Leveraging HEP Silicon Technology
(Example: VA Chip Application to PET)

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The University of Melbourne

HEP micro-strip technology

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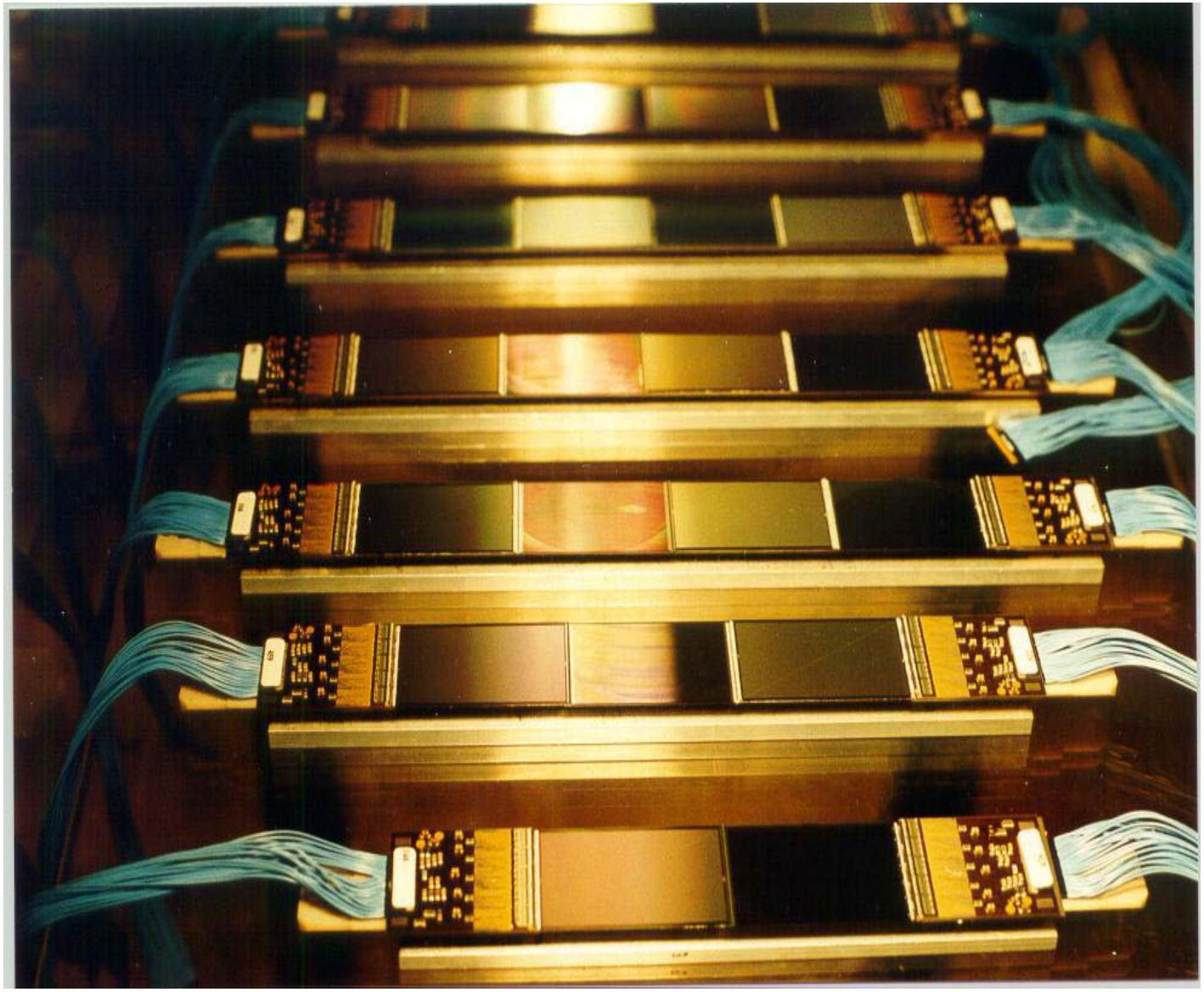
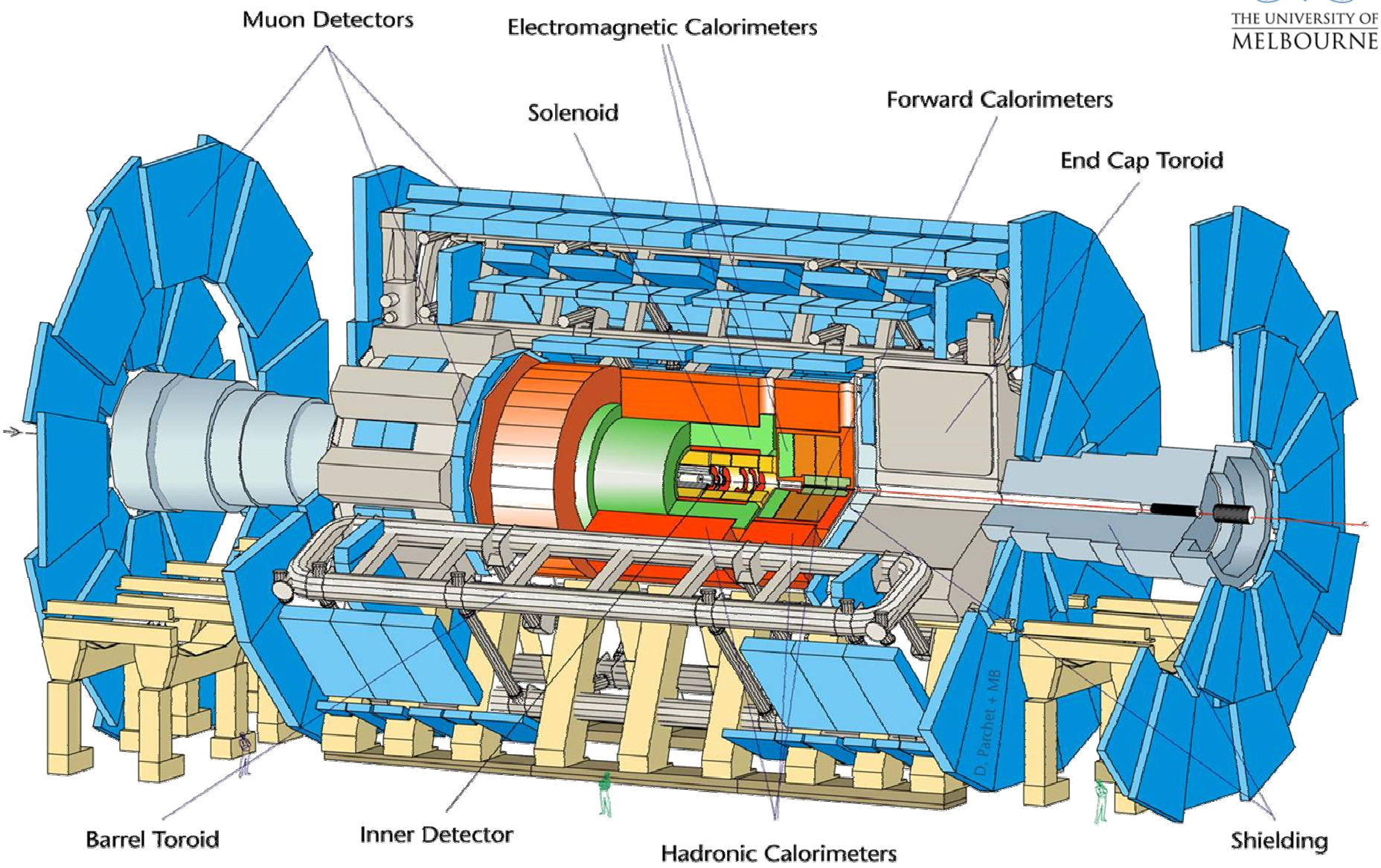
- (2-D detectors are still at cutting edge…)
- 1-D detectors/readout well established.
  - Single/double sided; various geometries; AC/DC coupled; …
- Silicon Strip Detectors are very mature technology – several manufacturers
- Readout Chips for Strip detectors mature technology, available, customized or off-the-shelf.
  - Many variants, much experience.
- Applications of this technology are now widespread.
  - A lot can be done without in-house chip development.
- Participation in HEP detector development provides a great jumping off point for such applications, (BUT not essential for getting value out of this spin-off.)

Belle SVD Ladder Assembly



ATLAS


Muon Detectors
Electromagnetic Calorimeters
Solenoid
Forward Calorimeters
End Cap Toroid
Barrel Toroid
Inner Detector
Hadronic Calorimeters
Shielding
D. Parchet + MB

