

Design of Plasma Chamber at PITZ

Plasma cell for self-modulation experiment at PITZ

Outline

- > Short Introduction
- > Plasma chamber
 - Design
 - Fabrication
 - Preliminary results

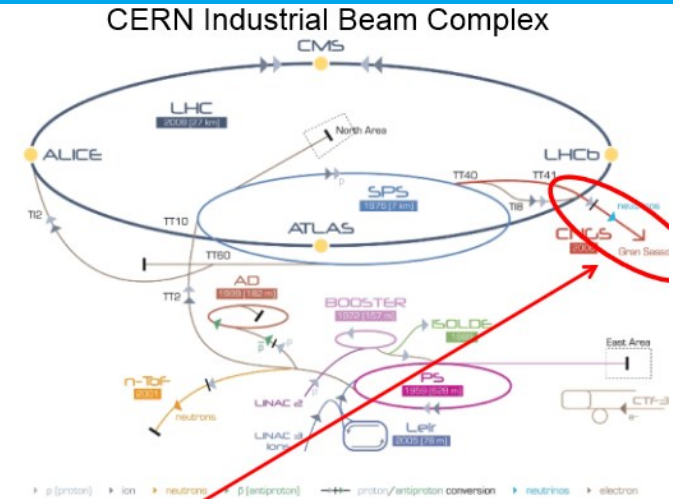
Matthias Groß

LAOLA Technical Seminar, DESY

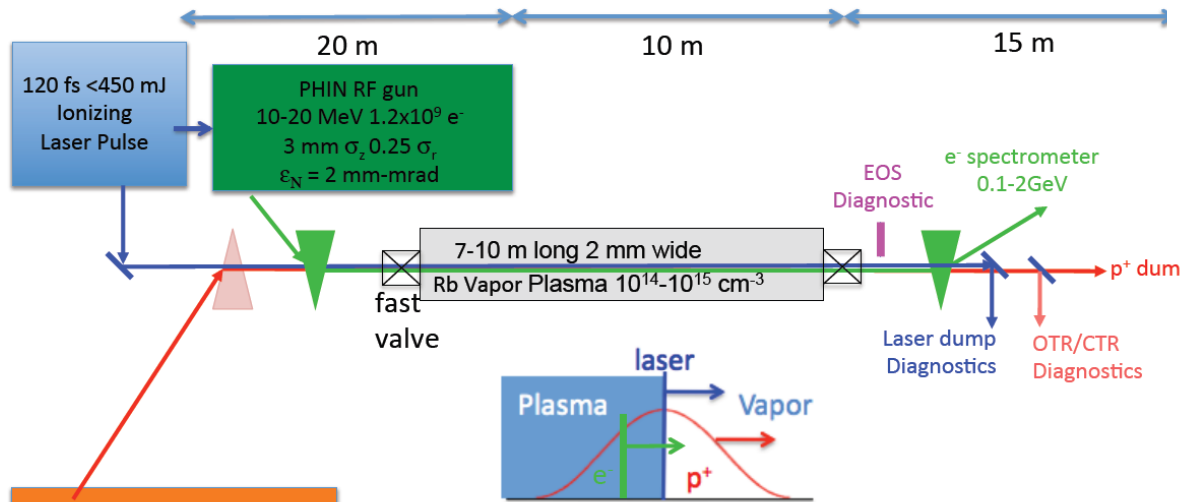
24. June 2014

EAAC Workshop 2013: Patric Muggli, AWAKE: A Proton-Driven Plasma Wakefield Experiment at CERN

- Use high energy proton beams from SPS to drive plasma wave
- Convert proton beam energy to accelerate electron beam in single stage



CNRS experimental area



400 GeV $3 \times 10^{11} \text{ p}^+$
 12 cm σ_z 0.2 σ_r
 $\epsilon_N = 3.5 \text{ mm-mrad}$
 from SPS

Caldwell et al., Nature Physics (2009):

$$E_{z,max} = 240 (\text{MV m}^{-1}) \left(\frac{N}{4 \times 10^{10}} \right) \left(\frac{0.6}{\sigma_z (\text{mm})} \right)^2$$

- High accelerating gradient requires **short** bunches (σ_z less than $100 \mu\text{m}$)
- Existing proton machines produce **long** bunches (10cm)

