Review of Material Budget Estimations

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Taken from many of Leo Greiner's presentations

Estimates for material in for EIC Si structures/services

Lawrence Berkeley National Laboratory

Radiation lengths for common materials

material	material radiation length (g*cm^-2)	density (g/cm^3)	X0 (cm)
Cu	12.86	8.96	1.43527
PVC	25.51	1.45	17.5931
FR4	30.17	1.8	16.7611
chip ceramic caps	11.16	6.02	1.85382
kapton	40.58	1.42	28.5775
PEEK	39.6	1.32	30
polyethylene	44.7	0.92	48.587
water	36.08	1	36.08
Al	24.01	2.7	8.89259
Carbon fiber (M55J, resin is similar)	42.70	1.55	27.5484
Silicon	21.82	2.33	9.356

https://cds.cern.ch/record/1279627/files/PH-EP-Tech-Note-2010-013.pdf

Estimates for material in for EIC Si structures/services

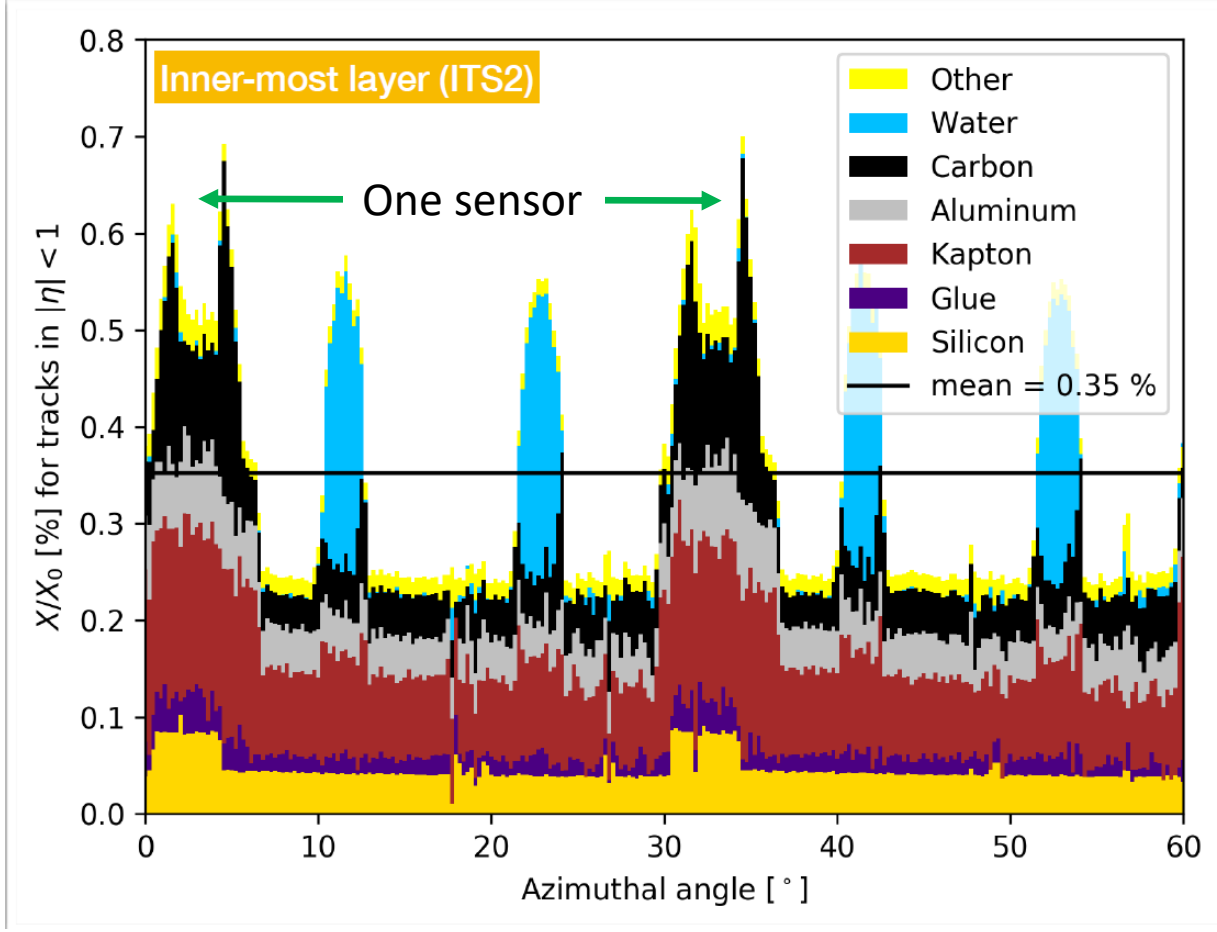
3 components to EIC tracking detector:

