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of the APS and the JPS
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Software/Simulation effort at E1039 experiment

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U.S. DEPARTMENT OF ENERGY | Office of Science

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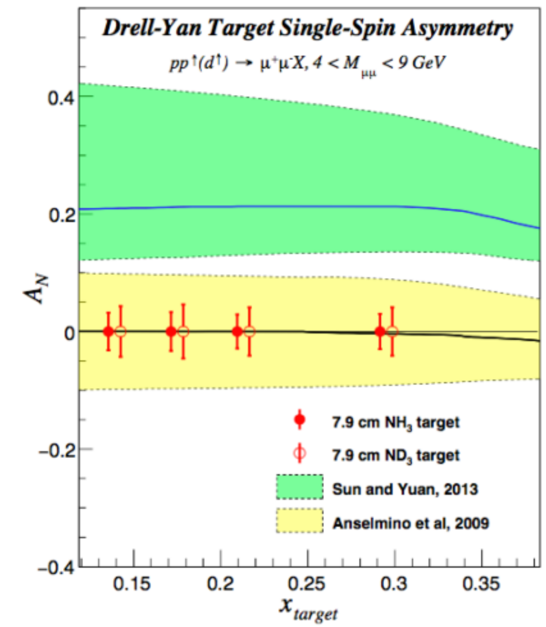
Introduction

- E1039 at Fermilab is a fix target experiment targeting sea quark Sivers functions measurements as the main physics goal.
- It is upgraded from E906 (SeaQuest) with polarized NH3 target.
- This talk focuses more on the software/simulation efforts on E1039 experiment.
- Experiment apparatus - D. Isenhower
- Physics - M. Yurov and M. Daugherity
- Also refer A. Tadepalli and D. Morton's E906 talks

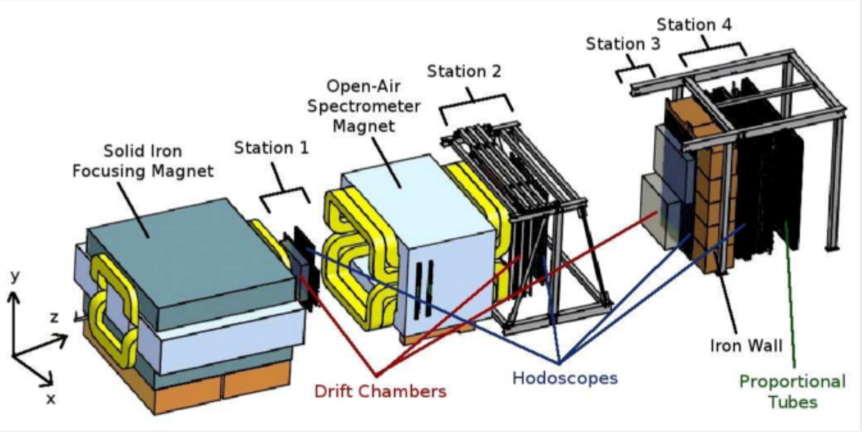
E1039 proposal
More in M. Yurov's talk



Outline
- ROOT IO software framework at E1039
- Unified interface for simulation and real data
- Simulation
  - Target heat load study
  - Hodoscope gap study
  - New shielding study

Beam

polarized target



More in D. Isenhower's talk

Motivation

In E906 we initially used MySQL database based software

- optimal for random access, less efficient for serial access

The simulation and real data processing were routed differently

- Difficult to map simulation knowledge to real data

- In E1039 we decided to develop a ROOT-based analysis software with uniformed interface for simulated data and real data
- We chose the PHENIX/sPHENIX Fun4All framework which come with a GEANT4-based simulation sub-framework
- Faster tracking algorithm that makes online Jpsi reconstruction possible

