The case for ECHIR:
a chip irradiation beamline at ESS

Presented by Giuseppe Gorini for CNR, Italy

giuseppe.gorini@unimib.it

A problem has been detected and Windows has been shut down to prevent damage to your computer.

The problem seems to be caused by the following file: SPCMDCON.SYS

PAGE_FAULT_IN_NONPAGED_AREA

If this is the first time you've seen this Stop error screen, restart your computer. If this screen appears again, follow these steps:

Check to make sure any new hardware or software is properly installed. If this is a new installation, ask your hardware or software manufacturer for any Windows updates you might need.

If problems continue, disable or remove any newly installed hardware or software. Disable BIOS memory options such as caching or shadowing. If you need to use Safe Mode to remove or disable components, restart your computer, press F8 to select Advanced Startup Options, and then select Safe Mode.

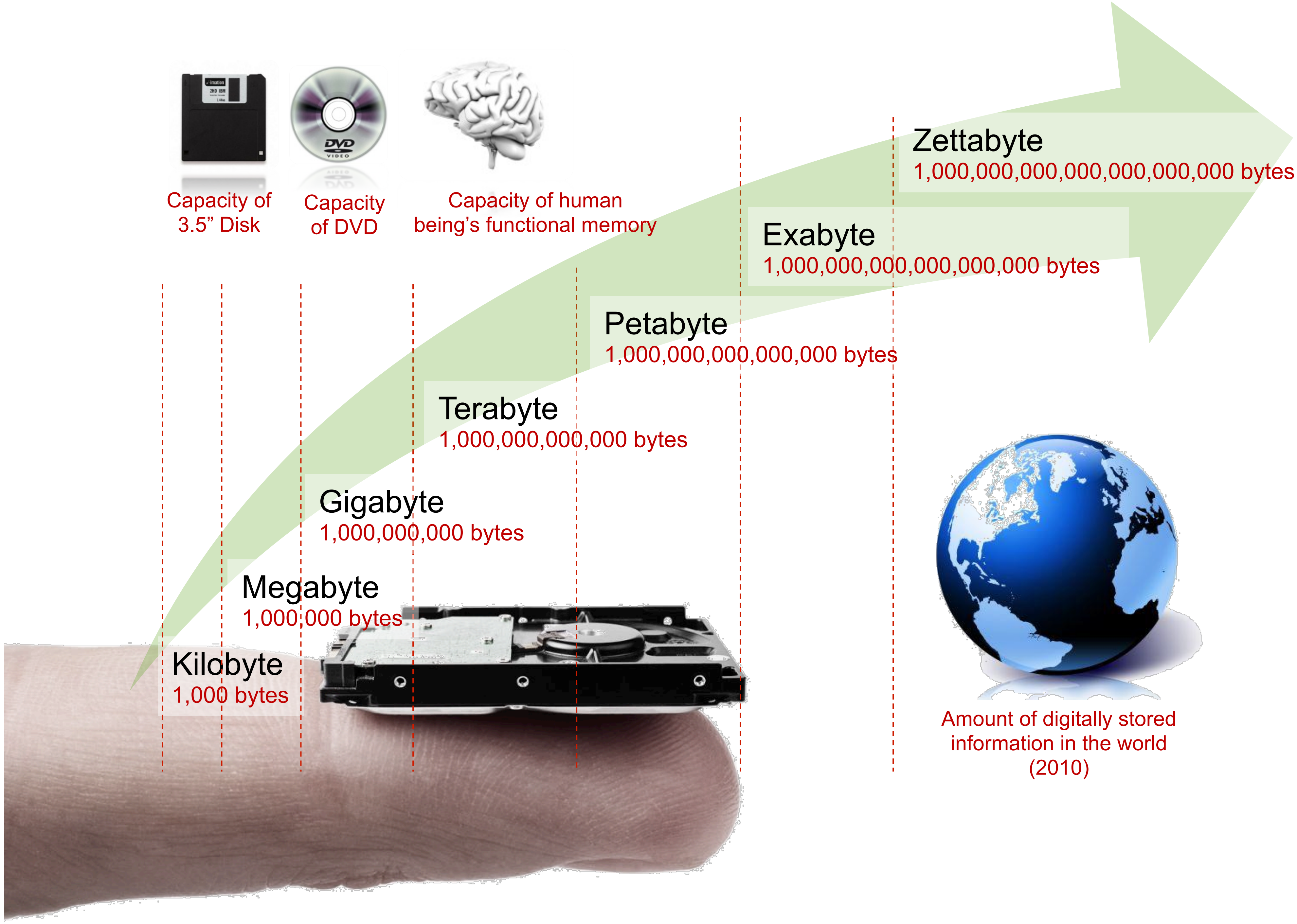
Technical information:

