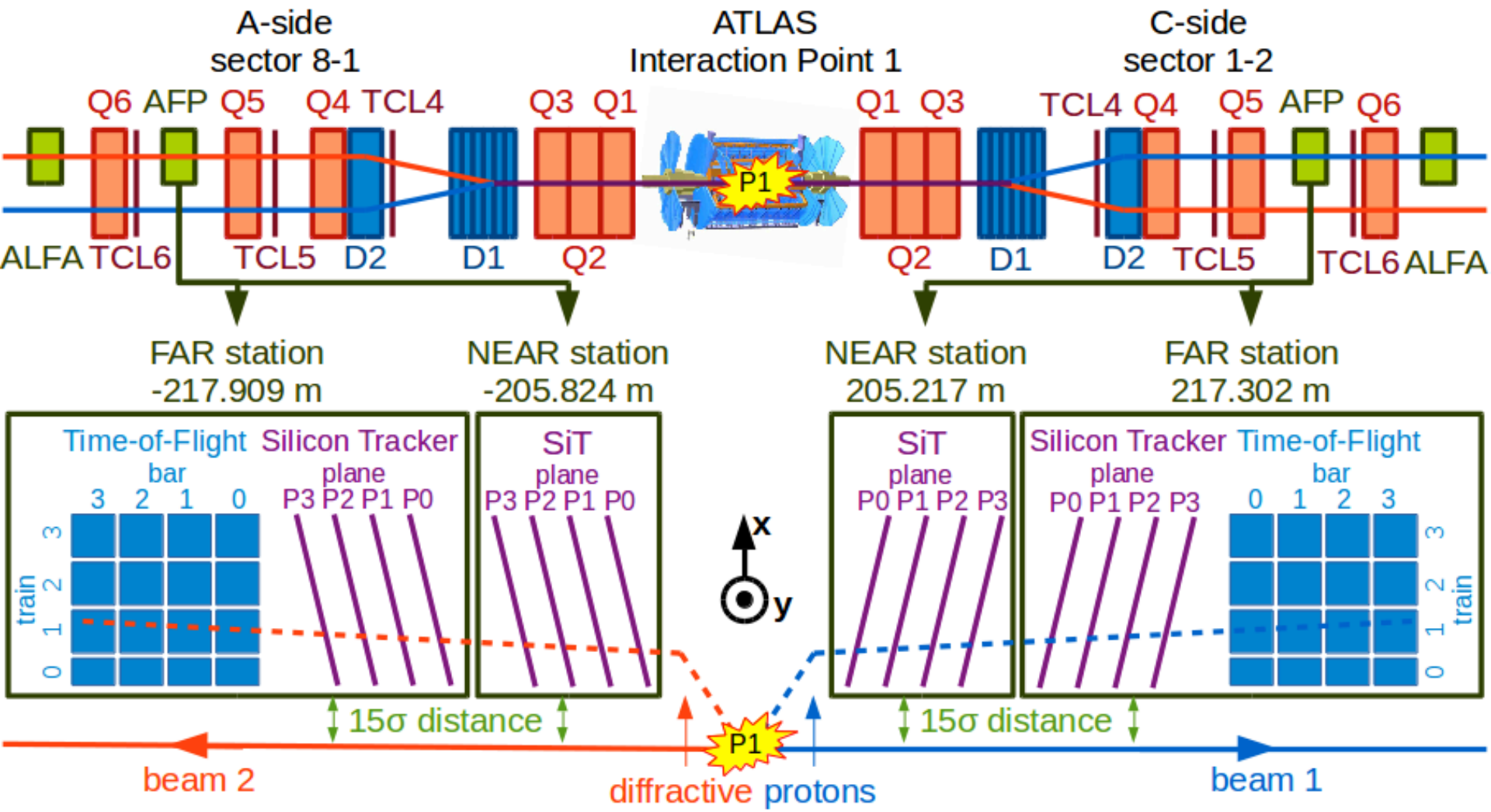
# OPTICS STUDIES FOR ATLAS FORWARD PROTON PROJECT

Tom Eichlersmith

Adivisor: Maciej Trzebinski

Thanks to: Grzegorz Gach and the National Science Foundation


A-side
sector 8-1
ATLAS
Interaction Point 1
C-side
sector 1-2
Q6 AFP Q5 Q4 TCL4 Q3 Q1
Q1 Q3 TCL4 Q4 Q5 AFP Q6
P1
ALFA TCL6 TCL5 D2 D1 Q2
Q2 D1 D2 TCL5 TCL6 ALFA
FAR station
-217.909 m
NEAR station
-205.824 m
NEAR station
205.217 m
FAR station
217.302 m
Time-of-Flight
bar
3 2 1 0
Silicon Tracker
plane
P3 P2 P1 P0
SiT
plane
P3 P2 P1 P0
SiT
plane
P0 P1 P2 P3
Silicon Tracker
plane
P0 P1 P2 P3
Time-of-Flight
bar
0 1 2 3
train
x
y
15σ distance
15σ distance
P1
beam 2
diffractive protons
beam 1

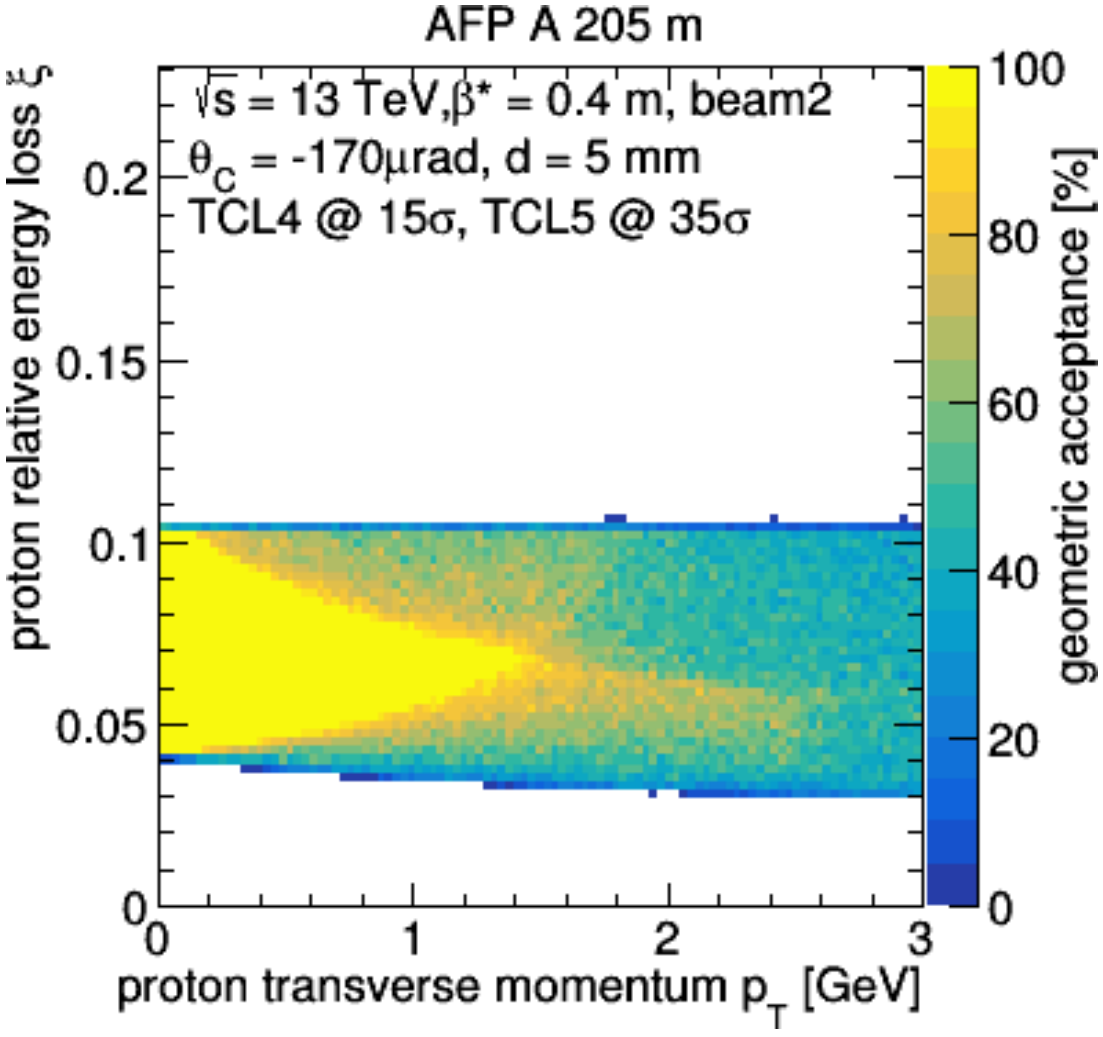
# Purpose

- Previously, many separate codes to produce plots and files related to optic settings
- This framework unifies them into one library

