DE LA RECHERCHE À L'INDUSTRIE

www.cea.fr

DMX-DANTE collaboration:

- DMX on LMJ latest results
- DMX-Dante Au M-band flat & sharp broadband channel update
- SNL/LLNL fast h-CMOS gated imaging for DMX
(wish can become true?)

J.L. BOURGADE & B. VILLETTE

(+ P. TROUSSEL and ML fab. & test teams)

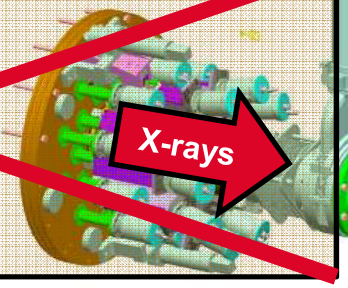
3rd LMJ-NIF diagnostic collaboration workshop

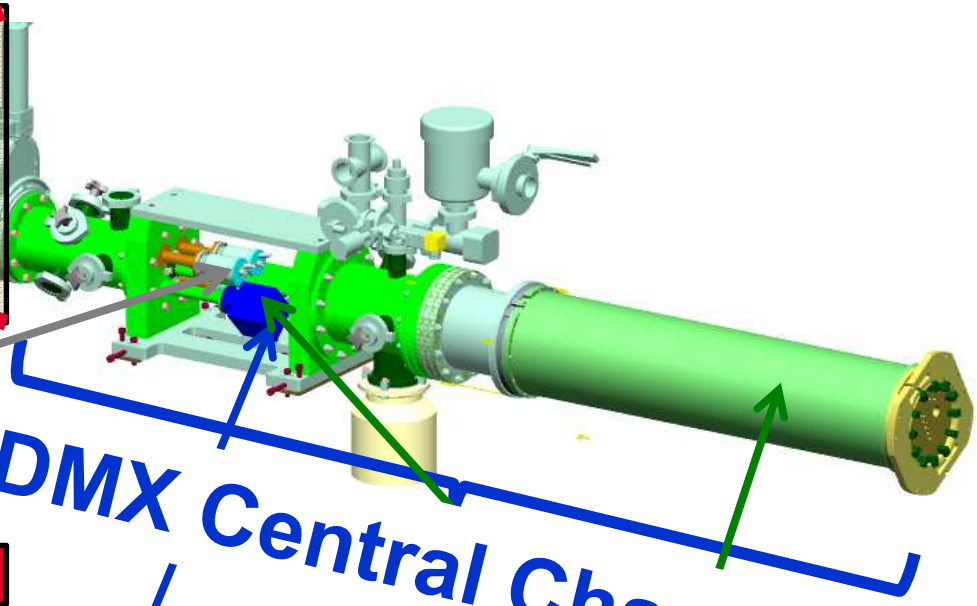
@ LLE, Rochester, USA

June 29th & 30th, 2016

DMX - LMJ : now commissioned on LMJ campaign shots (since 04/2016)

~~MAIN PART~~
~~SXLBt : broadband spectrometry~~
~~Absolutely calibrated~~
~~Spectral range: 50 eV – 20 keV~~
~~Resolving power: E/ΔE ~5~~
~~Temporal resolution: 100 ps~~
~~Fiducial accuracy: ± 150 ps/laser pulse~~
~~no common development~~





DMX Central Channels

PXt : broadband X-ray power
- thermal BB (100 eV – 2 keV) under development
- **Flat & sharp Gold M-band channel (2 – 4 keV & 4-6 keV) (NIF interested)**
- **Flat response diode (Au/Au) NEW**

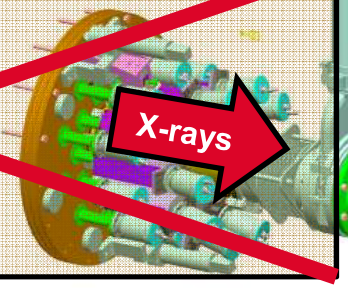
ITEL : LEH imager
MR ~6 on CID
Spatial resolution: 50-100 µm
- NEW first images of LMJ-LEH
- CEA interested by NNSA h-CMOS gated CCD

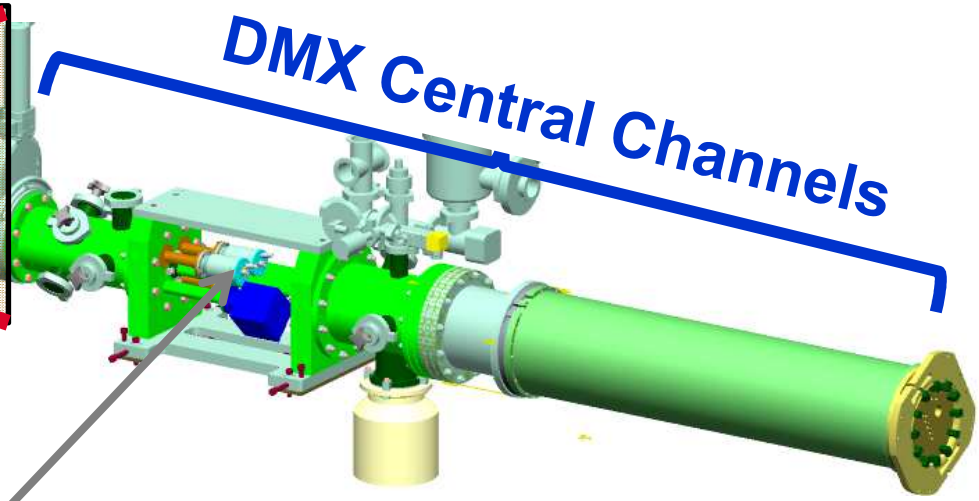
NEW

SXMt : Streaked Transmission Grating Spectrometer
Spectral range: 100 eV – 1500 eV
Resolving power: E/ΔE ~100
Temporal resolution: 30 ps (streak)
Fiducial accuracy: ± 100 ps
First time integrated and time resolved spectra measured on LMJ

DMX - LMJ : PXt broadband NEW results

~~MAIN PART~~
~~SXLBt : broadband spectrometry~~
~~Absolutely calibrated~~
~~Spectral range: 50 eV – 20 keV~~
~~Resolving power: E/ΔE ~5~~
~~Temporal resolution: 100 ps~~
~~Fiducial accuracy: ± 150 ps/laser pulse~~
~~no common development~~



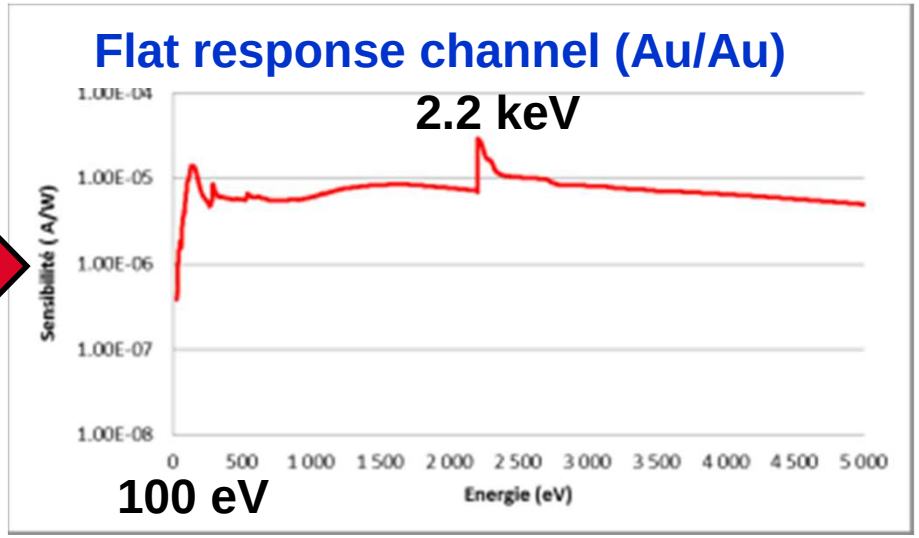


PXt : broadband X-ray power spool

1- Flat & sharp Gold M-band channel (2 – 4 keV) (NIF interested)

