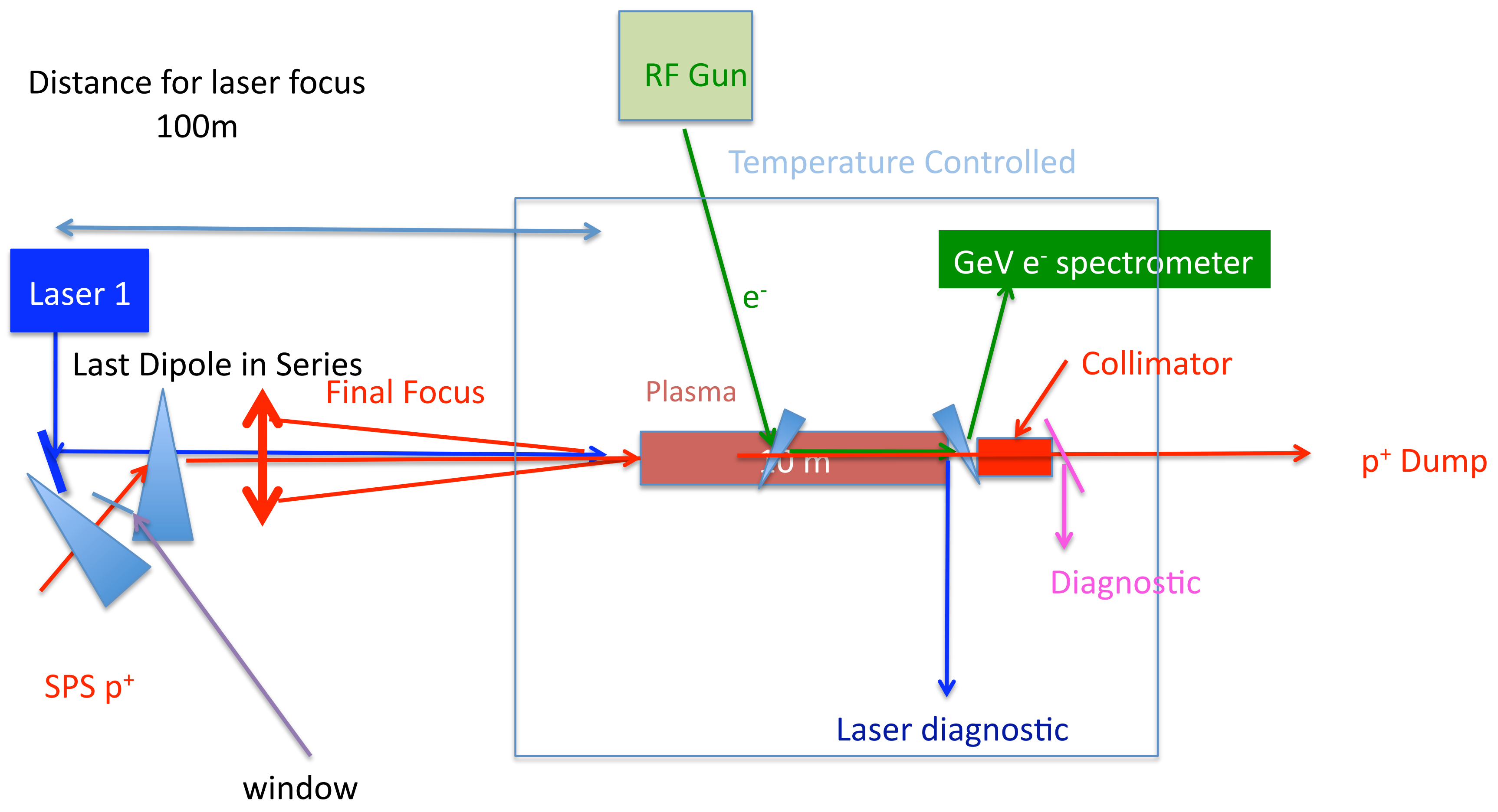
Introduction
June 21, 2012

1. News
   a) CERN Project Leader: Edda Gschwendtner
   b) Discussions leading to nominal design
   c) Selected news
2. This meeting
   a) Definition of tasks/organization teams for beams & expt areas
   b) Discussion West area vs CNGS
   c) Define steps & timeline towards CDR
   d) Task group leaders & coordinators (in CB)
3. Miscellaneous
   a) Name/logo competition

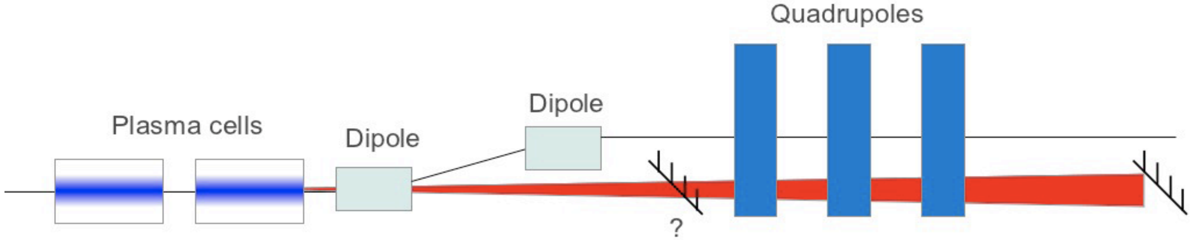
Allen Caldwell
Max-Planck-Institut für Physik

Patric will review discussions leading to this design

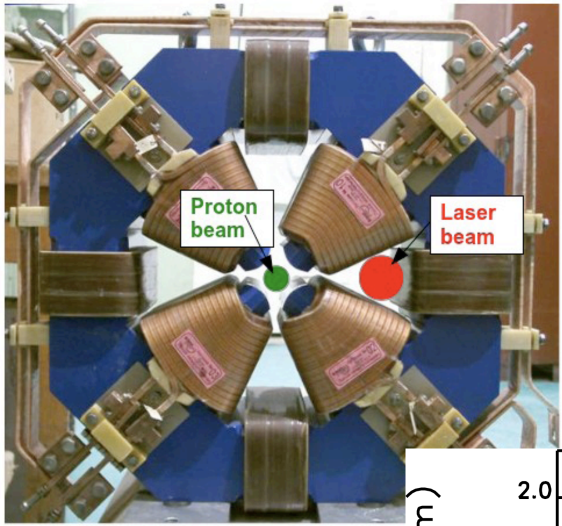


NOT TO SCALE!

