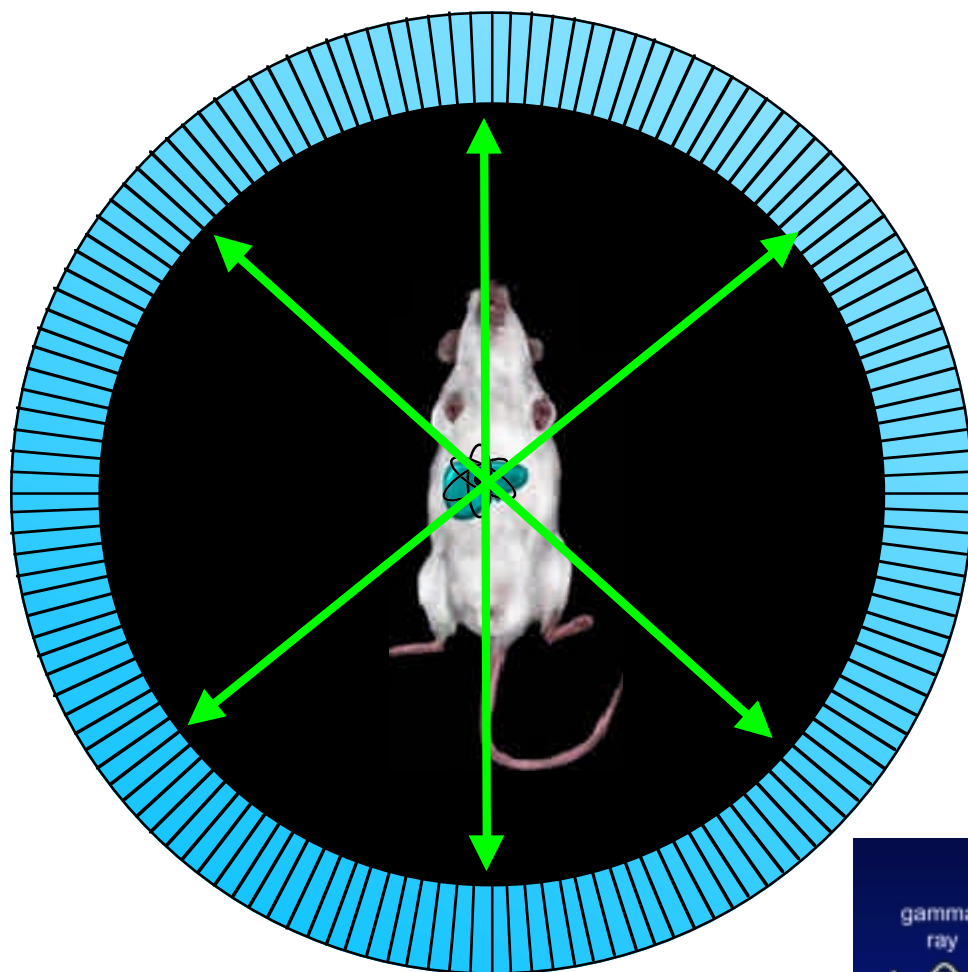
- ◆ A new generation of small animal PET scanner with
 - Sensitivity $> 3\%$
 - Resolution $\ll 2\text{mm}$
 - Good timing properties

- ◆ A modular system with high performance components
 - New very dense and fast crystals LuAP and LSO
 - Compact multichannel photodetectors (PMT and APD's)
 - Modern DAQ from recent telecommunication and LHC developments
 - High performance simulation and reconstruction software

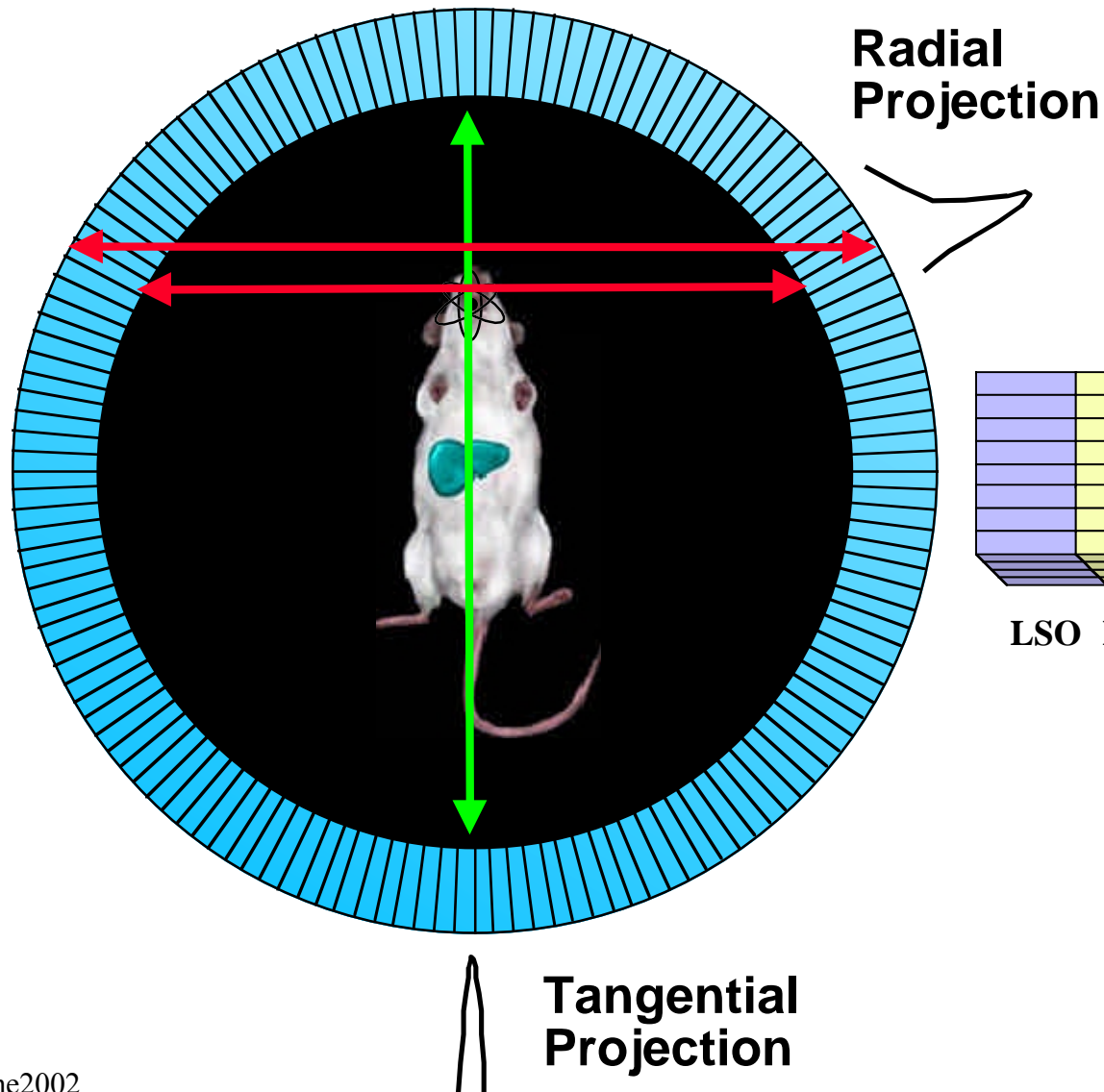
- ◆ A flexible organization of these modules for
 - Different configurations of small or medium size animal PET scanners
 - Dedicated clinical systems for Brain studies, Breast cancer, Prostate cancer, etc...
 - Full body PET scanners for oncology, hadrotherapy, etc...

- ◆ A potential for a multimodality approach to combine anatomic and metabolic images
 - High resolution X-Ray CT
 - MRI

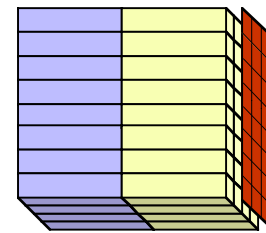
The PET Principle



PET Principle: The DOI scheme



- ◆ Penetration of 511 keV photons into crystal ring blurs measured position
- ◆ Effect variously known as Radial Elongation, Parallax Error, or Radial Astigmatism
- ◆ Can be removed by measuring depth of interaction



