Report
of the Working Subgroup
for the Strategic Long-range Plan of JINR

A. Ioffe, V. Aksenov
(co-chairmen of the WSG)

Working subgroup (since June 2018)

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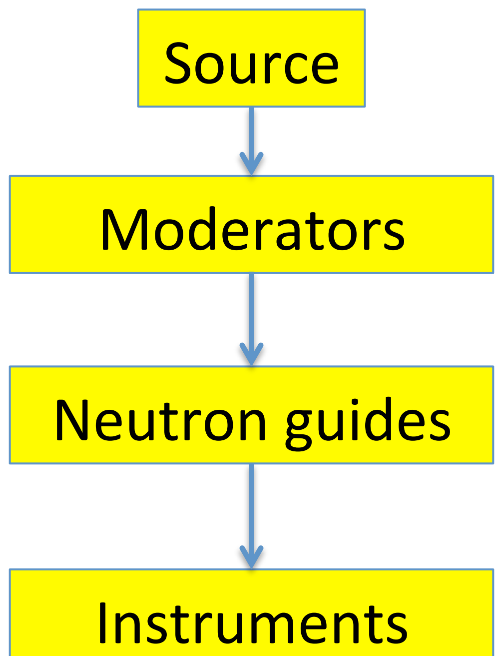
I.T. Tretyakov (Russia) – N.A. Dollezhal Research and Development Institute of Power Engineering (NIKIET), Moscow

Activities:

- Meeting on June 15, 2018
- Int. Workshop “Advanced ideas and experiments for DNS-IV” (December 6 – 7, 2018, Dubna)
- Meeting on January 23, 2019

Directions of work:

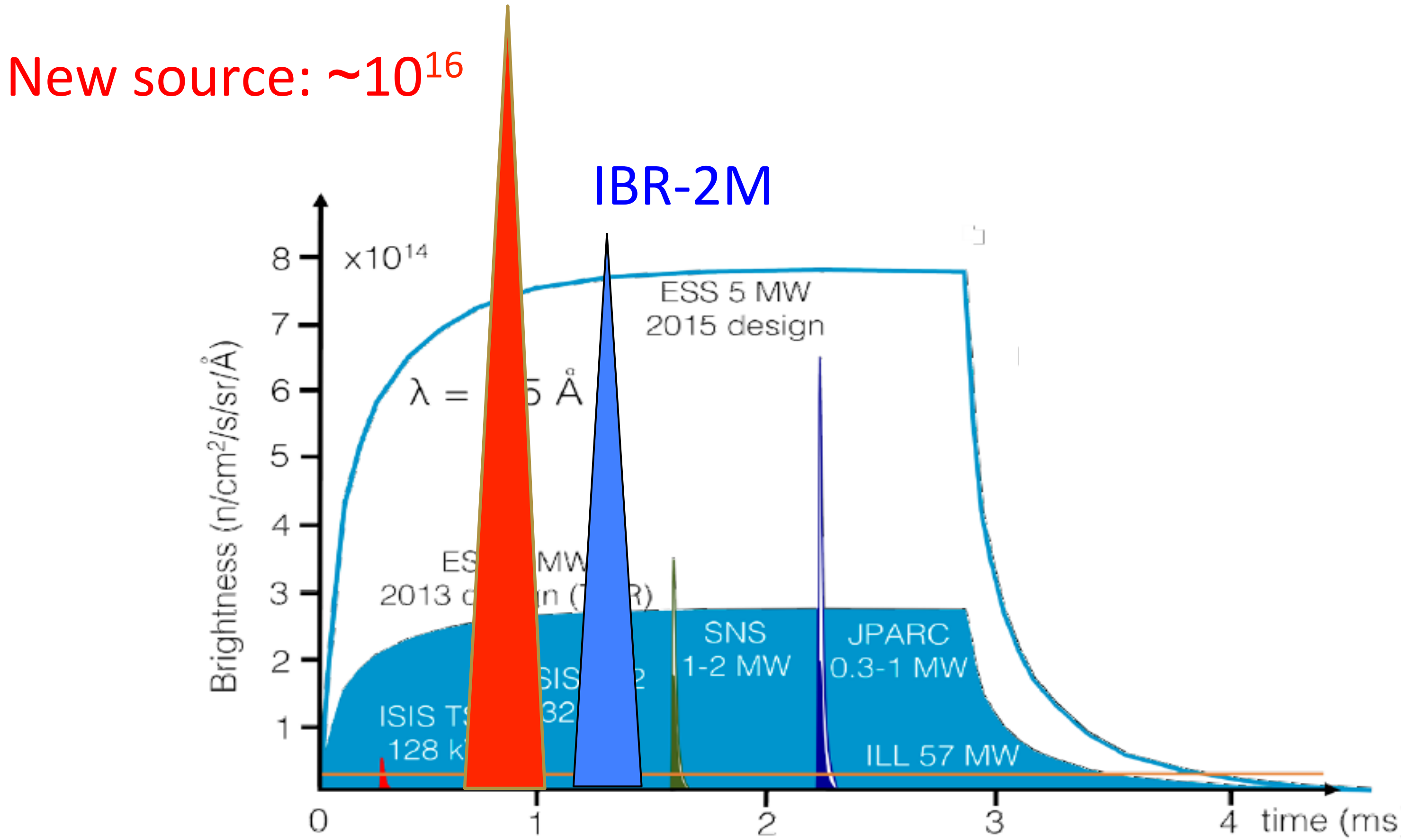


Requirements to the source:

<u>Assumption:</u> maximal allowable thermal power (10-15) MW.

