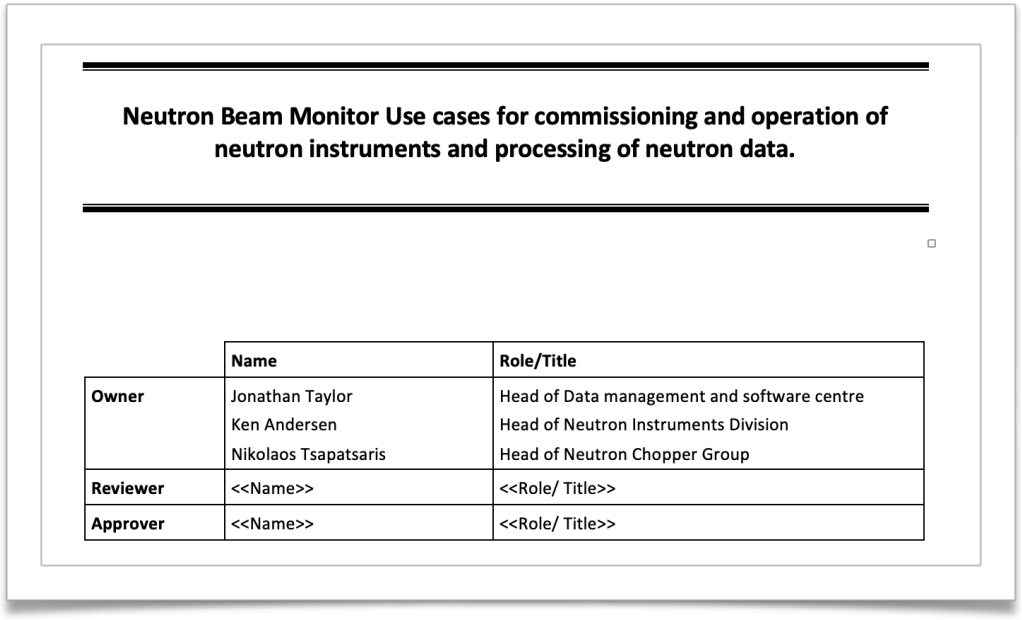
Neutron monitors: Use Case Requirements & Common Project Motivation

Jon Taylor
Richard Hall-Wilton
Ken Andersen
Oliver Kirstein
Shane Kennedy

Monitor Use Cases

- ESS-00419542 Document and excel table.
- Characterisation of moderator performance and in-monolith optics.
- Chopper diagnostics
- Spectral normalisation
- Transmission measurement
- Calibration of flight path(s).
- Definition of a fixed point of source emission.



Neutron Beam Monitor Use cases for commissioning and operation of neutron instruments and processing of neutron data.

	Name	Role/Title
Owner	Jonathan Taylor Ken Andersen Nikolaos Tsapatsaris	Head of Data management and software centre Head of Neutron Instruments Division Head of Neutron Chopper Group
Reviewer	<<Name>>	<<Role/ Title>>
Approver	<<Name>>	<<Role/ Title>>

- In document ESS-0419542, the following monitors are identified as essential for ESS:
  - A monitor to allow evaluation of source performance, placed as close as reasonably possible to the monolith face. In many cases for the evaluation the first monitor was placed behind the first chopper system to minimise the number of installations required in the bunker area.
  - Neutron monitors placed behind fast pulse shaping (or groups of) disc choppers.
  - Neutron monitors for incident flux determination on the sample (always required)
  - Transmitted flux determination (required for direct-geometry spectrometers & SANS)
  - Monitors behind choppers which should be used as a fixed point of source emission for direct-geometry spectrometers and for wavelength frame cascades.

Monitors for instrument suite

Table 1 Summary table of required beam monitors

("0,5" means the need for an additional monitor is still TBD.)

