

HITRAP Low Energy Diagnostics and Emittance Measurement

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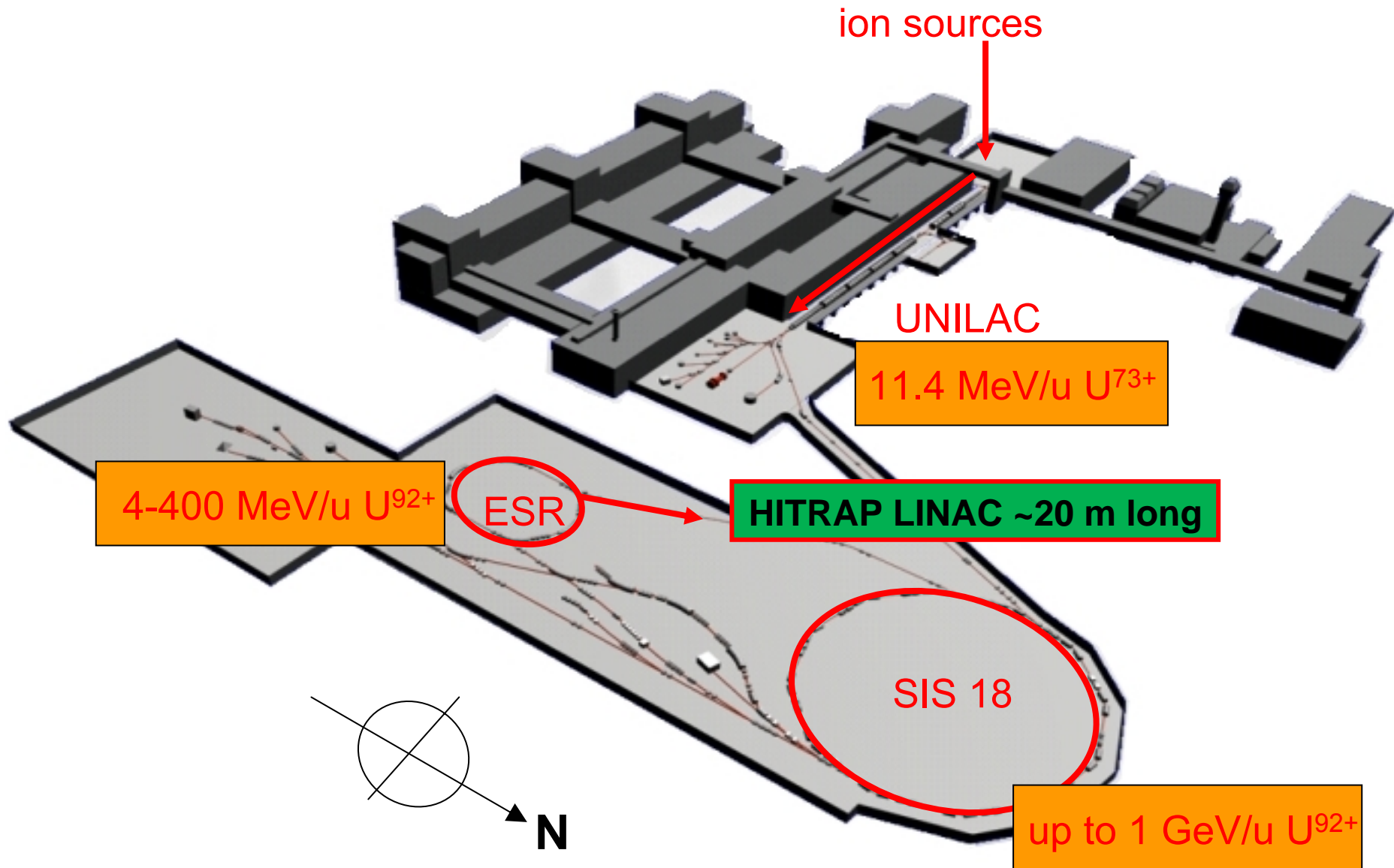
Workshop on "Low Current, low Energy Beam Diagnostics"

Großsachsen, November 24, 2009

- The HITRAP project at GSI
- Existing beam diagnostics for emittance measurements and particle detection
- Measurements and results
- Outlook

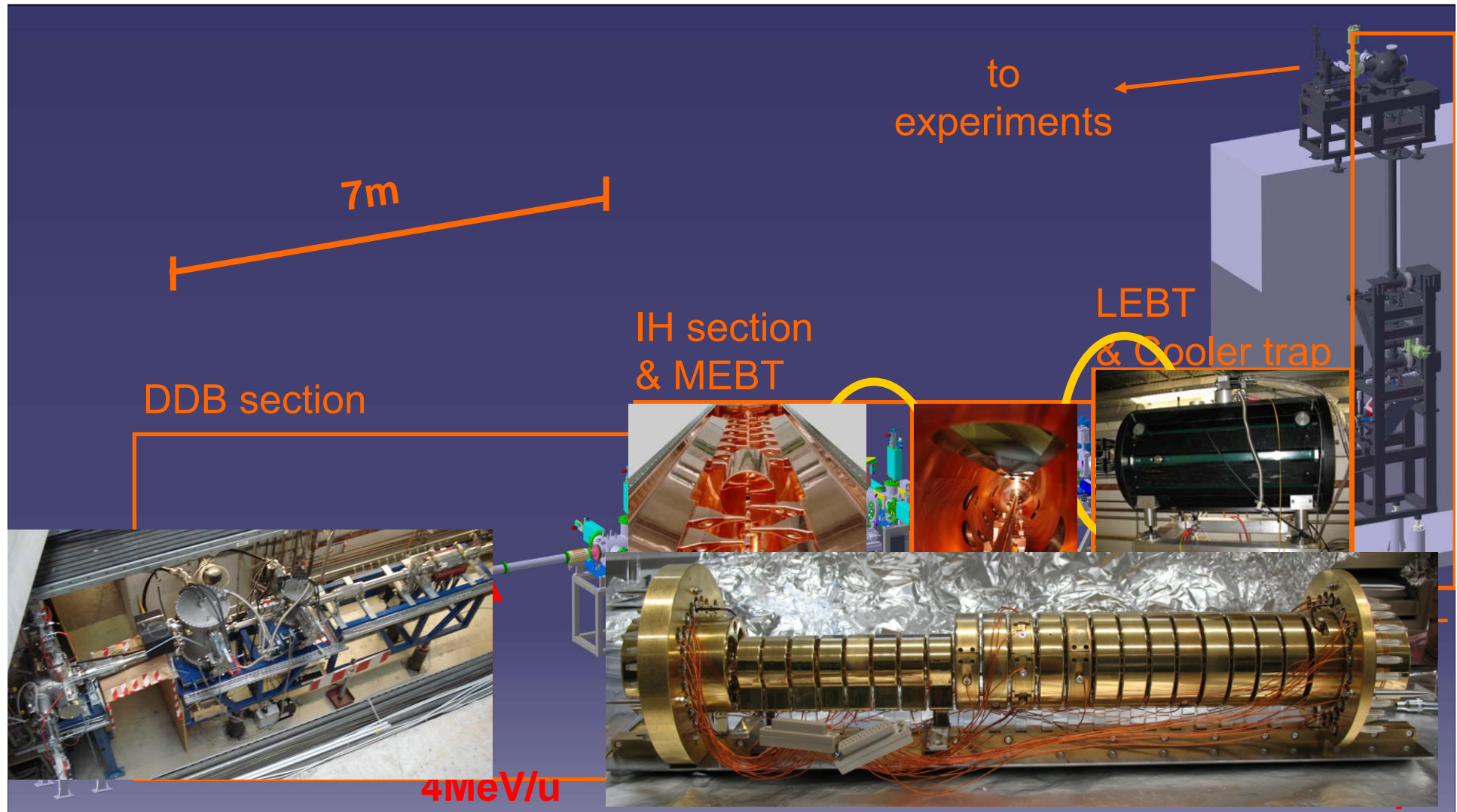
HITRAP @ ESR

HITRAP Beam Diagnostics Measurements Outlook



HITRAP overview

HITRAP Beam Diagnostics Measurements Outlook



- Experiments based on Penning traps
 - Laser spectroscopy
 - g-factor measurements of the bound electron
 - Mass measurements of extreme accuracy
 - Polarization of radionuclides
 - Decay spectroscopy of highly-charged radionuclides

