Bump Bonding Requirements for Nuclear Physics

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Overview

- Where NP uses bump bonding now
- Why NP often doesn't use bump bonding
- Possible futures uses

Compton Cameras

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Compton imaging with the PorGamRays spectrometer

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The PorGamRays Collaboration[1]

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ABSTRACT

The PorGamRays project aims to develop a portable gamma-ray detection system with both spectroscopic and imaging capabilities. The system is designed around a stack of thin Cadmium Zinc Telluride (CZT) detectors. The imaging capability utilises the Compton camera principle. Each detector is segmented into 100 pixels which are read out through custom designed Application Specific Integrated Circuits (ASICs). This device has potential applications in the security, decommissioning and medical fields. This work focuses on the near-field imaging performance of a lab-based demonstrator consisting of two pixelated CZT detectors, each of which is bonded to a NUCAM II ASIC. Measurements have been made with point ^{133}Ba and ^{57}Co sources located ~35 mm from the surface of the scattering detector. Position resolution of ~20 mm FWHM in the x and y planes is demonstrated.

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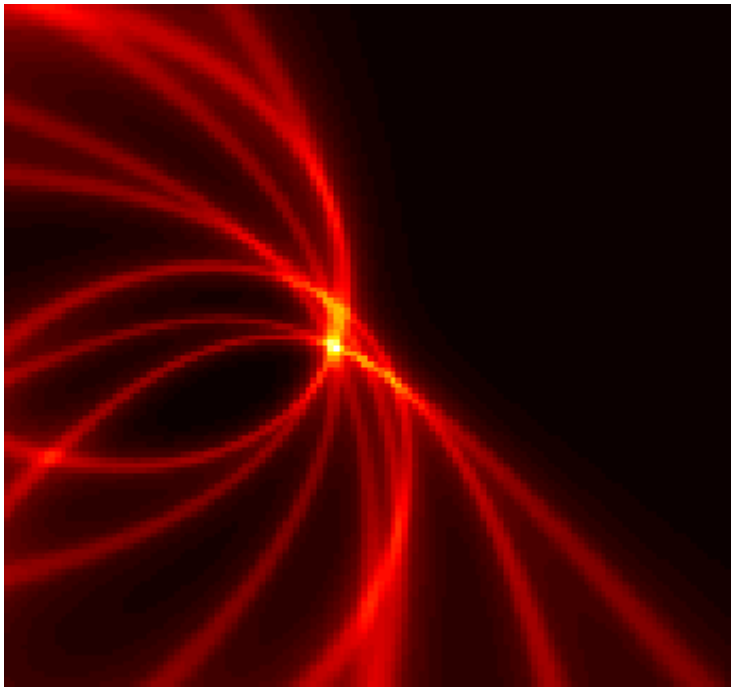
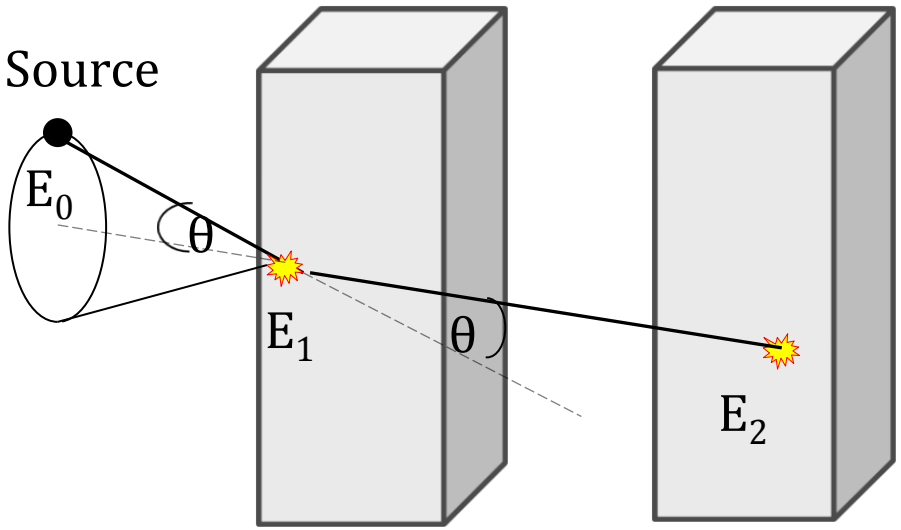
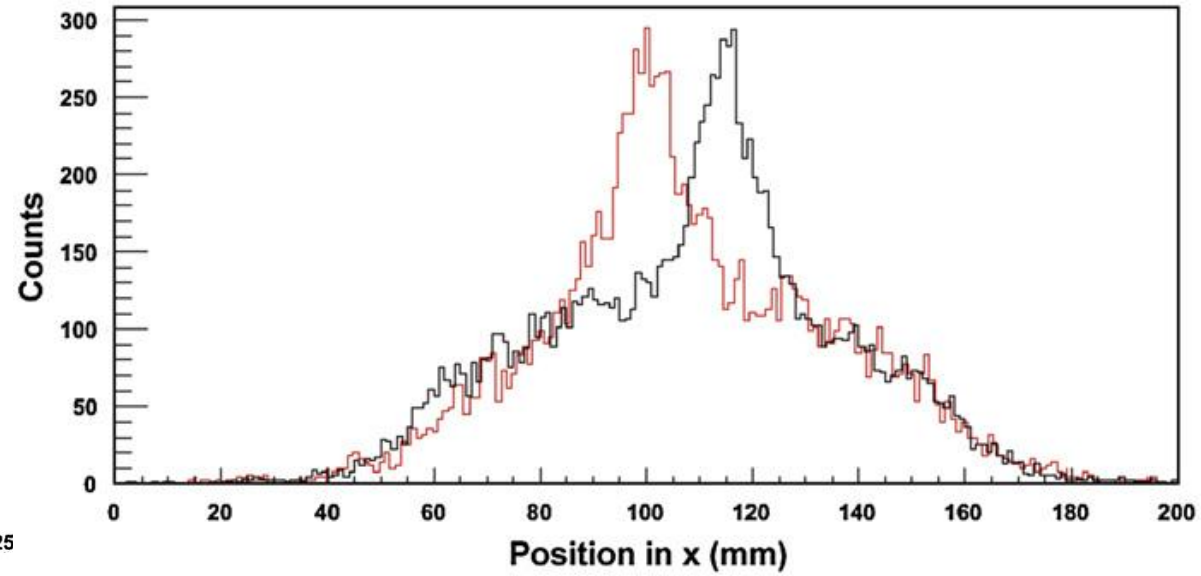
- Energy deposited by gamma-rays in both detectors
- Cone produced for each gamma ray using Compton kinematics
- Source located at max cone overlap

