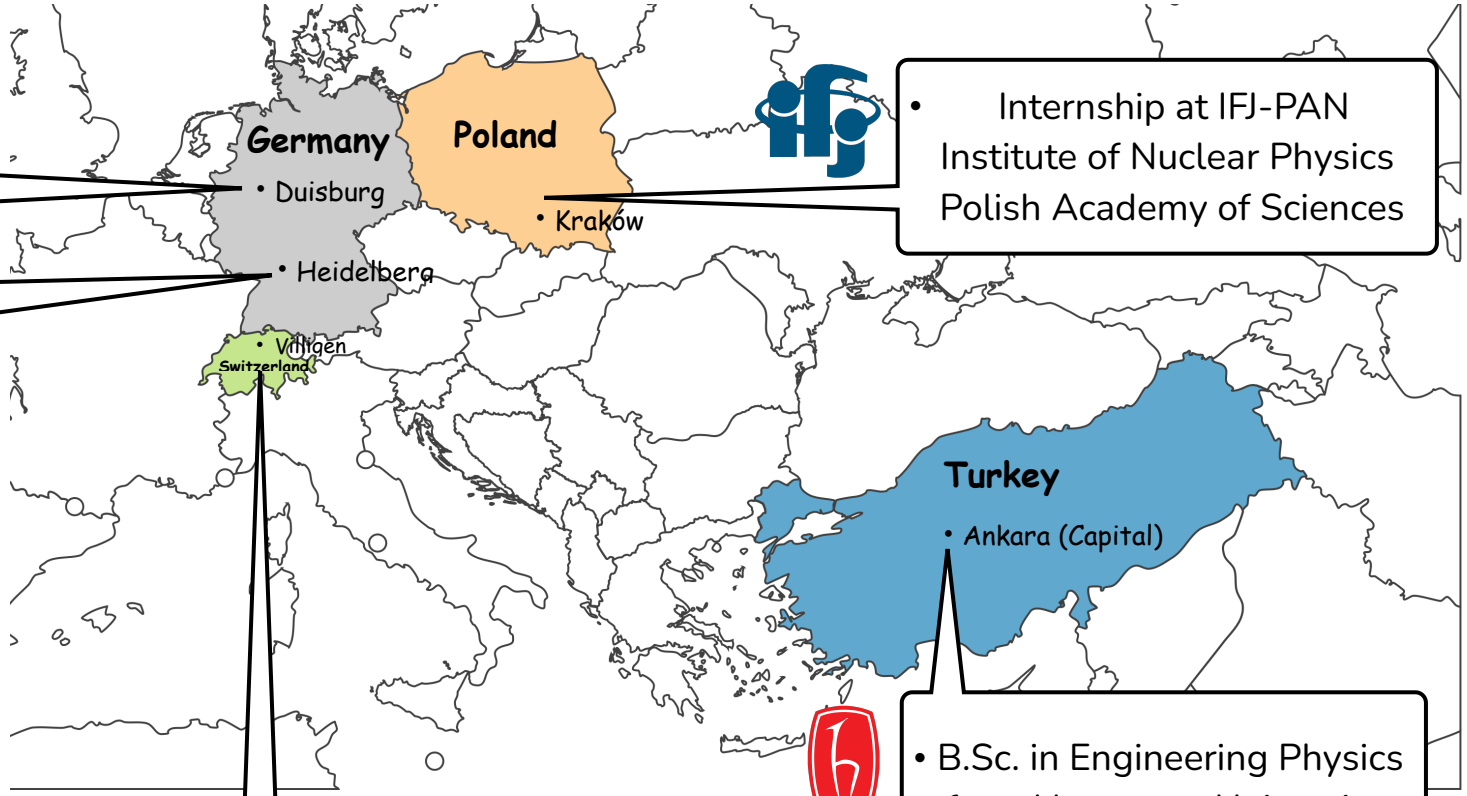
KIT - CMS Experiment

PhD Interview Presentation

12.02.2026

Kadir Tastepe

Kadir's Academic Journey



- Exchange Student in University of Duisburg-Essen

- Internship at IFJ-PAN Institute of Nuclear Physics Polish Academy of Sciences

- M.Sc. in Physics from Ruprecht-Karls University of Heidelberg
- Scientific Assistant in Mu3e Experiment
- Working Student at SAP

- Practical Course at Paul Scherrer Institute (PSI)

- B.Sc. in Engineering Physics from Hacettepe University
- Internship at Grid Computing Center (TUBITAK)

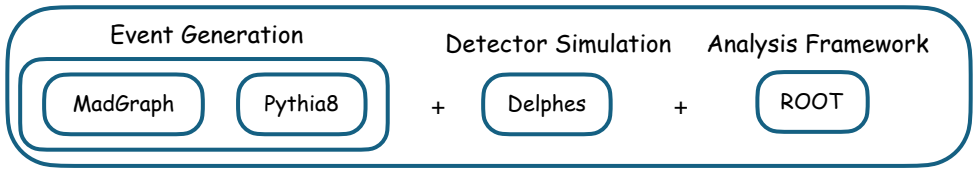
Undergraduate Experience

Bachelor Project:

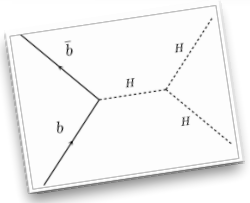
Motivation: The measurement of Higgs self-coupling represents one of the most important remaining tests of the Standard Model's electroweak sector.

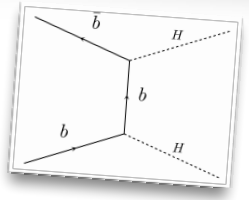
Higgs pair production $b\bar{b} \rightarrow HH$ at 14 TeV using Monte Carlo simulation tools has been studied, and the cross-section has been simulated.

End-to-end Monte Carlo Simulation chain has been created.



$$\sigma = 2.604 \times 10^{-5} \pm 3.3 \times 10^{-8}\ pb$$

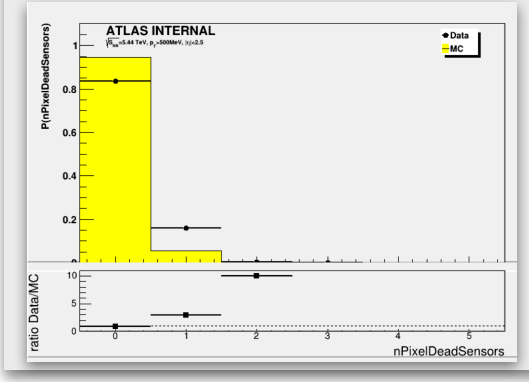




- Realistic Kinematic distributions are obtained.
- The lepton universality has been validated in the simulations.
- Baseline chain has been created for future analysis.

