

PAUL SCHERRER INSTITUT



M. Strobl - Neutron Imaging & Applied Materials Group :: Paul Scherrer Institut

## Neutron Imaging Instruments

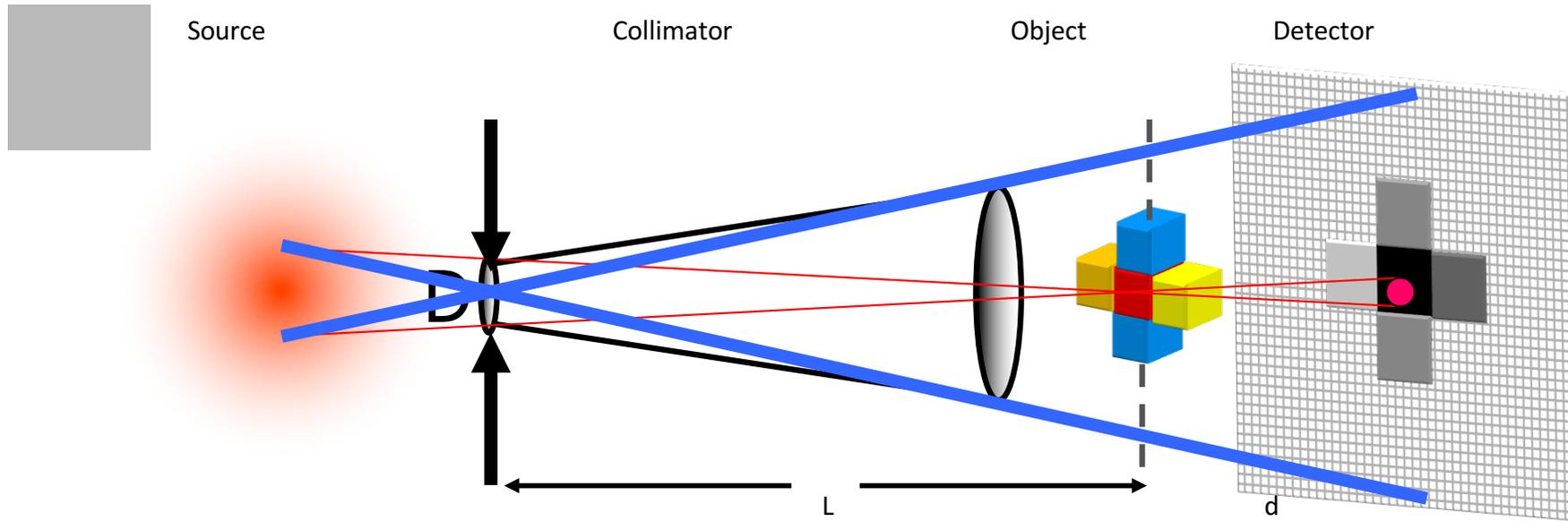
Oct. 2018

[markus.strobl@psi.ch](mailto:markus.strobl@psi.ch)

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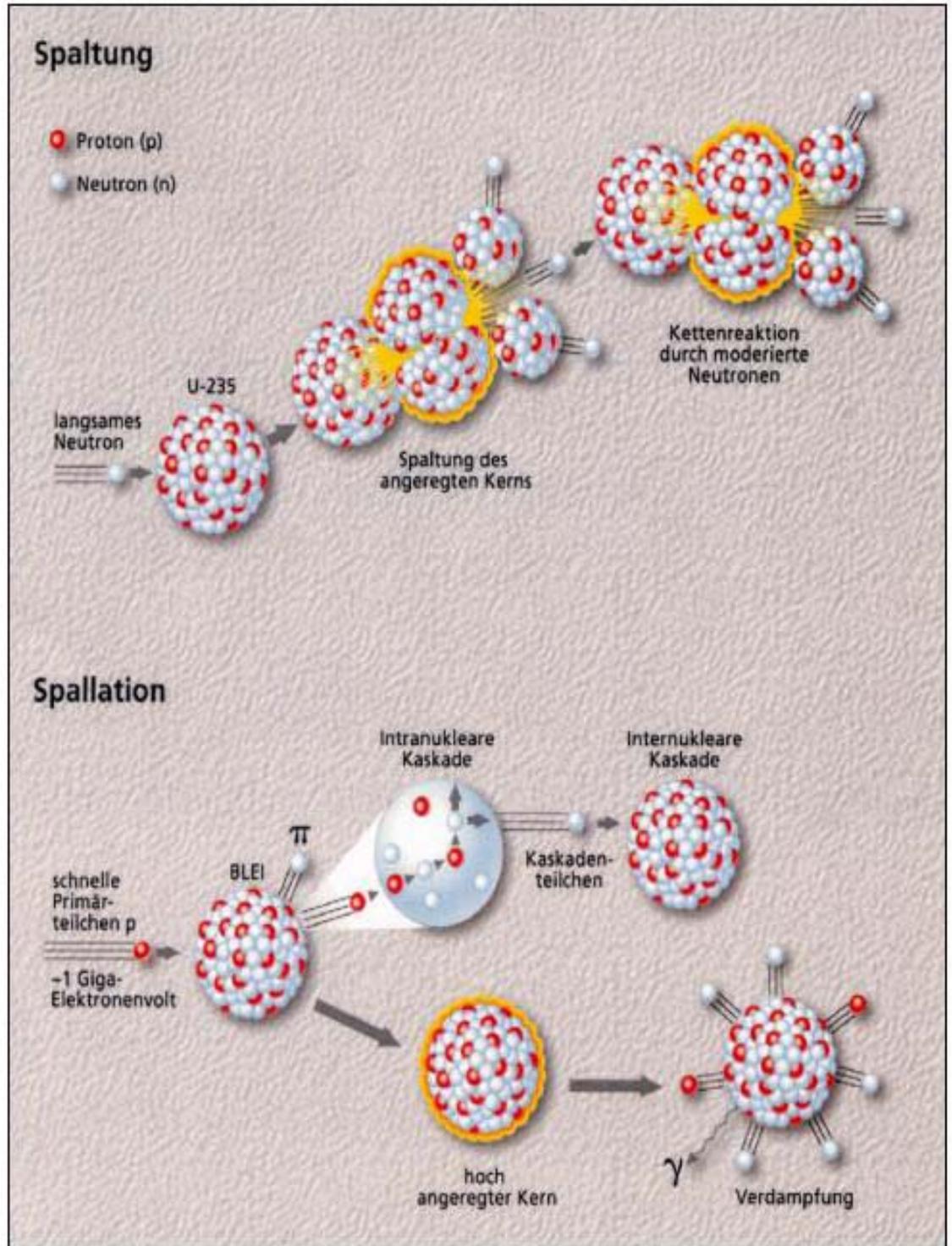


# Instrument



blur  
collimation ratio  $b = \frac{d}{L/D}$  typical: several 100

# Source



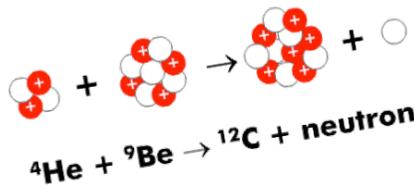
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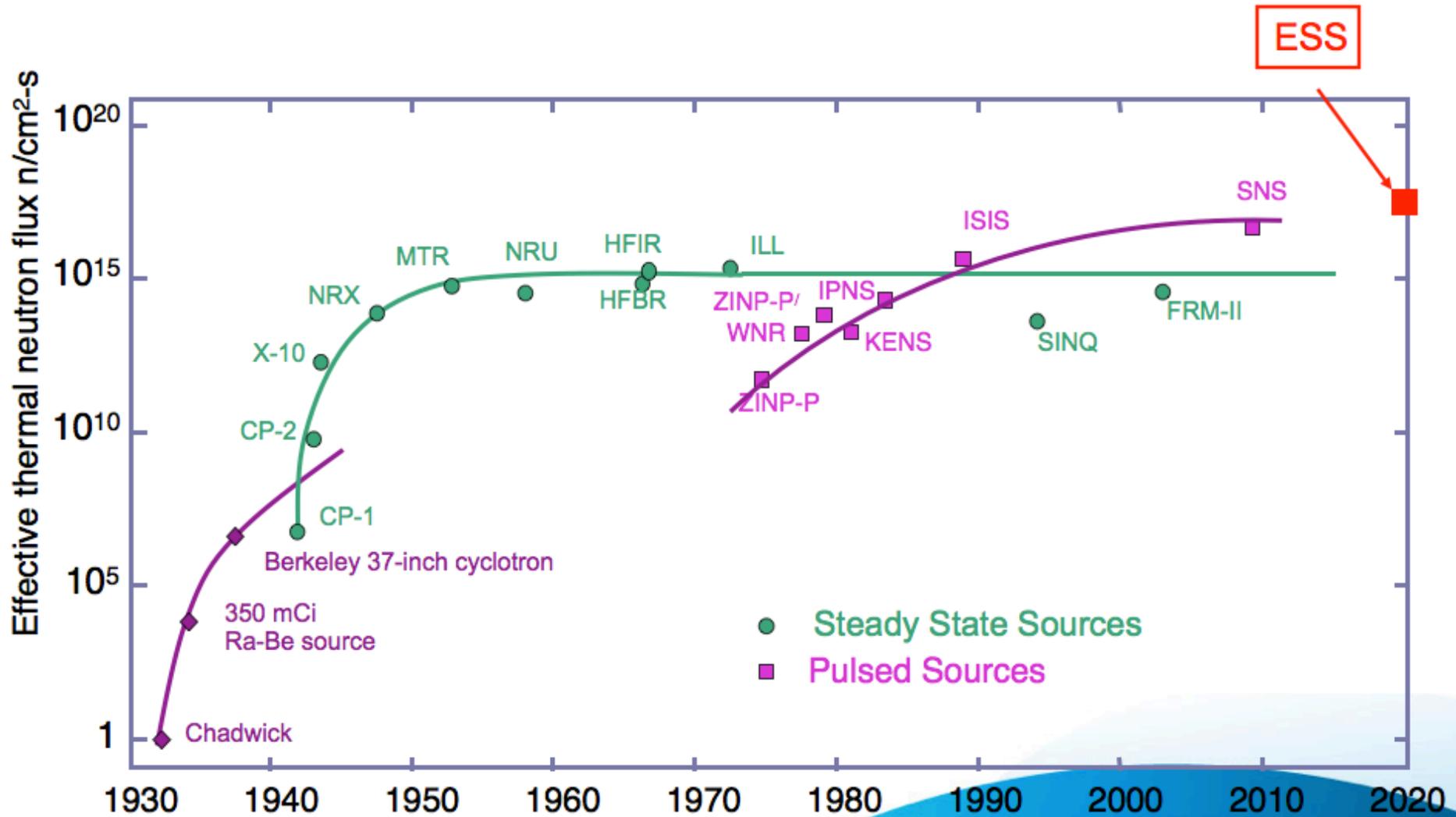
SNS Oakridge, TN

n

- Use Polonium as alpha emitter on Beryllium



# Source



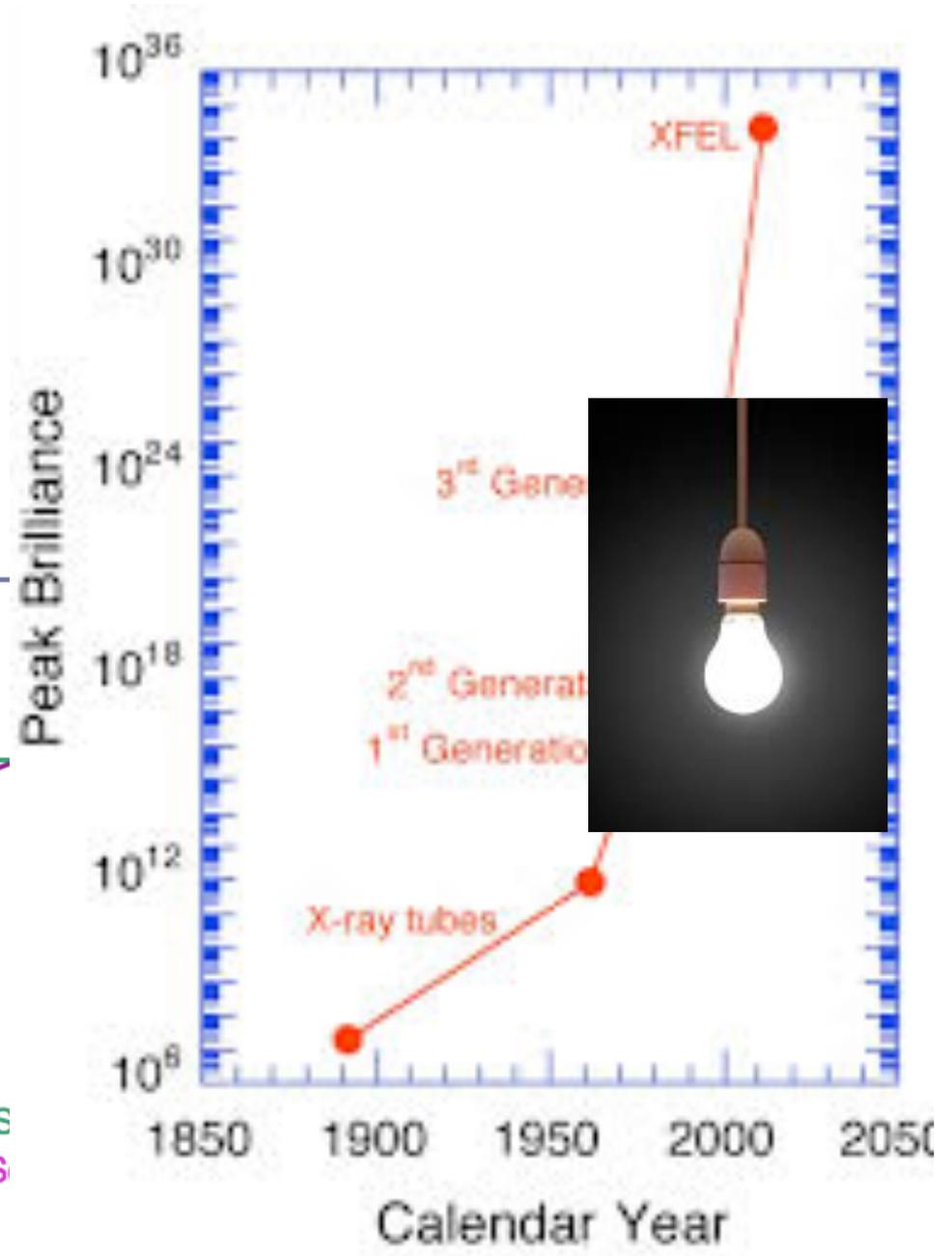
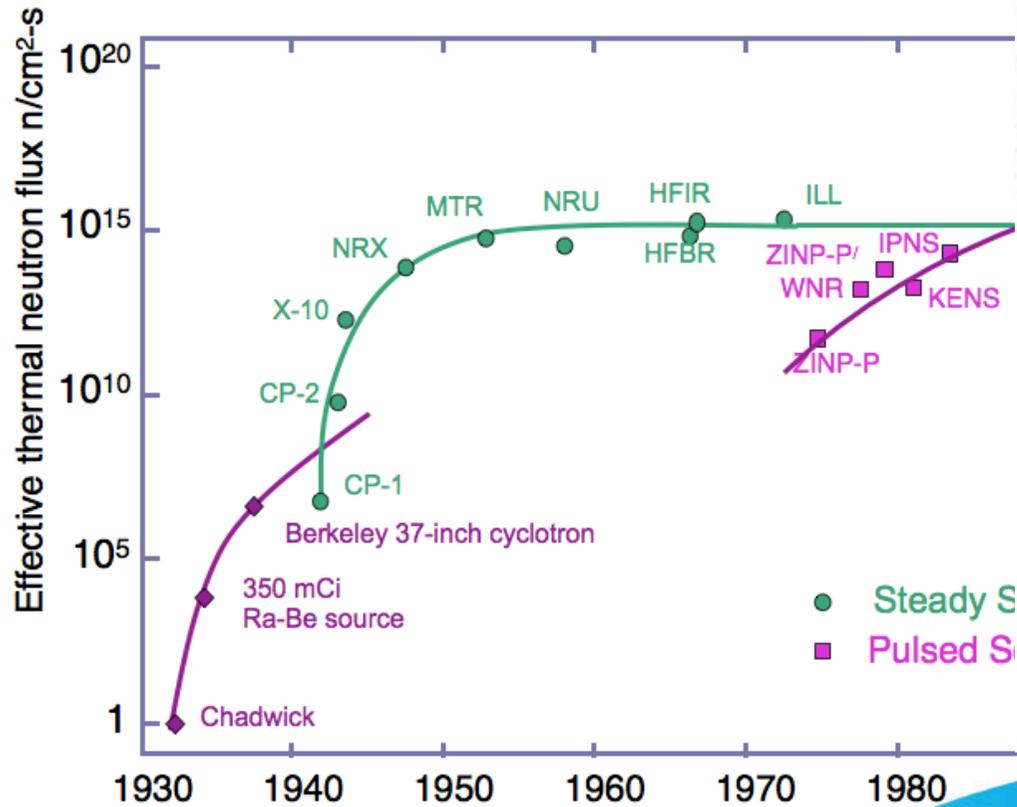
(Updated from *Neutron Scattering*, K. Skold and D. L. Price, eds., Academic Press, 1986)

# Source



EUROPEAN SPALLATION SOURCE

## Evolution of Neutron



# Source

## ESS

Baseline parameters:

14 Hz

2.86 ms

Time average flux of ILL

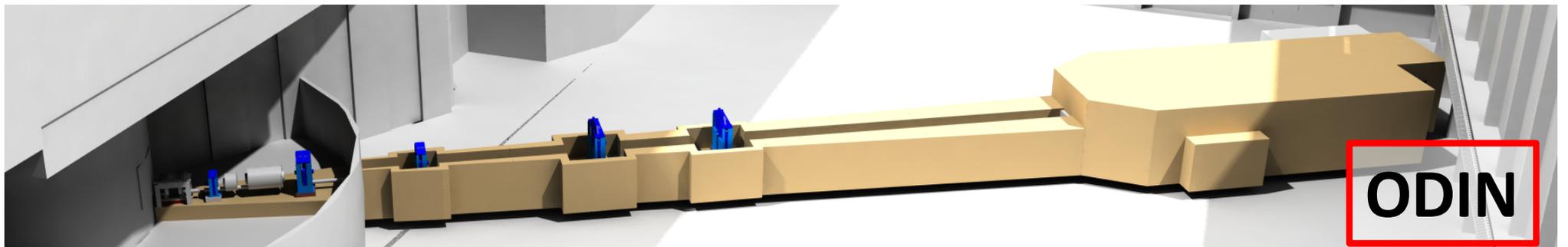
7 day one instruments

2019

22 instruments 2025

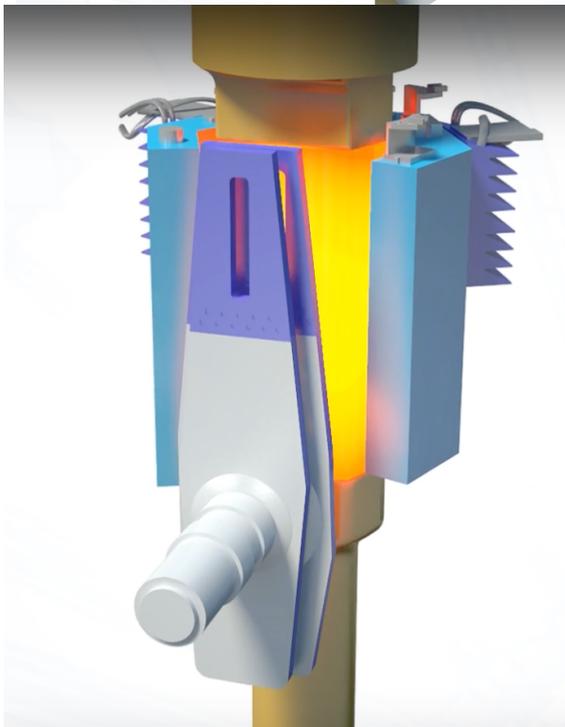
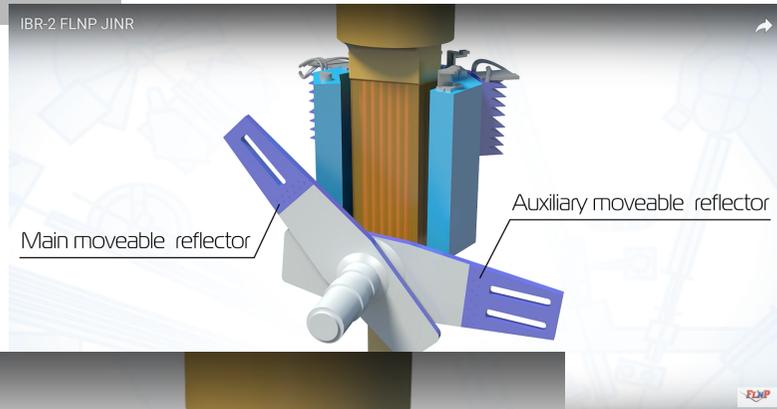