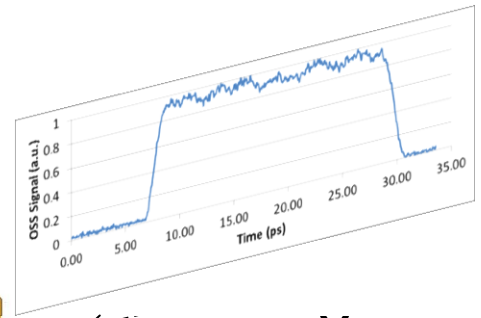
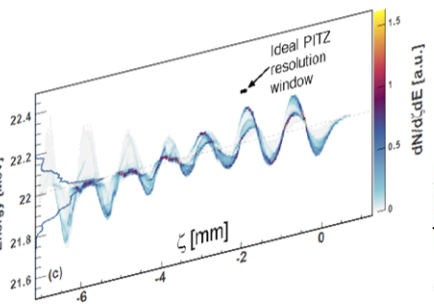
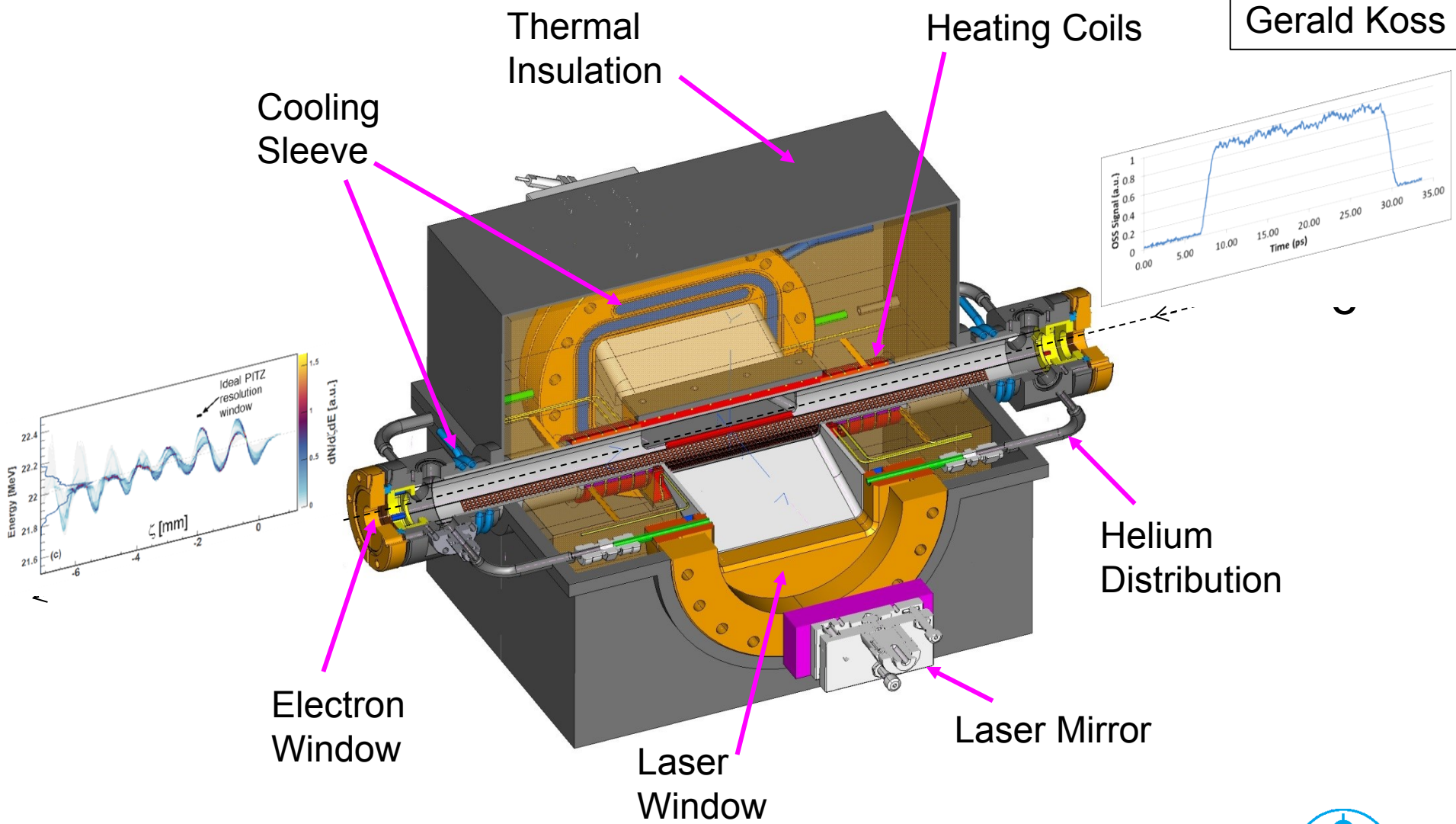
Self-modulation!

