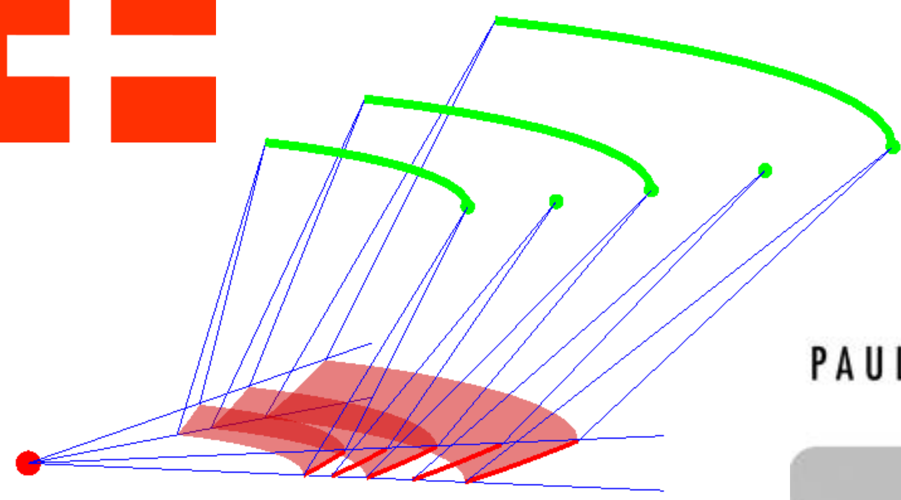
CAMEA

Jonas Okkels Birk, Maron Marko, Paul Freeman, Mads Bertelsen, Jacob Larsen, A. Hansen, Fanni Juyrani, Christof Niedermayer, Kim Lefmann, Niels Bech Christensen, Henrik M. Ronnow

McStas



PAUL SCHERRER INSTITUT

Technical University of Denmark

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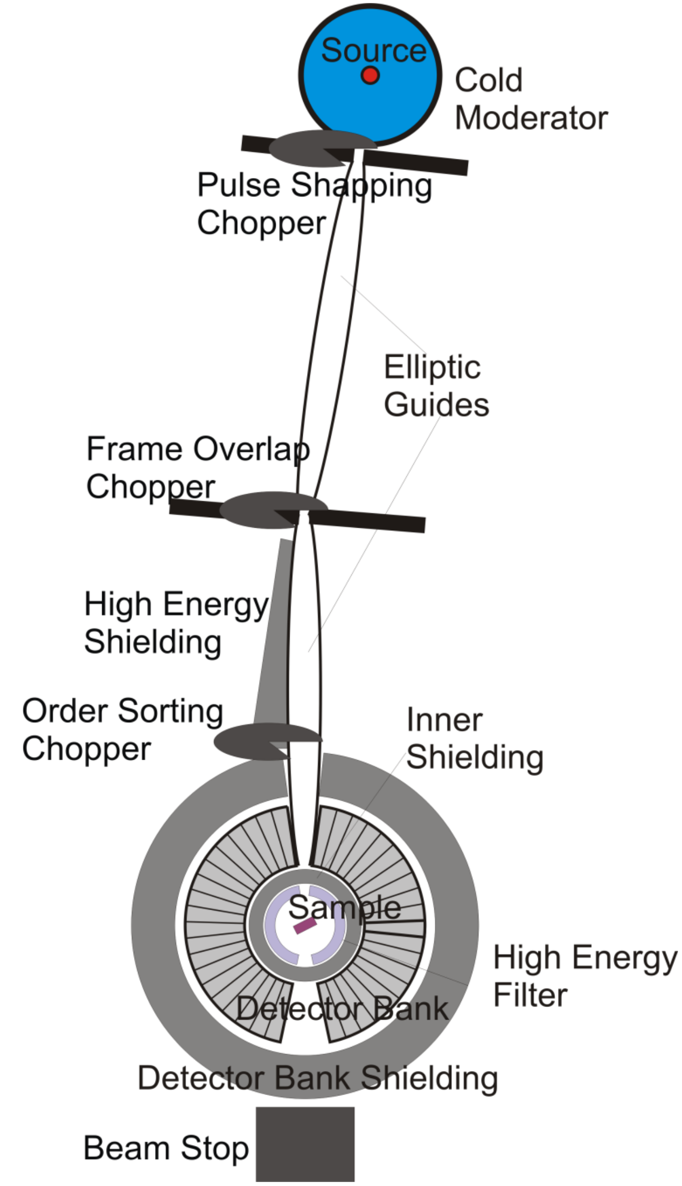
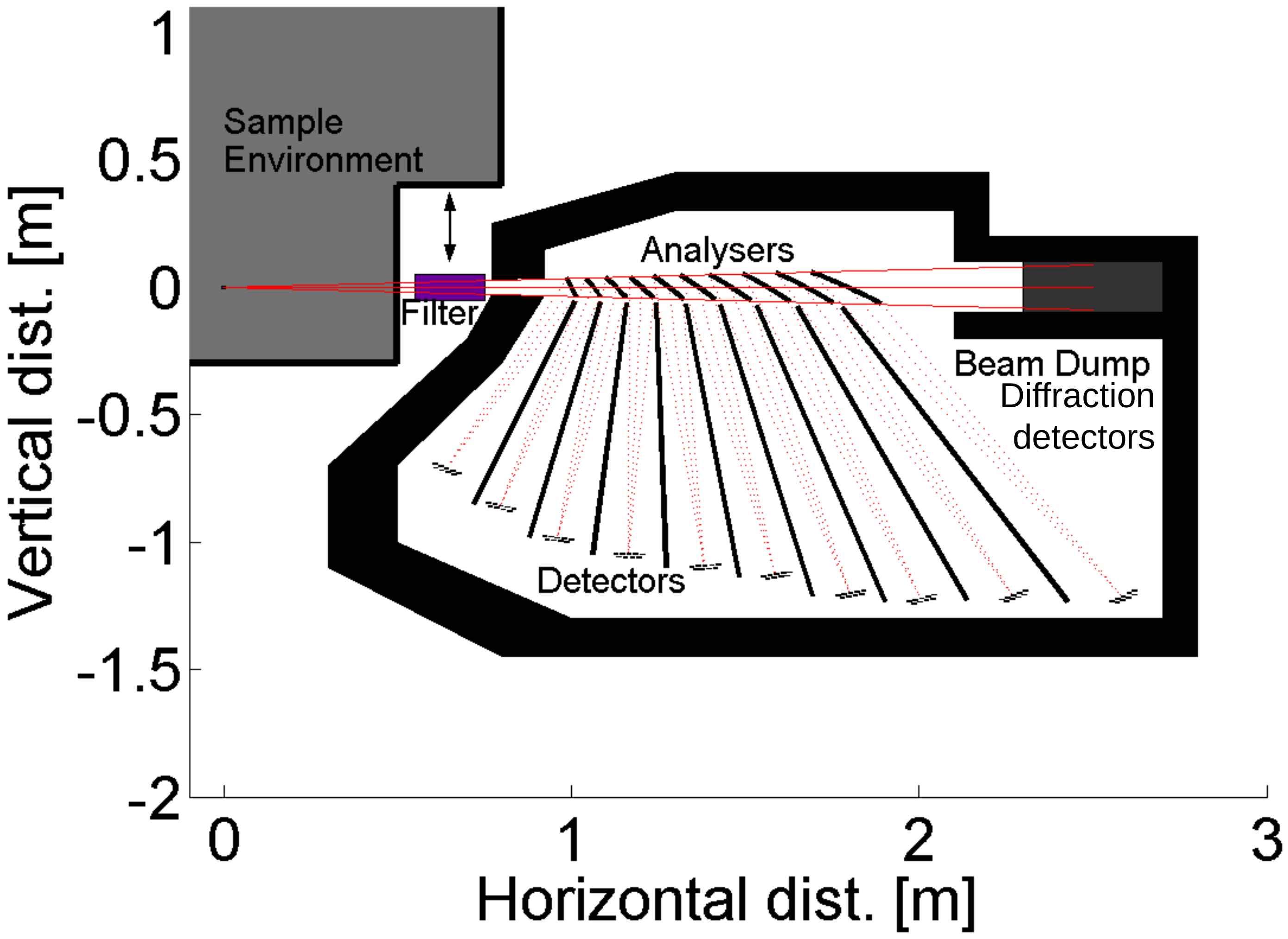
Continuous Angle Multiple Energy Analysis

CAMEA

- Inverse time of flight
- Vertically scattering analyzers.
- Multiple analyzers behind each other select several energies.
- E_f=2-32meV
- Energy resolution as cold TAS and medium cold TOF
- Can use full ESS long pulse shaping ⇒ better res
- Optimized for small sample size 1cm^3 down to 1mm^3
- High field (25T), high pressure (100kbar)
- Prototype tested at PSI-MARS



Multiple energies



Dimensions ✓

$E_{Analyser}$ (meV)	**2.5**	**2.8**	**3.1**	**3.5**	**4.0**	**4.5**	**5.0**	**5.5**	**6.5**	**8.0**
$D_{Sample\text{-}Analyser}$ (m)	1.00	1.06	1.13	1.20	1.28	1.37	1.46	1.56	1.67	1.79
$D_{Analyser\text{–}Detector}$ (m)	0.80	0.90	1.00	1.05	1.10	1.15	1.25	1.30	1.35	1.45

