Summary of the 1st Beam Line Review Meeting Injector (23.10.2006)

15.11.2006

Review the status of:

- beam dynamics understanding and simulations
- completeness of beam line description
- conceptual design of beam line components

Identify:

- What has been done
- What has to be done
- Which information or prerequisite is missing to continue the work

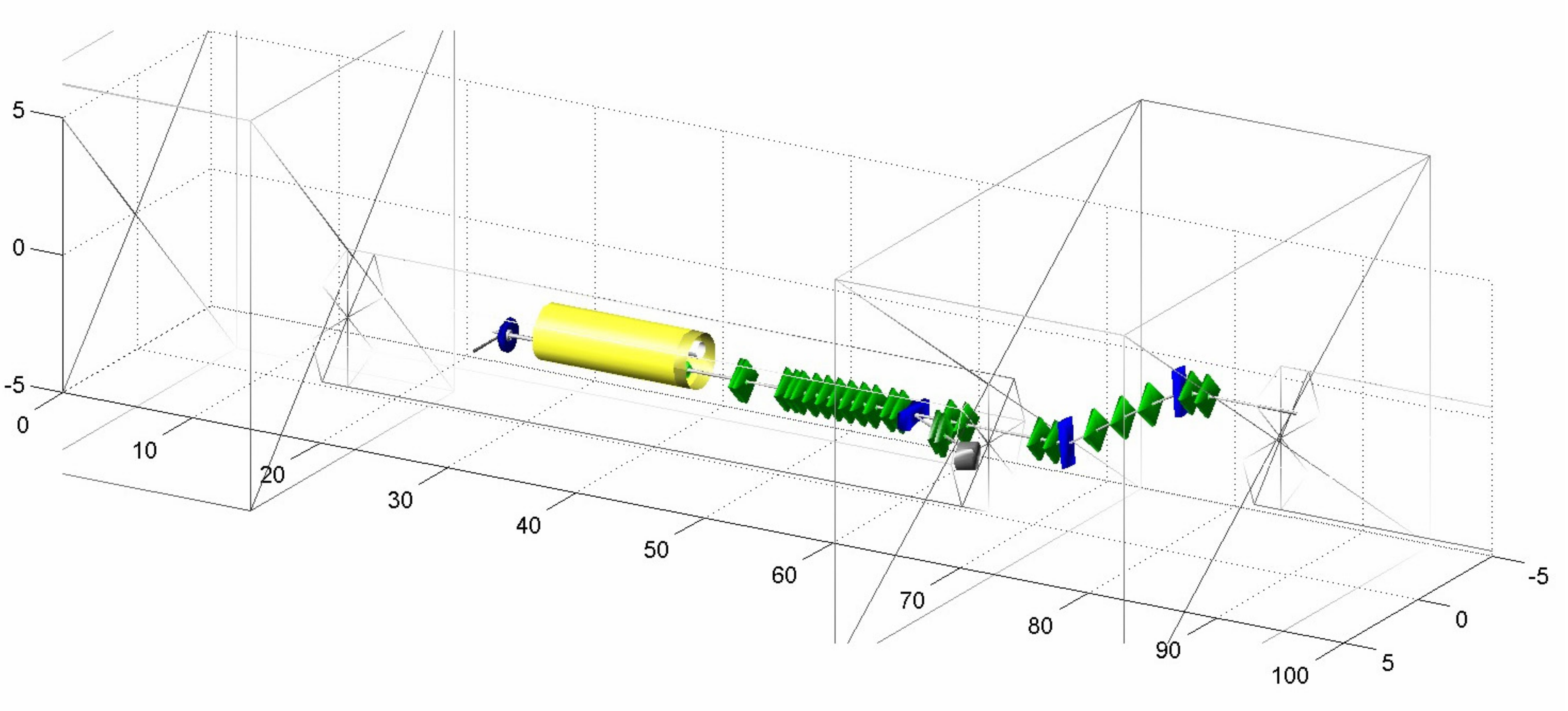
Winni Decking

Topics

Injector Introduction	- Klaus Flöttmann
Injector Simulations	- Mikhail Krasilnikov
Dark Current	- Jang-Hui Han
Optics	- Winfried Decking
Standard Diagnostics	- Dirk Nölle
PITZ Transverse Deflecting Structure	- Sergey Korepanov
Special Diagnostics	- Holger Schlarb
Beam Dump	- Michael Schmitz
Warm Magnets	- Bernward Krause
Vacuum Issues	- Kirsten Zapfe