Courtesy:
 Patric Muggli, Erdem Öz



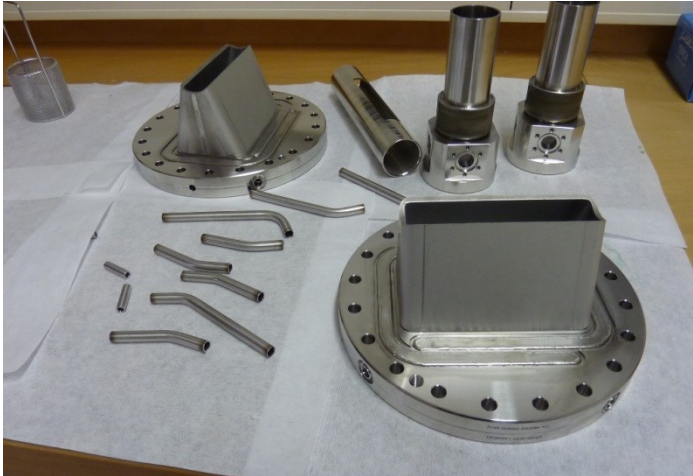
Plasma Cell Design

Design:
Gerald Koss



Plasma Cell Parts

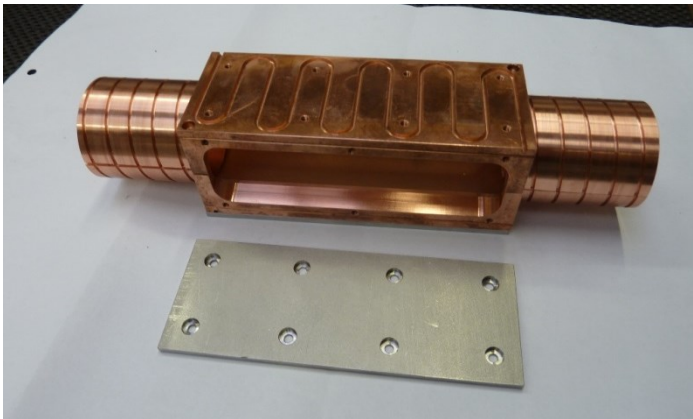
Stainless steel cell body



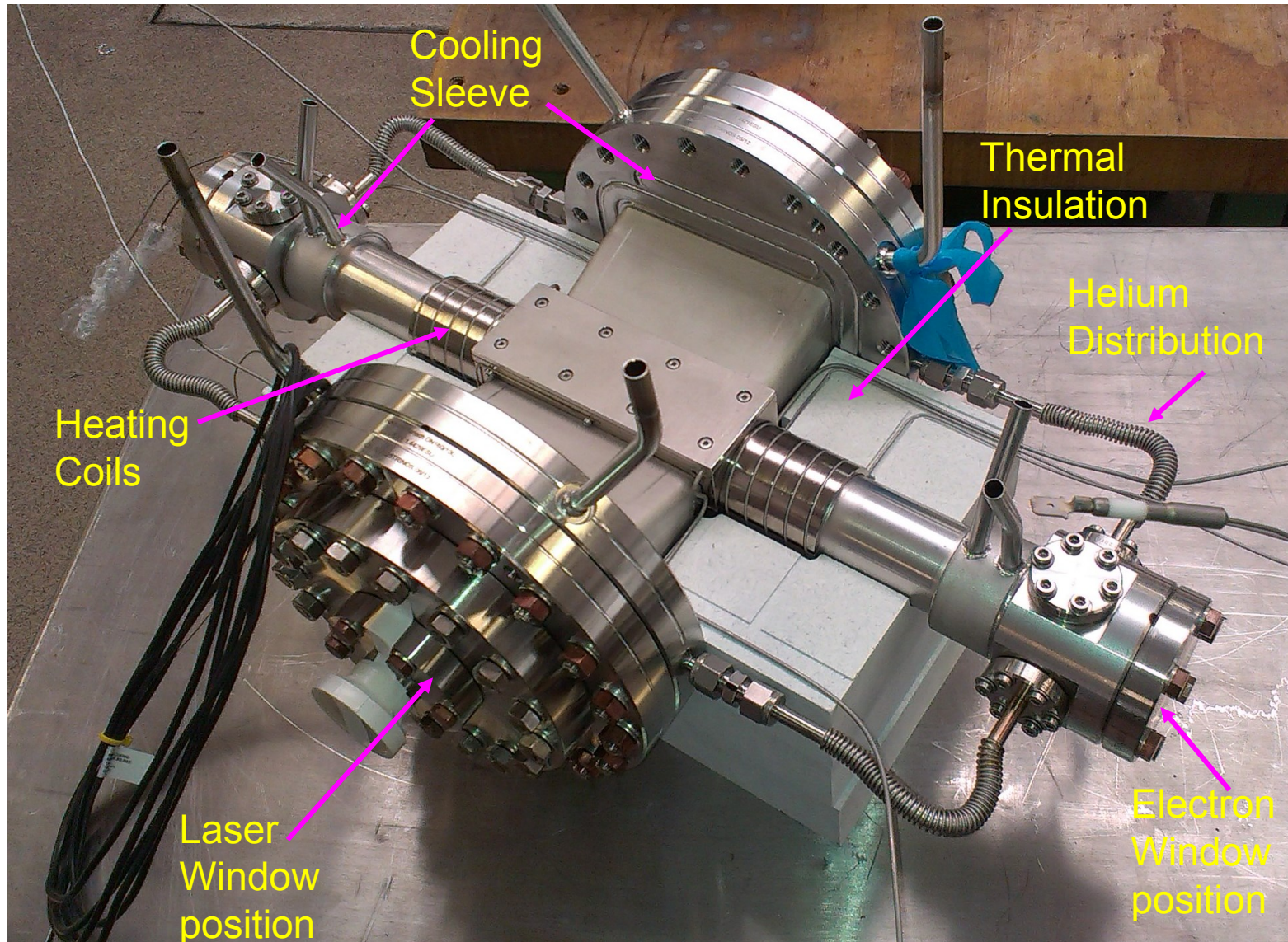
Heat insulation foam bricks



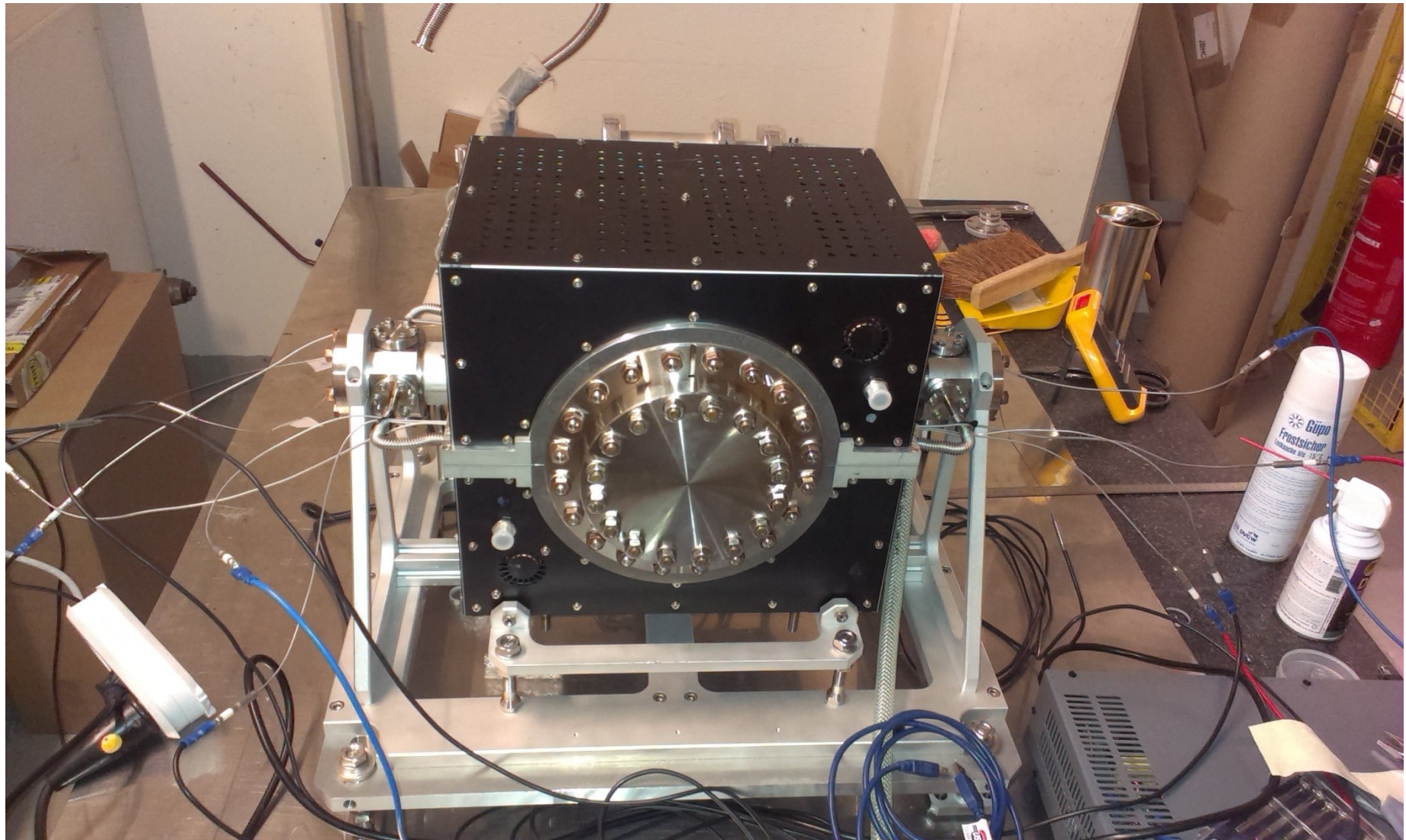
Copper heat distribution



