V 2.1

High pressure hydrogen cavity test

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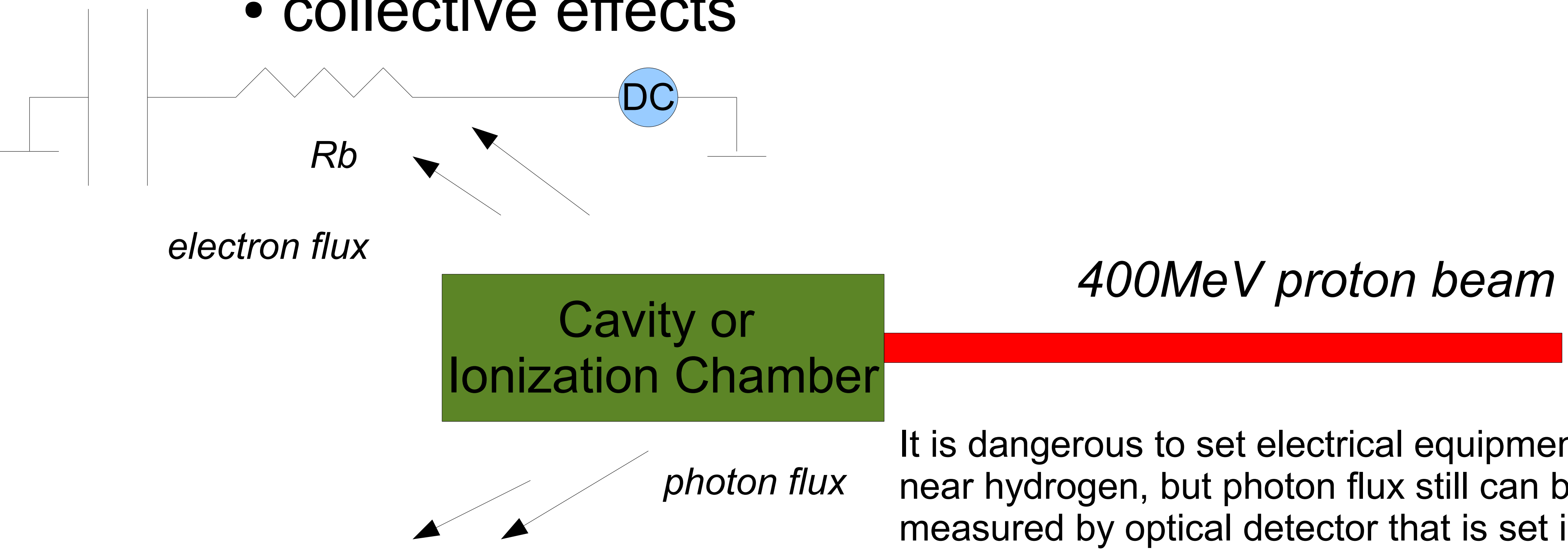
HPRF cavity test

My task was...

- electron current (due to ionization)
- radiation (optical measuring)
- transport channel-cavity misalignment
- collective effects



It is dangerous to set electrical equipment near hydrogen, but photon flux still can be measured by optical detector that is set in the save area.

The main purpose is to check cavity's behavior under high pressure, but we also should know the radiation level.

Future μ - colliders

What we should know about muons?

- leptons

no inner structure and, consequently, larger amount of energy per collision

- 207 times heavier than e

synchrotron radiation is greatly reduced in comparison with e, that's why one can use a circular machine