2- flat & sharp channel 4-6 keV (now available on LMJ

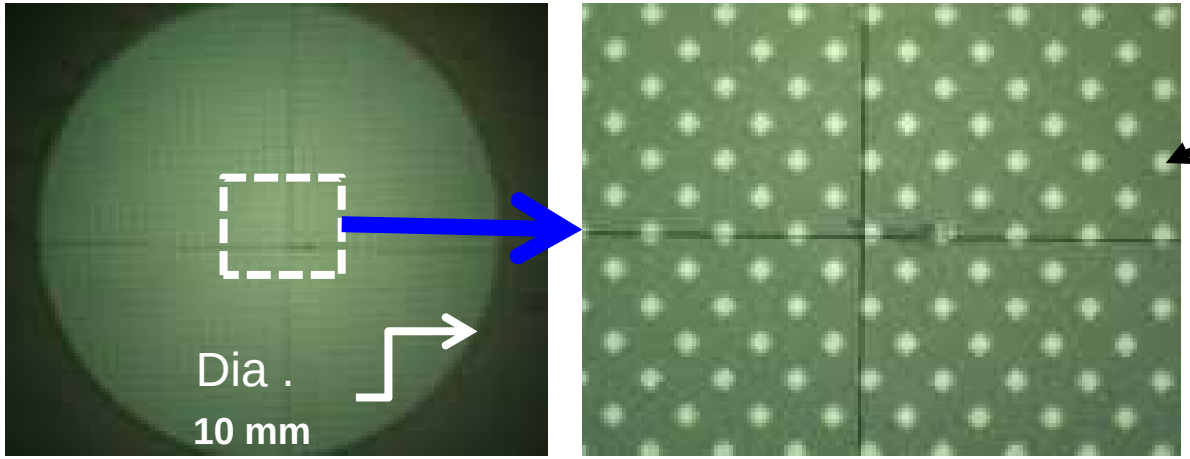
3- thermal BB (100 eV – 2.2 keV) Au flat response diode (NEW)



NEW: SPECTRALLY FLAT RESPONSE DIODE

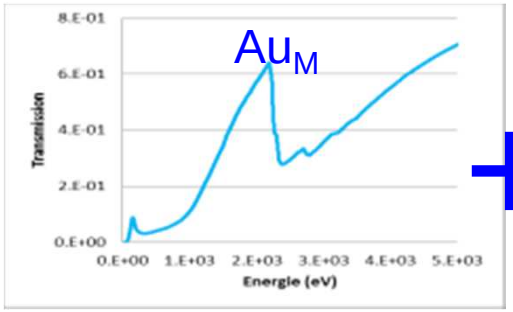
Combination of structured Au Filter / Au PK

filters (Luxel): Au layer deposited on 1000 Å thick polymide w/
19/20 of the surface w/ Au thickness of 3500 Å.
1/20 of the surface w/ Au thickness of 450 Å

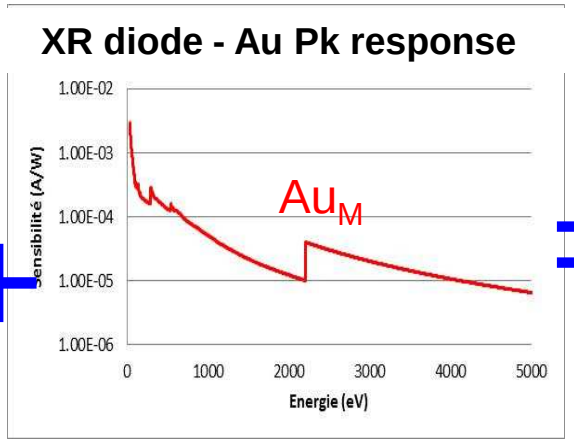


1/20 of the surface w/ thinner thickness obtained by square wells :
20 µm x 20 µm
Depth 3050 Å
step: 44 µm

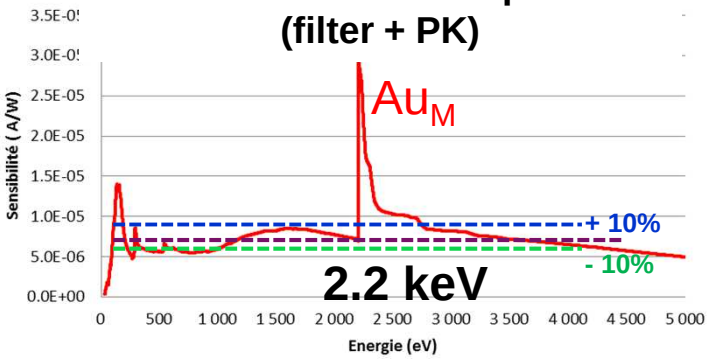
Au filter Transmission



XR diode - Au Pk response



Overall channel response (filter + PK)

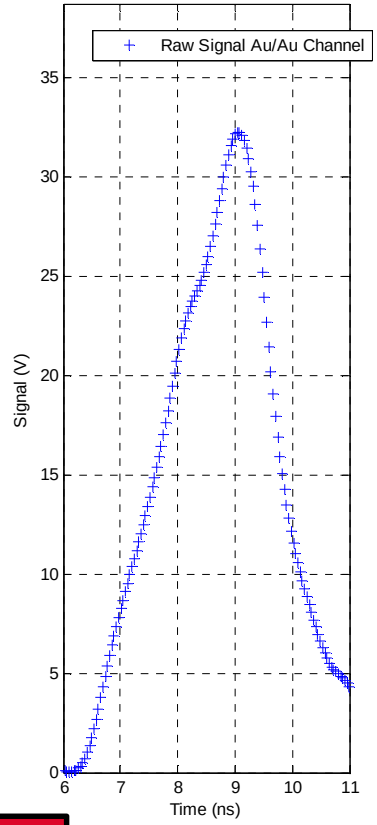


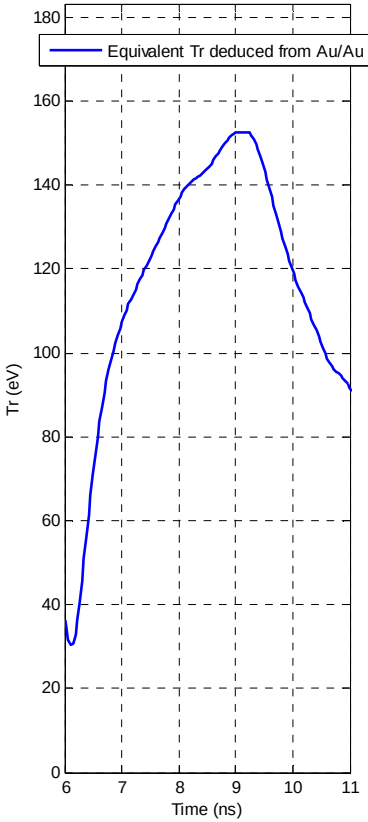
RSI, 073504, 2010 (Chinese) but initial idea @ LLNL since 1978 RSI 49(8), p.1204

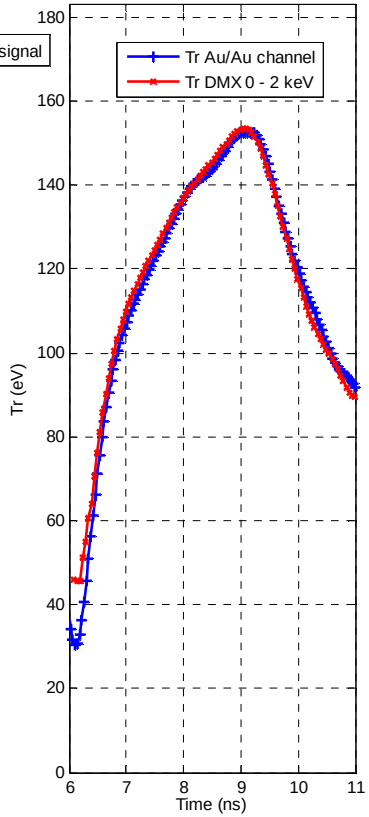
FLAT RESPONSE DIODE RESULTS ON LMJ

We perform a comparison in time of the timed signals measured from:

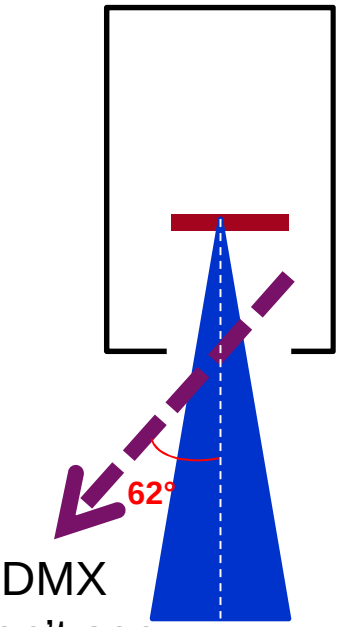
- Standard x-ray response of DMX broadband channels (/// to Tr)
- this new flat response diode converted into Tr (/// to σT^4)





