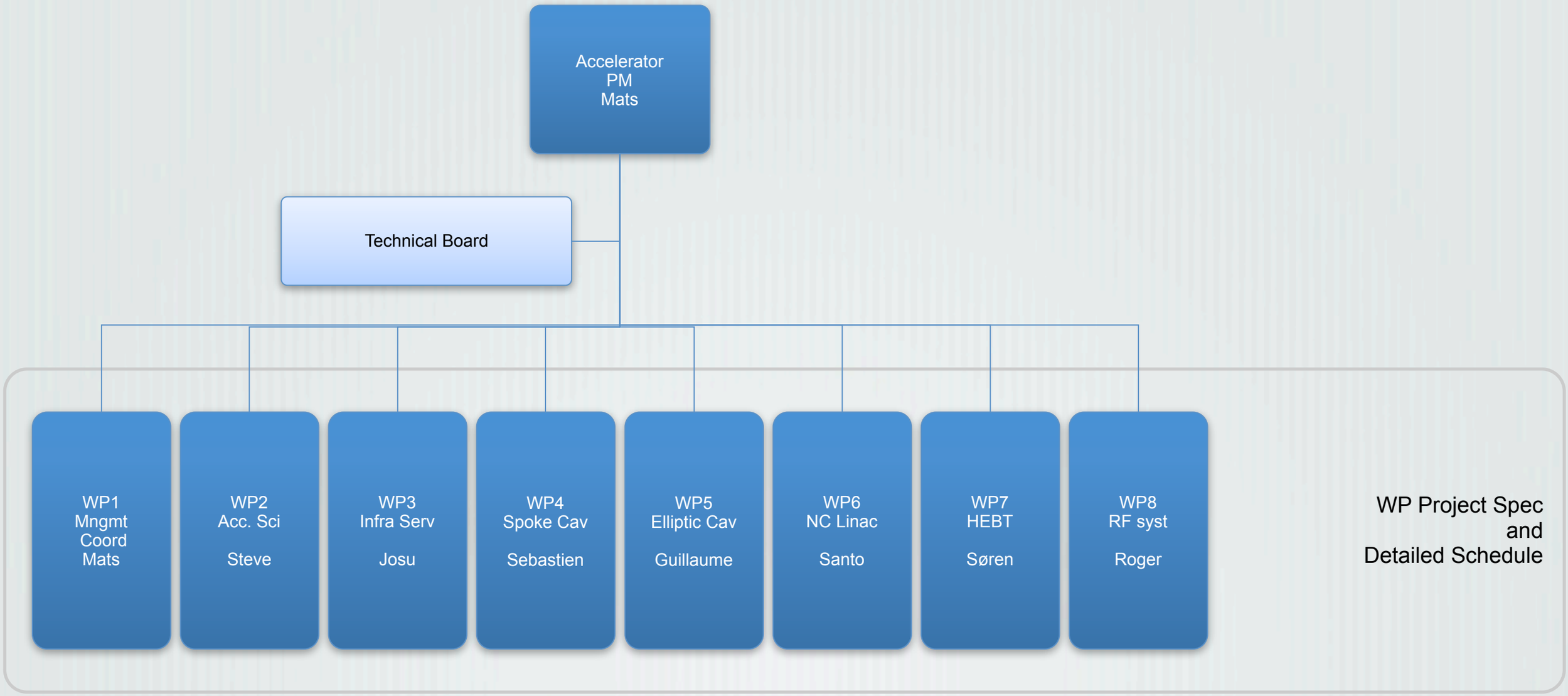
ESS Accelerator Science - WP2

Steve Peggs

ESS-SPL Collaboration Meeting – 1 July 2010

WP2 Accelerator Science

"In charge of Beam Physics, Control Systems, and Beam Instrumentation with the aim to identify and perform high-priority analyses and simulations that will be critical to determining the most suitable parameters in terms of performance, reliability and feasibility."



