Proposal for measurements at NSTX with the fast X-ray pinhole camera based on Gem Detector

In collaboration with JOHNS HOPKINS UNIVERSITY

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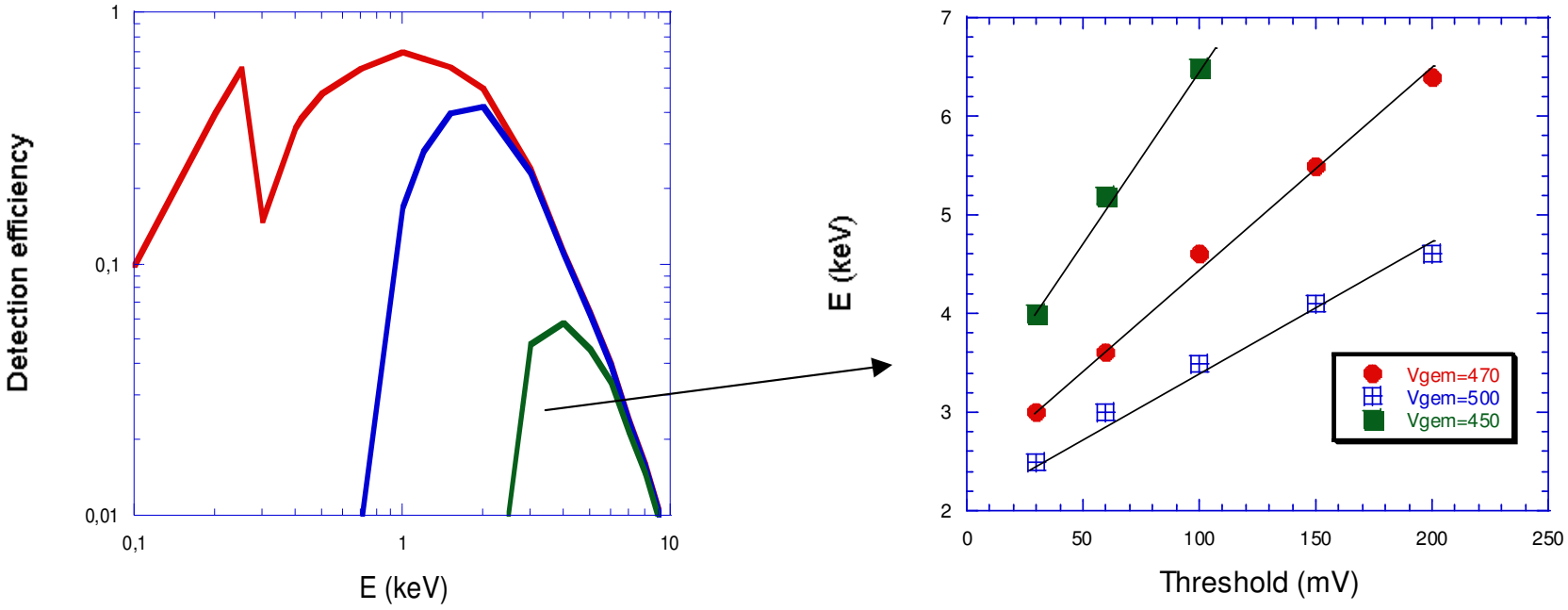
Plan

- **Present status** summary of the performances of the present system (2001-2001), **144 pixels (12*12)**
- **Next experimental campaign** (2002-2003) proposal with the present system, **144 pixels (12*12)**
- **Long term** (after 2003) proposal of the improved system, **1024 pixels (32*32)**

Selectable energy range in a wide interval and high detection efficiency



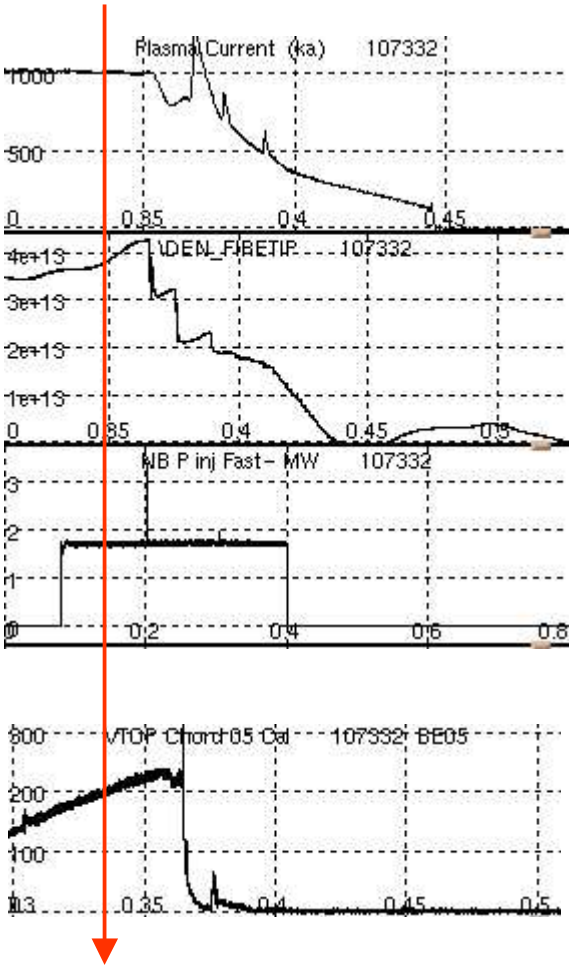
- Detector can work, with different configurations, in the range **0.2 – 10 keV**
- **0.2-1 keV** double gem, vacuum (red curve)
- **1- 5 keV** single gem, He, thin Be window on the machine (blue curve)
- **3 – 10 keV** single gem, air, thick Be window on the machine (green curve)

