

RHIC Reliability Overview

Suggested areas of Improvement

*Peter Ingrassia
RHIC Retreat
27 July 2015.*



U.S. DEPARTMENT OF
ENERGY

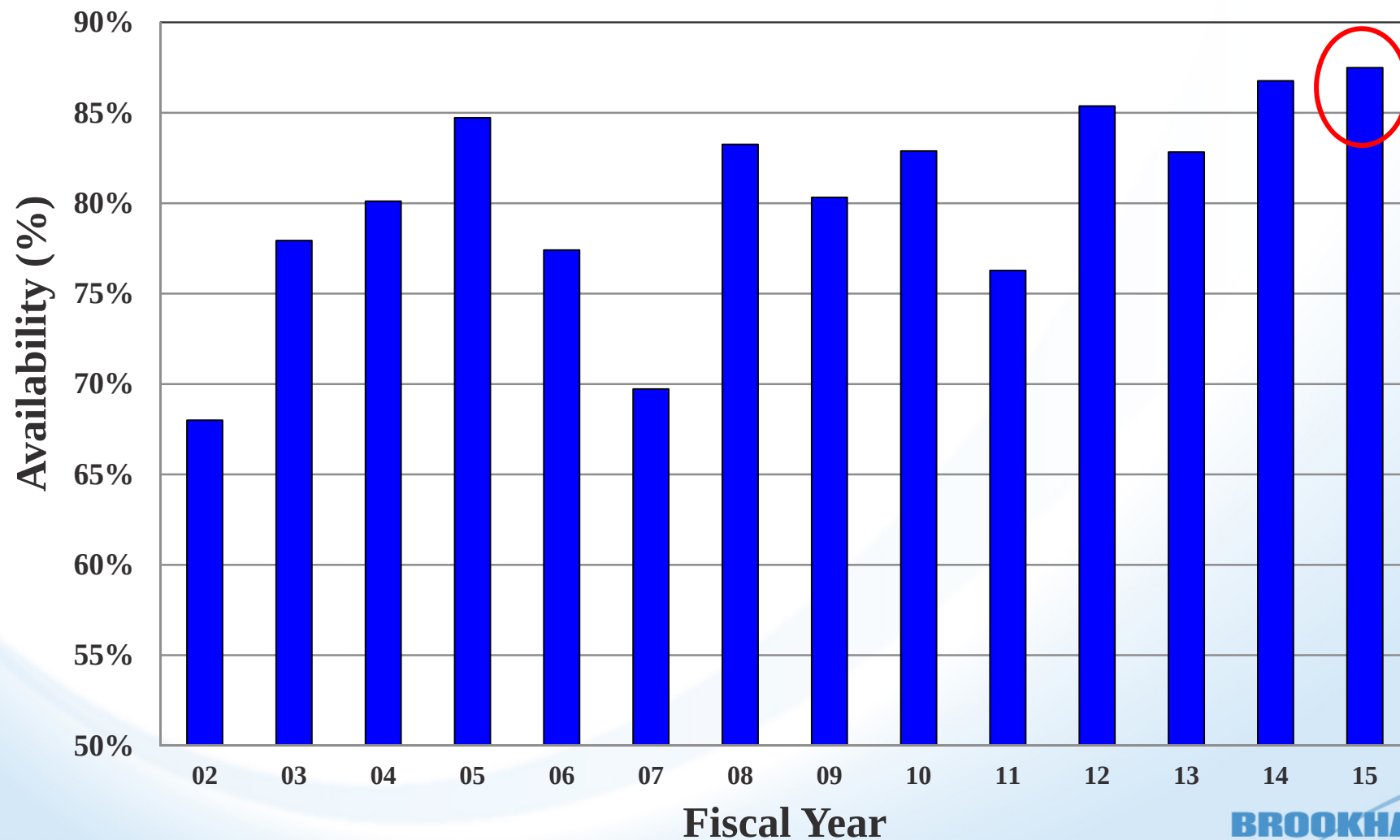
Office of
Science

This Talk

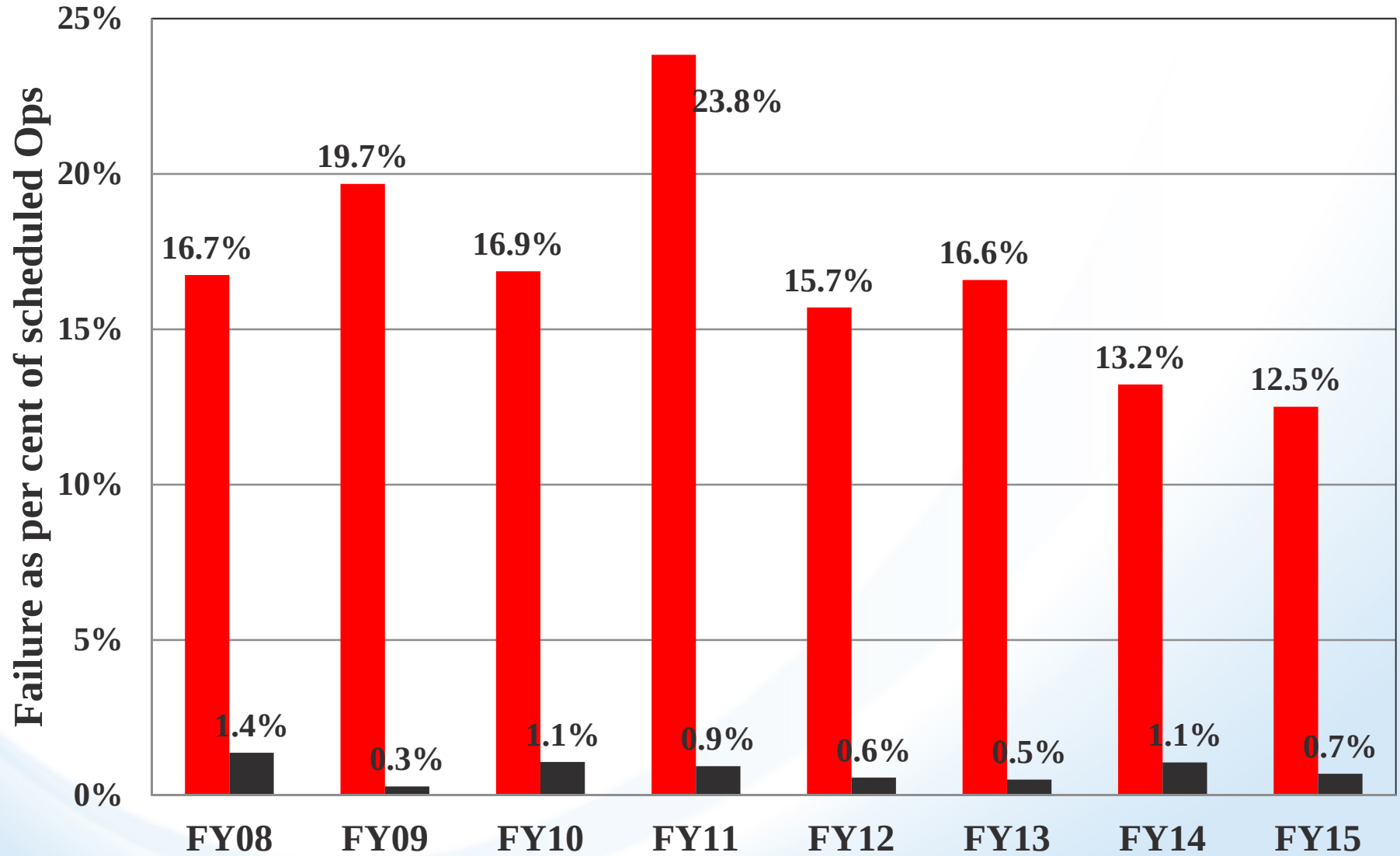
- Restates the obvious...
- SHORT review of RHIC availability from Run-2
- SHORT review of Run15 availability (RHIC Record).
- SHORT review of MTBF from Run-7
 - Ability to look back heavily dependent on the tool Operations uses to track failures
- SHORT review of Availability arithmetic
- Failure as a per cent of scheduled Operations
- Making a subjective case for areas of concentration for future reliability improvements
- “Hand waving” (“personal bias”) – no surprises!

