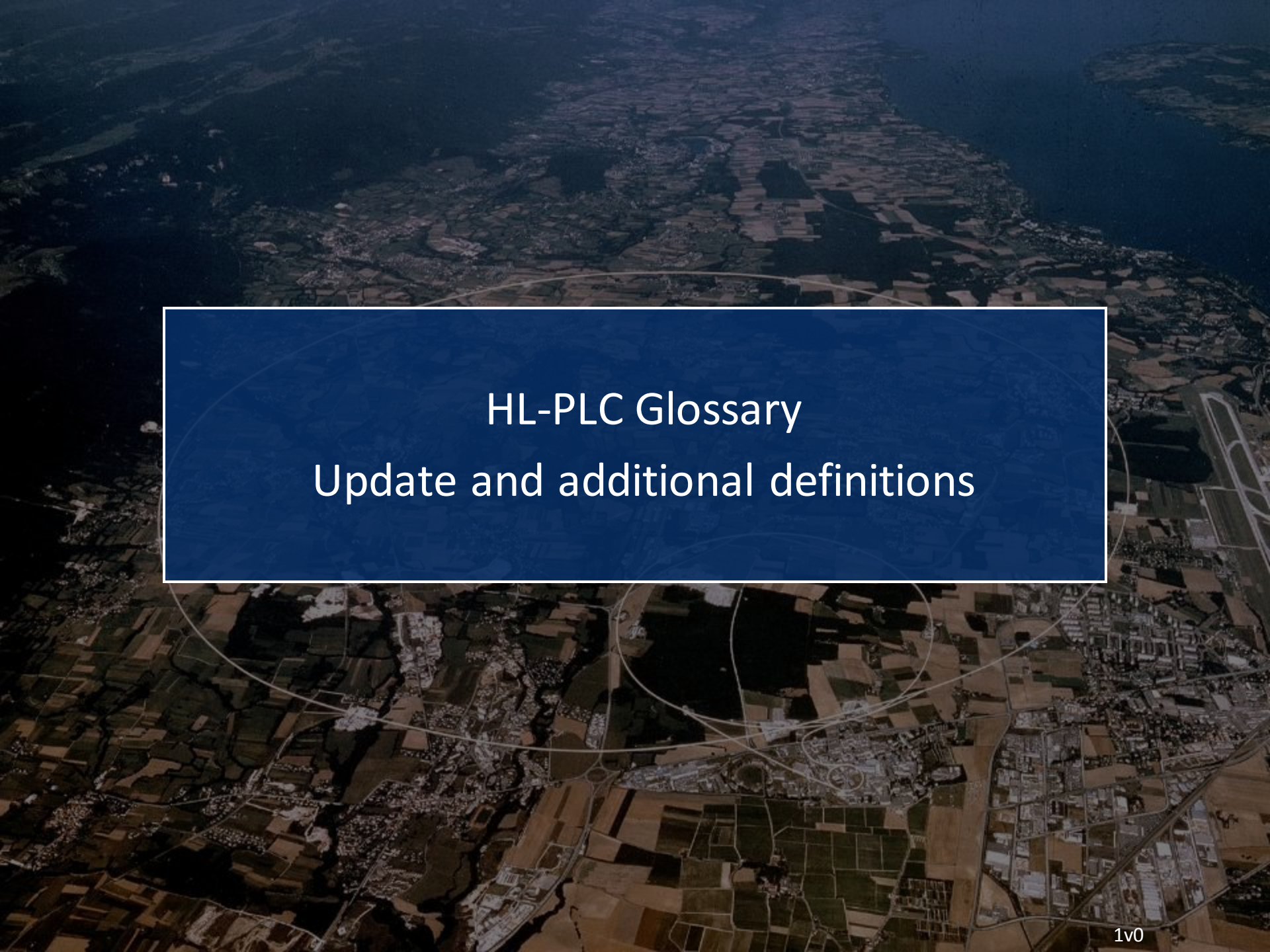


HL-PLC Glossary

Update and additional definitions

1v0

Glossary and Definitions

Glossary and Definitions

β^*:
Optical β-function at the IP.

η:
Machine slip factor.

η_D:
Normalized dispersion: $\eta_D = D/\sqrt{\beta}$, where D is the machine dispersion.

γ:
Optic gamma function: $\gamma(s) = (1 + \alpha^2(s))/\beta(s)$ where $\beta(s)$ is the optical betatron function along the machine and $\alpha(s) = \frac{d\beta}{2\,ds}$.

γ_r:
The relativistic gamma factor.

abort gap:
Area without any bunches in the bunch train that fits the time required for building up the nominal field of the LHC dump kicker.

arc:
The part of the ring occupied by regular half-cells. Each arc contains 46 half cells. The arc does not contain the dispersion suppressor.

arc cell:
It consists of two arc half-cells and presents the basic period of the optic functions.

arc half-cell:
Periodic part of the LHC arc lattice. Each half-cell consists of a string of three twin aperture main dipole magnets and one short straight section. The cryo magnets of all arc half-cells follow the same orientation with the dipole lead end pointing upstream of Beam 1 (downstream of Beam 2).

batch:

PS batch:
Train of 72 bunches that is injected into the SPS in one PS to SPS transfer.

