

MARCH 26 2012 NON-LINEAR BEAM EXPANDER SYSTEMS IN HIGH POWER ACCELERATOR FACILITIES

## STATUS OF THE BEAM EXPANDER SYSTEM FOR THE EUROPEAN SPALLATION SOURCE





#### > General layout of the HEBT

- > Upgrade section
- > Tune-up dump
- > Bending section

### > The ESS target and its requirements

- > The expander system
  - > The ESS baseline system
  - > The issues
  - > Misalignment
- > Collimation
- > Radiation
- > Open points

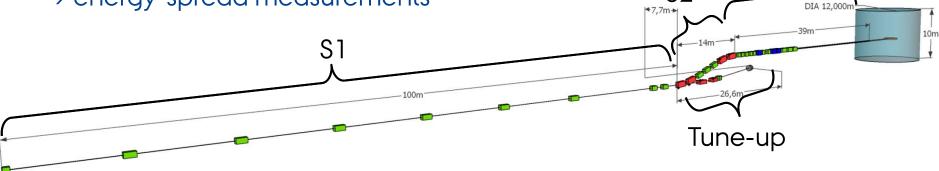


S3

S2

> S1: Space for a power (current or energy) and/or reliability upgrade

- > S2: Bending section (elevation ~4m)
- > S3: Expander system
- > Tune-up beam dump line
  - > energy-spread measurements



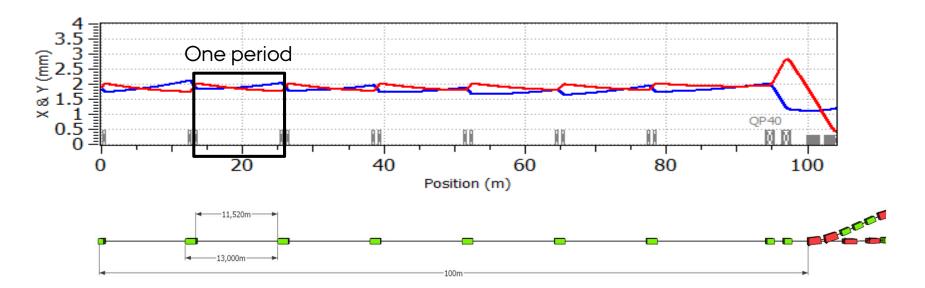
> Safety beam dump?



Purpose:

> Space for additional accelerator cryo-modules (7 periods) Design:

> Maintain linac focusing structure  $\rightarrow$  easy upgrade > Low phase advance for halo (~1 deg/m)