- not stable

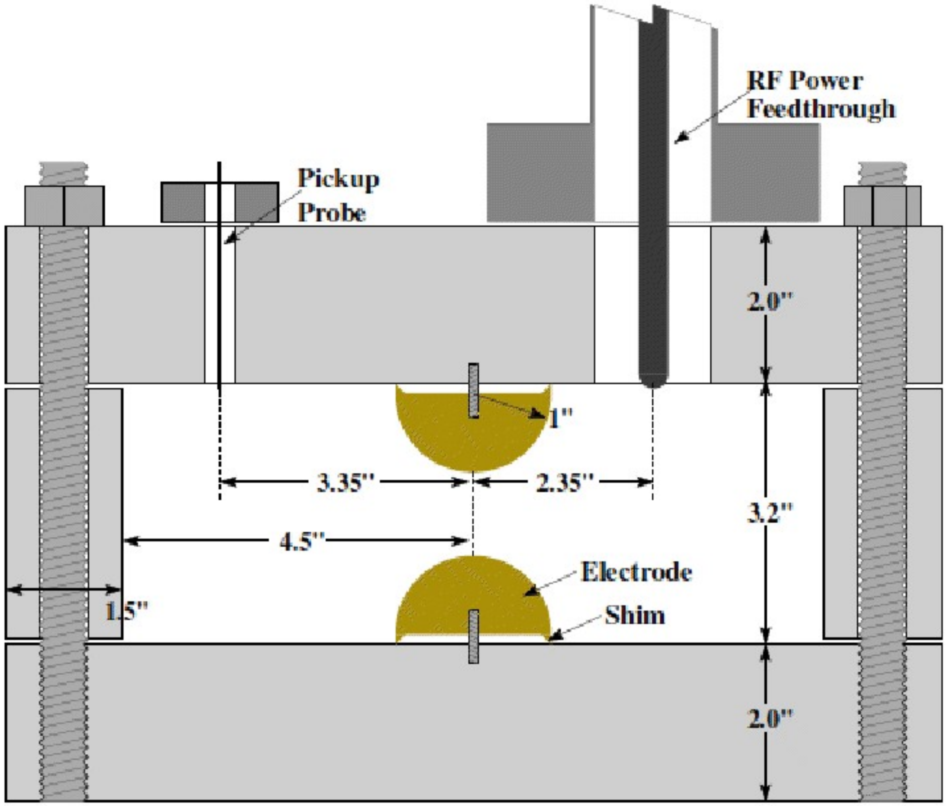
finite lifetime require a high gradient acceleration

- initial beam is "hot"

μ are produced via π decay and the initial beam has quite big transverse momentum components. It's not good both for acceleration (high dynamic aperture is required) and for colliding (low luminosity).

New approach in RF cavity design

HPRF = High Pressure Radio Frequency



Features

- P = 1...100 ATM
- Filled with hydrogen

Expected Benefits

- High electric field gradient
- Operation in magnetic field (tested under 4T)
- Ionization cooling

Beam-Matter interaction (1)

main effects due to the beam interaction and their analytical estimations are

- ionization losses (Bethe formula)