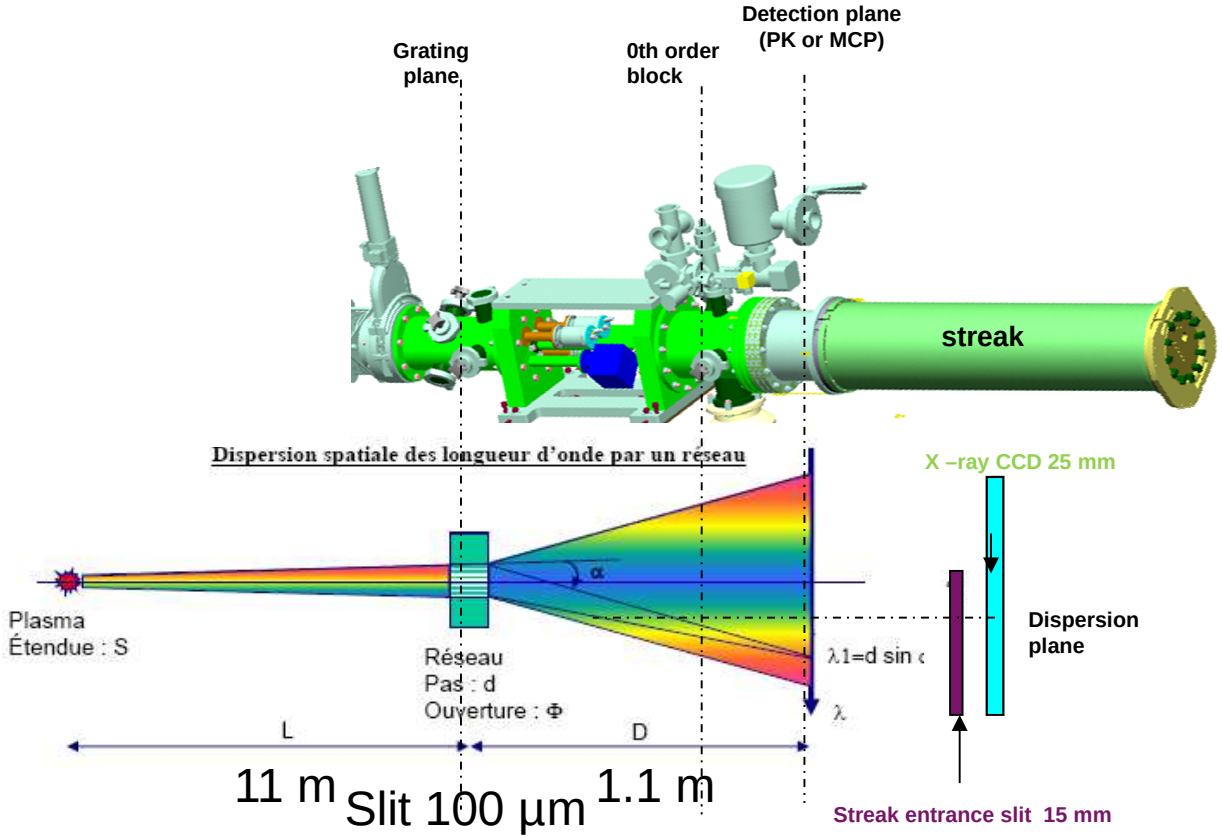


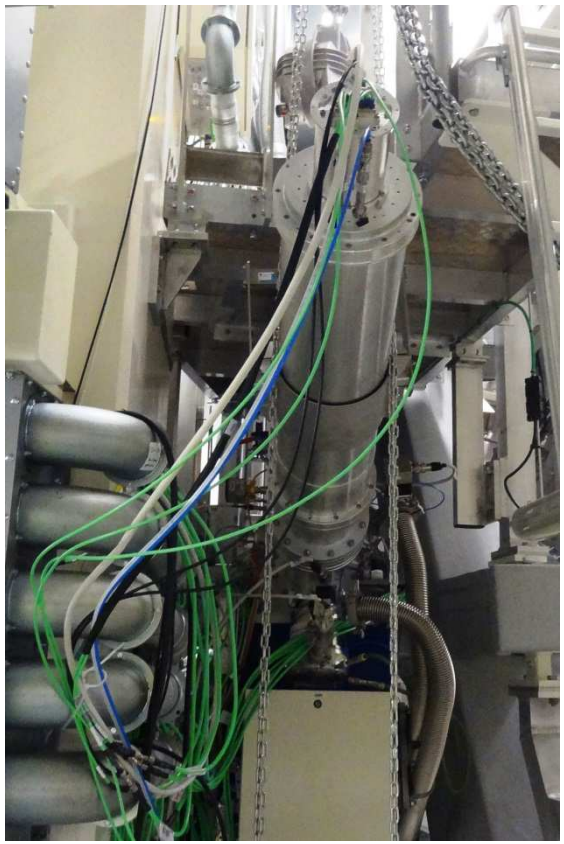
Hohlraum w/ Shield



DMX
(don't see
Laser focal spot)

DMX Central Channels:
NEW: SXMt (spectromètre X-mous résolu en temps)





SXMt (Time resolved Soft X-ray Spectrometer) :

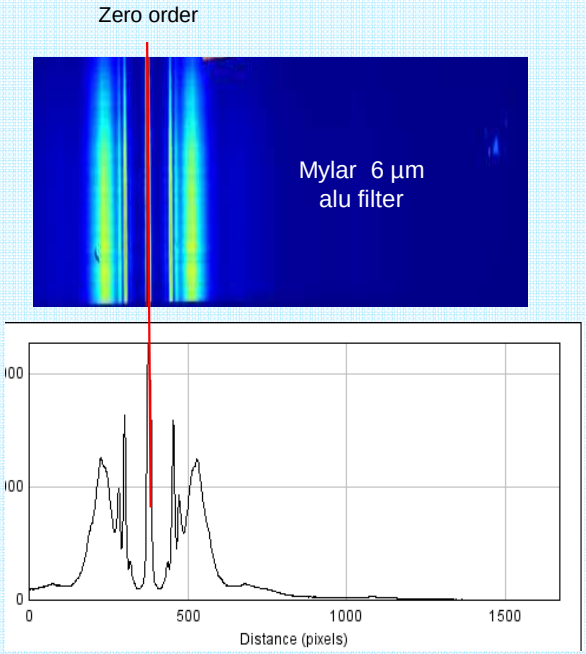
- **transmission grating (E/ΔE ~100)**
- **X-ray CCD (adjustment) or streak tube (temporal resolution)**

Gratings: Heidenhain (2000l/mm)
or X optics gratings (5000l/mm)
No longer available

SXM : time integrated & time resolved spectra

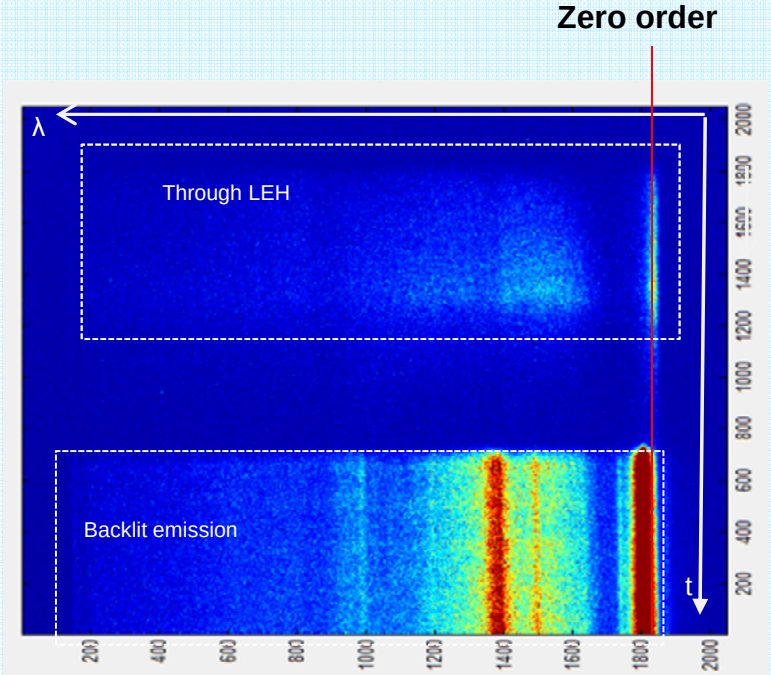
Mesure SXM w/ XR CCD

2000 l/mm grating



Back thinned CCD Andor
(2048 x 2048 px)

w/ streak camera



COLLABORATION STATUS ON A FLAT & SHARP LMJ/NIF AU M-BAND CHANNEL (FOR DANTE)

