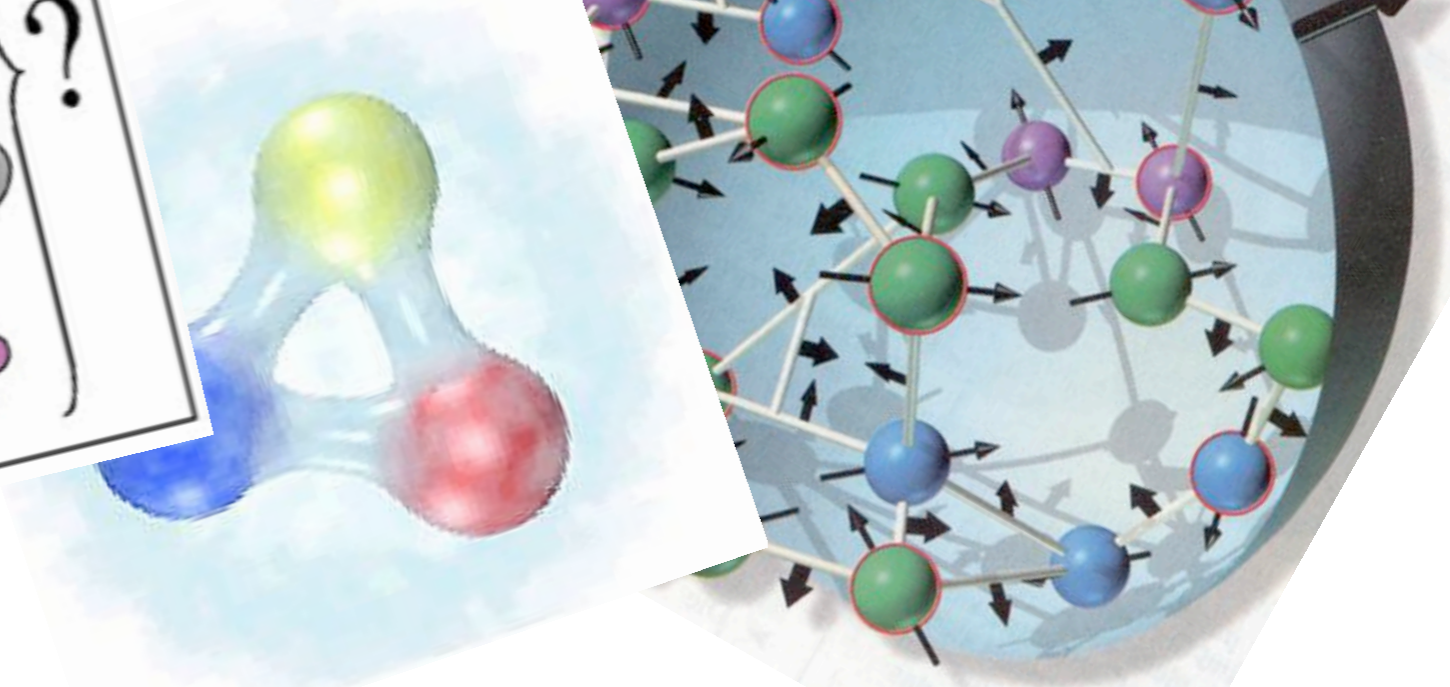
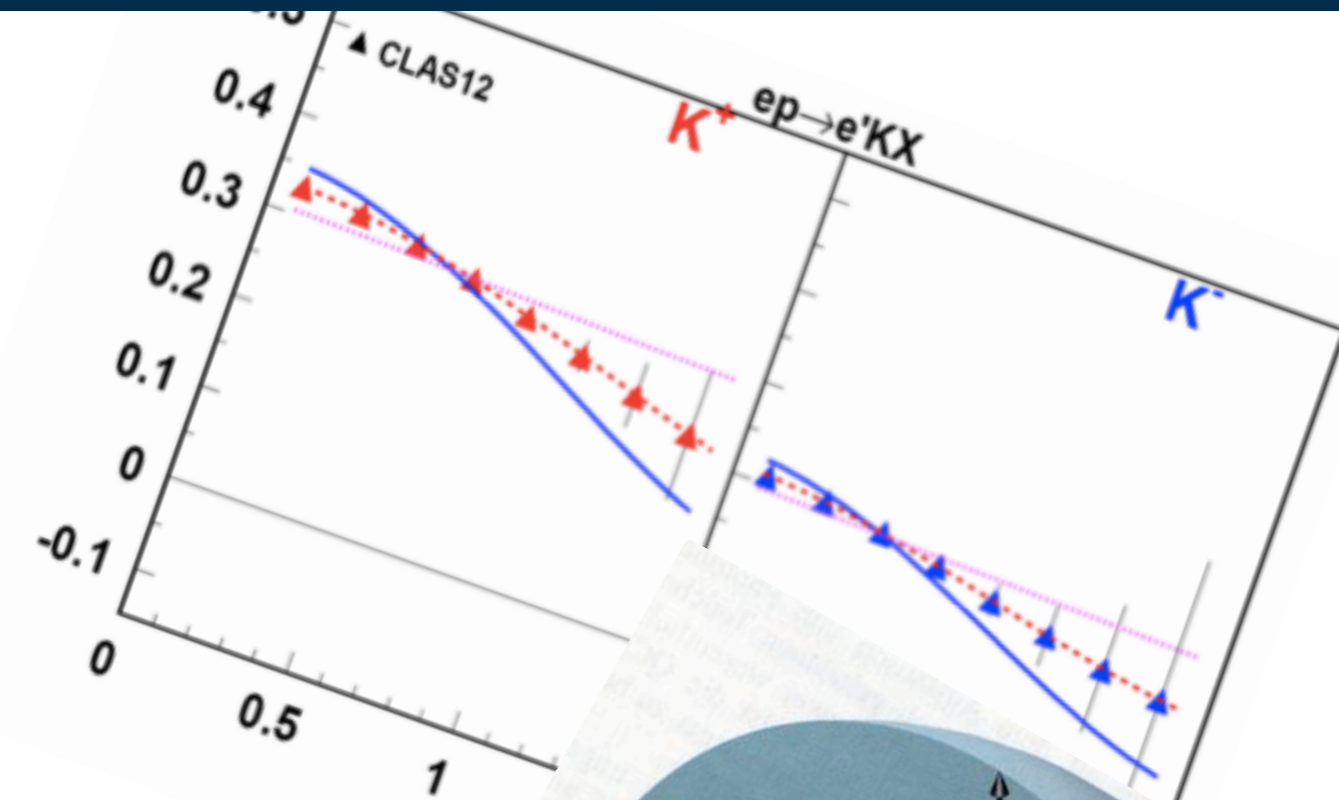
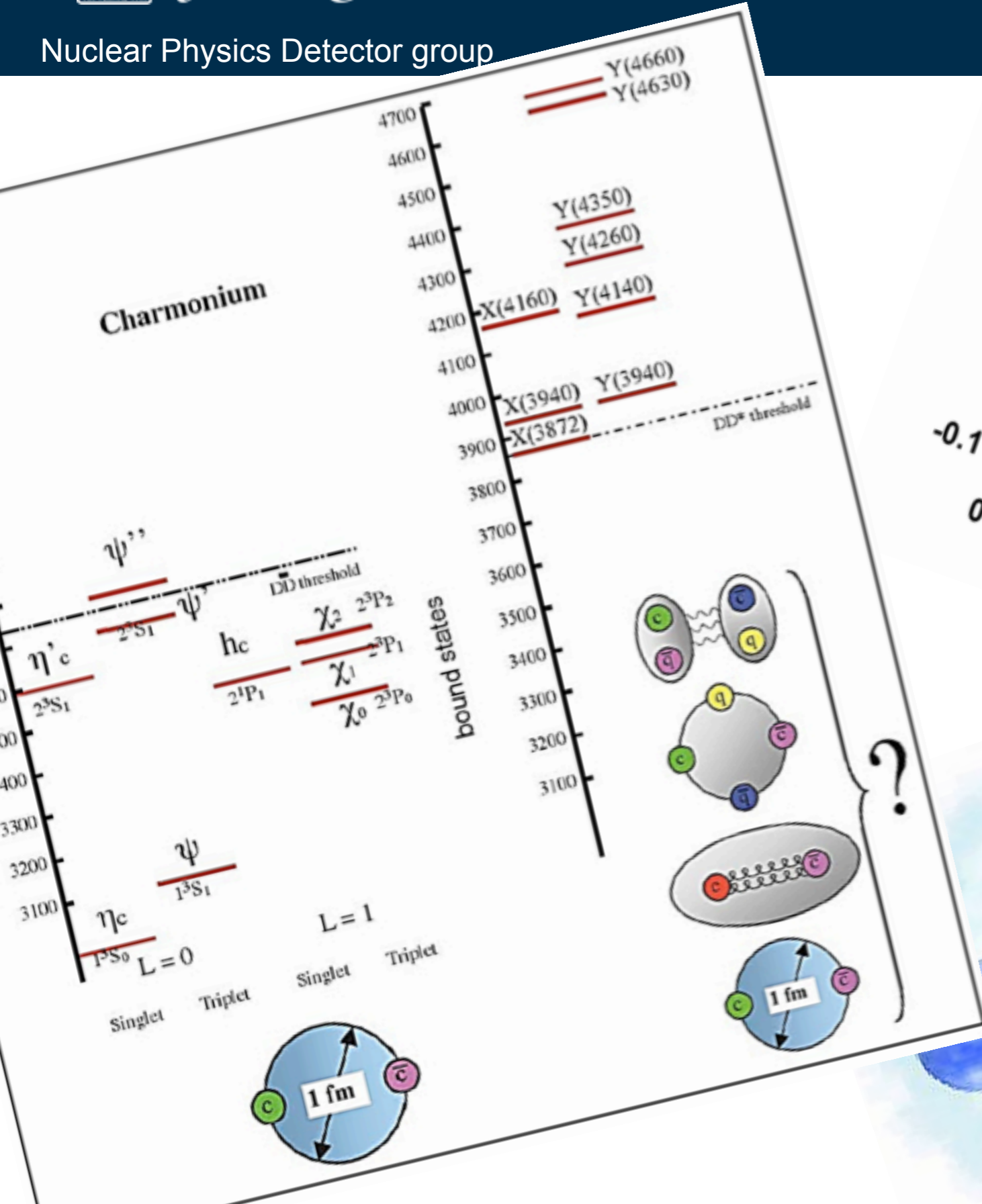


Position Sensitive Photon Detectors for Fundamental Physics & Healthcare

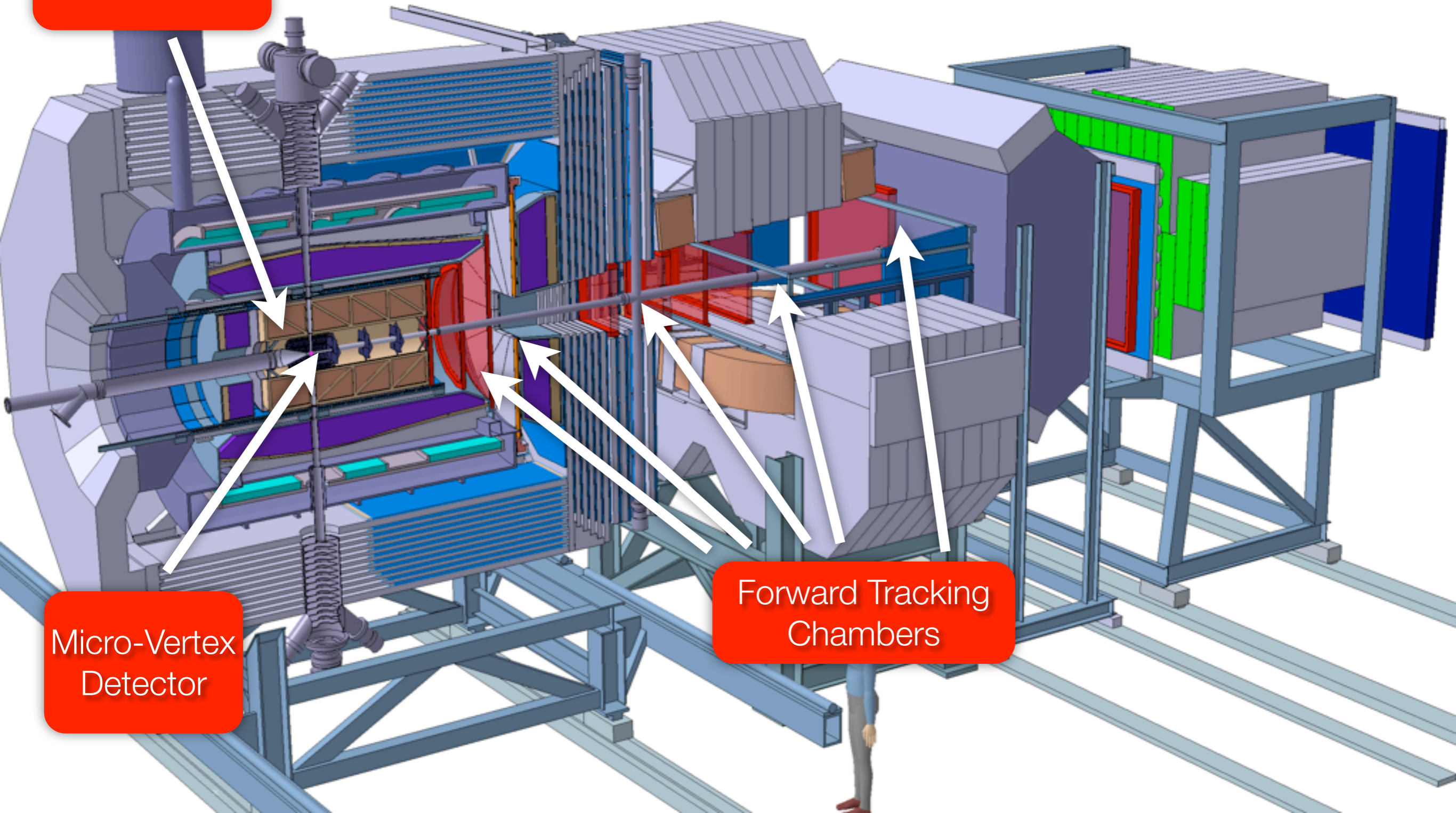
Bjoern Seitz, University of Glasgow
PSD 9, Aberystwyth, Wales



Open Problems in Hadron Physics

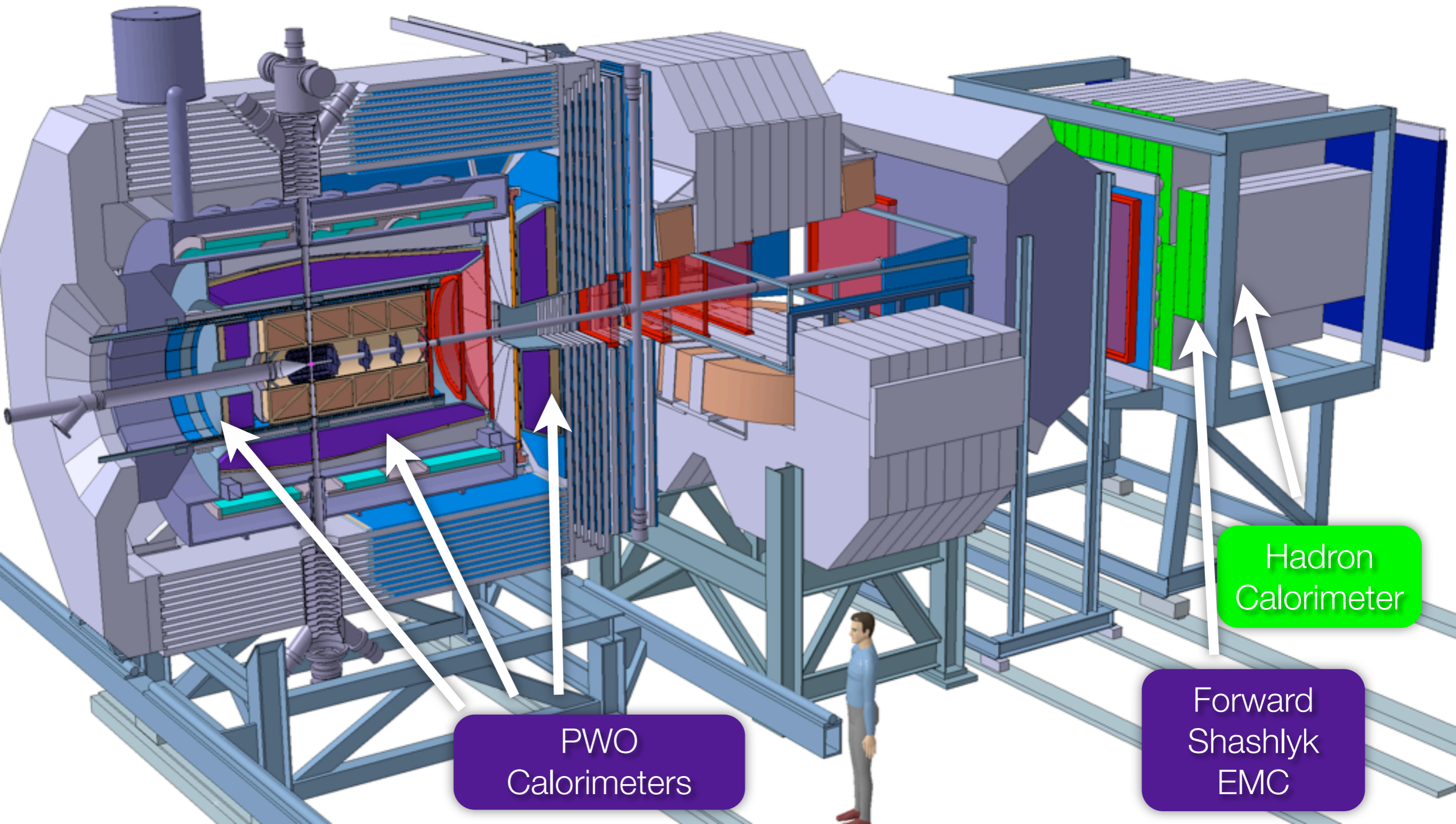


Central Tracker



Micro-Vertex Detector

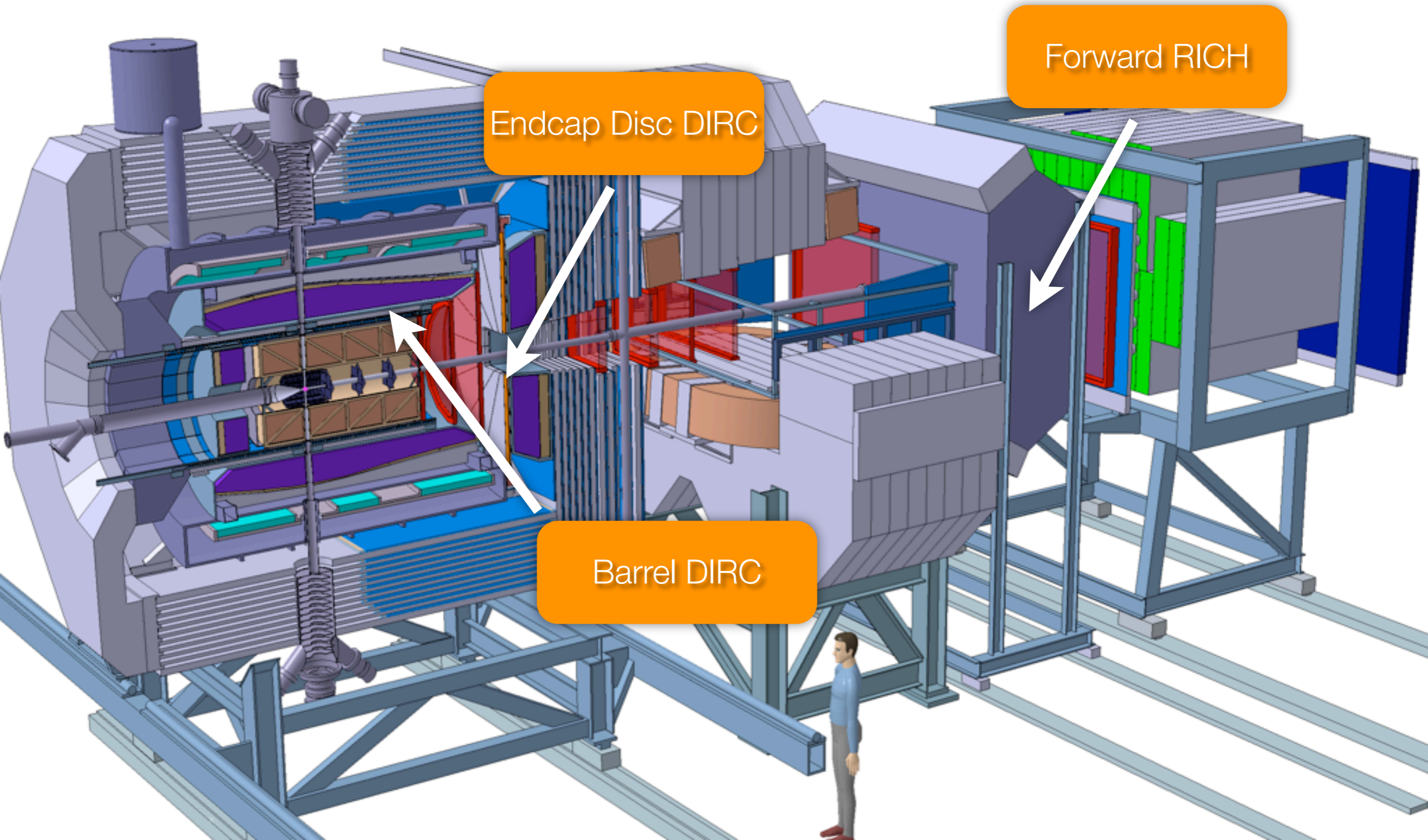
Forward Tracking Chambers



PWO
Calorimeters

Hadron
Calorimeter

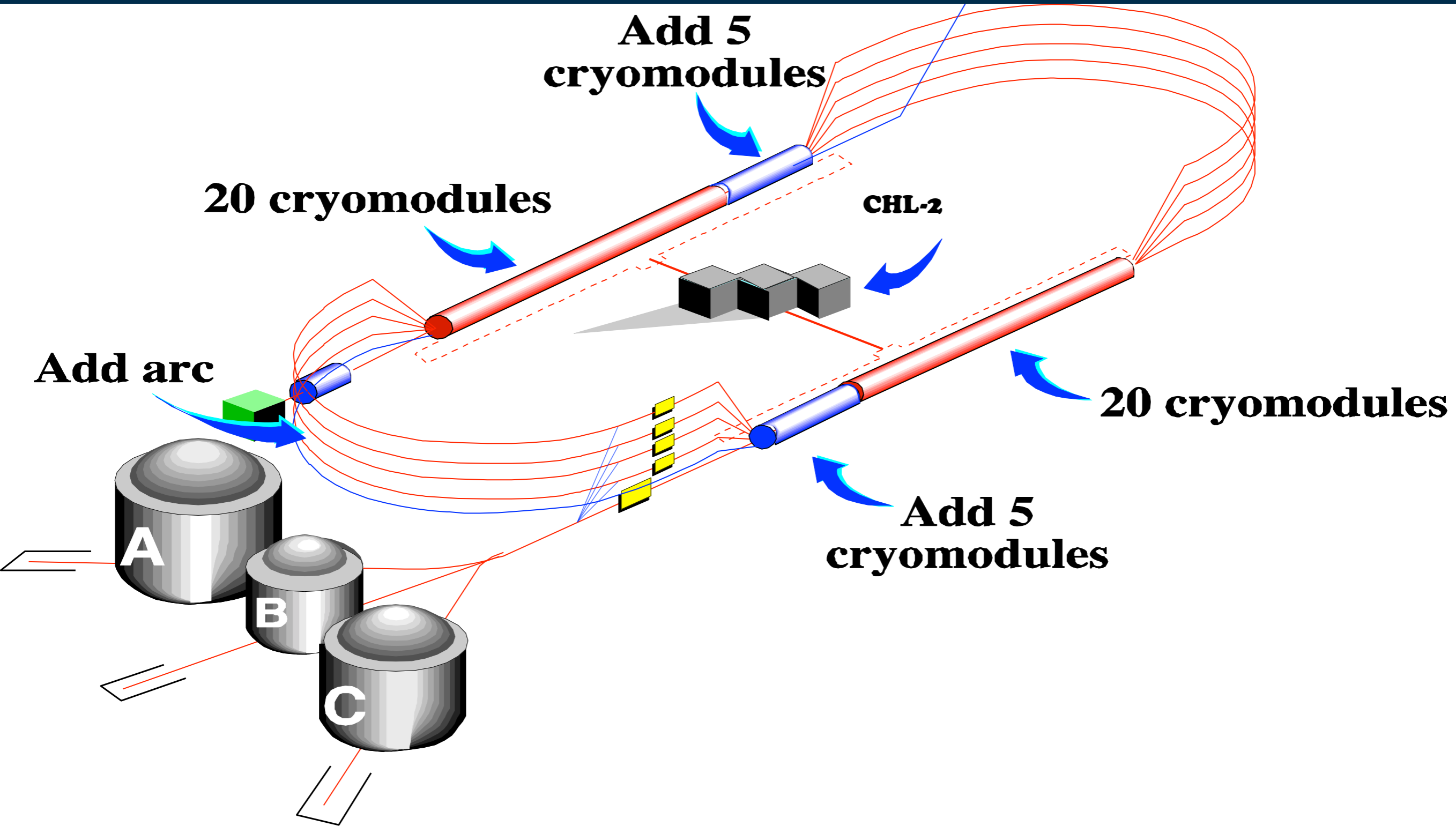
Forward
Shashlyk
EMC



Endcap Disc DIRC

Forward RICH

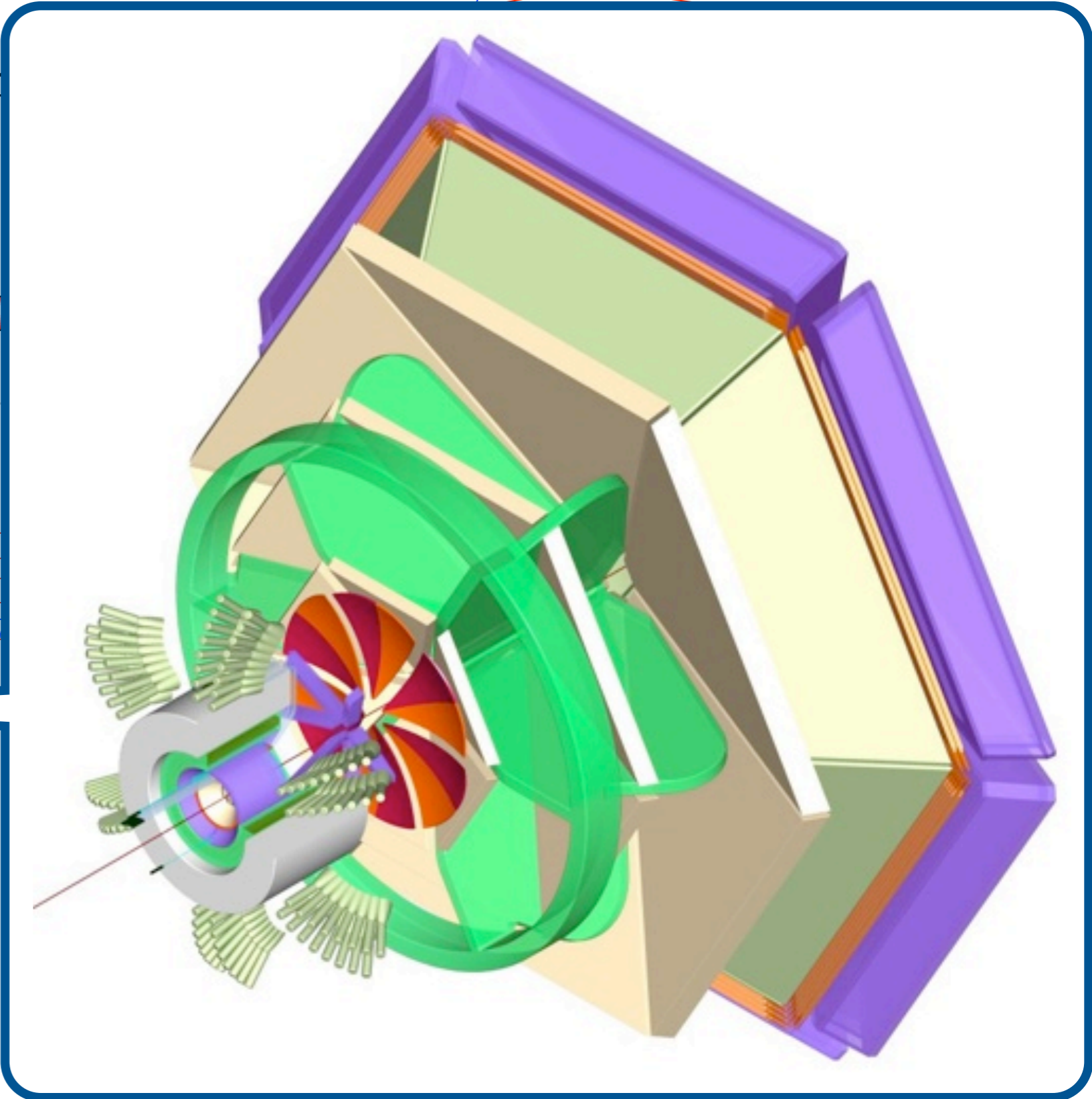
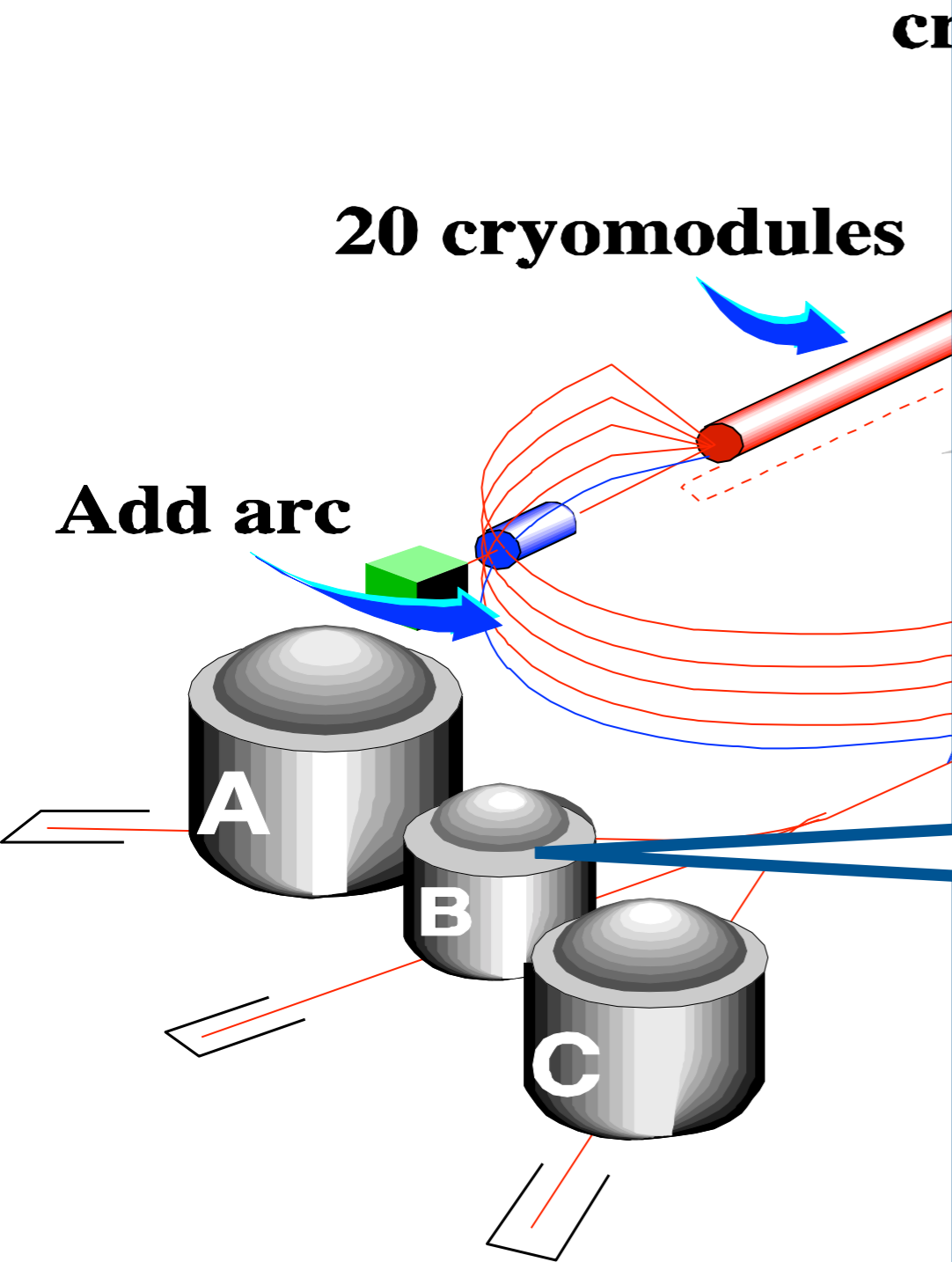
Barrel DIRC