Beamport	Instrument	Near-Monolith Flux Monitor	Diagnostic Monitors	Sample Position	Transmission Monitor	Total:
E2	ESTIA	1	1	1	0	3
E3	SKADI	1	0.5	1	1	3.5
E7	VESPA	1	2	1	0	4
S2	ODIN	1	2.5	1	0	4.5
S3	DREAM	1	1	1		3
W1	NMX	1	0	1		2
W2	BEER	1	1	1	0	3
W3	CSPEC	1	1.5	1	1	4.5
W4	BIFROST	1	0.5	1	0	2.5
W5	MIRACLES	1	0	1	0	2
W6	MAGIC	1	0	1	0	2
W7	TREX	1	1.5	1	1	4.5
W8	HEIMDAL	1	1.5	1	0	3.5
N5	FREIA	1	2	1	0	4
N7	LOKI	1	0.5	1	1	3.5
Total:		15	15.5	15	4	49.5

- ESS-0060903
- Near monolith is not at monolith
  - Somewhere within 10m of BBG
- Common project proposed
  - Agreed at ICB
- Common development of tech

Table 2 Budget of beam monitors common project

	#	Unit Cost (kEUR)	Equipment Cost (kEUR)	Labour/# (PM)	Labour/# (kEUR)	Total Labour (kEUR)	Total (kEUR)
Design	1	25	25	21	189	189	**214**
Monitors	50	10	500	1	9	450	**950**
Electronics	50	6.6	330				**330**
						GRAND TOTAL:	1494

Commissioning - Calibration

Considerable complexity for ESS Instruments with multiple axis chopper systems

Detector Geometry is challenging

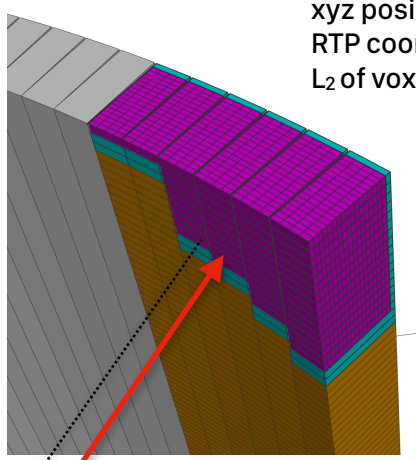
A number of methods of defining T_0 will be available

Calibration of chopper cascade will be aided by diagnostics

Neutron monitor project led by ESS

Detector List mode DAQ
offsets from Wall clock
:05
:06
...
+Pixel ID

xyz position
RTP coordinates
L_2 of voxel



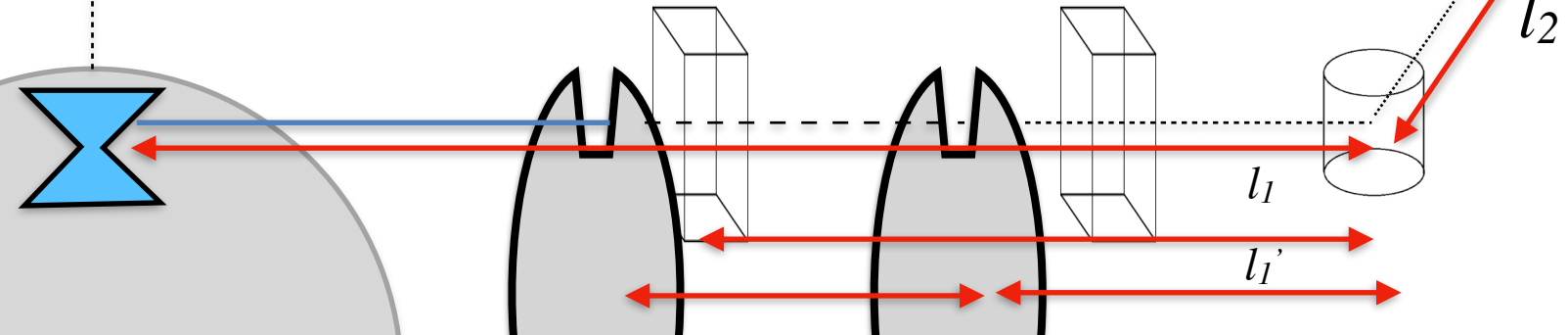
$$\lambda = \frac{h}{p} = \frac{h \,.\, tof}{m_N \,.\, L_{tot}} = 2dsin\theta$$

$$tof = t - t_0$$

$$L_{tot} = L_1 + L_2$$

Monitor List mode DAQ
offsets from Wall clock
:01
:02
...
+ ID
(Can histogram if required)