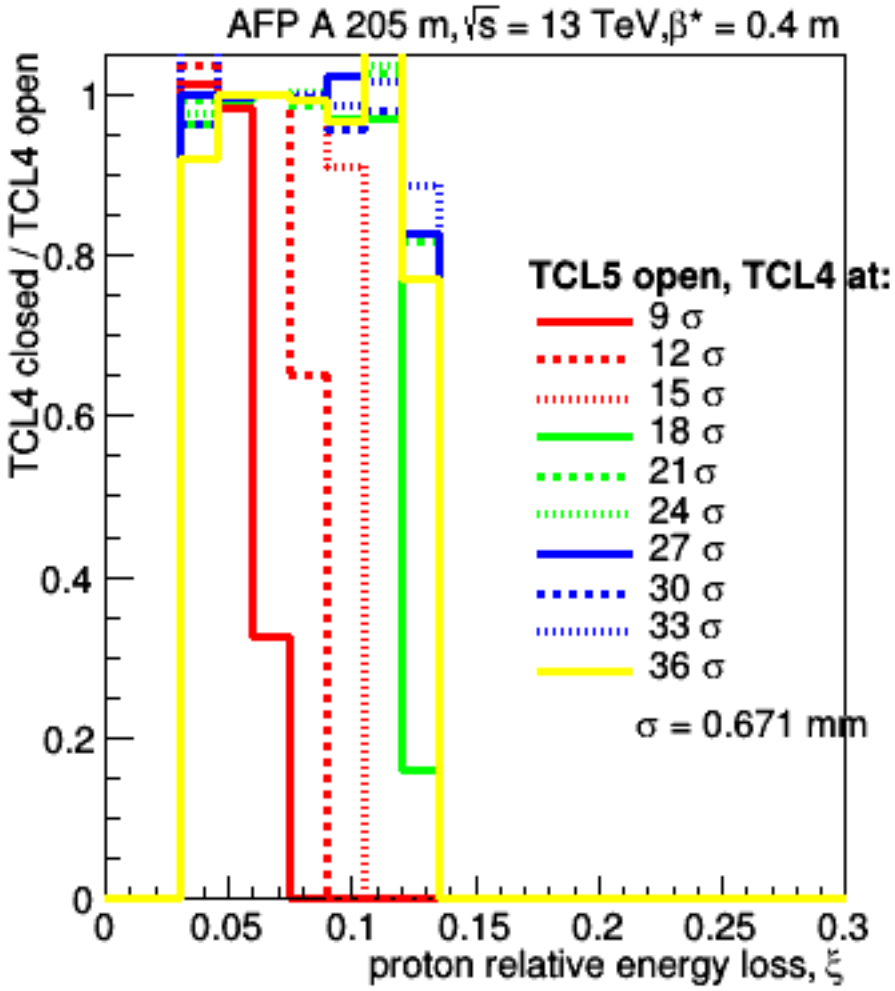
# Capabilities

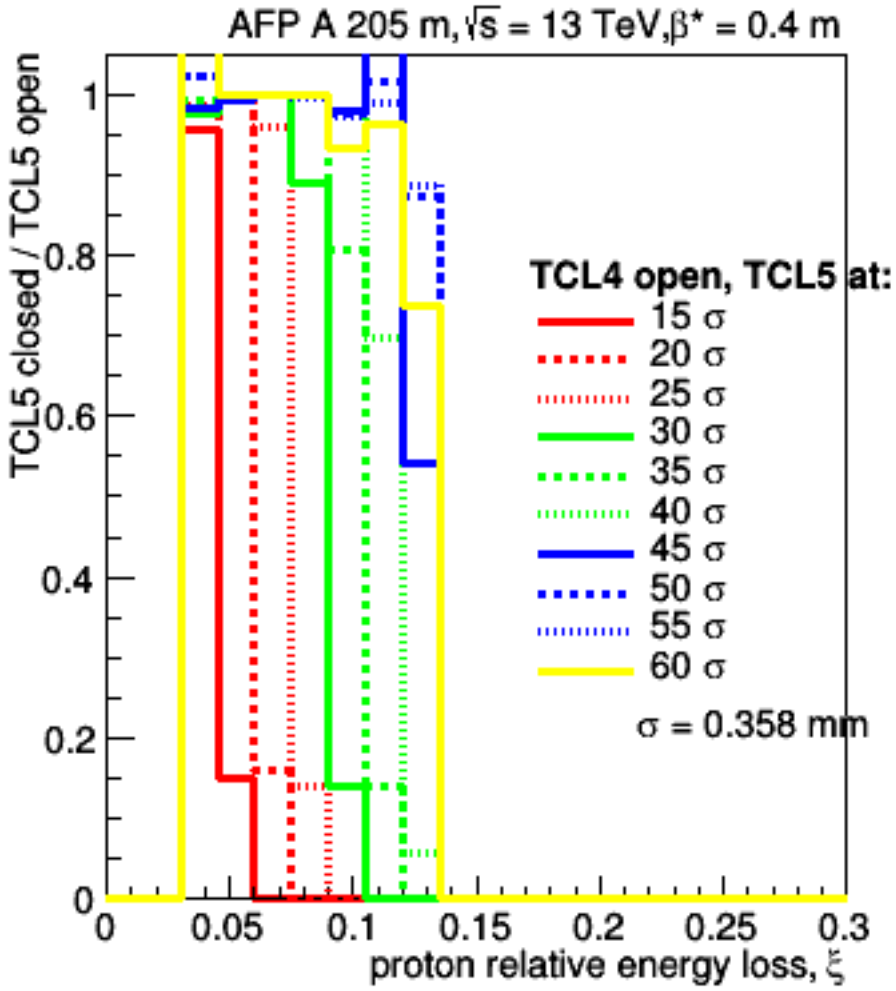
- Generate twiss files from MAD-X files (using MAD-X)
  - Assumes UNIX machine
- Geometric acceptance plots
- Collimator analysis plots
- Example proton positions in detector plane
- Example trajectories
- Probabilities of a single tag and double tag event as functions of pileup
- Probabilities of hitting floor of Roman pot
- Determine transport parameterization, print to file, compare parameterization to simulation
- Saves generated histograms to .root file
- Prints plots as both .png and .eps files

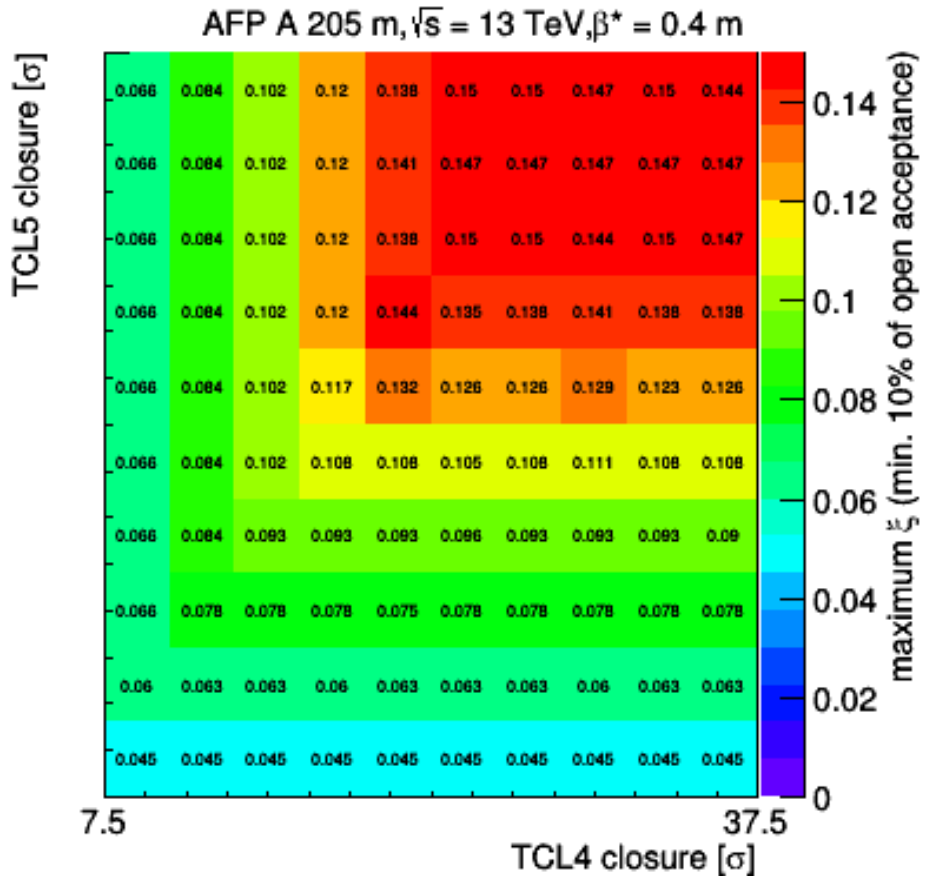
# example.GeometricAcceptance()