Run15 will be a tough act to follow

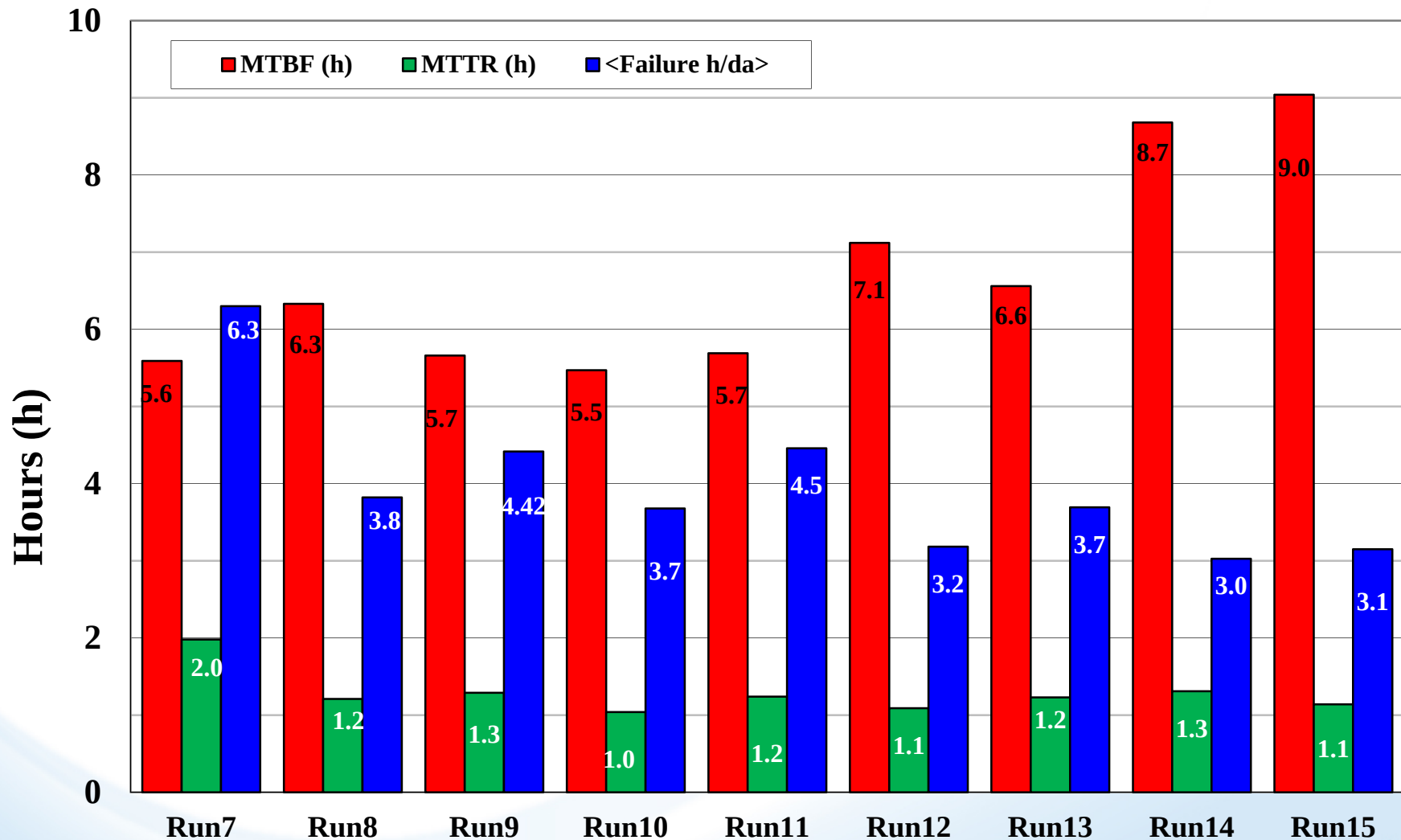
RHIC AVAILABILITY 2002-2015



Failure & “Resets” as % Scheduled Ops



MTBF, MTTR, <Failure hours/da>



A Review: DOE Availability Arithmetic

FY 2015											6/23/2015
3rd Quarter											
	Delivered Research (Hours)	Delivered Beam Study (Hours)	Delivered Tuning, Setup & Restore (Hours)	Total Delivered (Hours)	Expected Delivered (Hours)	Total/ Budgeted		Unscheduled Failure	Total Scheduled Operations (Hours)	Delivered Research Hours/Total Scheduled (Hours)	Availability
	MD + PHYSICS	APEX	EXP + MACH SETUP		Run15			Failure			
	1177.95	67.27	409.82	1655.04	2770	60%		240.58	1895.62	62%	87.3%

$$\text{Availability} = \frac{(\text{Research} + \text{Studies} + \text{Setup})}{(\text{Research} + \text{Studies} + \text{Setup} + \text{Failure})}$$

$$\text{Failure as \% Of scheduled Ops} = \frac{(\text{Failure})}{(\text{Research} + \text{Studies} + \text{Setup} + \text{Failure})}$$

	Failure as % of scheduled Ops	availability	0.45% ~ h
FY08	16.7%	83.3%	13.9
FY09	19.7%	80.3%	17.6
FY10	16.9%	82.9%	19.4
FY11	23.8%	76.3%	18.3
FY12	15.7%	85.4%	16.2
FY13	16.6%	82.8%	12.7
FY14	13.2%	86.8%	15.9
FY15	12.5%	87.5%	17.4

System “Failure Rate Trends”

