VERTEX 2023 Sestri Levante - Poster Session

Material Measurement of an ATLAS Pixel Module via Multiple Scattering

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The idea

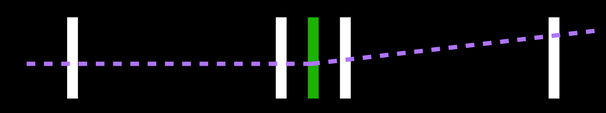
- Measurement of the fractional radiation length x/X_0 of an ITk hybrid pixel module through multiple scattering of low energy positrons in the material
- Scattering described by a Gaussian core with θ^{-4} Rutherford tails → use a double sided crystal ball function

$$\theta = \frac{13.6\,\text{MeV}}{\beta c p} z \sqrt{x/X_0}(1 + 0.038 \ln(x/X_0)) \quad [1]$$

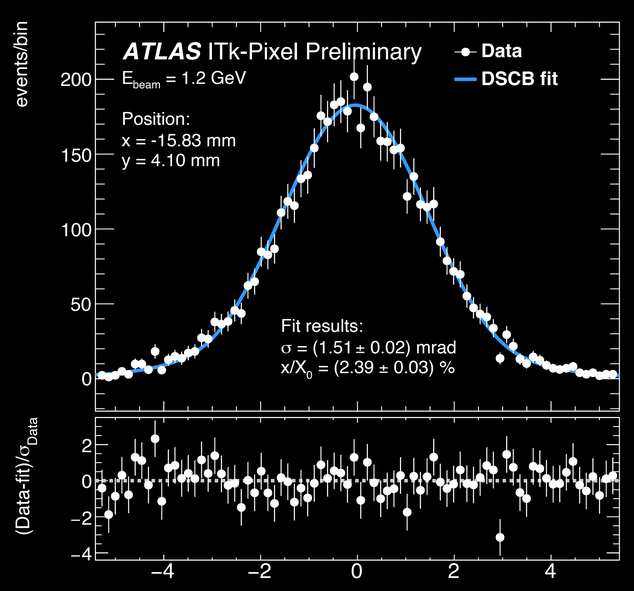
Scatter angle (RMS of the Gaussian core) · Beam energy · Fractional radiation length

- Needs a low X_0 telescope and at a beam line that can provide O(1 GeV) positrons → used T9 at the CERN Proton Synchrotron [e^+ created from γ conversions as tertiary particles]

The telescope



- MALTA monolithic sensors with 36.4µm x 36.4µm pitch
  - Low material content - down to 50µm
  - Used as trigger source [coincidence of first and last plane]
- ITkPix quad module [50µm x 50µm pitch] used as DUT on movable x-y stage [ITkPix size is 2cm x 2cm, MALTA size is 1cm x 1cm]
- ITkPix quad read out optically with FELIX that receives triggers from the MALTA TLU
- Event synchronization based on trigger counting
- Telescope length: 2m [optimised for 1.2 GeV e^+]