$$\frac{dE}{dt} \approx 6.3 \frac{MeV}{g/cm^2}$$

- appearing of delta electrons

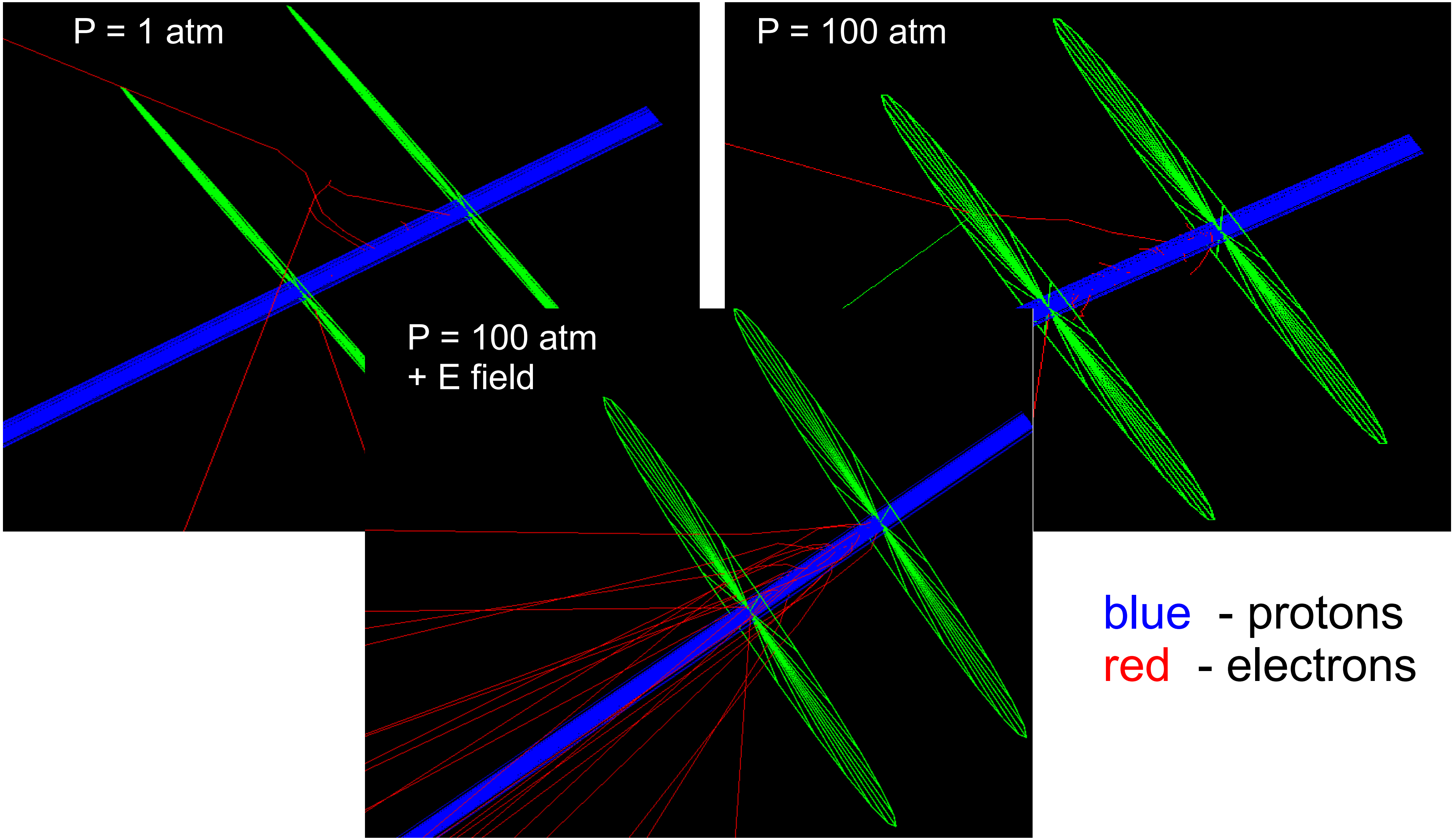
i. e. with enough energy for further ionization (>15eV)

In our case just several percents of total energy losses are carried by these electrons

- *total ionization* $N_{total} \approx \frac{dE}{W} \approx 10^3 (100\, atm)$

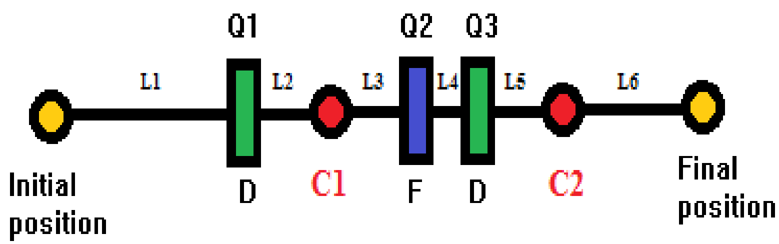
Beam-Matter interaction (2)

A sample of using G4beamline for beam-matter simulations,
here the cut-off energy for appearing electrons is 990 eV



blue - protons
red - electrons

Transport channel misalignment (1)