The ATLAS Semiconductor Tracker

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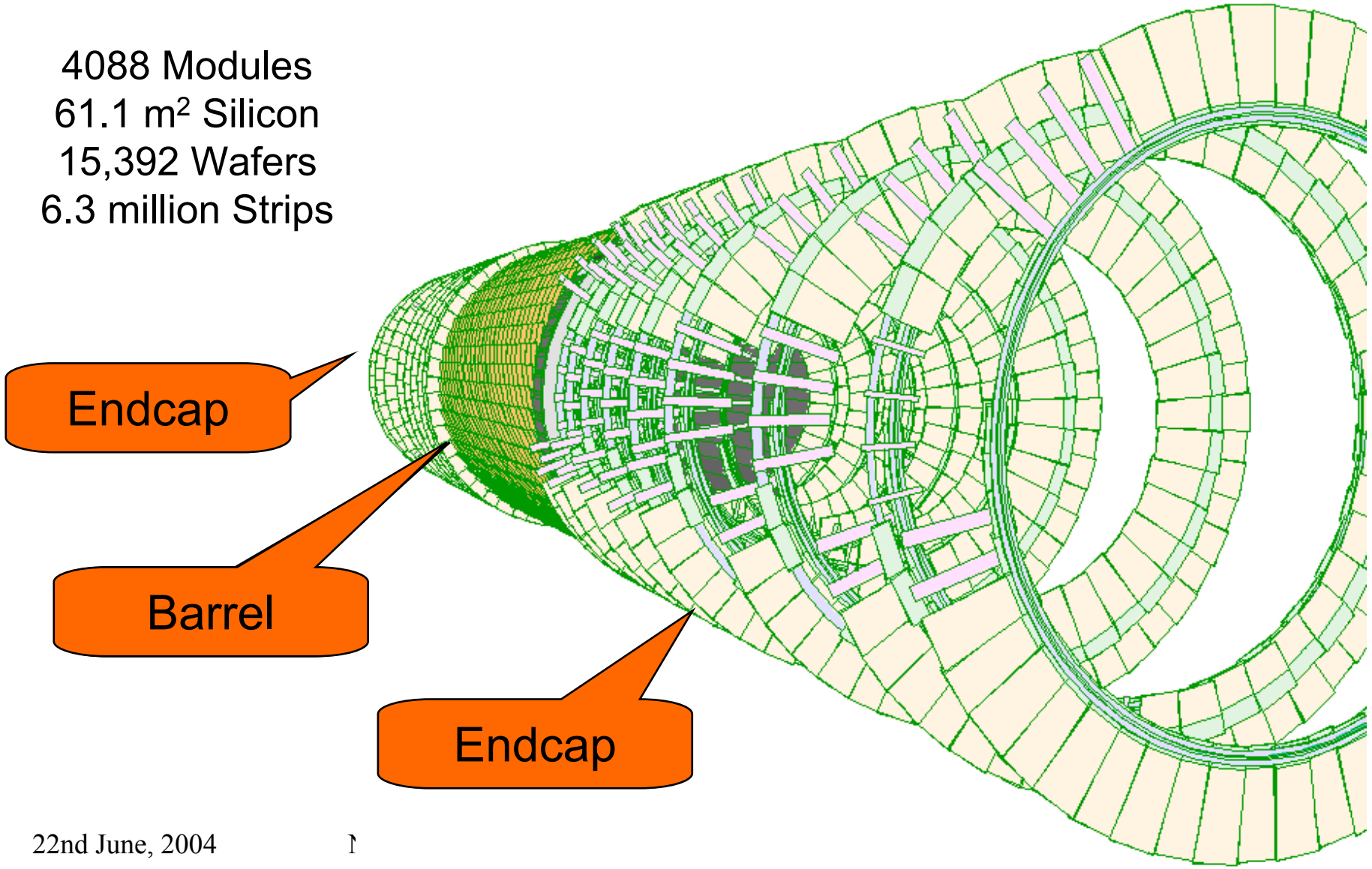
4088 Modules
61.1 m^2 Silicon
15,392 Wafers
6.3 million Strips



