WG-D:

Commissioning Strategies, Operations and Performance, Beam Loss Management, Activation, Machine Protection

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WG-D Charge

- **Commissioning Strategies, Operations and Performance, Beamloss Management, Activation and Machine Protection (2.5 sessions)**

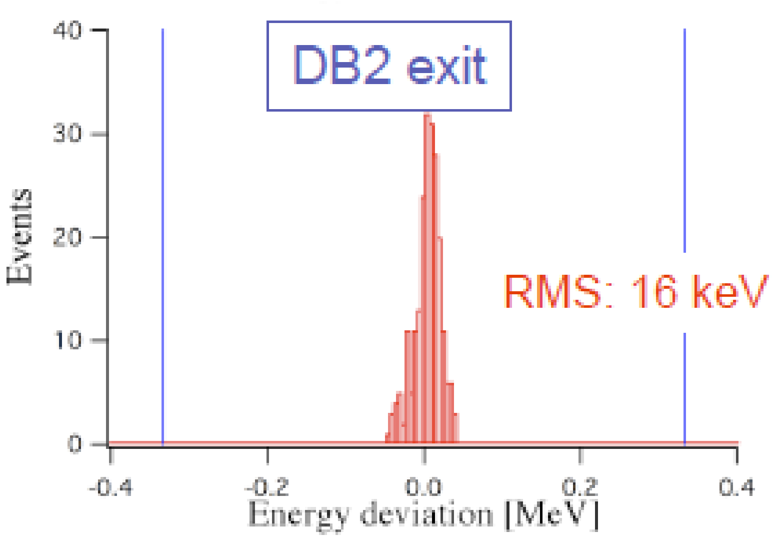
- **Scope:** Performance of operating facilities; limitations to intensity and beam power in operating facilities; commissioning and tune-up experience, algorithms and strategies at new and existing high intensity machines; beam loss performance of operating facilities; activation simulations and tracking; systems for machine protection and minimization of activation; active handling methods
- **Working Group Charge:**
- Summarize the present performance parameters of the existing high intensity facilities, and planned performance of new facilities.
- Summarize the key limitations to performance at each of the existing and planned high intensity facilities.
- Summarize the commissioning and tune-up algorithms and techniques in use and envisioned, and those that have proven to be especially useful.
- Summarize key needs from theory, simulation, controls, etc. to enhance performance, aid commissioning and tune-up.
- Summarize the beamloss and activation performance of existing high-power proton facilities.
- Summarize the strategies for operation and maintenance of loss-limited facilities.

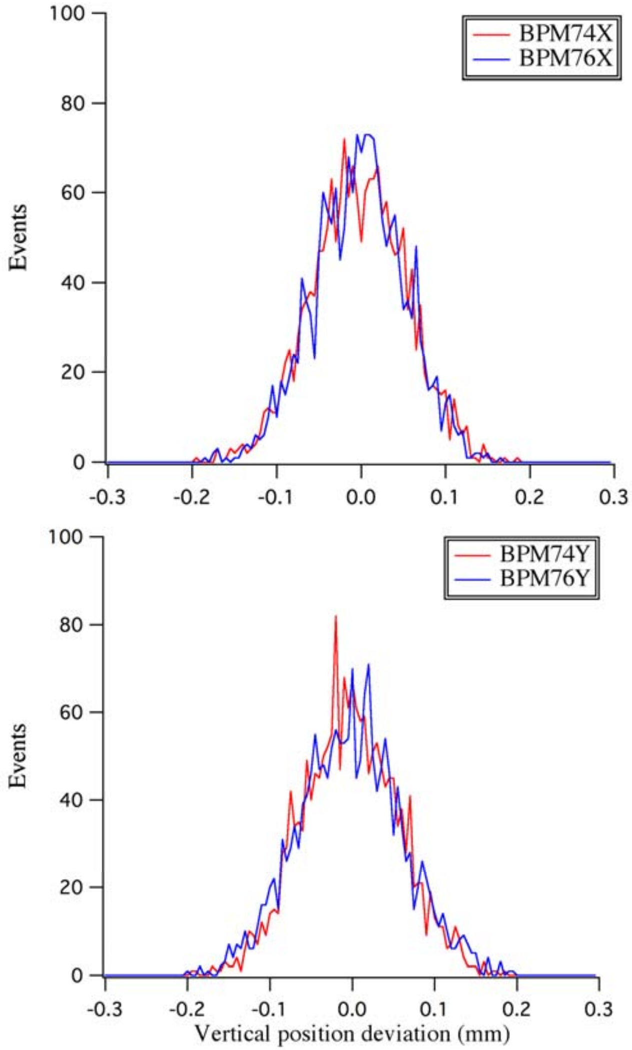
Summary of commissioning talks

1. J-PARC accelerators
2. SNS commissioning tool
3. Discussion & answers to the questions

J-PARC Accelerators (1) :Linac

The linac commissioning has been started in Nov. 2006. And the linac has been operated to provide a stable beam for the downstream facilities for nearly one year. Now the linac is in the transition phase from commissioning to operation.



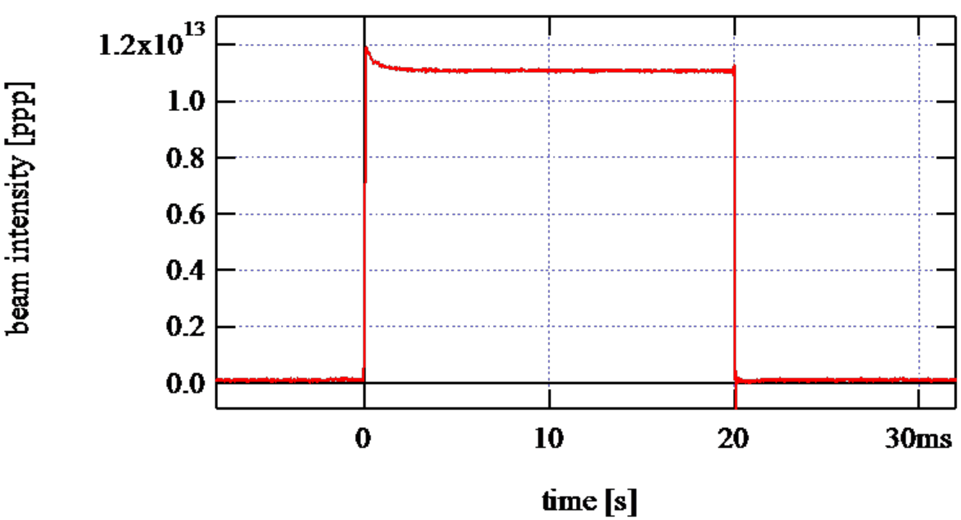


Stability of Linac:
Energy deviation is 16 keV (RMS) at exit of debuncher 2 for 9 hrs. operation.
Position jitter at the RCS injection is around 60μm in rms.