Flat & sharp broadband channel:
developped for Omega & LMJ - NIF interested for DANTE

Goal : X-ray emission measurement into some spectral broad bands

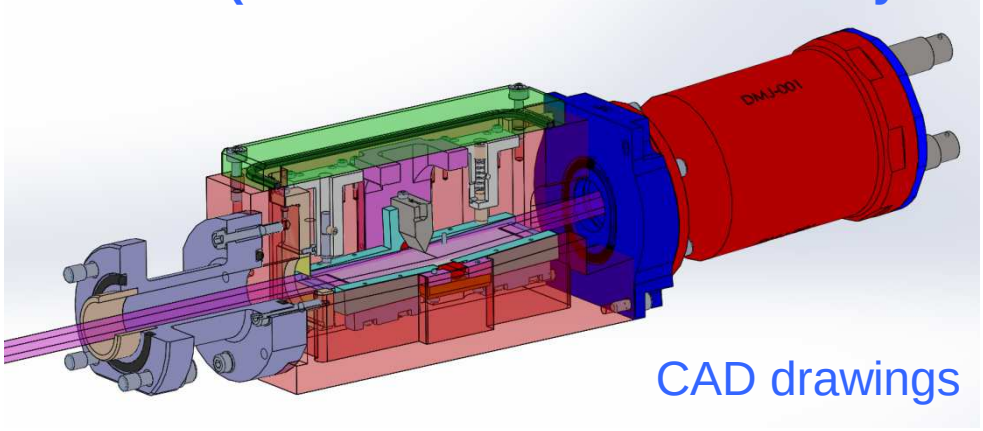
- **first priority for DMX: Gold M-band (2 keV – 4 keV)**
- **further developments**
  - **BB thermal emission (0,1 – 2keV))**

Wish ➔ **constant spectral response channel within the spectral band**
➔ **negligible contribution otherwise**
➔ **narrower band (1 keV instead of 2 keV - Alastair's wish during last VTC)**

Available technologies developed @ CEA:

- **super mirrors (MLM) – fabrication needed – (P. Troussel presentation)**
- **hardware same as LMJ channel (last VTC & workshop)**

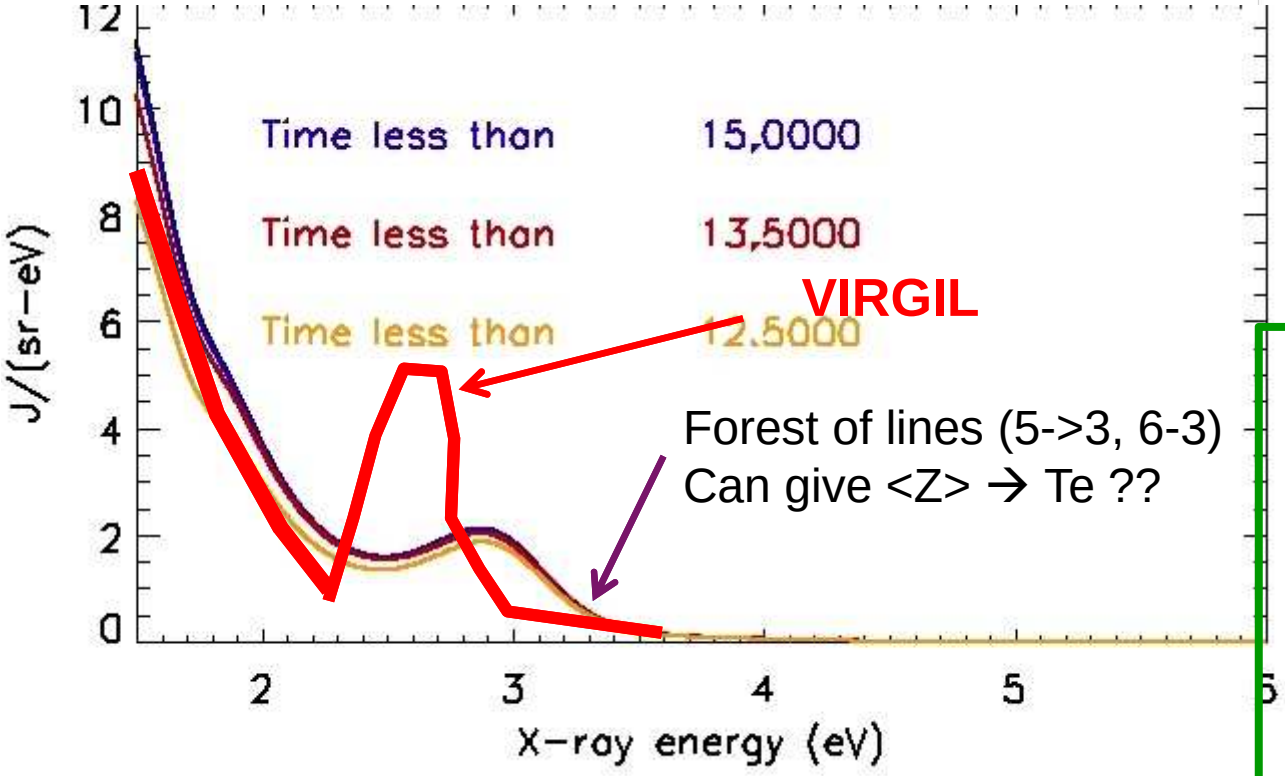
LMJ channel (installed in march 2016 not yet activated)

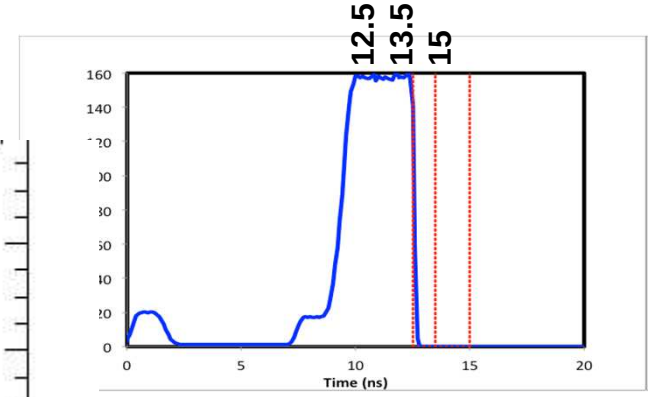


CAD drawings

VIRGIL – SCHNEIDER
(EXTRACTED FROM JOHN MOODY PRESENTATION – WORKSHOP @ CEA/DIF 5/29/2016)

