The GUINEVERE-project at VENUS

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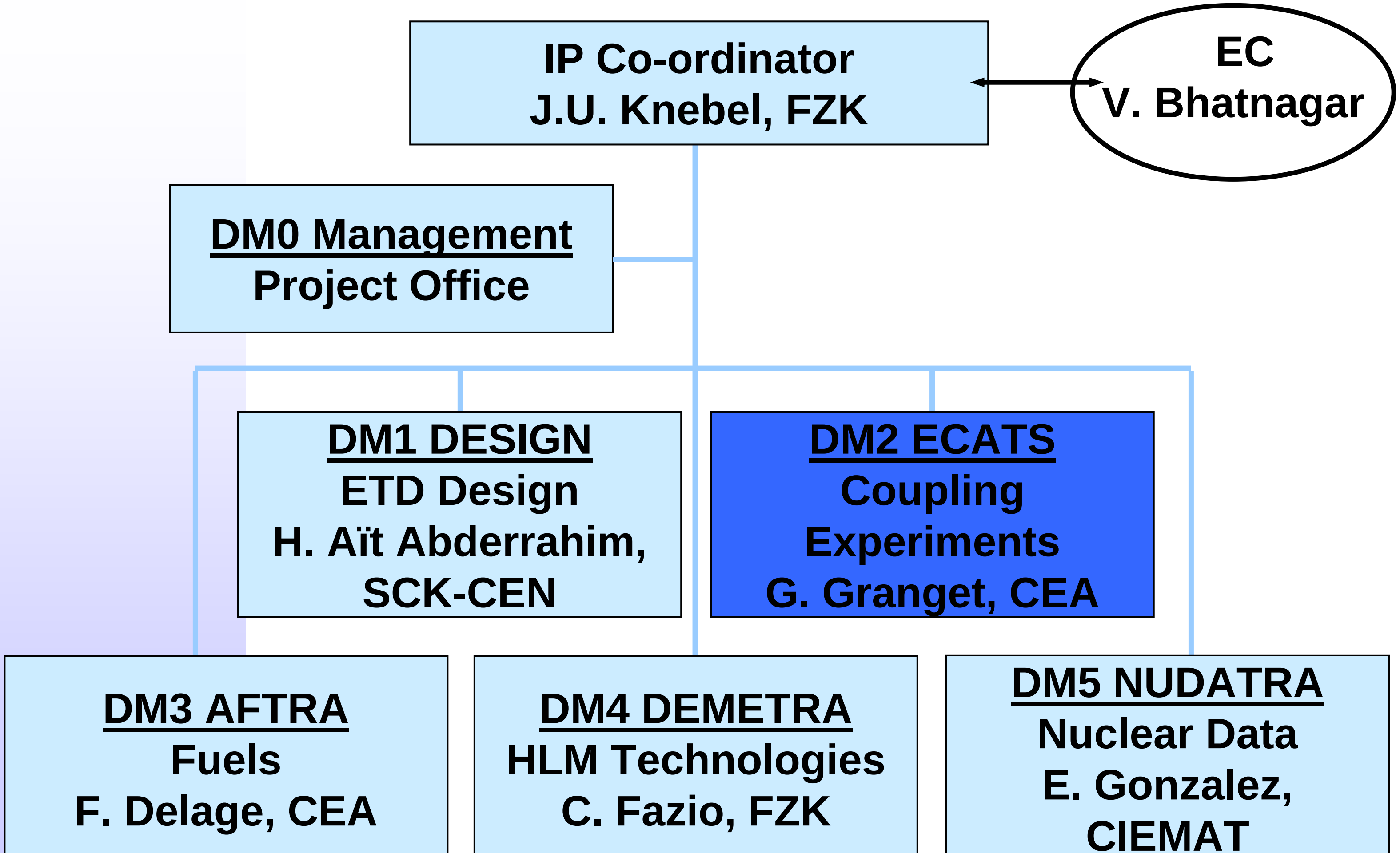
On behalf of the ECATS community

Structure of IP-EUROTRANS



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Objectives of DM2 ECATS

- Qualification of sub-criticality monitoring,
- Validation of the core power / beam current relationship,
- Start-up and shut-down procedures, instrumentation validation and specific dedicated experimentation,
- Interpretation and validation of experimental data, benchmarking and code validation activities etc.,
- Safety and licensing issues of different component parts as well as that of the integrated system as a whole.
- *Validation of generic dynamic behaviour of an ADS in a wide range of sub-critical levels, sub-criticality safety margins and thermal feedback effects,*

➡ Extend and complete the MUSE-experiments (CEA, Cadarache)

(pulsed GENEPI at sodium fast reactor MASURCA)

GUINEVERE Objective

- Perform a (low-power) coupling experiment:
  - With a continuous beam
    - Beam interruptions
    - Pulsed experiments
  - Implement all together the individual techniques tested in MUSE => sub-criticality monitoring
  - With a fast subcritical lead multiplying system
    - Reference to a critical state
- Use of the VENUS installation and coupling to GENEPI

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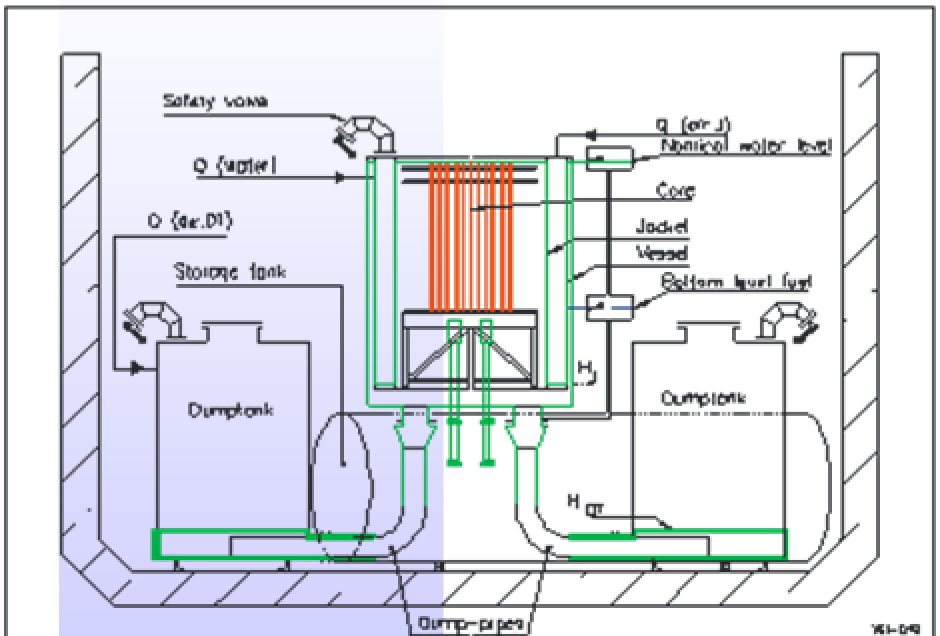
Modifications: VENUS Today

