XFT efficiency studies

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- Main goal:
  - Quantify gain in efficiency that could be provided by reduced COT thresholds
- Additional outcomes of studies:
  - Stereo pixel efficiency in terms of COT hit efficiency
  - SLAM efficiency in terms of stereo pixel efficiency
  - Trigger rate extrapolations for hadronic B triggers
  - Mapping dead wires in stereo superlayers and influence of masking them on trigger rates

Pixel Efficiency

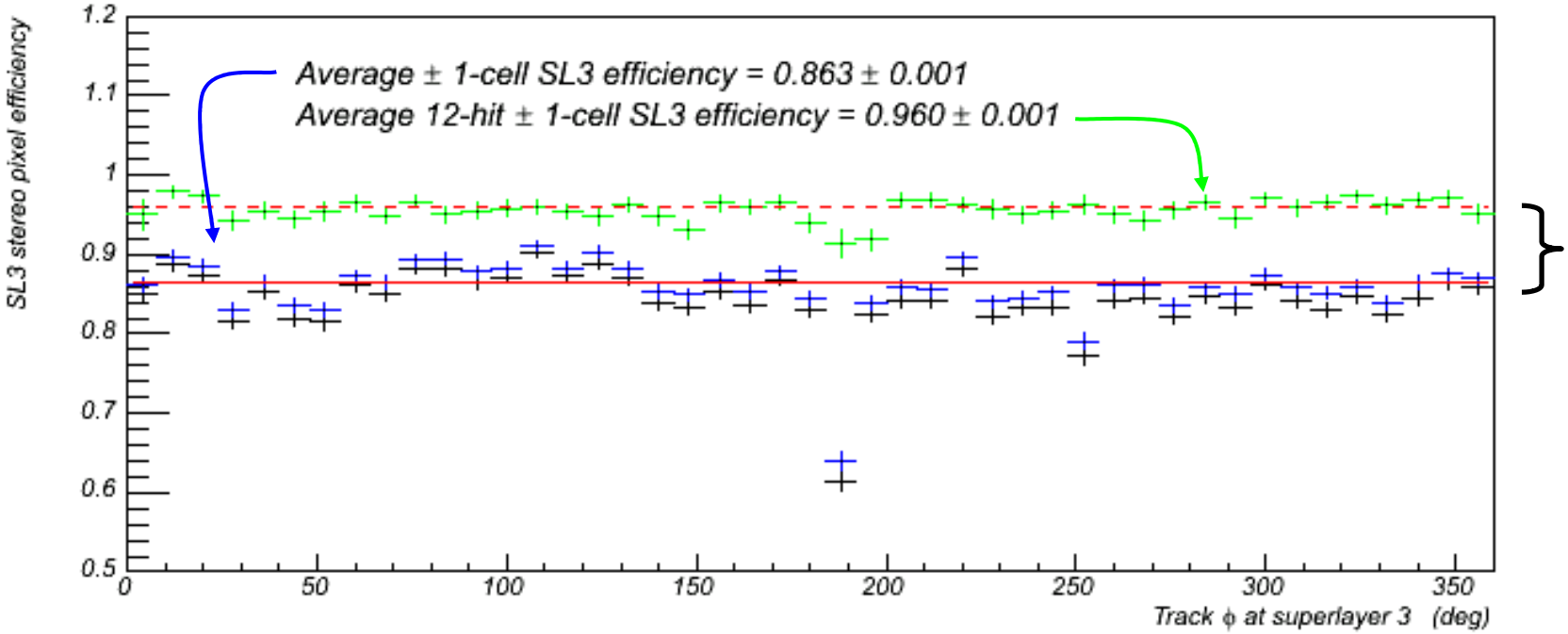
- Previous studies described in the XFT Upgrade Meeting on January 20
- Definition of efficiency:
  - Start with an offline COT track
  - Find the best matching axial XFT track
  - Extrapolate offline track to stereo superlayers
  - Did XFTSim find a stereo pixel near the cell through which the track passes?

Stereo Pixel Efficiencies

- Pixel finding efficiency depends on:
  - φ-position (ie, individual dead wires)
  - z-position in stereo superlayer
  - Axial XFT track p_T
- Pixel finding efficiency does not strongly depend on stereo finder pattern matching

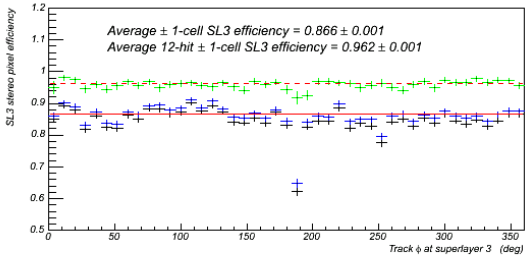
Pixel Finding Efficiency

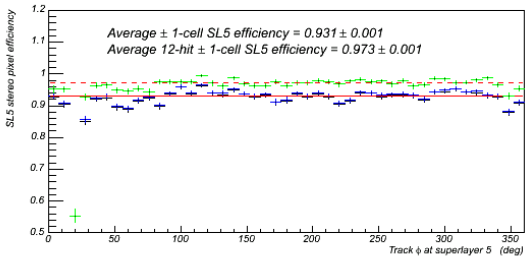
- When the offline COT track has 12-hits on the stereo superlayer the pixel finding efficiency increases.
- The difference is due to COT hit efficiency.

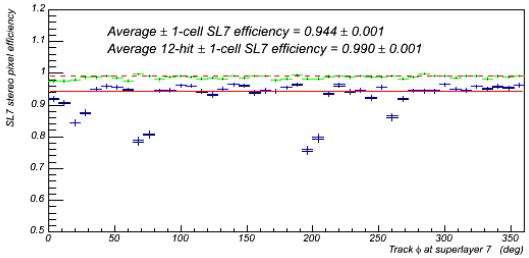


Pixel Efficiency

- Efficiency as a function of φ for XFT tracks with $p_T > 2$ GeV/c:







	ϵ_3	ϵ_5	ϵ_7
$p_T > 4$	0.866	0.931	0.944
$p_T > 2.5$	0.865	0.931	0.944
$p_T > 1.5$	0.863	0.930	0.944

Main point: although there is some p_T dependence, the efficiency averaged over all XFT tracks is still a representative statistic.