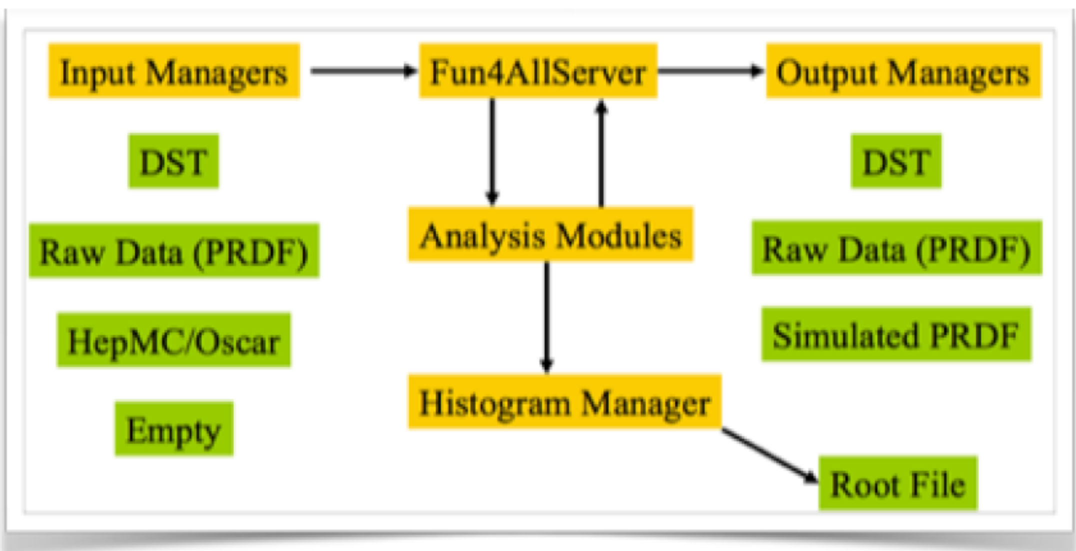
Fun4All framework at E1039

Fun4All framework

- Developed by C. Pinkenburg for PHENIX
- Light and versatile
- Tested in PHENIX and sPHENIX
- ROOT based I/O
- Modularized for easier collaborative development
- Comes with a GEANT4 based simulation sub-framework

Porting Fun4All to E1039

- Copy 3 framework related packages
- Adapt existing packages to Fun4All modules
- Automake $\Longrightarrow$ cmake
- https://github.com/E1039-Collaboration



C. Pinkenburg's Talk https://www.jlab.org/indico/event/187/contribution/4/material/slides/0.ppt

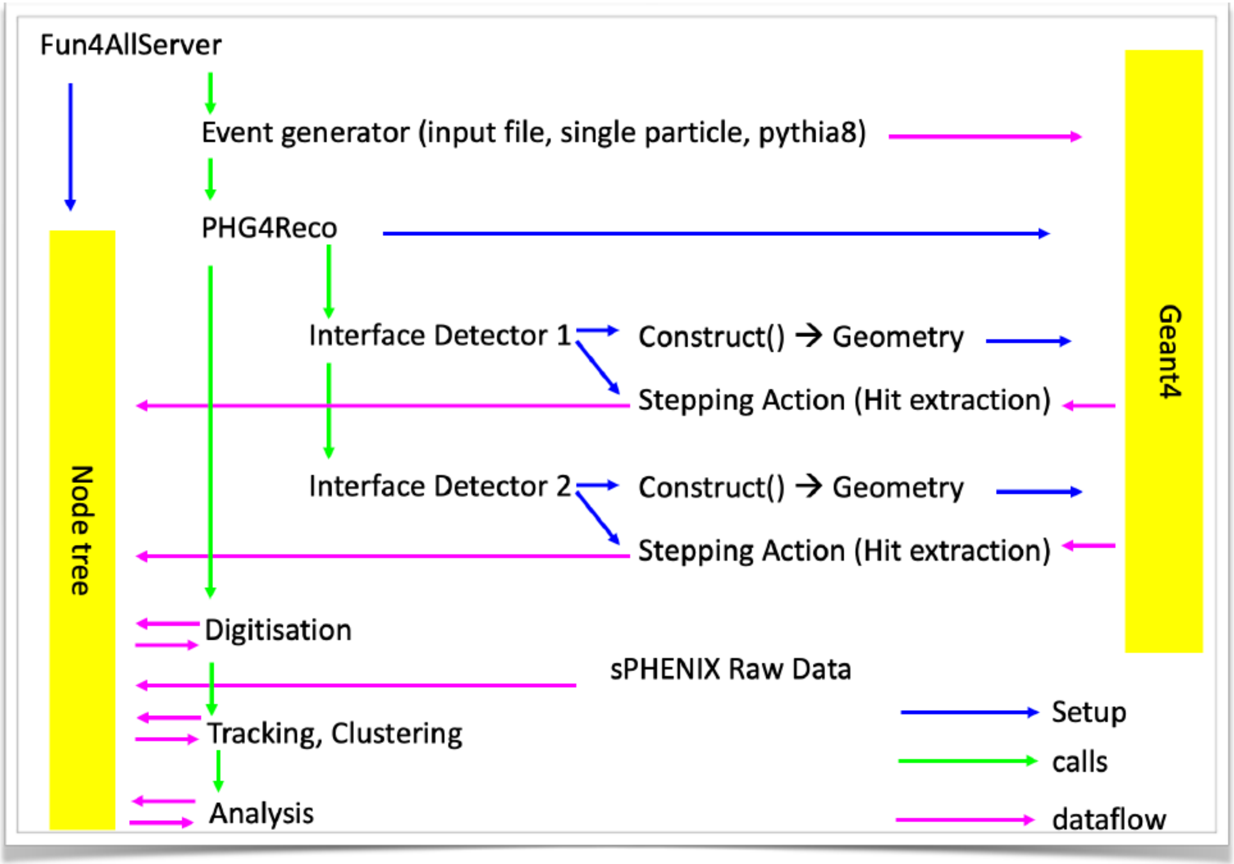
sPHENIX simulation sub-framework at E1039