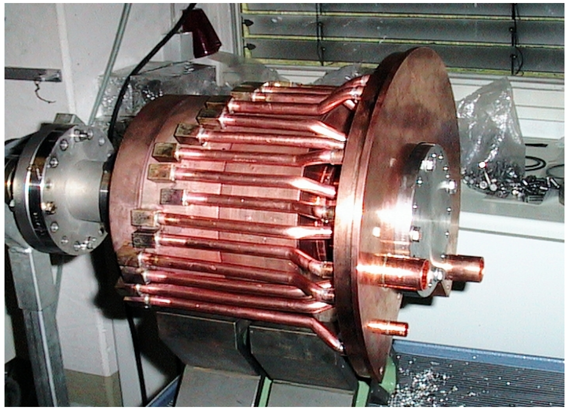
Current Injector 1

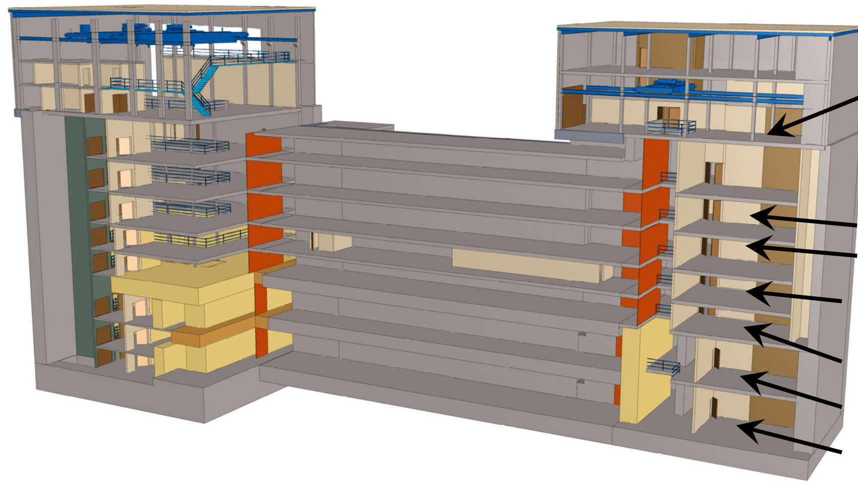
The injector starts at the gun and ends at the beginning of the first module in linac 1



