

WHAT'S NEW IN TRACKING ?

A summary of the ATLAS Inner Detector
Tracking Workshop 2025

Daniel Werner
DESY SM Meeting

03.06.2025

HELMHOLTZ



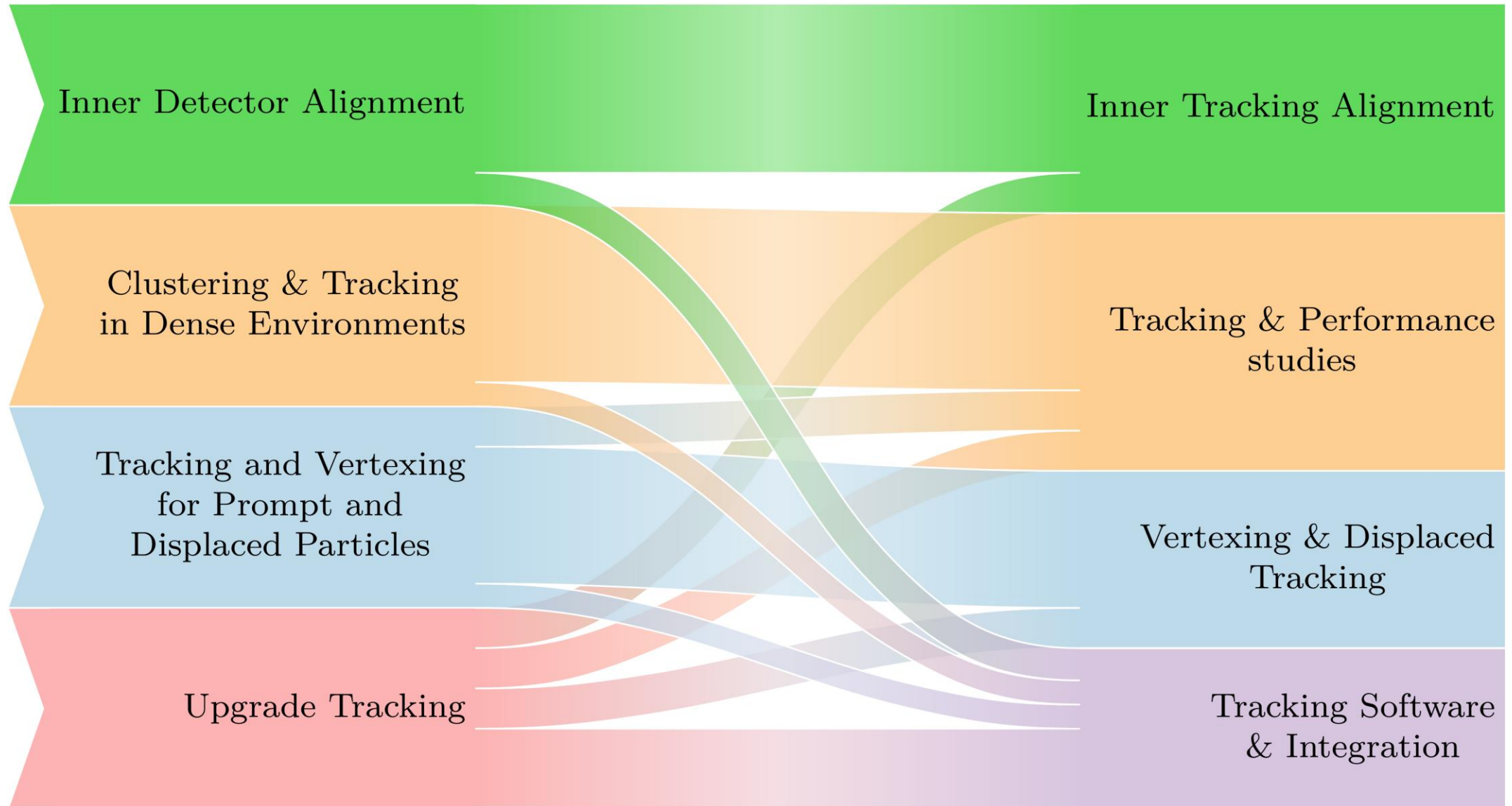
Overview

Agenda and Slides on [Indico](#)

- Day 1
 - Restructuring of subgroups
 - TVPD report
 - CTIDE report
- Day 2
 - ID and Itk status
 - Upgrade Tracking report
- Day 3
 - Alignment report
- Hands-on-Sessions



New Structure of Tracking Group



TVPD Activity report

Link to [Slides](#)

TVPD Activity report

Link to [Slides](#)

- New Recommendations

Recommendations Status

We're making **good progress** on recommendations!

- **MC23a** done by Sadaf for a few months
- **MC23d** done as of ~2 weeks ago 🥳 Both installed in tools and ready to use
- **MC23e** coming very soon, waiting on minbias MC AOD production. Expect **~O(1-2 months)**

Some **personpower issues** make it a bit slower than it could have been (more on that later...)

CP Tools have been [cleaned up and updated](#) as well! **Ready to develop CP Algs**

	2022 / MC23a	2023 / MC23d	2024 / MC23e
Prompt Efficiency	DONE ✓	DONE (NEW!) ✓	In Progress
Prompt Fake Rate	DONE ✓	DONE (NEW!) ✓	In Progress (waiting for MC)
LRT Efficiency	DONE ✓	DONE (NEW!) ✓	In Progress (waiting for MC)



Makayla Vessella

TVPD Activity report

Link to [Slides](#)

- New Recommendations
 - Issue with Fake rates in 2022

Recommendations Status

Prompt Fake Rate – MC23a/2022

Sadaf discovered that in 2022 data, the fake rate is **NOT suppressed by Tight Primary** as in all previous Run1+2. **Very surprising and concerning!**

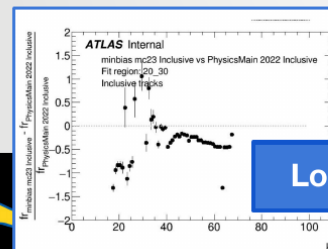
Some difficulties in selecting “fake free” linear fit as mu determination is... interesting at low mu for Run 3 even with strict GRL.

- End of fills etc., I checked on DQ side and nothing unusual, what we get is what we get...
- Already start to get contamination by the time we have stats

While very concerning, ultimately, this can't impact the tight recommendation as **already set at 100% drop rate** in the filter tool.

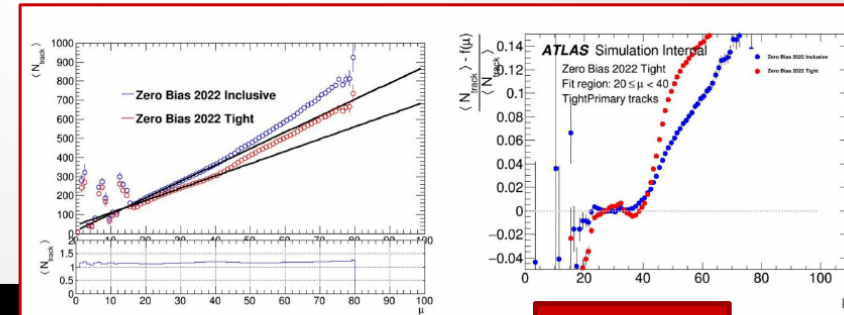
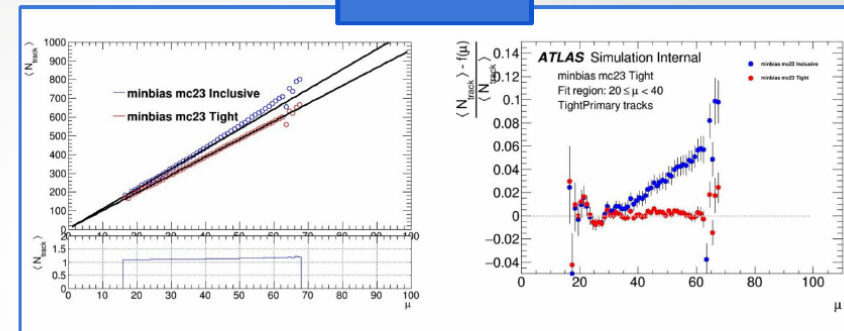
- Can't go higher as can't exactly **drop more fake tracks than exist** in the MC

Determine inclusive/loose recommendation at **40% uncertainty – much more than Run 2.**



Loose FR

MC23a



2022 Data

Makayla Vessella

Credit Sadaf Kadir

10

TVPD Activity report

Link to [Slides](#)

- New Recommendations
 - Issue with Fake rates in 2022
- QPs
 - ACTS Grid Seeder

Recommendations Status

Prompt Fake Rate – MC23a/2022

MC23a

Sadaf discovered **suppressed by T** **surprising and c**

Some difficulties i
determination is...
GRL.

- End of fil
what we
- Already s
stats

While very concer
recommendation :

- Can't go
than exi

Determine includ
much more than

Run 4 ttbar

COMPLETE

ACTS Grid Seeder in Athena

ACTS-based PV finding has been integrated into Athena since R22 – but only using the very precise **Gaussian seeder** which uses a **continuous density estim** along z

- **Very precise**, but computationally **more expensive** than some other seeding approaches

A **grid seeder** implementation also existed in ACTS, which uses **discretized bins in z and d_0** to identify seeds

- Now fully **integrated into Athena** by Lara and can be configured during PV reconstruction
- **~30% reduction in seeding CPU time** with **sub-1% reduction in HS vertex reconstruction efficiency**

Makes grid seeder available for **further performance studies** for Run 4! Let us know if you're interested 🙋

ATLAS Simulation Preliminary

Weight / 0.1 mm

Gaussian Smoother

Metric	Gaussian Seeder	Grid Seeder
CPU Time (per event)	0.45 s	0.30 s
Memory Usage	100 MB	120 MB
Tracks Processed	50,000	50,000
Reconstructed Vertices (avg.)	24.7	24.6
Vertex z Resolution	15.2 μ m	16.1 μ m
HS Vertex Efficiency	99.2%	98.9%
Comments	Very precise, but higher CPU cost.	More efficient, slight loss in precision.

ATLAS Tracking Internal

mc21 14TeV ttbar SingleLep

$N_{\text{events}} = 1000$

Number of Entries

ATLAS Tracking Internal

mc21 14TeV ttbar SingleLep

$N_{\text{events}} = 1000$

Fraction of events

Run 4 ttbar

COMPLETE

Credit Lara Calic

Makayla Vessella

TVPD Activity report

Link to [Slides](#)

- New Recommendations
 - Issue with Fake rates in 2022
- QPs
 - ACTS Grid Seeder
 - Low-pt tracking for ITk

Recommendations Status

Prompt Fake Rate – MC23a/2022

MC23a

Sadaf discovered
suppressed by T
surprising and c

Some difficulties i
determ
GRL.

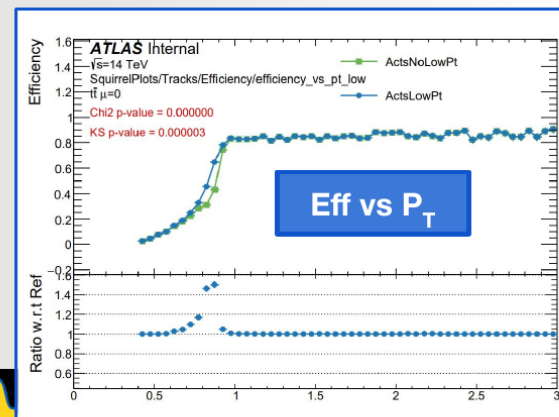
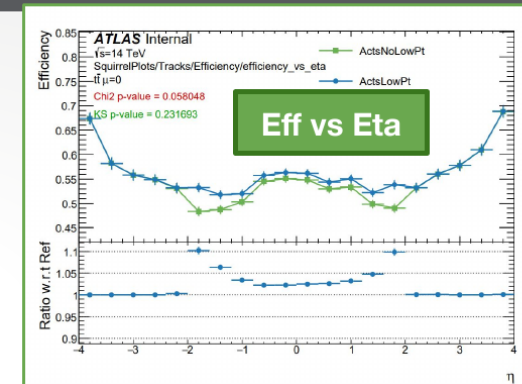
ACTS Grid Seeder in Athena

Low p_T tracking for ITk

The special **low p_T tracking** pass is already performing well in Legacy Athena for event filter workflows, but has **not yet been investigated and optimized for ACTS**

Daniel is now investigating the physics and CPU performance of the low p_T pass! Confirmed **working well** and now to evaluate and tune

Determ
much



ACTS track reconstruction

- > **Main Pass** reconstructs most tracks from primary interaction
- > **Specialized Passes** (e.g. Large Radius, Conversion, etc.)
- > **LowPt Pass** focuses on low- p_T tracks in central region

$0 \leq \eta < 2$	$2 \leq \eta < 2.6$	$2.6 \leq \eta < 4$
$ d_0 < 2$	$ d_0 < 2$	$ d_0 < 10$
$ z_0 < 200$	$ z_0 < 200$	$ z_0 < 200$
$p_T \geq 0.9$ GeV	$p_T \geq 0.4$ GeV	$p_T \geq 0.4$ GeV
$n_{\text{hits}} \leq 9$	$n_{\text{hits}} \leq 8$	$n_{\text{hits}} \leq 7$
$n_{\text{holes}} \leq 2$	$n_{\text{holes}} \leq 2$	$n_{\text{holes}} \leq 2$
$ d_0 < 2$	$ d_0 < 2$	$ d_0 < 10$
$ z_0 < 200$	$ z_0 < 200$	$ z_0 < 200$
$p_T \geq 0.4$ GeV	$p_T \geq 0.4$ GeV	$p_T \geq 0.4$ GeV
$n_{\text{hits}} \leq 9$	$n_{\text{hits}} \leq 8$	$n_{\text{hits}} \leq 7$
$n_{\text{holes}} \leq 2$	$n_{\text{holes}} \leq 2$	$n_{\text{holes}} \leq 2$

Makayla Vessella

Credit Daniel Werner

16

TVPD Activity report

Link to [Slides](#)

- New Recommendations
 - Issue with Fake rates in 2022
- QPs
 - ACTS Grid Seeder
 - Low-pt tracking for ITk
 - LRT for Itk

Recommendations Status

Prompt Fake Rate – MC23a/2022

MC23a

Sadaf discovered
suppressed by T
surprising and c

Some difficulties i
determ
GRL.

