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# AXIOMA - Pisa

**Alberto Di Lieto**

**Dipartimento di Fisica dell'Università di Pisa**  
**INFN – Sezione di Pisa**

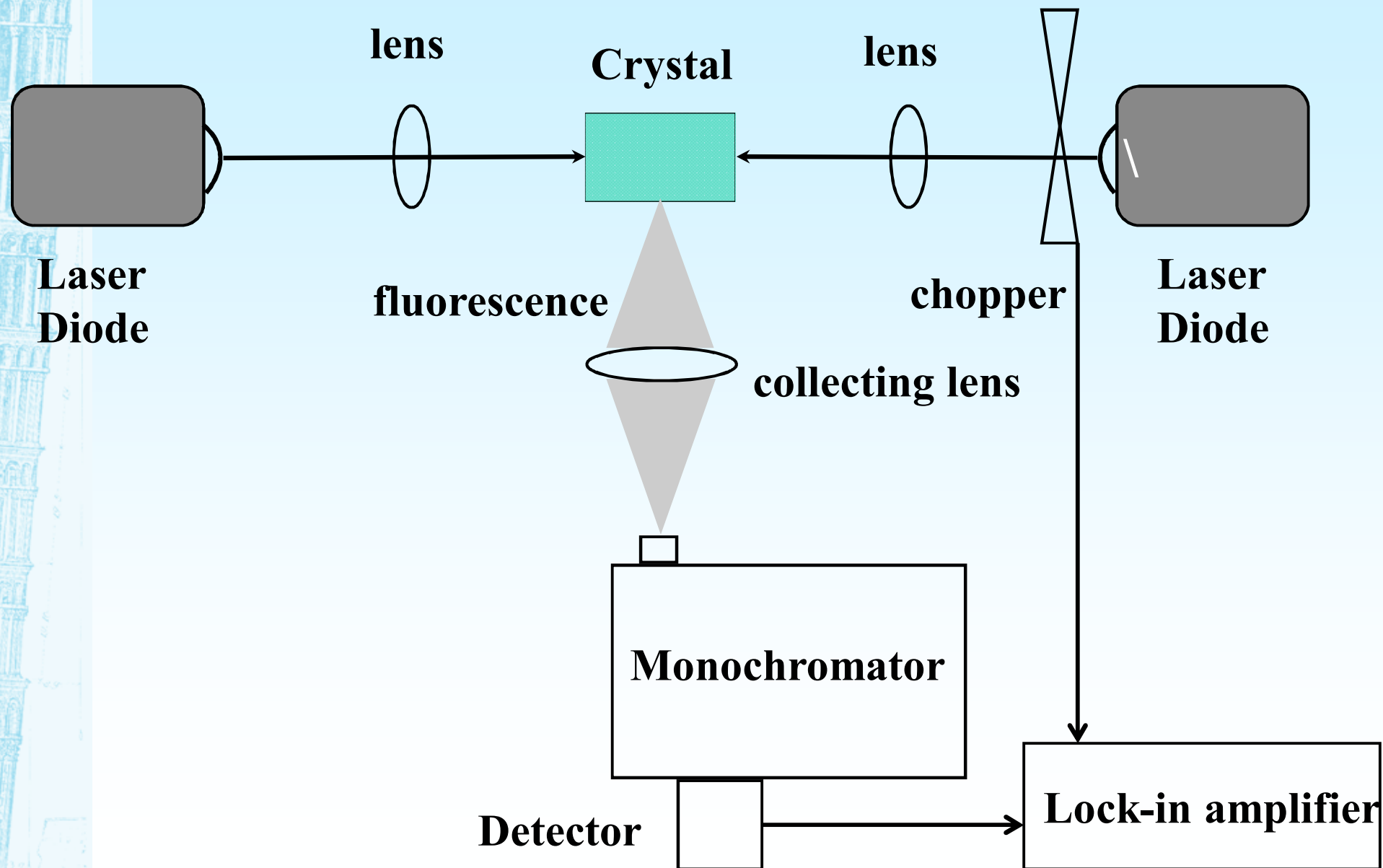




# Stato dell'arte

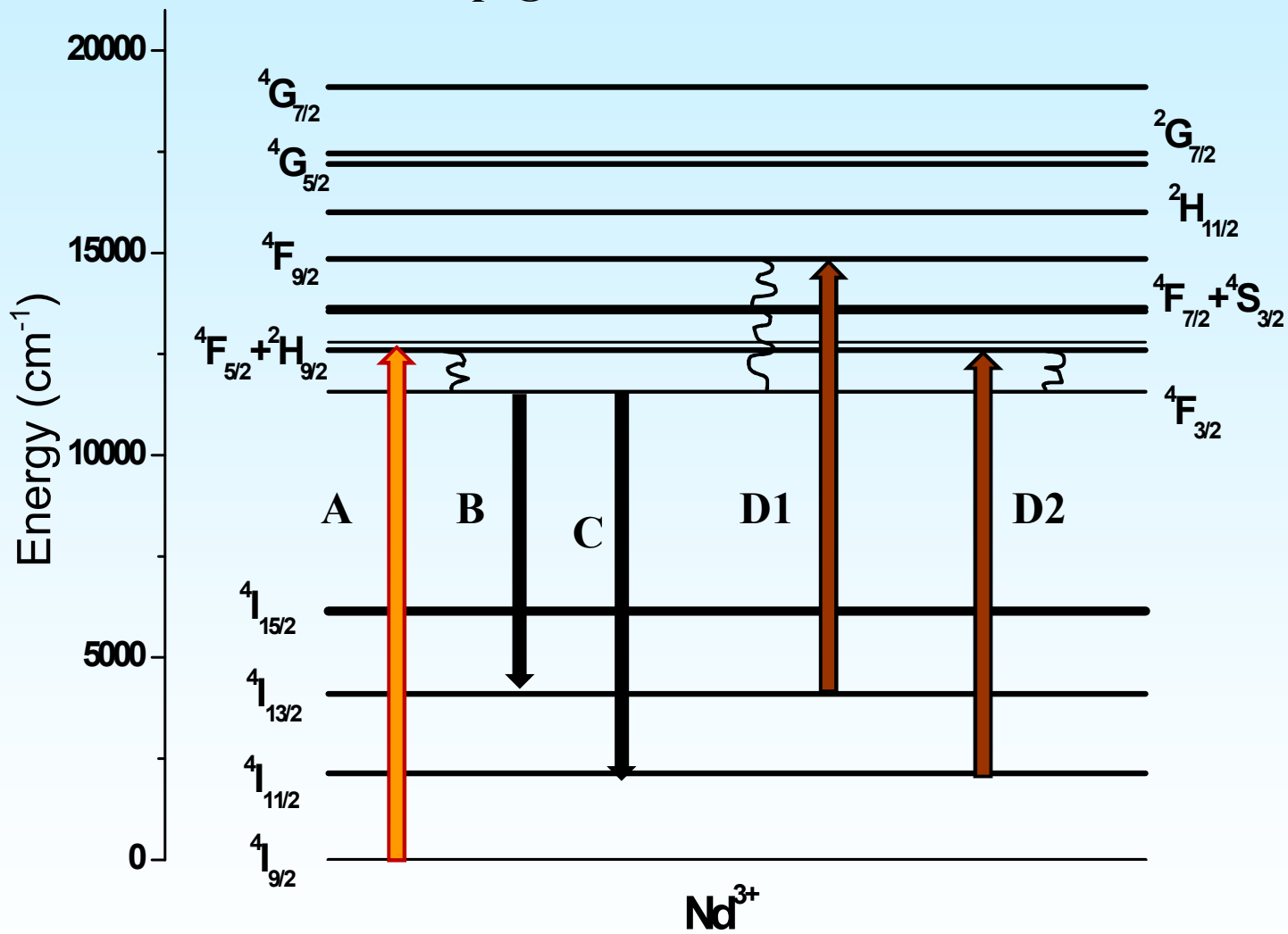
- Risultati ottenuti con DORELAS (*Double Resonance Laser*)
  - *Nd:BYF*
  - *Tm:BYF*
- Risultati ottenuti nella crescita di fluoruri monocristallini drogati con ioni di terre rare

# DORELAS

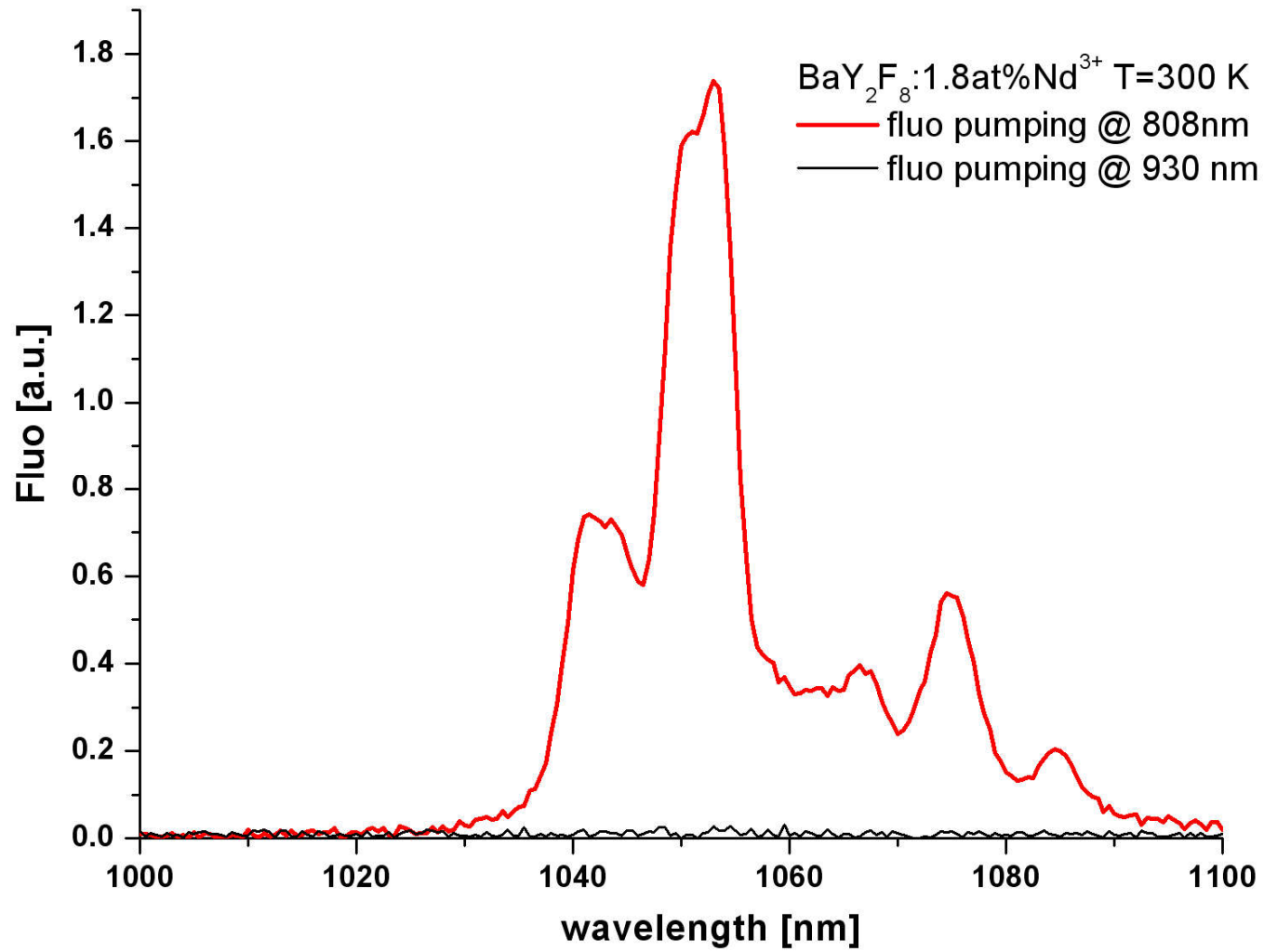




- A: Pump @ 808 nm**
- B: Emission @ 1300 nm**
- C: Emission @ 1050 nm**
- D1, D2: Pump @ 930 nm**



