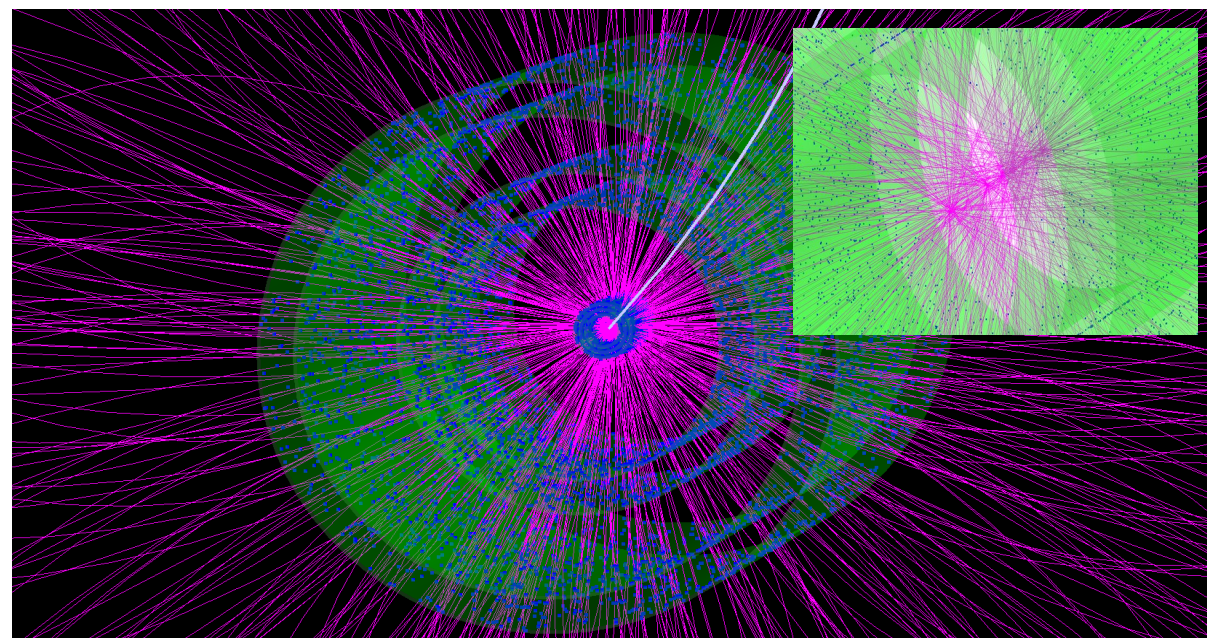A Large Ion Collider Experiment

ITS O2 status

- **Detector geometry**
  - classical geometry
  - geometry with sagging

- **Simulations:**
  - ALPIDE response
  - digitization

- **Reconstruction:**
  - cluster finding
  - cluster-topology handling
 - Cellular Automaton track finding

- **Overall status & plans**

cnrs
advancing the frontiers

Université de Strasbourg

iPHC
Institut Pluridisciplinaire Hubert CURIEN STRASBOURG

ALICE

"Classical" geometry

- Fully operational, down to FPC details in the acceptance
- Services (support wheels→patch panels) to be implemented

Checked with old (DCDC) services in AliRoot:
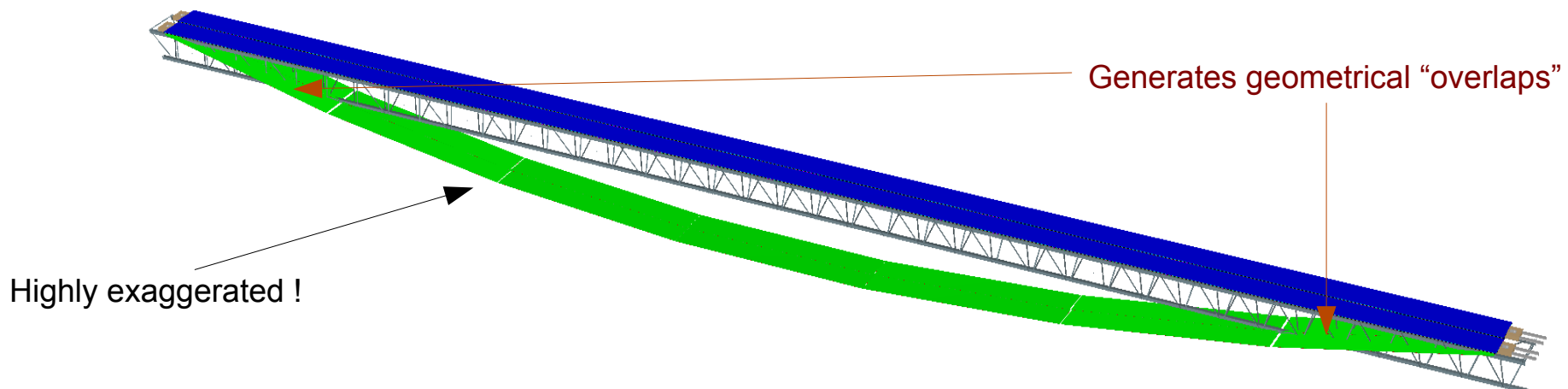very little impact on the reconstruction