# example.CollimatorAnalysis()




AFP A 205 m, √s = 13 TeV, β* = 0.4 m
TCL5 closure [σ]
TCL4 closure [σ]
7.5
37.5
maximum ξ (min. 10% of open acceptance)
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0.066 0.084 0.102 0.12 0.138 0.15 0.15 0.147 0.15 0.144
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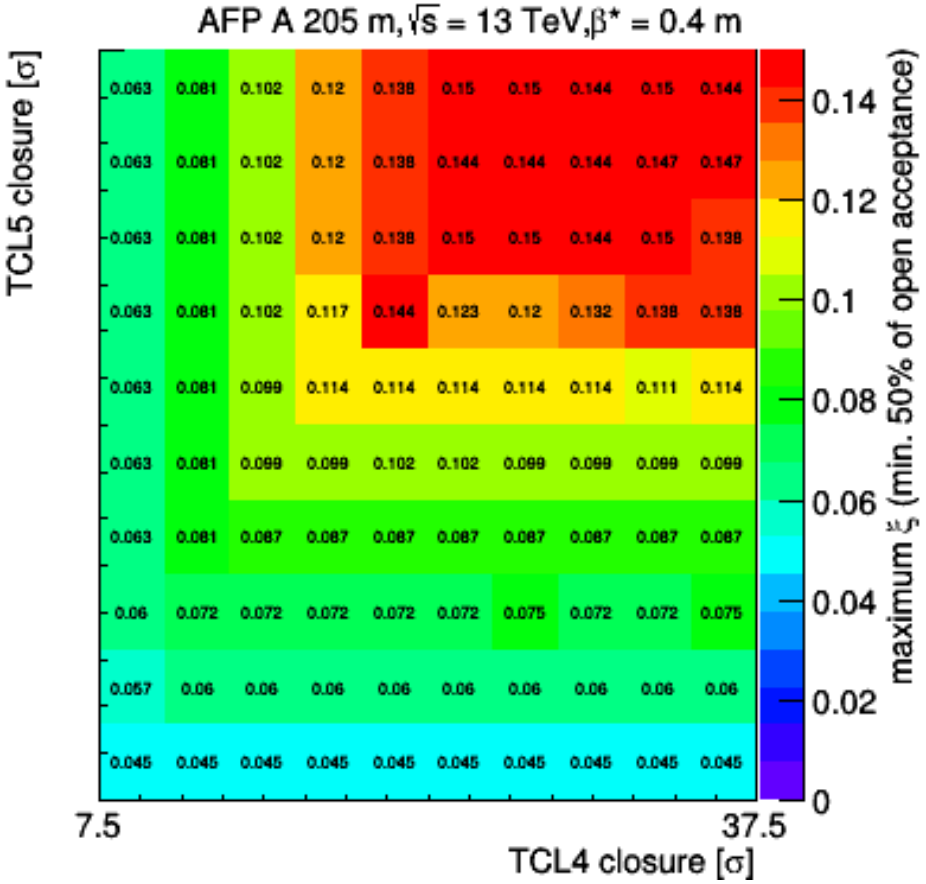
0.066 0.084 0.102 0.12 0.144 0.135 0.138 0.141 0.138 0.138
0.066 0.084 0.102 0.117 0.132 0.126 0.126 0.129 0.123 0.126
0.066 0.084 0.102 0.108 0.108 0.105 0.108 0.111 0.108 0.108
0.066 0.084 0.093 0.093 0.093 0.096 0.093 0.093 0.093 0.09
0.066 0.078 0.078 0.078 0.075 0.078 0.078 0.078 0.078 0.078
0.06 0.063 0.063 0.06 0.063 0.063 0.063 0.06 0.063 0.063
0.045 0.045 0.045 0.045 0.045 0.045 0.045 0.045 0.045 0.045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0.04
0.02
0
0.063 0.081 0.102 0.12 0.138 0.15 0.15 0.144 0.15 0.144
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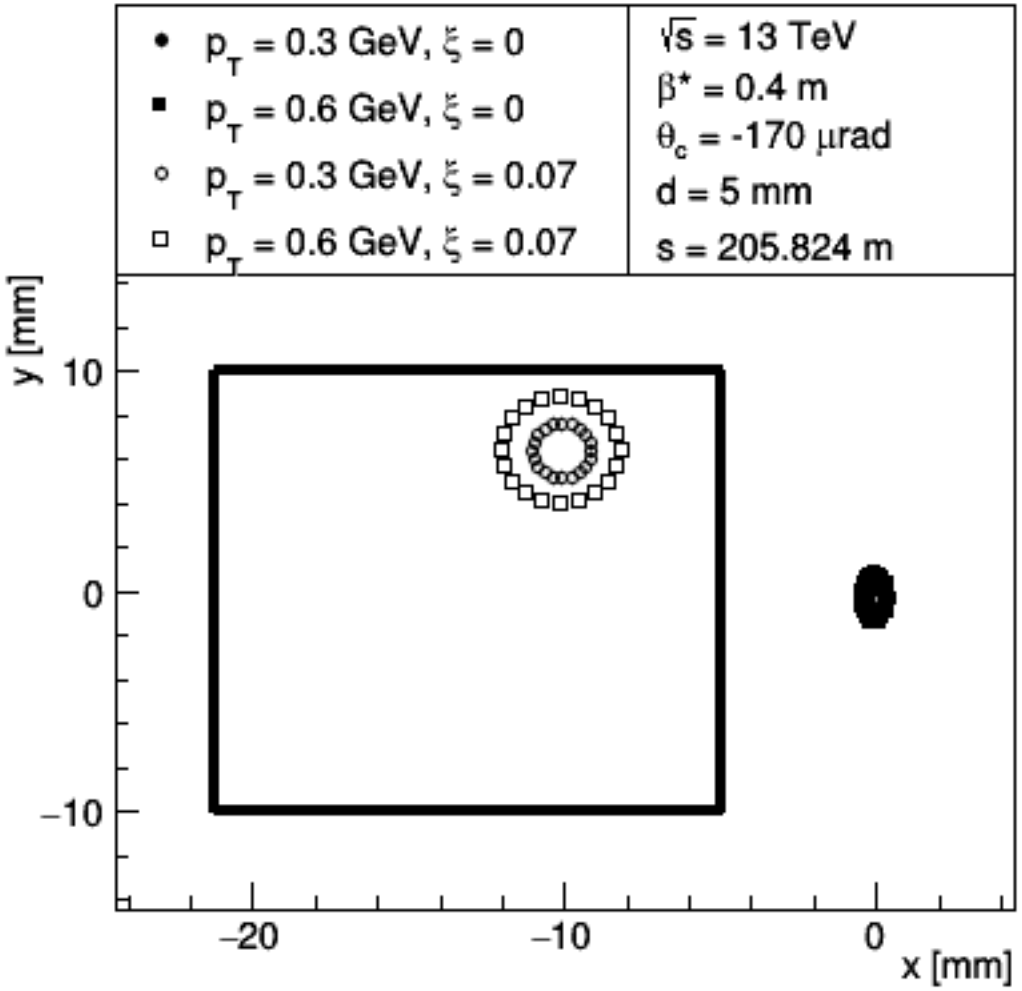
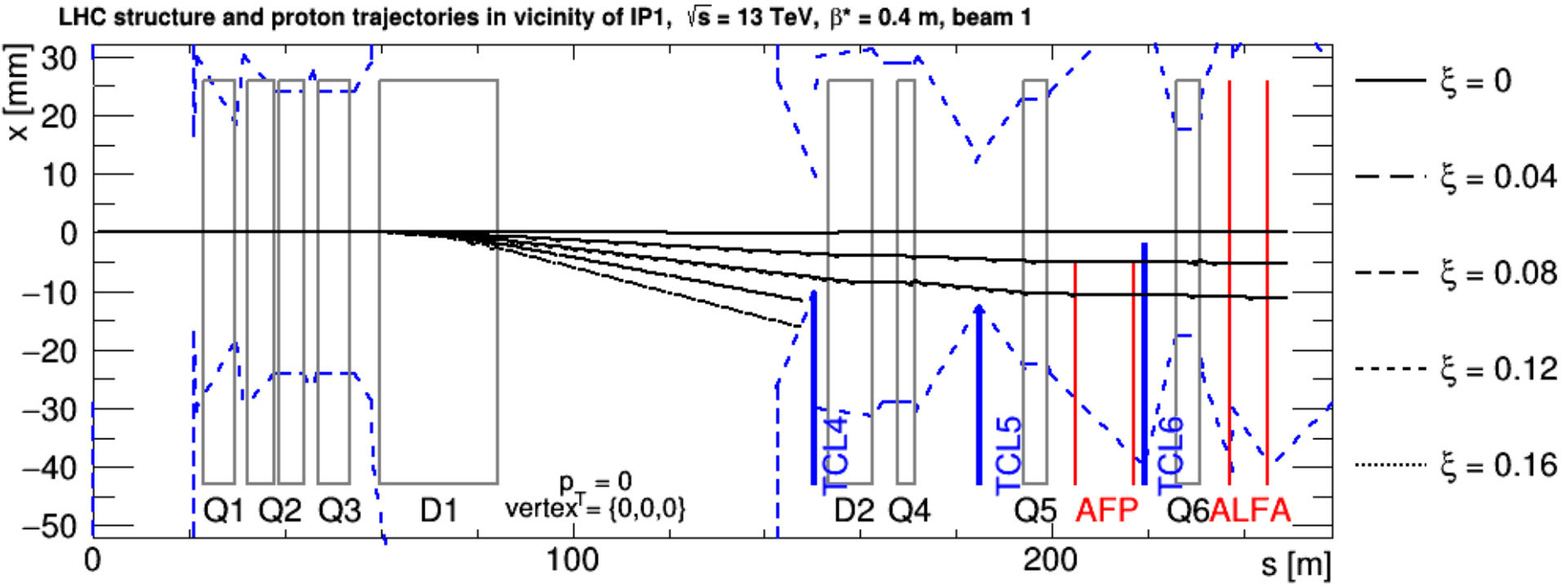
0.063 0.081 0.102 0.12 0.138 0.15 0.15 0.144 0.15 0.138
0.063 0.081 0.102 0.117 0.144 0.123 0.12 0.132 0.138 0.138
0.063 0.081 0.099 0.114 0.114 0.114 0.114 0.114 0.111 0.114
0.063 0.081 0.099 0.099 0.102 0.102 0.099 0.099 0.099 0.099
0.063 0.081 0.087 0.087 0.087 0.087 0.087 0.087 0.087 0.087
0.06 0.072 0.072 0.072 0.072 0.072 0.075 0.072 0.072 0.075
0.057 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06
0.045 0.045 0.045 0.045 0.045 0.045 0.045 0.045 0.045 0.045

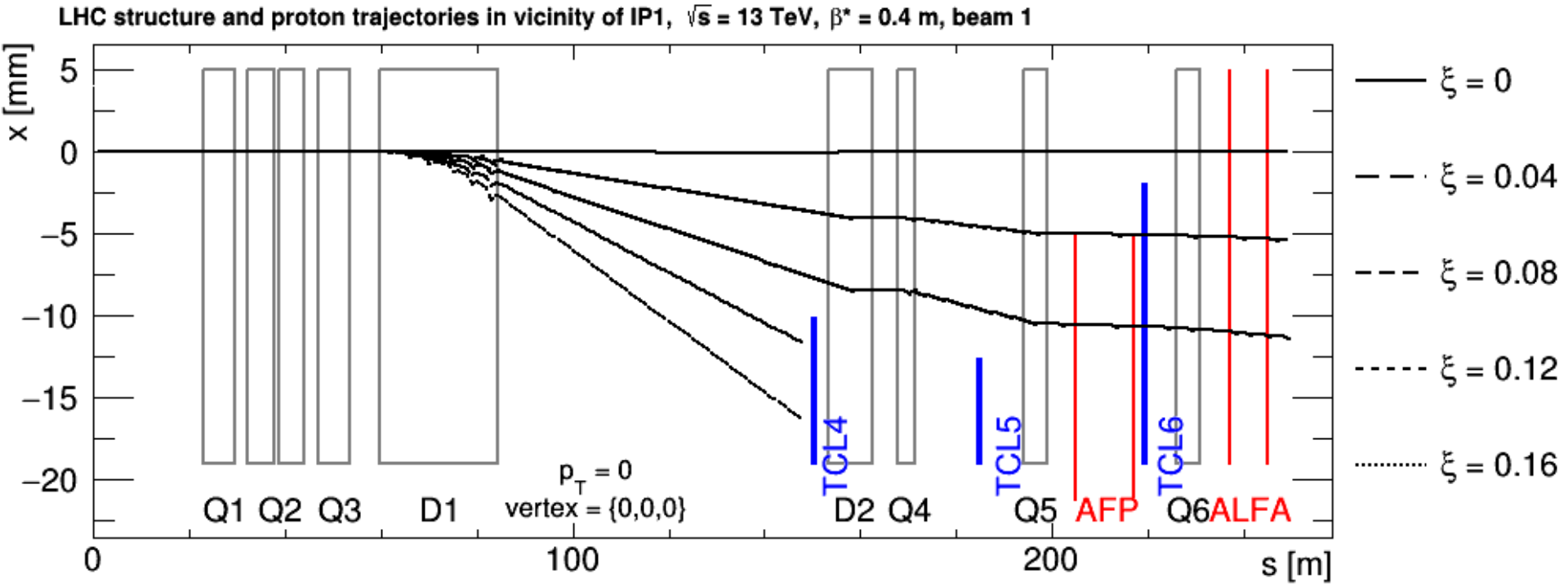
# example.ProtonPositions()