sPHENIX simulation sub-framework

- Links Geant4 to Fun4all
- Full truth tracing capability
- Run-time configurable Greant4
- HepMC as generator interface

Porting to E1039

- Several dependencies needs to be sorted out
- Adapt existing Geant4 models
- Implement new Geant4 models as needed
- https://github.com/E1039-Collaboration

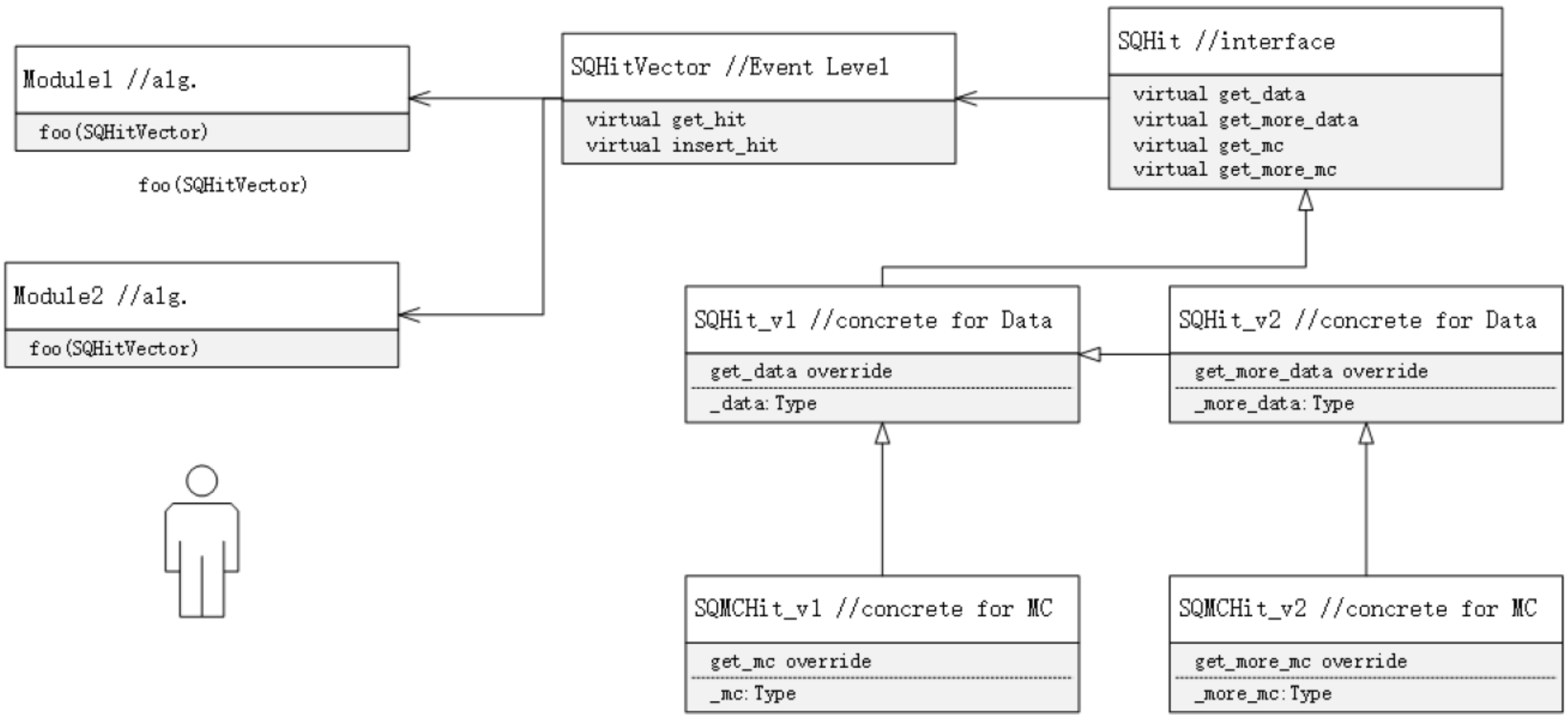


