



G. Simi
LHCb Padova meeting 2/12/2020

Introduction

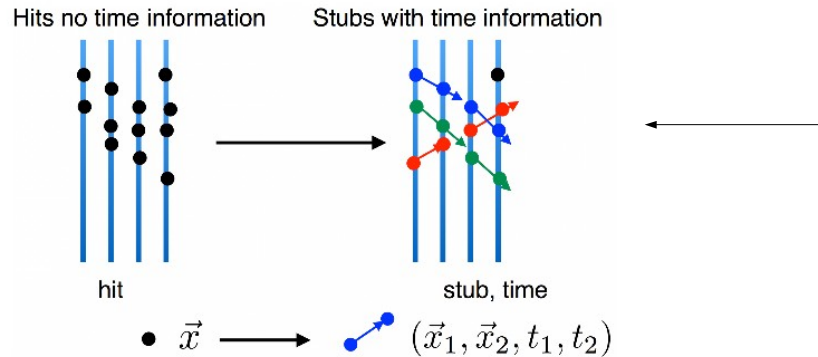
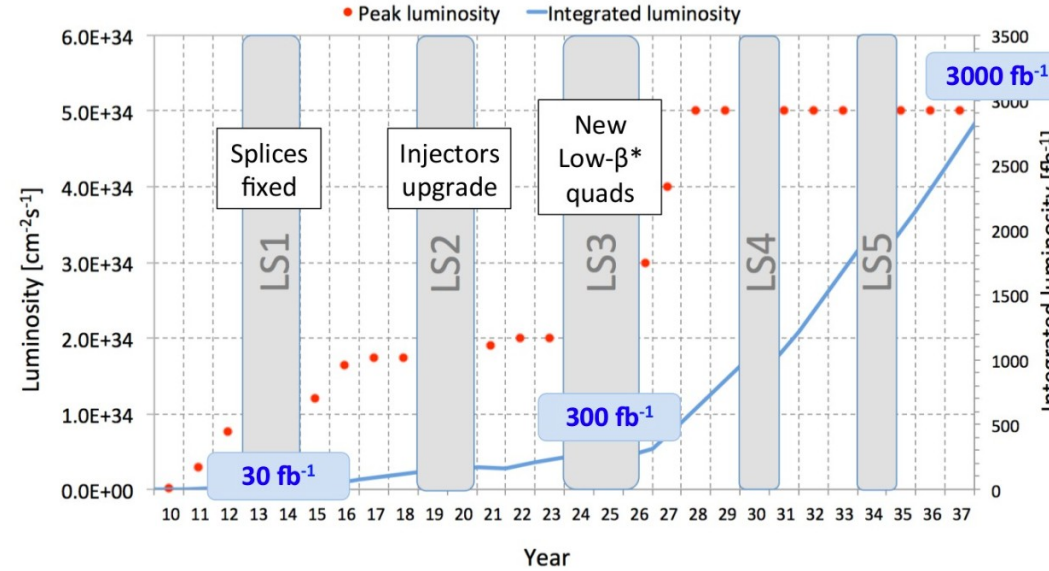
TimeSPOT

TIME and SPace real-time Operating Tracker



Partendo dalle tecnologie disponibili sviluppo di un sensore di vertice rad hard con misura del tempo per tracking in HL-LHC

- $5 \times 10^{34} \text{ cm}^{-2}\text{s}^{-1}$ con leveling (ATLAS and CMS) e $1\text{-}2 \times 10^{34} \text{ cm}^{-2}\text{s}^{-1}$ per LHCb
- Numero medio di interazioni visibili ~ 140 (~ 40 LHCb) LHCb)