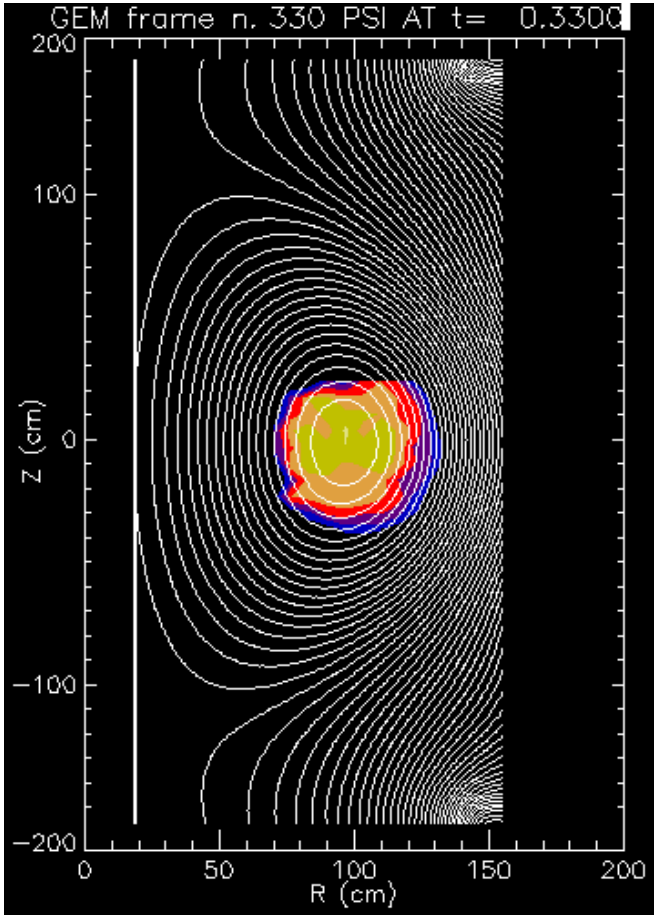
Imaging capabilities

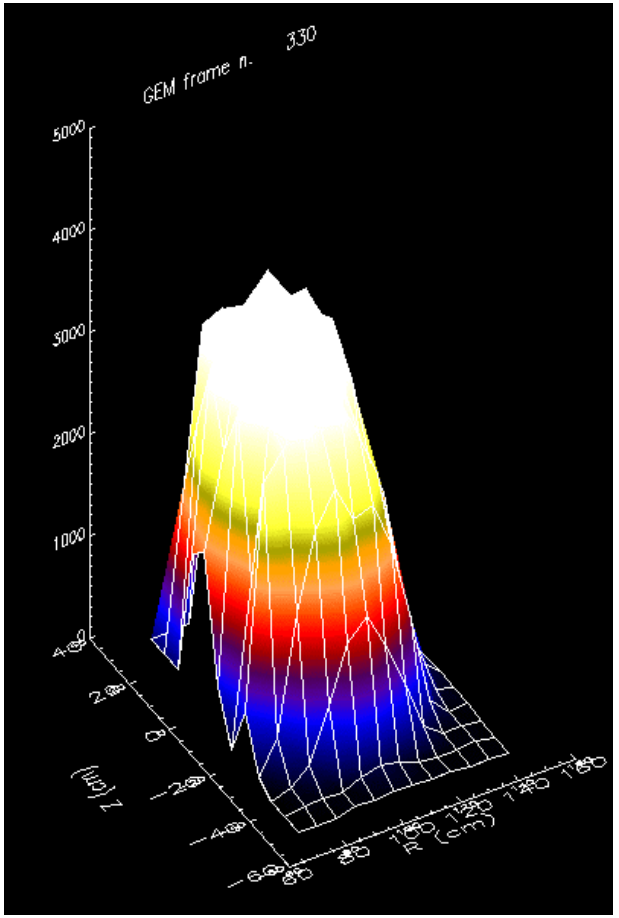
Tangential view

 # 107332

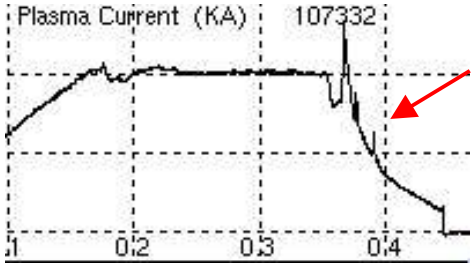
I_p ~ 1 MA, P_{NBI} = 2.0 MW t = 0.33 s H-mode

