Mokhtar Chmeissani, Symposium "Advanced Semiconductor Detectors for Medical Applications" 13-02-2015

PET

Compton Camera

PEM

VIP-ASIC

VIP-Module Construction

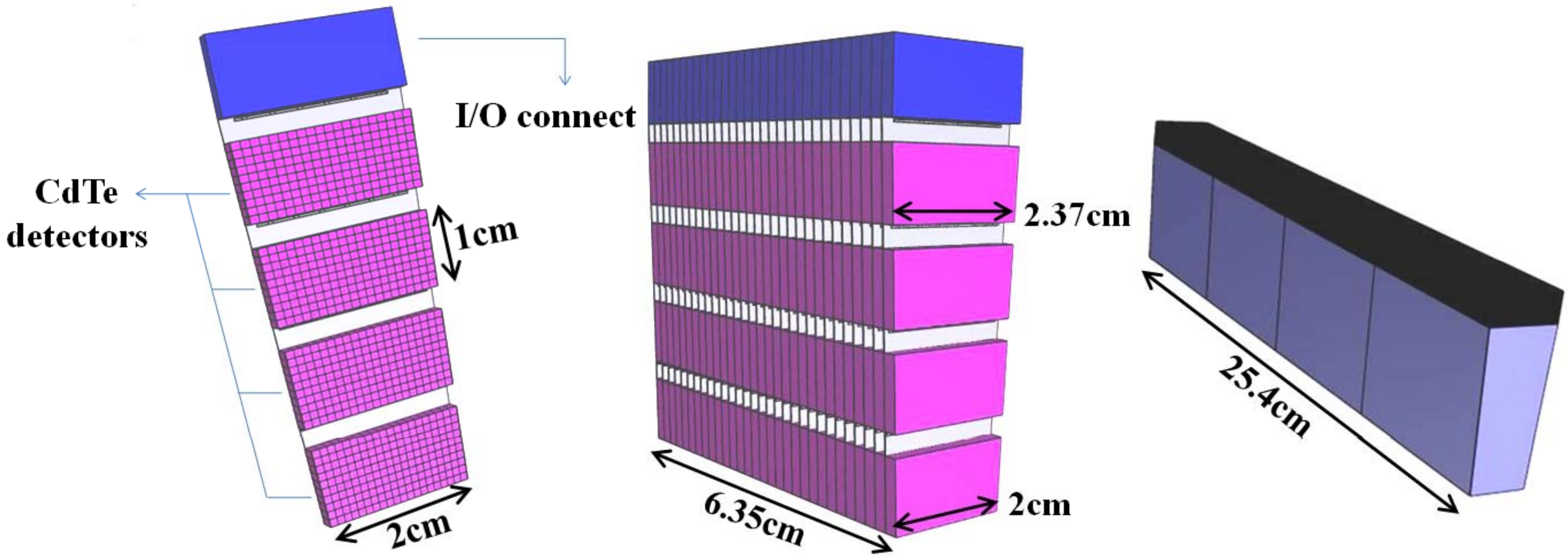
Schedule

Publications

Summary

PET

VIP Geometry

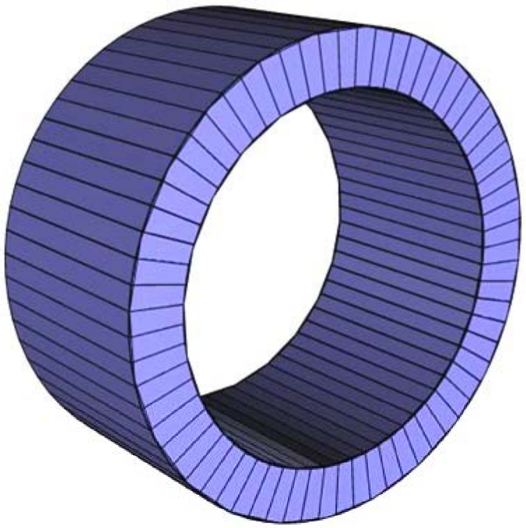


VIP detector module is made of pixelated CdTe detectors with trapezoidal shape. It is bonded to the thinned ROC and then

Module block consists of VIP detector modules and contains 450 voxels/cm^3. The voxel size is 1mm x 1mm x 2mm.

VIP sector is made of 4 module blocks connected to the same electronic bus.

VIP Distinctive Features



When 66 of the VIP sectors are put together, they form a cylindrical seamless PET scanner. A total number of the detector voxels is 6,336,000. Thus, the VIP has 6,336,000 independent readout electronic channels.

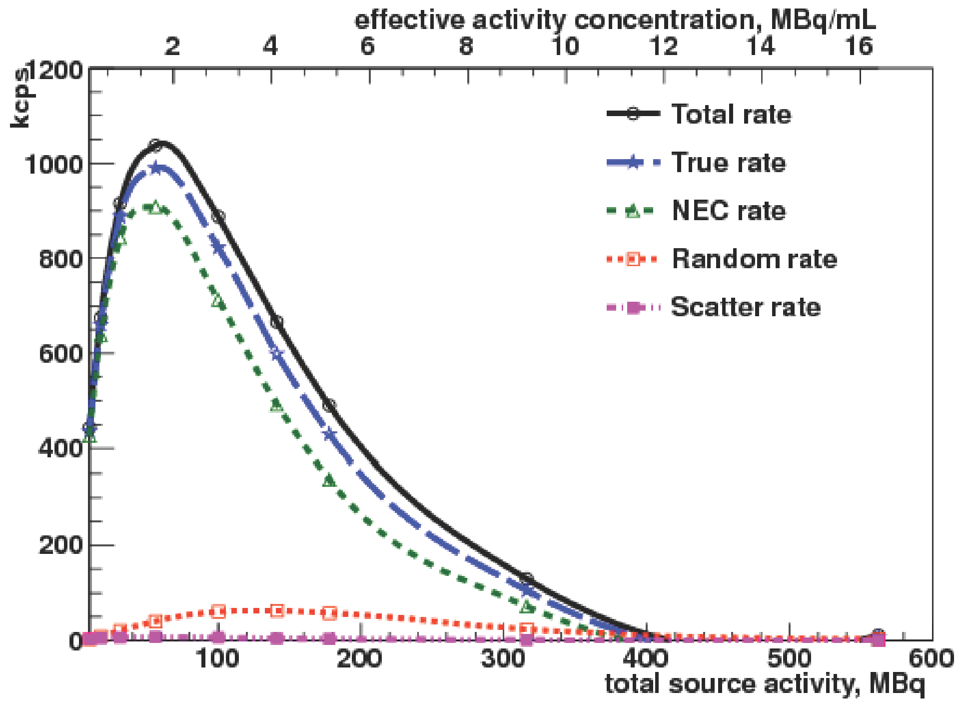
❖ Greatly improve the spatial resolution due to true 3D impact information (negligible parallax error).

❖ Has excellent energy resolution . FWHM ~1.57% at 511 keV @ room temperature. Eliminating most of the scattered events and thus achieve high signal-to-noise ratio

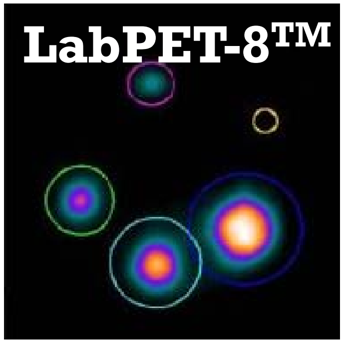
❖ Has adequate detection efficiency for 511 keV photons thanks to the high CdTe stopping power and seamless geometry.