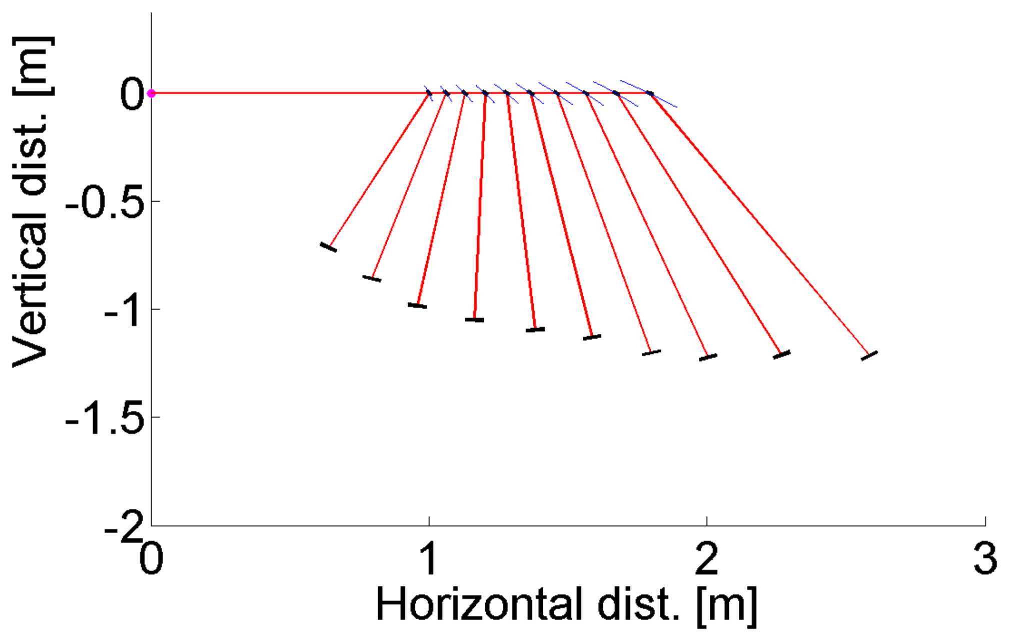
Scattering angle: 3°-135°

Mosaicity: 60 minutes

Sample size: ½*½*½ cm^3

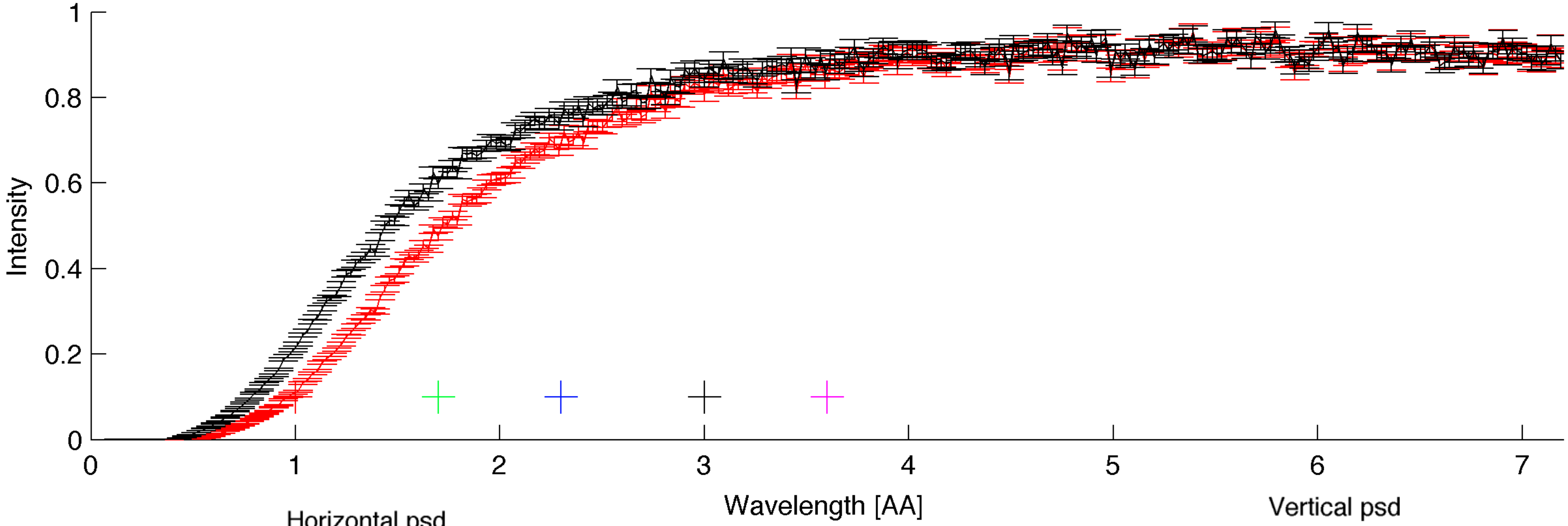
Detector width: ½ inch

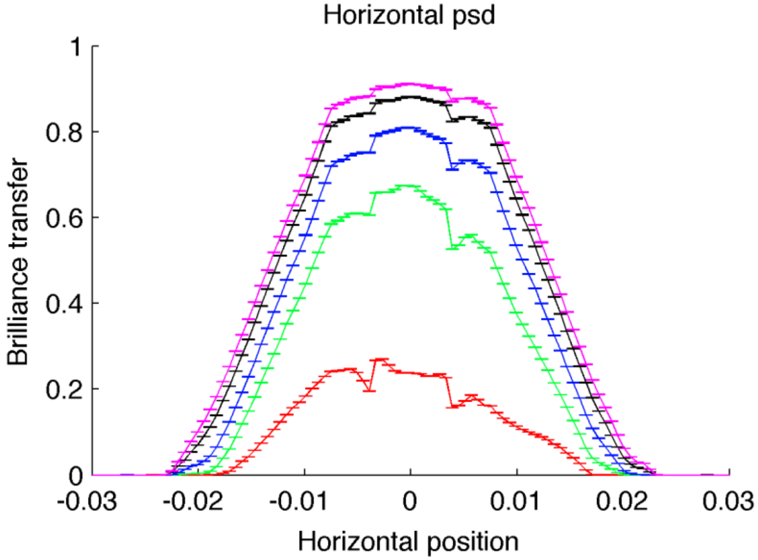
Pixel size: ½ cm

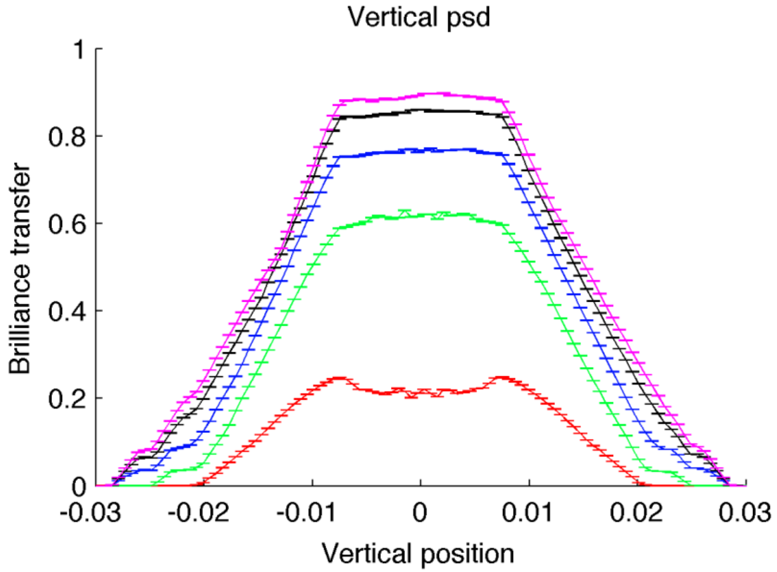


Guide ✓

Brilliance transfer of Guide very good above 2 Å even if mirrors degrade







Choppers ✓

2 Pulse shaping Choppers

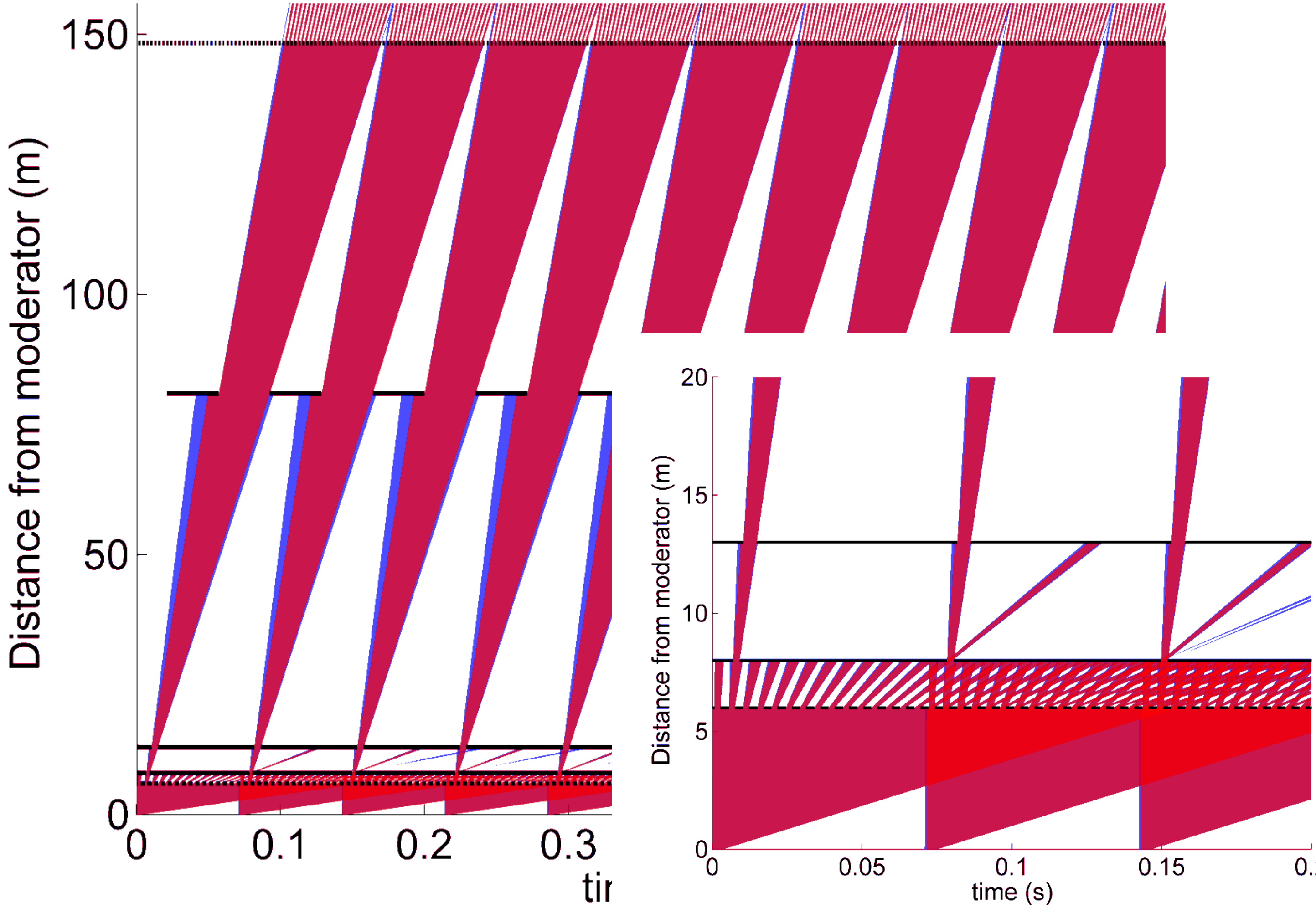
2 Frame overlap Choppers

1 Tail removal Chopper

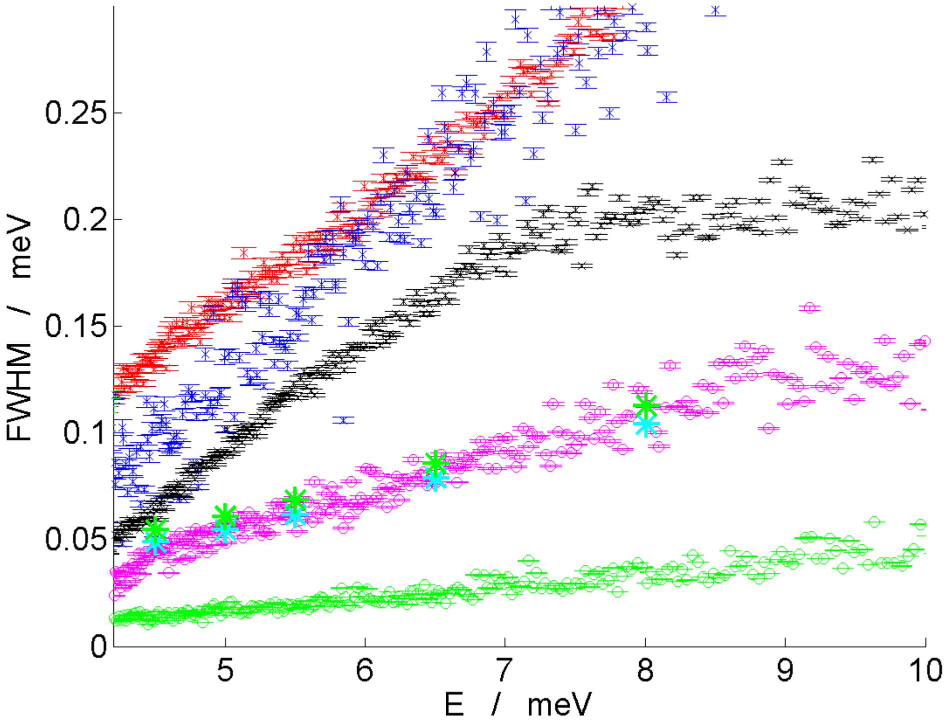
2 Order sorting Choppers

Selects:

- Bandwidth range of E_i
- Pulse-length resolution



E_i-band and resolution tuning ✓



<u>Bandwith chopper</u>

e.g. $\Delta\lambda$ = 1.8 Å, and

E_i= 4.2meV – 12meV

Only desired energy range hit sample

<u>Pulse length chopper:</u>

Full ESS long pulse

⇒ ~4% resolution

Pulse length: /3.3 neutrons

⇒ ~1.2 % resolution

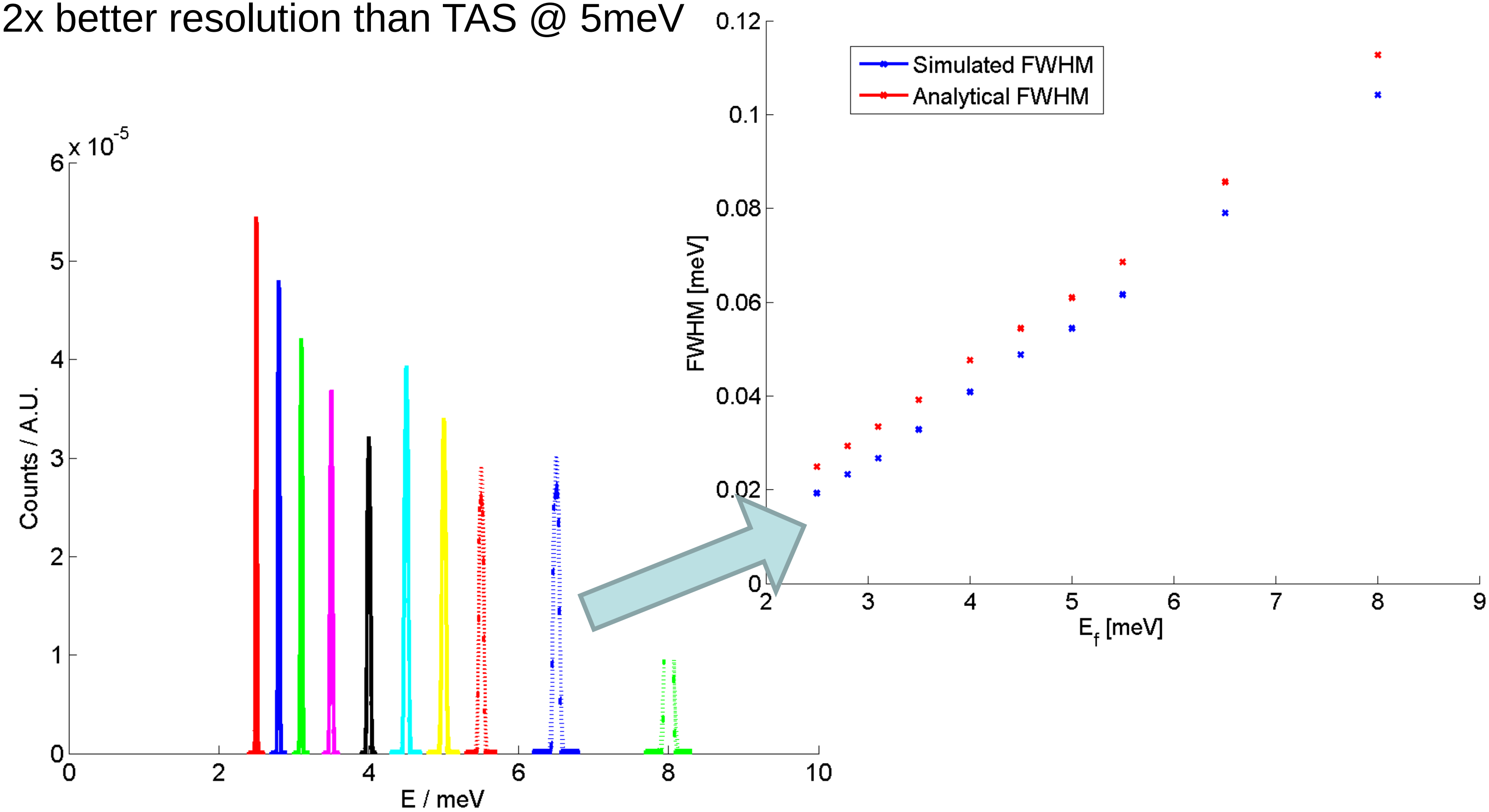
Analysers: ~1.2% resolution

Total ⇒ ~1.6% resolution

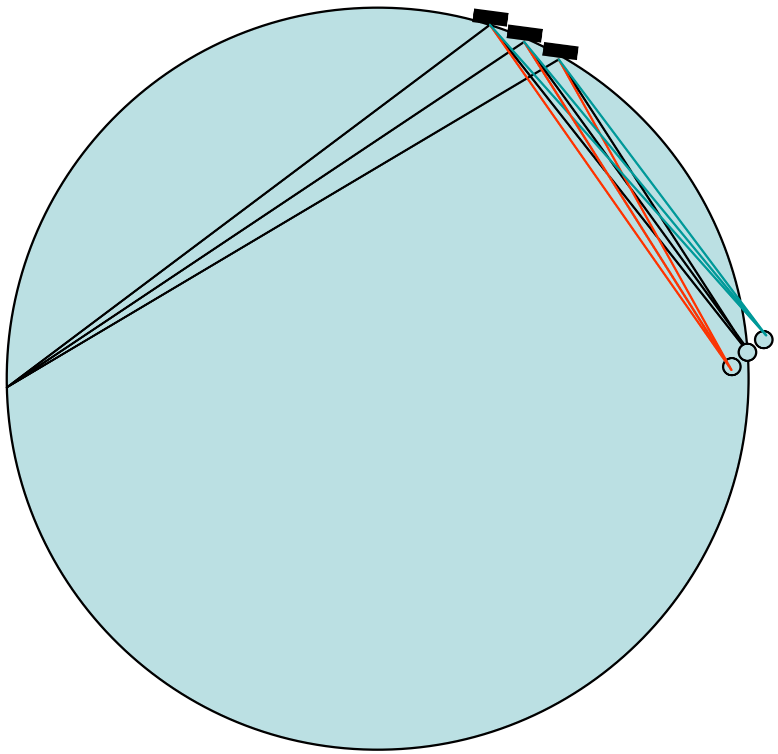
~30% better than focused TAS

Analyser energy resolution ✓

