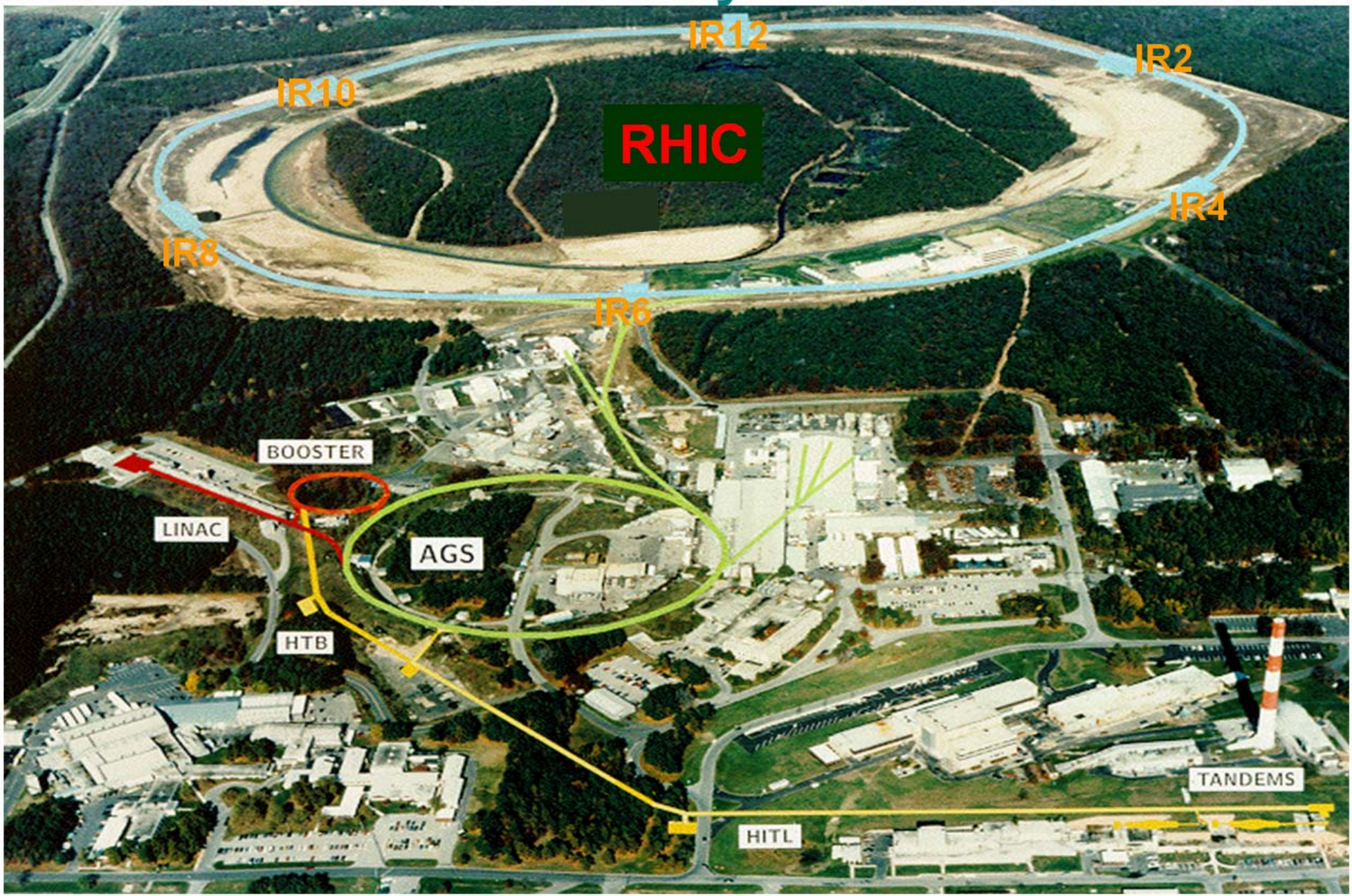
Summary of the RHIC Performance during the FY07 Heavy Ion Run

- RHIC HI Operation
- Expectations and goals for Run 7
- Run-7 achievements
- Conclusions

Angelika Drees

Relativistic Heavy Ion Collider



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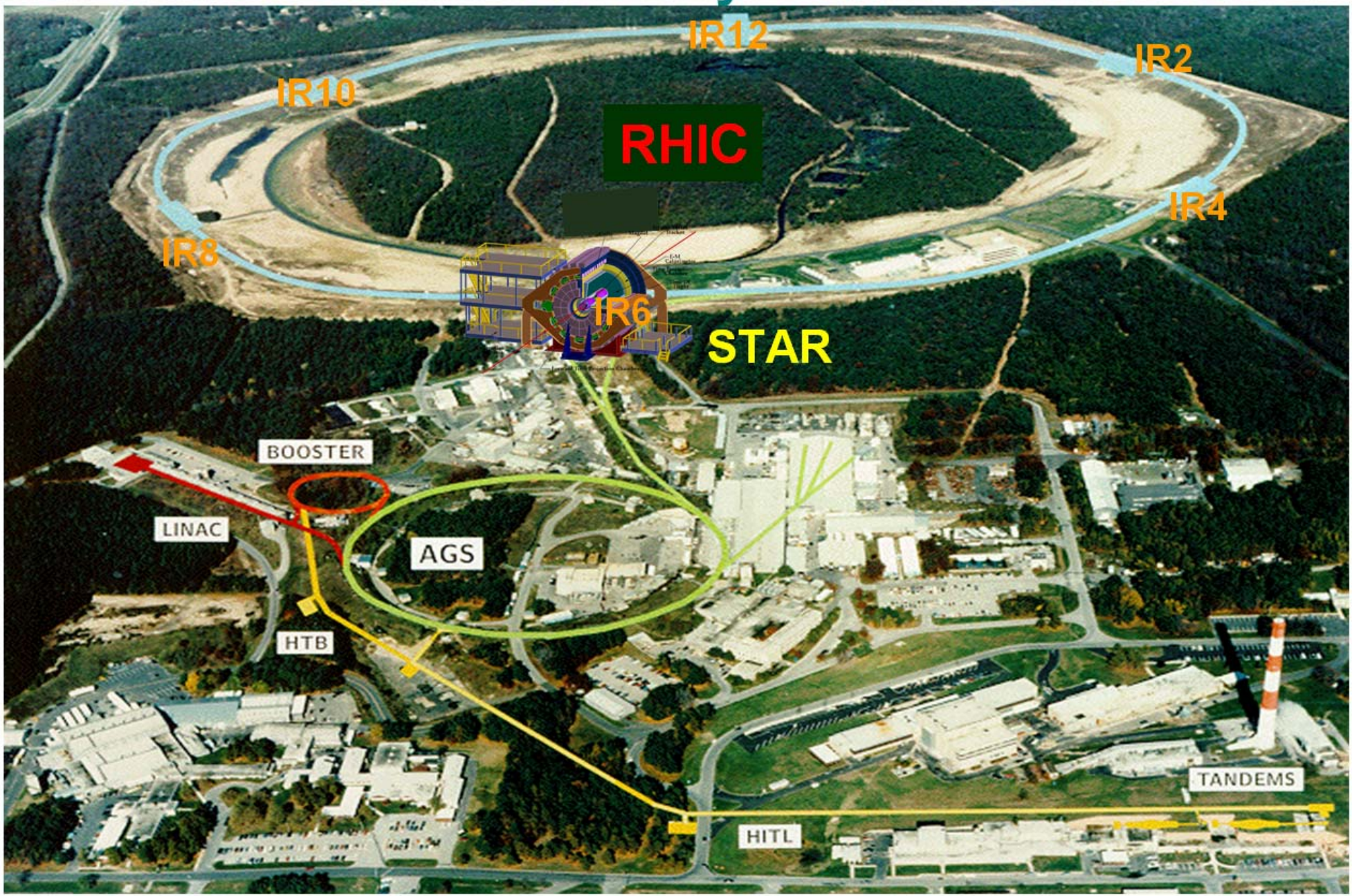

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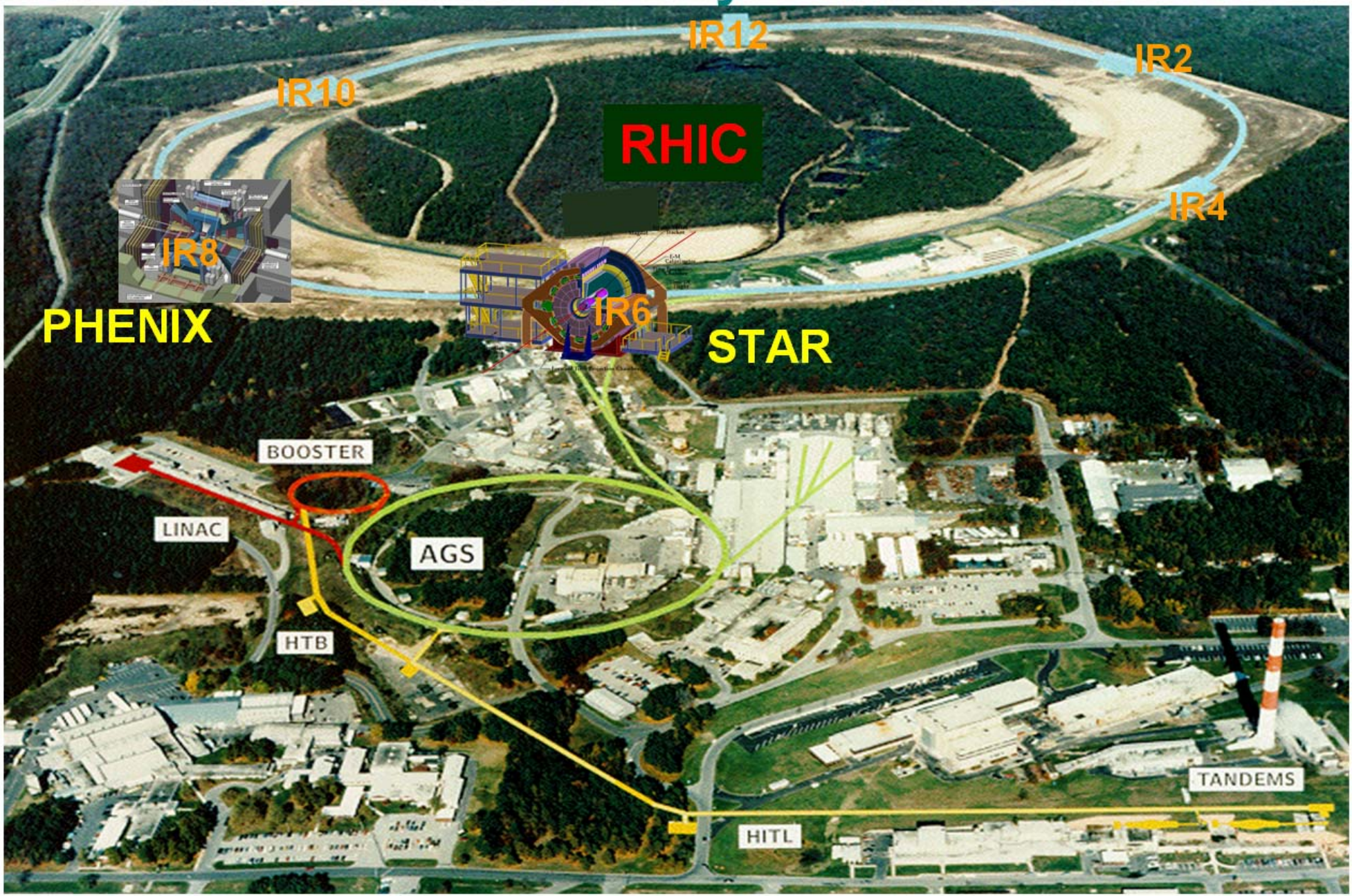

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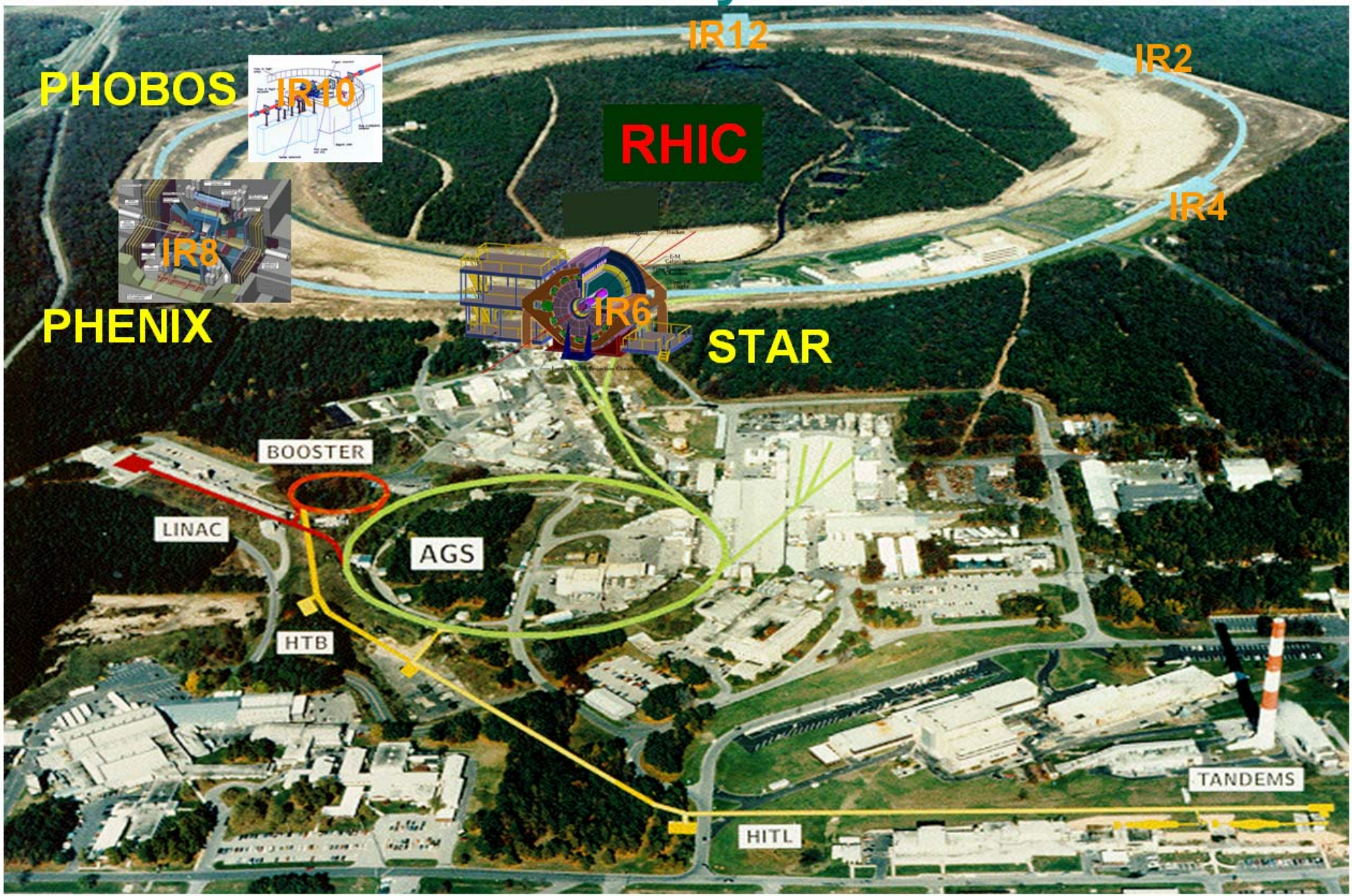