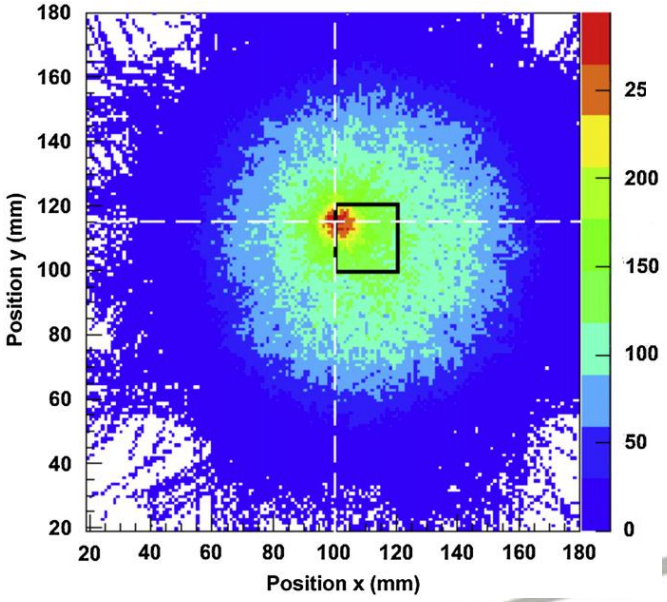




$$\cos\vartheta = 1 - m_e c^2 \left(\frac{1}{E_1} - \frac{1}{E_0} \right)$$

PorGamRays Results





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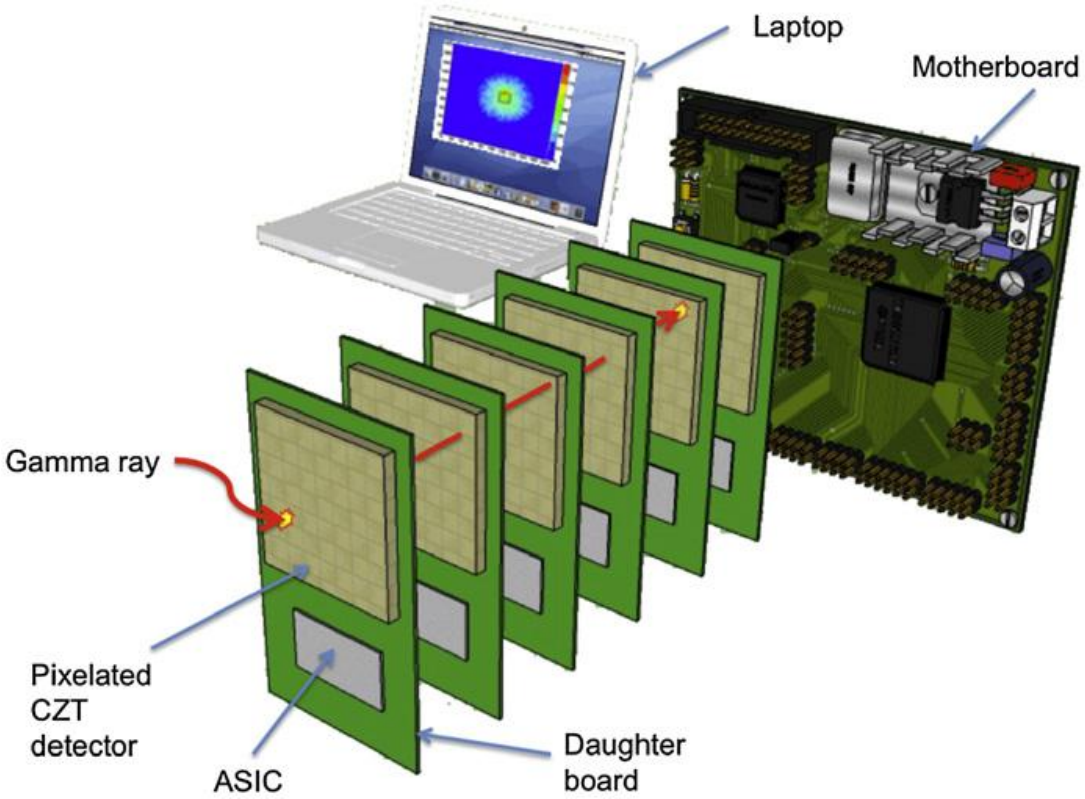
PorGamRayS



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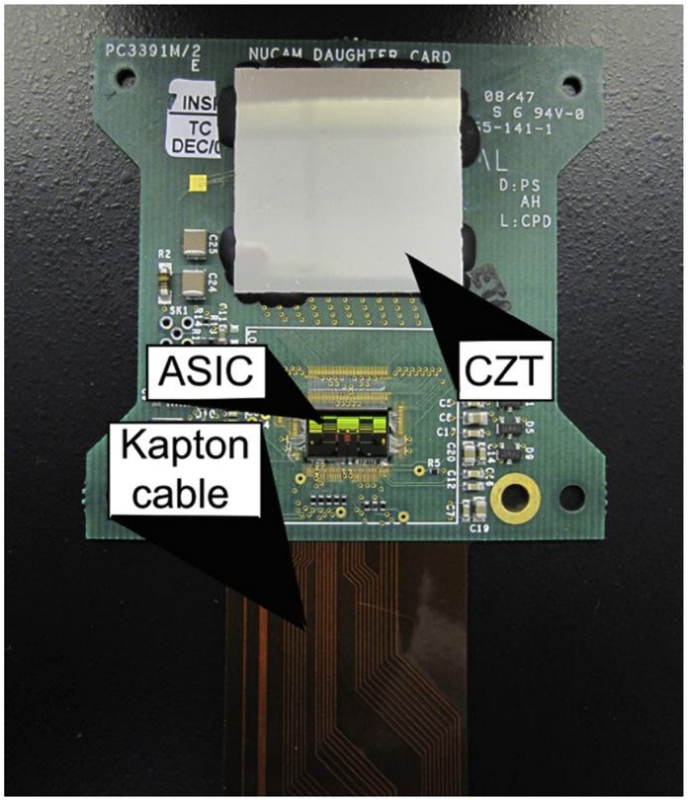
PorGamRays detector module