Assembled Plasma Cell

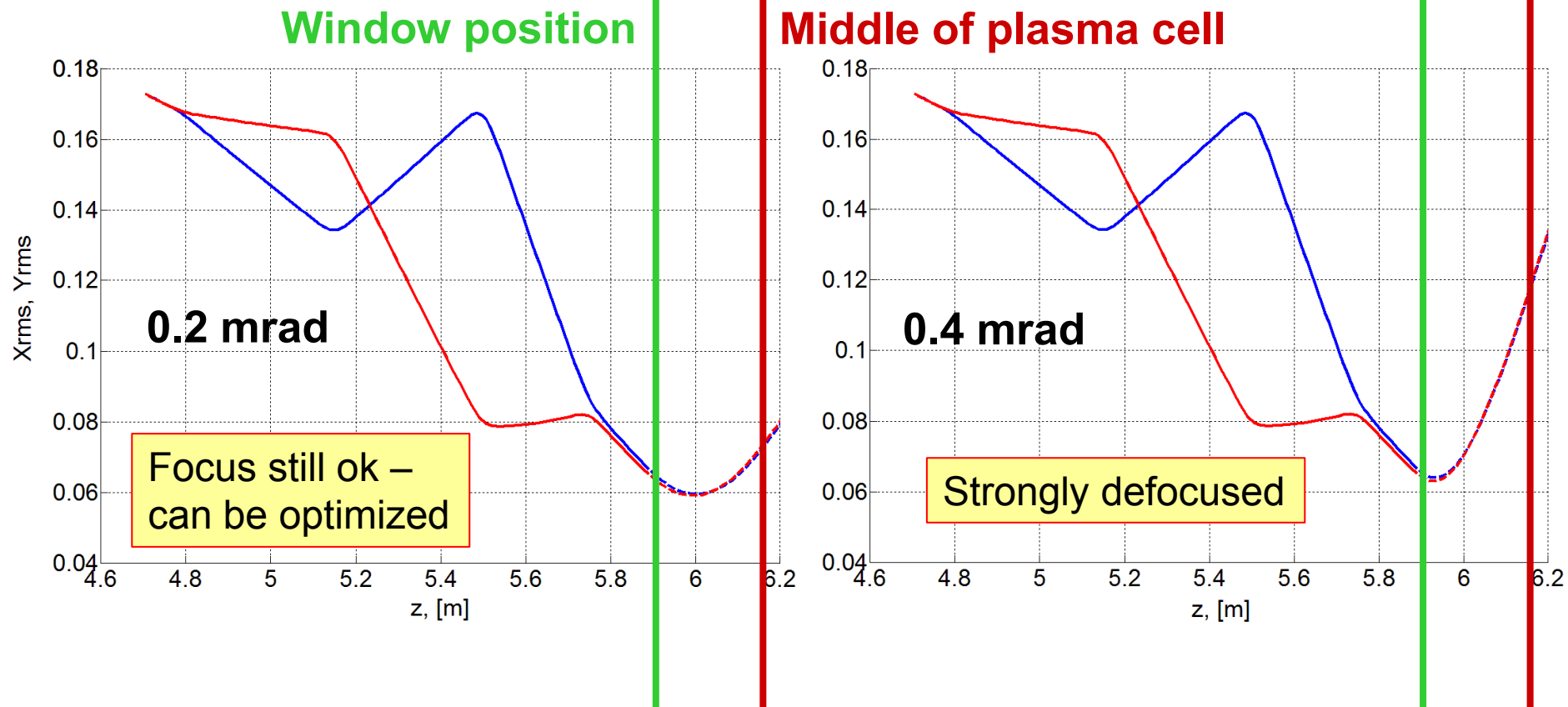


Plasma Cell Setup



Scattering at Electron Window

- ASTRA simulations: electron beam scattering impedes focusing into the plasma



- Maximal agreeable scattering angle: 0.2 mrad

Theory: Multiple Coulomb Scattering

> From: Claus Grupen “Teilchendetektoren”: Multiple Coulomb Scattering

