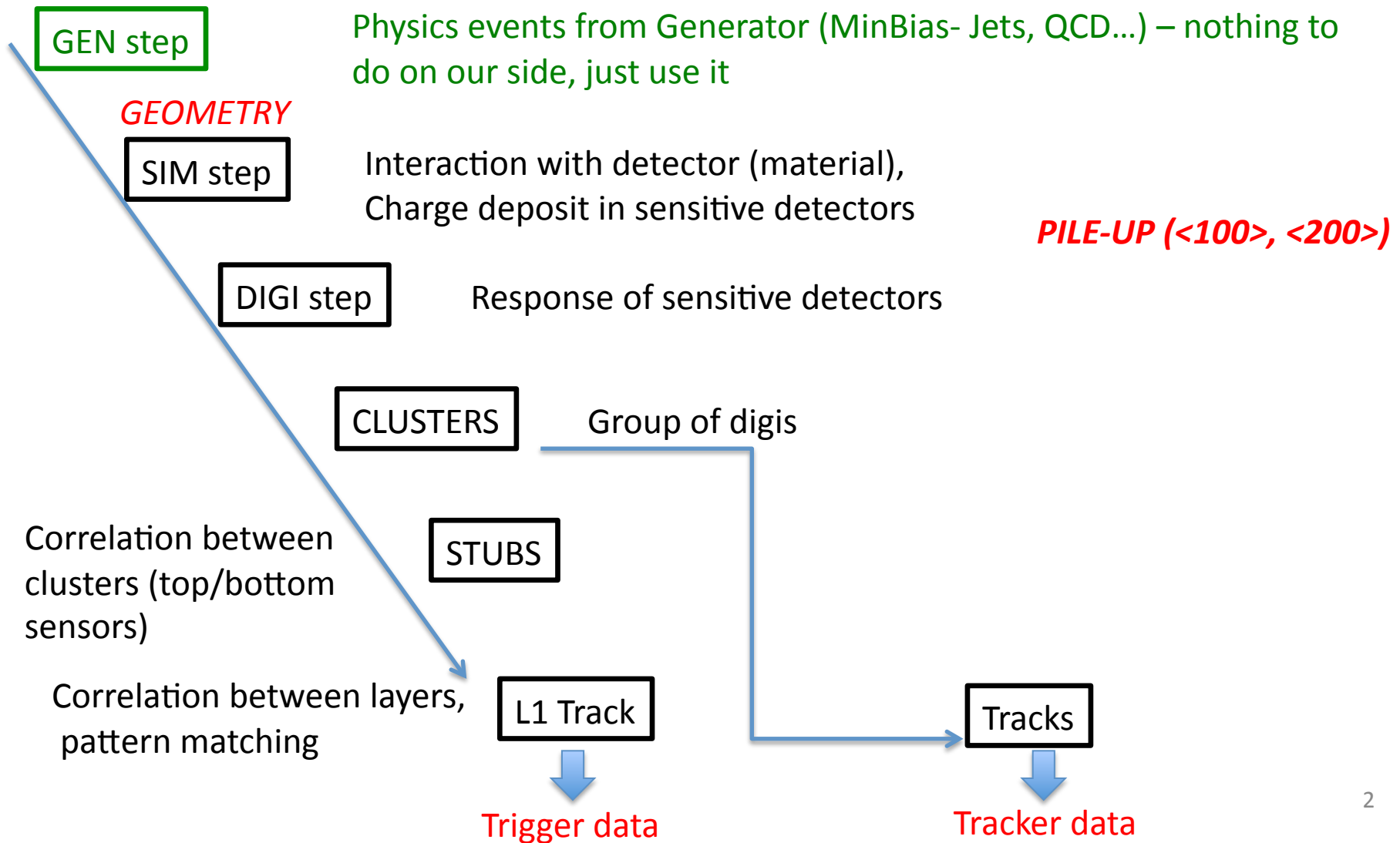# Overview of Tracker Phase 2 simulations
(Track Trigger WG)

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Track Trigger Integration WG
Oct 22, 2012

Stages of simulation in a nutshell…

GEN step

Physics events from Generator (MinBias- Jets, QCD…) – nothing to do on our side, just use it

GEOMETRY

SIM step

Interaction with detector (material), Charge deposit in sensitive detectors

PILE-UP (<100>, <200>)