SCT Forward Silicon Modules

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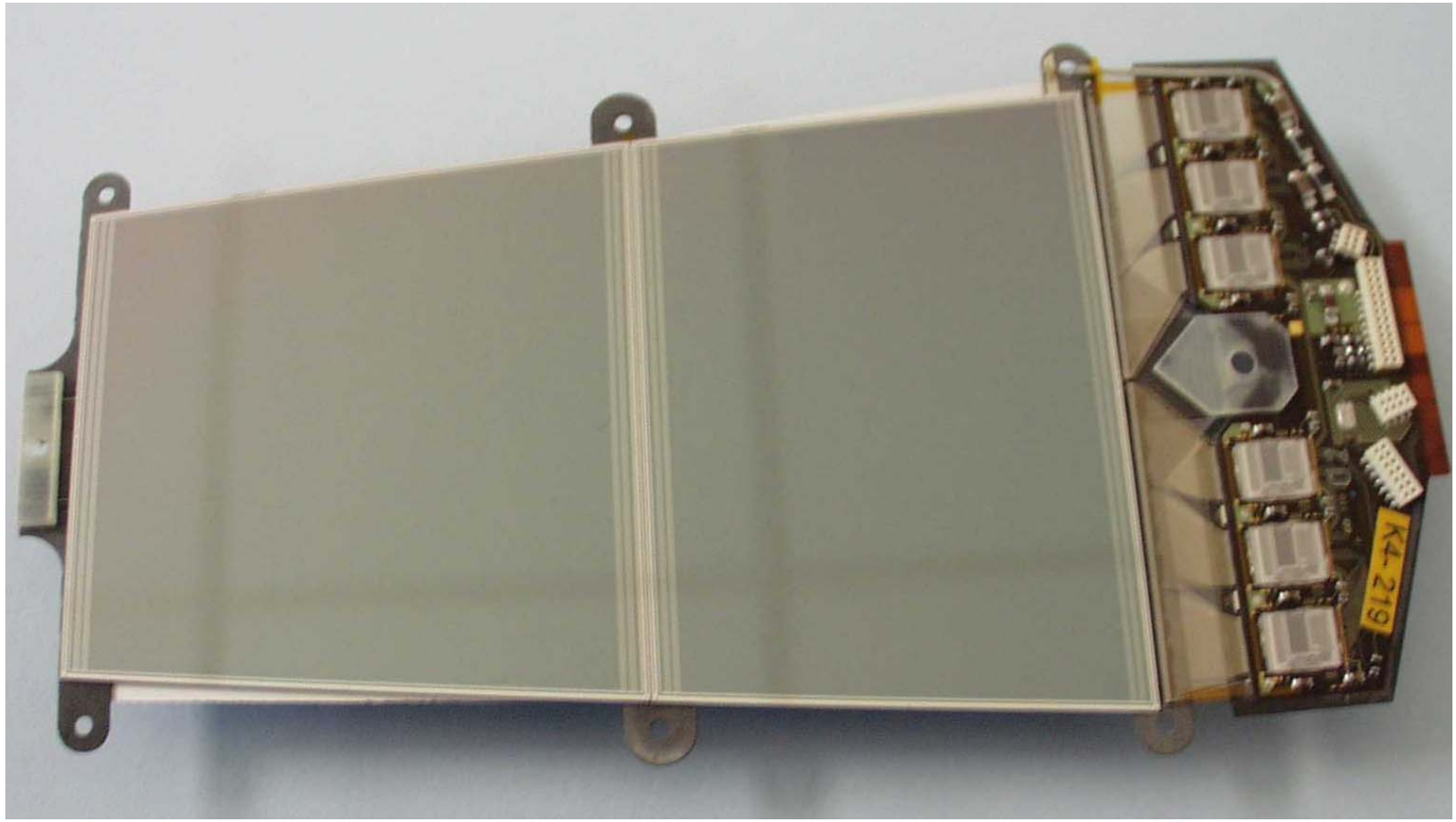
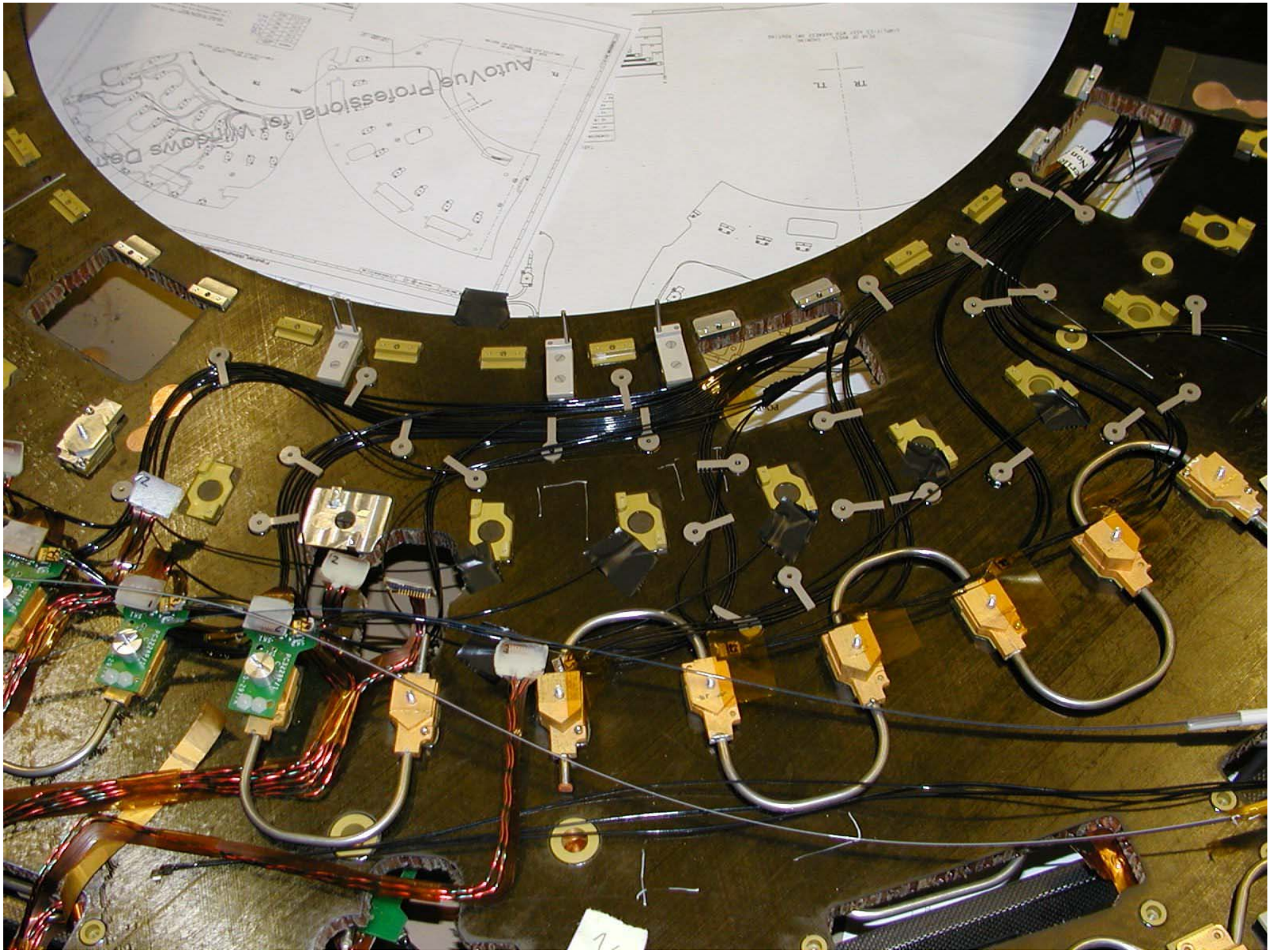
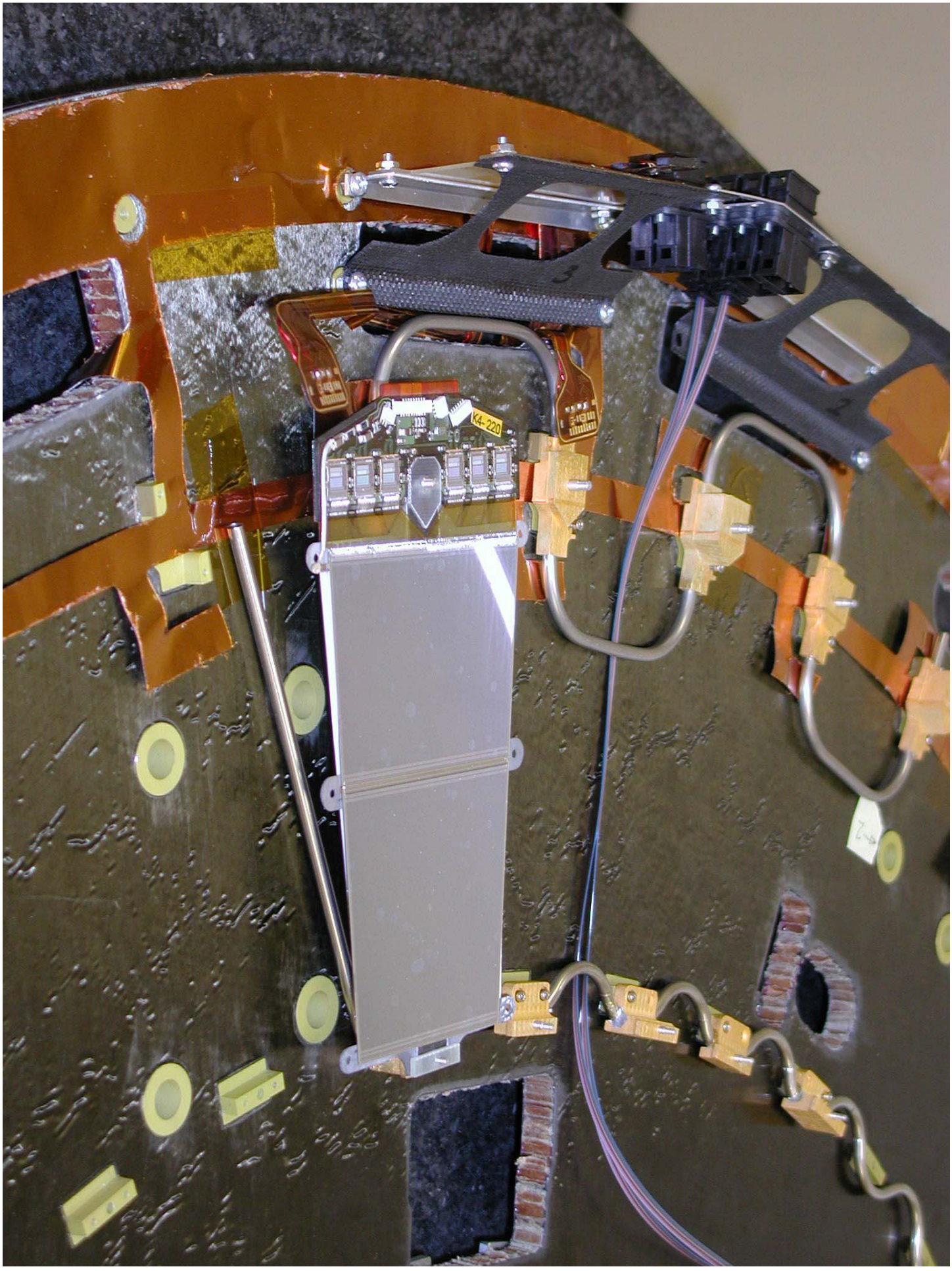
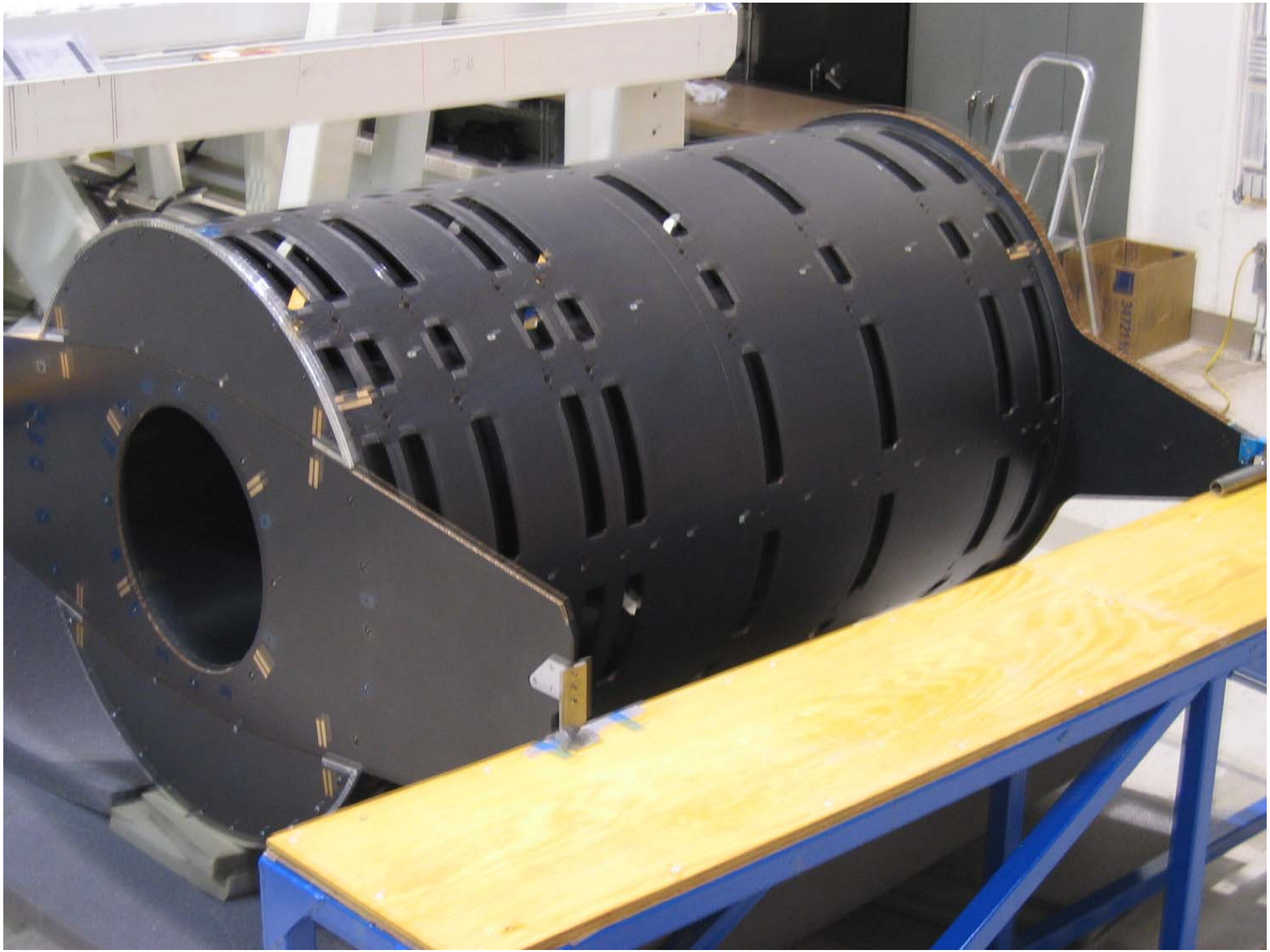



AutoVue Professional for Windows Des


K4-220



What to combine?