C. Pinkenburg's Talk https://www.jlab.org/indico/event/187/contribution/4/material/slides/0.ppt

Unified interfaces for Data and Simulation

We designed a unified interface following the facade design pattern:

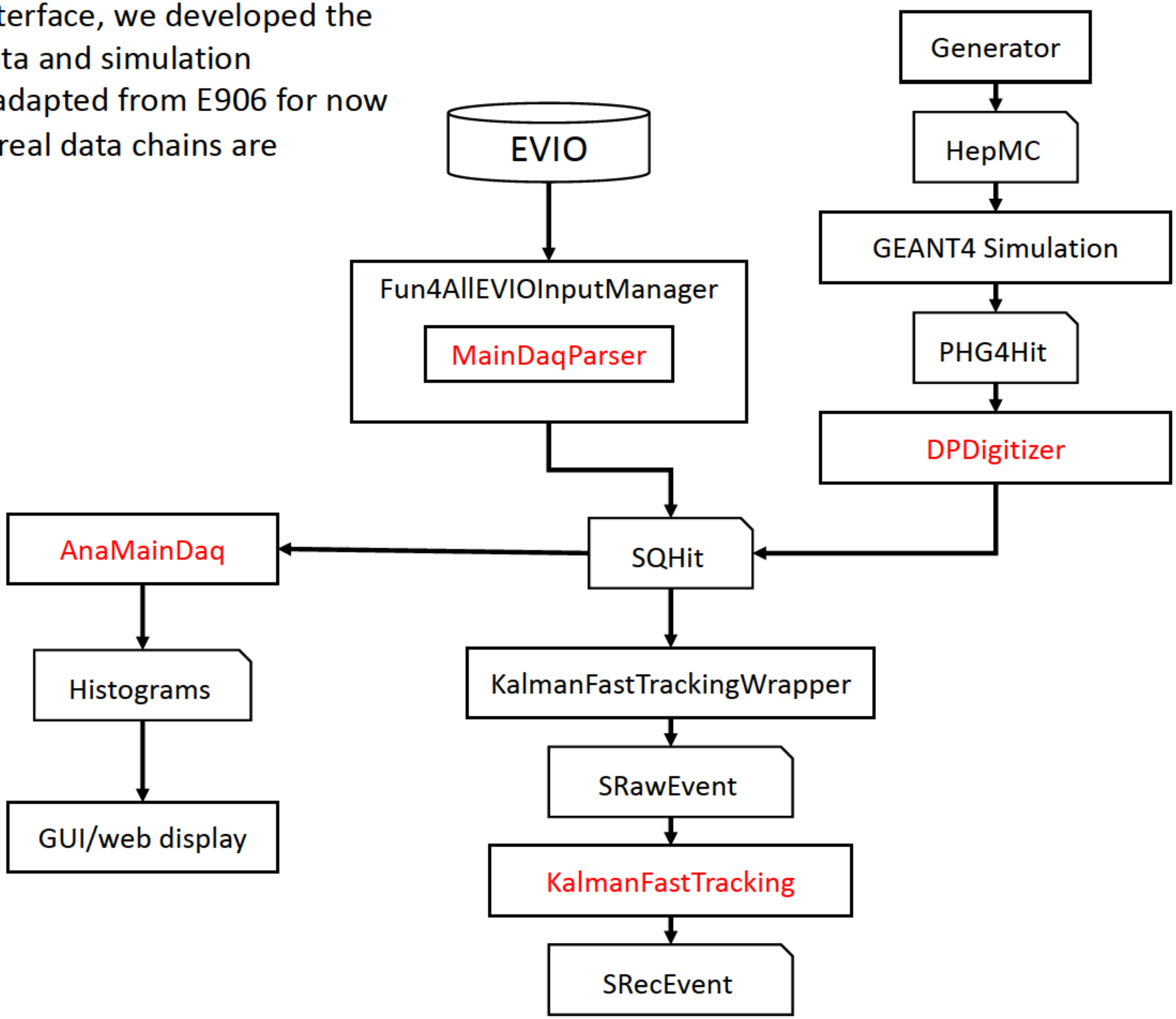
- unified interface for real data and simulation
- save disk space
- backward compatibility