Work Units

WP2 works especially closely with WP1 “Management Coordination” to identify and perform high-priority analyses and simulations

2.1	Project Management	Steve Peggs
2.2	Beam Physics	Hakan Danared
2.3	Control Systems	Garry Trahern
2.4	Beam Instrumentation	Andreas Jansson

Work Unit 5, “RF Modeling” (Rama Calaga) has been moved to Work Package 8 “RF Systems” (Roger Ruber).

Requires ~6 months lead time to set up resources (parameters, databases & software) to support:

- partner institutions
- other Work Packages

Accelerator Division staff

All Work Units are lead by members of the ESS Accelerator Division

AD members (including WU leaders) are coalescing .... thus WP2 is still coming into focus

18 physicists & engineers attended this weeks first Accelerator Division Retreat:

6 ESS AB employees
3 imminent employees (~Oct 1)
2 long-term secondments from other labs
4 students
3 consultants

2 imminent post-docs (~Oct 1) were unable to attend

WU2.2 - Beam Physics

"Perform detailed studies of beam dynamics and lattice layout issues for the ESS linac."

Single- & multi-particle simulations
- what are right questions to ask?
  - Dynamics? Design? Operations? Production line?

Interact with other WPs & WUs to optimize technical specifications

Make detailed studies of beam loss, and develop a multi-stage collimation system (with WP7).

Contribute to the evaluation of linac upgradability

Describe Beam Physics support activities during construction, commissioning, and operations

Linac layout

To generate, evolve and maintain an end-to-end integrated layout, need

1) A relational database management system (mySQL → Oracle), for efficient and robust configuration control

2) “Scientific Computing Environment” including U of Copenhagen

In particular the design of an optimized linac/target interface requires close collaboration with:

Work Package 7 “HEBT”
Target Division
Conventional Facilities Division

2009


E22
E22
Odarslövsvägen
Dammstorpsvägen
Kämpingevägen
500 ft
100 m
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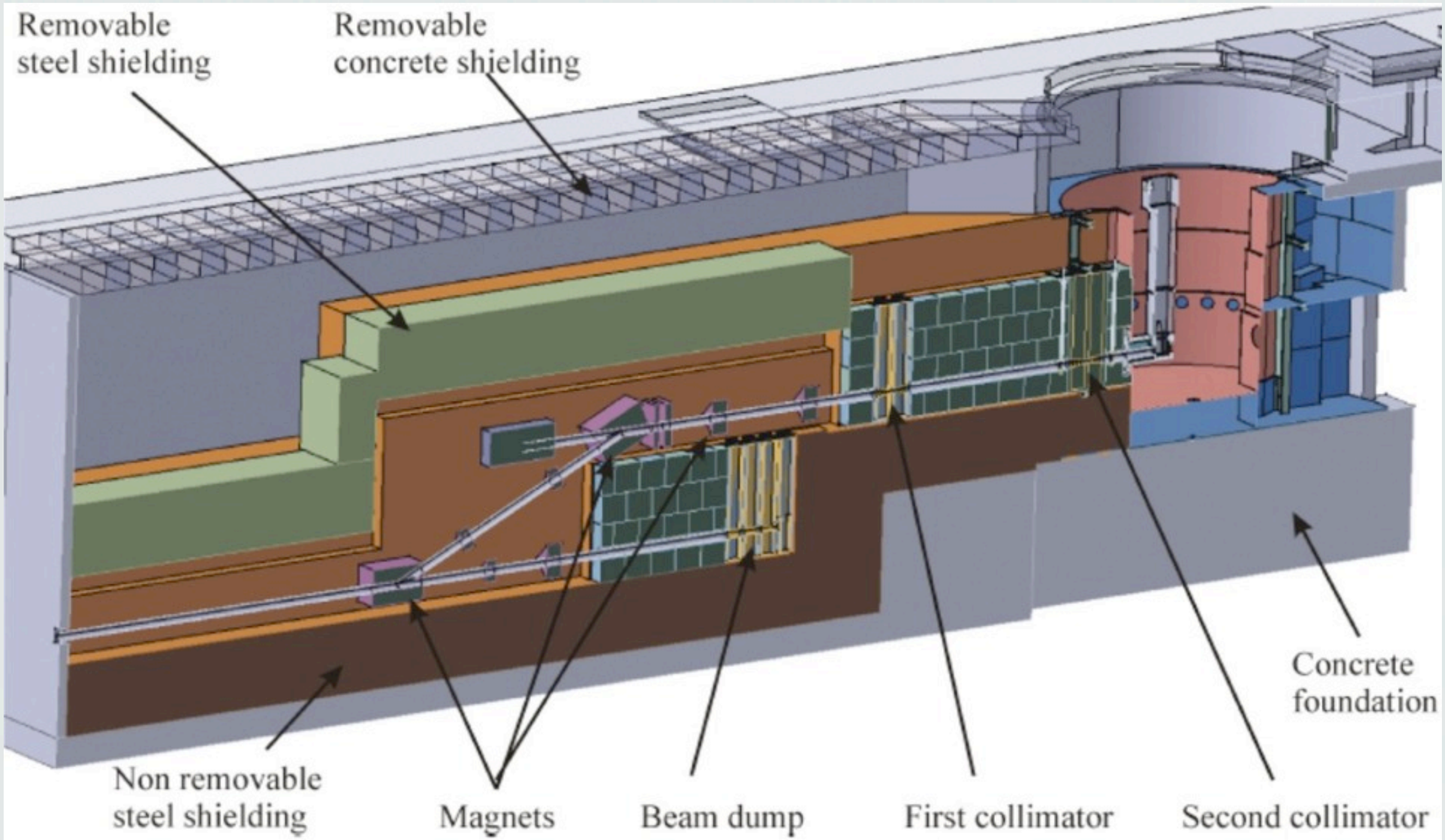
2018

