EUROPEAN UNION

GOVERNMENT OF ROMANIA

Structural Instruments 2007-2013

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Gamma beam monitoring instruments at ELI-NP

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Nuclear Physics

IFIN-HH

ELI-NP large equipment

- **High Power Laser System** - 2 x 10PW maximum power
  - *contracted by Thales Optronique SA (~65 M€)*
- **Gamma Beam System** - high intensity, tunable energy up to 20MeV
  - *contracted by EuroGammaS Consortium led by INFN Rome (~65 M€)*

gamma beams at ELI-NP

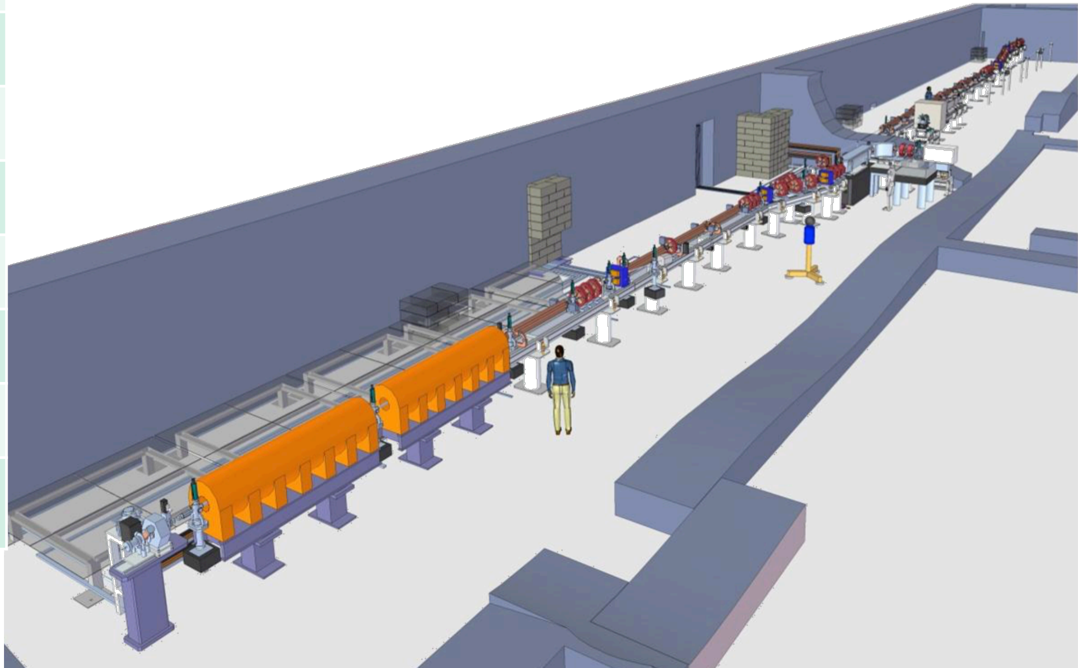
Parameter [units]	Value
Photon energy [MeV]	0.2 – 19.5
Spectral density [ph/s/eV]	> 10^4
Bandwidth (rms)	< 0.5 %
# photons / shot FWHM bdw.	$1.0 – 4.0 \cdot 10^5$
# photons/sec FWHM bdw.	$2.0 – 8.0 \cdot 10^8$
Source rms size [μm]	10 – 30
Source rms divergence [μrad]	25 – 250
Peak brill. [N_{ph}/sec·mm²mrad²·0.1%]	10^{22}– 10^{24}
Radiation pulse length [ps]	0.7 – 1.5
Linear polarization	> 99 %
Macro repetition rate [Hz]	100
# of pulses per macropulse	>31
Pulse–to–pulse separation [ns]	16