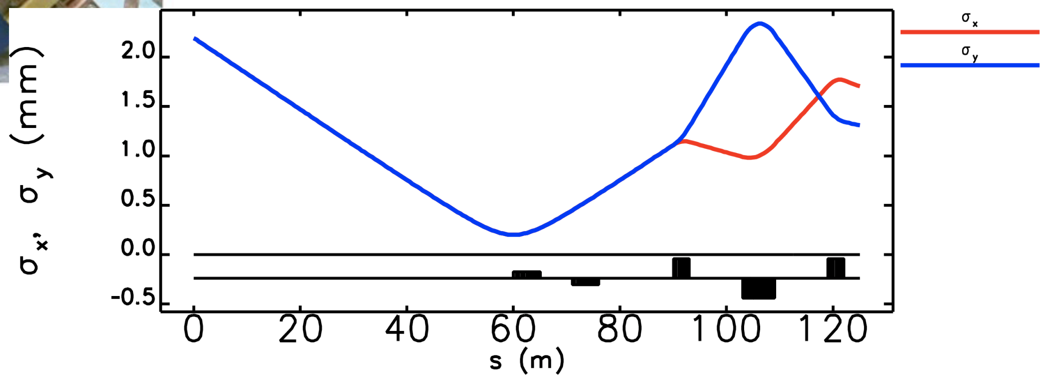
P. Muggli

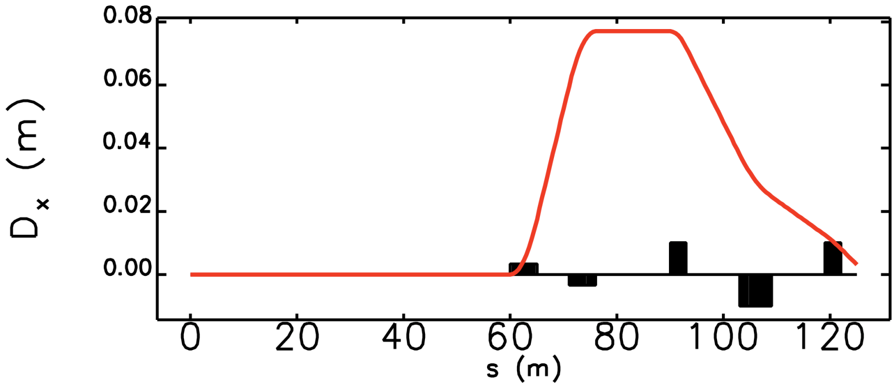


This option does not require expensive large-aperture dipoles and quadrupoles

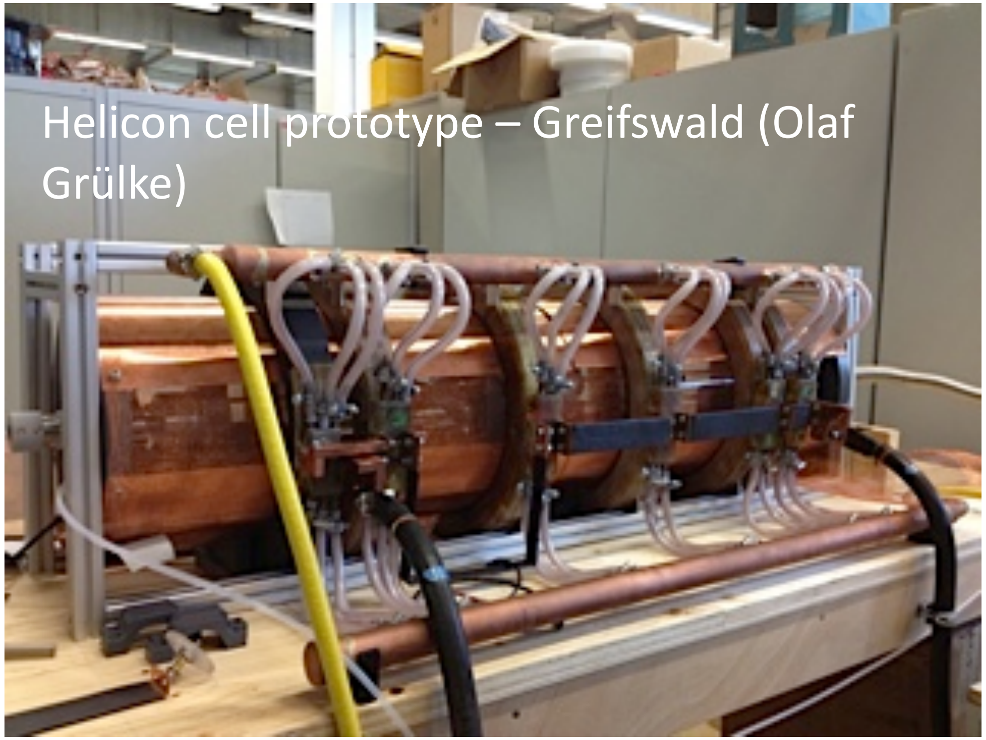


First look at final focus of proton beam (Alexei Petrenko).