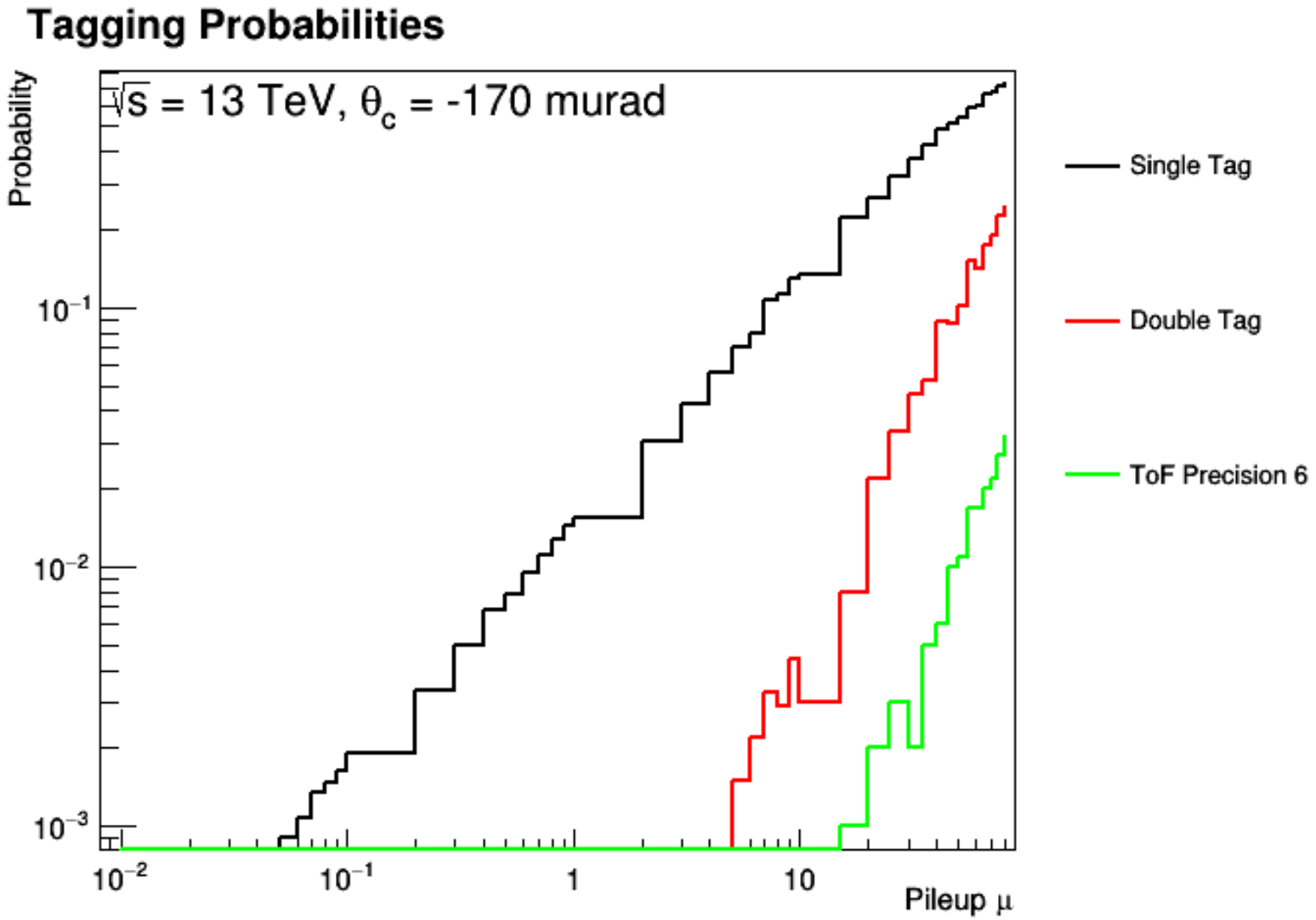
# example.TrajectoryExamples(true)



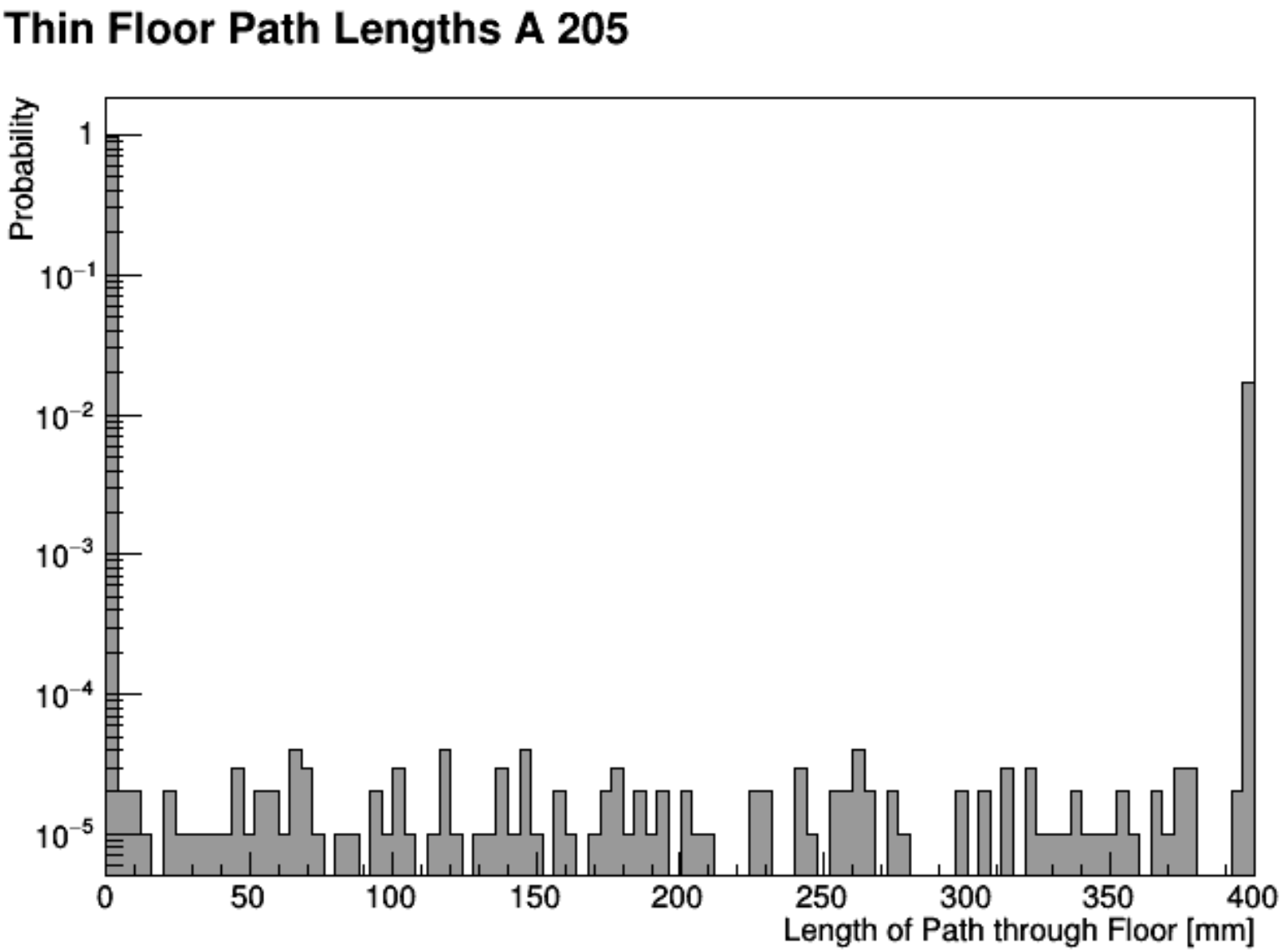
# example.TrajectoryExamples(false)

