Simulations

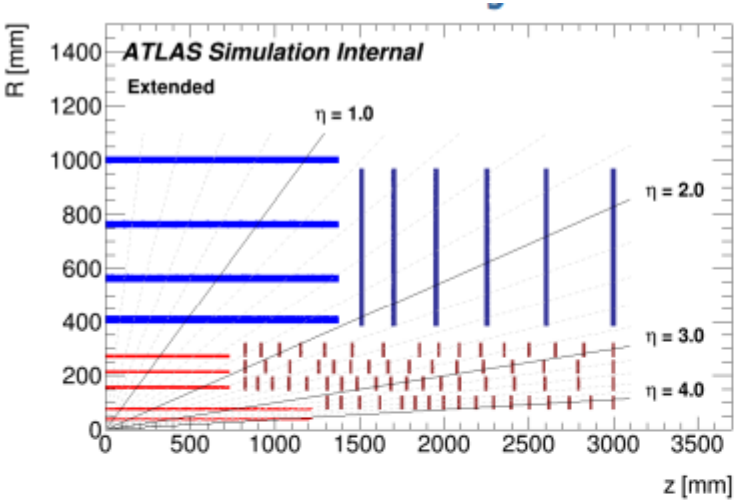
Antonio Sidoti

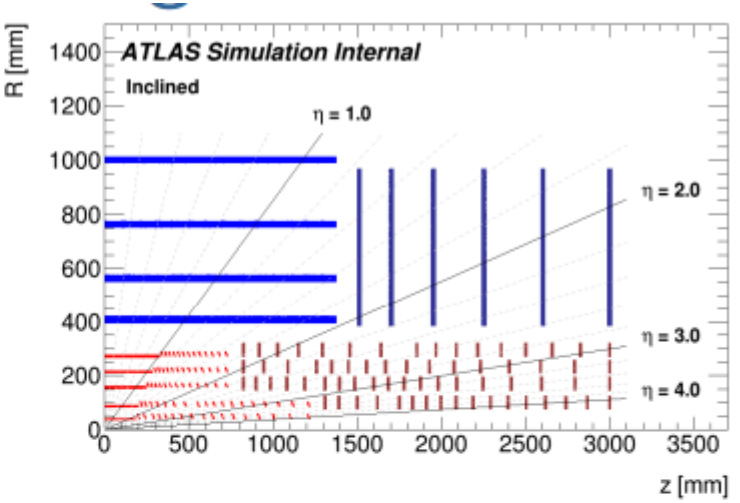
with contributions from many people (Giorgio Chiarelli, Alessia Damilano, Claudia Gemme, Gilberto Giugliarelli, Federica Fabbri, Tommaso Lari,Federico Massa, Lorenzo Rossin, Carla Sbarra, Matteo Scornajenghi, Marianna Testa)

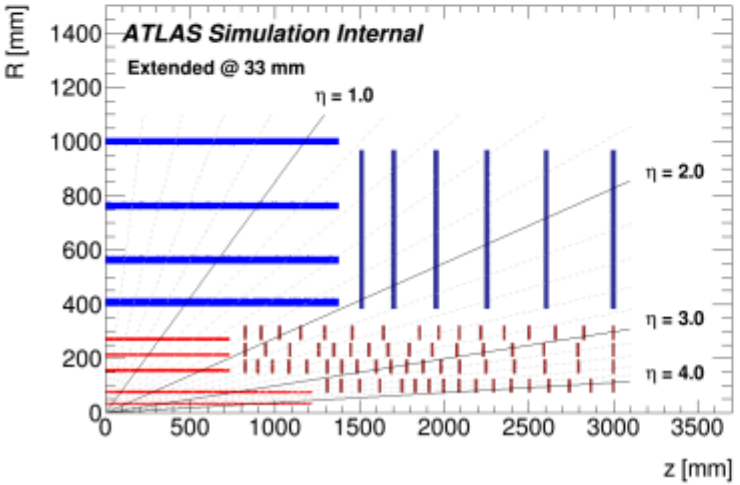
Simulation Layouts after LTF Review

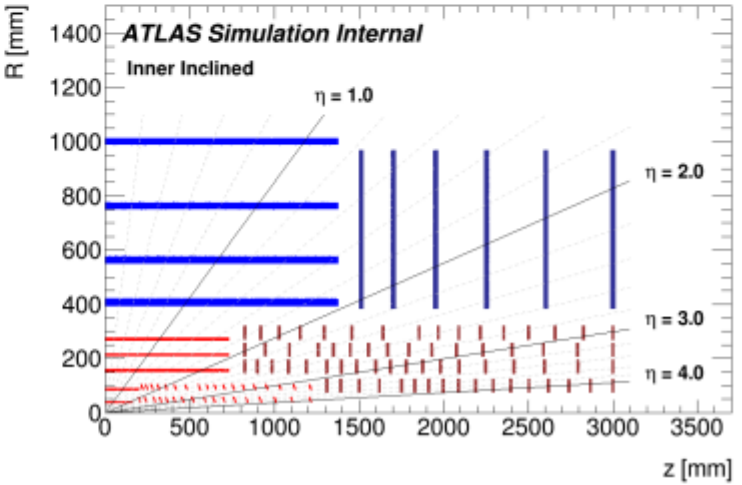
Draft 1.5 of Layout Task Force released last month:
ATL-COM-UPGRADE-2016-042