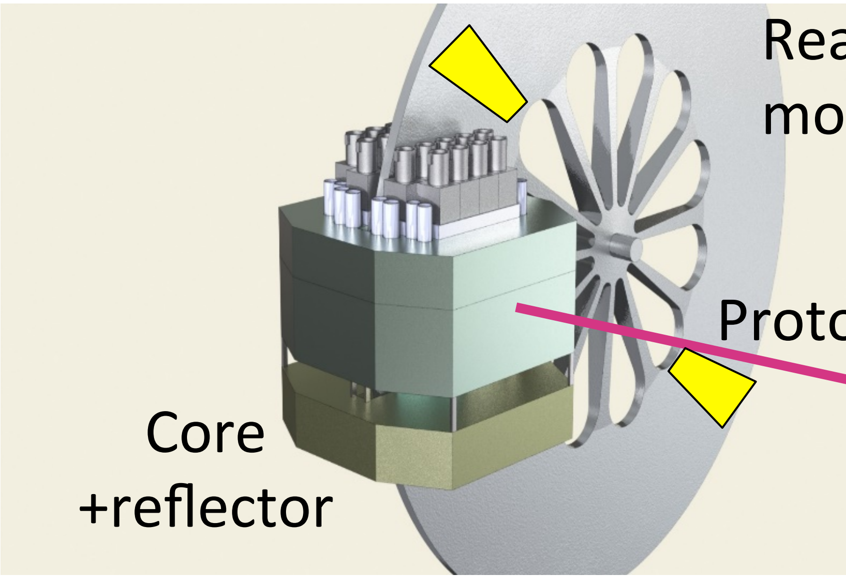
⇒ Mean neutron flux 10^{14} n/s/cm^2

⇒ Corresponds to mean flux of the world-leading pulsed sources



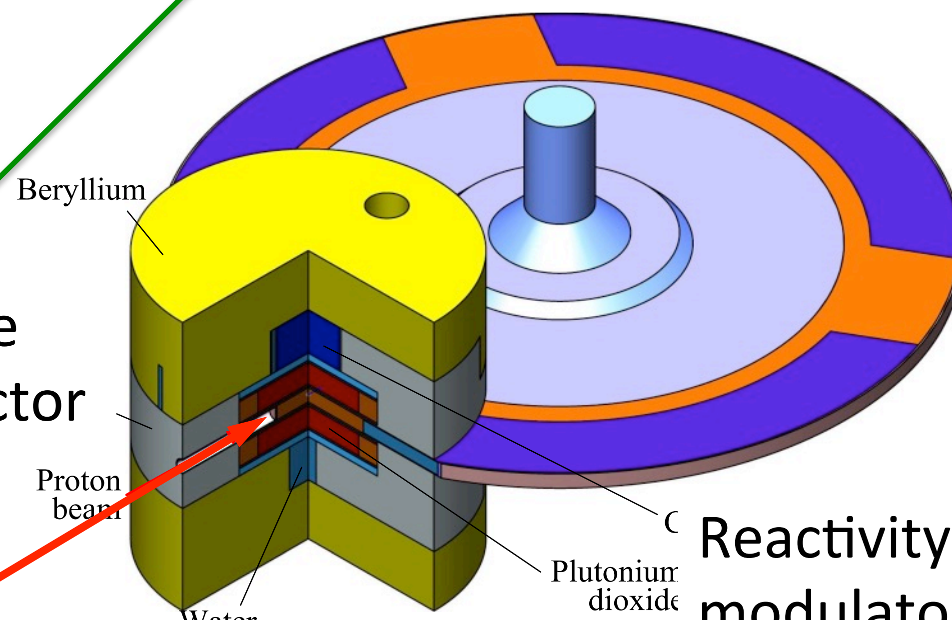
Pulsed neutron source with neutron multiplier: two alternative approaches