The rms of the projected scattering angle distribution:

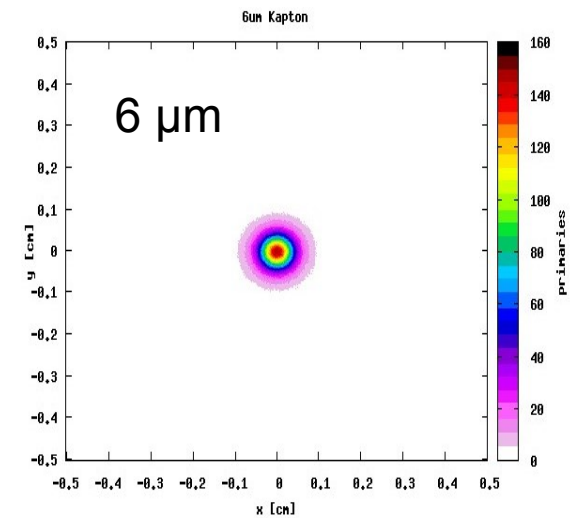
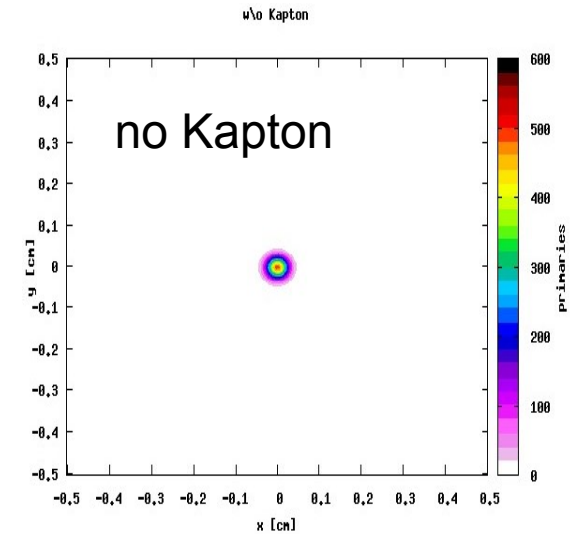
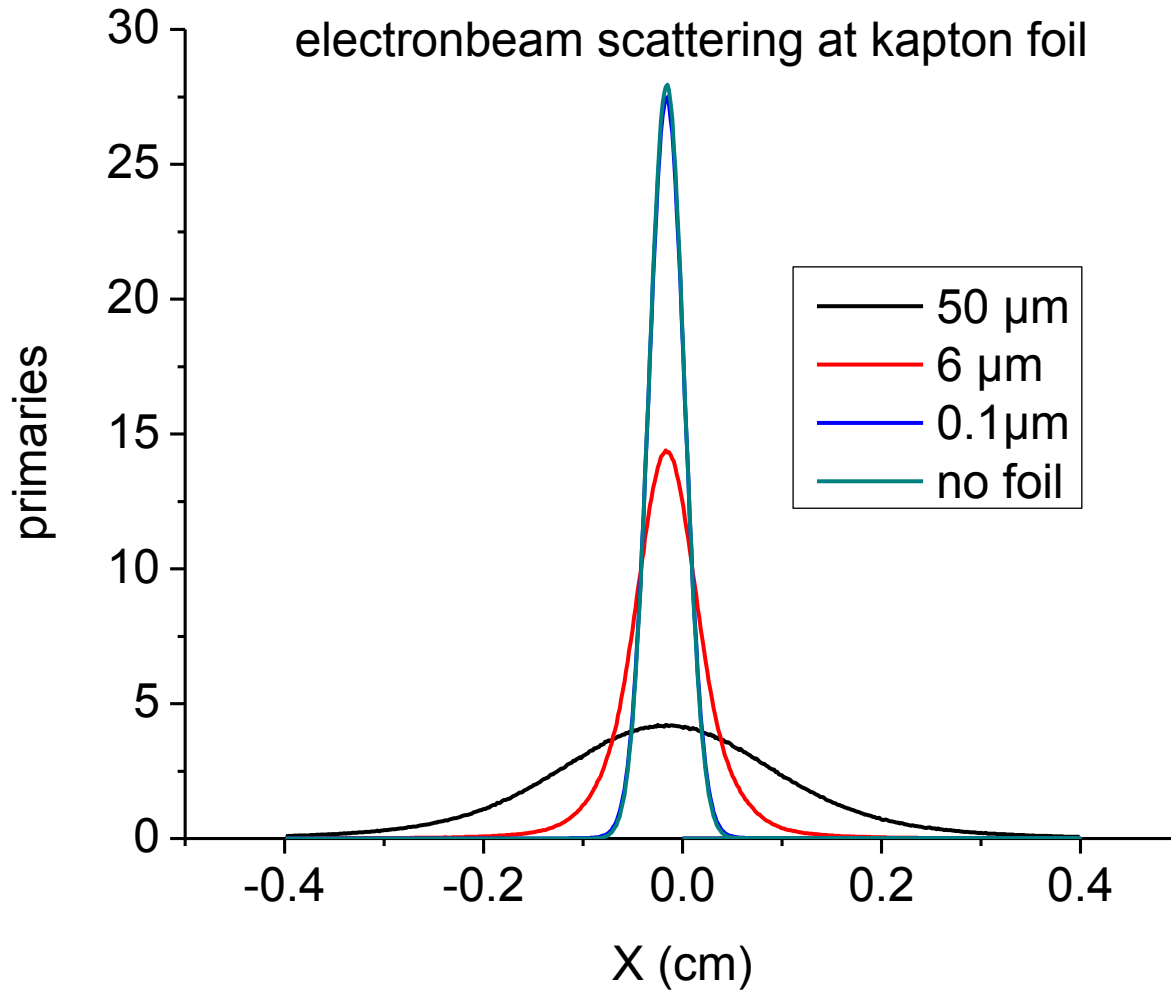
$$\theta_{rms} = \frac{13.6 \text{ MeV}}{\beta pc} z \sqrt{\frac{x}{X_0}} \left[1 + 0.038 \ln \left(\frac{x}{X_0} \right) \right]$$
$$\beta pc = 22 \text{ MeV}; z = 1; X_0 = 0.28 \text{ m}$$

