HGTDD (High Granularity Timing Detector) project: Status, Plans

A. Henriques, Francesco Lanni
HGTD in the upgrade scoping document

- ATLAS circulation process (15/8, 22/8) completed
  - [ ] https://cds.cern.ch/record/2046182
  - [ ] Approval by EB last Friday

- Part of the calorimeter upgrade plans in the “Reference Detector” scoping scenario chapter V.5. Motivation in chapter XI.2.7.5

- Release of final draft for review to the LHCC (in confidential form) and UCG last Wednesday
  - [ ] Draft to be used for review during LHCC week on September 21st
  - [ ] Final document to be made public before review (only polishing)
HGTG Steps towards a project

• In the discussions post-large eta task force between a few of us, upgrade coordination and LAr mgmt. was agreed to host this activity within the LAr system

• There are obvious implications/benefits/consequences to the LAr End-cap and Forward calorimeters if the region is instrumented with a new detector (timing or timing/preshower)

• There are existing successful examples of Phase-I upgrade projects, born from existing systems and sharing with them for example IBs: e.g. FTK, NSW
**HGTD envelope**

- Install in region partially used by MBTS (to be removed in phase 2 upgrades)
- 4 active layers per side (~10 m² in total)
- HGTD baseline dimensions:
  - \( Z = [3475, 3545] \text{ mm} ; \Delta Z = 70 \text{ mm} \)
  - \( R \) and \( \eta \) coverage:
    - \( R_{\text{min}} \sim 90 \text{ mm} \) \((\eta_{\text{max}} \approx 4.3)\)
    - \( R_{\text{max}} \sim 600 \text{ mm} \) \((\eta_{\text{min}} \approx 2.4)\)
    - Possible to extend \( \eta = 5.0 \) \((R_{\text{min}} \sim 50 \text{ mm})\)
- Recent idea to be evaluated: possible to fix instead in the barrel; advantages?
Dimensions of HGTD vs eta coverage

Extension to η=5 possible with an optimized mechanical support. Mostly dependent on radiation resistance of hardware, occupancy, needed granularity,…

Total surface if 8 layers (4 layers /side)

~ 10 m² (2.4<η<4.3)

Total surface highly dependent on η_{min}, much less on η_{max}
HGTD requirements and possible Technologies

- Time resolution ~30-50ps in total. If 4 layers /side the resolution requirement per single layer ~ 60-100ps (60-100 ps/sqrt 4).

- Granularity ~ 1-100mm², probably varying vs η (perf. vs. cost)

- Different technologies considered (rad. hardness, time resol., space constrains are challenging requirements), more details: https://indico.cern.ch/event/403701/contribution/2/0/attachments/808851/1108458/chiodini_timing_detector_2015_07_03.pdf

- Possible to instrument HGTD as pre-shower (~3X0 active/W). Full simulation needed to access performance for e/γ, **HIGH PRIORITY!**

<table>
<thead>
<tr>
<th>Area [mm²]</th>
<th>Resolution/MIP</th>
<th>Noise [e⁻ rms]</th>
<th>Efficiency/MIP</th>
<th>Max. Dose [Mrad]</th>
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</thead>
<tbody>
<tr>
<td>Hybrid pixel</td>
<td>20×20</td>
<td>100</td>
<td>10</td>
<td>100</td>
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<tr>
<td>HVCMOS pixel</td>
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<td>100</td>
<td>10</td>
<td>30-100</td>
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<td>Low-Gain Avalanche Detector</td>
<td></td>
<td>10</td>
<td>10-50</td>
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<tr>
<td>Poly-diamond strips</td>
<td>5×5</td>
<td>100</td>
<td>10</td>
<td>500</td>
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<tr>
<td>Photocathode MCP</td>
<td>50×50</td>
<td>10</td>
<td>100</td>
<td>photon statistics</td>
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<tr>
<td>Fiber bundle</td>
<td>1000×50</td>
<td>50</td>
<td>100</td>
<td>photon statistics</td>
</tr>
<tr>
<td>Ionization MCP</td>
<td>200×200</td>
<td>30</td>
<td>100</td>
<td>100</td>
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</tbody>
</table>

+ (missed in the table)

**MPGD**

2000x2000 35 100 ? photon statistics 10-100?
Timing Pre-sampler option

- For example: Si+W preshower (~ 3X0 in front of EMEC/FCAL1)
- Assume \(R_{\text{min}}=50-90 \text{ mm}; \ R_{\text{max}}=600 \text{ mm} \); \(DZ_{\text{max}}=70\text{ mm}\)
- Baseline: (4 Si + 3 W layers) /side (~3mm thick W layers)
- Each layer surface: \(\sim 1.1 \text{ m}^2 \Rightarrow \sim 10 \text{ m}^2 \) active layers
- Tungsten:
  - \(\sim 3X_0 \sim 10\text{mm} \) W \((X_0=3.5\text{mm}; R_M = 9 \text{ mm}; \lambda_i=96\text{mm})\)
  - Few hundred kilos (193 kg only W/side) to support on EC cryostat
- Readout Electronics. If pads of \(\sim 25 \) (50) \(\text{mm}^2 \Rightarrow 42k \) (21k) \(pads/layer \Rightarrow 336k \) (168k) \(total channels\)
- Cooling...dependent on technology chosen