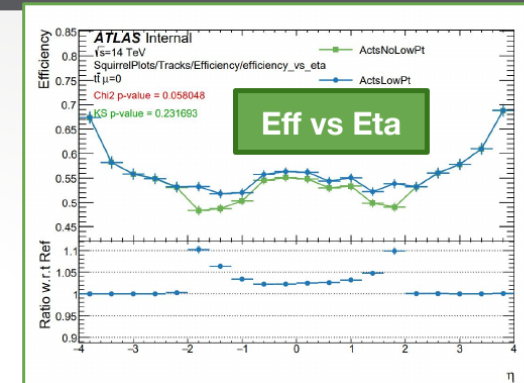
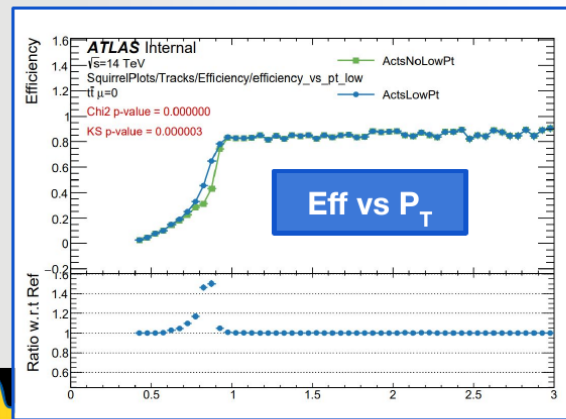
ACTS Grid Seeder in Athena

-
-
- While recom
- Determ much

Low p_T tracking for ITk

The special **low p_T tracking** pass is already performing well in Legacy Athena for event filter workflows, but has **not yet been investigated and optimized for ACTS**

Daniel **is now investigating** the physics and CPU performance of the low p_T pass! Confirmed **working well** and now to evaluate and tune



ACTS track reconstruction

- > **Main Pass** reconstructs most tracks from primary interaction
- > **Specialized Passes** (e.g. Large Radius, Conversion, etc.)
- > **LowPt Pass** focuses on low- p_T tracks in central region

$0 \leq \eta < 2$	$2 \leq \eta < 2.6$	$2.6 \leq \eta < 4$
$ d_0 < 2$	$ d_0 < 2$	$ d_0 < 10$
$ z_0 < 200$	$ z_0 < 200$	$ z_0 < 200$
$p_T \geq 0.9$ GeV	$p_T \geq 0.4$ GeV	$p_T \geq 0.4$ GeV
$n_{\text{hits}} \leq 9$	$n_{\text{hits}} \leq 8$	$n_{\text{hits}} \leq 7$
$n_{\text{holes}} \leq 2$	$n_{\text{holes}} \leq 2$	$n_{\text{holes}} \leq 2$
$ d_0 < 2$	$ d_0 < 2$	$ d_0 < 10$
$ z_0 < 200$	$ z_0 < 200$	$ z_0 < 200$
$p_T \geq 0.4$ GeV	$p_T \geq 0.4$ GeV	$p_T \geq 0.4$ GeV
$n_{\text{hits}} \leq 9$	$n_{\text{hits}} \leq 8$	$n_{\text{hits}} \leq 7$
$n_{\text{holes}} \leq 2$	$n_{\text{holes}} \leq 2$	$n_{\text{holes}} \leq 2$

Makayla Vessella

Credit Daniel Werner

16

TVPD Activity report

Link to [Slides](#)

- New Recommendations
 - Issue with Fake rates in 2022
 - QPs
 - ACTS Grid Seeder
 - Low-pt tracking for ITk
 - LRT for Itk
 - Efforts on PV finding/selection
 - New PVFinder

Recommendations Status

Prompt Fake Rate – MC23a/2022

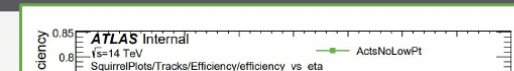
MC23a

Sadaf discovered
suppressed by T
surprising and c

ACTS Grid Seeder in Athena

Some difficulties i
determ
GRL.

Low p_T tracking for ITk



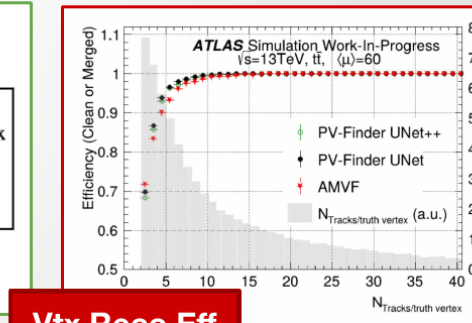
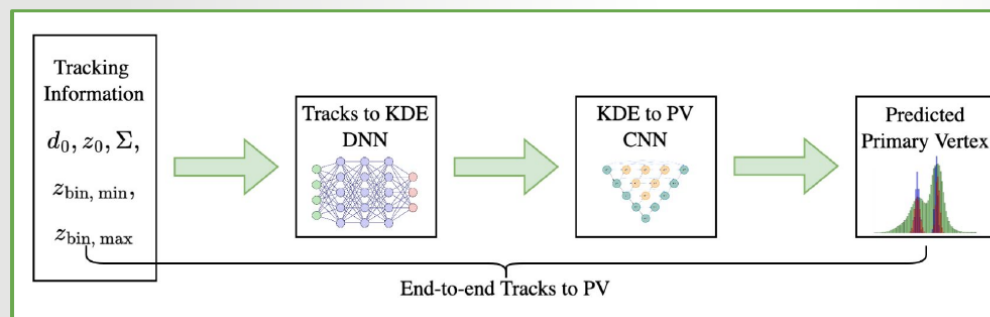
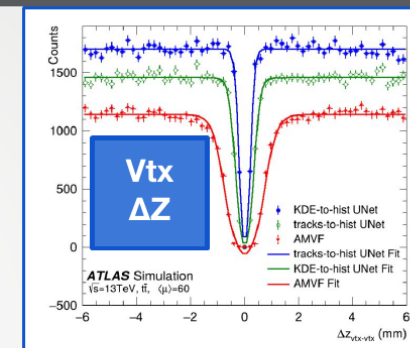
Ongoing activities: PV Finder

PVFinder aims to **outperform AMVF** with a **deep-learning approach** optimized for high PU environments

- [Previous PUBNote](#) in 2023 – great performance, but **needed optimization** for production-level speeds!

Rocky and Qi Bin have developed an [updated, fully end-to-end version](#) that eliminates the need for **hand-tuned intermediate KDE representations**

- **Tracks** → **KDE** → **PV** distribution via a combined MLP + UNet model
- **Better efficiency and resolution** than AMVF on PU=60 ttbar benchmark, and now **very fast** as well!



Vtx Reco Eff

Credit Qi Bin Lei, Rocky Garg



Makayla Vessella

21

TVPD Activity report

Link to [Slides](#)

- New Recommendations
 - Issue with Fake rates in 2022
 - QPs
 - ACTS Grid Seeder
 - Low-pt tracking for ITk
 - LRT for Itk
- Efforts on PV finding/selection
 - New PVFinder
 - GNN approach for low activity

Recommendations Status

Prompt Fake Rate – MC23a/2022

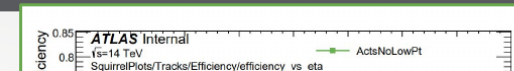
MC23a

Sadaf discovered
suppressed by T
surprising and c

ACTS Grid Seeder in Athena

Some difficulties i
determ
GRL.

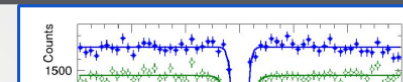
Low p_T tracking for ITk



Ongoing activities: PV Finder

PVFinder aims to outperform AMVE with a deep learning approach optimized for high PU
er

Credit Guglielmo Frattari, Jackson Burzynski, Hamza Hanif



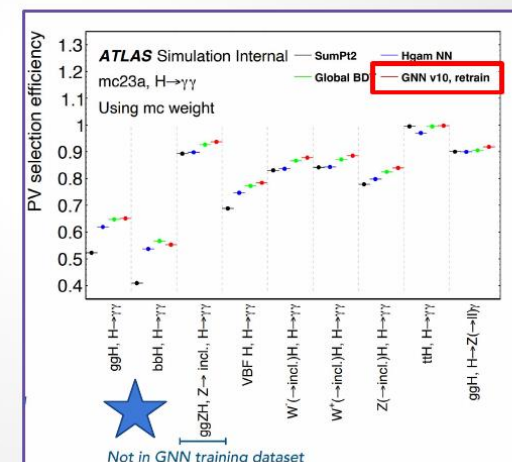
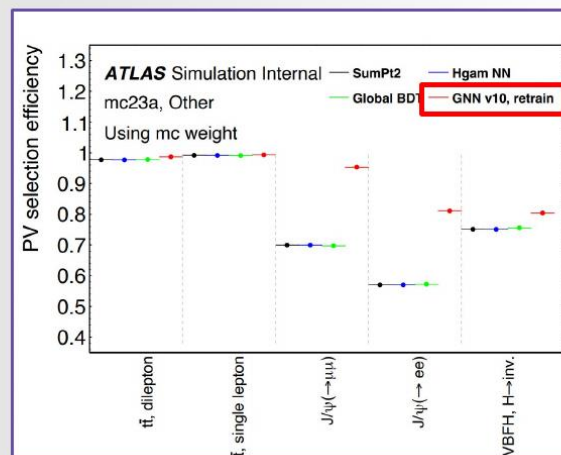
Global PV Selection: HSGN2

HSGN2 has higher HS selection efficiency than Σp_{\perp}^2 and $H \rightarrow \gamma\gamma$ NN across all tested processes, including those not in the training set.

- Scale of improvement varies strongly with process, ranging from sub 1% (as expected) for ttbar to 30+% for J/ψ
- This is a game-changer! PC enthusiastic about the prospect of consolidating Higgs derivations and improving efficiency across the physics program

Model is now implemented in Athena and available for preliminary testing in (private) PHYS production when enabled

Just needs a little help getting over the finish line...



Ttbar + extras

H -> yy

TVPD Activity report

Link to [Slides](#)

- New Recommendations
 - Issue with Fake rates in 2022
 - QPs
 - ACTS Grid Seeder
 - Low-pt tracking for ITk
 - LRT for Itk
- Efforts on PV finding/selection
 - New PVFinder
 - GNN approach for low activity
 - Multiple PV selection for HL-LHC

Recommendations Status

Prompt Fake Rate – MC23a/2022

MC23a

Sadaf discovered suppressed by T surprising and c

Some difficulties i determ GRL.

ACTS Grid Seeder in Athena

Low p_T tracking for ITk

ATLAS Internal
13-14 TeV
SquirrelPlots/Tracks/Efficiency/efficiency_vs_eta

Ongoing activities: PV Finder

PVFinder aims to outperform AMVF with a deep learning approach optimized for high PU

Credit Guglielmo Frattari, Jackson Burzynski, Hamza Hanif

Global PV Selection: HSGN2

Ongoing activities: HS and “hard PU” selection for ITk

HS Selection Eff vs

Wasikul is studying alternative PV selection for Run 4, complementary to the HSGN2 efforts!

Weighted Σp_T^2 approach previously studied and shown to be effective for some signatures

Downweights tracks that don't point to jets and can better suppress merged PU contributions.

But in HL-LHC environment, some events can't be resolved with just one PV and have multiple “hard” vertices.

Can we allow 2 PV candidates per event and associate different physics objects to either?

Selecting top 2 weighted Σp_T^2 and calling it successful if either is within 5mm of HS results in good efficiency

Next to investigate split vertex resolution and anomaly detection to identify “non PU like” vertices regardless of number

	Σp_T^2 (All events)	Σp_T^2 (W (All events)	Σp_T^2 (No split cases- events)	Σp_T^2 (W (No split cases- events)
R21 : Highest vertex within 5 mm	84.74%	93.96%	88.28%	95.80 %
R25 : Highest vertex within 5 mm	86.218 %	95.305%	89.215%	96.66 %
R21 : 2 Highest vertices, at least 1 vertex within 5 mm	92.52 %	97.78 %	94.32%	98.46 %
R25 : 2 Highest vertices, at least 1 vertex within 5 mm		97.98 %		98.56%

ATLAS Simulation Internal
13-14 TeV, $\langle \mu \rangle \approx 200$
VBF H \rightarrow invisible

Log of Reconstruction Loss Distribution

Anomaly Scores

$$\text{sumPTw} = \sum_{\text{tracks}} p_{T,w} = \sum_{\text{tracks}} p_T^2 p_{T(\text{closest jet})}^2 \frac{1}{\Delta R} \mathbb{1}(\Delta R < 0.8) \mathbb{1}(p_{T(\text{jet})} > p_{T(\text{threshold})})$$

Credit Wasikul Islam



TVPD Activity report

Link to [Slides](#)

- New Recommendations
 - Issue with Fake rates in 2022
 - QPs
 - ACTS Grid Seeder
 - Low-pt tracking for ITk
 - LRT for Itk
- Efforts on PV finding/selection
 - New PVFinder
 - GNN approach for low activity
 - Multiple PV selection for HL-LHC
- Highlight demands for CP algs

Recommendations Status

Prompt Fake Rate – MC23a/2022

MC23a

Sadaf discovered suppressed by T surprising and c

Some difficulties i determin GRL.