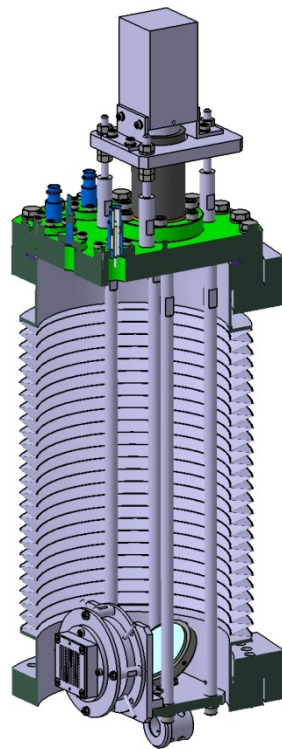
- Collision experiments:
 - Collisions at very low velocities
 - Surface studies and hollow-atom spectroscopy
 - X-ray spectroscopy

Low energy/low intensity pepperpot device

HITRAP **Beam Diagnostics** Measurements Outlook

Pepperpot Diamond Energy Analysis

- stand-alone device
- multi diagnostic



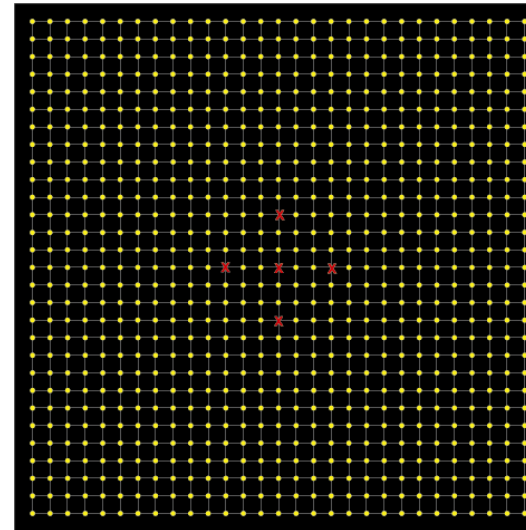
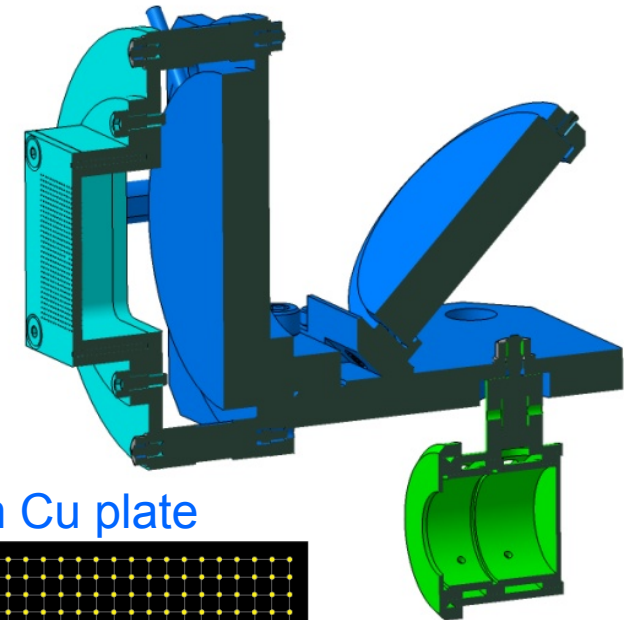
Pepperpot data:

hole diameter: 0,1mm (0,1mm W foil)

hole spacing: 1mm

drift distance: 31,8mm

sandwiched between Al frame and 2mm Cu plate

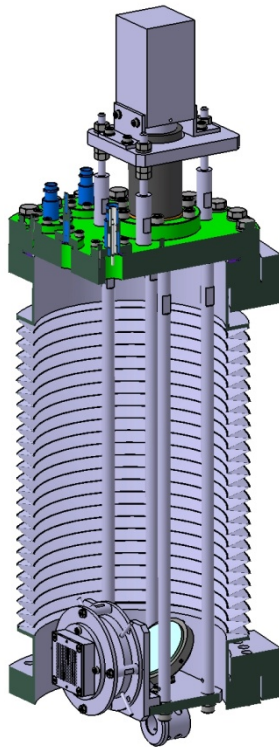


Low energy/low intensity pepperpot device

HITRAP **Beam Diagnostics** Measurements Outlook

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MCP data:

diameter: 40mm

channel diameter: 12 μ m

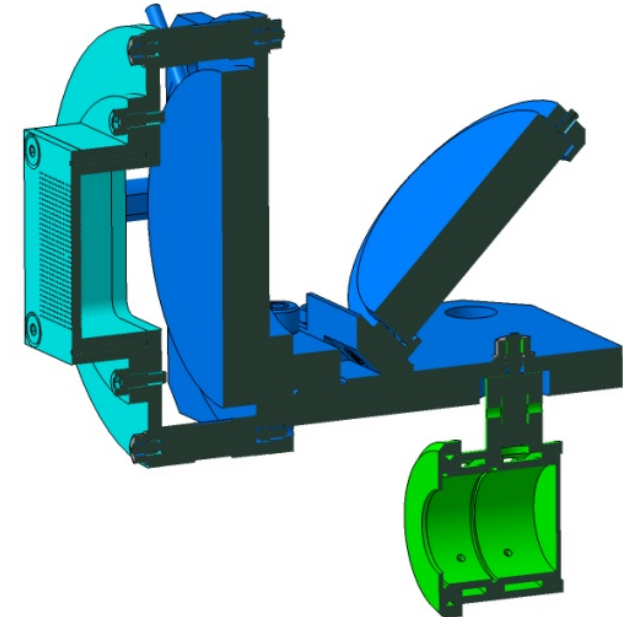
gain: 10⁴

scintillator: P-43 (λ_{\max} =545nm)

