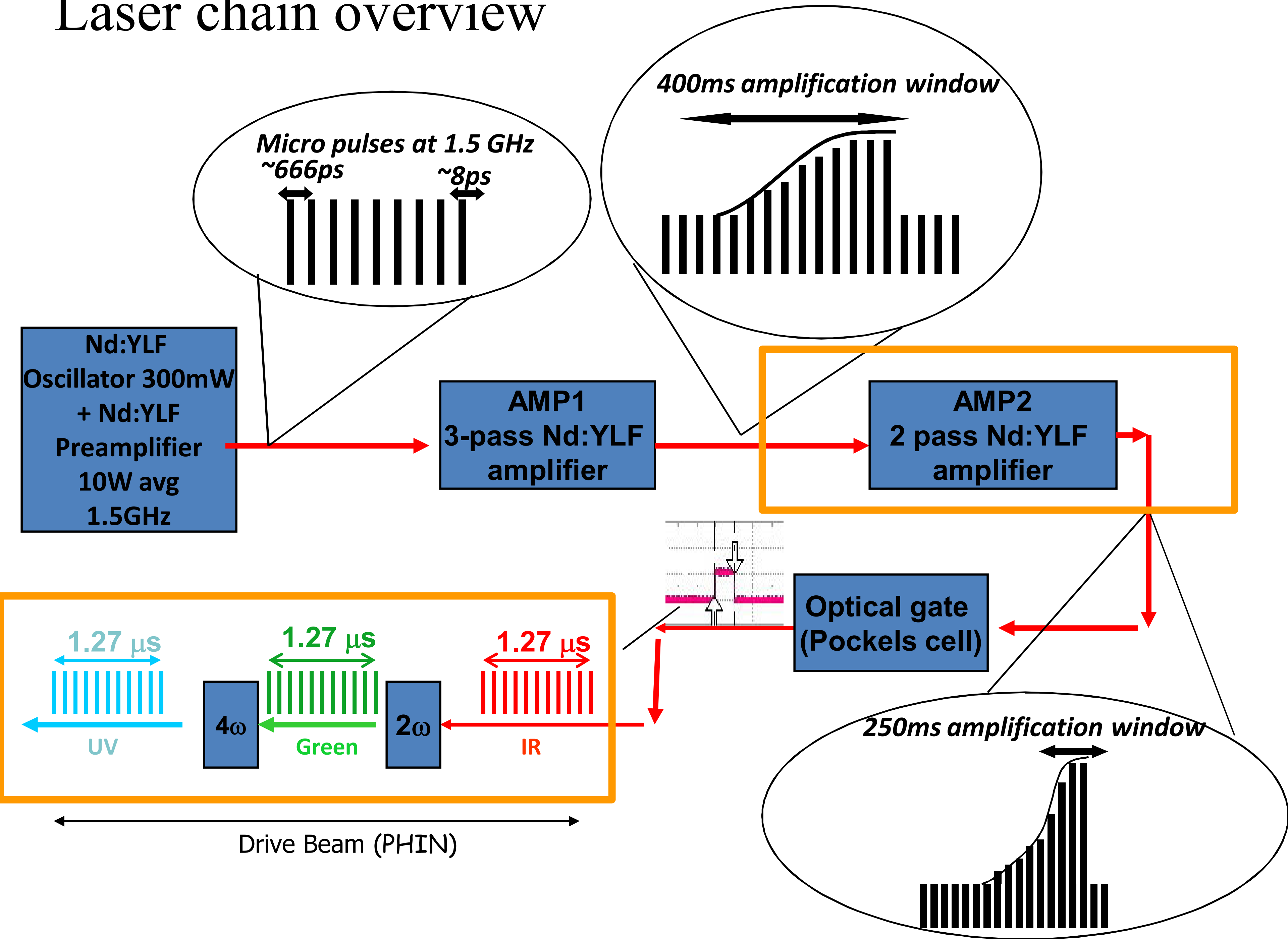
Advancement in photo-injector laser: Second Amplifier & Harmonic Generation