N151116-003-999



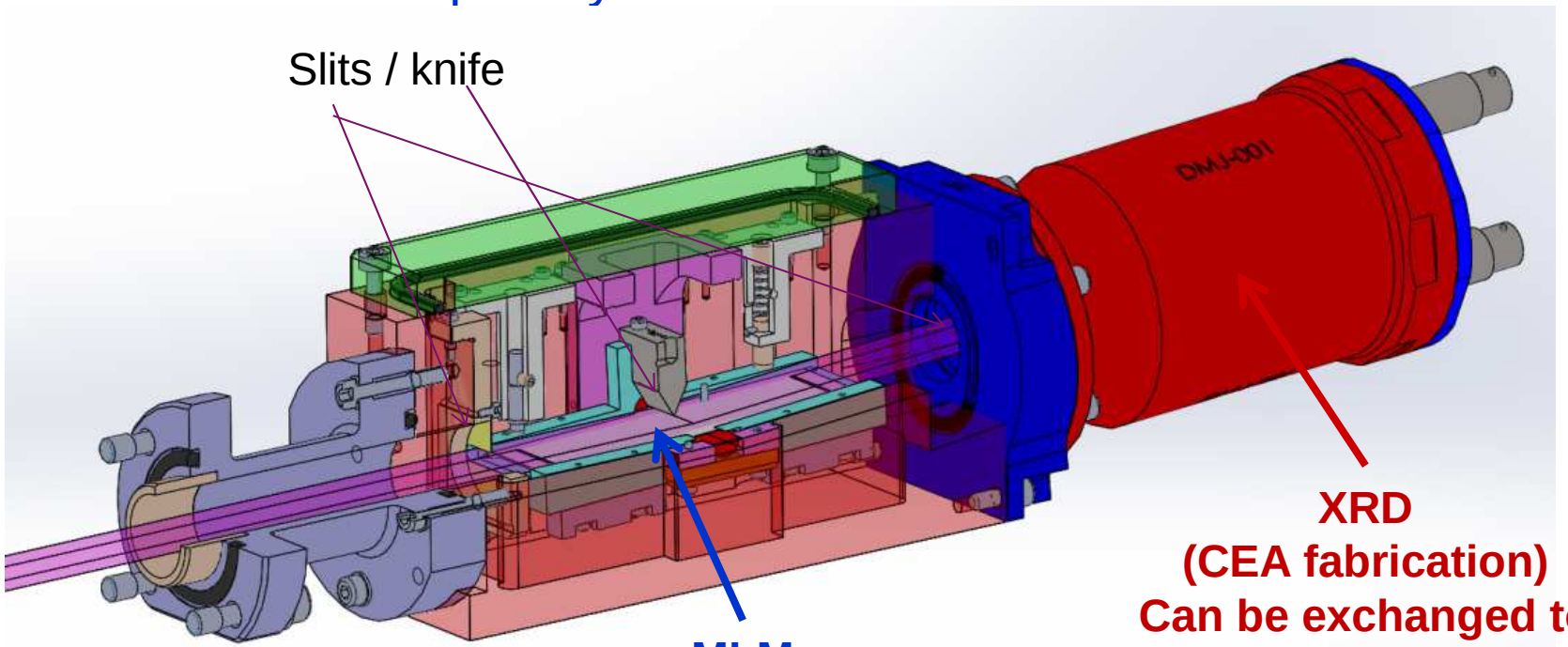


Better understanding by CEA of Alastair's wish (VTC) to get two narrower broadband channels (2- 3 keV and 3-4 kev) instead of only one @ 2-4 keV

This is not surprising -- DANTE cannot do good job on spectra; GOAL is to use VIRGIL spectra to correct DANTE

Flat & sharp broadband channel:

LMJ channel developed by CEA



CONCLUSIONS : FLAT & SHARP CHANNEL FOR DANTE

- This channel can be easily build w/ NIF requirements.
  - Some delay needed for the ML fabrication especially if narrower band are wished by LLNL/NIF team.
  - CEA fabrication is ready to be launched for a “standard” channel (2-4 keV) for its own LMJ needs.
  - Cost share?

- NIF & CEA have to determine which solution is the best for it:
  - The same fixture as LMJ (now available)

- Accurate enough alignment on NIF Dante port must be taken into account by LLNL/NIF team.

COLLABORATION ON A H-CMOS FRAMING CAMERA FOR THE DMX CENTRAL IMAGING CHANNEL

DMX Central LEH Imaging Channel:
ITELt (Imagerie Trou Entrée Laser résolue en temps)

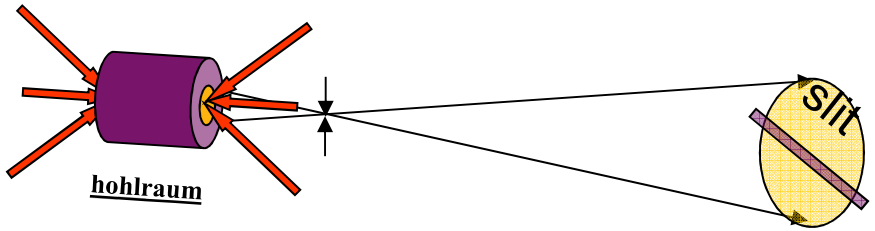
Goal : measure the closure effect on the LEH (TEL in French) in time.

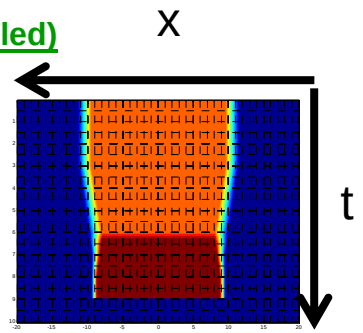
Constraint: compatible of DMX harware ➔ tradeoff mandatory (spatial & temporal resolution, FOV, …)

- **Pinhole imaging:** pinhole can only installed on the first collimator (maintenances issues)
  - ➔ MR ~6
  - ➔ spatial resolution 50 – 100 µm (pinhole 50 µm)
  - ➔ temporal resolution: 100 ps to 500 ps or more depending of the detector used

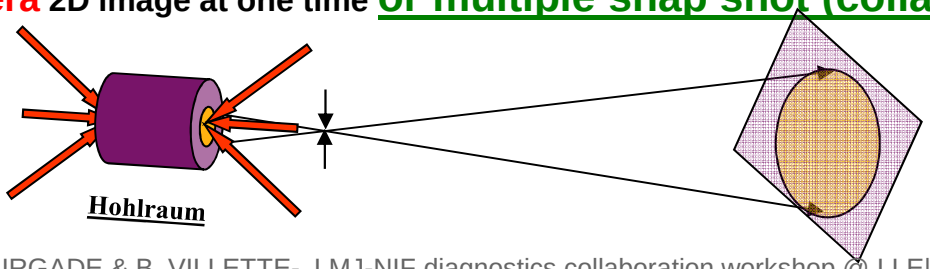
- **detector:**
  - **X-ray CID** — time integrated **(images already obtained on LMJ – next slide)**
  - **photodiode linear array** — spatial 1D + temporal resolution. **(available but not yet installed)**
  - **streak**

Soon CY16





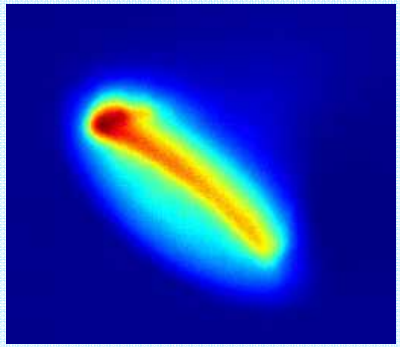
- **large area framing camera** 2D image at one time **or multiple snap shot (collaboration wished)**



DMX on LMJ: LEH imaging (time integrated)

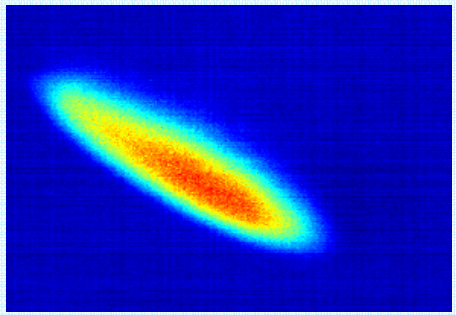
LEH dia. 1.4 mm view @ 62°
Standard LMJ Hohlraum

Mesure ITELt w/ CID



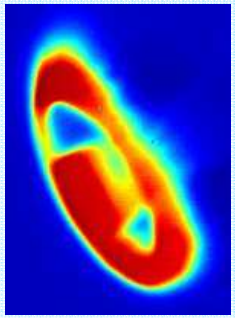
LEH dia. 1.5 mm view @ 74°

Mesure ITELt w/ CID



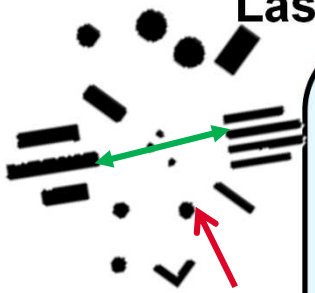
Direct drive on a foil

Mesure ITELt w/ CID



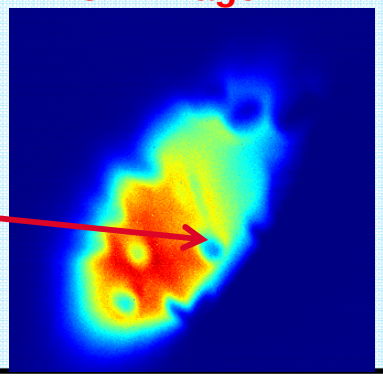
Bump on CH ablator (D.D.)