Four layouts under investigation







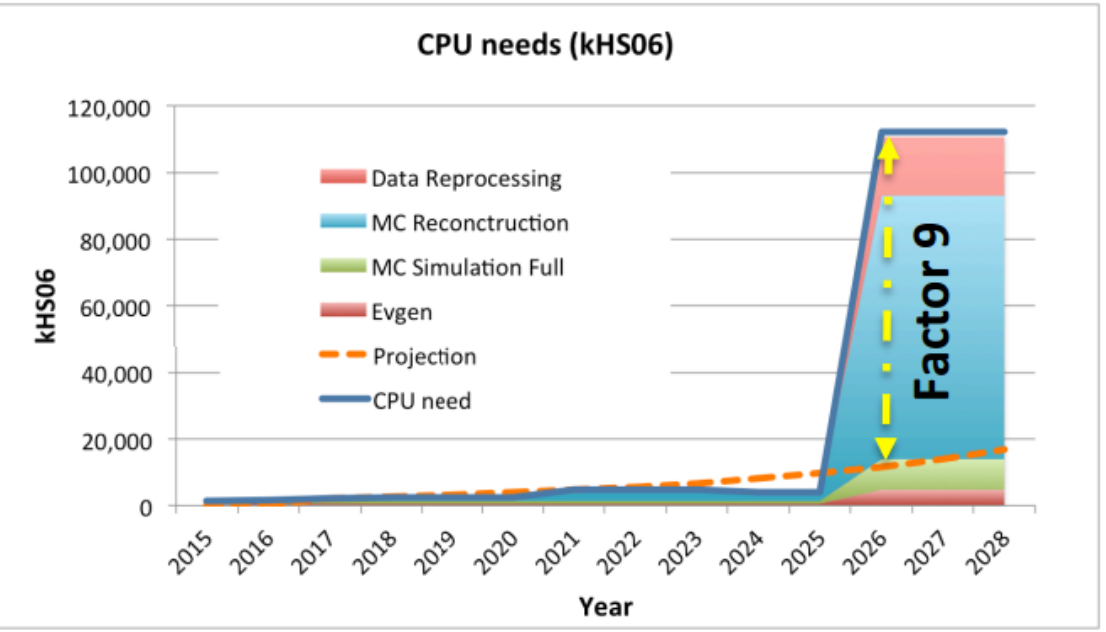


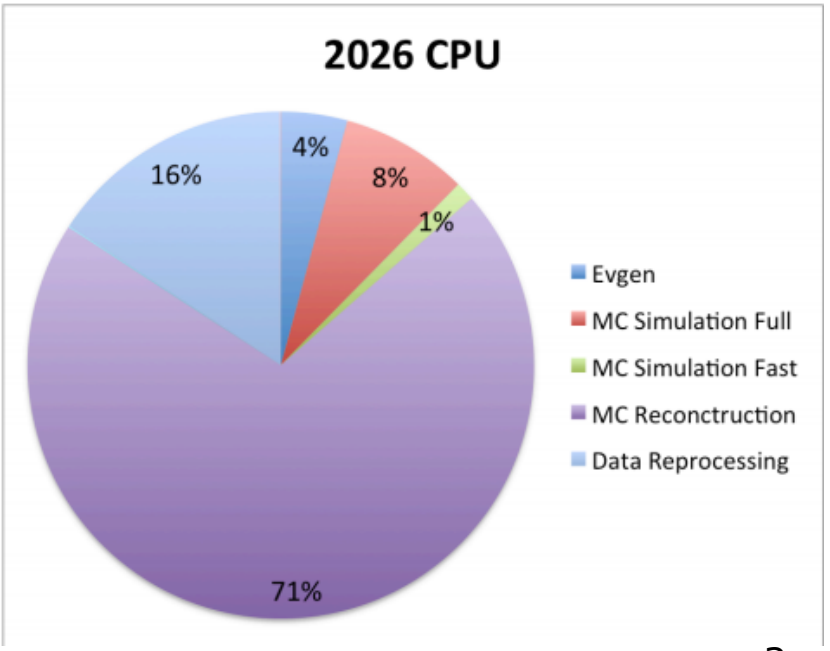
Simulation for Upgrade

Time needed for simulating single muon (P_T=15 GeV) with <μ>=200 pile up

	Fast sim./evt.	Full sim./evt.	Fast sim./50K evt.	Full sim./50K	Ratio(fast/full)
Gen	2.45s	2.45s	1d 10h	1d 10h	100%
Sim	0.20s	88 m	2h 46	8y	0.004%
Digit	0.04s	47s	33m	27d	0.1%
Reco	0.06s	2m 40s	50m	90d	0.04%
Total	2.75s	90m	1d 14h	8y	0.05%

Need “smart” simulation to cope with pile up increase



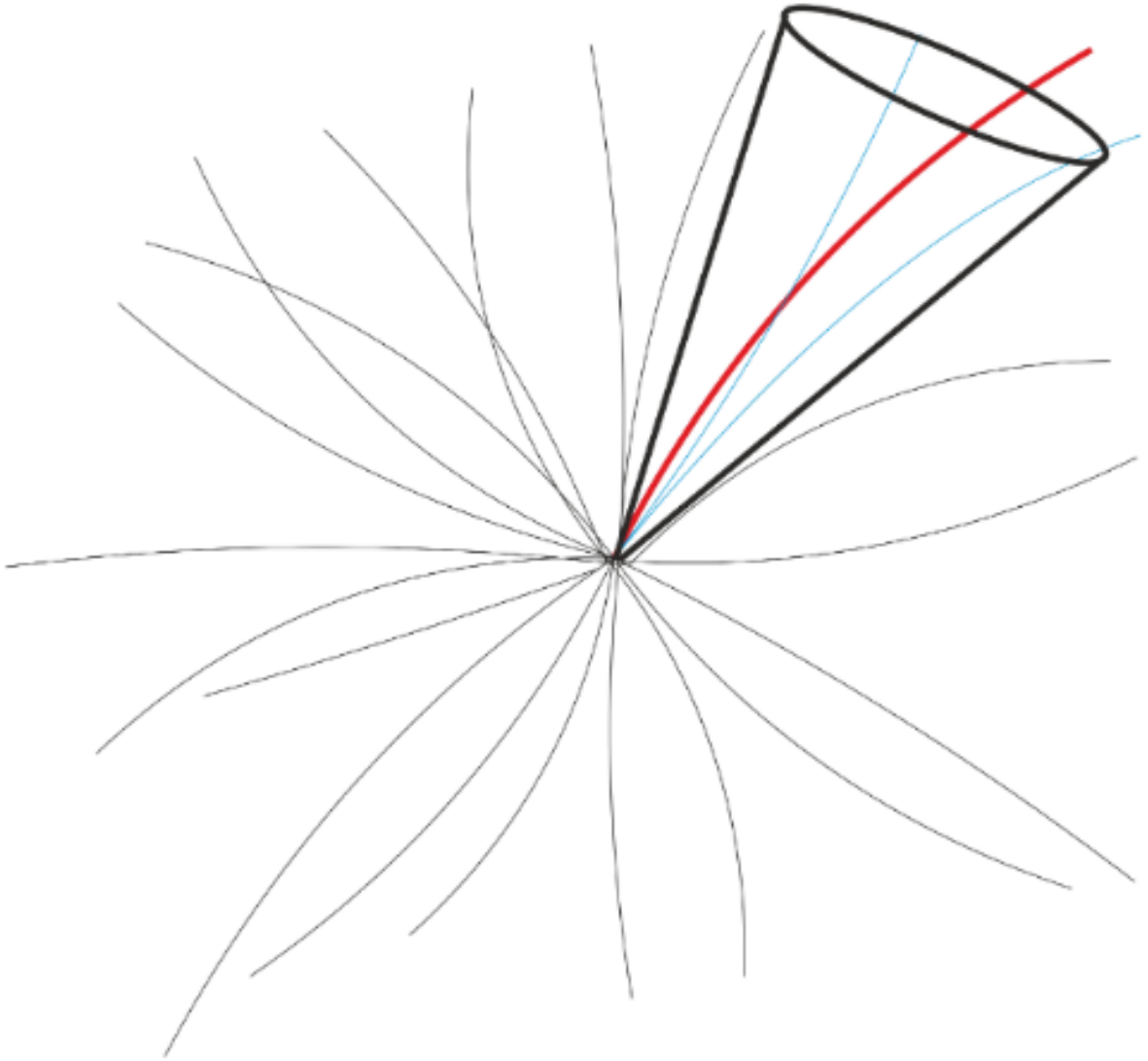


Activities from Italian groups

- “Smart” Simulation: Fast digitization, Fast Sim
- Charge collection studies (Pixel)
- Radiation damage simulation
- Performance studies on physics observables in specific physics channels

Fast Simulation and Full Simulation

Idea:
Full simulation only of hard scattering particles (and cone around it)
Fast Simulation only of part of event outside “hard scattering” particle