M. Petrarca
CERN
M. Martyanov, G. Luchinin, V. Lozhkarev
Institute of Applied Physics, Nizhny Novgorod, Russia

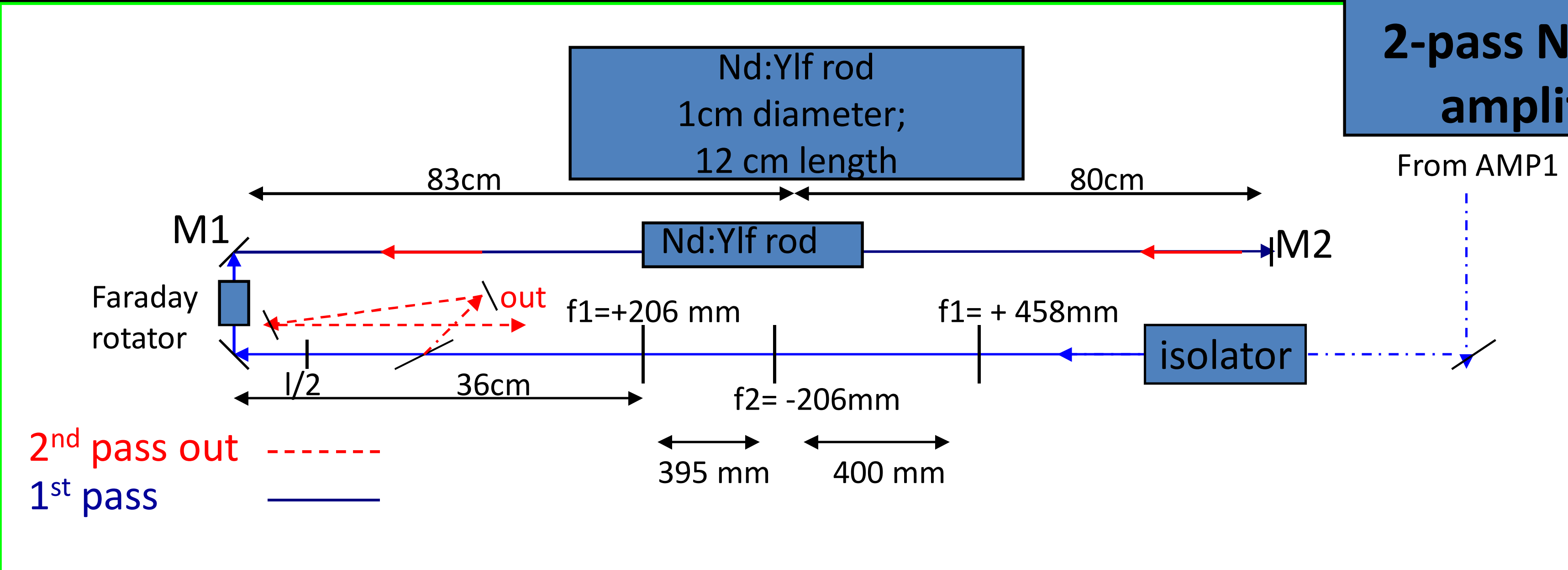
V. Fedosseev
CERN

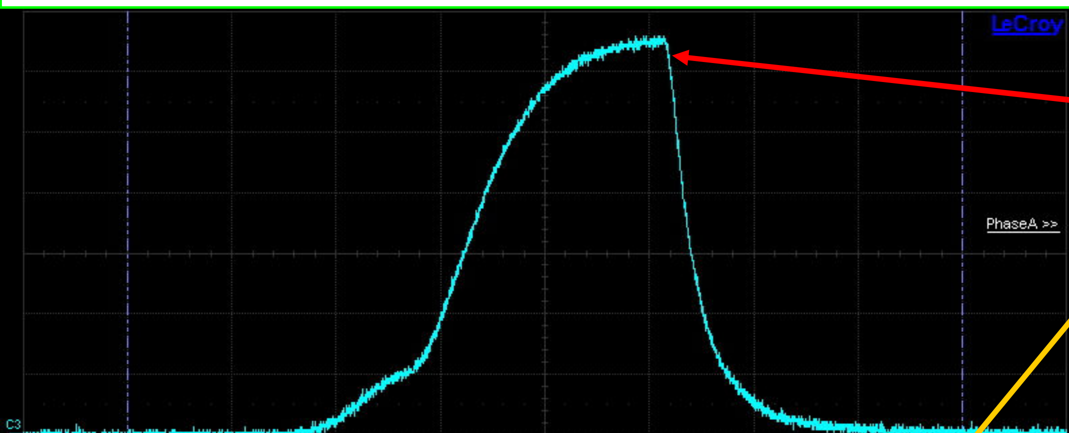