ACTS Grid Seeder in Athena

Low p_T tracking for ITk

ATLAS Internal
13-14 TeV
SquirrelPlots/Tracks/Efficiency/efficiency_vs_eta

Ongoing activities: PV Finder

PVFinder aims to outperform AMVF with a deep learning approach optimized for high PU

Credit Guglielmo Frattari, Jackson Burzynski, Hamza Hanif

Global PV Selection: HSGN2

Ongoing activities: HS and “hard PU” selection for ITk

HS Selection Eff vs

Wasikul is studying alternative PV selection for Run 4, complementary to the HSGN2 efforts!

Weighted Σp_T^2 approach previously studied and shown to be effective for some signatures

Downweights tracks that don't point to jets and can better suppress merged PU contributions.

But in HL-LHC environment, some events can't be resolved with just one PV and have multiple “hard” vertices.

Can we allow 2 PV candidates per event and associate different physics objects to either?

Selecting top 2 weighted Σp_T^2 and calling it successful if either is within 5mm of HS results in good efficiency

Next to investigate split vertex resolution and anomaly detection to identify “non PU like” vertices regardless of number

	Σp_T^2 (All events)	Σp_T^2 (W (All events))	Σp_T^2 (No split cases- events)	Σp_T^2 (W (No split cases- events))
R21 : Highest vertex within 5 mm	84.74%	93.96%	88.28%	95.80 %
R25 : Highest vertex within 5 mm	86.218 %	95.305%	89.215%	96.66 %
R21 : 2 Highest vertices, at least 1 vertex within 5 mm	92.52 %	97.78 %	94.32%	98.46 %
R25 : 2 Highest vertices, at least 1 vertex within 5 mm		97.98 %		98.56%

ATLAS Simulation Internal
13-14 TeV, $\langle \mu \rangle \approx 200$
VBF H \rightarrow invisible

Log of Reconstruction Loss Distribution

Anomaly Scores

$$\text{sumPTw} = \sum_{\text{tracks}} p_{T,w} = \sum_{\text{tracks}} p_T^2 p_{T(\text{closest jet})}^2 \frac{1}{\Delta R} \mathbb{1}(\Delta R < 0.8) \mathbb{1}(p_{T(\text{jet})} > p_{T(\text{threshold})})$$

Credit Wasikul Islam



TVPD Activity report

Link to [Slides](#)

- New Recommendations
 - Issue with Fake rates in 2022
- QPs
 - ACTS Grid Seeder
 - Low-pt tracking for ITk
 - LRT for Itk
- Efforts on PV finding/selection
 - New PVFinder
 - GNN approach for low activity
 - Multiple PV selection for HL-LHC
- Highlight demands for CP algs
- Dedicated presentation on Secondary Vertexing

Why do I care?

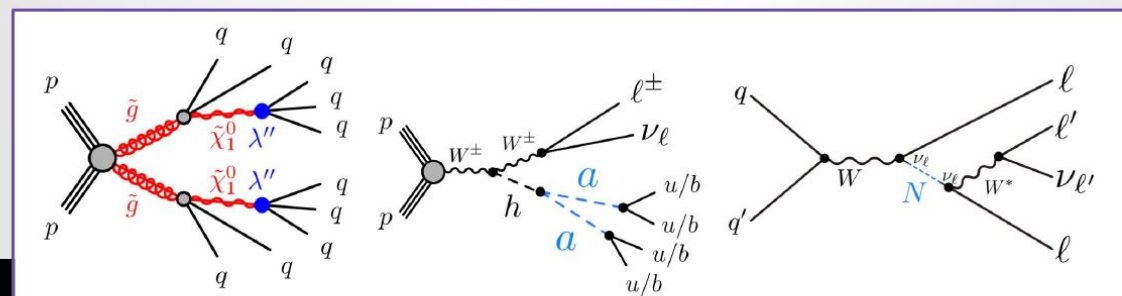
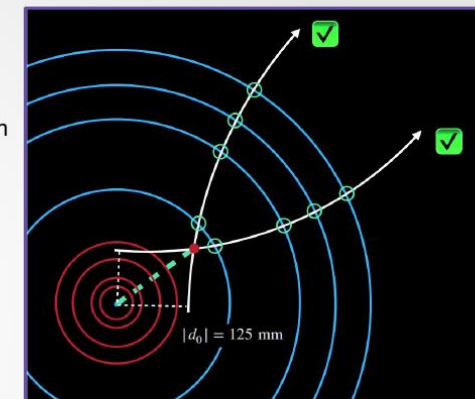
Secondary vertexing is a **core component** of our LLP search program!

Many BSM models include invisible particles that decay into multiple visible particles far from the IP, producing **displaced vertices (DVs)**

Accurately reconstructing the **positions and kinematics** of these DVs is **essential** for identifying many LLP signatures

Performance of DV reconstruction therefore underpins both **signal sensitivity** and **background rejection** for many LLP searches

- Like any reconstruction technique, the challenge is to **optimize both!**



ATLAS
EXPERIMENT

Makayla Vessella

ATL-PHYS-PUB-2019-013

3

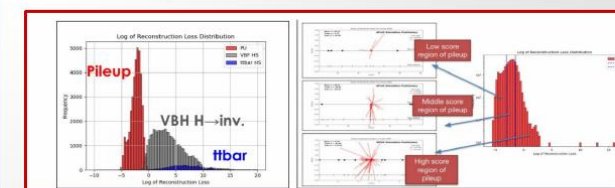
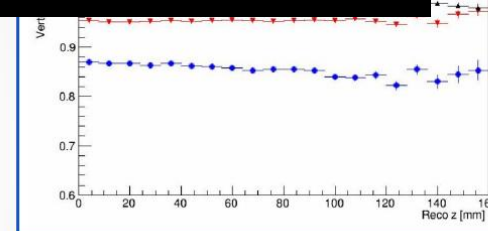
vertices.

- Can we allow **2 PV candidates per event** and associate different physics objects to either?

Selecting **top 2 weighted Σp_T^2** and calling it successful if **either is within 5mm of HS** results in good efficiency

Next to investigate split vertex resolution and **anomaly detection** to identify “non PU like” vertices regardless of number

	Sump_T^2 (All events)	Sump_T^2 (All events)	Sump_T^2 (No split cases- events)	Sump_T^2 (No split cases- events)
R21 : Highest vertex within 5 mm	84.74%	93.96%	88.28%	95.80 %
R25 : Highest vertex within 5 mm	86.218 %	95.305%	89.215%	96.66 %
R21 : 2 Highest vertices, at least 1 vertex within 5 mm	92.52 %	97.78 %	94.32%	98.46 %
R25 : 2 Highest vertices, at least 1 vertex within 5 mm		97.98 %		98.56%



$$\text{sumPTw} = \sum_{\text{tracks}} p_{T_w} = \sum_{\text{tracks}} p_T^2 p_{T(\text{closest jet})}^2 \frac{1}{\Delta R} \mathbb{1}(\Delta R < 0.8) \mathbb{1}(p_{T(\text{jet})} > p_{T(\text{threshold})})$$

Anomaly Scores

TVPD Activity report

Link to [Slides](#)

- New Recommendations
 - Issue with Fake rates in 2022
 - QPs
 - ACTS Grid Seeder
 - Low-pt tracking for ITk
 - LRT for Itk
- Efforts on PV finding/selection
 - New PVFinder
 - GNN approach for low activity
 - Multiple PV selection for HL-LHC
- Highlight demands for CP algs
- Dedicated presentation on Secondary Vertexing

Why do I care?

Secondary vertexing is a **core component** of our LLP search program!

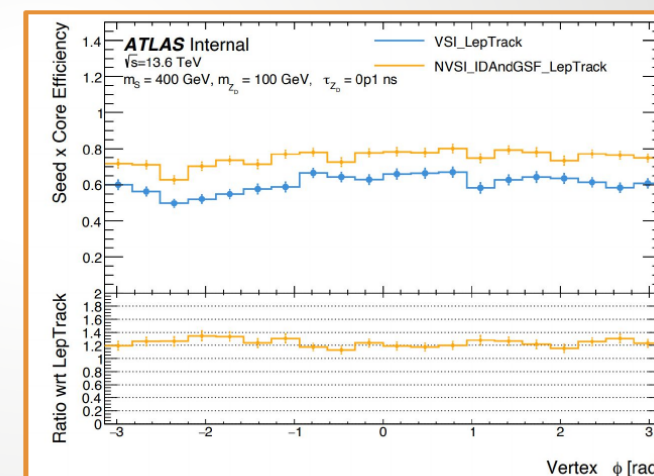
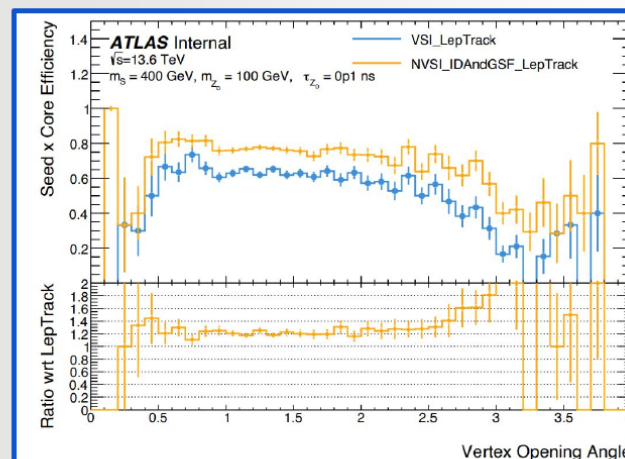
Many BSM models include invisible particles that decay into multiple visible particles far from the IP, producing **displaced vertices (DVs)**.



NewVSI

Results in **large efficiency gains** with analogous seeding, **>20% across kinematics!**

Original soft b-tag configuration has special BDT for **material secondary & fake rejection** – not performant for LLPs. Goal is to train some **new background rejection** for paper that is **performant for generic LLP signals**. Work ongoing!

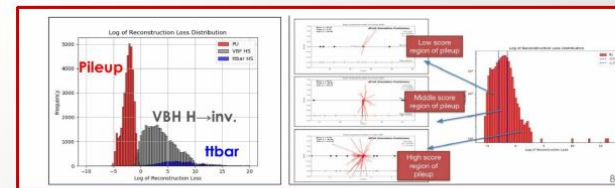


Makayla Vessella

Credit Sagar Addepalli

19

	Sump _r ² (All events)	Sump _r W (All events)	Sump _r ² (No split cases- events)	Sump _r W (No split cases- events)
R21 : Highest vertex within 5 mm	84.74%	93.96%	88.28%	95.80 %
R25 : Highest vertex within 5 mm	86.218 %	95.305%	89.215%	96.66 %
R21 : 2 Highest vertices, at least 1 vertex within 5 mm	92.52 %	97.78 %	94.32%	98.46 %
R25 : 2 Highest vertices, at least 1 vertex within 5 mm		97.98 %		98.56%



$$\text{sumPTw} = \sum_{\text{tracks}} p_{T_w} = \sum_{\text{tracks}} p_T^2 p_{T(\text{closest jet})}^2 \frac{1}{\Delta R} \mathbb{1}(\Delta R < 0.8) \mathbb{1}(p_{T(\text{jet})} > p_{T(\text{threshold})})$$

Anomaly Scores

Credit Wasikul Islam



Credit Jackson Burzynski

Why do I care?

Secondary vertexing is a **core component** of our LLP search program!

Many BSM models include invisible particles that decay into multiple visible particles far from the IP, producing **displaced vertices (DVs)**.

NewVSI

Results in **large efficiency gains** with analogous seeding, **>20% across kinematics!**

Original soft b-tag configuration has special BDT for **material secondary & fake rejection** – not performant for LLPs. Goal is to train some **new background rejection** for paper that is **performant for generic LLP signals**. Work ongoing!

MuSAVtxFitter

The result? Perfectly valid, **well-defined vertices** from crazy extrapolated tracks **up through the first MS layer**

- Position resolutions **within a few 100 mm**
- Mass resolutions varying on process but **within a few GeV**

Integrated now into DAOD_LL1 production and center of a **new general LLP search** using displaced HNLs and HAHM dark photons

“Crazy user” protections and I roughly share a birthday... which means...

```

56 /*          : vertex momentum in tracks          */
57 /*          : covariance matrix (x,y,z,stat(3))    */
58 /*          : total chi-squared                    */
59 /*          : chi-squared per track                */
60 /*          : error flag                          */
61 /*          : -1 bad fit chi2>1000000 (no fitted output) */
62 /*          : -2 fit is ready but without covariance matrix */
63 /*          : -3 no fit at all                    */
64 /*          : -4 noninvertible vert.error matrix for IFLAG=0 */
65 /*          : -5 Divergence of iterations          */
66 /*          : Author: V.Kasyanov (1996)            */
67 /*          : ----- */
68

```

25

Makayla Vessella

25

Credit Wasikul Islam

Credit Jackson Burzynski

Why do I care?

Secondary vertexing is a **core component** of our LLP search program!

Many BSM models include invisible particles that decay into multiple visible particles far from the IP, producing **displaced vertices (DVs)**.