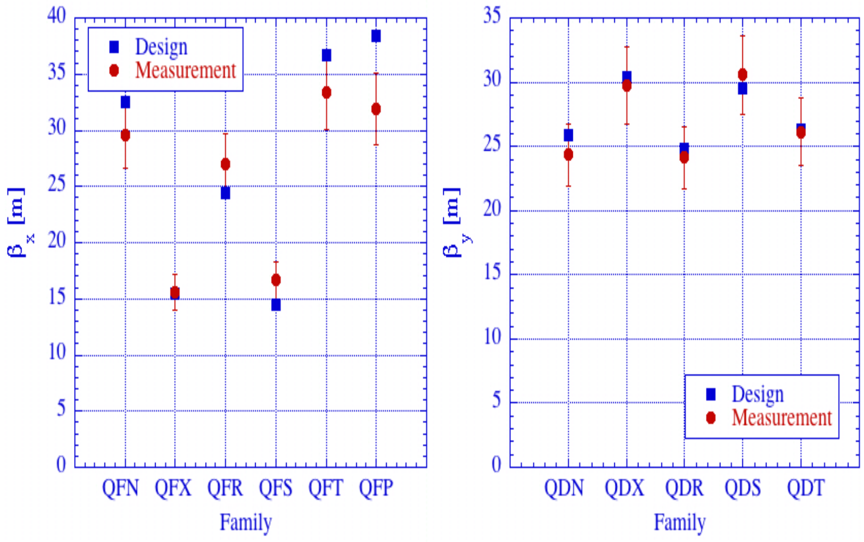
J-PARC Accelerators (2) : Synchrotrons

The RCS commissioning has been started in Oct. 2007. And the RCS has completed initial tunings of basic parameters. The efforts will be focus on high power operation.

The MR commissioning has started in May 2008. Beam tuning and parameter measurements in the injection energy of 3 GeV have been done successfully. Acceleration up to 30 GeV and extraction to experimental facility is scheduled from December 2008.



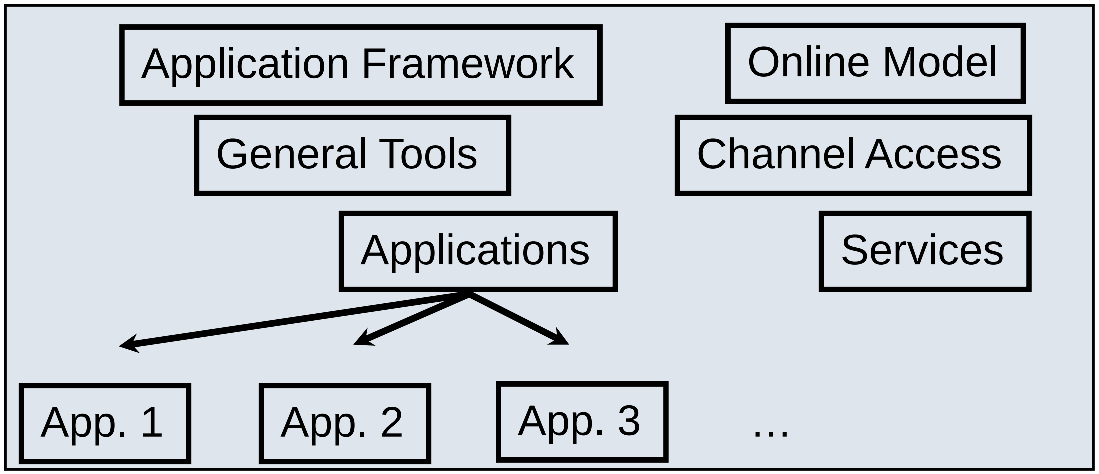
Demonstration of 1e13 ppp extraction from the RCS in single shot mode: It corresponds to 0.13 MW for 25 Hz.



Measured results of beta function of the MR.

SNS commissioning tools

XAL, a Java based high level programming for physics application, has been being developed since the beginning of the SNS commissioning.



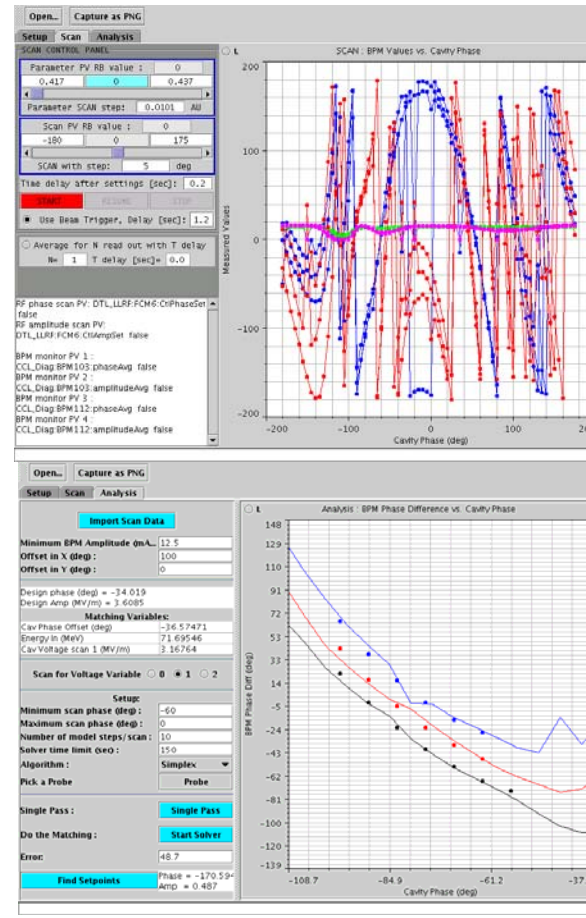
XAL structure

What we did right:

- **Early staged commissioning approach**
- **Iterative Approach for Commissioning Tools**
- **Using physicists (i.e. commissioners) to write applications (Need a core group of "mentor" programmers)**
- **Educational efforts**

What we did wrong:

- **Most applications and some of tools are SNS specific**
- **Lack of documentation**
- **Did not implement service daemons to reduce EPICS traffic**
- **We used commercial plotting package (JClass) in the open source software (XAL)**



An example:
PASTA-Phase/amplitude scan and tuning application

Discussion & answers to the questions

- Operation shifts for commissioning run
  - 24 hr. shifts : SNS, …
  - 12 hr. shifts (12 hr. operation and 12 hr. break): J-PARC, NuMI..
    - Reason of 12 hr. shift
    - NuMI: Real time participation of all system experts.
    - J-PARC: Reason is the same as NuMI. But in other words, shortage of man power.

- Most useful tools
  - J-PARC MR: BPMs (both turn-by-turn and COD modes), IPM.
  - NuMI: Beam permit system, 12 hr shift, autotune beam control system, and robust beam instrumentation performance especially, with BLM, BPM.

- Biggest problems
  - J-PARC MR: Ripple/fluctuation on the beam due to current ripple of magnet PS's.
  - NuMI: One corrector data base polarity bit was wrong, and some profile monitors had readout problems for a few pulses. A data base scaling error for one quad.

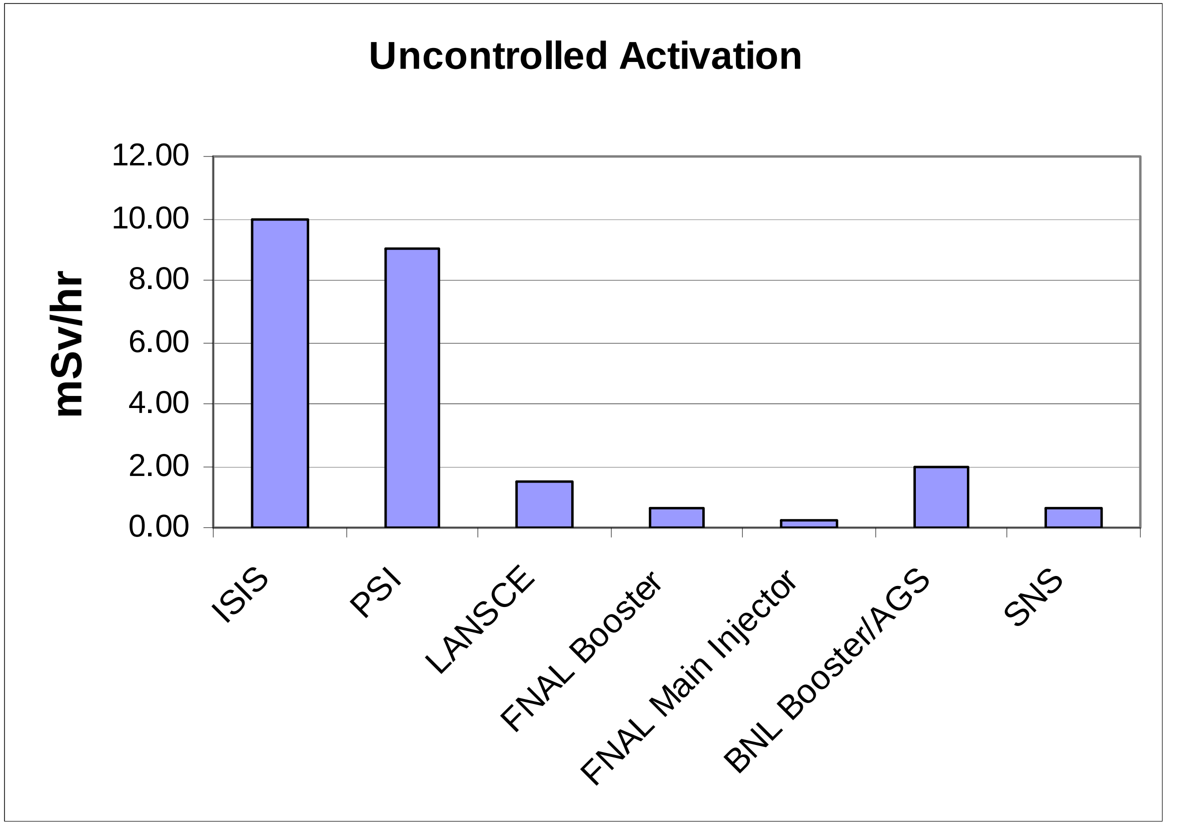
-How long does it take to get the first order beam commissioning
  - J-PARC MR: 4 days (transportation, injection, circulation with rf capture and extraction)
  - NuMI: After four 12 hour shifts, we accomplished all goals of establishing readiness for subsequent higher intensity beam commissioning, including instrumentation and beam control checkout.

