Tilt-supported Auto-calibration

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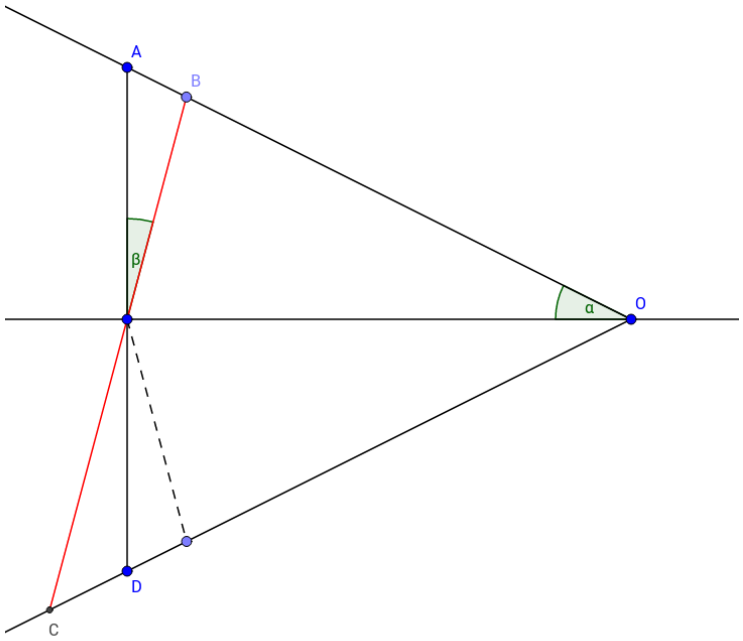
s.t. α is a calibrant ring angle, β is the detector tilt angle, automated calibration protocol:

1. **[WIP, Fang and Dinesh]** Segment point cloud into ellipses
2. **[WIP, Dinesh]** Fit an ellipse to each point cloud.
3. **[NP, Ron]** For each ellipse,
   (a) **[NP]** calculate tilt via eccentricity
   $e = \frac{\sin\beta}{\cos\alpha} = \sqrt{1 - \frac{b^2}{a^2}}$
   (b) **[NP]** calculate minor/major axes profiles
   (c) **[NP]** From tilt angle β, calculate position of direct beam. There are two solutions for each ellipse, since β is indistinguishable from $-\beta$ with one ellipse.
   Let $\overline{BC}$ represent the major tilt axis of a detector with tilt β; a calibrant ring is projected onto its plane with angle α.
   $\angle BAP = 90 - \alpha$
   $\angle CDP = 90 + \alpha$
   $\angle PCD = 180 - \beta - (90 + \alpha) = 90 - \beta - \alpha$
   let $\theta = 90 - \beta$
   by law of sines for each triangle $\triangle PCD$ and $\triangle PBA$ (with shared side $\overline{PD} = \overline{PA}$),
   $\overline{PD} = \overline{PC}\frac{\sin(\theta - \alpha)}{\sin(90 + \alpha)} = \overline{PB}\frac{\sin(\theta + \alpha)}{\sin(90 - \alpha)}$
   $\frac{\overline{PC}}{\overline{PB}} = \frac{\sin(\theta + \alpha)\sin(90 + \alpha)}{\sin(\theta - \alpha)\sin(90 - \alpha)} = -\frac{\sin(\theta + \alpha)}{\sin(\theta - \alpha)} = \frac{\cos(\alpha - \beta)}{\cos(\alpha + \beta)}$
   $\therefore$ Given a detector with tilt β, a calibrant ring with angle α intersects the detector plane forming an ellipse with major axis $\overline{BC}$, which intersects the direct beam at P s.t. $\frac{\overline{PC}}{\overline{PB}} = \frac{\cos(\alpha - \beta)}{\cos(\alpha + \beta)}$.



4. **[NP]** Compose set of correlating ellipses (filter out bad ellipses). Matching ellipses have shared minor/major axes orientations, tilt, and direct beam positions

5. **[NP]** Build pyFAI geometry