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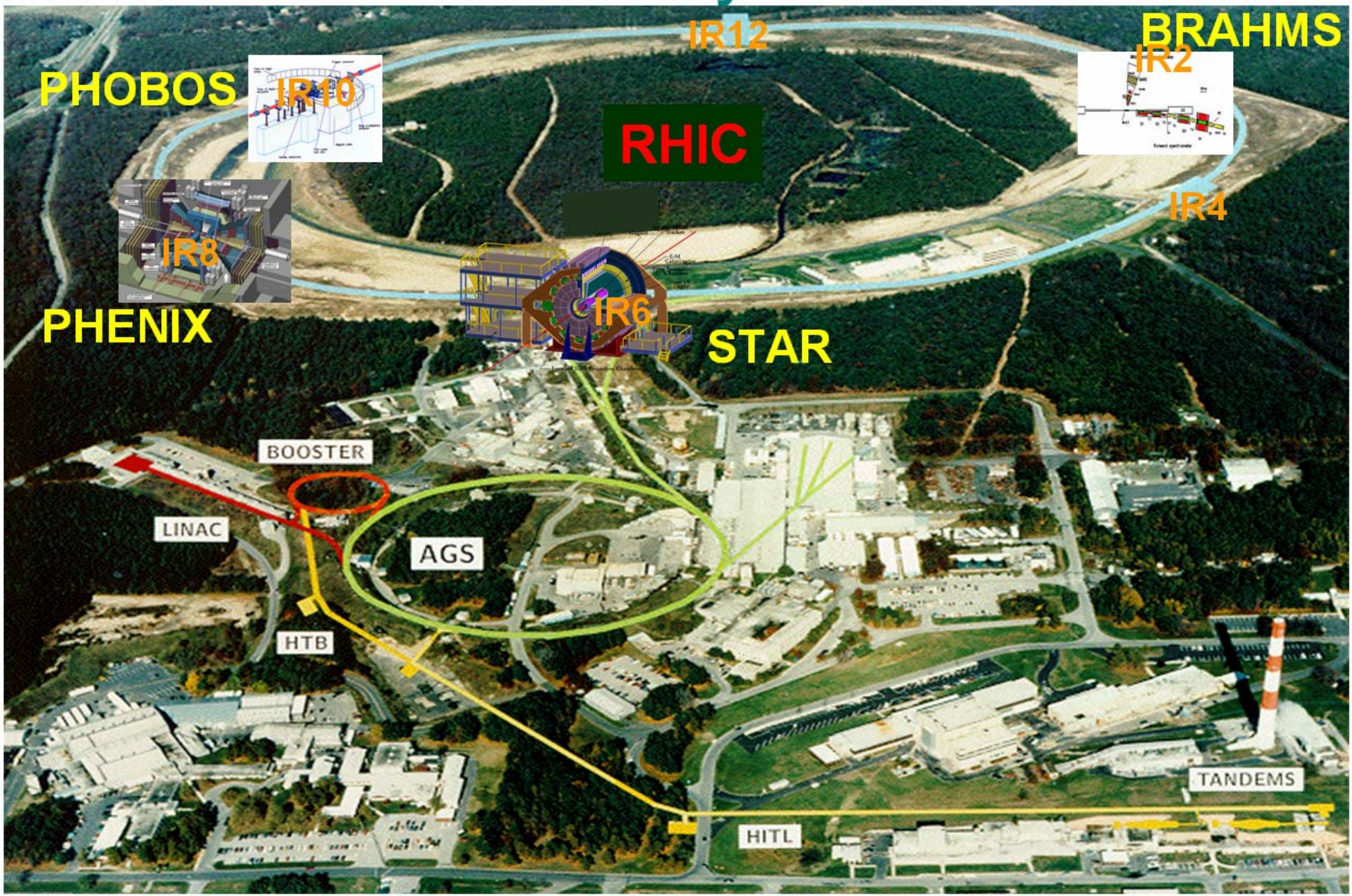
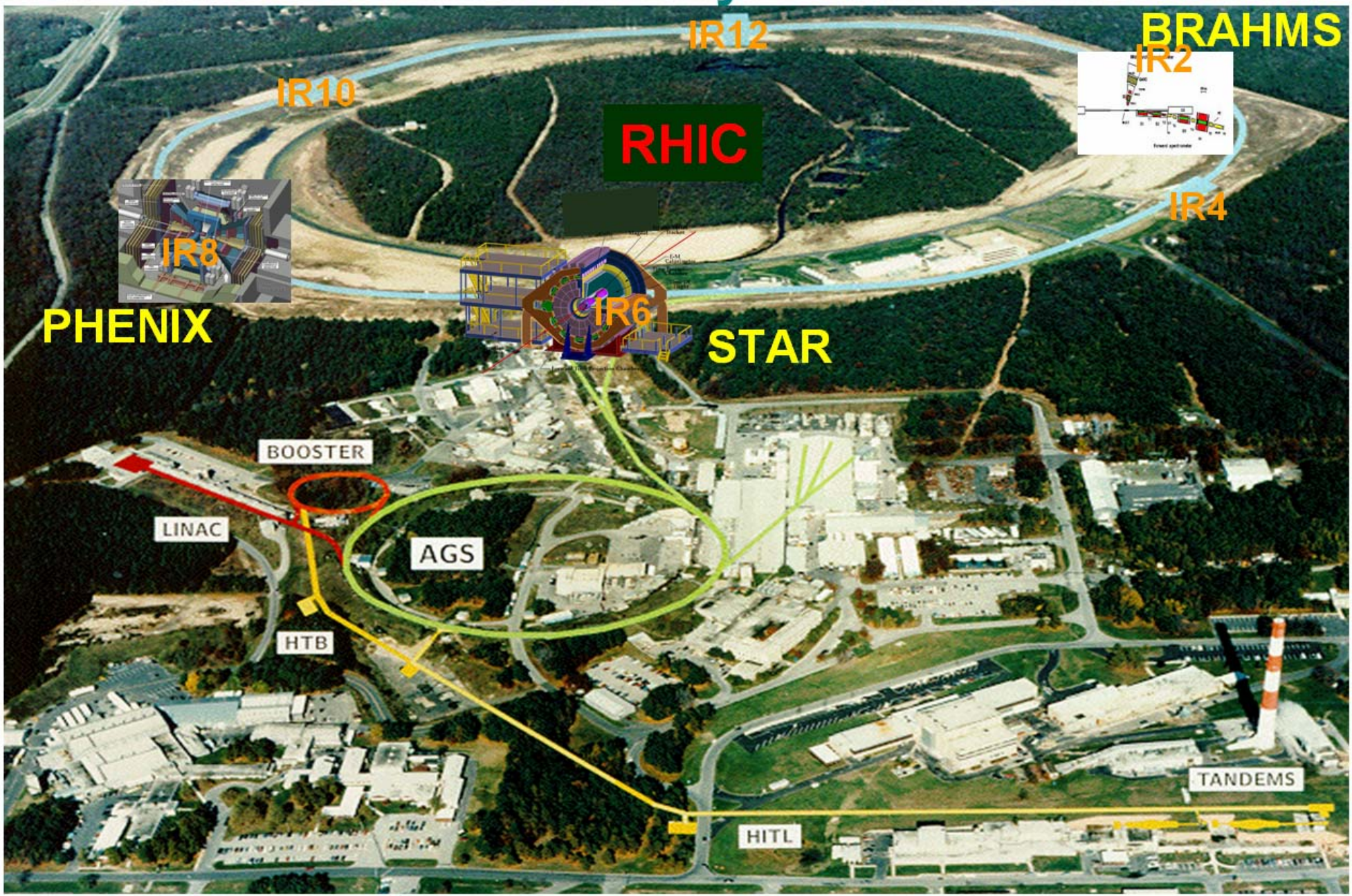


Relativistic Heavy Ion Collider



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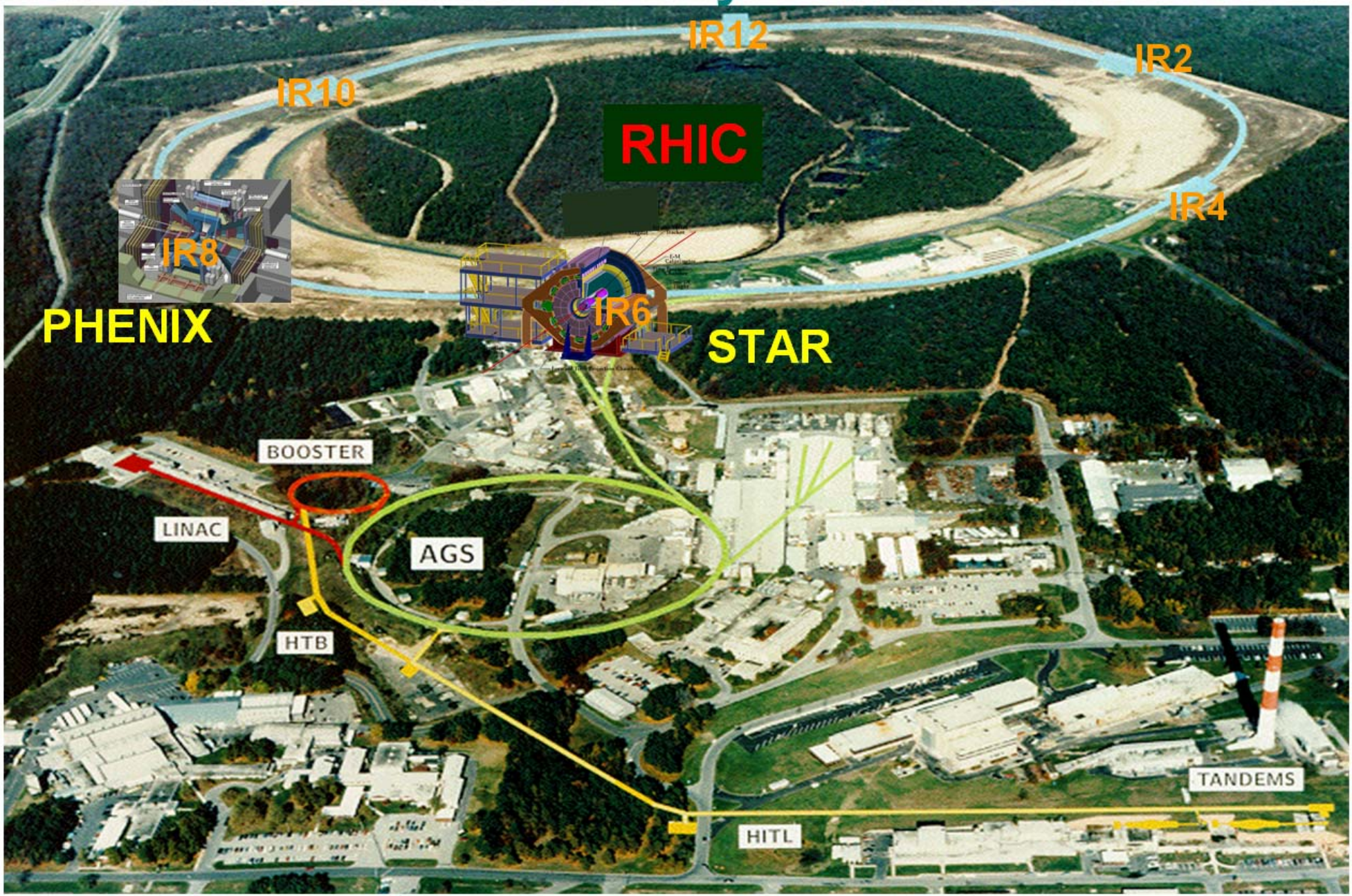

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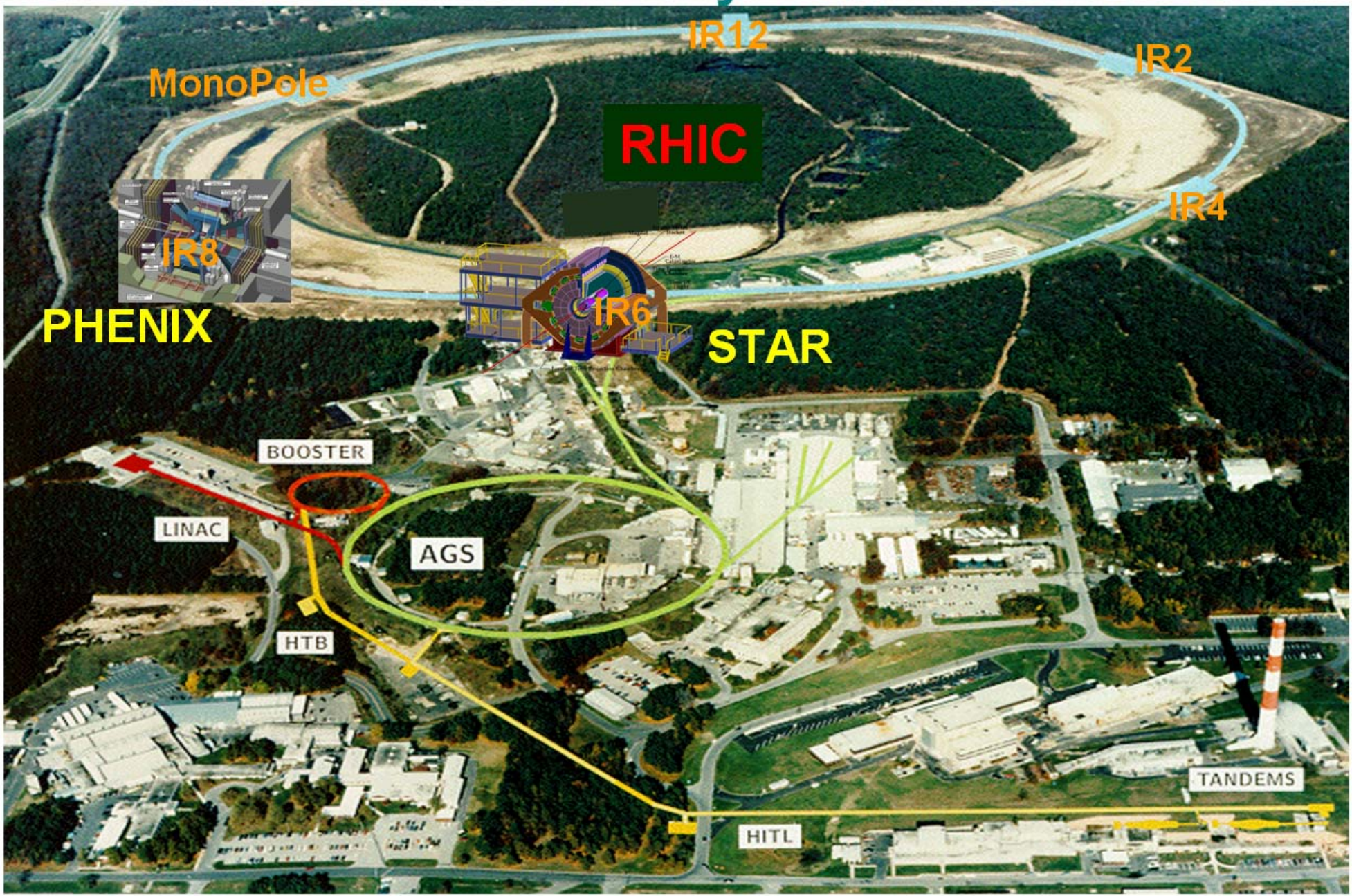

