Princeton Plasma Physics Laboratory

NSTX Experimental Proposal

Title: **Modifications to early discharge evolution to reduce impurity content**

OP-XP-1005	Revision:	Effective Date: **3/22/2010** *(Approval date unless otherwise stipulated)* Expiration Date: **3/22/2012** *(2 yrs. unless otherwise stipulated)*

PROPOSAL APPROVALS

Responsible Author: J. Menard, S. Gerhardt, J. Canik, R. Maingi	Date **3/22/2010**
ATI – ET Group Leader: S. Gerhardt	Date
RLM - Run Coordinator: E. Fredrickson	Date
Responsible Division: Experimental Research Operations	

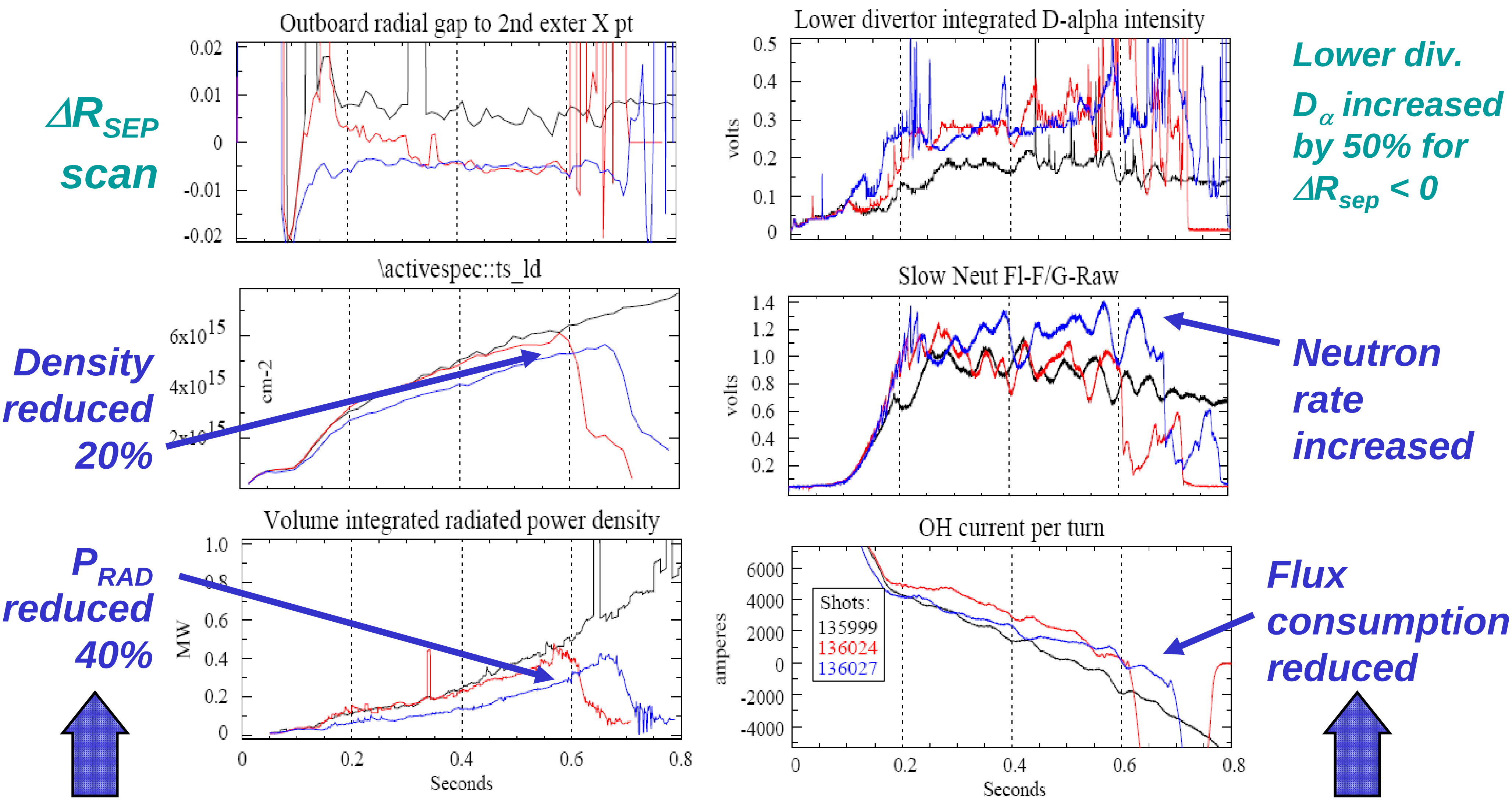
RESTRICTIONS or MINOR MODIFICATIONS

(Approved by Experimental Research Operations)