NewVSI

Results in **large efficiency gains** with analogous seeding, **>20% across kinematics!**

Original soft b-tag configuration has special BDT for **material secondary & fake rejection** – not performant for LLPs. Goal is to train some **new background rejection** for paper that is **performant for generic LLP signals**. Work ongoing!

MuSAVtxFitter

The result? Perfectly valid, **well-defined vertices** from crazy extrapolated tracks **up through the first MS layer**

- Position resolutions **within a few 100 mm**
- Mass resolutions varying on process but **within a few GeV**

Integrated now into DAOD_LL1 production and center of a **new general LLP search** using displaced HNLs and HAHM dark photons

“Crazy user” protections and I roughly share a birthday... which means...

```

56 /*          : vertex momentum in tracks          */
57 /*          : covariance matrix (x,y,z,stat(3))    */
58 /*          : total chi-squared                    */
59 /*          : chi-squared per track                */
60 /*          : error flag                          */
61 /*          : -1 bad fit chi2>1000000 (no fitted output) */
62 /*          : -2 fit is ready but without covariance matrix */
63 /*          : -3 no fit at all                    */
64 /*          : -4 noninvertible vert.error matrix for IFLAG=0 */
65 /*          : -5 Divergence of iterations          */
66 /*          : Author: V.Kasyanov (1996)            */
67 /*          : ----- */
68

```

25

Makayla Vessella

25

Credit Wasikul Islam

- Credit Jackson Burzynski
- ## Why do I care?
- Secondary vertexing is a **core component** of our LLP search program!
- Many BSM models include invisible particles that decay into multiple visible particles far from the IP, producing **displaced vertices (DVs)**.
-
- ## NewVSI
- Results in **large efficiency gains** with analogous seeding, **>20% across kinematics!**
- Original soft b-tag configuration has special BDT for **material secondary & fake rejection** – not performant for LLPs. Goal is to train some **new background rejection** for paper that is **performant for generic LLP signals**. Work ongoing!
-
-
- ## MuSAVtxFitter
- The result? Perfectly valid, **well-defined vertices** from crazy extrapolated tracks **up through the first MS layer**
- Position resolutions **within a few 100 mm**
 - Mass resolutions varying on process but **within a few GeV**
- Integrated now into DAOD_LL1 production and center of a **new general LLP search** using displaced HNLs and HAHM dark photons
- “Crazy user” protections and I roughly share a birthday... which means...
-
-
-
- ```

56 /* : vertex momentum in tracks */
57 /* : covariance matrix (x,y,z,stat(3)) */
58 /* : total chi-squared */
59 /* : chi-squared per track */
60 /* : error flag */
61 /* : -1 bad fit chi2>1000000 (no fitted output) */
62 /* : -2 fit is ready but without covariance matrix */
63 /* : -3 no fit at all */
64 /* : -4 noninvertible vert.error matrix for IFLAG=0 */
65 /* : -5 Divergence of iterations */
66 /* : Author: V.Kasyanov (1996) */
67 /* : ----- */
68

```
- 25
- 
- Makayla Vessella
- 25
- Credit Wasikul Islam



# CTIDE Activity report

Link to [Slides](#)

# CTIDE Activity report

Link to [Slides](#)

- New Recommendations:
  - Impact parameter ( $d_0$ ,  $z_0$ )

Thorsten Kuhl, Alessandro Sala, Wenjing Wang ([link](#), [link](#))

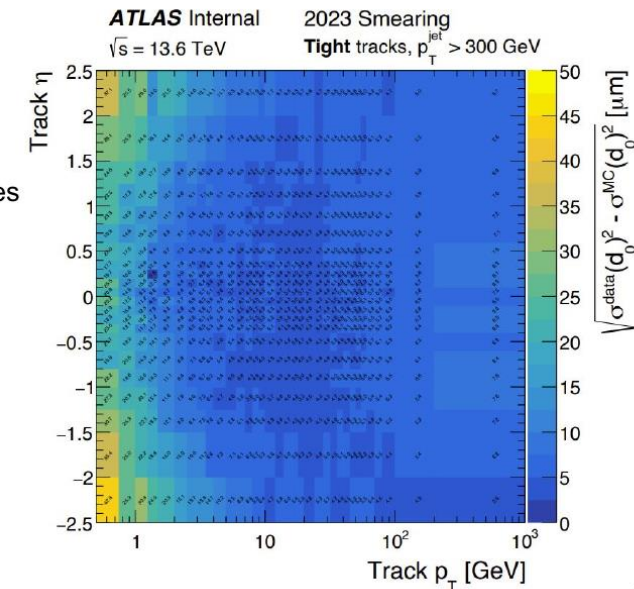
## Impact parameters resolution measurements

### $d_0$ & $z_0$ IP resolution values measured per data-taking year, per reprocessing campaign

- Needed to account for the difference in resolution between data and MC simulations

### Status of Run-3 measurements (by Alessandro Sala)

- Several results obtained: TightP & Loose WPs, jet  $p_T < 300$  GeV, jet  $p_T > 300$  GeV, 2022 & 2023 samples
- They will be [released](#) to ATLAS collaboration in the coming days (calib files available on [cvmfs](#))
  - Jackson is helping with the updates in the InDetTrackSmearingTool ([link](#), [MR!80106](#))
- See Alessandro's talk on Thursday ([link](#)) for more details



4

# CTIDE Activity report

## Impact parameters resolution measurements

Link to [Slides](#)

### • New Recommendations:

- Impact parameter ( $d_0, z_0$ )
- Lost Tracks (from  $dE/dx$ )

### Fraction of lost tracks (FLost) using $dE/dx$

Fiona Ann Jolly ([link](#), [link](#))

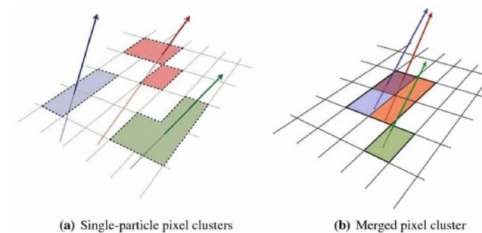
**FLost** → fraction of tracks that are not reconstructed, among true tracks contributing to merged clusters

Energy deposited in clusters,  $dE/dx$  → an estimate of the nr. of charged particles associated with that cluster

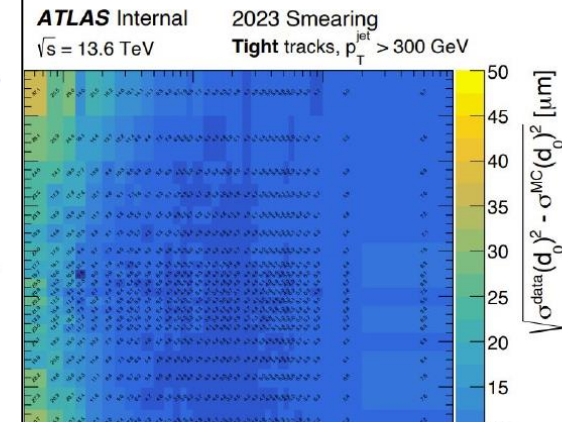
- Indication of track loss if cluster identified as n-particle cluster but has less than n tracks

**FLost measured using three  $dE/dx$  templates:**

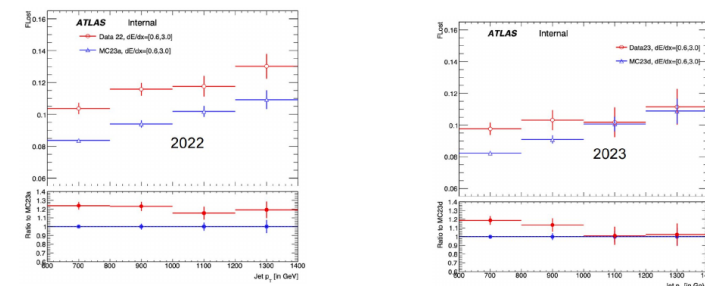
- 1-particle cluster template, using  $\Delta R(\text{jet}, \text{track}) > 0.1$
- 2-particle cluster template: convolution of one particle cluster templates (accounting for the jet  $p_T$  and eta bin, in a  $\Delta R(\text{jet}, \text{track}) < 0.05$  selection)
- 3-particle cluster template recently added
- **In-situ measurement done as a function of jet  $p_T$ , in both data and MC** (by Fiona Ann Jolly)
  - Eta dependency planned to be studied (not done)
  - The **fit model** uses  $dE/dx$  distributions constructed from single particle clusters



### Cluster reprocessing campaign



**FLost** → fraction of tracks that are not reconstructed, but contribute to merged cluster(s) used by another reconstructed track



- Results obtained using 2022 and 2023 samples (2024 measurements to be done by summer time)

**Current FLost recommendations:** uncertainty on fraction of lost tracks, as function of jet  $p_T$  (1 number)

- 24% ([link](#)) independent of the data taking year, independent of the jet  $p_T$ , independent of jet  $\eta$

# CTIDE Activity report

Thorsten Kuhl, Alessandro Sala, Wenjing Wang ([link](#), [link](#))

## Impact parameters resolution measurements

Link to [Slides](#)

- New Recommendations:
  - Impact parameter ( $d_0, z_0$ )
  - Lost Tracks (from  $dE/dx$ )
  - Fakes in jets

### Fraction of lost tracks (FLost) using $dE/dx$

Fiona Ann Jolly ([link](#), [link](#))

**FLost** → fraction of tracks that are not reconstructed, among true tracks contributing to merged clusters

Energy deposited in clusters,  $dE/dx$  → an estimate of the nr. of charged particles associated with that cluster

- Indication of track loss if cluster identified as n-particle cluster but has less than n tracks

FLost me

- 1-pa
- 2-pa
- 3-pa
- In-s
- in b

### Fake tracks in the jet core

**Goal: measure the modelling of fake tracks in data, in the jet core**

- Deliverable: the uncertainty on the modelling of rate of fake tracks when  $\Delta R(\text{jet1}, \text{trk}) < 0.2$
- Fake tracks: reconstructed tracks that don't have the majority of their hits associated to a single charged particle
- Real and fake tracks separated in MC di-jet simulations using the truthMatchProbability variable
  - The available NN real-fake tracks discriminant tool proposed by Sam, Gabriel & co also tried
    - Still need look at the results with the latest training
- Fake rate obtained by fitting MC fraction of fakes and real tracks to data through a LLH fit
- **Some effort put to automatize the measurement: QT recently finalized** (by Matei Filip, [ATLIDTRKCP-499](#))
  - Documentation: [ATL-COM-PHYS-2025-025](#)
- **Status: recommendations done for 2022 and 2023 data-taking ([1 number](#)), 2024 reco WIP**

er reprocessing campaign



Otilia Ducu, Matei Filip ([link](#) and [link](#))

$\sqrt{\sigma_{\text{data}}(d_0)^2 + \sigma_{\text{MC}}(d_0)^2}$  [ $\mu\text{m}$ ]

10 (time)



# CTIDE Activity report

## Impact parameters resolution measurements

Link to [Slides](#)

- New Recommendations:
  - Impact parameter ( $d_0, z_0$ )
  - Lost Tracks (from  $dE/dx$ )
  - Fakes in jets
- Ongoing work
  - Energy loss calibration

### Fraction of lost tracks (FLost) using $dE/dx$

Fiona Ann Jolly ([link](#), [link](#))

**FLost** → fraction of tracks that are not reconstructed, among true tracks contributing to merged clusters

Energy deposited in clusters,  $dE/dx$  → an estimate of the nr. of charged particles associated with that cluster

- Indication of track loss if cluster identified as n-particle cluster but has less than n tracks

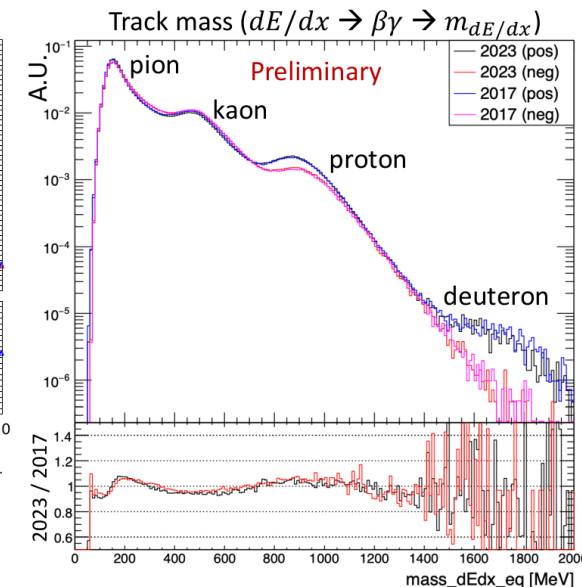
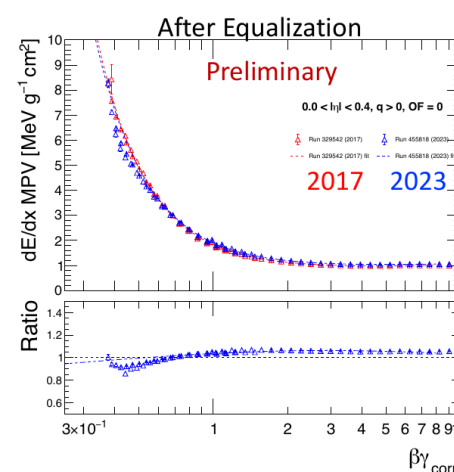
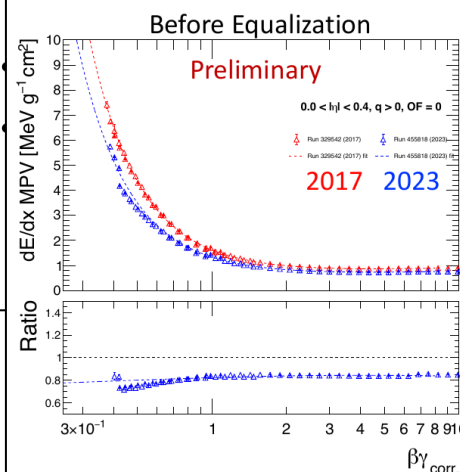
### reprocessing campaign