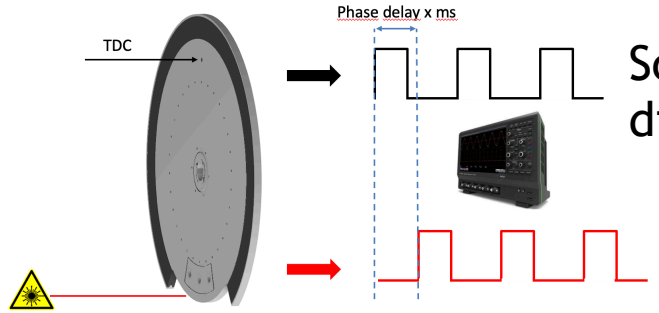
Wall clock time proton pulse
11:10
Proton Pulse ID



Calibration required for:
Motion axis
chopper offsets and transmission
Flight paths
Detector voxel / pixel positions

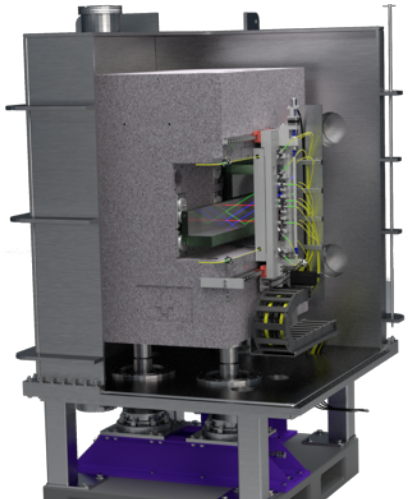
Commissioning

- Cold commission and integrate key components during installation.
- Scope, resources and framework are defined to execute.
  - BeamLine Controls Team
  - NT groups
  - Chopper group SAT includes calibration of axis geometry
- Instrument teams resources pre - builds and significant prototyping projects
  - Minimising / Mitigating future delays
- Hot commissioning plans are being developed, and reviewed at TG3
- Workshops with instruments teams to maintain schedule alignment, priorities and tasks.



