

Experiences from Phase 1 Detector Systems for LOKI

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Contents

- List of LoKI detector documents for phase 1
- Detector requirements
- Suitable detector technologies
- Realization schedule
- In-kind contributions

List of documents

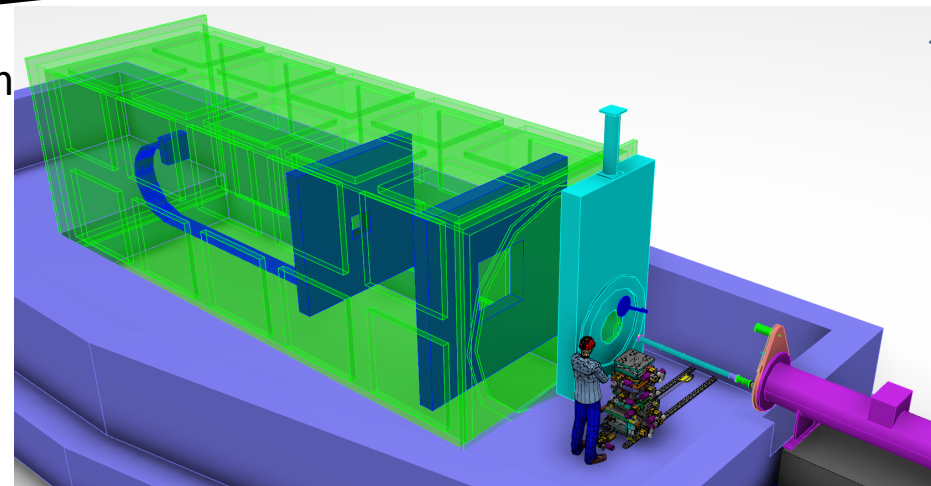
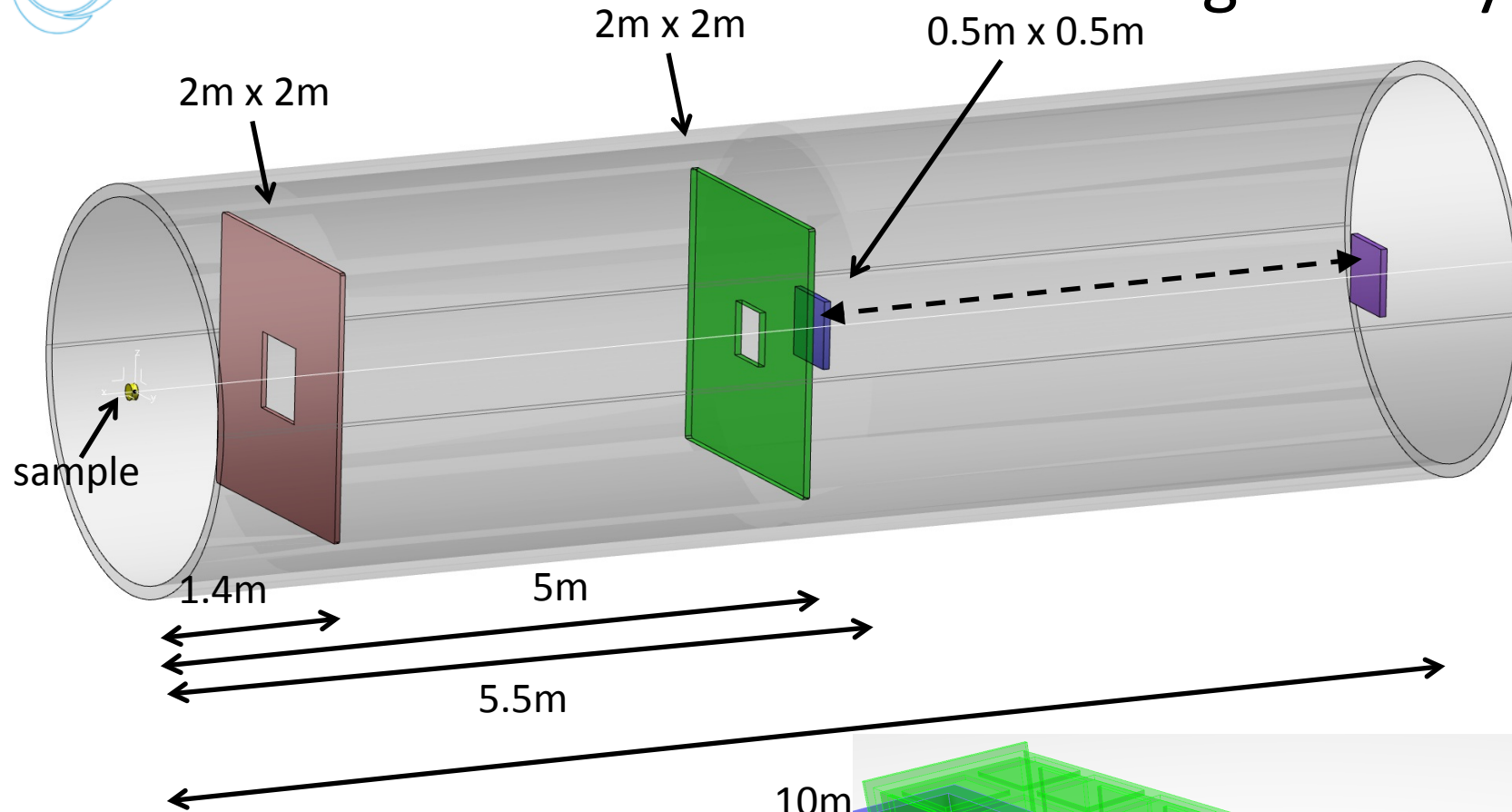
- Technical document/detector strategy for LoKI
- Detector work unit scope for the instrument
- Risk identification & mitigation for the detectors
- In-kind plan
- Draft commissioning plan
- Interfaces between detectors and instrument
- Schedule for scattering detector system
- Schedule for beam monitors
- Budget

Top level detector requirements

(independent of geometry)

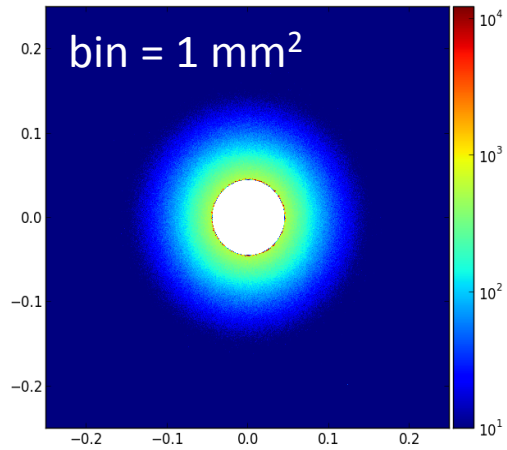
- Polar angle coverage $0^\circ - 45^\circ$
- Polar angle resolution $\delta\theta/\theta < 10\%$
- Rates $< 400 \text{ Hz}/\theta\text{-}\phi \text{ bin}$ ($\theta \text{ bin: } 0.25^\circ$, $\phi \text{ bin: } 1^\circ$)
- TOF resolution $< 100 \mu\text{s}$
- Instrument Q resolution $\sigma Q/Q < 10\%$
- Efficiency $> 20\%$ at 2 \AA
- γ background $10^{-6} - 10^{-5}$
- Azimuthal angle resolution ϕ : to be determined
- Total background tolerance: to be determined, not expected to be a problem

The 'window-frame' baseline geometry (WF)