Internship at Polish Academy of Sciences:

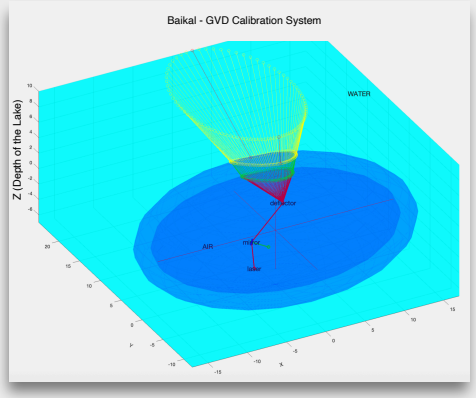
Monte Carlo and detector data compatibility check for charged particle production in Xe-Xe collisions.



Hijing 1.38b simulation vs ATLAS 2017 data; pixel dead sensor differences require correction.

For more: Presentation

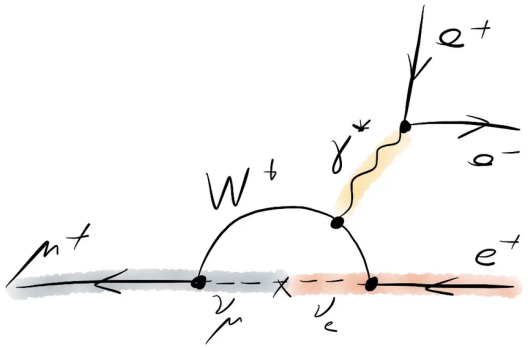
Baikal Gigatone Volume Detector (GVD) Underwater Alignment Studies



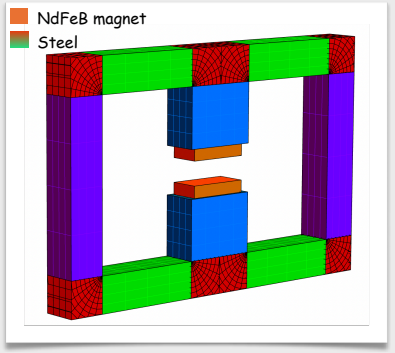
Laser-based calibration system for the Baikal-GVD. The detector's position (ellipsoid) is determined from the Cherenkov cone angle. Refraction effects are visualized using Snell's law.

Scientific Assistant in Mu3e Experiment

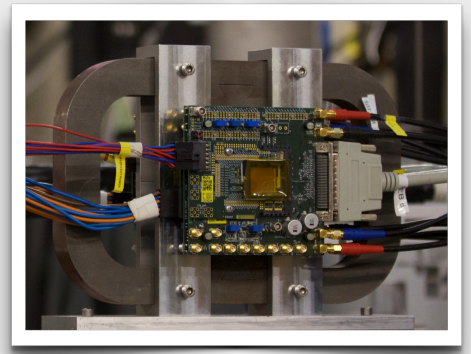
Search for a lepton flavor violation $\mu^+ \rightarrow e^+e^-e^+$



Magnetic Field Simulation of the Spectrometer:



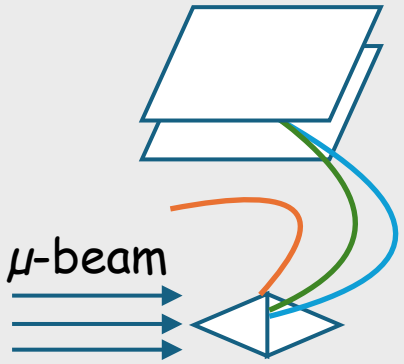
Radia Simulation



MuPix11 Testing

Impact of Increasing Magnetic Field:

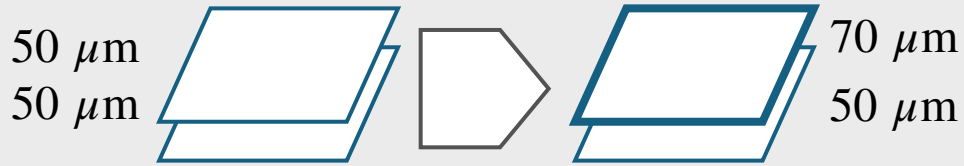
Simulated over 10^7 events in GEANT4 A SIMULATION TOOLKIT .



1.0 T
1.1 T
1.2 T

Mass Resolution improves
Efficiency decreases
Trade-Off

Impact of Increasing Sensor Thickness:



- Mass Resolution decreases
- Efficiency decreases

PSI Practical Course

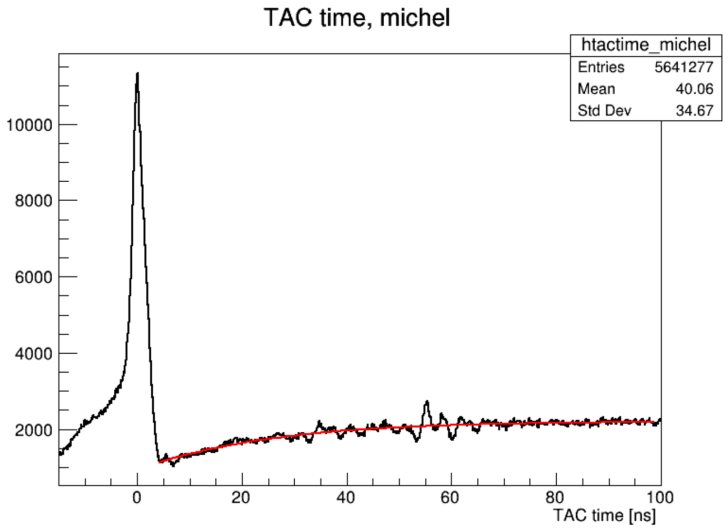
Pion life-time measurement:

- Constant λ_μ and background

Bateman Equation:

$$N(t) = N_0 \frac{\lambda_\pi}{\lambda_\mu - \lambda_\pi} \left(e^{-\lambda_\pi t} - e^{-\lambda_\mu t} \right) + \text{Background}$$

N(t) from a parent (λ_π) decaying into a daughter (λ_μ), including background.

