Using RHIC to verify simulated Loss Maps

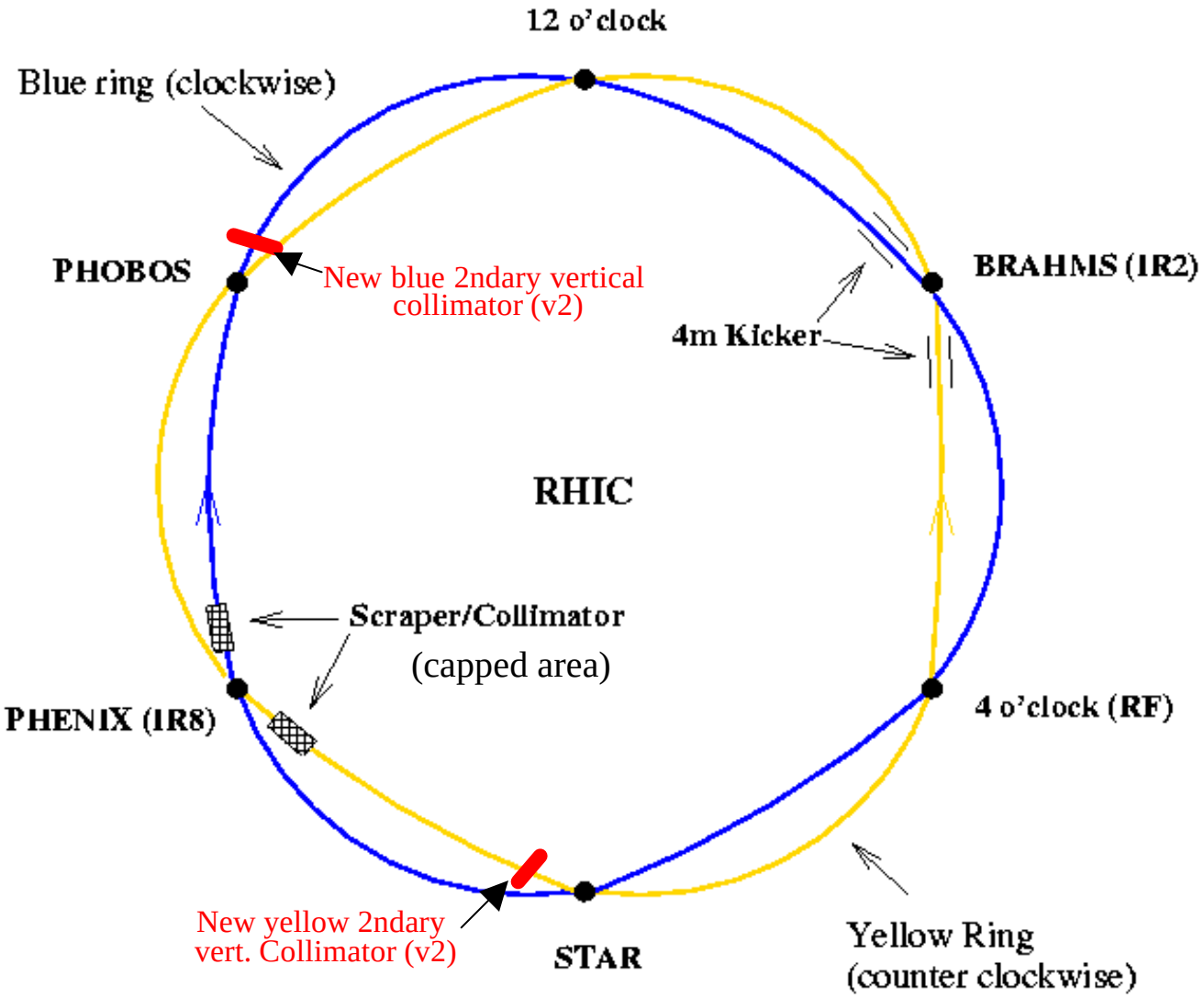
A. Drees

- The RHIC collimation system
- Protons and HI (Cu) Loss Maps
- Conclusions and Plan

RHIC Loss Limitations

- Operational limit: keep allowable loss budget (radiation safety) on the berm, monitored hour by hour
- Quench limit:
  - magnet quenches due to accidental local losses during ramp/store => BLMs thresholds
  - magnet quenches at beam dump due to debunched beam => gap cleaning
  - keep losses in 'safe' areas (during stores) => collimators
- Soil activation (not under radiation protection), depends on integrated yearly losses ("liners", soil sample monitoring)
  - soil activation is a potential problem in the collimator area
- Experimental backgrounds:
  - need 'clean' beams to allow good signal/noise ratio in experiments
  - keep false trigger rate small (dead time),
  - prevent detector trips (space charge)

RHIC overview: collimation system 2004 and upgrade



2000-2003:
1-stage system including bent crystal in 1 ring

2004:
Traditional 2-stage system with 2 horizontal and 1 vertical secondary collimators

2005:
Traditional 2-stage system with 2 horizontal and 2 vertical secondary collimators, intended for pp, were not used for HI

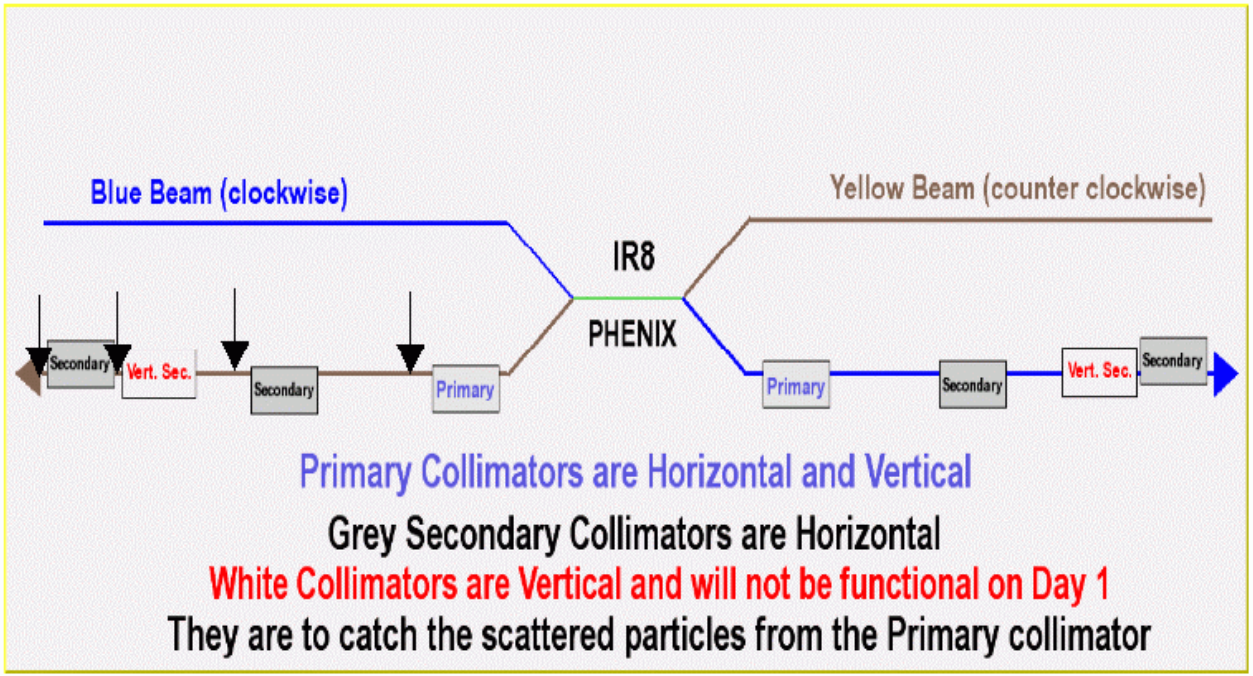
RHIC Collimator Configuration History

- RHIC was originally built with a 1-stage collimation system only:
  - 1 dual plane h/v scraper with 45 cm copper jaws, linear motion in both planes, skew motion only in horizontal
  - 1 bent crystal collimator for studies in 1 ring (yellow) only
- The system was upgraded after the 2003 run because of high experimental backgrounds and gap cleaning demands. Crystal approach proved non sufficient.
  - all collimators are single sided only

Collimator Section Layout

In the shutdown 2003-2004 the collimation system was upgraded to a conventional 2-stage system including new individual secondary collimators for both planes. The new system was first used in the run 2004 for both, Au and protons.