**Source(s)  
&  
Instrument(s)**



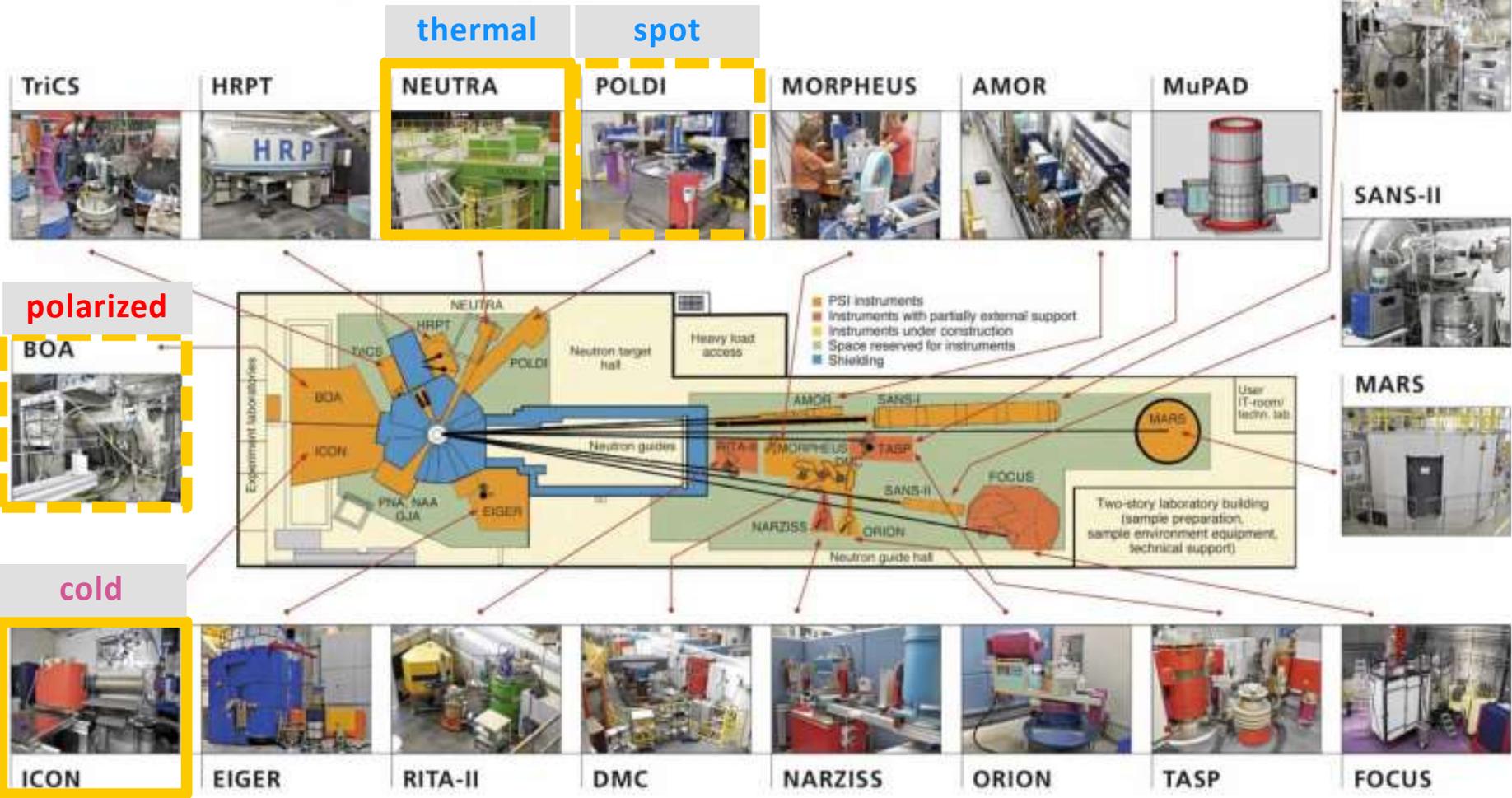
**ODIN**

## Reactor vs Spallation





## Neutron Scattering and Imaging Instruments at SINQ



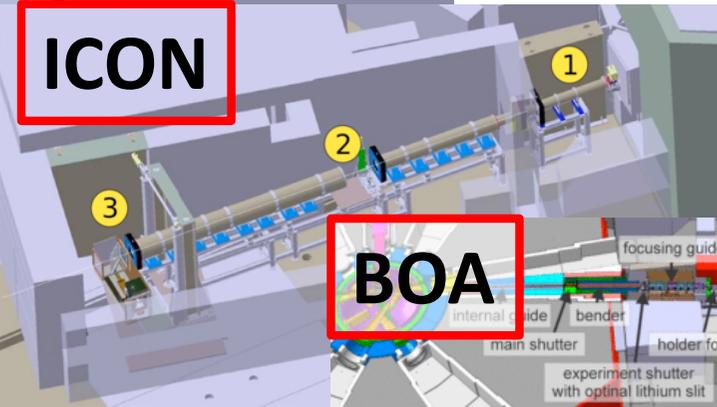
Further information: [www.psi.ch/sinq/instrumentation](http://www.psi.ch/sinq/instrumentation)

**19 Instruments: 12 User facilities (>2 Imaging beam lines) + Test facilities**



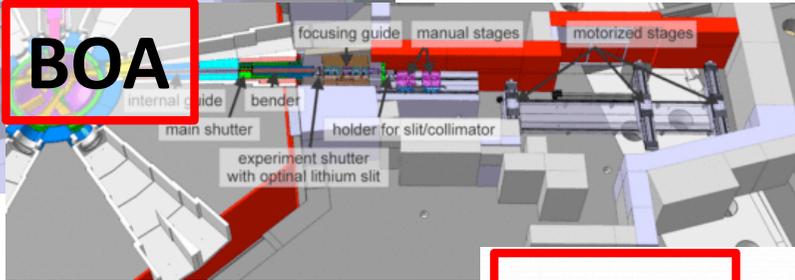
**NEUTRA**

**Thermal Neutron Imaging  
Conventional Applications  
Workhorse**



**ICON**

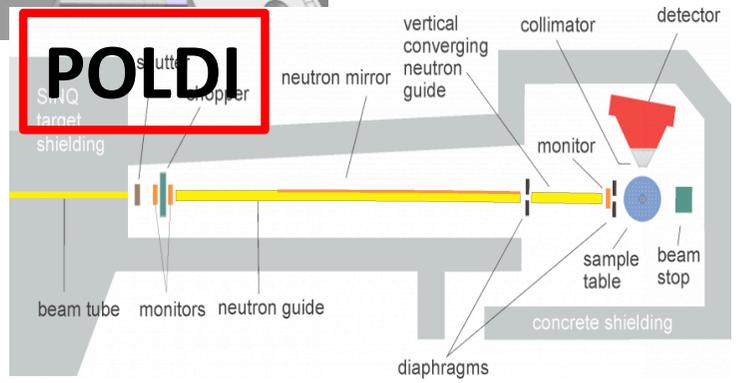
**Cold Neutron Imaging  
Conventional & Advanced  
Applications Workhorse**



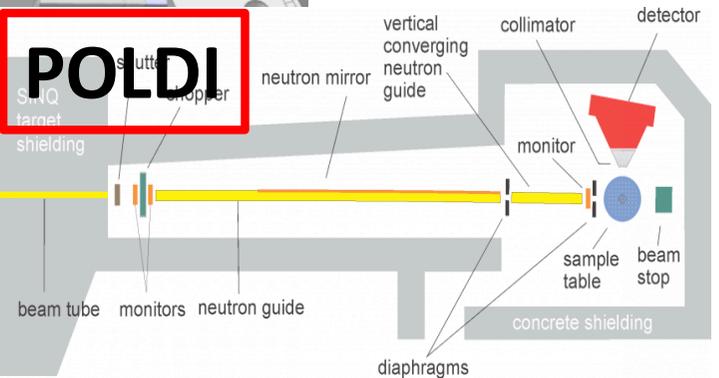
**BOA**

**Polarized Neutron  
Testbench  
Microscope**

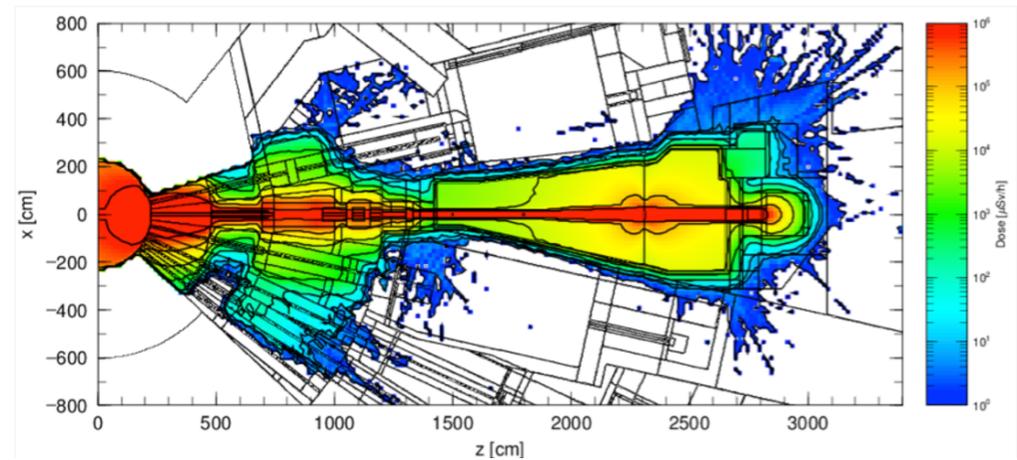
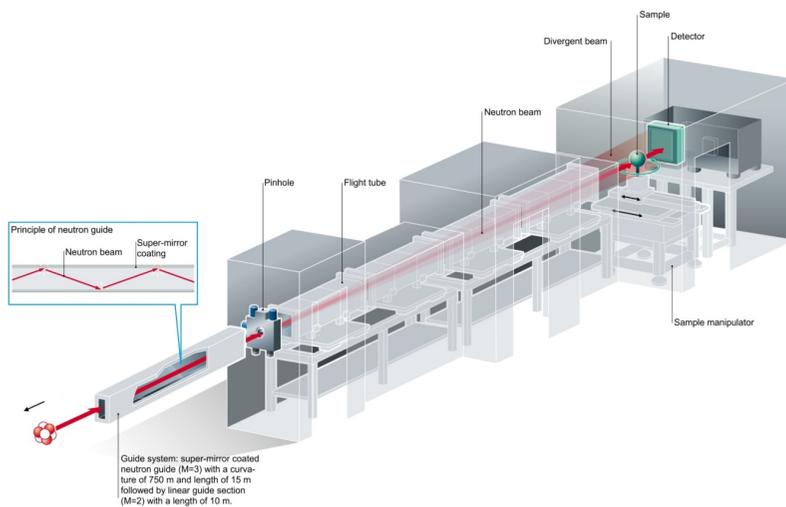
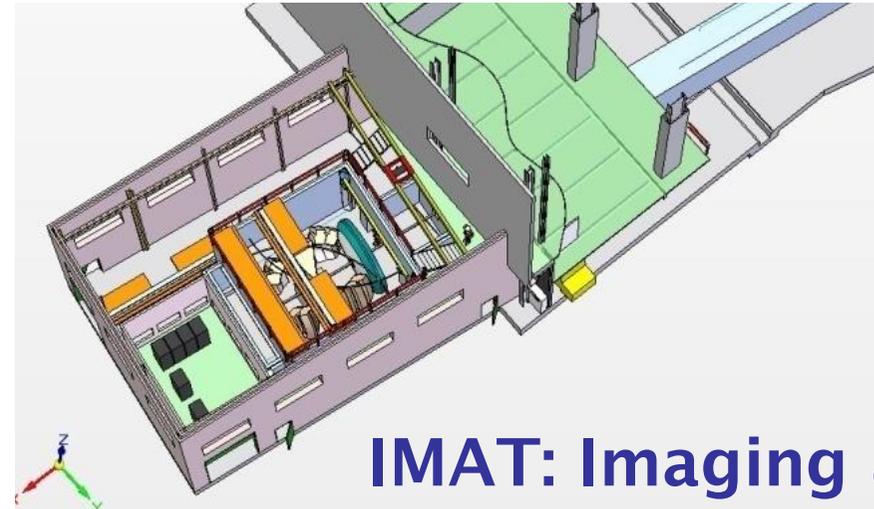
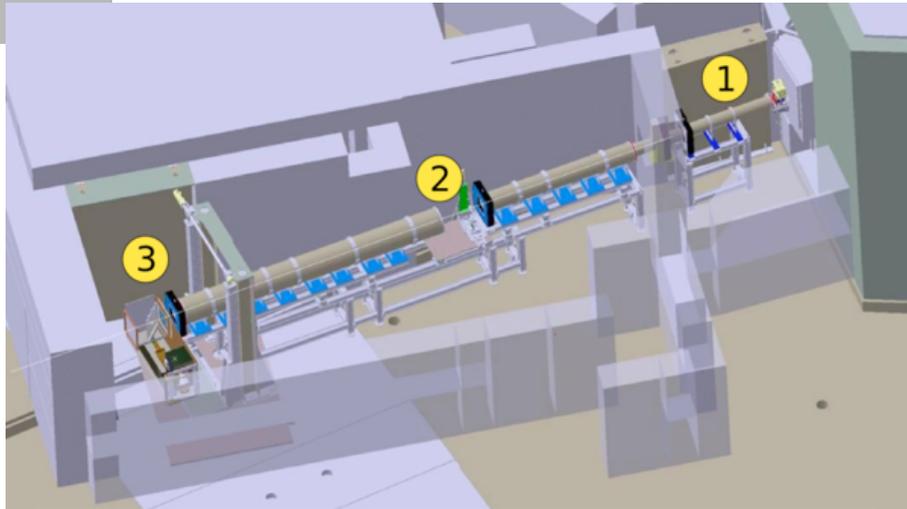
**Engineering Diffraction and microscope**



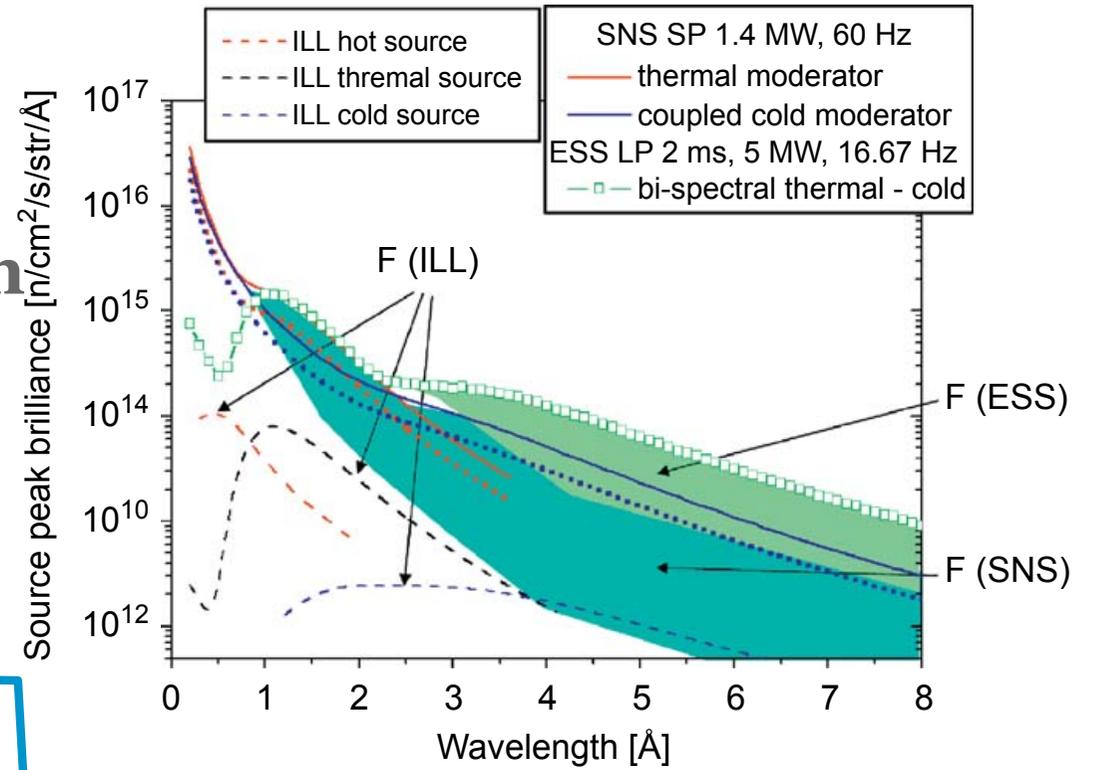
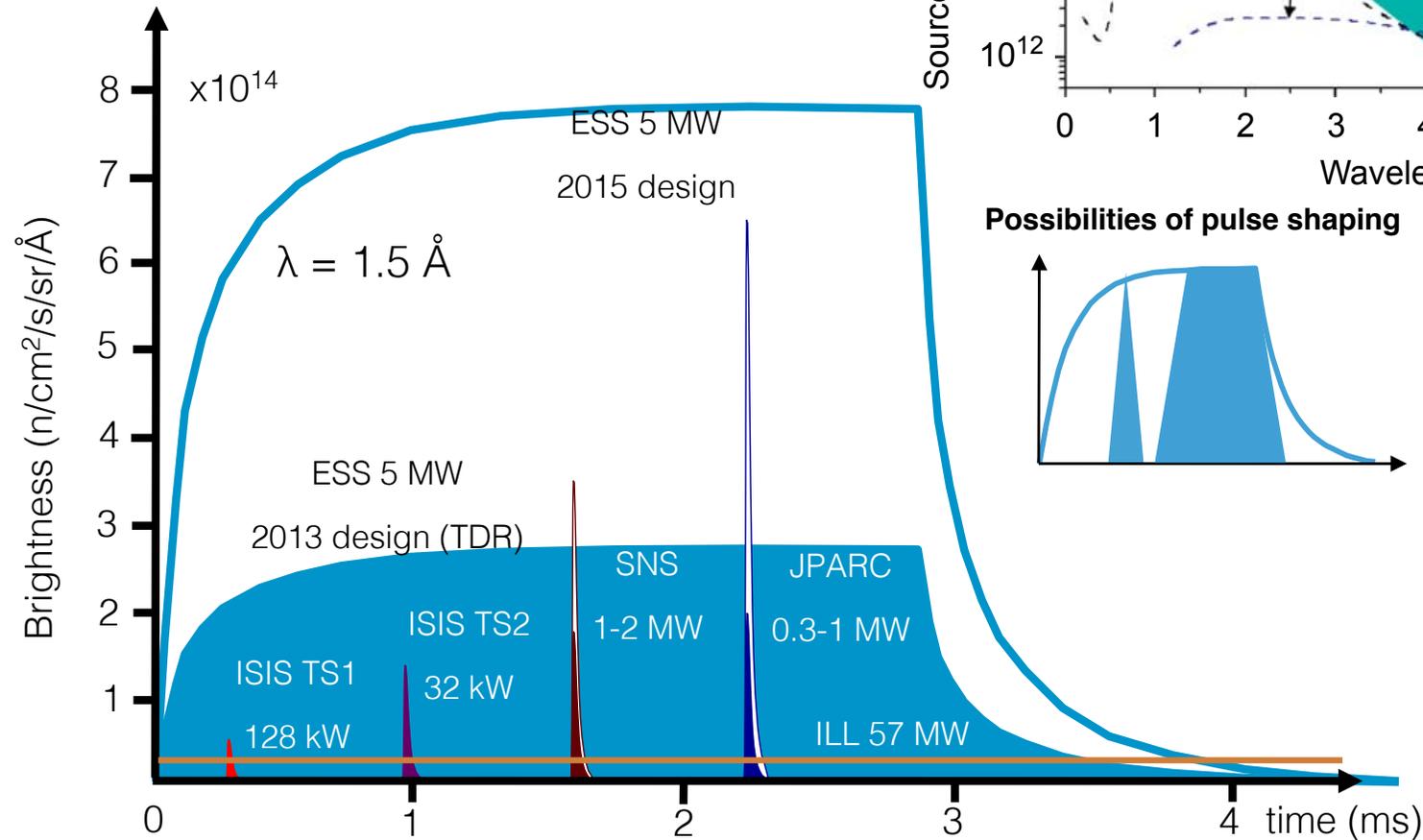
**POLDI**