Superbooster: pulsed reactor + spallation



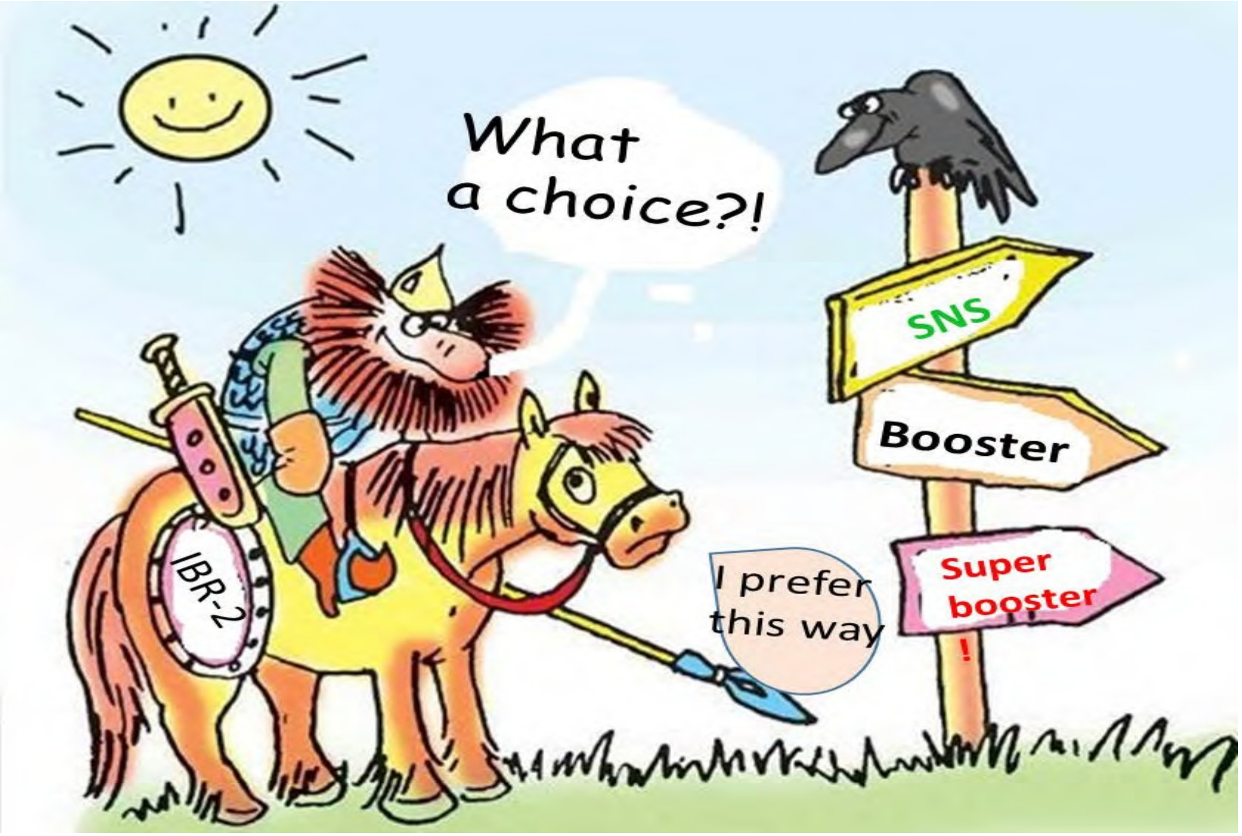
E. Shabalin et al.

Accelerator-driven neutron source: spallation + multiplier



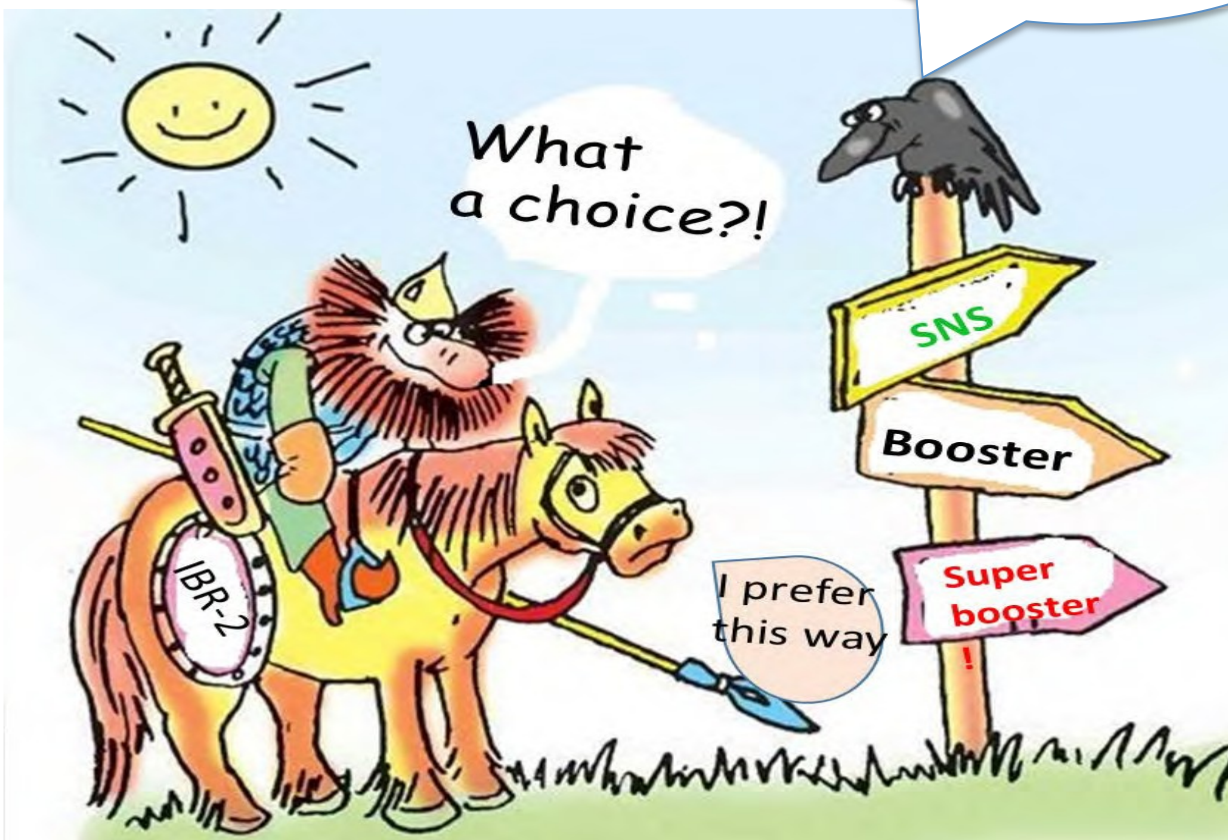
A. Vinogradov et al.