Track combination

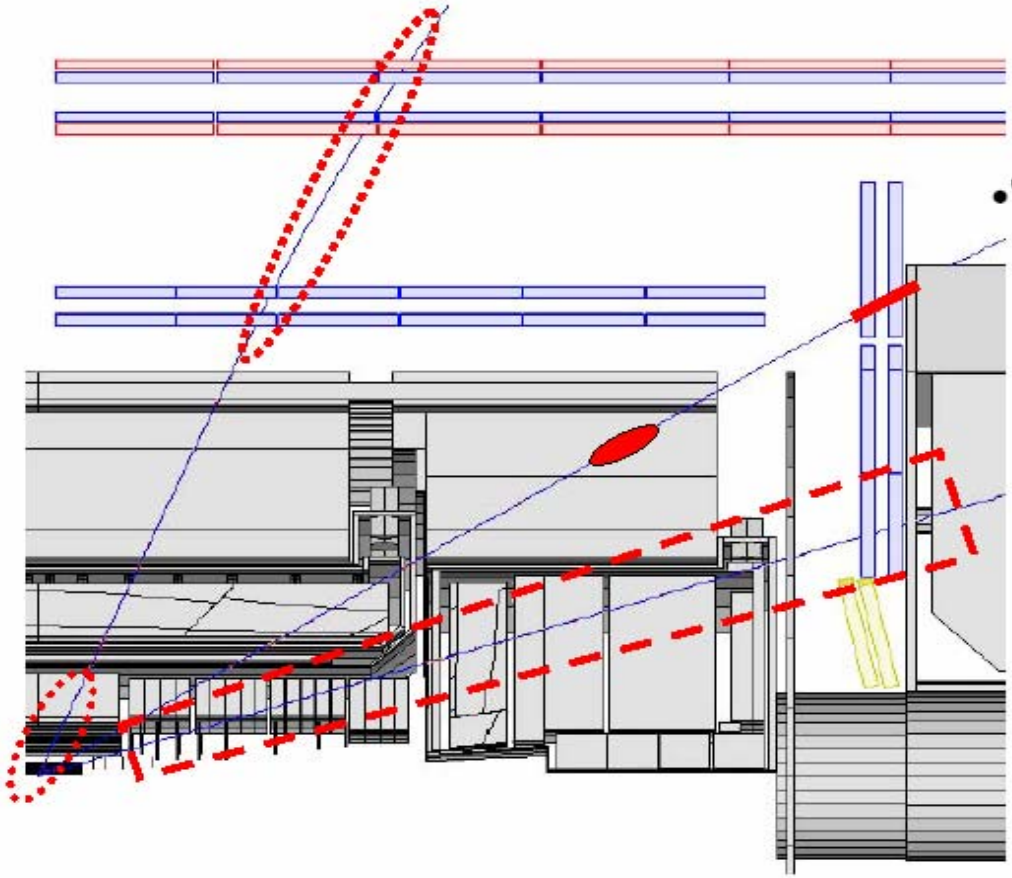
- µSyst track
  Moore/Muonbox

+

- E loss in Calo

+

- ID track
  xKalman/iPatRec



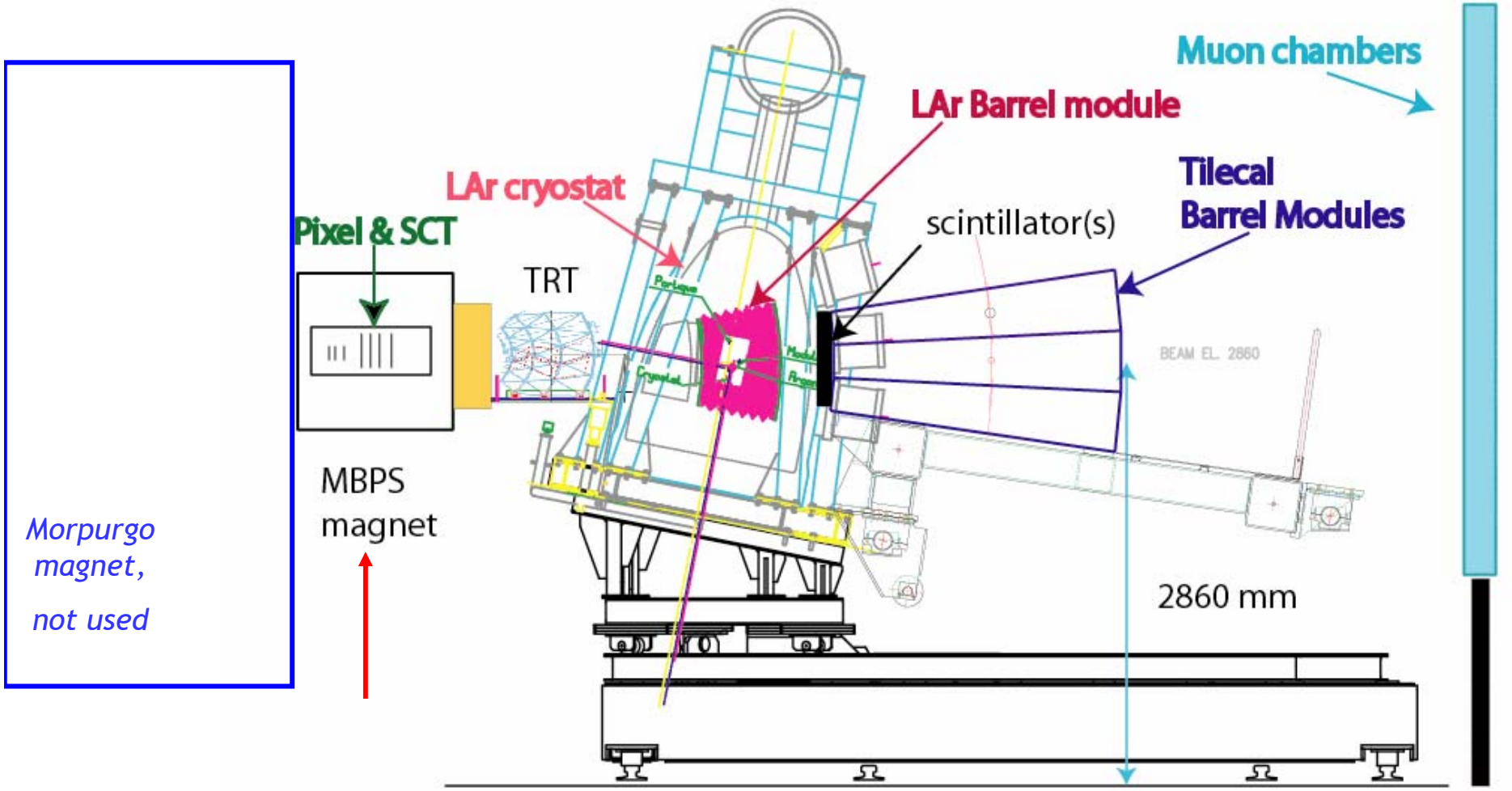
Low pt Identification

- Track Segments
- E in Tile

Isolation

- Look into Calo/ID

H8 Setup – Barrel Sector



Infrastructure and Expertise

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- Probe Station, IV, CV, equipment.
- Circuit design/prototype/construction.
- Precision assembly, measurement
- Wire Bonding Facilities
- DAQ systems (VME)
- Analysis
- Clean Room, Services

Future Australian HEP Instrumentation Developments

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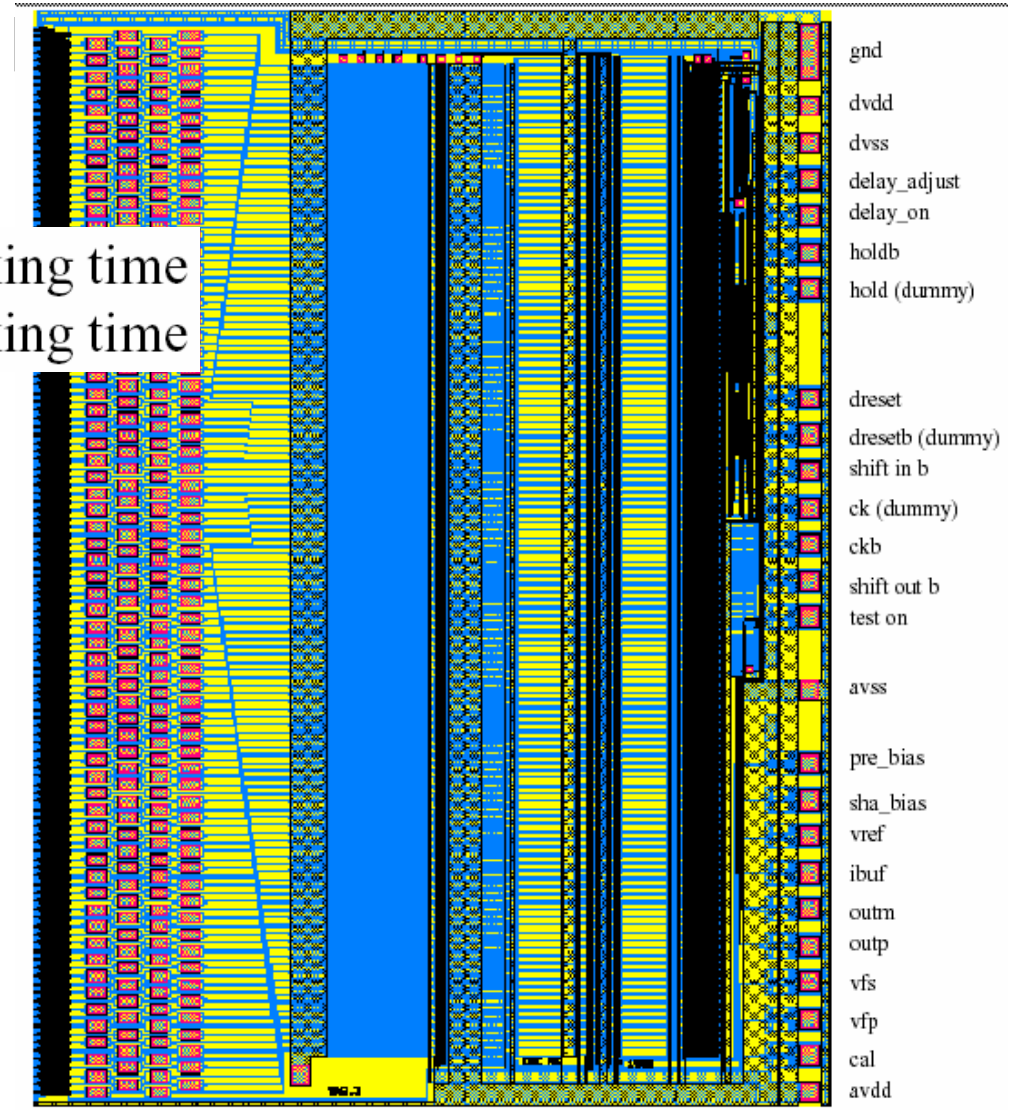
- Continue with ATLAS/SCT production and installation.
- Participate in Super-Belle SVD upgrade.
- Pixel detector development:
  - Future Vertex/Tracking detectors:
    - Super-Belle SVD; ATLAS tracker upgrade; Future LC
  - Synchrotron Detector Development
  - Other Imaging Applications (eg. PET)

