The Layout of the ITk

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on behalf of the ITk project
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Requirements for phase II tracker

• Record a total integrated luminosity of 3,000 fb$^{-1}$
  • Places stringent requirements on the radiation tolerance of components (particularly sensors).
  • $2 \times 10^{15} \text{1MeV n}_{\text{eq}}/\text{cm}^2$ for strips and 10 times this for pixels, TID of 1 GRad
• Maximum instantaneous luminosity of $7.5 \times 10^{34} \text{cm}^{-2}\text{s}^{-1} (\langle \mu \rangle \sim 200)$
• Reconstruct vertices of pile-up events & associate vertex with the hard scatter
• Identify secondary vertices in b-jets with high efficiency and purity
• Measure the tracks in the cores of high energy jets with high efficiency
• Ensure a low rate for reconstruction of fake tracks
• Reconstruct the tracks associated with converted photons
• Be able to reconstruct and trigger on tracks out to the largest pseudo-rapidity
• Minimize the inactive material in the detector volume
• Input to a track trigger run at Level-1 (talk by Nikos yesterday)
ITk - Radiation Fluences: $1 \text{ MeV } n_{eq} \text{ cm}^{-2}$

Simulations with FLUKA to $3,000 \text{ fb}^{-1}$

216kGy, $5.3 \times 10^{14} n \text{ cm}^{-2}$
63kGy, $2.9 \times 10^{14} n \text{ cm}^{-2}$
288kGy, $8.1 \times 10^{14} n \text{ cm}^{-2}$

7.7MGy, $1.4 \times 10^{16} n \text{ cm}^{-2}$
0.9MGy, $1.7 \times 10^{15} n \text{ cm}^{-2}$
0.9MGy, $1.8 \times 10^{15} n \text{ cm}^{-2}$

McMahon: Layout of the ITk; ACES 16
ITk Design builds on experience with existing tracker

• However,
  • The pattern recognition, tracking reconstruction and performance requirements at Phase II are more challenging
  • The ITk will be an all silicon design and extend to higher rapidities
  • It will be more radiation tolerant
  • It might use new sensor technologies possibly including CMOS/MAPS (talk by Tobias)
  • It will use lower power electronics (130nm GF-strips and 65nm TSMC-pixels, Alex, Tobias)
  • Exploit DC-DC and Serial Powering for Front-End electronics (talks Laura and Peter yesterday)
  • HV multiplexing (talk by Peter yesterday)
  • Challenges in data transmission at low mass (talk by Martin yesterday)
  • More efficient use of higher bandwidth optical links
  • It will use CO2 cooling (new environmental challenges)
  • **Lower mass construction**
    • It will use new readout technologies and architecture
    • It has to be installed differently
    • The access and maintenance constraints are more challenging
    • ...

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  - HV multiplexing (Peter)
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  - …
Detector Challenges: cooling at small radius...

$T_{\text{evap}} = -30^\circ\text{C}, 150\mu\text{m sensor}$

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Evolution of ITK including layouts

• Phase II - Letter of intent (December 2012)
  http://cds.cern.ch/record/1502664?ln=en

• ATLAS ITk Initial Design Report (Internal-October 2014)
  Internal

• ATLAS Scoping document (September 2015)
  https://cds.cern.ch/record/2055248?ln=en
  Cost vs performance of tracker studied in detail
  Compare 3 tracking detectors
The reference tracking detector presented in the scoping document: https://cds.cern.ch/record/2055248?ln=en
Motivations for the extension in acceptance

Figure 87. The efficiency for pile-up jets as a function of the efficiency for hard-scatter jets with $40 < p_T < 50$ GeV using a track-matching algorithm for $\mu = 140$ (left) and $\mu = 200$ (right). The algorithm can be applied in $|\eta| < 2.4$ the Low scenario, $|\eta| < 3.2$ in the Middle scenario and $|\eta| < 3.8$ in the Reference scenario.

https://cds.cern.ch/record/2055248?ln=en
New Layouts: Extended 4.0 (3.2 also under study)
New Layouts: Inclined 4.0 (3.2 also under study)
ITk Strips

See talk by Alex Grillo later this morning
ITk Strips

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ITk Strips

CF blades are single units. CF structure to hold blades.

CF wheels with spokes are single units. Wheels are put on inner tube. Petals are mounted on wheels.

See talk by Alex Grillo later this morning
The Extended Pixel Barrel Option

- **Main idea:** Long clusters = “tracklets”, providing initial precise estimates of $\theta$ and $z_0$
  - Seed pattern recognition
  - Potential to reduce fake rate
  - Potential to reduce CPU time

**Basic information about sensors:**
- Barrel Layer-0,1 & inner end-cap ring: $50 \times 50 \times 100 \, \mu m^3$
- Barrel Layer-2,3,4 & end-cap: $50 \times 50 \times 150 \, \mu m^3$

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Courtesy Sasha Pranko

See talk by Tobias Flick later this morning
The Extended Pixel Barrel Option

I-beams: low-mass carbon composite support structure

"tracklets", estimates of $\theta$

Barrel Layer-2,3,4 & end-cap: $50 \times 50 \times 150 \, \mu m^3$

Courtesy Sasha Pranko
The Extended Pixel Barrel Option

Courtesy Sasha Pranko
Inclined Sensor Option for Pixels: SLIM

- Single skin CFRP 0.325 mm thick [0, 45, 90, -45, 0]
- 2 meters long (5th layer)
- ~180 gr CFRP skin
Inclined Sensor Option for Pixels: SLIM

- Single skin CFRP 0.325 mm thick [0, 45, 90, -45, 01]
- 2 meters long
- ~180 gr CF

Conductive epoxy

TEMP °C

Soldering

Courtesy Sébastien Michal
Inclined Sensor Option for Pixels: SLIM

Courtesy Sébastien Michal
ITk Pixel Inclined Sensor Option: ALPINE

Courtesy ALPINE team
ITk Pixel Inclined Sensor Option: ALPINE
ITk Timeline

- Timeline: End-Game

![ITk Timeline Diagram]

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ITk Timeline

- Timeline: TDRs and into production...

![ITk Timeline Diagram]
Conclusion

• ITk design builds on the positive experience accumulated in the construction of the existing Inner Detector and its operation in Run-1
• However, the new design responds to the unique new challenges that are presented for a tracker to exploit the physics at Phase II
• Development is going very well
  • See talks of Alex and Tobias
• First stage of layout decisions will take place in 2016 (ahead of strip TDR)
• Preparing for TDRs in 2016 and 2017
• Will also deliver an ID decommissioning report at the end of 2017