THE FRAMEWORK PROGRAMME FOR RESEARCH AND INNOVATION

2020

HORI7



Commission

MYRTE

MYRRHA Research and Transmutation Endeavour

Availability studies for MYRRHA

- RAMI studies overview -(CERN, 07 July 2016)



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Introduction

MYRRHA - long term supporting research facility for Accelerator Dri Spallation system (ADS).



MAX - (MYRRHA Accelerator eXperiment research and development programme)



MYRTE - research activities to demonstrate the feasibility of transmutation of high-level nuclear waste at industrial scale (MYRRHA research facility)

MYRTE WP2 – continues MAX activities aimed to demonstrate high reliability of the Myrrha Linac is achievable



MYRTE

MYRRHA Accelerator eXperiment RESEARCH & DEVELOPMENT PROGRAMME



THE FRAMEWORK PROGRAMME FOR RESEARCH AND INNOVATION

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MYRRHA Research and Transmutation Endeavour

1. SNS & Myrrha linac – Risk Spectrum Reliability models (MAX project)

2. Linac 4 & Myrte (linac for Myrrha) – Reliability Modelling









SNS Linac Modeling (MAX Task 4.2)

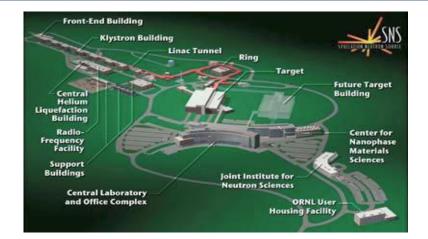
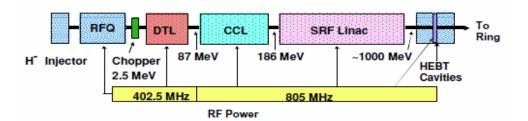




Figure 2-2. a) The 1,000-foot SNS linear accelerator is made up of three different types of accelerators. It is the first of its kind used to generate a pulsed energy beam. b) The SNS ring intensifies the high-speed ion beam and shoots it at the mercury target 60 times a second (60 Hz).

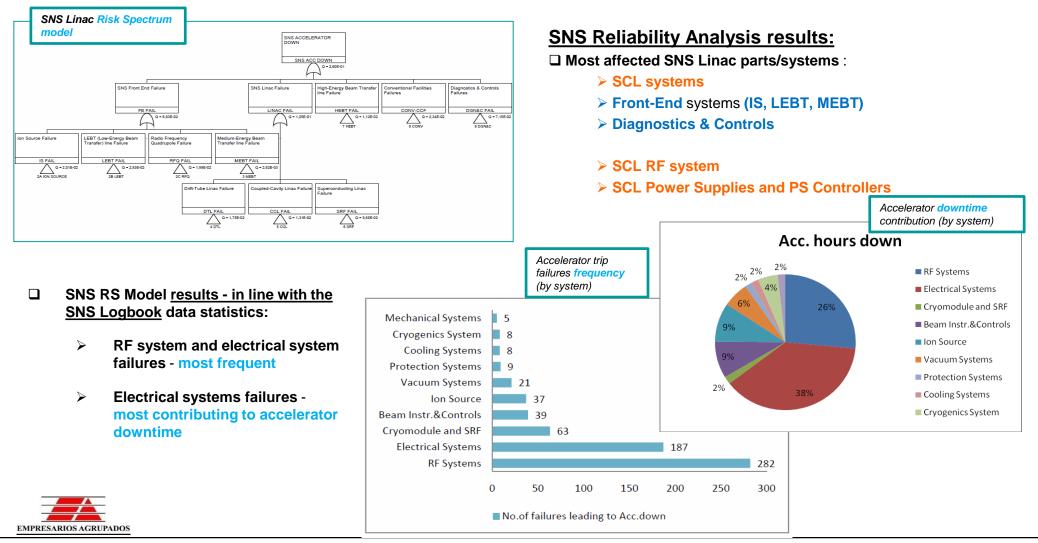


- MAX Task 4.2 SNS (ORNL) Linac Reliability modeling (methodology currently applied for NPPs –with Risk Spectrum (RS-PSA))
 - SNS Linac reliability analysis
 - feedback on SNS Linac reliability performance
 - modeling tool for Task 4.4
 - Draft preliminary conclusions and recommendations:
 - Maximize the reliability/availability/safety of MYRRHA Acc.
 - Guidance for designing the MYRRHA Accelerator.





SNS Linac Modeling – Results & evaluation vs. SNS Logbook data (Accelerator trip failures)





MYRRHA Accelerator eXperiment

RESEARCH & DEVELOPMENT PROGRAMME



Planned Shutdown Availability

8.0 h

0.5 h

Note

Date (Shift)

Experiments Availabilit

100.0%

97.5%

100.0%

86.25%

75.42%

98.33%

97.92%

96.17%

Logbook

7.5 h

Notes

1,3

0 0 0 0

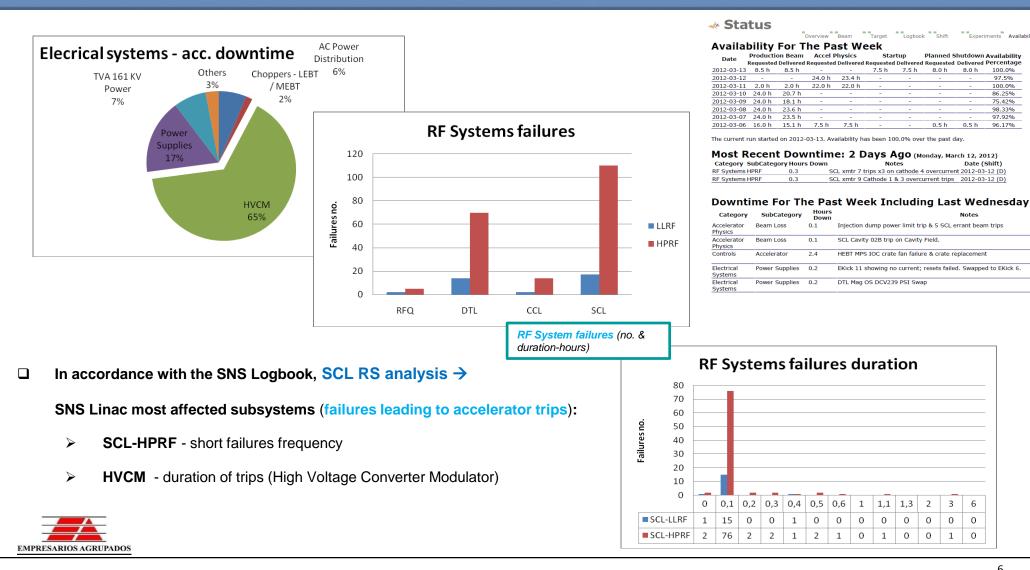
0 0 1 0

2 3

8.0 h

0.5 h

SNS Linac Modeling – Results vs. SNS Logbook data

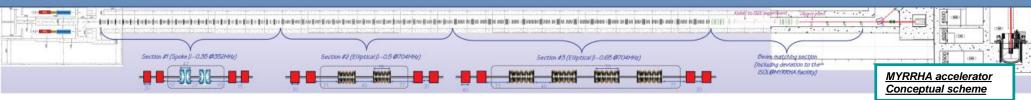


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SNS Linac Modeling (MAX Task 4.4

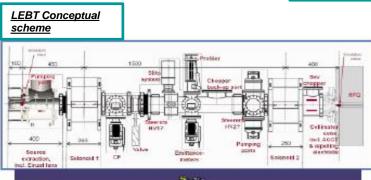
Myrrha Linac design:

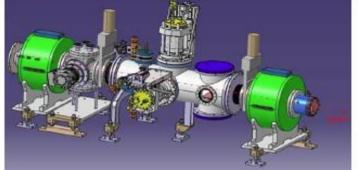
<u>Low energy section</u> – Injector/Linac front end:

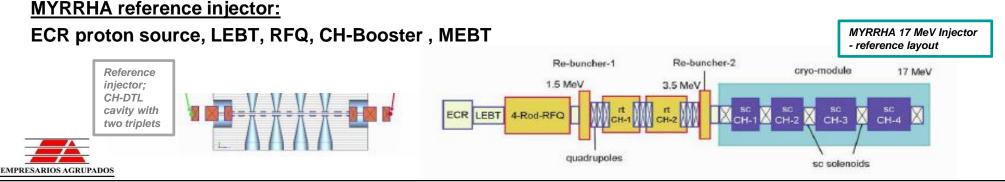
Multicell cavities – Modularity & fault tolerance not applicable

→ Parallel Redundancy - 2 Injectors with fast switching <u>Medium and High energy section</u> – Independentlyphased superconducting section - Highly modular (individual, independently controlled accelerating cavities).

→ Serial redundancy - strong tolerance to faults.



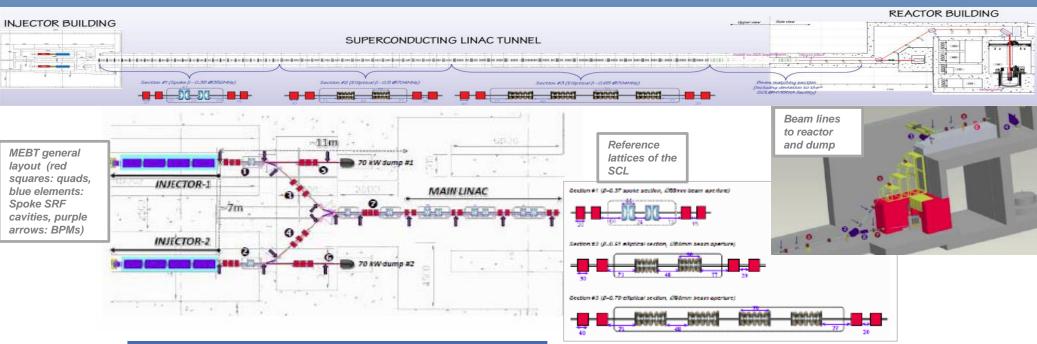




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J.L. Biarrotte

The ADS reliability requirement

- Beam trips longer than 3 sec must be very rare:
- To limit thermal stress & fatigue on the target window, reactor structures & fuel assemblies
- > To ensure a 80% availability given the foreseen reactor start-up procedures
- Present MYRRHA spécifications: <10 beam trips per 3-month operation period (i.e. MTBF > 250h) – derived from the PHENIX reactor operation analysis
- Far above present HPPA accelerator performance MTBF is a few hours at PSI or SNS
- > Far above present ADS specifications in US or Japan based on simulations
- In any case, reliability guidelines are needed for the ADS accelerator design:
- Strong design i.e. robust optics, simplicity, low thermal stress, operation margins...
- > Redundancy (serial where possible, or parallel) to be able to tolerate failures
- Repairability (on-line where possible) and efficient maintenance schemes

Reliability challenges:

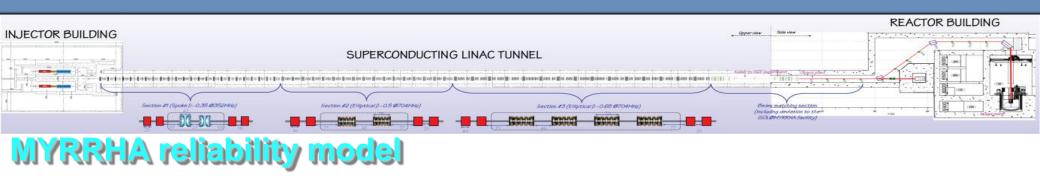
- > Injector Switch Magnet
- Fault tolerance/compensation function