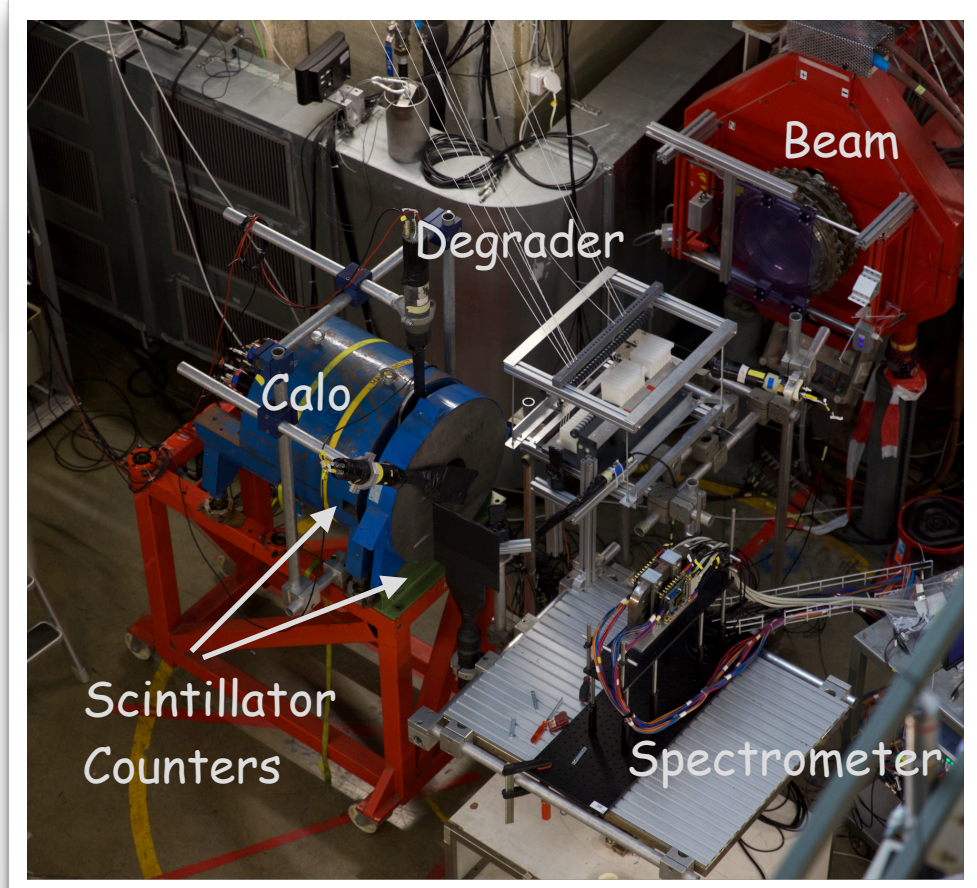


Calo analysis yields:

$$\tau_\pi = 26.01 \pm 0.71(\text{syst.}) \pm 0.35(\text{stat.})\ ns$$

PDG Value:

$$\tau_\pi = 26.0033 \pm 0.0005\ ns$$



Note: The same spectrometer is used to measure the pion lifetime.

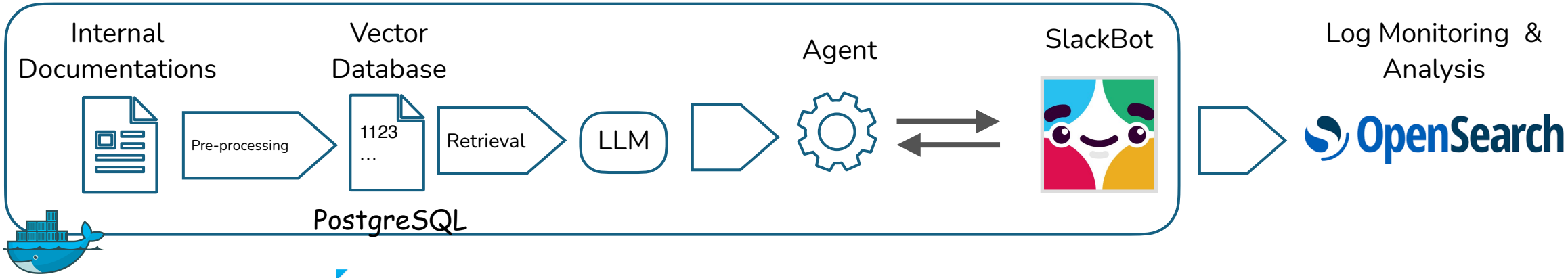
Part-time

Industry Experience at SAP (2+ years)

- Machine Learning Engineering in Business and Technology Platform

SAP BTP CLOUDFOUNDRY

Developing Agentic RAG Prototype



- Big Data Analyst in S/4 HANA

Organizational Tasks

Data Visualization

Prepare Weekly Reports & Presentations

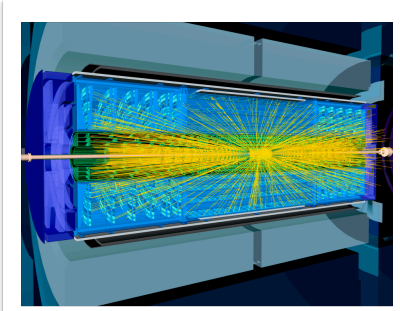
Wiki & Jira Maintenance

Jira

Judge at Finalist Selection

Master's Thesis: HLS-Based FPGA Implementation of the General Triplet Track Fit (GTTF) Algorithm for Real-time Particle Tracking

Pile-up Challenge



Computational Load

- Combinatorial explosion
- Up to 200 collisions per bunch crossing
- Real-time processing constraints

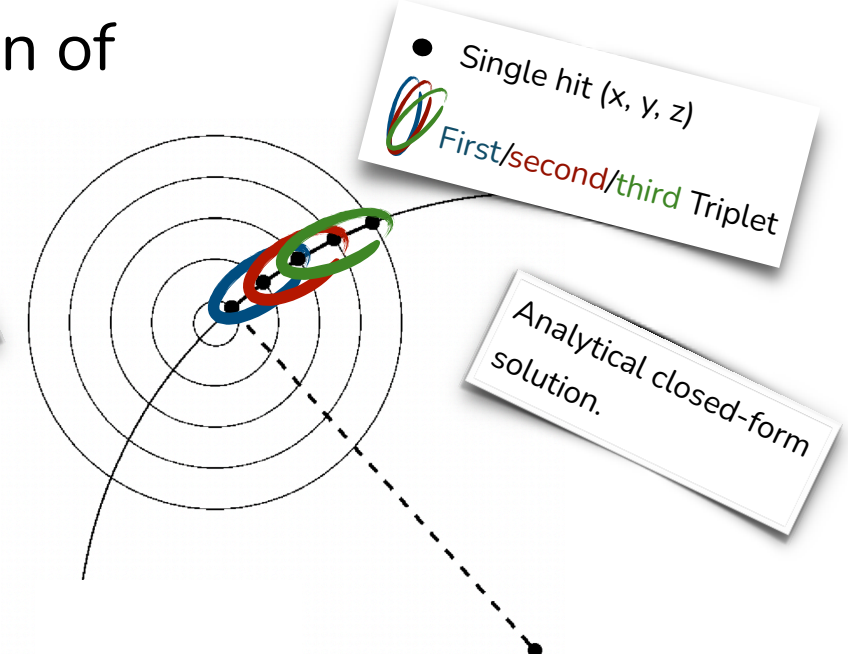
Solution

Minimize to get track parameters

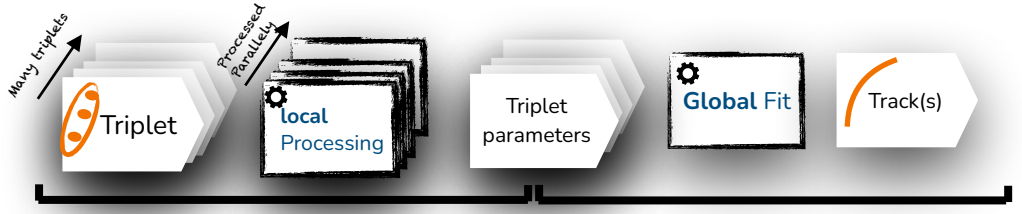
$$\chi^2 = \sum_{\text{Triplets } k} \left\{ \frac{\Delta\Theta^2}{\sigma_\Theta^2} + \frac{\Delta\Phi^2}{\sigma_\Phi^2} \right\}_{MS,k} + \sum_{\text{Hits } m} \left\{ \delta\vec{x}^\top V^{-1} \delta\vec{x} \right\}_m$$