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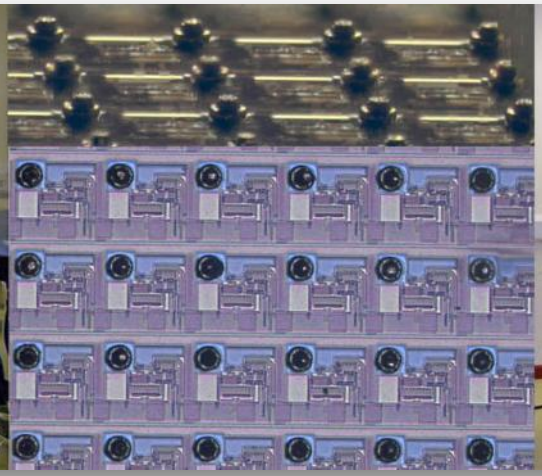
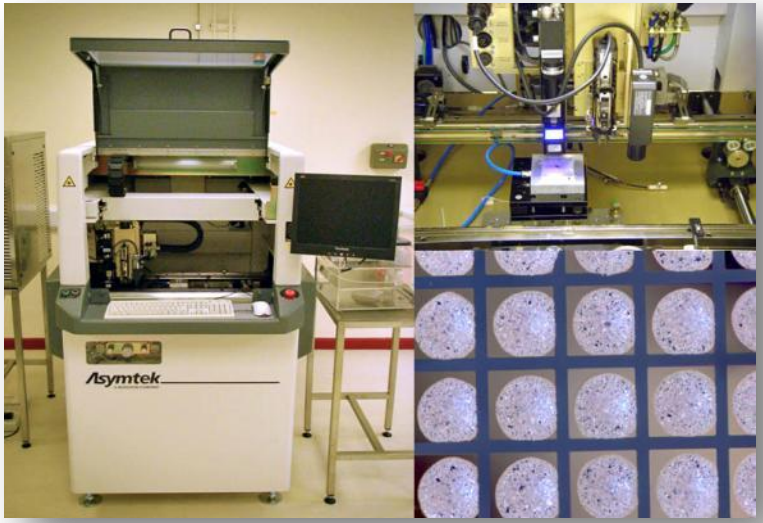
Gold Stud/Silver Epoxy Bump Bonding