E1039 data flow with Fun4All

Based on the uniform interface, we developed the analysis chain for real data and simulation

- Core algorithms are adapted from E906 for now
- Both simulation and real data chains are working now



Polarized target heat load simulation

Thanks to D. Keller, A. Klein, R. Tesarek, K. Liu etc. for many useful inputs

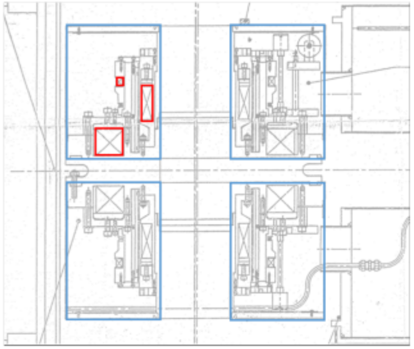
Goal is to estimate the maximum beam intensity that won't quench the superconducting coil of the target

Approach: shoot in protons and count the energy deposited on the superconducting coil. Then compare with previous BNL-E794 experiment where we know the maximum allowed beam intensity, in order to estimate the maximum allowed beam intensity at E1039.

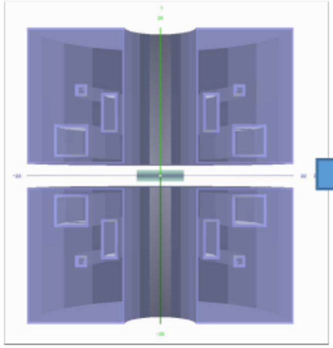
- Build semi-realistic target coil Geant4 model from design drawings
- Run G4 simulation and collected G4Hits with this sPHENIX simulation framework
- Count the energy deposited

- Current results showed we could be able to handle the heat from deigned luminosity
  - Some modification to the target G4 model is needed based on some recent information
  - Thermal dynamics simulation based on this heat load simulation is undergoing

