EURISOL DS

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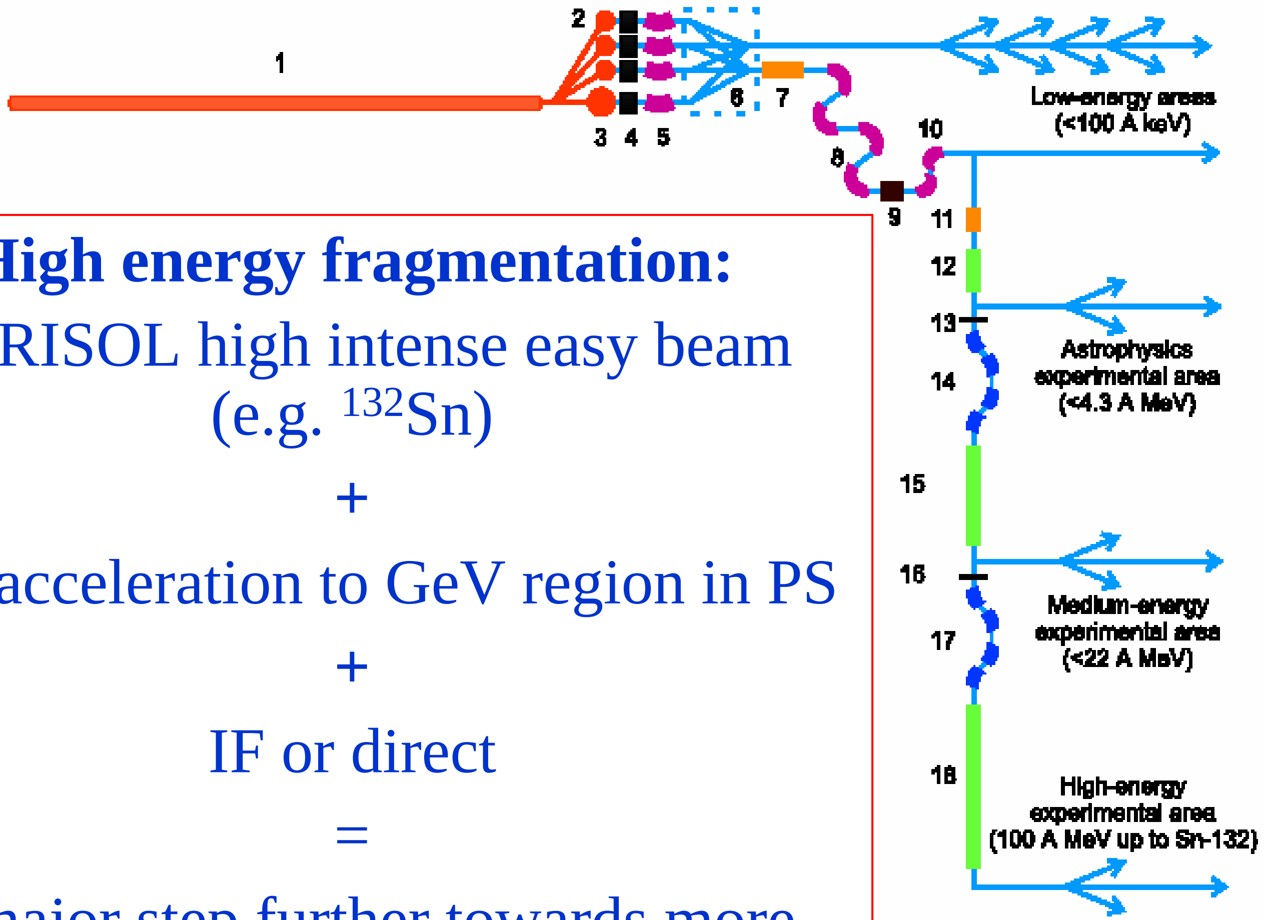
EURISOL and the beta-beam

- Future beta-beam R&D together with EURISOL project
- Design Study in the 6th Framework Programme of the EU

- The EURISOL Project
  - Design of an ISOL type (nuclear physics) facility.
  - Performance three orders of magnitude above todays facilities.
  - A first feasibility / conceptual design study was done within FP5.
  - Strong synergies with the beta-beam especially low-energy part:
    - Ion production (proton driver, high power targets).
    - Beam preparation (cleaning, ionization, bunching).
    - First stage acceleration (post accelerator ~100 MeV/u).
    - Radiation protection and safety issues.

