MOLLER Main Detector

Key Performance Parameters (KPP)
and
Task list

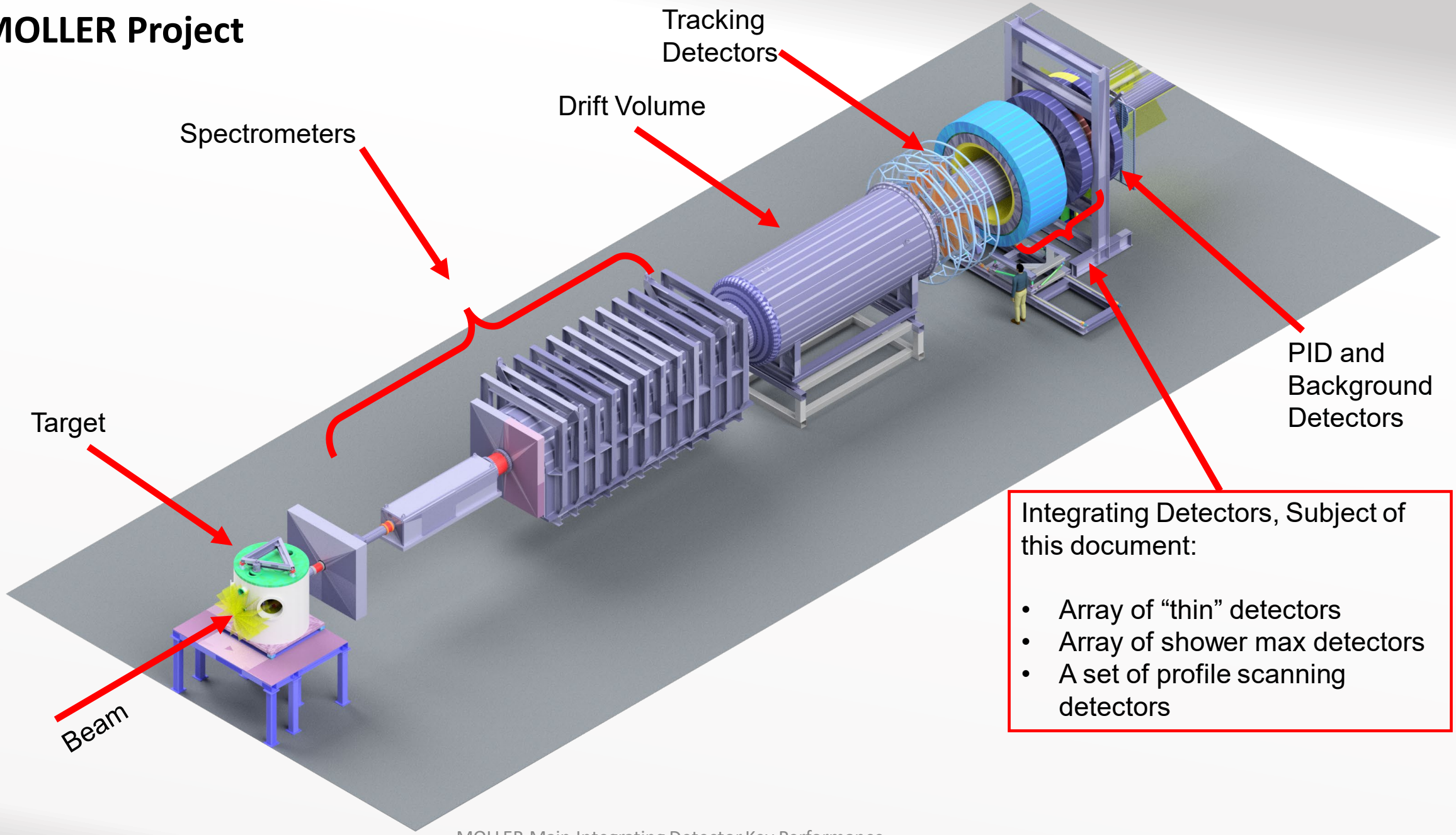
This is a starting compilation of Performance/Operational Parameters and Criteria for the Main Integrating Detectors.

The slides also includes a list of development and construction jobs for the main detector components and the people associated with that work (or yet unclaimed / unassigned jobs).

These slides will be presented and discussed in the bi-weekly Integrating Detector phone conference meetings and should be considered a work in progress until there is general agreement on the parameters and the development work details.

There will be an accompanying document that should reach its final state within the next few months, but at the least by the time of the 60% design review for the main detectors.