Operational Experience of High Power Machines

	Accelerator	Power (MW)
PSI	Cyclotron chain, (CW)	1.2
SNS	Linac/accumulator Ring, (pulsed)	0.5
NUMI (FNAL MI, Booster)	Linac / RCS chain, (pulsed)	0.34
ISIS	Linac / RCS, (pulsed)	~ 0.18
BNL Booster/AGS	Linac / RCS chain, (pulsed)	~ 0.06
LANSCE	Linac / accumulator ring (pulsed)	~ 0.1 (linac ran 1 MW)

Residual Activation – Uncontrolled Beam Loss

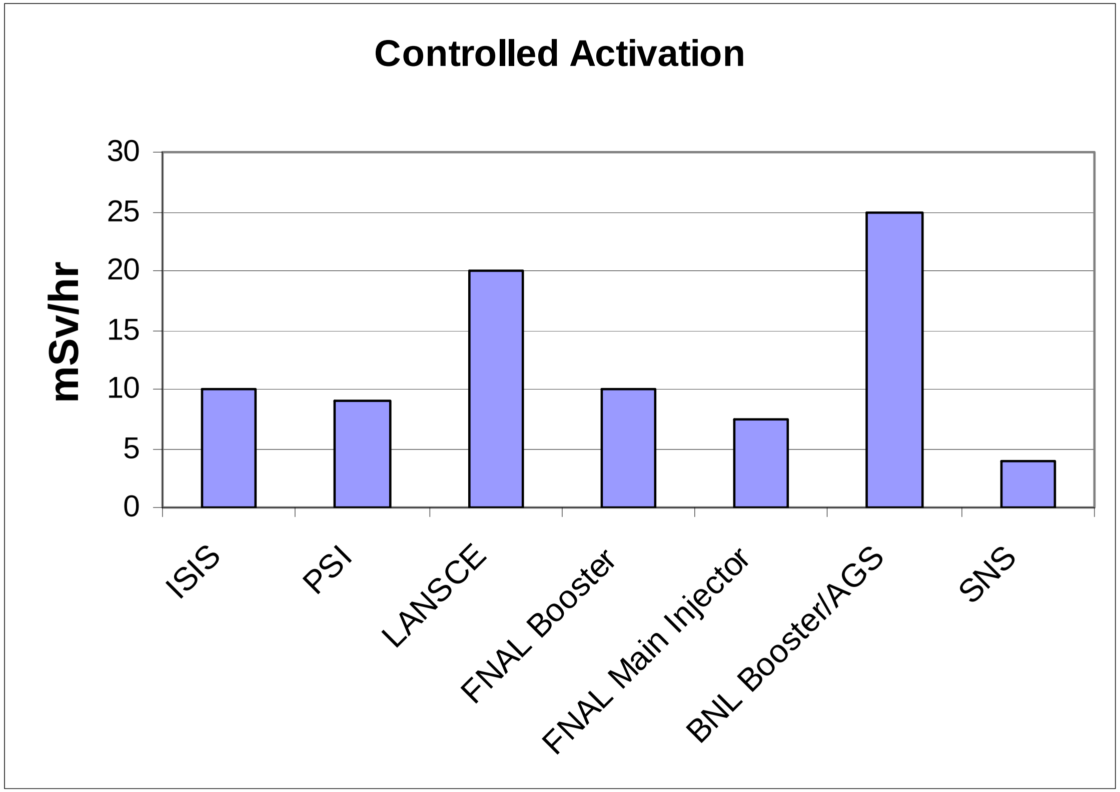
@ 30 cm, 24 hrs after shutdown



- Most areas are much lower (approaching 0)
- PSI: at extraction
- LANSCE: Linac is lower than Ring
- FNAL Booster: 1 hr cool-down, FNAL MI: 3-4 hr cool-down
- BNL: after 10 hours

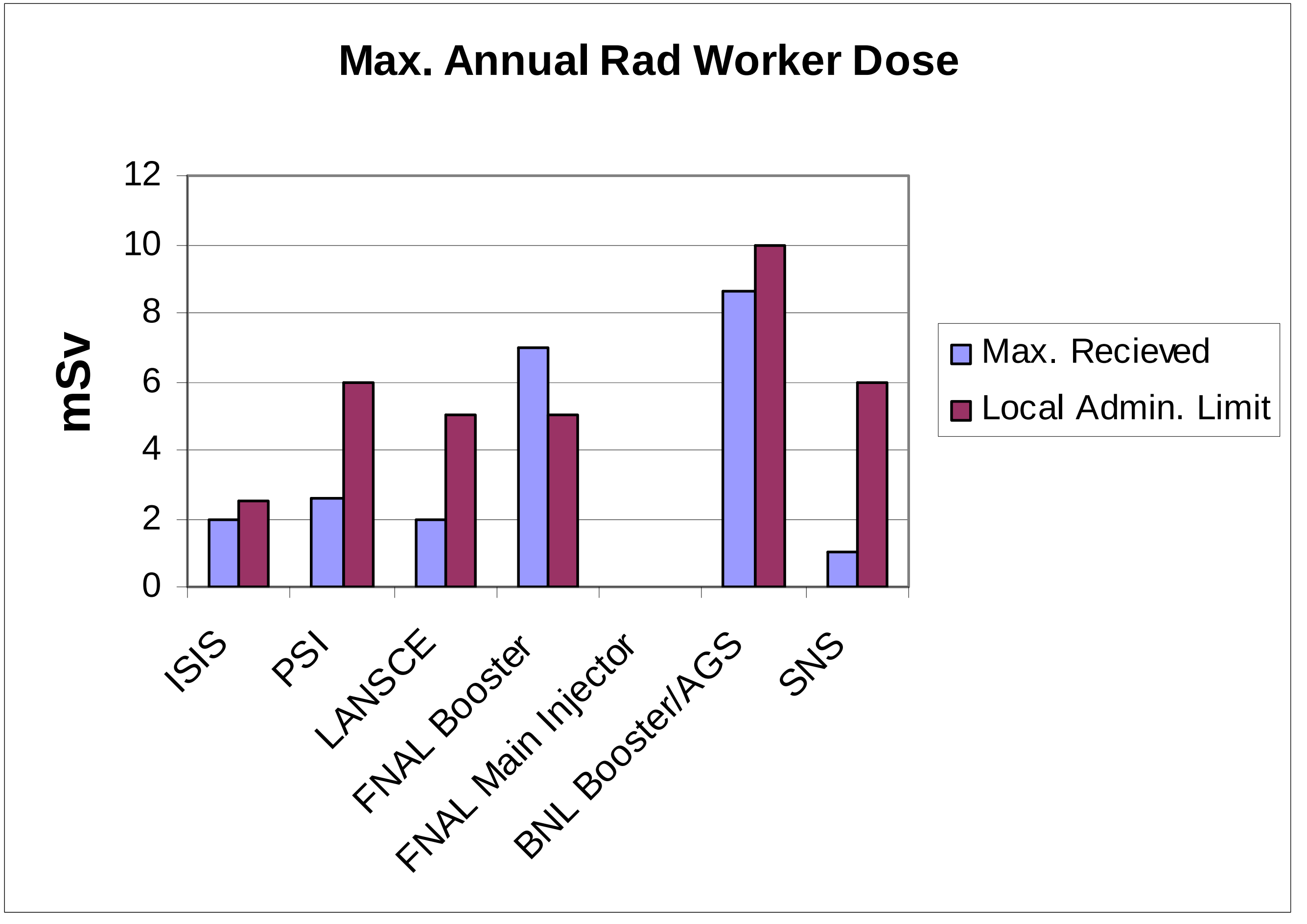
Residual Activation – Controlled Beam Loss