Hard-scattering particle

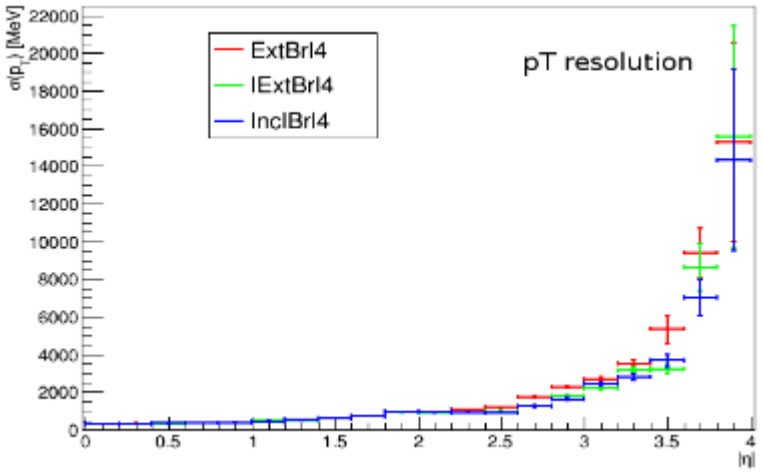
Pile-up particles in RoI

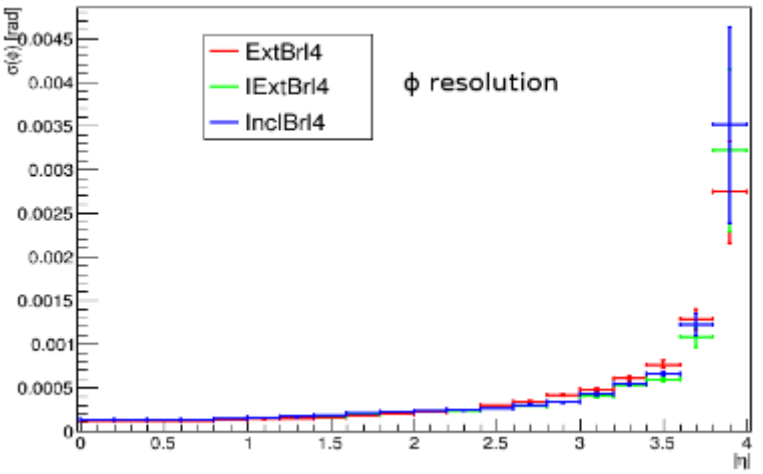
Pile-up particles outside RoI

Cone $\Delta R = 0.1$

G. Chiarelli, F, Massa

Results on realistic physics analysis (H→ 4μ)

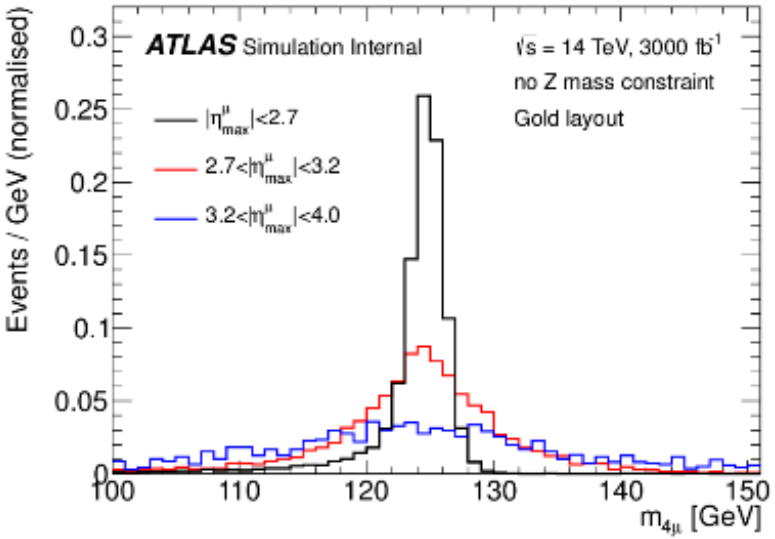


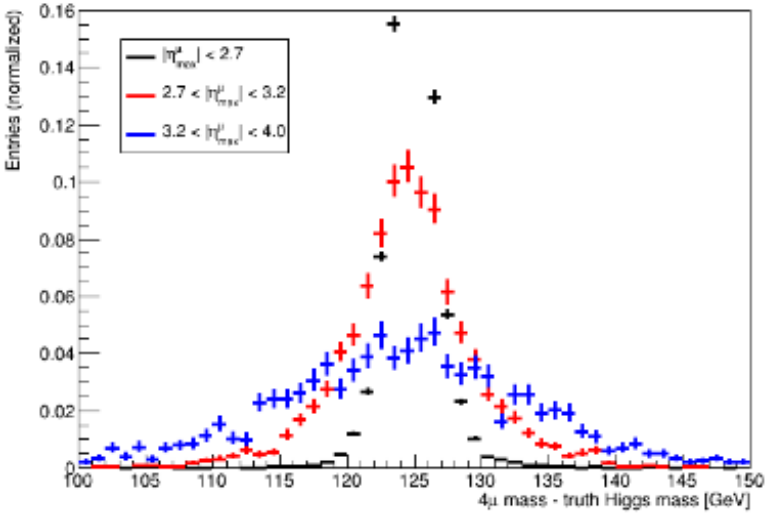


Fast Simulation

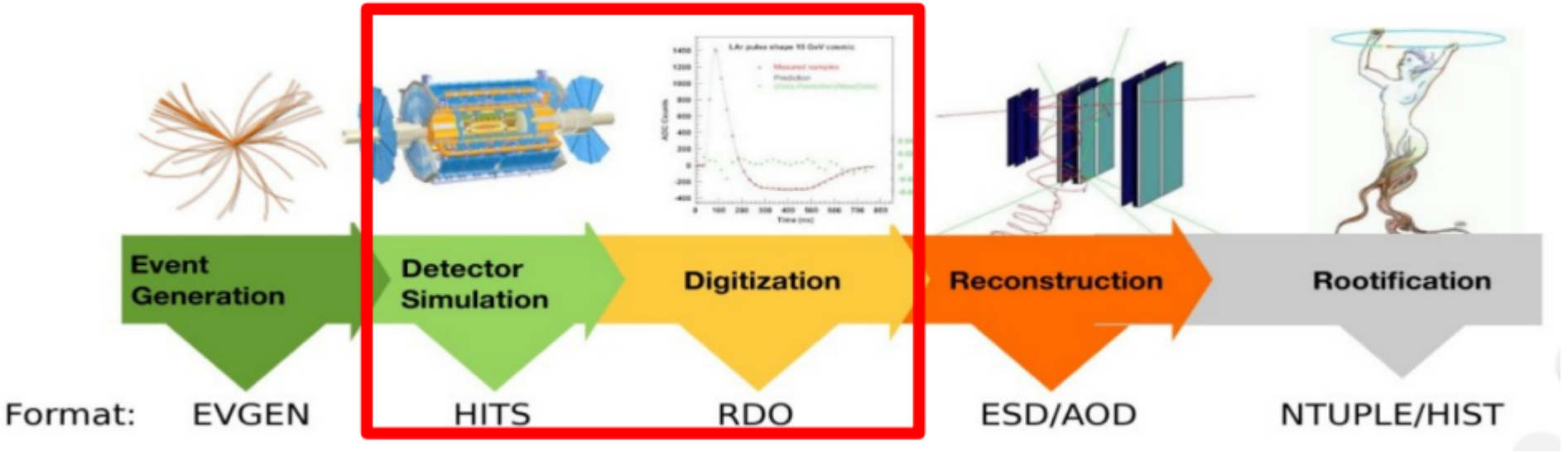
Scoping Document

(InclBrl4 layout, no mass constraint)