*** STOP: 0x00000050 (0xFD3094C2,0x00000001,0xFBFE7617,0x00000000)

*** SPCMDCON.SYS - Address FBFE7617 base at FBFE5000, DateStamp 3d6dd67c

ATSB TRANSPORT SAFETY REPORT Aviation Occurrence Investigation AO-2008-070

Final

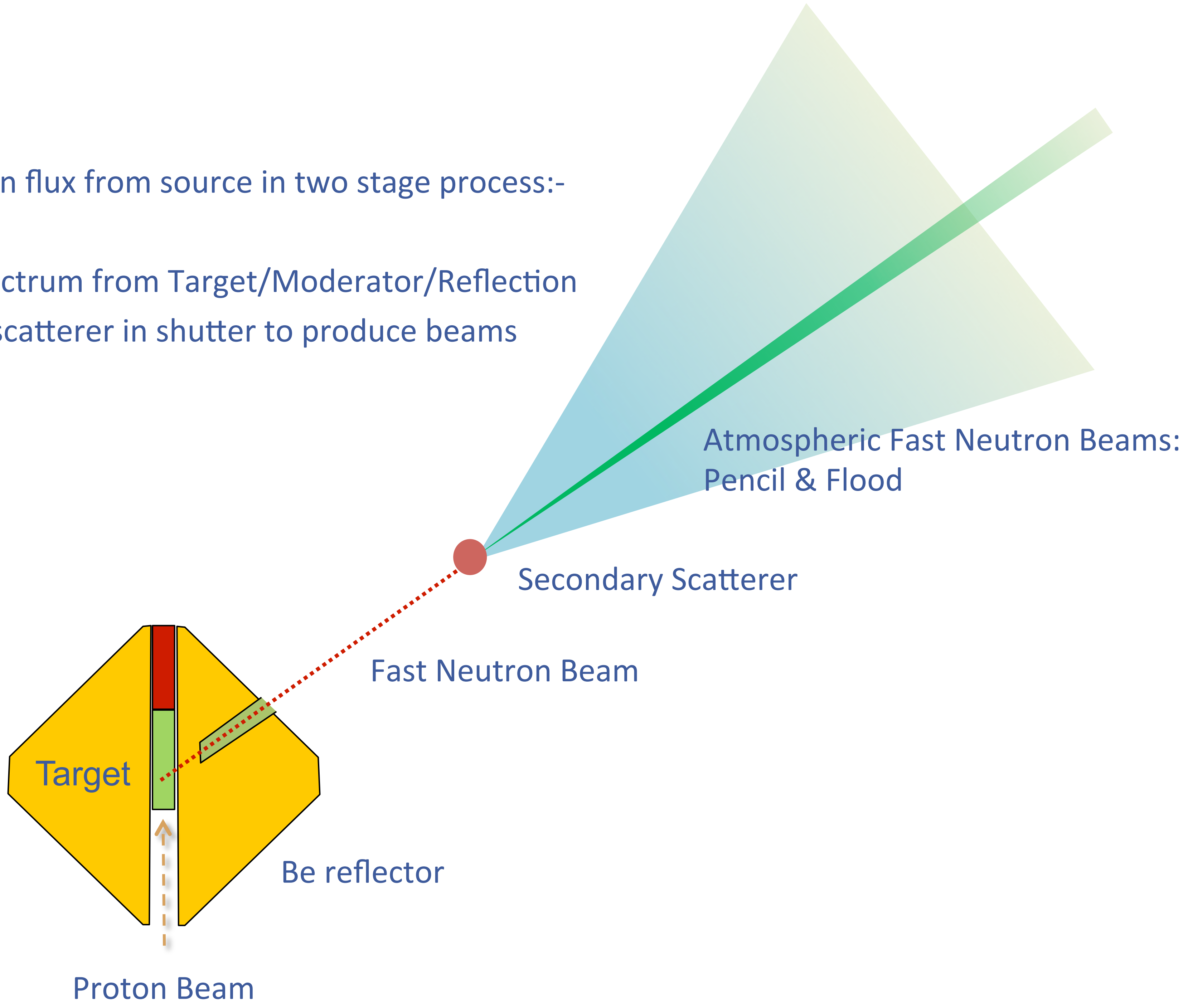


Source: Cisco

Basic Principle

Use fast neutron flux from source in two stage process:-

- Harden spectrum from Target/Moderator/Reflection
- Illuminate scatterer in shutter to produce beams



Outline

Introduction

State of the art

Science case

Business case

Conclusion

Introduction: CNR, chip irradiation, ESS

- CNR proposal formulated in 2011.
- CNR + ISIS + ESS Target division:

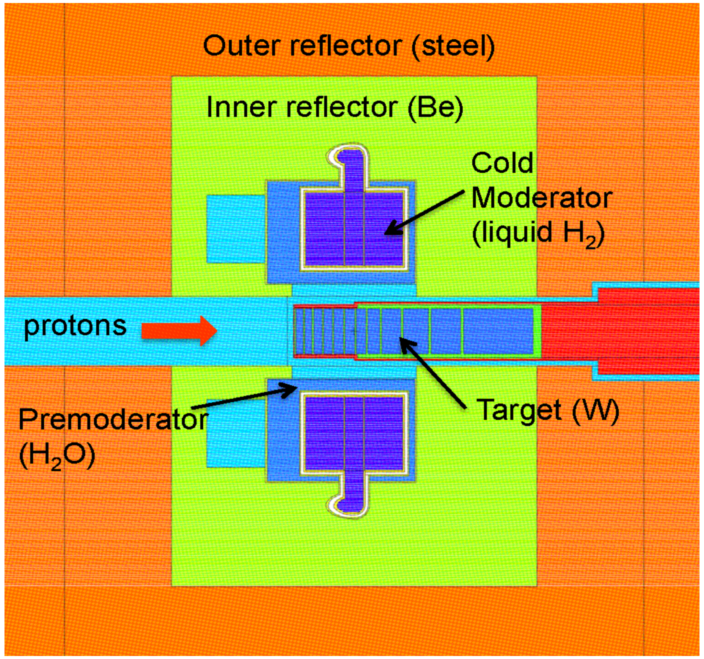
  neutronics simulation of ESS

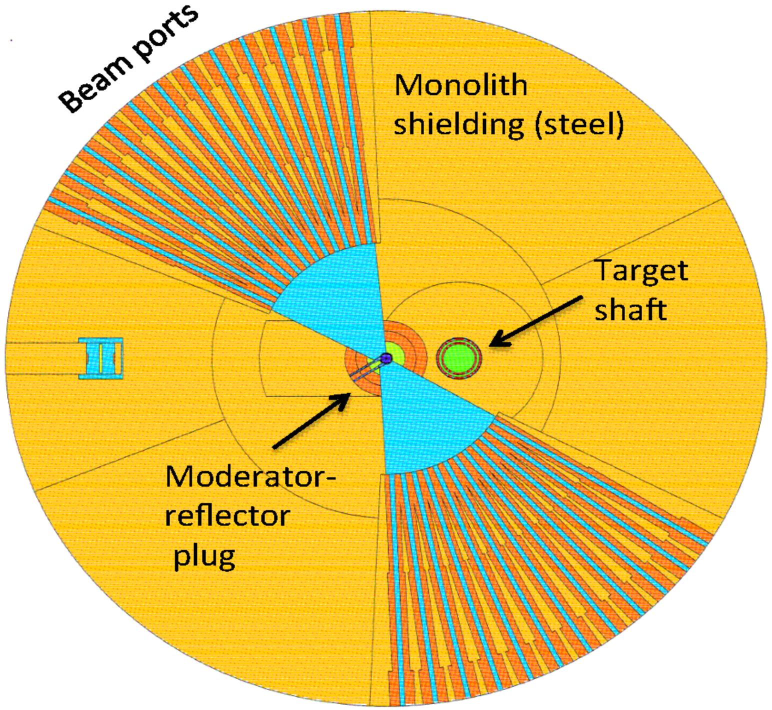
  fast neutron irradiation ports.
- See chapter 3.3.10 of TDR.
- ESS+ISIS+CNR workshop on fast neutron research and applications at ESS

  http://plone.esss.lu.se/fast-neutrons-workshop
- Most promising application: chip irradiation. **ECHIR**

ESS MCNPX model

Proton kinetic energy: 2.0 GeV [2.5 GeV]
Average beam power: 5 MW
Annual operating period: 5200 hours
Target material: Tungsten
Target geometry: 2.5 m diameter wheel
Number of moderators: 2 (symmetrical)
Moderator material: H2
Moderator geometry: h = 13 cm, r = 8 cm
Premoderator: 1 cm water layer
Number of beam ports: 44
Separation of ports: 5 degrees





Introduction: ComLayer

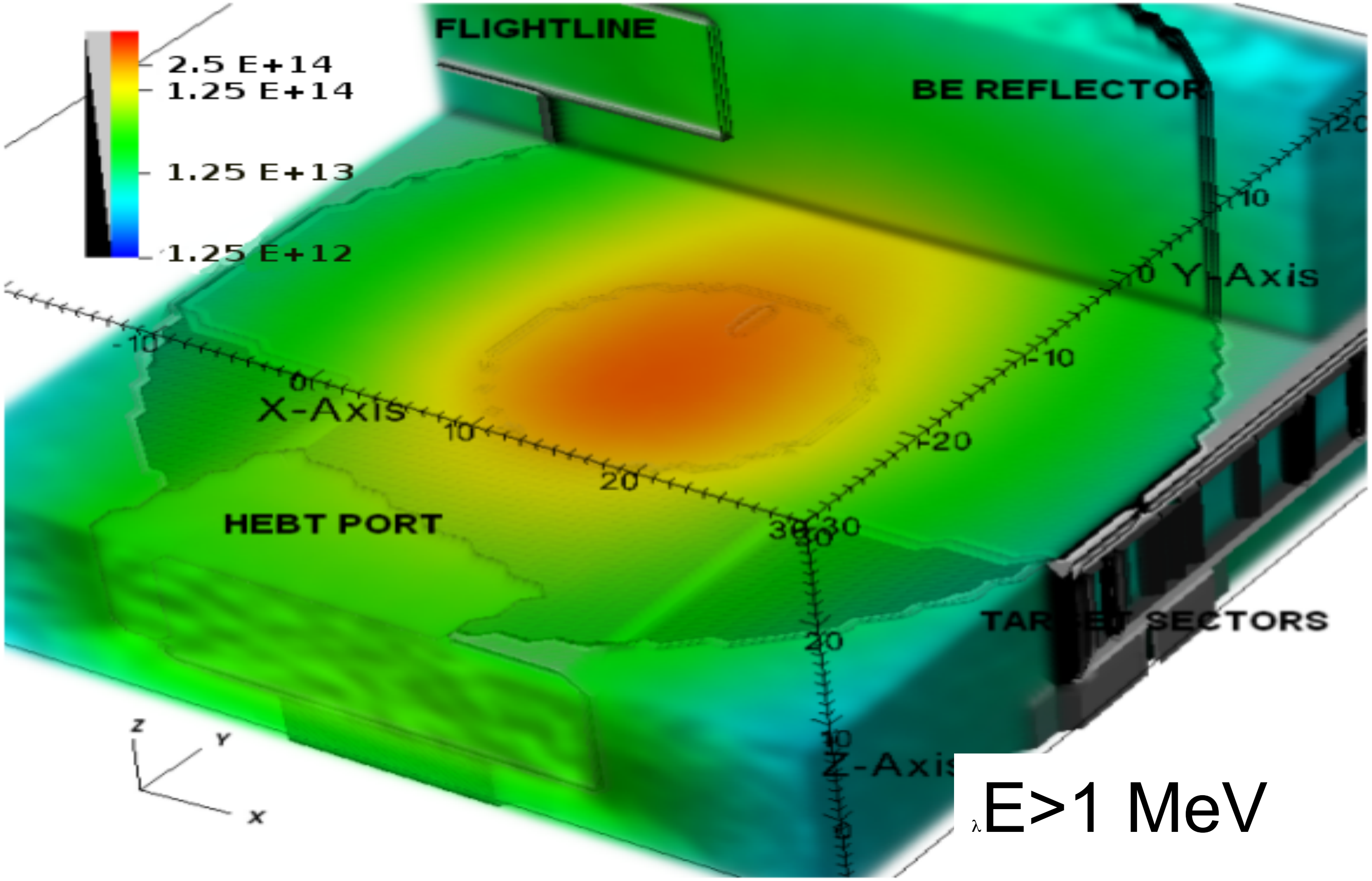
- As part of the collaborative development, the ComLayer code was applied to the ESS monolith.
- ComLayer is a tool for generating optimized input to MCNP.
- It also provides a framework for neutronic design optimization.
- The availability of a ComLayer model for the ESS monolith is a significant step forward in the design of a fast neutron beamline at ESS.