Low–energy stage: Eγ < 3.5 MeV

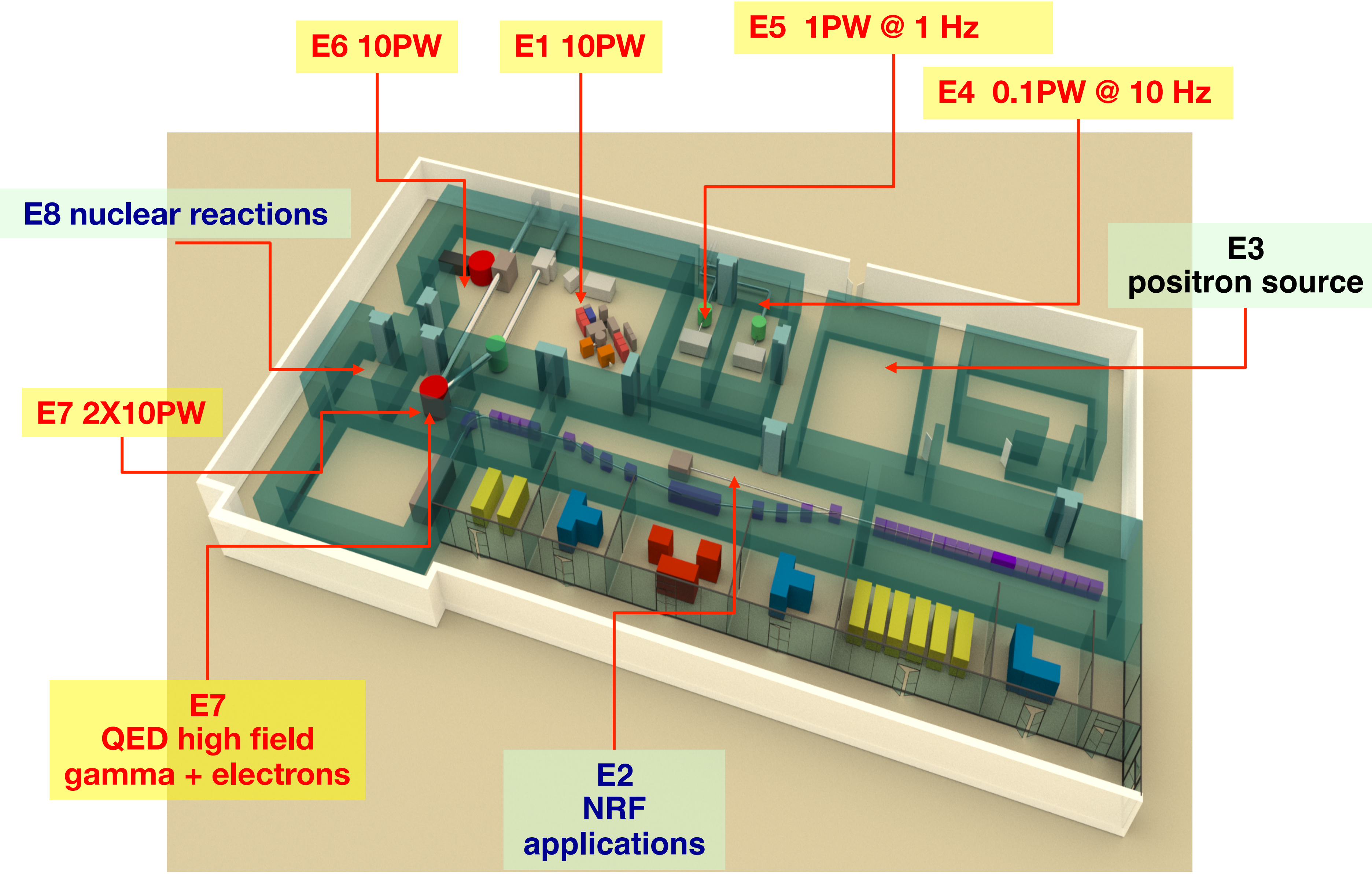
→ Q1 2017

High–energy stage: Eγ < 19.5 MeV

→ Q4 2018

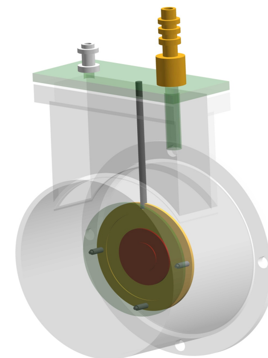


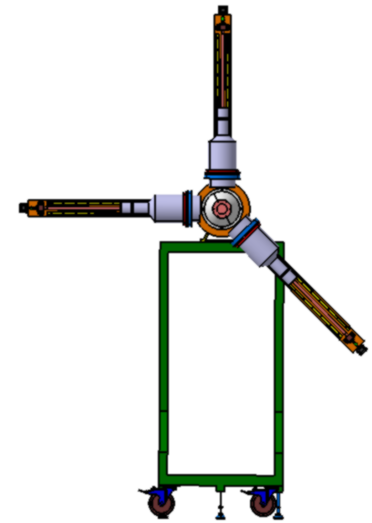
ELI-NP experimental areas



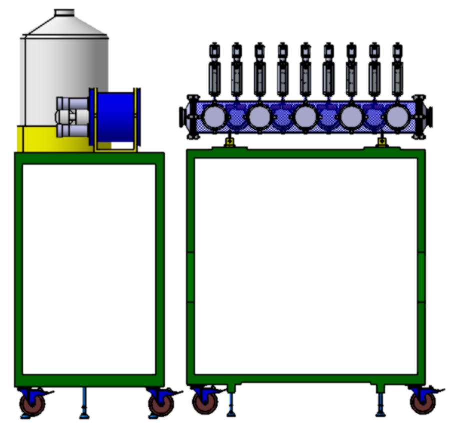
overview – gamma beam diagnostics

- **Intensity monitoring**
  - **deuteron photodisintegration**
  - **photo-fission**

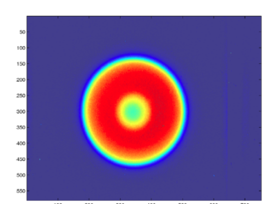


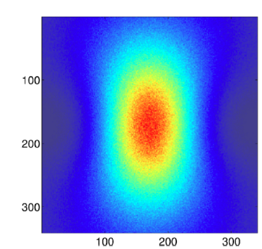


- **Energy monitoring**
  - **HPGe + anti-Compton shield**
  - **LaBr3 + anti-Compton shield**