~5% hits more, if "all is copper"
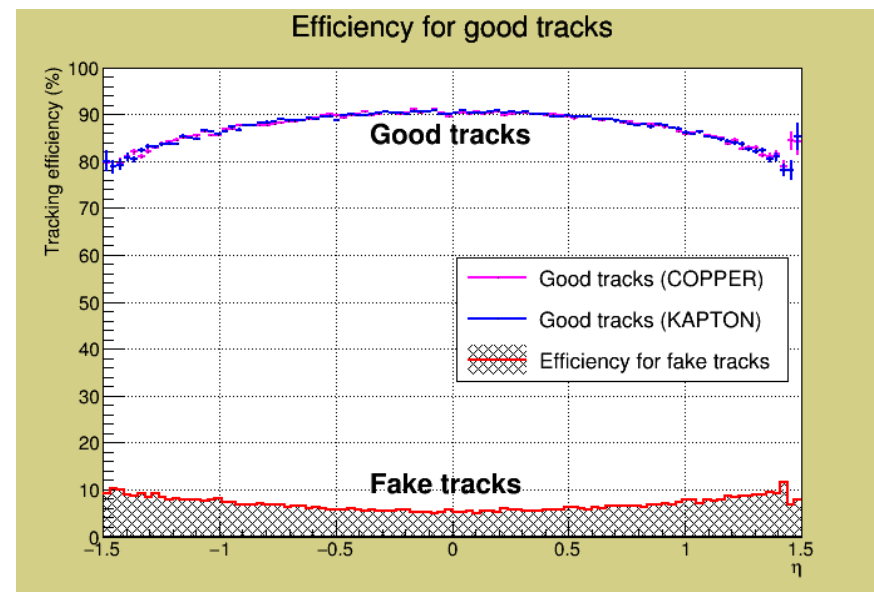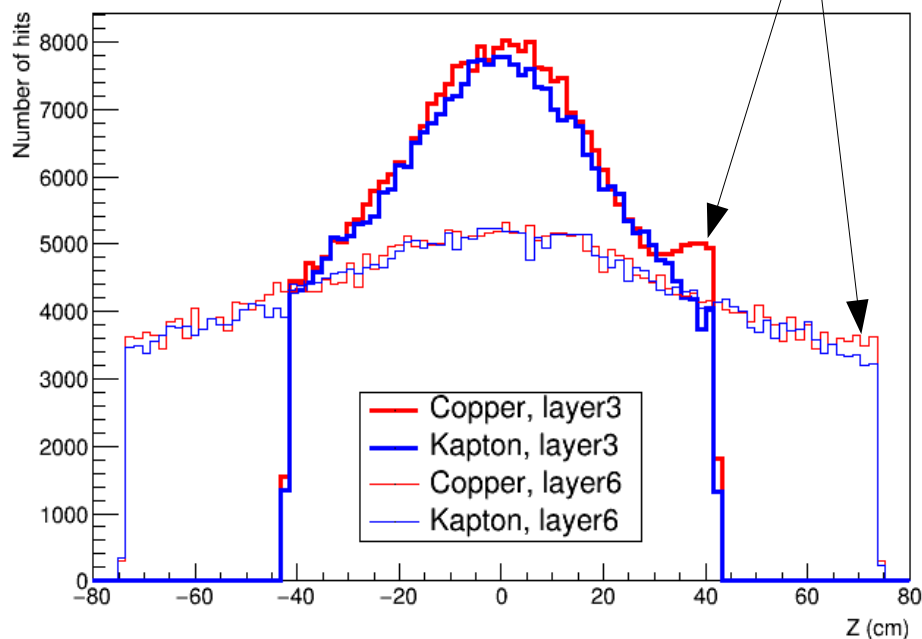
Geometry with sagging

- **To be implemented in 2019**

- **However, we may already say:**

  - ◆ Angular and impact parameter resolutions <u>at the primary vertex</u> do not change

  - ◆ Marginal deterioration of the momentum resolution

  - ◆ The angular track parameters <u>at the outermost layer</u> are slightly affected

  - ◆ The positional track parameters change according to the magnitude of sagging (~80 μm at z=0)

  - ◆ The ITS standalone tracking efficiency does not change

  - ◆ The TPC-ITS track-matching efficiency should not be dominated by sagging (to be demonstrated)

**The results obtained with a modified version of the "classical" geometry:**

- ◆ OB modules shifted and rotated according to expected sag deformations (z and ϕ dependent)