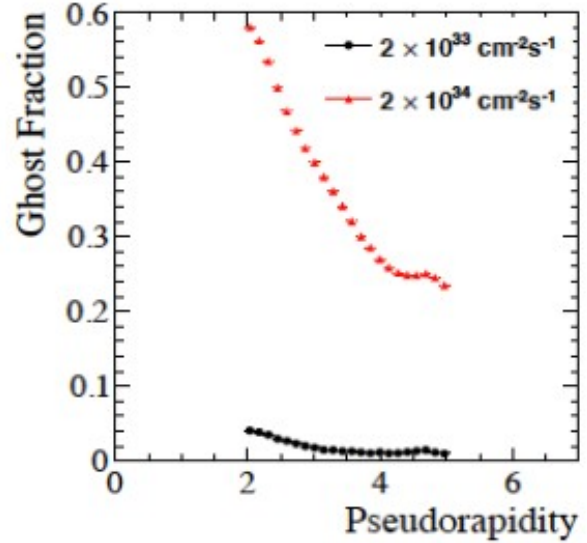


L'uso di informazioni temporali precise puo' migliorare drammaticamente il sistema di tracciature nelle condizioni di alto pile-up

- Semplificazione del pattern recognition e miglioramento della velocita' di ricostruzione
- Riduzione delle tracce fantasma
- Risoluzione necessaria: $< 200 \text{ ps/hit}$, rad hard: $> 10^{16} n_{\text{eq}}/\text{cm}^2$



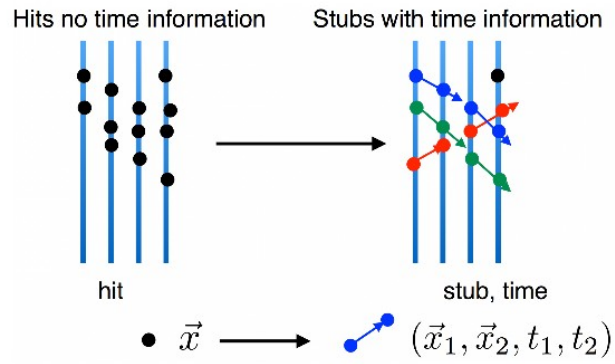
Degradation of LHCb detector at HL-LHC conditions



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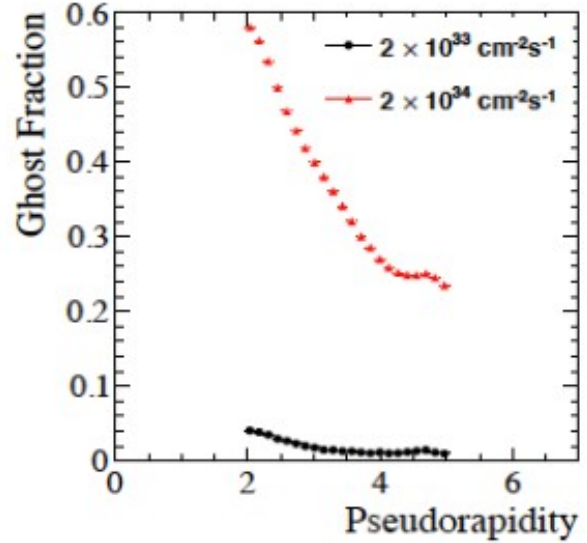
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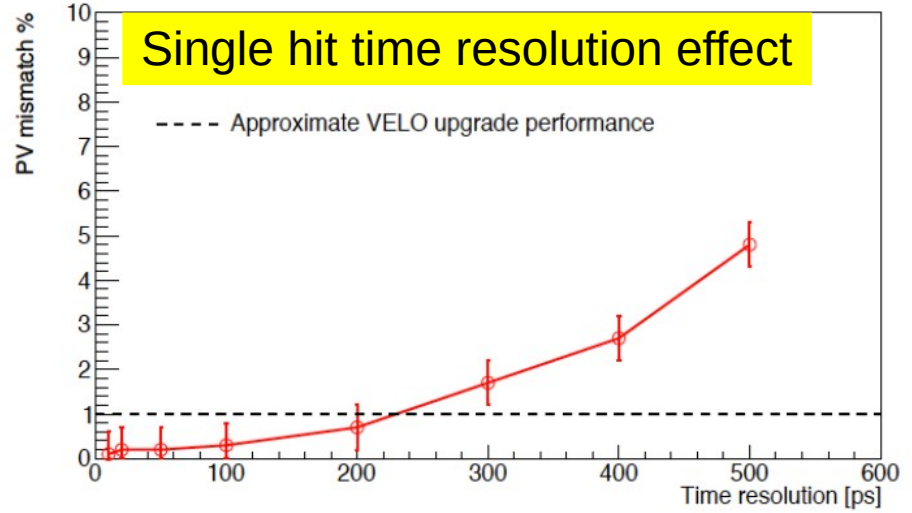
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Single hit time resolution effect