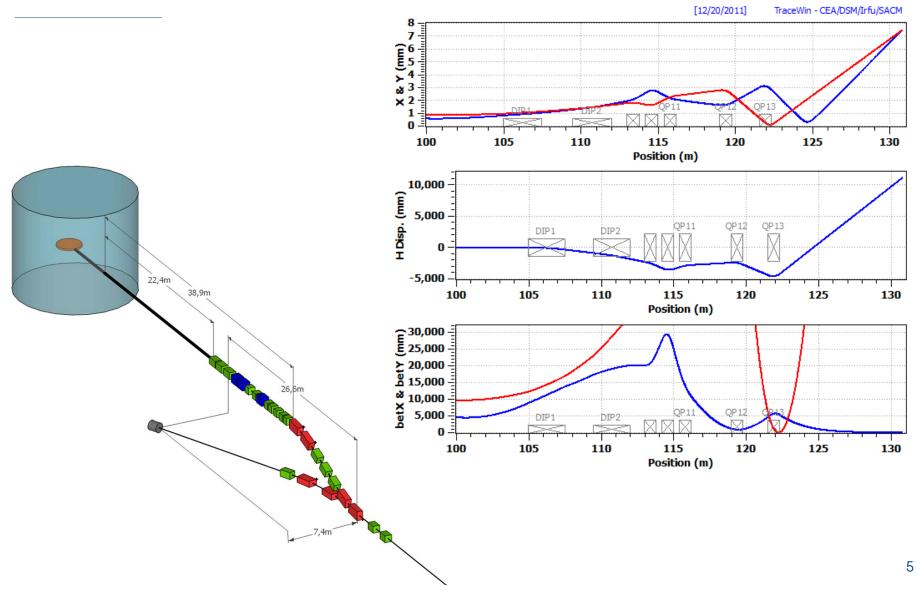


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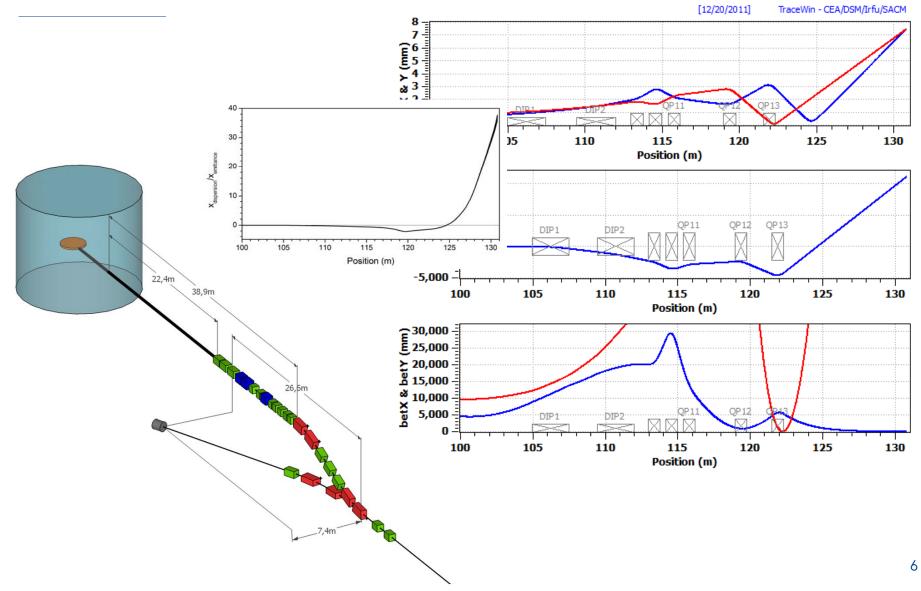
### **HEBT-TUNE-UP DUMP**