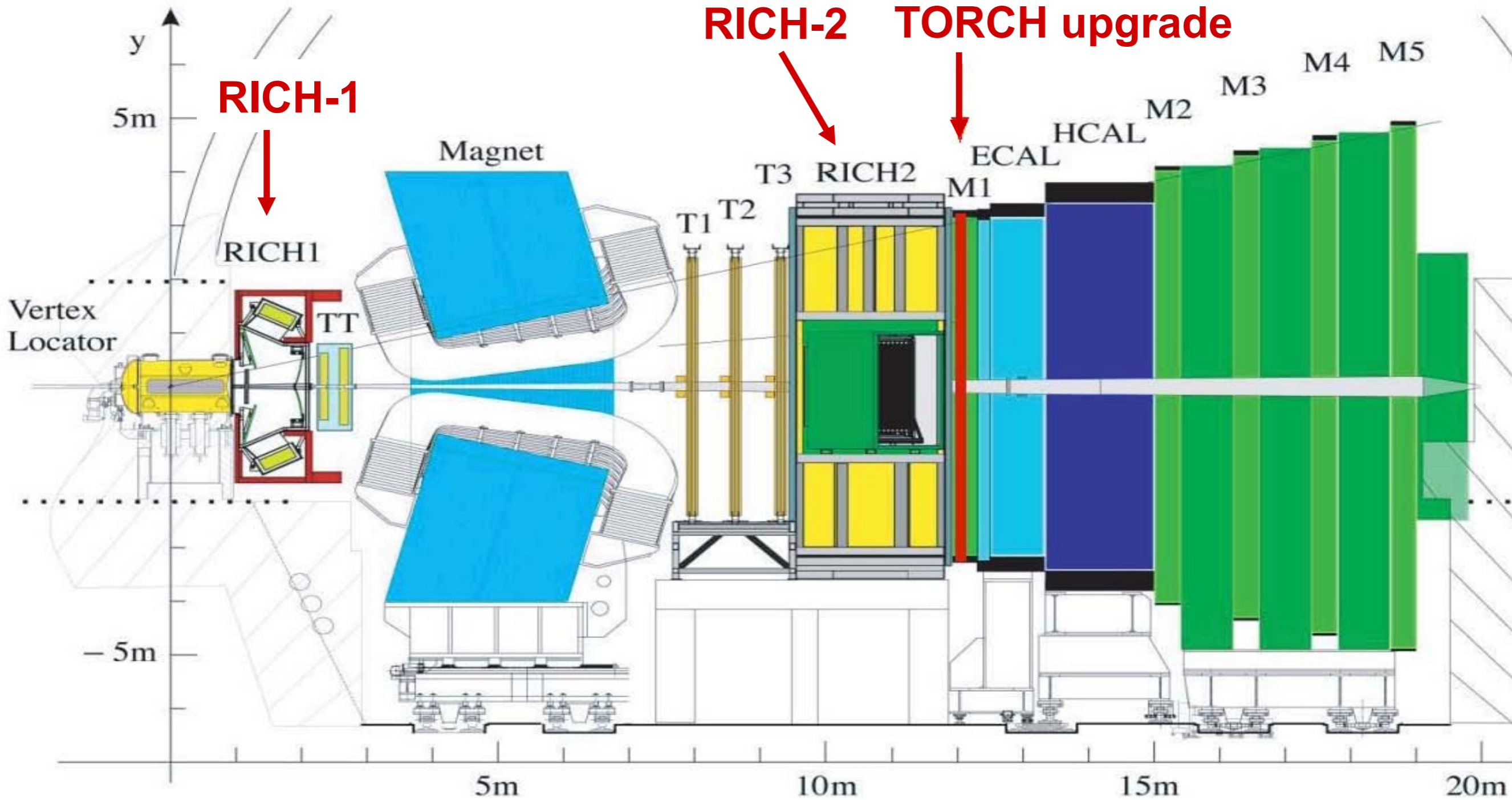
CLAS 12 -Jlab upgrade

20 cryomodules

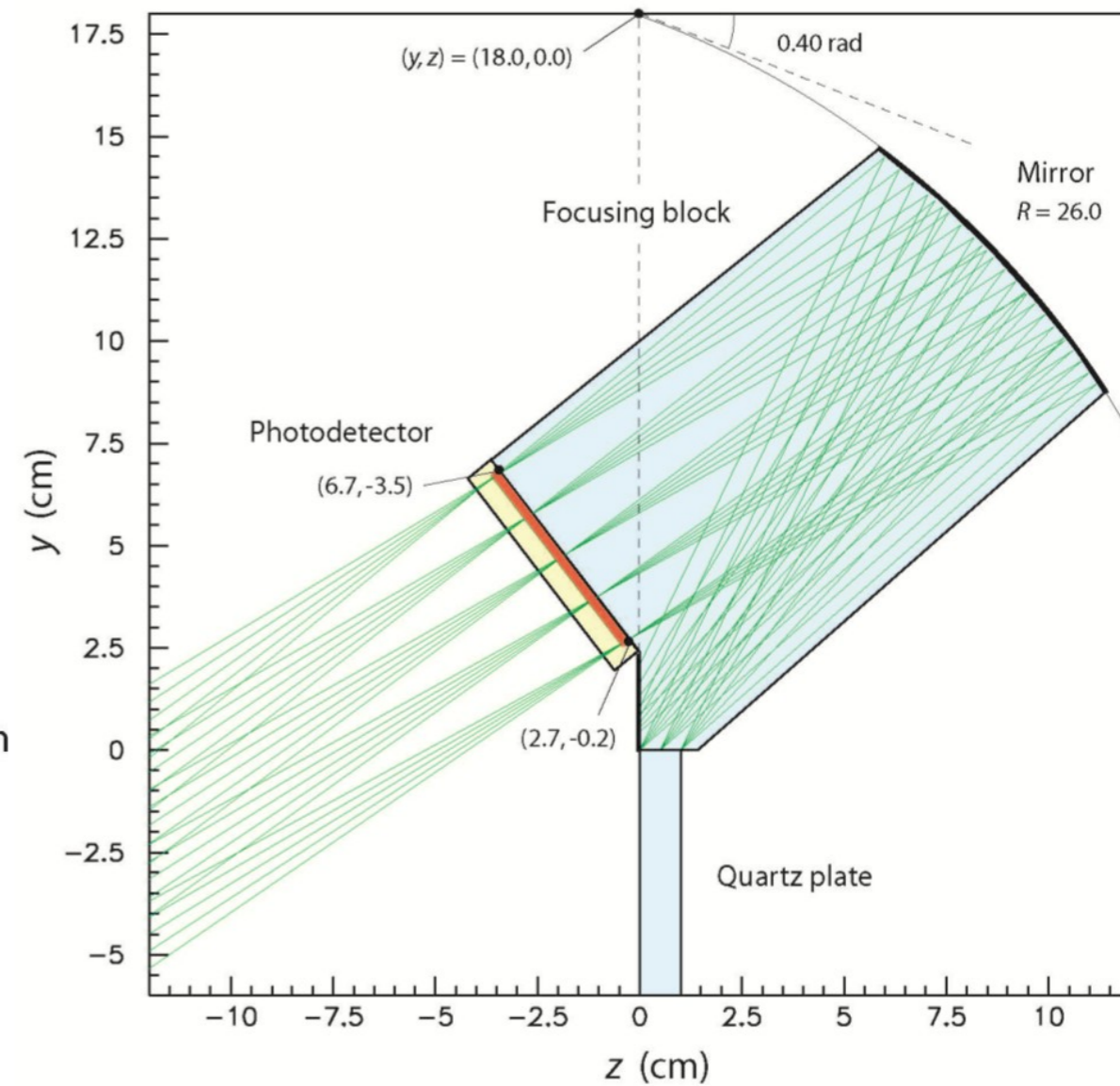
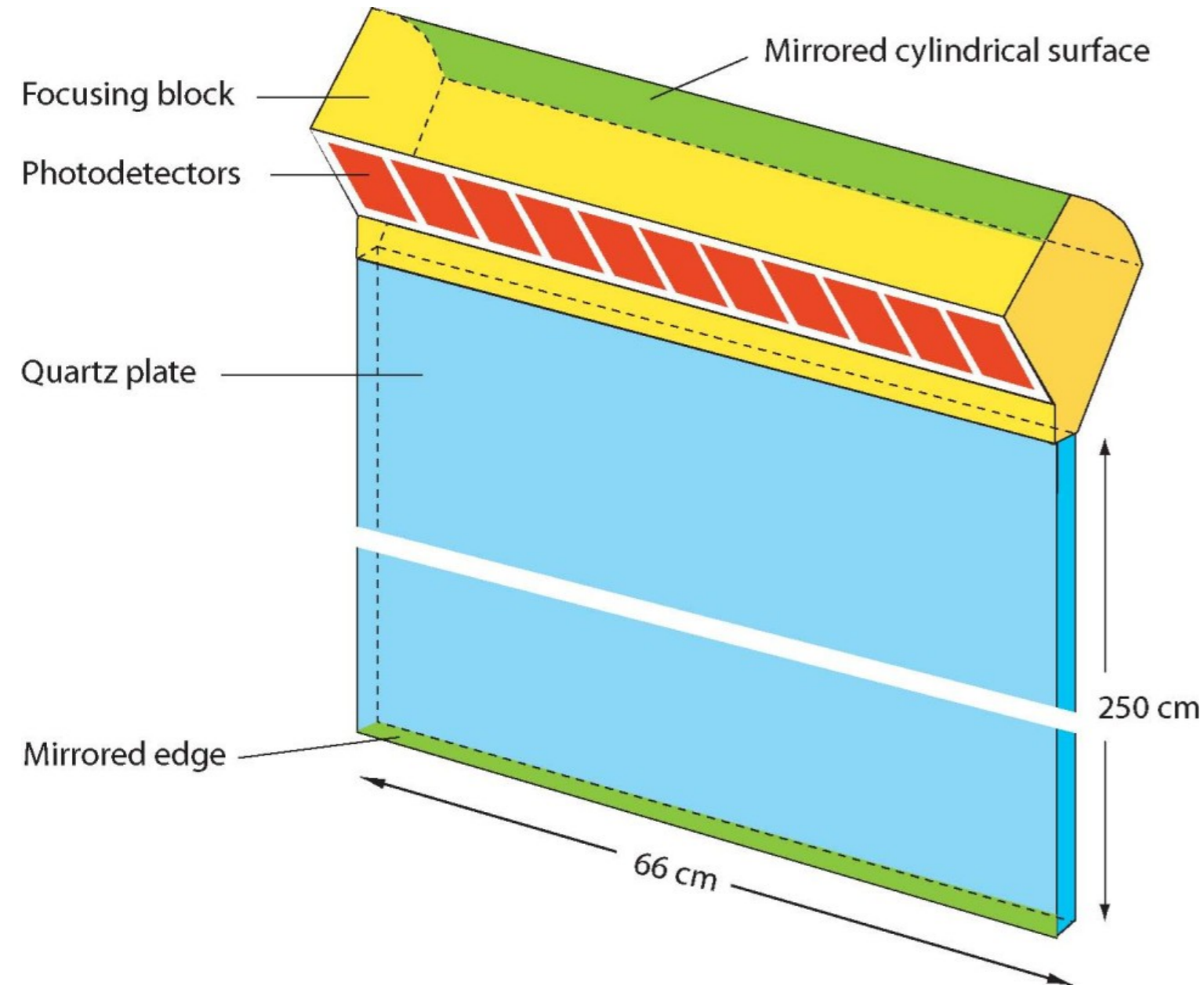
Add arc



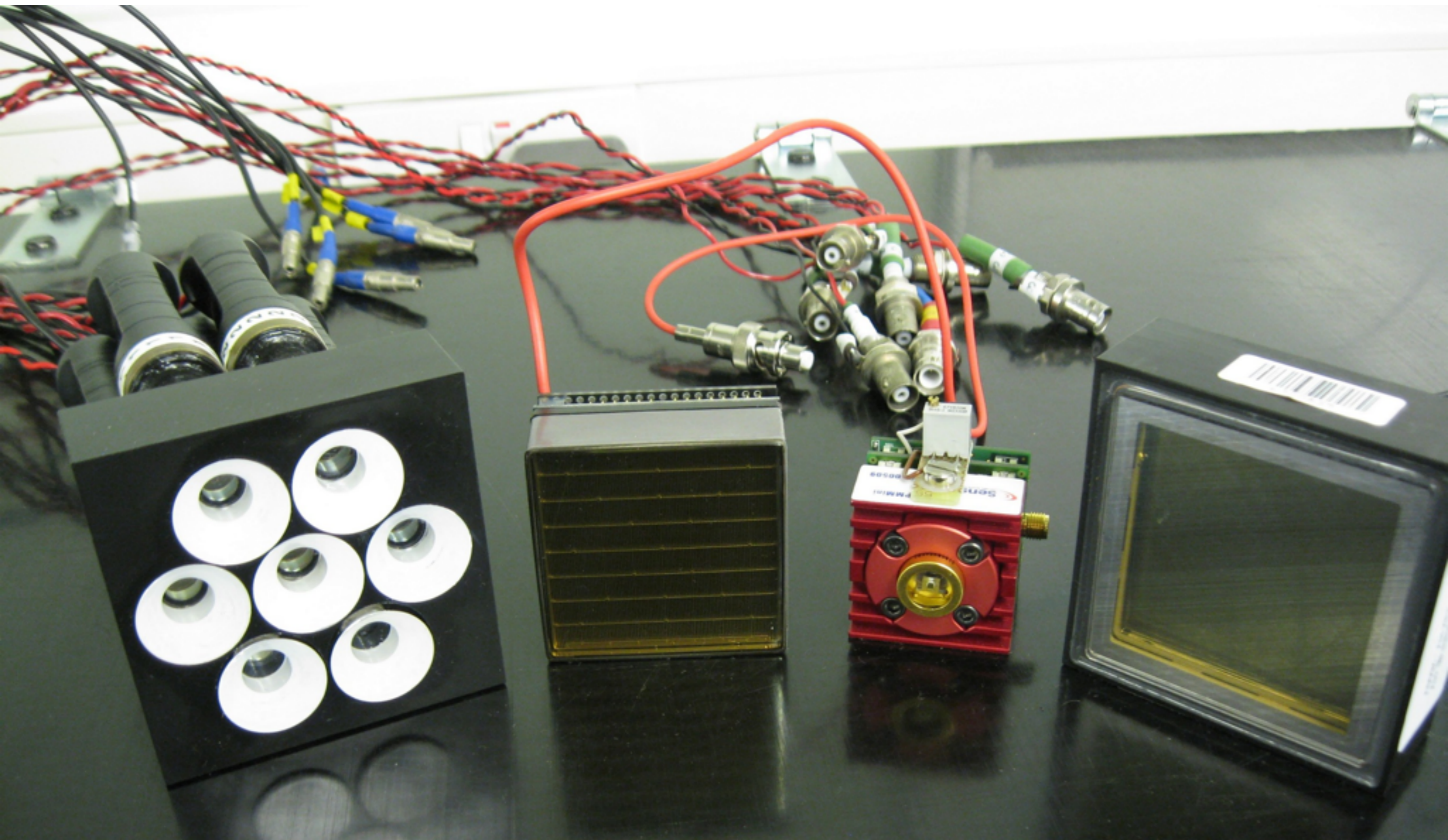
Cherenkov ToF - TORCH for LHCb

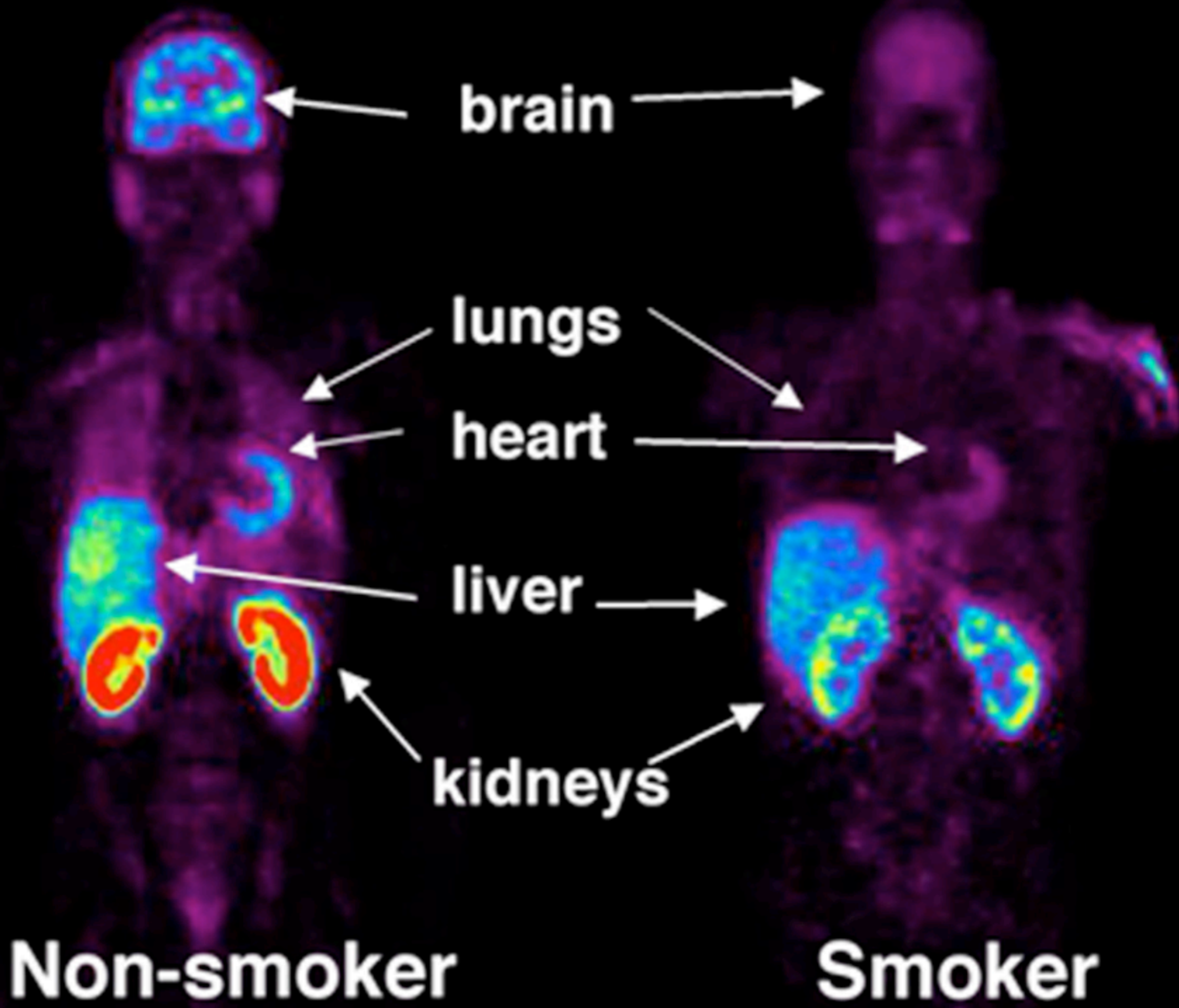


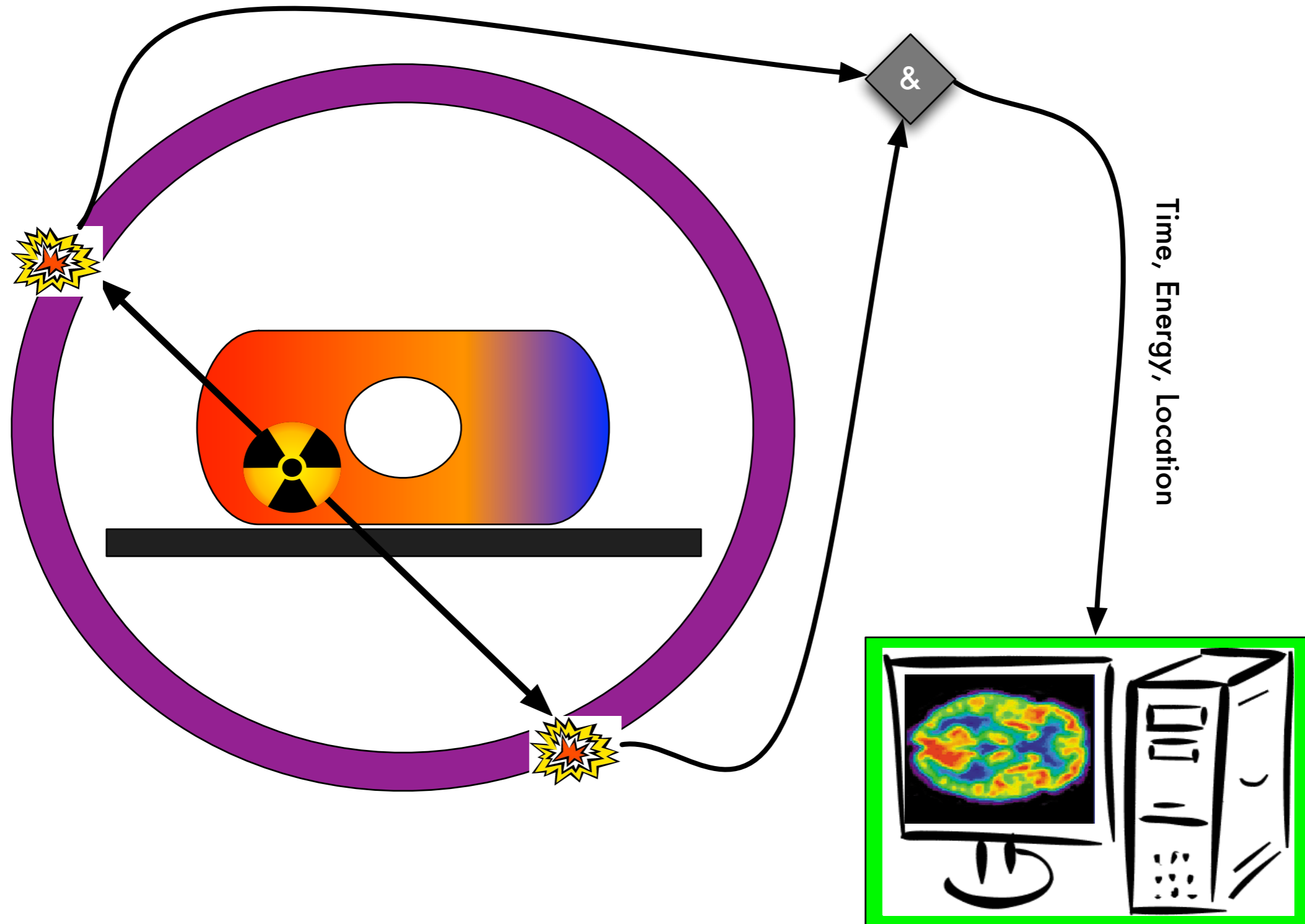
Cherenkov ToF - TORCH for LHCb



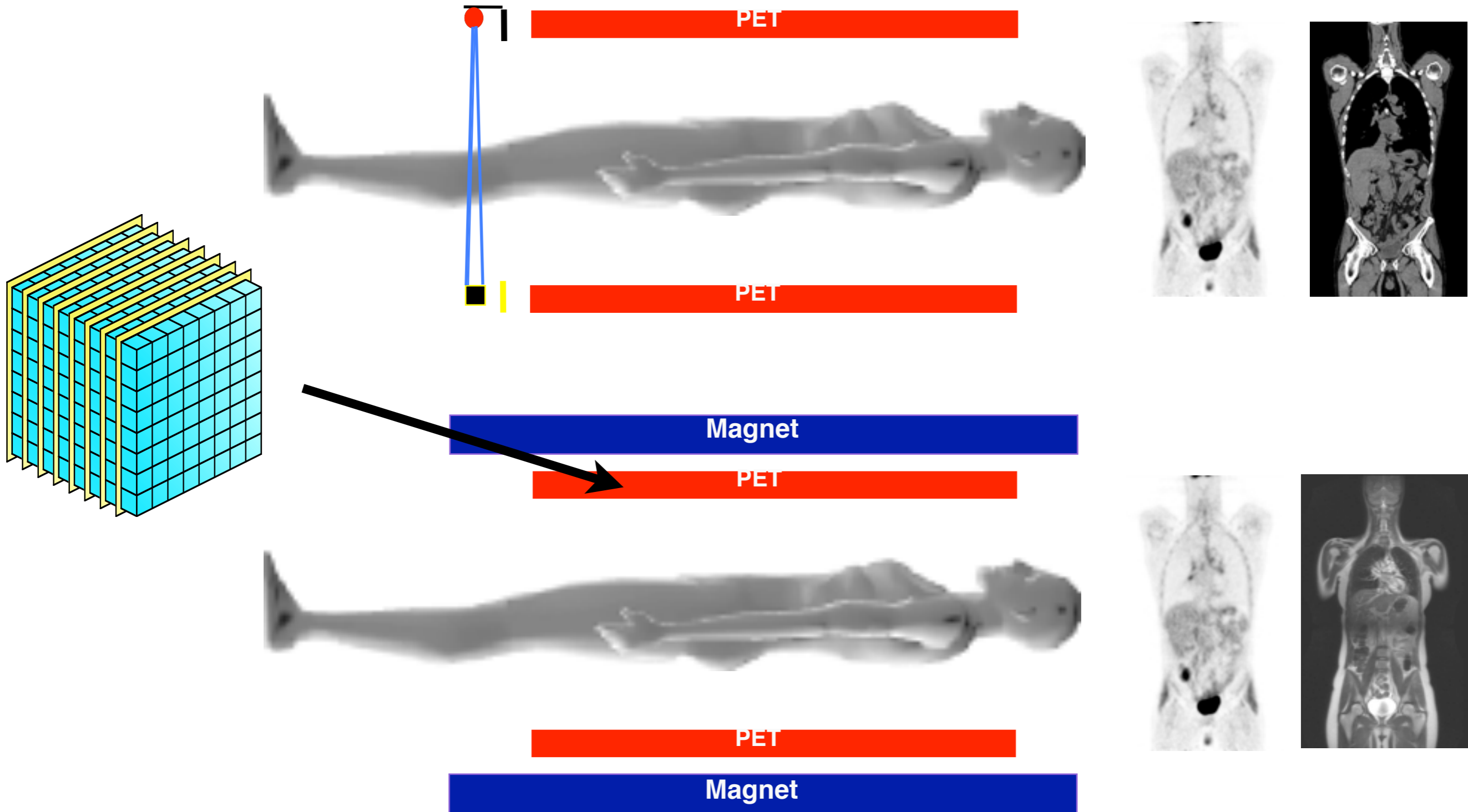
Fast position sensitive photon detectors