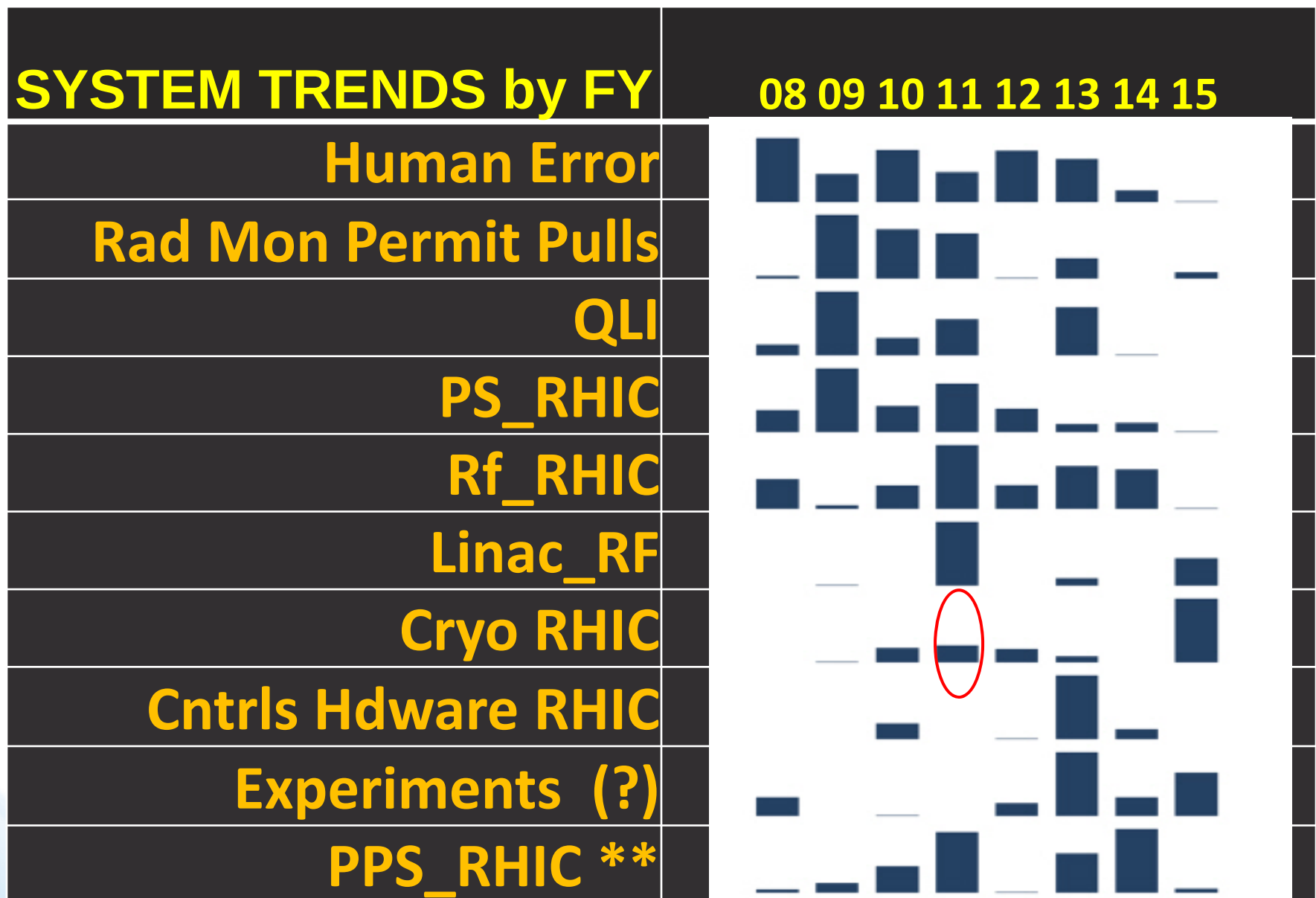
- Compute annual % Failure of Scheduled Ops for each “system”
- Eliminate from the list those systems where % Failure of Scheduled Ops < **0.45%**
 - “arbitrary limit”
- Eliminate from the list those systems where % Failure of Scheduled Ops < **0.45%** and frequency was three years or less of eight years
- With these cuts data set reduced from 96 elements to 26.