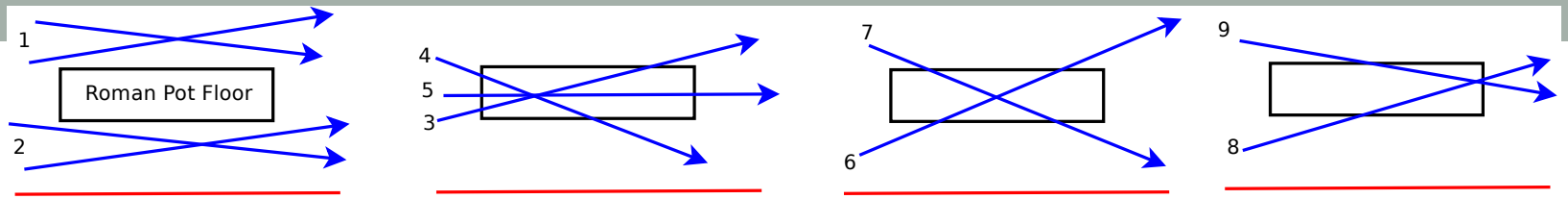


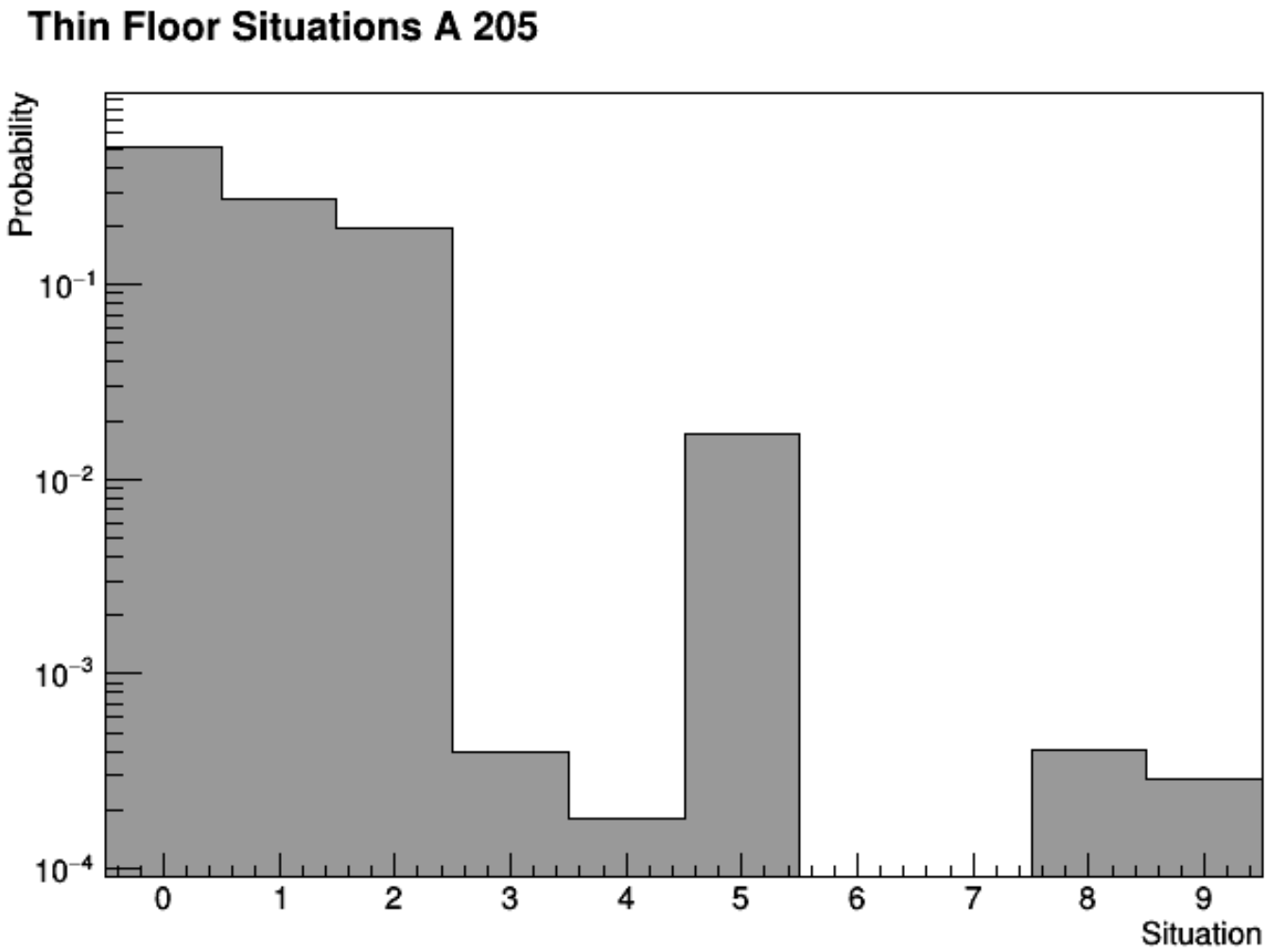
# example.TagTimeProbabilities()



example.FloorLengthProbabilities()




1
Roman Pot Floor
2
4
5
3
7
6
9
8
Beam line
0: Out of Aperture
*Not to Scale


Thin Floor Situations A 205
Probability
$10^{-1}$
$10^{-2}$
$10^{-3}$
$10^{-4}$
0
1
2
3
4
5
6
7
8
9
Situation

# Parameterization

```
example.FindParameterisation(false);
```

- Calculates coefficients for polynomials of multiple different degrees
- Header generated in the same style as other programs
- User can either:
  - choose degrees of polynomials

```
example.PrintSpecificParameterisation(degrees);
example.ValidateSpecificParameterisation(degrees);
```

  - run a method that tests each degree option against the simulation and chooses the best performing option

```
example.ValidateDegrees();
example.PrintPreciseParameterisation();
example.ValidatePreciseParameterisation();
```

# Conclusion

- After library is compiled, can use interface class in another program.
- Structure allows for easy incorporation of new methods

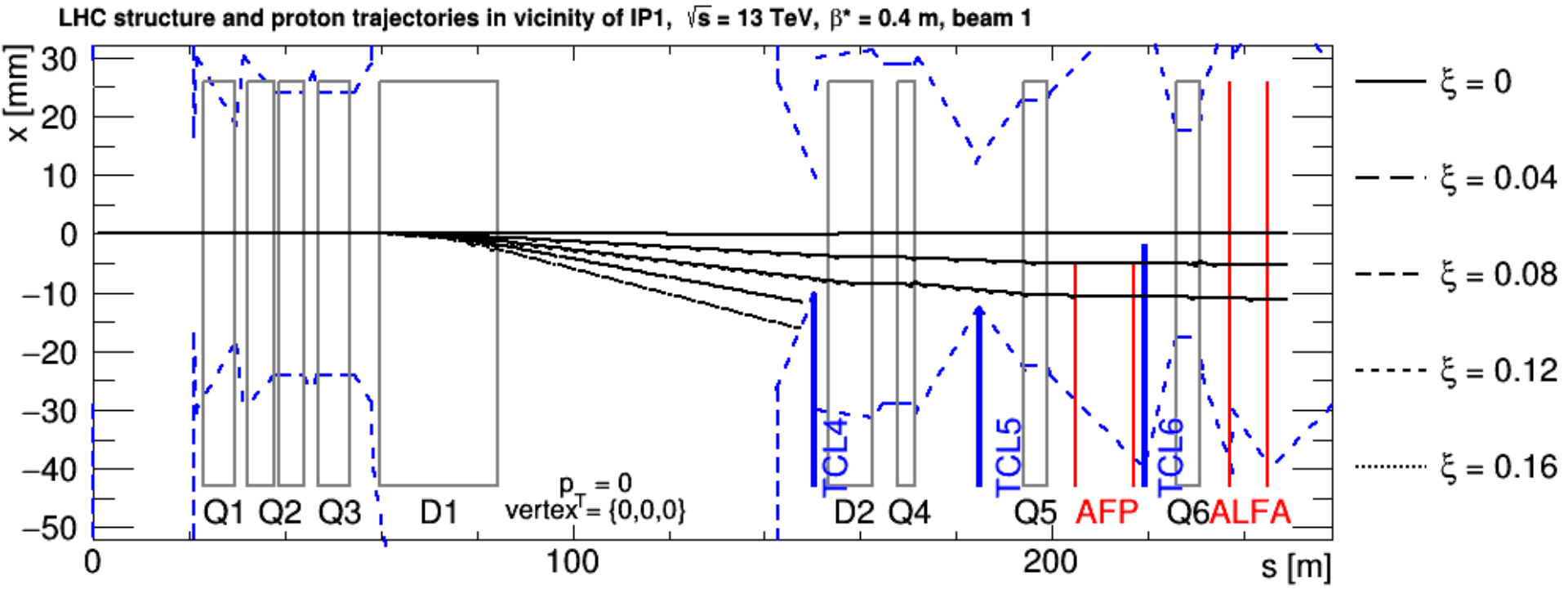
Questions?