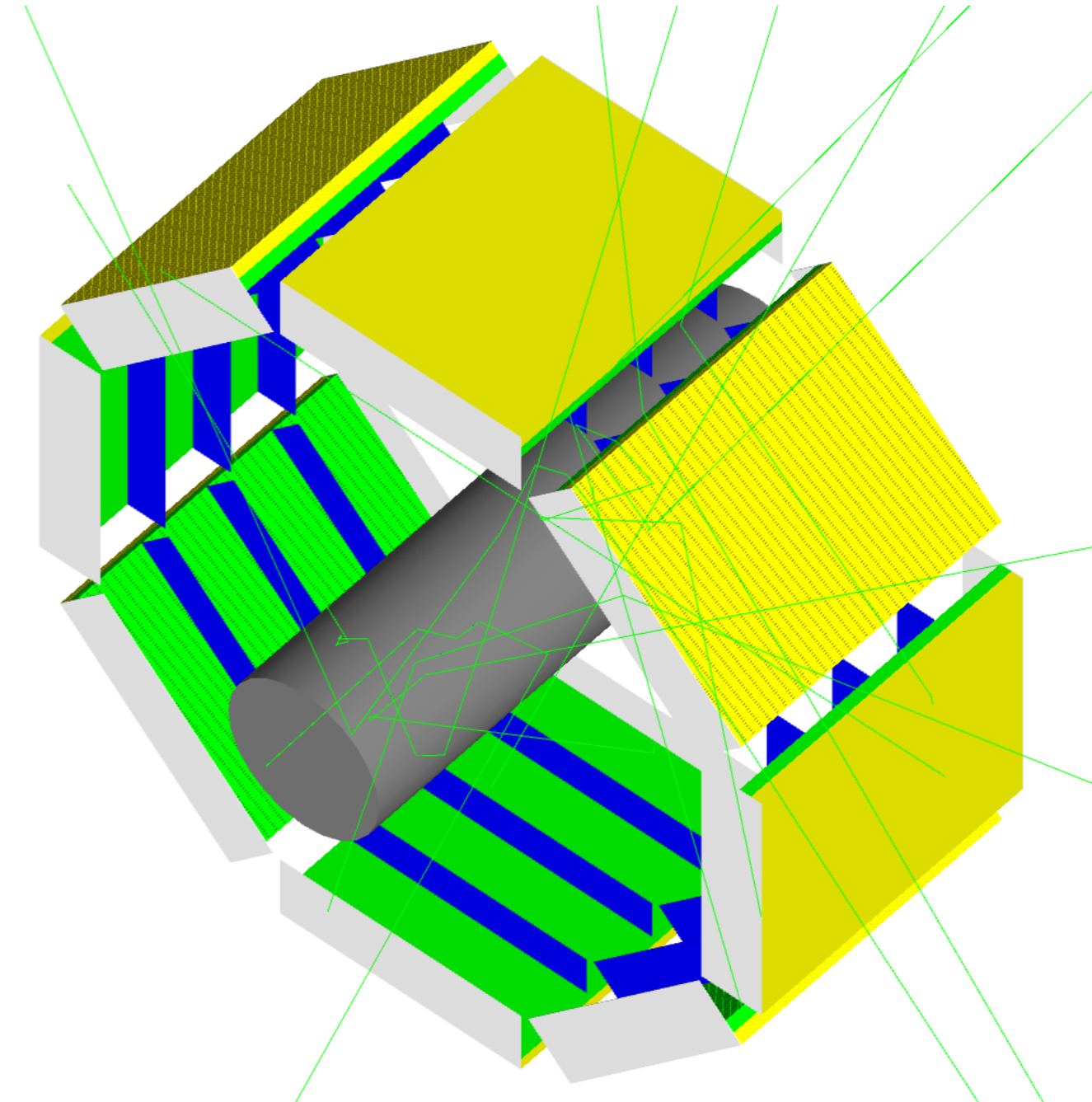
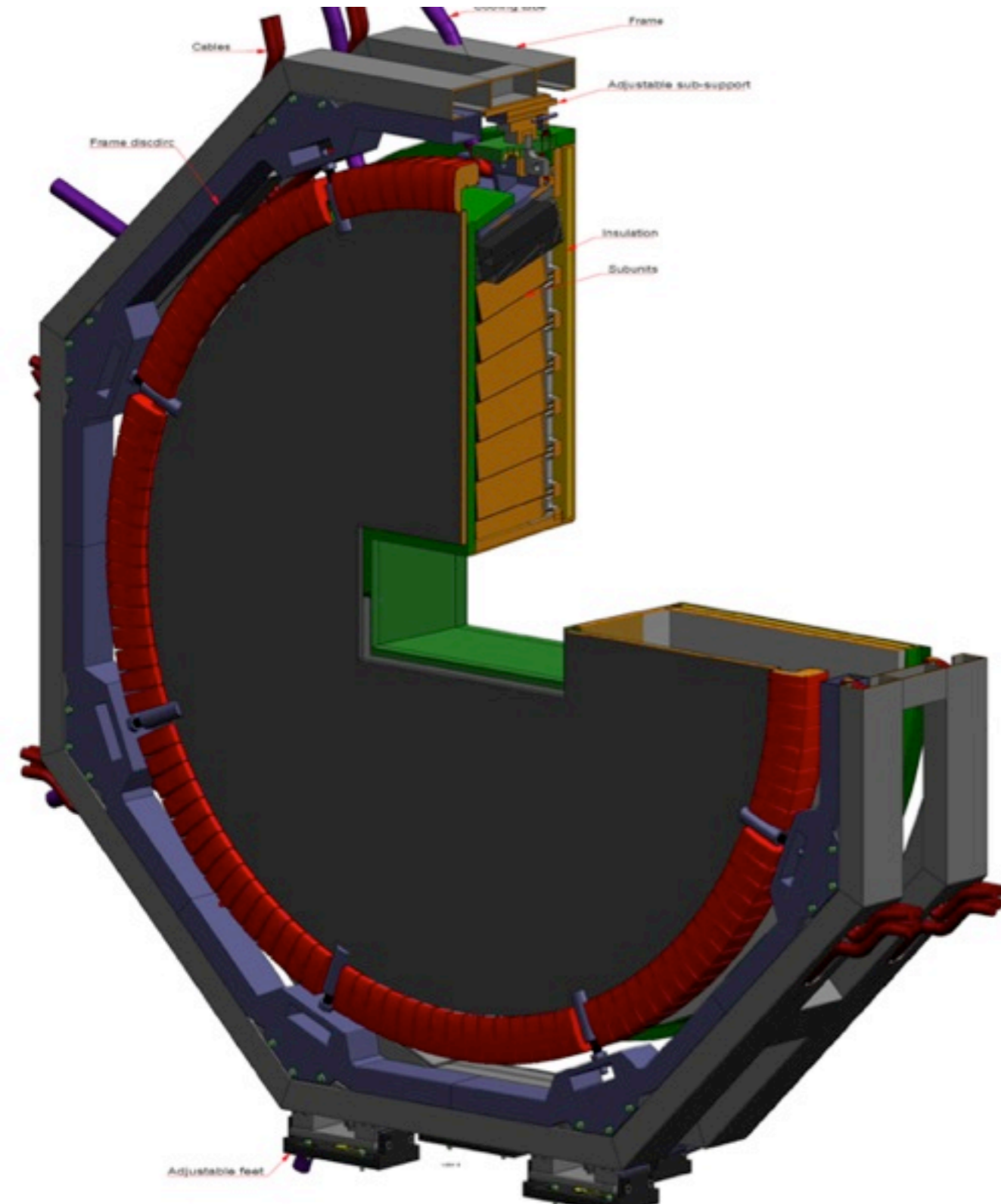




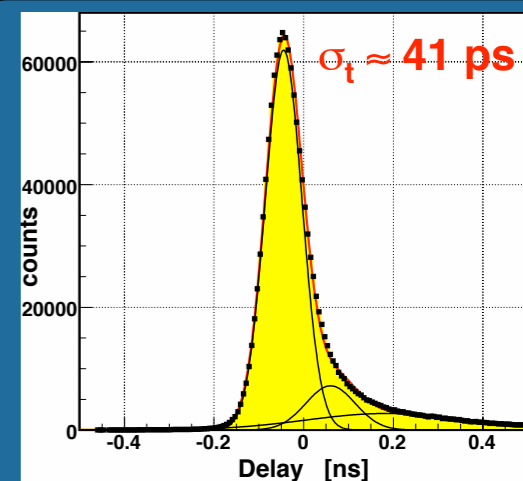
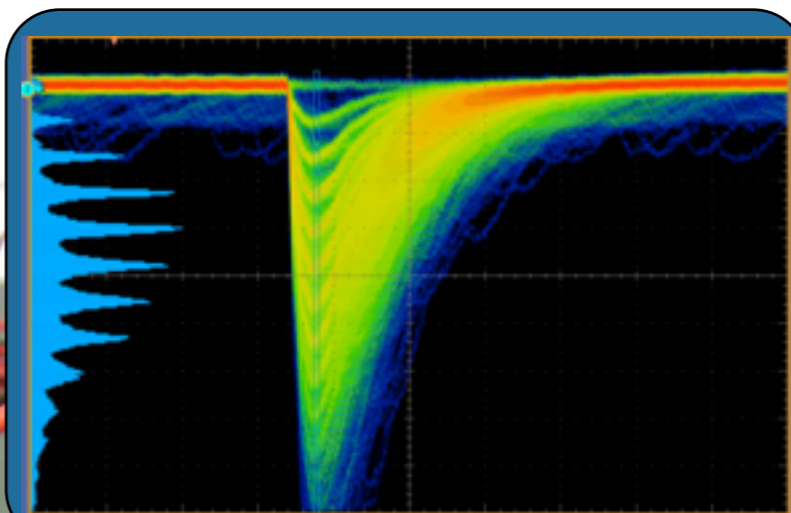
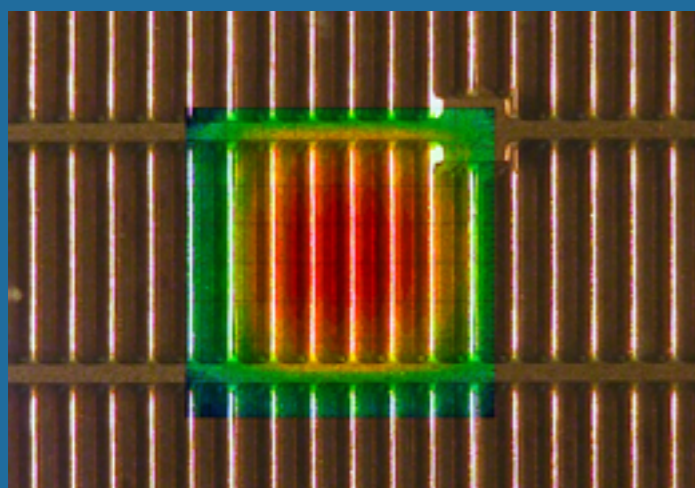
The Optimal PET



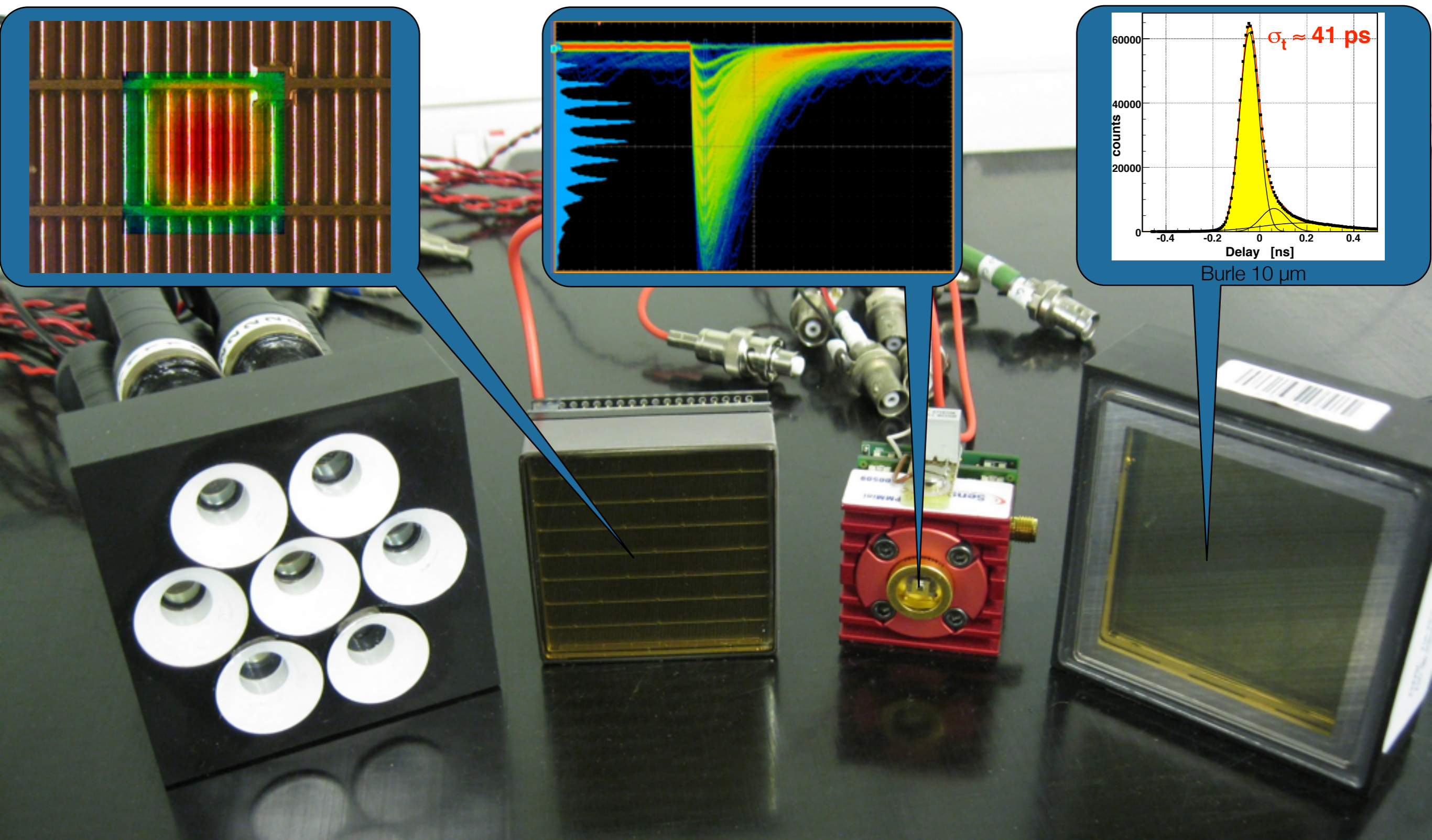
Exploiting Synergies

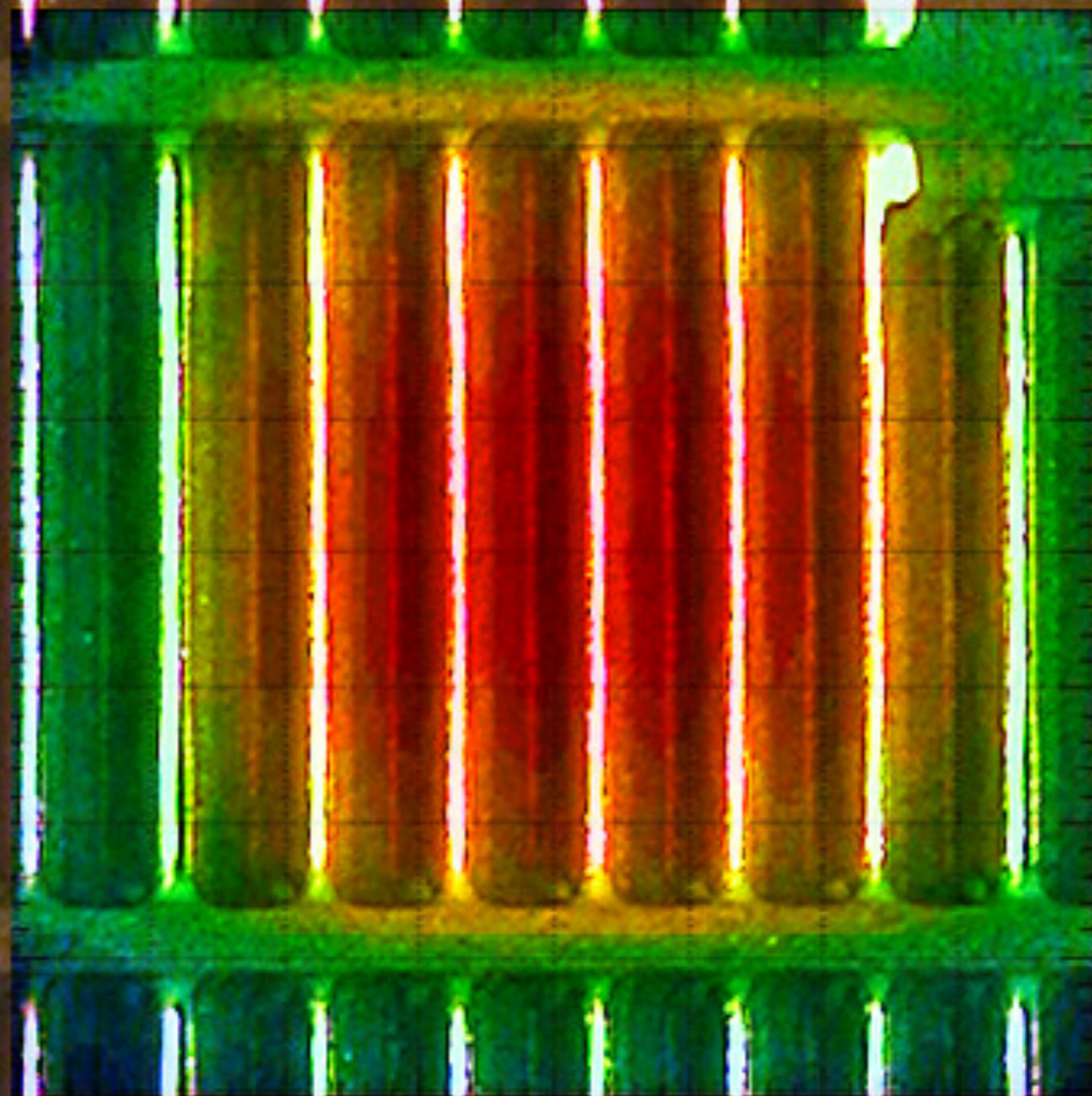


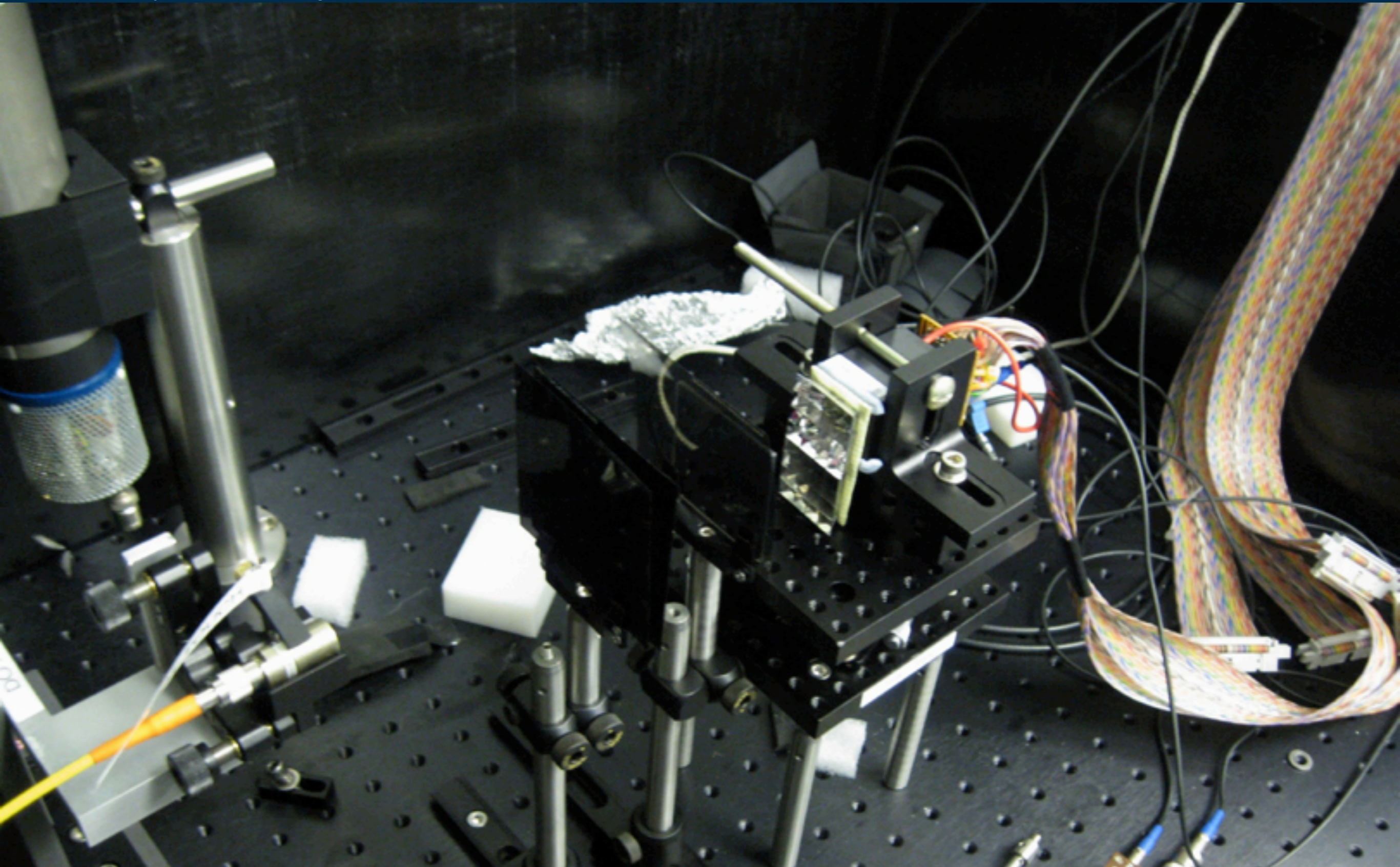
Fast position sensitive photon detectors



Burle 10 μm

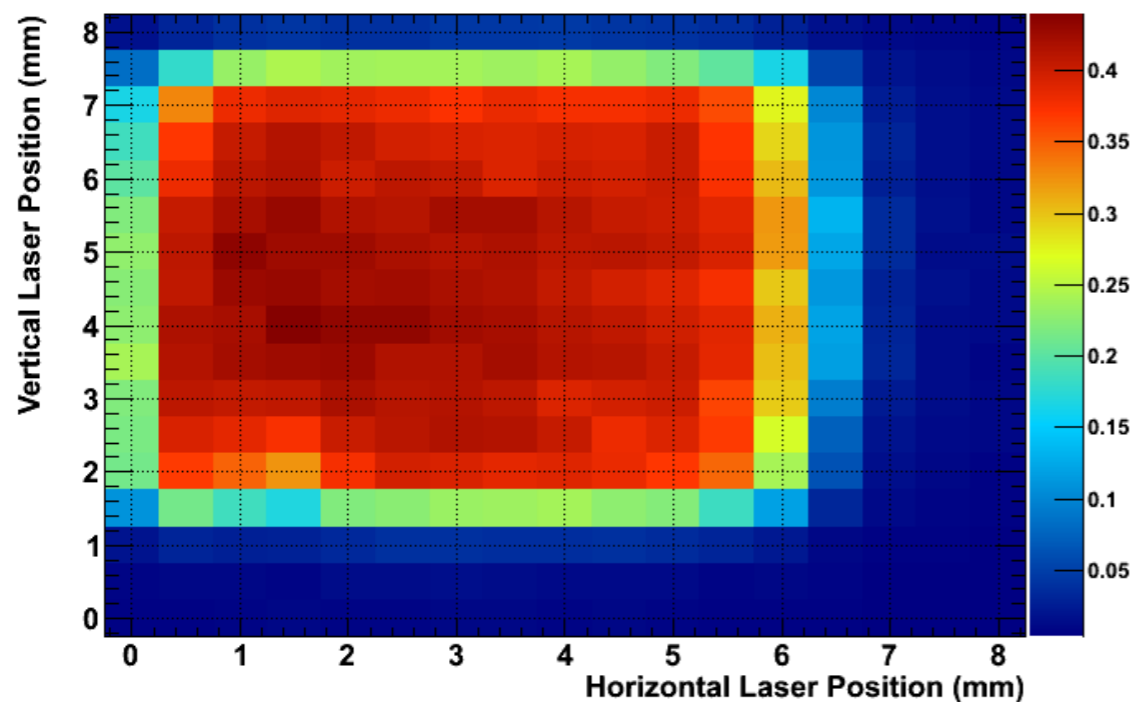




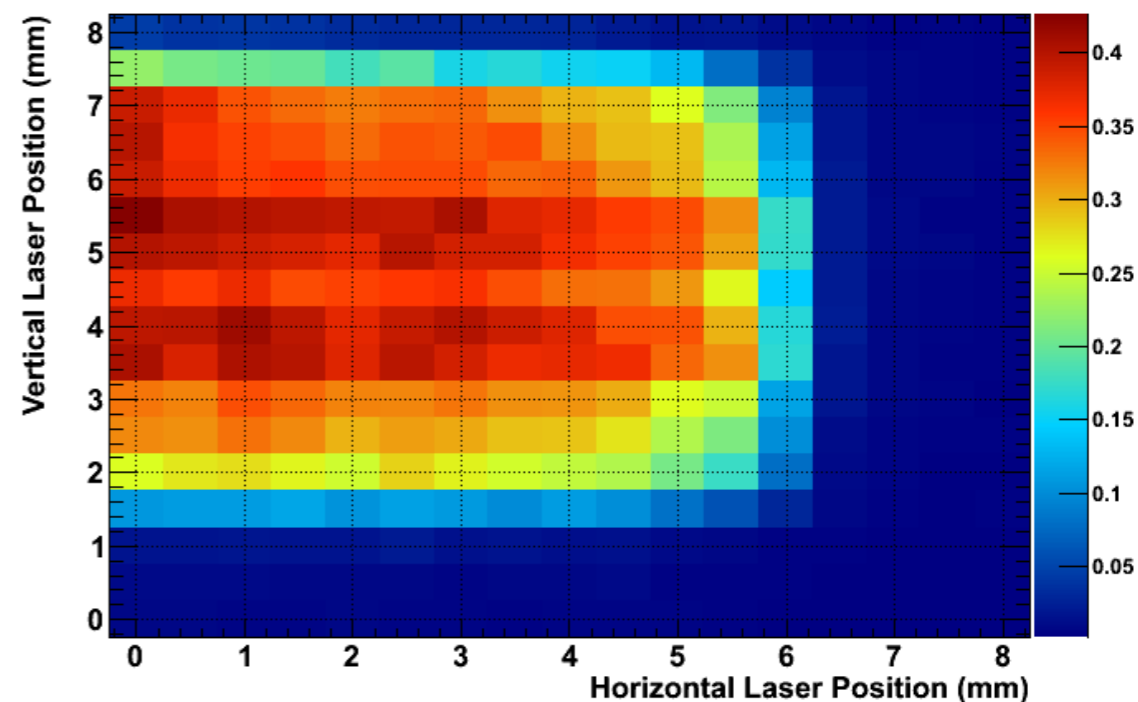


Nuclear Physics Detector group

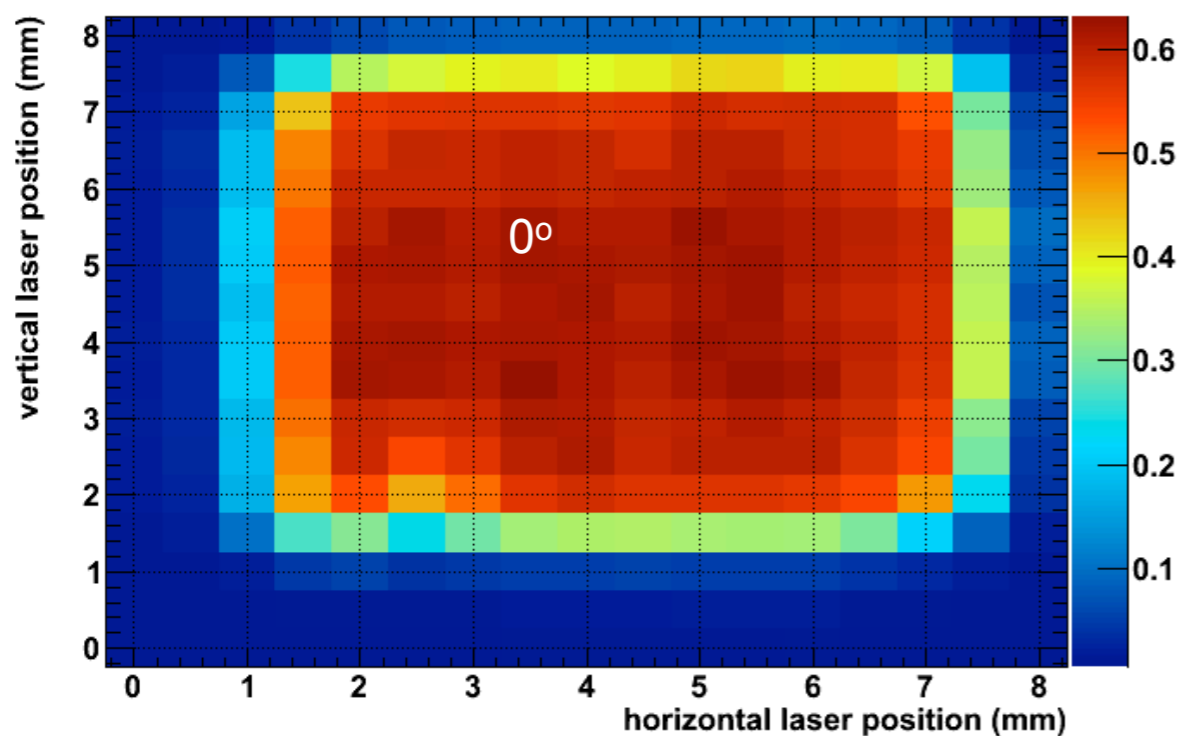
Pixel 45 Efficiency Map: -1000V, NDF 4.5