VENUS is a very flexible water moderated zero power facility used for accurate measurement in view of code validation



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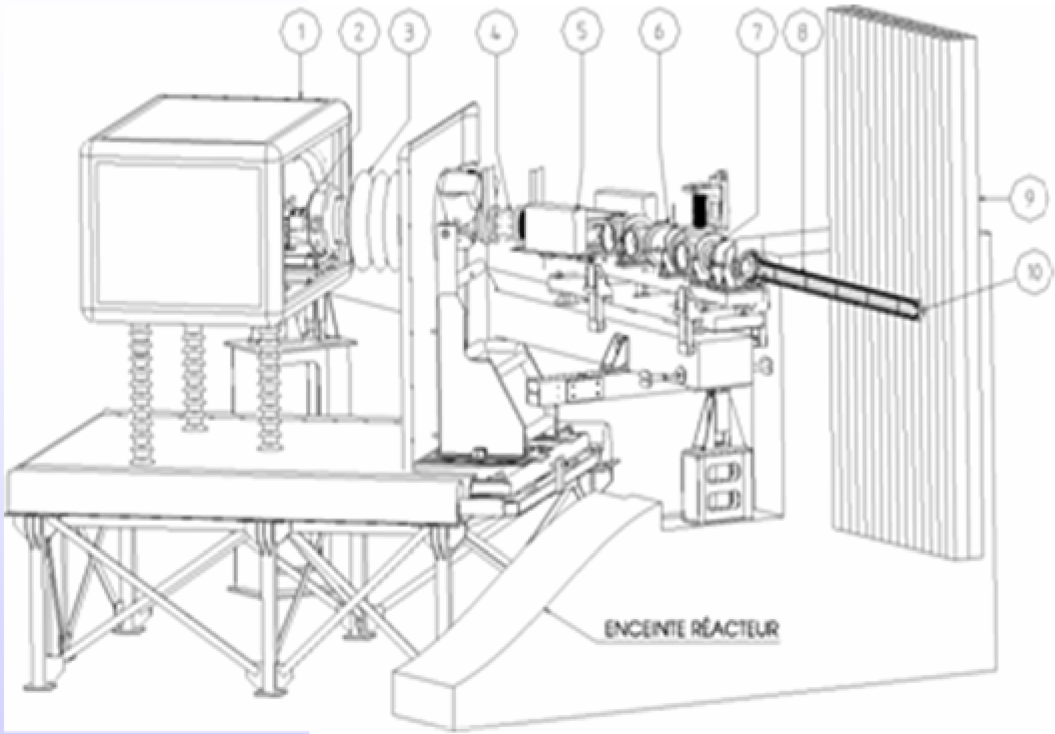
VENUS Needed Modifications

- Coupling of the GENEPI accelerator to the subcritical reactor VENUS will imply the adaptation of the current infrastructure to host GENEPI
  - A coupling with a 14 MeV neutron generator has already been performed at VENUS in the 60's
- To modify the water-moderated reactor in a solid lead reactor, the following main items were identified:
  - A similar shut-down system, as in the first years of the VENUS facility (VULCAIN-project), based on shut-down rods, will have to be installed.
  - Construction of fuel assemblies (lead + fuel rodlets) for the core and lead for the reflector --> 30 t lead
  - Possible support structure to reinforce the structures to carry the lead
  - The scram logic remains almost the same, only the shut-down action changes from fast water dump to safety rod drop