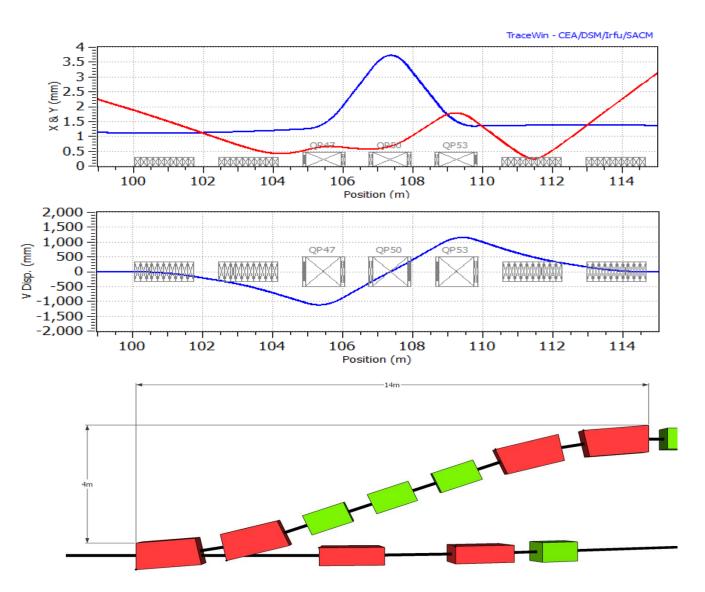


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### **HEBT-TUNE-UP DUMP**









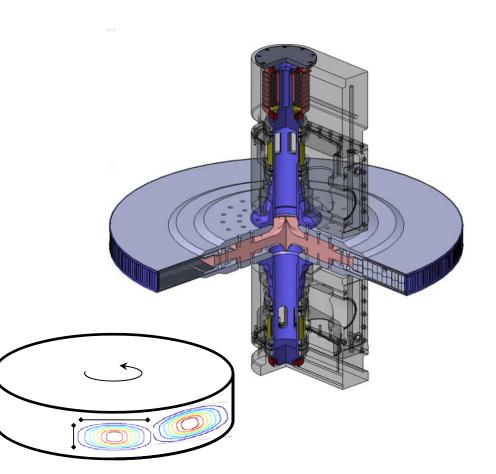
# THE ESS TARGET

### > A rotating tungsten wheel

BEAM		
Frequency	14	Hz
Pulse length	2.86	ms
TARGET		
Diameter	2.5	m
Diameter Rot. Frequency	2.5 0.5	m Hz

Status of the beam expander system for the European Spallation Source

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#### > Requirements:

- > Beam footprint of 160 mm (H) x 60 mm (V)
- > No sharp edges
- > Low peak current density (~70  $\mu$ A/cm<sup>2</sup>)

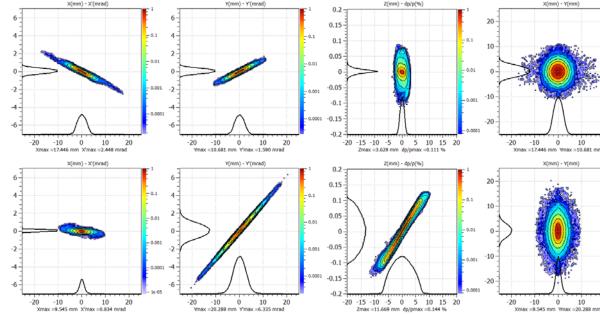


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X(mm) - Y(mm

Ó 10

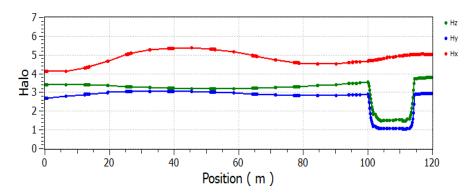
# PARTICLE DISTRIBUTIONS



Linac output= HEBT input (3M particles generated at the entrance of the RFQ with a Gaussian distribution (5 sigma tail) and tracked all the way through the linac)

S2 output = input to the expander system



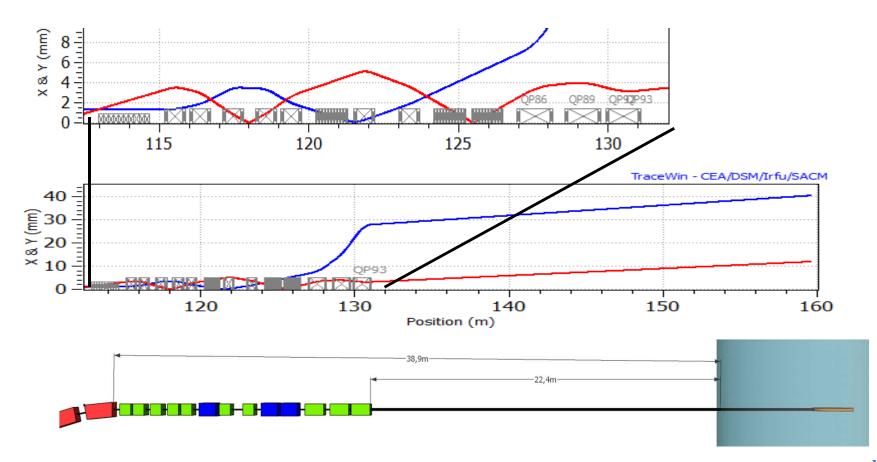


H is a measure of the spatial halo formation.  $H = 6/7 \rightarrow Gaussian beam$ Large H  $\rightarrow$  long tails