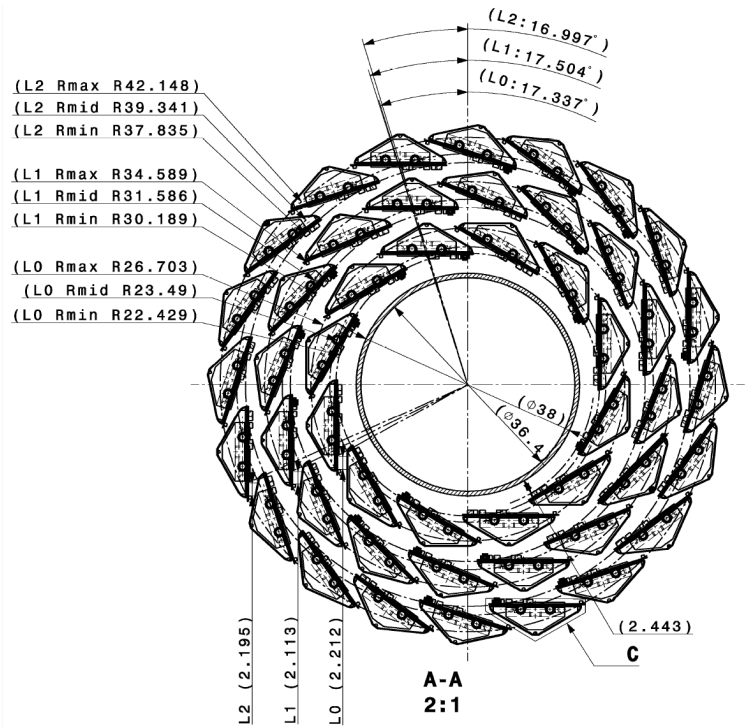
- Vertexing layers – 2-3 layers close to beam pipe with limited length (active area ~30 cm in z)
- Barrel layers – as many layers as needed. Generally built from “staves”. Lengths up to 2m.
- Discs – usually constructed of overlapping “staves” . Diameters up to 1m.

For all of the above structures, the lowest radiation length Silicon based constructions have been made with MAPS.

Estimates here follow the method used in the initial estimates described in:
https://indico.bnl.gov/event/7449/contributions/36038/attachments/27241/41530/2020_03_20_EIC_Si_services_parametrization_for_sim.pdf

Basis for rough estimation of radiation lengths





Si = 0.05% X/X0
Kapton = 0.1% X/X0
Al = 0.05% X/X0
Carbon = 0.05% X/X0

glue = 0.02% X/X0
other = 0.02% X/X0
water = 0.05% X/X0

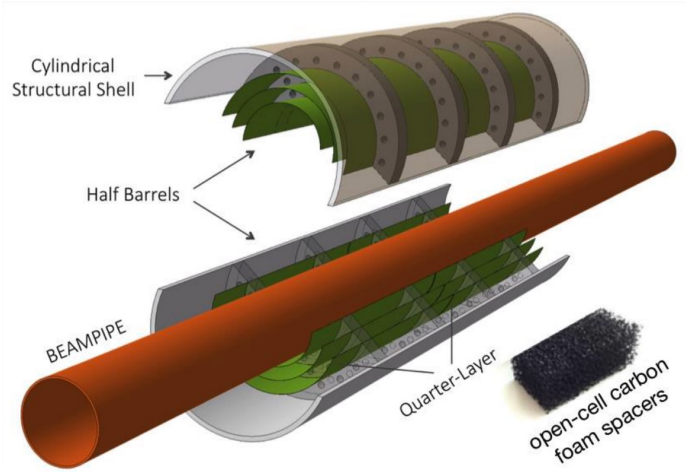
For perpendicular incidence without overlap (only slightly high in sum)