GENEPI accelerator of CNRS

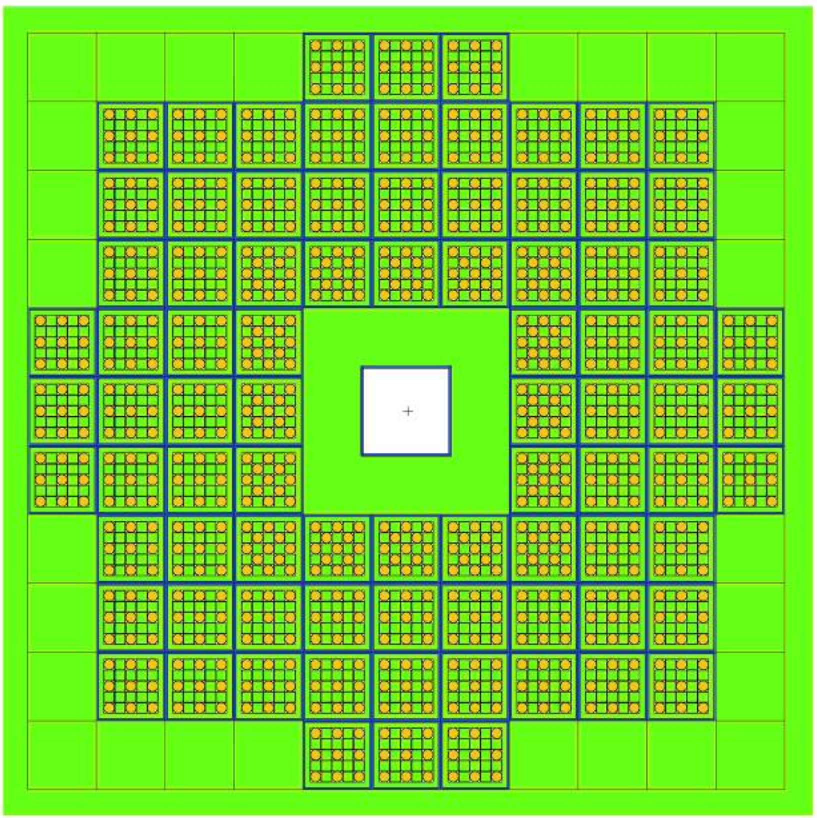


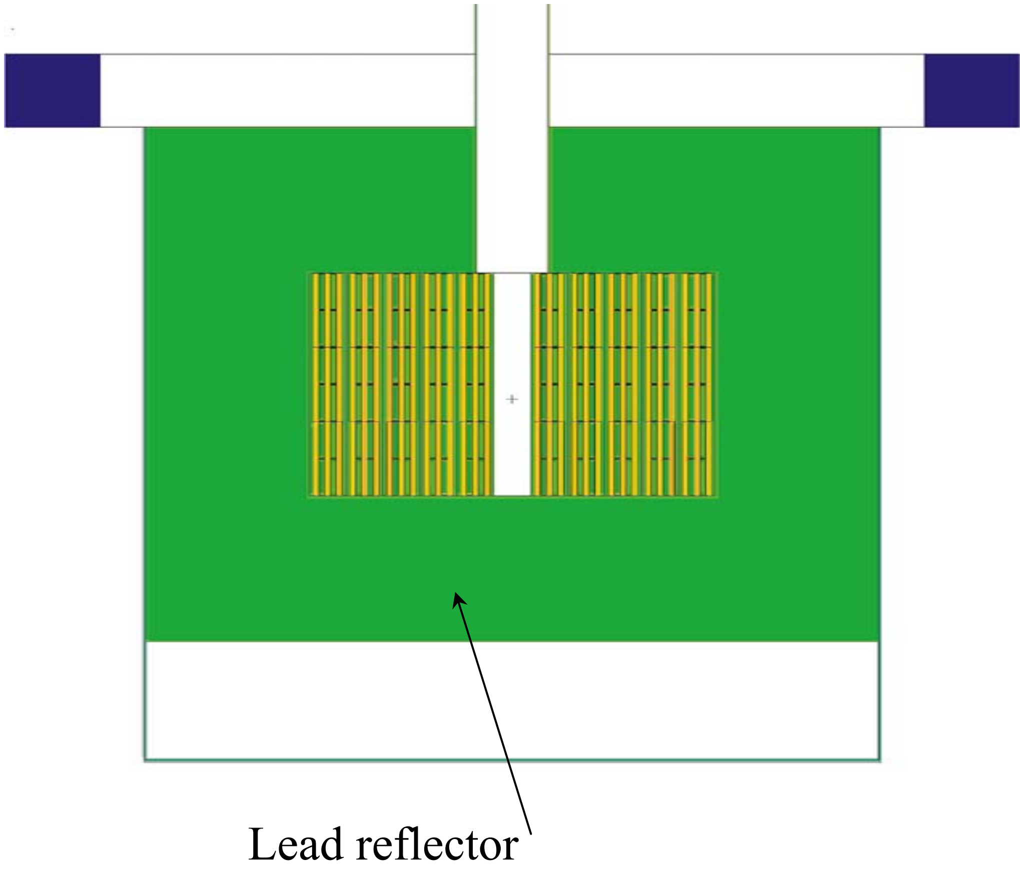
1) High Voltage Head,
2) duoplasmatron,
3) accelerator tube,
4) quad Q1,
5) magnet,
6) quad Q2,
7) quad Q3,
8) quad Q4 + T2 part,
9) MASURCA tube,
10) target

GENEPI needed modifications to existing GENEPI 1-2

- The duoplasmatron source used at the present time is designed for a pulsed use and has to be changed to work in continuous mode.
- Beam interruption operation will have to implemented by driving the source itself
- The focusing structure has to be redesigned for the whole intensity range required now (intense for pulsed mode and less intense in continuous mode).
- The pulsed source (or a continuous of 160 μA) gives a maximum power on the target to be evacuated around 40 W. The cooling is ensured by a compressed air flow. At max 1 mA beam, the power to be evacuated is 250 W. The performances of the cooling system have then to be improved (without oil or water), which does not seem to be a major problem.
- The monitoring and control system of GENEPI 1-2 is performed by a PC computer and electronics which are based on out of date items (dates from 1998). A completely new system based on modern components and techniques has to be studied.

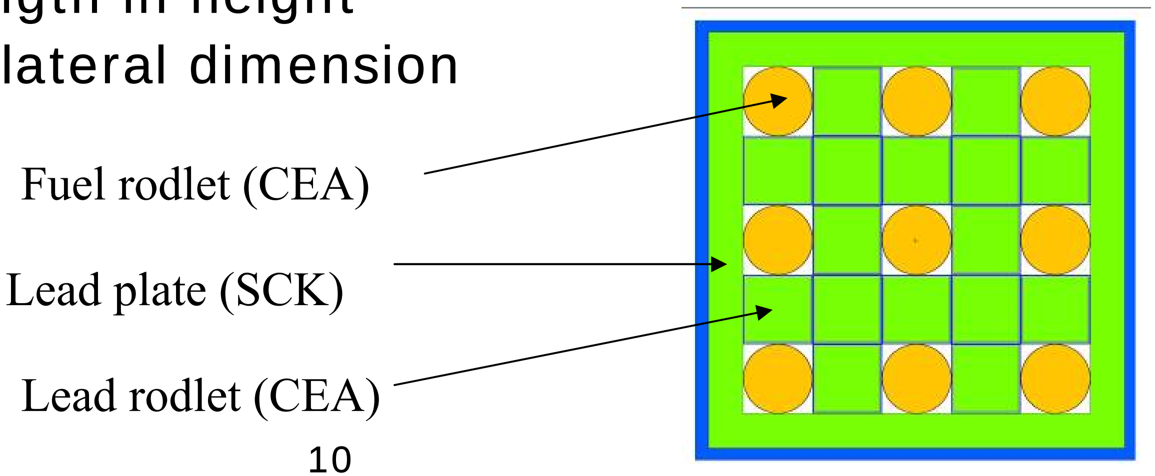
"GUINEVERE" critical configuration





Fuel (assembly) characteristics

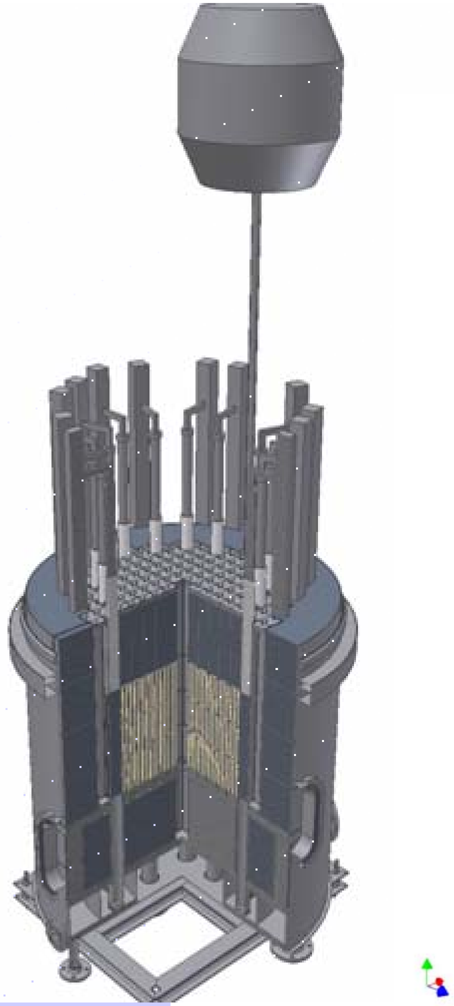
- Fuel rodlets provided by CEA
  - U-metal
  - Enrichment 30 %
  - Diameter= 1,27 cm
  - Length= 20 cm
- Lead rodlets from CEA or lead blocks
- Fuel assembly
  - 60 cm active length in height
  - About 10 cm in lateral dimension