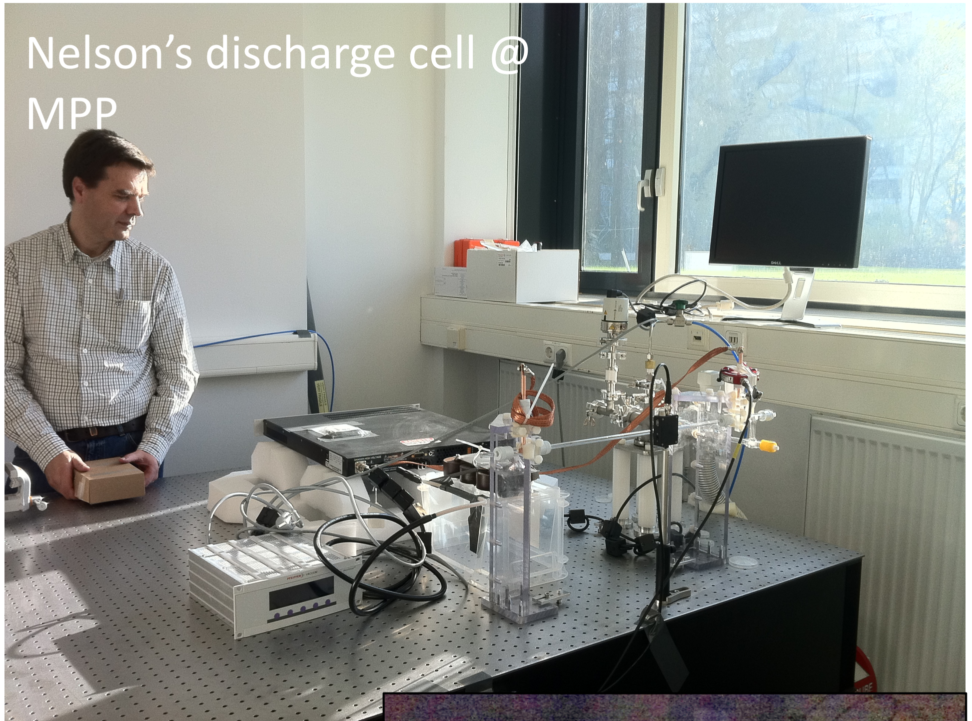




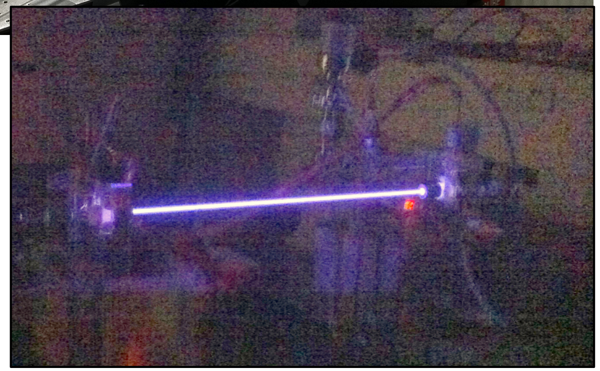
Plasma cell R&D

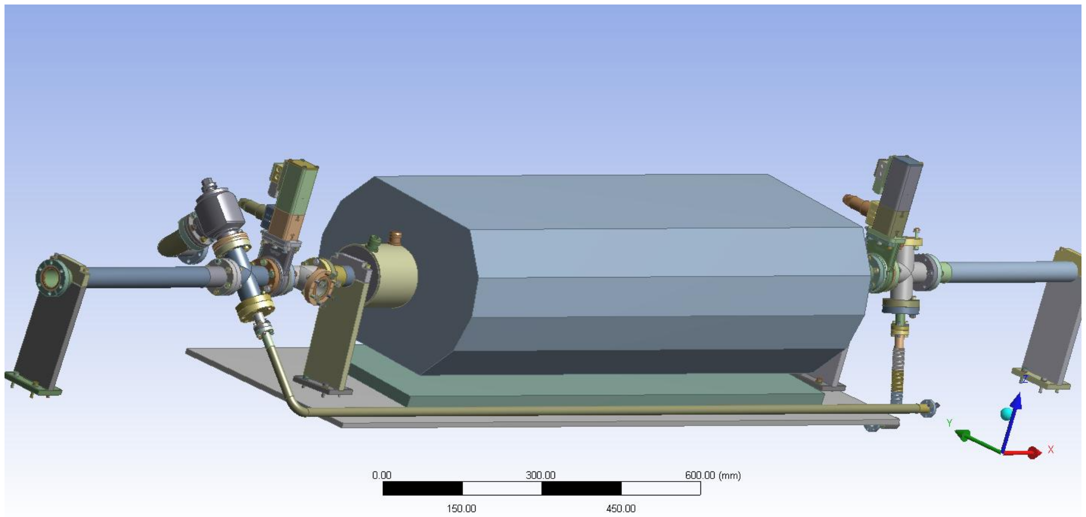


Helicon cell prototype – Greifswald (Olaf Grülke)