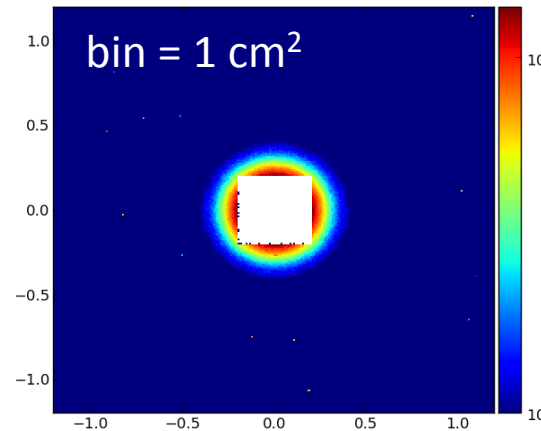


Extracting rates with McStas

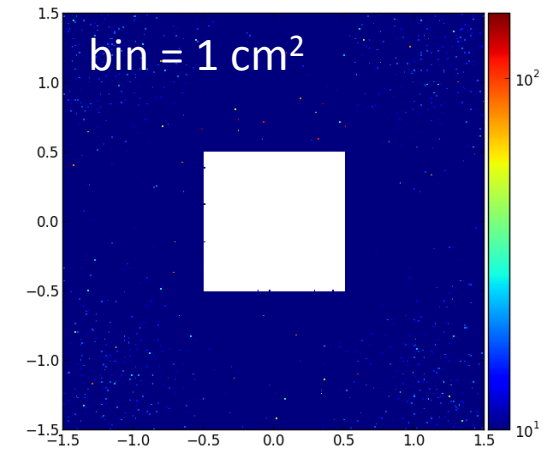
rear (low angle)



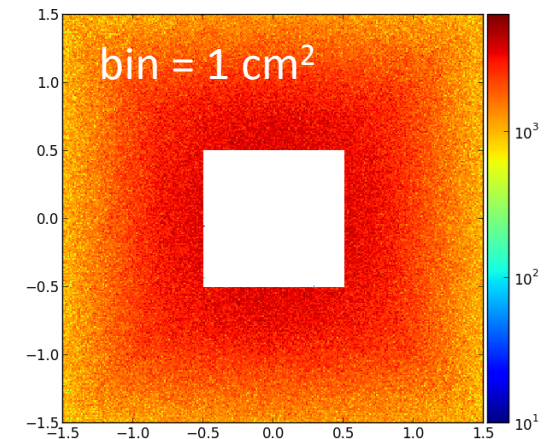
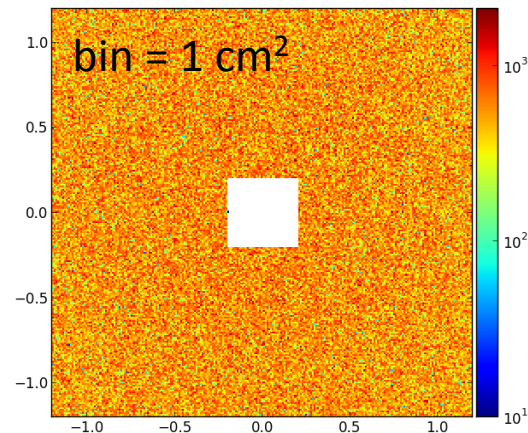
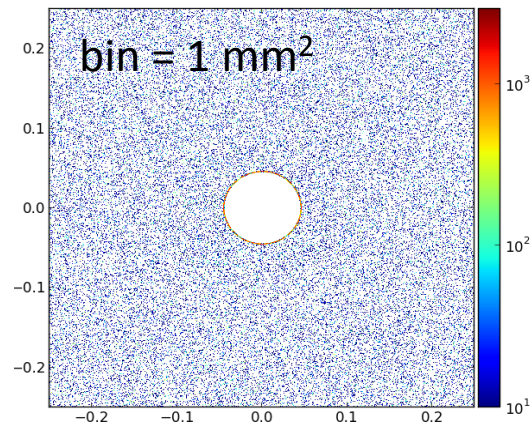
mid (high angle)



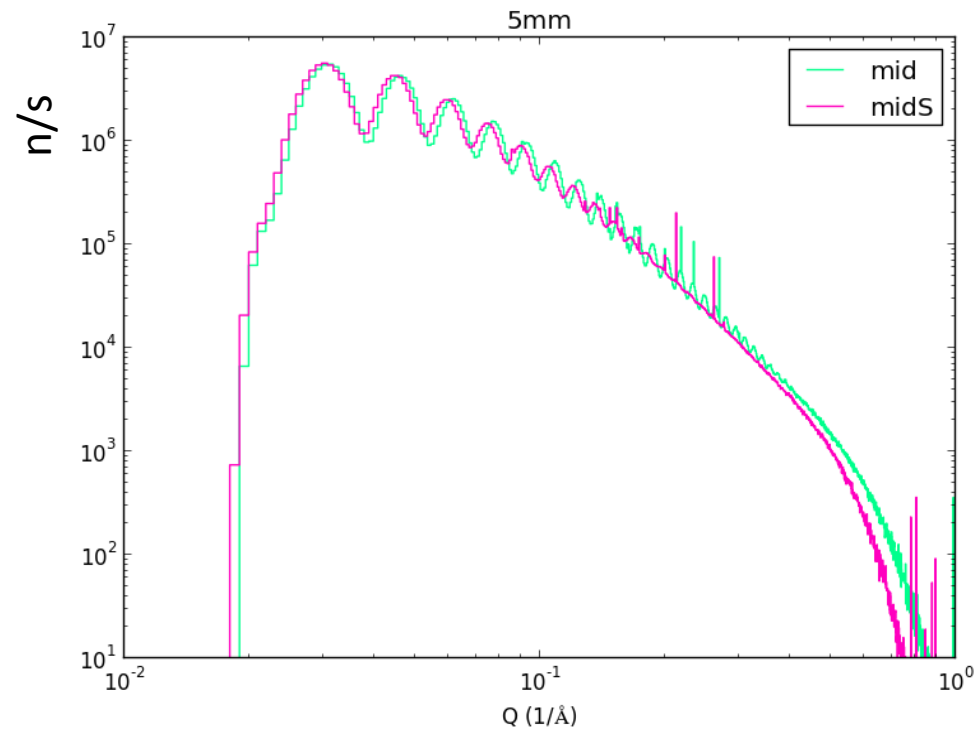
front (high angle)



xy neutron hit distributions for spheres (up) and water (down)



Extracting resolution requirements with McStas



- Compare the reconstructed Q with the Monte-Carlo Q for various detector spatial resolution values

Detector requirements for WF

	active area	θ coverage	spatial res.	local rates	instantaneous rates
0-angle	$\sim 70 \text{ cm}^2$	$0^\circ\text{-}0.5^\circ$	mm	$9 \times 10^8 \text{ Hz/cm}^2$	
low-angle	$0.25\text{-}1 \text{ m}^2$	$0.5^\circ\text{-}4^\circ$	3 mm	60 Hz/mm ² (S) 15 Hz/mm ² (W)	0.45/mm ² /ms (S) 2/cm ² /ms (W)
high-angle mid-panel front-panel	3.8 m ² 3.7 m ²	$4^\circ\text{-}15^\circ$ $15^\circ\text{-}45^\circ$	0.5-1 cm 1-3 cm	18 Hz/cm ² (S), 160 Hz/cm ² (W) 18 Hz/cm ² (S), 640 Hz/cm ² (W)	0.006/cm ² /ms(S), 2.3/cm ² /ms(W) 0.3/cm ² /ms(S), 5.4/cm ² /ms(W)