Laser pointing / alignment accuracy checking target

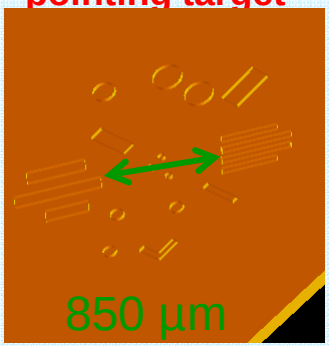


LMJ pointing target
(Green arrow length = 850 µm)

CID image



pointing target

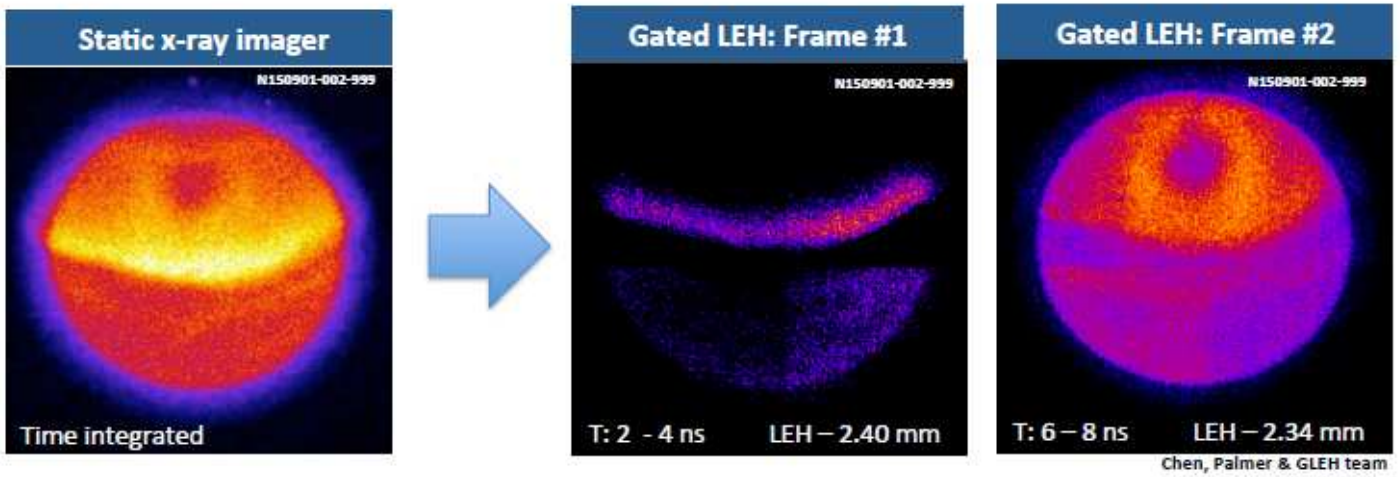


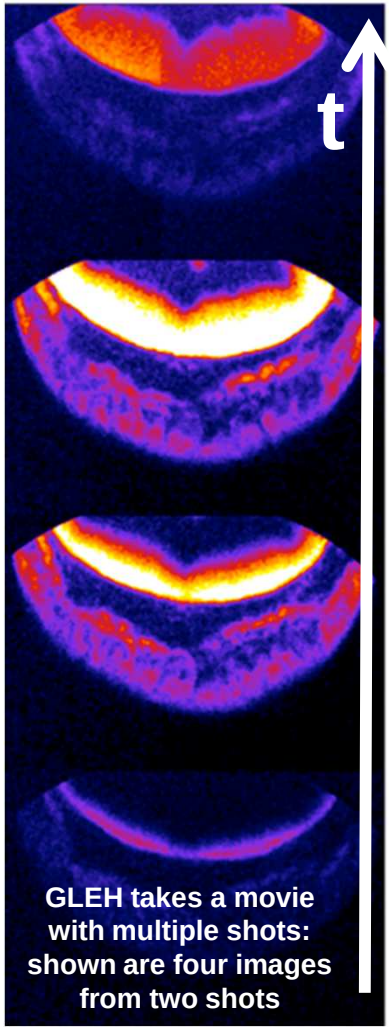
Pinhole 50 µm
Filter 6 µm My

DMX Central Channel LEH Imaging: can be as fruitful for DMX as G-LEH for Dante ?

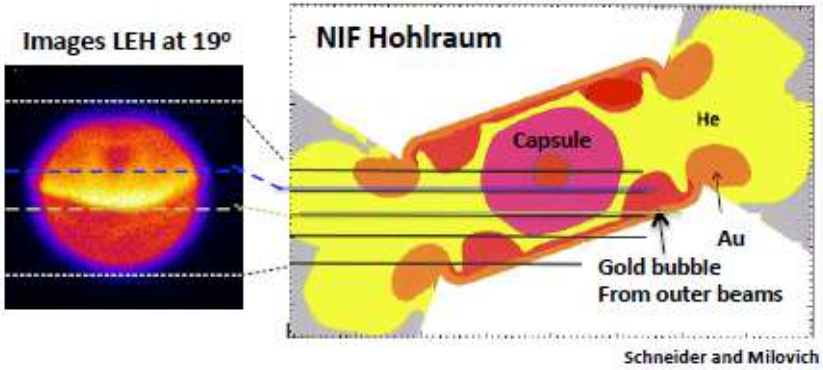
Adding time resolution on NIF SXI seems fruitful

A SNL CMOS based G-LEH Imager was successfully implemented and recorded time-resolved images on NIF





G-LEH enables studies of cross beam energy transfer, LEH dynamics and instability as a function of time.



Source: Chen & Moody

CONCLUSIONS: DMX LEH IMAGING CENTRAL CHANNEL

- LEH Time resolved imaging are a common wish for NIF & LMJ:
  - Recent time resolved images on NIF Hohlraum's LEH on SXI seems fruitful.

- H-CMOS new detector used now on NIF seems the best candidate for LMJ DMX LEH central channel imaging
  - External export clearance must be fulfilled by US authorities?
  - Other export channel is possible…
  - When? & which cost?

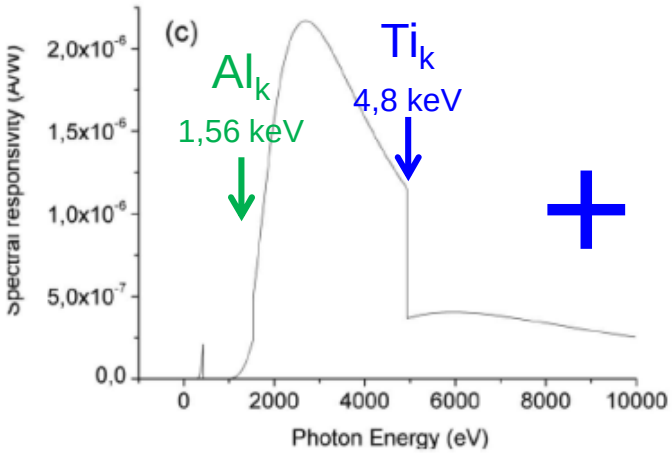
BACKUP SLIDES

LES VOIES X LARGE BANDE : OMEGA 2012
L'AVANCÉE PERMISE PAR UN MIROIR MC APÉRIODIQUE SCULPTÉ

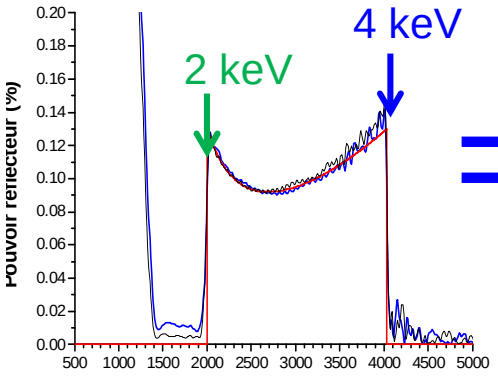
voie à réponse « plate » et bord raide

REVIEW OF SCIENTIFIC INSTRUMENTS 85, 013503 (2014)

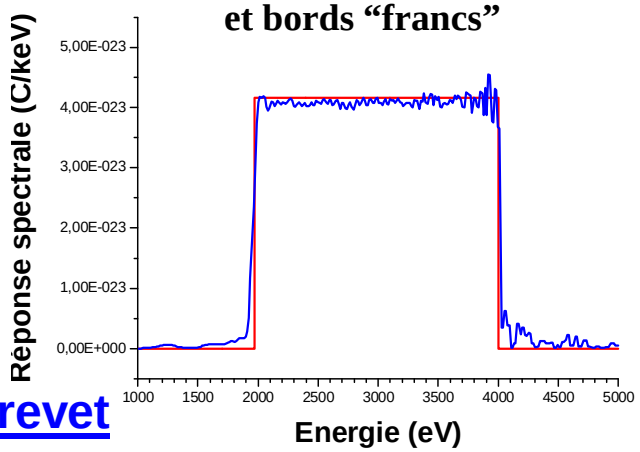
Réponse voie « classique » DMX (filtreTi + XRD:Al)