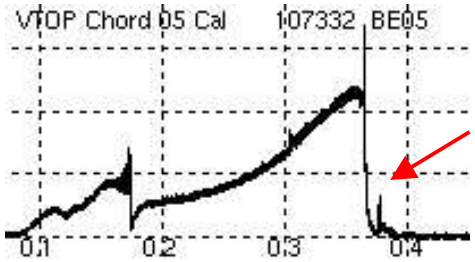




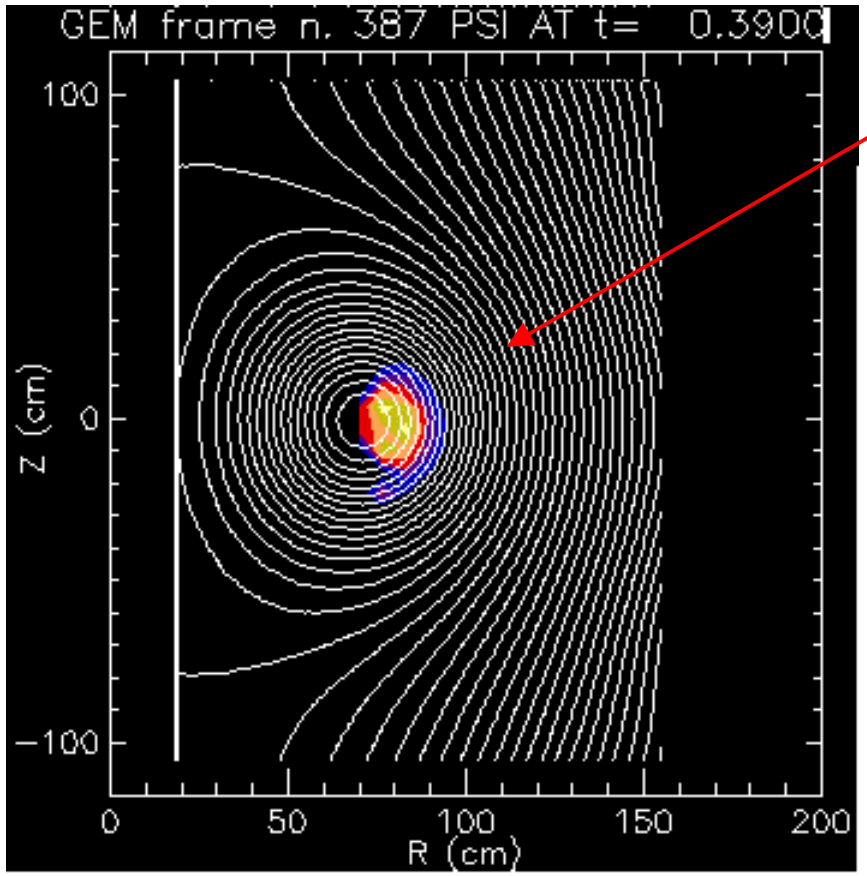


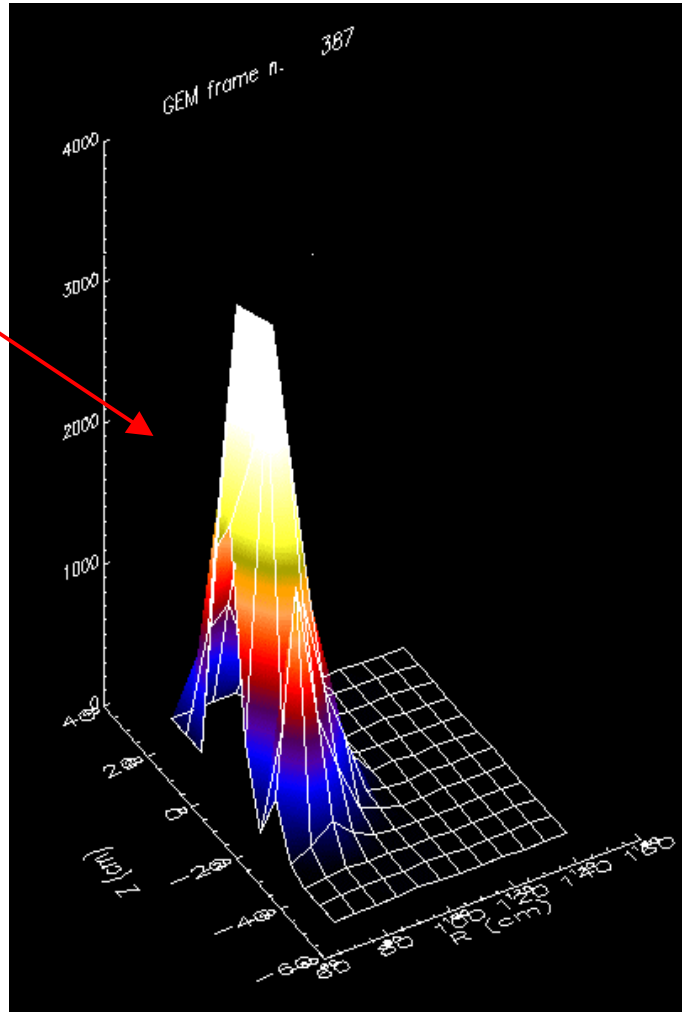
Imaging capabilities



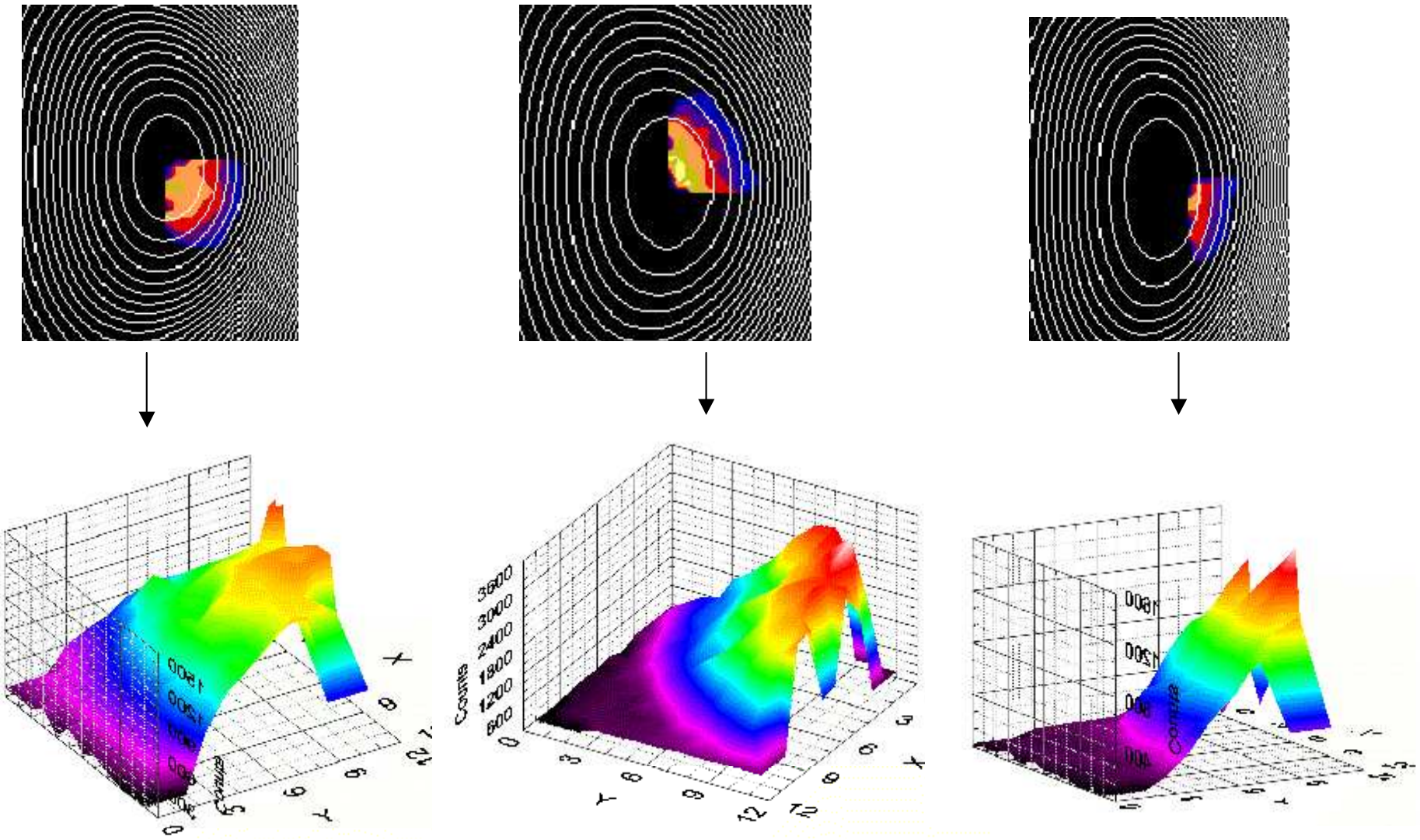


Sh 7332

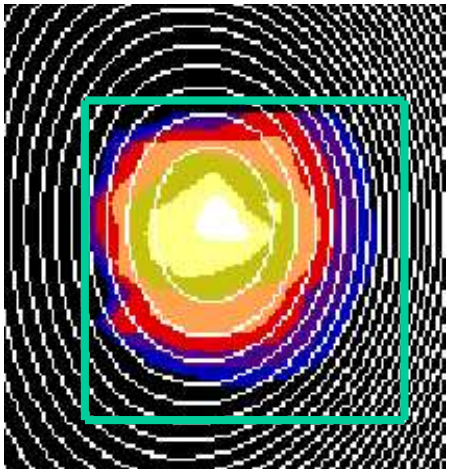




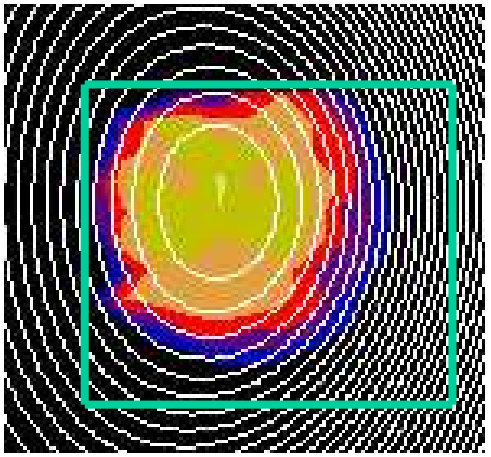
Imaging capabilities (zooming and tilting)



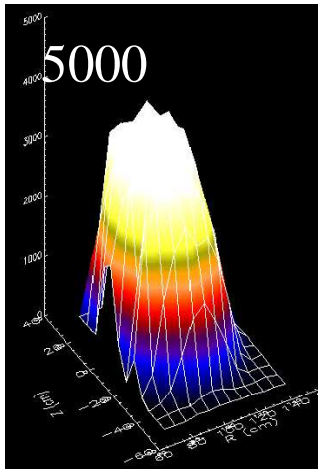
ARE THESE SPATIAL MODULATIONS REAL ?



280 ms



330 ms



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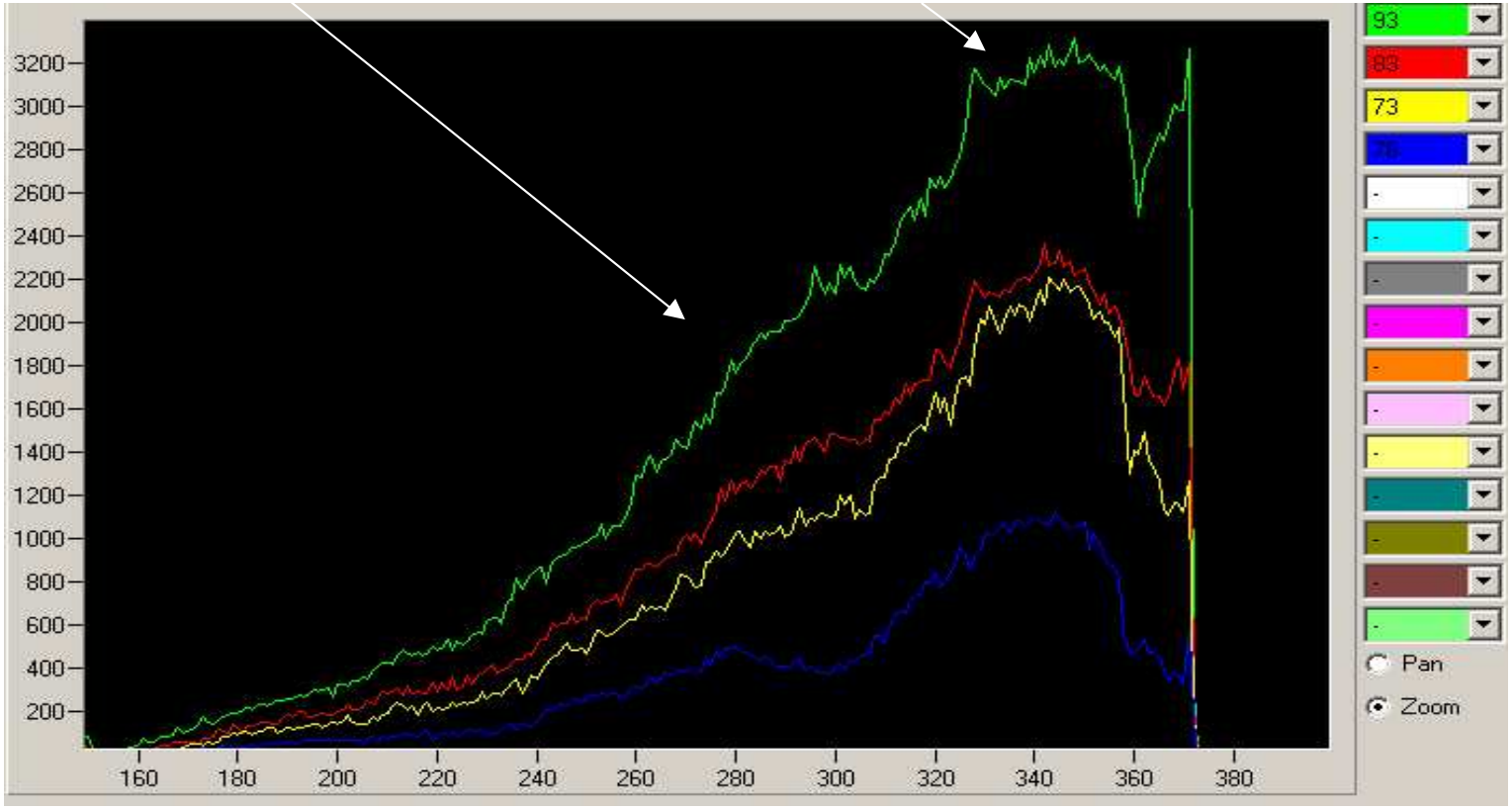
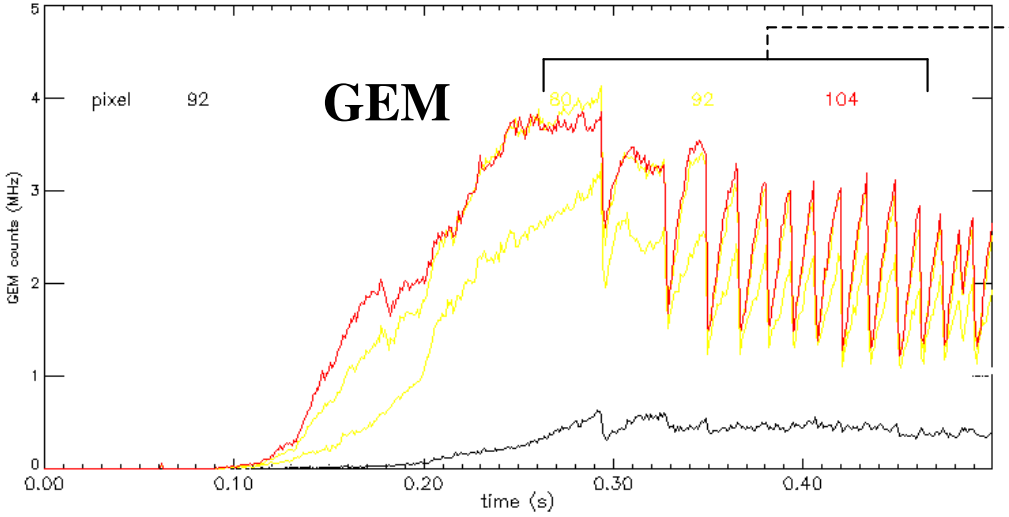