SPS batch:
Train of 4 × 72 or 3 × 72 bunches that is injected into the LHC in one SPS to LHC transfer.

Beam 1 and Beam 2:
Beam 1 and Beam 2 refer to the two LHC beams. Beam 1 circulates clockwise in Ring 1 and Beam 2 circulates counter clockwise in Ring 2. If colors are used for

HL-PLC Glossary & Definitions based on LHC Design report:

https://espace.cern.ch/HiLumi/PLC/SiteAssets/LHC_Glossary_high_resolution.pdf

Progressing HL-LHC Design (and future operation) requires maintenance/extension of glossary and definitions to ensure coherence across activities + prepare future integration into existing Layout Database

Proposal for additional definitions to be added to the existing glossary (if endorsed today)

Additional definitions – 1/3

- Event pile-up ‘μ’:

  Number of visible inelastic proton-proton interactions in a given bunch crossing

- Average pile-up:

  Mean value of the pile-up over a fill (averaged over all bunch crossings)

- Peak pile-up:

  Maximum pile-up in any bunch crossing at any time (usually at the start of the fill)

Courtsey F.Gianotti

Additional definitions - 2/3

- Peak average pile-up:

  Mean pile-up at the beginning of the fill. It corresponds to the peak luminosity of the fill. In practice, it is determined as the maximum of the pile-up values obtained by averaging over all bunch crossings within time intervals of typically one minute

- Luminous region:

  The 3-dimensional distribution of the collision event vertices

- Average pile-up density:

  Number of inelastic proton-proton interactions in a given bunch-crossing divided by the size of the luminous region in Z

Courtsey F.Gianotti

Additional definitions - 3/3

- Hourglass effect 'H‘:

  Luminosity loss due to longitudinal modulation of beta function over the length of the bunch for small β*

- Geometric luminosity reduction factor due to beam offset 'R‘:

  Reduced beam overlap due to transversal offset of collisions, frequently used for reduction of luminosity (leveling) and VdM scans

- Luminosity reduction factor due to crossing angle 'S':

  Reduced beam overlap due to tilted bunch shape due to crossing angle

- Total luminosity reduction factor ‘F’ = R*H*S

- Piwinsky parameter: Parametrisation of reduced beam overlap due to finite crossing-angle

Preamble - Machine statistics

- Definition of machine availability requires to clearly delineate normal operational cycle from faults, downtime, technical stops, MDs / special physics runs, etc.
- Assessing fault/downtime of the machine not obvious (need dedicated tools to identify blocking fault,..)
- Following several discussions, LHC operation and the Availability Working Group (AWG) [Evian 2012] endorse to adopt the following simple definitons having the aim to
  - Allow for comparison of data sets (operation years/runs, etc…)
  - Allow an easy calculation/implementation of definitions with current and future data (on-line statistics)
  - Allow for luminosity predictions for post LS1 and HL-LHC [HL-LHC: Integrated Luminosity and Availability, Simple Models for the integrated luminosity?]

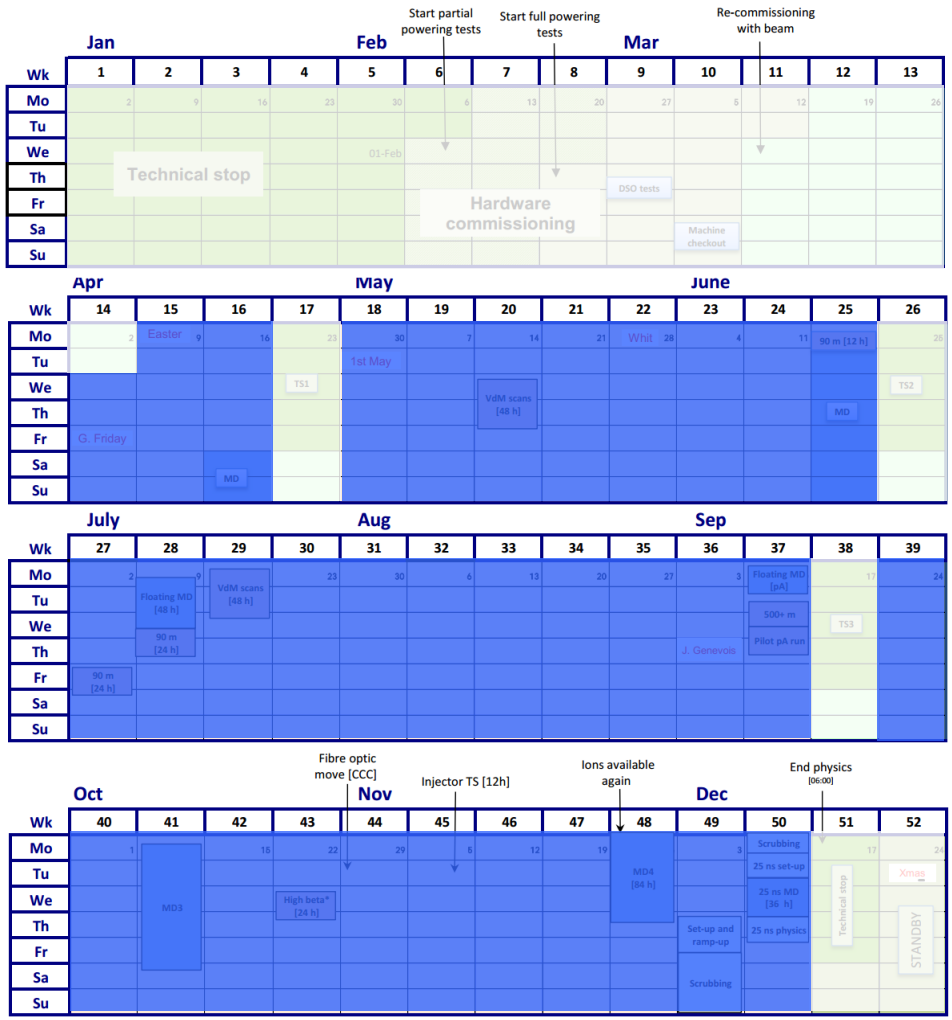
Courtsey B.Todd, J.Wenninger, A.Appoloni, M.Lamont, A.MacPherson

