Beam Loss Instrumentation and Profile Measurement R&D within the QUASAR Group

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QUASAR GROUP

The Cockcroft Institute of Accelerator Science and Technology

Overview of Activities

Medical Physics

- Beam Extraction
- APCT

SC Linacs

- HOM Studies
- Material Studies

USR @ FLAIR

- Ring design
- Instrumentation
- Experiments

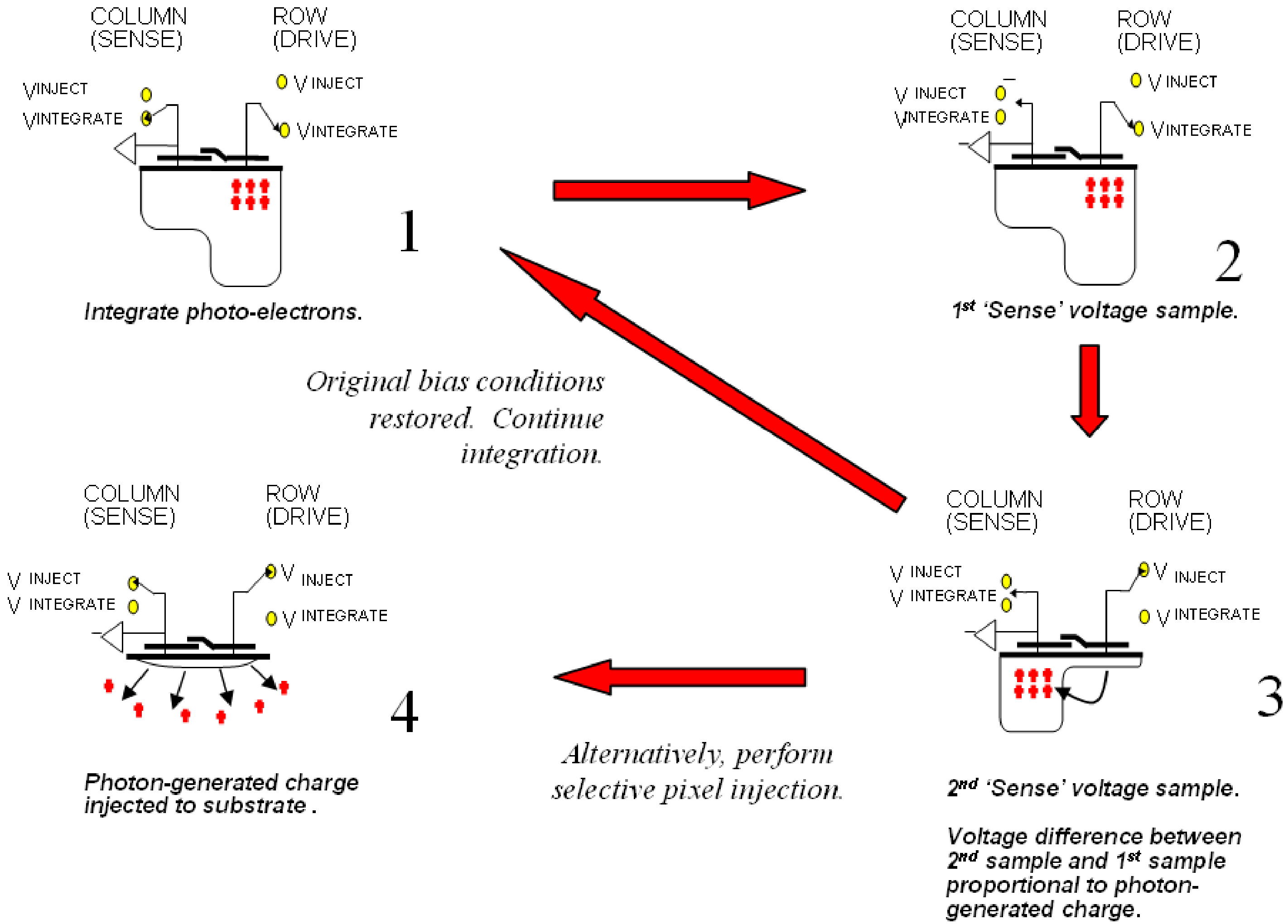
CTF3 / CLIC

- Halo studies
- BLM (Fibres)

