CsI crystals for the **HIgh Resolution Array** uniformity of the response.

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Introduction

We need 80 good CsI(Tl) crystals to detect the energy of charged particles that punch through the silicon detectors.

The silicon detector defines 32x32 pixels on the CsI surface.

4x CsI(Tl) 4cm

Si-E 1.5 mm

Pixel

Si-ΔE 65 μm

Individual calibration of each of the (20x) 1024 pixels is unpractical.

We need CsI Crystals with a uniform response across the surface.
We need crystals with a uniform response to particles that enter the crystal at different positions.
Some important questions

- Does the non-uniformity depend on the method of fabrication?

- Is the non-uniformity measured for alpha’s from an $^{241}$Am source the same for particles with higher energies?

We tested 8 crystals
  
  3 normal CsI(Tl) crystals 3x3x3 cm$^3$
  3 annealed CsI(Tl) crystals 3x3x3 cm$^3$
  2 CsI(Tl) crystals with higher Tl concentration 3x3x4 cm$^3$

In-beam test at Texas A&M cyclotron facility with Alpha’s at 220 MeV and deuterons at 110 MeV → correlate to the $^{241}$Am source scans.
Collimated $^{241}\text{Am}$ source scan of crystals

We test crystals by taking spectra for each point on a 10x10 grid across the crystal surface.

Automated setup takes a 80 seconds of data at each grid point.
Texas A&M setup

Beam pipe

CsI crystal

2x4 stack of the 8 test crystals

CsI crystal

Double sided Si strip detector defines 3x3mm^2 pixels on crystal

Exit window

Movable tray
Annealed Csi(Tl) Crystal

Stopped at Front surface

Stopped midway

Stopped at back

The ‘large’ gradient for the three different energies is in the same direction (alpha-source shows largest gradient)
The overall resolution is bad due to the large non-uniformities of the response to particles entering the crystal at different positions.
Csi(Tl) super doped

Much smaller differences from the mean
Csi(Tl) super doped

220 MeV alphas

- Whole crystal (integrated over all pixels)
  FWHM=1.1 MeV (0.51%)

- 1 pixel (3x3 mm²)
  FWHM=0.7 MeV (0.32%)

The overall resolution is better.
Local fluctuations

Non-uniformity has two components

- Large scale fluctuation
- Local fluctuations

Correct for the global gradient by fitting it and subtracting the fitted gradient.

The residual fluctuations seem to be of order 0.3% for all 8 crystals does not seem to depend on manufacturing method.
Conclusions

-The higher Tl doping seems to produce crystals which have a better global uniformity across the surface

-We did not observe a significant difference between the annealed and not-annealed crystals.

-The uniformity measured with an $^{241}\text{Am}$ source is indicative for particles at higher energies

-Local uniformity fluctuations seem to be about the same size for all 8 crystals
Preparation and testing of crystals will be completed in about three weeks.

Preparation Details:

- Light-guides are glued on crystal with BC-600 optical cement.
- Light-guides are painted with BC-620 reflective paint.
- Photodiodes (Hamamatsu 1.8x1.8cm$^2$) are glued on with RTV-glue.
- Crystals are wrapped with 1.5 layers of Cellulose Nitrate membrane paper.
- Crystal and light-guides are wrapped with a layer of aluminized mylar.
- Each set of 4 crystals of one telescope are wrapped together with teflon tape.

12 Crystals were scanned with the $^{241}$Am alpha source.
They are well within the specifications
fractional deviation from mean <0.5%
Fluctuations seem to be smaller than those of the tested crystal