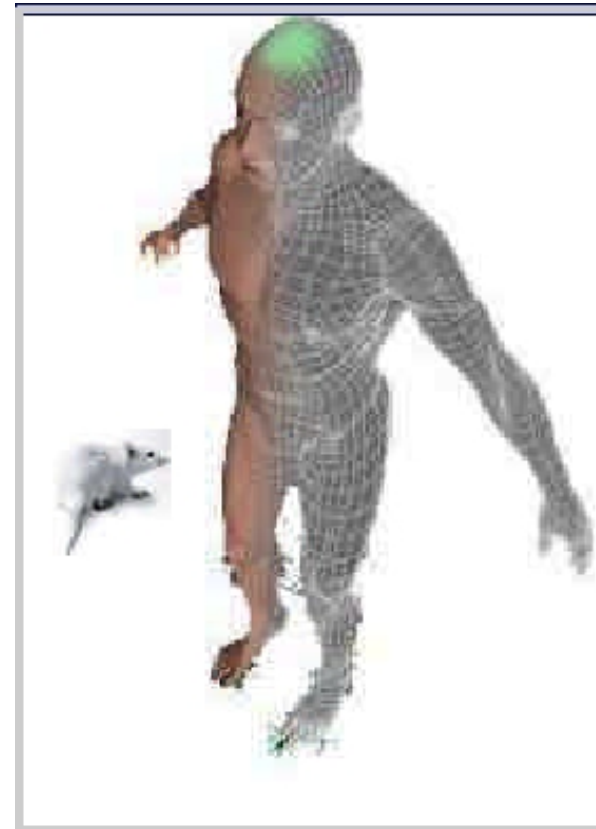
32 APD Matrix

LSO LuAP

Crystal Clear
CTI (commercial)

Material	Density g/cm ³	$Z_{\text{eff}}/\text{Ph.Abs.Coeff}$ at 511keV, cm ⁻¹ /X ₀ ,cm	LY ph/MeV	τ ns	λ nm
LuAlO₃:Ce	8.34	64.9/0.29/1.1	11400	17	365
Lu₂SiO₅:Ce	7.4	66/0.28/1.1	27000	40	420

- ◆ Good timing properties
- ◆ Sensitivity > 3%
- ◆ Resolution << 2mm
 - Human = 75kg
 - Monkey = 5kg /15
 - Rat = 0.3kg /250
 - Mouse = 0.03kg /2500



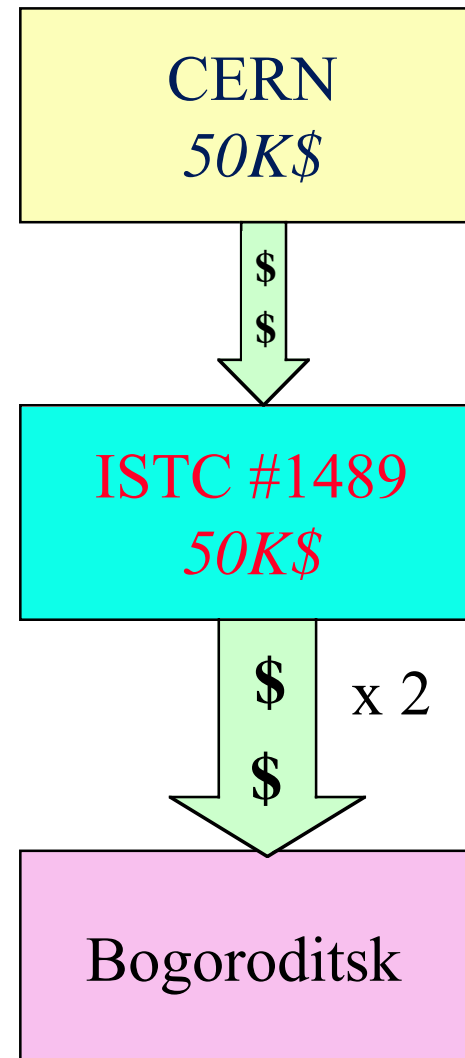


LuAP technology development

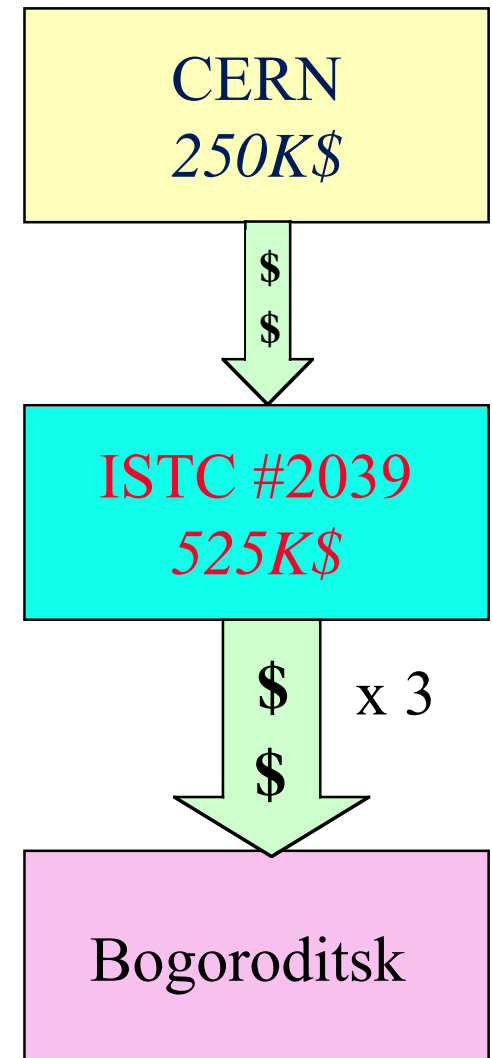


- ◆ CERN-ISTC cooperation
- ◆ Conversion program for former Soviet Union militaro-industrial complex funded by the G8
- ◆ Very positive experience with the Bogoroditsk Plant for the production of 100 tons of Lead Tunstate crystals for the CERN CMS experiment (20M\$ project)
- ◆ New ISTC project (200K\$) recently approved for LuAP technology development in Ashtarak

