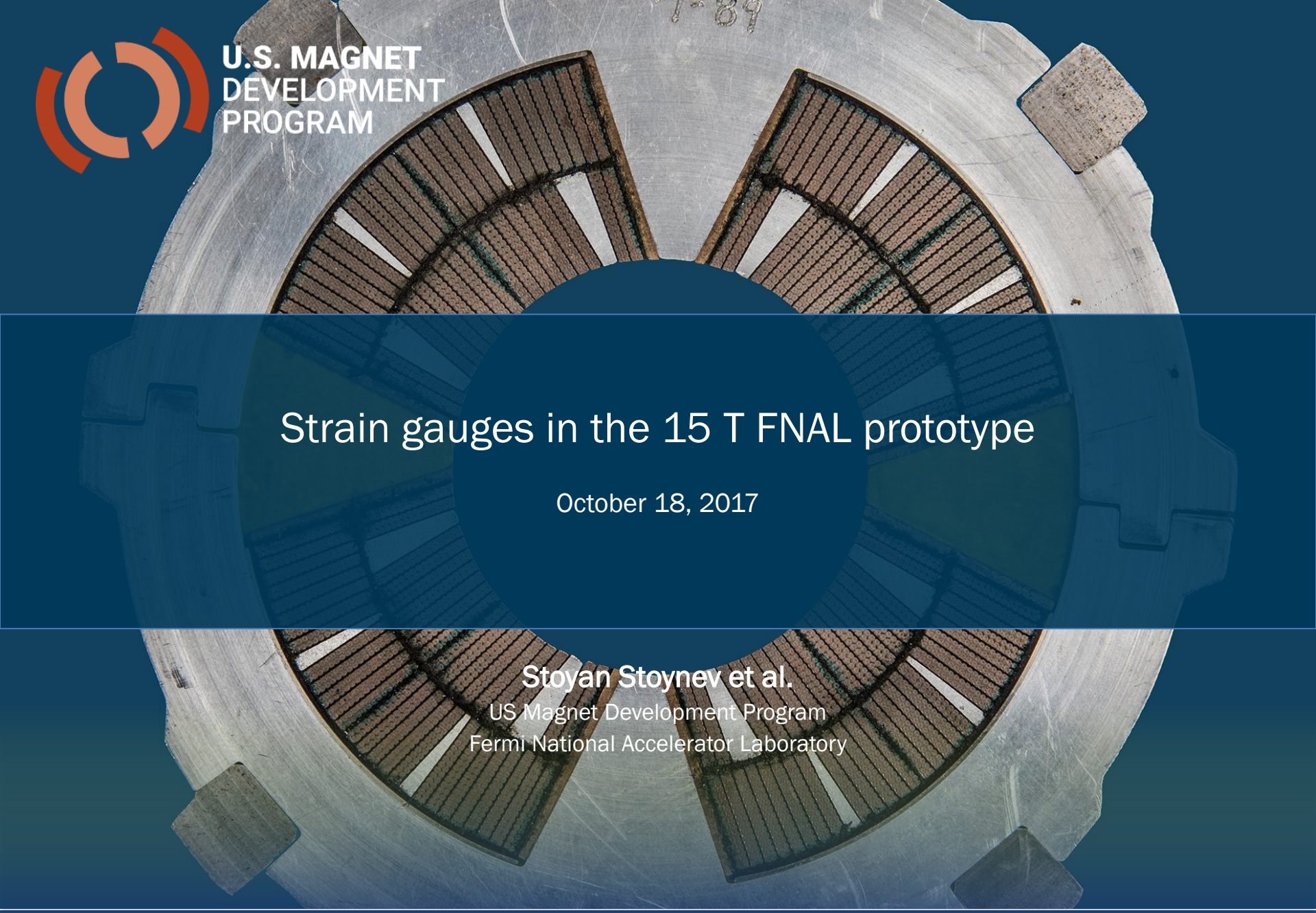

U.S. MAGNET DEVELOPMENT PROGRAM

Strain gauges in the 15 T FNAL prototype

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U.S. DEPARTMENT OF ENERGY | Office of Science

