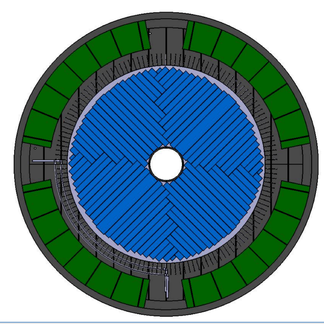
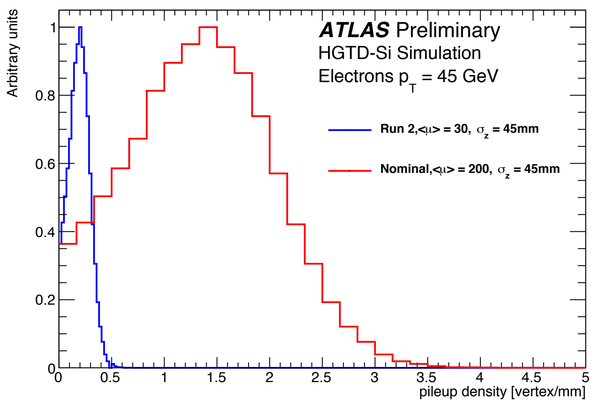
Poster Session HSTD – OIST - December, 2017

A High-Granularity Timing Detector (HGTD) in ATLAS : Performance at the HL-LHC

The High Granularity Timing Detector (HGTD) is a detector composed of silicon layers with pads of 1.3x1.3mm^2 that is proposed to be put in front of the end cap of ATLAS for the HL-LHC. The high granularity and excellent timing resolution adds new capabilities for physics analyses at the HL-LHC.



Pile-up Mitigation

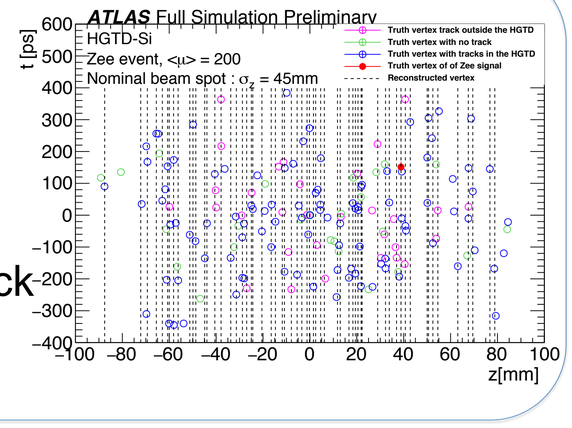


HL-LHC beam spot :

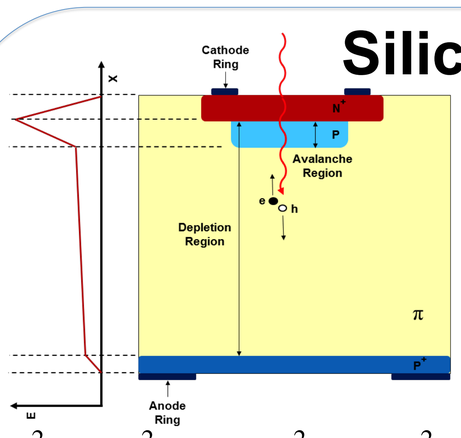
- 200 pileup (PU) interactions
- σ_z = 150ps (45mm)
- σ_t = 175ps
- in average : 1.6 vertex/mm

HGTD :

- Coverage : 2.4 < |η| < 4.0
- End-caps : z = ± 3.5m
- 30ps resolution per MIP
- Can assign a time to each track
- Time measurement resolves vertices merged in space



Silicon Sensors

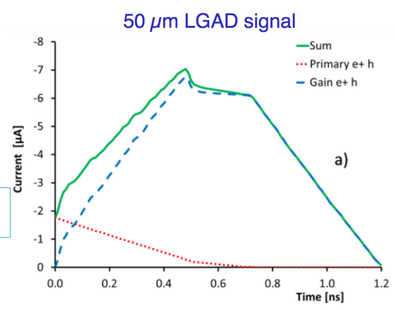


- 1.3x1.3 mm^2 pads
- LGAD sensors
- Moderate gain ≈ 20
- Thin sensors ≈ 50 μm
- Good time resolution

$$\sigma^2_{\text{det}} = \sigma^2_{Landau} + \sigma^2_{jitter} + \sigma^2_{TW} + \sigma^2_{TDC}$$