Run Time

Definition: annual time allocated to running with beam

Units: days

Run Time

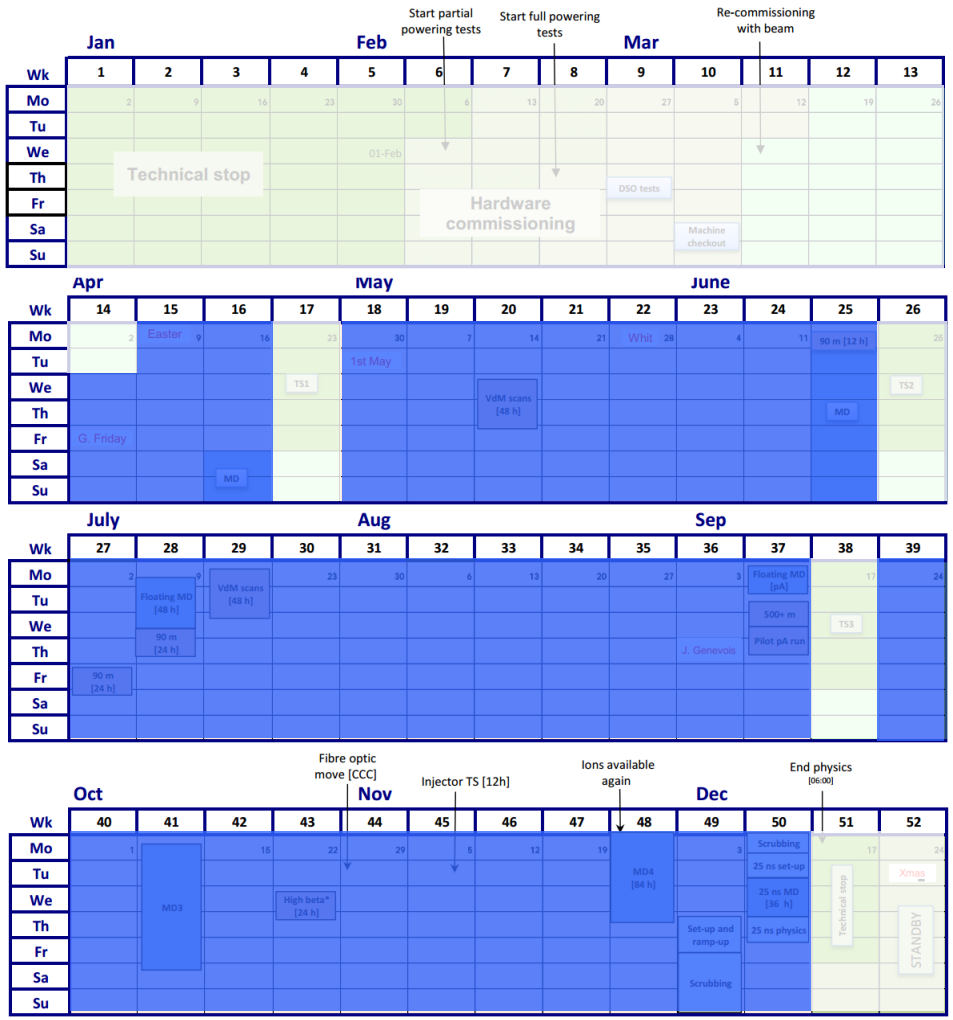


Definition: annual time allocated to running with beam

Units: days

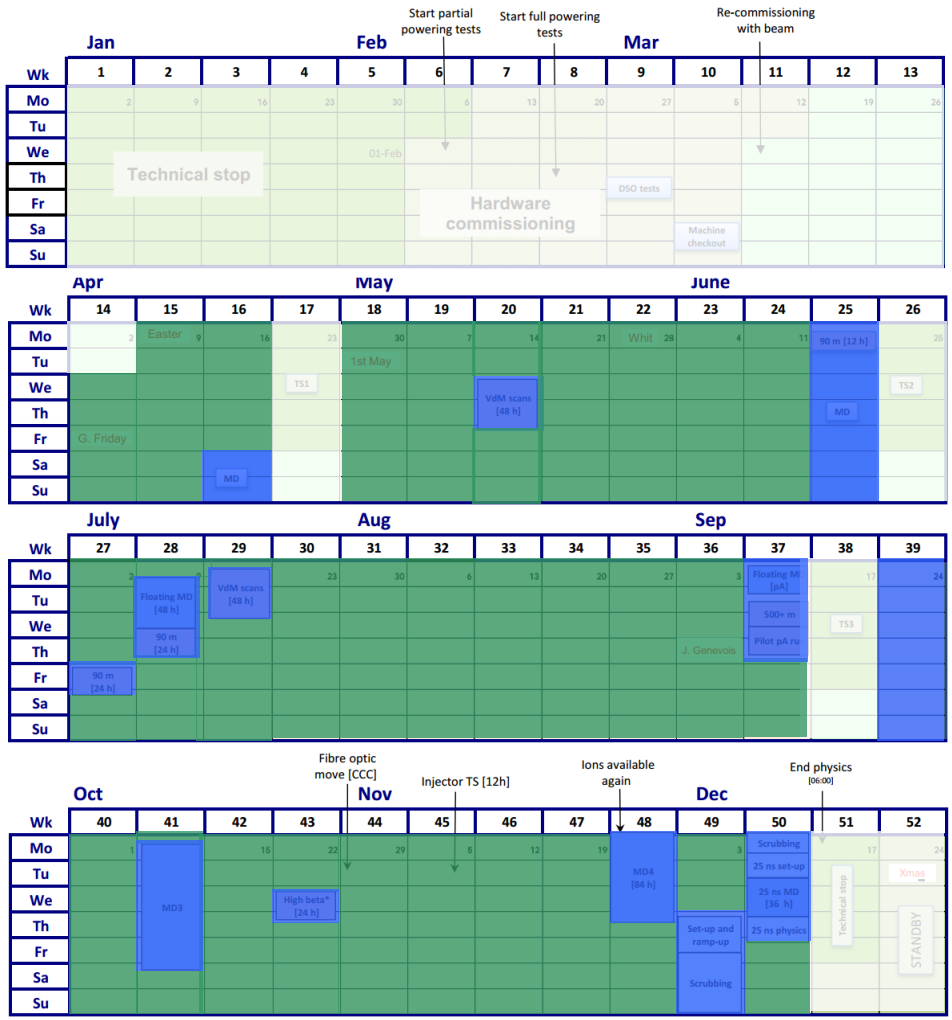
t_{rt} = 236 days

Scheduled Physics Time



Definition: annual time allocated to physics (excluding initial beam commissioning, scrubbing, TS, recovery from TS, MDs, special physics) Units: days

Scheduled Physics Time



Definition: annual time allocated to physics

Units: days

t_{spt} = 190.5 days

Physics Efficiency

Definition: $t_{inphysics}$ time with both beams present and stable beams, versus t_{spt} scheduled physics time

Units: scalar [%]

$$\frac{t_{inphysics}}{t_{spt}} = \text{Physics Efficiency}$$

73.2 days

190.5 days

Physics Efficiency = 38.4%

according to this paper

Machine Availability

"without fault preventing operation with beam"

Definition: time when machine is in a state allowing operations to take beam and run through nominal physics cycle, versus run time

Units: scalar [%]

