T-CAD simulation of Lorentz angle

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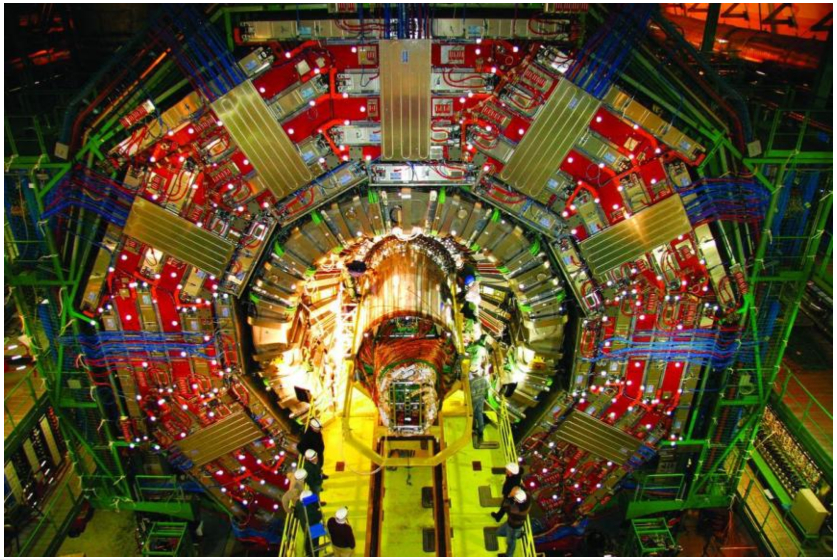
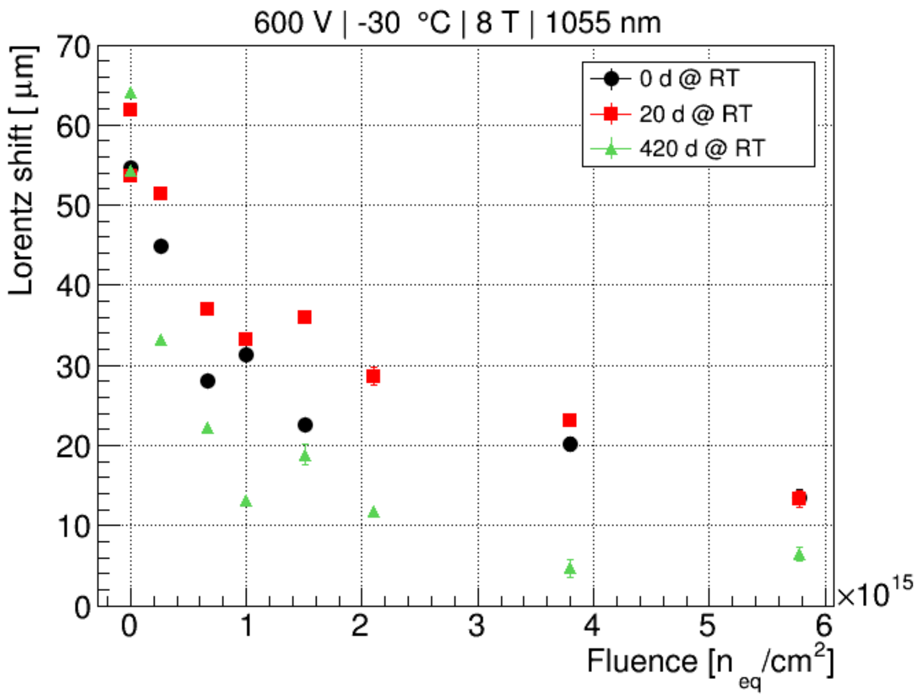


Motivation

- Distribution of electric field in sensor is important for understanding radiation induced damage
- Lorentz angle changes with irradiation fluence



- It would be great to have a simulation describing fluence dependence, especially since every tracker layer will accumulate different fluence