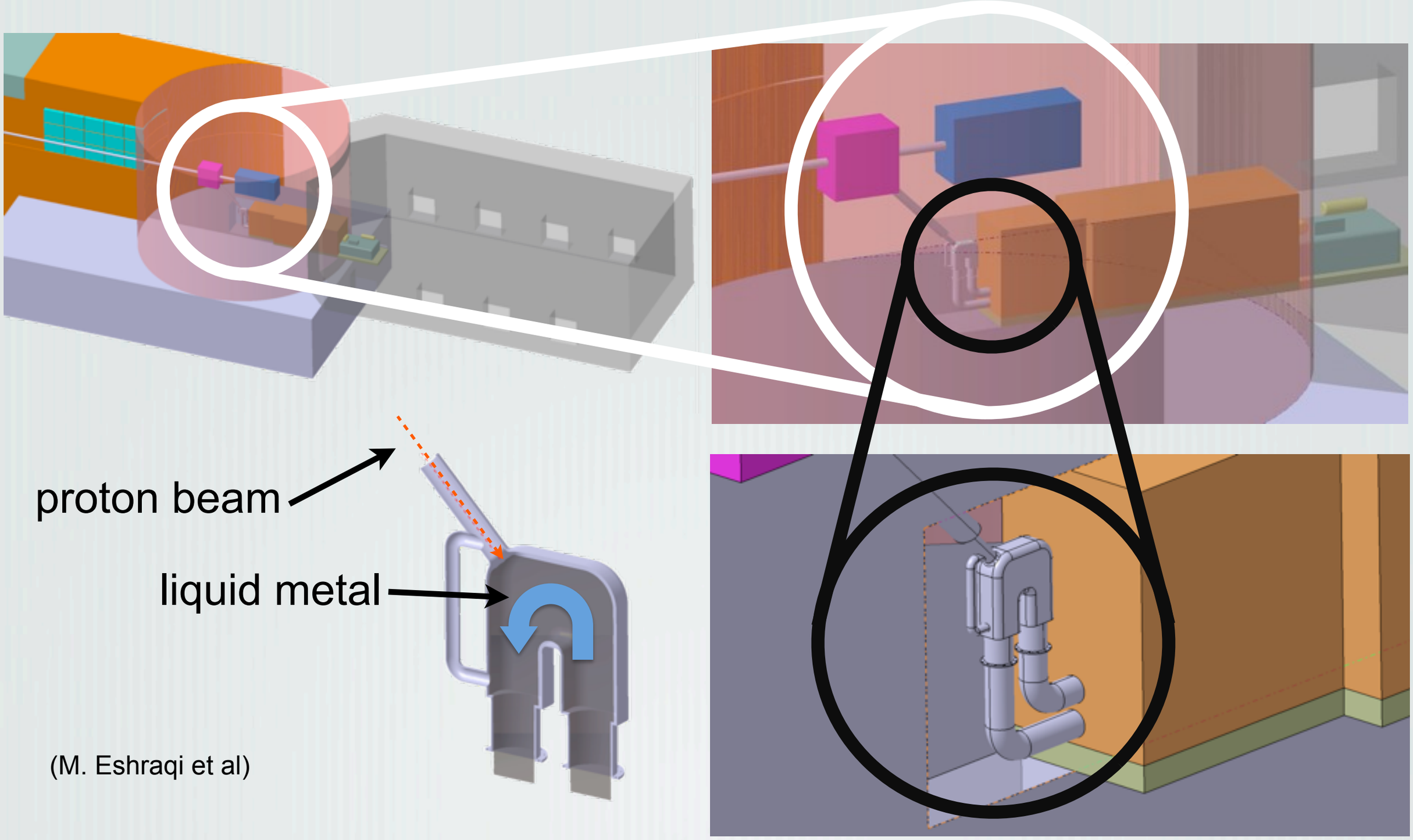
Linac-target interface - 2003

From the first proton bend magnet to target - work with WP7 “HEBT”



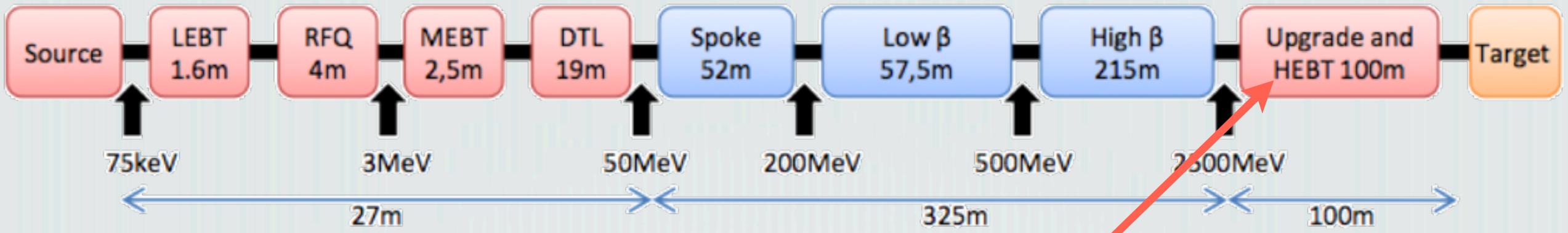
Eg “windowless” liquid metal target?

One option - 45 degree approach



(M. Eshraqi et al)

Linac layout



What can extra cryomodules in the 100 m section do?