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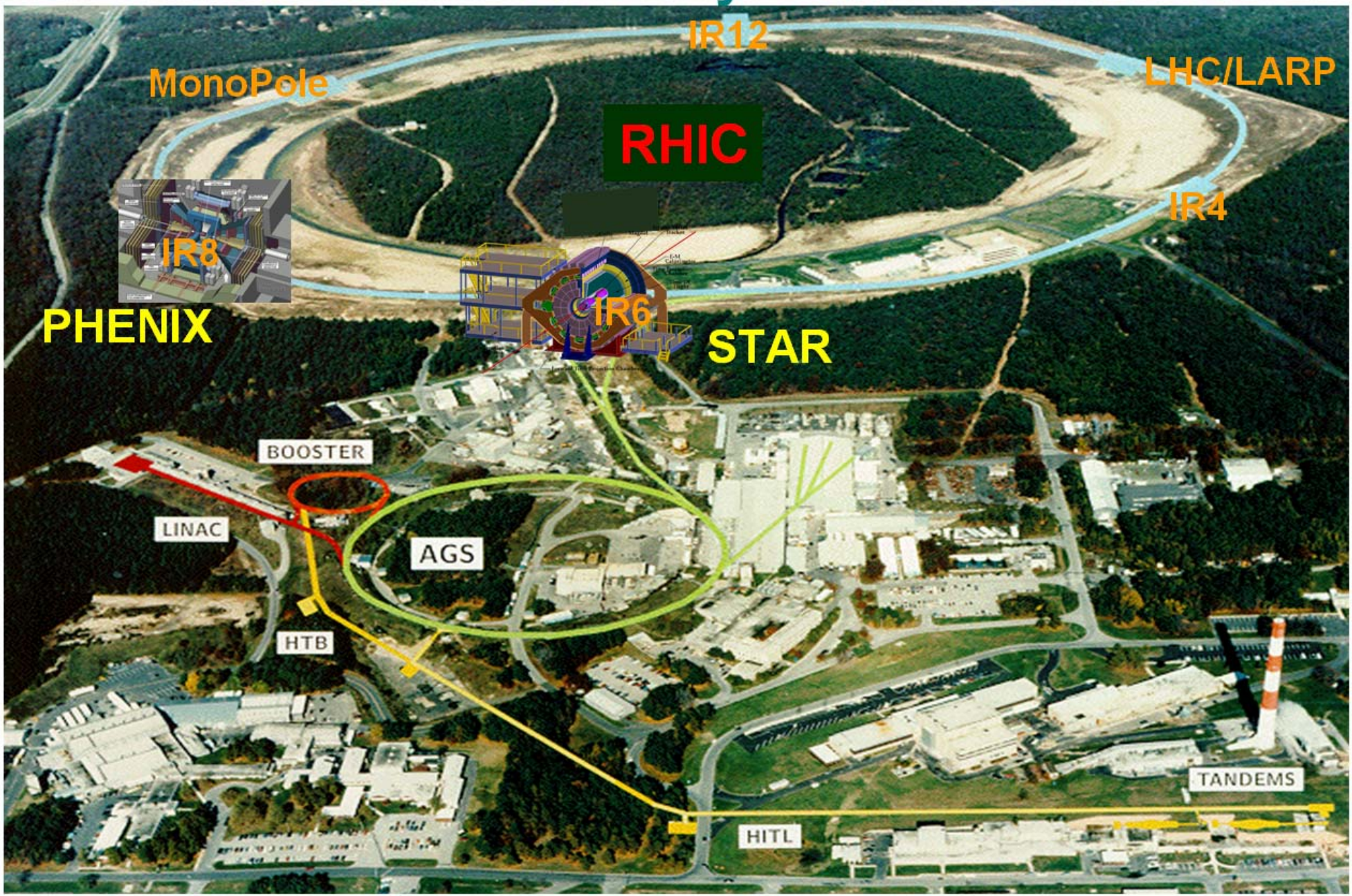


Achieved beam parameters for Run7

- Avg. Luminosity gain: x2-3
- Int. Luminosity gain: x2
- Peak Luminosity gain: x2-2.5
- Reached maximum
  - Number of bunches
  - Transition crossing/bunch intensity
  - Luminosity lifetime? -> cooling
- **We reached the enhanced design goal**

run	year	$\beta*$ (m)	no. of bunches	ions/bunch 10^9	$\epsilon_{x,y}^{norm.}$ (π mm mrad)	$\mathcal{L}_{peak}$ (10^{26}cm^{-2}s^{-1})	$\mathcal{L}_{avg.}$	$\mathcal{L}_{week}$ (μb^{-1})
design		2	55	1.0	15-40	9	2	50
enhanced design		1	111	1.0	15-40	30	8	300
Run-2	FY2001/02	1	55	0.5	15-40	3.7	1.5	24
Run-4	FY2004	1	45	1.1	15-40	15	5	160
Run-7	**FY2007**	**0.8 (1.1?)**	**111**	**1.1**	**15-40**	**30**	**10-14**	**200-400**

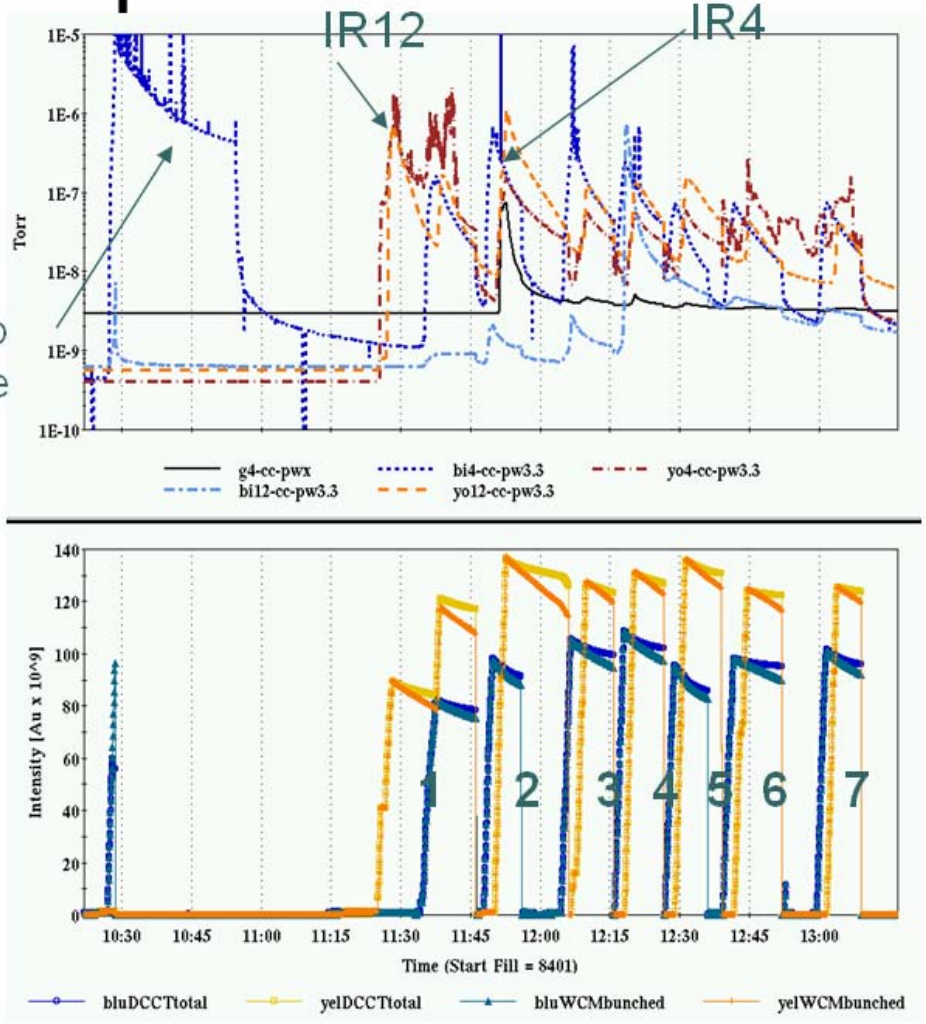
Expectations and Goals for Run-7

- Do better than Run-4
- Increase number of bunches to 111
- Reach 60% time at store on average
- Reach avg. luminosity/store
  - > 8 10^{26} cm^{-2} s^{-1} routinely
- Reach peak luminosity/store
  - > 30 10^{26} cm^{-2} s^{-1}
- Increase bunch intensity

Expectations and Goals for Run-7

- Do better than Run-4 — yes
- Increase number of bunches to 111 — yes
- Reach 60% time at store on average — no
- Reach avg. luminosity/store — yes
  - > 8 10^{26} cm^{-2} s^{-1} routinely
- Reach peak luminosity/store — yes
  - > 30 10^{26} cm^{-2} s^{-1}
- Increase bunch intensity — not really

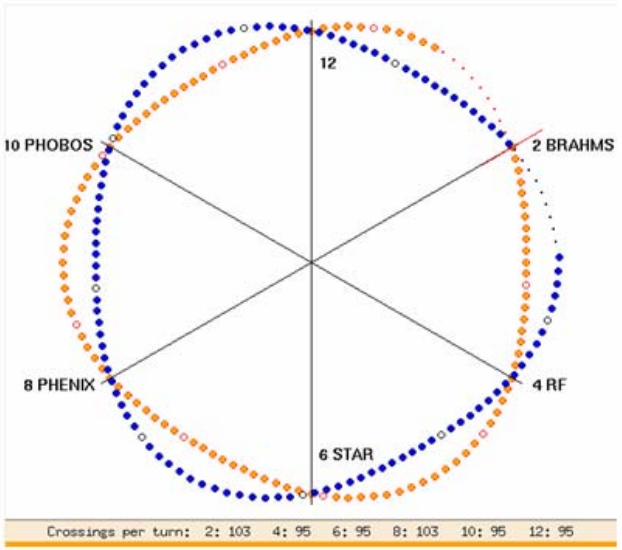
Scrubbing at the beginning of the run



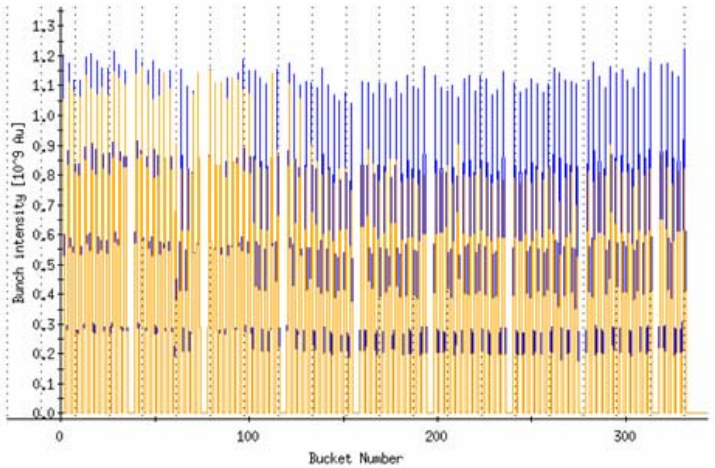
Before we could go for higher bunch numbers:

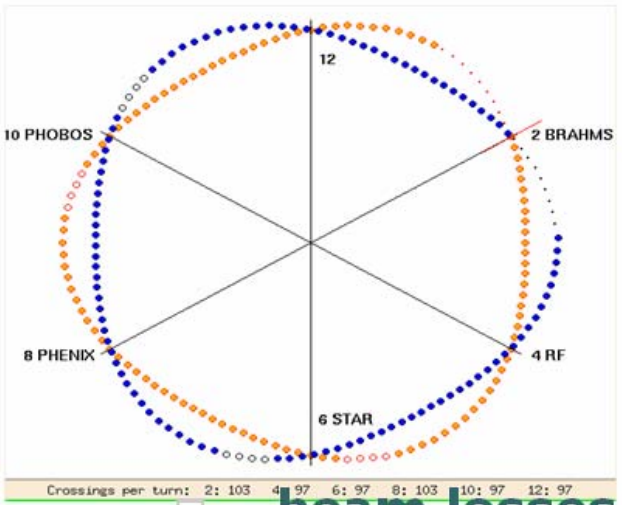
- Pressure bump moves from IR12 to IR4
- Pressure bump reduces after 4th high intensity injection
- Spend a total of 2 hours

Total Bunch Number 111->103

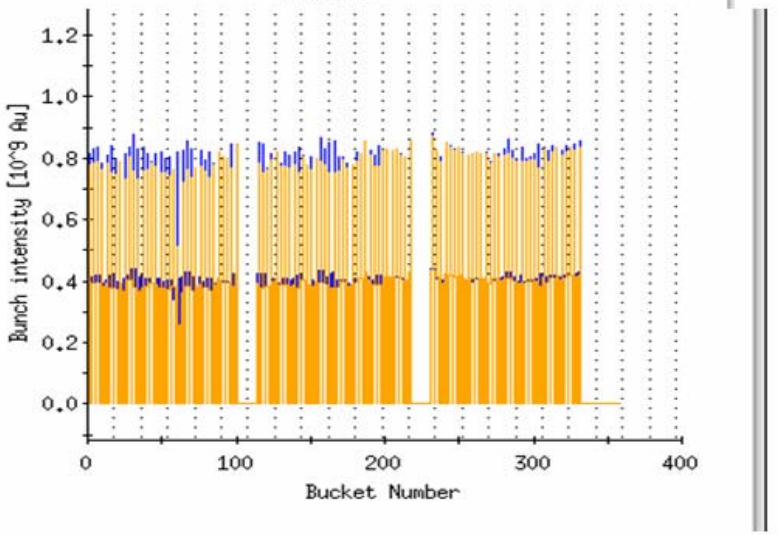


standard





Fancy Gap:
More crossings:
95->97



- **beam losses along the bunch train (next slide)**
- **Rebucketing issues: debunching beam**
- **Higher bunch intensity?**

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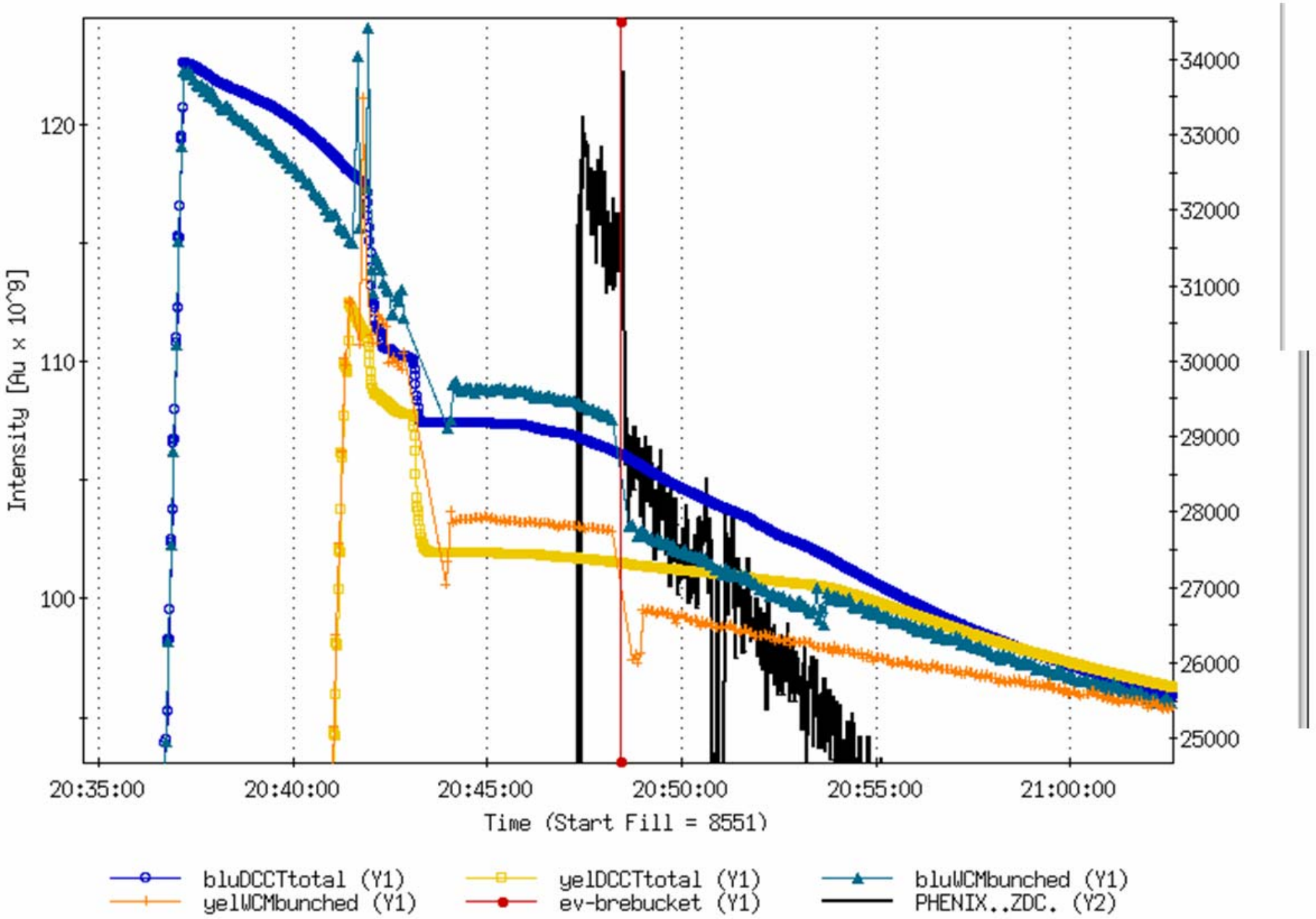