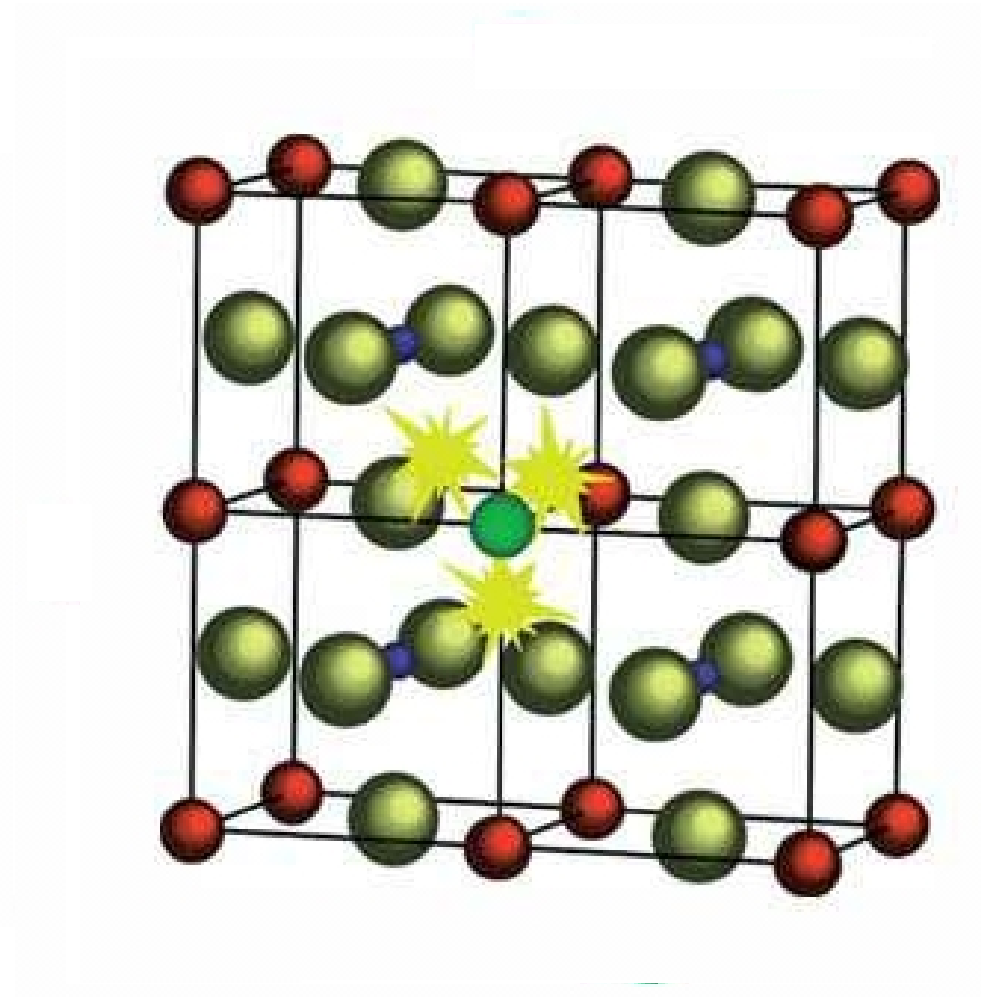
2000-2001: Feasibility study



2001-2002: Industrial phase



LuAP scintillation mechanism



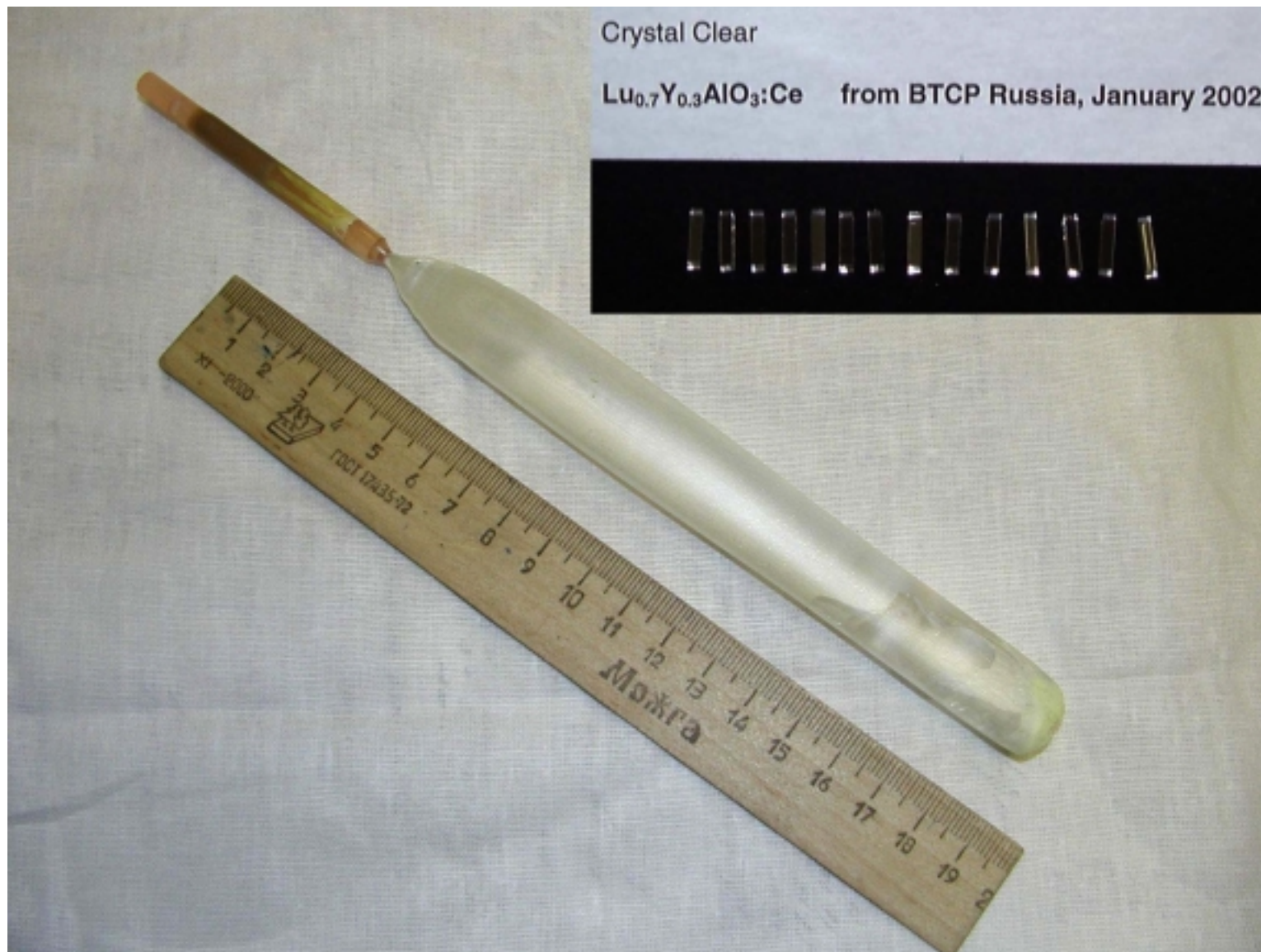


LuAP technology development Bogoroditsk, Russia

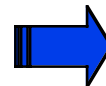
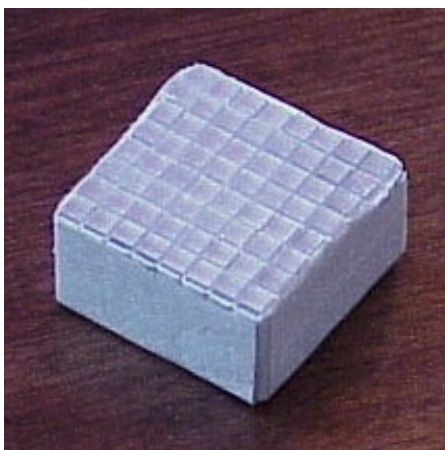
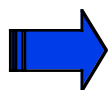




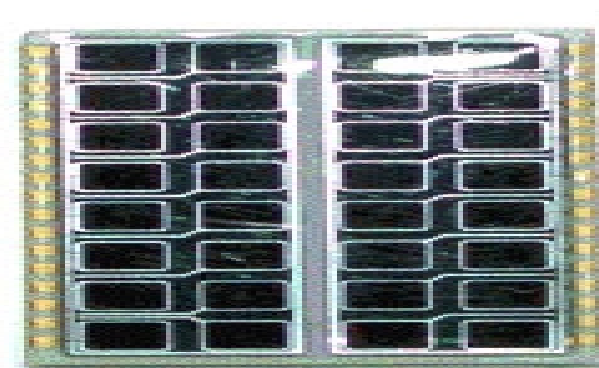
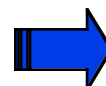
LuAP pixel production Bogoroditsk, Russia



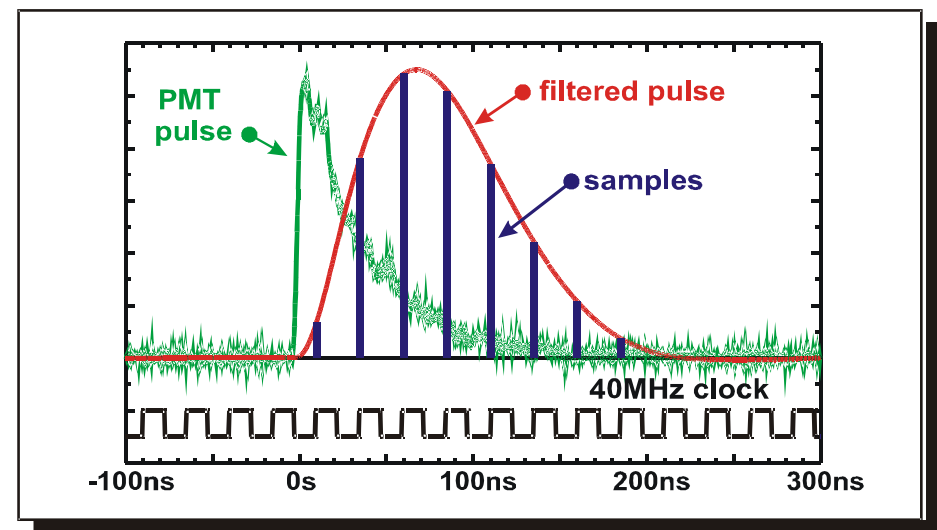
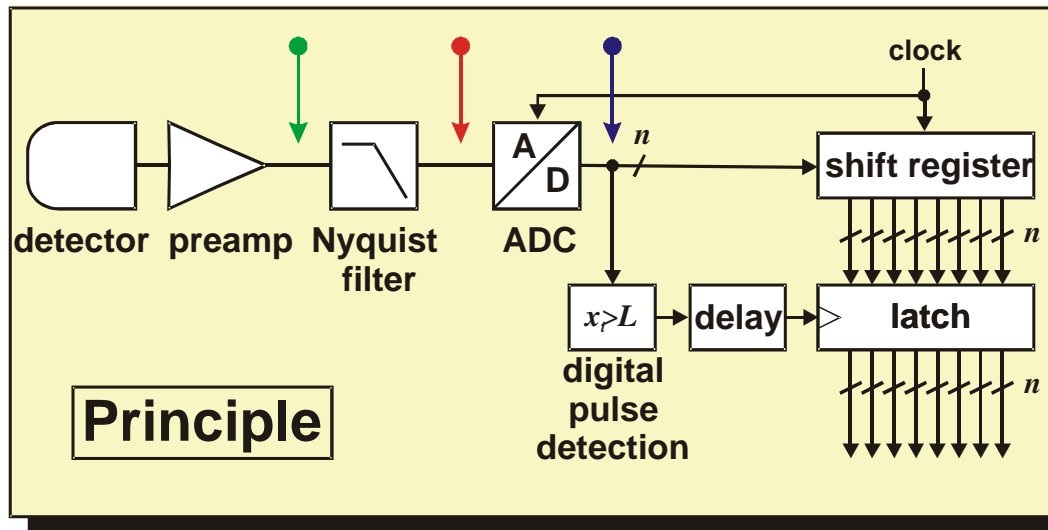
Module assembly