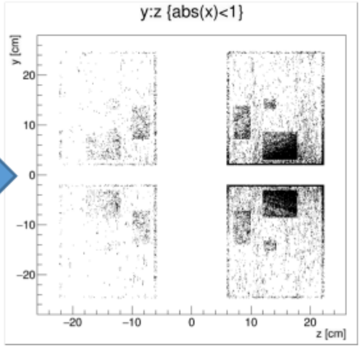
design drawing



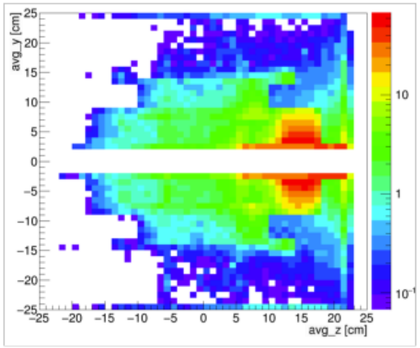
G4 model



G4 simulation
w/ sPHENIX framework



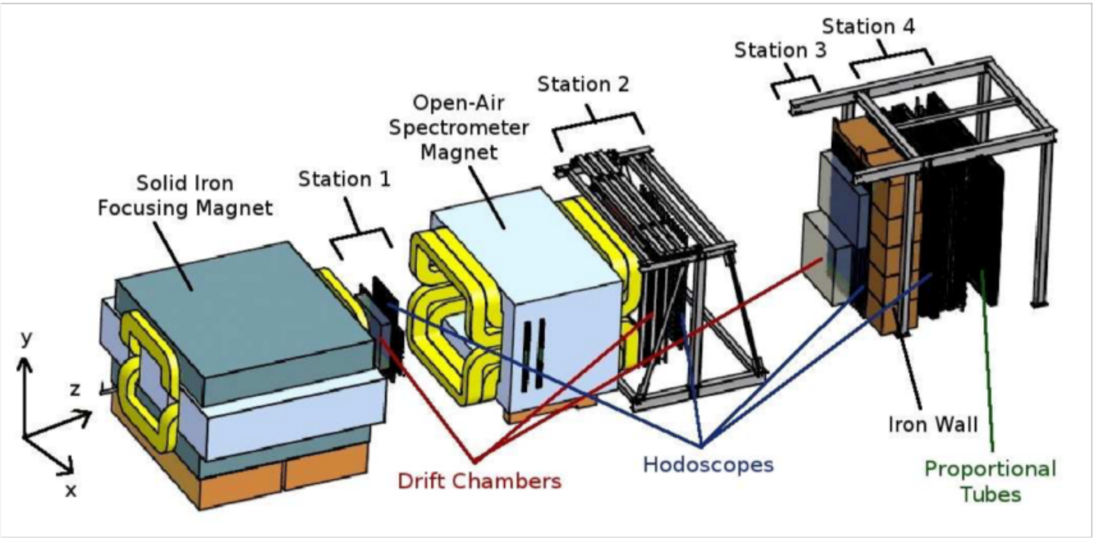
Analysis:
sum up energy of G4Hits



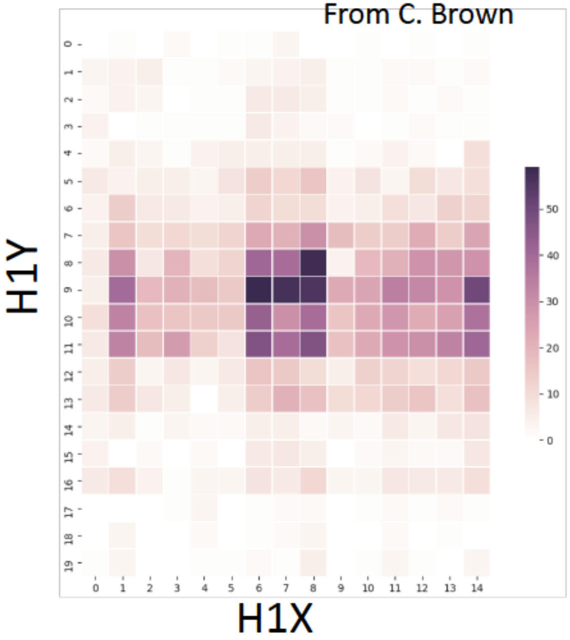
Hodoscope gap optimization

- DAQ dead time caused by high trigger rate in E906 introduced systematic uncertainties
- A very large number of hits occurred along the x-axis of the first hodoscope plane; analysis showed a very high fraction of these hits are random combinations instead of physics signals.