Introduction

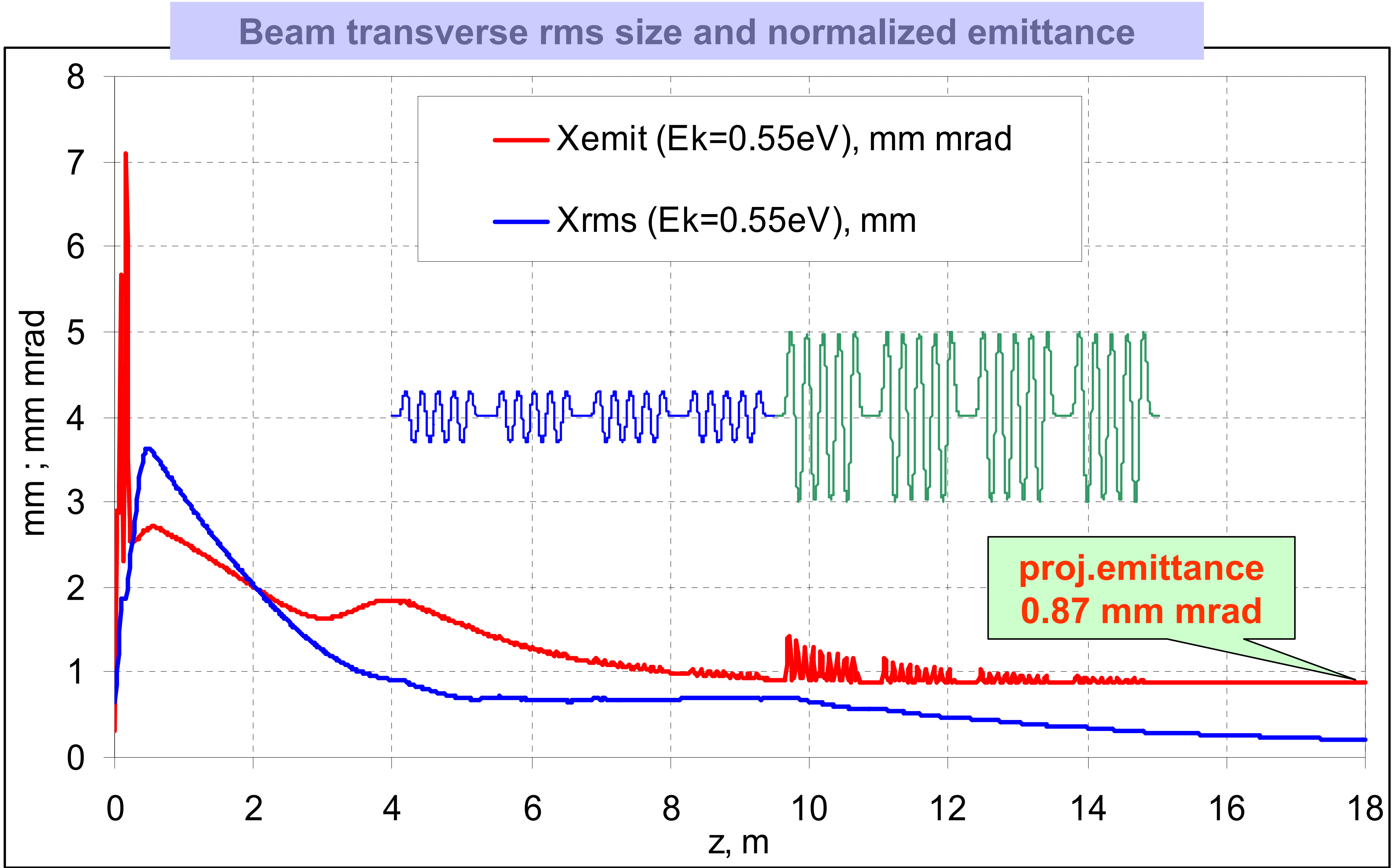
- XFEL Injector is based on the FLASH / PITZ injector
- Will be housed in large hall on DESY site XSIN/XSE





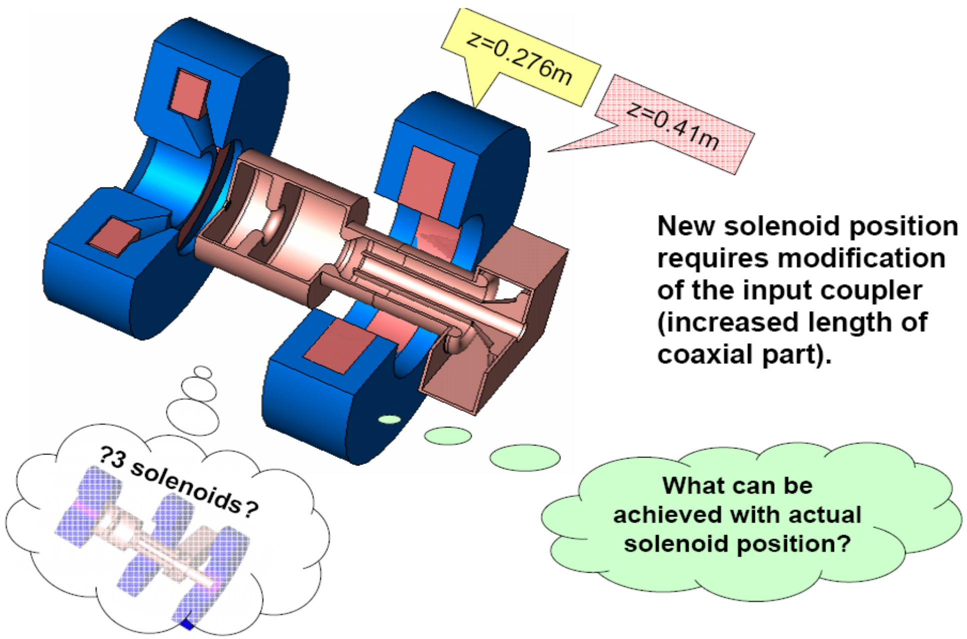
- New design of section between gun and module
  - more space for more diagnostic and dark current removal kicker
- Special Gun RF components
  - high power T-combiner
  - high power RF window
  - high power, high precision directional coupler

