Measurement of beam induced background in USC

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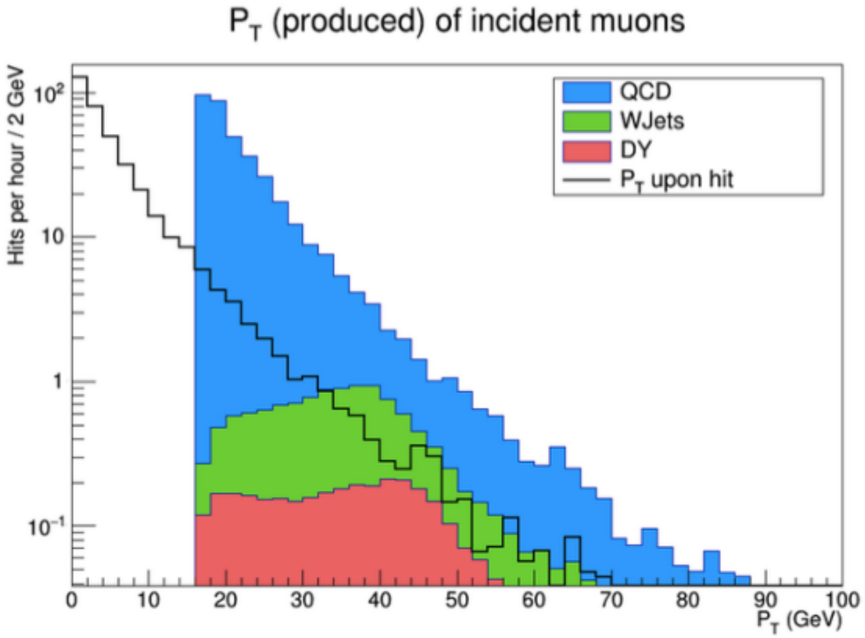
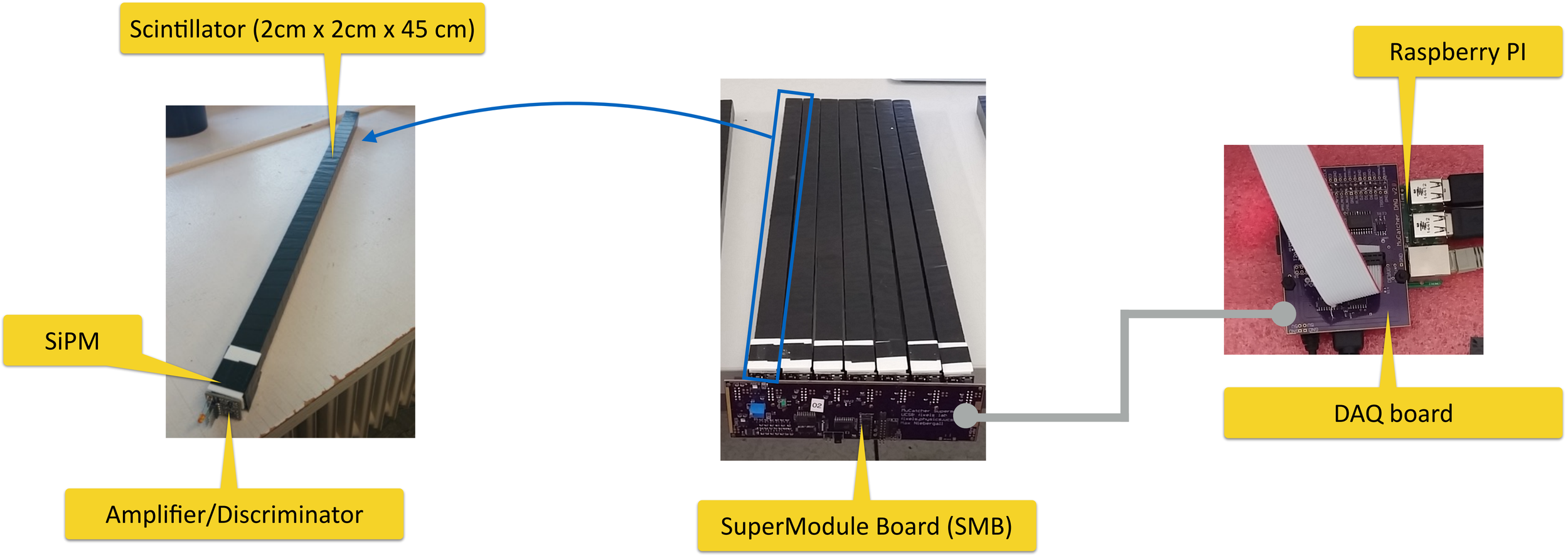
Introduction

- From [simulation by Frank Golf et. al.](), the major beam-induced background is muons from QCD
- Small enough to be not a problem as a background or dead time
- Since QCD is not generally well-modeled, validation in data is necessary
- We measured the beam-induced background in USC at Point 5 using a hodoscope made with long scintillator bars
- Compared the measured background level with the simulation



	Rate (hits/sec)
QCD	0.114
WJets	0.0025
DY	0.00092
Total	0.118

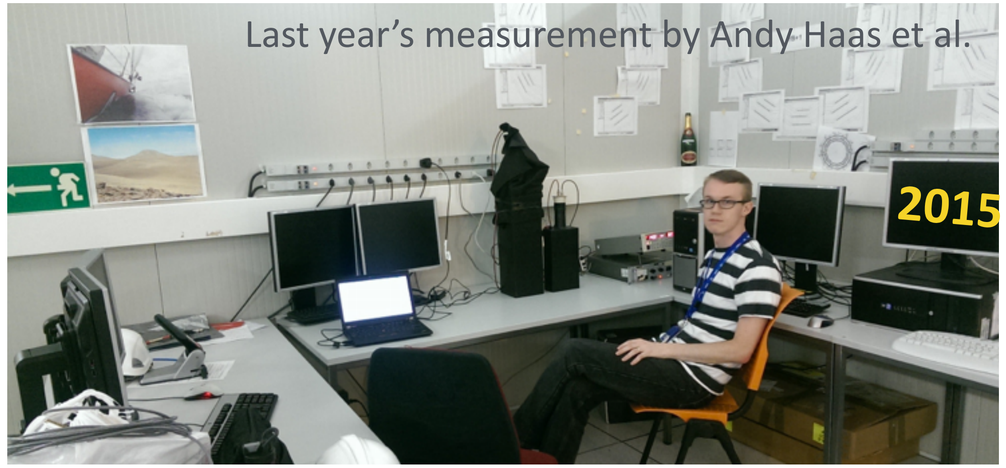
Detector (hodoscope) components

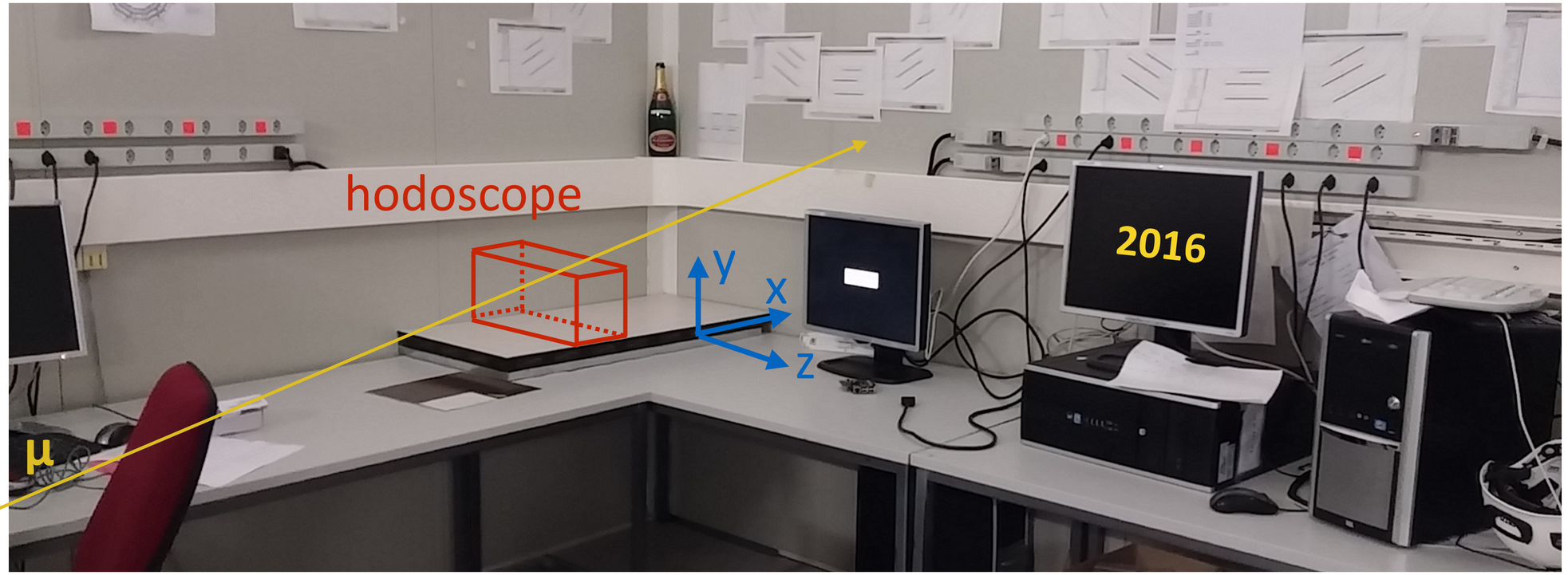


Location of detector

- Measurements in USC at Point 5
- Same place where last year's measurement was made

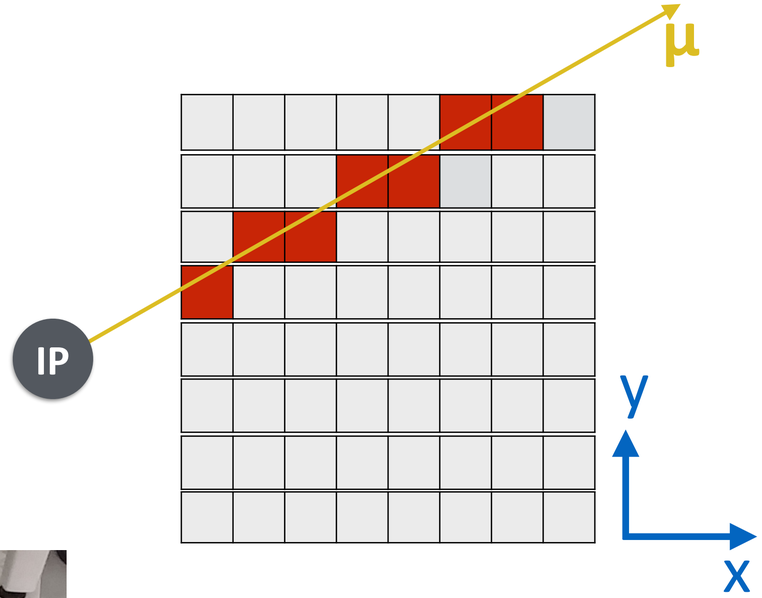
https://indico.cern.ch/event/443535/contributions/1104061/attachments/1167692/1684120/MilliQan_Workshop_CERNtests_10-8-2015.pdf