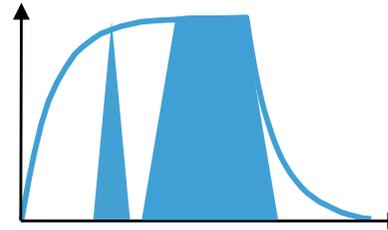
## Continuous vs Pulsed



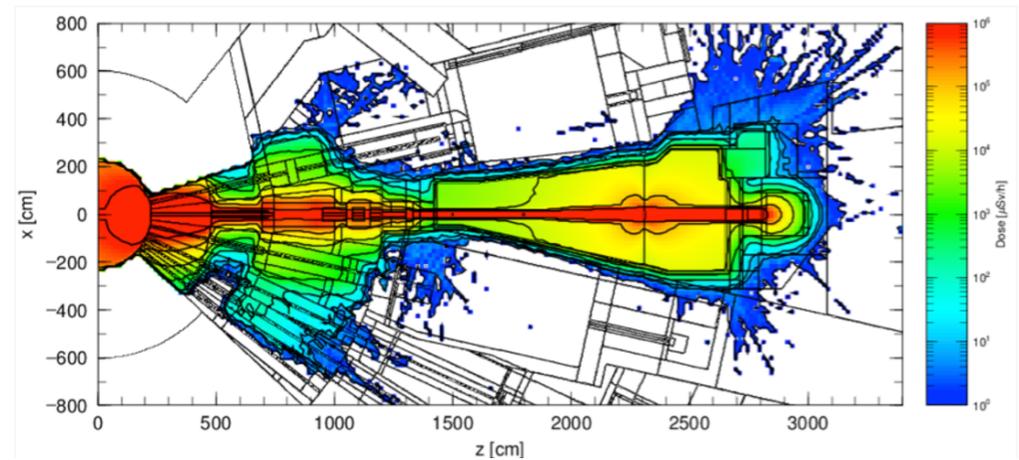
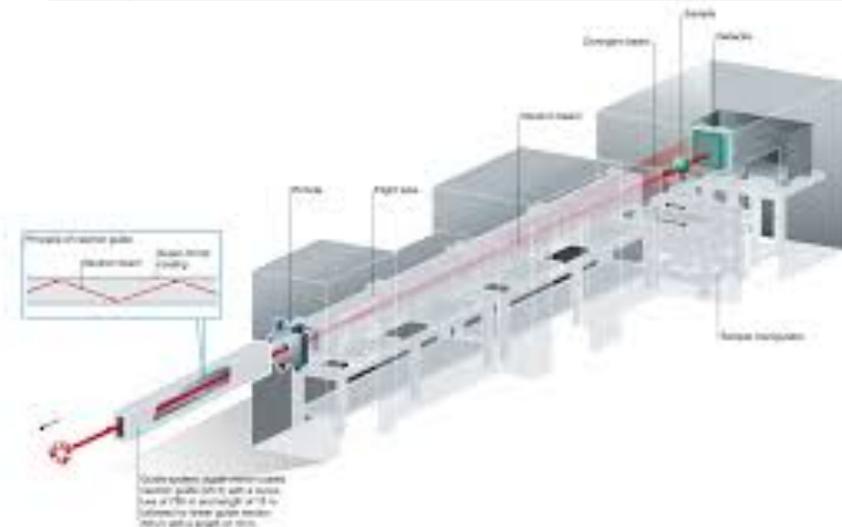
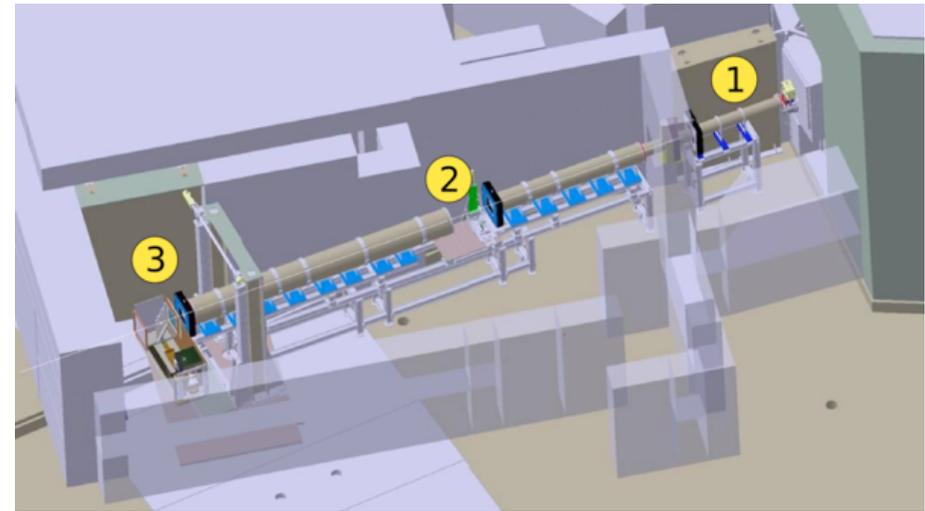
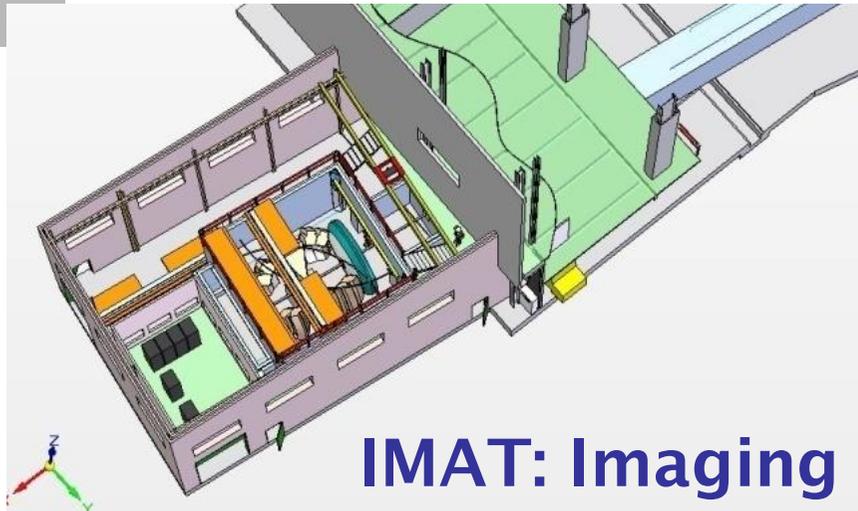
## Reactor vs Spallation



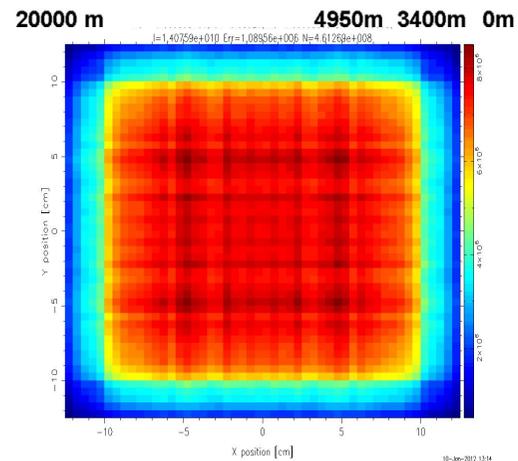
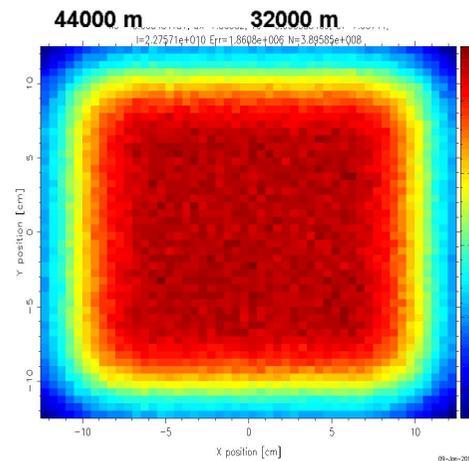
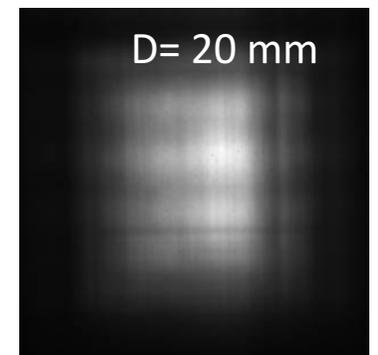
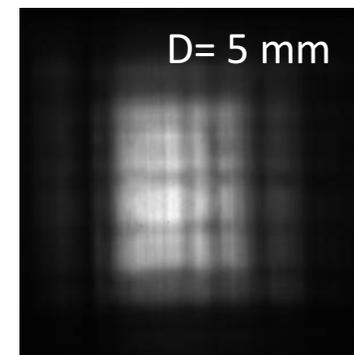
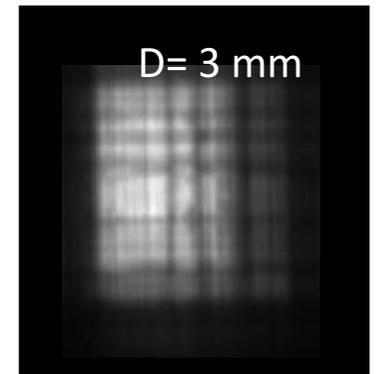
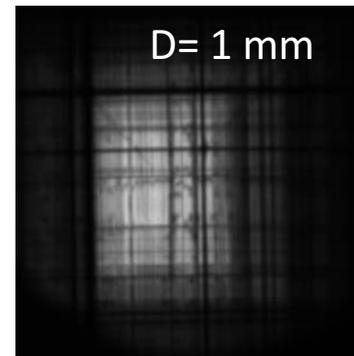
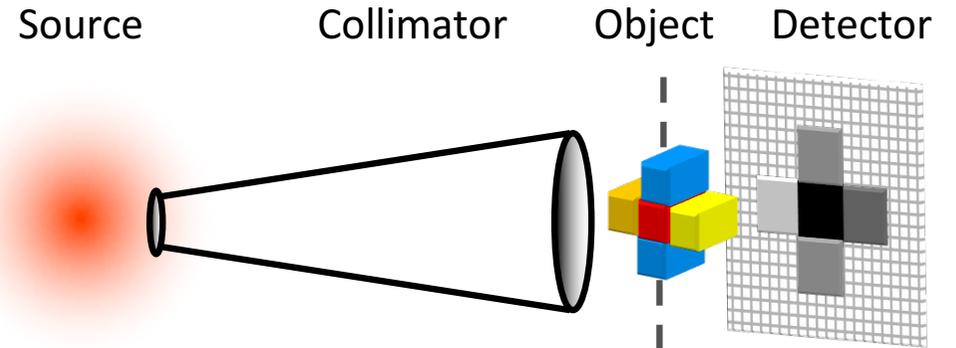
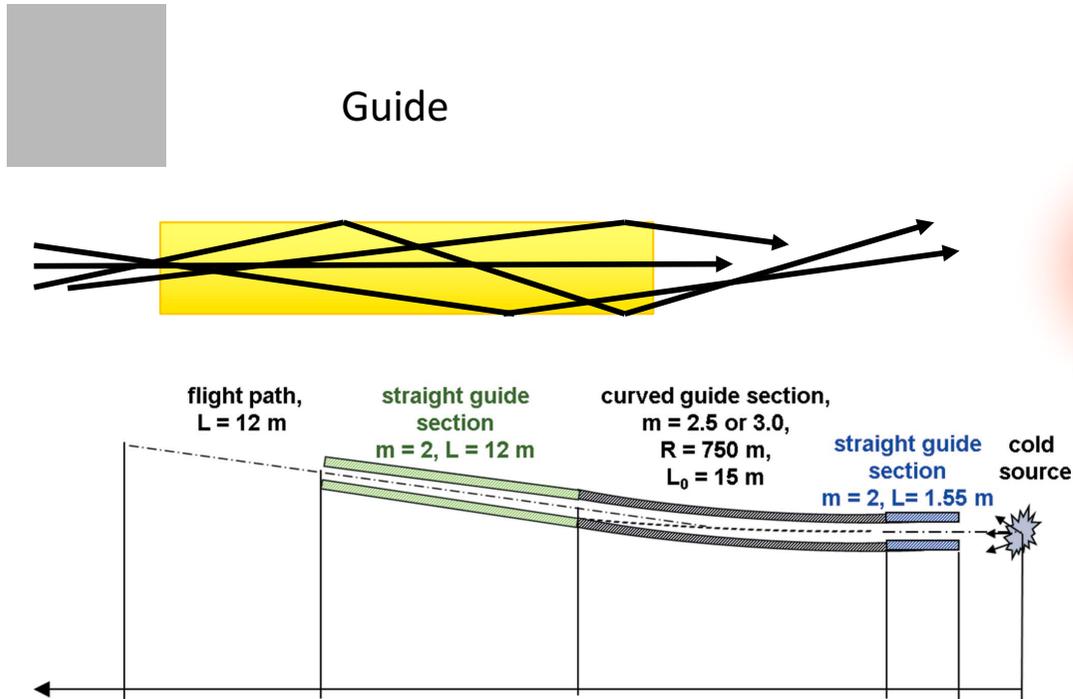
Possibilities of pulse shaping



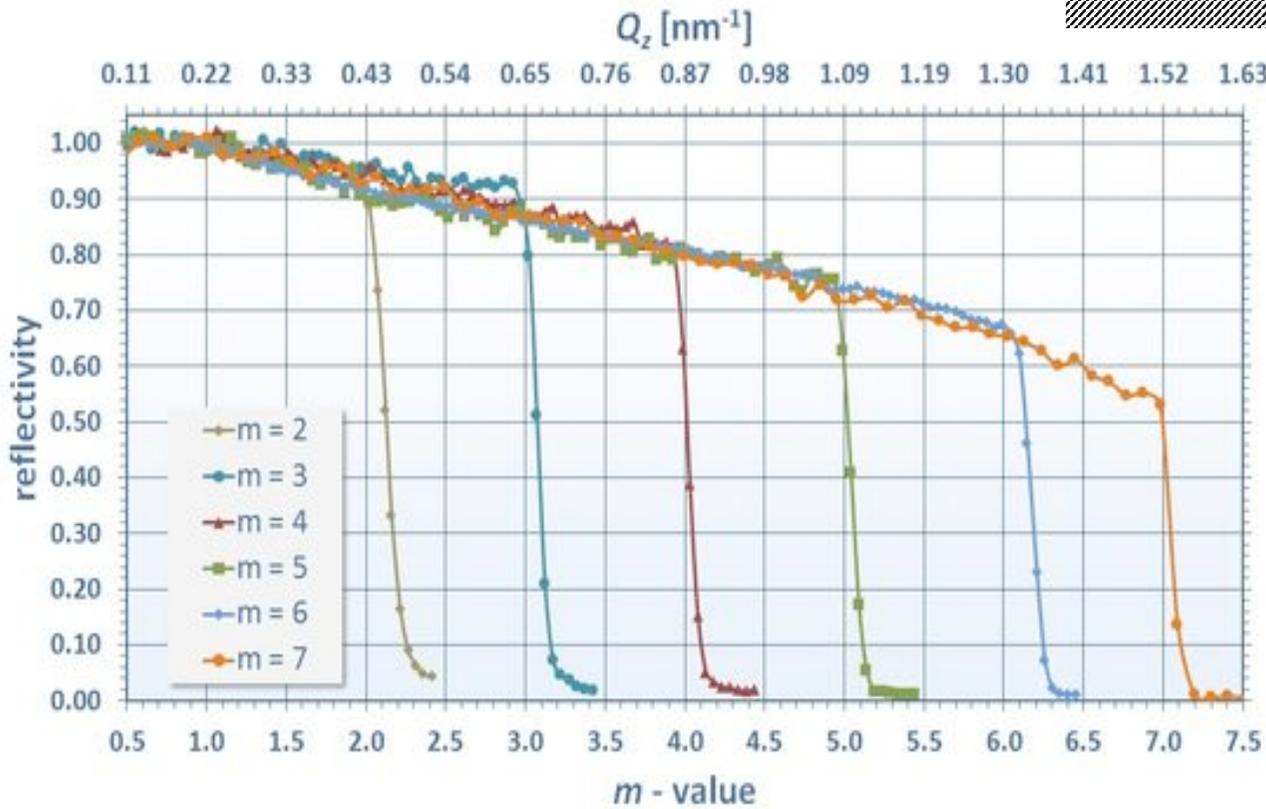
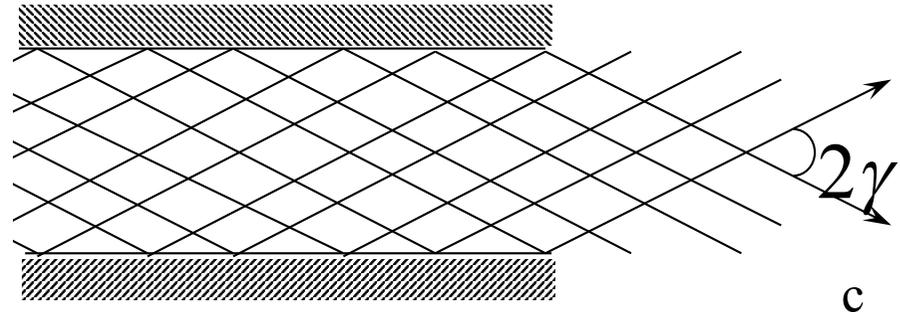
## Guide vs Direct view