New Collimation System



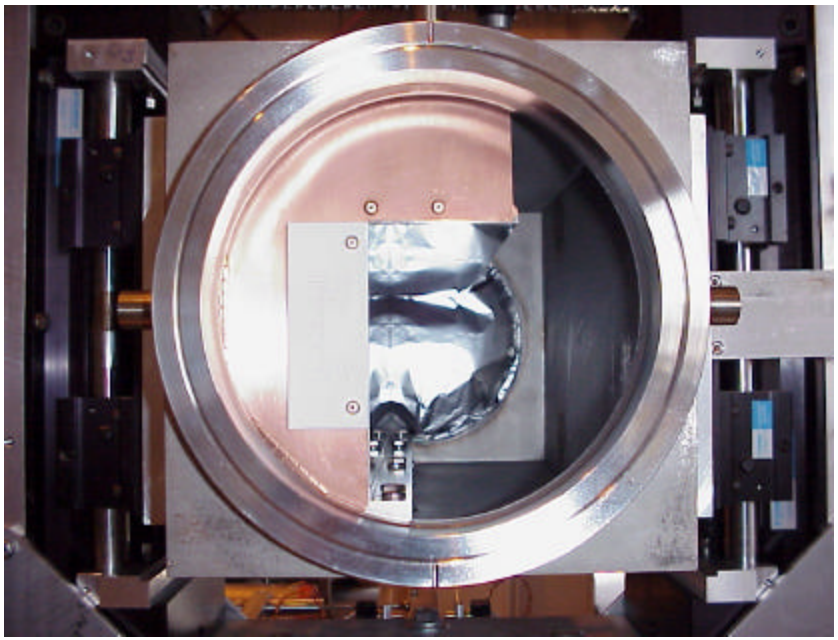
The positions in [m] from the IR are:

primary	41.2
1. secondary H	51.1
secondary V	57.3
2. secondary H	58.3

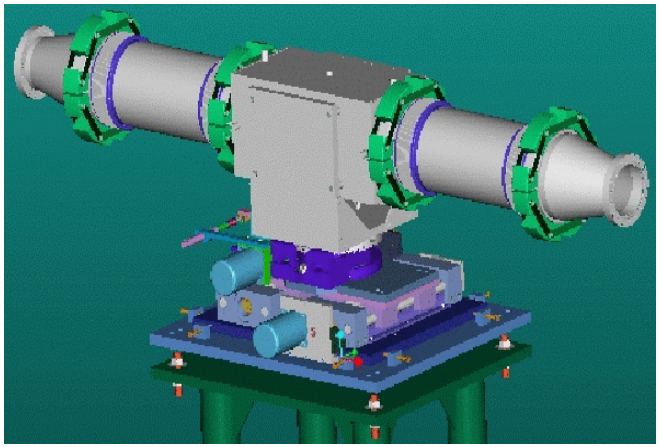
↓ position PD 1m downstream of collimator (or as much downstream as possible)

Collimator Design

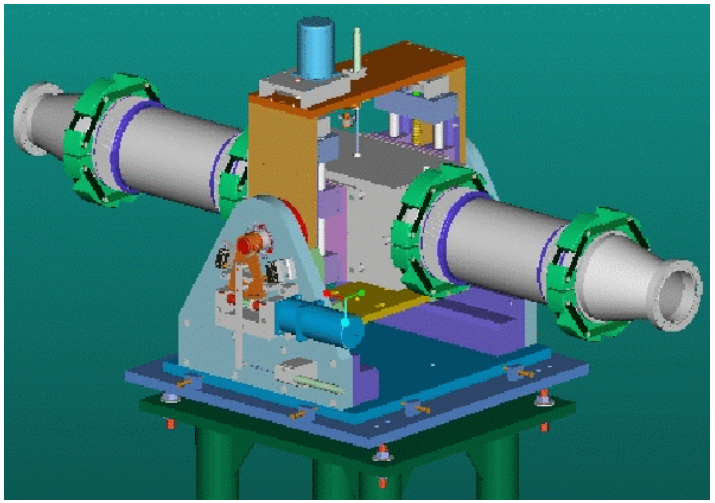
45 cm copper jaws
One side only
Rotatable, positioning: few μm



cross-section of the primary collimator (dual plane)



H



V

RHIC has many similarities with LHC

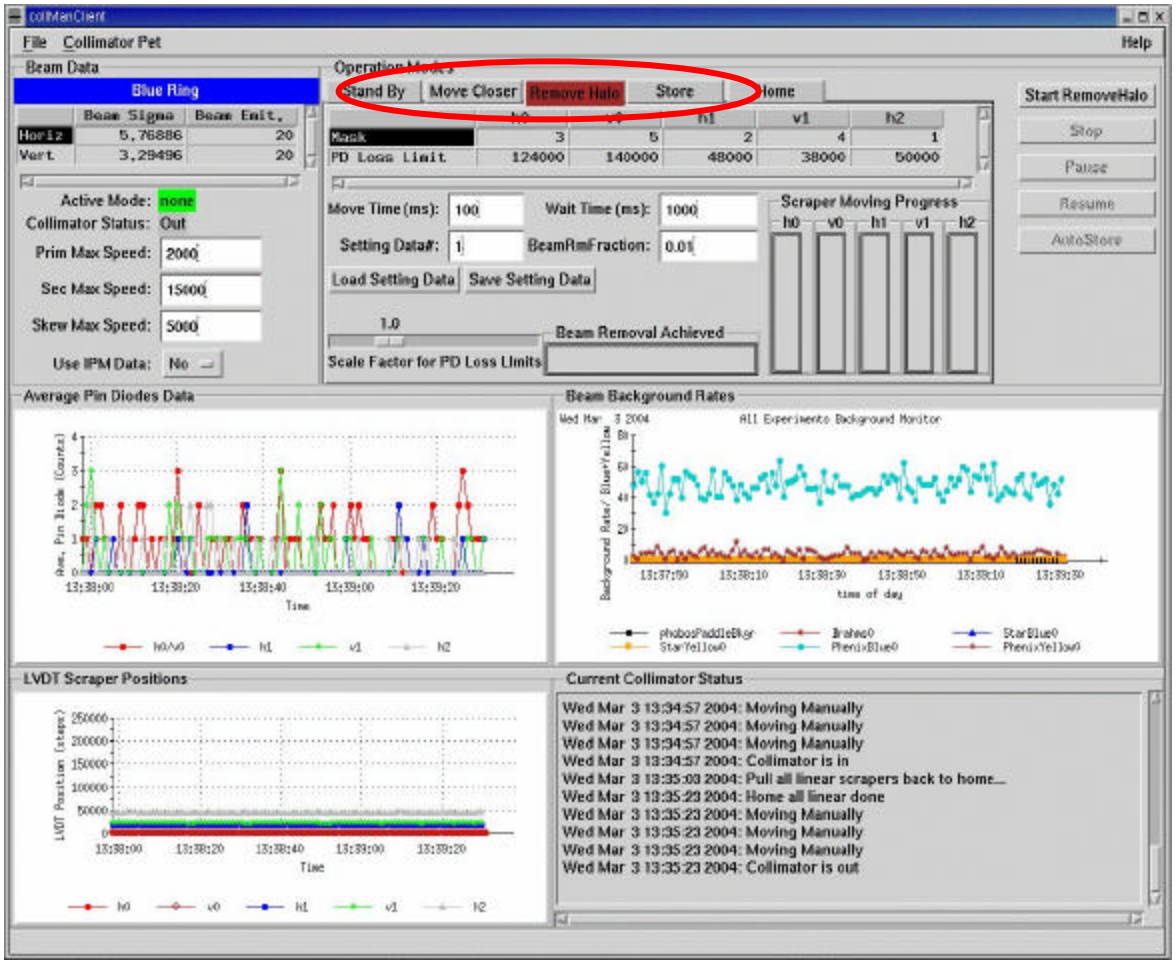
- Two intersecting superconducting rings
- Complex injector chain
- Operation with protons and heavy ions

But also differences

- The RHIC rings have magnets in separate cryostates,
  combiner/splitter magnets around IP's are the only common magnets
- RHIC is not in a deep tunnel, but just covered with soil
  ? radiation issues
- Purpose of collimation is mainly reduction of experimental backgrounds

	Circumference	Energy / nucleon	Stored energy / beam	rms Emittance	chamber width (arc)
	m	GeV/u	MJ	mm (norm,)	mm
RHIC p	3834	200	0.2	2.5-10	78
RHIC Au		100	0.2		
RHIC Cu		100	0.2		
LHC p	26659	7000	362	3.8	44
LHC Pb		2760	3.8	1.5	

Automatic Steering Algorithm



RHIC has 5 jaws per ring, most allow both, linear motion and angular motion (to parallelize with beam). Potentially time consuming!