@ 30 cm, 24 hrs after shutdown



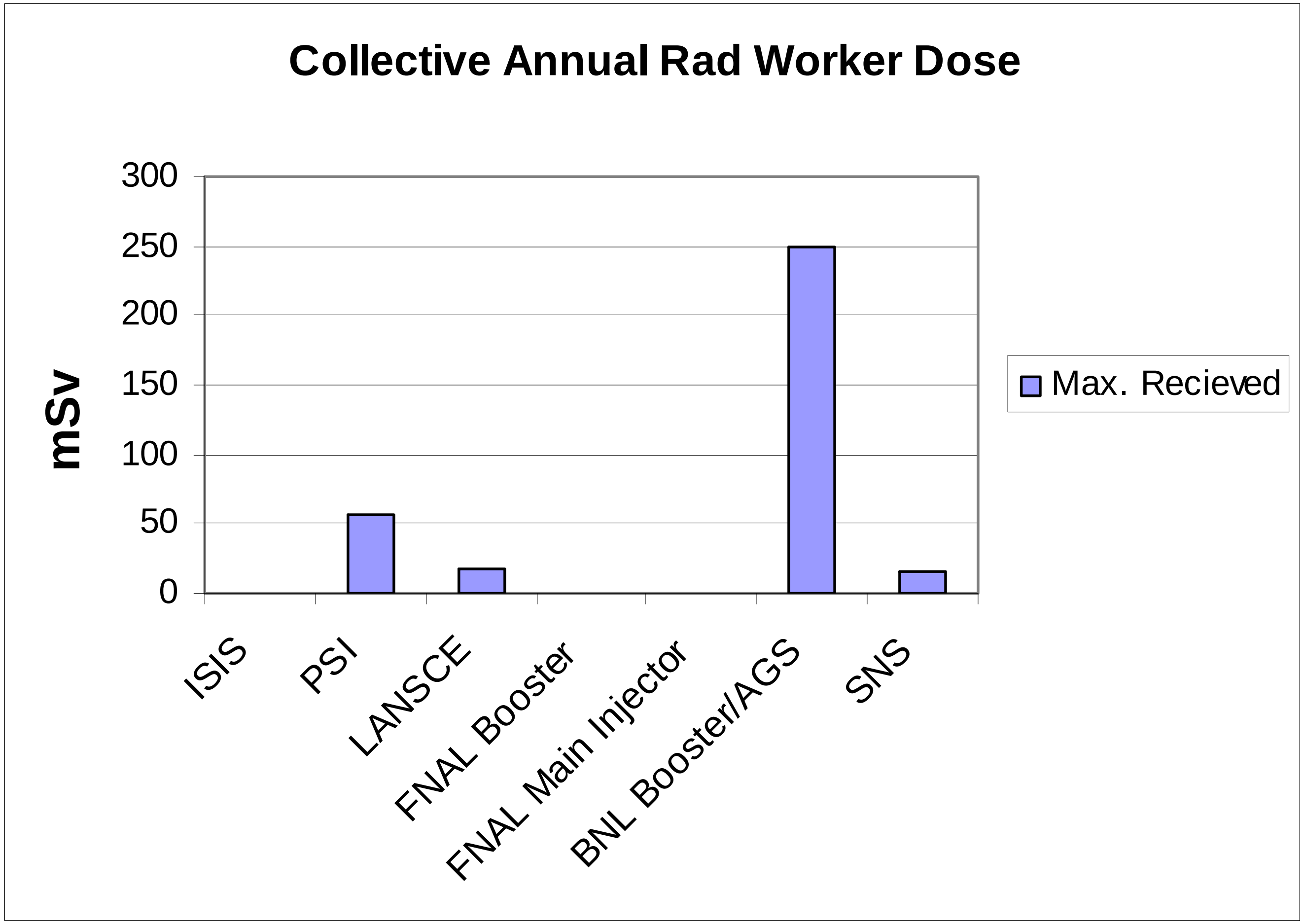
- ISIS: Collimation after a few days (???)
- PSI: at extraction
- LANSCE: after 4 hrs at PSR Injection
- FNAL Booster: 1 hr cool-down, extraction, collimation
- FNAL MI: contact, extraction, abort
- BNL: cool-down, 10 hrs – NOT beam loss limited
- SNS: Injection