The MOLLER Project



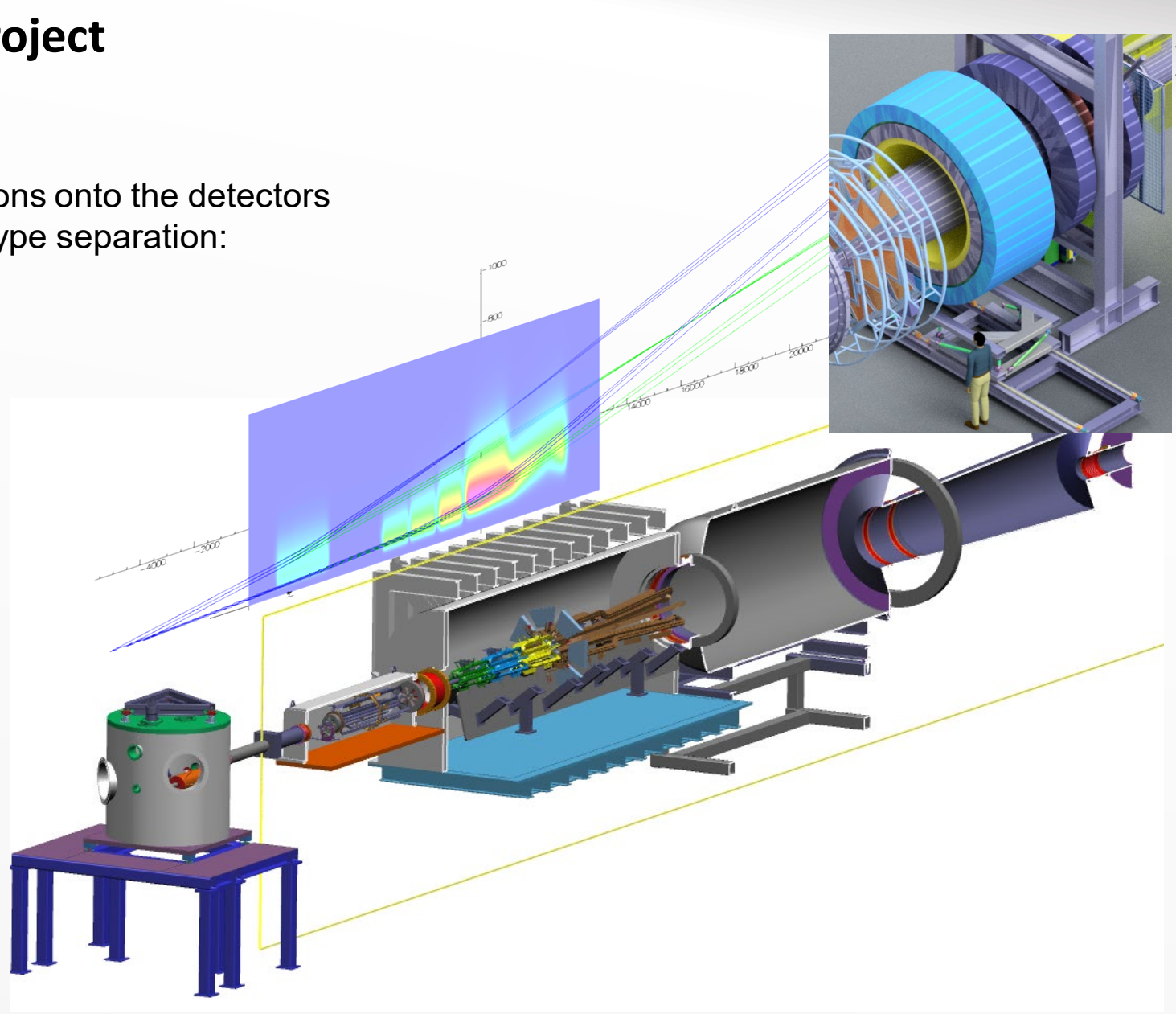
Integrating Detectors, Subject of this document:

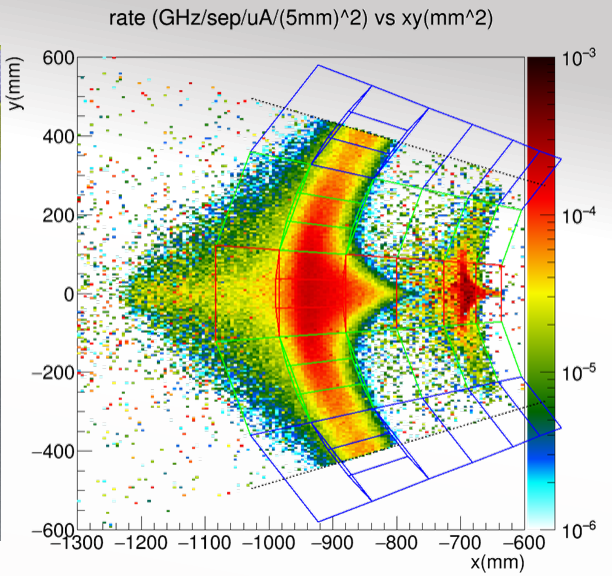
- Array of “thin” detectors
- Array of shower max detectors
- A set of profile scanning detectors