afterglow (10%): 1ms

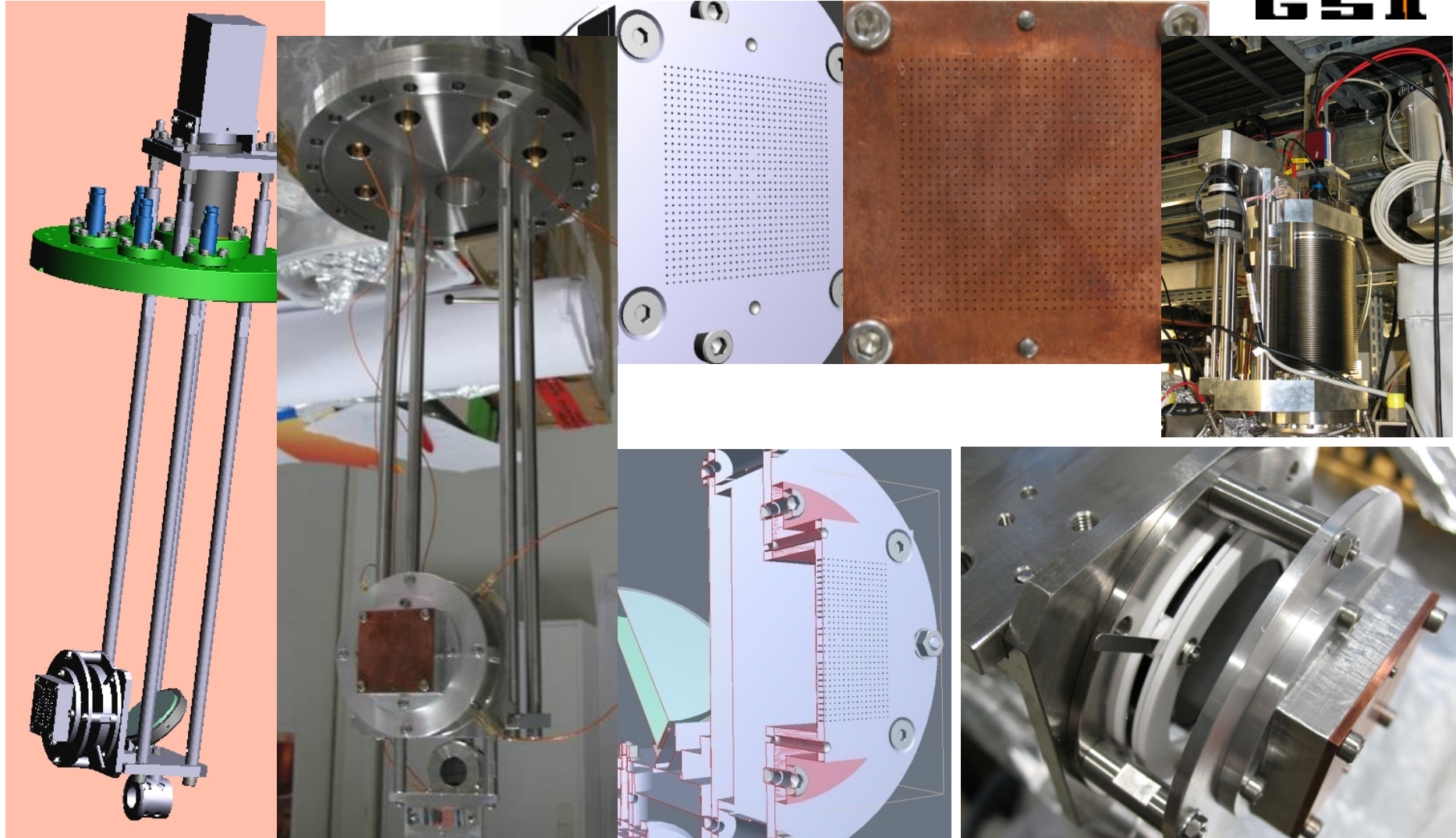
camera: resolution: 1392x1040pixels \rightarrow ~40 μ m
spatial resolution

lens: fixed focus f=50mm, high quality with narrow
band pass filter with λ_{\max} @ 545nm



Low energy/low intensity pepper pot device

HITRAP **Beam Diagnostics** Measurements Outlook
Pepperpot Diamond Energy Analysis



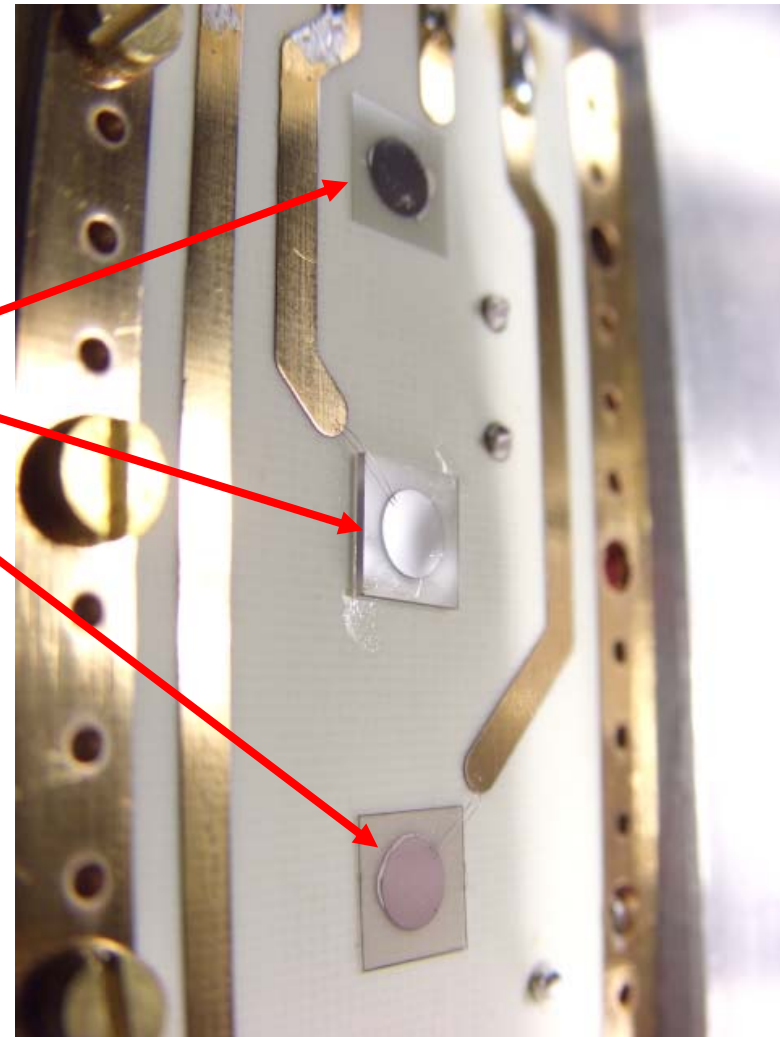
Diamond detector

HITRAP **Beam Diagnostics** Measurements Outlook
Pepperpot Diamond Energy Analysis

4 different separate diamond layers:

- poly-crystalline CVD 10/15 μm
- single-crystal CVD 480/380 μm
- poly-crystalline CVD 15 μm
- poly-crystalline CVD 600 μm

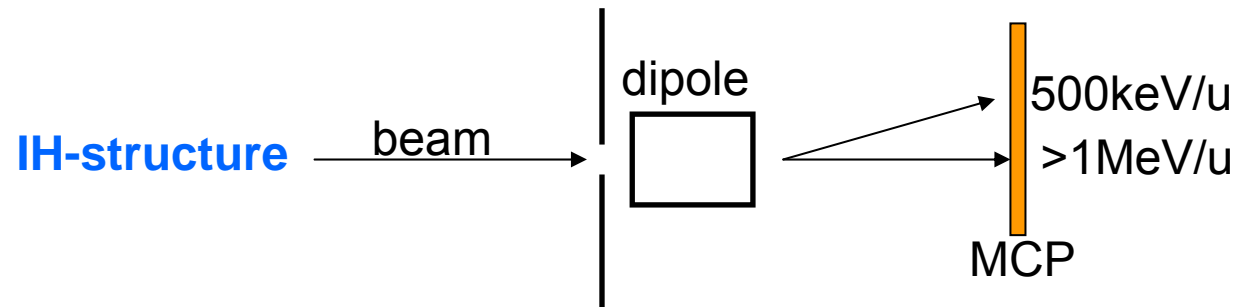
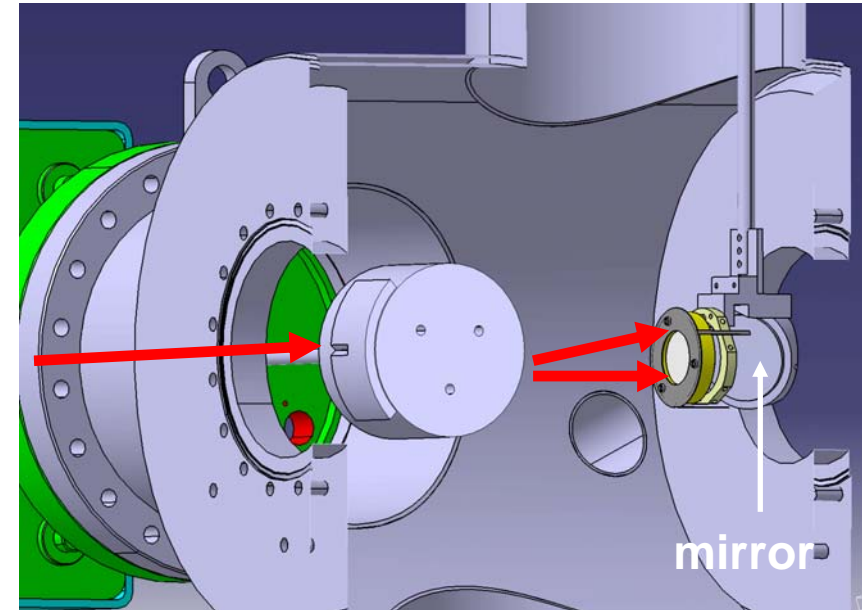
(diameter: 3mm each)