1) potential power upgrade to 7.5 MW, with 1 Target Station or 2
   - cf SNS & J-Parc planning

2) production line QA contingency
   - eg at constant or reduced beam loss, following SNS experience

3) hot spares for reliability
   - following ADS (MYRRHA/Eurotrans) “fault tolerant” studies
   - response time desired is < 100 s, not required to be < 3 s

Simulations - SNS

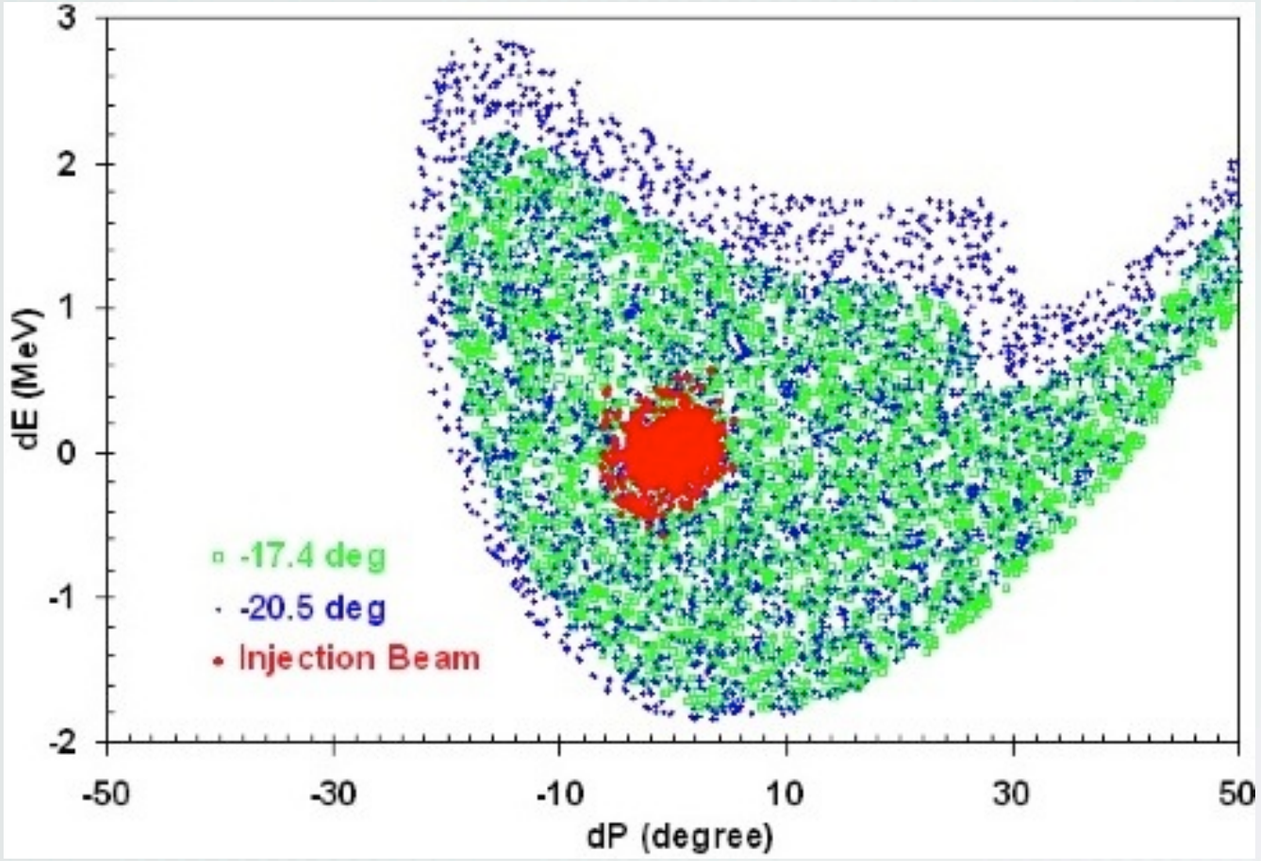
PHYSICAL REVIEW SPECIAL TOPICS - ACCELERATORS AND BEAMS **11**, 104001 (2008)