SYSTEM	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15
H Human Error	1.64%	1.02%	1.43%	1.04%	1.42%	1.26%	0.72%	0.53%
Pulsed Power RHIC	0.51%	0.57%	0.74%	1.10%	0.48%	0.88%	1.13%	0.51%
Power Supply RHIC	2.45%	4.16%	2.62%	3.51%	2.50%	1.85%	1.91%	1.57%
Rf RHIC	1.12%	0.55%	0.98%	1.87%	0.99%	1.41%	1.33%	0.48%
RadMonIntlk	0.62%	1.73%	1.47%	1.39%	0.59%	0.95%		0.69%
Cryo RHIC		0.54%	0.74%	0.77%	0.72%	0.62%		1.44%
Experiments	0.69%		0.47%		0.61%	1.21%	0.69%	0.97%
QLI	0.54%	0.97%	0.60%	0.75%		0.84%	0.46%	
Controls Hdwr RHIC			0.57%		0.46%	0.92%	0.53%	
Linac RF		0.46%		1.02%		0.51%		0.70%
Quench Protect		0.73%		0.67%	0.50%	1.08%		
Access Controls RHIC	1.31%				0.53%		0.72%	
Controls Software	0.63%			0.49%		0.45%		
AtR magnet/power supply		0.52%					0.66%	0.48%
Rf AGS		0.70%	0.61%			0.49%		
PS AGS				0.51%			0.98%	
E Electric AGS					0.62%			
E Electric Booster					0.61%			
Pulsed Power AGS					0.60%			
PS_Booster / BtA / LtB		0.59%						
Quench Detect		1.42%						
Vacuum AGS	0.54%							
List of 96 reduced to 26								
ESHQ fire protect RHIC Phenix - AuthAlternative		0.51%						
TMP7			0.55%					
Instrument RHIC SC			0.69%					
Power Supply Experiment			0.50%					

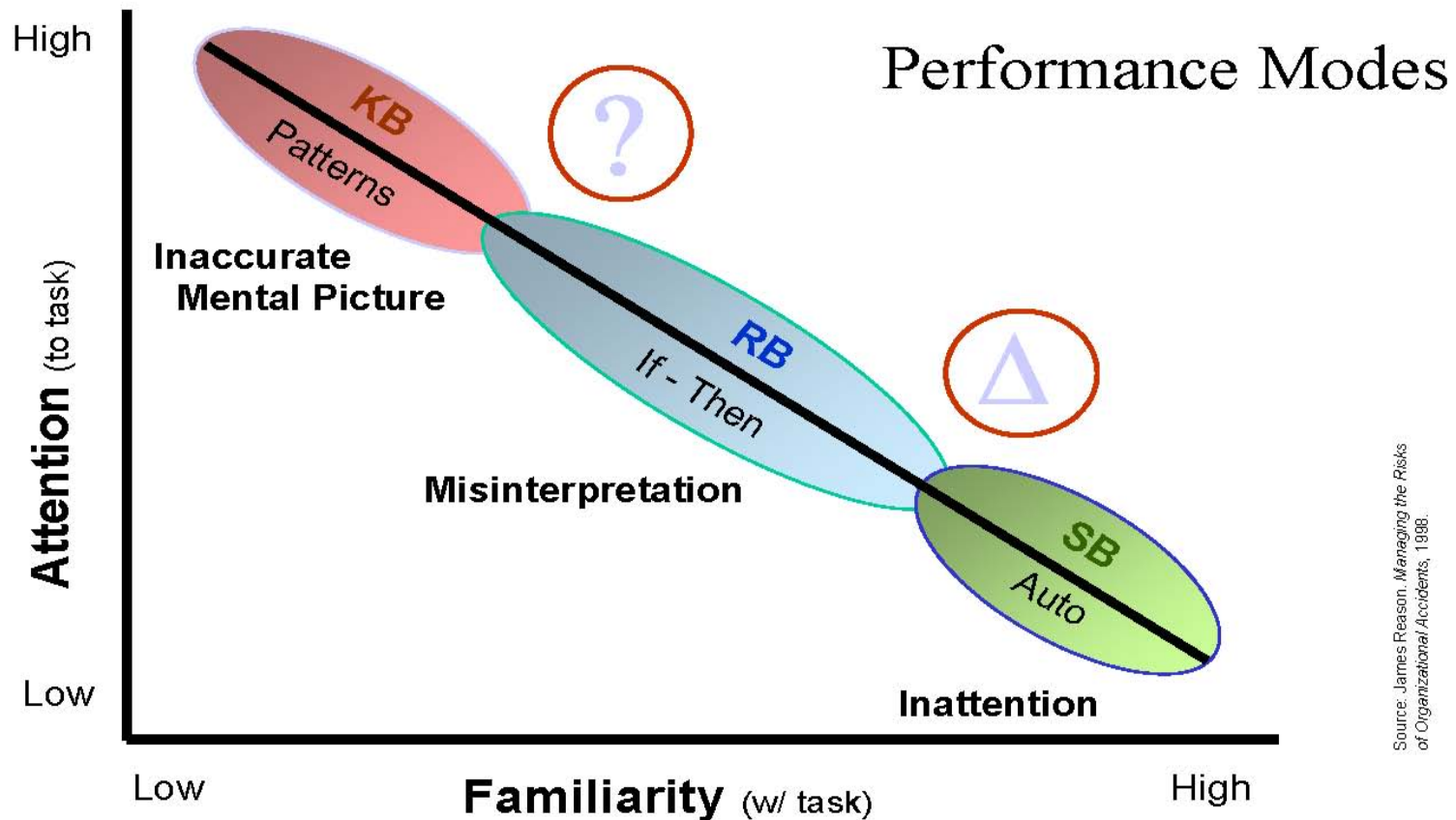
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Pulsed Power AGS					0.60%			
H AtR magnet/PS cool		0.52%					0.66%	0.48%
E Electric AGS Sub Q					0.62% Q			
PS AGS Cyclo Converter				0.51%			0.98%	
E Electric Booster					0.61%			
E PS Booster / BtA / LtB		0.59%						
H Quench Detect loose cables		1.42%						
H Vacuum AGS	0.54%							