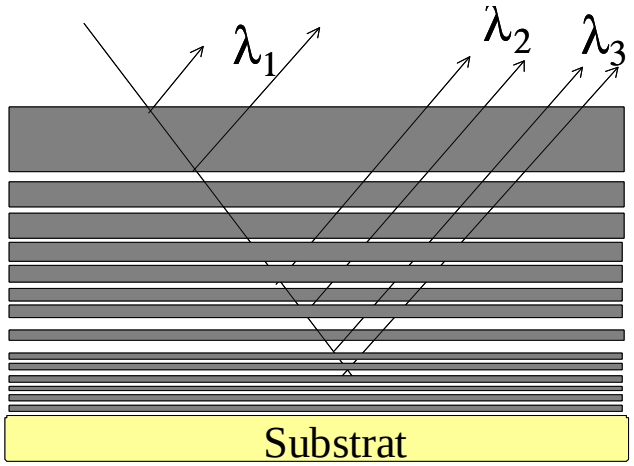
Reflection sur un miroir multicouche apériodique à réponse spectrale "sculpté"

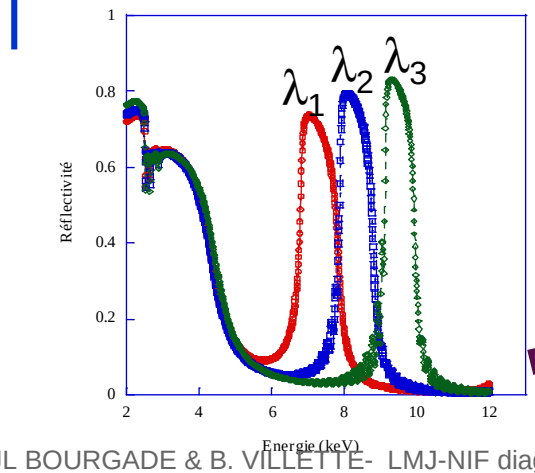


Voie à réponse spectrale plate et bords "francs"

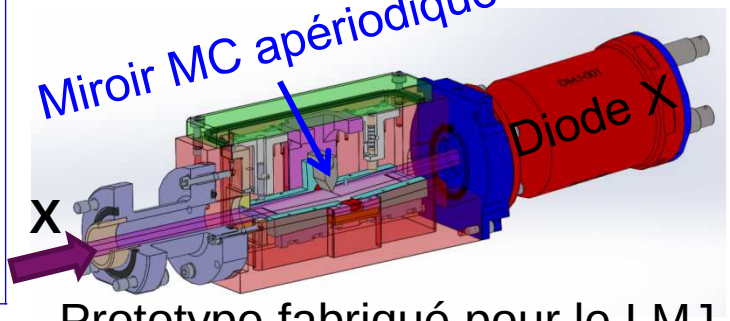


Brevet France 2011





Testé sur Omega depuis 2013



Prototype fabriqué pour le LMJ

- Miroir apériodique:

➔ **réflexion Bragg**

DMX : telescopic collimation system

Main goal: limit the FOV (umbra & penumbral) and channels cross talk

front Collimator

- adjustable manually (X/Y). Tilt & steering compensation (depend on DMX orientation polar/equatorial).
- Holder for the imaging pinholes

middle Collimator

Equipped w/ permanents magnet for charged particle deviation.

➔ Limit damages to the filters

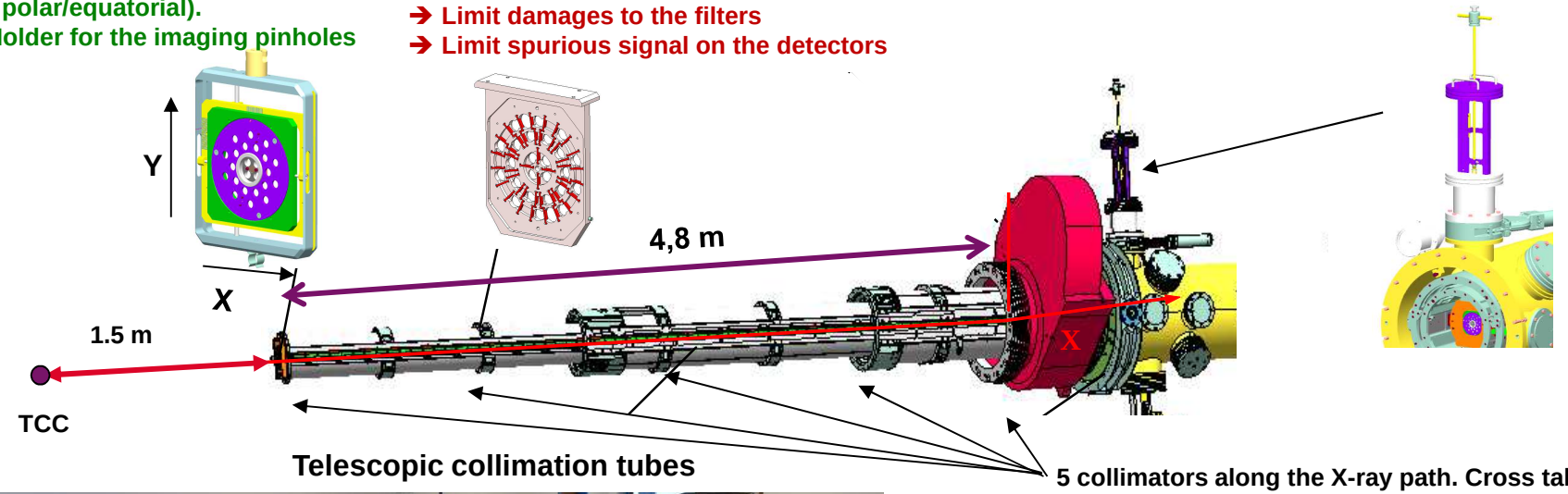
➔ Limit spurious signal on the detectors

Transfer spool (allows collimator exchange w/ radioactive waste confinement).

➔ Access to the X/Y adjustments screws

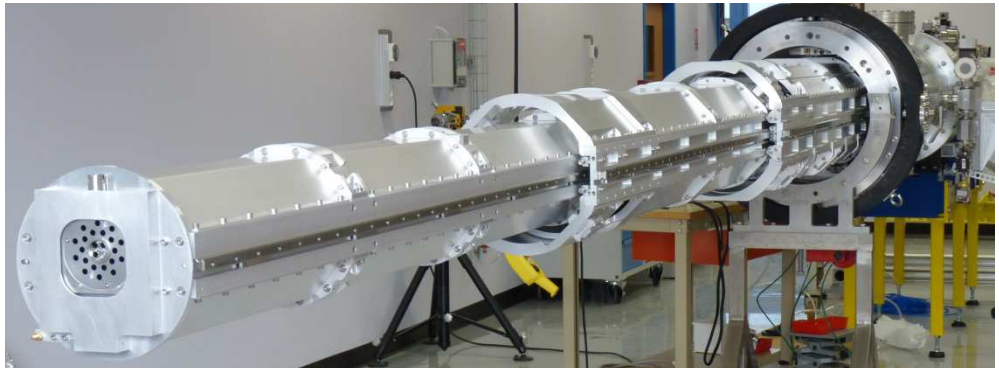
➔ Changing FoV (Umbra adjustable from ∅ 2 to ∅ 5 mm)