Reliability of SSAs (Solid State Amplifiers)



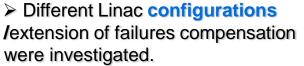




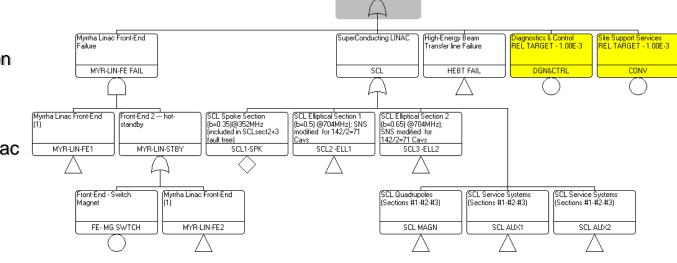


Failure database – developed from SNS/Myrrha, other; system of failure coding defined, e.g. failure IDs (basic events in Fault Tree)

Myrrha Linac Reliability model (Risk Spectrum fault tree) - based on SNS design&rel. data and MAX project design



Calculation of Availability + Linac Fault Frequency - for optimized configuration/design



MAX LINAC DOWN







MYRRHA Accelerator eXperiment

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Input Data; General assumptions

| Model code | Part | System | No. | MTBT | MITTR | Ma R | aufacturer/ ef. Design | Med | | Details; | Obs. | | | |
|------------------|--------------------------------|-------------|--------------|-------------|---------|----------|---------------------------|----------|--------------------------|---|------------|---|--|--|
| | Farad | day Cup | | no data | no data | IPHC | | - | | Not considered; bea normal beam | | | | |
| | Alliso | n scanner | | no data | no data | Emittano | e-meter | - | | Not considered; bea normal beam | | | | |
| | Vacuur | n chamber | | no data | no data | UCL/CF | UCL/CRC | | | Not considered; Exp chamber (not norma | | | | |
| | Bear | n dump | 1 | 5000 | 8 | SNS IS I | SNS IS Edump electrode | | Not considered; const | | | under | | |
| LE (XX-UUUvv) | L | EBT | | | | LPSC | | - | | Reference lay | rout (D1.2 | 9 | | |
| ECR EXT | REXT Source Extraction system | | | | | SNS IS | | SNS | | | | | | |
| LE-EXE | -EXE Extraction electrodes | | | 5000 | 8 | SNS IS (| (2 extractor s) | SNS | | Multi-electro | de system | 1 | | |
| LE-RPL | Electro | on repeller | 1 | 50000 | 8 | | other LEBT | SNS | • • | Intermediate CH-Booster) model | | | | |
| LE-ESP | Extrac | Model code | 1 | Part/System | | No. | MTBF | MITTR | | Manufacturer/Ref. | Model/T | Details; Obs. | | |
| | Pumj | REQ (VYY- | 220 | | | | | | | Design | TPO | | | |
| | Ein | UUUvv) | ~~~~ | | | | | | | | | | | |
| | Vacua | RFQ-CAV | RFQ Cavity | | | 1 | 1000000 | 4380 | SN | S RFQ | SNS | SNS RFQ Structure | | |
| LE-SLP | Sere | RFQ-WIN | Window | | | 1 | 100000 | 12 | SN | S RFQ windows | SNS | | | |
| LE-TBP | Turt | | RF System | | | | | | Τ | | | | | |
| LE-QMA | Sel | RFQ-AMP | SS Amplifie | r | | | 50000 | 4 | Sol | leil technology | - | Power RF for RFQ: 176.1 MHz, 160 kW CW | | |
| LE-STR | H,V steet | | Transmitter | r & Aur | | 1 | | | In | enomitters & Ann | SNS | Transmitters & Aux | | |
| | | SNS tree | LLRF | | | 1 | 100000 | 2 | SN | S DTL-LLRF | SNS | | | |
| | Fara | SNS tree | AC distribut | tion | | 1 | 77700 | 4 | SN | S DTL-HPRF | SNS | RF power-line | | |
| ł | | RFQ-WCL | Water-cooli | ng | | 1 | 30000 | 3 | SN | S DTL | SNS | RFQ stems, SSA water-cooling (deionised water) | | |
| | | | _ | | | | | | 1- | | | _ | | |
| | | SNS tree | Vacuum Sy | stem | | 1 | SNS tree | SNS tree | SN | S RFQ Vacuum syst. | SNS | SNS tree | | |
| | | SNS tree | Scroll Pump | 18 | | 2 | 20000 | 2 | SN | S RFQ Vacuum syst. | SNS | 2 pumps considered instead of 4-in SNS | | |
| | | SNS tree | Gauges | | | 2 | 100000 | 4 | SN | S RFQ Vacuum syst. | SNS | 2 gauges considered instead of 4-in SNS | | |
| | | SNS tree | Cryo Pump | | | 3 | 35714 | 1 | SN | S RFQ Vacuum syst. | SNS | 3 pumps considered instead of 6-in SNS | | |
| | | | | | | | | | | | | | | |
| | IJB (YYY- CH-Bosster UUUvy) | | | | | | | | | | | | | |
| | | SNS tree | CH-Booster | rsupport | | 1 | 5000000 | 504 | SN | S DTL support | SNS | Support structure | | |
| | | SNS tree | mags1 (Sole | moid) | | 1 | 1000000 | 4 | | S quads -Magnet sembly | SNS | Assumed- similar to the SNS quadrupole (MYRRHA Linac-solenoid) | | |
| | | IJB-RBC1 | RB-1 | | | 1 | 100000 | 4 | SN | S MEBT rb-cav | SNS | Rebuncher cavity 1 | | |
| MPRESARIOS | AGRUPADO: | , | | | | | | | | | | | | |

Linac design - General hypotheses & assumptions

- (A1) Radiofrequency (RF) System similar to SNS (excepting Klystron and Modulator subsystems and related). All MYRRHA Linac amplifiers are solid-state type.
- (A2) 'Transmitter "subsyst. (SNS model) equipment to run the SSA for RF cavity control. Generally, the transmitters consist of a low level RF system, amplifier water-cooling, AC distribution, etc.
- (A3) Auxiliary systems (AUX) -based on SNS (reference), modified to MYRRHA Acc. Design, adjusted to a lower level of detail. No glycol cooling -not applicable to the MYRRHA Linac case.
- (A4) Relevant Beam Diagnostics -those related to possible beam failures and/or linked to the Machine Protection System (MPS).

Diagnostics for monitoring and tuning - not relevant to normal operation.

(A5) MTBF=10e5h (SNS) SC Cavs -cavity failures due connected systems failures (other than cav. Mechanical failure)

(A6-7)

- Comps. Missing data SNS similitude, assumptions
- Impact on global reliability:
 - Injector Switch magnet
 - Fault tolerance and compensation system/function -high reliability
 - objectives for detection and control 10 systems.

Table 4.5 - MAIN SUPERCONDUCTING LINAC modeling data



Input Data; Detailed assumptions

> MAIN SUPERCONDUCTING LINAC modeling data

| Model code | Part/System | No. | MTBF | MTTR | Manufacturer/Ref. Design | Model/T ype | Details; Obs. |
|---------------------|------------------------------------|------------|--------|---------------|------------------------------|----------------|---|
| SCL (YYY- UUUvv) | SCL | | | | | | |
| | Section 1 | | | | | | |
| | Spoke CAVs | 48 | 100000 | 3 | SNS RF SCL cavity | SNS | Spoke 2-gap (β=0.37); (included in SCLsect2+3 fault tree) |
| | Section 2 | | | | | | |
| SNS tree | Elliptical-1 CAVs | 34 | 100000 | 3 | SNS RF SCL cavity | SNS | Elliptical1-5cell (β=0.51); SNS modified for 142/2=71 Cavs |
| | Section 3 | | | | | | |
| SNS tree | Elliptical-2 CAVs | 60 | 100000 | 3 | SNS RF SCL cavity | SNS | Elliptical2-5cell (β=0.7)); SNS modified for 142/2=71 Cavs |
| SNS tree | SCL cavities-total (spoke+ellipt.) | 142 (2x71) | SNS S | CL: 81 caviti | es (33mb + 48 hb) => 1.75 -2 | multiplicati | on factor for SCL AUX systems capacity |
| SNS tree | Cryostats (cryomodules) | 56 (2x28) | | | | MAX | 24+17+15 (configuration in Figure 2.10) |
| SCL-SSAS | SS Amplifier | 2x71 | 50000 | 4 | Soleil technology | - | |
| SNS tree | RF Feedthroughs | 2x71 | 100000 | 24 | SNS SCL-RF | SNS | |
| SNS tree | SCL Cavity | 142 | | | SNS RF SCL Cavity | SNS | |
| | SCL Circulator | 2x71 | 50000 | 3 | SNS scl | SNS | |
| | SCL Load | 2x71 | 75019 | 3 | SNS scl | SNS | |
| | SCL Waveguide | 2x71 | 100000 | 3 | SNS scl | SNS | |
| | SCL Window | 2x71 | 100000 | 3 | SNS scl | SNS | |
| | SCL Cavity | 2x71 | 100000 | 3 | SNS scl | SNS | |



Modeling Assumptions (Risk Spectrum)

MYRRHA Accelerator eXperiment

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"Continuously monitored repairable component" - Risk Spectrum Type 1 reliability model – Linac components

"Constant Frequency" - Risk Spectrum Type 5 reliability model – accelerator trip frequency

"Mean Unavailability" and "Frequency" types of calculation unavailability/frequency values (basic events). The long-term average unavailability (Q) and frequency (F), the expected number of failures per unit time) were calculated





EMPRESARIOS AGRUPADOS



MYRRHA Accelerator eXperiment research & development programme



RS Modeling - methodology

RS Reliability model - Availability

- Risk Spectrum Type 1 Repairable components (continuously monitored) –modeling the SNS Linac components
 - Failure/Repair processes exponential distributions; failure/repair rates -ct.
 It is assumed q=0

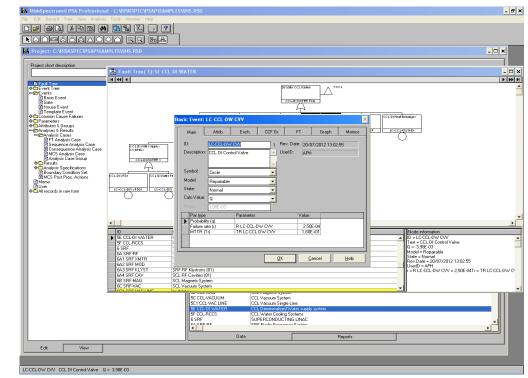
$$Q(t) = q e^{-\mu t} + \left(\frac{\lambda}{\lambda}\right) \left(1 - e^{-(\lambda + \mu)t}\right) \qquad Q_{max} = \frac{\lambda}{\lambda}$$

 $\lambda {=} 1/MTTF$ -failure rate); $\mu {=} 1/MTTR$ -repair rate

• "Mean Unavailability" type of calculation used to obtain the unavailability values for the basic events:

Q= $\lambda/(\lambda+\mu)$ (the long-term average unavailability

- Q calculated for each basic event)



□ <u>other RS Reliability models</u>

- Type 2 Periodically Tested Component (most complex)
- Type 3 Constant Unavailability
- Type 4 Component with Fixed Mission Time
- Type 5 Constant Frequency
- Type 6 Non-Repairable Component







RS Modeling - methodology

RS Reliability model - Frequency

 Risk Spectrum Type 5 – Type 5 - "Constant Frequency", used for accelerator trip frequency

Q(t) = 0 Q = 0(evel W(t) = f scribed by a Poisson process).