# Fluorescence ${}^4F_{3/2} \rightarrow {}^4I_{11/2}$

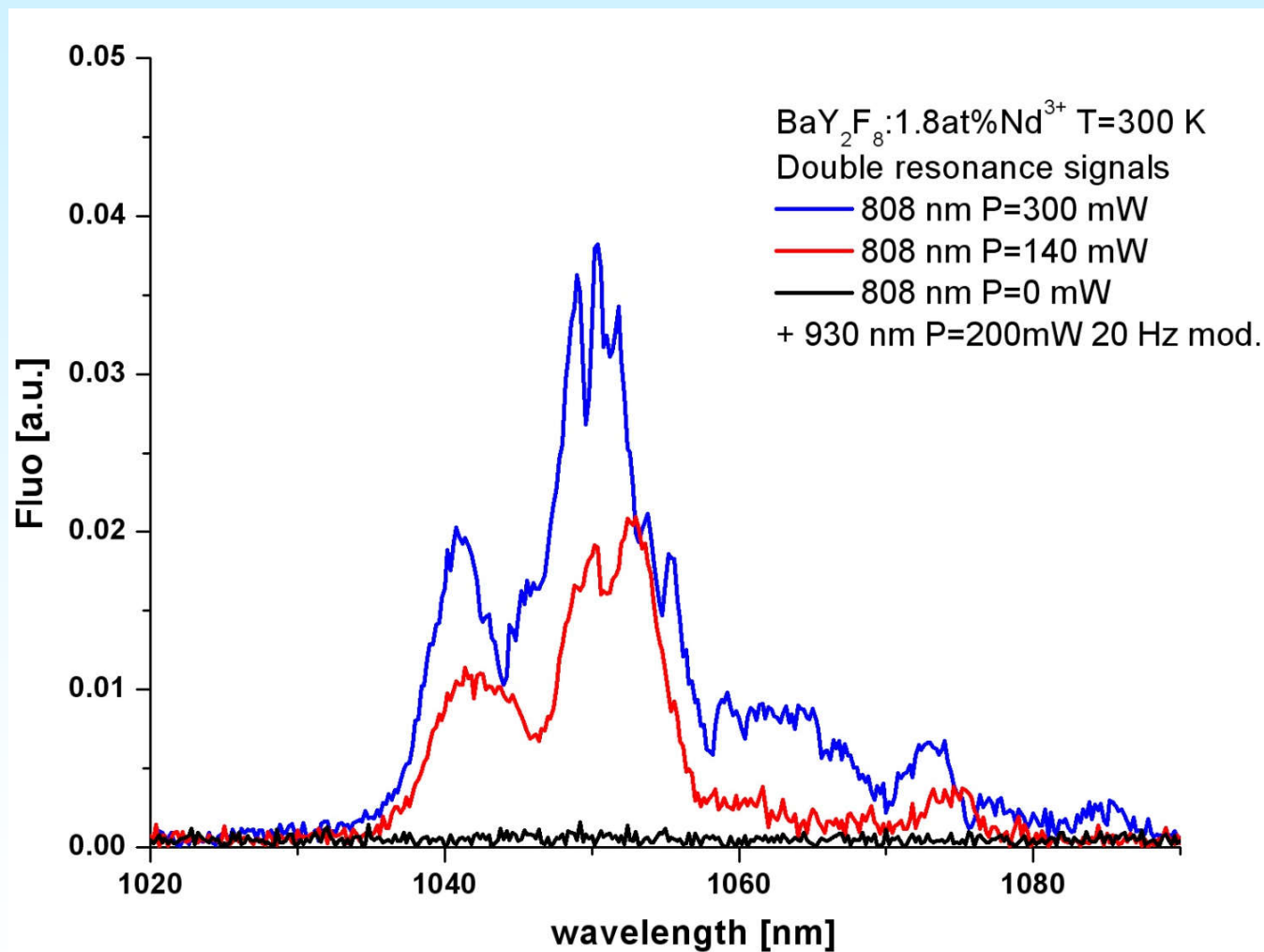




## Double Resonance Spectrum

Pump :  $^4I_{11/2}$  -----  $^4F_{3/2}$  ( 930 nm)

Emission:  $^4F_{3/2}$  -----  $^4I_{11/2}$  (1050 nm)

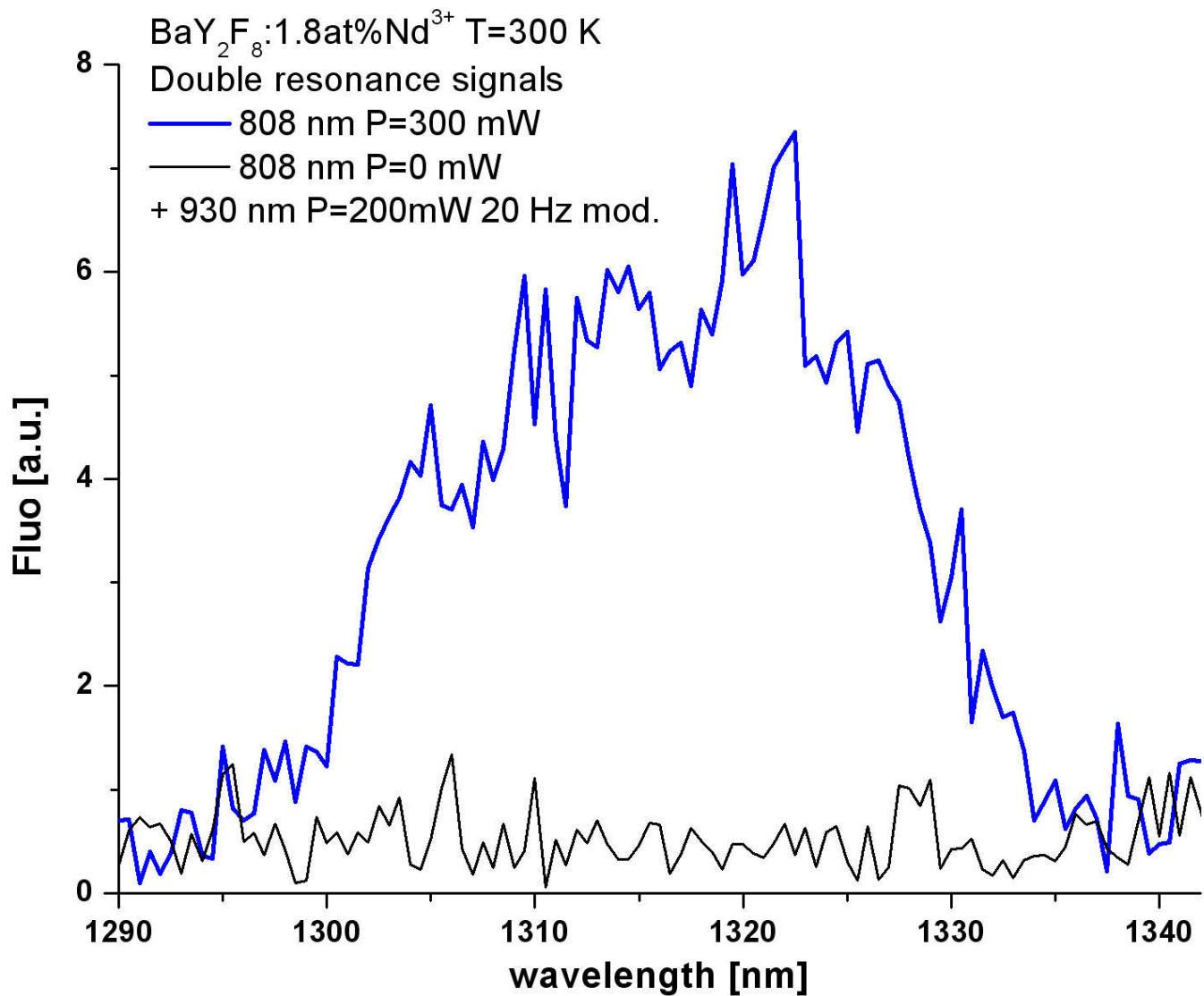




## Double Resonance Spectrum

Pump :  $^4I_{11/2}$  -----  $^4F_{7/2}$  ( 930 nm)

Emission:  $^4F_{3/2}$  -----  $^4I_{13/2}$  (1300 nm)





**BaY<sub>2</sub>F<sub>8</sub>: 1.8% Nd<sup>3+</sup>,  
Nd density: 9.5 x10<sup>21</sup> ions/cm<sup>3</sup>**

- **Excited populations:**

$${}^4I_{11/2}: 10^{18} \text{ ions/cm}^3$$

$${}^4I_{13/2}: 2 \times 10^{17} \text{ ions/cm}^3$$

- **Excited population by DR**

$${}^4I_{11/2} \text{ --- } {}^4F_{5/2} + {}^2H_{9/2} : 4 \times 10^{15} \text{ ions/cm}^3$$