Particle/radiation evolution sensitive to ΔR_{SEP} evolution

(shots shown purposely have no/few-small ELMs due to Li-conditioning)

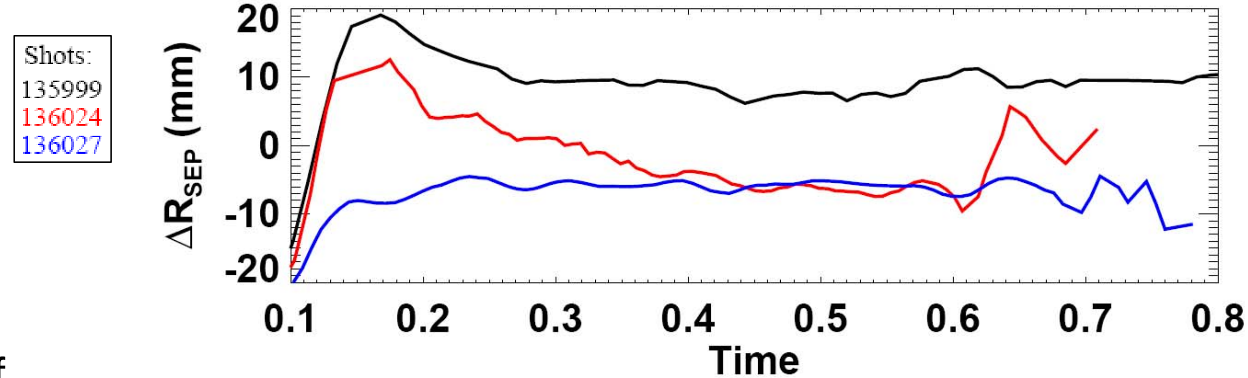
∇B drift up + USN	*∇B drift up, USN → LSN*	*∇B drift up + LSN*



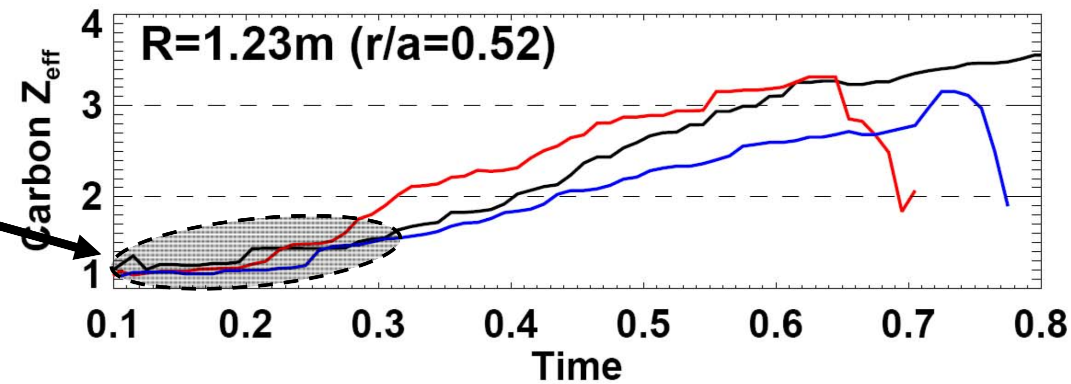
"Unfavorable" ∇B drift up (away from X-point) with LSN has several favorable properties

Carbon Z_{eff} evolution sensitive to magnetic balance during ramp-up (immediately following early H-mode)