## Guide vs Direct view



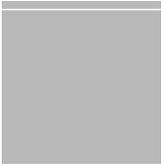
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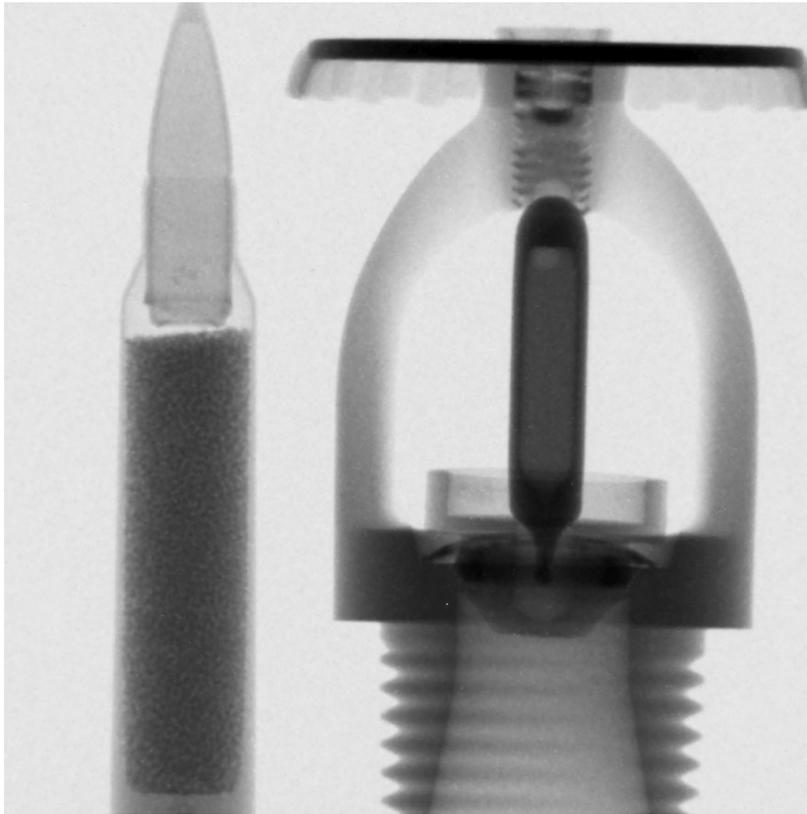
$$L/D = 1/\tan(2\gamma_c(\lambda)).$$

# Source

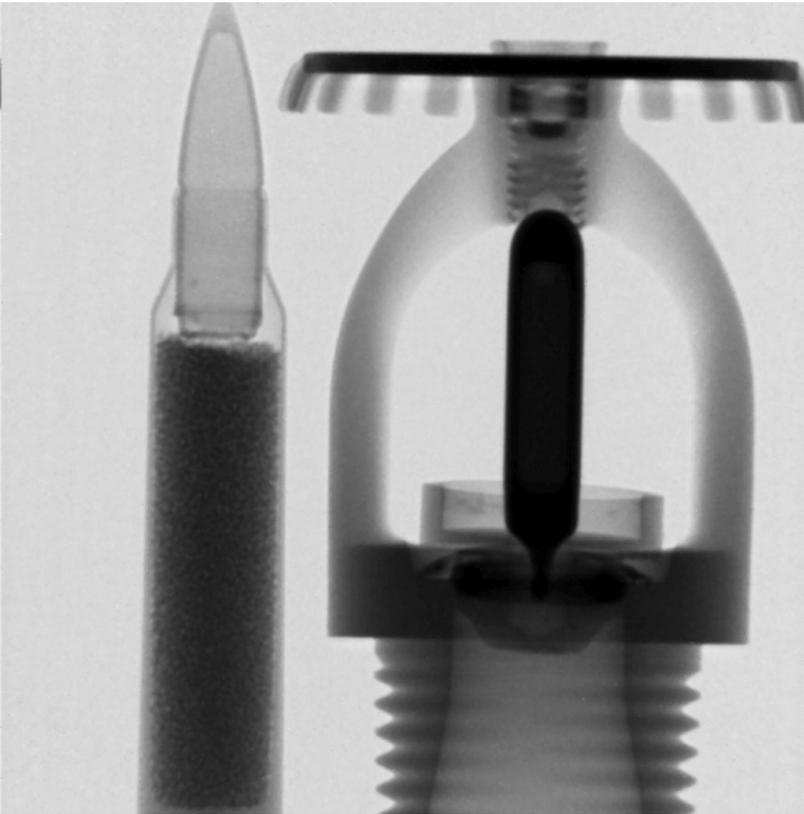
## Cold vs Thermal



Thermal neutrons

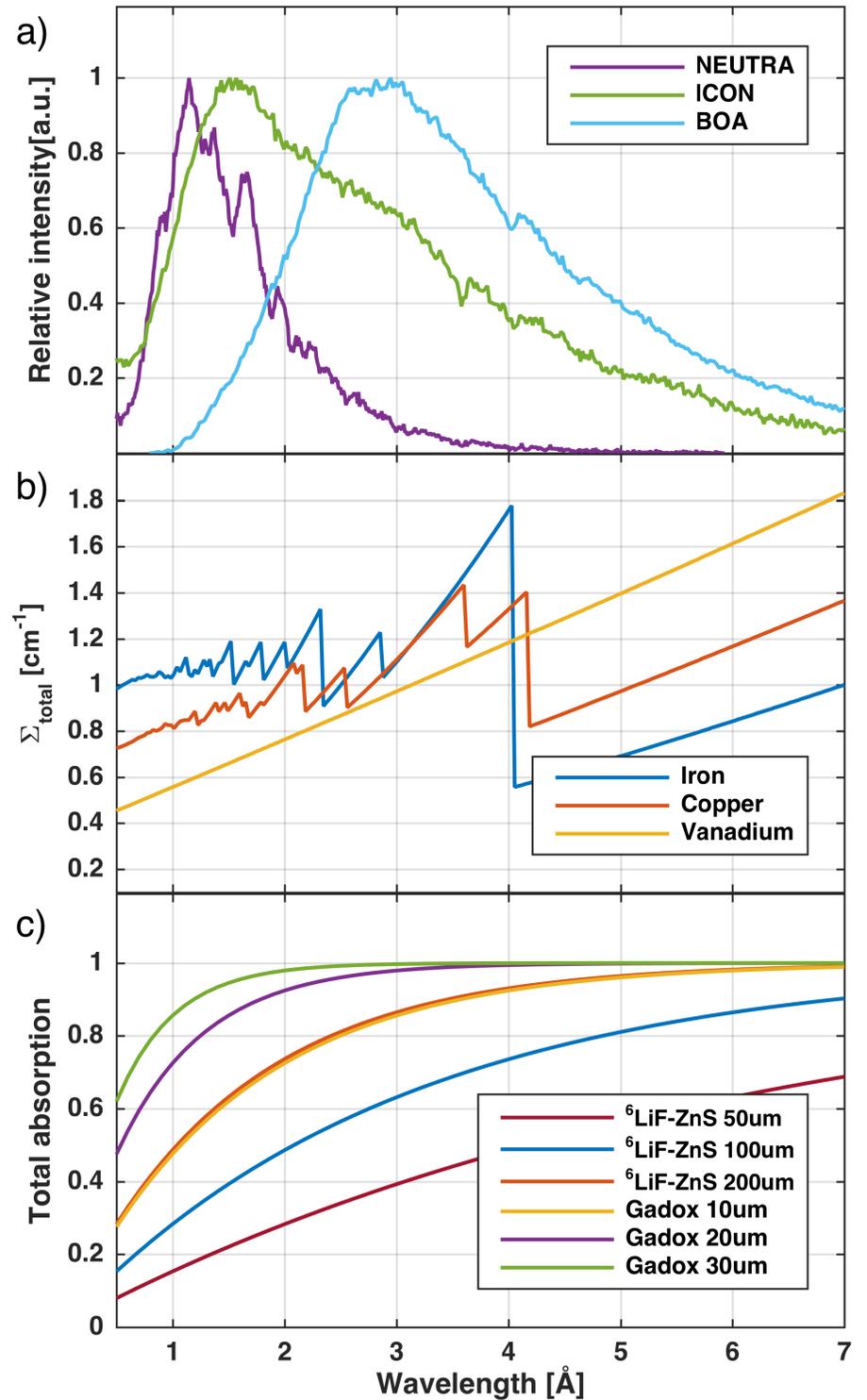


Cold neutrons

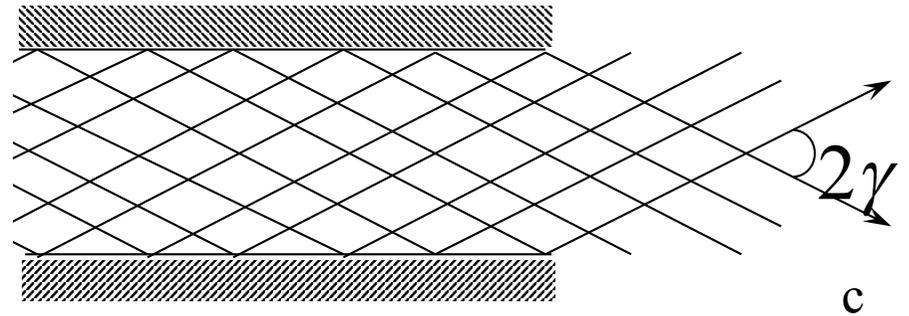


# Source

## Cold vs Thermal



# Collimation – beam preparation

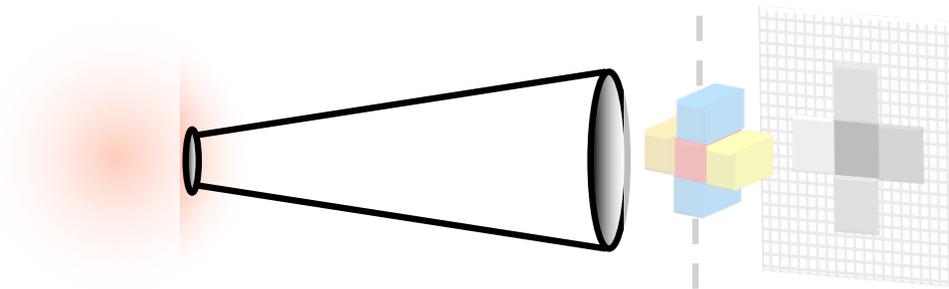


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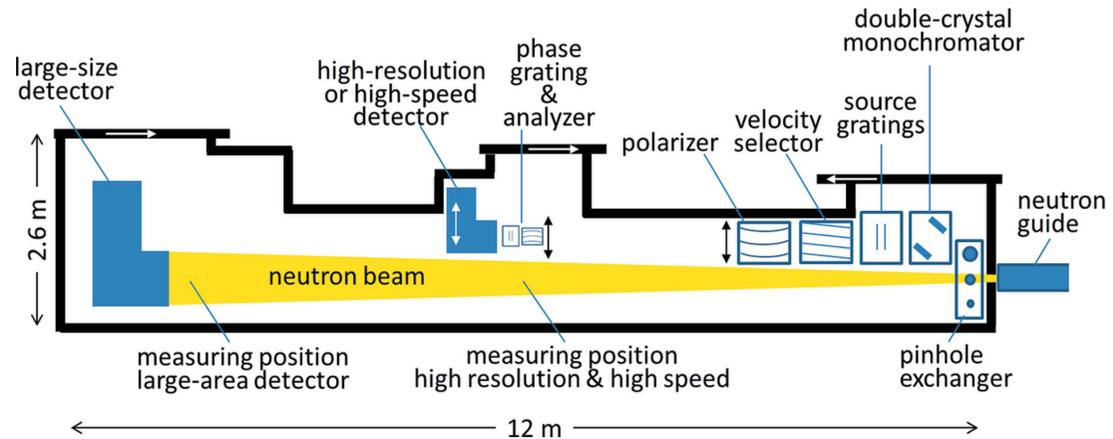
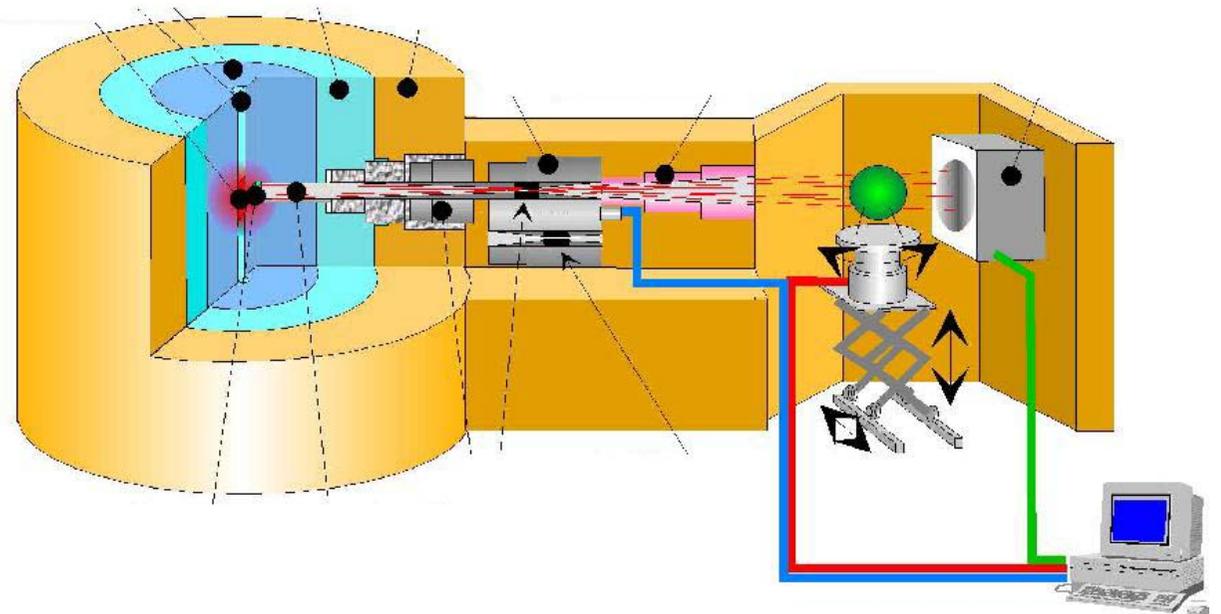
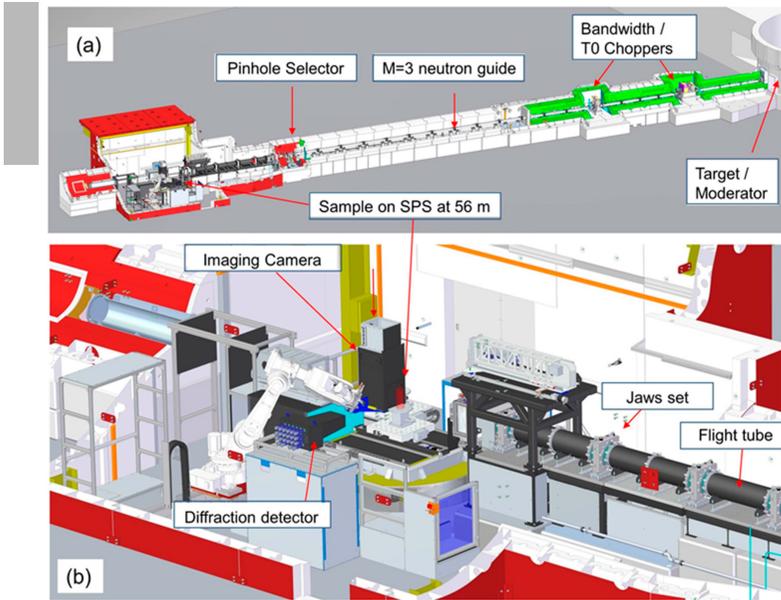
Collimator