$${}^4I_{11/2} \text{ --- } {}^4F_{7/2} : 10^{14} \text{ ions/cm}^3$$

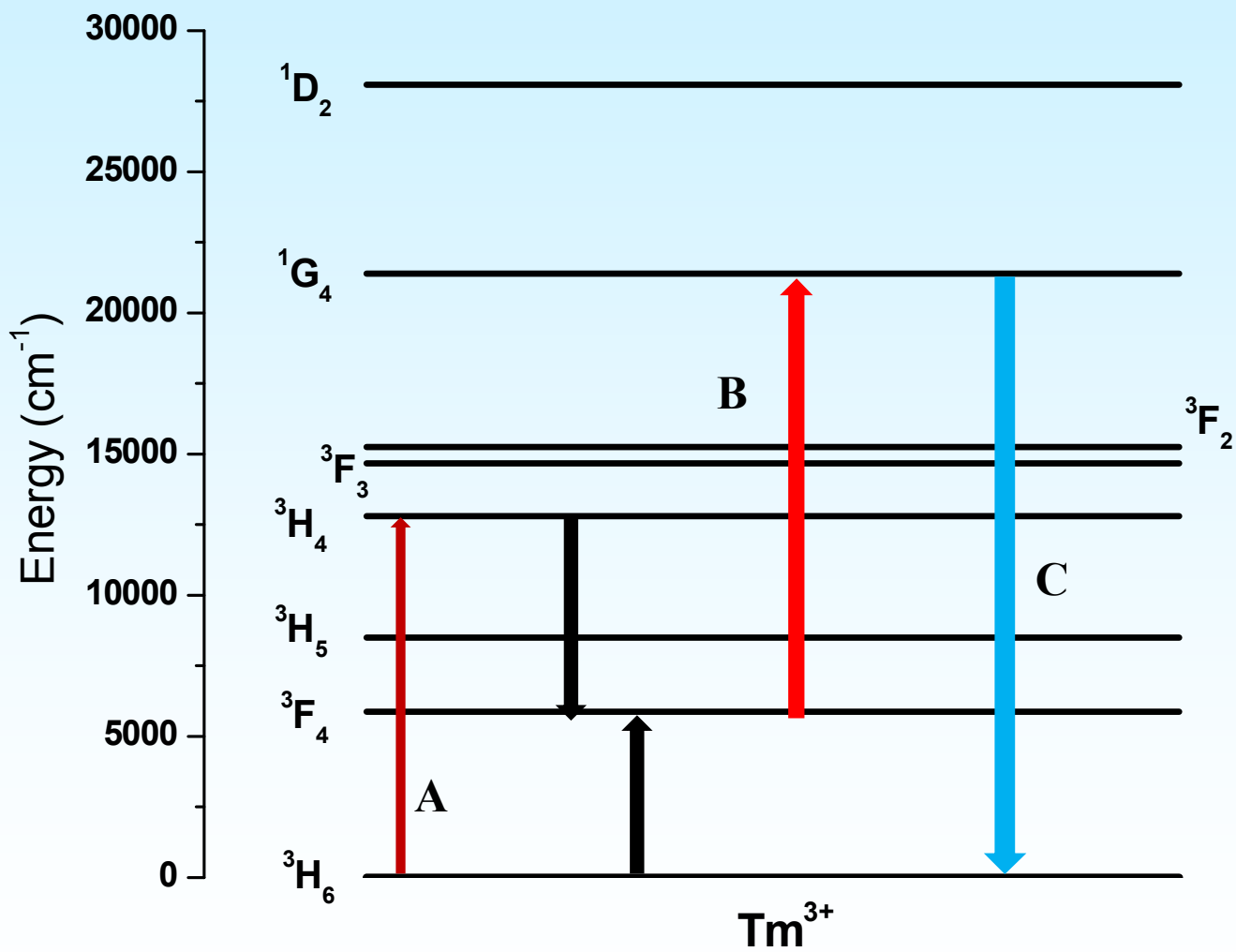




**A: Pump @ 780 nm**

**B: Pump @ 635 nm**

**C: Emission @ 480 nm**

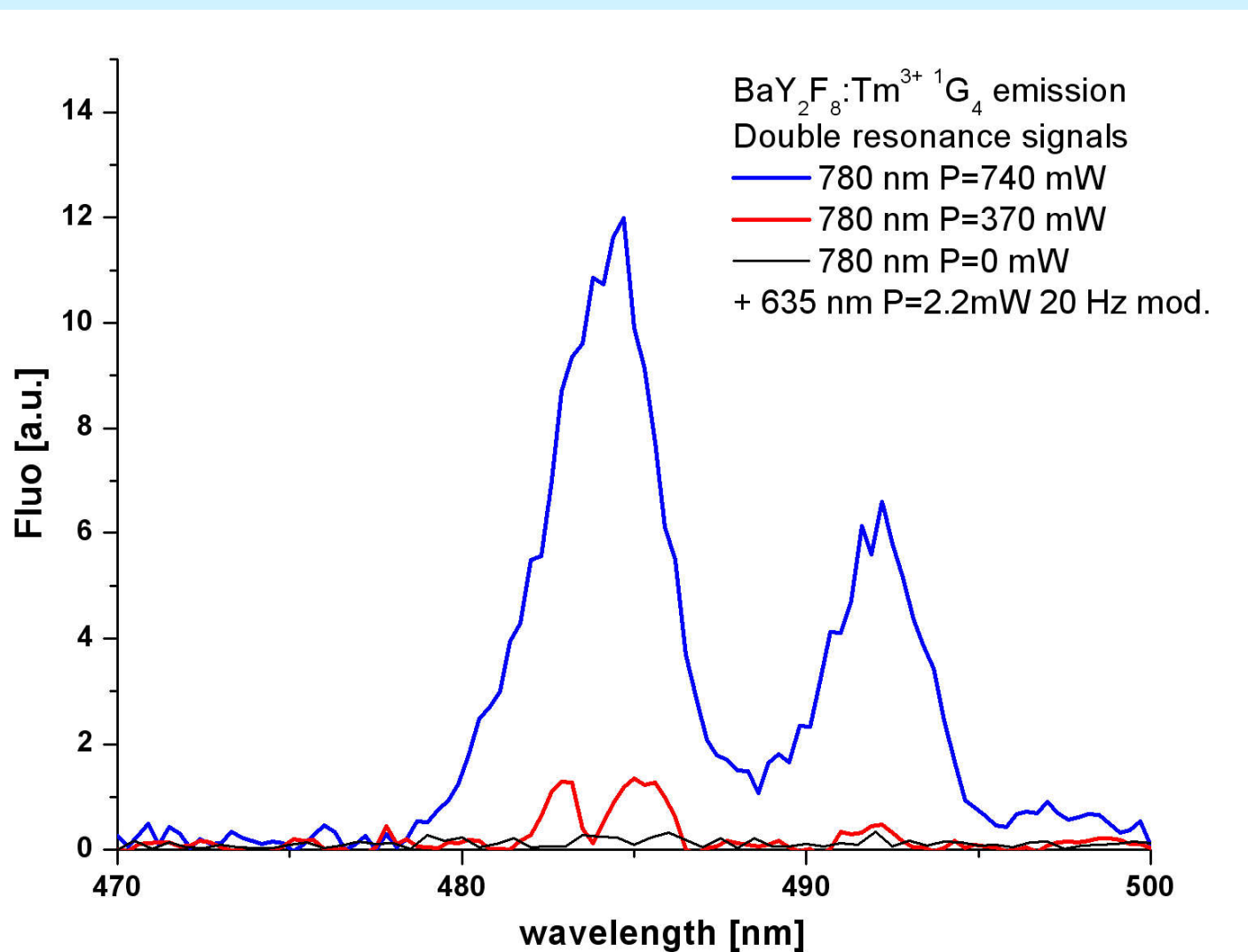




## Double Resonance Spectrum

Pump :  ${}^3F_4$  -----  ${}^1G_4$  ( 633 nm)

Emission:  ${}^1G_4$  -----  ${}^3H_6$  (480 nm)





**BaY<sub>2</sub>F<sub>8</sub>: 8% Tm<sup>3+</sup>,**  
**Tm density: 10<sup>23</sup> ions/cm<sup>3</sup>**

- **Excited population**

$${}^3F_4: 8 \times 10^{20} \text{ ions/cm}^3$$

- **Excited population by DR**

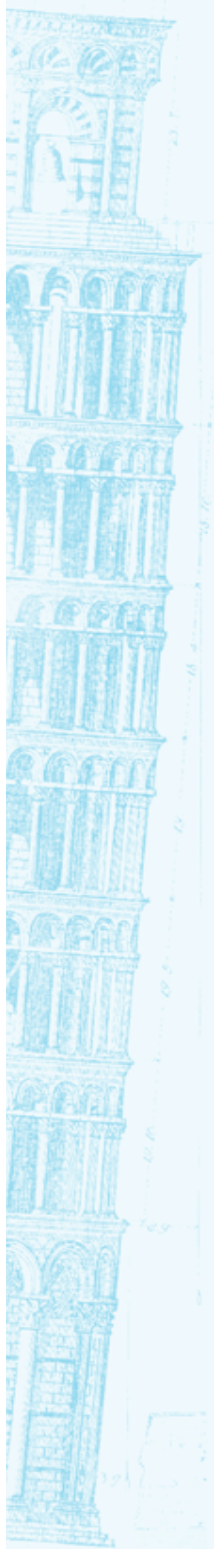
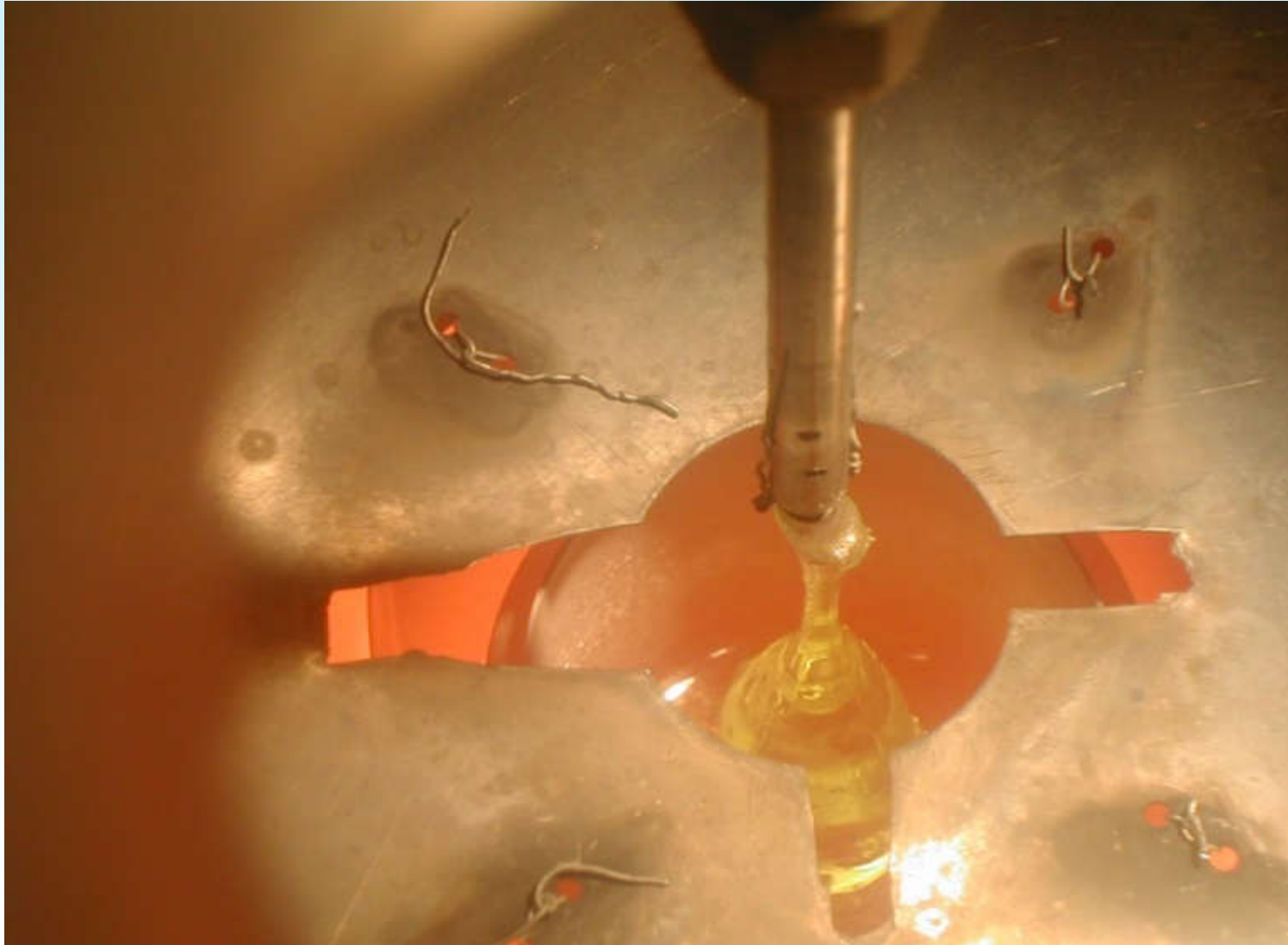
$${}^3F_4 \text{ --- } {}^1G_4: \quad \mathbf{8 \times 10^{13} \text{ ions/cm}^3}$$