New Energy Analyzer

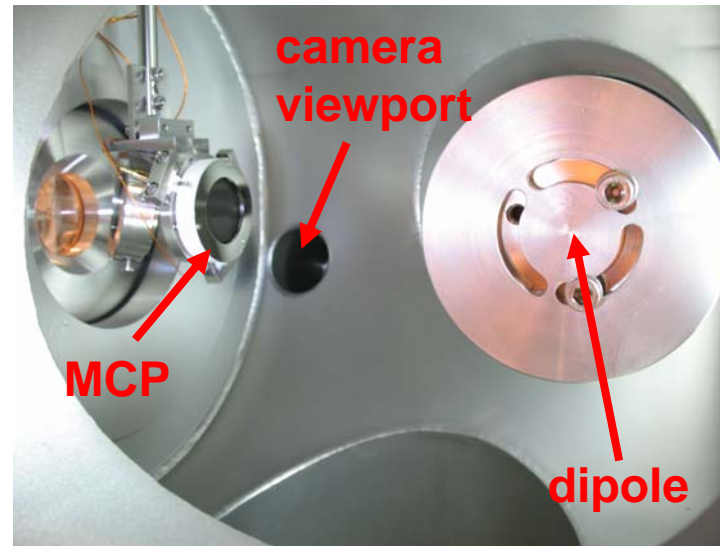
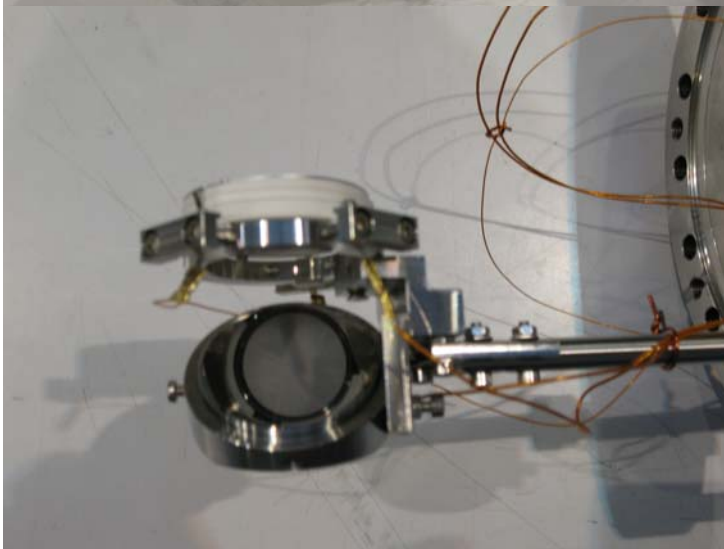
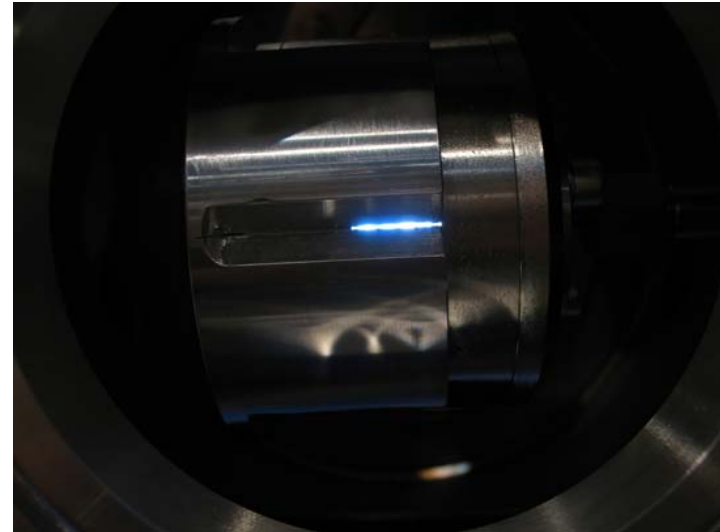
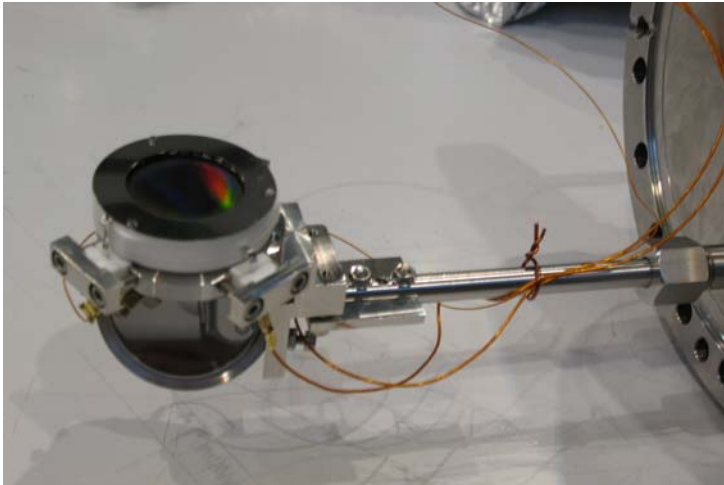
HITRAP **Beam Diagnostics** Measurements Outlook
Pepperpot Diamond Energy Analysis

- 0,3mm slit
- 0,5T permanent magnet
- MCP (chevron type)
- SONY CCD camera
 - 1034x779px
 - 4.65x4.65 μm pixel size



New Energy Analyzer

HITRAP **Beam Diagnostics** Measurements Outlook
Pepperpot Diamond Energy Analysis