The energy discrimination enhances the core imaging capability



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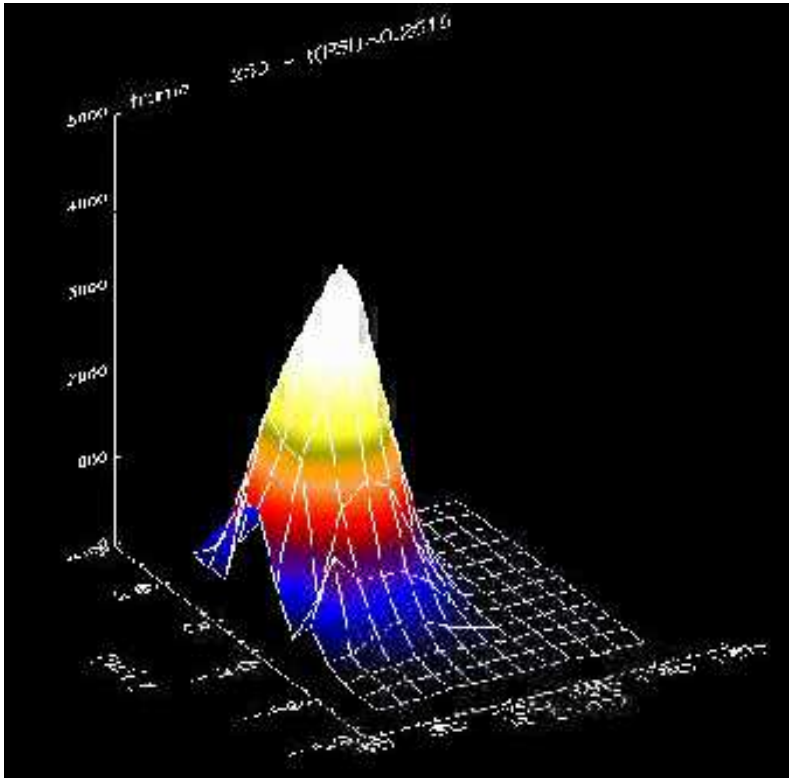
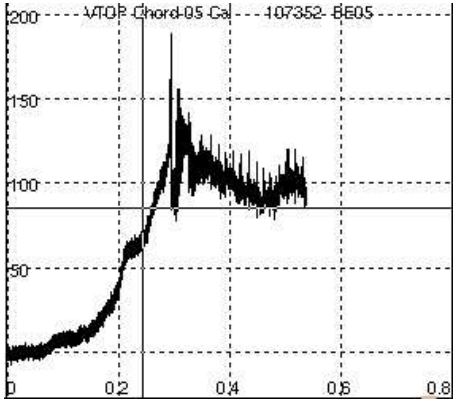
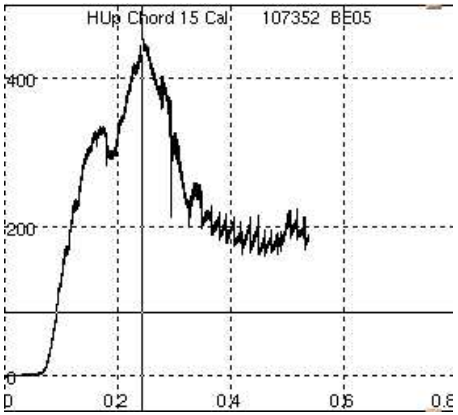


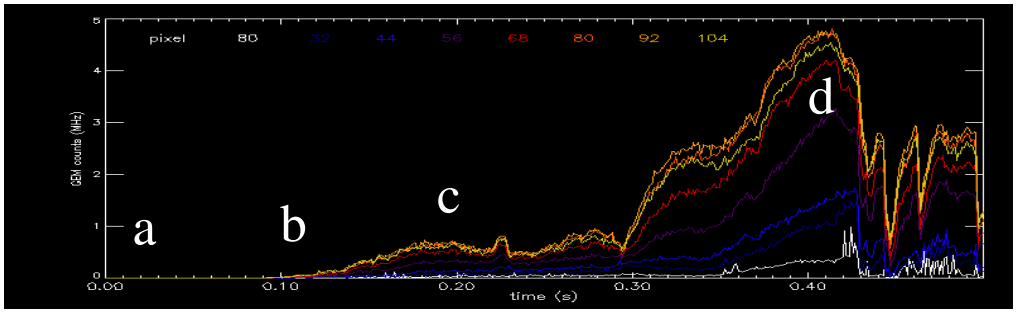
USXR_VTOP



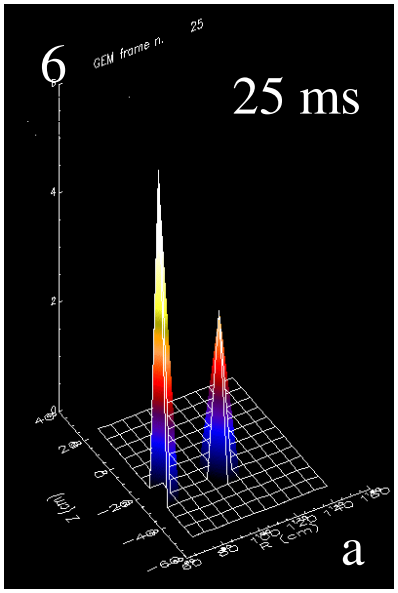
USXR_HUP



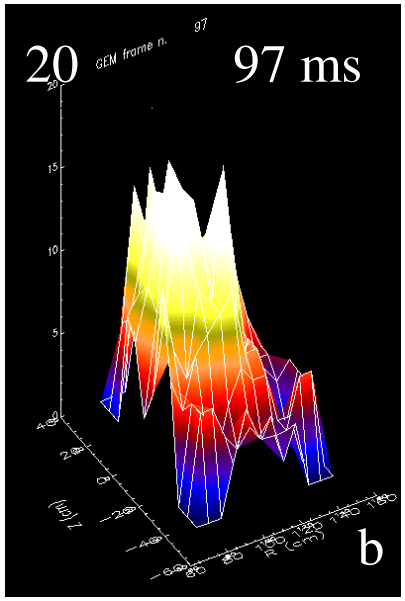
Low noise (statistical) – High dynamic range

