Lepta - Facility for Fundamental and Applied Research

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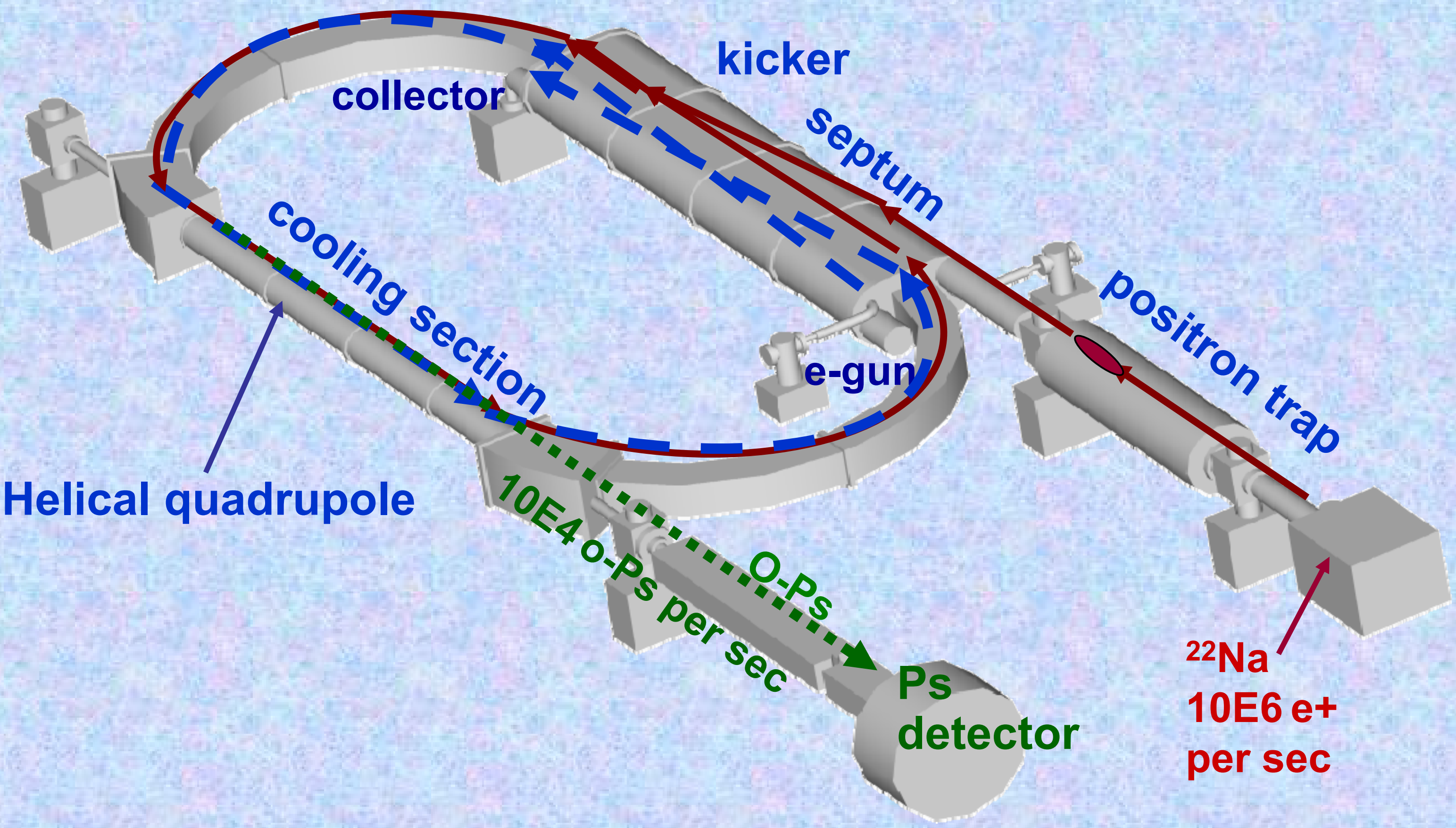
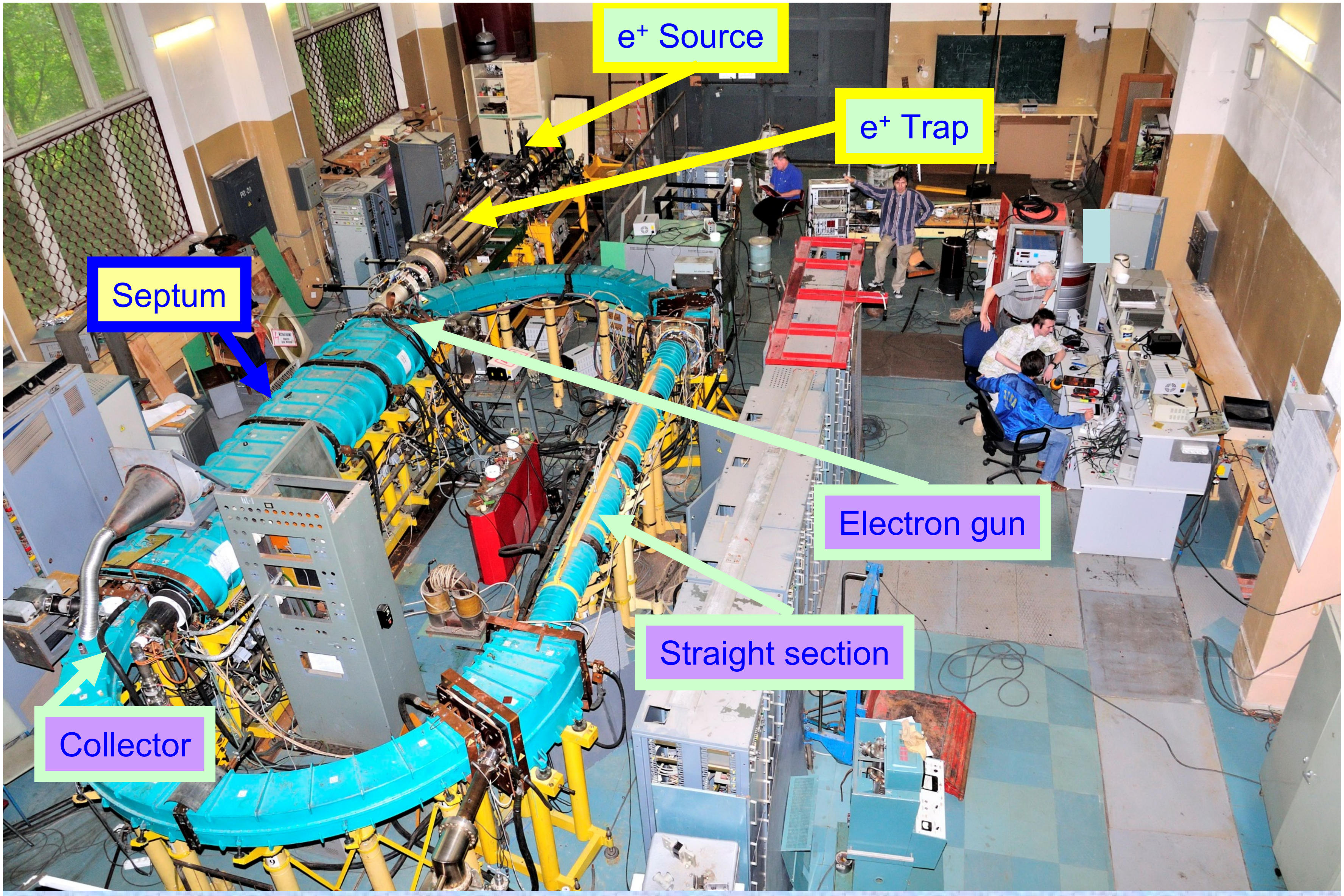
1. LEPTA Facility