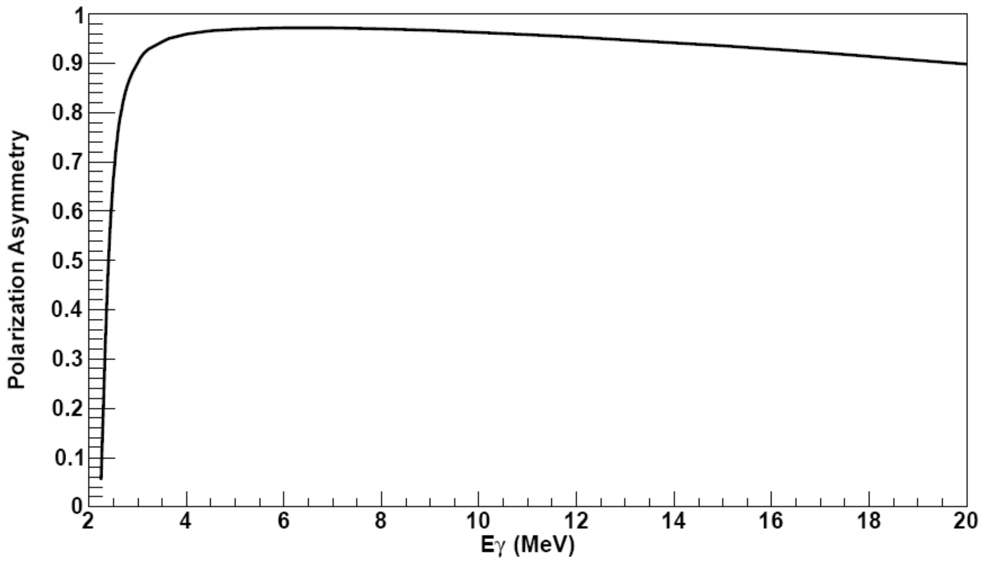


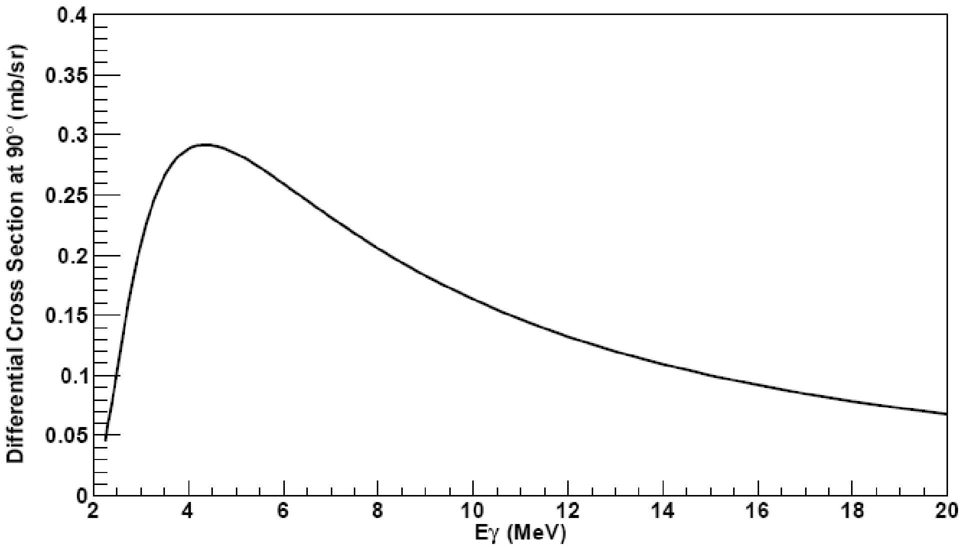
- **Time structure monitoring**
  - **small LaBr3**
- **Spatial structure monitoring**
  - **CCD camera**