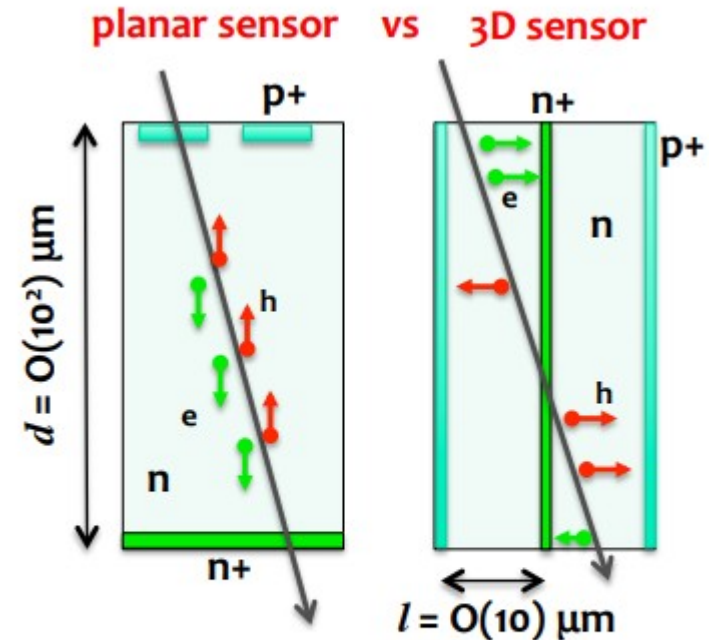


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Why 3D sensors

- Unmatched radiation hardness (signal efficiency) extensively verified
 - due to small deposition distance
- Uniform “weighting field” and small Landau fluctuations
 - give excellent time resolution by design



Charge deposition distance is decoupled from electrode distance



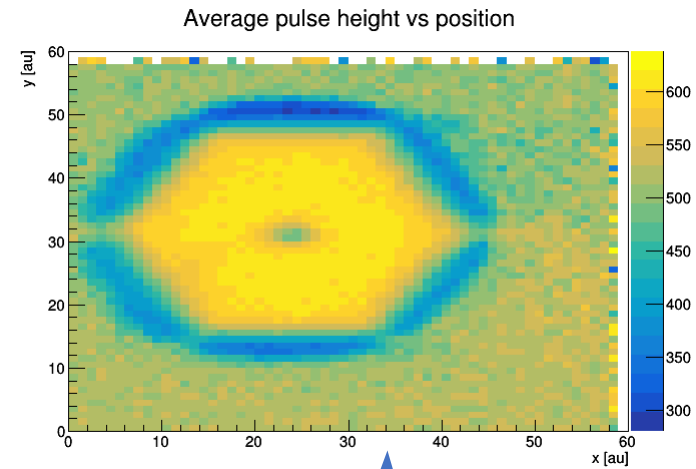
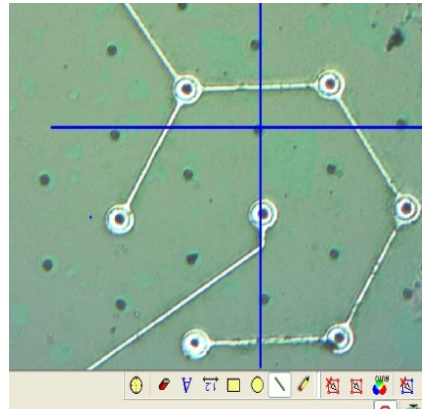
Status