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E Electric AGS Sub Q					0.62% Q			
E Electric Booster					0.61%			
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E Electric AGS					0.62% Sub Q			
Sub Q					0.61% Alt Feed			
E Electric								
Booster								
E PS_Booster /								
BtA / LtB		0.59%XFMR						
H Vacuum AGS	0.54%							
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loose cables		1.42%						



RadMonIntlks – Feedbacks – less tuning



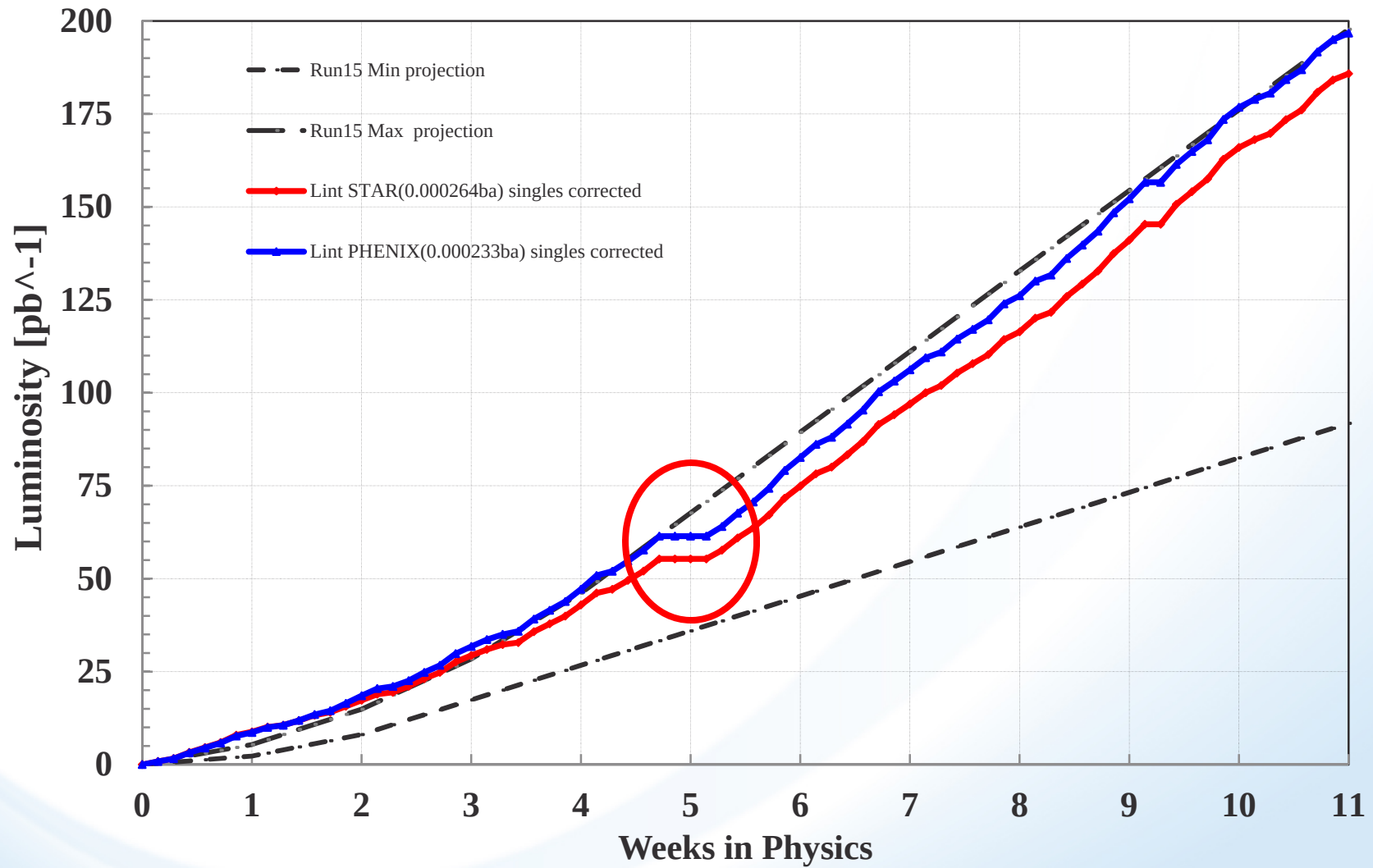