Beam Halo Monitoring

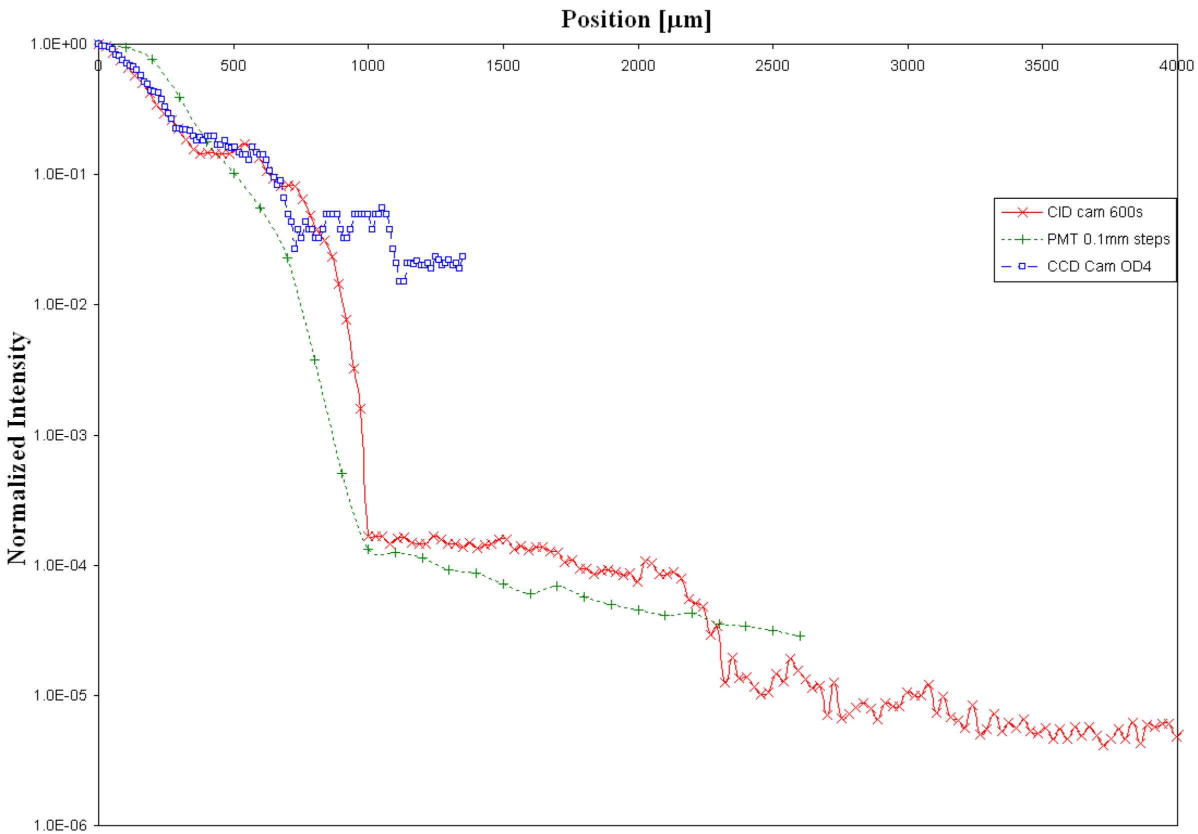
- Studies ongoing since 2004
  - Fixed mask technique *(T.L.)*
  - CID camera
  - Flexible mask technique
- Requires close interaction with beam dynamics experts (CI ↔ CERN)
- Monitors characterized in lab 2008 and 2009, first tests with beam will be done at U Maryland.