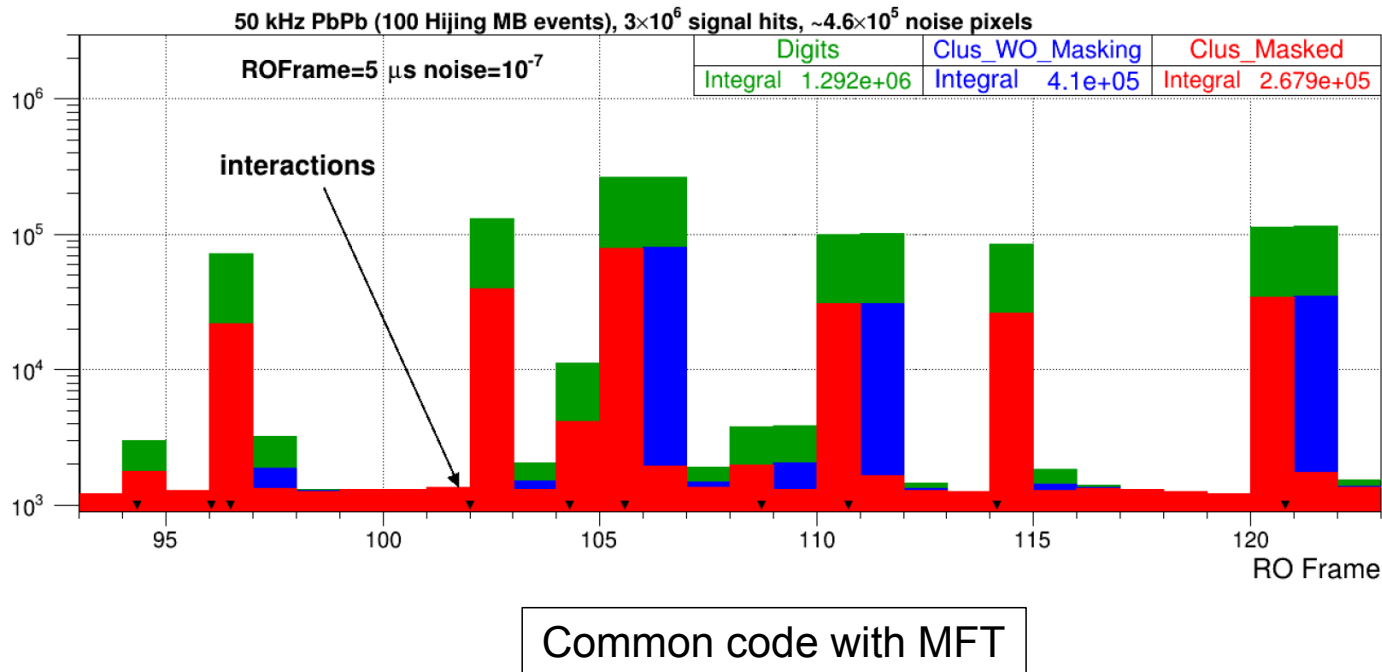- ◆ Good for a quick look at produced effects, but cannot be the final solution

Generates geometrical "overlaps"

Highly exaggerated !

3

Simulated ALPIDE response

- **Input 3D tables extracted from external to O² simulations**

  - ◆ Tables: probability for an electron deposited at (x,y,z) to reach a collecting diode

  - ◆ Tables for V_{bb}=-3V provided and successfully used in MC productions

  - ◆ Tables for V_{bb}= 0V coming early in 2019

- **The tables are queried when digitizing Geant hits**

  - ◆ Electrons distributed along particle trajectories inside sensitive Si

  - ◆ "Collection" by pixels in accordance with the provided probability tables

  - ◆ Works quite well for MIPs in a wide range of track inclination angles

  - ◆ To be checked for highly ionizing particles

Common code with MFT

ALI−PERF−311632

Digitization

- **An effective time response applied as a function of the number collected electrons**
  - ◆ Extracted from actual measurements

- **The output of the time response compared with a threshold and a strobe**
  - ◆ The threshold, strobe delay and length are parameters
  - ◆ Additional parameter for continuous readout: time interval between strobes

Common code with MFT
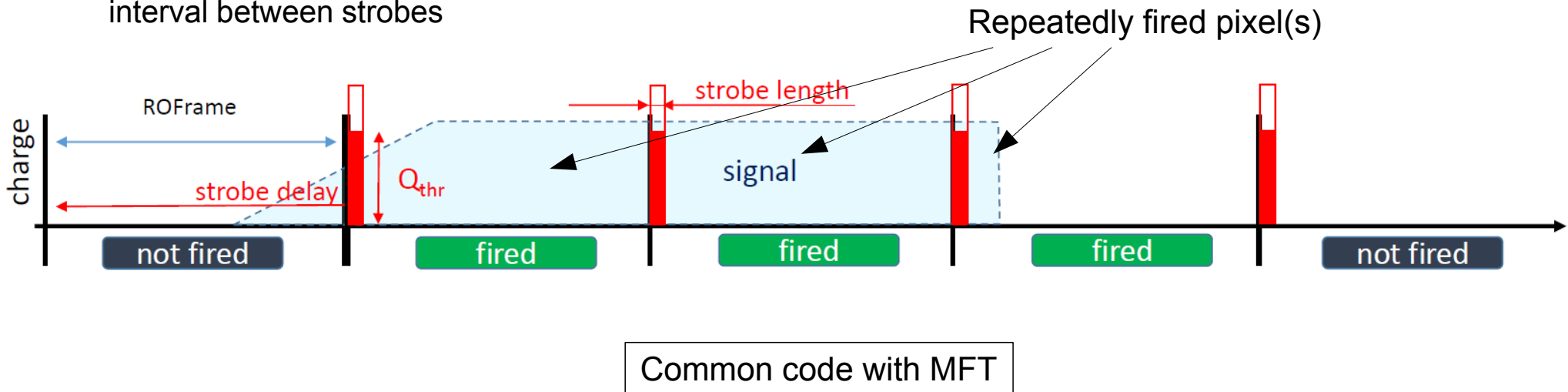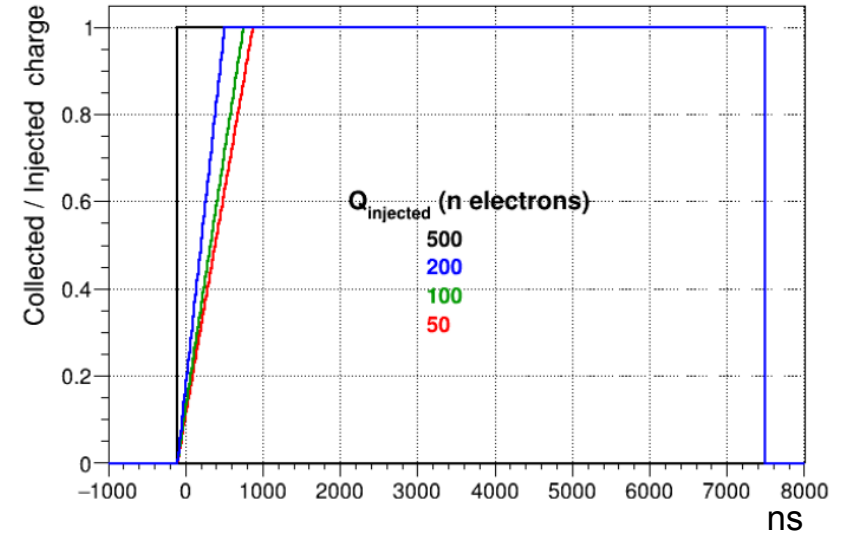
Cluster finding