=> 18 degrees of freedom
(+ 4 more next run)

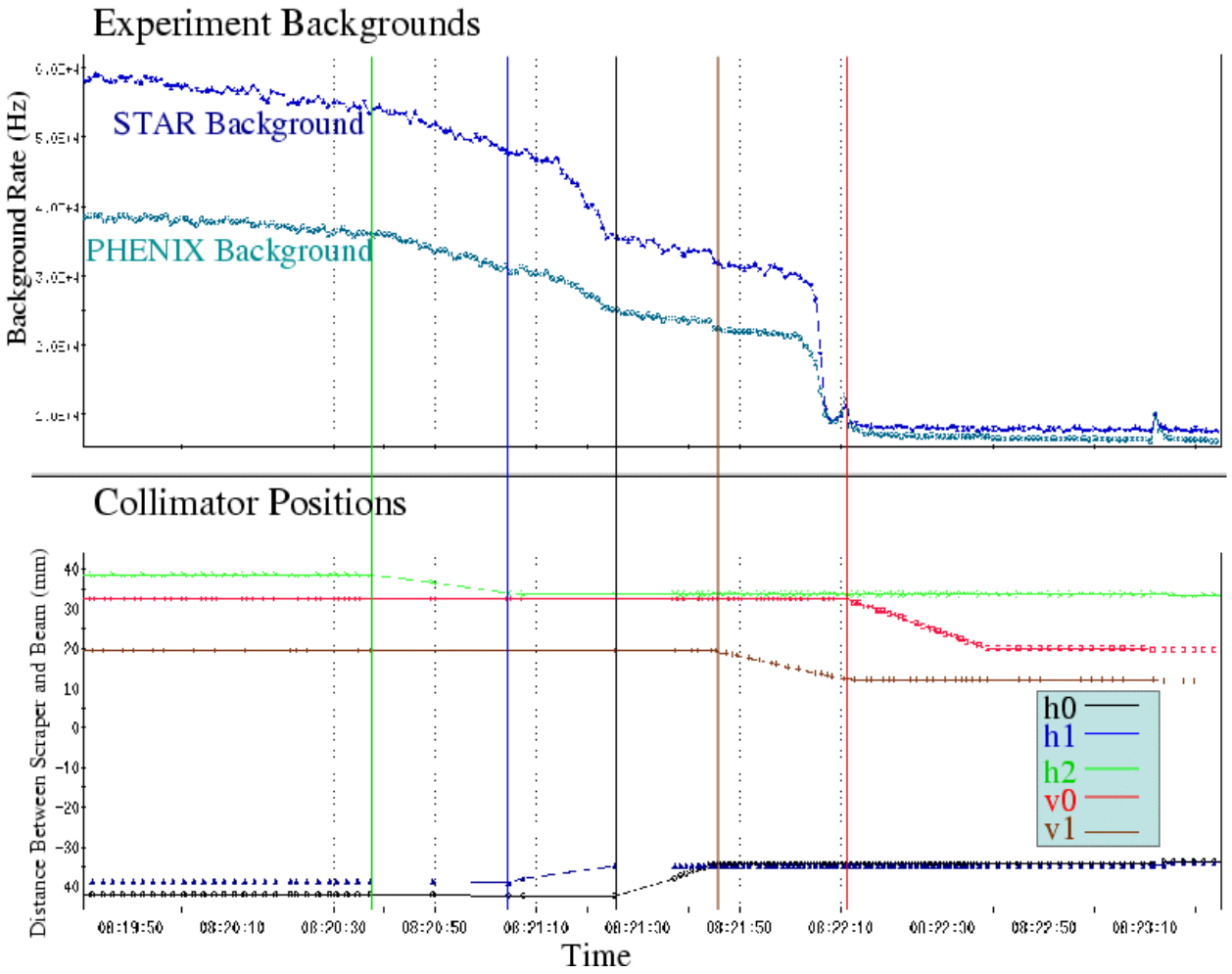
Requires automation (3 steps):

⇒ Move to **STDBY** position (based on BPM readings)

⇒ **Move Closer** to beam (based on loss monitor feedback, serial)

⇒ **Remove Halo/Store** (based on lattice functions, parallel)

Collimation during Fill 4854 (Au) in the blue ring



Serial collimator steering (mode: Move Closer), following parallel mode does not improve backgrounds.

Vertical lines denote when each collimator moves. Background improvement approx. x6.

Note: secondary vertical collimator quite efficient.

Comparison of Simulation with Measured Loss Maps

RHIC

Benchmarking of ICOSIM with RHIC HI data

- ***Concept:***
  compare loss maps measured with BLM's with those computed from ICOSIM

- ***RHIC has ion-chamber BLM's all around the rings.***
  Normally they cannot distinguish between losses in BLUE and YELLOW ring.

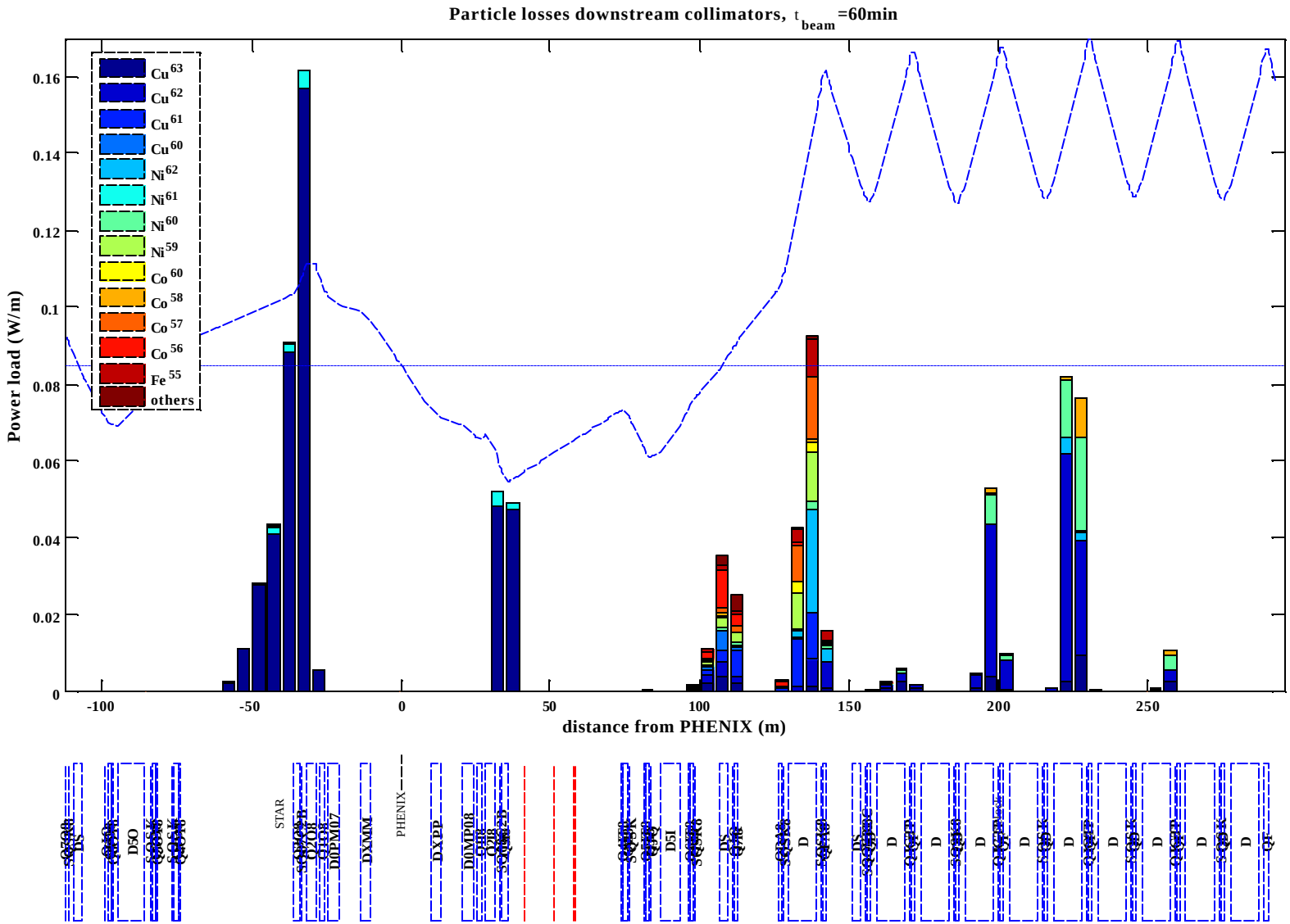
- ***During normal store BLM's on cryostats see nothing until something goes wrong.***