The MOLLER Project

The spectrometer:

- Steers the electrons onto the detectors
- Performs event type separation:





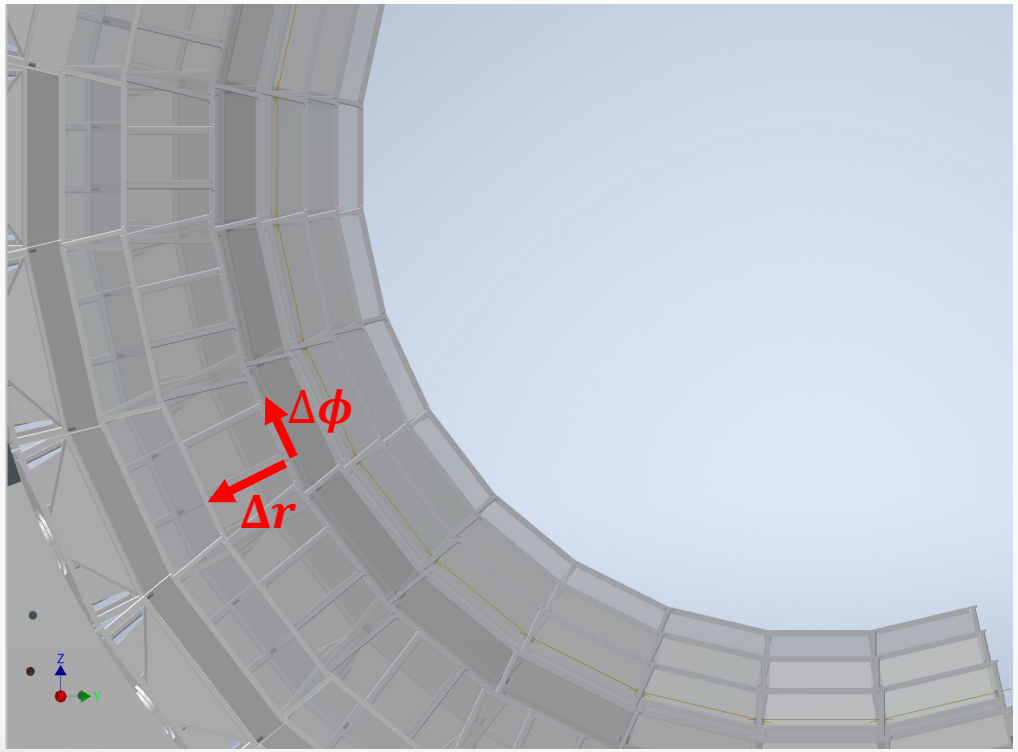
The scattering profile in the detector planes has to be separated into a suitable number of radial and azimuthal bins to allow:

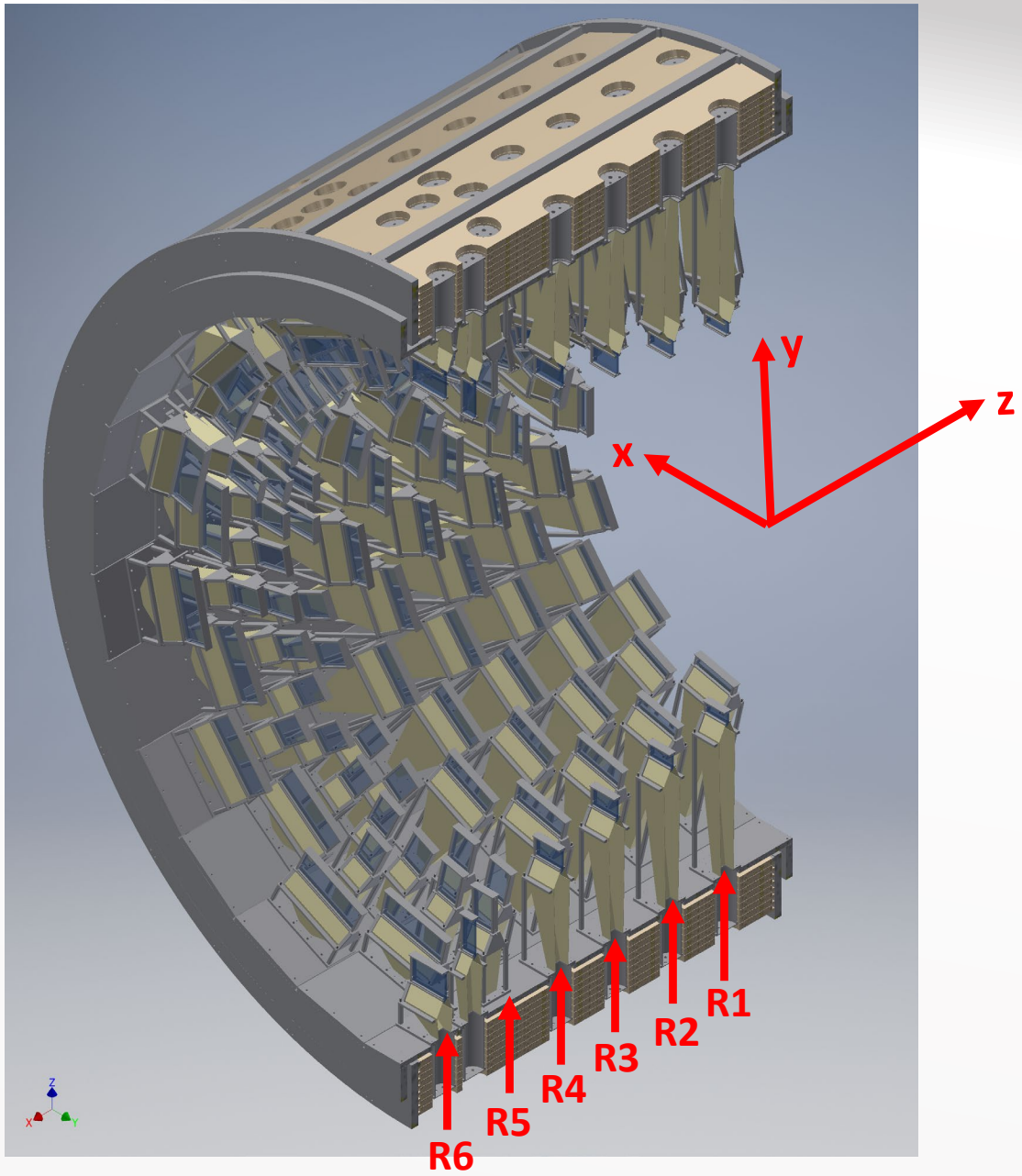
- Event separation,
- Statistics collection
- Control of systematic effects, such
  - Beam effects
  - Backgrounds

Integrating Detectors

Coordinate System:

- z: beam direction
- y: beam up
- x: beam left
- Δr: size of detector tile in the radial direction
- $\Delta \phi$: width size of detector tile
- Δz: thickness of detector tile