Introduction

- During the latest coil readiness review for layer 1 and 2 for the 15 T magnet at FNAL a discussion on strain gauges was advised
- This presentation summarizes the information on strain gauges and intention of use
- Limitations and considerations are emphasized
- The slides are aimed to serve as a guide for the discussion

Strain gauges at FNAL

- There are typical gauge types being regularly reordered or anyway available at FNAL
- They are suitable and enough to cover the needs for the 15 model

Gauges suitable for Stainless Steel

Skin, Bullets (long)

Layer 3/4 Pole (short)

Suitable for Ti

Layer 1/2 pole

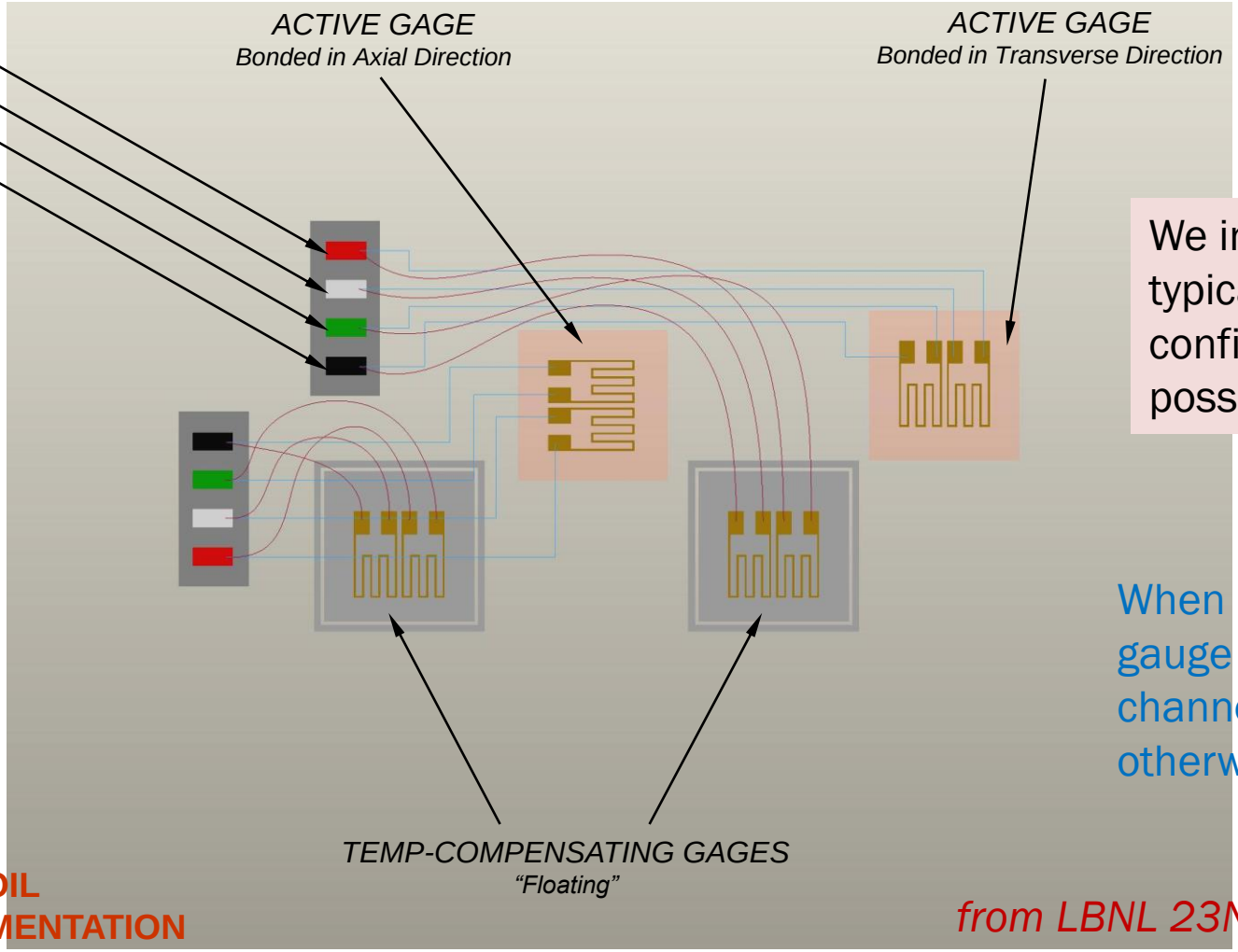
Suitable for coil (Cu)