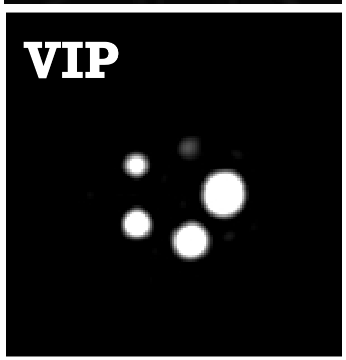
Performance Evaluation

NEMA NU 4-2008 small phantom

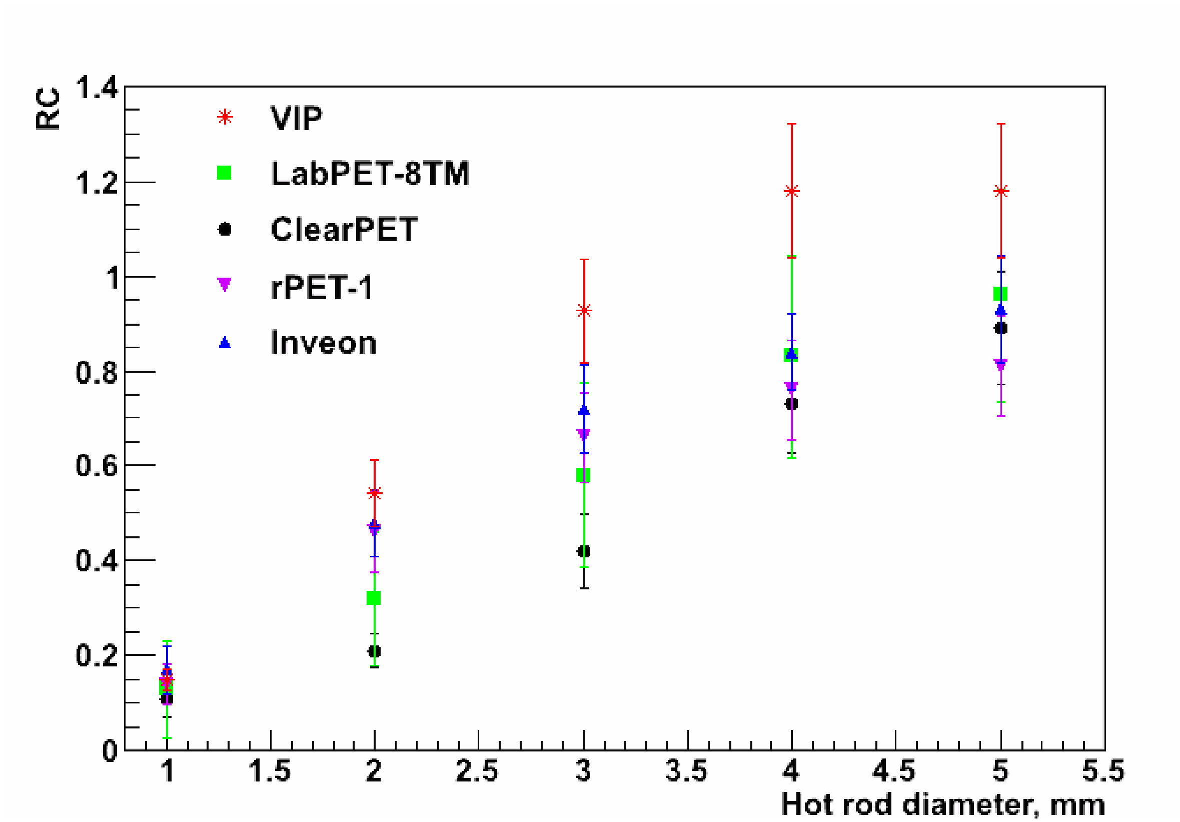


Performance Evaluation





Hot Rods Contrast and Noise Comparison

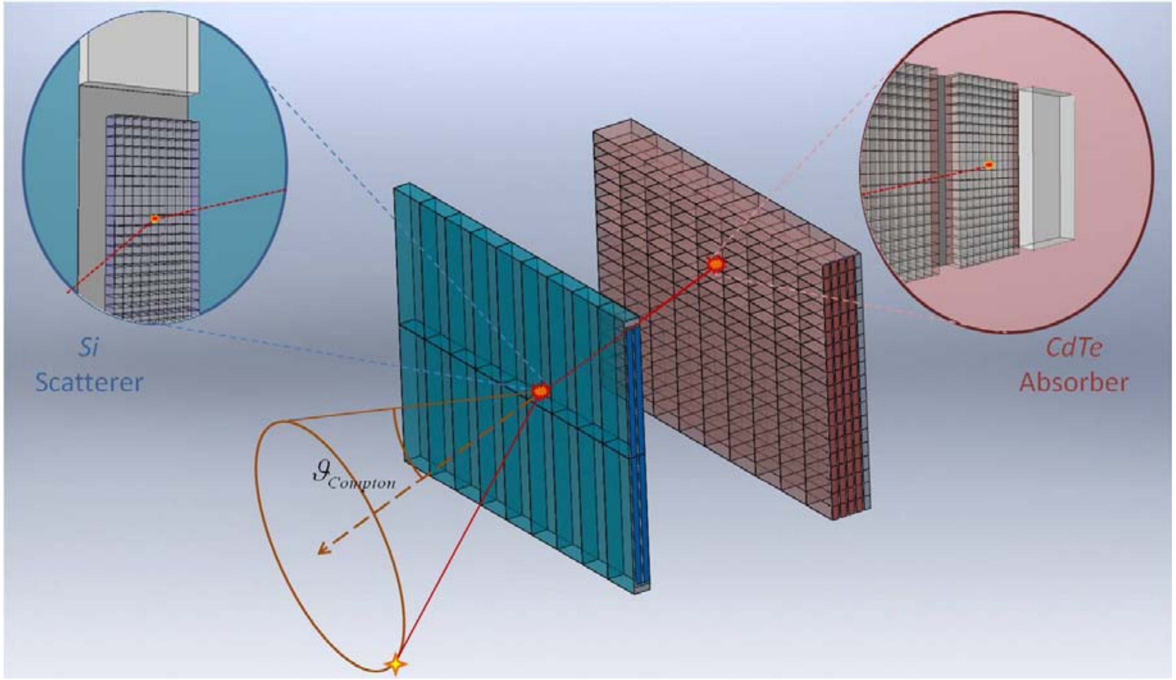


Performance Evaluation

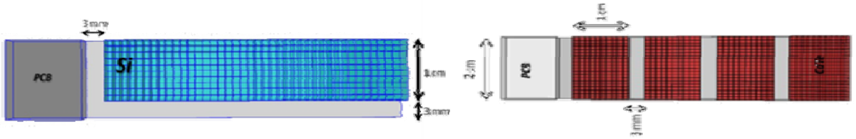
Characteristic	VIP NEMA NU 4-2008	NEMA NU 4-2008: One of the best results	VIP NEMA NU 2-2001	NEMA NU 2-2001: One of the best results
Scatter fraction	0.73%	7.8% (Inveon DPET)	3.95%	34% (PENN-PET)
Sensitivity	21 cps/kBq	16.98 cps/kBq (ClearPET)	14.37 cps/kBq	6.6 cps/kBq (HR+)
Radial spatial resolution near the center of FOV	0.75 mm	1.5 mm (rPET-1)	0.694 mm	2.3 mm (CdTe based PET) 4.1 mm (G-PET)