DIGI step

Response of sensitive detectors

CLUSTERS

Group of digis

Correlation between clusters (top/bottom sensors)

STUBS

Correlation between layers, pattern matching

L1 Track

Tracks

Trigger data

Tracker data

2

Stages of simulation

GEOMETRY

SIM step

Interaction with detector (material), secondaries production
Charge deposit in sensitive detector

- Two complementary layouts currently under study
- Geometry described as xml files
  - The xml files are used by Geant4 to build simulated hits (simhits) in cmssw when a simulated tracks is crossing sensitive detectors (also described in the xmls)
- Crucial to have a realistic description of the material, accurate positions of the components etc..

Two complementary Tracker layouts
I) Long Barrel geometry

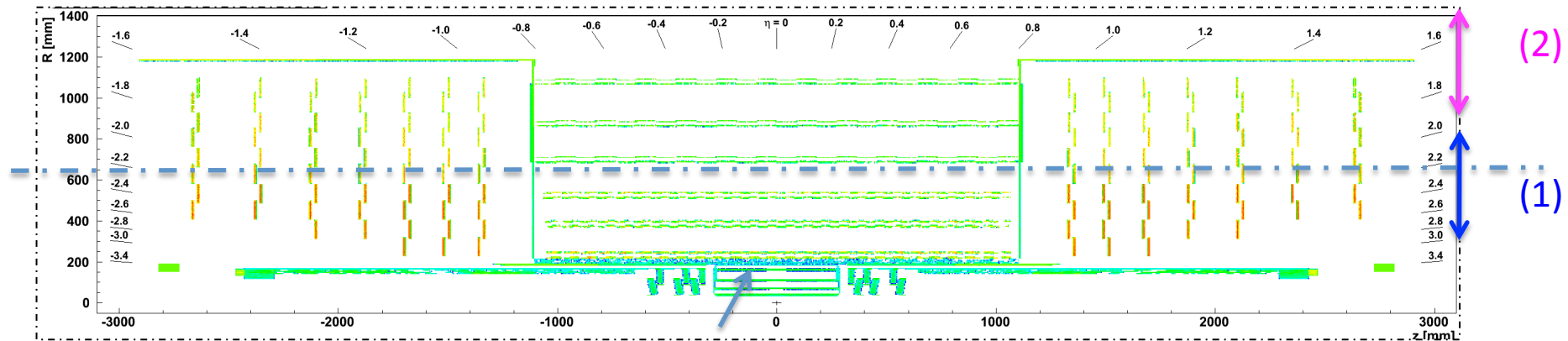Long closely spaced layers of Pt Modules arranged in Double Stacks separated by ~4 cm

(Full long Barrel outer tracker of stacked triggering layers)
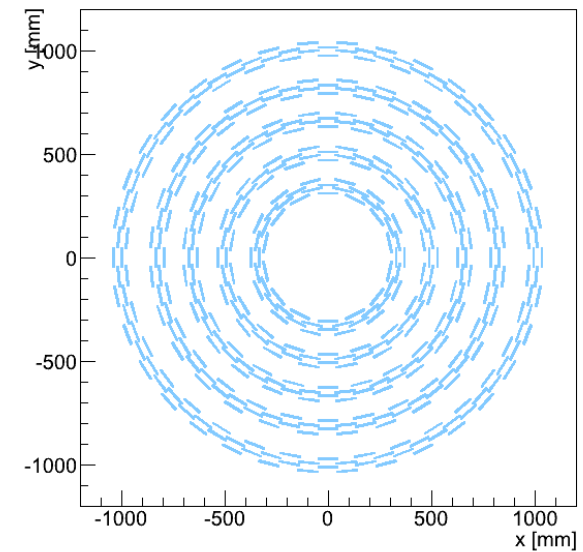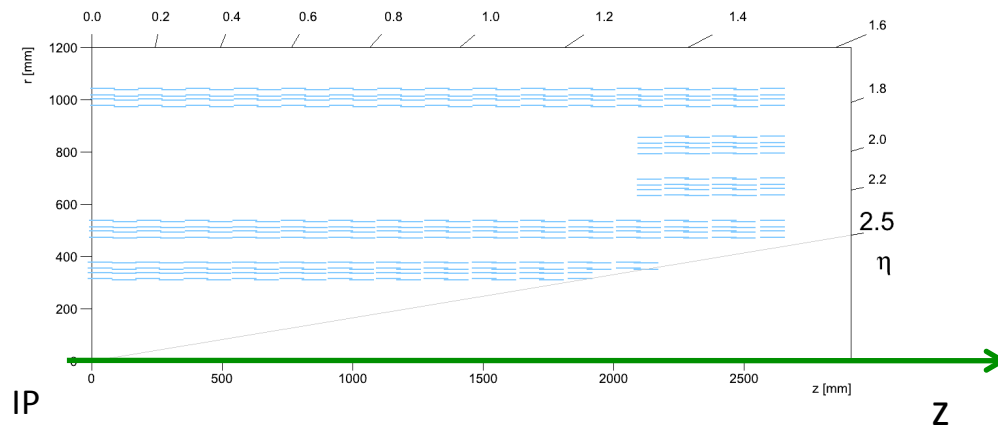
XY section of the barrel