New Energy Analyzer

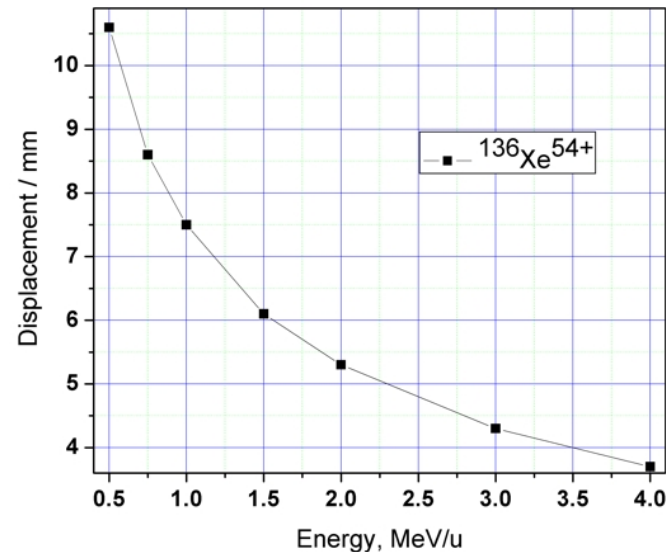
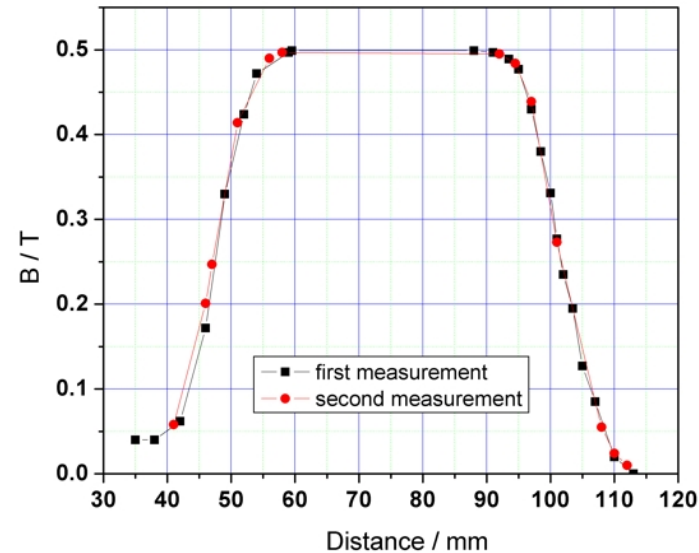
HITRAP **Beam Diagnostics** Measurements Outlook

Pepperpot Diamond Energy Analysis

Homogeneous field on magnet axis measured with hall probe

Drift distance between magnetic field edge and MCP: 95mm

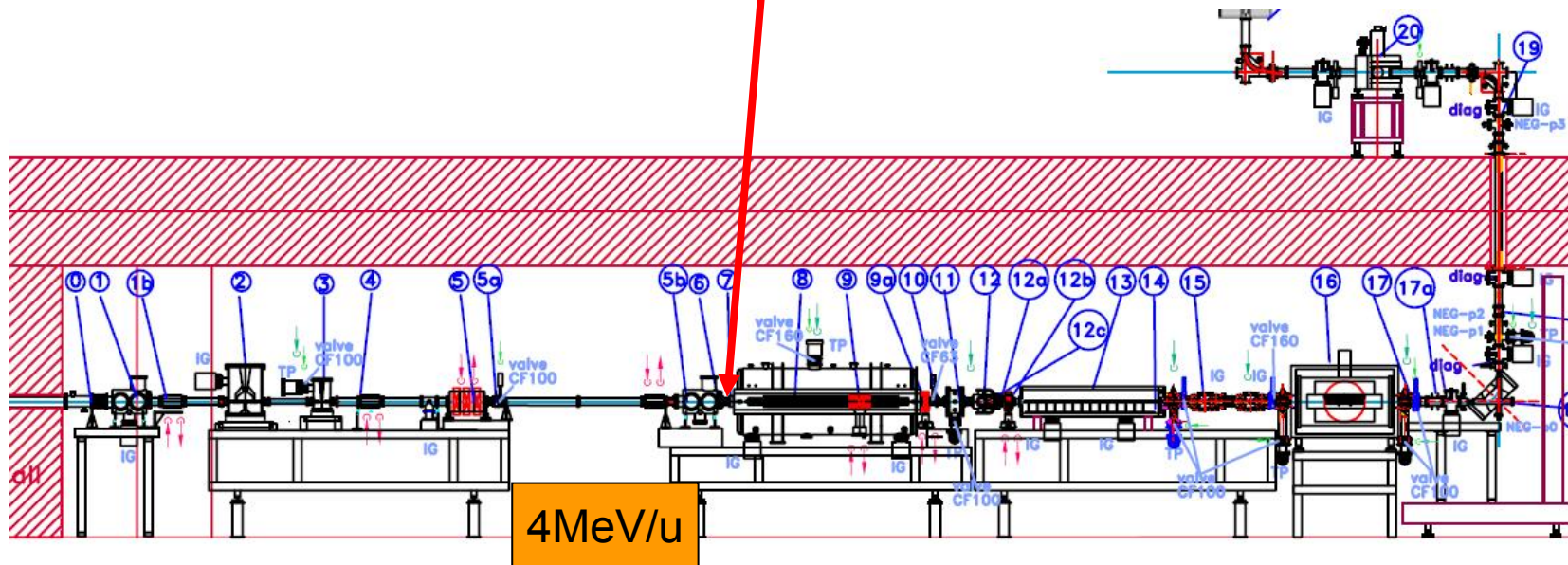
Residual field on axis if magnet out: <1 gauss



Bunch shape measurement

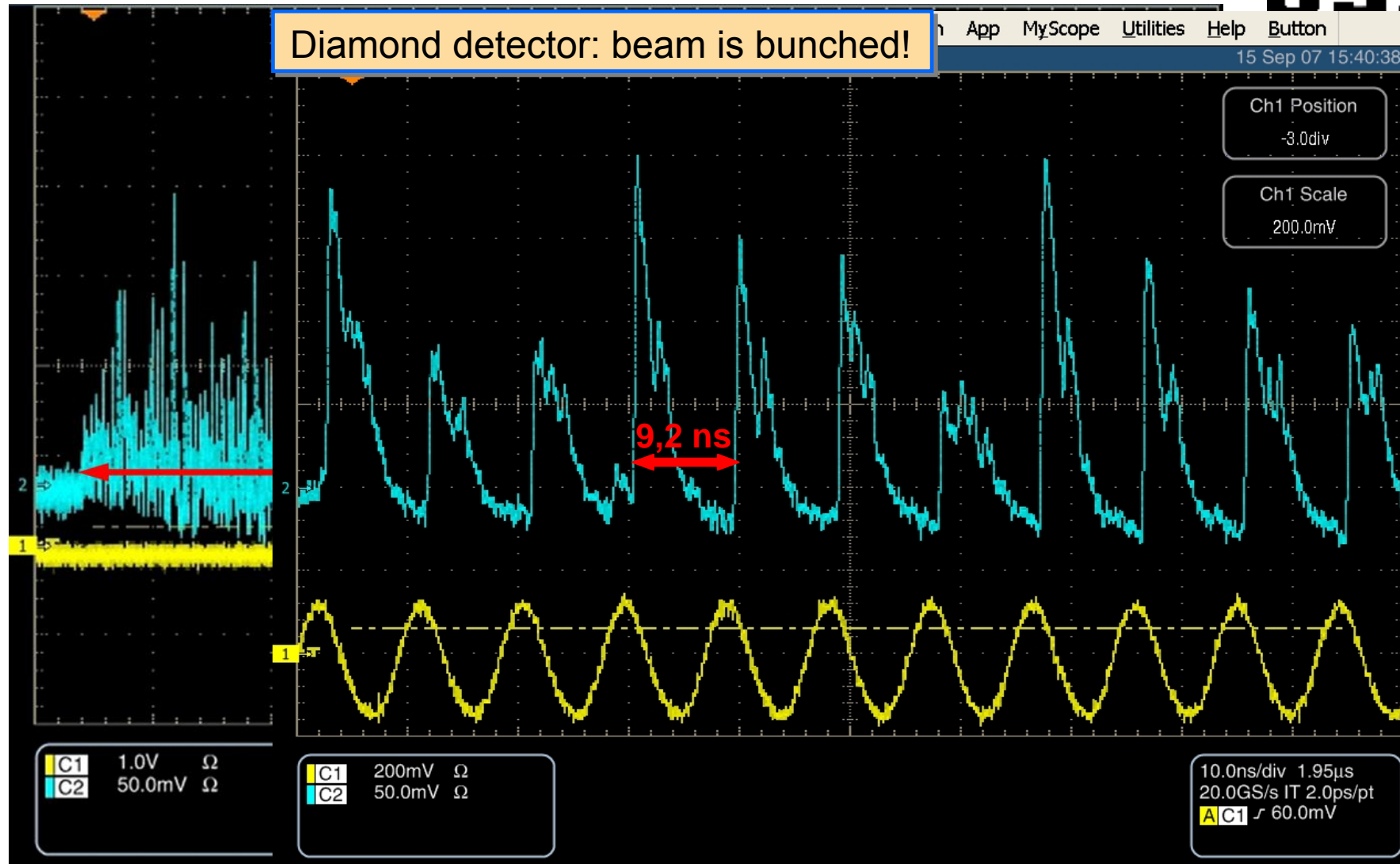
HITRAP Beam Diagnostics **Measurements** Outlook

macro bunch: 1-3 μ s from ESR or
micro-structured: 108MHz (measured) /
370ps (not resolved)