> Important: Radiation length X_0

- Gold: 0.3 cm
- Kapton (Polyimide): 28.6 cm
- Beryllium: 35.3 cm
- Polyethylene: 50.3 cm



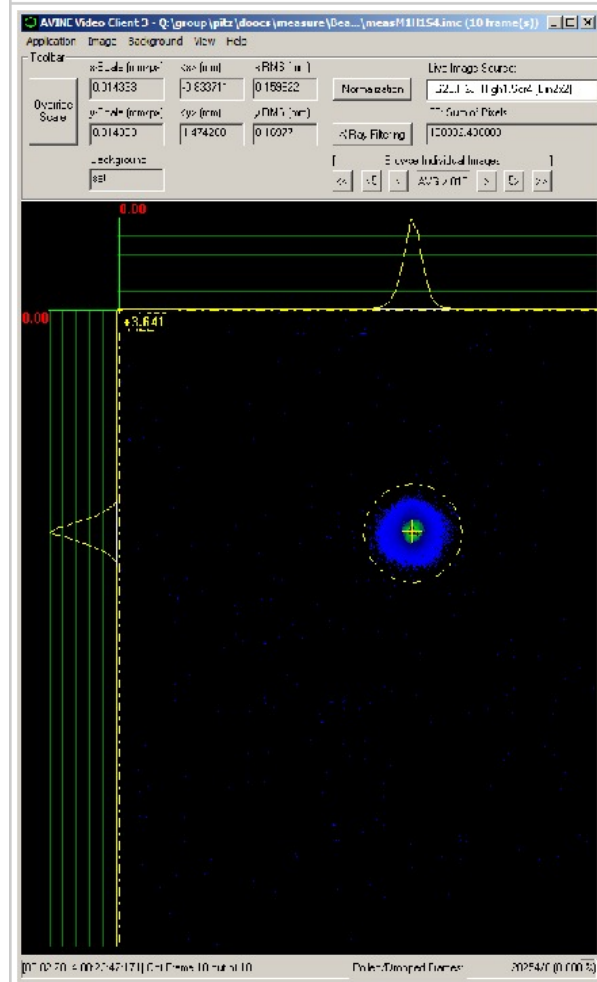
Simulation: FLUKA



Experiment in PITZ Beam Line – 50um Kapton

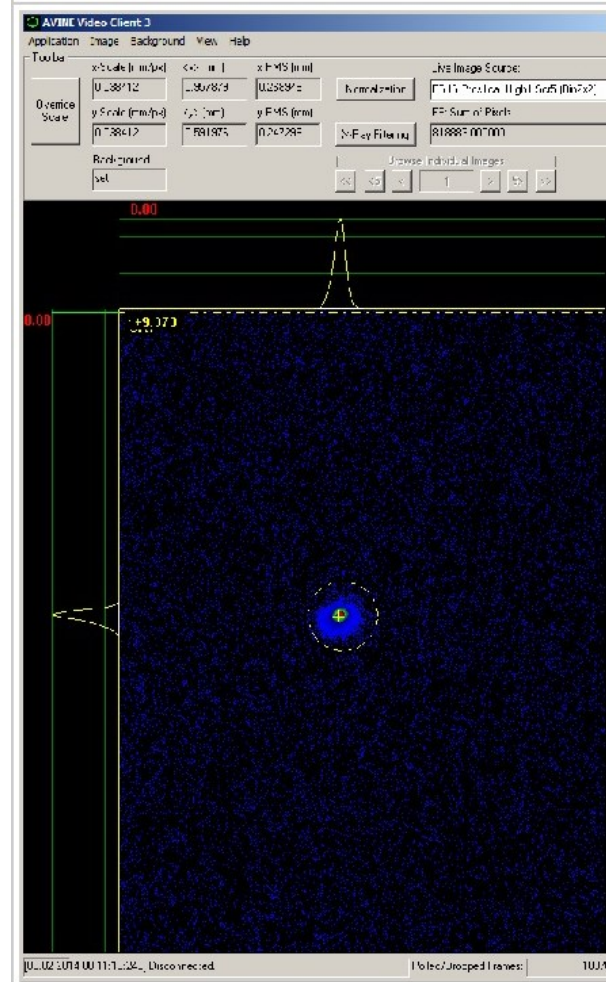
08.02.2014 00:36 M. Gross, G. Pathak Beam at High1.Scr4