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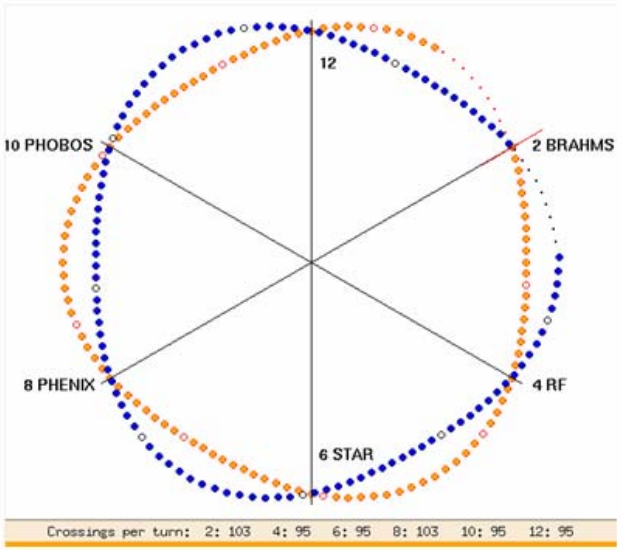

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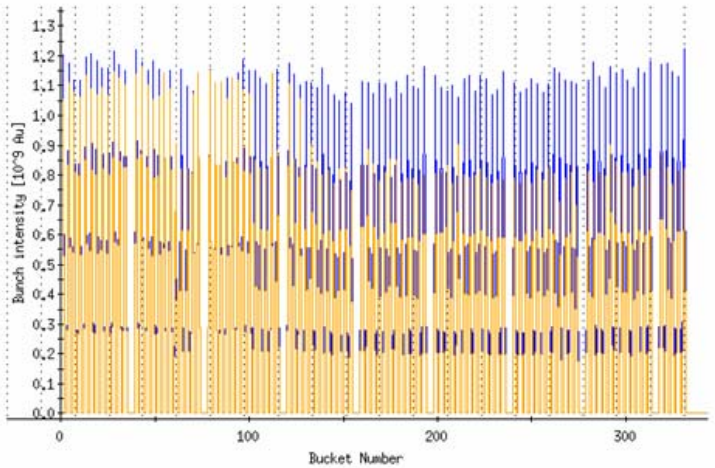

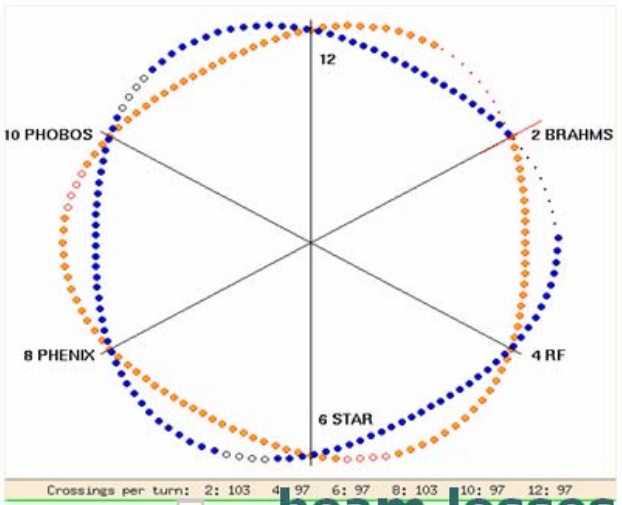

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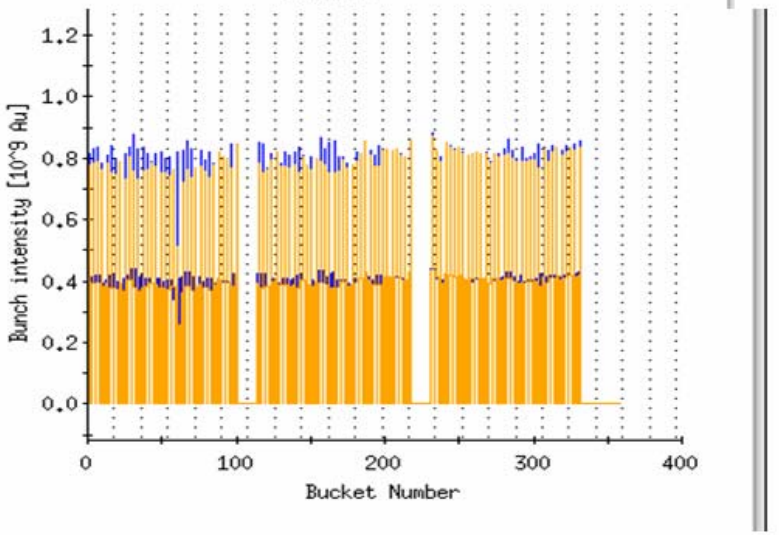

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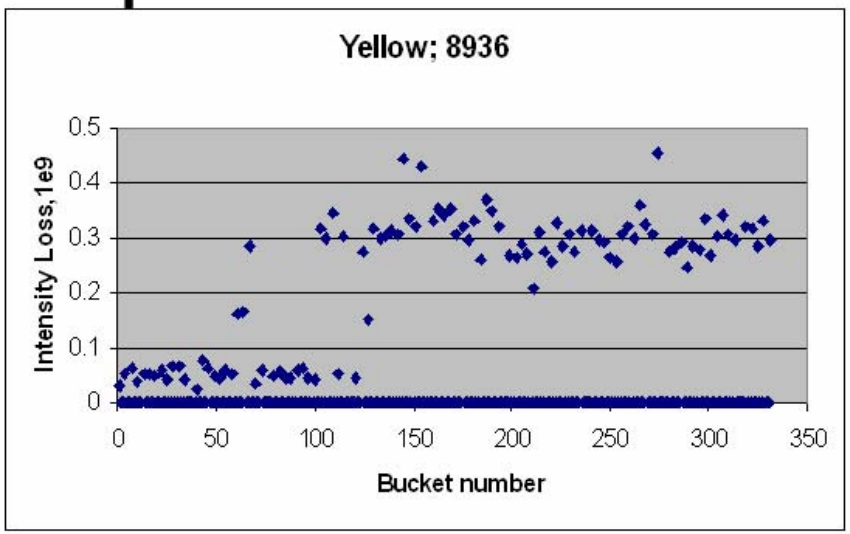
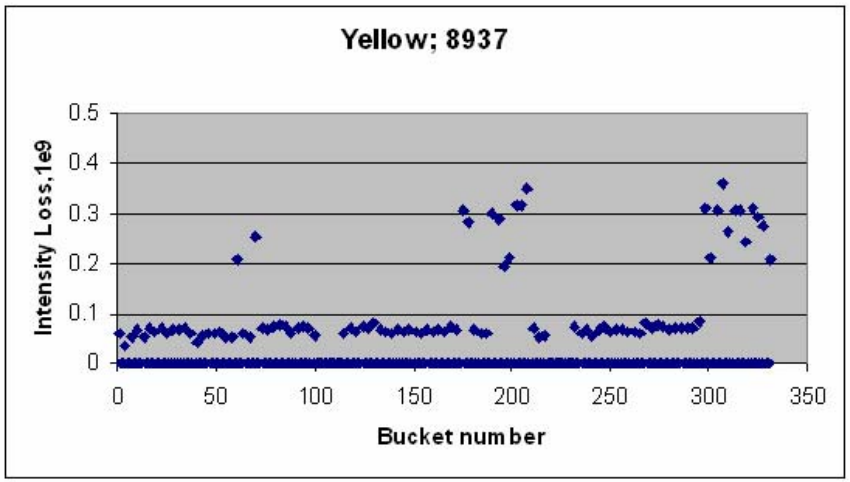
Losses along the bunch train

1o3 Std.



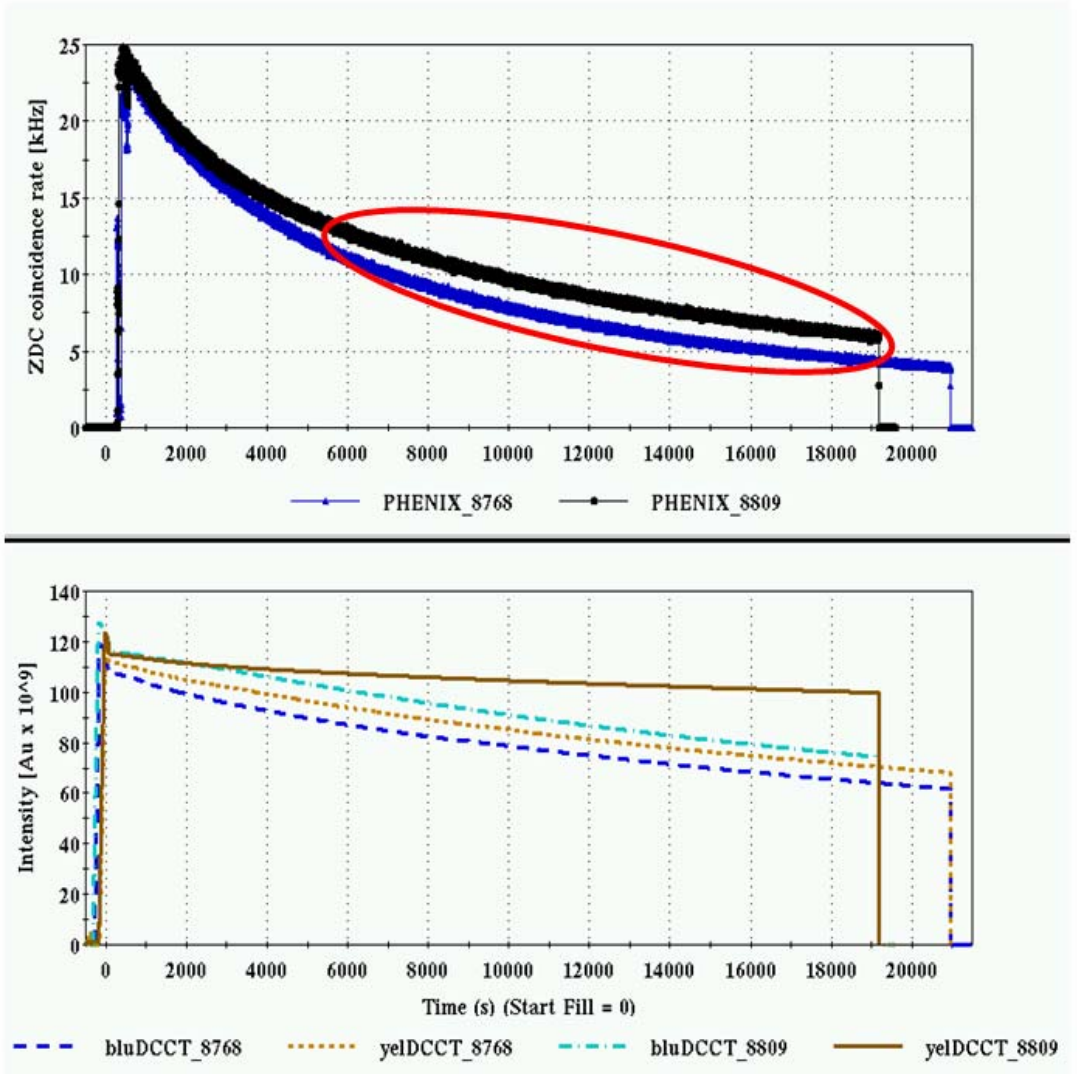
103 f.g.



- 103 std. ramp (1.15e9) shows beam blow up in all late bunches (ramp failed)
- Next 103 f.g. ramp with same bunch intensity (1.17e9) worked
- Gap pattern clearly visible in 8837
- 103 f.g. set to be default

Stochastic Cooling (Yellow only)

- Stochastic cooling was commissioned and made operational for the 2nd half of the run
- Yellow beam decay reduced to "burn-off" rate
- More beam in the center bucket
- Increased luminosity lifetime
- Net-effect on integrated luminosity 10%-20% (analysis not yet finished)
- Mechanical problems at the end of Run7



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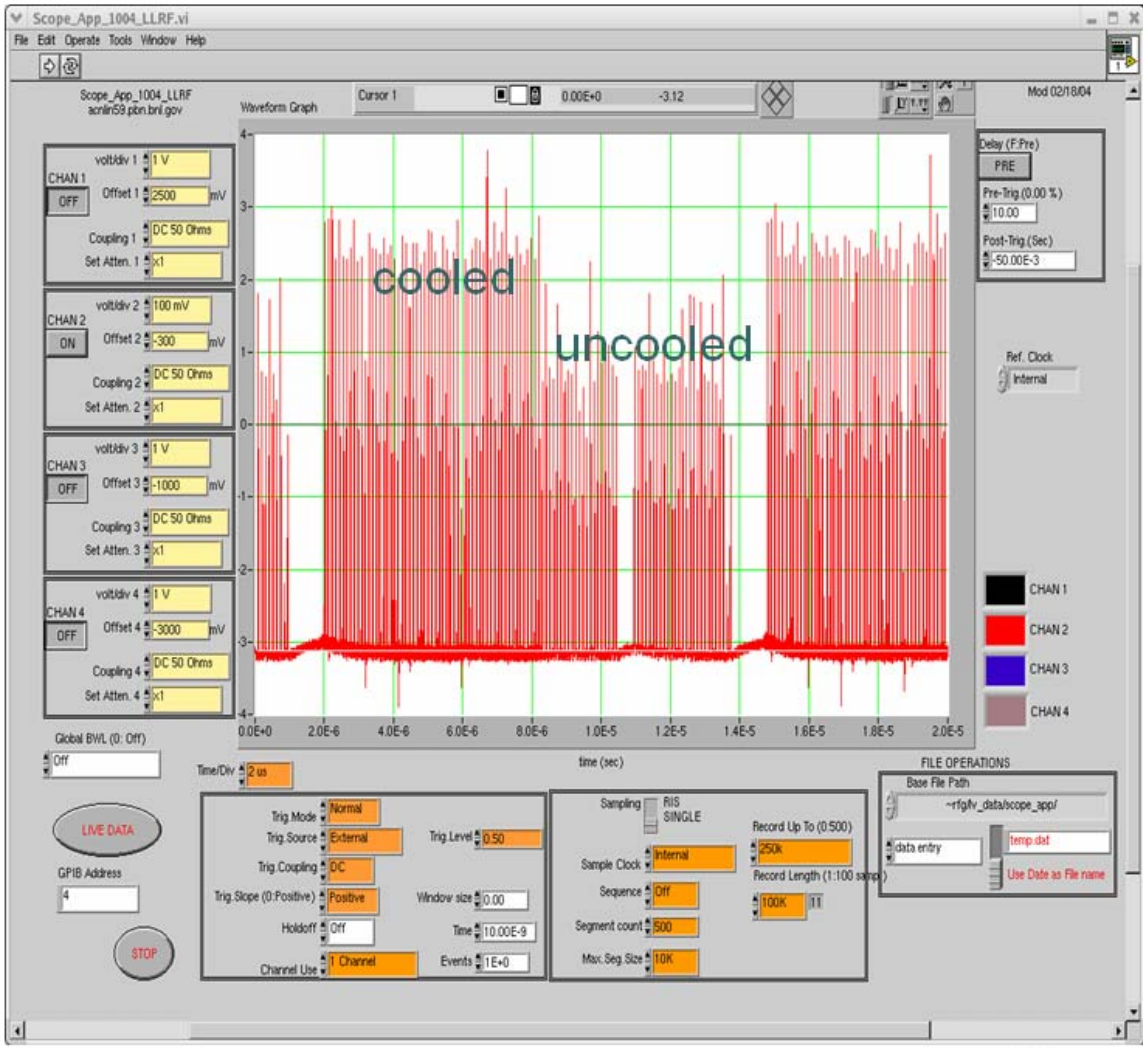