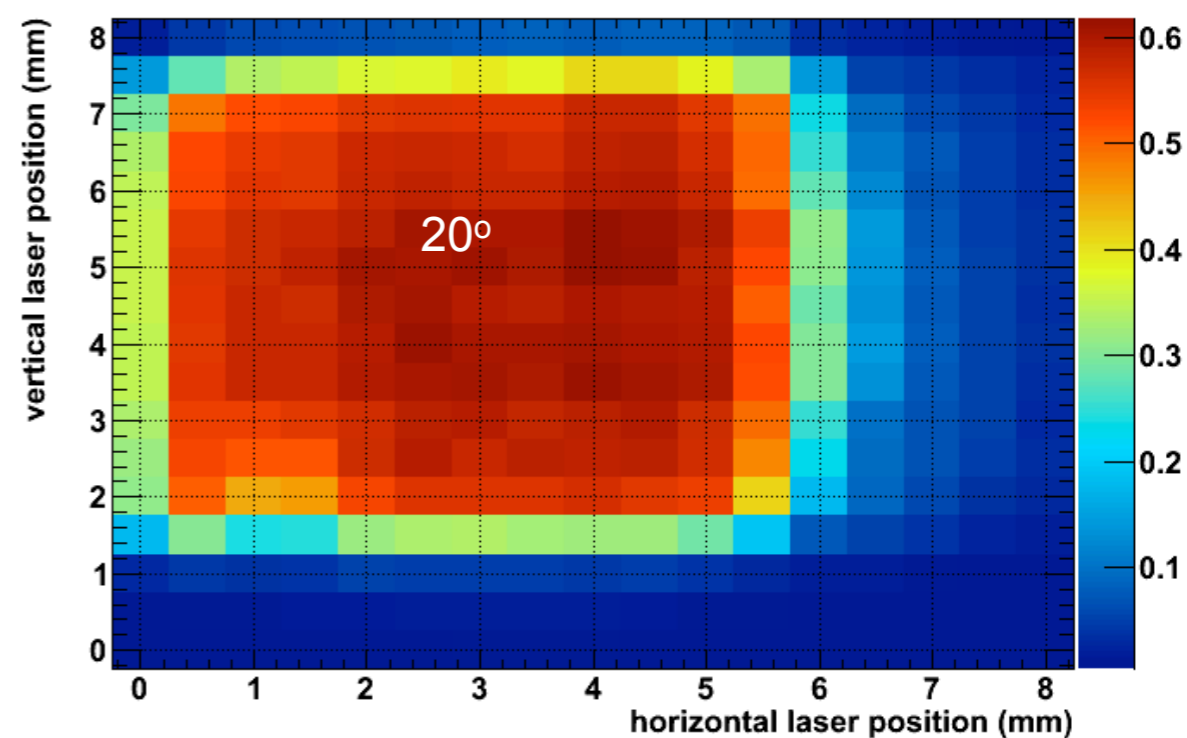
Pixel 14 Efficiency Map: -1000V, NDF 4.5

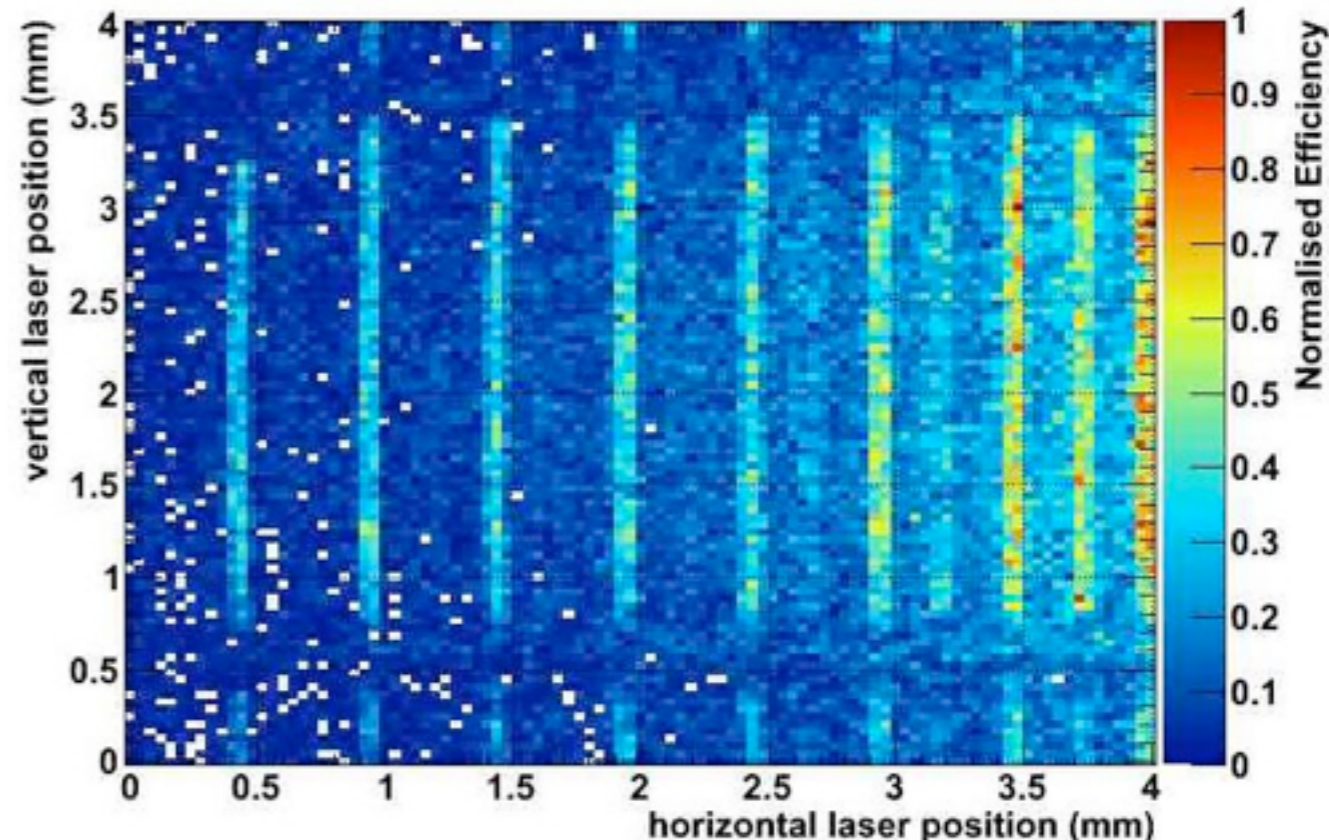
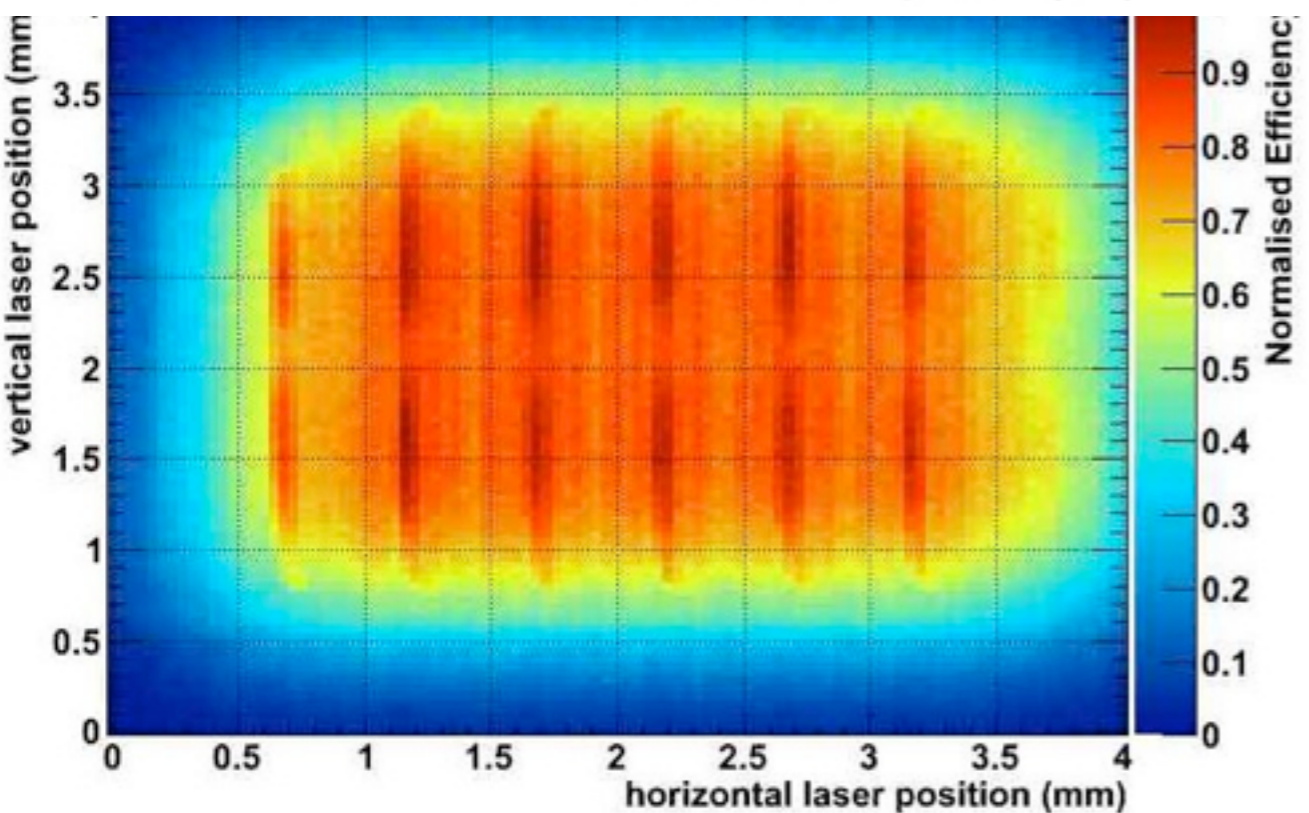
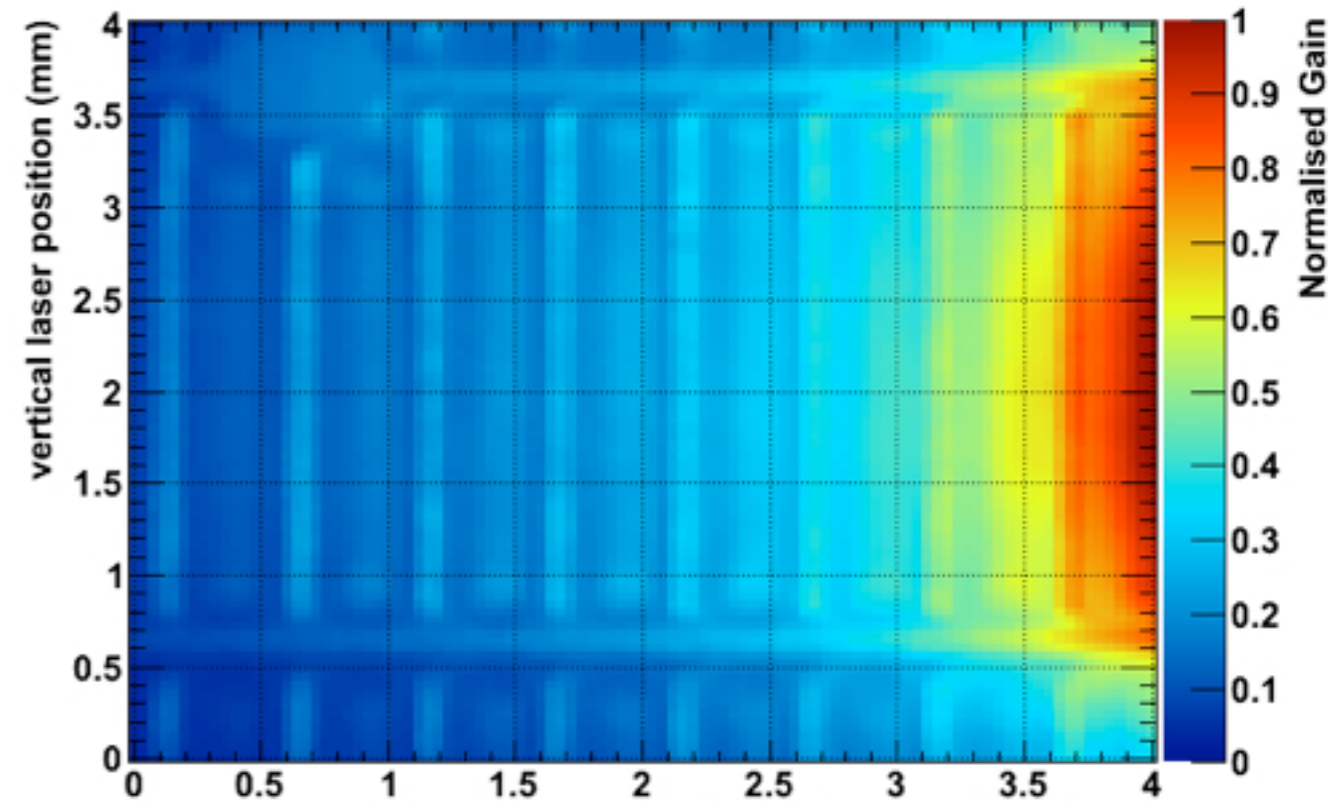
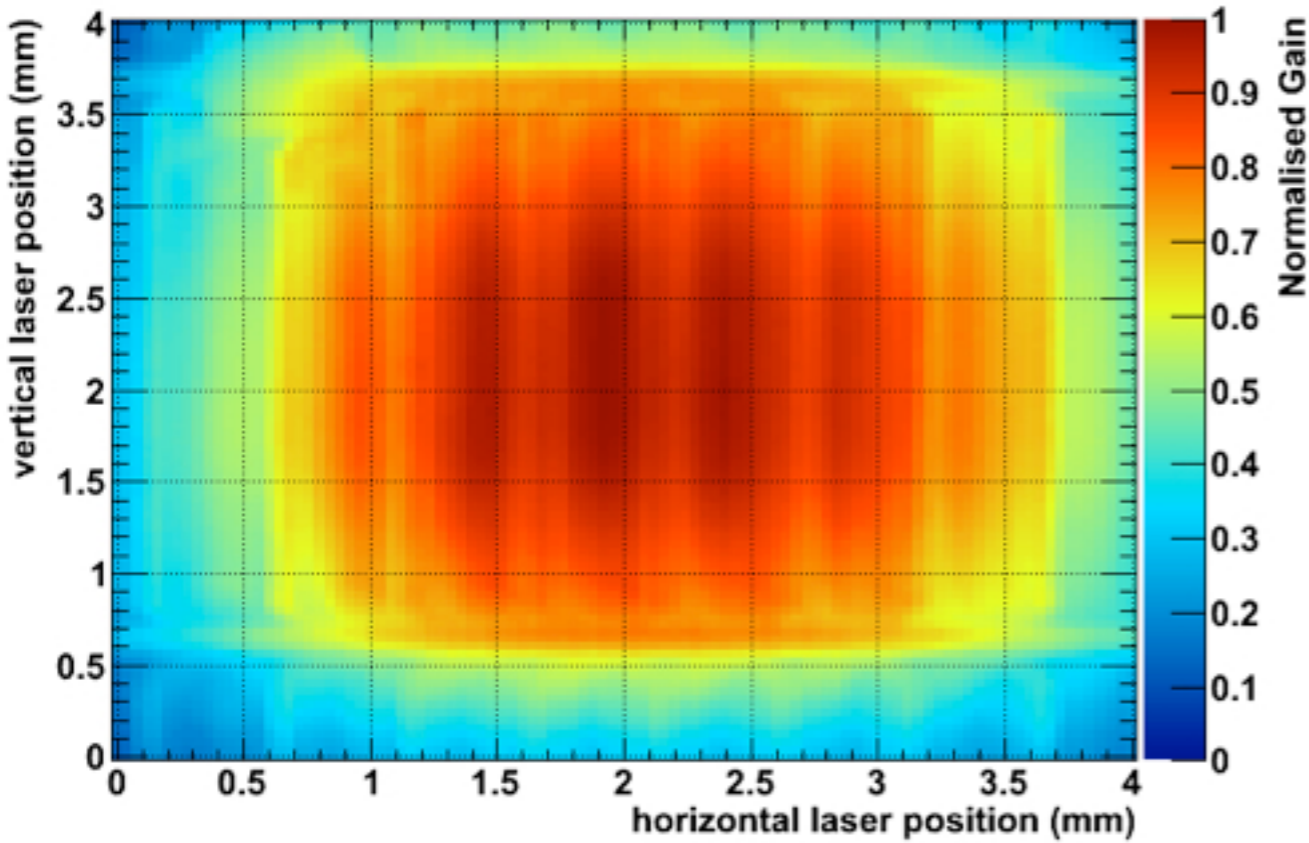


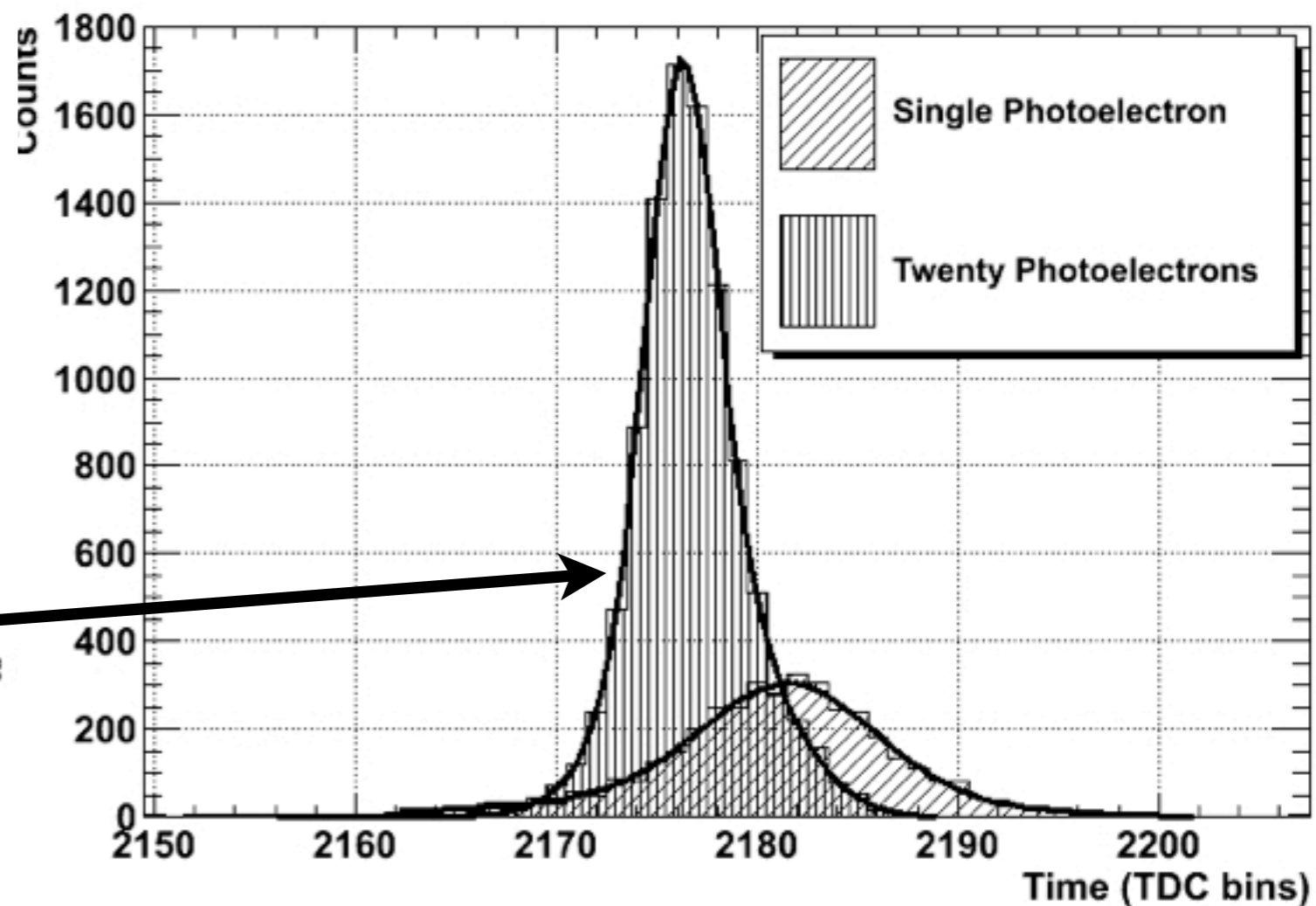
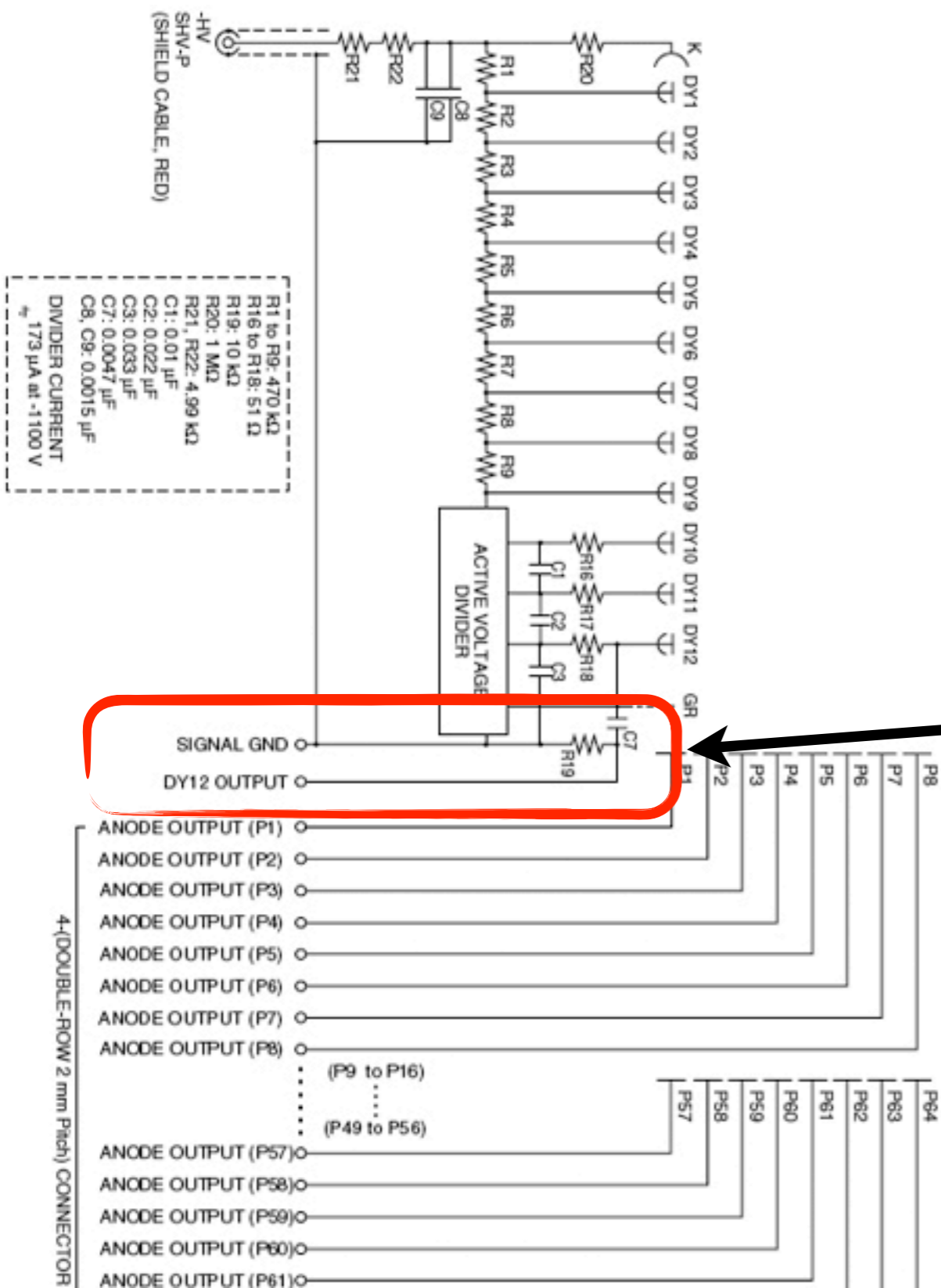
H8500 Efficiency Map - QDC Channel 10 at 0 deg



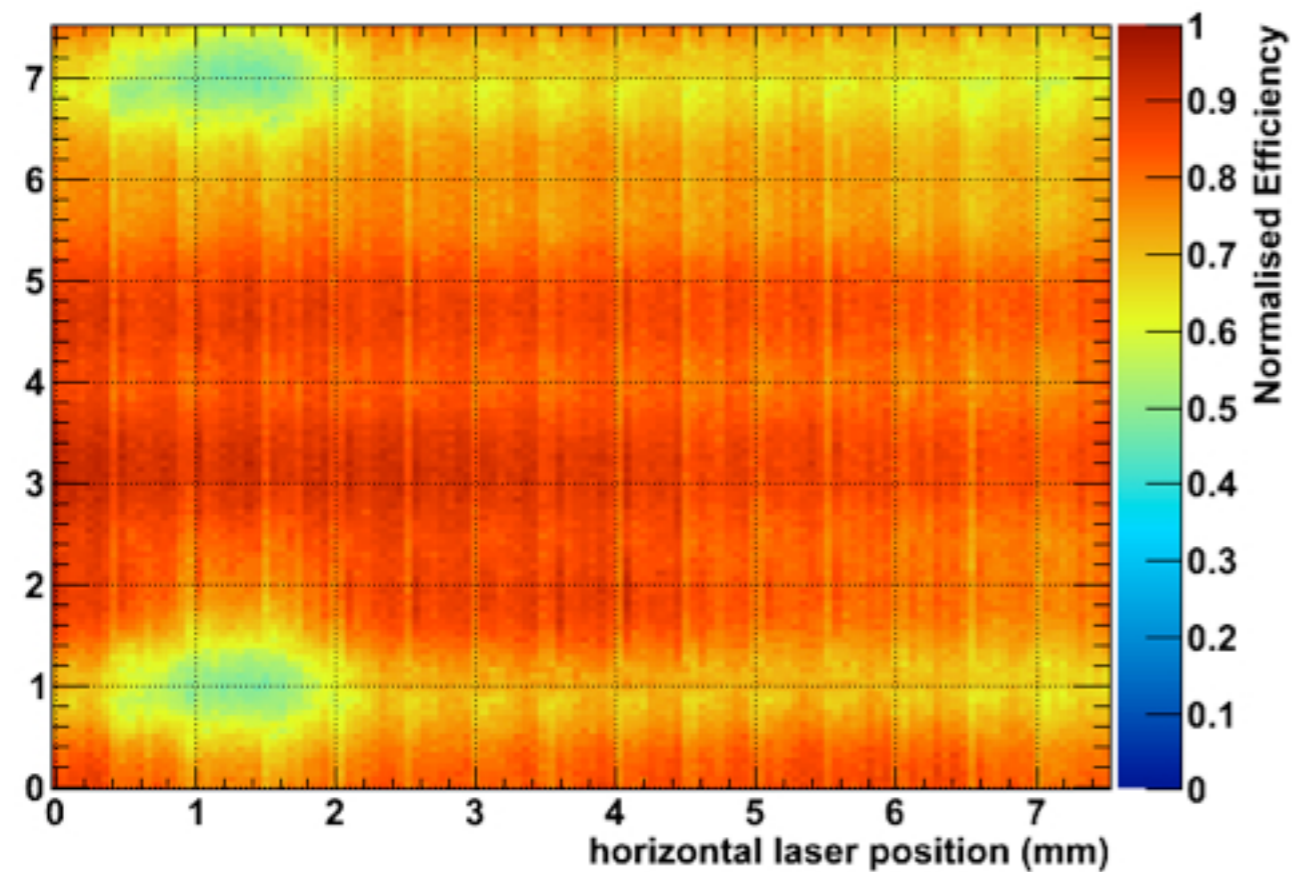
H8500 Efficiency Map - QDC Channel 10 at 20 deg