Full simulation required to prove benefit for performance (photon conversions), in parallel with radiation level estimations for ITK and calorimeter.
Radiation Levels in HGTD region:

• Simulations required, in particular for the pre-shower option (synergies with ongoing checks impact on ITk, min-FCAL vs sFCAL, …)

• Calculations for the Run-2 geometry (scaled to 3000 fb⁻¹):

  - \((0.1-0.3) \times 10^{16}\) n/cm²
  - \((3-24) \times 10^{14}\) hadrons/cm² (>20 MeV)
  - many Mrad

C. Young
HGTD general information

- Please subscribe to email list ! : atlas-larg-upgrade-hgtiming@cern.ch
- Twiki: https://twiki.cern.ch/twiki/bin/view/LAr/HighGranularityTimingDetector
- Meetings (~ monthly, Friday 3pm) Indico: https://indico.cern.ch/category/6660/
- Meetings in 2015 : 3 July; 4 Sept.; 2 Oct.; 6 Nov.; 4 Dec
Next steps and priorities:

- **Organization:**
  - *Structure the activities in a more formal organization that we will propose and share by the next meetings.*
  - We need it to progress efficiently and effectively toward a potential upgrade project.

- **Call for expression of interests:**
  - Get feedback of the community, at an individual or institutional
  - *Collect 1-2 pages of what is your specific interests* wrt. detector technologies, integration aspects with the existing calorimeters and in ATLAS, and, critically importantly, wrt. performance & physics studies

- **Simulation and Performance:**
  - *Need to establish as highest priority, proper full simulation framework of the HGTD,* to quantitatively estimate benefits for object performance and physics analysis: Geometry, digitization/readout, reconstruction etc…are critical steps to this activity to mature in a formal upgrade project within ATLAS.
  - *Definition of performance benchmark studies to be prioritized* (together with CP groups and Upgrade Physics community)
  - *Groups interested to a specific technology are strongly encouraged to contribute to simulation and performance studies.*
  - Please contact us!
<table>
<thead>
<tr>
<th>Time</th>
<th>Session Description</th>
<th>Speaker(s)</th>
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<tbody>
<tr>
<td>15:00 - 15:15</td>
<td>Introduction 15'</td>
<td>Ana Maria Henriques Correia (CERN), Francesco Lanni (Brookhaven National Laboratory (US))</td>
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<tr>
<td>15:15 - 15:30</td>
<td>A Silicon HGTD detector inspired in Calice 15'</td>
<td>Laurent Serin (LAL-CNRS/IN2P3 Orsay(Fr)), Dirk Zerwas (Laboratoire de l'Accelerateur Lineaire (FR))</td>
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<td>15:30 - 15:45</td>
<td>Update of jet performance 15'</td>
<td>Ariel Gustavo Schwartzman (SLAC National Accelerator Laboratory (US)), Francesco Rubbo (SLAC National Accelerator Laboratory (US))</td>
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<td>15:45 - 16:00</td>
<td>Plans for e/g perf. studies and implementation of timing device in full simulation 15'</td>
<td>Usha Mallik (University of Iowa (US))</td>
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<td>16:00 - 16:15</td>
<td>Update on ETmiss performance (tbc) 15'</td>
<td>Stephanie Majewski (University of Oregon (US))</td>
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<td>16:15 - 16:45</td>
<td>Institutes that expressed so far interest to join the timing device (HGT D) project 30'</td>
<td>Brazil Cluster (Sao Paulo); Canada (Vancouver, Victoria); CERN; France (Orsay LAL, Orsay Omega, Paris V &amp; VII, Saclay); Russia (Novosibirsk, Protvino); Sweden (Stockholm); USA (BNL, Iowa, Oregon, Pittsburgh)</td>
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<td><strong>IN2P3</strong></td>
<td>Laurent Serin (LAL-CNRS/IN2P3 Orsay(Fr))</td>
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<td><strong>University of California, Santa Cruz</strong></td>
<td>Abraham Seiden (University of California, Santa Cruz (US))</td>
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<td><strong>SLAC</strong></td>
<td>Ariel Gustavo Schwartzman (SLAC National Accelerator Laboratory (US))</td>
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<td><strong>Iowa University</strong></td>
<td>Usha Mallik (Iowa)</td>
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<td><strong>University of Pennsylvania</strong></td>
<td>Elliot Lipeles (University of Pennsylvania (US))</td>
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...Institutes xxx to be added once confirmed...
Back-up slides