S: 200 Å spheres, W: water

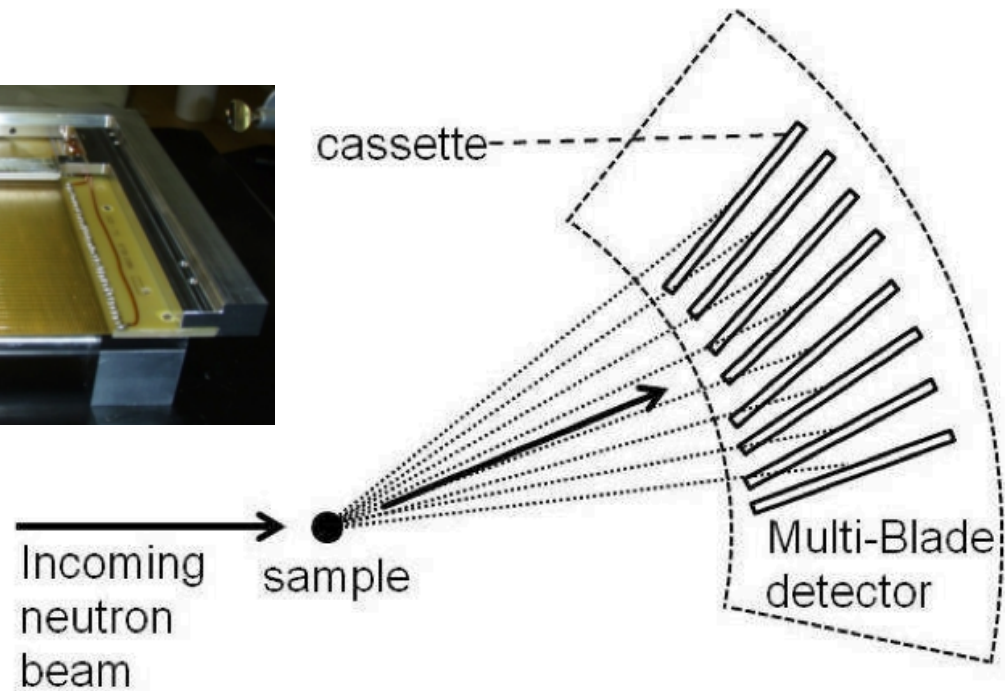
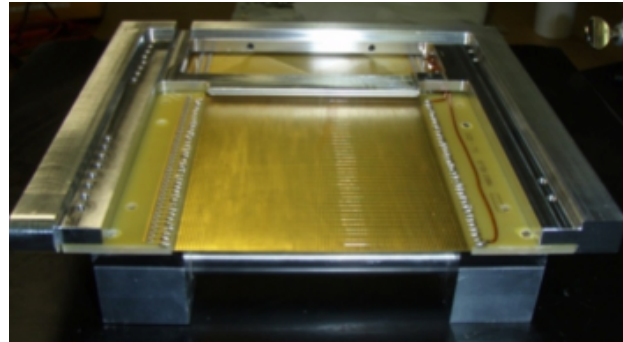
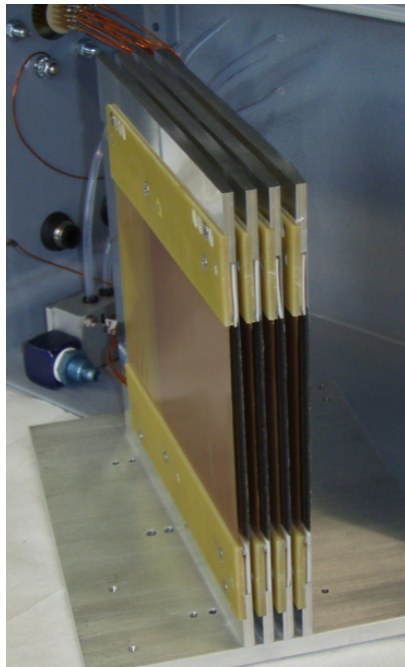
- spatial resolution
 - 3 mm for the rear detector
 - 8 mm for the middle panel
 - 15 mm for the front detector
- rates known within less than an order of magnitude

Detector options for LoKI

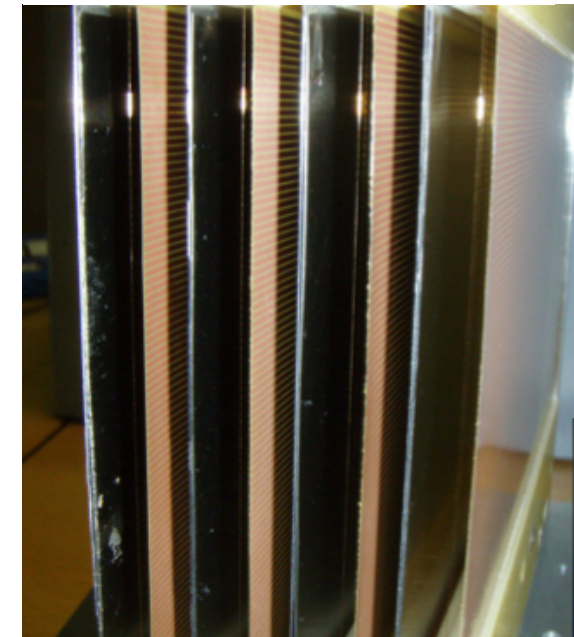
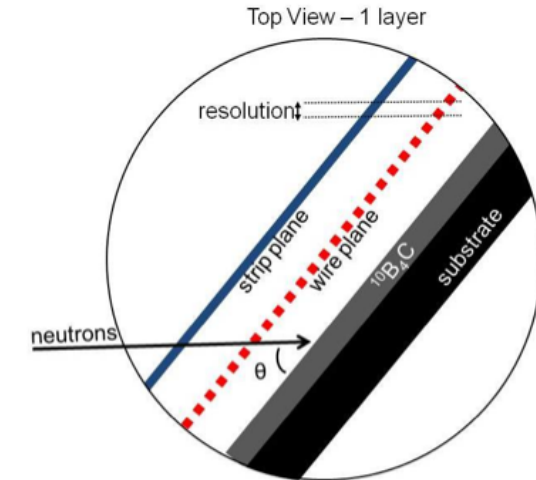
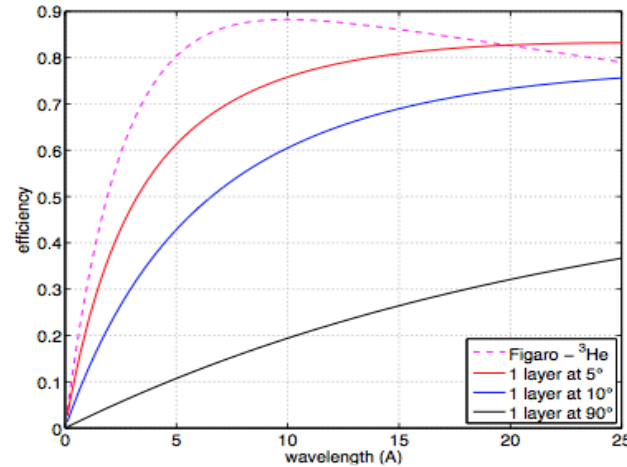
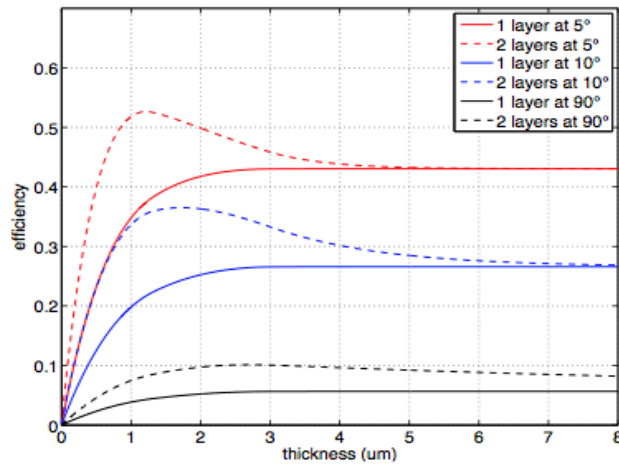
	spatial resolution	rate capability	cost	maturity
zero-angle				
gaseous detectors	ok	maybe	ok	development
scintillators	ok	maybe	ok	development
semiconductors	ok	ok	maybe	concept
fission chambers	ok	maybe	ok	development
micromegas	ok	ok	ok	concept
low-angle				
Multi-Blade	ok	ok	ok	prototype
MPGD/GEM	ok	ok	ok	concept
A1-CLD	ok	maybe	maybe	prototype
scintillators	maybe	maybe	maybe	development
³ He	no	no	no	mature
high-angle				
Multi-Blade	ok	ok	ok	prototype
MPGD/GEM	ok	ok	ok	concept
scintillators	ok	ok	no	N/A
³ He	ok	ok	no	N/A