ATLAS Internal  
 $\sqrt{s} = 13.6$  TeV  
2023 Smearing  
Tight tracks,  $p_T^{\text{jet}} > 300$  GeV



Otilia Dugu, Matei Filip ([link](#) and [link](#))

### $dE/dx$ Equalization



- Performed Bethe-Bloch calibration with data from 2017 and 2023 low- $\mu$  runs.
  - Using **very preliminary** scale factors.
  - Much better agreement after equalization.
- Applied calibration to check pion, kaon, proton mass stability.
  - Separated by year and sign of track charge.
  - Decent agreement, but some interesting features to study.

$$m_{dE/dx} = \frac{p}{(\beta\gamma)_{dE/dx}}$$

Ian Dyckes

MAY 20, 2025

11

# CTIDE Activity report

## Impact parameters resolution measurements

Link to [Slides](#)

- New Recommendations:
  - Impact parameter ( $d_0, z_0$ )
  - Lost Tracks (from  $dE/dx$ )
  - Fakes in jets
- Ongoing work
  - Energy loss calibration
  - Migration to ACTS

### Fraction of lost tracks (FLost) using $dE/dx$

Fiona Ann Jolly ([link](#), [link](#))

**FLost** → fraction of tracks that are not reconstructed, among true tracks contributing to merged clusters

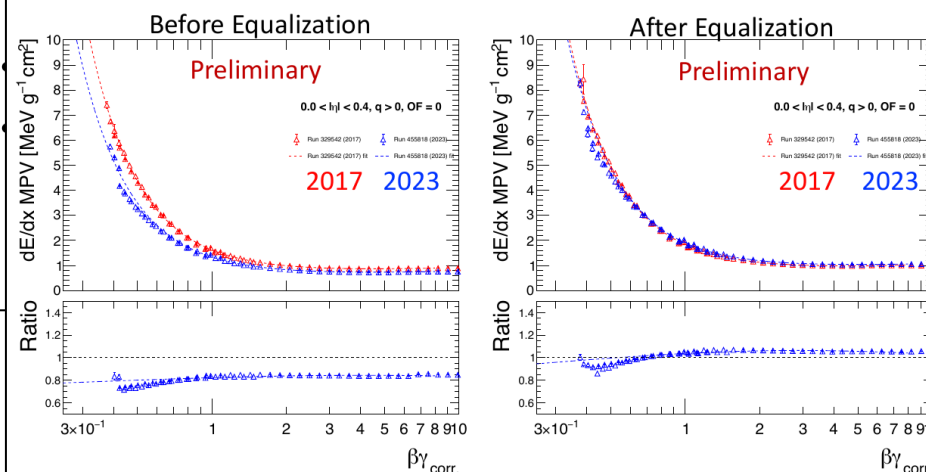
Energy deposited in clusters,  $dE/dx$  → an estimate of the nr. of charged particles associated with that cluster

- Indication of track loss if cluster identified as n-particle cluster but has less than n tracks

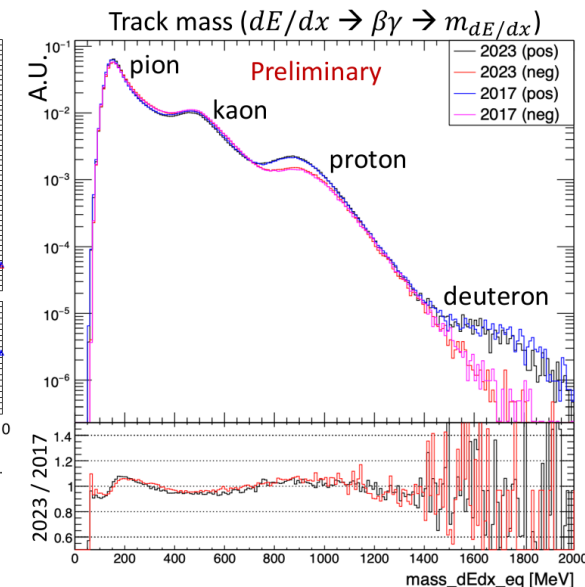
### reprocessing campaign



### $dE/dx$ Equalization



- Performed Bethe-Bloch calibration with data from 2017 and 2023 low- $\mu$  runs.
  - Using **very preliminary** scale factors.
  - Much better agreement after equalization.
- Applied calibration to check pion, kaon, proton mass stability.
  - Separated by year and sign of track charge.
  - Decent agreement, but some interesting features to study.



$$m_{dE/dx} = \frac{p}{(\beta\gamma)_{dE/dx}}$$

Ian Dyckes

MAY 20, 2025

11

# ID and ITk status

Link to Slides for [ID](#) and [ITk](#)

# ID and ITk status

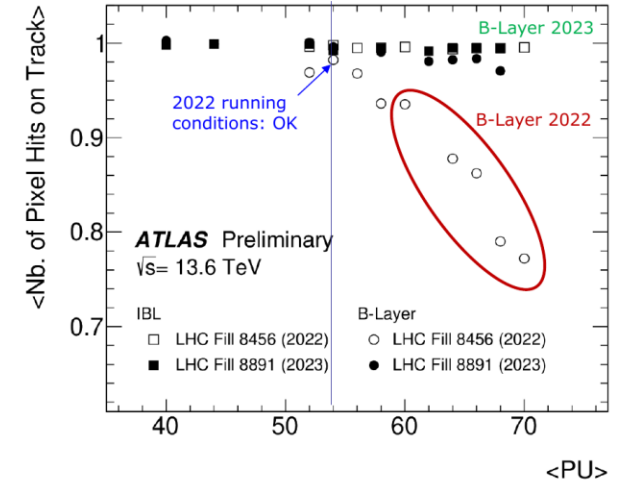
Link to Slides for [ID](#) and [ITk](#)

- Status of ID
  - Ongoing work to keep performance

## Pixel Readout Performance



- The readout performance can be affected by **Single Event Effects**, and by **limitations in bandwidth and buffer sizes**. A continuous effort has been made to limit the effects on the performance.
- Test Fill in 2022: LHC is able to increase the instantaneous luminosity above  $2.1 \times 10^{33} \text{cm}^{-2}\text{s}^{-1}$  without running into thermal issues in the arcs.
- ATLAS target conditions were raised accordingly for Run 3: first to a pile-up of 60 and then to 64 in 2024, at trigger rates above 90 kHz. 2025?
- Challenging conditions for Pixel Readout Performance, especially for B-Layer!



- *Readout improvements prepared during LS2*



# ID and ITk status

Link to Slides for [ID](#) and [ITk](#)

- Status of ID
  - Ongoing work to keep performance

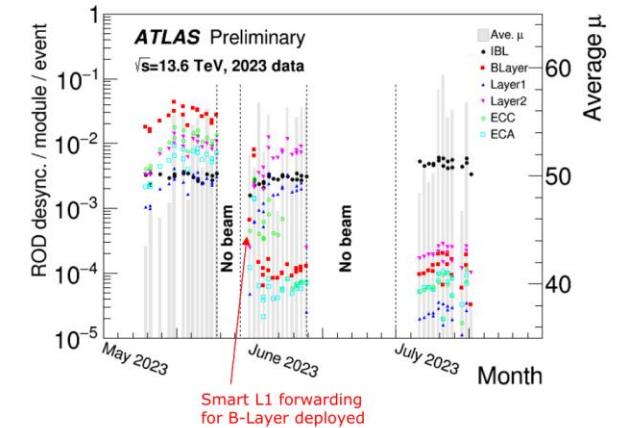
## Pixel Readout Performance



### ➤ Desynchronisation I

- The Pixel modules can only buffer 16 events, and transmit events with maximum 160 Mbit/second to the off-detector ROD/BOC system. The bandwidth usage depends on the hit occupancy, i.e. (very) large events take longer (too long) to transmit. Once a trigger has been missed, the module event data will be out of sync with the rest of ATLAS until the next Event Counter Reset/ECR.
- A mechanism to reset the backend electronics and the FE chips at each ECR had been implemented already in Run 2.
- In 2023, a new ROD firmware was deployed which keeps track of the number of pending triggers for each module. A module that is already handling the maximum number of triggers, will not receive a new trigger. The firmware will instead insert a dummy fragment into the data stream, keeping track of the trigger IDs („Smart L1 forwarding”). Instead of seconds of data, only single events are lost. This is clearly visible in the number of ROD level desynchronisation errors.

21.05.2025



21.05.2025

Kerstin Lantzsich (University of Bonn)

9

# ID and ITk status




Link to Slides for [ID](#) and [ITk](#)

- Status of ID
  - Ongoing work to keep performance
  - Increasing module failure

Pixel Readout Performance

Desynchronisation I

Detector working fraction



|                    | % Disabled |            |            | Average $\mu$ |
|--------------------|------------|------------|------------|---------------|
| Layer              | 2018       | 2023       | 2024       |               |
| B-Layer            | 6.2        | 5.2        | 7.3        |               |
| Layer 1            | 5.8        | 4.4        | 3.6        |               |
| Layer 2            | 4.8        | 6.3        | 7.4        |               |
| Disks              | 5.2        | 4.5        | 5.2        |               |
| <b>Pixel Total</b> | <b>5.4</b> | <b>5.3</b> | <b>6.0</b> |               |
| IBL (Frontends)    | 0.7        | 0.9        | 1.1        |               |

*almost 99% working fraction in IBL  
and 94% working fraction in the outer Layers*

- Pixel Detector non-working fraction (end of 2024):
  - 1.1% IBL (5 out of 448 frontends)
  - 6.0% outer layers (104/1744 modules)
- Total number of disabled modules increases slowly with time.
- Two major recoveries:
  - ~30 modules recovered in LS2 by replacing optoboards with dead VCSEL channels
  - 6 Layer 1 modules with one problematic readout link recovered in 2024 by going to half readout speed (i.e. from 2 to 1 link)
- **Failures inside the detector volume are inaccessible.**

# ID and ITk status

Link to Slides for [ID](#) and [ITk](#)

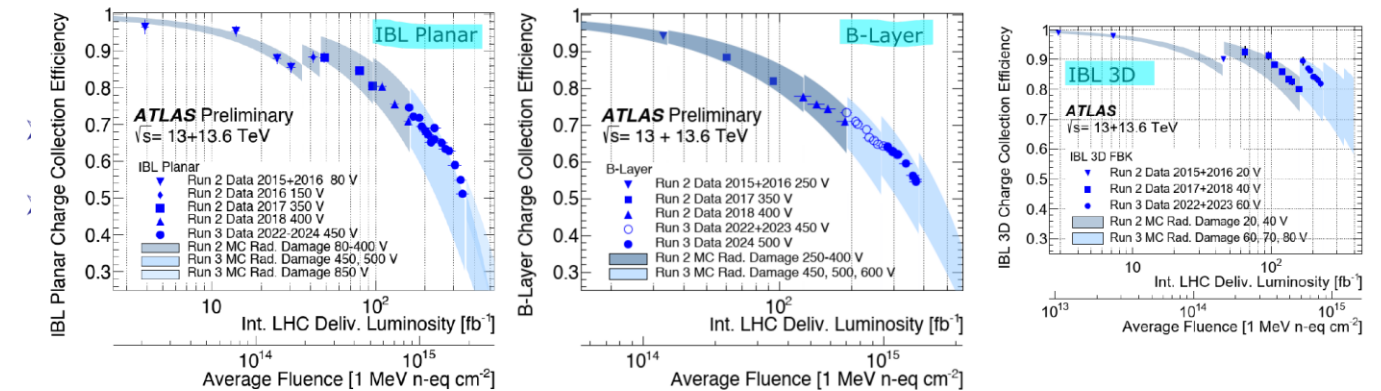
- Status of ID
  - Ongoing work to keep performance
  - Increasing module failure
  - Decreased charge collection

## Pixel Readout Performance

## Desynchronisation I

## Detector working fraction

## Charge Collection Efficiency



- About 30% of original Charge Collection Efficiency (CCE) at the end of Run 3 for IBL planar sensors and B-Layer
- Response of IBL 3D sensors at the same fluence shows a better behaviour in terms of CCE
- Discontinuities in the simulation band are due to HV changes.
- Number of hits on track affected to a significantly lesser degree than charge: expect loss of 2-3% of hits on track from today until the end of Run 3. → B-Layer holes will affect tight tracks
- Keeping the IBL performance up is critical

21.05

21.05.2025

Kerstin Lantzsch (University of Bonn)

16

# ID and ITk status

Link to Slides for [ID](#) and [ITk](#)

- Status of ID
  - Ongoing work to keep performance
  - Increasing module failure
  - Decreased charge collection
- Production of ITk
  - Multiple schedules