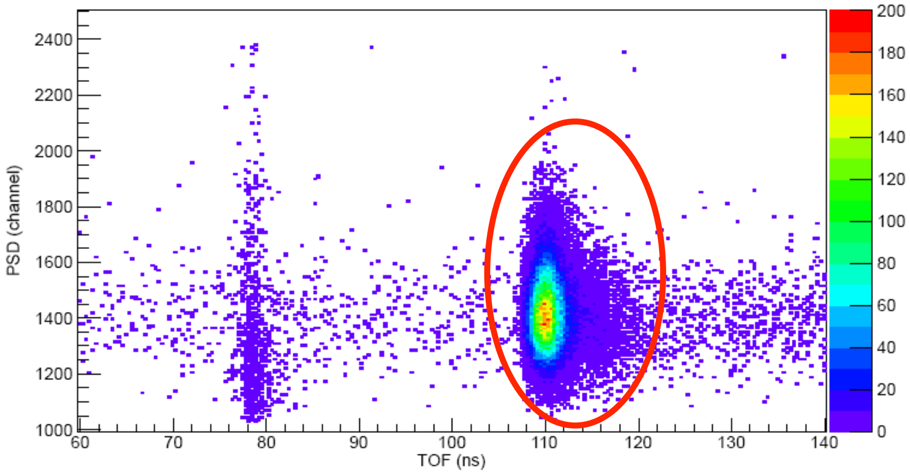


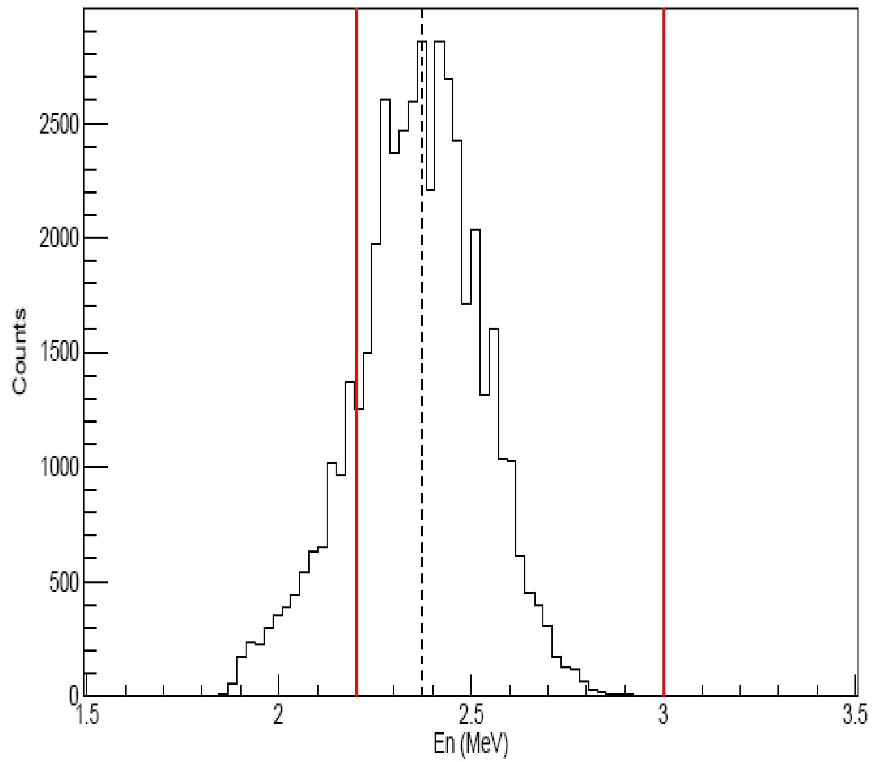
flux monitor / polarization – d(γ,n)p





d(γ,n)p – test at HIγS



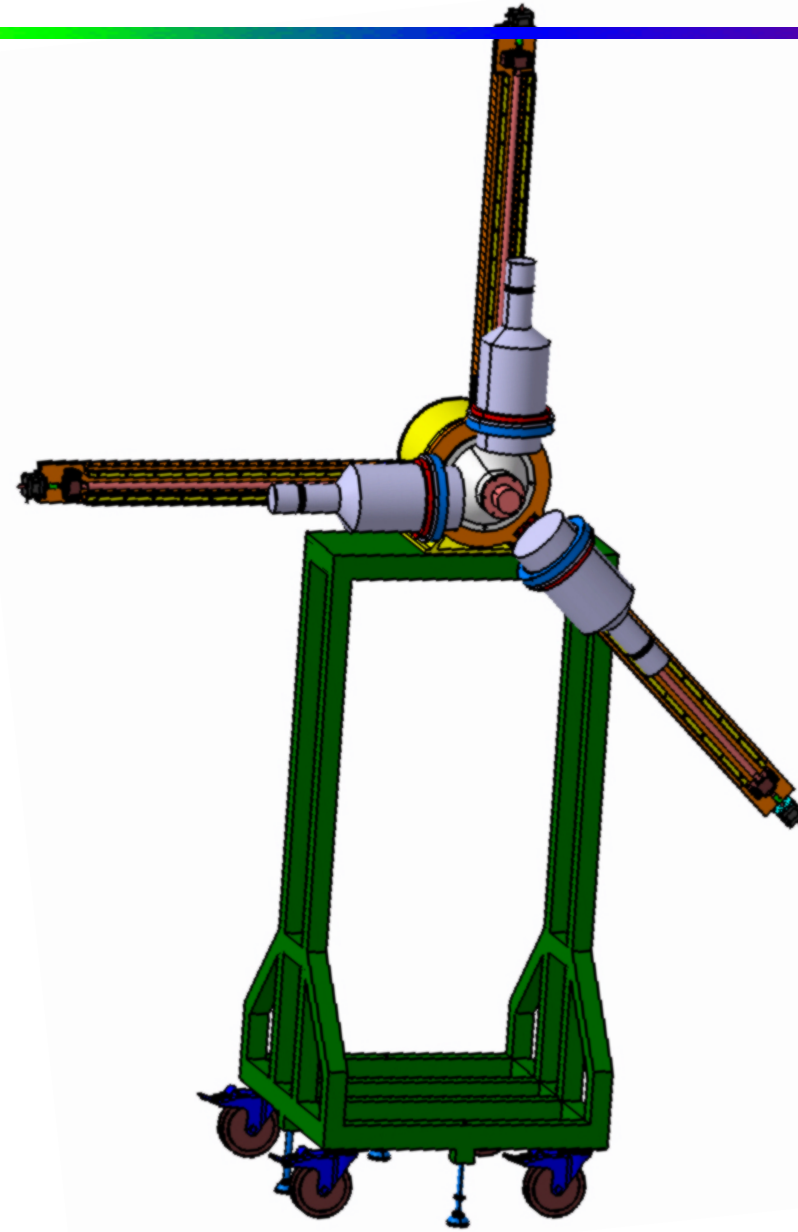


- recent experiments at HIGS
- BC-501 detectors for E_γ= 5, 6.1, 7, 15, 20 MeV
- Li-glass detectors for E_γ= 2.5, 2.75, 3 MeV
- exp. asymmetry = 0.93±0.02

d(γ,n)p – proposal at ELI-NP

- d(γ,n)p systems used at HIGS
- D_2O cell – 4 cm long
- threshold reaction 3 MeV
- well known cross sections ~3%
- 3-4 neutron detectors
- Li-glass below 4 MeV
- NE213-type above 4 MeV
- beam fluence accurate to 5%

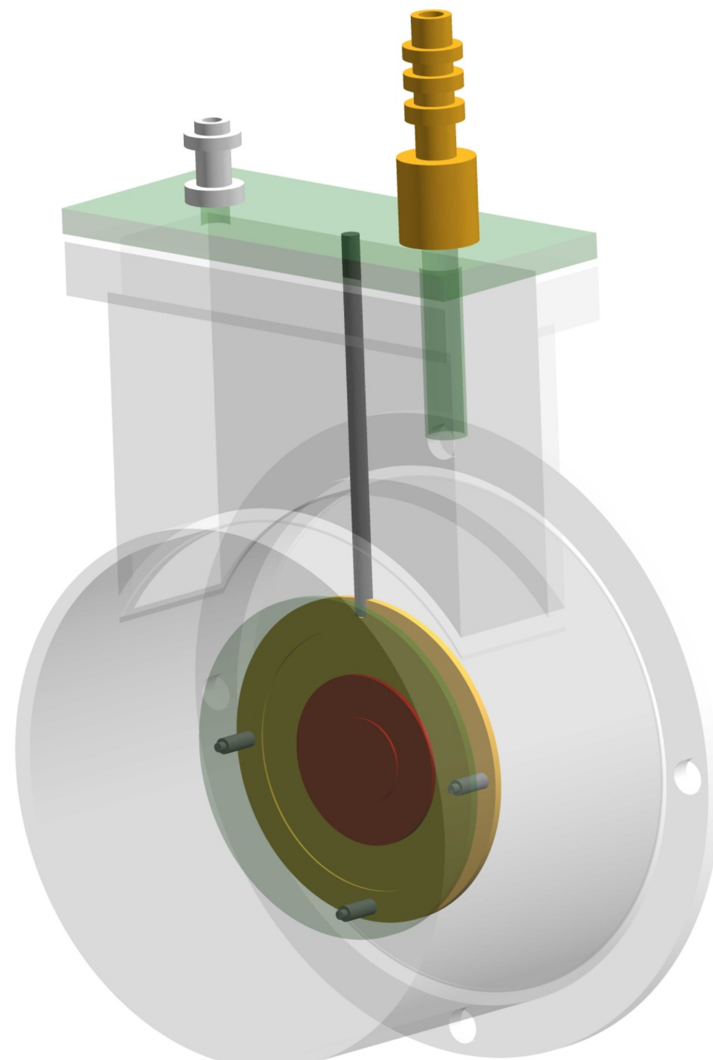
- 200 Hz rate
- DAQ: 14-bit, 500 MHz



flux monitor – fission chamber

- simple design
- almost 100% efficiency
- U-235, U-238, Pu-239
- areal density determined to 1%
- photofission cross sections to 1%
- usable above 6 MeV
- P-10 gas at max 1.2 bar
- beam fluence accurate to 2%