Fast Digitization



Effort started with Federica Fabbri qualification task
→ Also application in Fast chain simulation (not covered here but timescale is shorter term than Phase 2!)
Can change granularity and thickness of sensors (change in xml propagated to geometry)

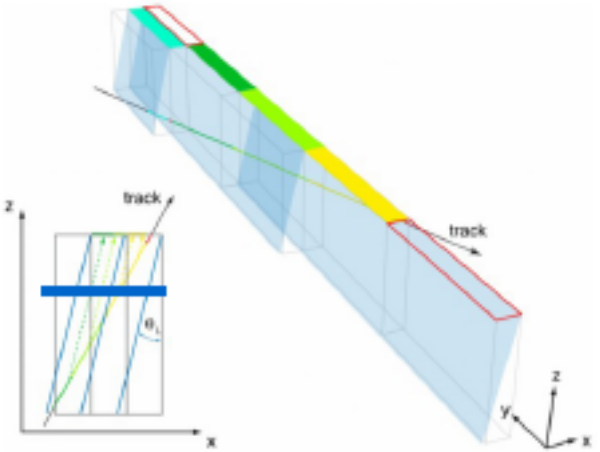
F. Fabbri, F. Lasagni, C. Sbarra A. Sidoti

Fast Digitizazion

Digitization → simulated energy deposits converted into the detector readout format by detailed simulation of the detector response

Fast Digitization →
- Ignore the simulated energy deposits
- Pixel charge depends only on geometrical path of tracks in pixel
- Applied correction due to presence of magnetic field (Lorentz angle correction)

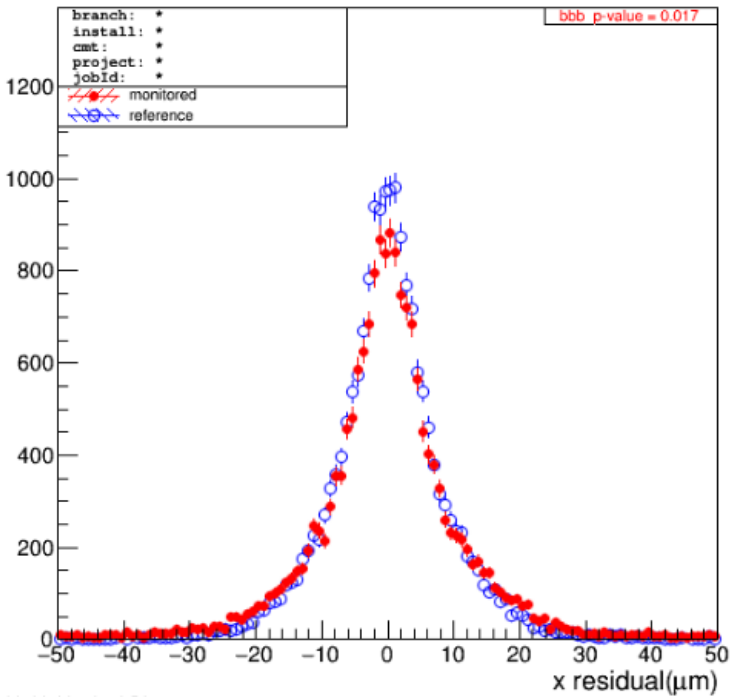
Changes in pixel geometry are applicable during fast digitization without rerun GEANT4 simulation (detector simulation) →



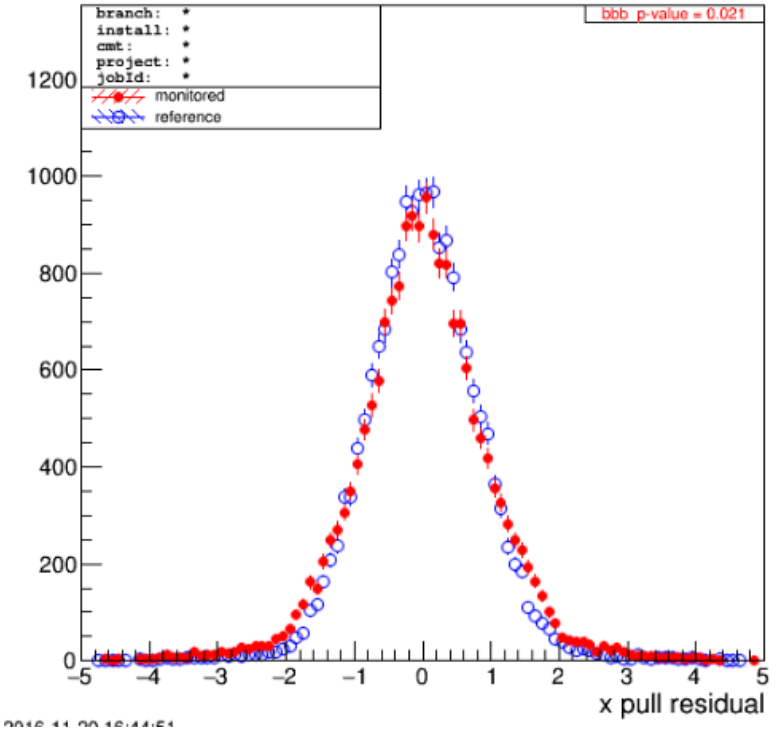
Note: Fast Digitization return culsters! (no clusterization studies possible)

Fast Digitization

In 2016 focused on asserting quality of Fast Digitization vs Full Digitization to understand if it can be used to get reliable performance measurements
Many improvements in 2016:
Better determination of Lorentz angle
More realistic pixel creation in clusters, merging and smearing and many others