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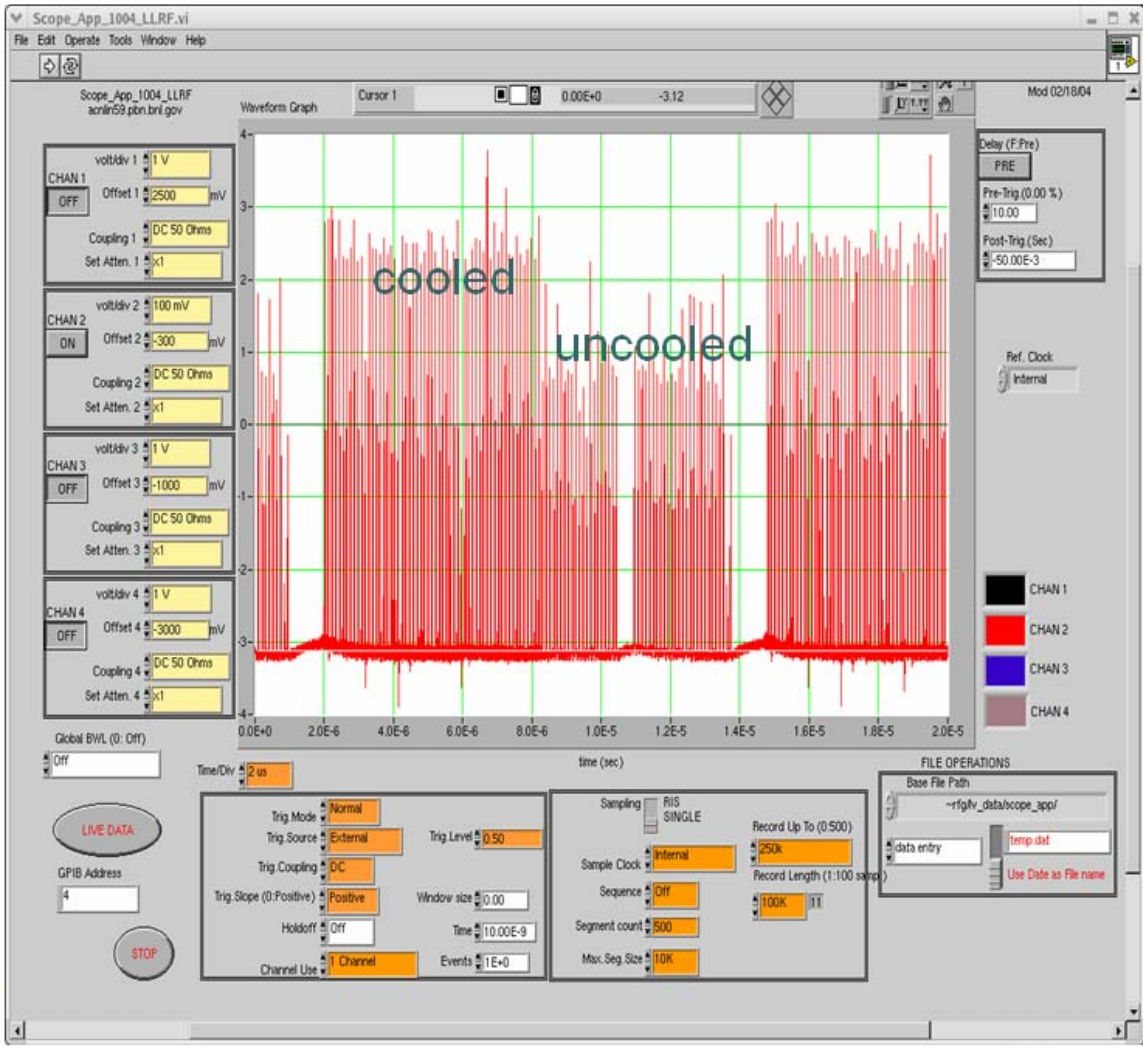
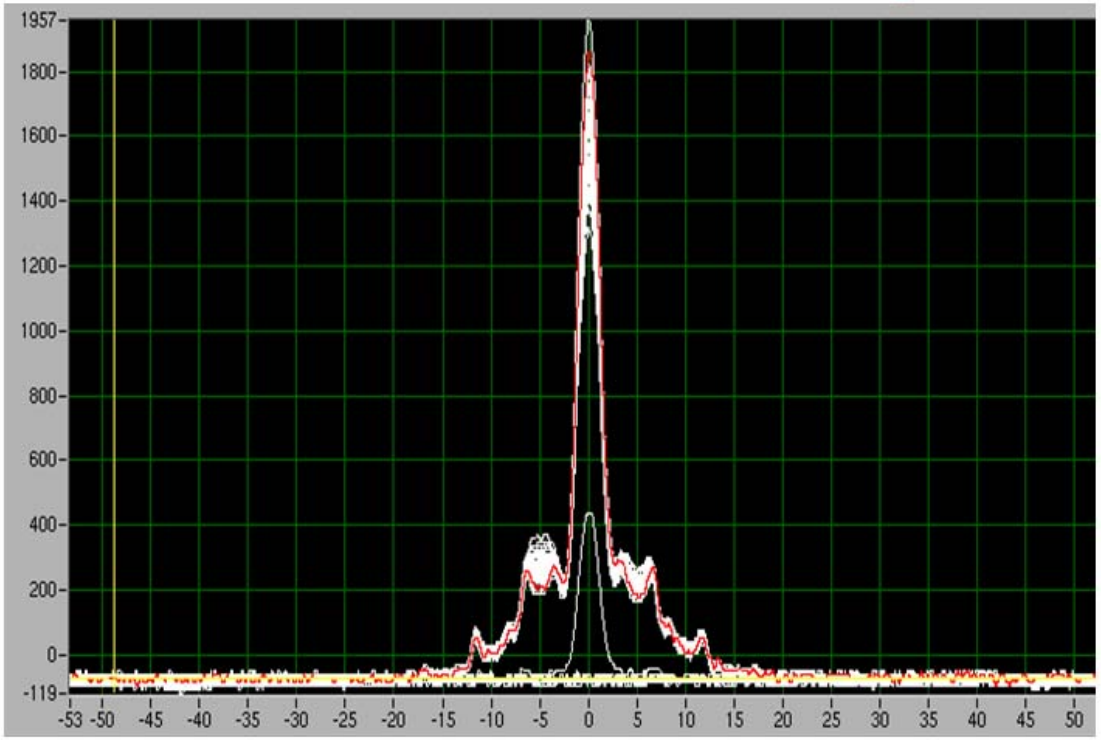
M. Blaskiewicz, "Stochastic Cooling of High Energy Bunched Beams", WEYC02



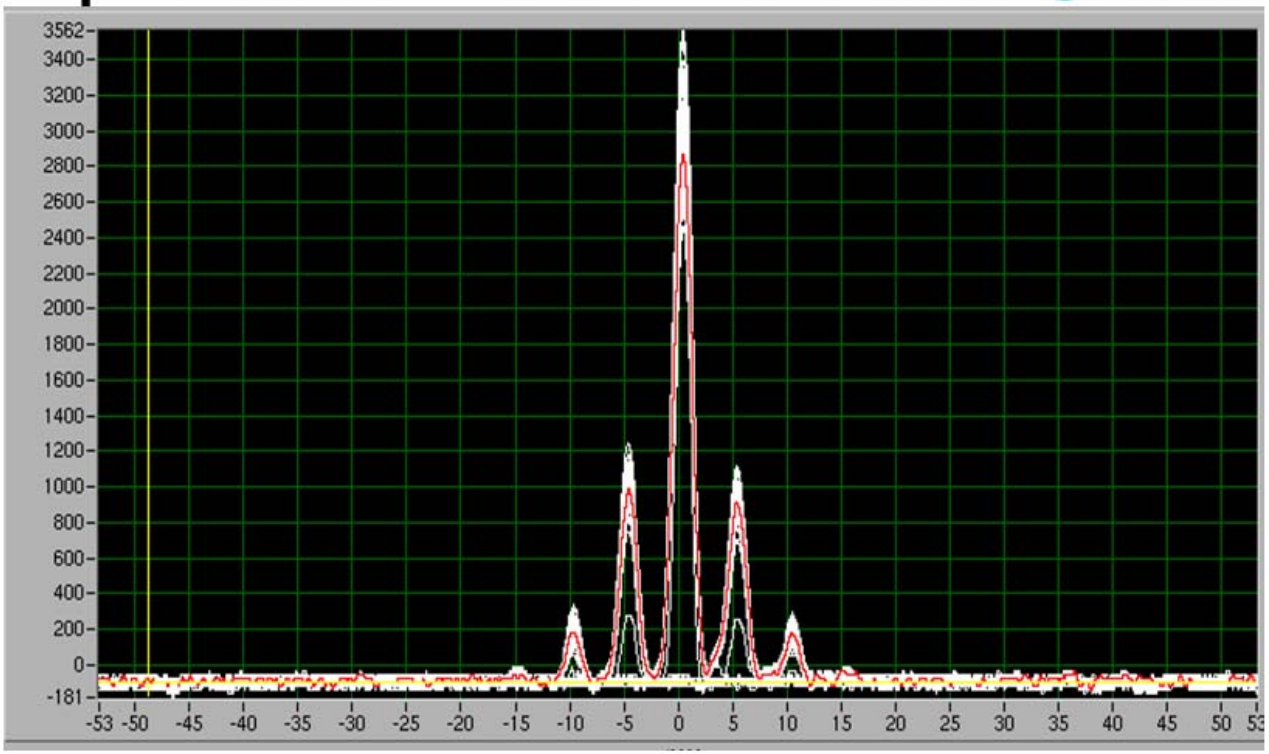
Stochastic Cooling (contd.)



Blue beam uncooled

- Uncooled beam has larger width of center bucket
- Cooled beam has significantly pronounced center and satellite buckets
- Exp. recorded luminosity (vertex cut) benefited from cooling as well

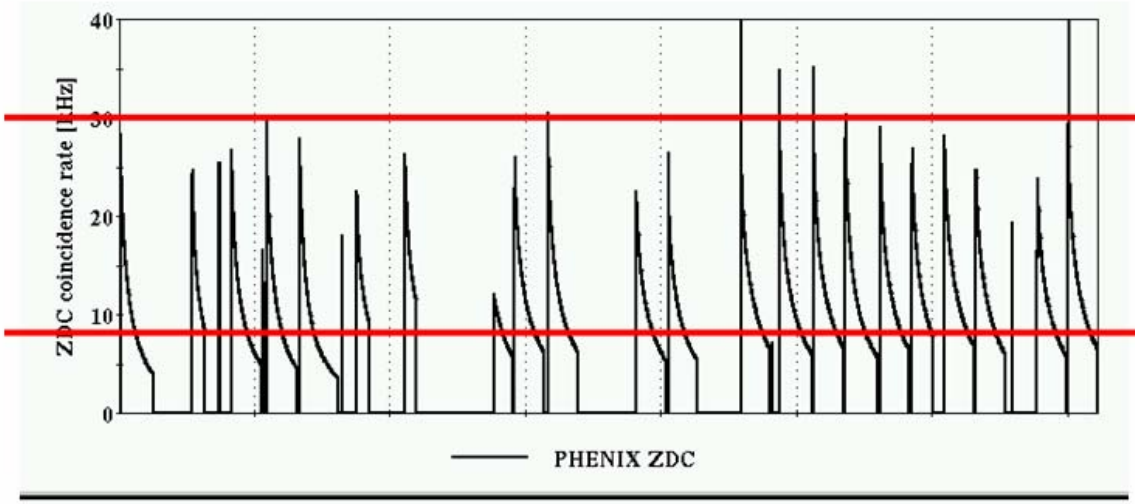
Stochastic Cooling (contd.)

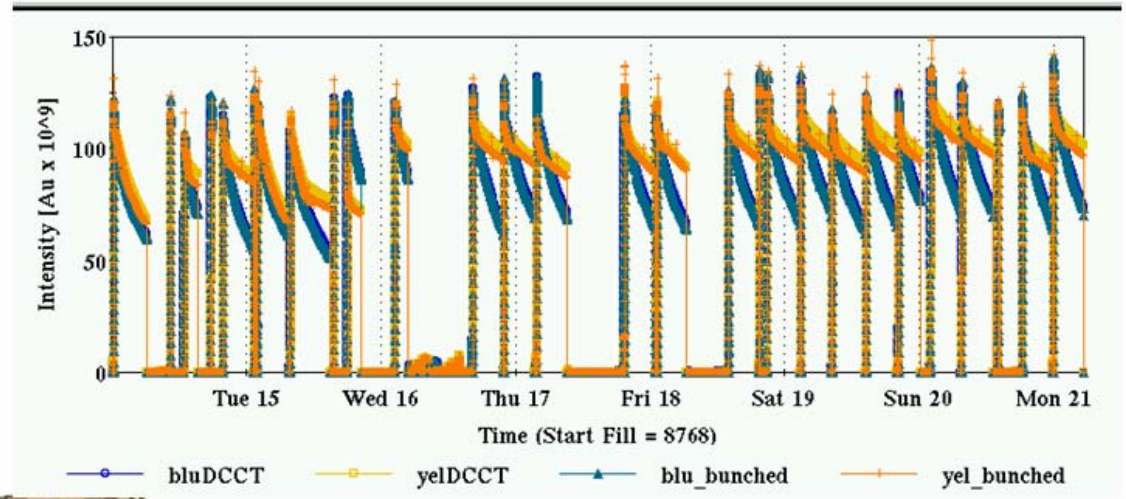


Yellow beam cooled

- Uncooled beam has larger width of center bucket
- Cooled beam has significantly pronounced center and satellite buckets
- Exp. recorded luminosity (vertex cut) benefited from cooling as well

Example of a good week (May 14-May 20)