The CombLayer code

Building MCNPX model is a time consuming process.
***CombLayer**:*
MCNPX models produced rapidly and in a highly parametric manner.
Benefits:
(i) the model automatically optimizes runtime performance,
(ii) explore a large number of model configurations to optimize the neutronic performances,
(iii) Strong error mitigation.

- Gain of a factor of 5 in runtime based on geometry
- MCNP outputs processed with LayerAnalysis
- *No variance reduction techniques yet*

Fast Neutron Integral Flux at TMR



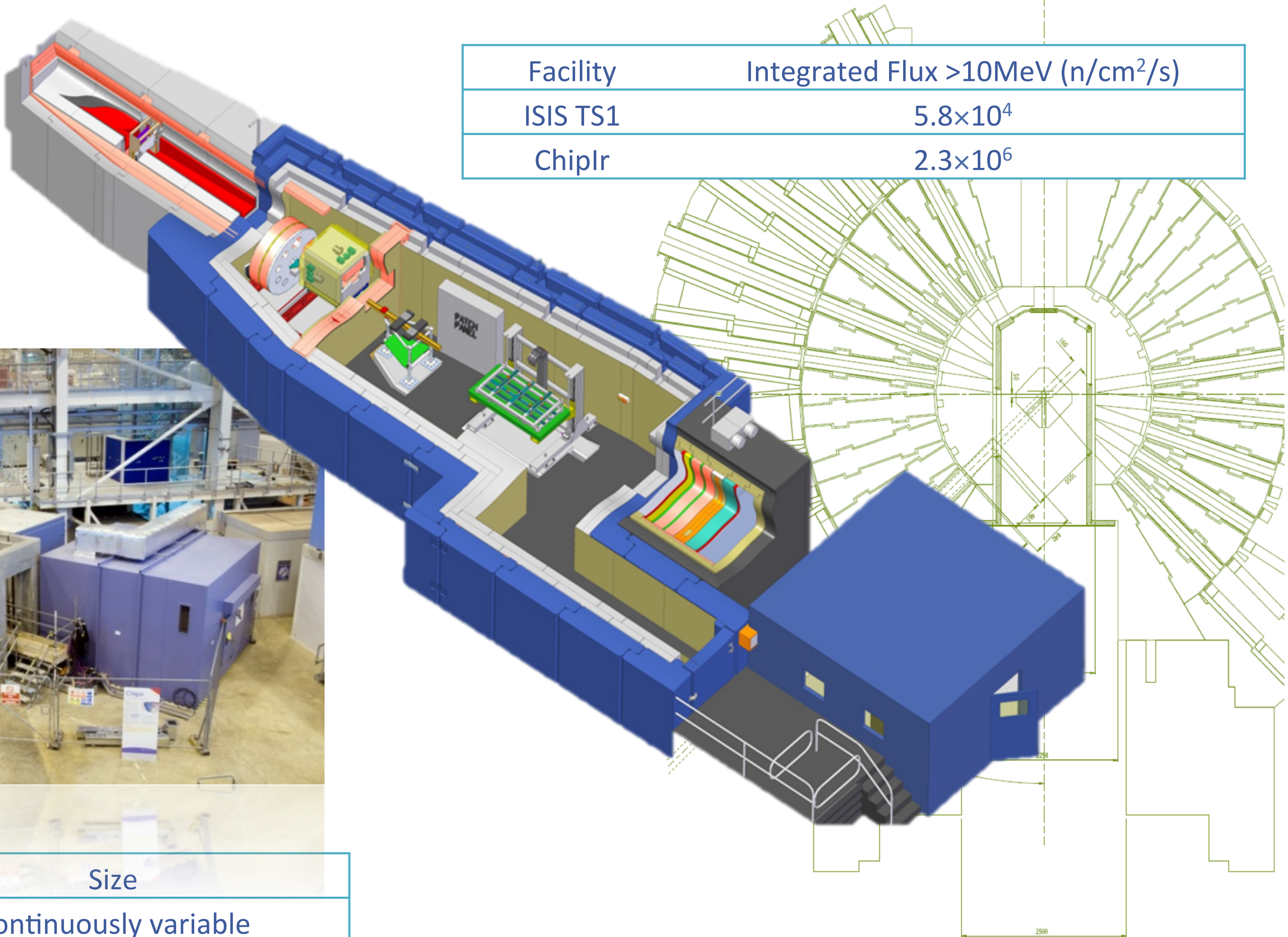
Maximum flux under the moderator

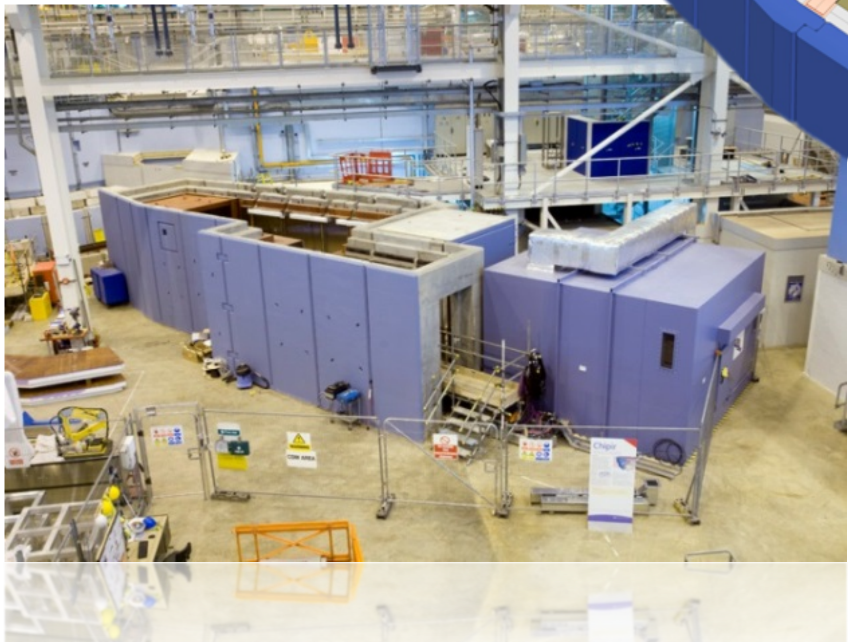
Must be extracted via irradiation ports through the monolith

State of the art: CHIPIR

- Irradiation of electronic components to simulate the disruptive effect of atmospheric neutrons.
- Most common effect is Single Event Error (SEE) flipping the logical state of a memory bit.
- Typically 10-100 SEE per hour on VESUVIO
- x100 on CHIPIR, first beamline dedicated to chip irradiation at a spallation source.
- CHIPIR built at ISIS with in-kind contributions from CNR.
- Will be brought into service in the coming months and will be fully operational in 2015.