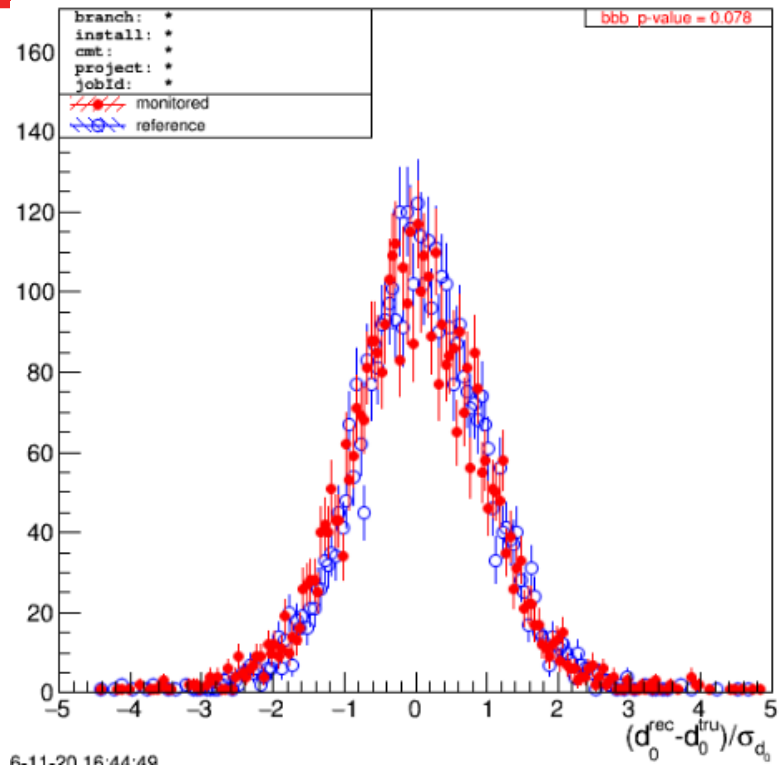
Residual x

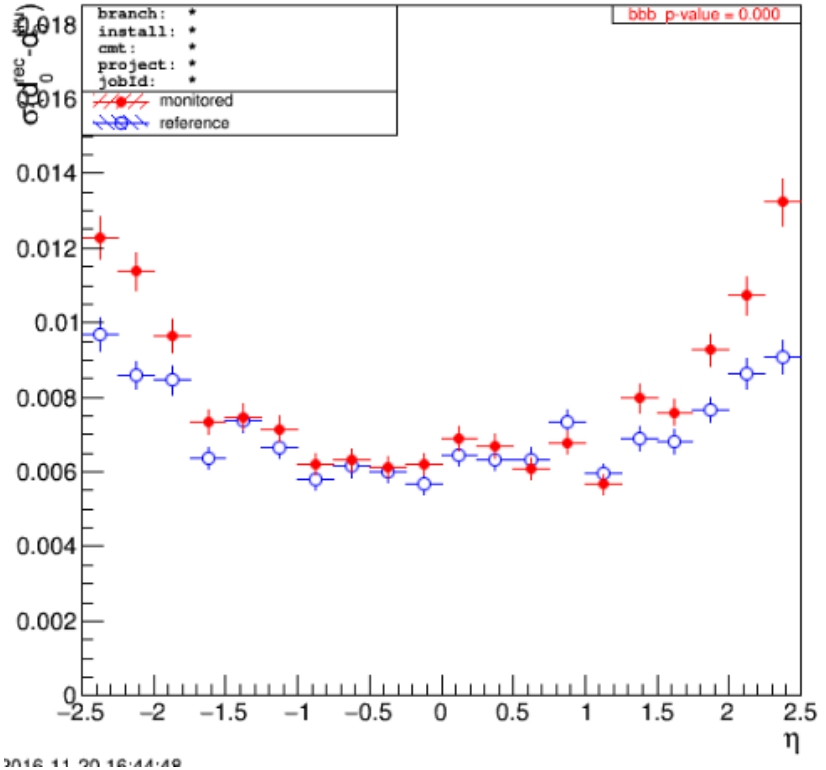


Pull residual

8000 single muons
P_T=50 GeV (no pile up
Full digi vs **Fast Digi**

Fast Digitization





Many improvements in the last year but stilll some inconsistencies in d0 resolution vs η

Need to assess impact on physics performance (e.g. b-tagging, pflow, JVT, etc….)

More results in
https://test-dcubeffabbri.web.cern.ch/test-dcubeffabbri/ITKTEST/Test4/InDetStandardPlots.root.dcube.xml.php

Fast Digitization in TDR (Pixel)

Check available granularity of different options for planar pixels (50 x 50 or 25 x 100?).
Assess performance replacing outer pixel layer with monolithic sensors →
Granularity parameter scan (z-pitch, depletion) → possibile with Fast digi
Digitization parameters studies (threshold, noise, …) → need full digi

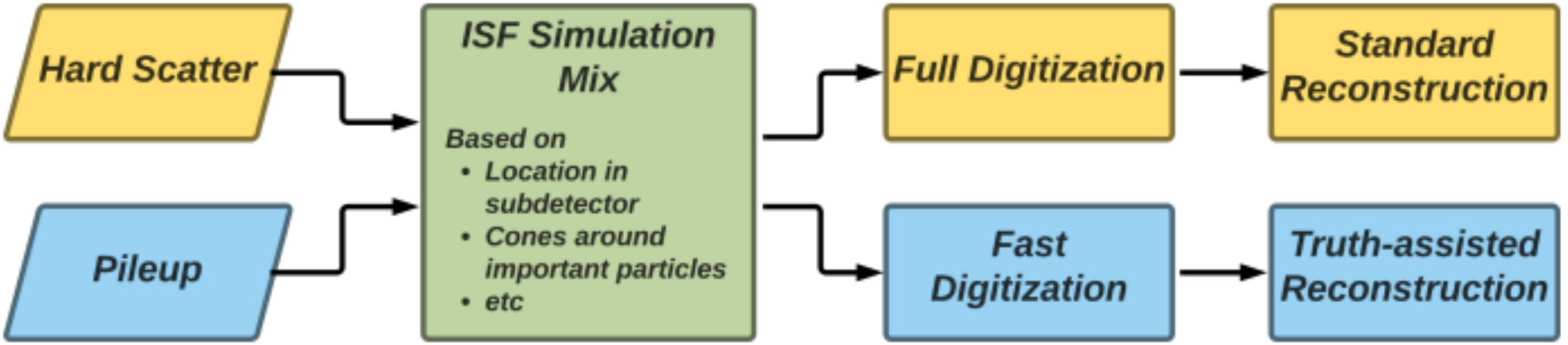
→ Timescale May-June 2017

In parallel effort to insert Fast Digitization in the Fast Chain for MC production (pile up)

Fast Chain

Fast Chain speeds up simulation for large pile up. Combines Fast Simulation, Fast Digitization and Fast track reconstruction

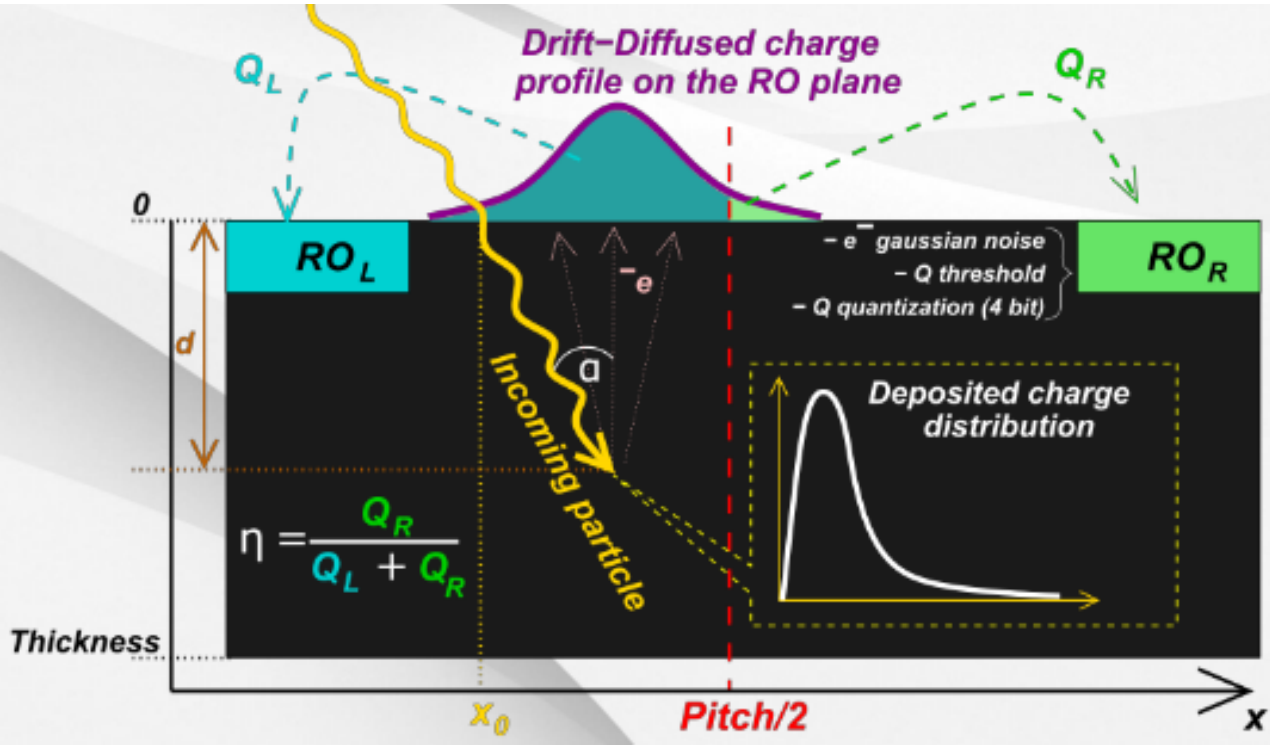
Several orders of magnitude faster than standard simulation.
Different simulation paths for Hard Scattering (HS) and Pile Up (PU)