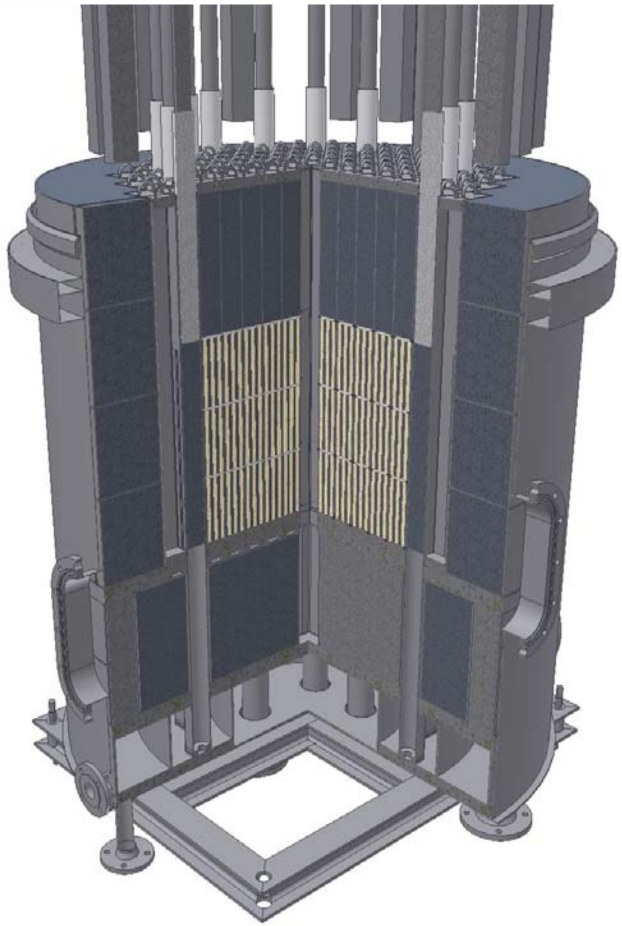


"GUINEVERE" critical configuration

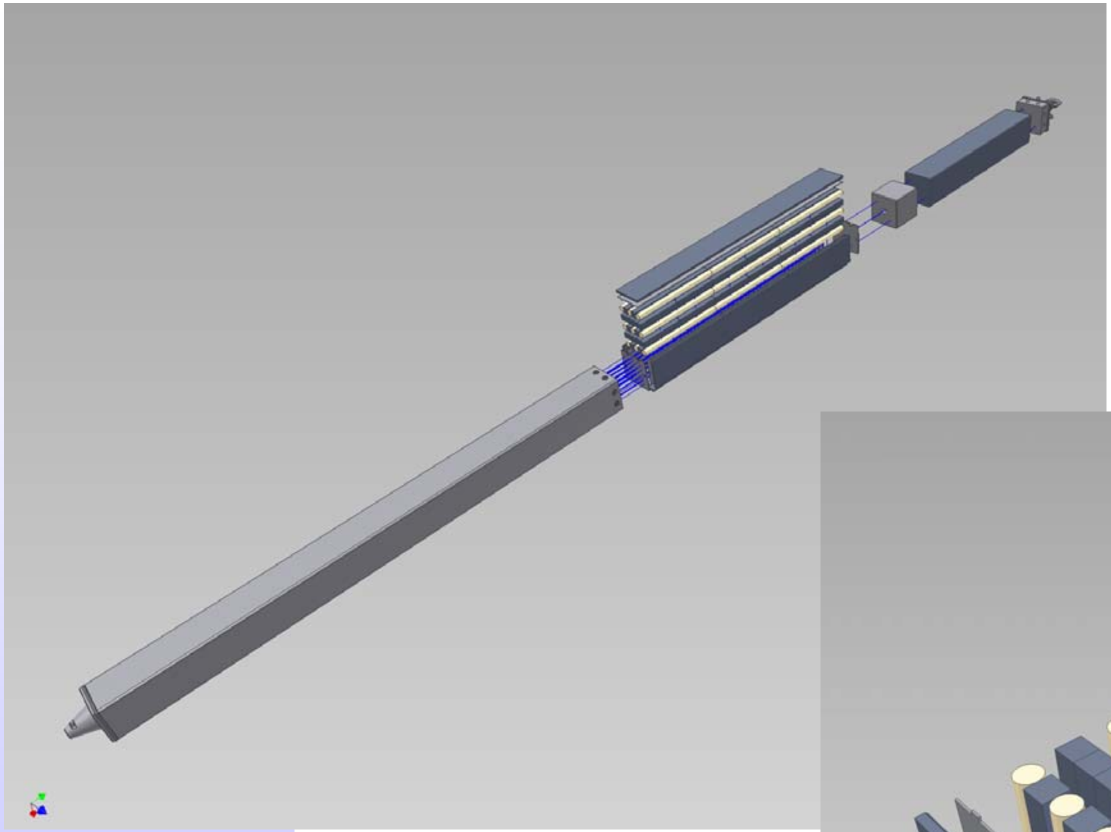
- Basic critical configuration
  - Two fuel loading assembly types (9/25 & 13/25)
  - With fuel rods of 1.27 cm diameter, 60 cm, 30% U-metal
  - Equivalent diameter of core 100 cm
  - Radial lead reflector of about 30 cm, top lead reflector of 40 cm and a bottom lead reflector of 40 cm
  - configuration contains 2460 rods
  - k_{eff} = 1,0071± 0.0005
  - Total mass is about 1200 kg (360 kg U-235)