CID Technology



Source: Thermo Fisher Scientific

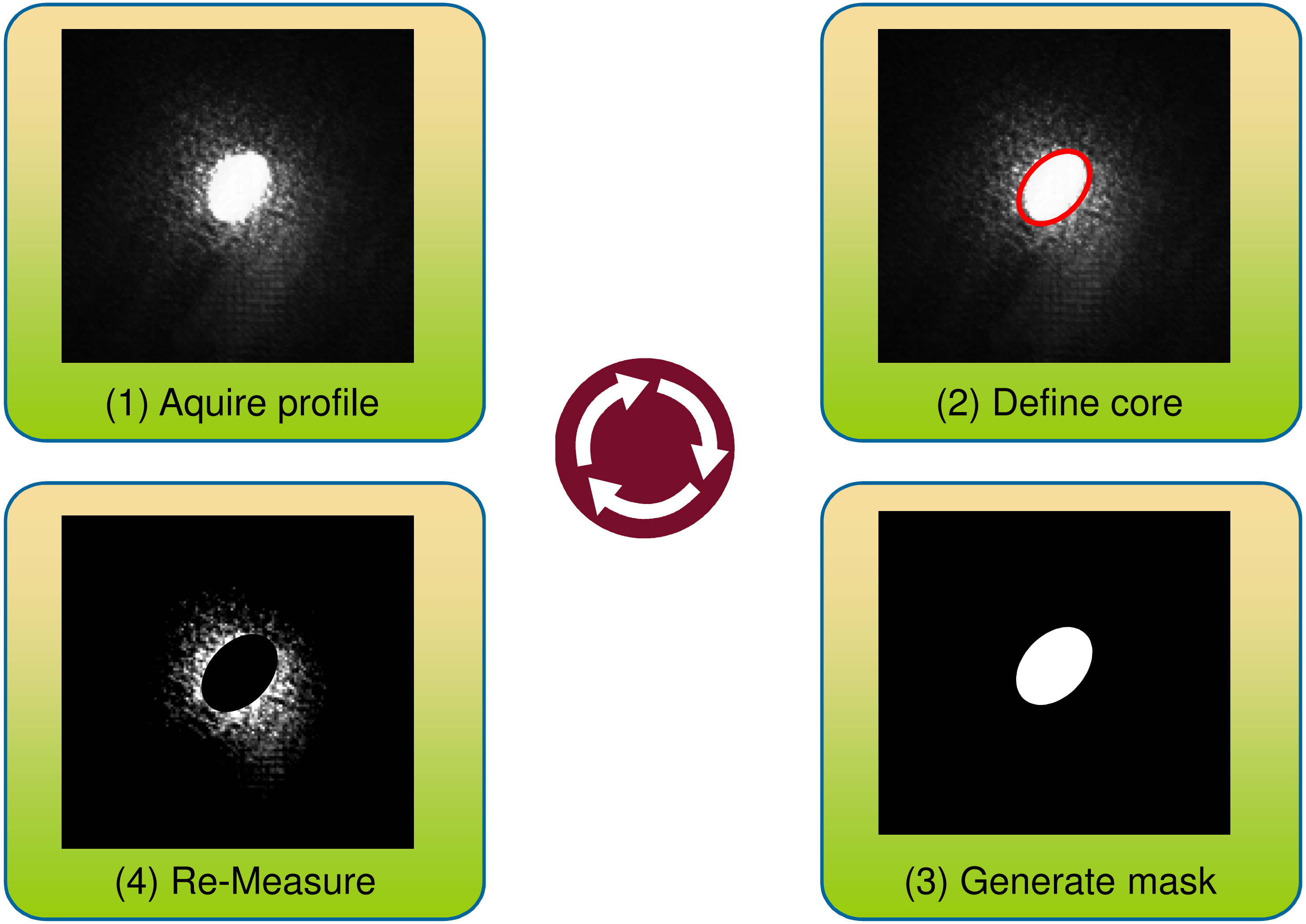
CID Camera Measurements



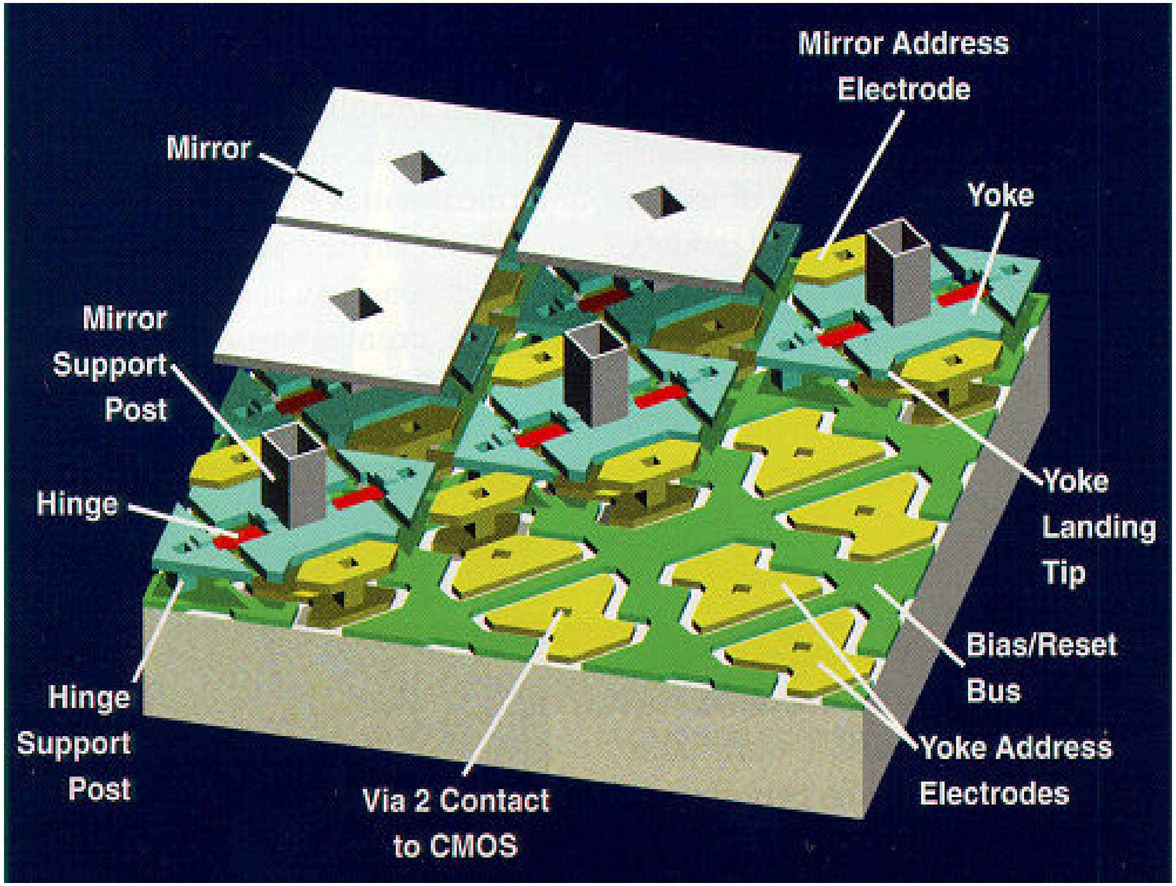
C.P. Welsch et al., Meas. Sci. Technol. **17** (2006) 2035c

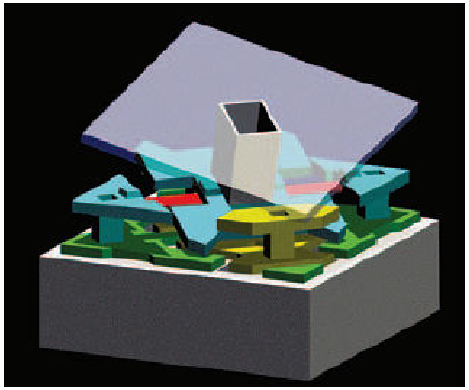
- New model (XDR): Dynamic range of up to 10^7 in lab tests.
- Laser beam used as reference
- Long acquisition times (10s of min.)
- High costs