Two complementary Tracker layouts
II) Barrel-EndCap Geometry

The "Barrel-EndCap" design comprises 6 barrel layers and 7 endcap disks composed of rings.

Inner pixel Detector : 4 layers- 3disks

The inner part (1) is populated by Pixel-Strip stacked (PS) modules .

The outer part (2) is populated by Strip stacked (2S) modules.

The number of endcap disk is optimized for tracking performance.

Geometry Description in simulations

- **Tklayout tool** : Standalone code to describe tracker configurations and give a very good estimation of the TT performance
  - Parameterization of hits (including interactions, MS, resolution, validated with real data)
  - It is easy, fast to use, flexible.
  - It is easily customizable
  - New features can be implemented when interest is expressed by the community for a given solution
  - Provides the output needed to compare two competing solutions in terms of number of measurement points, power consumption, etc…
  - Description of the Material

Xml files describing the geometry are provided by Tklayout tool

Those xmls are then inserted into cmssw for full simulation of the detector

XMLs files need to be reworked to be fully compatible with cmssw (See Nicola's presentation)

Will be used to keep geometry and material upto-date

Dedicated twiki page (tools, recipes, status) on a dedicated twiki page maintained by Nicola Pozzobon: https://twiki.cern.ch/twiki/bin/viewauth/CMS/SLHCTrackerTriggerSWTools

First analysis on the MB budget in cmssw started, and should be compared with what we do expect from the tool (work started)
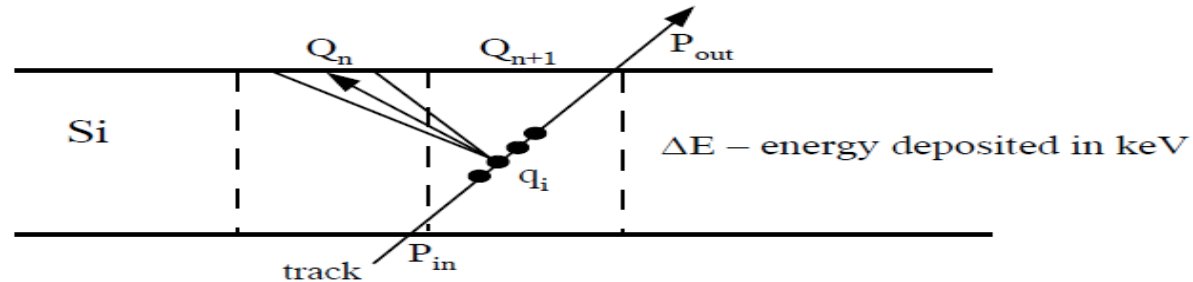
Stages of simulation

DIGI step   Response of sensitive detectors

- The digitizer should reflect as much as possible what will be the detector response
  - Strong interaction with sensor R&D developments
  - Strong interation with FE circuits developments

Digizer

- Up to now, the actual pixel digizer is used
  - Dedicated studies indicate that this is not appropriate (inefficiencies...)
  - A dedicated digizer for TK phase2 should be developed
    - Flexible enough to cope with 2 types of sensors (pixel or strips)
    - Parameters (thresholds, cross talk, LA,....) should be carefully reviewed
      - Strong indication of inefficiencies due to the current thresholds
      - Interaction with electronic R&D developments is needed
    - Performance and validation tools should be provided