• "Frequency" type of calculation, used to obtain the frequency values for basic events.

Frequency results for case 1.5.1 (Redundant FE/INJ + Compensation)

| t Explorer 🛛 🕹 🗸 | Fault Tree | FT Analysis Ca | ise Basic Event (F | haved | | | | | | - |
|---|--|--|---|---|----------|--------|--|---|---|---------|
| | ID Char#1 | | Description | itered) | | | Calculation t | ype MCS Result | UNC Mean | TD Mean |
| Fault Tree Event Tree | 1 ION SOURC | | Description | | | | Q | 2.01E-02 | UNC Mean | TD Mean |
| Event | 2 LEBT | | | | | | Q | 2,83E-02 | | |
| Basic Event | 3 BFQ | | | | | | Ū. | 1.98E-02 | | |
| Gate | 4 MEBT | | | | | | Q | 2,82E-03 | | |
| House Event | 4A FRONT EN | ND | front end | | | | Q | 6,93E-02 | | |
| Template Event | 5 DTL | | | | | | Q | 1,75E-02 | | |
| Common Cause Failure | 6 CCL | | | | | | Q | 1,31E-02 | | |
| Parameter | 7 SCL | | | | | | Q | 9,85E-02 | | |
| Attributes & Groups | 7A1 SCL RF | | | | | | Q | 6,33E-02 | | |
| Analyses & Results | 7A2 SCL MAG | | | | | | Q | 4,29E-03 | | |
| 📄 Analysis Case | 7A3 SCL VAC 7A4 SCL DIW | | | | | | Q | 1,34E-02 1.06E-02 | | |
| FT Analysis Case | 7A4 SCL DIW 7A5 SCL CHL | | | | | | Q | 9,71E-03 | | |
| Sequence Analysis Case | 7A5 SUL UHL 7B LINAC | | dtl-ccl-scl | | | | Q | 9,71E-03 1,25E-01 | | |
| Consequence Analysis Case | 8 HEBT | | ur consci | | | | Q | 1.126-02 | | |
| Analysis Case Group | 9 CDNV | | | | | | 0 | 2,34E-02 | | _ |
| Analysis Case circup Analysis Specifications | 9A DGN&C | | diagnostics | | | | â | 7,15E-02 | | - |
| Boundary Condition Set | ACC DOWN1 | | | me 1 (RFQ-MEBT-DTL) | | | Q | 2,09E-02 | | |
| MCS Post Proc. Action | ACC DOWN2 | | | me 1a (RFQ-MEBT-DTL) | | | Q | 2,61E-02 | | |
| Memo | MAX LINAC D | DOWN | MYRRHA ACCELERA | TOR DOWN | | | F | 4,45E+02 | | |
| User | SNS ACC DO | WN | < | Ш. | | | | | | |
| | Top Event frequ No | Probability | % | Event 1 | Event 2 | Event | з е | Event 4 | Event 5 | Event |
| | | Probability 1,58E+02 6,01E+01 3,19E+01 | % 35,40 13,50 07,16 | DC-DGC-ZZ PIC DC-DGC-ZZ PPM DC-DGC-ZZ IOC | Event 2 | Event | 3 6 | Event 4 | Event 5 | Event 6 |
| | | Probability 1,58E+02 6,01E+01 3,19E+01 1,75E+01 | % 35,40 13,50 07,16 03,93 | DC-DGC-ZZ PIC DC-DGC-ZZ PPM DC-DGC-ZZ IOC DC-DGC-ZZ MPM | Event 2 | Event | 3 6 | Event 4 | Event 5 | Event |
| | | Probability 1.58E+02 6.01E+01 3.19E+01 1.75E+01 1.23E+01 | 25,40 35,40 13,50 07,16 03,93 02,75 | DC-DGC-ZZ PIC DC-DGC-ZZ PPM DC-DGC-ZZ IOC DC-DGC-ZZ MPM DC-DGC-ZZ VM2 | Event 2 | Event | 3 6 | Event 4 | Event 5 | Event |
| | No 1 2 3 4 5 | Probability 1,58E+02 6,01E+01 3,19E+01 1,75E+01 1,23E+01 1,16E+01 | 2% 35,40 13,50 07,16 03,93 02,75 02,60 | DC-DGC-ZZ PIC DC-DGC-ZZ PPM DC-DGC-ZZ IOC DC-DGC-ZZ MPM | Event 2 | Event | | | | |
| | No 1 2 3 4 5 6 | Probability 1.58E+02 6.01E+01 3.19E+01 1.75E+01 1.23E+01 | % 35,40 13,50 07,16 03,93 02,75 02,60 02,56 02,52 | DC-DGC-ZZ PIC DC-DGC-ZZ PPM DC-DGC-ZZ IOC DC-DGC-ZZ MPM DC-DGC-ZZ VM2 LC-SCL-MGCR PSC | Event 2 | Event | | iS - Risk Spectrur | | |
| | No 1 2 3 4 5 6 7 8 9 | Probability 1,58E+02 6,01E+01 3,19E+01 1,75E+01 1,28E+01 1,16E+01 1,14E+01 1,12E+01 1,12E+01 | \$ 35,40 13,50 07,16 03,33 02,75 02,50 02,56 02,56 02,52 02,52 | DC-06C-22 PIC DC-06C-22 PPM DC-06C-22 IOC DC-06C-22 WPM DC-06C-22 WI2 LC-5CL-M6 QSC DC-06C-22 PIC DC-06C-22 PIC | Event 2 | Event | | iS - Risk Spectrur | | |
| | No 1 2 3 4 5 6 7 8 9 10 | Probability 1,58E+02 6,01E+01 3,19E+01 1,75E+01 1,25E+01 1,16E+01 1,16E+01 1,14E+01 1,12E+01 1,12E+01 1,05E+01 | \$ 35,40 13,50 07,16 03,33 02,75 02,50 02,56 02,56 02,52 02,52 02,52 02,52 | DC-DGC-ZZ FIC DC-DGC-ZZ FIC DC-DGC-ZZ IDC DC-DGC-ZZ MPM DC-DGC-ZZ VM2 LC-SCL-MGCR PSC LC-SCL-MG QSC DC-DGC-ZZ PK DC-DGC-ZZ FK | Event 2 | Event | RUNINFO.RS File View Analy | 5 <mark>5 - Risk Spectrur</mark> sis Help | | |
| | No 1 2 3 4 5 6 7 8 9 10 10 11 | Probability 1.59E +02 6.01E +01 3.19E +01 1.75E +01 1.28E +01 1.18E +01 1.14E +01 1.12E +01 1.12E +01 1.05E +01 | \$ 35,40 13,50 07,16 02,75 02,50 02,56 02,52 02,52 02,52 02,52 02,36 02,36 | DC-06C-22 PPM DC-06C-22 PPM DC-06C-22 I0C DC-06C-22 I0C DC-06C-22 VMM LC-SCL-M6 QSC DC-06C-22 PM DC-06C-22 PK DC-06C-22 PK DC-06C-22 VMI | Event 2 | Event | | 55 - Risk Spectrur sis Help SE 1(1) | | |
| | No 1 2 3 4 5 6 7 8 9 10 11 12 | Probability 1.56E +02 6.01E +01 1.55E +01 1.25E +01 1.25E +01 1.14E +01 1.14E +01 1.12E +01 1.05E +01 1.05E +01 7.18E +00 | % 35,40 13,50 07,16 03,93 02,75 02,60 02,56 02,52 02,52 02,52 02,52 02,56 02,52 02,52 02,52 02,56 02,52 02,56 02,52 02,56 02,52 02,56 02,56 02,56 02,56 02,56 02,56 | DC66C22 PPC DC66C22 PPM DC66C22 PPM DC66C22 MPM DC66C22 MP LC5CL-M60PSC LC5CL-M60PSC DC66C22 PPC DC66C22 PPK DC66C22 PK DC66C22 PK DC66C22 PK DC66C22 VMI HEPSC | Event 2 | Event | RUNINFO.RS File View Analy ANALYSIS CA | 55 - Risk Spectrur sis Help ISE 1(1) LINAC DOWN | | |
| | No 1 2 3 4 5 6 7 8 9 10 11 12 13 | Probability 1,598+02 6,018+01 3,198+01 1,758+01 1,188+01 1,188+01 1,128+01 1,128+01 1,128+01 1,128+01 1,128+01 1,058+01 1,058+01 1,058+00 0,588+00 0,588+00 1,128+00 1,128+00 1,128+00 1,128+00 1,128+00 1,128+01 1,1 | % 35,40 13,50 07,16 06,93 02,75 02,56 02,55 02,55 02,52 02,52 02,52 02,36 02,36 01,51 01,61 01,40 01,40 | DCDGCZZ FIC DCDGCZZ FPM DCDGCZZ V0C DCDGCZZ VM2 LCSCLMGCR FSC LCSCLMGCR FSC DCDGCZZ FIC DCDGCZZ FIC DCDGCZZ FIC DCDGCZZ FIC DCDGCZZ FFK DCDGCZZ FFFT | Event 2 | Event | RUNINFO.RS File View Analy ANALYSIS CA Name : MAX | 55 - Risk Spectrur sis Help ISE 1(1) LINAC DOWN | | |
| | No 1 2 3 4 5 6 7 8 9 10 11 12 13 14 | Probability 1,58E +02 6,01E +01 3,19E +01 1,75E +01 1,75E +01 1,75E +01 1,75E +01 1,12E +01 1,12E +01 1,05E +01 7,18E +00 6,22E +00 6,22E +00 5,76E +00 | 2 35,40 13,50 07,16 03,33 02,75 02,56 02,56 02,55 02,55 02,55 02,55 02,56 02,55 02,56 02,56 02,56 02,56 02,56 02,56 02,56 02,36 01,61 01,40 01,30 | DCGGC22 FIC DCGGC22 FPM DCGGC22 FPM DCGGC22 VM2 UCSCL_WAR DCGGC22 VM2 UCSCL_WARGP FSC UCSCL_WARG 9SC DCGGC22 VM2 DCGGC22 VM1 DCGGC22 VM1 HE FSC UCSCL_FF FTH UCSCL_MGGP FSS | E vent 2 | Event | RUNINFO.RS File View Analy ANALYSIS CA Name : MAX | 55 - Risk Spectrur sis Help ISE 1(1) LINAC DOWN tree gate | m Analysis Tools | |
| | No ▶ 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 | Probability 1,50E +02 6,01E +01 3,19E +01 1,75E +01 1,75E +01 1,12E +01 1,12E +01 1,12E +01 1,12E +01 1,12E +01 1,05E +01 5,78E +00 5,58E +00 5,58E +00 | \$ 35,40 13,500 07,16 00,33 02,75 02,56 02,56 02,56 02,56 02,56 02,56 02,56 01,56 01,56 01,56 01,26 01,28 00,28 01, | DCGGC22 PIC DCGGC22 PIC DCGGC22 PIC DCGGC22 VIC DCGGC22 VIC DCGGC22 VIC ULSCLMGCPSC DCGGC22 PIC DCGGC22 PIC DCGGC22 VIC DCGGC22 VIC DCGGC2 | E vent 2 | Event | RUNINFO.RS File View Analy AnaLySIS CA Name : MAX Type : Fault MCS ANALYS F : | 55 - Risk Spectrur sis Help ISE 1(1) LINAC DOWN tree gate 115 4.452E+002 N | m Analysis Tools | |
| | No 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 16 | Probability 1,586 +02 6,012 +01 3,196 +01 1,756 +01 1,256 +01 1,126 +01 1,126 +01 1,126 +01 1,056 +01 1,056 +01 0,526 +00 5,766 +00 5,568 +00 | * 35,40 13,50 07,16 03,33 02,25 02,260 02,25 02,25 02,25 02,25 02,25 02,25 02,25 02,25 02,25 02,25 02,25 02,25 01,51 01,61 01,28 01, | DC06C22 PIC DC06C22 PIC DC06C22 I0C DC06C22 I0C DC06C22 WH DC06C22 WH DC06C22 WH DC06C22 WH DC06C22 PIC DC06C22 VH DC06C22 VH DC06C22 FIC DC06C22 FIC DC06C22 FIC DC06C22 FIC DC06C24 FITH HEPSC LCSCLW6CP SS LCSCLW4B IPS | Event 2 | Event | RUNINFO.RS File View Analy ANALYSIS CA Name : MAX Type : Fault MCS ANALYS | 55 - Risk Spectrur sis Help ISE 1(1) LINAC DOWN tree gate 115 4.452E+002 N | m Analysis Tools | |
| | No 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 | Probability 1,588 +02 6,01E +01 3,195 +01 1,258 +01 1,258 +01 1,148 +01 1,128 +01 1,128 +01 1,128 +01 1,058 +00 6,228 +00 6,5698 +00 4,828 +00 4,828 +00 4,208 +00 | * (5,40) 13,50) 07,16 02,55 02,56 02,56 02,56 02,56 02,56 02,56 02,56 02,56 02,56 01,55 01,55 01,55 01,56 01,56 01,28 01,56 01,28 00 | DCGGC22 PIC DCGGC22 PIC DCGGC22 VIC DCGGC22 VIC DCGGC22 VIC LCSCLM6GF PIC DCGGC22 VIC DCGGC22 PIC DCGGC22 PIC DCGGC22 VIC DCGGC22 VIC DCGGC22 VIC DCGGC22 VIC DCGGC22 VIC DCGGC22 VIC DCGGC22 VIC DCGGC22 VIC DCGGC22 VIC DCGGC24 VIC DCGGC44 VIC DCGG | E vent 2 | E vent | RUNINFO.RS Fle View Analy AnaLYSIS CA Name : MAX Type : Fault MCS ANALYS F : Cutoff error : | SS - Risk Spectrum sis Help SEE 1(1) LINAC DOWN tree gate IS 4.452E+002 M 0.000E+000 F | m Analysis Tools | |