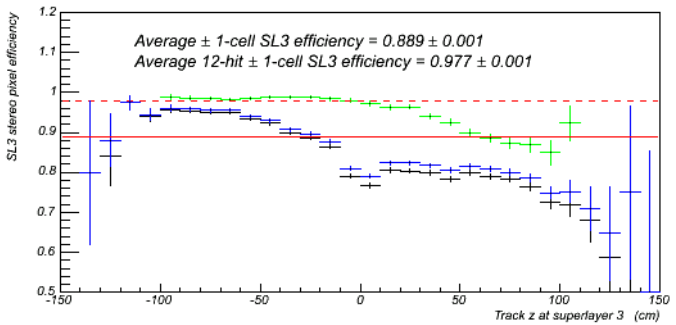
(this happens to be for run 0x0337a2)

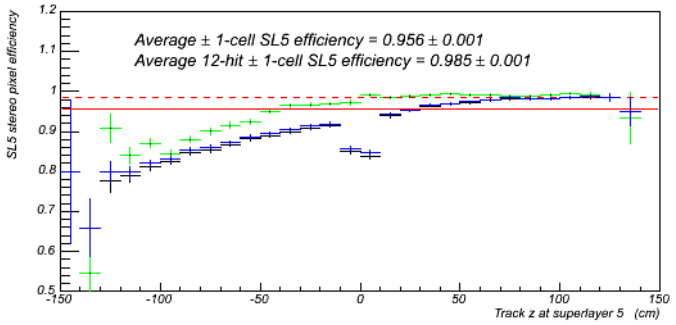
φ-dependence

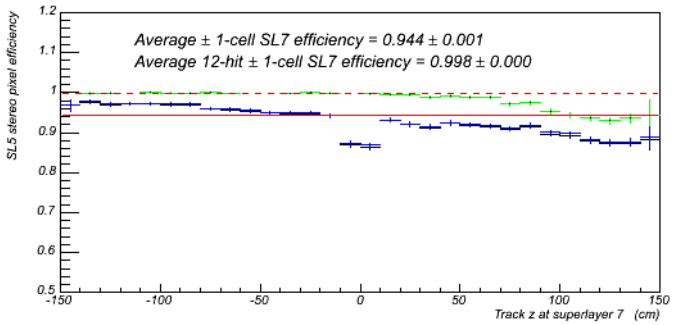
- Since oxygen was added, φ-dependence is uniform
- Exceptions are individual cells with dead wires
- In the future these will be masked on
- Introduces some bias, but not enough to drastically change conclusions

z-dependence

- Strong z-dependence
- Some dependence even when track has 12-hits on stereo superlayers

