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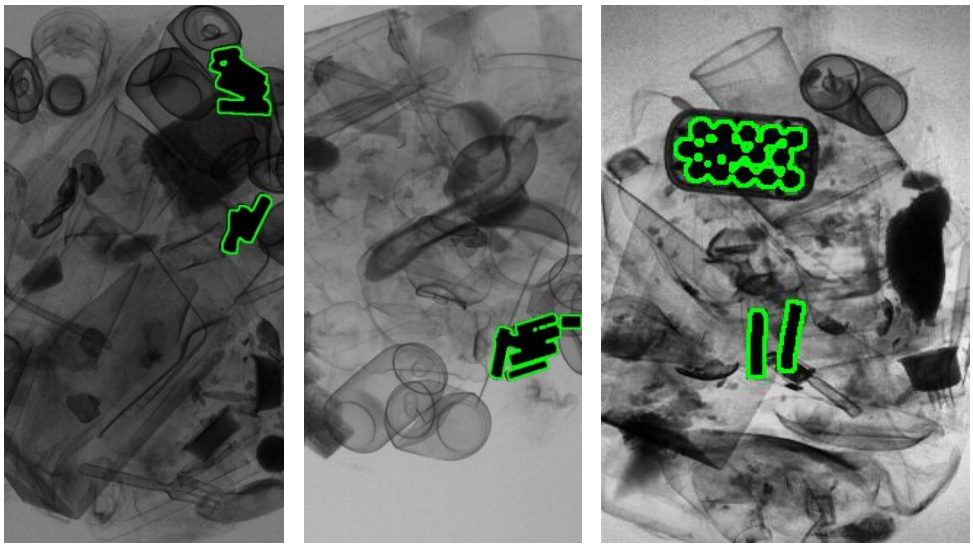
Application Note: X-Ray Sorting and Multiple Detectors to Expand Coverage Area

- Automate detection and sorting of hazardous materials such as lithium batteries, gas canisters and other items in waste streams.
- Separation of minerals, coal, rock, or glass
- Long conveyor belt monitoring
- Process monitoring of building materials in production



Example of Li-ion batteries highlighted on an X-ray image

1. Introduction

Many sorting applications use a wide conveyor to maximize throughput. It can be challenging to fit a single detector covering the entire width of the conveyor because it requires a wide-angle X-Ray source. Though this configuration is possible, there can be a performance penalty as the X-Ray strength decreases further away from the source. The difference in source-to-detector distance between the center and ends of the detector can also result in image distortion. A curved detector could also be used where this distance is constant across the detector, but it adds complexity to the design. This application note discusses using multiple straight detectors and X-Ray sources to expand the coverage area without sacrificing performance.

2. Stagger Configuration

Using multiple detectors in a staggered configuration is one way to optimize the performance in a wide conveyor application.

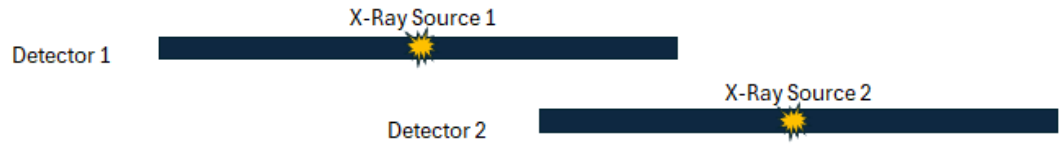


Figure 1. Two detectors in a staggered configuration, viewed from above.

Figure 1 shows a simplified setup using two detectors and two X-Ray sources. Most applications using line scan detectors will use a fan beam X-Ray source. We can choose a source with a commonly available beam angle less than 90 degrees along the detector length. The angle across the detector width should be small to minimize the footprint of the system without interference from adjacent beams. Collimation can also be added to achieve the same goal. This pattern of detector-source pairs can be repeated to cover larger areas.

3. Application Example with Calculations

Suppose we have an application with a conveyor length of two meters. We would like to use two X-Ray sources and detectors to cover the full width. The X-Ray source fan beam output angles are 80° x 10°.