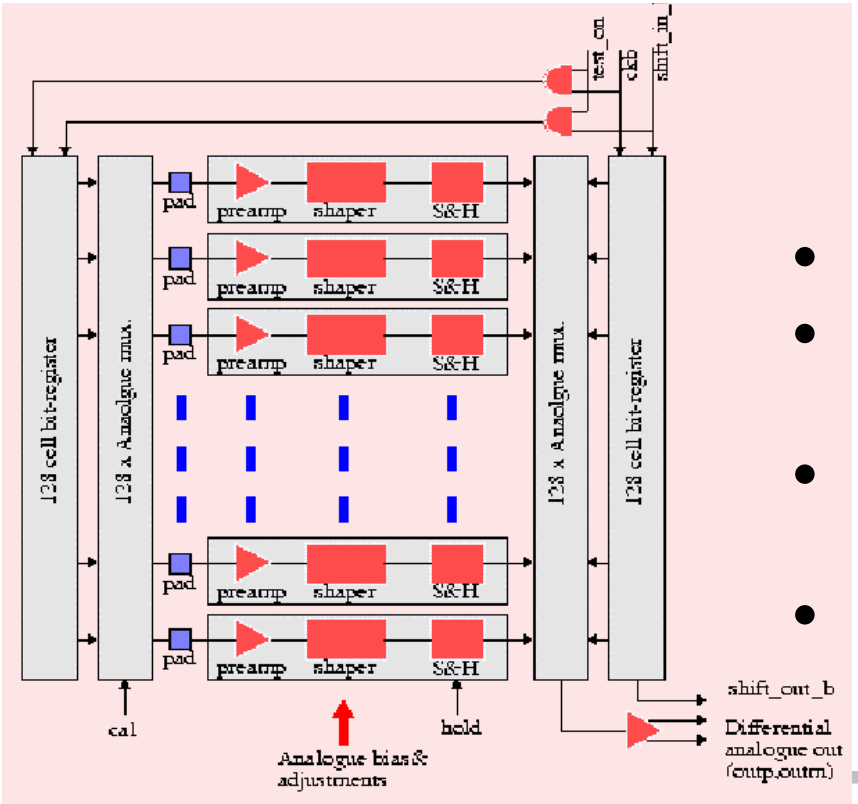
VA Series Chips

- VA2 Chip (IDE As,
  - 128 Channels

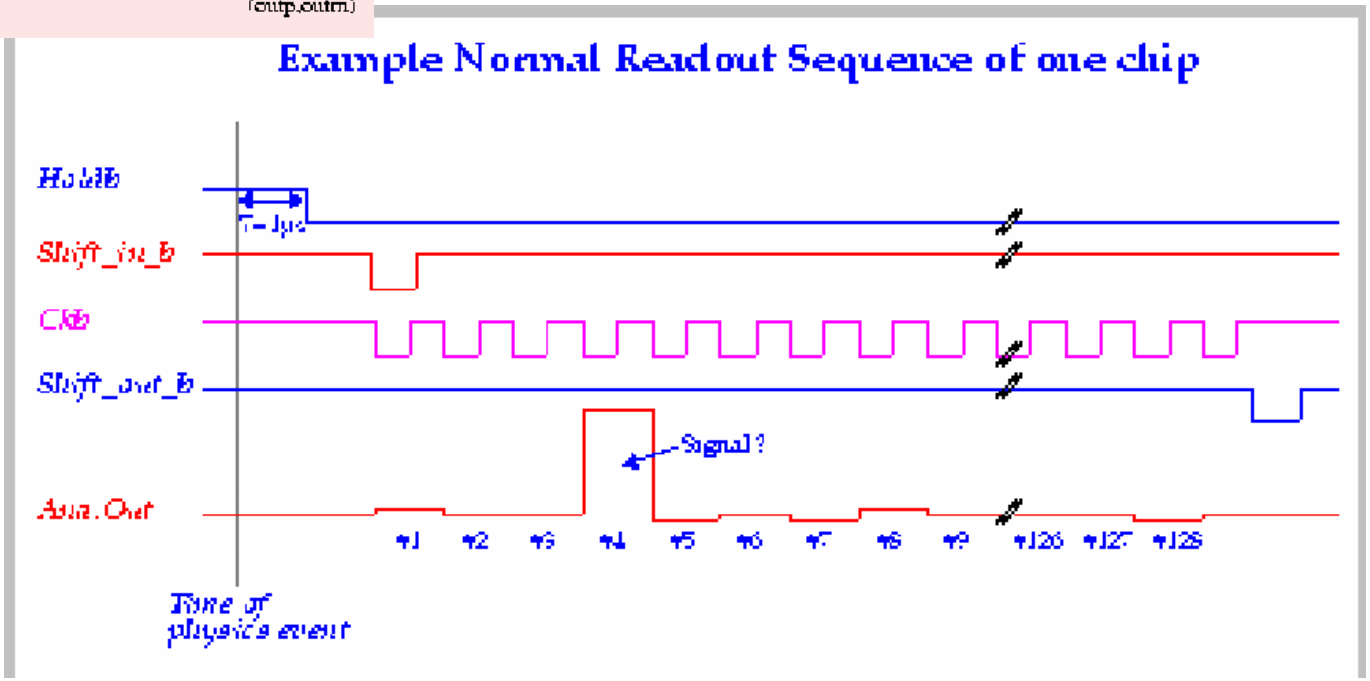
80 + 15/pF e⁻rms for 1 µsec peaking time
60 + 11/pF e⁻rms for 2 µsec peaking time



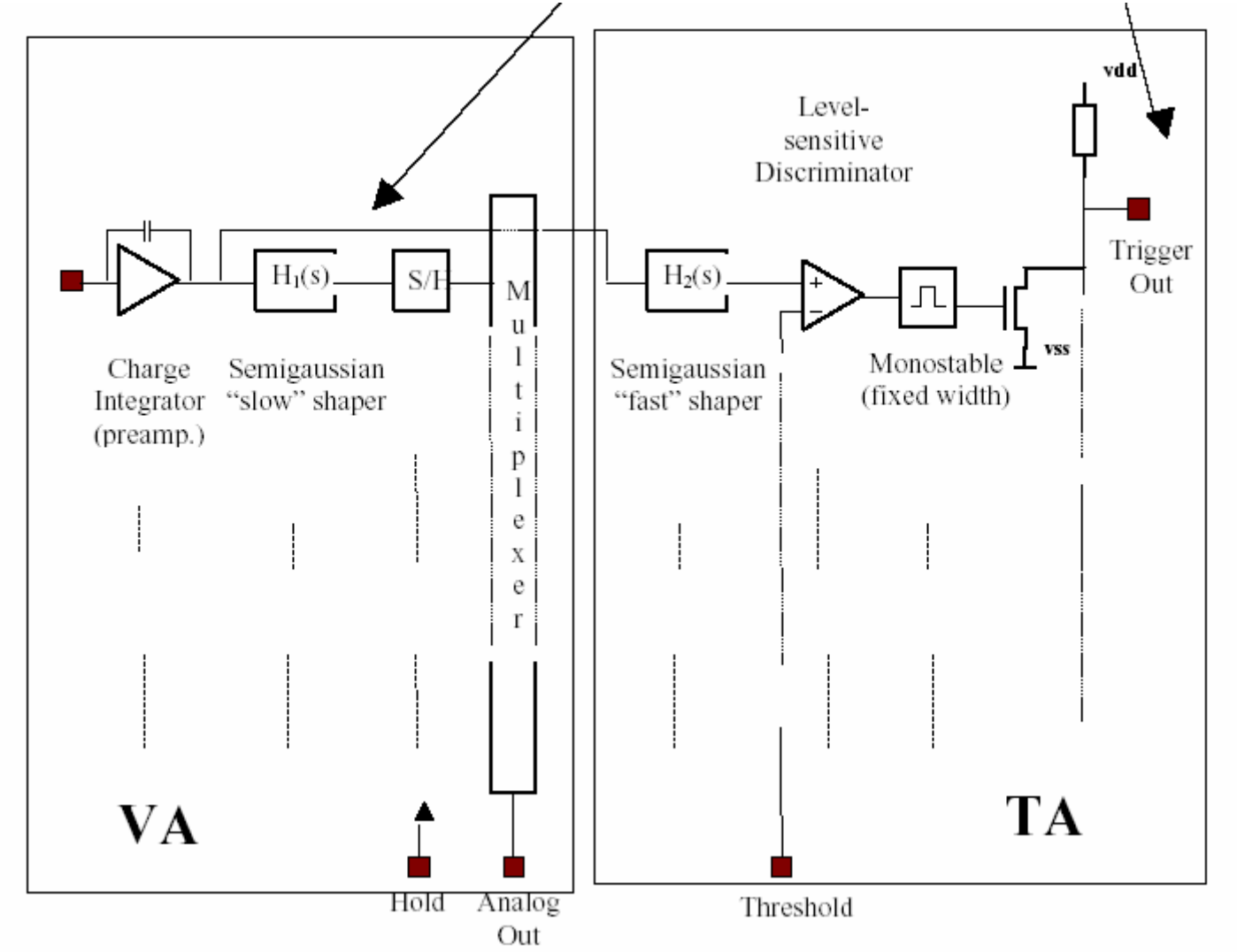
VA Operation



- Typically 128 channels
- Low noise, depending upon shaping time
- Serial readout: ~5MHz, 20-30usec readout.
- Timing?