Xrms = 0.159mm
Yrms = 0.169mm



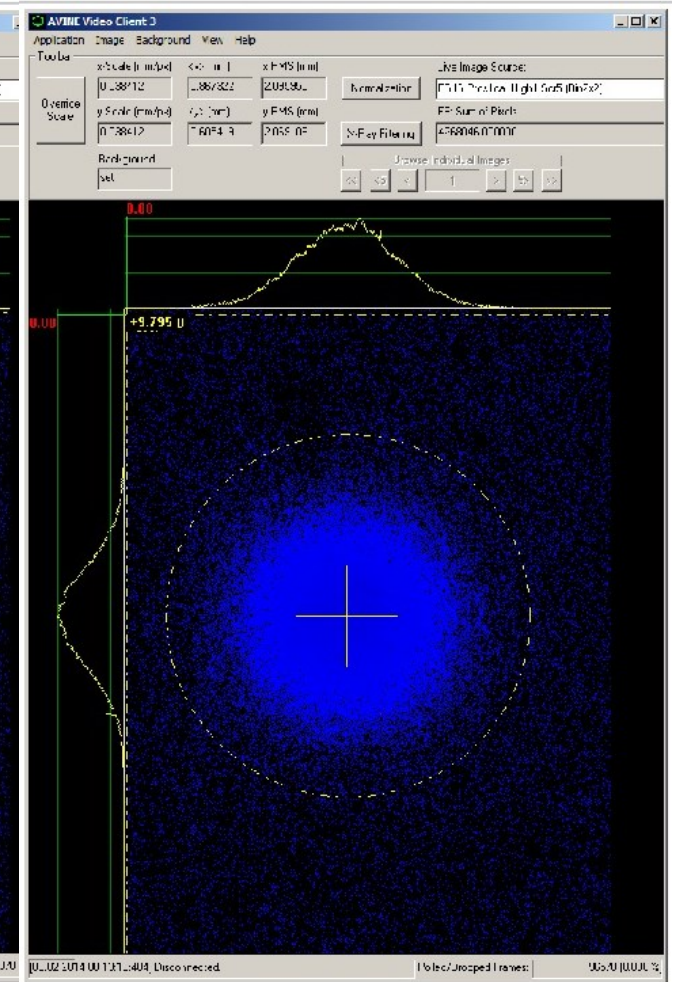
08.02.2014 00:11 M. Gross, G. Pathak Beam at High1.Scr5 - M1, n