| | No 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 | Probability 1,598 +02 6,01E +01 3,19E +01 1,75E +01 1,25E +01 1,15E +01 1,15E +01 1,12E +01 1,12E +01 1,12E +01 1,12E +01 1,05E +01 7,18E +00 5,59E +00 4,82E +00 4,82E +00 3,59E +00 3,59E +00 | * 35.40 13.50 07.16 03.33 02.55 02.55 02.55 02.55 02.55 02.55 01.61 01.40 01.30 01.28 01.61 01.28 01.08 00.54 | DC06C22 PIC DC06C22 PIC DC06C22 I0C DC06C22 I0T DC06C22 WH DC06C22 WH DC06C22 WH DC06C22 WH DC06C22 WL DC06C22 WL DC06C22 WL DC06C22 WL DC06C22 WL DC06C22 PIC DC06C22 PIC DC06C2 DC06C2 PIC DC06C2 | Event 2 | E vent | RUNINFO.RS Flo View Analy ANALYSIS CA Name : MAX Type : Fault MCS ANALYS F Cutoff error : UNCERTAINT | 55 - Risk Spectrur ss Help ISE 1(1) LINAC DOWN tree gate 15 4.452E+002 N 0.000E+000 F Y ANALYSIS | m Analysis Tools | |
| | No 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 | Probability 1.588 +002 6.01E +011 3.195 +011 1.755 +011 1.155 +011 1.155 +011 1.155 +011 1.155 +011 1.125 +011 1.055 +011 7.185 +000 5.595 +000 4.205 +000 4.205 +000 3.555 +100 3.555 +10055 +100 3.555 +100 3.555 +100 3.555 +100 3.555 +100 | * (5,40) 13,50) 07,16 02,25 02,25 02,25 02,25 02,25 02,25 02,25 02,25 02,25 02,25 02,25 01,51 01,40 01,40 01,23 01,28 01,26 01,28 01,25 00 | DCDGC22 PIC DCDGC22 PIM DCDGC22 IDC DCDGC22 VMM DCDGC22 VMM DCDGC22 VM LCSCLMGG PSC DCDGC22 VM DCDGC22 PIC DCDGC22 PIC DCDGC22 PIC DCDGC22 PIC DCDGC22 PIC LCSCLMG PS LCSCLVAMB IGS LCSCLVAMB IGS DCDGC22 TSM | Event 2 | E vent | RUNINFO.RS Fle View Analy AnaLYSIS CA Name : MAX Type : Fault MCS ANALYS F : Cutoff error : | 55 - Risk Spectrur ss Help ISE 1(1) LINAC DOWN tree gate 15 4.452E+002 N 0.000E+000 F Y ANALYSIS | m Analysis Tools | |
| | No 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 | Probability 1,598 +02 6,01E +01 3,19E +01 1,75E +01 1,25E +01 1,15E +01 1,15E +01 1,12E +01 1,12E +01 1,12E +01 1,12E +01 1,05E +01 7,18E +00 5,59E +00 4,82E +00 4,82E +00 3,59E +00 3,59E +00 | * (5,40) 13,50) 07,16 02,25 02,25 02,25 02,25 02,25 02,25 02,25 02,25 02,25 02,25 02,25 01,51 01,40 01,40 01,23 01,28 01,26 01,28 01,25 00 | DC06C22 PIC DC06C22 PIC DC06C22 IOC DC06C22 IOC DC06C22 WH DC06C22 WH DC06C22 WH DC06C22 WH DC06C22 WL DC06C22 WL DC06C22 WL DC06C22 WL DC06C22 PIC DC06C22 PIC DC | Event 2 | E vent | RUNINFO.RS Flo View Analy ANALYSIS CA Name : MAX Type : Fault MCS ANALYS F Cutoff error UNCERTAINT Simulations | 55 - Risk Spectrum sis Help ISE 1(1) LINAC DOWN tree gate IS IS 0.000E+0000 F Y ANALYSIS : | m Analysis Tools No of MCS : 344 Remains : 0.00 | |
| | No 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 | Probability 1,958+702 6,01E-011 3,19E-011 3,19E-011 1,75E-011 1,27E-011 1,12E+011 1,12E+011 1,12E+011 1,05E-011 1,05E-011 1,05E-011 1,05E-010 5,78E+000 3,59E+000 3,59E+000 2,89E+0000 2,89E+0000 2,89E+000 2,89E+000 2,89E+0 | * 35.40 13.50 07.16 03.33 02.55 02.55 02.55 02.55 02.55 07.16 11.40 01.30 01.28 07.18 11.08 00.54 | DC06C22 PIC DC06C22 PIC DC06C22 I0C DC06C22 I0C DC06C22 WH DC06C22 WH DC06C22 WH DC06C22 WH DC06C22 VH DC06C22 VH DC06C22 VH DC06C22 VH LC5CLWH GCP SS LC5CLWH GCP SLC5CLWH BGS DC06C22 TSM | Event 2 | E vent | RUNINFO.RS Fie View Analy ANALYSIS CA Name : MAX Type : Fault MCS ANALYS F : Cutoff error : UNCERTAINT Simulations TIME DEPENI | 55 - Risk Spectrum sis Help SE 1(1) LINAC DOWN tree gate IS 4.452E+002 N 0.000E+000 F Y ANALYSIS : DENT ANALYSIS | m Analysis Tools No of MCS : 344 Remains : 0.00 | |
| | No 1 2 3 4 5 6 7 8 9 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 | Probability 1,988-102 6,016-011 3,196-011 3,196-011 1,256-011 1,256-011 1,256-011 1,256-011 1,256-011 1,256-011 1,256-011 1,256-010 5,252-000 6,226-000 6,2568-000 5,598-000 5,598-000 5,598-000 5,598-000 5,598-000 5,598-000 5,598-000 5,598-000 3,595-40 | * 55.40 15.540 13.50 07.16 03.33 02.25 02.25 02.25 02.25 02.25 02.25 02.25 01.51 07.40 07.30 07.32 07.28 07.18 00.59 00.54 00.49 00.49 00.49 00.49 | DC06C22 PIC DC06C22 PIC DC06C22 IOC DC06C22 VMM DC06C22 VMM DC06C22 VM LC5CLM6G PSC LC5CLM6G PSC DC06C22 VM DC06C22 VM DC06C22 VM LC5CLM6G PSS LC5CLM6G PSS LC5CLM4B 6GS HE PSS DC06C22 TSM LC5CLV4M8 6GS LC5CLV4M8 6GS | Event 2 | E vent | RUNINFO.RS Flo View Analy ANALYSIS CA Name : MAX Type : Fault MCS ANALYS F Cutoff error UNCERTAINT Simulations | 55 - Risk Spectrum sis Help SE 1(1) LINAC DOWN tree gate IS 4.452E+002 N 0.000E+000 F Y ANALYSIS : DENT ANALYSIS | m Analysis Tools No of MCS : 344 Remains : 0.00 | |
| | № 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 | Probability 1,958 +102 6,016 +011 1,3196 +011 1,3196 +011 1,258 +011 1,168 +001 1,168 +001 1,168 +001 1,056 +011 1,056 +011 1,056 +001 5,568 +000 5,568 +000 3,558 +000 3,075 +000 2,195 +000 2,1 | * 35,40 13,50 07,76 03,33 02,55 02,26 02,26 02,26 02,26 02,26 02,26 02,26 07,46 07,46 07,46 07,1 | DC06C22 PIC DC06C22 PIC DC06C22 I0C DC06C22 I0C DC06C22 WM DC06C22 WM DC06C22 WM DC06C22 WM DC06C22 WM DC06C22 PIC DC06C22 PIC | Event 2 | Event | RUNINFO.RS Fle View Analy AnalySis Ca AnalySis Ca Max Type : Fault MCS ANALYS F : Cutoff error : UNCERTAINT Simulations TIME DEPENI Time points | 55 - Risk Spectrum sis Help SE 1(1) LINAC DOWN tree gate IS 4.452E+002 M 0.000E+000 F Y ANALYSIS : DENT ANALYSIS : | m Analysis Tools No of MCS : 344 Remains : 0.00 | |
| | No 2 3 4 5 6 7 9 9 10 11 12 13 14 15 16 17 18 20 21 22 23 24 25 | Produktive 1566-402 6.00 Fe/0 3.156-401 3.156-401 1.256-401 1.126-401 1.126-401 1.126-401 1.126-401 1.126-401 1.126-401 1.126-401 1.126-401 1.126-401 5.556-400 5.556-400 3.5556-400 3.5556-400 3.5556-400 3.5556-400 3.5556-400 3.5556-400 3.5556-400 3.5556-400 3.5556-400 3.5556-400 3.5556-400 3.5556-400 3.5556-400 3.5556-400 3.5556-400 3.5566-400 2.1566-400000000000000000000 | ½ 35,40 13,50 07,76 03,33 02,25 02,25 02,25 02,25 02,25 02,25 02,25 01,25 02,26 01,26 01,61 01,161 01,30 01,26 00,34 00,034 00,49 00,49 00,49 00,49 00,49 00,49 00,49 00,49 00,49 | DCDGC22 PIC DCDGC22 PIC DCDGC22 PIC DCDGC22 VIC DCDGC22 VIC DCDGC22 VIA DCDGC22 VIA DCGC22 VIA DCGC20 VIA DCGCC20 VIA DCGC20 V | Event 2 | E vent | RUNINFORS File View Analy ANALYSIS CA Name : MAX- Type : Fault MCS ANALYS Cutoff error: UNCERTAINT Simulations TIME DEPEN Time points IMPORTANCE | 55 - Risk Spectrum sis Help SE 1(1) LINAC DOWN tree gate IS 4.452E+002 M 0.000E+000 F Y ANALYSIS : DENT ANALYSIS : | m Analysis Tools No of MCS : 344 Remains : 0.00 | |
| | No 2 3 4 5 6 7 7 8 9 9 9 10 10 10 10 10 10 10 10 10 10 10 10 10 | Produktive 1566-420 6.00 E-01 3.156-01 1.756-01 1.756-01 1.126-01 1.126-01 1.126-01 1.126-01 1.126-01 1.126-01 1.126-01 1.126-01 2.156-00 2.556-000 | * 35,40 13,50 07,76 03,33 02,55 02,26 02,26 02,26 02,26 02,26 02,26 02,26 07,1 | DCDGC22 FIC DCDGC22 FIC DCDGC22 IOE DCDGC22 VMM DCDGC22 VMM DCDGC22 VM2 LCSCL MGG FSC LCSCL MG DSC DCDGC22 FM DCDGC22 FM DCDGC22 FM DCDGC22 FM LCSCL VMR IFS LCSCL VMR IFS LCSCL VMR IG DCDGC22 FM LCSCL VMR IGS LCSCL VMR IGS LCS | Event 2 | Event | RUNINFORS Fle View Analy ANALYSIS CA Name: MAX- Type : Fault Mame: MAX- Fault F Cutoff error : Cutoff error : UNCERTAINT Simulations TIME DEPPEN Time points IMPORTANCE Events | 55 - Risk Spectrum sis Help SE 1(1) LINAC DOWN tree gate IS 4.452E+002 M 0.000E+000 F Y ANALYSIS : DENT ANALYSIS : | m Analysis Tools No of MCS : 344 Remains : 0.00 | |
| | No 2 3 4 5 6 7 9 9 10 11 12 13 14 15 16 17 18 20 21 22 23 24 25 | Produktive 1566-402 6.00 Fe/0 3.156-401 3.156-401 1.256-401 1.126-401 1.126-401 1.126-401 1.126-401 1.126-401 1.126-401 1.126-401 1.126-401 1.126-401 5.556-400 5.556-400 3.5556-400 3.5556-400 3.5556-400 3.5556-400 3.5556-400 3.5556-400 3.5556-400 3.5556-400 3.5556-400 3.5556-400 3.5556-400 3.5556-400 3.5556-400 3.5556-400 3.5556-400 3.5566-400 2.1566-400000000000000000000 | ½ 35,40 13,50 07,76 03,33 02,25 02,25 02,25 02,25 02,25 02,25 02,25 01,25 02,26 01,26 01,61 01,161 01,30 01,26 00,34 00,034 00,49 00,49 00,49 00,49 00,49 00,49 00,49 00,49 00,49 | DCDGC22 PIC DCDGC22 PIC DCDGC22 PIC DCDGC22 VIC DCDGC22 VIC DCDGC22 VIA DCDGC22 VIA DCGC22 VIA DCGC20 VIA DCGCC20 VIA DCGC20 V | Event 2 | E vent | RUNINFORS File View Analy ANALYSIS CA Name : MAX- Type : Fault MCS ANALYS Cutoff error: UNCERTAINT Simulations TIME DEPEN Time points IMPORTANCE | 55 - Risk Spectrum sis Help SE 1(1) LINAC DOWN tree gate IS 4.452E+002 M 0.000E+000 F Y ANALYSIS : DENT ANALYSIS : | m Analysis Tools No of MCS : 344 Remains : 0.00 | 0E+000 |