Charge deposition improvements

A. Damilano

Work performed in IBL performance paper but could be extended for Itk → Planar and 3D sensors as well (in principle)



Goal: Simulate physical phenomena occurring on IBL pixels to achieve information on charge collection as a function of different parameters:

Particle related:

impact point, Impact angle

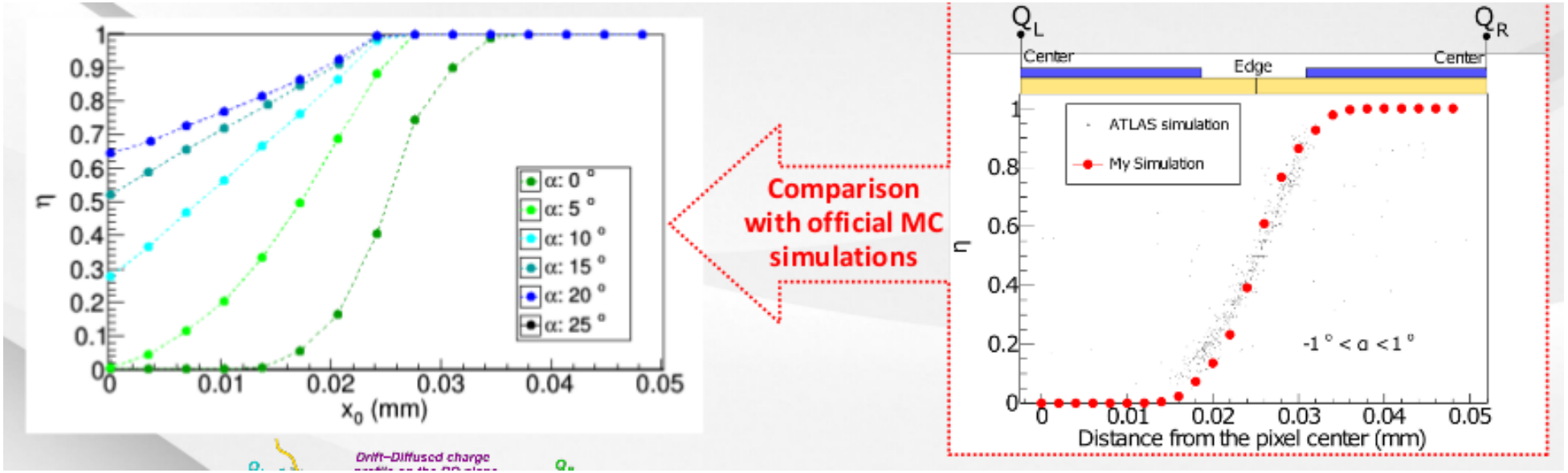
Sensor related:

Pitch, thickness, electron mobility

Readout:

Threshold, noise

Charge deposition improvements



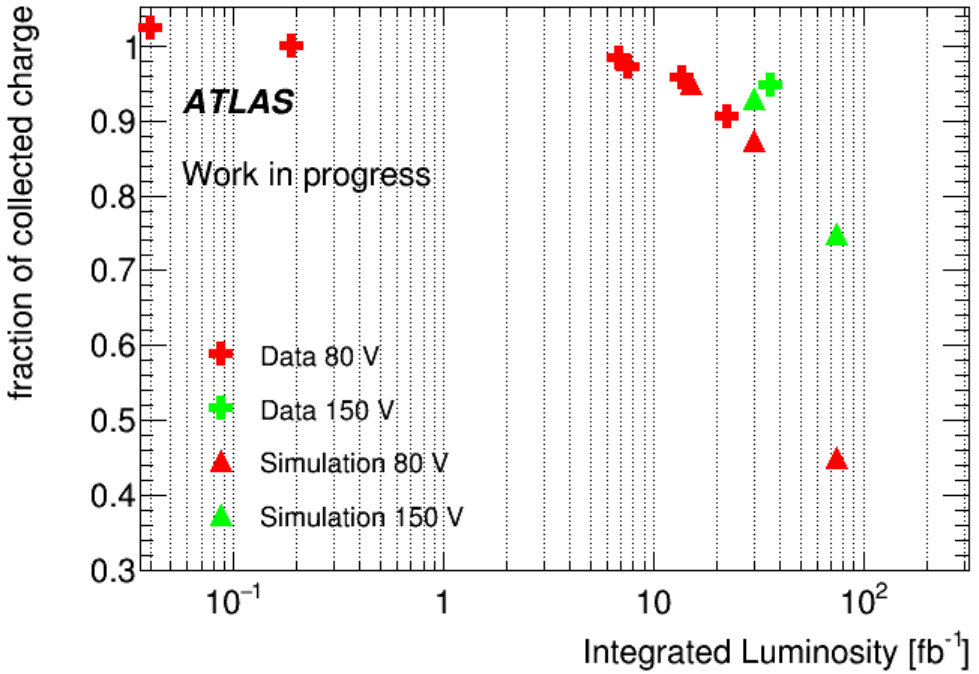
η function from "official" MC simulation

η function from charge deposition method

Radiation damage tool

G. Giugliarelli, T. Lari, L. Rossin

Goal: Implement a radiation damage tool in digitizer to simulate degradation due to radiation received during operations → crucial to get realistic physics performance after N years of data taking (and dose received)