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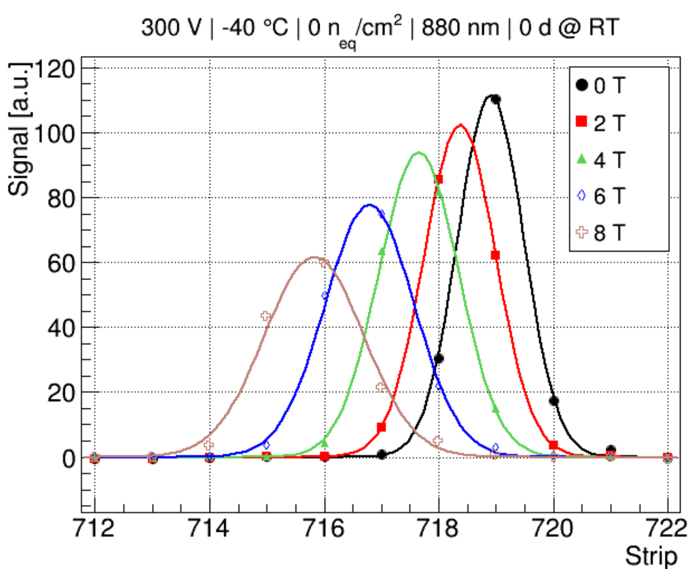
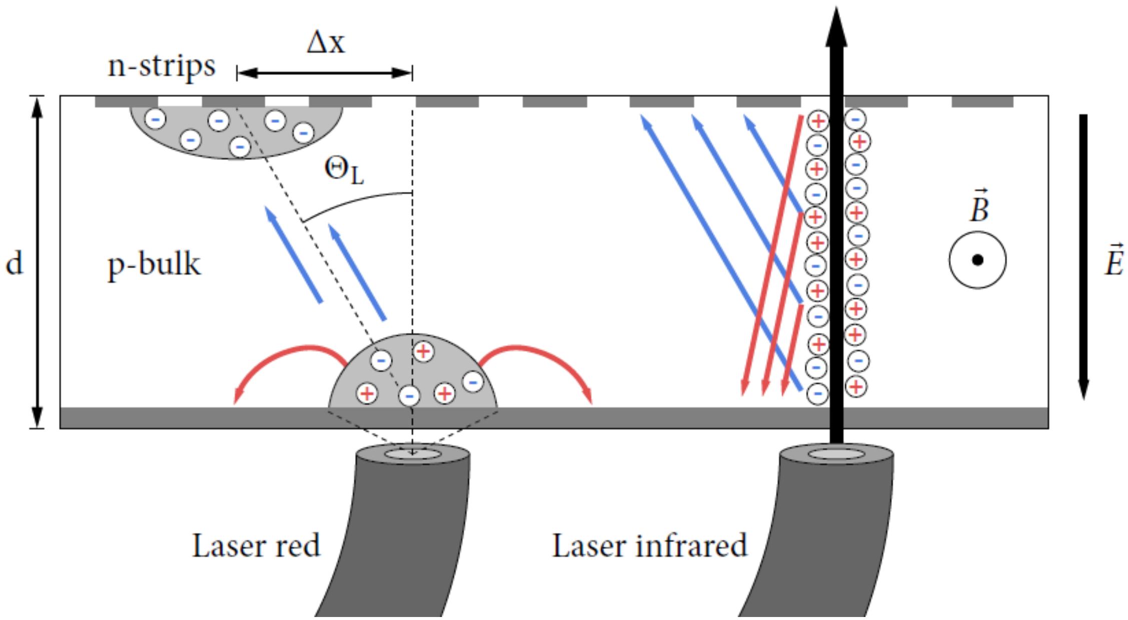
Measurement principle

- Illuminate backside of silicon strip sensor with a short laser pulse in a magnetic field
- Drifting charge is deflected by the Lorentz force
- Measure shift as a function of the magnetic field and applied bias voltage