MYRRHA Accelerator eXperiment RESEARCH & DEVELOPMENT PROGRAMME

Top Event probability Q = 2,598E-01

Minimal Cutsets



SNS Systems - MCS Analysis

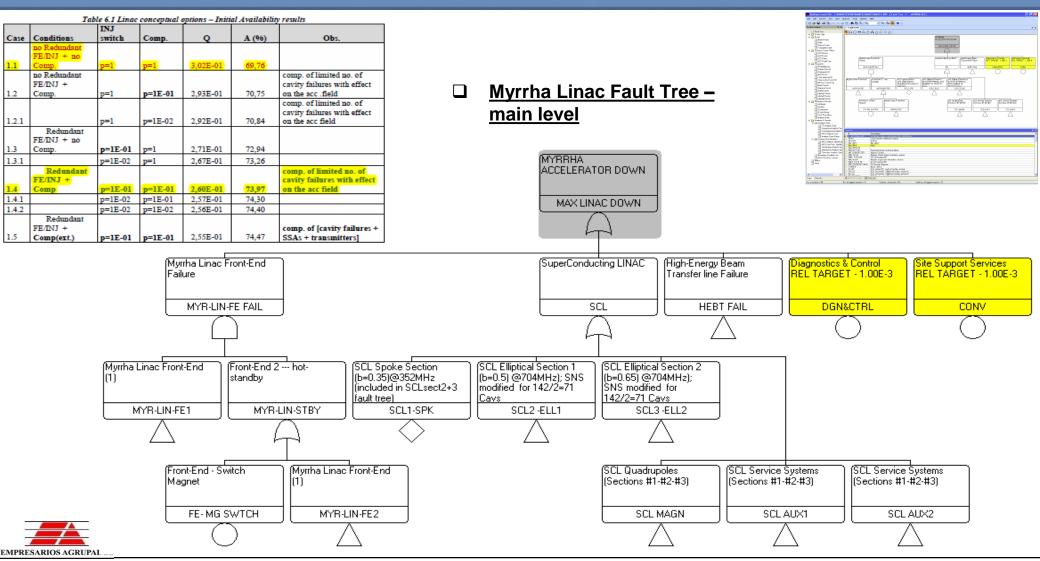
| 🔣 RiskSpectrum® PSA Profe | ssional - C:\RISKSPEC\PSAP | SAMPLES\SNS.R | SD - [FT Results(1 | SNS ACC DO | WN] | | | | No. | Prob. | % | | Event | Description |
|------------------------------------|---|-------------------|--|--------------|------------------|----------------------------------|-------------------|---------|----------------|--------------|-------|-----------|--------------------|---|
| File Edit Record View Anal | ysis Tools Window Help | | | | | | | | 1 | 3,475E-02 | 13,38 | 3,475E-02 | DC-DGC-ZZ PIC | EPIC Modules -900serles |
| D 🛩 🖉 📐 🗡 🖻 🗇 | M 🔁 🖫 🕟 | ? | | | | | | | | | | | | |
| 1 4 4 | | | | | | | | | 2 | 1,907E-02 | 7,34 | 1,907E-02 | LC-SCL-RF FTH | SCL RF Feedthroughs (81):(12+12+12+6+6+ |
| | Description | Calc.type | | Median 95 | ith perc. | | | | 3 | 4 4005 00 | e | | ****** | 1 m 2000 - 25 audus |
| 7A2 SCL MAG 7A3 SCL VAC | | Q | 4,29E-03 1.34E-02 | \square | | | | | - 3 | 1,420E-02 | 5,46 | 1,420E-02 | XX-YYY-MGAC PSC | Arc PSC - 36 series |
| 7A4 SCL DIW | | Q | 1,06E-02 | | | | | | 4 | 4 3535 88 | 5.04 | 4 3535 88 | | 200 Madding 3/2andre |
| 7A5 SCL CHL 7B LINAC | dti-cci-sci | Q | 9,71E-03 1,25E-01 | | | | | | 4 | 1,353E-02 | 5,21 | 1,353E-02 | DC-DGC-ZZ PPM | PPS Modules -343series |
| 8 HEBT | | Q | 1,12E-02 | | | | | | 5 | 8,027E-03 | 2.00 | 8 0075 02 | LC-SCL-RFKY CHD | COL Optimedra (vR4) |
| 9 CONV 94 DGN&C | diagnostics | Q | 2,34E-02 7,15E-02 | | | | | | 9 | 0,027E-03 | 3,09 | 0,027E-03 | LU-SUL-RENT CHD | SCL Cathode (x81) |
| ACC DOWN1 | SNS Fault Tree - Volume 1 | Q | 2,09E-02 | | | | | | 6 | 8,027E-03 | 3.09 | 9 0075 02 | LC-SCL-RFKY IPP | SCI Jon Dump (vR1) |
| ACC DOWN2 SNS ACC DOWN | SNS Fault Tree - Volume 1a SNS Fault Tree model - complete | U O | 2,61E-02 2,60E-01 | | | | | | • | 0,027E-03 | 9,09 | 0,027E-03 | LU-SUL-REKT IPP | SCL Ion Pump (x81) |
| | | | | | | | | | 7 | 8,027E-03 | 3.09 | 9 0075 02 | LC-SCL-RFKY RFS | SCL RF Structure (x81) |
| Top Event probability Q = 2,598E-0 | 1 | | | | | | | | · · | 0,0272-05 | 0,05 | 0,0270-00 | E0-30E-NIKT NI 3 | Soc In Suddale (xor) |
| No. Prob. % | | rent 2 | Event 3 | Even | it 4 | Event 5 | Event 6 | Event 7 | I | 8.027E-03 | 3.09 | 8 027E-03 | LC-SCL-RFKY AOD | SCL Anode (x81) |
| 2 1 9075 02 7 | 38 DC-DGC-ZZ PIC 34 LC-SCL-RF FTH | | | | | | | | | - | 0,00 | 0,0272-00 | 20-002-111117400 | |
| 3 1,420E-02 5,4 4 1,353E-02 5,2 | 46 XX-YYY-MGAC PS | sults(2):SNS ACC | DOWN | | | | | | | - - × | 3.09 | 8 027E-03 | LC-SCL-RFKY MAG | SCL Magnet (x81) |
| 4 1,353E-02 5, 5 8,027E-03 3,0 | 21 DC-DGC-ZZ PPM | | | | | | | | | | 0,00 | 0,0272.00 | 20 002 10 10 10 10 | |
| | 09 LC-SCL-RFKY IPP D 09 LC-SCL-RFKY RFS 0 HED | 1 | Description | | Calc.type | Mean 5th perc. M 1,12E-02 | ectian 95th perc. | | | | 3.06 | 7 937E-03 | FE-ISR-ZZ ANN | ISR Antenna |
| | 19 LC-SCL-BEKY ADI 9 CON | / | _ | | Q | 2.34E-02 | | | | - | 0,00 | 1,5012.00 | | |
| | 09 LC-SCL-RFKY MA ACC DI | | SNS Fault Tree - Yol | ume 1 | Q 0 | 7,15E-02 2.09E-02 | | | | | 2,78 | 7 227E-03 | DC-DGC-ZZ IOC | IOCs -182series |
| 11 7,227E-03 2,3 | 78 DC-DGC-ZZ IOC ACC DI | | SNS Fault Tree - Volt SNS Fault Tree mode | | Q | 2,61E-02 2,60E-01 | | | | | | ., | 0000022.000 | |
| | 45 XX-YYY-MGEK PF | CC D'OWN | IS NS Pault Tree mode | i complete | | 2,808 01 | | | | <u> </u> | 2.45 | 6.359E-03 | XX-YYY-MGEK PFN | PFN - 10 series |
| 14 4,361E-03 1,6 | 58 FE-RFQ-ZZ SST | | | | | | | | | | | | | |
| | 53 DC-DGC-ZZ MPM | | | | | | | | ие Туре | | 2,30 | 5 964E-03 | CV-CAR-ZZ CMP | CAR Compressor |
| 17 3,984E-03 1,5 | 53 LC-CCL-DW CVV MC | S #1 | | aitin | anipani t | | | M | S contribution | | | | | |
| | 53 FE-ISR-ZZ PMG 53 FE-RFQ-GY CVV MC | S#2 | | | | | | | | | | | | |
| | 53 FE-RFQ-DW CVV | 5 #3 | | | =++ | | | | | | | | S analysi | |
| 22 3,984E-03 1,5 | 53 HE-RWS-DW CV | | | | | | MCS Contrib | ution | | | | | S analysis | 5 |
| | 24 LC-SCL-RFKY RF MC 23 FE-ISR-ZZ EXE | 5#4 | | | | | | | | | | | | |
| 25 2,991E-03 1, | 15 CV-WCT-CD CDF(MC | 5#5 | | | | | | | | | | | | |
| | 15 CV-WCT-CD CDF(15 CV-WCT-TP TLF0 MC | 5.46 | | | | | | | | | | Minim | al cut-set (N | ICS) - combination |
| 28 2,991E-03 1,1 | 15 CV-WCT-TP TLF0 | | | ⊒++ | + | | | | | | | | • | 2 |
| | 07 DC-DGC-ZZ VM2 MC 05 LC-CYS-HB TAS | S#7 | | _ | | | | | | | of | events | s which caus | ses the top event to |
| 31 2,553E-03 0,9 | 88 DC-DGC-ZZ VXI MC | S #8 | | | | | | | | | | | | |
| | 98 DC-DGC-ZZ PLC 96 LC-CCL-VA IPP MC | S#9 | | | | | | | | | 00 | cur | | |
| | 32 LC-SCL-VAHB IPS 32 DC-DGC-ZZ VM1 MCS | *10 | | | | | | | | | | | | |
| | 32 DC-DGC-ZZ PPK | | | - | \rightarrow | | | | | | | | | |
| | 35 LC-SCL-VAMB IPS 79 LC-CYS-MB TAS | 1,05-03 | | 1,0E-02 | | 1,0E-01 | | 1,0E+00 | | | | "minim | al" - if any o | of events is |
| | 74 LC-SCL-VAHB GG | | | | | | | | | | | | • | |
| | MC Sy | | HCS Bas.ev. . Gips CDF | | | Param. Attrib. Time-dep. Stat | Comp. | Γ | | | re | moved | from the se | et, the top event no |
| MCS Mod.MCS System Ev. Grp | Bas.ev. | PDF | Time des | | Chart | | | | | | | | | ., |
| System Ev. Grp | | FUP | Time-dep. S | itat. | | | | | | | 10 | nger o | ccurs. | |
| | | | | | | | | | | | | - | | |