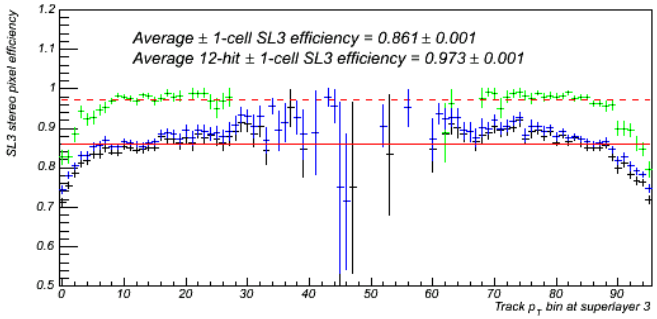


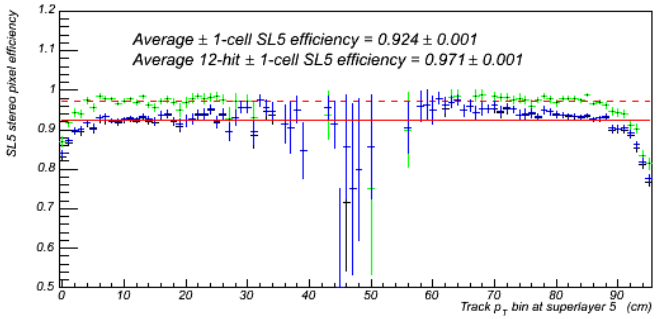


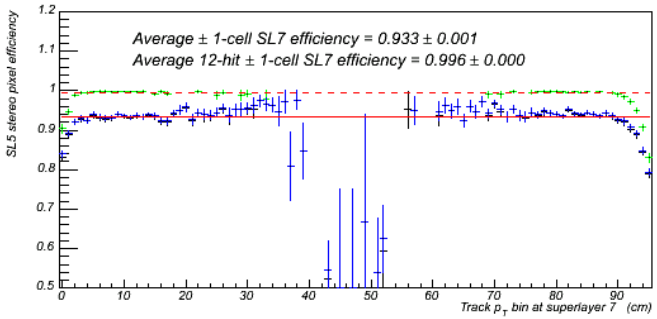


p_T Dependence

- p_T dependence is generally flat above 2 GeV/c





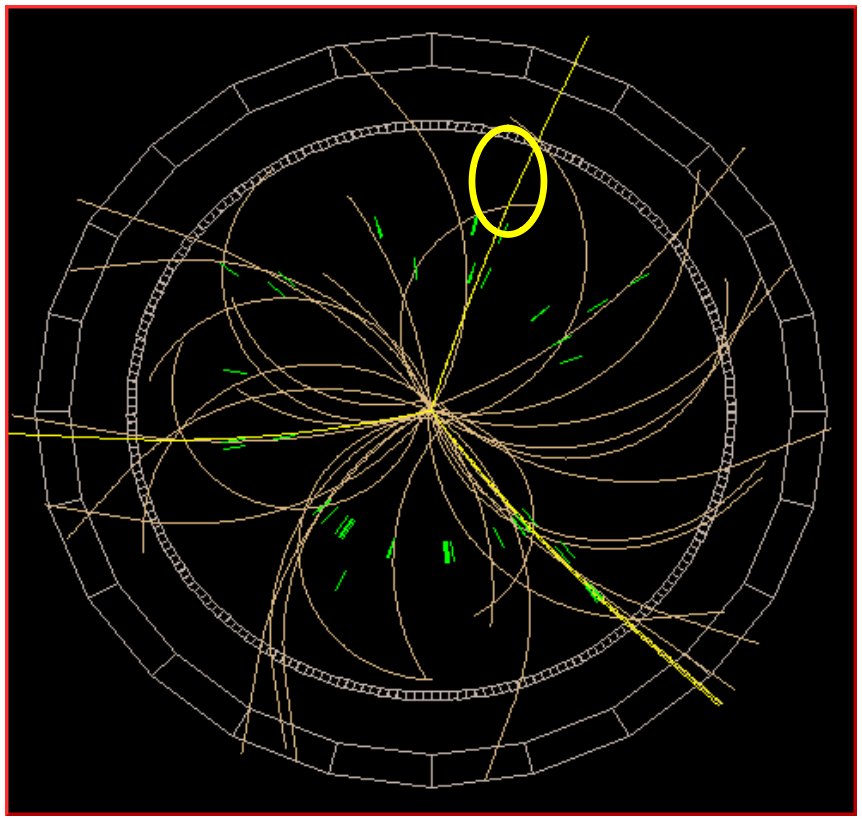


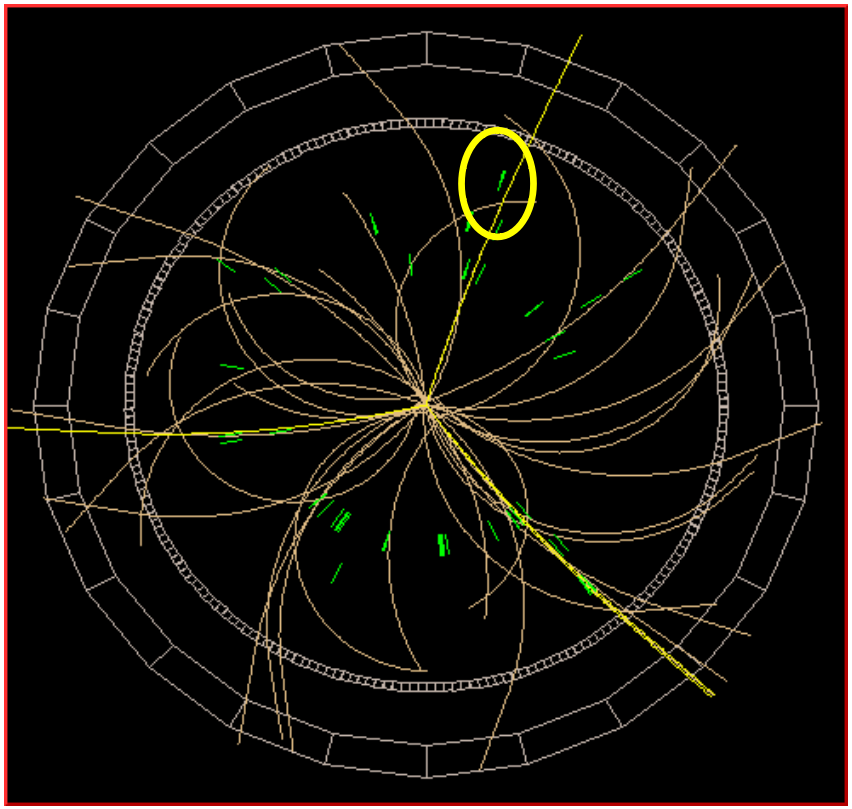
Masking Dead Wires

- Some inefficiency will be mitigated by masking on inefficient wires in stereo superlayers
- Identify such wires by comparing hit occupancy with average occupancy in superlayer

Masking Dead Wires

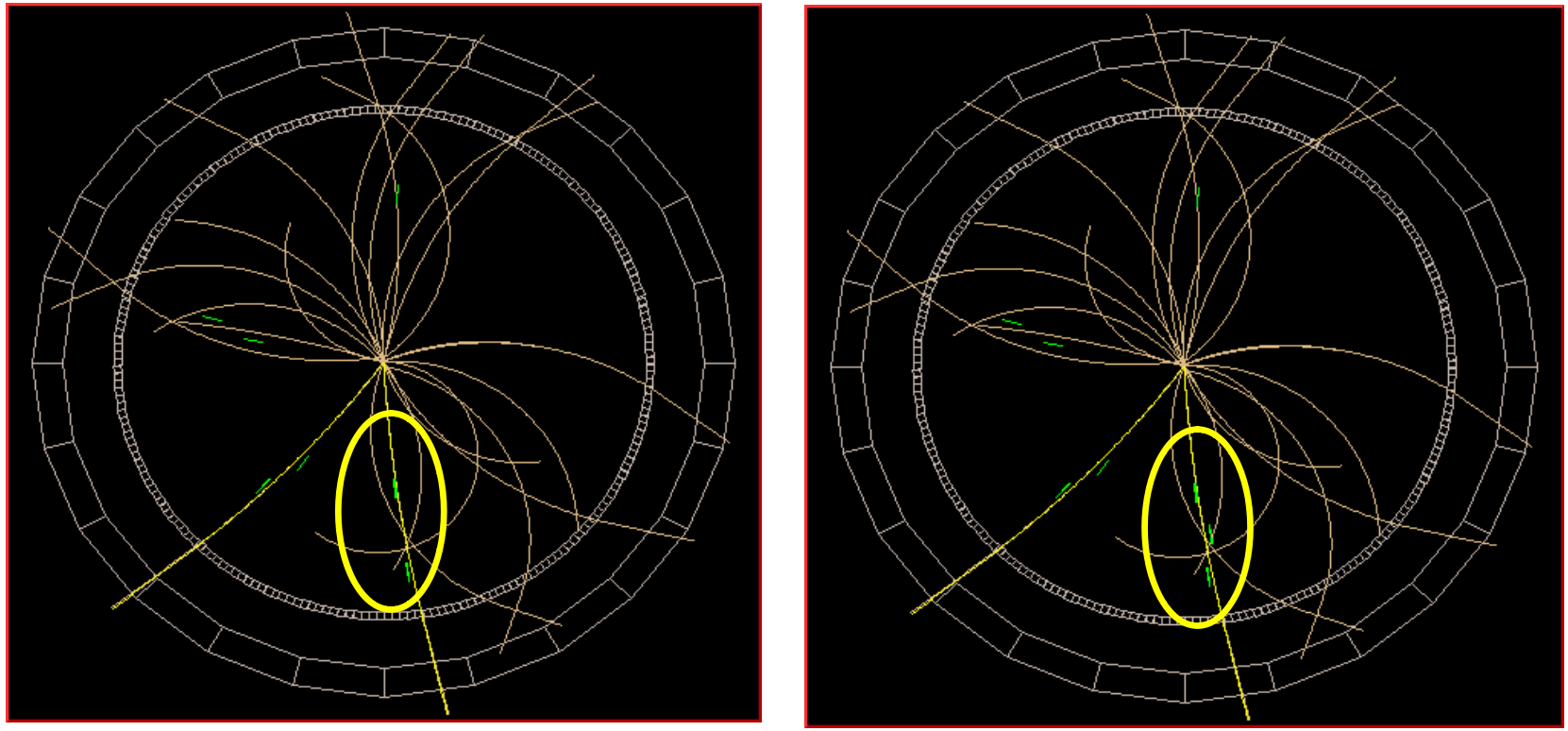
- Example: All wires in cell 86 in superlayer 7 have very low occupancy (about 5% of the average)