VMTF limitation:

At VMTF we are capable of reading no more than **64** strain gauge channels through the standard DAQ (typically reading at <1 Hz)

During loading operations there are no specific limitations

Strain gauge connections



We intend to use the typical LBNL SG configuration where possible

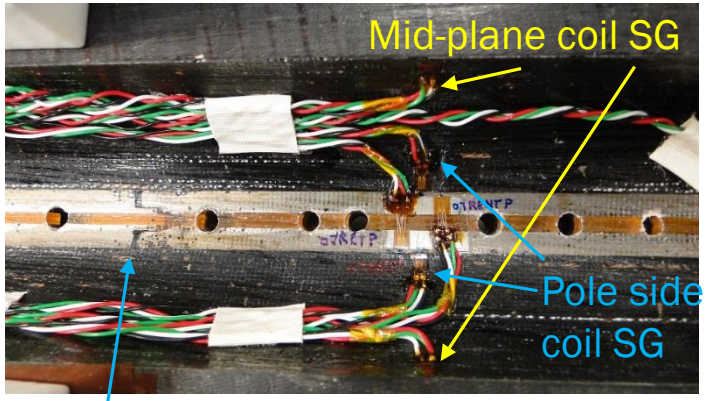
When I later refer to a gauge (SG) I mean gauge channel except if stated otherwise

LBNL COIL INSTRUMENTATION

from LBNL 23N928 SPEC DWG

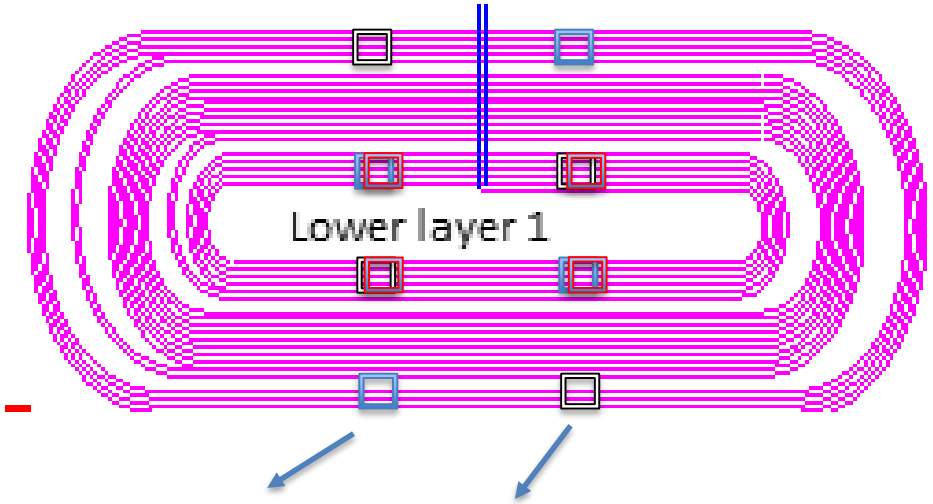
15 T magnet: Strain gauges on coil (L1)