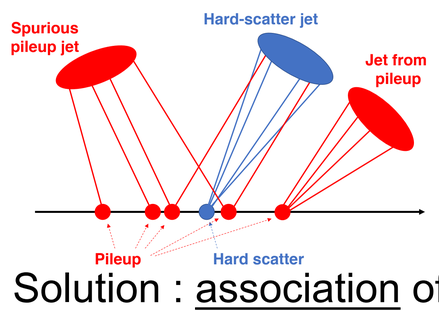
$$\sigma^2_{jitter} = \left(\frac{t_{rise}}{(S/N)}\right)^2$$

- σ^2_{Landau} → Thin sensor
- σ^2_{jitter} → Gain
- σ^2_{TW} → time walk compensation
- σ^2_{TDC} → Fine digitisation



Expected time resolution : 30 ps (60ps after irradiation)

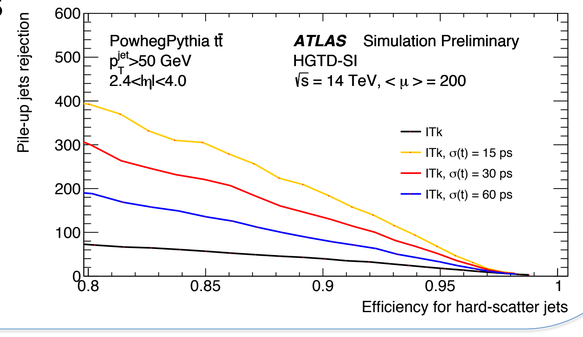
Object reconstruction : Jets



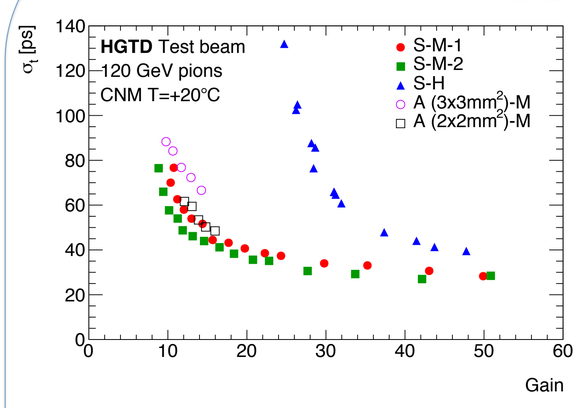
Pileup :

- Can contaminate the jets of interest
- Can also produce additional jets :
  - ➢ As hard QCD process
  - ➢ As particles from multiple vertices

- Solution : association of jets with tracks and primary vertices
- Improved by timing information
- With σ(t) = 30 ps, rejection improved by factor of 4