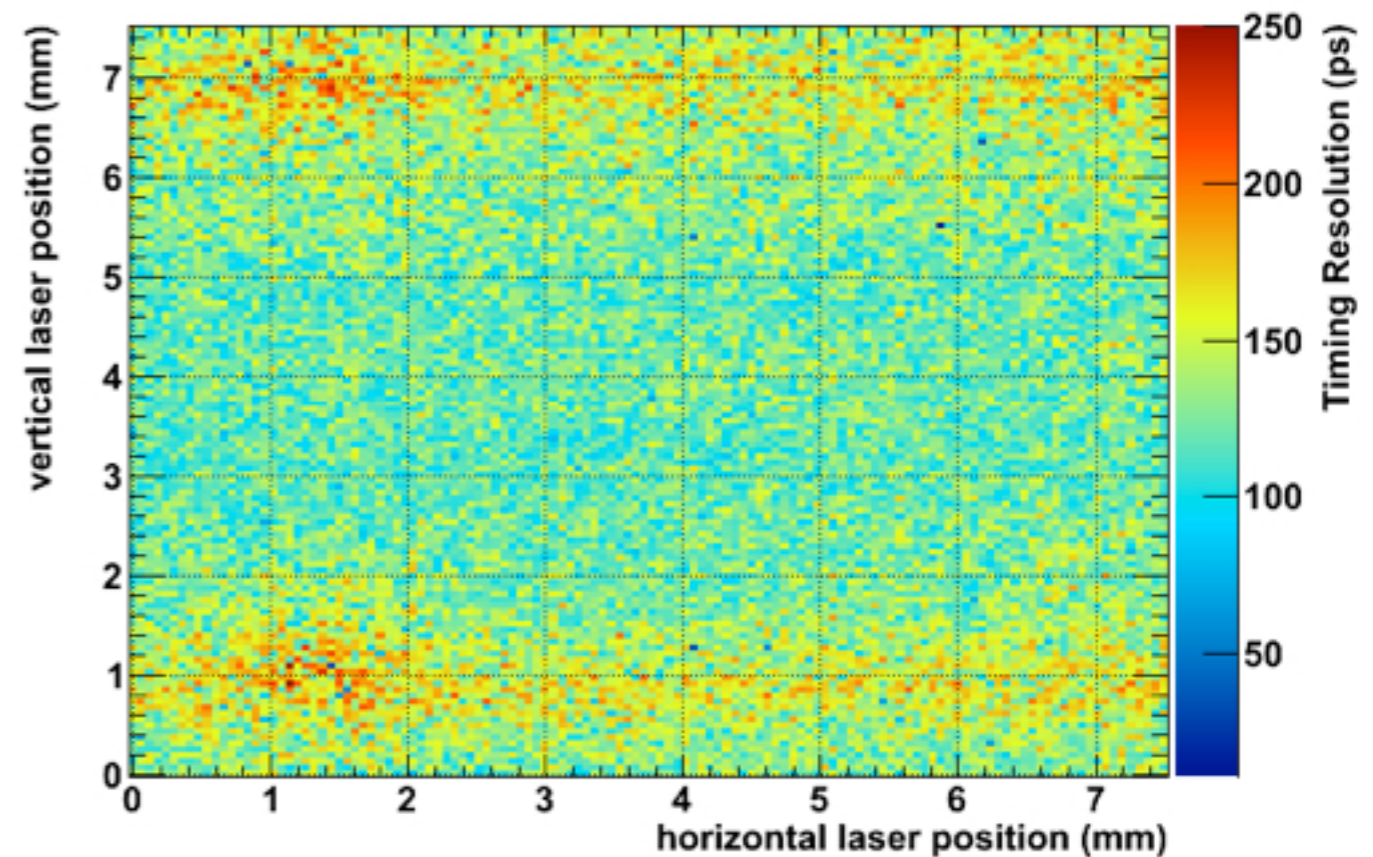




Common OR Timing



Normalised
detection
efficiency

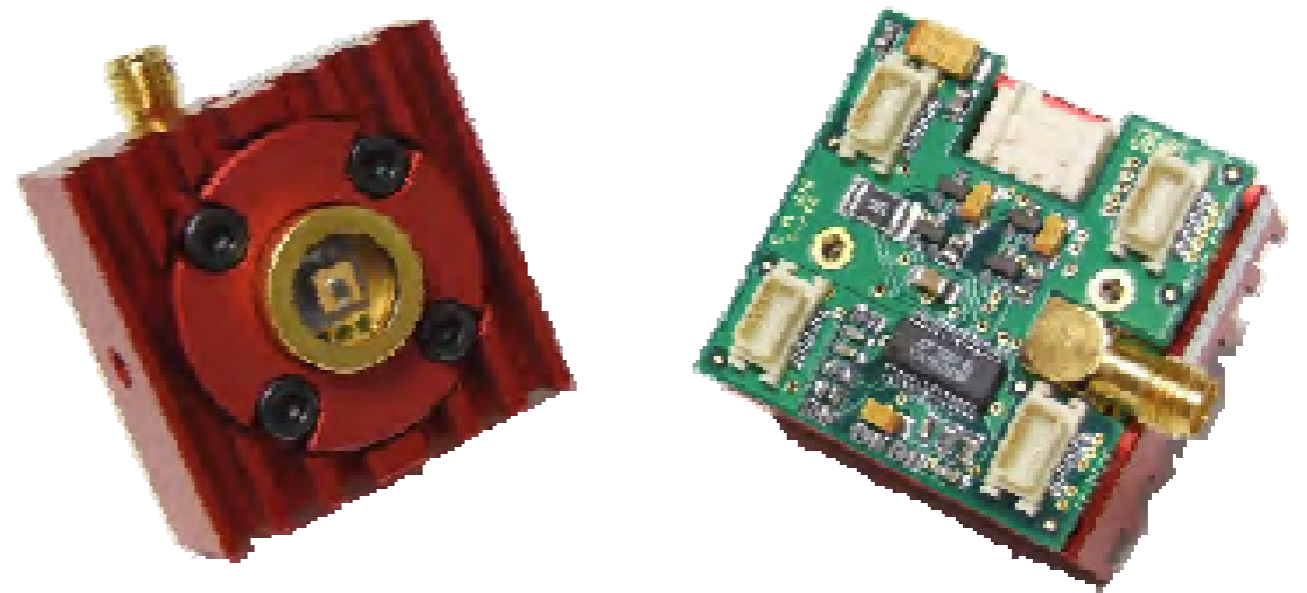


Time resolution
map H-8500

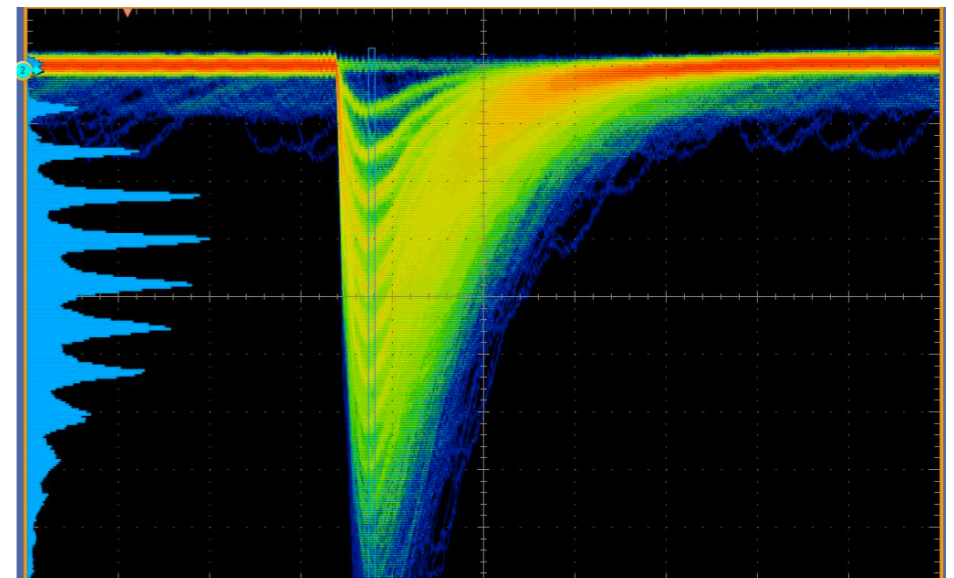
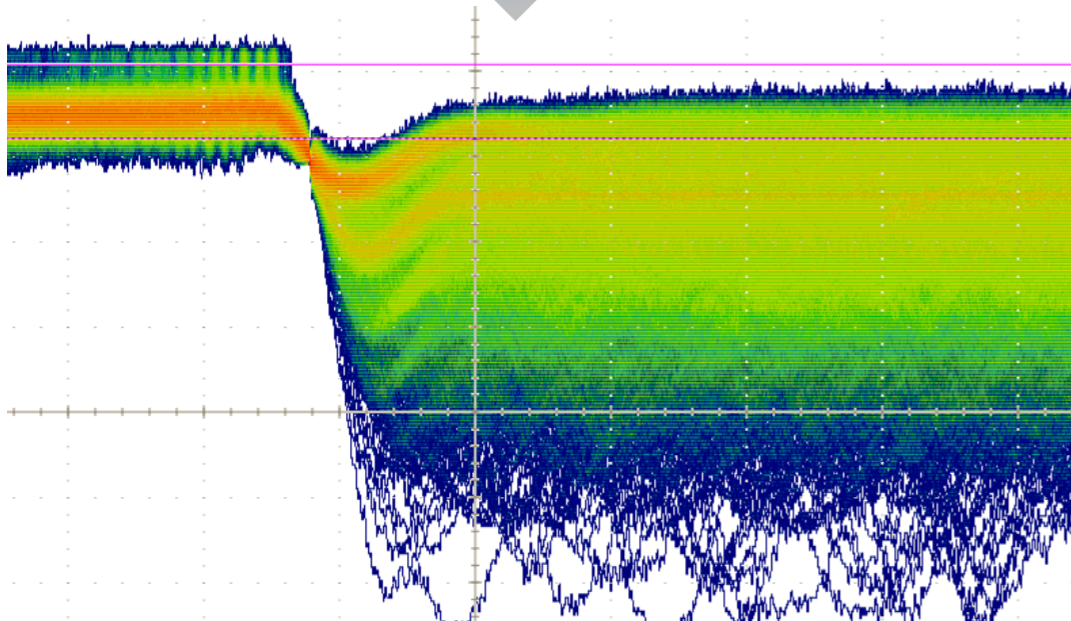
Silicon PhotoMultiplier



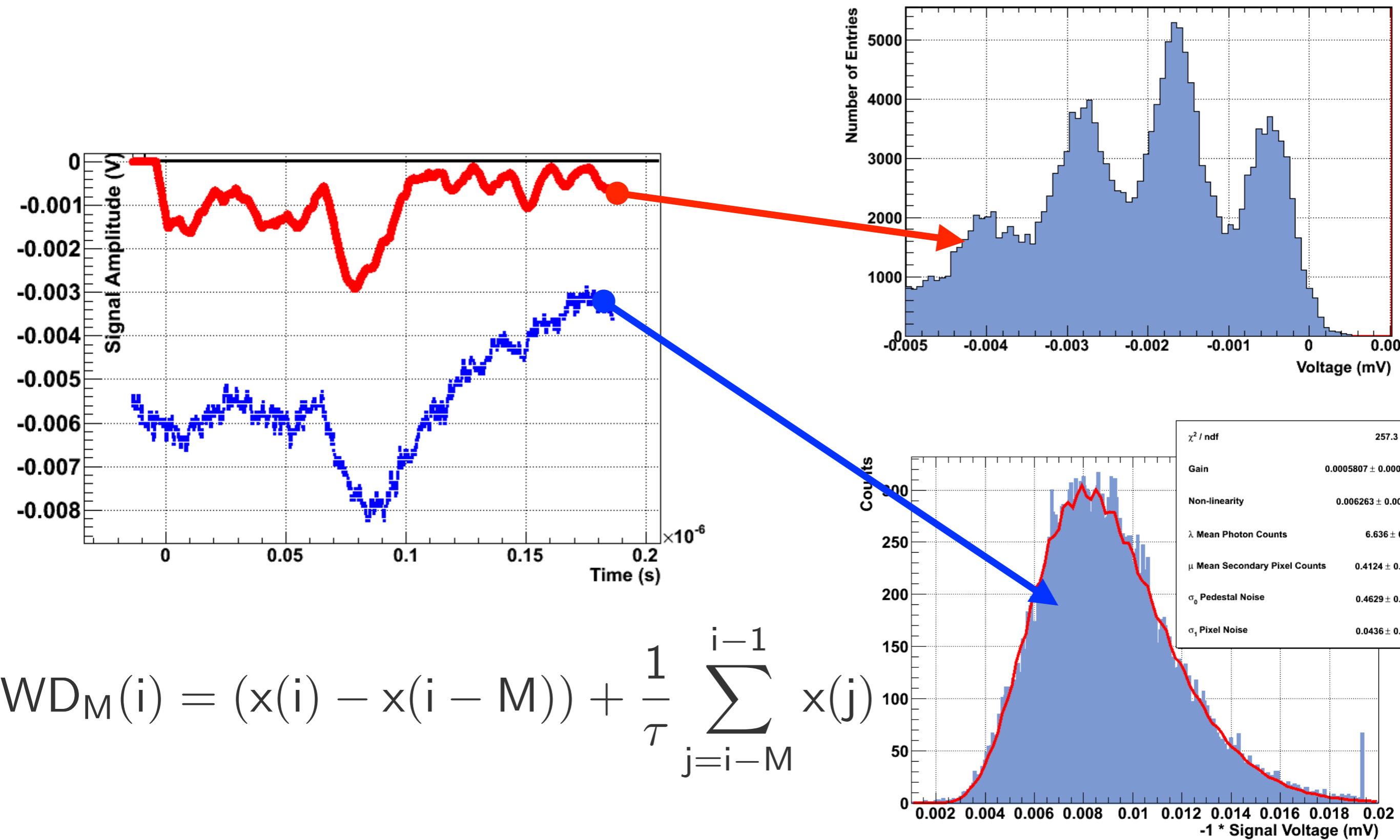
SPMArray4 (SensL)



SPMMini (SensL)

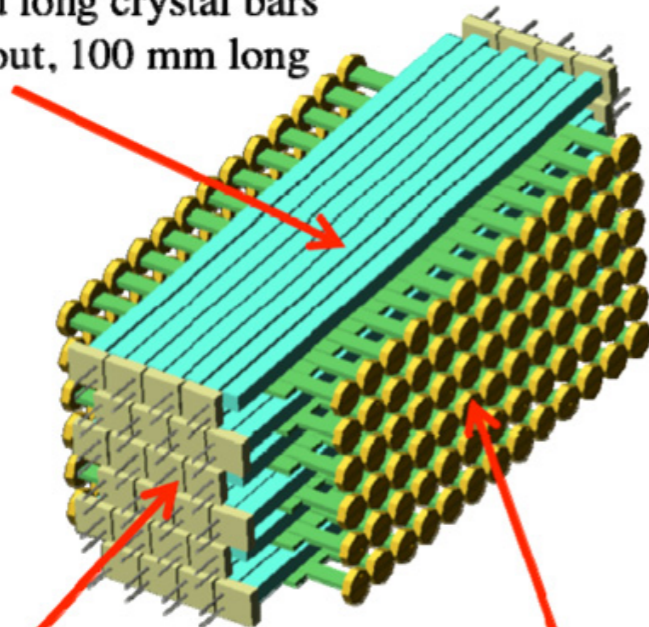


Digital Filters



AX-PET

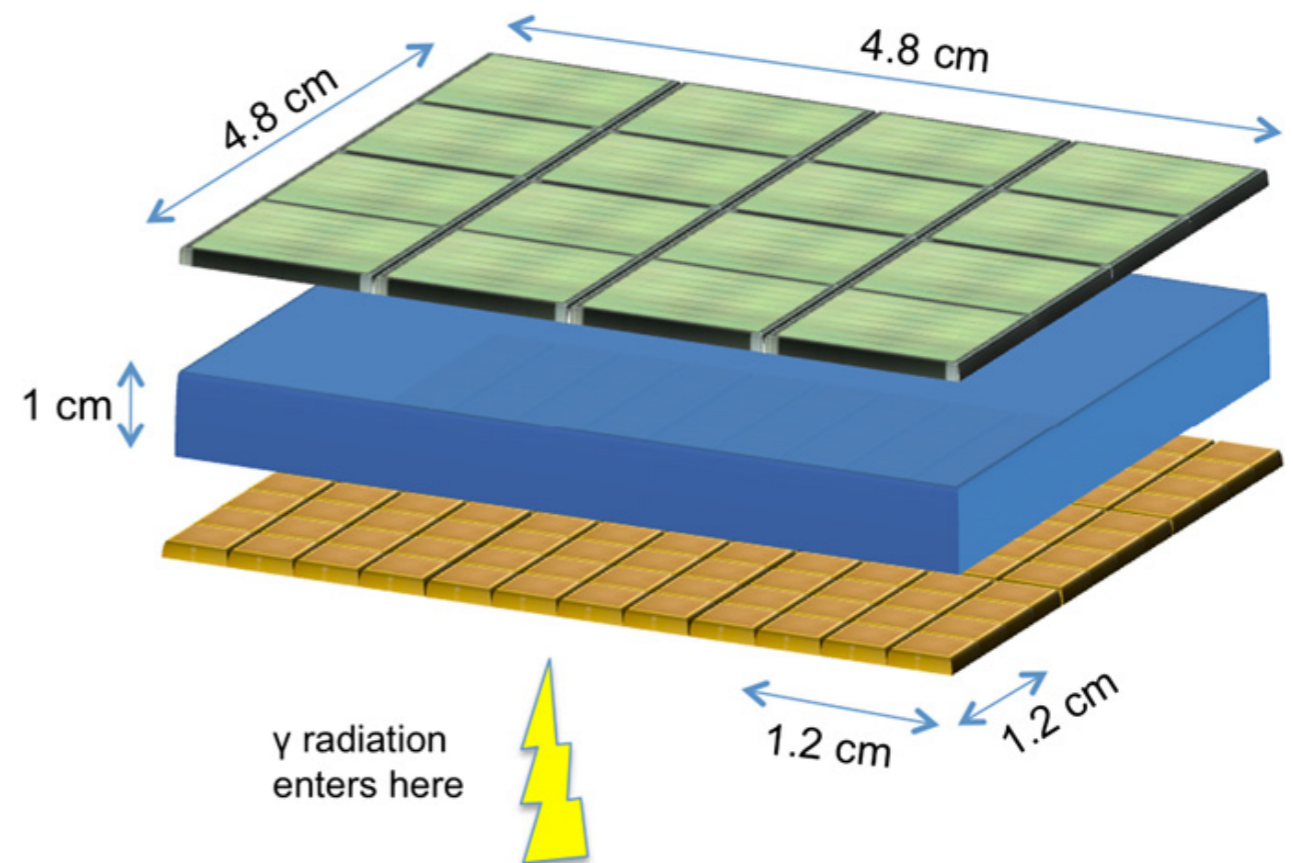
Axially arranged long crystal bars
with SiPM readout, 100 mm long



3 mm x 3 mm SiPM

Interleaved WLS strip matrix
with SiPM readout

4D PET



S. Marcatelli et al. Nucl. Instr. Meth., *in press*

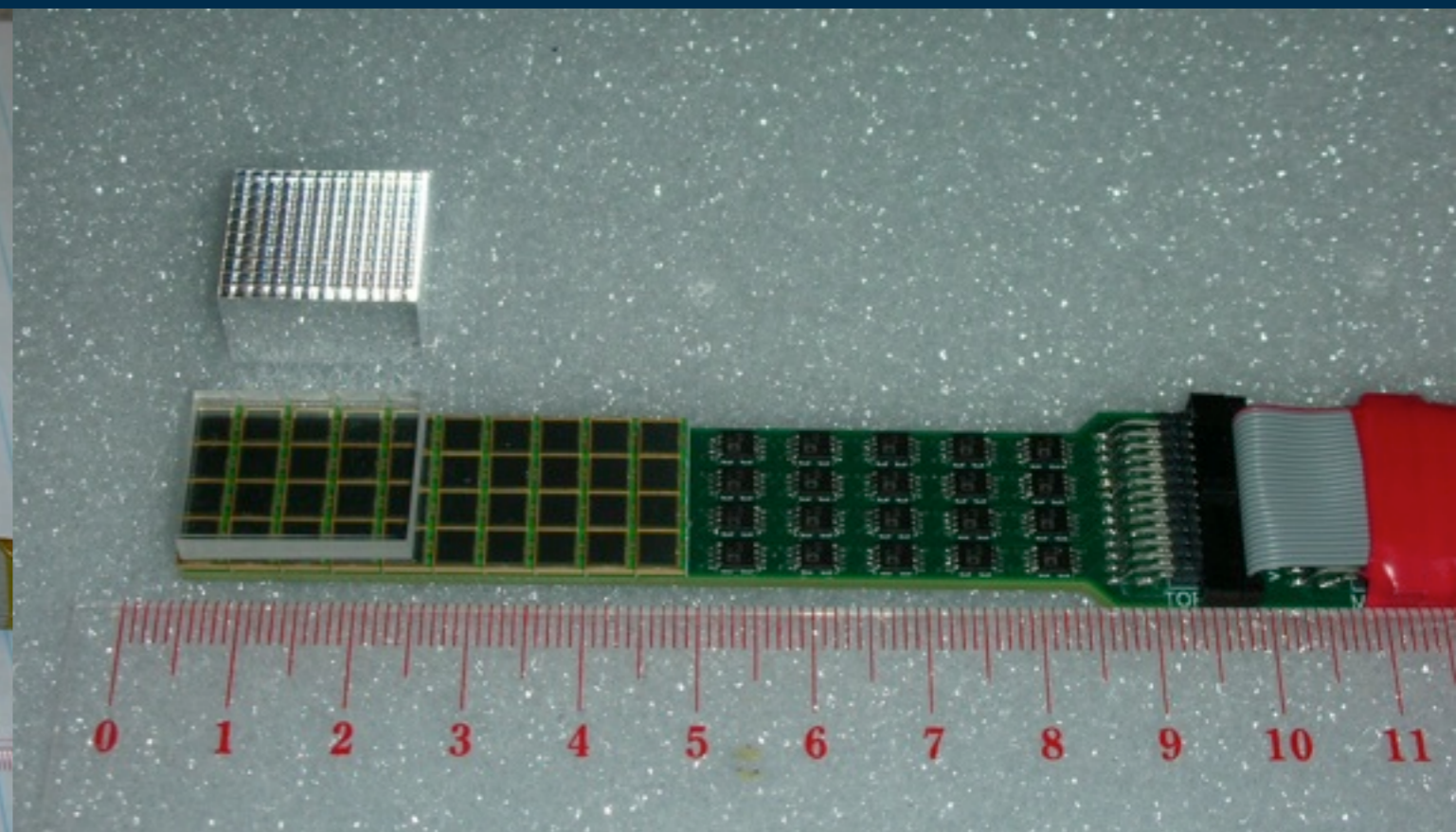
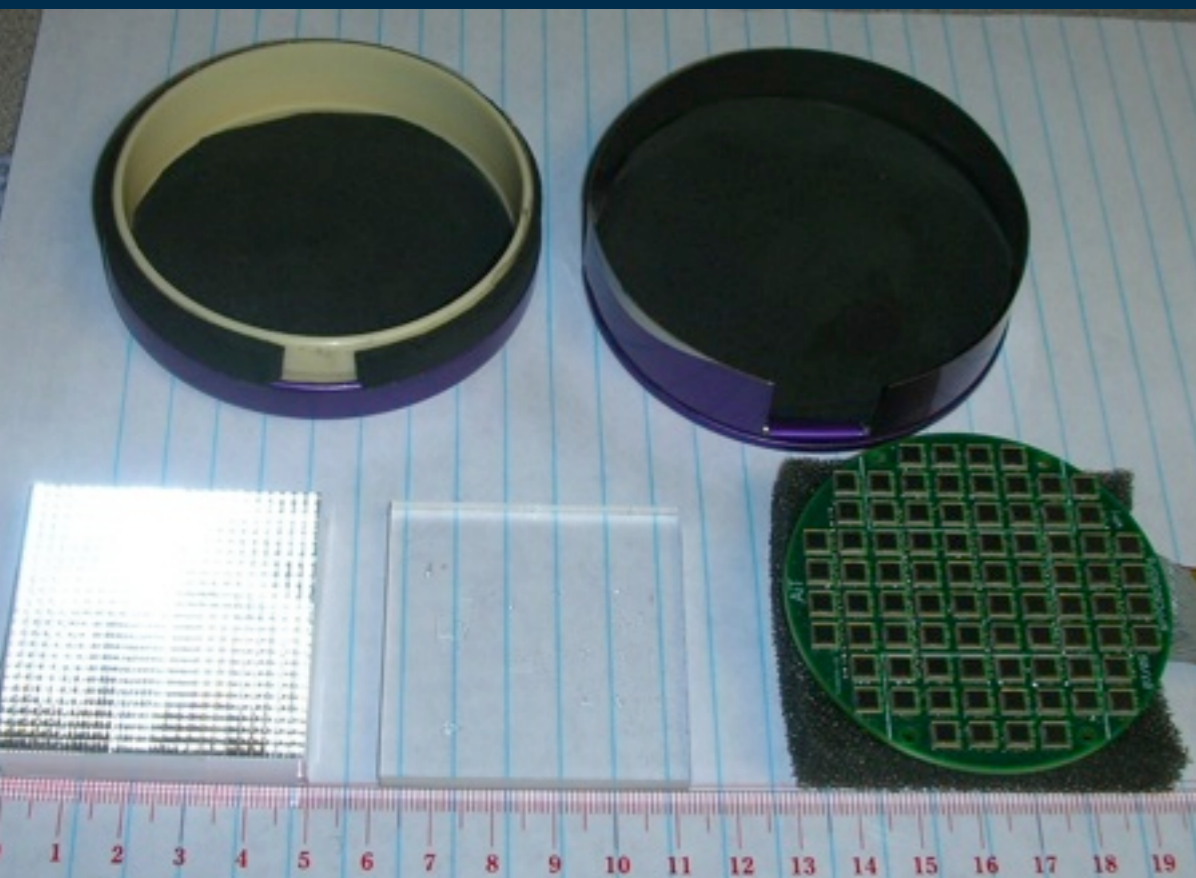
A. Braem et al., Nucl. Instr. Meth. A 610 (2009) 192