Example from 11 T models



Separation between two pole blocks

Coil SG positions in 15 T

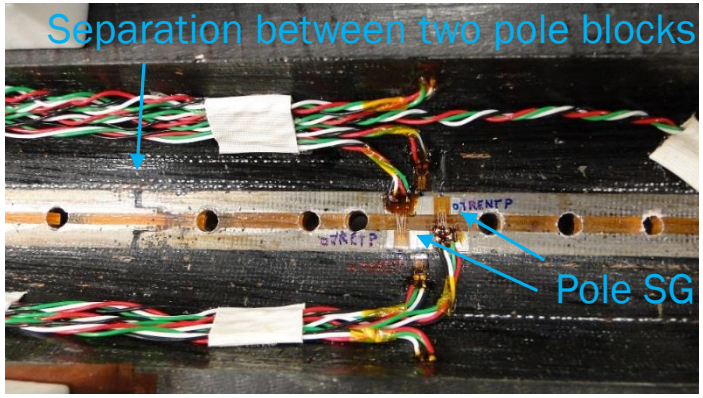


At several inches from the pole block separation

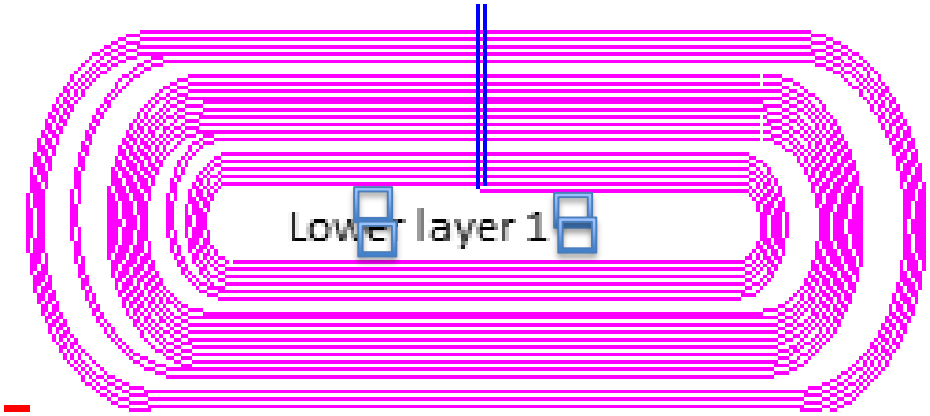
There are 8+4 SG per coil (24 in total) – 16 azimuthal and 8 axial.
Not all of them will be read – the ones in black (▣) are to be skipped (or back up)
The axial SG are optional and debatable (▣) – from review comments
So 8 (+ 8) active coil SG foreseen.