TimeSPOT

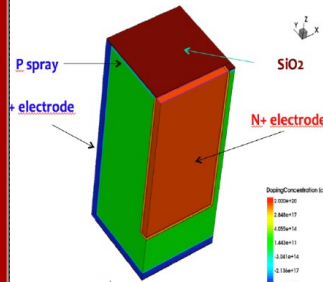
← TIME and SPace real-time Operating Tracker



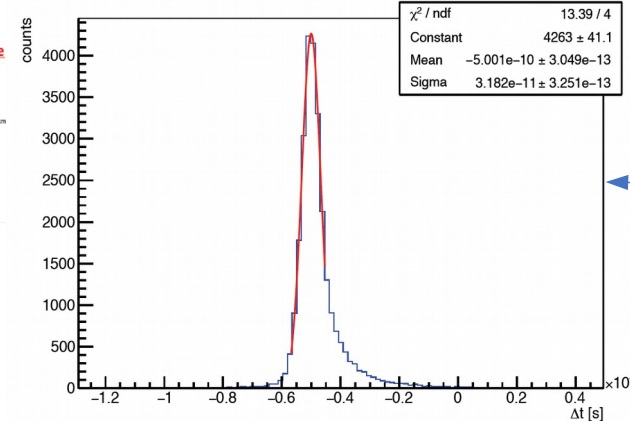
INFN
Istituto Nazionale di Fisica Nucleare



Column 3D sensors tested with 2MeV proton beam at Legnaro



Δt (Si - MCP) Costant Fraction method



Trench 3D sensors time resolution measured with laser and with pions at PSI ~30ps

Trench 3D sensors developed with FBK & Trento compatible with 55 μm TIMEPIX



Perspectives

Sensor characterization perspectives

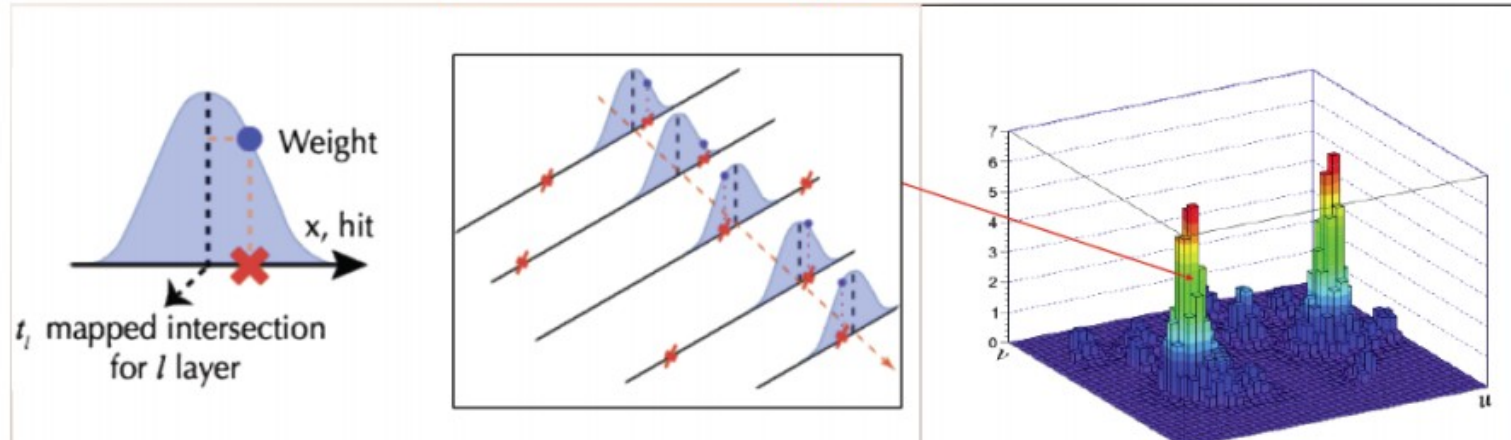
- Test beam @ Legnaro (2021-2022)
 - Measurement of the time resolution as a function of the position within the pixel (uniformity) using the micro-beam facility
 - Position resolution given by beam size (2um)
 - Time tag given by thin scintillator layer deposited on top of the sensor and readout by SiPM
 - Innovative techniques never used before
 - Response uniformity never measured before
 - Con: 2MeV protons penetrate only 40um within the silicon
 - Measurement of the time resolution after irradiation
 - Defining characteristic of 3D detector is their intrinsic radiation hardness and signal efficiency after irradiation has been verified extensively
 - Time resolution after irradiation has never been measured
 - Master thesis starting in spring 2021