Multi-Blade Detector (ILL/ESS/Linköping)

- Position sensitive ^{10}B (MWPC) gaseous detector originally developed for reflectometry
- Exploits grazing angle for high efficiency
- The inclined geometry results in improved spatial resolution and rate capability



Multi-Blade prototype performance

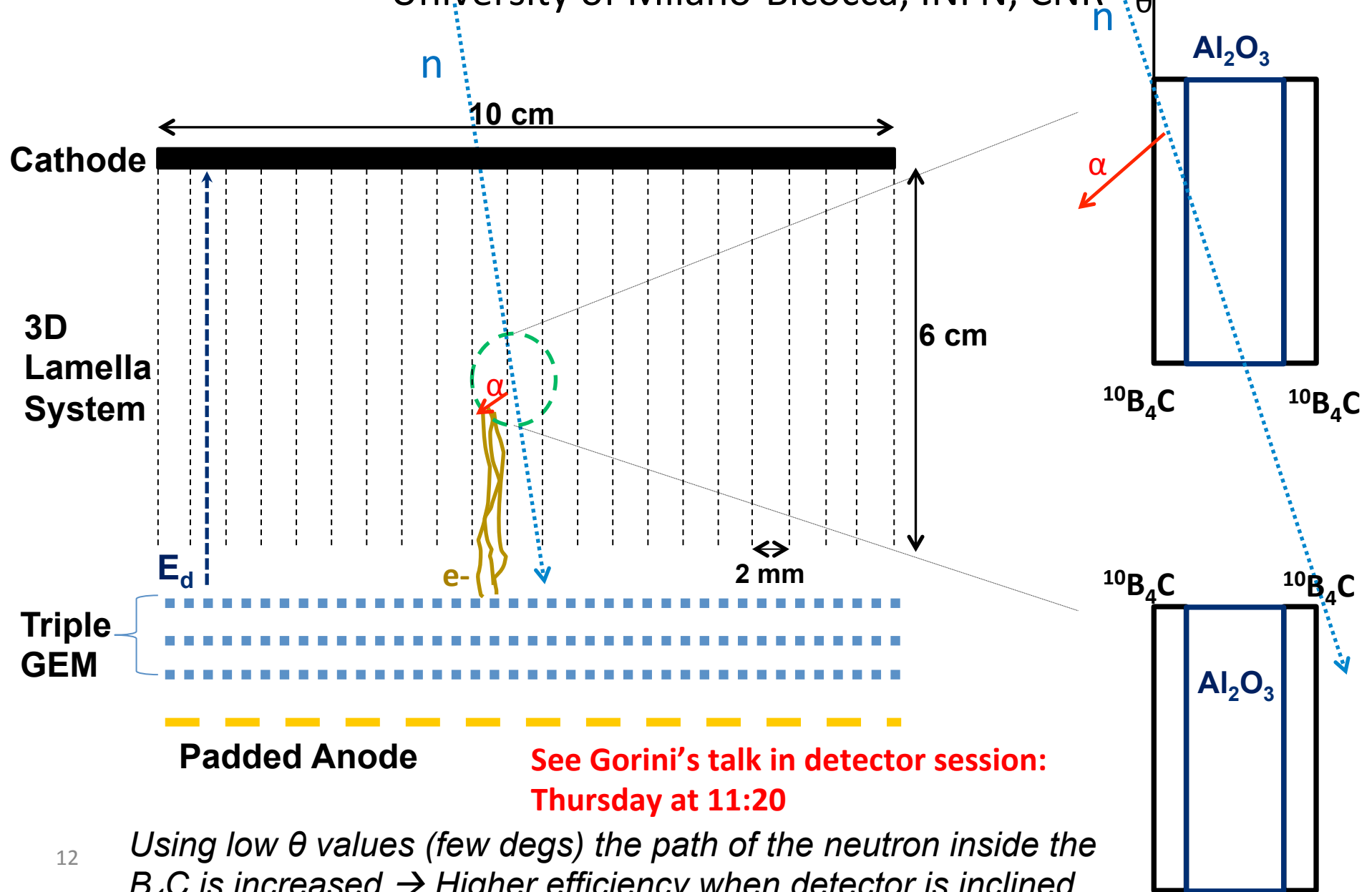


- position resolution: 0.6 mm x 4.4 mm for 10°
0.3 mm x 4 mm for 5°
- rate capability: 2 kHz/mm²
(an order of magnitude better than needed)
- measured efficiency: 27.8% ± 0.2% at 2.5 Å at 10°

**See Piscitelli's talk in detector session:
Thursday at 11:40**

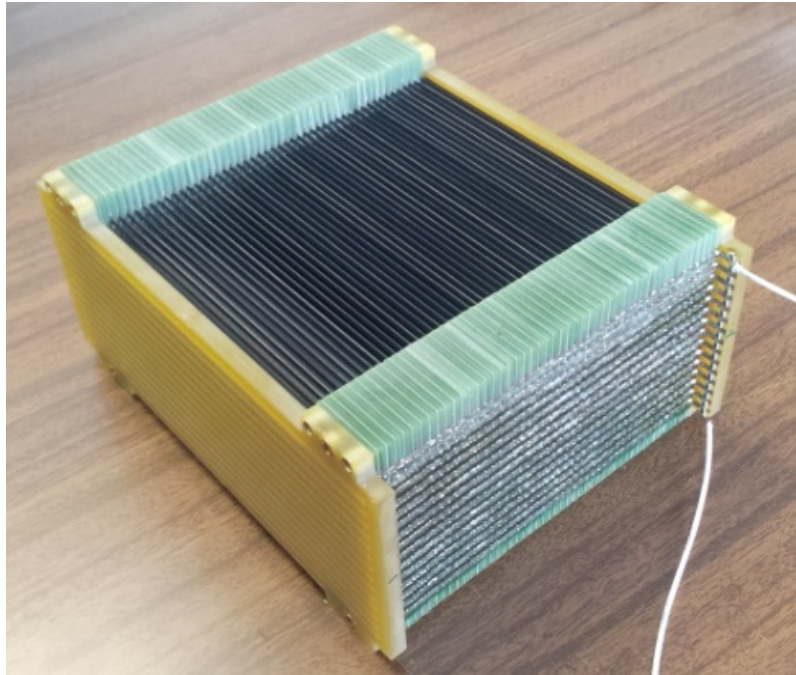
Boron Array Neutron Detector (BAND-GEM)

