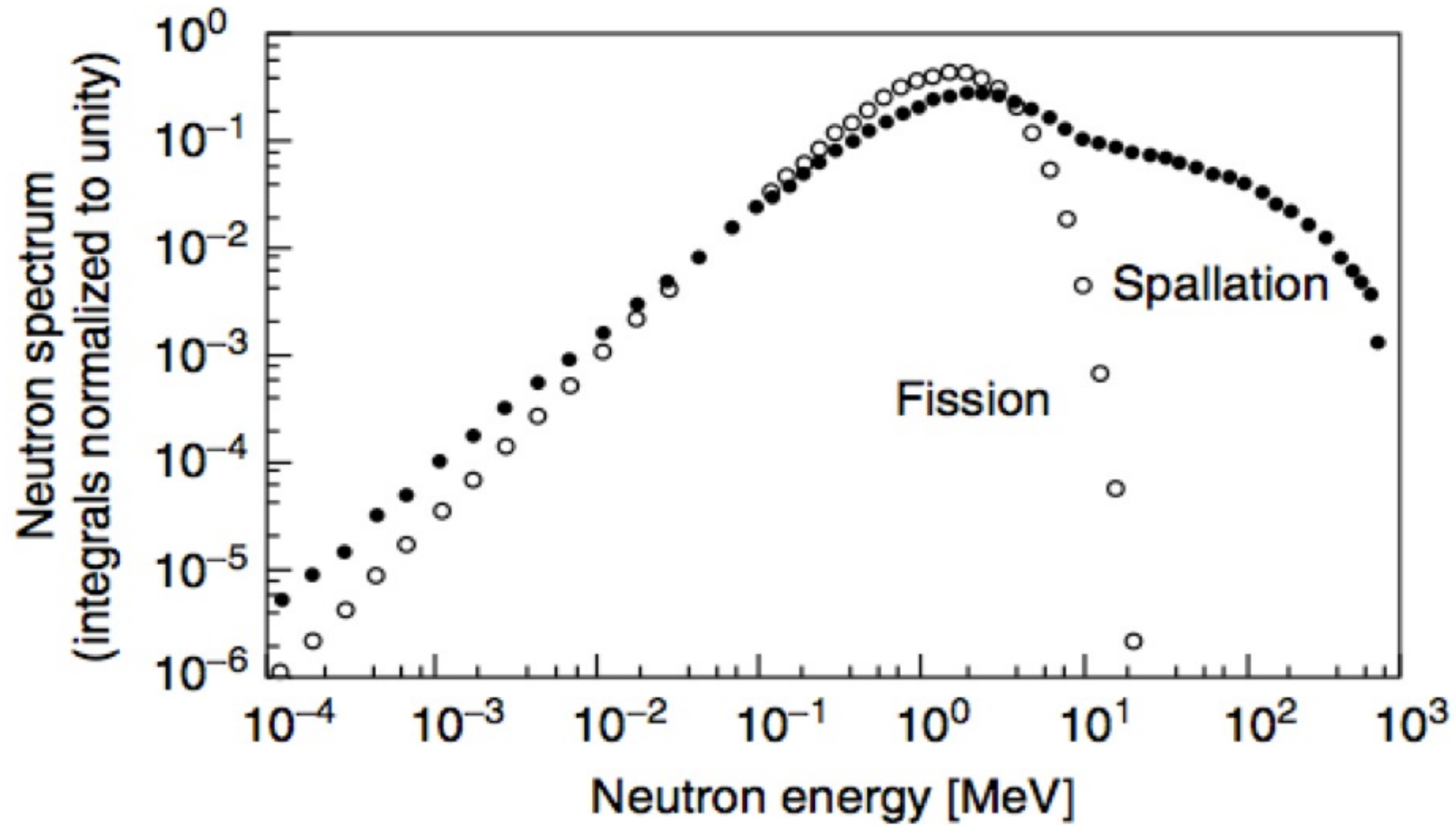


# Motion Control Components in Radiation Environment

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- Spectrum reactor vs. spallation source
- Synergies within ESS projects
- Strategy
- Components
- First results for Target Wheel Control