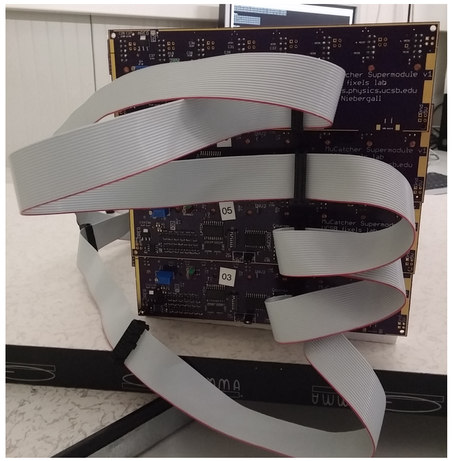


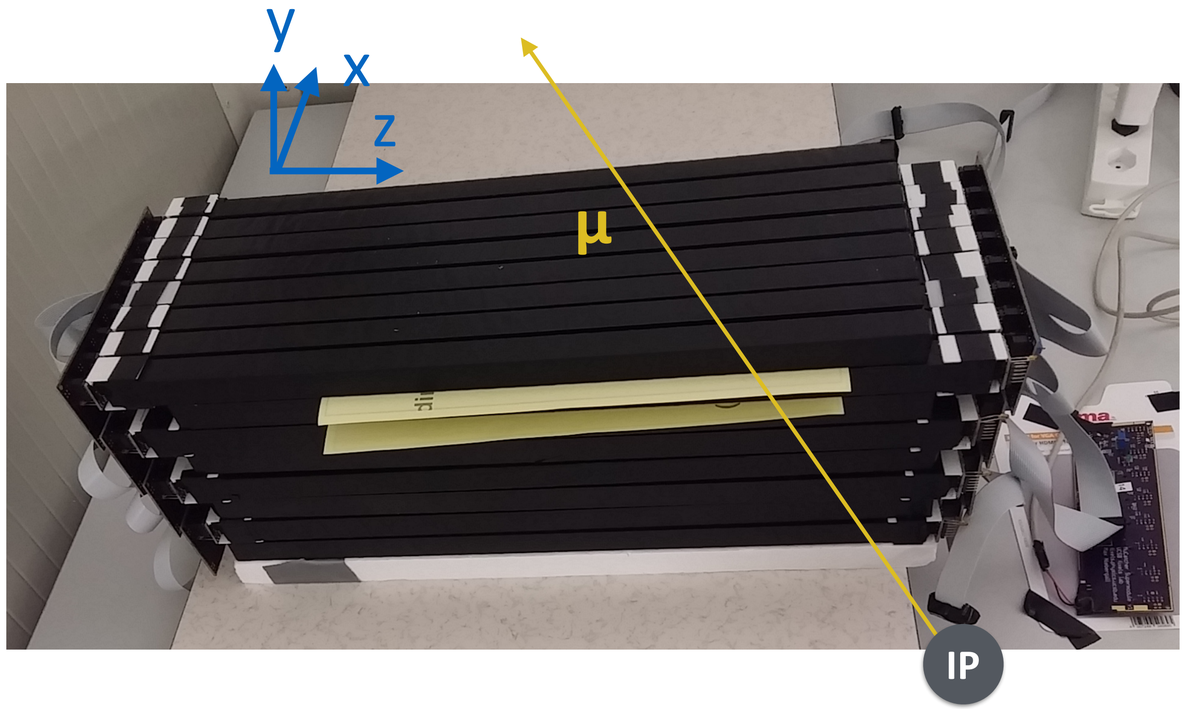


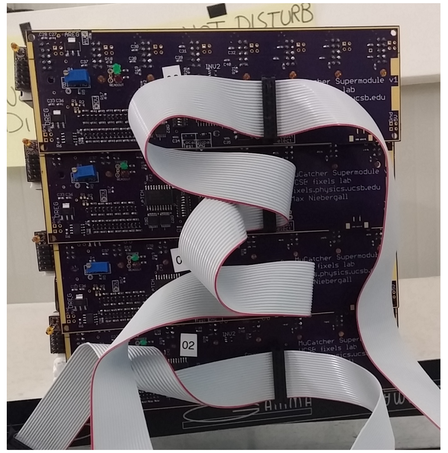
Hodoscope configuration 1

- Configuration 1: stack 8 units on one another
- Provides x/y angle (ϕ) measurement

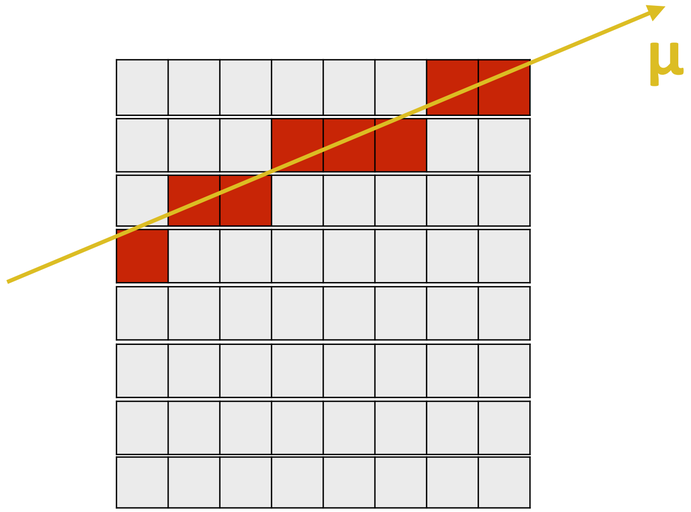




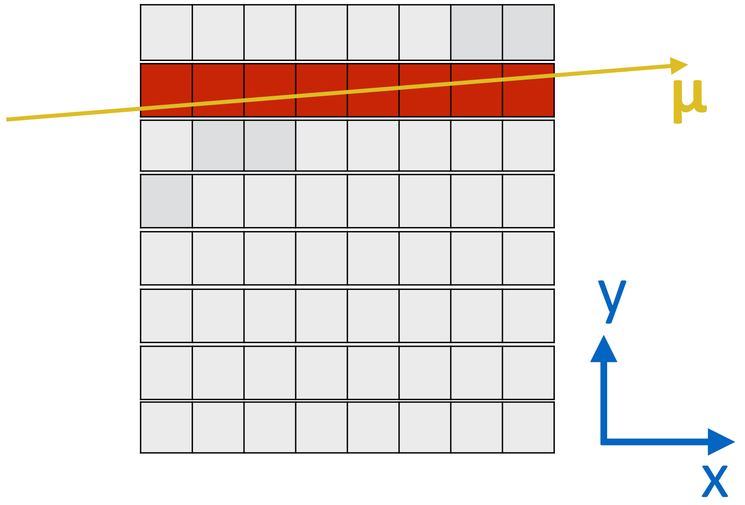




Trigger algorithm



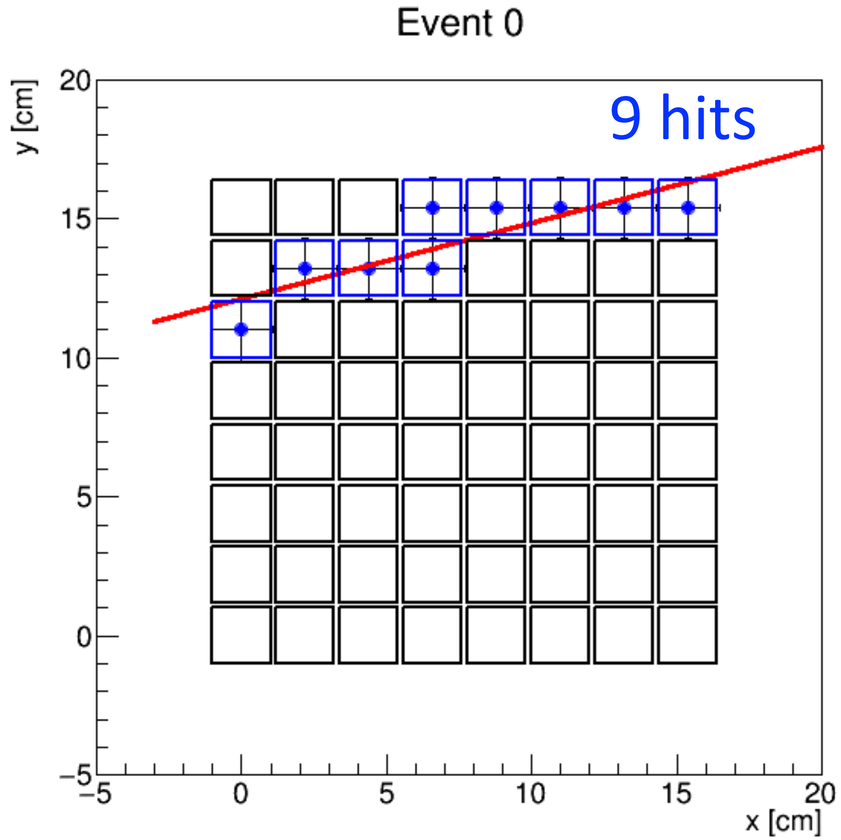
OR



At least two layers with at least one hit

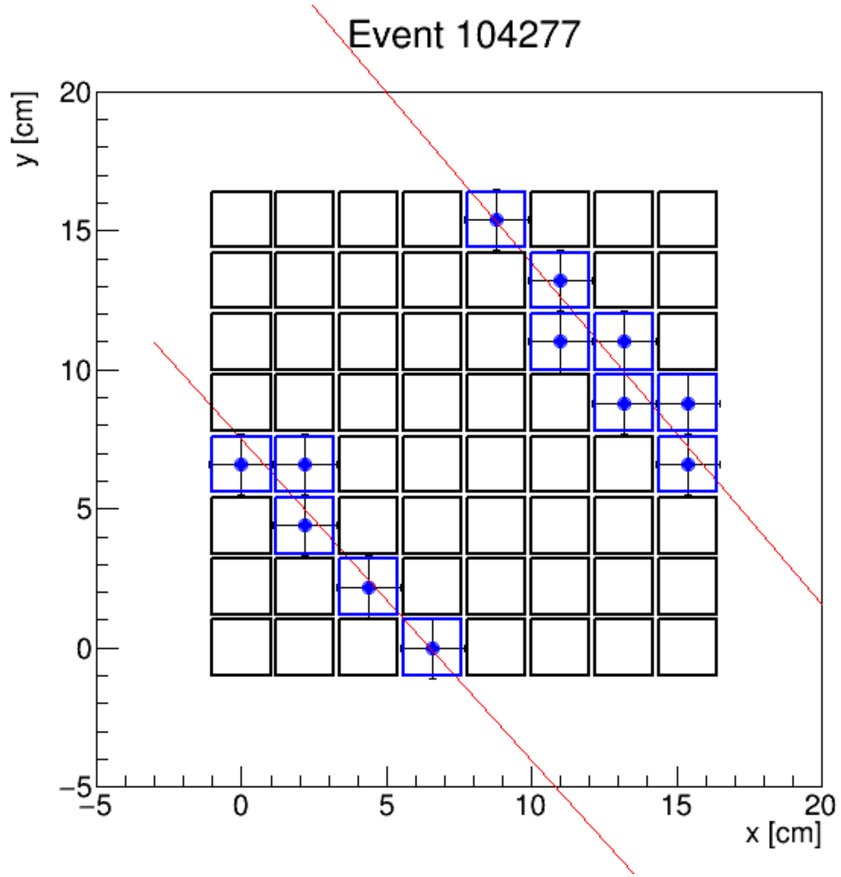
At least one layer with at least one hit
This is to capture horizontal tracks
Prescaled, but prescale=1 is used