Schematic of chopper disc laser alignment

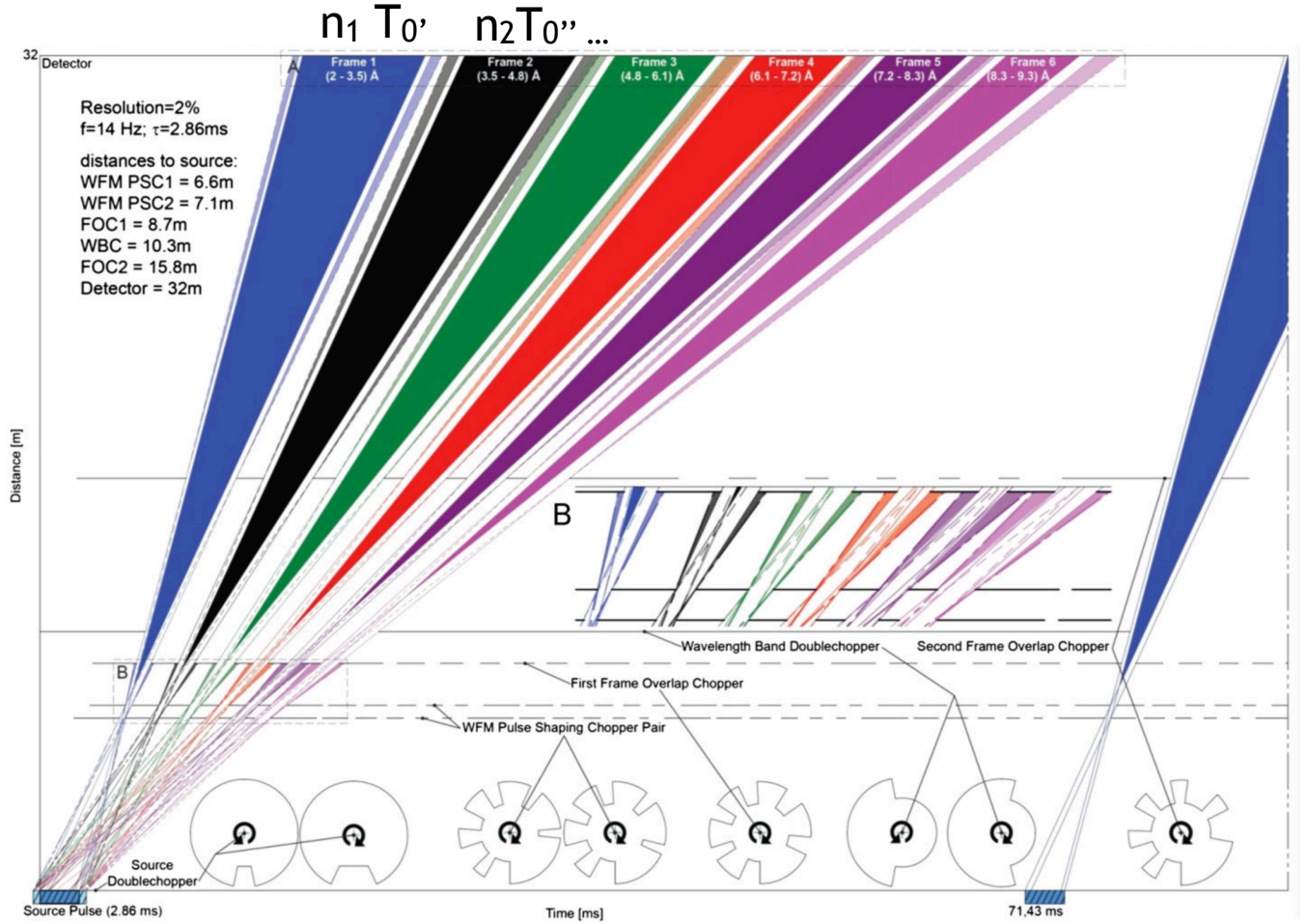
Selene Guide prototype Build at PSI and fully integrated into control system



Construction of R106 where STFC will pre-build LOKI and FRIEA

Hot Commissioning & Data Processing

- Normalisation of individual frames of data.
  - Each frame is extracted from a different region of the pulse
- Defining T_0 and T_0 for each frame
- Target segment and moderator coupling
- Current activities aimed understanding these key complexities