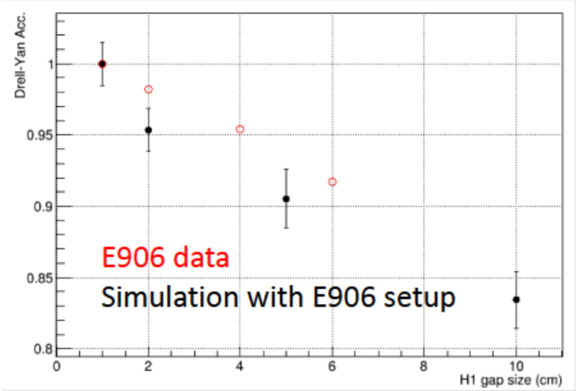
- We propose to make a horizontal gap in the first hodoscope to reduce this trigger rate without affecting the signal acceptance significantly.
- We studied this proposal by simulating Drell-Yan dimuon signal events and minimum bias pp events



H1Y vs. H1X
From C. Brown

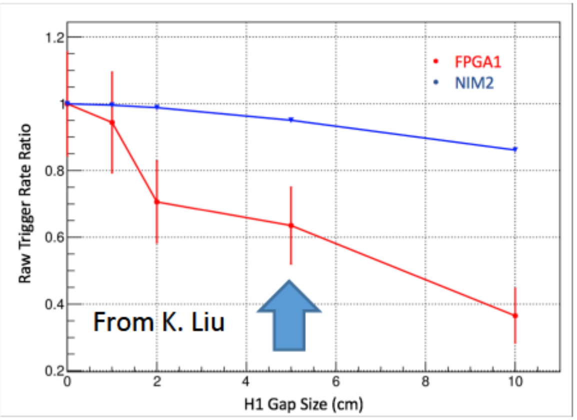


Hodoscope gap optimization - cont'd



Simulation verification with E906 setup

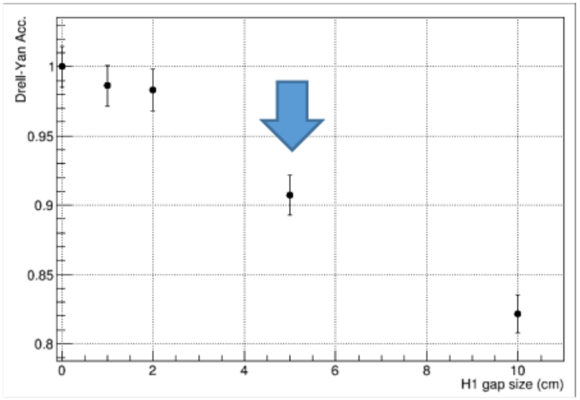
- Compare Drell-Yan simulation with good reconstructed dimuon tracks
- Consistent with in statistical uncertainties
  - Note some background remains in real data



Trigger rate using minimum bias pp simulation

- Based on 5E10 pp collisions
- Assuming RF bucket size is 40k protons

- **If we create a 5 cm gap (+/- 2.5 cm) on H1, the main dimuon trigger rate will be reduced by 40%**



DY relative acceptance

- Based on 100k DY event for each gap
- Generator cuts: inv. mass > 4 GeV, muon pz > 10 GeV

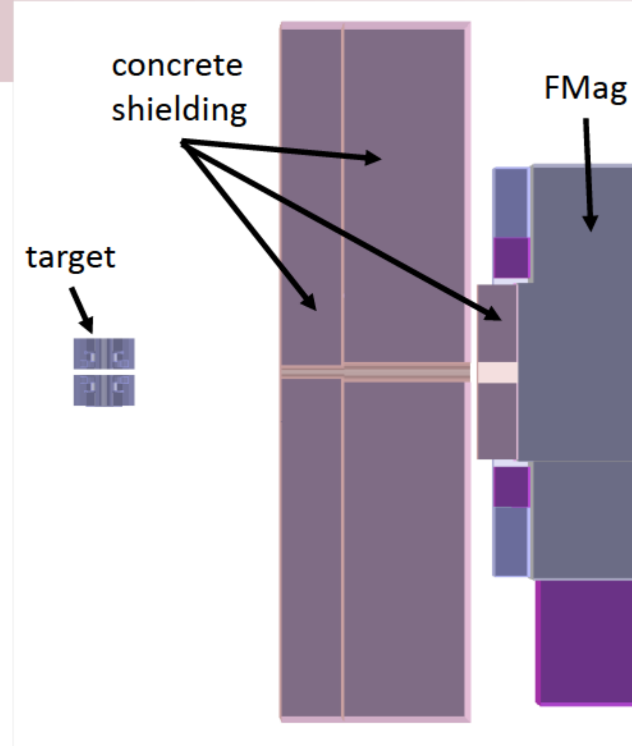
- **Only losing 10% DY acceptance if we make a 5cm gap on H1**