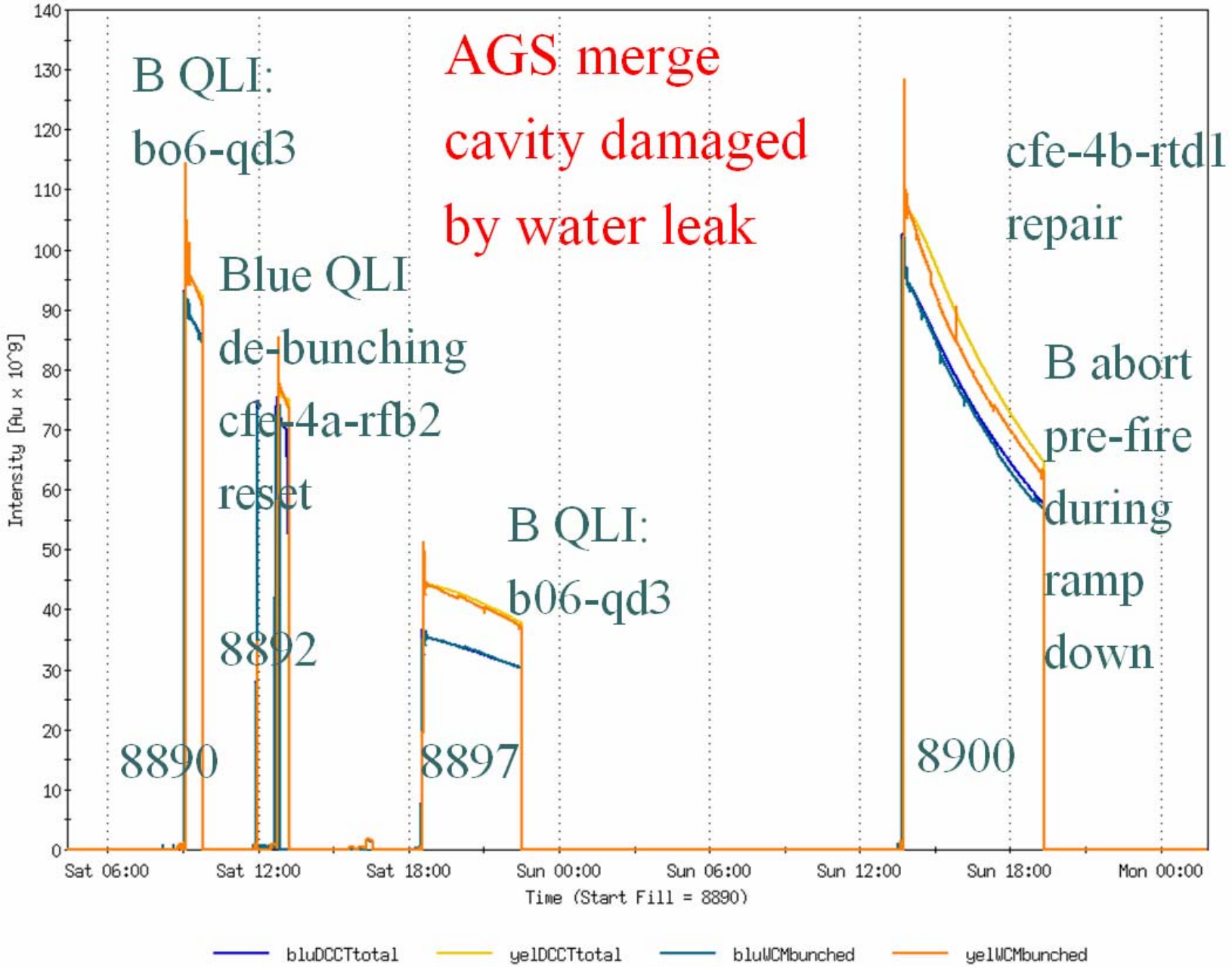


Peak luminosity of 30 10^{26} cm^{-2} s^{-1}

Avg. store luminosity of 8 10^{26} cm^{-2} s^{-1}

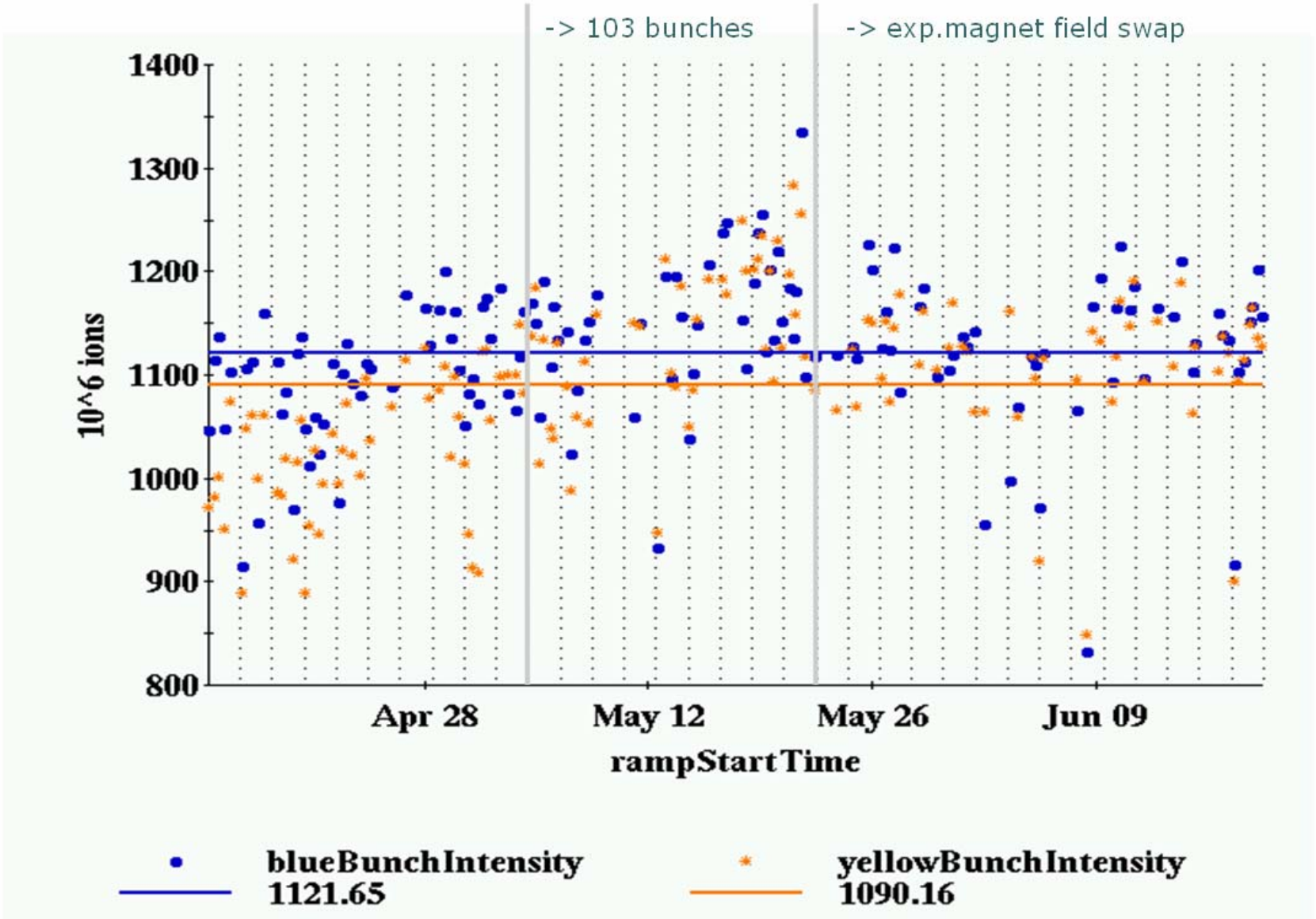
- 5 hours per store (nominal)
- This weeks integrated luminosity totaled 380 μb-1
- Stochastic cooling effect clearly visible
- Initial beam intensity routinely above 120 10^9

… and a not so good week …

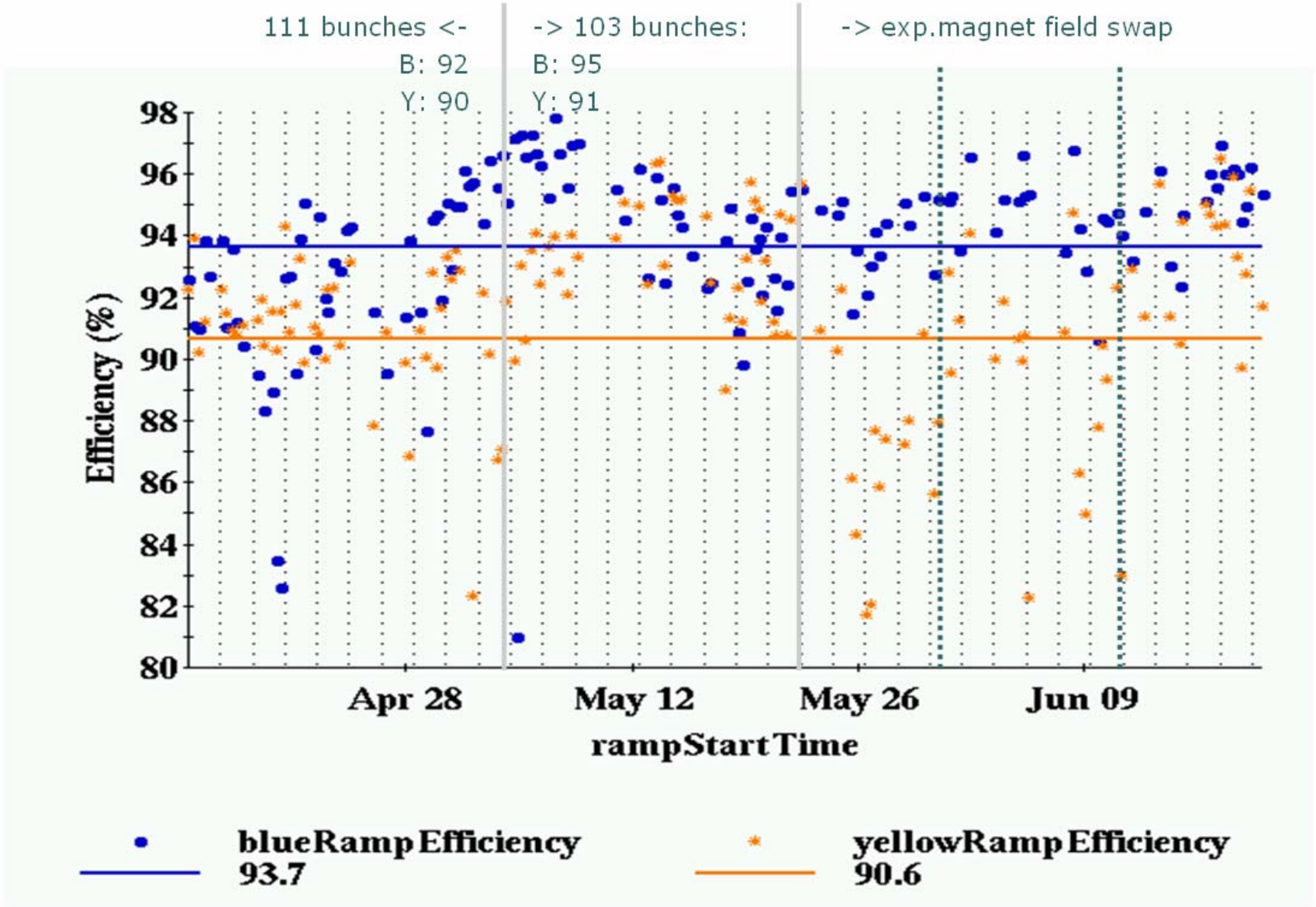


Bunch Intensity at Injection

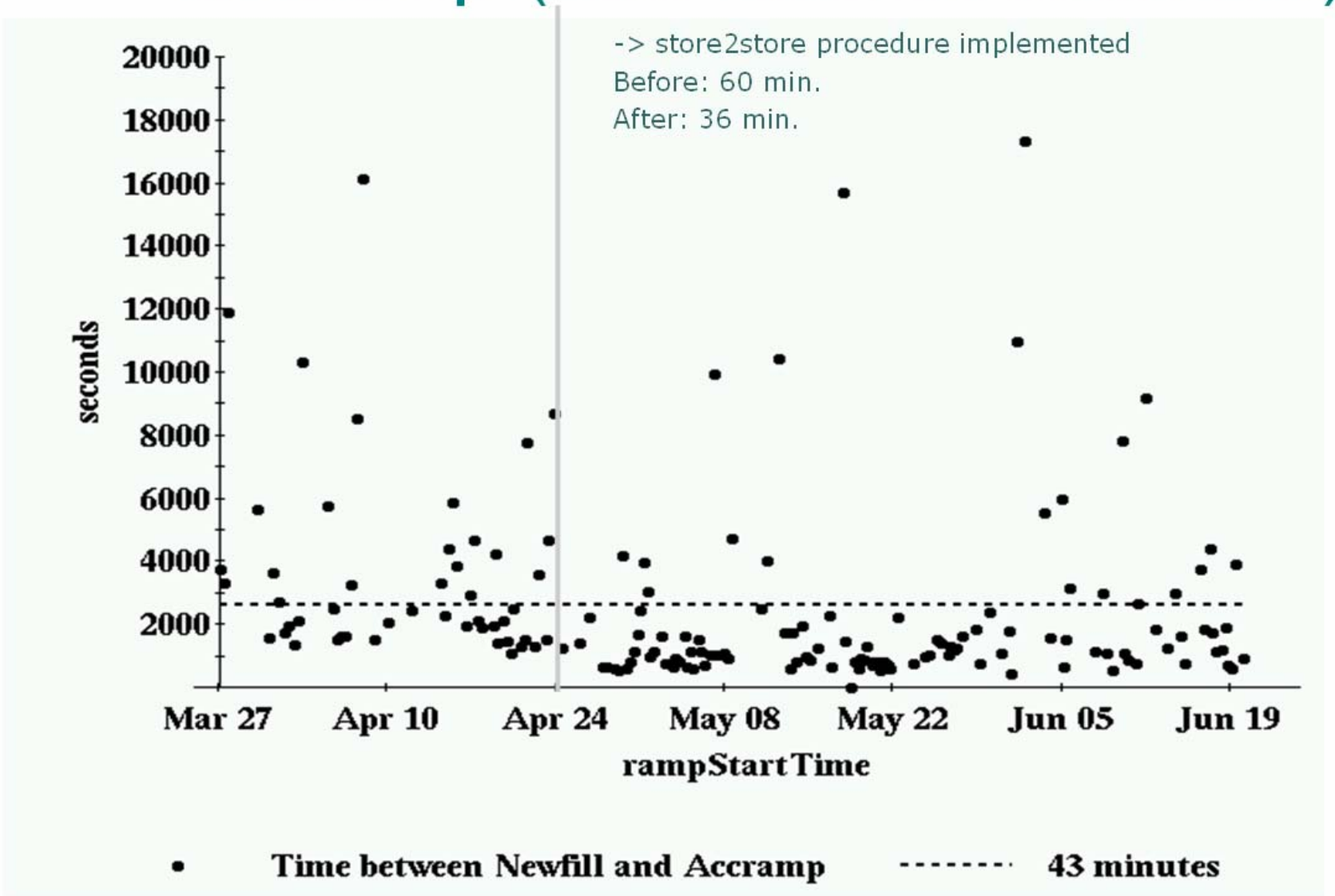
Limited by transition crossing, e-cloud effects and exp. magnet polarity change