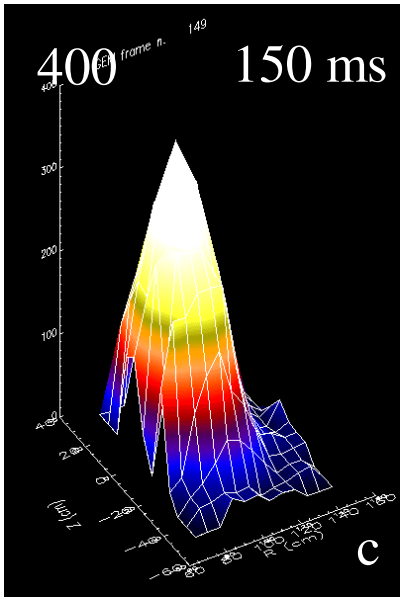


noise

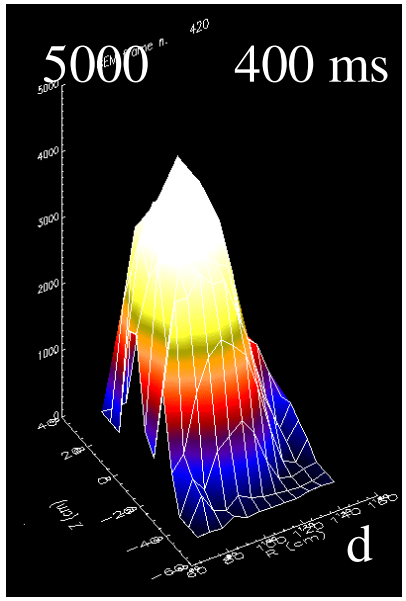


minimum





max

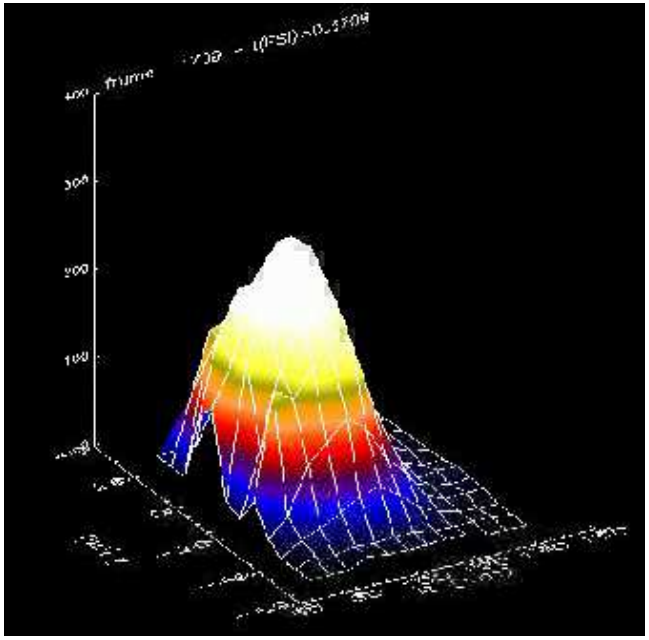


Signal / noise = 1000

Effective dynamic range = 300

Fast acquisition (1 – 100 KHz)

10 khz



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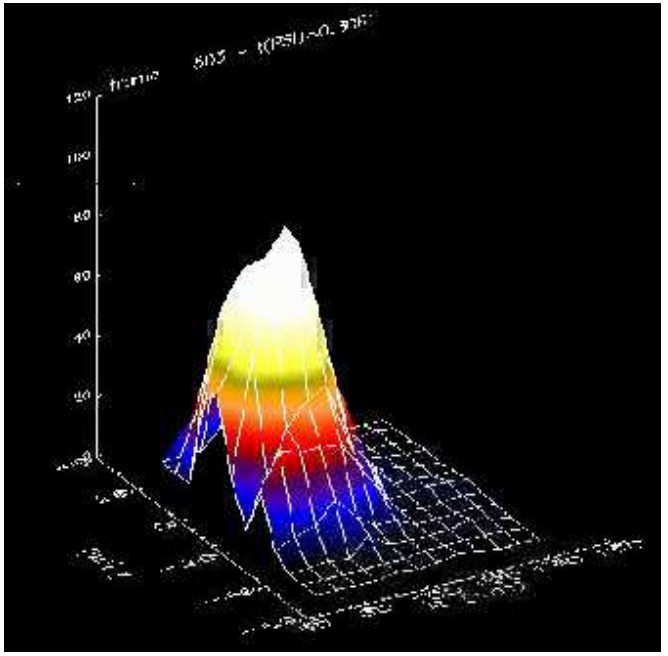
50 khz



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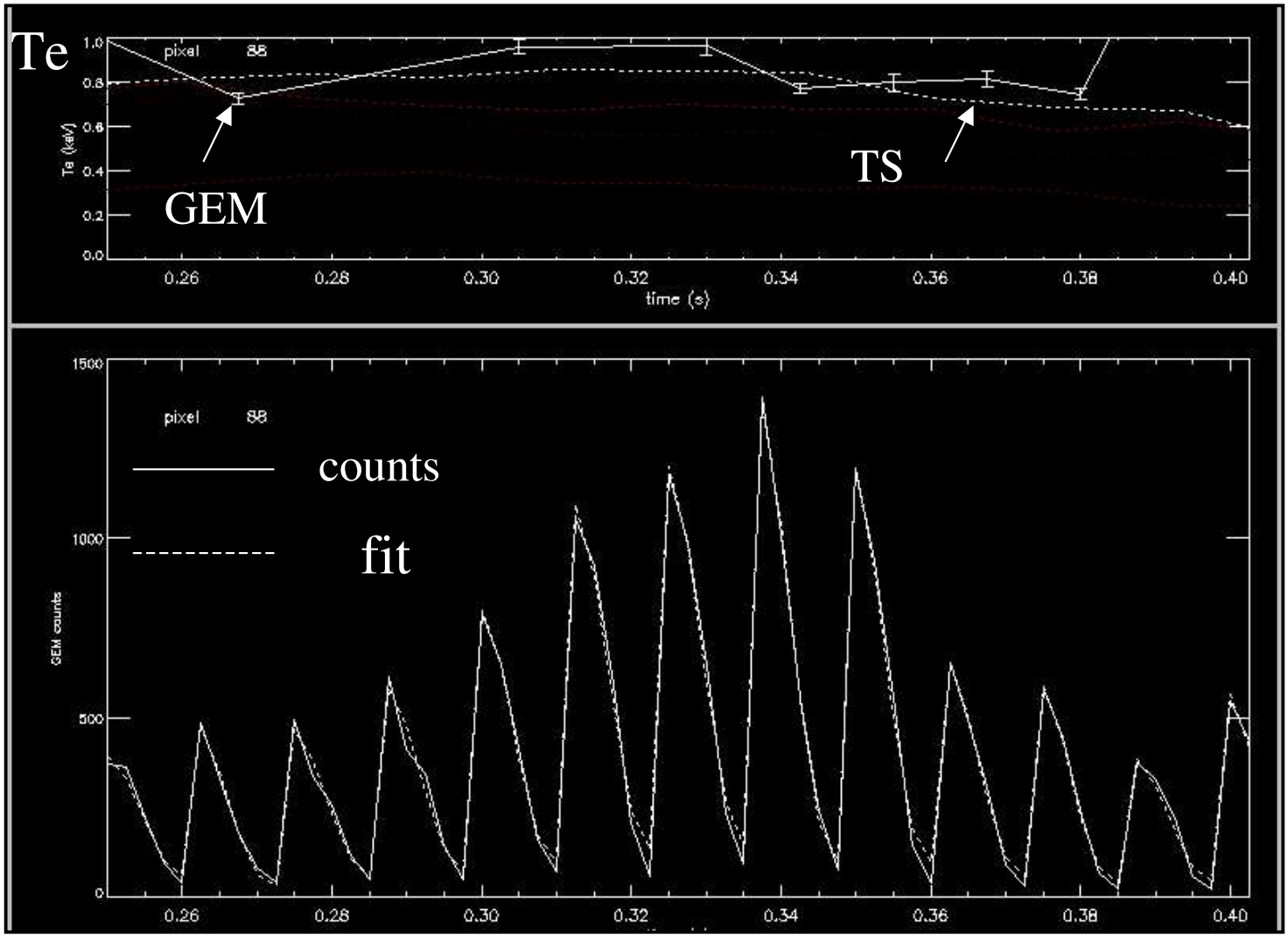
Threshold scan (5) and temperature assessment for one central pixel

5 energy intervals

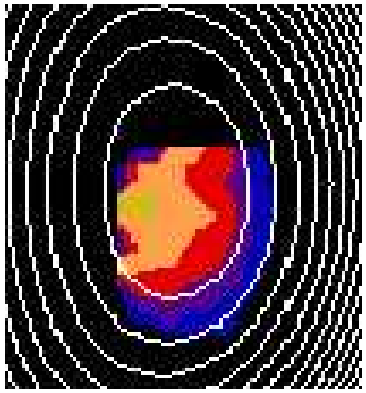
3-8 keV
3.5-8 keV
4.3-8 keV
5-8 keV
6-8 keV