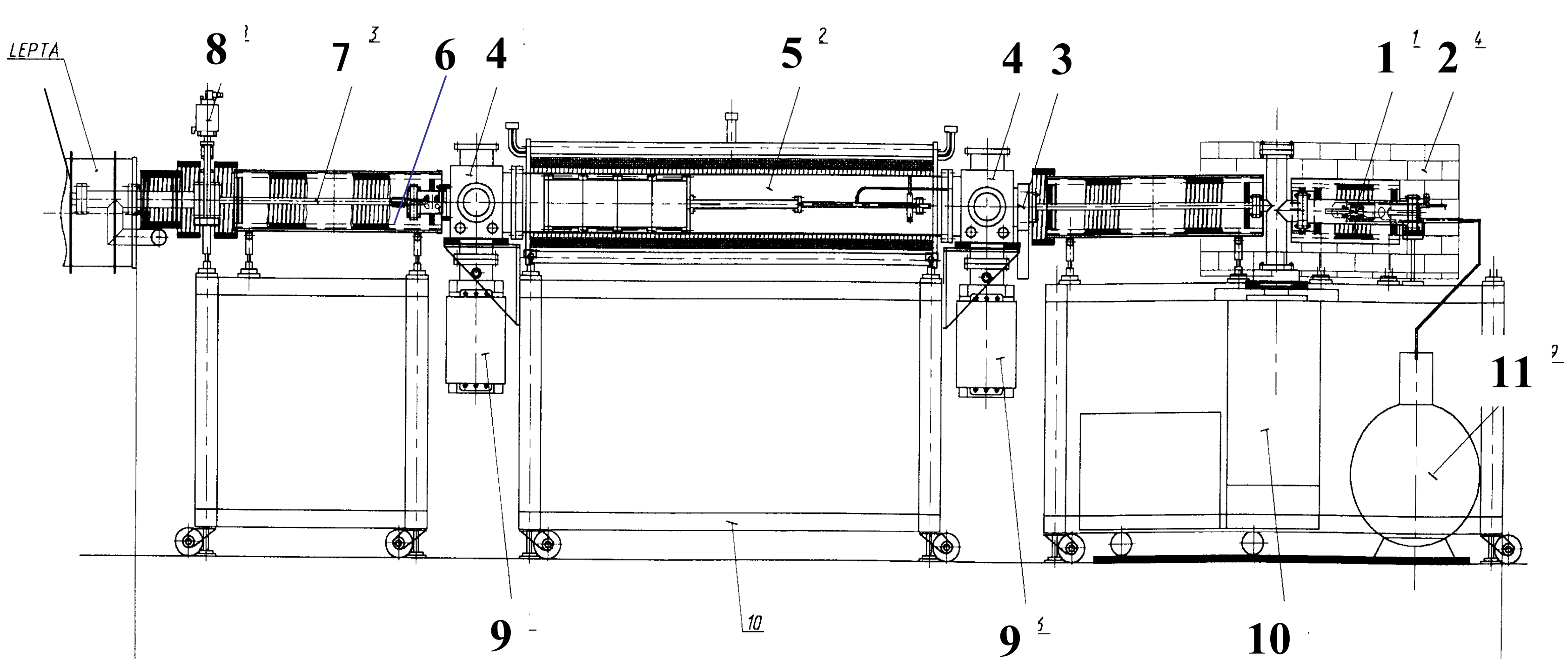

e+ Source
e+ Trap
Septum
Electron gun
Straight section
Collector

1. LEPTA Facility

LEPTA Project Parameters

Circumference , m	17.2
Positron energy, keV	10.0
Revolution time, ns	300
Longitudinal magnetic field, G	400
Average radius of the toroidal magnets, m	1.45
Helical quadrupole gradient, G/cm	10.0
Positron beam radius, cm	0.5
Number of positrons in the ring	$1{\cdot}10^8$

2. Positron Injector



1 - positron source ^{22}Na, 2 - radioactive protection shield, 3 - vacuum valve,

4 - vacuum chamber for pumping out and diagnostic tools, 5 -positron trap,

6 - vacuum isolator, 7 - positron vacuum channel,

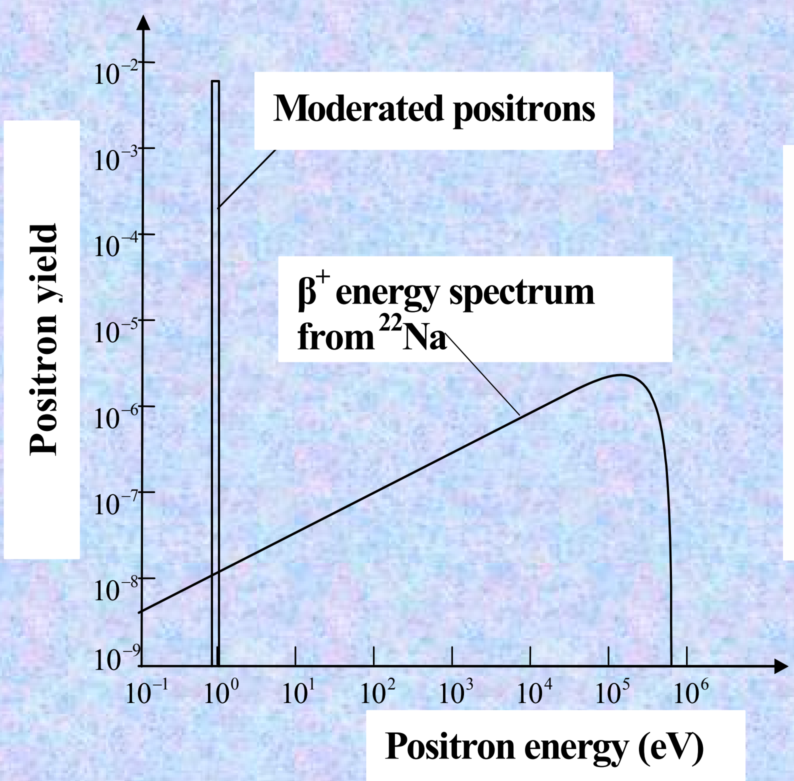
8 - vacuum “shutter” (fast valve), 9 - ion pump, 10 - turbo pump, 11 - He vessel.