Superbooster

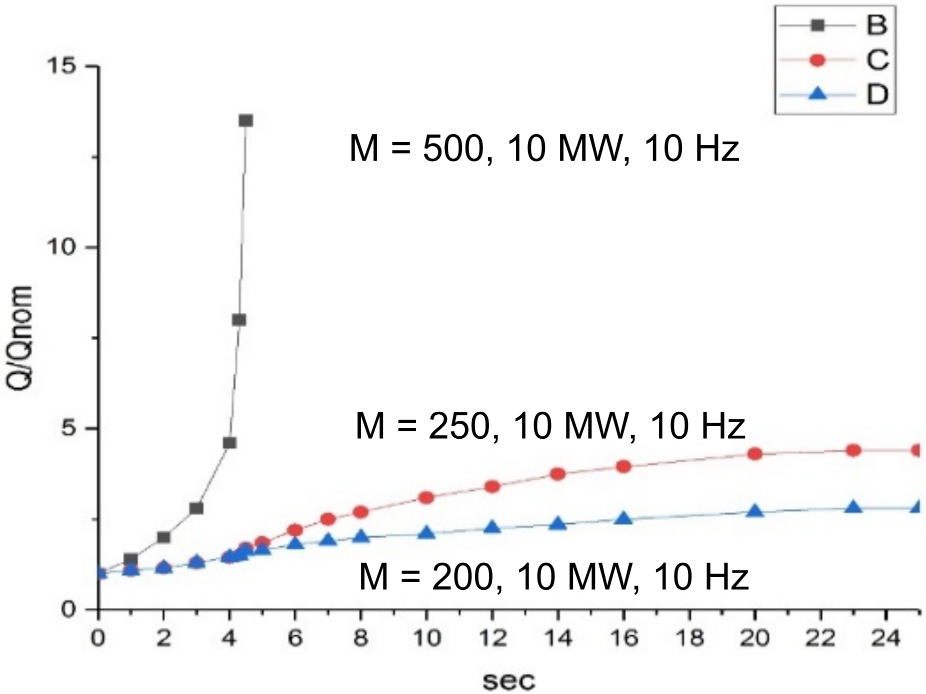


Superbooster

Oh-oh... Accelerator instabilities!



Superbooster NEPTUN: power deviation after proton beam breakdown



- It is permissible to triple the prompt power exceeding to the nominal value.
- A tenfold excess lead to damage of fuel elements.
- The reason is negative temperature reactivity feedback. When power is down, coolant decreases temperature of fuel that arises reactivity of the reactor core.

Each beam breakdown can lead to a long interruption of the subcritical system operation for the restoration of a normal regime.

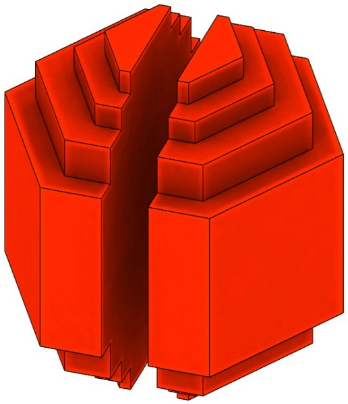
=> Superbooster NEPTUN is highly depend on accelerator stability.

Decreasing of M up to 200 leads to increasing of E_p up to 2.5 GeV

Rzyanin M., Shabalin E., European Cyclotron Progress Meeting, Sept. 2018, Dubna;
Workshop “Advanced ideas for DNS-IV”, December, 2018, Dubna.

Superbooster => IBR-3:

- no accelerator
- Power 10MW, f=10Hz, τ = (200-300)μs
- Np core

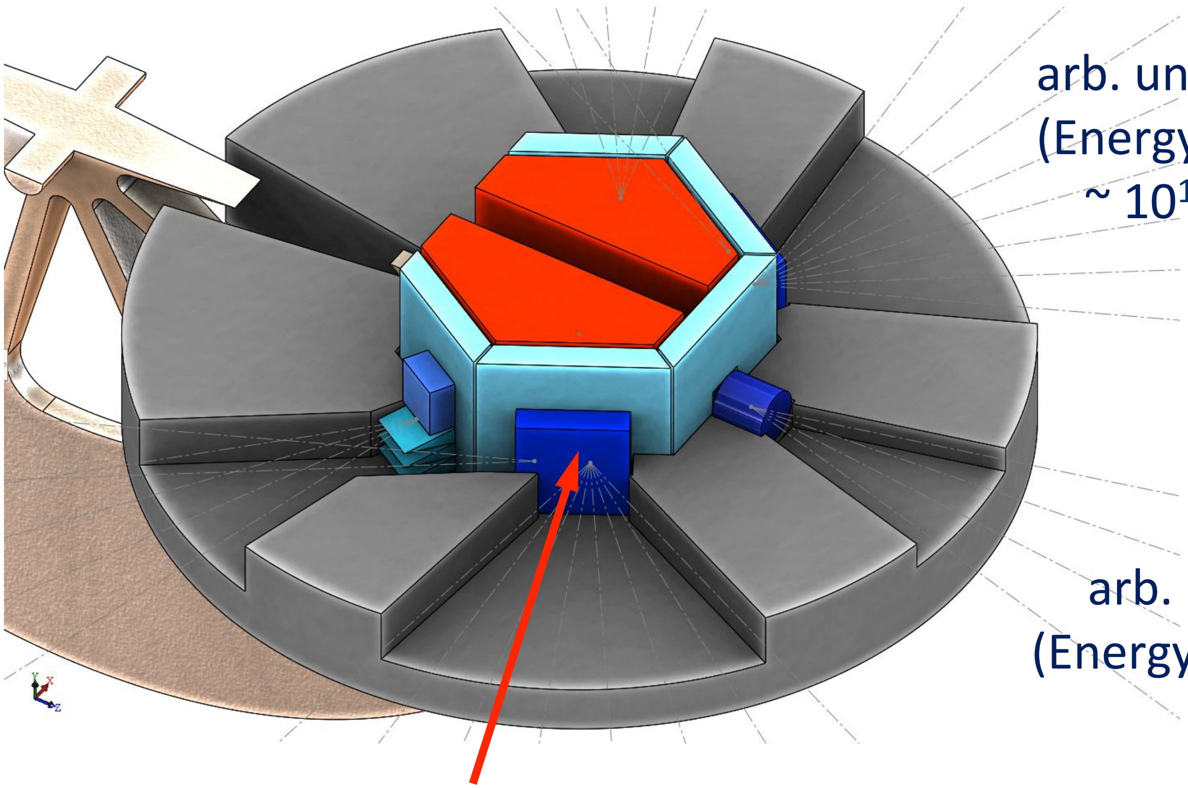


Spherical core to reduce the amount of Np.

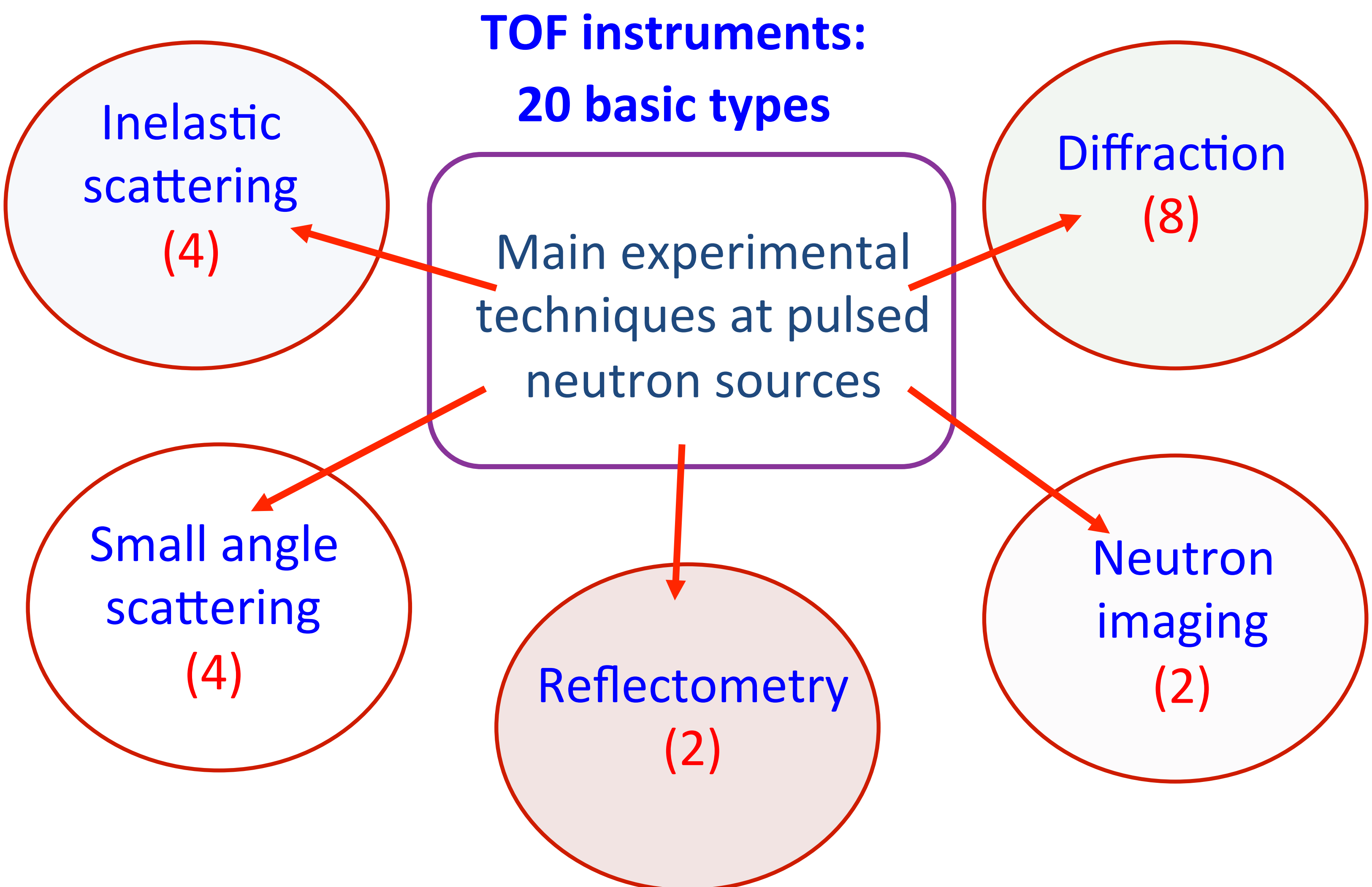
- Still the same neutron flux is expected