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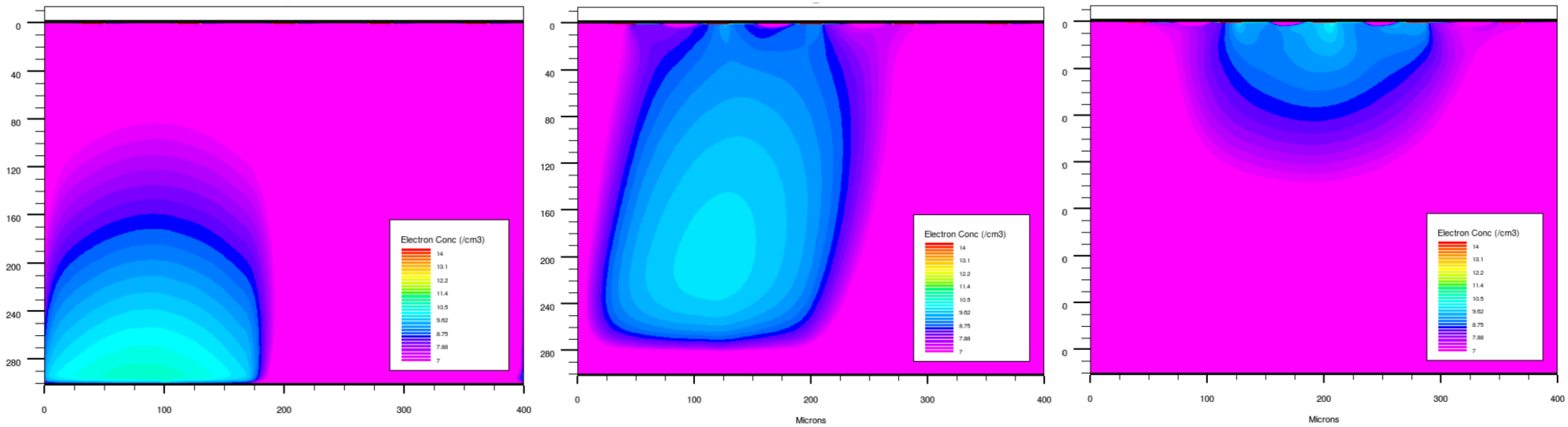
T-CAD simulation of drift in B-field

- Transient simulation of induced signals on AC coupled strips
- 880nm laser wavelength

- Simulated electron density at three time steps



- Charge is created at the sensor backside
- Deflection due to Lorentz force

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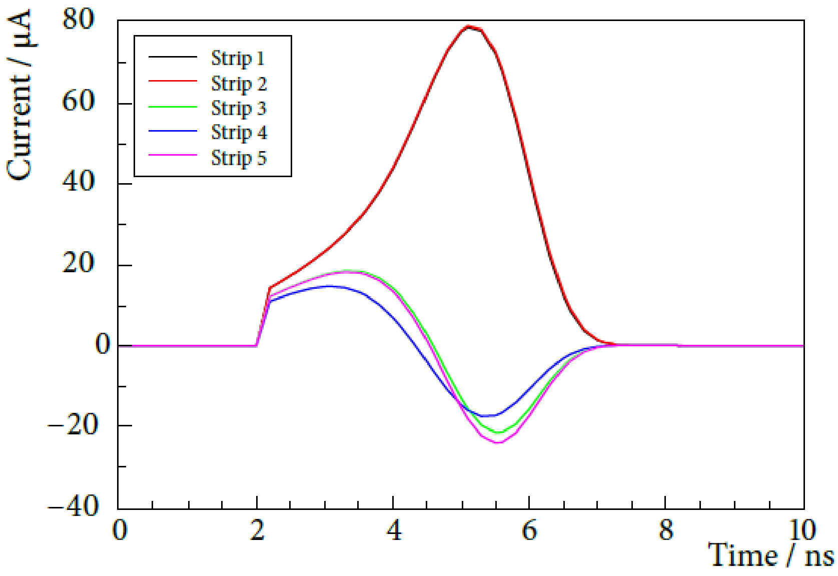
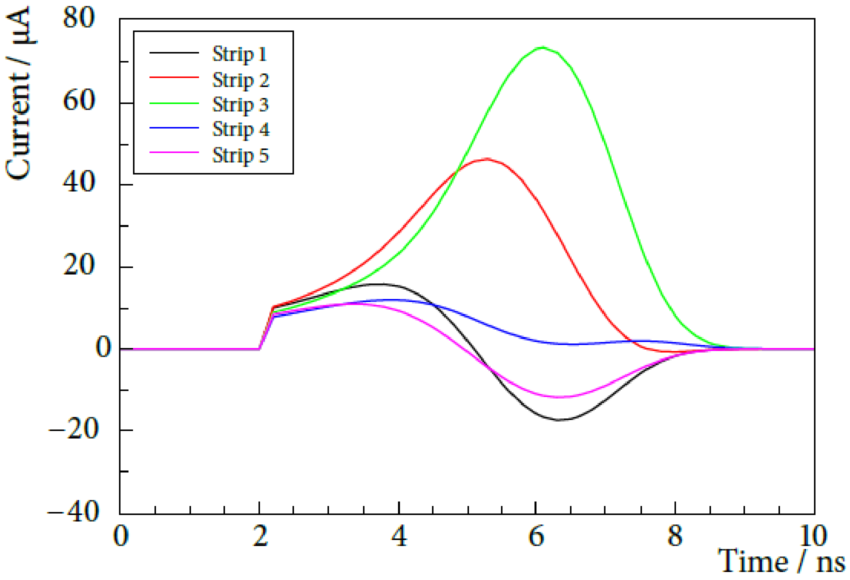
Induced current