EURISOL



High energy fragmentation:

EURISOL high intense easy beam (e.g. ^{132}Sn)

+

post-acceleration to GeV region in PS

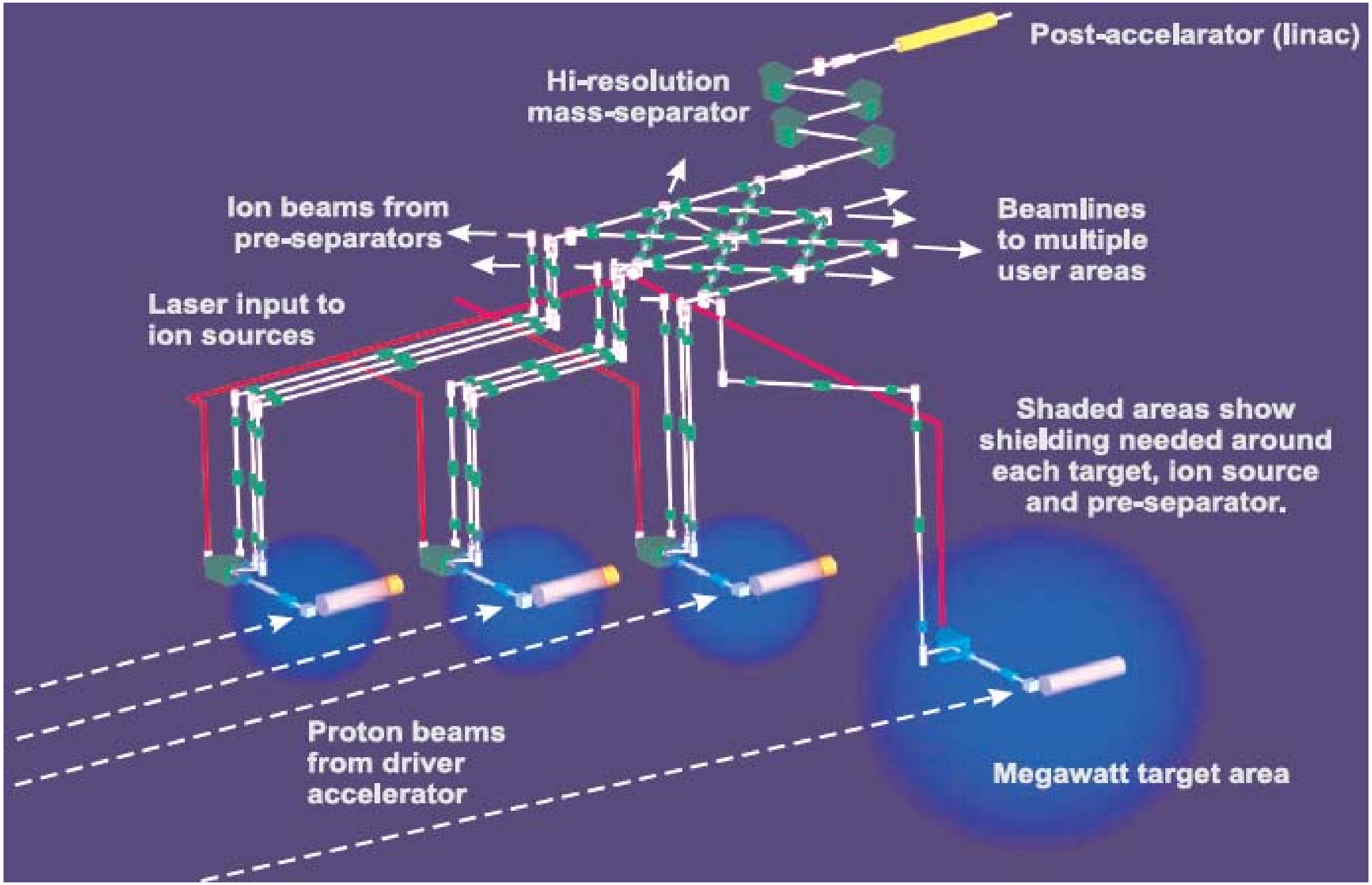
+

IF or direct

=

A major step further towards more exotic nuclei

EURISOL


Post-accelarator (linac)
Hi-resolution mass-separator
Ion beams from pre-separators
Beamlines to multiple user areas
Laser input to ion sources
Shaded areas show shielding needed around each target, ion source and pre-separator.
Proton beams from driver accelerator
Megawatt target area

EURISOL design study

Production of an engineering oriented design of the facility, in particular in relation to its most technologically advanced aspect (i.e., excluding the detailed design of standard elements of the infrastructure).