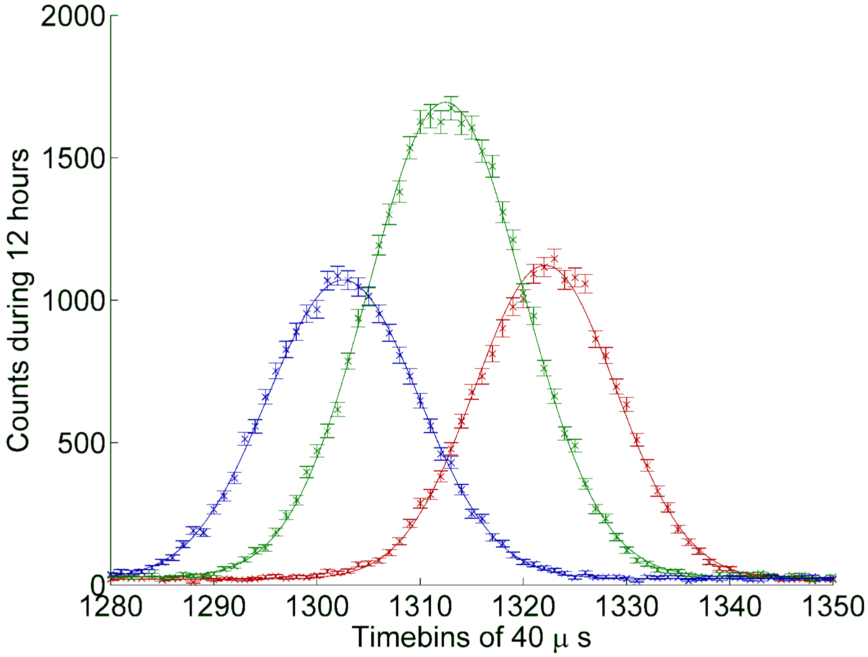
Simulated and calculated energy-resolutions of secondary spectrometer shows ~1.2%
~2x better resolution than TAS @ 5meV



Better E_f resolution at no flux cost !

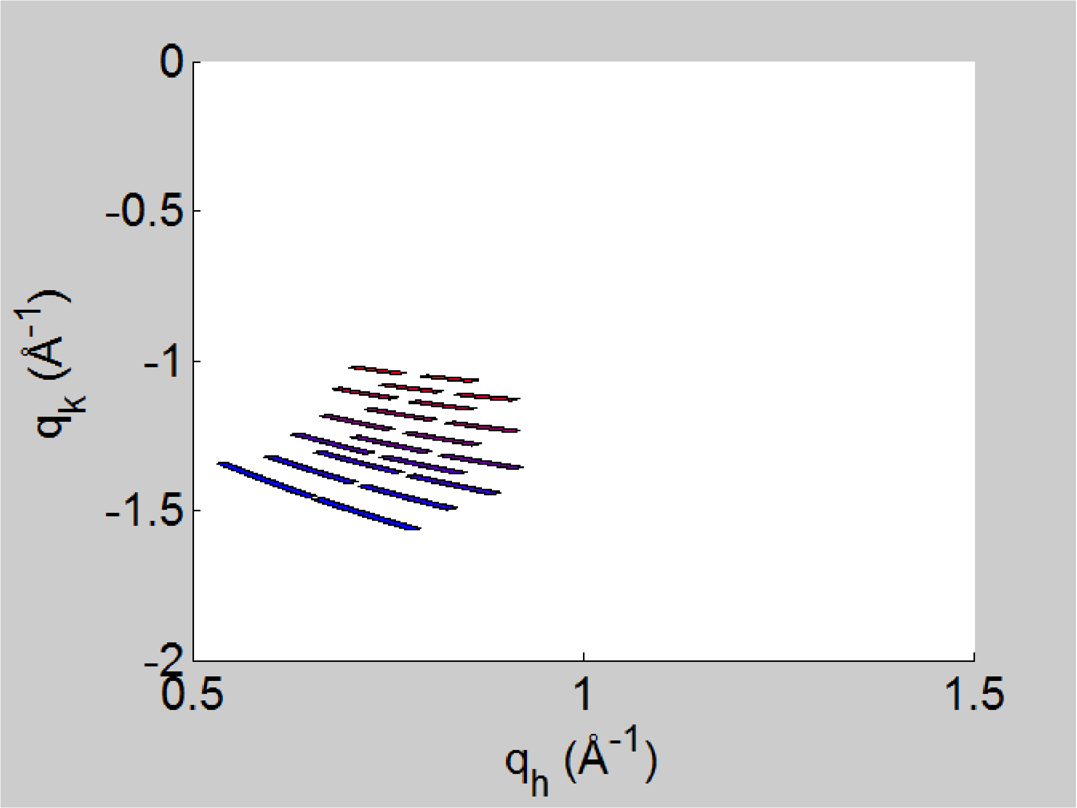


- Distance collimation ⇒ better resolution than standard TAS
- Multiple energies for each analyser
- Adjacent detectors record different energies ⇒ 2.7x neutrons



Momentum coverage ✓

Coverage at ΔE=0



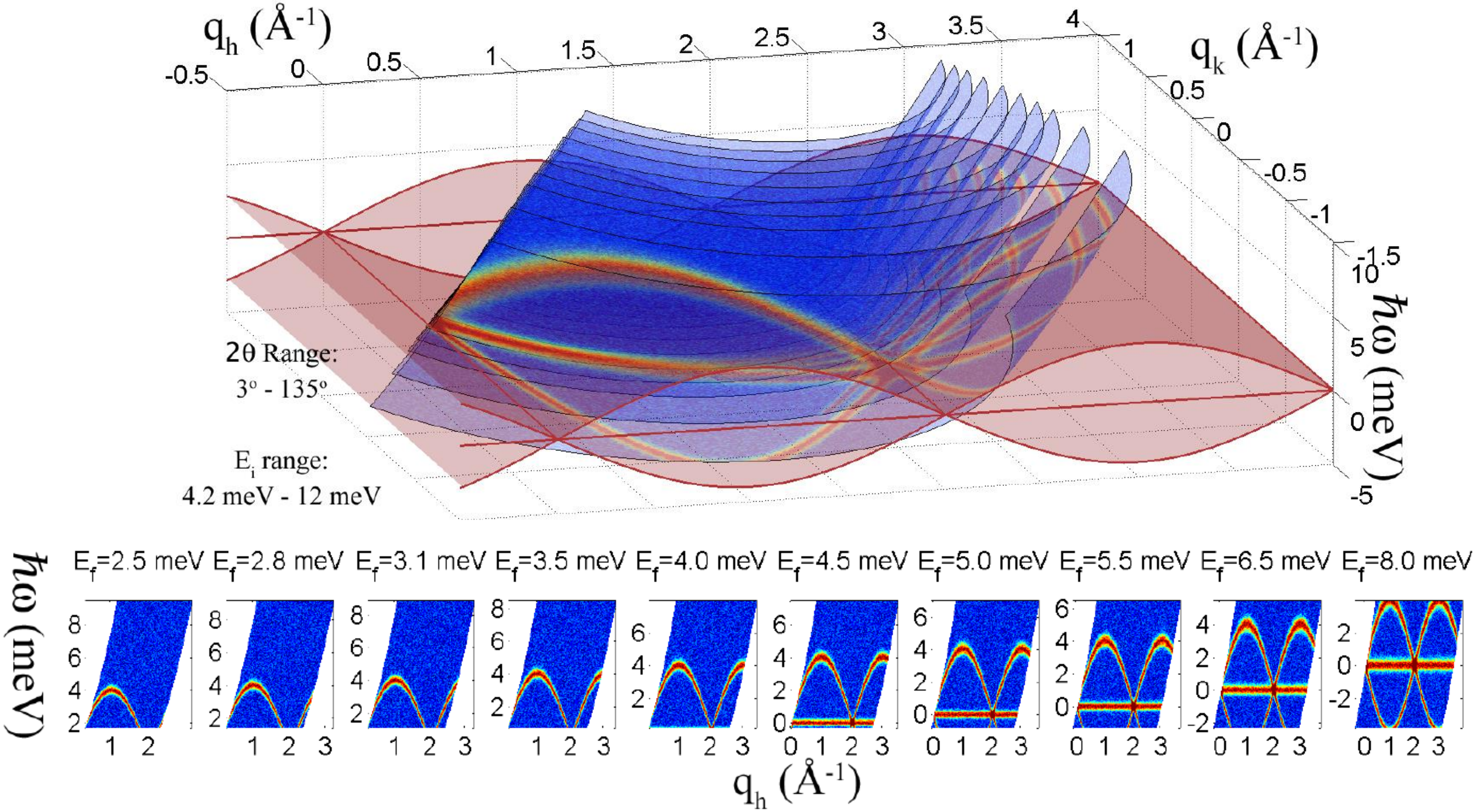
Each analyser covers a line in Q-plane (with small gaps)