Multiple scattering

Hit uncertainties



Triplet track fit based on *two-step* procedure that can be factorized:

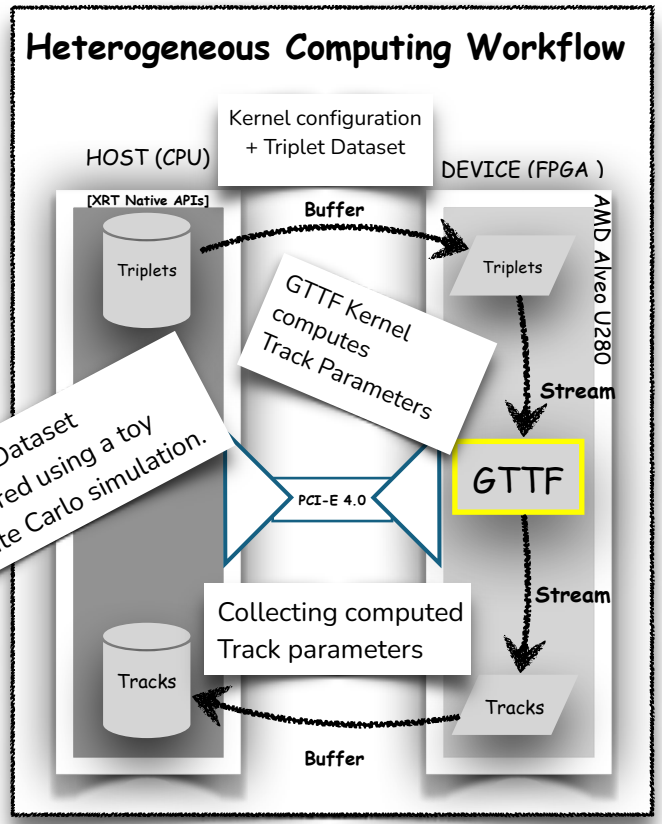


1. Accounts for all detector-specific information, e.g., B field, material budget. **Local Fit** is optional for filtering.
2. Detector independent; compute track parameters from triplet parameters.

Poster available:

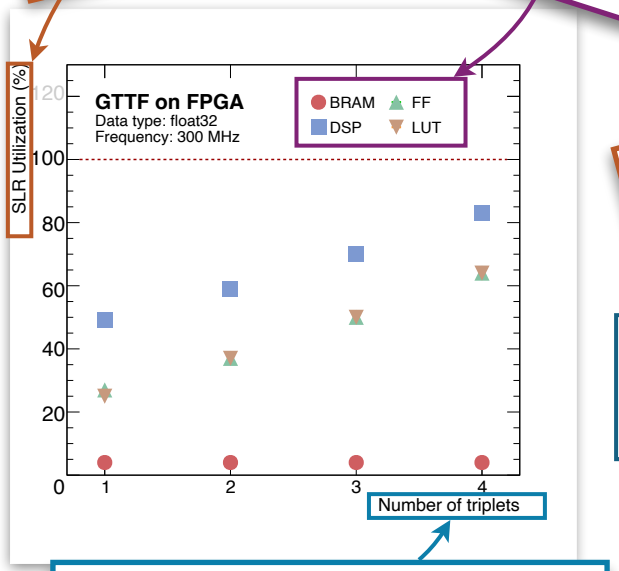
- *K. Tastepe, S. Dittmeier, A. Nandi, C. Sauer, and A. Schöning, FPGA Implementation of the General Triplet Track Fit, EPJ Web Conf., vol. 337, p. 01198, 2025.*

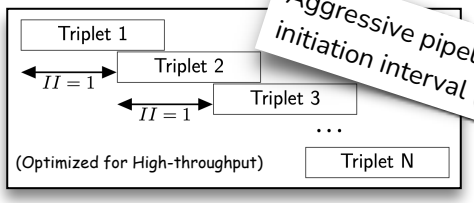
Master's Thesis: **HLS-Based FPGA Implementation** of the **GTTF Algorithm** for **Real-time Particle Tracking**

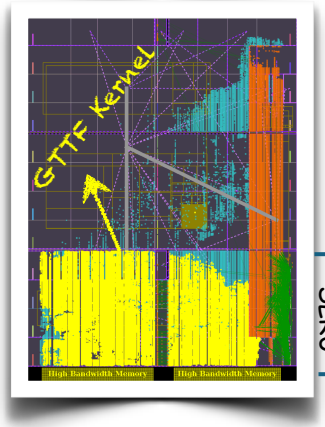


Workflow shows track parameter computation on an FPGA.

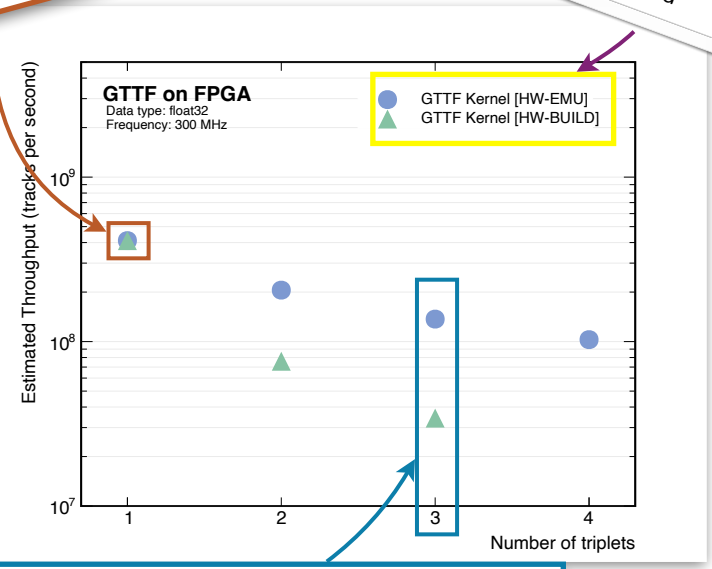
Link to repository: [hls_triplet_fit]