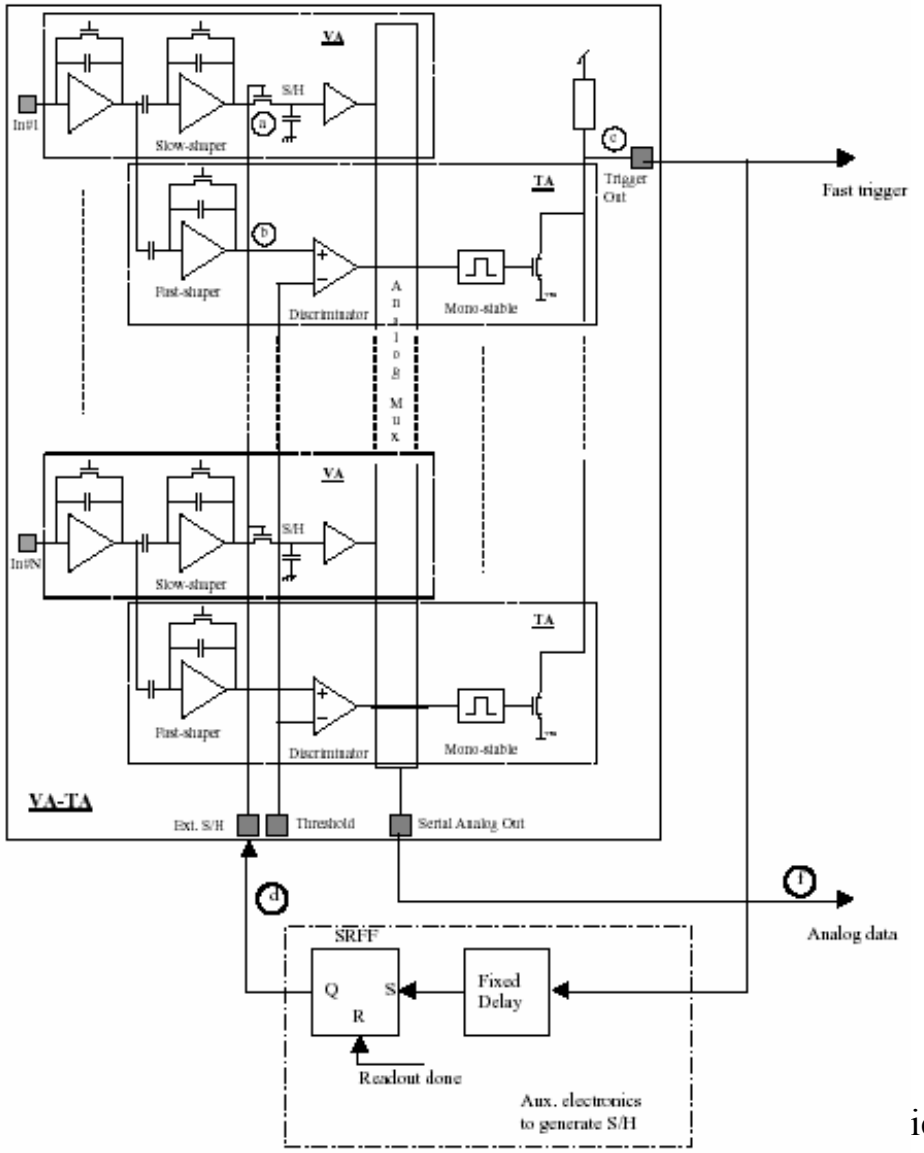


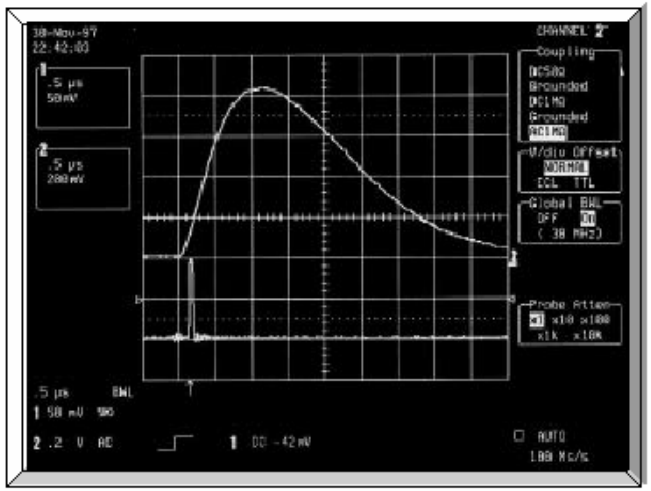
VA-TA chips


Level-
sensitive
Discriminator
vdd
Trigger
Out
$H_1(s)$
S/H
M
u
l
t
i
p
l
e
x
e
r
$H_2(s)$
vss
Charge
Integrator
(preamp.)
Semigaussian
"slow" shaper
Semigaussian
"fast" shaper
Monostable
(fixed width)
VA
TA
Hold
Analog
Out
Threshold

VA-TA Option

Basic principle of VA-TA showing how a precise S/H of the slow-shaper output easily can be generated from the fast trigger:

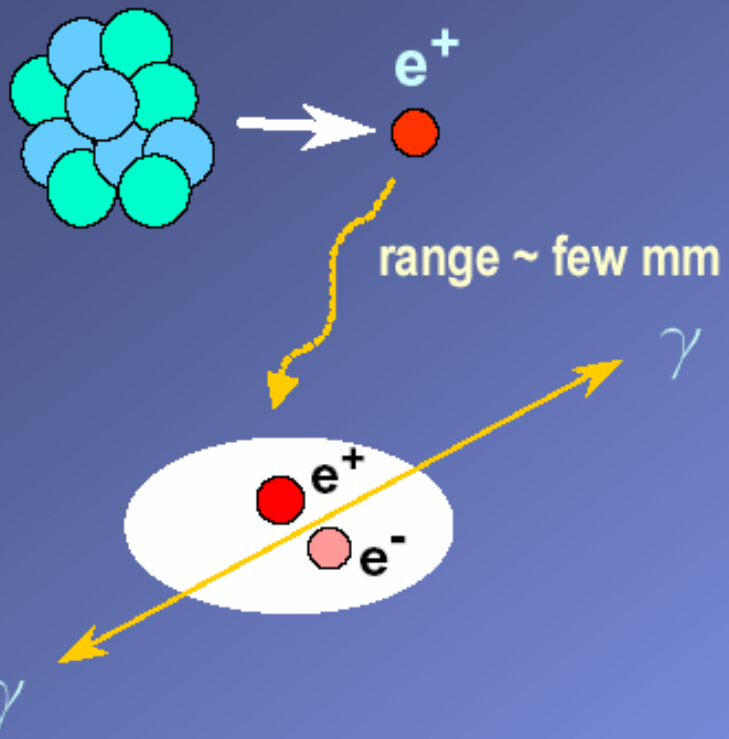




- 75nsec fast shaper
- Upper and lower thresholds.
- OR’ed output from entire chip
- Can trigger readout of analog section.

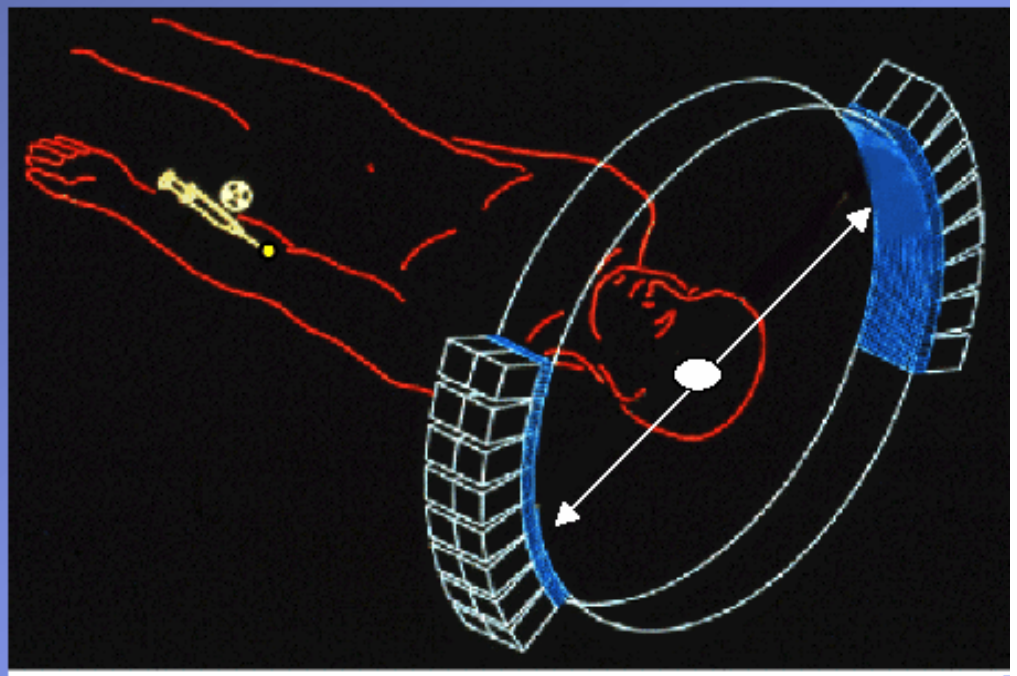
Positron Emission Tomography

Radioisotope



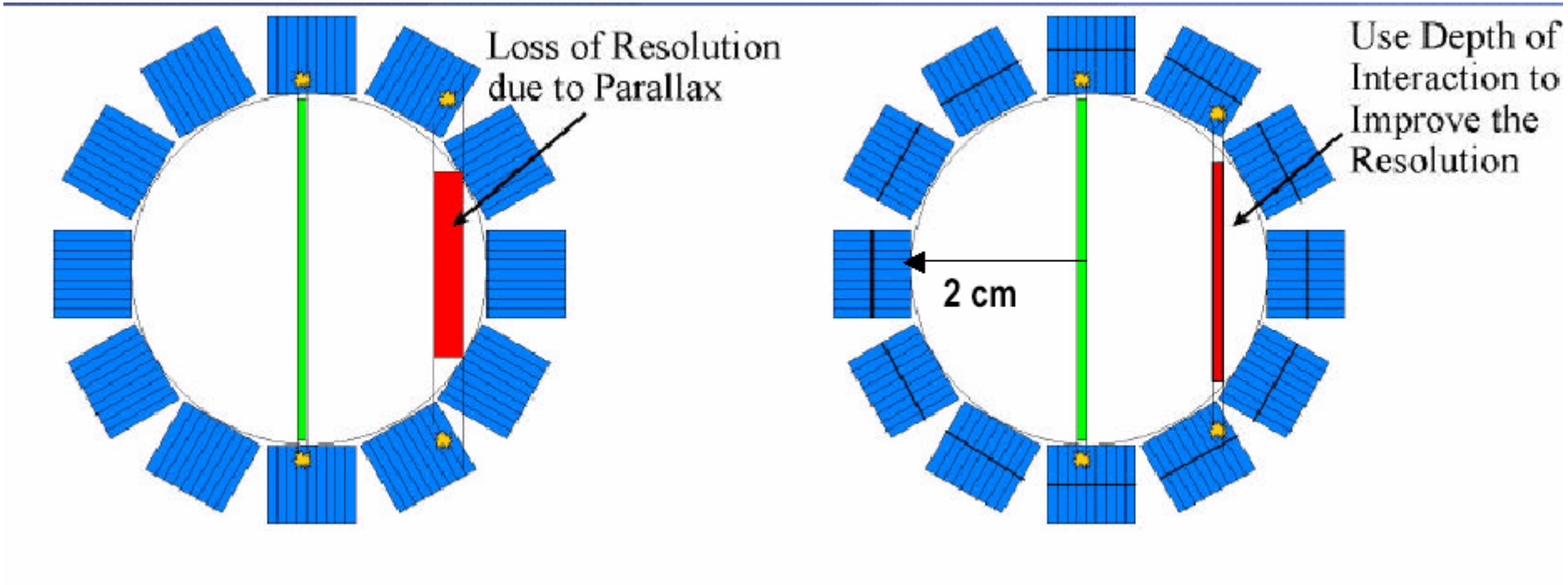
Isotopes emit positrons with energies of a few hundred keV