Compton Camera

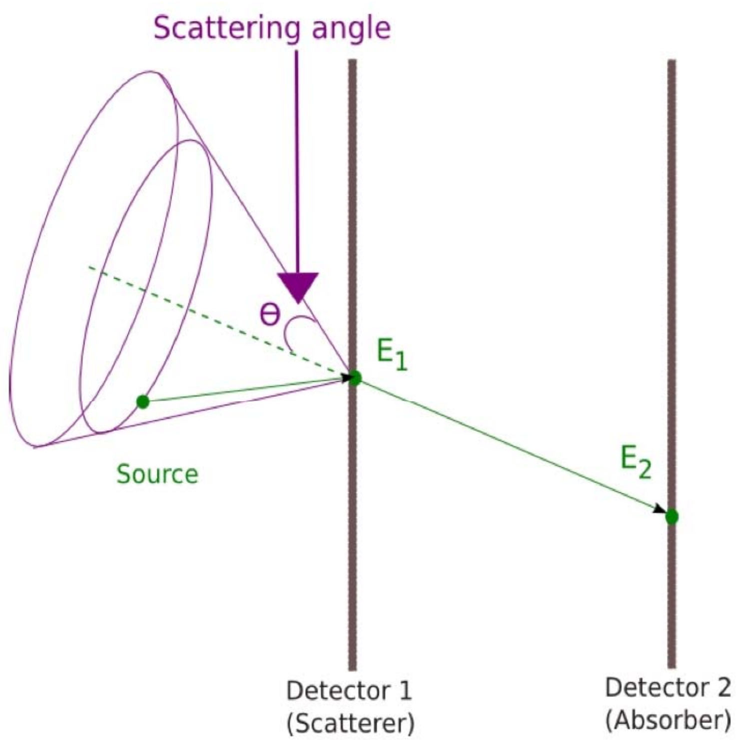
VIP Compton Camera



Scatterer module **Absorber module**

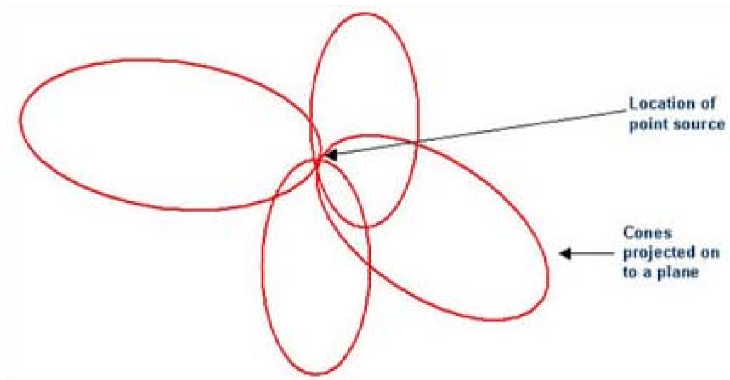


Compton Camera Principle



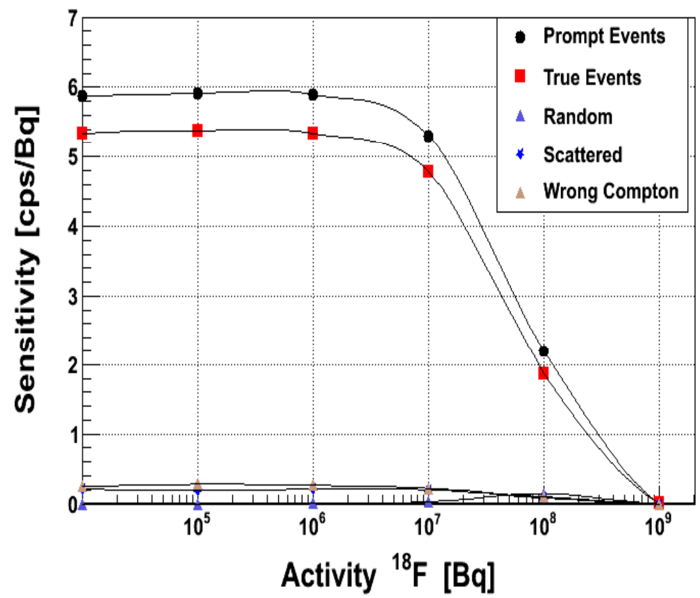
$$\cos\vartheta = 1 - mc^2\left(\frac{1}{E_{total} - E_{scatter}} - \frac{1}{E_{total}}\right)$$

- Electronic collimation exploits the Compton interaction to reconstruct a cone surface in which the emitting source lay.



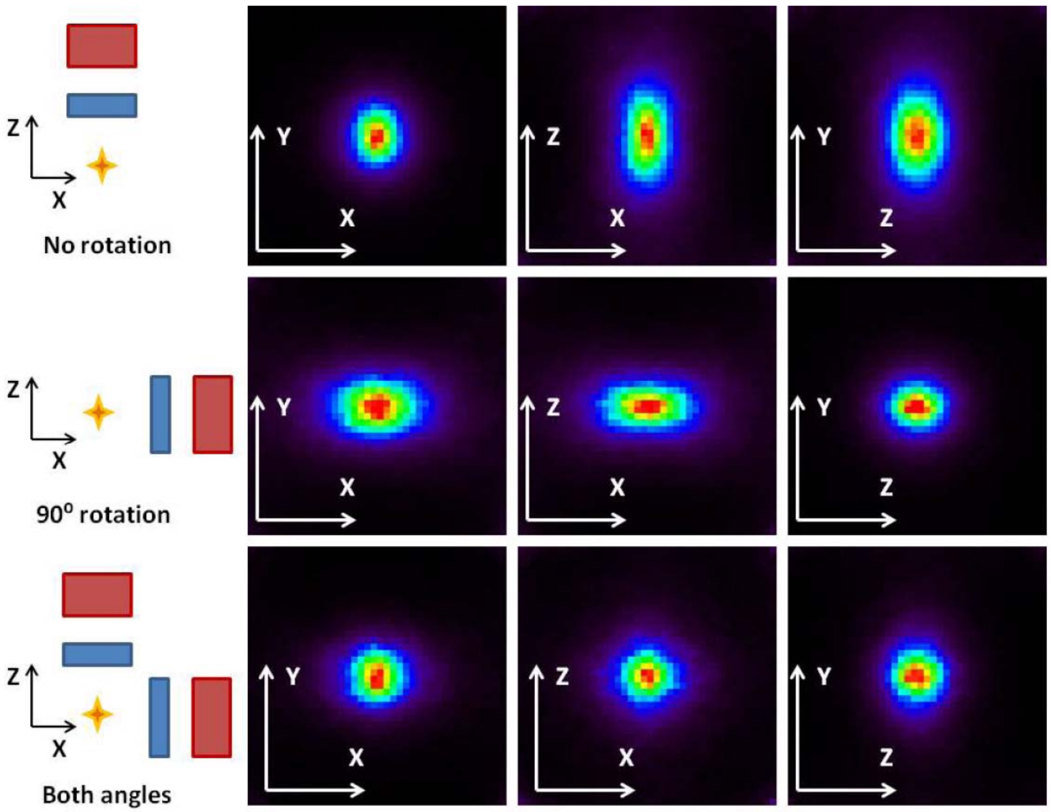
- In a Compton camera the gamma photons emitted suffer a Compton interaction in the 1rst detector (scatterer) and a photoelectric absorption in the 2nd (Absorber).
- The intersection of cone surfaces allows to determine the source position.

VIP-CC Sensitivity



VIP Compton camera sensitivity for different activities of ^{18}F isotope. The good energy resolution of the CdTe detector allow us to discard most of the random and scattered events achieving a signal-to-noise ratio of 93%.

VIP-CC Point Spread Resolution



VIP-CC Derenzo Phantom

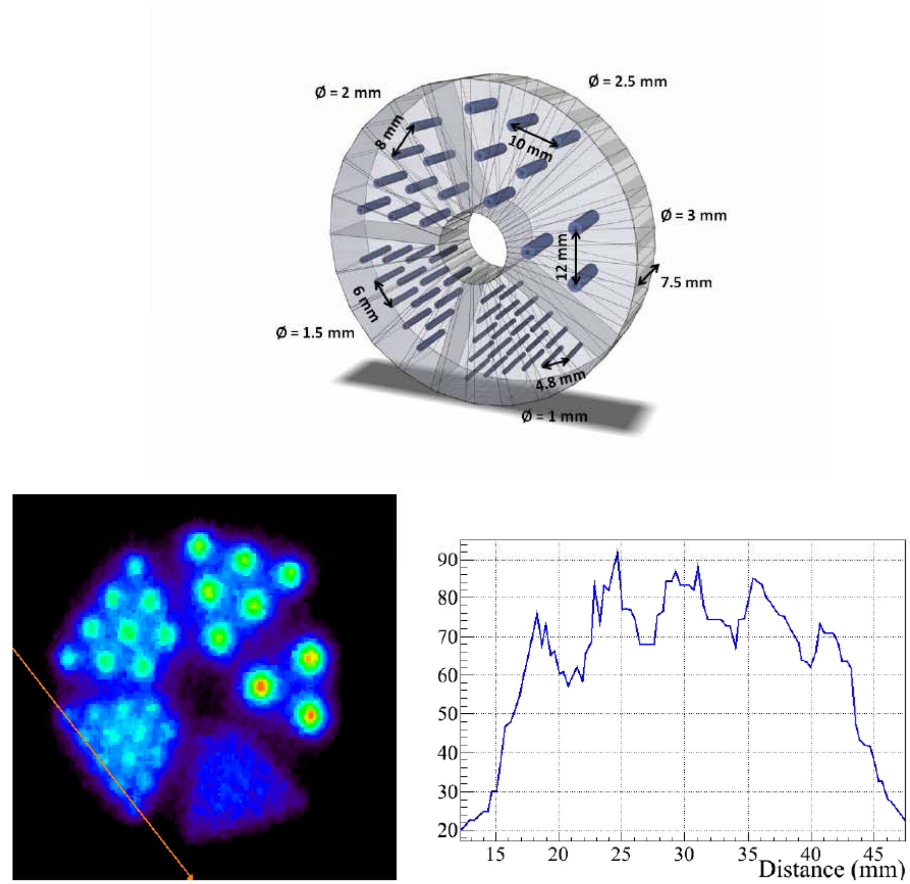


FIGURE 6.28: *Top:* scheme of the phantom. *Bottom:* reconstructed image with LM-OSEM and corresponding line profile of the 1.5 mm diameter rods. [75]