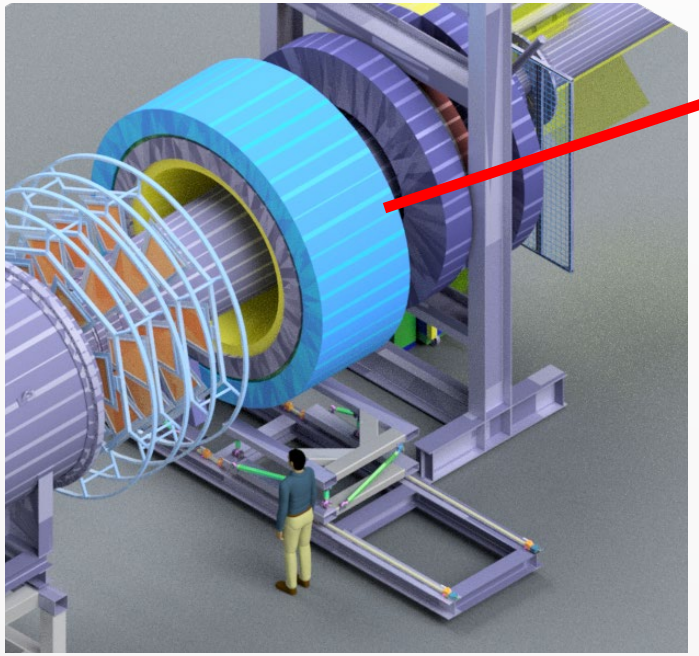


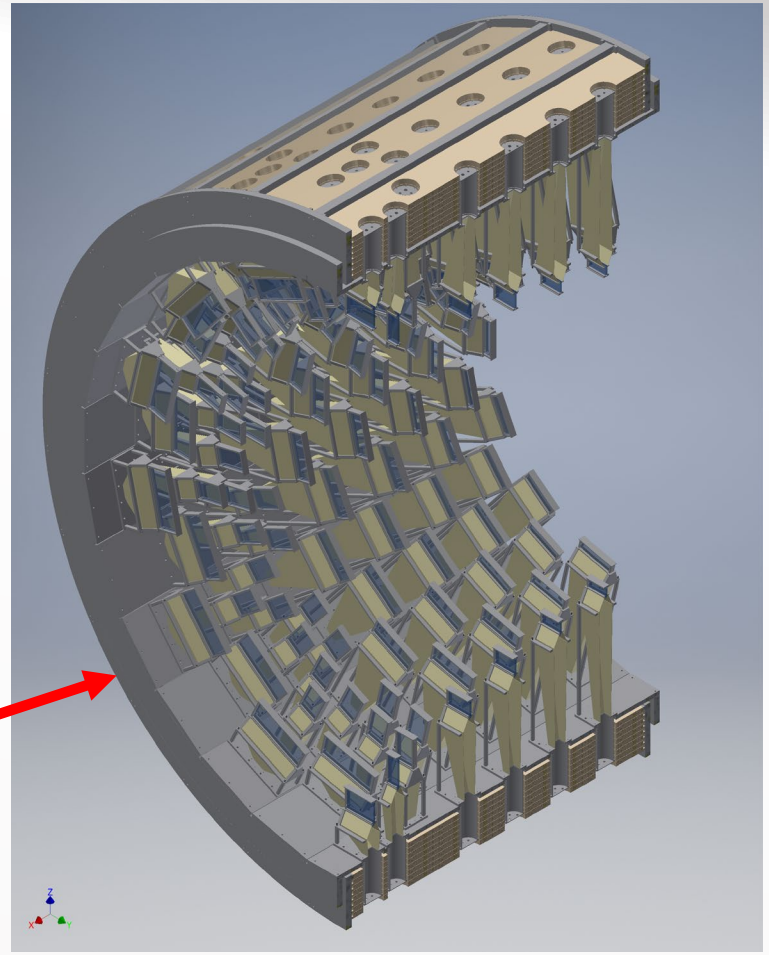


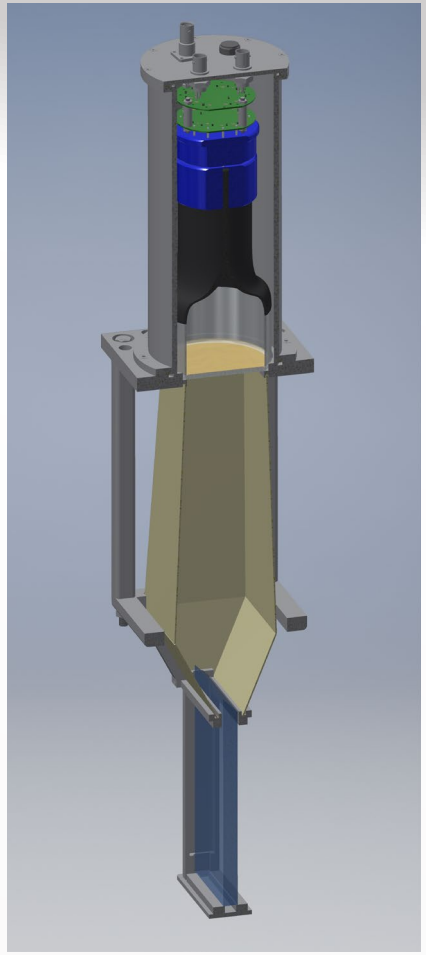
The Thin Integrating Detectors

The detector package consists of 224 separate detector modules, including:

1. Mounting structure
2. Quartz active material
3. Light guide
4. Photo-multiplier tube and base
5. Preamplifier
6. Cabling
7. Cooling/dry air flushing







Integrating Detector Positioning and Size

Detector size:

Subsystem	Parameter	Description	Value		
Thin Integrating Detectors	Exclusion Zone	Overall size including PMTs and patch panels (not including floor offset)	$r = 170\ cm$	$\phi = 2\pi$	$dz = 200\ cm$
	Detector Coverage	Active area of detector array	$70\ cm \leq r \leq 120\ cm$	$\phi = 2\pi$	$dz = 140\ cm$
	Segmentation	224 total detector tiles	$6\ in\ r$	28 in ϕ for $R = 1,2,3,4,6$	84 in ϕ for $R = 5$
	Tile Size	Ring 1 Open (R1O)	$\Delta r = a \pm \delta a\ cm$	$\Delta\phi = a \pm \delta a\ cm$	$\Delta z = a \pm \delta a\ cm$
		Ring 1 Closed (R1C)	$\Delta r = a \pm \delta a\ cm$	$\Delta\phi = a \pm \delta a\ cm$	$\Delta z = a \pm \delta a\ cm$
		Ring 1 Transition (R1T)	$\Delta r = a \pm \delta a\ cm$	$\Delta\phi = a \pm \delta a\ cm$	$\Delta z = a \pm \delta a\ cm$
		Ring 2 Open (R2O)	$\Delta r = a \pm \delta a\ cm$	$\Delta\phi = a \pm \delta a\ cm$	$\Delta z = a \pm \delta a\ cm$
		Ring 2 Closed (R2C)	$\Delta r = a \pm \delta a\ cm$	$\Delta\phi = a \pm \delta a\ cm$	$\Delta z = a \pm \delta a\ cm$
		Ring 2 Transition (R2T)	$\Delta r = a \pm \delta a\ cm$	$\Delta\phi = a \pm \delta a\ cm$	$\Delta z = a \pm \delta a\ cm$
		Ring 3 Open (R3O)	$\Delta r = a \pm \delta a\ cm$	$\Delta\phi = a \pm \delta a\ cm$	$\Delta z = a \pm \delta a\ cm$
		Ring 3 Closed (R3C)	$\Delta r = a \pm \delta a\ cm$	$\Delta\phi = a \pm \delta a\ cm$	$\Delta z = a \pm \delta a\ cm$
		Ring 3 Transition (R3T)	$\Delta r = a \pm \delta a\ cm$	$\Delta\phi = a \pm \delta a\ cm$	$\Delta z = a \pm \delta a\ cm$
		Ring 4 Open (R4O)	$\Delta r = a \pm \delta a\ cm$	$\Delta\phi = a \pm \delta a\ cm$	$\Delta z = a \pm \delta a\ cm$
		Ring 4 Closed (R4C)	$\Delta r = a \pm \delta a\ cm$	$\Delta\phi = a \pm \delta a\ cm$	$\Delta z = a \pm \delta a\ cm$
		Ring 4 Transition (R1T)	$\Delta r = a \pm \delta a\ cm$	$\Delta\phi = a \pm \delta a\ cm$	$\Delta z = a \pm \delta a\ cm$

Integrating Detector Positioning and Size

Detector size:

Subsystem	Parameter	Description	Value		
Thin Integrating Detectors	Tile Size	Ring 6 Open (R6O)	$\Delta r = a \pm \delta a\ cm$	$\Delta\phi = a \pm \delta a\ cm$	$\Delta z = a \pm \delta a\ cm$
		Ring 6 Closed (R6C)	$\Delta r = a \pm \delta a\ cm$	$\Delta\phi = a \pm \delta a\ cm$	$\Delta z = a \pm \delta a\ cm$
		Ring 6 Transition (R6T)	$\Delta r = a \pm \delta a\ cm$	$\Delta\phi = a \pm \delta a\ cm$	$\Delta z = a \pm \delta a\ cm$
		Ring 5 Open (center) (R5Oc)	$\Delta r = a \pm \delta a\ cm$	$\Delta\phi = a \pm \delta a\ cm$	$\Delta z = a \pm \delta a\ cm$
		Ring 2 Open (side) (R5Os)	$\Delta r = a \pm \delta a\ cm$	$\Delta\phi = a \pm \delta a\ cm$	$\Delta z = a \pm \delta a\ cm$
		Ring 5 Closed (center) (R5Cc)	$\Delta r = a \pm \delta a\ cm$	$\Delta\phi = a \pm \delta a\ cm$	$\Delta z = a \pm \delta a\ cm$
		Ring 2 Closed (side) (R5Cs)	$\Delta r = a \pm \delta a\ cm$	$\Delta\phi = a \pm \delta a\ cm$	$\Delta z = a \pm \delta a\ cm$
		Ring 5 Transition (center) (R5Tc)	$\Delta r = a \pm \delta a\ cm$	$\Delta\phi = a \pm \delta a\ cm$	$\Delta z = a \pm \delta a\ cm$
		Ring 2 Transition (side) (R5Ts)	$\Delta r = a \pm \delta a\ cm$	$\Delta\phi = a \pm \delta a\ cm$	$\Delta z = a \pm \delta a\ cm$
Shower Max Detectors	Exclusion Zone	Overall size including PMTs and patch panels (not including floor offset)	$r = 170\ cm$	$\phi = 2\pi$	$\Delta z = 30\ cm$
	Detector Coverage	Active area of detector array	$95\ cm \leq r \leq 106\ cm$	$\phi = 2\pi$	$\Delta z = 15\ cm$
	Segmentation	28 total detector tiles	$1\ in\ r$	28 in ϕ for $R = 5$	
		Open (SM6O)	$\Delta r = a \pm \delta a\ cm$	$\Delta\phi = a \pm \delta a\ cm$	$\Delta z = a \pm \delta a\ cm$
		Closed (SM6C)	$\Delta r = a \pm \delta a\ cm$	$\Delta\phi = a \pm \delta a\ cm$	$\Delta z = a \pm \delta a\ cm$
		Transition (SM6T)	$\Delta r = a \pm \delta a\ cm$	$\Delta\phi = a \pm \delta a\ cm$	$\Delta z = a \pm \delta a\ cm$
Scanner	Detector Size	(place holder)	$\Delta r = a \pm \delta a\ cm$	$\Delta\phi = a \pm \delta a\ cm$	$\Delta z = a \pm \delta a\ cm$
Scanner	Detector Size	(place holder)	$\Delta r = a \pm \delta a\ cm$	$\Delta\phi = a \pm \delta a\ cm$	$\Delta z = a \pm \delta a\ cm$