P. Beltrame et al., Nucl. Instr. Meth. A 636 (2011) S226

A Possible Application - handheld PET probe



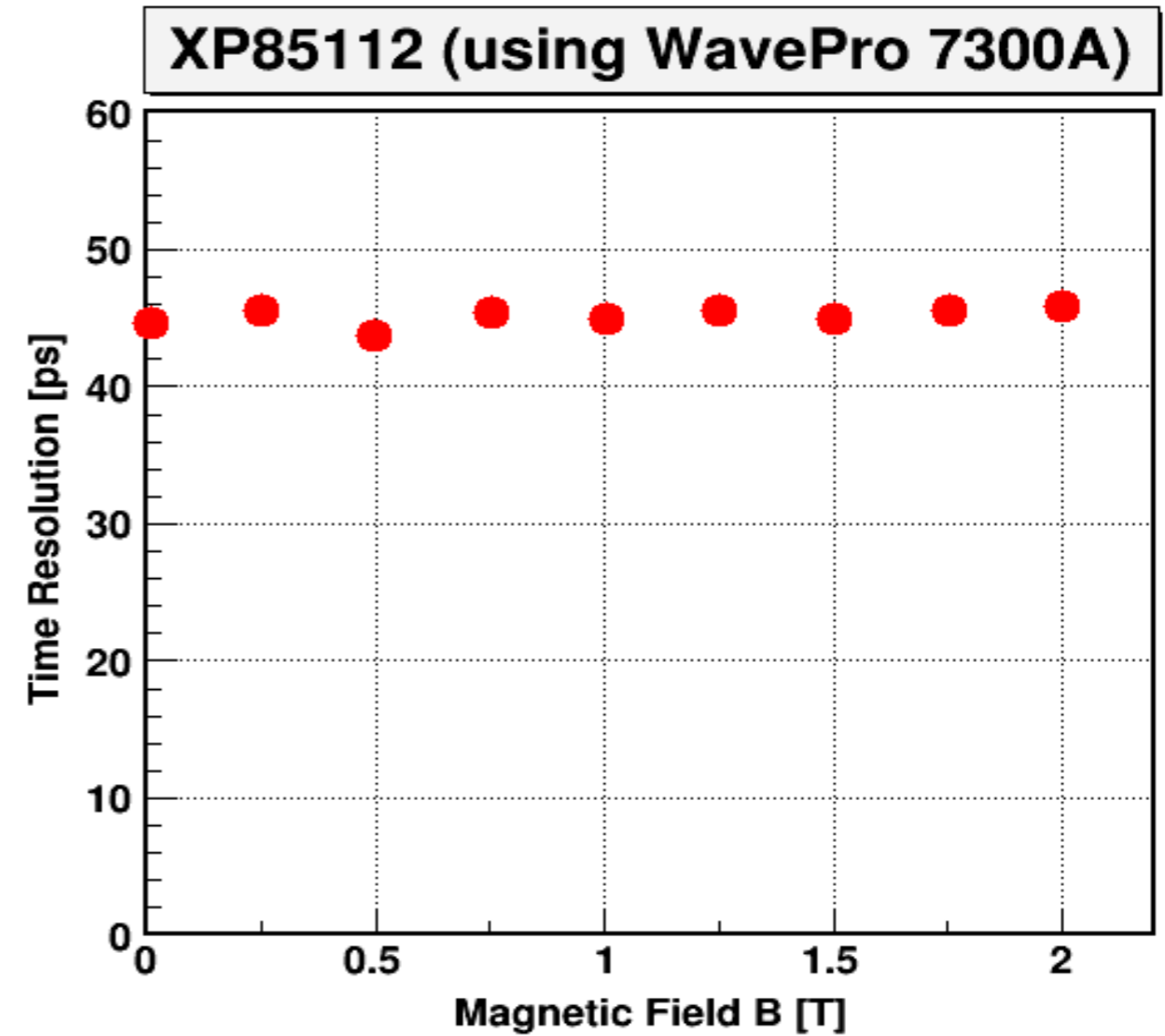
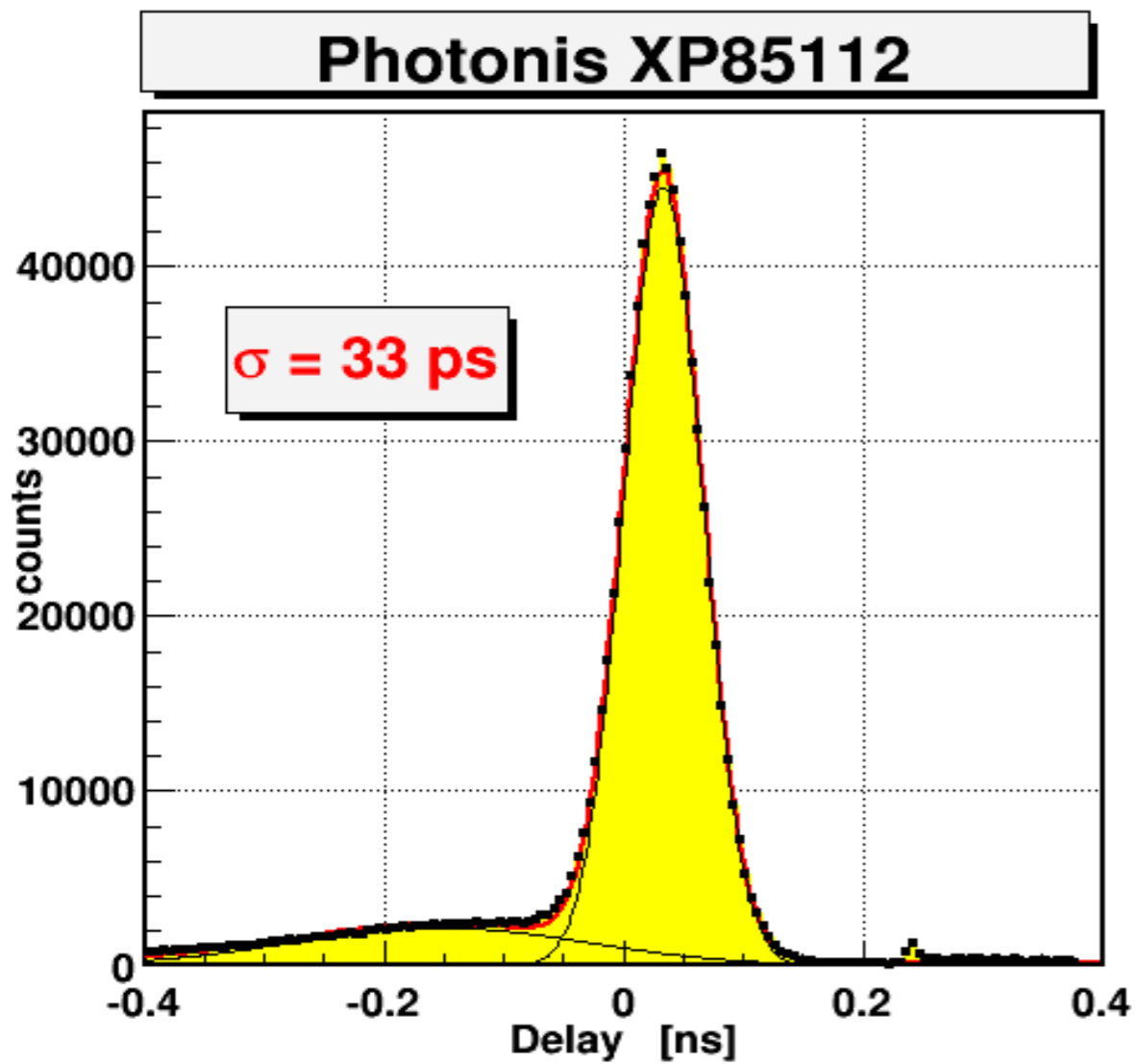
A Possible Application - handheld PET probe

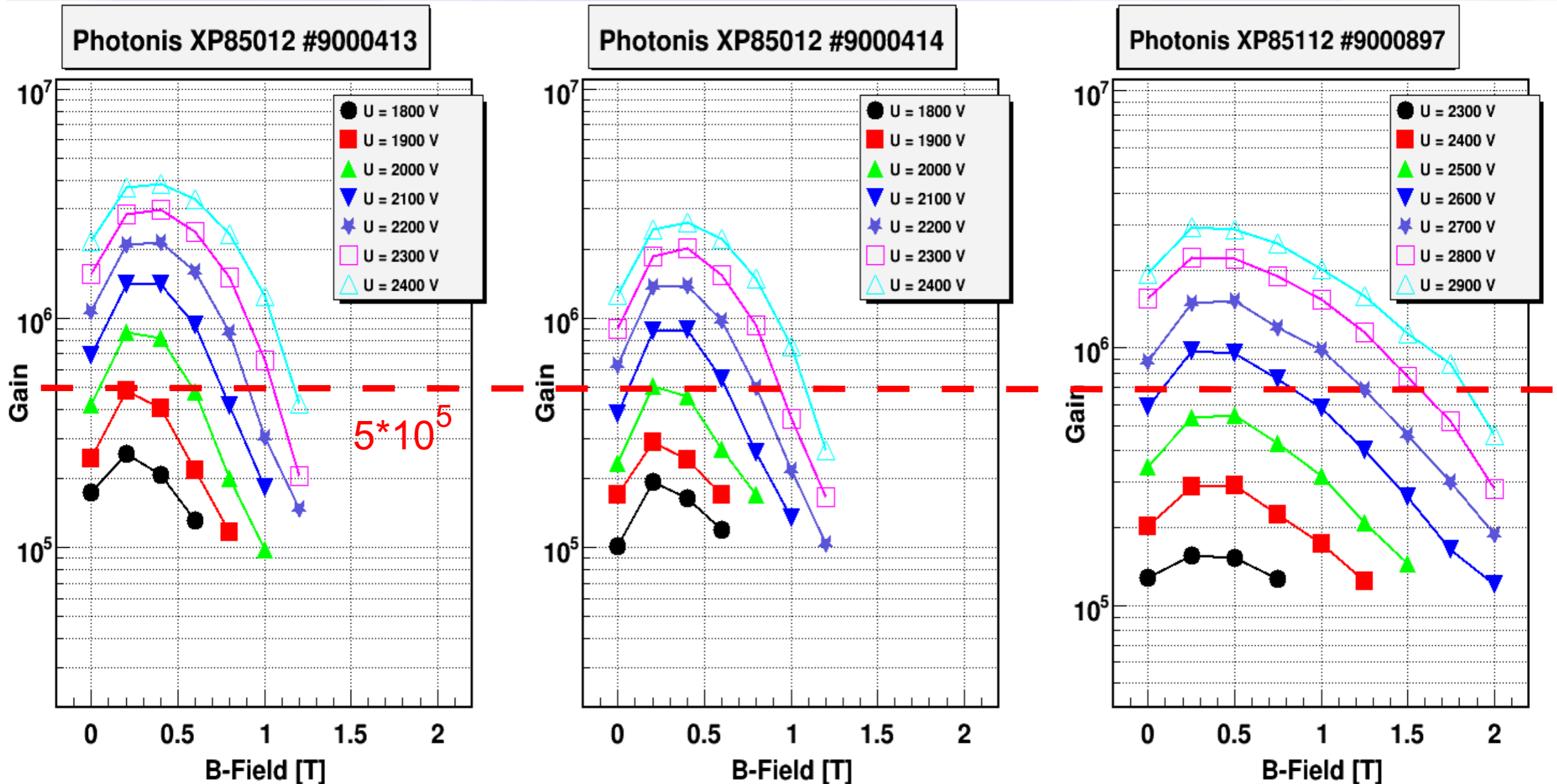


64 MPPC coupled
to LYSO crystals

4x10 MPPC with
LYSO and electronic

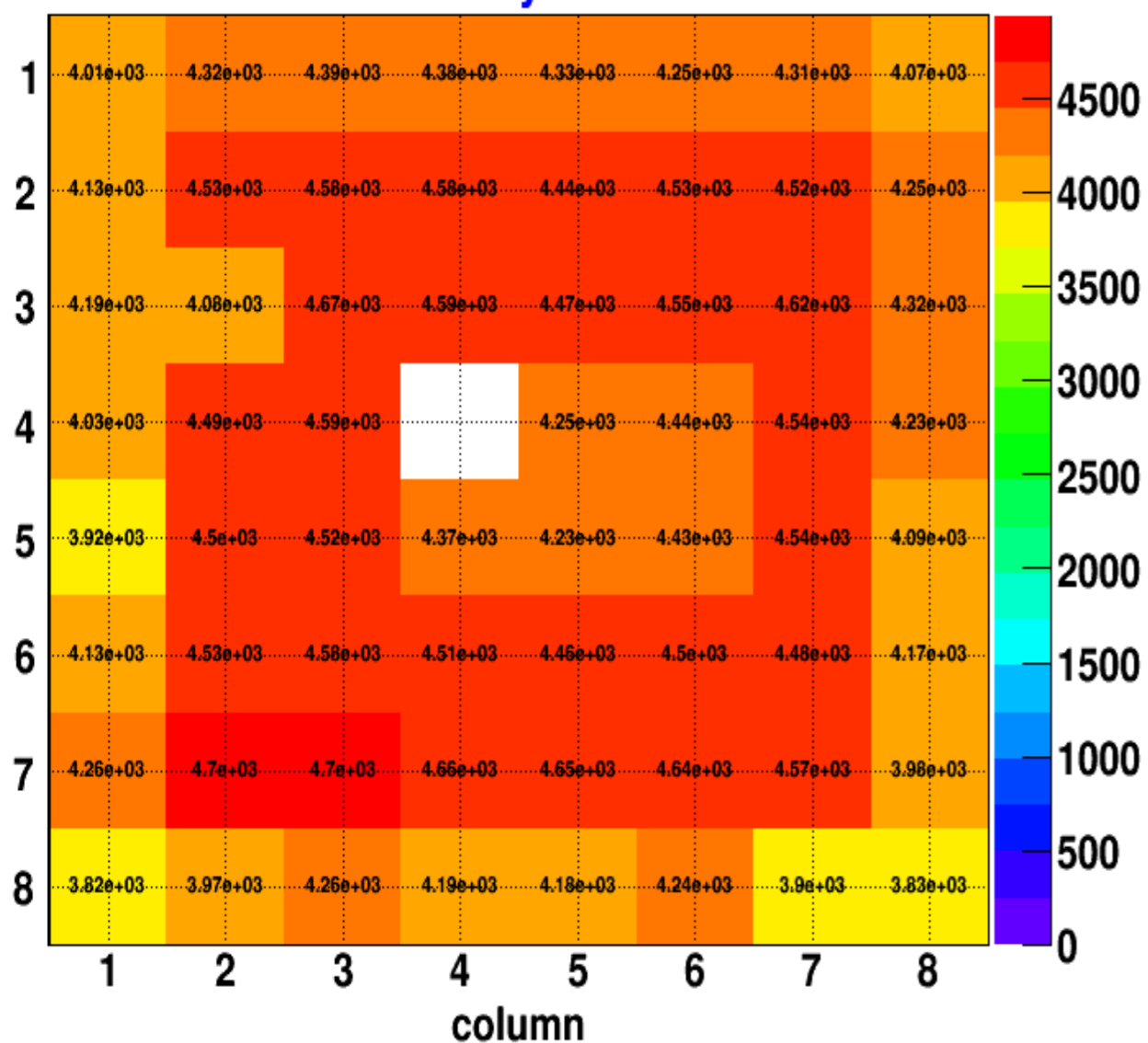
- **useful for biopsy guidance**
- **surgical imaging for radio-guided surgery procedures**





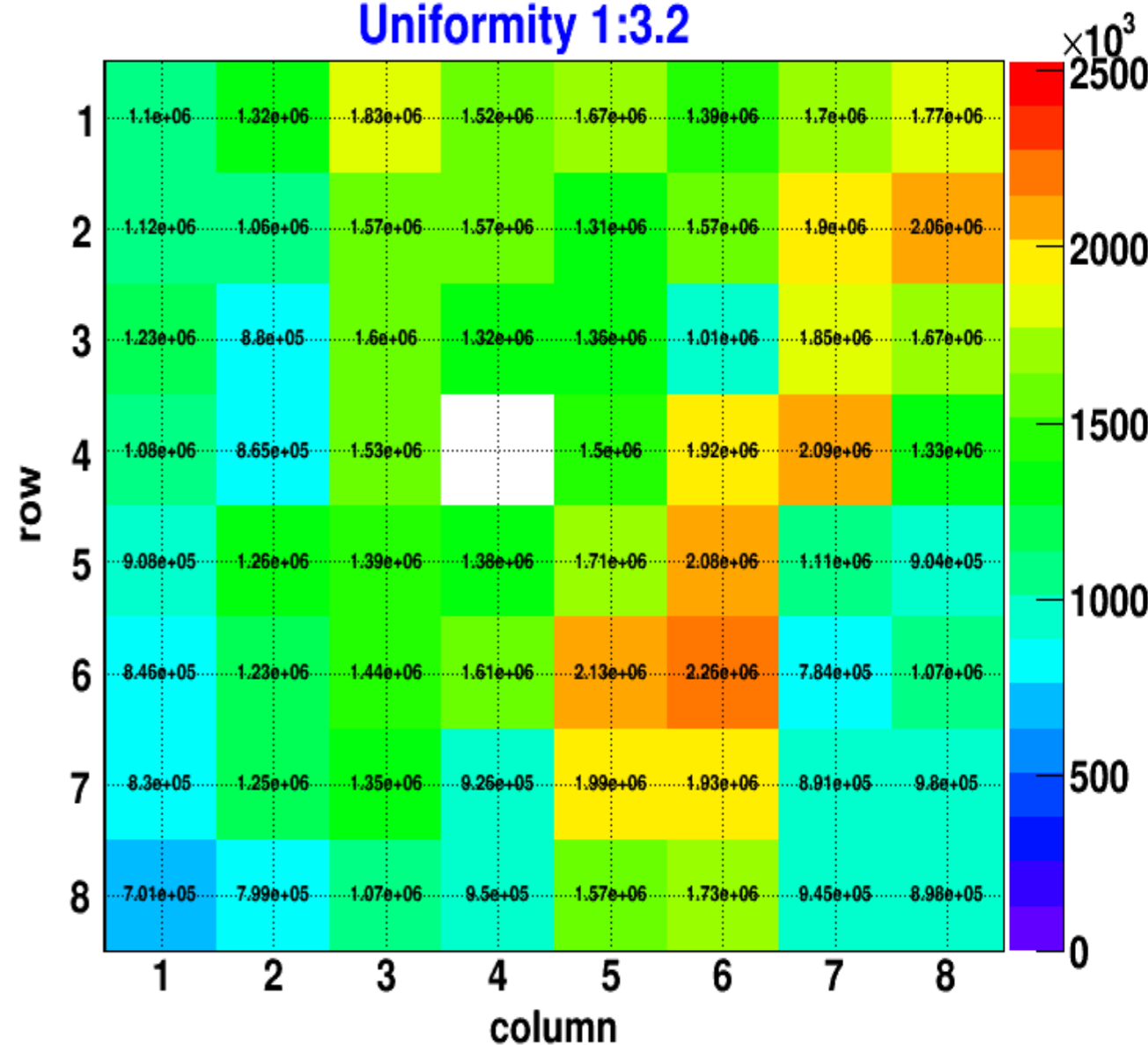
Photonis XP85112 #9000897 MCP Count Rates

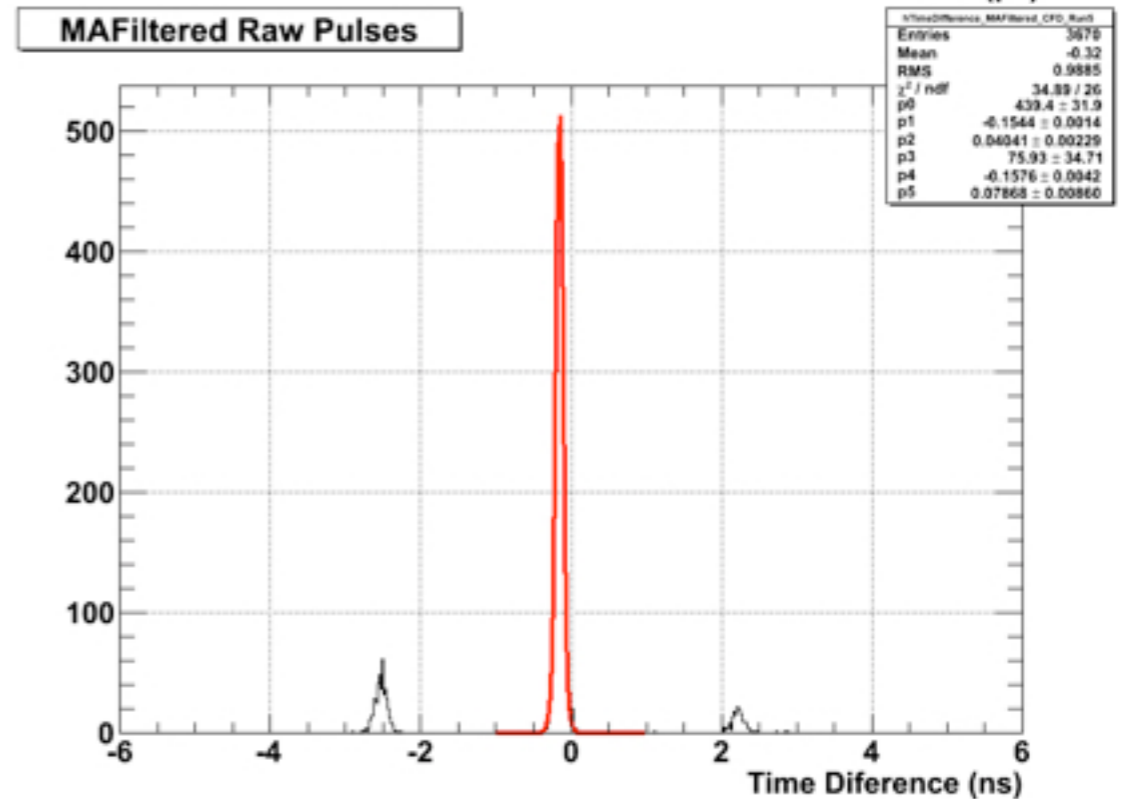
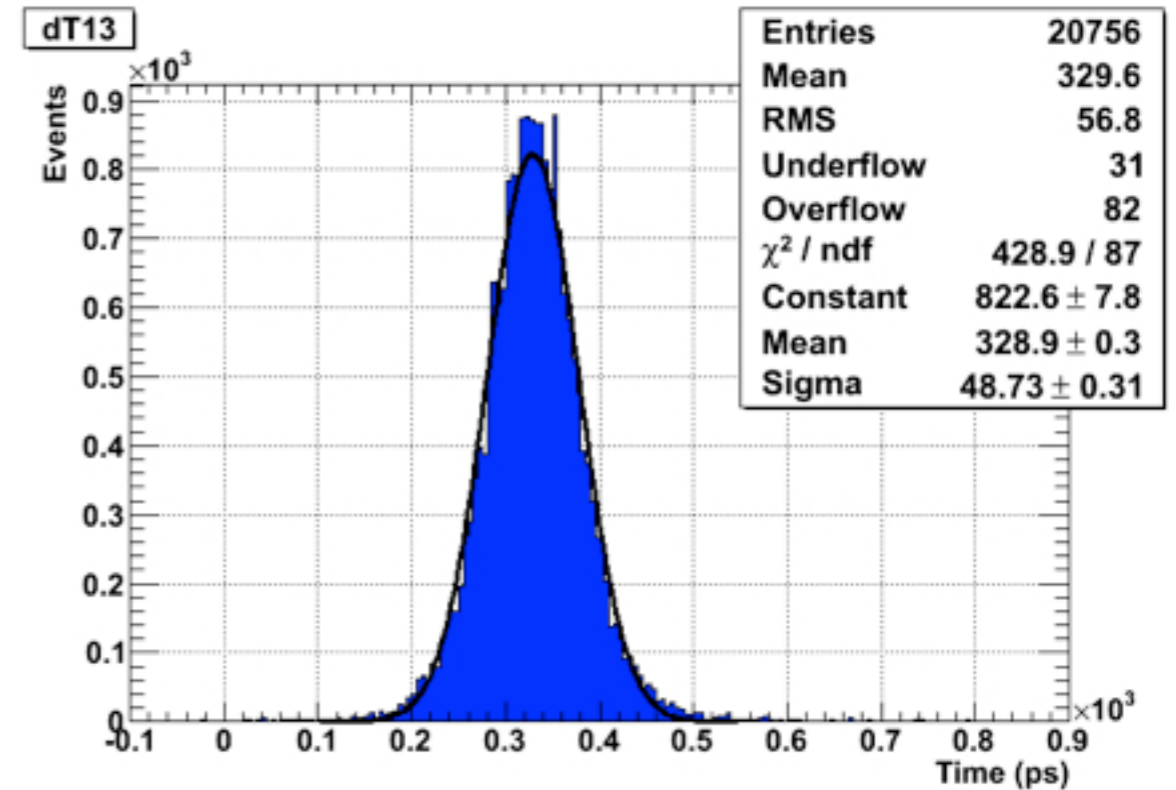
Uniformity 1:1.2



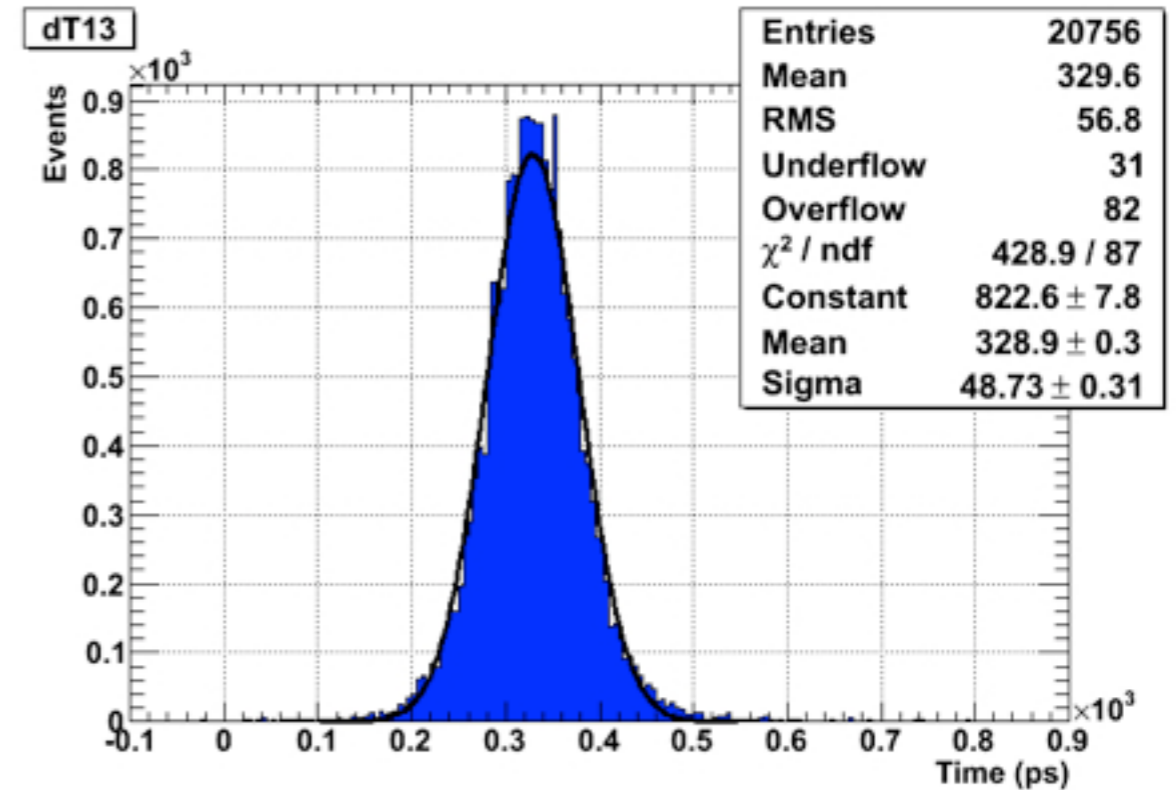
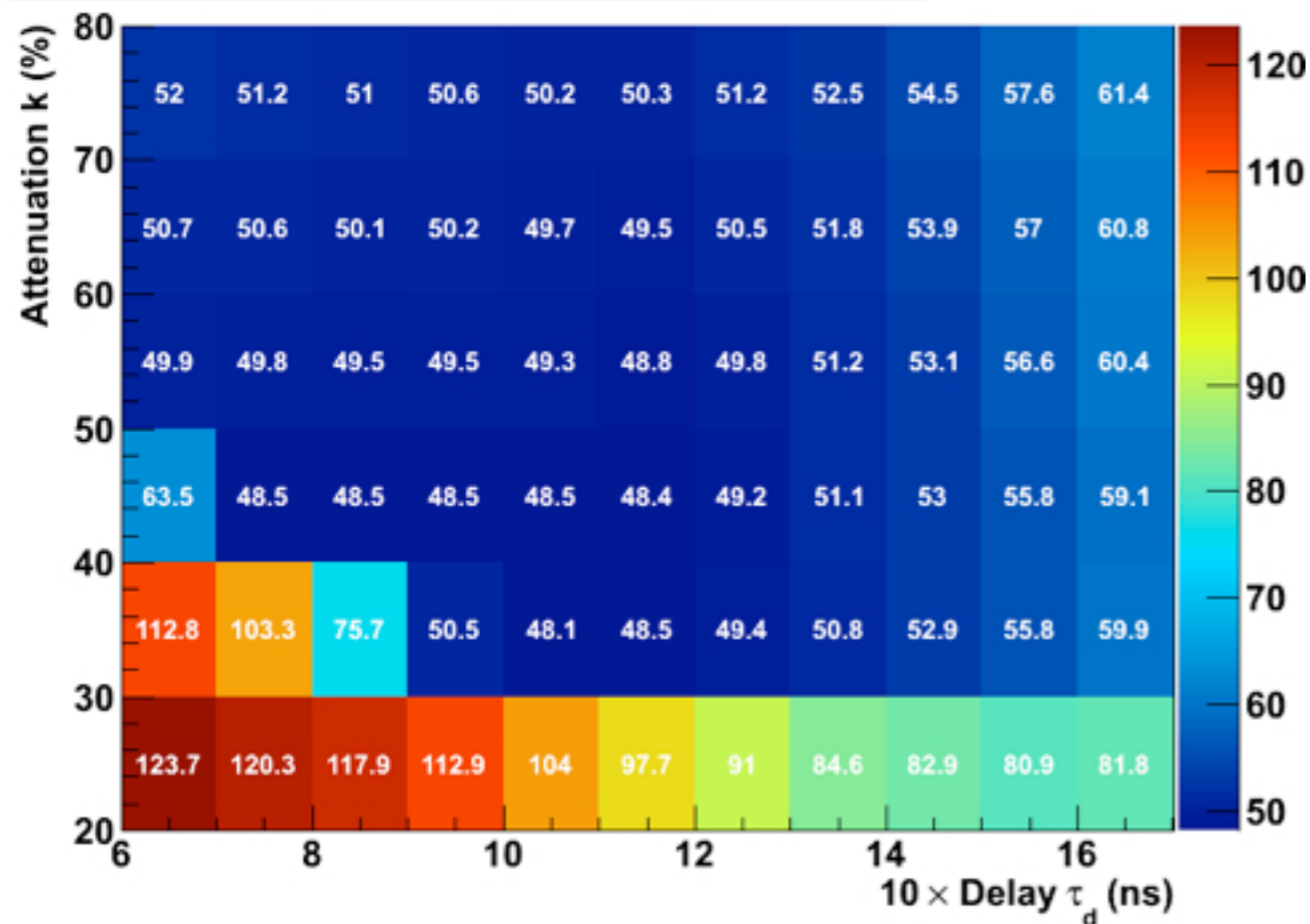
Photonis XP85112 #9000897 MCP Gain