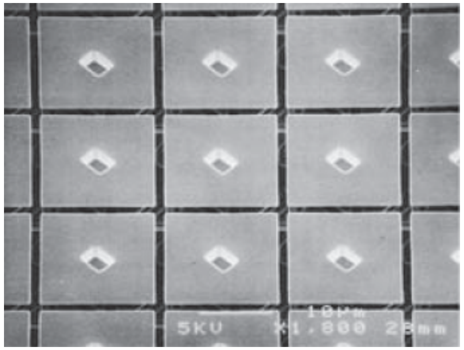
Core Masking Technique: The Idea



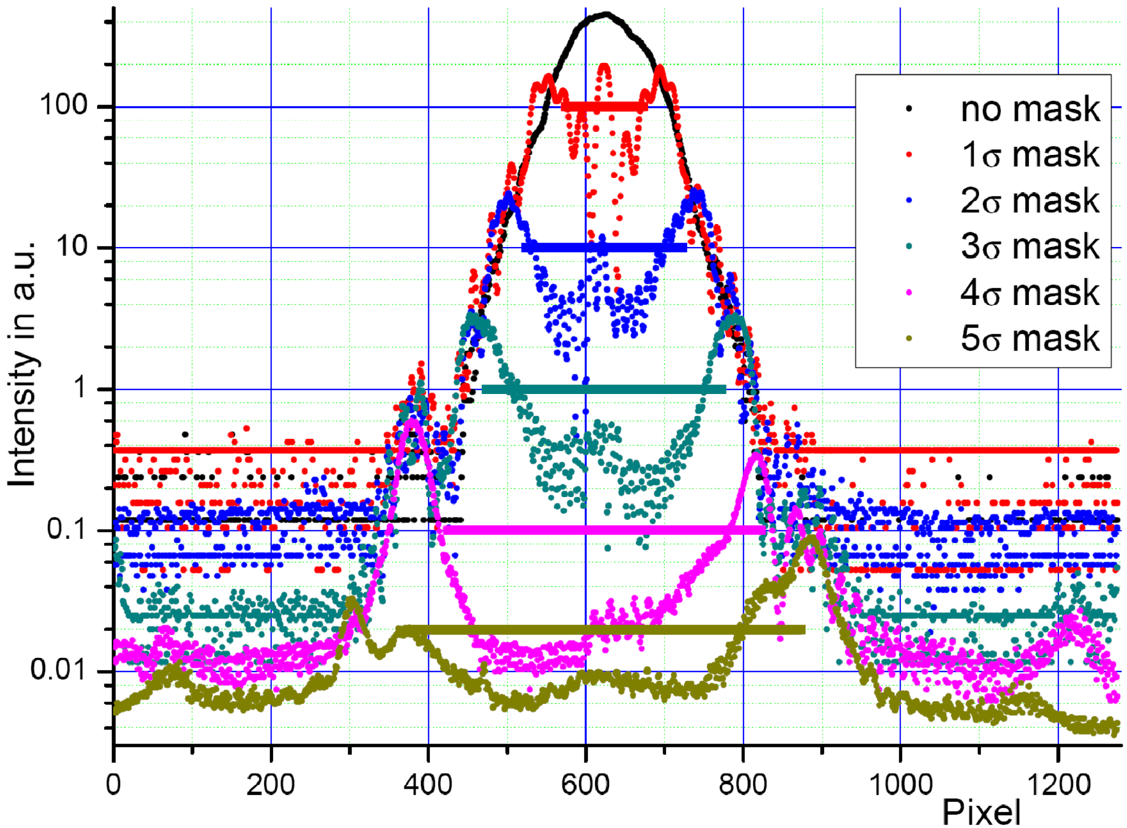
Micro Mirror Array







Results from Measurements

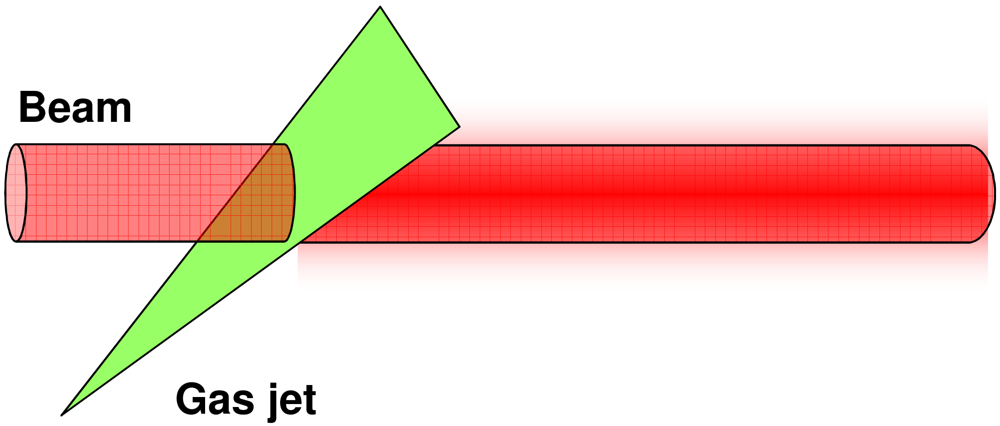


J. Egberts et al., *DIPAC 2009*

- Dynamic range of up to $10^{5.5}$
- Interference in centre
- Now: Fully automized
- Next step: Measurements with beam