Nelson's discharge cell @ MPP



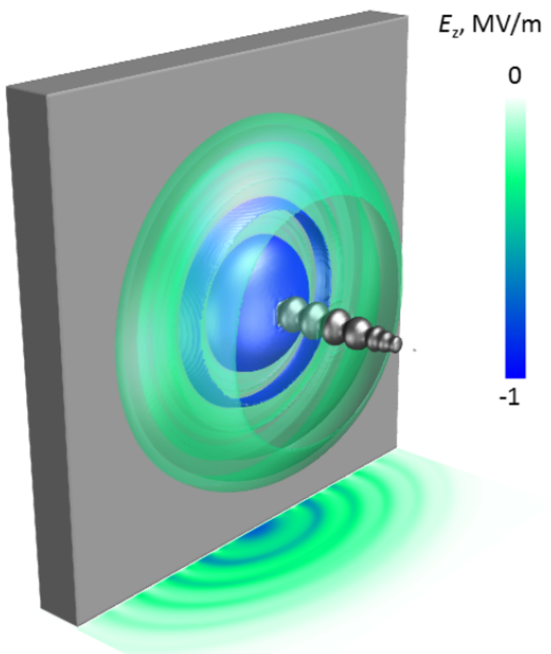


Heat pipe oven concept + vapor cell
E. Öz, P. Muggli

Transverse Coherent Transition Radiation (TCTR)

Introduced by A . Pukhov

- Coherent Transition Radiation emitted radially around a charged beam along the surface of a (metallic) screen
- Normal (to the screen) electric field component
- Dipole-like radiation pattern
- Can be modulated by beam density



Picture taken from the paper

arXiv:submit/0475902 [physics.acc-ph] 16 May 2012

Transverse coherent transition radiation for diagnosis of modulated proton bunches

A. Pukhov and T.Tueckmantel
Insitut fuer Theoretische Physik I, Universitaet Duesseldorf, 40225 Germany

Transverse coherent transition radiation (TCTR) emitted by a relativistic particle bunch traversing a conducting surface is analyzed. The bunch emits dipole-like radiation in the direction transverse to the bunch axis when the beam radius is smaller than the radiation wavelength. The radiation wavelength is defined by the longitudinal structure of the particle bunch. The particular case of proton bunches modified by propagation in plasma, but still carrying an unmodulated current is considered. Radius-modulated bunches with a constant current emit axially symmetric radiation. Hosed bunches emit antisymmetric radiation in the plane of hosing. The TCTR field amplitude may reach 100 kV/m for the existing proton bunches.

PACS numbers: 41.60.Dk, 52.40.Mj

Coherent transition radiation (CTR) is one of the most common techniques used for diagnosis of a longitudinal structure of charged particles bunches [1–5]. The method particularly demonstrated its power to characterize accelerated electron bunches in laser-plasma experiments [6–8]. An elementary charge propagating through a medium with a particular dielectric permittivity is dressed by a field matched to that medium. When the charge traverses a sharp boundary of two media with different permittivities, its field must be adjusted. The unmatched field can be radiated. The strongest radiation is observed when a charge passes a boundary between a conductor and vacuum. A point-like relativistic charge with the relativistic factor γ emits a radiation burst that is collimated within a cone with the opening angle $\theta \approx 1/\gamma$ around the axis, although the emission is exactly zero in the propagation direction itself. The radiation is broadband. A bunch of particles can emit this radiation coherently at the wavelength comparable with its longitudinal structure.

Recently, a concept of proton bunch-driven plasma wake field accelerator has been put forward [9–11]. In this concept, a long proton bunch is sent through plasma where it undergoes self-modulation at the plasma wave period and excites a strong resonant wake field. A test experiment is in preparation at CERN. One of the experimental challenges will be the detection and characterization of the proton bunch modulation after it exits the plasma cell.

The nature of the proton bunch modulation is such that the proton bunch radius is modulated, but the total bunch current remains the same in each cross-section. For this reason, there will be no signatures of the proton bunch modulation in the forward coherent transition radiation. The classic forward CTR is cast useless in this case. Moreover, it is important in the experiment to distinguish between the axisymmetric modulation mode when the radius of the proton bunch is changing periodically [11] and the possible hosing mode when the proton bunch centroid oscillates periodically in the transverse plain [12].

Below we show that the transverse coherent transition radiation (TCTR) does contain the signature of the bunch modulation and allows to distinguish between the axisymmetric modulation mode and the hosing. The TCTR is emitted perpendicularly to the particle bunch propagation direction and its amplitude does not depend on the particles γ–factor as soon as it is large enough.

ORIGIN OF TRANSVERSE TRANSITION RADIATION

Let us consider a transition radiation emitted by a particle bunch as it traverses normally a conductor plate. The interaction geometry is illustrated in Fig. 1. When an elementary charge dq exits from the conducting plate in the normal direction with the velocity $\mathbf{v}$, the radiated field is given by the formula (63.8) from the Landau textbook [13]:

$$\mathrm{d}\mathbf{E} = \frac{dq}{c^2\left(R - \frac{\mathbf{R}\mathbf{v}}{c}\right)^3}\mathbf{R} \times \left[\left(\mathbf{R} - \frac{\mathbf{v}}{c}R\right) \times \frac{d\mathbf{v}}{dt'}\right] + \frac{dq}{c^2\left(R + \frac{\mathbf{R}\mathbf{v}}{c}\right)^3}\mathbf{R} \times \left[\left(\mathbf{R} + \frac{\mathbf{v}}{c}R\right) \times \frac{d\mathbf{v}}{dt'}\right] \quad (1)$$

where t' is the retarded time so that

$$t' + R(t')/c = t. \quad (2)$$

The second term in Eq. (1) is generated by the image of the physical charge in the conducting plate.

When the elementary charge is inside the metal plate, its field is completely screened. Thus, the current is created abruptly when the charge exits into the free space. We can write for the velocity $\mathbf{v}(t') = \mathbf{v}_0\Theta(t' - t_0)$, where t_0 is the time the charge exits into vacuum and $\Theta(t)$ is the Heaviside step function.