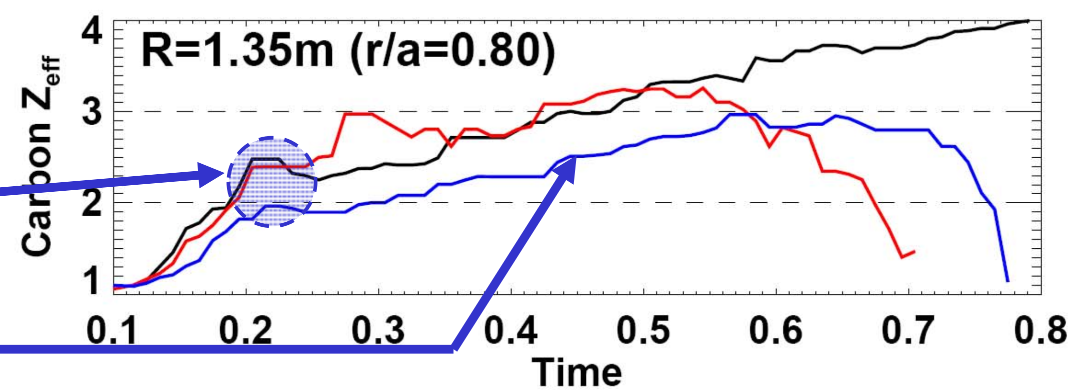
∇B drift up + USN	*∇B drift up, USN → LSN*	*∇B drift up + LSN*



- Core/mid-radius C Z_{eff} similar for all 3 magnetic bias configurations for first ~300ms of shot