CERN
18 June 2009

Laser chain overview

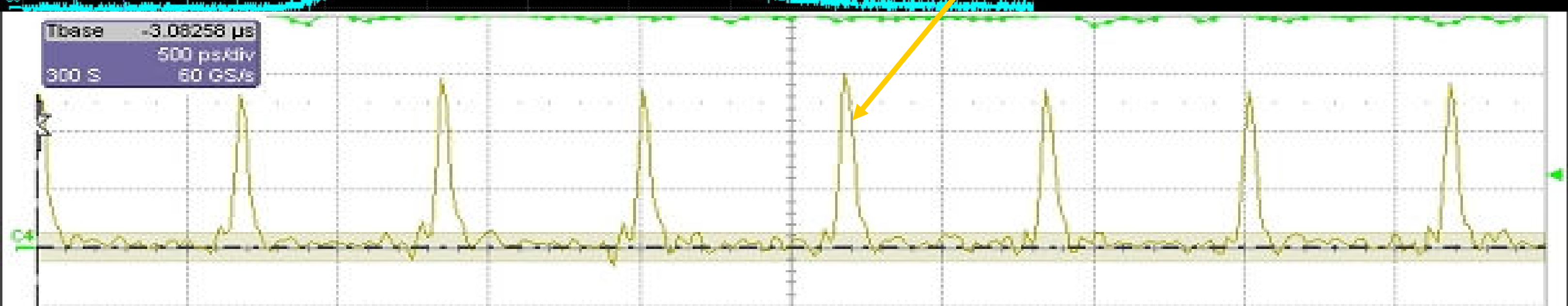


AMP2 2-pass Nd:YLF amplifier



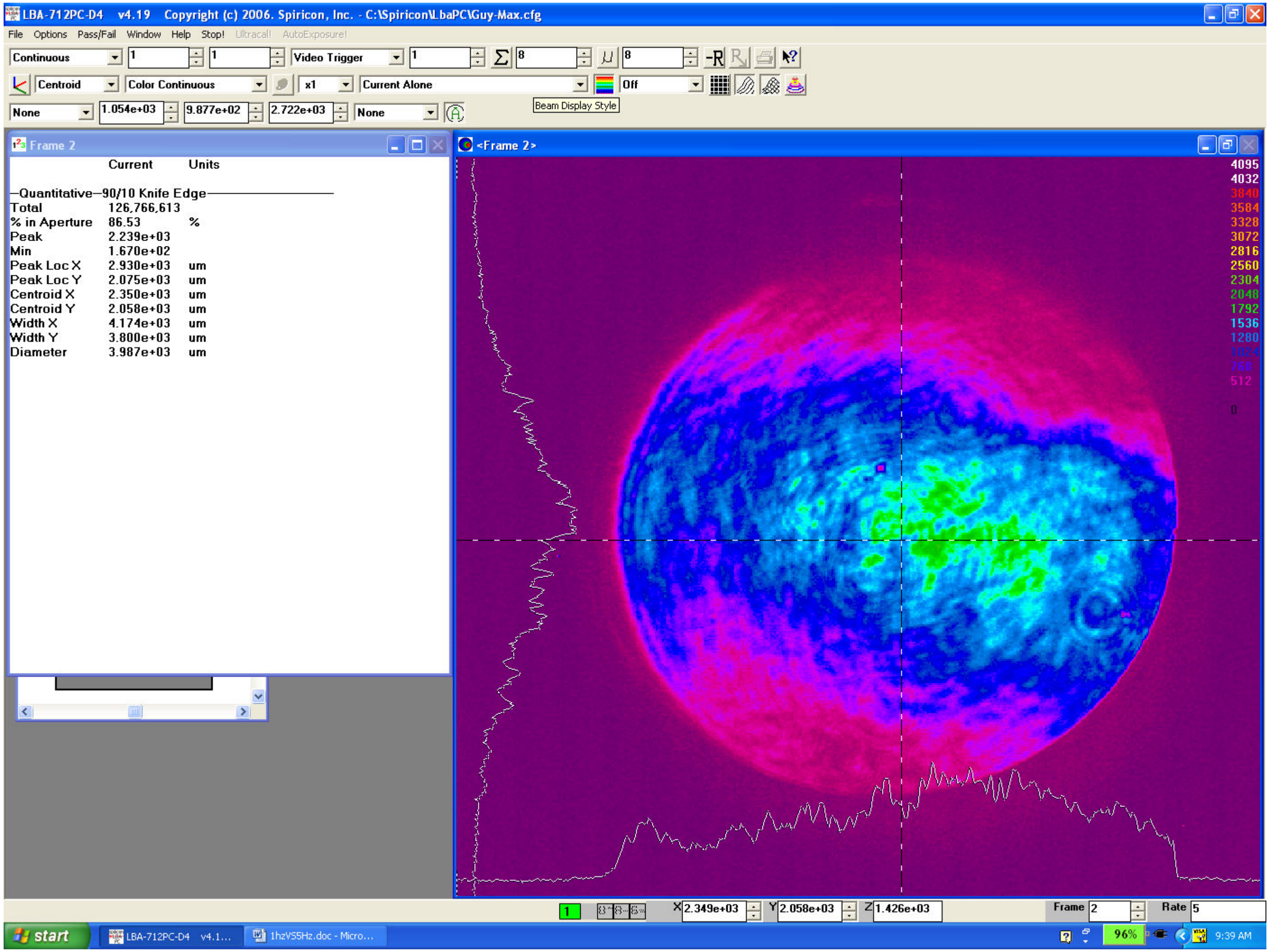


•~8.5KW peak power (pumping diodes @90amps)