Moderators:
neutron fluxes at "Neptun" neutron source

S. Kulikov et al.

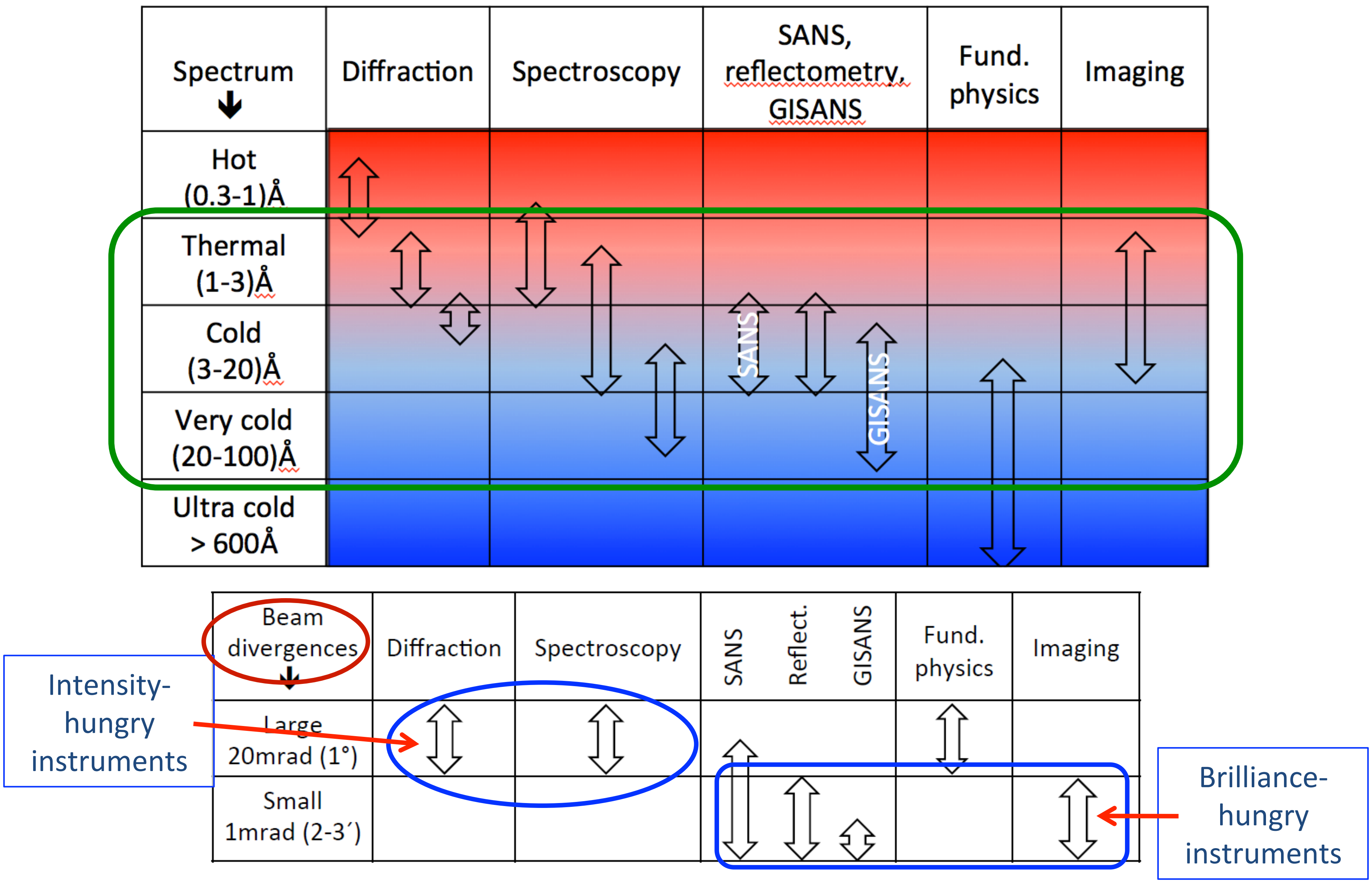


Neutron instruments



A. Balagurov

Different requirements for different topics



A. Ioffe

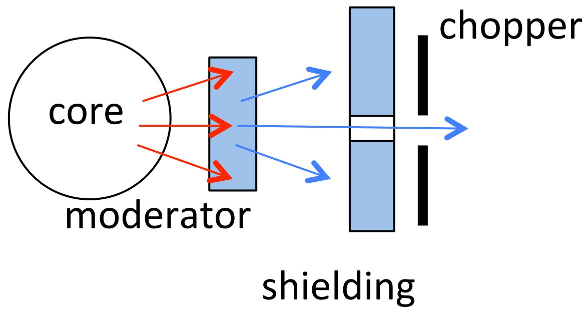
Pulsed sources: pulse length (in μs) requirements

Irradiation work:	**∞**
SANS, NSE	**2000 – 4000**
Reflectometry	**500 – 2000**
Imaging	500
Single crystal diffraction	**100 – 500**
Powder diffraction	**10 – 500**
Cold neutron spectroscopy	**50 – 2000**
Thermal neutron spectroscopy	**20 – 600**