# Piano Ricerca

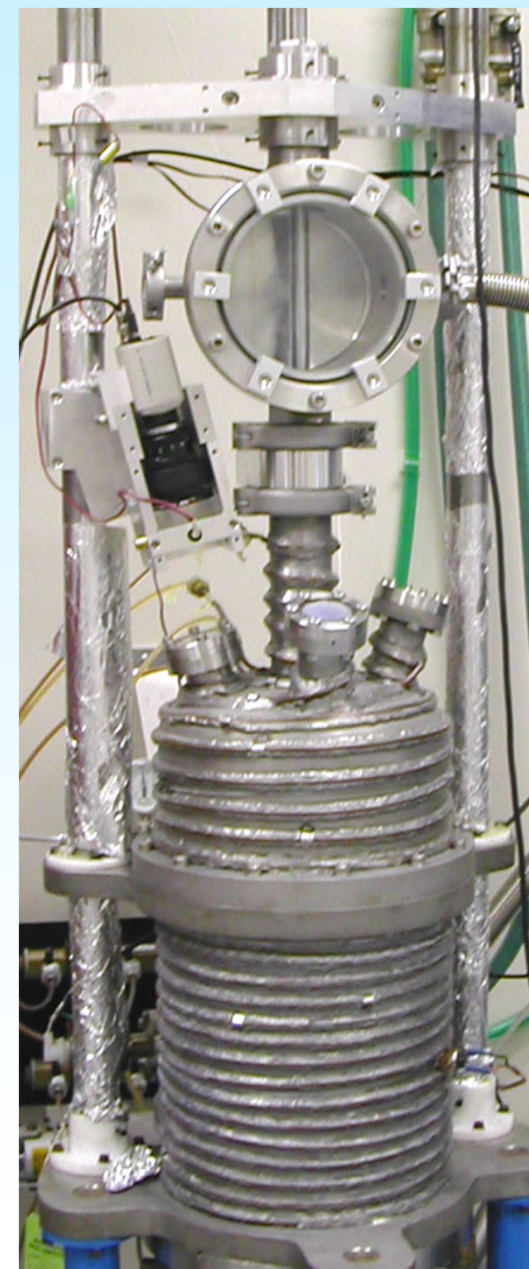
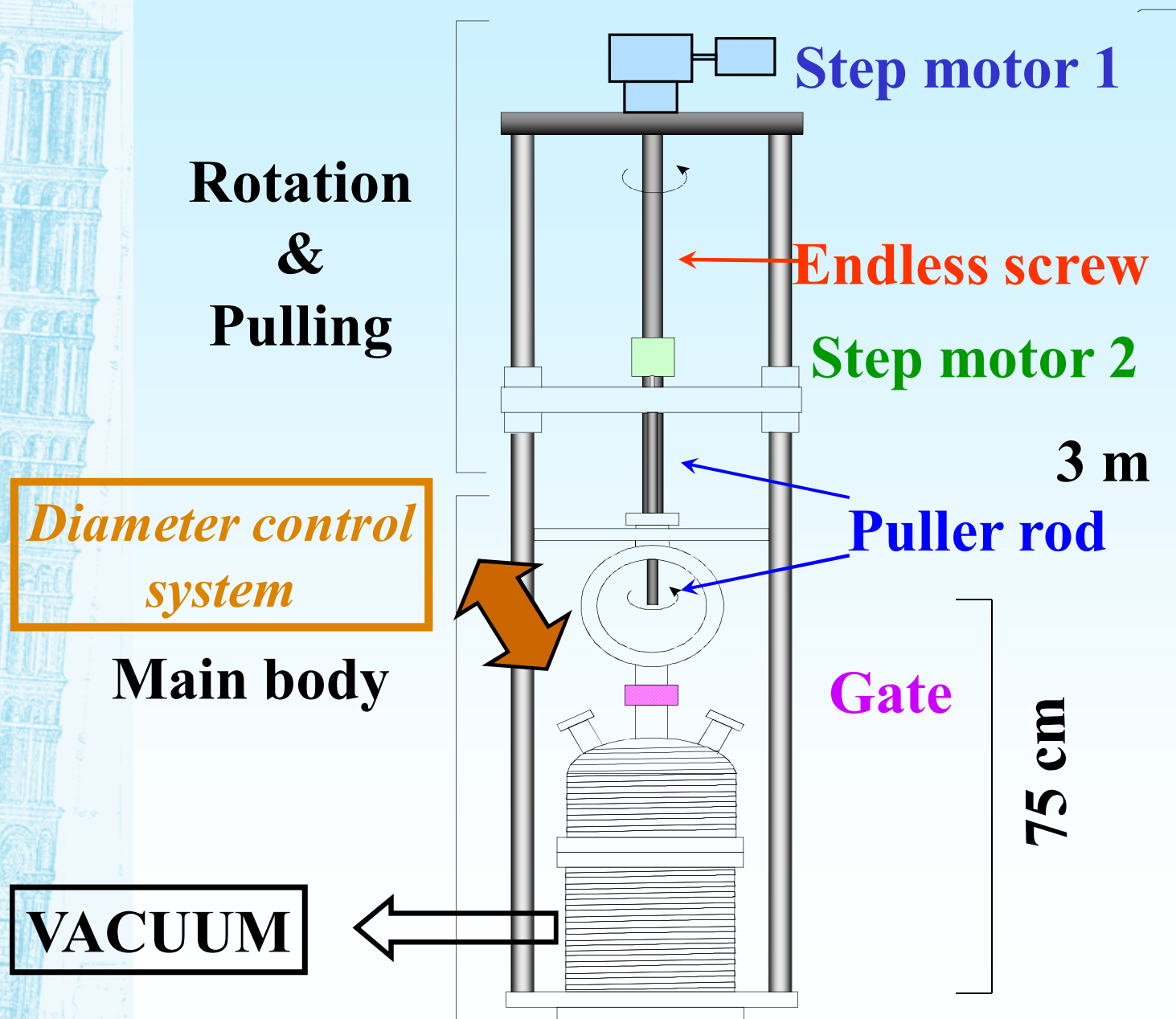
- Crescita cristalli (LLF, GLF, YAG, LuAG) drogati con Nd, Pr, Er e Ho
- Confronto tra i diversi materiali in termini di qualità ottica/spettroscopica/cristallografica
- Osservazione della catodoluminescenza quando irraggiati con X-ray (continua e impulsata) nella regione 80 – 600 meV
- Confronto tra i diversi materiali in termini di efficienza di catodoluminescenza
- Selezione dei materiali