Object

Detector

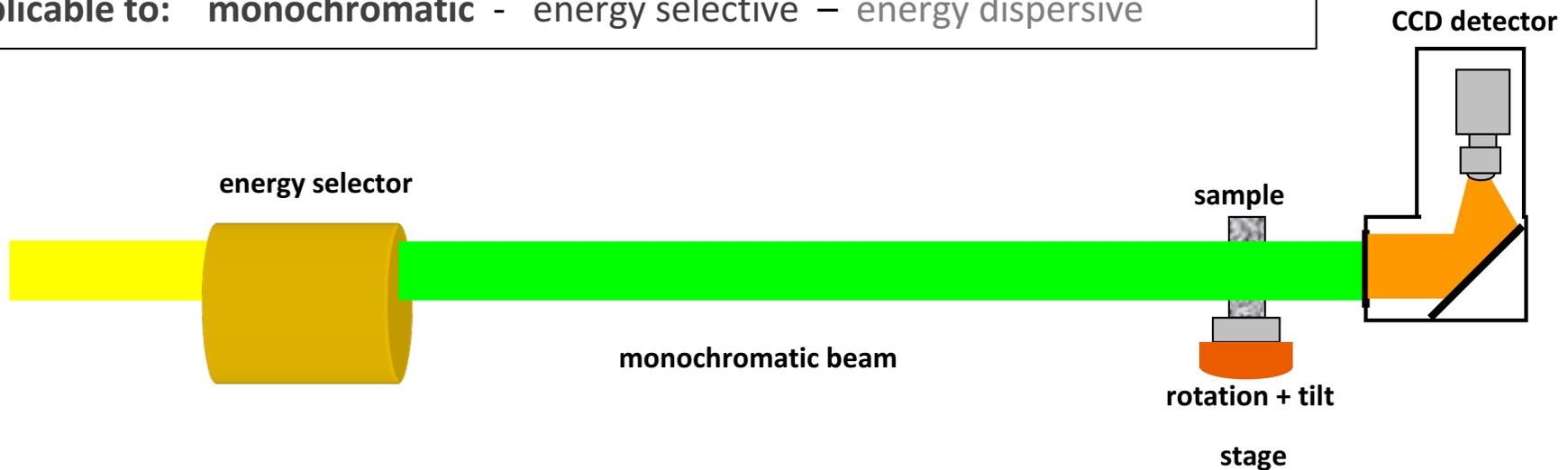


# Collimation – pinhole



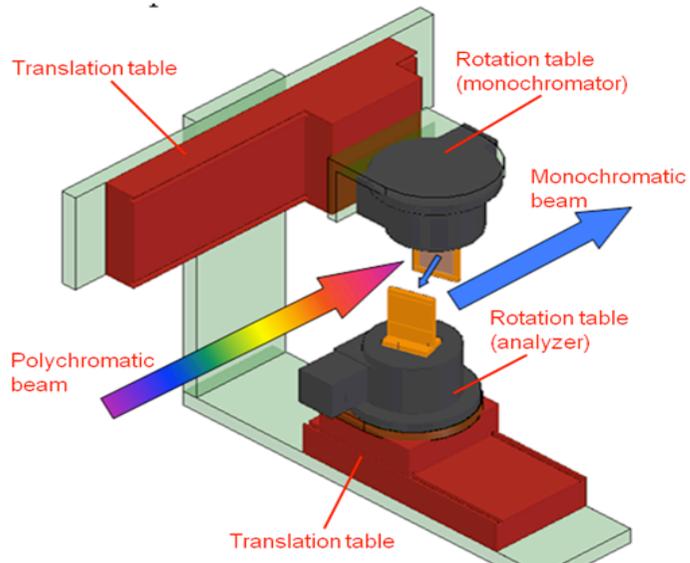
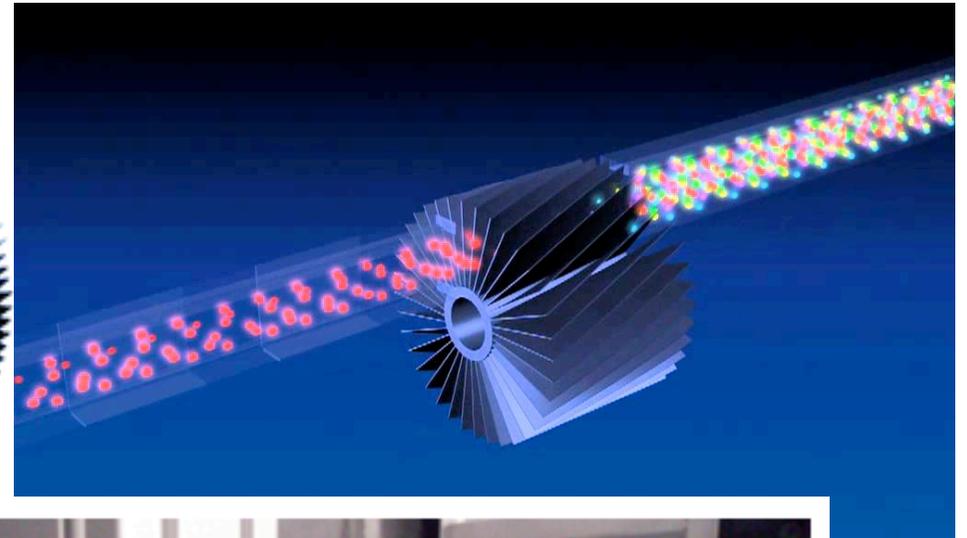
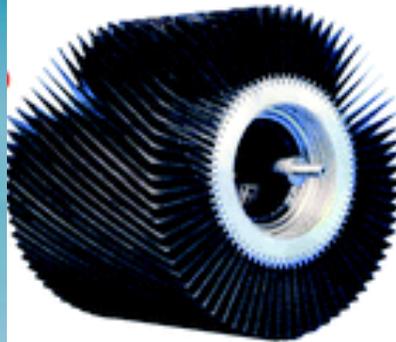
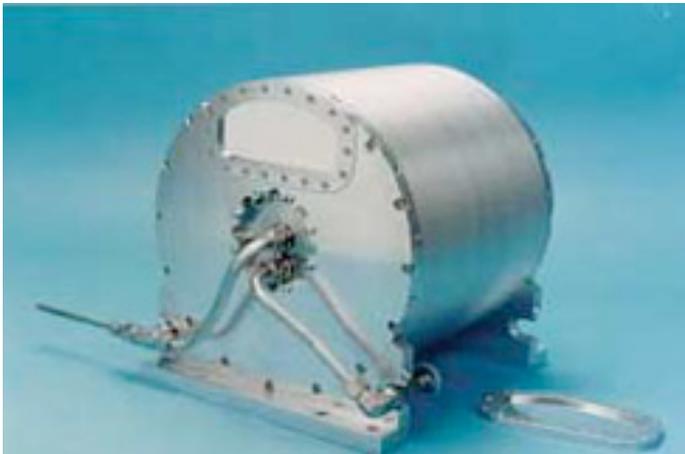
- Wavelength resolved imaging → INSTRUMENTATION (cont.)

Applicable to: monochromatic - energy selective – energy dispersive

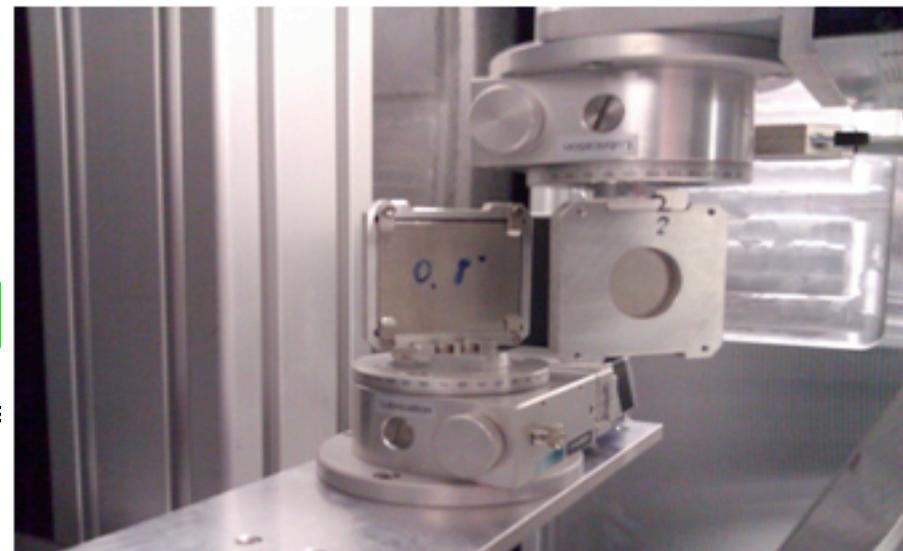


# Advanced Imaging – beam preparation

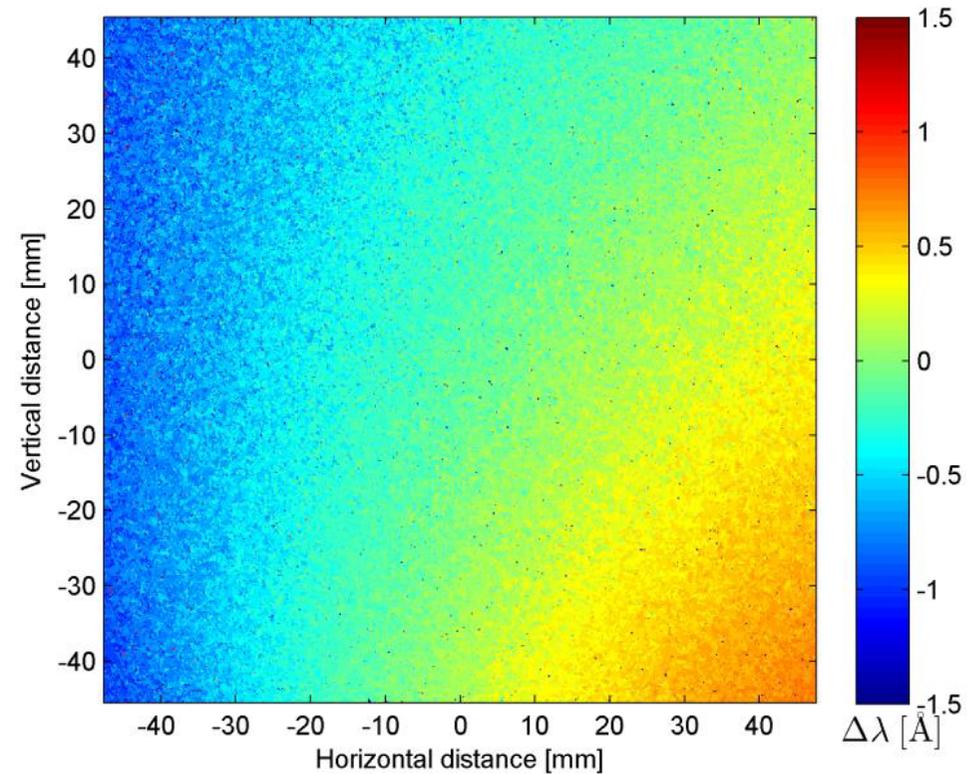
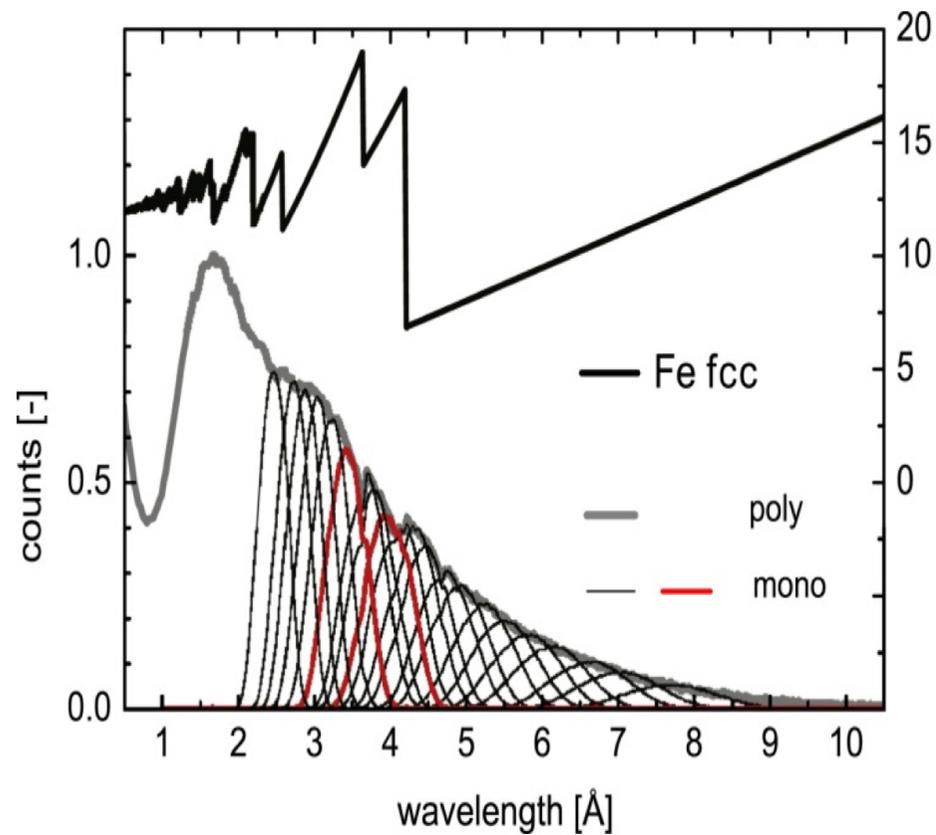
- Wavelength resolved imaging → INSTRUMENTATION



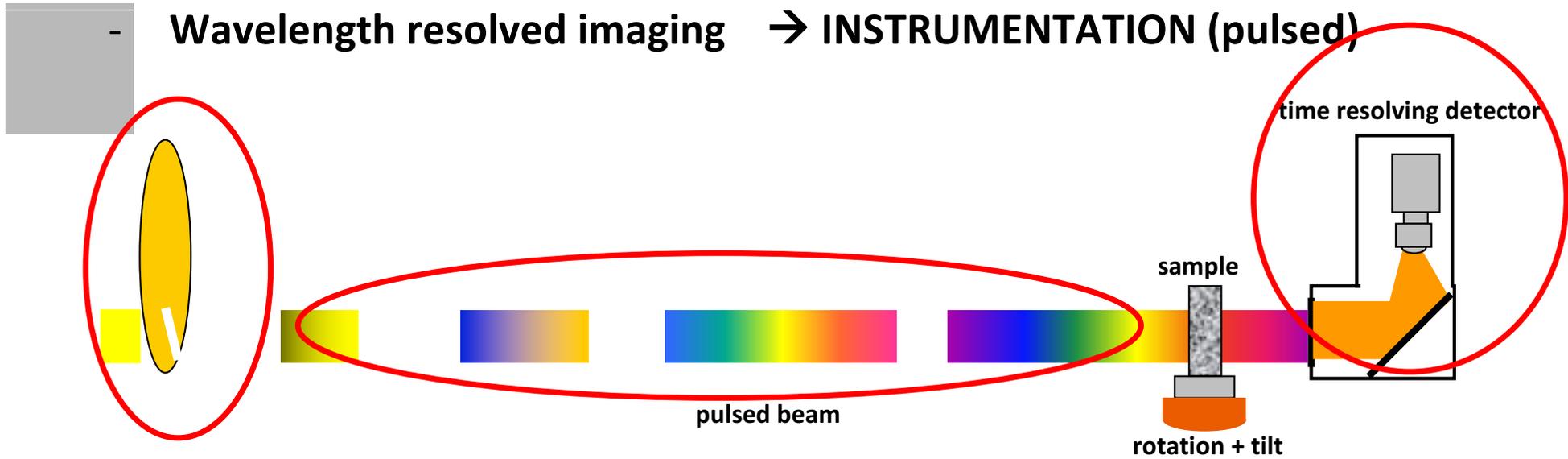
monochromator



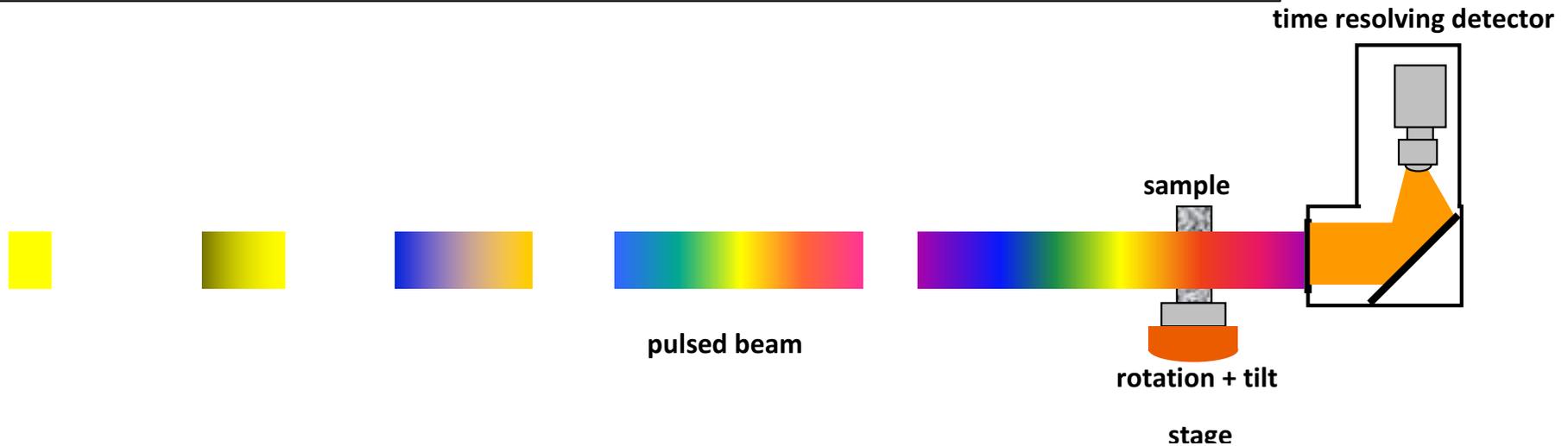
- Wavelength resolved imaging → INSTRUMENTATION



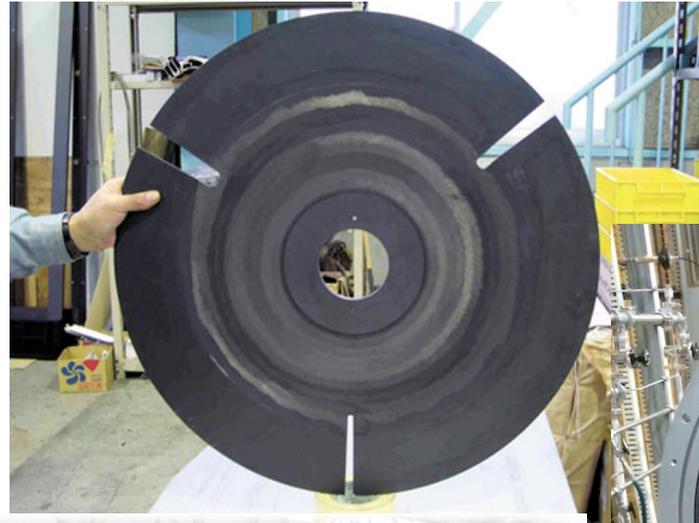
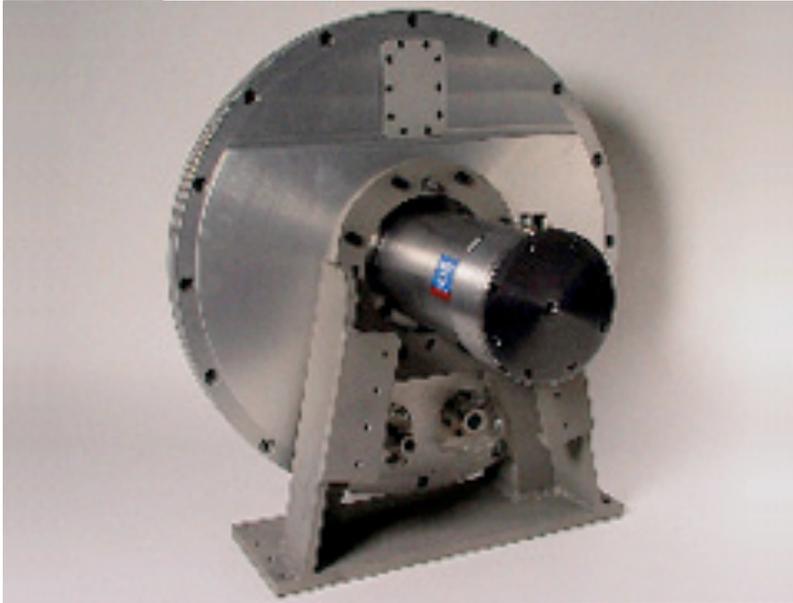
**Wavelength resolved imaging → INSTRUMENTATION (pulsed)**



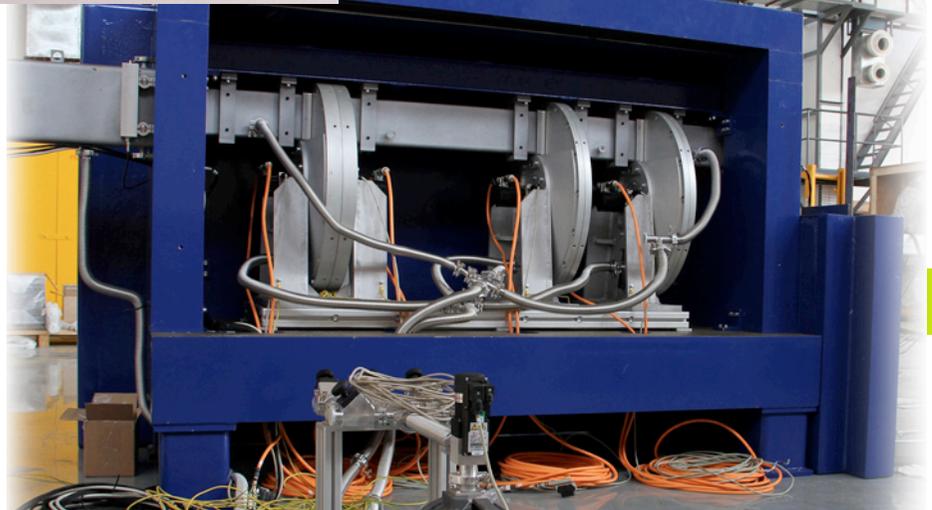
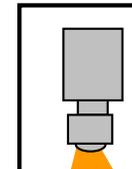
**Applicable to:** monochromatic - energy selective – energy dispersive