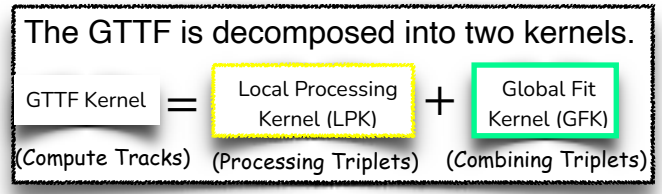


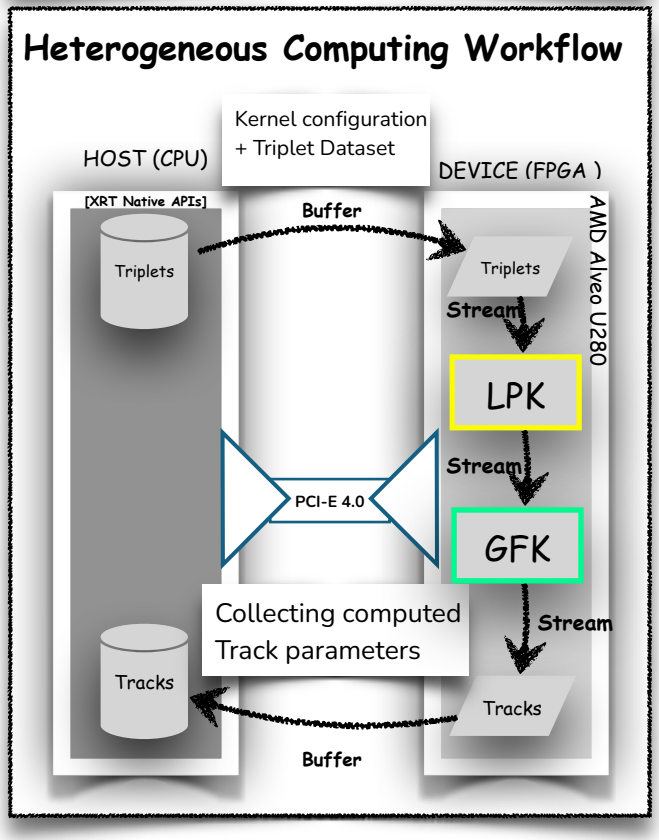


411 MHz throughput of triplet processing.

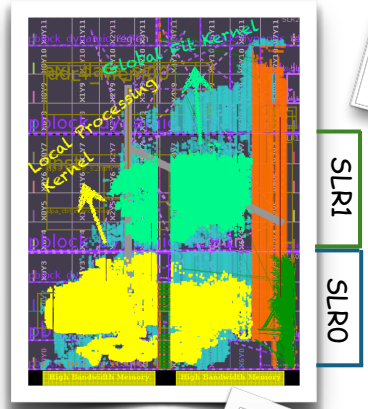


Master's Thesis: HLS-Based FPGA Implementation of the GTTF Algorithm for Real-time Particle Tracking





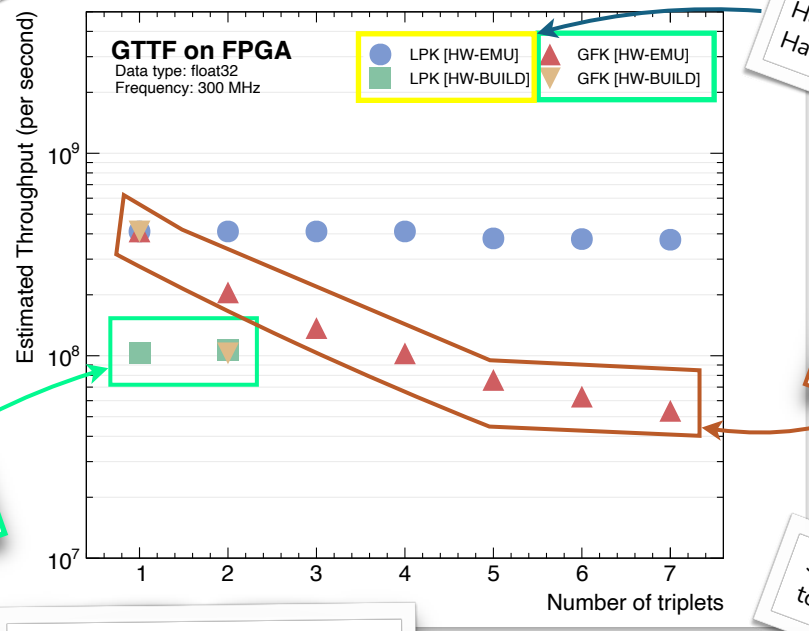
Clock frequency, **initiation intervals**, and **data types** have to be defined manually to guide the synthesis.



Multi-kernel design. Each is assigned to a different SLR.

As the design gets more complex, HLS struggles to meet timing requirements.

Global Fit is the *bottleneck* for the design.



Initiation interval-based throughput estimation: Hardware Emulation vs Hardware Build

Combining more triplets leads to a decrease in throughput.

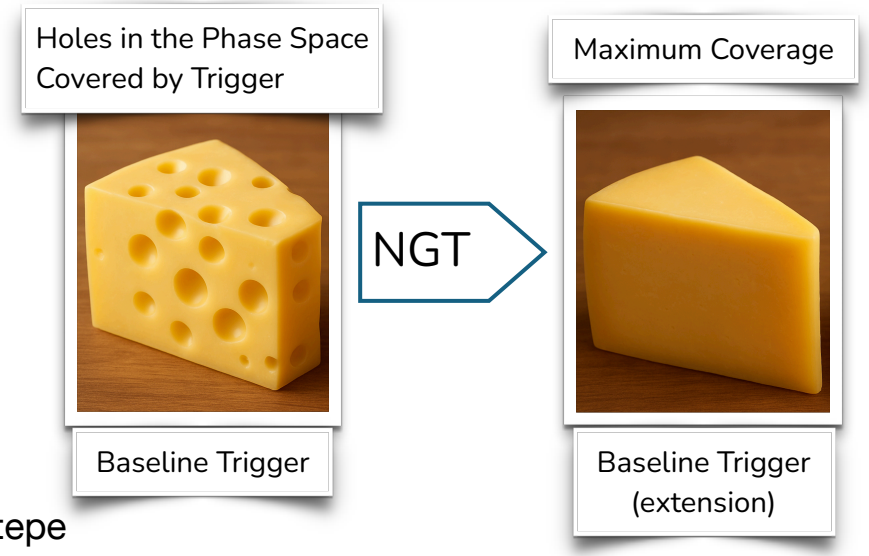
Supports up to 7 triplets.