15 T magnet: Strain gauges on pole (L1)

Example from 11 T models

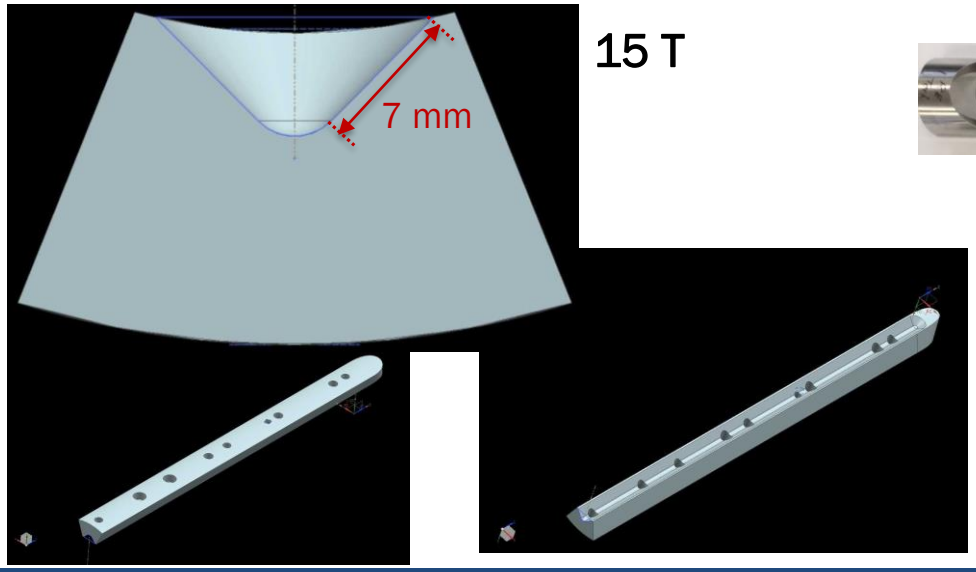


Pole SG positions in 15 T



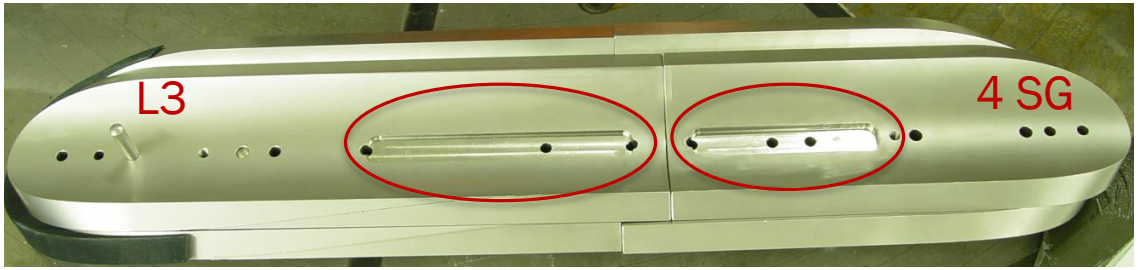
SG are attached from below

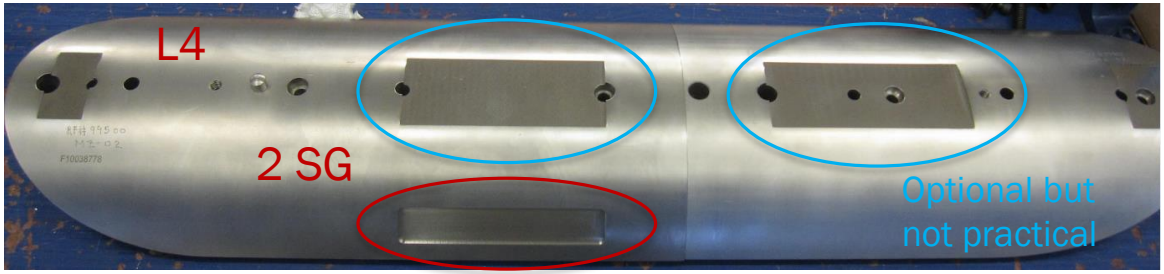
15 T



There are 4 SG per coil (8 in total) – half of them axial , half - azimuthal.
8 L1 pole SG foreseen.

15 T magnet: Strain gauges on pole (L3/L4)



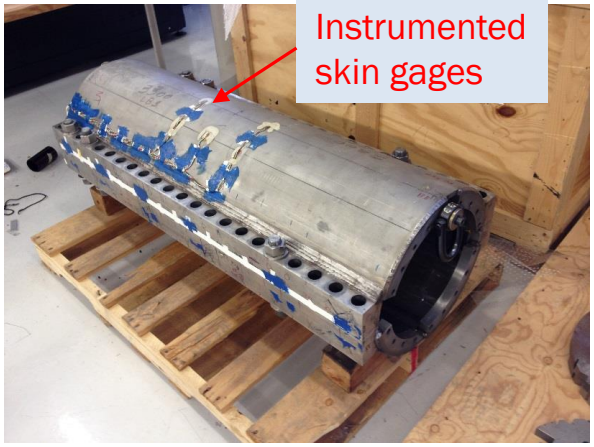


Groove positions circled in red show will contain each one azimuthal and one axial SG

Each groove will have one azimuthal and one axial gauge.
12 L3 and L4 pole SG foreseen for the magnet.