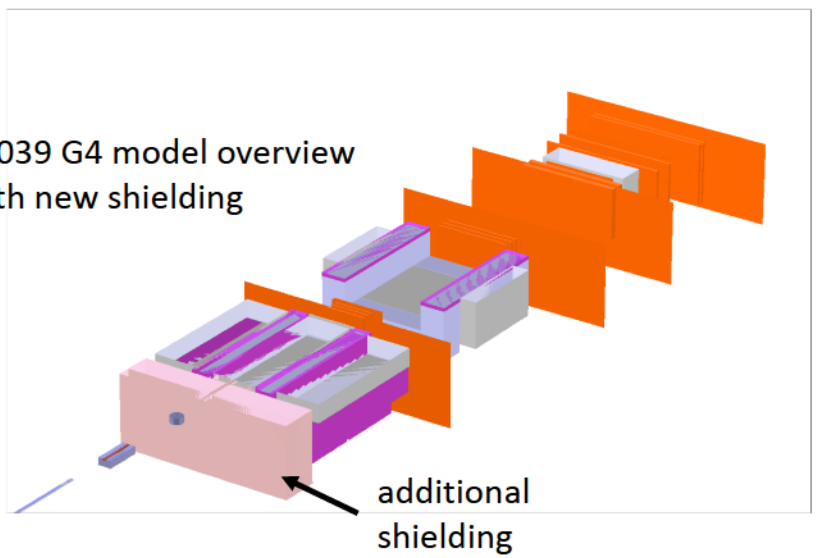
New shielding study

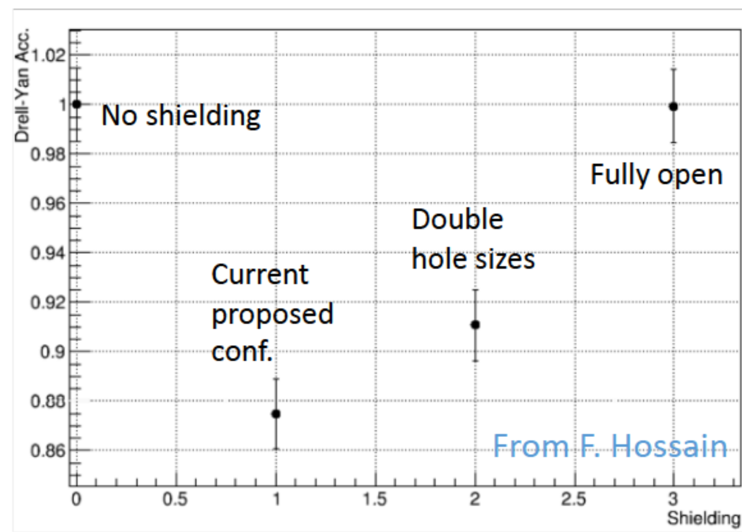
To make the IR hall safer for people, additional shielding will be added between the target and the spectrometer. What effect will this have on the signal acceptance of the spectrometer?

We performed simulation with run-time configurable shielding blocks

- About 12% losing in Drell-Yan acceptance observed in the first batch simulation
- Trying different field scaling to recover - balancing between momentum resolution and statistics







Epilogue

Status:

- Ported Fun4All framework with GEANT4 based simulation
- Now both real data chain and simulation chain are working
- Several task based simulation studies performed to help hardware works
    - Target heat load simulation - promising results, further studies going on
    - Hodoscope gap study - 5cm as the optimum gap at H1X
    - New shielding study - acceptable losing in acceptance, trying to recover by scaling the field

Plans:

- Online monitoring utilities
- Faster tracking algorithms

E1039 data taking in 2019!

Open access:

- https://github.com/E1039-Collaboration

Sincere thanks to C. Pinkenburg and J. Huang from BNL

- https://github.com/sPHENIX-Collaboration