University of Milano-Bicocca, INFN, CNR

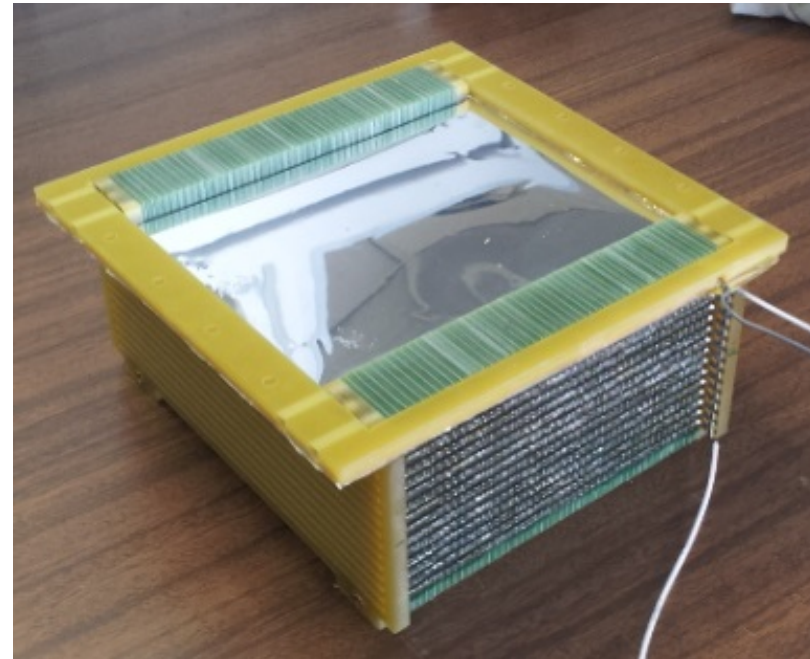


Using low θ values (few degs) the path of the neutron inside the B_4C is increased \rightarrow Higher efficiency when detector is inclined

Detector Assembly (1)

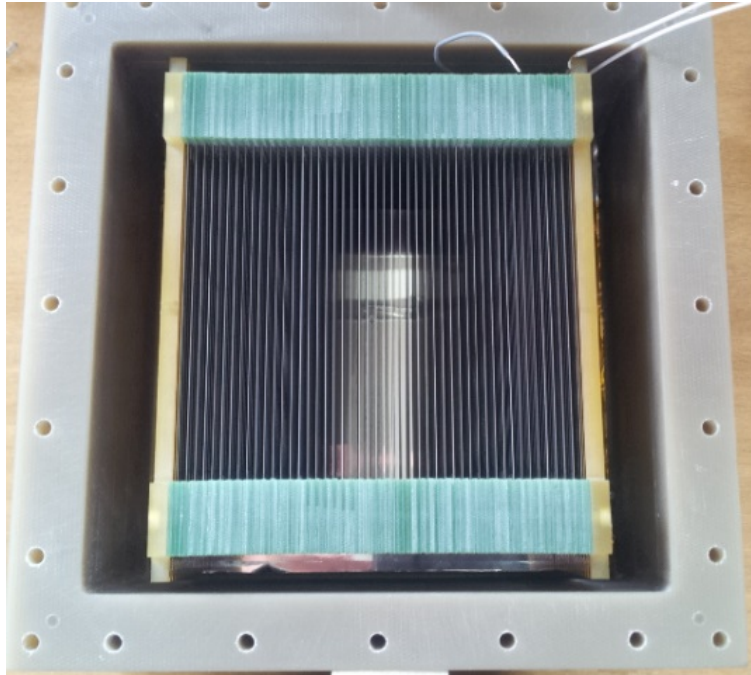


The full Lamella System. A total of 48 lamellas have been mounted mounted. Their distance is 2 mm

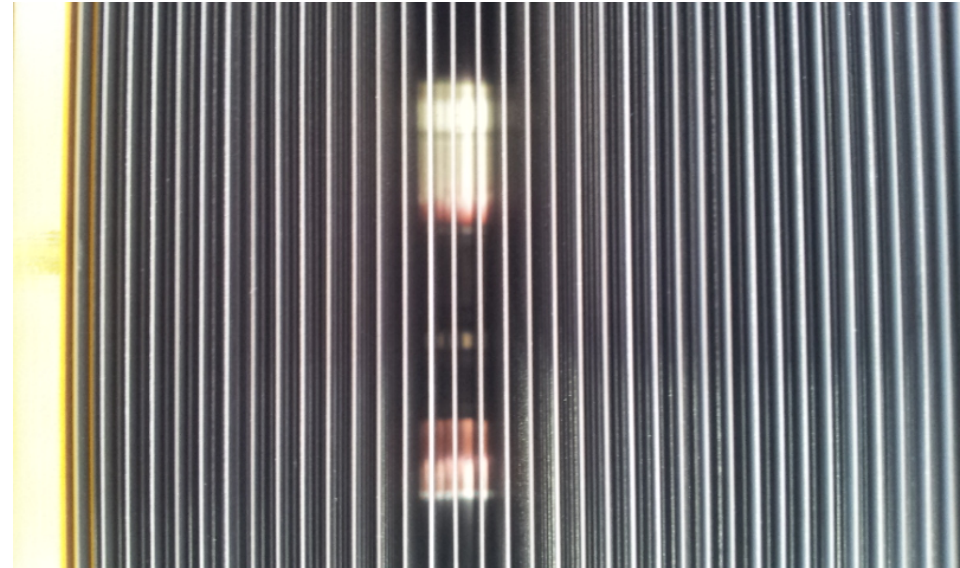


An aluminium cathode (few microns thick) has been mounted on top

Detector Assembly (2)

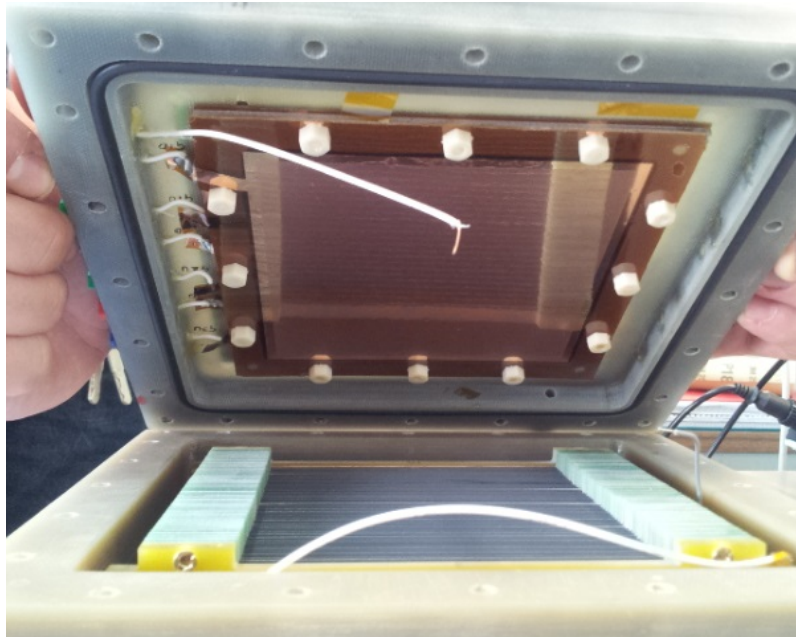


3D cathode mounted inside the
detector box

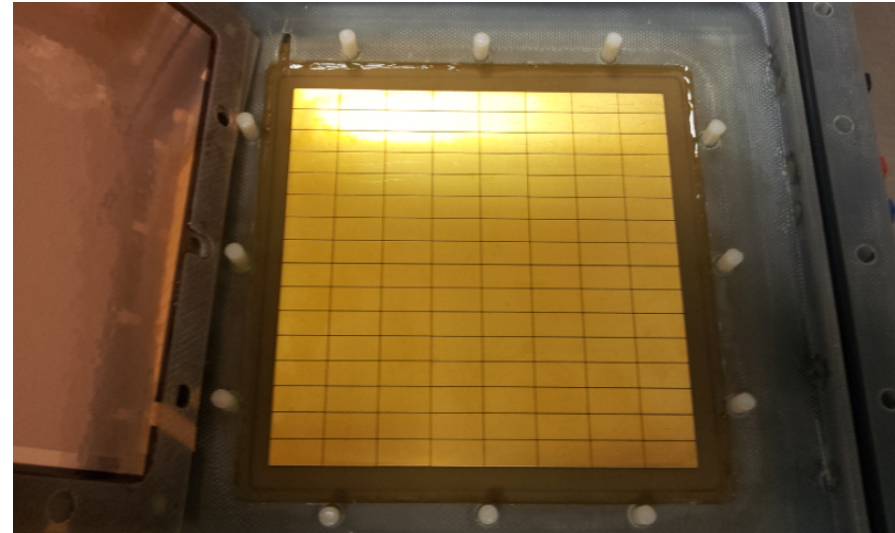


Zoom of the lamellae

Detector Assembly (3)