- **Described in IB's talk at the 11th Workshop in Hiroshima**
- **New : Treatment of repeatedly fired pixels**
  - ◆ Two buffers: "previous" and "current" readout frames
  - ◆ "Previous" used to mask the repeated pixels propagated to "current"
  - ◆ Virtually instant switching between the buffers (std::vector::swap)

50 kHz PbPb (100 Hijing MB events), 3×10^6 signal hits, $\sim4.6\times10^5$ noise pixels

	Digits	Clus_WO_Masking	Clus_Masked
	Integral 1.292e+06	Integral 4.1e+05	Integral 2.679e+05

Common code with MFT

Cluster-topology handling

- Cluster objects (many): {row,col} of ref. pixel + cluster ID

- LUT (fixed size): offsets with respect to the ref. pixel + σ's

Most of the topologies have a pattern contained in 1 byte!
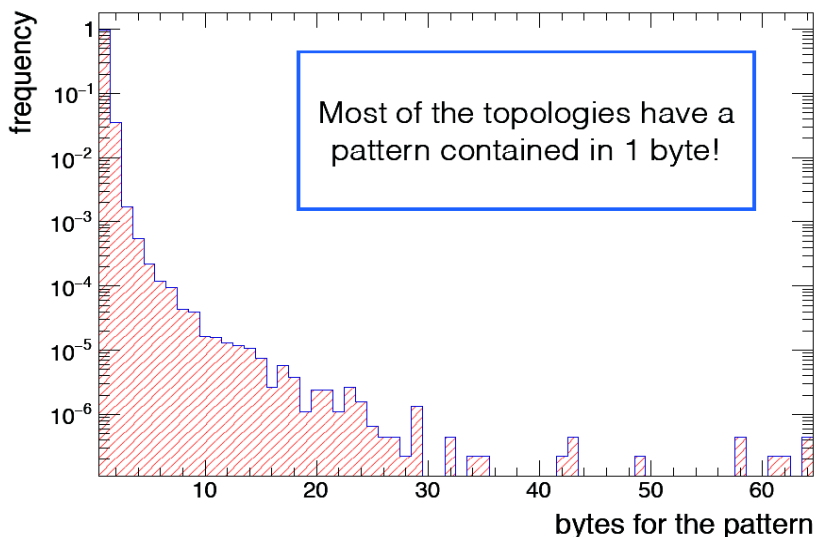
Fraction of topologies with the bit pattern contained in N bytes

```
Up to 1 B : 0.961552
Up to 2 B : 0.997095
Up to 3 B : 0.998826
Up to 4 B : 0.999379
```


Blue elements belongs to the new look-up flow
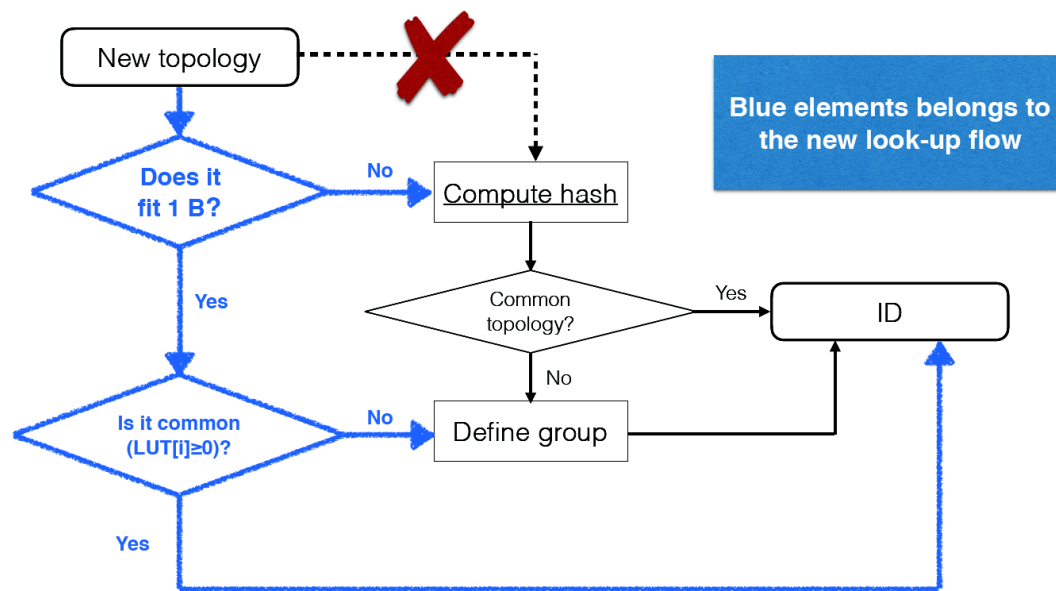
The new algorithm is more than 3x faster !
The time needed to identify the topologies is totally negligible compared with the CF time

Common code with MFT

Cellular Automaton track finding

- Work-in-progress development
  - ◆ Pattern recognition with **Cellular Automaton (CPU & GPU)**
  - ◆ Track fitting with **Kalman Filter (CPU, soon on GPU)**

- Challenge: wrong cluster-to-track association at low p_T
  - ◆ Multiple scattering, fluctuations of energy losses...