- Drifting charge induces current in ac readout strips
- Integrate pulse to obtain charge signal per strip

- Perform same analysis as for measured data
  - Charge position from gauss fit
  - Calculate shift by comparing to 0T reference point





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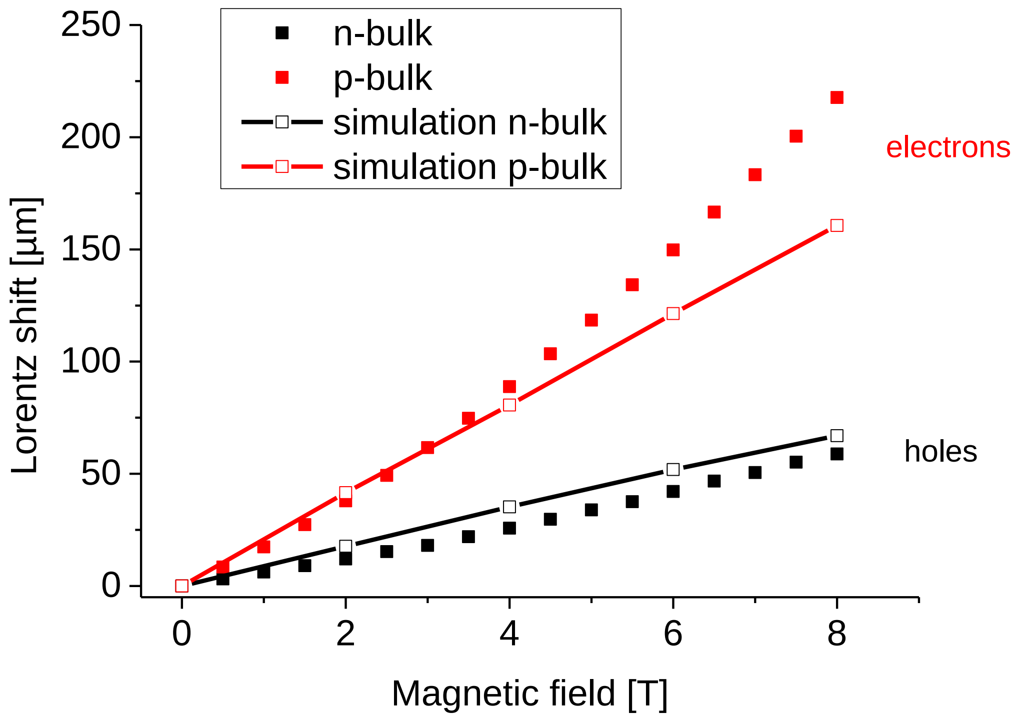
Results (non-irradiated)