- 10-100 Hz rate
- DAQ: 12-bit, 250 MHz



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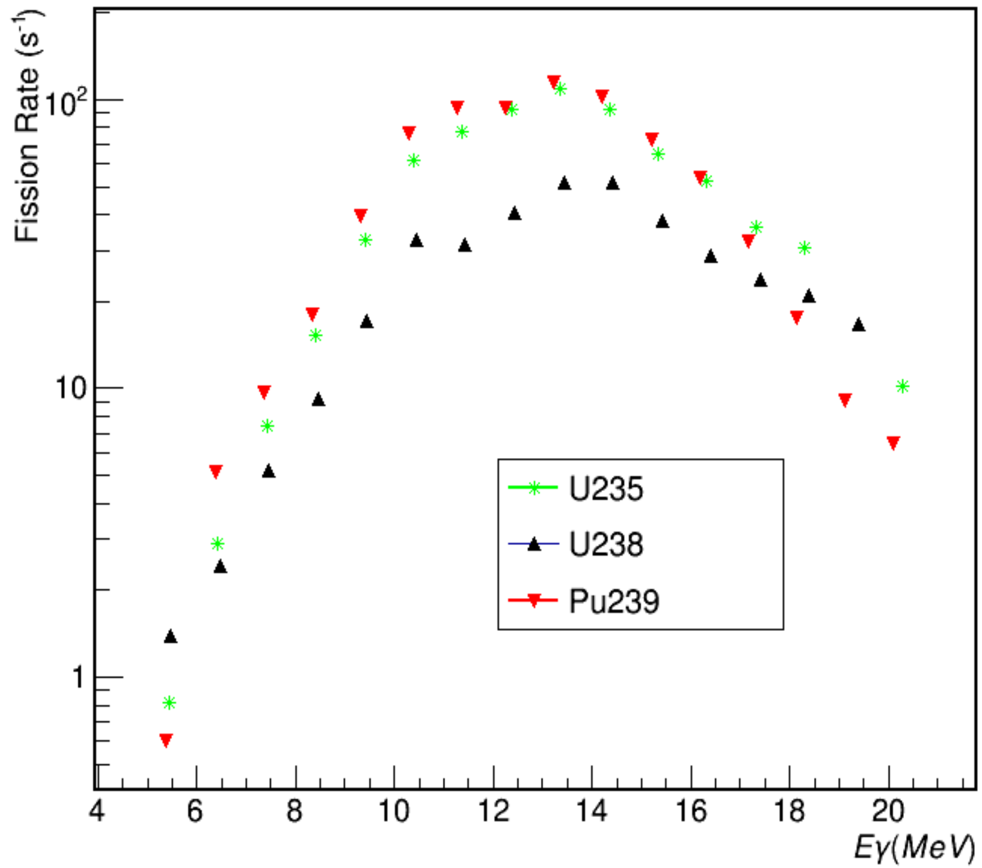
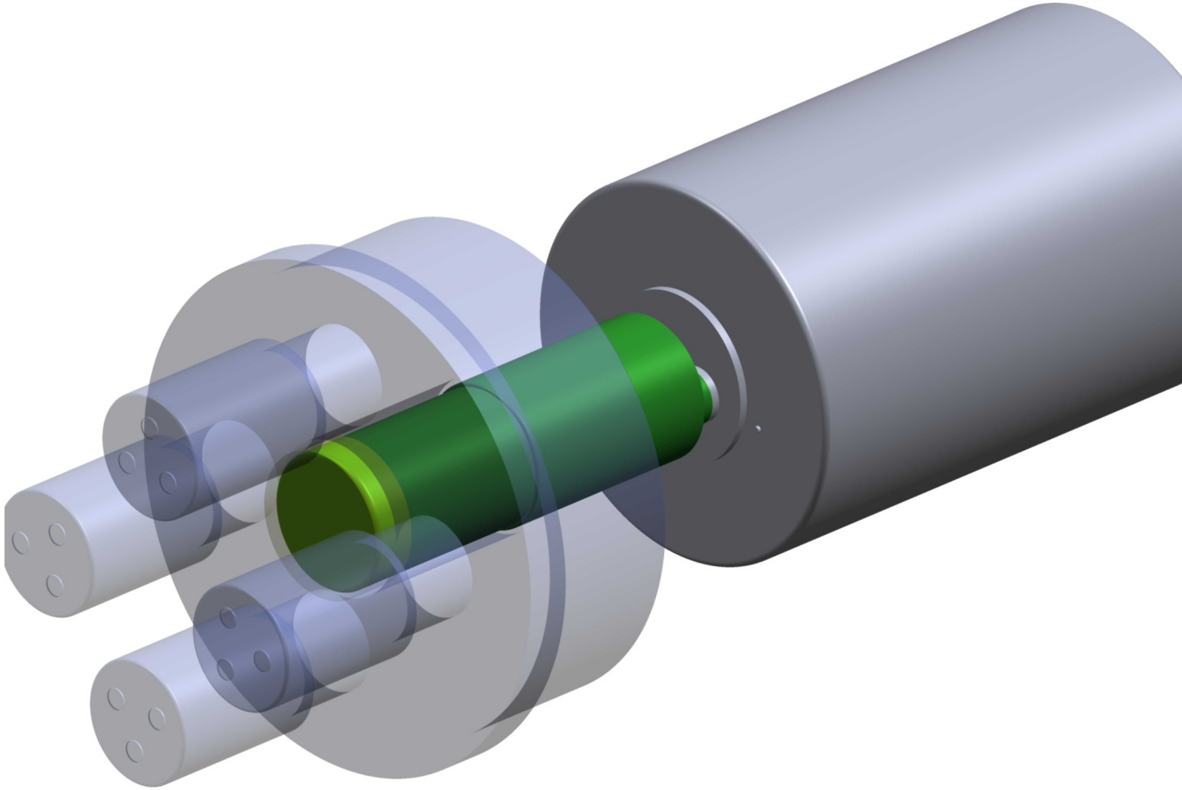