Tracking algorithm



- χ^2 fit with a straight line
- Iterative: start with 8 hits and try until 4

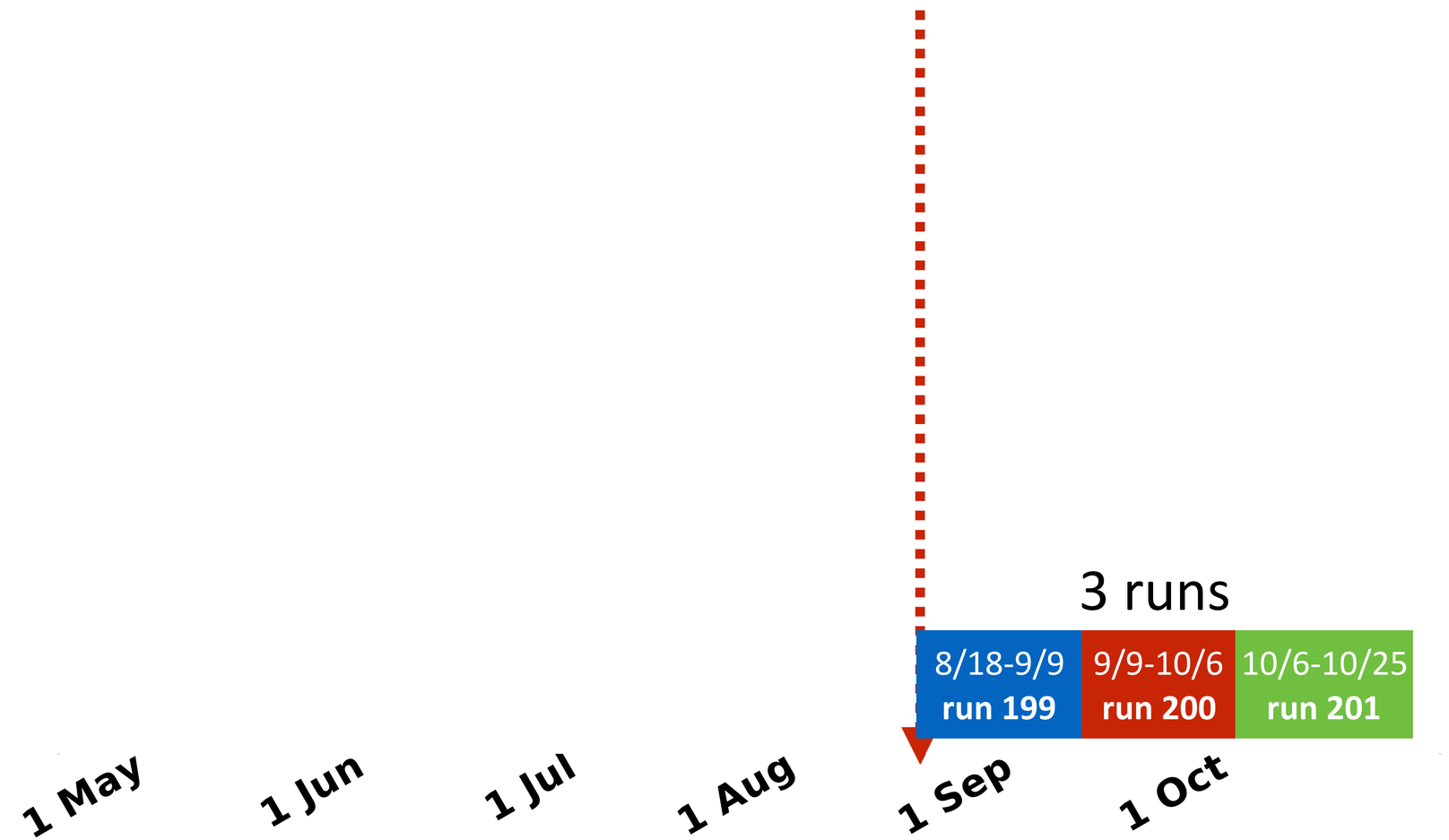
Tracking algorithm



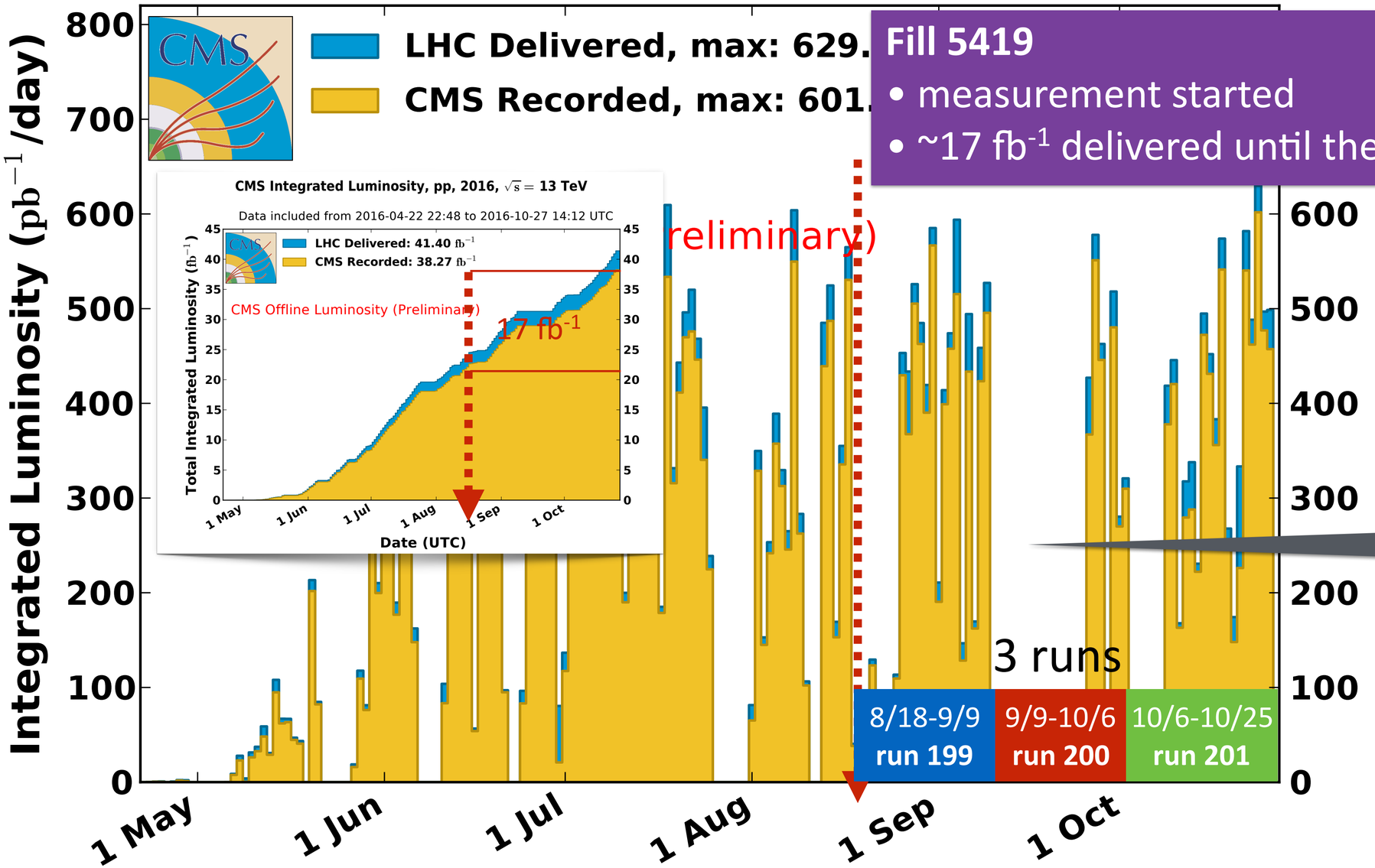
- χ^2 fit with a straight line
- Iterative: start with 8 hits and try until 4
- There are cases with more than one track
- Ratio of single-track to multiple-track events is 50:1
  - small impact on our measurement