## Pixel Readout Performance

## Desynchronisation I

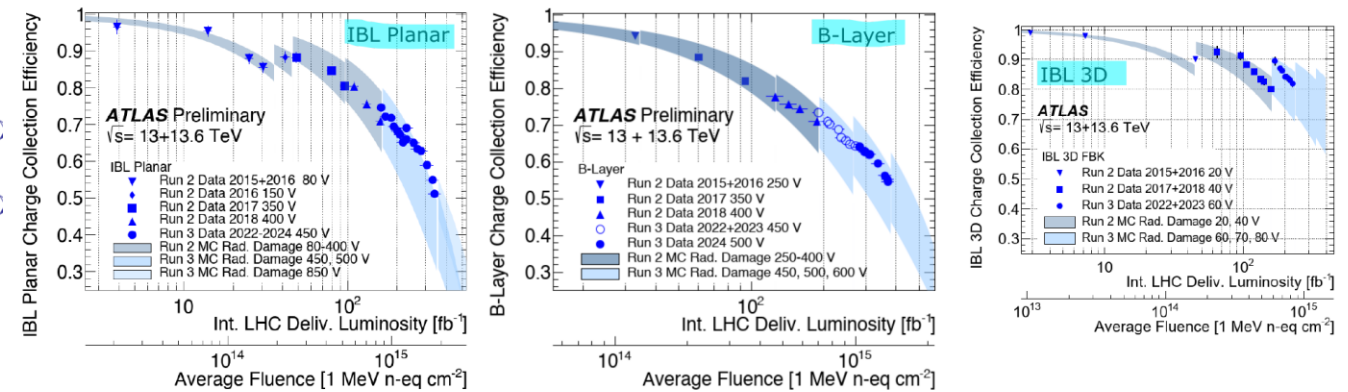
## Detector working fraction

## Charge Collection Efficiency

ATLAS  
EXPERIMENT

ATLAS  
EXPERIMENT

ATLAS  
EXPERIMENT



- About 30% of original Charge Collection Efficiency (CCE) at the end of Run 3 for IBL planar sensors and B-Layer
- Response of IBL 3D sensors at the same fluence shows a better behaviour in terms of CCE
- Discontinuities in the simulation band are due to HV changes.
- Number of hits on track affected to a significantly lesser degree than charge: expect loss of 2-3% of hits on track from today until the end of Run 3. → B-Layer holes will affect tight tracks
- Keeping the IBL performance up is critical

21.05

21.05.2025

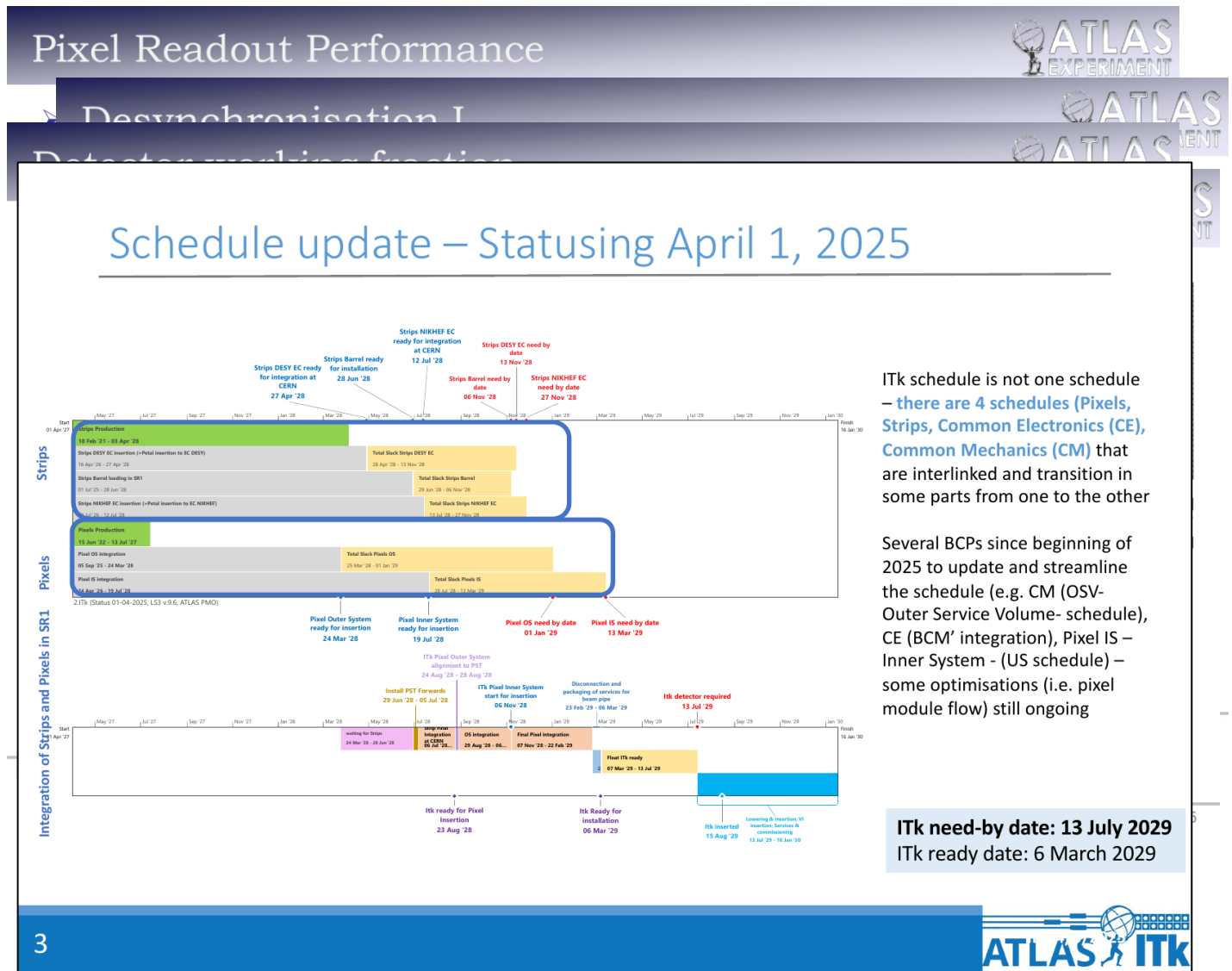
Kerstin Lantzsch (University of Bonn)

16

# ID and ITk status

Link to Slides for [ID](#) and [ITk](#)

- Status of ID
  - Ongoing work to keep performance
  - Increasing module failure
  - Decreased charge collection
- Production of ITk
  - Multiple schedules
  - "Still" 4 months slack





# ID and ITk status

Link to Slides for [ID](#) and [ITk](#)

- Status of ID
  - Ongoing work to keep performance
  - Increasing module failure
  - Decreased charge collection
- Production of ITk
  - Multiple schedules
  - "Still" 4 months slack

Pixel Readout Performance

ATLAS  
EXPERIMENT

Desynchronisation I

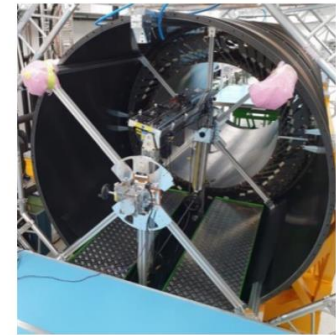
ATLAS  
EXPERIMENT

Detector working fraction

Schedule update - Status as April 1, 2025

## Global mechanics and integration highlights

- **Global mechanics** progressing well with PST and L1 expected in autumn
- **Polymoderator** for IWV (Inner Warm Vessel) material available; design work on support and installation tooling has started
- **Strip Integration in SR1 and at NIKHEF and DESY**; Barrel stave insertion tool installed in SR1 –first insertions completed successfully; EC integration preparation in parallel at NIKHEF and DESY – infrastructure and all tools available at both sites
- **Pixel integration** preparation advancing well at Liverpool, Frascati, SLAC and SR1; all cooling racks installed in SR1; cables and optical fibres installed; shipments with services to integration sites ongoing;



Strip barrel stave insertion tooling



Pixel cooling racks and electronic racks in SR1



Strip EC structure

10

ATLAS  
ITk

# ID and ITk status

Link to Slides for [ID](#) and [ITk](#)

- Status of ID
  - Ongoing work to keep performance
  - Increasing module failure
  - Decreased charge collection
- Production of ITk
  - Multiple schedules
  - "Still" 4 months slack
  - First strip insertion to barrel passed

Pixel Readout Performance

ATLAS  
EXPERIMENT

Desynchronisation I

ATLAS  
EXPERIMENT

Detector working fraction

Schedule update - Status in April 1, 2025



Strip stave insertion test L2 (talk by Charles Evans in ITk week)

ATLAS  
ITk

# ID and ITk status

Link to Slides for [ID](#) and [ITk](#)



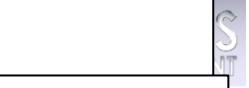
- Status of ID
  - Ongoing work to keep performance
  - Increasing module failure
  - Decreased charge collection
- Production of ITk
  - Multiple schedules
  - "Still" 4 months slack
  - First strip insertion to barrel passed
  - Plenty of challenges remain

## Pixel Readout Performance

### Desynchronisation I

### Detector-making fraction

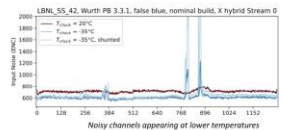

### Schedule update - Status April 1, 2025

#### Technical challenges




In the past years ITk has tackled and solved a number of technical challenges which could impact the performance, e.g.:

- **Cold noise in strips**
  - Vibration in powerboard capacitors cause noisy channels to appear when tested cold
  - Affecting long strip (LS) and short strip modules, effect not seen in endcap modules
  - Mitigation using "True Blue" glue removed CN in LS modules, SS still saw some small effects, but mitigation for cracking solved this
- **Strip sensor cracking**
  - CTE (coefficient of thermal expansion) mismatch on modules causing cracking of the sensor
  - Interposer solution adopted for barrel and EC – production of modules has started

#### Technical challenges

- **lpGBT V1**
  - Issues discovered within the V1 of the chip that could lead to unrecoverable failure
  - Affects more strips than pixels due to integration process → needed to take decision urgently how to proceed for strips
  - switching to V2 as early as possible (aiming for <5% V1 in Strip EC and <10% V1 in Strip barrel);
- **Pixel 3D sensor corner delamination**
  - Early deliveries of 3D single chip modules with Sintef sensors showed bump delamination on the edges due to stress in the sensor
  - Process adapted in the sensor fabrication plus in the hybridisation → new samples showed good connection between sensor and FE chip and production started; more samples expected in the next weeks
- **Proposal to move BLM outside of BCM'**
  - To repositioning them on the **ITk mechanical endplate**, at approximately **R = 10 cm** and **Z = 320 cm**, similar to the current BLM setup
  - ECR draft document prepared

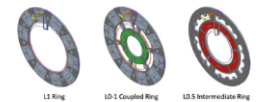
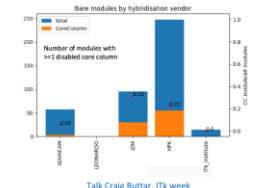
#### Technical challenges

**Pixel module thickness IS rings**

- Originally foreseen to use 100 um thick sensors in the IS, but encountered challenges to build large quantity of good modules → potential delay
- ECR prepared to change sensor thickness from 100 um to 150 in June 2024
- Cannot be adopted to L1, but only fewer modules needed

**Pixel core columns**

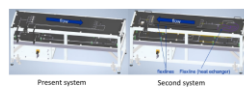
- In few cases chip does not return events until reset → disable columns (8 at a time)
- Task force created, issue likely due to debris trapped between chip and sensor, working with hybridisation vendors
- Estimations of effects based on top few statistics (up to 23% of V2 modules could be affected) – more data to be available soon
- Also looking at sLDO (shunt Low Drop Output) failures if core columns are disabled
- Work ongoing

#### Technical challenges - Capillaries (Pixels and Strips)

- Study of pressure drops on Titanium capillaries for strips and pixels show variable results when tuning due to contaminated bore
- Different cleaning techniques tested - no improvement observed so far, further tests still under way
- Variability during tuning not seen on stainless steel capillaries (e.g. used by CMS or Strip EC)
- **Considering changing tube type to stainless steel 316**
  - Requires welding preparation to be validated – different brazing techniques being investigated
  - Cu/Ni also being investigated for Strip Barrel
  - Prepare ECR for possible change of capillary type
- Potential impact on schedule estimated for strips to be ~6m, but already being expedited with extra help
- **Capillary tests system is critical to this activity**
  - Already decided to build a 2<sup>nd</sup> system to help with testing throughput in fall 2024; design has been completed and component procurement ongoing
- JIRA ticket: <https://its.cern.ch/jira/browse/ATLTKSW-307>

|                 |                 | ID [mm] |
|-----------------|-----------------|---------|
| Strip EC        | Stainless steel | 0.35    |
| Strip Barrel SS | Titanium        | 0.8     |
| Strip Barrel LS | Titanium        | 0.8     |
| Pixel OB        | INL2            | 0.76    |
|                 | INL4            | 0.87    |
| Pixel OEC       | INL2            | 0.76    |
|                 | INL4            | 0.87    |
| Pixel IS        | INL2            | 0.76    |
|                 | INL4            | 0.87    |
| CMS             | INL2            | 0.76    |
|                 | INL4            | 0.87    |



# Upgrade Tracking report

Link to [Slides](#)