Facility	Integrated Flux >10MeV (n/cm^2/s)
ISIS TS1	5.8×10^4
ChipIr	2.3×10^6

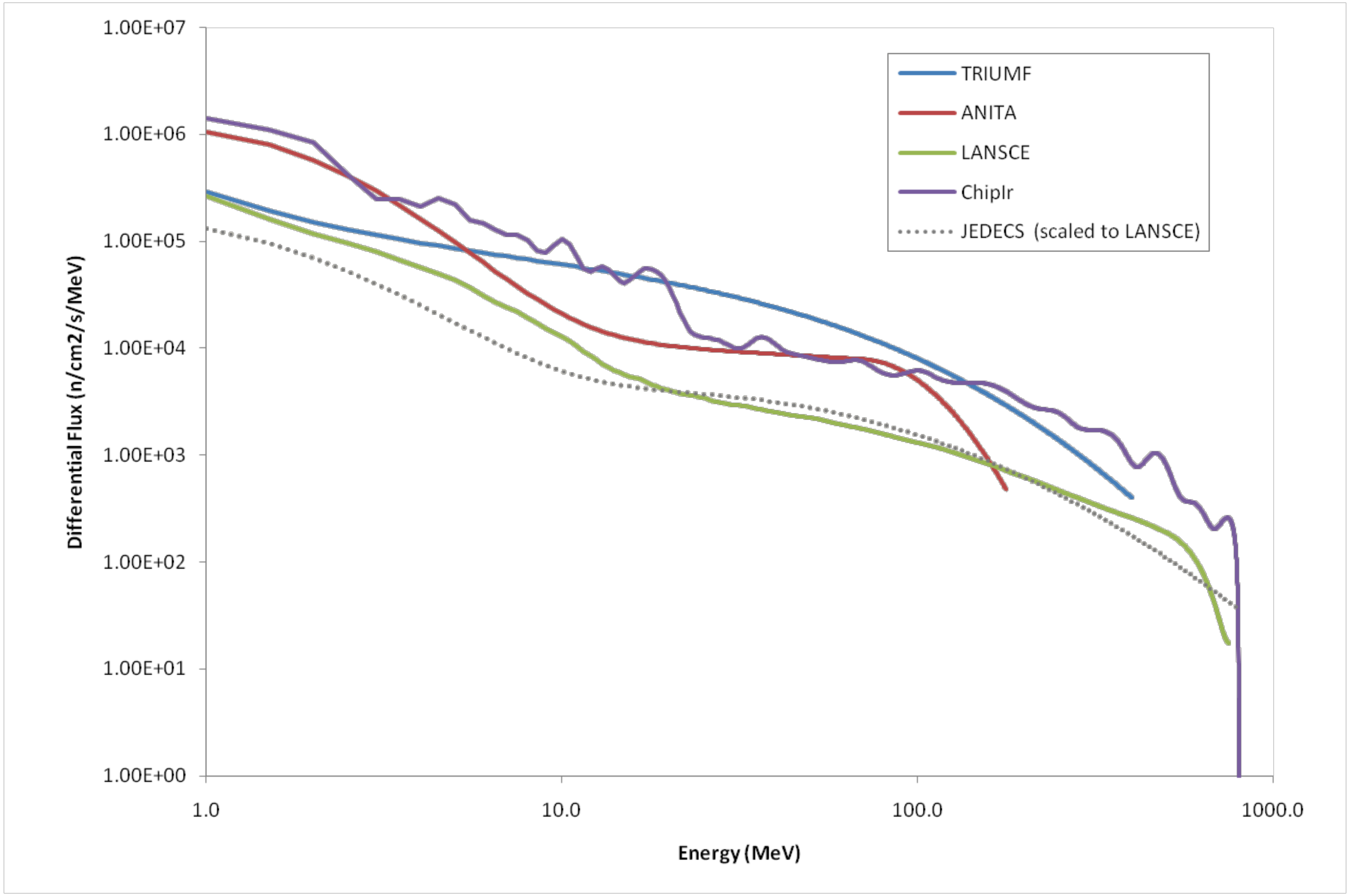




Beam	Size
Collimated	Continuously variable 250mm×250mm to 1mm×1mm
Flood	Fixed sizes 1000m×1000mm 500mm×500mm

State of the art: ANITA, LANSCE, ...

- ANITA: a chip irradiation facility located in Scandinavia (TSL Laboratory, Uppsala, Sweden).
- Part of an accelerator complex where the main application is proton irradiation therapy.
- Building ECHIR on ESS would allow for the ANITA users to migrate to ESS.
- There are few facilities operating around the world (e.g. TRIUMF, LANSCE at Los Alamos).
- A few more are considered for construction (CSNS in China or SNS in the USA).