Wire bonder

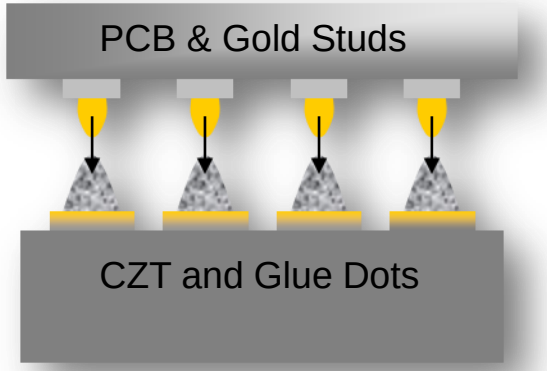


Gold studs

Flip chip bonder



Conductive glue dot dispenser



Flip chip gold stud bonding

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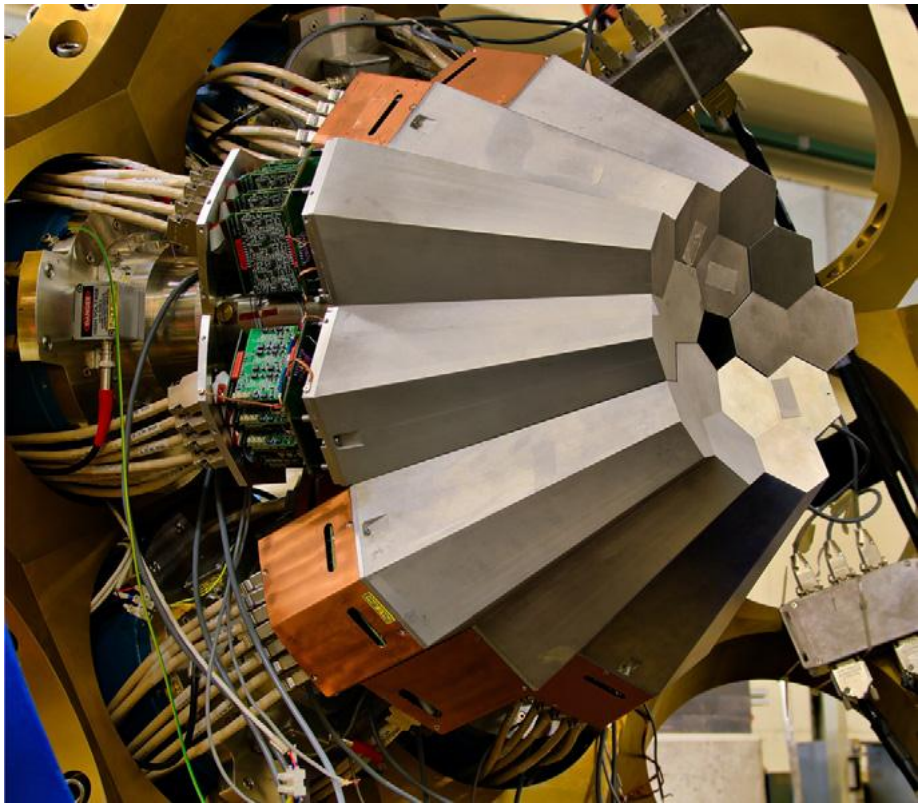
Main types of NP detector