Estimated fission rates for 200 μg target

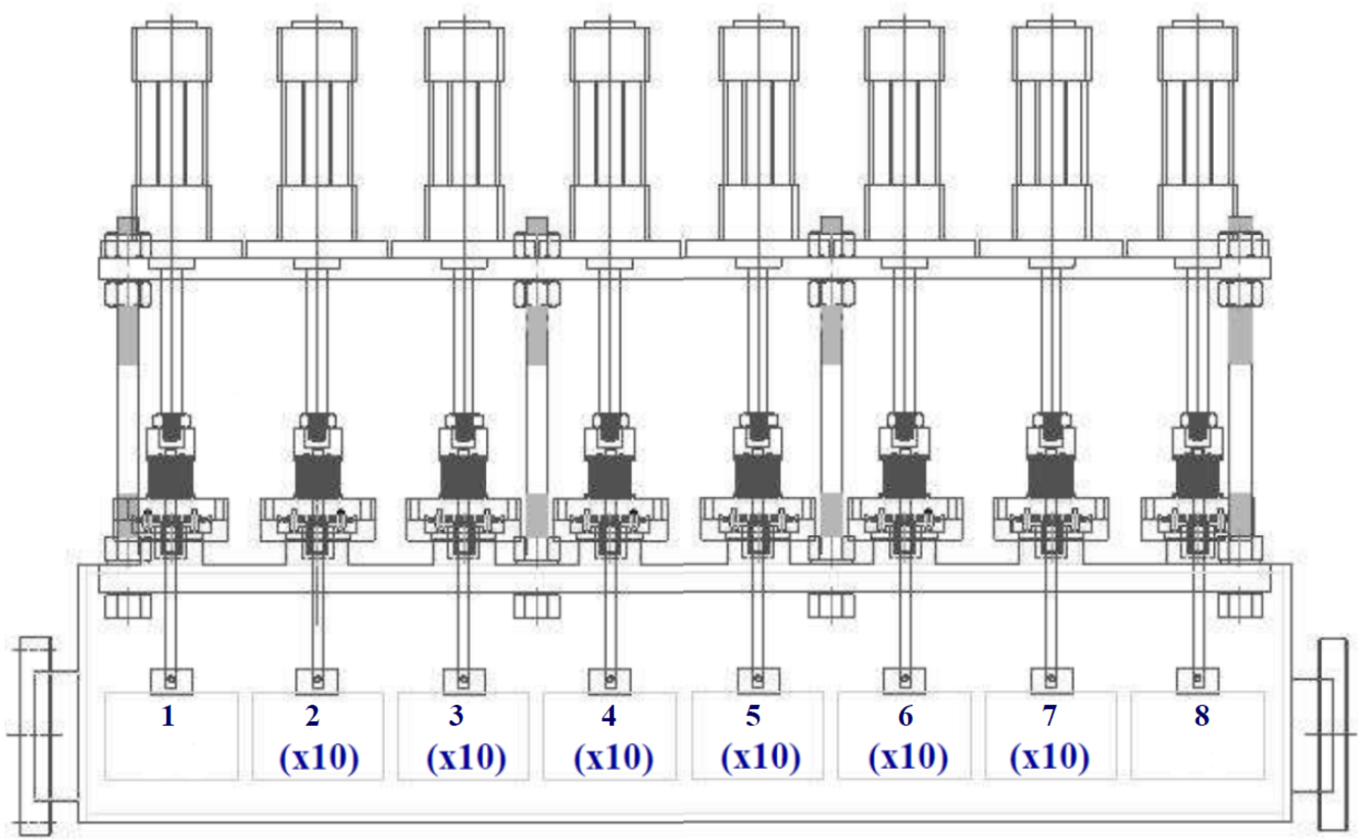
energy spread - detectors

- attenuated beam
- HPGe (150%)
- $LaBr_3$ (3” x 4”)
- anti-Compton shield
- 10 Hz rate
- # channels: 7
- DAQ:14-bit, 500 MHz



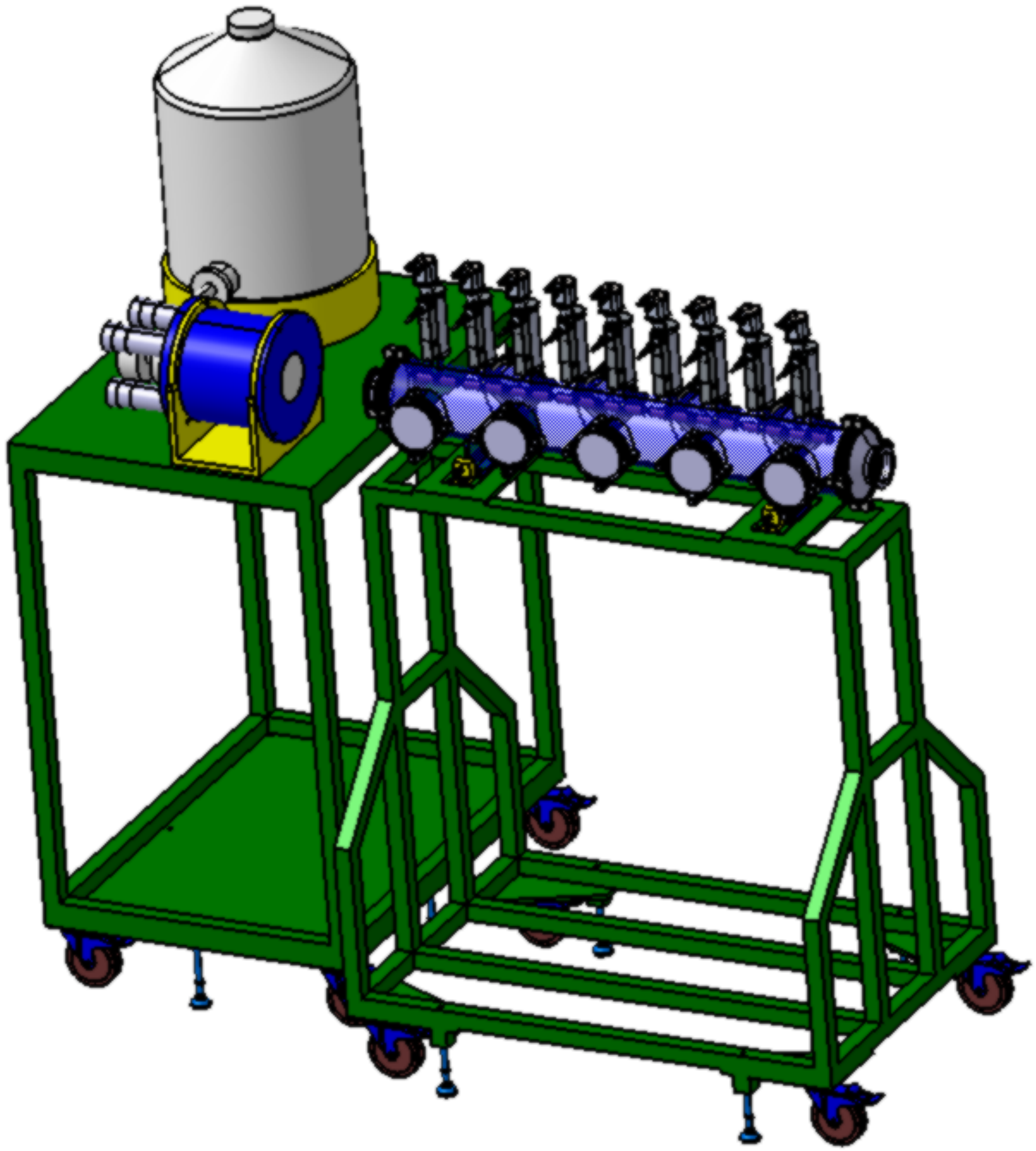
- main use for energy spread w/ HPGe
- possible use for intensity and time structure w/ $LaBr_3$
- NaI annulus – 15 cm diameter, 25 cm long, segmented