- Technical Design Report for EURISOL.
- Conceptual Design Report for Beta-Beam (first study).

Acronym:	EURISOL DS
Requested budget:	9.1 M€
Deadline for proposal:	4 March 2004
Starting date:	1 February 2005
Duration of the project:	48 months
Coordinating Institution:	GANIL (Graziano Fortuna – INFN)

- **Target tasks:** 100 kW and MW targets
  - CERN
- **Beam preparation:** 60 GHz ECR source
  - IN2P3-LPSC
- **Heavy-ion accelerator:** acceleration up to 100 MeV/u
  - GANIL
- **Physics:** Low energy beta-beam
  - IN2P3-Orsay
- And more…

Introduction to beta-beams

- Beta-beam proposal by Piero Zucchelli
  - *A novel concept for a neutrino factory: the beta-beam*, Phys. Let. B, 532 (2002) 166-172.

- AIM: production of a pure beam of electron neutrinos (or antineutrinos) through the beta decay of radioactive ions circulating in a high-energy (γ~100) storage ring.

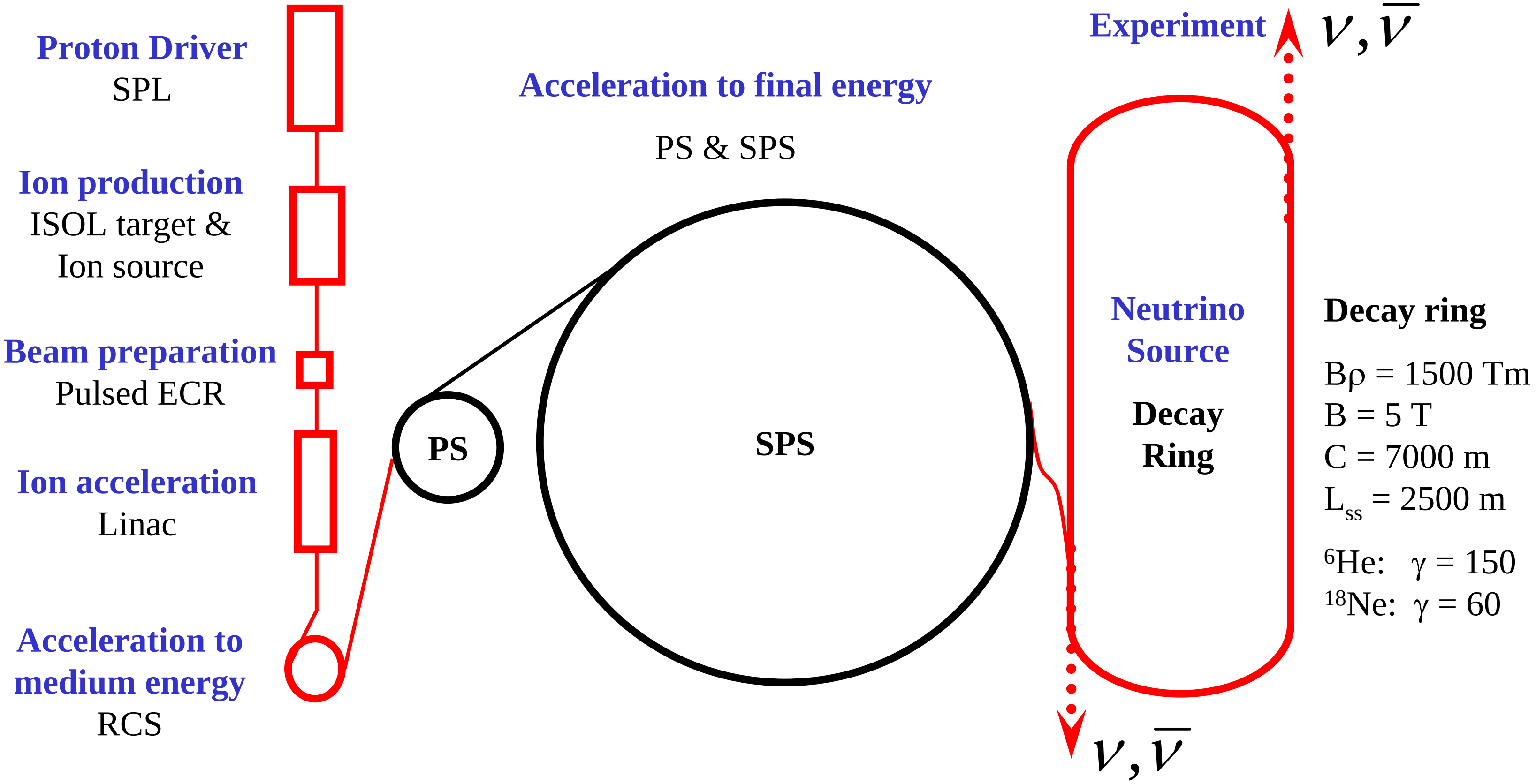
- The baseline scenario
  - Avoid anything that requires a "technology jump" which would cost time and money (and be risky).
  - Make maximum use of the existing infrastructure.