# Czochralski Furnace – 1





# Czochralski Furnace – 2



# BaY<sub>2</sub>F<sub>8</sub>



**Crystal Structure: Monoclinic**

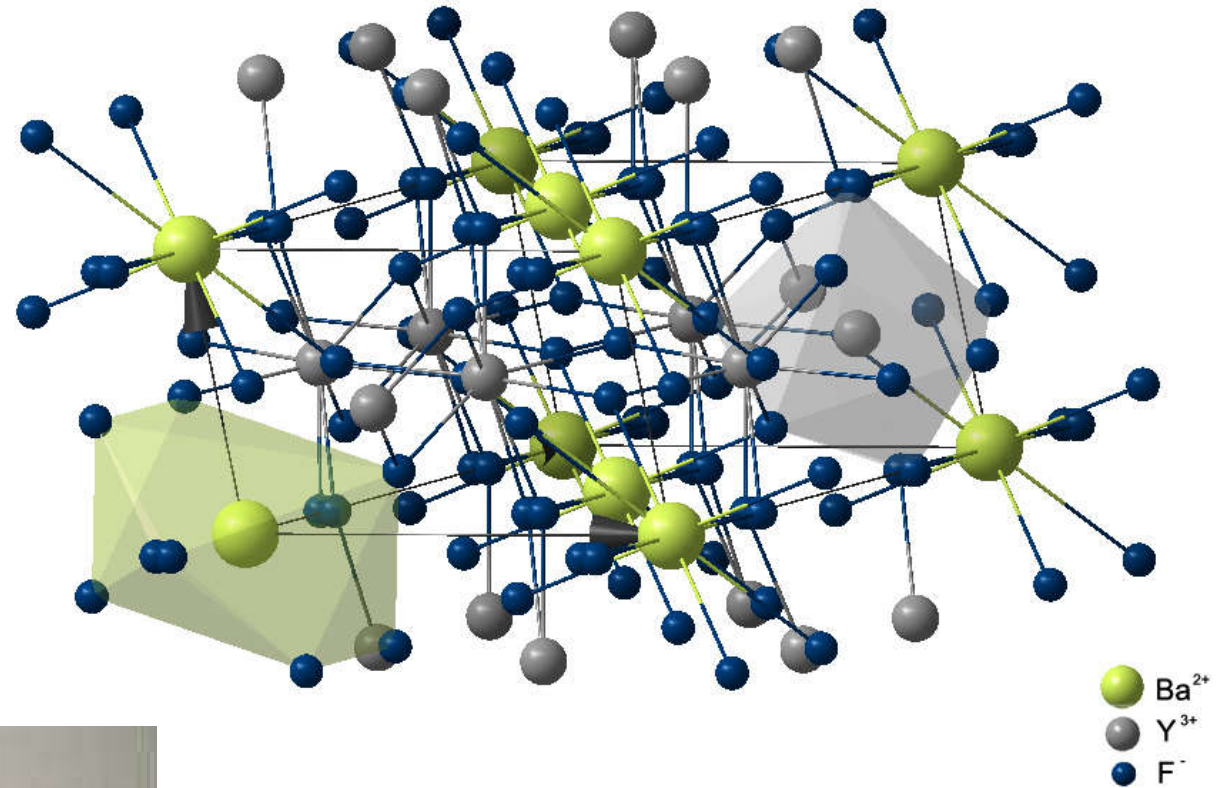
**Space group: C1 2/m**

**$a = 6.9829 \text{ \AA}$**

**$b = 10.519 \text{ \AA}$**

**$c = 4.2644 \text{ \AA}$**

**$\beta = 99.7^\circ$**

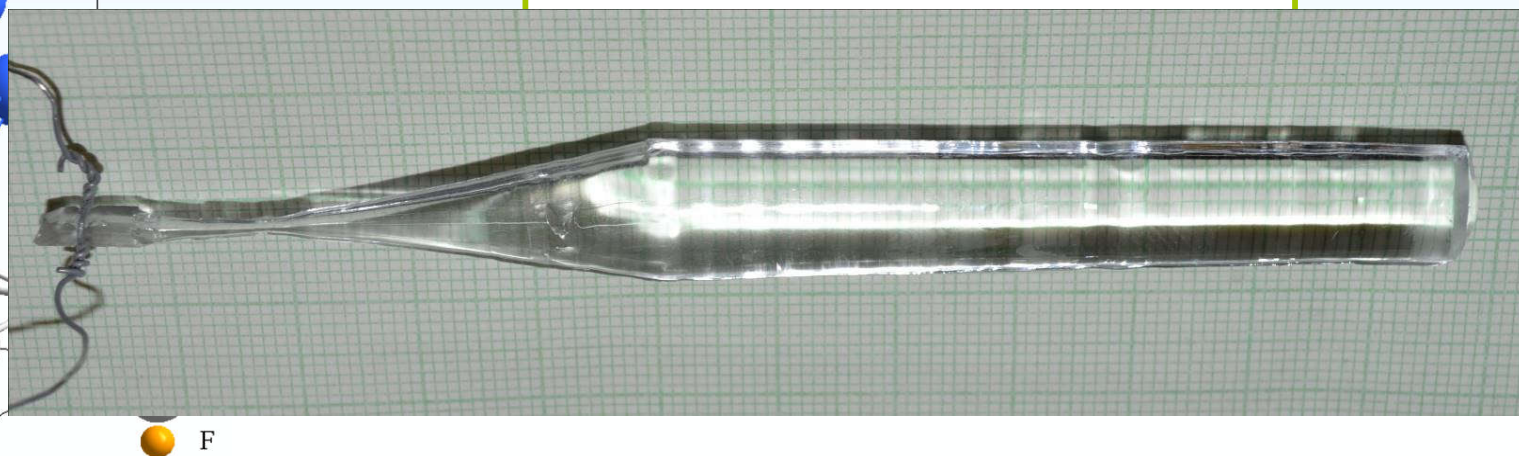
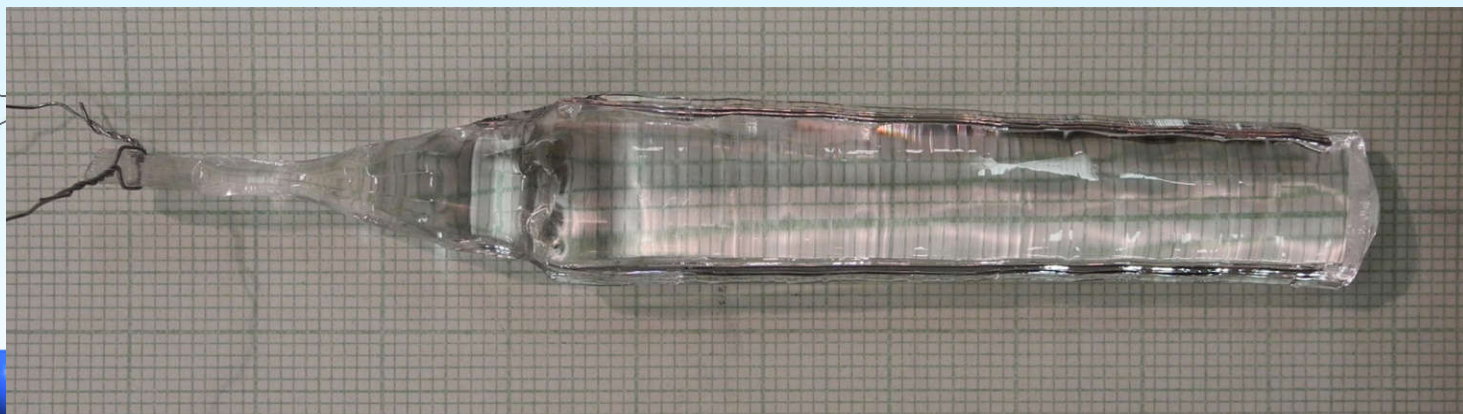
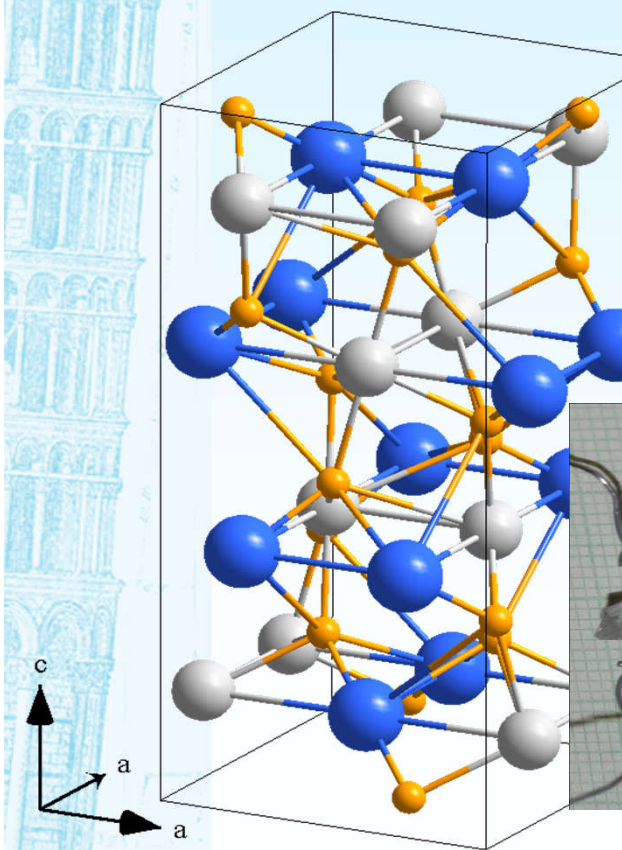


- **Melting point 995° C**
- **pulling rate: 0.5 mm/h**
- **rotation rate: 5 RPM**
- **doping density: 1.8at% Nd<sup>3+</sup>**

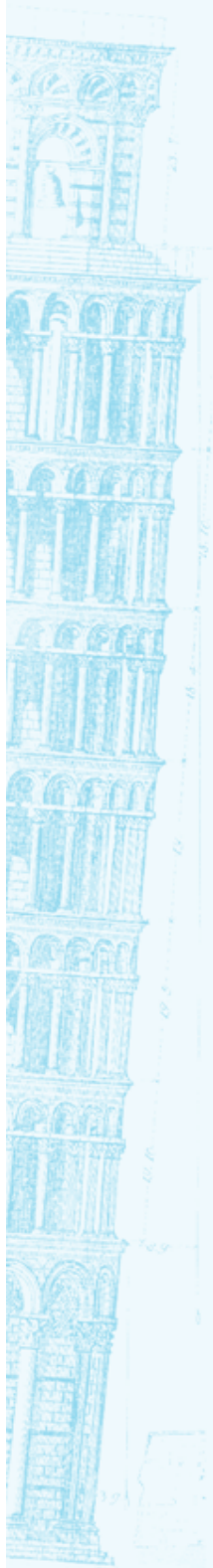
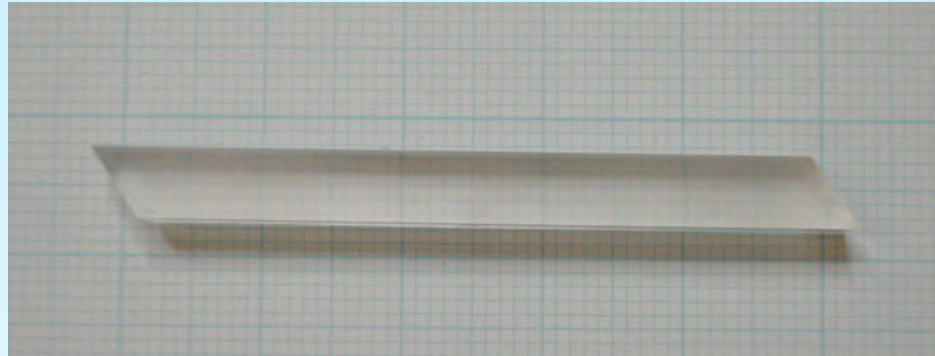


# YLF crystal - ( $\text{LiYF}_4$ )

- Low phonon energy
- Wide transparency window
- Good thermal conductivity
- Tetragonal structure
- Yttrium can effectively be replaced by rare earths
- High performances as solid-state laser medium