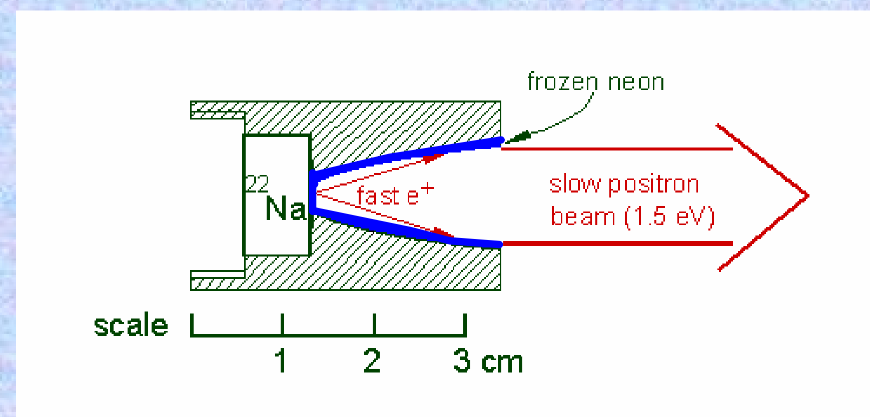
2. Positron Injector

LEPTA Injector Parameters

Parameter	Design	Achieved
Length, *m*	6,2	
Positron injection energy, *keV*	≤ 10.0	
Longitudinal magnetic field, *G*	400	
Longitudinal magnetic field in the trap, *G*	1000	
Residual gas pressure, *Torr*	$1\cdot10^{-9}$	$1\cdot10^{-8}$
Beam radius, *cm*	0.5	
Accumulation time, *s*	100	80
Injection pulse duration, ns	300	
Number of positrons per injection pulse	$1\cdot10^{8}$	$5\cdot10^{5}$
Positron momentum spread	$1\cdot10^{-4}$	
Low energy positron flux from 22Na source, s^{-1}	$1\cdot10^{6}$	$2\cdot10^{5}$