Simulations



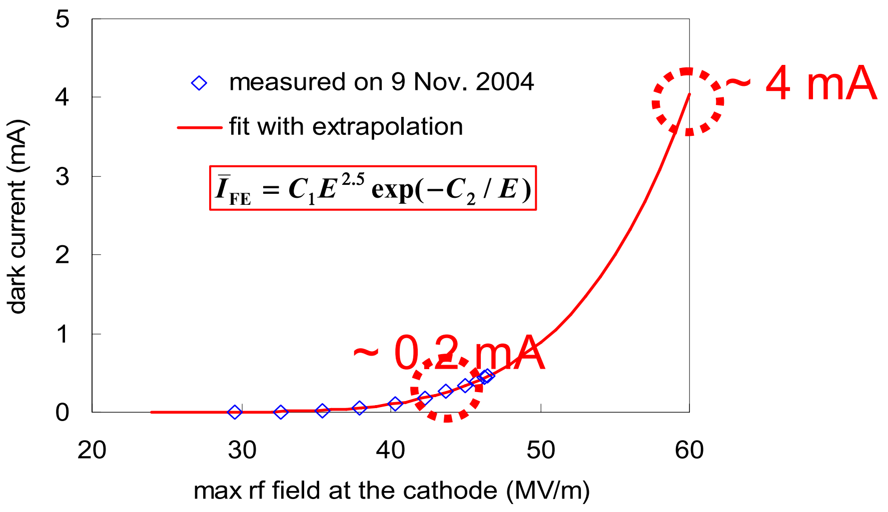
Simulations

– Finalize Design of Gun-Module-Intersection



– Studies of tolerances for cathode laser parameters: FWHM, rise/fall time, flat-top modulation
– Influence of the vacuum components (like a vacuum mirror, diagnostic cross etc) on the beam quality
– Impact of photo injector imperfections (misalignment)
– Velocity bunching
– Explore gun parameter space (charge, bunch shaping, …)