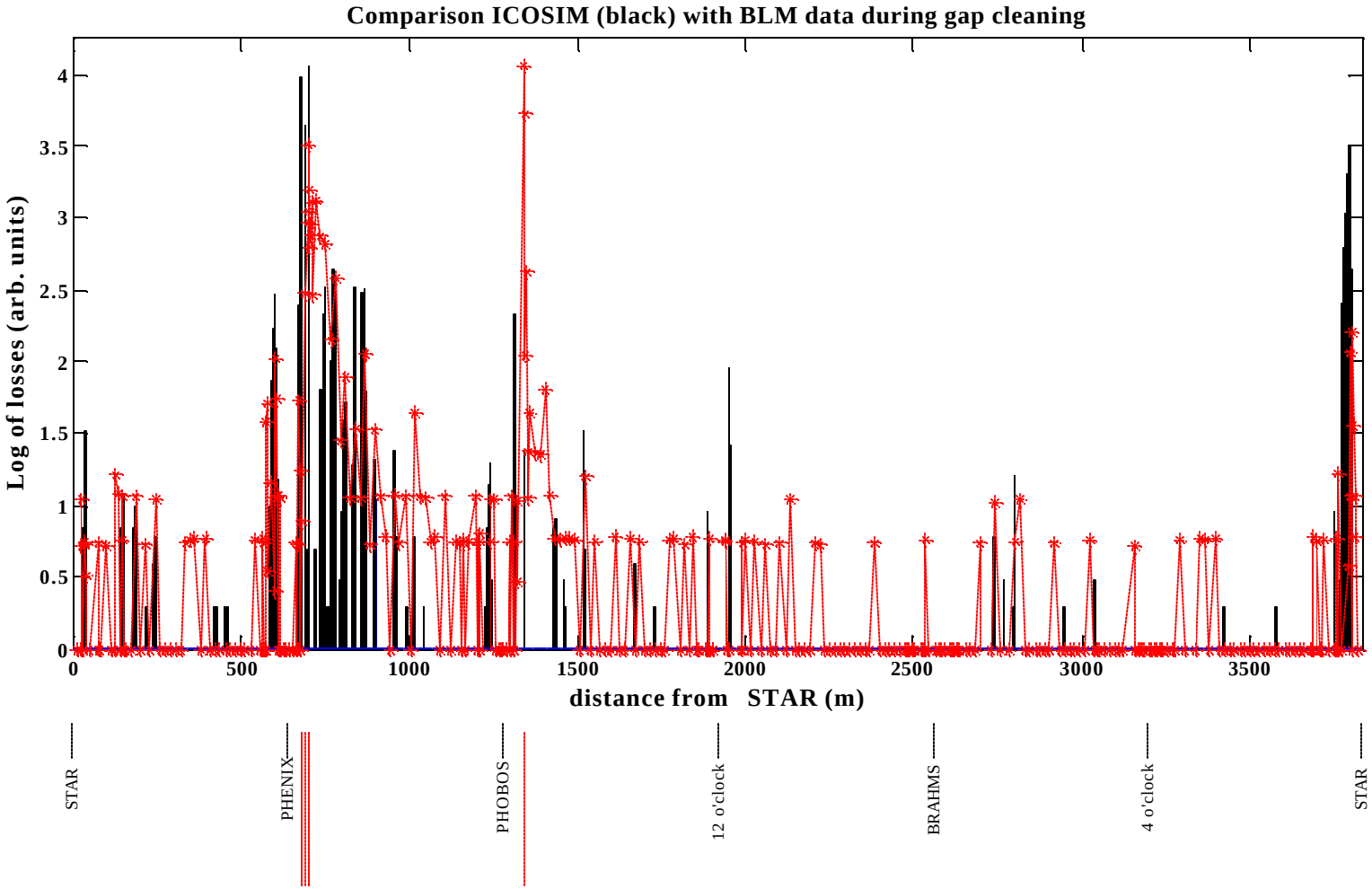
- ***Sometimes continues abort gap cleaning is off, but gap is cleaned before beam abort. This is a case when BLM signals go high and loss map for one ring can be obtained by subtracting loss map before cleaning from loss map during cleaning.***

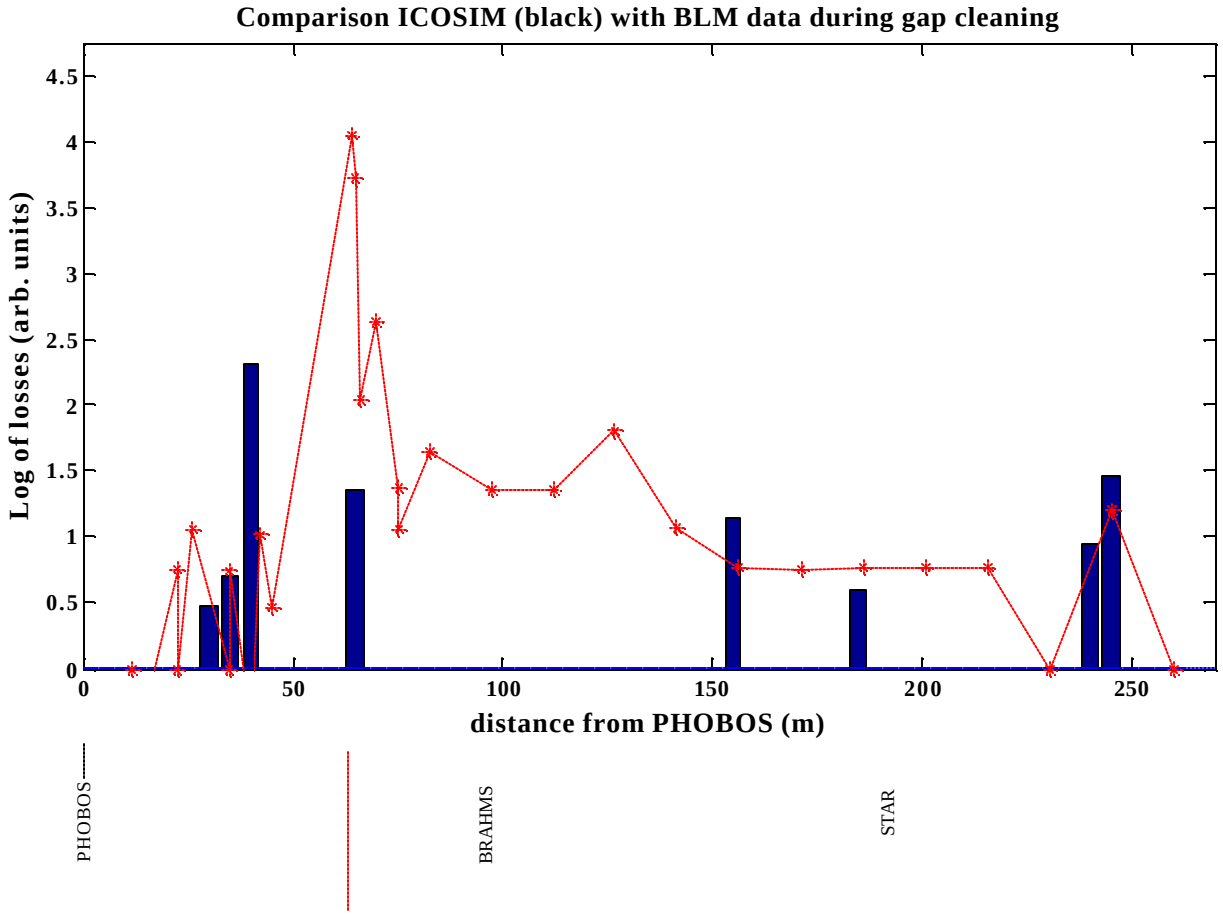
- ***To start with some existing log files of loss maps were used (from gap cleaning). Data obtained in a more controlled manner would be desirable.***

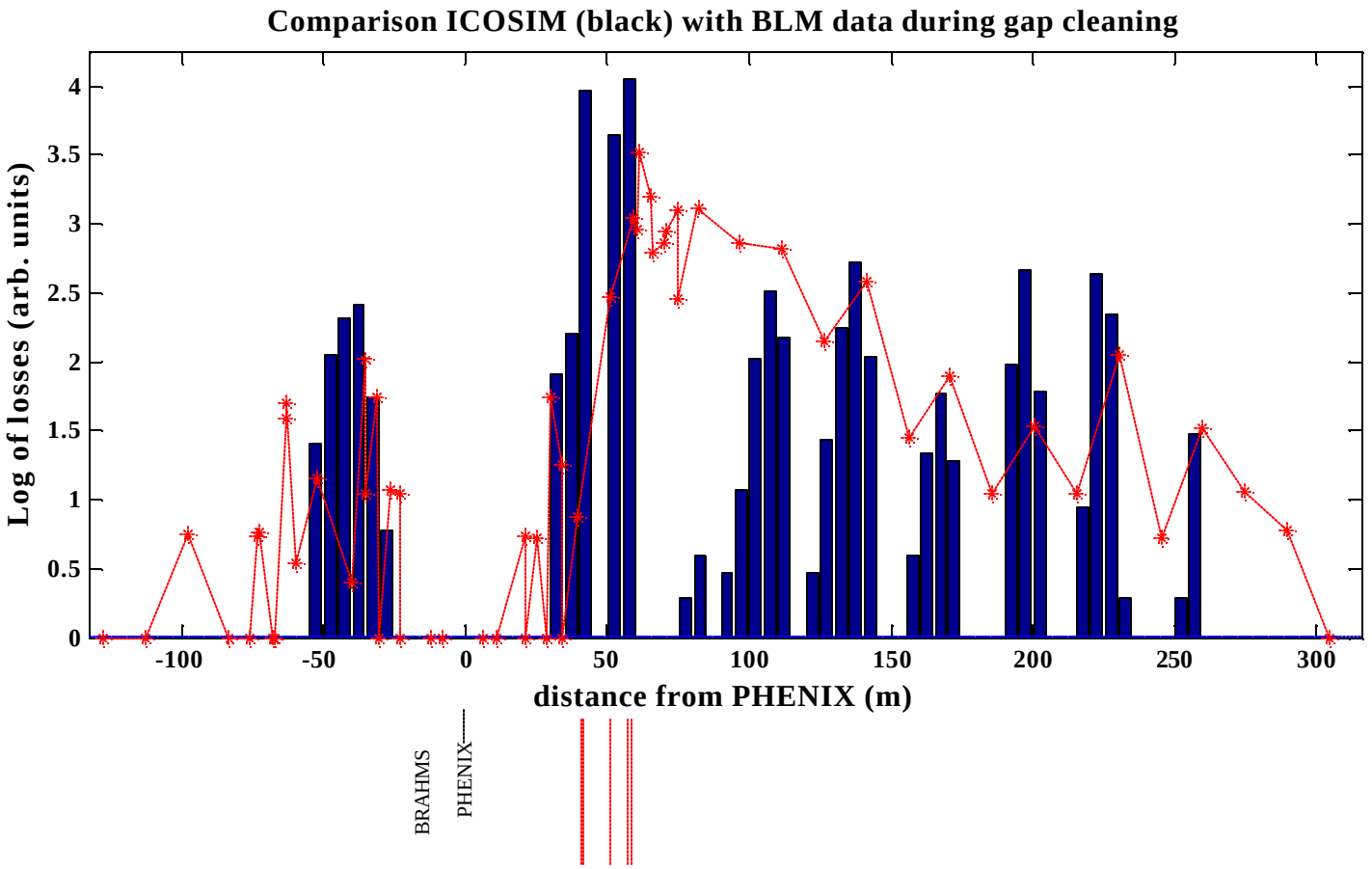
- ***An overall calibration factor and the ratio between BLM's on cold and warm sections were used as free fit parameters.***