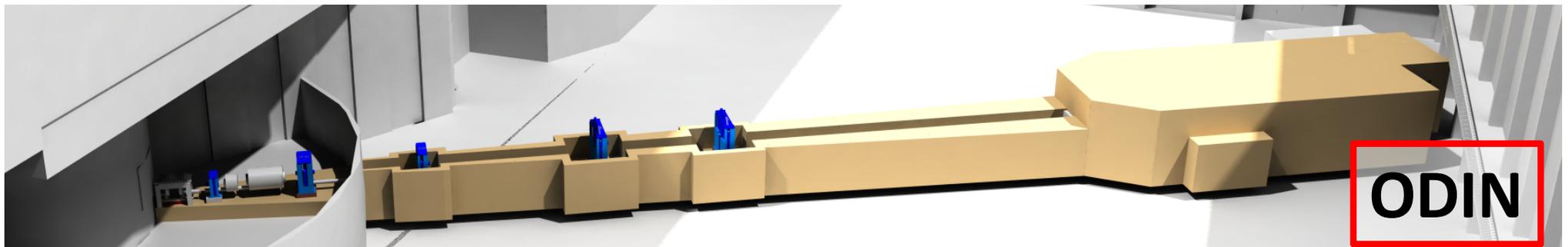
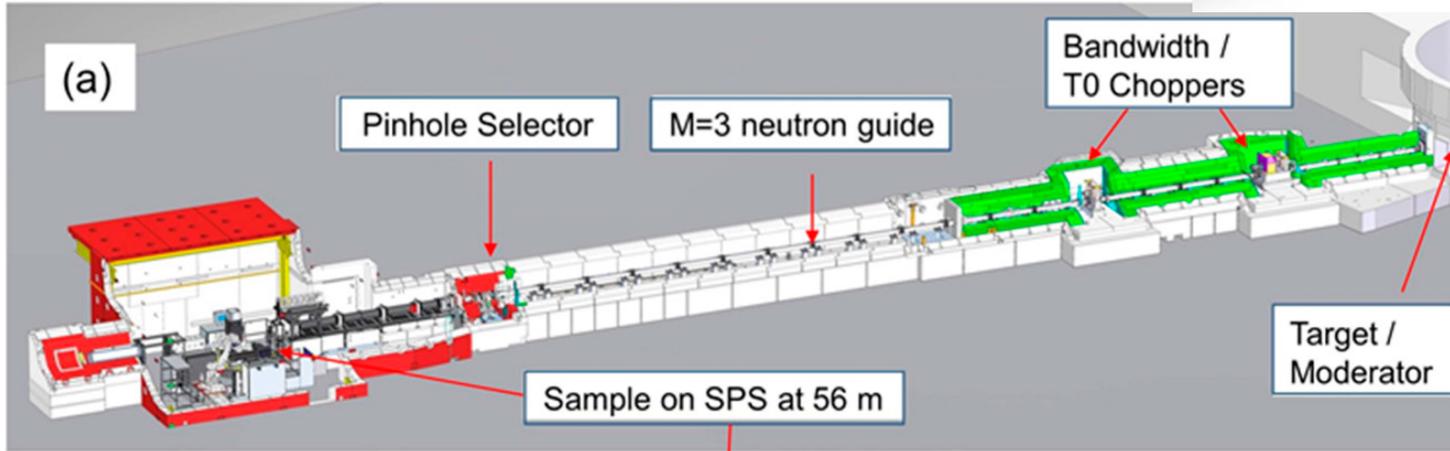
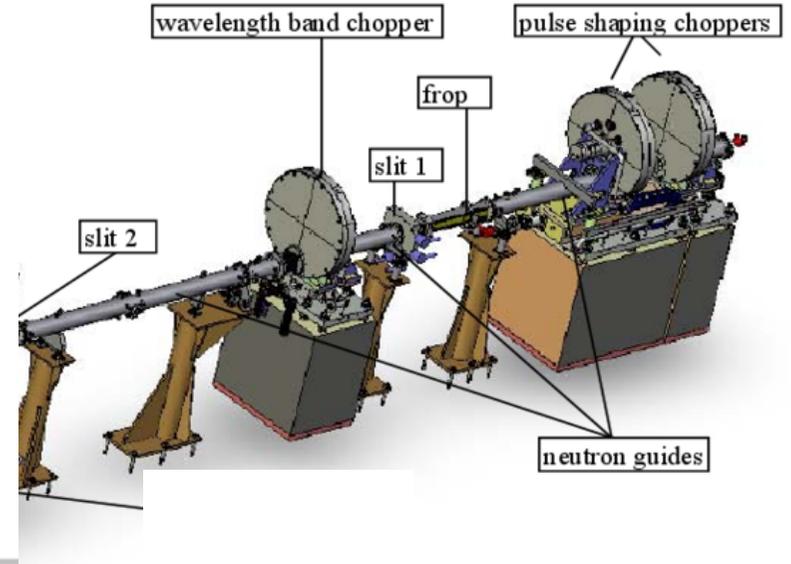
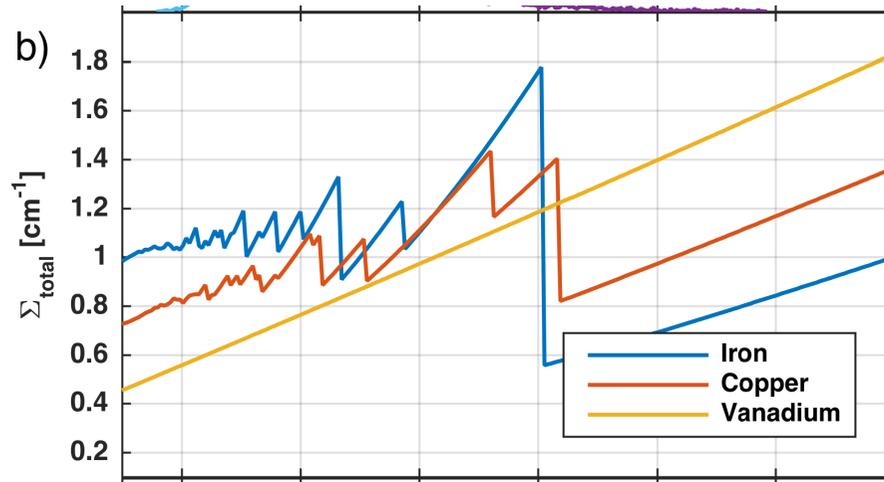
- **Wavelength resolved imaging → INSTRUMENTATION**



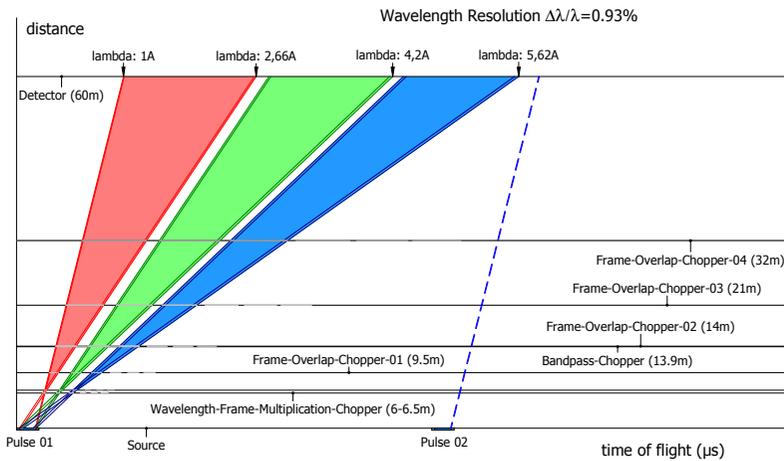
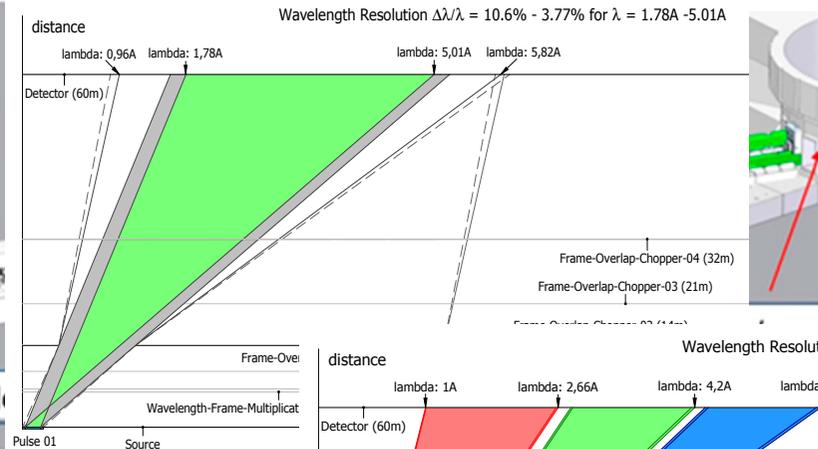
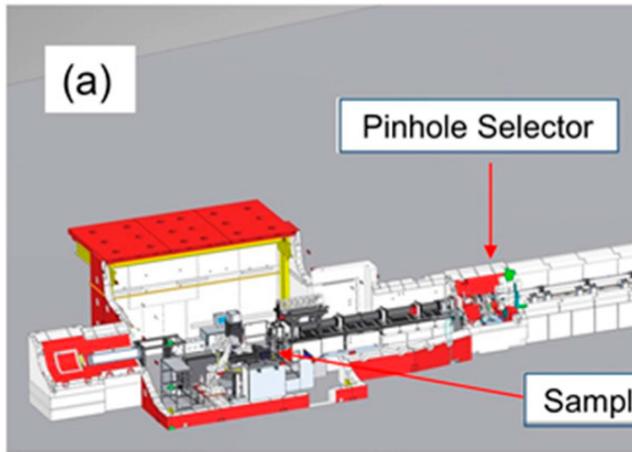
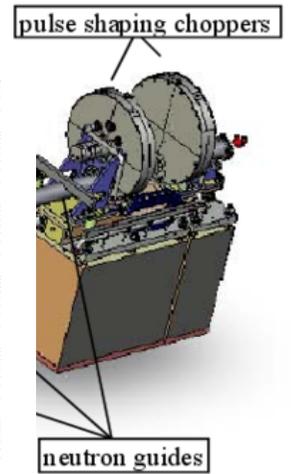
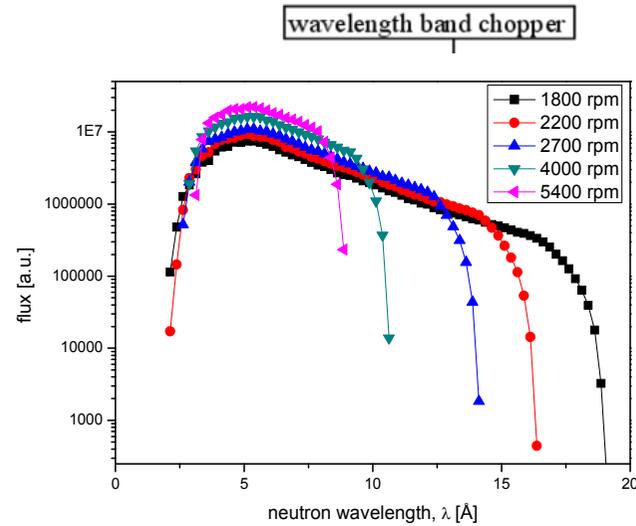
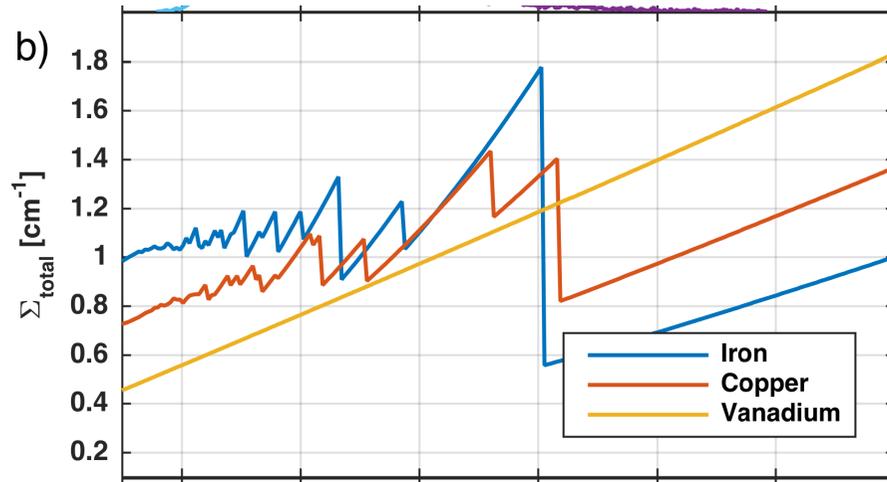
time resolving detector



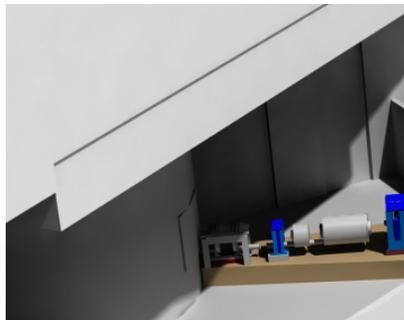
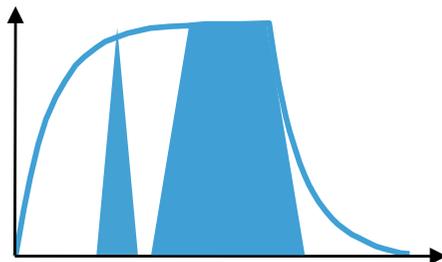
# Advanced Imaging – beam preparation



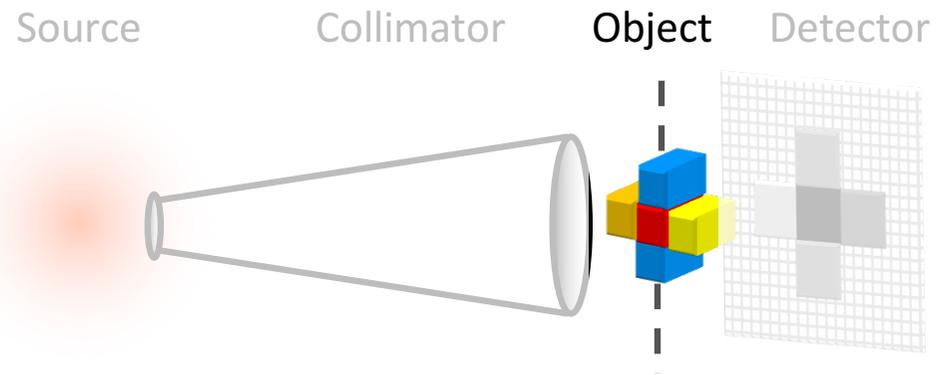
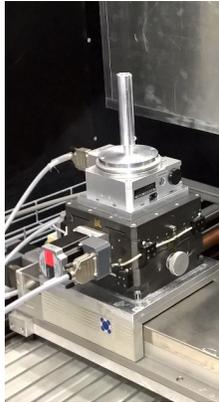
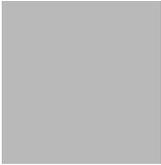
# Advanced Imaging – beam preparation



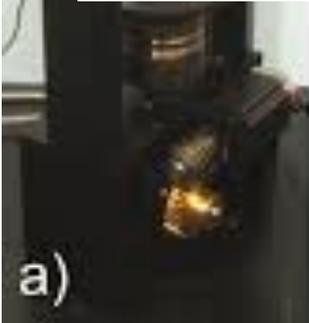
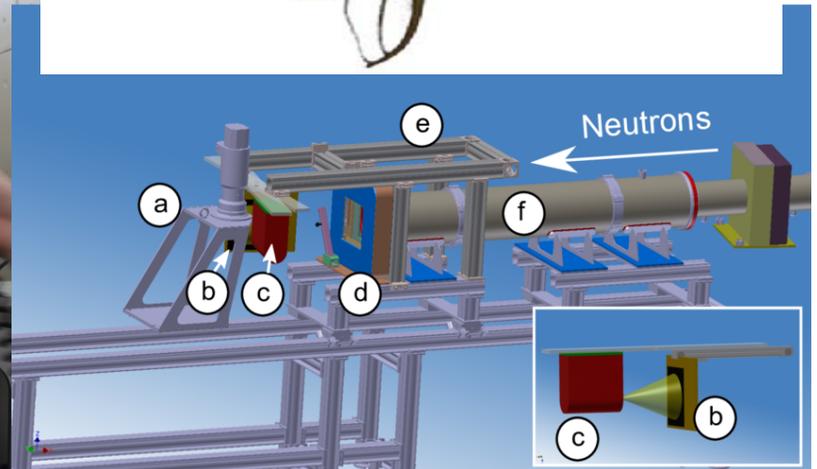
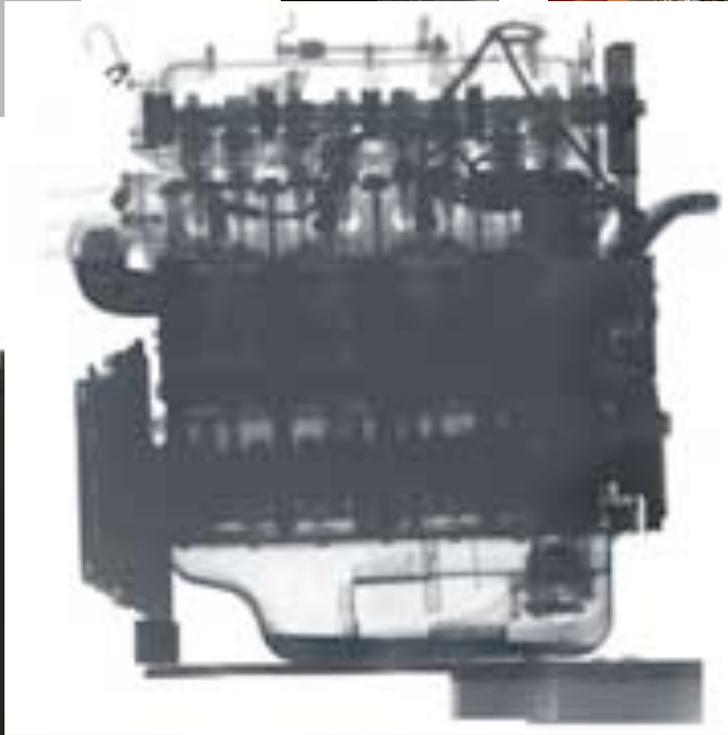
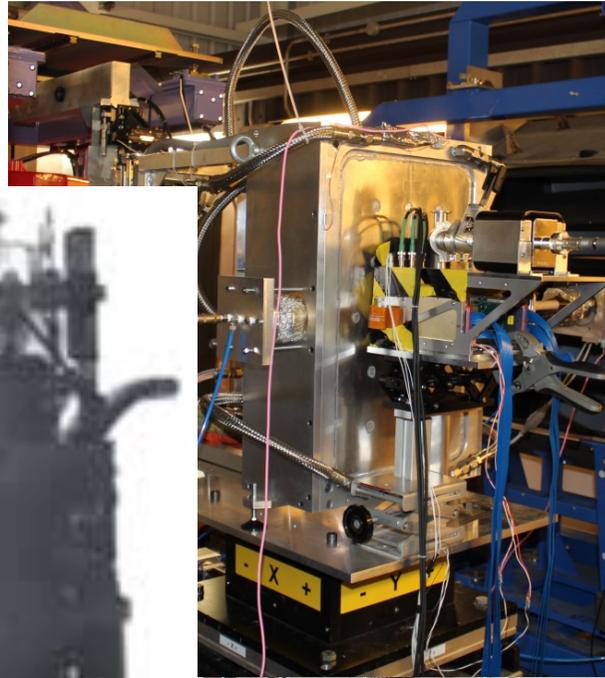
## Possibilities of pulse shaping



