Considerations for APD readout of the LYSO Endcap

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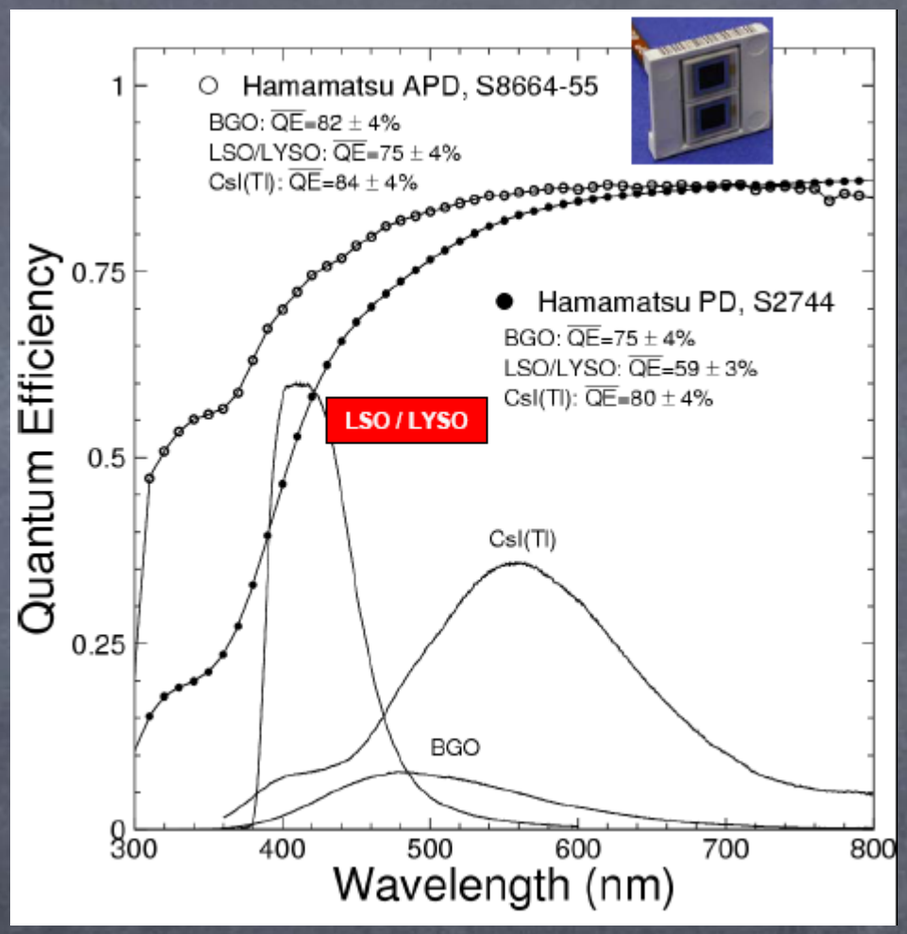
The Case for APD Readout of LYSO