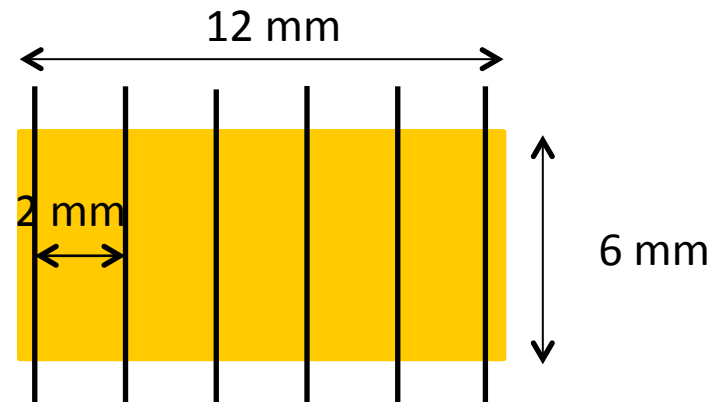


Assembly with Triple GEM detector



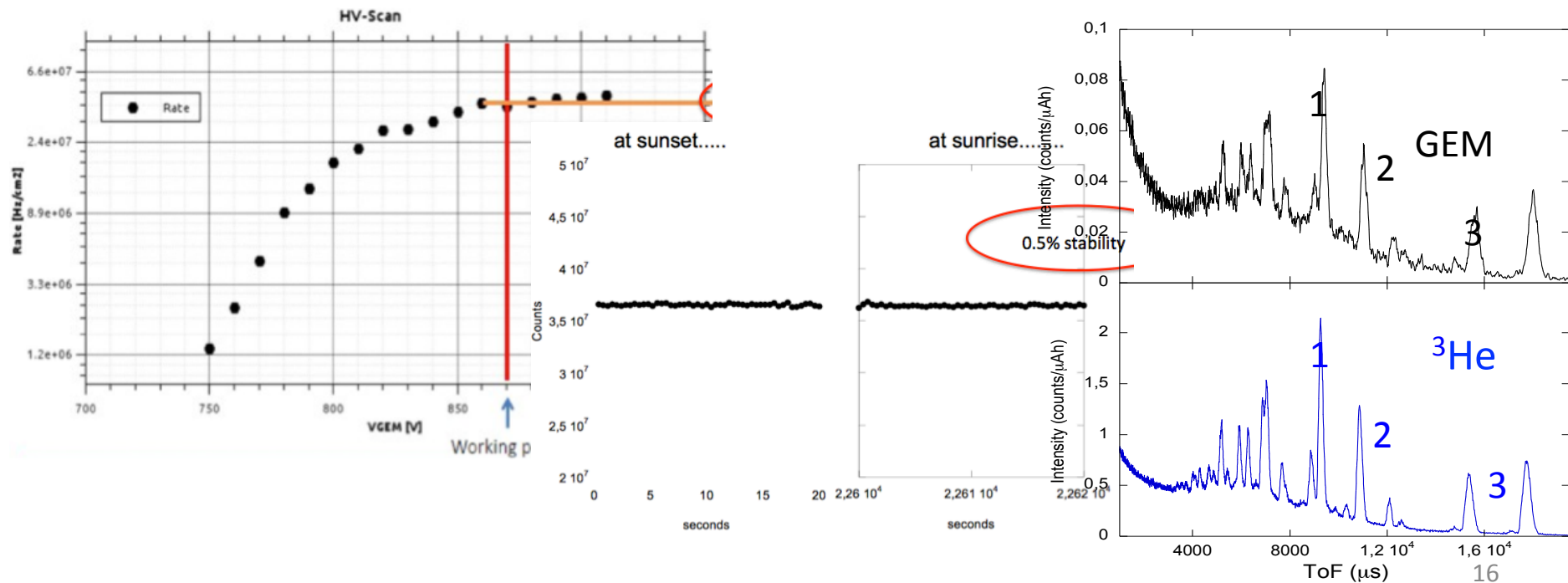
128 Pads of area $6 \times 12 \text{ mm}^2$ have been used as anode

Lamella disposition on the pads



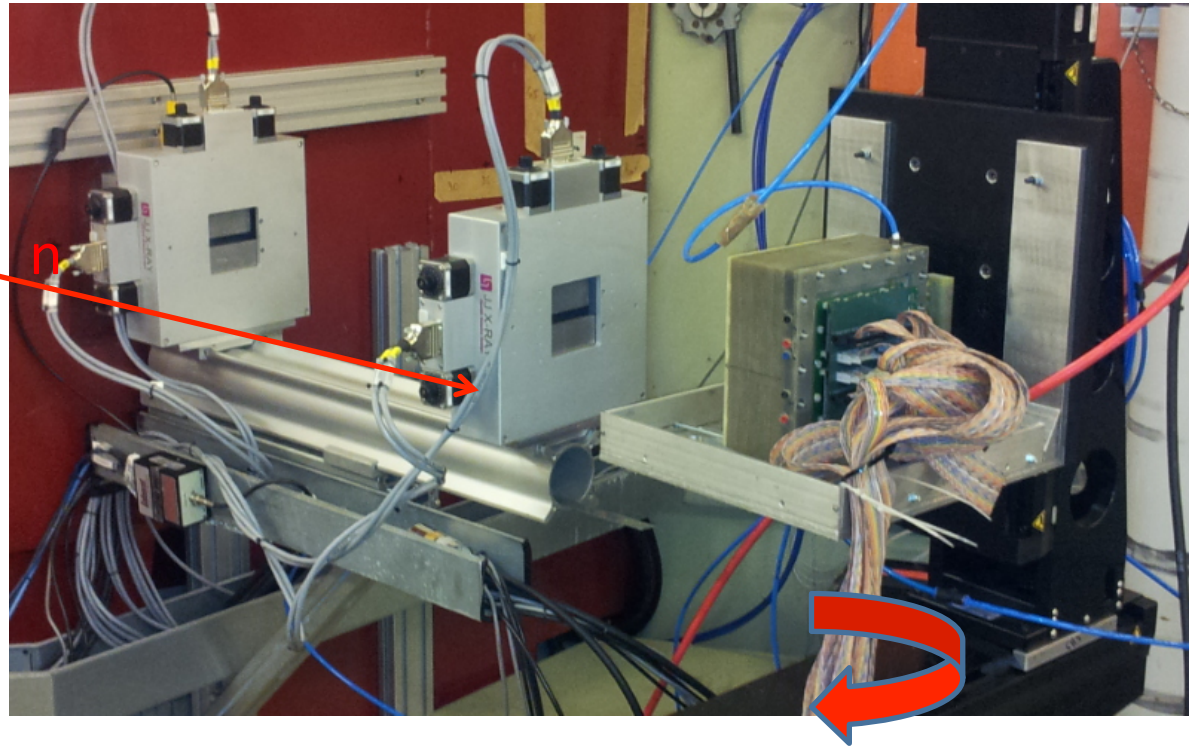
BAND-GEM performance evaluation

- Rate capability 40 MHz/cm²
- Stability ~ 0.5%
- Tests at the INES diffractometer
- Efficiency measurements in Kjeller