Uniformity 1:3.2

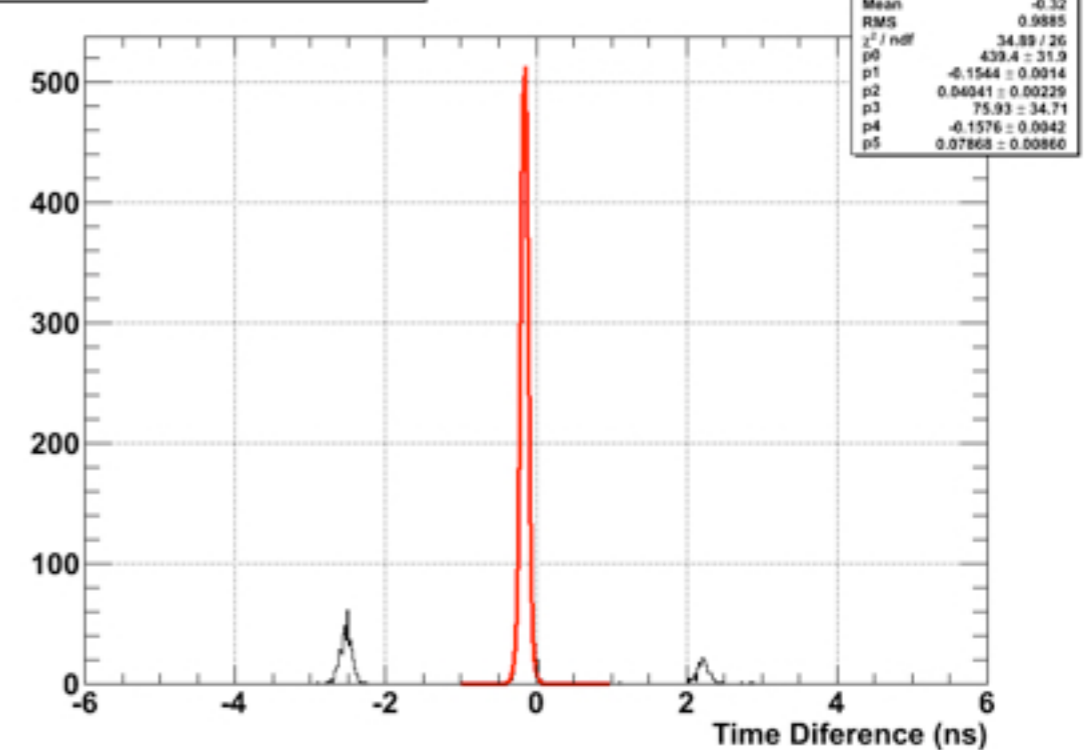


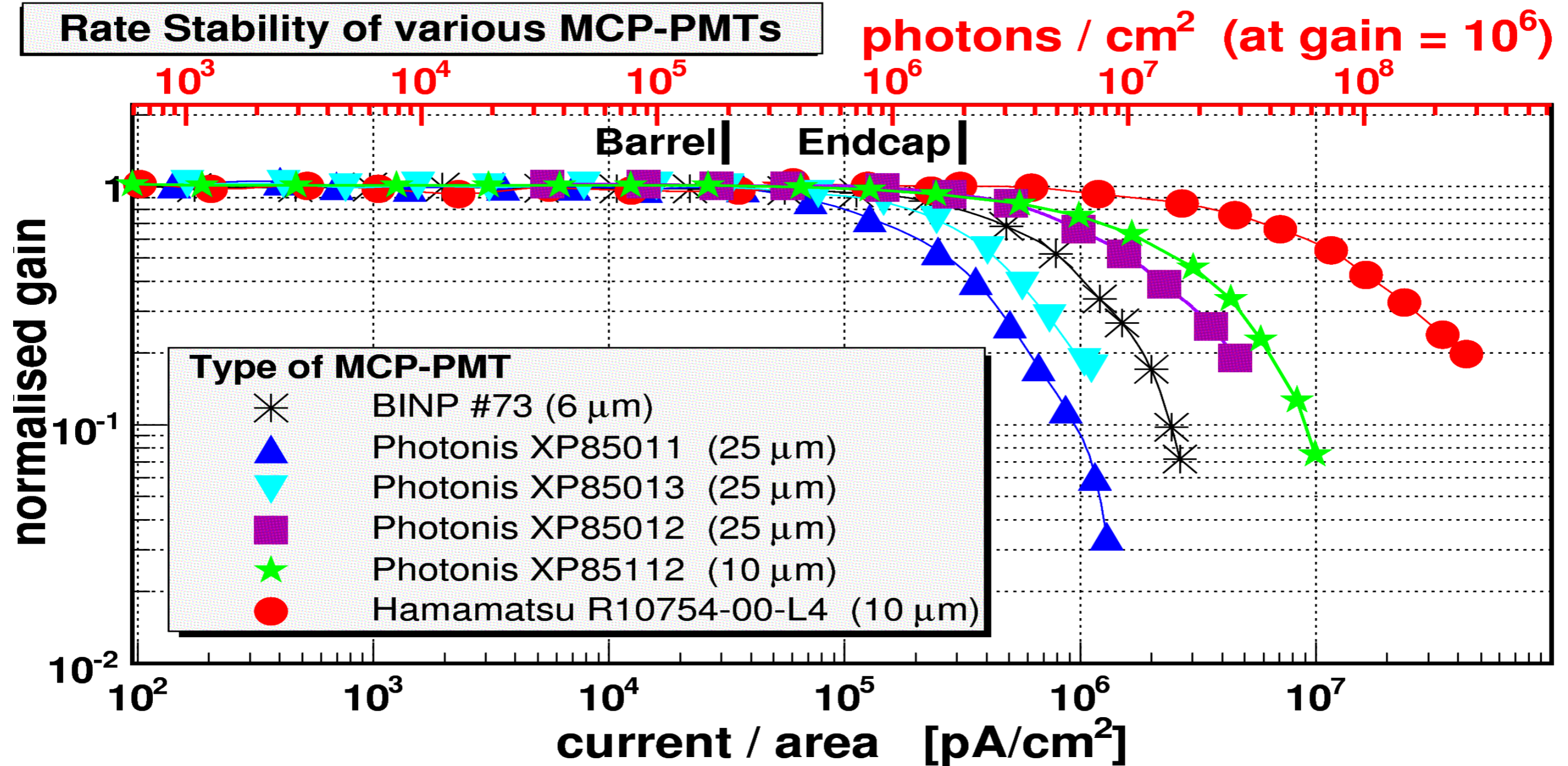


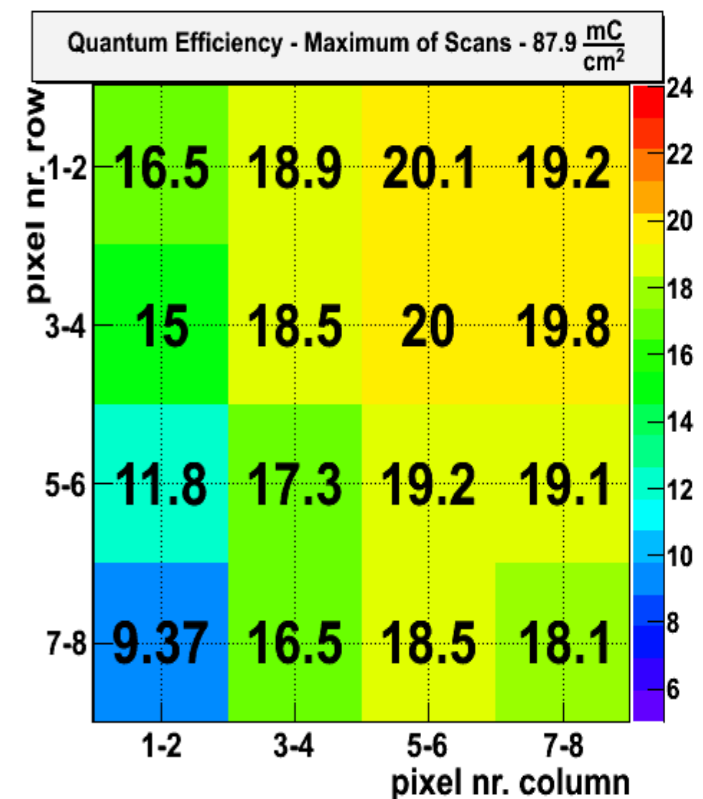
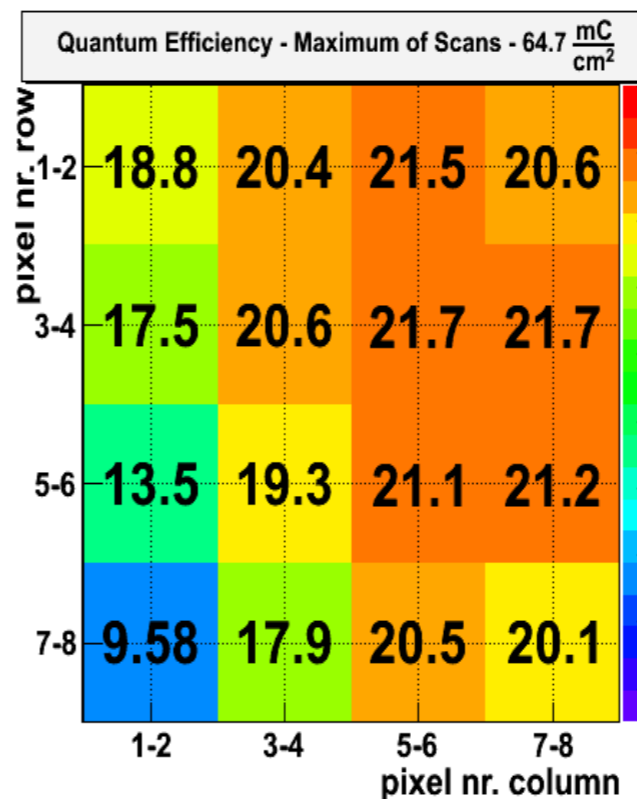
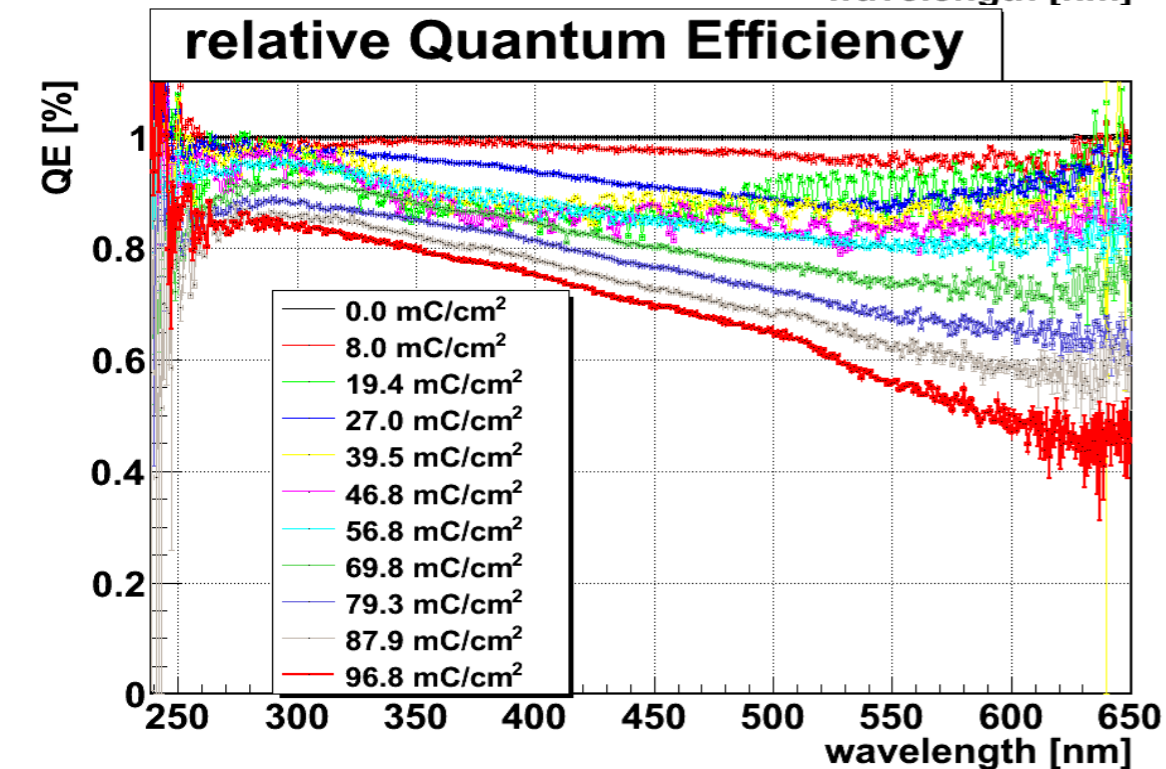
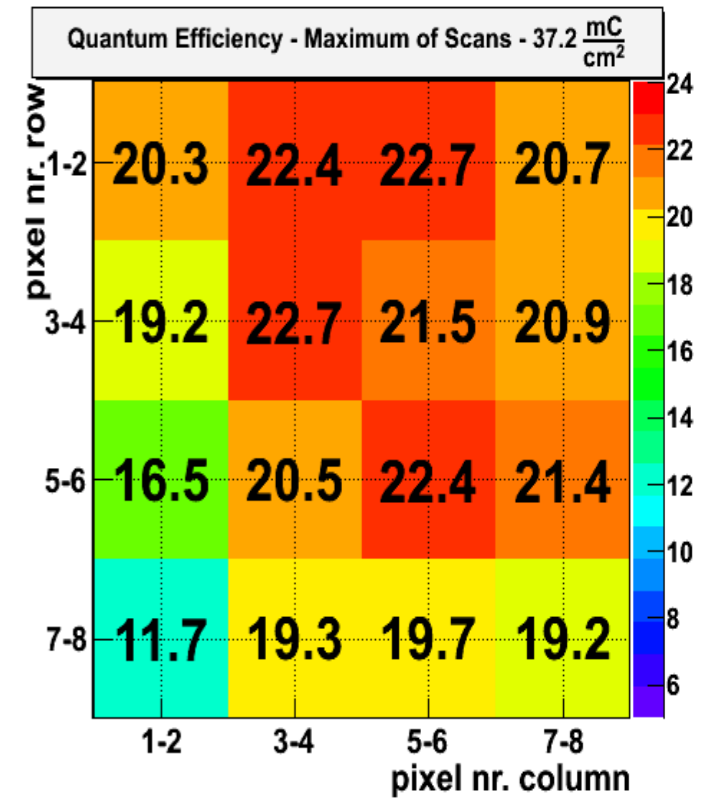
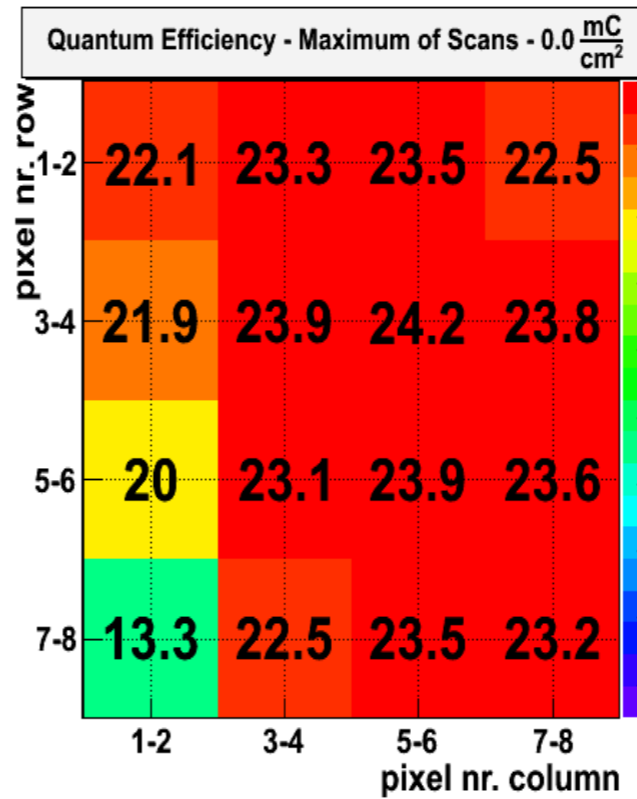
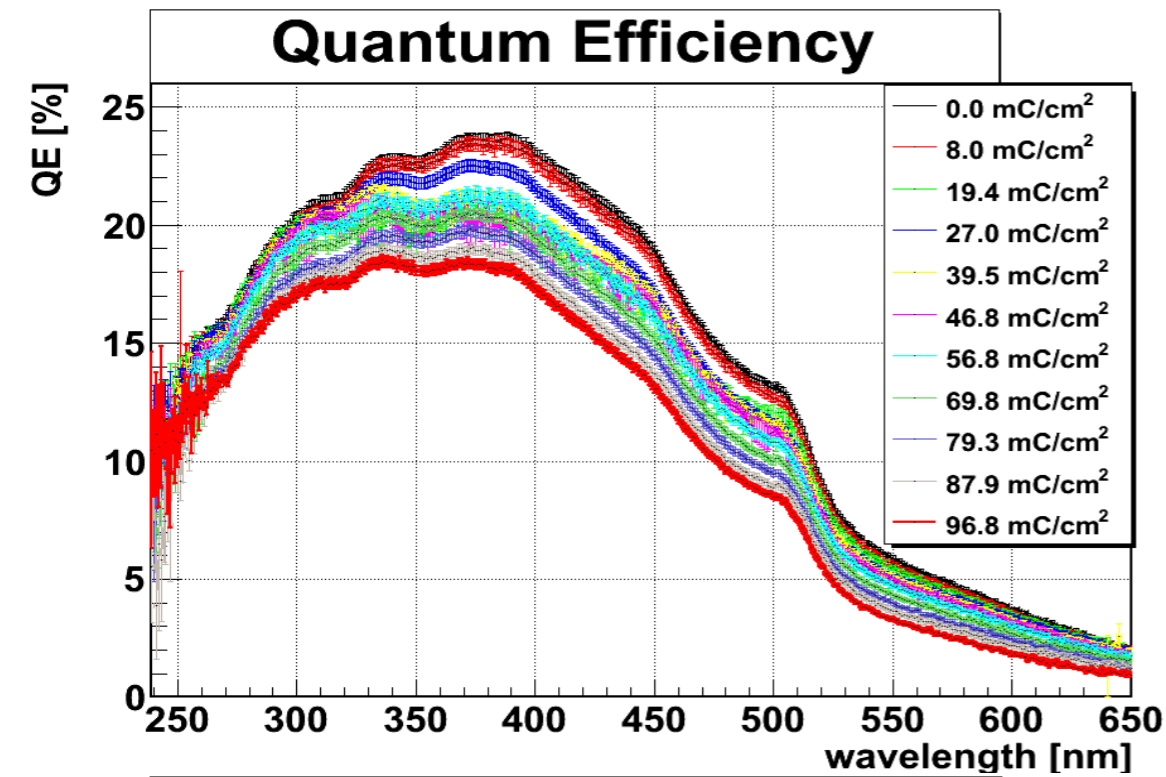
Software CFD Time Resolution Dependency Upon τ_d and k

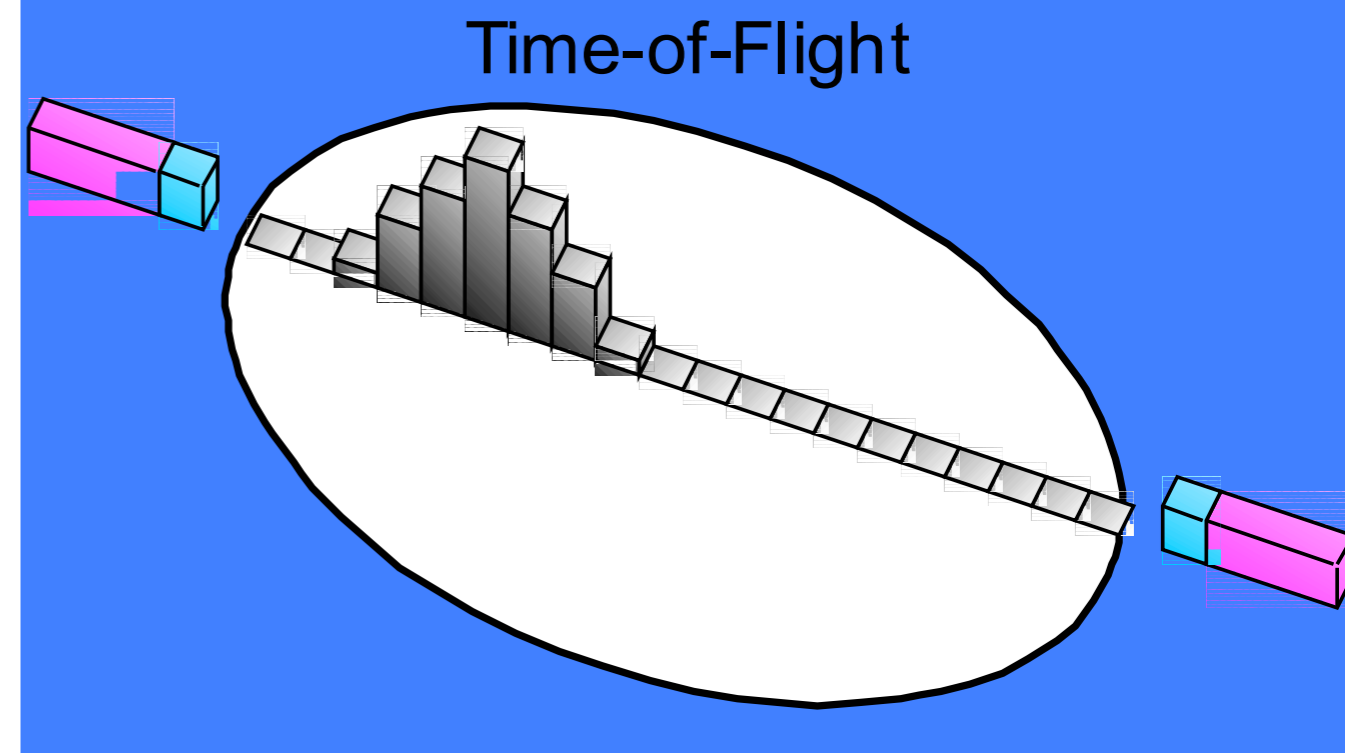
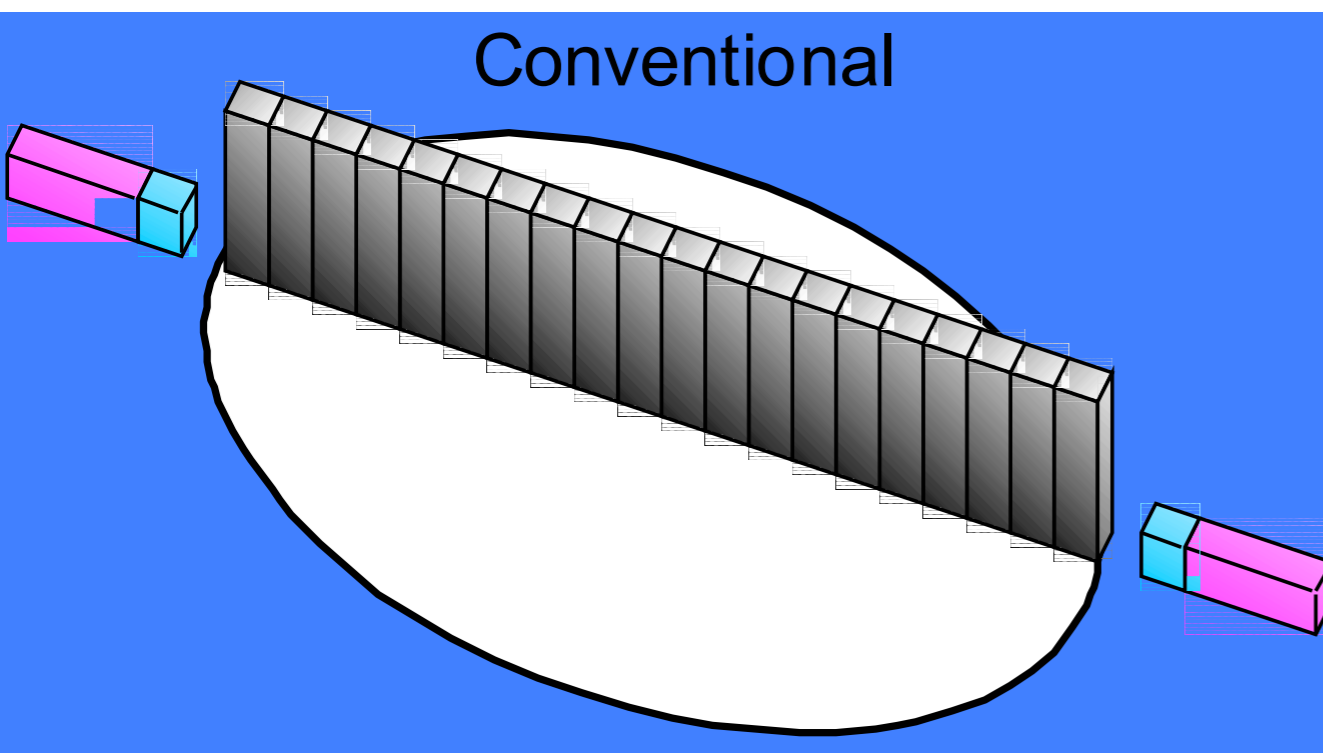


MAFiltered Raw Pulses



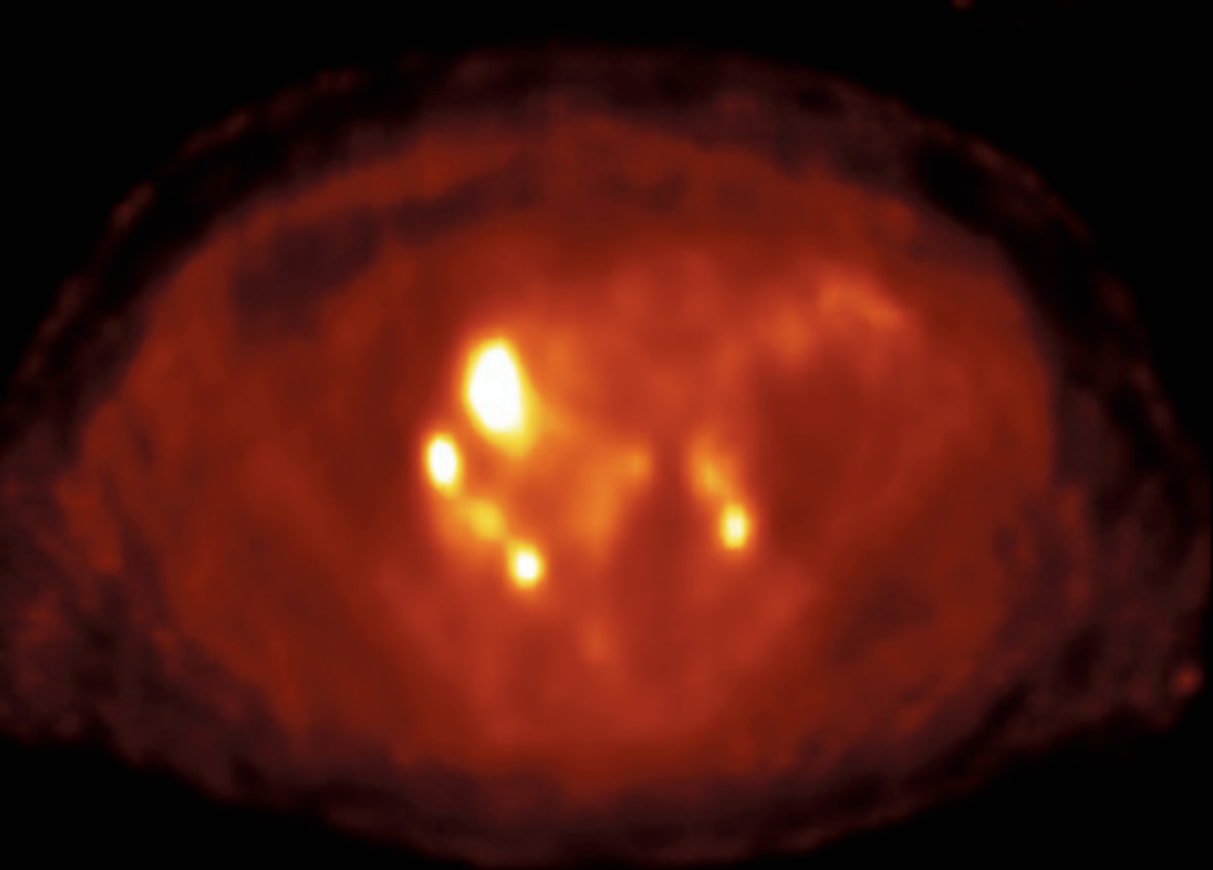




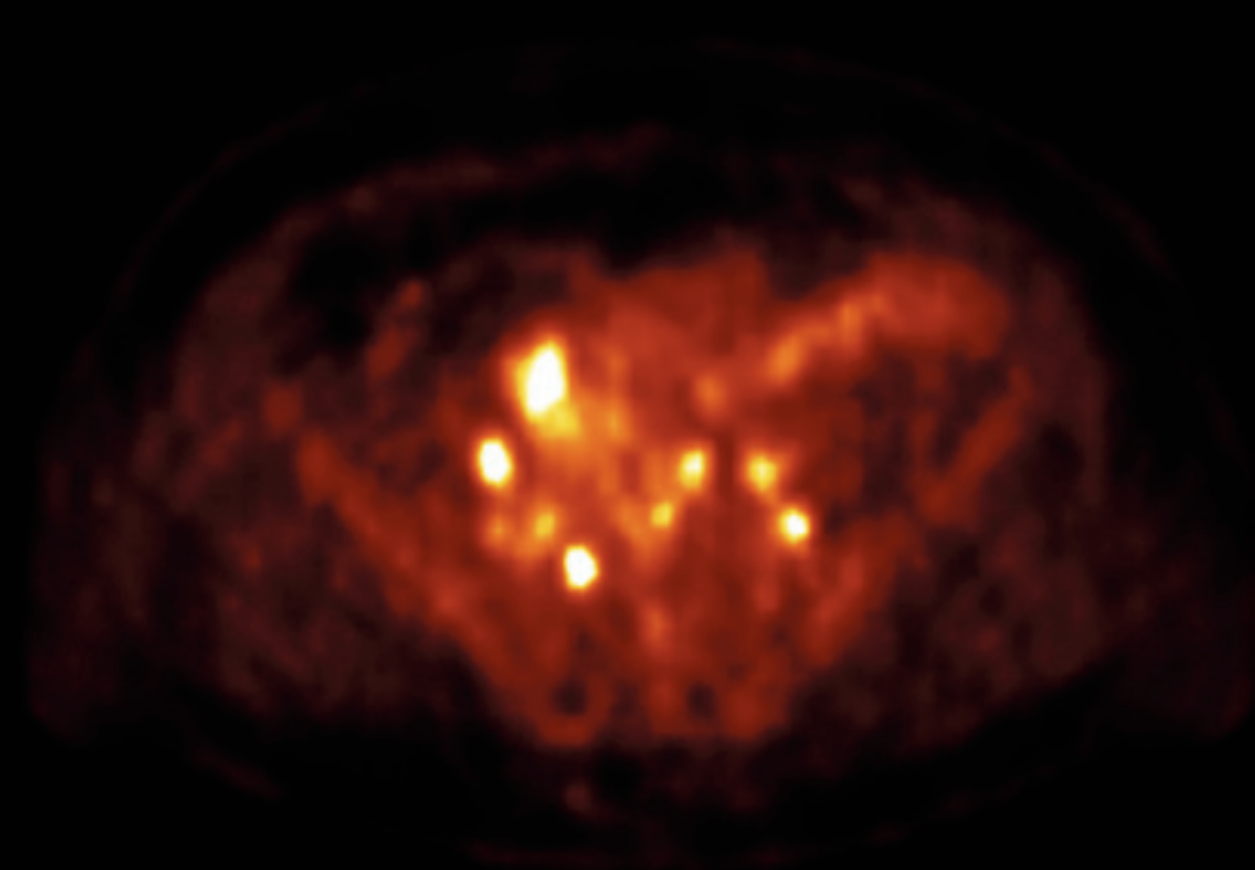


$$\frac{\text{SNR}_{\text{ToF}}}{\text{SNR}_{\text{PET}}} = \sqrt{\frac{2D}{c\Delta t}}$$