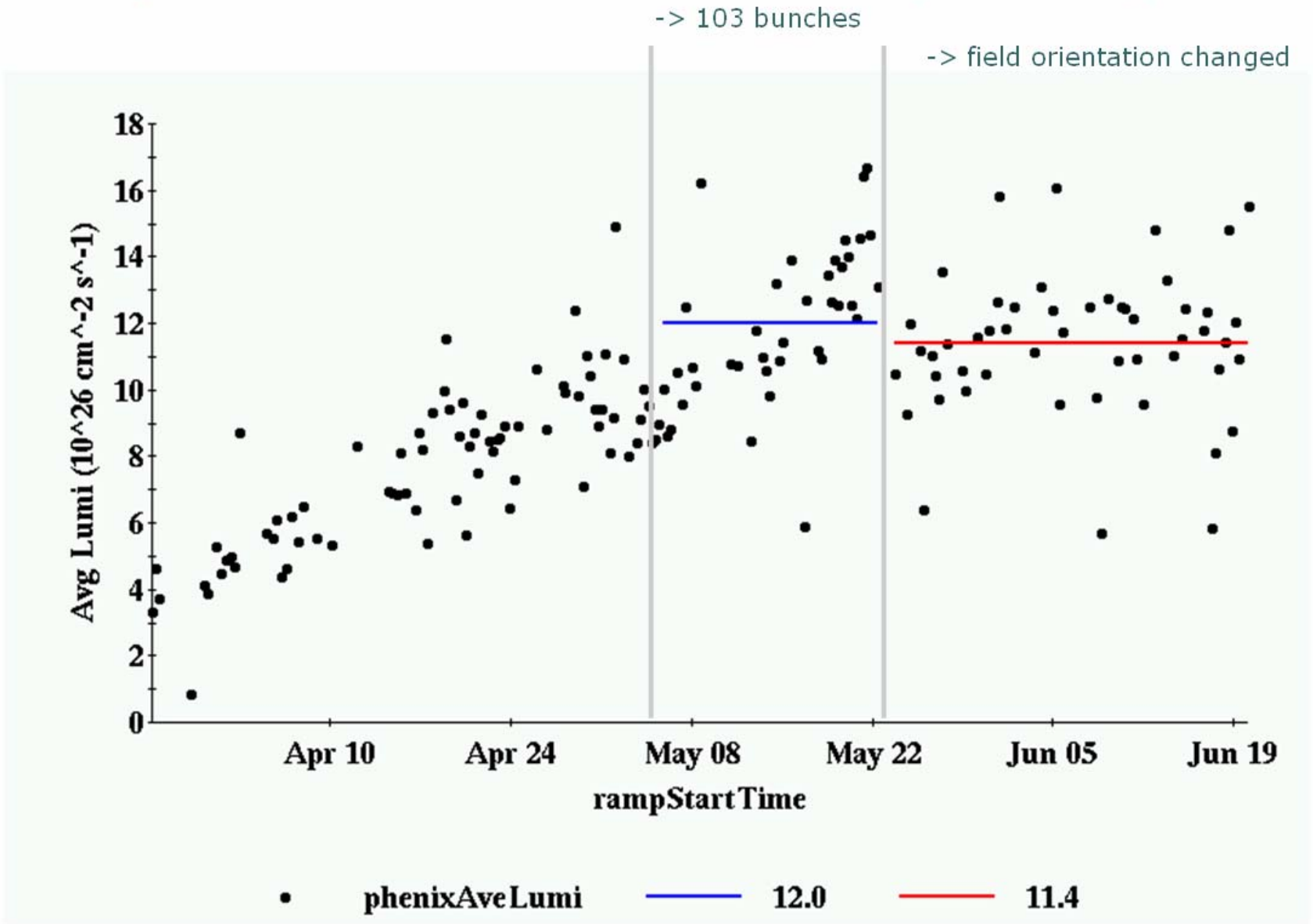
Ramp Efficiency



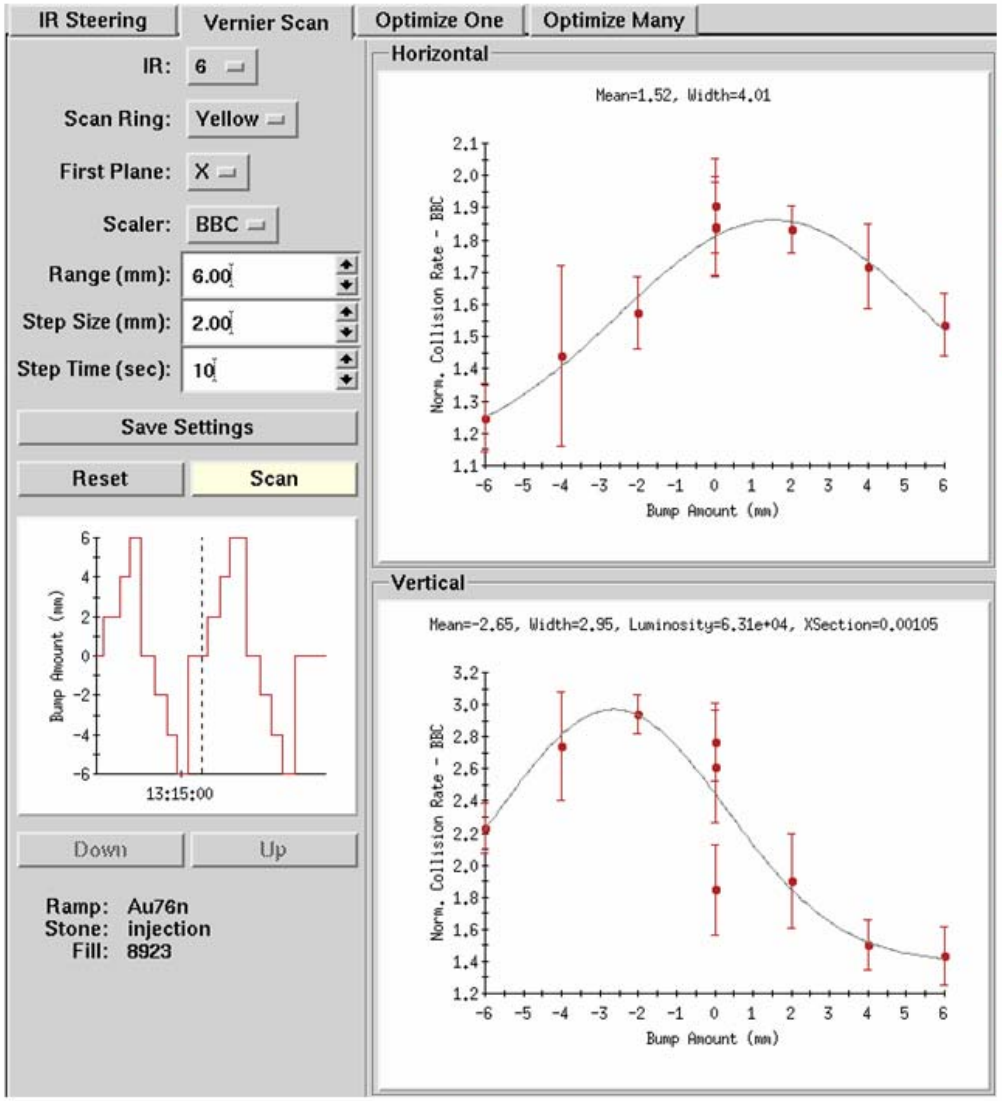
Time between newfill and accramp (turn-around indicator)

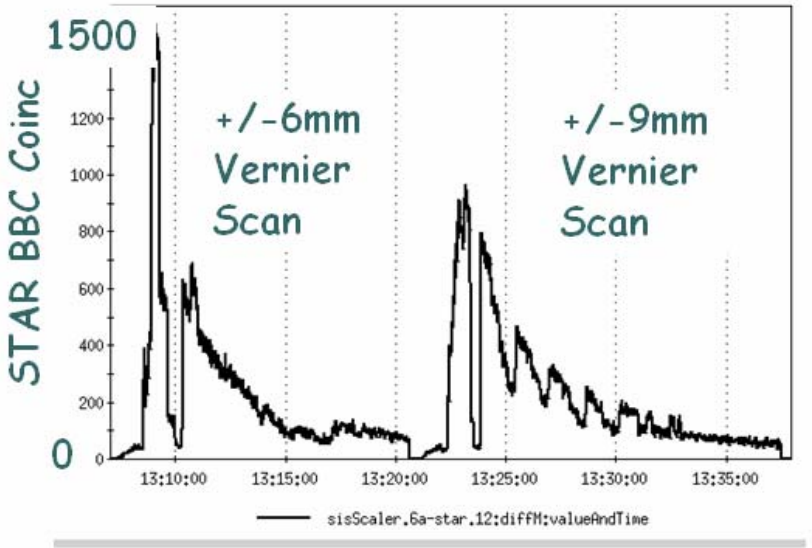


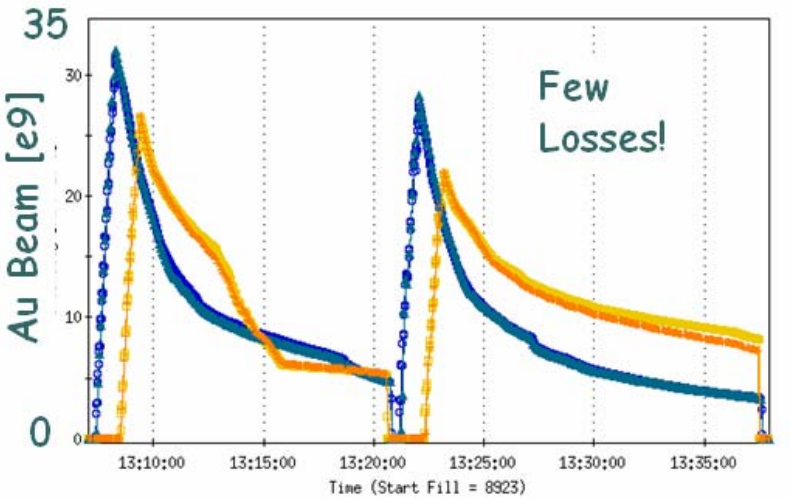
Run7 average luminosity/store highest with 103 bunches per ring



Low Energy Test @ 4.6 GeV
24 hour setup, collisions provided, vernier scan(s)







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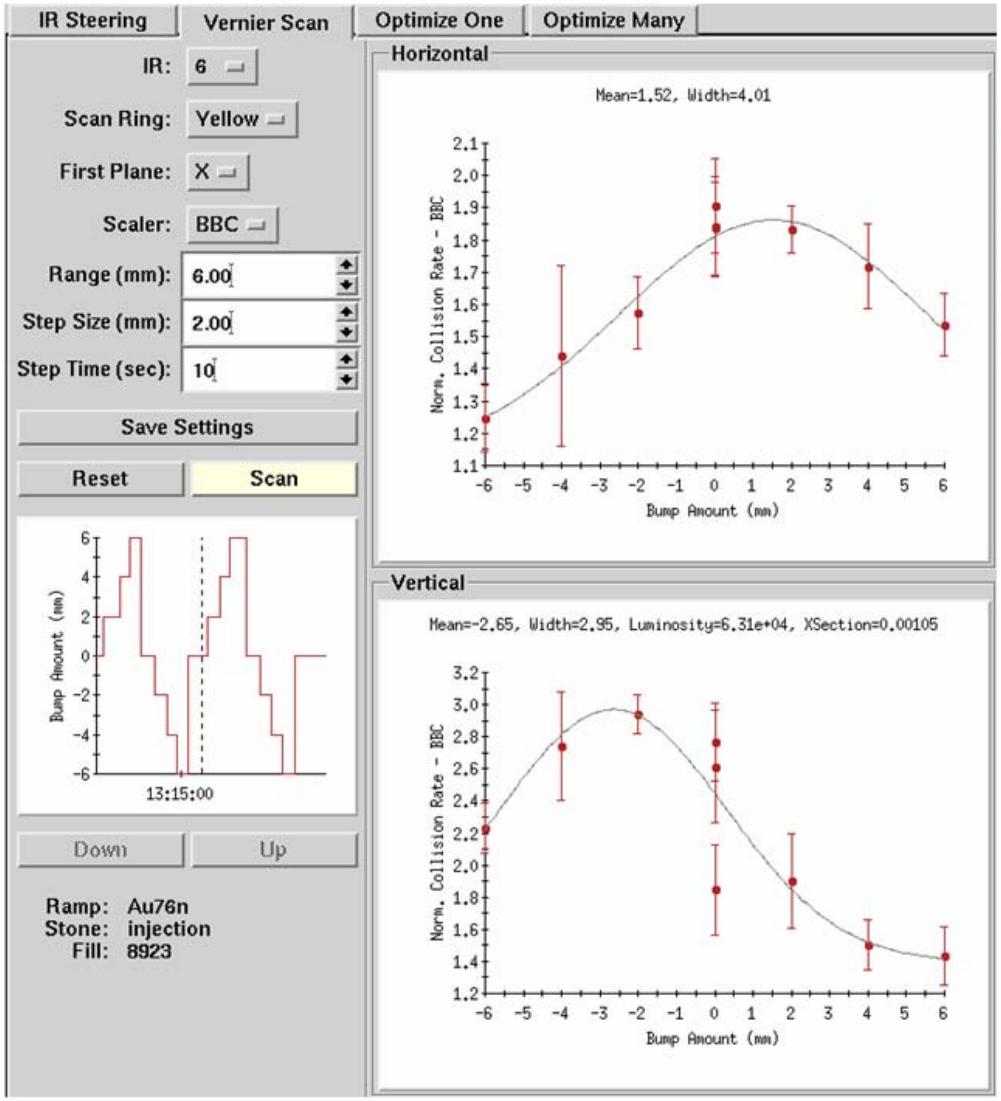
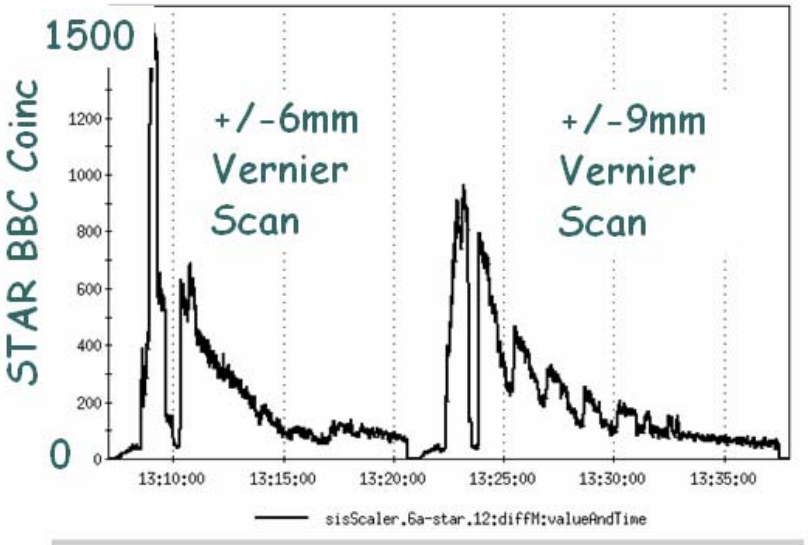
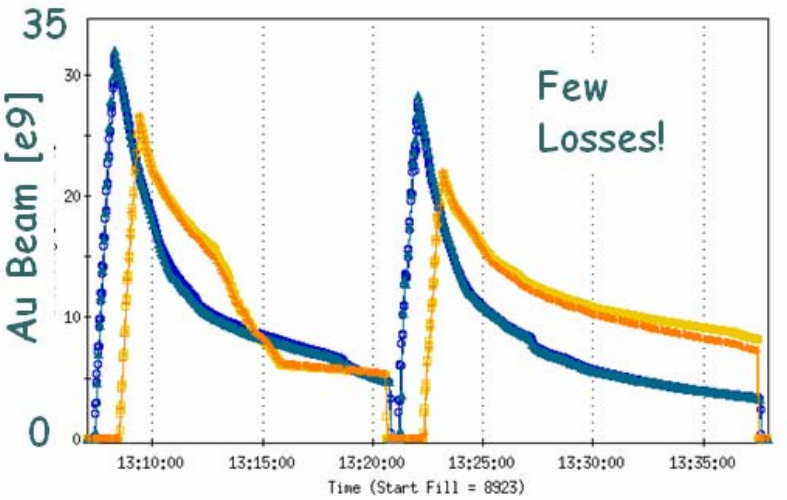


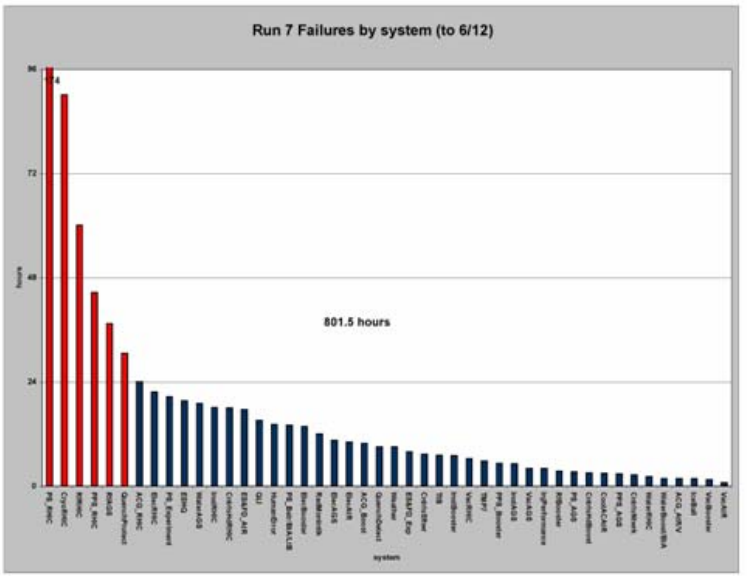


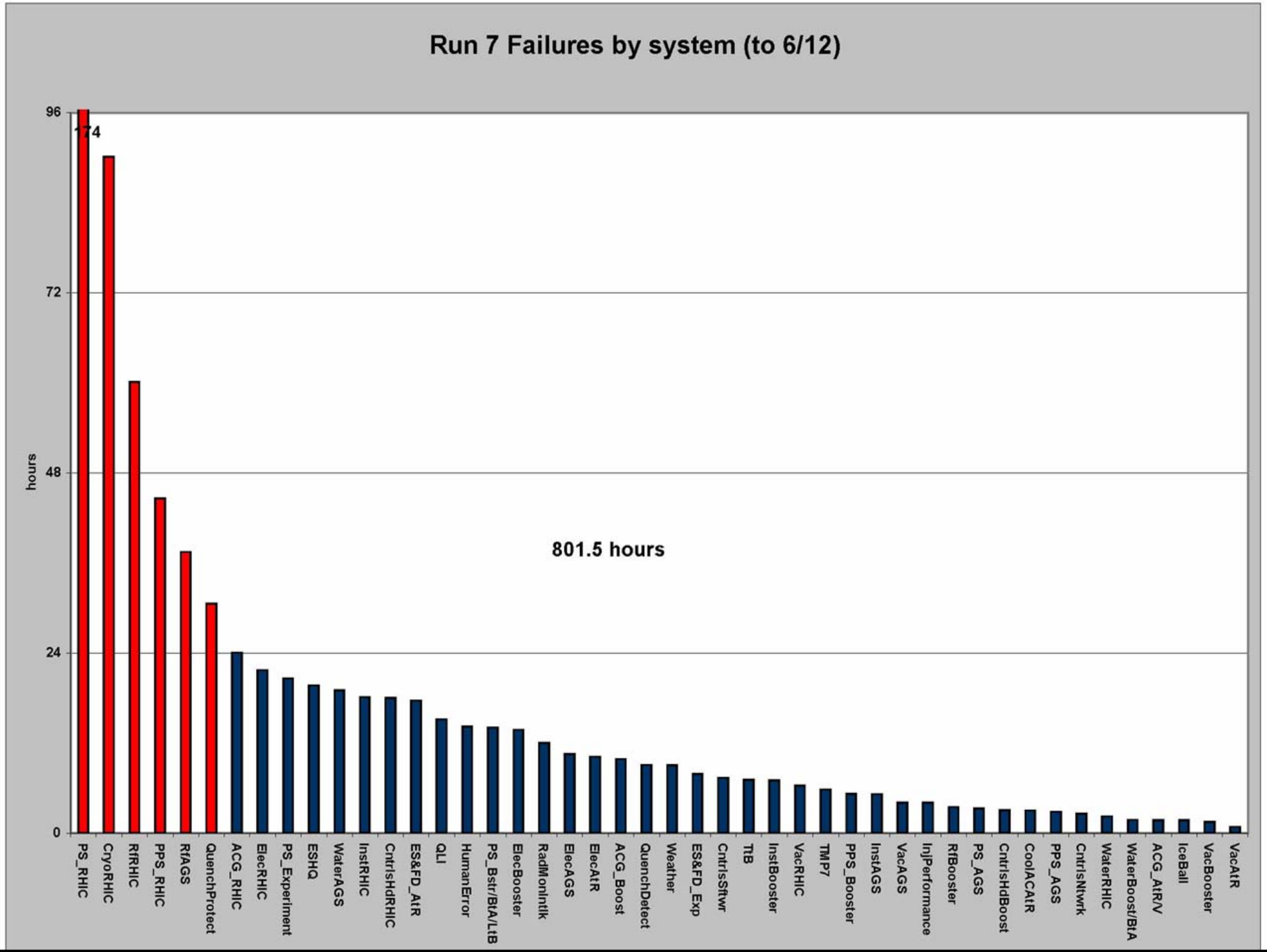


T. Satogata et al. , "RHIC challenges for low energy operations", TUPAS103

Failures in hours for Run-7 system by system

- Run-7 had
  - 13 weeks
  - late spring (temperature)
  - full magnetic field/current (Au@100 GeV)
  - Aging?
- Top 3: PS, cryo, RHIC RF
- Increase factors (from previous run to this run)
  - PS: x2.2
  - RF: x2.5
  - Cryo: x4.5