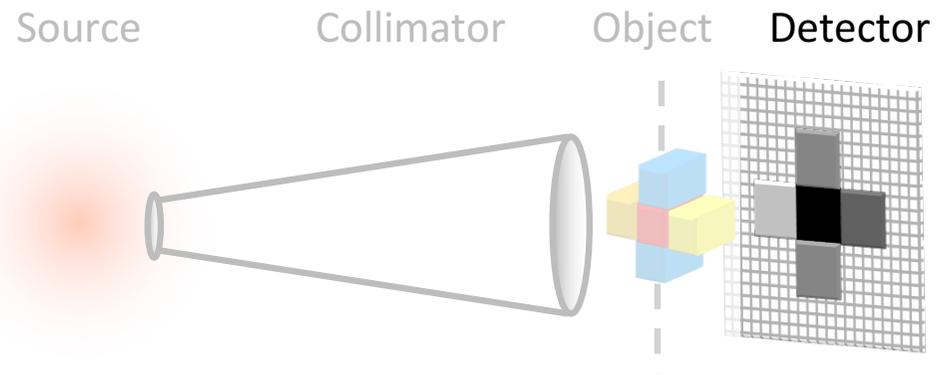
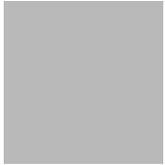
# Sample position



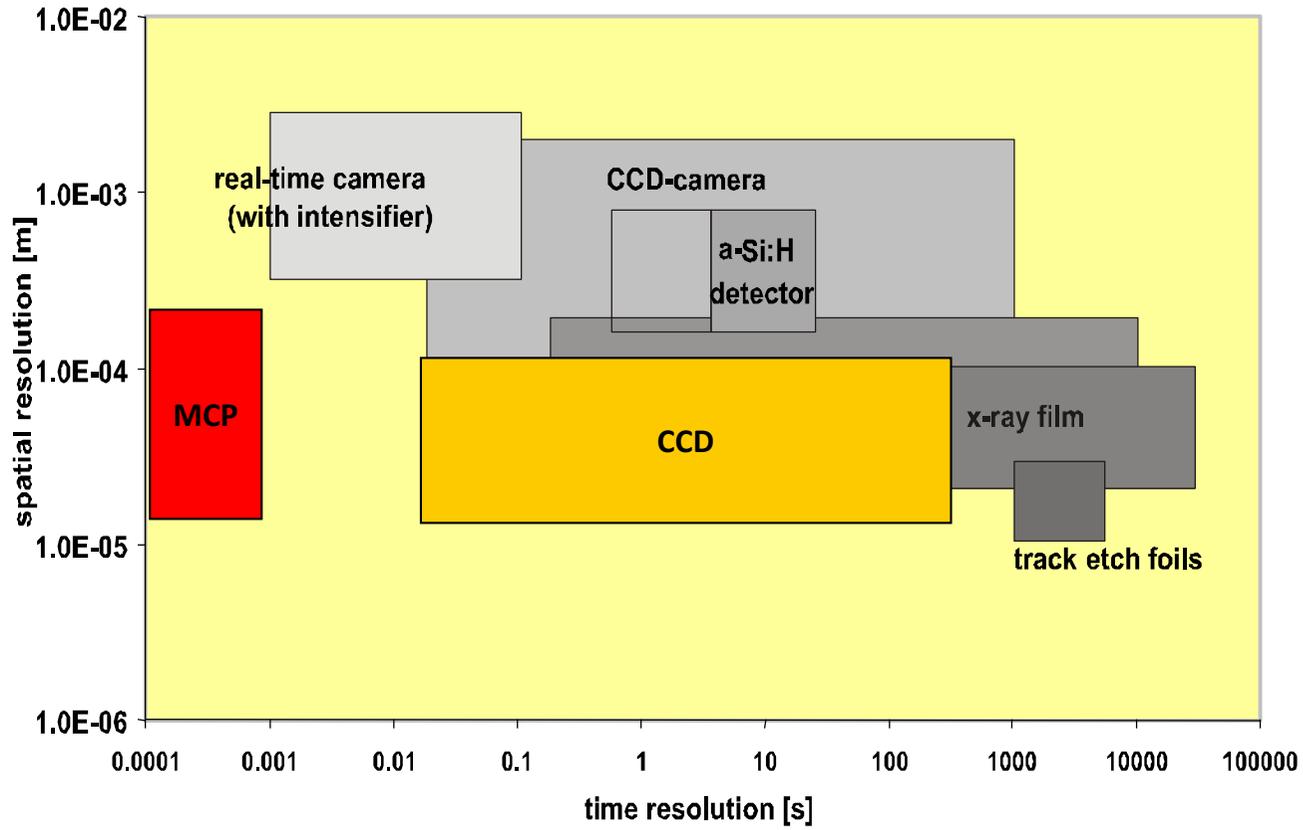
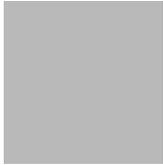
# Sample position

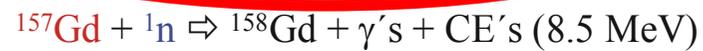
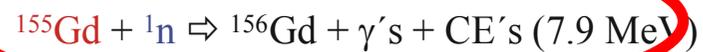
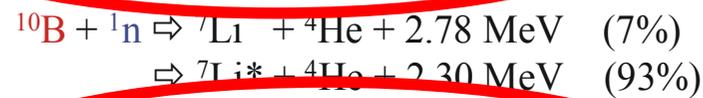
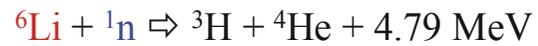
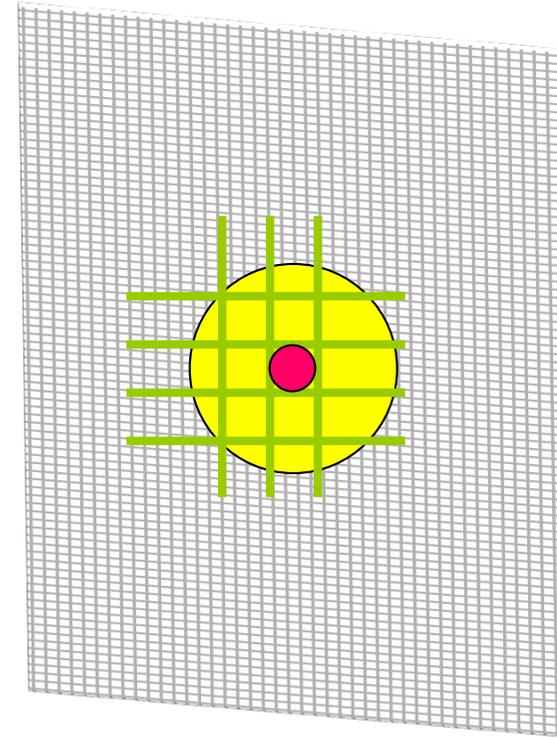
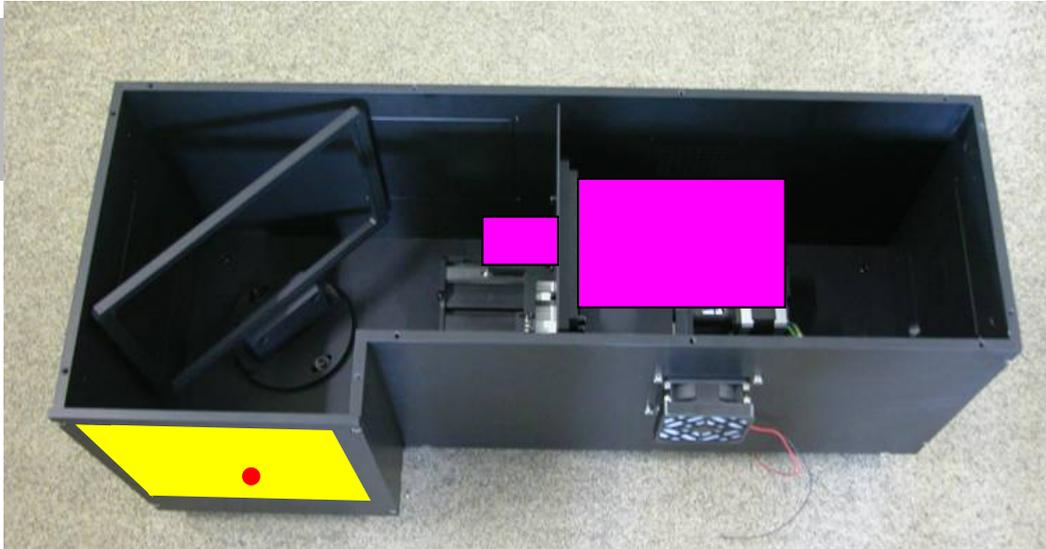


# Detector



# Detector

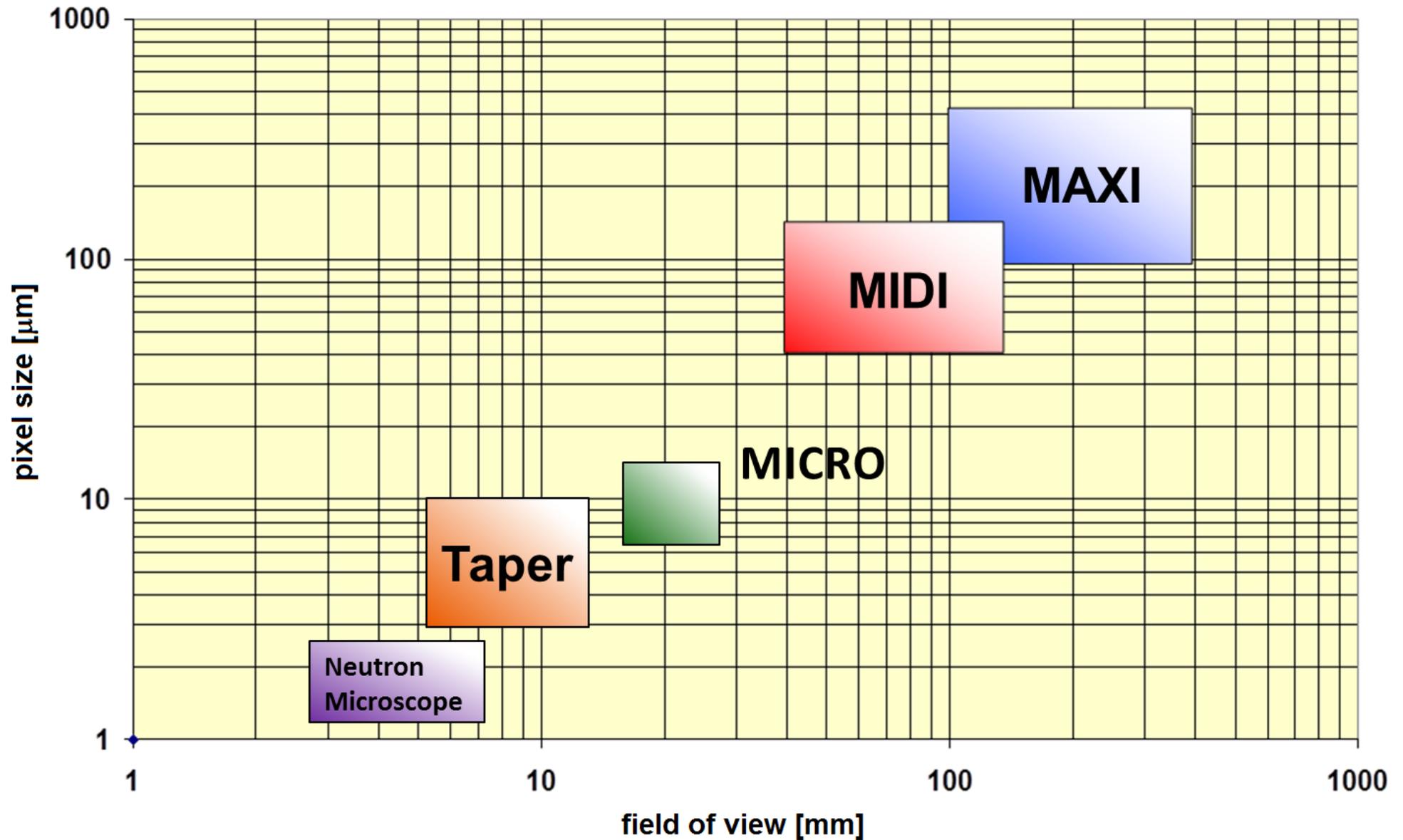




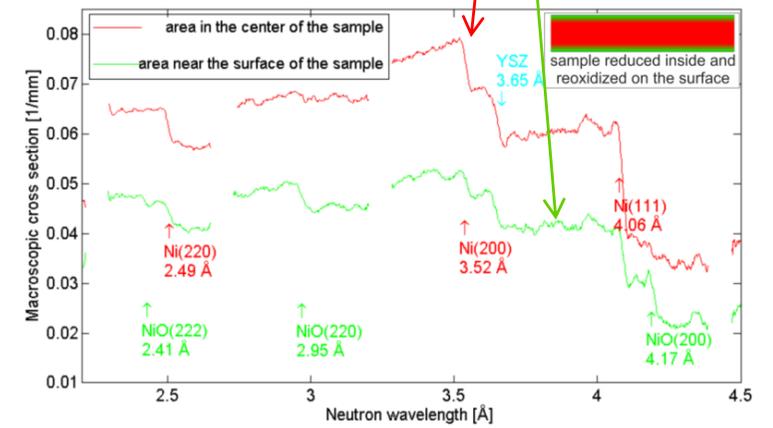
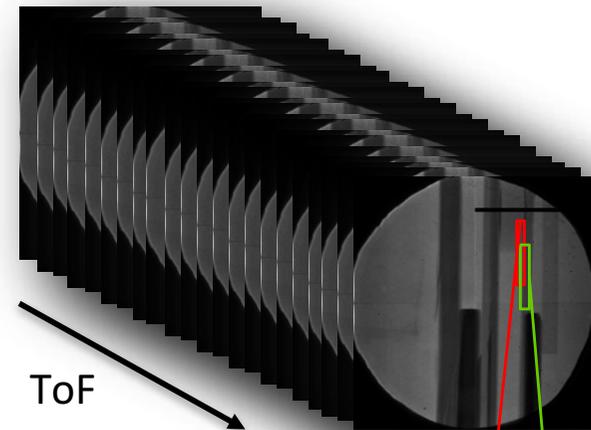
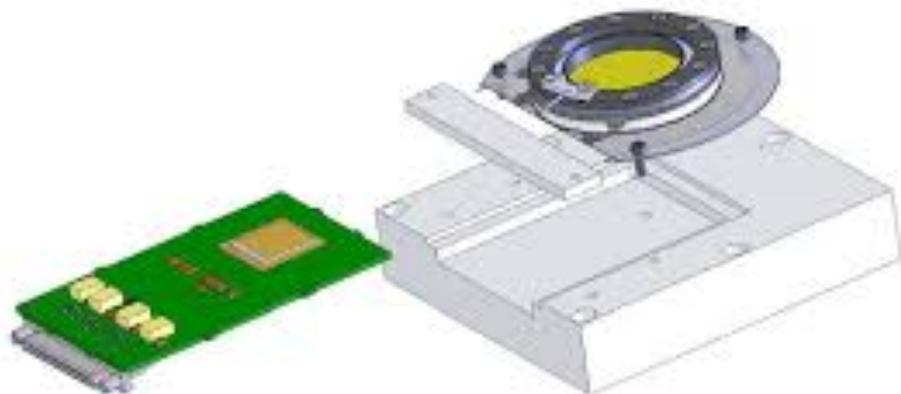
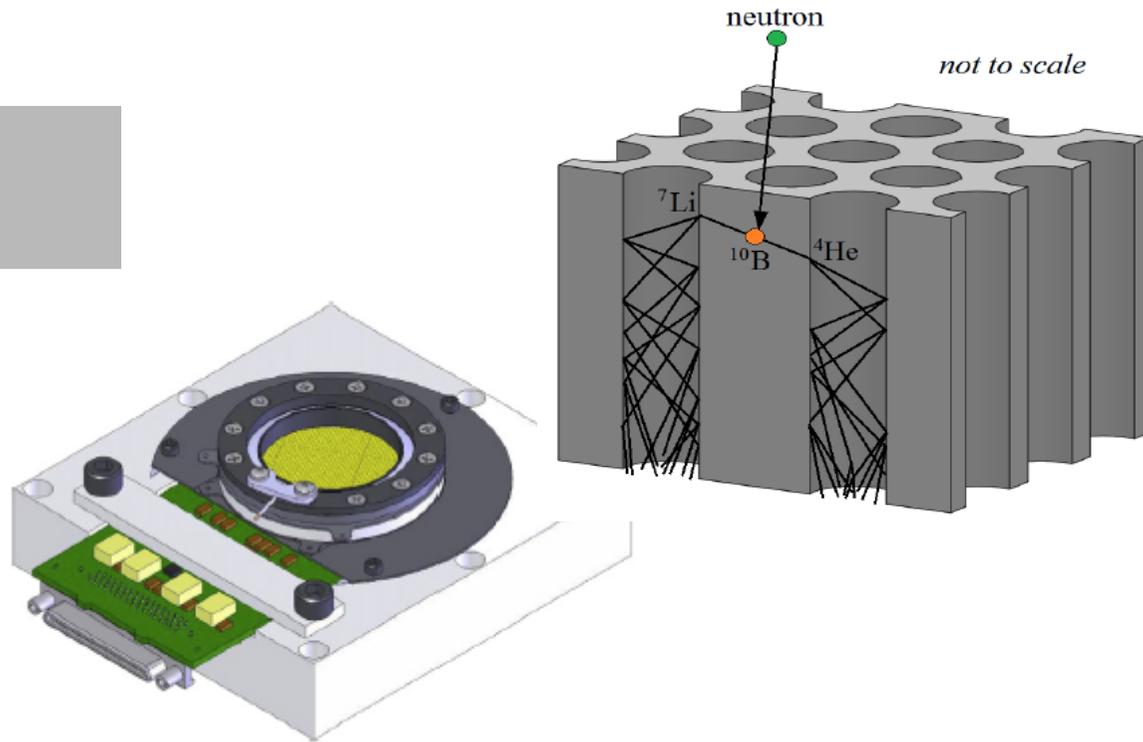
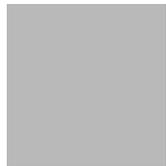
LiF-ZnS/Ag