Sample rotation covers reciprocal plane

Small gaps are covered by adjacent energies

For completely homogeneous coverage, analyser tank can be rotated

Example

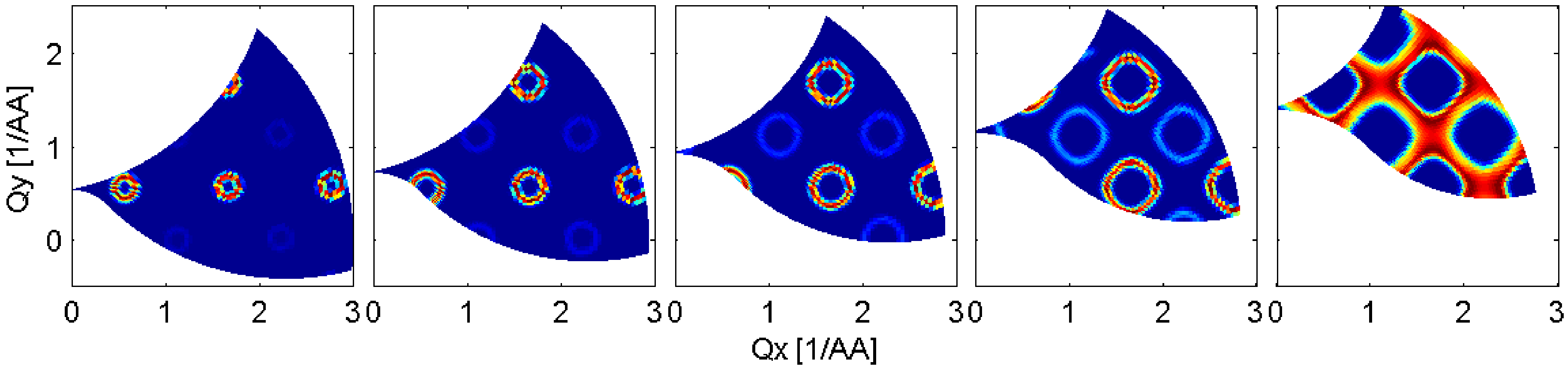


- Single acquisition gives N Q-E manifolds
- Often sufficient to determine dispersion changes
- Fast parametric studies, or sufficient stats for very small samples

CAMEA: best possible "in-plane spectrometer"

- Direct TOF give 3D parabolic manifold of 4D S(q,w)
  - Must analyse off-symmetry data
  - Or perform full "Horace" scan

- CAMEA: focus on flat 2D Q-plane and energy
  - Allows measuring Q-planes in 3D systems
    - $\Rightarrow$ larger fraction of measured neutrons analysed
  - Several complete Q-Energy manifolds in one acquisition



Analyzer Solid Angle

Instrument	Facility	Analyzer	Solid Angle (steradians)	±1.4° Solid Angle (steradians)	±1.4° Gain per analyzer
CAMEA		PG (002) or (004)	0.13 x 10	0.13 x10	-
OSIRIS	ISIS	PG (002) or (004)	1.09	0.12	1.08
Iris	ISIS	PG (002) or (004)	0.36	0.11	1.18
PRISMA	ISIS	PG (002)	0.021 @ 5 meV	0.0147	8.8
MACS	NIST	PG (002)	0.15	0.075	1.7
Flatcone	ILL	Si(111)	0.05	0.05	2.6

- Same coverage as other indirect time of flight.
- Higher coverage than multiplexing TAS
- Multiply these numbers by the 10 analyser energies

Flux ✓

CAMEA ±1° vertical, ±0.75° horizontal,1.4 x 10^9 ncm^{-1} s^{-1} centered on 3 Å

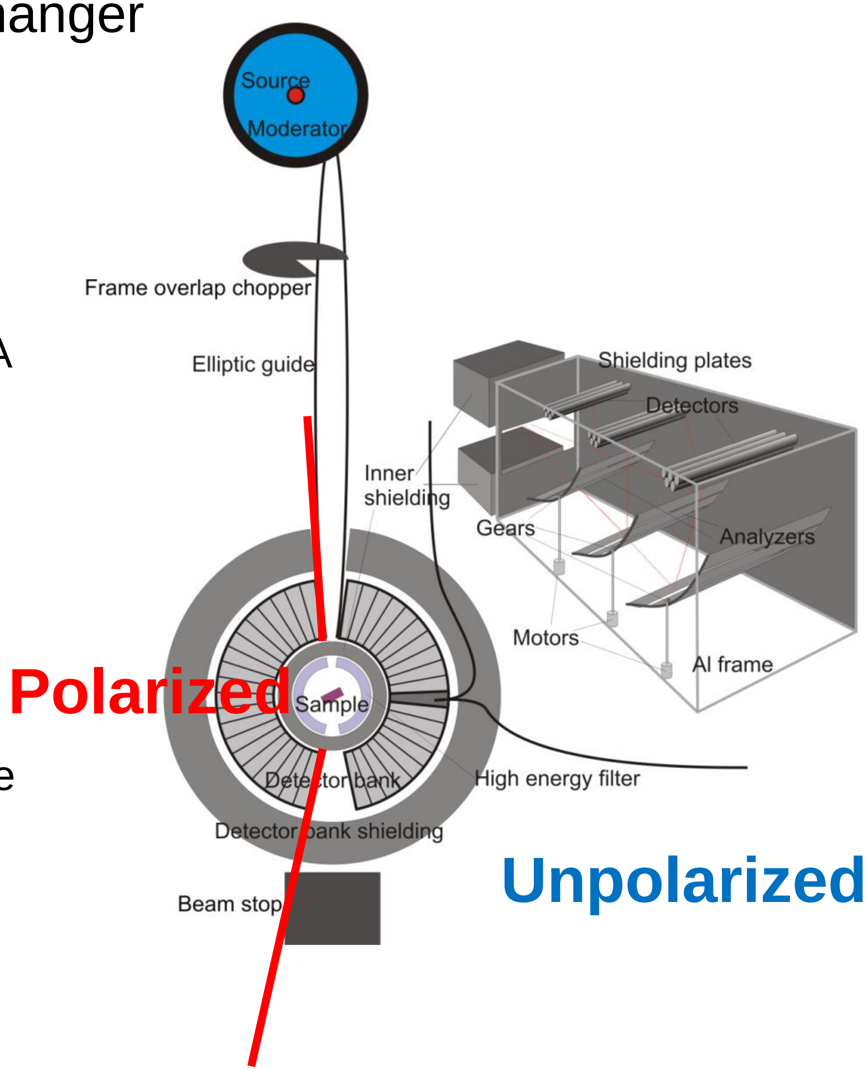
Instrument	Facility	Monochromator	Flux	CAMEA Gain	Energy Range
			N per cm^2 per s		(meV)
IN14	ILL	PG(002)	1.6 x 10^7	88	0.1-17
PANDA	FRM-II	PG(002)	1.9 x 10^7	74	0.1-20
MACS	NIST	PG(002)	$5x10^8$	2.8	2.3-14*
THALES	ILL	PG(002)	$3.5x10^8$	4	0.1-20
OSIRIS	ISIS	Time-of-Flight	$3.24x10^7$@ 180uA	43	-3 to 4
IRIS	ISIS	Time-of-Flight	$1.2x10^7$ @180uA	117	-3.5 to 4
IN20 (polarized)	ILL	Heusler	1.05 x 10^7	>30??	2-90

THERMAL Spectrometer

Wide divergence – Simulated Flux

Polarization analysis ✓

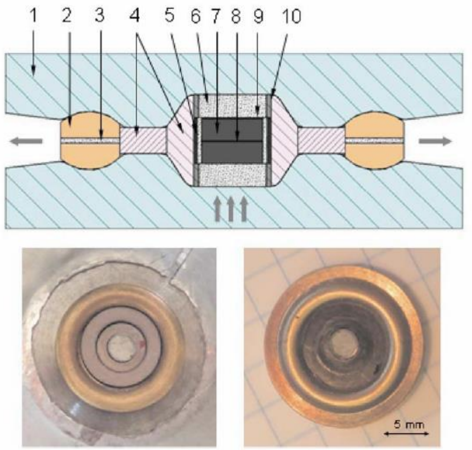
- Supermirror polarizers in a guide changer
- Option 1: PASTIS- wide angle He-3 spin cell
  - consistent with sample space of CAMEA
  - OK for pressure cells
  - Not OK for magnets
- Option 2: Supermirror array
  - Easier/cheaper than direct TOF because only +-2 degree vertically
  - D7 proven concept
  - Cost based on D7 quote 2M Euros