Individual Worker Dose



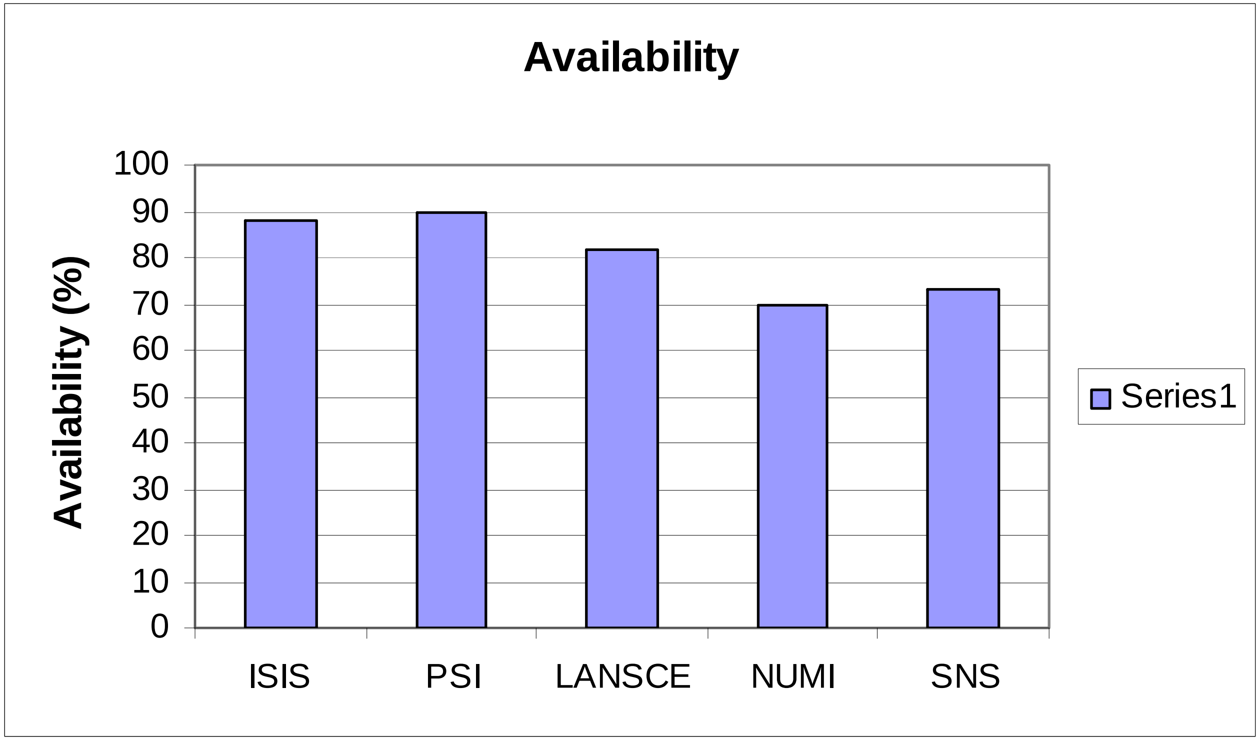
- Facilities tend to impose factors of 3-4 safety on government limits
- BNL: max. for highest intensity running period of 2000-2002

Collective Worker Dose (In Progress)



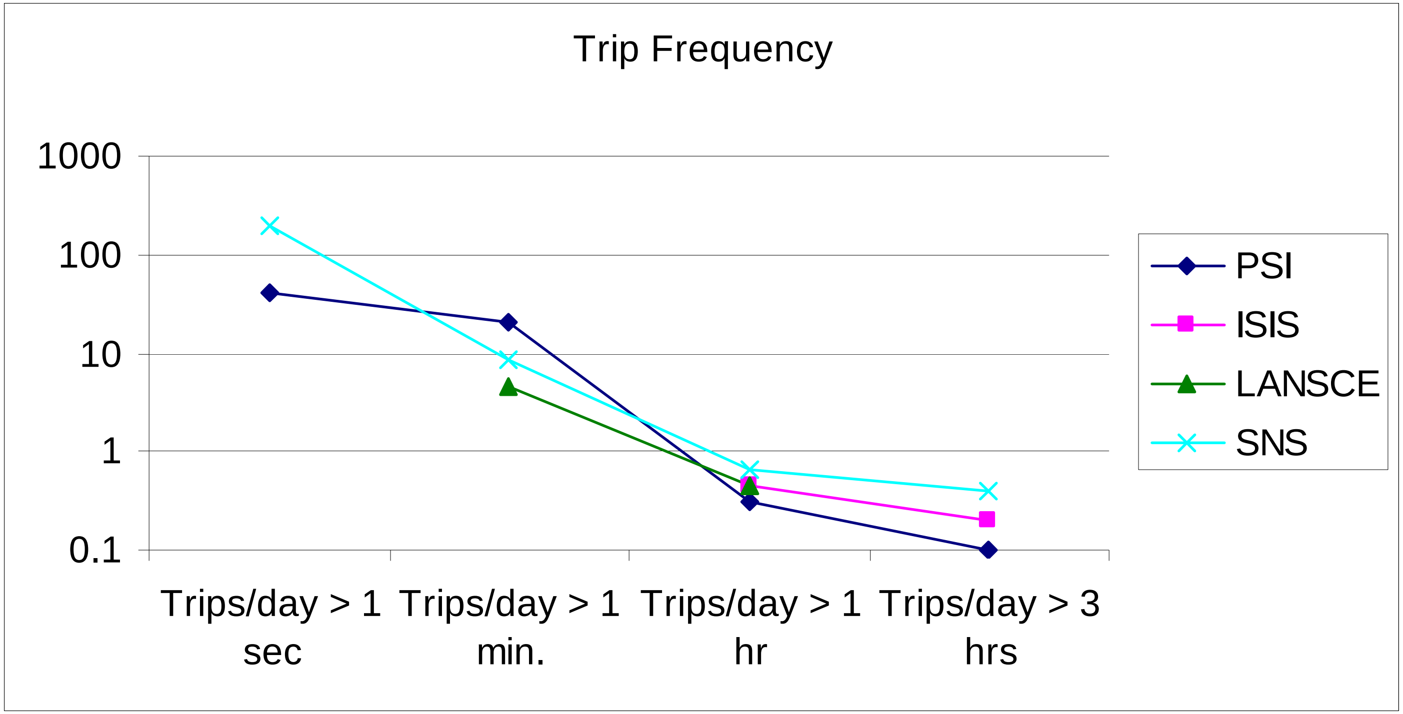
- Some different rules about who is included,
- LANSCE data is for one particularly hot job
- BNL is average for 2000-2002
- SNS is 2008 to date

Availability
(= beam on time / promised beam on time)



- ISIS = average for ~ last 10 years, Lujan and PSI are 2007, SNS is 2008 to date
- NUMI availability is dominated by Target hall – FNAL total accelerator chain is ~ 90% availability

Trip Frequency



- 1000’s of trips / year for CW, high rep rate cases (PSI, SNS)
- SNS is not a mature facility

Operation Rhythm (I)