GADOX

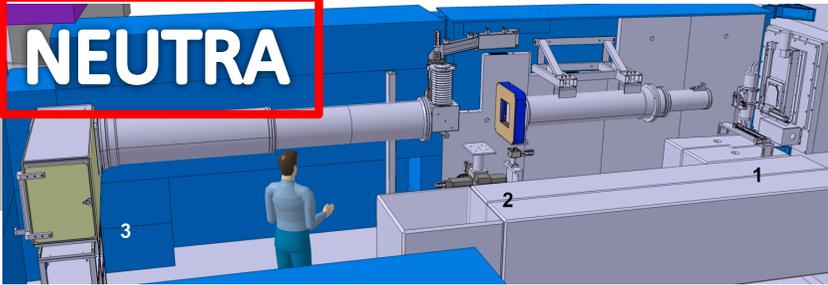
# Detector



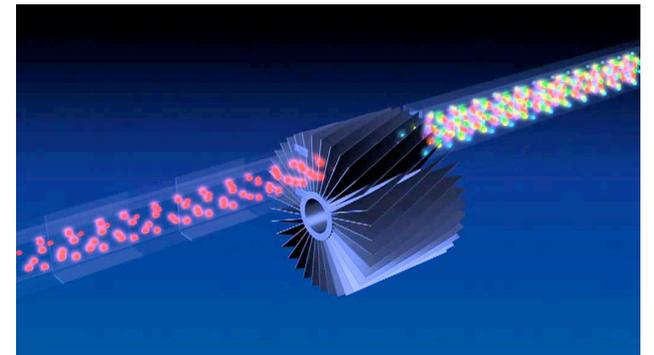
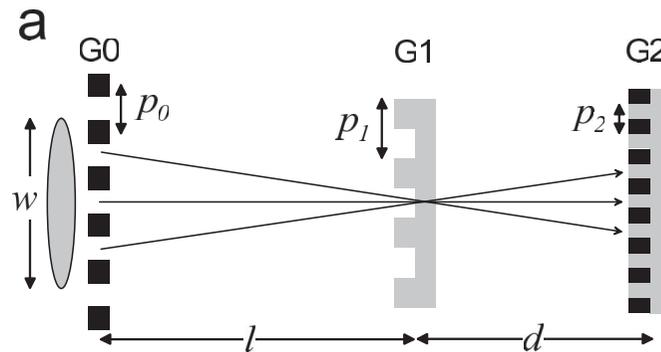
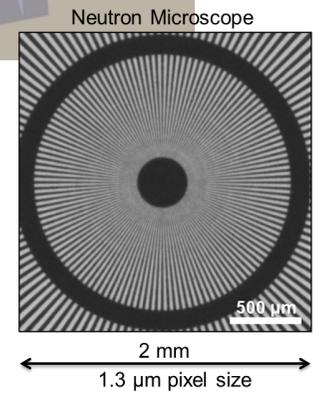
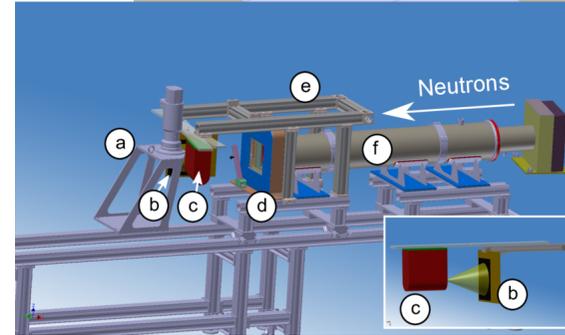
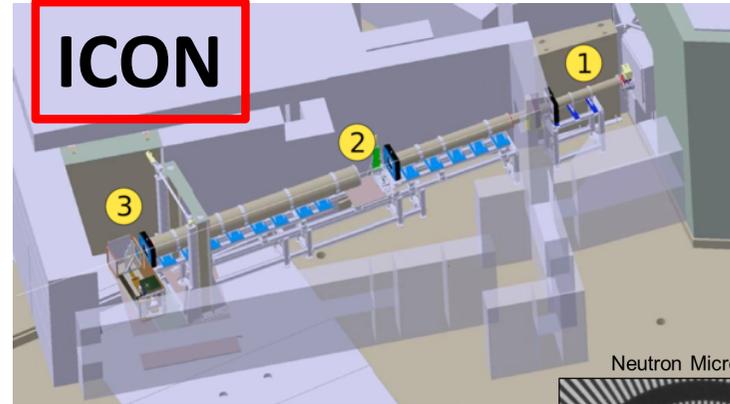
# Detector



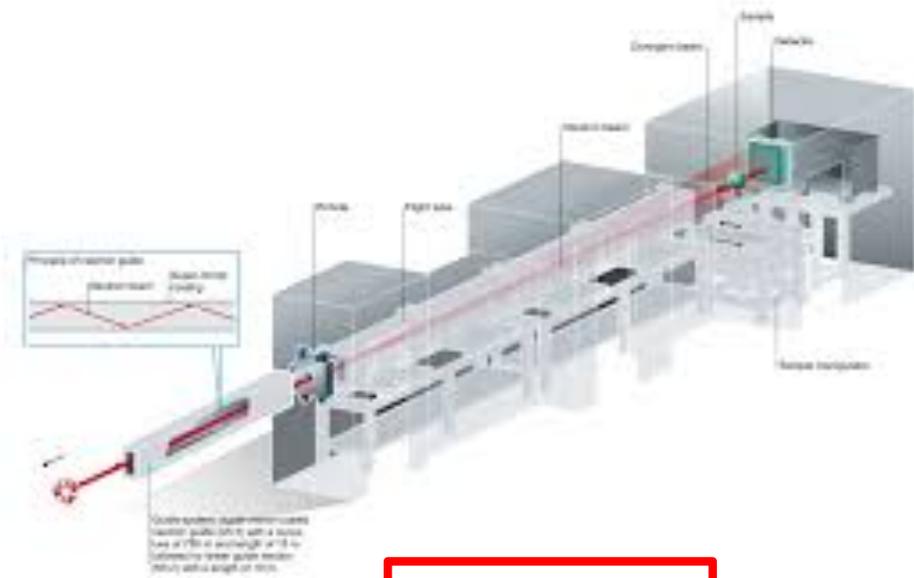
**NEUTRA**



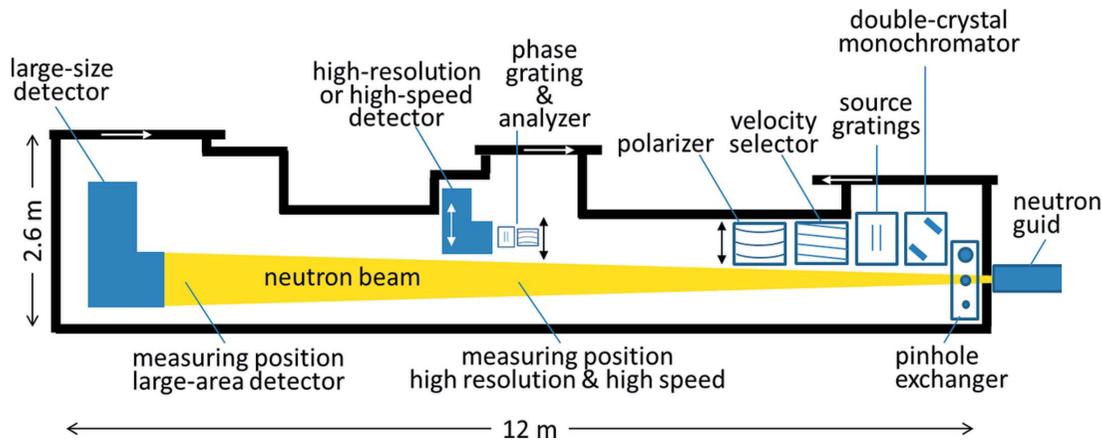
**ICON**



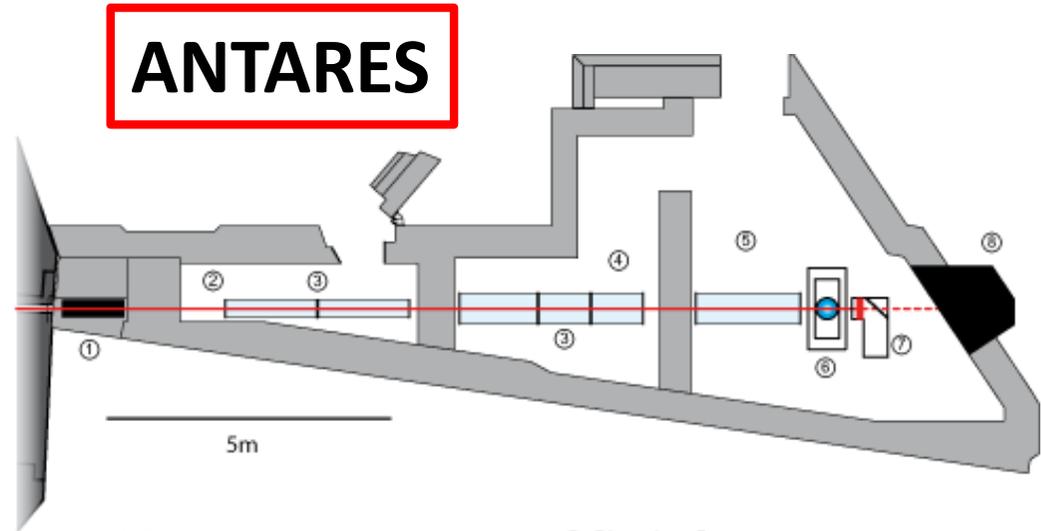
# Beamlines – HZB and TUM



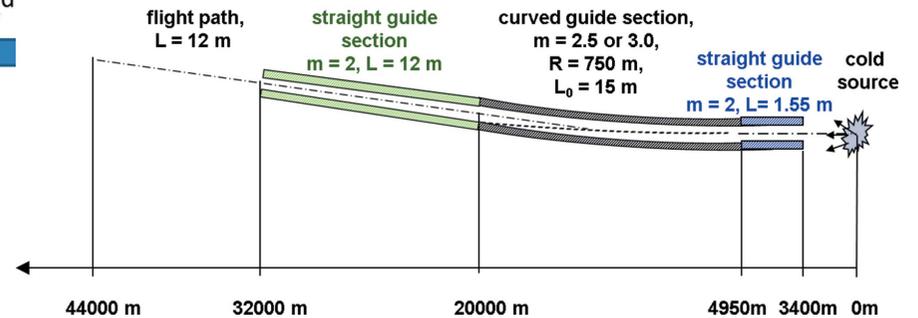
## CONRAD



## ANTARES

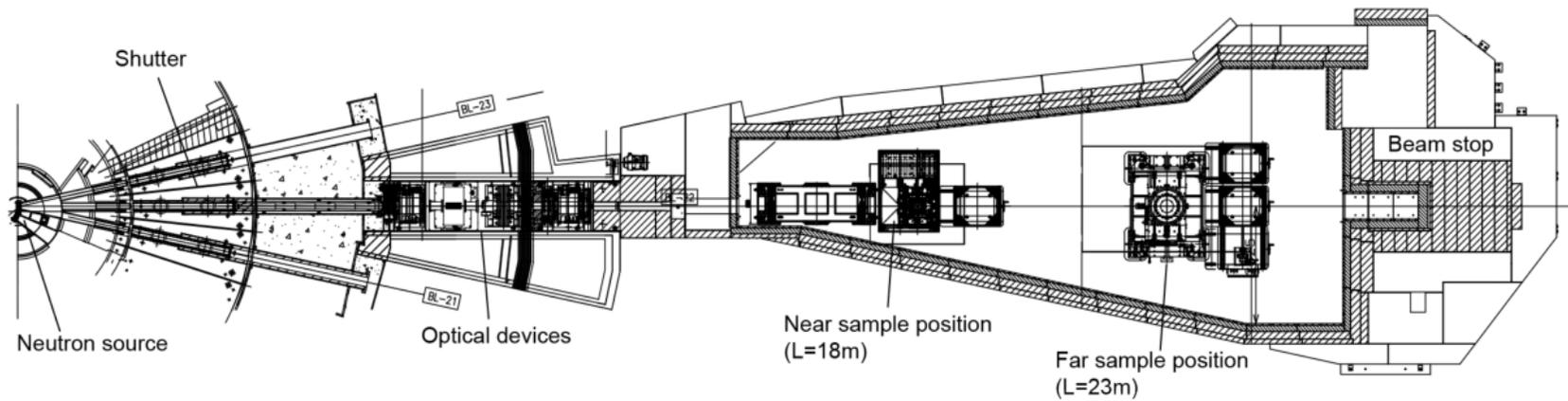


- ① Beam shutter
- ② Chamber 1
- ③ Flight tubes
- ④ Chamber 2
- ⑤ Chamber 3
- ⑥ Sample Space
- ⑦ Detector
- ⑧ Beam Stop

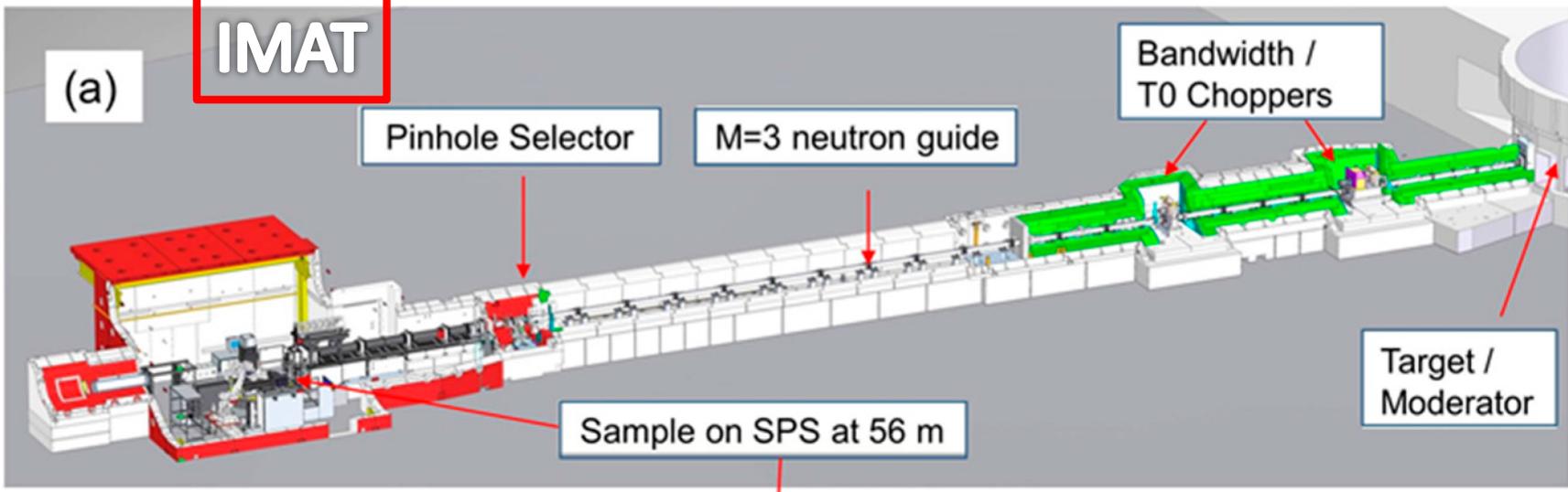


# Beamlines – ISIS and JPARC

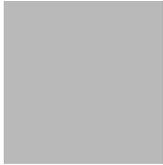
## RADEN



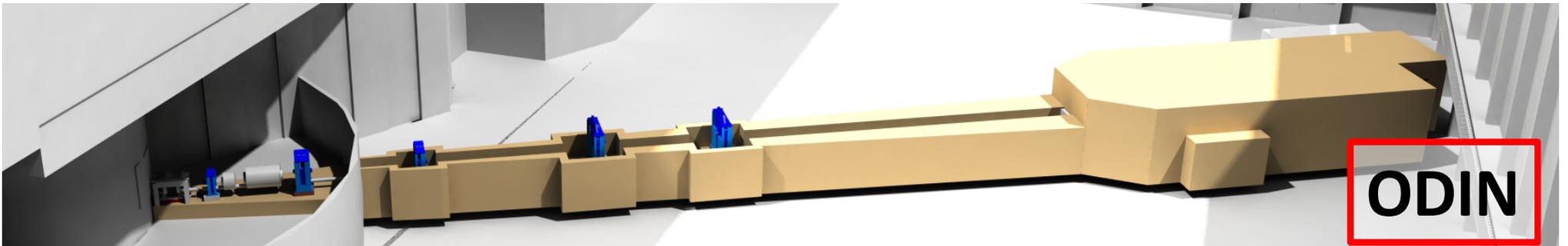
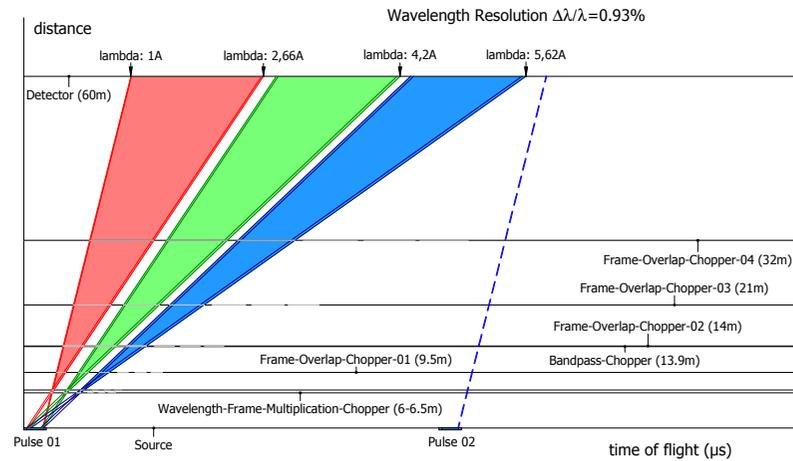
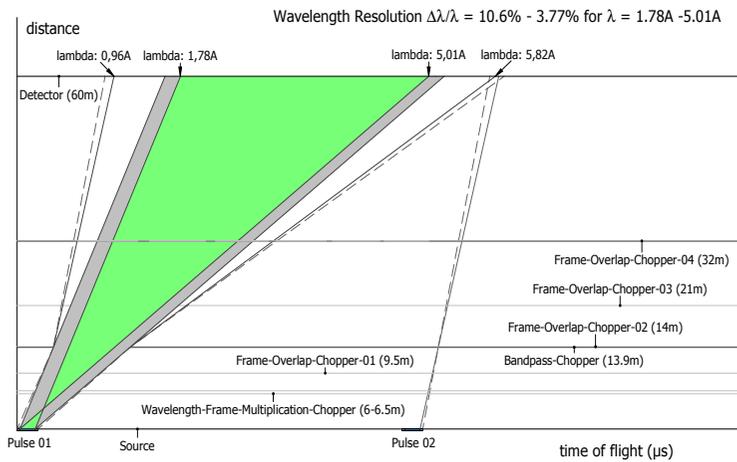
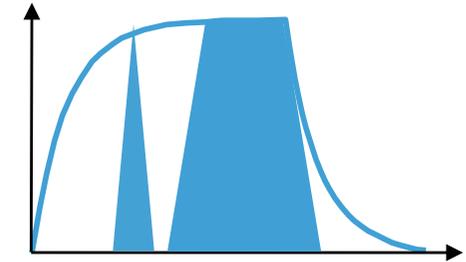
## IMAT



# Beamlines – ODIN at ESS



## Possibilities of pulse shaping



**ODIN**