Hamamatsu H7546
64 channel PMT

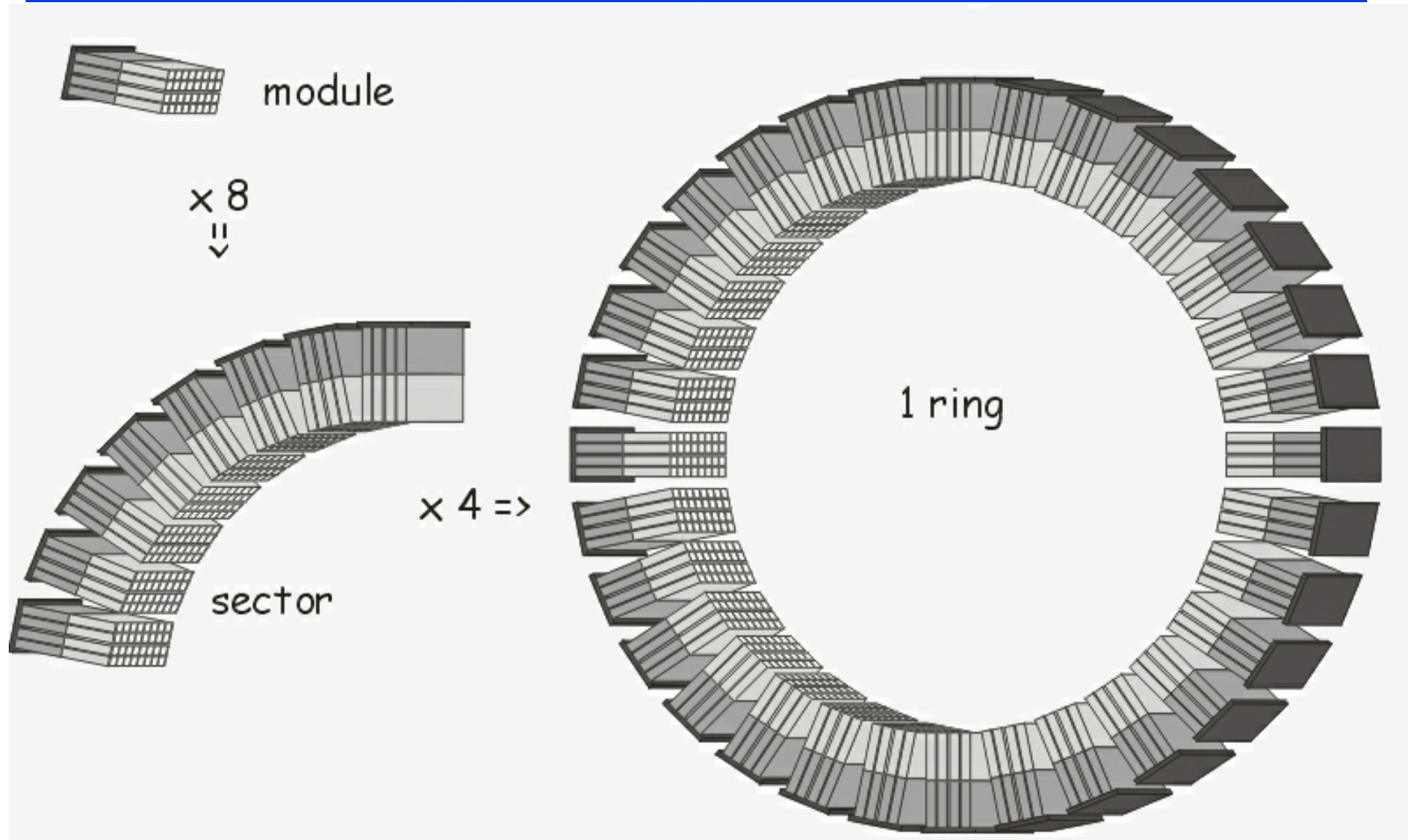


Hamamatsu 32 channels APD array

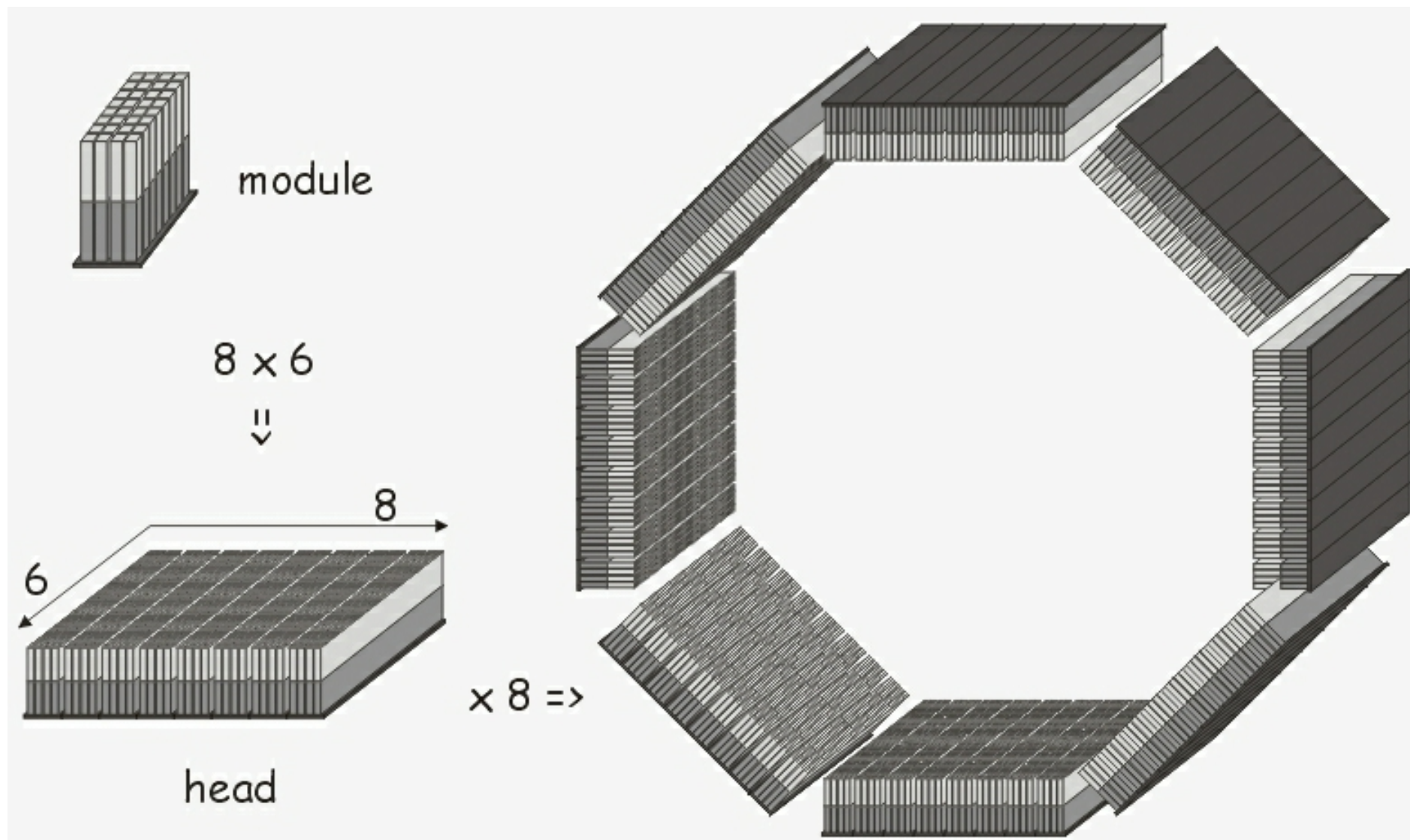


- ◆ Continuous sampling of the signal
- ◆ The whole pulse is recorded by a free sampling ADC
- ◆ Digital processing of the recorded samples to determine
 - Pulse charge
 - Pulse time
 - Pulse shape