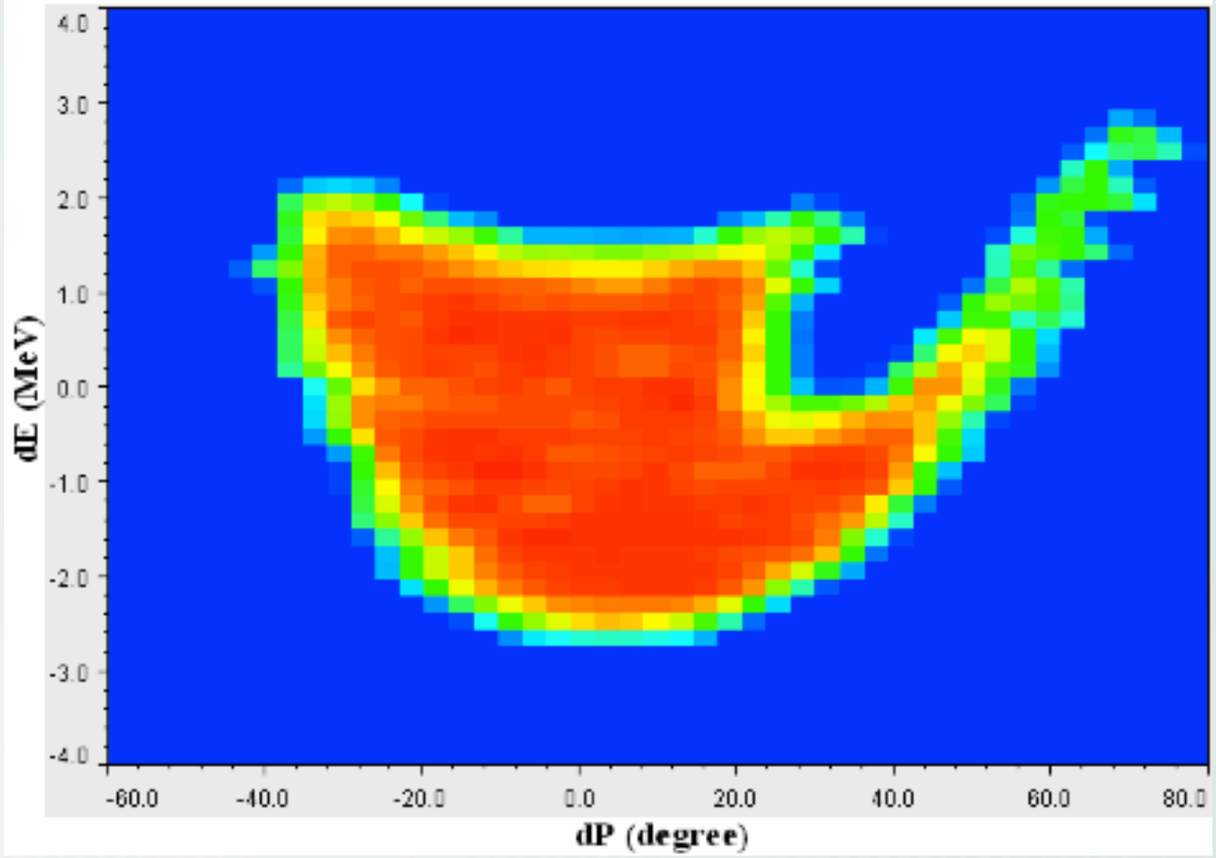
Measurement of longitudinal acceptance and emittance of the Oak Ridge Spallation Neutron Source Superconducting Linac