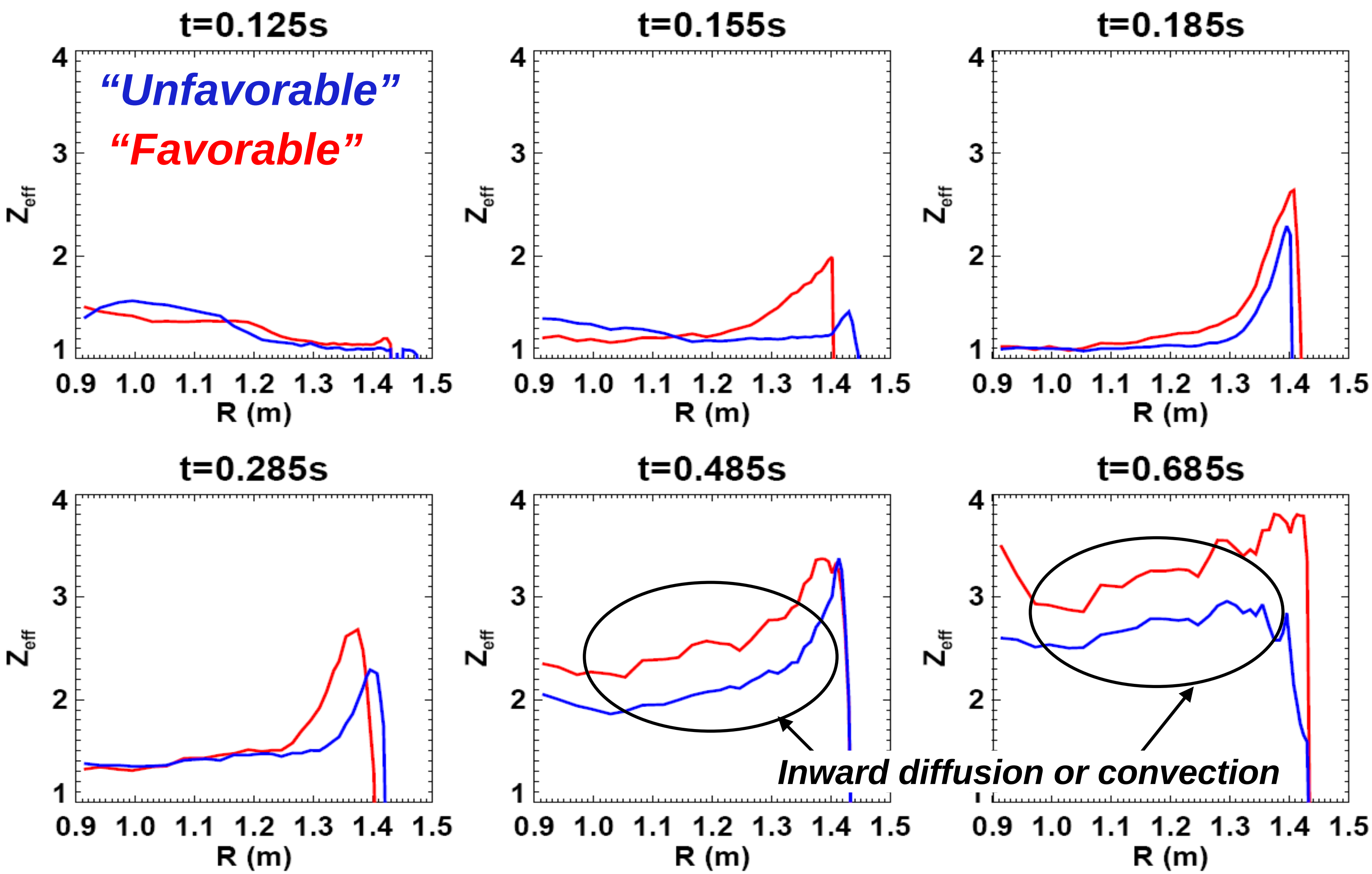


- **∇B drift up + LSN:**
  - Reduces C influx and/or confinement **at top of pedestal** immediately after early H-mode
  - Lowers C Z_{eff} thereafter



“Unfavorable” direction reduces width and height of edge region where carbon is concentrated

- Question for XP: Can minimizing / flushing the C early keep it from diffusing into the core later in the discharge?



NSTX EXPERIMENTAL PROPOSAL

TITLE: **Modifications to early discharge evolution to reduce impurity content** No. **OP-XP-1005**

AUTHORS: **J. Menard, S. Gerhardt, J. Canik, R. Maingi** DATE: **3/22/1010**

1. Overview of planned experiment

The goal of the proposed experiment is to reduce the accumulation of low-Z and high-Z impurities in LITER/LLD ELM-free H-mode plasmas by reducing the impurity influx and confinement during the early H-mode and current ramp-up phase of the discharge. Variations in magnetic balance and early ELM triggering with 3D fields will be utilized to modify the early and late impurity content.

2. Theoretical/ empirical justification

Previous operation with LITER led to favorable ELM-free H-mode operation with very high confinement. However, unfavorable confinement of C and metallic impurities has also been observed often leading to high radiation and/or H→L back-transitions after t=0.7-1s. In 2009, shifting the plasma vertically in the unfavorable ∇B drift direction during the current ramp-up phase (t=80-200ms) was observed to reduce the early and late carbon accumulation. Carbon density profile evolution data indicates that C is confined near the plasma edge until approximately t=0.4s, after which it is transported inward. Thus, reduction of the edge C density in the first 200-300ms using 3D fields for ELM triggering could also be effective for reducing the late C accumulation.

3. Experimental run plan

A. Reproduce long-pulse scenario with LITER/LLD which is ELM-free and with strong C impurity accumulation in edge – reference shot is 136027 (3 shots)

B. Scan magnetic balance direction (DRSEP) before, during, after early H-mode, assess impact on early impurity accumulation to determine discharge phase most responsible for C accumulation:

  a. During t=0.05-0.4s, scan DRSEP = -2, -1, 0, 1, 2 cm (constant in time) (9 shots)

    i. Add early NBI power as needed to trigger/retain early H-mode during ramp-up

  b. After above scan, for case with lowest C content, scan late DRSEP to assess changes in late C accumulation (DRSEP ramp between 0.3-0.5s) (6 shots)

C. In conditions w/ minimized C content, add n=3 RMP pulses during ramp-up + early flat-top, i.e. t= 100-300ms (i.e. attempt to "clip" the density ears) (9 to18 shots)

  a. Optimize amplitude, duty-factor, start-time to reduce C during ramp

    i. Use 50Hz (20ms period), start 50ms before, during, after early H-mode, off at 0.3s

    ii. 1, 1.5, 2kA and Δt = 8ms to 4ms

  b. Modify amplitude/duration to minimize early rotation damping and MHD instability

4. Required machine, NBI, RF, CHI and diagnostic capabilities

See Physics Operations Request

5. Planned analysis

MSE LRDFIT + TRANSP + NCLASS to model neoclassical impurity transport.