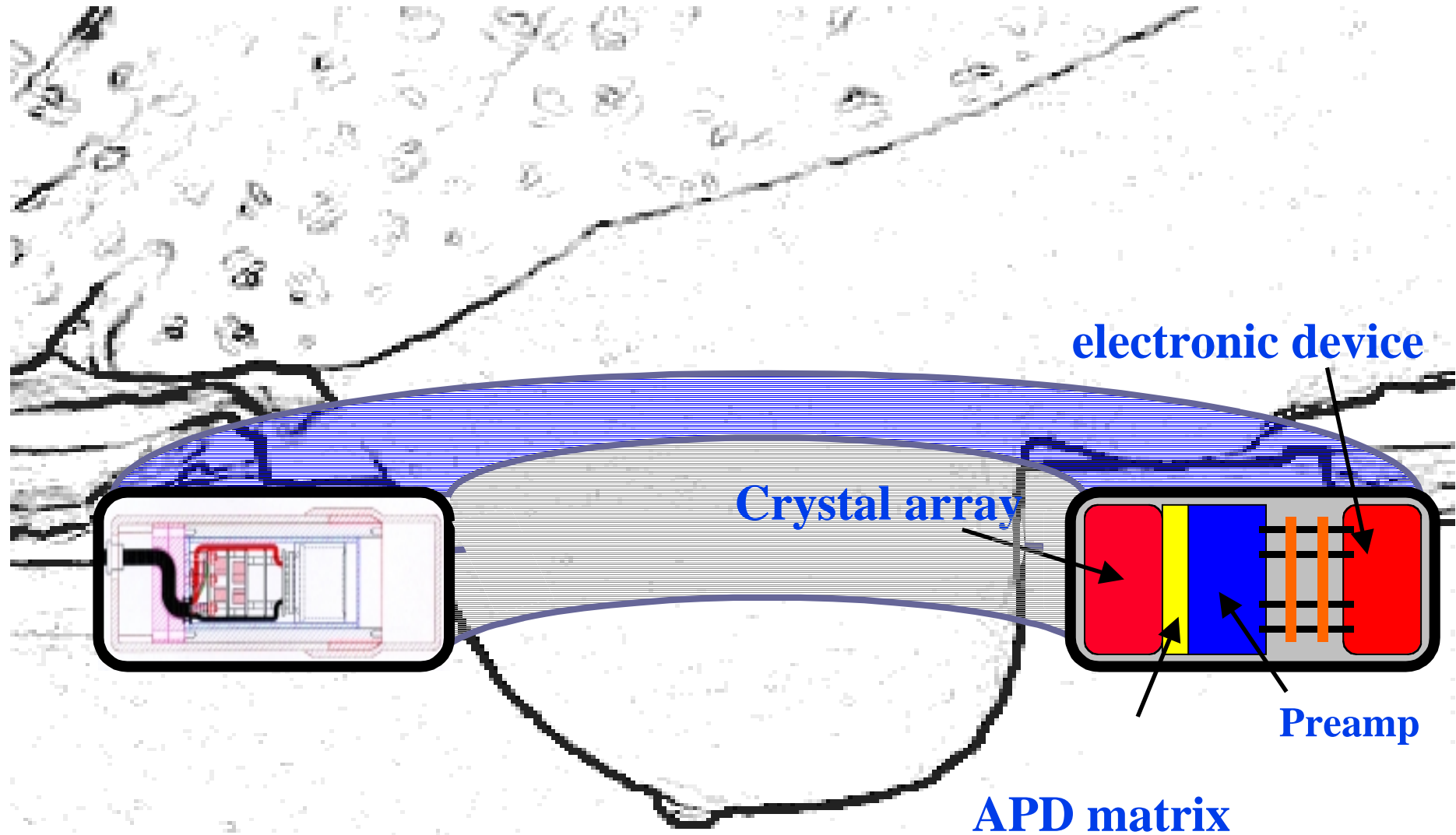
Modularity



Modularity

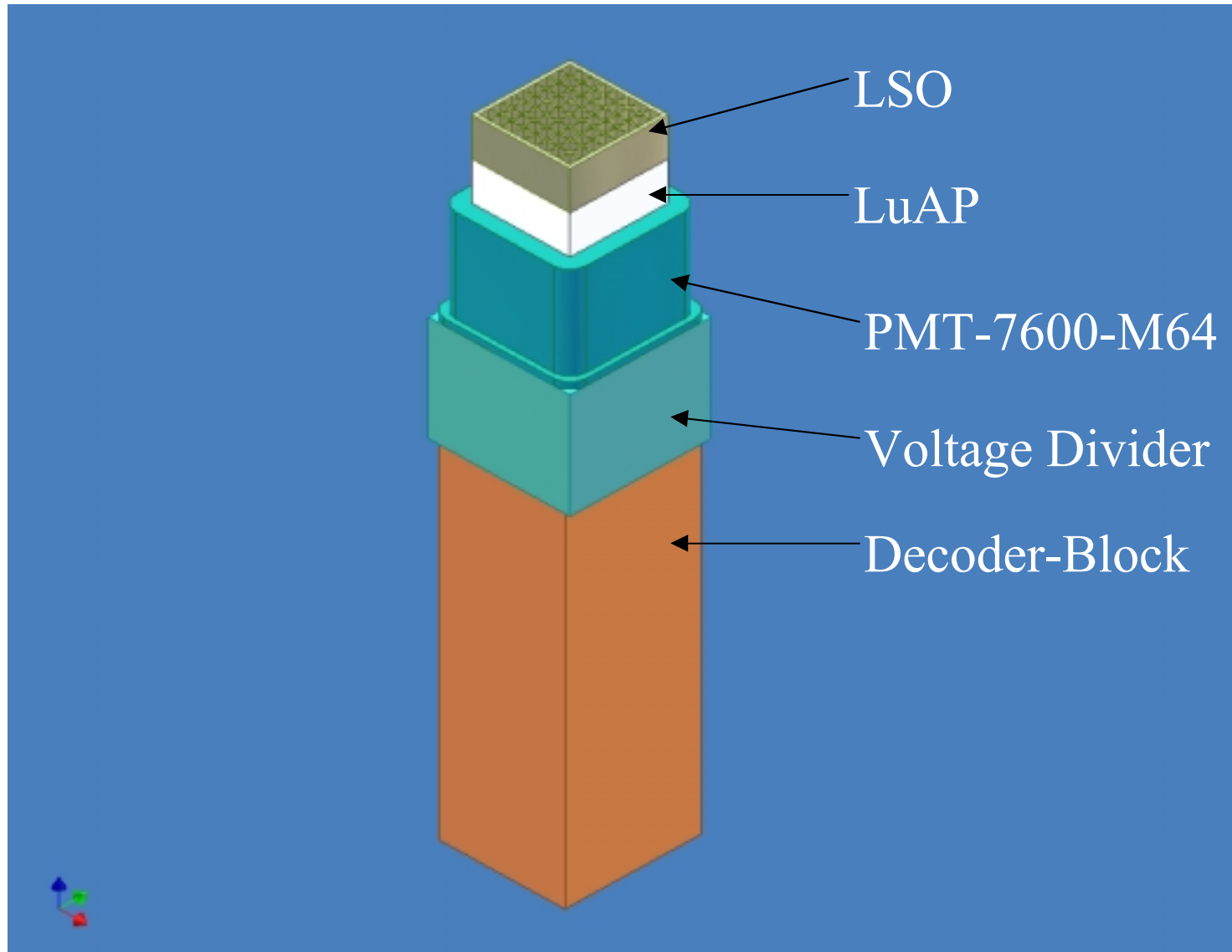


Cylindrical PEM

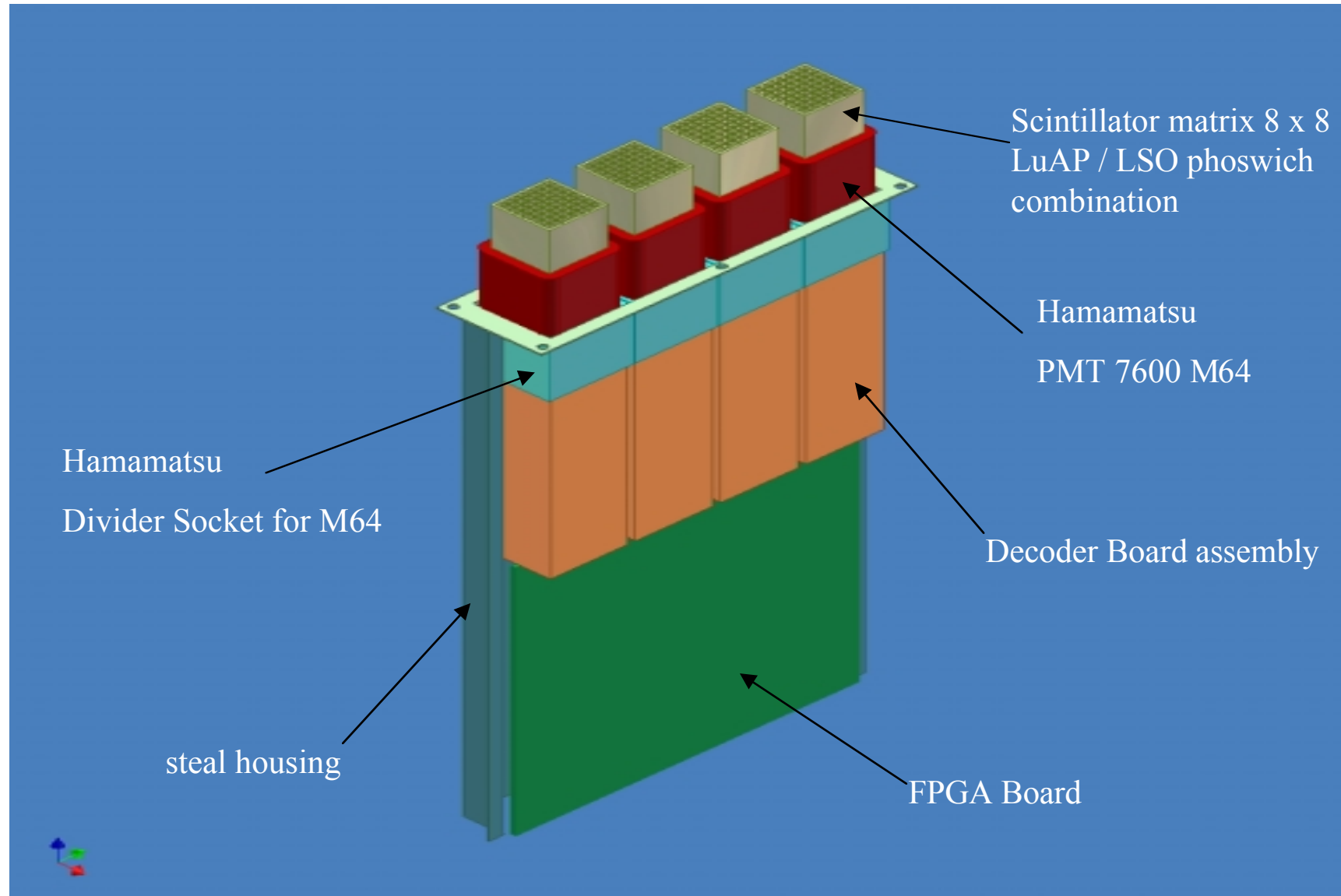




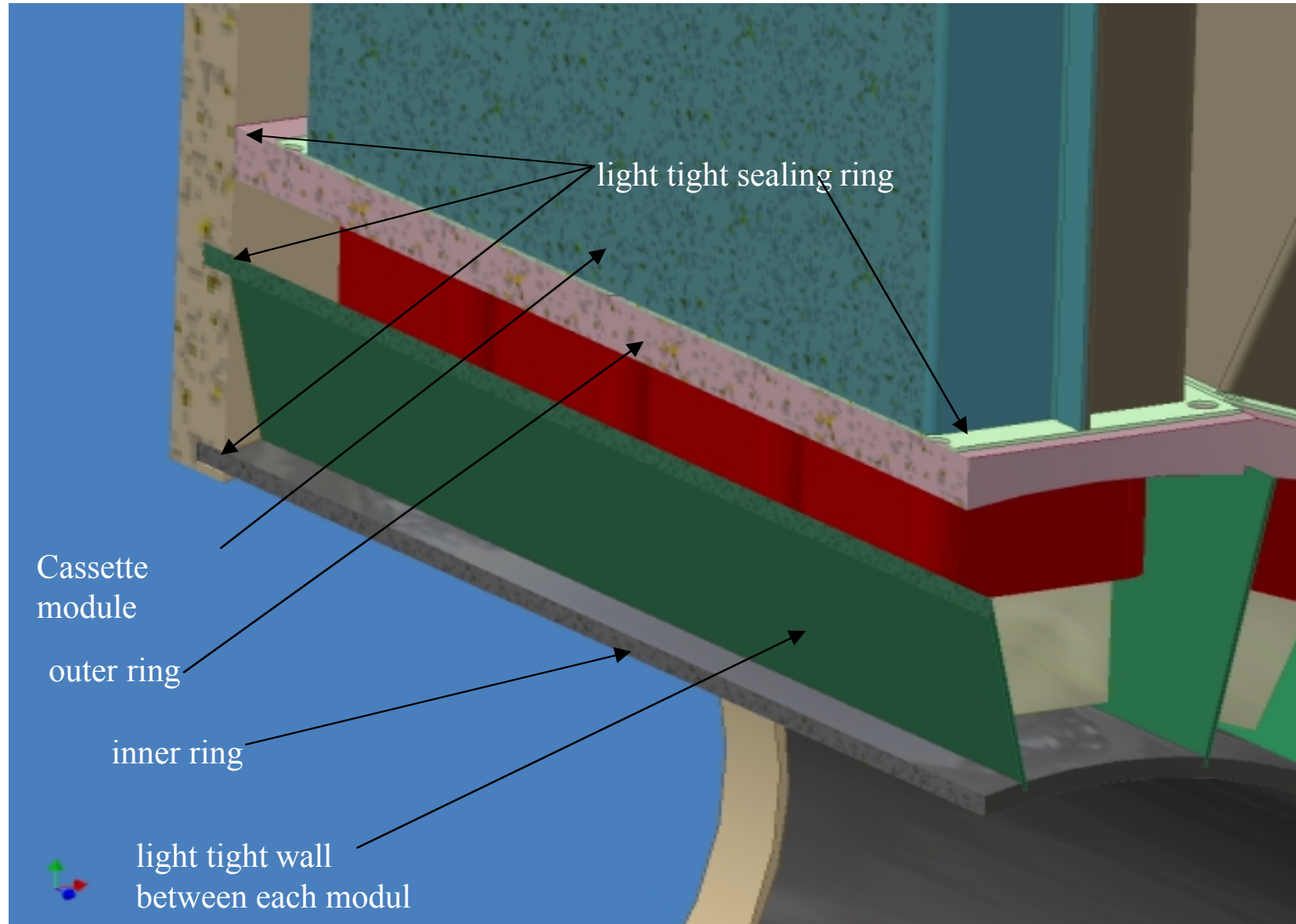