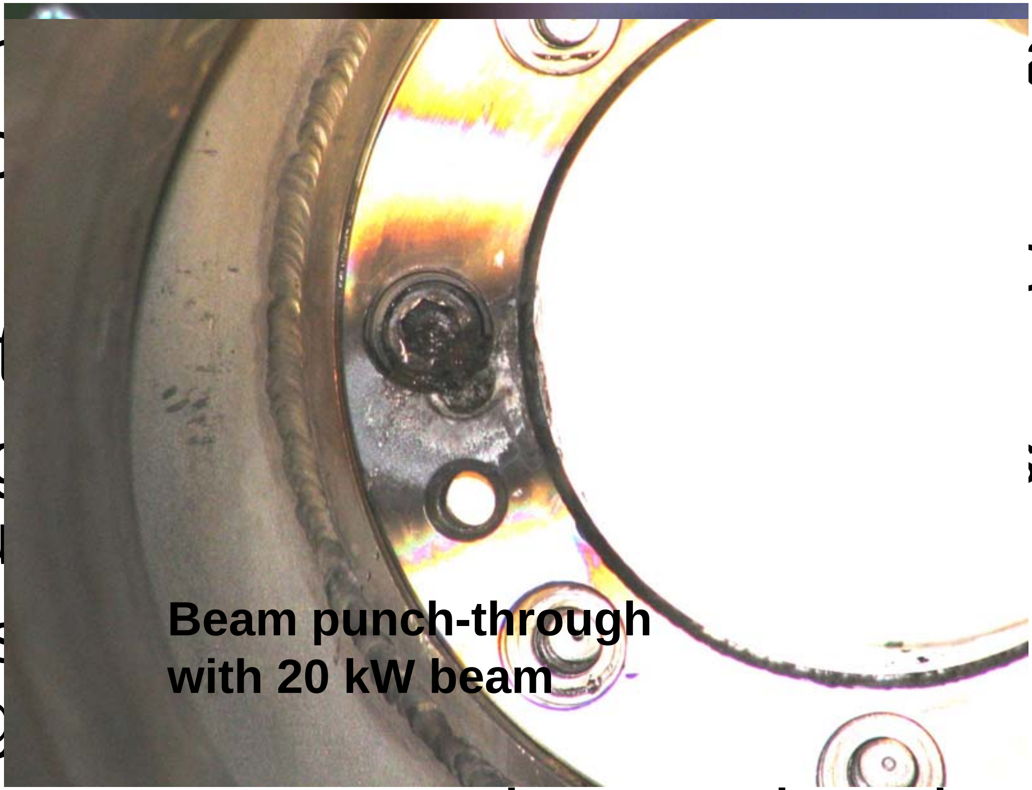
- How long does it take to restore beam to previous capability after an extended maintenance:
  - PSI:~2-4 days tuning + 4 days equipment readiness
  - ISIS: 1 week/month
  - FNAL booster (MI):1 week/month off (2 days)
  - LANSCE: 1 month - includes conditioning, protection certification, machine tuning, equipment issues - 1 shutdown/year
  - SNS: 10-14 painful days

Operational Rhythm II

- What is a typical run cycle
  - ISIS: ~50-60 days: 40 days run / 3 days beam studies, 10 day sort shutdown, 10 days startup
  - PSI: 3 weeks with 2-3 day beam study / maintenenace
  - LANSCE: ~1 month cycle: 24 day block: 1-2 day beam studies + 4-13 day maintenance + 1 day recovery
  - FNAL/NUMI:10-14 week planned shutdown/year, otherwise run to failure
  - SNS: 3 weeks with 5 day beam study/maintenance