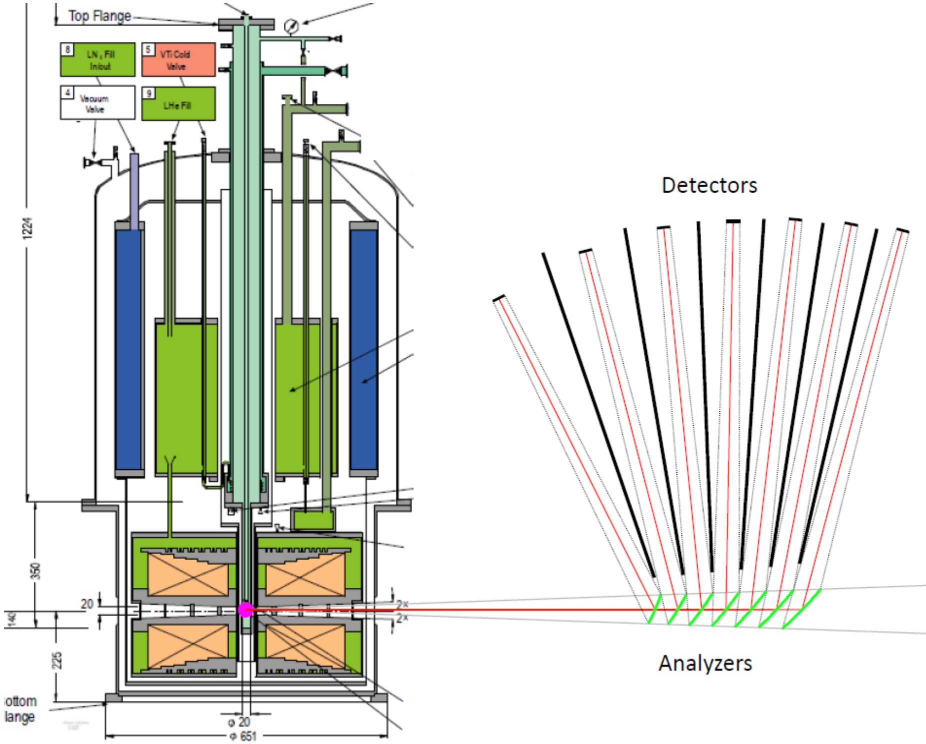


Experimental capabilities

- Planar Q-E maps by sample rotation
- Small samples $1mm^3$ to $1cm^3$
- Single acquisition scans $\Rightarrow$ parametric studies
  - Magnetic field, Pressure, Temperature, etc.
- Extreme conditions
- In situ studies
- Time resolved studies: 20μs resolution

Ideal for extreme environments





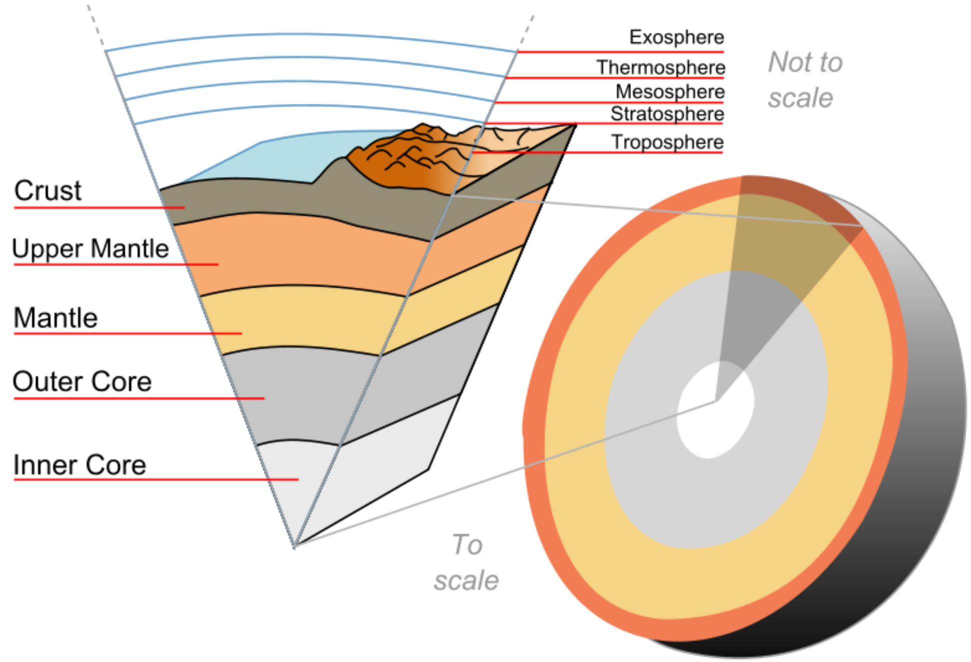
- 16+2T exists today, 25 T split coil HTSC likely in 2020
  - Quantum Magnetism, Supercondictivity, Magnetoelectrics, Magnetocalorics
  - 18T is x2 over existing mapping instruments
- 100kbar, 0.3K-300K and 300-2000K possible
  - Quantum phase transitions, Planetary sciences

Planetary science: High pressure and High Temperature

- Study of the structure of planets
- Upper mantle studies 30 GPa
- **High Temperatures** and **30 GPa** maximum **1-5 mm^3**
- **QENS H-diffusion** water dynamics, Sound velocities

- PE cells used for geo-science
- Sintered DAC for NS emerging

- Pressure determination: **1% wavelength resolution** mode and **diffraction detector** ✓