# Spectrum reactor vs. spallation



# Comparison / synergies

- Motion control components in bunker
- Chopper components
- Target wheel control
- Other radiation facilities and applications

	Gamma	Thermal n	Fast n	Max. energy
<b>ILL</b>	$10^{1+}$	1	$10^{-5}$	20 MeV
<b>SNS</b>			$10^{-2}$	200 MeV
<b>ESS</b>	1	1	1	200 MeV
<b>CERN</b>			$10^{1+ *}$ )	TeV
<b>ITER</b>	n.a.	n.a.	$10^{6+ **}$ )	14 MeV

- Define critical (bunker, cave) and non critical areas (hall)
- Avoid electronics and optics (made of plastics) in critical areas
- Use supplier certification wherever appropriated (reactor technologies)
- Gamma/thermal neutrons: Compare to reactor applications
- Fast neutrons: Take numbers from SNS and J-PARC multiplied by 50 - 100, use experience from CERN and ITER project

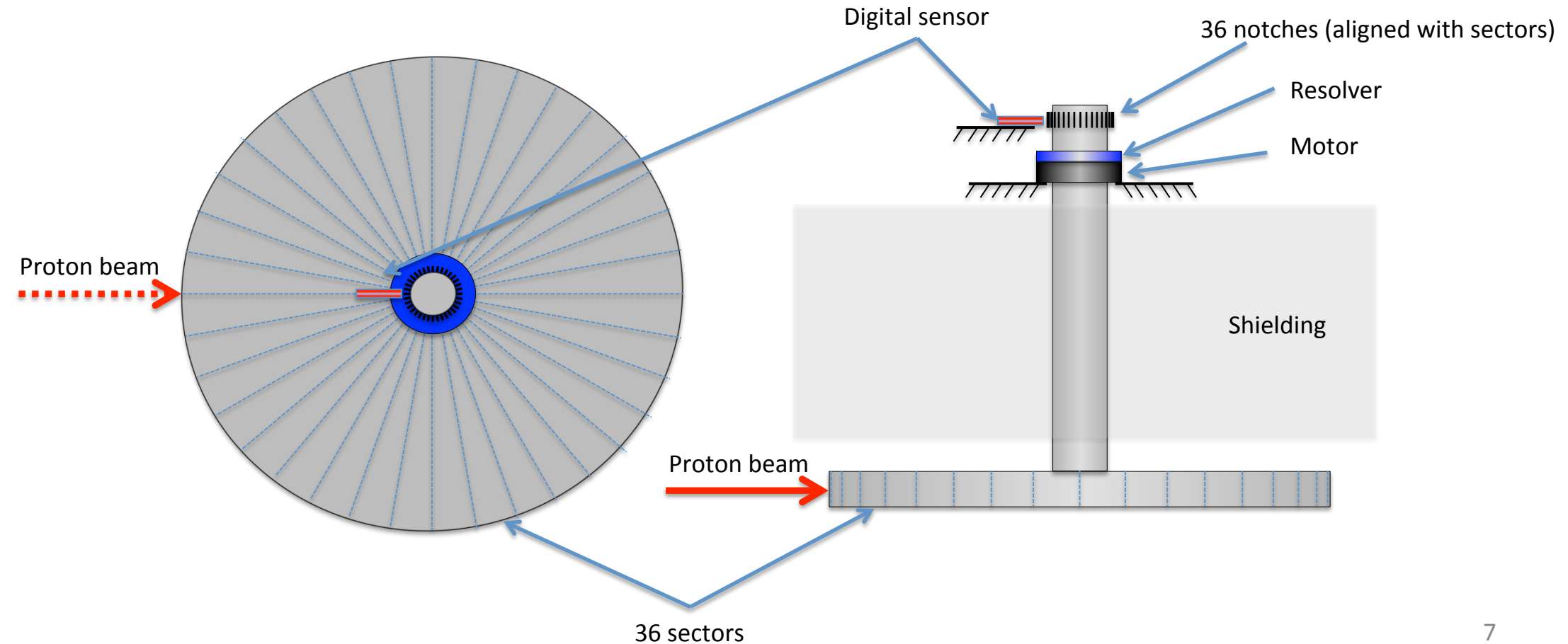
- **Motors**
  - Radhard stepper motors (PHYTRON, Empire Magnetics)
  - Radhard BLDC motors (Wittenstein)
  - Other companies
- **Encoders**
  - Resolver (rotary)
  - LVDT (linear)
- **Switches**
  - Radhard Hall sensors (Lakeshore, ITER)
  - Optical sensors with fiber (CERN)
  - Inductive (with separated electronics)
  - Capacitive