Beta-beam baseline design

Ion production

Acceleration

Neutrino source



Proton Driver
SPL

Ion production
ISOL target &
Ion source

Beam preparation
Pulsed ECR

Ion acceleration
Linac

Acceleration to medium energy
RCS

Acceleration to final energy

PS & SPS

PS

SPS

Experiment $\nu, \bar{\nu}$

Neutrino Source

Decay Ring

$\nu, \bar{\nu}$

Decay ring

Bρ = 1500 Tm
B = 5 T
C = 7000 m
L_{ss} = 2500 m

^{6}He: γ = 150
^{18}Ne: γ = 60

Main parameters (1)

- Factors influencing ion choice
  - Need to produce reasonable amounts of ions.
  - Noble gases preferred - simple diffusion out of target, gaseous at room temperature.
  - Not too short half-life to get reasonable intensities.
  - Not too long half-life as otherwise no decay at high energy.
  - Avoid potentially dangerous and long-lived decay products.

- Best compromise
  - Helium-6 to produce antineutrinos:

$${}^{6}_{2}He \rightarrow {}^{6}_{3}Li\, e^{-}\, \overline{\nu}$$

$$\text{Average } E_{cms} = 1.937 \text{ MeV}$$

  - Neon-18 to produce neutrinos:

$${}^{18}_{10}Ne \rightarrow {}^{18}_{9}F\, e^{+}\, \nu$$

$$\text{Average } E_{cms} = 1.86 \text{ MeV}$$

Main parameters

- CERN original Baseline design

^{6}Helium^{2+}

- **Inj. flux 9x10^{12} ions/batch from SPS to decay ring**
- **Energy 139 GeV/u**
- **Gamma 150**
- **Rigidity 1500 Tm**