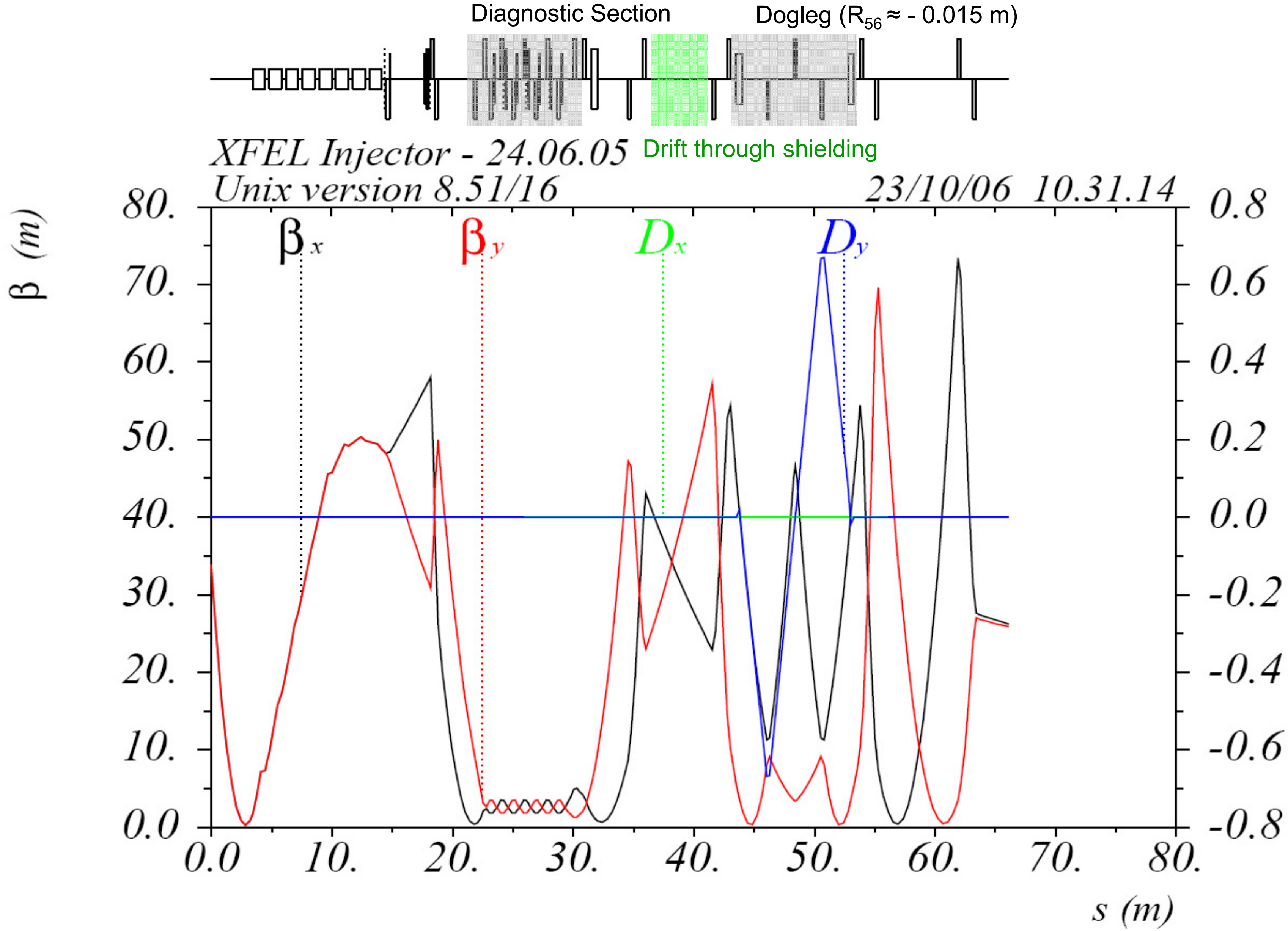
Dark Current



- extrapolation of PITZ measured dark current to XFEL parameters
  - ➢ a reduction by 3 - 4 orders of magnitude is needed

- include momentum and geometrical collimators between gun and module
  - momentum collimation especially efficient with longer half cell
  - position of geometrical collimator not optimized
  - these measures give reduction by factor of 30 in simulations
- improve cathode preparation (cleaning & polishing), conditioning, geometry (larger plug area) and mounting
- dark current kicker to collimate in time domain
  - this may require placement of absorbers into the module
- foresee additional momentum collimation in dogleg

Injector Beam Line Optics



Injector Beam Line Optics

- What's missing
  - laser heater section (before diagnostic)
  - transverse deflecting structure
  - possibility of additional bunch compression
- Next Steps
  - refine diagnostic section, include laser heater, study bunch compression options

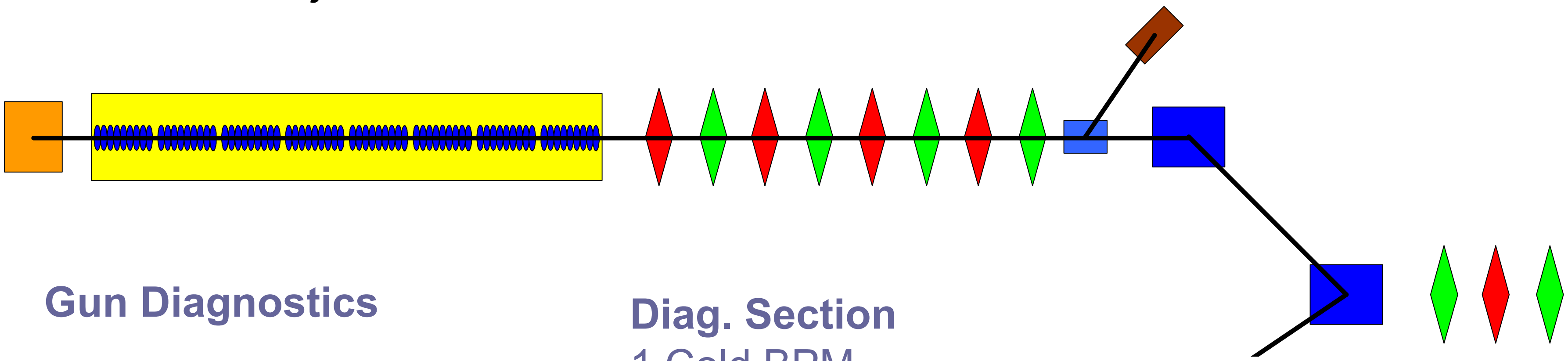
    Affects only XTIN, enough space, less time critical
  - improve chromatic/dispersive properties of dogleg