Conclusions

- Problems with hardware are understood.
- Support groups have their systems under control
- Pulsed Power (RHIC abort kicker pre-fires) only concern (of mine)
 - Dealing with a problem that has stymied some of the 21st century's best engineers/physicists.

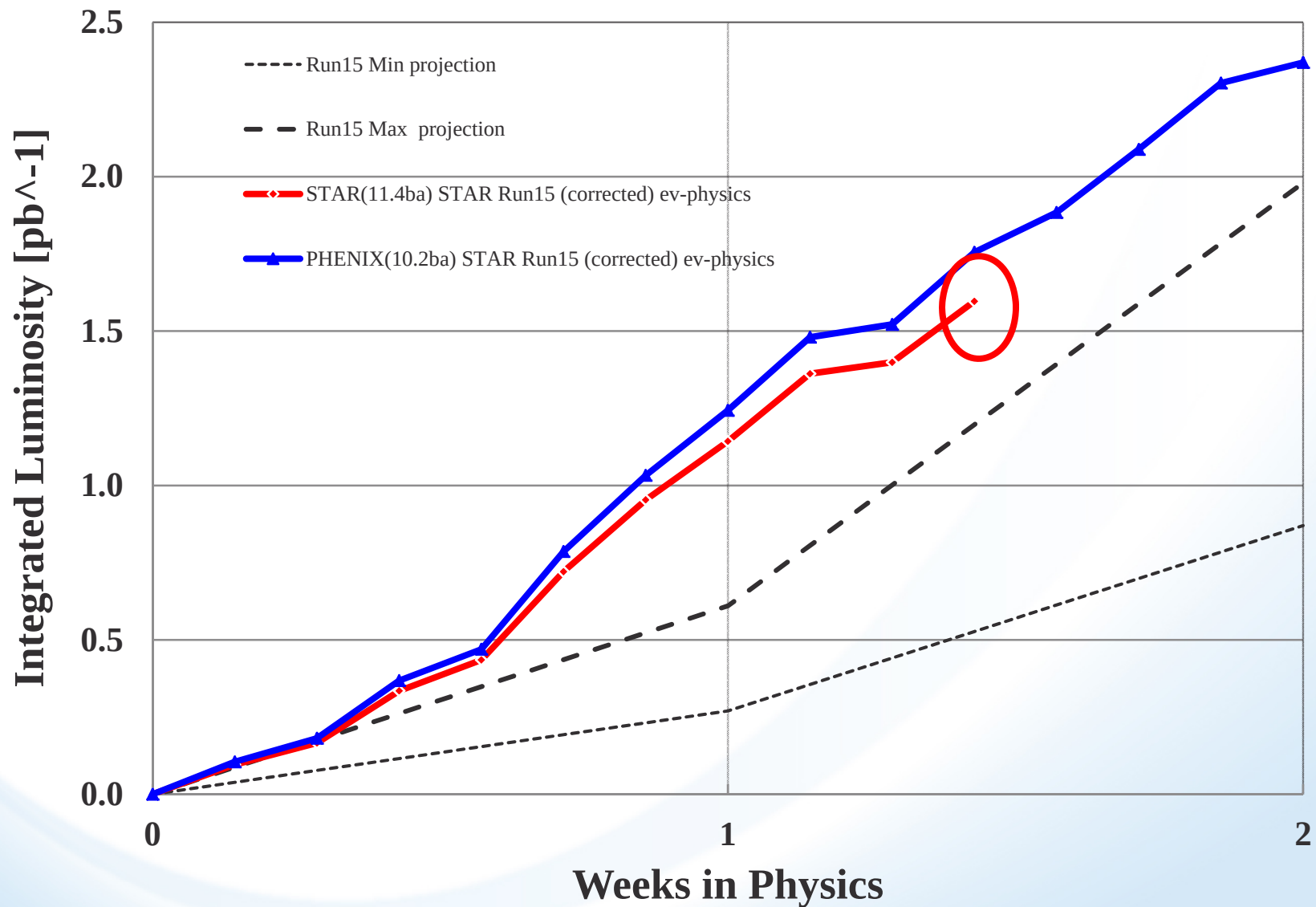
Conclusions

- **ELECTRICAL**
INFRASTRUCTURE
- Injector legacy electrical grid
 - Assistance from the Laboratory?
DOE?
 - Expect no changes
 - Need for spare power transformers,
JNS?
 - Money to pay for them?