Myrrha Linac Modeling – Fault Tree





MYRRHA Accelerator eXperiment

research & development programme



Myrrha Linac Modeling – Quantification & Analysis

Risk Spectrum basic events quantification window

| | | | | | is – Initial point-ea ion of the top eve | | |
|---|---|--|---|---|--|---------------|----------|
| | | | | ACC DOWN) | | | - |
| Project: C:\RISKSPEC\PSAP\SAMPLES\SNS.RSD | | | SE2 MODELS\MAX14-COMMS | COMP -AVAILAB2.RPP - [FT Analysis Case : MAX L | INAC DOWN] | | ð× |
| Froject short description | | s Too <u>l</u> s <u>Wi</u> ndow <u>H</u> elp | | | | | |
| Rault Tree(1):5E CCL-DI WATER | | | | | | | |
| | Project Explorer 🛛 🗘 🗙 | Basic Event FT Analysis | | | | | ▼ × |
| Fould Tree • Construction Analysis Case • Consequence Analysis • Consequence Analy | Event Tree Event Tree Initiating Event Function Event Sequence Consequence Consequence Consequence Consequence Consequence Consequence Consequence Consequence Consequence Correat Co | | veršion : 176 ANALYSES CASE 1(1) Name: MAX LINAC DOWN Type: Fault tree gate MCS ANALYSIS Saving Mod. MCS Saving Demod. MCS Analysis completed. | Ayuda | File View Analysis Help An ANALYSIS CASE 1(1) Name : MAX LINAC DOWN Type : Fault tree gate MCS ANALYSIS MCS ANALYSIS Q : 3.024E-001 No c | nalysis Tools | |
| Edit View | MCS Post Proc. Action | Importance/Sensitivity Analy | | Calculate=1 | Events : Parameters : | | |
| LC-CCL-DW CVV CCL DI Control Valve Q = 3,98E-03 | User | Time-Dependency Analysis ! | <u><</u> | | Attributes : CCF groups : Components : Systems : Event groups : | | |
| EMPRESARIOS AGRUPADOS | Data Reports | Specification Gate BC Set | Memo | | Analysis completed. | | |
| | No. of records = 21 | No. of tagged records = 5 | Total no. of records = 21 | | Ready | 00:00:01 | <u> </u> |



MYRRHA Accelerator eXperiment

research & development programme



0110

Myrrha Linac Modeling –optimization (Availability)

Myrrha Linac Design optimization - Availability

| | Condition | INJ | Come | | A (04) | | 01- | | | | fa | ault tree | e); DG&C fa | ilures | | |
|-----|----------------------------|--------------|-------------|-----------------|-----------|-----------|--|---------------------------|--------------------|--------------------|------------|----------------------|---|------------------|---|------|
| ase | Conditions no Redunds | | Comp. | Q | A (%) | | Obs. | | | | | | | | | |
| 1 | FE/INJ + : | no n=1 | | 3.02E-01 | 69,76 | | | | | | els\MAX | K14-comms-com | ıp -Availab2+Optimiz.RI | PP - [FT Analys | is Case : MAX LINAC DOWN] | L |
| - | <u>comp.</u> no Redund: | | <u>p-1</u> | <u>5,02E-01</u> | 09,70 | comp. of | f limited no. of | ew <u>A</u> nalysis Tools | | | | | | | | |
| | FE/INJ + | | | | | cavity fa | ilures with effect | | , | ee FT Analysi | e Care | 1 | | | | |
| 2 | Comp. | p=1 | p=1E-01 | 2,93E-01 | 70,75 | on the ac | | | ID Char | | | scription | | | Calculation type MCS Result UNC Mean | TDM |
| | | | | | | | f limited no. of ilures with effect | | 1 ION SO | | | | | | Q 2.01E-02 Q 2.83E-02 | |
| 2.1 | | p=1 | p=1E-02 | 2,92E-01 | 70,84 | on the ac | | ailure | 3 RFQ | | | | | | Q 1,98E-02 | |
| | Redund | | | | - | | | | 4 MEBT | T END | from | nt end | | | Q 2,82E-03 Q 6,93E-02 | |
| , | FE/INJ + 1 | | | | 72.04 | | | 'S S | 5 DTL | | - non | in original | | | Q 1,75E-02 | |
| 3 | Comp. | p=1E-01 | p=1 | 2,71E-01 | 72,94 | | | is Case | 6 CCL 7 SCL | | | | | | Q 1,31E-02 Q 9,85E-02 | |
| .1 | Redund | p=1E-02 | p=1 | 2,67E-01 | 73,26 | COMP. | f limited no. of | • Analysis Case | 7A1 SCL | | | | | | Q 6,33E-02 | |
| | FE/INJ + | | | | | | f limited no. of ailures with effe | nce Analysis Case | 7A2 SCL 7A3 SCL | VAC | | | | | Q 4,29E-03 Q 1,34E-02 | |
| | Comp | p=1E-01 | p=1E-01 | 2,60E-01 | 73,97 | | cc field | Lase Group | 7A4 SCL 7A5 SCL | DIW | | | | | Q 1,06E-02 Q 9,71E-03 | |
| .1 | | p=1E-02 | p=1E-01 | 2,57E-01 | 74,30 | | | ifications Idition Set | 78 LINAC | | dti-c | cel-sel | | | Q 1,25E-01 | |
| .2 | | p=1E-02 | p=1E-02 | 2,56E-01 | 74,40 | | | ic. Action | 8 HEBT 9 CONV | | | | | | Q 1,12E-02 Q 2,34E-02 | |
| | Redund FE/INJ + | ant | | | | | (Includes for it | | SA DGN& | | | gnostics | | | Q 7,15E-02 | |
| ; | FE/INJ + Comp(ext.) |) p=1E-01 | p=1E-01 | 2,55E-01 | 74,47 | | f [cavity failures transmitters] | + | ACC DOV | | | | ne 1 (RFQ-MEBT-DTL) ne 1a (RFQ-MEBT-DTL) | | Q 2,09E-02 Q 2,61E-02 | |
| | complext. | , 12-01 | P-12-01 | | | 0025 | | | MAX LINA | AC DOWN | MY | 'RRHA ACCELERAT | | | 0 2,60E-01 | |
| | | Tal | le 6 5 Lina | c concentual | ontions - | Ontimiz | ed Availabilit | results | SNS ACC | | < | | Ш | | | |
| | | 141 | INJ | C Conceptinu | | Spanac | cu . i runu onn | - Contraction | | obability Q = 2,60 | 3E-01 | | | | RUNINFO.RSS - Risk Spectrum Analysis Tools | |
| | Case | Conditions | switch | Comp | | o | A (%) | Obs. | | Proba 6,02E | bility | % 23,10 | Event 1 LC-SCL-DW CVV01 | Event 2 | File View Analysis Help | |
| | | no Redundant | | | | | | | | 6,02E | ·02 | 23,10 | LC-SCL-DW CW02 | | ANALYSIS CASE 1(1) | |
| | | FE/INJ + no | | | | | | | | 3,47E | | 13,40 06,44 | DC-DGC-ZZ PIC LC-SCL-RF FTH | | Name : MAX LINAC DOWN Type : Fault tree gate | |
| | 2.1 | Comp | p=1 | p=1 | 8,38 | 5E-02 | 91,61 | | | 1,35E | ·02 | 05,20 | DC-DGC-ZZ PPM | | | |
| | | no Redundant | | | | | | comp. of limited n | | 7,23E 5,96E | -03 | 02,78 02,29 | DC-DGC-ZZ IOC CV-CAR-ZZ CMP | | MCS ANALYSIS Q : 2.603E-001 No of MCS : 492 | |
| | - I - I | FE/INJ + | | | | | | cavity failures wit | h effect | 5,65E 3,98E | -03 | 02,17 01,53 | SCL SSAS COMP LC-SCL-DW VLV01 | SCL-AMP | Cutoff error: 0.000E+000 Remains : 0.000E+ | 000 |
| | 2.2 | Comp | p=1 | p=1E-0 | 01 7,08 | 5E-02 | 92,91 | on the acc field | | 3,98E | ·03 | 01,53 | DC-DGC-ZZ MPM | | UNCERTAINTY ANALYSIS | |
| | | | | | | | | comp. of limited n | | 3,98E 3,98E | | 01,53 01,53 | HE-RWS-DW CVV LC-SCL-DW VLV02 | | Simulations : | |
| | | | | | | | | cavity failures wit | h effect | 2,99E | ·03 | 01,15 | CV-WCT-CD CDF02 | | TIME DEPENDENT ANALYSIS | |
| | 2.2.1 | | p=1 | p=1E-0 | 02 6,95 | 5E-02 | 93,04 | on the acc field | | 2,99E 2,99E | | 01,15 01,15 | CV-WCT-TP TLF02 CV-WCT-TP TLF01 | | Time points : | |
| | | Redundant | | | | | | | | 2,99E | -03 | 01,15 | CV-WCT-CD CDF01 | | IMPORTANCE ANALYSIS | |
| | - I - I | FE/INJ + no | | | | | | | | 2,79E 2,73E | -03 -03 | 01,07 | DC-DGC-ZZ VM2 LC-CYS-HB TAS | | Events : Parameters : | |
| | 2.3 | Comp | p=1E-0 |)1 p=1 | 4,20 | 4E-02 | 95,79 | | | 2,73E | ·03 | 01,05 | LC-CYS-MB TAS | | Attributes : | |
| | 2.3.1 | | p=1E-0 |)2 p=1 | 3,78 | 6E-02 | 96.21 | | | 2,63E 2,59E | ·03 | 01,00 | LC-SCL-MGCR PSC LC-SCL-MG QSC | | CCF groups : Components : | |
| | | Redundan | | | | | | comp. of limited n | 10. of | 2,55E 2,55E | -03 | 00,98 00,98 | DC-DGC-ZZ PLC DC-DGC-ZZ VXI | | Systems : Event groups : | |
| | | FE/INJ + | | | | | | cavity failures wit | | 2.39E | -03 | 00,92 | DC-DGC-ZZ PPK | | | |
| | | Comp | p=1E-0 |)1 p=1E-0 | 2.84 | 5E-02 | 97.15 | on the acc field | | 2,39E 2,20E | | 00,92 | DC-DGC-ZZ VM1 LC-SCL-VAMB IPS | | Analysis completed. | |
| IOS | AGRUPAD | | | | -,-,- | | | | 21 | 2,20E | | 00,84 | LC-SCL-VAMB IPS | | Ready 00:0 | 0:00 |
| aus | AGRUPAD | 03 | | | | | | | < | | | | | | | |
| | | | | | | | Data Reports | | MCS MO | d. MCS Basic Eve | ent CCF | = Group Parameter | Attribute Component Sy | stem Event Group | CDF PDF Time-dep. STAT Graph | |
| | | | | | | | Data | | 1 | | | | | | | |