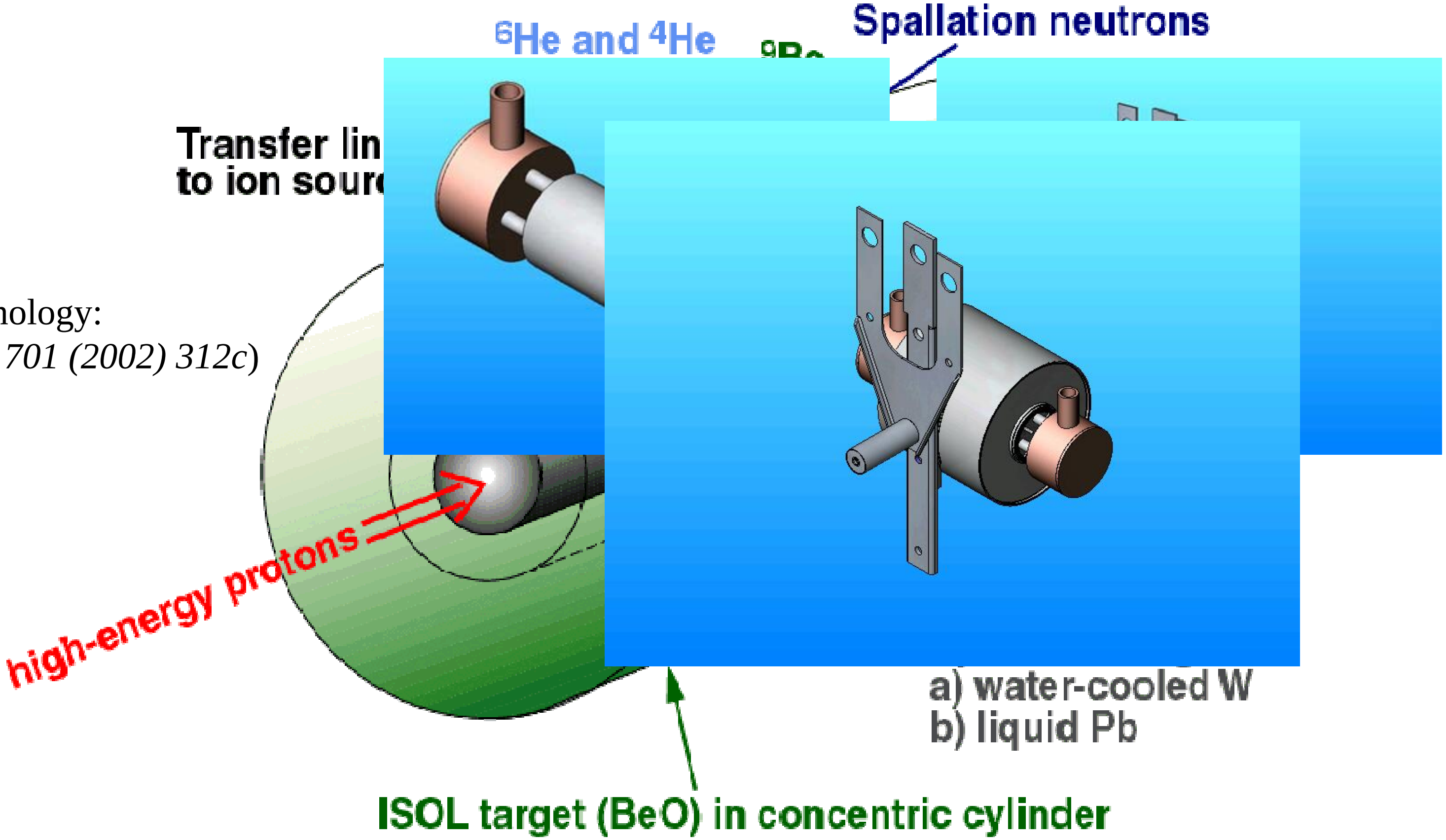
^{18}Neon^{10+}

- **Inj. flux 0.5x10^{12} ions/batch from SPS to dacey ring**
- **Energy 55 GeV/u**
- **Gamma 60**
- **Rigidity 335 Tm**

- The neutrino beam at the experiment has the “time stamp” of the circulating beam in the decay ring.
- The beam has to be concentrated in as few and as short bunches as possible to maximize the number of ions/nanosecond for background suppression.
- Aim for a duty factor of 10^{-4} . This is a major design challenge!

^{6}He production from ^{9}Be(n,α)

Converter technology:
(*J. Nolen, NPA 701 (2002) 312c*)