# Upgrade Tracking report

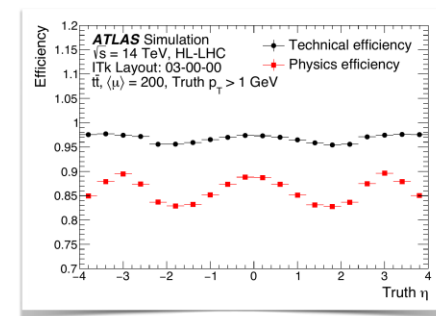
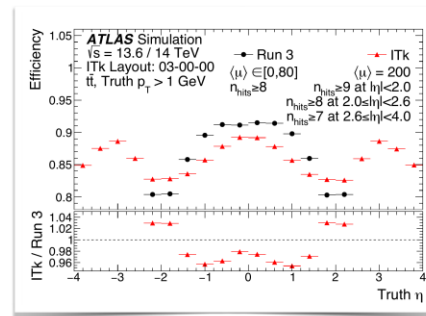
Link to [Slides](#)

- Legacy ITk tracking
  - High Efficiency
  - Low Fake rate

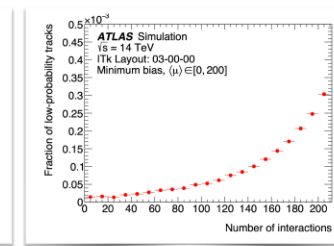
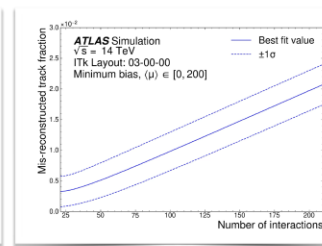
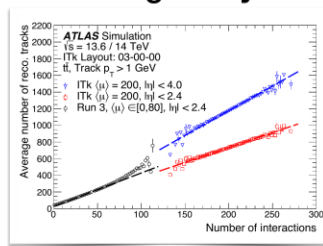
## Legacy ITk tracking chain

### Tracking efficiency

- While **50% more material** in  $|\eta| < 1.5$  compared to Run 3, **efficiency still within 5%**
- **New accessible region** in  $2.5 < |\eta| < 4$ , with same efficiency as central region
- Tracking **algorithms are performant**: they work well on reconstructable particles



### Tracking Purity



- **Mis-reconstructed tracks = fake tracks + short tracks polluted by pile-up hits**
  - Origin of **non linear scaling** of  $N_{\text{tracks}}$  vs  $\mu$
  - At  $\langle \mu \rangle = 200$  : **2% of mis-reconstructed tracks** [ Run 3 ~6.5%]
  - Fake tracks negligible :  $3 \times 10^{-4}$

# Upgrade Tracking report

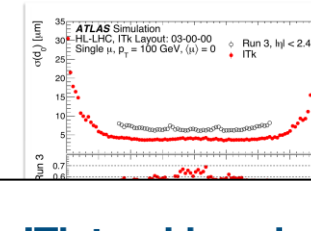
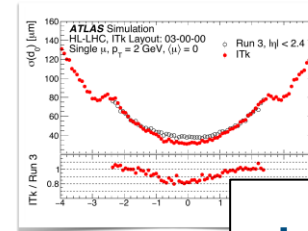
Link to [Slides](#)

- Legacy ITk tracking
  - High Efficiency
  - Low Fake rate
  - Good resolution

## Legacy ITk tracking chain

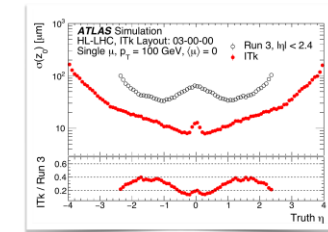
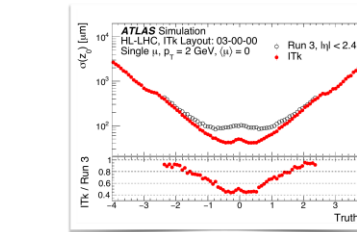
### $d_0$ resolution

- Smaller pixel pitch comp. to Run 3: improved impact parameters resolution
  - $\sigma(d_0)$  :  $30\mu\text{m}$   $\rightarrow$  up to 20% better for 2 GeV ,  $4\mu\text{m}$   $\rightarrow$  2x better for 100 GeV



## Legacy ITk tracking chain

### $z_0$ resolution

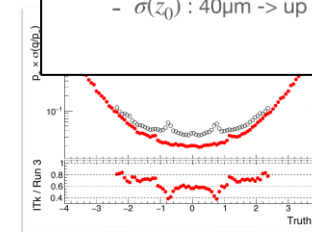
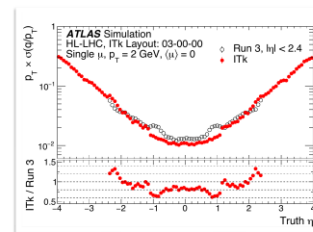


- Smaller pixel pitch comp. to Run 3: improved impact parameters resolution
  - $\sigma(z_0)$  :  $40\mu\text{m}$   $\rightarrow$  up to 2x better for 2 GeV,  $8\mu\text{m}$   $\rightarrow$  4x better for 100 GeV

## Legacy ITk tracking chain

### $p_T$ resolution

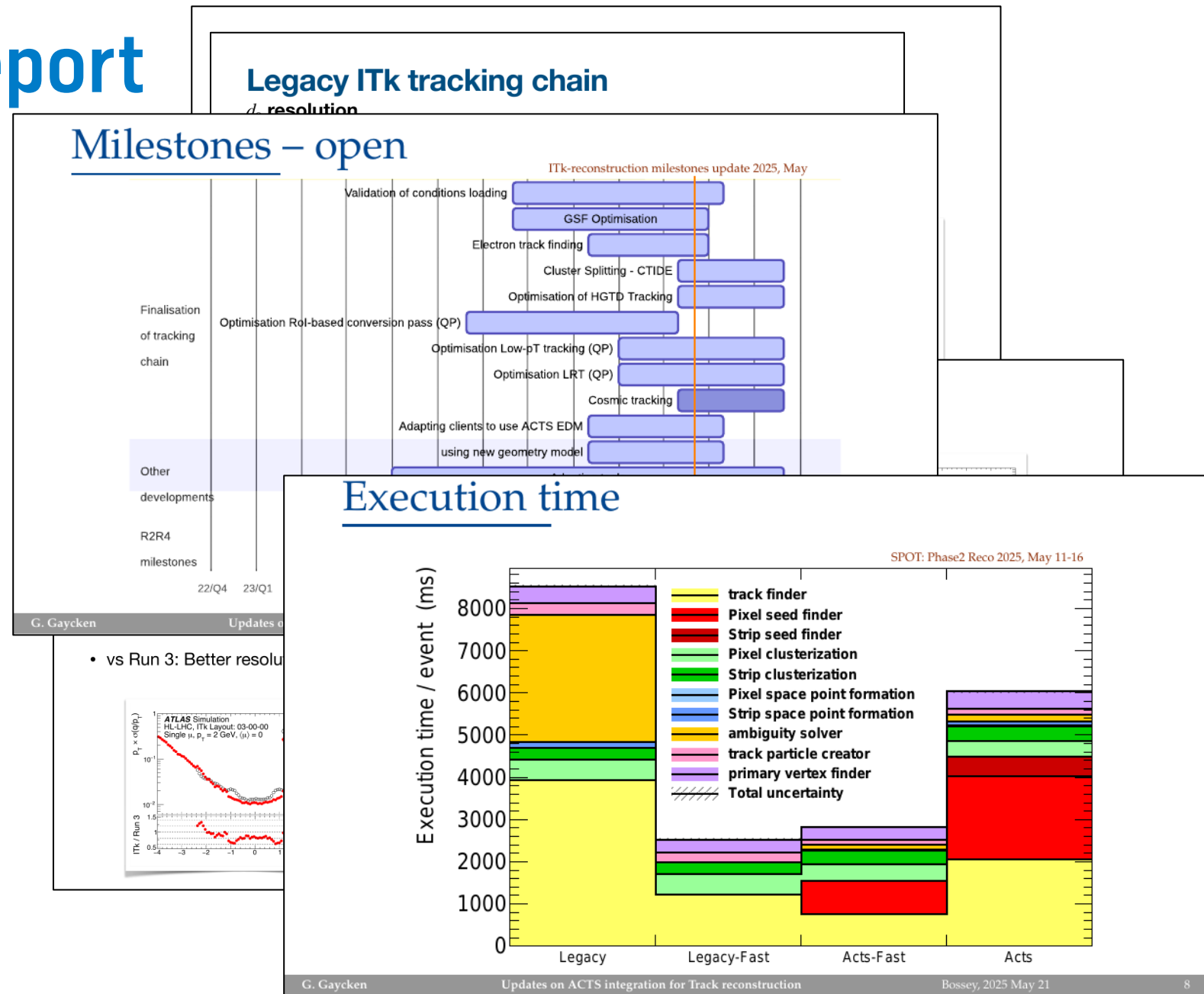
- Up to 1%  $p_T$  resolution at 2 GeV , 20% at 100 GeV
- vs Run 3: Better resolution of strips than s



# Upgrade Tracking report

Link to [Slides](#)

- Legacy ITk tracking
  - High Efficiency
  - Low Fake rate
  - Good resolution
- ACTS integration
  - Implemented fast versions



# Upgrade Tracking report

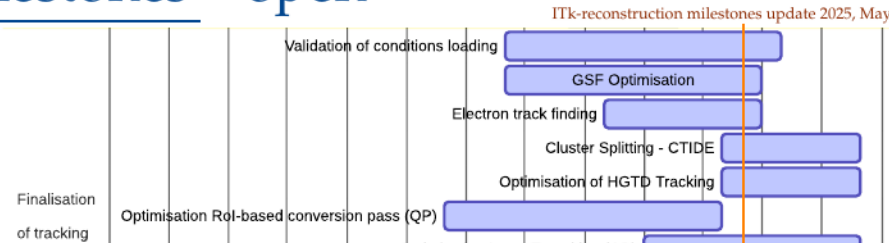
Link to [Slides](#)

- Legacy ITk tracking
  - High Efficiency
  - Low Fake rate
  - Good resolution
- ACTS integration
  - Implemented fast versions
  - Slightly lower Performance and Efficiency

## Legacy ITk tracking chain

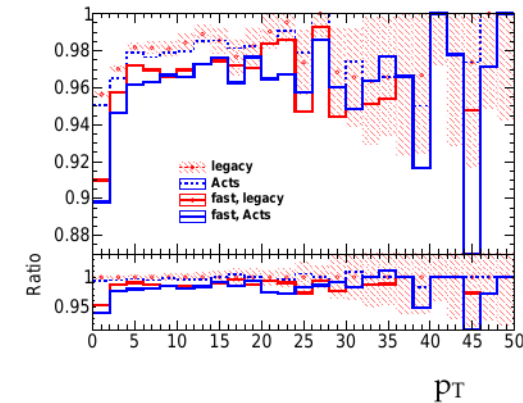
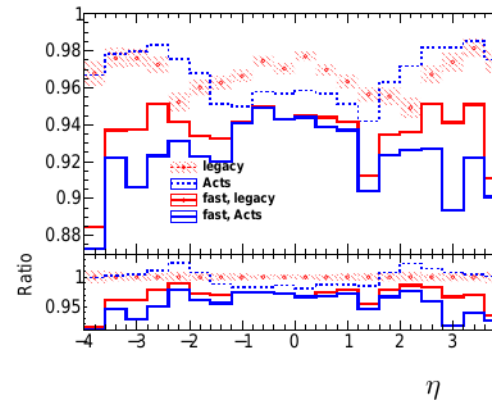
$d$  resolution

## Milestones – open



## Technical efficiency

$t\bar{t}$ , PU200, HS truth, 1k events, s4149\_r14700  
(ATLAS-P2-RUN4-03-00-00, OFLCOND-MC15c-SDR-14-05)



G. Gaycken

Updates on ACTS integration for Track reconstruction

Bossey, 2025 May 21

9

1000

Legacy

Legacy-Fast

Acts-Fast

Acts

G. Gaycken

Updates on ACTS integration for Track reconstruction

Bossey, 2025 May 21

8



# Upgrade Tracking report

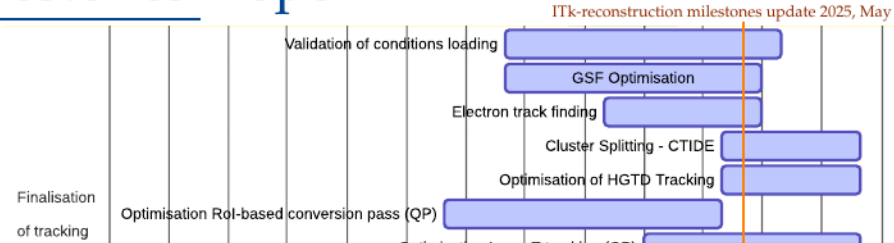
Link to [Slides](#)

- Legacy ITk tracking
  - High Efficiency
  - Low Fake rate
  - Good resolution
- ACTS integration
  - Implemented fast versions
  - Slightly lower Performance and Efficiency
- GNN4ITk workflow
  - Improved Performance
  - Effort to run on FPGAs

## Legacy ITk tracking chain

d. resolution

## Milestones – open



## Technical efficiency

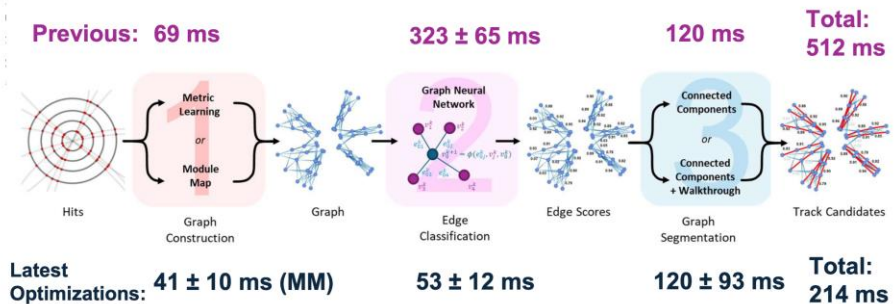
$t\bar{t}$ , PU  
(ATLAS)

## GNN4ITk

### Compute optimisation

More details in [Alina Lazar's UT talk](#)

- Lots of effort to optimize the pipeline: reached sub-second processing
  - Graph building in CUDA, Automatic Mixed Precision, torch.compile(), Track building
- More to come on track building and model reduction & quantization



Per-event running times of each stage in the GNN4ITk pipeline. Stages 1 and 2 are evaluated on Nvidia A100 80GB GPUs, on 1,000 events. Stage 3 is evaluated on CPU (AMD EPYC 7763).