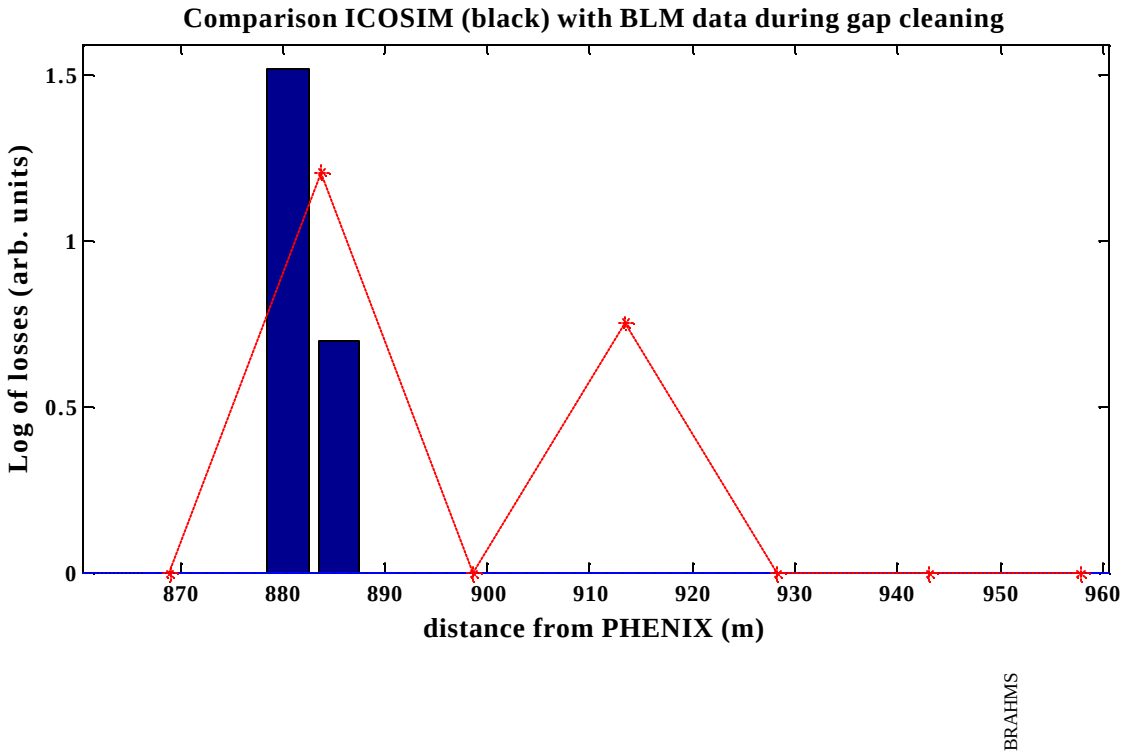
RHIC BLUE downstream of collimators during abort gap cleaning

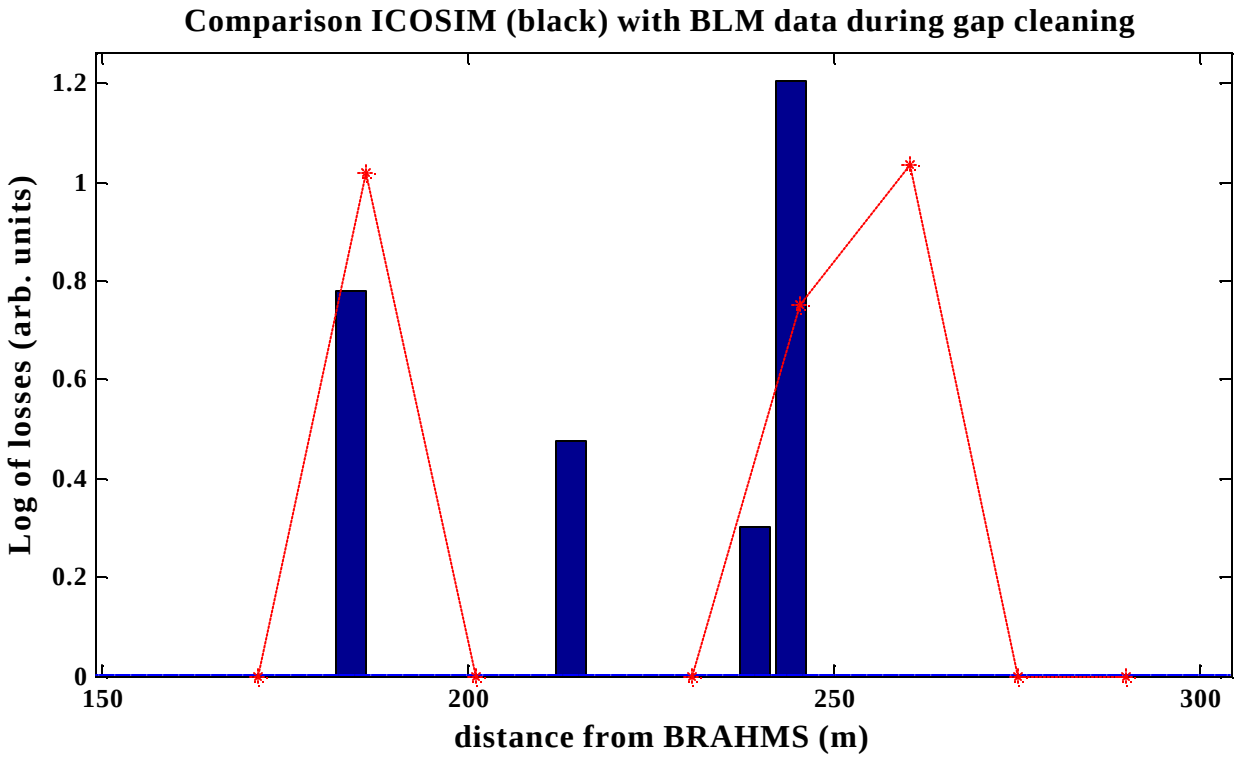


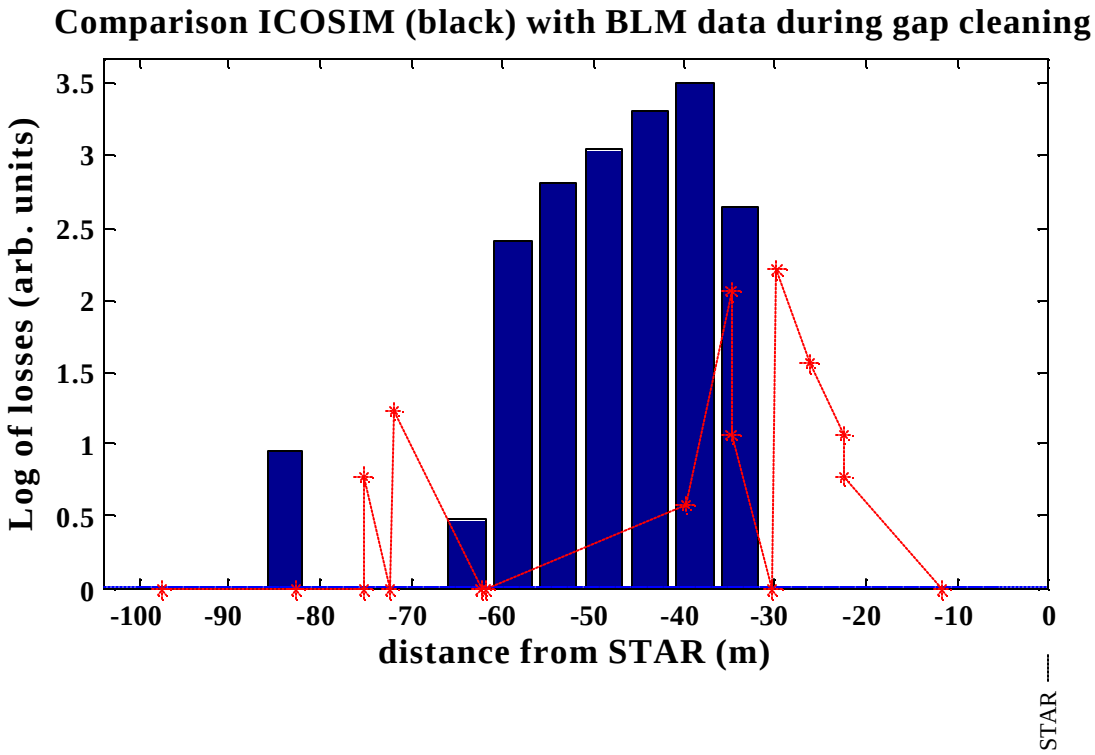

Comparison ICOSIM (black) with BLM data during gap cleaning
Log of losses (arb. units)
distance from STAR (m)
0
0.5
1
1.5
2
2.5
3
3.5
4
0
500
1000
1500
2000
2500
3000
3500
STAR
PHENIX
PHOBOS
12 o'clock
BRAHMS
4 o'clock
STAR