Real Time processing perspectives

- The amount of information generated by the front-end is huge
(n Tbits/sec = #bits x event rate x occupancy)
- To overcome this difficulty the approach foreseen is
 - Trigger-less data taking with real-time processing of the tracks

Our strategy is to follow the RETINA project approach (1), adding time information into the algorithm structure (2)

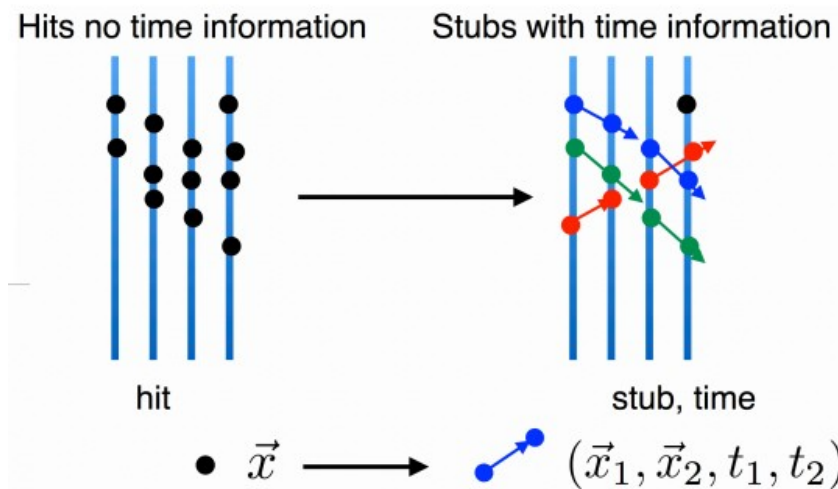
RETINA project concept



L'algoritmo retina si basa su una opportuna trasformazione dello spazio dei parametri che descrivono gli hit in modo da trasformare il problema di identificare il pattern di una traccia nel problema di trovare dei massimi (clusters) nel nuovo spazio dei parametri.

Ad ogni hit viene associato un peso in base alla compatibilità con l'appartenere a una traccia (dipende dalla geometria del detector) e può essere processato in parallelo.