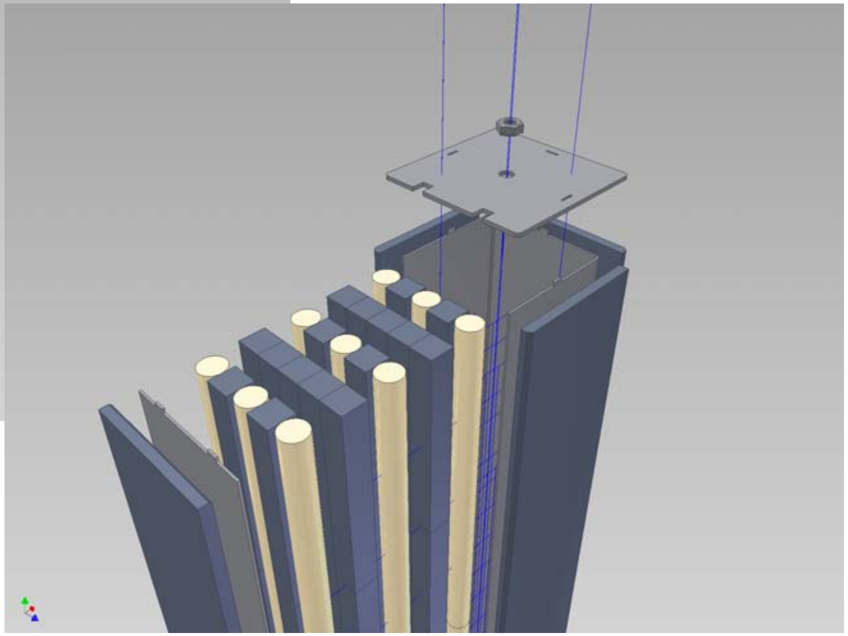
Core Lay-out





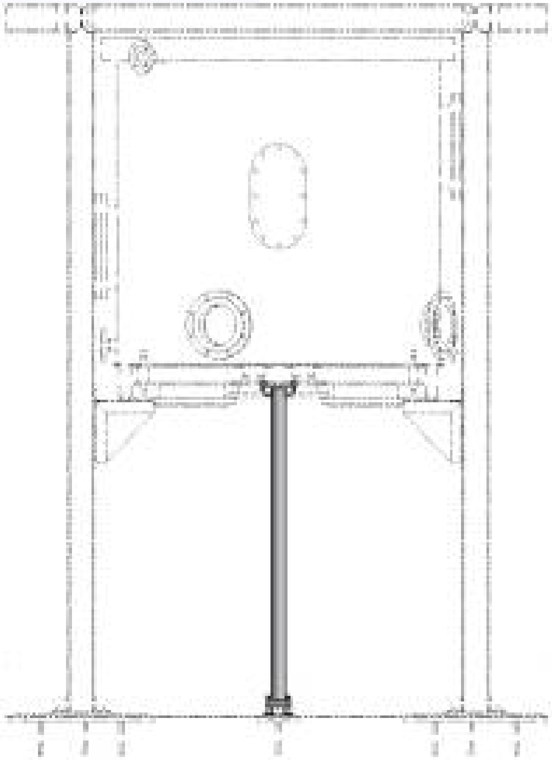
Fuel Assembly Design

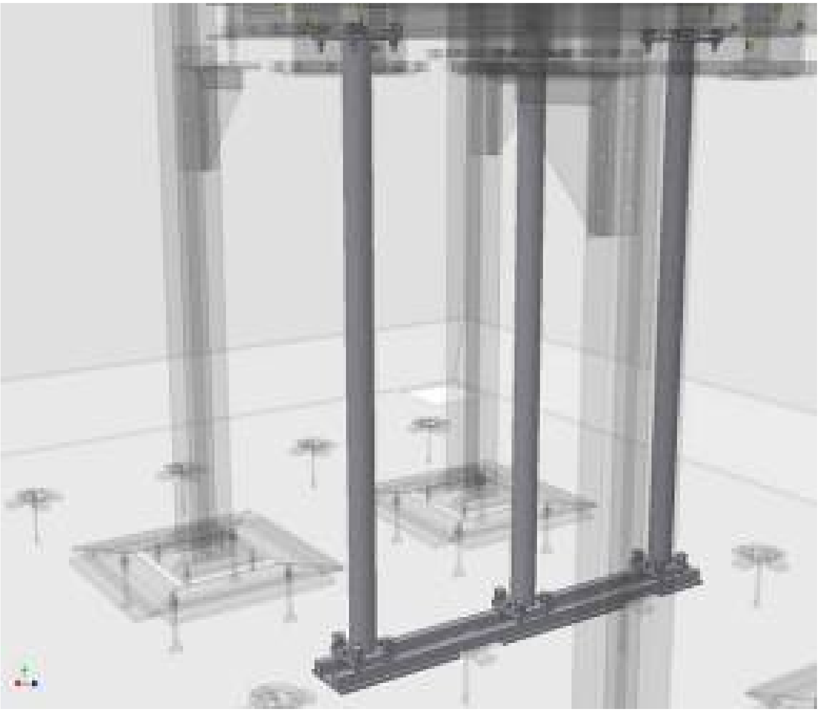




Additional supporting structure to carry the lead in the vessel

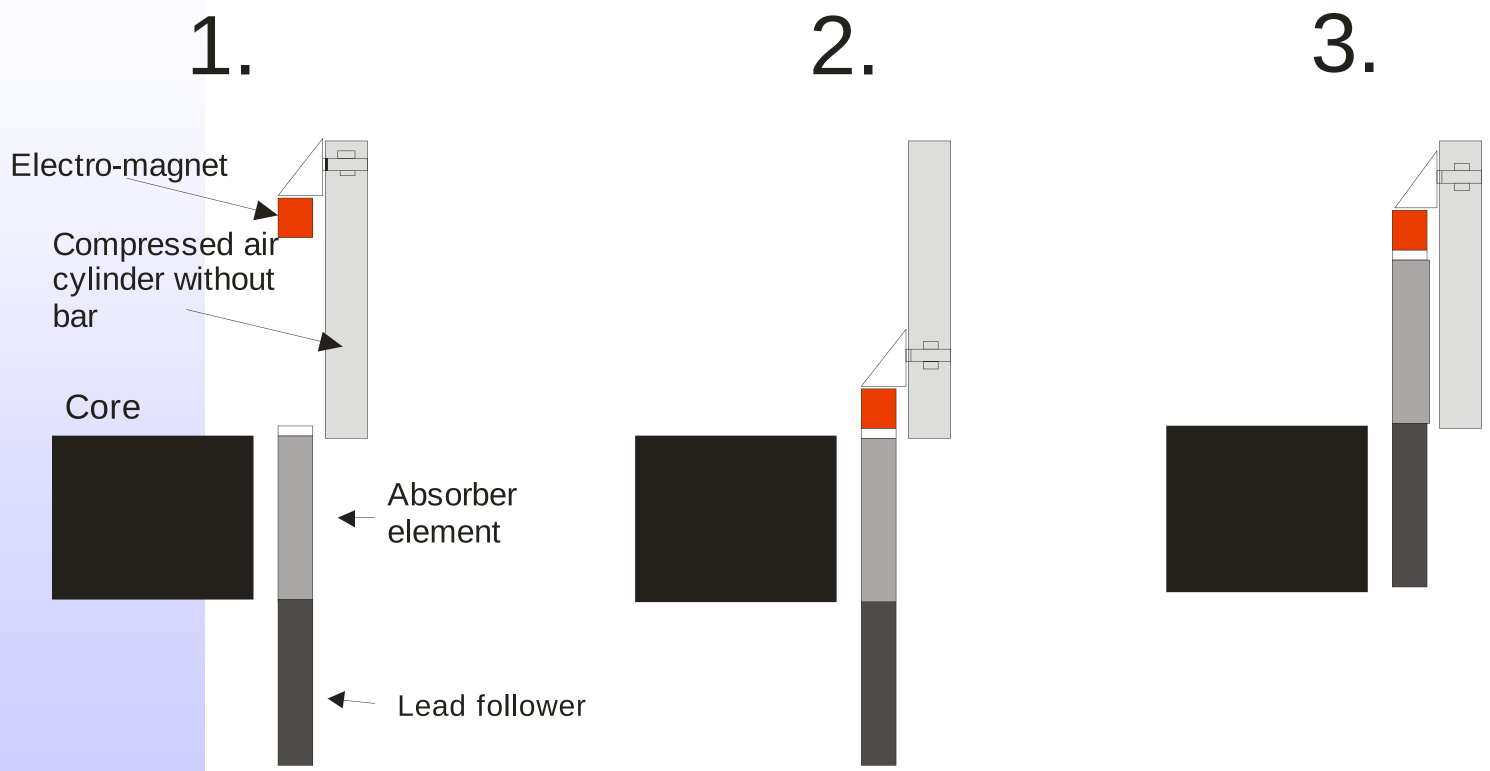
- Calculations have demonstrated that the additional supporting structure is sufficient