Xrms = 0.268mm
Yrms = 0.247mm

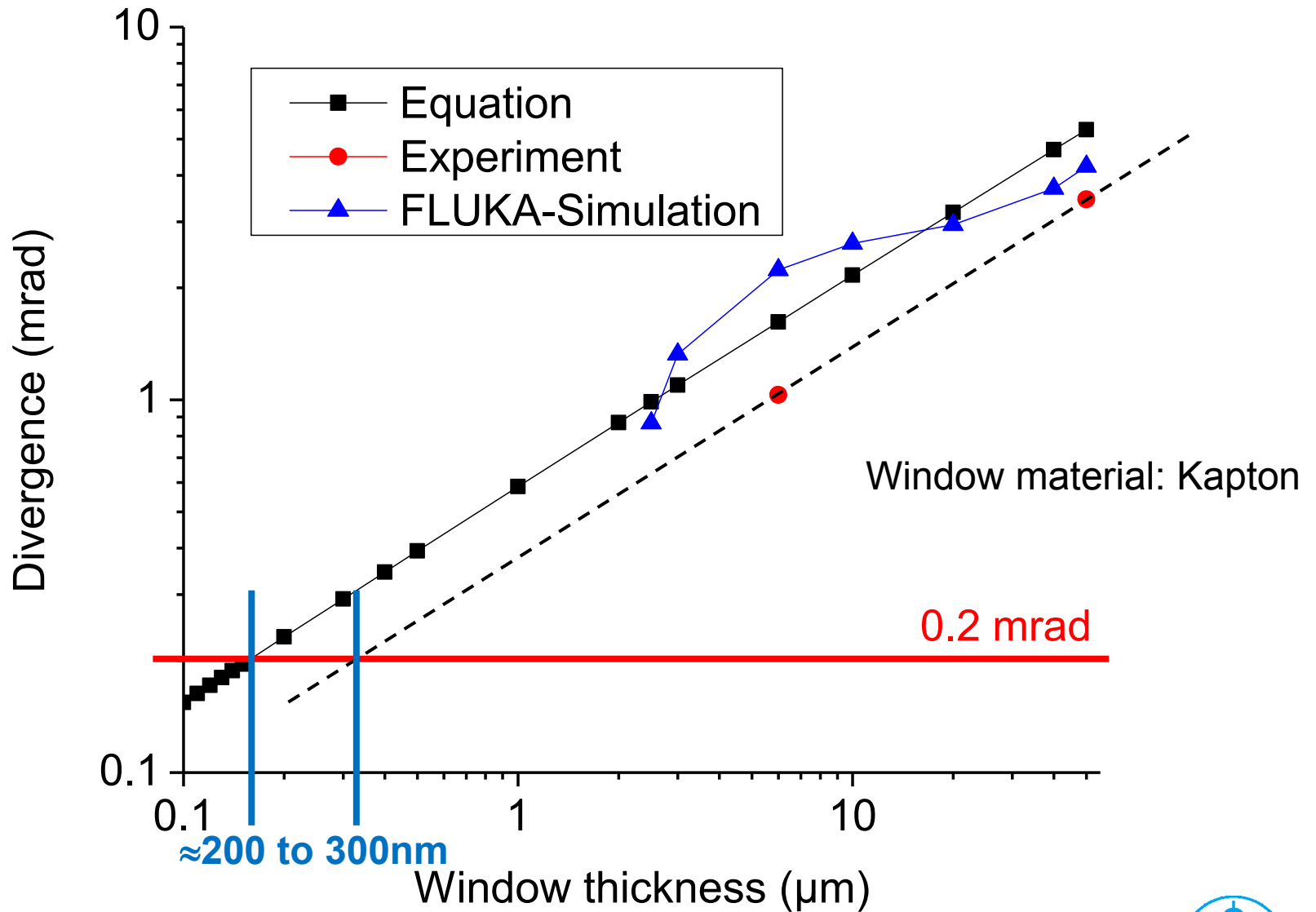


08.02.2014 00:13 M. Gross, G. Pathak Beam with Kapton at High1.Scr.5

Xrms = 2.095mm
Yrms = 2.069mm



Scattering Results

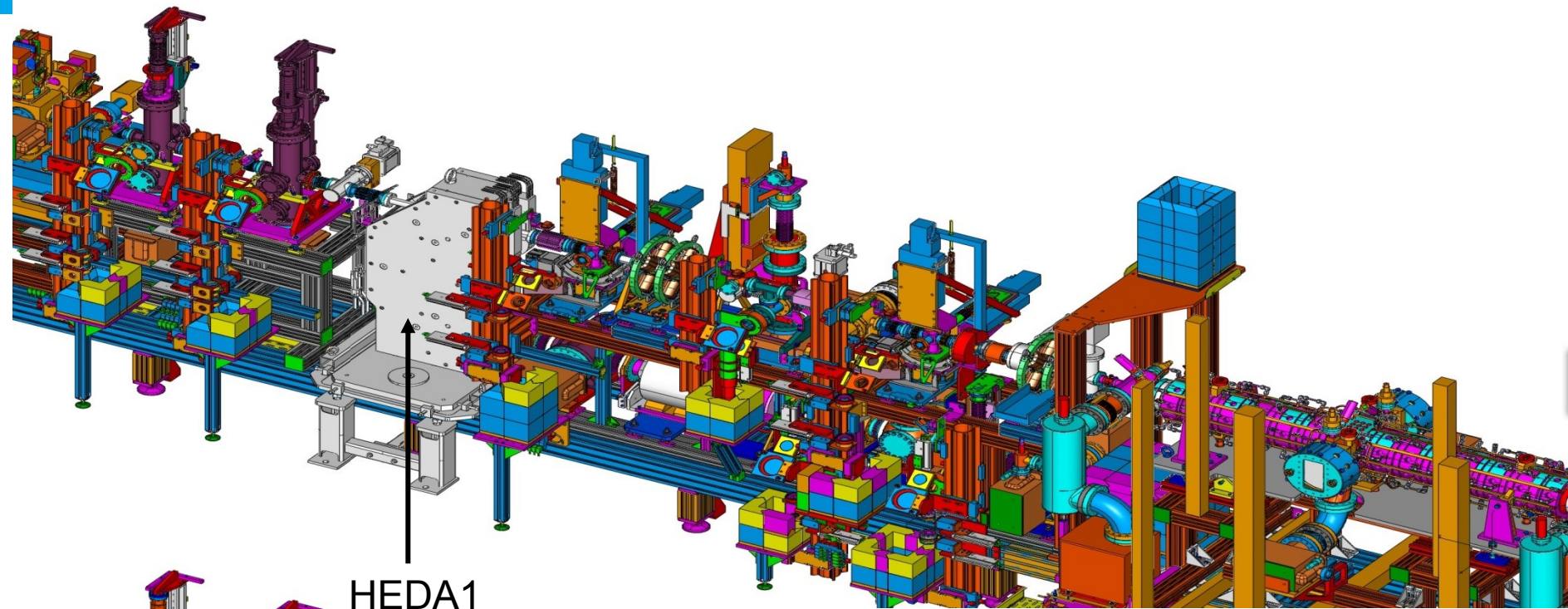


Summary

- Self-modulation experiments are in preparation
- PITZ plasma cell was designed and fabricated
- Thin electron window is necessary to minimize scattering



Beam Line Remodeling



HEDA1

Plasma cell

Electron Beam

Quadrupoles

Ionization laser

ite 13