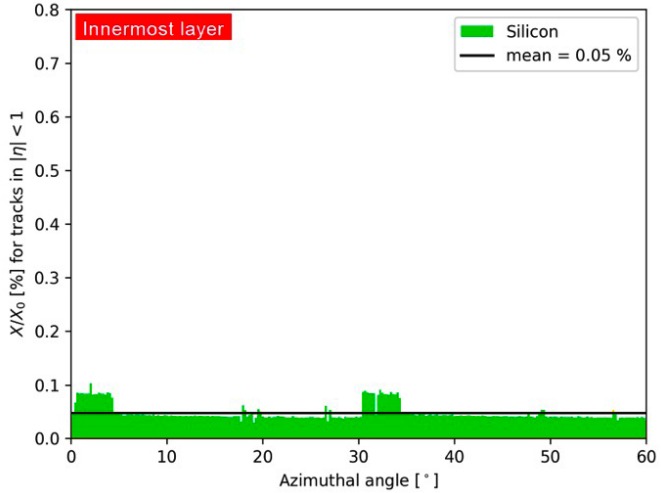
EICSC Estimates for Proposals

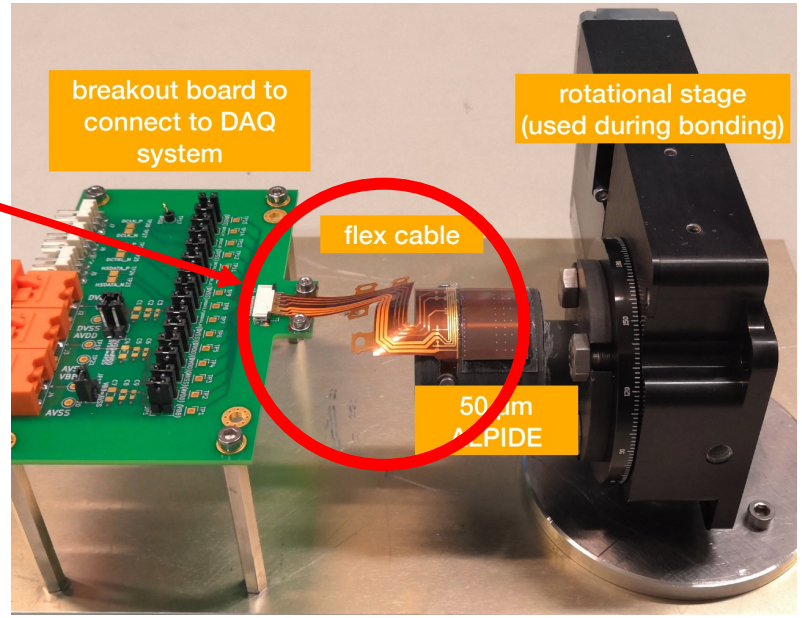
- ITS3 Like:
  - ITS3 sensor
  - Services & sensor barrel/vertexing layer X/X0 scaled from ITS2
  - Discs are based on extrapolation of ITS2 inner layer staves
- Reduced Services compared to ITS2
  - Less power needed (1.2 V instead of 1.8 V, 2/3 current)
  - Thinner silicon