Data-taking: period

Fill 5419
- measurement started



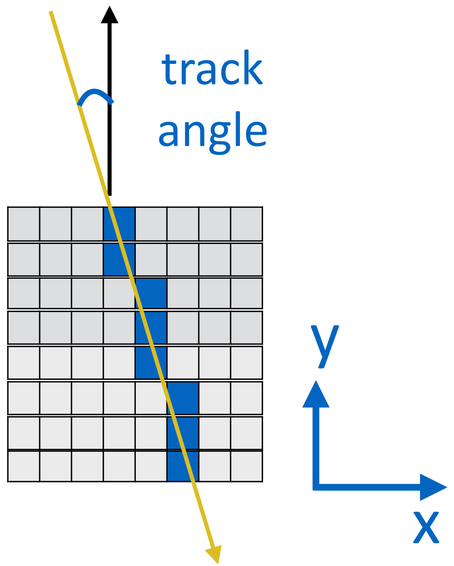
Data-taking: beam condition

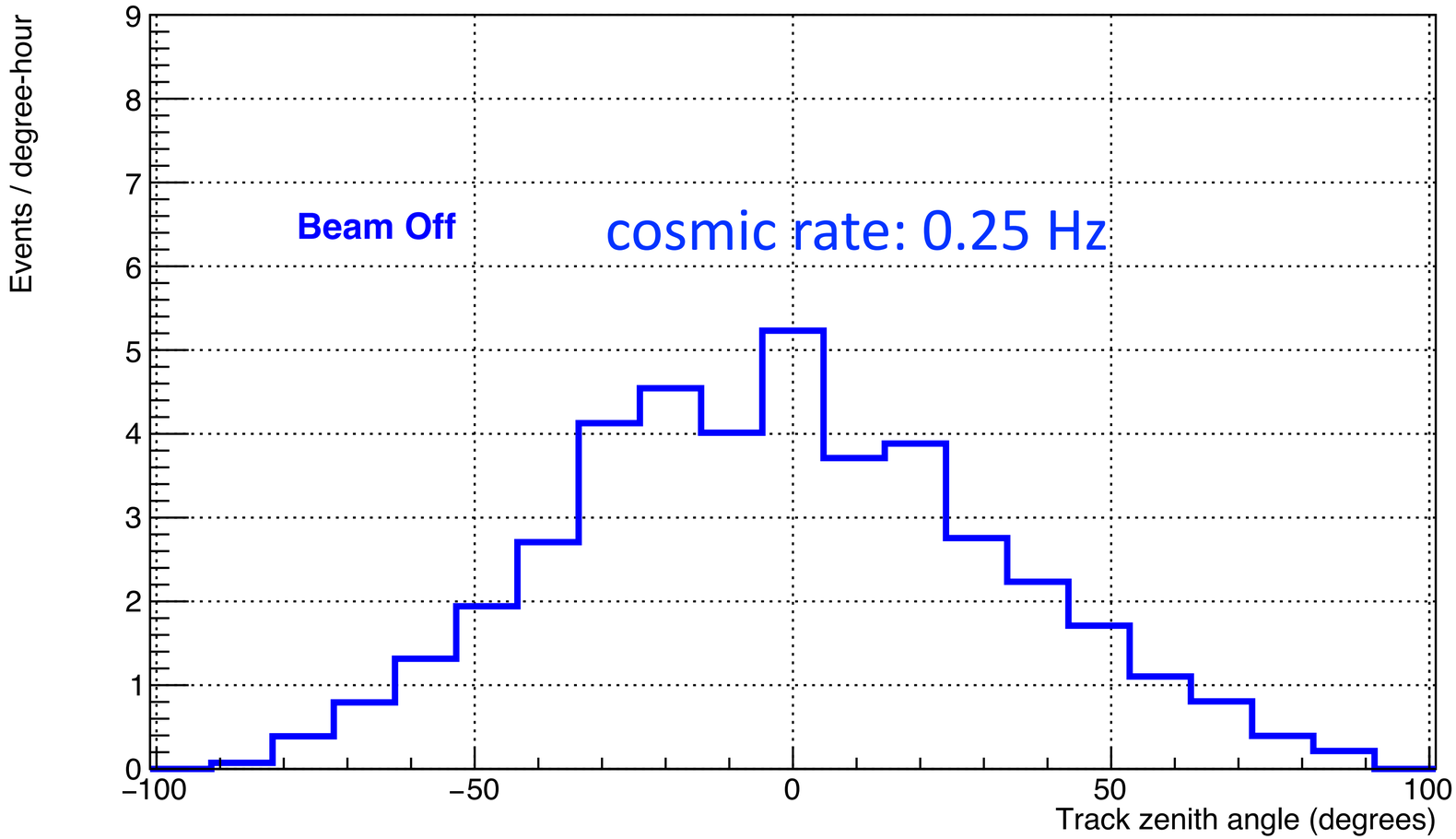


Fill 5419
- measurement started
- ~17 fb^{-1} delivered until the end of pp run

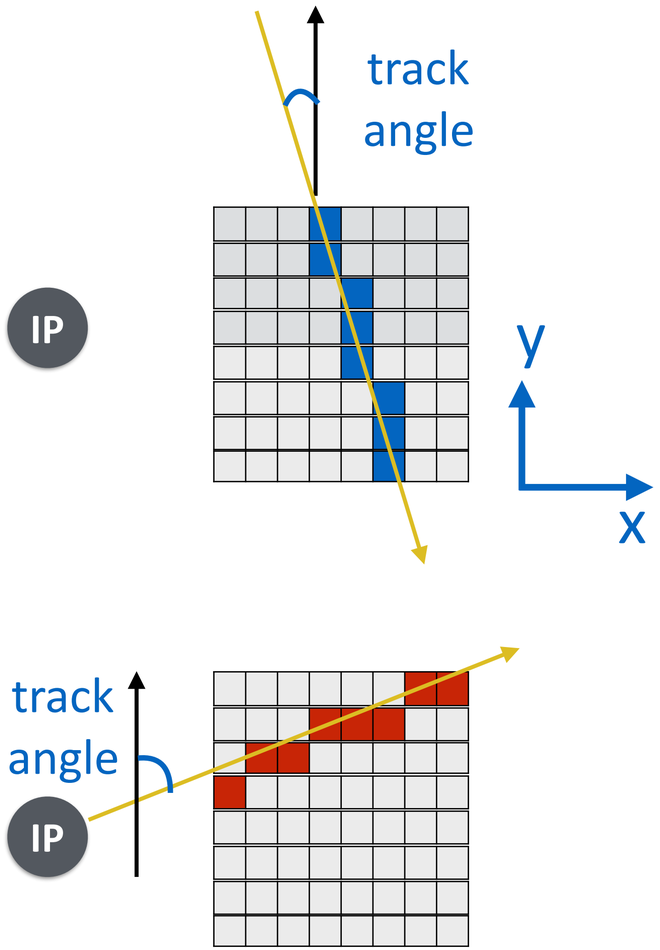
There are beam-off periods: used to estimate non beam-induced background

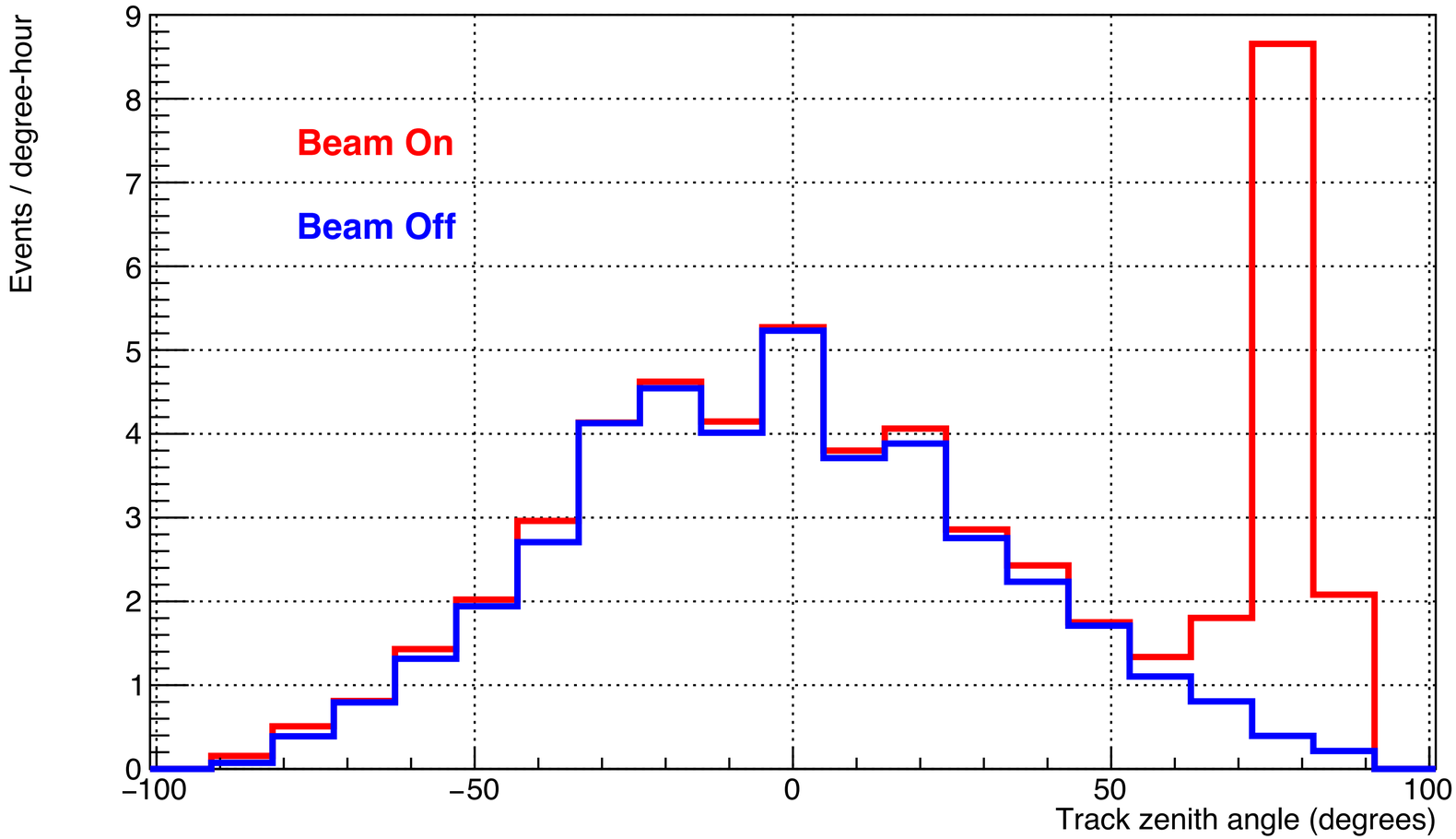
Track angle


track
angle
IP
y
x

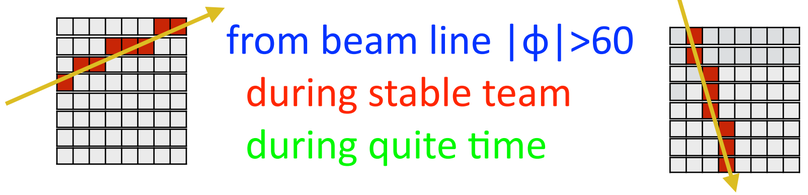

Events / degree-hour
Beam Off
cosmic rate: 0.25 Hz
Track zenith angle (degrees)
0
1
2
3
4
5
6
7
8
9
−100
−50
0
50
100

Track angle


track
angle
IP
y
x
track
angle
IP

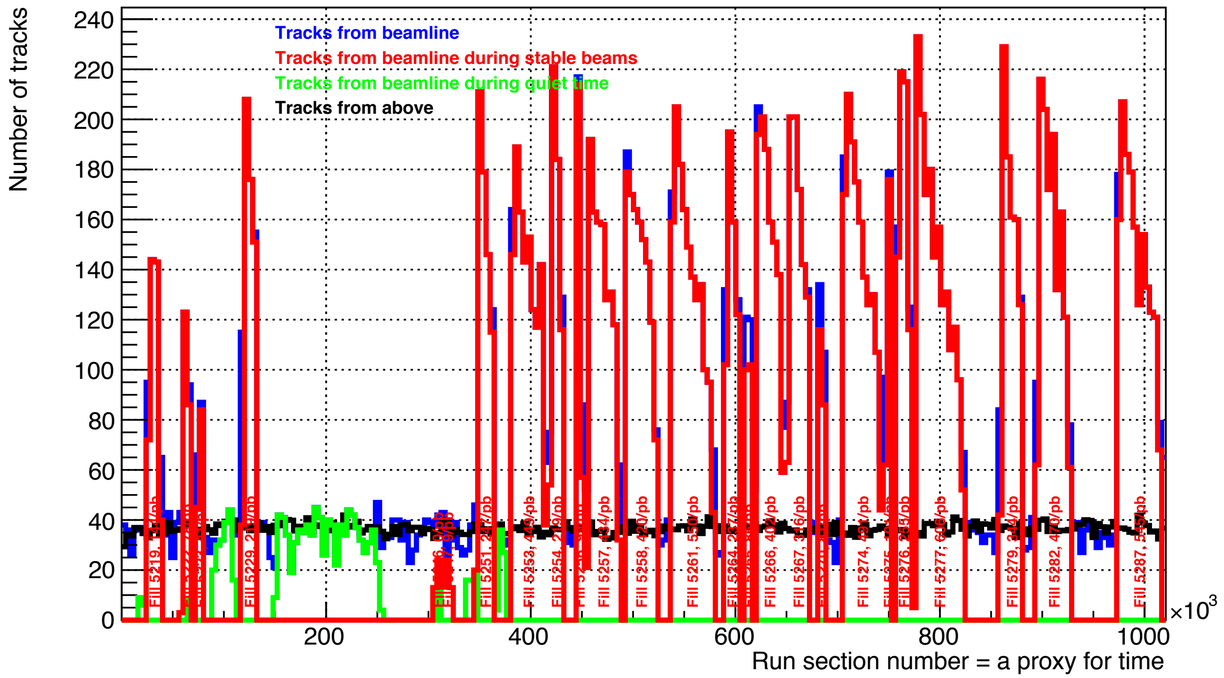

Events / degree-hour
Beam On
Beam Off
Track zenith angle (degrees)
0
1
2
3
4
5
6
7
8
9
−100
−50
0
50
100