Run 7 Failures by system (to 6/12)
hours
96
72
48
24
0
174
801.5 hours
PS_RHIC
CryoRHIC
RfRHIC
PPS_RHIC
RfAGS
QuenchProtect
ACG_RHIC
ElecRHIC
PS_Experiment
ESHQ
WaterAGS
InstRHIC
CntrlsHdRHIC
ES&FD_AtR
QLI
HumanError
PS_Bstr/BtA/LtB
ElecBooster
RadMonIntlk
ElecAGS
ElecAtR
ACG_Boost
QuenchDetect
Weather
ES&FD_Exp
CntrlsSftwr
TtB
InstBooster
VacRHIC
TMP7
PPS_Booster
InstAGS
VacAGS
InjPerformance
RfBooster
PS_AGS
CntrlsHdBoost
CoolACAtR
PPS_AGS
CntrlsNtwrk
WaterRHIC
WaterBoost/BtA
ACG_AtR/V
IceBall
VacBooster
VacAtR

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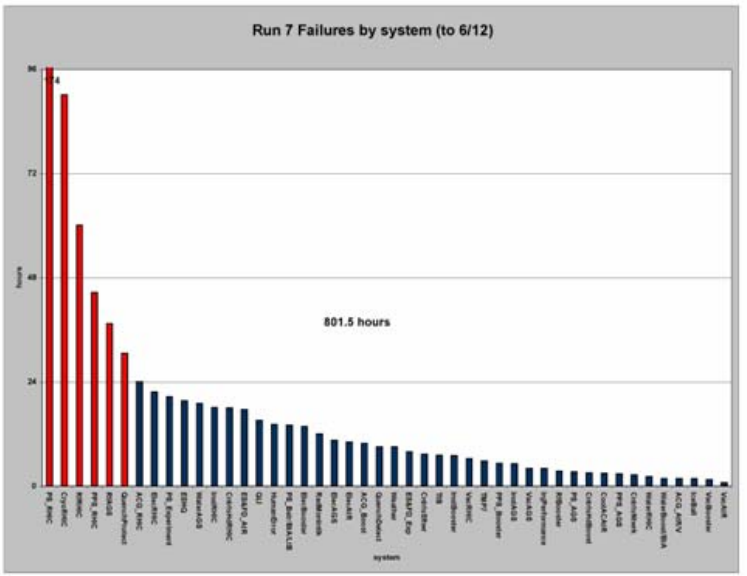
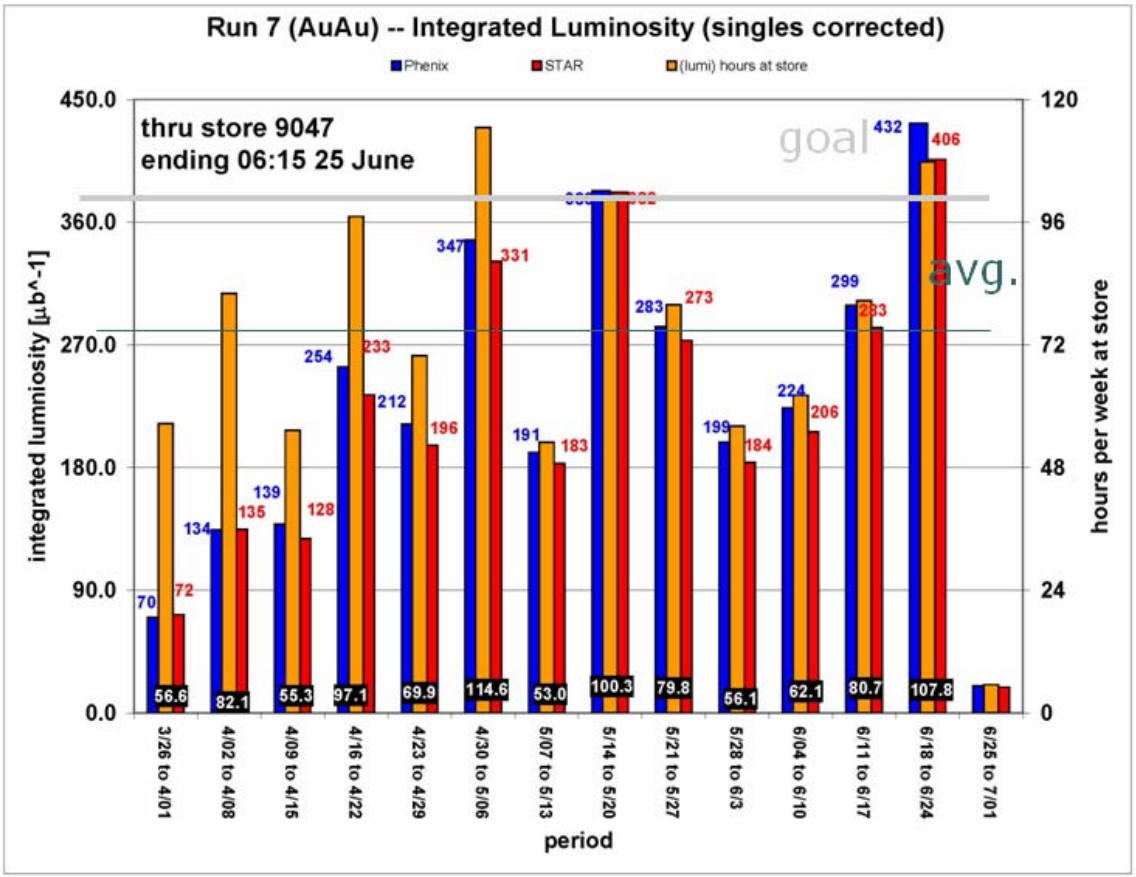


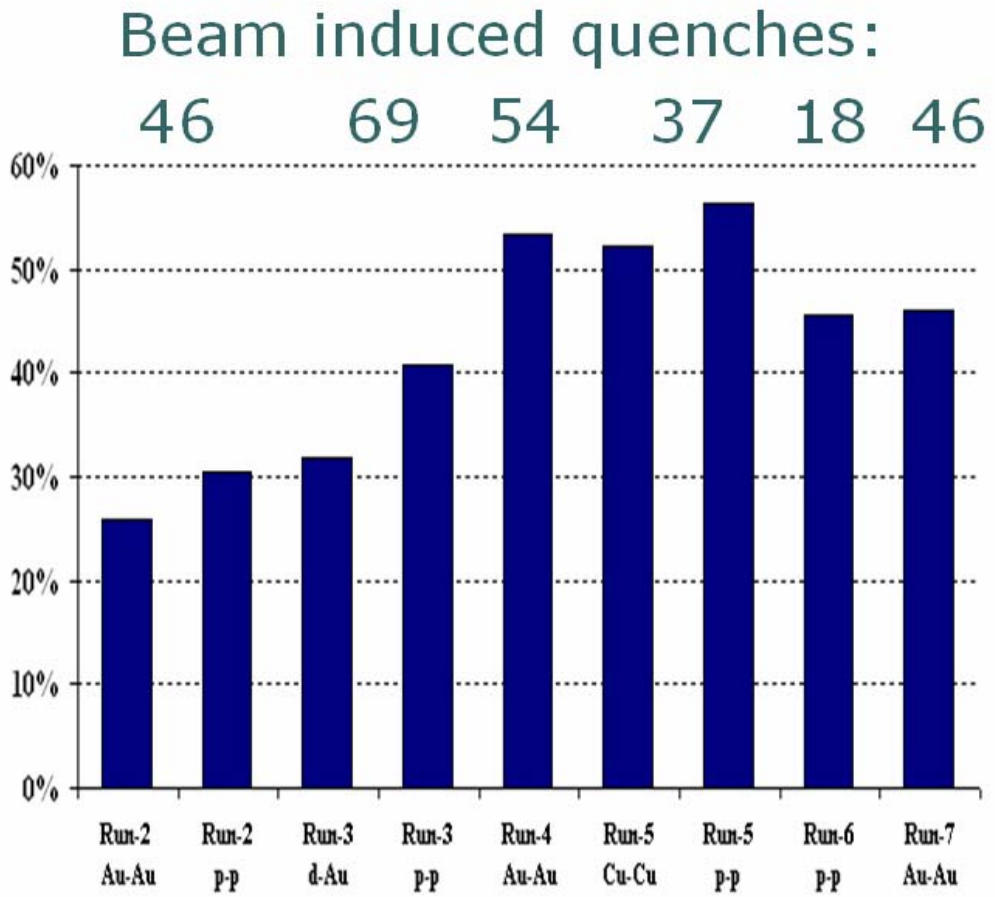
Week-by-week integrated luminosity Run 7



- 3 weeks above goal
- Contributing factors:
  - Temperature (late start of run), weather
  - Full field (Au @ 100 GeV)
  - Unprecedented intensity (beam loading)
  - Pushing the envelope (transition crossing, pressure rise, number of bunches etc.)
  - Aging?

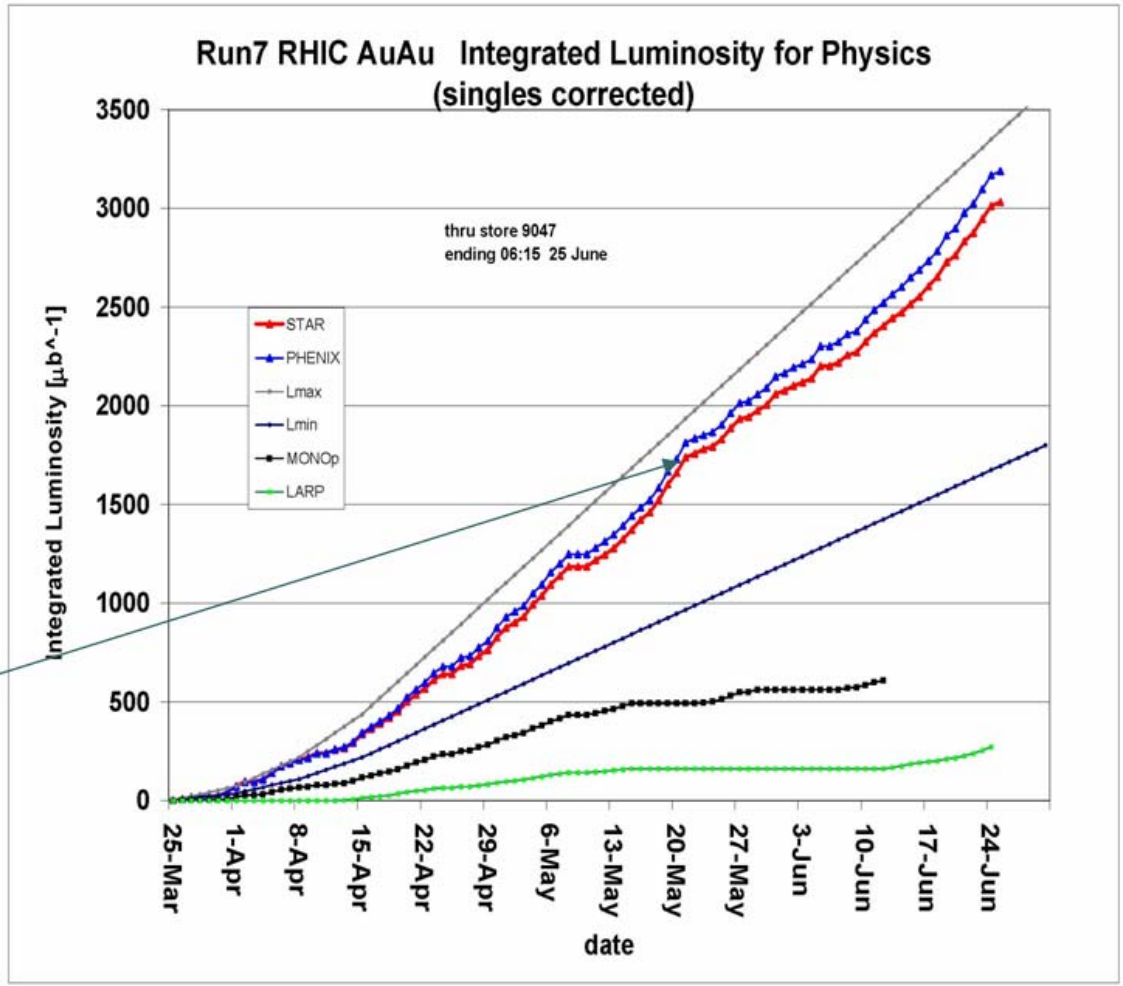
Time at store over the years

- Data included until Jun 9th 2007
- Goal: 60%
- Reached 46%
- Failed to reach goal by about 15%
- Beam induced quenches not correlated with uptime but species => magnet current



Integrated Au-Au Luminosity Run-7

- Integrated luminosity well between min. and max. expectation
- Corrected for acc. collisions (due to high coll. rate)
- “bi-weekly” performance oscillation coinciding with maintenance days
- Slope change after experimental magnets polarity flip
- Integrated luminosity still in upper half even with only 45% time at store!



Conclusions

- Analysis of data not yet finished (Run-7 ended today)
- We met our goals (almost)
  - 111 (103) bunches
  - Exceeded 8 10^{26} cm^{-2} s^{-1} avg. luminosity/store routinely
  - 30 10^{26} cm-1 s-1 peak luminosity
  - Some weeks (3!) exceeded 300 ub-1 integrated luminosity
  - Achieved x2-3 more integrated luminosity than Run-4
- Bunch intensity limit (~1.2 10^{9})
- Up-time or reliability needs significant changes:
  - Plans for next year
  - Long-term plans
- Stochastic Cooling concept worked very well

supplemental

Low Energy study: Challenges and Successes

- Challenges
  - h=366 invalid events stopped PHENIX, nearly stopped STAR, interfered with V125 abort trigger module
  - 3-bucket cogging in h=366 prevented simultaneous expt cogging
  - Unipolar defocusing sextupoles limited chromaticity to near zero
  - Minor online model issues prevented full range of tune adjustment
  - All challenges are addressible either offline or during test run setup

- Successes
  - LLRF worked like a charm, RF capture quick with phase detectors
  - Instrumentation worked remarkably well with h=366 timing
  - Orbit correction, coupling corrections worked well
  - Longitudinal beam distribution shorter than expected (scraping?)
  - Vernier scans still feasible even with 2-20 minute beam lifetimes
  - Have data for luminosity measurement deliverable

Courtesy T. Satogata

Setup within 24 hours!