Detectors are typically:

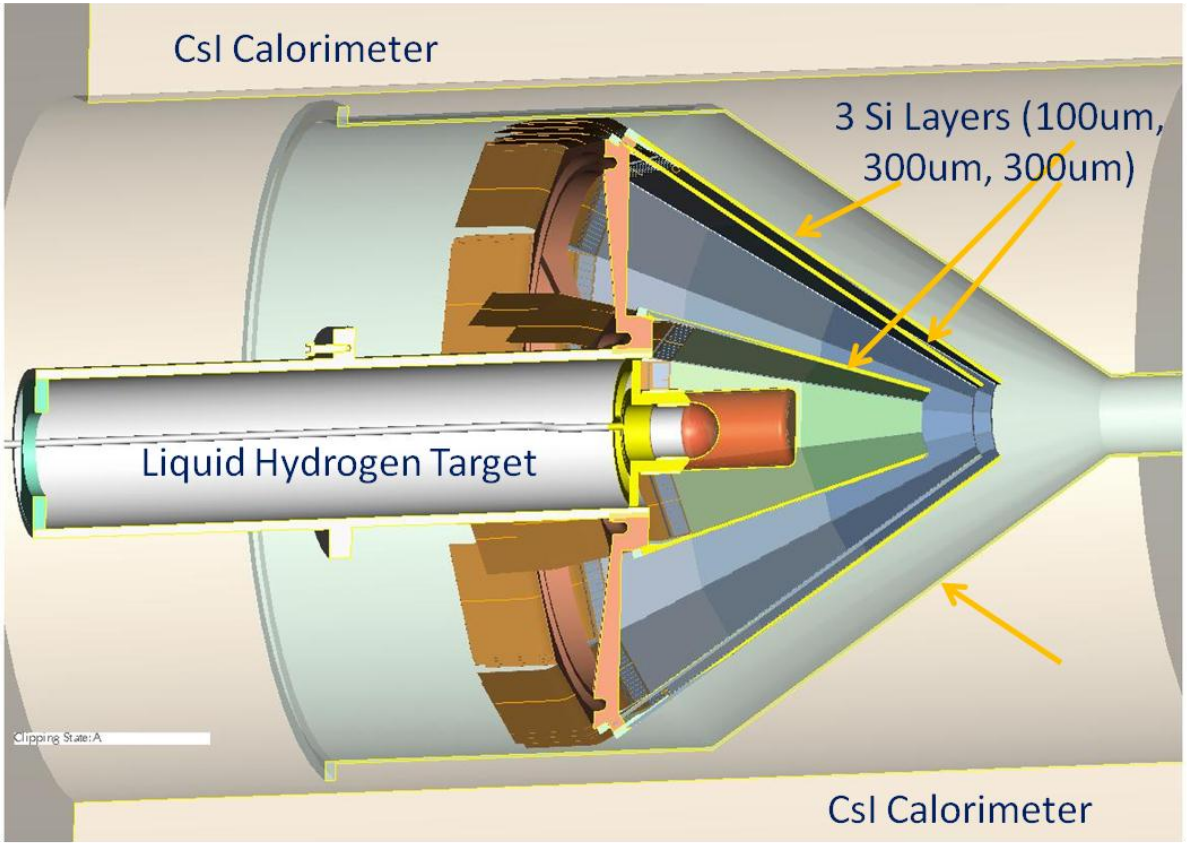
- Gamma- Large coax Ge gamma detectors
  - Sometimes CZT can be big enough (tiling?)
- Protons/CP Si trackers (fine pitch- typ 50um)
- Gas based CP detectors and active targets