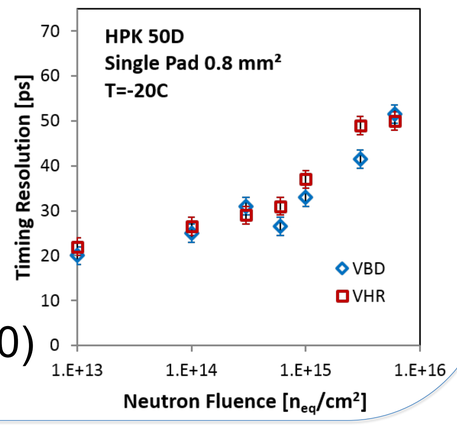


Test Beam

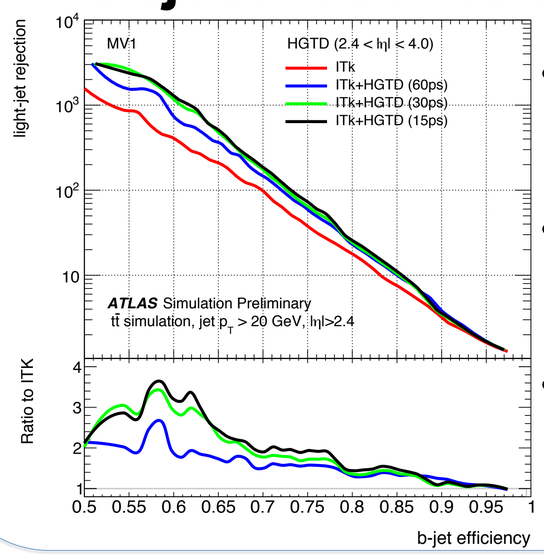


- Beam test campaign at CERN in Autumn 2016
- Gain 20 : σ_t = 40ps
- Gain 40 : σ_t = 27ps
- Very good efficiency and time resolution uniformity

- Irradiation change the effective doping concentration
- Gain decrease with irradiation
- Above 10^{15} neq/cm^2 : no difference with a pin diode
- Bulk gain created by irradiation (≈10)



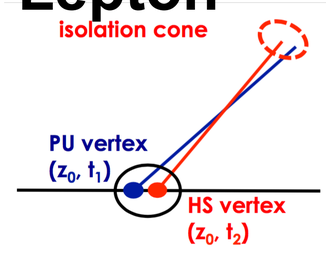
Object reconstruction : *b*-tagging

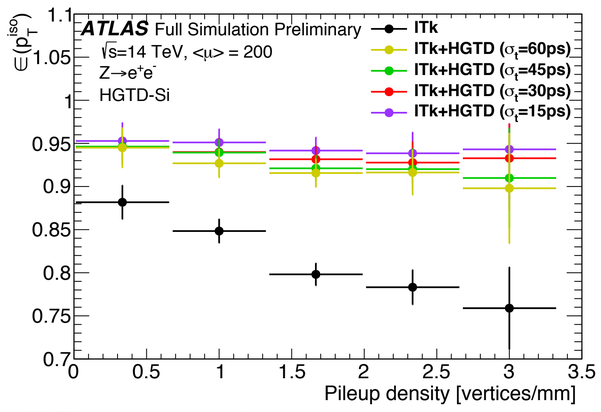


- *b*-jets ➔ displaced vertex ➔ large z_0 window ➔ very sensitive to pileup
- HGTD ➔ reduction of the PU contamination ➔ Improvement of the *b*-tagging efficiency
- 70% efficiency ➔ rejection improved by a factor of 2

Object reconstruction : Lepton

- Isolation efficiency : probability that no PU track with pT>1GeV is within dR = 0.2 from the electron
- Needed to separate HS electrons from electrons coming from decays, conversions or fakes

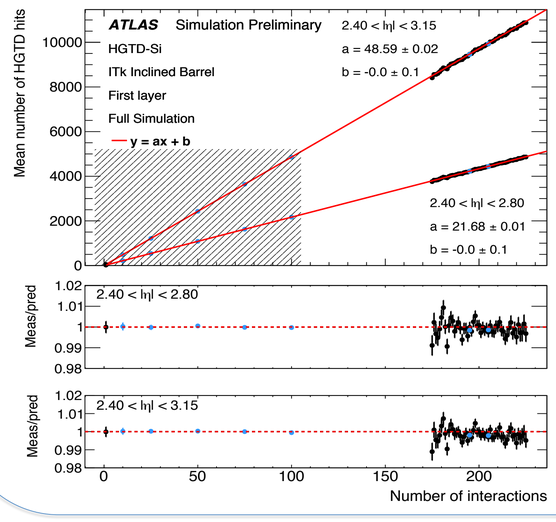




- ITK : only the track from the primary vertex
- HGTD+ITK : tracks with a time compatible with the vertex

- Efficiency almost independent of the PU density with the HGTD

Luminosity



- HGTD : measurement of the luminosity at each bunch crossing
- Number of HGTD hits ∝ number of interactions per crossing (μ)
- Good linearity ➔ precision of a few % on μ

Corentin Allaire (LAL-Orsay), on behalf of the HGTD activity