PEM

VIP-PEM Design

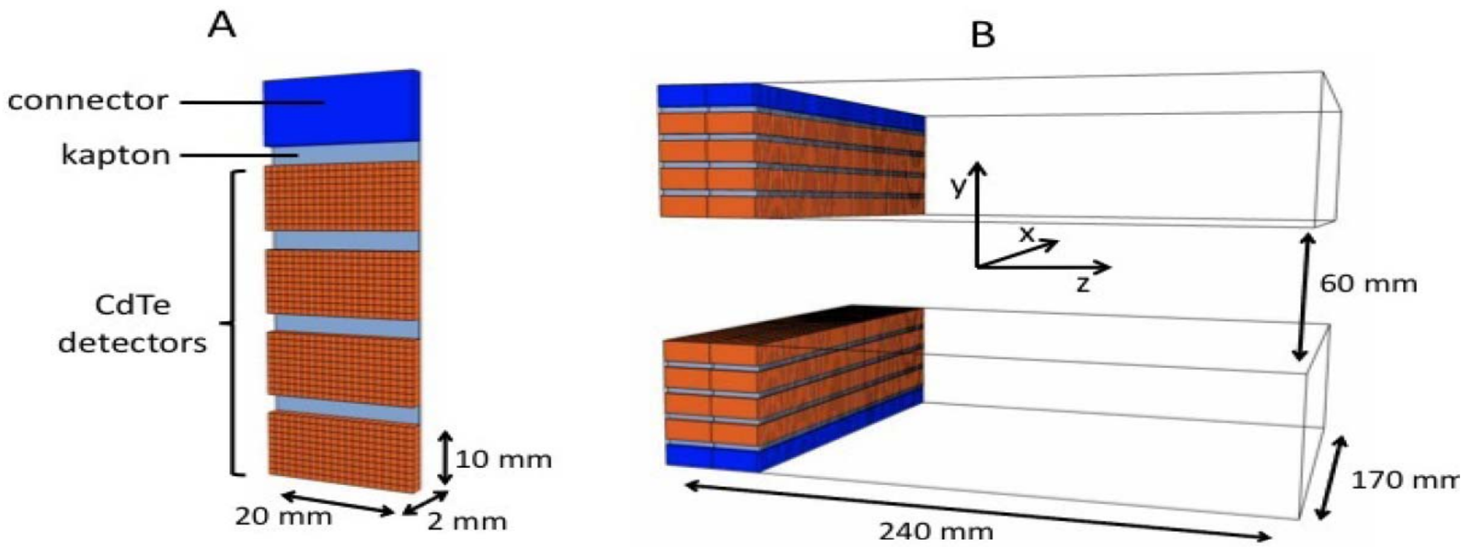


Figure 1. Basic unit detector and detector specifics.

- VIP mammography consists of two parallel paddles, each one hosting one sliding detector head. Each head has 64000 voxel/channels.
- The head section is 170 mm wide along the x-axis and 40 mm wide along the z-axis, and the two detector heads must slide axially for a complete scan of the 170 mm x 60 mm x 240 mm FOV.

Naviscan PEM design

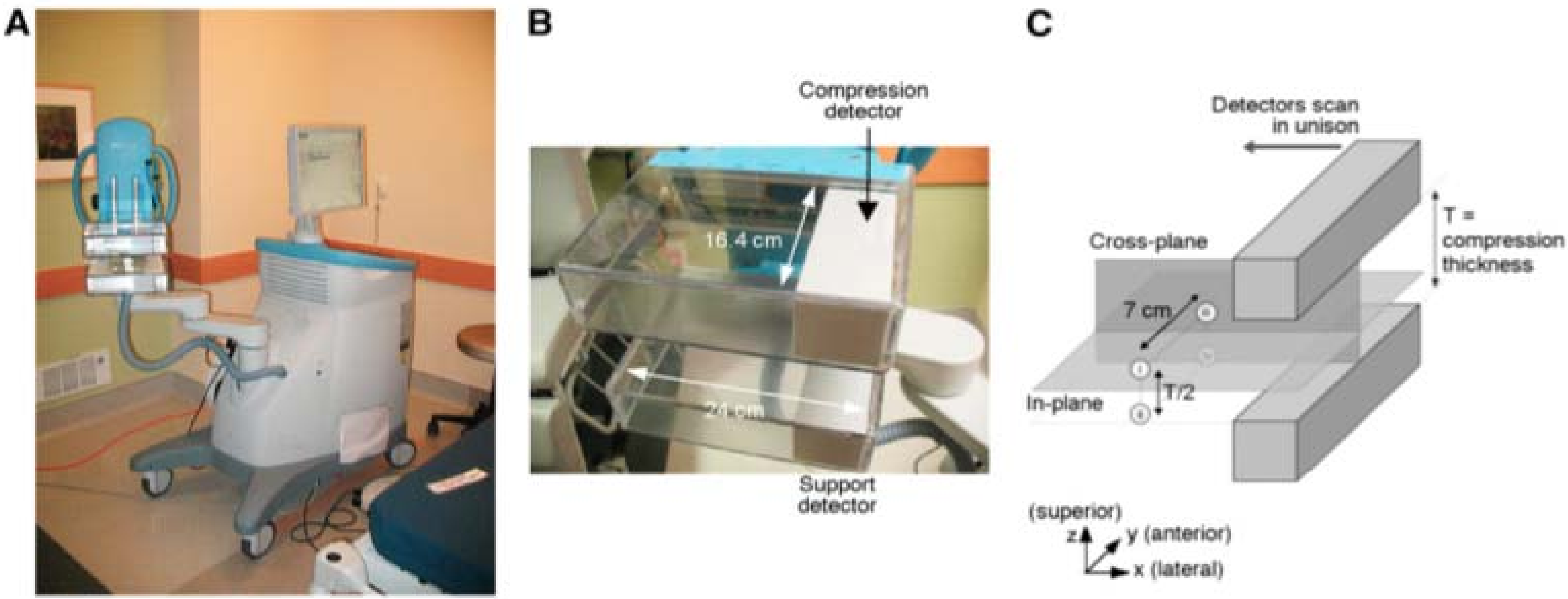
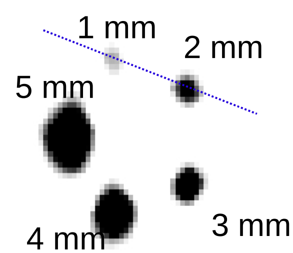
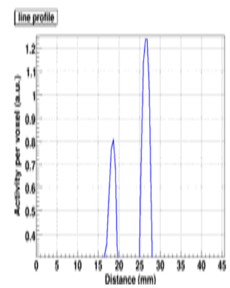


FIGURE 1. (A) PEM Flex Solo II system. (B) Close-up of detectors. (C) Illustration of in-planes and cross-planes. Four cardinal positions (i, ii, iii, and iv) within PEM Flex FOV used to investigate quantification consistency.

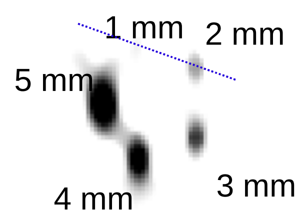
VIP Versus Naviscan Phantom Image Quality

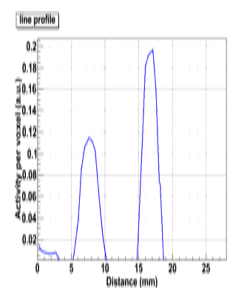
In Plane

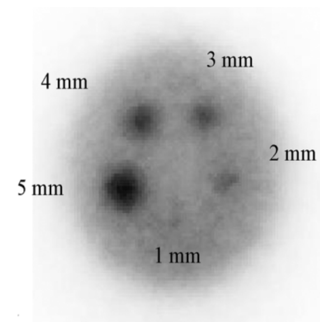


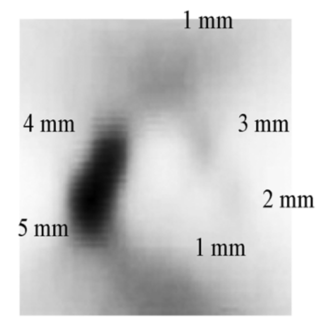


In Cross Plane







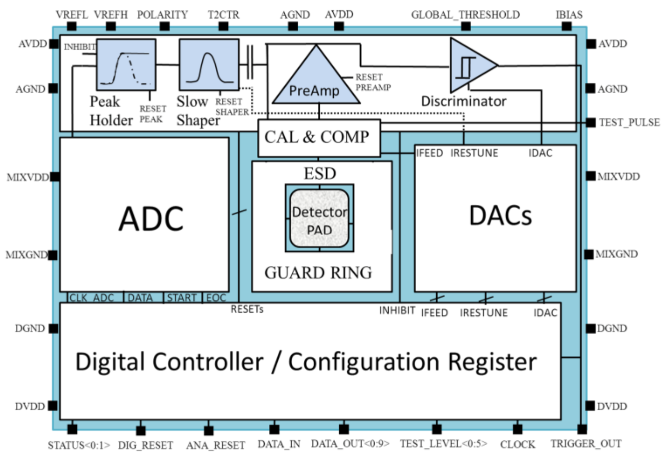


VIP-PEM with 1.3M coincidences

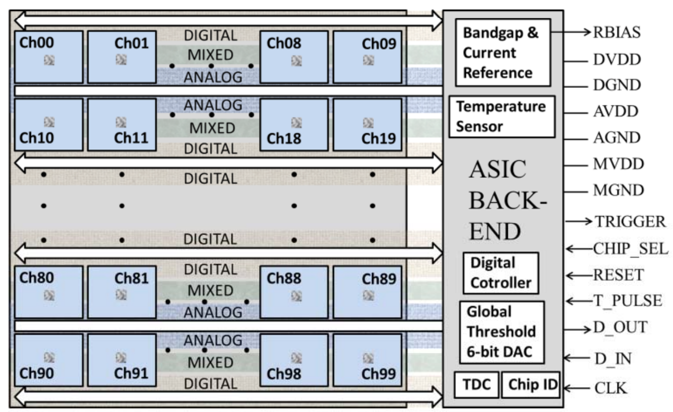
Naviscan with 10M coincidences

VIP-ASIC

VIP Design Architect



Architecture of the pixel readout electronics.