AGATA Gamma Detectors



Ge in Al cans
LN2 cooling (vacuum)
9x8cm cylinder (tapered)
LN2 cooling,
vacuum- feed throughs
+heat load.
Fine pixelation not useful
(e.g. 1mm Compton
electron range)

R3B Proton Tracker



0-50MeV in Si (min 40keV)

Proton energy 250-300MeV

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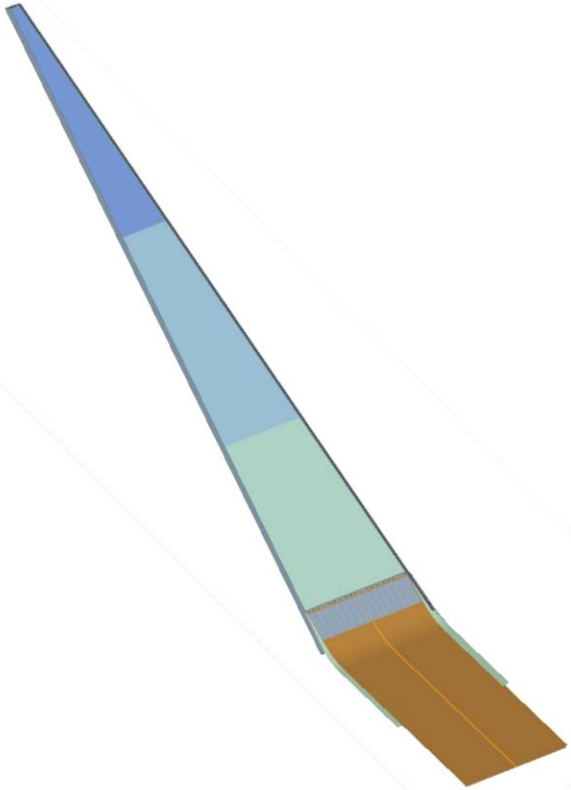
Part of R3B Si tracker



Measure dE and position in each layer

Can’t have inactive material in track path

Why NP often doesn't use bump bonding

Detectors are typically:

- Gamma- Large coax Ge gamma detectors
  - LN2 cooling, vacuum- feed throughs+heat load. Fine pixelation not useful (e.g. 1mm Compton electron range)
- Protons/CP Si trackers (fine pitch- typ 50um)
  - Measure dE and position in each layer- minimise inactive material; measure energy loss in Si.
- Gas based CP detectors and active targets
  - Currently pitch is few mm

Possible areas where bump bonding could benefit NP

- Thick CZT bonded onto ASICs and buttable for tiling (coarse- mm pixels OK)
- 3-d ASICs to increase performance?
- MCP-PMT for fast timing- cathodes with direct bump-bonded connection to analogue pipeline ASICs or preamps? (Pitch??)
- SiPM based instrumentation?
- Possibly TPC/GEM??