ClearPET detector assembly



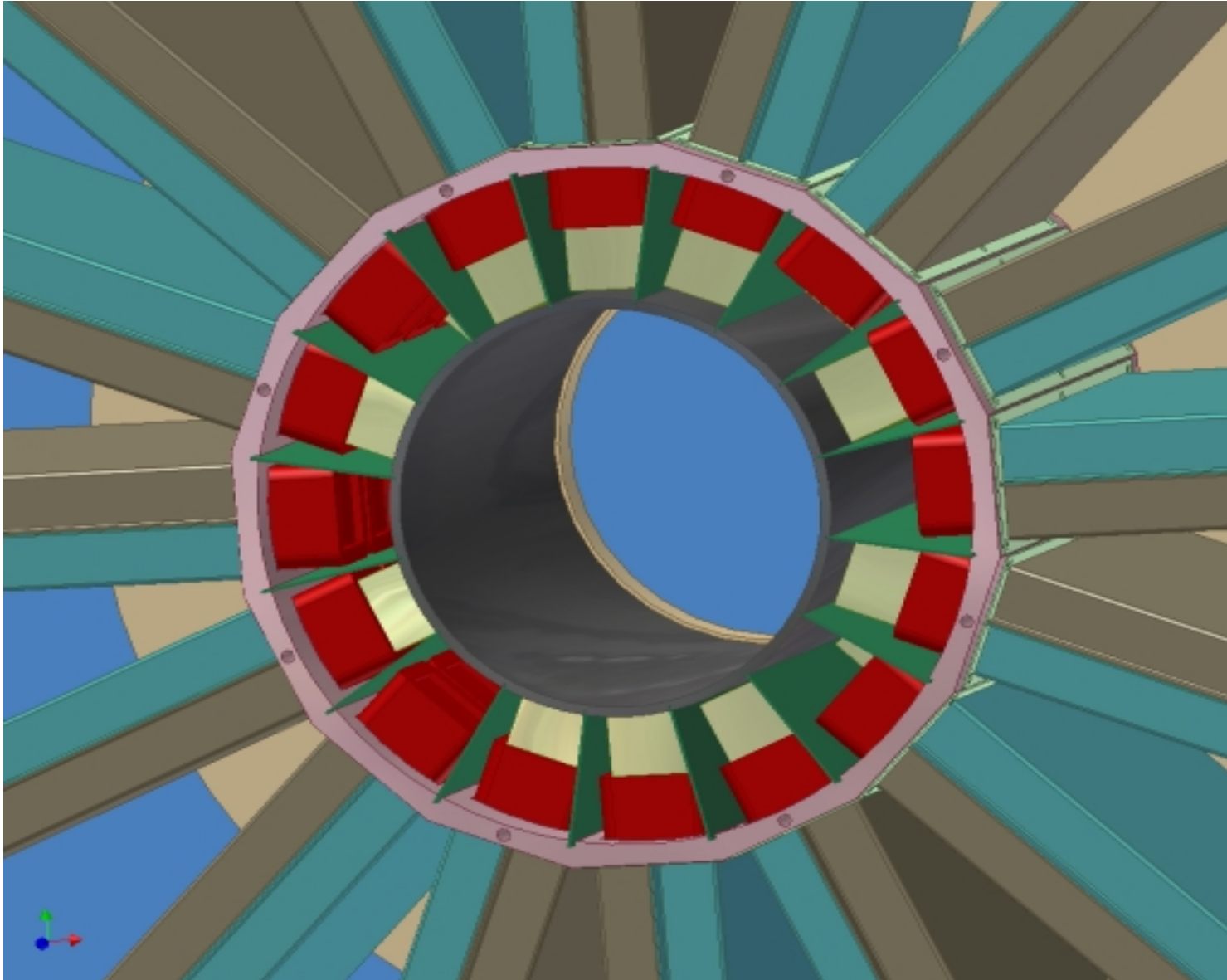
Cassette 1x4 array



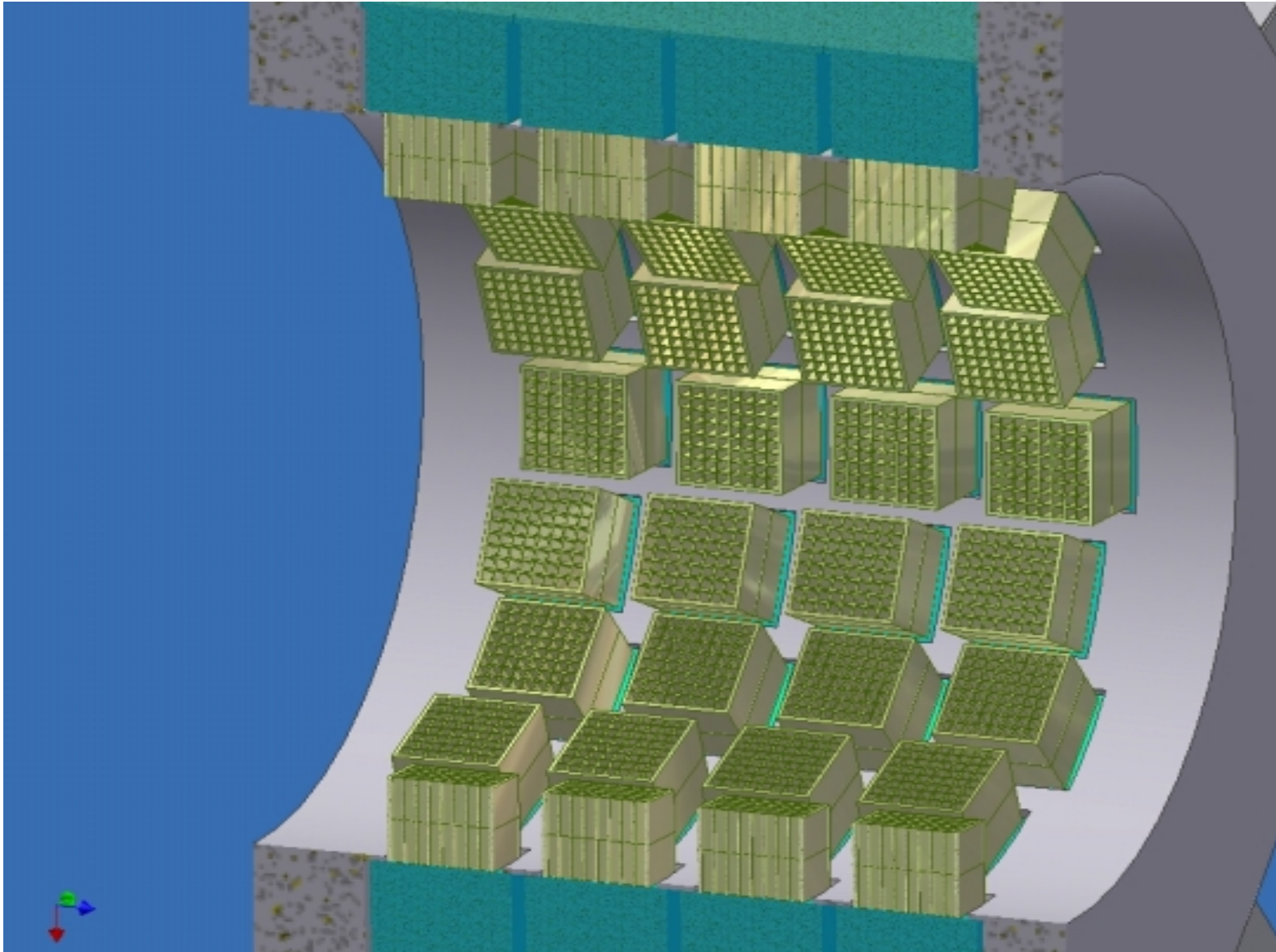
16x4 ring assembly



System Integration