TRIUMF
ANITA
LANSCE
ChipIr
JEDECS (scaled to LANSCE)
1.00E+07
1.00E+06
1.00E+05
1.00E+04
1.00E+03
1.00E+02
1.00E+01
1.00E+00
Differential Flux (n/cm2/s/MeV)
1.0
10.0
100.0
1000.0
Energy (MeV)

Science case: why at ESS

- ECHIR will provide fast neutron beams of higher intensity than available on CHIPIR.
- Strong potential for SEE testing: as devices become more reliable higher fluxes will be required.
- ESS will have the highest energy neutrons (2 GeV).
- ESS will extend the neutron energy range beyond what easily available today; there are indeed cosmic ray neutrons extending to GeV energies.
- New materials: new problems at higher energies. New failure modes?
- A totally new understanding of failure mechanisms.

Fast Neutron Irradiation Ports

I) Basement port

- from irradiated target wedge to the bottom of the monc

II) Beamline port

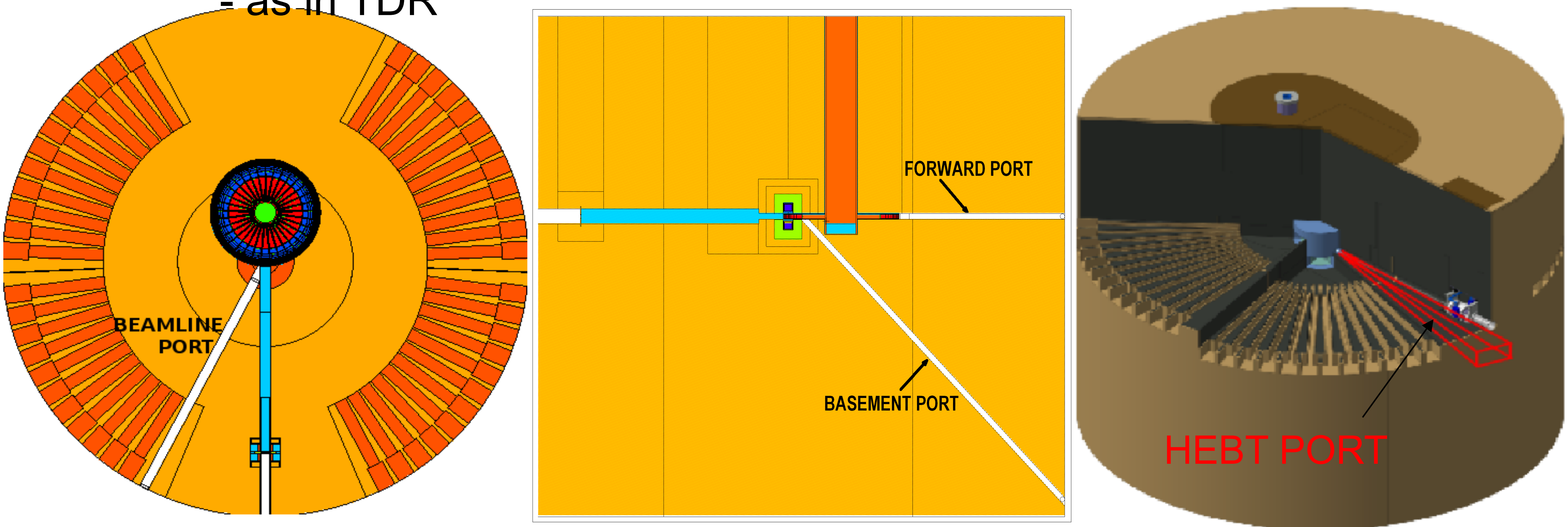
- removes one of the backward beamlines

II) Forward port

- just opposite to proton beam

IV) HEBT port

- as in TDR



Science case: “basement port”

- “Basement Port” considered in the TDR.
- Looking downwards: not very convenient.
- Not a fundamental drawback:

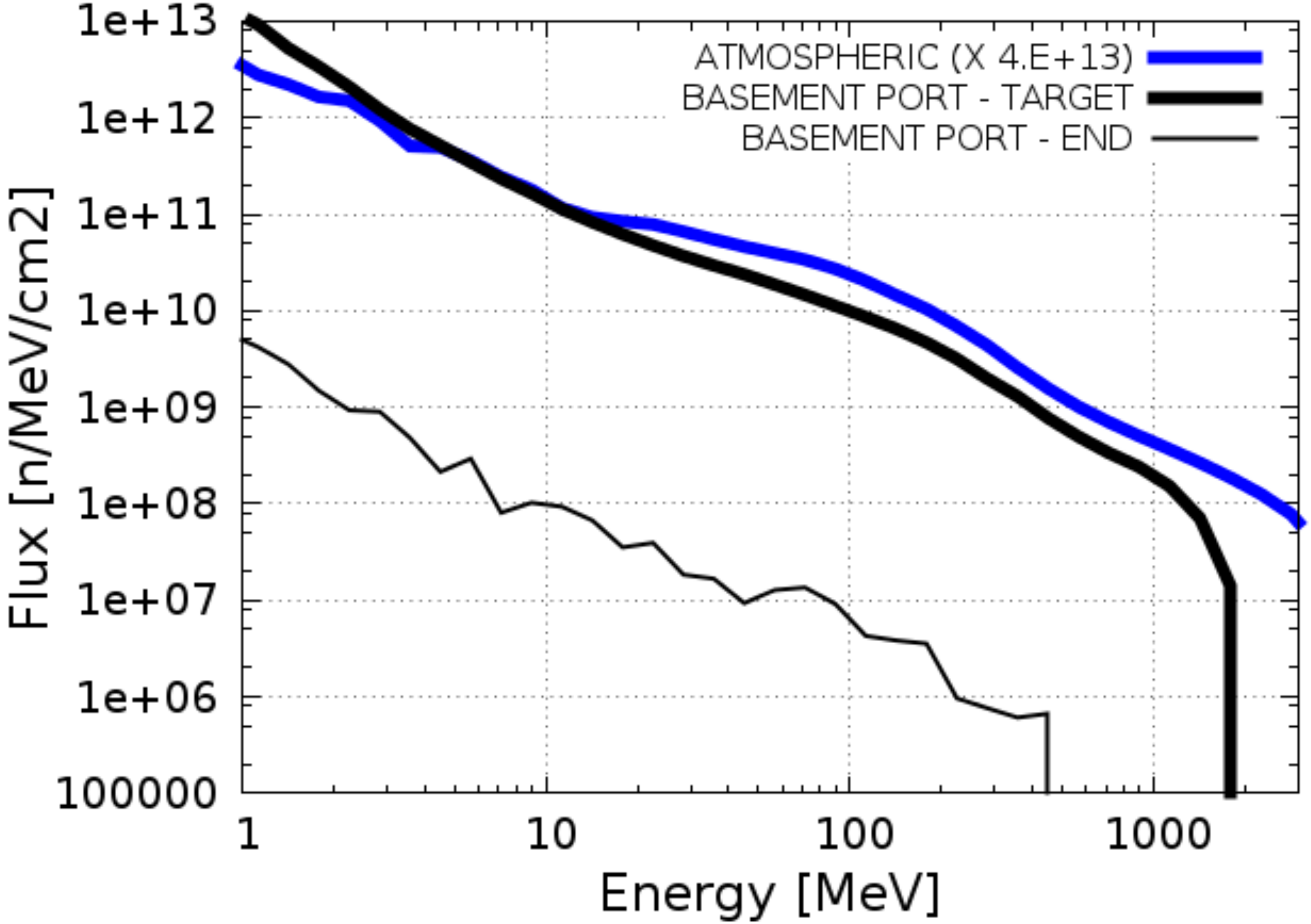
  use a scatterer material to broaden the beam and irradiate large volume samples.
- Irradiation room in the ESS basement,