2. Positron Injector

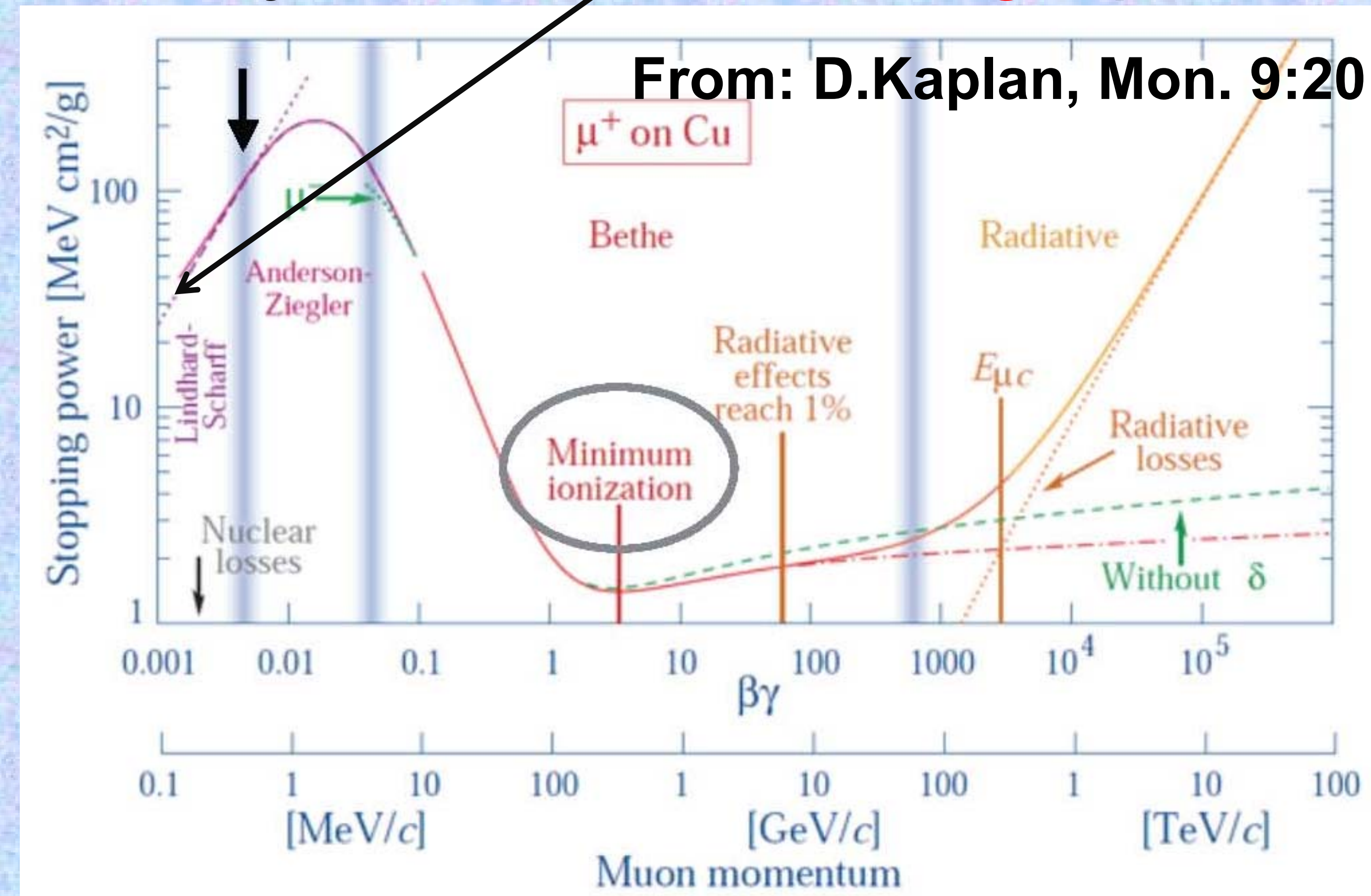




2. Positron Injector

Actually we have frictional cooling of positrons

From: D.Kaplan, Mon. 9:20



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