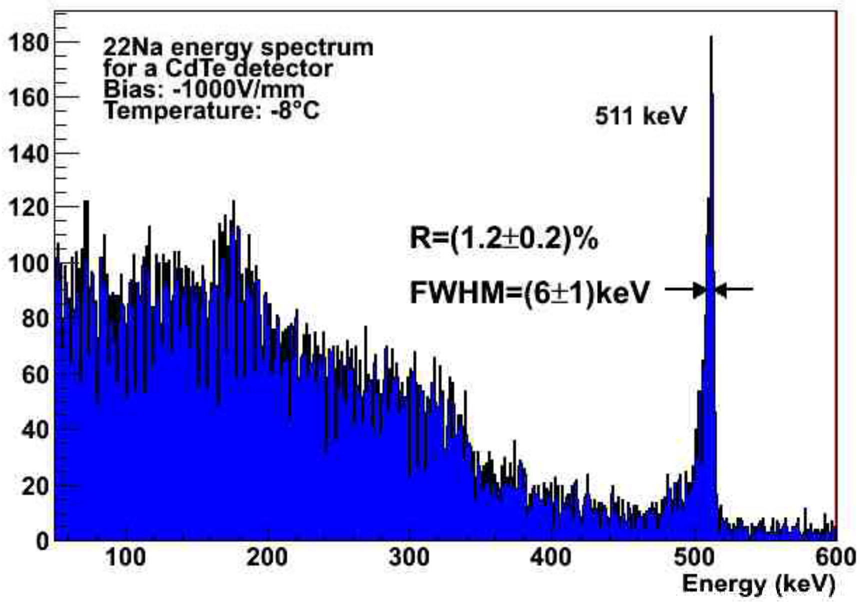


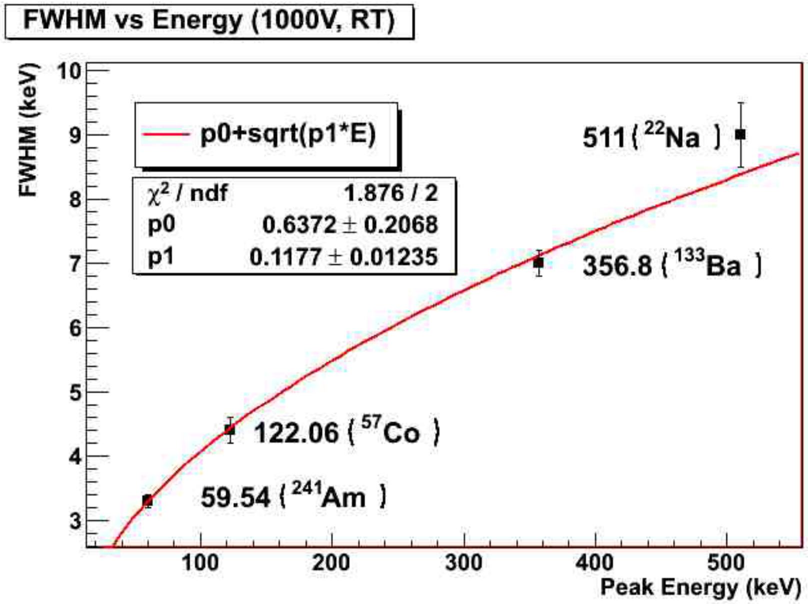
Architecture of the readout integrated circuit for the pixelated CdTe detectors of the VIP project.

Detector/Pixel Specifications

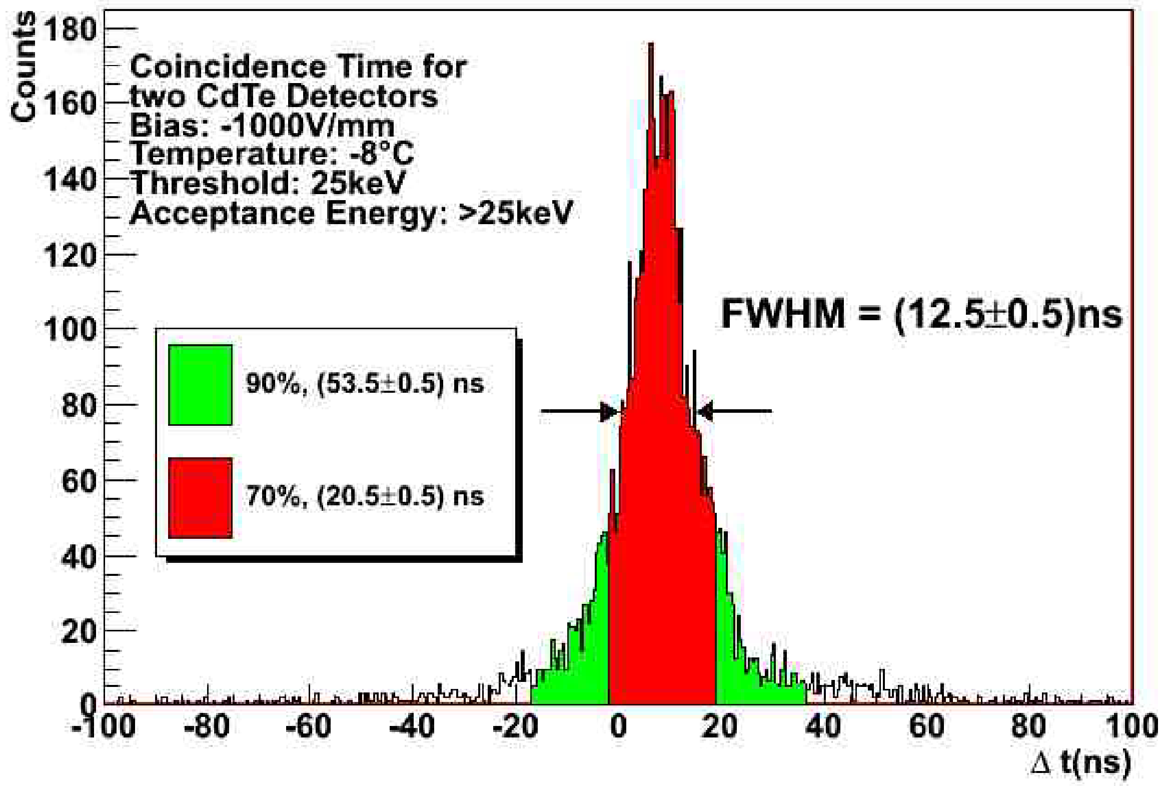
Specification	Value
Detector size	10x10x2 mm^3
Voxel size	1x1x2 mm^3
Detector DC bias voltage	1000 V/2mm
Detector leakage current	1000 pA/pixel
Electron/Hole drift time	35 ns/385 ns
Pixel capacitance	80 fF
Coincidence time window	20 nsec
Energy resolution	
Energy resolution	10bits for 511 keV
Maximum Jitter of time stamp	10 ns
Maximum power consumption	200 µW/pixel