> Expander system

> Octupole folding and quadrupole spreading

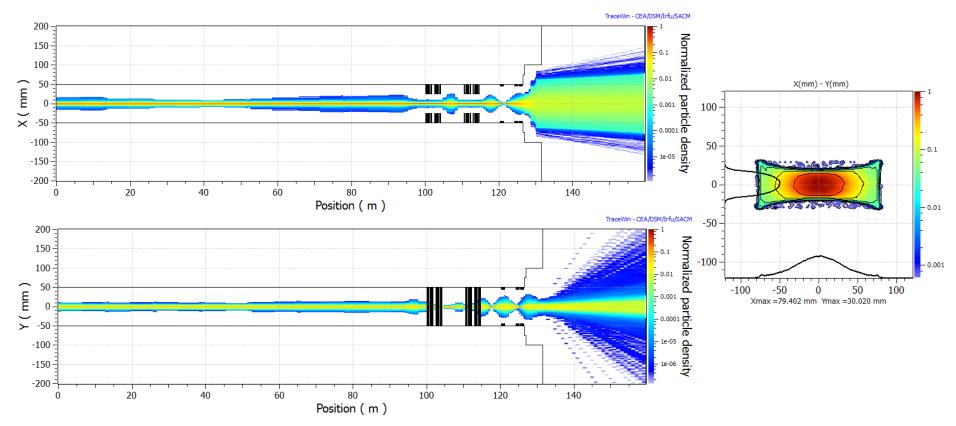




### HEBT-S3 (EXAMPLE 12.6 KW IN COLLIMATOR)

#### > Expander system

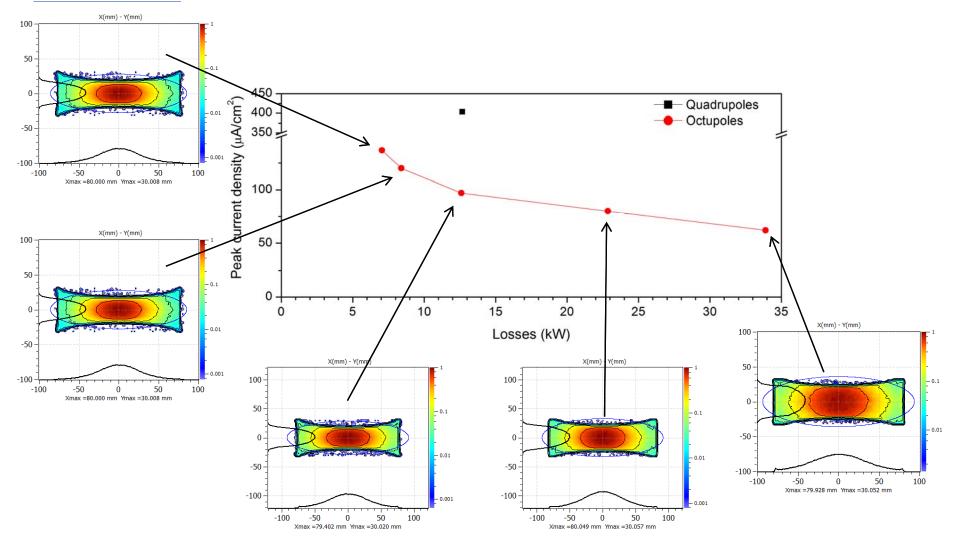
> Octupole folding and quadrupole spreading





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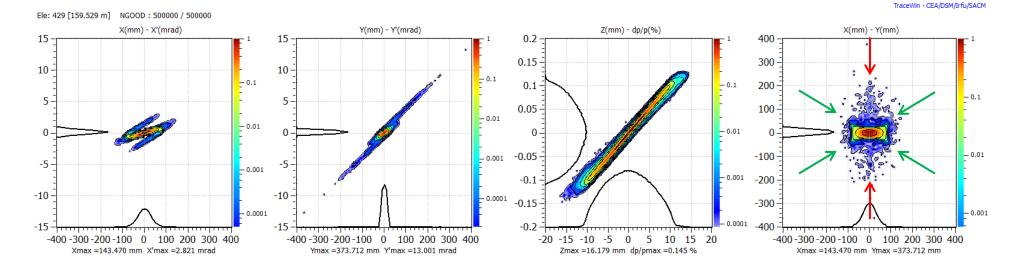
### HEBT-S3 (PARTICLES OUTSIDE FOOTPRINT)