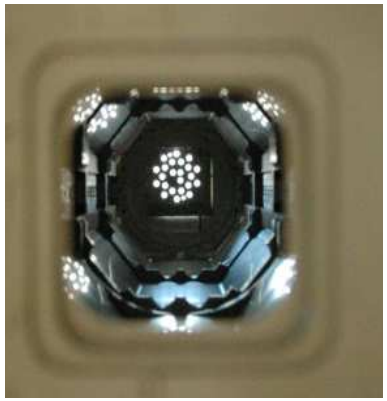
➔ Exchanging the pinholes

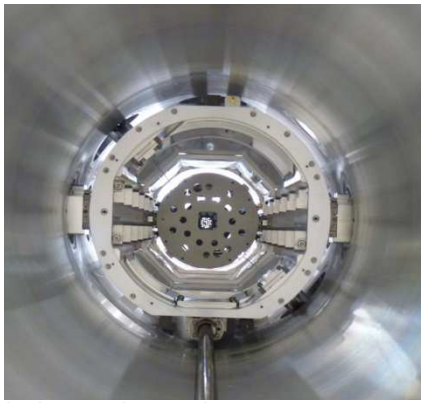


Telescopic collimation tubes

5 collimators along the X-ray path. Cross talk < 0.1%



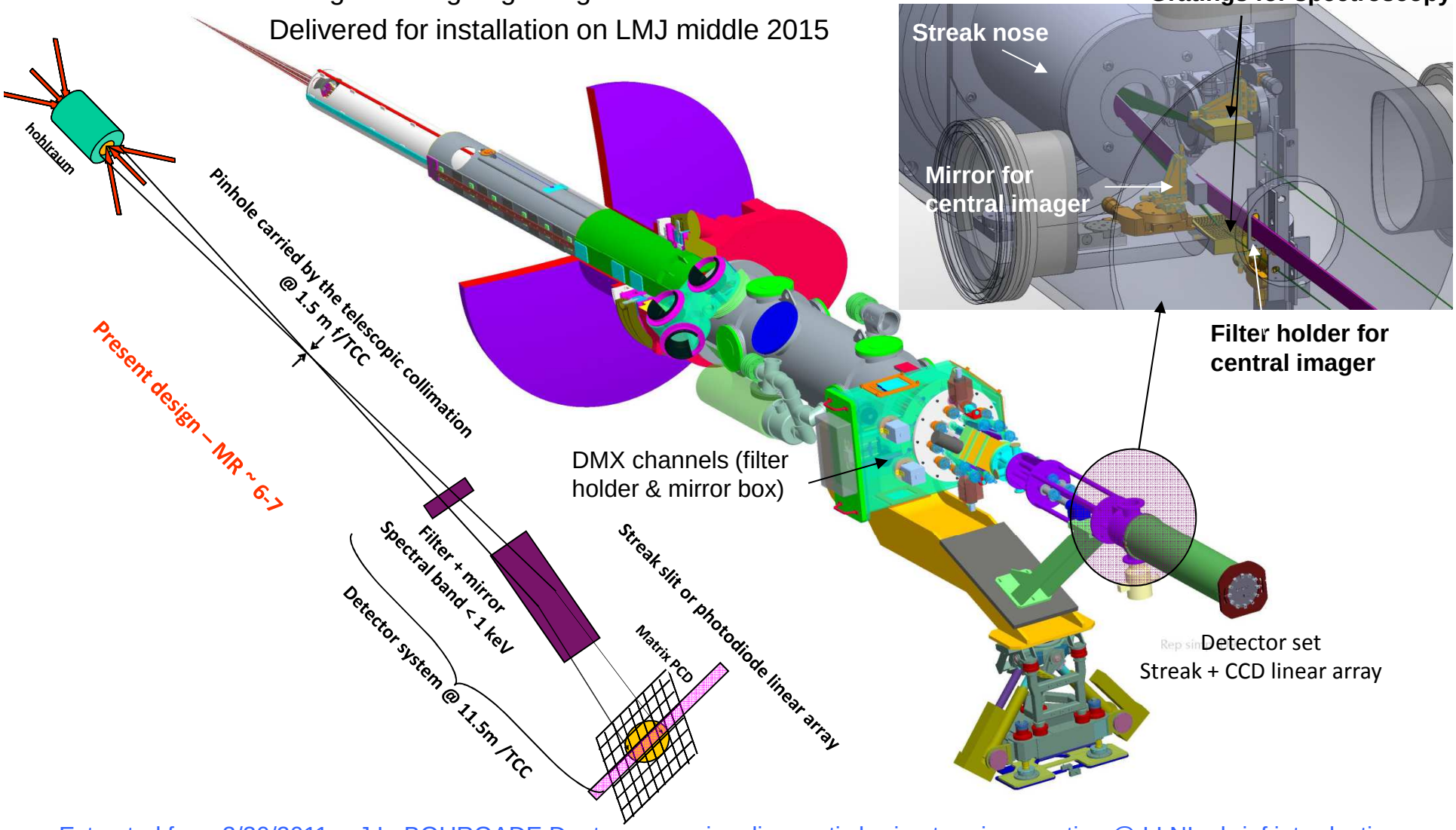




DMX Central Channels:
3/3:ITELt (Imagerie Trou Entrée Laser résolue en temps)

Delivered for assembling & testing beginning 2015

Delivered for installation on LMJ middle 2015



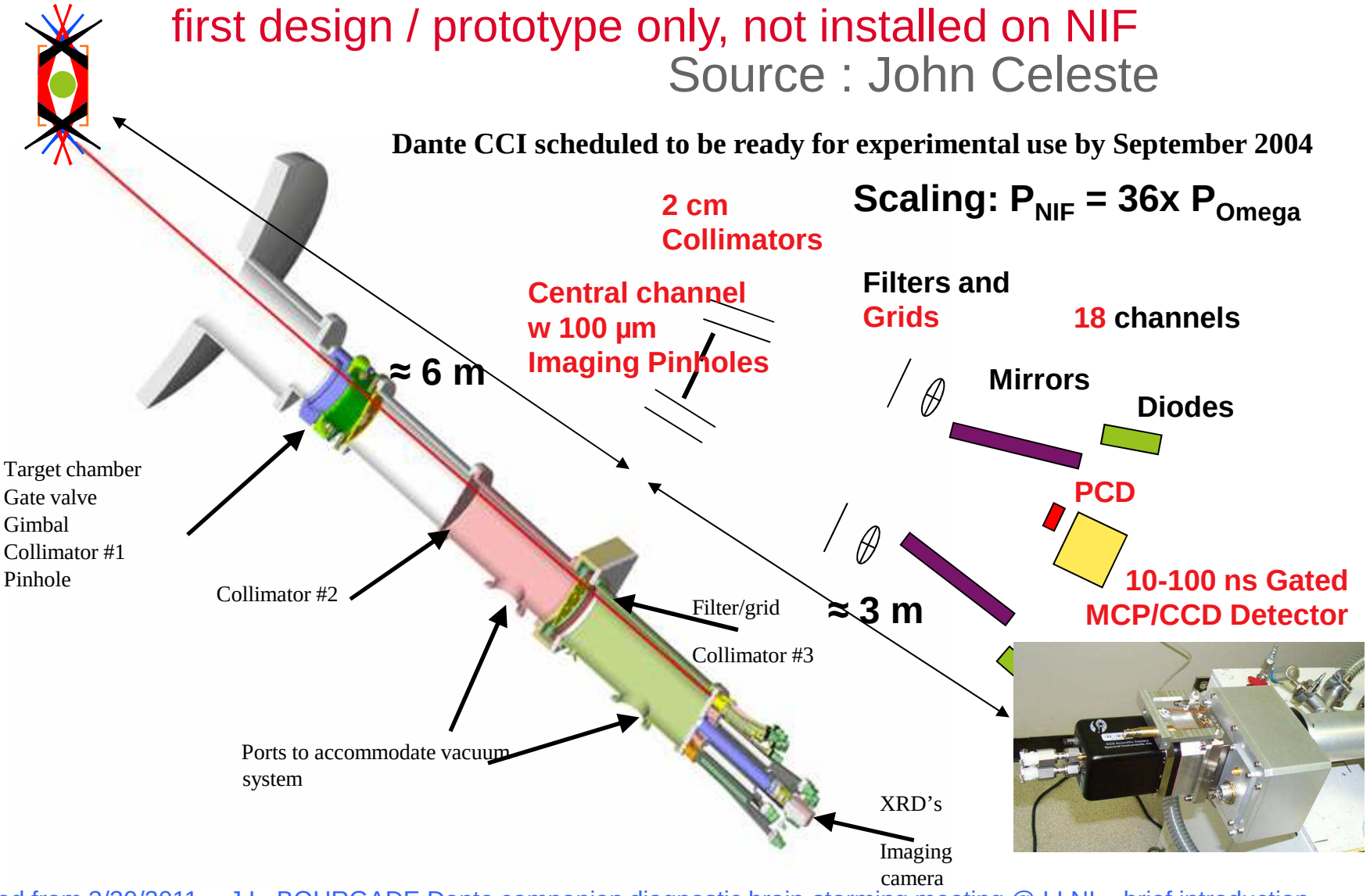
Extracted from 3/30/2011 J.L. BOURGADE Dante companion diagnostic brain-storming meeting @ LLNL - brief introduction

DANTE CENTRAL CHANNEL IMAGING (CCI)

first design / prototype only, not installed on NIF

Source : John Celeste

Dante CCI scheduled to be ready for experimental use by September 2004



Extracted from 3/30/2011 J.L. BOURGADE Dante companion diagnostic brain-storming meeting @ LLNL - brief introduction