CdTe Energy Resolution



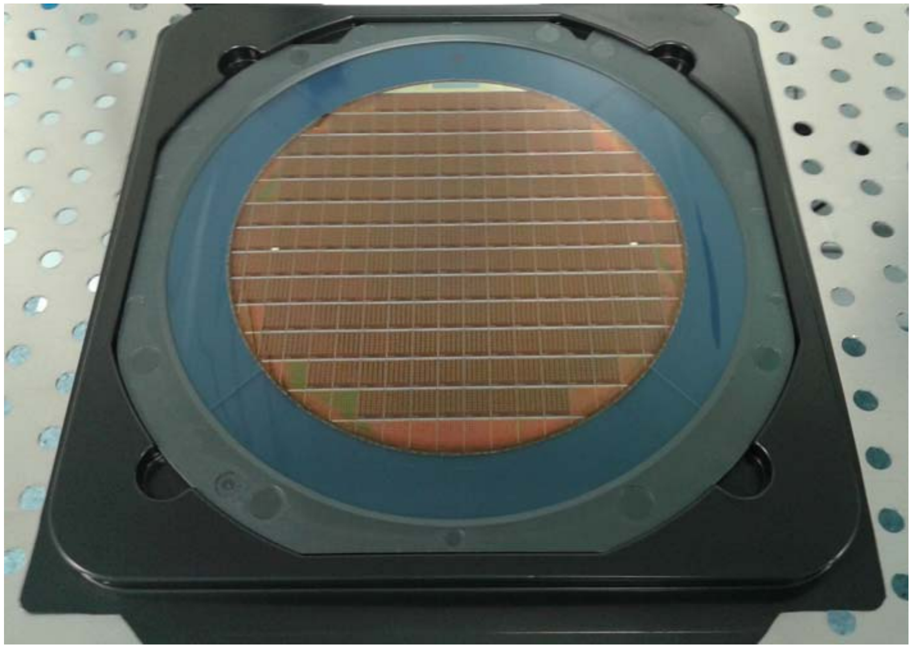


CdTe Time Resolution



With such timing resolution VIP detector will be able it to handle high FDG dose

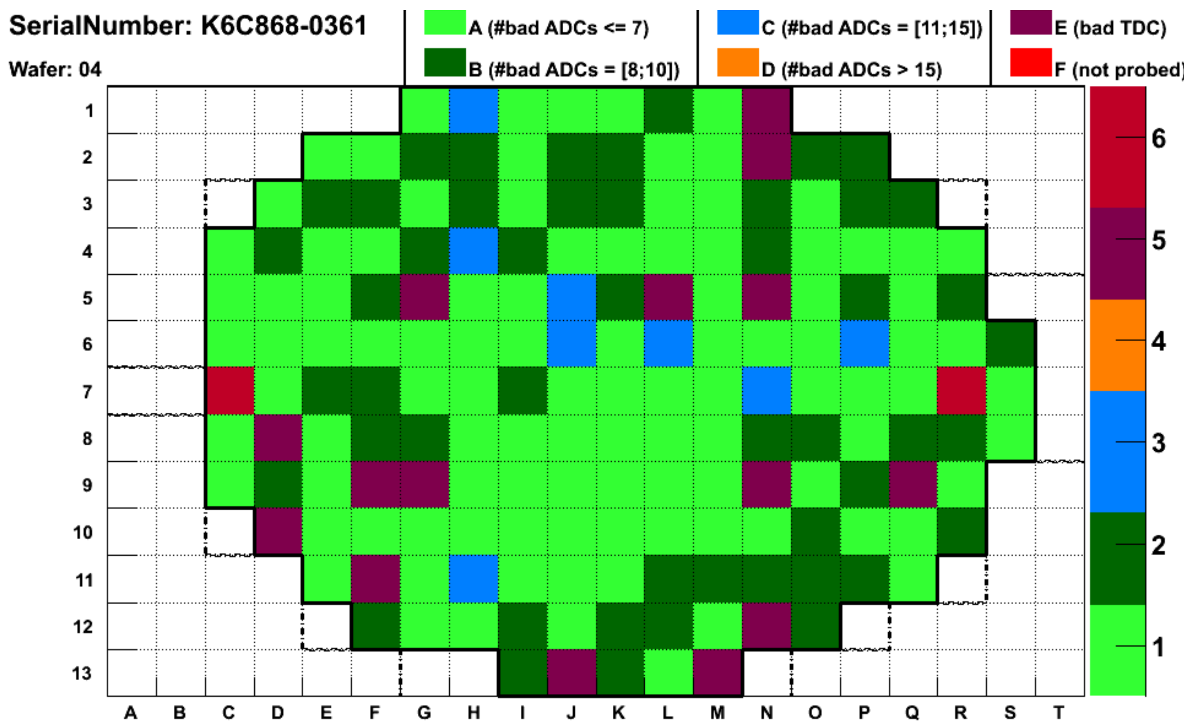
VIP Wafer production



VIP wafer thinned to 50um, diced and put on tape.

- Single submission
-12 Wafers produced
-Delivered in May 2014
-One wafer diced for basic tests
-11 sent to IZM for UBM. We received them back in the 2nd week of July.
-One wafer sent to DISCO-HiTech for dicing/thinning down to 50um

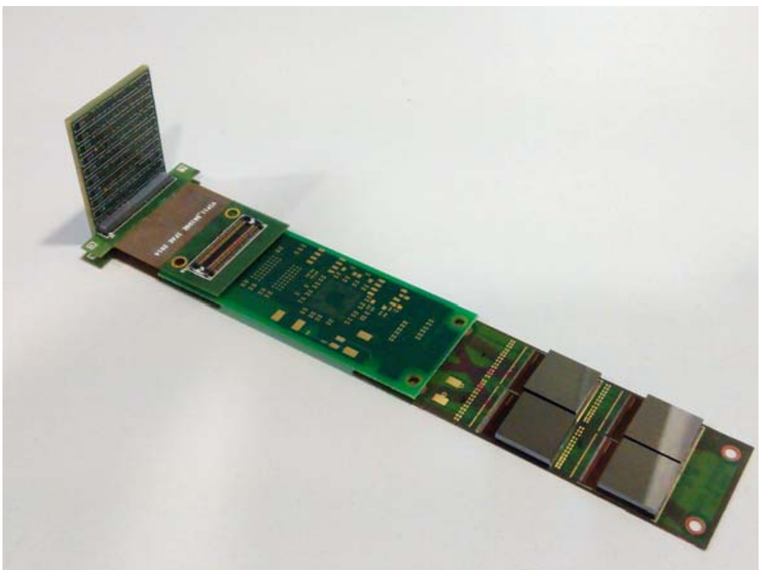
VIP Wafer Map

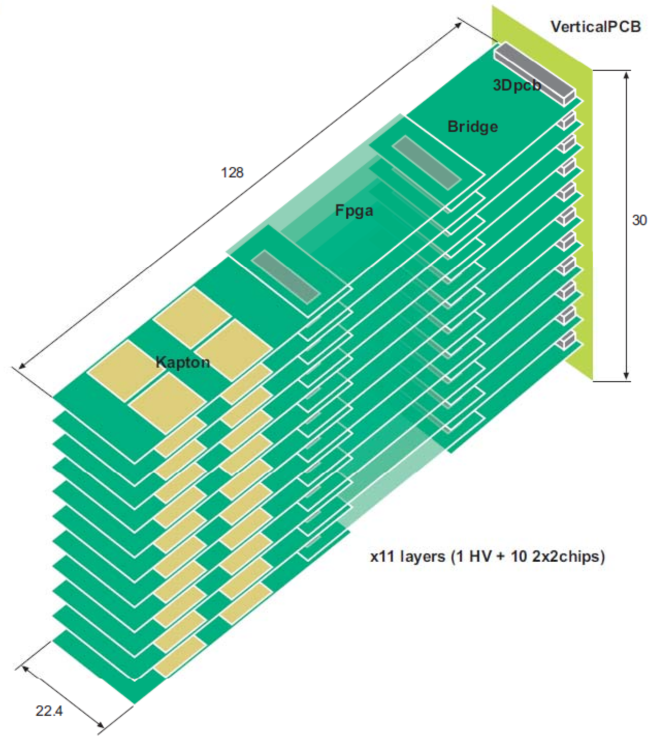


Typical results after probing. Each wafer can provide enough chips of class A for 2 Modules (80 chips)

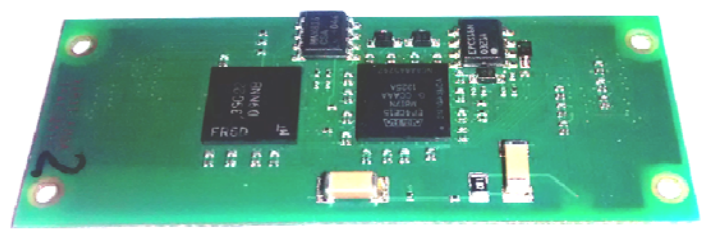
VIP Module Construction

VIP Module Construction

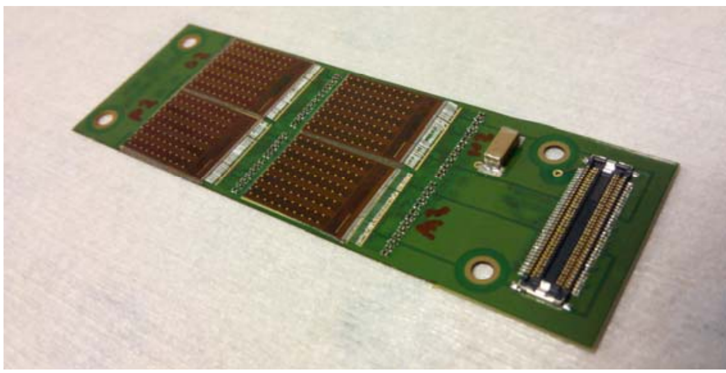




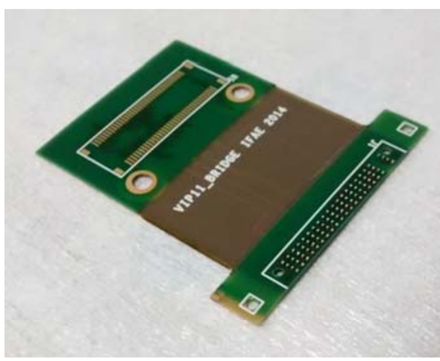
VIP Module Construction



FPGA PCB in our hands. Passed the test. 100 PCBs will be sent this week to be populated with SMD components.