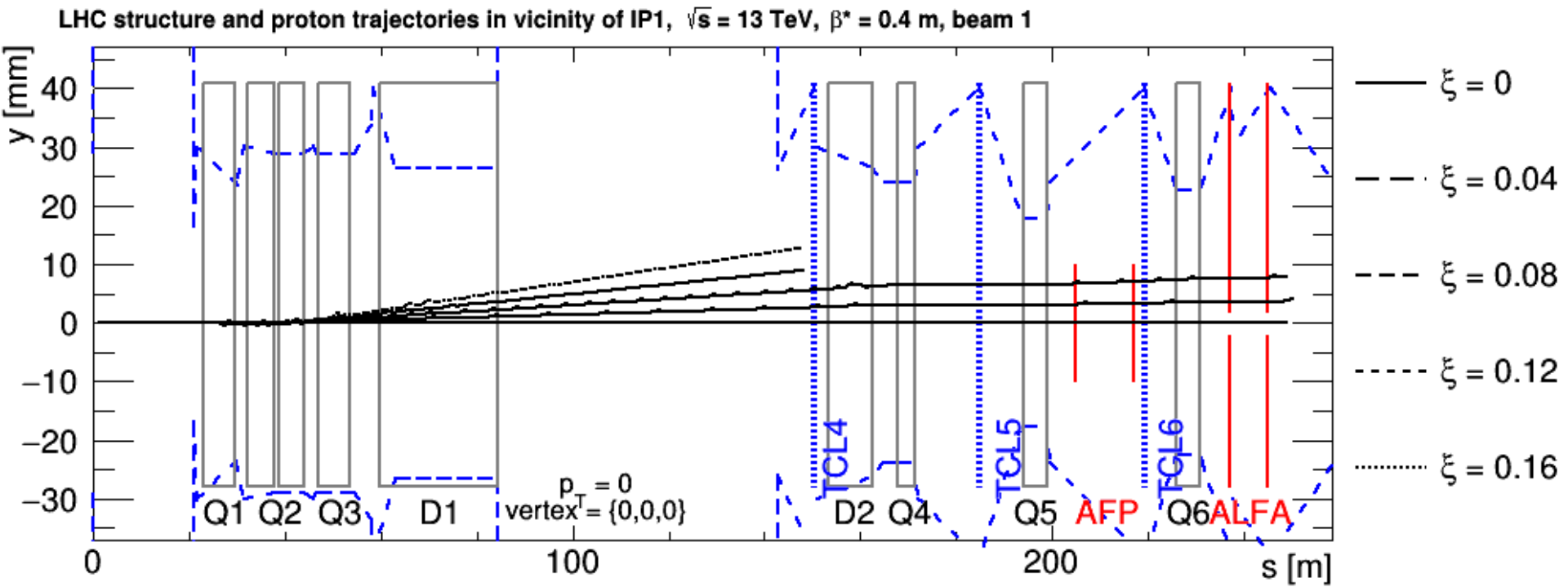
# Code Structure

- Separates details into several different classes:
  - OpticsStudy: interface class
  - AFPStation: stores details on AFP detectors
  - OpticsMode: stores details on beam settings
  - Simulator: runs simulations using FPTracker
  - WriteTwiss: generates twiss files from MAD-X files
  - canvases/*: prints simulated data in specific method
  - parameterisation/*: determines and stores transport parameterization
  - simulationparameters/*: stores details of how simulations should be run

# System Requirements

- All root libraries
  - Written using root v6.08/06
- Boost libraries:
  - boost_program_options, boost_filesystem, boost_system
- Compiler with C++ 11 as possible standard
- Compiled version of FPTracker
- MAD-X executable