  - We don't need to reinvent the wheel! The actual digizers (pixel and/or strips) together with validation tools can be recycled for phase2
  - Work started

Stages of simulation

CLUSTERS   Group of digis

First steps to reduce Trigger data volume (based on the track deviation in the plan perpendicular to the CMS magnetic field):

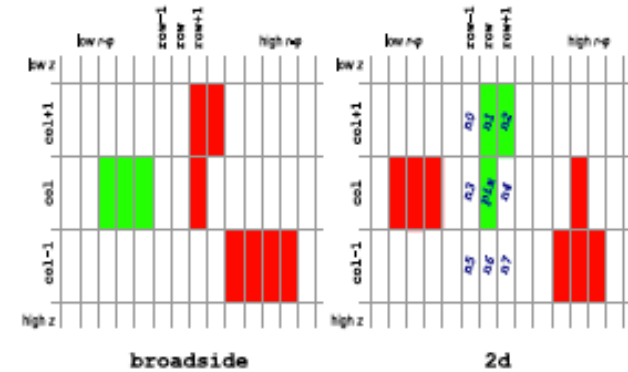Preselection of hits according to their cluster width (CW)

CW is proportional to the radial distance of the sensor from the IP and inversly proportional to the Pt

Clusterizer

Clusters from "2d" ☝
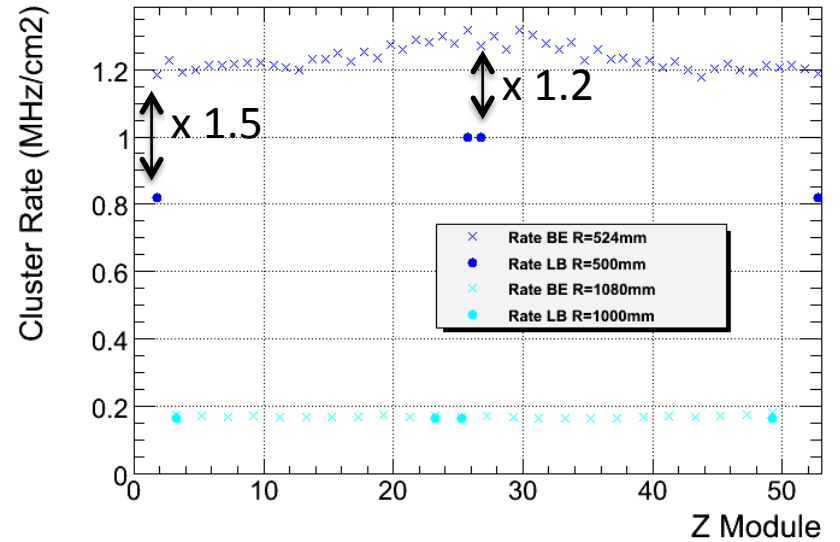(other option: "broadside")

LongBarrel: Clusters from 2d algorithm (described in DN-2012-003) available in cmssw

BarrelEndcaps : clusters from private code
To be integrated in a common clusterizer

- Performance (rates, cluster width) presented last year in both cases
  - Rate variation between LB and BE not fully understood (most likely due to a different way to clusterize digis)

- The goal is to develop a common clusterizer flexible enough to deal with both types of sensors (pixel/strips)