Shut-down system based on safety rods

- 8 absorber rods symmetrically placed at the interface core-reflector



SCK•CEN

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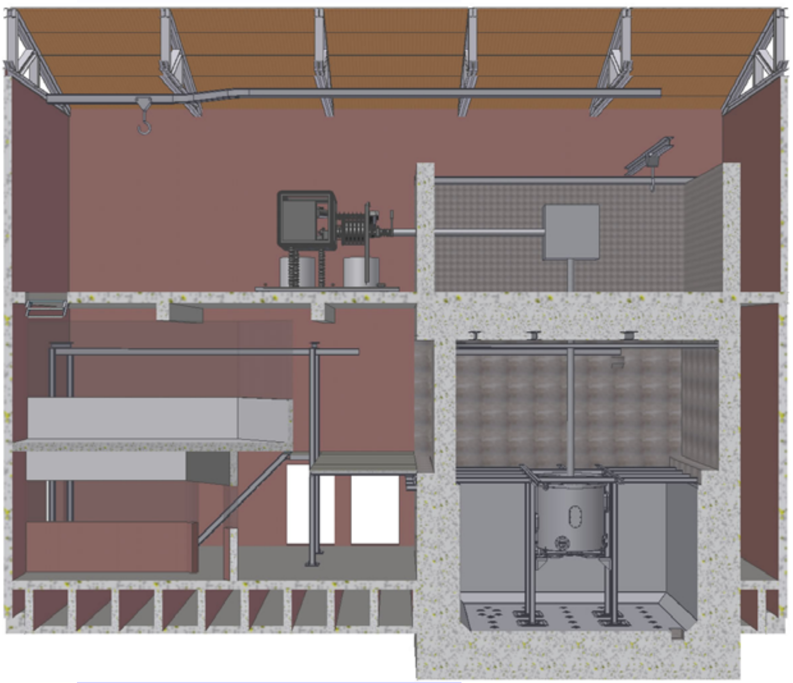
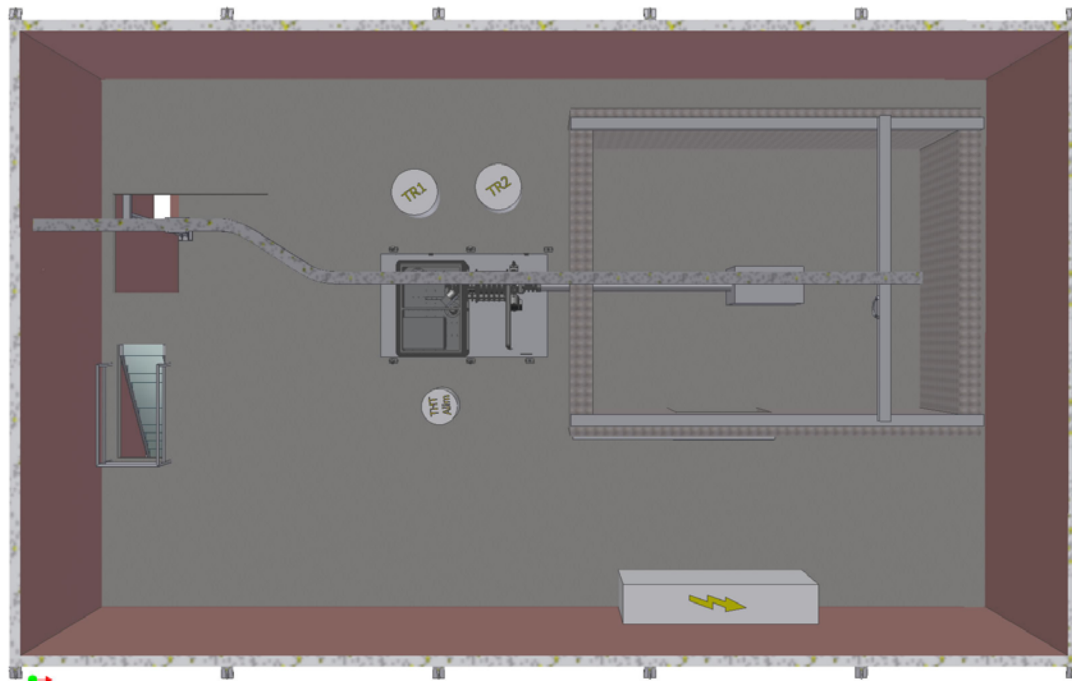
Coupling of accelerator to VENUS (1)