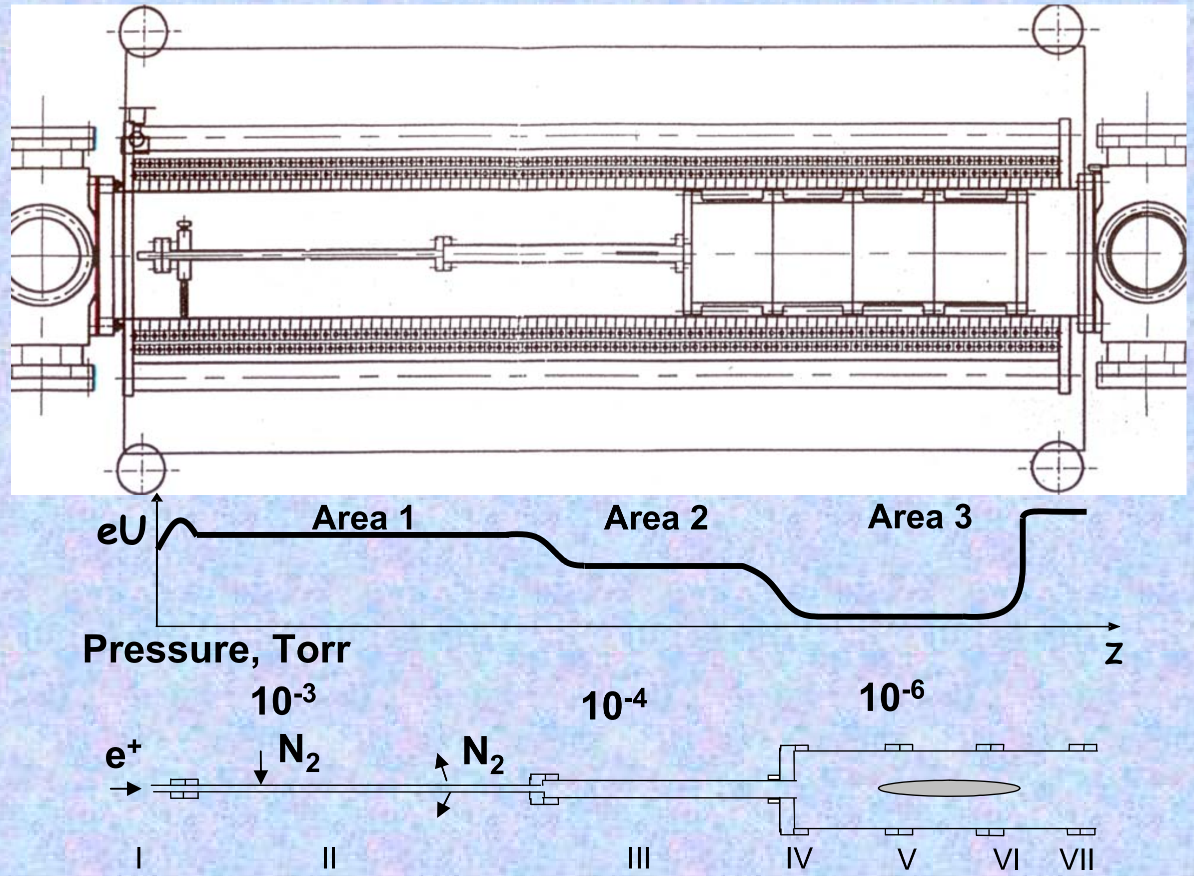

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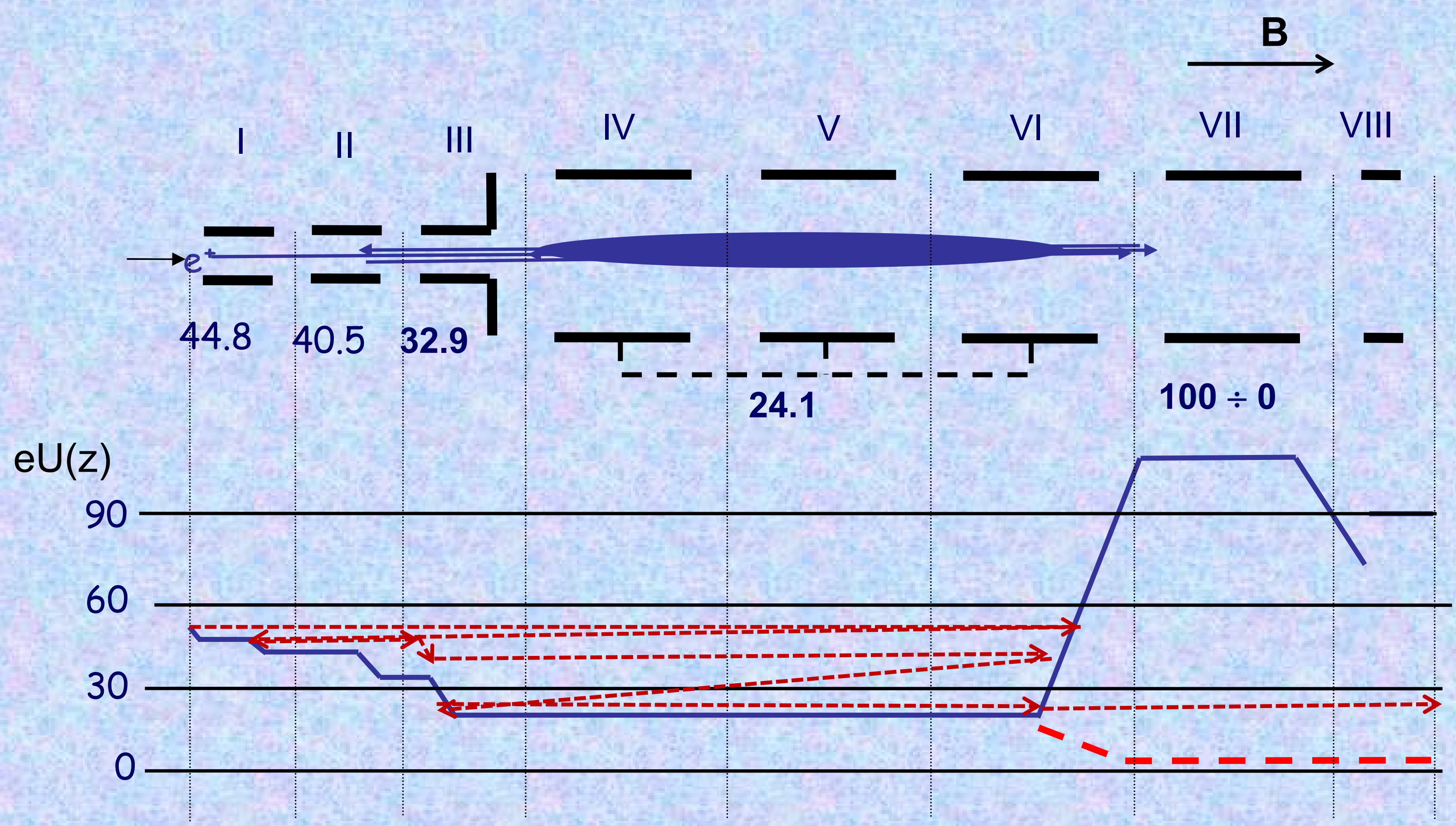
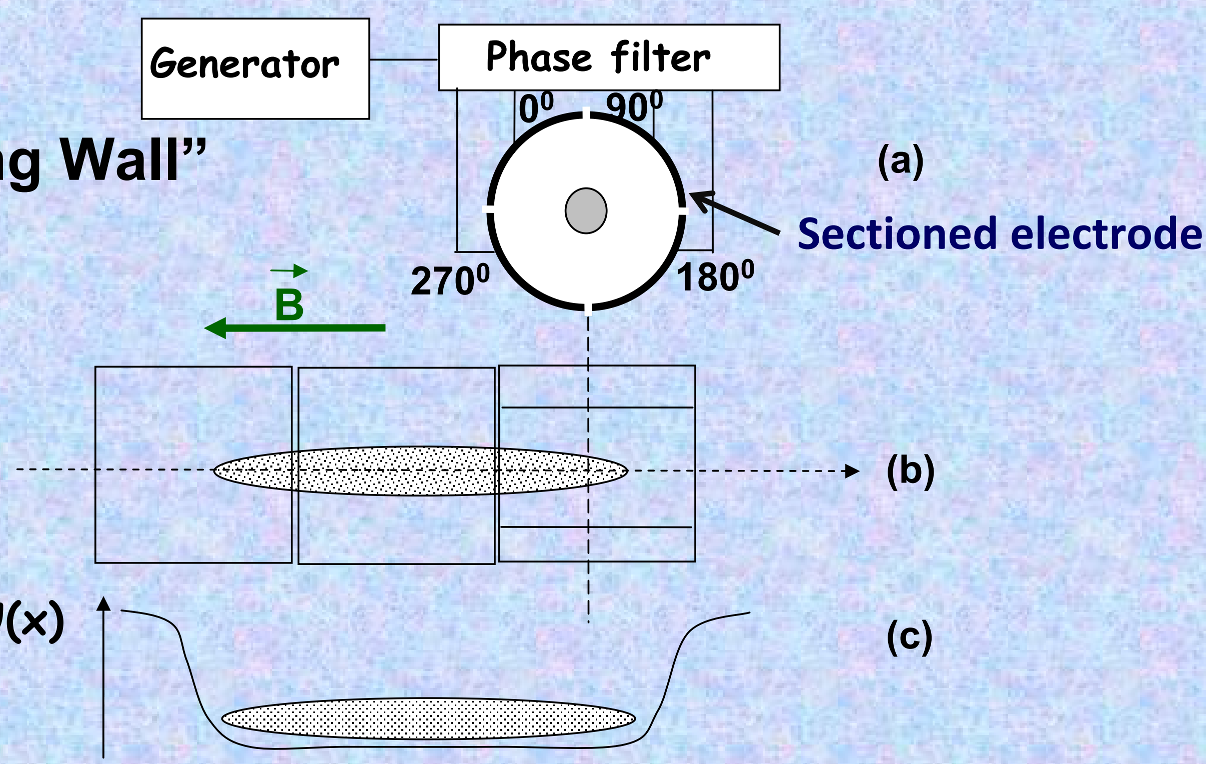