Hot neutron spectroscopy	**10 – 300**
Backscattering spectroscopy	**10 – 100**
Electronvolt spectroscopy	1 – 10

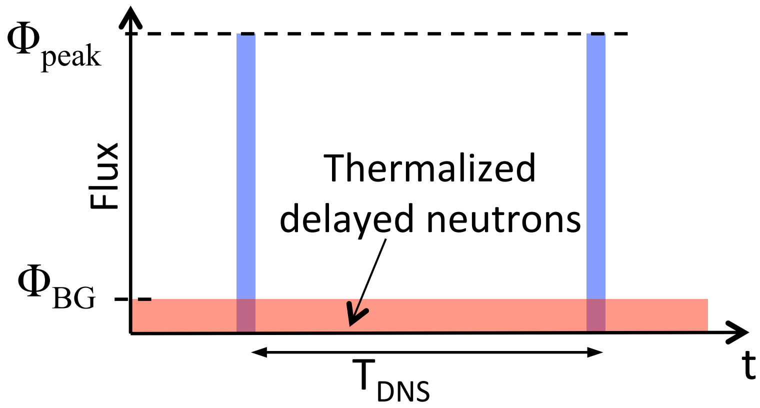
Comment: There is a need for sufficiently long pulse to avoid intensity loss by excessive resolution!

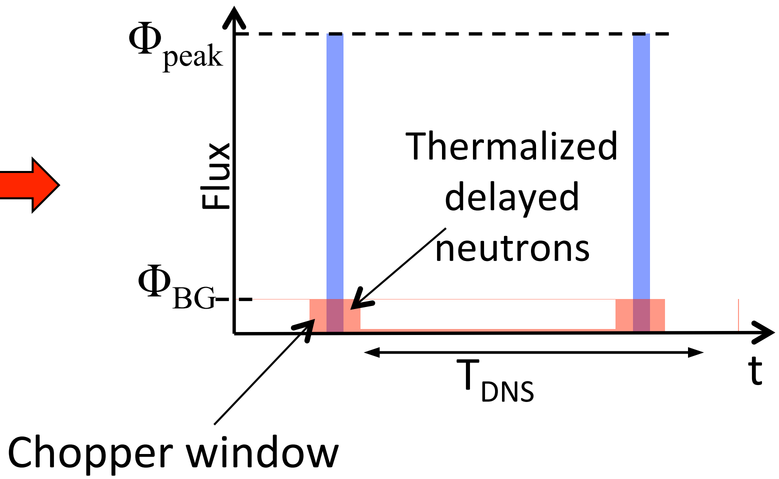
courtesy Feri Mezei & Peter Tindemans (ESS)

Delayed neutrons: small amount, however a big problem…



Solution: reduce the opening time of moderator to τ_{pulse} by a chopper:
=> no delayed neutrons outside the neutron pulse are emitted