Testing & prototyping @ V20 HZB ++

- Deploy the ESS controls stack onto a real instrument

- Real world testing of WFM and data processing

- Controls integration

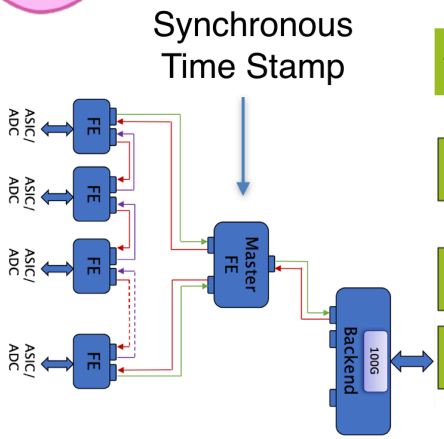
- DAQ - detectors and meta data

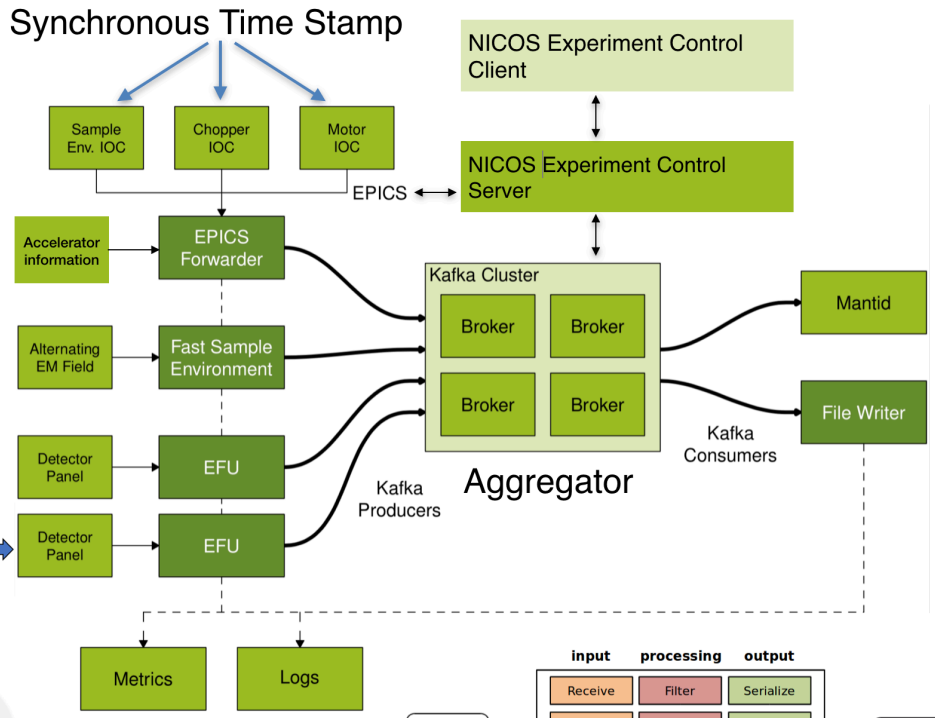
- Chopper cascade TDC time-stamping and and phase control