Solution of a linear problem is

$$X_{final} = T_3 \cdot T_2 \cdot T_1 \cdot X_{initial} + T_3 \cdot T_2 \cdot (0, \theta_1) + T_3 \cdot (0, \theta_2)$$

-quadrupole strength errors (1)
-space misalignment (2)
-rotation (3)

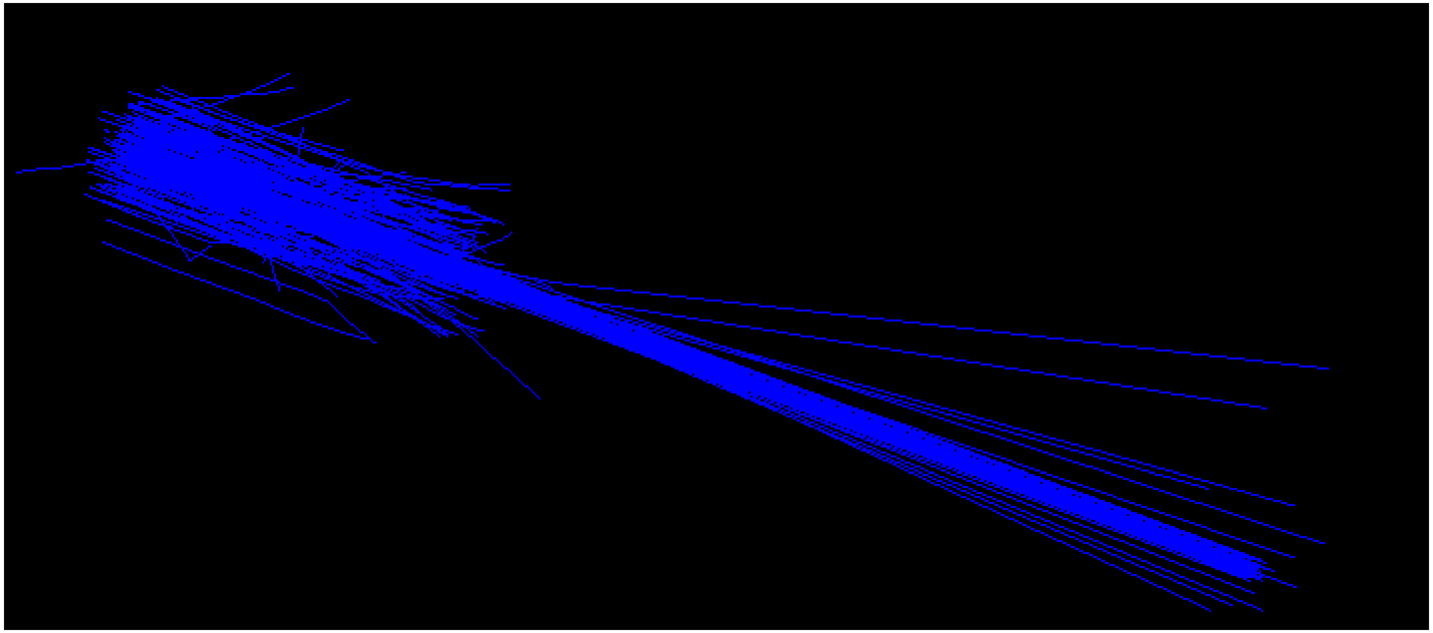
possible kinds of errors

simulations based on elegant tracking code give...