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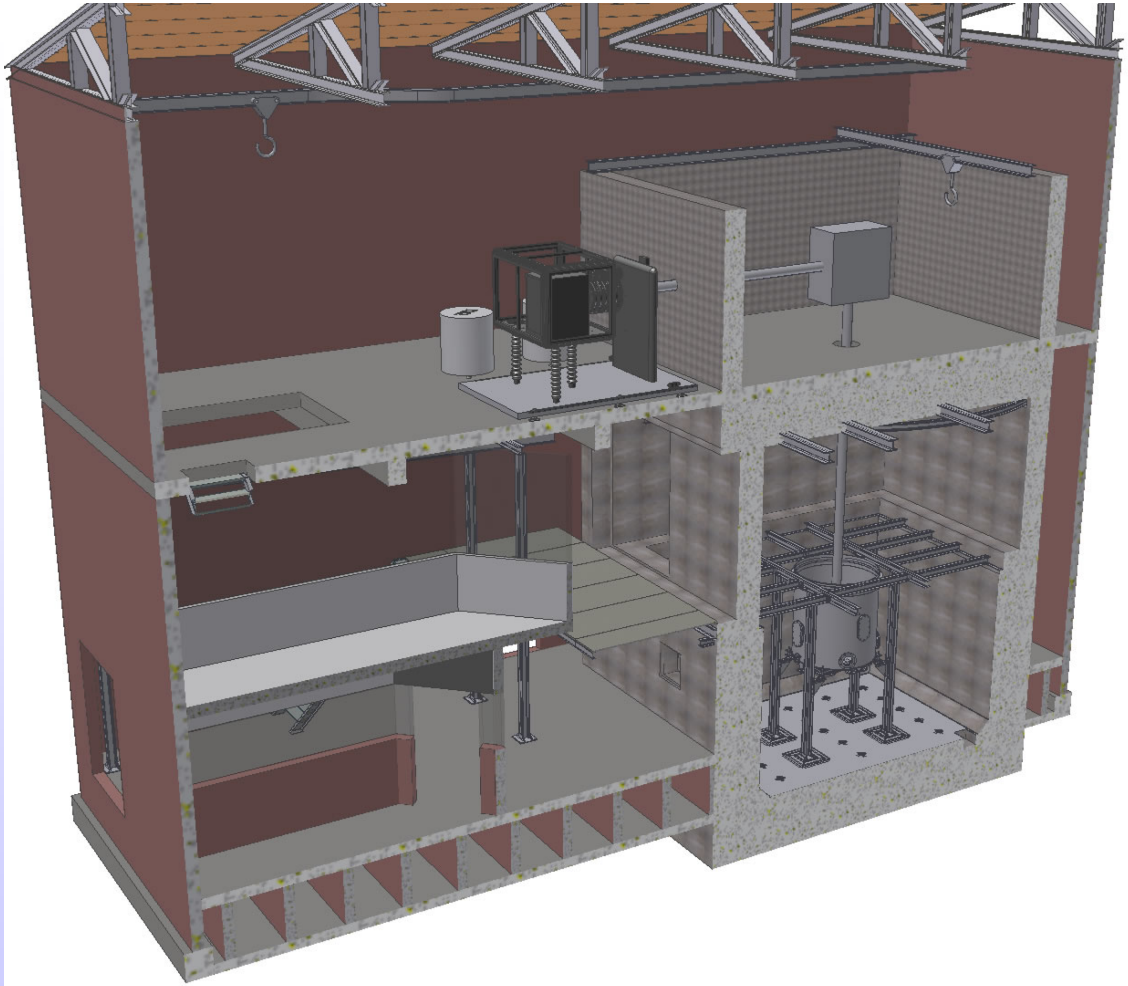
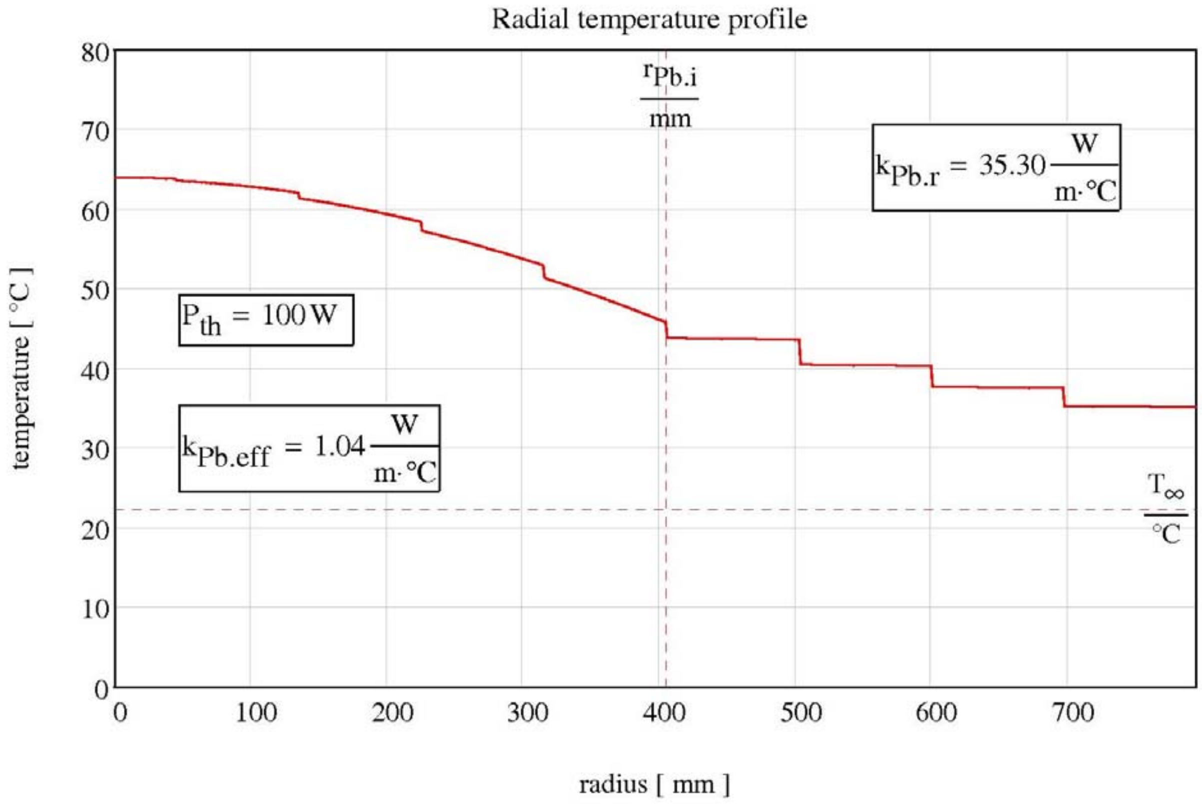
Coupling of accelerator to VENUS (2)



Natural air cooling

- Calculations with pessimistic equivalent heat conductivity for the fuel assembly



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Main keydates in the planning

- Stop of VENUS reactor: 1-4-2007
- Design of fuel assembly: 1-4-2007
- Removal of internal parts of VENUS: 1-7-2007
- Design of core: 1-7-2007
- Transport of fuel from CEA to SCK-CEN: 1-1-2008
- Fuel assembly construction: 1-7-2008
- Accelerator room construction: 1-1-2008→1-7-2008
- Installation new components in VENUS: 1-12-2008
- Commissioning installation: 1-1-2009→1-7-2009
- Transfer of GENEPI from CNRS to SCK-CEN: 1-5-2009
- Start of experiments: 1-9-2009