MYRRHA ACCELERATOR EXPERIMENT

research & development programme

Frequency results for case 1.5.1 (Redundant FE/INJ +



Myrrha Linac Modeling –optimization (Frequency)

Myrrha Linac Design optimization - Frequency

| | Table 6. | | ceptual op | tions – | Initial Frequen | cy results | | | | Compensation) | | | | | | | |
|--------|---------------------|------------|------------|------------|-----------------------------|---------------------|--------------------|-------------------------------|----------------------|---|-------------------|------------------|-------|--------------------|--------------------------------------|------------------|-----------|
| | | INJ | | | A | | | | | Compensation) | | | | | | | |
| Case | Conditions | switch | Comp | F (| /yr) (/3mth) | Ob | s. | PECVPSAP\SAMP | LESVANALYSE2 | MODELSVMAX14-FREC1_2.RPP - [FT / | Analysis Ca | se : MAX LINAC D | OWN 1 | | | | _ = X |
| | no Redundant | | | | | | | Too <u>l</u> s <u>W</u> indow | Help | | | | | | | | |
| 1.1 | FE/INJ + no Comp | p=1 | p=1 | | 50 137.50 | | | C A 🔁 🛛 | | | | | | | | | |
| 1.1 | no Redundant | <u>p-1</u> | p-1 | | 50 157,50 | comp. of limi | ted no. of | ₽× Fau | It Tree FT Ana | ysis Case Basic Event (Filtered) | | | | | | | • × |
| | FE/INJ + | | | | | cavity failure | | ID | Char #:1 I SOURCE | Description | | | | Calc | culation type MCS Result 2,01E-02 | UNC Mean | TD Mean 🔥 |
| 1.2 | Comp | p=1 | p=1E-01 | 5 | 09 127.25 | effect on the | | 2 LEE | 3T | | | | | Q | 2,83E-02 | | |
| | | | | | | comp. of limi | | 3 RF 4 ME | | | | | | Q | 1,98E-02 2,82E-03 | | |
| | | | | | | cavity failure | | 4A FF | RONT END | front end | | | | Q | 6,93E-02 | | |
| 1.2.1 | | p=1 | p=1E-02 | 5 | 05 126,25 | effect on the | acc field | 5 D T 6 C C | _ | | | | | Q | 1,75E-02 1,31E-02 | | |
| | Redundant | | | | | | | 7 SCI 741 9 | L SCL RF | | | | | Q | 9,85E-02 6,33E-02 | | - |
| | FE/INJ + no | | | | | | | 7A2 9 | SCL MAG | | | | | Q | 4,29E-03 | | |
| 1.3 | Comp | p=1E-01 | p=1 | 4 | 99 124,75 | | | 7A4 9 | SCL VAC SCL DIW | | | | | Q | 1,34E-02 1,06E-02 | | |
| 1.3.1 | | p=1E-02 | p=1 | | Table | 6.8 Linac conc | eptual optio | ns – Optimiz | - | ncy results | | | | Q | 9,71E-03 1,25E-01 | | |
| | Redundant | | | | | INJ | | | A | | | | | Q | 1,12E-02 2,34E-02 | | |
| - | FE/INJ + | | | Case | Conditions | switch | Comp | F(/yr) | (/3mth) | Obs. | | | | Q | 7,15E-02 | | |
| 1.4 | Comp | p=1E-01 | p=1E-01 | | no Redundant FE/INJ + no | | | | | | TL) DTL) | | | Q | 2,09E-02 2,61E-02 | | |
| 1.4.1 | | p=1E-02 | p=1E-01 | 1.1 | Comp | p=1 | p=1 | 130.00 | 32.50 | | | | | F | 4,45E+02 | | × |
| 1.4.2 | Redundant | p=1E-02 | p=1E-02 | *.* | no Redundant | | P-1 | 150.00 | 52.50 | comp. of limited no. of | | | | | | | > |
| | FE/INJ + | | | | FE/INJ + | | | | | cavity failures with effect | | | | | | | |
| 1.5 | Comp(ext.) | p=1E-01 | p=1E-01 | 1.2 | Comp | p=1 | p=1E-01 | 88.50 | 22.12 | on the acc field | 2.010 | Event 2 | Ever | nt 3 | Event 4 | Event 5 | Event 6 🔨 |
| 1.5.1 | comp(ext.) | • | p=1E-01 | | | - | | | | comp. of limited no. of | Z PPU Z PPM | | | | | | |
| | | P 12 02 | P 12 01 | | | | | | | cavity failures with effect | Z IOC Z MPM | | | | | | |
| | | | | 1.2.1 | | p=1 | p=1E-02 | 84.43 | 21.10 | on the acc field | 2 VM2 iCR PSC | | | | | | |
| | | | | | Redundant | | | | | | i QSC | | | | NFO.RSS - Risk Spectrur | n Analysis Tools | |
| | | | | | FE/INJ + no | | | 79.60 | 19.90 | | Z PLC Z VXI | | | File View | v Analysis Help | | |
| | > Optimized | -Eroque | ancy | 1.3 | Comp | p=1E-01 | p=1 | | | | 2 PPK 2 VM1 | | | | SIS CASE 1(1) | | |
| | - | i -i requi | city | 1.3.1 | | p=1E-02 | p=1 | 74.60 | 18.65 | | | | | | : MAX LINAC DOWN Fault tree gate | | |
| | results | | | | Redundar FE/INJ + | t | | | | comp. of limited no. of cavity failures with | FTH iCR PSS | | | _ | | | |
| | | | | 1.4 | Comp | p=1E-01 | p=1E-01 | 38.47 | 9.62 | effect on the acc field | i QPS MB IPS | | | F | : 4.452E+002 N | | |
| | | | | 1.4.1 | comp | p=1E-02 | p=1E-01 | 33.46 | 8.36 | enerrou the act here | HB GGS | | | _ Cutoff e | error: 0.000E+000 F | lemains : 0.00 | 0E+000 |
| | | | | 1.4.2 | | p=1E-02 | p=1E-01 p=1E-02 | 29.35 | 7.33 | | ZITSM | | | | TAINTY ANALYSIS | | |
| | | | | 1.7.2 | Redundant | - | p-12-02 | 25.55 | 1.33 | | MB GGS / CVV02 | | | | | | |
| | | | | | FE/INJ + | | | | | comp. of (cavity failures | : CMP | | | | DEPENDENT ANALYSIS oints : | | |
| - | | | | 1.5 | Comp(ext.) | p=1E-01 | p=1E-01 | 35.1 | 8.77 | + SSAs + transmitters) | W CVV 2 PPR | | | _ | TANCE ANALYSIS | | |
| - | | | | 1.5.1 | | p=1E-02 | p=1E-02 | 25.64 | 6.41 | | 7 CVV01 HB VVS | | | Events | : | | |
| EMDDE | SARIOS AGRUPADOS | | | | • | | | < | 2, | JTE+UU UU,45 LL-SUL- | VAHB IPS | | | Parame Attribut | | | |
| EMPRES | SARIOS AGRUFADOS | | | | | | | | | | | | ()(| CCF gr | oups : | | |
| | | | | | | Data Reports | | | | Event CCF Group Parameter Attribute Co | | | | System | ns : | | |
| | | | | | | No. of records = 21 | | No. of tagged record | s = 5 | Total no. of records = 21 Total | I no. of tagged | records = 5 | | Event (| groups : | | |

MYRRHA reliability model - Results

Outcomes of the study:

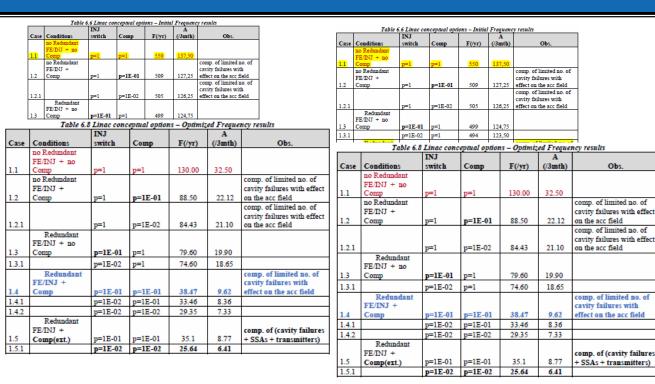
Without/With injector redundancy: Availability from 70% to 75%

If MTBFs of diagnostics replaced by reliability target value (not from SNS experience) + target value for compensation function reliability: Availability to 80%.