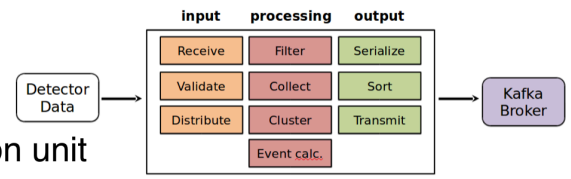
- Sample environment integration

- Can extend to BL10 JPARC to test instantaneous rate capability

github.com/ess-dmsc

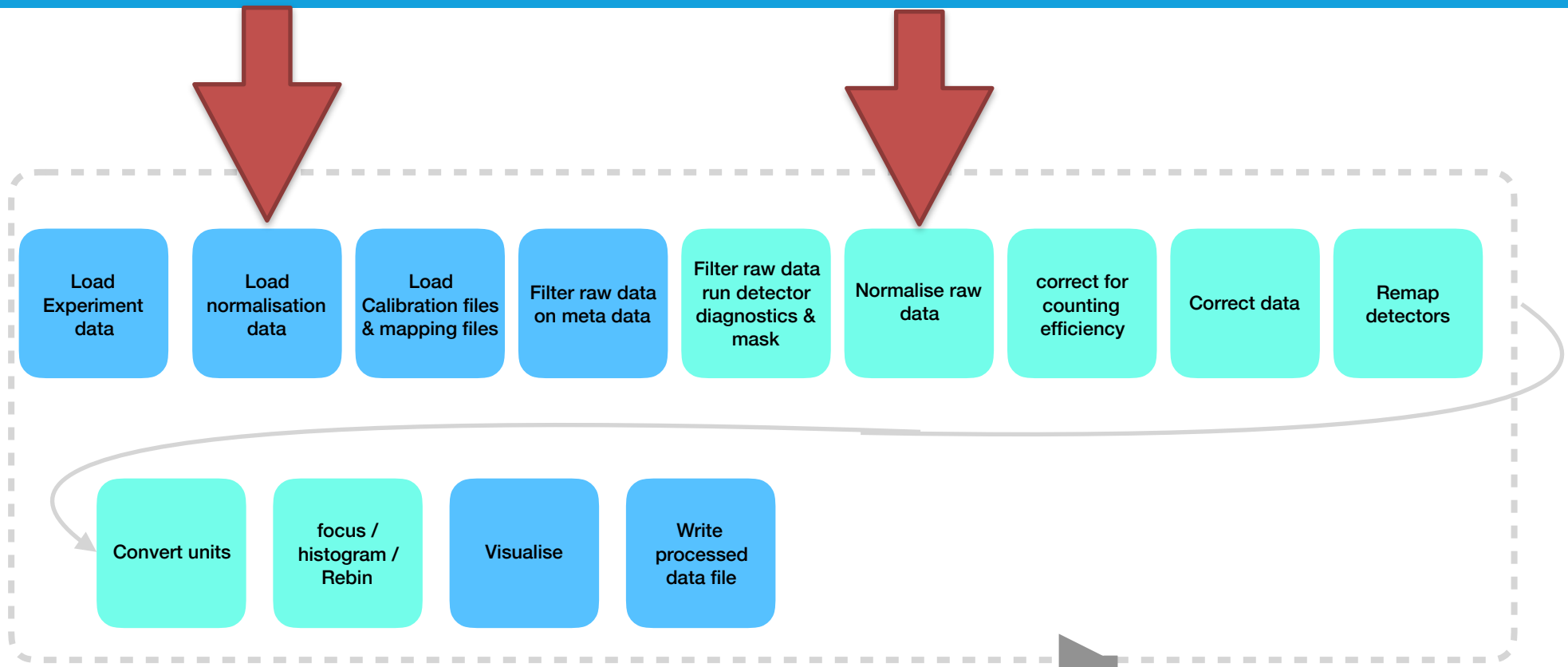






EFU - Event formation unit
(A computer)

Data Processing / data reduction



Each box requires a myriad of input data or parameters which have a direct effect on the processed data.

Is part of a data reduction workflow

Monitors in Mantid Data Processing

- Normalisation to Monitor.
  - Whole spectrum, Sum of <UNIT> region
  - Monitor 1,2,3 …
- Determination of Ei - Direct Geometry inelastic.
- Determination of T0 - back projection (SNS)
- Definition of Source position (ISIS)
- Transmission corrections
- General Diagnostics for instrument staff

Data processing contd.