$$\frac{t_{rt} - t_{infault}}{t_{rt}} = \text{Machine Availability}$$

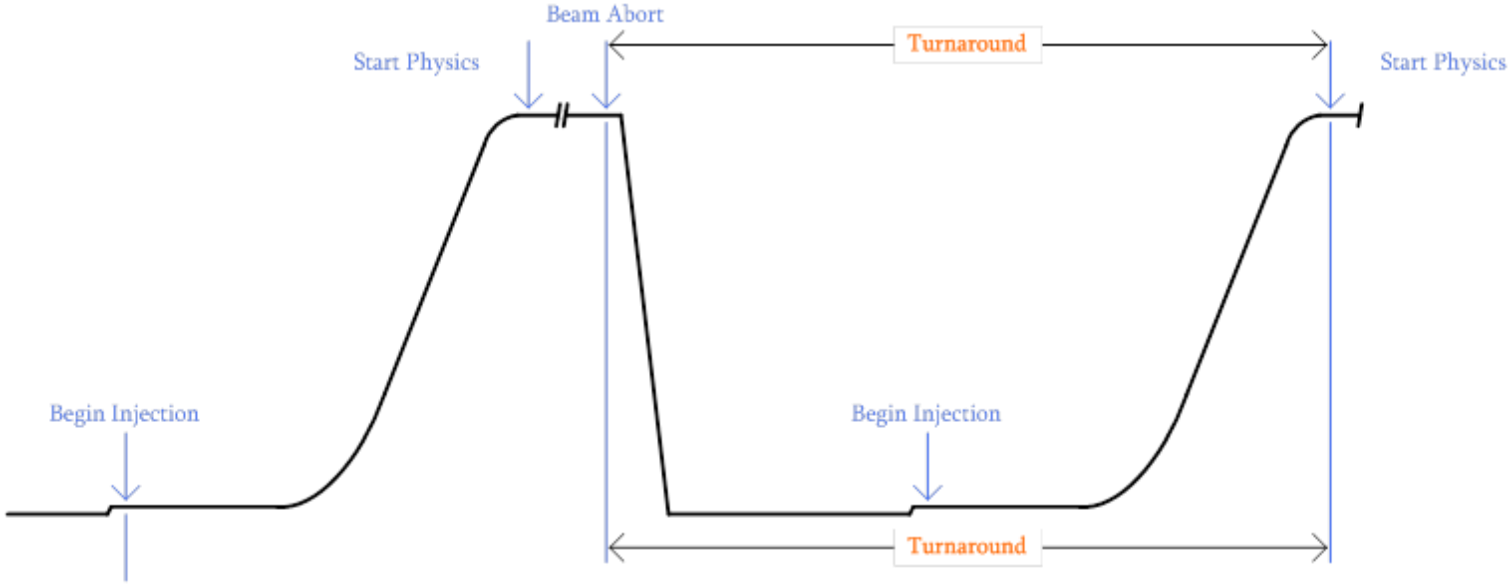
$$\frac{190.5 \text{ days} - 63.5 \text{ days}}{190.5 \text{ days}} = 66.7\%$$

according to this paper

Turnaround time

- Turnaround time [h]:

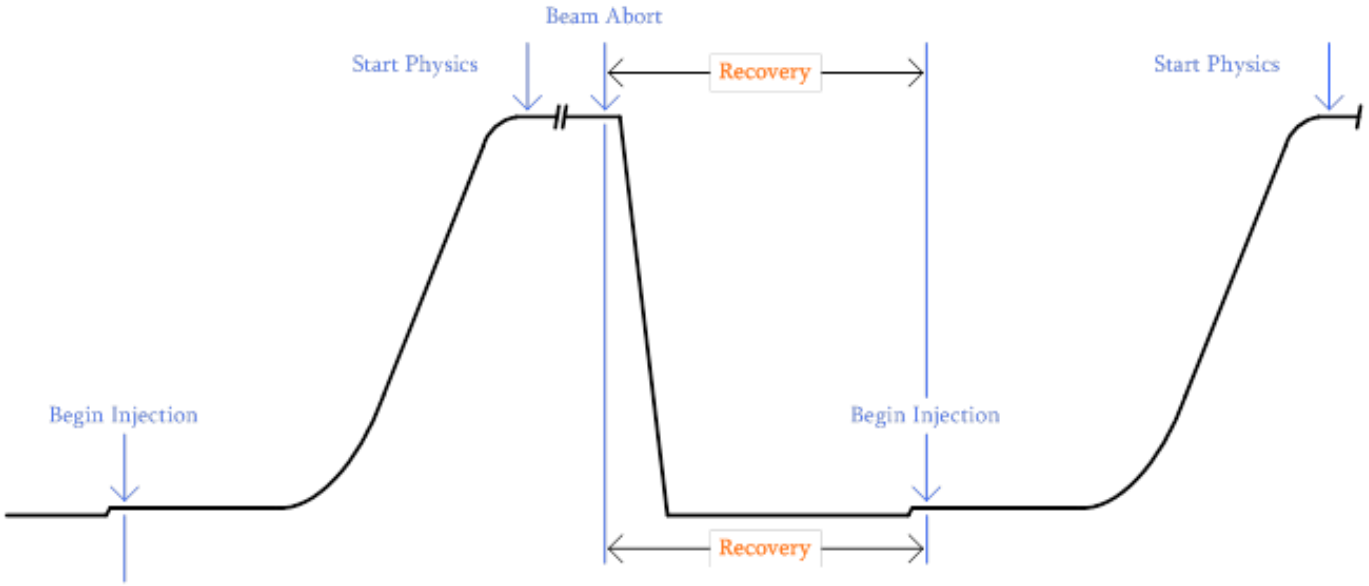
  Time between the end of one and the start of the next physics run / data taking by the experiments (delimited by the loss of beam presence/beam dump back to declaration of STABLE_BEAMS)



Recovery Time

- Recovery time [h]:

  Time between the end of one and the readiness for injection of new particles of the next (delimited by the loss of beam presence/beam dump and resuming of the normal operational cycle)