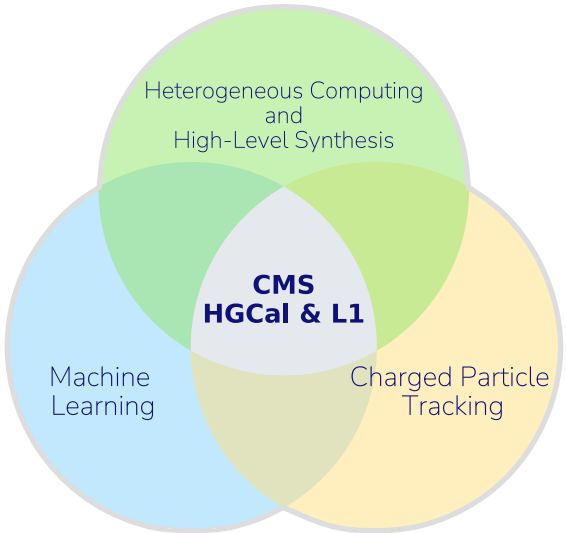
An estimated ~**100 MHz stable throughput** of **triplet processing**.

LPK: Triplet per second
GFK: Global Track Fit per second

Data acquisition, trigger and online reconstruction for the CMS High Granularity Calorimeter and the L1 Track Trigger

- As the HL-LHC will be the last hadron-hadron collider operating at comparable energies for many years, it is essential to maximize its potential by optimizing the trigger strategy!
- Developing faster, smarter, and more efficient trigger and data acquisition systems of CMS in HL-LHC to identify rare events (such as exotic particles, long-lived particles, etc.).
- Including cutting-edge detector technologies such as machine learning, novel algorithms, and heterogeneous computing architectures to improve the performance of trigger systems.





The intersection of my skills and the project's needs is exactly where I can make a difference.

Scientific Outreach Activities

Hacettepe University Physics Society
- Founding Member

Together with my team, we have organized many conferences, seminars, and scientific excursions. (2017-2022)

Voluntary Science Communication

Interdisciplinary Da Vinci Symposium.
(200+ participants, including the rector)

- Continues to thrive today https://www.instagram.com/hacettepefiziktoplulugu/

Extracurricular Activities

Kayaking/Playing Canoe Polo

Winter Expedition

Stand-Up Paddling

Birdwatching

Hiking

Thank you very much for your attention!

Feel free to ask any questions.

Backup

User Interface

Input

Output

What is High Level Synthesis?

- From this C++ to this HDL (Verilog) to run on this  .

In other words: HLS translates high-level languages (C, C++) to FPGA

This is C/C++ code with some compiler statements to tell HLS what to do.

Source Code

Software Emulation

This is just for debugging the C/C++ code using HLS libraries. Compiling: **FAST ~ O(seconds)**

This is for emulating the synthesised code on target hardware. Compiling: **NOT SO FAST ~ O(minutes)**

Hardware Emulation

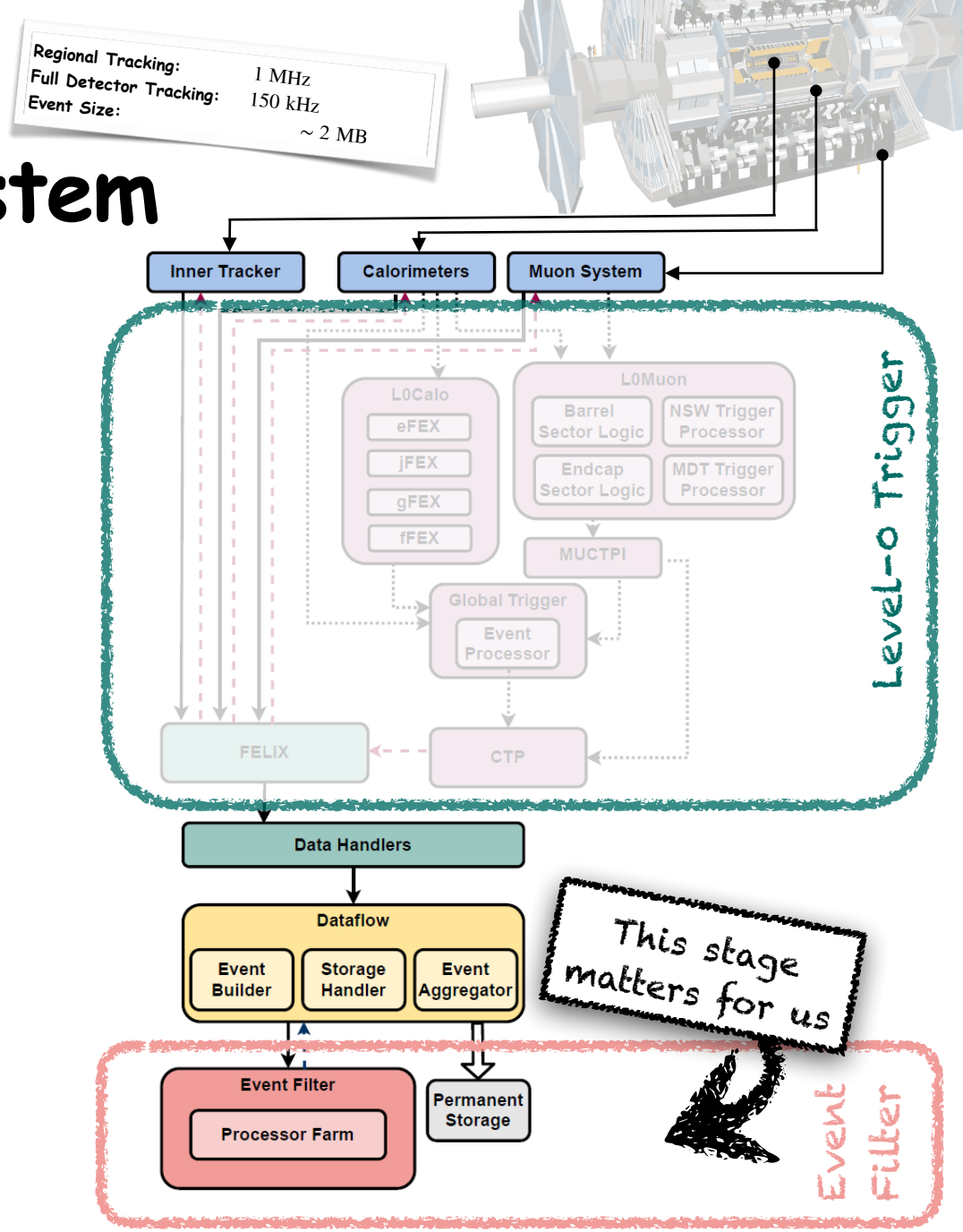
Hardware

If everything works, build for actual hardware. Compiling: **VERY SLOW ~ O(hours)**

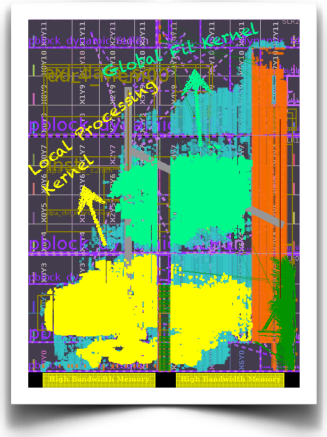
The ATLAS Trigger & Data AcQuisition (TDAQ) System