3. Studies of the Rotating Field mechanism

The "Rotating Wall" (RW)



Each electrode is placed under combination of AC and DC potentials (Fig.a, b, c). AC potentials of sector electrodes are shifted by 90^0 each to other.

The first experiment: Mg+ (Laboratory Univ. of California at San Diego) X-P. Huang et al., PRL. 78, 875 (1997).

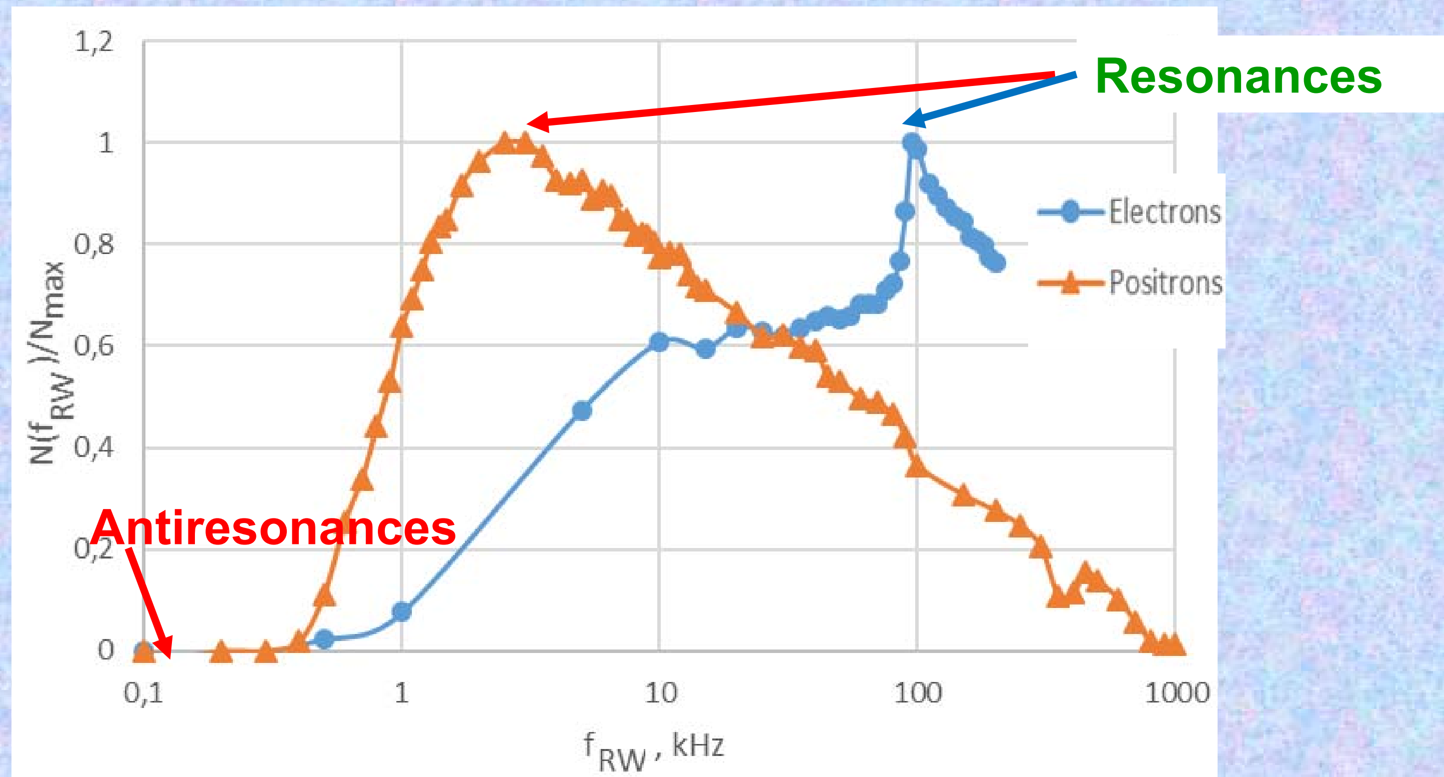
3. Studies of the RW-field mechanism

Dependence of storage process parameters on buffer gas pressure

P, 10^{-6} Top	τ, sec RW off/RW on	ε, % RW off/RW on	ε × τ, % × sec RW off/RW on
1.5	4,1/10,5	2,3/2,1	9,43/22,05
2	4/9,5	3/2,9	12/27,55
2.5	3,7/9	4,3/3,6	15,91/32,4
4	3,9/8	6,7/6,4	26,13/51,2

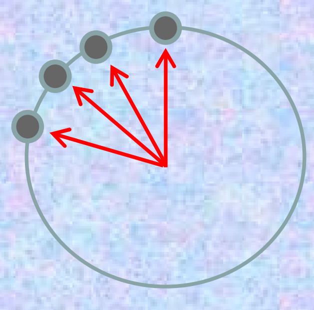
$$N_{bunch}(t) = \varepsilon \dot{N} \tau \left(1 - e^{-t/\tau}\right) \Rightarrow \begin{cases} \varepsilon \dot{N} t, t << \tau, \\ \varepsilon \dot{N} \tau, t >> \tau \end{cases}$$

3. Studies of the RW-field mechanism



The resonant dependence of the stored particles' number (normalized) – positrons and electrons – on the RW-field frequency (kHz).

3. Studies of the RW-field mechanism



Particle rotation in RW-field

Charged particle rotates in the RW-field along the circular orbit of the radius

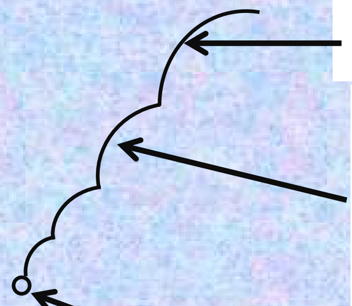
$$R_{RW} = cE_{RW}/B\omega_{RW} \gg \rho_L.$$

Here E_{RW} and ω_{RW} are the amplitude and frequency of the RW-field, B is the trap magnetic field, c – the speed of light, ρ_L – the particle Larmor radius.

After reflection from potential barrier the particle escapes from RW-field and travel along the trap magnetic field until it reaches the exit potential barrier. Reflected on it the particle returns into RW field at certain phase of the field rotation.

When traveling in the trap the particle rotates around the trap axis in the crossed fields B and E_r – radial component of the electric fields of the trap electrodes and the bunch space charge ("magnetron rotation").

3. Studies of the RW-field mechanism



In the RW-field the particle has time to move along a short arc of the circular orbit:

If after traveling in the trap it returns into RW-field at optimal phase of RW-field and "magnetron rotation" it will continue its way in the same direction as in the previous "round".

And so on…

When traveling ("bouncing") in the trap the particle loses its energy in the collisions with the buffer gas atoms (the "frictional cooling" again!). As result, the length of the arcs is decreasing and finally the particle does not penetrate into RW-field that is overlapped with the potential barrier of the sectioned electrode. And the particle looks as a small Larmor circle.

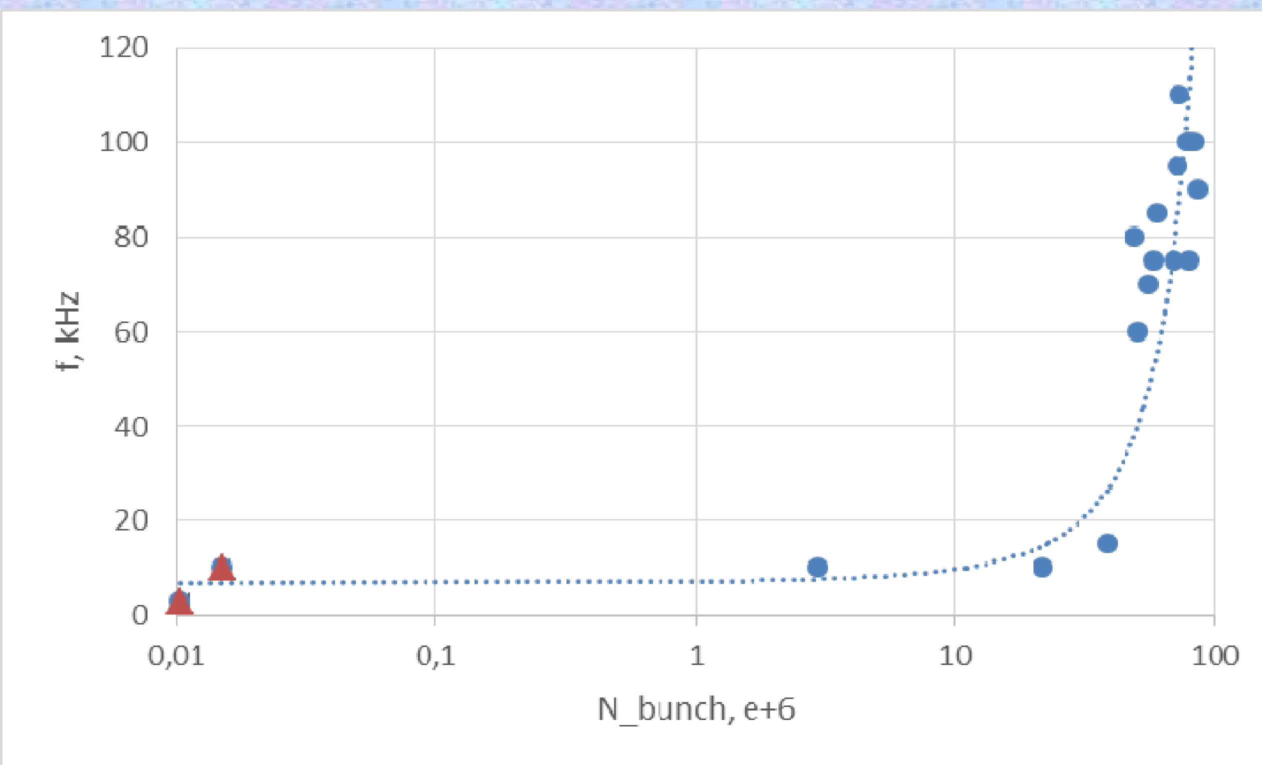
The Formula for the resonance condition has been derived:

$$(\omega_{RW})_{res} = \frac{\int_0^{T_{bounce}} \omega_{magn}(t)dt + 2\pi n}{T_{bounce} - \tau_{RW}}$$