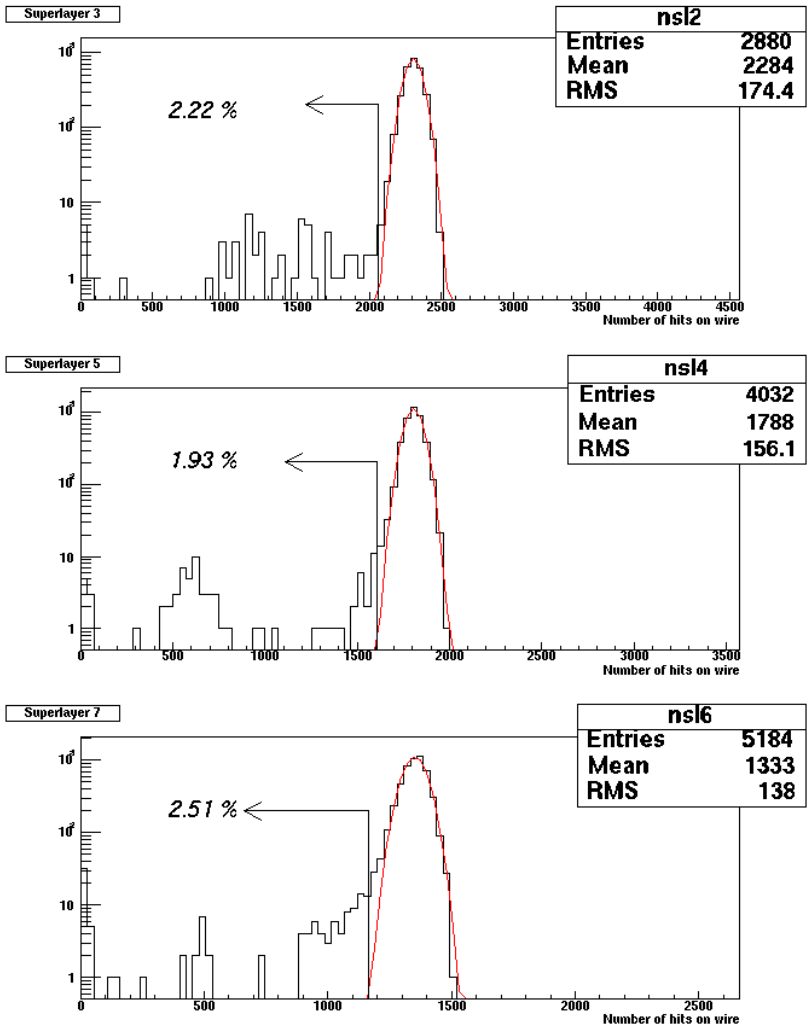


Masking Dead Wires

- Example: 3 wires in SL5 cell 260 are among the lowest 2.5% of all wires in SL5.



Masking Dead Wires



- Count number of hits on wires associated with offline COT tracks
- Classify wires with hit multiplicities lower than 5σ from mean as “dead”
- Dead wire fraction:

SL	4σ	5σ
3	2.22%	1.98%
5	1.93%	1.66%
7	2.51%	1.99%

Specific Comparisons

- Restrict comparisons to the subset of tracks with $p_T > 2.5$ GeV/c
  - Appropriate for high-p_T and Scenario C triggers
- Compare stereo pixel and overall SLAM efficiencies on normal data and data with reduced COT thresholds.
  - Normal COT thresholds: Run 0x0338a6
  - Reduced COT thresholds: Run 0x0338a7

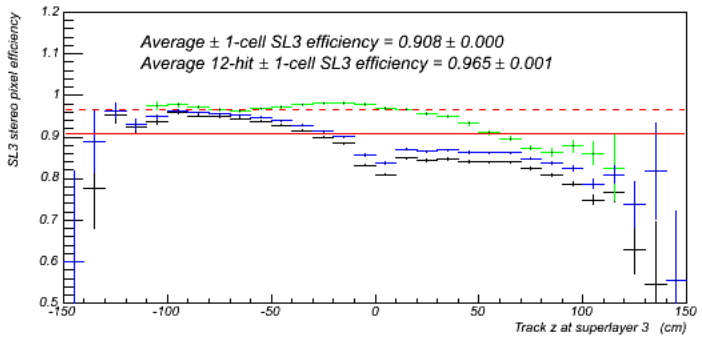
Average Pixel Efficiencies

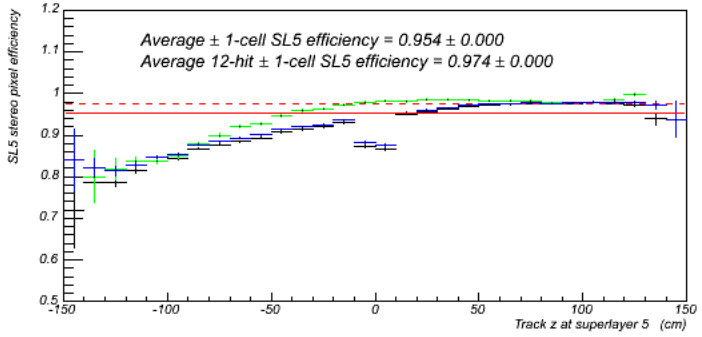
	normal thresholds	reduced thresholds
$\epsilon(SL3)$	0.903	0.950
$\epsilon(SL5)$	0.939	0.961
$\epsilon(SL7)$	0.952	0.971
product	0.807	0.886
$\epsilon(SLAM)$	0.803	0.886

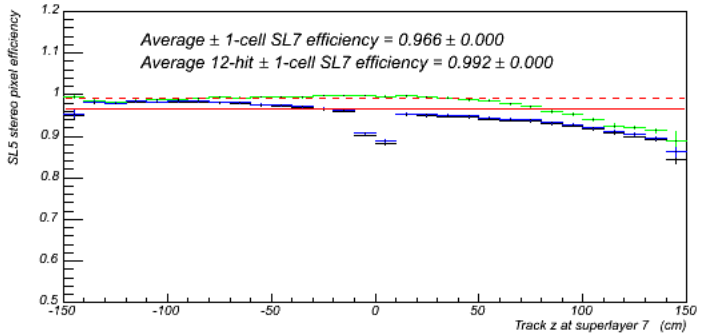
- Single-track efficiency increase of 8.3% with reduced thresholds at L=75x10^{30} $cm^{-2}s^{-1}$