Y. Zhang,* J. Galambos, and A. Shishlo

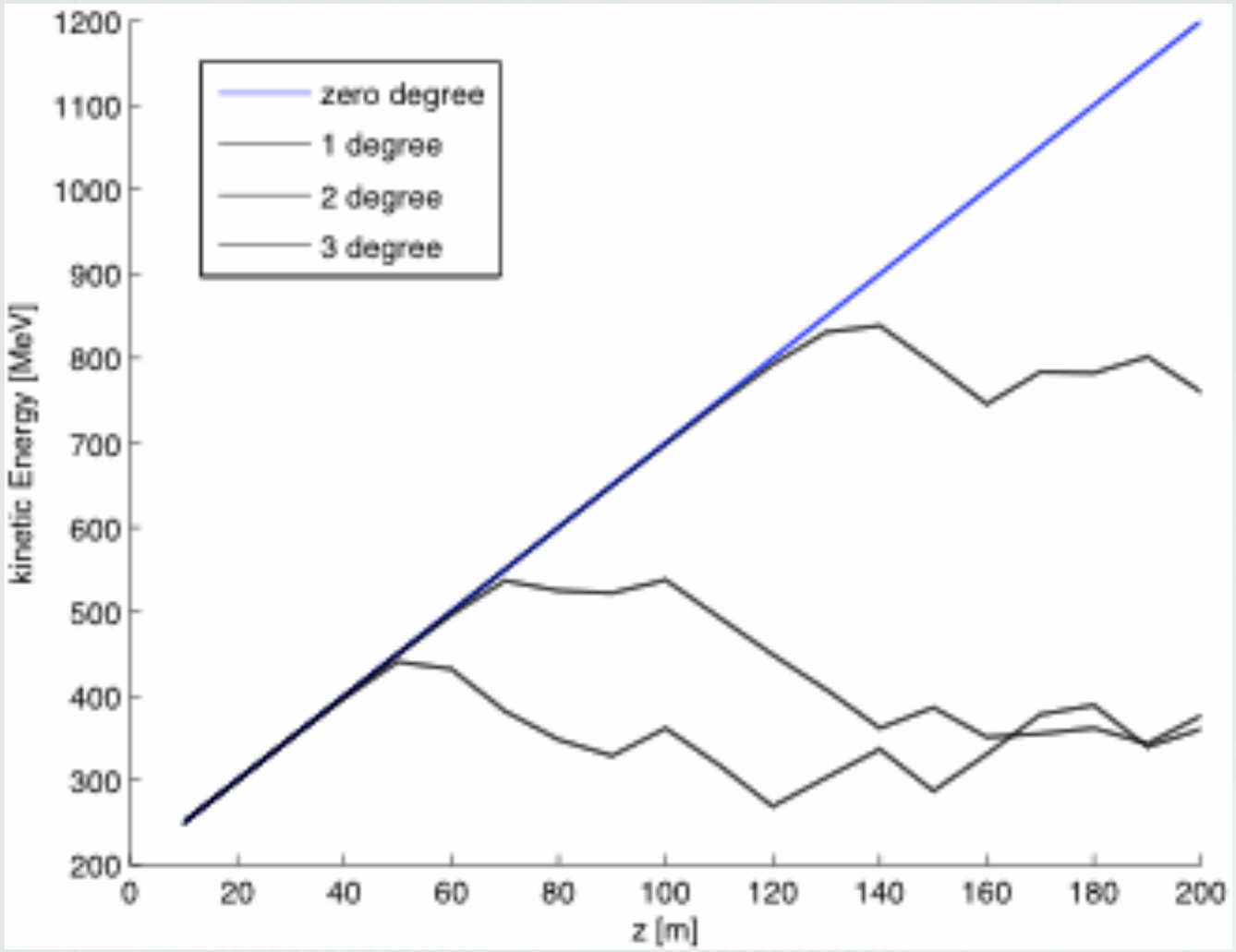
Oak Ridge National Laboratory, P.O. Box 2008, Oak Ridge, Tennessee 37831-6461, USA

(Received 19 May 2008; published 8 October 2008)





One model of beam loss



".. when particles fall out of the .. longitudinal acceptance .. they are no longer accelerated .. [are] not matched to the downstream quadrupole lattice .. and .. are lost .."
(Zhang et al)

But where does the "invisible" longitudinal halo come from? RFQ? DTL?