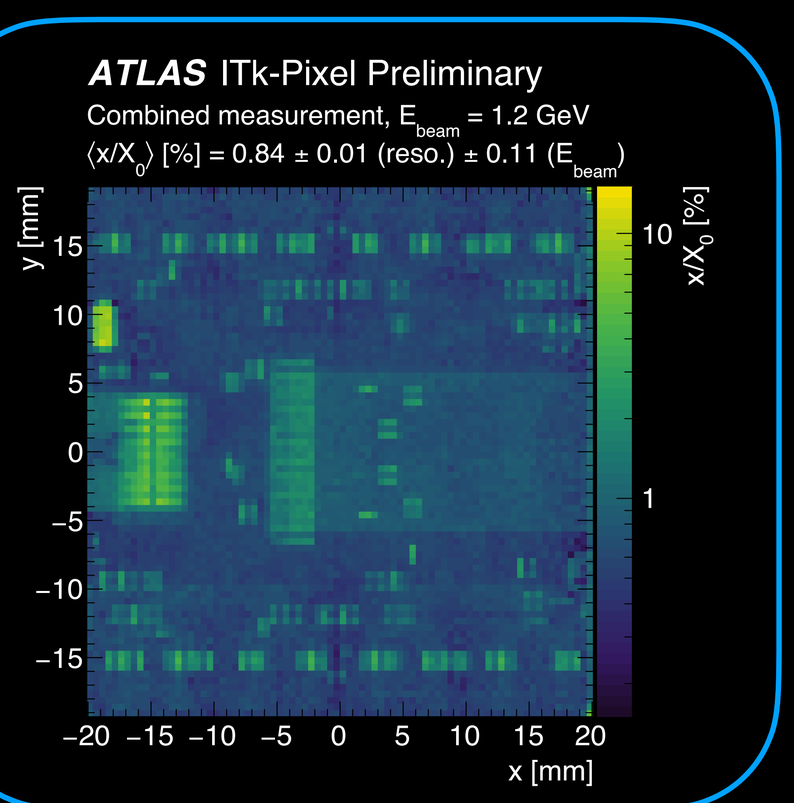


ITkPix Quad Module

The analysis

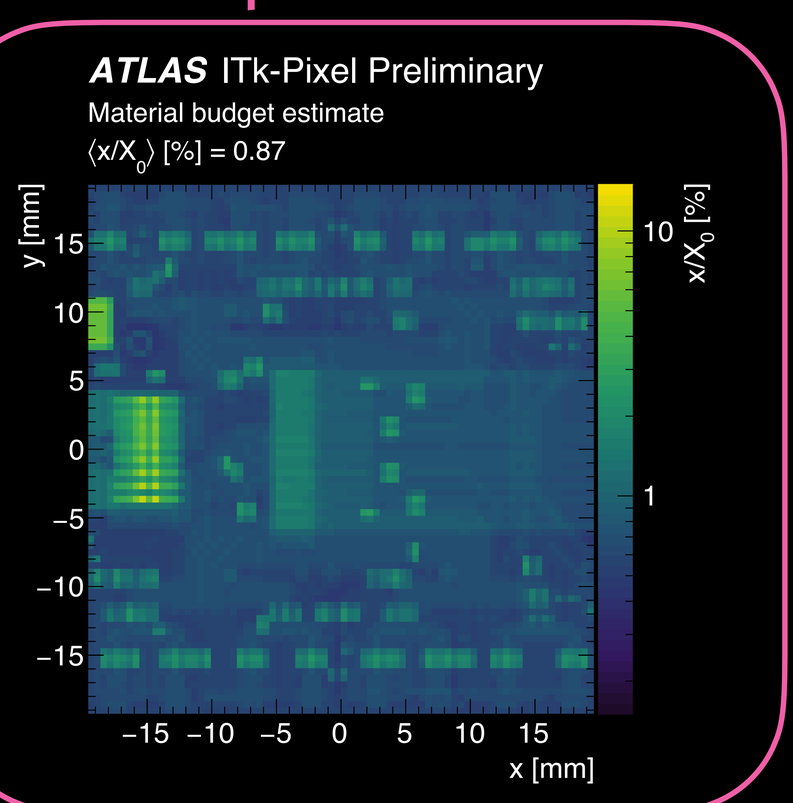
- Multiplet tracking algorithm [either with or without DUT] to extract the scattering angle θ
- Used projections of the scatter angle in x- and y-direction [two independent measurements that can be combined]
- Compared with ϕ-invariant angle analysis → good agreement
- Acceptance corrections for telescope geometry
- Subtraction of air component based on reference measurement
- Subtraction of overlapping testbeam infrastructure components

Measurement



- Measured x/X_0 with sub-mm resolution and a 14% relative uncertainty
- SMD components and wirebond pads clearly visible
- Largest contributors are the HV filter capacitor, the power- and the data cable connectors
- Precision limited by the beam energy uncertainty

Expectation



- Estimated expected x/X_0 map based on design drawings and component expectations
- Overall good agreement with the measurement

The results

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[1] R.L. Workman et al. (Particle Data Group), Prog. Theor. Exp. Phys. 2022, 083C01 (2022)