Detector test at IFE (JEEP II reactor, R2D2 beamline)

$\lambda = 1.54 \text{ \AA}$, $E = 34.5 \text{ meV}$
 $\lambda = 2 \text{ \AA}$, $E = 20.45 \text{ meV}$



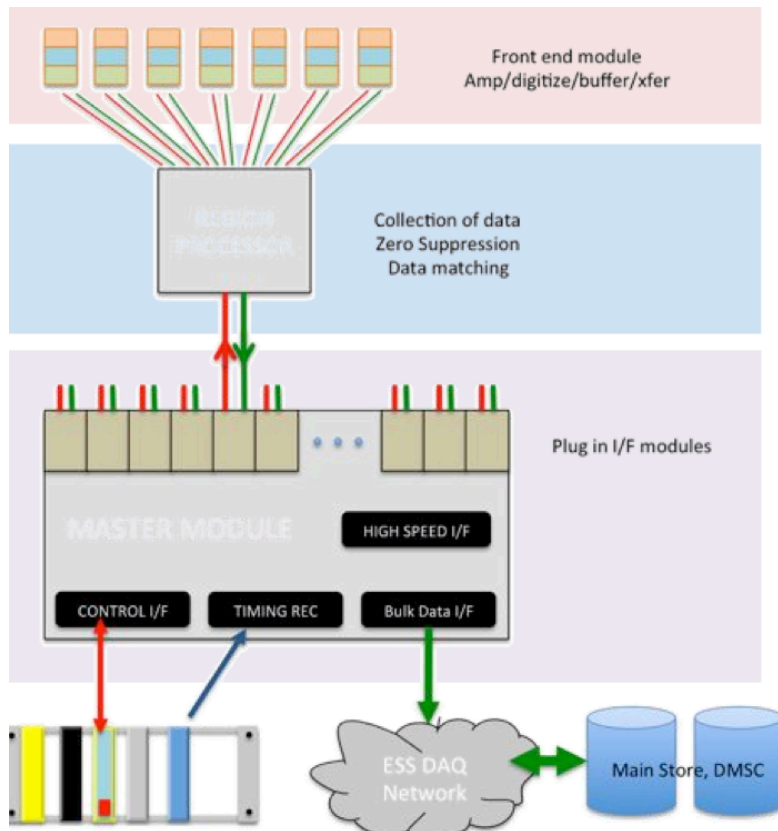
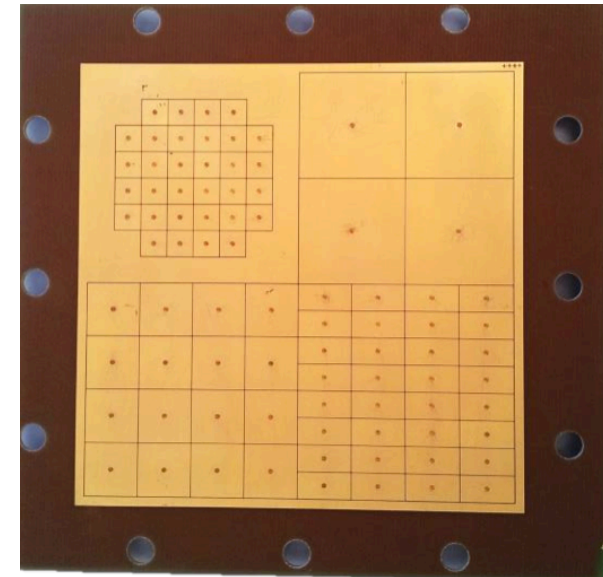
Preliminary raw data from 2 months ago, analysis not yet complete

$\epsilon_{\text{GEM}} = 18.27 \%$ at $E_n = 34.5 \text{ meV}$, (1.54 \AA), as expected from simulation

Expected $\epsilon_{\text{GEM}} = 21.5 \%$ at $E_n = 25 \text{ meV}$ (1.8 \AA)

Electronics

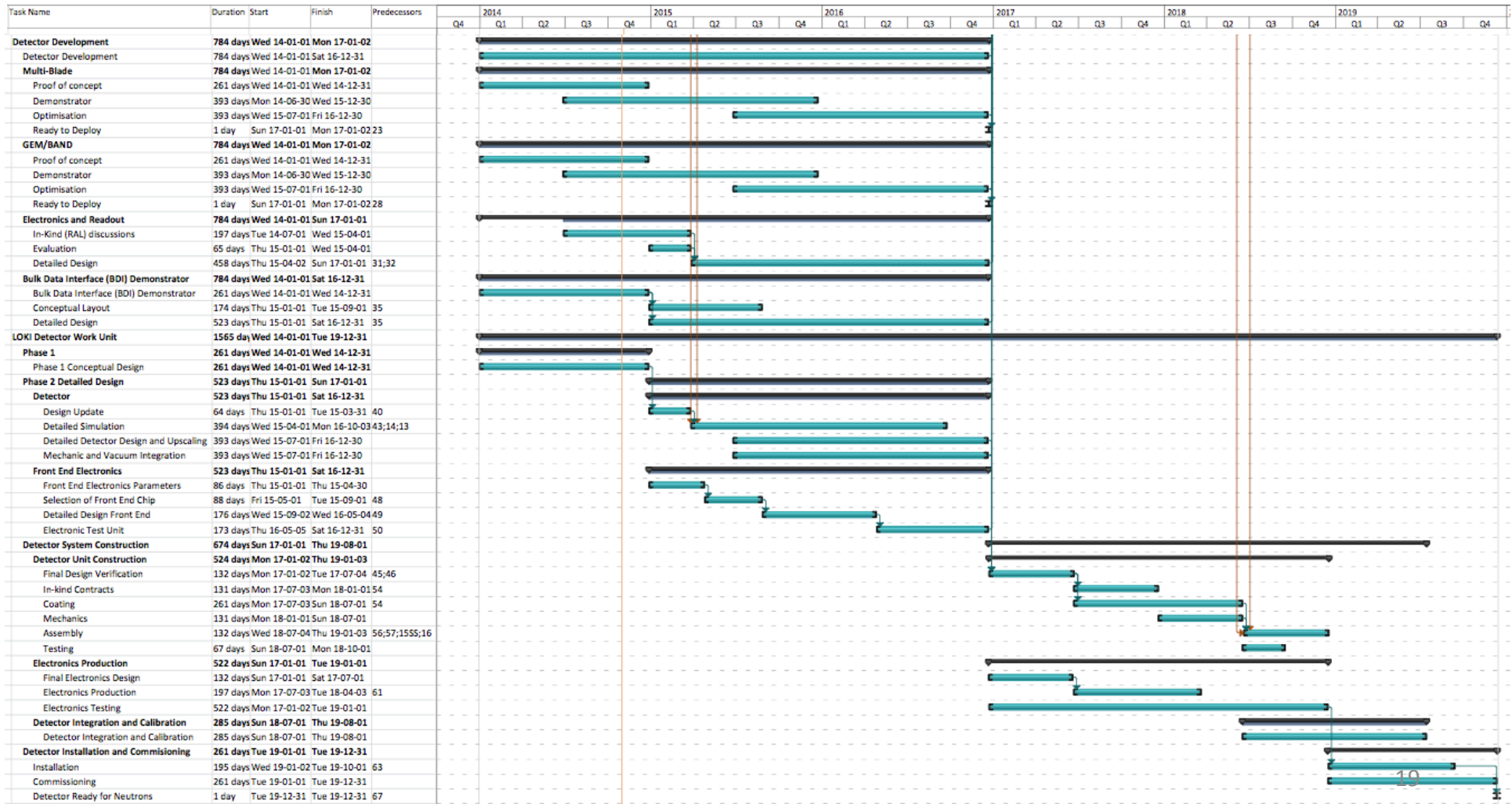
- See Kolya's talk in detector session:
Thursday at 12:20
- See Gahl's talk today at 12:10