- The **GPU** version is **2.5x – 5x** faster
  - ◆ The gain factor increases with the number of pileup events
- Can already be used for the on-line TPC calibration
  - ◆ Parameters tuned for high-p_T tracks

Pb-Pb at 5.5 TeV
0-5% centrality
At least 4 out of 7 clusters

Fast Tool (ITS Upgrade)
Fast Tool (ITS)
Cellular Automaton Tracker (ITS Upgrade)

Implementation
CUDA [Titan Xp GPU]
OpenCL [Titan Xp GPU]
Serial [Intel(R) Xeon(R) W-2133 CPU]
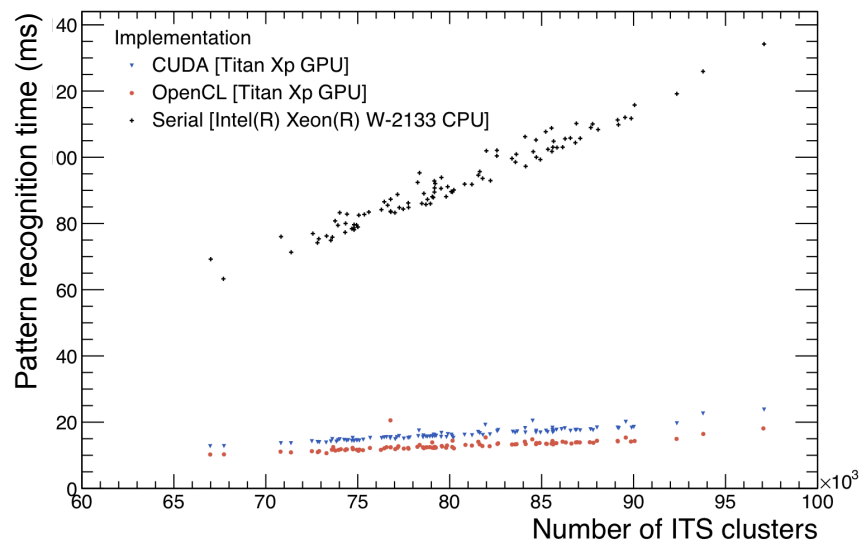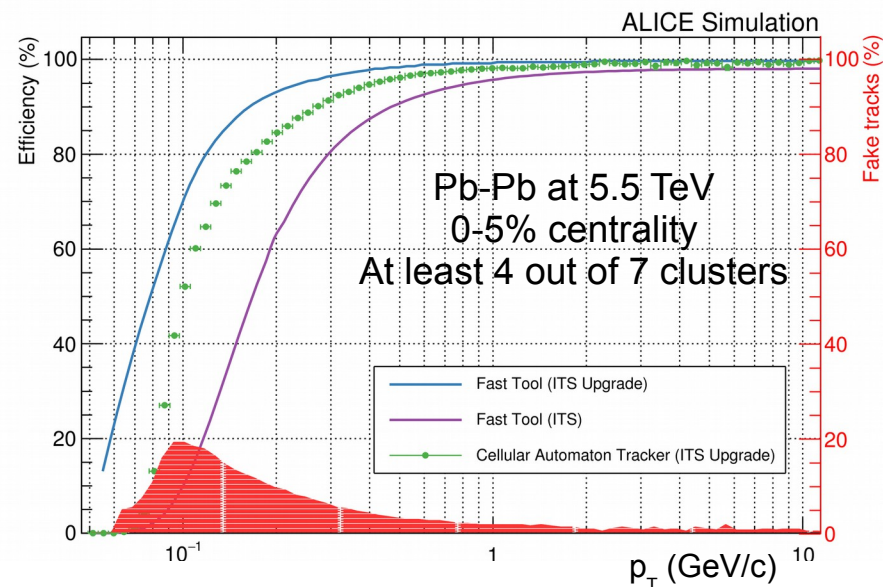
ITS O^2 overall status & plans

	Task	Contact	People	When	Comments
1					
2	General ITS geometry	Mario Sitta		Done	No services yet
3	Sagging geometry	Mario Sitta	Cristina Bedda	Q4 2019	
4					
5	ALPIDE response simulation	Artem Isakov	Miljenko Suljic	Q1 2019	Vbb=0 missing
6					
7	Time dependent digitiser	Ruben Shahoyan		Done	
8	Digitisation in DPL			Done	
9					
10	Raw data decoder	Ruben Shahoyan		Q4 2018	Ongoing discussions with WP10
11	Cluster finder (CPU)	Iouri Belikov	Ruben Shahoyan	Done	
12	Time effects in clusterisation	Ruben Shahoyan		Done	
13	Clusterisation in DPL			Q1 2019	
14	Cluster finder (FPGA)	Anisa Qazi ?		Done ?	Repetitive signal handling in FPGA ?
15	Cluster-topology handling	Luca Barioglio		Done	To be integrated with the Cluster Finder
16					
17	Primary vertex finder (CPU)	Matteo Concas	Ruben Shahoyan	Done	May need a new approach
18	Primary vertex finder (GPU)	Matteo Concas	David Rohr	Q2 2019	May take longer
19					
20	CA tracker (CPU)	Maximiliano Puccio		Done	
21	CA tracker (GPU)	Maximiliano Puccio	Matteo Concas, David Rohr	Q2 2019	
22	Tracking in DPL			Q2 2019	Connected with the primary vertexer in DPL
23					
24	Comparison with Monte Carlo	Arthur Gal	Iouri Belikov	Q4 2019	Sevice task (~30% of time)
25					
26	Event display			2019	Needed: Simplified geomety, data convertor
27					
28	Calibration (noise, dead)				
29					
30	Quality Control				