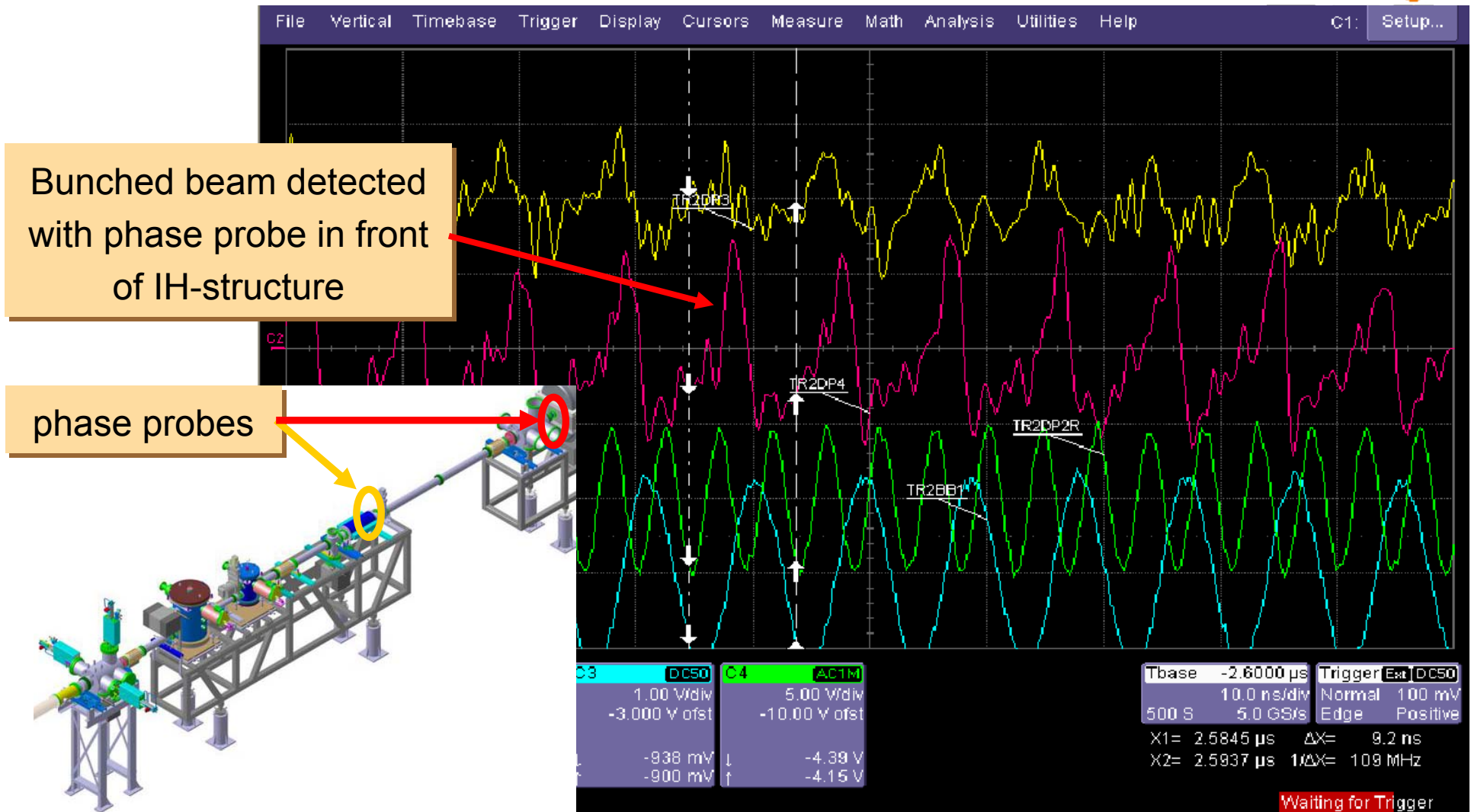


Diamond detector

HITRAP Beam Diagnostics **Measurements** Outlook

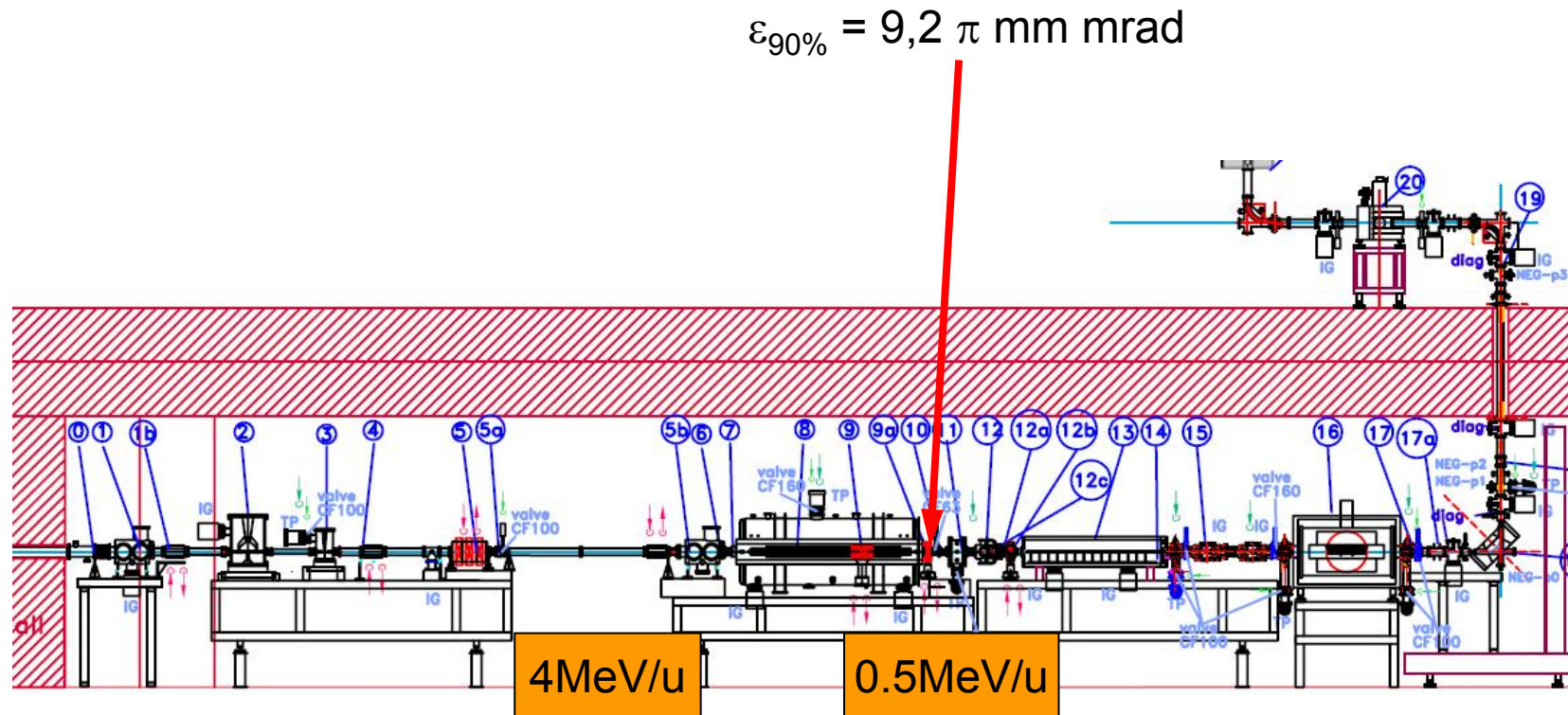


Phase probes



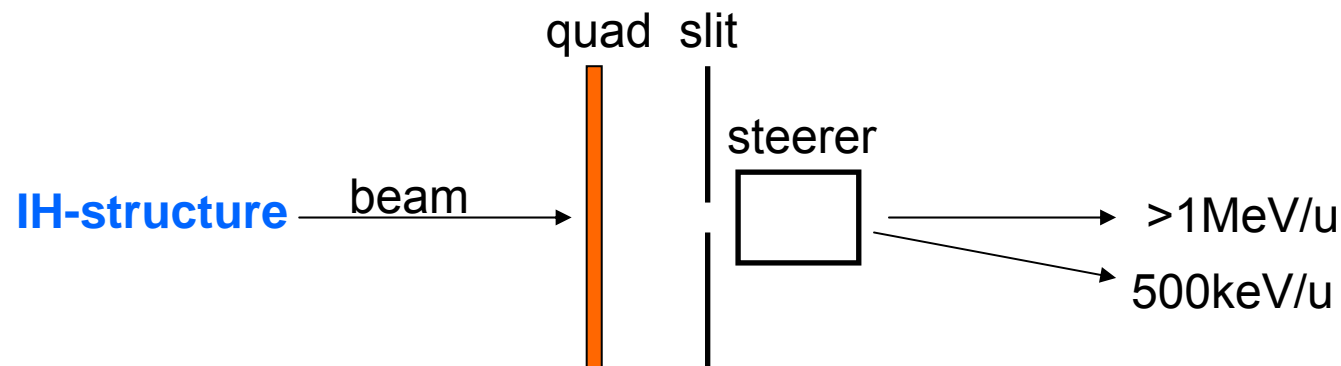
IH commissioning in 2008/2009

HITRAP Beam Diagnostics **Measurements** Outlook

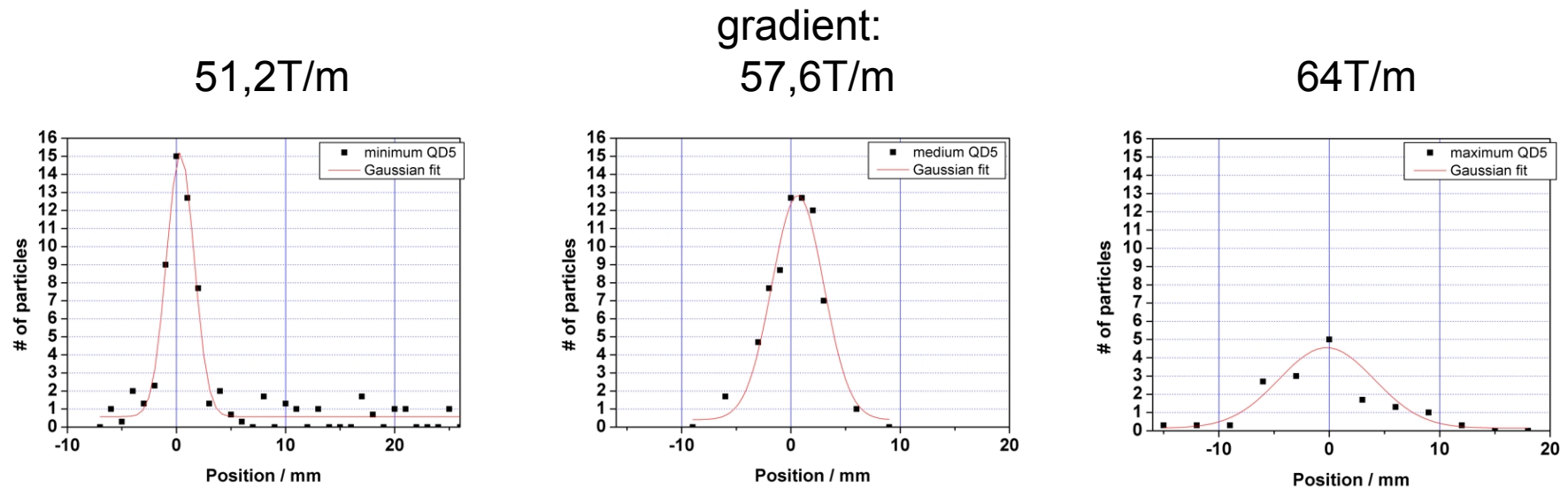