# Concept Overview

Target wheel top view

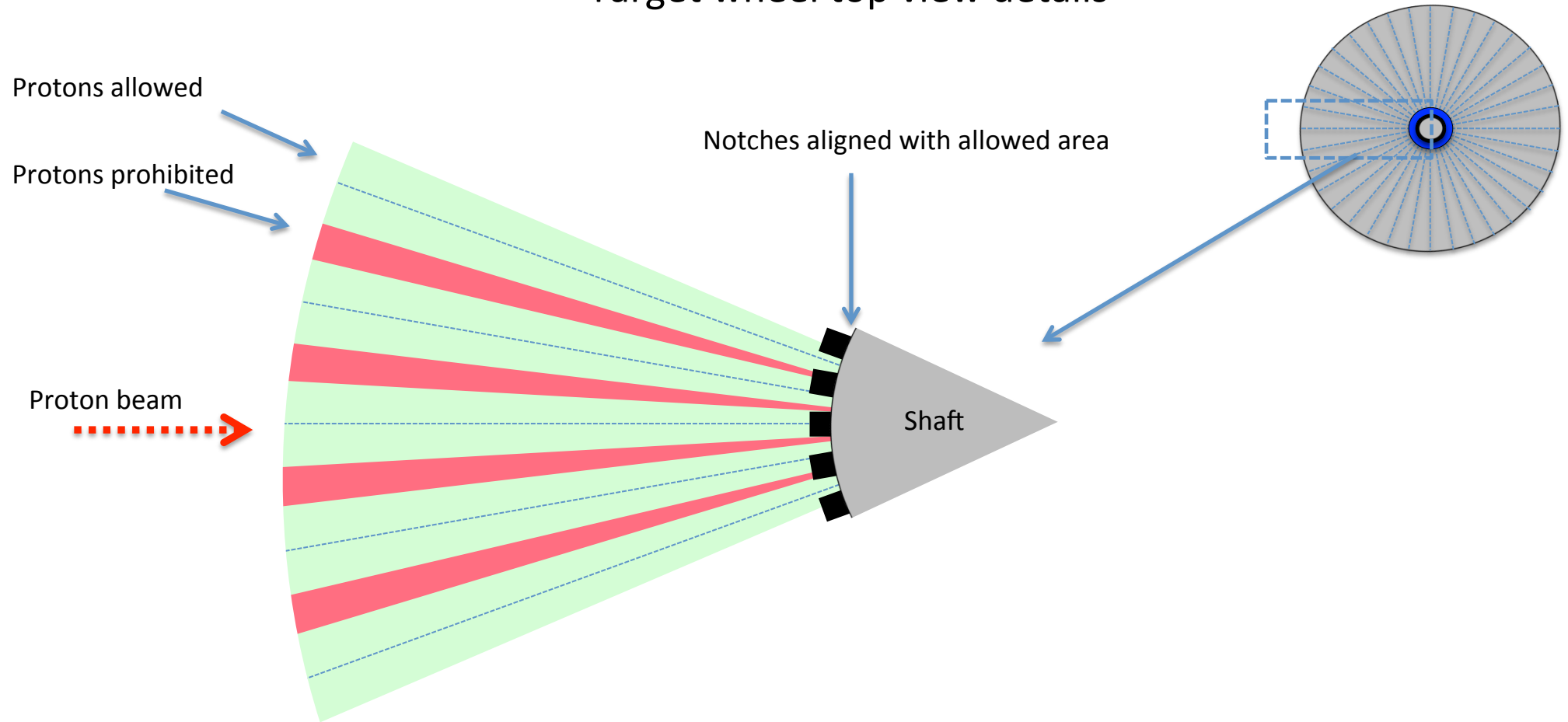
Target wheel side view

Fast neutron flux (at motor):  
 $10^5 \text{ n / cm}^2 / \text{s}$



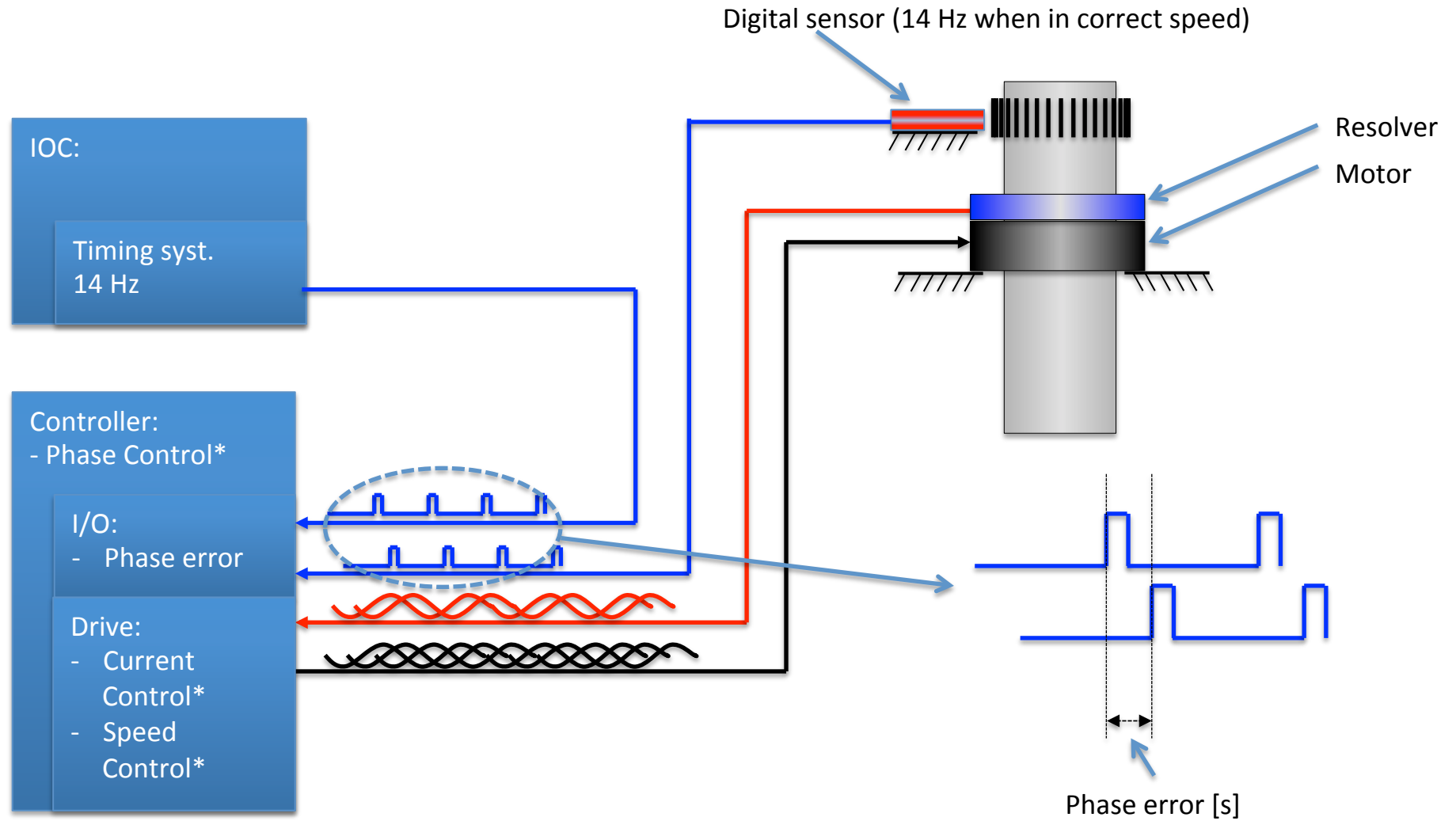
# Notch Alignment

Target wheel top view details





# Control Concept

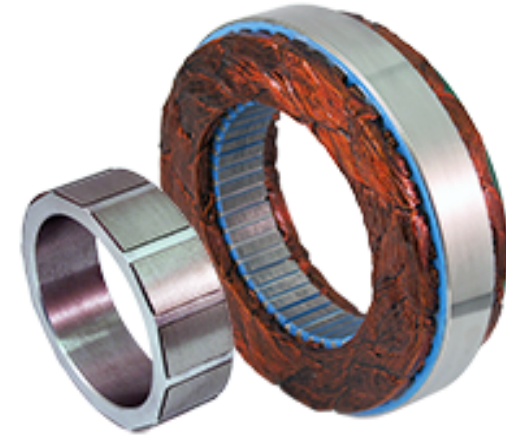


\* "location" of control loops depend on the hardware choice