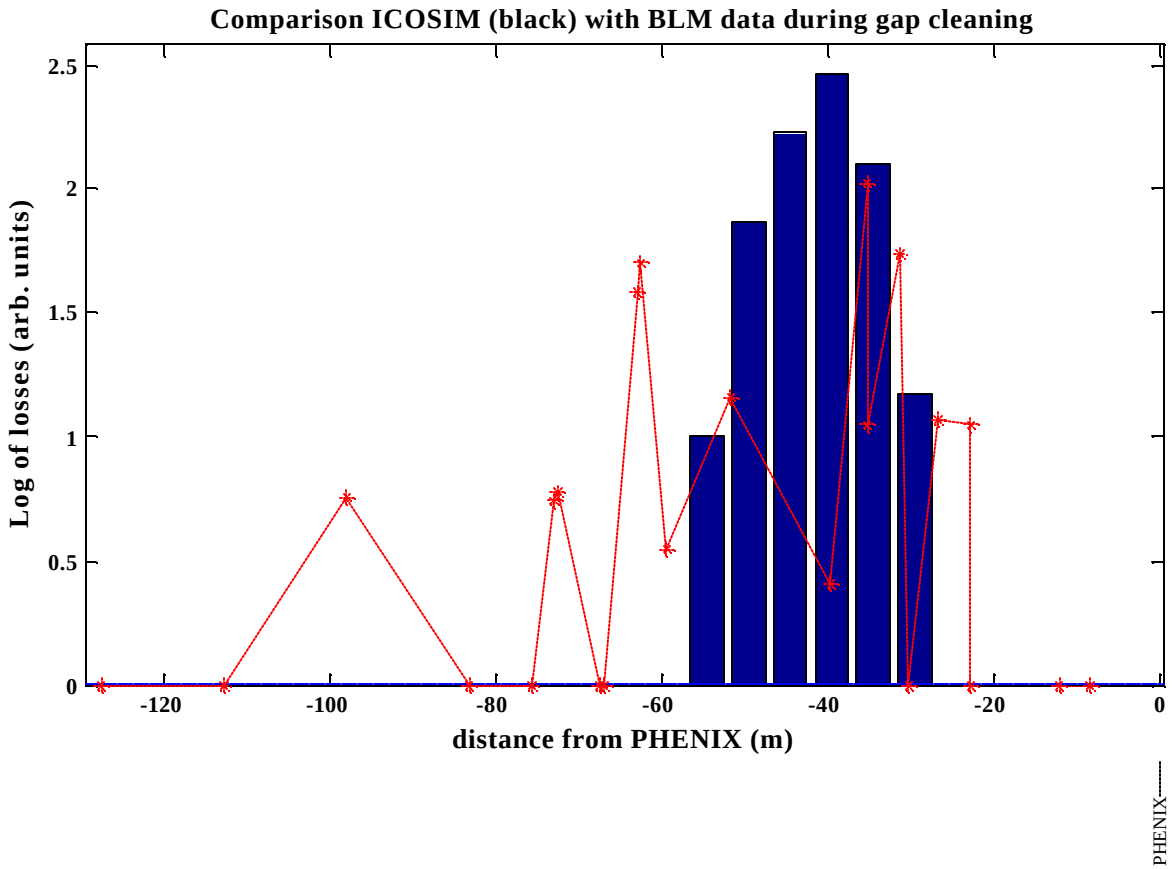

Comparison ICOSIM (black) with BLM data during gap cleaning
Log of losses (arb. units)
distance from PHOBOS (m)
PHOBOS
BRAHMS
STAR


Comparison ICOSIM (black) with BLM data during gap cleaning
Log of losses (arb. units)
0
0.5
1
1.5
2
2.5
3
3.5
4
-100
-50
0
50
100
150
200
250
300
distance from PHENIX (m)
BRAHMS
PHENIX

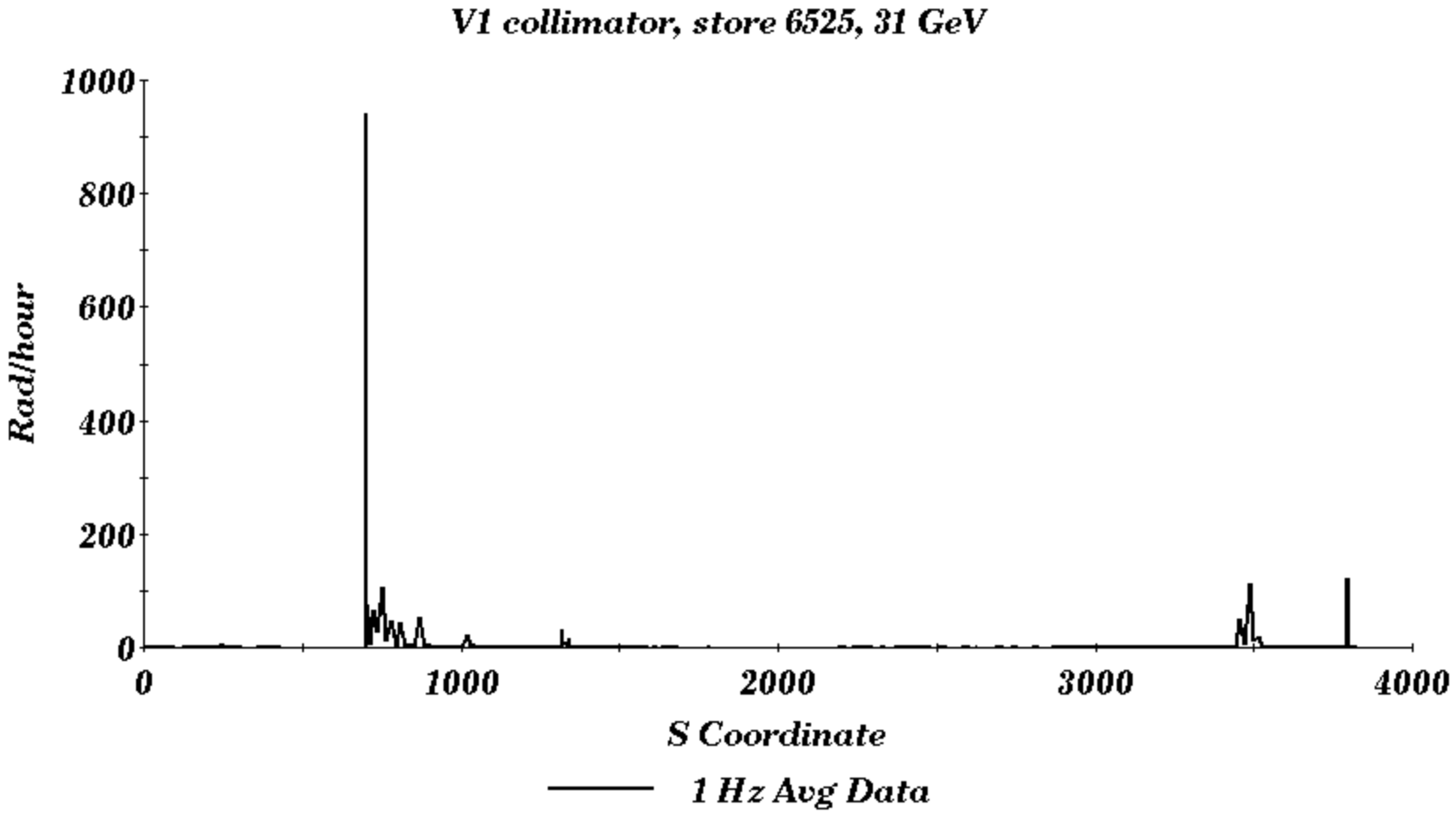

Comparison ICOSIM (black) with BLM data during gap cleaning
Log of losses (arb. units)
1.5
1
0.5
0
870
880
890
900
910
920
930
940
950
960
distance from PHENIX (m)
BRAHMS