6. Planned publication of results

Results will be published in Nuclear Fusion, Phys. Plasmas, or possibly Phys. Rev. Lett. within 1 year.

PHYSICS OPERATIONS REQUEST

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Brief description of the most important operational plasma conditions required:

- DRSEP scans will be performed, so some discharge and/or control development/optimization will be required for this XP.
- Reproducible 800kA NBI discharge (or best available fiducial) with early H-mode.
- Implementation of early EF correction could be beneficial if early RMP is observed to reduce the early rotation leading to increased mode locking.

Previous shot(s) which can be repeated: 136027 or 135999 or fiducial

Previous shot(s) which can be modified: (see above)

Machine conditions *(specify ranges as appropriate, strike out inapplicable cases)*

I_{TF} (kA): **53kA** Flattop start/stop (s): **-0.040/1.4s**

I_P (MA): **0.8MA** Flattop start/stop (s): **0.15-1.2s**

Configuration: **LSN, balanced DND, and USN will be utilized (DRSEP = -2 to 2cm)**

Equilibrium Control: **Isoflux** (rtEFIT)

Outer gap (m): **see reference** Inner gap (m): Z position (m):

Elongation: Triangularity (U/L): OSP radius (m):

Gas Species: **D** Injector(s): **see reference shot**

NBI Species: **D** Voltage (kV) **A: 90** **B: 90** **C:** 70 Duration (s): **1.2s**

ICRF Power (MW): **0** Phase between straps (°): Duration (s):

CHI: **Off** Bank capacitance (mF):

LITERs: On Total deposition rate (mg/min): **20mg/min**

LLD: Temperature (°C): **warm (if warm LLD provides reproducible pumping)**

EFC coils: On Configuration: **Odd**

DIAGNOSTIC CHECKLIST

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Note special diagnostic requirements in Sec. 4

Diagnostic	**Need**	**Want**
Beam Emission Spectroscopy		X
Bolometer – divertor	X	
Bolometer – midplane array		X
CHERS – poloidal		X
CHERS – toroidal	X	
Dust detector		X
Edge deposition monitors		X
Edge neutral density diag.		X
Edge pressure gauges		X
Edge rotation diagnostic		X
Fast cameras – divertor/LLD	X	
Fast ion D_alpha - FIDA		X
Fast lost ion probes - IFLIP		X
Fast lost ion probes - SFLIP		X
Filterscopes	X	
FIReTIP		X
Gas puff imaging – divertor		X
Gas puff imaging – midplane		X
Hα camera - 1D		X
High-k scattering		X
Infrared cameras		X
Interferometer - 1 mm		X
Langmuir probes – divertor		X
Langmuir probes – LLD		X
Langmuir probes – bias tile		X
Langmuir probes – RF ant.		X
Magnetics – B coils	X	
Magnetics – Diamagnetism		X
Magnetics – Flux loops	X	
Magnetics – Locked modes	X	
Magnetics – Rogowski coils	X	
Magnetics – Halo currents		X
Magnetics – RWM sensors	X	
Mirnov coils – high f.		X
Mirnov coils – poloidal array		X
Mirnov coils – toroidal array	X	
Mirnov coils – 3-axis proto.		X

Note special diagnostic requirements in Sec. 4

Diagnostic	**Need**	**Want**
MSE		X
NPA – E‖B scanning		X
NPA – solid state		X
Neutron detectors	X	
Plasma TV	X	
Reflectometer – 65GHz		X
Reflectometer – correlation		X
Reflectometer – FM/CW		X
Reflectometer – fixed f		X
Reflectometer – SOL		X
RF edge probes		X
Spectrometer – divertor		X
Spectrometer – SPRED		X
Spectrometer – VIPS		X
Spectrometer – LOWEUS		X
Spectrometer – XEUS		X
SWIFT – 2D flow		X
Thomson scattering	X	
Ultrasoft X-ray – pol. arrays	X	
Ultrasoft X-rays – bicolor		X
Ultrasoft X-rays – TG spectr.		X
Visible bremsstrahlung det.		X
X-ray crystal spectrom. - H		X
X-ray crystal spectrom. - V		X
X-ray tang. pinhole camera		X