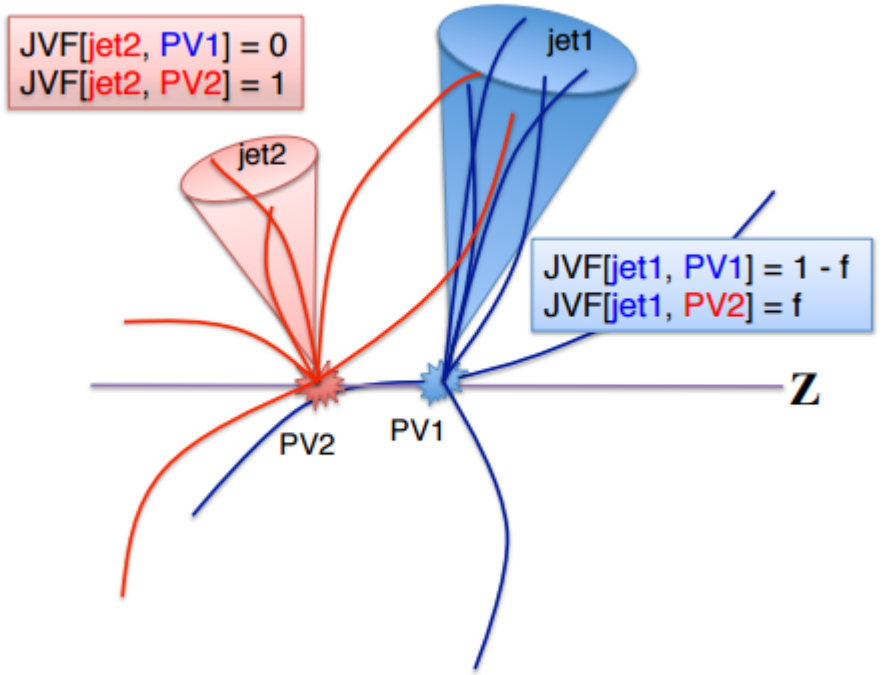
Electric field maps for different fluences from TCAD simulations
→ Integration in AllPix simulation.
Ongoing work on planars and 3D

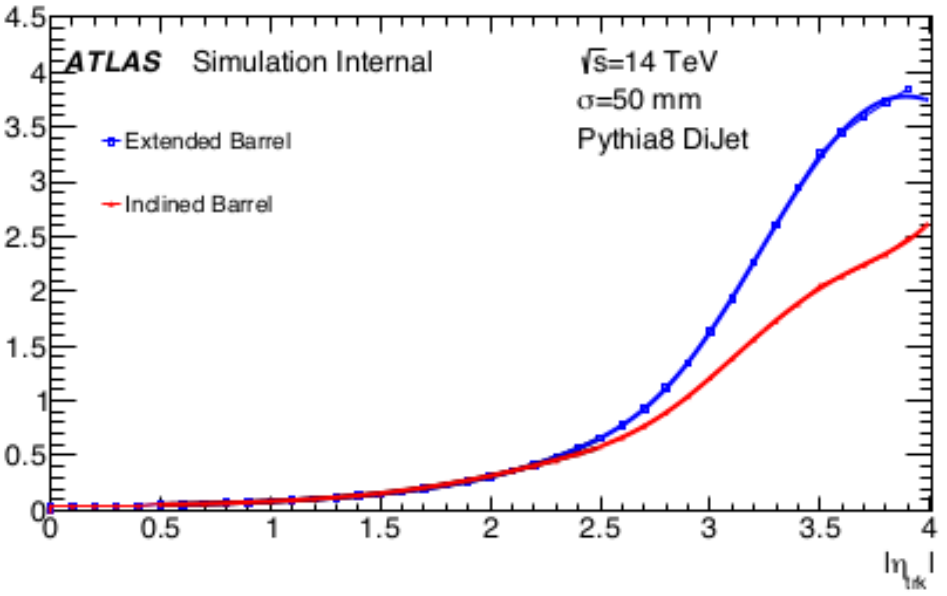
Detailed internal note in preparation
https://cds.cern.ch/record/2216540

Performance evaluation: Extended vs Inclined

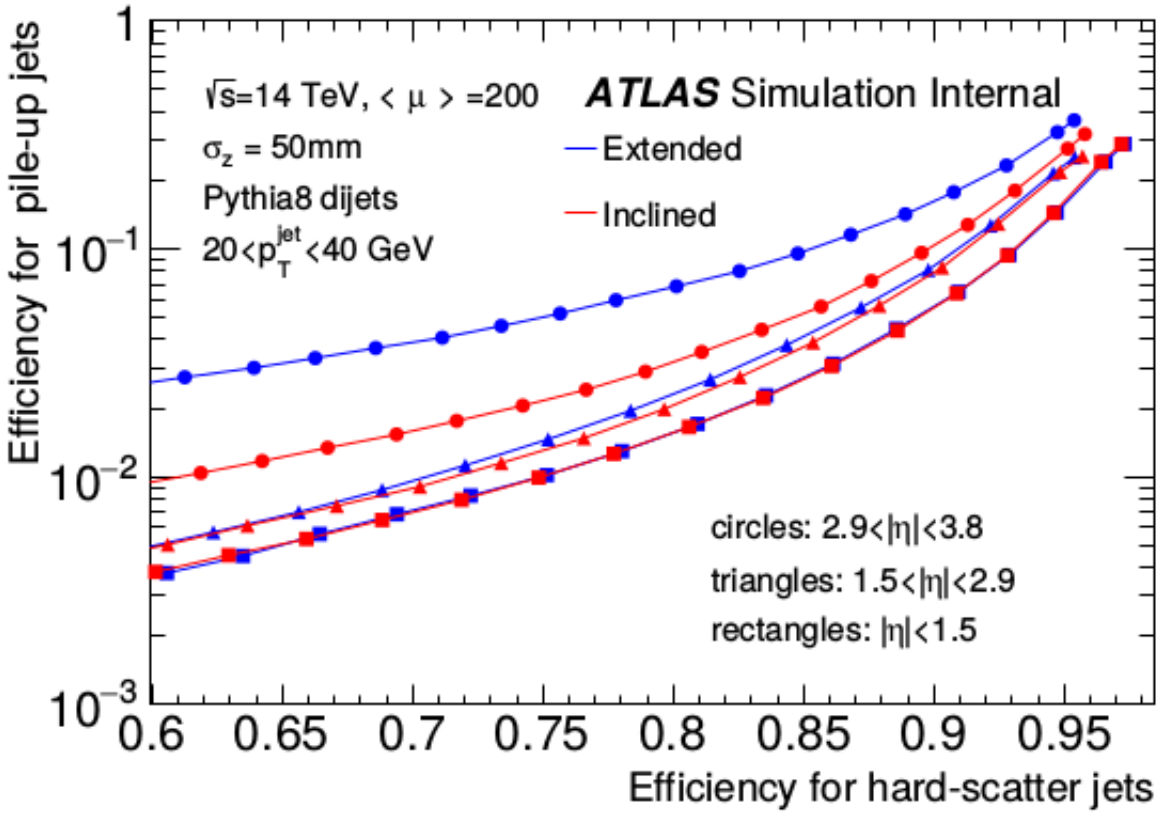
M. Scornajenghi, M. Testa

Assess physics performance with realistic mu (<μ>=190 to 210) for realistic physics events (dijet, ttbar) for different layout: Extended vs Inclined
Tracking involved in all reconstructed objects
Impressive amount of work for LTF report