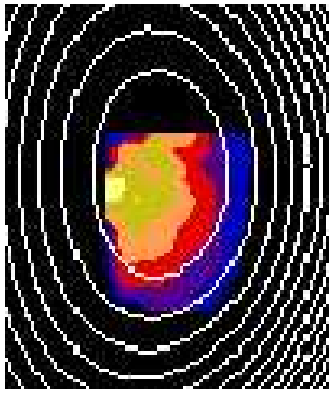


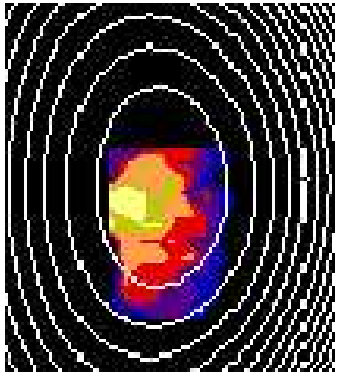
Energy discrimination + Imaging

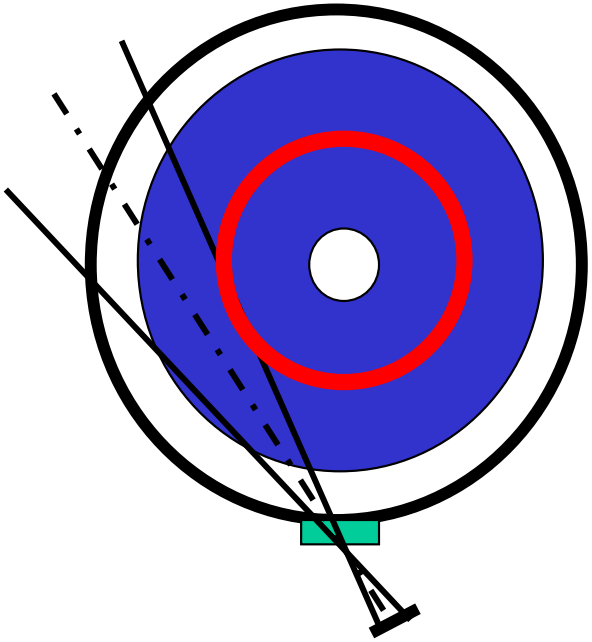
Energy scan

Outside view





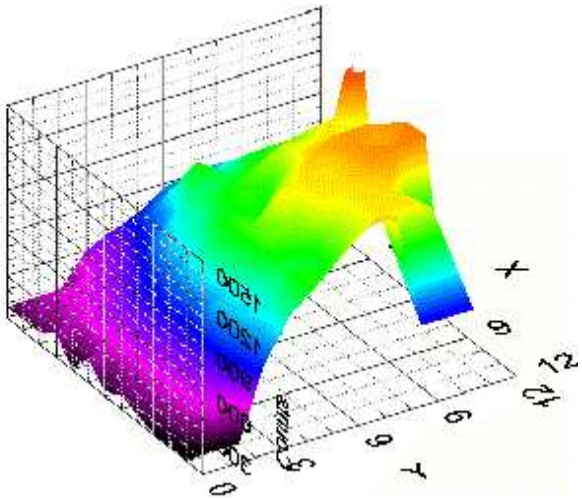


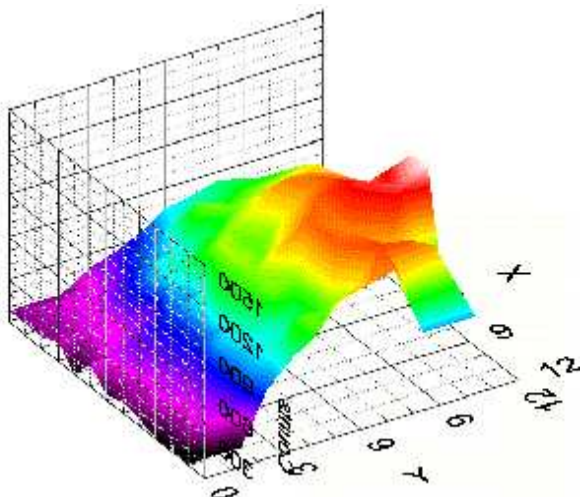


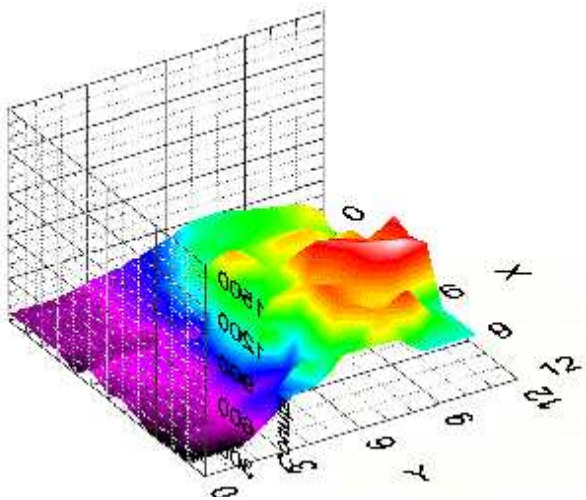
3 – 8 keV

3.5 – 8 keV

4.3 – 8 keV



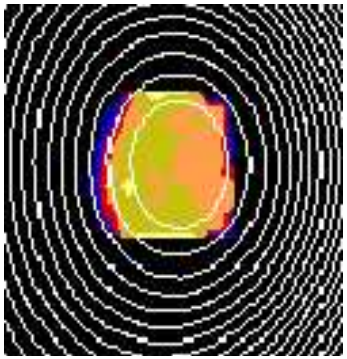


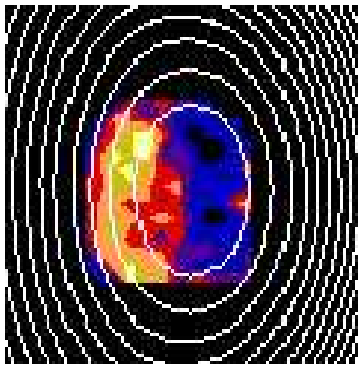


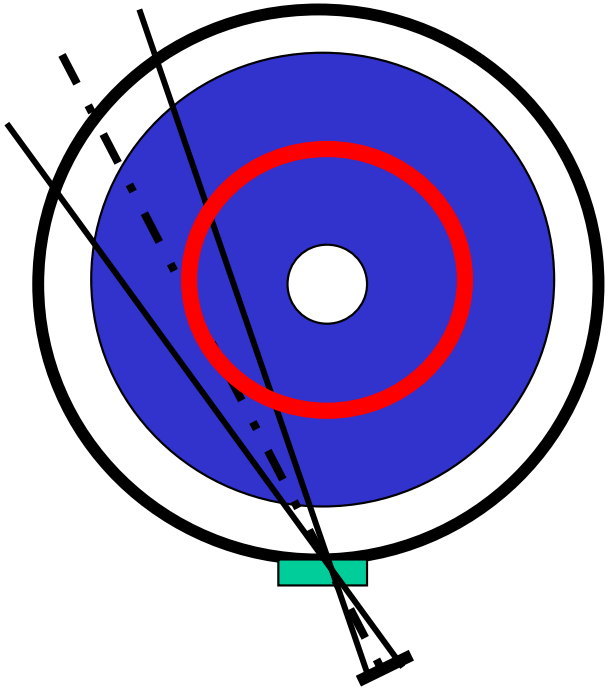
Energy discrimination + Imaging

Energy scan

Inside view



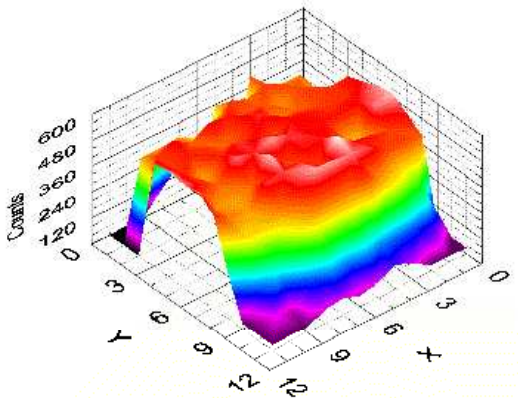


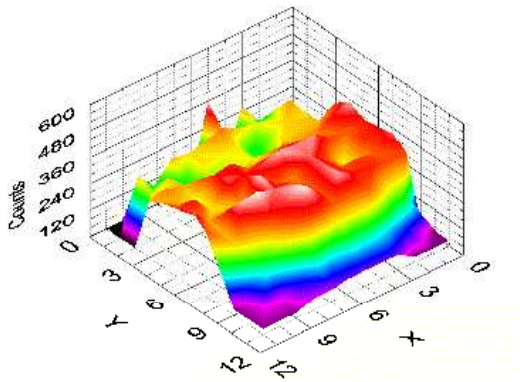


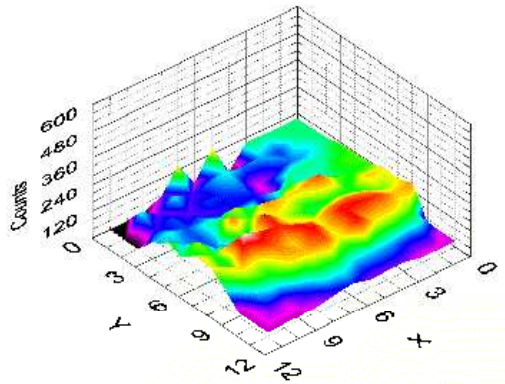
3 – 8 keV

3.5 – 8 keV

4.3 – 8 keV







Measurements with the X-ray Gem camera

- Fast core MHD
- Perturbative transport
- 2D map of electron temperature
- RF Heating effects (?)