Comparison ICOSIM (black) with BLM data during gap cleaning
Log of losses (arb. units)
1.2
1
0.8
0.6
0.4
0.2
0
150
200
250
300
distance from BRAHMS (m)


Comparison ICOSIM (black) with BLM data during gap cleaning
Log of losses (arb. units)
3.5
3
2.5
2
1.5
1
0.5
0
-100
-90
-80
-70
-60
-50
-40
-30
-20
-10
0
distance from STAR (m)
STAR


Comparison ICOSIM (black) with BLM data during gap cleaning
Log of losses (arb. units)
2.5
2
1.5
1
0.5
0
-120
-100
-80
-60
-40
-20
0
distance from PHENIX (m)
PHENIX

Single Collimator Loss Maps (Cu, 31 GeV, 1 beam)



Conclusions on HI benchmarking

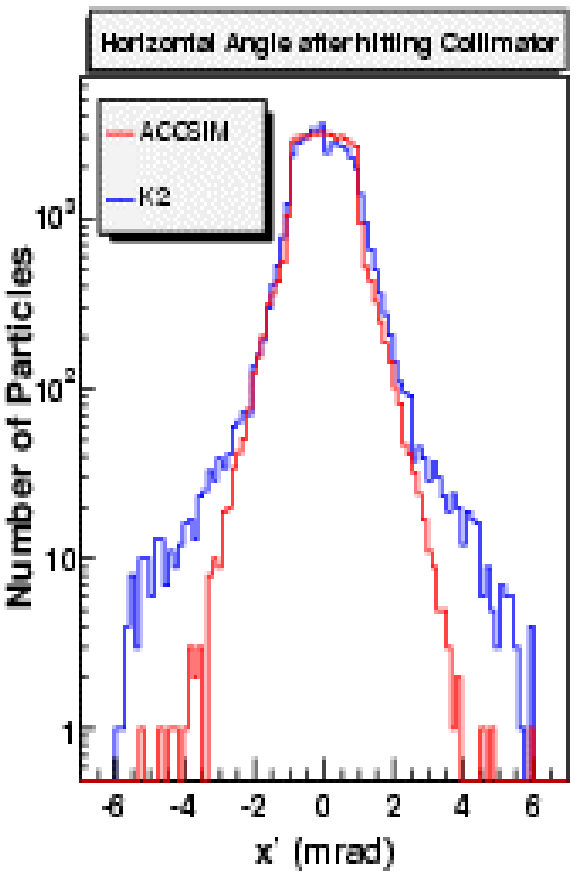
- First comparisons show that ICOSIM results are not unreasonable
- For RHIC parameters the separation between different ion species is less pronounced. Therefore difficult to get results on ion fragmentation in different channels.
- More data with better controlled conditions i.e. loss maps with only one collimator in and all others out, are available now for Cu (different energy!)
- analysis done at CERN with input from BNL
- need to import/install code to RHIC

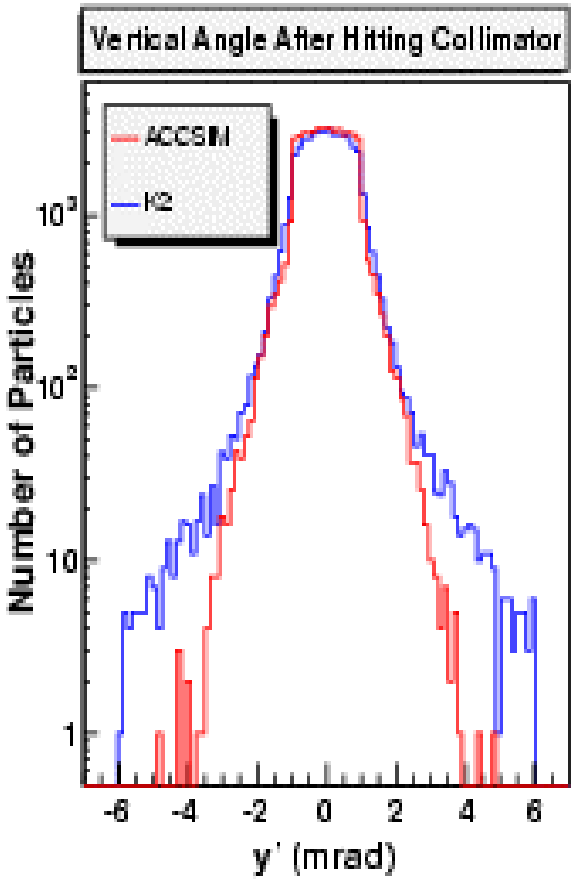
Programs used at BNL for Collimator simulation (so far)

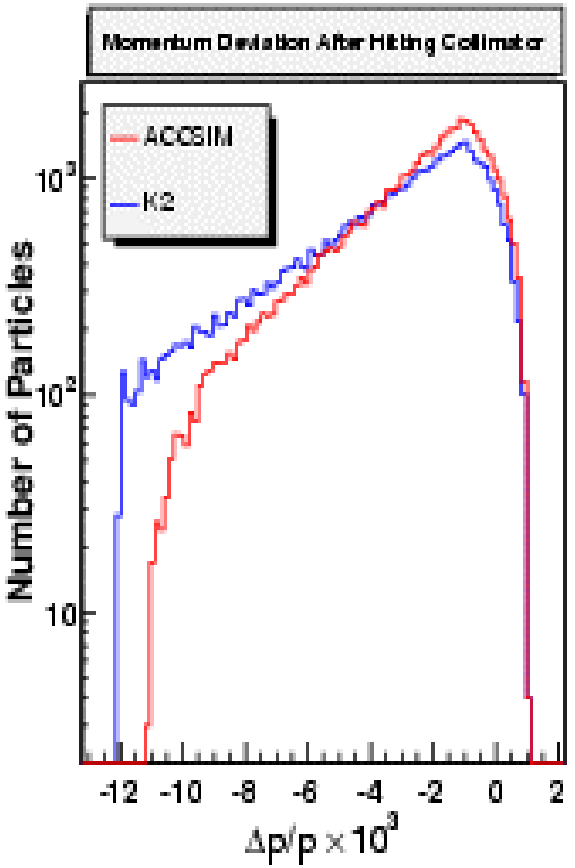
- Teapot – used to track particles around accelerator. Part of UAL framework.
- K2 – used to track protons in collimator. Not part of UAL.
- ACCSIM – used to track protons in collimator. Part of UAL.

K2 and ACCSIM simulate protons ONLY. Heavy Ions are not simulated at all. So far, our simulations assume scrapers are perfect absorbers.