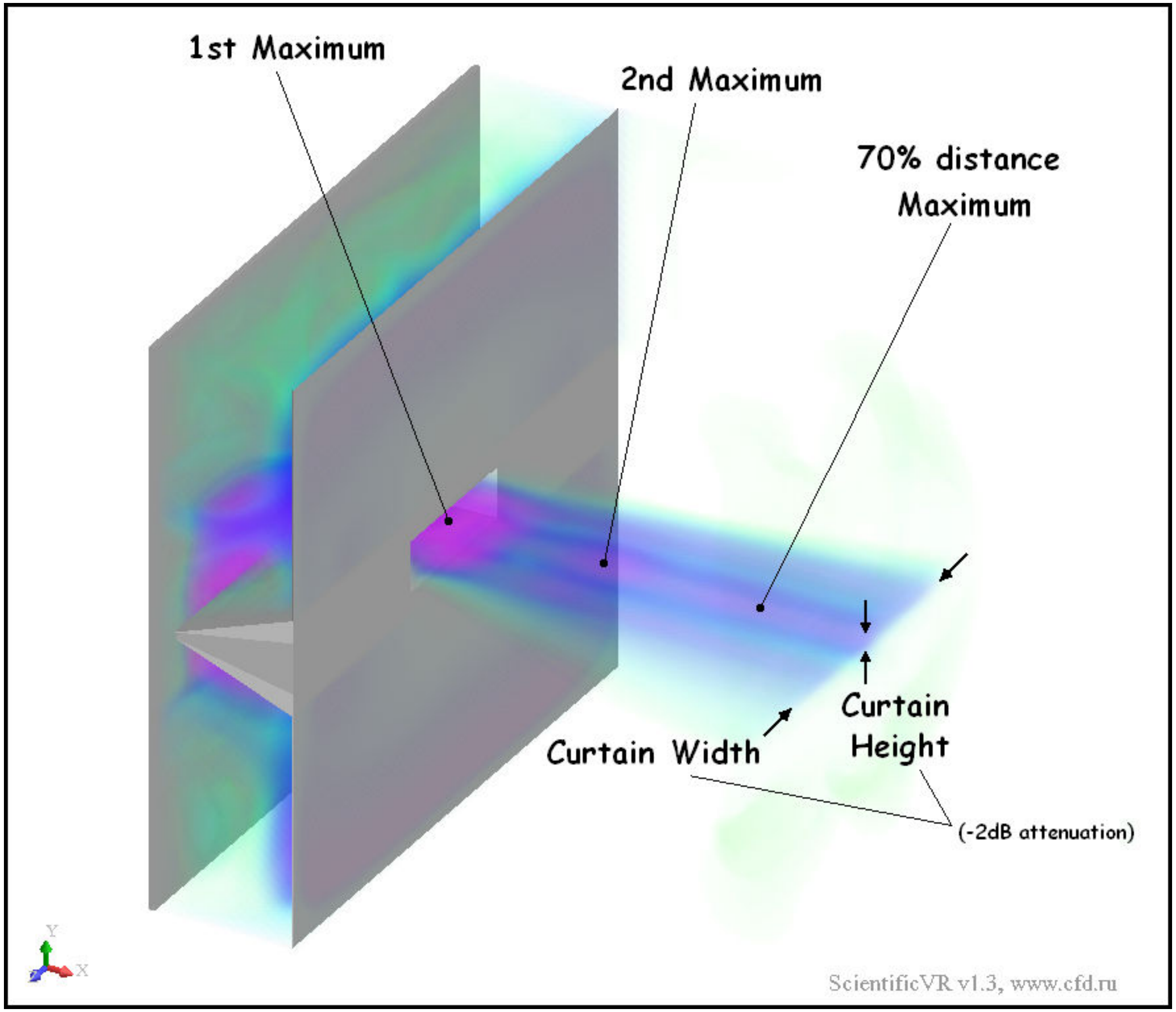
Gas Jet-based Monitor

<u>Principle</u>:



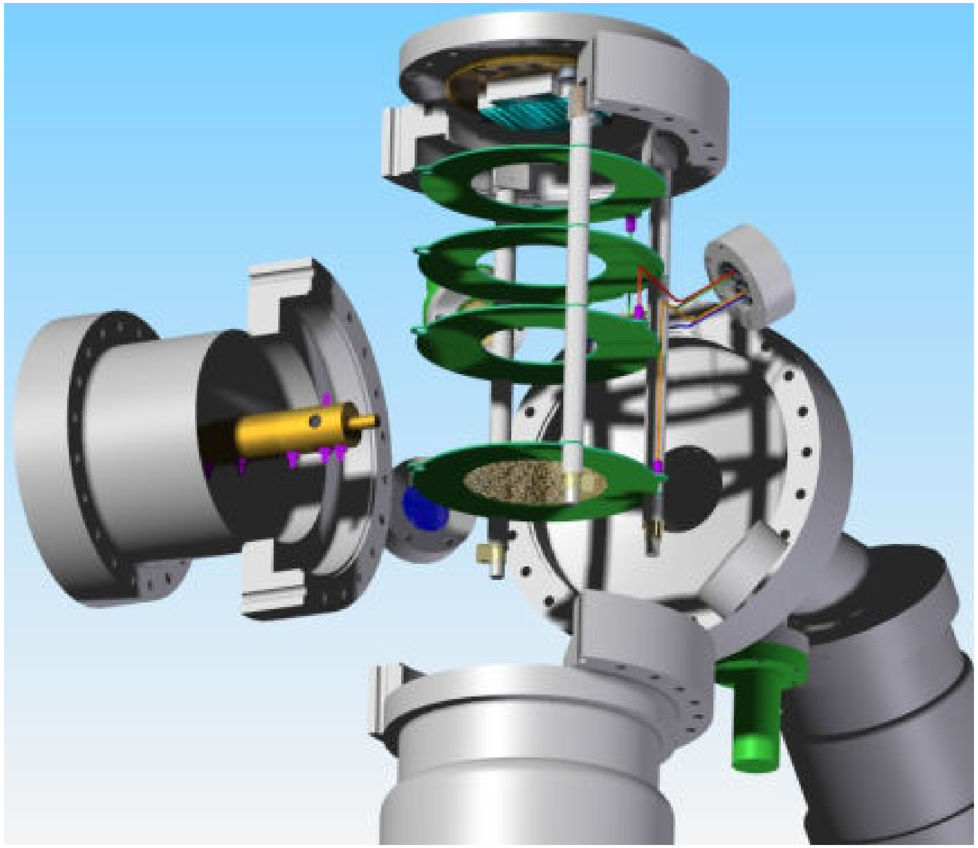
- Development of gas jet with highly flexible geometry (intensity <u>and</u> shape),
- Measurements with high dynamic range by curtain,
- (Generation of desired halo distribution)
- <u>Goal</u>: Benchmarking and improvement of models.

Numerical Investigations with GDT



M. Putignano

Experimental Setup

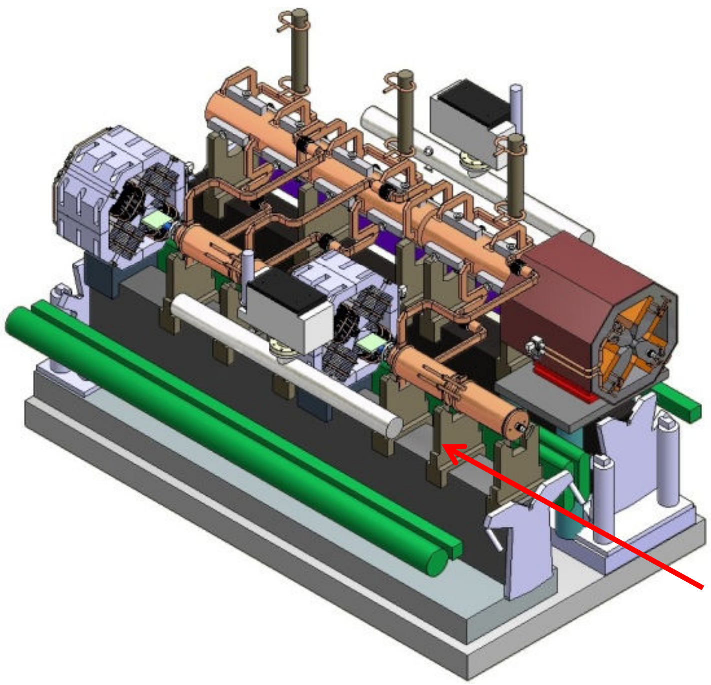


M. Putignano

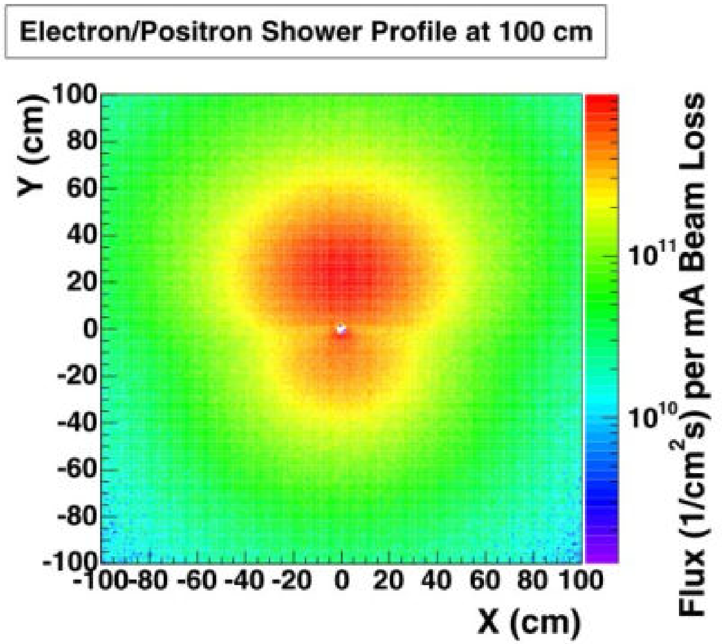
- Jet characterization by e^- beam and laser self-mixing
- Vacuum chambers presently build up
- First tests 2nd half of 2009
- Tests at CTF3 could be an interesting option.

Beam loss monitoring

Major complication: Two beams !