  away from the instrument hall.
- Neutron energy spectra similar

  to the reference atmospheric neutron spectrum.
- Agreement can be improved by neutronics design

  as done on CHIPIR.

"Basement Port"

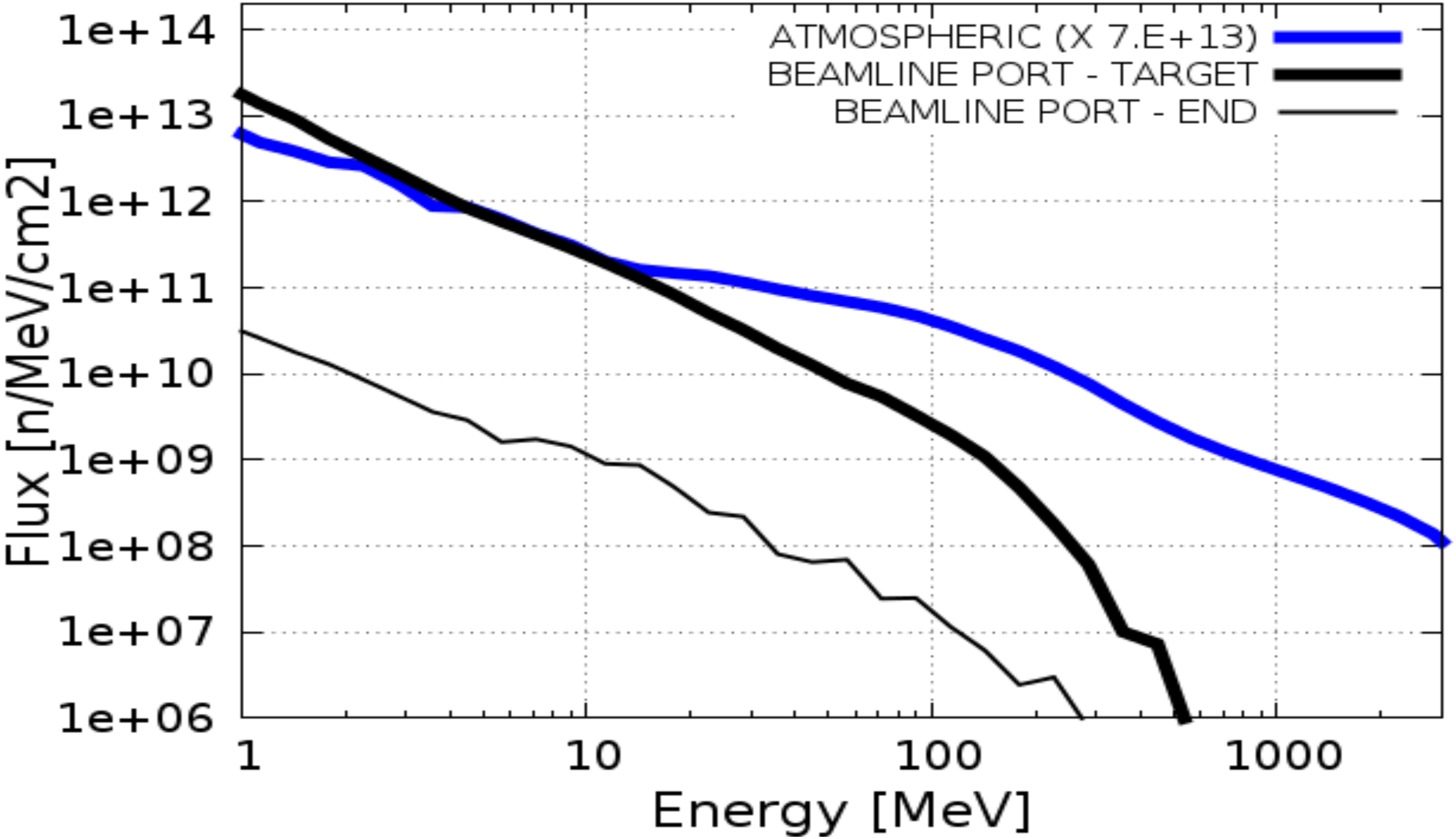


Good match to the atmospheric spectrum up to > 1 GeV

Science case: “beamline port”