no signal of 0.5MeV/u beam on either YAG scintillator or P-43 for 3-gradient method or pepperpot measurement

→ 3-gradient method via profile measurements using diamond detector (vertical direction only!)



varying gradient of quadrupole doublet 5 behind IH structure

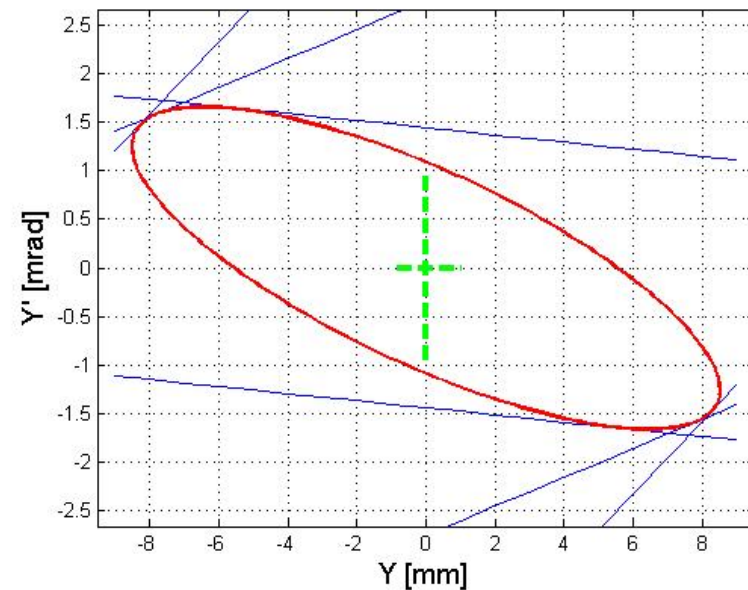
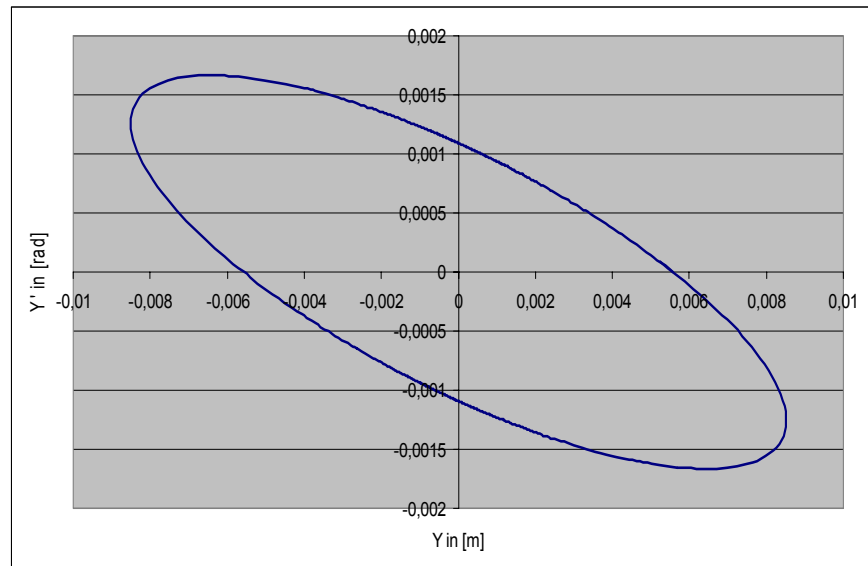