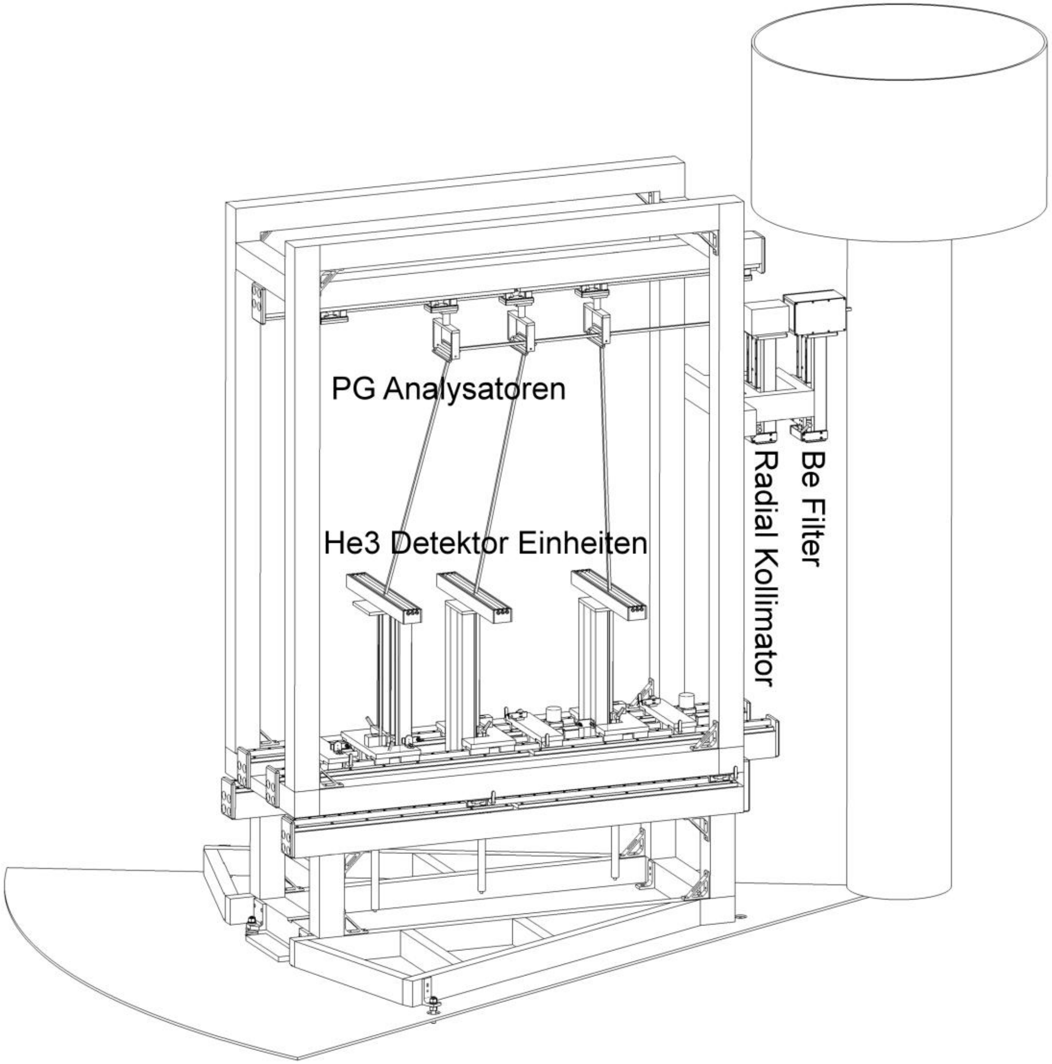
Scientific case

Report On Instrument Concept and Scientific Case

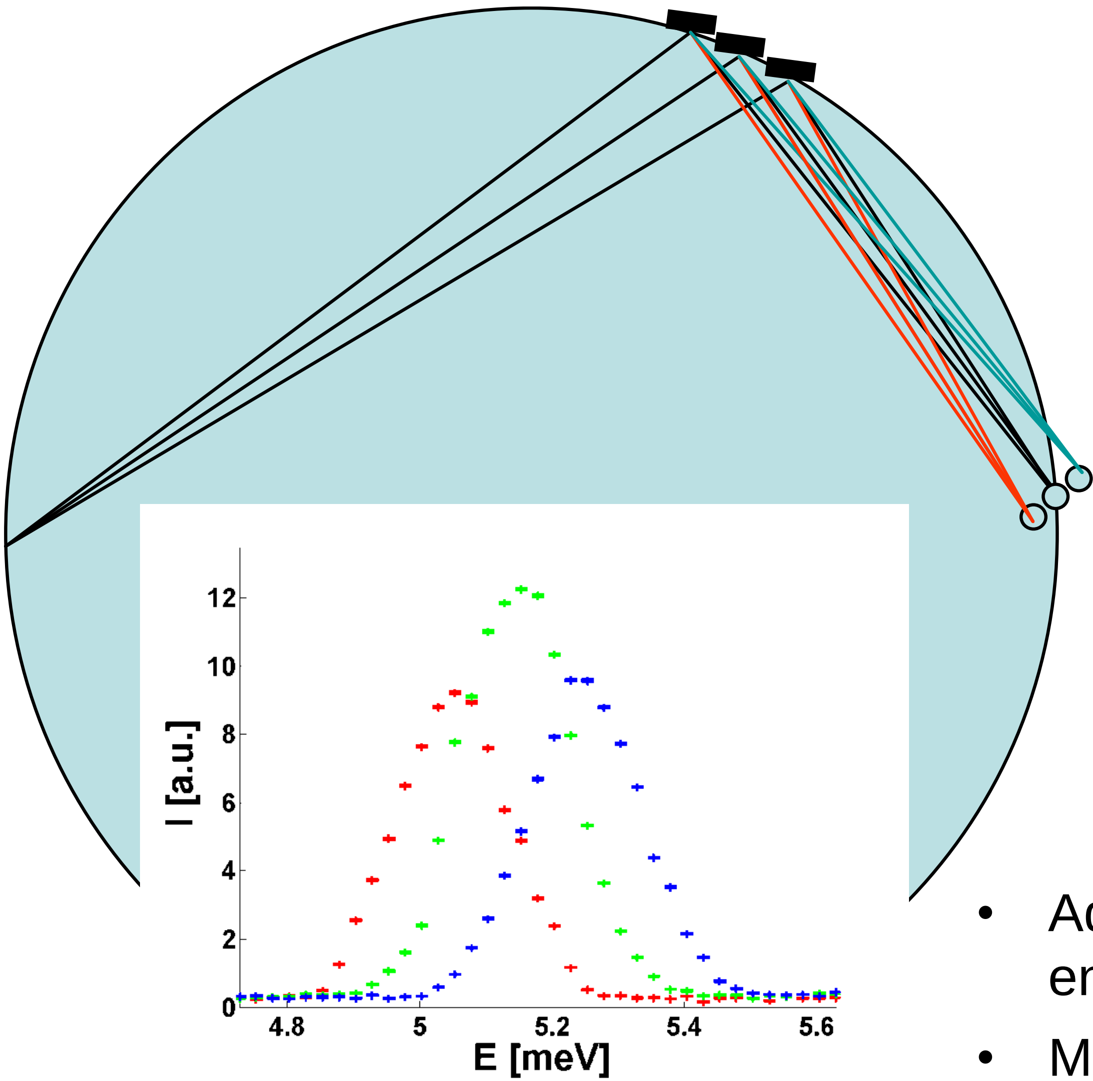
PG Freeman et al. 2013

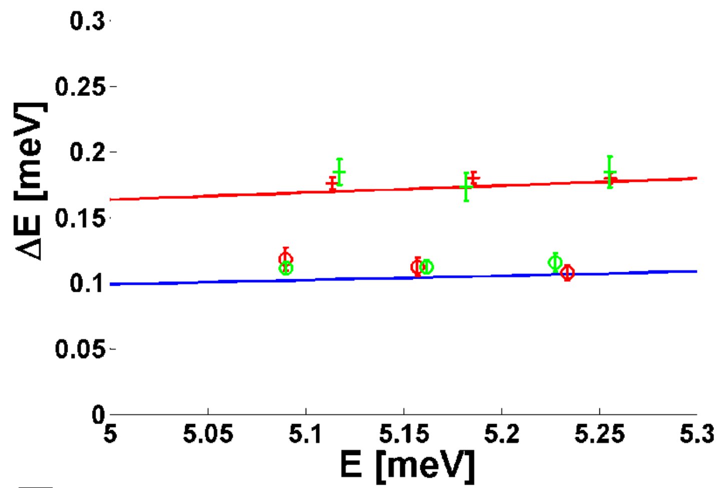
Prototype at PSI

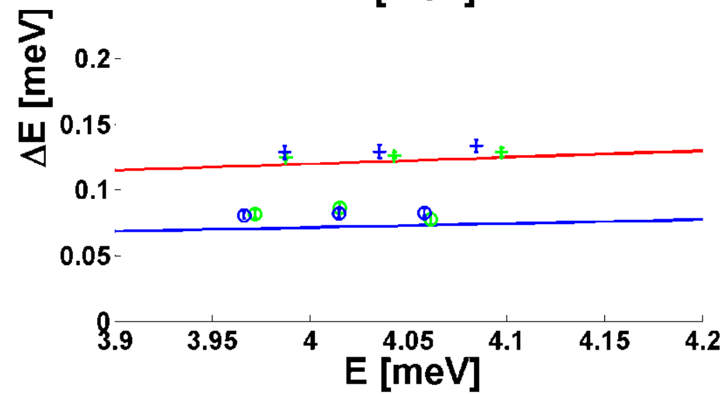
- Proving that CAMEA works
- Validation of calculations (McStas, analytical)
- Trying different geometries and solutions
- Getting experiences in building
- Checking background conditions, and searching for unknown effects



Resolution and energy multiplication works as calculated



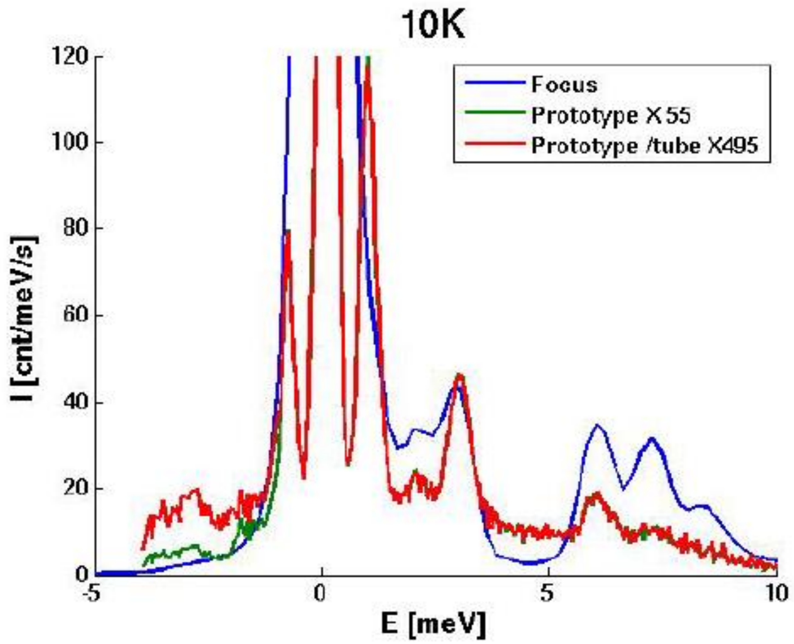




- Adjacent detectors record different energies ⇒ 2.7x neutrons
- Mosaicity no effect on resolution

Real experiments

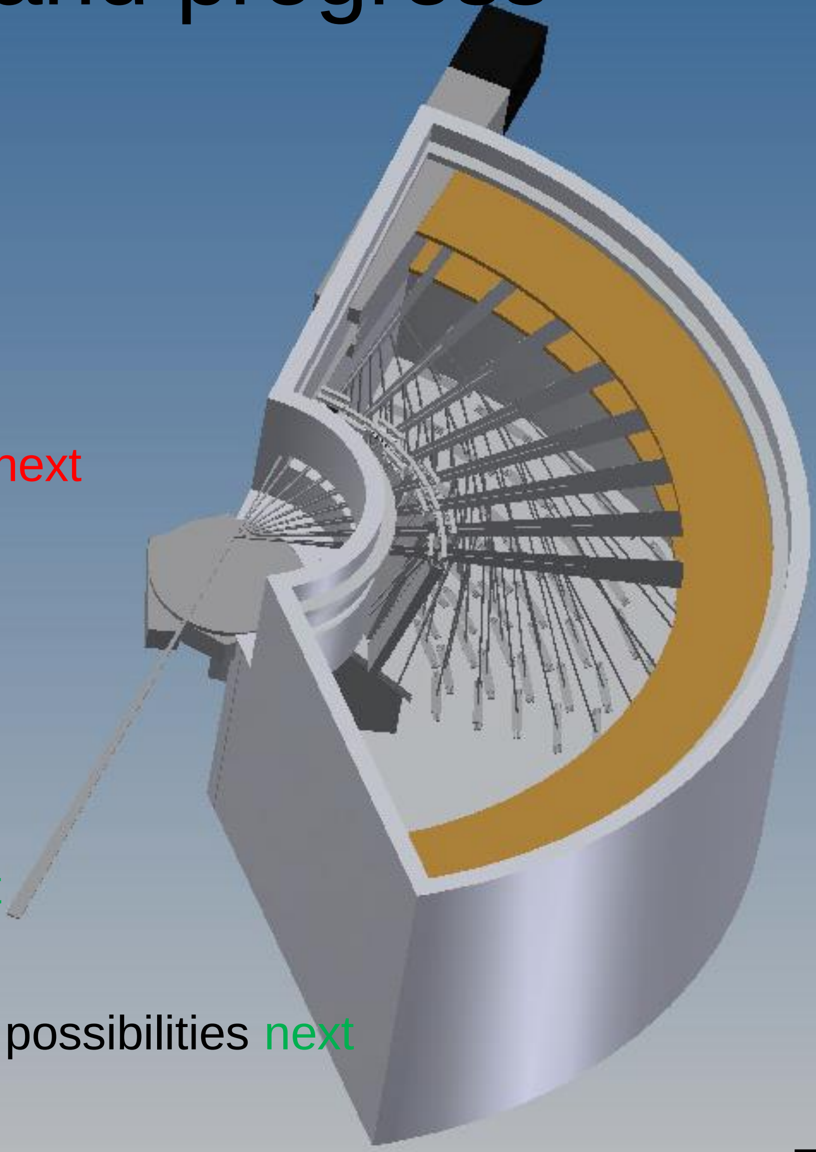
- $LiHoF_4$ crystal field excitations
- Comparison with FOCUS direct TOF