RHIC Run15 p⁺p⁺ Delivered Luminosity ($\sqrt{s} = 200$ GeV)



Run15 (p^{Al}) Delivered Luminosity ($\sqrt{s}=200$ GeV)



Conclusions

- **HUMAN ERROR** is all around us
 - Doon Gibbs –
“Keep your head in the game”
- He is right!
 - VHS – “Situational Awareness”

Error Traps or Error Precursors

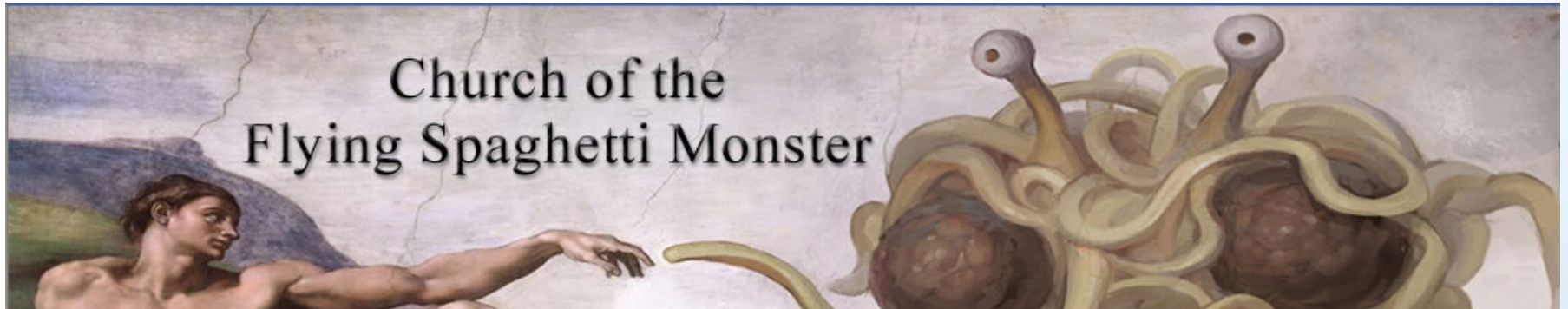
characteristic of a task or individual that increases the probability for error

- **TASK Related**
- Time Pressure
- Distractions
- High Workload
- First time Evolution
- First day at work after 4 or more days off
- Vague or incorrect guidance
- **Related to the “Individual”**
- Overconfidence
- Poor Communications
- Work/Home Stress
- Fatigue
- Peer Pressure
- Multi-tasking
- Off-normal Conditions

How do we proceed?

- To date C-AD Strategy has been brilliant given limited staff and financial resources.
- Invested in accelerator performance as well as equipment reliability.
- Repeatedly performance has trumped reliability.
 - We play catchup and WIN!
- Continue to emphasize Human Performance
- Continue to invest in the “Best and the Brightest”
 - The Problem Solvers
- Consider regular Cryo Control Room mitigation exercises/drills – scenario – loss of electrical power.

“pray” for reliability
and trust the
engineers/technicians/physicists/operators



fin

Supporting Documentation (human error)

TR File #042220150817

Current Date: Fri Jul 24 14:56:30 EDT 2015

Operator's Trouble Report			042220150817
1. Equip. Code: FOAC	2. Repair Group: scaduto@bnl.gov,pendzick@bnl.gov,pkfeng@bnl.gov,sampson@bnl.gov		3. RHIC Mode: PhysicS
4. Major Fault: Store lost due to blue 28's tripping off. J. Butler was called in. He found that a screw compressor to the RF cavities had tripped on an overtemp fault. The overtemp fault was resolved by adding 2 gallons of oil to the compressor.			
5. RHIC Off: Apr 21, 2015 03:05	Equip. Ready: Apr 21, 2015 06:31	Time Elapsed: 3h 26m	RHIC On: Apr 21, 2015 06:31

System Engineer's TR Review		workmanship -- a number of TF	050820140759
11. System Engineer: Don Bruno		12. Date: May 09, 2014	
13. Repair Type: Permanent		Details: N/A	
14. Explanation: We have installed a new kepcos in the y2-q89 which has been running very well with no problem since 4/17/13. We wanted to gain more experience with these new kepcos so we installed another new kepcos supply in the y6-q89 slot. This is the 3rd time it tripped in this slot but this time it would not put out any current after it was turned back on once to 200A. It tripped again during our testing at 200A. We decided to put the original ps back in and then figure out what happened to the ps later on.			