•~6µJ micro pulse energy (4µJ old value)

Transverse beam profile:
Imaging rode from 1st passage amplification



Harmonic Conversion (overcoming pulse pickers)

FHG:

For 500 ns macro pulse duration; rms UV energy fluctuaction (1-2)%:

KDP 7.5 mm: E_g=1.45mJ→ E_{UV} =0.44mJ → ~580nJ micro bunch

KDP 10 mm: E_g=1.45mJ→ E_{UV} =0.54mJ

BBO 11 mm: E_g=1.45mJ→ E_{UV} =0.47mJ

ADP 20 mm: E_g=1.49mJ→ E_{UV} =0.61mJ

ADP 7.5 mm: E_g=1.45mJ→ E_{UV} =0.60mJ → ~800nJ micro bunch

For 1300ns macro pulse duration rms UV energy fluctuations (1-2)% :

ADP 15 mm: E_g=3.6mJ→ E_{UV} =1.3mJ → ~666nJ micro bunch

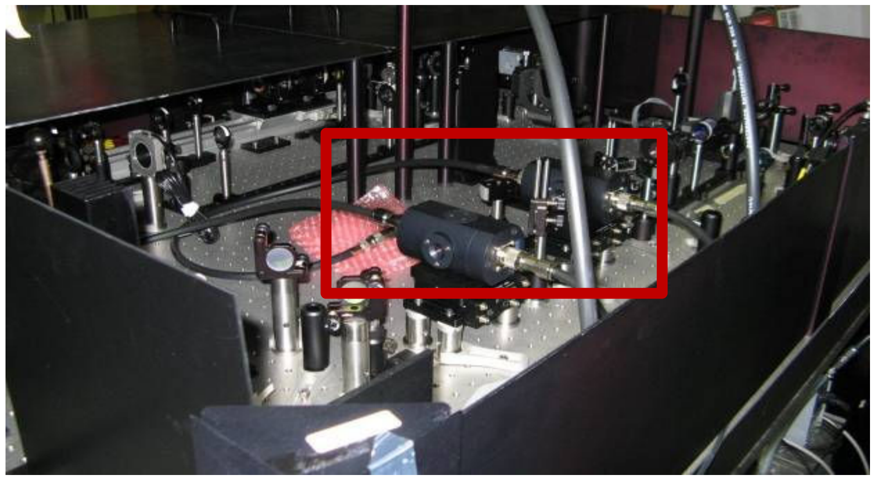
ADP 20 mm: E_g=3.6mJ→ E_{UV} =1.29mJ

PHIN

Considering the losses (10% beam line + 8% window + 20% metallic mirror =38%)
The ~350nJ energy required is now available from the laser
Note that with ~340nJ on laser table = ~235nJ estimated on cathode we obtain ~1.6nC stable charge (and 2.3 nC with a new cathode)

CALIFES

Pulse picker



8.7mJ → Pulse pickers + wave plate and polarizer → 5.6mJ → T=64%

1) Pulse Picker system → loss = > Transmittivity ~64%
2) Total losses CALIFES transport line: 43% (transport ~21% + Coupling ~22%)
   → Now! UV energy KDP(15mm) ~500nJ on laser table → 290nJ on cathode (~200 Before)
   → Available! UV energy KDP(20mm) ~640nJ on laser table → 364nJ on cathode

Phase Coding

1) Further work on the fiber system should be performed on the real 1.5 GHz laser
2) Fiber system introduces too high losses, thus it can not be installed in the existing laser chain………

    a possible solution is to install a booster amplifier:

    fiber amplifier could be used but the reliability and feasibility should be investigated with a company
3) A stand alone test can be performed on the non amplified beam:

    HighQ oscillator + phase coding system

Laser time is required in order to perform this test.

Conclusions

1) The second amplifier configuration has been modified:

2 collinear passages Now!

2 cross passages Before!

→ losses are reduced, final peak power ~8.5KW, ~6μJ in micro pulse [~4μJ before]

→ Future improvement:

1) better matching of the beam profile and intensity distribution into the amplifier (re-design of beam line)

2) different principles of operation (seeding of the already pumped amplifier)…

2) Different harmonic generation crystals tried:

ADP, KDP - look promising :

high efficiency, satisfactory transverse beam quality

BBO – lowest conversion efficiency and bad transverse beam quality due to walk off

Further studies on harmonic conversion: temperature stabilization, longer KDP crystals; DKDP in non-critical phase matching

3) Further development of the phase coding must be organized in compatibility with the running time of the machine