(1) small errors in K1 do not contribute a lot
(2) DX=0.001 for Q1 <=> <x> ~ 1e-3, <xp> ~ 1e-4
the same story for DY displacement and not sensitive to DZ
(3) small rotation doesn't effects mean beam position

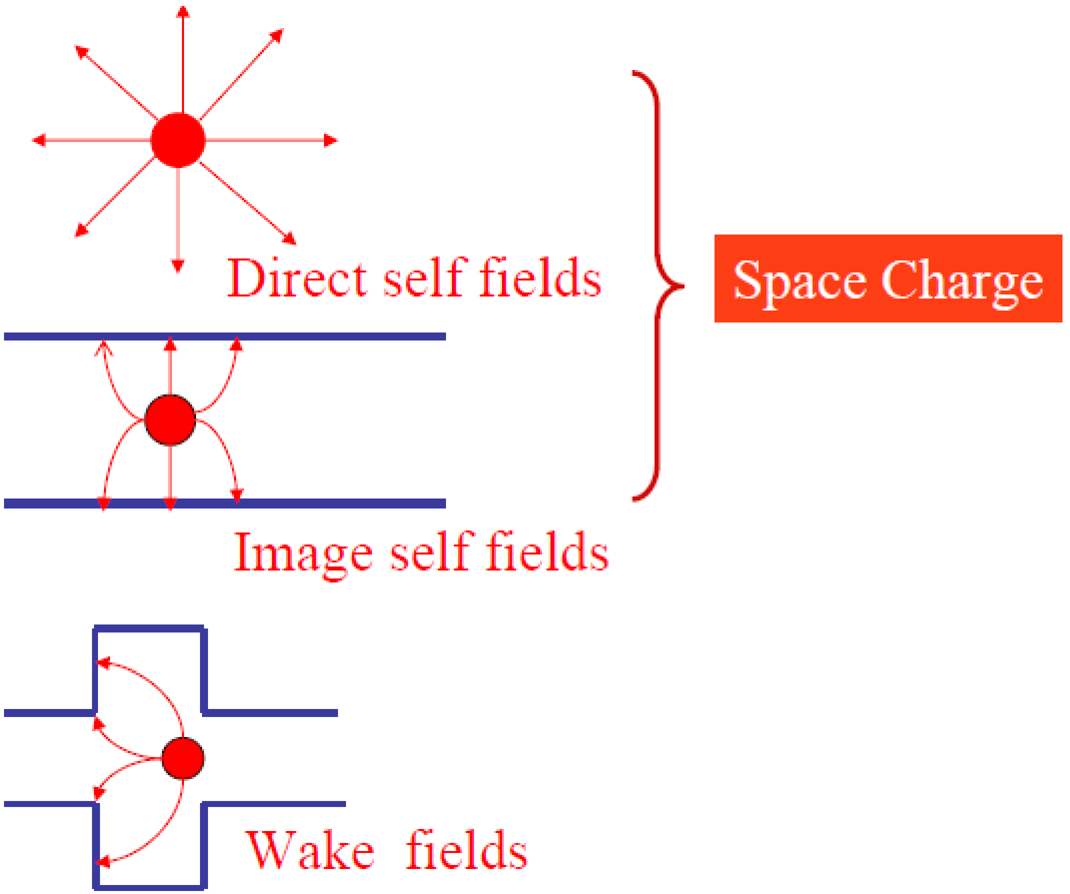
Transport channel misalignment (2)

This is a beam with zero angular distribution passing thought 200 mm Fe collimator.
Note that angular spread appears!



More harmful thing to appear is collimator misalignment instead of quad one.
Such errors will strongly influence the radiation level.

Collective effects (3)



$$F_r = e\left(E_r - \beta c B_\vartheta\right) = e\left(1 - \beta^2\right)E_r = \frac{eE_r}{\gamma^2}$$

Conclusion

1) estimations for beam-hydrogen interaction are made:

- ionization losses
- ionized electron and total ionization
- G4beamline was implemented to simulate processes in HPRF

2) beam-lattice misalignment is in process,
but we already know:

- how to solve a pure linear problem
- gradient errors and longitudinal quads displacements
  as well as small quad's angular rotation don't contribute a lot
- transverse quad's displacements can result in beam's shift up to a centimeter
  and appearing of an angle about 1e-3 (and it can be fixed experimentally)
- beam reserves an angular spread while passing thought collimator
- collective effects are in process (PARMILA and theory)