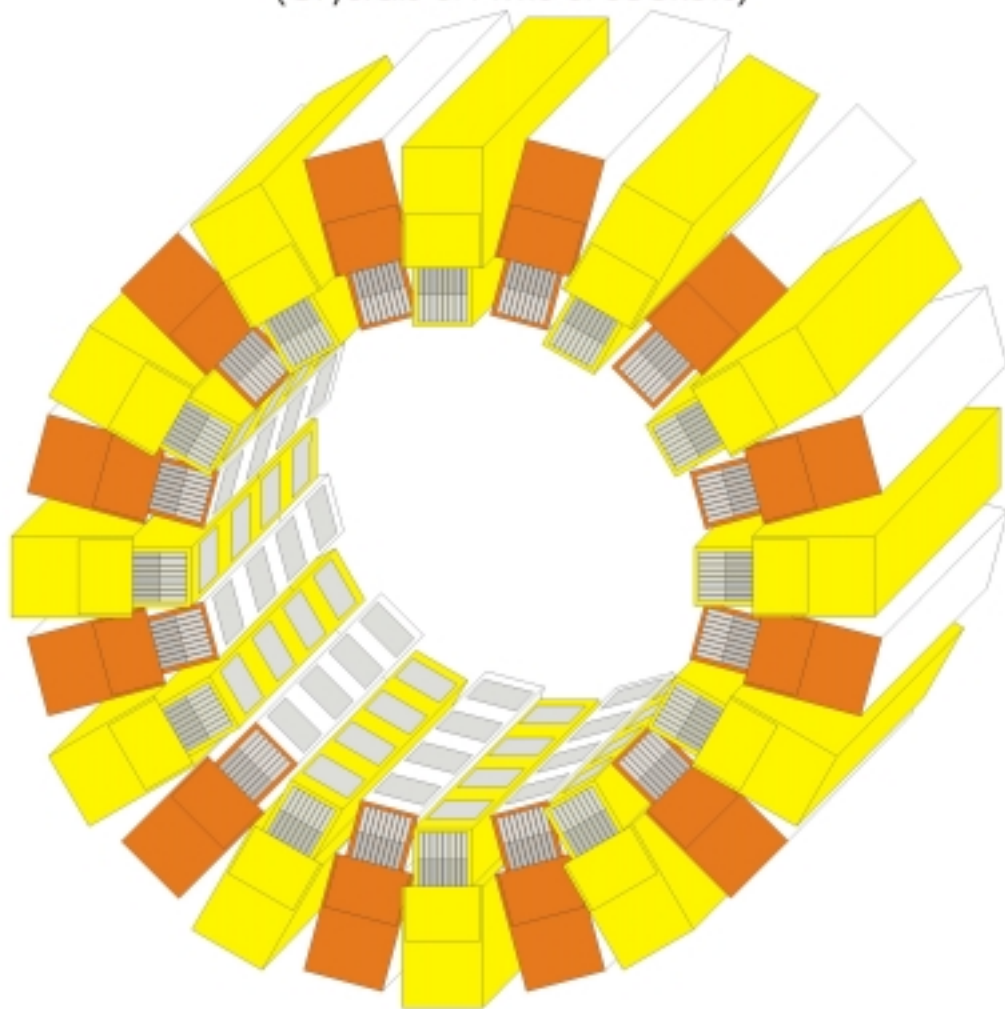


System Integration

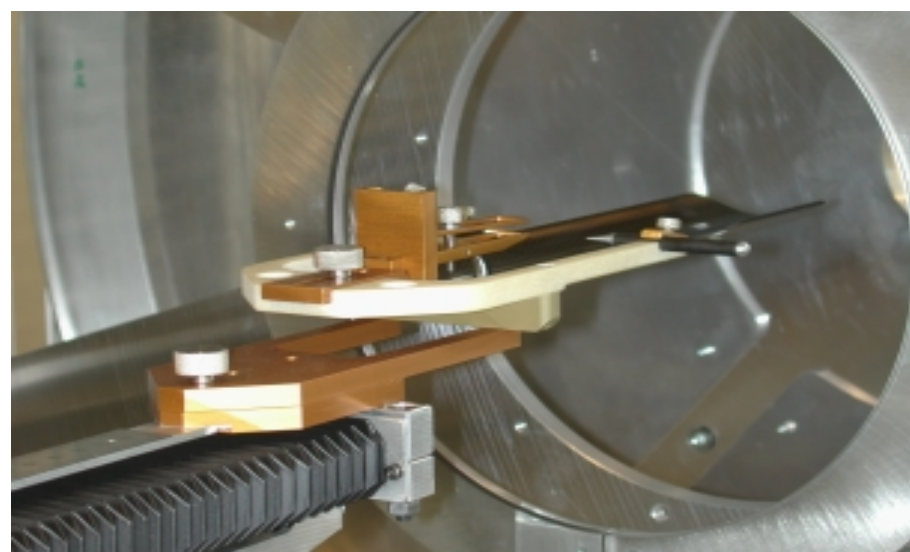
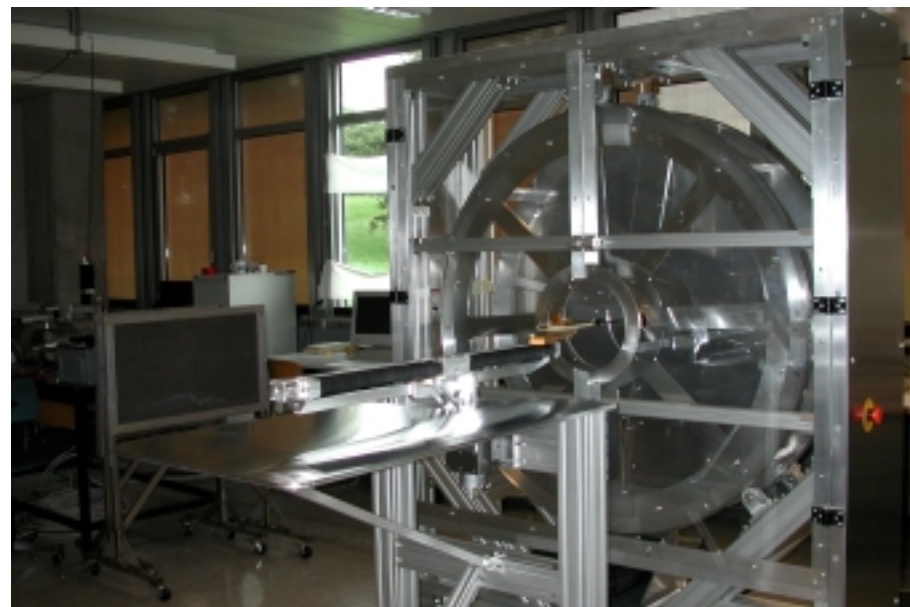
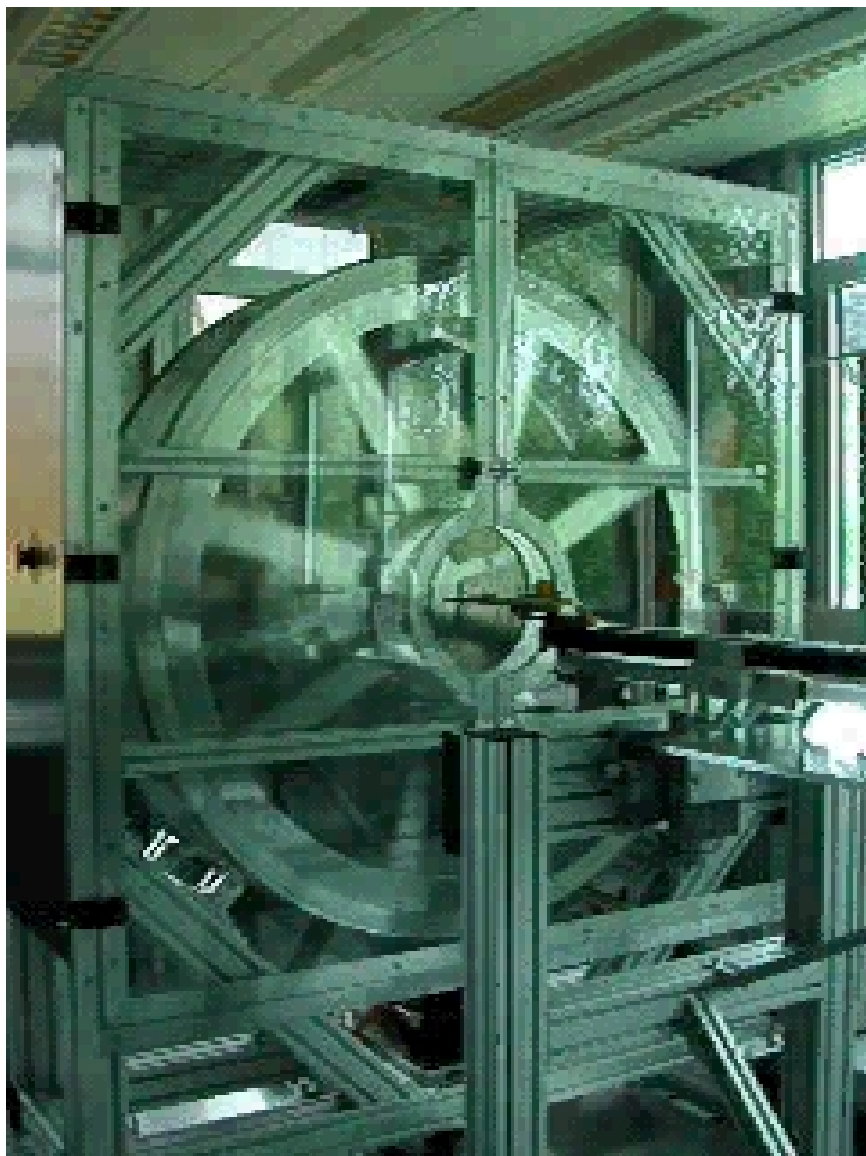


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