    May influence XSIN layout, asap

Standard Diagnostics

Spectrometer/Dump
2 BPM
1 Toroid
1 OTR/WS

Injektor II



Gun Diagnostics

2+1 BPM (Button)
2+1 Screen & Faraday Cup
1 Toroid
1 Dark Current

Diag. Section
1 Cold BPM
5 BPM (Stripline?)
4 OTR/WS
2 Toroid
1 Dark Current

Dogleg + U-Booster
6 BPM
1 OTR/WS
1 Toroid
1 Dark Current
1 SR Port

- Precision aligned BPMs needed
- Procure HOMCoupler-BPM electronics
- add SR ports

PITZ Transverse Deflecting Cavities

- Standing wave (classic and 'Paramonov') and traveling wave cavities (1.3 GHz) studied for diagnostic section at PITZ
- Resolution limited due to longitudinal field component

	Classic cavity		"Paramonov" cavity		Travelling wave cavity	
	Tomography	Dispersive	Tomography	Dispersive	Tomography	Dispersive
Distance, m	2-4.2	6	2-4.2	6	2-4.2	6
$V_{\perp}$, MV	0.85-1.8	0.6	0.85-1.8	0.6	0.85-1.8	0.6
Q	21000	21000	15000	15000	19000	19000
P_{RF}, MW	up to 1	0.12	up to 0.17	0.02	up to 9.1	1.01
Field build up, µs	~20	~20	~20	~20	~0.2	~0.2
Resolution	0.35 mm	25 keV	0.35 mm	25 keV	0.35 mm	25 keV

Special Diagnostics - Wish List

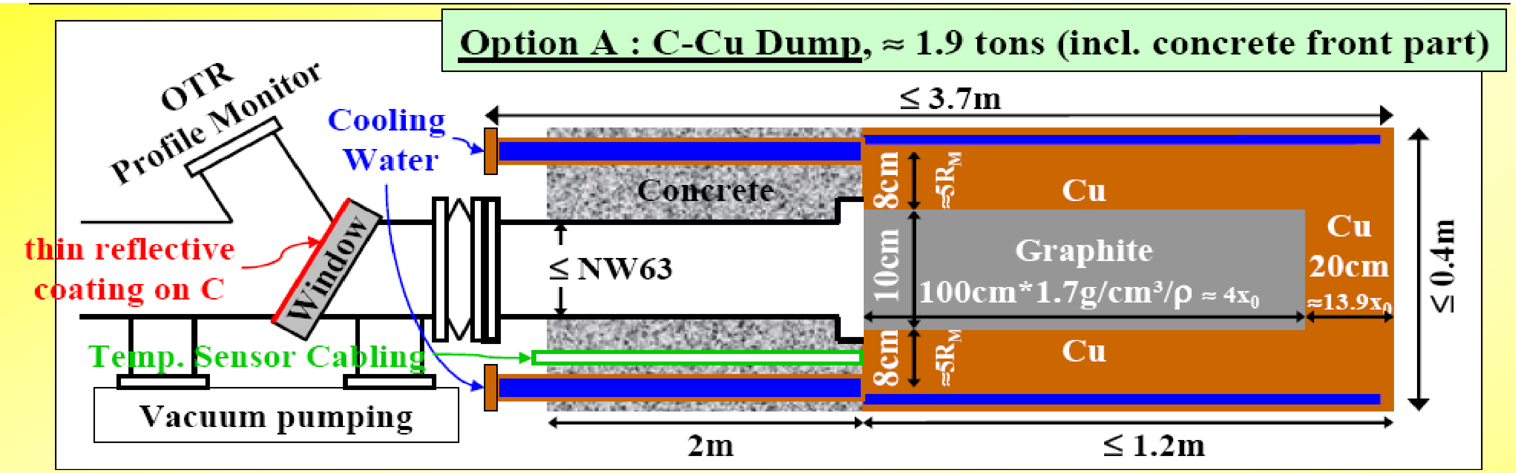
- **laser arrival time monitor (< 50 fs) (must)**
  - EOM technique
  - balanced DFG generation (LbSyn versus UV)
- **relative gun phase to laser phase monitor (can)**
  - launch of parasitic laser pulses (<50fs)
- **high precision e-beam arrival time monitor (must)**
  - specs: < 30fs arrival time precision w.r.t *LbSyn* @ 5MHz readout
- **transverse deflection structure for (must)**
  - longitudinal profile measurements: $\sigma_{res} < \sigma_t/20 = 300\text{fs}$
  - slice emittance measurements: $\sigma_{res} < \sigma_t/10,\ d\varepsilon_{res}/\varepsilon < 10\%$
  - slice energy spread: $\sigma_E < 1.3\ \text{keV}$
- **online transverse profile control within macro-pulse (recommended)**
  - kicker and off-axis screens
- **online longitudinal profile control (recommended)**
  - low frequency detector (50-400GHz), [fast, no bunch info]
  - steak camera [only single shot, pure dynamic range]
  - EO [multi-bunch possible, medium dynamic range]