energy spread - attenuator

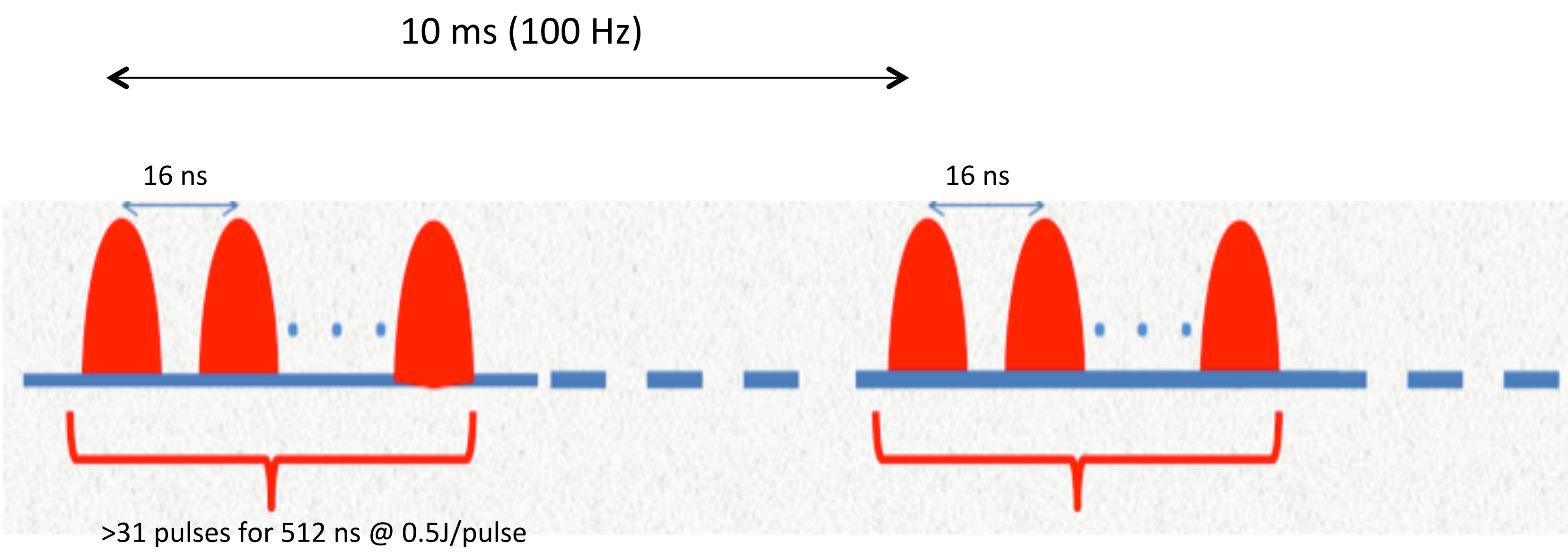


- 60 cm Cu for HPGe
- 50 cm Cu for $LaBr_3$
- factor of 10 attenuation in 8 cm Cu cylinder
- 1×1.5 cm, 1×2.5 cm, 1×5 cm, 6×10 cm