LHC structure and proton trajectories in vicinity of IP1, √s = 13 TeV, β* = 0.4 m, beam 1
x [mm]
30
20
10
0
−10
−20
−30
−40
−50
0
100
200
s [m]
Q1
Q2
Q3
D1
D2
Q4
Q5
AFP
Q6
ALFA
TCL4
TCL5
TCL6
p_T = 0
vertex = {0,0,0}
ξ = 0
ξ = 0.04
ξ = 0.08
ξ = 0.12
ξ = 0.16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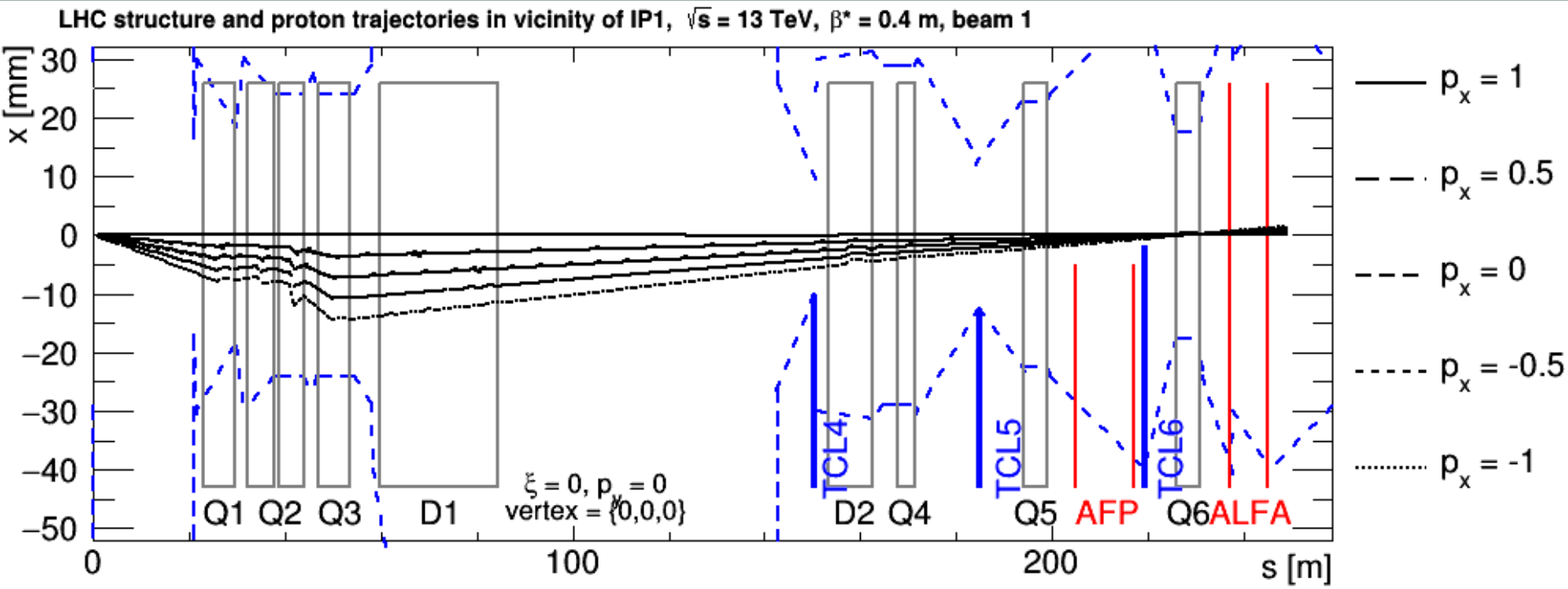
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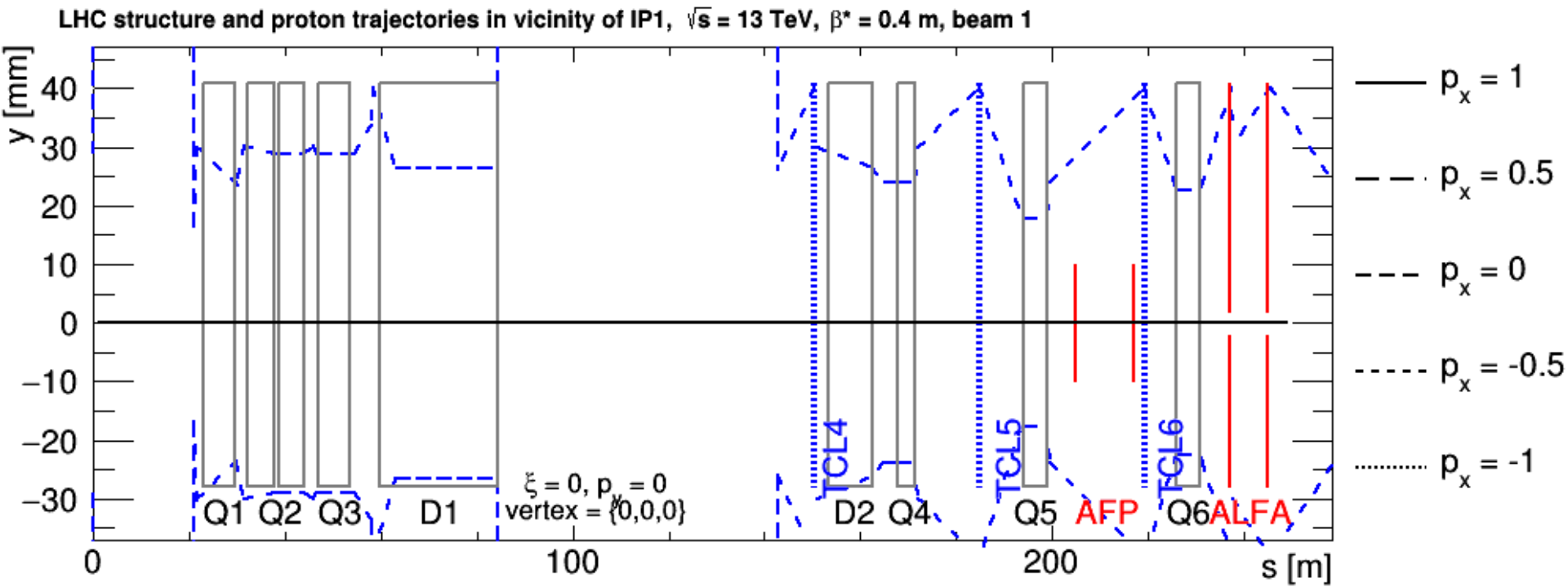
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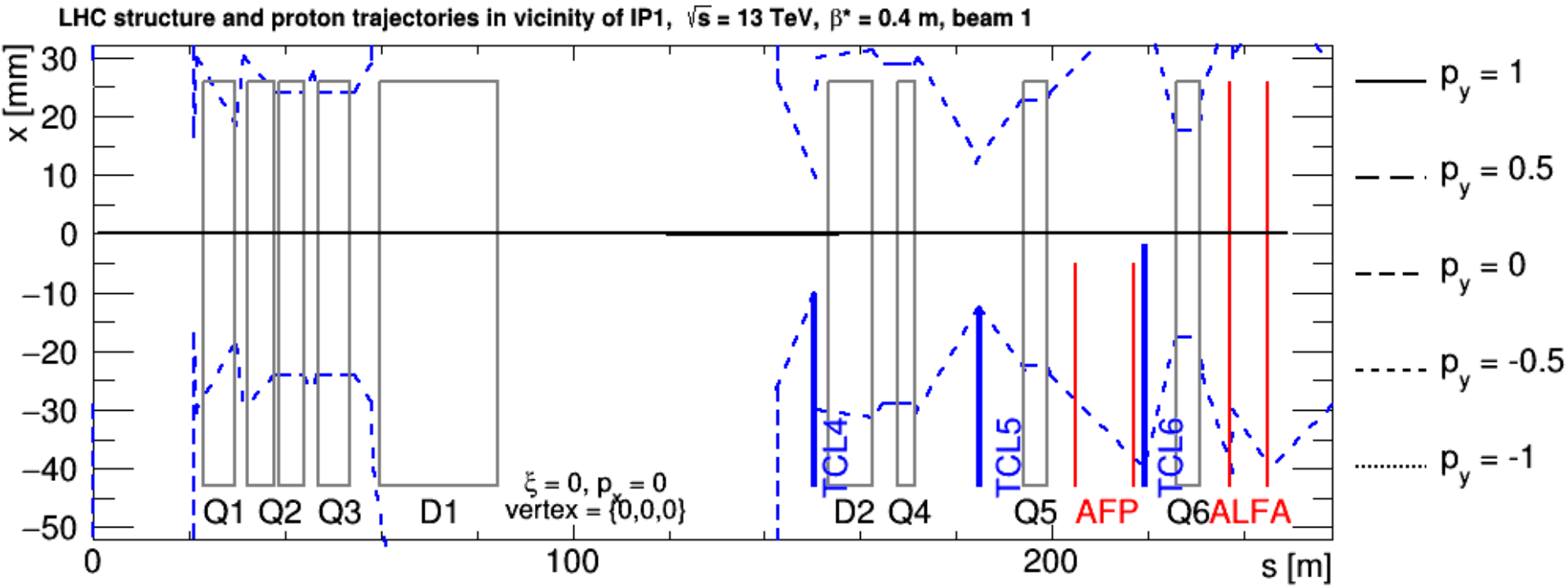
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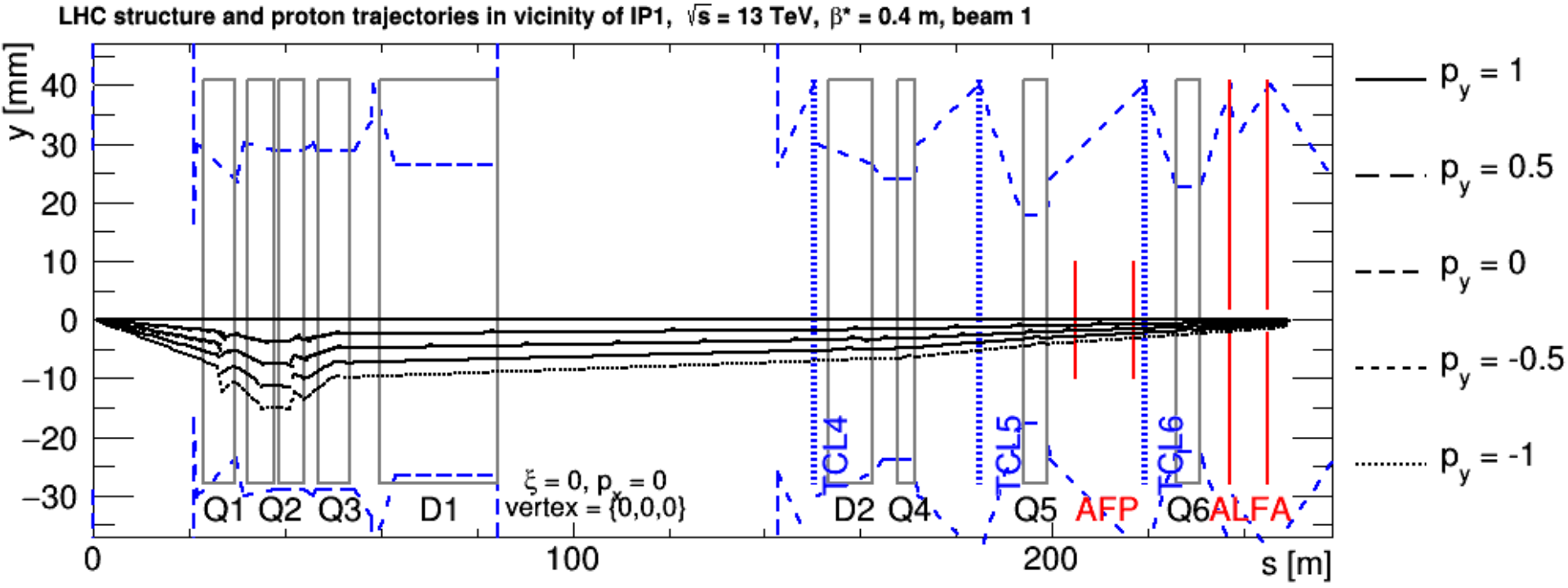