M.Eseev, A.Kobets, I.Meshkov, A.Sidorin, O.Orlov, JETP Lett., v. 192 (2015) 291

3. Studies of the RW-field mechanism

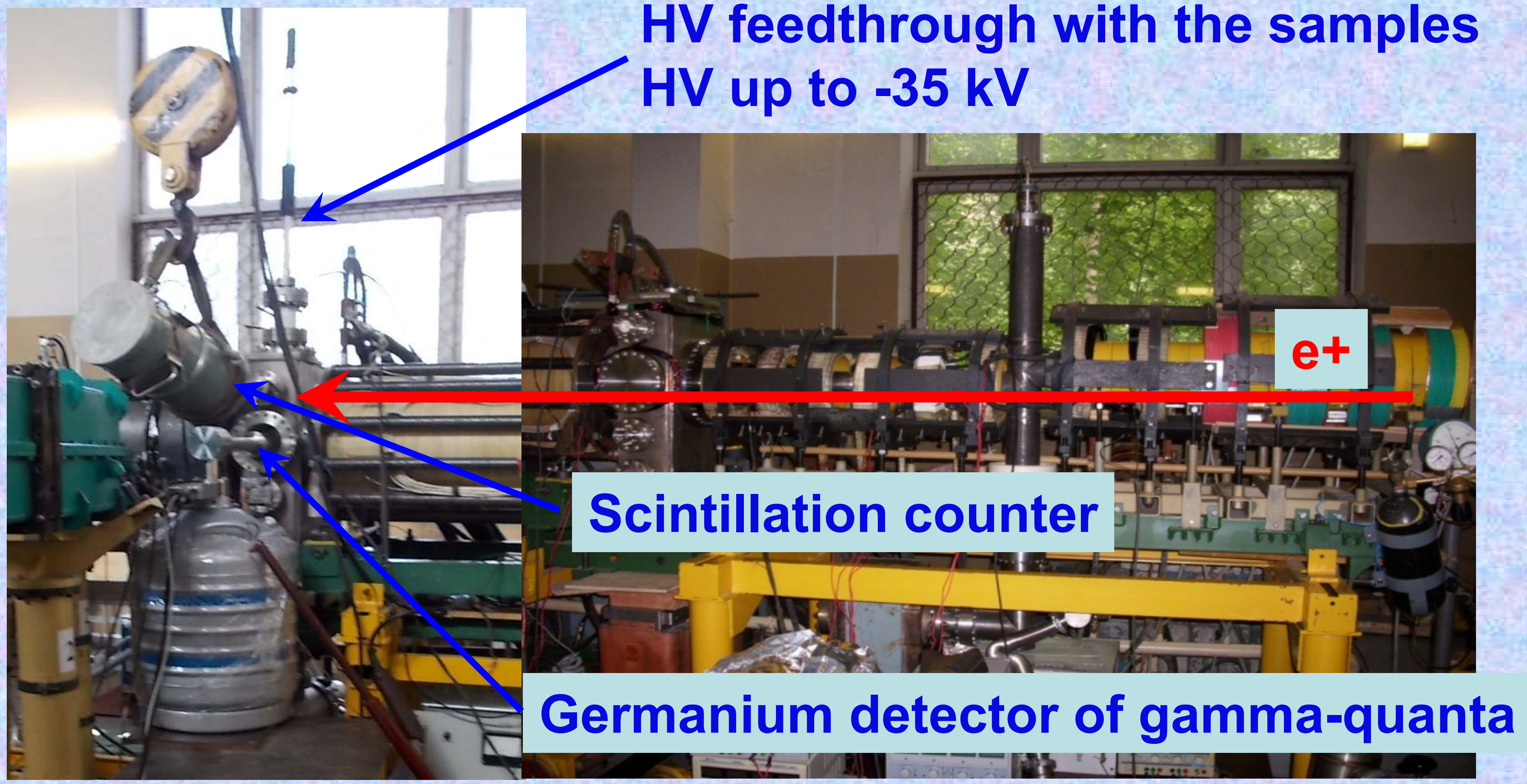
With the increase of the intensity, the azimuthal drift in crossed fields of the bunch space charge and longitudinal magnetic field plays the decisive role and increases the resonant frequency.



Storage time 20 sec: ● — electrons, ▲— positrons;
Trend line *y(x)* = *6,9514×exp(0,0374·x)*

4. Positron Annihilation Spectroscopy (PAS)

THE METHOD OF THE DOPPLER BROADENING OF THE ANNIHILATION GAMMA LINE



4. Positron Annihilation Spectroscopy (PAS)

The laboratory for the samples preparation has been equipped with the different tools (sendblast apparatus, vacuum oven and press).

The main problems we have:

- Deficit of liquid helium
- Low vacuum conditions in the storage area
- Low intensity of slow positron flux