The denominators in Eq. (3) suggest that a point-like charge emits the strongest field at the angle $\theta \approx 1/\gamma$ around the propagation direction. Yet, we will be not interested in the emission in this direction, because it does

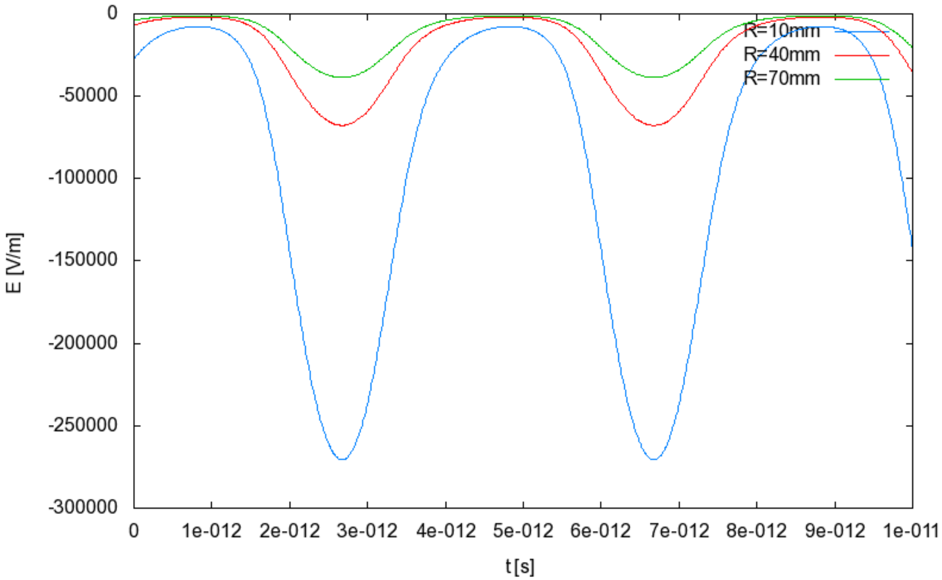
TCTR in combination with EO-sampling

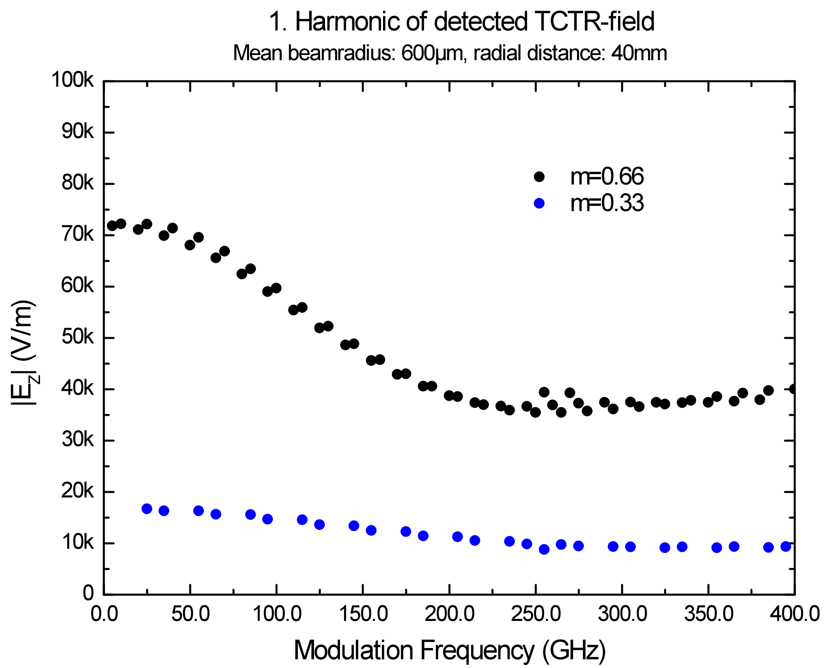
Investigated by O. Reimann

- Electric fields with amplitudes up to hundreds of kV/m at a distance of 10mm
- Signal is to first order proportional to the beam density
- High frequencies (several hundred GHz)
  $\longrightarrow$ Make use of electrooptic sampling
- But: No simple frequency response curve

$$E_z(\omega, R_0) = \frac{e v_0^2}{\pi c^2 R_0} \exp(j\omega(-\frac{R_0}{c}) \int \int \exp(j\omega \frac{\rho}{c} \cos(\phi)) \tilde{n}(\omega, \mathbf{r}) \rho \, d\rho \, d\phi$$

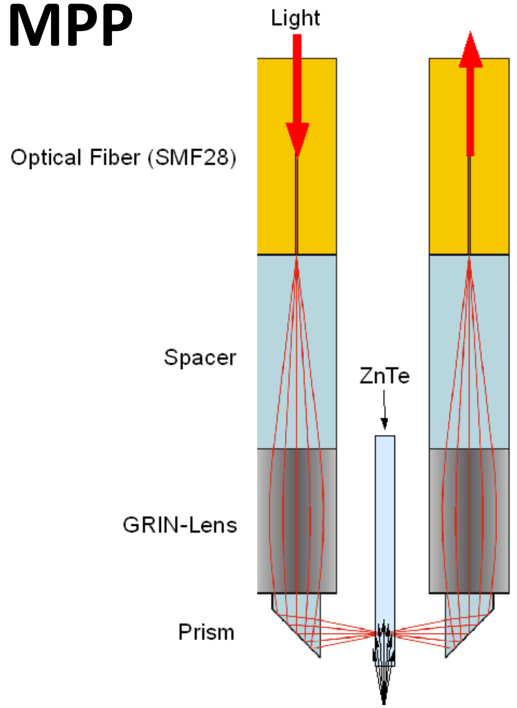
Typical E-field for TCTR at different radial distances