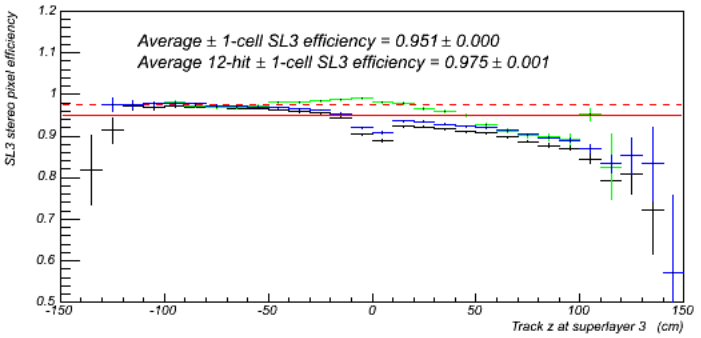
Improved Detector Uniformity

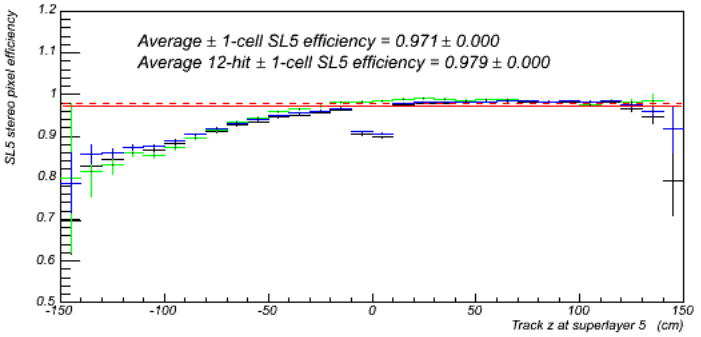
Normal thresholds

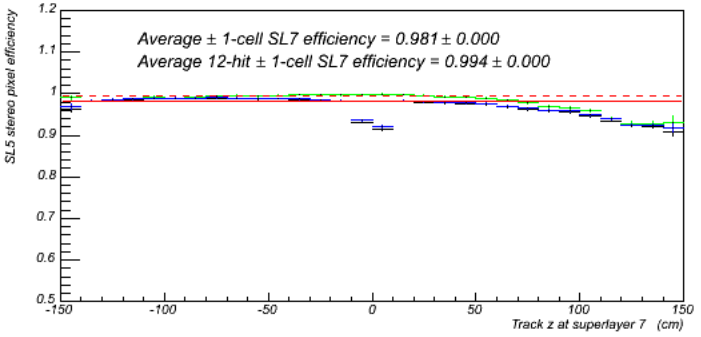












Reduced thresholds

Trigger Rates

- Model for interpretation within a given run:
  - "real" tracks are matched to COT track in both $\Delta 1/p_T$ and $\Delta\phi_{SL6}$
  - "fake" tracks fail one or both of these criteria
  - These are not mutually exclusive: about 3.6% of tracks in this sample are neither "real" nor "fake" (ie, the COT track matched one but not both criteria).
  - Real tracks are definitely real, fake tracks are definitely fake.

Trigger Rates

- Apply this classification to a “Scenario C-like” trigger:
  - Two tracks with $p_T > 2.5$ GeV/c, opposite Q
  - Sum $p_T > 6.5$ GeV/c
  - $2^o < \Delta \phi_{SL6} < 90^o$
- Fake trigger has at least one fake track, real trigger has two real tracks
- Also consider a “low p_T” trigger:
  - Two tracks with p_T > 1.5 GeV/c, opposite Q
  - $2^o < \Delta \phi_{SL6} < 90^o$

Comparison Scenario C-like trigger

	normal 1-miss	reduced 1-miss	normal 2-miss	reduced 2-miss
Triggers	14827	11881	14827	11881
real fraction	0.523	0.528	0.523	0.528
fake fraction	0.384	0.380	0.384	0.380
real SLAM ϵ	0.726	0.846	0.894	0.929
fake SLAM ϵ	0.132	0.173	0.275	0.380
σ (μb)	168	158	168	158
$\sigma(SLAM)$ (μb)	72.1	81.2	96.1	96.8

- 12% increase in Scenario-C trigger efficiency
- Single track SLAM efficiency squared is 0.645 for normal thresholds, 0.785 for reduced thresholds. Not perfect agreement because there can be multiple pairs per event.

Comparison Low-p_T trigger

	normal 1-miss	reduced 1-miss	normal 2-miss	reduced 2-miss
Triggers	22084	23529	22084	23529
real fraction	0.956	0.959	0.956	0.959
fake fraction	0.065	0.063	0.065	0.063
real SLAM ϵ	0.640	0.766	0.886	0.926
fake SLAM ϵ	0.216	0.273	0.416	0.473
σ (μb)	735	722	735	722
$\sigma(SLAM)$ (μb)	460	542	643	663

- Similar 12% increase in efficiency.