- Lorentz shift rises with B-field
- Shift is larger for electrons compared to holes
- General trend is reproduced by simulation
  - Deviations for electrons above 4T

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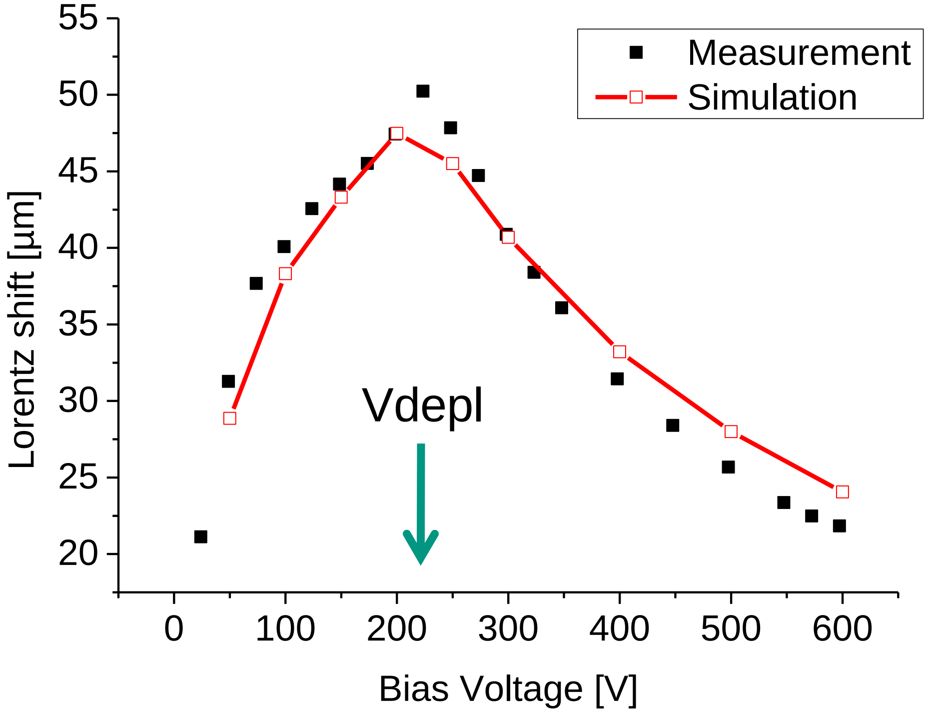
Bias voltage