0.5MeV/u emittance

independent evaluation in MS EXCEL and
MATLAB shows exactly same result

design value at this point: $9,2 \pi$ mm mrad

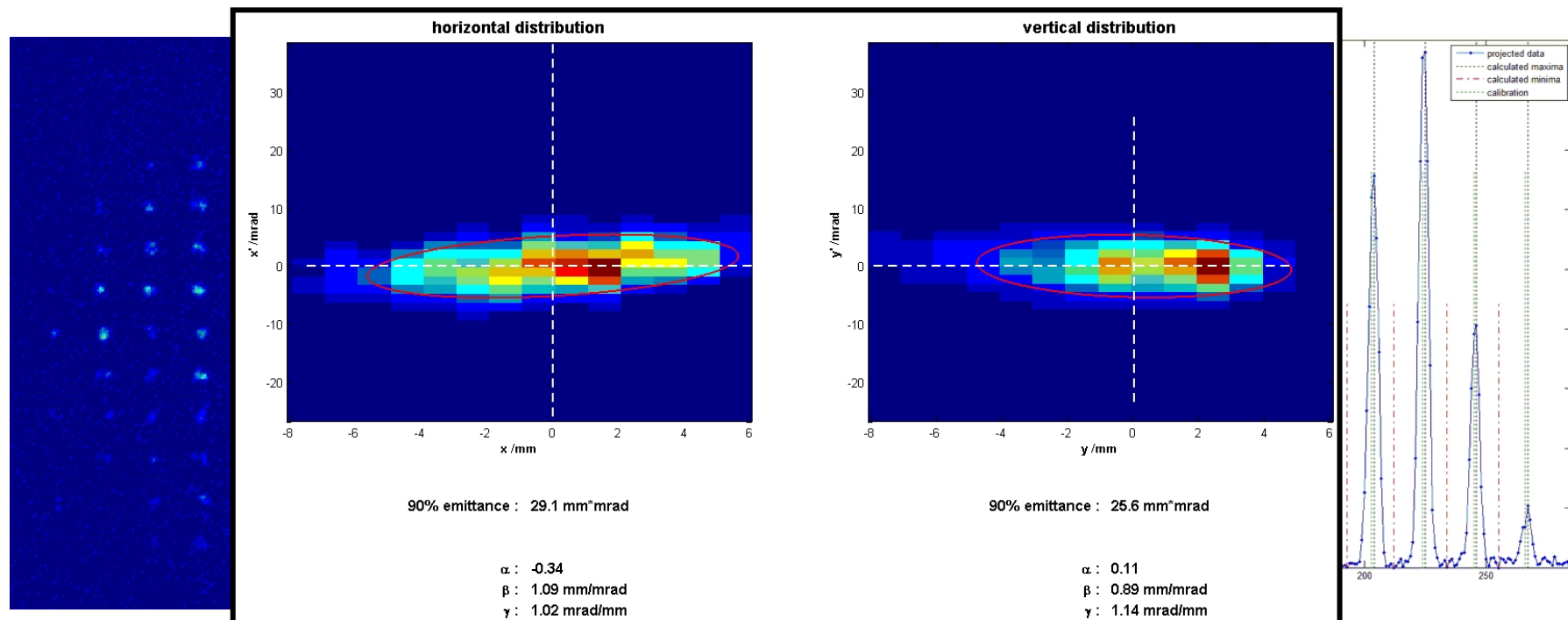
$\varepsilon_{y,kv}$	= $9,3 \pi$ mm mrad
α	= 1,15
β	= 7,80 mm/mrad
γ	= 0,30 mrad/mm



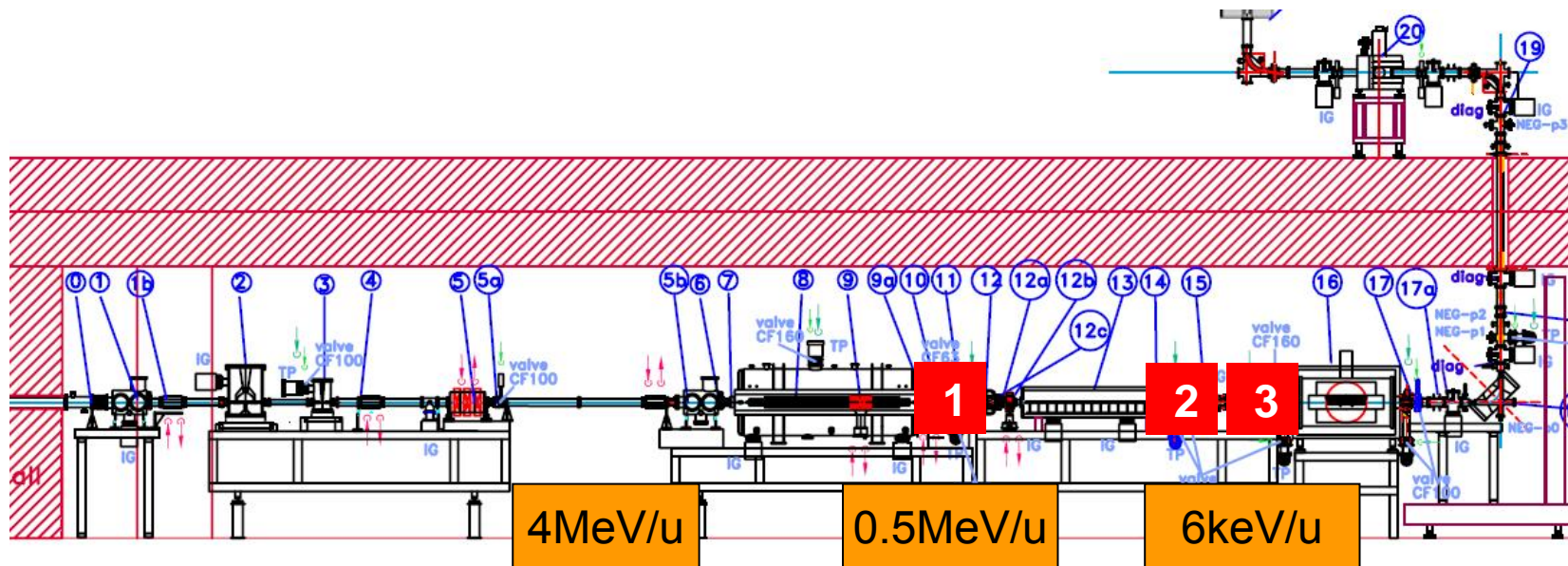
First test of MCP-Pepperpot-Emittance Meter

HITRAP Beam Diagnostics **Measurements** Outlook
3-gradient method Pepperpot

- Measurement behind RFQ (LEBT)
- Energy mixture: $4\text{MeV}/u > E > 6\text{keV}/u$



- MCP-based energy analysis tests ongoing
- tune IH-structure based on energy distribution measurements (1)(spring 2010)
- energy analysis behind RFQ (2) and low energy emittance measurements (3)



Thank you for your attention!

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