PET detects coincident 511 keV gamma rays

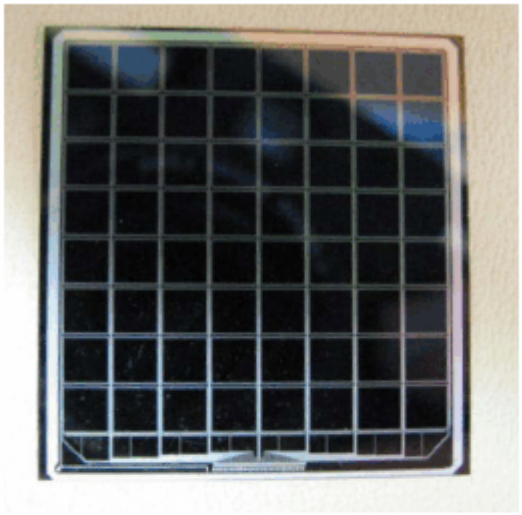


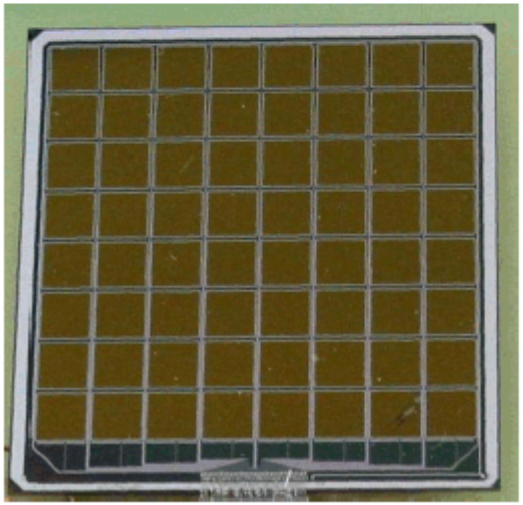
PET Scanner

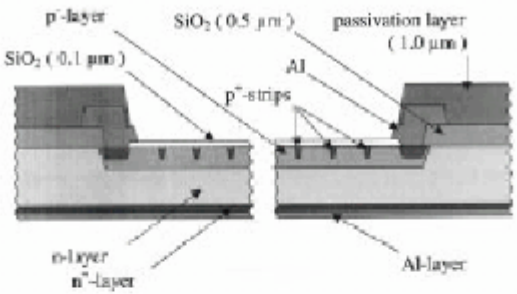
Depth of interaction in PET resolution



PAD Array (Spa, Kiev)







The two photodiode array differ in the Anti-Reflective Coating (ARC) that minimises the reflections off the surface of the array

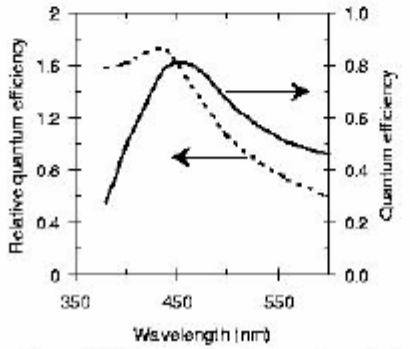


Figure 1. QE curves for the new photodiode

Crystal Array

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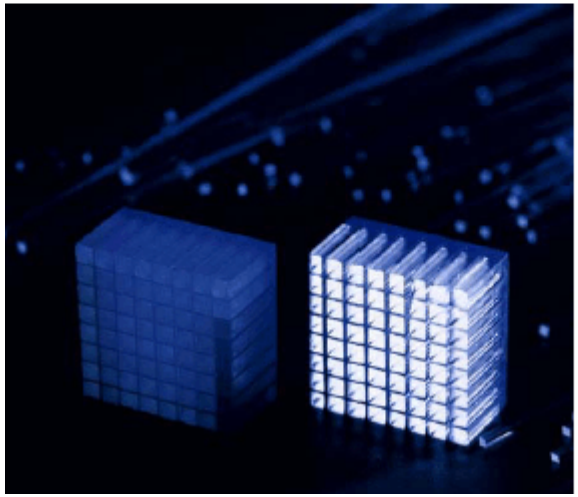
Scintillator	Photons/MeV	Density (gcm^{-3})	Decay constant (ns)	Effective Z	Wavelength of emission (nm)
NaI(Tl)	40000	3.67	230	50.6	410
BaF_2	2300	4.89	0.8	52.2	220
	10000		630		310
BGO	8000	7.13	300	74.2	480
GSO	10000	6.71	60	58.6	440
LSO	30000	7.40	40	65.5	420



Scintillator Type	Photons Generated	Photons Detected	ϵ	$\theta^{\circ}_{c_1}$
BGO	4087	1123	0.2748	46.52
GSO	5110	1851	0.3622	54.76
LSO	15329	6259	0.4083	58.99

Test Module – MSc Project, Jo Culpepper

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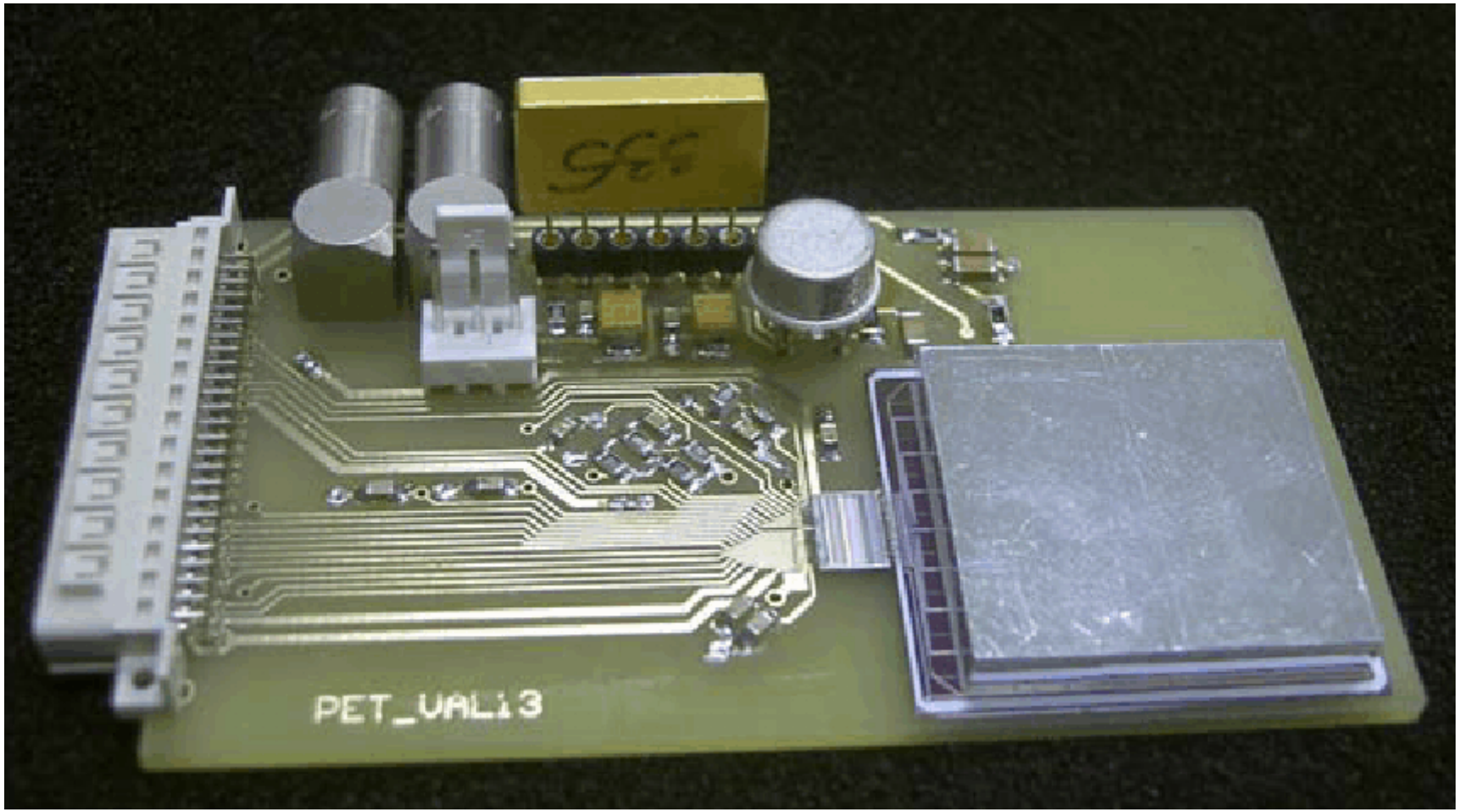