# ID Alignment report

Link to [Slides](#)

# ID Alignment report

Link to [Slides](#)

- Existing Alignment calibration is working
  - Keep code up-to-date
  - New web monitor

# ID Alignment report

Link to [Slides](#)

- Existing Alignment calibration is working
  - Keep code up-to-date
  - New web monitor

## Alignment in the calibration loop

### What is happening during data taking

- As initial geometry, the previous year realigned geometry is used
- At the start of each run, the L1 alignment is performed for three blocks of 20 LBs
- Afterwards, the L1 alignment is performed each 100 LBs

### Current status of calibration loop

- It is working! (from [tzcontzole01](#) of tasktype “idalignreco”)

| Run Nr | Task Name                                                               | User    | taskID  | Type        | Status   | Total | Done | Run. | Proc. | TBD | Abtr. | Failed |
|--------|-------------------------------------------------------------------------|---------|---------|-------------|----------|-------|------|------|-------|-----|-------|--------|
| 498182 | data25_13p6TeV.00498182.calibration_IDCalib.merge.RAW.iter0.rel23_c0... | idalign | 3193511 | idalignreco |          | 51    | 12   | 31   | 0     | 8   | 0     | 0      |
| 498088 | data25_13p6TeV.00498088.calibration_IDCalib.merge.RAW.iter3.rel23_c0... | idalign | 3193470 | idalignreco | FINISHED | 111   | 111  | 0    | 0     | 0   | 0     | 0      |
| 498088 | data25_13p6TeV.00498088.calibration_IDCalib.merge.RAW.iter2.rel23_c0... | idalign | 3193311 | idalignreco | FINISHED | 111   | 111  | 0    | 0     | 0   | 0     | 0      |
| 498088 | data25_13p6TeV.00498088.calibration_IDCalib.merge.RAW.iter1.rel23_c0... | idalign | 3193290 | idalignreco | FINISHED | 111   | 111  | 0    | 0     | 0   | 0     | 0      |
| 498088 | data25_13p6TeV.00498088.calibration_IDCalib.merge.RAW.iter0.rel23_c0... | idalign | 3193200 | idalignreco | FINISHED | 111   | 111  | 0    | 0     | 0   | 0     | 0      |
| 498075 | data25_13p6TeV.00498075.calibration_IDCalib.merge.RAW.iter3.rel23_c0... | idalign | 3193278 | idalignreco | FINISHED | 626   | 626  | 0    | 0     | 0   | 0     | 0      |
| 498075 | data25_13p6TeV.00498075.calibration_IDCalib.merge.RAW.iter2.rel23_c0... | idalign | 3193210 | idalignreco | FINISHED | 626   | 626  | 0    | 0     | 0   | 0     | 0      |
| 498075 | data25_13p6TeV.00498075.calibration_IDCalib.merge.RAW.iter1.rel23_c0... | idalign | 3193112 | idalignreco | FINISHED | 626   | 626  | 0    | 0     | 0   | 0     | 0      |

### But ...

- Using deprecated release 23
- Highly non-trivial to setup the production code from scratch again
- Current production code not part of athena



Activity report from Alignment

David Brunner ATLAS Inner Detector Tracking Workshop 2025 22.05.2025



# ID Alignment report

Link to [Slides](#)

- Existing Alignment calibration is working
  - Keep code up-to-date
  - New web monitor
- Starting work to prepare for ITk
  - Simulate misalignment to validate calibration ([Xilin's talk](#))

## ITk Alignment Update

Tracking Workshop 2025

Nicolas Styles, Hannah Herde, Noemi Calace, Krisztian Peters, [Xilin Wang](#) 王熙临

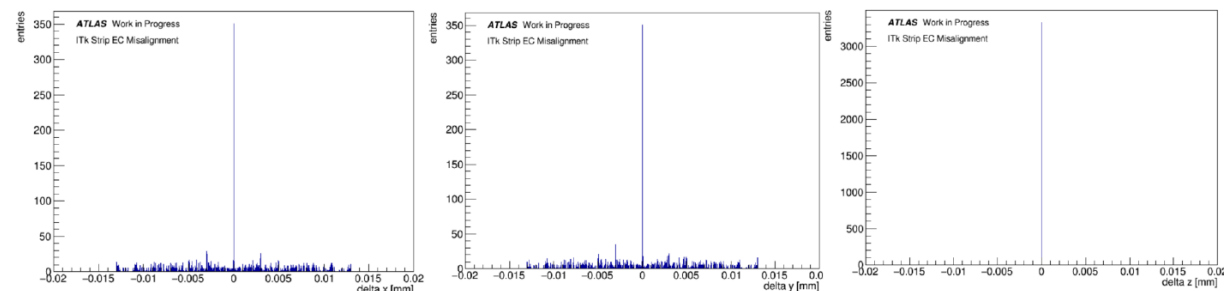
22.6

### Test on Strip Endcap

customized misalignment --- [assignment](#)

- With [RunExEngineTestITk.py](#)
- Check misalignment in global frame
- Plot script: [New.cc](#)

HEL



# Hands-on-project

## Accessing tracks and their systematics via CP Algorithms

## Overview

# Hands-on-project

## Accessing tracks and their systematics via CP Algorithms

### Overview

- Existing tools:
  - InDetTrackSmearingTool (d0, z0)
  - InDetTrackSelectionTool (WPs)

# Hands-on-project

## Accessing tracks and their systematics via CP Algorithms

### Overview

- Existing tools:
  - InDetTrackSmearingTool (d0, z0)
  - InDetTrackSelectionTool (WPs)
- Needed:
  - Algorithm wrapper: <toolName>Alg.cxx
  - Python config: InDetTrackAnalysisConfig.py
  - Header files
  - Cmake files
  - Register block in ConfigFactory.py
  - Register factories in ComponentFactoryPreloader

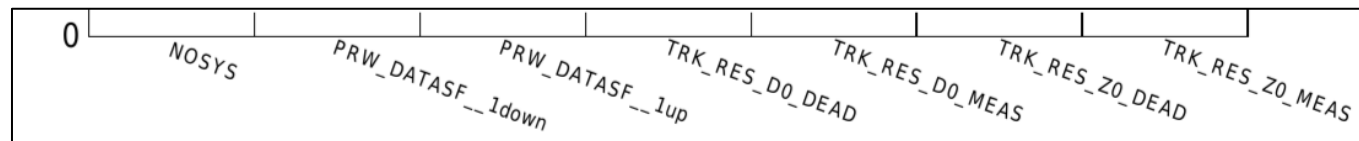


# Hands-on-project

## Accessing tracks and their systematics via CP Algorithms

### Overview

- Existing tools:
  - InDetTrackSmearingTool (d0, z0)
  - InDetTrackSelectionTool (WPs)
- Needed:
  - Algorithm wrapper: <toolName>Alg.cxx
  - Python config: InDetTrackAnalysisConfig.py
  - Header files
  - Cmake files
  - Register block in ConfigFactory.py
  - Register factories in ComponentFactoryPreloader
- Implemented:
  - Smearing Alg (working example, no full config)

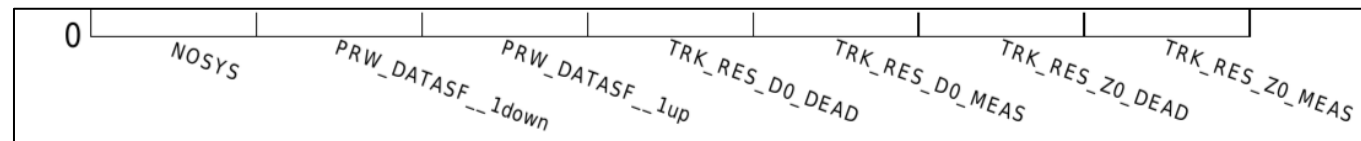


# Hands-on-project

## Accessing tracks and their systematics via CP Algorithms

### Overview

- Existing tools:
  - InDetTrackSmearingTool (d0, z0)
  - InDetTrackSelectionTool (WPs)
- Needed:
  - Algorithm wrapper: <toolName>Alg.cxx
  - Python config: InDetTrackAnalysisConfig.py
  - Header files
  - Cmake files
  - Register block in ConfigFactory.py
  - Register factories in ComponentFactoryPreloader
- Implemented:
  - Smearing Alg (working example, no full config)



### ToDo

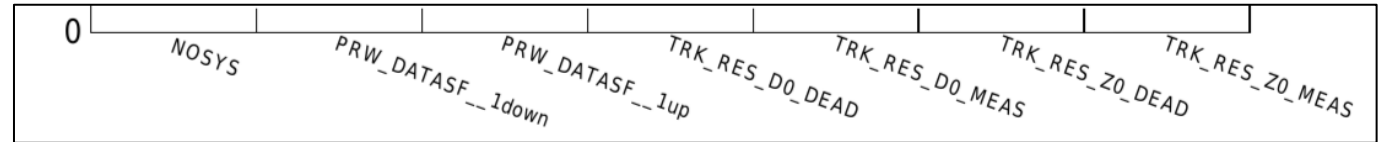
- Pass options to Smearing
- Try adding selection tool

# Hands-on-project

## Accessing tracks and their systematics via CP Algorithms

### Overview

- Existing tools:
  - InDetTrackSmearingTool (d0, z0)
  - InDetTrackSelectionTool (WPs)
- Needed:
  - Algorithm wrapper: <toolName>Alg.cxx
  - Python config: InDetTrackAnalysisConfig.py
  - Header files
  - Cmake files
  - Register block in ConfigFactory.py
  - Register factories in ComponentFactoryPreloader
- Implemented:
  - Smearing Alg (working example, no full config)



### ToDo

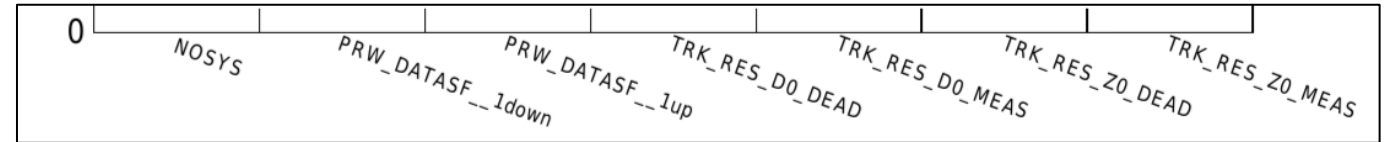
- Pass options to Smearing
- Try adding selection tool
- (Split block into calibration and working point)
- (Check whether to combine with other tools/algs)
- (Look for unslimmed track collection to check pt)

# Hands-on-project

## Accessing tracks and their systematics via CP Algorithms

### Overview

- Existing tools:
  - InDetTrackSmearingTool (d0, z0)
  - InDetTrackSelectionTool (WPs)
- Needed:
  - Algorithm wrapper: `<toolName>Alg.cxx`
  - Python config: `InDetTrackAnalysisConfig.py`
  - Header files
  - Cmake files
  - Register block in `ConfigFactory.py`
  - Register factories in `ComponentFactoryPreloader`
- Implemented:
  - Smearing Alg (working example, no full config)



### ToDo

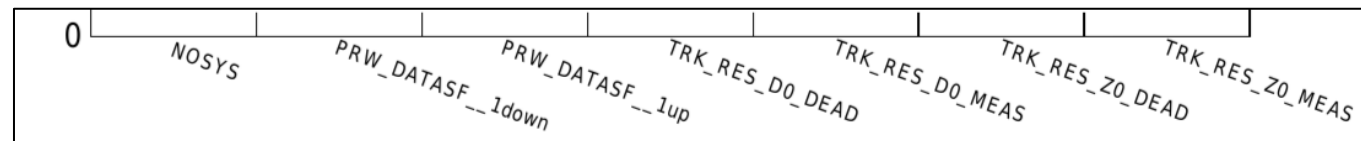
- Pass options to Smearing
- Try adding selection tool
- (Split block into calibration and working point)
- (Check whether to combine with other tools/algs)
- (Look for unslimmed track collection to check pt)
- Eventually, merge new algs to athena

# Hands-on-project

## Accessing tracks and their systematics via CP Algorithms

### Overview

- Existing tools:
  - InDetTrackSmearingTool (d0, z0)
  - InDetTrackSelectionTool (WPs)
- Needed:
  - Algorithm wrapper: `<toolName>Alg.cxx`
  - Python config: `InDetTrackAnalysisConfig.py`
  - Header files
  - Cmake files
  - Register block in `ConfigFactory.py`
  - Register factories in `ComponentFactoryPreloader`
- Implemented:
  - Smearing Alg (working example, no full config)



### ToDo

- Pass options to Smearing
- Try adding selection tool
- (Split block into calibration and working point)
- (Check whether to combine with other tools/algs)
- (Look for unslimmed track collection to check pt)
- Eventually, merge new algs to athena

**Many thanks to Makayla !!!**



# Thank you for your attention!