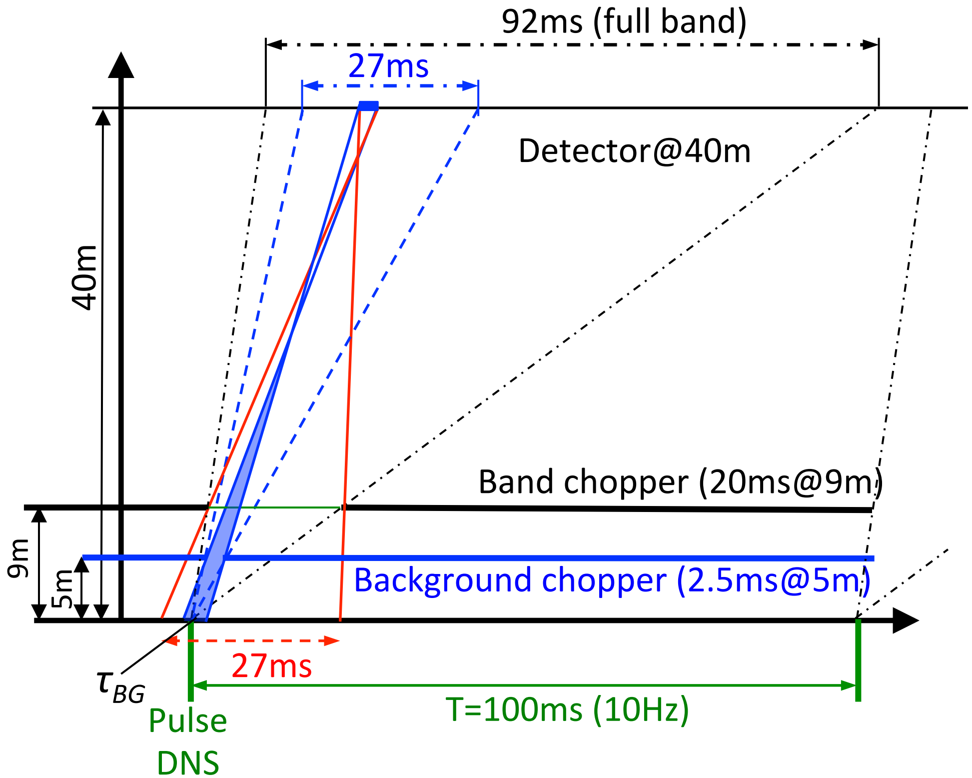


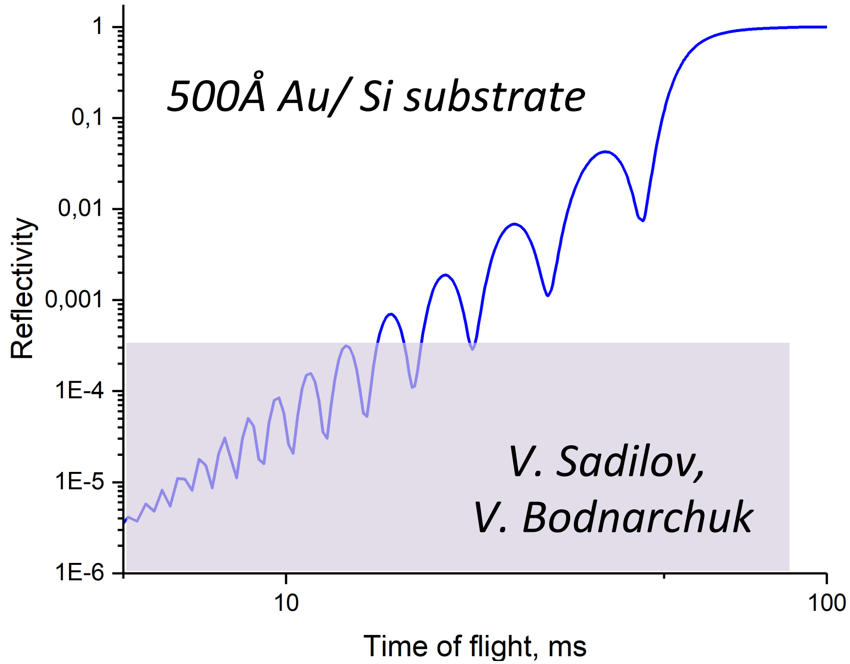


A. Ioffe, DNS-IV Workshop

Delayed neutrons: a possible solution

Chopper after the shielding: the time when detector is exposed to the moderated delayed neutrons is reduced to ≈ $1.15\tau_{BG}$ (broadening because of 5m to the source).





- Now only neutrons with a small λ-shift relative λ0 are seen in the detector time channel.
- The spectrum inside τ_{BG} is practically the same Maxwellian as in the neutron pulse
- **These neutrons are not the BG anymore - they are a part of the signal.**

Int. Workshop "Advanced ideas & experiments for DNS-IV"

Recommendations for source:

1. The vector (in 2π) neutron flux density in the range of $(1\div2)\cdot10^{14}$ n/cm^2/s at $10\div15$ MW is taken as the key parameter of DNS-IV.
2. In cooperation with the Chief Designer (NIKIET), work on the conceptual project of DNS-IV should be carried out in two directions:
   a) pulsed periodic reactor IBR-3;
   b) pulsed neutron source driven by a proton accelerator with a multiplying target.
3. The fast neutron pulse duration in the range of $150\div200$ μs with 10 Hz repetition is considered to satisfy the majority of experimental research areas: diffraction, inelastic and small-angle scattering, reflectometry, tomography.
4. Provision should be made in the design of the source for a system of choppers to suppress background between pulses and to form an optimal pulse length.

Int. Workshop “Advanced ideas & experiments for DNS-IV”

Recommendations for source:

5. It is necessary to develop and provide a cost estimate of experimental stations including infrastructure and personnel costs.
6. The development of the concept of neutron moderators on DNS-IV should be considered as a top-priority task for 2019.
7. It is suggested to develop proposals for ultracold and very cold neutrons factory.

Conclusions

1. The WSG group started to work 6 months ago
2. Steady progress
3. Two alternative concepts; both are under development and will be evaluated by NIKIET during 2019.
4. Instrumentation
5. Moderators
6. Scientific program