# Top Requirements Target Wheel Control

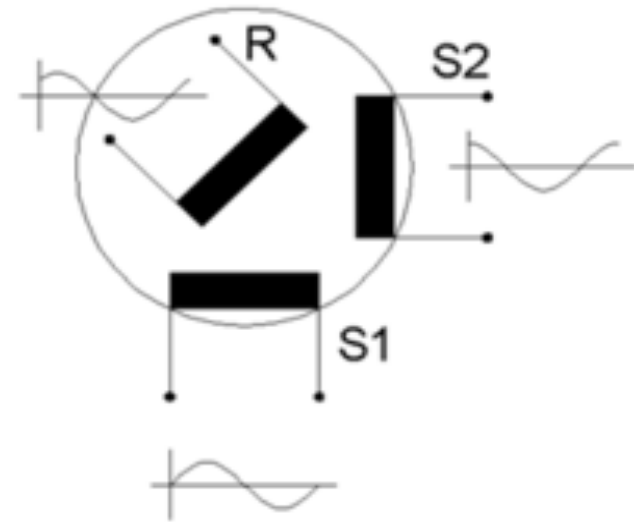
- Radiation hard solution
  - Radiation dominated by fast neutron irradiation ( $> 0,1$  MeV) with a flux  $10^5$  n / cm<sup>2</sup> / s.
- Phase accuracy  $\pm 2$ mm on circumference (diameter 2.5m)
- Park position accuracy =  $\pm 2$ mm
- Nominal speed =  $14/36 \approx 0.39$ Hz
- Startup time (0-0.39Hz +phasing) = 20 minutes
- More requirements in CHESS...

- Radiation hard kit torque motor:
  - High torque at low rpm
  - No need for gearbox
  - Samarium-Cobalt permanent magnets (avoid Neodym, degrades in radiation)
  - Insulation material: Kapton
  - Rad. Hard cables
- Contacted suppliers:
  - Wittenstein
  - Maccon
  - Siemens
  - Rexroth