# LARGE AMPLITUDE PARTICLES

#### > Two issues





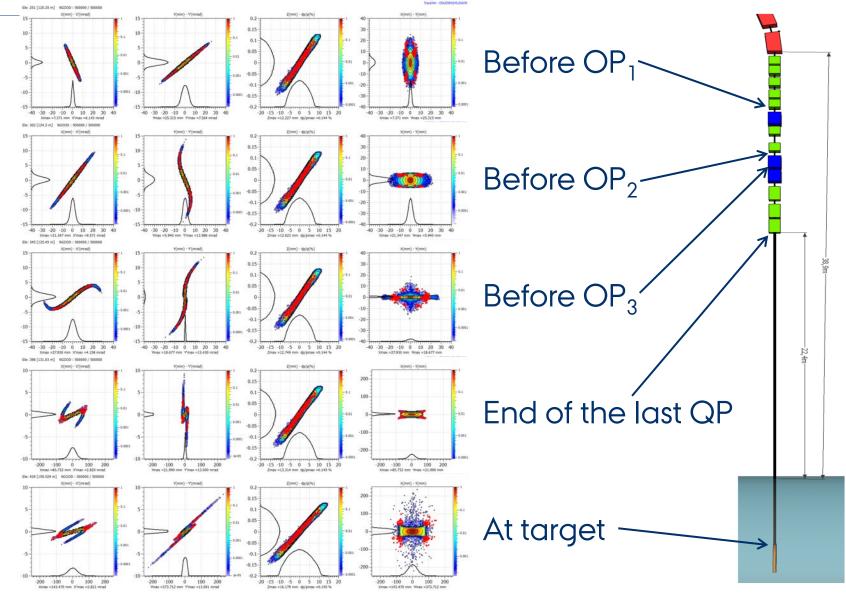
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#### **OCUCED PARTICLES** FR-X(mm) - X'(mrad) 0.15 Before OP<sub>1</sub> 0.05 -0.0 -0.1 -0.2 -40 -30 -20 -10 0 10 20 30 40 Xinax =7.371 mm X<sup>-</sup>max =6.145 mrad -40 -30 -20 -10 0 10 20 30 Vitax +25.315 mm Vitax +7.364 mead 20 -15 -10 -5 0 5 10 15 20 2max =12.227 mm do/amax =0.144 % -40 -30 -20 -10 0 10 20 30 Ele: 302 [124.2 m] NGOCO : 500000 / 500000 X(mm) - X'(med) 0.2 0.15 0. Before OP<sub>2</sub>-0.05 -0.0 -0.3 30 -20 -10 0 10 20 30 -40 -30 -20 -10 0 10 20 30 20 -15 -10 -5 0 5 10 15 20 -40 -30 -20 -10 0 10 20 30 Xmax =21.347 mm Xmax =9.571 mra Ele: 345 [125.45 m] NGDCD : 500000 / 500000 X(mm) - X'(mrad) 0.15 Before OP<sub>3</sub> 0.02 -0.2 -40 -30 -20 -10 0 10 20 30 40 Xinax =27,930 mm Xinax =4.158 mcad -40 -30 -20 -10 0 10 20 30 40 Vitras =18.677 mm Vitras =13.430 mrad 20 -15 -10 -5 0 5 10 15 20 Zmax =12.749 mm\_do/amax =0.144 % -40 -30 -20 -10 0 10 20 30 40 -22, ÷£ lie: 398 [131.03 m] NGDOD : 500000 / 50000 0.2 0.15 End of the last QP 0.0 -0.05 -0.15 -0.2 -50 0 50 ax =85.732 mm Xmax =2.820 mrad -100 -50 0 50 100 -100 -50 0 50 100 20 -15 -10 -5 0 5 10 15 20 159.529 m] NGOCO : 500000 / 5000 X(mm) - X'(mead) 0.15 At target 0.0 -0.07 -0.1 -400 -300 -200 -100 0 100 200 300 400 -20 -15 -10 -5 0 5 10 15 20 Zmax =16.129 mm datagene =0.145 % -400 -300 -200 -100 0 100 200 300 400 Xmax =143.470 mm Xmax =2.821 mrad -400-300-200-100 0 100 200 300 400 Xmax =142.470 mm Ymax =372.712 mm