- Calibrated instrument Geometry & component type geometry & size.

```
<!-- Detectors types -->
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  <component type="monitor">
    <location r="17.758" t="180.0" p="0.0" name="monitor1" />
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    <location r="16.558" t="180.0" p="0.0" name="monitor3" />
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    <location r="1.333" t="180.0" p="0.0" name="monitor6" />
    <location r="1.088" t="180.0" p="0.0" name="monitor7" />
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  </component>
</type>
```
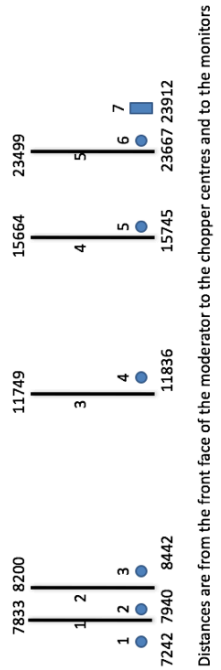
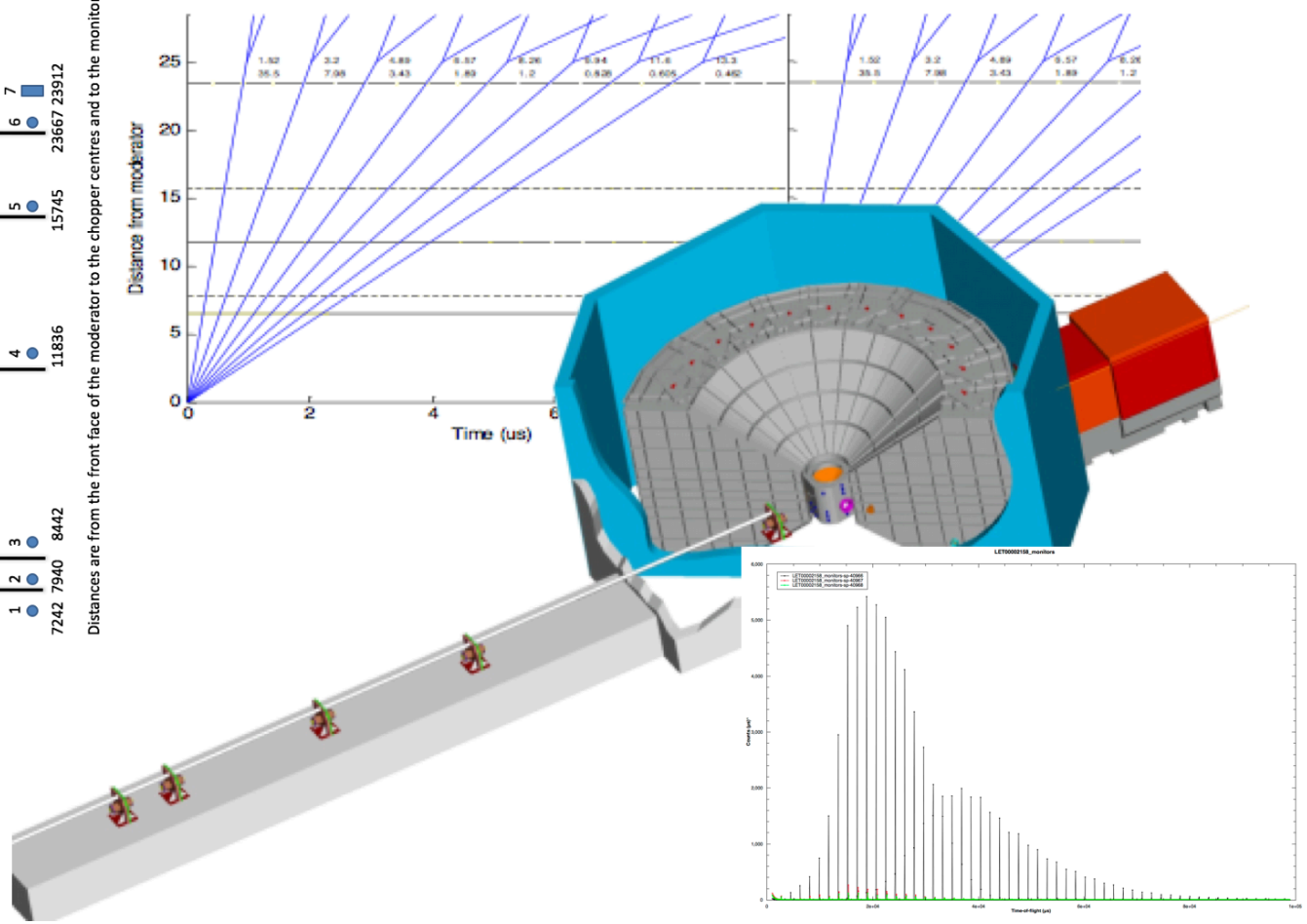

LET- Chopper and monitor distance
From John Randall and Jeremy Balchin





Other thoughts

- DAQ from monitors will be standardised
  - Can be either Event Mode.
  - Clustered Event mode - Sum of events for each pulse.
- Beam profile measurements will be needed
- There is no current technology that satisfies very hight rate capability, bandwidth and absorption.
  - There is no Unicorn.
- Consider day 1 operation - Low power to 1MW