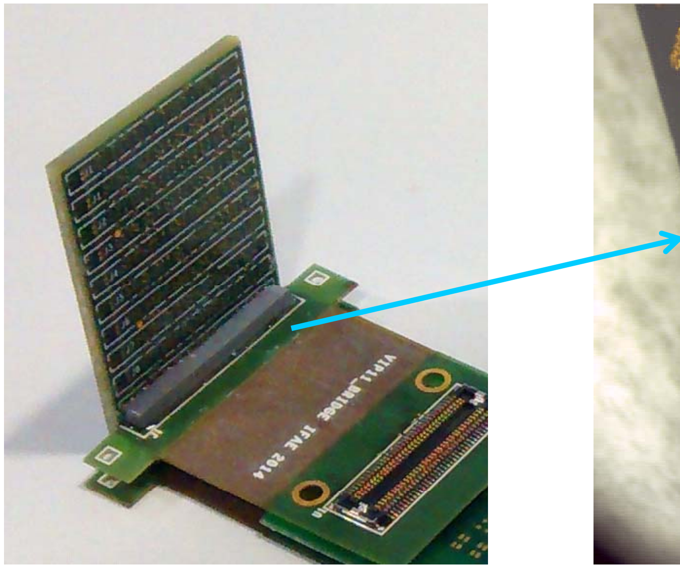


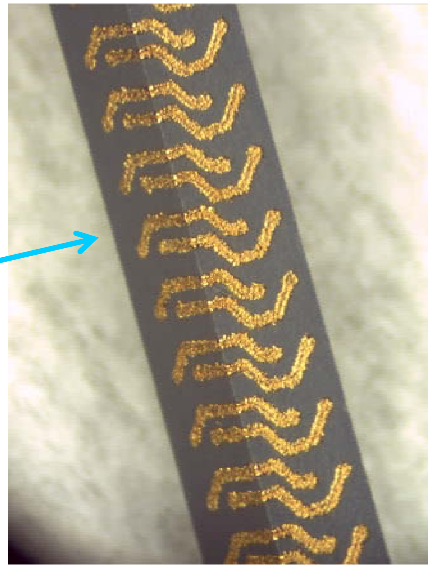
Rigid-flex PCB (255um) in our hands. Passed the test. 100 PCBs were sent to be populated with SMD components.



Bridge PCB in our hand. It will be process Later

VIP Module Construction

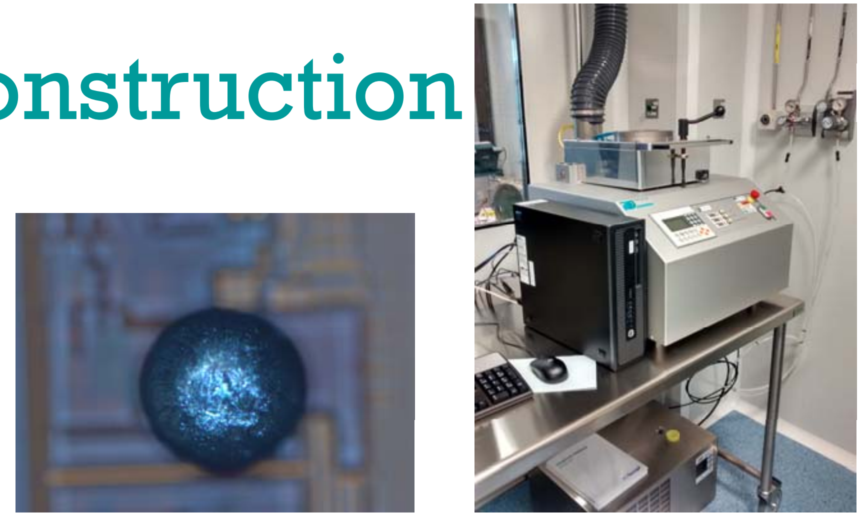




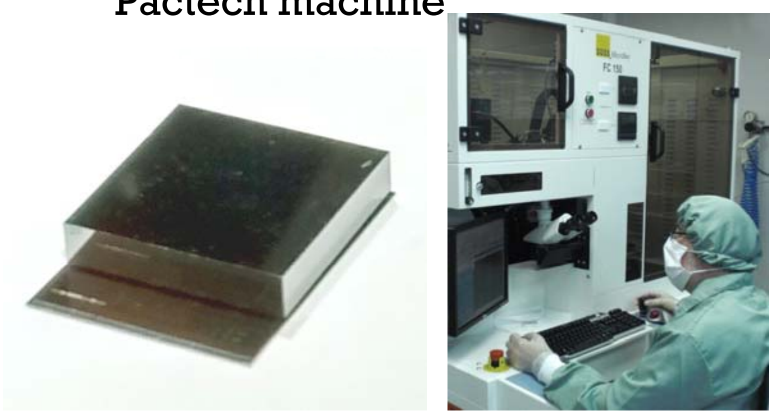
Original design was based on 3D plastic PCB but after long R&D we realized that it does not fit for 250um solder balls. We decided to go for 3D Ceramic PCB. The delivery will be by end of November

VIP Module Construction

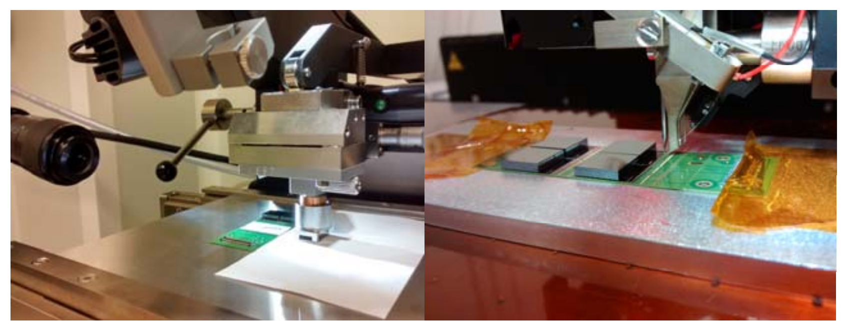
Solder Ball (250um) after deposition with Pactech machine