Number of tracks vs time/angle

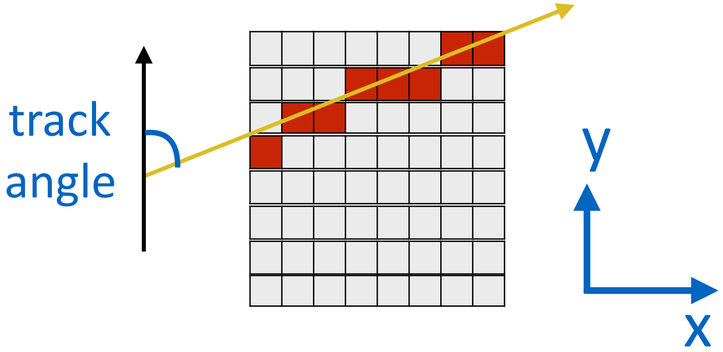


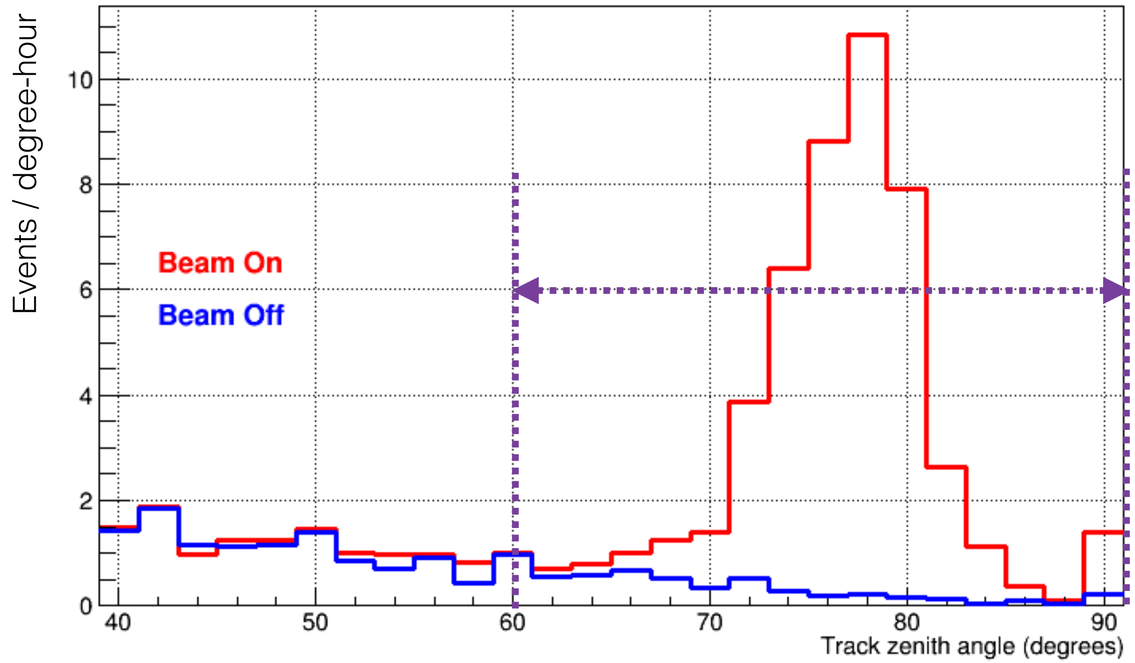
from beam line |ϕ|>60
during stable team
during quite time