100 A, 2.4GeV



M. Wood, T. Lefevre

A. Intermite

The Monitor

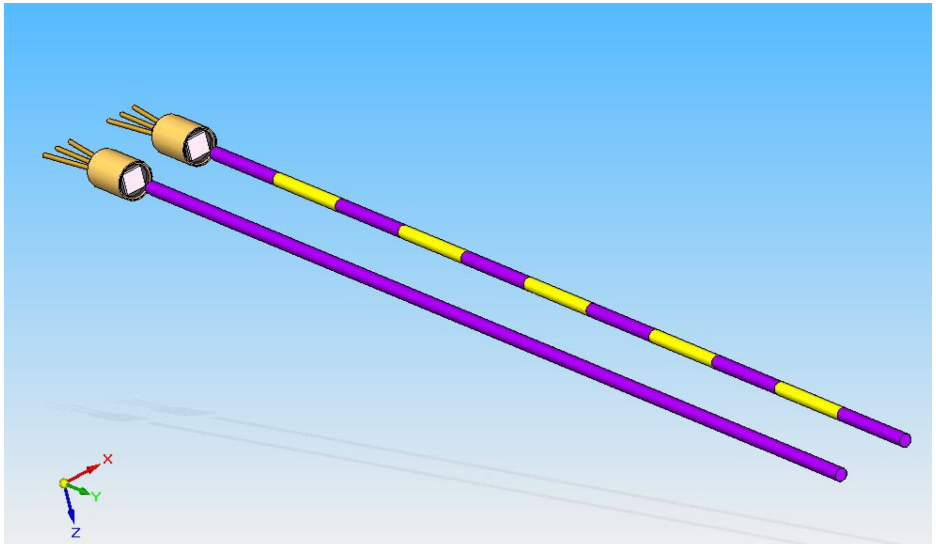
- Exploitation of Cherenkov-radiation in optical fibres
  - Based on DESY work
  - $4^{x}2$ fibres around vacuum chamber
  - Short individual fibres for true 3D analysis
- Goal: Detect on 10^{-4} level of nominal current
- Steps:
  - Optimization of light capture in fibres
  - Lab tests of fibre coupling/splicing
  - Monte Carlo studies *(@ CERN)*
  - "cross-talk" between losses from both beams

Advantages

- Fast time response
- Transverse and longitudinal information
- Insensitive against E and B fields
- Radiation hard
- Space requirement of monitor
- Losses can be tuned continuously
- Malfunctions of machine elements can be monitored

Working Principle

- Optical Fiber Sensor based on SiPM composed of SPAD Array.
- Two arms:
  - Reference fiber.
  - Composite fiber.

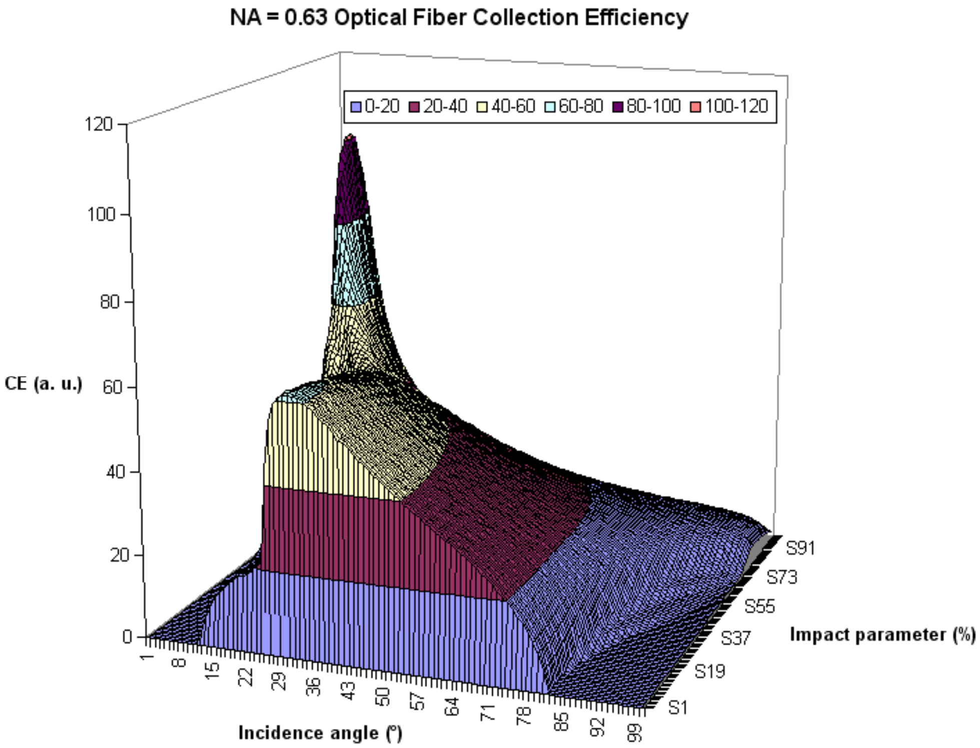


Features:

- Optical fiber diameter: 1mm^2 as the dimensions of SiPM active surface.
- Numerical aperture of fibers between 0.22 and 0.63. (+ photonic bandgap fibres ?)
- Pure silica (and PMMA ?) multimode step index fibers with n = 1.46.
- SiPM recovery time ca. 4 ns.
- SiPM quantum efficiency 15 % in the blue wavelength range