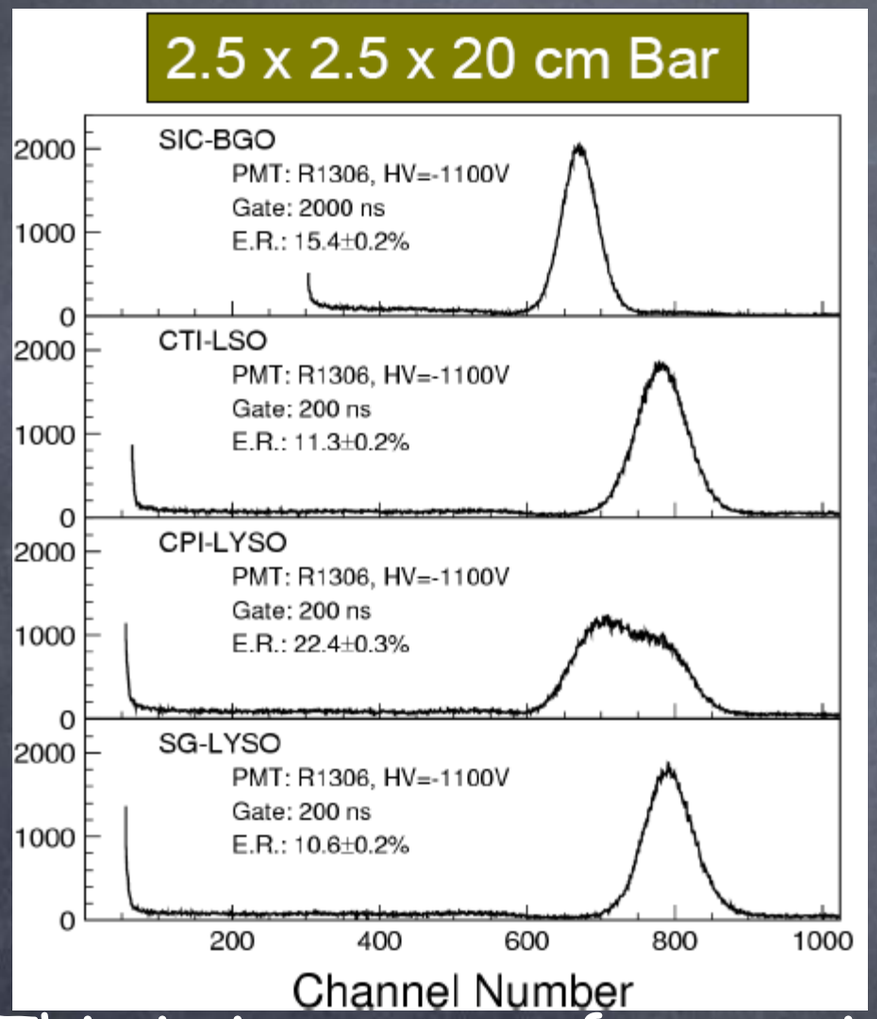
- Pro
  - APD QE is a somewhat better match to LYSO scintillation spectrum
    - More pe/MeV = smaller statistical term in energy resolution (not dominant)
  - Better S/N allows straightforward linearization of crystal response with a radioactive source
  - Lowest noise way to achieve required gain – can then attenuate to use same electronics as barrel CsI(Tl)
- Con
  - Requires good temperature control
  - Somewhat more expensive, but negligible compared to crystal cost