Objective of the experimental programme

- Characterisation of the reference core SC0
  - Reference to the critical state
- Reactivity measurements in subcritical cores
  - SC1 (0.97), SC2 (0.95), SC3 (0.985)
  - Current-to-flux measurements
    - Static measurements
    - Kinetic measurements

$$S = source\ neutrons / s = \frac{I}{e} N_{neutrons/ion}$$

$$-\rho = c\varphi * \frac{S}{R}$$

$$R = \varepsilon \Sigma_d \Phi_d V_d$$

  - Interim cross-checking techniques at beam interruptions
  - Reactivity calibration techniques
    - Mainly Pulsed Neutron Source techniques

Interim cross checking techniques at beam interruptions

- This part of the programme requires to pilot the source in a continuous mode with short and prompt beam interruptions repeated several times
- *2 techniques are planned to be applied at beam trips (separately):*
  - prompt decay fitting techniques
    - fitting of the prompt population decay (expo) or its decrease rate (kp) after the source interruption
    - Highly depends on the spectrum conditions of the core → fast core is needed

$$\tau = \frac{l}{\beta + \rho}$$

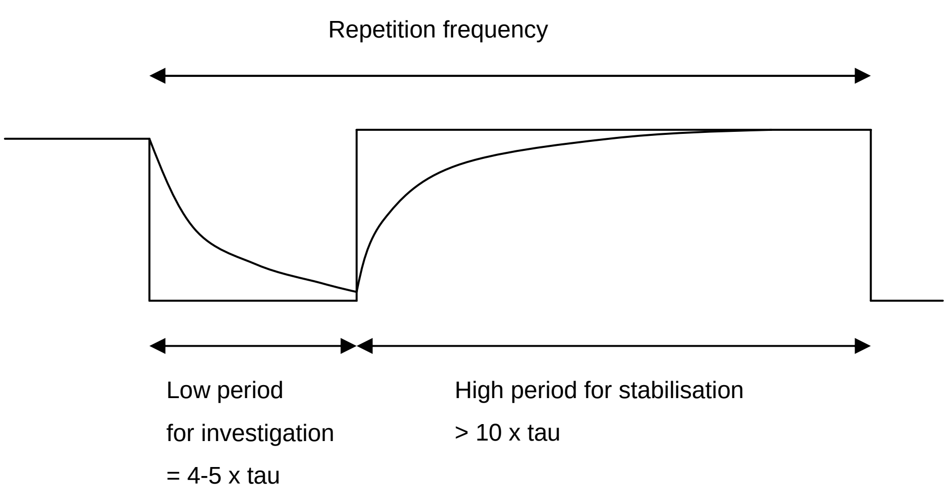
For l=1 μs (MYRRHA),

β = 300 pcm

ρ = 5000 pcm

we obtain: τ= 20 μs

Fitting techniques at beam trips

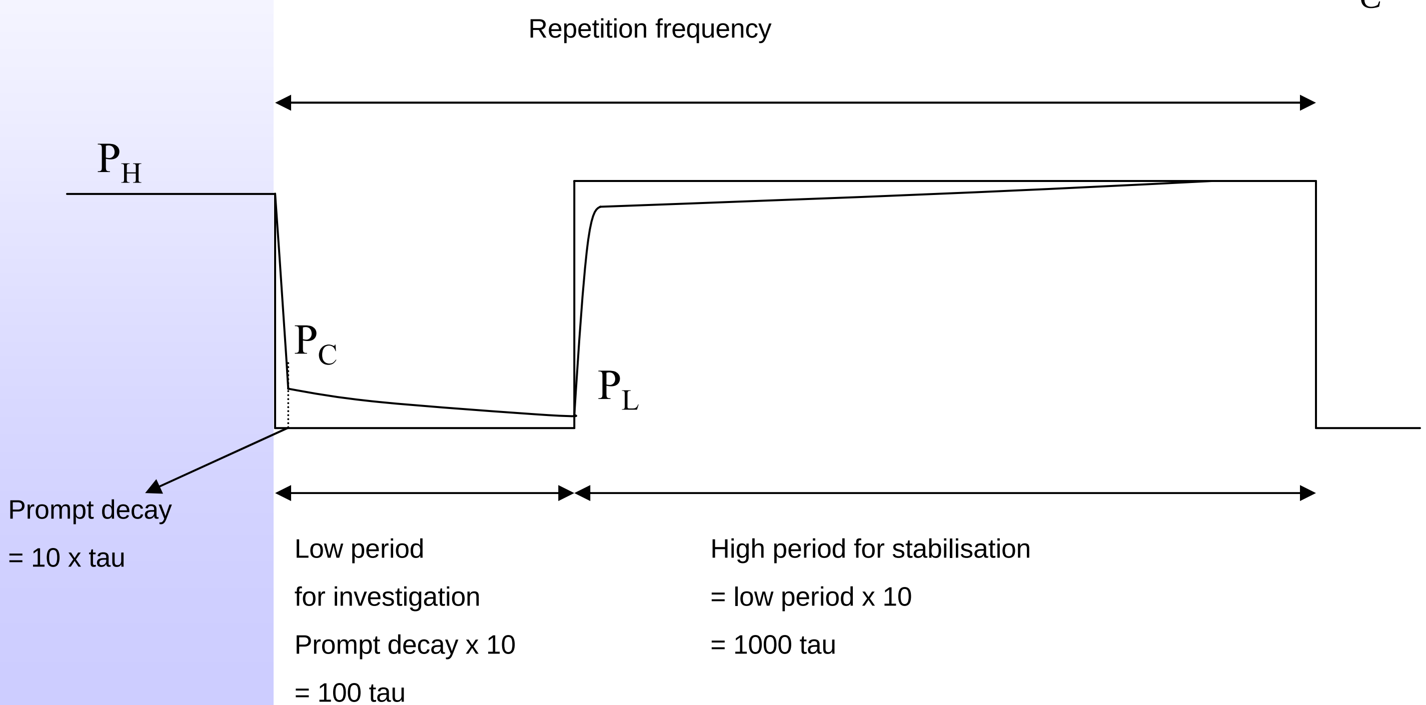


Interim cross-checking techniques at beam interruptions

- Prompt Jump Techniques
  - Reactivity determination based on the measurement of P_H, P_C and P_L

Prompt jump technique at beam trips

$$-\rho(\$) = \frac{P_H - P_C}{P_C - P_L}$$



Conclusions

The GUINEVERE-project will provide a unique experiment with a continuous beam coupled to a fast (sub)critical assembly allowing full investigation of the methodology of reactivity monitoring for XT-ADS and EFIT.