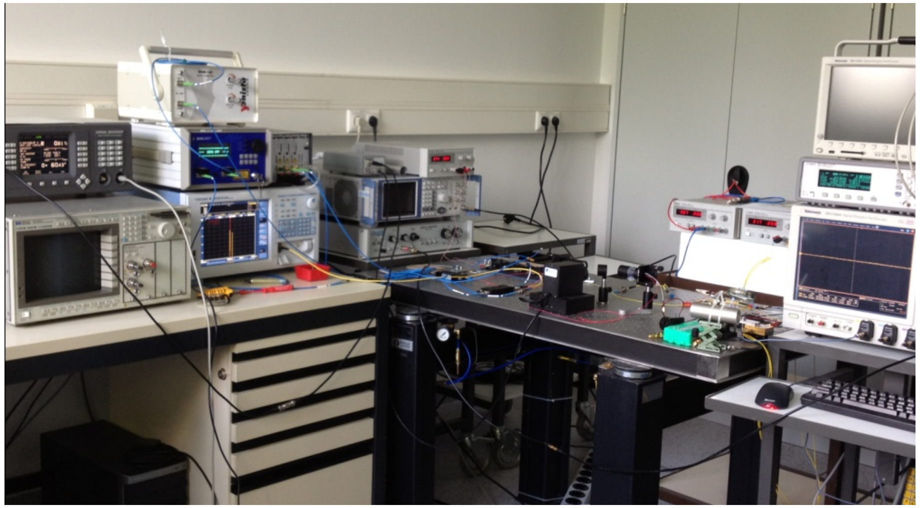
Development of EO-sampling (for TCTR) at MPP

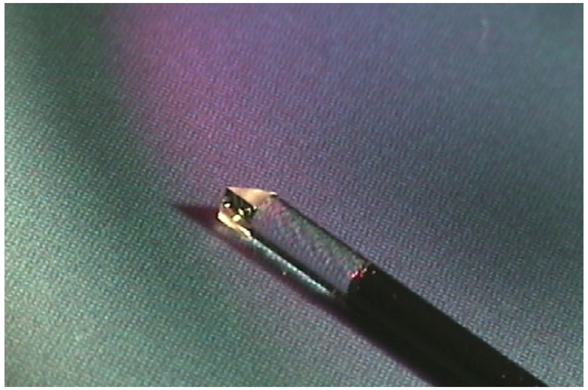
- Using dispersive Fourier-transform
- First test setup is working fine
- Development of special probes in the near future



Probe setup with a "closed" optical path using GRIN-Lenses and prisms:
Possible length of probe in longitudinal (beam) direction: < 1cm

