

# Shield Design Cost Matters

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# First KPI: ALARA

- As Low As Reasonable Achievable
- Reasonable vs Conservative Assumptions
- Reasonable target limits
  - ensure compliance with effective dose limits (e.g. IAEA 1mSv/a, Norway 0.25mSv/a)
  - Apply a risk based approach: who, how often, control
  - Beam **on** vs Beam **off** time: Find agreement with regulator on dose rate limits ( $\mu\text{Sv/h}$ )  
i.e. how to measure Dose rate

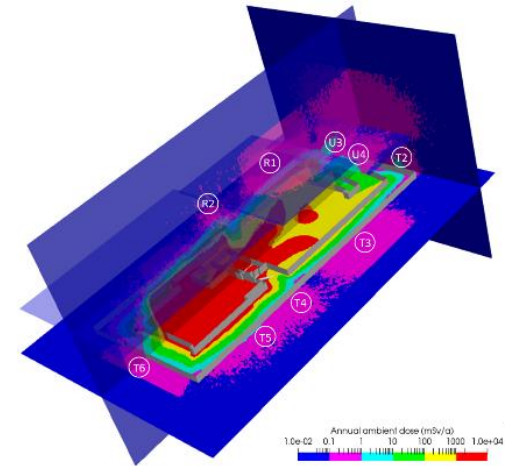
## Examples

- USA/Thailand: 20 $\mu\text{Sv}$  in any one hour
- Germany: 20 $\mu\text{Sv}$  per week; but < 3mSv/h IDR
- China: 2.5  $\mu\text{Sv}$  per hour IDR – instantaneous!
- UK: 7.5 $\mu\text{Sv}$  per hour IDR; averaged over 1min by ACOP
- Singapore: 10 $\mu\text{Sv}$  per hour IDR “outside the X-ray room”
- India 1 $\mu\text{Sv/h}$ ; AERB has relaxed this in specific cases

# Time to Permit

KPI: Time to regulatory permit issue

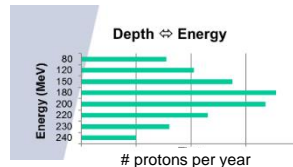
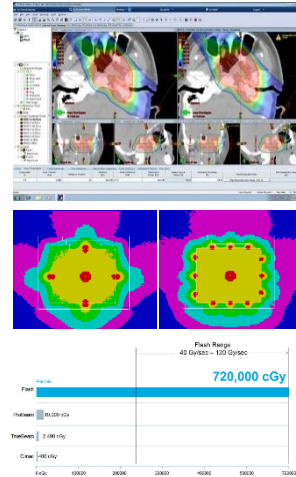
- Time spend in coordination with the regulator always saves time to permit issue.
  - Propose solutions – do not ask open question
  - Agree on target limits
    - Workload, futurization
    - Dose rate
  - Propose your method and ensure comfort level
    - Monte Carlo vs line-of-sight
    - National and Int's standards
    - Benchmarking
  - Pretty pictures count more than 1000 words



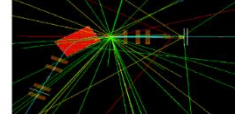
# Workload now and in the future

## KPI: Reasonable Work-Load

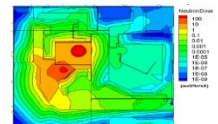
- We are treating a mix of patients – not all at  $E_{max}$
- Today's expectation vs Future
  - Changes in patient mix and number due to referral system?
  - FLASH, proton arc, other new methods
- Document cases considered for robustness
- Evaluate uncertainties and effects on protected locations



Neutron Generation along Beamline



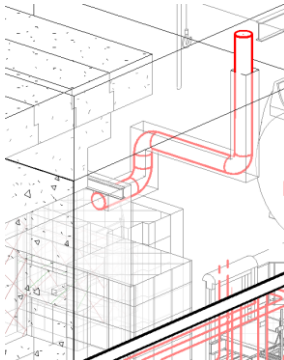
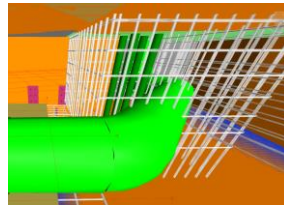
Neutron Radiation Dose



# Site and construction cost

## Define cost relevant Indicators for the specific project (1)

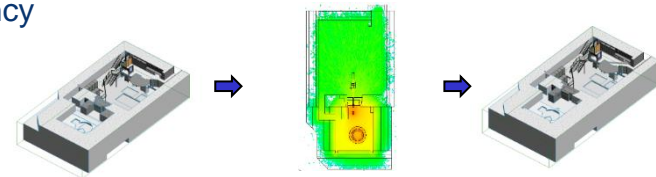
- Hard footprint constraints?
  - Use special shielding materials only where really necessary
  - Shielding door vs access maze
- Calculate shielding with locally available concrete
  - Density needs to be specified, but deviations from the usual  $2.35 \text{ t/m}^3$  are possible, and may reduce cost
- Moving structural items (i.e. rebar) is more expensive than a different ventilation routing.
- Smart duct planning may save a bend or concrete thickness
- Complex geometries vs straight walls
- Construction joints & pre-fab elements



# Time as a Cost KPI

## Define cost relevant Indicators for the specific project (2)

- Construction delays due to conflicts of embedded objects with ducts
  - Ensure shielding consultant is available for Q&A during construction
- Just-in-time results of shielding calculations
  - Schematic Design phase: vault on site, integrated in clinic, maze vs shielding door
  - Decommissioning cost at end-of-life: reduction of cost or financial securities required
  - Design Development phase (e.g. with ducts, penetrations, etc)
- Impact of Radiation Safety topics on Time-to-1<sup>st</sup> patient
  - Ensure collaboration with regulator
  - Permit needed prior to construction?
  - Setup radiation safety program in time for building occupancy
  - Adequate # of RSO on board
  - RAM license to receive equipment
  - Operating permit to start-up



# Some Key Performance Indicators (KPI)

- Reasonable target limits: e.g. FLASH dose rates; duty cycle; risk based
- Robustness: chosen workload-scenario vs future
- Duct location and routing: impact on
  - Structural elements, such as re-bar
  - Wall thickness
  - Comparison to duct material and installation cost
- Construction Cost: KIP comparison for
  - Concrete volume vs formwork, rebar  
= complex vs standard shape
- Just-in-time for all radiation relevant services

# Thank You!