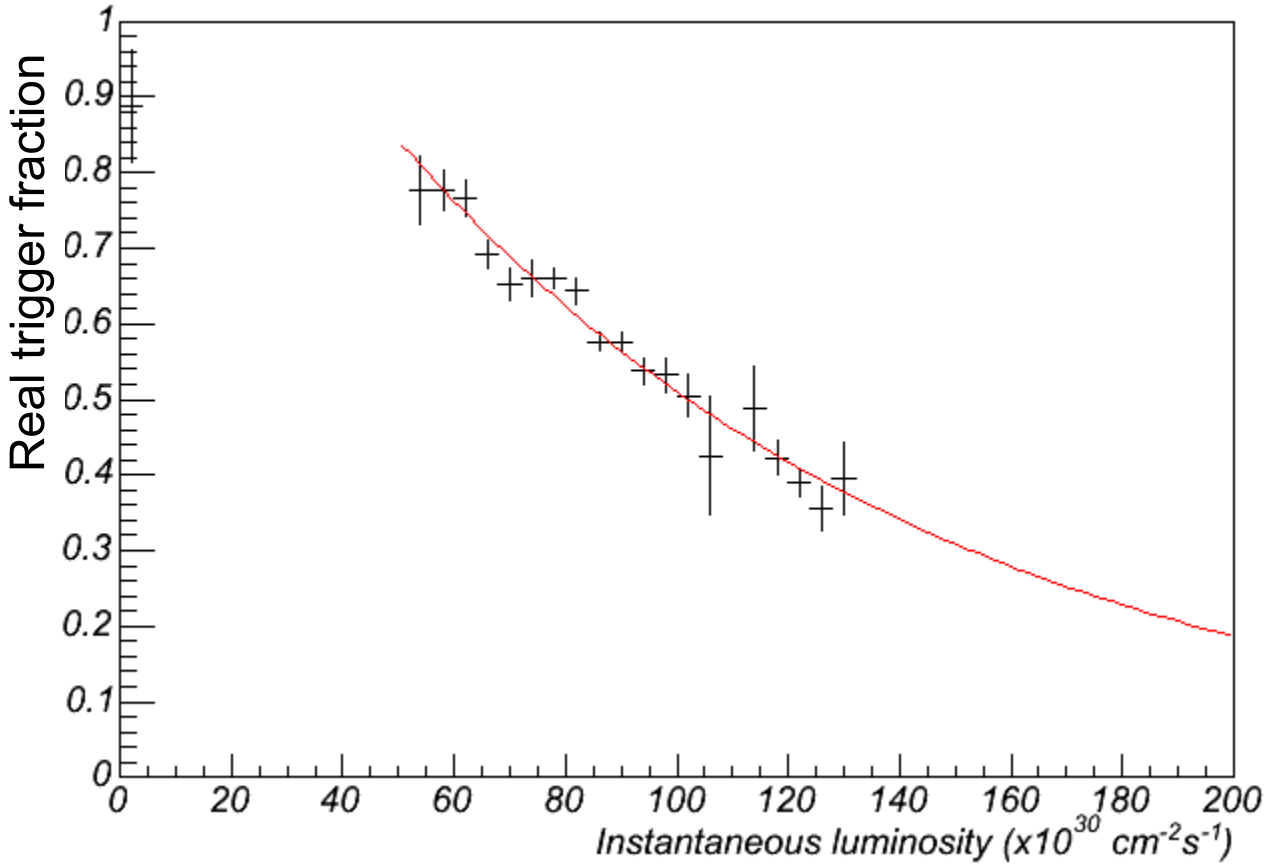
(These numbers are from low-luminosity test runs without dead wires masked on.)

Analysis of high luminosity test runs

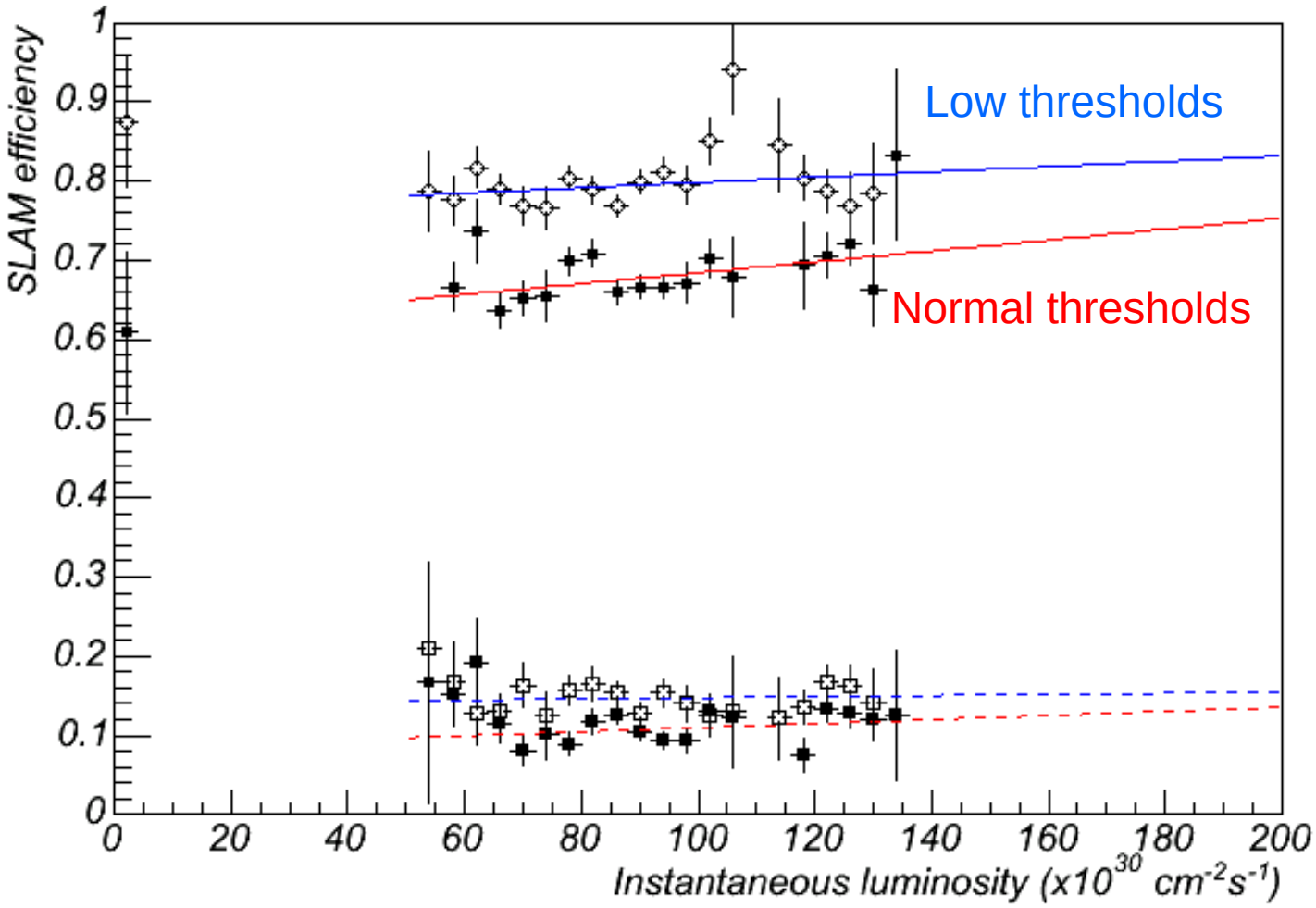
- More statistics at L ~ 75×10^{30} $cm^{-2}s^{-1}$:
  - Run 211110: 134,022 TWO_TRK1.5 triggers (PS500)
  - Run 211111: 109,547 TWO_TRK1.5 triggers (PS600)
- Use bunch-by-bunch luminosity to project cross sections, fake fractions and SLAM efficiencies
- Predict cross section as a function of instantaneous luminosity for two-track triggers with SLAM confirmation