from above: |ϕ|<40



Aug 18

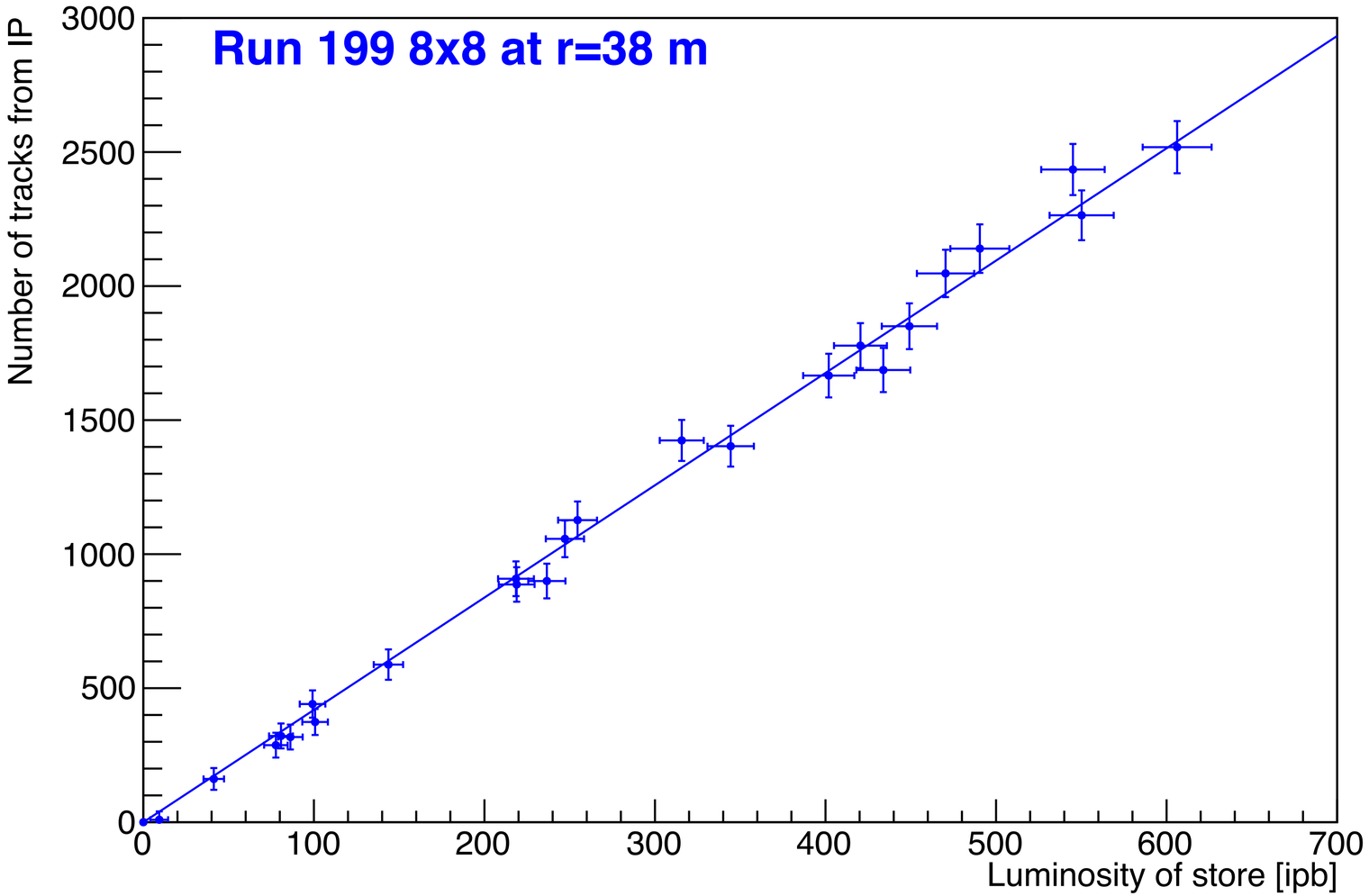




Sep 9

$N_{excess} = N_{beam\ on} - N_{beam\ off}$

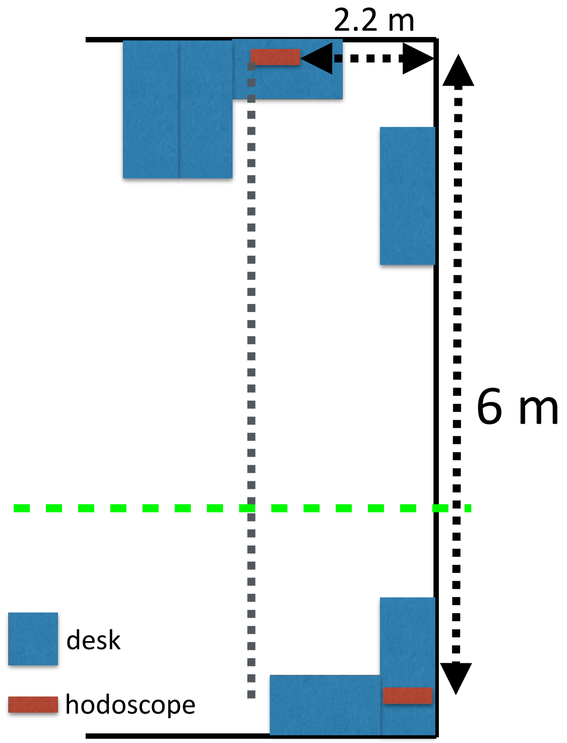
Number of tracks vs Luminosity

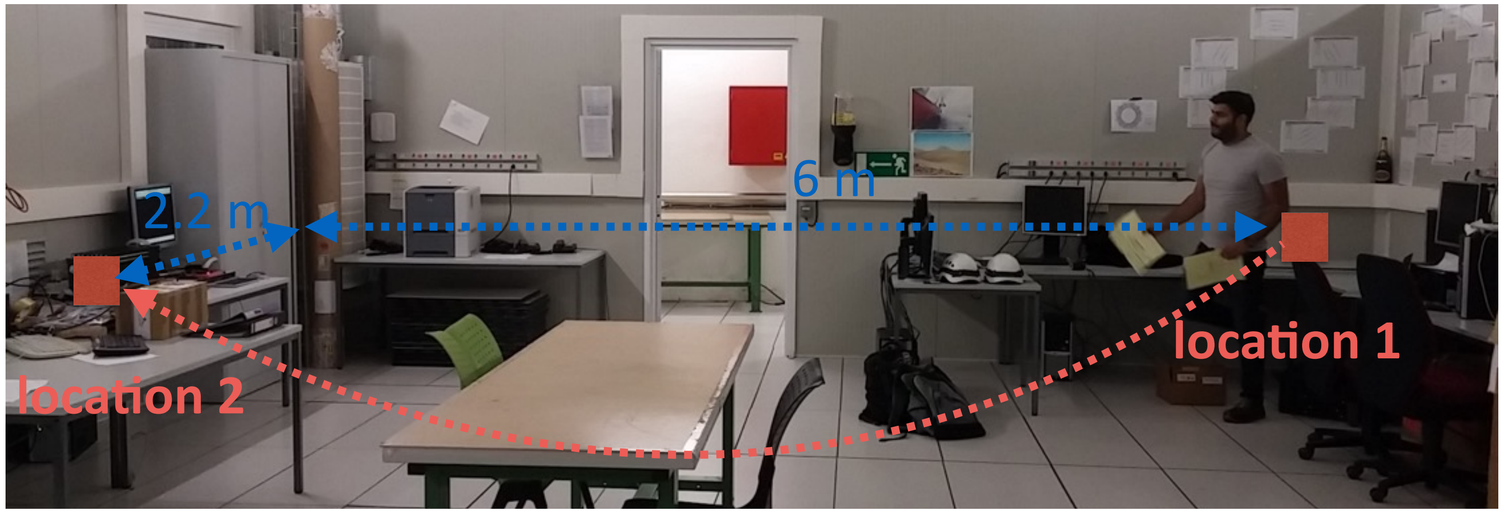


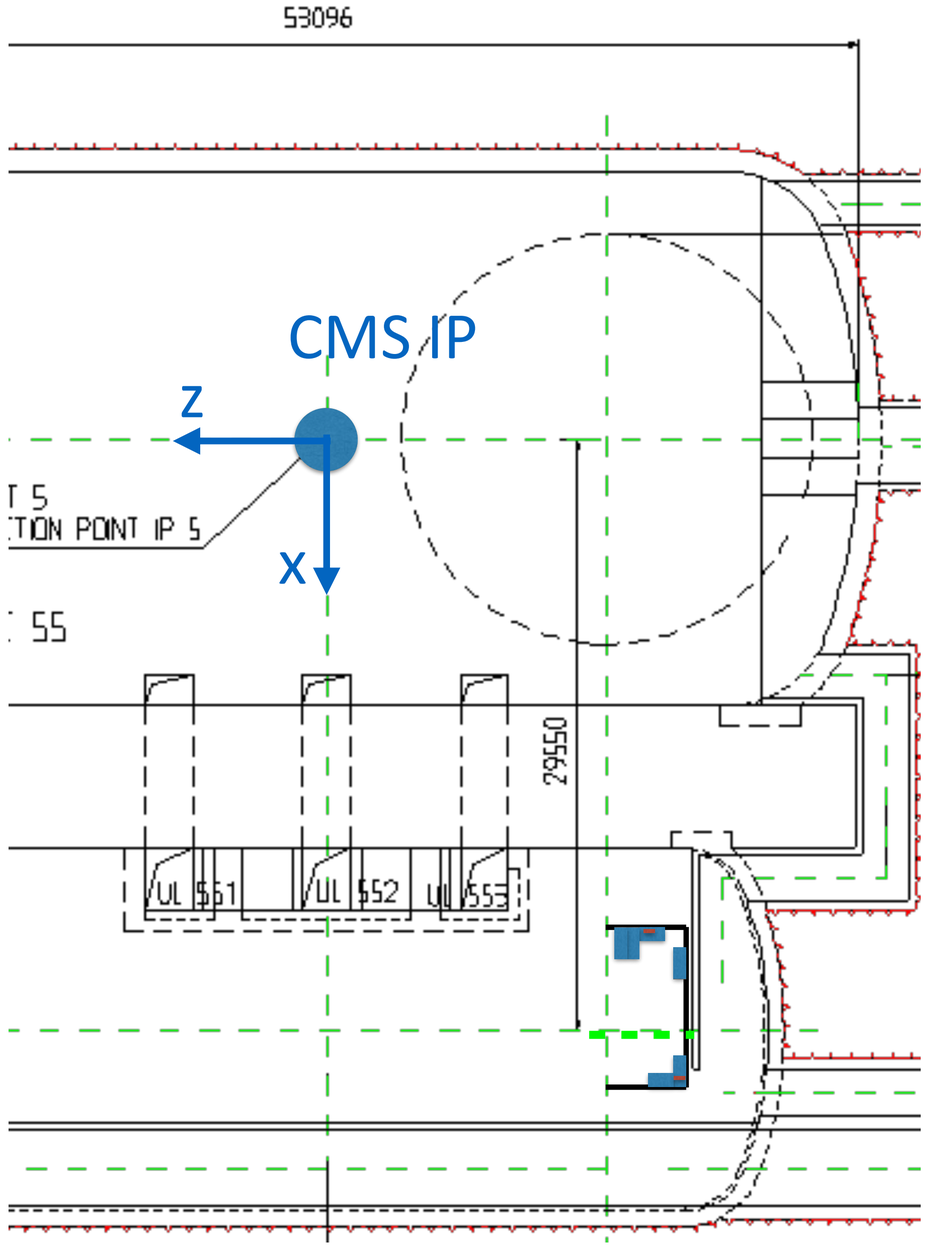
slope(RUN199)
= 4.2 tracks/pb^{-1}

Detector locations

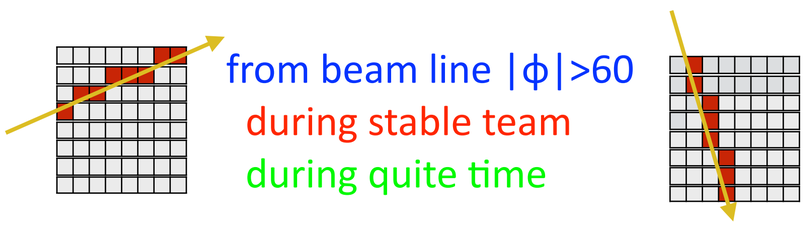
- Moved the detector to location 2 to measure the distance from the IP
- Two locations are 6 m and 2.2 m apart in z and x directions