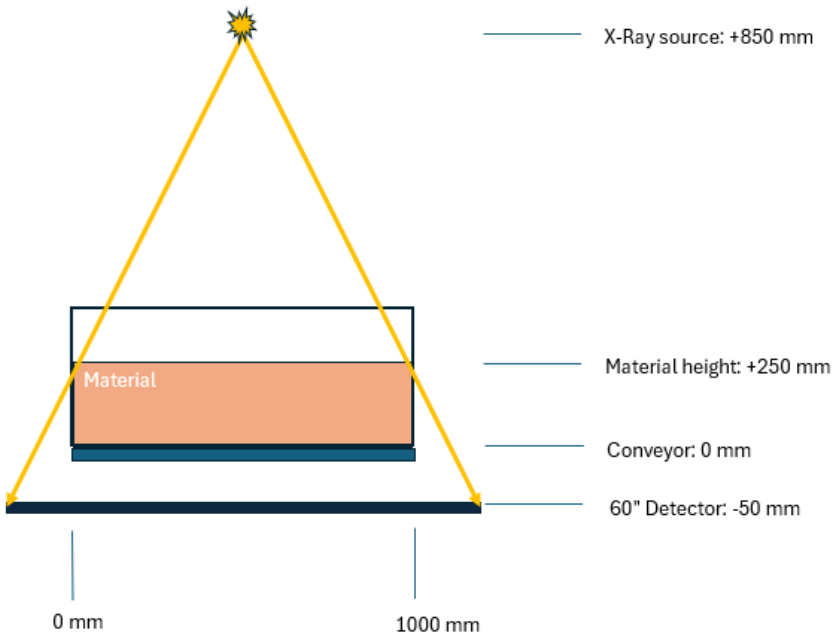


Figure 2. Diagram of source and detector covering one meter

First, we need to consider the height of the material above the conveyor and calculate the placement of the source to cover the whole area. We can calculate this value from *tan(50°) * 1 meter / 2 ≈ 0.6 meters*. Next, we need to calculate the detector length required. If we set the detector to be 50 mm below the conveyor, the length needed can be calculated by *2 * 0.9 meters / tan(50°) ≈ 1.51 meters*. Figure 2 shows a diagram of this setup and the component placement relative to the conveyor. Note the detector length is longer than the conveyor section. This is needed to cover the height of the material. The material height is given at 0.25 meters and the X-Ray source is placed at the calculated distance of 0.6 meters above the material. A 60” detector, slightly longer than the required 1.51 meters or 59.4”, can be used for this application.

Now that we know the dimensions required to cover a length of one meter, we can simply duplicate the configuration to cover two meters. We just need to calculate the minimum stagger distance so one fan beam does not interfere with the other. For a fan beam with a 10° angle on the narrow side, the distance is calculated as *2 * 0.9 meters / tan(85°) ≈ 0.157 meters*. Technically, with the X-Ray source centered over the detector, the fan beam will only spread out to half of this distance. It is recommended to allow sufficient stagger distance to avoid overlapping beams. This prevents the overlapping areas of the detectors from receiving double the radiation dose. Figures 3 and 4 show the complete setup covering two meters. The pattern can be repeated to cover additional length.

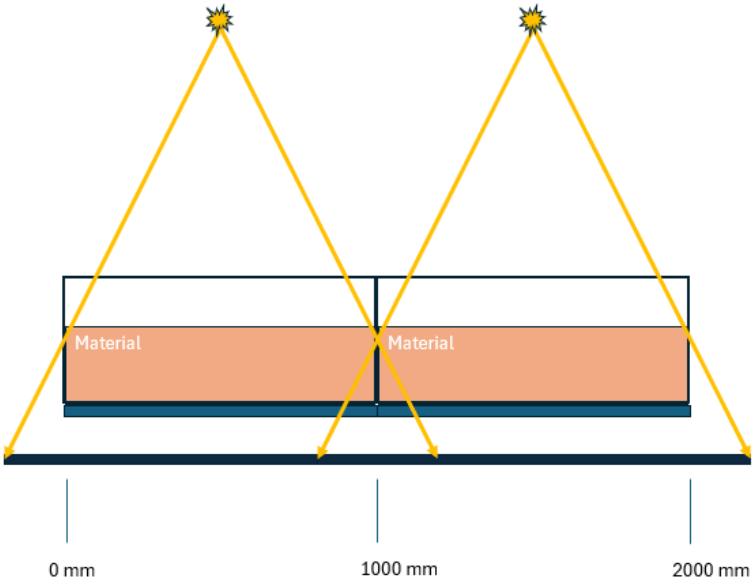


Figure 3. Diagram of staggered setup looking toward the conveyor.

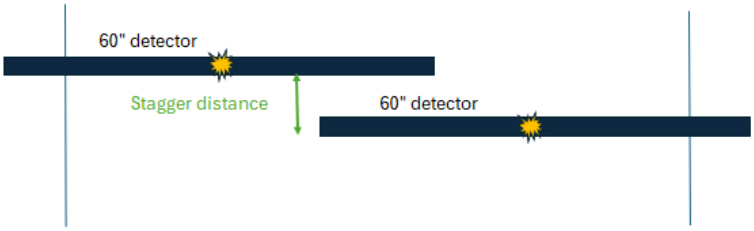


Figure 4. Diagram of stagger viewed from above.

4. Conclusion

This application note demonstrated a stagger configuration that can be adapted to expand the coverage area for a conveyor application. One additional note is that the material in the overlapping areas will appear on each detector during the scan. The final image representing the whole conveyor can be constructed by stitching together the images in software.

5. X-Scan Products

Single Energy Falcon

Dual Energy Hawk