Backup slides

ITS geometry : details
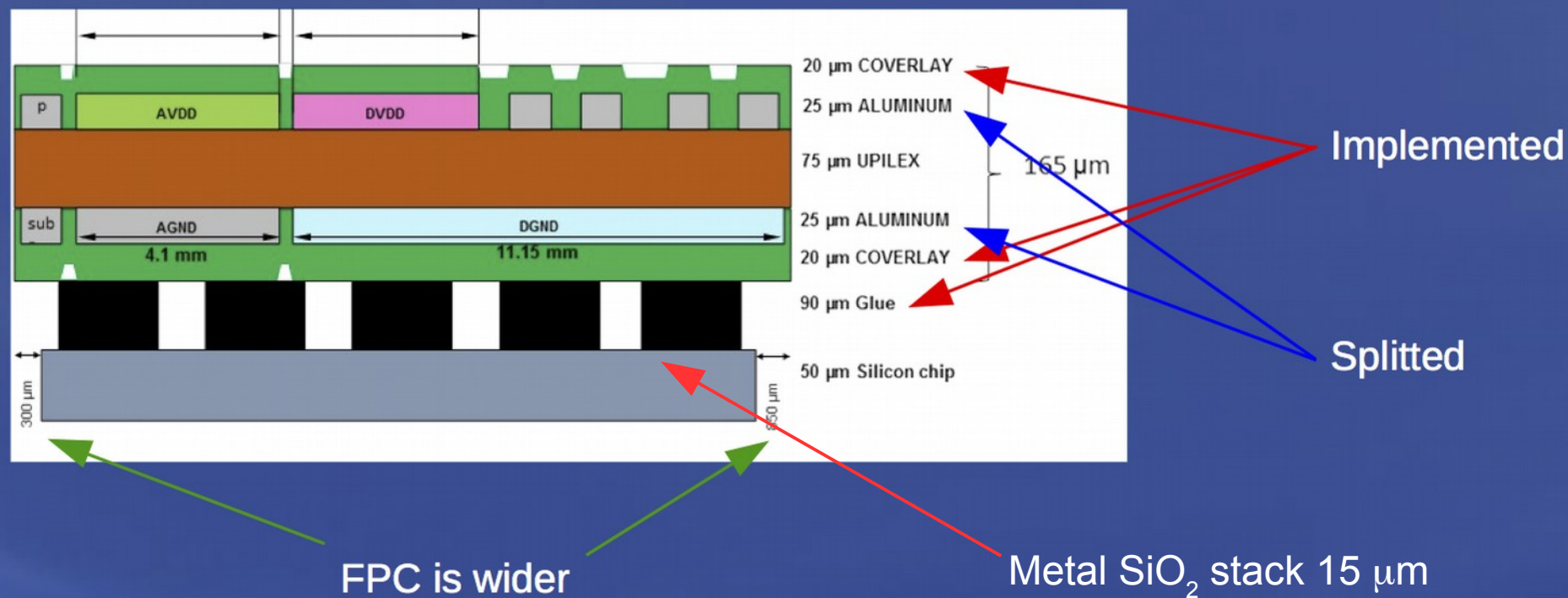
Sagging : "Self-compensation"
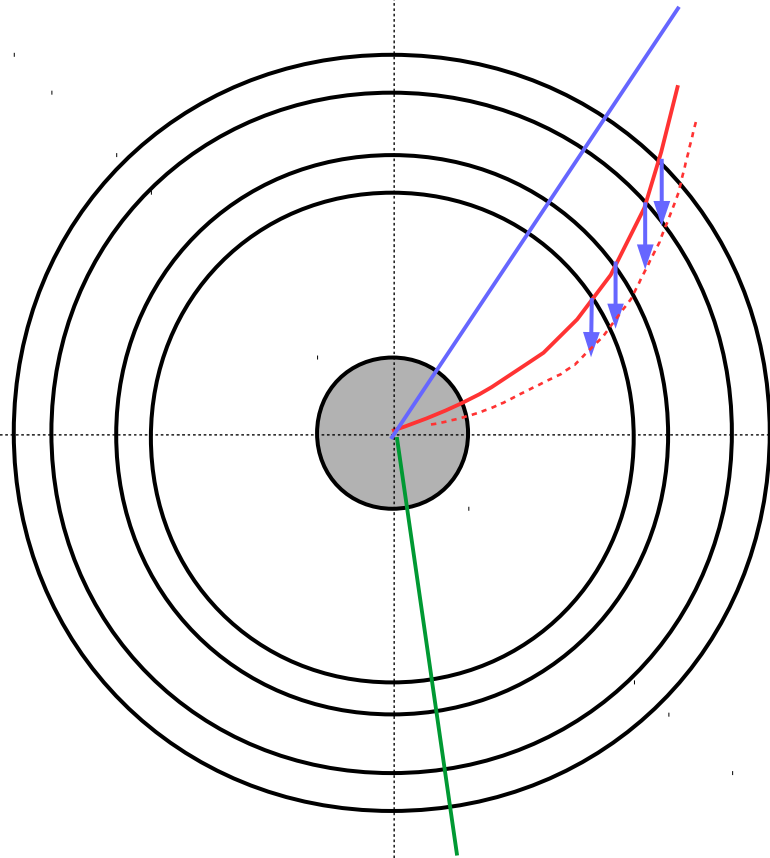
The **maximal sag** is $f(\phi)$.
Each track has its own maximal sag.
But this max sag is the same ($\phi \sim const$) within this track.