- Some work already done to accommodate the two geometry descriptions (detids) with the existing clusterizer
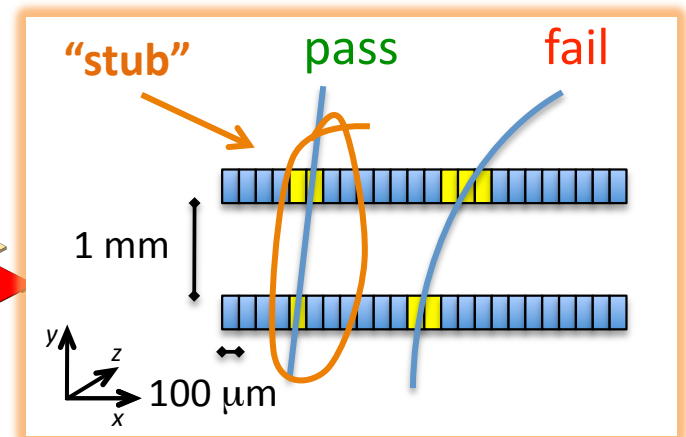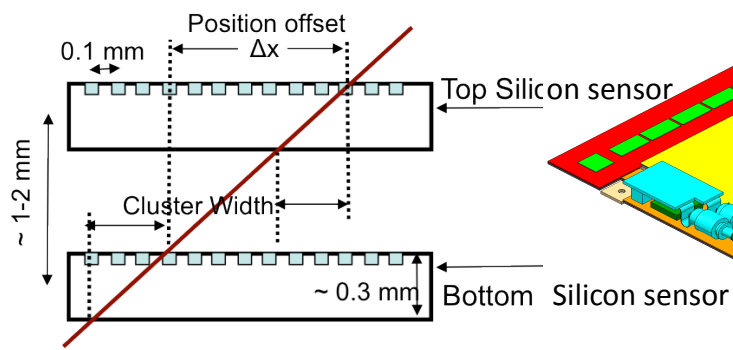
Stages of simulation

STUBS

Correlation between preselected clusters in nearby sensors (top/bottom sensor)
2nd step to reduce data volume

Exploit track direction of flight measurement to reconstruct 'track stubs' above a given Pt threshold.

Stubs

- Barrel-EndCaps: Private code providing stubs (barrel only, endcaps to be done) and performing analysis (rates, efficiency- primaries/secondaries)
- Long Barrel Stubs (pixelray algorithm) + Tracklets in cmssw + performance – Validation Tools (L1Triger Tools) :
  - SLHCUpgradeSimulations/Utilities (tools to address stacked sensors)
  - SLHCUpgradeSimulations/L1TrackTrigger (production of L1 primitives and objects)
  - Twiki page: https://twiki.cern.ch/twiki/bin/viewauth/CMS/SLHCTrackerTriggerSWTools

Performance, dataflow, efficiency are crucial for R&D developments and trigger performance.

Results presented in the past in TT sessions, working meetings
Again differences between the rates are not fully understood.
 A common code based on the already existing one producing stubs should be developed
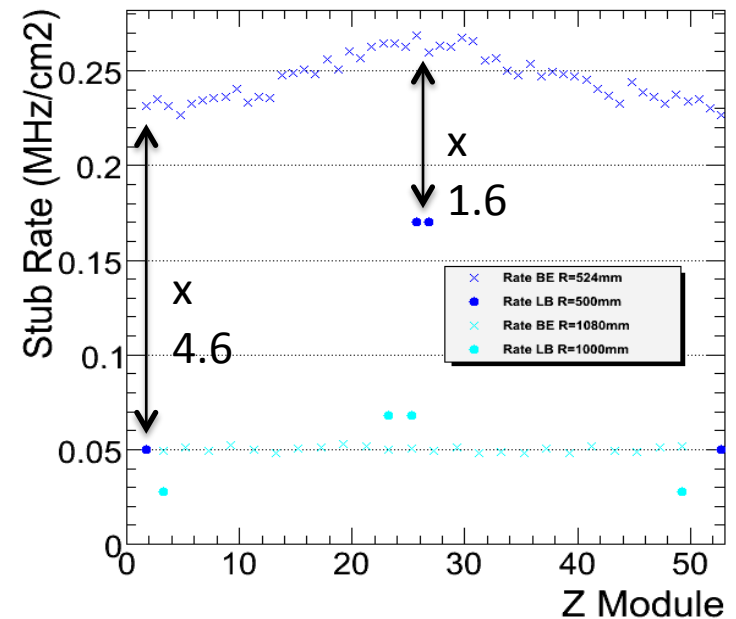
Community wants to test also strip---pixel, strip---strip, different pitch pixel--pixel, and BarrelEndCap layouts
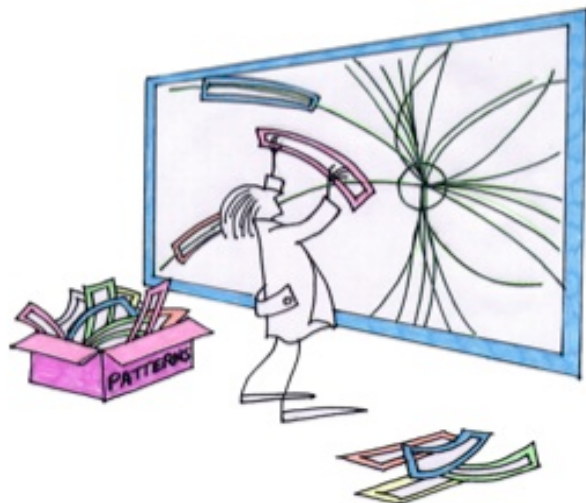   **Track trigger code should fit these needs**