EO-sampling and plasma density measurement at MPP

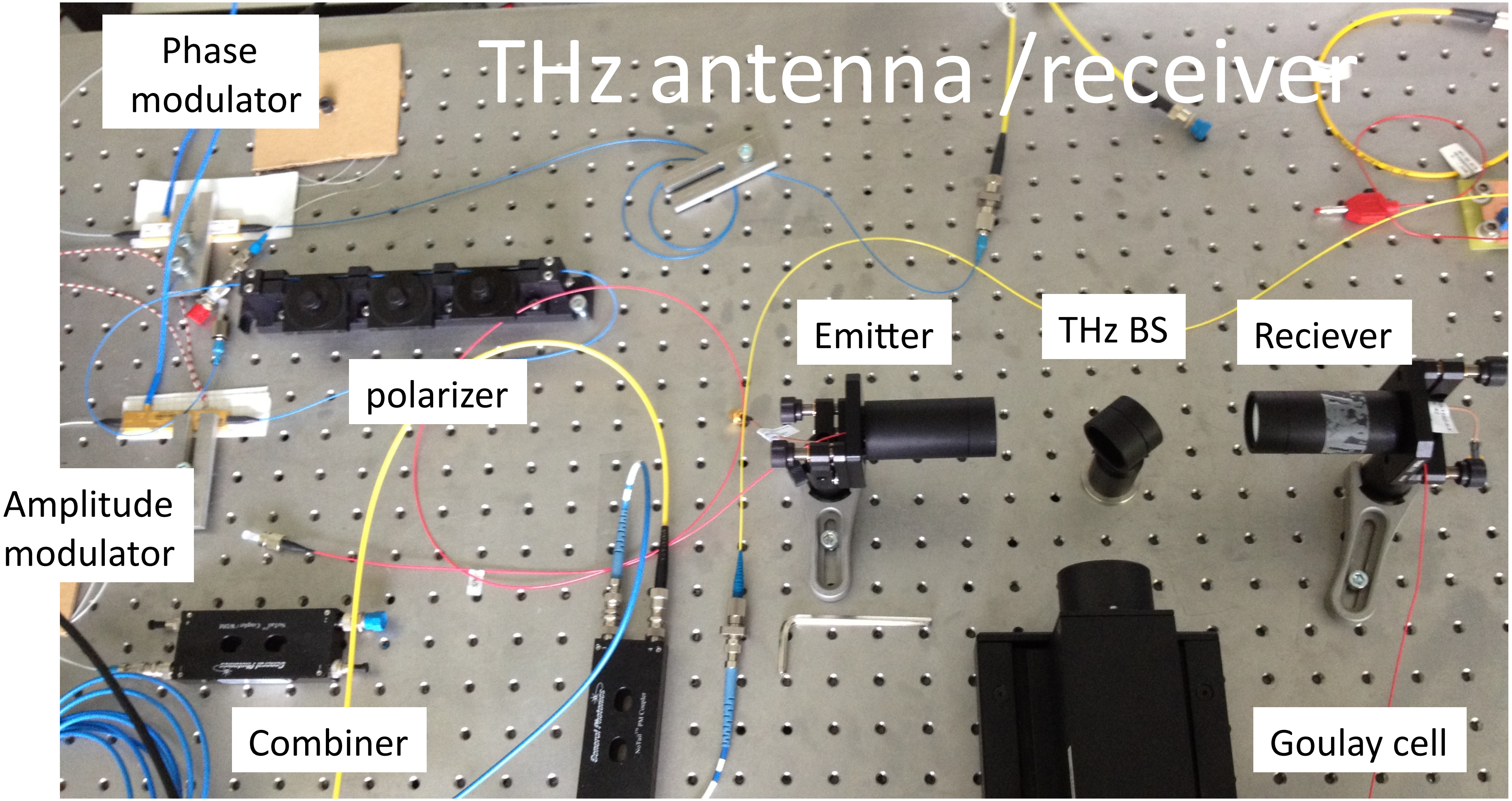


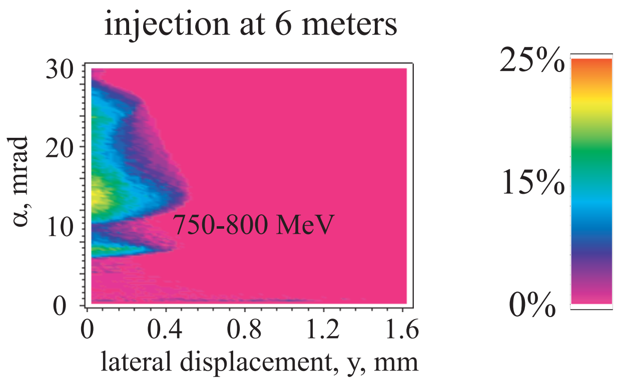


GRIN-Lens with prism (GRINTECH)

O. Reimann + R. Tarkeshian

MPP Diagnostics Lab (R. Tarkeshian)

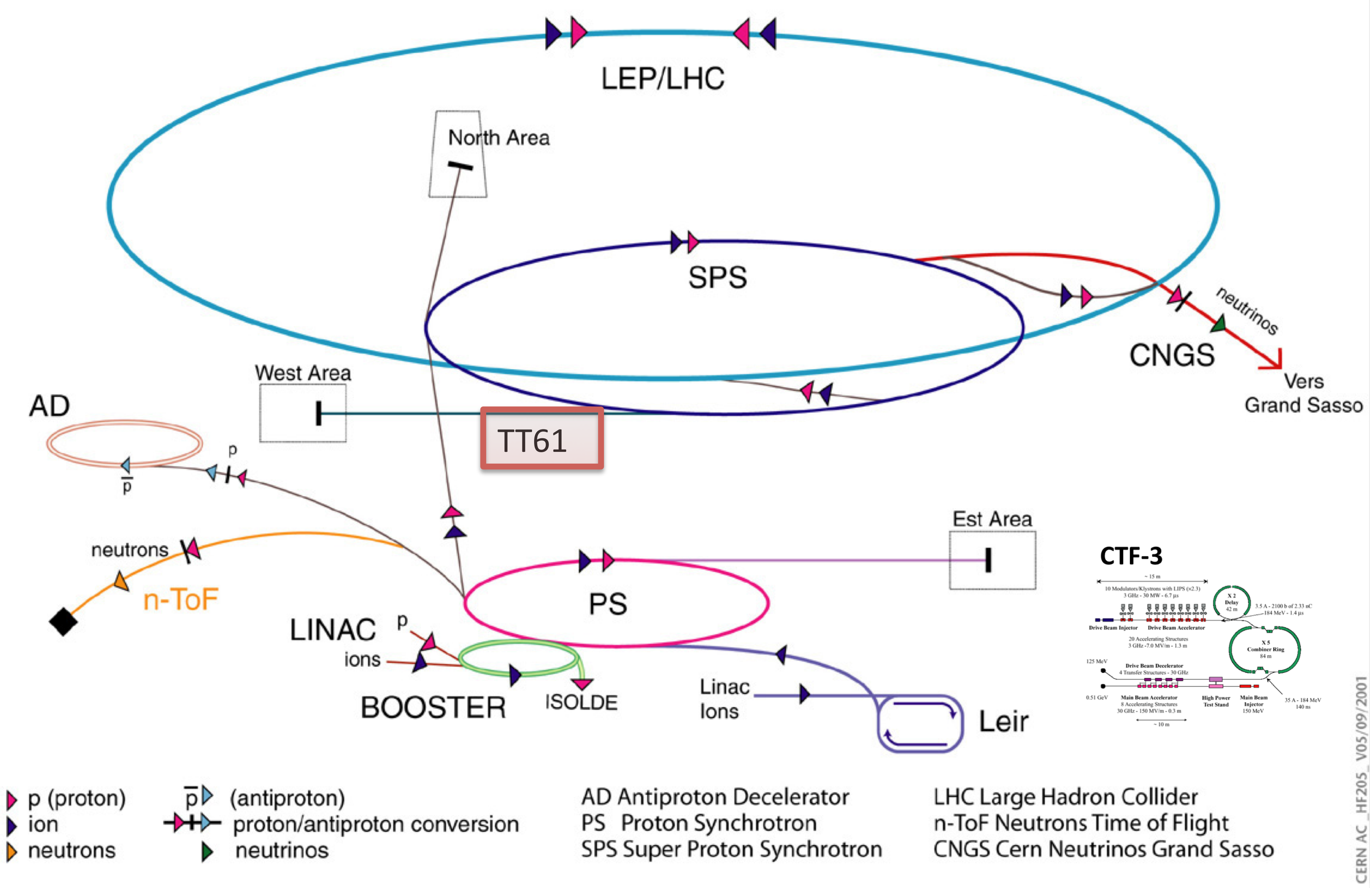




Acceptance study for electrons in plasma at different energies (Konstantin).