The track directions at the outer layer do not change (almost).
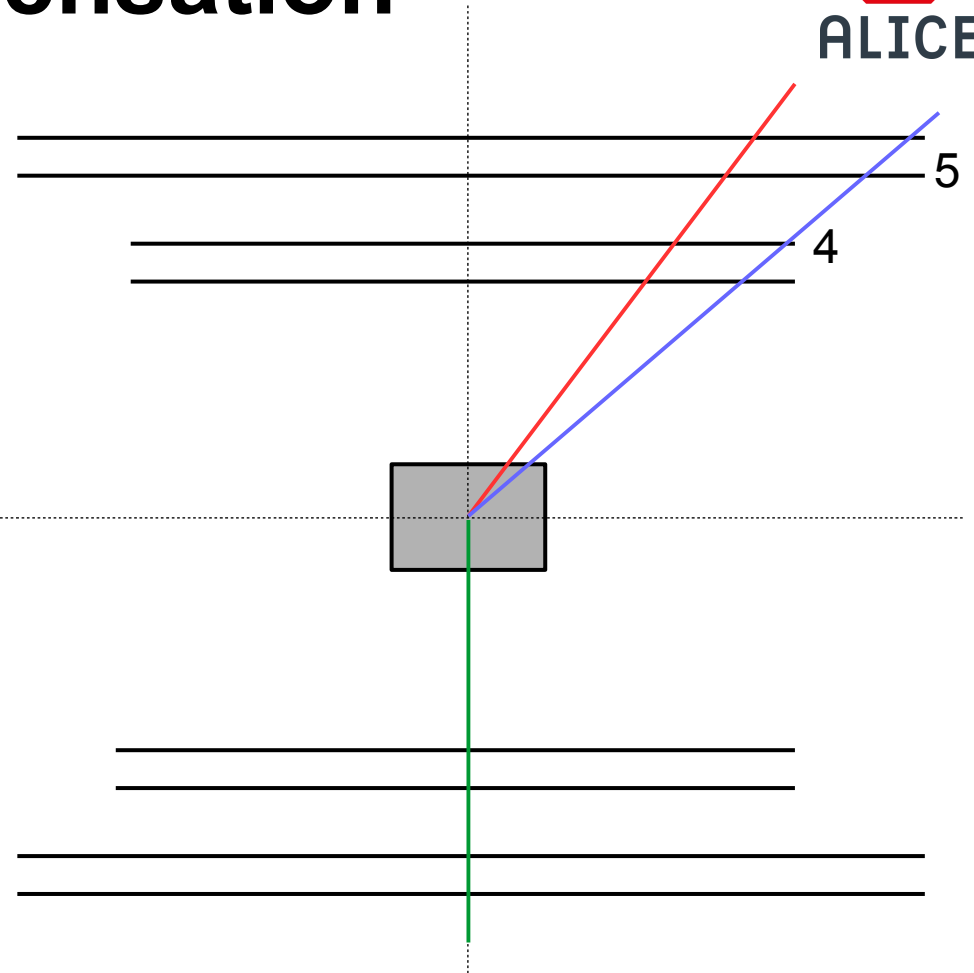
The **local sag** is $f(\phi,z)$.
The directions of the green track are not affected.
The directions of the blue track do get distorted.
But this distortion is not large, because the local sags are small.
The red track is the most affected.