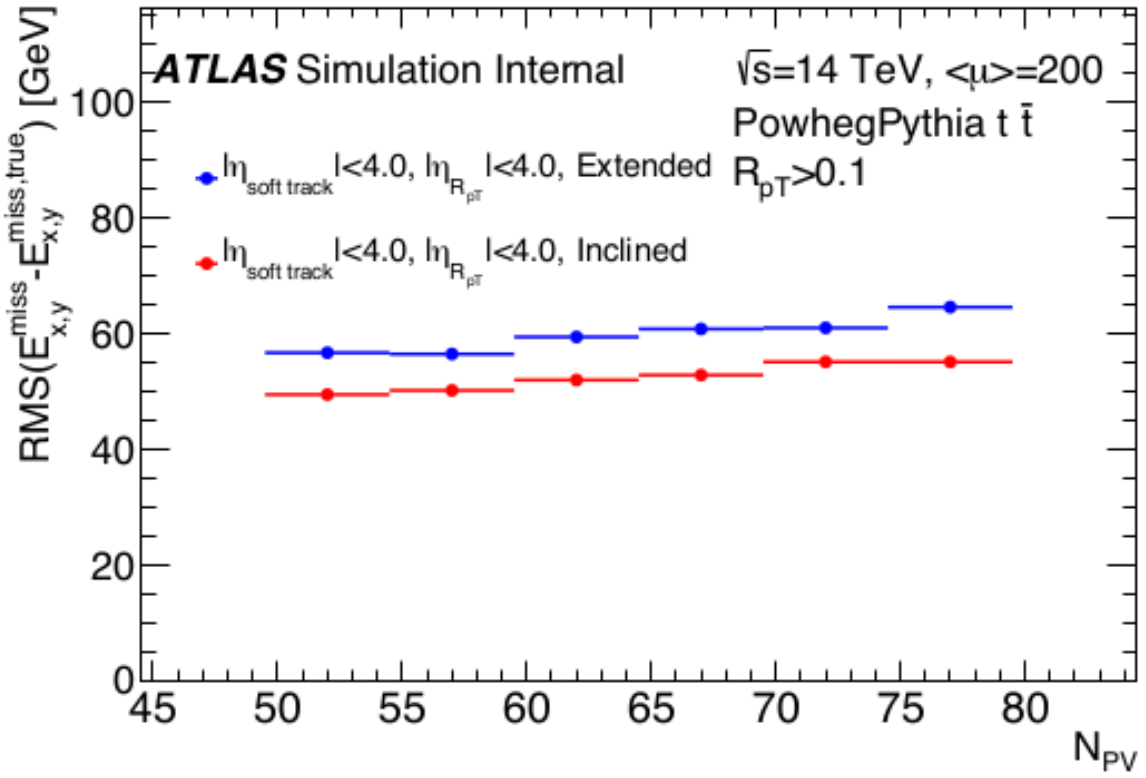
Performance evaluation: Extended vs Inclined



Crucial to discriminate pile up jets from hard scatterinn jets

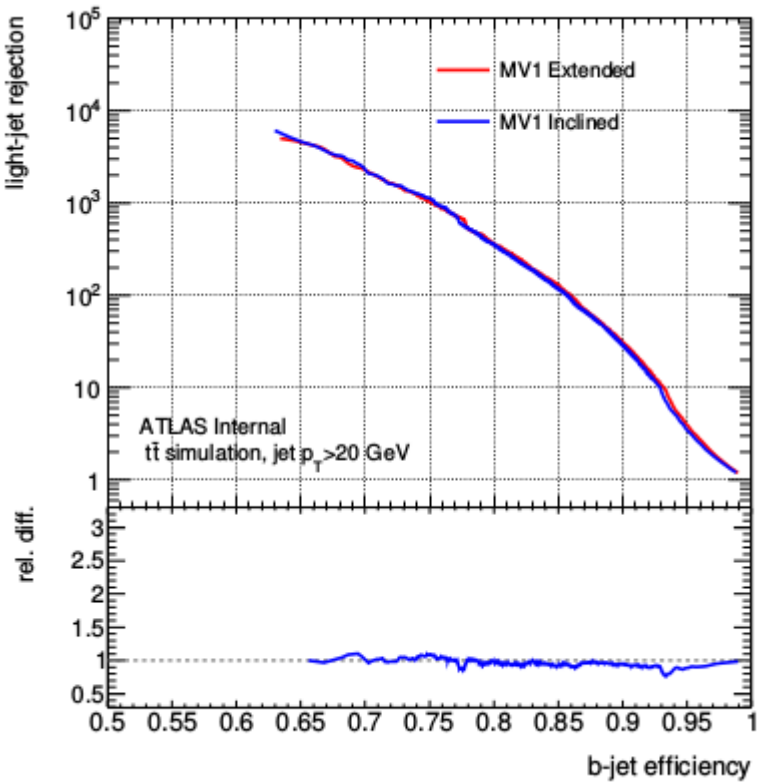
$$R_{\mathrm{pT}} = \frac{\Sigma_k p_{\mathrm{T}}^{\mathrm{trk_k}}(\mathrm{PV}_0)}{p_{\mathrm{T}}^{\mathrm{jet}}}$$

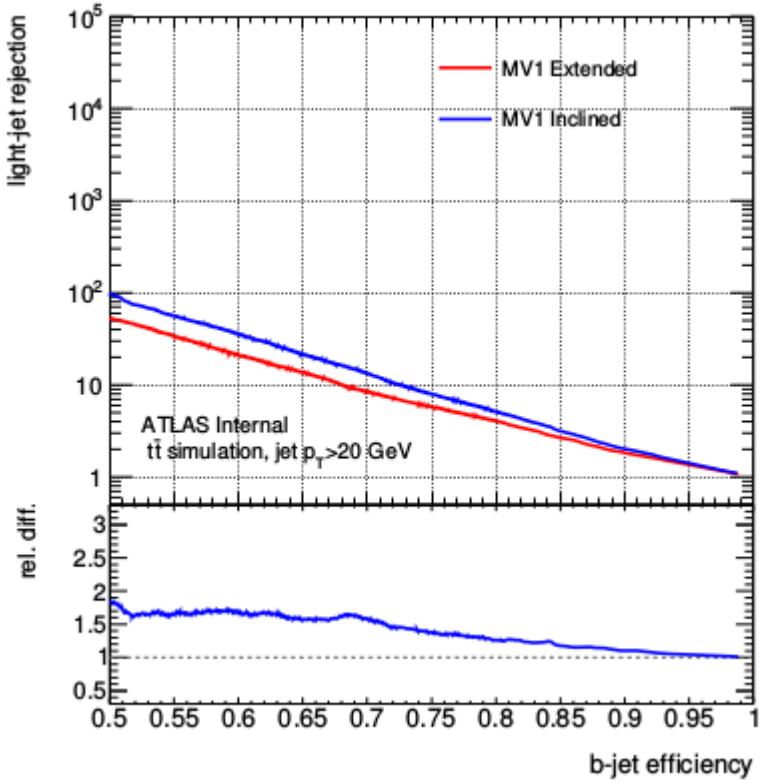
Performance evaluation: Extended vs Inclined



Improvement on Missing ET (soft term calculation) with Inclined layout

Performance evaluation: Extended vs Inclined





$|\eta|<1$

Impact of layouts on b-tagging
Improvement performance of inclined layout wrt extended on at large pseudorapidity

$|\eta|>2.7$

Conclusions

Simulation is a key ingredient for finalization of the ITk project
After LTF report, inclined solution seems to be preferred.
Several questions still need to be addressed: granularity, CMOS monolithic option, …

→ 2017 is a crucial year

Beam condition requirements (mu=200) require “smart simulation”

→ Several tools are under development and performance studies