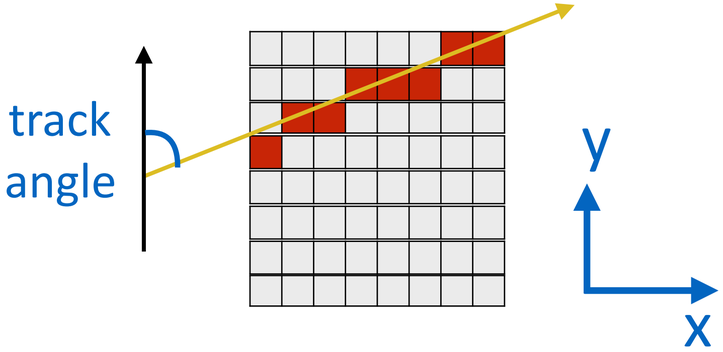


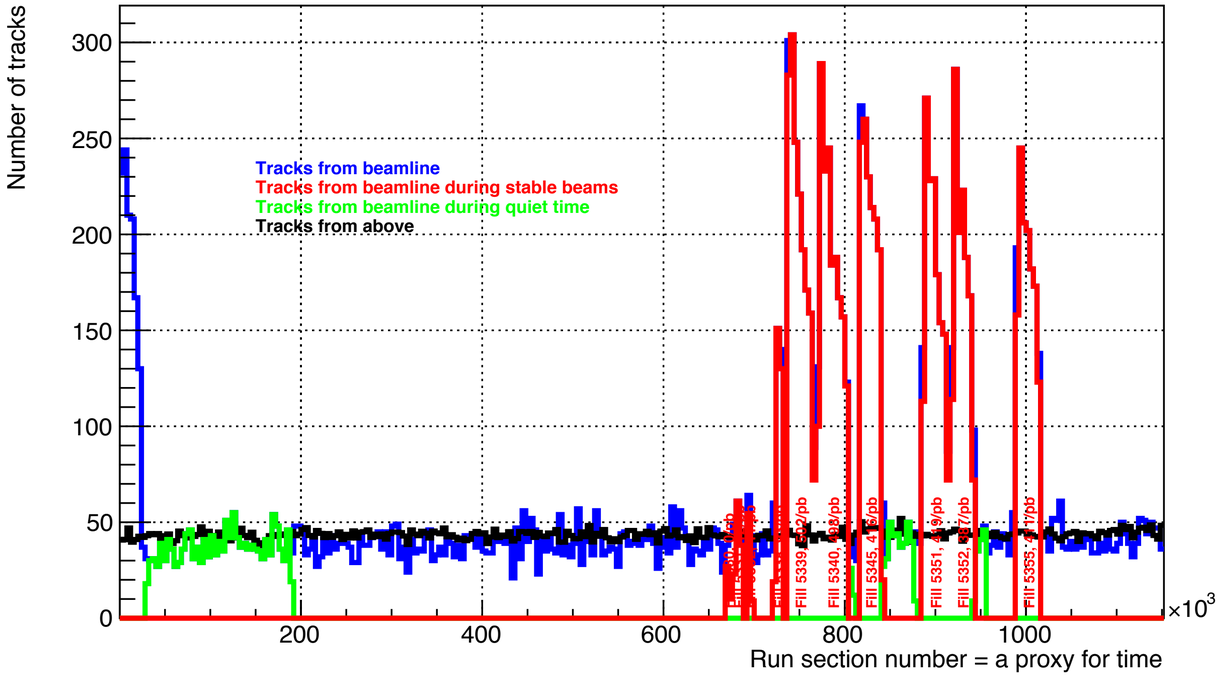
Number of tracks vs time/angle



from beam line |ϕ|>60
during stable team
during quite time

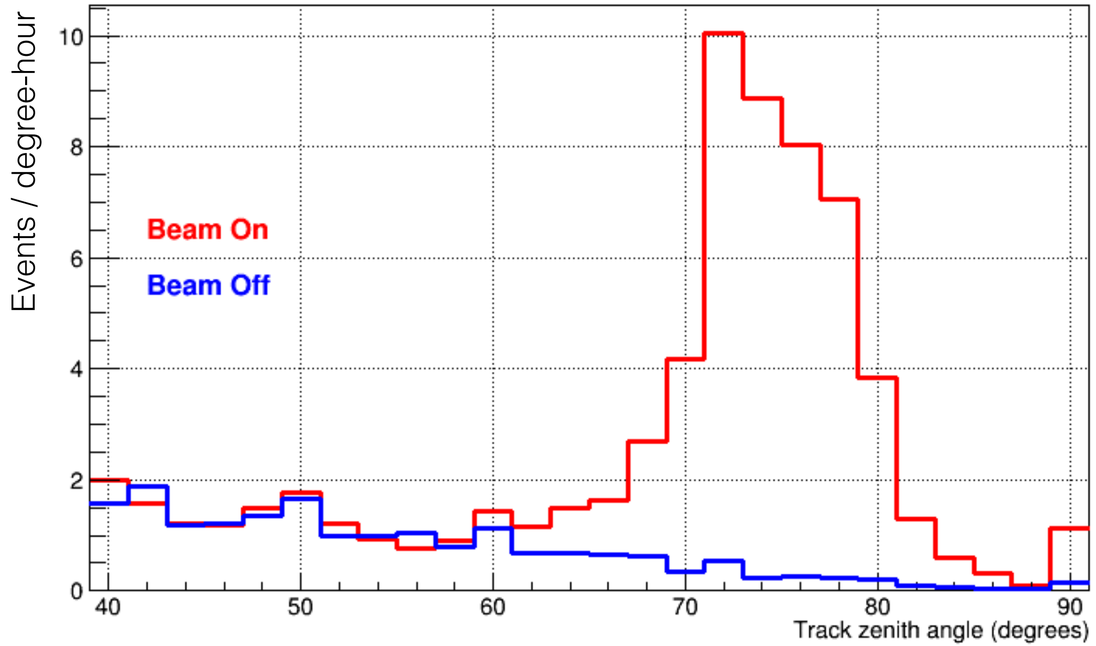
from above: |ϕ|<40



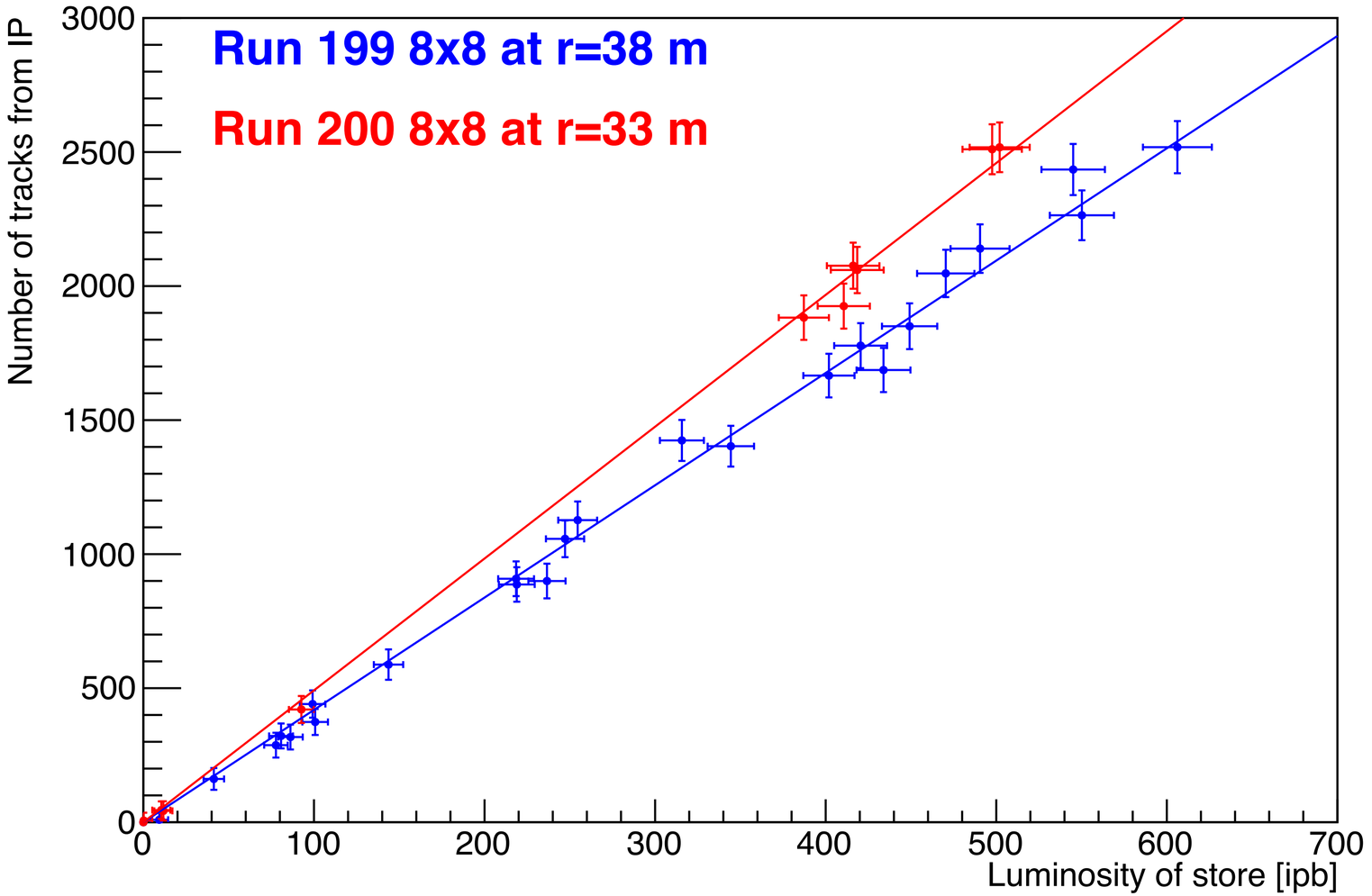


Sep 9

Oct 6



Number of muons vs Luminosity

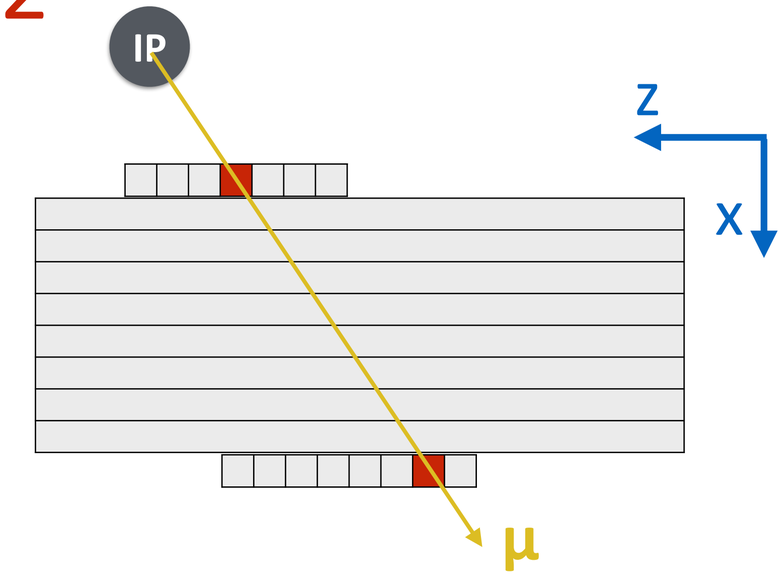


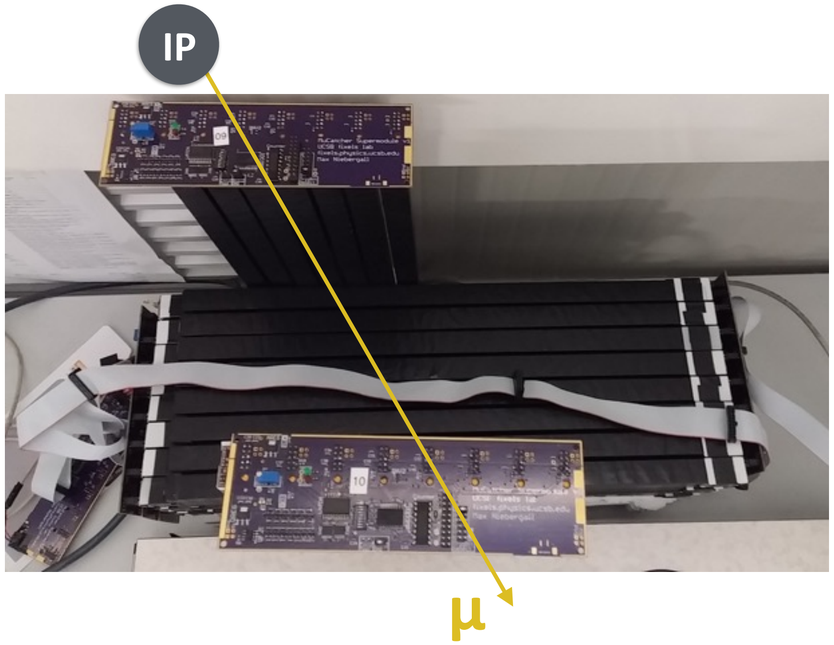
slope(RUN200)
= 4.9 tracks/pb^{-1}

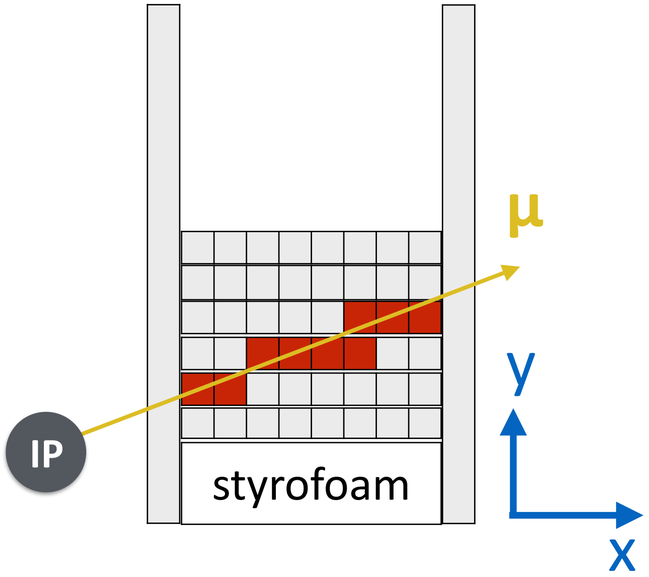
slope(RUN199)
= 4.2 tracks/pb^{-1}

Hodoscope configuration 2

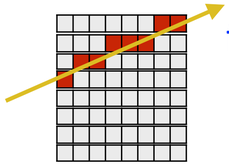
- Configuration 2: stack 6 units on one another and put two vertically on each side
- Used at location 2
- Provides x/y and x/z angle measurements