Vertexing Layers

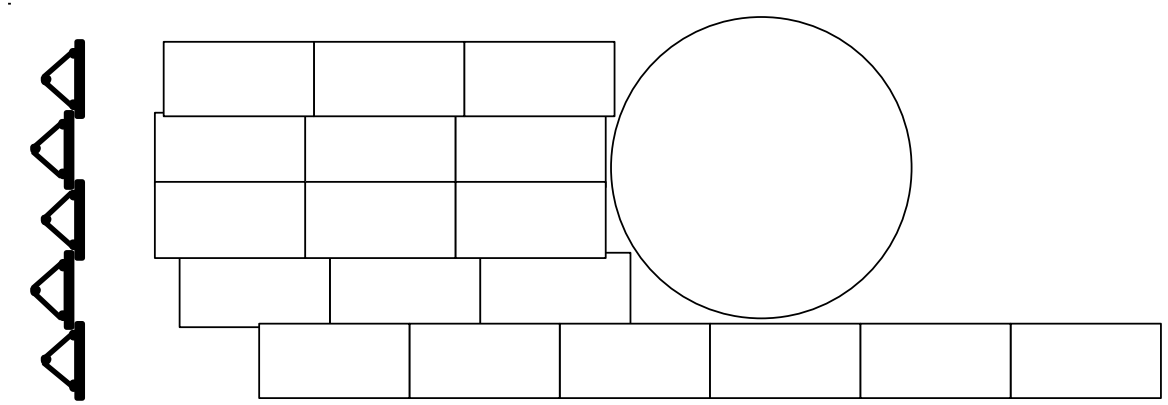
- Air cooling
- Carbon foam for support
- 0.05% X/X0
- Material at the ends of the vertexing layers





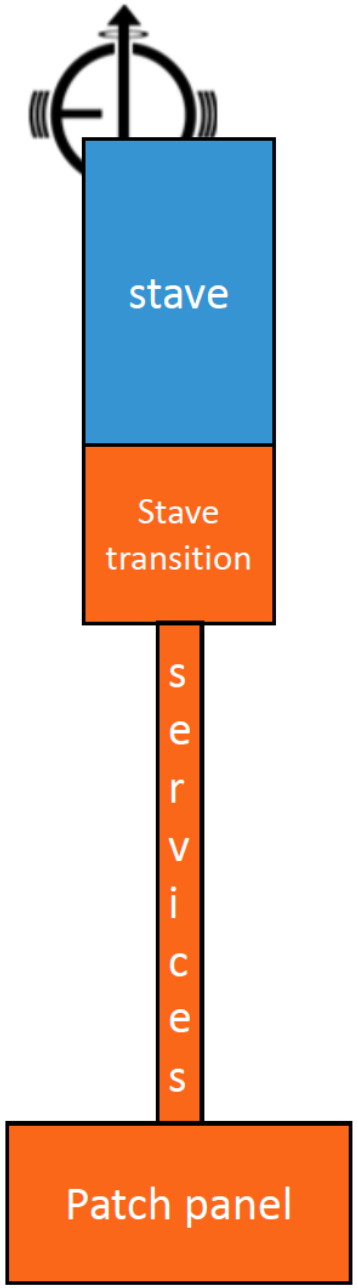


Staves/Discs



- Staves: 0.55% X/X0
  - Scaled from ITS2 outer barrel staves (~1% X/X0)
  - Up to 1.5 m length
  - Water cooling assumed
- Discs: 0.24% X/X0
  - Up to 60cm
  - Composed of ITS2 inner layer stave designs
    - Material budget the same (scaled)
  - Water cooling assumed

Summary of ITS3 like Si tracking



	Stave X/X0	Stave transition (per 100 cm^2 of Si surface)*	Services (per 100 cm^2 of Si surface)*	Patch panel (per 100 cm^2 of Si surface)*
ITS3 like vertexing	~0.1%	6.66 cm^3 of material with X/X0 of 0.0684 per traversed cm	2.96 cm^2 cross section with X/X0 of 0.022 per traversed cm	4.32 cm x 1cm x 1 cm with 0.102 X/X0 per traversed cm
ITS3 like barrel (up to 1.5m length)	0.55 %	4.286 cm^3 of material with X/X0 of 0.0684 per traversed cm	1.905 cm^2 cross section with X/X0 of 0.022 per traversed cm	2.778cm x 1cm x 1 cm with 0.102 X/X0 per traversed cm
ITS3 like disc (up to 60 cm diameter)	0.24%	6.66 cm^3 of material with X/X0 of 0.0684 per traversed cm	2.96 cm^2 cross section with X/X0 of 0.022 per traversed cm	4.321 cm x 1cm x 1 cm with 0.102 X/X0 per traversed cm

* Corrected 2021_03_13