The Wollongong Gantry

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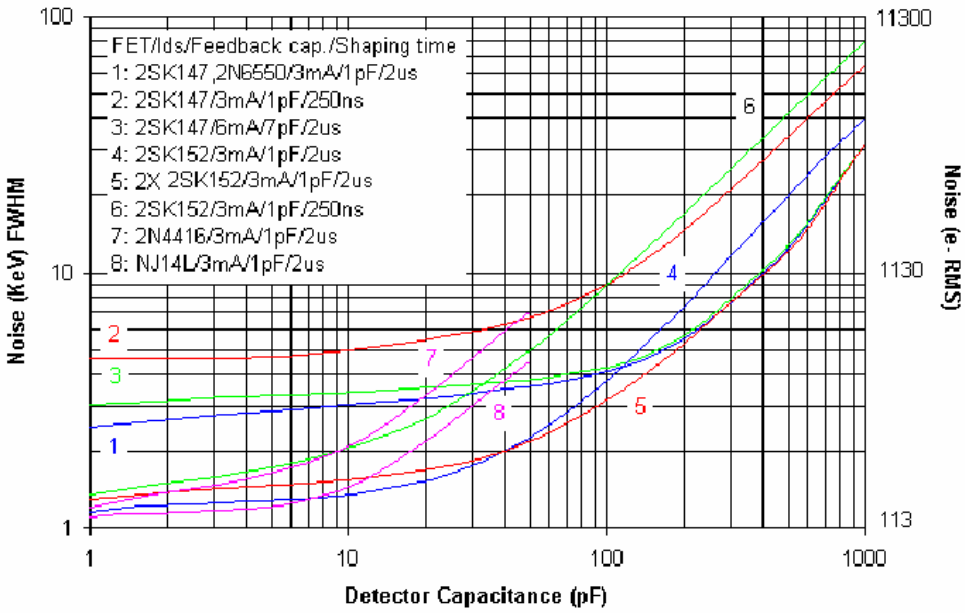
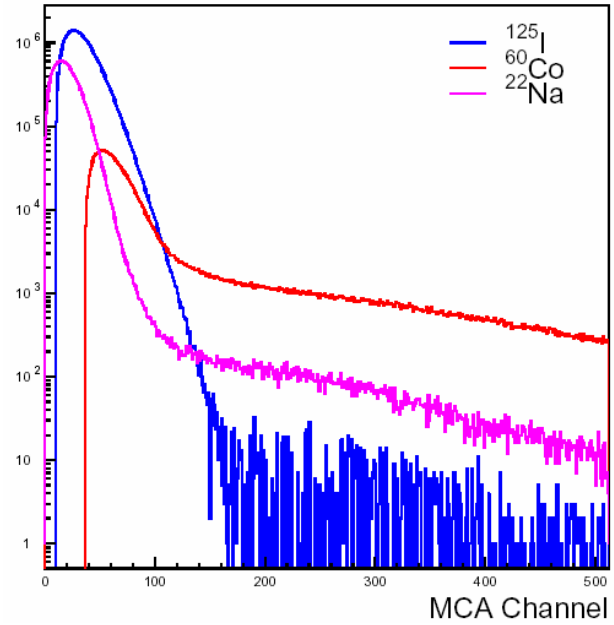
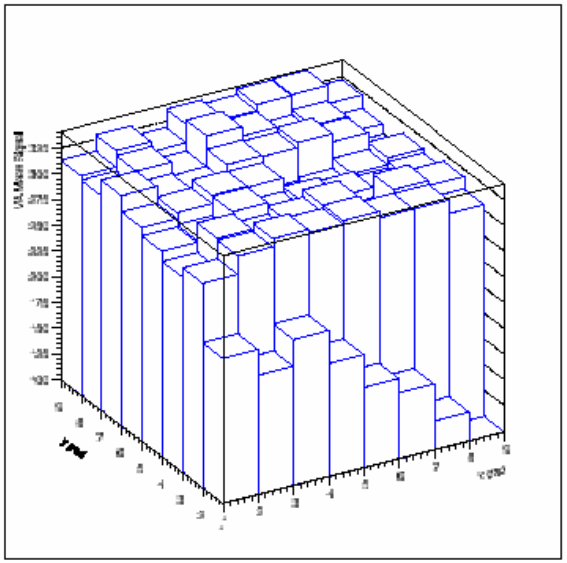
- Backside Trigger using Amptek A250



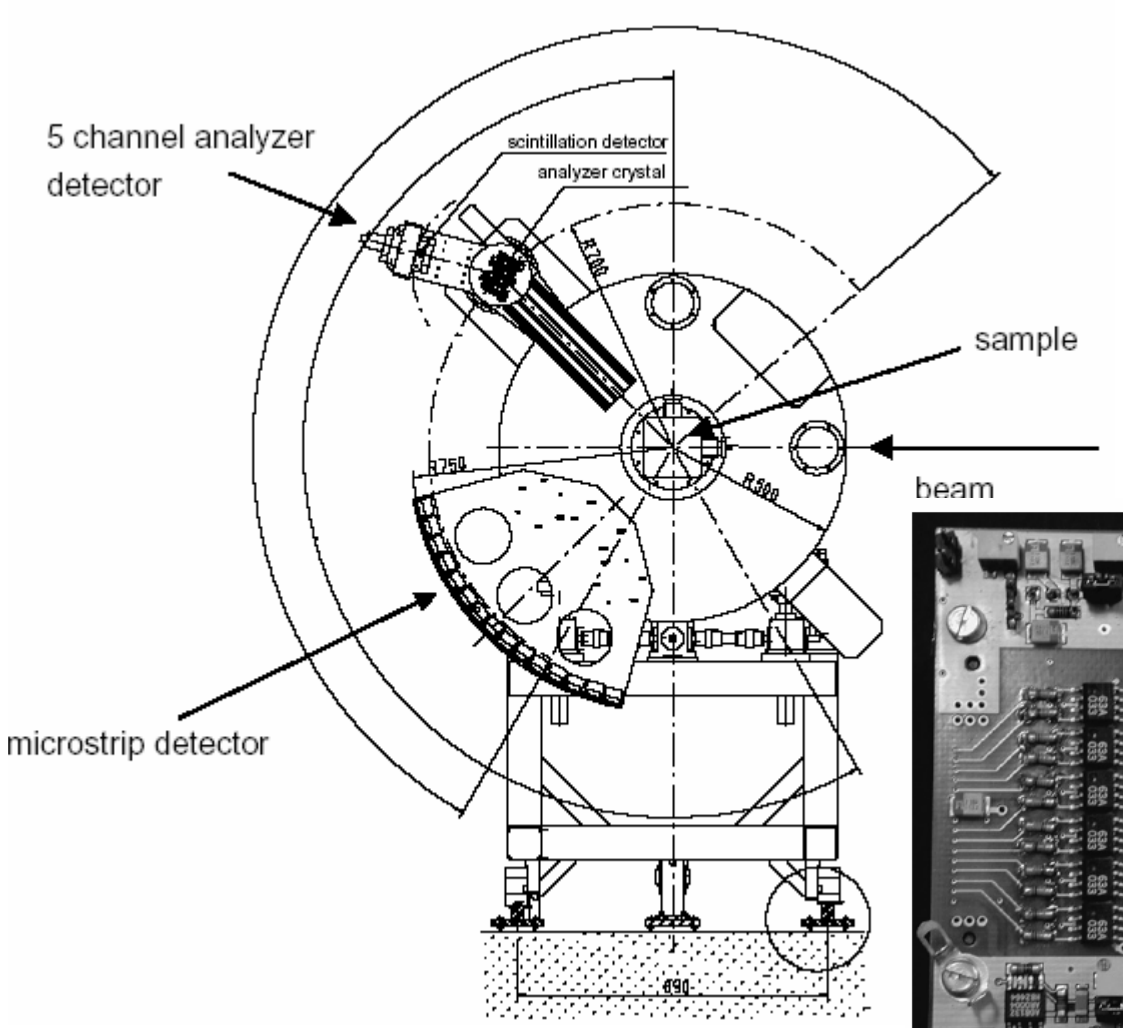
A250 trigger signal



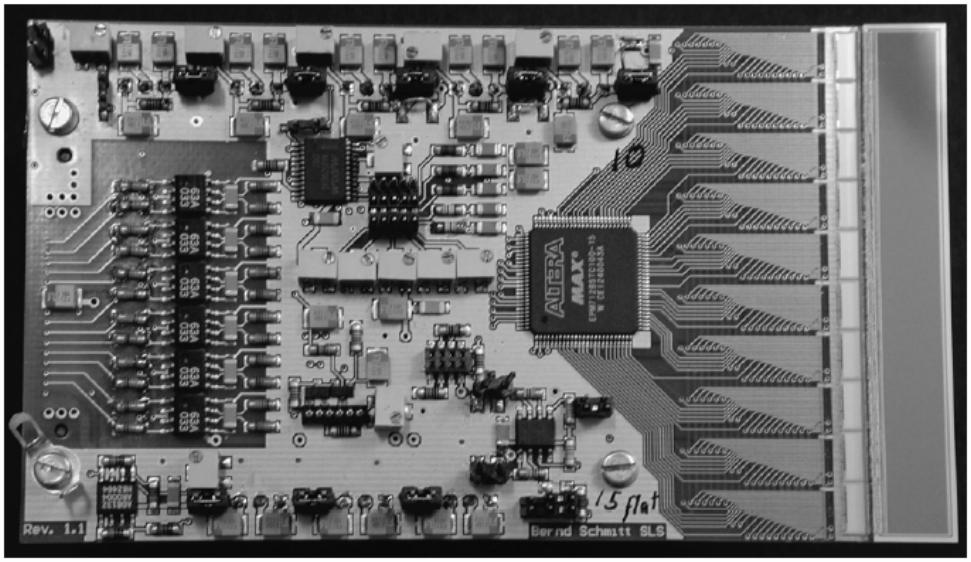
Pixel array signal uniformity



Future Projects with 1-D Silicon/Readout



Mythen Project – SLS
(B. Schmidt)



Proposal for NZ-Australia Project

(In addition to high-tech pixel development for HEP and applications ….)

- PET detector collaboration???
- Development of high performance powder diffraction detector for the Australian Synchrotron???

… Fast path to silicon expertise/applications