5. Positron Injector Development

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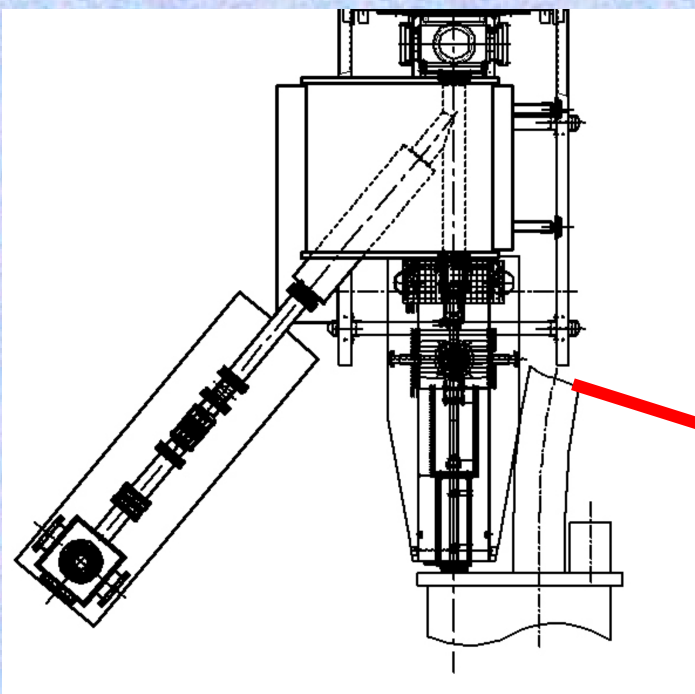
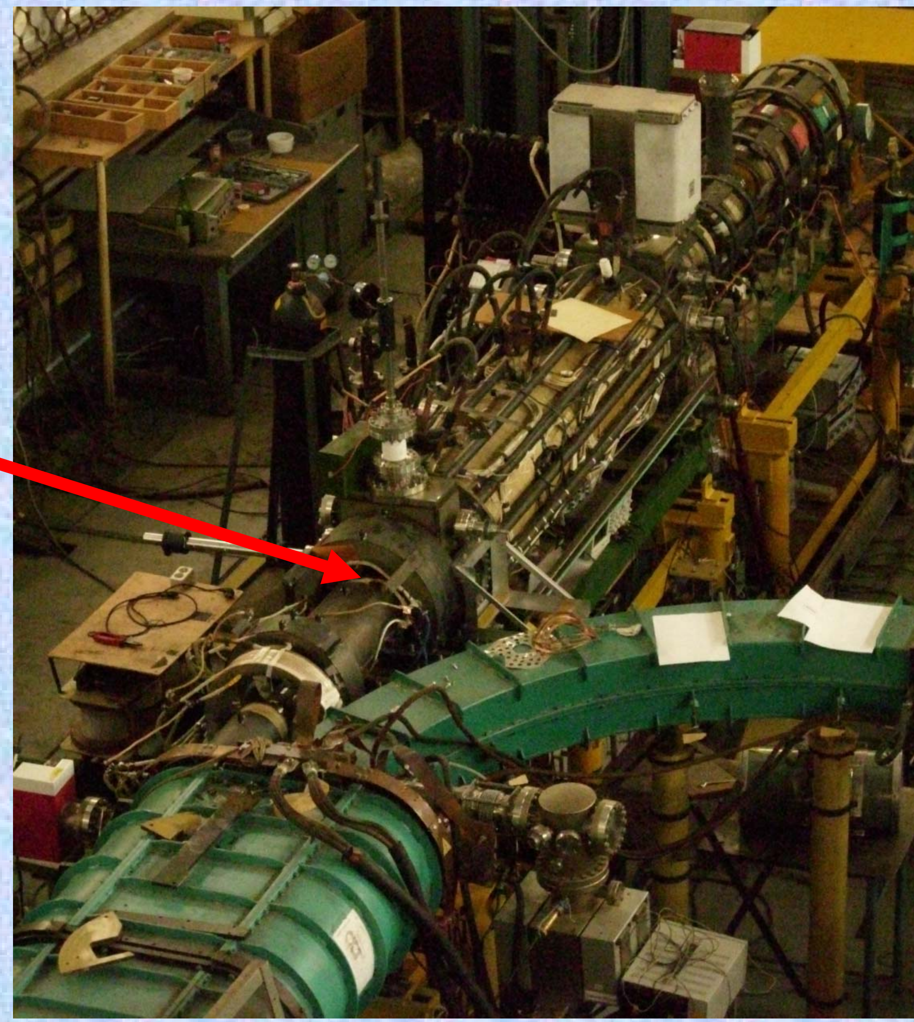
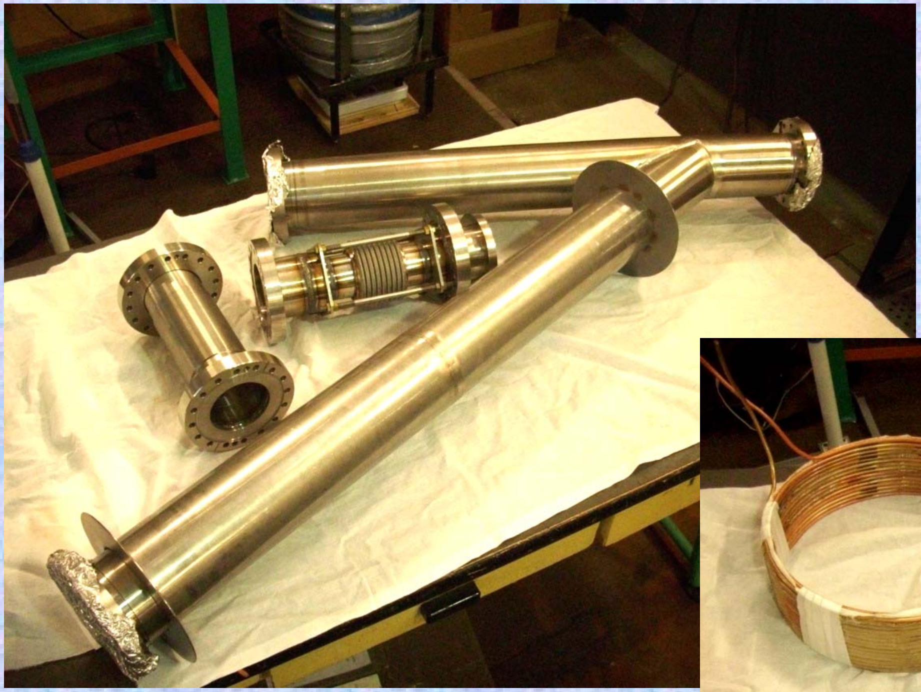




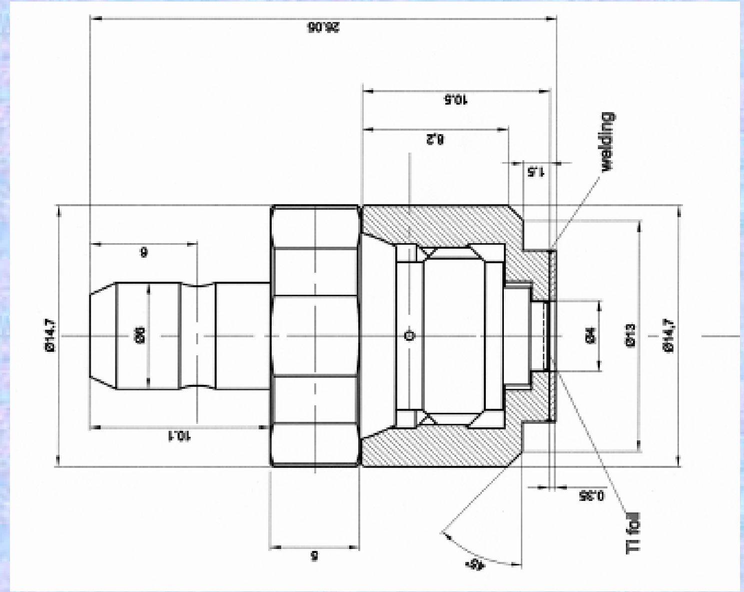
5. Positron Injector Development



5. Positron Injector Development

New positron source from iThemba LABS (SAR)

July 2015



New positron source of the activity of 30 mCi for LEPTA facility

6. Nearest Plans

- Testing new positron emitter 22Na with existing cryosource
- Testing new cryogenic source
- Assembling the new PAS channel
- Positron injection into the ring and formation circulating positron beam

Thanks for your attention !