Theory

- Study of Cerenkov effect in optical fibers (*ongoing*).
- C++ code for simulation of coupling efficiency of Cerenkov photons in multimode step index fibers with numerical aperture in the range between 0.22 and 0.63
  (*ongoing, see right*).
- To be included until end of summer 2009:
  - Splicing losses
  - Cleaving angle of Optical Fibers
  - Optical Fiber-SiPM Coupling losses



Experiment

- SiPM results on simulating bunches' sequence by a pulsed laser with *λ= 450 nm*;
- Splicing tests for choosing suitable fibers: about 15 stages with losses between 0.45-0.20 dB;
- Monitor splicing losses for high radiation levels;
- Calibration of the sensor with the SiPMs: 400×400 or 289×289 SPADs for 1 mm^2 active surface will be used;
- We need *(in collaboration)*:

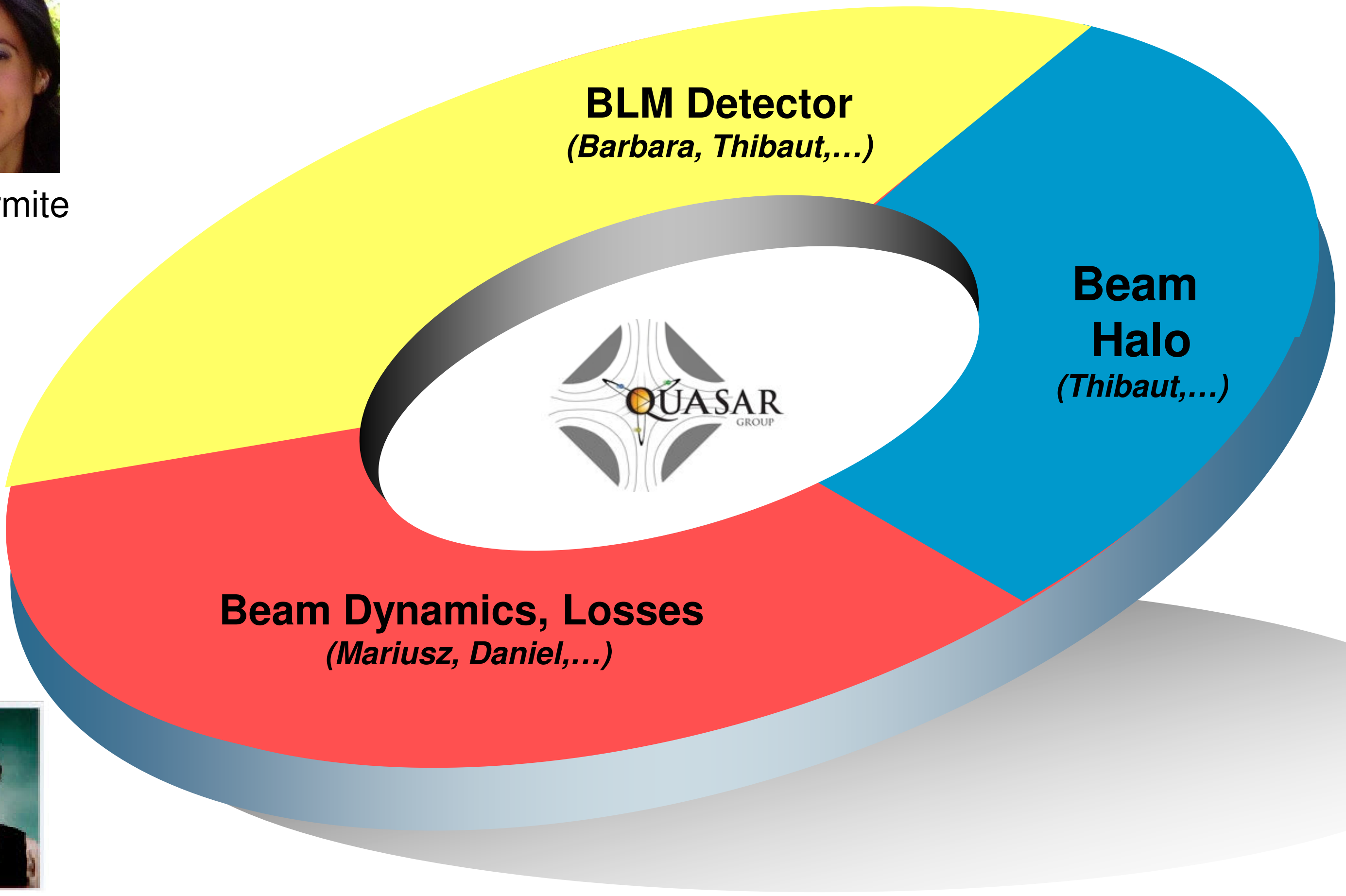
  Accurate simulations of losses.

- Work plan until end of 2010 presently being finalized.

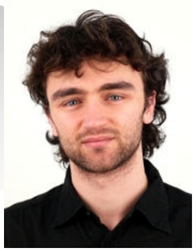
Beam Loss and Halo Monitoring

A. Intermite

J. Egberts



S. Artikova



M. Putignano

Conclusion

- Beam loss and profile monitoring ongoing activities;
- Close collaboration between CERN, CI, RHUL,… one of the key ingredients.

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