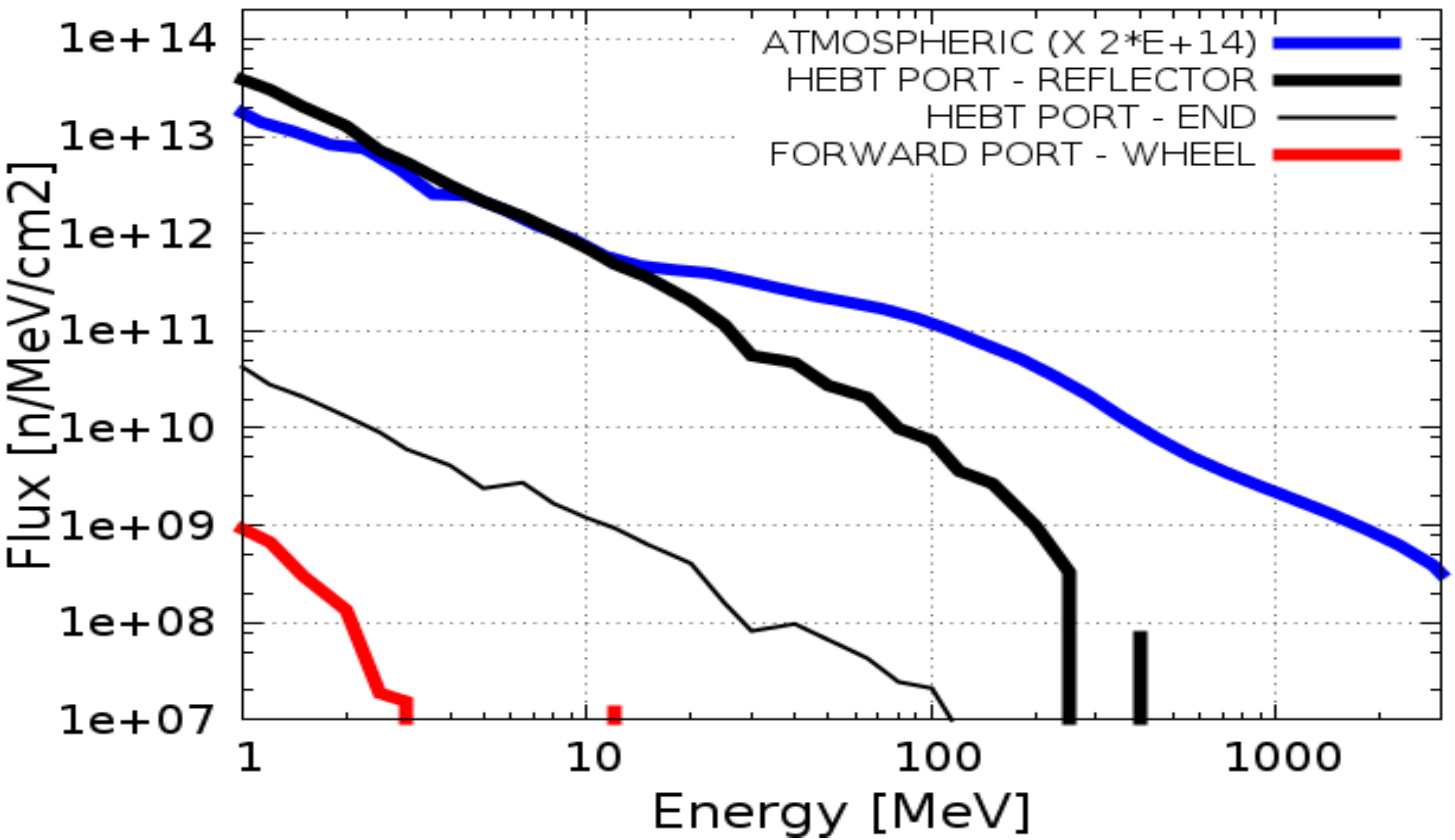
- Option that still needs to be assessed:
  use one of the 22 beam lines for chip irradiation.
- With this choice ECHIR would look very much like the other instruments except that
  - it is laid in the target midplane
  - shielding must stop fast neutrons.
- First simulations indicate spectrum too soft above 10 MeV
- Would have to be tailored using ComLayer

“Beamline Port”



- Spectrum too soft above 10 MeV for backward view
- Forward view: impossible?

“HEBT” and “Forward” Ports



“HEBT port” similar to “beamline port”

Forward port: obstructed by target

Business case: supply vs demand

- Current provision of SEE testing inadequate.
- Further provision will enable the field to expand from the current supply limited situation into one where adequate provision can be achieved. This will have several major effects:
- Single event testing to become a routine ‘tool’ and a normal part of device development
- Expansion into emerging fields and sectors where single event effects have not been considered
- Authorities may ‘require’ testing with neutrons rather than ‘recommend’ testing as part of a more generalized reliability requirement

Business case: ECHIR vs CHIPIR

- ECHIR will be unique in terms of flux levels and energy range.
- Up to now, the setting of global standards has been limited by lack of global capacity.
- Thus we see no competition, but rather synergies in the future availability of CHIPIR at ISIS and ECHIR at ESS.
- The business case for ECHIR can be further strengthened by a consultation with key stakeholders; was done for CHIPIR.

Further Applications of Fast Neutrons

Material test irradiation on:
* Spallation materials
* Fusion materials
* NPP (fast reactor) components

- Production of radioisotopes

- High energy neutron science

- Require irradiation station inside the target

- Not addressed in this presentation

Conclusion

- ECHIR: a unique tool for chip irradiation studies at extreme flux and neutron energy conditions.
- ECHIR will enhance the capacity of chip irradiation making it possible for regulators to prescribe, rather than recommend, SEE testing.
- A timely decision is required in order to include a suitable penetration in the ESS monolith.
- Indeed one of the CHIPIR lessons is that early inclusion in the design allows for substantial cost reduction.
- The CHIPIR experience will also allow for optimized design and shorter delivery times.