Integrating Detector Positioning and Size

Detector position:

Subsystem	Parameter	Description	Value		
Thin Integrating Detectors	Position of detector array	Absolute position of array	$r = 0 \pm 0.3\ cm$		$z = a \pm 0.3\ cm$
	Position of tile center w.r.t. array center	Ring 1 Open (R1O)	$r = a \pm 0.3\ cm$	$\phi = a \pm 0.3\ cm$	$z = a \pm 0.3\ cm$
		Ring 1 Closed (R1C)	$r = a \pm 0.3\ cm$	$\phi = a \pm 0.3\ cm$	$z_T = a \pm 0.3\ cm$
		Ring 1 Transition (R1T)	$r = a \pm 0.3\ cm$	$\phi = a \pm 0.3\ cm$	$z_T = a \pm 0.3\ cm$
		Ring 2 Open (R2O)	$r = a \pm 0.3\ cm$	$\phi = a \pm 0.3\ cm$	$z_T = a \pm 0.3\ cm$
		Ring 2 Closed (R2C)	$r = a \pm 0.3\ cm$	$\phi = a \pm 0.3\ cm$	$z_T = a \pm 0.3\ cm$
		Ring 2 Transition (R2T)	$r = a \pm 0.3\ cm$	$\phi = a \pm 0.3\ cm$	$z_T = a \pm 0.3\ cm$
		Ring 3 Open (R3O)	$r = a \pm 0.3\ cm$	$\phi = a \pm 0.3\ cm$	$z_T = a \pm 0.3\ cm$
		Ring 3 Closed (R3C)	$r = a \pm 0.3\ cm$	$\phi = a \pm 0.3\ cm$	$z_T = a \pm 0.3\ cm$
		Ring 3 Transition (R3T)	$r = a \pm 0.3\ cm$	$\phi = a \pm 0.3\ cm$	$z_T = a \pm 0.3\ cm$
		Ring 4 Open (R4O)	$r = a \pm 0.3\ cm$	$\phi = a \pm 0.3\ cm$	$z_T = a \pm 0.3\ cm$
		Ring 4 Closed (R4C)	$r = a \pm 0.3\ cm$	$\phi = a \pm 0.3\ cm$	$z_T = a \pm 0.3\ cm$
		Ring 4 Transition (R1T)	$r = a \pm 0.3\ cm$	$\phi = a \pm 0.3\ cm$	$z_T = a \pm 0.3\ cm$
		Ring 6 Open (R6O)	$r = a \pm 0.3\ cm$	$\phi = a \pm 0.3\ cm$	$z_T = a \pm 0.3\ cm$
		Ring 6 Closed (R6C)	$r = a \pm 0.3\ cm$	$\phi = a \pm 0.3\ cm$	$z_T = a \pm 0.3\ cm$
		Ring 6 Transition (R6T)	$r = a \pm 0.3\ cm$	$\phi = a \pm 0.3\ cm$	$z_T = a \pm 0.3\ cm$

Integrating Detector Positioning and Size

Detector position:

Subsystem	Parameter	Description	Value		
Thin Integrating Detectors	Position of tile center	Ring 5 Open (center) (R5Oc)	$r = a \pm 0.3\ cm$	$\phi = a \pm 0.3\ cm$	$z = a \pm 0.3\ cm$
		Ring 2 Open (side) (R5Os)	$r = a \pm 0.3\ cm$	$\phi = a \pm 0.3\ cm$	$z = a \pm 0.3\ cm$
		Ring 5 Closed (center) (R5Cc)	$r = a \pm 0.3\ cm$	$\phi = a \pm 0.3\ cm$	$z = a \pm 0.3\ cm$
		Ring 2 Closed (side) (R5Cs)	$r = a \pm 0.3\ cm$	$\phi = a \pm 0.3\ cm$	$z = a \pm 0.3\ cm$
		Ring 5 Transition (center) (R5Tc)	$r = a \pm 0.3\ cm$	$\phi = a \pm 0.3\ cm$	$z = a \pm 0.3\ cm$
		Ring 2 Transition (side) (R5Ts)	$r = a \pm 0.3\ cm$	$\phi = a \pm 0.3\ cm$	$z = a \pm 0.3\ cm$
Shower Max Detectors	Position of detector array	Absolute position of array	$r = 0 \pm 0.3\ cm$		$z = a \pm 0.3\ cm$
	Position of tile center w.r.t. array center	Open (SM6O)	$r = a \pm 0.3\ cm$	$\phi = a \pm 0.3\ cm$	$z = a \pm 0.3\ cm$
		Closed (SM6C)	$r = a \pm 0.3\ cm$	$\phi = a \pm 0.3\ cm$	$z = a \pm 0.3\ cm$
		Transition (SM6T)	$r = a \pm 0.3\ cm$	$\phi = a \pm 0.3\ cm$	$z = a \pm 0.3\ cm$
Scanner					