{ **Timespot**: i punti sono sostituiti da stubs compatibili temporalmente

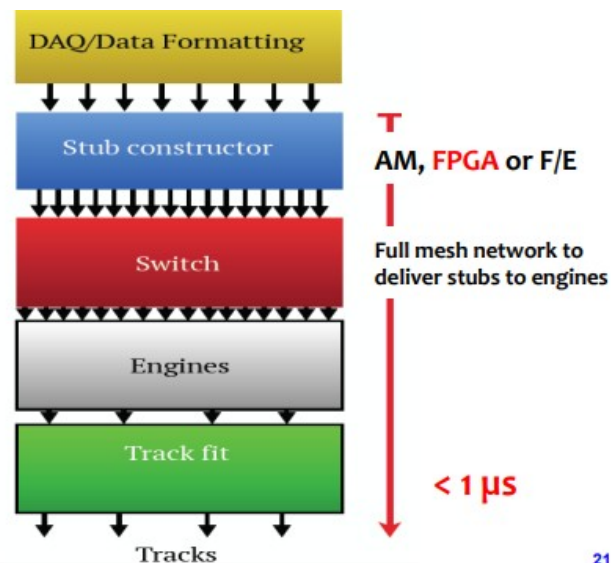


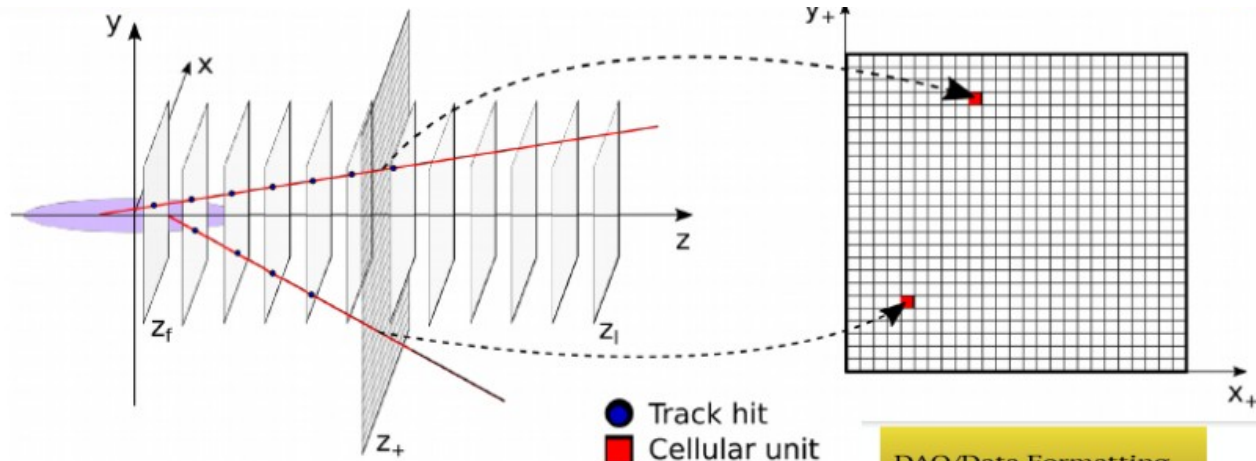
$\forall z_+$

Cellular unit

Algorithm steps:

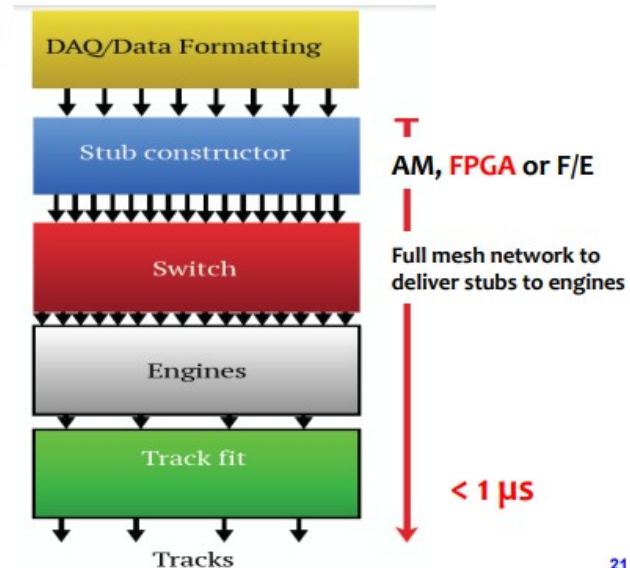
1. Identify stubs i.e. couples of hit in adjacent planes compatible in space and time with tracks from the bunch interaction area;
2. Distribute the stubs in parallel to the Engines;
3. Engines identify tracks from clusters of stubs with similar parameters.





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Test on an LHCb like tracker

- Algorithms being developed using the simulation of an lhcb like tracker
- Using an FPGA on a custom board
- Possible collaboration with Milan group (Neri)