ALPIDE response, external to O^2 part
(Miljenko Šuljić, Jacobus W. van Hoorne)

"Microscopic" simulations using the electrical field extracted from TCAD

ITS digitization
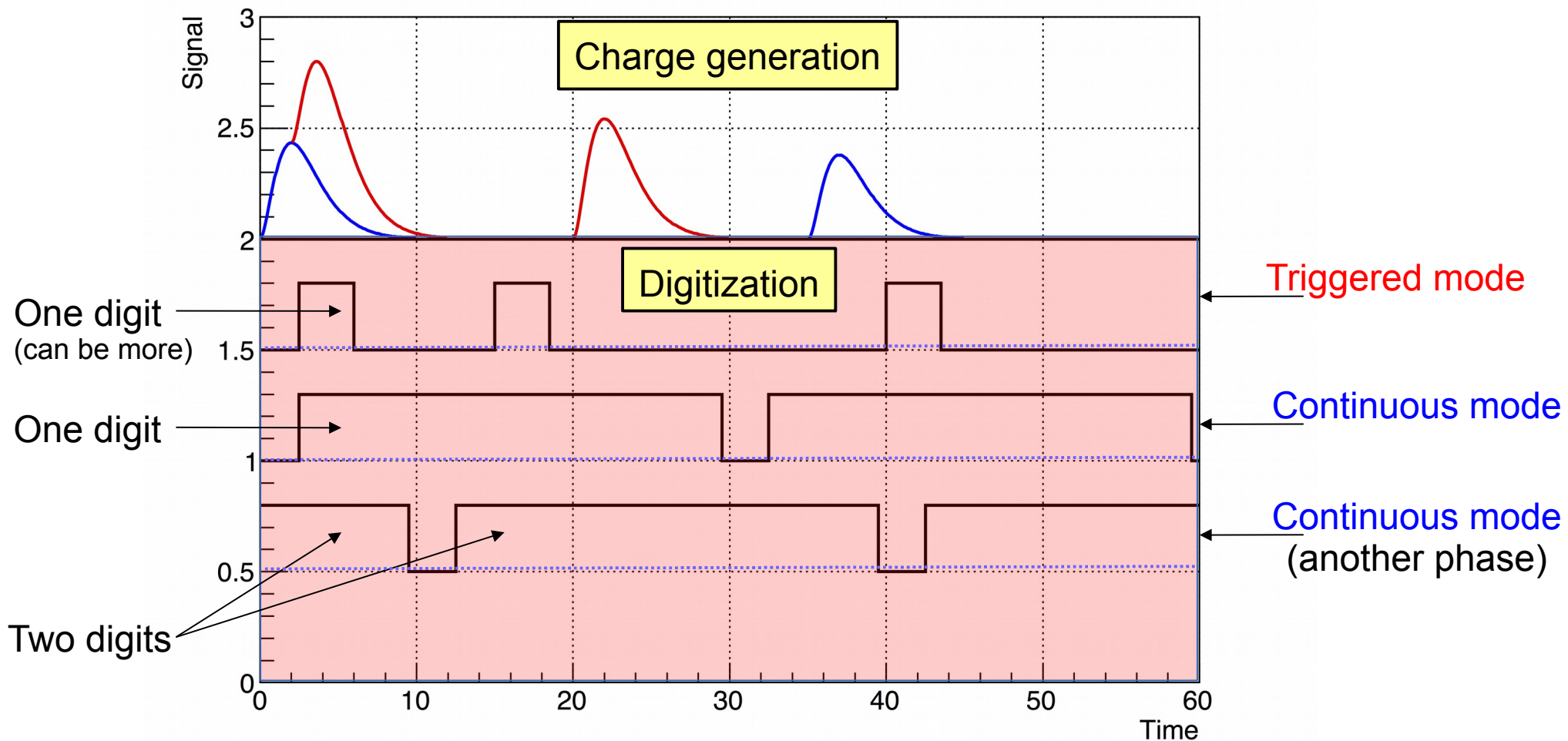
At the end, we want to be able to generate the data in TimeFrame format

Cluster-topologies

All MC clusters

Number of clusters: 20295

MC clusters, no noise

- ALL the clusters not associated to a track have the same topology, i.e. single pixel cluster

Number of clusters: 7659 (noise: 12726)

Tracking time vs number of threads

ALICE

- **2011 mac, 2 GHz Intel Core i7**
  - ◆ 4 cores, 8 threads
- **4000 pions in |η|<0.9**
  - ◆ 0.2<p_T<2.0 GeV/c, flat
  - ◆ No noise
  - ◆ Constant 0.5 T mag. field

Speedup Factor

55 msec

"Cooked Matrix" tracker

175 msec

Number of threads
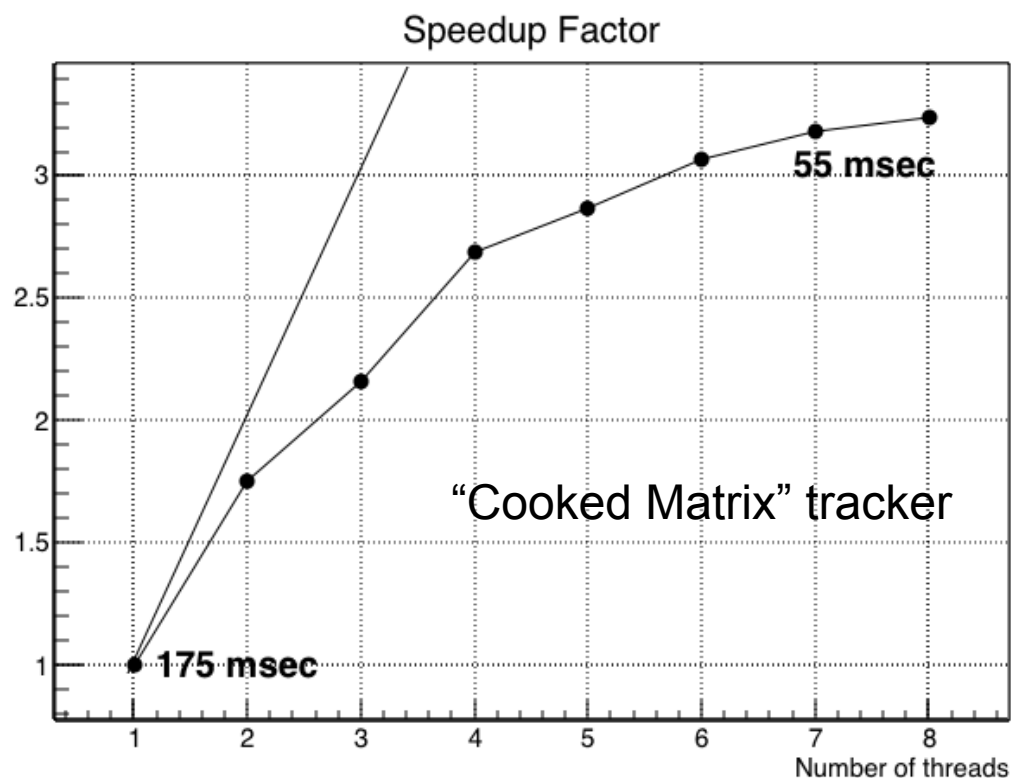
Native C++11 multi-threading

Linux/gcc and macOS/clang

(bottle neck of the moment – cluster sorting)