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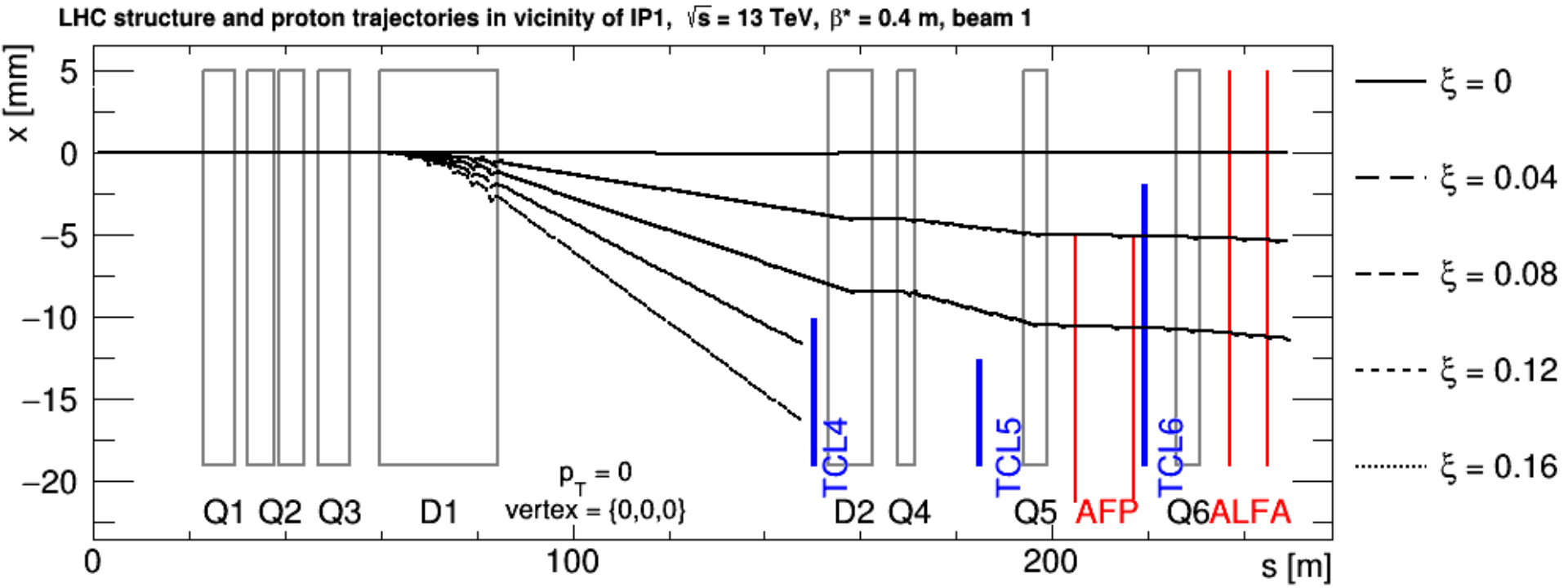
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x [mm]
5
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200
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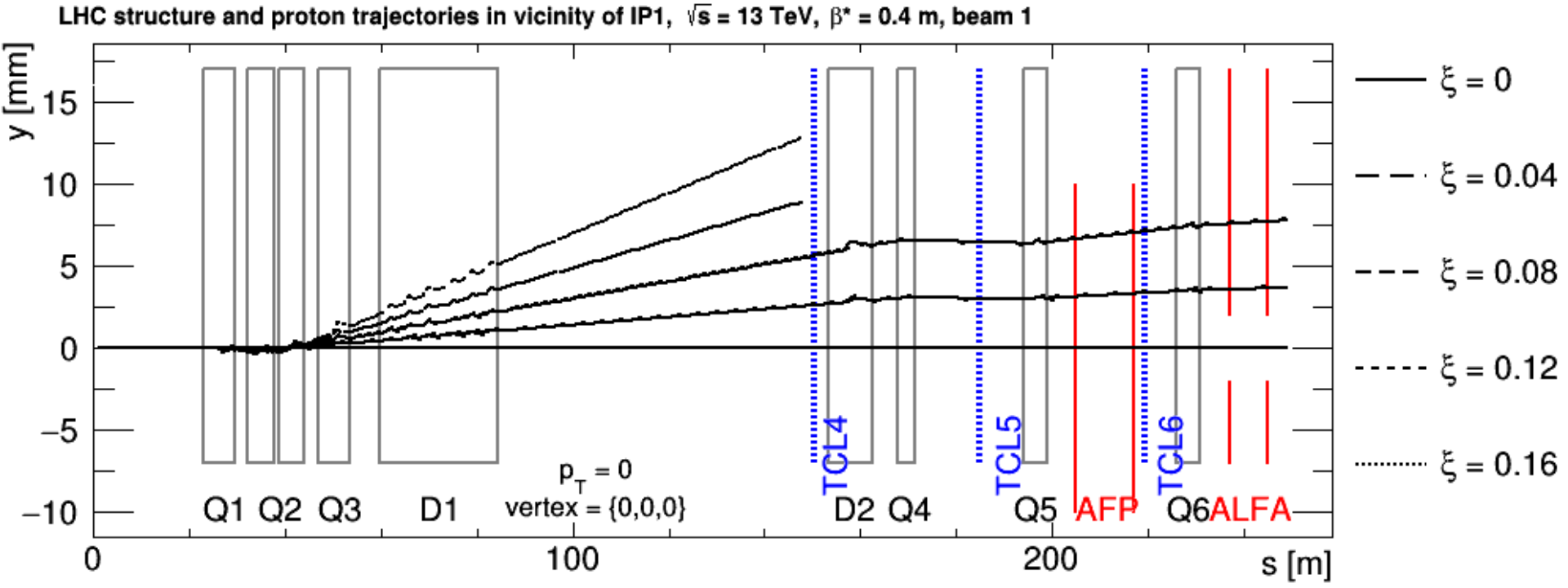
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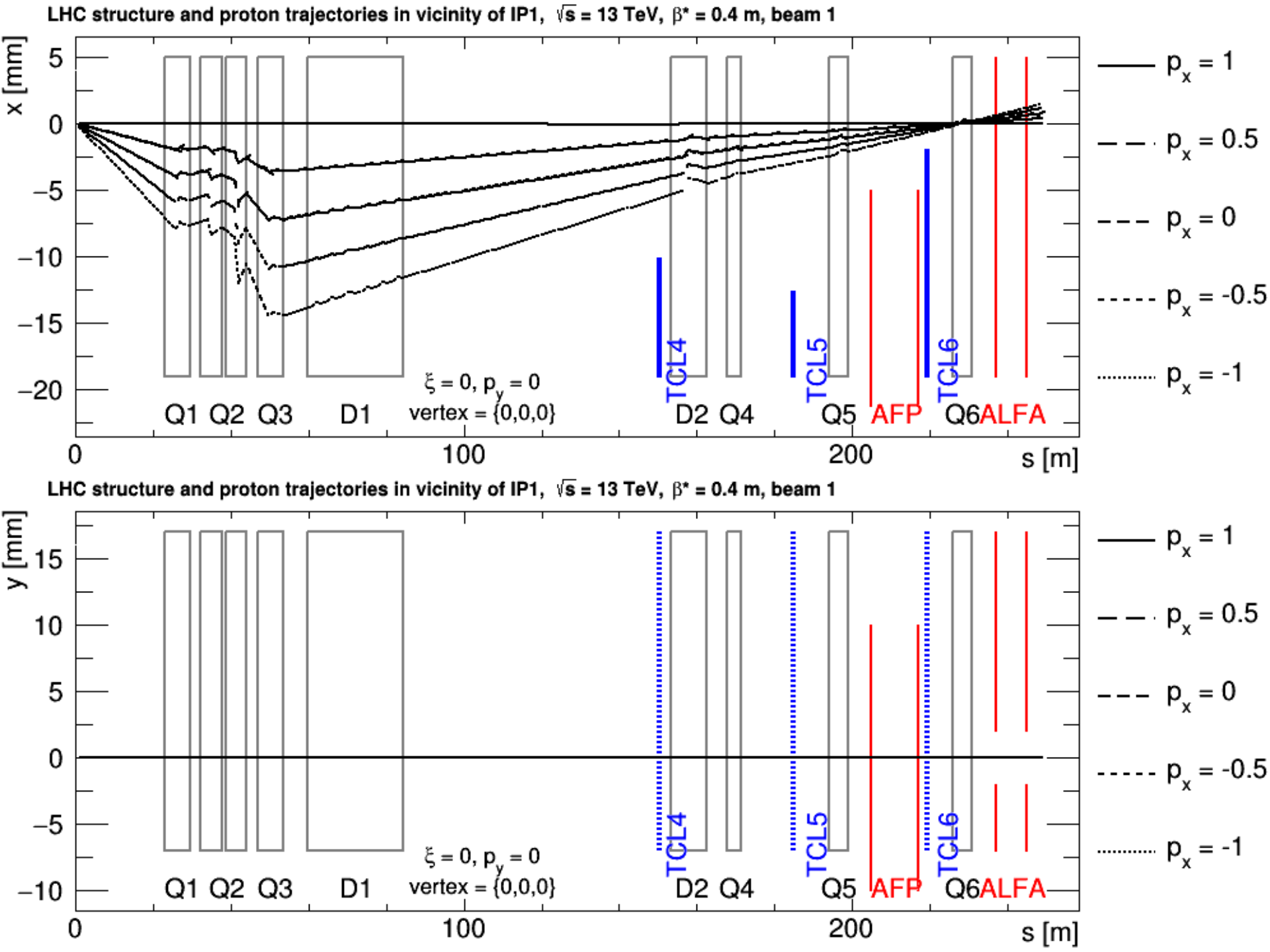
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200
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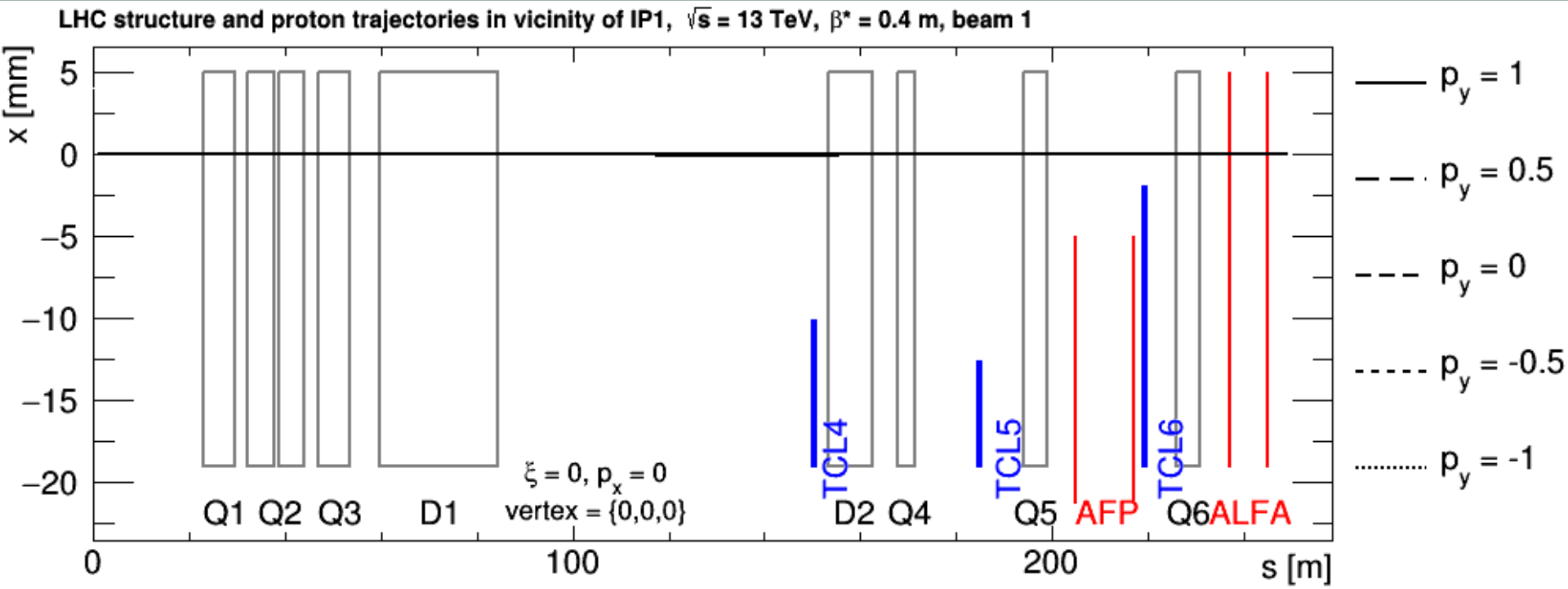
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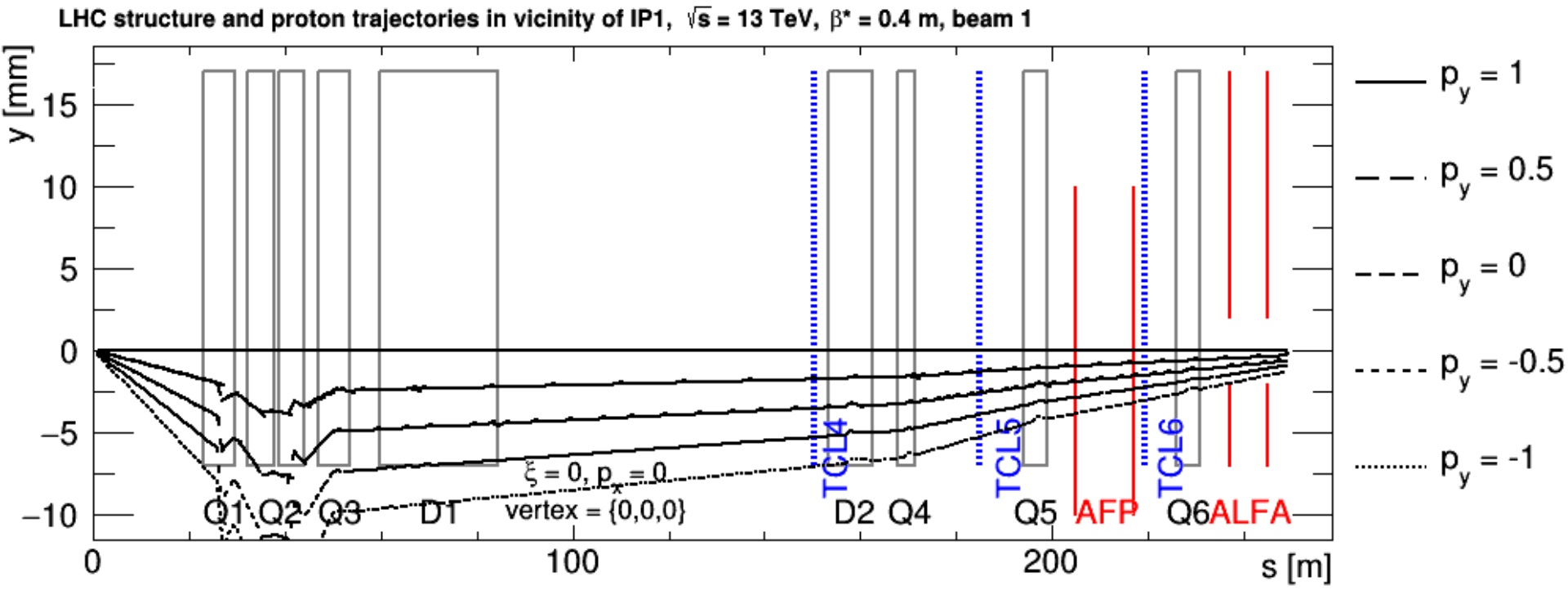
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