energy spread - proposed design

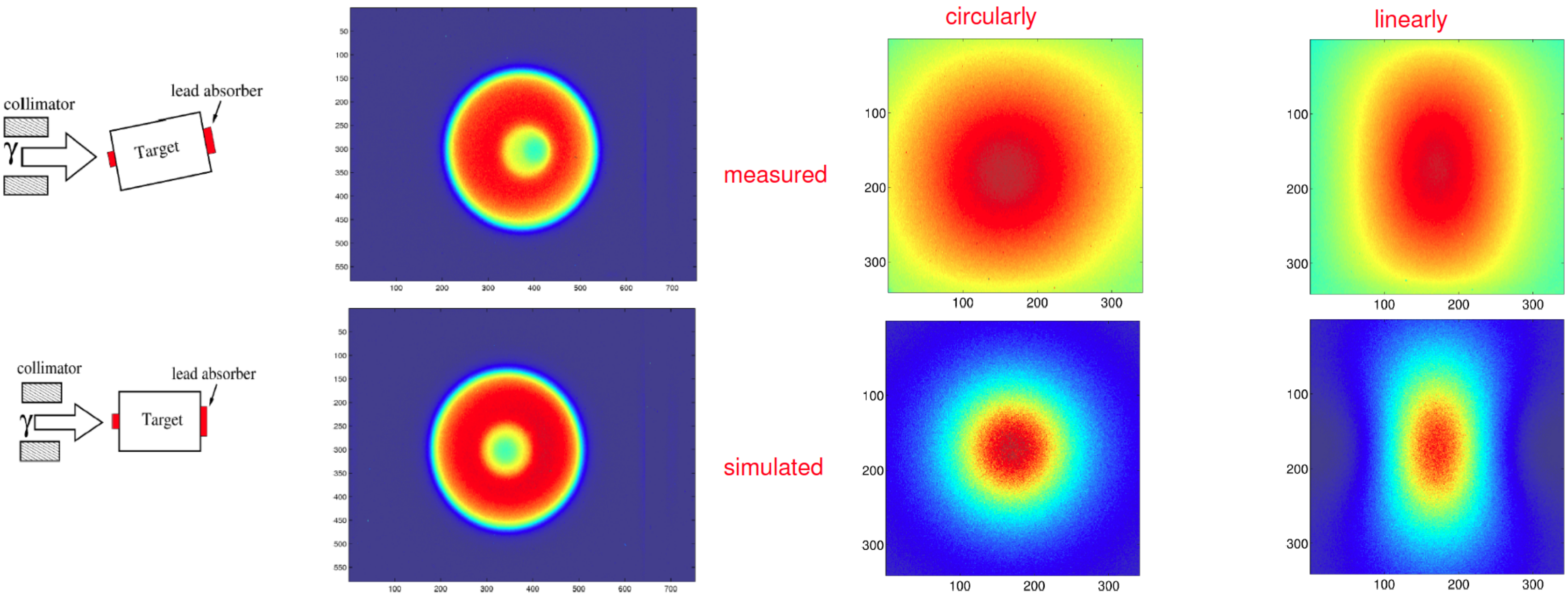


time structure



- beam monitor would be placed near one of the major beam-matter interaction points: collimators, attenuator, beam dump
- use a small 2”x2” $LaBr_3$ – may be able to count microbunches

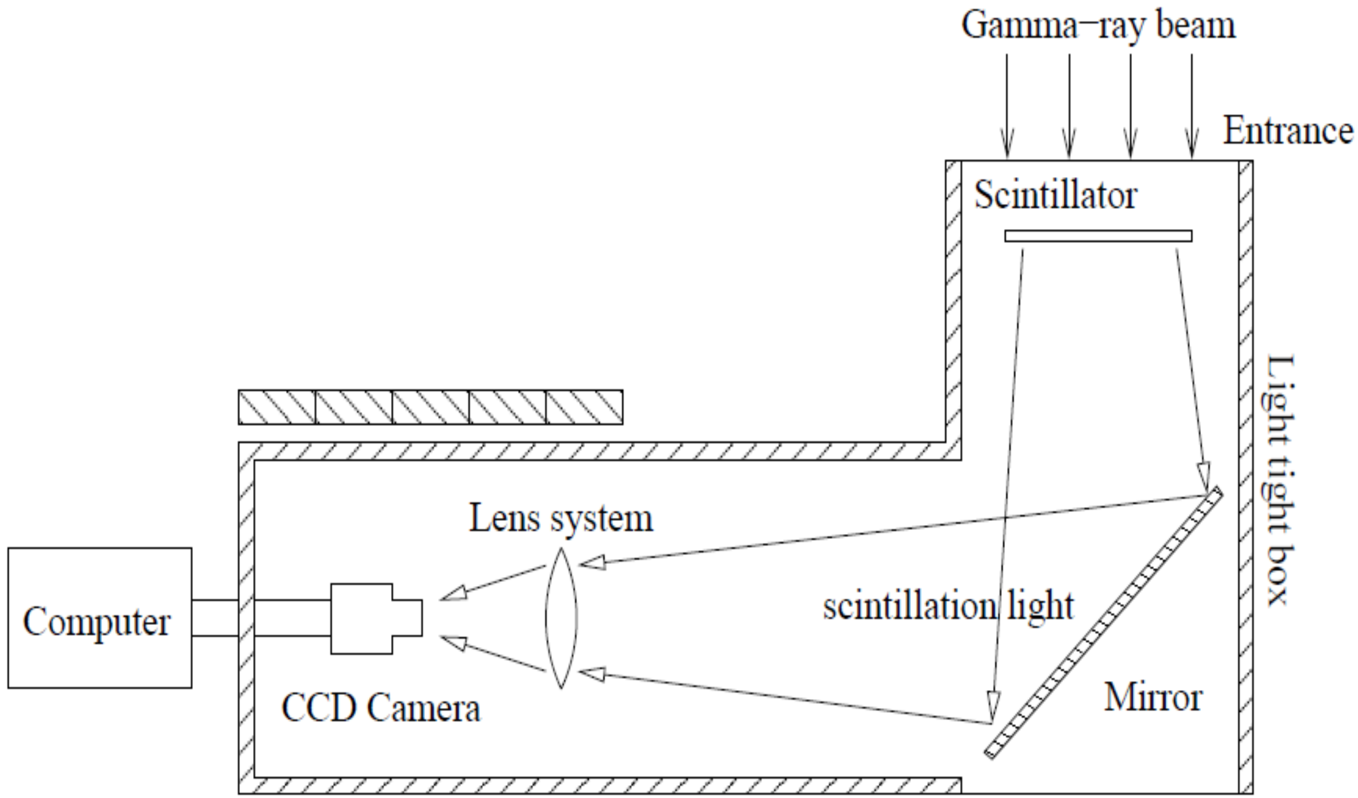
spatial monitoring



from HIGS

- fast alignment of the collimators to maximize flux and reduce energy spread
- fast alignment of the experimental setup to minimize scattering
- possible polarization, intensity monitor

spatial monitoring



- CCD camera detector system, scintillator converter, mirror
- possible image collection at microbunch level with fast CCD
- design requirements: sub-mm resolution and high contrast

ELI-NP next steps

- Summer 2015: TDRs approved by ISAB
- Fall 2015: Start construction of instruments
- Q1 2017: Gamma Beam – end of Phase 1
- Q4 2018: Gamma Beam – begin operation