Improve superconducting part and assume larger MTBF for components (better comps. Reliability): improvement of the availability to 97%.

Generally, Linac Fault Frequency could evolve from 100/3mths to less than10/3mths





High-reliability for MYRRHA Linac - achieved if anticipated in the design of the machine.

Compensation (fault-tolerance) - solution to minimize the effect of RF/magnets failures.

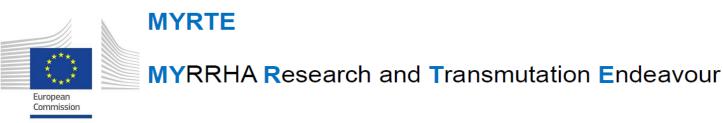
Double injector definitely improves the overall reliability (avoid trips caused by components in the front-end), assuming a reliable switching magnet can be provided.

> Critical failures leading directly to Acc. trip (i.e. cooling control valves, common cause failures, etc.) should be prevented by classical parallel redundancy

Parallel redundancy should also be implemented for power supplies and their controllers and other components in the SCL and HEBT.



Obs.

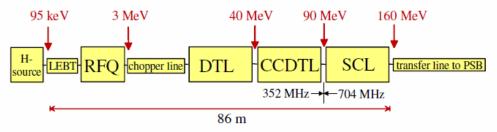




Myrte WP2 – Task 2.9, To be developed:

- LINAC4 reliability model
- > AFT for LINAC4

| | 2015, October 1 (Milestone #1) | 2016, April 1 | 2016, October 1 (Milestone #2) | 2017, April 1 | 2017, October 1 (Milestone #3) | 2018, April 1 | 2018, October 1 | 2019, April 1 (Milestone #4) |
|---------------|---|--|--|---|---|---|---------------------------------------|---|
| Task 2.9 CERN | A detailed work programme should have been defined and agreed between EA and CERN. | modification of the LHC accelerator fault tracking tool | I he first AF I version for LINAC4 should be operational. The LINAC4 reliability model should be complete. | The reliability run of the LINAC4 should have started. The operational data from the reliability run (e.g. faults and their characteristics) should be entered in the AFT. | be carried out, using operational data available in AFT for a period of at least 6 month from the reliability | enhancement should be derived. Applicability of these recommendation to MYRRHA reliability model | LINAC4 reliability work performed. | recommendations towards the MYRRHA linac reliability enhancement should be gathered into Deliverable 2.9. |

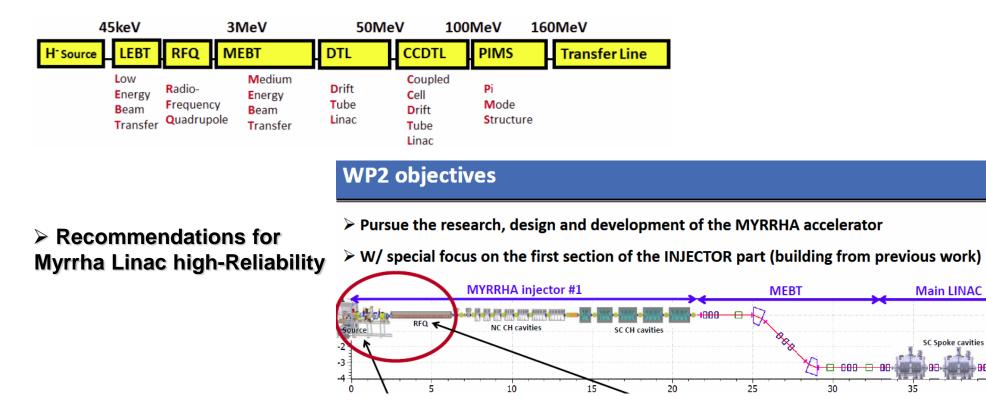








> LINAC4 Reliability modeling conclusions – to be extended to Myrrha Linac: LINAC injector + accelerator up to 100 MeV)





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2020



MYRTE

MYRRHA Research and Transmutation Endeavour

Data for Linac Reliability Modelling

- Development of a common database for reliability analyses for MYRRHA (CERN + EA)
- All figures currently being reviewed at CERN in view of the Linac4 reliability run (2017)

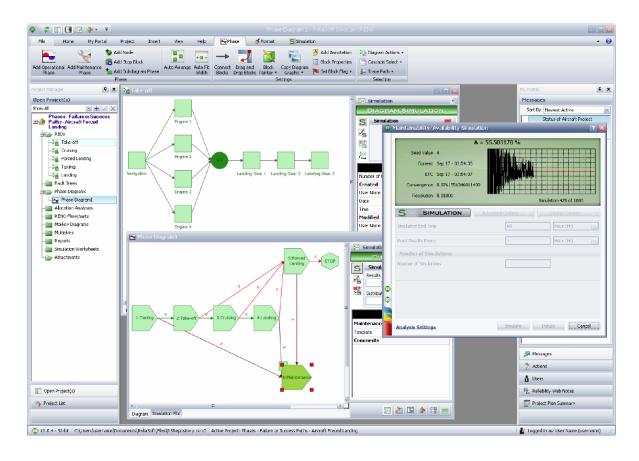
| Failure Catalogues | Availability studies for MYRRHA Linac 4 Failure | edit links Catalogue | | CE | RN | | | | | | | |
|---|--|---------------------------------|--|---|---|--------------------------|-------------------------|------------------------------|------|-----------------------------------|----------|--|
| LINAC 4 | 🕼 Excel Web Access - FC_Lir | nac4 | | | | | | | | | | |
| MYRRHA | FILE ROPEN IN EXCEL DATA | A ▼ FIND | | | Availability studies for MYRRHA 🛛 💉 EDI | | | | | _ | | |
| SNS Documents | | | FAILURE | s > | SNS Failure Catal | ogi | ue <u>Empresarios</u> | | | | | |
| Notebook Site Contents EDIT LINKS | section: Linac4 | BEAM CONDITION | FAILURE MODE | Failure Catalogues LINAC 4 MYRRHA | FILE X OPEN IN EXCEL DATA - | FIND | gueEmpresariosAgrupados | | | | | |
| | | | | | | | FA | ILURE CATALOGU | JE | | | |
| | 1) SOURCE | 80mA H-, 45keV, 0.25 mm*mrad | H- source not available (source short stop) | SNS | | _ | | | | | | |
| | | 80mA H-, 45keV, 0.25 mm*mrad | H- source not available (source long-stop) | Documents Notebook Site Contents | SECTION: SNS | BEA M CON DITIC | FAILURE MODE | LOCATION | MTTR | FAILURE RATE (per component, 1/h) | SEVERITY | |
| | 2) LEBT | 80mA H-, 45keV | | 🖍 EDIT LINKS | | N | | | | | | |
| | 2.1) SOLENOIDS | | Powering Failure | - | ION SOURCE | | | | | | | |
| | 2.1) 301210103 | | | - | Plasma Electrode | | | Ion Source | 8 | 2.00E-05 | | |
| | | | Wrong Magnetic Field | | Permanent Magnets | | | Ion Source | 8 | 1.00E-05 | | |
| | | | | | HV Insulators | | | Ion Source | 8 | 2.00E-05 | | |
| | 2.2) BEAM STOPPER | | Mechanical Failure | | Power Supply | | | Ion Source | 1 | 2.00E-05 | | |
| | | | Electronic Failure | | RF Amplifier | | | Ion Source | 0.8 | 2.00E-05 | | |
| | | | Incorrect Position | | RF Circulator | _ | | Ion Source | 3 | 2.00E-05 | | |
| | | | | - | Gas Supply | | | Ion Source | 4 | 2.00E-05 | | |
| | 2.3) PRE-CHOPPER | | Powering Failure | | Pumping | _ | | Ion Source | 1 | 5.00E-05 | | |
| | | | | - | Valves | | | Ion Source | 4 | 1.00E-05 | | |
| | | | Wrong Electric Field | - | Gauges | | | Ion Source | 4 | 5.00E-06 | | |
| | | | PSB Synchrnization | | Support Beam Dump | | | Ion Source Ion Source | 8 | 8.00E-05 2.00E-04 | | |
| | | 70mA H-, | | | | | | Ton source | 0 | 2.002-04 | | |
| | 3) RFQ | 3MeV | Powering Failure | | LEBT | | | | | | | |
| | | | Wrong Field | 1 | Extraction Electrodes | | | LEBT | 8 | 2.00E-04 | | |
| | | | ~ | | Electron Repeller | | | LEBT | 8 | 2.00E-05 | | |
| | | | | 1 | Extractor Supply | | | LEBT | 0.8 | 2.00E-05 | | |
| Morgina | g relevant inf | ormatio | n to | 1 | Scroll pump | _ | | LEBT - Vacuum System | 1 | 5.00E-05 | | |
| merging | j relevant ini | omalio | | | Turbo pump | | | LEBT - Vacuum System | 1 | 1.00E-05 | | |
| | | | | | Turbo pump Gauge Turbo pump Valve | | | LEBT - Vacuum System | 4 | 1.00E-05 1.00E-05 | | |
| build a | MYRRHA fai | iure cat | aloque | | Solenoid 1 | | | LEBT - Vacuum System LEBT | 2 | 1.00E-05 | | |
| | | | 3.3 | 1 | H,V Steerers (dipoles) | | | LEBT | 2 | 1.00E-06 | | |
| | | | | 1 | Valve | + | | LEBT | 4 | 1.00E-00 | | |
| | | | | 1 | Slits System (collimator) | | | LEBT | 4 | 1.11E-05 | | |
| | | | | 1 | Solenoid 2 | - | | LEBT | 2 | 1.00E-06 | | |
| | | | | 1 | H,V Steerers (dipoles) | - | | LEBT | 2 | 1.00E-06 | | |
| N EMPRESA | PLOG A CONTRACTOR | | | 1 | Inj. Cone Cooling | | | LEBT | 8 | 2.00E-05 | | |
| EMPRESA | RIOS AGRUPADOS | | | | | | | | - | | | |

THE FRAMEWORK PROGRAMME FOR RESEARCH AND INNOVATION

HORIZ N 2020



- ReliaSoft's BlockSim software tool comprehensive platform for system reliability, availability, maintainability and related analyses.
- Sophisticated graphical interface, modeling the simplest/most complex systems and processes using reliability block diagrams (RBDs) or fault tree analysis (FTA)







MYRTE

MYRRHA Accelerator eXperiment research & development programme

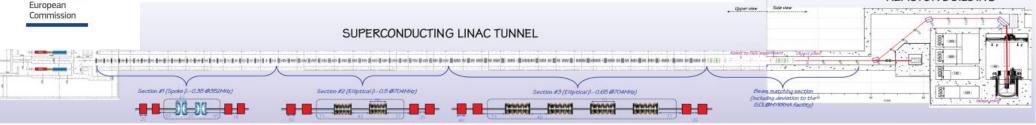


THE FRAMEWORK PROGRAMME FOR RESEARCH AND INNOVATION

**** * **

MYRRHA Research and Transmutation Endeavour





Thank you

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P. FERNANDEZ RAMOS – EA pfr@empre.es