FAST CORE MHD

2 D IMAGING

wide view 80*80 cm

Spatial resolution : 6.5 cm

Framing rate : up to 50 khz

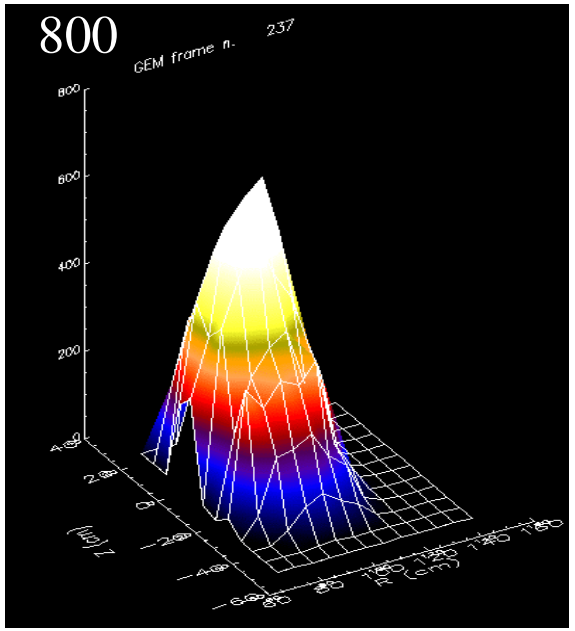
Phenomena

1) Inner modes or islands

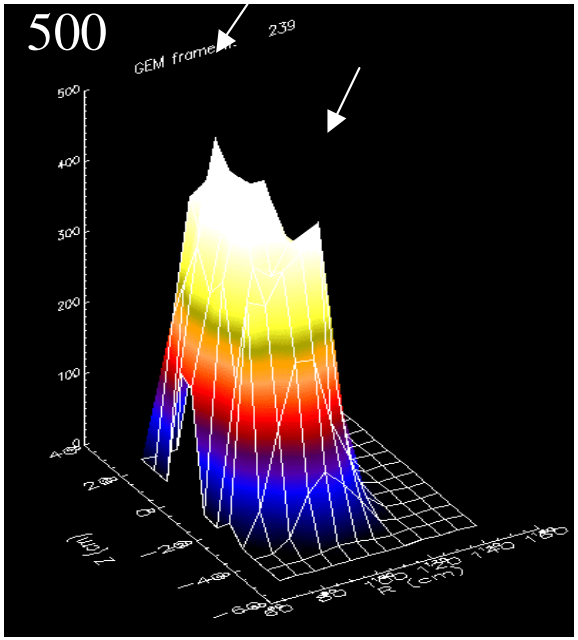
2) sawtooth

3) Plasma asymmetries during IRE

Example



IRE



FAST CORE MHD

2 D IMAGING

zoom 40*40 cm (20*20)

Spatial resolution : 3 (1.5) cm

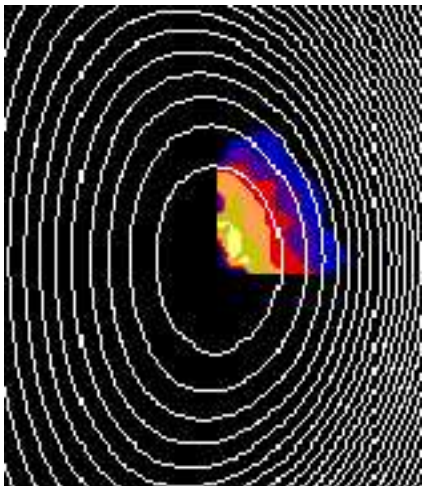
Framing rate : up to 10 khz

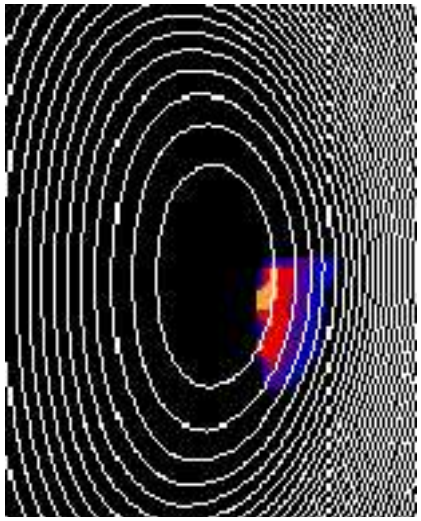
Phenomena

1) magnetic surfaces up to 2/3 a
(50 < R < 30)

2) asymmetries

Examples





Perturbative transport

X-ray emissivity perturbation on the magnetic surfaces

2D IMAGING

wide view 80*80

Rate : up to 50 (100) khz

zoom 40*40 cm (20*20)

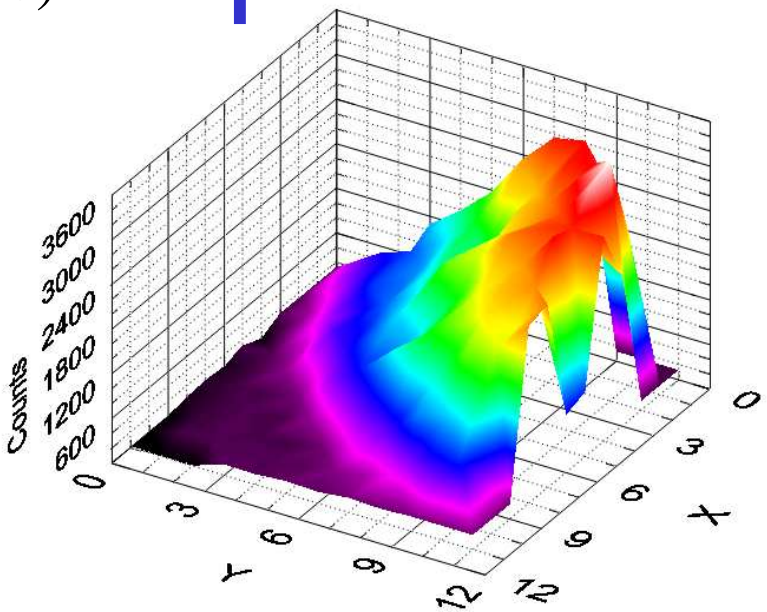
Rate : up to 10 khz

1 D IMAGING

sum over the bent magnetic surface (same color line)

zoom 40*40 cm (20*20)

Rate : up to 100 khz

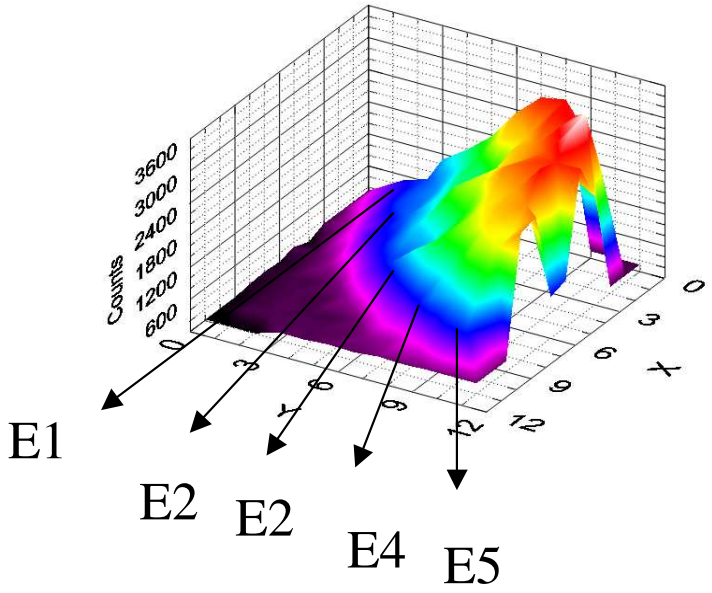


Perturbative transport

Perturbation of the spectral X emissivity on the magnetic surfaces

zoom 40*40 cm (20*20)

Rate : up to 1 khz



Different energy threshols

2 D temperature map

Proof of principle checked on NSTX

Time resolution : 20 ms (10 ms minimum)

RF heating effect ?