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# **UNDER-FOCUCED PARTICLES**





Position (m)

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#### MISALIGNMENT 1mm (H) + 1mm (V) 22,4m TraceWin - CEA/DSM/Irfu/SACM 200 150· Normalized particle density 1,2 100 -Horizontal 24 mm -∎-BL 1,0 Misaligned E 0. × -50. 0,8 7 mm 0,6 0,4 Normalized intensity 0'0 0'0 1'5 1'0 8'0 5 mm -100--150 --100 -80 -60 -40 -20 20 40 60 80 100 0 -200 -120 130 140 150 200 20 mm -∎-BL Vertical •0.01 Normalized particle density 150-— Misaligned 100-0,6 ( um ) 0,4 0,2 -21 mm 27 mm ≻ -50 0,0 --100 -60 20 -100 -80 -60 -40 -20 0 40 80 100 position (mm) -150-10-06 -200 -130 120 140 150

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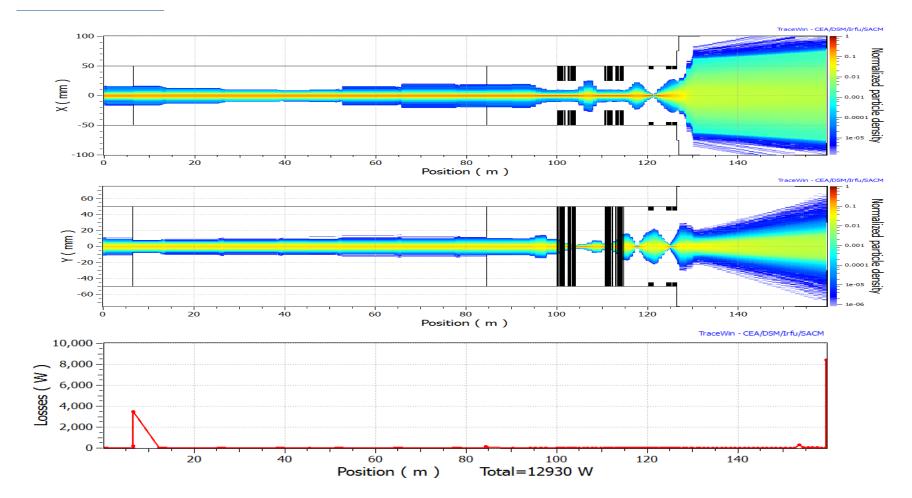
# COLLIMATION

> What collimation strategy to use?

- > Movable collimators
  - > In S1: Low phase advance, would take space away from upgrade
  - > In S2: No space
  - > In S3: E.g. before octupoles
- > Fixed collimators
  - > In S3 !