Fin

Additional definitions - 4/7

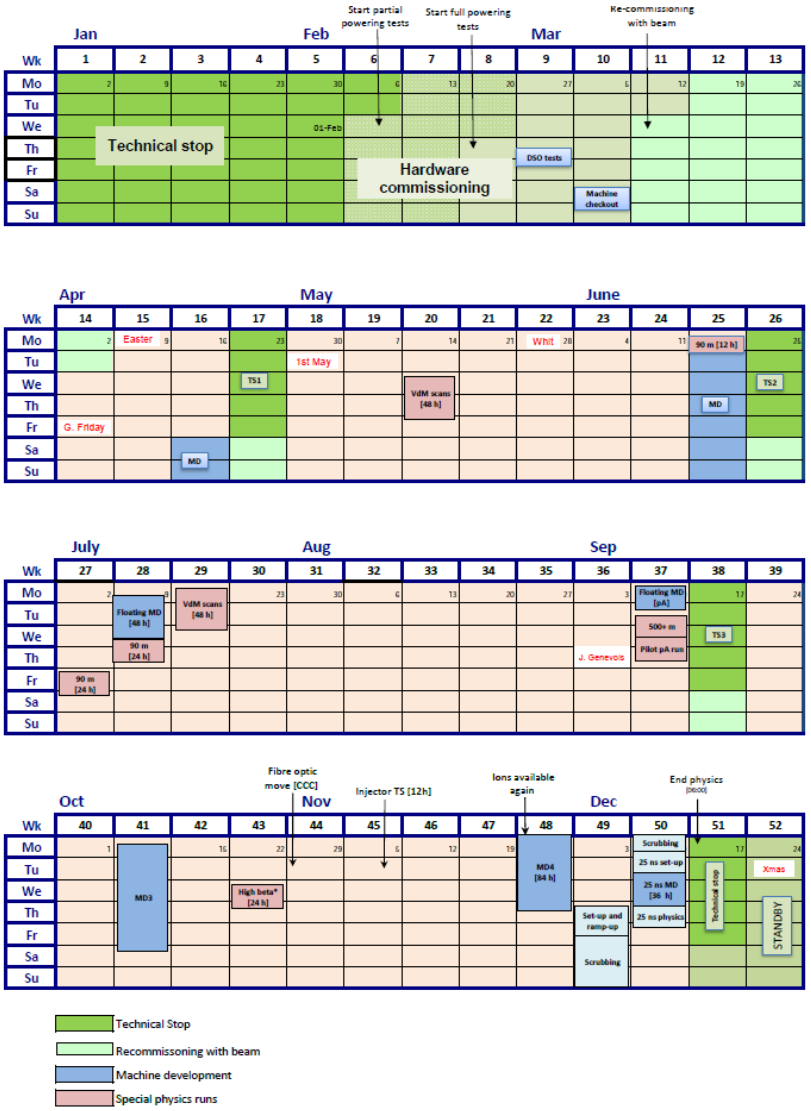
- Run Time [days]:

  Calendar time allocated to running of the LHC with beam, excluding technical stops (TS)

- Scheduled Physics Time [days]:

  Calendar time allocated to production of physics (excluding commissioning, TS, MDs, special runs)

  = Run Time – MDs – special runs



Additional definitions - 5/7

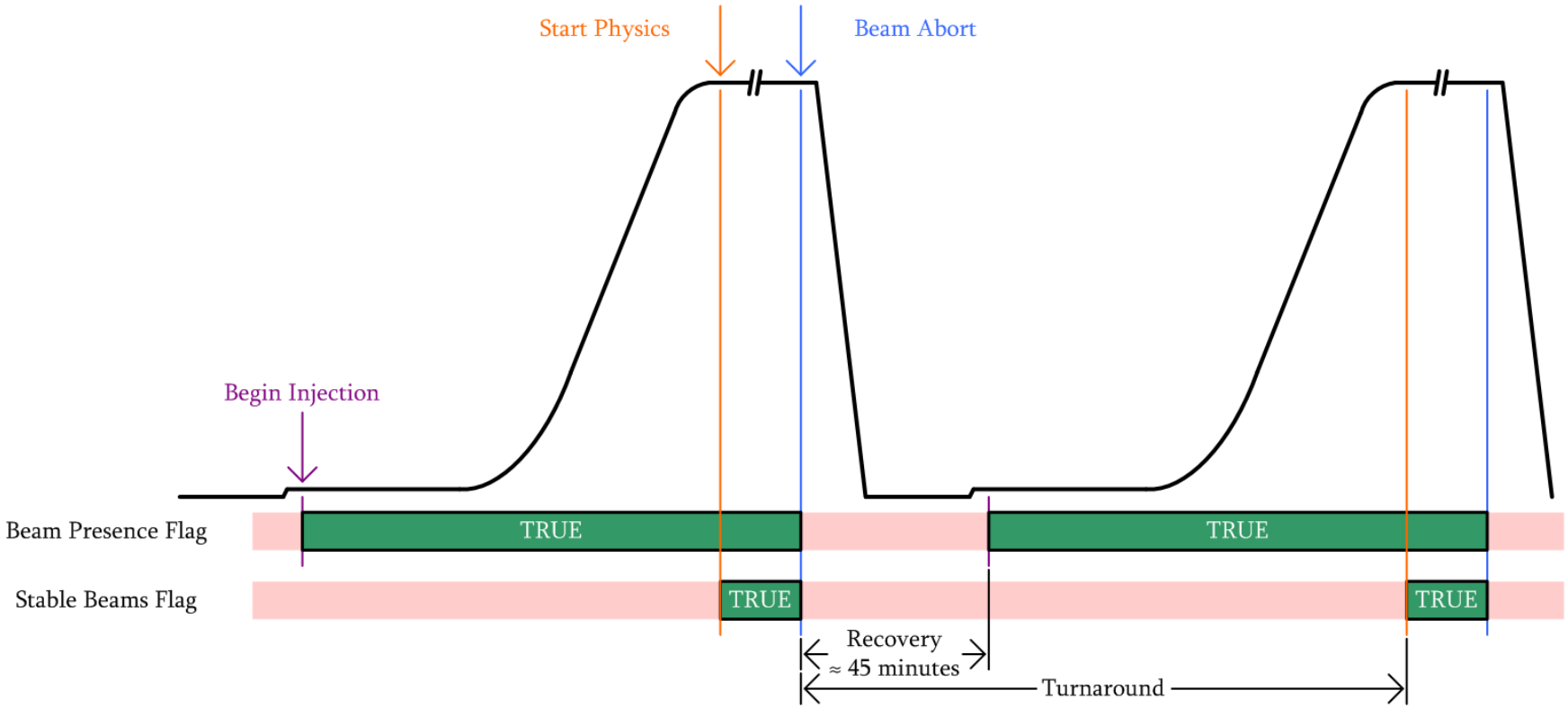
- Physics efficieny [%]:

  Fraction of calendar time in STABLE_BEAMS divided by the scheduled Physics time

- Machine availability [%]:

  Fraction of calendar time in which the machine is ready to accept and accelerate particles

- Note: Meaningful definitons of Machine efficiency and machine downtime require inclusion of beam parameters/operational envelope, respectively an appropriate tracing mechanism of blocking failures for operation [AWG work in progress for (LHC) fault tracker] -> Postponed as not needed for high level statistics

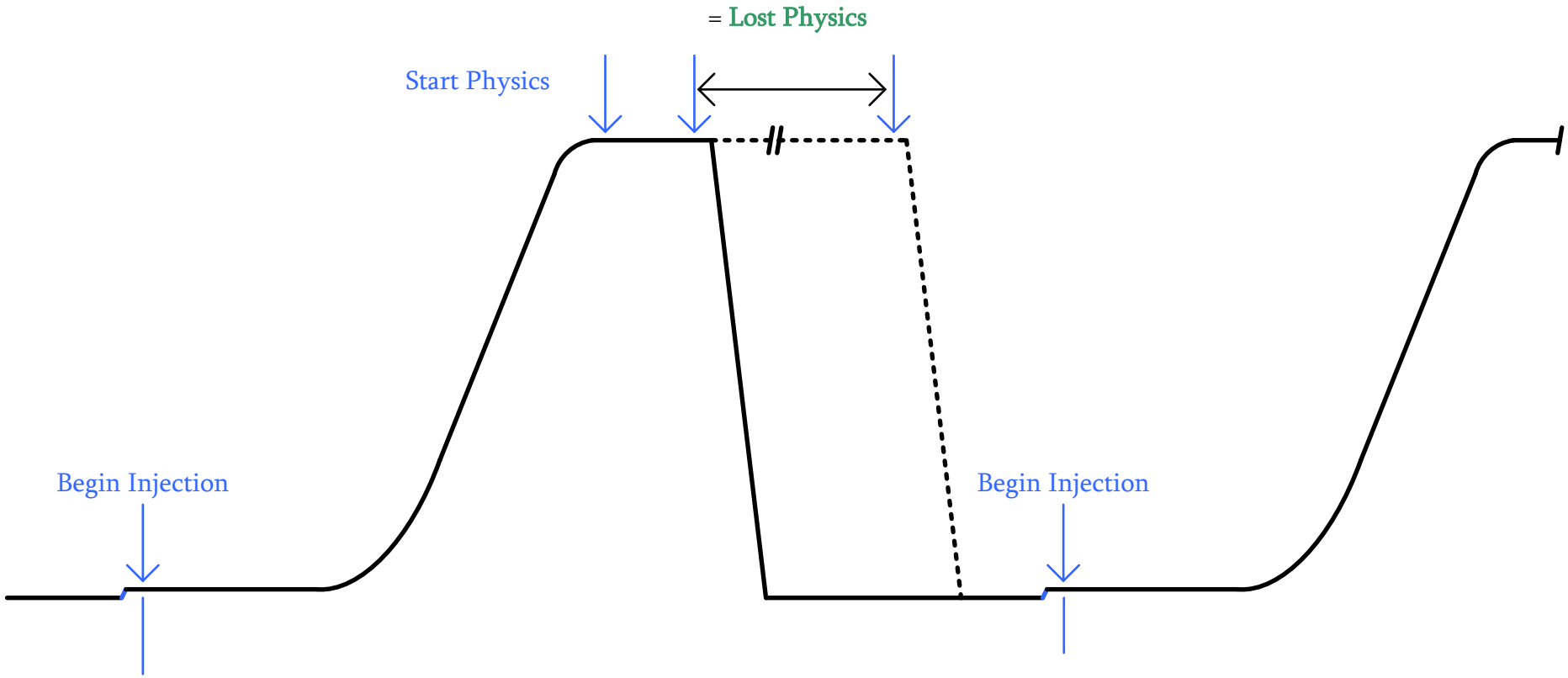

Start Physics
Beam Abort
Begin Injection
Beam Presence Flag
TRUE
TRUE
Stable Beams Flag
TRUE
TRUE
Recovery
≈ 45 minutes
Turnaround