- 2 Level Trigger System Level 0 and Event Filter to select interesting events
- Event Filter will be based on Heterogeneous computing farm
- Current ongoing competition of ideas for future tracking concepts

(General) Triplet Track Fit

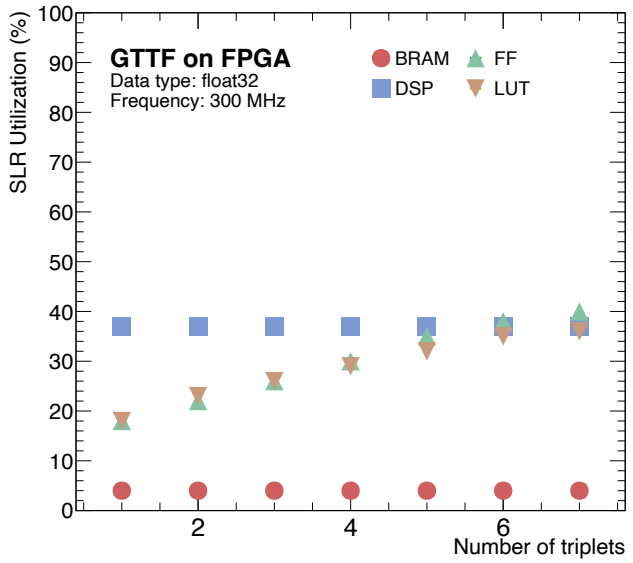


Master's Thesis: HLS-Based FPGA Implementation of the GTTF Algorithm for Real-time Particle Tracking

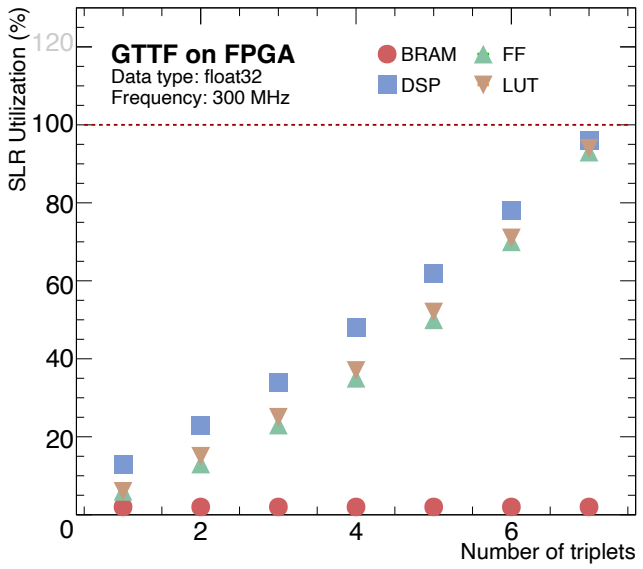


Resource Usage for HW-EMU

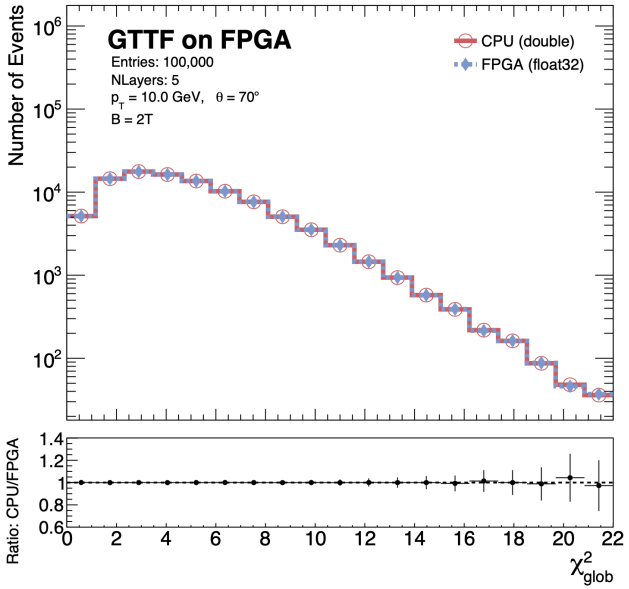
Local Processing Kernel (LPK)



Global Fit Kernel (GFK)



Functional Verification



Floorplan of Kernels

Access Global Memory → Read From Global Memory → Triplet Parameters → Hit Gradients & Local Fit → Compute Global Fit → Write to Global Memory → Access Global Memory

(6) Hit Gradients + Local Processing

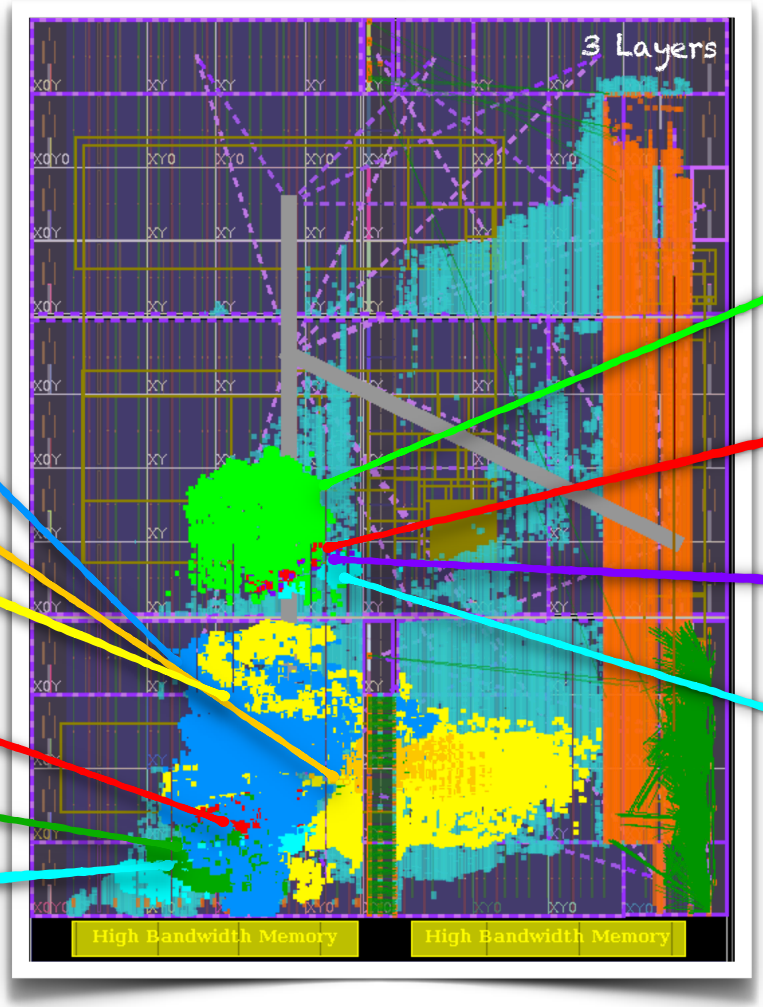
(5) Streaming calculated parameters to Local "Fit" Function

(4) Triplet Parameter Calculation

(3) Streaming Triplets to Triplet Parameters function.