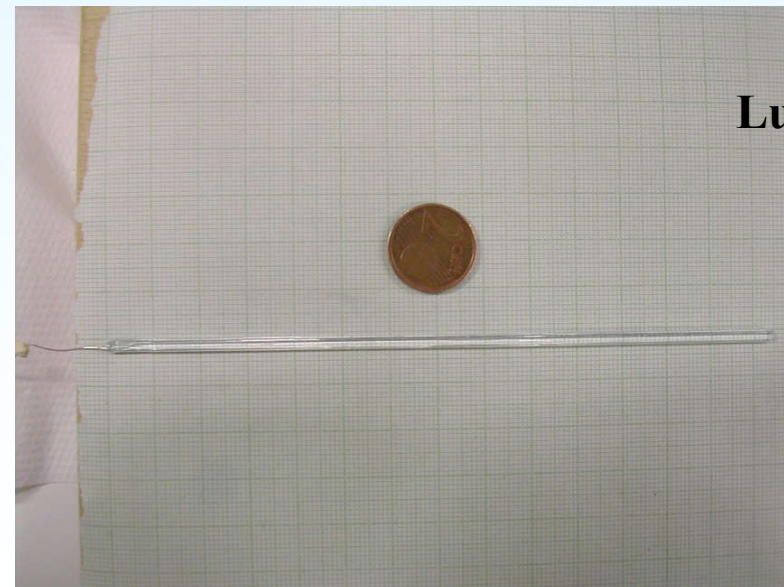
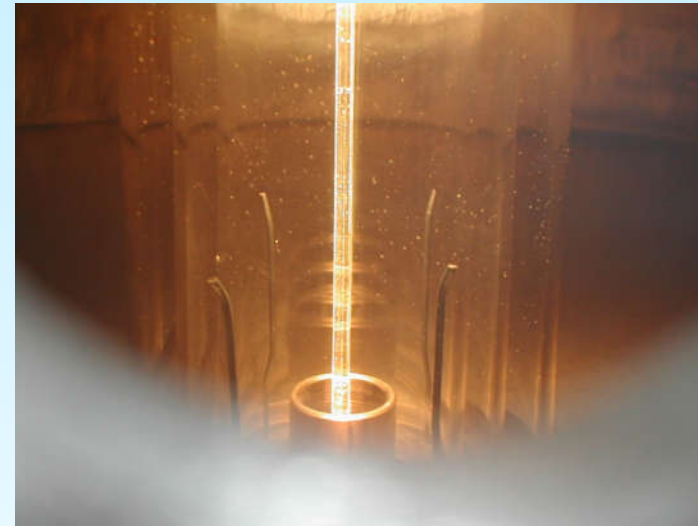
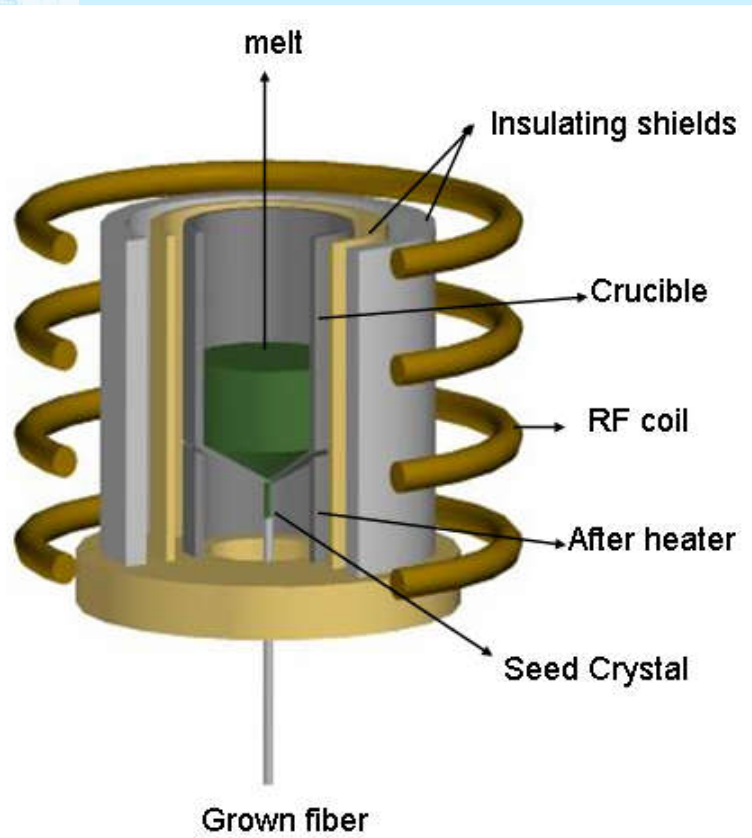




# $\mu\text{m}$ -PD Growth Technique



Pulling



LuAG:1%Yb<sup>3+</sup>

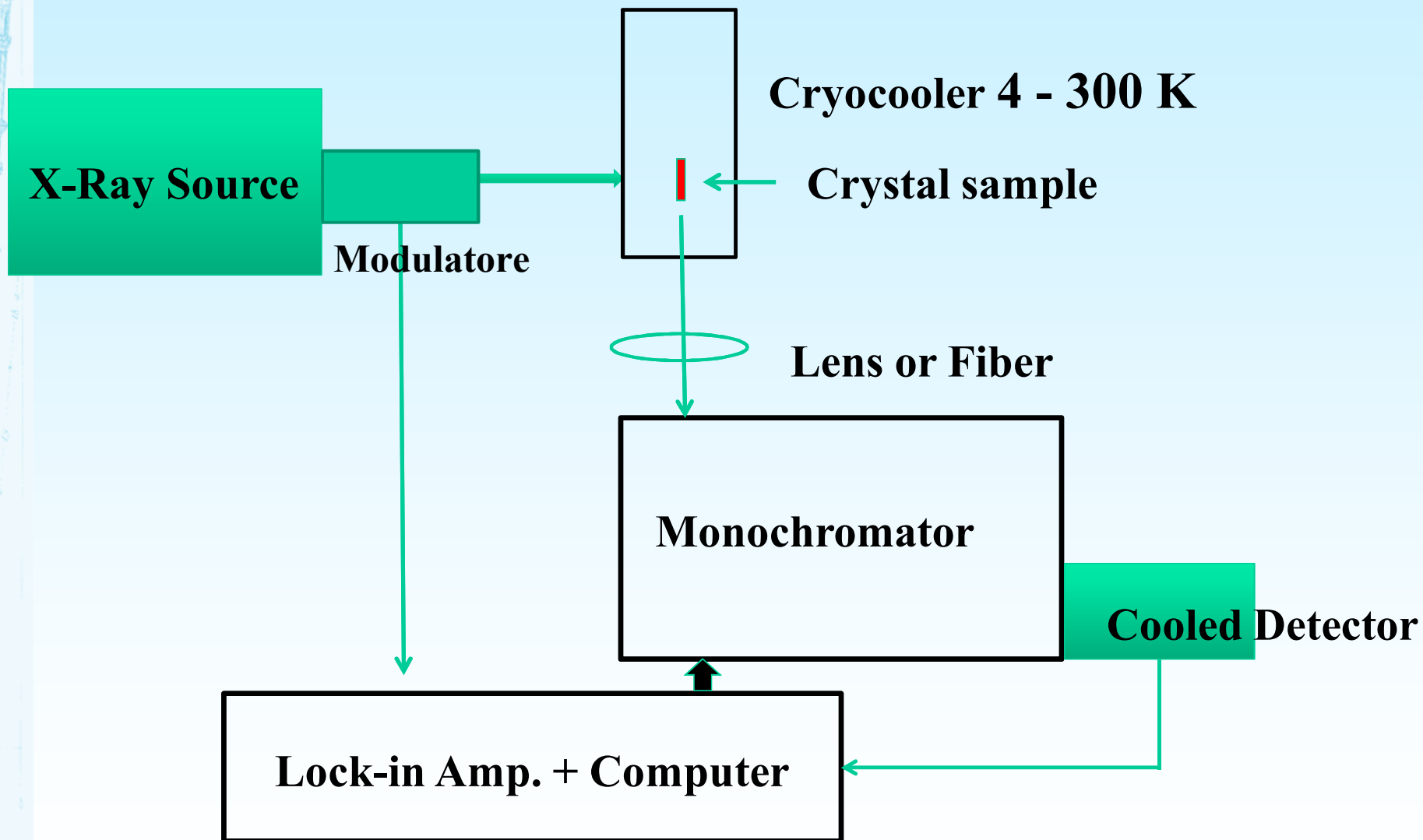


2.1% Pr<sup>3+</sup>:LuAG

Length = 142 mm , Diameter = 2.6 mm (+/- 0.1 mm)

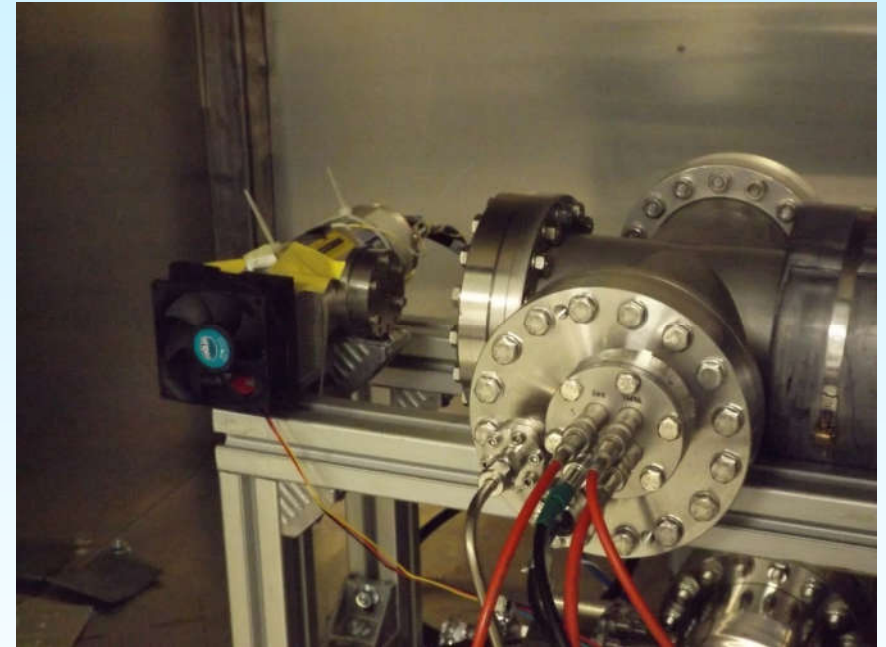
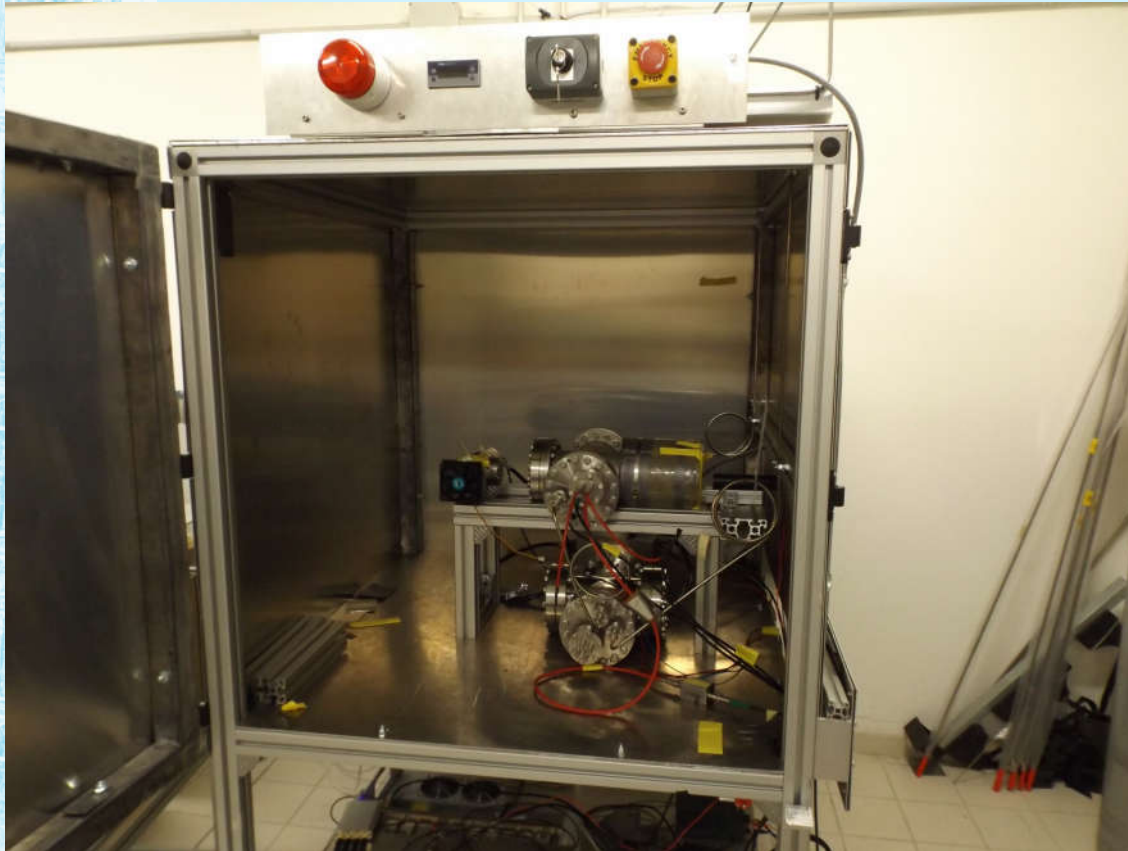