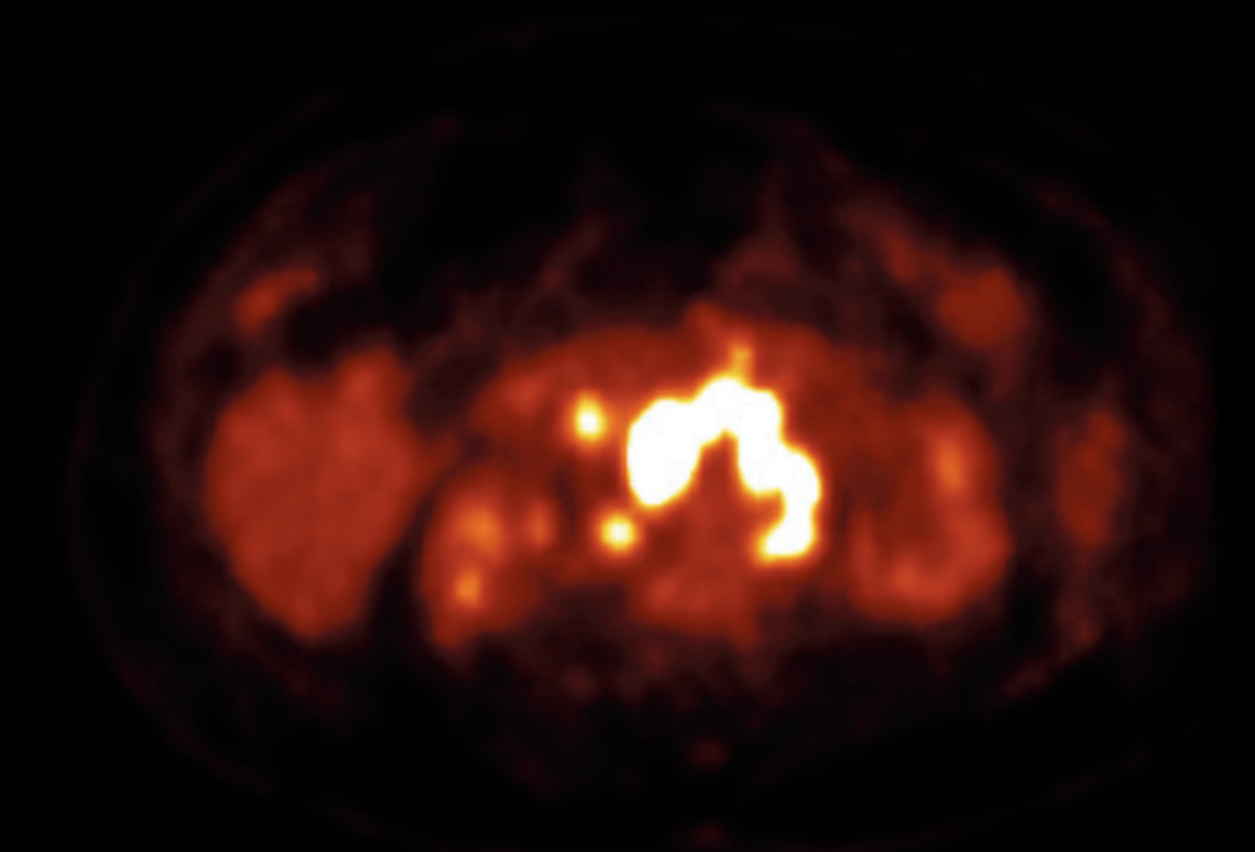
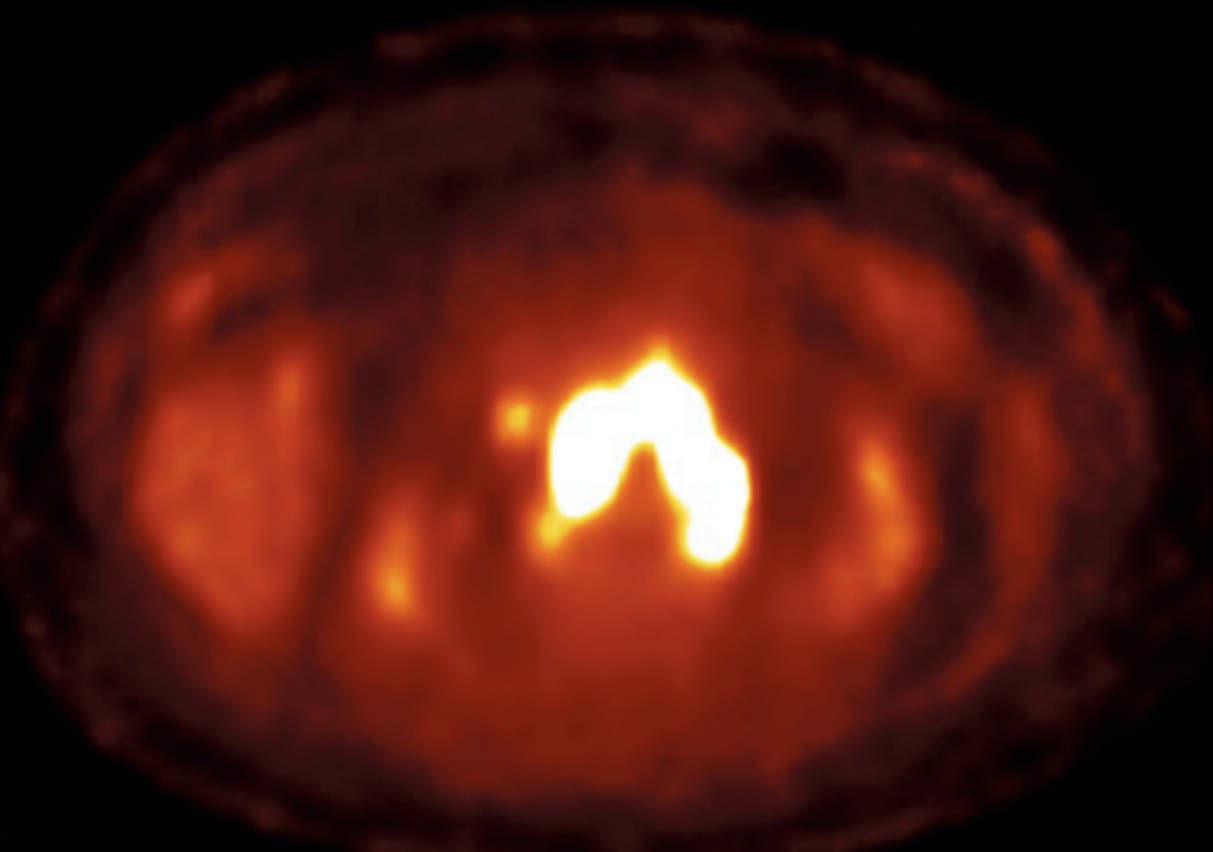
	Δt (ps)
BGO (block)	3000
LSO (block)	1400
LSO (ToF,block)	550
LaBr ₃ (block)	350
LaBr ₃ (single crystal)	70



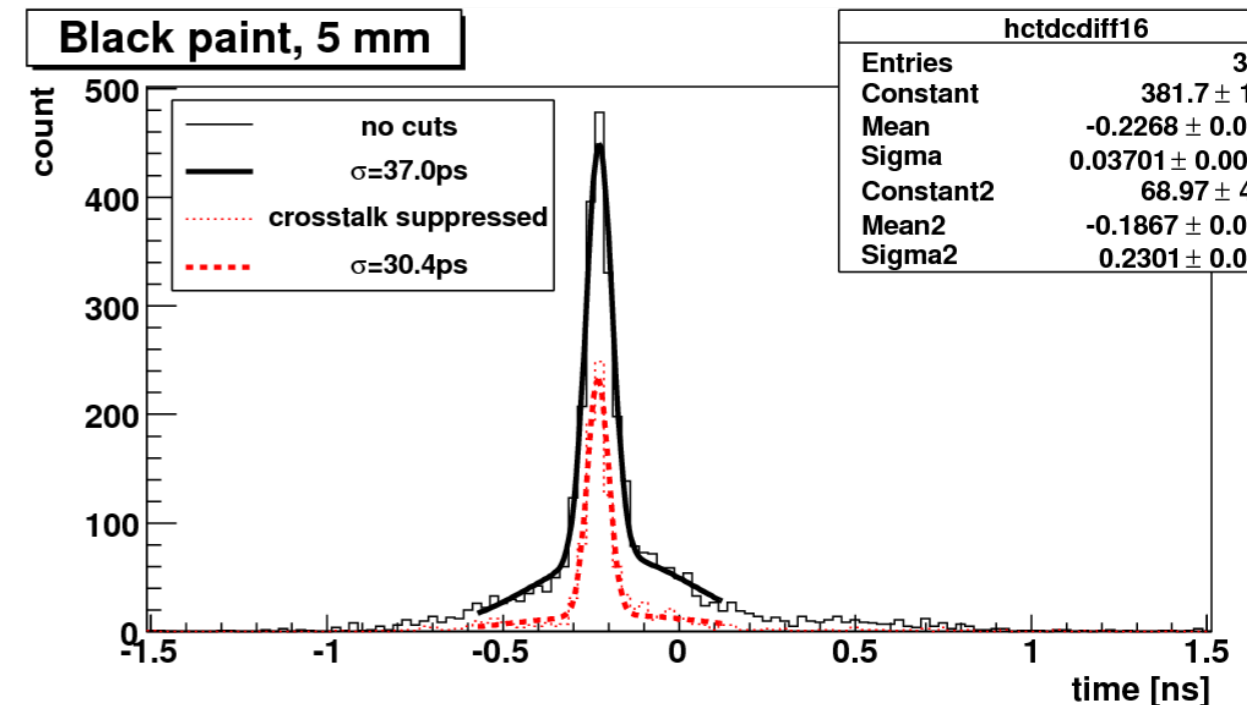
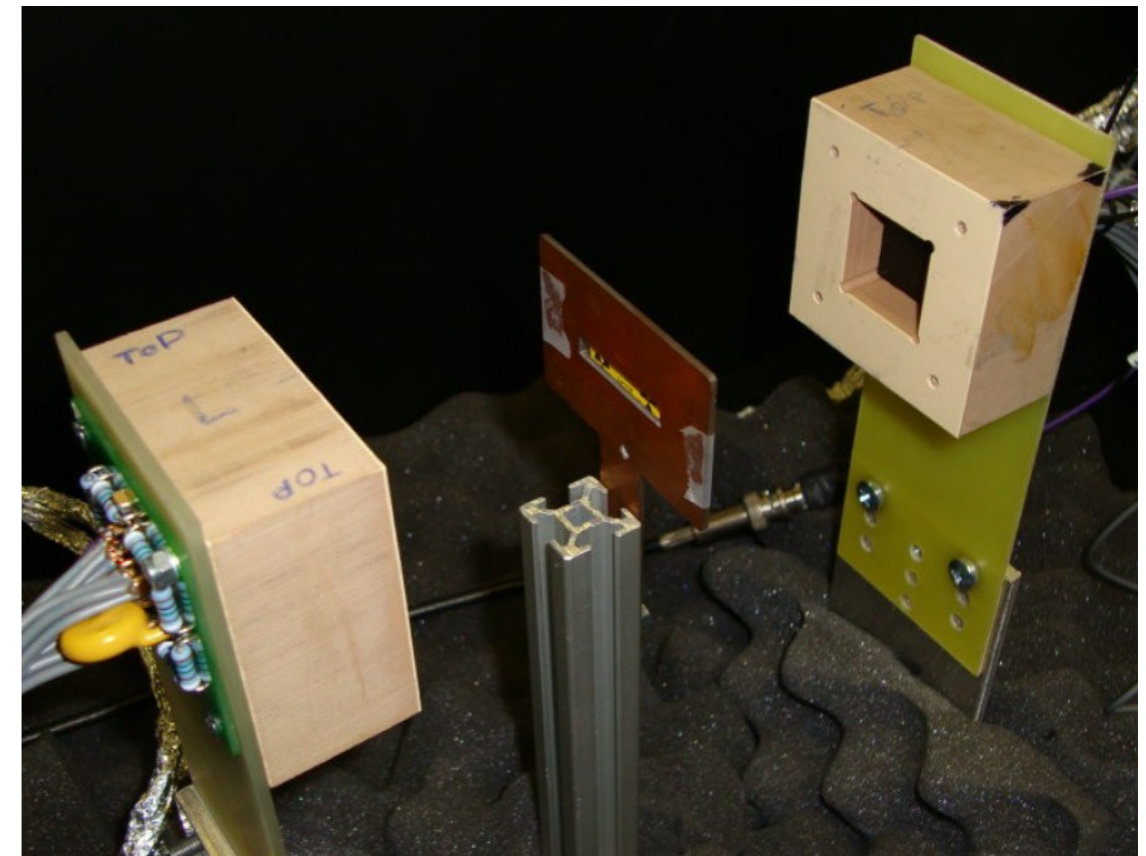
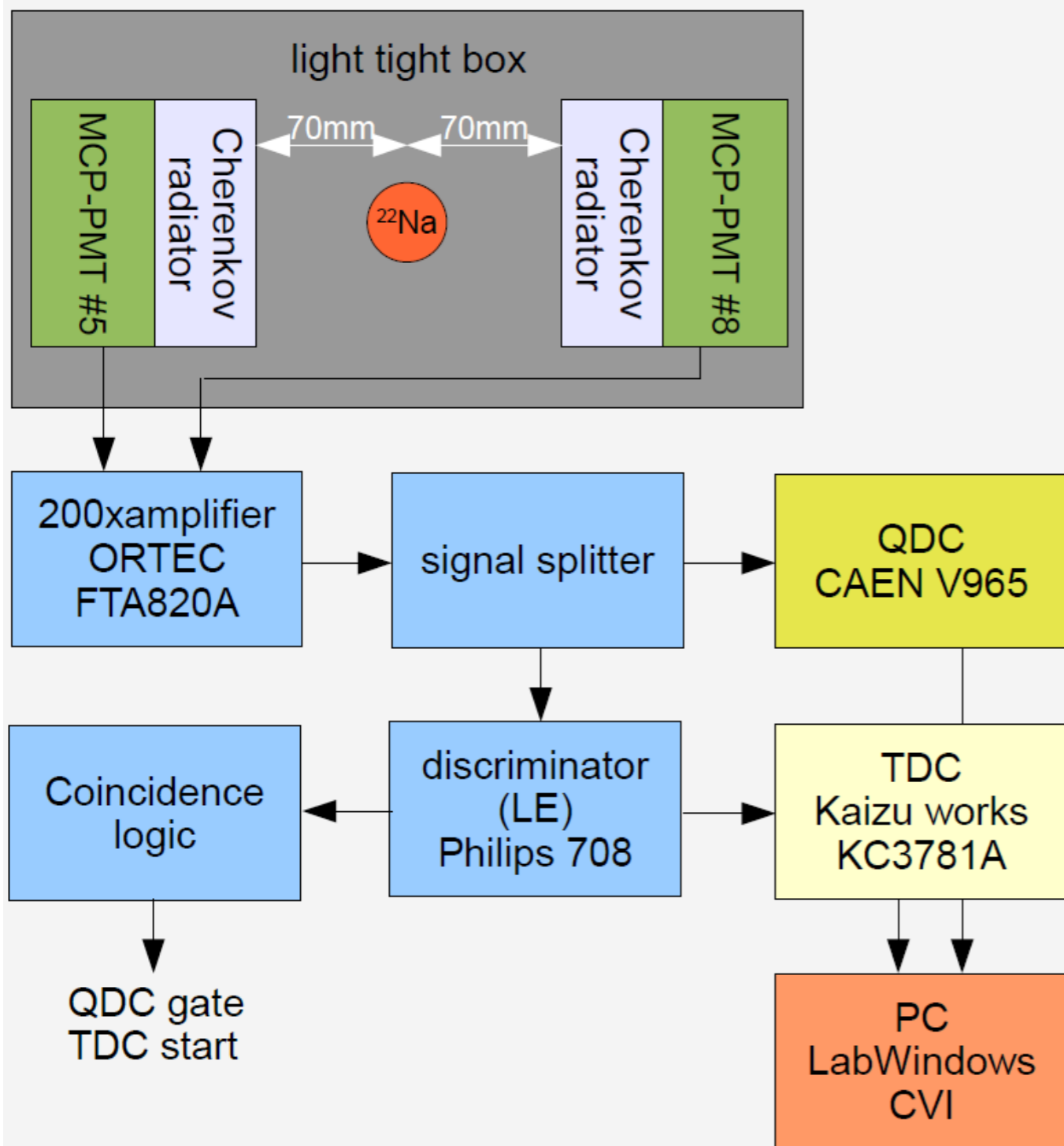
no TOF



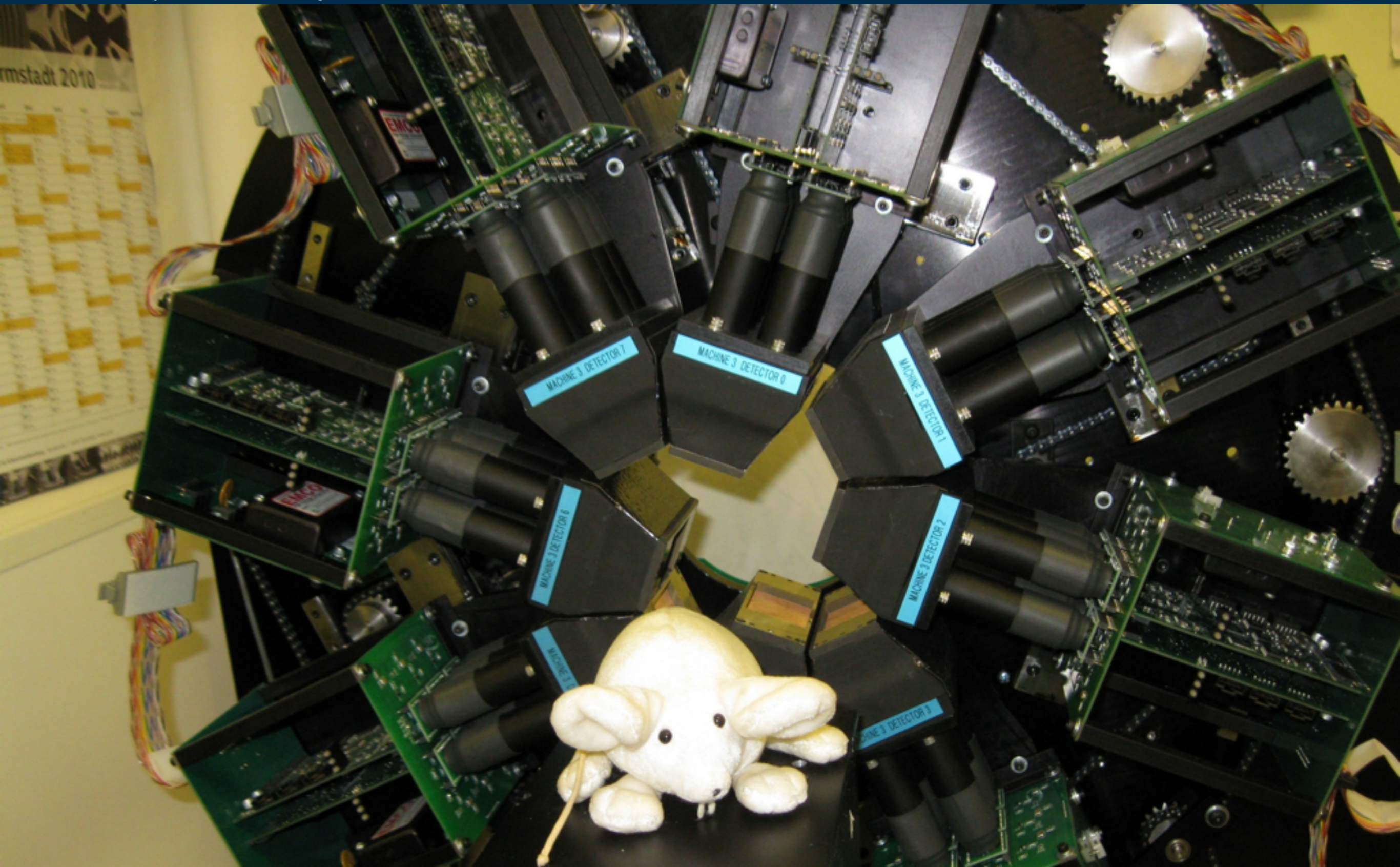
~600 ps TOF



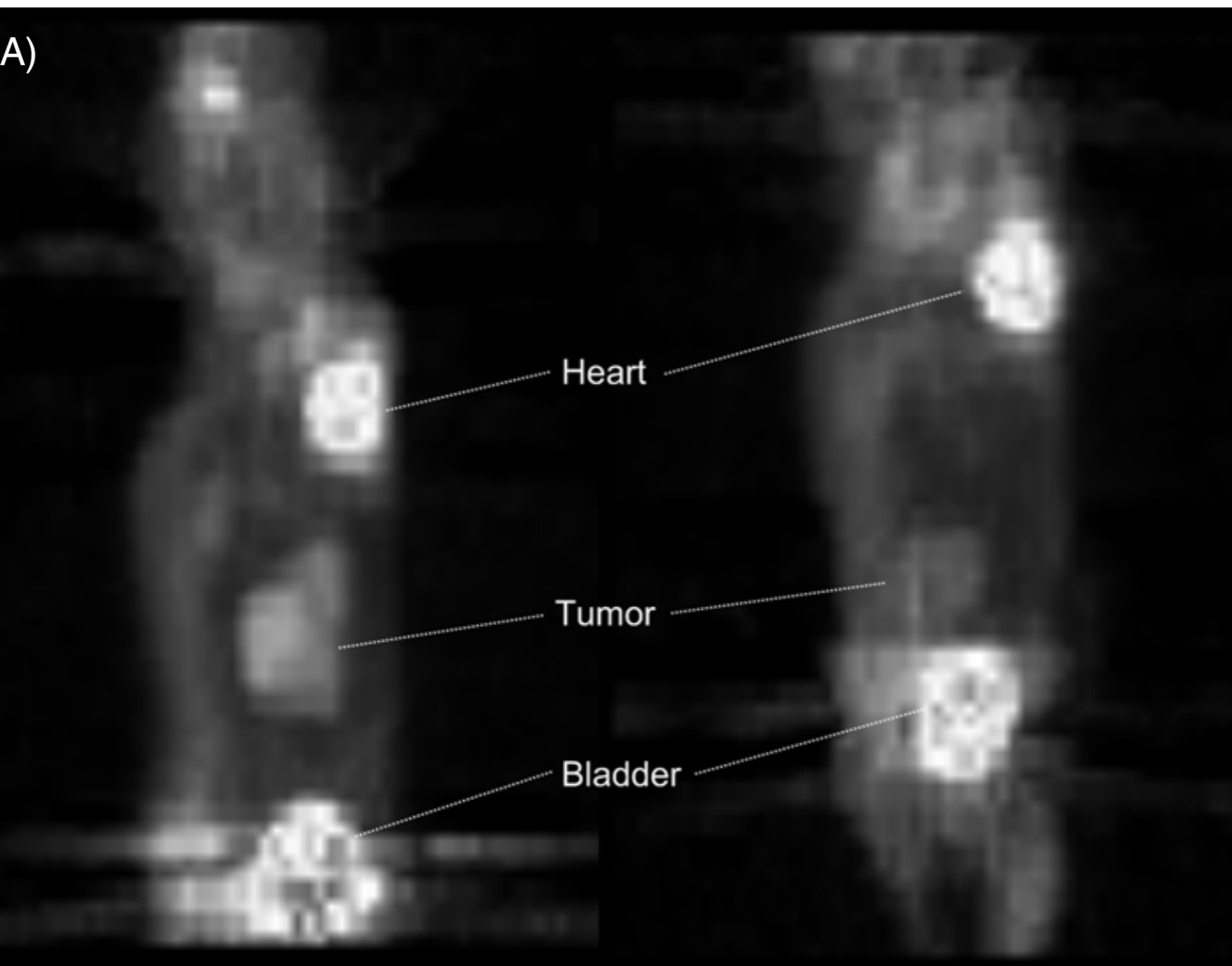
Another Possible Application - Cherenkov PET



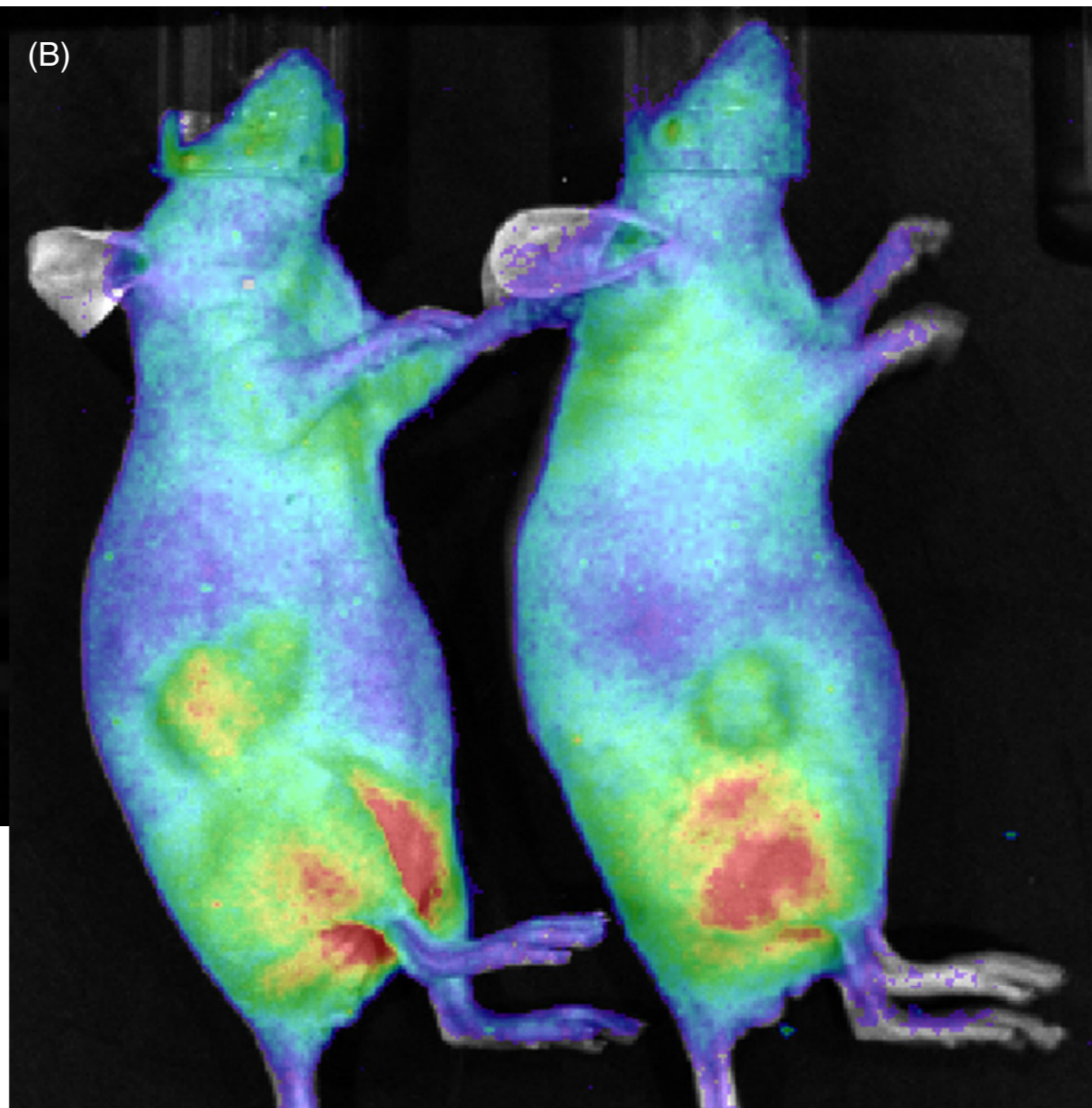
An aside - Imaging for Translational Medicine



Conventional PET



Cherenkov Imaging



from: R. Robertson et al., Phys. Med. Biol. **54** (2009)N355

- **Position sensitive photon detectors are crucial for the new generation of fundamental nuclear and particle physics experiments**
- **Medical Imaging Modalities share many of these requirements and operate on the same scale (and with similar problems)**
- **Many good photon detection solutions exist for both, but all require detailed studies to be operated successfully**
- **... and many more exciting ideas to come at this conference**