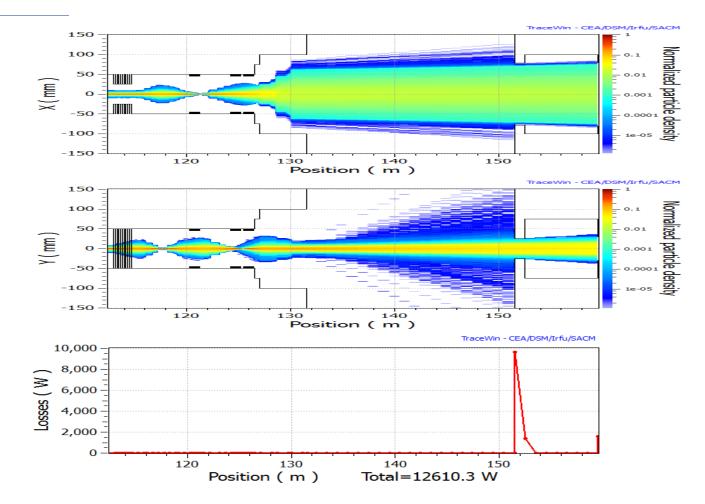


## COLLIMATION IN S1 = MOVEABLE



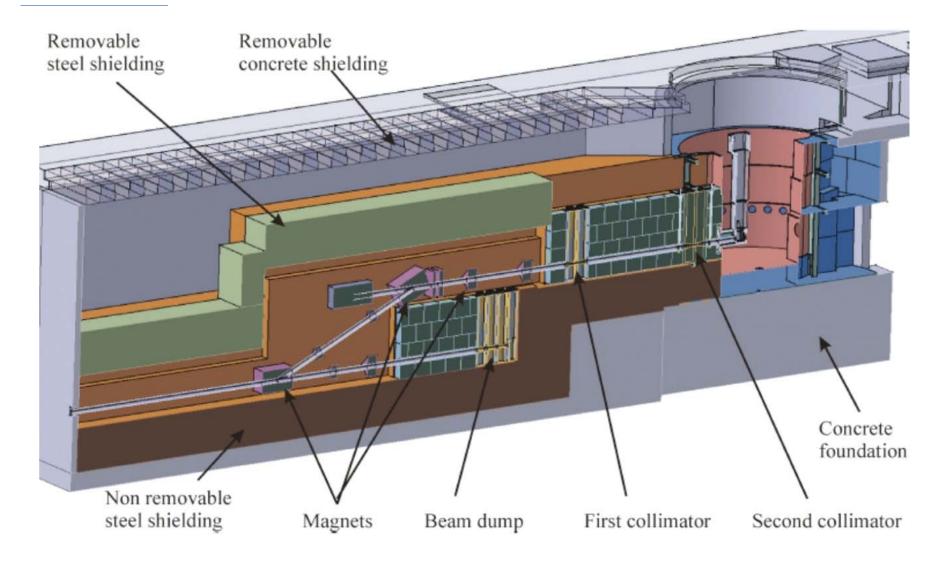


### COLLIMATION IN S3 = FIXED





# HIGH RADIATION LEVEL ( $\rightarrow$ 10 MGY/Y)

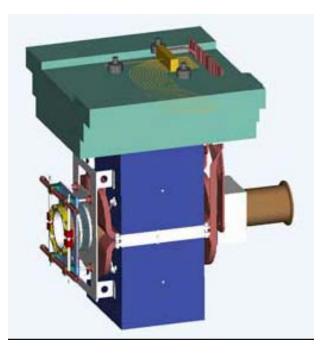


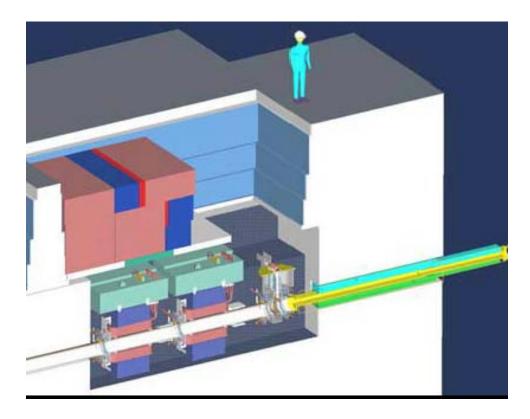


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# HIGH RADIATION LEVEL ( $\rightarrow$ 10 MGY/Y)

#### > Remote exchange







# OPEN POINTS...

>Apertures in magnets?

- > Optimize peak current density *vs*. Power on the fixed collimator?
- >How useful would S1 collimation be?
- > How do we define a "worst case" beam?
  - > For commissioning
  - > For operation
- > Influence of errors?





### > Part of work package 7

2.1.7.2 1.7.2: High-Energy Beam Transport (S. Pape-Møller, Aarhus)

This work unit is designing the high-energy beam transport from linac output to targets. It includes the following main points

- Beam transport and expander design
- Upgrade transport systems
- Collimation systems design
- HEBT Mechanical systems



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Steel/Marble mask to protect downstream magnets

Steel/Concrete mask to capture outscattered particles and neutrons