# Setup catodoluminescenza



**Detection Range : 80 - 600 meV**

# X- Ray Tube with Pb-shielded cabinet



# Sorgente raggi X

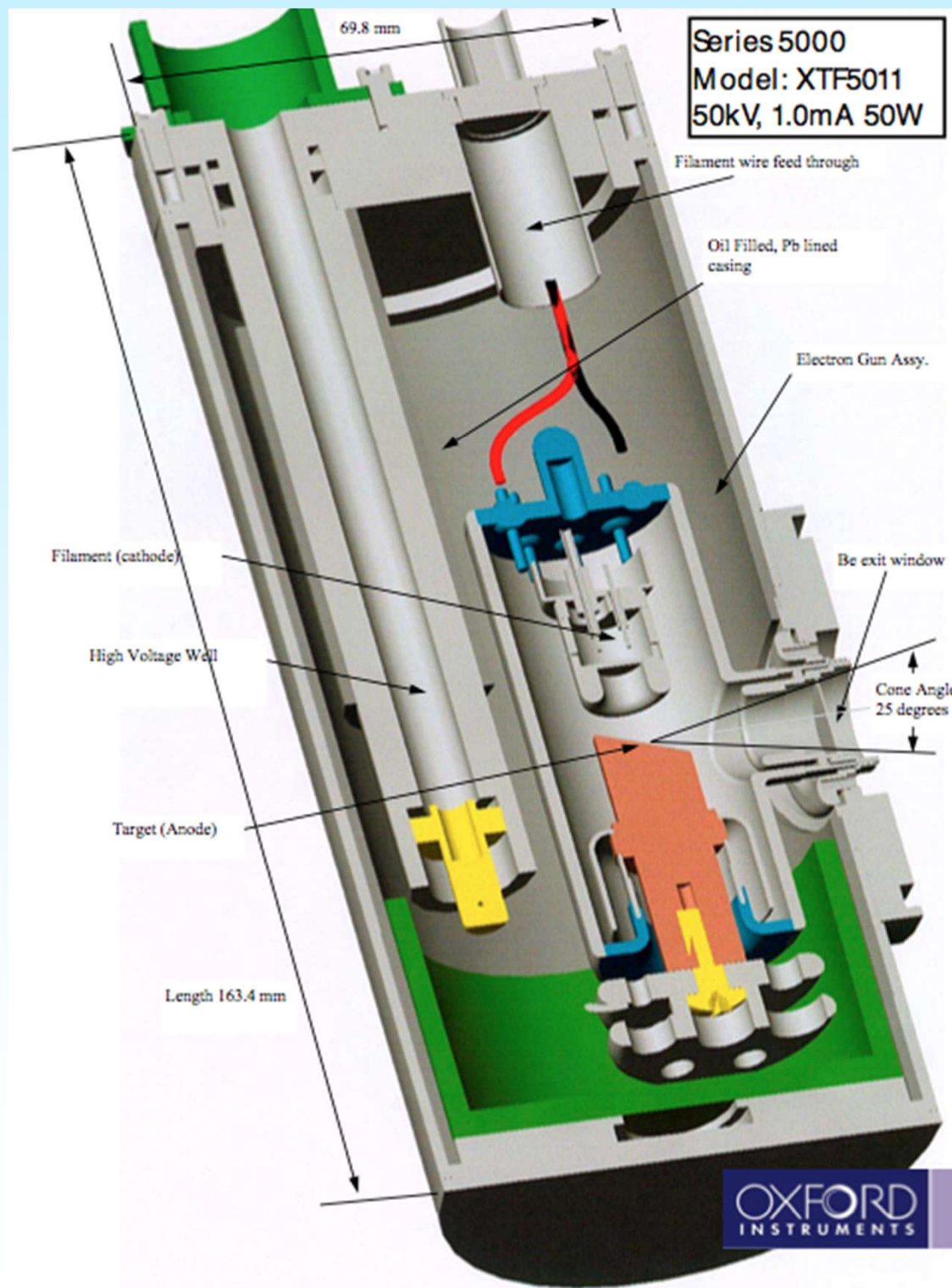
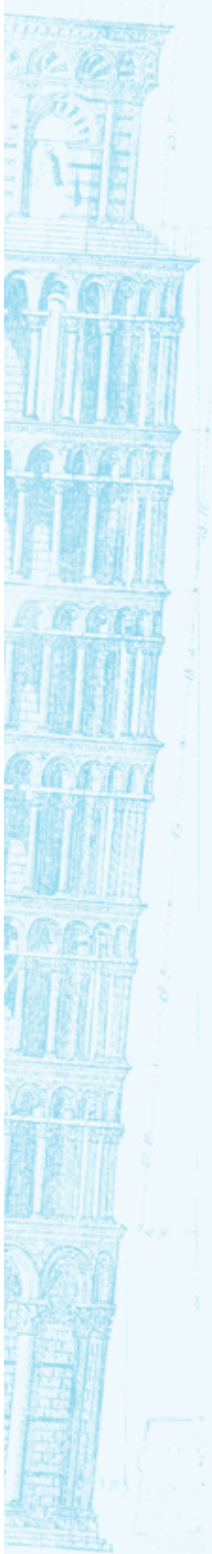


- Oxford Apogee XTF5011
- Specifiche



Feature	Series 5000
Max Anode Current	1.0 mA
Max Anode Voltage	50 kV
Maximum Power	50 W continuous
Nominal Filament Voltage	2.0 V @50 kV, 1 mA
Max Filament Current	1.7 A
Stability	0.2% over 4 hours
Focal Spot Size (Nominal*)	110 $\mu\text{m}$
Anode Material	W, Mo, Rh (other materials available)
Be Window Thickness	125 $\mu\text{m}$ (75 $\mu\text{m}$ , 250 $\mu\text{m}$ options available)
Approximate Weight	4 lbs (1816 g)
Cooling Method	Forced air @150 CFM
Cone Angle	25°

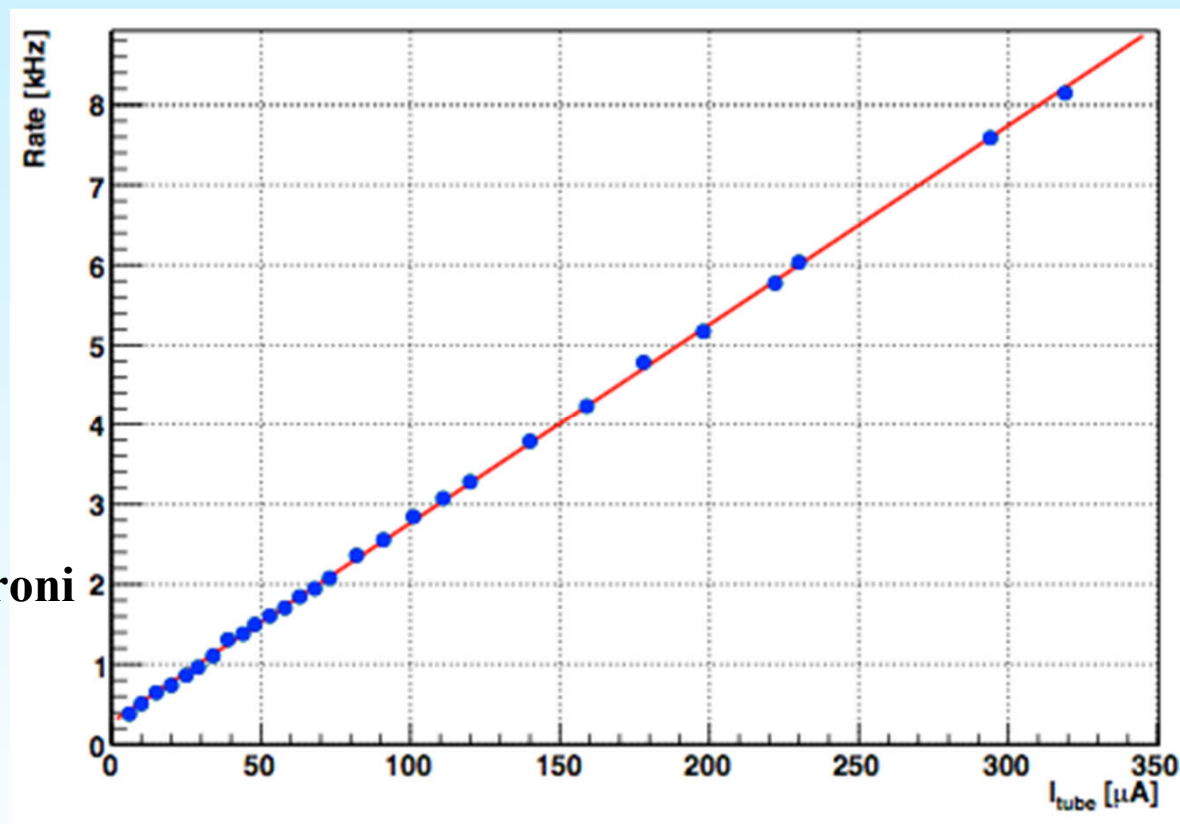
distribuzione angolare isotropa →



# Flusso (previsione)



- Flusso integrato vs. corrente anodica (misura con scintillatore plastico)
- Rate tot. =  $2.5 \times 10^4 \text{ s}^{-1}/\text{mA}$
- flusso max. =  $1.6 \times 10^5 \text{ s}^{-1} \text{ sr}^{-1}$  (nel cono di apertura del tubo)
- rate max. =  $34 \text{ s}^{-1}$  per sezione =  $1 \text{ mm}^2$  e distanza = 7 cm dal fuoco degli elettroni