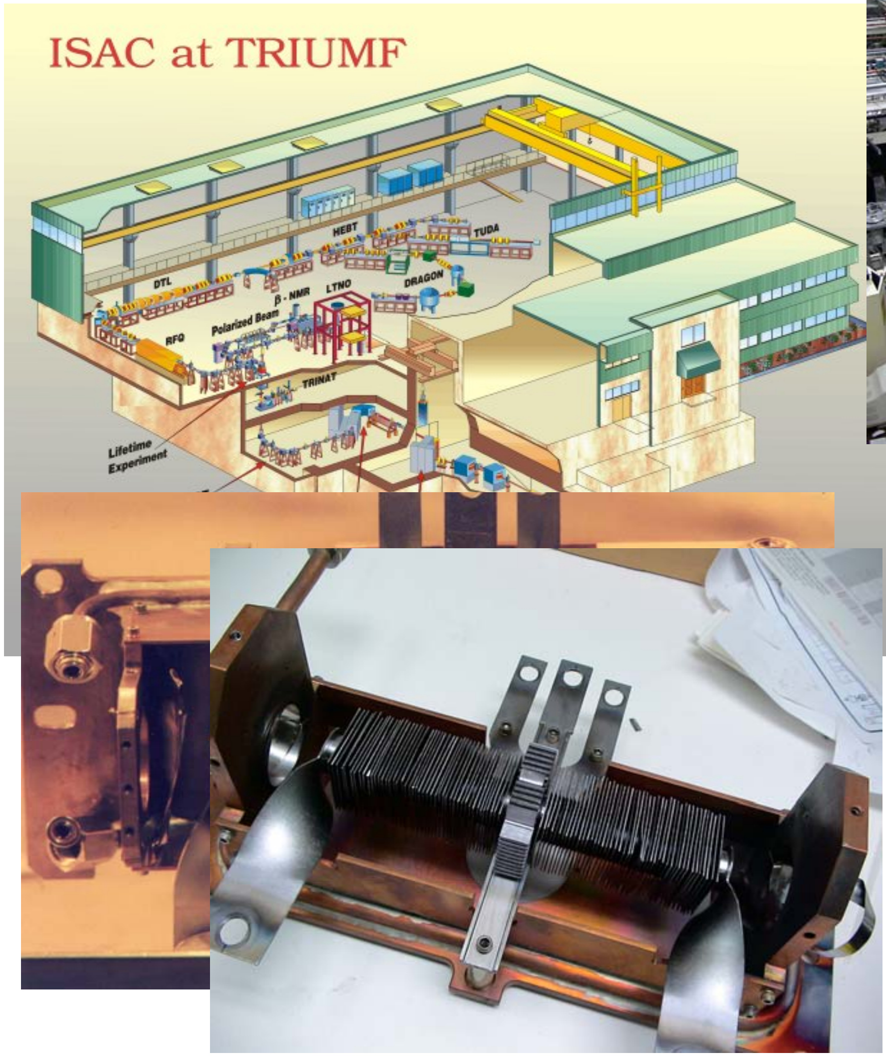


- Converter technology preferred to direct irradiation (heat transfer and efficient cooling allows higher power compared to insulating BeO).
- ^{6}He production rate is ~2x10^{13} ions/s (dc) for ~200 kW on target.