We need to establish a central coordinate system to specify all positions:

- Where is $z = 0$ along the beam line ?
- Where is $\phi = 0$?
- Obviously, $r = 0$ at the beam line center …

Integrating Detector Signal Parameters

Subsystem	Parameter	Description	Value		
Thin Integrating Detectors	Radiation hardness	All tiles	$> 160\ MRad$		
	Maximum Cathode Current	All tiles	$25\ nA$		
	Maximum Anode Current	All tiles	$25\ \mu A$		
	Preamp voltage range	All tiles	$-4V\ \leq V_{pamp} \leq 4V$	$-2V\ \leq V^{+}_{pamp} \leq 2V$	$-2V\ \leq V^{-}_{pamp} \leq 2V$
	Preamp Bandwidth	All tiles	$\sim 1\ MHz$		
	Electronic Noise	All sources	$< 10\%$ of Counting Stat. Width ($< 6\ mV$ at $3\ V$ mean signal)		
	Detector resolution	All tiles	$< 25\ \%$		
	Detector excess noise	All tiles	$< 4\ \%$		
Shower Max Detectors	Radiation hardness	All tiles	$> 160\ MRad$		
	Maximum Cathode Current	All tiles	$25\ nA$		
	Maximum Anode Current	All tiles	$25\ \mu A$		
	Preamp voltage range	All tiles	$-4V\ \leq V_{pamp} \leq 4V$	$-2V\ \leq V^{+}_{pamp} \leq 2V$	
	Preamp Bandwidth	All tiles	$\sim 1\ MHz$		
	Electronic Noise	All sources	$< 10\%$ of Counting Stat. Width ($< 6\ mV$ at $3\ V$ mean signal)		
	Detector resolution ($2\ -8\ GeV$)	All tiles	$\sim 25\ \%$		
	Detector excess noise	All tiles	$< 4\ \%$		
Scanners	Same as thin detectors above (?)	All			

Integrating Detector Development Work Tasks

This is running list of open detector development tasks and the associated people/groups that are working on them. Some tasks currently don't have an owner (there is room for people to contribute).

Subsystem	Parameter	Description	Owner
Integrating Detectors	Tiling (geometry optimization)	Simulations and deconvolution	SBU / UMass (Ciprian Gal, Krishna Kumar)
	Radiation Exposure/Hardness	Simulations/Calculations	SBU / Idaho (Ciprian Gal, Dustin McNulty)
	Cabling / Patch Panel	Planning and integration	Idaho/Manitoba (Dustin McNulty, Michael Gericke)
	Air Flush/Electronics Cooling	Simulation/Design	Idaho / Manitoba (Michael Gericke)
Thin Integrating Detectors	Mounting Structure Design	CAD and integration	UMass (Krishna Kumar)
	Ring 1 Modules	Simulation & Design	Open (or Manitoba)
	Ring 2 Modules	Simulation & Design	Idaho (Dustin McNulty)
	Ring 3 Modules	Simulation & Design	Open (or Manitoba)
	Ring 4 Modules	Simulation & Design	Manitoba (Wouter Deconinck)
	Ring 5 Modules	Simulation & Design	UMass/ Manitoba (M. Gericke, Krishna Kumar)
	Ring 6 Modules	Simulation & Design	UMass (Krishna Kumar)
Shower Max Detectors	Mounting Structure Design	CAD and integration	Idaho (Dustin McNulty)
	Modules	Simulation & Design	Idaho (Dustin McNulty)
Front-end Electronics	PMT base	Design/Testing/Fabrication	Manitoba (Michael Gericke)
	Base switching control unti	Design/Testing/Fabrication	Mainz / Manitoba (Michael Gericke)
	Preamplifier	Design/Testing/Fabrication	Manitoba/TRIUMF (Michael Gericke)
	Preamp control unit	Design/Testing/Fabrication	Open (Manitoba – tied to preamp design)

Integrating Detector Development Work Tasks

This is running list of open detector development tasks and the associated people/groups that are working on them.
Some tasks currently don't have an owner (there is room for people to contribute).

Subsystem	Parameter	Description	Owner
Scanner	Mounting Design	CAD and integration	VaTech (Mark Pitt)
	Detector design	Simulation and Design	VaTech (Mark Pitt)
	Cabling / Patch Panel	Planning and integration	VaTech (Mark Pitt)

There are probably more tasks that need to be added …