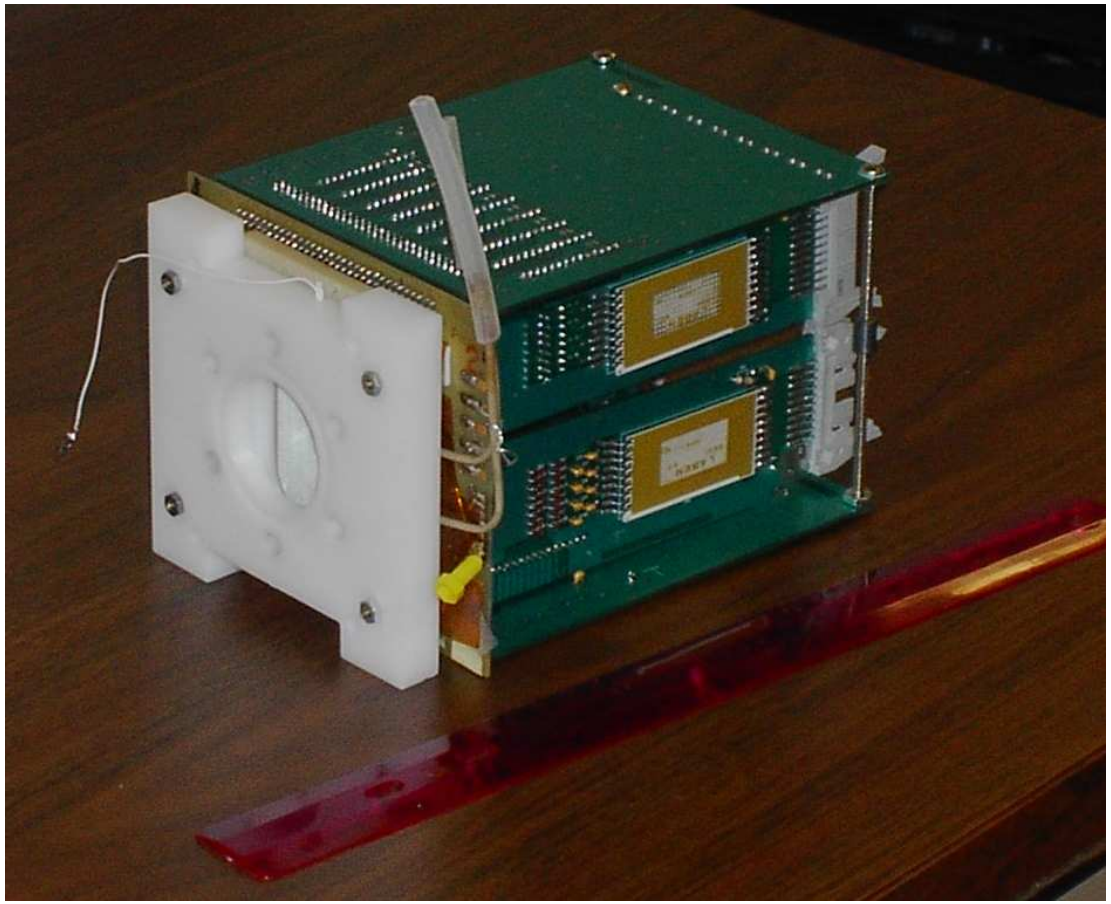
At the present no data available because of the RF noise on the bare electronics

Possible contributions:

Asymmetries in the X-ray emissivity

Spectral changes (temperature)

Next experimental campaign (2002-2003)



New detector layout , compact, light, easy to be moved and shielded

Next experimental campaign

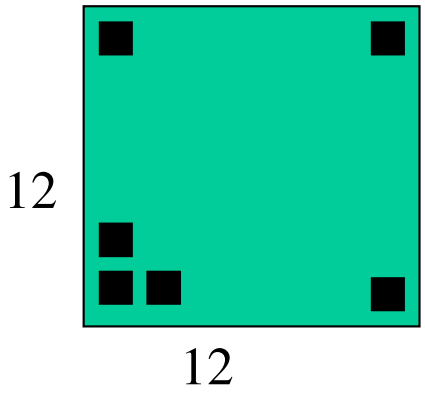
- Fast core MHD: systematic analysis
- Perturbative transport : check of the ideas
- RF: new tests with shielded detector
- 2D temperature: analysis of the sensitivity

- **Development of the software tools**: signal processing, FFT transform, spatial correlations
- **Development of a 3D code for imaging reconstruction**

Long term program

- A new X-ray imaging system based on a Micro Pattern Gas Detector having a GEM as amplifying stage stage is under development
- It has **1032 pixels (32*32)**
- Local highly integrated analog electronics
- Remote digital electronics and data acquisition system
- Improved features with respect to the present system
- Approximately same detector (whose capabilities have been well tested)
- Available in one year and half

Present



2*2 mm

144 pixels

F = 10^6 ph/smm^2

R = 4$10^6$ ph/s pixel

Single threshold discriminator (Eth)

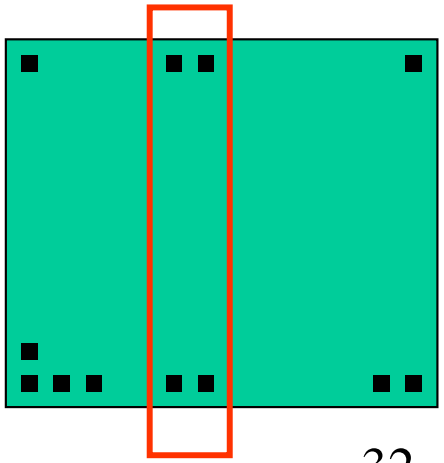
E > Eth

Independent threshold for each pixels

New

1*1 mm

1032 pixels



Emin, Emax

F = 10^6 ph/smm^2

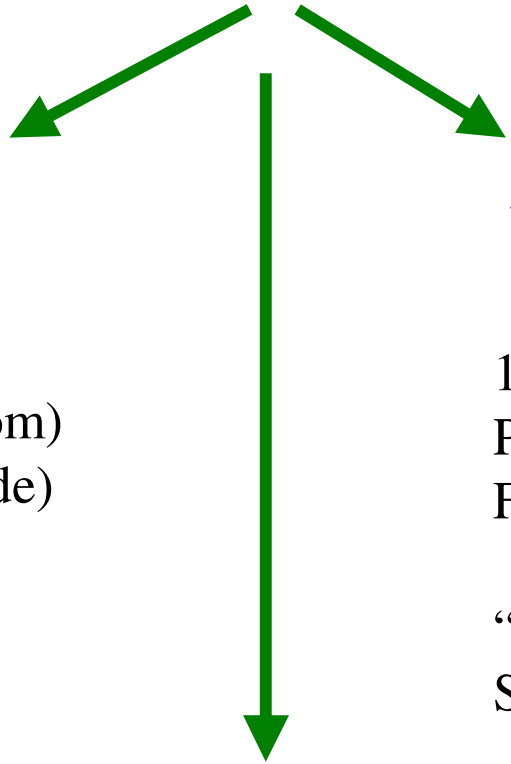
R=10^6 ph/s pixel

Window discriminator (Emin, Emax)

Emin < E < Emax

Common threshold for 64 pixels

New system



2 D High resolution

1032 pixels 32*32
pixels size 1mm*1mm
Framing rate : 10 khz (zoom)
50 khz (wide)
“Monocromatic” image
Scan in energy

2 D low resolution (software binning)

10 *10 pixels
Pixels size 3*3 mm
Framing rate: 50 khz (zoom)
250 kHz (wide)
“monocromatic image
Scan in energy

1D + Energy

High resolution

Low resolution

CONCLUSIONS

- This new system has been developed at ENEA Frascati by the author and his collaborators
- This camera has been successfully tested in the present year at NSTX
- In the next experimental campaign it will be routinely used in the plasma physics experiments
- A new system with 1032 pixels, available in 2004, is proposed for the long term program