Solder Ball (250um) after reflow with formic acid using ATV oven

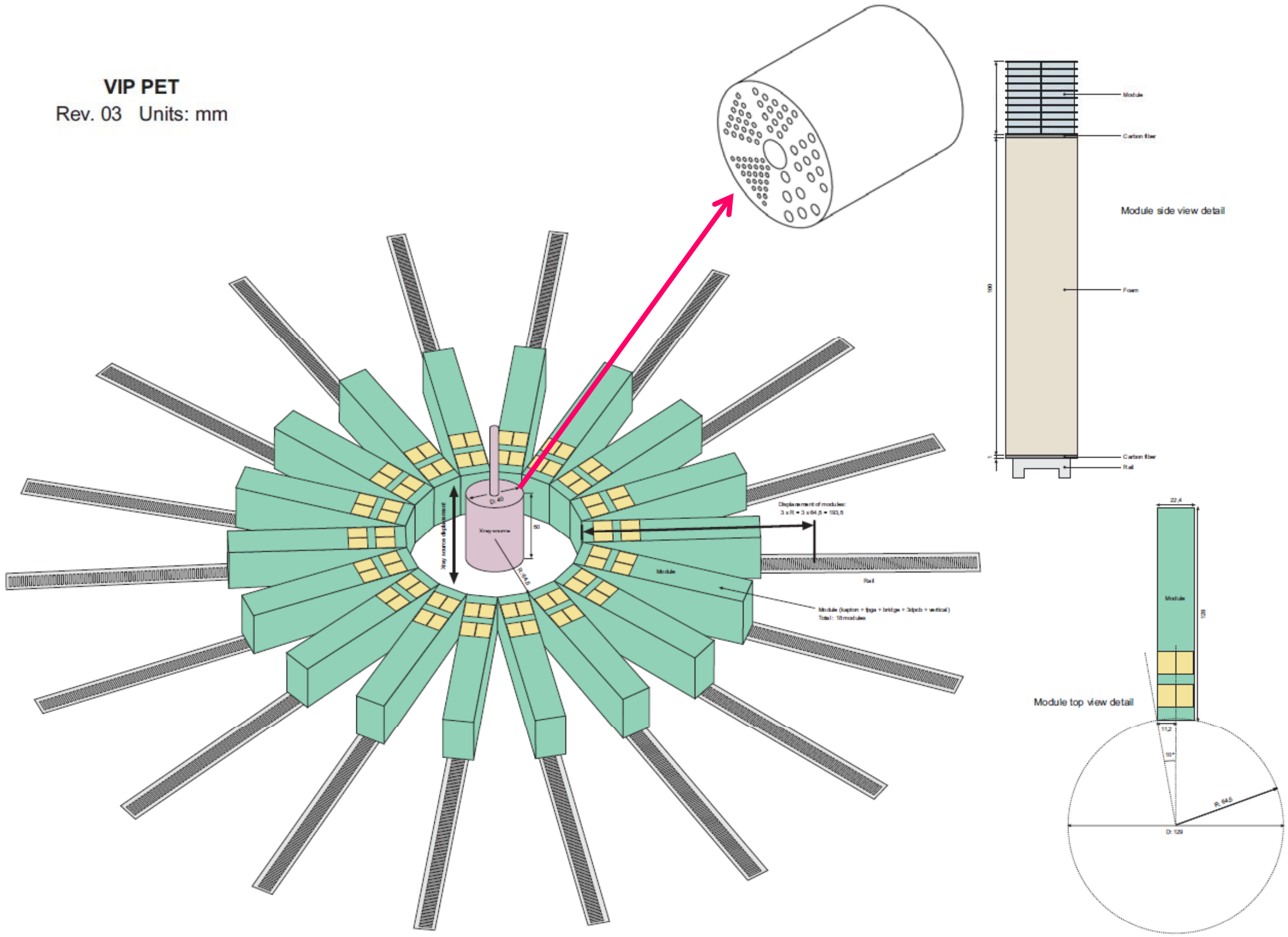


Bonding CdTe-to-VIP ASIC using FC150

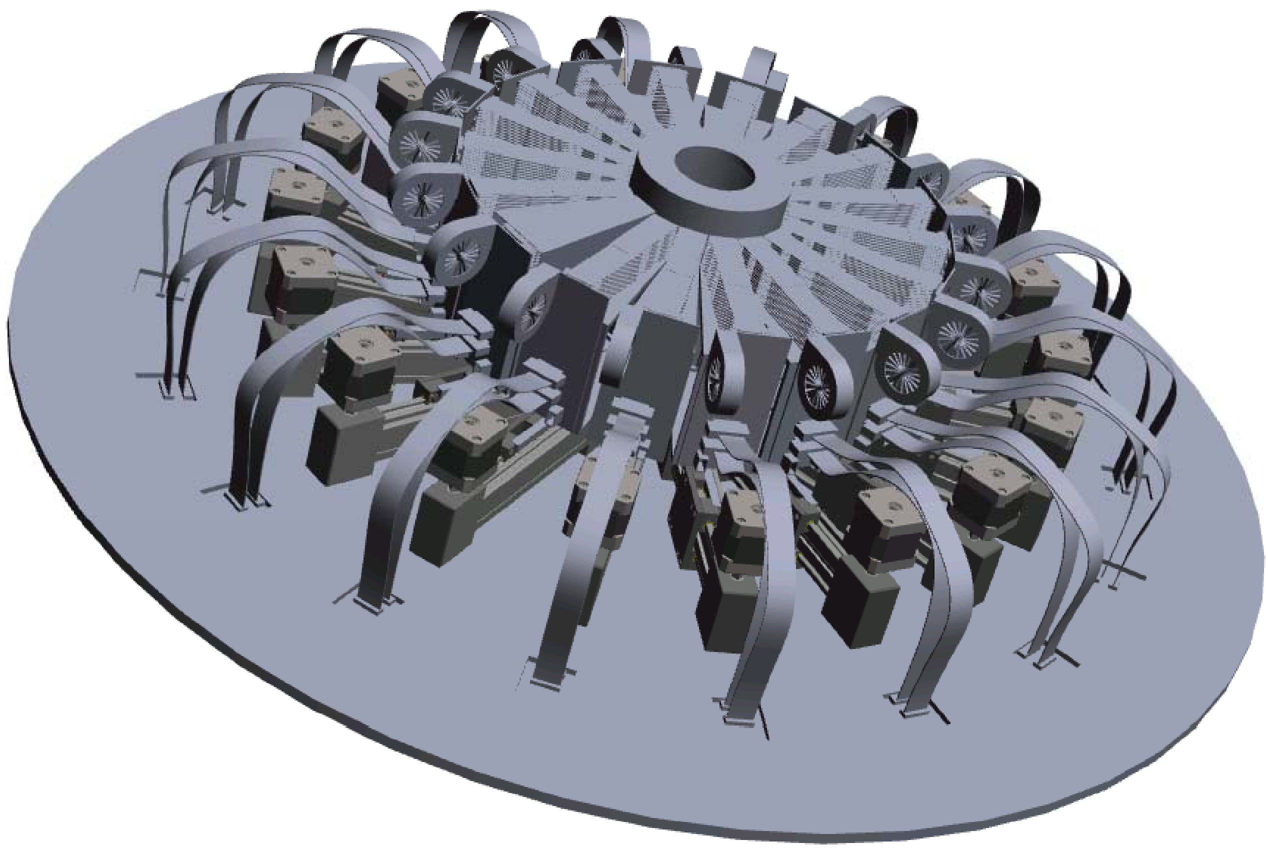


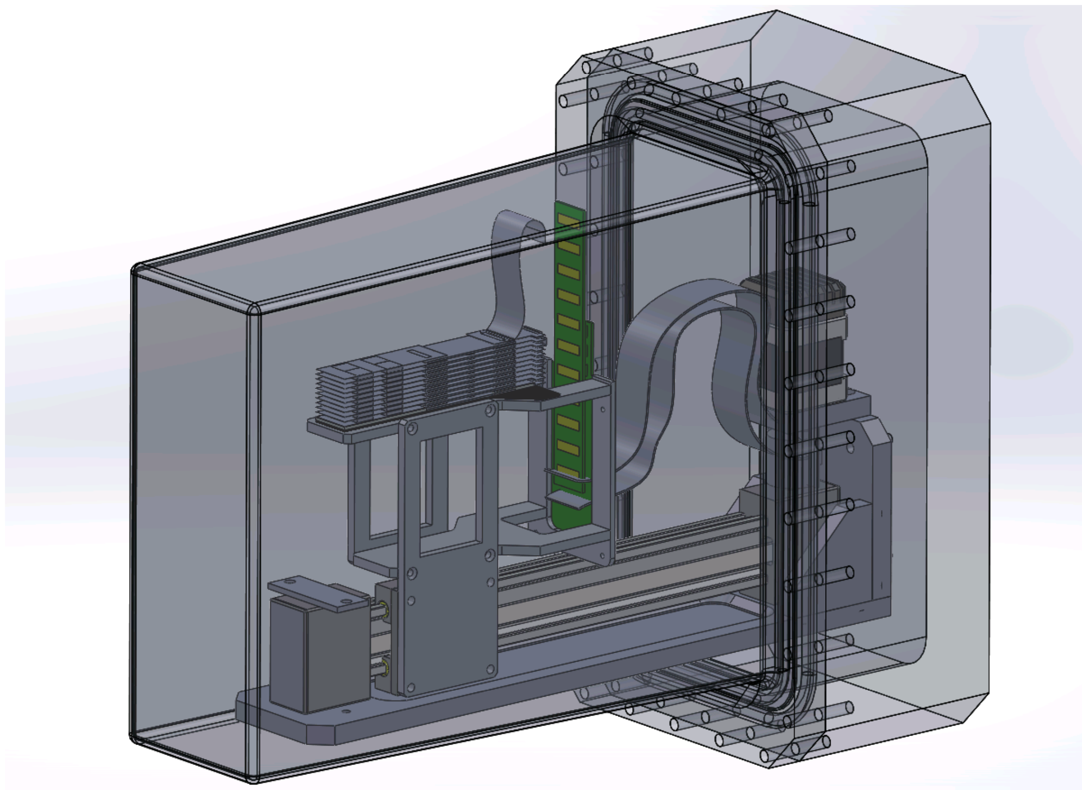
Pick & Place and Wire-bonding

VIP Ring Construction



VIP Ring Construction





Thank you for your attention