- Can it be suppressed further?
- Can it be seen? (Beam Instrumentation)
- Can it - & transverse halos - be collimated? (WP7)

WU2.3 - Control Systems

The "ESS Control System Strategy" document released in March includes a preliminary integration strategy:

- EPICS 3-layer architecture
- Deferred specification of the upper (user interface) layer
- Linux operating system in the middle (services) layer
- Distributed controls development environment, to collect and standardize sub-system controls and software development
- Broad use of an rDBMS, consistent with Beam Physics WU

Also see ITER "Yellow Book"

Deliverables

As soon as possible (2010?) in the 2 year Design Update process:

"Scientific Computing" environment (with Beam Physics)
Information control system
Control Box implementation (with ITER)

Less urgently in the DU, analyze:

Machine Protection System (MPS)
Personnel Protection Systems (PPS)
Timing

“Scientific Computing”

Scientific Computing is across the border from the Office Computing

In the demilitarized zone: project management, EDMS, ...

Inside the border (scope of Scientific Computing):

- Modeling & simulation for Accelerator (& Target Division?)
- Control system development
- Accelerator Division & other technical publications

Niels Bohr Institute (U. Copenhagen) will host a near term environment:

- File system for source repository, staging/release system
- 3rd party codes
- Scientific Linux & MacOS images to be downloadable
- Control box/ITER framework already available
- XAL available

Offload/transition to Lund site as needed in the longer run

Information Control System

Device naming convention

Lattice databases

- central reference for accelerator baseline layout
- generate input files from a single source
- generate input for graphic layouts

EPICS configuration database development (Alceli)

Operations database (CED/JLab)

EDMS for documents that must be controlled

Control Boxes

Provide prototype Control Boxes to ESS collaborating institutions working on ESS Work Packages

- Enable rapid deployment of a useful (equipment level) controls environment
- Administer consistency between sub-systems
- Minimize throw-away hardware and software development
- Encourage and enable the rapid maturation of the Controls Box implementation through realistic user feedback

WP3 “Infrastructure Services” and WP6 “NC Linac” as early adopters?

Controls collaborations

Institutes

- Bilbao, DMC, FRIB, INFN-Catania, ITER, JLab, Niels Bohr Institute, SNS

Topics

- CED, Controls Box, EPICS, Pansophy, XAL

Companies

- Alceli, CosyLab

Work Packages

- Infrastructure Services
- Normal Conducting Linac

WU2.4 - Beam Instrumentation

"Design and prototype linac beam diagnostic instrumentation, eg loss, current and position monitors, and transverse and longitudinal beam profile monitors"

Interface with WPs: Spoke, Elliptical, Front End, & HEBT

- design a minimum set of different beam instrumentation designs for each function

Participate in cryomodule design and prototype testing

Interact with the HEBT WP and Target Division to design instrumentation for beam-on-target observation and tuning

Work with the Control Systems WU to provisionally define data acquisition interface standards, MPS, PPS, et cetera.

Beam Instrumentation - 2

What needs to be measured?

Position: including HOM diagnostics (if HOM dampers)
Current (average & bunch): cold if linac is not segmented
Losses (& activation?): inside cryomdules?
Bunch arrival time (wrt RF)
Bunch shape & length
Size (core)
Halo: not measurable?

What are the measurement specifications?

Accuracy (reproducibility)
Precision
Macro-pulse (2 ms) average vs. single bunch evolution along pulse

Beam Instrumentation - 3

Size measurement options

Wire scanners/harps (limit in beam power)
Laser wire (does not work for protons)
Electron/ion beam scanner? (exotic)
Quadrupole pick-ups
Slit scanners with dedicated beam dump lines

Interceptive diagnostics may not be possible at full power

Damage to instrument & activation
Special studies mode for interceptibe
- low rep rate, shorter pulse

Prefer H- beam & segmentation !

Summary - address early priorities!