- Prototype has better resolution
- Prototype has >100 times less graphite than CAMEA
- MARS has "slightly" less flux than optimized guide at ESS

Project plan and progress

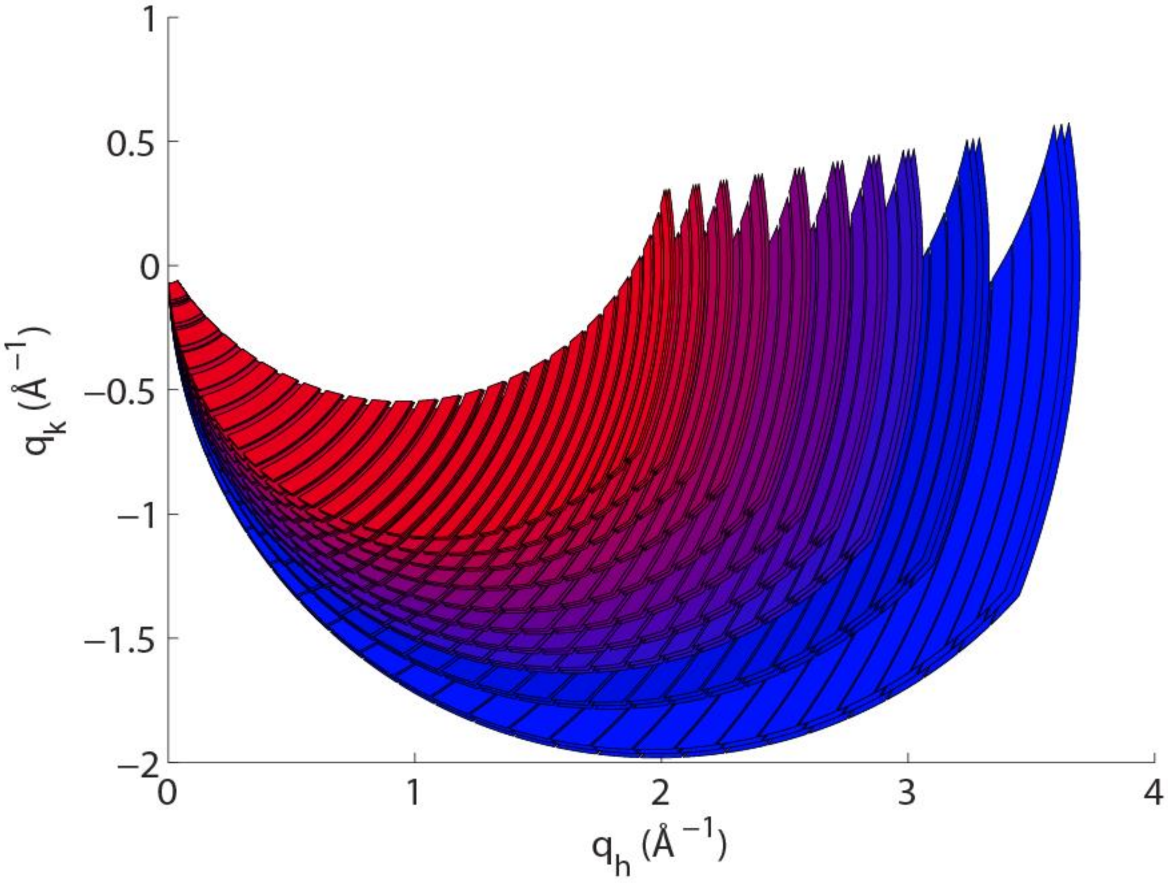
- Concept and science case ✓
- Calculations and Simulations:
  - Kinetics and (q,ω) coverage ✓
  - Flux and resolution possibilities ✓
  - Guide and chopper system ✓
  - background and spurious scattering next
  - Virtual experiments next
  - Geometry optimizations ongoing
- Prototyping
  - Demonstration on RITA II ✓
  - Prototype on MARS at PSI in ✓
  - Pilot-project on RITA-II at PSI in next
- Sample environment
  - Magnet, P-cell 18T,100kbar ✓; 2020 possibilities next



- ⇒ Instrument proposal October 2013 ✓

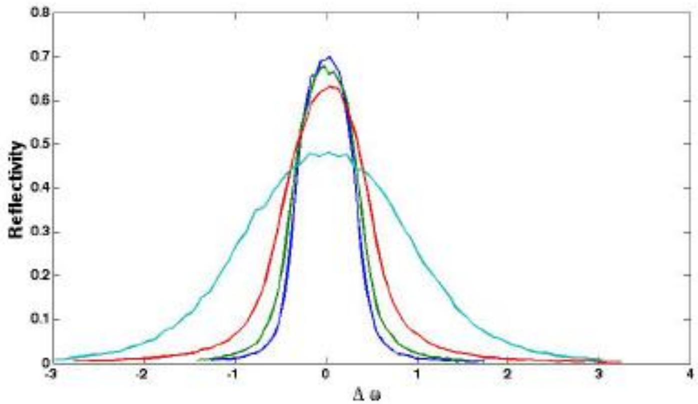
Thank y

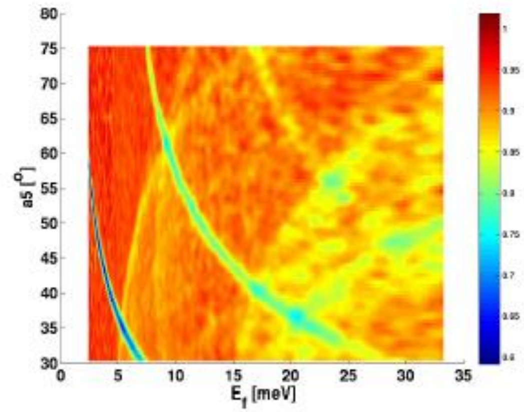
Momentum coverage ✓



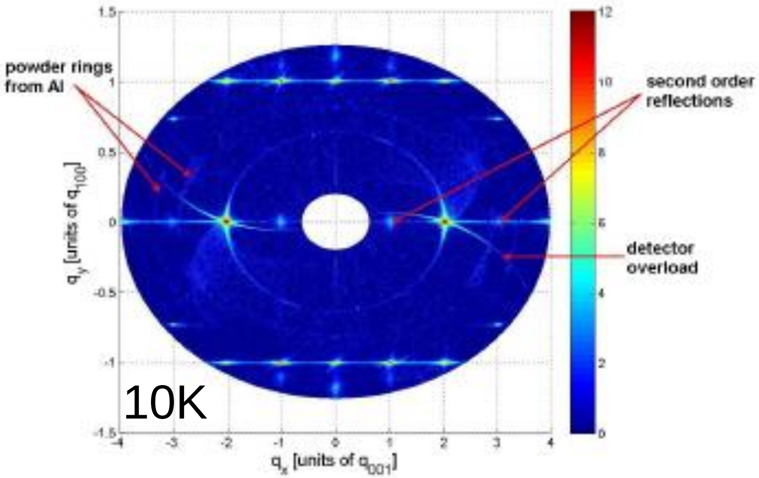
Graphite thoroughly characterized

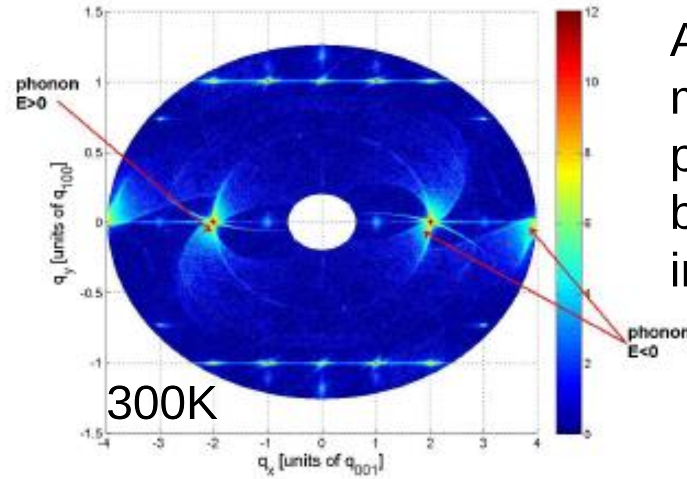
Reflectivity and transmission





Inelastic contamination





Analysers
mounted on
pulse-tube cooled
base plate
in vacuum tank

Background

- Background suppression
  so far successful
  still being optimized
- Important: so far we understanc
  all sources of bck.