Stages of simulation

Correlation between layers, pattern matching

L1 Track

Two different approaches

Independent Pt layers => Stubs -> L1 Tracks
Barrel -EndCap track reconstruction from pattern comparison using Associative Memories
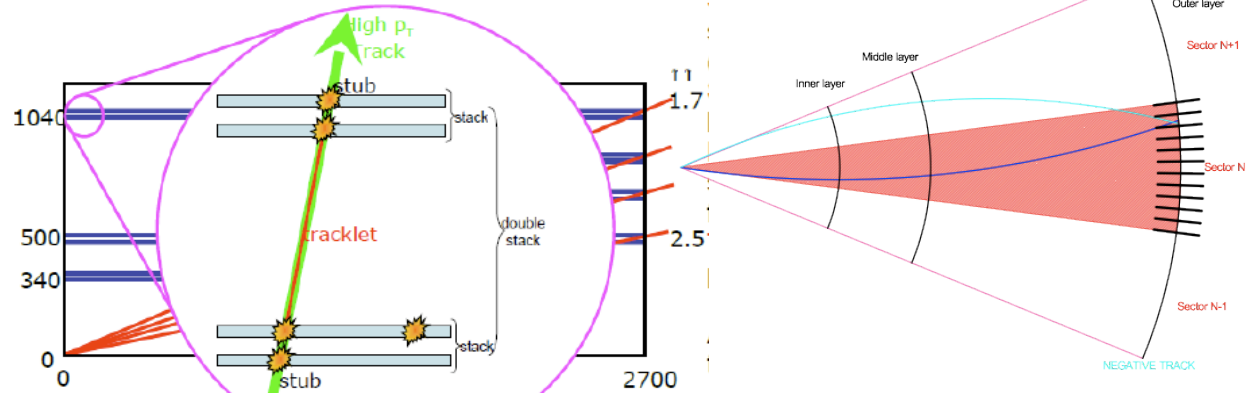
From Hits to L1 Tracks:
Super Layers => Stubs -> Tracklets -> L1 Tracks
Long Barrel Tracklet reconstruction followed by propagation to next super layer

First studies are just starting

Tracklets object already present in cmssw for use of studies in track trigger performance, studies to be pursued to be close to the implementation we envision in hardware

Important to get Feedback from Hardware designers and R&Ds

Simulation activities and prospects

- A lot of work has already been done by a (small) group of people.

- Each steps of the reconstruction should be now optimized and validated.

- The already existing software should be modified in order to:
  - Develop a common scheme in terms of geometry description (Detids,Material Budget, ….)
  - Be flexible enough to allow relevant comparisons between different layouts
  - Any developments on low-level reconstruction should follow and reflect as much as possible the ongoing hardware R&Ds. Digitizer, clusterizer and front-end logic to be developed coherently with electronics (and sensors) R&D
  - Tracker input to Level-1 trigger Stub rates are a crucial input for the design of the electronics system! Studies to be pursued.

- The Tracker Trigger simulations are integrated in TK-DPG
  - Working group meetings are organized every 2 weeks (news and annoucement hn-cms-slhc-trackersim@cern.ch)
  - The project starts taking shape!
  - Level-1 "stubs" are processed in the back-end → Level-1 track finding and trigger architecture integrated in TK phase-2 Upgrade electronics
  - Phase 2 pixels (Trigger) starts to receive attention, beyond the scope of this WG group for the moment (Track trigger simulations currently based on the assumption that Pixel is not used for the trigger)

- Interation between this group and TTI WG are crucial:
  - Gradual effort
  - From the TTCi we would need requirements on L1 tracking Trigger (Pt thresholds, rates, efficiency acceptable level of fakes…)
  - TTWG goal is to provide to the community realistic track trigger L1 objects