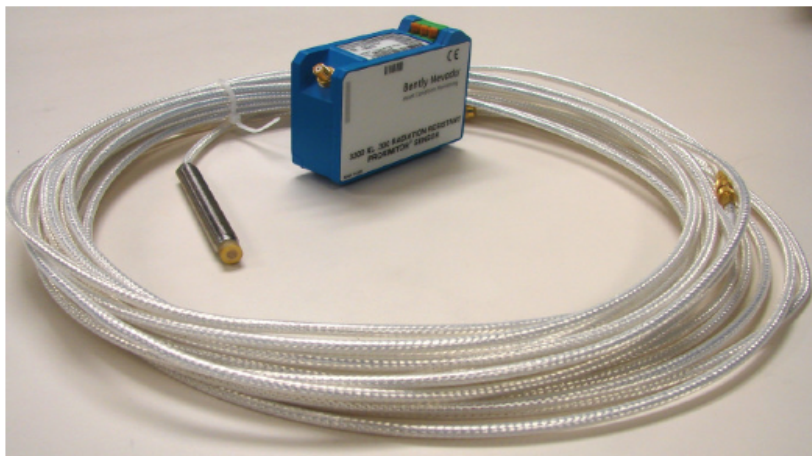
# Resolver

- Single turn absolute position
- Pure analog, no electronics (3 coils)
- Radiation hard insulation
- Accuracy expectation: less than  $\pm 20$  arcmin ( $0.33^\circ$ )
  
- Contacted suppliers:
  - Admotec
  - Ducommum
  - LTN



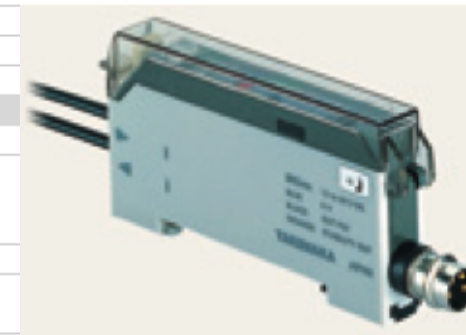
# Proximity Sensor

- Sensors with separated electronics
  - Inductive
  - Capacitive
  - Ultrasonic
- Hall probe



# Proximity Sensor: Fiber optic

Target wheel control components				
Fiber optics sensors				
Company	Description	Name/Serial number	Supply voltage	Response time
Allen-Bradley	High-speed fiber optics sensor	Bulletin 45FSL	12-24V DC	30 $\mu$ s
Takex	Fiber optics sensor	Takex F71	12-24V DC	30 $\mu$ s
Keyence	Digital fiber optic sensors	FS-V30 series	12-24V DC	33 $\mu$ s
Sick	High-performance fiber optic sensor	WLL180T		16 $\mu$ s
Banner	High-performance fiber optic sensor	D10 series	12-24V DC	50 $\mu$ s
Datalogic	High performance fiber optic amplifier	S70 series		10 $\mu$ s
Optex	Fiber optic sensor	D3RF series		16 $\mu$ s
Panasonic	High speed LED sensing fiber sensor	FX2 - A3R		15 $\mu$ s
Idec	High-speed fiber optic sensor	SA1C - F	12-24V DC	50 $\mu$ s
Omron	Fiber optic sensor amplifier	E3X - HD		50 $\mu$ s



# Proximity Sensor: Fibers

Target wheel control components			
Company	Description	Radiation level	Name/Serial number
Optical fibre			
Draka elite	Radiation hard multimode and single-mode fiber	Don't have specific numbers, just says can be used in radiation, and with protons and neutrons radiation. Radiation hard and MIL-PRF-49291 certifications.	50 µm MMF/62.5 µm MMF/SMF qualified under MIL-PRF-49291
Ofs	Radiation hard PM optical fiber	1 krad and 1Mrad with different dose rates	GyroSil Rad-Hard PM optical fiber
Sumitomo electric lightwave	Radiation hardened single mode optical fiber	No numbers for the radiation dose, test procedure EIA/TIA-455-45	OS1
j-fiber Jena	Radiation resistant singlemode fiber for 1310 nm and 1550 nm uses	Tested according to TIA/EIA 455-64	
Nufern	1310/1550 nm single mode radiation hardened fibers	No numbers	R1310-HTA and 1310M-HTA
Fujikura	Radiation resistant fibre	10 <sup>6</sup> R/h dose rate and 60 min . They have done their own research: <a href="http://www.fujikura.co.uk/media/132094/radiation_resistant_fibre_pdf.pdf?iframe=true">http://www.fujikura.co.uk/media/132094/radiation_resistant_fibre_pdf.pdf?iframe=true</a>	RRSMFA, RRSMFB and RRSMFC



# Questions?