(2) Reading Triplets from the Global Memory

(1) Using m_axi port to access Global Memory.



Global Fit (7)

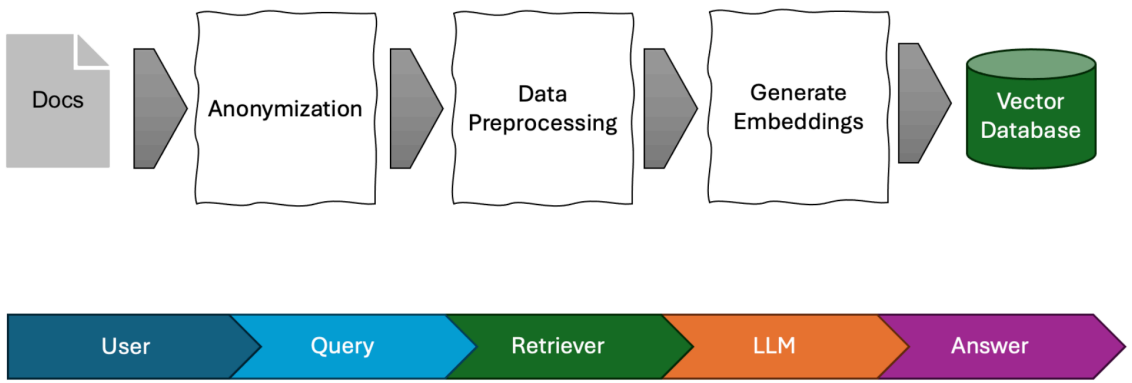
Streaming Track Parameters to Write Global Memory (8)

Writing Track Parameters to Global Memory (9)

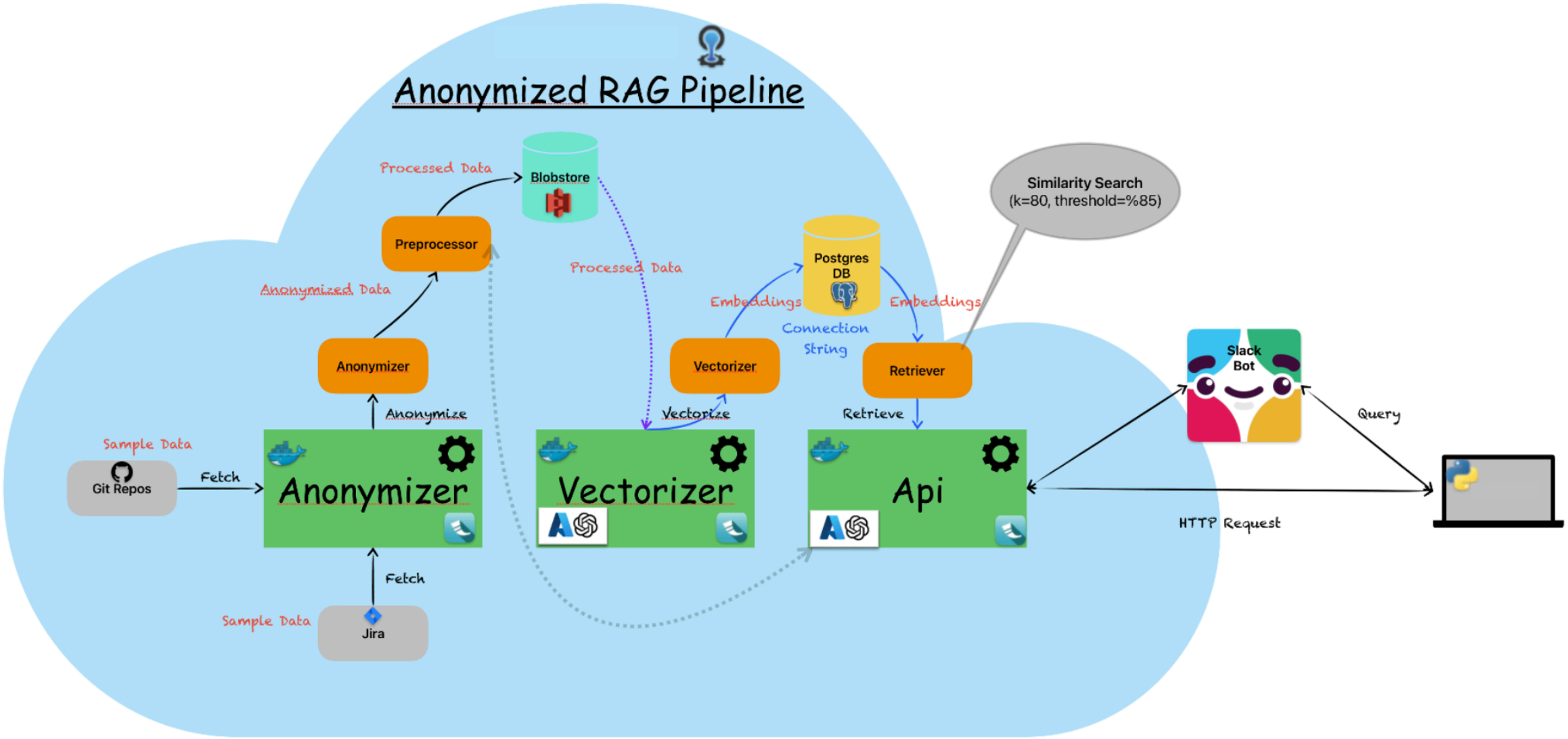
Using m_axi port to access Global Memory (10)

Kadir Tastepe

RAG
(Retrieval Augmented Generation)



- Identify and resolve common software issues faster. (Accelerate **RCA**)
- Prevent re-investigating known issues, **saving hours of** employee **time**.
- **Context aware** troubleshooting.
- Track frequently asked questions and suggest missing documentation.
- Keep internal knowledge bases fresh, allows **rapid database change**. (~ 2 MB per minute)
- Effective **knowledge transfer**, document summarization.
- Boost **developer onboarding**.
- Enable cross-team collaboration.
- The same project can be used by other teams.


Anonymized RAG Pipeline
Processed Data
Blobstore
Preprocessor
Anonymized Data
Anonymizer
Anonymize
Sample Data
Git Repos
Fetch
Anonymizer
Fetch
Sample Data
Jira
Processed Data
Postgres DB
Embeddings
Connection String
Vectorizer
Vectorize
Vectorizer
Embeddings
Retriever
Retrieve
Api
Similarity Search
(k=80, threshold=%85)
Slack Bot
Query
HTTP Request