Later today – electron source studies (Tim Noakes)
- scattering in entrance window to plasma (Scott Mandry)

Accelerator chain of CERN (operating or approved projects)



p (proton)
ion
neutrons

p̄ (antiproton)
proton/antiproton conversion
neutrinos

AD Antiproton Decelerator
PS Proton Synchrotron
SPS Super Proton Synchrotron

LHC Large Hadron Collider
n-ToF Neutrons Time of Flight
CNGS Cern Neutrinos Grand Sasso

Milestones

Oct 2012 (Technical Design Report) → **Conceptual design report**

Demonstrate at least one technology for a 1m long plasma cell with 10^{14} cm^{-3} density, uniformity better than 5%

Define seeding scenario in 3D simulations, define experimental test

Technical design of electron beam injection into plasma + spectrometer + dump + proton beam line.

Radiation and safety study.

Layout of experimental area (p delivery&dump, e injector+spectrometer +dump, plasma cell, diagnostics, lasers)

Form Collaboration & commit on work packages for CERN & collaborators.

Milestones-Continued

Dec 2013

Demonstrate at least one technology for a plasma length 5m with 10^{15} cm^{-3} , uniformity better than 2%, define baseline choice(s)

Demonstrate seeding in experimental tests, define baseline

Dec 2014

Demonstrate 1% uniformity and complete operational plasma cell(s)

installation of switch/delivery into TT61 by end of LHC shutdown

Aug 2015

Installation of beam lines, experimental area

Sep 2015

Beam commissioning, first beam to plasma

Logos & Names

WAKE

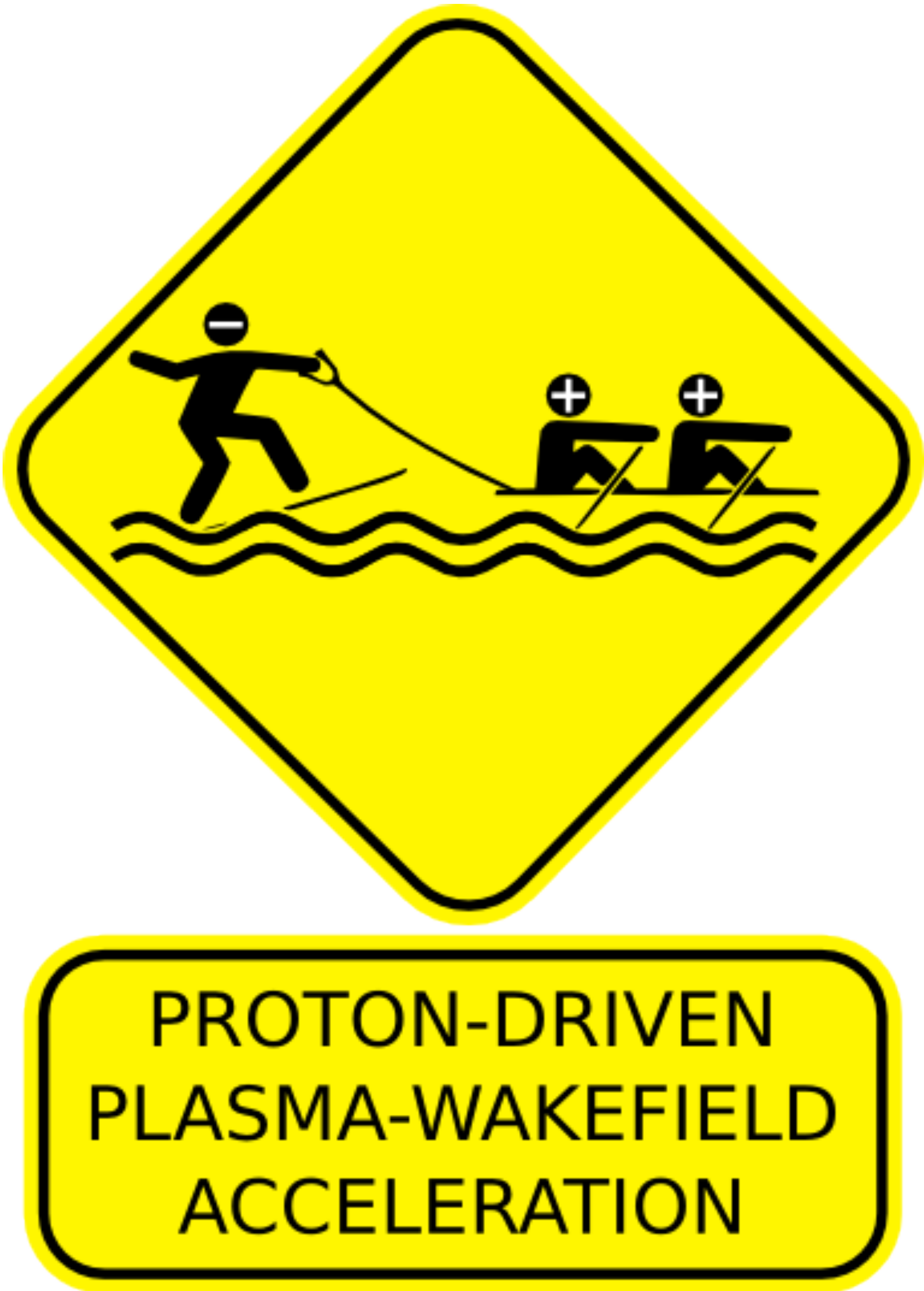
PROTON DRIVEN PLASMA WAKEFIELD ACCELERATION

WAKE

PADPAW

PROPEL

WAKE


PROTON-DRIVEN
PLASMA-WAKEFIELD
ACCELERATION