Lost Physics

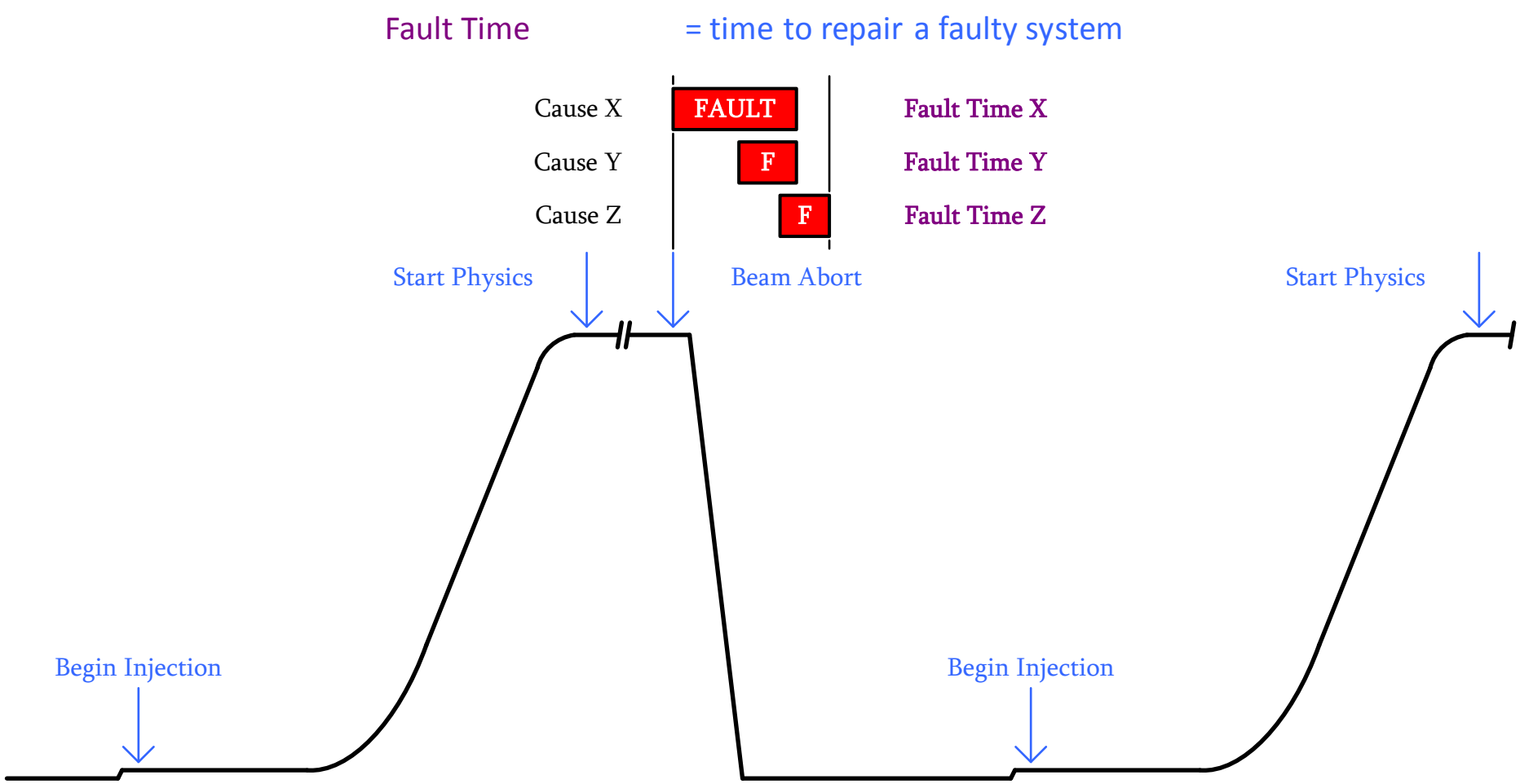
Lost Physics = stable beams cut short by faults

Average time in physics when reaching End of Fill = 9 hours … good turnaround = 3 hours

if fill did not have 9 hours stable beams : dump cause is assigned up to 3 hours lost physics



Fault Time


Fault Time
= time to repair a faulty system
Cause X
FAULT
Fault Time X
Cause Y
F
Fault Time Y
Cause Z
F
Fault Time Z
Start Physics
Beam Abort
Start Physics
Begin Injection
Begin Injection

Using consistent definitions – an example