Fake Trigger Fraction

- First for the Scenario C-like trigger:



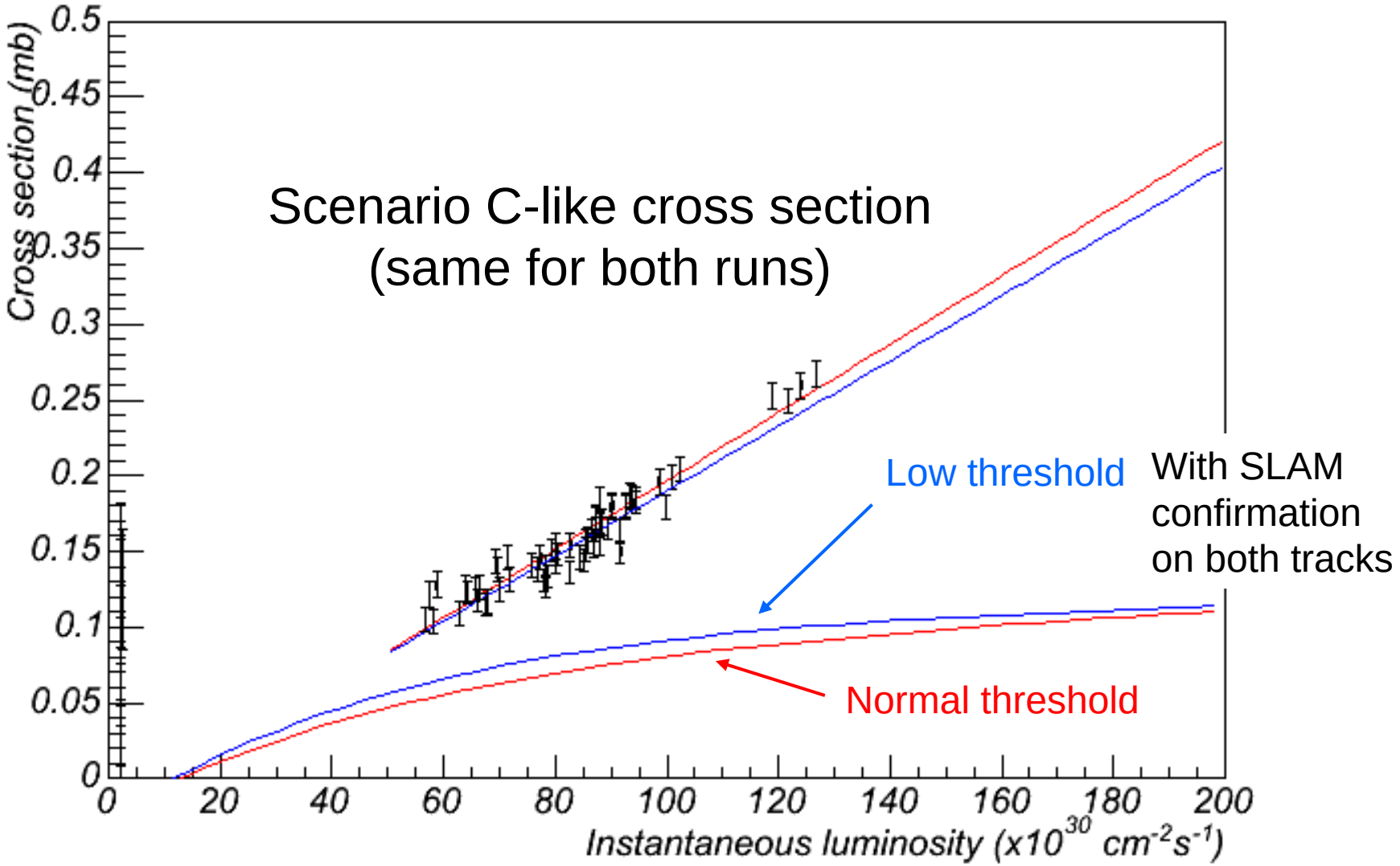
SLAM efficiencies



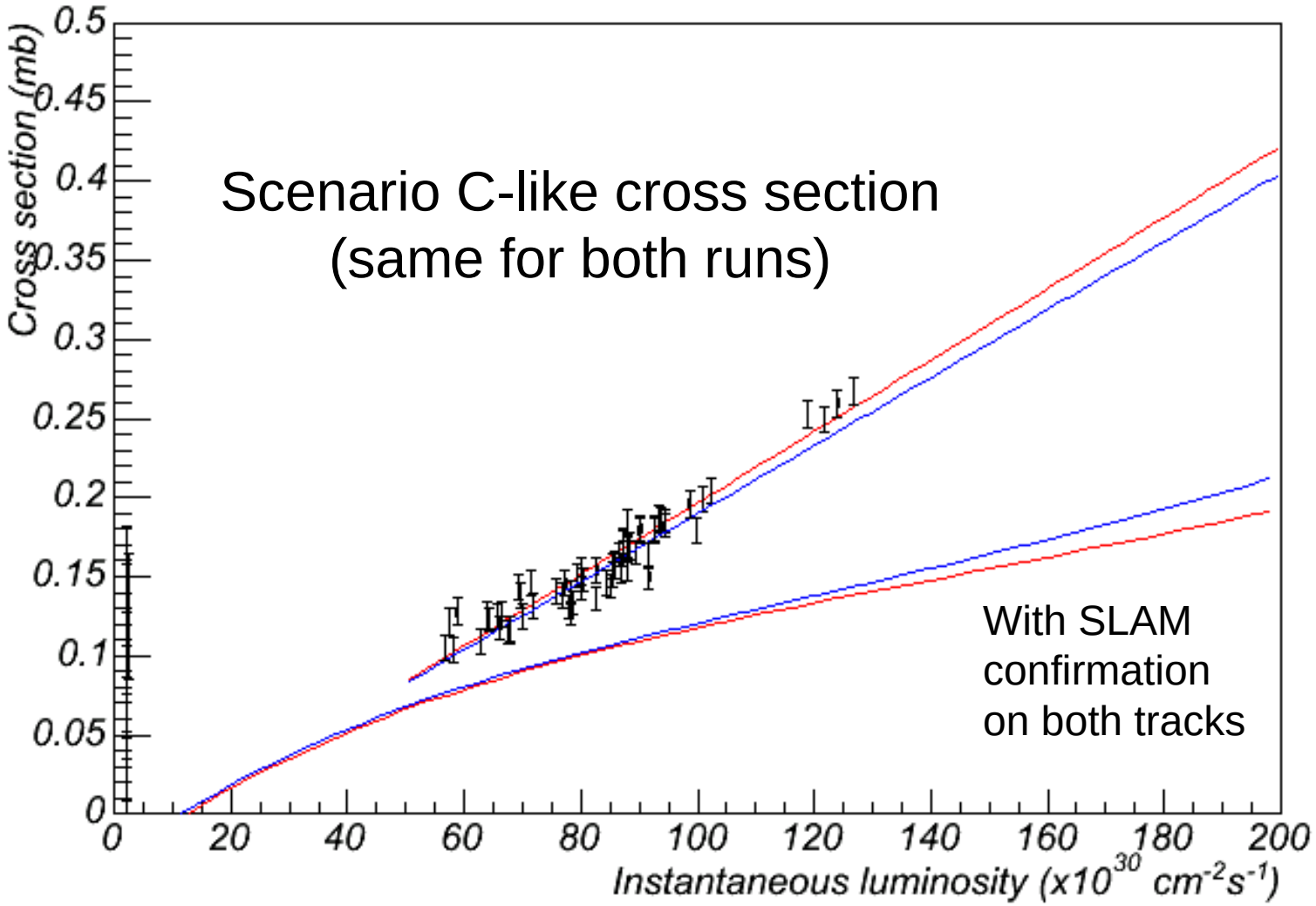
Real triggers

Fake triggers

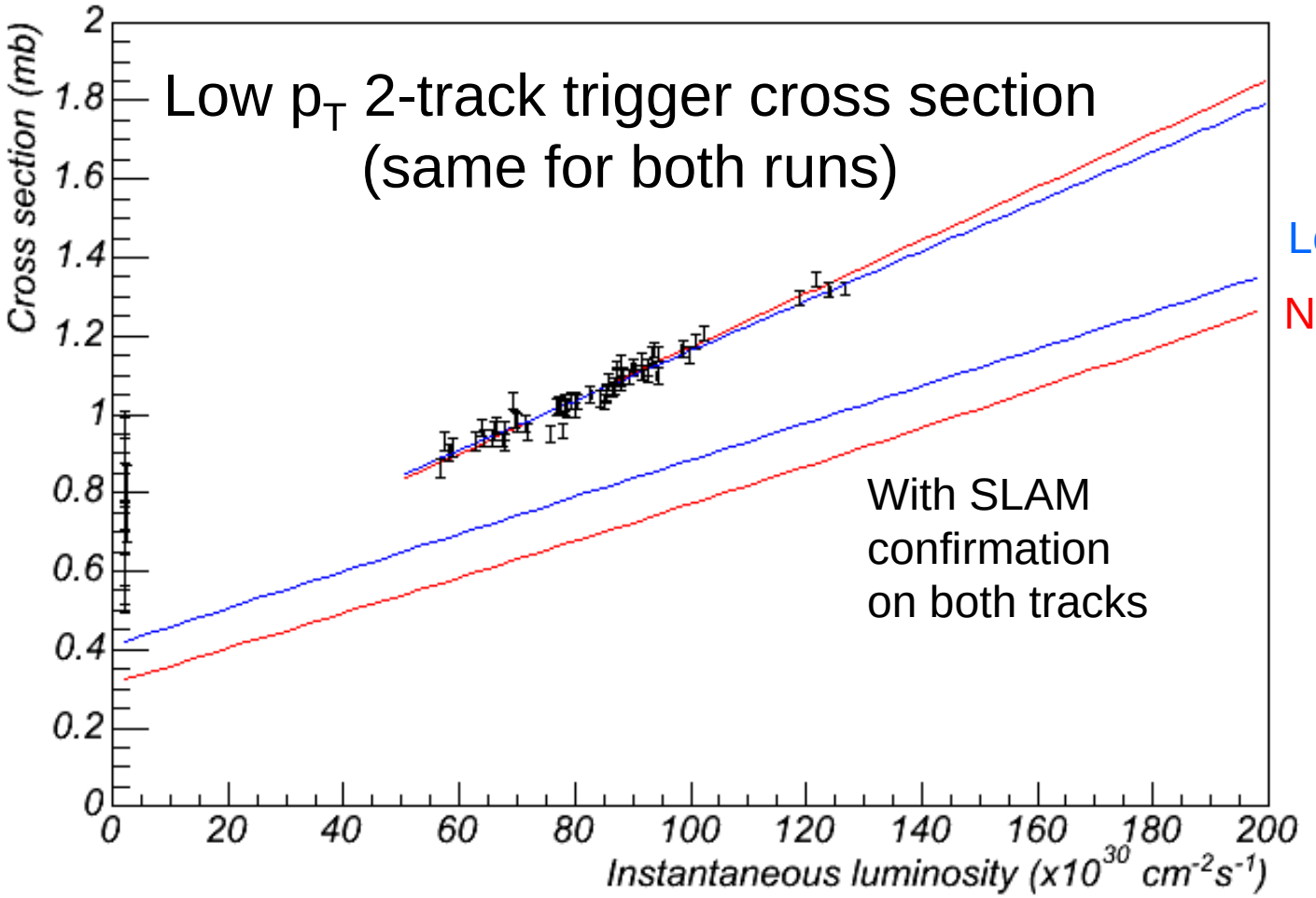
Projected Trigger Rates



Projected Trigger Rates with 2-miss patterns



Projected Trigger Rates



Low threshold

Normal threshold

Connection with single high p_T tracks

- High p_T lepton triggers are an important contribution to level 1 rate at high luminosity
  - CMX is the most offensive trigger in the 2B straw trigger table even after all improvements
- Dominated by fake XFT tracks
- Vadim's study of CMX trigger rates suggests that 2-miss patterns increase the rate by 25-30%

Past Experience with Axial System

- Examined in great detail in response to COT aging issues.
- Historical development summarized in December 2003 trigger hardware meeting.
- Main point:
  - Lowering thresholds was the only way to retain efficiency without increasing COT gain itself.

Conclusions

- SLAM efficiency show to be proportional to product of stereo pixel efficiencies
- Pixel efficiencies increase with reduced thresholds on stereo superlayers
- Trigger efficiency proportional to product of SLAM efficiencies
  - 12% increase in 2-track efficiency
  - Very small increase in overall trigger rate
- Undesirable growth of cross section results from use of 2-miss patterns in stereo finders.