Comparison of ACCSIM and K2: Output

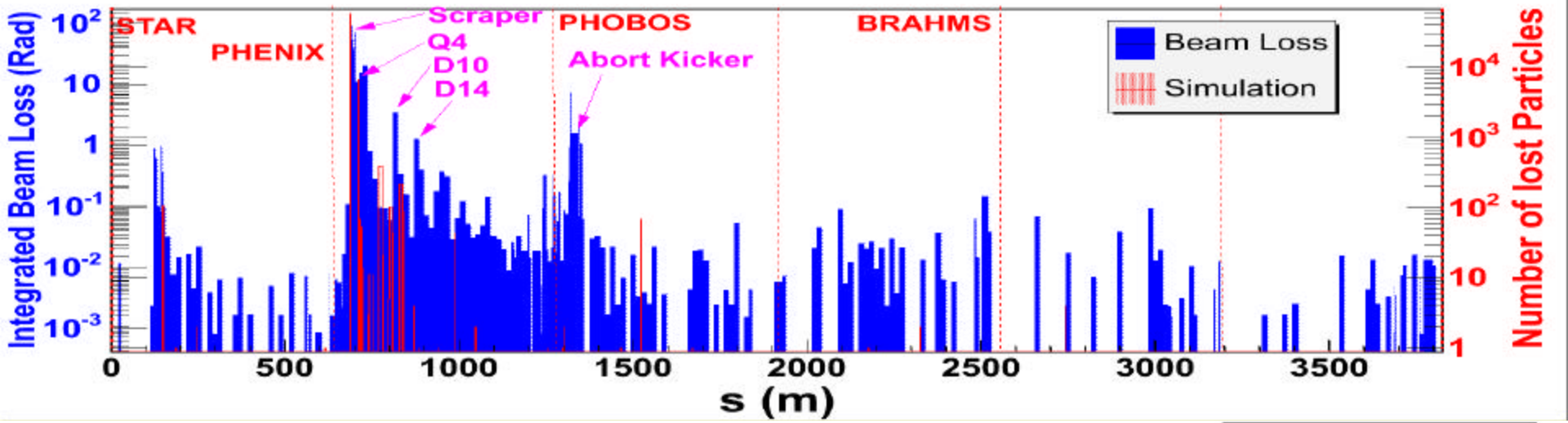


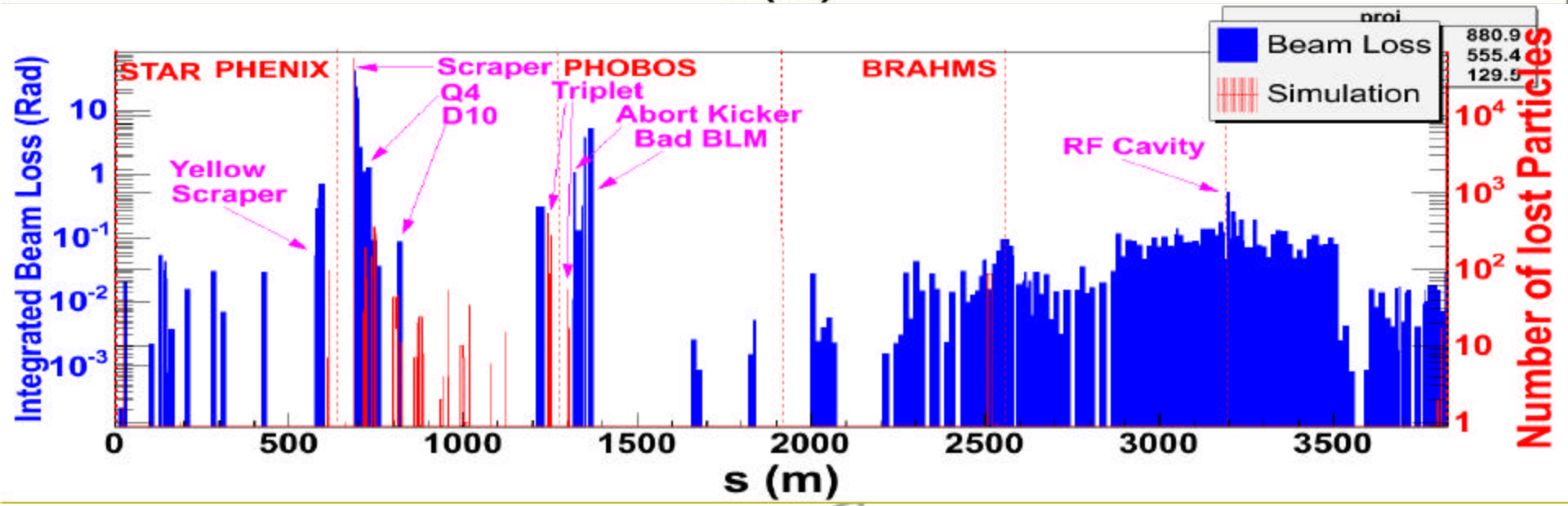




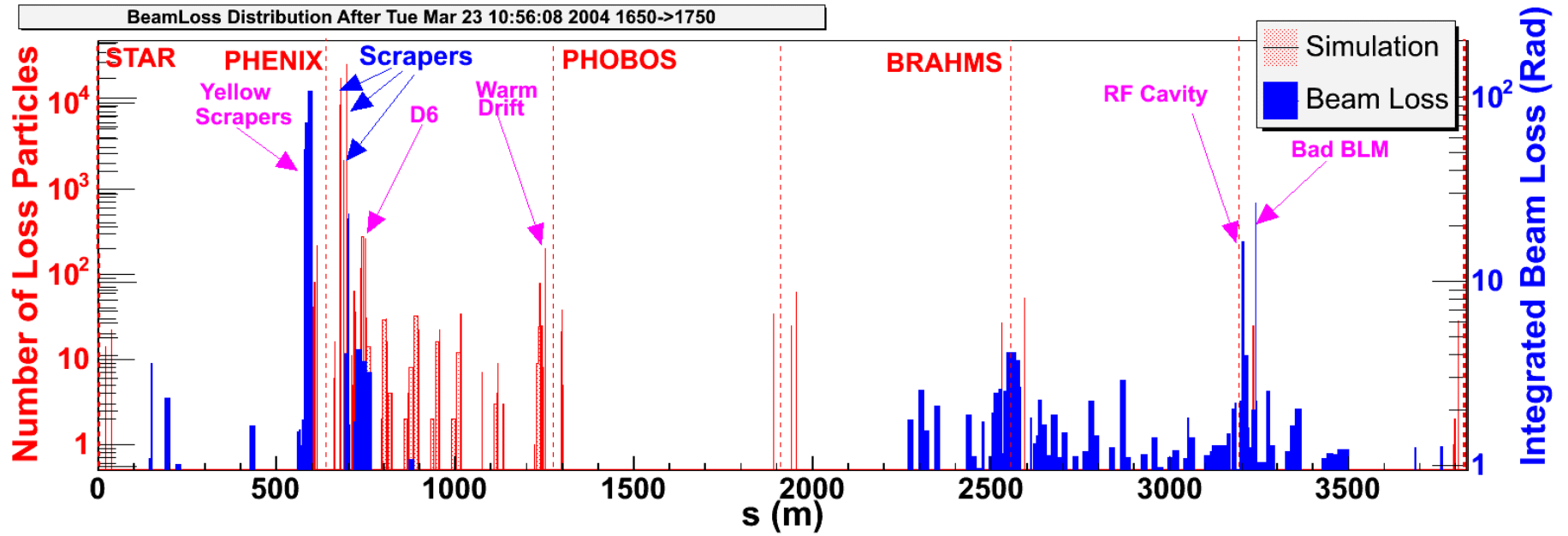
K2 angle distributions have larger tails. Approximately 50 particles in the K2 tail are not shown The energy distributions are different. K2 has a much larger tail, 3% of the particles in the K2 tail have $\Delta p/p<-12x10^{3}$.

Loss Maps with 1-stage system, (different

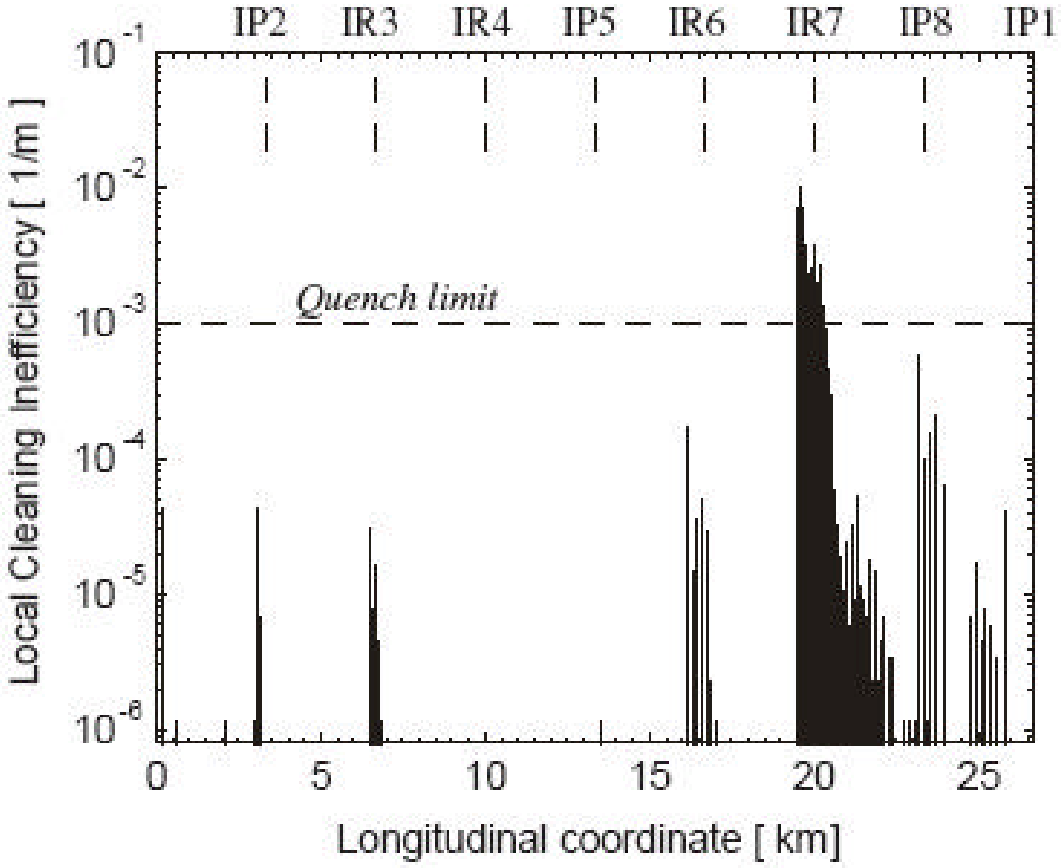




Loss Map with 2-stage system



Simulated Loss Map at LHC Injection (450 GeV)



Courtesy of G. Robert Demolaize

Conclusion for pp loss maps & simulations

- We don't have sixtrackwColl simulations for RHIC (yet)
- teapot+K2 simulations only gets to the 'ballpark'
- Dedicated loss maps needed (1 jaw, 1 beam) with protons, data will be taken during ongoing pp run (we are still in setup!)
- code (sixtrackwColl) at BNL needs to be updated, RHIC lattice has to be fully implemented
- single jaws are implemented, need testing
- collaborator from CERN is coming after PAC for 3 wks
- after hire freeze new efforts going on to get exclusive LARP grad student and/or postdoc (Toohig fellow?)