Higher QE with LYSO spectrum

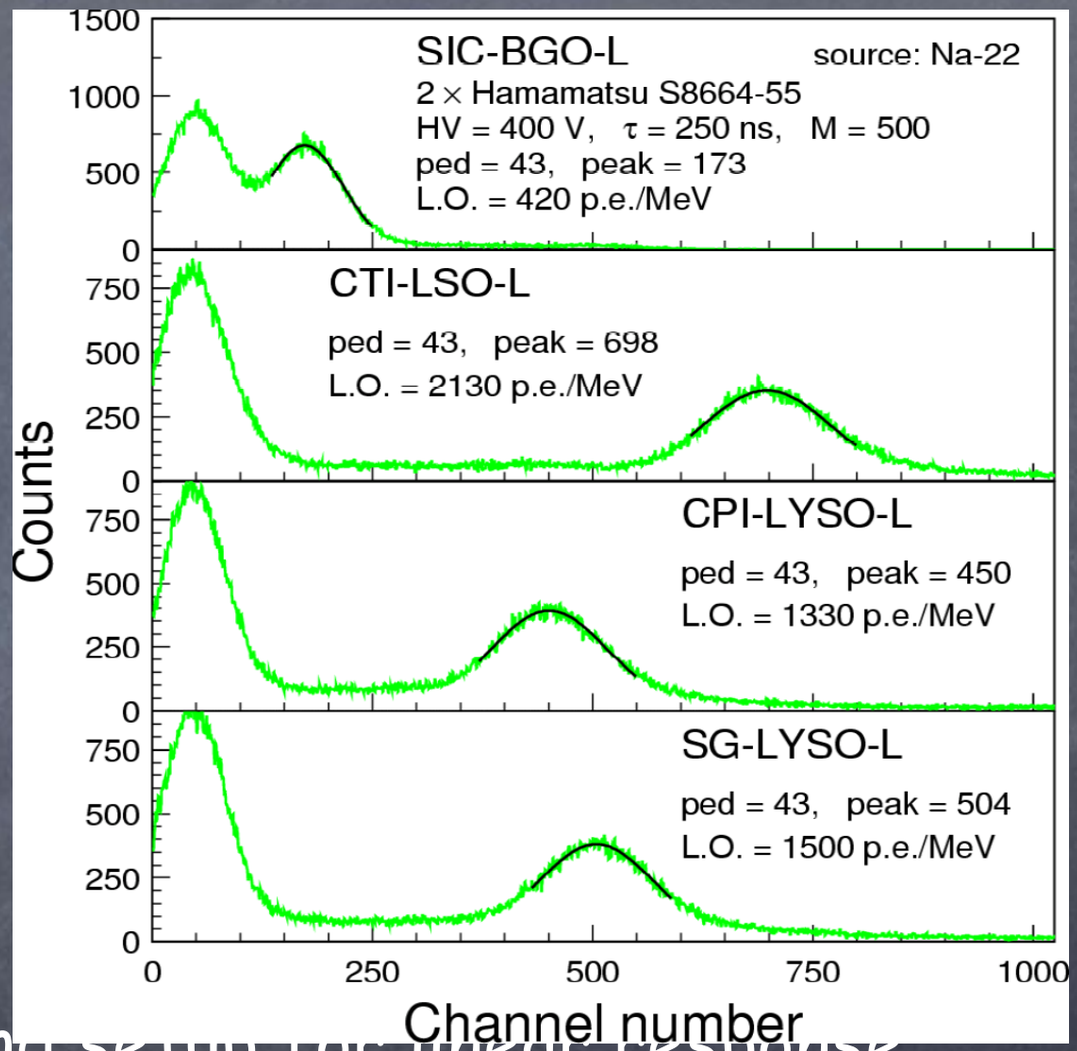


Can see radioactive source with full size crystal

PMT



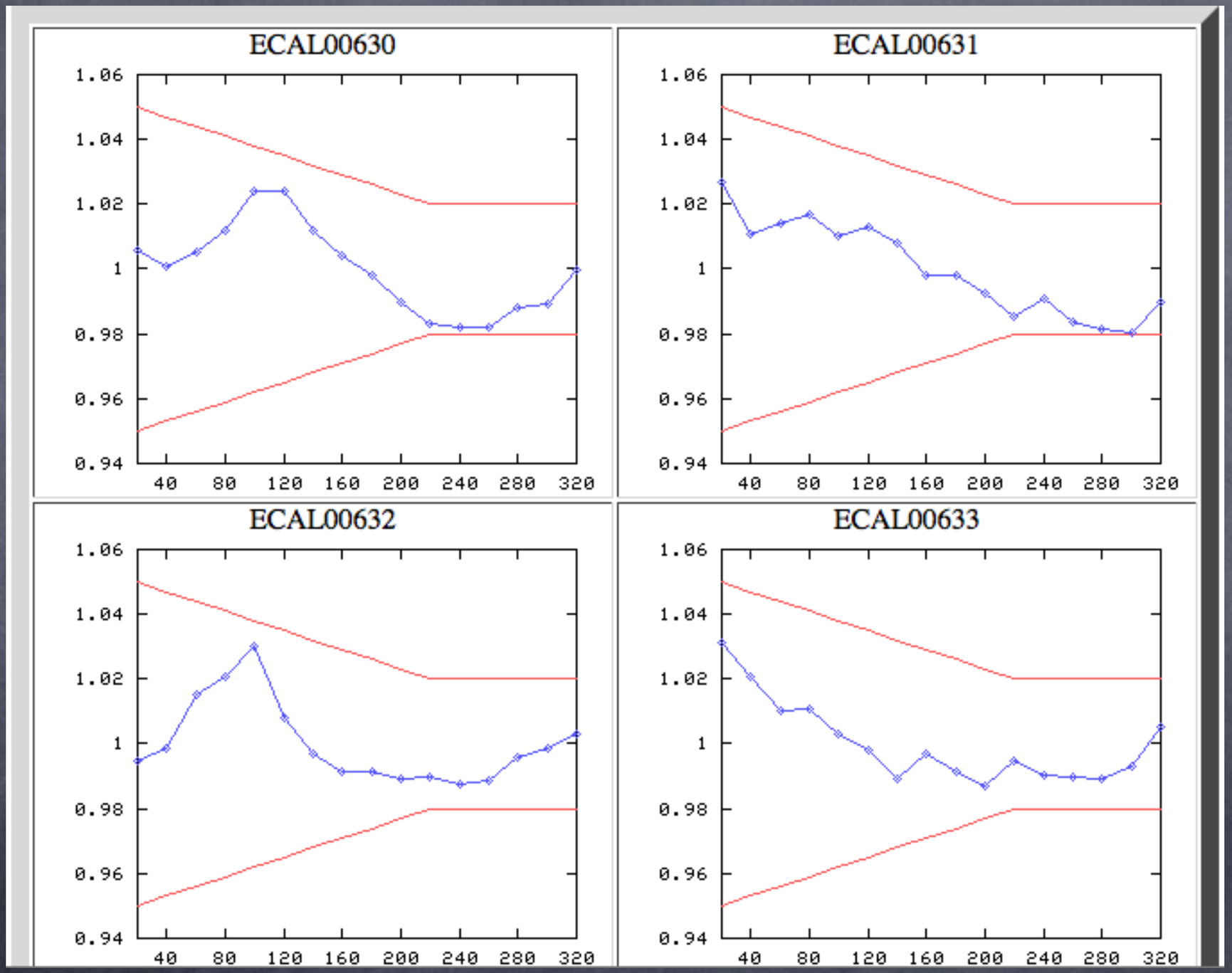
APD



- This is important for testing and setup for linear response

A protocol to achieve uniform response with trapezoidal crystals

An example: *BABAR* endcap crystals

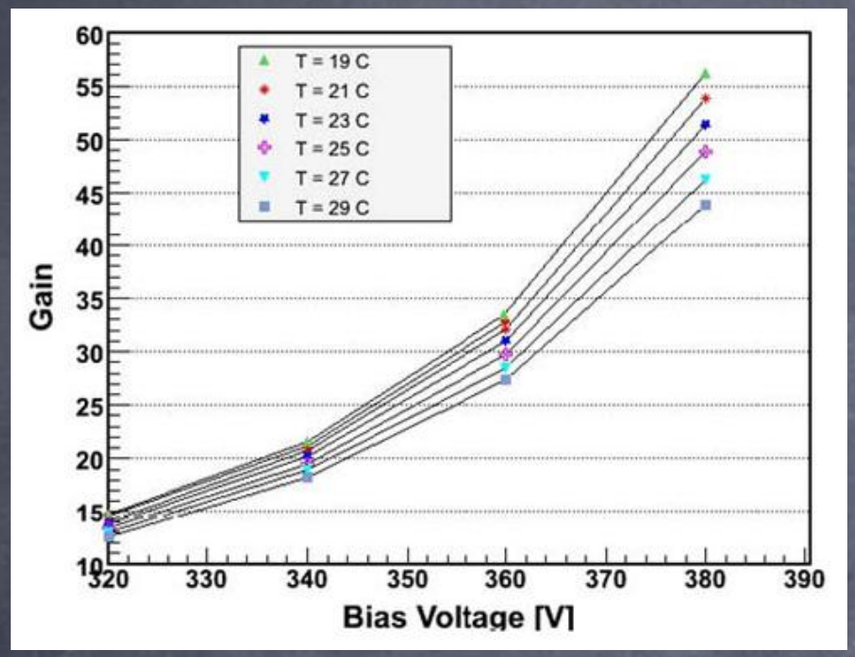


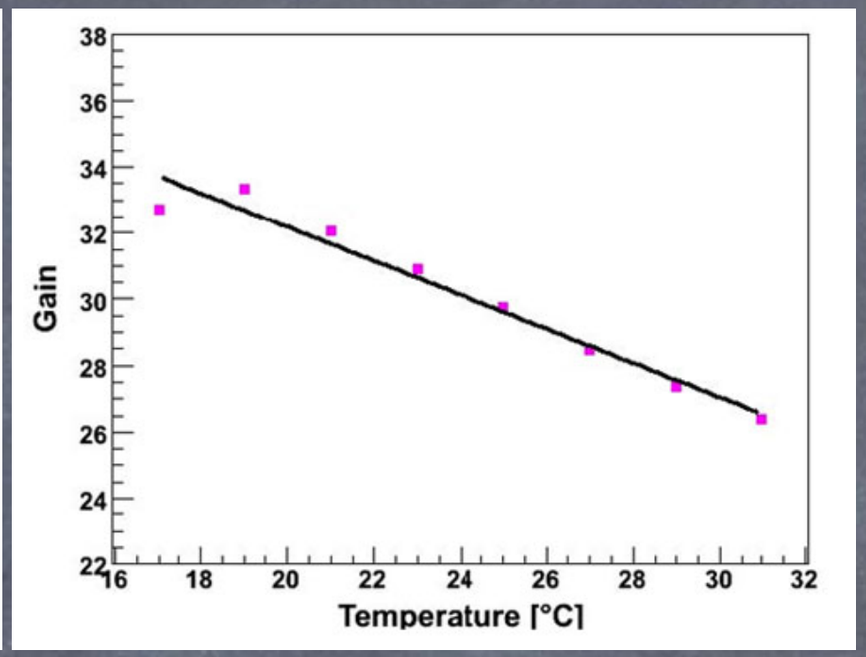
Linearization protocol

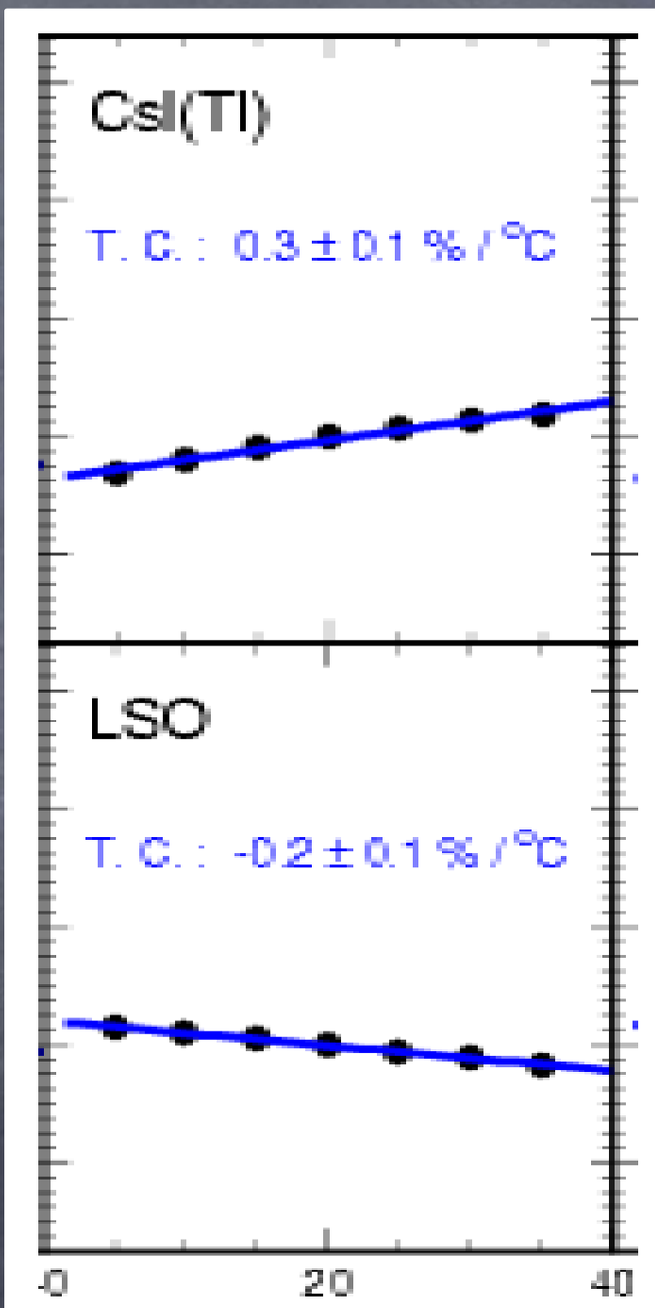
1. Determine an acceptable variation of response with distance from readout end. This requires:
   a) MC studies of effect of calorimeter energy resolution on appropriate physics quantities, *e.g.*, π^0 mass resolution
   b) Ray tracing studies of projective crystals, including spectrum information, *i.e.*, emission/absorption spectra and QE spectral response
2. An automated, or semi-automated device to measure each crystal's response and adjust it to achieve the required uniformity
3. This is best done using a radioactive source, e.g. ^{60}Co, ^{22}Na or ^{137}Cs
   a) This cannot be done with a photodiode
   b) It can be done with a PMT, but the corrections to convert to response of a PD are not simple
   c) This can easily be done using an APD – the same APD that will be matched with the individual crystal and used in the detector

APD's require stable temperature and HV

- This is very well understood and straightforward to achieve
- Example : ALICE calorimeter (Catania)







- Note that temperature control is also required for stable scintillation light output
  - (humidity control is required for the barrel as well)

- $\Delta T = 0.2^{\circ}C \Rightarrow \Delta G = 0.5\%, \Delta LYSO = -0.04\%$