Special Diagnostics - To Do

- Several special diagnostic instruments still under development
- Special diagnostics concept has to be detailed
  – Reevaluate TDS specifications and resolution
  – Redesign lattice
  – Evaluate possible conflicts with dump requirements in the spectrometer/dump arm

Beam Dump

Required capability: $E_0 \leq 300$ MeV, $N_t \leq 2.5 \cdot 10^{13}$ e- = 4 μC, $I_{ave} \leq 40$ μA, $P_{ave} \leq 12$ kW



- Average heating no issue, slow sweep not required
- Cyclic effects determine the beam size
  - single bunch limit ≥ 20μm to 35 μm, can not be decreased by fast sweeping
  - bunch train limit ≥ 0.9mm to 1.6mm w/o fast sweep
- Fast sweeper requires 1m installation length and 2.5m resp. 5m drift space
- C-Cu dump can deal with smaller spot size than Al dump

Magnets

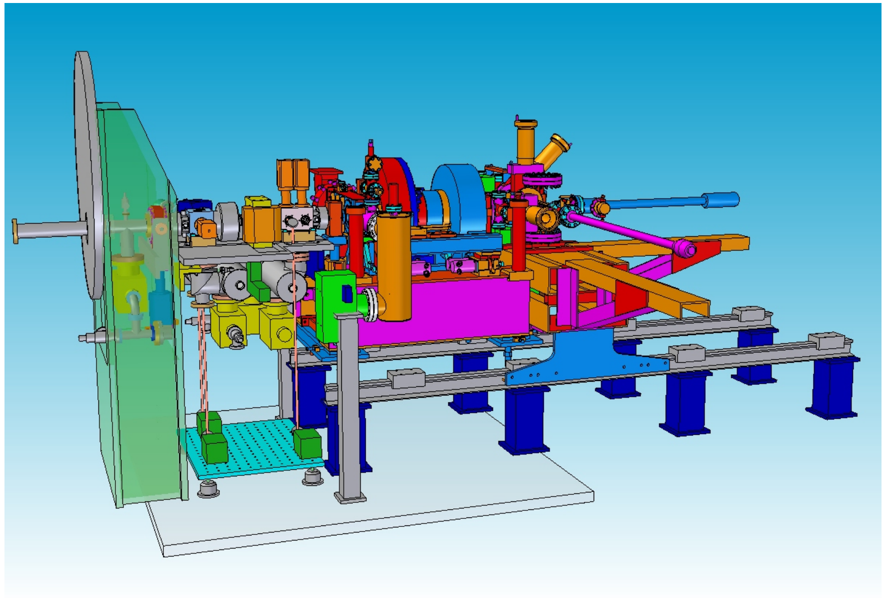
- Technical Specifiactions
  - magnet bore radius (half aperture): >20 mm
  - energy reach for magnet system: 100-150 MeV

- Quadrupols: 24
  Magnet length in beam direction: 250 mm
  Max. Gradient: 2.402 T/m
  Pole tip field: 0.048 T
- Corrector magnets 24
  Magnet length in beam direction: 100 mm
  Field in the gap: 0.003 T
- Dipole magnets in the dogleg: 6
  Magnet length in beam direction: 500 mm
  Field in the gap: 0.314 T

- Magnet System specified
  - magnet field quality specifications missing
  - reduction of XFEL magnet types
  - responsibility for gun area magnets

Vacuum System

- FLASH injector perfect test bed for XFEL injector
  - test improvements for XFEL as soon as possible
- careful planning of complete system necessary
  - reserve sufficient space for installation of components
  - modular set-up for good accessibility of components
  - avoid patchwork installations as we do have at FLASH



Example: Flash gun section upgrade

Summary

- The present design of the injector is mainly based on FLASH
- Many system improvements under way but not fully incorporated into a coherent design

- Space contingency in the injector tunnel relieves time pressure somewhat
- Experimental program at FLASH and PITZ directed at XFEL needs has to be detailed (performance stability and reproducibility, diagnostic concepts, …)

Next Meeting

2nd Beam Line Review – Bunch Compression

December 11, 2006

14:00- 17:00