- Lorenz shift depends on bias voltage
- Behavior of electrons reproduced nicely

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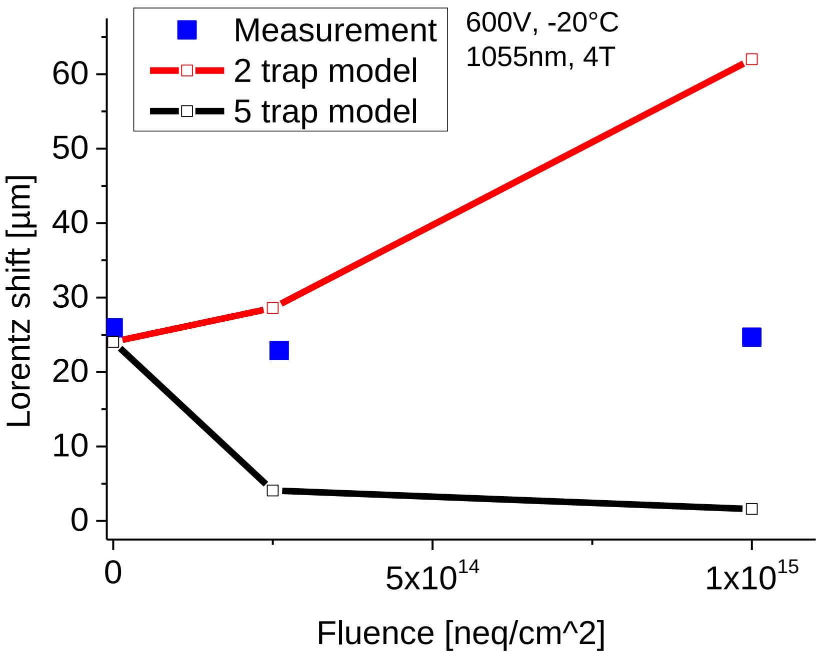
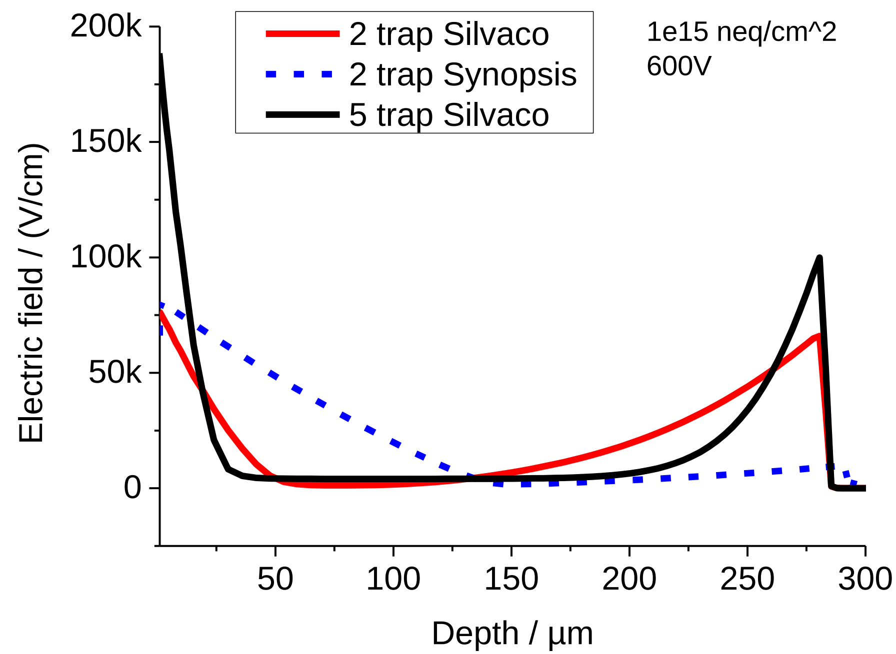
Irradiation model

- Include defects in simulation
- Effective trap models
  - 2-trap model for proton irradiation (R. Eber, PhD thesis)
    - Developed for Synopsis T-CAD
    - Describes TCT and CCE correctly (with Synopsis T-CAD)
  - 5-trap model (Univ. Delhi)
- Study influence on charge carrier drift and Lorentz angle

Comparison to measurement

- Testing different irradiation models





- Proton irradiated micron FZ sensors
- Models do not describe fluence dependence of Lorentz shift correctly
- Models give different shape of E-field than in Synopsis
- Tuning with Silvaco necessary

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Summary

- Silvaco T-CAD simulation of silicon strip sensor including B-field
- Describes measurements on non-irradiated sensors
- This opens door for combination with effective trap models describing radiation damage

- Ongoing work to adapt and refine damage model to describe Lorentz angle measurement performed with laser method

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BACKUP

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2 trap model

- PhD thesis Robert Eber
- Effective irradiation model (tuned especially for proton irradiation)
- Tuned with Synopsis T-CAD

- 2 traps
  - 1 donor
  - 1 acceptor

Parameter	Donor	Acceptor
Energy	E_V + 0.48eV	E_C - 0.525eV
Concentration (cm^3)	5.598 * **F** – 0.959e14	1.189 * **F** + 0.645e14
σ(e)	1.0e-14cm^2	1.0e-14cm^2
σ(h)	1.0e-14cm^2	1.0e-14cm^2

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