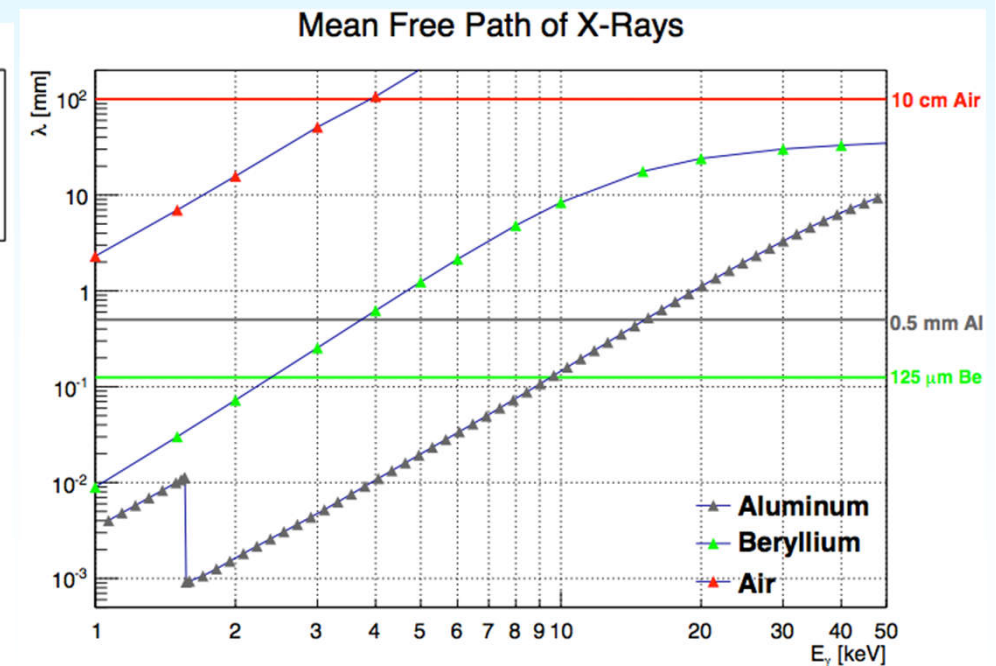
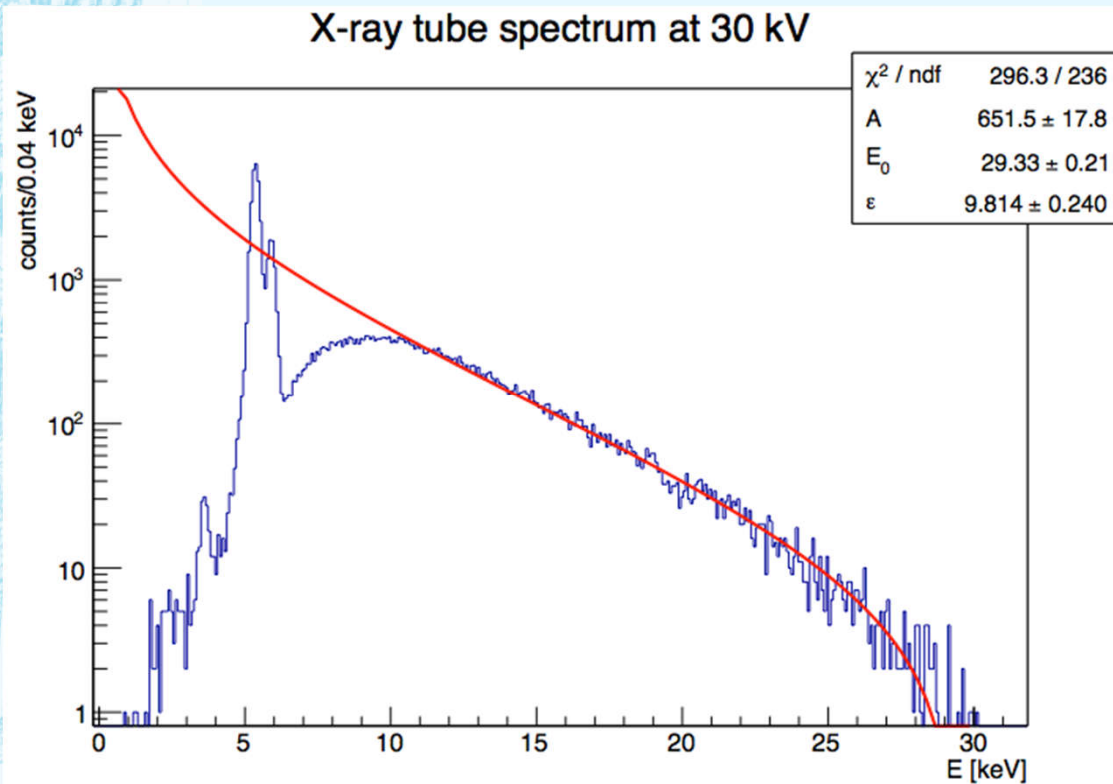


- Stima conservativa, non corretta per assorbimento di raggi X nel wrap dello scintillatore (e in aria)

# Spettro in energia



- **Misure effettuate con rivelatore a silicio (Amptek XR-100CR)**
- **Spettro risultante da diverse cause concorrenti:**
  - un continuo decrescente con end-point all'energia degli elettroni (dovuta a Bremsstrahlung, legge di Kramers)
  - righe di fluorescenza caratteristiche del bersaglio (in questo caso linee  $K\alpha$  e  $K\beta$  del Cromo a 5412 e 5947 eV rispettivamente)
  - taglio a basse energie dovuto all'assorbimento nella finestra di Berillio ( $E \approx 2.5$  keV, ineliminabile) ed a 60 cm di aria (necessari a moderare il flusso sul silicio)

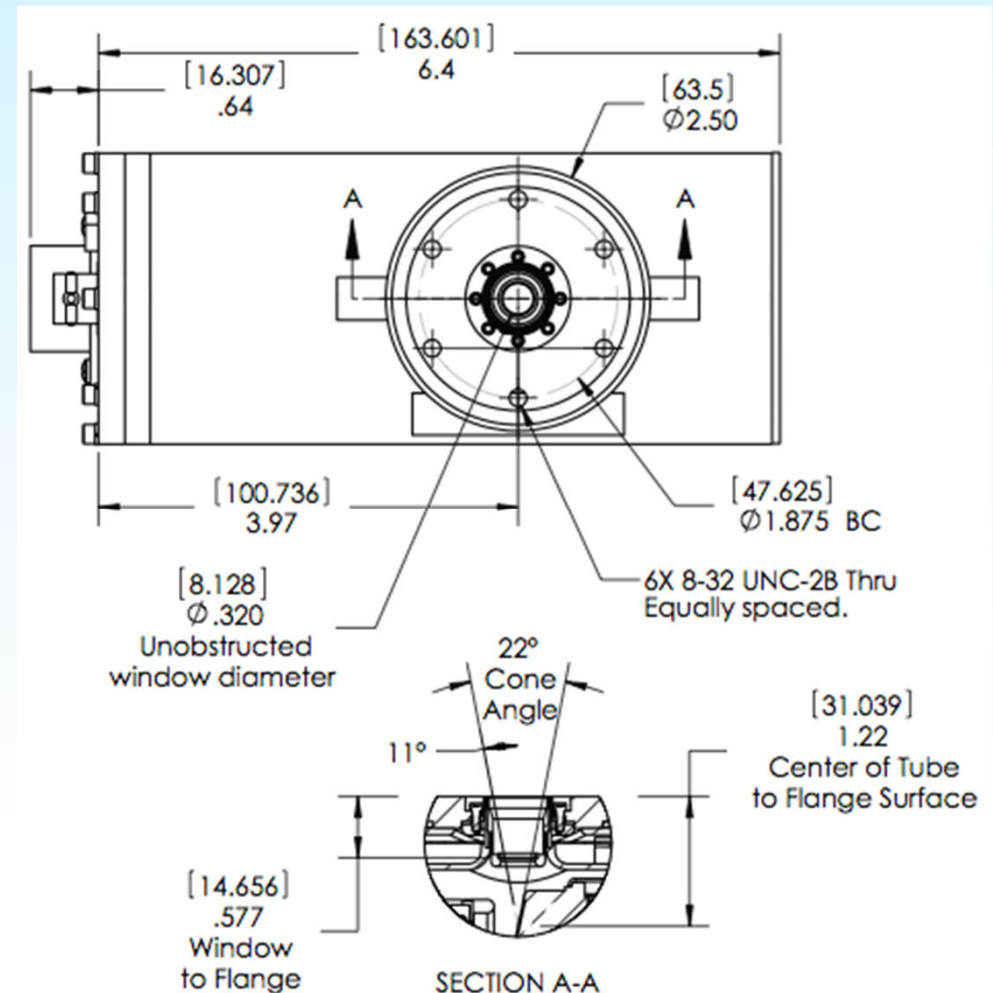




# Adattamento meccanico



- L'accoppiamento meccanico tra il generatore di raggi X ed il criostato deve essere tale da massimizzarne il flusso sul cristallo
  - effetti di materia (con modifica dello spettro)
- ➔ *raccordo a tenuta di vuoto con adattamento di flange*
  
- Potrebbe essere opportuno inoltre separare il tubo dalla linea di vuoto del criostato per permettere l'estrazione/inserimento del cristallo in modo semplice
  - **Opzione 1:** inserire un'ulteriore finestra di Berillio di spessore analogo ( $127\ \mu\text{m}$ ) nella linea del fascio
    - ➔ *energia soglia  $E \approx 3\ \text{keV}$  (vedi slide prec.)*
  - **Opzione 2:** inserire una gate valve per permettere la separazione dei due ambienti durante la sostituzione del cristallo
    - ➔ *allungamento linea fascio, riduzione flusso*



# Versione pulsata



- Il tubo e la power supply sono predisposti per operare in continua
- Per la caratterizzazione dei cristalli sarebbe opportuno modulare il flusso di raggi X
- Struttura pulsata con
  - periodo  $>$  tempo di decadimento ( $O(1 \text{ ms})$ )
  - durata  $\ll$  “ “ “
- possibili soluzioni:
  - chopper sulla linea di fascio
    - *modifica linea con inserimento elementi ottici*
    - *impossibile utilizzare un raccordo a vuoto*
  - controllo in tensione (da investigare con la Oxford)
    - *disabilitare la produzione di raggi X durante la diseccitazione del cristallo*
    - *dump del fascio di elettroni prima che raggiungano il bersaglio*
    - *idea di intercettare la tensione di controllo della griglia (0 – 100 Vdc all'uscita della power supply) e di “abilitarla” mediante un opportuno switch CMOS analogico (per tensioni simili sono disponibili integrati dedicati ad applicazioni ultrasound) ad esempio: MAX4800A, (impulsi fino a 200 V , banda passante 50 MHz)*

# Persone



- A. Di Lieto (50%)
- D. Nicolo' (10%)
- M. Tonelli (50%)
- A. Volpi (PhD, 30%)
- G. Cittadino (PhD, 30%)



# CH-202 System



## Key Features

- CH-202 Displex® Cold Head
  - Enhanced cold head design for lower noise, lower vibration operation and longer life
  - Highly reliable design, proven in hundreds of Lab and Cryopump Installations
  - Displex® technology allows for service "in-situ"
  - MTBM of 13,000 hours operation
- HC-4E1 Compressor
  - Hermetically sealed, water-cooled, rotary compressor design
  - Specifically designed for helium service
  - Refined oil and gas management
  - Highly reliable design
  - MTBM of 30,000 hours operation
  - ON and OFF buttons for local operation of the compressor and cold head
  - Automatic restart after power interruptions
  - Front panel LCD display of elapsed run time
  - Automatic relief from an over pressure condition
  - Easy access as all utilities are located on front panel
  - CE approved