Name	Customer	Maker	Type	Chan	Shaping	Det Cap (pF)	Sens (mV/fC)	Noise	Timestamp
Carioca	LHCb Muon (MWPC)	CERN/INFN	Discriminator A-S-D MWPC	8	15nsec	<220pF	~10	~6000e (100pF)	N/A
GEMROK (MSGCROK derivative)	DETRI Neutrons	Krakov Heidelberg HMI Berlin	A-2S-PD-A-T MSGC/GEM Peak Analog Pipe Prompt disc TS	32	Dual 25/85nsec	aim 25pF	2	aim 2000e	12-14 bit 8nsec
APV25	CMS Tracker (Si Strip)	RAL	Analog Pipe A-S-BUF	128	50nsec +fast deconvolve ASIC used for R&D	low	~1mA/fC Current output	~2000e 430+61/pF	LHC
VFAT	CMS	CEA INFN CERN	Disc Pipe A-S-D-BUF	128	25-400nsec	5-80pF	1-50	~1000 + 40/pF (1100)	LHC
CBC	CMS Si Strip	RAL	A-S-D Analog prototype	128	20nsec	3-6pF	50	~1000e at 10pF	Pipe only
VMM	Atlas Muon Micromegas Thin gap	BNL	A-S-D-PA-TOT	64	25-200nsec	wide	1-9	~1000e at 100pF	N/A
VMM2			+6bit peak FADC 10bit slowADC						

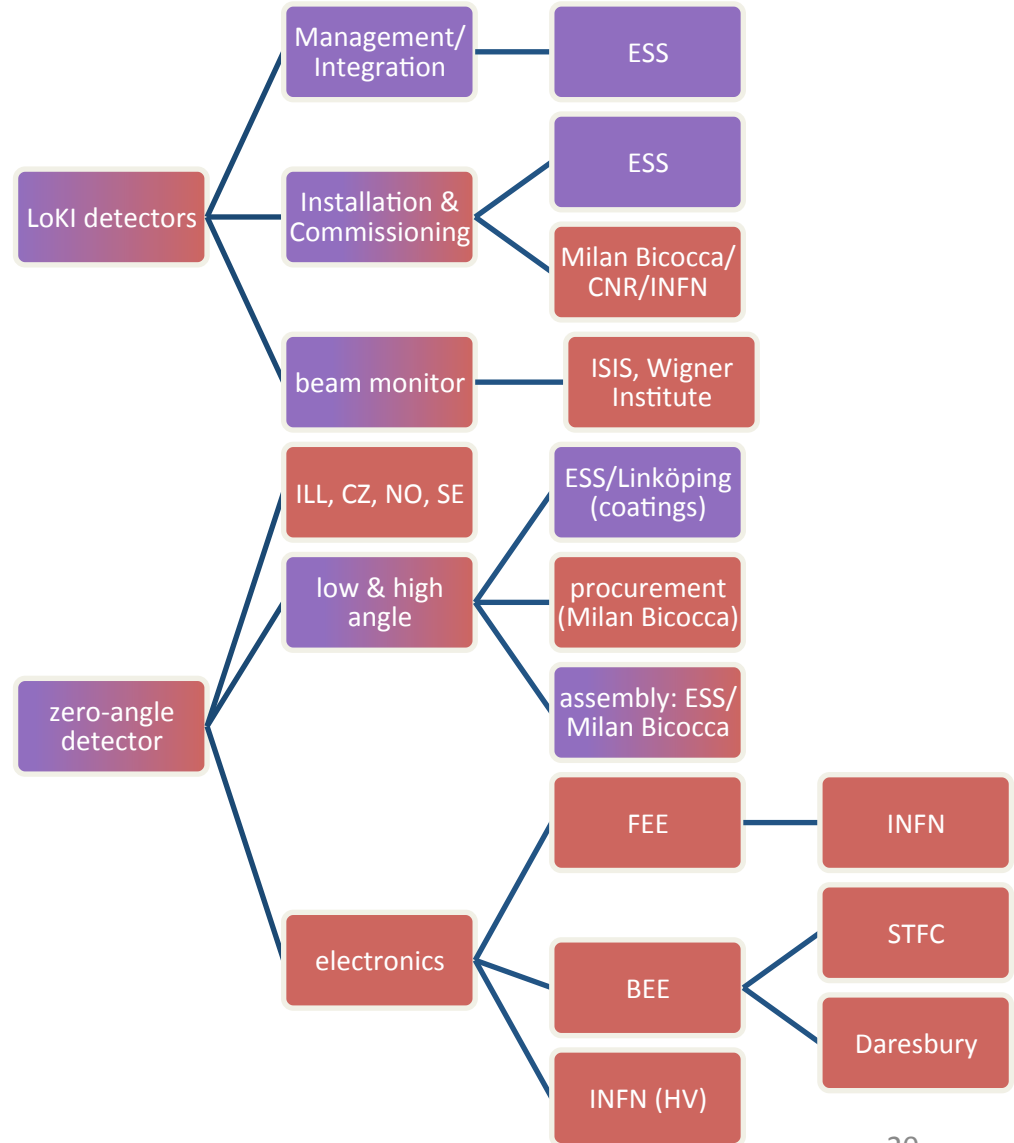
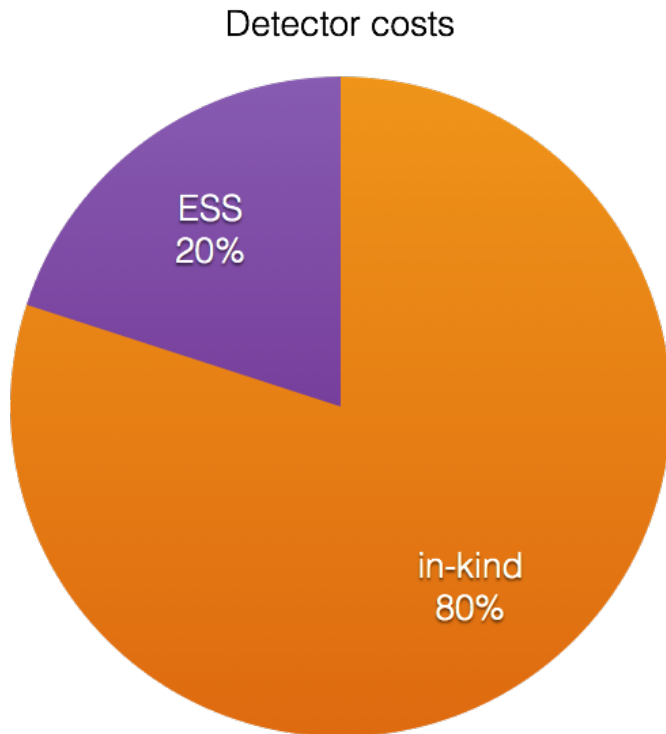
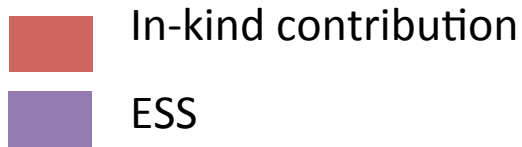
Schedule – Detector work unit

- Schedule exists for detectors and beam monitors
- Schedule is integrated/coordinated with corresponding items within detector systems



Involving the partners

- In-kind plan in place
- >80% in-kind detector costs



Summary

- Phase 1 was about
 - requirements
 - identification of detector solutions
 - engaging with in-kind partners
 - schedule implementation
- Phase 1 technical documents to be merged into a CDR
- Phase 2 will be about
 - following the schedule
 - implementing the technical solutions
- Phase 2 documents to be merged into a TDR