15 T magnet: Skin and bullet strain gauges

Example from 11 T models

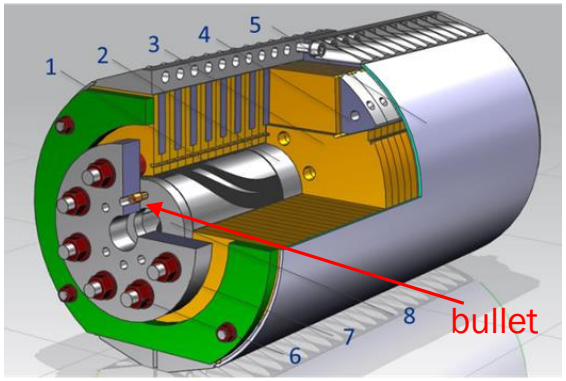


Two positions (~ 70 cm apart longitudinally) around the magnet center to be instrumented

- At 90° and 45°
- Azimuthal and axial gages
- Two opposite sides of the magnet circumference

16 skin SG foreseen.

15 T model



There are 8 bullet holes on the LE and 10 bullet holes on the RE

- A bullet is instrumented with 2 SG
- One TC on each side of the magnet
- Only part to be instrumented

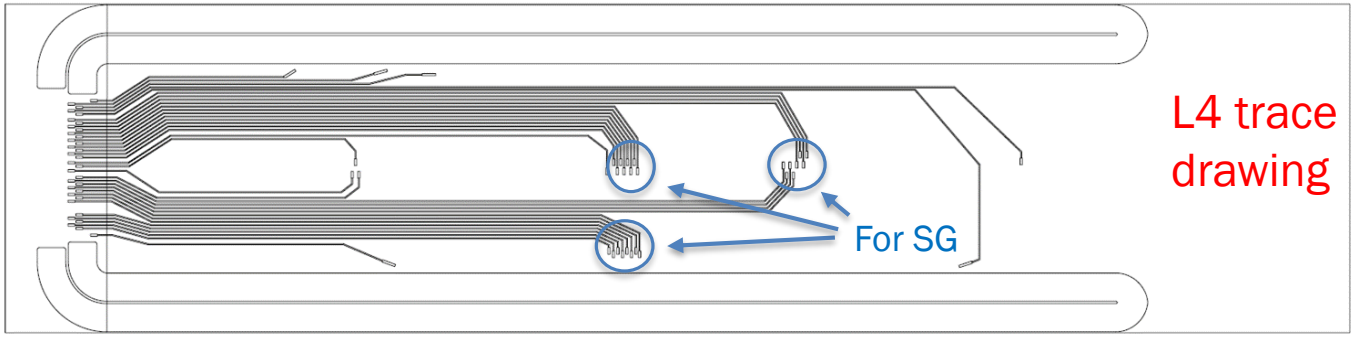
20 bullet SG foreseen.

15 T magnet: Strain gauge wiring

- Layer 4 SG are directly wired to the trace strip pads in the grooves
- Layer 3 SG are wired to the trace on Layer 4 through pole holes

Only 24 strips are available on one trace for SG

thus only 6 SG (per trace) can be read during testing



- Layer 2 has no SG
- Layer 1 SG are wired manually (as in 11 T models)
- The rest (skin, bullets) – as usual

15 T magnet: Total number of SG

	coil	pole	skin	bullet		SUM
All	16+8	20	16	20		72+8
Active	8	20	16	20		**64**

Optional
(to reshuffle)

During magnet testing

This is already a reduced number

We want to read all of them

We can probably skip 2 SG (half the axial ones)

Instrument more coil gauges?

With this we instrument 9 out of 18 bullets; it could be reduced to read more coil gauges

15 T magnet: L4 grooves