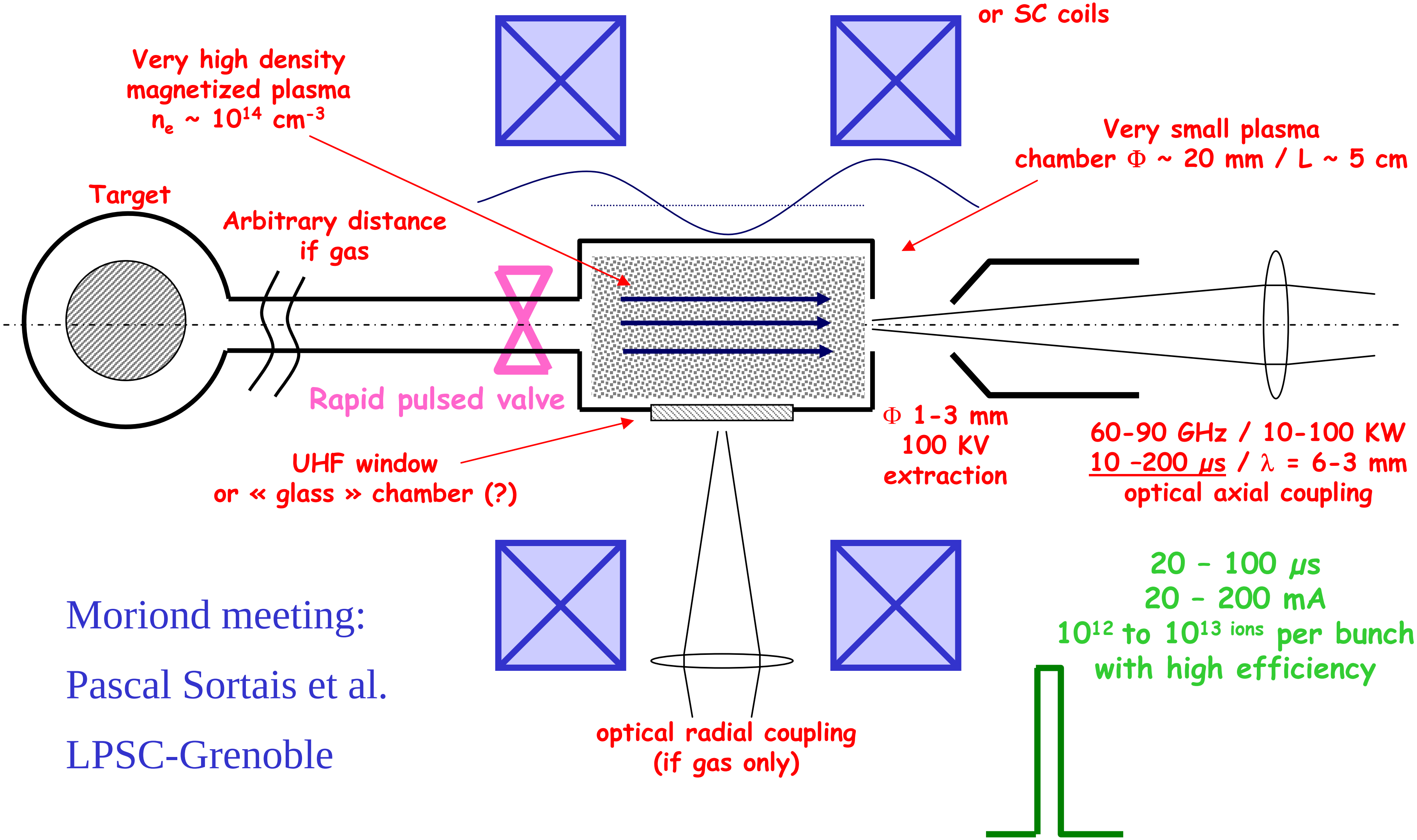
^{18}Ne production

- Spallation of close-by target nuclides
  - $^{24}Mg^{12}$ (p, p_3 n_4) $^{18}Ne^{10}$.
  - Converter technology cannot be used; the beam hits directly the magnesium oxide target.
  - Production rate for ^{18}Ne is ~ 1x10^{12} ions/s (dc) for ~200 kW on target.
  - ^{19}Ne can be produced with one order of magnitude higher intensity but the half-life is 17 seconds!

ISAC at TRIUMF: High power targets!



60-90 GHz « ECR Duoplasmatron » for pre-bunching of gaseous RIB



2.0 – 3.0 T pulsed coils
or SC coils

Very high density
magnetized plasma
$n_e \sim 10^{14}$ cm^{-3}

Very small plasma
chamber $\Phi \sim 20$ mm / L ~ 5 cm

Target

Arbitrary distance
if gas

Rapid pulsed valve

UHF window
or « glass » chamber (?)

Φ 1-3 mm
100 KV
extraction

60-90 GHz / 10-100 KW
10 –200 μs / λ = 6-3 mm
optical axial coupling

20 – 100 μs
20 – 200 mA
10^{12} to 10^{13} ions per bunch
with high efficiency

optical radial coupling
(if gas only)

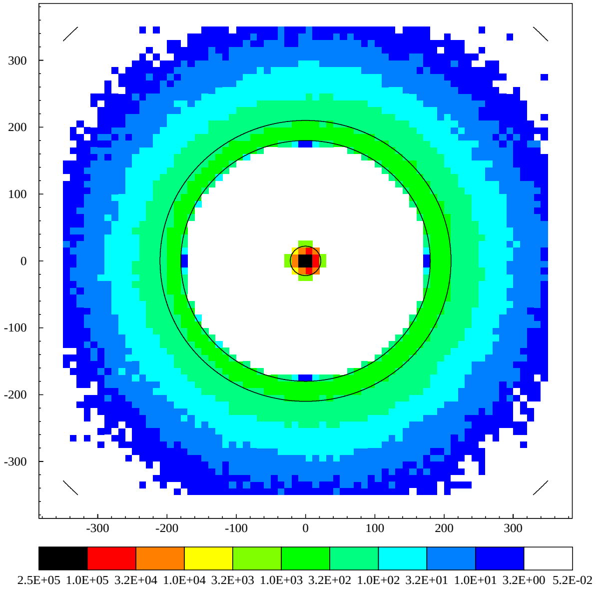
Moriond meeting:

Pascal Sortais et al.

LPSC-Grenoble

Decay losses

- Losses during acceleration
  - Full FLUKA simulations in progress for all stages (M. Magistris and M. Silari, *Parameters of radiological interest for a beta-beam decay ring*, TIS-2003-017-RP-TN).
- Preliminary results:
  - Manageable in low-energy part.
  - PS heavily activated (1 s flat bottom).
    - Collimation? New machine?
  - SPS ok.
  - Decay ring losses:
    - Tritium and sodium production in rock is well below national limits.
    - Reasonable requirements for tunnel wall thickness to enable decommissioning of the tunnel and fixation of tritium and sodium.
    - Heat load should be ok for superconductor.



FLUKA simulated losses in surrounding rock (no public health implications)