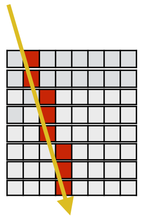




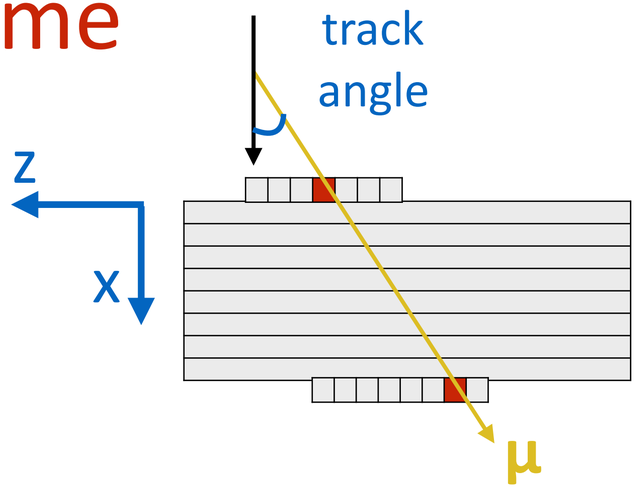
Number of muons vs time

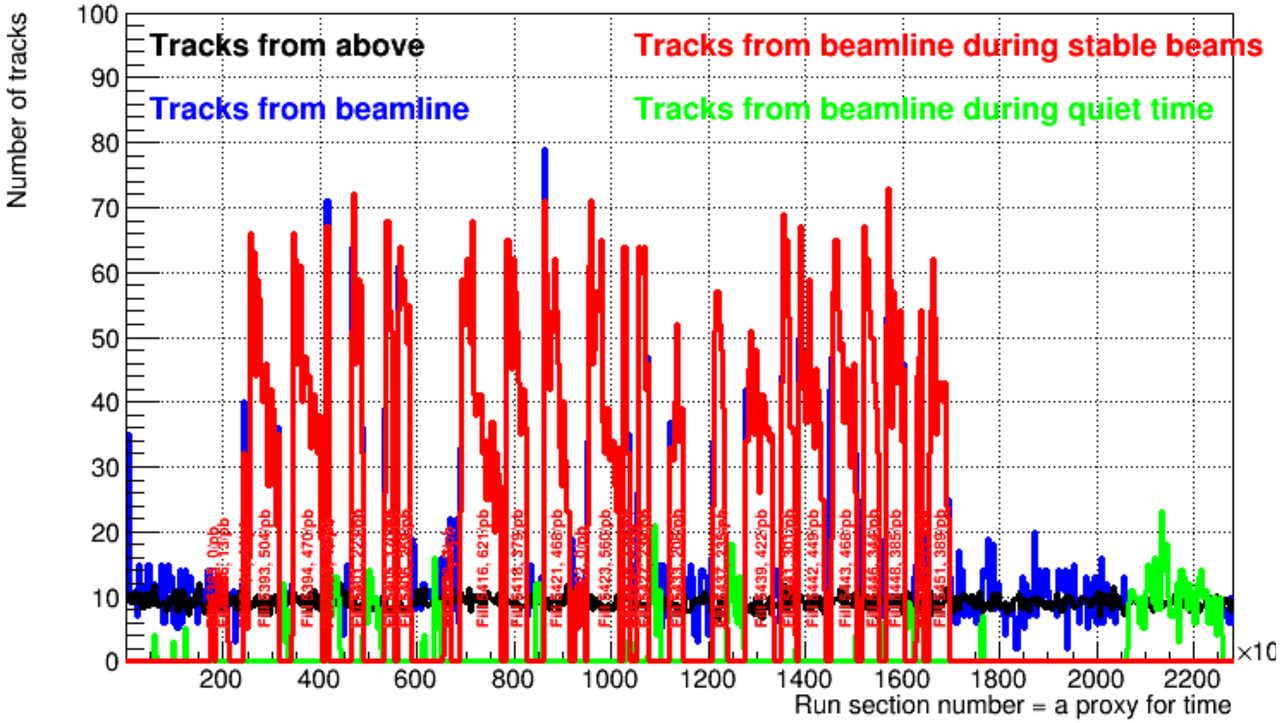


from beam line |ϕ|>60
during stable team
during quite time



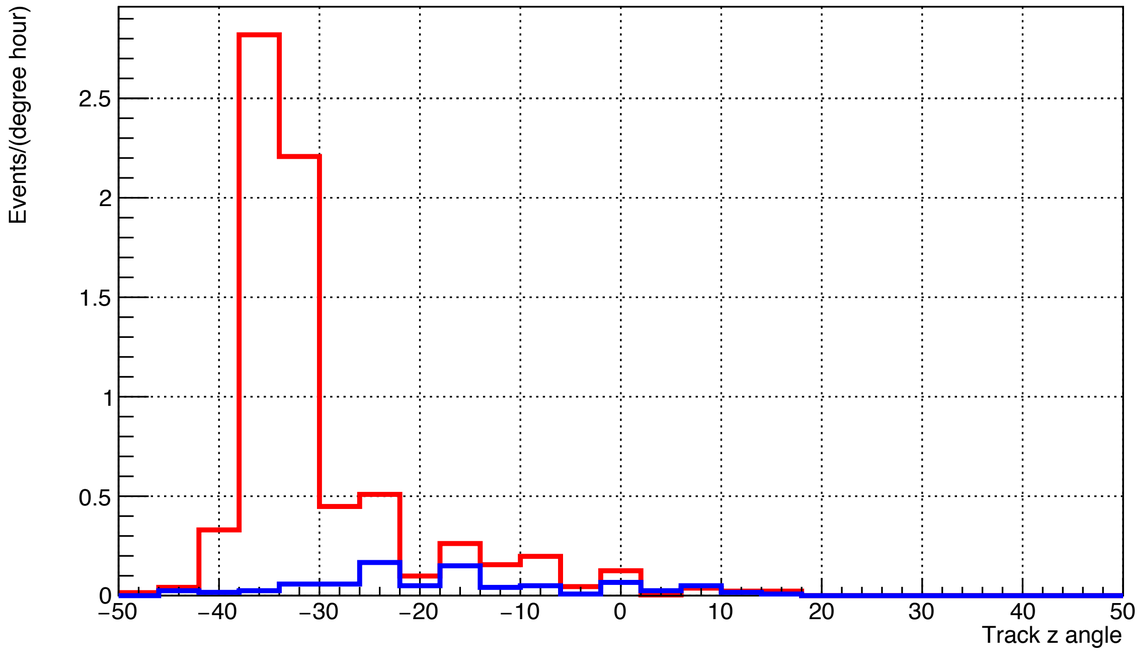
from above: |ϕ|<40



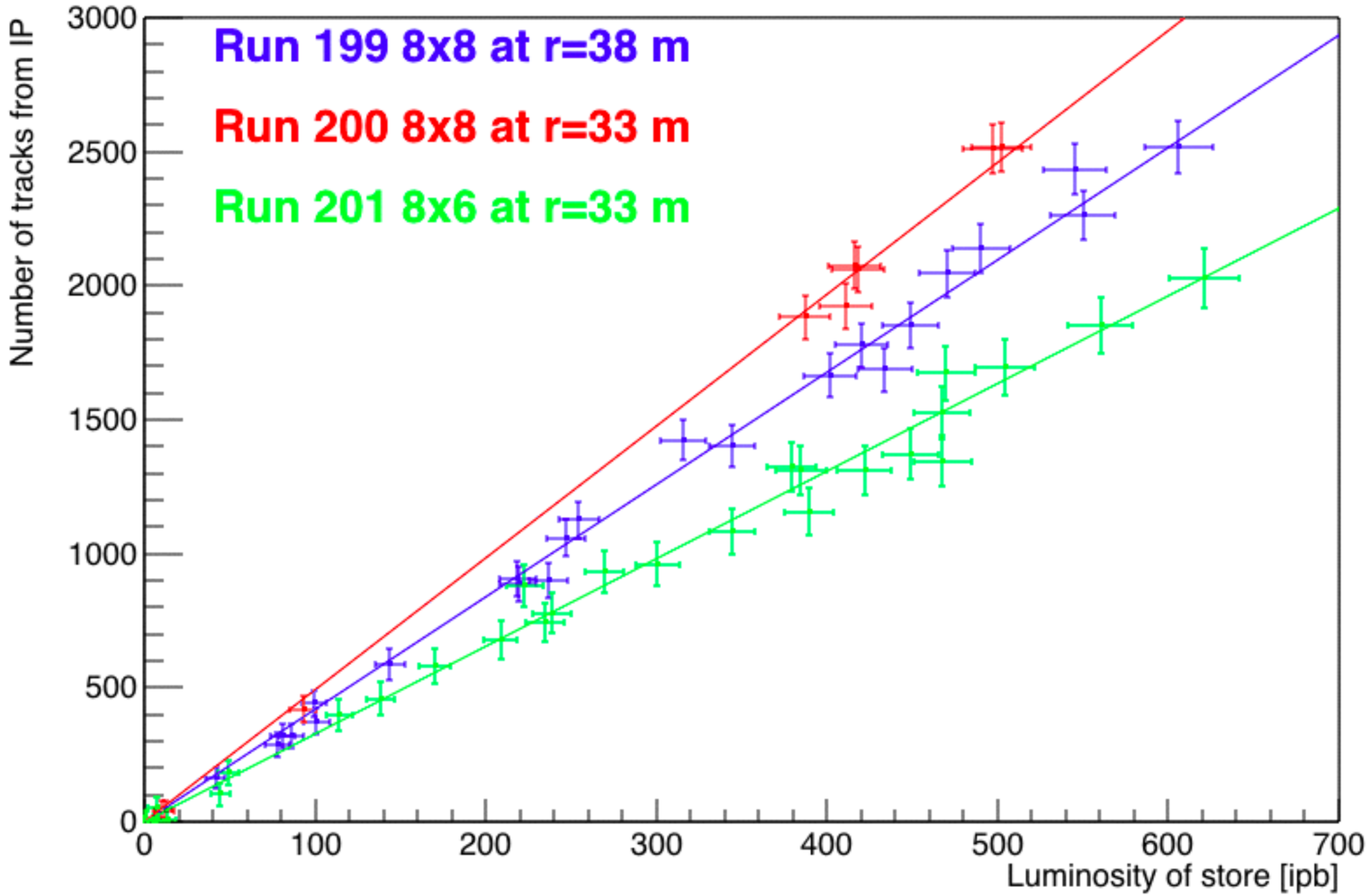


Oct 6

Oct 25



Number of tracks vs Luminosity



slope(RUN200)
= 4.9 muons/pb^{-1}

slope(RUN199)
= 4.2 muons/pb^{-1}

slope(RUN201)
= 3.3 muons/pb^{-1}

Comparison with simulation

$$N_{muons\ 1x1} = \frac{N_{measured\ muons\ 0.2x0.5}}{acceptance\ x\ efficiency}$$

	$N_{muons\ 0.2x0.5}/pb^{-1}$	acceptance x efficiency	$N_{muons\ 1x1}/pb^{-1}$
Run 199	4.2	0.09	46 ± 5
Run 200	4.9	0.14	36 ± 4
Run 201	3.3	0.1	33 ± 3

$N_{muons\ 1x1}/pb^{-1} = 38 \pm 6\ /pb^{-1}$
$(0.53 \pm 0.08\ Hz)$

Golf's simulation

0.26 Hz at L=1.4E34

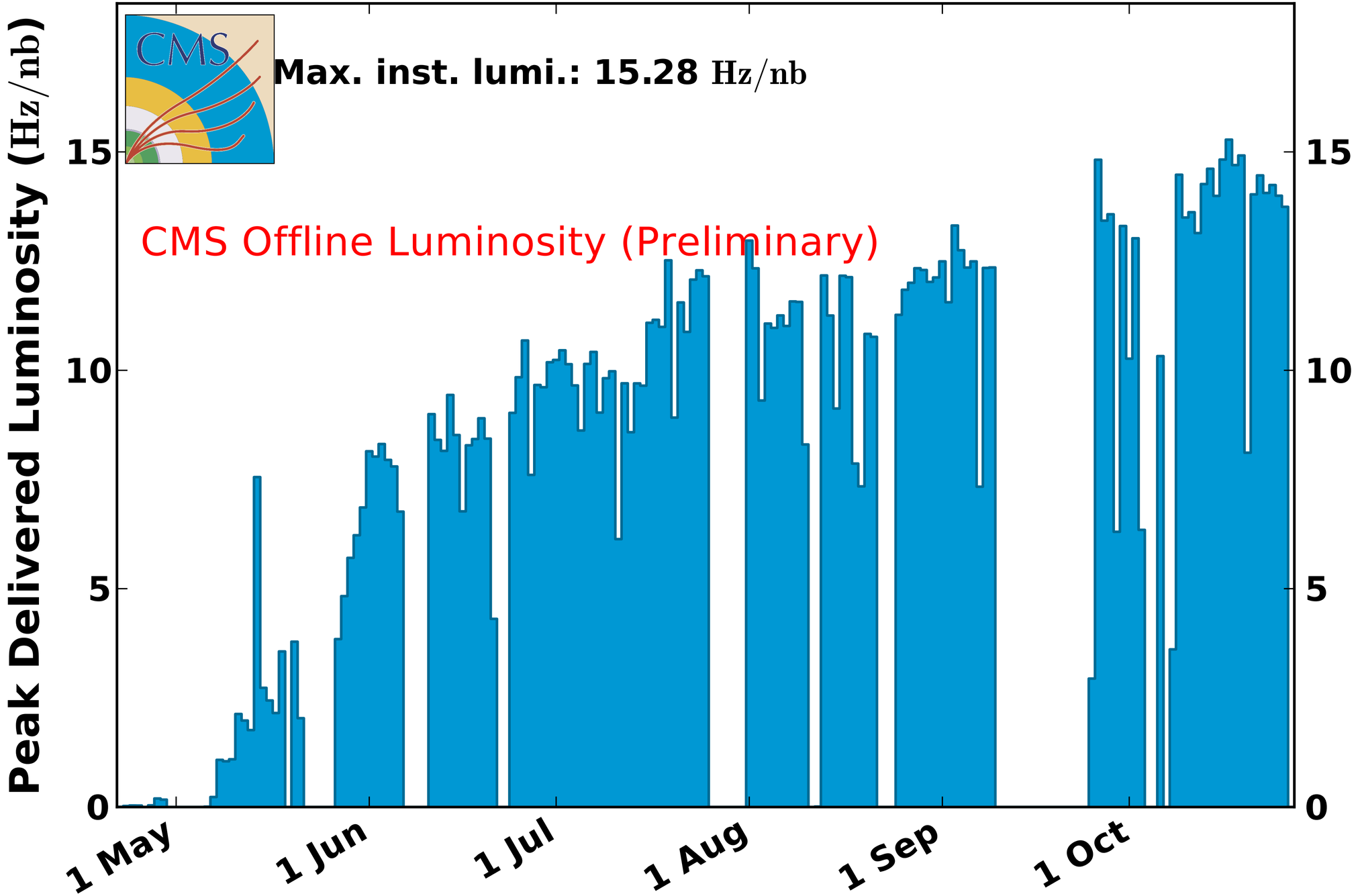
$18\ /pb^{-1}$

Difference due to p_T(muon)>15 GeV cut which was used to make the simulation faster with 16m of concrete. With 7.2 m we are loosing some spectrum

Summary

- Measured the rate of muons from CMS IP during the last half of data-taking period in 2016 (17 fb^{-1})
- The measurement is larger by factor 2
  - 38 ± 6 /pb^{-1} vs 18 /pb^{-1} (0.53 ± 0.08 Hz vs 0.26 Hz)
  - Expected to be closer with updated simulation
- Still the beam induced background is negligible

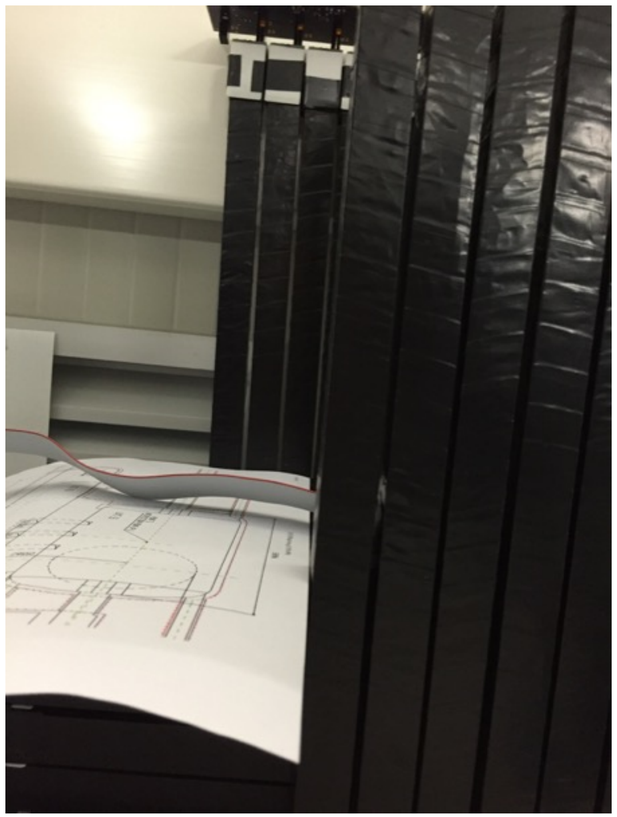
Backup


CMS
Max. inst. lumi.: 15.28 Hz/nb
CMS Offline Luminosity (Preliminary)
Peak Delivered Luminosity (Hz/nb)
0
5
10
15
1 May
1 Jun
1 Jul
1 Aug
1 Sep
1 Oct

Precise tracker alignment

using precise tape measure

using precise A4



EXACTLY 3 bars off

Calculation of distance