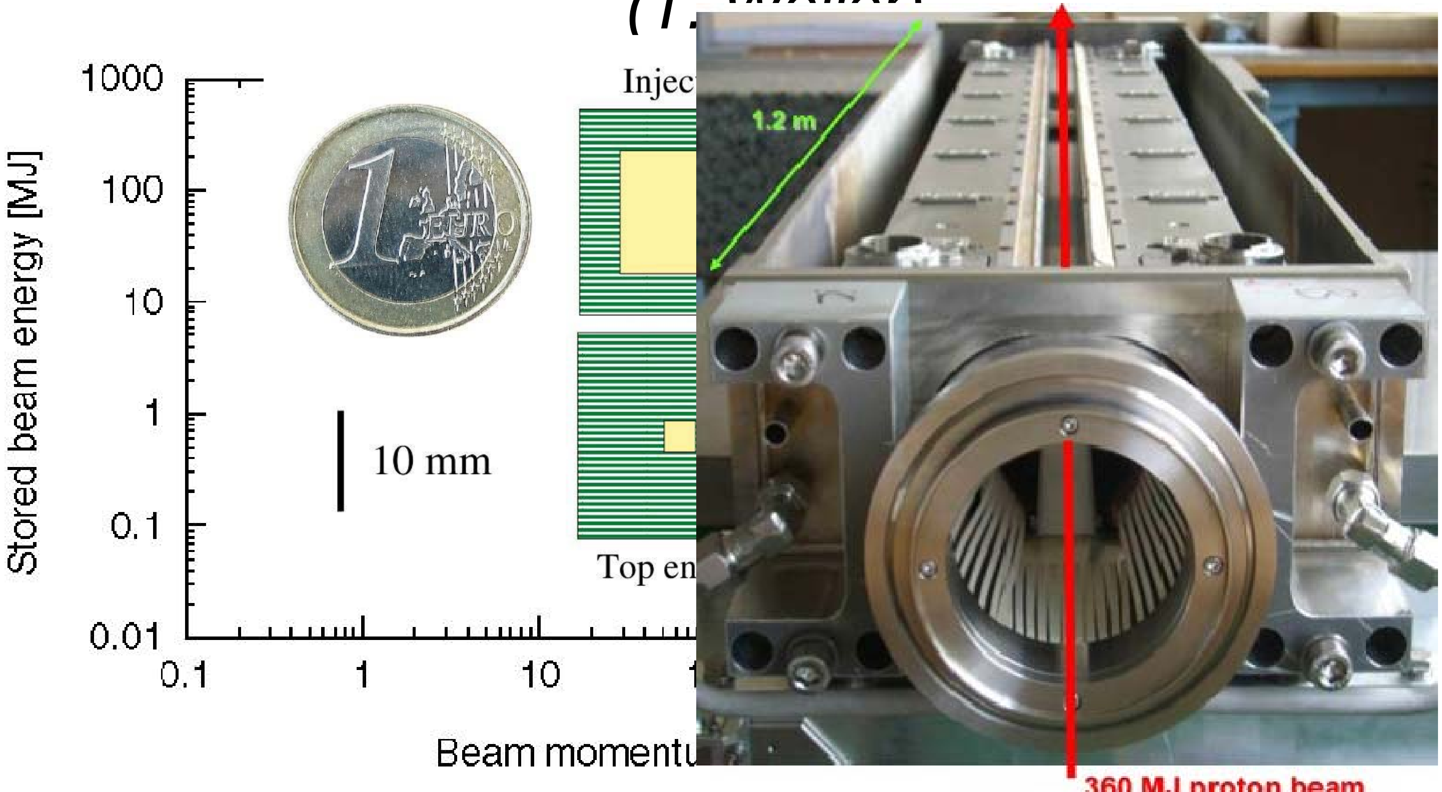
Impact of High Power

- The ir … a strong impac…
- Need … off normal condit…
  - Targ … strong influ…
  - Nuis … am diag…
  - High power protection needs to be considered in the machine designs



LHC Collimation

(T. Weiler)



- High intensity (stored energy) beams also impose severe constraints on the accelerator protection against continuous loss and other fault conditions
- Need highly reliable collimation systems that effectively protect Accelerator hardware during long stores that track the beam size

Simulation and Monitoring of Component Activation for High Power Accelerators

is important in order to ..

• to predict activation to be expected for maintenance work

• to obtain a better understanding of loss mechanisms [compare models and observations]

• to make extrapolations what is to be expected at higher beam currents

• prediction of isotope inventory required for material disposal [legally required]

comments:

• activation measurements in accelerator can be used to estimate the average current loss if appropriate models exist

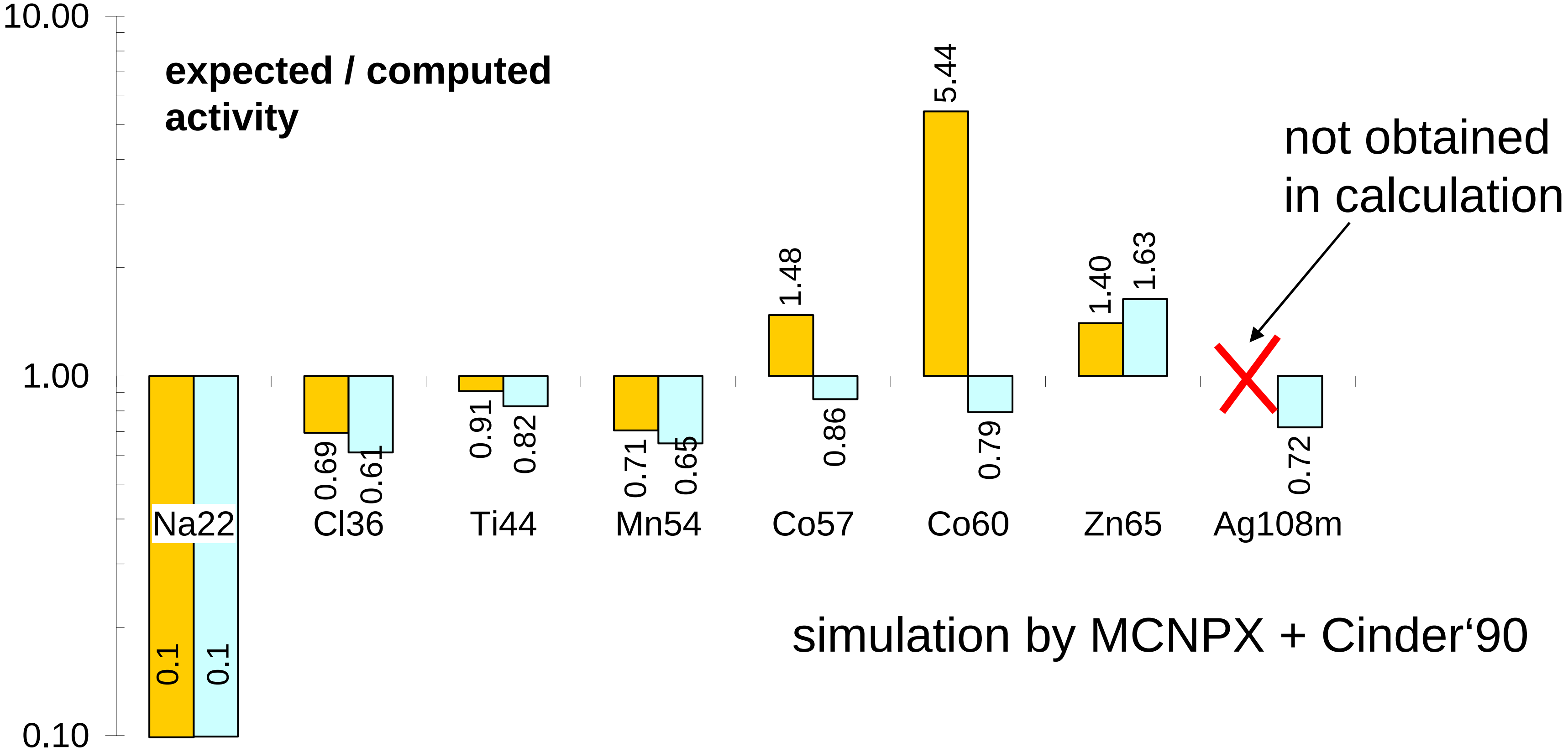
• precision of prediction typically within factor 3 compared to measurements

• extrapolation of previous experience provides a similar precision

• specialized codes are developed in cooperation at different labs; synergies should be used

• can use loss monitors for a live monitoring of residual radiation

Example for computational precision: prediction of isotopes in Al-target hull at PSI [D.Kiselev]



Example: prediction of accumulated activation and measurements at SNS [I.Popova]