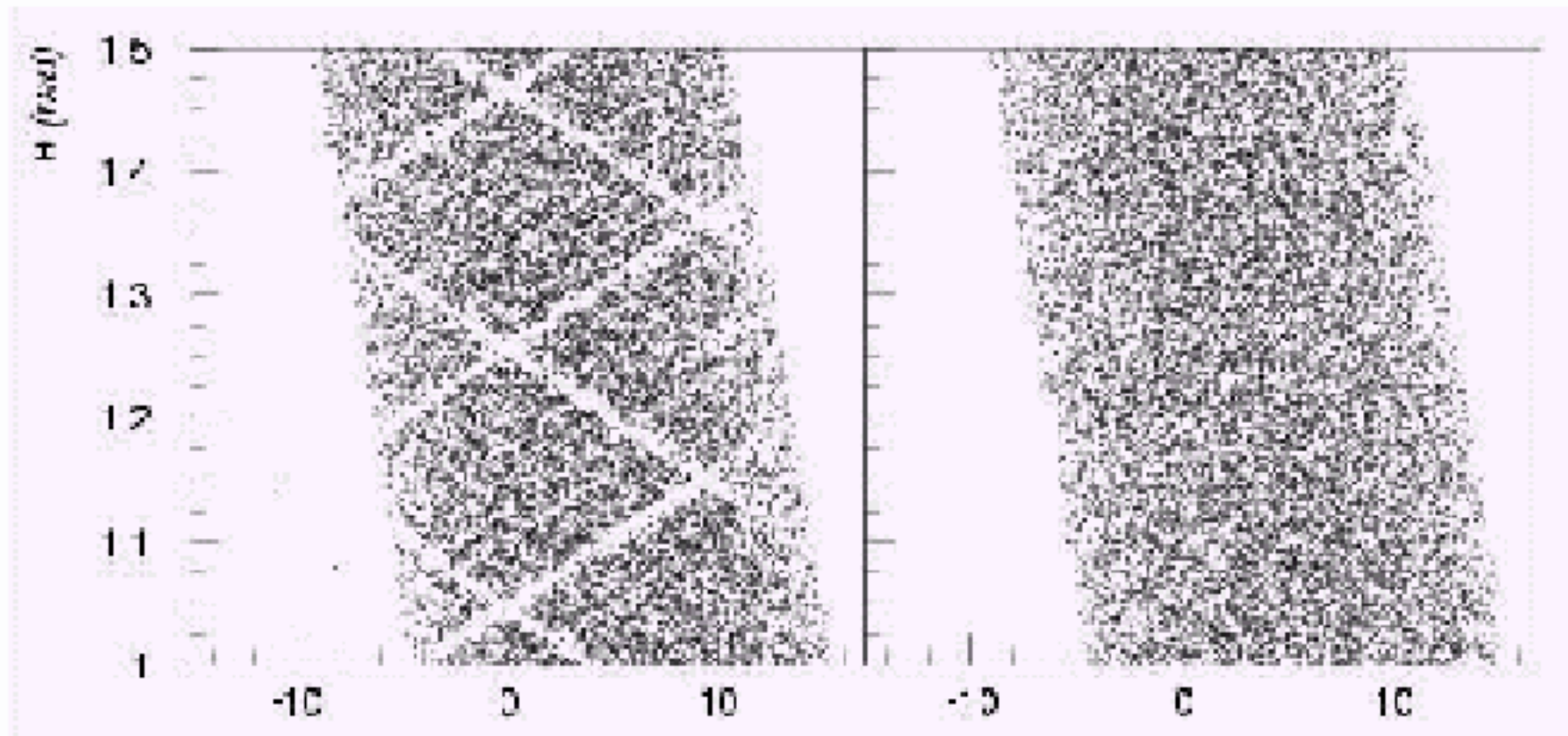
Ring-Design
(Crystals & PMTs & Sockets)



The Gantry



Test sinograms generated from ROOT output



Static scanner

Rotating scanner

Simulation

